SOUTHERN LEE COUNTY
FLOOD MITIGATION PLAN

AUGUST 31, 2020

Lee County
Southwest Florida
BOARD OF COUNTY COMMISSIONERS

Prepared by:

AIM Engineering & Surveying, Inc.
AIM 1980-2020

JOHNSON ENGINEERING

ATM DESIGN ENGINEERING CONSULTING

A·D·A ENGINEERING

EXECUTIVE SUMMARY

BACKGROUND

In late August and early September of 2017, Lee County experienced two consecutive storm events, Invest 92L and Hurricane Irma. These cumulative rainfall events were categorized as 100-year storms, and even more in some locations. These storms caused significant structure flooding in downstream locations across Lee County, such as along the Imperial River/Bonita Springs, Island Park, Bedman Creek, Hickey Creek, Orange River, as well as others. Widespread and prolonged roadway flooding also affected many citizens for several days. Following this severe flooding of multiple areas within Lee County, Lee County Department of Natural Resources implemented a phased approach to address flooding potential within a large portion of Lee County south of the Caloosahatchee River:

- Phase 1, conducted by County staff, focused on the immediate removal of known obstructions in waterways identified in initial assessments.
- In Phase 2, selected engineering consulting firms provided a more detailed field assessment including mapping of drainage impediments to provide an inventory of issues that could be remedied quickly. As part of Phase 2, the engineering consultants also provided preliminary high-level flood mitigation concept suggestions for further evaluation. In both Phase 1 and 2, the observed effects of flooding and the impacts to Lee County residents revealed the limitations of many primary drainage flow ways within Lee County.
- For this Phase 3 effort, Lee County commissioned AIM Engineering & Surveying to further develop flood mitigation concepts to address extreme rainfall events for most of southern Lee County (see study area **Figure 1** below).

These extreme storm events and the associated flooding impacts emphasized the need to develop a functional regional system solution. Development of this Southern Lee County Flood Mitigation Plan (SLCFMP) therefore involved preparing a regional hydrologic/hydraulic model, which included the majority of the southern Lee County area lying south of the Caloosahatchee River, to analyze the system-wide performance of the conceptual projects for the given storm event scenarios. Portions of contributing drainage from Hendry and Collier Counties were also included to model this large 485-square-mile portion of Lee County. A second large-scale model addressing the southeast area of the SLCFMP was also developed utilizing an Interconnect Channel and Pond Routing Model (ICPR4), which included evaluating two of the preliminary concept projects. After completion of the regional model, three local models were also prepared for specific County selected projects.

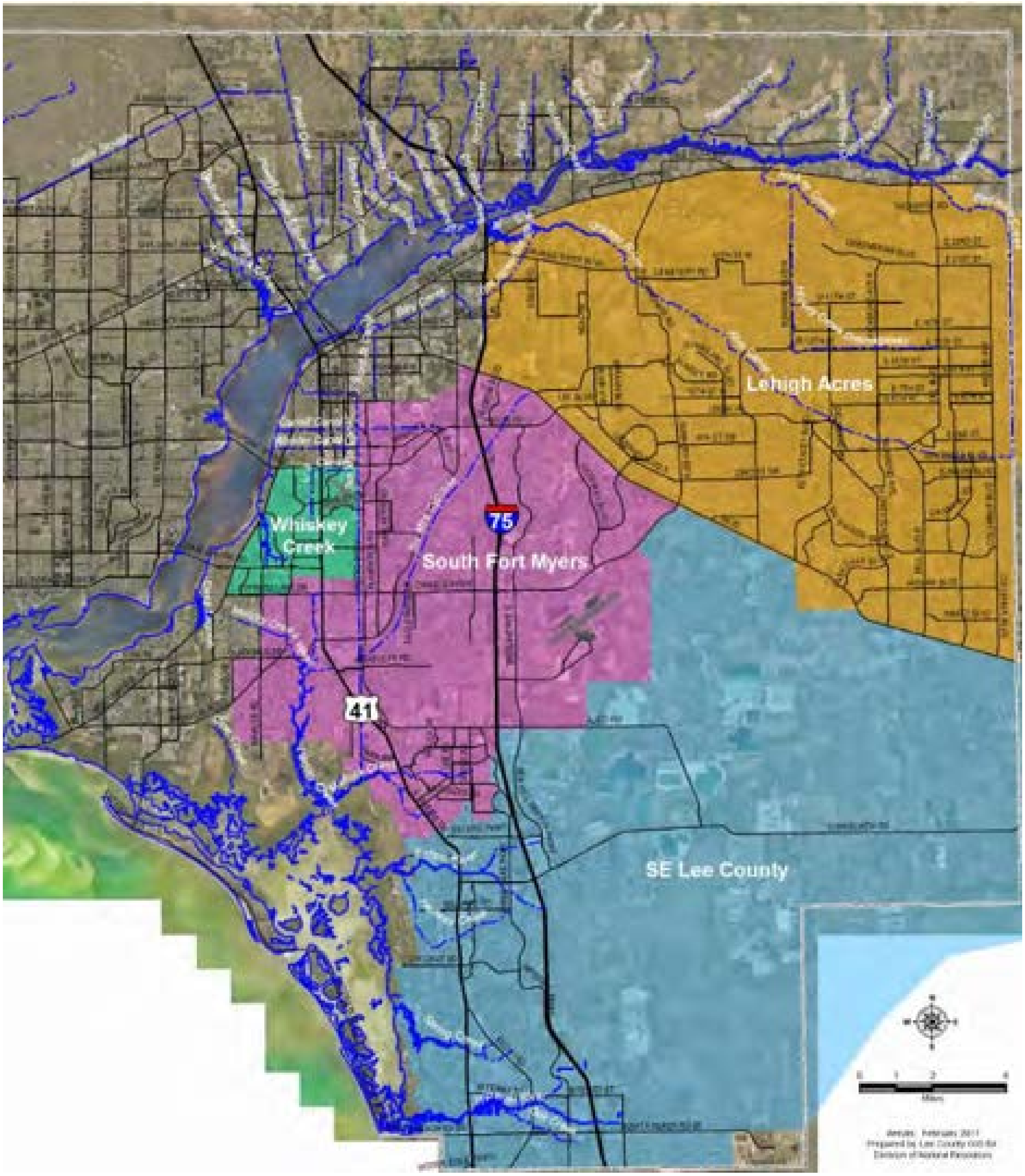

Figure 1 - Study Area

OBJECTIVES

The primary objective was the development of preliminary concept projects within the study area that would provide the ability to substantially mitigate future flooding due to significant storm events such as the combined Invest 92L and Hurricane Irma event. A system-wide approach aided in understanding the regional improvements when implementing concept projects, as well as identifying and mitigating adverse impacts to upstream and downstream components. The objectives of the SLCFMP included the development of a large scale regional hydrologic model for southern Lee County to evaluate the system impact of the collective concept projects for mitigating flood conditions. With data from this model, high-level evaluation reports were prepared for each concept including a preliminary Opinion of Probable cost. From this report, a Project Prioritization Matrix was prepared to assist Lee County in evaluating concept implementation. As part of the regional modeling effort, a future conditions model was developed to look at the impacts of development growth as well as sea level rise. This same model looked at basin storage needs based on new development, and also evaluated and recommended allowable stormwater discharge rates for these new developments within each watershed basin. Finally, there was a model developed to focus on analyzing a storage/controlled discharge concept for the Crew-Flint Pen area relative to flood mitigation, but also looking at the year-round hydrological effect on this property. Throughout all of this effort, coordination with various agencies and stakeholders was an on-going objective.

METHODOLOGY

The objectives were accomplished as follows:

- Review of existing flood condition documents (including the Phase 2 report), studies, and post-Hurricane Irma flood photographs.
- Interviewing local officials for flooding impacts in their relative areas.
- Analysis of the watershed for potential concept projects for improving floodway conveyance and flood water storage components.
- Development of the hydrologic model using other existing models where possible, which was calibrated and reviewed.
- Preparation of preliminary concept project data for implementation into the model for analysis.
- Further development of a hydrologic model to provide initial concept project screening.
- Provision of a final hydrologic model demonstrating the concept project performance during a 25-year, 3-day storm event, a 100-year, 3-day storm with two different antecedent conditions, and a 2017 year-long simulated period that included Invest 92L and Hurricane Irma storm events.

The hydrologic model results were prepared from a calibrated hydrologic model with a focus on the 2017 wet season of the summer of 2017 for the purpose of evaluating flood mitigation projects. In order to provide a useful modeling tool, the Existing Conditions model was prepared with the assumption that the model network channels are maintained, or rather, are not blockaded by overgrown vegetation, fallen trees due to high hurricane winds, or other conveyance limiting debris. The concept projects for each area were incorporated into the regional model and the system-wide improvements comparing existing and proposed conditions are reported for a given design storm.

RESULTS

The model outputs confirmed the flood mitigation value of the projects as a combined system. Peak water levels were reduced in targeted areas that had demonstrated structure flooding as a result of the 2017 major storms. These peak water levels were reduced in these key downstream areas by one foot to several feet. In addition, the duration of peak stages was significantly reduced in many cases. The overall reduction of peak water levels and improvement in recovery time will provide significant benefits to the widespread prolonged road flooding previously encountered. Select results are summarized within each study area and ADA accompanying regional model report, as appropriate. The conceptual projects were evaluated and preliminary opinions of cost were developed, along with a high-level review of project benefits. These outputs were summarized within the priority matrix section of this project.

LIMITATIONS

The regional model was developed utilizing the Mike SHE / Mike 11 computer modeling tool on a 750-foot grid cell size over this very large study area. To control costs, previously completed models were integrated where possible. This conceptual level study included sufficient model input detail for analysis in demonstrating regional flood mitigation results. The focus of the model was flood mitigation and therefore, the calibration also focused on this. Due to the large scale, a coarse grid size was used. Further model refinement for selected areas may be beneficial for more reduced size study areas. Continued collection of surface and groundwater data is encouraged, as is the expansion of these collection points to further refine the model. The concepts were not based on a field survey, environmental studies, geotechnical information, utility adjustments, and other site specific data, and therefore do not reflect a design level scenario. Further, more local scale modeling and analysis are required to determine conveyance dimensions, configurations, structures, and other factors for the most practical, cost-effective, agency-approvable, constructible, and acceptable design. For the developed ICPR4 model, while the area is somewhat reduced, it is still a large-scale model that includes the limitations listed herein. While the SLCFMP provides very useful guidance, the focus is regional flood mitigation. Other stormwater master plans, documents, and localized models should be considered for purposes beyond this focus. While this system of concepts would provide substantial flood mitigation benefits, it is important to note that it is not capable of addressing all levels of storm events. In addition, based on Lee County's coastal region, the potential for storm surge or other rises in the receiving tidal waters would greatly affect flooding outcomes.

CONCLUSIONS & RECOMMENDATIONS

The presented concept projects made improvements towards mitigating flooding. As a system of projects, the flood mitigation was significant. The concepts ranged from straightforward drainage improvements, such as a pipe in an existing easement, to large-scale complicated and substantial improvements with land acquisition, significant environmental impacts, involved lengthy permitting, and multi-governmental entities. While it is not feasible to mitigate all flooding conditions, implementation of these concept projects would significantly mitigate flooding of roadways including evacuation routes, mitigate the number of structures negatively affected by flooding, reduce post-storm flood durations, and provide the ability to reduce neighborhood flooding via connections to these regional backbone concept projects. While the focus of the SLCFMP concepts was flood mitigation, many of the developed concepts provide additional benefits such as water storage, water quality enhancements, and potential wetland hydro-period extension.

The SLCFMP provides a valuable master plan to guide long term flood mitigation efforts for the majority of Lee County south of the Caloosahatchee River. This document can aid in developing long term implementation plans. High priority projects can be programmed with Capital Improvement Programs. The SLCFMP will also be useful as County staff review new developments, providing the ability to consider and coordinate development stormwater needs with this Regional Plan. The plan allows for the identification of opportunities for coordination with other governmental projects such as roads, 20/20 property acquisition, and water quality projects. The concept project list also provides a useful tool as County staff look to pursue pertinent grants.

Several strategies should be considered when implementing this flood mitigation program. Straightforward low-cost improvements can be funded, designed, permitted, and constructed as quickly as practical. Several concepts are currently being implemented. Some components of the plan may be coordinated with land developers or with highway construction as those opportunities become available. Some highway projects can be planned to utilize SLCFMP projects for needed drainage conveyance, water quality treatment, and stormwater attenuation. Excavation from the SLCFMP project can also provide for road embankment needs by generating cost-effective fill material. Coordination with programs such as Conservation 20/20 can also be pursued. In some cases, these same type of lands can provide the flood mitigation conveyance needs, as well as water quality treatment, and typical passive preserve area. Flow way easements or land rights can be pursued for as many of the conveyance routes as soon as practical to avoid routes being hindered by development, incorporated into a property association, or otherwise having a diminished practicality. For example, this may involve coordinating with mine lake owners, land developers, or property owner associations sooner rather than later. Some very large concept projects may require development in phases. Implementation of the concept project can therefore be a phased approach. The first phase can focus on acquiring lands or easements with subsequent design, permitting, and construction phases delayed until funding allows.

FUTURE CONSIDERATIONS

Although not a part of this project development, a maintenance plan should be developed for each significant conveyance and facility. This plan should include but not be limited to routine cleaning of the natural rivers and creeks, removal of excessive and invasive vegetation, removal of sediment buildup in conveyances and structures, routine maintenance and operation of all gates and associated improvements, and replacement of drainage facilities that are failing. A good maintenance plan will increase the longevity of the drainage facilities and will allow for maximum conveyance capacity during storm events. This is important with the County's current stormwater system, but even more notable as additional automated weirs with telemetry and pumps are added to the network.

The ability to operate these significant projects as a group can provide great flexibility to Lee County in the future. With the implementation of modern remote-controlled automated water control structures/devices, the County can react to needs quickly. A centralized control facility could be a future consideration to coordinate this effort fully.

As with most master plans, this document should be a living document that is used well, but also updated and amended as future development occurs and subsequent localized modeling is performed. Continually updating the plan and the model will provide optimum on-going value for this document. Continued collection of relevant data for groundwater and surface water is encouraged, as is expansion of the data collection points. With the installation of new weirs, this surface water data should be collected automatically.

FORMAT OF THE REPORT

This report is divided into four parts, which includes summary and introduction sections as follows:

- Summary of Concept Projects
- Introduction
- Part 1 – Concept Projects
  - Addresses the development and analysis of preliminary flood mitigation projects in the four study areas.
- Part 2 – Project Prioritization Matrix
  - Addresses the development of a priority matrix for the concept projects in each of the four study areas.
- Part 3 – Regional Modeling
  - Addresses the development of the MIKE SHE/MIKE 11 regional model, modeling of the concept projects, future conditions modeling, and basin storage/discharge.
- Part 4 – Appendixes
  - Information and data that supported the development of Parts 1 through 5.
  - Summary of three local models that were developed in the South Fort Myers study area.
  - Summary of the ICPR4 model development for a portion of the Southeast Lee County area, and modeling of two of the preliminary concept projects.
  - Summary of the 5-year and 10-year storm events.

SUMMARY OF CONCEPT PROJECTS

The study area was subdivided into the approximate East Lee County, Whiskey Creek, South East Lee County, and South Fort Myers boundaries demonstrated in **Figure 1**.

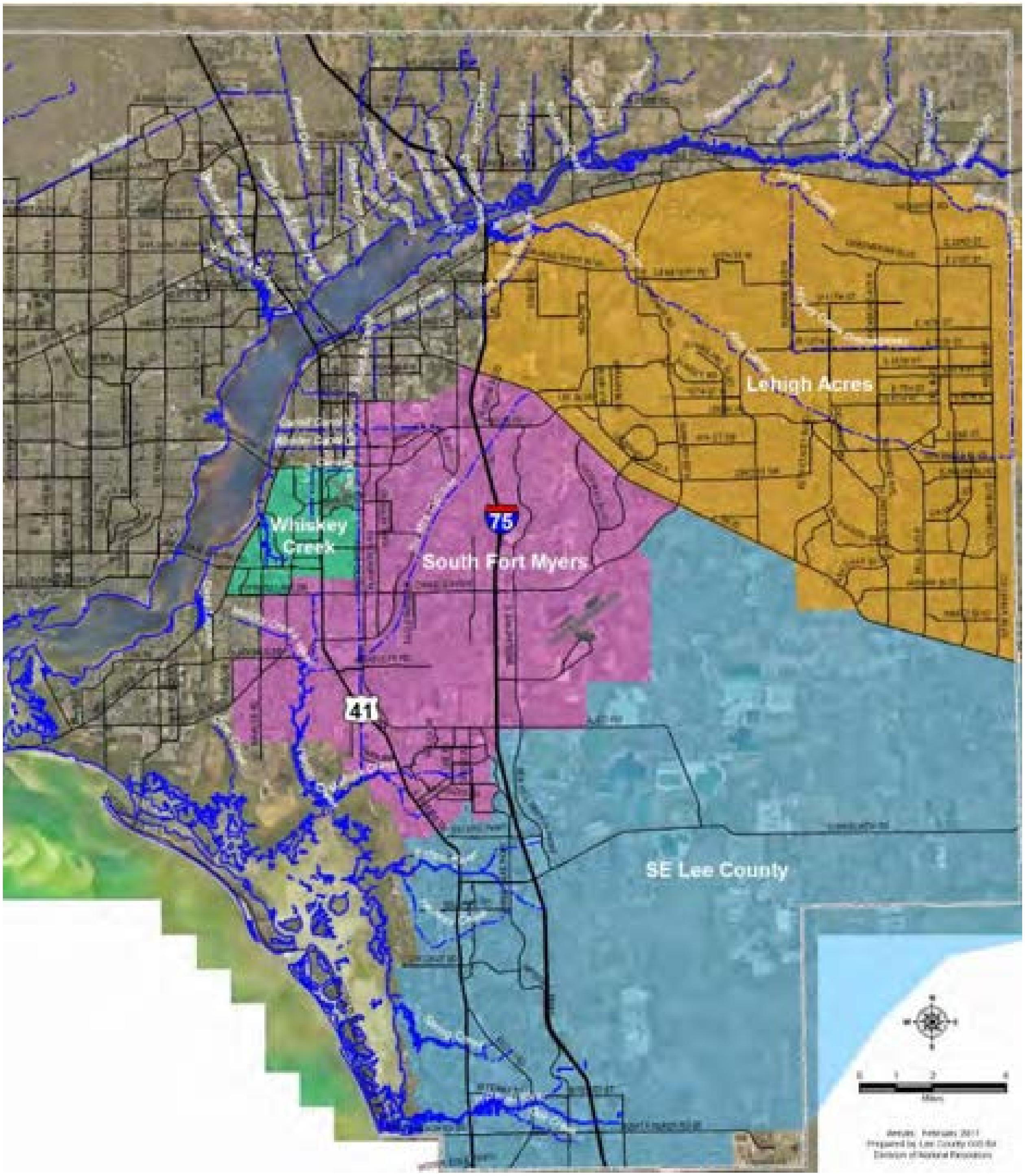

Figure 1 – Overall study area and approximate sub-area boundaries.

SUMMARY OF EAST LEE COUNTY FLOOD MITIGATION BENEFITS

Flood mitigation benefits are in general achieved when excess storm water is conveyed and/or stored appropriately to reduce flooding levels and duration that would otherwise inundate structures and have prolonged road flooding. These adverse conditions impact the health, safety, welfare of the residents and have a significant economic impact to the community. The flood mitigation improvement would be achieved by developing flow paths to open water and/or reservoirs to store flood waters for later release following the storm event. Most concept projects in the East Lee County area share in handling excess flood water on a regional basis and this system of concept projects contributes to a flood mitigation solution. This system approach to meeting the flood mitigation goals is necessary since many flooding problems are not solvable on a local level. For instance, areas of Lehigh Acres drain large flows to natural streams that result in high water levels for an extended period. Placing improvements in natural streams to handle high flows is challenging due to environmental impacts and other constraints, and alternately blocking flow from entering natural streams results in upstream basin flooding. Current conditions show both upstream and downstream residents with flooding problems.

Eleven preliminary concept projects were developed for the East Lee County study area as shown in **Exhibit 1.1**. The projects work in concert to develop an overall system improvement to this approximately 150 square mile drainage basin. Targeted areas for reduction in structure flooding included those structures abutting the natural conveyances of Orange River, Hickey Creek, and Bedman Creek. Again, the greatest benefit is seen with implementation of these concept projects as a system. This is reflected in the Regional Model which was run with all concepts stitched together in this system approach.

AIM reviewed the Regional Model system output and then considered the relative individual concept contribution to provide an evaluation of each project's flood mitigation benefit. This was assisted by review of documents such as the Phase 2 reports for this project and Post Irma flooding aerials which showed the potential impact to structures and significant roadway flooding. The contribution or benefit of each project concept is discussed as follows based on modeling results for the 100-Yr, 3-Day storm events:

Bedman Creek/Bedman Basin

Projects 1.1.1, 1.1.2, and 1.1.3 collectively benefit the Bedman Creek area and Bedman Basin. The projects work together to store and redirect large storm flows to greatly reduce flooding impacts to the constrained natural Bedman Creek. The three projects combined to reduce flood levels in downstream sections of Bedman Creek by over four to five feet. This substantial reduction in water levels greatly reduces the flooding potential for those structures previously affected by Hurricane Irma. In addition, Lehigh Acres and other adjacent road flooding would be reduced in extent and duration. The model indicated on average approximately a one-foot reduction for peak water levels upstream within Lehigh that would benefit that goal. Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.1 ***Dog to Hendry Drainageway (CREST)*** - This conveyance and storage concept project was developed to direct flood flow away from Bedman Creek. The modeling results show approximately a 300 cfs reduction in the peak flood flow in Dog Canal that drains to Bedman Creek. Water quality treatment is an additional benefit of this project.

1.1.2 ***Bedman Creek Overflow Bypass*** - This conveyance concept project was developed for flood mitigation of the Bedman Creek area using an overflow bypass to direct flood flow to Carlos Waterway and then the Caloosahatchee River. The modeling results show a reduction in Bedman Creek flood flow of over 300 cfs, with a conveyance potential to positively redirect over 800 cfs. Water quality treatment is an additional benefit of this project.

1.1.3 ***GS-10 Stormwater Quality Reservoir***- This flood reservoir storage concept project was developed to store excess flood waters to reduce flows in Dog Canal and Hickey Canal that flow to Bedman Creek and Hickey Creek respectively. The modeling results show over a 300 cfs reduction in the peak flood flow to Dog Canal that drains to Bedman Creek and over a 300 cfs reduction in the peak flood flow to Hickey Canal that drains to Hickey Creek. Water quality treatment is an additional benefit of this project along with improved hydration of Greenbriar Swamp.

Orange River/Orange River Basin

Projects 1.1.4, 1.1.5, 1.1.7, and 1.1.9 collectively benefit the Orange River natural stream area and Orange River Basin. The projects work together to store and redirect large storm flows to greatly reduce flooding impacts to the constrained natural Orange River. The four projects combined to reduce flood levels for the 100-year storm in downstream sections of Orange River by up to approximately one foot. This reduction in water level reduces the flooding potential for those structures previously affected by Hurricane Irma and previous major storms. In addition, Lehigh Acres and other downstream Orange River adjacent road flooding would be reduced in extent and duration. The model indicated on average approximately a half foot reduction for water levels upstream within Lehigh that would benefit that goal. Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.4 ***Buckingham Bypass Drainageway*** – This conveyance concept project was developed to direct flow away from the Buckingham Road/Orange River area and to improve flood flow out of Lehigh Acres. The modeling results show a 155 cfs increase to 366 cfs flood flow from Lehigh Acres at this location, as well as, intercepting an additional flood flow reaching 1,474 cfs in the bypass drainageway. Intercepting the large flood flow significantly reduces flooding in the Buckingham/Orange River area. Both Lehigh Acres and Buckingham residents are the beneficiaries of this project.

1.1.5 ***Buckingham Trails Water Quality Reservoir*** - This flood reservoir concept project stores excess flood water until the storm event passes. This reservoir reduces the volume of flood water flow to Orange River. A benefit to Buckingham/Orange River area residents would be realized from this improvement. Water quality treatment is an additional benefit.

1.1.7 ***Hickey Creek Overflow Bypass*** - This conveyance concept project was developed for flood mitigation of the Hickey Creek area using an overflow bypass to direct flood flow to the Caloosahatchee River. The modeling results show a reduction in Hickey Creek flood flow of over 1900 cfs which is approximately what this new project is conveying. While this project provides strong flood mitigation benefit to the Hickey Creek basin, due to the Charlie Diversion connection it also can provide benefit to the Orange River.

1.1.9 ***Charlie Diversion-Hickey Canal Improvement*** - This conveyance concept project was developed to direct flow away from the Orange River to the Hickey Canal and on to the Caloosahatchee River. This diversion is intended to reduce the flood flow to the Buckingham/Orange River area. The modeling results show over 400 cfs increase in flood flow away from the Orange River. Buckingham and Lehigh Acres residents are the beneficiaries of this project.

Hickey Creek/Hickey Basin

Projects 1.1.3, 1.1.6, 1.1.7, and 1.1.9 collectively benefit the Hickey Creek area and Hickey Basin. The projects work together to store and redirect large storm flows to greatly reduce flooding impacts to the constrained natural Hickey Creek. The four projects combined to reduce flood levels for the 100-year storm in downstream sections of Hickey Creek by over six feet. This substantial reduction in water levels greatly reduces the flooding potential for those structures previously affected by Hurricane Irma and previous major storms. In addition, Lehigh Acres and other adjacent road flooding would be reduced in extent and duration. The model indicated on average approximately a three-foot reduction for water levels upstream within Lehigh that would benefit that goal. Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.3 ***GS-10 Stormwater Quality Reservoir***- This flood reservoir storage concept project was developed to store excess flood waters to reduce flows in Dog Canal and Hickey Canal that flow to Bedman Creek and Hickey Creek, respectively. The modeling results show over a 300 cfs reduction in the peak flood flow to Dog Canal that drains to Bedman Creek and an over 300 cfs reduction in the peak flood flow to Hickey Canal that drains to Hickey Creek. Water quality treatment is an additional benefit of this project along with improved hydration of Greenbriar Swamp.

1.1.6 ***Lehigh-River Hall to Olga Outfall*** – This conveyance concept project was developed to improve flood flow out of Lehigh Acres. The modeling results show over a 100 cfs flood flow from Lehigh Acres at a water level being 5.35 feet below the top of bank at this location. Lehigh Acres residents are the beneficiaries of this project.

1.1.7 ***Hickey Creek Overflow Bypass*** - This conveyance concept project was developed for flood mitigation of the Hickey Creek area using an overflow bypass to direct flood flow to the Caloosahatchee River. The modeling results show a reduction in Hickey Creek flood flow of over 1900 cfs which is approximately what this new project is conveying. While this project provides strong flood mitigation benefit to the Hickey Creek basin, due to the Charlie Diversion connection it also can provide benefit to the Orange River.

1.1.9 ***Charlie Diversion-Hickey Canal Improvement*** - This conveyance concept project was developed to direct flow away from the Orange River to the Hickey Canal and on to the Caloosahatchee River. This diversion is intended to reduce the flood flow to the Buckingham/Orange River area. The modeling results show over 400 cfs increase in flood flow away from the Orange River. Buckingham and Lehigh Acres residents are the beneficiaries of this project.

1.1.10 ***Hickey Creek Swamp Drainageway*** - This conveyance concept project was developed to direct flow away from the Hickey Creek area. In large storm events the Hickey Creek Swamp and flow from the River Hall community flows towards the Hickey Creek area. The modeling results show 83 cfs flood flow towards the Caloosahatchee River. Hickey Creek residents are the beneficiaries of this project.

Western Buckingham/Staley & Luckett Road Area

Projects 1.1.8 and 1.1.11 benefit western Buckingham in the Staley Road vicinity. These projects collectively benefit this area by providing a positive drainage facility couple with a storage component. These projects would reduce road flooding extent and duration in this area. Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.8 ***Strayhorn Drainageway*** - This conveyance concept project was developed to improve flood flow out of the Luckett Road and Staley Road area. The modeling results show a 200 to 500 cfs flood flow from the area and a water level at the top of bank for this location. The Luckett Road and Staley Road area residents are the beneficiaries of this project as well as the beneficiaries of the Six-Mile Cypress North concept project that has a connection to this concept project.

1.1.11 ***Six-Mile Cypress North Catchment Reservoir*** - This flood reservoir concept captures all the rainfall from storm events. If desired, flow may be directed to Six-Mile Cypress Slough to the south or Strayhorn drainageway and the Orange River to the north. An additional benefit is available to direct flood water in the slough toward the Orange River. The hydrologic environmental enhancement is a primary benefit for the concept project. Providing a flood flow path for residents in the Six-Mile Cypress Slough basin would be an additional benefit.

EXHIBIT 1.1

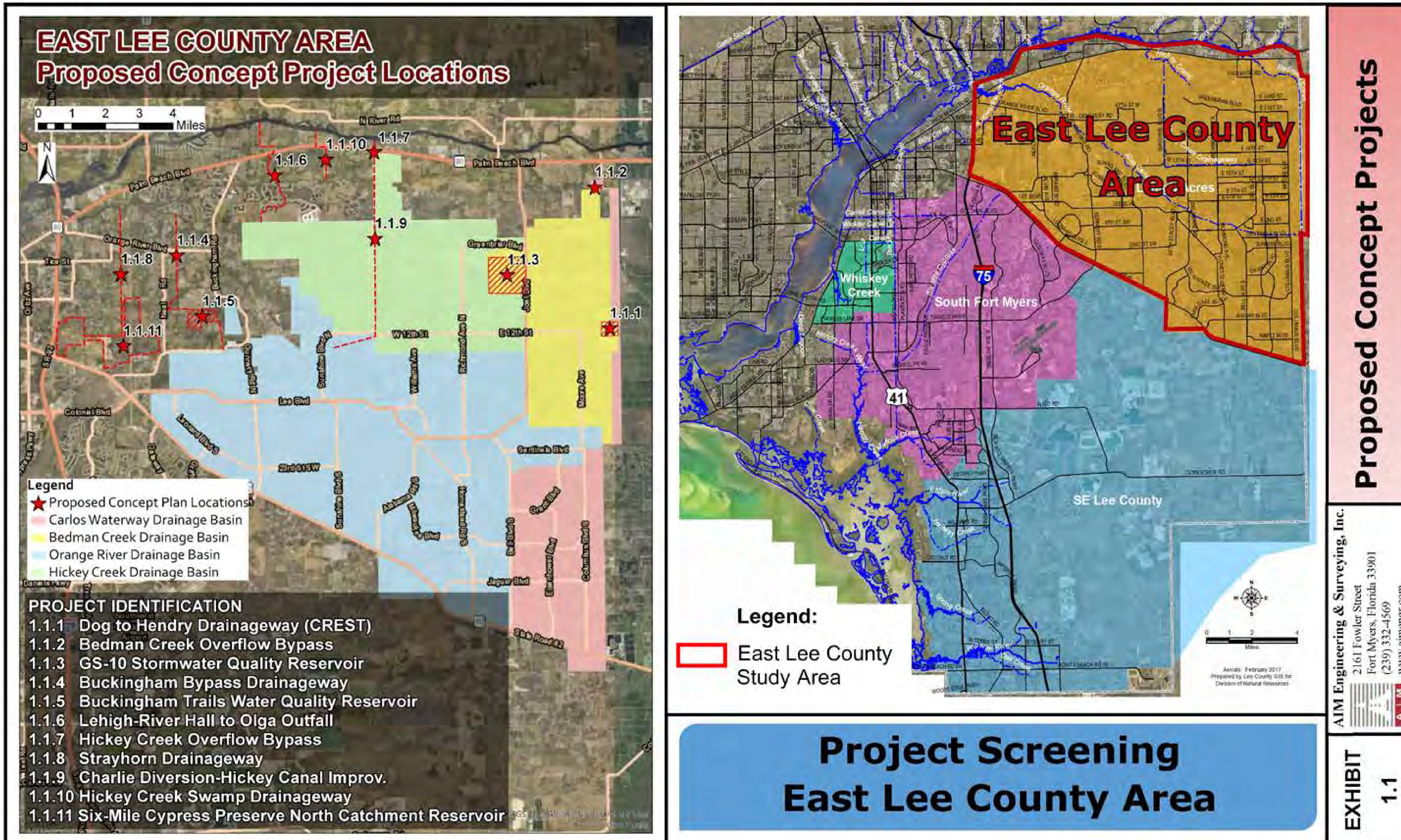
EAST LEE COUNTY AREA
Proposed Concept Project Locations
Legend
Proposed Concept Plan Locations
Carlos Waterway Drainage Basin
Bedman Creek Drainage Basin
Orange River Drainage Basin
Hickey Creek Drainage Basin
PROJECT IDENTIFICATION
1.1.1 Dog to Hendry Drainageway (CREST)
1.1.2 Bedman Creek Overflow Bypass
1.1.3 GS-10 Stormwater Quality Reservoir
1.1.4 Buckingham Bypass Drainageway
1.1.5 Buckingham Trails Water Quality Reservoir
1.1.6 Lehigh-River Hall to Olga Outfall
1.1.7 Hickey Creek Overflow Bypass
1.1.8 Strayhorn Drainageway
1.1.9 Charlie Diversion-Hickey Canal Improv.
1.1.10 Hickey Creek Swamp Drainageway
1.1.11 Six-Mile Cypress Preserve North Catchment Reservoir
East Lee County Area
Whiskey Creek
South Fort Myers
SE Lee County
Legend:
East Lee County Study Area
Project Screening
East Lee County Area
Proposed Concept Projects
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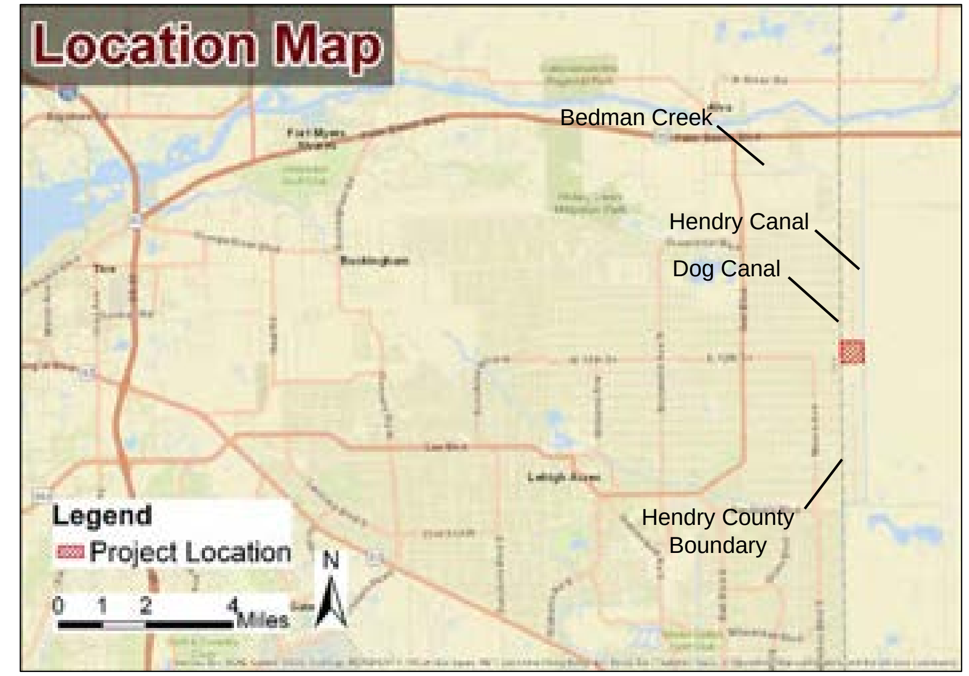
EXHIBIT 1.1

EXHIBIT 1.1.1

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project interconnects Dog Canal with the Hendry Canal just south of the S-D-2 weir and equalizes water level with the Hendry Canal to divert excess stormwater flow away from Bedman Creek and to the Caloosahatchee River via the Carlos Waterway.

Along with this canal interconnection is an opportunity to create a water quality treatment and stormwater storage reservoir on a 105-acre parcel recently obtained by LA-MSID. This parcel would provide large excavated lake areas for additional storage capacity and a channelized filter marsh for water quality improvements.

PURPOSE: This project offers a flow diversion from Dog Canal to Hendry Canal that reduces excess flow to the Bedman Creek area and provides for possible creation of a filter marsh for water quality treatment and a reservoir for attenuation of peak flows.

CONSTRAINTS: Since the land is owned by LA-MSID and no adverse environmental impacts are evident, constraints, if any, are not apparent.

May 2020

Dog to Hendry Drainageway (CREST)
East Lee County Area

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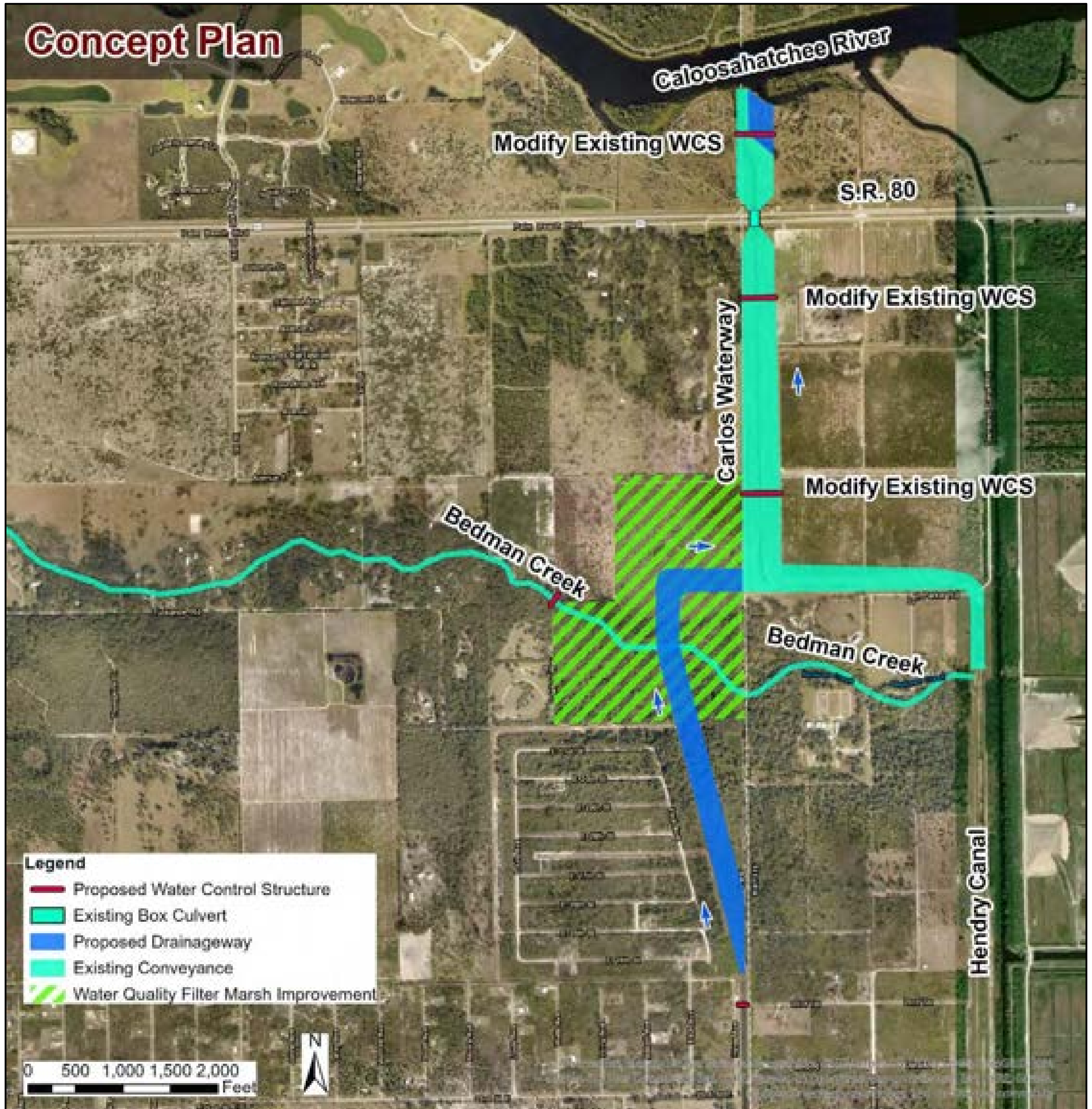
EXHIBIT 1.1.1

EXHIBIT 1.1.2



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Project Narrative

DESCRIPTION: This proposed conceptual project interconnects Dog Canal at Bedman Creek to the Carlos Waterway to divert excess stormwater flow directly to the Caloosahatchee River. Approximately 25% or 2,000 CFS out of Lehigh Acres 65,000-acre watershed is anticipated with this project at a three (3") inch per day removal rate.

PURPOSE: This project offers a very significant conveyance of excess stormwater runoff from the Lehigh Acres area and greatly reduces the dependence on the natural Bedman Creek while providing a much-reduced recovery time between large storm events. Home and roadway flooding in the area would be reduced.

CONSTRAINTS: This project, as planned, crosses public and private lands requiring governmental approvals and land acquisition. Weir structures to manage water levels and a large drainage structure at S.R. 80 would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Bedman Creek Overflow Bypass

East Lee County Area

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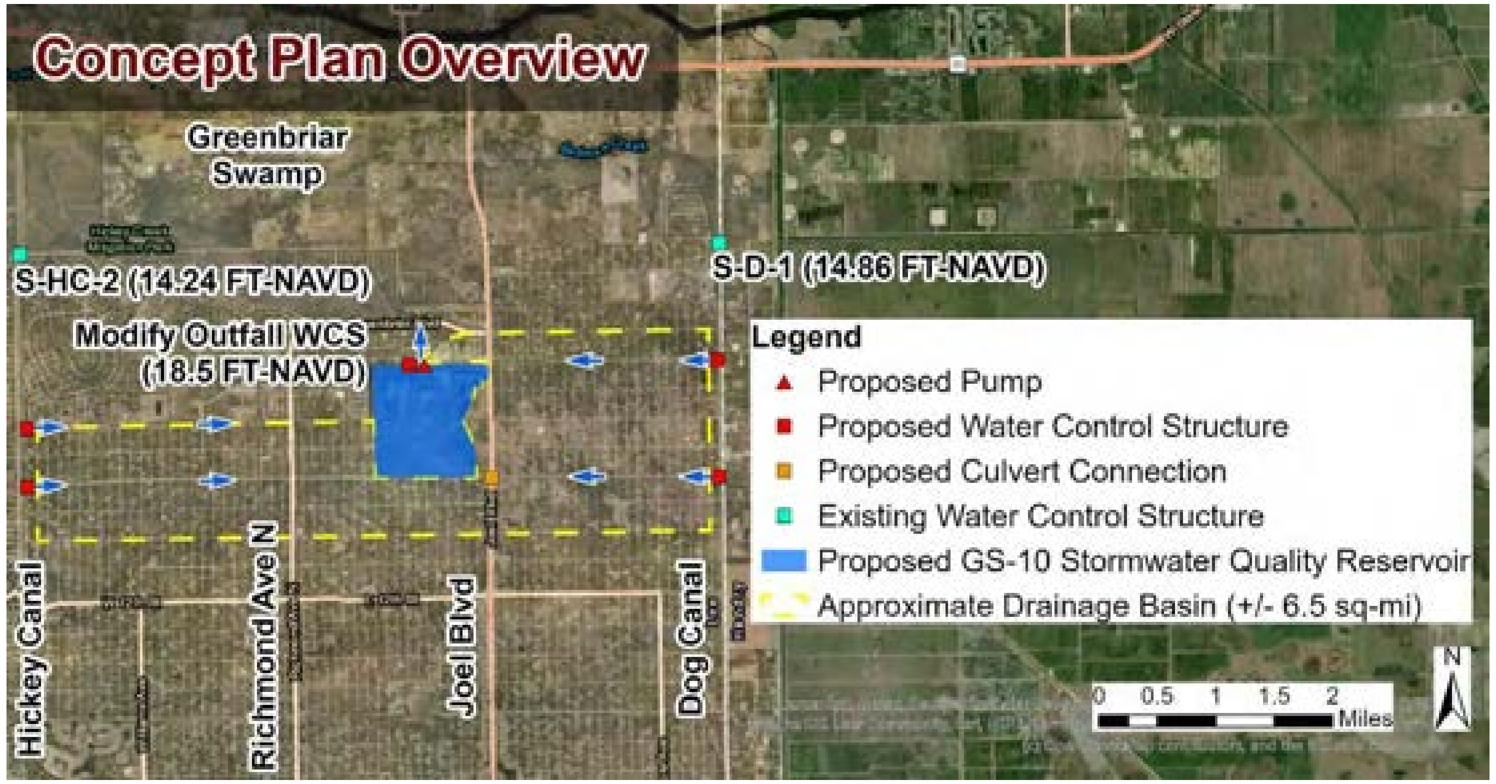
EXHIBIT 1.1.2

EXHIBIT 1.1.3



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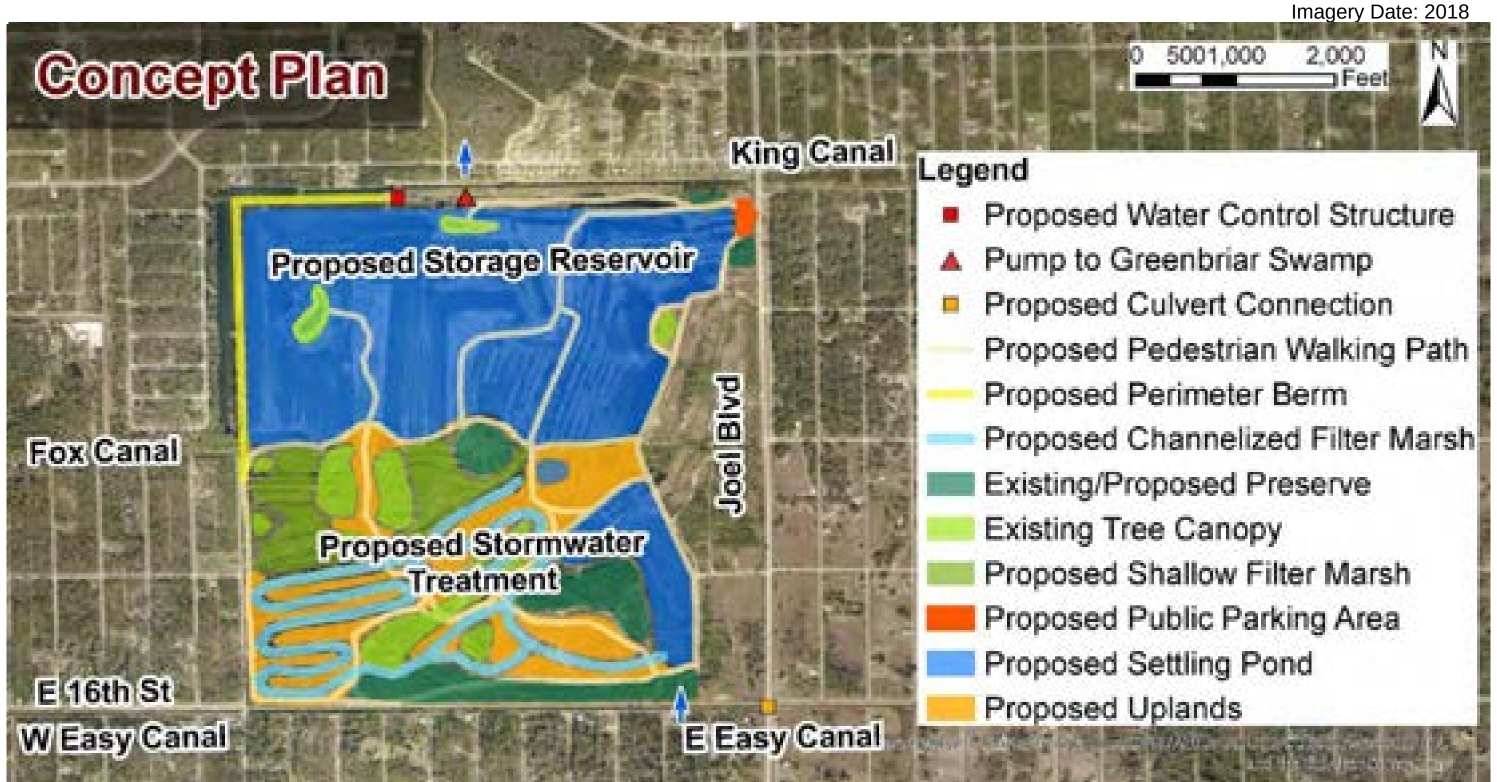

Project Narrative

DESCRIPTION: This proposed conceptual project reconfigures an existing mine lake into a filter marsh for stormwater treatment and a storage reservoir for flood control. Stored water may be diverted into the Greenbriar Swamp for extending wetland hydro-periods. This conceptual project controls flow in a six square mile area with control weirs to control discharges and utilizes the mine lake as a stormwater detention basin.

PURPOSE: This project offers a storage reservoir to attenuate peak flows from large storm events, a water quality treatment improvement, and a water source for hydration of offsite wetlands.

CONSTRAINTS: This project is planned as a public lands project and may include private lands requiring governmental approvals and land acquisition. Weir structures to manage water levels and drainage structures would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

GS-10 Stormwater Quality Reservoir

East Lee County Area

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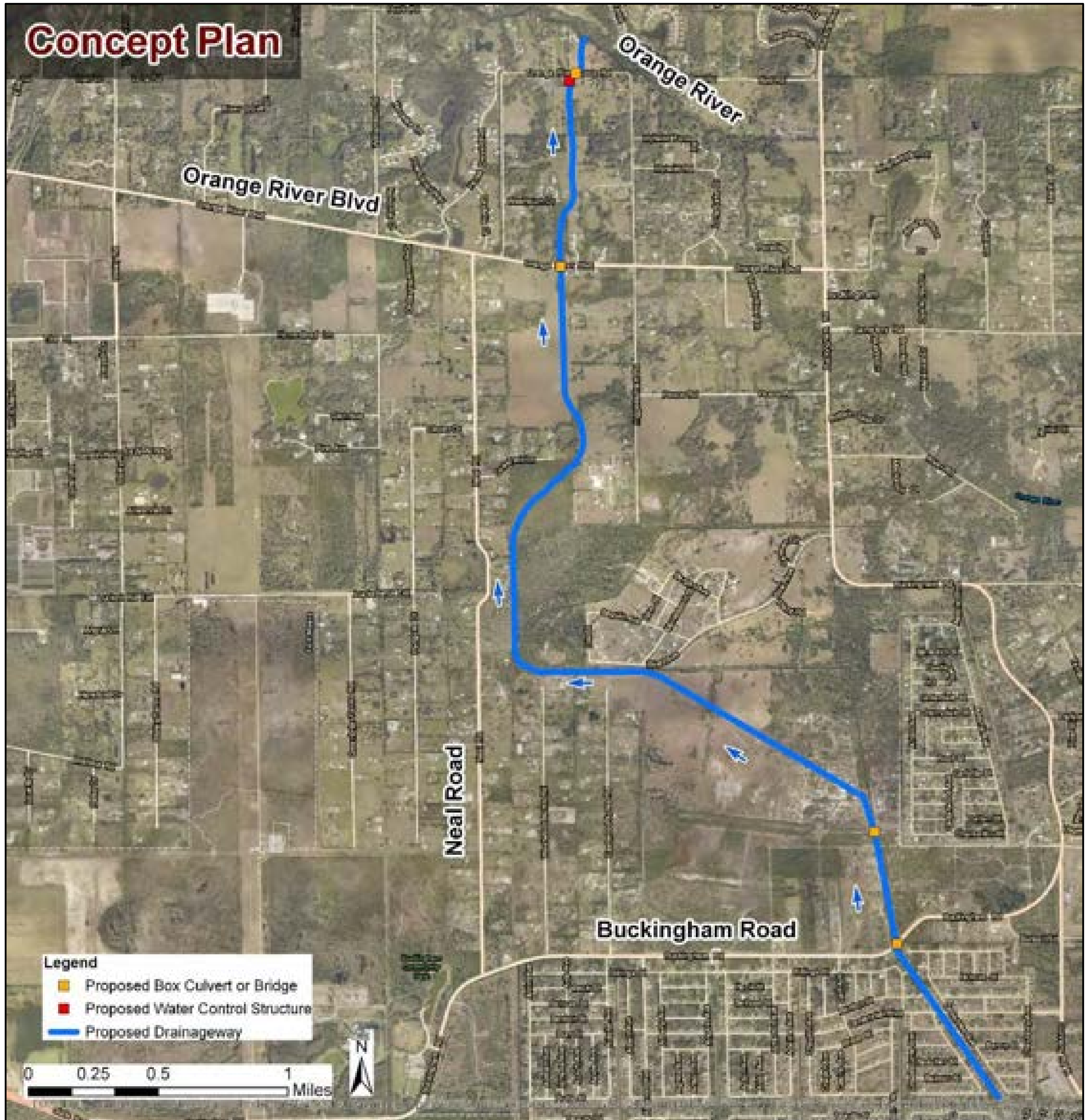
EXHIBIT 1.1.3

EXHIBIT 1.1.4



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Project Narrative

DESCRIPTION: This proposed conceptual project provides a drainageway from the Lehigh Acres area north of Lee Blvd through the Buckingham Trails 2020 tract. This drainageway would extend north to a larger portion of the Orange River and avoid the Buckingham area. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Interconnection conveyances would be approximately 130 feet wide.

PURPOSE: This proposed project provides a diversion of stormwater flow around Buckingham and reduces the dependence of stormwater flow in the upper reaches of the Orange River. Additionally, this conveyance would intercept flow coming from the west that was reported to contribute to Buckingham flooding.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Buckingham Bypass Drainageway
East Lee County Area

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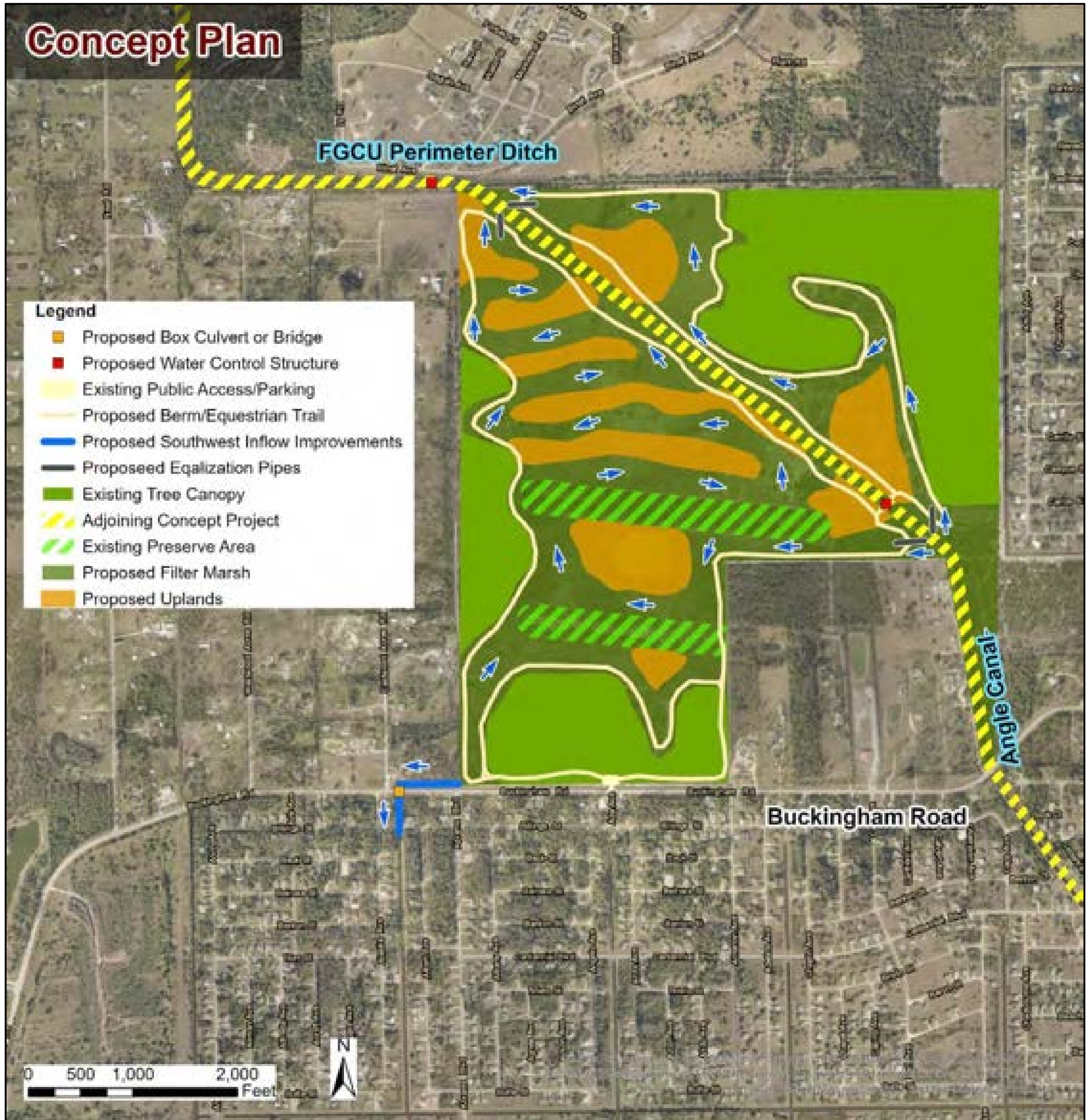
EXHIBIT 1.1.4

EXHIBIT 1.1.5



Imagery Date: 2018

May 2020

Buckingham Trails Water Quality Reservoir

East Lee County Area

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EXHIBIT 1.1.5

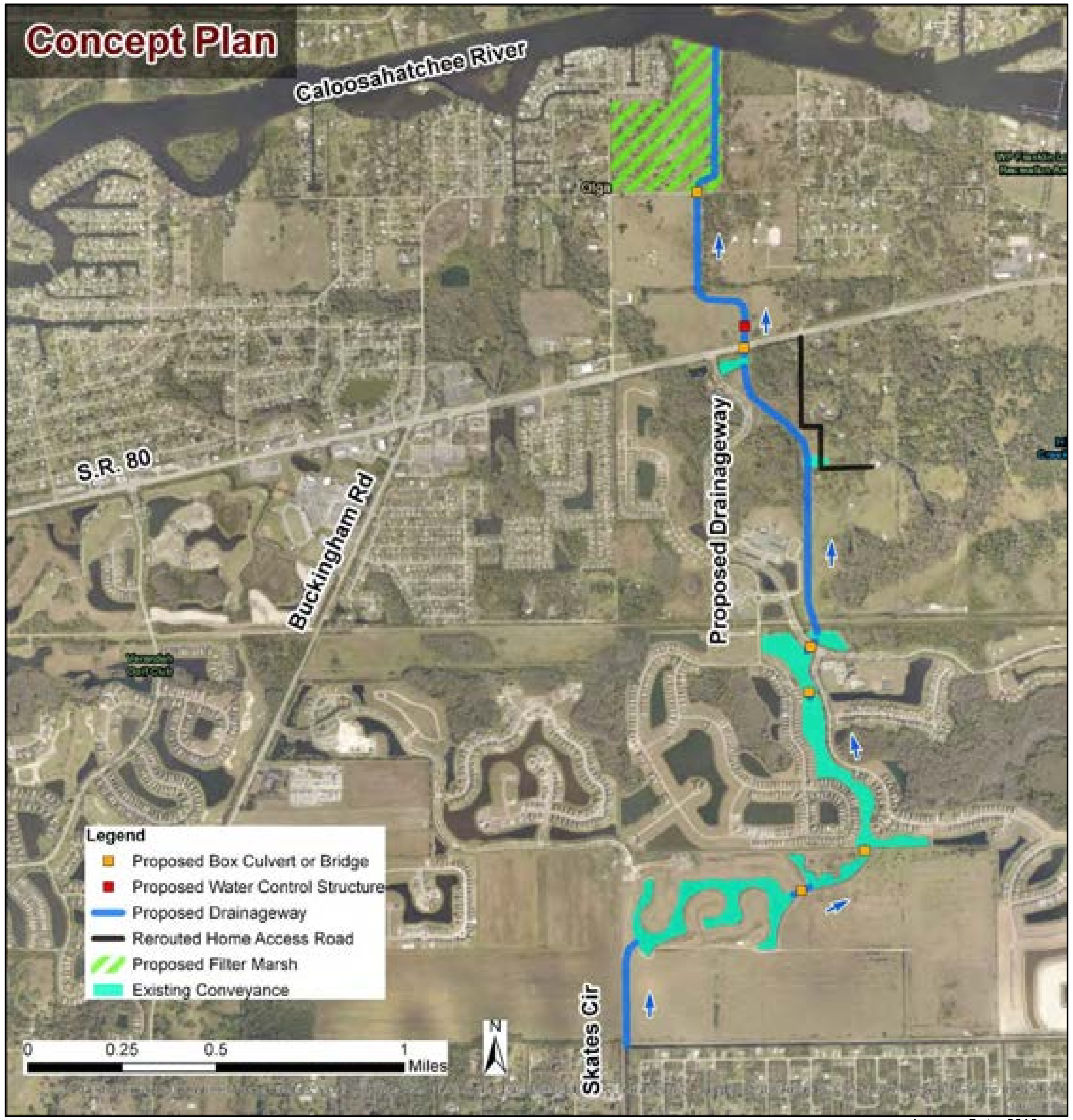
Project Narrative

DESCRIPTION: This proposed conceptual project would create a filter marsh and reservoir to provide water quality treatment and storage of stormwater flow from Lehigh Acres via the Nine-Mile Run Drainageway. The flow would route through the tract into offline stormwater treatment and storage areas planted with wetland vegetation. Preservation of historical features and establishment of riding trails would be incorporated into the design.

PURPOSE: This project offers a very significant stormwater storage area with related peak flow attenuation of excess stormwater runoff from the Lehigh Acres area while providing water quality treatment. Soil material from excavation may be used to add riding trail elements, or for road projects in the area.

CONSTRAINTS: This project as proposed is located on public property requiring governmental approval. Weir structures to manage water levels and a large drainage structure at Buckingham Road would be required. Environmental impacts, if any, would necessitate mitigation.

EXHIBIT 1.1.6



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project provides a drainageway from the Lehigh Acres area near Skates Circle North through River Hall community across S.R. 80 to Olga and the Caloosahatchee River. This region of the LA-MSID Hickey Creek Drainage Basin naturally falls towards the Orange River. However, the LA-MSID canal system directs flows towards Hickey Creek which increases the travel distance to the natural Hickey Creek.

PURPOSE: This concept plan seeks to create a more direct outfall for this region while also diverting flows away from Hickey Creek and Orange River. The new conveyance passes through the River Hall community's stormwater ponds, which is allowable condition in River Hall's permit. Box culverts and/or bridges would be required as well as water control structures.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Lehigh-River Hall to Olga Outfall

East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
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www.aimengr.com

EXHIBIT 1.1.6

EXHIBIT 1.1.7

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project extends Hickey Canal directly to the Caloosahatchee River and would convey large storm flows from Lehigh Acres. The Hickey Creek Overflow Bypass is being planned for a very large conveyance of the Lehigh Acres excess stormwater runoff removal. Portions of the drainageway will require a seawall with rip-rap rubble shorelines. Land area exists to create filter marshes for water quality and a stormwater storage reservoir, if desired.

PURPOSE: This project offers a very significant conveyance of excess stormwater runoff from the Lehigh Acres area and greatly reduces the dependence on natural streams while providing a reduced recovery time between large storm events. Home and roadway flooding in the area would be reduced.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and a large drainage structure at S.R. 80 would be required. Environmental impacts will necessitate mitigation along with modification of existing conservation easement agreements.

May 2020

Hickey Creek Overflow Bypass

East Lee County Area

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EXHIBIT 1.1.7

EXHIBIT 1.1.8

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project improves a conveyance in an approximately 3,400 acres watershed area. At a three (3") inch per day removal rate, an approximate peak flow would be 430 CFS. The drainageway would have appropriate planted wetland vegetation for water quality enhancement.

PURPOSE: Stormwater runoff from this area caused roadway flooding and may have contributed overflow drainage into the Lehigh Acres and the Buckingham area. This project would provide controlled stormwater runoff though a positive outfall to the Orange River, limit roadway flooding, and direct stormwater runoff away from Lehigh Acres and Buckingham. Spoil material from the excavation of the drainageway may be utilized for road projects in the area.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to step water levels and drainage structures at road crossings would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Strayhorn Drainageway
East Lee County Area

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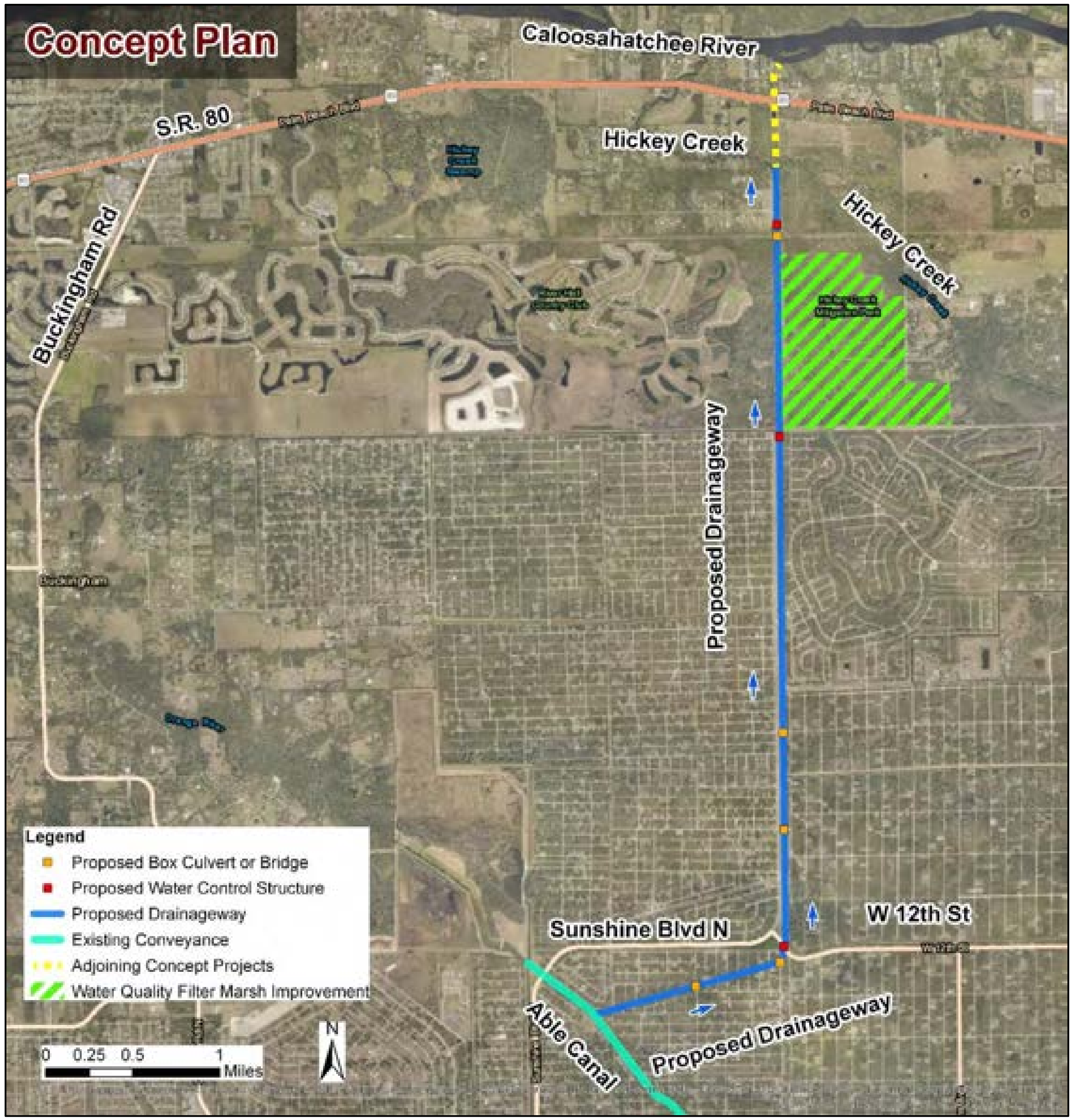
EXHIBIT 1.1.8

EXHIBIT 1.1.9



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project transfers high flows from the Able Canal to the Hickey Canal. Included in this project is the widening of the Hickey Canal to the Hickey Creek. Improving weir structures to handle high flows is required. This project is dependent on the construction of the Hickey Creek Overflow Bypass Concept Plan to the Caloosahatchee River. The Charlie Diversion-Hickey Canal Improvement conveyances would be approximately 150 feet wide. Approximately 200 feet of R/W is available on Hickey Canal.

PURPOSE: This proposed project provides diversion of high stormwater flows from the Orange River directly to the Caloosahatchee River. A water quality filter marsh improvement is possible on the 2020 parcel at Hickey Creek Mitigation Park.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Charlie Diversion-Hickey Canal Improvement
East Lee County Area

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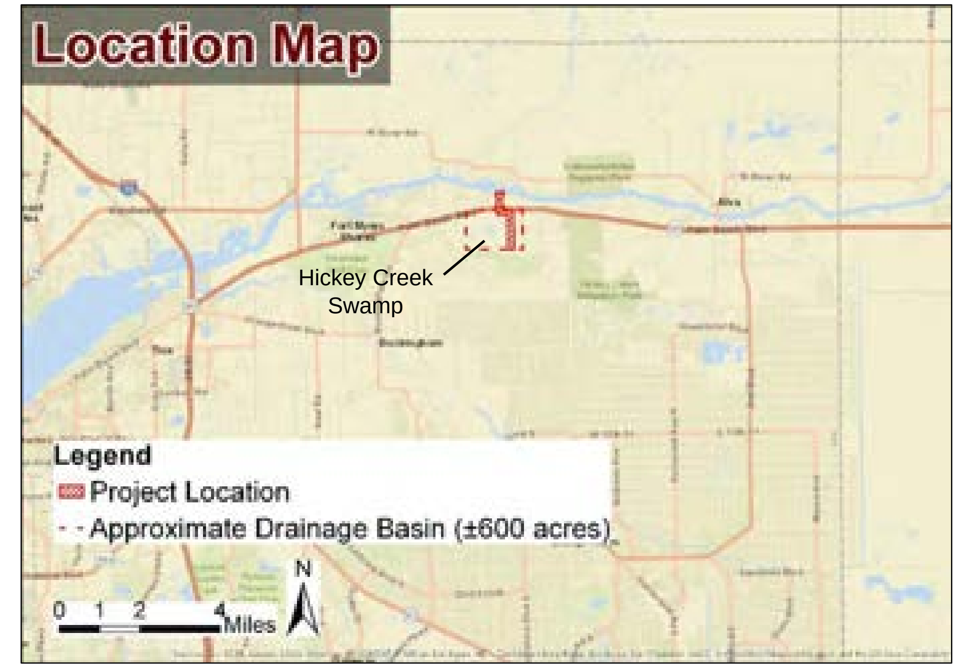
EXHIBIT 1.1.9

EXHIBIT 1.1.10

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project improves the drainage conveyance to the Caloosahatchee River and provides a swale and berm along the easterly boundary to limit flooding in the Hickey Creek area.

PURPOSE: This proposed project reduces flooding in the Hickey Creek area and provides water control structures to maintain desirable water levels in the Hickey Creek Swamp.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Hickey Creek Swamp Drainageway

East Lee County Area

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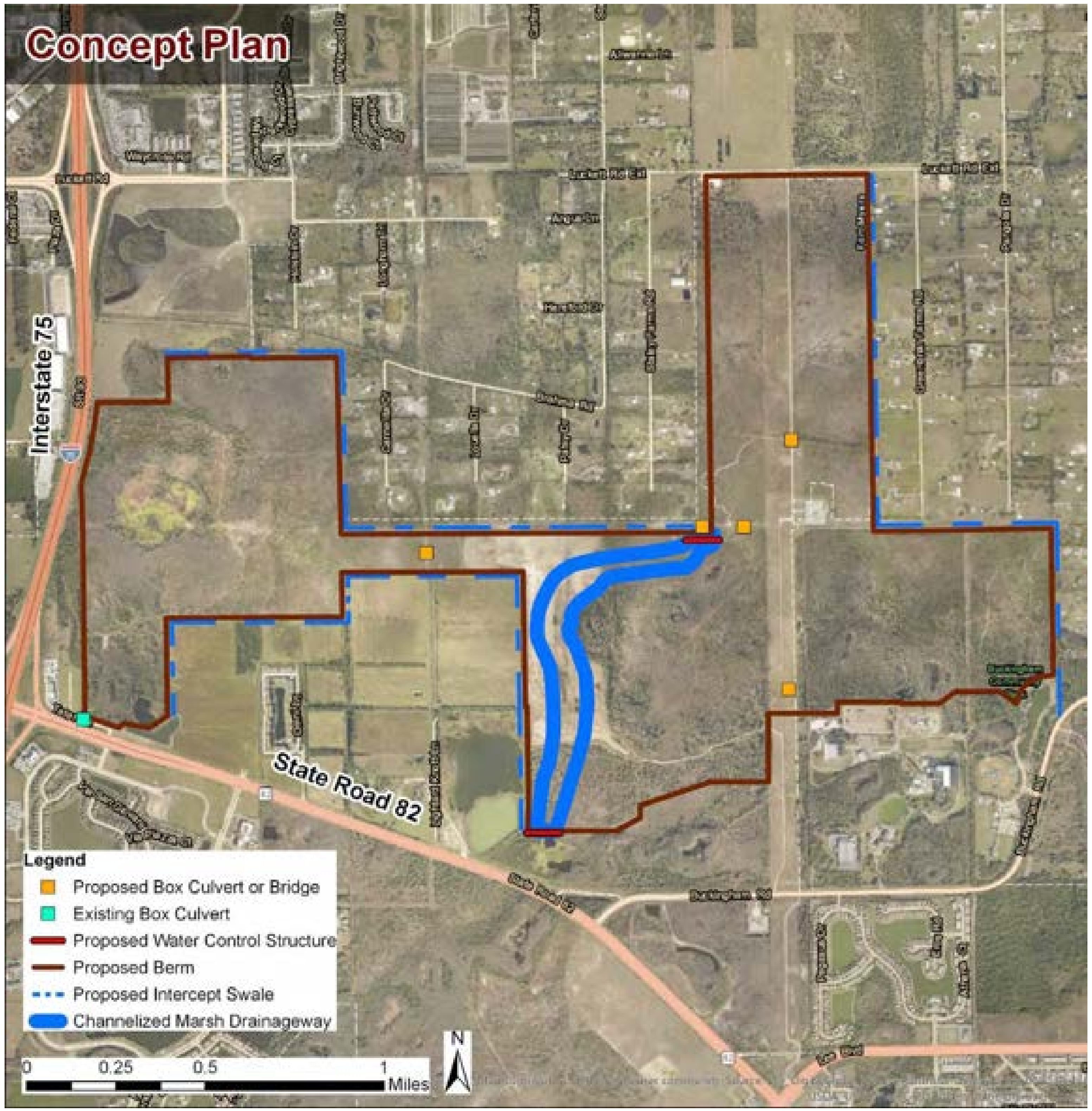
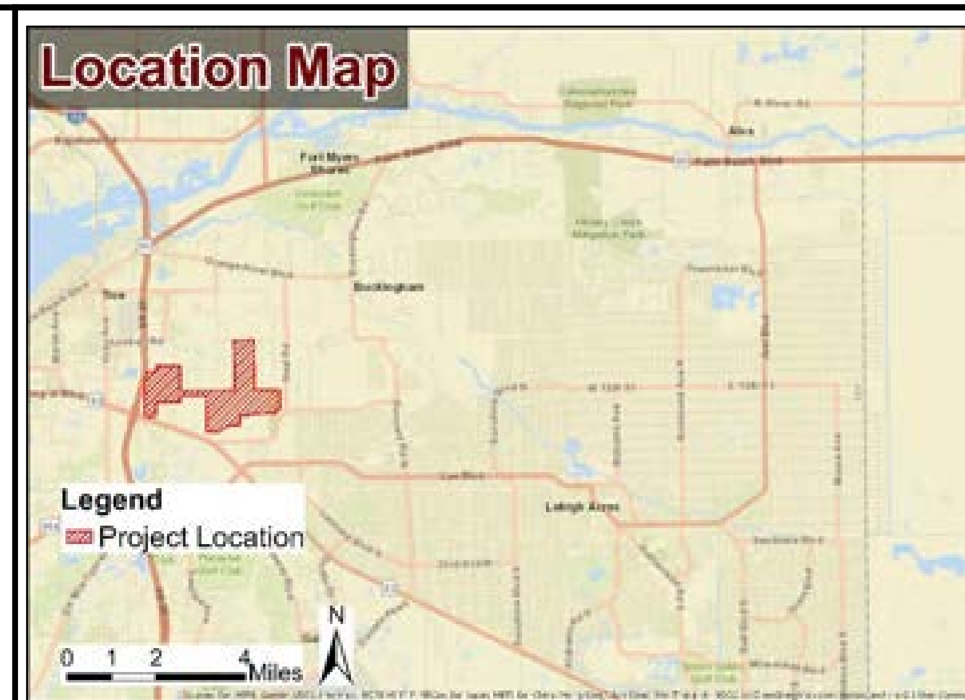
EXHIBIT 1.1.10

EXHIBIT 1.1.11



Imagery Date: 2018



Project Narrative

DESCRIPTION: The land is owned by Lee County and is commonly referred to as Six Mile Cypress Preserve North. By-directional outfalls would allow for operational flexibility to discharge flows north to the Strayhorn area or south though the Six Mile Cypress Preserve.

PURPOSE: This project concept consists of placing a berm around this large natural area to catch and capture rainfall at the site and to direct controlled releases of excess water down Six-mile Cypress Slough for wetland hydration. Multiple emergency outfalls for release of very high-water levels will be provided along with an intercept swale to protect neighboring at-grade developed properties.

CONSTRAINTS: The goals and objectives of Conservation Lands include other factor other than water quality. The design will need to balance the flood mitigation goals with the Conservation Lands goals to ensure that the lands set aside as preserves can fulfill each of those goals.

May 2020

Six-Mile Cypress Preserve North Catchment Reservoir

East Lee County Area

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EXHIBIT 1.1.11

SUMMARY OF WHISKEY CREEK LEE COUNTY FLOOD MITIGATION BENEFITS

Flood mitigation benefits are presented here for two of the three projects described in the previous sections (Brantley-Dover Canal and FSW Canal). For the L-canal project, the benefits are more associated with relief for Ten-Mile Canal rather than to abate local flooding, therefore its benefits are included in other sections.

Flood mitigation benefits are achieved when water is conveyed and/or stored appropriately to reduce flooding levels and duration. The reduction in flood levels and duration reduces the overall impacts to commercial and private structures along with improving the Level of Service (LOS) for roadways that serve communities. Flooding impacts the health, safety, and welfare of the residents, along with significant economic impact to the community. Within the two project areas presented herein (Brantley-Dover and FSW Canal) the flooding issues are primarily local in nature and associated with limited conveyance.

Section 1.2.3 presented in detail the results of the model simulations along the primary canals from the MIKE-11 simulations. The results focused mainly on the changes in water level along the canals for the 25-year, 100-year and Continuous simulations. Generally, for the purpose of evaluating benefits, the pre- and post-project flooding is depicted in an aerial framework showing areas that are flooded and those that are not.

The contribution or benefits of each project concept is discussed as follows based on modeling results for the 100-Yr, 3-Day storm events.

Brantley-Dover Canal Improvements

The Brantley-Dover project focused on providing flood reduction within the Villas (upstream of Tamiami Trail).

For the 100-year, 3-day simulations the most significant flood reductions were seen for the July simulations. The potential changes in flooded area are significant.

FSW State College Canal Improvements (Iona Drainage District Canal H-7)

The FSW State College Canal focused on providing flood reduction within neighborhoods upstream of Summerlin Blvd.

For the 100-year, 3-day simulations the most significant flood reductions were seen for the August simulations. The potential changes in flooded area are significant.

EXHIBIT 1.2

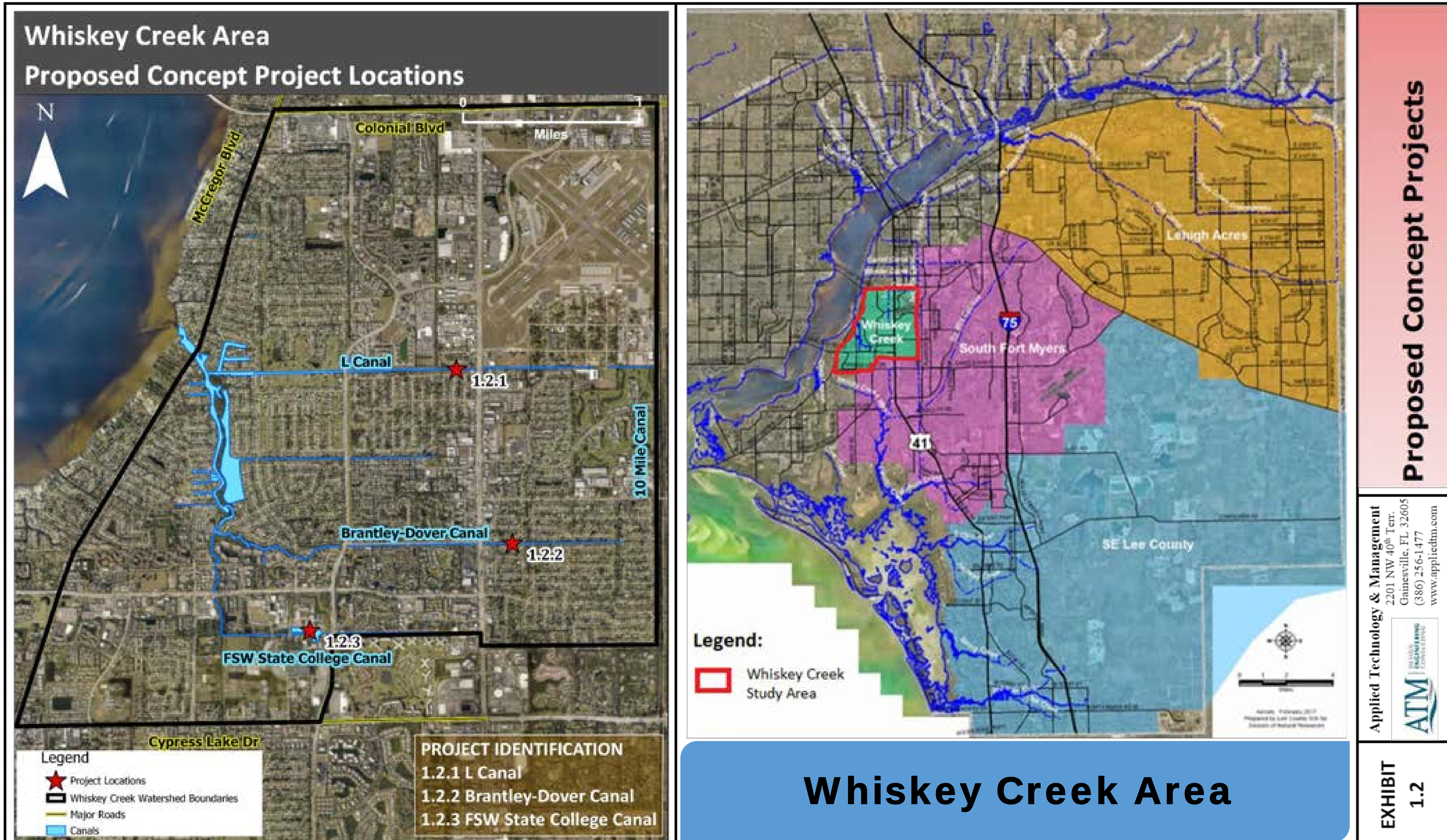
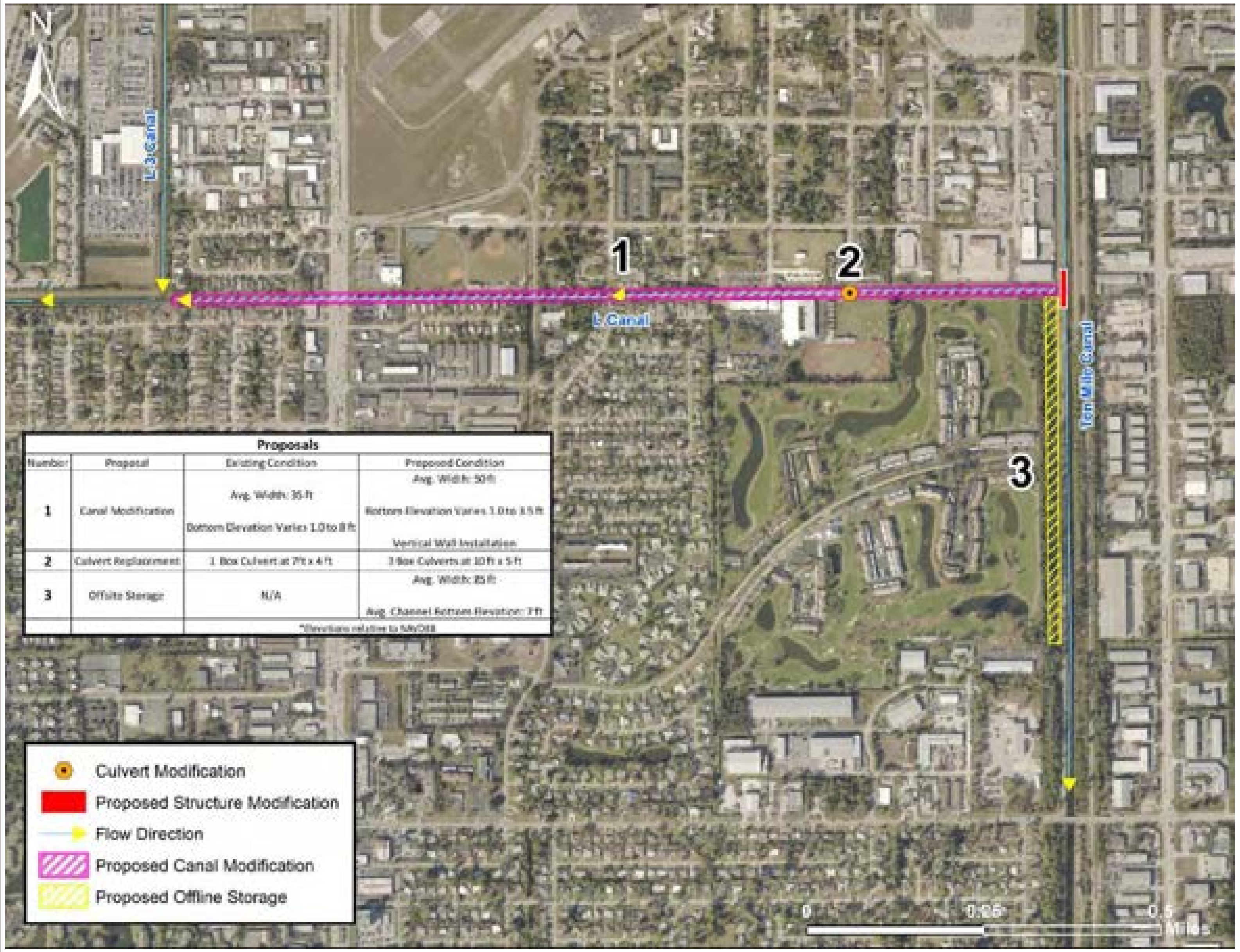

Whiskey Creek Area
Proposed Concept Project Locations
N
0
1
Miles
Colonial Blvd
McGregor Blvd
L Canal
1.2.1
10 Mile Canal
Brantley-Dover Canal
1.2.2
1.2.3
FSW State College Canal
Cypress Lake Dr
Legend
Project Locations
Whiskey Creek Watershed Boundaries
Major Roads
Canals
PROJECT IDENTIFICATION
1.2.1 L Canal
1.2.2 Brantley-Dover Canal
1.2.3 FSW State College Canal
Lehigh Acres
Whiskey Creek
South Fort Myers
75
41
SE Lee County
Legend:
Whiskey Creek Study Area
Whiskey Creek Area
Proposed Concept Projects
Applied Technology & Management
2201 NW 40th Terr.
Gainesville, FL 32605
(386) 256-1477
www.appliedtm.com
ATM
EXHIBIT 1.2

EXHIBIT 1.2.1

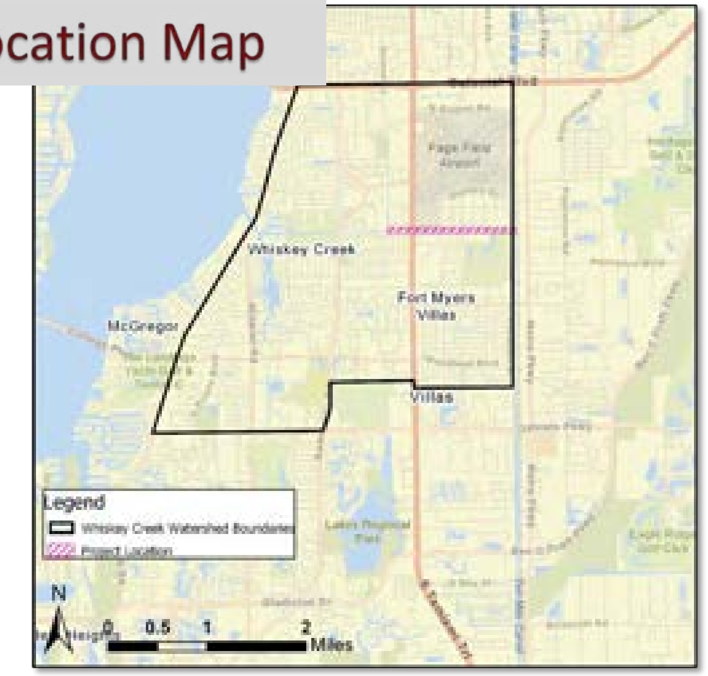
Concept Plan



Proposals

Number	Proposal	Existing Condition	Proposed Condition
1	Canal Modification	Avg. Width: 35 ft Bottom Elevation Varies 1.0 to 8 ft	Avg. Width: 50 ft Bottom Elevation Varies 1.0 to 3.5 ft Vertical Wall Installation
2	Culvert Replacement	1 Box Culvert at 7 ft x 4 ft	3 Box Culverts at 10 ft x 5 ft
3	Offsite Storage	N/A	Avg. Width: 85 ft Avg. Channel Bottom Elevation: 7 ft
		*Elevations relative to NAVD88	

Location Map



Project Narrative

DESCRIPTION: The L Canal is approximately 2.4 miles in length between Whiskey Creek and Ten-Mile Canal. The project improves surface water conveyance in the canal by removing constrictions, increasing cross-sections, removing sediment, and replacing an existing structure at Ten-Mile Canal. The new structure is designed to allow flow into or out of Ten-Mile Canal depending on need to provide flood relief for neighboring areas. Retention is provided via linear holding areas along the L Canal for inline water quality treatment to ensure no increase in nutrient loading. Additional flood relief from offline storage will be provided south of the canal along Ten-Mile Canal adjacent to the Hideaway Country Club property.

PURPOSE: The primary purpose is to provide flood relief via increased surface water conveyance in the L Canal, with specific emphasis on the constricted areas upstream of the point at which the L-3 Canal discharges to the L Canal.

CONSTRAINTS: Potential constraints include limitations within the existing right-of-way and transferring water from Ten-Mile Canal to the Caloosahatchee River, which may affect water quality.

February 2019

L Canal Improvements Concept Plan

Whiskey Creek Watershed

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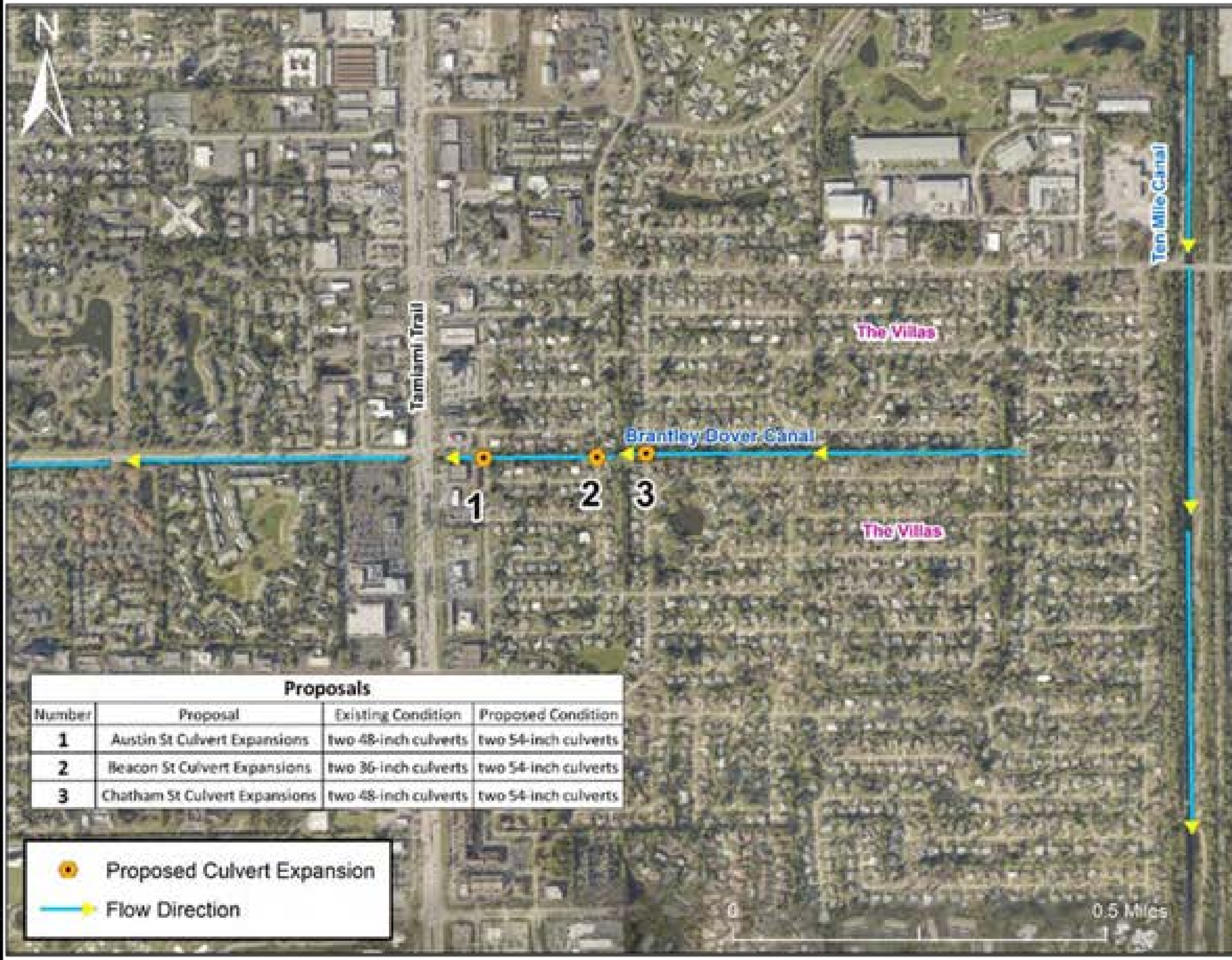
EXHIBIT 1.2.1

EXHIBIT 1.2.2

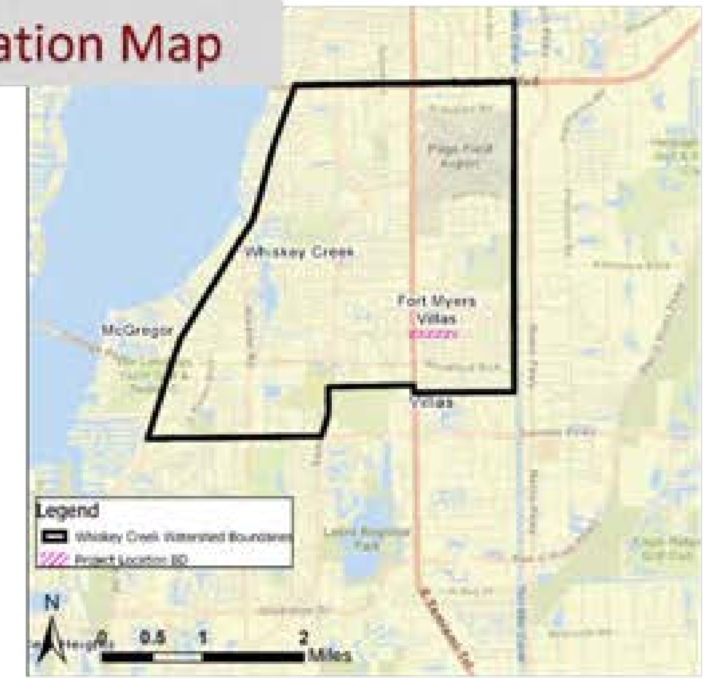
Concept Plan



Proposals

Number	Proposal	Existing Condition	Proposed Condition
1	Austin St Culvert Expansions	two 48-inch culverts	two 54-inch culverts
2	Beacon St Culvert Expansions	two 36-inch culverts	two 54-inch culverts
3	Chatham St Culvert Expansions	two 48-inch culverts	two 54-inch culverts

Location Map



Project Narrative

DESCRIPTION: The Brantley-Dover Canal is approximately 1.8 miles in length between Summerlin Road and Ten-Mile Canal. The project improves surface water conveyance in the canal through installation of larger culverts at three crossings along the canal upstream of Tamiami Trail which showed significant restriction in flows during storm events.

PURPOSE: The primary purpose is to increase surface water conveyance in the Brantley-Dover Canal to alleviate flooding in The Villas residential area.

CONSTRAINTS: Potential constraints include limitations within the existing right-of-way, replacing major road crossings to achieve conveyance, and localized conveyance issues in The Villas.

May 2020

Brantley Canal Area Improvements
Concept Plan
Whiskey Creek Watershed

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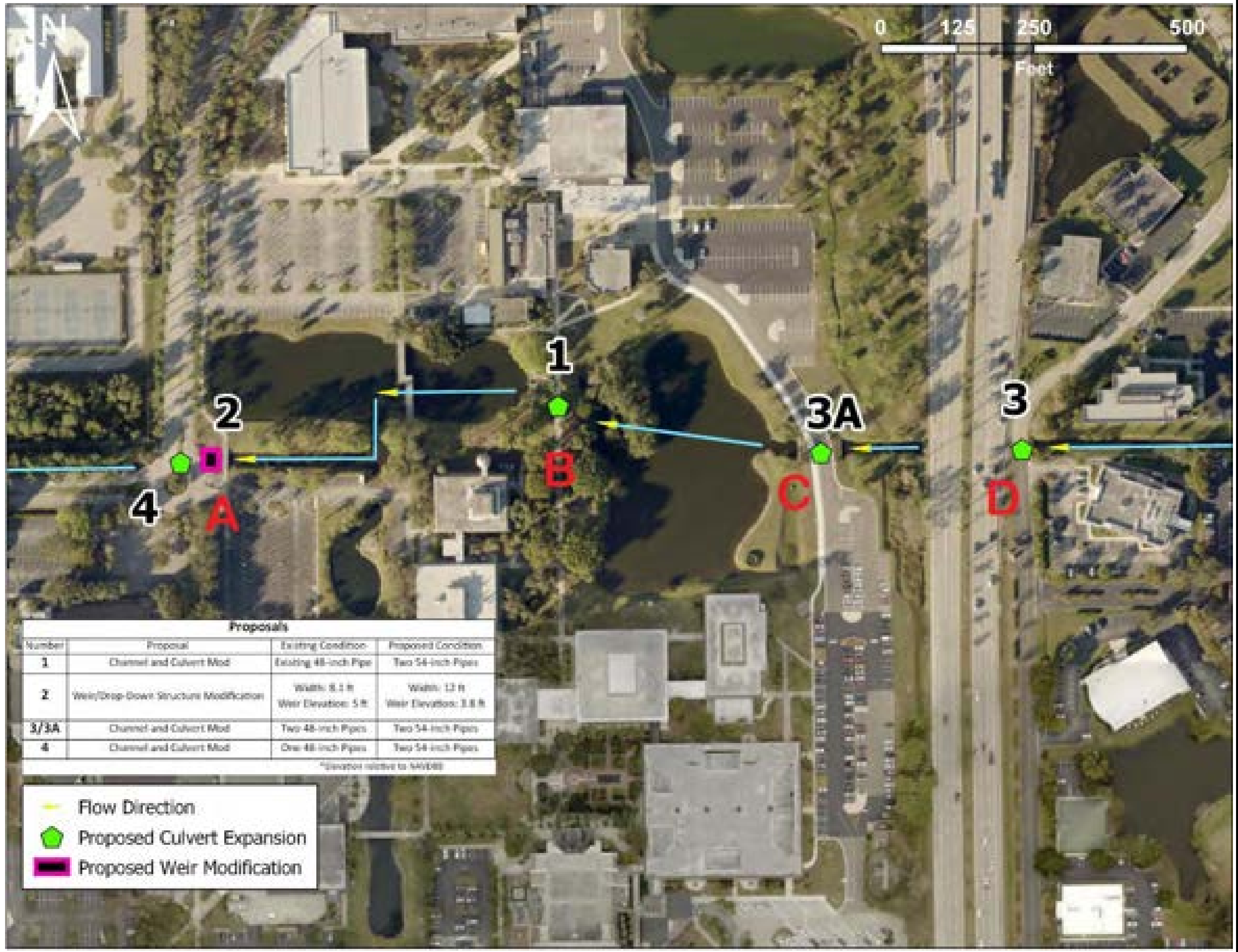
EXHIBIT 1.2.2

EXHIBIT 1.2.3

Concept Plan

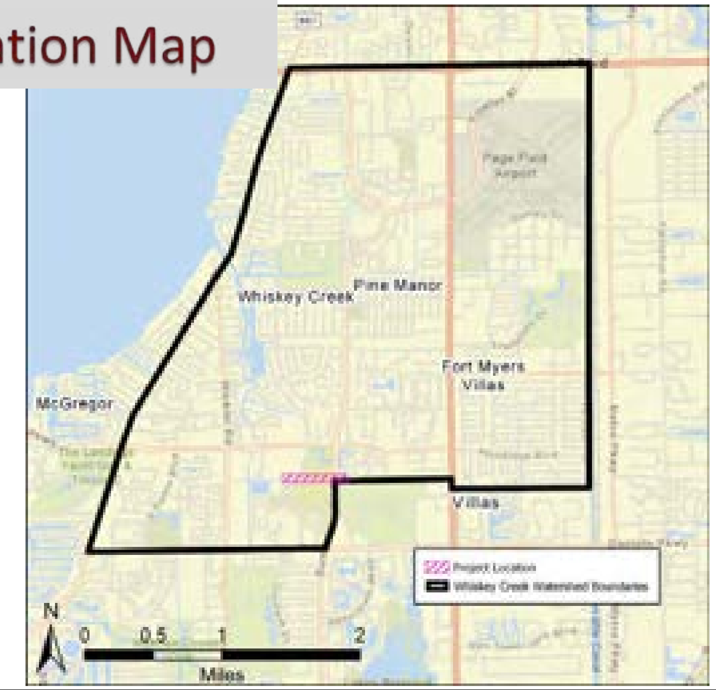


Proposals

Number	Proposal	Existing Condition	Proposed Condition
1	Channel and Culvert Mod	Existing 48-inch Pipe	Two 54-inch Pipes
2	Weir/Drop-Down Structure Modification	Width: 8.1 ft Weir Elevation: 5 ft	Width: 12 ft Weir Elevation: 3.8 ft
3/3A	Channel and Culvert Mod	Two 48-inch Pipes	Two 54-inch Pipes
4	Channel and Culvert Mod	One 48-inch Pipes	Two 54-inch Pipes

*Elevation relative to NAVD88

Location Map



Project Narrative

DESCRIPTION: This project is an evaluation of the canal and pond system (flows and constrictions) within, downstream, and upstream of Florida SouthWestern State College to Provincetown Condominiums to identify remedial actions to alleviate flooding upstream of Summerlin Road (Provincetown area). Potential remedial activities include lowering and enlarging an existing weir and enhancing culverts on the college property. Linear retention options will be explored for water quality treatment to offset any increase in nutrient loading caused by increased conveyance.

PURPOSE: The primary purpose is to improve drainage south of College Parkway that flows east under Summerlin Road, potentially to the Provincetown residential area.

CONSTRAINTS: Potential constraints include limitations in weir modifications, maintaining aesthetics of college lakes, and replacing major crossings to achieve conveyance.

February 2019

S. Whiskey Creek Drainage Improvements – Concept Plan

Whiskey Creek Watershed

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ATM DESIGN ENGINEERING CONSULTING

EXHIBIT 1.2.3

SUMMARY OF SOUTH EAST LEE COUNTY FLOOD MITIGATION BENEFITS

Flood mitigation benefits are in general achieved when excess storm water is conveyed and/or stored appropriately to reduce flooding levels and duration that would otherwise inundate structures and have prolonged road flooding. These adverse conditions impact the health, safety, welfare of the residents and have a significant economic impact to the community.

As stated previously in this section, based on the land availability restrictions, the developed system is a two-step process. The downstream conveyances generally west of I-75 are enhanced to provide greater ability to discharge higher volumes of water. Upstream, generally east of I-75, a connected system of storage facilities and conveyances is developed. These upstream improvements are then connected to the improved downstream conveyances and all are controlled with several water control structures. All sixteen concepts were modeled together in one “stitched” model. Therefore, the positive results from the model output reflects the system benefit.

Sixteen preliminary concept projects were developed for the South East Lee County study area. The projects work in concert to develop an overall system improvement to this 150 square mile drainage basin. Targeted areas for reduction in structure flooding included those structures abutting the natural conveyance of the Imperial River. This downstream natural conveyance has been a location of repetitive flooding. In addition, flood mitigation was desired due to substantial prolonged flooding of many roadways within the overall SE Lee County study area.

Again, the benefit is seen with implementation of these concept projects as a system. This is reflected in the Regional Model which was run with all concepts stitched together in this system approach. AIM reviewed the Regional Model system output and then noted the concept contribution to this SE system flood mitigation benefit. This was assisted by review of documents such as the Phase 2 reports for this project and Post Irma flooding aerials which showed the potential impact to structures and significant roadway flooding.

As the South East Lee County concepts function so strongly as a system determining an individual projects benefit is somewhat unique in this area. The typical recommended phasing order for this type of system would be to address the downstream projects first. This would provide the best capacity for release of the upstream storage when necessary. However, there may be opportunities based on unique funding to pursue upstream projects first. This may be an option with several of these projects with temporary restrictions on their downstream releases. The downstream projects would be deemed the higher initial benefit based on this; and would be further prioritized based on impact to immediately surrounding flood reduction target areas as well as conveyance capacity. The upstream would be recommended to also occur in a downstream to upstream order and where being compared to other upstream projects the storage volume capability could be considered as a secondary factor.

The contribution or benefit of each project concept is discussed as follows based on modeling results for the August 2017, 100-Yr, 3-Day storm event with gates west of I-75 open at 0 hour, and gates east of I-75 open at 0 hour, closed at the 48th hour and re-opened at 96th hour.

The system of concept projects for SE Lee County provided the following benefits:

Imperial River

The modeling results show a reduction in flood water levels between 1.5 and 4.75 feet with a recovery to normal levels within a few days without increasing the peak flow in the river. This substantial reduction in water levels greatly reduces the flooding potential for those structures previously affected by Hurricane Irma.

Estero River

The Estero River South Branch experienced significant flooding during Hurricane Irma and the system modeling shows a reduction in the flood levels by approximately 3.5 feet. For the Estero River N. Branch the modeling results show a reduction in flood level of 4.24 feet in the Country Creek neighborhood which was noted to have experienced prolonged roadway flooding.

SE Lee County Total Study Area

In this study area road flooding would be reduced in extent and duration. The model generally indicated reductions in water levels and improved recovery times within that would benefit that goal. Below are the individual concept summaries noting the stitched model system benefit:

3.1 ***Halfway Creek Drainageways*** - This conveyance concept project was developed to handle a large portion of the flood flow from east of I-75 and direct excess storm water to Estero Bay. The modeling results show a 419 cfs flow increase to 1,254 cfs. The benefits to directing large flows via this underutilized flow path connected via water control structures to the large preserve areas east of I-75 is to the Estero River North Branch and the Imperial River basins that experienced extreme flooding. Provision to timely recover from high water levels in the preserve areas may warrant a large capacity drainageway.

3.2 ***Estero River N. Branch Improvements*** - This conveyance concept project was developed for mitigation of flooding of the Estero River N. Branch basin, as well as, areas east of I-75. The Estero River N. Branch would be enhanced with overflow bypasses conveyances to better handle high flow conditions. The modeling results show a reduction in flood level of 4.24 feet in Country Creek neighborhood while slightly increasing the flow through this area. The downstream peak flow in the Estero River was reduced from the existing 1,781 cfs to 1,104 cfs with the system of concepts.

3.3 ***FGCU Flow-way Improvements*** - This conveyance concept project was developed to improve flood flow in the FGCU area that has limited flow capacity to reach bridge and box culvert crossings under I-75. The trapped stormwater caused flooding in the NE quadrant of I-75 and Corkscrew Road that extended for many weeks. Under the concept project flow gates would close to utilize the vast wetlands as a storage reservoir and open following the storm. The system modeling results show flows increase by 305 cfs to 640 cfs and that water levels recovered soon after the storm. The area east and north of I-75 and Corkscrew Road residents are the beneficiaries of this project.

3.4 ***Alico Mine Lake Interconnects (West)*** – This conveyance concept project which includes incorporating mine lakes for storm water reservoir storage was developed to direct flow to either the Estero River N. Branch or to the Crew/Flint-Pen/Kiker preserve to mitigate flooding in the vast area extending to the SW Regional Airport and the Wild Turkey Strand. Having water control through conveyance and storage allows limiting peak flows, conservation of water resources and the potential to direct flow south to the large preserve areas. When conditions are favorable the SW Regional Airport excess flows may be directed south to avoid overloading the Briarcliff and Ten-Mile Canal areas. The system modeling results show the potential to direct 279 cfs from the airport, to 186 cfs to the FGCU flow way and increase flow from 108 cfs to 559 cfs to the large Crew-Flint Pen/Kiker preserve areas. Water levels improve significantly in the mine lake near the regional airport from EL 25.44 to EL. 20.81 or a decrease of 4.63 feet and the potential to accept flood flow from the Regional Airport. The beneficiaries of this improvement include residents in the NE Quadrant of I-75 and Corkscrew Road, Ten-Mile Canal area and the hydrologic restoration of the Crew/Flint-Pen/Kiker preserve.

3.5 ***Alico Mine Lake Interconnects (East)*** - This flood reservoir concept project stores excess flood water in mine lakes until the storm event passes. The mine lakes are connected by drainageway conveyances. The system model results show that large quantities of stormwater were satisfactorily stored to natural ground level, attenuated to and released with recovery to normal levels within a few days following the storm event. Approximately, one and one-half feet of vertical storage was achieved between EL. 24.91 and EL. 26.42 in the mine lakes and flows entering the lake system of 1,081 cfs (Blackstone Drive concept project) were reduced to 559 cfs at Corkscrew Road crossing. This concept project develops water control to mitigate flooding, so the Southeast Lee County community is the beneficiary of this project.

3.6 ***Alico Road Extension Drainageway*** – This conveyance concept project was developed to as part of the proposed Alico Road to improve flood flow out the Green Meadows area and avoid flood flow overloading of the Wild Turkey Strand Preserve and the downstream community on Mallard/Devore Roads of Alico Road. The system modeling results show a 144 cfs flood flow concept project drainageway. The two communities are the beneficiaries of this project.

3.7 ***Blackstone Drive to Alico Mine Lakes Drainageway*** - This conveyance concept project was developed to direct flow from Lehigh Acres at Blackstone Drive to the south. Although the flood peak elevations were not high enough to flow south, this area of south of State Road No. 82 directed substantial flows to the south. The system modeling results show the flood flow of 1,081 cfs entering the mine lakes which are attenuated by the mine lake reservoir storage. This concept project develops water control to mitigate flooding, so the Southeast Lee County community is the beneficiary of this project.

3.8 ***Alico Mine Lake to Halfway Creek Drainageway*** - This conveyance concept project was developed to direct flood flow from the Alico Mine Lakes area lying north of Corkscrew Road in a southerly direction to the Crew-Flint Pen/Kiker Preserve. The excess stormwater will be stored in this natural reservoir and eventually released to the Imperial River, Spring Creek and Halfway Creek outfalls to Estero Bay. The system modeling results show increasing the flow to the south side of Corkscrew Road from 108 cfs to 559 cfs or a 451 cfs increase in flood flow. Water levels are increased from EL. 16.60 to EL. 17.39 or an increase of 0.79 feet. The Estero River and Grandezza residents and the business area at the intersection of I-75 and Corkscrew are the beneficiaries of this project. The hydrologic restoration of the Preserve areas is an additional benefit.

3.9 ***I-75 to Spring Creek Drainageway (North)*** - This conveyance concept project was developed to improve flood flow out of the old Bonita Springs Golf & Country Club area to Spring Creek. The system modeling results show a peak water level reduction from EL. 12.72 to EL. 8.57 or a decrease of a 4.15 feet. This concept project was planned to accept flow from the east side of I-75, so flow increased in the golf course area from 42 cfs to 299 cfs. The Bonita Springs

Golf Club residents are the main beneficiaries of this project along with Estero and Imperial River residents who benefit by the acceptance of flow from east of I-75.

3.10 ***I-75 to Spring Creek Drainageway (South)*** - This conveyance concept project was developed to direct flow away from the Tropical Acres area lying northwesterly from the Bonita Springs High School. The system modeling results show 97 cfs flood flow towards the Spring Creek outfall with peak water levels at the approximate top of bank with a recovery to normal levels within a few days following the storm event. The Tropical Acres residents of Bonita Springs are the beneficiaries of this project.

3.11 ***East I-75 Overland Flow Collection Drainageway*** - This conveyance concept project was developed to collect flood flow from the area east of I-75 that is being planned as a flood reservoir. This collector drainageway allows a balancing of flows through the various drainage structures under I-75. The residents west of I-75 along the Estero River and Imperial River are the beneficiaries of collecting flood flow and improving the outfall to the west of I-75.

3.12 ***Imperial River Improvements East of I-75*** - This conveyance type concept project was developed to improve flow along the Imperial River. The system modeling results show a reduction in flood water levels between 2.47 feet and 4.75 feet with a recovery to normal levels within a few days without increasing the peak flow in the river. The Bonita Springs residents along the Imperial River are the beneficiaries of this project.

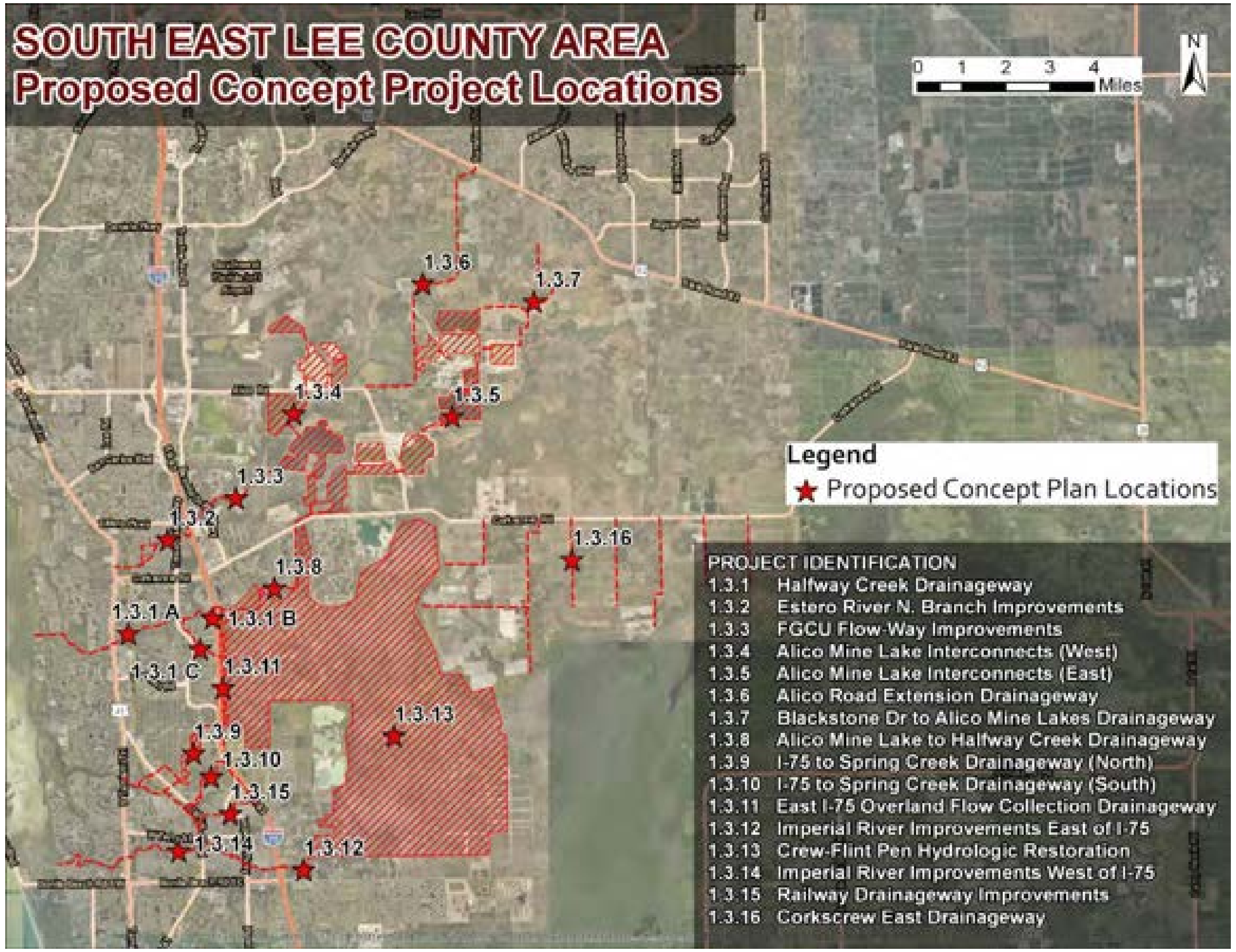
3.13 ***Crew-Flint Pen Hydrologic Restoration*** - This flood reservoir concept project stores flood water on the east side of Interstate No. 75 until the storm event passes. The system modeling shows a reduction in the peak water level on the west side of I-75 from EL. 14.80 to EL. 11.17, or a 3.63-foot decrease in flood levels with a recovery to normal levels within a few days. Additionally, the system model results show a reduction in the peak flow for the Imperial River at Kehl Canal Gate from 526 cfs to 267 cfs or a 259 cfs decrease. The concept project provides an additional benefit with the ability to hold water and provide hydrologic restoration of extensive preserve lands east of I-75. The residents west of I-75 are the beneficiaries of this concept project.

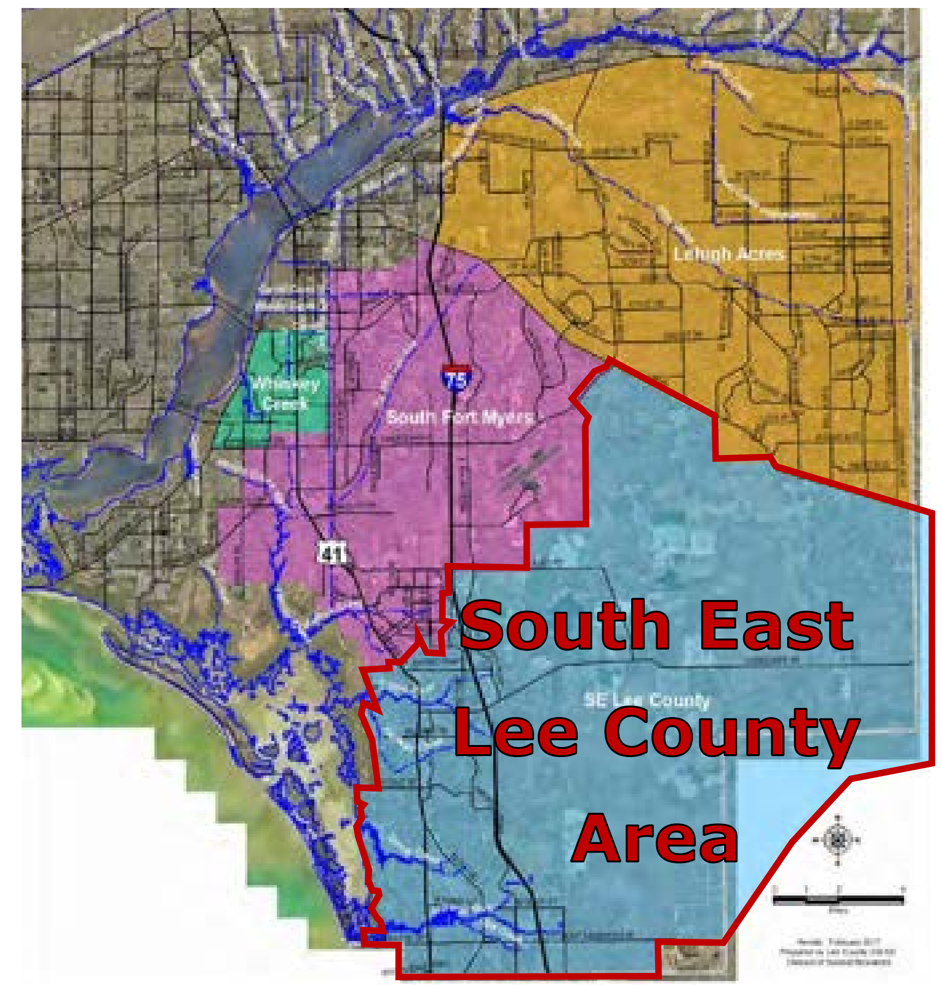
3.14 ***Imperial River Improvements West of I-75*** - This conveyance type concept project was developed to improve flow along the Imperial River. The system modeling results show a reduction in flood water levels between 1.55 feet and 4.33 feet with a recovery to normal levels within a few days following the storm event. The Bonita Springs residents along the Imperial River are the beneficiaries of this project.

3.15 ***Railway Drainageway Improvements*** - This conveyance concept project was developed to improve flow in the Rosemary Canal area of Bonita Springs. The system modeling results show a reduction in flood water levels between 0.94 feet and 1.49 feet with a recovery to normal levels within a few days without increasing the peak flow to the river. The residents in this area of Bonita Springs are the beneficiaries of this project.

3.16 ***Corkscrew East*** - This conveyance concept project was developed to direct flow southerly away from Corkscrew Road and on to the Corkscrew Swamp Sanctuary. These conveyances are intended to carry future flood flow through future development tracts to avoid blocking drainage to the south. The system modeling results show discharges ranging from 119 cfs to 398 cfs in flood flow to the Corkscrew Swamp. The beneficiaries of the planned conveyances will be the residents in this area along with travelers on Corkscrew Road.

EXHIBIT 1.3





South East Lee County Area

Proposed Concept Projects

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3

EXHIBIT 1.3.1

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from the existing bridge on I-75, located approximately one-mile south of Corkscrew Road, southwesterly towards Halfway Creek. This drainageway would utilize the Brooks Community stormwater management system and includes excavated channels, existing lakes and major drainage structures under roadways, ultimately discharging to tidal waters in Estero Bay. The drainage area is very large, and the proposed conveyance would be intended for very large flow. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Significant environmental impacts would necessitate mitigation.

May 2020

Halfway Creek Drainageways
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
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(239) 332-4569
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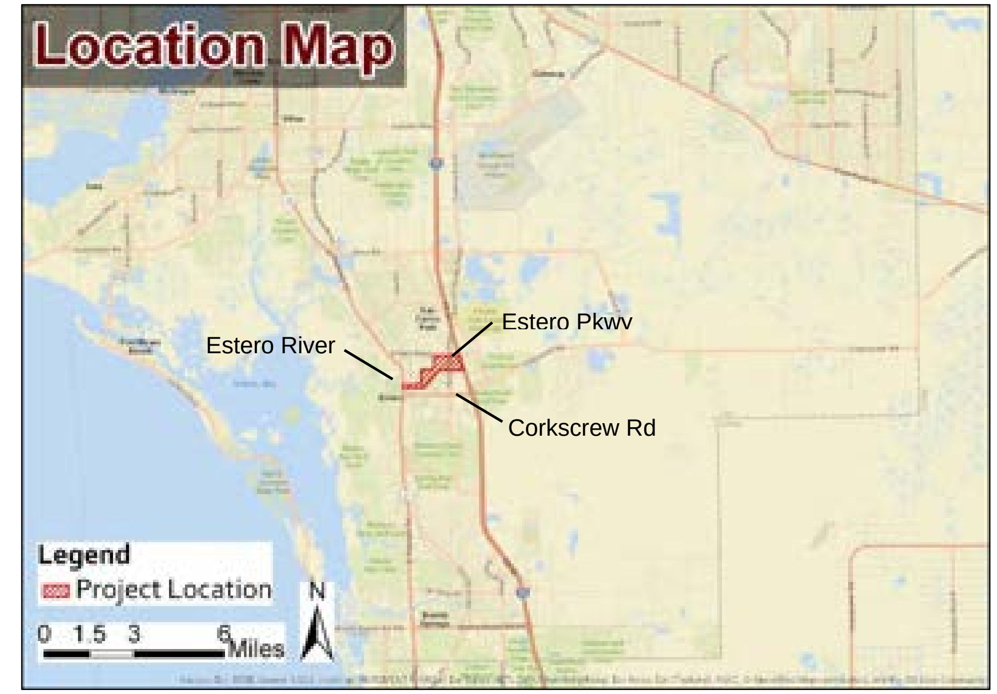
EXHIBIT 1.3.1

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project improves conveyance from existing I-75 bridge crossing at the Estero Parkway overpass to the Estero River with channel widening, excavation of a bypass flow-way and re-directing the flow path for extreme storm events. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project increases drainage capacity for handling large stormwater flow from the Alico Mine Lakes area. The development of drainage flow-way capacity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Working in the natural areas of the Estero River will require special attention to preserve the character of the stream. Environmental impacts would necessitate mitigation.

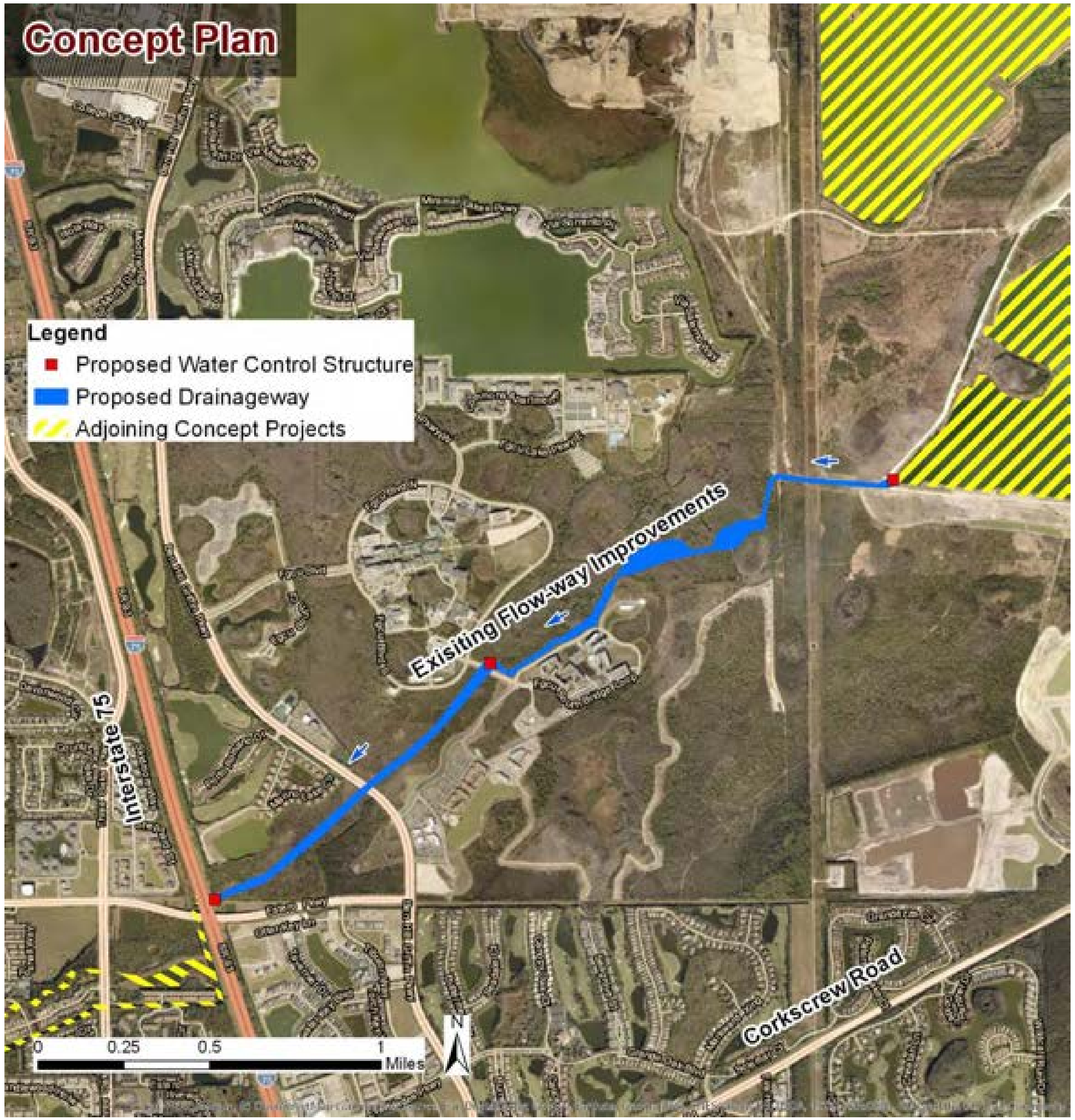
May 2020

Estero River N. Branch Improvements

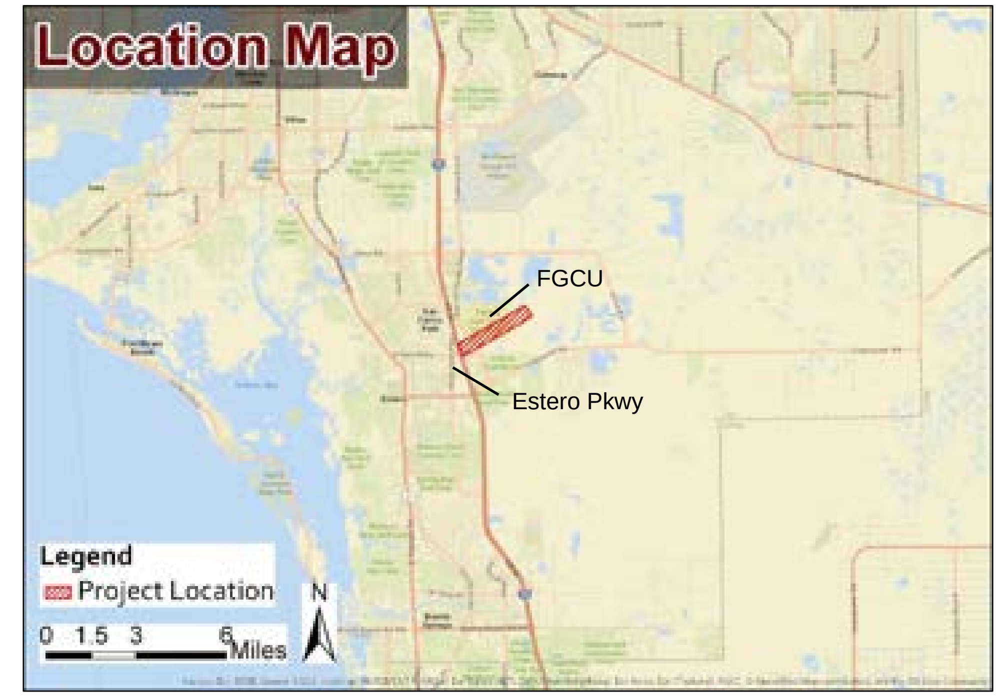
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.2



Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project interconnects the "Wild Blue" existing mine lake in the Alico area to the Interstate 75 bridge crossing at the Estero Parkway overpass with an excavated channel to carry extreme event stormwater flows across the FGCU campus. This mine lake connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Interconnection conveyances would be approximately 130 feet wide channels which may be irregular shaped to appear as lakes.

PURPOSE: This proposed project extends drainage control into the Alico Mine Lakes area and allows development of storage reservoirs for attenuation of large storm events. The development of drainage flow-way connectivity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. Environmental impacts, if any, would necessitate mitigation.

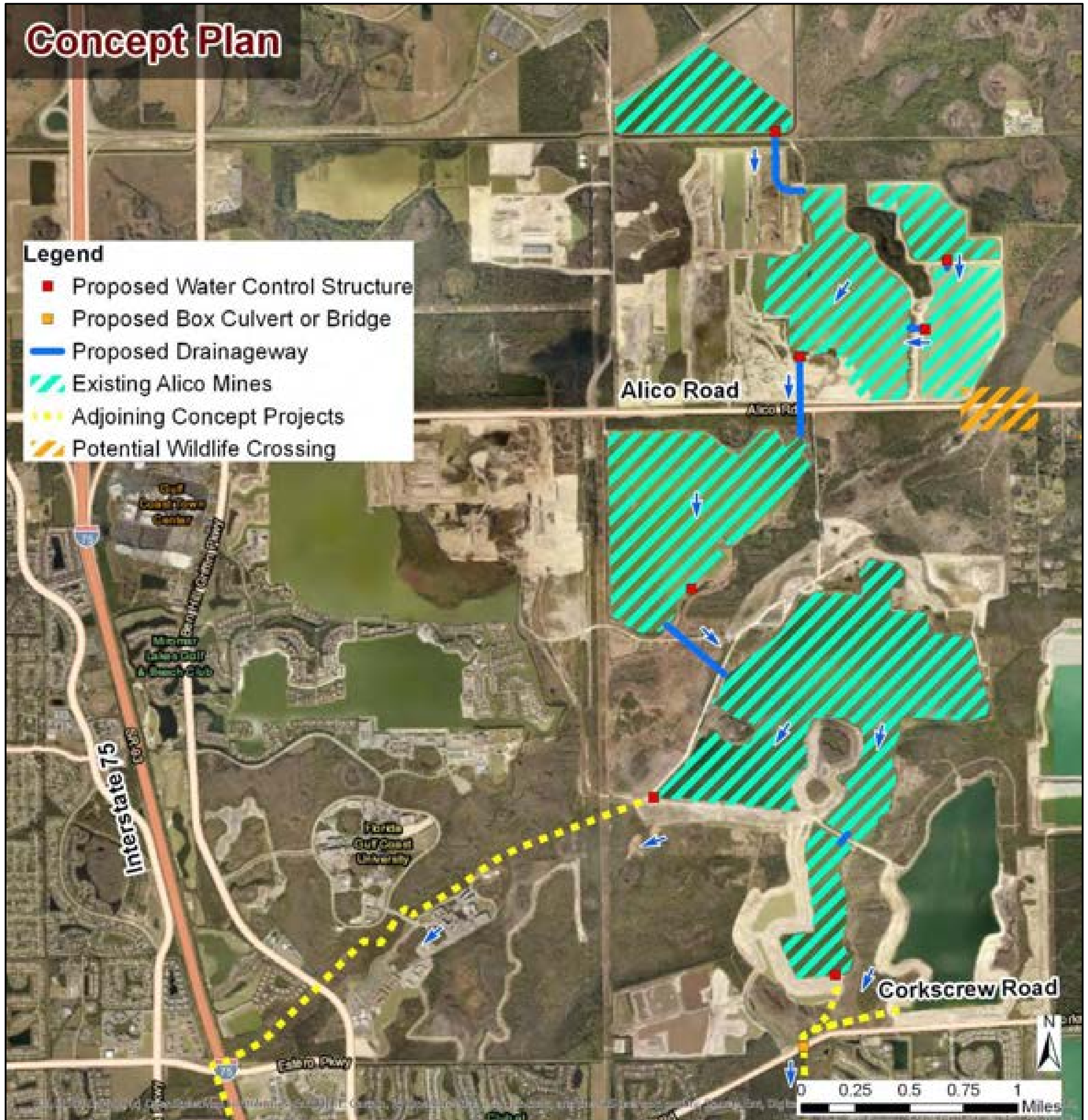
May 2020

FGCU Flow- Way

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBT 1.3.3



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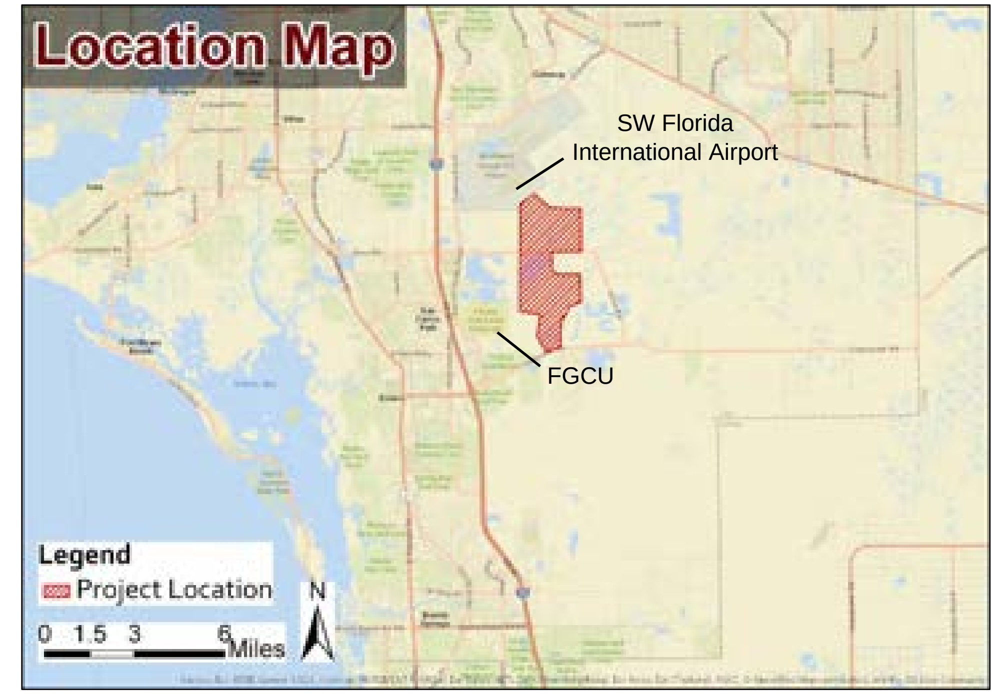

Project Narrative

DESCRIPTION: This proposed conceptual project interconnects existing mine lakes in the west Alico mine area to store and convey excess stormwater run-off to the south across Corkscrew Road towards the halfway creek bridge crossing under I-75. The mine lake connections would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project extends drainage control into the Alico Mine Lakes area and provides reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. Environmental impacts, if any, would necessitate mitigation.

May 2020

Alico Mine Lake Interconnects (West)

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
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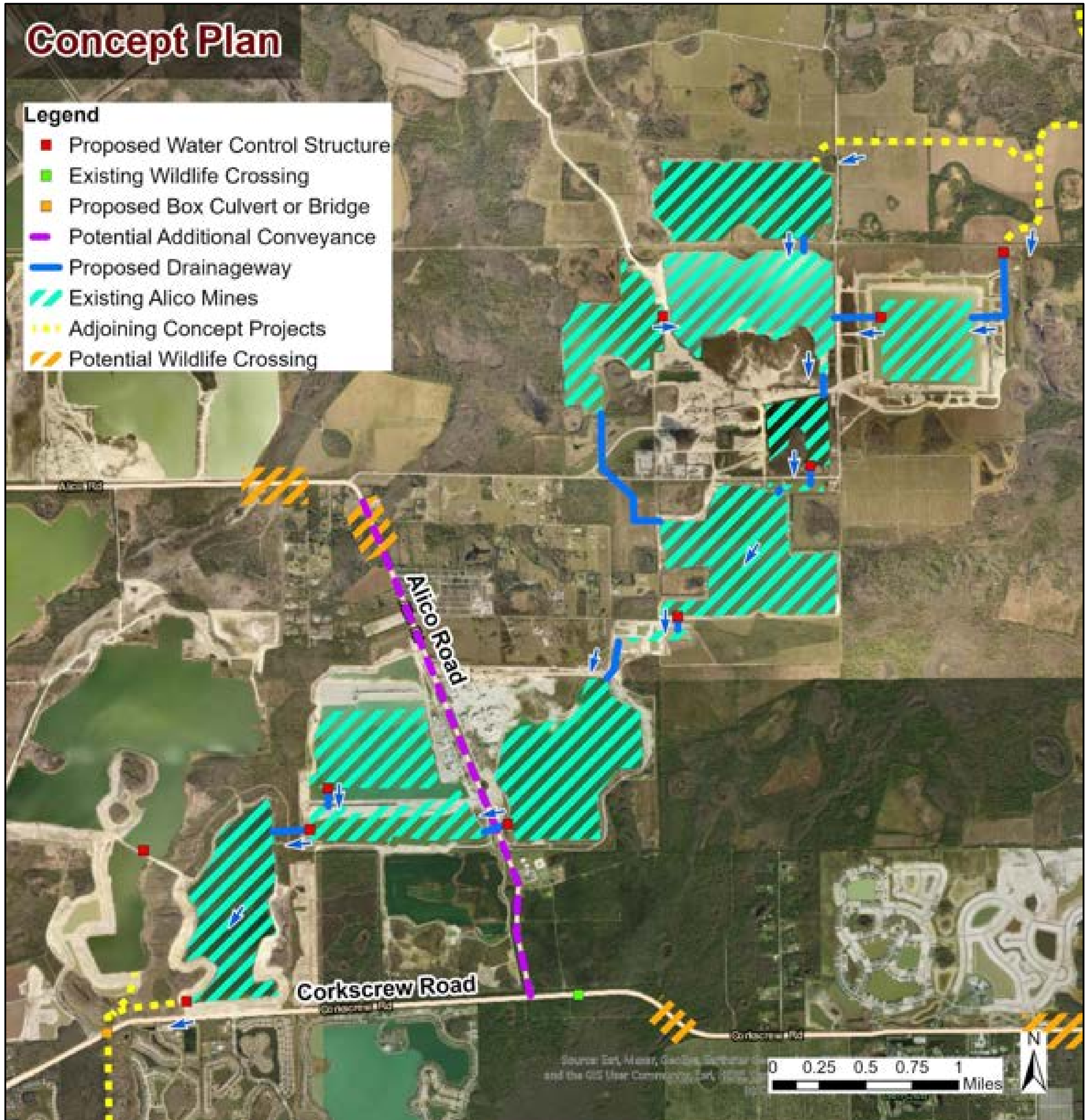
www.aimengr.com

EXHIBIT 1.3.4



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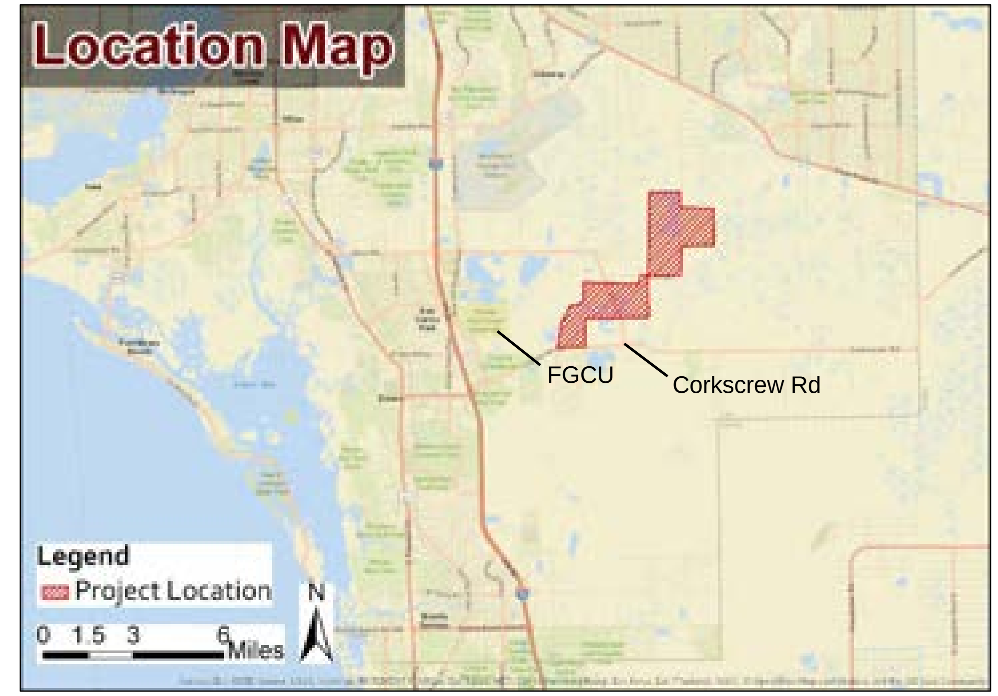

Project Narrative

DESCRIPTION: This proposed conceptual project interconnects existing mine lakes in the east Alico area to store and convey excess stormwater run-off to the southwest towards Corkscrew Road. The mine lake connections would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project extends drainageways into the Alico mines area and provides reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Alico Mine Lake Interconnects (East)

SE Lee County Area

AIM Engineering & Surveying, Inc.
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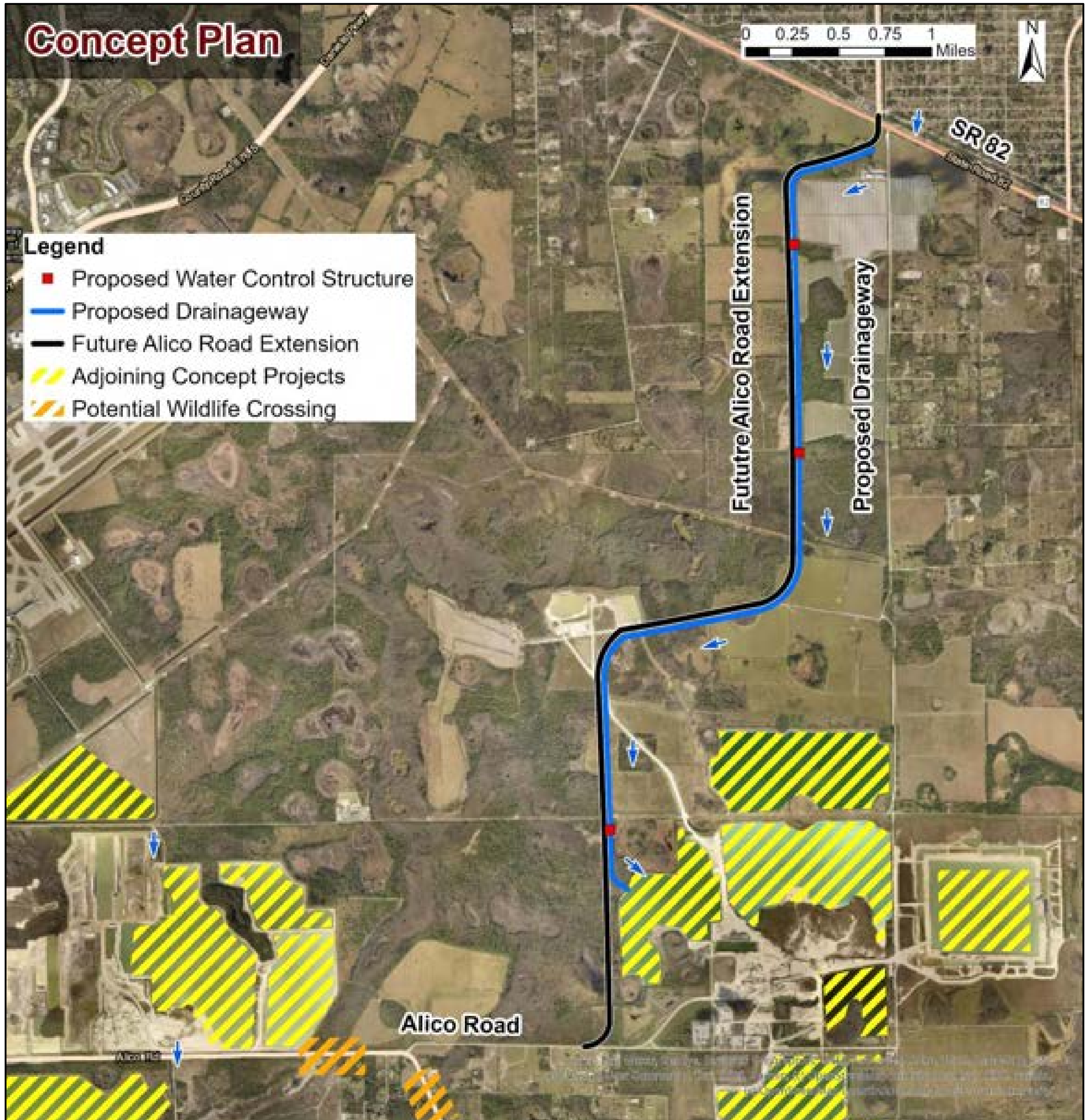
EXHIBIT 1.3.5



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project is for a drainageway running south from SR 82 along the east boundary of the RSW International Airport lands and generally following the proposed Alico Road extension to SR 82. This drainageway would convey excess stormwater from large rainfall events to the existing Alico Mine Lakes.

PURPOSE: This proposed project provides routing of excess stormwater run-off away from the Ten-Mile Canal which is experiencing severe over loading. The drainageway would provide fill material for roadway embankment, as well as, road drainage outfall and water quality treatment.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Coordination with the road extension would be required to utilize fill spoil material. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts would necessitate mitigation.

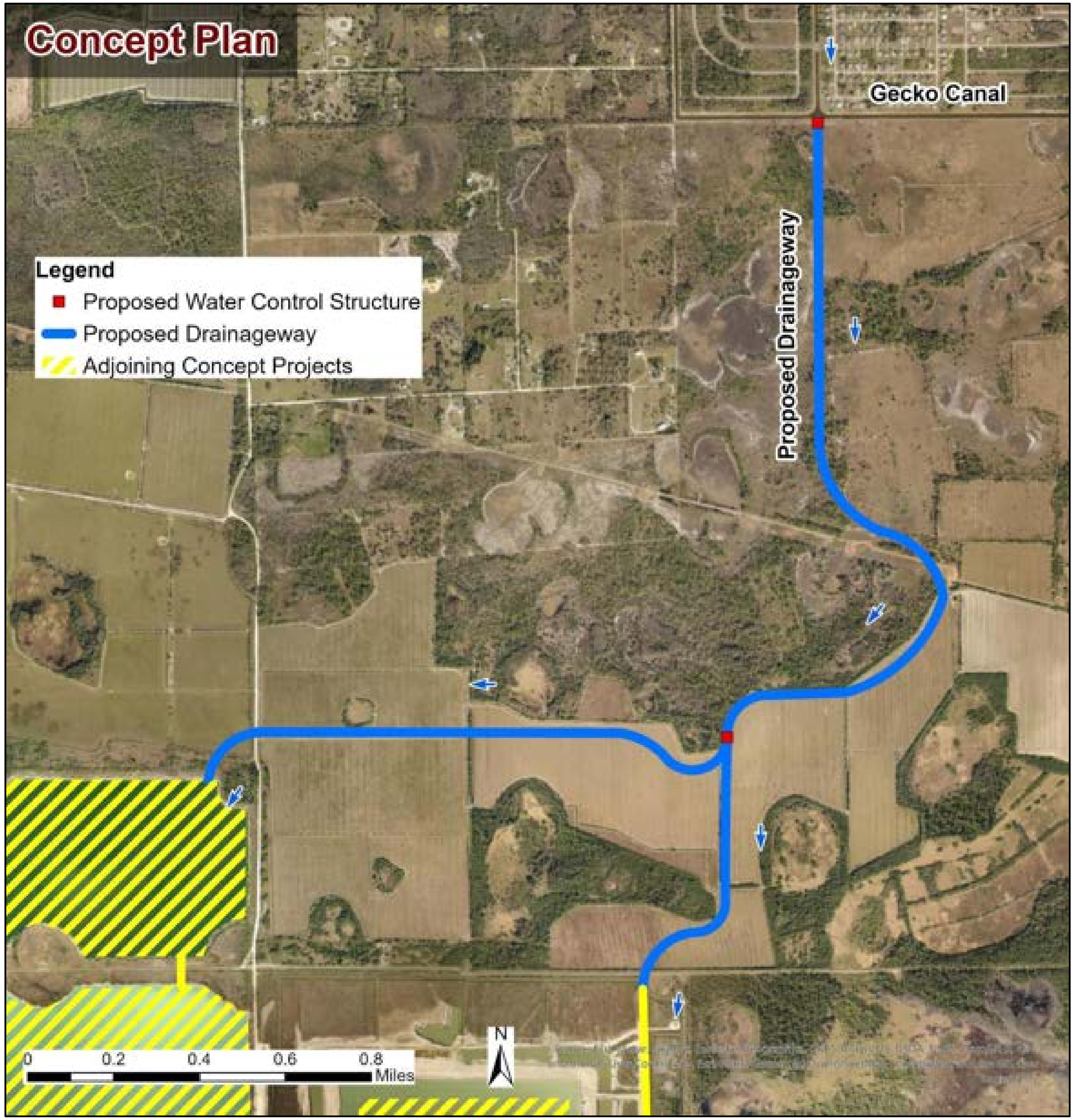
May 2020

Alico Road Extension Drainageway

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.6



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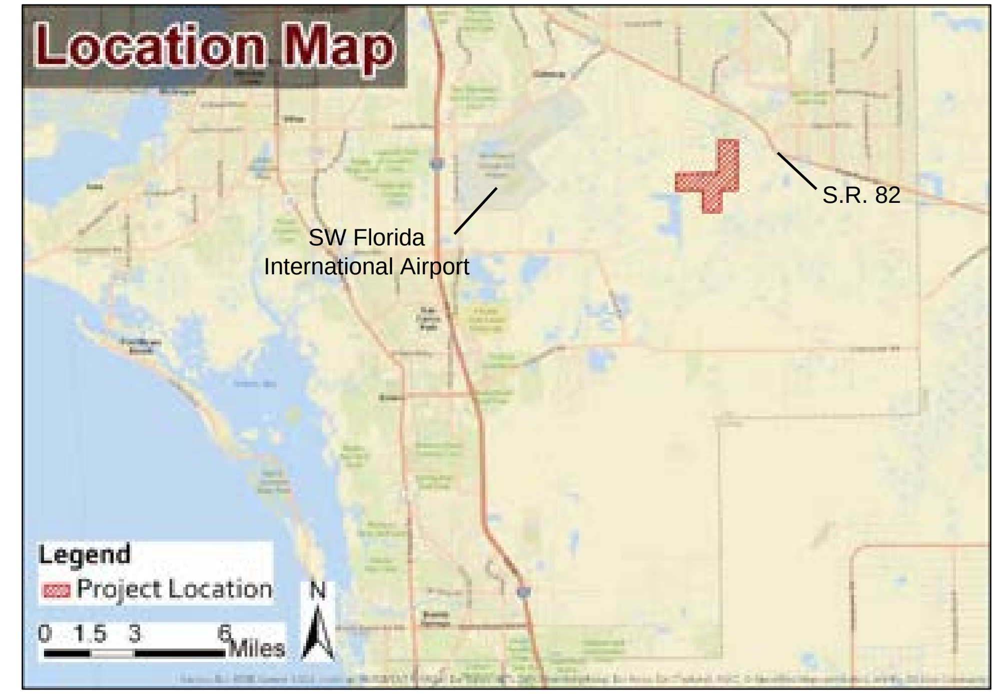

Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from Blackstone Drive area in Lehigh Acres lying south of SR 82 to the existing Alico Mining Lakes and/or the Flint Pen Preserve. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to the south to reduce flooding and improving hydrologic restoration of the Flint Pen area.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Blackstone Dr to Alico Mine Lakes Drainageway

SE Lee County Area

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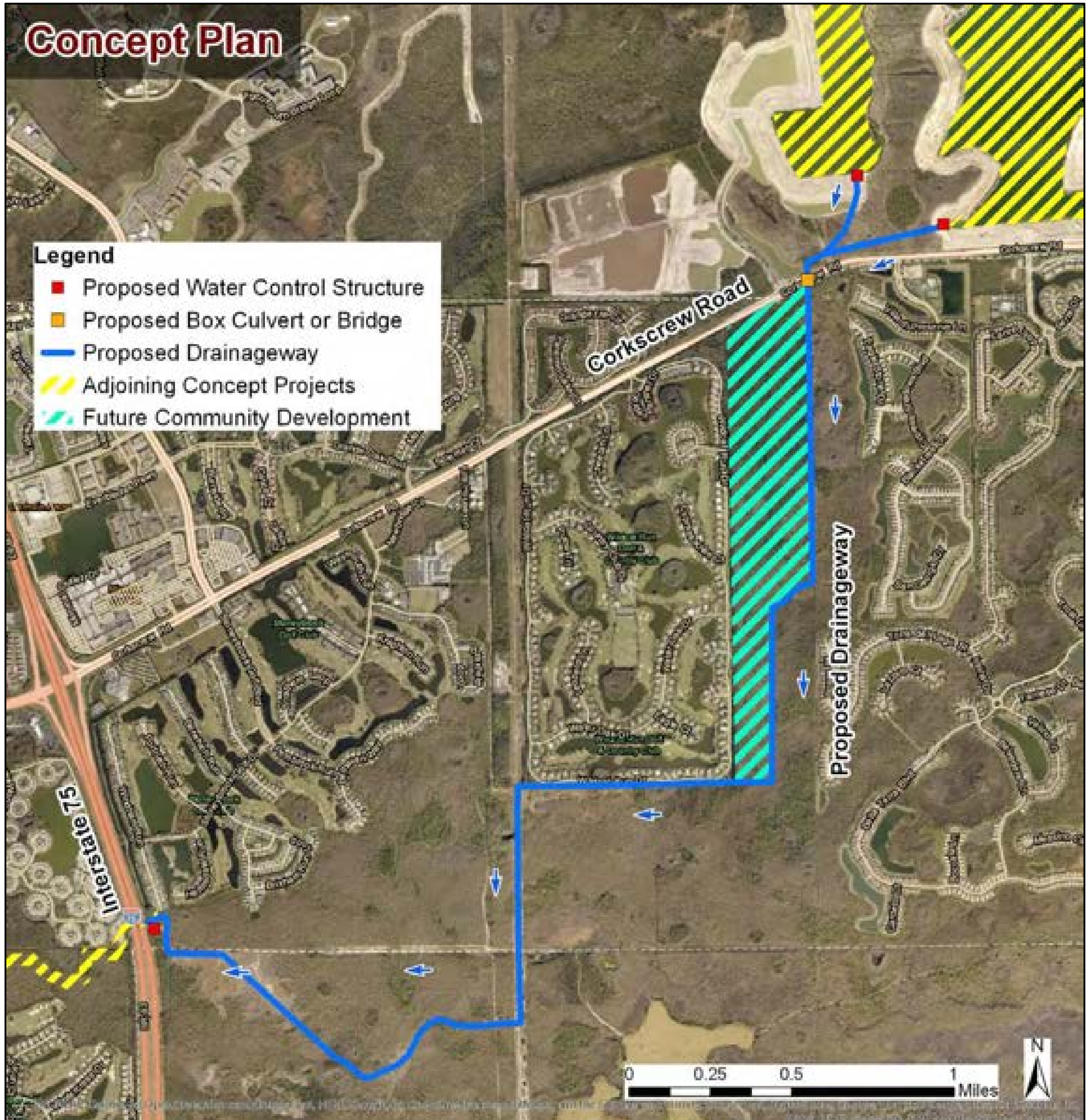
EXHIBIT 1.3.7



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project conveys the existing mine lakes in the Alico area north of Corkscrew Road into the Crew Flint preservation area and directs excess flow towards the Halfway Creek bridge under I-75. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project extends drainage control into the Alico Mine Lakes area and allows reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding. Water flow is directed to the Crew Flint preservation area which improves natural system hydrology in this area.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Alico Mine Lake to Halfway Creek Drainageway

SE Lee County Area

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2161 Fowler Street
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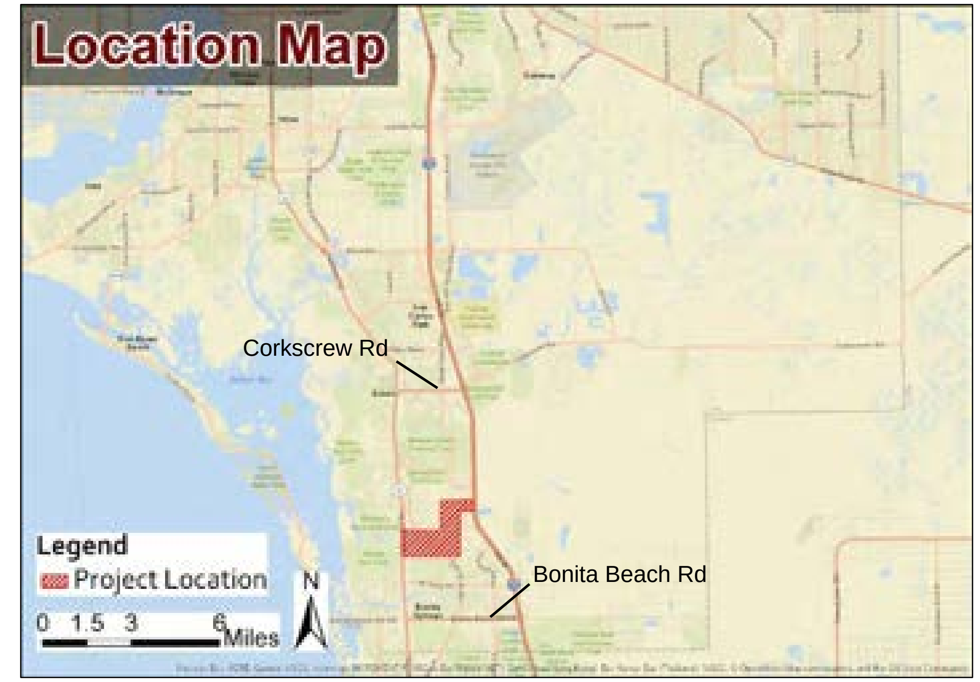
EXHIBIT 1.3.8

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from a proposed drainage structure under I-75 through the Spring Creek Drainageway extension. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Utilizing an abandoned golf course for conveyance and water quality treatment is possible.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Utilization of the golf course has the potential of special soil handling. Environmental impacts, if any, would necessitate mitigation.

May 2020

I-75 to Spring Creek Drainageway (North)

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
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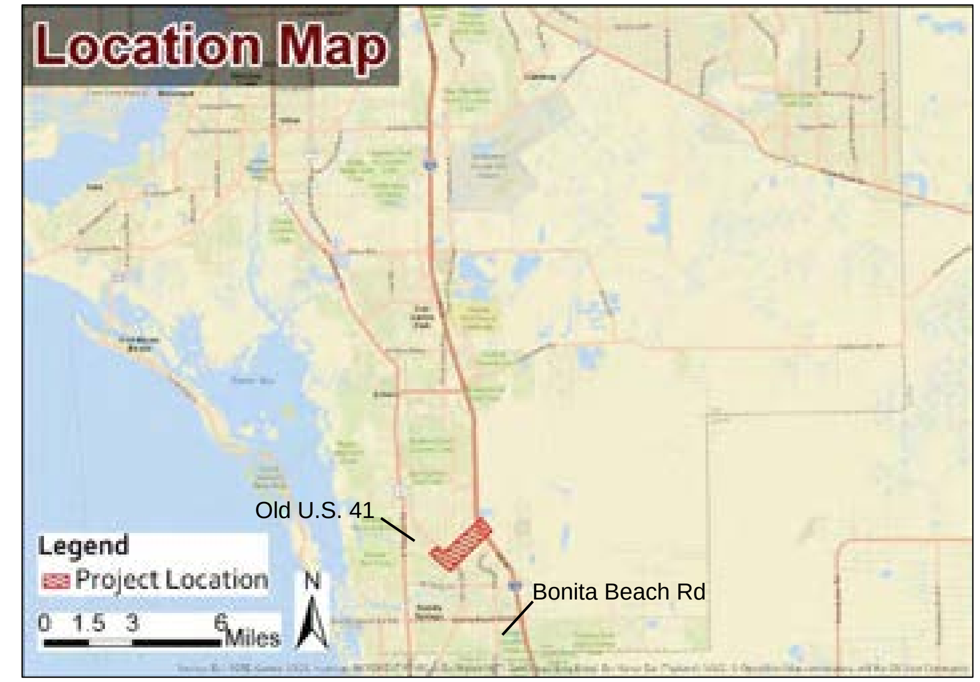
EXHIBIT 1.3.9

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from an existing drainage structure under I-75 to Spring Creek Drainageway extension. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

I-75 to Spring Creek Drainageway (South)

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
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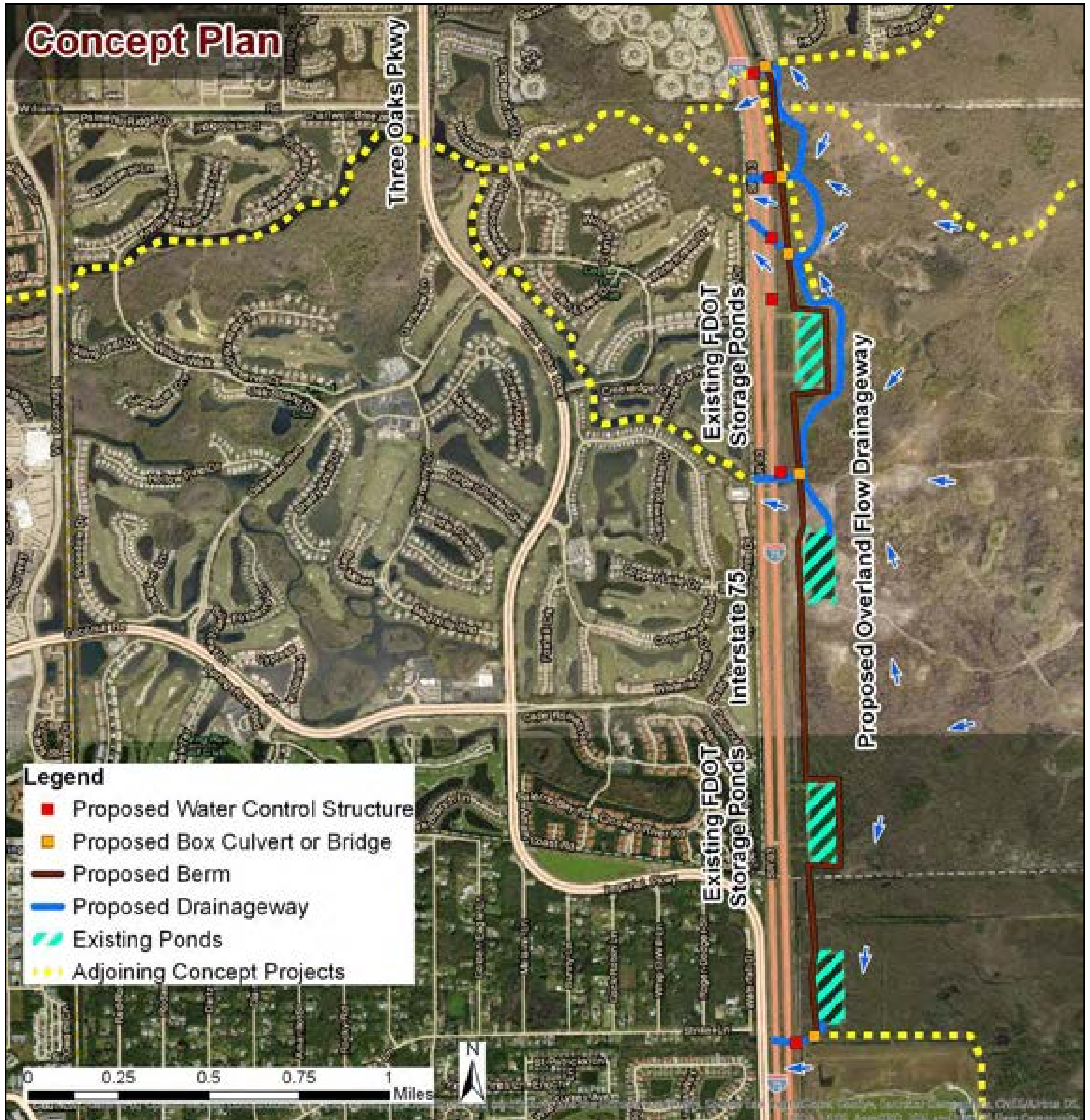
EXHIBIT 1.3.10



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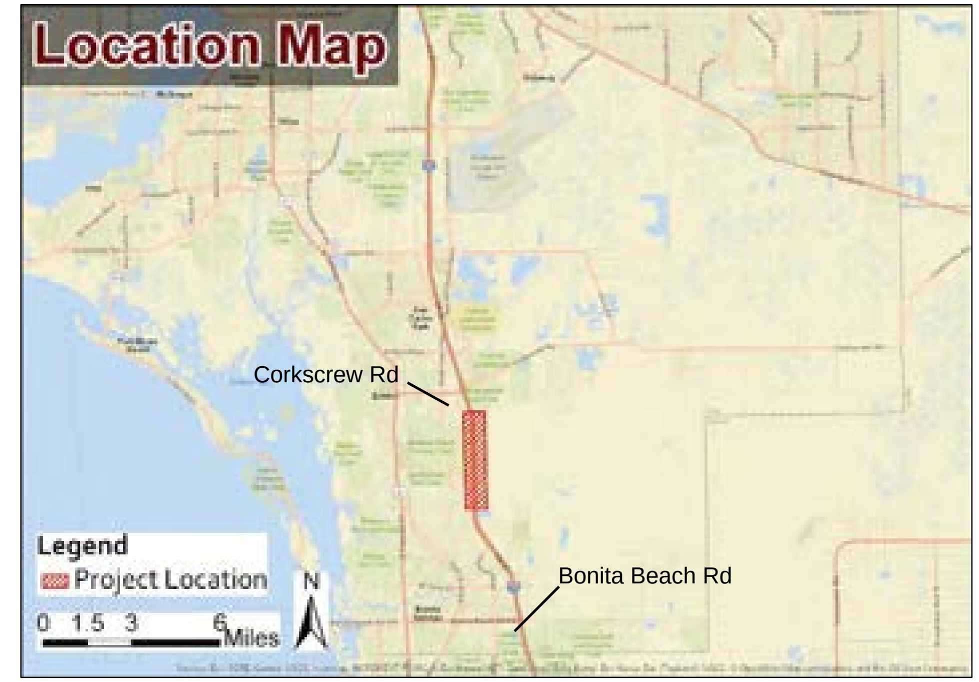

May 2020

East I-75 Overland Flow Collection Drainageway

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.11

Project Narrative

DESCRIPTION: This proposed conceptual project connects existing borrow pit lakes to the conveyance structures under I-75. This collector drainageway would collect overland flow and equalize water levels at each I-75 road crossing to fully utilize each structure. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts would necessitate mitigation.

Imagery Date: 2018

May 2020

Imperial River Improvements East of I-75

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
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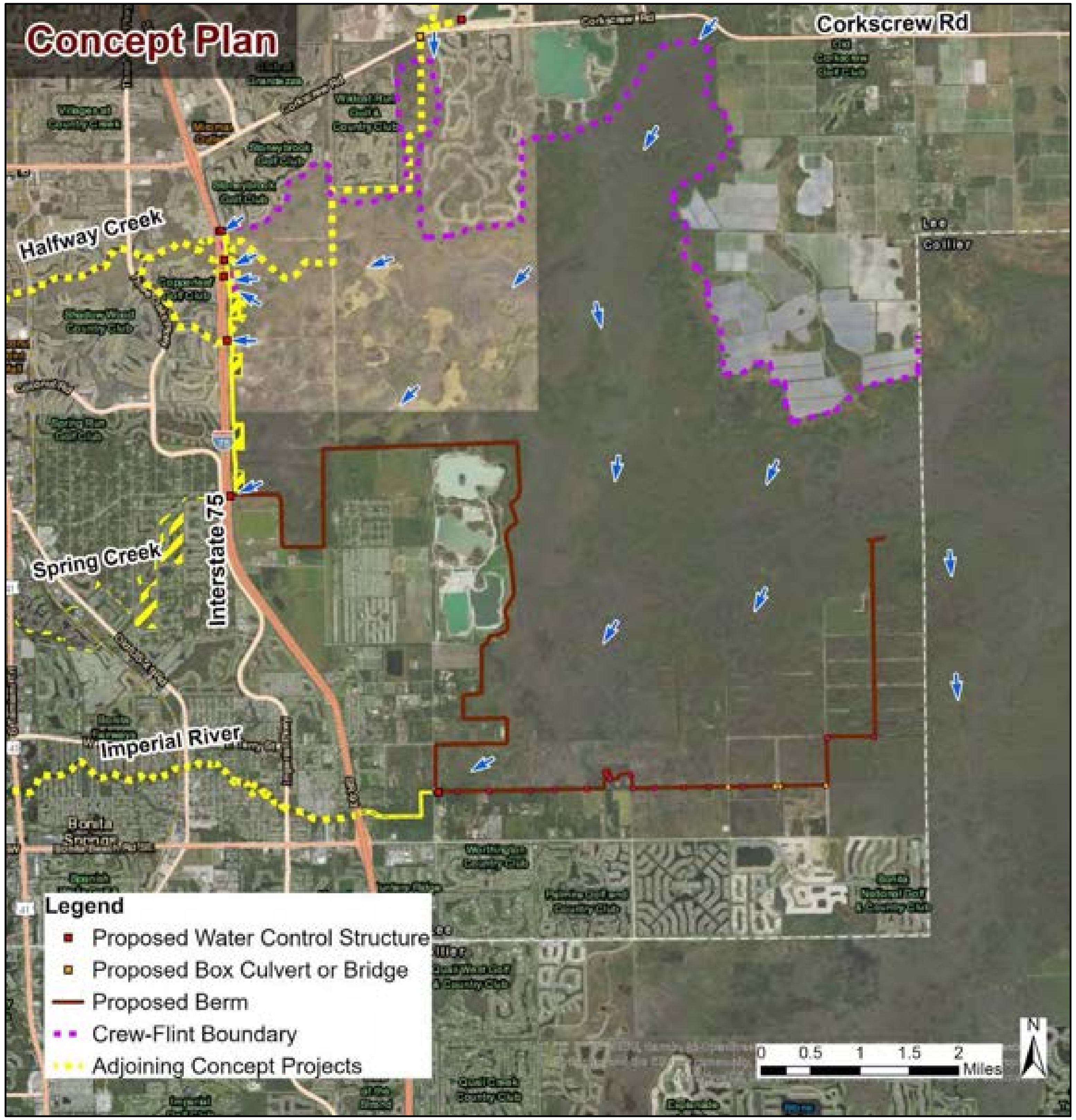
EXHIBIT 1.3.12

Project Narrative

DESCRIPTION: This proposed conceptual project improves conveyance from Kehl Canal weir westerly to the I-75 bridge crossing at the Imperial River and includes channel flow enhancements for conveying flow from extreme storm events. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project increases drainage capacity for handling large storm events and resulting excess stormwater flow from the Corkscrew Swamp, Flint Pen, Crew Flint and Edison Farms areas. The development of drainage flow-way capacity is critical to avoid excess water in the preserve.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Working in the natural areas of the headwaters of Imperial River will require special attention to preserve the character of the stream. Environmental impacts would necessitate mitigation.



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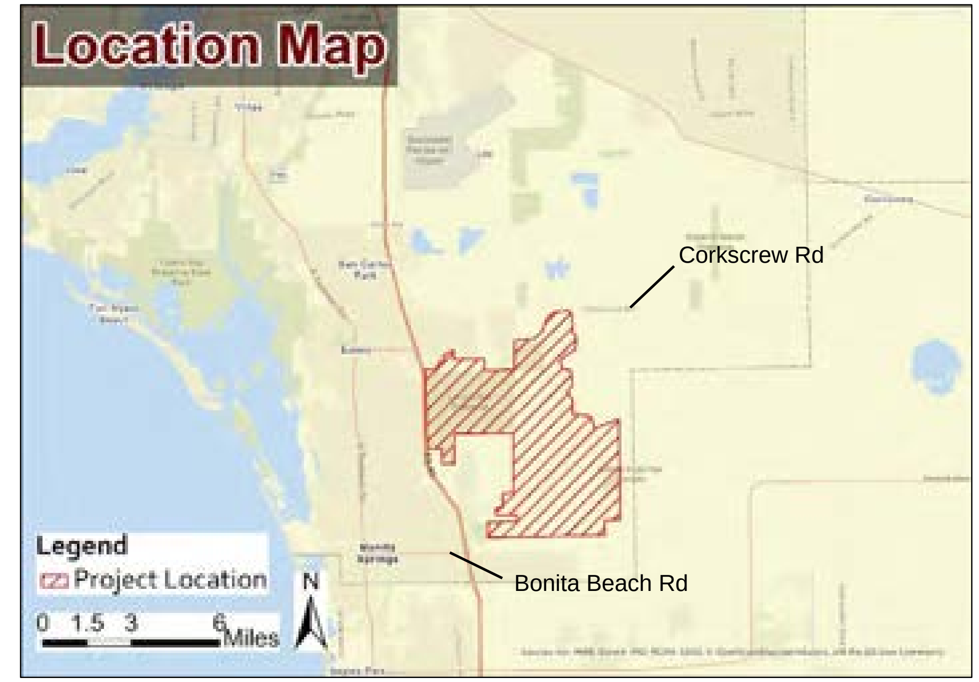

Project Narrative

DESCRIPTION: This proposed conceptual project would develop a reservoir area on the Crew Flint–Edison Farms area to hold excess stormwater until downstream developed areas have drained following a large storm event. This area would be contained within a perimeter berm and remotely operated weir gates would be necessary to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves storage of excess stormwater to reduce flooding downstream and improves hydrologic conditions in the preserve by controlling runoff during non-storm periods.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Crew-Flint Pen Hydrologic Restoration

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
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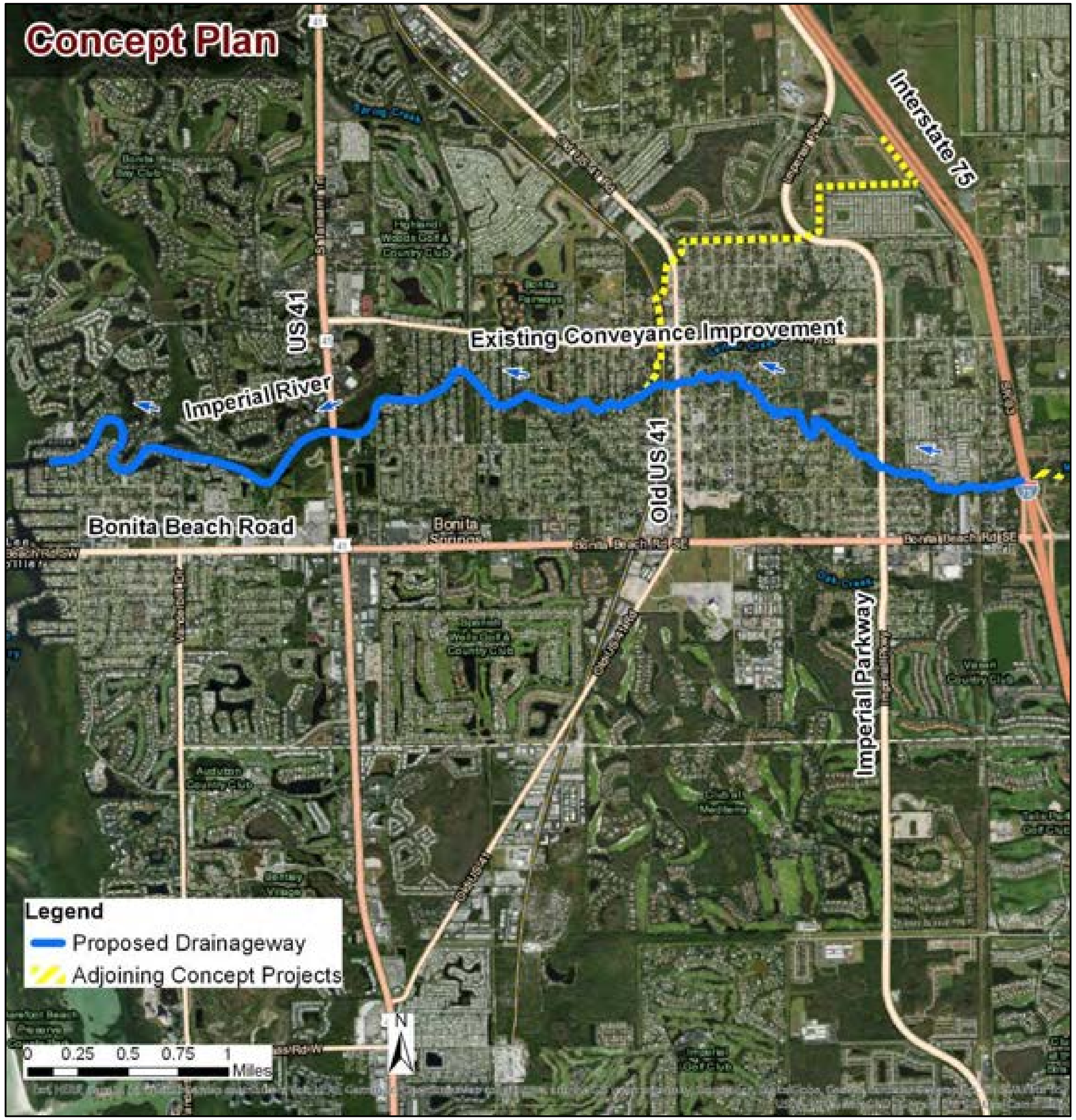
EXHIBIT 1.3.13



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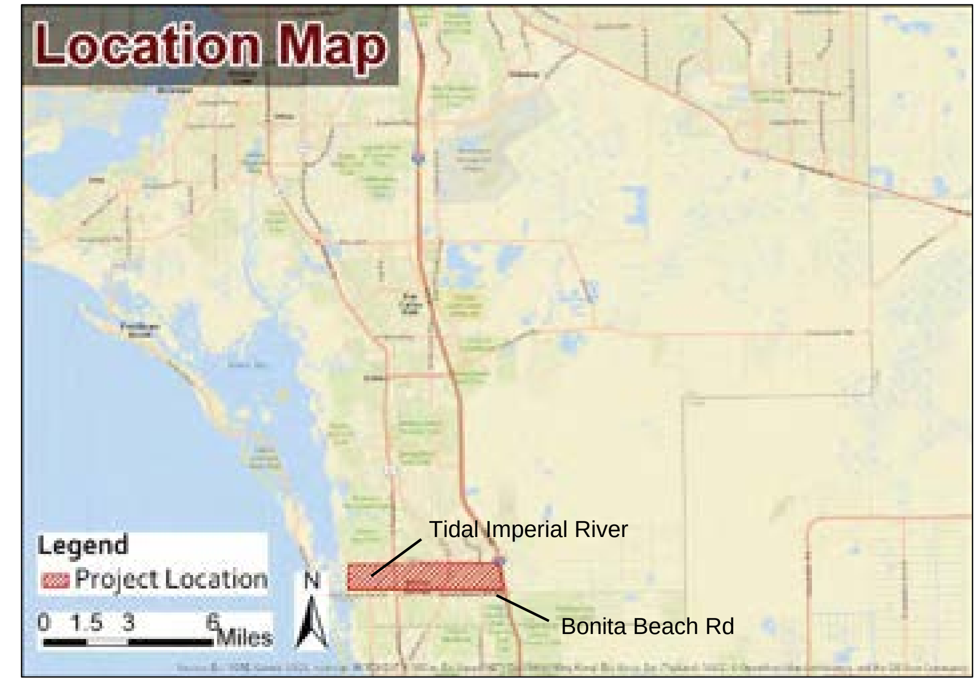

Project Narrative

DESCRIPTION: This proposed conceptual project improves the Imperial River conveyance downstream of the I-75 bridge crossing. These improvements would include sandbar and shoaling deposits, removal of debris and overhanging vegetation that would impede flow and enlarge channel constrictions on the Imperial River that restrict river channel flow during extreme storm events.

PURPOSE: This proposed project increases drainage capacity for handling large storm events and resulting excess stormwater flow from the Corkscrew Swamp, Flint Pen, Crew Flint and Edison Farms areas. The development of drainage flow-way capacity is critical to avoid excess water in the preserve.

CONSTRAINTS: This project as planned requires access across public and private properties requiring governmental approvals and land acquisition. Working in the natural areas of the Imperial River will require special attention to preserve the natural character. Environmental impacts would necessitate mitigation.

May 2020

Imperial River Improvements West of I-75

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
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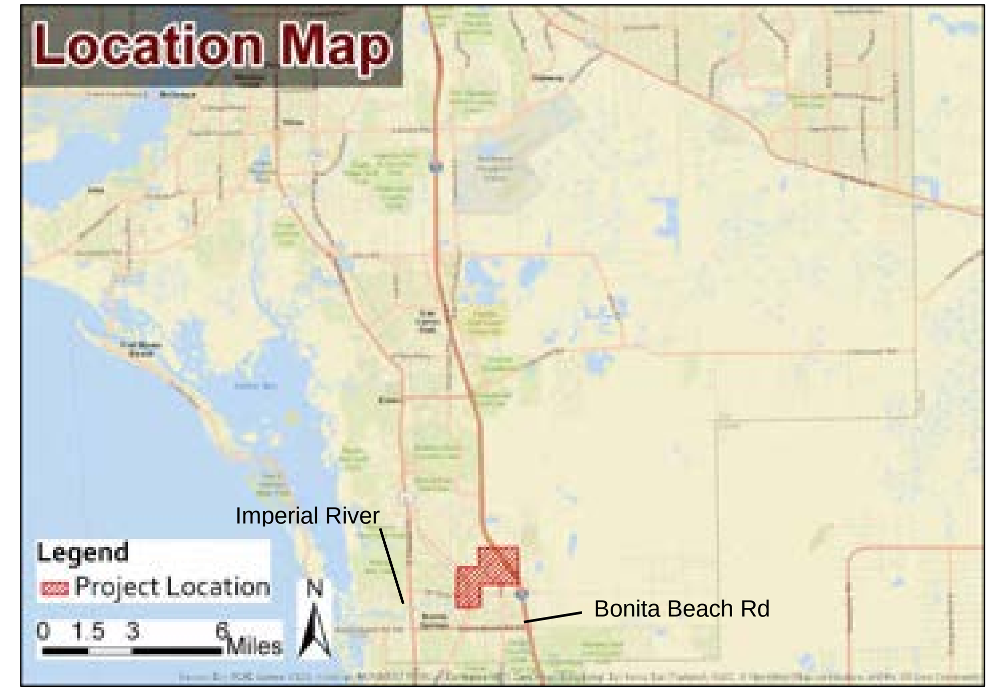
EXHIBIT 1.3.14

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project improves conveyance from the drainageway along the westerly side of I-75 to the Imperial River with a focus on the conveyance along the railway approaching the Imperial River. This conveyance may have weirs and structures to manage flow conditions and water levels within desirable ranges.

PURPOSE: This proposed project increases drainage capacity for handling large storm excess runoff from the area and would provide a drainage outfall for the Bonita Grand Lakes area on the easterly side of I-75.

CONSTRAINTS: This project as planned crosses private properties requiring approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Working near natural areas will require special attention and environmental impacts would necessitate mitigation.

May 2020

Railway Drainageway Improvements

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
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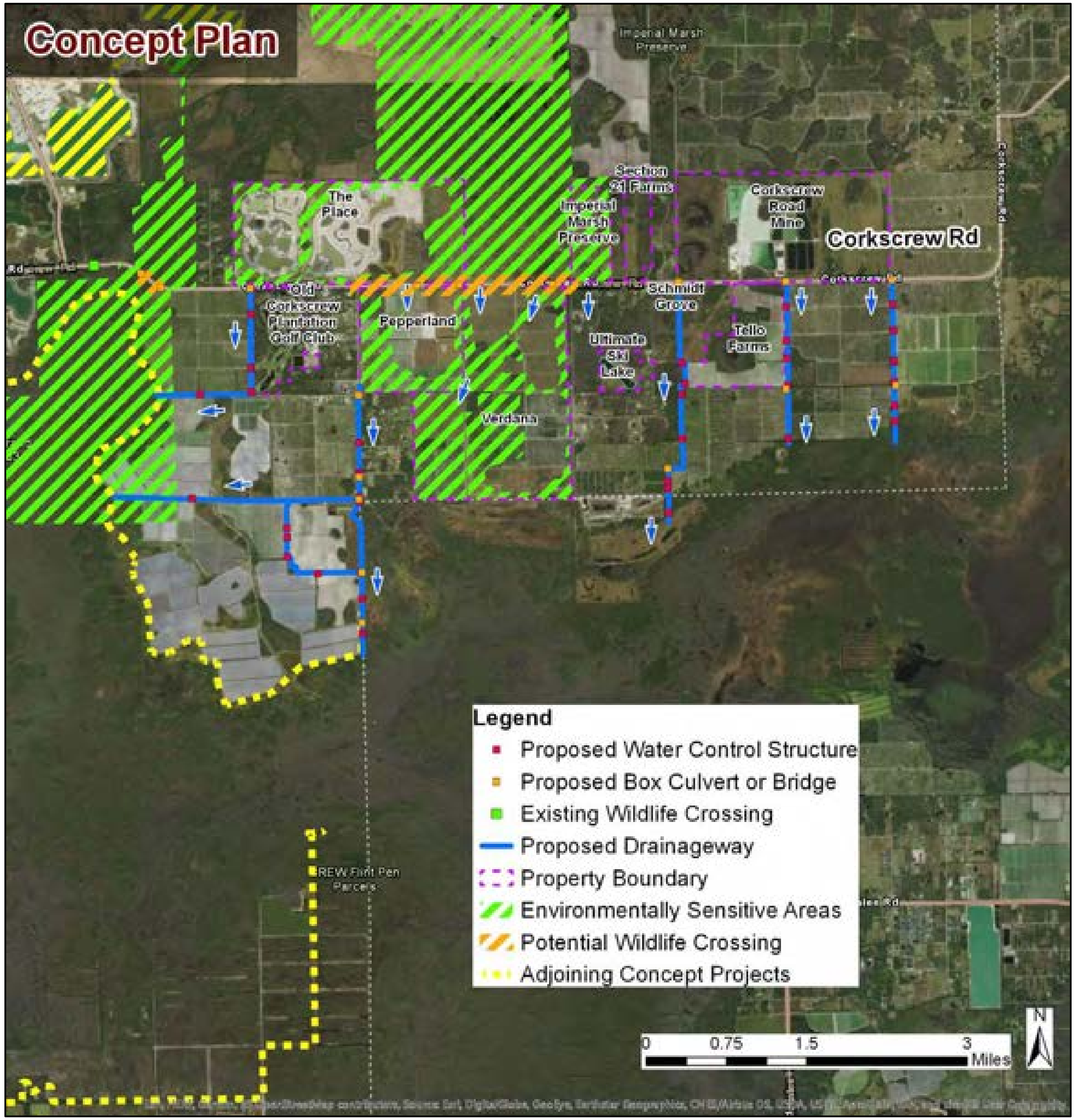
EXHIBIT 1.3.15



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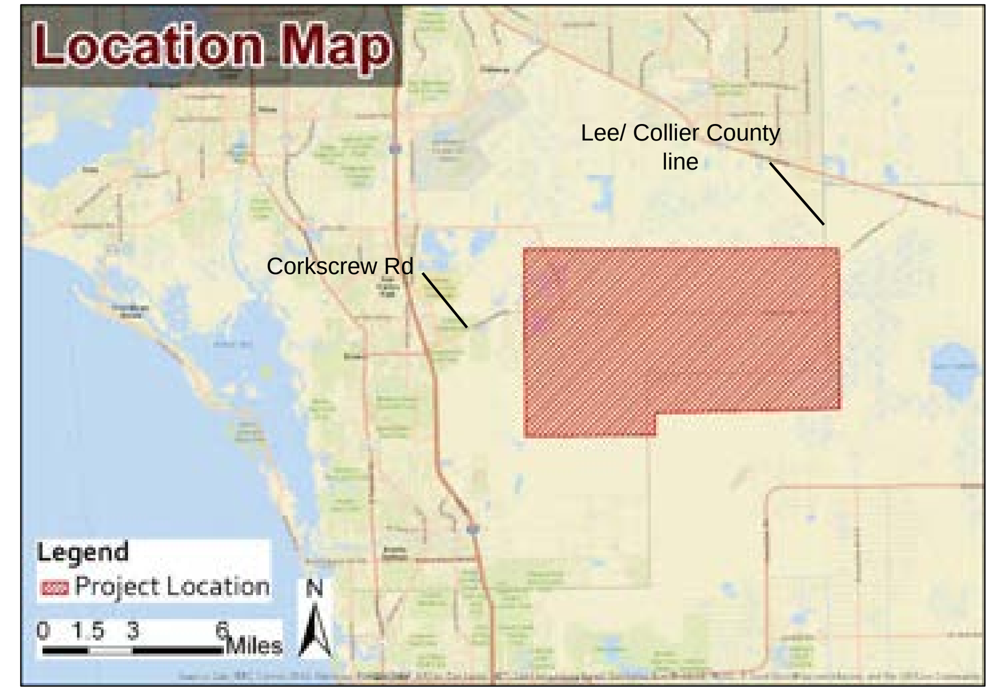

Project Narrative

DESCRIPTION: This proposed conceptual project would provide natural and manmade drainage conveyances for the upcoming development of this area to account for surface water runoff from the lands north of Corkscrew Road flowing southerly to the Corkscrew Swamp. These conveyances would utilize natural flow paths and have drainageways with weirs to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project would make provisions for drainage through proposed developments in this area to handle runoff from large storm events.

CONSTRAINTS: This project as planned involves private properties and requires planning provisions during project reviews.

May 2020

Corkscrew East Drainageway

SE Lee County Area

AIM Engineering & Surveying, Inc.
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Fort Myers, Florida 33901
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EXHIBIT 1.3.16

SUMMARY OF SOUTH FORT MYERS LEE COUNTY FLOOD MITIGATION BENEFITS

Adverse flooding conditions impact the health, safety, and welfare of residents and have significant economic impact to the community. Primary flood mitigation benefits are achieved when water levels on roadways and inside building structures are reduced. A reduction in flooding duration is also beneficial, but to a lesser extent than a reduction in flood water levels. These two objectives are achieved when increased stormwater is carried through existing conveyances (culverts, rivers, canals, wetlands, etc.), diverted out of the upstream portion of the watershed, and/or stored appropriately within the watershed. The concept projects in the South Fort Myers Flood Mitigation Area are designed to provide flood mitigation benefits to areas throughout the study area that have known historical regional flooding issues.

This regional approach to meeting the flood mitigation goals is necessary since many flooding problems are not solvable on a local level. For instance, if a primary drainage canal does not have sufficient capacity to convey the required flows, then the adjacent communities relying on the canal will experience adverse tailwater conditions that inhibit and/or prevent outflow that was anticipated in the original design of the community.

Seven preliminary concept projects are proposed for the South Fort Myers study area as shown in **Exhibit 1.4**. The projects generally work in concert to develop an overall plan to reduce flooding in the region. Targeted areas for reduction in structure flooding included the communities abutting the southern portion of Ten Mile Canal.

A prerequisite of some of the upstream projects is that downstream improvements must occur first so that flooding problems are not simply transferred from one area to another. The regional model was therefore run with all conceptual projects stitched together to demonstrate the regional effects of the proposed projects. The individual conceptual projects were modeled independently in the previous interim project screening report. The results from the previous modeling are not shown graphically in this report but are mentioned occasionally. The following discussion of each project is based on the modeling results from the 100-year, 3-day design storm event.

Projects 1.4.1 and 1.4.2 collectively benefit the Island Park Road area. The projects work together to reduce flood stages in south Ten Mile Canal and the surrounding communities by diverting flow, controlling overflow, and improving the conveyance capacity of Ten Mile Canal. The two projects combined to reduce the peak flood level at the US 41 crossing of Ten Mile Canal by nearly three feet. This substantial reduction in water levels greatly reduces the flooding potential for those communities previously affected by Hurricane Irma.

Project 1.4.3 is designed to benefit the communities directly south of Daniels Parkway between Six Mile Cypress Slough and Interstate 75. The project provides flood mitigation benefit through increased conveyance capacity of existing east-to-west flow ways. Reductions in peak water levels by six inches or more were observed in the regional modeling results on only a limited number of parcels, but the peak flows into the Six Mile Cypress Slough were increased and the area had a reduction in flood duration.

Due to their small scale relative to the model, the final version of the regional model did not include projects 1.4.4 or 1.4.5, which are designed to provide flood mitigation benefit for the Briarcliff and Park Road areas, respectively. However, the individual conceptual projects were modeled independently in a previous interim project screening report and were shown to provide increased conveyance capacity for areas that have limited outfall options today.

The wetland areas east of the Southwest Florida International Airport currently flow to the west and contribute to flows in the southern portion of Ten Mile Canal. In conjunction with construction of the second runway, the airport received authorization to divert a portion of the flows to the east and south to the Estero River. Project 1.4.6 is designed to store additional water in the wetlands north of Green Meadows Road and thereby reduce the peak flows in Estero River.

Limited regional stormwater management capabilities exist in the middle and southern portions of the Six Mile Cypress Slough. Project 1.4.7 proposes to provide additional storage capacity in the Slough ahead of a major storm event to reduce peak flows in the lower reaches of Ten Mile Canal. While the regional model did not include a gate operations schedule to instruct the gate to open, the individual conceptual project was modeled independently previously in the interim project screening report and the gate operation schedule allowed the gate to open before and after the design storm event. The previous model results demonstrated a reduced recovery time following the peak of the storm event by more than 20 days, but it did not reduce the peak stages in the Slough upstream or downstream of Daniels Parkway. In the previous modeling the transfer of flow from the Slough to Ten Mile Canal did not increase the peak stages in Ten Mile Canal and the project did not affect the recovery time of Ten Mile Canal south of Daniels Parkway.

The following are concept project summaries of the anticipated flood mitigation benefit for each project.

1.4.1 ***Ten Mile Canal-North*** - This flow diversion and storage concept project was developed to direct flood flow away from the southern end of Ten Mile Canal. The modeling results show a 100 cfs upstream diversion into Carrell Canal, 200 cfs upstream diversion into Canal L, and 50 cfs upstream diversion into the Six Mile Cypress Parkway roadside swale. These combine to a total flow diversion of approximately 21,000 acre-feet over a 30-day period. An increase in upstream storage was proposed through redesigning the existing weir adjacent to Page Field Airport, but the increased storage volume was not quantified in the regional model.

1.4.2 ***Ten Mile Canal-South*** - This flow diversion and conveyance improvement concept project was developed to provide flood mitigation for the Island Park Road area. The modeling results show a 400 cfs diversion into Canal J, 200 cfs diversion into Canal K, 100 cfs diversion into Canal T, and a 1,100-cfs increase in capacity for Ten Mile Canal. These combine to a total flow diversion and conveyance increase of approximately 47,000 acre-feet.

1.4.3 ***Daniels Parkway-South Area*** - This conveyance improvement concept project was developed for flood mitigation of the communities south of Daniels Parkway, between Six Mile Cypress Slough and Interstate 75. The modeling results show 540 acre-feet of increased capacity in the swale north of the Legends community and a capacity increase of 1,100 acre-feet in the swale south of the Eagle Ridge community.

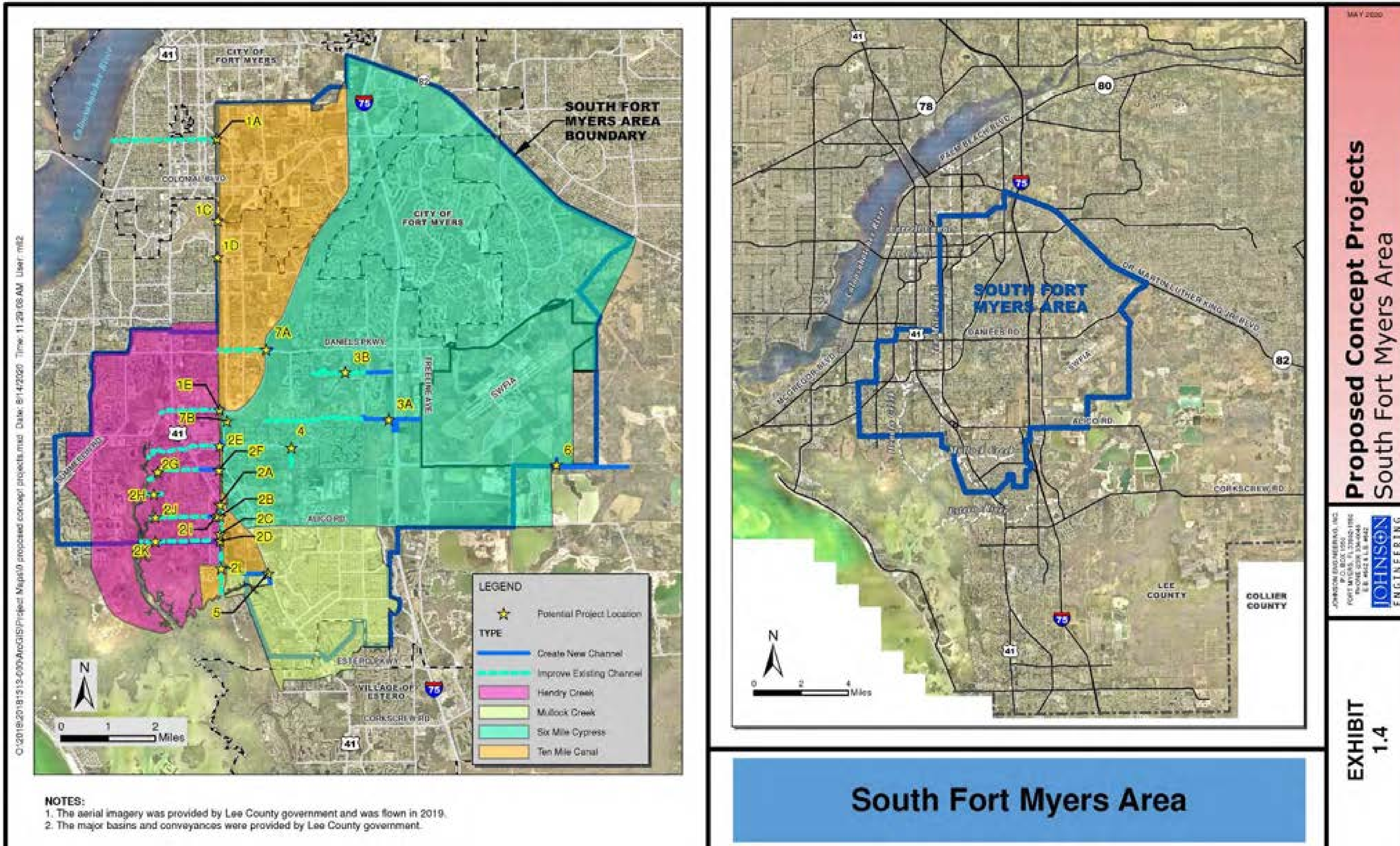
1.4.4 ***Briarcliff Area*** - This conveyance improvement concept project was developed for flood mitigation in the Briarcliff area. While this project was not included in the regional modeling, it is anticipated the project could provide up to 150 acre-feet of increased capacity for an existing area that has limited existing outfall options.

1.4.5 ***Park Road Area*** - This conveyance improvement concept project was developed for flood mitigation in the Park Road area. While this project was not included in the regional modeling, it is anticipated the project could provide up to 180 acre-feet of increased capacity for an existing area that has limited existing outfall options.

1.4.6 ***LCPA Diversion to Estero Basin*** - This flow diversion and storage concept project was developed for flood mitigation of the downstream portions of Ten Mile Canal and Estero River. The regional modeling results show the project could provide up to 800 acre-feet of increase storage in the wetland areas east of the airport. This project has a secondary benefit of increased wetland hydration.

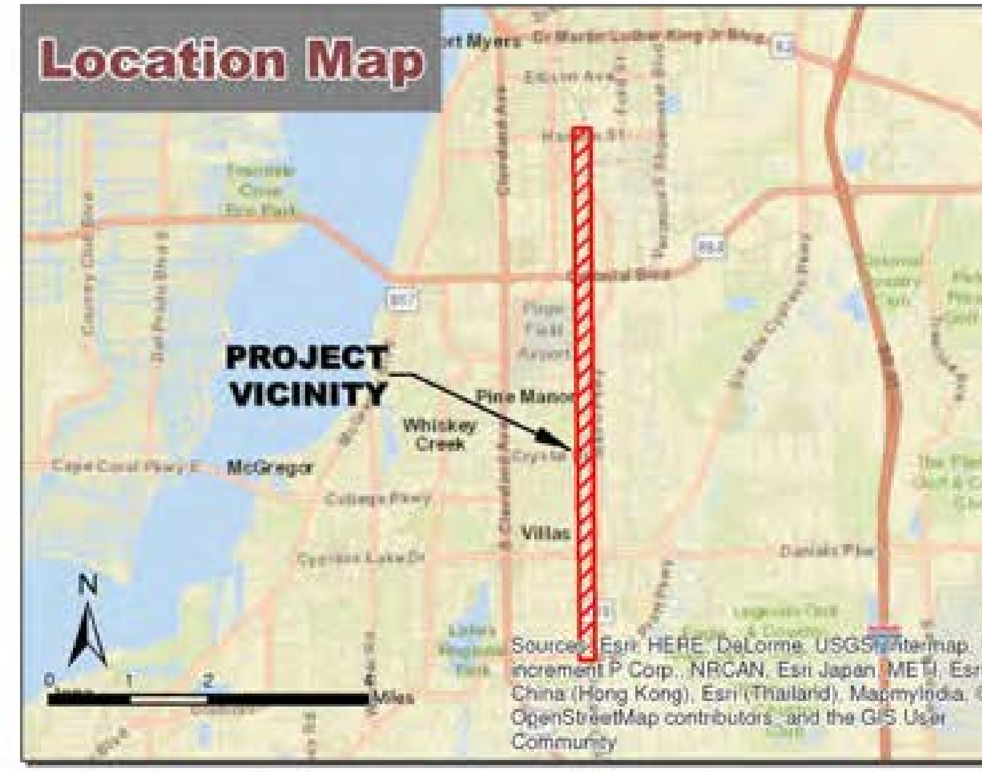
1.4.7 ***Six Mile Cypress Slough-South*** - This flow diversion concept project was developed to provide increase stormwater management in the Six Mile Cypress Slough watershed. While the gate operations were not included in the regional modeling, the model results from the interim project screening report showed this project could provide up to 5,300 acre-feet of increased water management flexibility in the watershed. This project has a secondary benefit of increased wetland hydration.

EXHIBIT 1.4



NOTES:
1. The aerial imagery was provided by Lee County government and was flown in 2019.
2. The major basins and conveyances were provided by Lee County government.

NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.



Project Narrative

DESCRIPTION: Prior to the construction of Ten Mile Canal and its west berm, runoff east of Fort Myers proceeded westerly towards the Caloosahatchee River. This project restores a portion of that historical flow via diversion from Ten Mile Canal into Carrell Canal, IDD Canal L, and along Six Mile Cypress Parkway to downstream of Lakes Regional Park. Additional storage is proposed to be created by slightly raising the crest elevation of the existing weir in Ten Mile Canal, east of Page Field airport.

PURPOSE: This series of interrelated projects restores some of the historical flows to the tidal Caloosahatchee and Hendry Creek and reduces high-flow contributions to Ten Mile Canal through diversions and storage.

CONSTRAINTS: The northerly diversion project will require coordination with the City of Fort Myers. Preliminary meetings with City staff have indicated a willingness to consider these projects. In conjunction with these flow diversions, the downstream conveyances may need to be improved, determined by later studies.

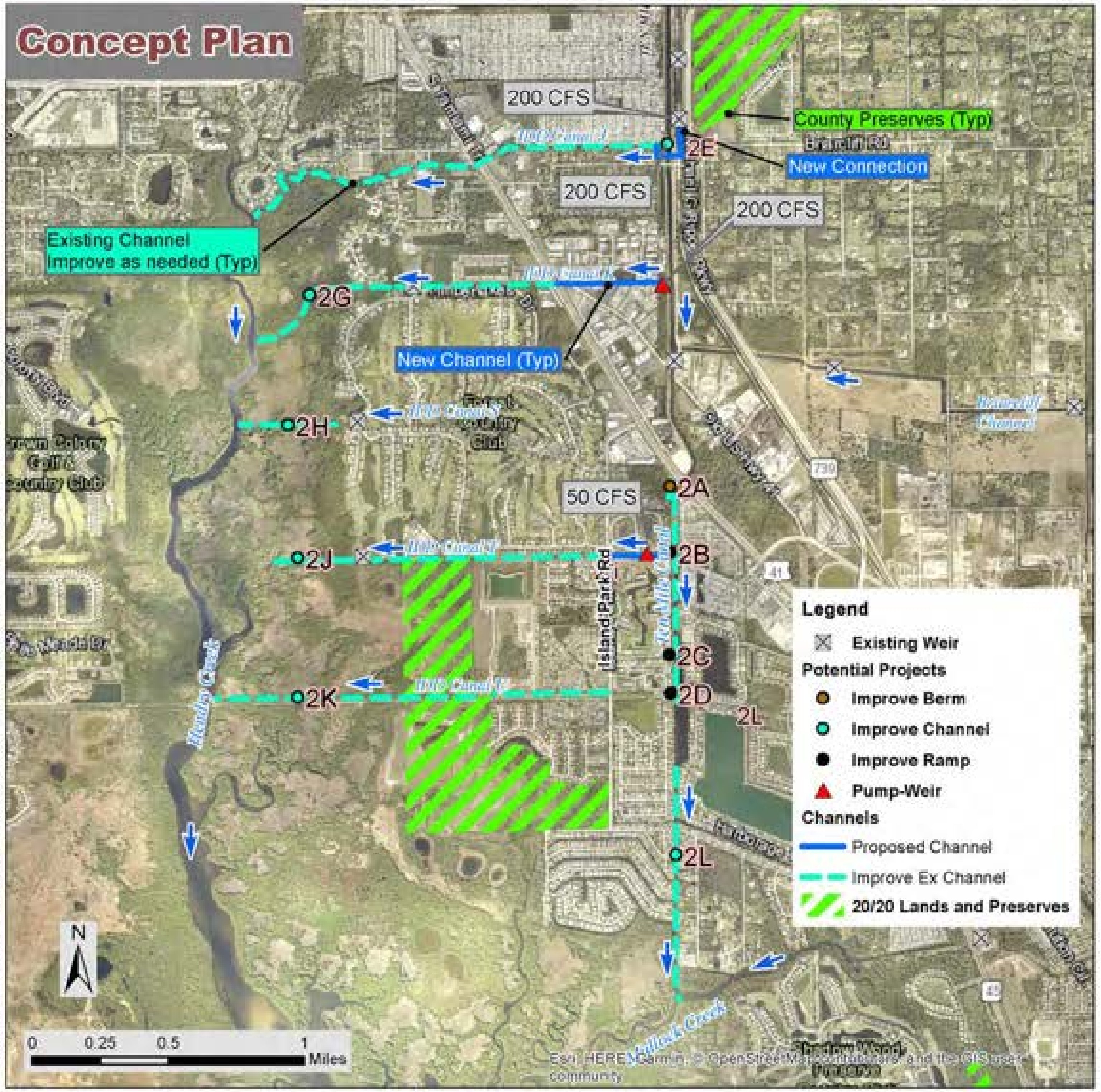
MAY 2020

Ten Mile Canal - North
South Fort Myers Area

JOHNSON ENGINEERING

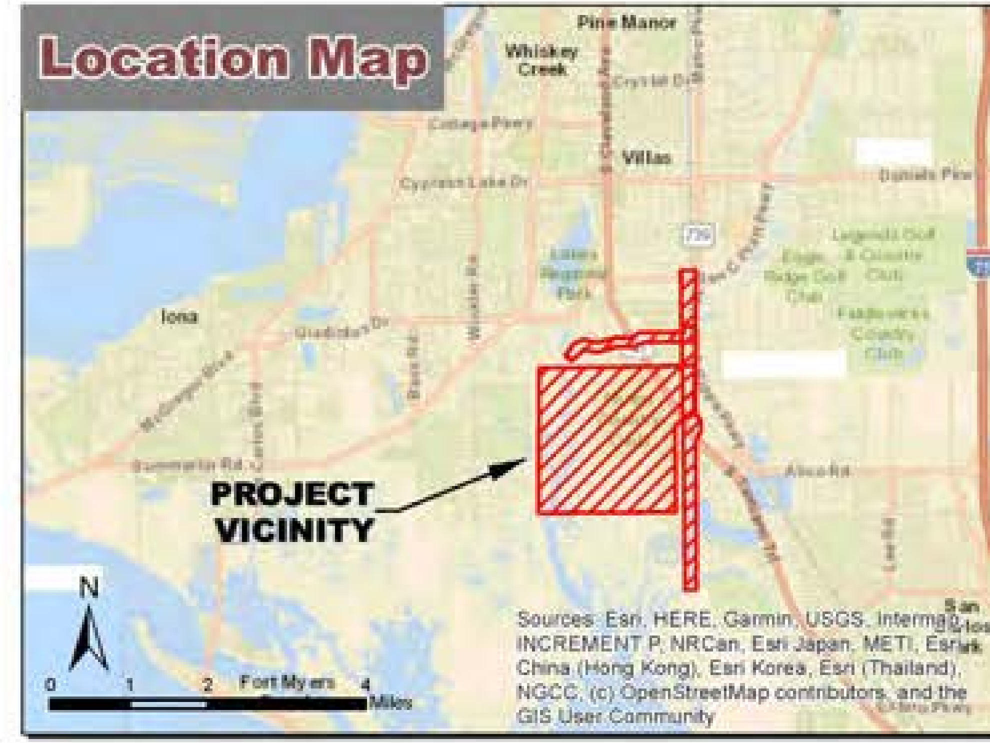
EXHIBIT 1.4.1(a)

Concept Plan



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Location Map



Project Narrative

DESCRIPTION: Prior to the construction of Ten Mile Canal, Hendry Creek was hydrologically connected to Six Mile Cypress Slough. This project partially restores this connection using a series of interrelated projects to divert flows out of the Ten Mile Canal and Six Mile Crpress Slough to Hendry Creek via IDD Canals K, J, and T. The project also proposes to restore the Ten Mile Canal west berm in the Island Park Road area, improve existing IDD canals west of Island Park Road and improve the conveyance capacity of the southern end of Ten Mile Canal.

PURPOSE: This project reduces high-flow contributions to south Ten Mile Canal and improves the conveyance capacity of Ten Mile Canal, while partially restoring historical flows to Hendry Creek.

CONSTRAINTS: The conveyance capacity of the IDD canals will need to be increased to accept the diverted flow, which will potentially require the acquisition of drainage easements. Improving the conveyance at the south end of Ten Mile Canal will be expensive. To restore the Ten Mile Canal west berm, work may require acquisition of construction easements.

MAY 2020

Ten Mile Canal South \ Island Park Rd
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.2

NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Project Narrative

DESCRIPTION: This project proposes conveyance improvements along two corridors south of Daniels Parkway to address existing flood concerns and prepare for new developments currently planned in conjunction with the Three Oaks Parkway extension.

PURPOSE: Improvements along the north side of The Legends returns the existing conveyance swale to its original design or enlarge, if needed. The implementation of both projects will reduce flooding impacts to the surrounding communities and the airport (SWFIA) by providing adequate and well-defined outfall routes.

CONSTRAINTS: Close coordination with surrounding communities and LCPA staff would be required for these improvements, with modifications to existing permits and review of applicable ordinances. This project relies on the completion of other improvement projects to achieve maximum results in reduced peak flows to Ten Mile Canal.

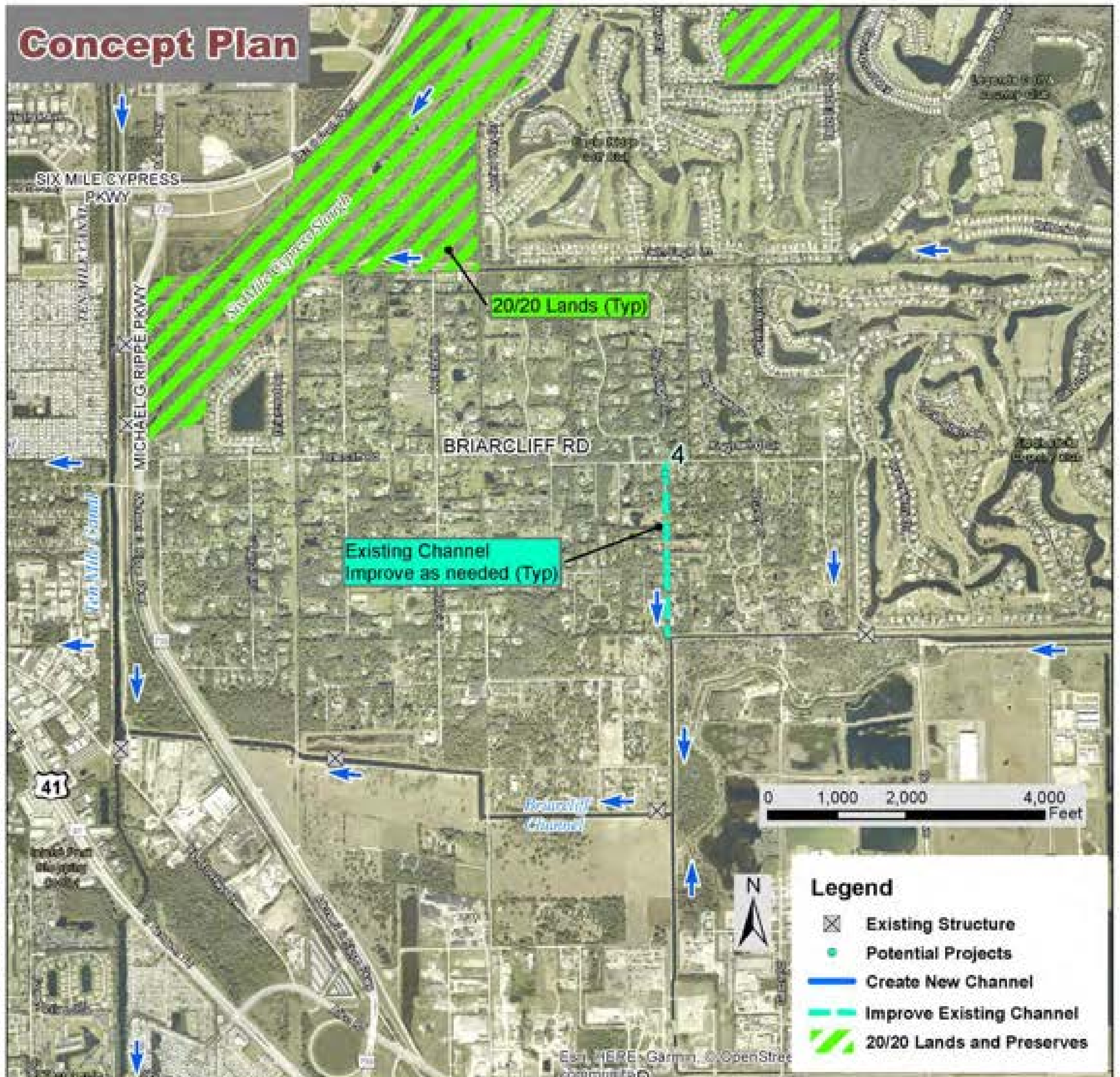
MAY 2020

Daniels Parkway South Area
South Fort Myers Area

JOHNSON ENGINEERING

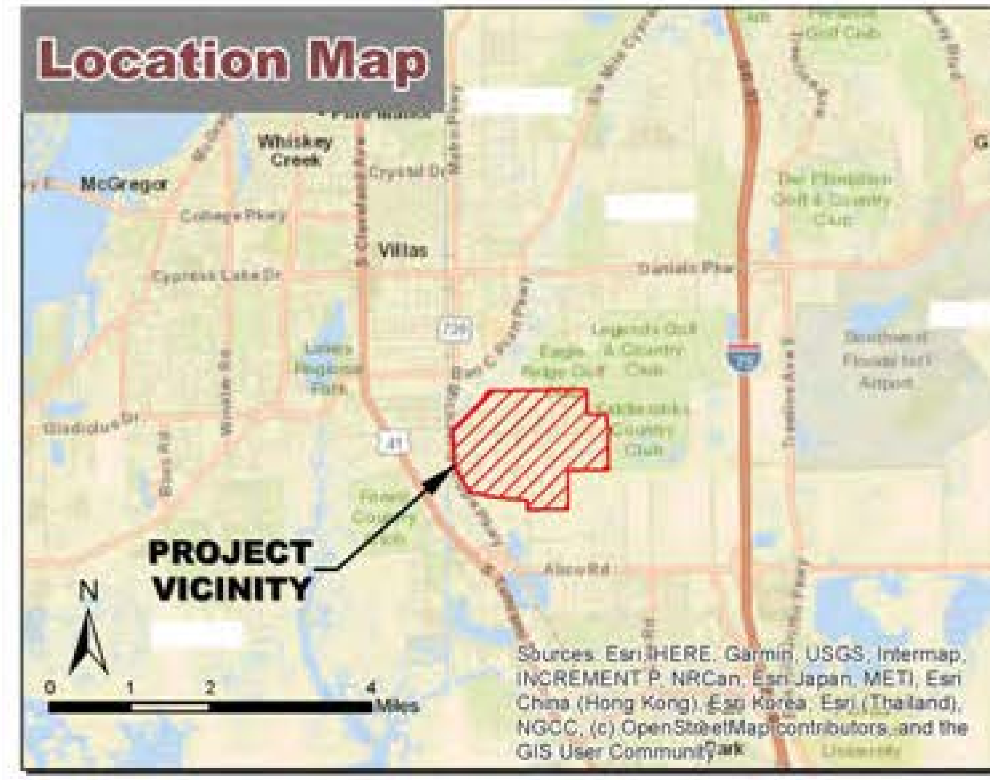
EXHIBIT 1.4.3

Concept Plan



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Location Map



Project Narrative

DESCRIPTION: This project consists of general drainage improvements in the Briarcliff area with an enhanced conveyance running north and south, delivering runoff to Briarcliff Channel to the south.

PURPOSE: This project results in less roadway flooding and reduced potential for high water to enter residences in the project area. Berms in the 1990s along the northern project area adjacent to Six Mile Cypress Slough provided substantial relief to residents from sheet flow out of the slough running south through the Briarcliff area. This project continues those benefits while providing additional well-defined conveyances for runoff with the opportunities for water quality treatment.

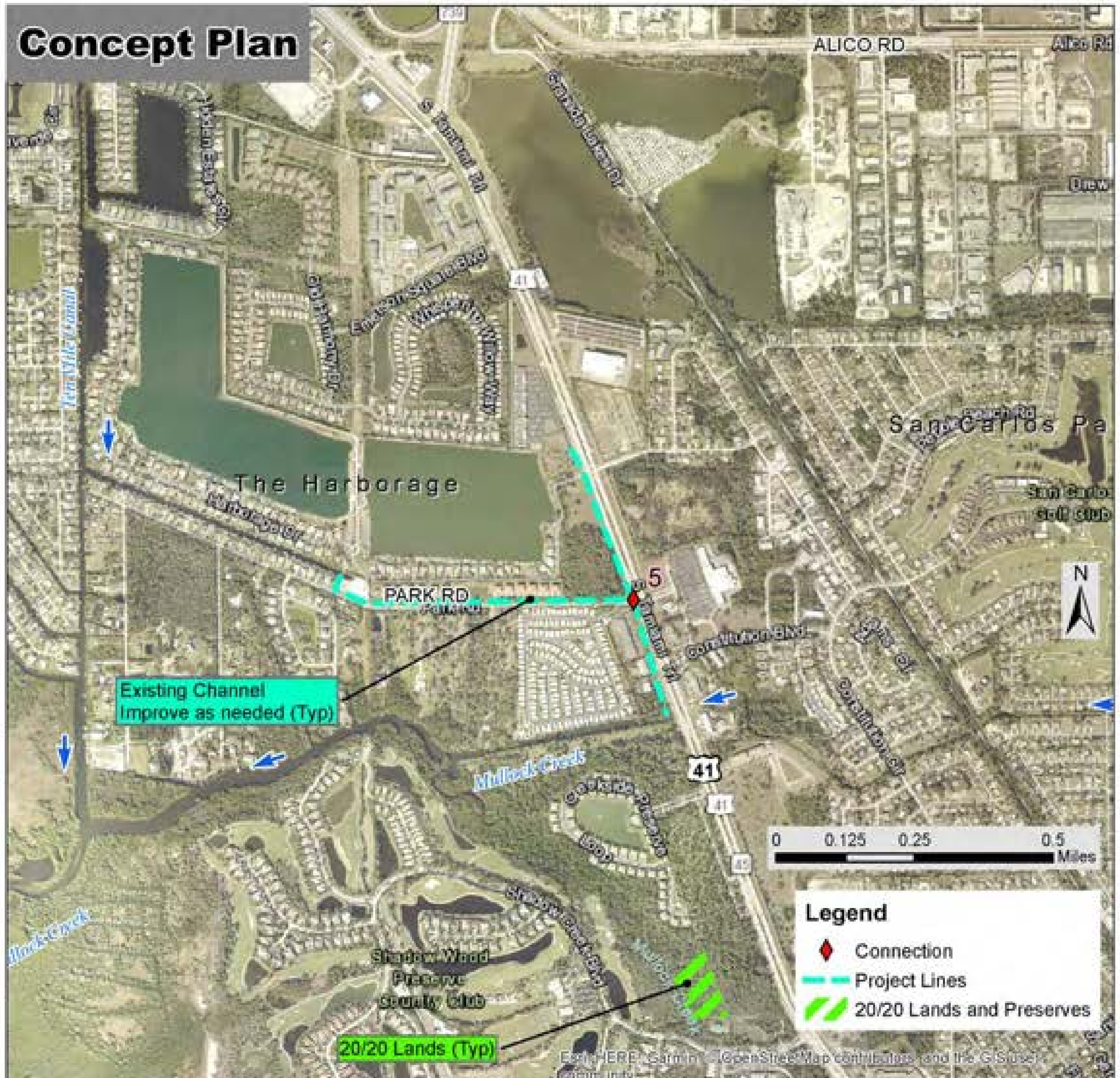
CONSTRAINTS: This is a residential area with limited existing improvements for storage and water quality treatment. Downstream communities may raise concerns if the project results in additional peak flows from this sub-watershed. By ordinance, the Briarcliff area is in the Six Mile Cypress watershed.

MAY 2020

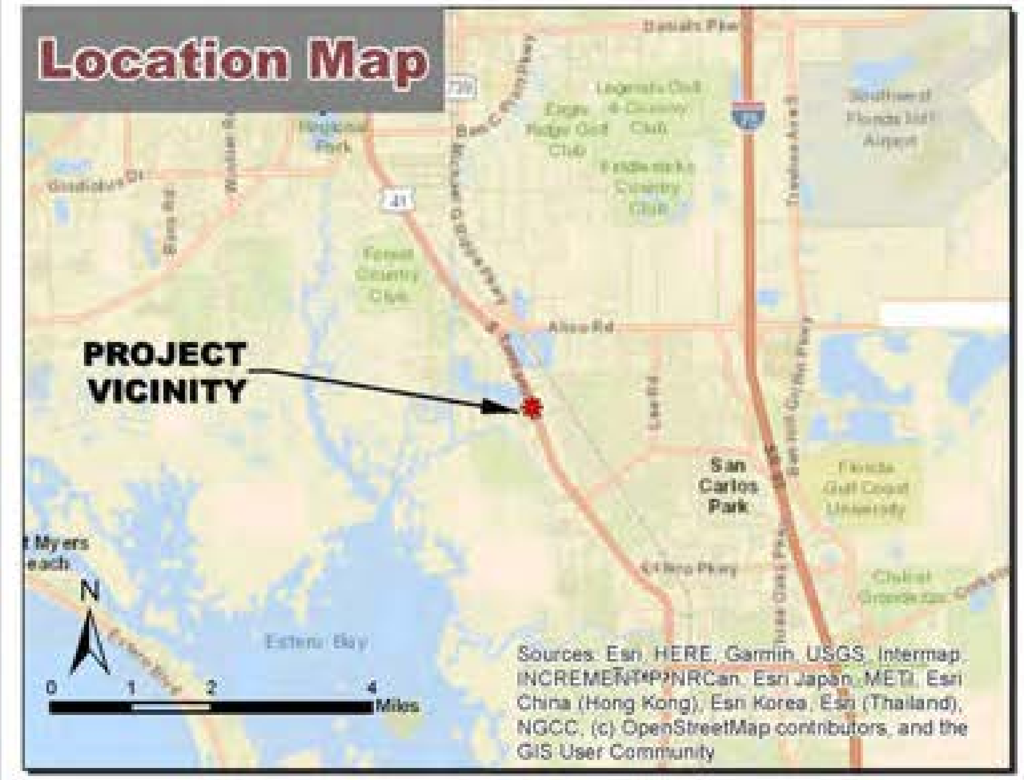
Briarcliff Area
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.4



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands and 20/20 Lands were provided by Lee County GIS.



Project Narrative

DESCRIPTION: The roadside swale along the northern portion of Park Road has minimal conveyance capacity and is not connected to a dedicated outfall, causing a bottleneck for runoff from Park Road and a portion of US 41. This project consists of general roadway drainage improvements in the Park Road area.

PURPOSE: An improved conveyance along Park Road reduces flooding and allows surrounding drainage systems to recover between repeated storm events.

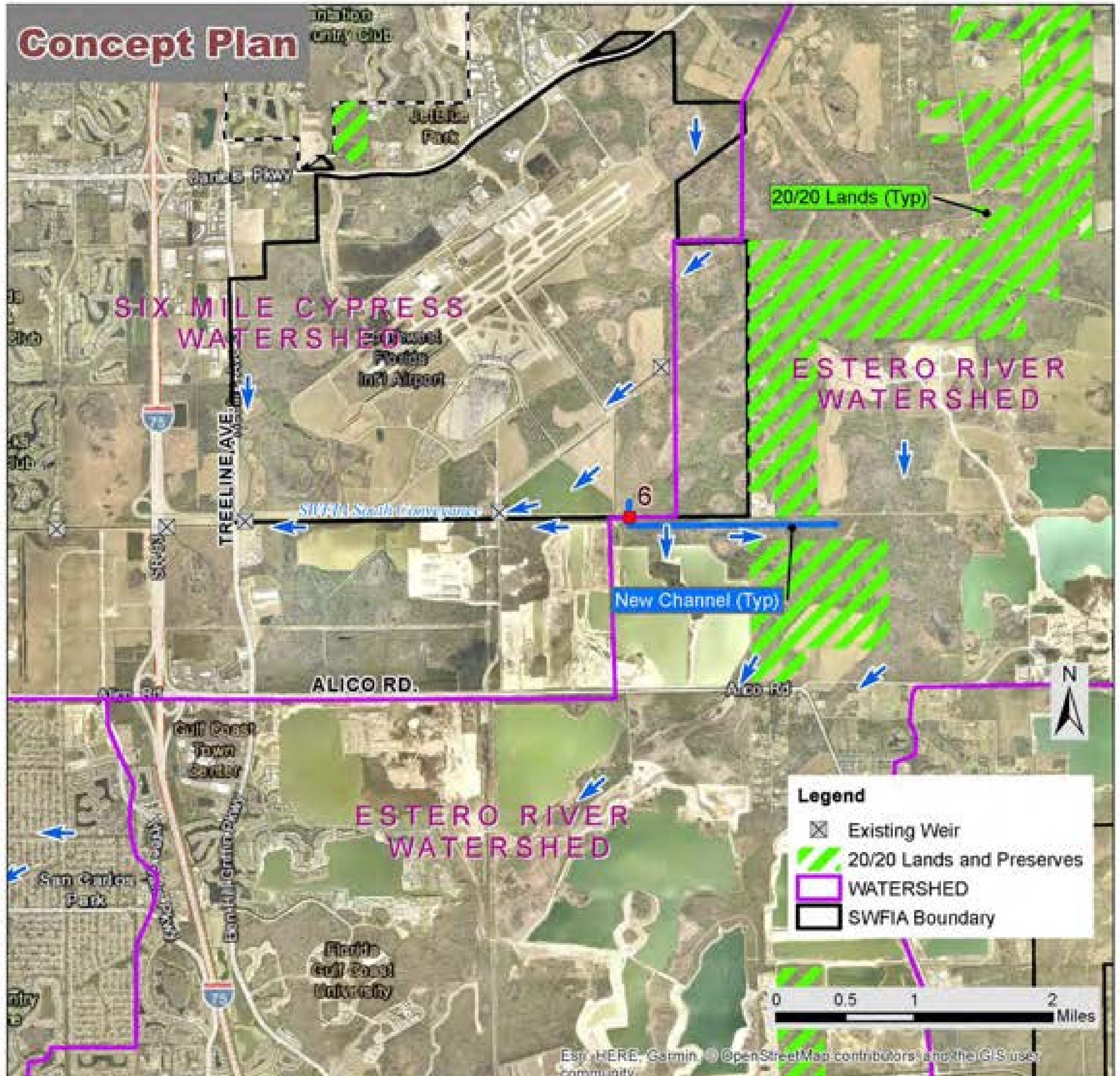
CONSTRAINTS: The acquisition of a drainage easement will be required to connect the drainage to Park Road Canal. Work within US 41 right of way will require coordination with FDOT staff, but may also offer an opportunity to seek some funding from FDOT.

MAY 2020

Park Road Area
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.5



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands and 20/20 Lands were provided by Lee County GIS.

Project Narrative

DESCRIPTION: The southeast corner of SWFIA was historically within the Estero River watershed. Permitting in the early 2000s allowed this area into the SWFIA water management system, which ultimately discharges to Ten Mile Canal via the Briarcliff Channel.The master stormwater management system for SWFIA was modified in the past few years to instead direct this discharge to the Estero River watershed as a part of the parallel runway project. This project proposes berms and weirs on County-owned lands east of SWFIA.

PURPOSE: This project creates additional storage and redirects additional water to the Estero River watershed, reducing runoff volumes to Ten Mile Canal.

CONSTRAINTS: Permits currently support this downstream route, but modeling to ensure additional flows to Estero are within system capacities is required. Existing and proposed mine operations immediately to the south have the potential to negatively or positively impact conveyance capacity and storage volume. Developments along the North Branch of the Estero River already experience flooding and delivery of more water to this region will test the storage capacity needed to not move flooding from one location to another.

MAY 2020

LCPA Diversion to Estero Basin
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.6

NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Project Narrative

DESCRIPTION: Water levels in the Six Mile Cypress Slough are controlled by existing weirs at Daniels Parkway and at the interface with the Ten Mile Canal. The weirs are used to lengthen the hydroperiod of the Slough and have operable gates that can lower the water levels in the Slough ahead of a major storm to provide additional storage capacity in the basin. Projects to improve stormwater management of the southern portion of the Slough include restoration of the perimeter swale along the Metro Parkway Extension (Michael G. Rippe Parkway), and an enhancement of the existing westward flow diversion point at Daniels Parkway.

PURPOSE: The proposed projects provide additional stormwater management flexibility in the Slough ahead of a major storm event.

CONSTRAINTS: Most of the proposed work area is within or adjacent to preserve and conservation lands, making this type of flow capacity restoration challenging.

MAY 2020

Six Mile Cypress Slough - South
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.7

PART 4 – APPENDIXES

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3.4 BASIN STORAGE AND ALLOWABLE DISCHARGE REPORT

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3.2 PROJECT ANALYSIS

3.3 FUTURE CONDITIONS ANALYSIS

INTRODUCTION

PURPOSE

Lee County is on Florida's gulf coast and subject to high tides and storm surges. These tidal conditions and the area's low lying and flat terrain significantly affect stormwater drainage functions. With the presence of hurricanes and other tropical disturbances, the volume and intensity of rainfall can be extreme. Communities in Lee County require adequate drainage facilities to limit flooding hazards that disrupt and endanger the public wellbeing. Areas of Lee County have experienced repetitive flooding from storm events, with notable extreme events in 2017, 2008, 1995, 1992, 1970, and as far back as 1936.

Following the catastrophic flooding that resulted from Tropical Storm Invest 92L/Hurricane Irma in 2017, the Lee County Department of Natural Resources began efforts quickly to address these flooding issues in a phased approach. Phase 1 focused on the immediate removal of known obstructions in waterways identified in initial assessments. In Phase 2, selected engineering consulting firms provided a more detailed field assessment including mapping of drainage impediments to provide an inventory of issues that could be remedied quickly. As part of Phase 2, the engineering consultants provided preliminary high level flood mitigation concept suggestions for further evaluation. In both Phase 1 and 2, the observed effects of flooding and the impacts to Lee County residents revealed the limitations of current drainage flow ways.

This report documents Phase 3 of the mitigation study and includes proposed conceptual projects and results from a regional hydrologic computer model used to evaluate the concepts. The study area encompasses Lee County south of the Caloosahatchee River and is divided into East Lee County, Whiskey Creek, South Fort Myers, and South East Lee County. The primary objective of this post-Irma Phase 3 effort is to develop regional concepts to significantly mitigate flooding problems (flood stages, flows, and duration) highlighted by the Invest 92L/Hurricane Irma events. It is important to note that this effort is to minimize flooding, as it is not possible to eliminate all flooding for all potential storm events and tidal conditions.

The concept projects developed during this study provide a network system of high-functioning conveyances and water control structures. This effort sets a 'benchmark' for comprehensive flood control needs on a regional basis and provides a 'measuring stick' as the County works towards regional flood mitigation improvements. While the viability of each concept is addressed at a high level using metrics of cost, environmental permitability, etc., each concept's ability to mitigate flooding is the primary driver. The flood mitigation concepts are only intended to utilize the high-capacity conveyance functionality during severe storm events and not alter normal seasonal flows or hydroperiods. The regional model developed for this effort is focused on the wet season and flood mitigation. The refinement of each flood control concept will occur subsequently in the design phase.

Effects of Flooding on a Regional Basis

From August 23 through September 11, 2017, Lee County residents endured 20 days of rainfall that totaled approximately 20 inches from the combined effects of Tropical Storm Invest 92L and Hurricane Irma. The distribution of rainfall is shown in **Figure 1**. The intensity of this rain event was classified as a 1,000-year storm reoccurrence in some areas. The subsequent peak stages exceeded the capacity of the County's drainage conveyances, causing widespread flooding to roads, buildings, and facilities with prolonged recovery times for select areas. The challenges to Lee County were increased due to the back to back nature of the storms in a number of ways including preparation and maintenance between the events. The Hurricane Irma wind event also contributed significantly creating significant debris in major drainage conveyances.

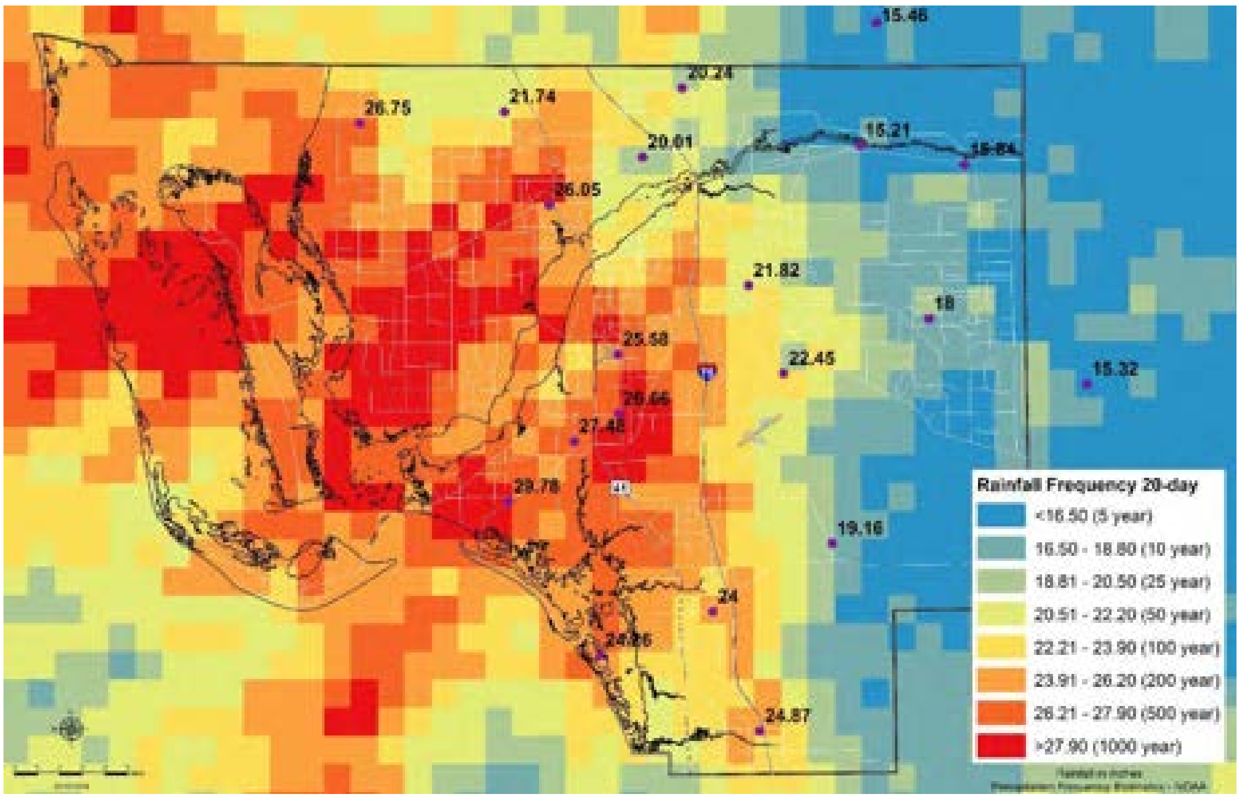


Figure 1 - 20-day rainfall total depth and frequency (8/23 thru 9/11, 2017)

The following text and photographs illustrate the limitations of the existing floodway conveyances and the resulting risk to the health and public safety of Lee County residents. From the photographs, the reader can see clearly that some locations could only be accessed by watercraft. Inadequate and overloaded conveyance flow ways caused flood stages to rise into buildings. Flooding remained for over a week in some locations. The submerged roadways hindered emergency vehicle access as well as basic services of mail delivery, garbage pickup, and access to basic supplies for trapped residents.

Flooding Photographs

Although the public interest for flood mitigation may fade the longer that time passes from the Invest 92L/Hurricane Irma flooding event, it is important to recall the catastrophic flooding that occurred throughout Lee County. In the Buckingham area, the divide between the Orange River and the adjacent roadway was indistinguishable if not for utility poles as seen in **Figure 2**. Some buildings in the Buckingham area were flooded more than waist-high. **Figure 3** also shows how other structures were surrounded by flood water that left residents isolated for a week.

Figure 2 - Example of Orange River flood stages exceeding riverbanks and flooding adjacent roadway/structures.

Figure 3 - Examples of structure flooding, roadway inundation, and isolated residents along the Orange River.

The Island Park area experienced not only flooding of structures, but also prolonged recovery. As seen in **Figure 4**, Island Park Road at US 41 was flooded for over a week, which limited emergency vehicle access to the affected communities. Roadway indicators were placed at the edge of the pavement to help drivers distinguish the roadway limits from roadside hazards in some flooded areas. **Figure 5** also shows how 'no wake zone' buoys were placed along some flooded streets to slow vehicles and reduce waves splashing into homes. Some of the photographs from August 2017 show flooding due to Invest 92L.

Figure 4 - Example of Island Park Road limited access.

Figure 5 - Example of Island Park area flooding and hazardous conditions.

The flood stages in the natural flow ways exceeded the banks in the South East Lee County study area, as shown in **Figure 6**. The Imperial River and adjacent development experienced severe flooding of streets and homes, as shown in **Figure 7**. The delayed time of concentration for the Corkscrew Regional Ecosystem Watershed (CREW) Flint Pen Strand's flows to reach the areas west of Interstate-75 prolonged flood recovery while potentially attenuating peak flood levels.

Figure 6 - Nature flow way bank exceedance.

Figure 7 - Examples of flooded structures and prolonged flooding recovery durations in the South East Lee County study area.

Causes of Flooding

Generally, stormwater flooding results when a large rainfall event or closely timed significant multiple rainfall events occur, and the conveyances and available storage areas are inadequate to move or to hold the excess stormwater volume for safe release to open water. At present, many of the primary flow ways in Lee County are undersized, poorly linked for continuity, connected though undersized structures, subject to debris blockages, and with once natural miles-wide sheet flow now constricted.

Highways, shopping centers, land developments, and facilities have been constructed within the flood plains and floodways, restricting the previous overbank flow capacity these streams had historically. These developments have reduced the width of flow paths to just a few hundred feet in places. Also, these remaining flow paths lack the controls of a managed system resulting in large regional areas being prone to flooding from extreme storm events. To mitigate these flood issues, conveyances, weirs, culverts, berms, and pumps are proposed to be constructed or improved, along with the addition of stormwater storage reservoirs where practical. These facilities will require modern controls to allow operation of the managed stormwater system while reducing impacts to natural systems by diverting or better controlling extreme storm event flows.

East Lee County and South East Lee County Study Area

In many areas of Lee County, development growth over the past 100 years has fundamentally changed the characteristics of the historical natural system. A contrast of pre-development conditions to current conditions aids in understanding the limitation of the remaining natural flow ways. An 1856 military map demonstrates how South East Lee County lost about a 10-mile width of dispersed water sheet-flow conveyance to the Gulf of Mexico. Within the project study area, land development activities have blocked most of the wide, shallow flow paths. In the South East Lee County area, there are four possible flow path breaks between a wall of back-to-back developments that link to the rivers and creeks shown in **Figure 8** below. Note that the miles of sheet flow conveyance have been reduced in places to channels less than 100 feet wide. East Lee County conveyance is primarily limited to three natural conveyance rivers and creeks within the project study area as shown in **Figure 9**. Additionally, the natural creeks, streams, and rivers are often attractive for residential development. As a result, developers have built many homes in nature's floodplain. To mitigate flooding of these homes, bypassing flood flows to manmade conveyances is a practical alternative to convey excess flows.

Figure 8 - Limited natural conveyance passageways in south east Lee County

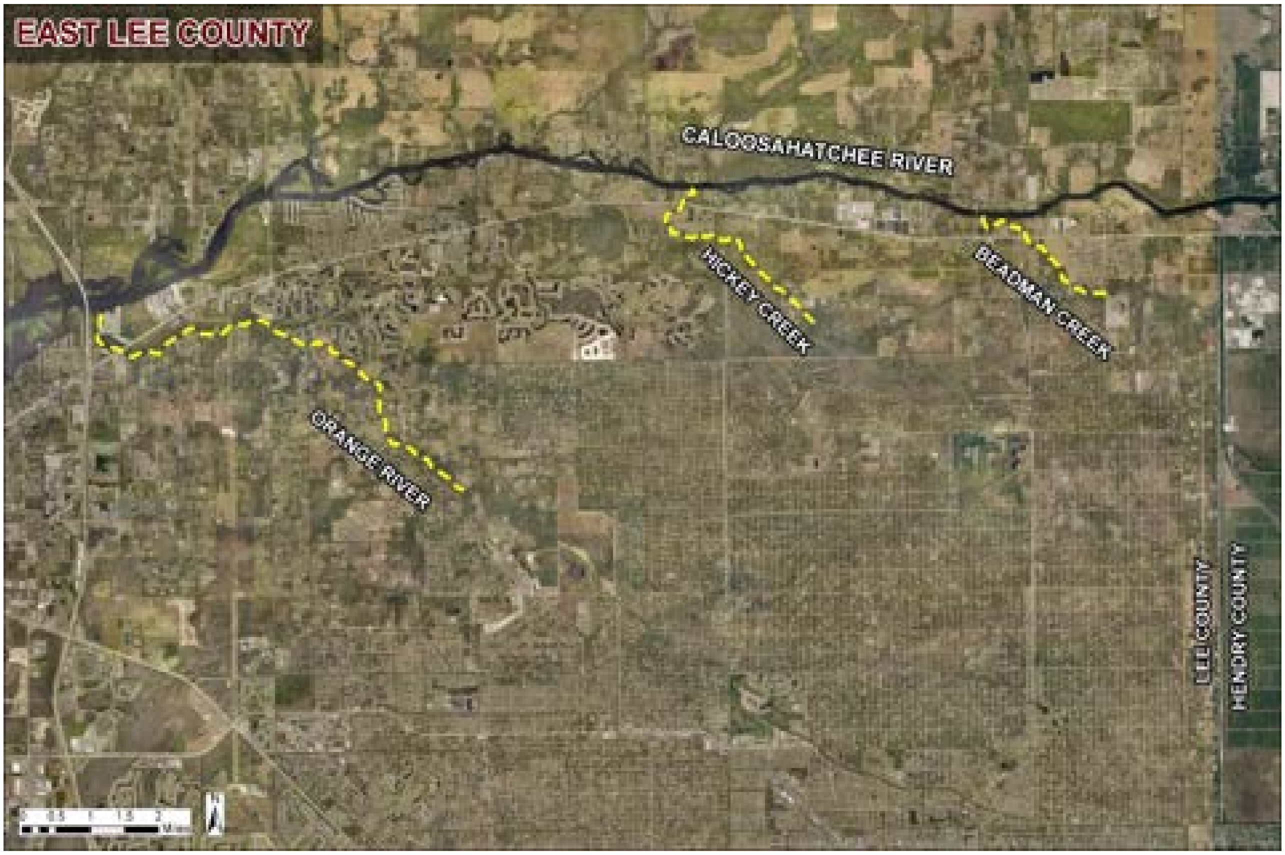


Figure 9 - Limited natural conveyance passageways in east Lee County

South Lee County Study Area

Before the construction of the Ten Mile Canal, runoff east of Fort Myers flowed westerly towards the Caloosahatchee River or Hendry Creek. The Iona Drainage District (IDD) constructed a series of canals in the 1920s to provide drainage and flood protection for areas west of Ten Mile Canal, formerly known as the Line A Dike. Spoil material from excavating the Ten Mile Canal was placed on the western bank of the canal to create a north-south berm that diverts the water south to Estero Bay. Most of the canals constructed west of Ten Mile Canal still exist today and continue to serve as the primary conveyances for west Fort Myers. The Ten Mile Canal was later modified in the 1970s to provide increased conveyance capacity to better-serve upstream areas to the east. Much of the South Fort Myers study area depends on the Ten Mile Canal for drainage. Along the southern end of the Ten Mile Canal, the cross-section is reduced to its narrowest width. The effects of the constricted conveyance is visualized in **Figure 10**, where flood stages exceeded banks after the extreme storm events in 2017.

Figure 10 - Example of the limited Ten Mile Canal conveyance and canal bank flood-stage exceedance.

Whiskey Creek Study Area

The Whiskey Creek Watershed (WCW) is a tidal tributary located in the south-central area of Lee County. It drains directly to the Caloosahatchee River between the Cape Coral Bridge and the Mid-Point Bridge (**Figure 11**). The watershed is bordered on the north by Colonial Boulevard, the east along Ten Mile Canal, the south by Cypress Lake Drive and the west by McGregor Boulevard. The watershed has the following two primary drainage ways: the L-Canal and Brantley Dover Canal (**Figure 11**). Additionally, a third drainageway located at the southern end of the watershed passes through Florida Southwestern College.

Figure 11 – The Whiskey Creek Watershed

In the Final Post Storm Flood Assessment Analysis Report (Hole Montes, 2018), the primary causes of flooding throughout the Whiskey Creek watershed revolved around issues of reduced conveyance. The report identified issues associated with maintenance (debris and sediments) as well as undersized culverts and channels in key portions of the watershed. The primary focus for Whiskey Creek for this regional study will be evaluations of existing culverts and channels in the primary drainageways to address identified flood risk areas, the potential for additional storage within limited areas, and provision for additional relief to reduce flooding issues along Ten Mile Canal.

Although the concepts proposed cannot eliminate the flooding of all buildings for all potential storm events, a planned approach to an improved system can help reduce flooding peak elevations and durations. An interconnected conveyance system with advanced telemetry control can better convey the rainfall experienced during the 2017 storm events. This study seeks to identify and prioritize needed high-volume conveyance flow ways to connect and convey drainage from local communities. The proposed high capacity drainageways would be fully engaged only during extreme storm events to avoid adverse impacts. Structures and protective measures would be implemented to maintain existing groundwater levels and divert normal flows to natural areas, where possible.

Limitations of Existing Stormwater System

The Phase 2 study reported that the existing stormwater network, consisting of manmade and natural conveyances, is inadequate for conveying extreme storm event flows. Natural river and creek conveyances are inherently narrow with broad flood plains. The conveyance capacity of natural conveyances is often reduced due to vegetation across the conveyance section as illustrated in **Figure 12**. However, it is neither permitted nor desirable to remove certain vegetation, such as cypress knees, since doing so would negatively impact the natural system.

Figure 12 - Example of vegetation congestion of a natural flow way during normal conditions.

Manmade blockades, such as cattle crossings, property boundary fences, and pedestrian footbridges, decrease conveyance capacities as shown in **Figure 13**. These blockades accumulate debris, causing an increase in peak stages and reduction to the system's recovery capability. Boat docks and other manmade structures in maintained conveyances similarly limit conveyance capacity and accumulate debris.

Figure 13 – Examples of manmade blockades in natural conveyances.

Even when the vegetation in natural flow ways is maintained within permitting guidelines, the destructive nature of extreme storm events causes downed trees to further impede the conveyance capacity as shown in **Figure 14**. Even if these conveyances are cleared of all vegetation and manmade blockades, the narrow, shallow, and winding geometry of the main channels of natural rivers/streams provide limited capacity to convey flood flows, resulting in flooding of the adjacent floodplain.

Figure 14 - Examples of downed vegetation impeding flow conveyance in natural flow ways.

A comparison of adjacent land elevations to those of the natural flow ways shows more evidence of the limitations of the main channel of natural flow ways to convey extreme storm flows. Comparing the LiDAR elevation map shown in **Figure 15** with the broad overbank floodways identified by FEMA, also shown in the same figure, indicates broad overbank flooding may occur along the Orange River, Hickey's Creek, and Bedman Creek during a 100-year storm event. This example is common throughout Lee County, whereby extreme storm events flow through narrow and shallow natural flow ways, exceeding the banks and utilizing the adjacent floodplain.

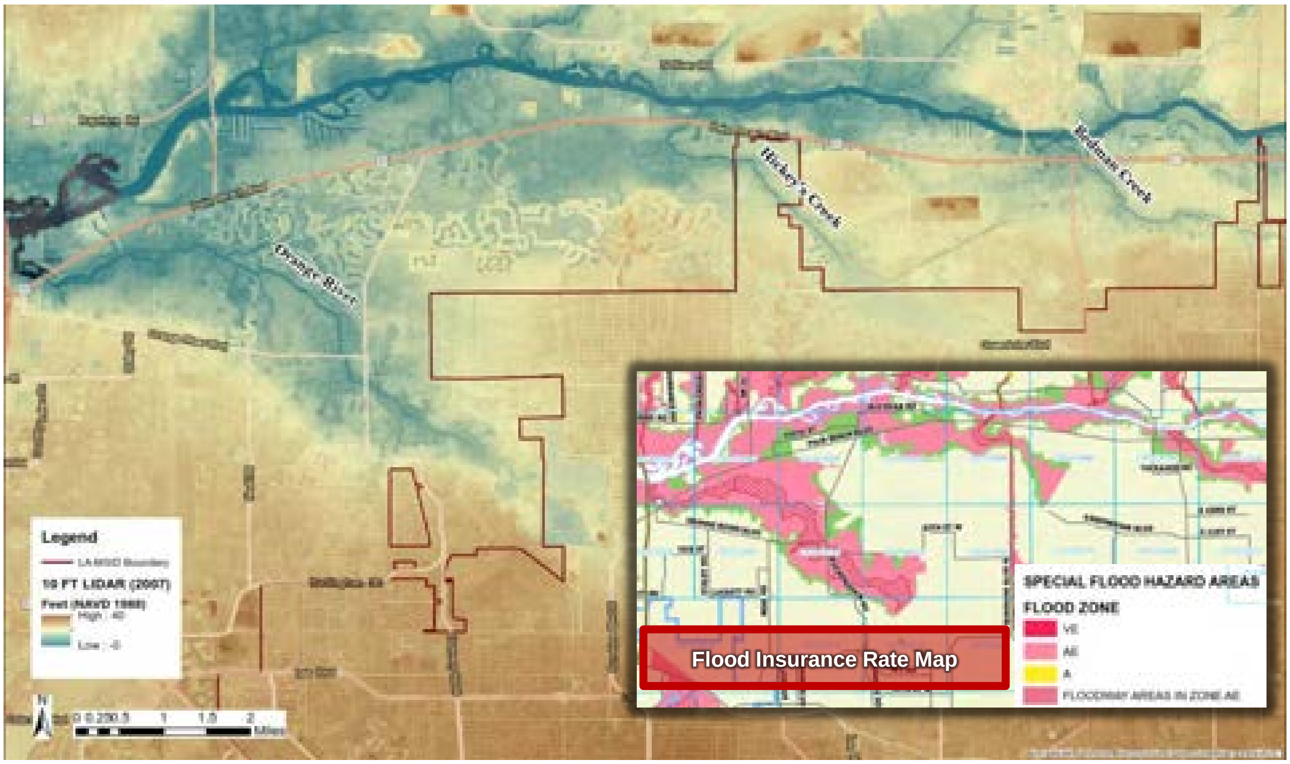


Figure 15 - Example of floodplain and FEMA-recognized flooding risk during extreme storm events.

As previously discussed, most existing conveyance passageways and outfalls are limited to these natural flow ways. Although manmade, non-vegetated, and maintained conveyances exist in some regions of the study area, the existing capacity often narrows and is restricted by both development, siltation, and/or obstructions such as boat docks during extreme storm events. There is a need to bypass or improve the limitations of existing flow ways for additional conveyance capacity in order to mitigate the flooding impacts of extreme storm events.

Flood Mitigation Methodology

Limitations of a Regional Study

The purpose of this project is to establish a plan to mitigate flooding on a regional scale occurring from major storm events affecting the health and safety of the public. The term mitigate is a fundamental definition as all flooding issues cannot be completely alleviated. Structures built adjacent to natural flow ways and lying within the floodplain may continue to experience flooding during extreme storm events unless the finished floor is elevated. An example is provided in **Figure 16,** which shows the flood stages exceeded the trampoline, but not the finished floor elevation of the stilted structure along Hickey Creek. Water management on a regional scale is a complex system that must be addressed holistically since what is proposed in one part of the system or watershed can have unintended consequences elsewhere. In considering larger projects with components such as dredging, diking, diverting, berming, or storing water, a regional more coarse-scale model grid size is utilized to evaluate projects to determine if they perform as intended and to assess downstream impacts. The scope of this regional study encompasses about half of Lee County, since recent modeling efforts have been conducted for Fort Myers, Cape Coral, and North Fort Myers. The large scale of the model necessary for this project cannot accurately produce mitigation recommendations for more localized flooding issues. For example, although some private communities experienced flooding, this regional study cannot fully evaluate those localized secondary issues. In referencing a transportation analogy, this project addresses the major highway capacity needs, not the localized access roads leading to each house. The scale of the study includes stormwater system capacity improvements able to convey hundreds and even thousands of cubic feet per second (CFS) of flow. Localized improvements are often limited by the capacity of the downstream outfall conveyance. If the outfall network is overburdened, localized improvements are not able to perform as intended since tailwater conditions are at capacity. As previously discussed, the existing major stormwater conveyance system was found to be inadequate in conveying localized flows to the River/Gulf.

Figure 16 - Example of floodplain and localized flooding issues.

Although this study focuses on regional modeling efforts, the project scope did include three localized models of select flood mitigation concepts. High-level, conceptual environmental and water quality analyses are included alongside the proposed modifications to the major conveyances. As the County pursues the implementation of the conceptual projects, additional efforts will be required to address design level details such as local modeling, survey data collection, route selection, size optimization, permitting, and the inclusion of secondary benefits such as recreational opportunities, habitat restoration, and water quality enhancement.

Project Scope

The development of Lee County's Flood Mitigation Plan was divided into phases. Phase 1 occurred immediately after Hurricane Irma and focused on clearing bodies of water through the immediate and short term removal of known obstructions in waterways identified in initial assessments. Work included numerous creeks downstream of Lehigh Acres and the Island Park, Estero River, and San Carlos Park areas. In Phase 2, the County retained four local engineering firms to observe conditions in the field where flooding had occurred, map locations where impediments to flow existed to identify what could be quickly remedied, review development permits to determine if any were causing or contributing to the flooding issues, and propose potential initial high-level concepts for subsequent evaluation in Phase 3. Observed flooding issues were mostly comprised of vegetation, debris, sediment, and erosion, which further constricted natural and manmade conveyances. Phase 2 was completed in February of 2018. This Phase 3 effort continues the mitigation efforts by focusing on the long-term plan and recommends concept projects to reduce flooding on a regional scale. **Table 1** outlines the tasks of this project.

Table 1 - Phase 3 tasks and timeframe of task duration.

Task Number	Task Description
Task 1	Project Coordination
Task 2	Identification of Potential Flood Improvement Projects
Task 3	Regional Model Development
Task 4	Modeling of Flood Mitigation Projects
Task 5	Surveying
Task 6	Agency Coordination
Task 7	Project Evaluation Reports
Task 8	Priority Matrix
Task 9	Public Involvement
Task 10	Future Conditions Analysis
Task 11	Basin Storage/Discharge Analysis
Task 12	Summary Report

Although North Fort Myers experienced significant flooding, similar efforts were completed in 2010, and were therefore not included in this analysis. A comprehensive regional model was developed to identify areas of flood risk and to determine regional effects of proposed flood mitigation concept projects within the four major County watersheds south of the Caloosahatchee River. As shown in **Figure 17**, the four watersheds were divided among the project team of consultants:

- East Lee County by AIM Engineering & Surveying, Inc. (AIM),
- South East Lee County by AIM,
- South Fort Myers by Johnson Engineering, Inc. (Johnson), and
- Whiskey Creek by Applied Technology & Management, Inc. (ATM).

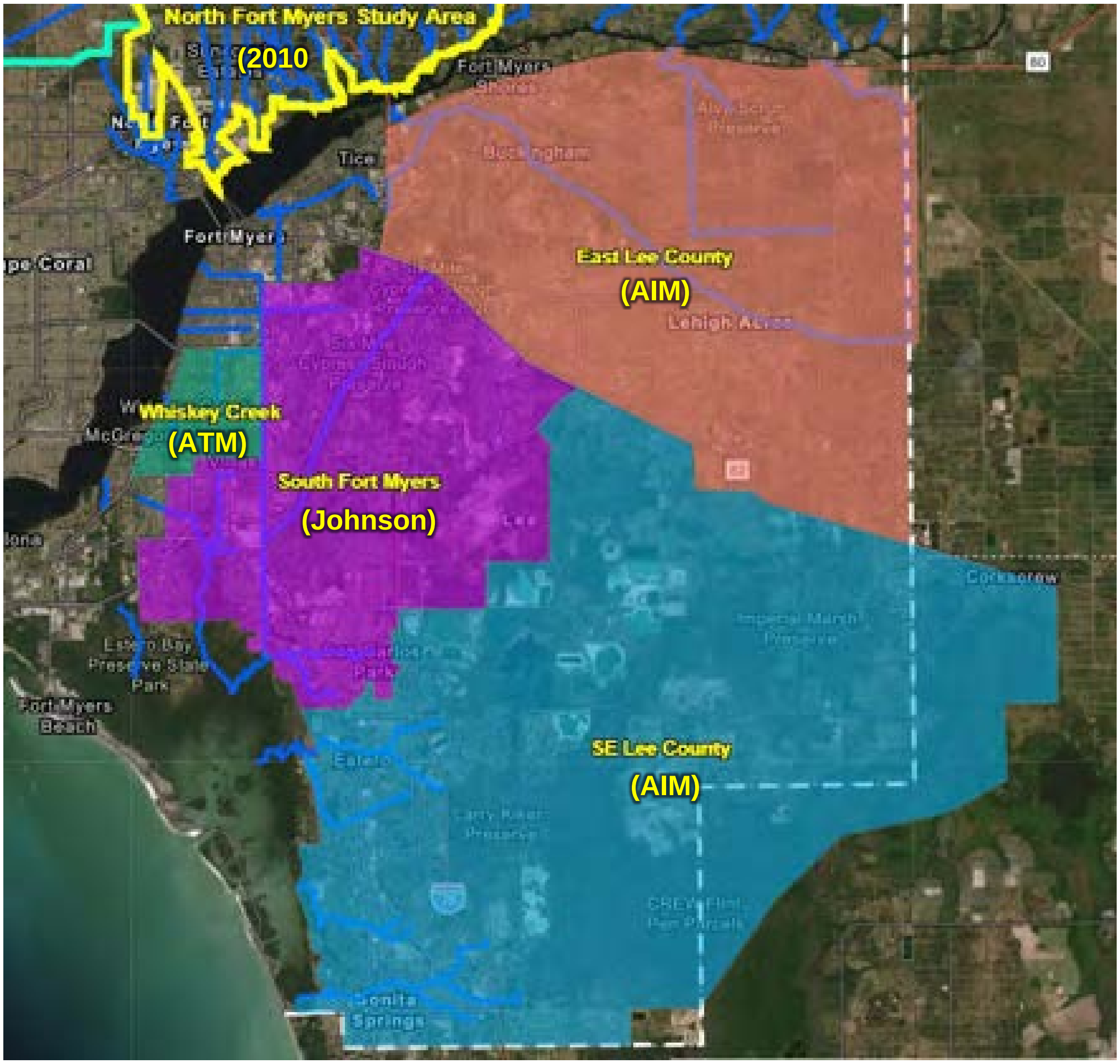


Figure 17 - Four main watersheds study areas south of the Caloosahatchee River

As a part of Task 2, identification of potential flood improvement projects, over 40 conceptual projects were developed. Johnson and AIM were two of the four firms involved with the Phase 2 flooding assessments, which proved useful in identifying not only current, but also known historical flood risk areas. Flooding impacts of the Phase 2 reports of the other areas were considered in the approach. Several of the initial individual concepts were grouped into a combined concept for further evaluation.

Available Pathways for Additional Conveyance

Early in concept projects development, the allowable criterion for routing the required conveyance capacity was defined and limited to pathways that did not require extensive acquisition and demolition of existing residential and commercial structures. This decision added significant challenges for the selection of drainage pathways in highly developed areas, but it was determined that the feasibility of acquiring and removing existing development would be an even more significant challenge than utilization of the limited environmental and natural areas between developments.

Required Conveyance Capacity

Since portions of Lee County are not as developed as others, the study team took varying approaches for each of the four study areas. Some areas still have opportunities for drainageway pathways through undeveloped and non-environmentally sensitive areas, while other areas nearly built out seek to improve flood conditions as much as allowable without impacting existing structures. Each study area required a unique approach to mitigate the flooding impacts specific to the area

The East Lee County and South East Lee County watersheds were preliminarily analyzed using a basic daily volumetric removal rate analysis for planning purposes, and a goal of between 2 and 3-inches per day rainfall removal rate was established. The direction provided for the flood mitigation project involved handling the 100-year storm event with a reasonable recovery time duration should a secondary storm occur soon after the first storm event. The hydrologic analysis by volumetric removal rate was initially used for pre-planning the number of conveyances and the capacity to discharge a large storm event with a reasonable recovery time. This analysis is a basic mass-in, mass out in a reasonable time duration approach. This aspect of hydrologic analysis has been most important with agricultural operations for plant protection aspects per the USDA-NRCS. Often with residential designs, the only concern is handling the peak discharge rate with an acceptable high-water level for a single storm event. A concern with just handling the peak flow is that it does not account for unexpected events, multiple storms, unexpected intensity, duration of flow, developing watersheds, and possible mismanaged system operations that would result in higher than expected water levels from a marginal discharge system. The volumetric removal methodology was used by the state drainage engineers in the design of the structures under Interstate 75. In proposing the utilization of large storage components, it is important to provide emergency discharge relief capacity to avoid potential catastrophic failure resulting from a berm breach. Although the modeling results suggest that the proposed capacity potential of certain downstream drainageways could be refined/reduced, the design of the drainageways that provide potential emergency relief capacity for large storage components should be cautious in limiting this capability. These downstream drainageways were conceptually sized for high flows to allow for very large storm runoff with reasonable recovery time duration and applied to the model results. To avoid potential adverse environmental impacts due to several feet of water being stacked in the storage components for elongated periods of time, larger downstream conveyance capacity may be desired to gain greater functionality and control of the hydro-periods within the storage area. As the watersheds contributing to the proposed large storage areas continue to develop, increased imperviousness and urbanized stormwater systems will only increase the storage system's recovery time duration and desired discharge capacity. This runoff removal rate was evaluated to discharge the 100-year, 3-day storm event of 13.6-inches of rainfall with manageable peak stages and a reasonable recovery time for water levels to return to normal conditions. Excess rainfall that could not be discharged immediately is stored to manageable water levels by filling up canals, ponds, reservoirs, roadside swales, and residential open spaces, which is acceptable for communities during extreme storm events on a short-term basis.

In the South Lee County and Whiskey Creek a substantial existing drainage system was in place, and the focus was on ways to improve the function of the system through enhancements such as enlarging conveyance sizes within existing easements. The following is a brief summary of the approaches in the four study areas.

- **East Lee County:** Per the discussion above, the goal of the concept projects proposed for East Lee County study area, in general, is to be able to convey approximately the 100-year rainfall event. Since East Lee County still has stretches of limited development, pathways for manmade conveyance are still viable with limited environmental impact.
- **Whiskey Creek**: The Whiskey Creek area has existing conveyance canals with limited right-of-way availability for large scale drainageway projects. The objective of this study area is to improve the existing conveyance pathways and, where possible, provide some level of offsite storage. Additionally, an existing flow way to provide relief for Ten Mile Canal was evaluated.
- **South East Lee County:** The South East Lee County area west of Interstate-75 is at or near full build-out developed conditions. The remaining pathways to the Gulf of Mexico that are not already developed are thereby limited to the four major natural rivers/creeks and other environmentally sensitive areas. Unlike the East Lee County study area, the required conveyance capacity for South East Lee County cannot be conceptually accomplished though only utilizing the available undeveloped pathways. A two-staged storage approach was therefore developed to hold back conveyance east of Interstate 75 until the areas west of Interstate 75 area are able to convey flows without adverse flooding and recovery duration impacts.
- **South Fort Myers:** The South Fort Myers study area consists mostly of manmade conveyances with limited and narrow outfalls. Residential boat docks further limit the conveyance of flows along the southern outfall of Ten Mile Canal. With limited areas for constructing additional conveyance outfalls without impacting existing structures, making improvements to the existing stormwater system is the goal for this study area.

In areas that are almost fully developed and where it is not desirable to remove existing structures, concept plans involved conveyance routings through the available space between developments. The actual selected pathway of the proposed conveyance can be further refined during the design phase to be routed around the most environmentally sensitive areas as conceptualized in **Figure 18**. The channels would function as vegetated deep marshes with normal flow during seasonal conditions. Water control structures would control the desired hydroperiod stages while also allowing for large conveyance discharge during extreme storm events. Where additional conveyance capacity is proposed through existing rivers, shallow littoral benches could be created to provide a direct conveyance pathway with increased capacity during large storm events (**Figure 19**). A 3-D view of this concept is visualized in **Figure 20**.

Figure 18 - Examples of winding high-capacity flow paths functioning as deep marshes during non-emergency conditions.

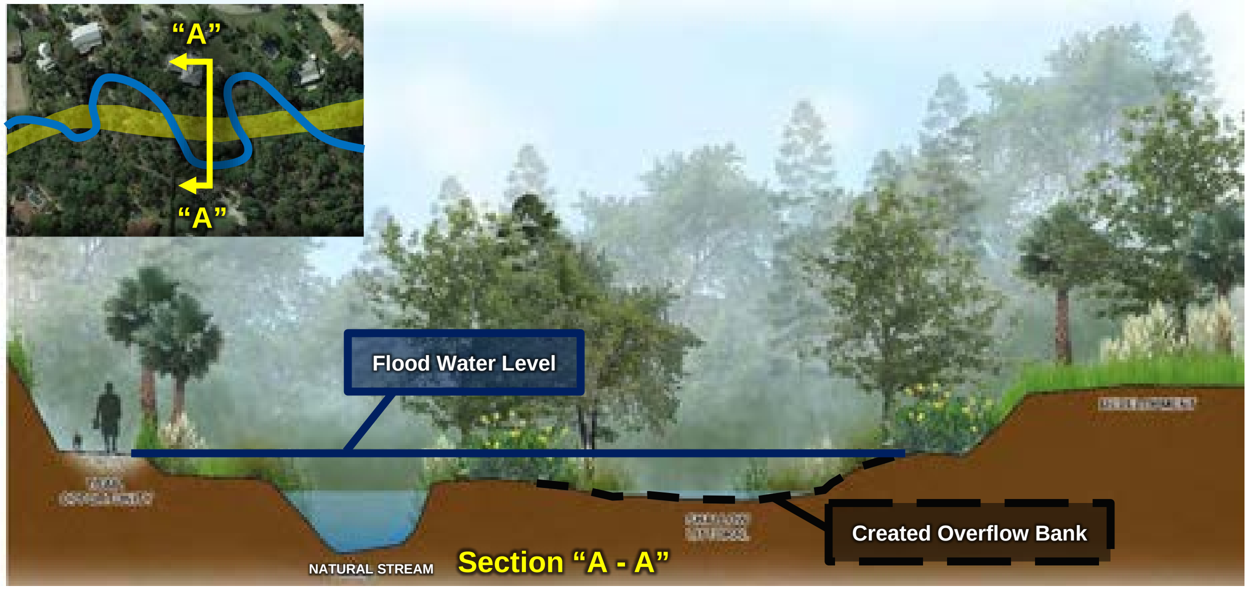


Figure 19 – Example of a shallow littoral bench to provide a direct conveyance pathway with increased conveyance capacity during large storm events.

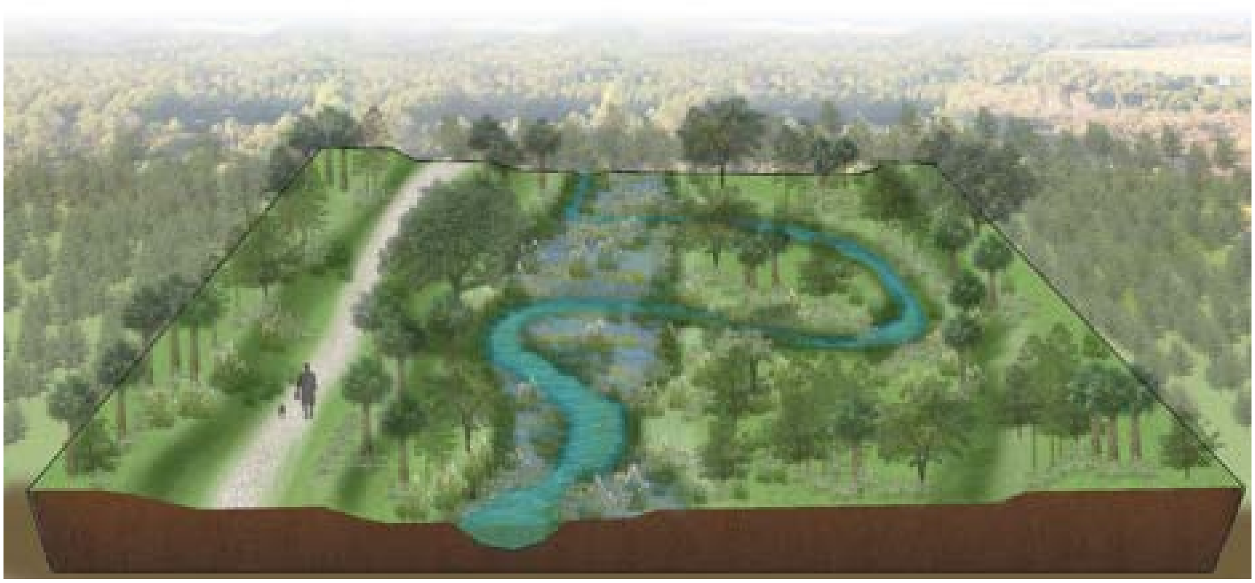


Figure 20 – Three-dimensional representation of a shallow littoral bench to provide a direct conveyance pathway with increased conveyance capacity during large storm events.

Conceptual Plan Development

The project team developed concepts that complied with the constraint that proposed concept projects and corresponding drainageway pathways are not to result in the removal of existing structures. The concepts were developed to address the flooding documented in the previous Phase 2 reports. Obtaining feedback on concept plan development and concurrence on approach methodology at the various project benchmarks was critical. The various stakeholder issues, concerns and desired outcomes guided conceptual plan development and refinement and included coordination with agencies such as Lehigh Acres Municipal Services Improvement

District, South Florida Water Management District, The Village of Estero, City of Bonita Springs, City of Fort Myers, Florida Southwestern State College, Collier County, and Big Cypress Basin Regional Watershed Group. Workshops were held with various branches of Lee County, including the Division of Natural Resources, Department of Transportation, and Conservation 20/20. Monthly progress meetings were conducted, and project status memos were produced throughout the length of the project.

Regional Model Development

A comprehensive regional model was developed by A.D.A. Engineering, Inc. (ADA) to determine regional effects of proposed flood concept projects within multiple watersheds south of the Caloosahatchee River. The model was calibrated and validated using the available measured data for the years 2016 and 2017, with a focus on the wet season. At the time of this study, the regional model was the largest scaled model ever developed for Lee County and combined the 2018 Estero Model, 2016 LA-MSID Model, and the 2011 update to the TCRB Model. Additional survey data was selectively collected as requested by ADA to further improve the accuracy of the regional model. However, model refinement was limited by the scale of the model and available project timeframe. Once the regional model was developed and calibrated, ADA incorporated the concept projects into the model for initial project screening.

Conceptual Plan Refinement

Upon review of the model findings, and coordination with agencies, the project team further evaluated the concept projects identified as being beneficial to proceed to project funding and design phases. A preliminary Opinion of Probable Cost (OPC) was prepared for the projects that proved beneficial. A project prioritization matrix was then developed utilizing the information identified for each potential concept project. This matrix can assist the County in prioritizing projects for further analysis, budgeting, and capital improvement project consideration. The most viable concept projects may be selected for budgeting and implementation. This future step includes funding development, grant applications, land acquisition (where necessary), permitting, design, bid, and construction. It is important to note that this Flood Mitigation Plan is intended to serve as a master plan level document, assisting Lee County by conceptually identifying a system of flood mitigation improvements that could be implemented over a multi-year planning horizon. It is common for improvements of this magnitude to be implemented over planning horizons as substantial as 20 years depending on funding availability.

Additional Regional Model Scenario Developments

A future conditions scenario was developed based on future land use and population increase projections looking 20-years into the future. This scenario was simulated and compared to the existing conditions model output and represents conditions with and without flood mitigation projects. An analysis quantifying the amount of storage required to meet the flood mitigation goals for the entire study area was also conducted using the future conditions model developed. The objective of the evaluation was to determine how many acre-feet of water should be stored during the wet season to mitigate the additional flooding impacts resulting from increased imperviousness in each of the four areas. A model analysis of watershed discharge rates was performed followed with recommendations on basin allowable discharge rates. Detailed model development, calibration, and findings are summarized in the accompanying modeling report by ADA.

Regional Scale ICPR4 Modeling

A regional scale ICPR4 model was updated, refined, and calibrated for the SE Lee County area. Two preliminary concepts were modeled and evaluated as part of this effort: Crew-Flint Pen Hydrologic Restoration and East I-75 Overland Flow Collection Drainageway. The 25-year and 100-year, 3-day storm events were modeled. This effort provided a high level evaluation of flood mitigation benefits associated with the two projects. Long term simulations were also conducted to determine hydroperiods with the two proposed improvements in place.

Maintenance Plan Consideration

Although not a part of this project development, a maintenance plan should be developed for each significant conveyance and facility. This plan should include but not be limited to routine cleaning of the natural rivers and creeks, removal of excessive and invasive vegetation, removal of sediment buildup in conveyances and structures, routine maintenance and operation of all gates and associated improvements, and replacement of drainage facilities that are failing. A good maintenance plan will increase the longevity of the drainage facilities and will allow for maximum conveyance capacity during storm events. This is important with the County's current stormwater system, but even more notable as additional automated weirs with telemetry and pumps are added to the network.

Study Area Analysis and Report Structure

Each study area section of this report provides general commentary and an overall location map of the concept plans specific to the area's unique challenges and necessary approach. Concept plan development is further detailed through the discussion of each concept plan's background, location, description, and purpose. Evaluation of each concept plan includes the discussion of each concept plan's viability, community considerations, environmental/permitting considerations, land availability, preliminary opinion of probable cost, opportunities for multiple benefits/uses, and other considerations; all of which must be further evaluated in future design phases for each concept project. The concept plan's findings & recommendations are also summarized with accompanying time vs. stage and time vs. discharge graphs for the 25-year design storm, 100-year design storm with July 2017 antecedent conditions, 100-year design storm with August 2017 antecedent conditions, and continuous simulation for the Invest 92L/Hurricane Irma storms. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality.

- Part 1 – Concept Projects
  - Addresses the development and analysis of preliminary flood mitigation projects in the four study areas.
- Part 2 – Project Prioritization Matrix
  - Addresses the development of a priority matrix for the concept projects in each of the four study areas.
- Part 3 – Regional Modeling
  - Addresses the development of the MIKE SHE/MIKE 11 regional model, modeling of the concept projects, future conditions modeling, and basin storage/discharge.
- Part 4 – Appendixes
  - Information and data that supported the development of Parts 1 through 5.
  - Summary of three local models that were developed in the South Fort Myers study area.
  - Summary of the ICPR4 model development for a portion of the Southeast Lee County area, and modeling of two of the preliminary concept projects.

Part 1

Concept Projects

1.1 EAST LEE COUNTY FLOOD MITIGATION AREA

BACKGROUND

The East Lee County watershed is bounded approximately by the Caloosahatchee River on the north, Interstate 75 to the west, the Lee-Hendry County line on the east and S.R. 82 along the southern border. The watershed is an approximate 150 square mile area with the Lehigh Acres community comprising a substantial portion of this watershed. There are a few recent land developments, such as the Verandah, River Hall, Portico and other smaller developments that have designed storm water management systems. This area also contains many rural farm tracts, large home sites and pasture areas. The watershed varies in land elevation from a high of 30 feet above sea level down to tidal waters in the section of the Caloosahatchee River located below the WP Franklin Lock & Dam. Drainage outfall in this watershed is principally dependent on natural flow-ways, such as the Orange River, Hickeys Creek, Bedman Creek and other natural tributaries.

GENERAL COMMENTARY

From the Phase 2 Study of Hurricane Irma Flood Impacts in the East Lee County area, it was generally observed that the natural streams, creeks and rivers draining this area are not capable of satisfactorily passing the high stormwater runoff flows caused by this severe storm events. The lack of stream flow capacity resulted in bank overflow flooding in natural flow-ways along with upstream flooding impacts. Bank overflow flooding is a common occurrence in natural systems as flood waters rise into the floodplain increasing stormwater conveyance and storage. Historically, re-occurring floods in the East Lee County natural flow-way systems are well documented.

In addition to having limited flow capacity, the natural systems were impacted with downed trees from high winds, debris, shoaling and other flow impediments that further restricted the water flow resulting in increased flood levels and extended recovery times for flood waters to recede to normal levels. The high-water levels inundated homes, roads and vehicles thereby risking the health, safety and welfare of the public. For flood mitigation, it is proposed that high capacity bypass conveyances, large reservoir storage areas, and a managed system capability be developed to lessen flooding upstream and downstream of the natural flow-ways.

To implement the flood mitigation program for this area, alternative bypass conveyance routes were identified to direct high rate water flows to large waterways capable of receiving high flows. Normal seasonal flows would continue to the natural systems in order to maintain the environmental ecosystem of those streams. The focus of the flood mitigation plan is to develop a stormwater control system for managing runoff from severe storm events by concentrating on main drainageways in creating a principal outfall system. Minor conveyance connections may be made to the principal drainageways as needed in the future to address localized flow restrictions. Where practical, opportunities to create water storage reservoirs and water quality treatment areas were included in the project concepts.

The project concepts vary from direct flow bypass conveyances to a combination of flow conveyance and stormwater reservoir storage to stormwater reservoir storage only. Flow conveyance capacities are conceptionally designed to handle flows at a rate below erosion causing velocities. Flow paths were selected to meet a specific flooding concern while utilizing governmental agency-owned properties to minimize impacts to private property owners, where available. Note that when developing the conveyances, improvements to downstream areas are typically required prior to upstream improvements to avoid overloading a downstream area with increased flow from an upstream improvement.

The potential conceptual projects are preliminary planning ideas that will be presented for modeling input to evaluate the effectiveness and viability of the proposed conveyance and storage components. Some project concepts appear to have an obvious benefit in removal of excess stormwater while other project concepts have complex effects requiring computer modeling for evaluation. A basic volumetric flow analysis has been performed for initial estimation of needed projects. Where practical, project concepts locations were selected in areas of observed flood re-occurrence and areas lacking significant drainageways to convey runoff from severe storm events.

Using a basic volumetric analysis for planning purposes, a goal of 3" per day rainfall removal rate was established. This runoff removal rate is anticipated to reasonably discharge the 100-year, 3-day storm event of 13.6" of rainfall with manageable peak stages and a reasonable recovery time for water levels to return to normal conditions. Excess rainfall that could not be discharged immediately would be stored to manageable water levels by filling up canals, ponds, reservoirs, roadside swales and residential open spaces which is acceptable for communities during extreme storm events on a short time basis.

Using the 3" per day rainfall removal rate, the 65,000-acre community of Lehigh Acres would generate 8,000 CFS (3 ½ million gallons a minute). Bypassing 8,000 CFS away from natural streams, creeks and rivers requires multiple flow paths. A visual analysis representation is shown in **Figure 1** below. The concept plans address this goal as follows and a visual breakdown is shown in **Table 1**:

Hickeys Creek Overflow Bypass	3,000 CFS
Bedman Creek Overflow Bypass	2,000 CFS
Buckingham Bypass Drainageway	1,000 CFS
Lehigh-River Hall to Olga Outfall	1,000 CFS
*Upper Orange River Natural Flow-way	500 CFS
*Hickeys Creek Natural Flow-way	250 CFS
*Bedman Creek Natural Flow-way	250 CFS
Total:	8,000 CFS

*Indicates preliminary estimated maximum conveyance of natural flow-way

Areas not having a project concept are generally sloped to drain by existing topography without severe flooding. Complex modeling of the regional area will verify how well the proposed project concepts perform after considering the land topography, geohydrology, overland flow characteristics, impervious areas and interconnected flow paths.

Table 1: Removal Rate Analysis, East Lee County

Run-off				
Basins	**Area (acres)**	**Daily Rate (inches)**	**Discharge (CFS)**	
Orange River	33,289	3	4196	
Hickey's Creek	13,167	3	1660	
Carlos Waterway	9,038	3	1139	
Bedman Creek	9,145	3	1153	
Storage				
100 yr storm, 3-day duration (10" one day rainfall)				
Time period (hours)	0 - 24	24 - 48	48 - 60	60 - 72
Rainfall (inches)	1.46	3.60	10.15	13.60
Inches per time period	1.46	2.14	6.55	3.45
Removal (inches)	3.00	3.00	1.50	1.50
Storage (inches) without drawdown	0.00	0.00	5.05	7.00
Storage (inches) with drawdown	-1.54	-2.40	2.65	4.60
Result				
56 hours recovery without preparation				
37 hours recovery with preparation				

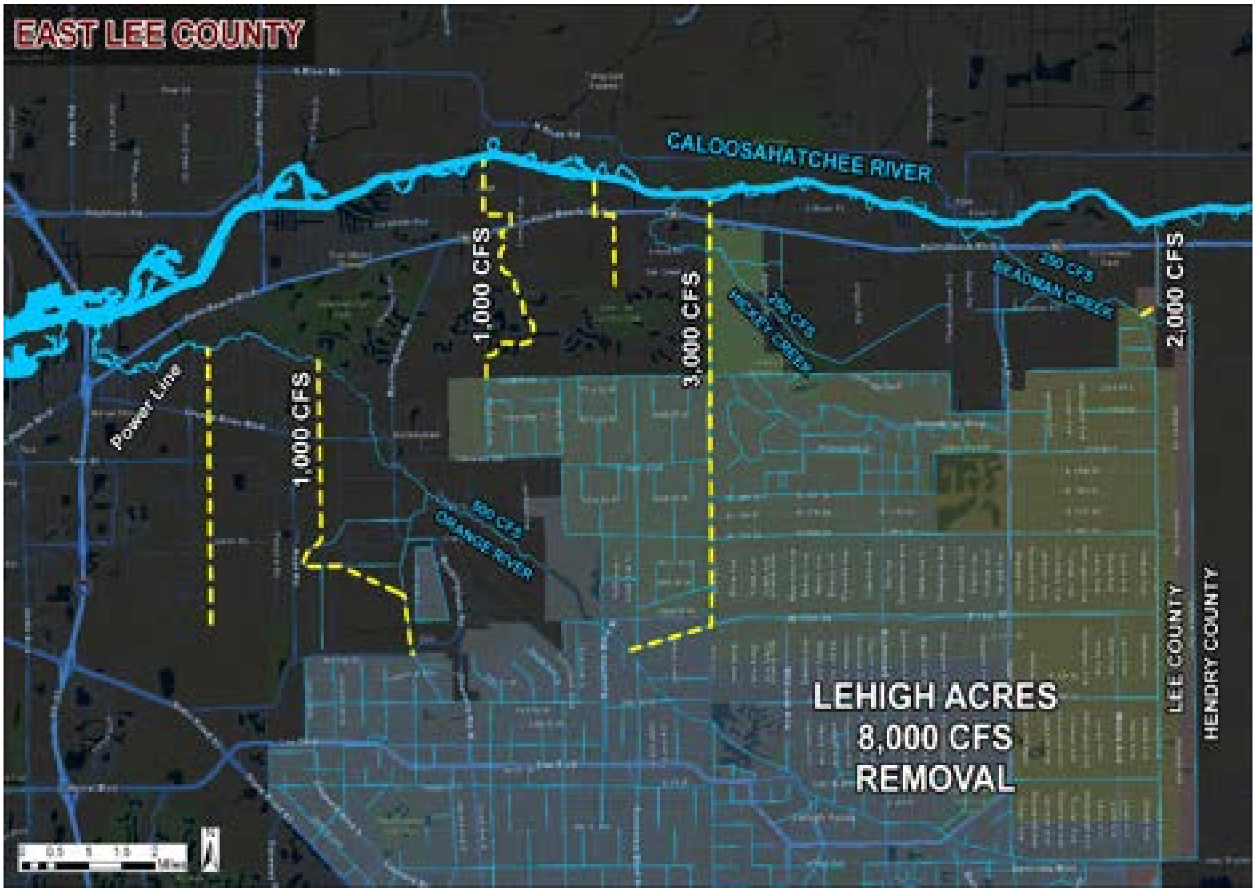


Figure 1: East Lee County Removal

PROJECT CONCEPTS PROVISIONS

- Flood mitigation is intended to improve drainage to reduce flood levels and post storm recovery times
- The approach involves conveyance and storage stormwater management methods
- The initial design storm for preliminary concept development is the 100-year, 3-day event as published by the SFWMD.
- The focus is on major flow-ways and therefore not specific neighborhood drainage issues
- It is anticipated that large flow-way conveyances will be equipped with water control structures having telemetry, data collectors, remote operable motorized gates, camera viewing and standby power facilities
- A knowledgeable staff will manage the system prior to, during and following large storm events
- Maintenance of the proposed facilities is required for proper operation

CONCEPT PROJECT IDENTIFICATION

1.1.1 Dog to Hendry Drainageway (CREST)
1.1.2 Bedman Creek Overflow Bypass
1.1.3 GS-10 Stormwater Quality Reservoir
1.1.4 Buckingham Bypass Drainageway
1.1.5 Buckingham Trails Water Quality Reservoir
1.1.6 Lehigh-River Hall to Olga Outfall
1.1.7 Hickey Creek Overflow Bypass
1.1.8 Strayhorn Drainageway
1.1.9 Charlie Diversion-Hickey Canal Improv.
1.1.10 Hickey Creek Swamp Drainageway
1.1.11 Six-Mile Preserve North Catchment Reservoir

STORMWATER MANAGEMENT METHODS UTILIZED

Figure 2 and **Figure 3** below illustrate the various types of stormwater management methods utilized in this area. These figures visually illustrate the need for engineered and well-maintained conveyance networks which include channel stabilization systems to mitigate erosion and remote gate operational capability during extreme storm events.

Figure 2 – Example of a water control structure with remote operable gates

Figure 3 – Example of a high flow drainageway channel conveyance

FLOOD MITIGATION BENEFITS OF PRELIMINARY CONCEPT LEVEL PROJECTS

Flood mitigation benefits are in general achieved when excess storm water is conveyed and/or stored appropriately to reduce flooding levels and duration that would otherwise inundate structures and have prolonged road flooding. These adverse conditions impact the health, safety, welfare of the residents and have a significant economic impact to the community. The flood mitigation improvement would be achieved by developing flow paths to open water and/or reservoirs to store flood waters for later release following the storm event. Most concept projects in the East Lee County area share in handling excess flood water on a regional basis and this system of concept projects contributes to a flood mitigation solution.

This system approach to meeting the flood mitigation goals is necessary since many flooding problems are not solvable on a local level. For instance, areas of Lehigh Acres drain large flows to natural streams that result in high water levels for an extended period. Placing improvements in natural streams to handle high flows is challenging due to environmental impacts and other constraints, and alternately blocking flow from entering natural streams results in upstream basin flooding. Current conditions show both upstream and downstream residents with flooding problems.

Eleven preliminary concept projects were developed for the East Lee County study area as shown in **Exhibit 1.1**. The projects work in concert to develop an overall system improvement to this approximately 150 square mile drainage basin. Targeted areas for reduction in structure flooding included those structures abutting the natural conveyances of Orange River, Hickey Creek, and Bedman Creek. These three downstream natural conveyances have been locations of repetitive flooding (See **Figure 4** depicting FEMA Flood Insurance Claims and Repetitive Loss Areas. Please note that other structures incurred flood damage but were not covered by flood insurance and therefore not recorded by FEMA). In addition, flood mitigation was desired due to substantial prolonged flooding of many roadways within Lehigh Acres and those adjacent to the natural flow ways.

Again, the greatest benefit is seen with implementation of these concept projects as a system. This is reflected in the Regional Model which was run with all concepts stitched together in this system approach. **Figure 5** below depicts the approximate system improvement areas at a high level for East Lee County where flood mitigation was considered improved when the peak groundwater stage difference is reduced by more than one tenth of a foot from the existing to proposed model condition for a 100-yr, 3-day storm event. The approximate value of the buildings located within these areas was compiled by Lee County staff from the Lee County Property Appraiser parcel building values for the 2020 tax roll. This value for the East Lee County area was approximately $550 million. AIM reviewed the Regional Model system output and then considered the relative individual concept contribution to provide an evaluation of each project's flood mitigation benefit. This was assisted by review of documents such as the Phase 2 reports for this project and Post Irma flooding aerials which showed the potential impact to structures and significant roadway flooding.

The contribution or benefit of each project concept is discussed as follows based on modeling results for the 100-Yr, 3-Day storm events:

Bedman Creek/Bedman Basin

Projects 1.1.1, 1.1.2, and 1.1.3 collectively benefit the Bedman Creek area and Bedman Basin. The projects work together to store and redirect large storm flows to greatly reduce flooding impacts to the constrained natural Bedman Creek. The three projects combined to reduce flood levels in downstream sections of Bedman Creek by over four to five feet. This substantial reduction in water levels greatly reduces the flooding potential for those structures previously affected by Hurricane Irma. For the repetitive flooding area adjacent to Bedman Creek, these improvements mitigate flood waters for approximately 195 parcels based on the 100-year, 3-day modeled storm (see **Figure 6** below). Note that the number of approximately benefited parcels that are conceptually shown to be impacted by high peak stages during extreme storm events are limited to the clipped area shown in the maps. The number of parcels effected could therefore be greatly increase or decrease if the subjective clipped region changes. Localized modeling should be conducted to refine the concepts to gain an increased understanding on how these concept projects benefit the surrounding areas. These figures do not necessarily reflect actual structure flooding, but more of an overall benefit to the area. In addition, Lehigh Acres and other adjacent road flooding would be reduced in extent and duration. The model indicated on average approximately a one-foot reduction for peak water levels upstream within Lehigh that would benefit that goal. Additionally, the model showed a positive reduction in water levels greater than a tenth of a foot for approximately 1,175 acres (see **Figure 5**). Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.1 ***Dog to Hendry Drainageway (CREST)*** - This conveyance and storage concept project was developed to direct flood flow away from Bedman Creek. The modeling results show approximately a 300 cfs reduction in the peak flood flow in Dog Canal that drains to Bedman Creek. Water quality treatment is an additional benefit of this project.

1.1.2 ***Bedman Creek Overflow Bypass*** - This conveyance concept project was developed for flood mitigation of the Bedman Creek area using an overflow bypass to direct flood flow to Carlos Waterway and then the Caloosahatchee River. The modeling results show a reduction in Bedman Creek flood flow of over 300 cfs, with a conveyance potential to positively redirect over 800 cfs. Water quality treatment is an additional benefit of this project.

1.1.3 ***GS-10 Stormwater Quality Reservoir***- This flood reservoir storage concept project was developed to store excess flood waters to reduce flows in Dog Canal and Hickey Canal that flow to Bedman Creek and Hickey Creek respectively. The modeling results show over a 300 cfs reduction in the peak flood flow to Dog Canal that drains to Bedman Creek and over a 300 cfs reduction in the peak flood flow to Hickey Canal that drains to Hickey Creek. Water quality treatment is an additional benefit of this project along with improved hydration of Greenbriar Swamp.

Orange River/Orange River Basin

Projects 1.1.4, 1.1.5, 1.1.7, and 1.1.9 collectively benefit the Orange River natural stream area and Orange River Basin. The projects work together to store and redirect large storm flows to greatly reduce flooding impacts to the constrained natural Orange River. The four projects combined to reduce flood levels for the 100-year storm in downstream sections of Orange River by up to approximately one foot. This reduction in water level reduces the flooding potential for those structures previously affected by Hurricane Irma and previous major storms. For the repetitive flooding area adjacent to the Orange River, these improvements mitigate flood waters from approximately 684 parcels based on the 100-year, 3-day modeled storm (see **Figure 7** below). In addition, Lehigh Acres and other downstream Orange River adjacent road flooding would be reduced in extent and duration. The model indicated on average approximately a half foot reduction for water levels upstream within Lehigh that would benefit that goal. The model showed a positive reduction in water levels greater than a tenth of a foot for approximately 1,730 acres (see **Figure 5**). Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.4 ***Buckingham Bypass Drainageway*** – This conveyance concept project was developed to direct flow away from the Buckingham Road/Orange River area and to improve flood flow out of Lehigh Acres. The modeling results show a 155 cfs increase to 366 cfs flood flow from Lehigh Acres at this location, as well as, intercepting an additional flood flow reaching 1,474 cfs in the bypass drainageway. Intercepting the large flood flow significantly reduces flooding in the Buckingham/Orange River area. Both Lehigh Acres and Buckingham residents are the beneficiaries of this project.

1.1.5 ***Buckingham Trails Water Quality Reservoir*** - This flood reservoir concept project stores excess flood water until the storm event passes. This reservoir reduces the volume of flood water flow to Orange River. A benefit to Buckingham/Orange River area residents would be realized from this improvement. Water quality treatment is an additional benefit.

1.1.7 ***Hickey Creek Overflow Bypass*** - This conveyance concept project was developed for flood mitigation of the Hickey Creek area using an overflow bypass to direct flood flow to the Caloosahatchee River. The modeling results show a reduction in Hickey Creek flood flow of over 1900 cfs which is approximately what this new project is conveying. While this project provides strong flood mitigation benefit to the Hickey Creek basin, due to the Charlie Diversion connection it also can provide benefit to the Orange River.

1.1.9 ***Charlie Diversion-Hickey Canal Improvement*** - This conveyance concept project was developed to direct flow away from the Orange River to the Hickey Canal and on to the Caloosahatchee River. This diversion is intended to reduce the flood flow to the Buckingham/Orange River area. The modeling results show over 400 cfs increase in flood flow away from the Orange River. Buckingham and Lehigh Acres residents are the beneficiaries of this project.

Hickey Creek/Hickey Basin

Projects 1.1.3, 1.1.6, 1.1.7, and 1.1.9 collectively benefit the Hickey Creek area and Hickey Basin. The projects work together to store and redirect large storm flows to greatly reduce flooding impacts to the constrained natural Hickey Creek. The four projects combined to reduce flood levels for the 100-year storm in downstream sections of Hickey Creek by over six feet. This substantial reduction in water levels greatly reduces the flooding potential for those structures previously affected by Hurricane Irma and previous major storms. For the repetitive flooding area adjacent to Hickey Creek, these improvements remove flood waters from approximately 88 parcels based on the 100-year, 3-day modeled storm (see **Figure 8**). In addition, Lehigh Acres and other adjacent road flooding would be reduced in extent and duration. The model indicated on average approximately a three-foot reduction for water levels upstream within Lehigh that would benefit that goal. The model showed a positive reduction in water levels greater than a tenth of a foot for approximately 1,834 acres (see **Figure 5**). Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.3 ***GS-10 Stormwater Quality Reservoir***- This flood reservoir storage concept project was developed to store excess flood waters to reduce flows in Dog Canal and Hickey Canal that flow to Bedman Creek and Hickey Creek, respectively. The modeling results show over a 300 cfs reduction in the peak flood flow to Dog Canal that drains to Bedman Creek and an over 300 cfs reduction in the peak flood flow to Hickey Canal that drains to Hickey Creek. Water quality treatment is an additional benefit of this project along with improved hydration of Greenbriar Swamp.

1.1.6 ***Lehigh-River Hall to Olga Outfall*** – This conveyance concept project was developed to improve flood flow out of Lehigh Acres. The modeling results show over a 100 cfs flood flow from Lehigh Acres at a water level being 5.35 feet below the top of bank at this location. Lehigh Acres residents are the beneficiaries of this project.

1.1.7 ***Hickey Creek Overflow Bypass*** - This conveyance concept project was developed for flood mitigation of the Hickey Creek area using an overflow bypass to direct flood flow to the Caloosahatchee River. The modeling results show a reduction in Hickey Creek flood flow of over 1900 cfs which is approximately what this new project is conveying. While this project provides strong flood mitigation benefit to the Hickey Creek basin, due to the Charlie Diversion connection it also can provide benefit to the Orange River.

1.1.9 ***Charlie Diversion-Hickey Canal Improvement*** - This conveyance concept project was developed to direct flow away from the Orange River to the Hickey Canal and on to the Caloosahatchee River. This diversion is intended to reduce the flood flow to the Buckingham/Orange River area. The modeling results show over 400 cfs increase in flood flow away from the Orange River. Buckingham and Lehigh Acres residents are the beneficiaries of this project.

1.1.10 ***Hickey Creek Swamp Drainageway*** - This conveyance concept project was developed to direct flow away from the Hickey Creek area. In large storm events the Hickey Creek Swamp and flow from the River Hall community flows towards the Hickey Creek area. The modeling results show 83 cfs flood flow towards the Caloosahatchee River. Hickey Creek residents are the beneficiaries of this project.

Western Buckingham/Staley & Luckett Road Area

Projects 1.1.8 and 1.1.11 benefit western Buckingham in the Staley Road vicinity. These projects collectively benefit this area by providing a positive drainage facility couple with a storage component. These projects would reduce road flooding extent and duration in this area. The model showed a positive reduction in water levels for approximately 2,260 acres (See **Figure 5** below). Below are concept project summaries for this group, as well as their relative contribution to the area benefit.

1.1.8 ***Strayhorn Drainageway*** - This conveyance concept project was developed to improve flood flow out of the Luckett Road and Staley Road area. The modeling results show a 200 to 500 cfs flood flow from the area and a water level at the top of bank for this location. The Luckett Road and Staley Road area residents are the beneficiaries of this project as well as the beneficiaries of the Six-Mile Cypress North concept project that has a connection to this concept project.

1.1.11 ***Six-Mile Cypress North Catchment Reservoir*** - This flood reservoir concept captures all the rainfall from storm events. If desired, flow may be directed to Six-Mile Cypress Slough to the south or Strayhorn drainageway and the Orange River to the north. An additional benefit is available to direct flood water in the slough toward the Orange River. The hydrologic environmental enhancement is a primary benefit for the concept project. Providing a flood flow path for residents in the Six-Mile Cypress Slough basin would be an additional benefit.

Flow Reductions for Targeted Natural Streams with Concepts Implementation

100-Yr, 3-Day Storm Event with gates open at 0 hour:

Peak Flow from Lehigh Acres	Existing	Proposed	Reduction
Bedman Creek	1,032 cfs	168 cfs	864 cfs
Hickey Creek	2,283 cfs	287 cfs	1,996 cfs
Orange River	1,959 cfs	1,051 cfs	908 cfs

Overall, the East County residents are the beneficiaries of these concept projects by reducing discharges and flood levels, recovery water levels in soon after the extreme storm event, handling large flows with moderate flow rates to limit scouring of channels that carry sediments downstream that impact water quality. Improved water control facilities would allow water conservation through creation of reservoir storage and water quality treatment.

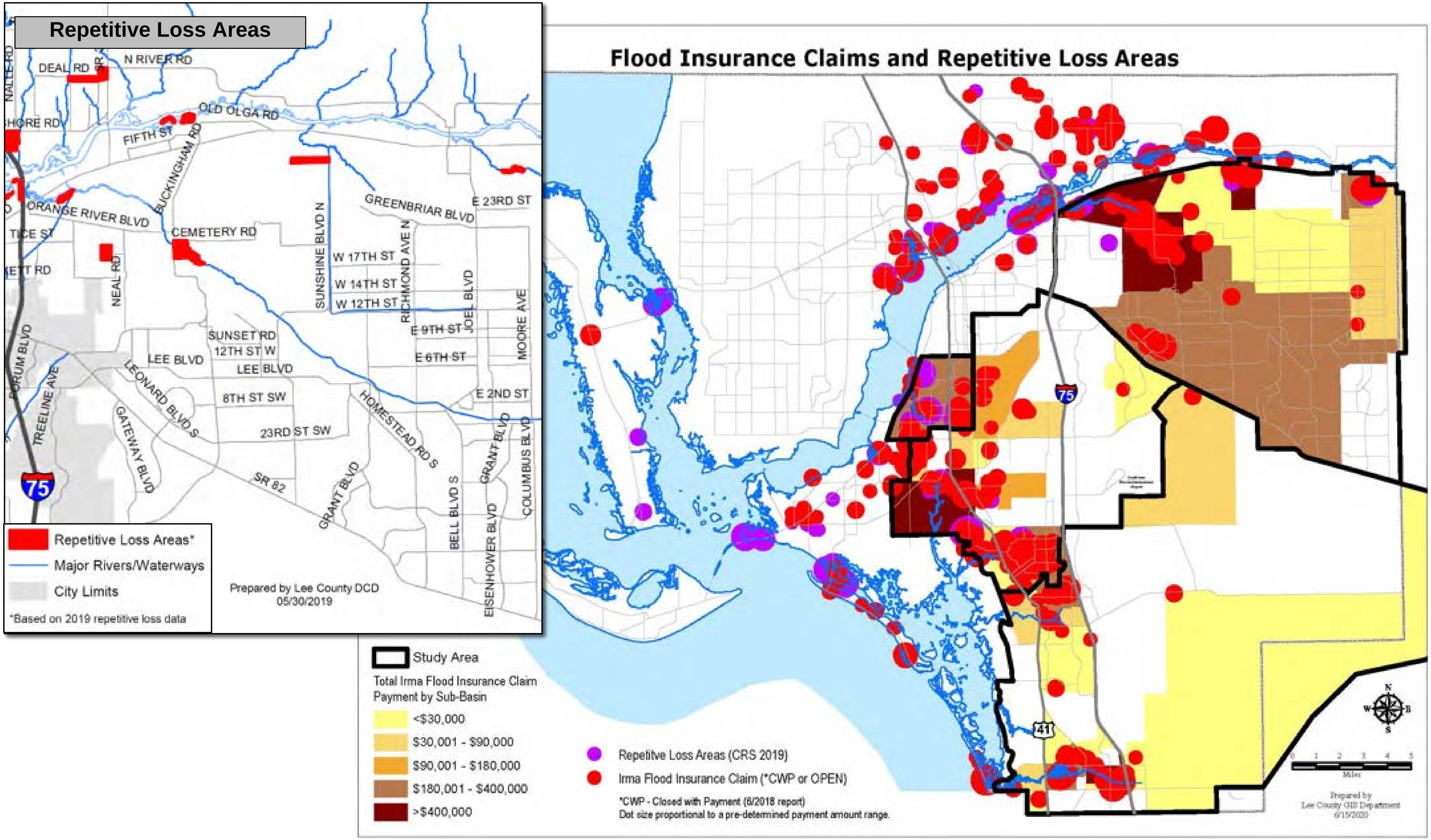


Figure 4 - Flood insurance claims and repetitive loss areas

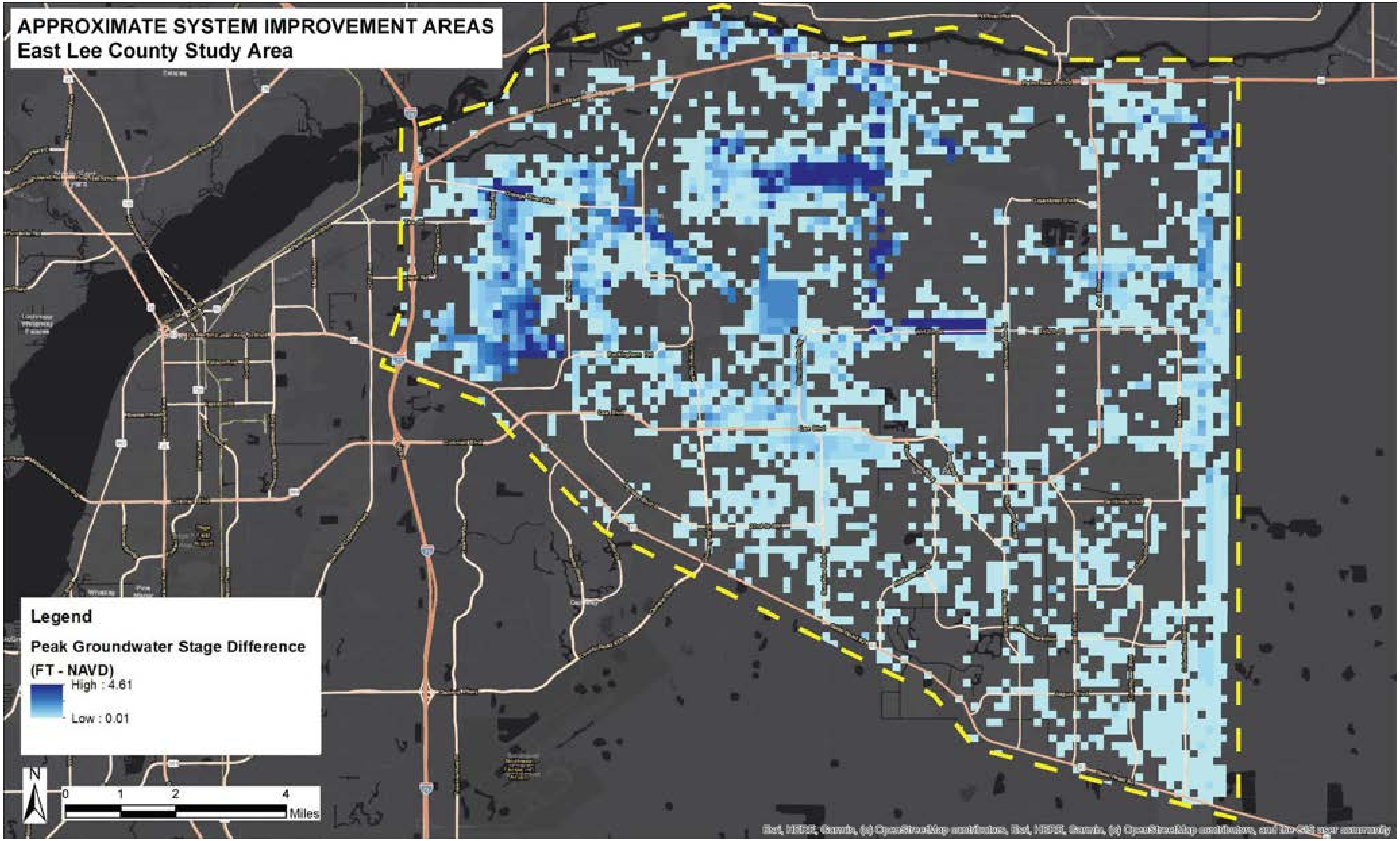
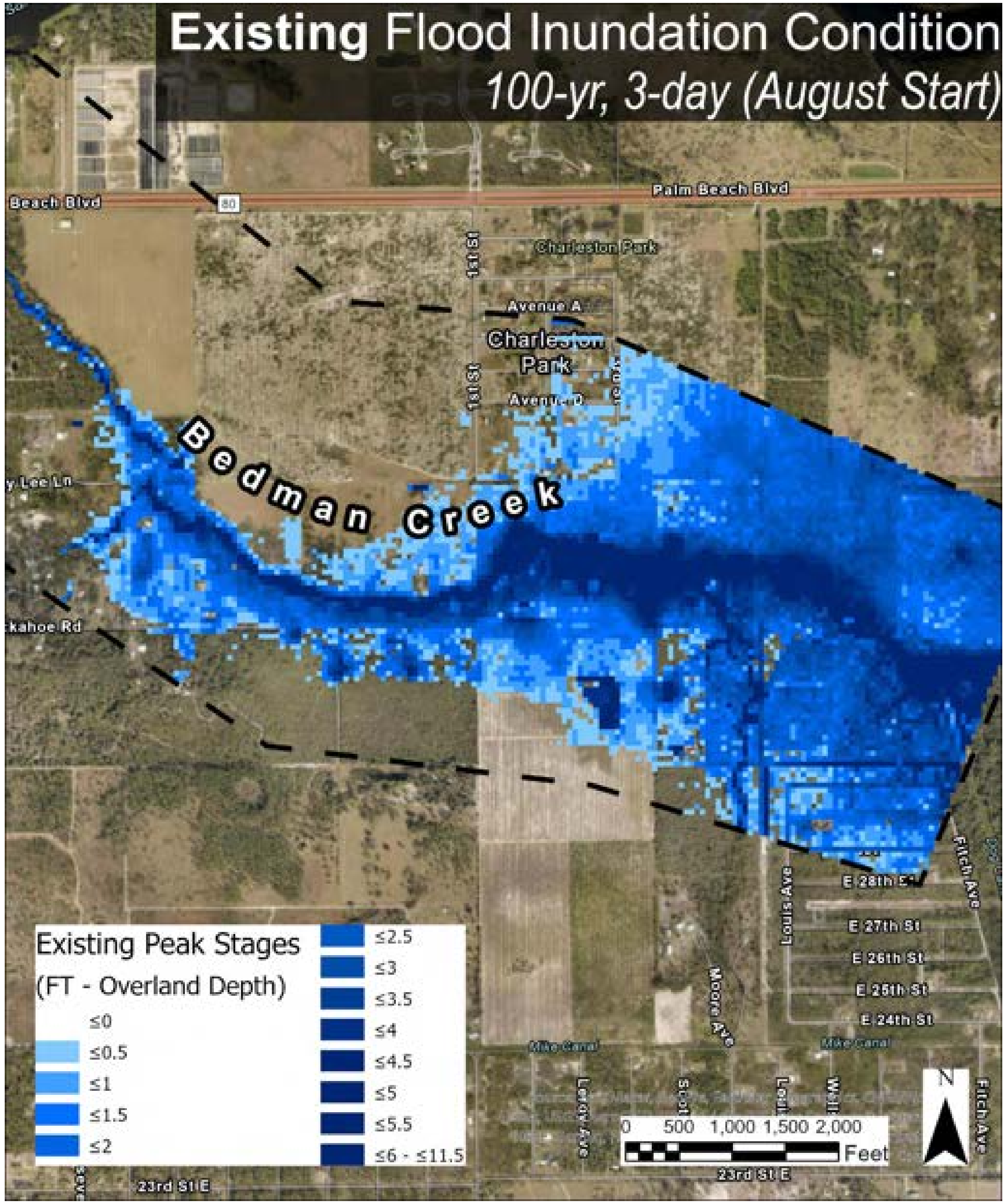


Figure 5 - Approximate system improvement areas for East Lee County Study Area



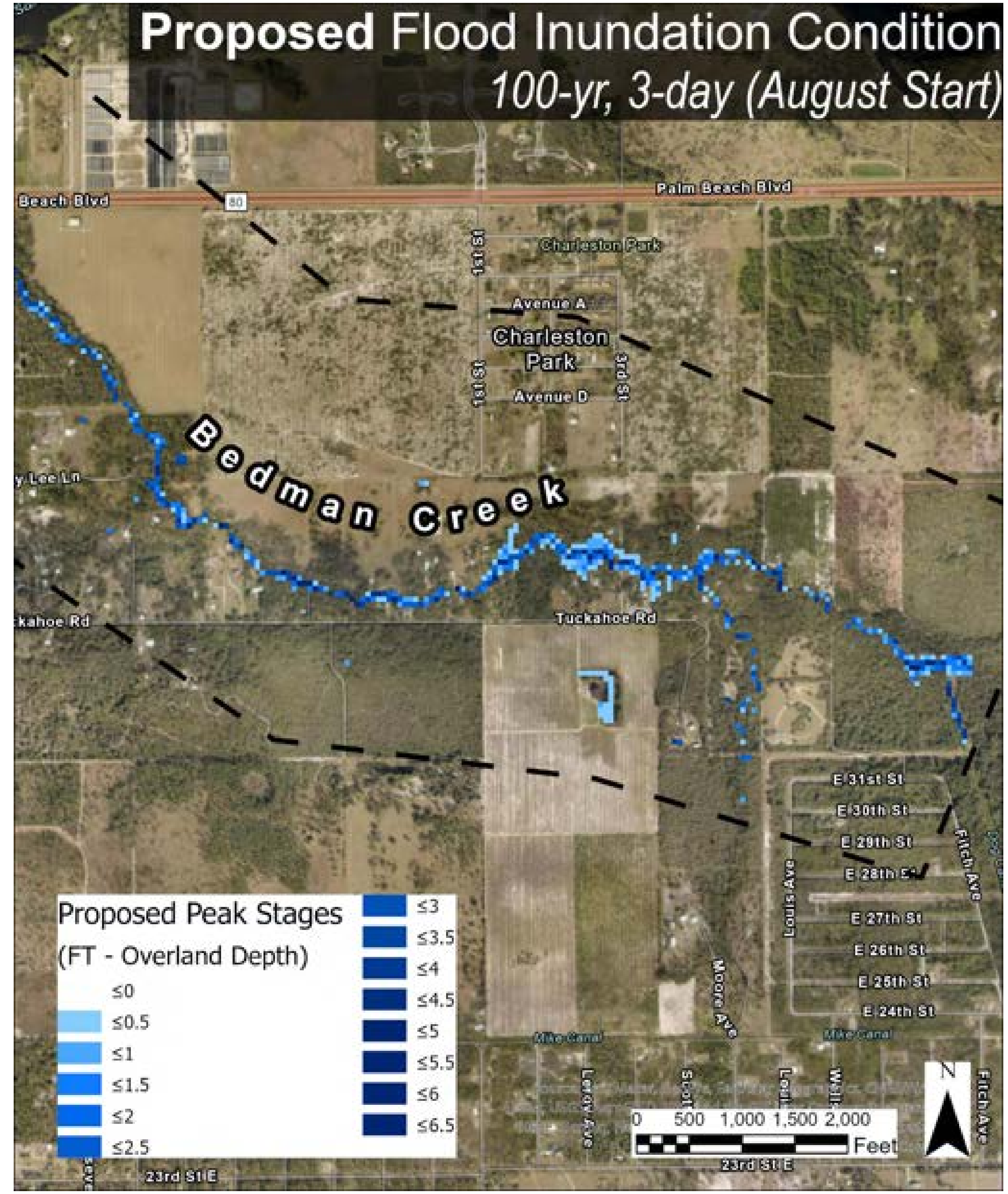
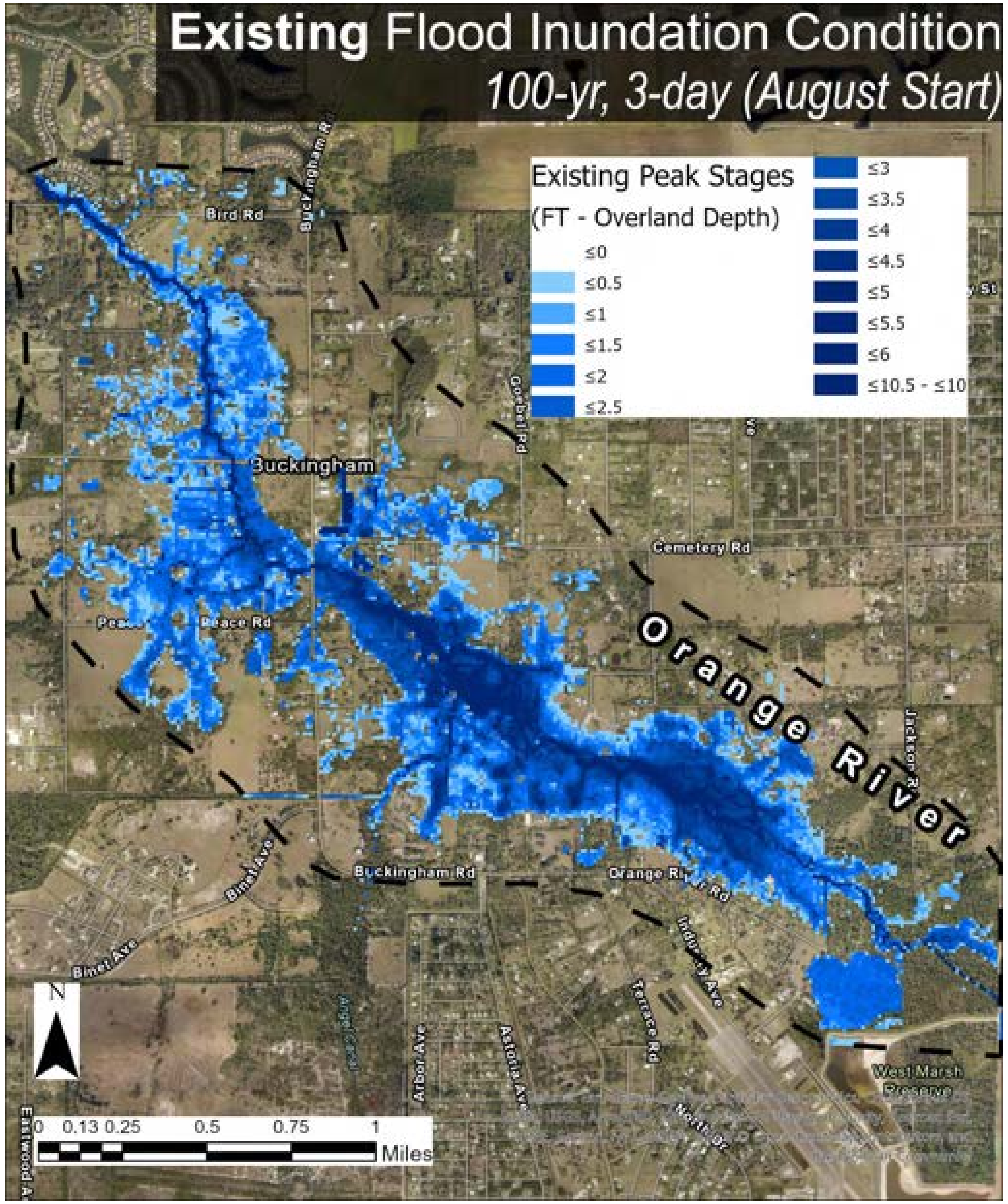


Figure 6 - Example benefited area maps for Bedman Creek

Conceptual Map Limitations: *These demonstration maps were developed by extending the modeled hydraulic grade line peak stages withing the Bedman Creek channel for the existing and proposed conditions to the offset shown by the dashed line to demonstrate how the improvements to the reduction in peak stages in a model network translate over LIDAR to benefit the adjacent areas. These maps are not intended for financial decision-making or design-level analysis as the concept plans and model coarseness were developed on a conceptual basis.*



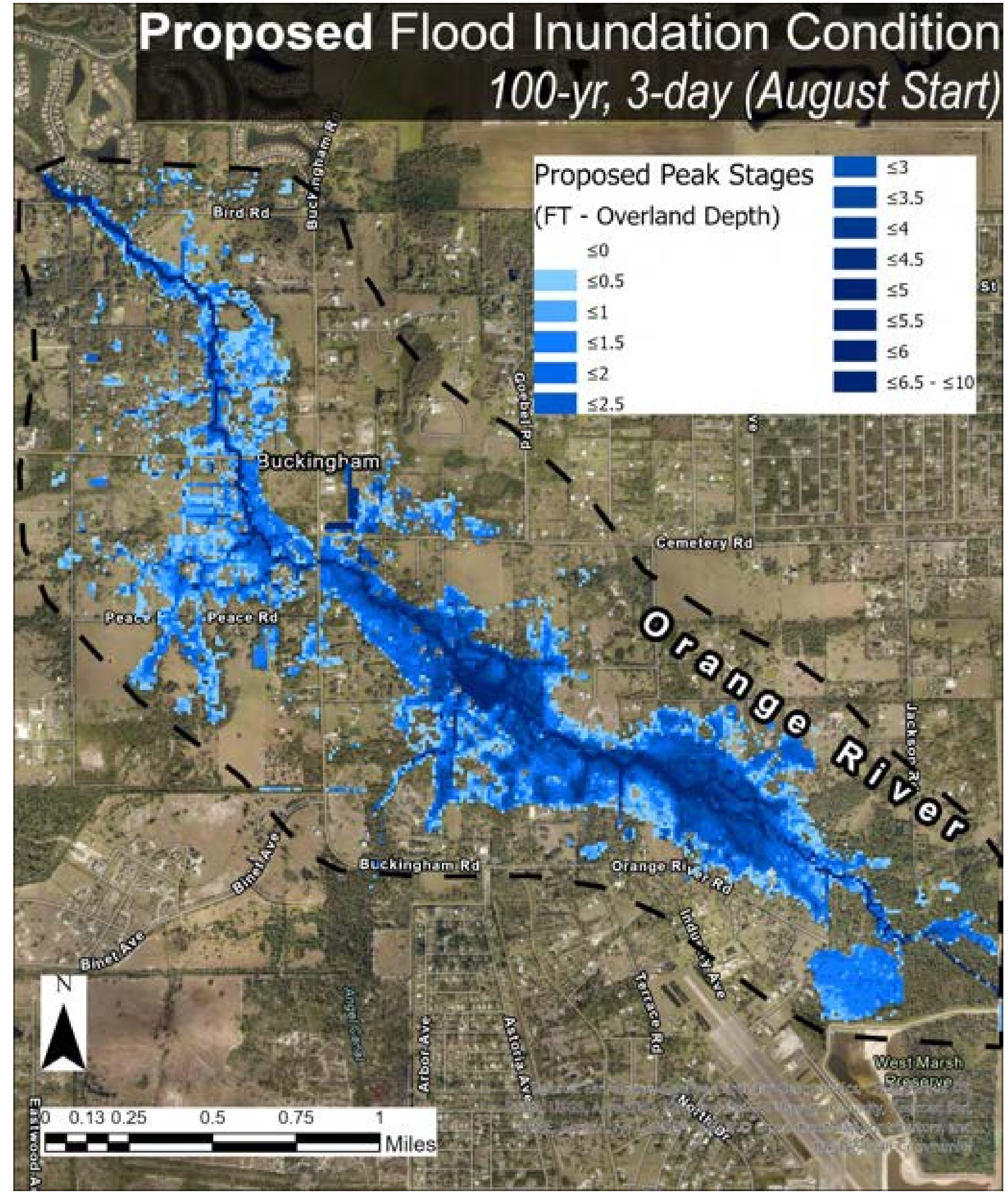


Figure 7 - Example benefited area maps for Orange River

Conceptual Map Limitations: *These demonstration maps were developed by extending the modeled hydraulic grade line peak stages withing the Orange River channel for the existing and proposed conditions to the offset shown by the dashed line to demonstrate how the improvements to the reduction in peak stages in a model network translate over LIDAR to benefit the adjacent areas. These maps are not intended for financial decision-making or design-level analysis as the concept plans and model coarseness were developed on a conceptual basis.*

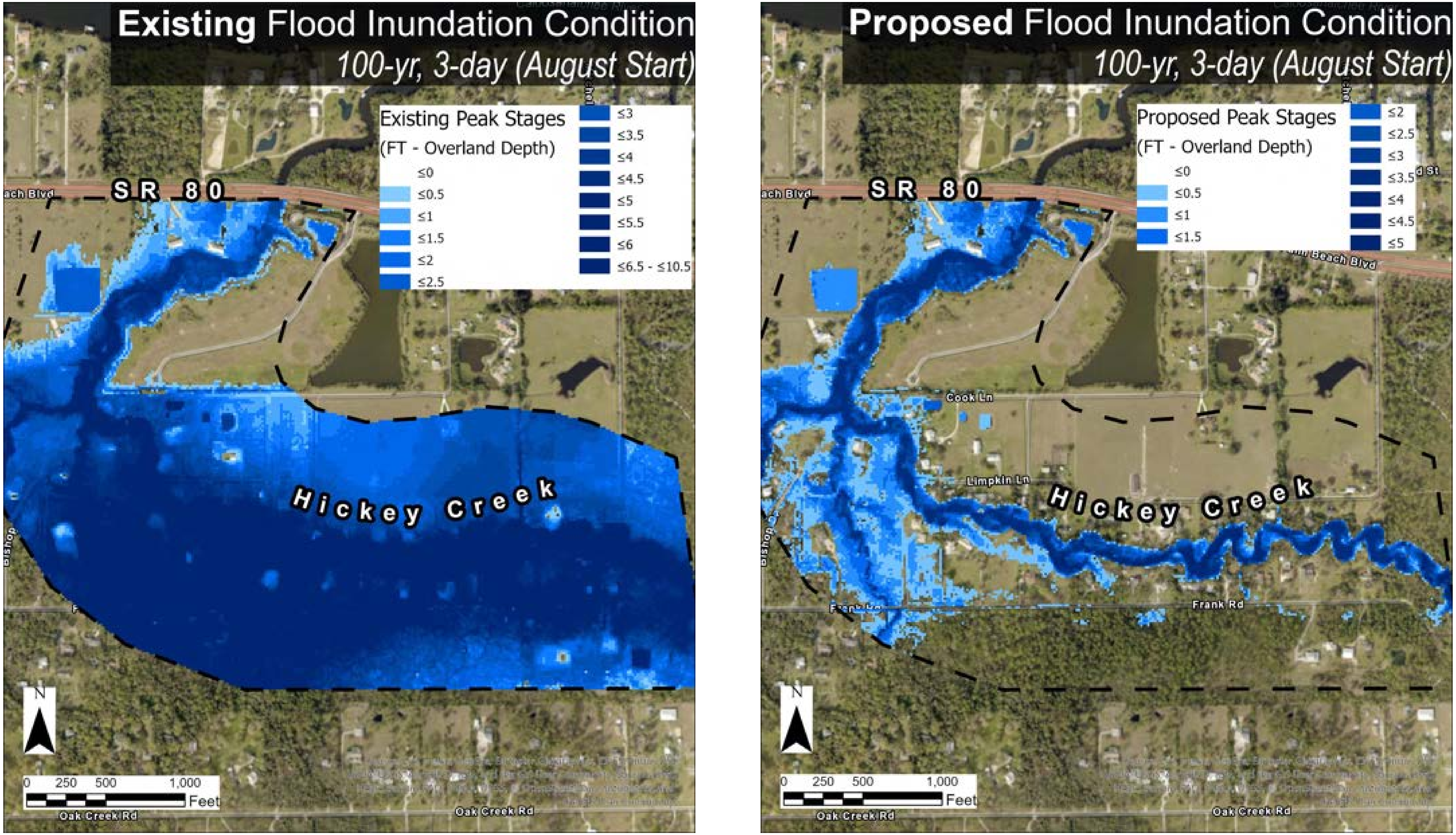
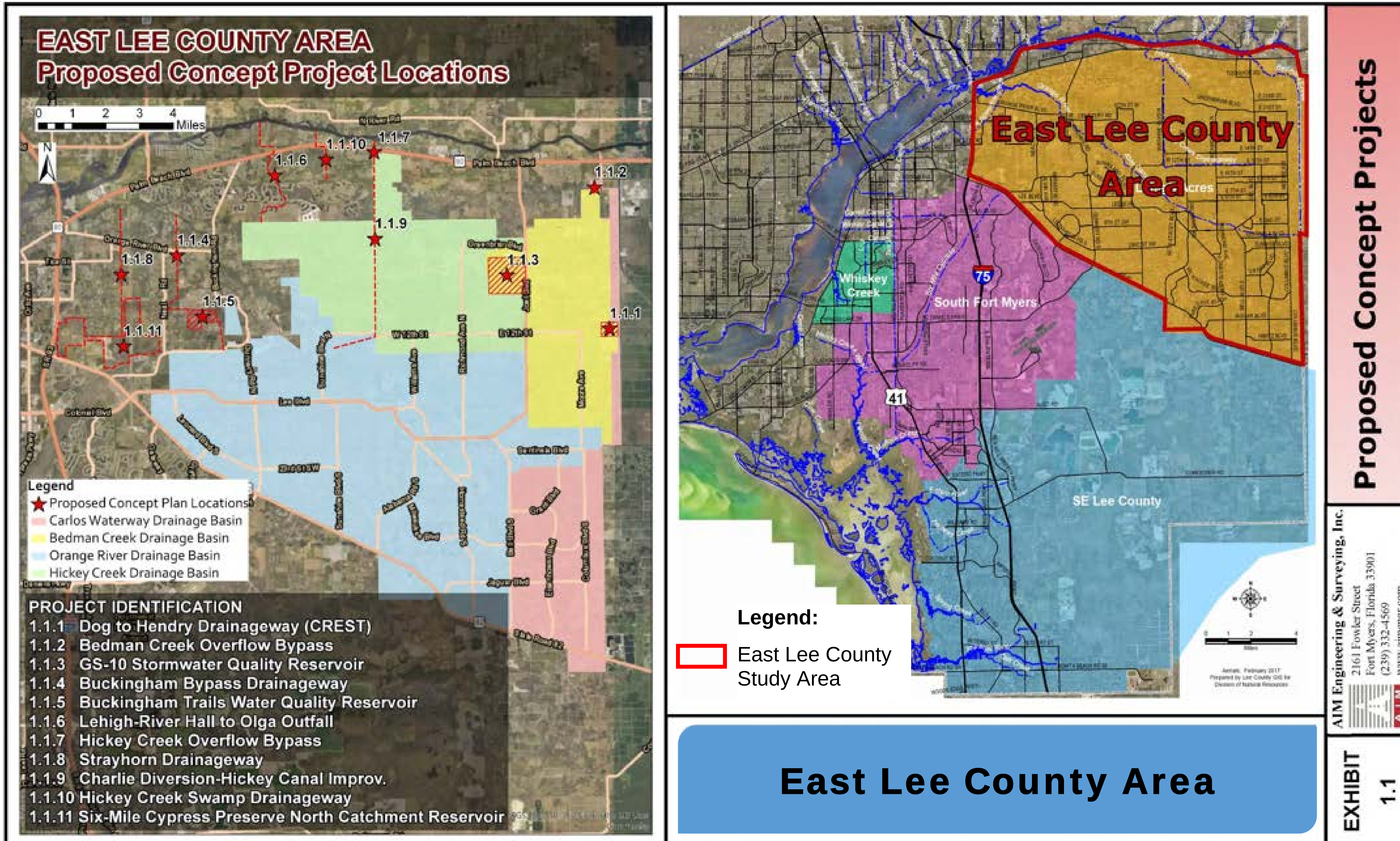


Figure 8 - Example benefited area maps along Hickey Creek

Conceptual Map Limitations: *These demonstration maps were developed by extending the modeled hydraulic grade line peak stages withing the Hickey Creek channel for the existing and proposed conditions to the offset shown by the dashed line to demonstrate how the improvements to the reduction in peak stages in a model network translate over LIDAR to benefit the adjacent areas. These maps are not intended for financial decision-making or design-level analysis as the concept plans and model coarseness were developed on a conceptual basis.*

EXHIBIT 1.1


EAST LEE COUNTY AREA
Proposed Concept Project Locations
0 1 2 3 4 Miles
1.1.1
1.1.2
1.1.3
1.1.4
1.1.5
1.1.6
1.1.7
1.1.8
1.1.9
1.1.10
1.1.11
Legend
Proposed Concept Plan Locations
Carlos Waterway Drainage Basin
Bedman Creek Drainage Basin
Orange River Drainage Basin
Hickey Creek Drainage Basin
PROJECT IDENTIFICATION
1.1.1 Dog to Hendry Drainageway (CREST)
1.1.2 Bedman Creek Overflow Bypass
1.1.3 GS-10 Stormwater Quality Reservoir
1.1.4 Buckingham Bypass Drainageway
1.1.5 Buckingham Trails Water Quality Reservoir
1.1.6 Lehigh-River Hall to Olga Outfall
1.1.7 Hickey Creek Overflow Bypass
1.1.8 Strayhorn Drainageway
1.1.9 Charlie Diversion-Hickey Canal Improv.
1.1.10 Hickey Creek Swamp Drainageway
1.1.11 Six-Mile Cypress Preserve North Catchment Reservoir
East Lee County Area
Whiskey Creek
South Fort Myers
SE Lee County
75
41
Legend:
East Lee County Study Area
East Lee County Area
Proposed Concept Projects
AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com
EXHIBIT 1.1

1.1.1 Dog to Hendry Drainageway (CREST)

Background

This concept project connects Lehigh Acres Dog Canal to Hendry Canal to divert excess storm flows away from Bedman Creek where Dog Canal currently discharges. Along with the drainageway connection is a parcel planned for stormwater reservoir storage and wetland marsh creation for water quality treatment. LA-MSID has recently acquired this parcel for use in improving water quality, storage, and drainage improvements. This parcel was previously utilized as farm fields and contains the recently constructed major water control structure S-H-2.

Location

This concept project is located in eastern Lehigh Acres within a 105-acre parcel between Dog and Hendry Canals along the Lee and Hendry County line in Section 19, Township 44 South, and Range 28 East as illustrated in **Figure** 9 below:

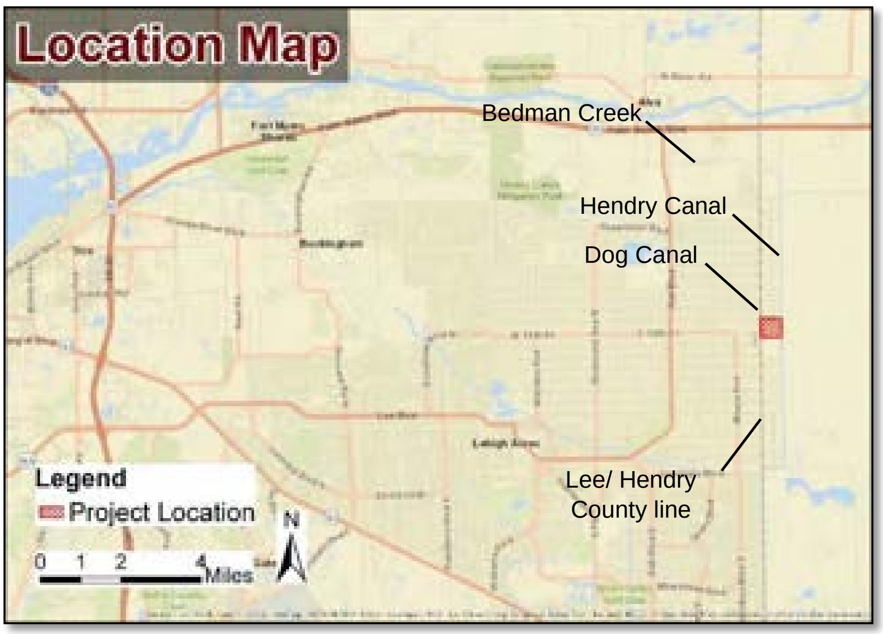


Figure 9 – Location Map, 1.1.1 Dog to Hendry Drainageway (CREST)

Description

This proposed conceptual project interconnects Dog Canal with the Hendry Canal just south of the S-D-2 weir and equalizes water level with the Hendry Canal to divert excess stormwater flow away from Bedman Creek directly to the Caloosahatchee River via the Carlos Waterway. This proposed conveyance is expected to have a cross section of a 40-foot canal bottom, 2:1 bank side slope to natural ground, and a +/-100-foot top width which is the same cross section as the existing Hendry Canal.

Along with this canal interconnection is the opportunity to create a water quality treatment and stormwater storage reservoir on the 105-acre parcel recently obtained by LA-MSID. This parcel will provide large excavated lake areas for additional storage capacity and a channelized filter marsh for water quality improvements. Elements include lake storage areas, channelized filter marsh and provides a corridor for the future E 12th Street and Wheeler Road. Inflow would be gravity fed from Hendry Canal with the option to pump inflow from Dog Canal for additional water quality treatment of the waters from Bedman Creek Drainage Basin. Inflow will first enter the lake areas, travel through a channelized filter marsh, and then to deep lake storage before discharging as illustrated in **Figure 10**:

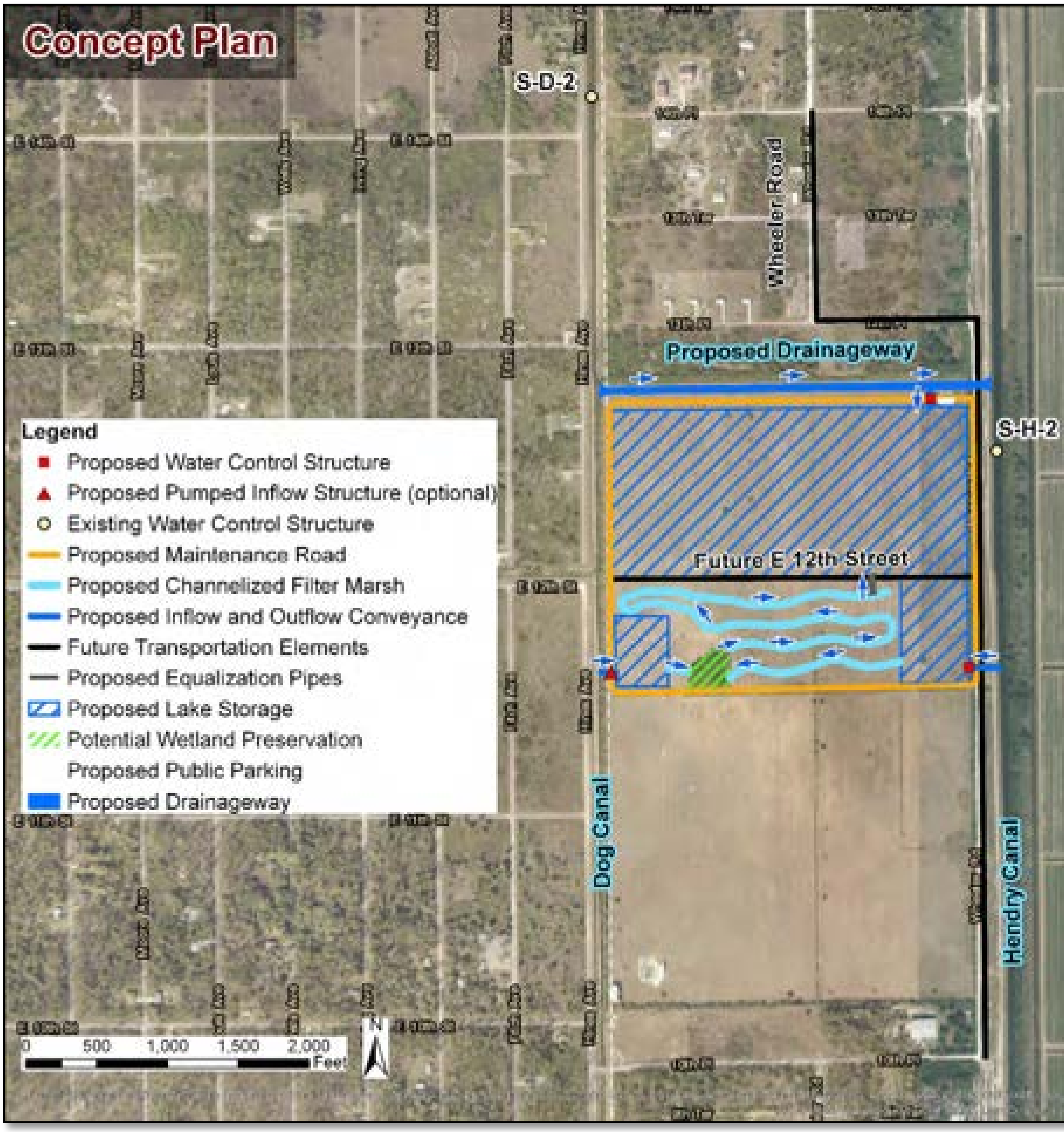


Figure 10 - Concept Plan, 1.1.1 Dog to Hendry Drainageway (CREST)

Purpose

The primary purpose of this project is to divert flow from Dog Canal to Hendry Canal that reduces flow in the Bedman Creek area to mitigate flooding issues. Hendry Canal has a greater potential for conveyance as it is a channelized outfall flow-way to the Caloosahatchee River. The Bedman Creek flow-way capacity is limited by the constrictive natural features that caused the experienced flooding during Hurricane Irma as indicated in aerial photo **Figure 11**. Note that this aerial photograph was taken a few days after the storm, so floodwaters had receded to some extent. Natural streams are also inherently surrounded by vegetation cover which limits the visibility of underlying waters. Nonetheless, water is still shown to surrounding structures days after Hurricane Irma.

Figure 11 - Aerial along Bedman Creek Taken 9-12-17

The concept project also creates a filter marsh for water quality treatment and storage reservoir for attenuation of peak flows. The large reservoir area provides necessary water storage during severe storm events benefitting the Carlos Waterway/Hendry Canal Drainage Basin. Although the Hendry Canal/Carlos Waterway is actually located within Hendry County, near the Lee/Hendry County line, all of the Hendry Canal flows are contributed by the Carlos Waterway Drainage Basin which is primarily located within Lehigh Acres/Lee County. During extreme storm events, water quality feature functionality would temporarily give way to increasing conveyance and storage capacity to reduce peak stages and increase recovery time. Optional pumped inflow from Dog Canal provides additional storage capacity for the Bedman Creek Drainage Basin along with water quality treatment benefits.

Evaluation

Viability

With the 350-foot Hendry Canal right-of-way, the ability to widen Hendry Canal and thus increase the conveyance capacity is available in the future. This concept plan does not necessitate increasing the conveyance of Hendry Canal. The widening of Hendry Canal is considered a possible future effort, should future build-out condition of Lehigh Acres necessitate this widening improvement. There is however a narrowing of the right-of-way on the north end of Hendry Canal to a 150-feet right-of-way as shown **Figure 12** below:

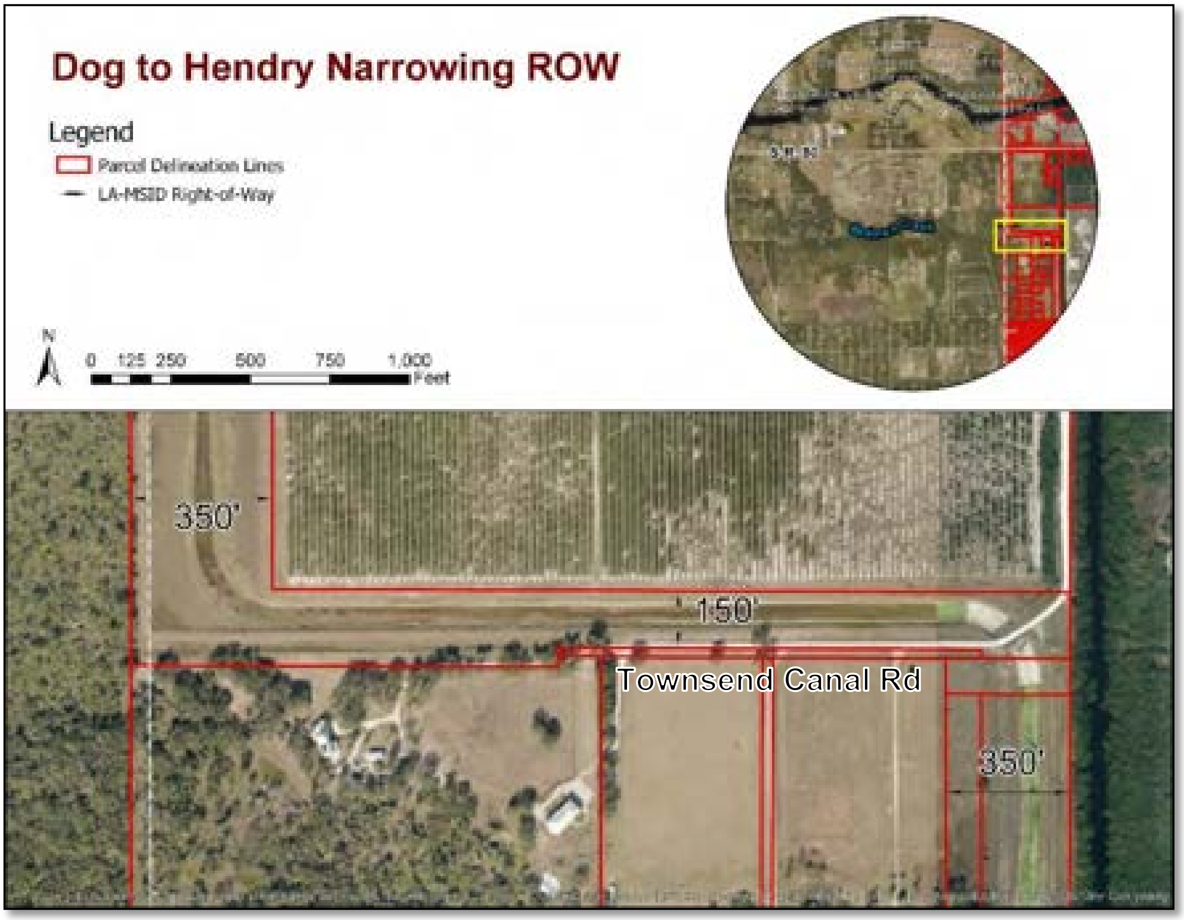


Figure 12 - Narrowing of LA-MSID Right-of-Way from 350' to 150'

Community Considerations

Adverse community impacts are minimal as this region is mostly undeveloped. The provision for public parking and access for passive recreation purposed may raise community support.

Environmental & Permittability Considerations

The site is not conducive for a panther habitat. The former agricultural lands would be enhanced by the incorporation of marsh plantings. The banks of the lake storage areas would be curvilinear and lined with pockets of shallow planting shelves for an ecologically productive and aesthetically pleasing ecosystem. There appears to be an existing depressional area that may be classified as a wetland by SFWMD. This area is proposed to be preserved and incorporated into the design without having adverse impacts. Permitting should not be an overly difficult effort for this project.

Land Availability

With the land already acquired by LA-MSID, the need for land acquisition has been accomplished to construct the Dog to Hendry Canal conveyance, reservoir storage, and water quality features. The 150-foot right-of-way on the north end of Hendry Canal at the Carlos Waterway may require future land acquisition to increase the right-of-way along the entire length of Hendry Canal.

Opinion of Probable Cost

The cost estimate shown in **Table 2** below is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the Hendry Canal thereby reducing trucking distance requirements.

Table 2 – Opinion of Probable Cost breakdown, 1.1.1 Dog to Hendry Drainageway (CREST)

Component	Quantity	UNIT	UNIT COST	COST
Construction Costs Phase I	1	LS	$ 1,900,000	$ 1,900,000
			Construction Cost Sub-Total:	**$ 1,900,000**
			Professional Services: Eng, Survey, Environ, Geotech (10%)	$ 190,000
			Land Acquisition	$ -
			Project Administration/ CEI (10%):	$ 190,000
			Project Unknowns	$ -
			Conceptual Project Cost:	**$ 2,280,000**
			Contengency (NA)	$ 420,000
			Conceptual Project Cost (with Contengency):	**$ 2,700,000**

*A Lump Sum for construction is provided for this project as design is underway and a more specific cost opinion of probable cost was prepared for that effort. This is also reflected in the selected 10% percentage for professional services on this particular project.

Opportunities for Multiple Benefits & Uses

Besides the hydraulic/hydrologic benefits, this project concept creates additional opportunities for providing a water quality treatment component. The incorporation of a passive recreational facility in the project concept would be an additional benefit to the community.

Other Considerations

As this project concept generates surplus fill material, coordinating the earthwork activity of this project concept with another community project requiring fill may be mutually beneficial. A summary of this concept project is shown below in **Exhibit 1.1.1** herein.

Findings & Recommendations

Regional Modeling Findings

The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.1.1 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

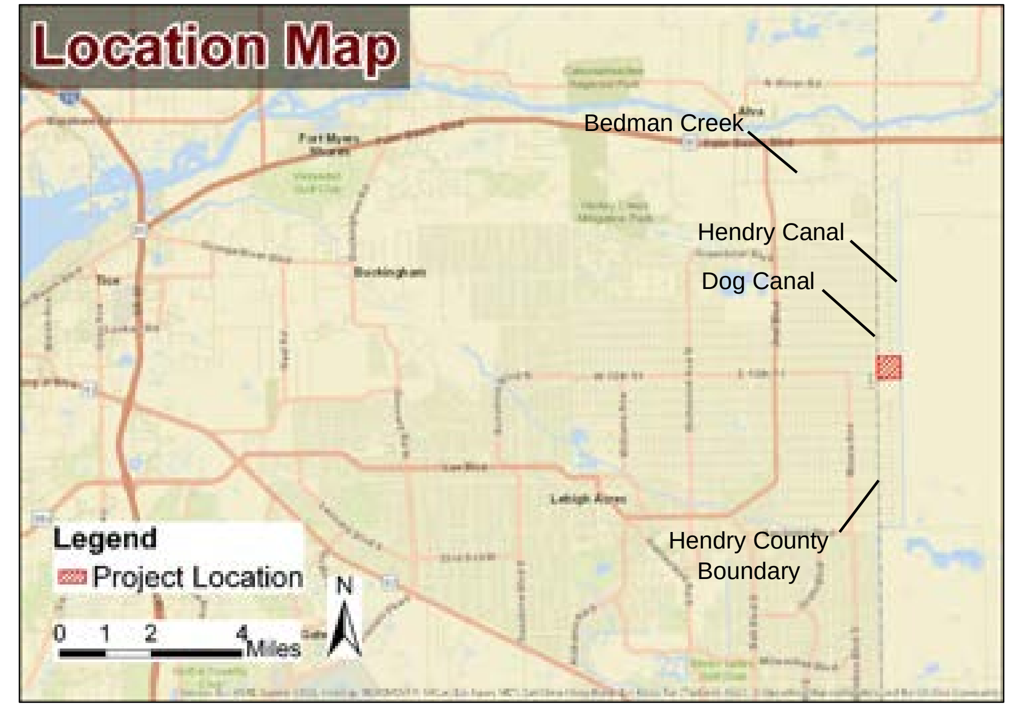
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.1 (b) EXHIBIT 1.1.1 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.1 (d) EXHIBIT 1.1.1 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.1 (f) EXHIBIT 1.1.1 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.1 (h) EXHIBIT 1.1.1 (i)

The proposed drainageway allows for flow from Dog Canal to Hendry Canal thereby reducing the peak stage within Dog Canal. Incorporating the stormwater storage reservoir improves the peak stages within Hendry Canal. The proposed drainageway reduces the peak flow and flow volume in Dog Canal. Although additional flow is being diverted to Hendry Canal, the stormwater reservoir reduces downstream peak flow downstream of the concept project.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by diverting flow from Dog Canal to Hendry Canal which reduces excess flow to the Bedman Creek area, provides for possible creation of a filter marsh for water quality treatment and creation of a storage reservoir for attenuation of peak flows.

EXHIBIT 1.1.1



Project Narrative

DESCRIPTION: This proposed conceptual project interconnects Dog Canal with the Hendry Canal just south of the S-D-2 weir and equalizes water level with the Hendry Canal to divert excess stormwater flow away from Bedman Creek and to the Caloosahatchee River via the Carlos Waterway.

Along with this canal interconnection is an opportunity to create a water quality treatment and stormwater storage reservoir on a 105-acre parcel recently obtained by LA-MSID. This parcel would provide large excavated lake areas for additional storage capacity and a channelized filter marsh for water quality improvements.

PURPOSE: This project offers a flow diversion from Dog Canal to Hendry Canal that reduces excess flow to the Bedman Creek area and provides for possible creation of a filter marsh for water quality treatment and a reservoir for attenuation of peak flows.

CONSTRAINTS: Since the land is owned by LA-MSID and no adverse environmental impacts are evident, constraints, if any, are not apparent.

May 2020

Dog to Hendry Drainageway (CREST)
East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.1

EXHIBIT 1.1.1 (a)

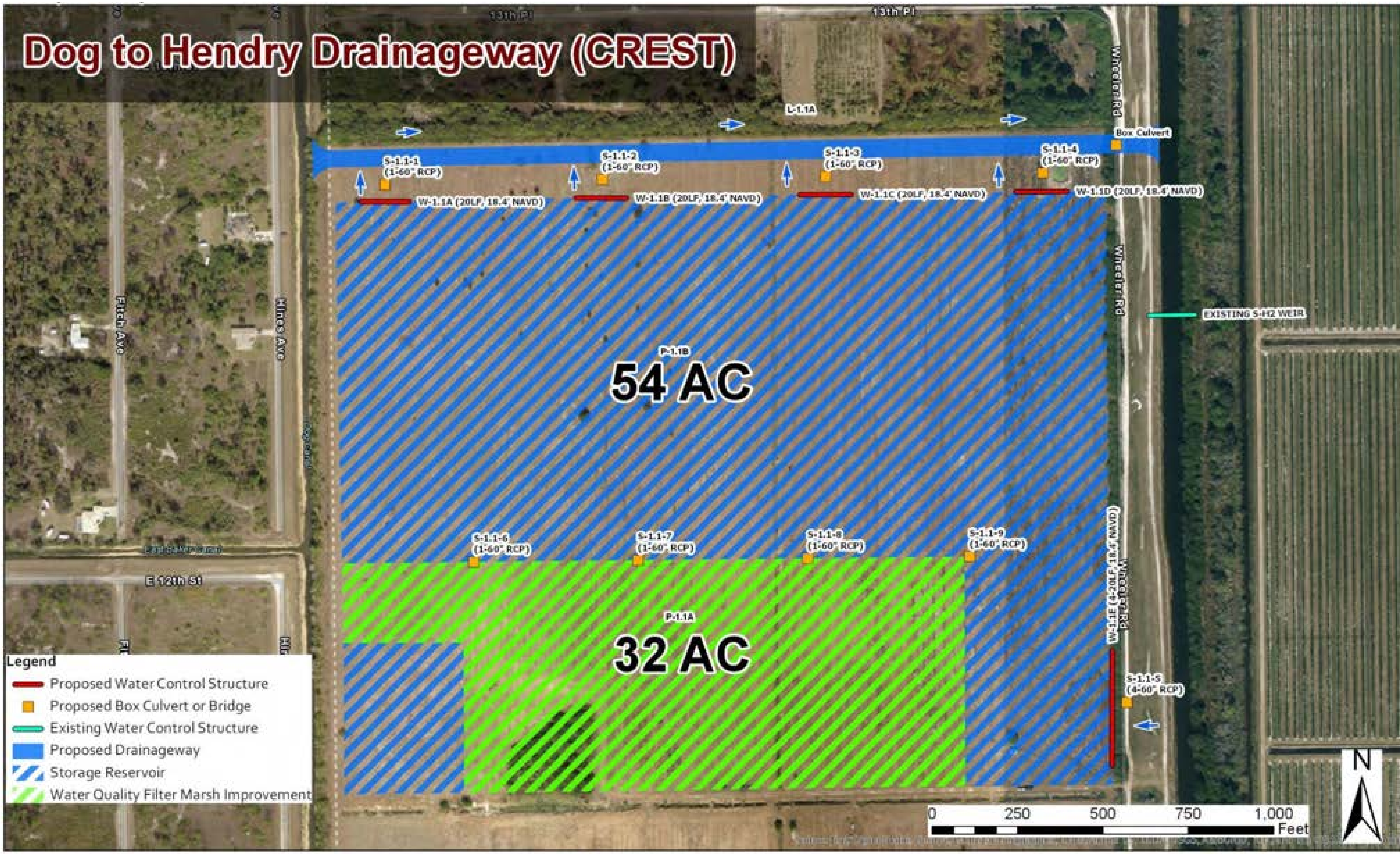


EXHIBIT 1.1.1 (b)

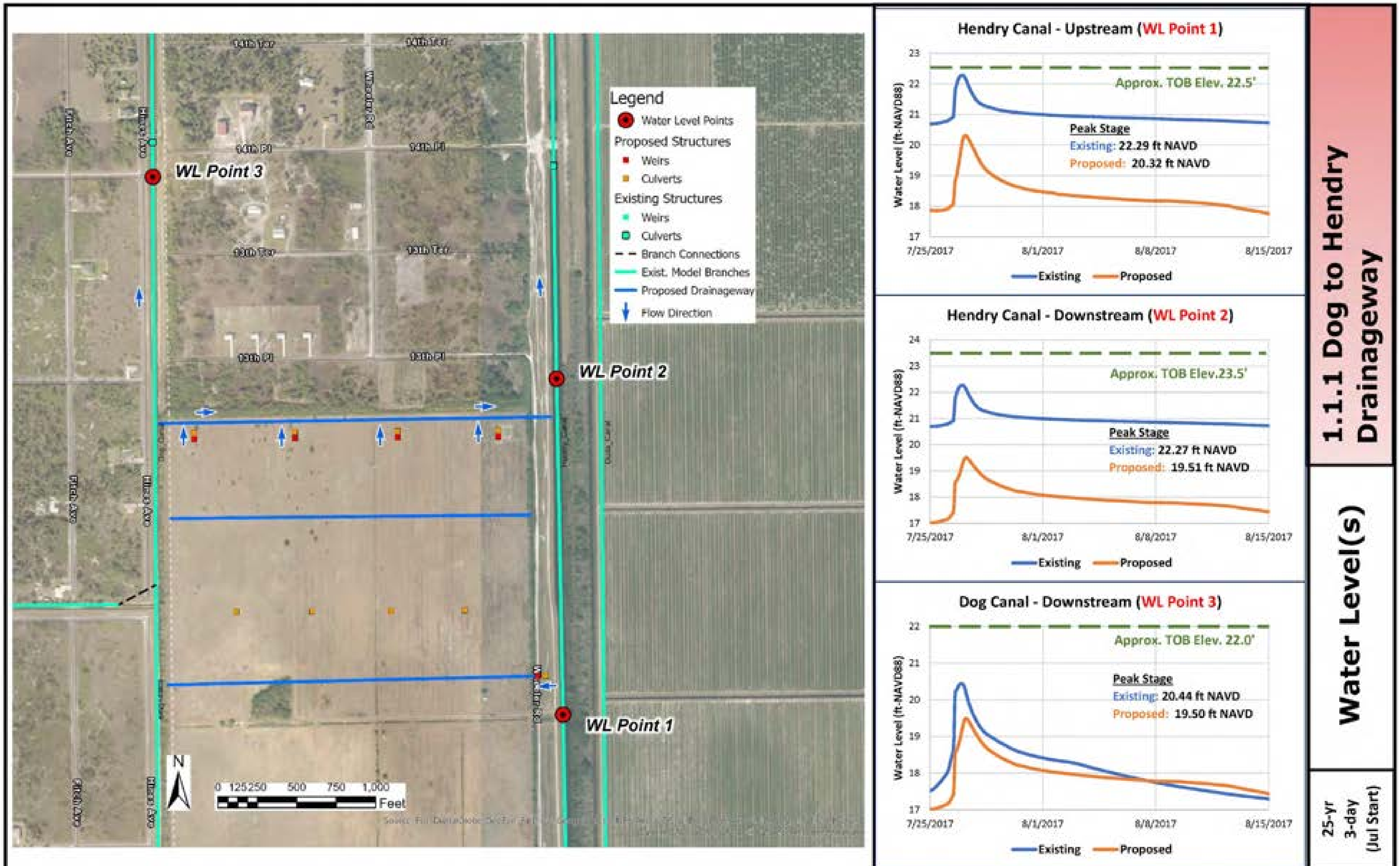


EXHIBIT 1.1.1 (c)

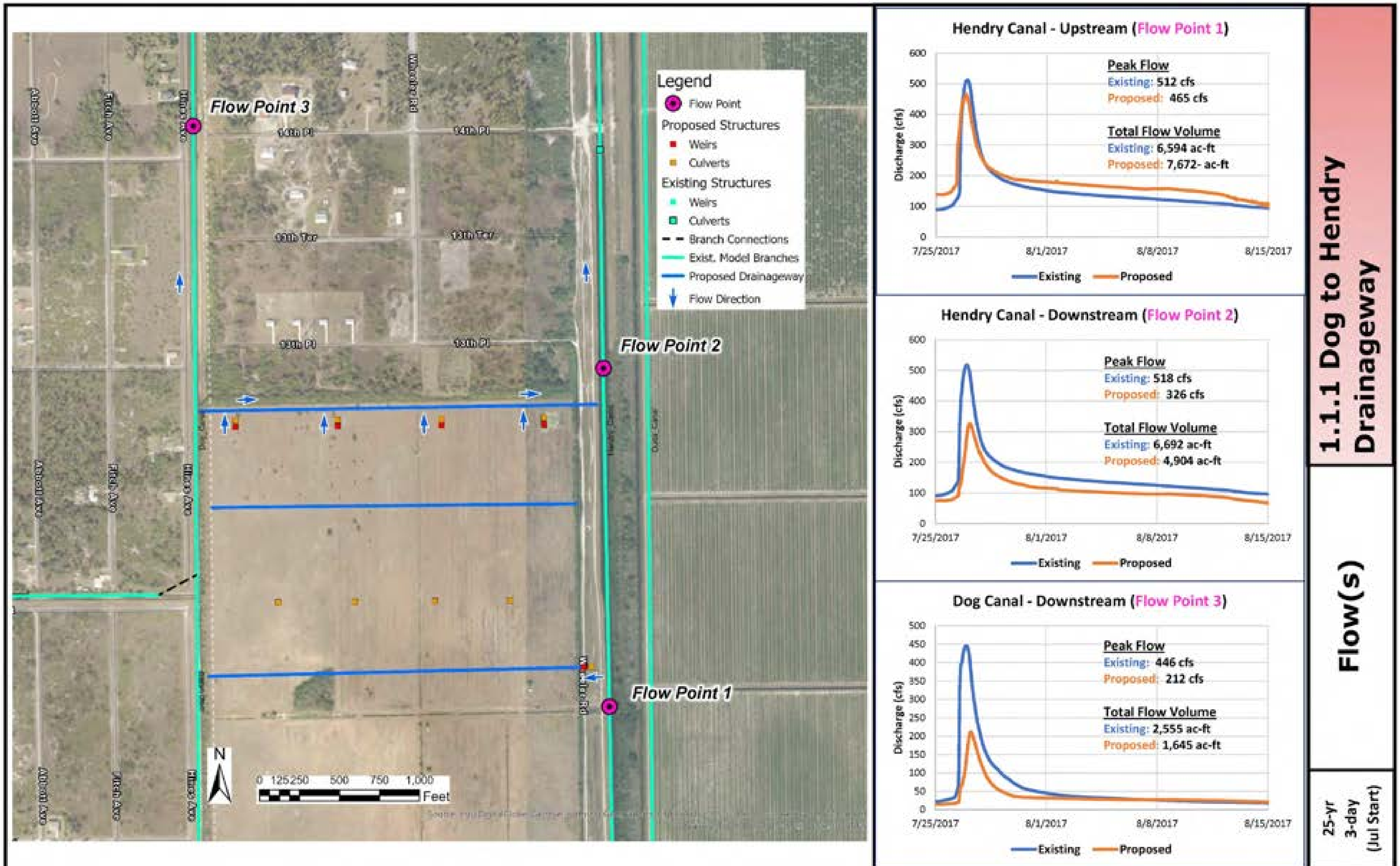


EXHIBIT 1.1.1 (d)

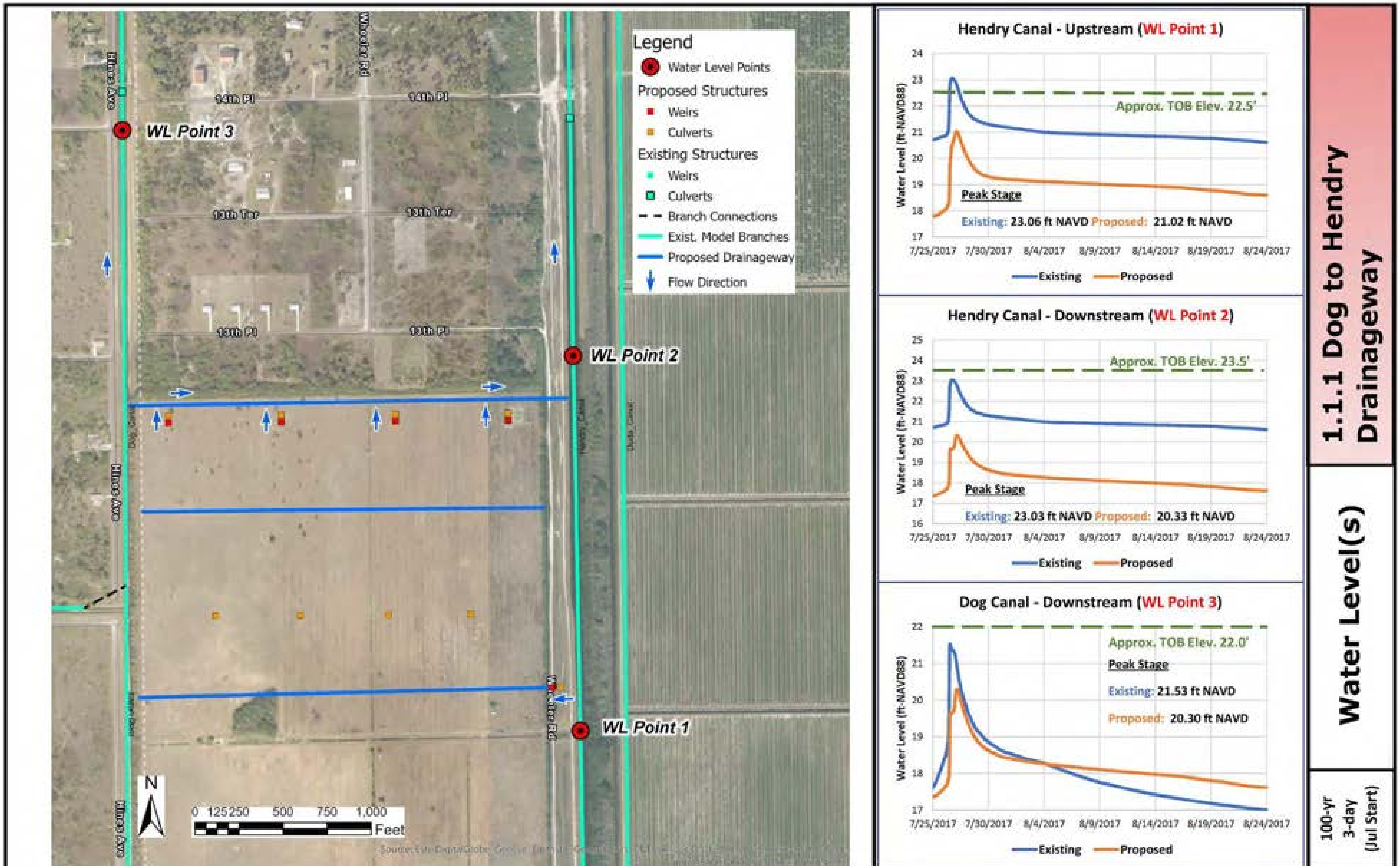


EXHIBIT 1.1.1 (e)

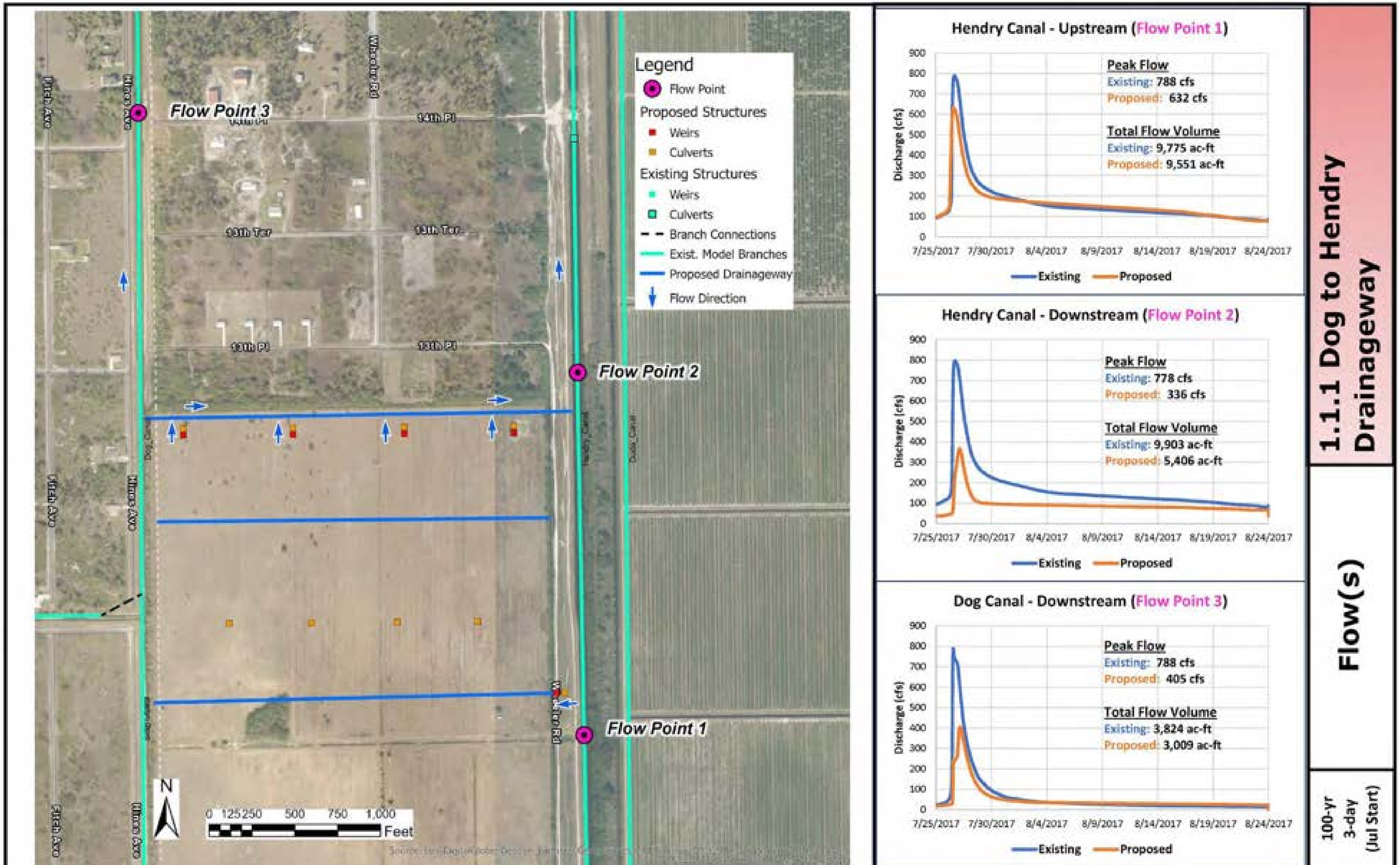


EXHIBIT 1.1.1 (f)

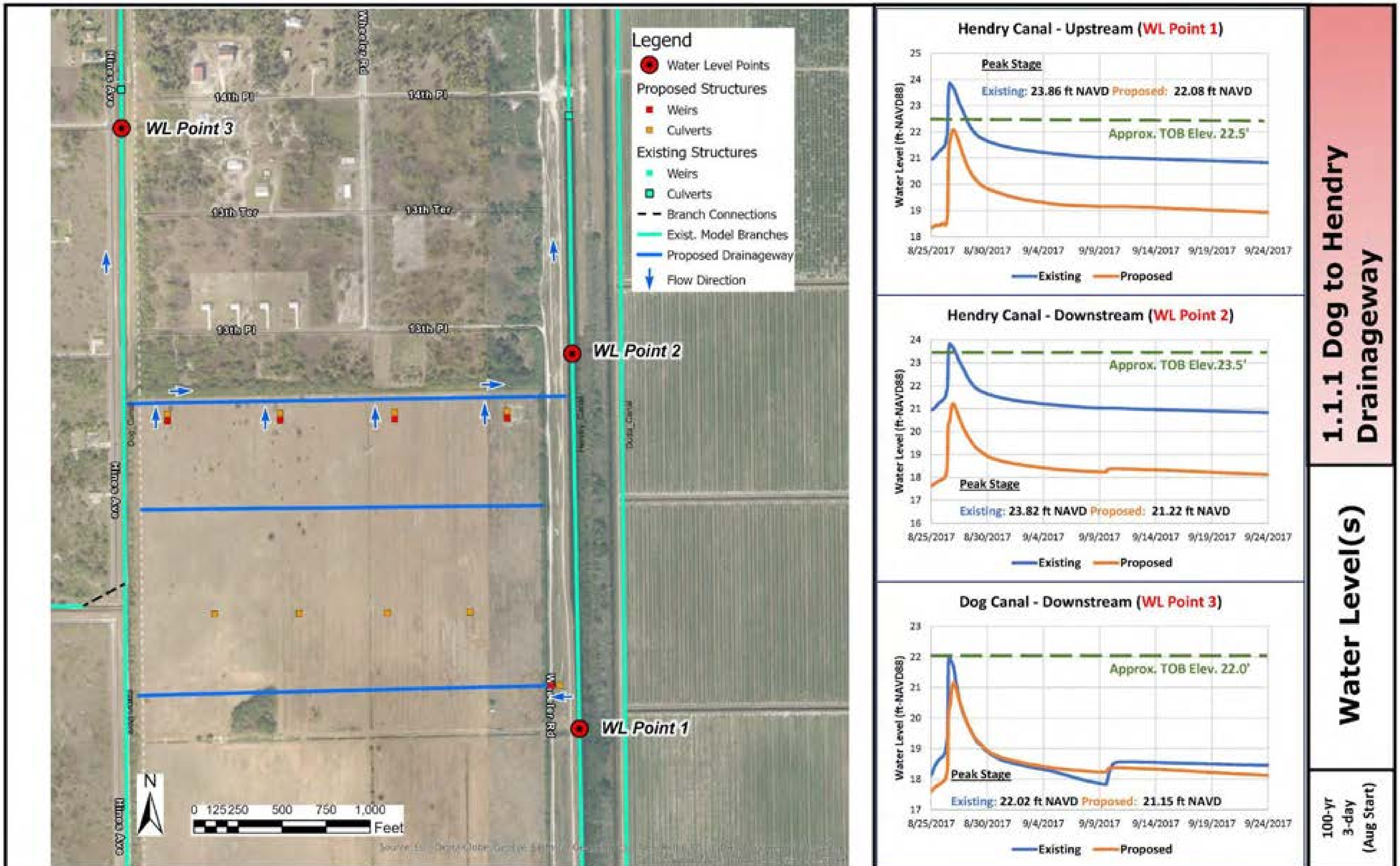


EXHIBIT 1.1.1 (g)

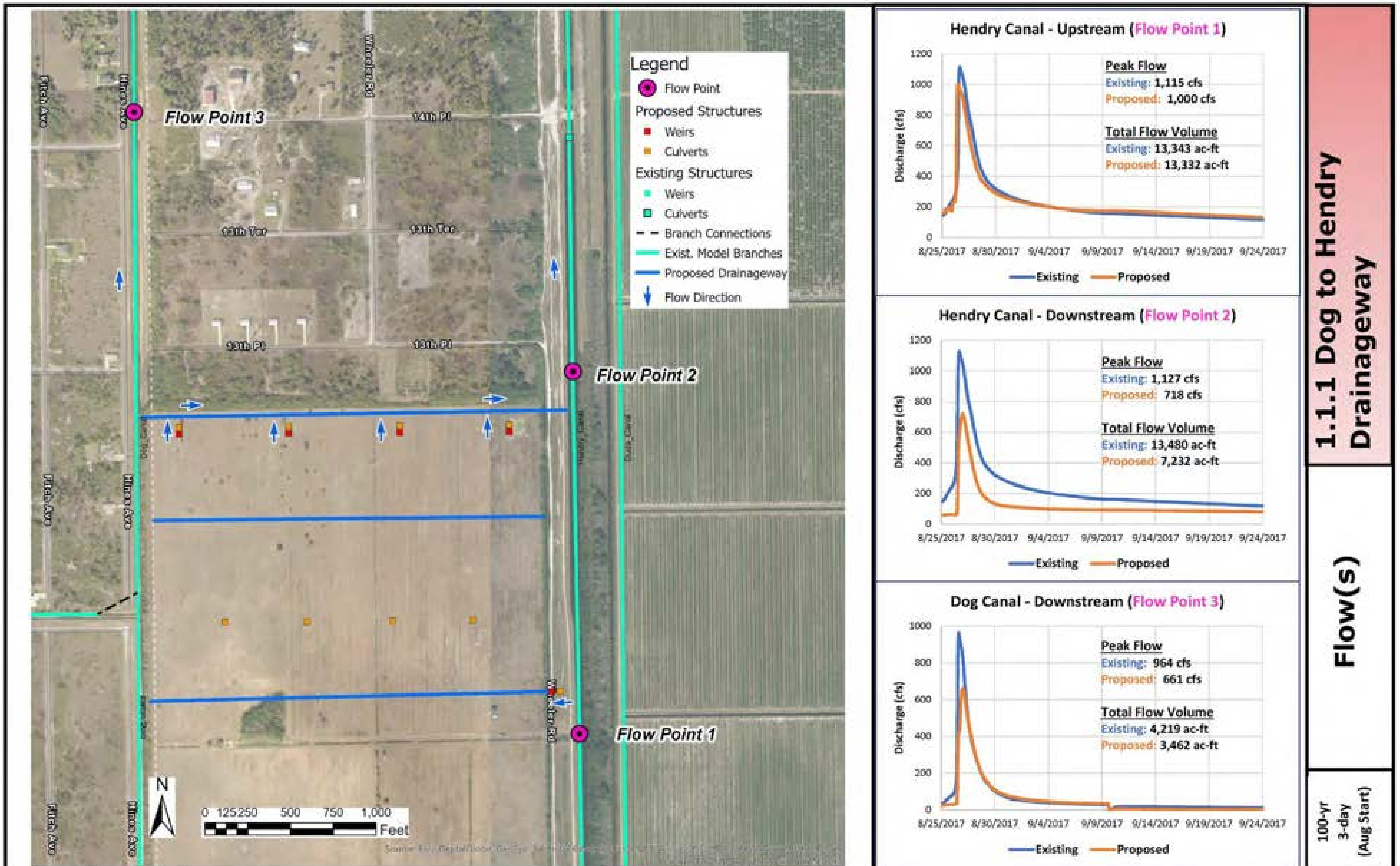


EXHIBIT 1.1.1 (h)

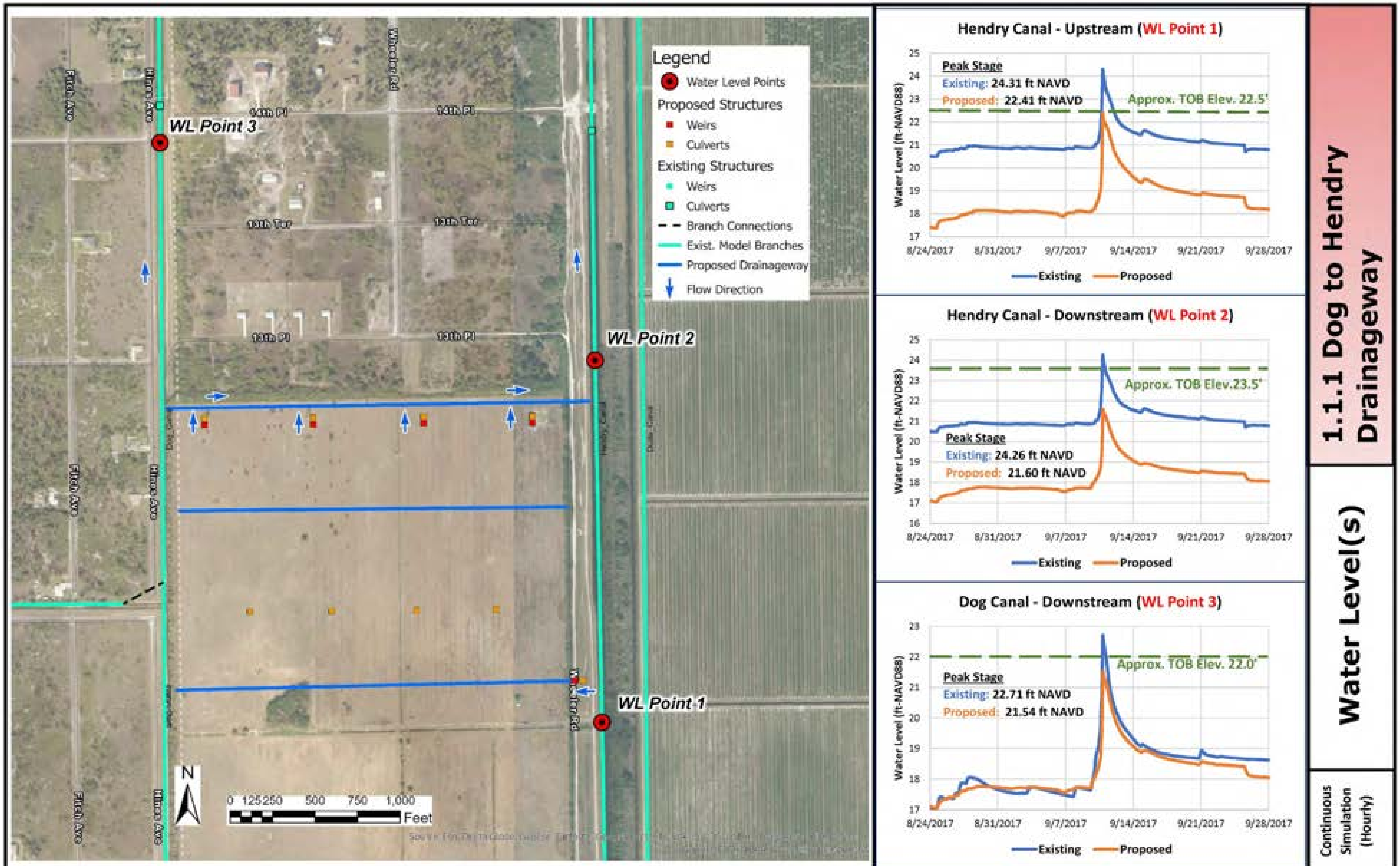
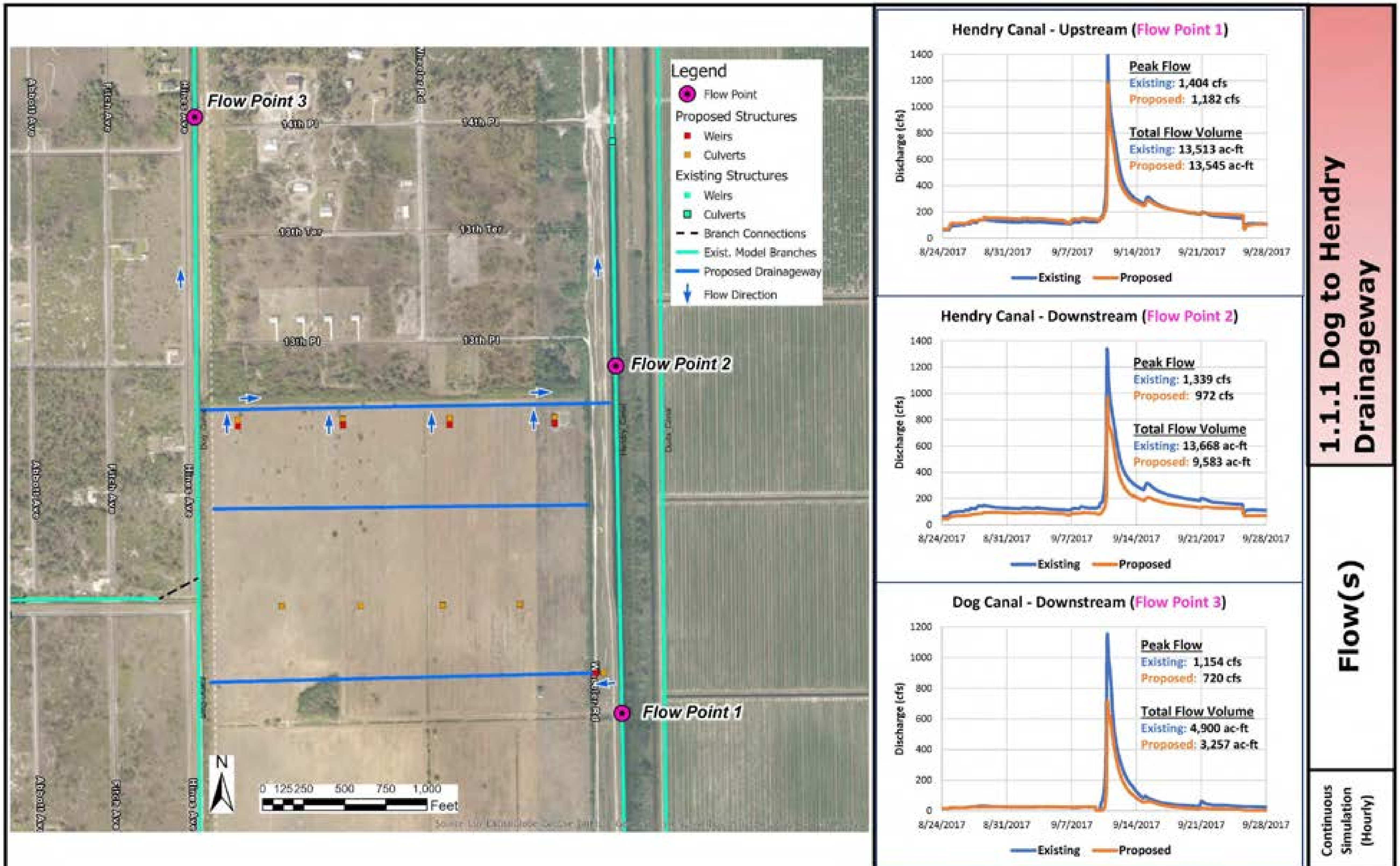


EXHIBIT 1.1.1 (i)



1.1.2 Bedman Creek Overflow Bypass

Background

The concept project diverts flow from the intersection of Dog Canal and Bedman Creek northeasterly to Carlos Waterway. The land cover of the area surrounding this concept project historically includes a natural creek bed, heavy tree coverage with cabbage palms, and mixed wetland hardwoods. Bedman Creek has an approximately 500-foot floodplain that is subject to flooding. This area serves as a major outfall for Lehigh Acres and Carlos Waterway connects to Hendry Canal. Flows are now limited by water control structures to minimize flows to Bedman Creek. Select parcels adjacent to this concept project have been submitted for consideration of purchase to the Lee County Conservation 20/20 land purchase program, but the parcels remain in private ownership.

Location

This concept project is located on a 116-acre parcel(s) at the northeast corner of the East Lee County area along the Lee and Hendry County line in Section 36, Township 43 South, and Range 28 East as illustrated by **Figure 13** below.

Figure 13 - Location Map, 1.1.2 Bedman Creek Overflow Bypass

Description

This proposed conceptual project interconnects Dog Canal at Bedman Creek to the Carlos Waterway to divert excess stormwater flow directly to the Caloosahatchee River. Approximately 25% or 2,000 CFS out of Lehigh Acres 65,000-acre watershed is anticipated with this project at a three (3”) inch per day removal rate. Water control structures would regulate flow of the conveyance connection, as well as maintain Bedman Creek baseflow and recreational activities.

Along with this conveyance interconnection is an opportunity to create a water quality treatment and stormwater storage. This parcel would provide +/-17 acres of deep lake detention areas for additional storage capacity and +/-20 acres of shallow vegetated filter marsh for water quality improvements. Existing land elevations may warrant pumped inflow from the adjoining conveyance connection from Dog Canal to Carlos Waterway. Outflow could discharge back into the conveyance connection, as well as Bedman Creek downstream of the water control structures as illustrated by **Figure 14** below:

Figure 14 - Concept Plan, 1.1.2 Bedman Creek Overflow Bypass

Purpose

This project offers a very significant conveyance of excess stormwater runoff from the Lehigh Acres area and greatly reduces the dependence on the natural Bedman Creek while providing a much-reduced recovery time between large storm events. Home and roadway flooding in the area would be reduced. The secondary purposes include the water quality benefits achieved though the potential filter marsh area. The residents within the Bedman Creek area and Lehigh Acres would greatly benefit from this project.

Evaluation

Viability

LA-MSID is in current ownership of the 20-acre Dog Canal parcel consisting of a +/-170-foot wide canal right-of-way. There is however a narrowing of the right-of-way on the north end of the concept project where Carlos Waterway outfalls to the Caloosahatchee River. This narrowing of the 350-foot Carlos Waterway right-of-way to 150 feet likely requires expansion and land acquisition. The water control structure at this location could also need to be revised to accommodate the increase conveyance. However due to the substantial amount of flow this project is anticipated to handle, this project concept is considered to be highly viable.

Community Considerations

Adverse community impacts are minimal as this region is mostly undeveloped. The water control structure for Bedman Creek could include a narrow opening to allow for the continuation of Bedman Creek baseflow and passage of canoes/kayaks through the structure. The filter marsh area could include community access for bird watching, pedestrian trail hiking, etc.

Environmental & Permittability Considerations

From the Lee County Appraiser map, the site is not designated as an eagle nesting site buffer or panther habitat. The soil composition consists of 53% Oldsmar Sand, 15% Electra Fine Sand, 14% Boca Fins Sand, 11% Felda Fine Sand, and 7% Copeland Sandy Loam (Depressional) which is conducive for proper filter marsh infiltration. A 69% portion of the site has an archaeological sensitivity level 2 and a Rural planning land use (2010). Flood insurance zones include 59% AE (EL 16’ NAVD 88), 27% AE (EL 17’ NAVD 88), 8% X (shaded), and 6% X. With 26% of the site already designated as a FIRM Floodway area, using this site for flood reduction appears compatible.

The extent of native vegetation and/or wetland mitigation as a part of the SFWMD permitting process necessitates future design level analysis, although permit approval appears favorable for this project with the incorporation of the large water quality area as illustrated by the example concept filter marsh in **Figure 15** below:

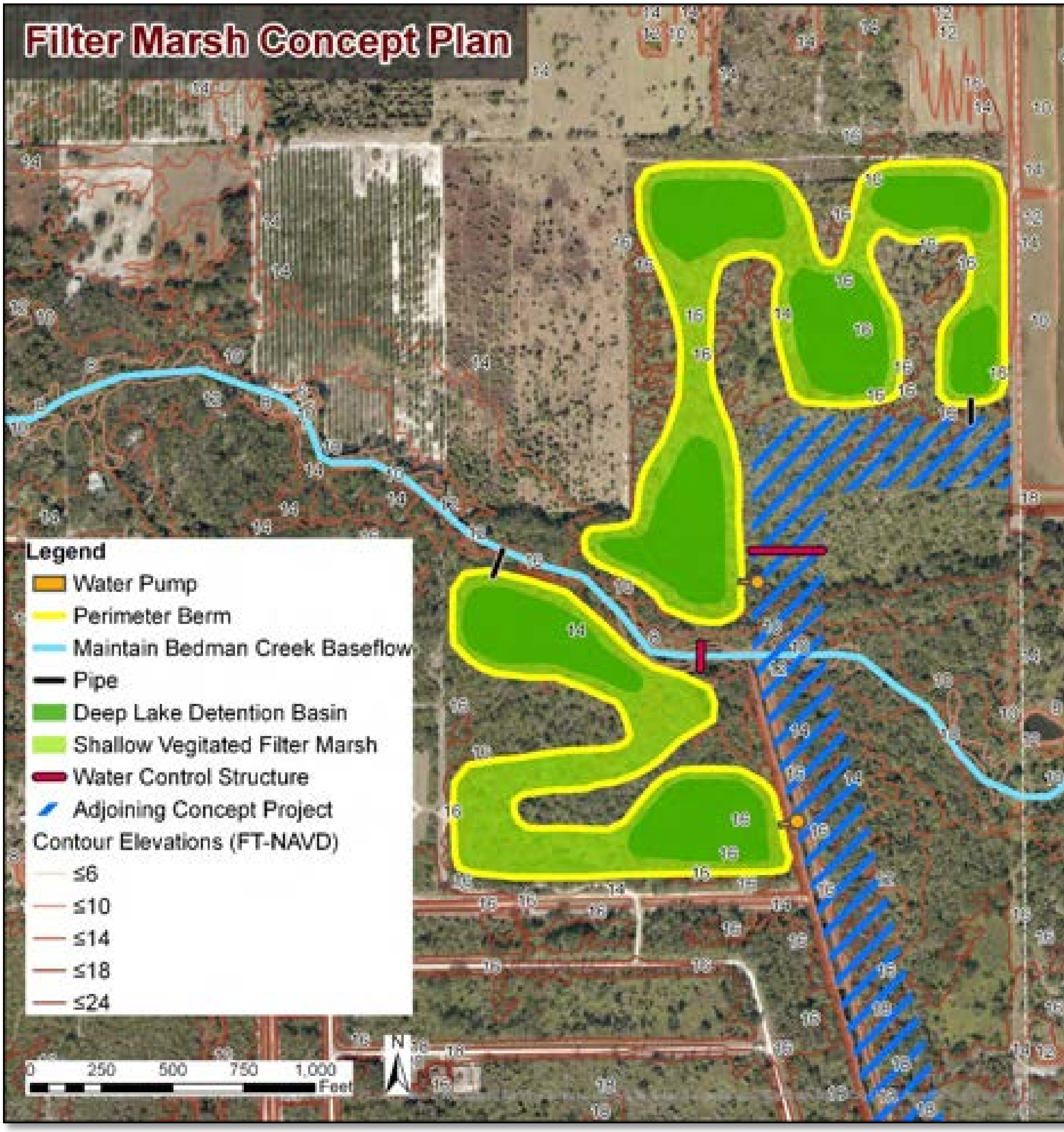


Figure 15 - Example Filter Marsh Concept Plan, 1.1.2 Bedman Creek Overflow Bypass

Land Availability

With LA-MSID in current ownership of the Dog Canal right-of-way, the need for land acquisition is limited to the 95.95-acre parcel and a smaller parcel at the Carlos Waterway outfall. The extent of increased culvert capacity under S.R. 80 within FDOT right-of-way can be further analyzed in the design phase.

Opinion of Probable Cost

The cost opinion shown in **Table 3** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 3 - Opinion of Probable Cost breakdown, 1.1.2 Bedman Creek Overflow Bypass

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,347,000	$ 1,347,000
Clearing & Grubbing	23	AC	$ 14,000	$ 322,000
Earthwork	300,000	CY	$ 6	$ 1,800,000
Weir Structure 1.2A (Major/ Extension)	180	LF	$ 10,000	$ 1,800,000
Weir Structure 1.2B (Basic/ Modification)	280	LF	$ 1,000	$ 280,000
Weir Structure 1.2C (Basic/ Modification)	280	LF	$ 1,000	$ 280,000
Weir Structure 1.2D (Standard)	120	LF	$ 5,000	$ 600,000
Box Culvert 1.2-2	320	CY	$ 1,200	$ 384,000
Permanent Erosion Control	28,000	SF	$ 25	$ 700,000
Grassing	43,500	SY	$ 2	$ 87,000
Conceptual Construction Costs:				$ 7,600,000
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 2,280,000
Land Acquisition				$ 1,900,000
Project Administration/ CEI (10%)				$ 760,000
Project Unknowns				$ 560,000
Conceptual Project Cost:				$ 13,100,000
Contengency (30%)				$ 3,900,000
Conceptual Project Cost (with Contengency):				$ 17,000,000

Opportunities for Multiple Benefits & Uses

Accomplishing approximately 25% or 2,000 CFS out of Lehigh Acres 65,000-acre watershed in one project is an outstanding opportunity. As Lehigh Acres continues to reach full build-out conditions, improving the conveyance of the Bedman Creek Drainage Basin is a critical priority. Providing water quality solutions will also become increasingly difficult as development diminishes the available undeveloped land. This project allows for potential incorporation of water quality improvement components.

Other Considerations

This 96-acre parcel has been previously evaluated for purchase by Lee County Conservation 20/20. Although not selected for purchased at the time, reconsideration is appropriate as this parcel is a prime flood mitigation location. A summary of this concept project is shown below in **Exhibit 1.1.2** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of bypassing excess stormwater flows from Dog Canal to Carlos Waterway to direct high flows to the Caloosahatchee River to mitigate flooding on Bedman Creek. The refined concept plan is shown in **Exhibit 1.1.2 (a)**. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

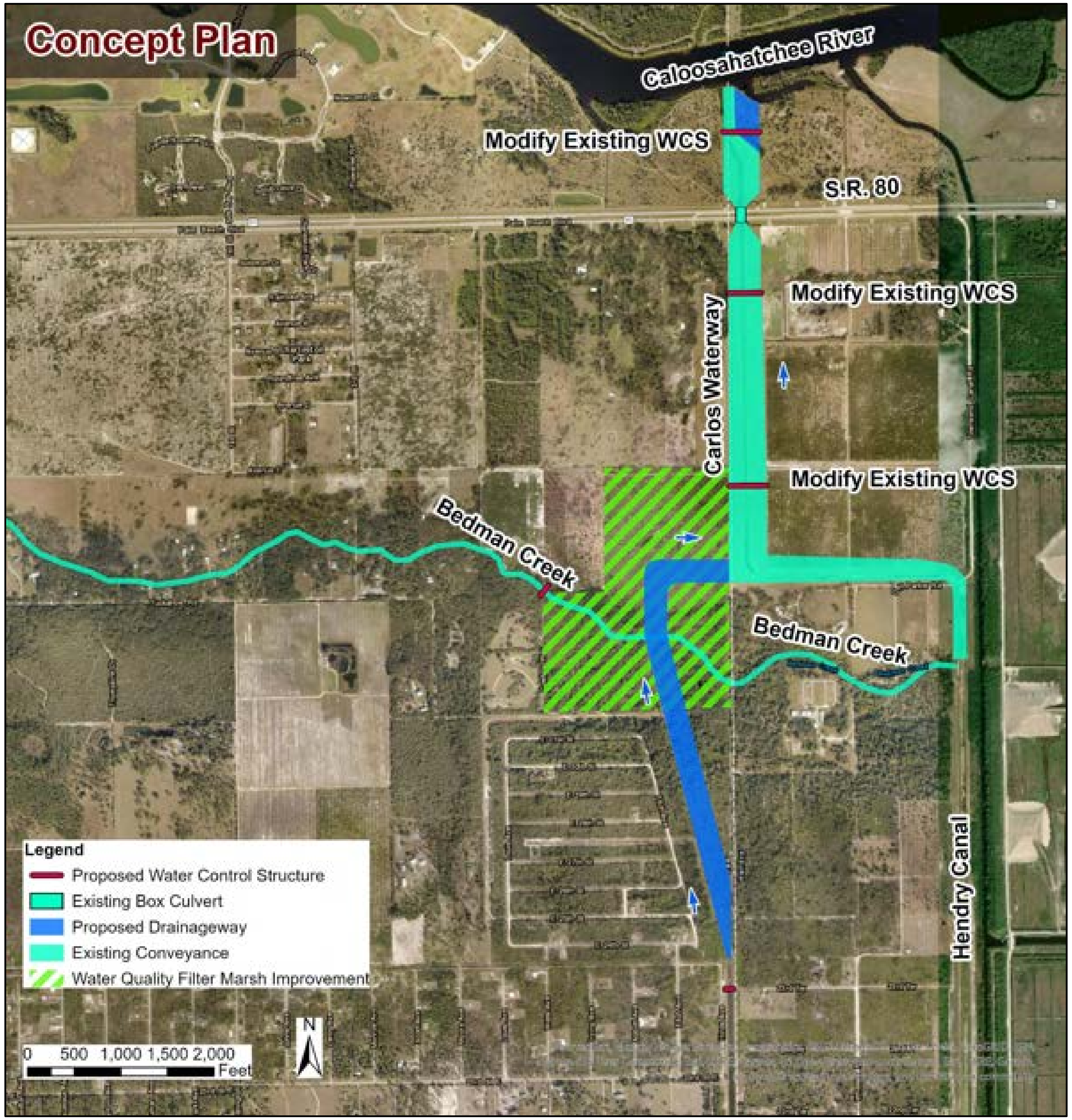
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.2 (b) EXHIBIT 1.1.2 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.2 (d) EXHIBIT 1.1.2 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.2 (f) EXHIBIT 1.1.2 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.2 (h) EXHIBIT 1.1.2 (i)

Peak stages within Bedman Creek are seen to dramatically decrease. Water levels in Dog Canal, Hendry Canal, and Carlos Waterway are also shown to decrease in modeling the proposed conveyance improvements. Flow in Bedman Creek was reduced, while additional discharge was directed down Carlos Waterway as intended. This project concept screening demonstrates a benefit in reducing peak flow to Bedman Creek while achieving high flows in Carlos Waterway to mitigate flooding in Lehigh Acres. These positive improvements of this project concept warrant proceeding to design-level development.

Recommendations

Creating the bypass proposed through Bedman Creek allows for excess stormwater from Dog Canal to Carlos Waterway to direct high flows to the Caloosahatchee River, thus mitigating flood stages along Bedman Creek. Adjacent land, if purchased, could provide for possible creation of a filter marsh for water quality treatment and a storage reservoir for attenuation of peak

EXHIBIT 1.1.2



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project interconnects Dog Canal at Bedman Creek to the Carlos Waterway to divert excess stormwater flow directly to the Caloosahatchee River. Approximately 25% or 2,000 CFS out of Lehigh Acres 65,000-acre watershed is anticipated with this project at a three (3”) inch per day removal rate.

PURPOSE: This project offers a very significant conveyance of excess stormwater runoff from the Lehigh Acres area and greatly reduces the dependence on the natural Bedman Creek while providing a much-reduced recovery time between large storm events. Home and roadway flooding in the area would be reduced.

CONSTRAINTS: This project, as planned, crosses public and private lands requiring governmental approvals and land acquisition. Weir structures to manage water levels and a large drainage structure at S.R. 80 would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Bedman Creek Overflow Bypass

East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.2

EXHIBIT 1.1.2 (a)

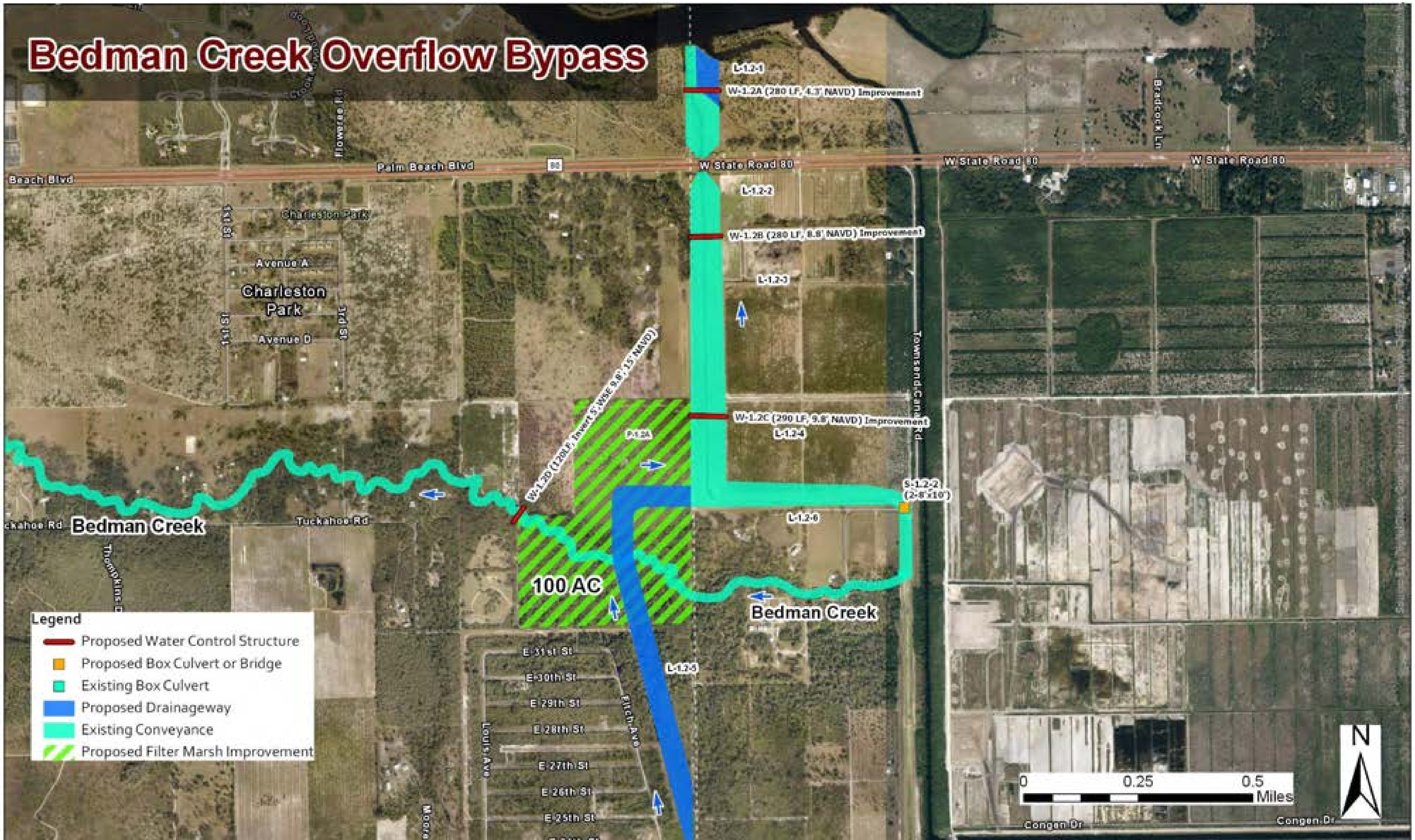


EXHIBIT 1.1.2 (b)

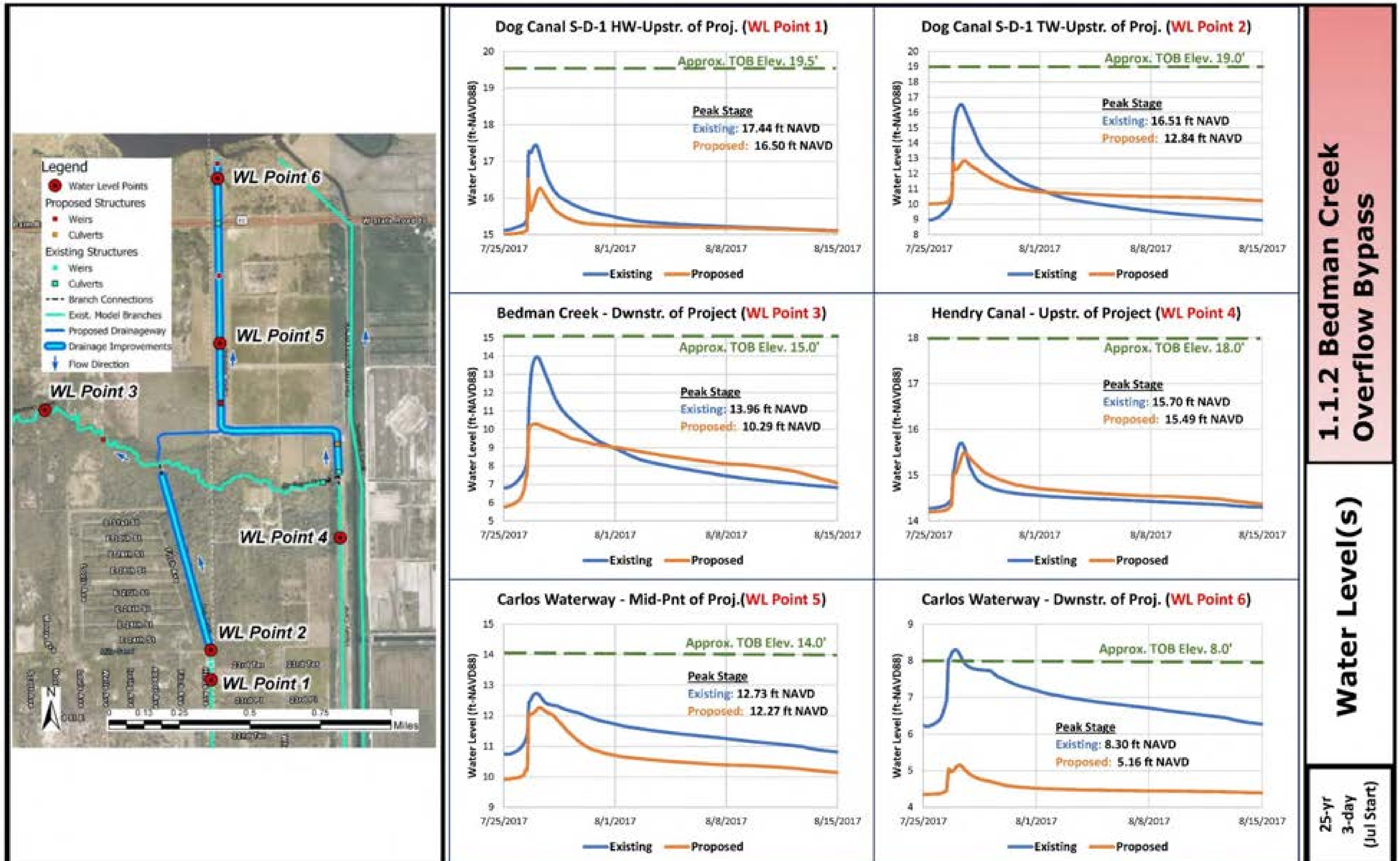


EXHIBIT 1.1.2 (c)

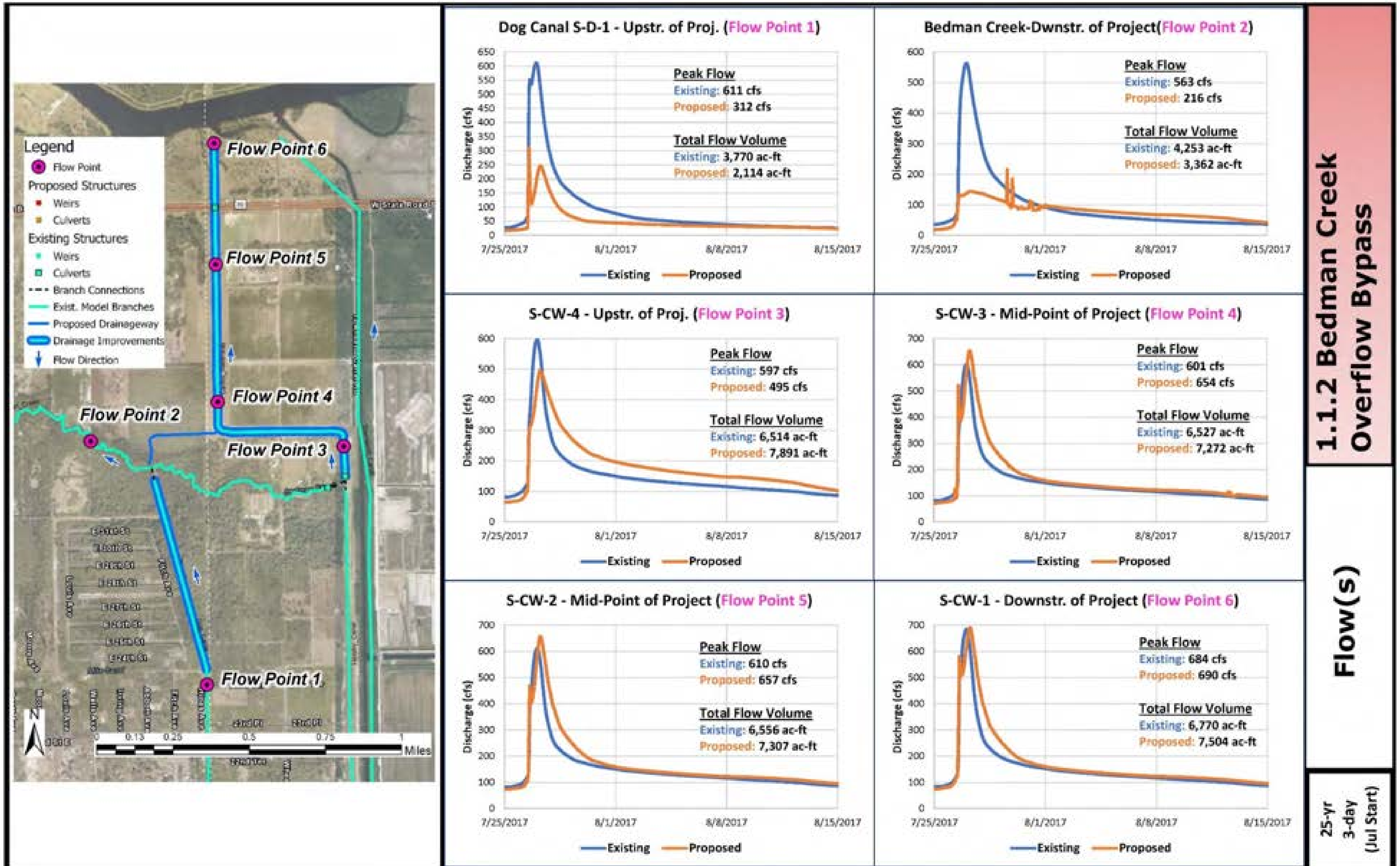


EXHIBIT 1.1.2 (d)

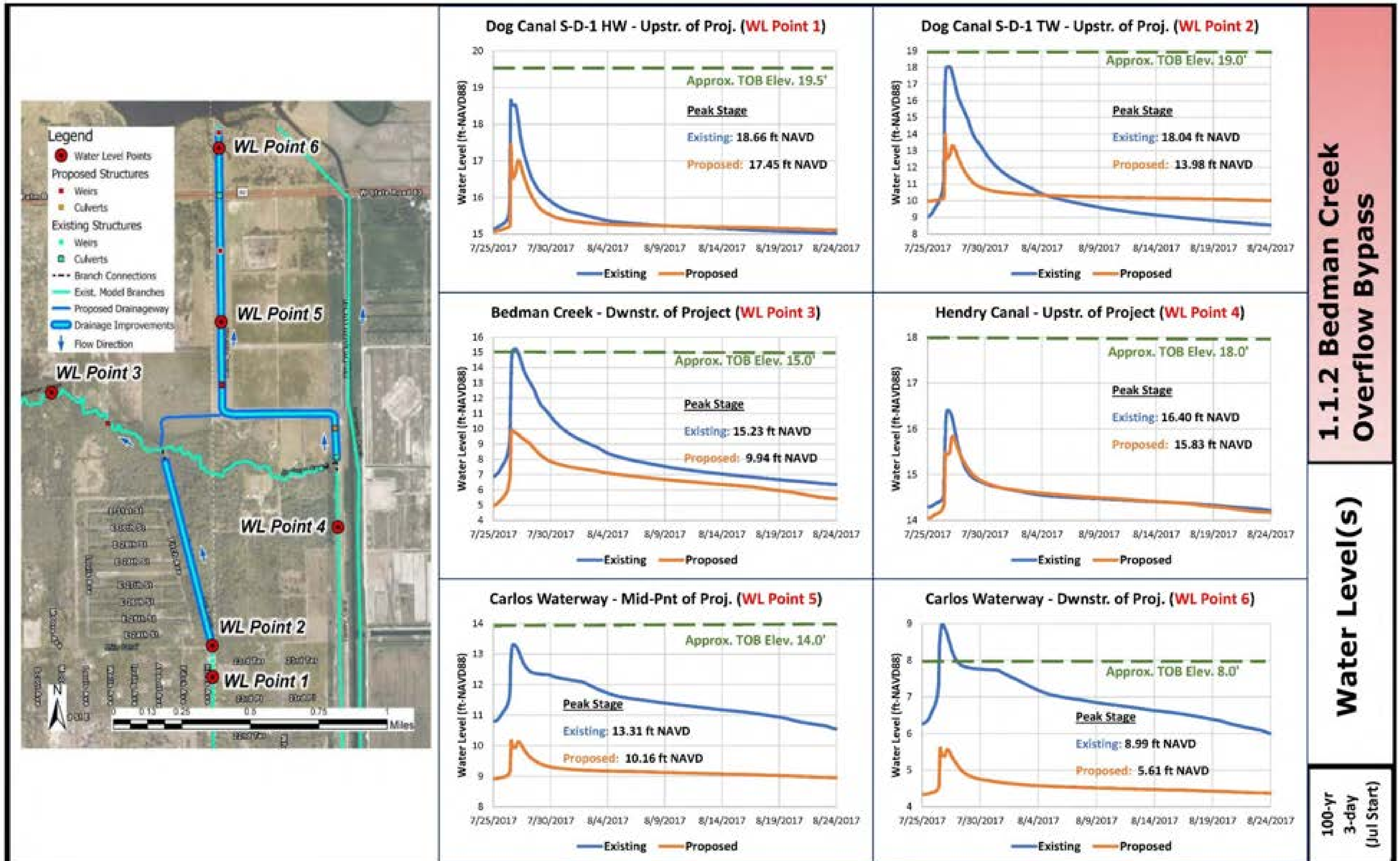
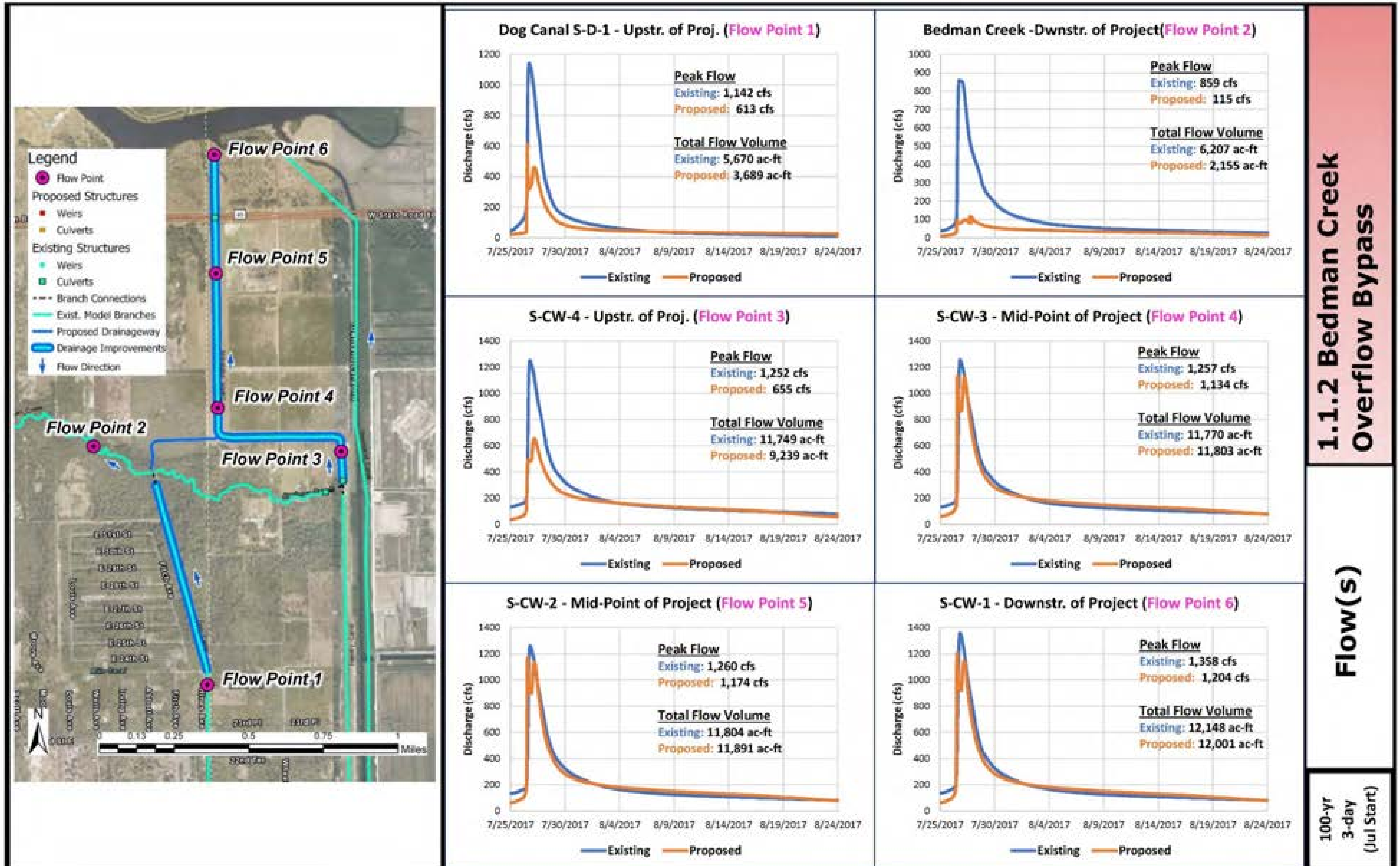


EXHIBIT 1.1.2 (e)



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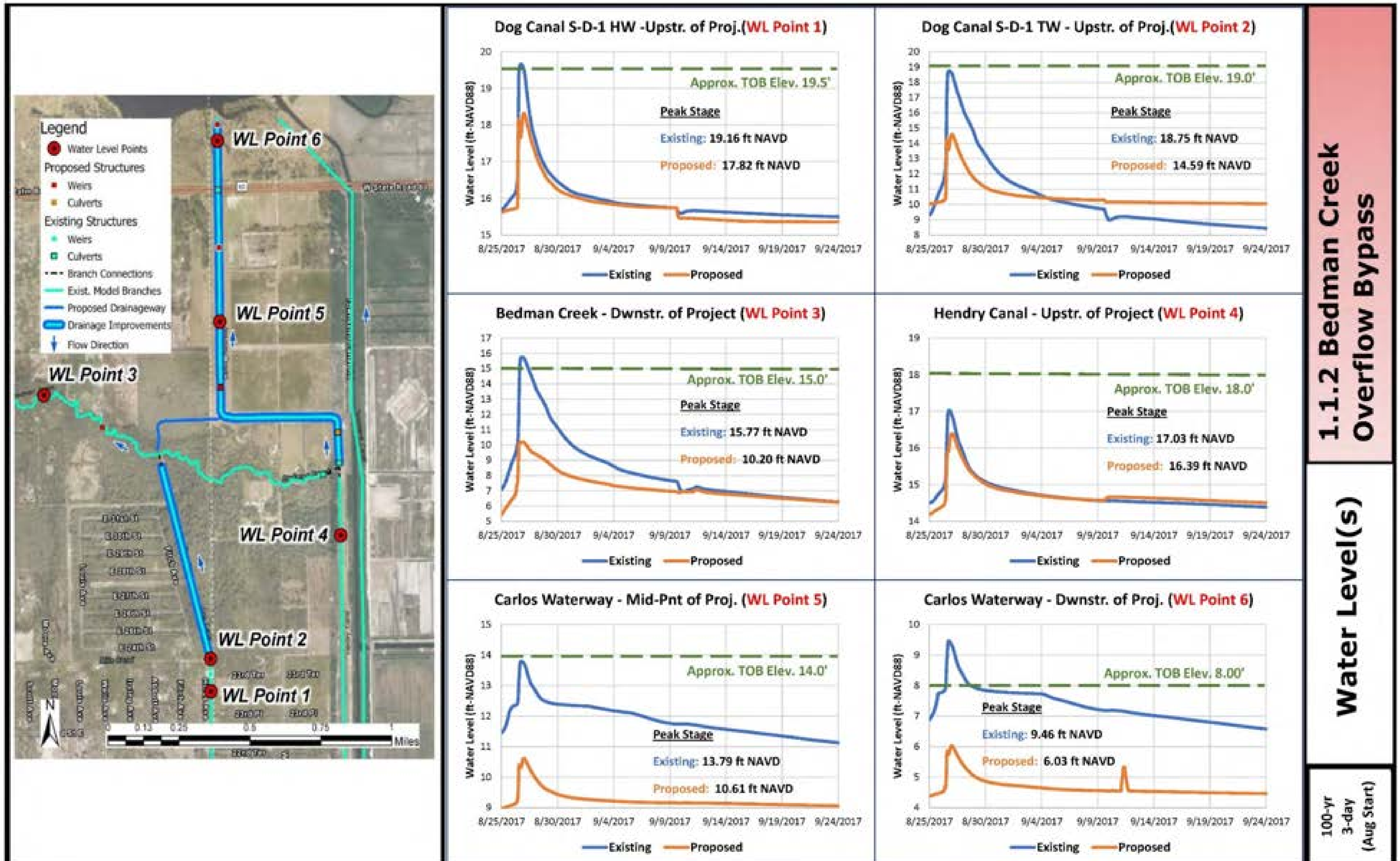
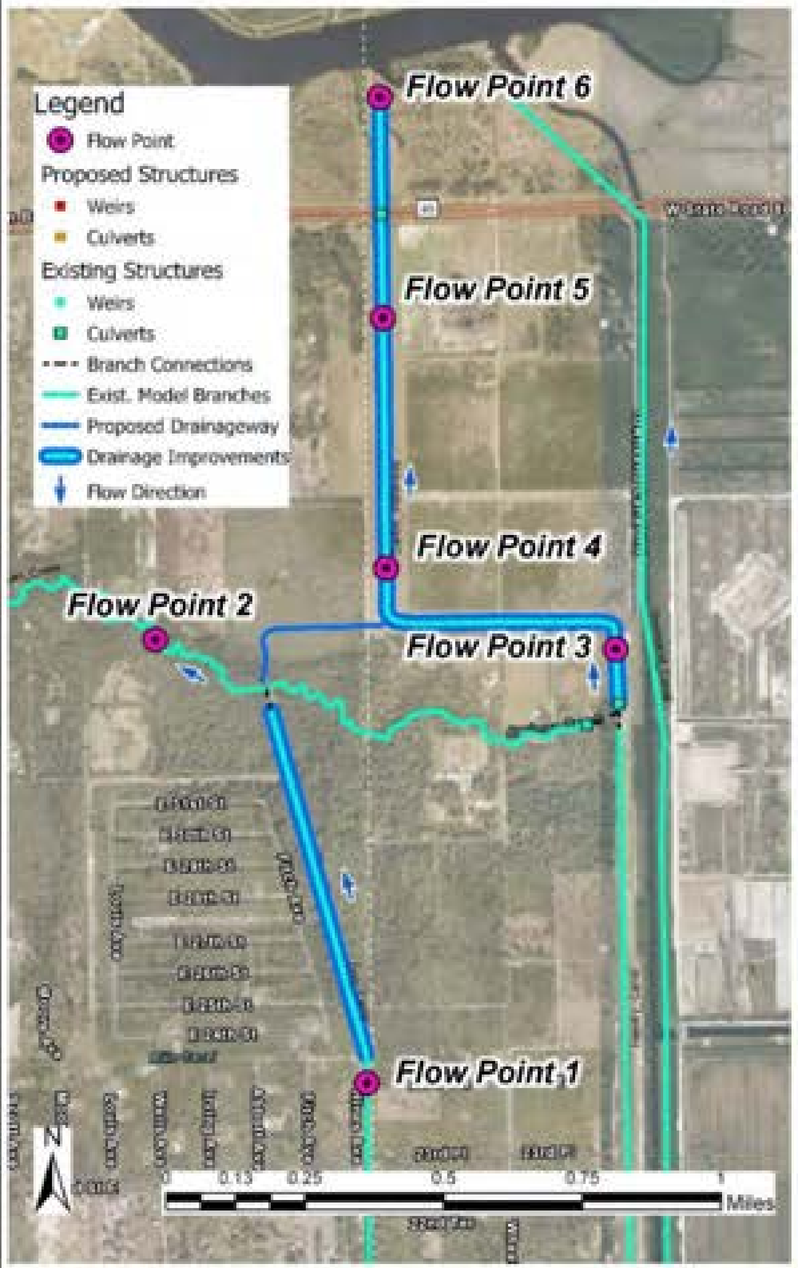
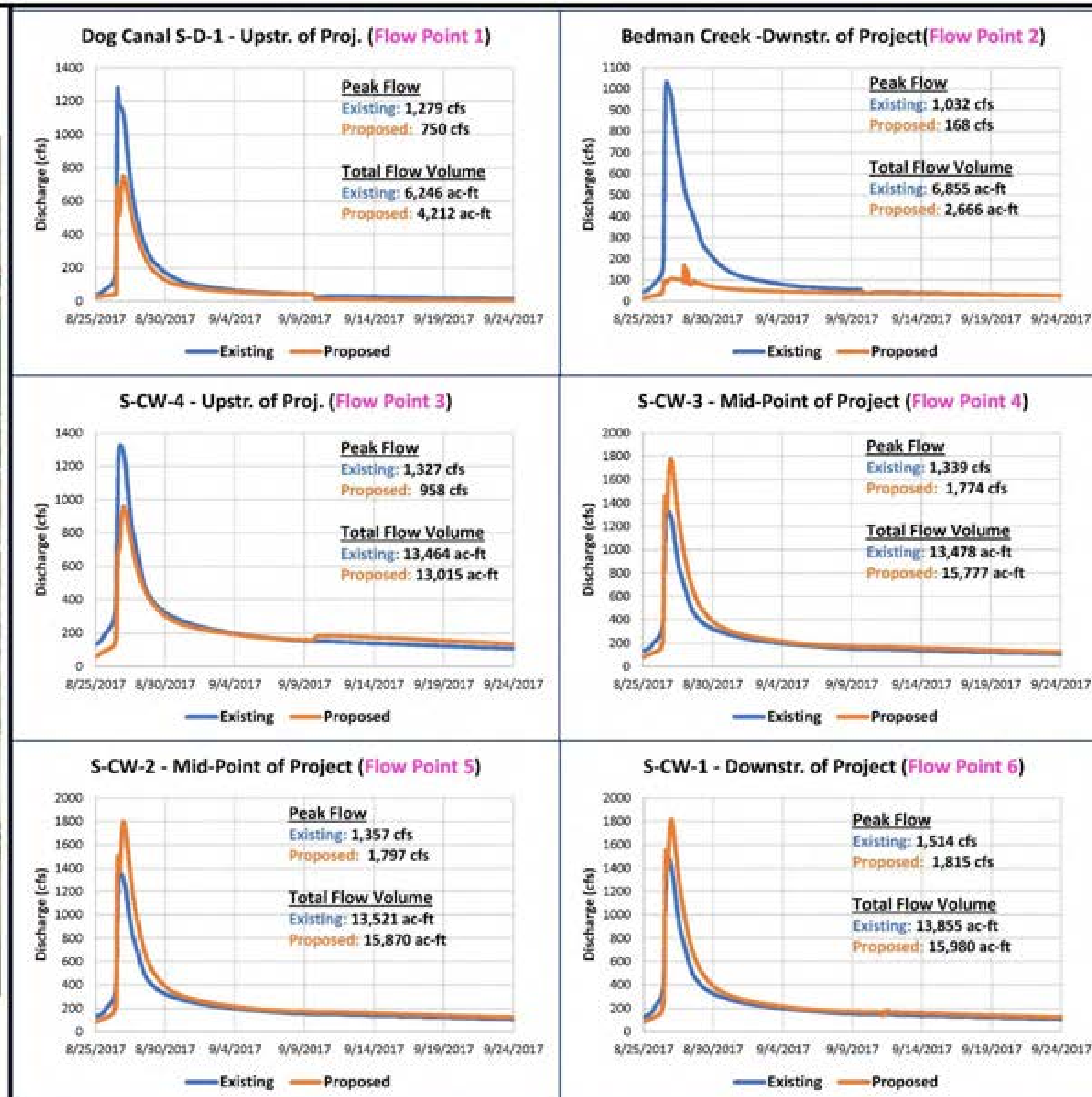


EXHIBIT 1.1.2 (g)





1.1.2 Bedman Creek Overflow Bypass

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.1.2 (h)

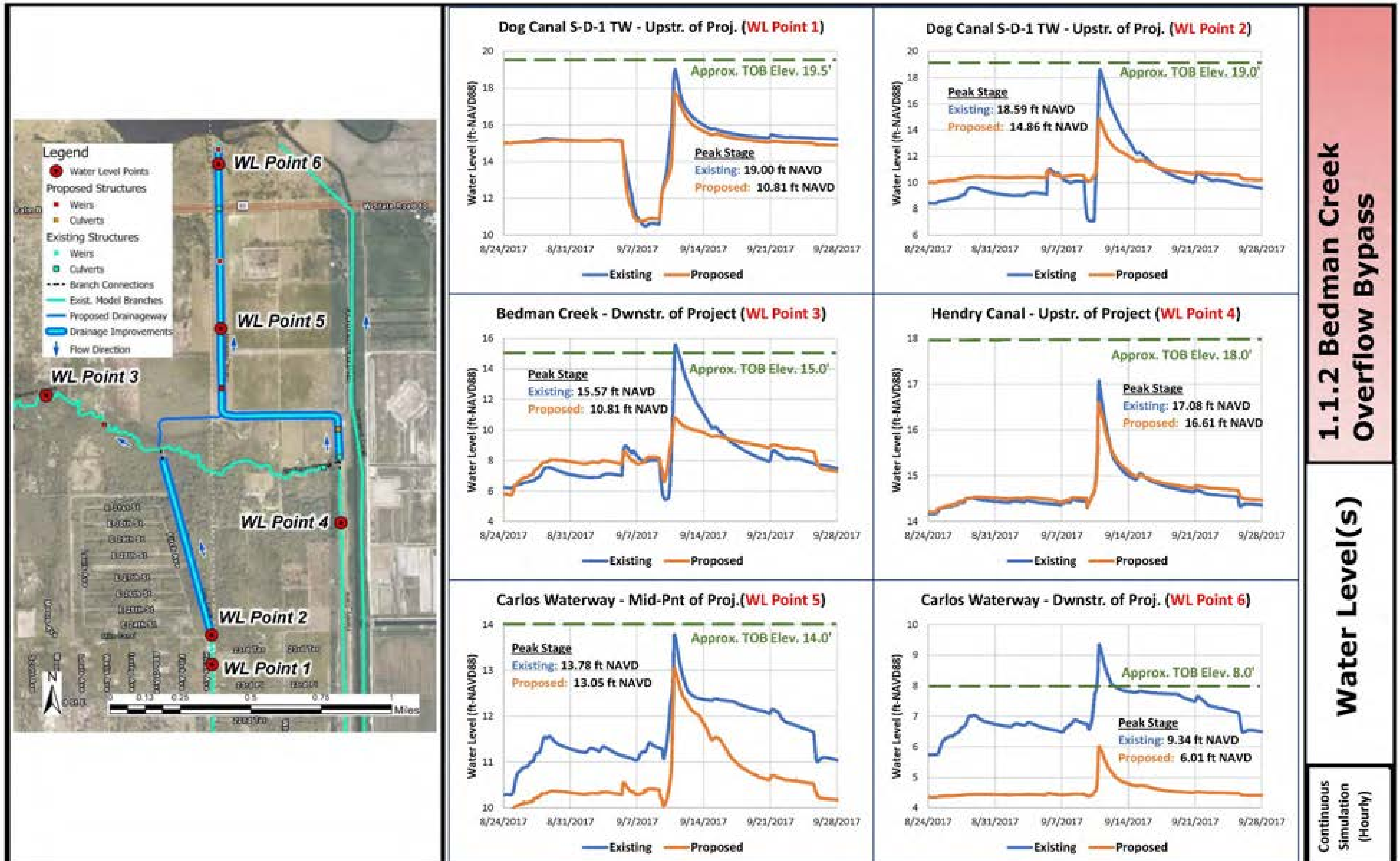
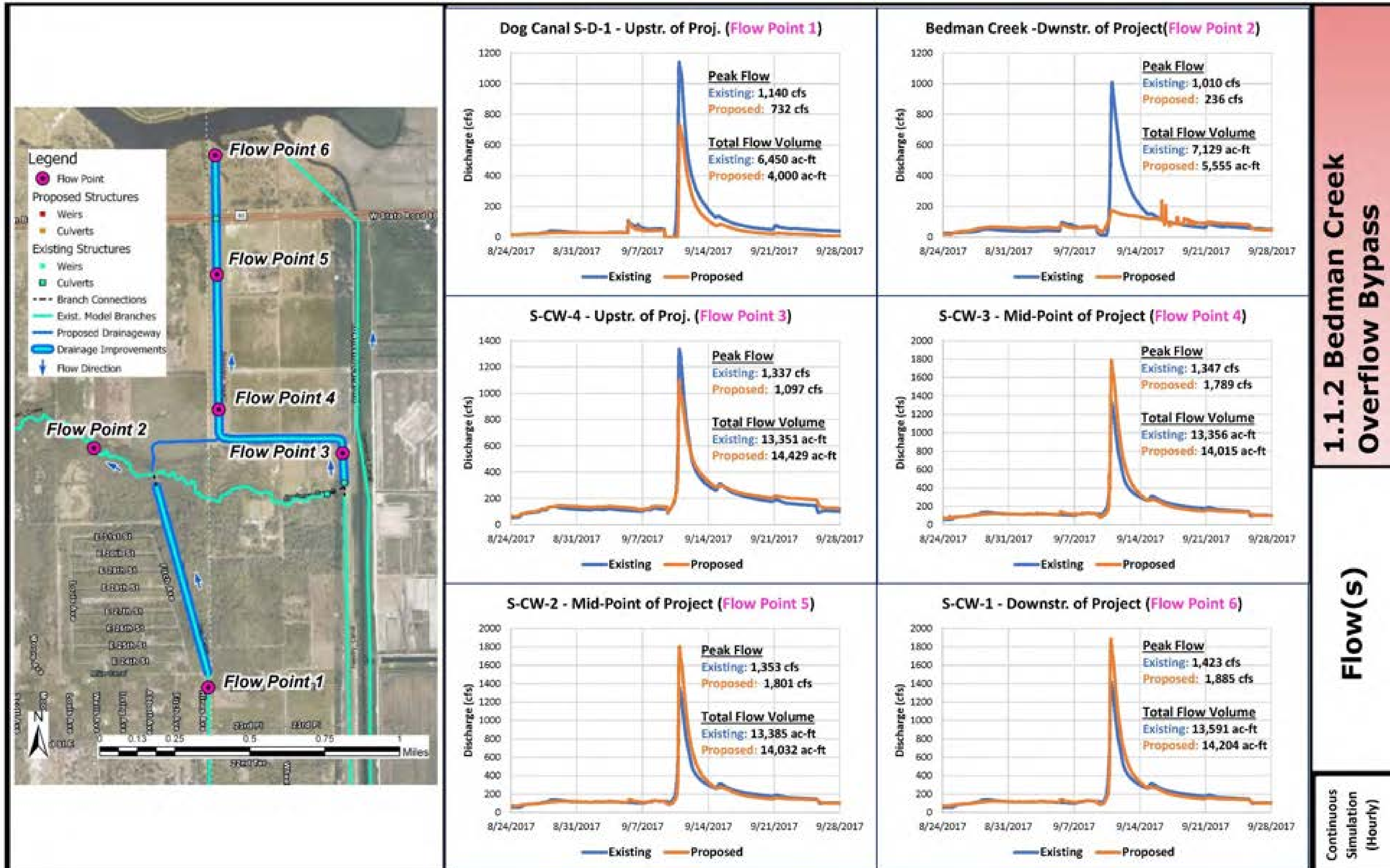


EXHIBIT 1.1.2 (i)



1.1.3 GS-10 Stormwater Quality Reservoir

Background

Section 10 was formerly utilized for limerock mining for the construction of the Lehigh Acres roadway system as evidenced by the old spoil piles that have not been removed. The surrounding development has altered the natural flow conditions and patterns for discharge to the Greenbriar Swamp and the headwaters of Hickey Creek. The surrounding areas have been developed for home sites with drainageways constructed to direct flow the major drainageway.

Location

This concept project site, known as the Greenbriar Swamp (GS)-Section 10 was formerly used for mining activities and is located within Section 10, Township 44 South, and Range 27 East in the East Lee County area as illustrated by the location map in **Figure 16** below:

Figure 16 - Location Map, 1.1.3 GS-10 Stormwater Quality Reservoir

Description

This proposed conceptual project reconfigures an existing mine lake into a filter marsh for stormwater treatment and a storage reservoir for flood control. Stored water may be diverted into the Greenbriar Swamp for extending wetland hydro-periods. This conceptual project controls flow in a six square-mile area with weirs to control discharges and utilizes the mine lake as a stormwater detention basin.

Existing water downstream control structures, S-HC-2 (existing control EL 14.24' NAVD) and S-D-1 (existing control EL 14.86' NAVD) would remain. A new water control structure would be constructed in W. Easy, Fox, King, and E. Easy Canals at water control elevation 18.5' NAVD to divert flow into Section 10, piped conveyance under Edwards Avenue, a pump system for flows to Greenbriar Swamp, and a modification to the existing Section 10 outfall to water control elevation 18.5' NAVD. The approximate 6.5 square-mile drainage basin would store water to control elevation 18.5' NAVD during extreme storm events. The new structures would have gates to allow for lowering in advance of a storm and allowing storage of roughly 3 feet across the entire area during a severe storm event as illustrated in **Figure 17**:

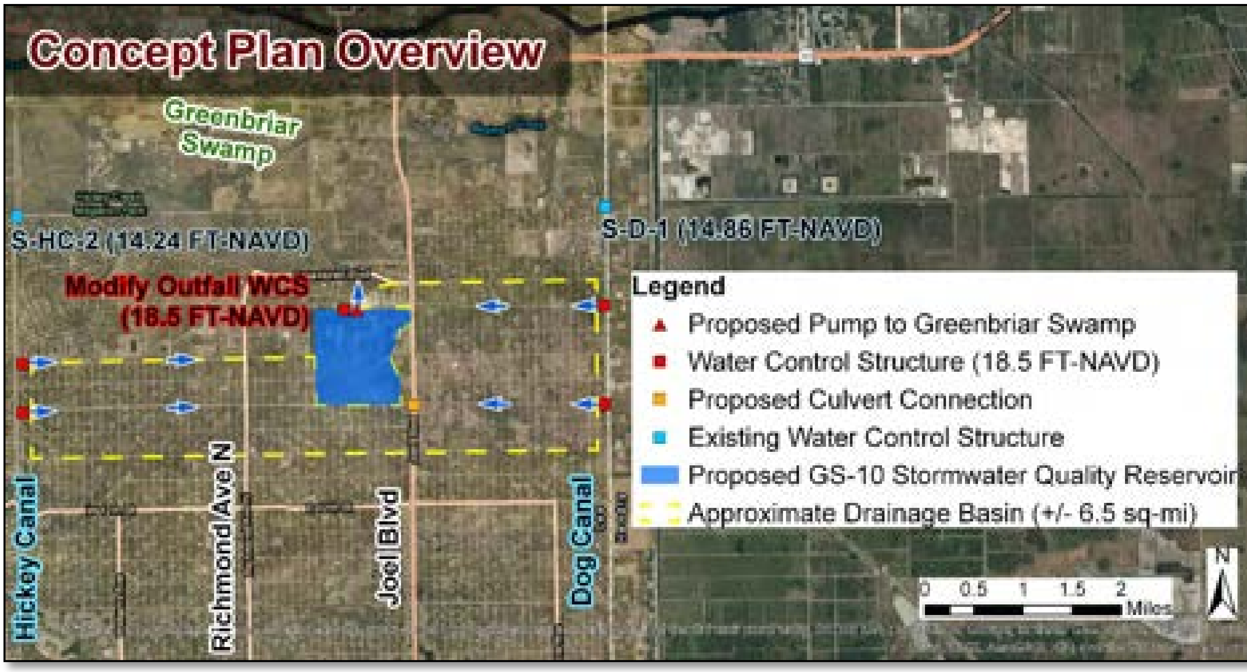


Figure 17 - Concept Plan, 1.1.3 GS-10 Stormwater Quality Reservoir

Roughly 88% (550.1 acres) of the total 624-acre site would be utilized for flood mitigation and water quality improvements, with the remaining 12% (73.9 acres) for storage of excess excavated soil material as outlined in blue in **Figure 18**:

Figure 18 - Excess Soil Storage Map, 1.1.3 GS-10 Stormwater Quality Reservoir

Of the 550.1-acre area, roughly half would be utilized as a storage reservoir and the other half for water quality improvements.

Purpose

The purpose of this project offers a storage reservoir to attenuate peak flows from large storm events and a water quality treatment improvement. The anticipated 6.5 square-mile contributing drainage basin would benefit from this concept project. Moreover, the entire Hickey Creek and Bedman Creek Drainage Basin residents will benefit from the reduced peak flow impact to the basins which currently outfall to natural conveyances.

Secondary purposes include the ability to direct more flow into Greenbriar Swamp Preserve, thereby re-hydrating the offsite wetlands, and incorporating community passive recreational amenities into the project.

Evaluation

Viability

Lee County has purchased of this land so no additional land acquisition is required. LIDAR elevations suggest that the system is conducive to gravity inflow into Section 10 by controlling water elevation to 18.5' NAVD in the approximate drainage basin without causing adverse impacts to property owners.

Community Considerations

Adverse community impacts are minimal as this region is mostly undeveloped. With the incorporation of public parking/access, pedestrian walking paths and other small watercraft recreational activities, community approval should be favorable.

Environmental & Permittability Considerations

From the Lee county Appraiser Website, there are no designations for an eagle nesting site buffer or panther habitat. Most of soils are classified as Matlacha Gravelly Fine Sand, and Boca Fine Sand. As this concept project proposes converting an existing mining pit into environmentally enhanced areas, permitting approval should be favorable for this project. An example of conceptual storage reservoir and stormwater treatment areas are illustrated in the **Figure 19** plan detail. During the actual design, the actual layout of environmental features could be integrated. Uplands/natural areas could be more contiguous to make them more viable as wildlife habitat as well as for long term management. The berms could include native plants at the toe of slope to help prevent sod/nonnative species from spreading into created on site natural areas. The control elevation of the system could be further modeled and refined to ensure complementary to Greenbrier Swamp hydrology. Passive recreation can be concentrated in areas already planned for disturbance/construction to allow more habitat to be available for local wildlife and facilitate long term habitat management.

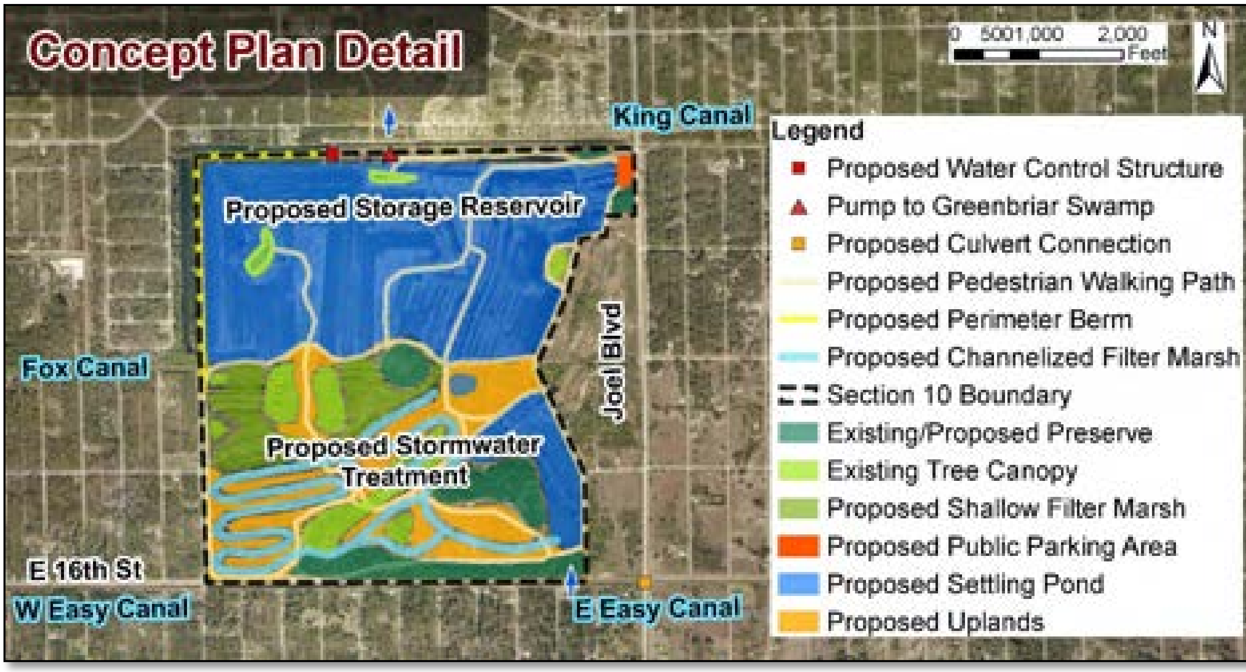


Figure 19 - Concept Plan Detail, 1.1.3 GS-10 Stormwater Quality Reservoir

Land Availability

With the land purchase complete, other avenues to construct the proposed storage reservoir, stormwater treatment, and excess soil storage areas are being pursued. Coordination with the Lee County 2020 Conversation Lands is necessary for project approval since the site must be developed to meet the intent in the County/LA-MSID agreement.

Opinion of Probable Cost

The cost opinion shown in **Table 4** below is at a budgetary conceptual level for flood mitigation aspects only with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 4: Opinion of Probable Cost breakdown, 1.1.3 GS-10 Stormwater Quality Reservoir

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 565,800	$ 565,800
Clearing & Grubbing	2	AC	$ 14,000	$ 28,000
Earthwork	13,000	CY	$ 8	$ 104,000
Weir Structure 1.3A (Standard)	30	LF	$ 5,000	$ 150,000
Weir Structure 1.3B (Standard)	30	LF	$ 5,000	$ 150,000
Weir Structure 1.3C (Standard)	30	LF	$ 5,000	$ 150,000
Weir Structure 1.3D (Standard)	30	LF	$ 5,000	$ 150,000
Weir Structure 1.3E (Standard)	30	LF	$ 5,000	$ 150,000
Detour Joel Blvd.	1	LS	$ 150,000	$ 150,000
Box Culvert 1.3-1	100	CY	$ 1,200	$ 120,000
Box Culvert 1.3-2	120	CY	$ 1,200	$ 144,000
Box Culvert 1.3-3	100	CY	$ 1,200	$ 120,000
Box Culvert 1.3-4	100	CY	$ 1,200	$ 120,000
Box Culvert 1.3-5	150	CY	$ 1,200	$ 180,000
Box Culvert 1.3-6	150	CY	$ 1,200	$ 180,000
Box Culvert 1.3-7	100	CY	$ 1,200	$ 120,000
Box Culvert 1.3-8	100	CY	$ 1,200	$ 120,000
Road Repairs	1	LS	$ 80,200	$ 80,200
Electric Supply	5	EA	$ 10,000	$ 50,000
Permanent Erosion Control	26,000	SF	$ 15	$ 390,000
Sod	26,000	SY	$ 3	$ 78,000
			Conceptual Construction Costs:	**$ 3,300,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 990,000
			Land Acquisition	$ -
			Project Administration/ CEI (10%)	$ 330,000
			Project Unknowns	$ 80,000
			Conceptual Project Cost:	**$ 4,700,000**
			Contengency (30%)	$ 1,300,000
			Conceptual Project Cost (with Contengency):	**$ 6,000,000**

Opportunities for Multiple Benefits & Uses

As Lehigh Acres continues to reach full build-out conditions, being able to utilize an entire section of land for flood mitigation is an outstanding opportunity. Providing storage solutions will also become increasingly difficult as development diminishes the available land. This project allows for potential incorporation of water quality improvement components.

Other Considerations

Incorporating passive recreational amenities and water quality treatment provisions may generate multi-agency involvement. A summary of this concept project is shown below in **Exhibit 1.1.3** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of modifying the former Section 10 mine to a stormwater management system for the attenuation and water quality treatment of storm water runoff prior to releasing controlled flow to the Greenbriar Swamp. The stormwater for the approximately six (6) square mile surrounding area would be directed to the Section 10 detention lake by redirecting the existing canals. Weirs would be constructed at connection points to the Hickey and Dog Canals. This system would provide year-round water quality treatment and stormwater attenuation while providing flood mitigation for severe events and hydration of the Greenbriar swamp. The refined concept plan is shown in **Exhibit 1.1.3 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

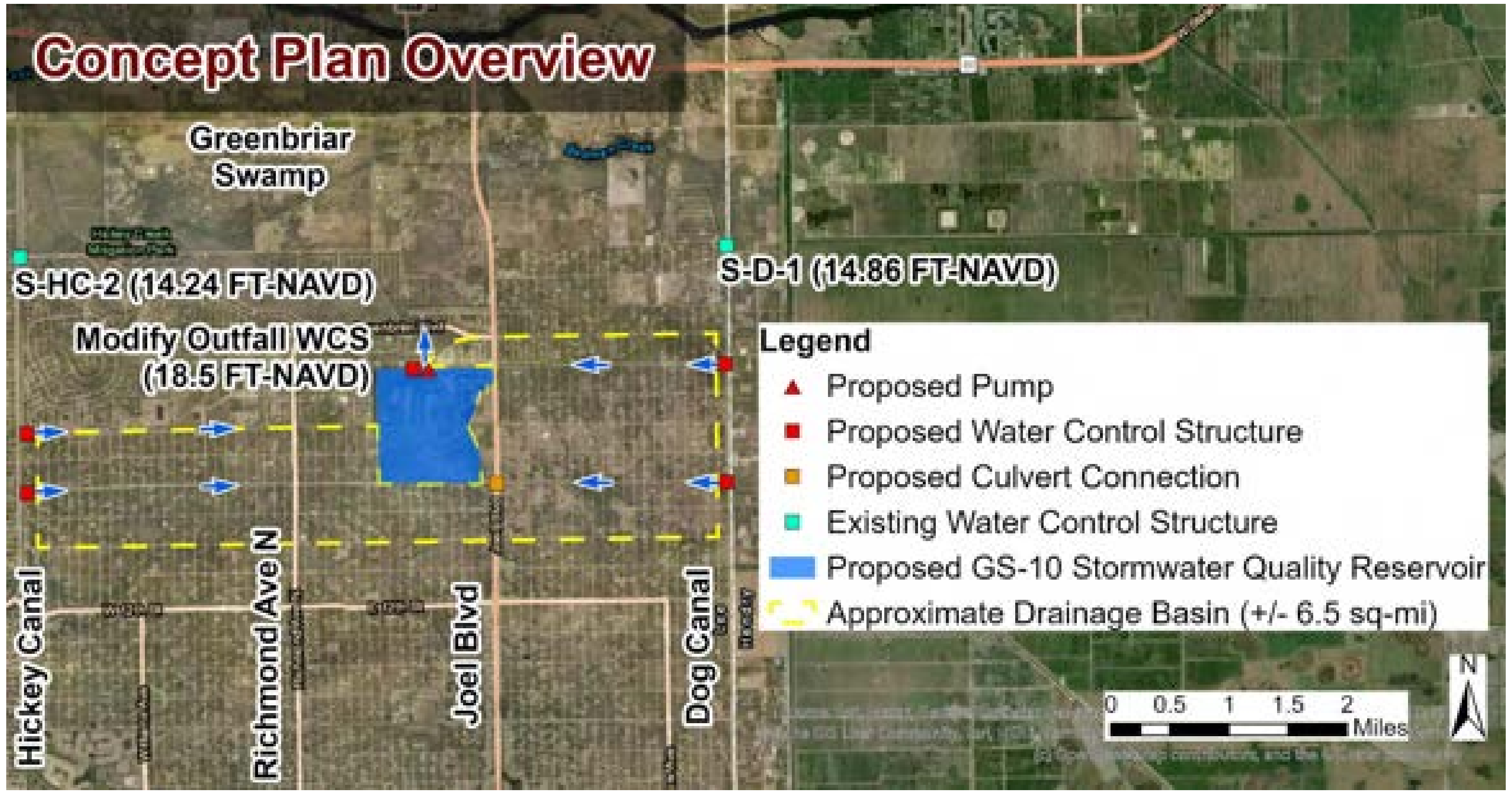
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.3 (b) EXHIBIT 1.1.3 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.3 (d) EXHIBIT 1.1.3 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.3 (f) EXHIBIT 1.1.3 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.3 (h) EXHIBIT 1.1.3 (i)

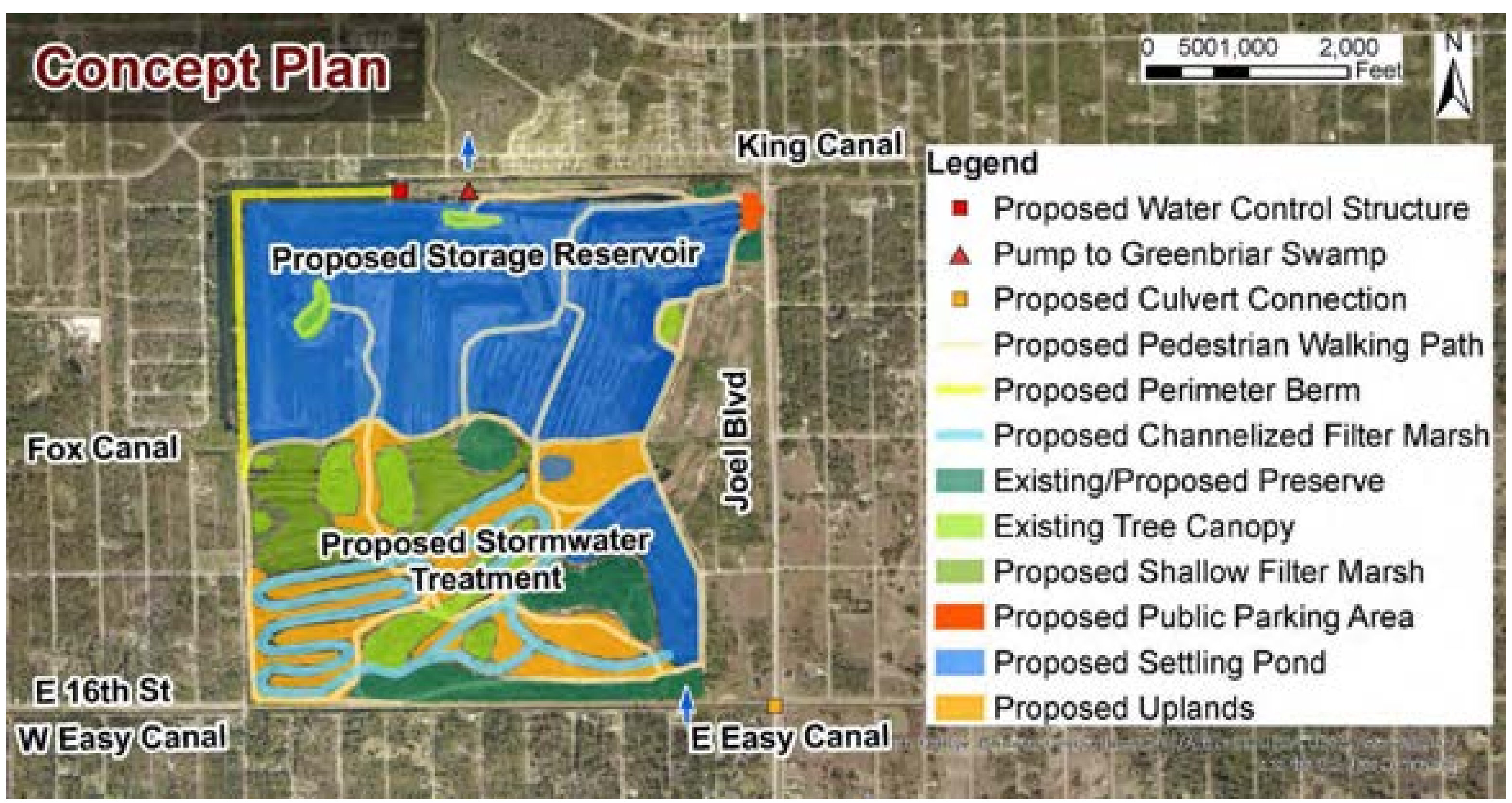
Improvements were shown with water level reductions from the existing to the proposed condition in Hickey Canal and Dog Canal and increased water levels in Greenbriar Swamp as intended. This concept project was observed to serve as a rainfall catchment basin effectively removing the approximately six (6) square mile concept project drainage basin from portions of the Hickey Creek and Bedman Creek Drainage Basins. Peak flows from the anticipated concept project drainage basin to Hickey and Dog Canals were reduced, and the total flow volume downstream Dog Canal was reduced. This project concept demonstrates an overall benefit by reducing peak flow into Hickey Creek and Bedman Creek.

Recommendations

Modifying the former Section 10 mine to a stormwater management system to attenuate and treat storm water runoff prior to releasing controlled flow to the Greenbriar Swamp is demonstrated as a benefit to this area. By directing the stormwater for the approximately six (6) square mile surrounding area into the Section 10 detention lake, peak stages in both Hickey Canal and Dog Canal are reduced. Weirs should be further evaluated for construction at the connection points to the Hickey and Dog Canals allowing stormwater control. This system would provide year-round water quality treatment and stormwater attenuation while providing flood mitigation for severe events and hydration of the Greenbriar swamp. The positive improvements of this project concept warrant further design-level project development.

EXHIBIT 1.1.3





Project Narrative

DESCRIPTION: This proposed conceptual project reconfigures an existing mine lake into a filter marsh for stormwater treatment and a storage reservoir for flood control. Stored water may be diverted into the Greenbriar Swamp for extending wetland hydro-periods. This conceptual project controls flow in a six square mile area with control weirs to control discharges and utilizes the mine lake as a stormwater detention basin.

PURPOSE: This project offers a storage reservoir to attenuate peak flows from large storm events, a water quality treatment improvement, and a water source for hydration of offsite wetlands.

CONSTRAINTS: This project is planned as a public lands project and may include private lands requiring governmental approvals and land acquisition. Weir structures to manage water levels and drainage structures would be required. Environmental impacts, if any, would necessitate mitigation.

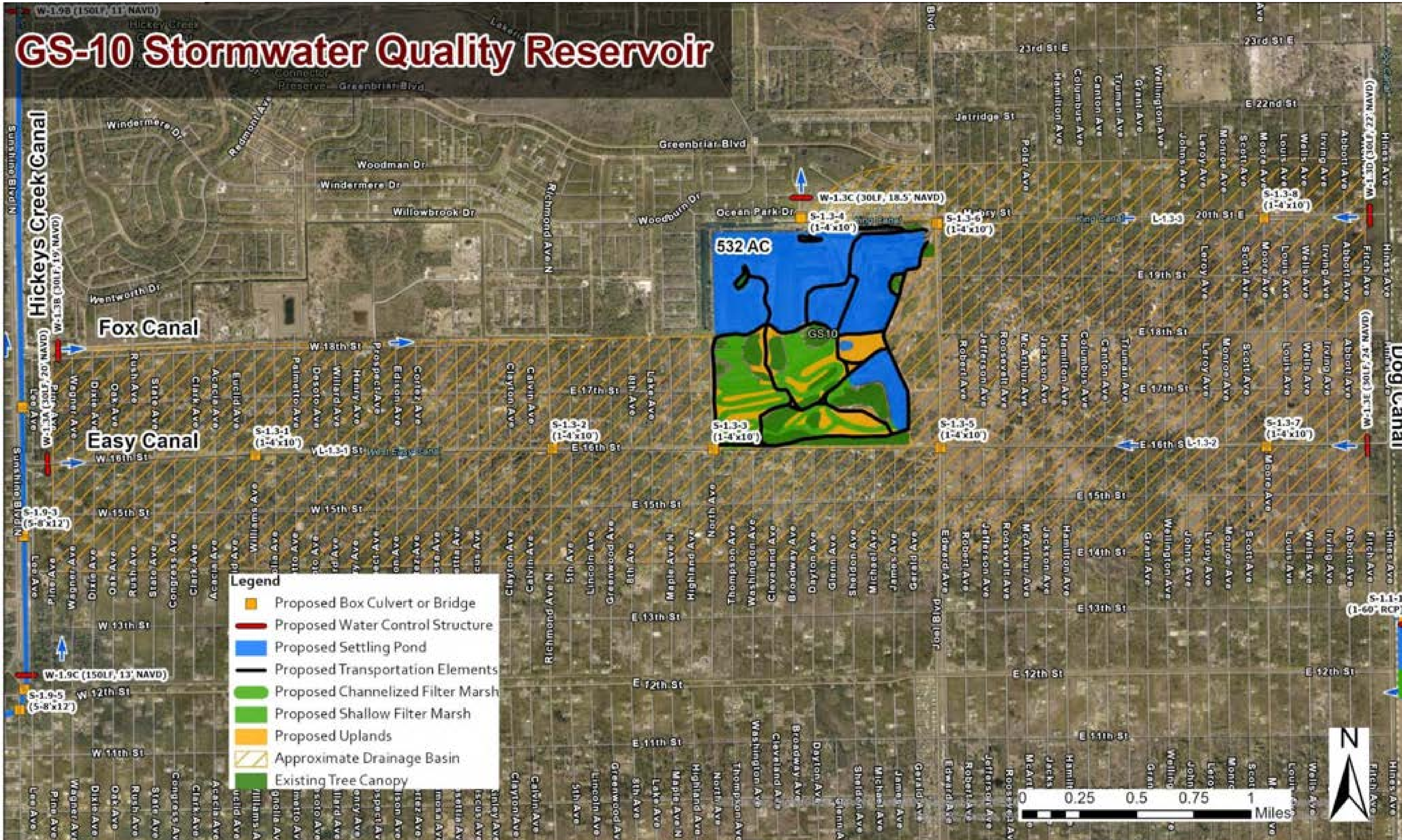
May 2020

GS-10 Stormwater Quality Reservoir
East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.3

EXHIBIT 1.1.3 (a)



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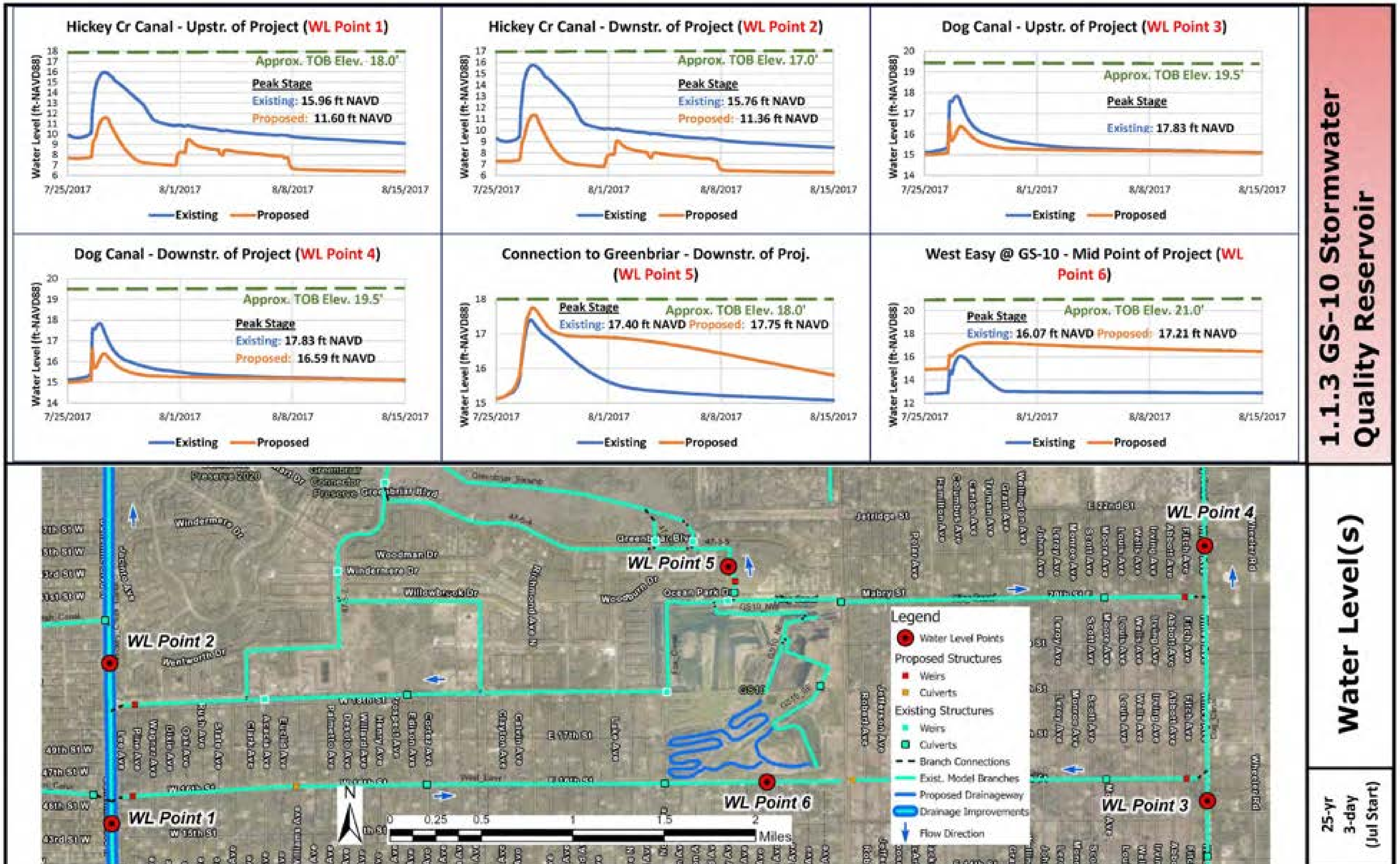

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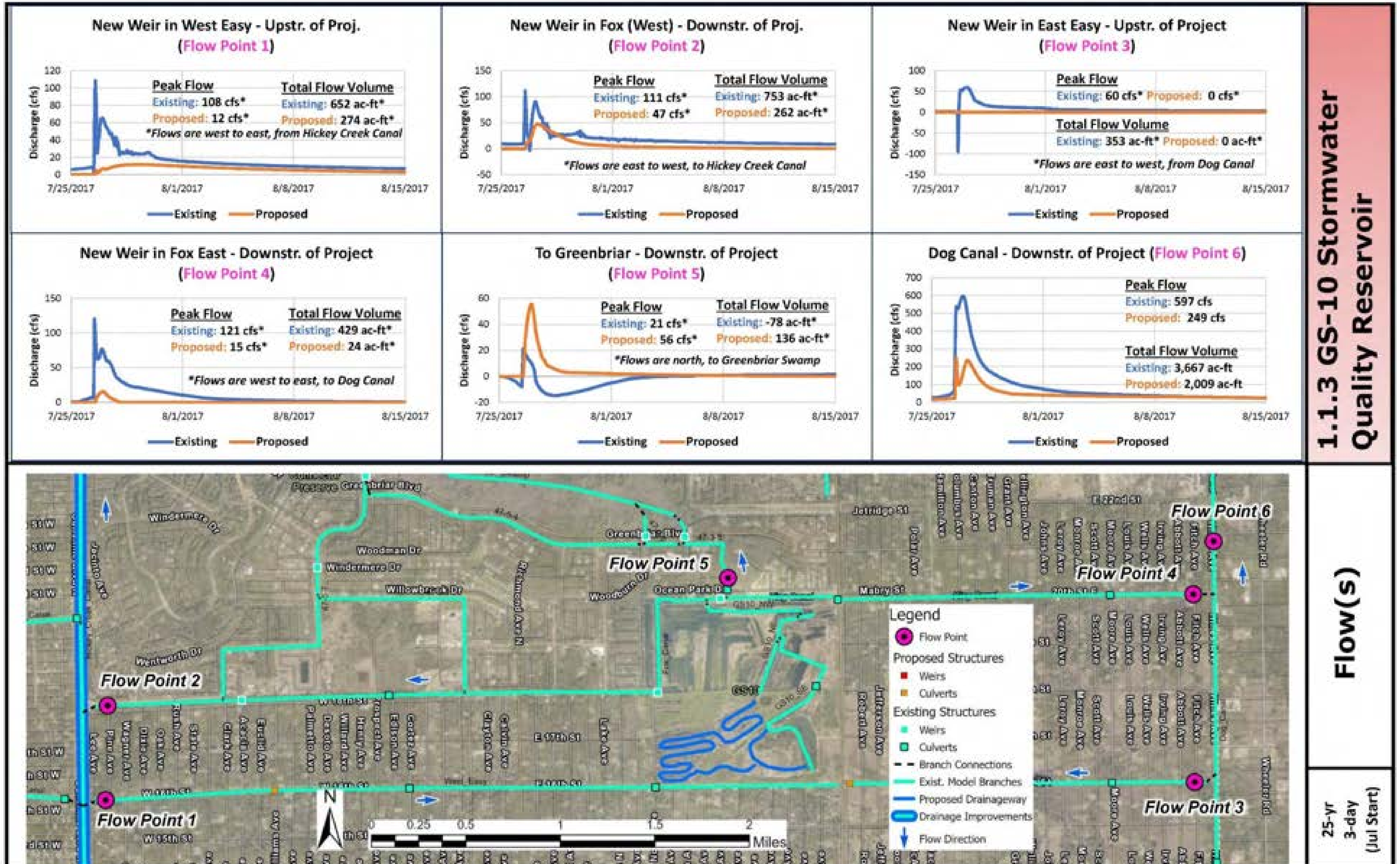

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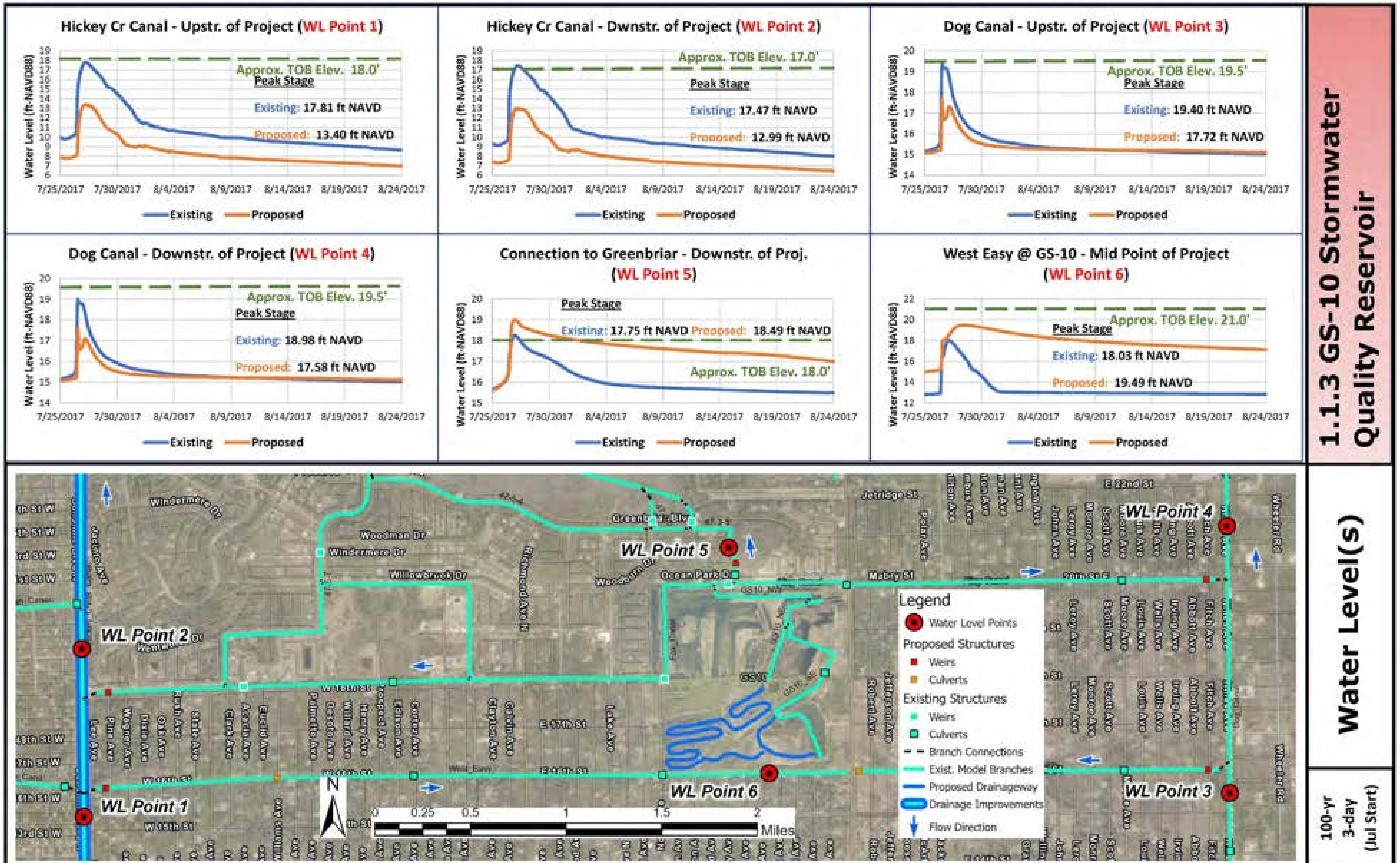

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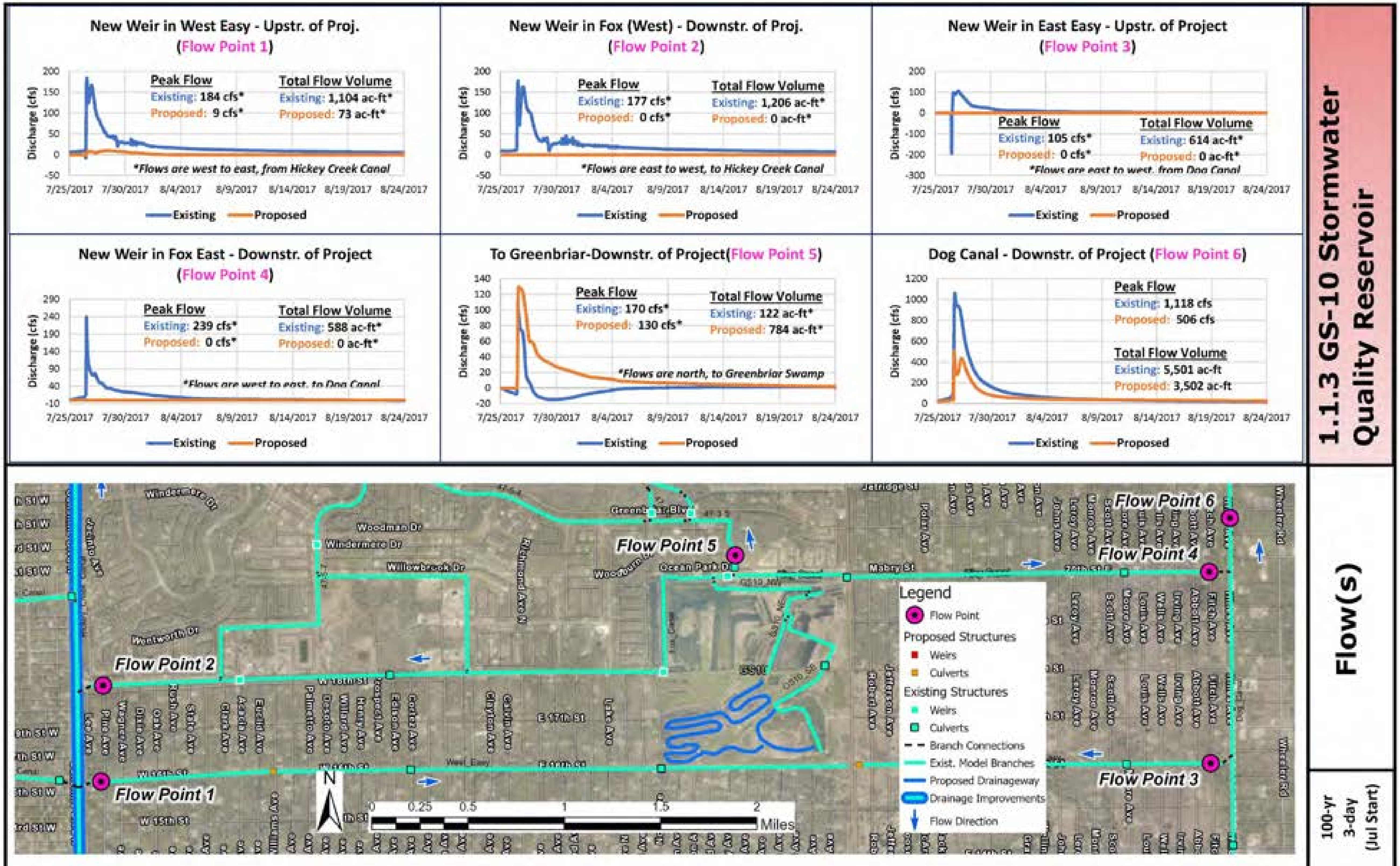

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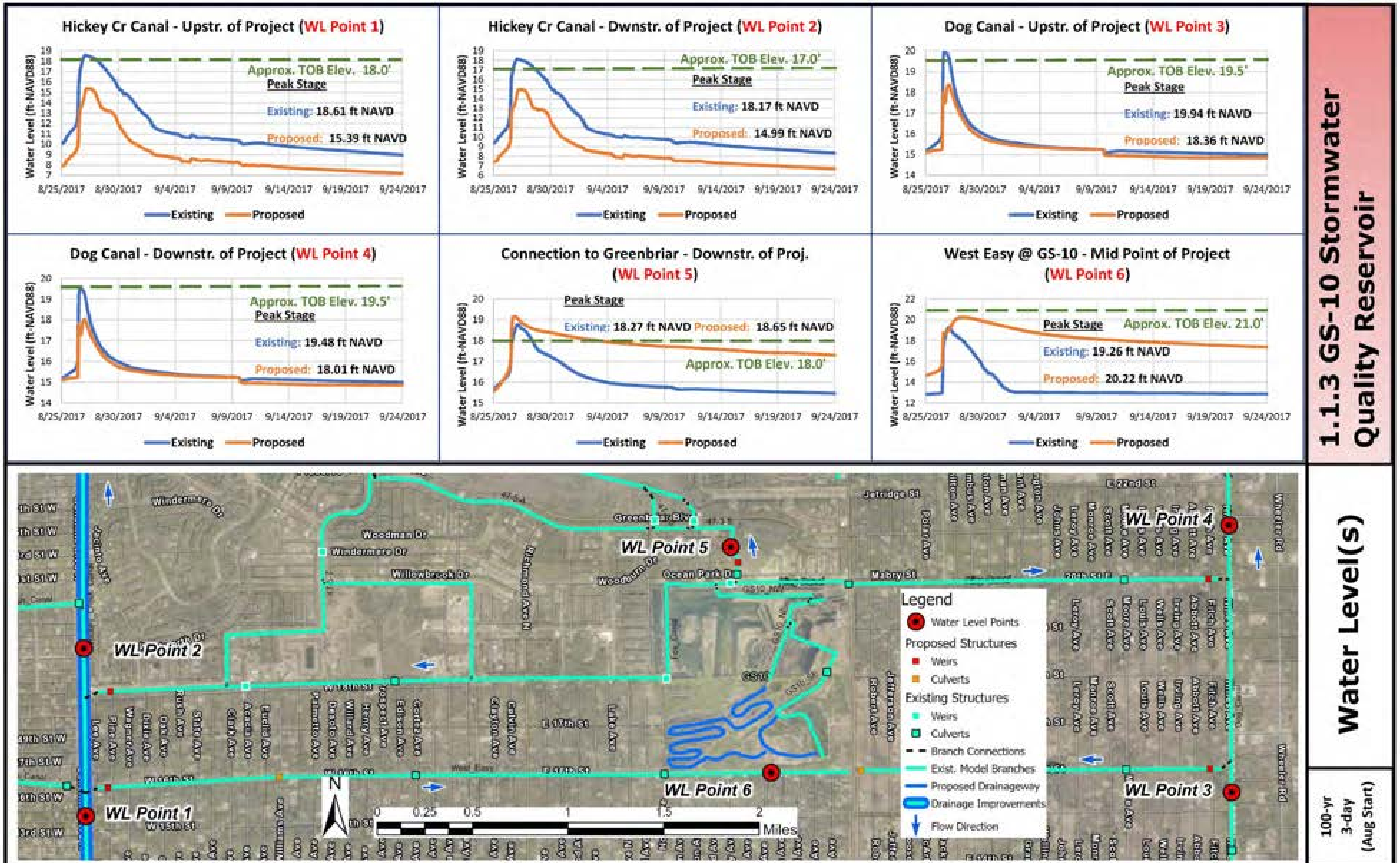


EXHIBIT 1.1.3 (g)

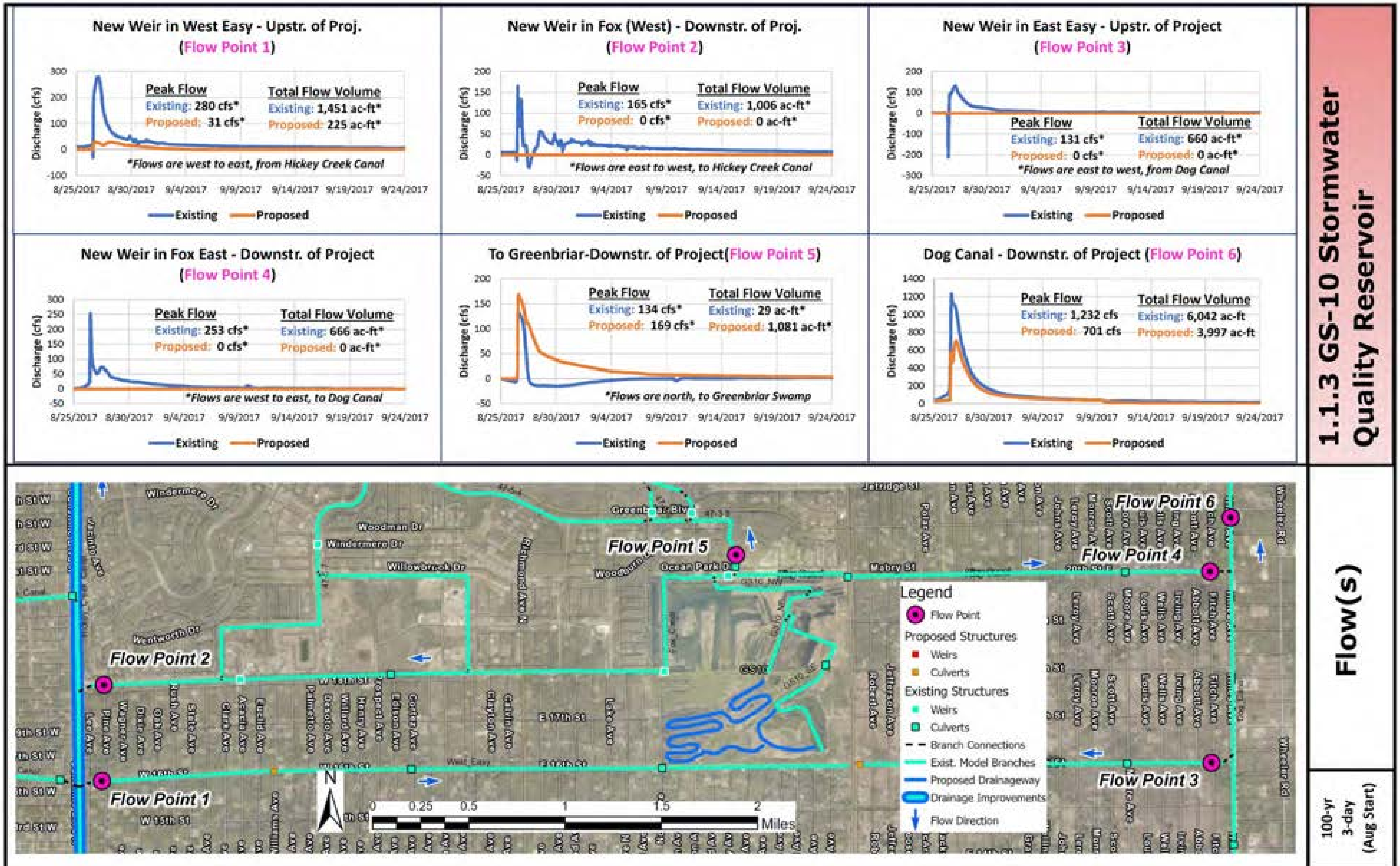


EXHIBIT 1.1.3 (h)

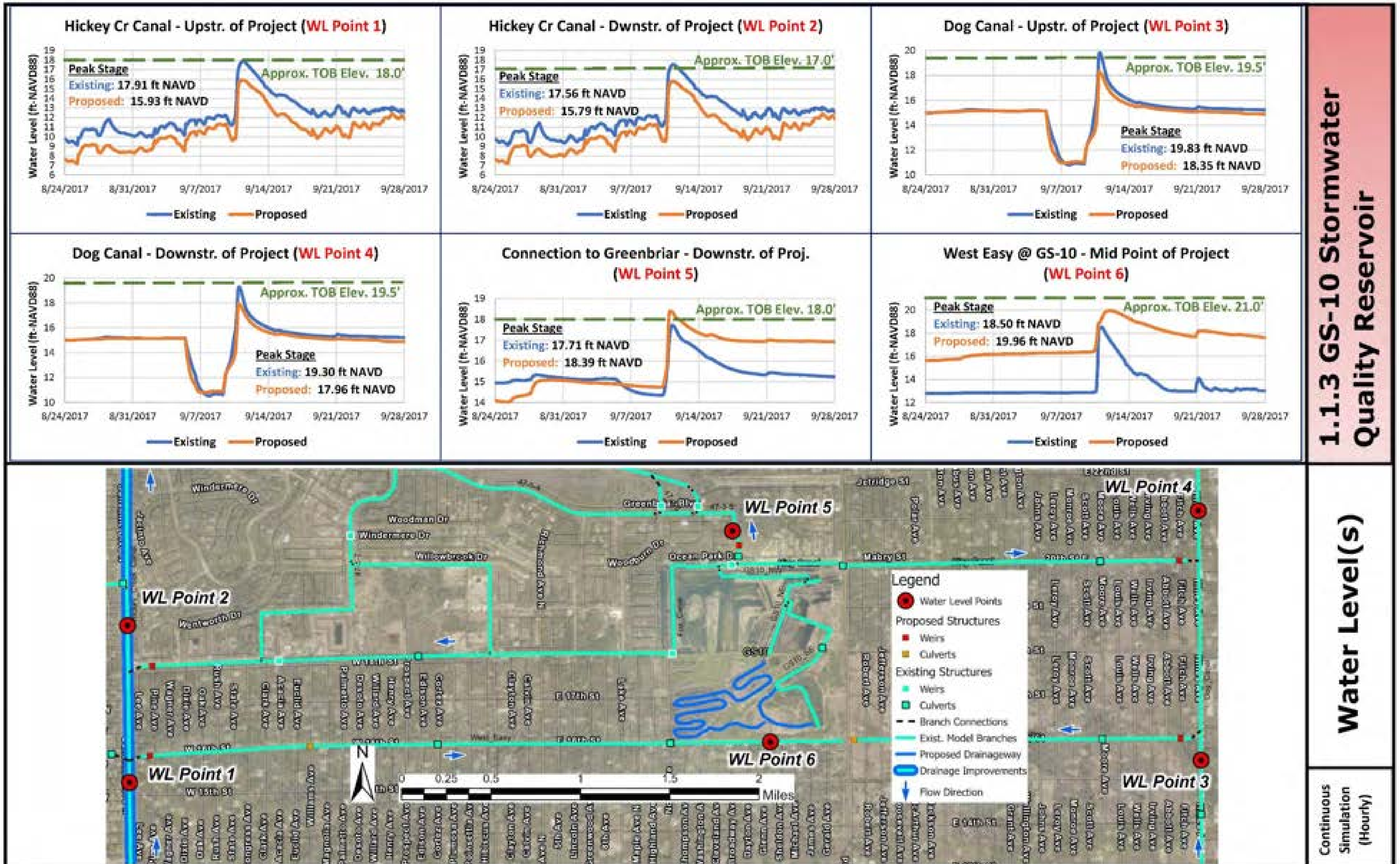
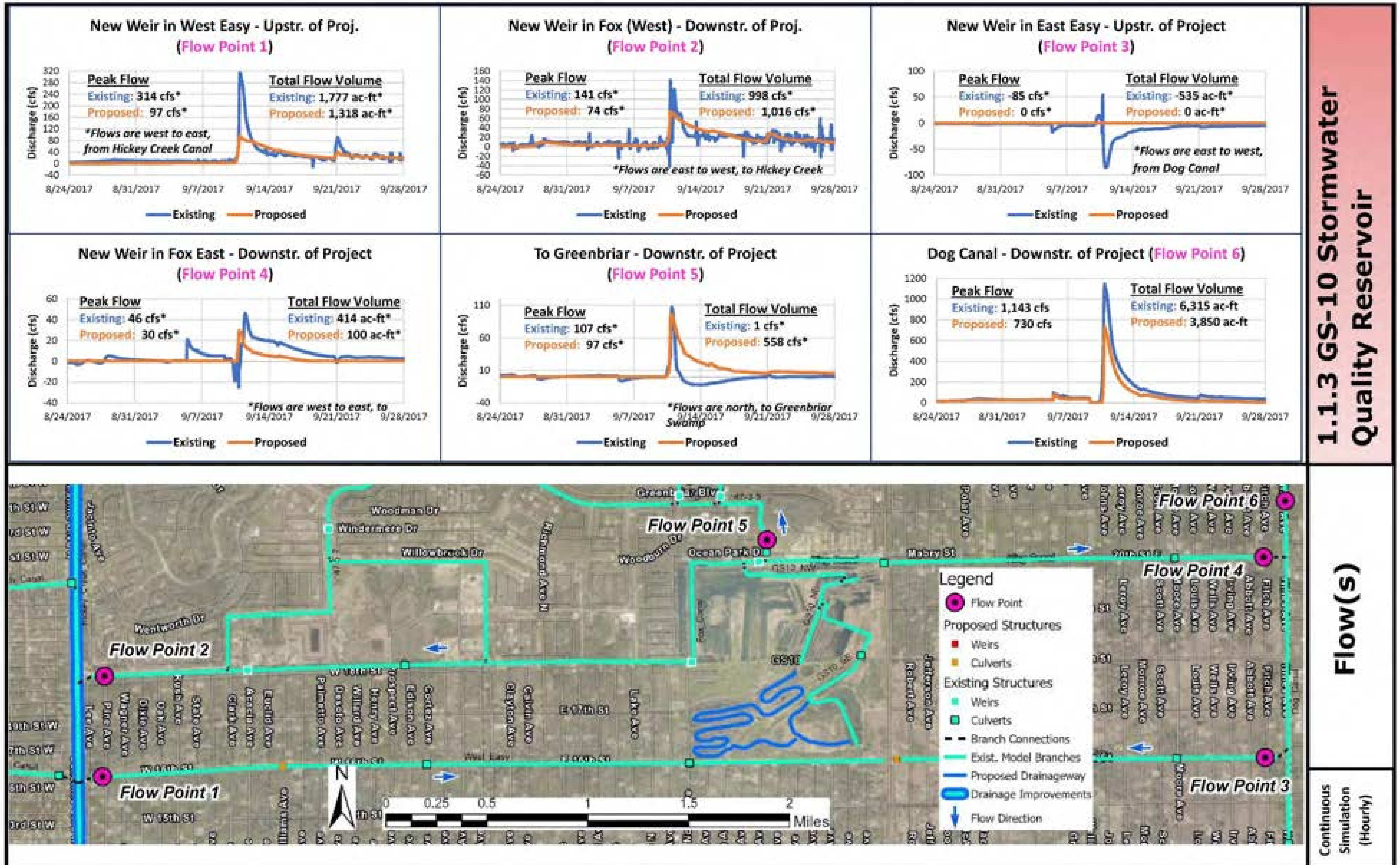


EXHIBIT 1.1.3 (i)



1.1.4 Buckingham Bypass Drainageway

Background

This concept project routes an approximately five-mile long bypass drainageway through a rural area from Lehigh Acres to a wider, higher capacity portion of the Orange River. The land cover is generally pastures, farmlands with large tract home sites. This concept project traverses the Buckingham Trails 2020 Conservation Lands located on a portion of the old Army Airfield, and borders the Hickory Swamp and the old Sunland Training Center which is now owned by FGCU. During World War II, the Buckingham Airfield was built by the Army Air Corps for gunnery school training which extended throughout east Lee County areas. Stormwater runoff from this area sheet flows to the Orange River with some drainageway to direct the flow.

Location

This proposed drainageway concept project is located along Buckingham Trails Preserve, Florida Gulf Coast University Buckingham Complex, and the area east of Neal Road in Sections 6, 7, 17, 18 and 20, Township 44 South, and Range 26 East as illustrated by the location map in **Figure 20** below:

Figure 20 - Location Map, 1.1.4 Buckingham Bypass Drainageway

Description

This proposed conceptual project provides a drainageway from the Lehigh Acres area north of Lee Blvd. through the Buckingham Trails 2020 tract. This drainageway would extend north to a larger portion of the Orange River and limit flows to the Buckingham area which experienced flooding during Hurricane Irma. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

The existing Angle Canal cross section would require improvements to accommodate for the desired 1,000 CFS conveyance to reach the proposed drainageway. A diagonal route is suggested though the Buckingham Trails 2020 tract to utilize favorable topography land slopes.

Improving the existing FGCU perimeter drainageway avoids disturbance of the interior FGCU drainage system functionality. The path then weaves through open areas and previous farmland operations to avoid existing residential housing. Existing box culverts at roadway crossings would require improvement to accommodate the planned 1,000 CFS conveyance, as well as intermediate water control structures to step down the flow in conjunction with the changes in ground surface elevations every few feet as shown in **Figure 21** below:

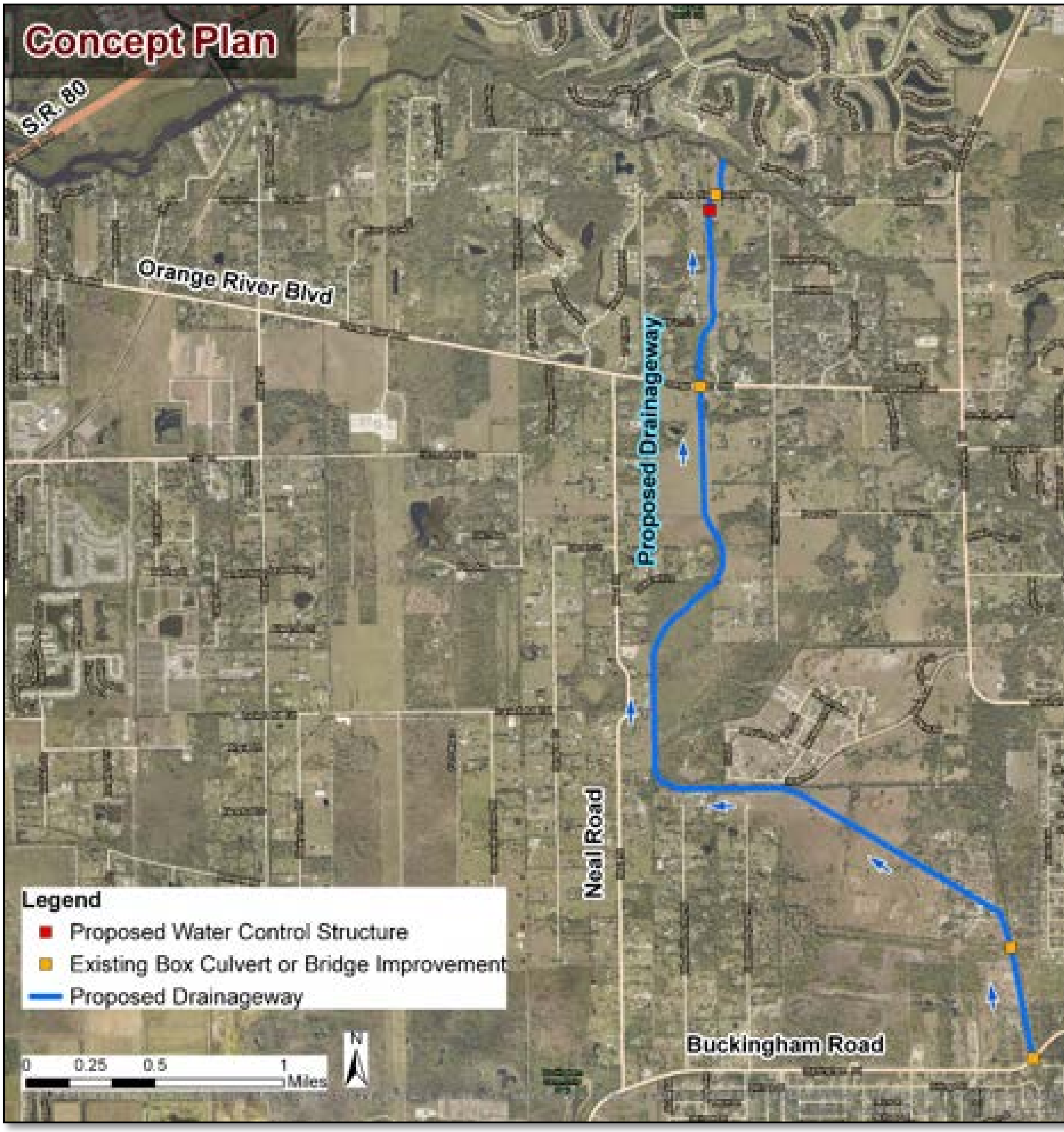


Figure 21 - Concept Plan, 1.1.4 Buckingham Bypass Drainageway

Purpose

This proposed project provides a diversion of stormwater flow around Buckingham and reduces the dependence of stormwater flow in the upper reaches of the Orange River where the river becomes narrow, winding, vegetated and often blocked by downed trees or resident fencing across the channel. The upper reaches of the river are naturally narrow, vegetated, shallow and winding. During extreme storm events, these natural conveyances were observed to vastly overflow into the surrounding floodplains that are lined with residential housing as demonstrated in photo **Figure 22**:

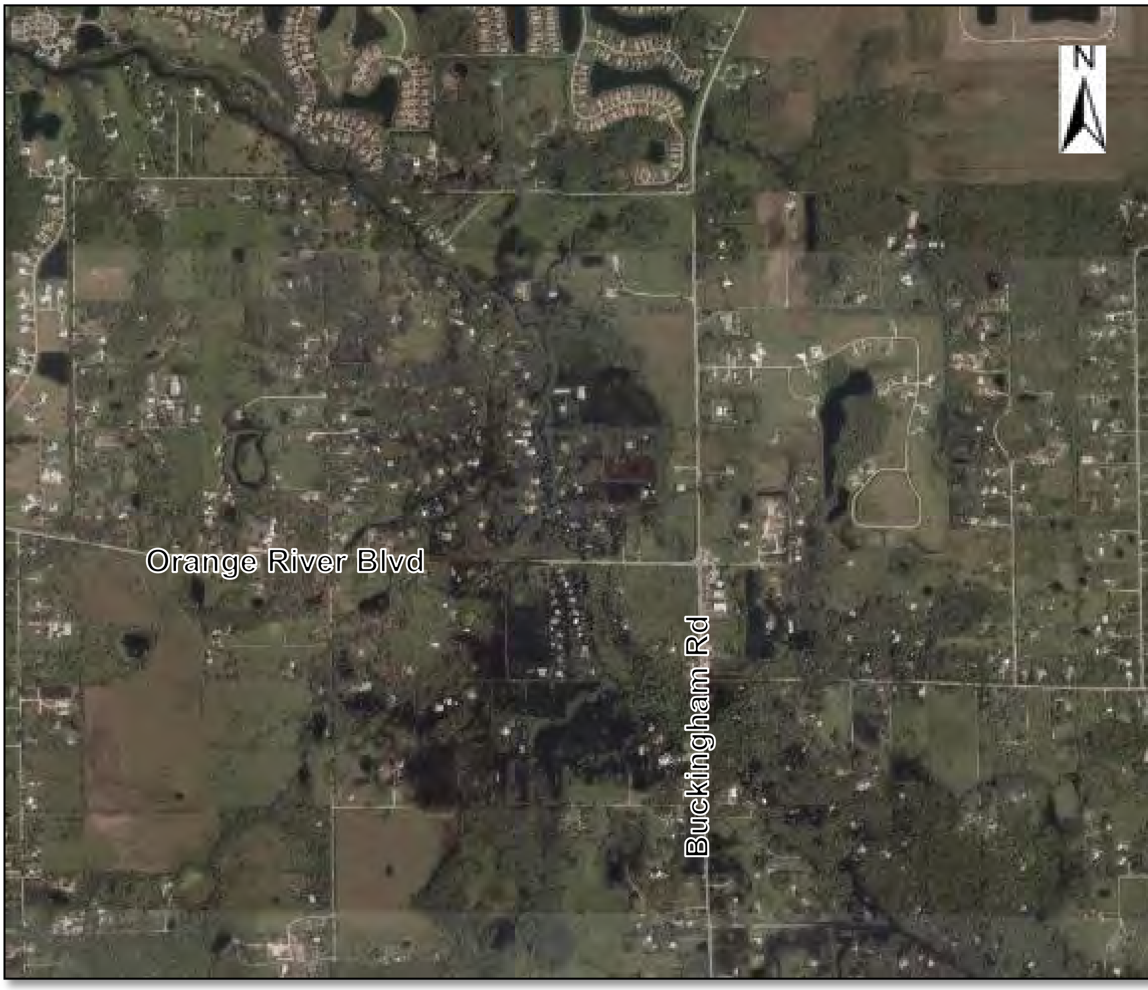


Figure 22 – Aerial along the upper reaches of the Orange River taken around 9-12-17

Evaluation

Viability

Lee County and LA-MSID are already the owners of the Buckingham Trails preserve and Angle Canal right-of-way, respectively. Initial analysis of the LIDAR ground surface elevations and the proposed drainageway cross section are favorable for a highly functional flood mitigation project. The project will require extensive land acquisition. Coordinating this project with a roadway construction project, such as the Luckett Road Extension Project, would have mutual benefits.

Community Considerations

This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Community education on how this project benefits the surrounding properties will be an important component to a successful partnership between Lee County and local residents who may have not experienced severe flooding during Hurricane Irma.

Environmental & Permittability Considerations

The Buckingham Trails Preserve contains historically sensitive areas which are proposed to remain undisturbed. Some of the parcels along the drainageway route were previously disturbed for farming activities. Other undisturbed areas appear to have dense trees or depressional areas which can be avoided by routing though the open areas. In improving conveyance on the flow that will still reach the Orange River, a ‘snag removal’ program could be implemented within the natural rivers and streams to remove snag trees and low-hanging vegetation before a major storm comes. Environmental impacts, if any, would necessitate mitigation.

Land Availability

Legal considerations on the upstream portion of the proposed drainageway are minimal as this region is mostly undeveloped. There are land acquisition challenges along the northern portion of the route where residential development is growing. The selection of the drainageway route in this area is proposed to be located near property lines and back yards to minimize homeowner impact. Coordinating with Lee County 2020 Lands and FGCU will be required.

Opinion of Probable Cost

The cost opinion shown in **Table 5** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 5: Opinion of Probable Cost breakdown, 1.1.4 Buckingham Bypass Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc	1	LS	$ 2,553,000	$ 2,553,000
Clearing & Grubbing	62	AC	$ 14,000	$ 868,000
Earthwork	350,000	CY	$ 6	$ 2,100,000
Construction/ Maintenance Access	10,000	SY	$ 20	$ 200,000
Weir Structure 1.4A (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4B (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4C (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4D (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4E (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4F (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4G (Major)	120	LF	$ 10,000	$ 1,200,000
Detours	1	LS	$ 210,000	$ 210,000
Box Culvert 1.4-1	190	CY	$ 1,200	$ 228,000
Box Culvert 1.4-2	320	CY	$ 1,200	$ 384,000
Box Culvert 1.4-4	320	CY	$ 1,200	$ 384,000
Box Culvert 1.4-5	190	CY	$ 1,200	$ 228,000
Electric Supply	1	LS	$ 70,000	$ 70,000
Permanent Erosion Control	8,000	SF	$ 25	$ 200,000
Grassing	87,500	SY	$ 2	$ 175,000
			Conceptual Construction Costs:	**$ 16,000,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 4,800,000
			Land Acquisition	$ 1,400,000
			Project Administration/ CEI (10%)	$ 1,600,000
			Project Unknowns	$ 200,000
			Conceptual Project Cost:	**$ 24,000,000**
			Contengency (30%)	$ 7,000,000
			Conceptual Project Cost (with Contengency):	**$ 31,000,000**

Opportunities for Multiple Benefits & Uses

The drainageway may offer an opportunity for horse riders to travel to and from the Buckingham Trails Preserve or to take an extended ride. This project allows for potential incorporation of water quality improvement components.

Other Considerations

Additionally, this conveyance would intercept flow coming from the west that was reported to contribute to Buckingham flooding. This flow from the west was first observed by residents prior to flooding from the east initiated by rising waters in the Orange River. Flows from outside of the Orange River Drainage Basin were also reported to be entering the LA-MSID system at Alvin and Sunfish Canals. During extreme storm events, the Orange River's headwater backs up to the point where Nile Mile Run canal was observed to be backflowing upstream into Lehigh Acres. This concept project aids in diverting various flow contributions further downstream on the Orange River to mitigate flows to the Buckingham area. A summary of this concept project is shown below in **Exhibit 1.1.4** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from western Lehigh Acres and the southwest area of Buckingham to the larger portion of the Orange River. Previous flooding reports showed significant flow from this area towards Peace Road and Cemetery Road at Buckingham Road resulting in severe house flooding. The refined concept plan is shown in **Exhibit 1.1.4 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

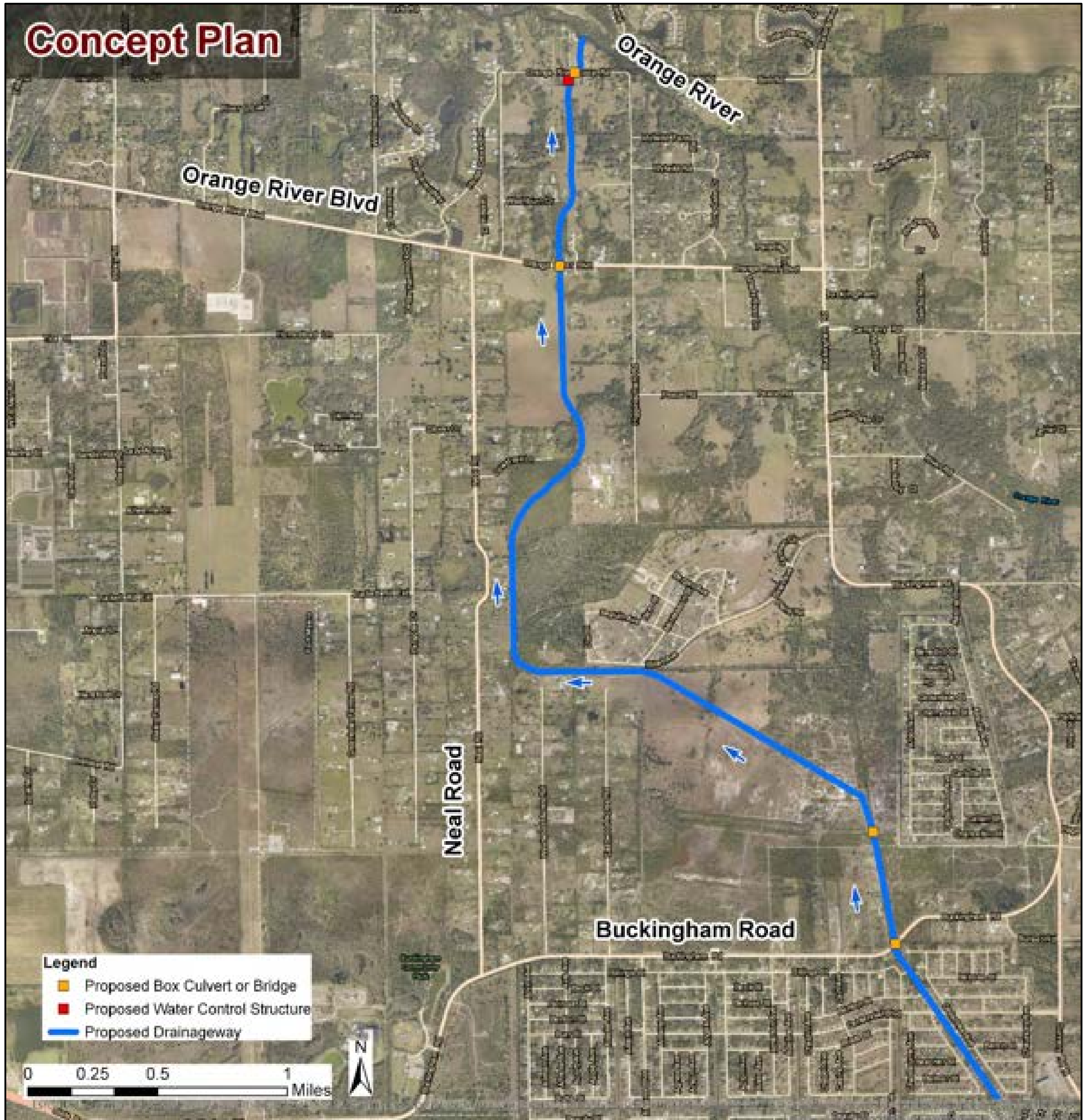
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.4 (b) EXHIBIT 1.1.4 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.4 (d) EXHIBIT 1.1.4 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.4 (f) EXHIBIT 1.1.4 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.4 (h) EXHIBIT 1.1.4 (i)

Improvements were shown with water level reductions in western Lehigh Acres, downstream nine-mile run, and at the NW corner of the Buckingham Trails parcel. Water levels near the Buckingham area at the connection point of Orange River were reduced. Further modeling refinement allowed for a reduction in peak flows heading towards the orange river as seen in the 100-year, 3-day design storm results. Peak flows out of western Lehigh are lower than anticipated but increased flows leaving the Buckingham Trails parcel are demonstrated. A greater benefit is realized though the discharge and corresponding volume of flows that are being redirected from the Buckingham area to further downstream of the Orange River where the flow capacity is not as limited. Bypassing this large peak flow will be a significant improvement for the Buckingham area.

Recommendations

Conveying excess stormwater flows from western Lehigh Acres and the southwest area of Buckingham to the larger cross-sectional portion of the Orange River helps mitigate ongoing flooding during storm events. The inclusion of the proposed water control structures throughout the proposed drainageway allow for greater stormwater runoff control within the Lehigh Acres and Buckingham areas. This drainageway is also expected to intercept flood waters flowing from the Six Mile Cypress Preserve North towards the Orange River which were observed during the Hurricane Irma event. The design of this project should avoid recirculation issues through greater analysis, survey-collected data, flow gates, and berming. Additionally, berming protection should be considered along the bypass conveyance to block bank overflow to the lower Buckingham elevations. At the FGCU drainageway, ditch blocks with a small pipe for limited flow is advised be constructed to protect downstream areas. The positive improvements of this project concept warrant further design-level project development.

EXHIBIT 1.1.4



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project provides a drainageway from the Lehigh Acres area north of Lee Blvd through the Buckingham Trails 2020 tract. This drainageway would extend north to a larger portion of the Orange River and avoid the Buckingham area. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Interconnection conveyances would be approximately 130 feet wide.

PURPOSE: This proposed project provides a diversion of stormwater flow around Buckingham and reduces the dependence of stormwater flow in the upper reaches of the Orange River. Additionally, this conveyance would intercept flow coming from the west that was reported to contribute to Buckingham flooding.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Buckingham Bypass Drainageway

East Lee County Area

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2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.4

EXHIBIT 1.1.4 (a)

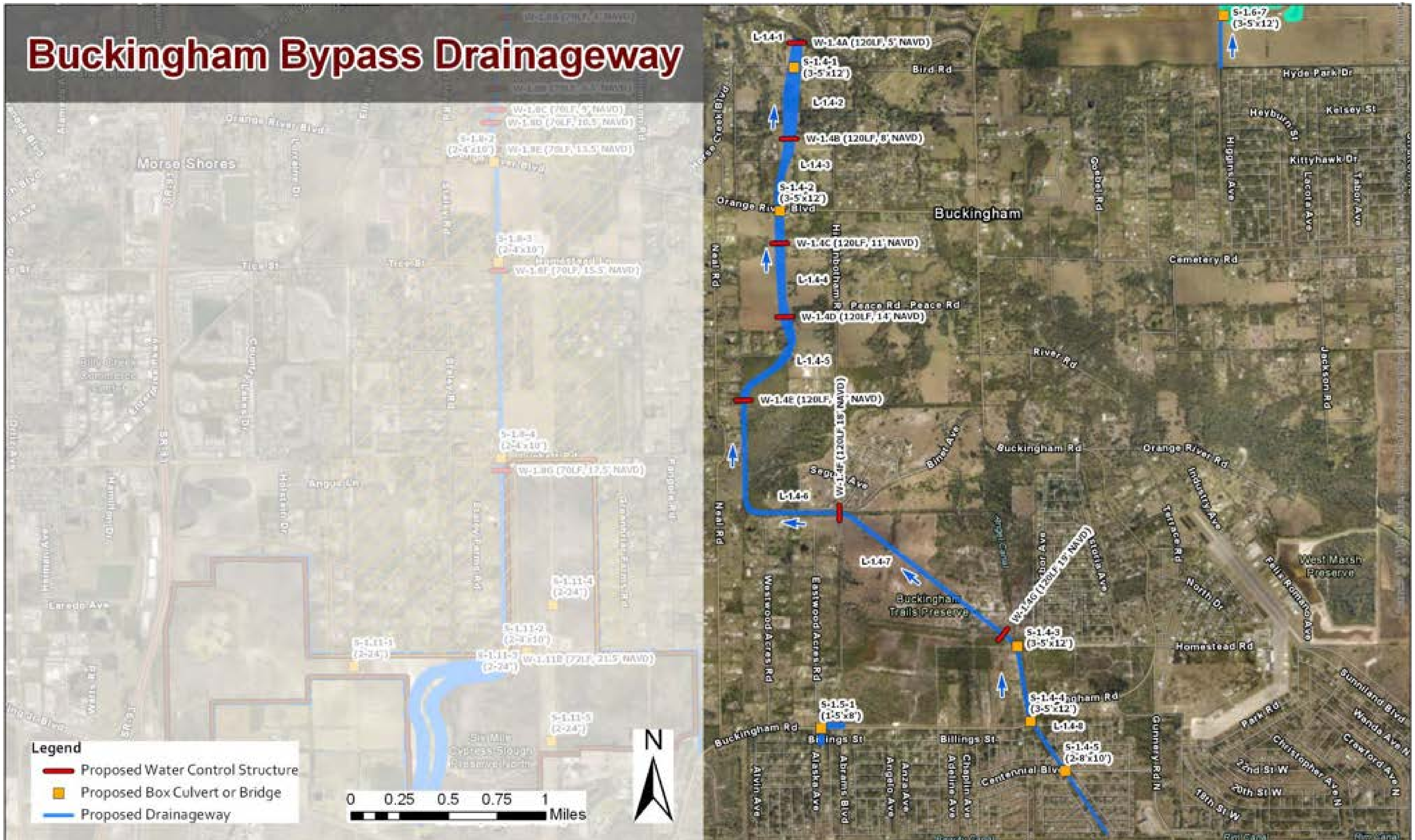


EXHIBIT 1.1.4 (b)

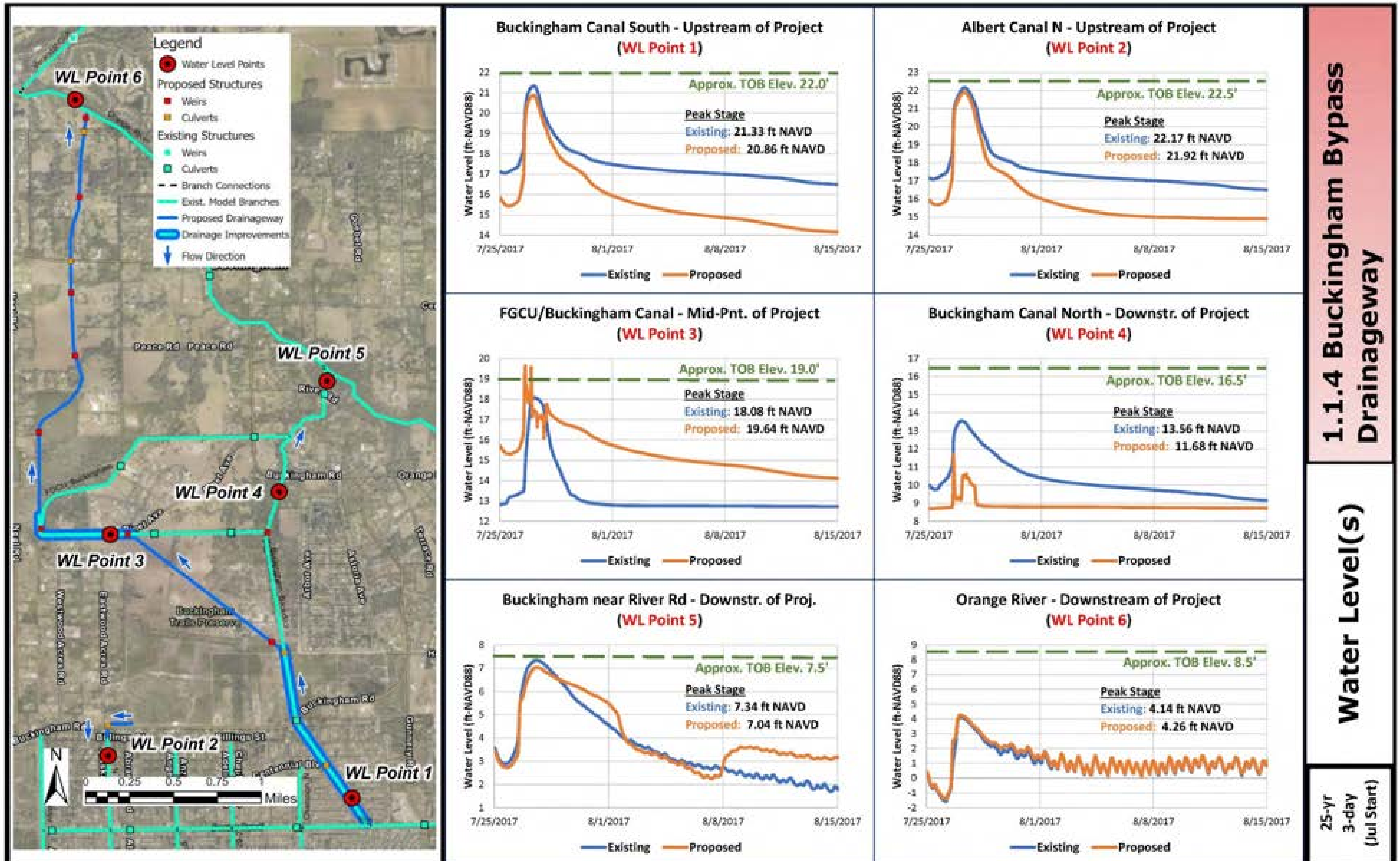


EXHIBIT 1.1.4 (c)

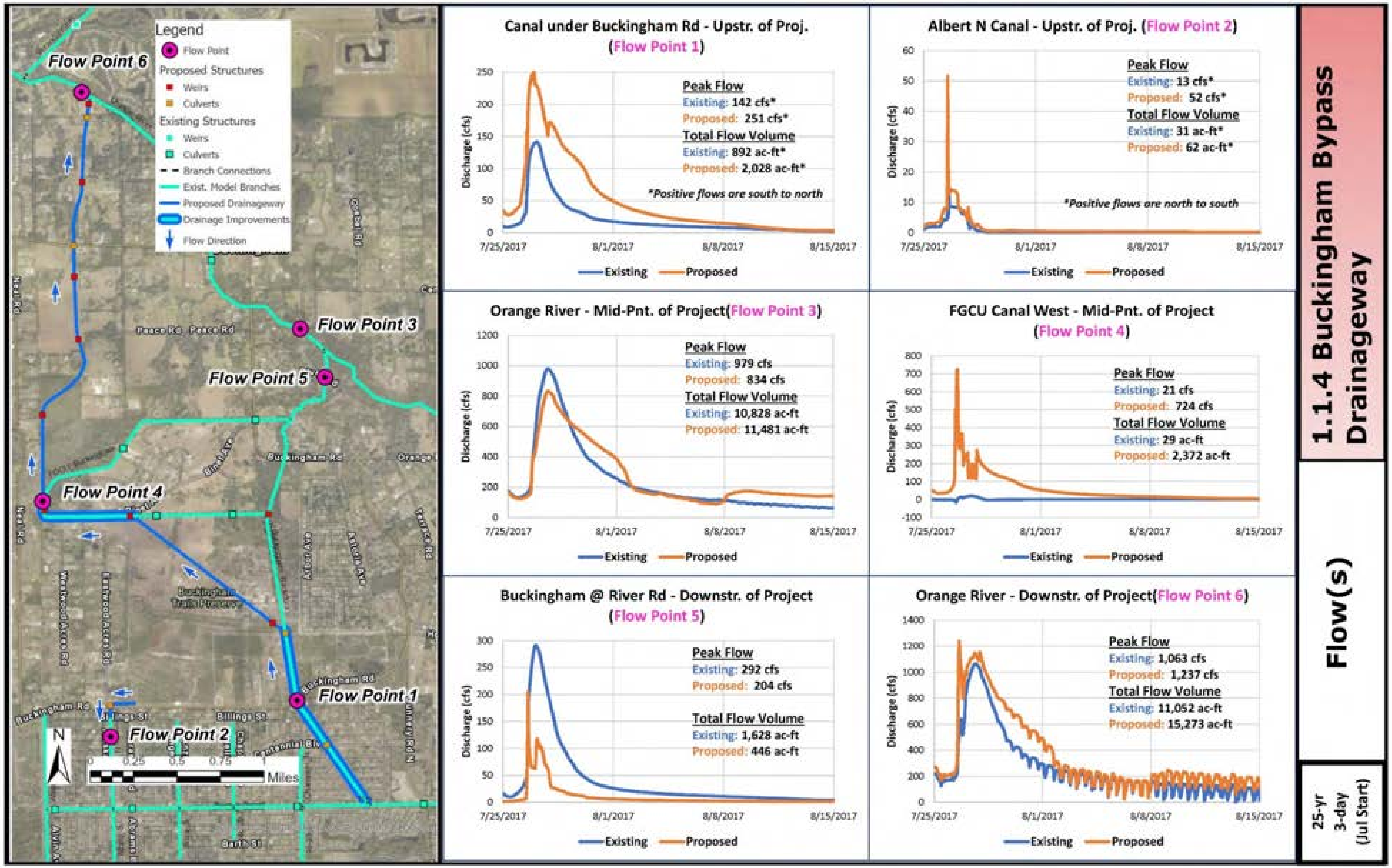


EXHIBIT 1.1.4 (d)

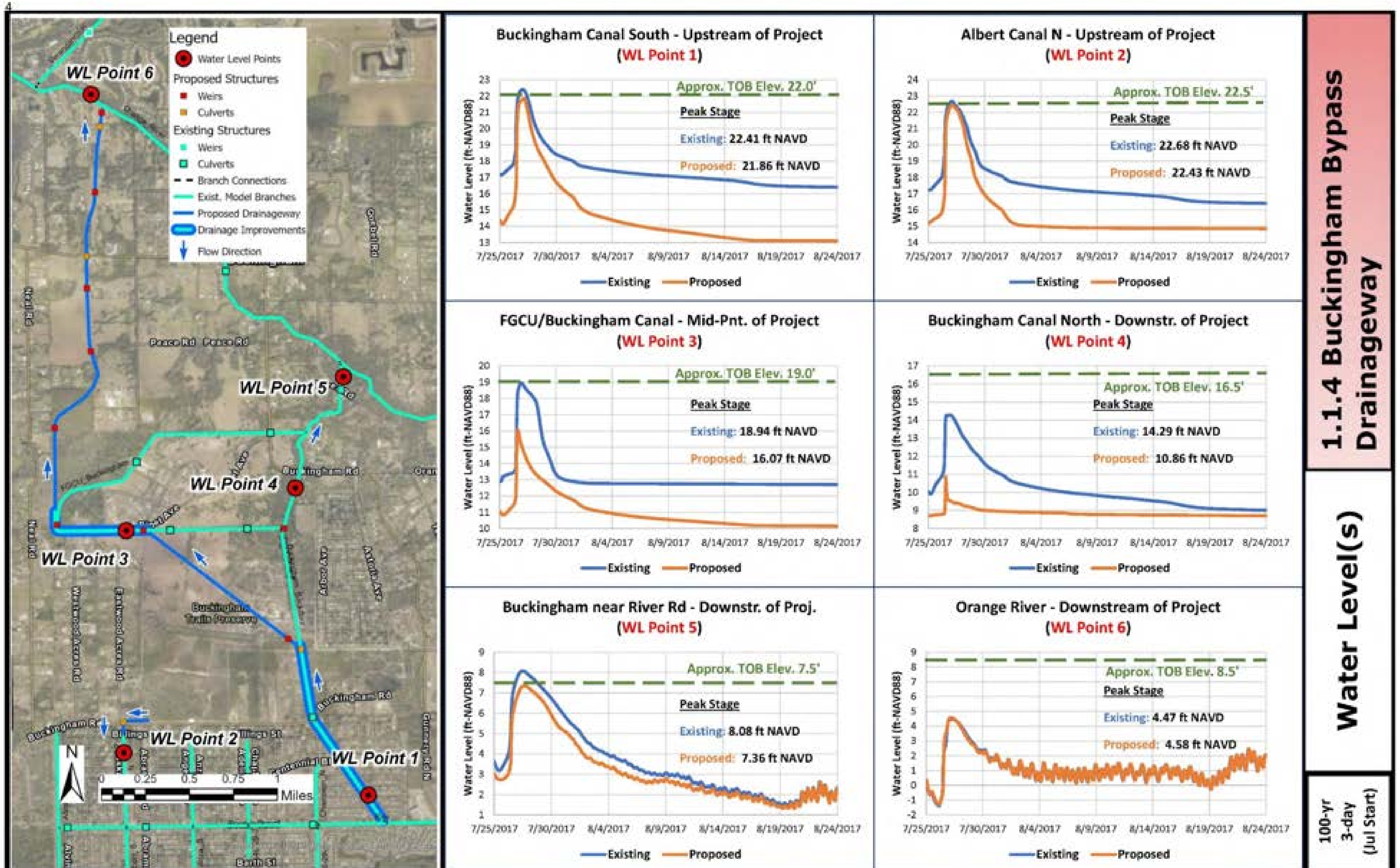


EXHIBIT 1.1.4 (e)

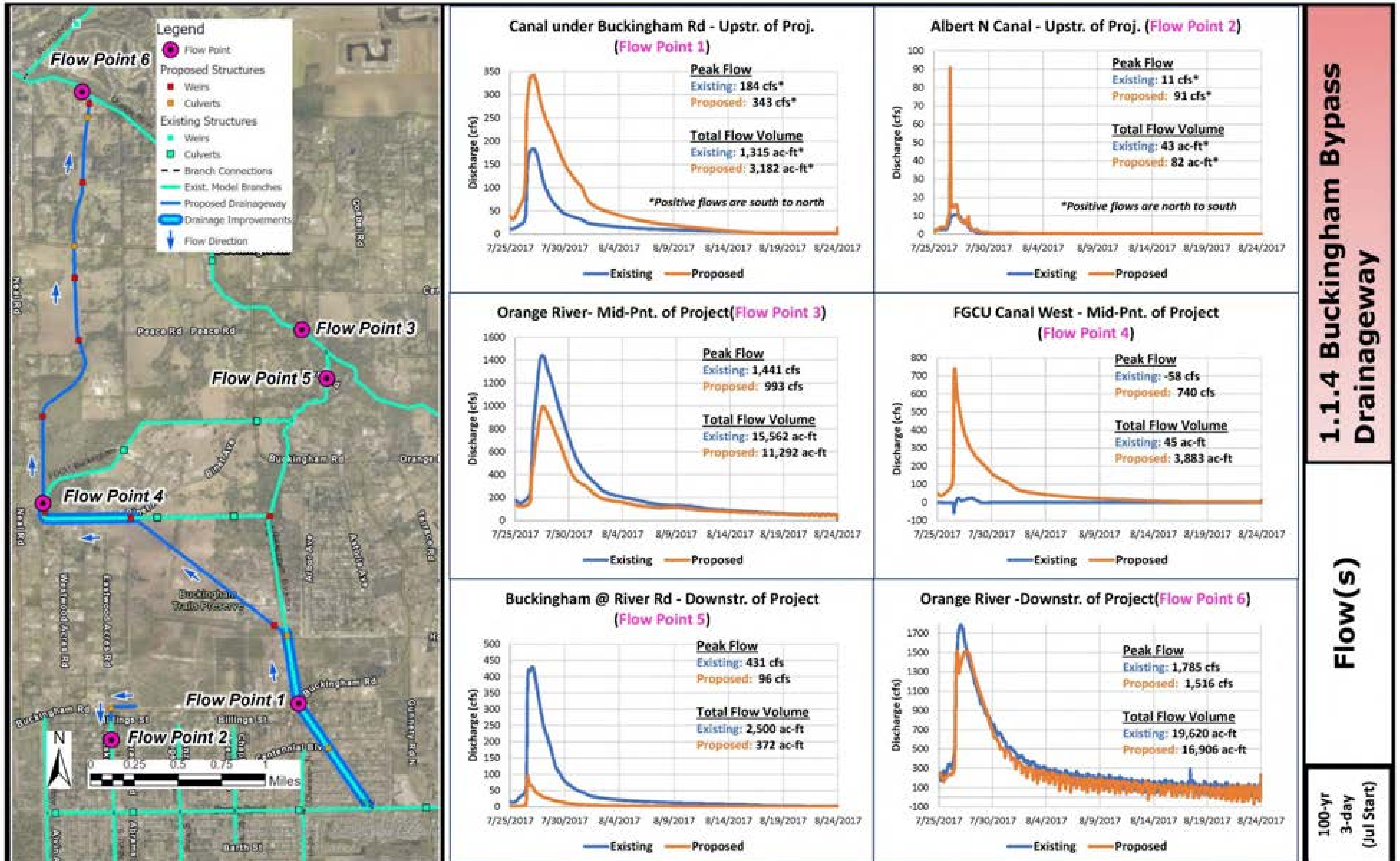


EXHIBIT 1.1.4 (f)

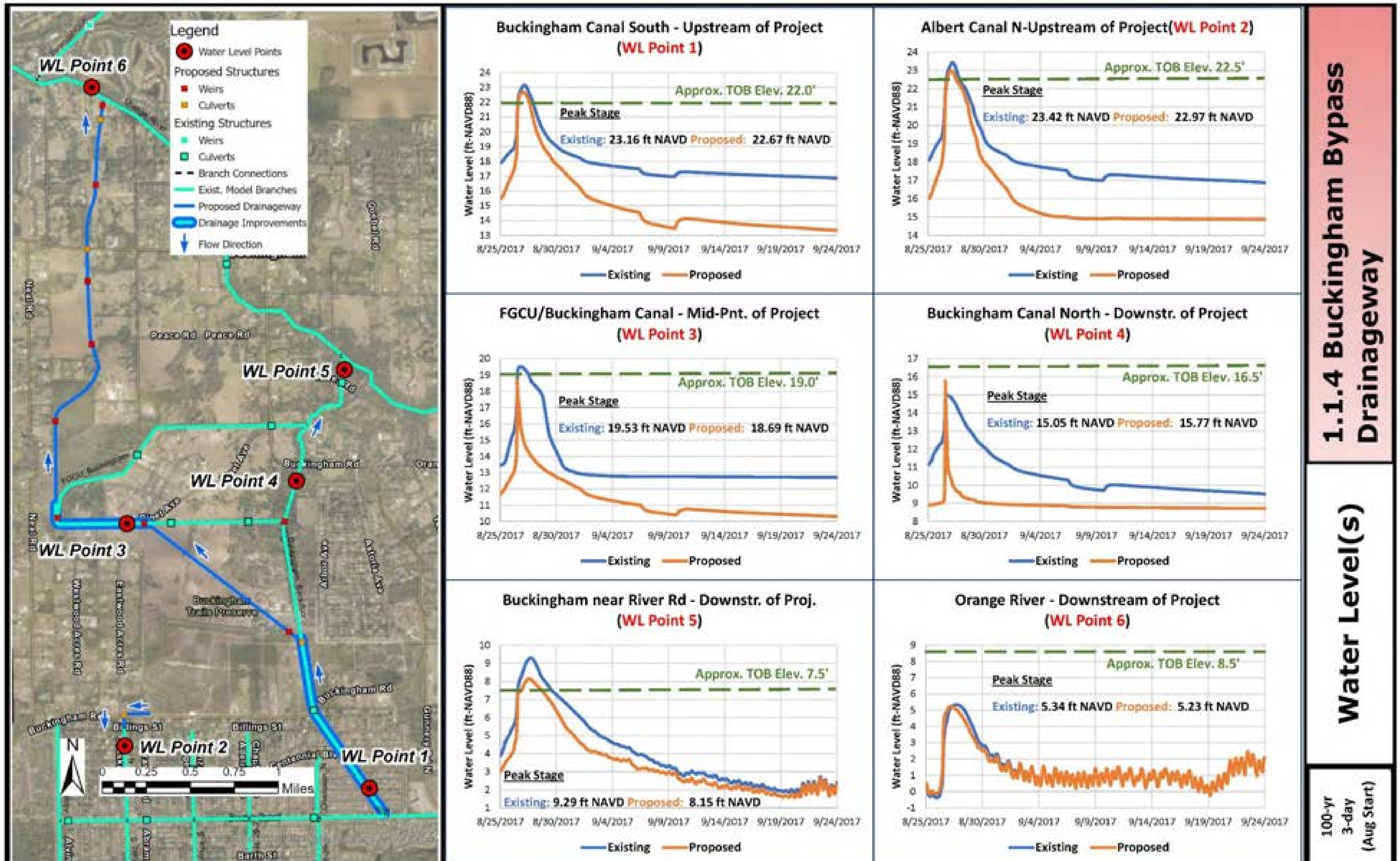


EXHIBIT 1.1.4 (g)

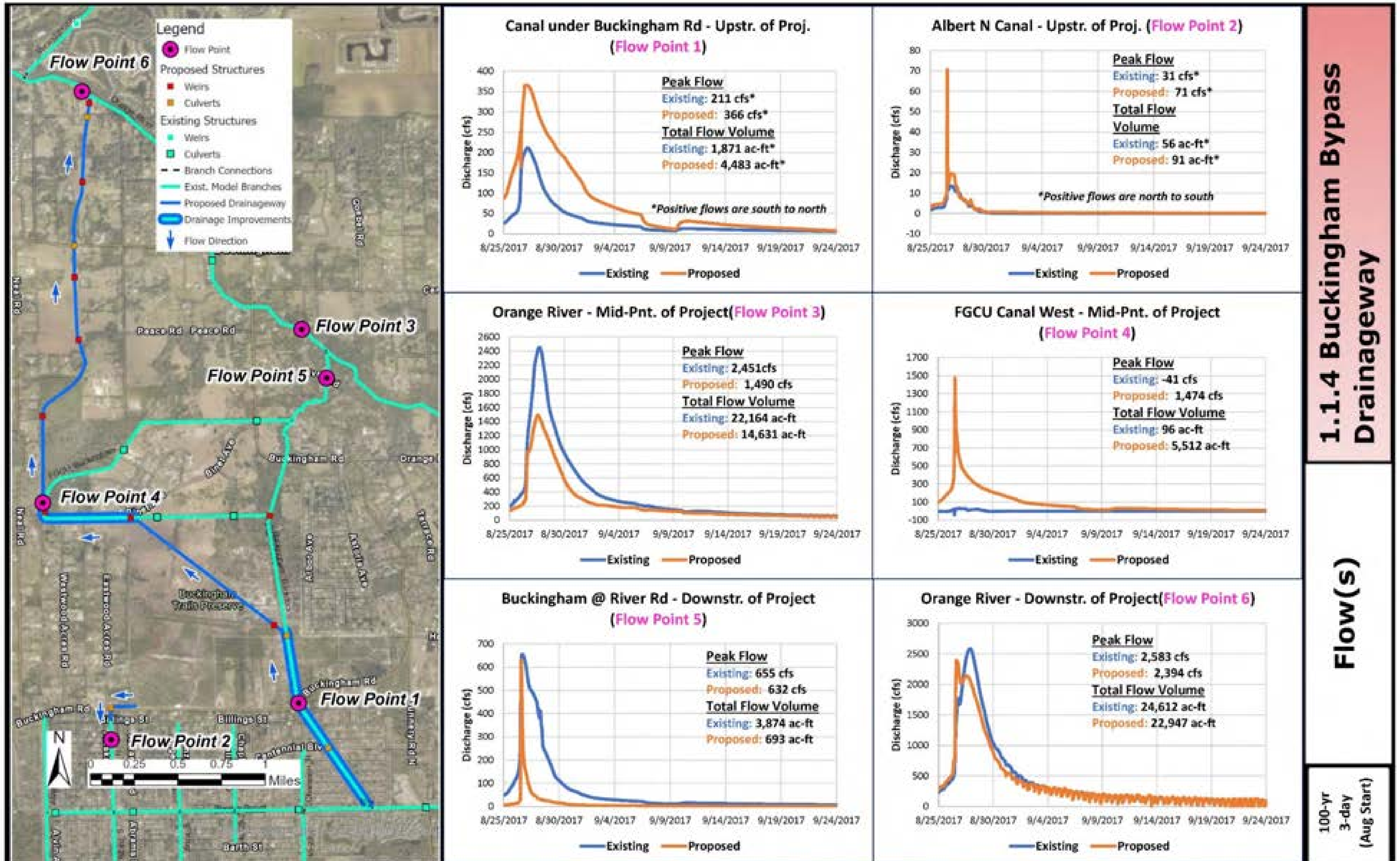


EXHIBIT 1.1.4 (h)

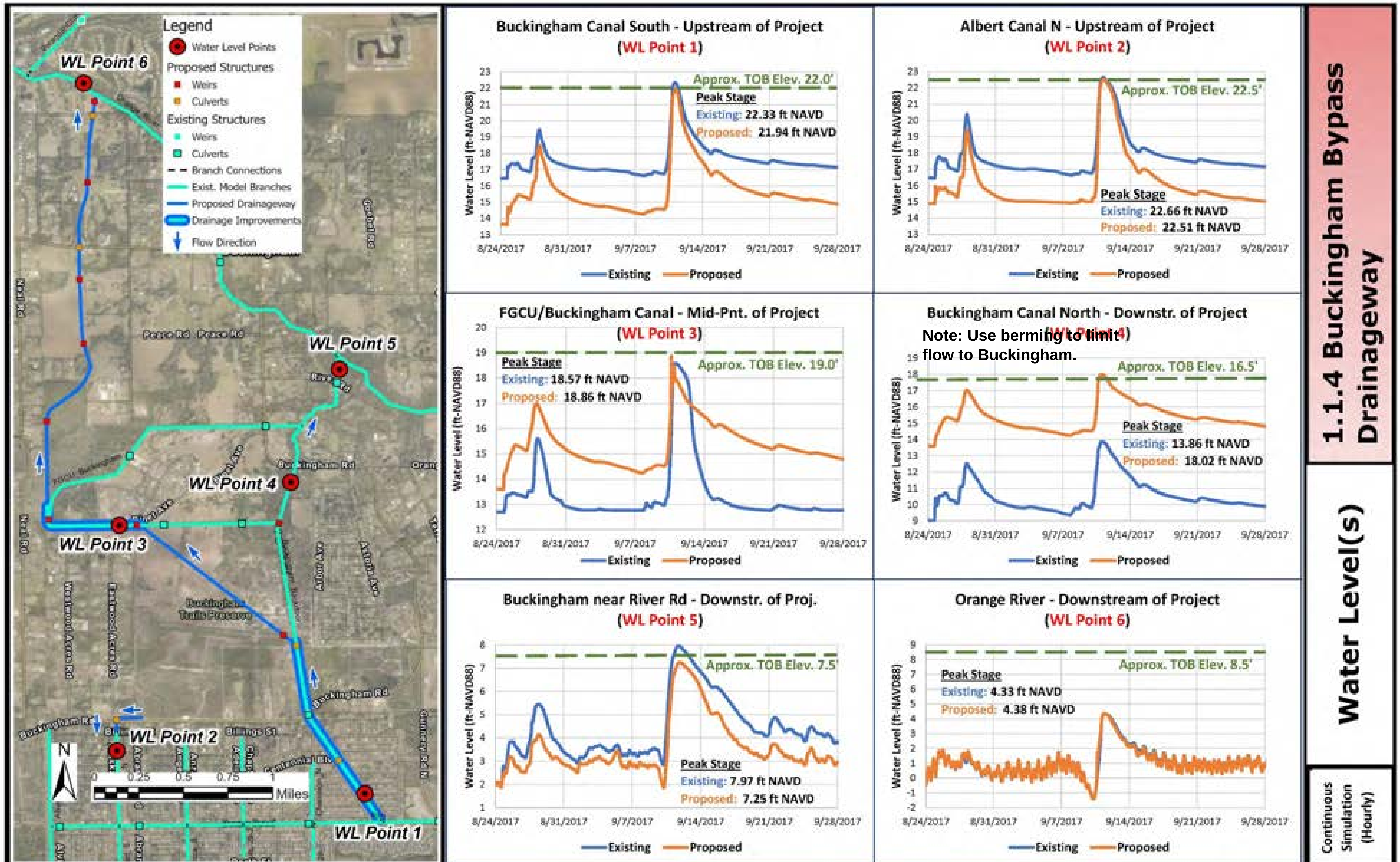
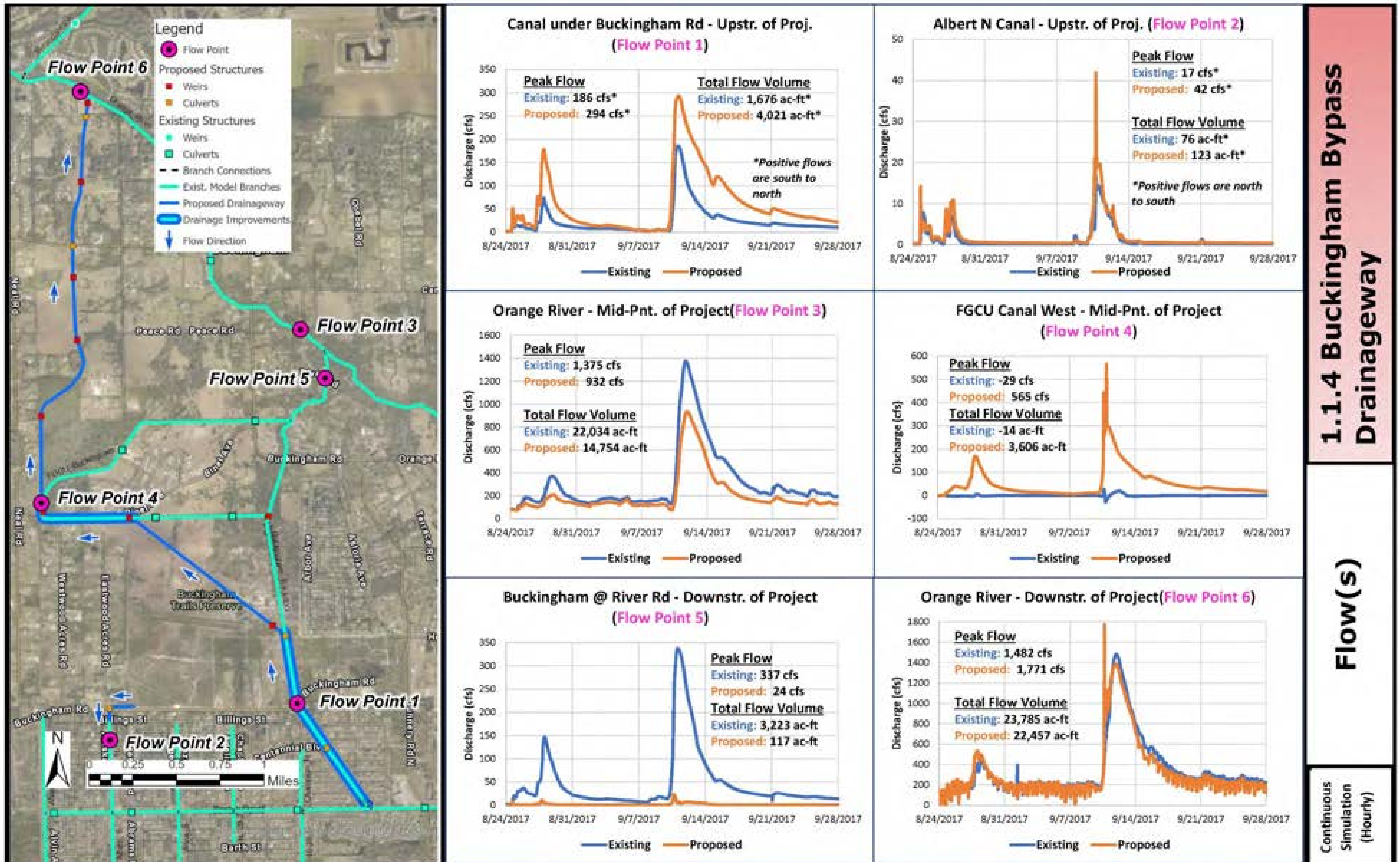


EXHIBIT 1.1.4 (i)



1.1.5 Buckingham Trails Water Quality Reservoir

Background

This 2020 Conservation Lands parcel is located south of the Orange River, north of Lehigh Acres, westerly of the old Army Airfield and adjoins the FGCU property that was formerly Sunland Training Center. The land cover within the concept project is pastures and farmlands and is currently used for horse riding trails. The land naturally slopes towards the Orange River. The old Buckingham Army Airfield encompassed the lands of the proposed water quality reservoir and the historical artifacts within this site should be preserved.

Location

This concept project in located within the Buckingham Trials Preserve in Sections 17 and 20, Township 44 South, and Range 26 East just north of Buckingham Road as shown by the location map in **Figure 23** below:

Figure 23 - Location Map, 1.1.5 Buckingham Trails Water Quality Reservoir

Description

This proposed conceptual project would create a filter marsh and reservoir to provide water quality treatment and storage of stormwater flowing from Lehigh Acres via the Nine-Mile Run Drainageway. The stormwater flow would route through the tract into offline stormwater treatment and storage areas planted with wetland vegetation.

There are existing tree canopy and historical features that would remain. Flow would be directed through winding channels regraded for filter marsh water quality treatment. Inflows would gravity flow enter either the southeast corner, via Angle Canal, or enter the southwest corner, via Alaska Canal. Improvements to the conveyance crossings at Buckingham road are required. Preservation of historical features and establishment of interesting and unique riding trails may be incorporated into the design utilizing the excavated fill material. See illustrated example layout in **Figure 24**:

Figure 24 - Concept Plan, 1.1.5 Buckingham Trails Water Quality Reservoir

Purpose

This project offers a very significant stormwater storage area with related peak flow attenuation of excess stormwater runoff from the Lehigh Acres area while providing water quality treatment. Spoil material from the excavation work may be used to add riding trail elements, or for road projects in the area.

Evaluation

Viability

This project appears to meet flood management, surface water storage, and water quality goals consistent with the municipal separate storm sewer system (MS4) stormwater permit. Existing LIDAR land elevation suggest this offline gravity treatment of flows would be a highly effective and functional water quality improvement system. Other preliminary routes have been previously analyzed, such as continuing North with the existing conveyance to the FGCU perimeter ditch rather than the proposed adjoining concept. However, the natural elevations of the Northeast corner are approximately 3 feet lower than the outflow area in the Northwest corner of the project. **Figure 25,** provides an aerial LIDAR of the project location indicating the proposed adjoining concept and elevation changes in the Buckingham Trails location.

Community Considerations

Adverse community impacts are minimal as this region is mostly undeveloped. The existing public access/parking area is proposed to remain. The Buckingham Trails Preserve currently accommodates equestrian activities. Proposed berms for the project can also double as equestrian trails.

Environmental & Permittability Considerations

From the Lee County Property Appraiser Site, there are no listings of an eagle nesting site buffer or panther habitat. Most soils listed include Oldsmar Sand, Malabar Fine Sand, Immokalee Sand, Pineda Fine Sand (Limestone Substratum) and Halladale Fine Sand. Most of the land cover includes Improved Pastures, Pine Flatwoods, Palmetto Prairies, and Upland Shrub and Brushland. The existing land use of Rural Community Preserve could remain unchanged. Existing wetlands identified during the SFWMD permitting process could remain unaltered. During the design process, the preferred placement of environmental systems can be refined. Natural areas and nonfilter marsh areas can be more contiguous to facilitate habitat management and provide better wildlife habitat. Mitigation of environmental impacts, if any, would require mitigation.

Land Availability

With the land already acquired by Lee County, creating environmental enhancements should not be a legally stringent process. Making the connection from Alaska Canal to the concept project would require limited land acquisition. Inclusion of community involvement and education would also ensure support from the stakeholders. Coordination with Lee County Lands is required.

Opinion of Probable Cost

The cost opinion shown in **Table 6** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 6: Opinion of Probable Cost breakdown, 1.1.5 Buckingham Trails Water Quality Reservoir

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,404,000	$ 1,404,000
Clearing & Grubbing	90	AC	$ 14,000	$ 1,260,000
Earthwork	726,000	CY	$ 6	$ 4,356,000
Construction/ Maintenance Access	12,000	SY	$ 20	$ 240,000
Detours	1	LS	$ 140,000	$ 140,000
Box Culvert 1.5-1	100	CY	$ 1,200	$ 120,000
Box Culvert 1.5-2	120	CY	$ 1,200	$ 144,000
Box Culvert 1.5-3	100	CY	$ 1,200	$ 120,000
Trail bridge	1,200	SF	$ 300	$ 360,000
24" ERCP	540	LF	$ 100	$ 54,000
Permanent Erosion Control	10,000	SF	$ 15	$ 150,000
Grassing	126,000	SY	$ 2	$ 252,000
Plantings	1,210,000	EA	$ 1	$ 1,210,000
			Conceptual Construction Costs:	**$ 8,600,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 2,580,000
			Land Acquisition	$ 200,000
			Project Administration/ CEI (10%)	$ 860,000
			Project Unknowns	$ 160,000
			Conceptual Project Cost:	**$ 12,400,000**
			Contengency (30%)	$ 3,600,000
			Conceptual Project Cost (with Contengency):	**$ 16,000,000**

Opportunities for Multiple Benefits & Uses

As Lehigh Acres continues to reach full build-out conditions, improving the conveyance of the Orange River Drainage Basin is a critical priority. Providing storage solutions will also become increasingly difficult as development diminishes the available land. This project allows for potential incorporation of water quality improvement components.

Other Considerations

In order to achieve the most benefits, the conveyance improvements of the Buckingham Bypass Drainageway concept plan should be implemented with this project to provide sustaining stormwater flow to the filter marsh plantings. A summary of this concept project is shown below in **Exhibit 1.1.5** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of implementing a water quality treatment system and storm water reservoir at the Buckingham Trails parcel to store and attenuate high peak flows. This project concept would rely on project concept 1.1.4 for inflow and outflow. The refined concept plan is shown in **Exhibit 1.1.5 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.5 (b) EXHIBIT 1.1.5 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.5 (d) EXHIBIT 1.1.5 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.5 (f) EXHIBIT 1.1.5 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.5 (h) EXHIBIT 1.1.5 (i)

Improvements were shown with a reduction in water levels within this region of Lehigh Acres. Peak flows leaving Buckingham Trails significantly increased with a reduction in flows to the upper reaches of the Orange River.

Recommendations

The implementation of a water quality treatment system and storm water reservoir at the Buckingham Trails parcel allows for extra storage and the attenuation of high peak flows. The intent of the southwest connection at Albert Canal is to increase discharge leaving Lehigh Acres. The design of this project should avoid recirculation issues though greater analysis of survey-collected data and exact placement of berming and water control structures. It is very important to provide berming along the lower boundaries of the reservoir to avoid overtopping and allowing excess flows to Buckingham and the Orange River. These positive improvements with this project concept warrant further design-level project development.

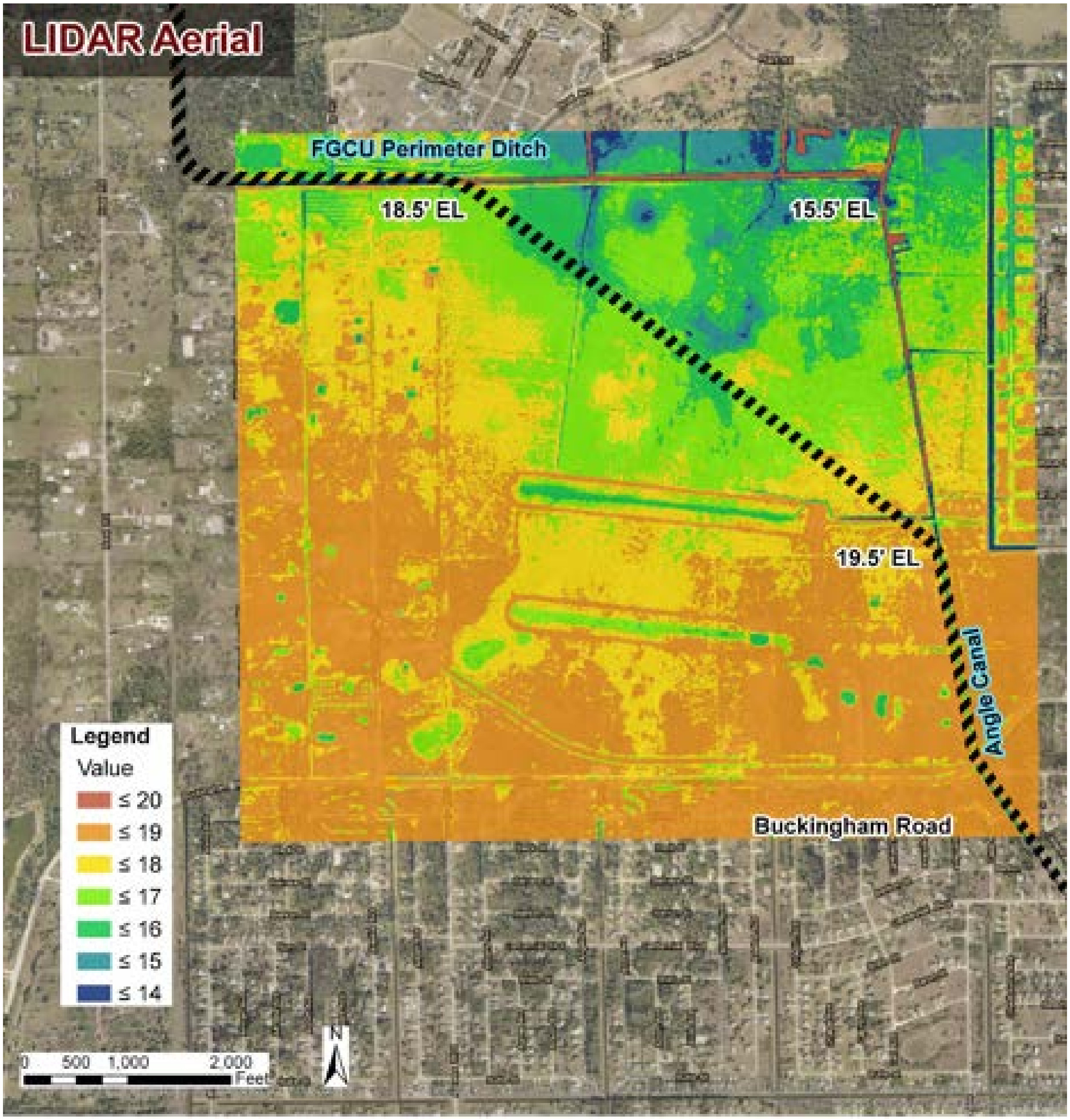
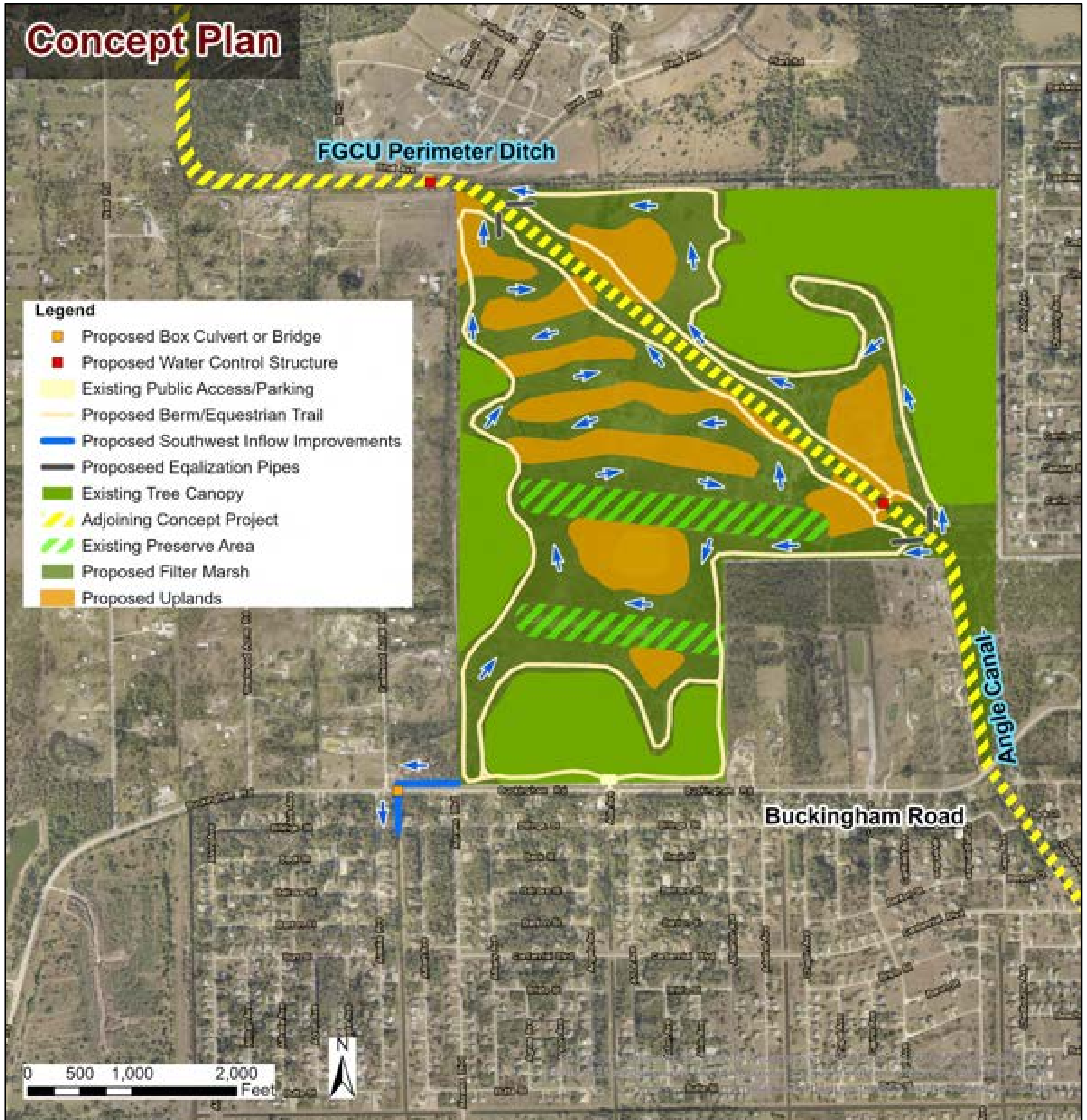


Figure 25: Aerial with LIDAR Imagery, 1.1.5 Buckingham Trails Water Quality Reservoir

EXHIBIT 1.1.5



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project would create a filter marsh and reservoir to provide water quality treatment and storage of stormwater flow from Lehigh Acres via the Nine-Mile Run Drainageway. The flow would route through the tract into offline stormwater treatment and storage areas planted with wetland vegetation. Preservation of historical features and establishment of riding trails would be incorporated into the design.

PURPOSE: This project offers a very significant stormwater storage area with related peak flow attenuation of excess stormwater runoff from the Lehigh Acres area while providing water quality treatment. Soil material from excavation may be used to add riding trail elements, or for road projects in the area.

CONSTRAINTS: This project as proposed is located on public property requiring governmental approval. Weir structures to manage water levels and a large drainage structure at Buckingham Road would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

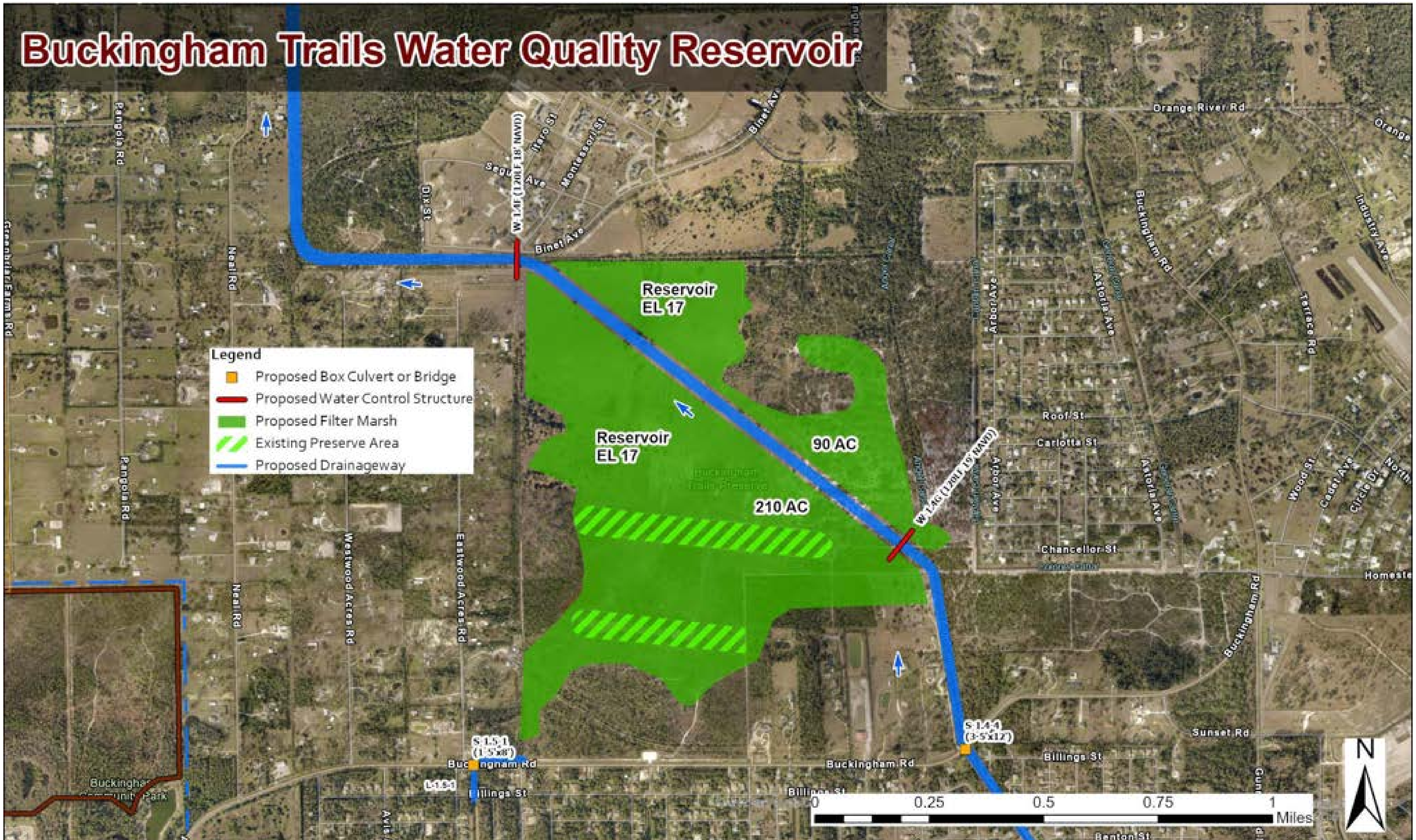
Buckingham Trails Water Quality Reservoir

East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.5

EXHIBIT 1.1.5 (a)



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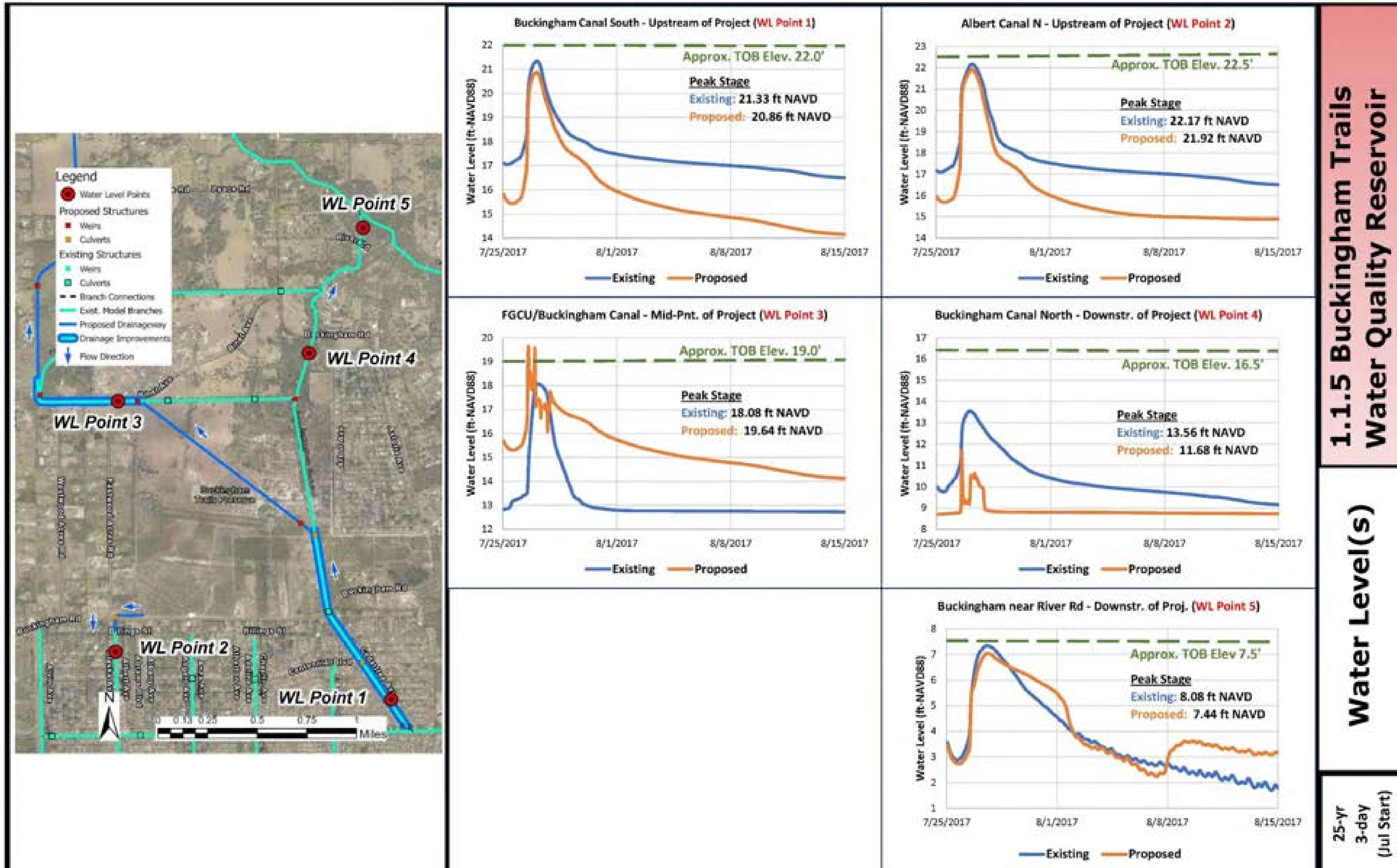


EXHIBIT 1.1.5 (c)

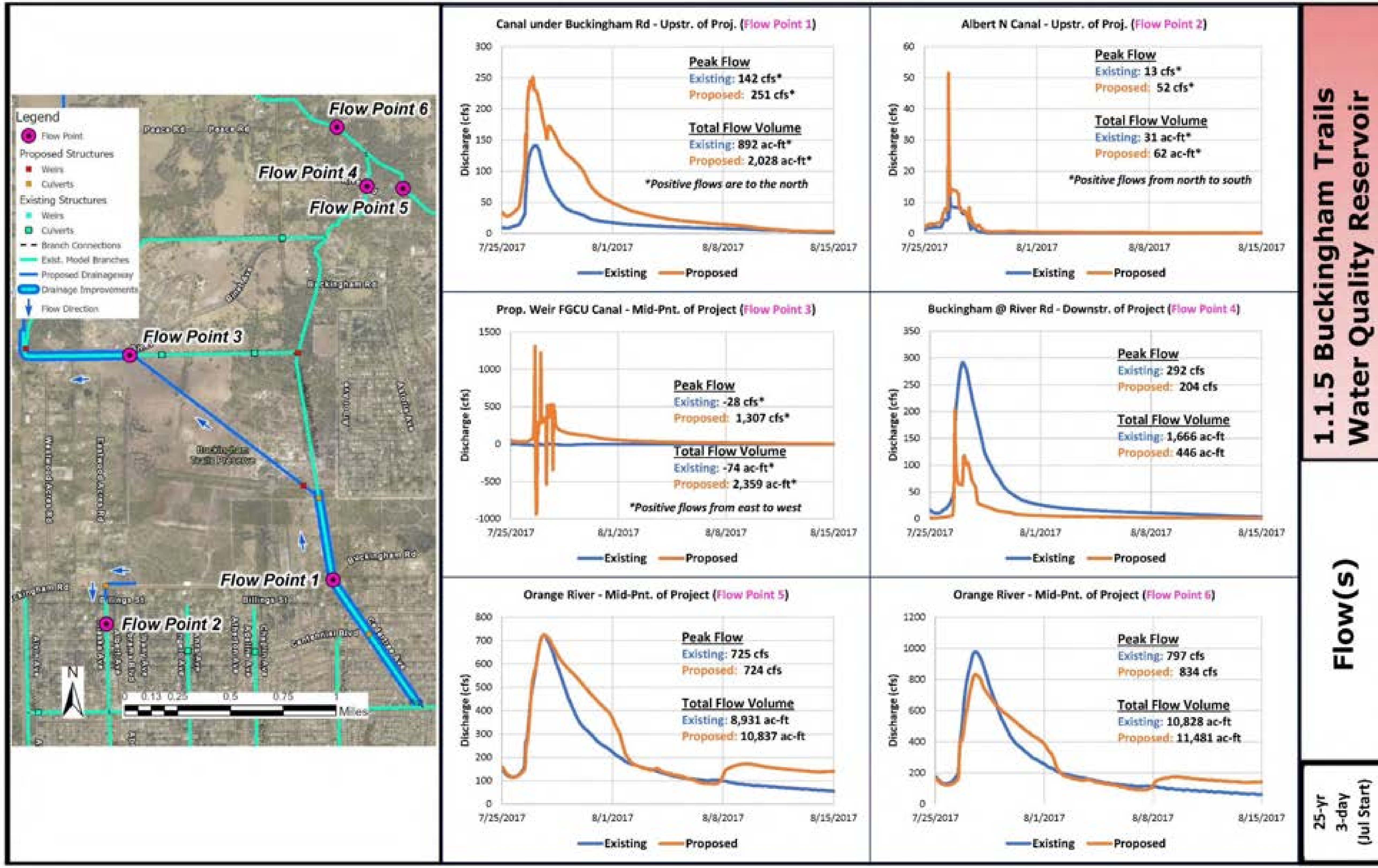


EXHIBIT 1.1.5 (d)

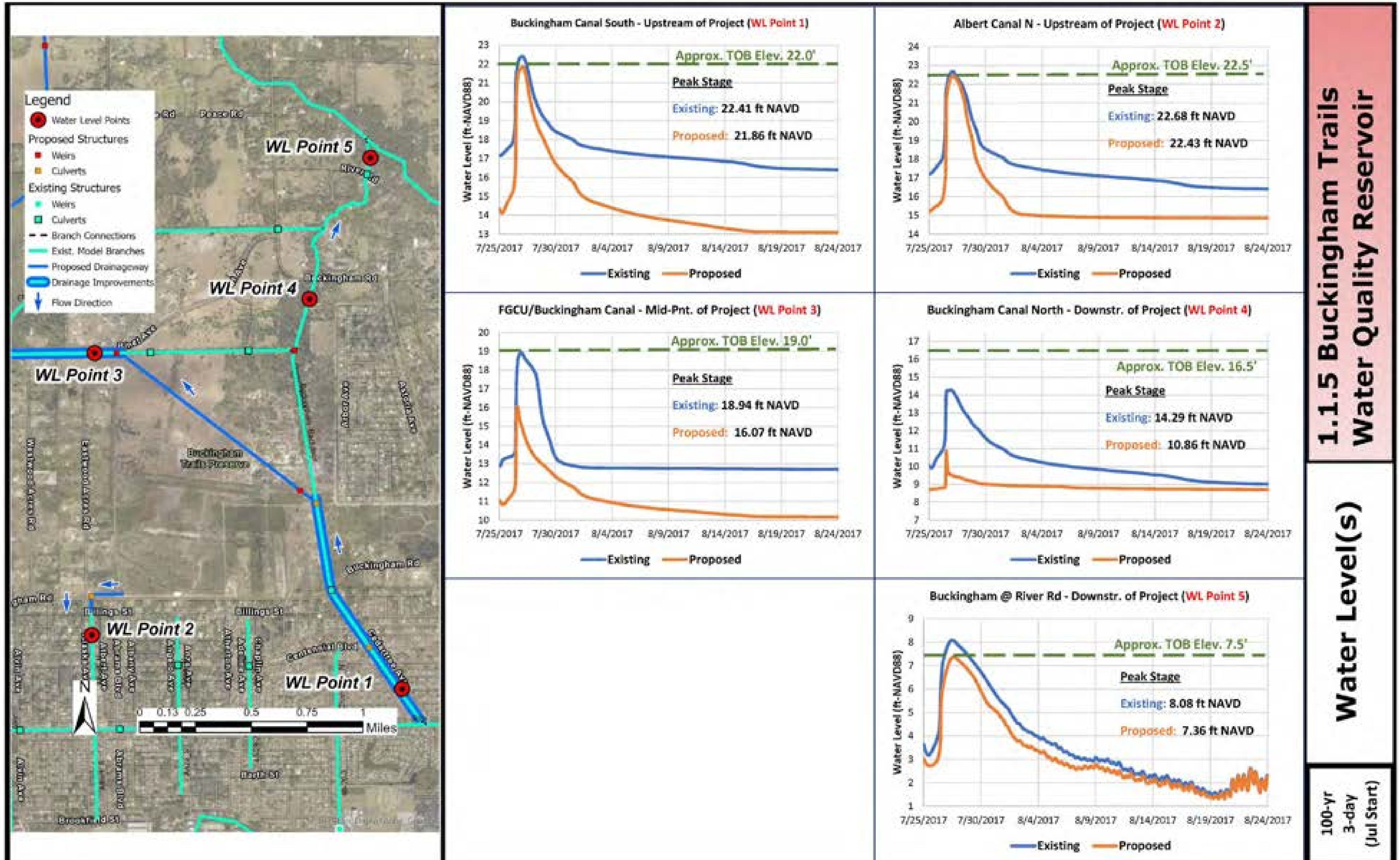


EXHIBIT 1.1.5 (e)

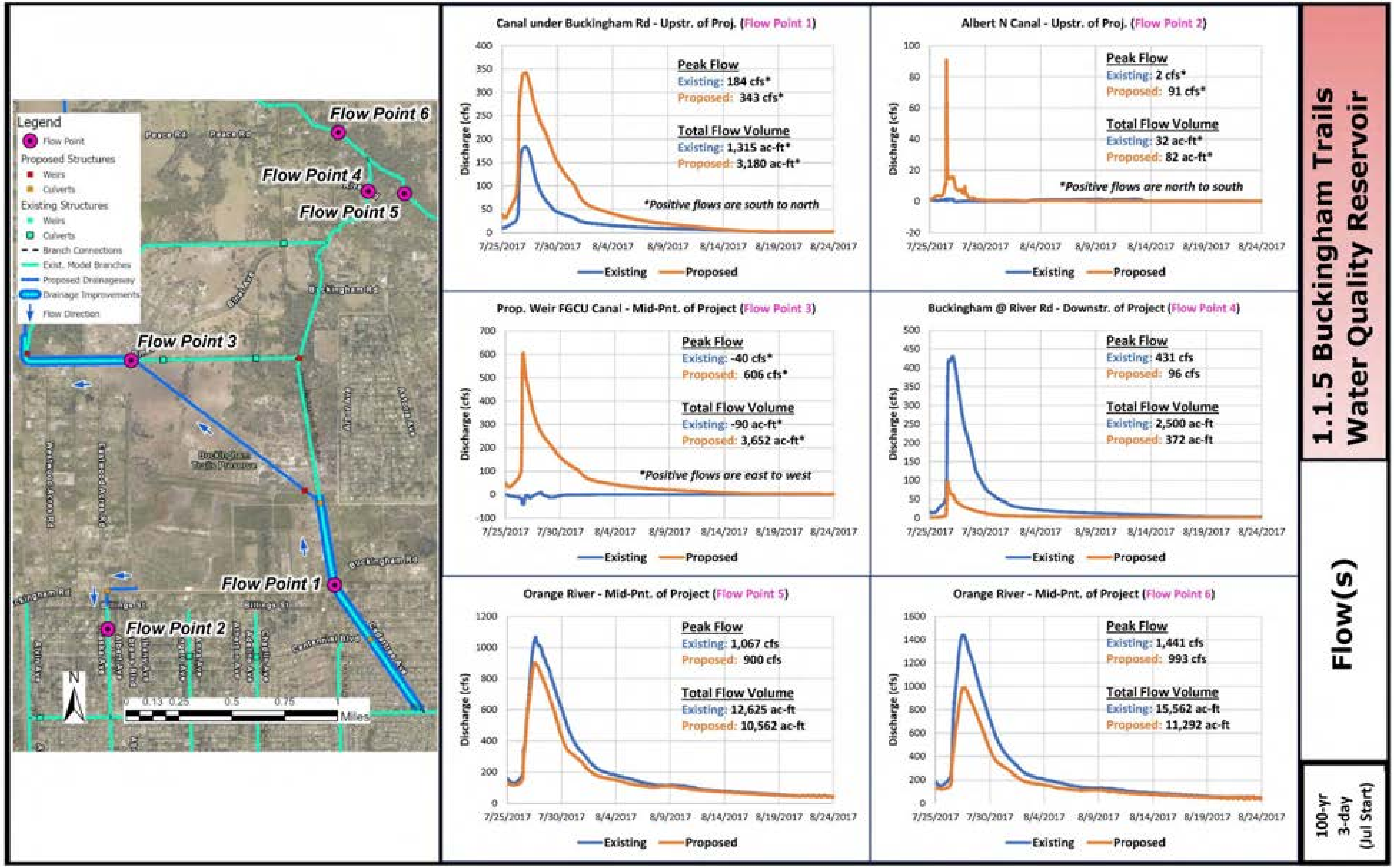


EXHIBIT 1.1.5 (f)

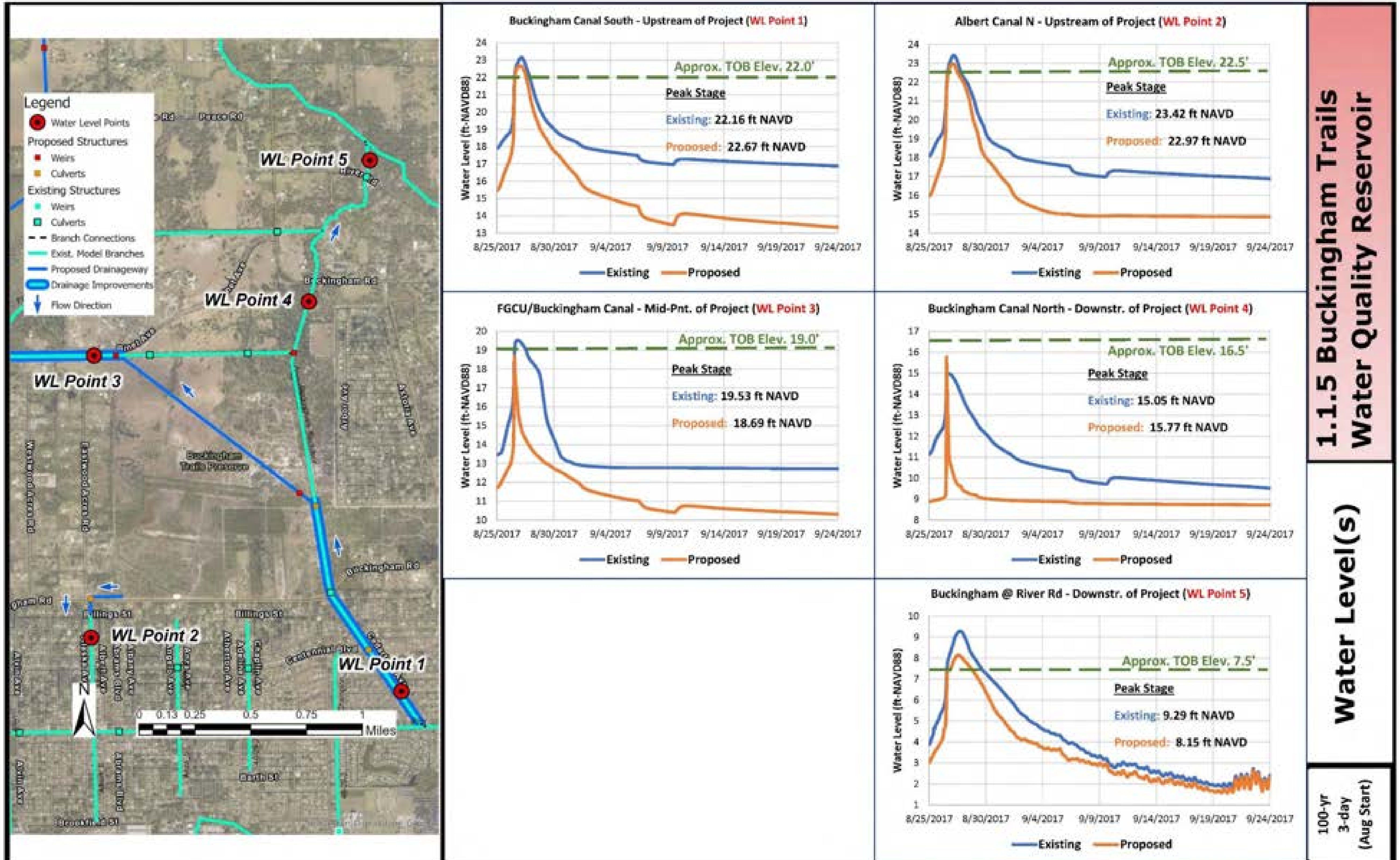


EXHIBIT 1.1.5 (g)

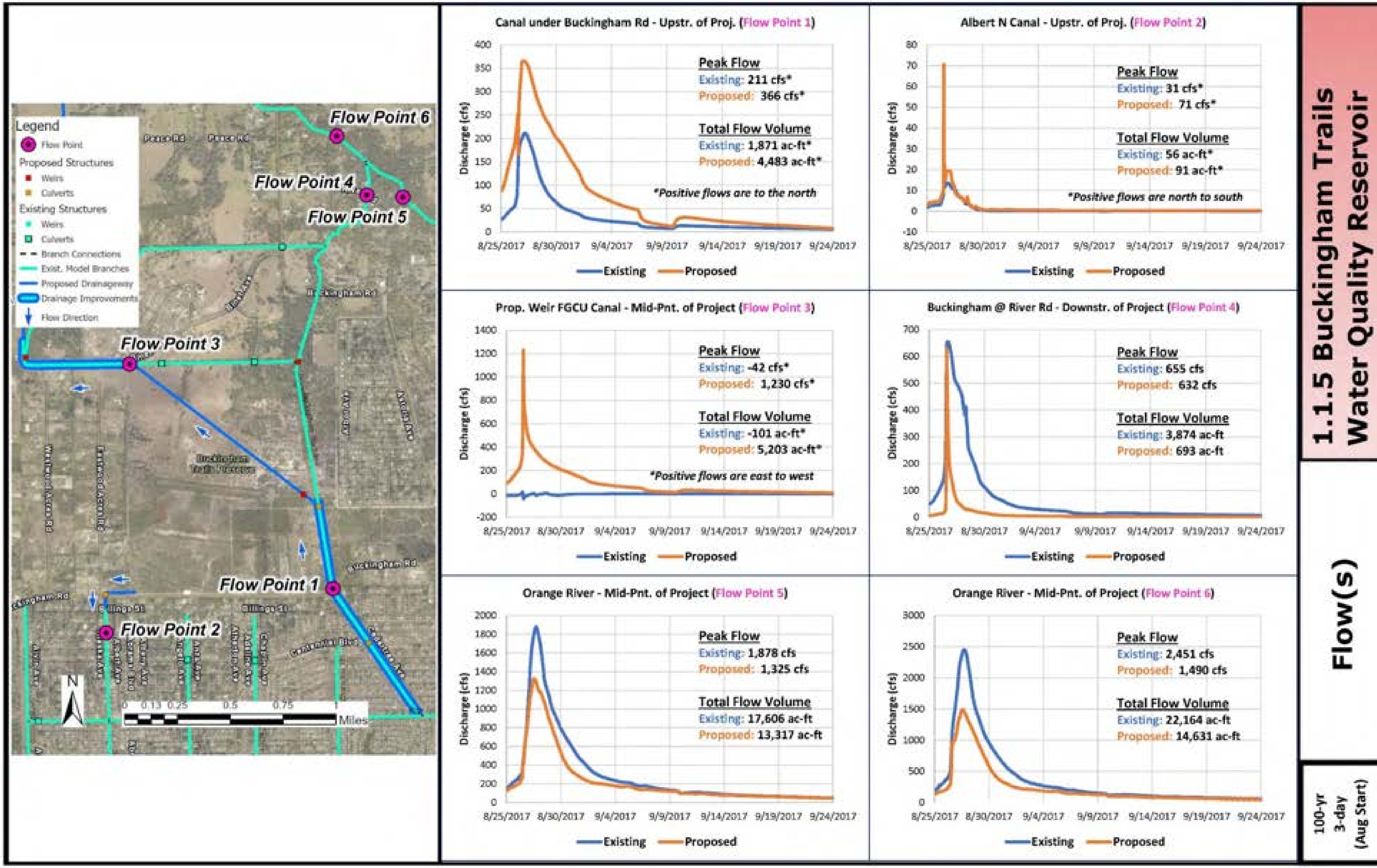


EXHIBIT 1.1.5 (h)

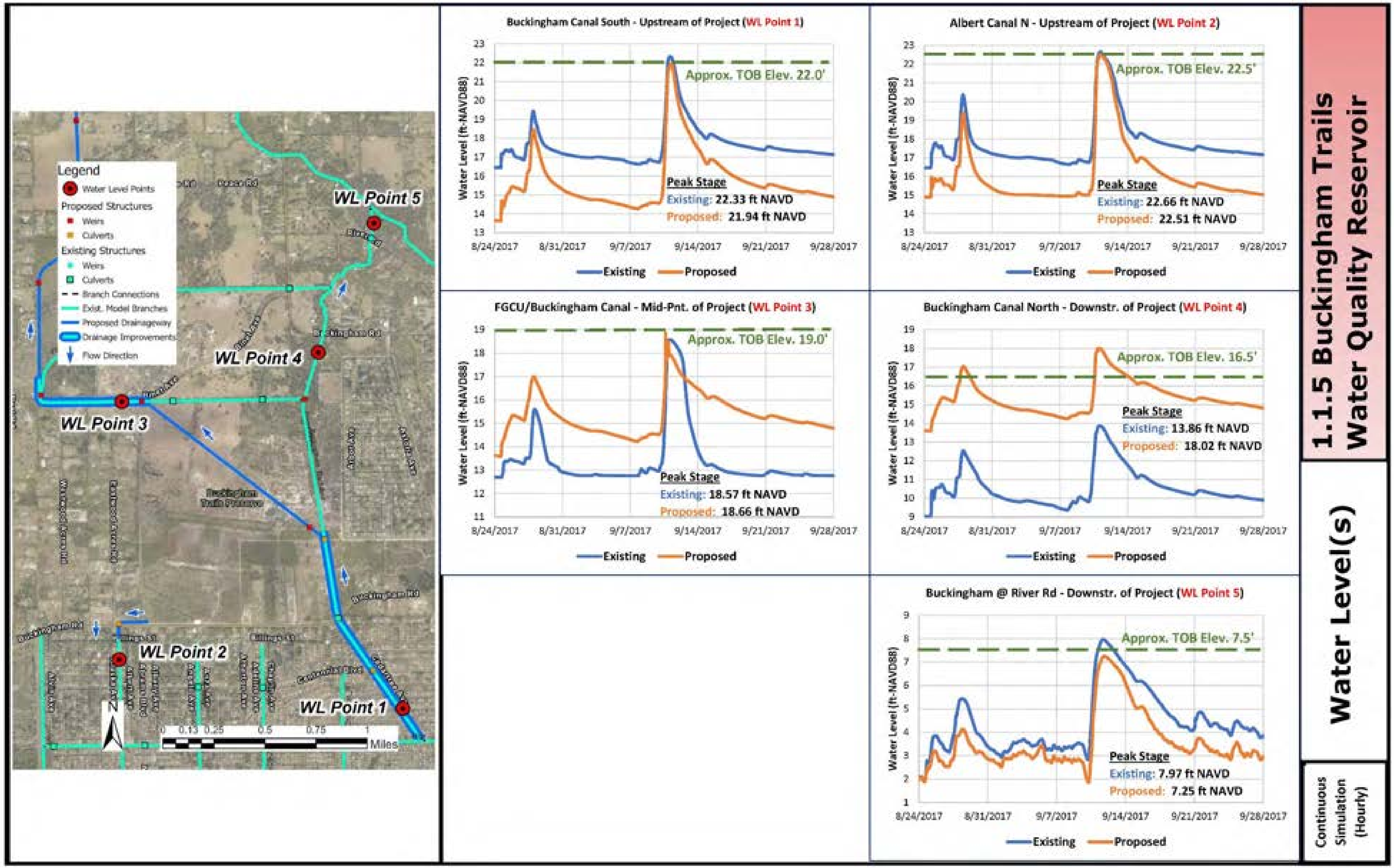
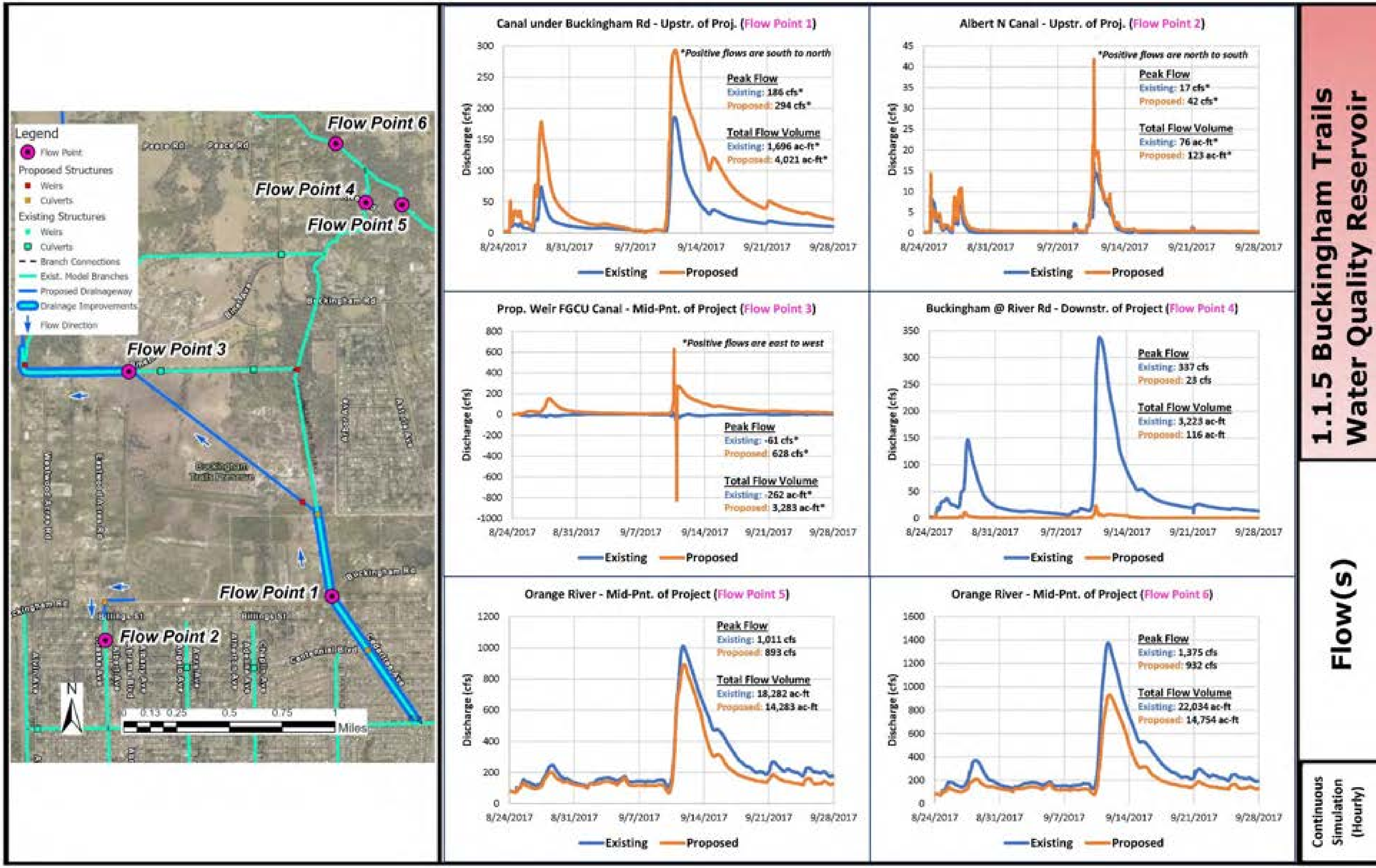


EXHIBIT 1.1.5 (i)



1.1.6 Lehigh-River Hall to Olga Outfall

Background

The River Hall community is located in the Olga area lying north of the northwesterly portion of Lehigh Acres. The land cover historically consisted of pastures and some wetlands and sloughs. A small portion of the area drained to the Orange River with the greater portion naturally sloping towards the Olga area and the Caloosahatchee River. This proposed drainageway crosses and old railroad grade which is now used for power transmission lines. The River Hall community is a recently developed area with a stormwater management system.

Location

This concept project is located near Olga and the River Hall communities which is just north of Lehigh Acres in Sections 22, 27 and 34, Township 43 South, and Range 26 East as depicted in the location map in **Figure 26** below.

Figure 26 - Location Map, 1.1.6 Lehigh-River Hall to Olga Outfall

Description

This proposed conceptual project provides a drainageway from the Lehigh Acres area near Skates Circle North through a portion of the River Hall community across S.R. 80 to Olga and the Caloosahatchee River. This region of the LA-MSID Hickey Creek Drainage Basin naturally falls towards the Orange River. However, the LA-MSID canal system directs flows towards Hickey Creek Canal which increases the travel distance along with adverse uphill flow conditions. The proposed drainageway route is illustrated in **Figure 27**:

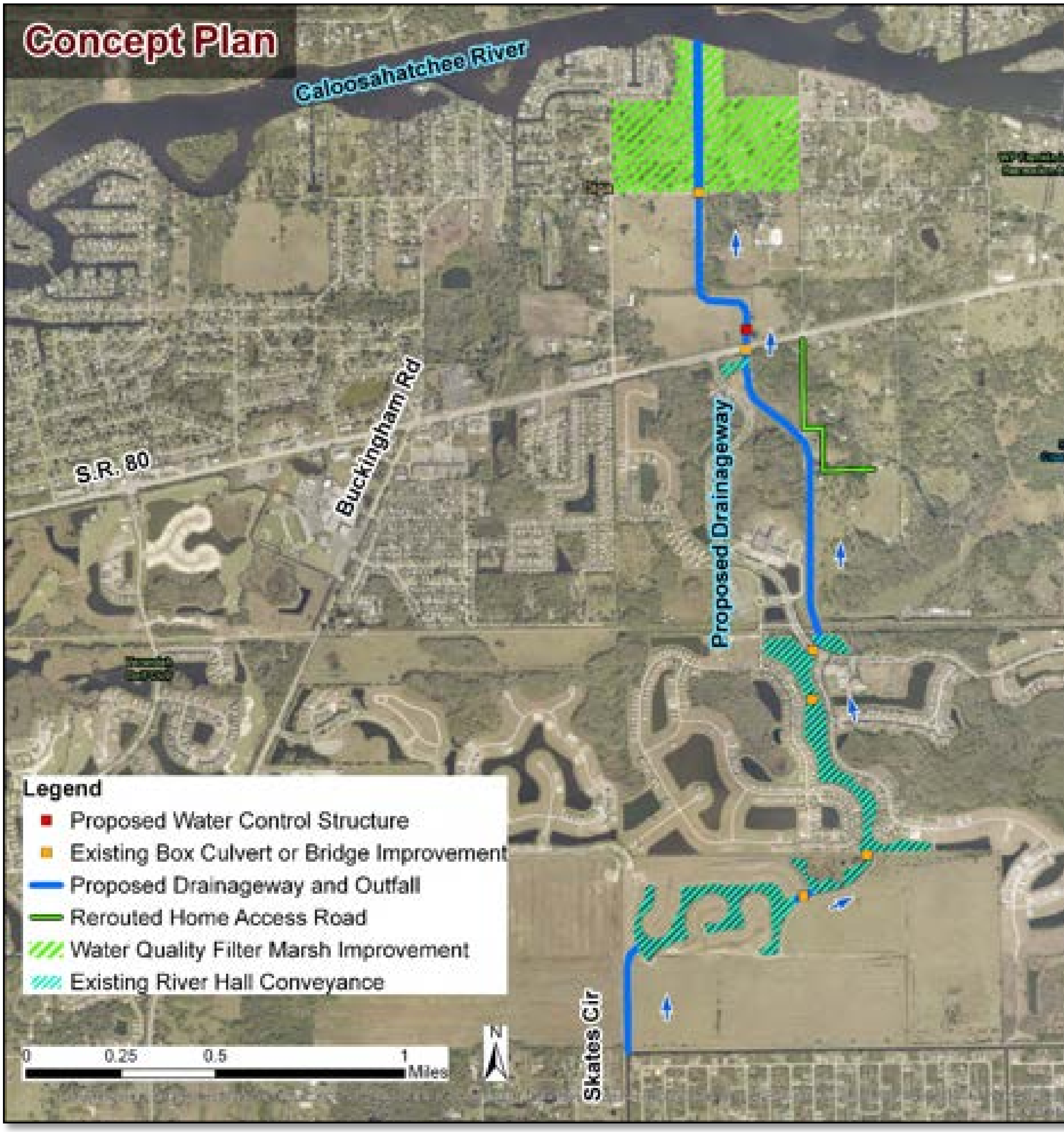


Figure 27 - Concept Plan, 1.1.6 Lehigh-River Hall to Olga Outfall

Purpose

This concept plan seeks to create a more direct outfall for this region while also diverting flows away from Hickey Creek and Orange River. The new conveyance passes through a portion of the River Hall community's stormwater ponds, which is an allowable condition in River Hall's water management permit. Box culverts and/or bridges would be required, as well as water control structures.

Evaluation

Viability

This project appears to meet the flood management, surface water storage, and water quality goals consistent with the municipal separate storm sewer system (MS4) stormwater permit. Lee County owns the large parcel identified above as a potential water quality improvement area. The SFWMD ERP permit for the River Hall community has provisions for routing stormwater management conveyance through the community already established.

Community Considerations

Adverse community impacts are involved since the drainageway will flow through the private lake system and cross several roadways. Routing flow though River Hall existing storm lakes system and making the road crossing improvements within River Hall is visually a minimal change to the residents. River Hall has a history of frequent perimeter berm breaches. If this is planned to go through the River Hall system, Improvements may be needed to the River Hall perimeter berm to prevent system breach.

Environmental & Permittability Considerations

A portion of the 2020 Conservation Land parcel near the outfall of the proposed conveyance could be utilized as a water quality improvement area as shown in **Figure 28**. The goals and objectives of Conservation Lands include other factor other than water quality, so there needs to be balance so that the lands set aside as preserves can fulfill each of those goals.

Inflows could be pumped into the south side of the marsh and filter though vegetated channels before discharging back into the proposed drainageway. Existing facilities would be maintained and the creation of walking paths with recreational areas for public access. The existing vegetated canal would remain as a buffer between the filter marsh and the residents along Buckeye Drive.

An excavated area near the outfall would serve as a deep settling lake for further treatment of stormwater flows, as well as increased storage capacity for the system. Excavated material can be utilized to establish a diverse species habitat through the creation of upland areas, shaping of the perimeter berm, and/or providing fill for roadway projects.

Figure 28 - Water Quality Improvement Filter Marsh and Storage Concept Map

Land Availability

Easements and/or land acquisition is required for the parcels between Lehigh Acres and the Lee County 2020 Olga parcel. The route is suggested along property lines to minimize impact to residents. Coordination with Lee County 2020 Conservation Lands is required.

Opinion of Probable Cost

The cost opinion shown in **Table 7** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 7: Opinion of Probable Cost Breakdown, 1.1.6 Lehigh-River Hall to Olga Outfall

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,887,000	$ 1,887,000
Clearing & Grubbing	35	AC	$ 14,000	$ 490,000
Earthwork	230,000	CY	$ 6	$ 1,380,000
Weir Structure 1.6A (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.6B (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.6C (Major)	120	LF	$ 10,000	$ 1,200,000
Detours	1	LS	$ 250,000	$ 250,000
Box Culvert 1.6-1	260	CY	$ 1,200	$ 312,000
Box Culvert 1.6-2	780	CY	$ 1,200	$ 936,000
Box Culvert 1.6-3	550	CY	$ 1,200	$ 660,000
Box Culvert 1.6-4	260	CY	$ 1,200	$ 312,000
Box Culvert 1.6-5	260	CY	$ 1,200	$ 312,000
Box Culvert 1.6-6	405	CY	$ 1,200	$ 486,000
Box Culvert 1.6-7	405	CY	$ 1,200	$ 486,000
Road Repairs	1	LS	$ 244,000	$ 244,000
Electric Supply	1	LS	$ 30,000	$ 30,000
Permanent Erosion Control	14,000	SF	$ 15	$ 210,000
Grassing	52,500	SY	$ 2	$ 105,000
Conceptual Construction Costs:				**$ 11,700,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 3,510,000
Land Acquisition				$ 2,500,000
Project Administration/ CEI (10%)				$ 1,170,000
Project Unknowns				$ 1,120,000
Conceptual Project Cost:				**$ 20,000,000**
Contengency (30%)				$ 6,000,000
Conceptual Project Cost (with Contengency):				**$ 26,000,000**

Opportunities for Multiple Benefits & Uses

As this area continues to reach full build-out conditions, improving the conveyance of the Hickey's Creek Drainage Basin is a priority. Providing storage solutions will also become increasingly difficult as development diminishes the available land. This project allows for potential incorporation of water quality improvement components.

Other Considerations

In avoidance of environmentally sensitive areas, an existing residential access would need to be rerouted to maintain the proposed drainageway route. The residents near Skates Circle reported flooding as the Orange River floodplain expanded to this area and even overtopped the LA-MSID boundary entering Warmouth Canal. During extreme storm events, this concept plan diverts a portion of the Hickey Creek Drainage Basin excess stormwater flow. A summary of this concept project is shown below in Exhibit 1.1.6 herein. A summary of this concept project is shown below in **Exhibit 1.1.6** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from Lehigh Acres through the River Hall development lakes on to Olga Shores and the Caloosahatchee River at a point downstream of the Olga Locks. The land contour elevations show this conveyance route to be a natural flow direction. The refined concept plan is shown in **Exhibit 1.1.6 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

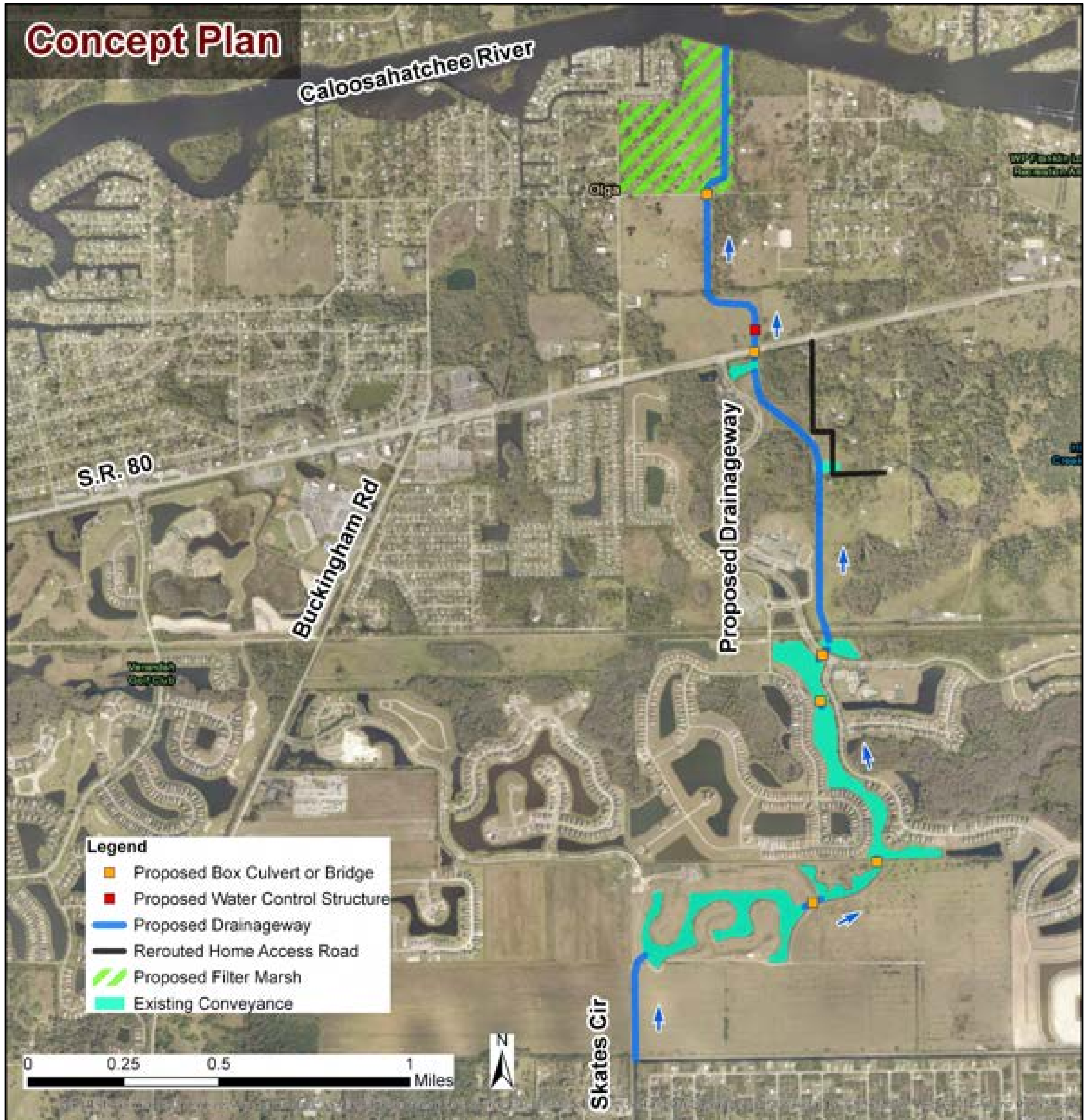
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.6 (b) EXHIBIT 1.1.6 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.6 (d) EXHIBIT 1.1.6 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.6 (f) EXHIBIT 1.1.6 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.6 (h) EXHIBIT 1.1.6 (i)

Improvements were shown in a water level reduction with minimal changes to existing water levels in River Hall and Olga Shores. The greater benefit is seen in the discharge and corresponding volume of flow being redirected from the limited conveyance capacity of natural river/creek outfalls. Although the anticipated flow discharging from Lehigh Acres was anticipated to be much larger, a moderate discharge rate was computed.

Recommendations

Land contour elevations show the proposed conveyance route to be a natural flow from Lehigh Acres through the River Hall development lakes to Olga Shores. The cost for limited benefit for this concept project does not warrant proceeding as currently setup. A more practical approach appears to be to discharge the Lehigh Acres excess rainfall runoff into the River Hall stormwater management system and make improvements to the current River Hall system and outfall for the additional moderate flow. The overall volume removal of excess runoff from Lehigh Acres will continue to be significant. The positive improvements with this project concept warrant further design-level project development.

EXHIBIT 1.1.6



Project Narrative

DESCRIPTION: This proposed conceptual project provides a drainageway from the Lehigh Acres area near Skates Circle North through River Hall community across S.R. 80 to Olga and the Caloosahatchee River. This region of the LA-MSID Hickey Creek Drainage Basin naturally falls towards the Orange River. However, the LA-MSID canal system directs flows towards Hickey Creek which increases the travel distance to the natural Hickey Creek.

PURPOSE: This concept plan seeks to create a more direct outfall for this region while also diverting flows away from Hickey Creek and Orange River. The new conveyance passes through the River Hall community's stormwater ponds, which is allowable condition in River Hall's permit. Box culverts and/or bridges would be required as well as water control structures.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Lehigh-River Hall to Olga Outfall

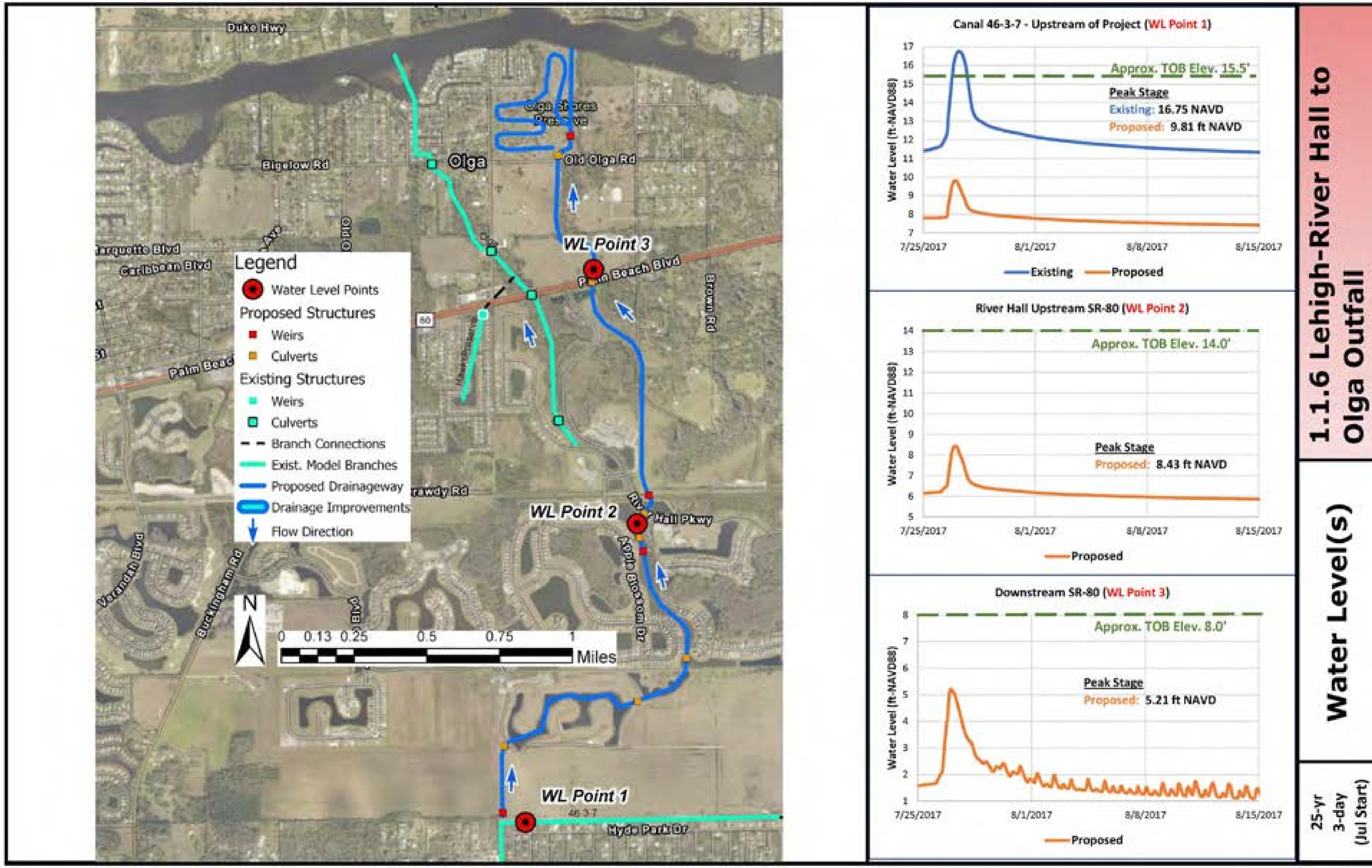
East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.6

EXHIBIT 1.1.6 (a)

EXHIBIT 1.1.6 (b)



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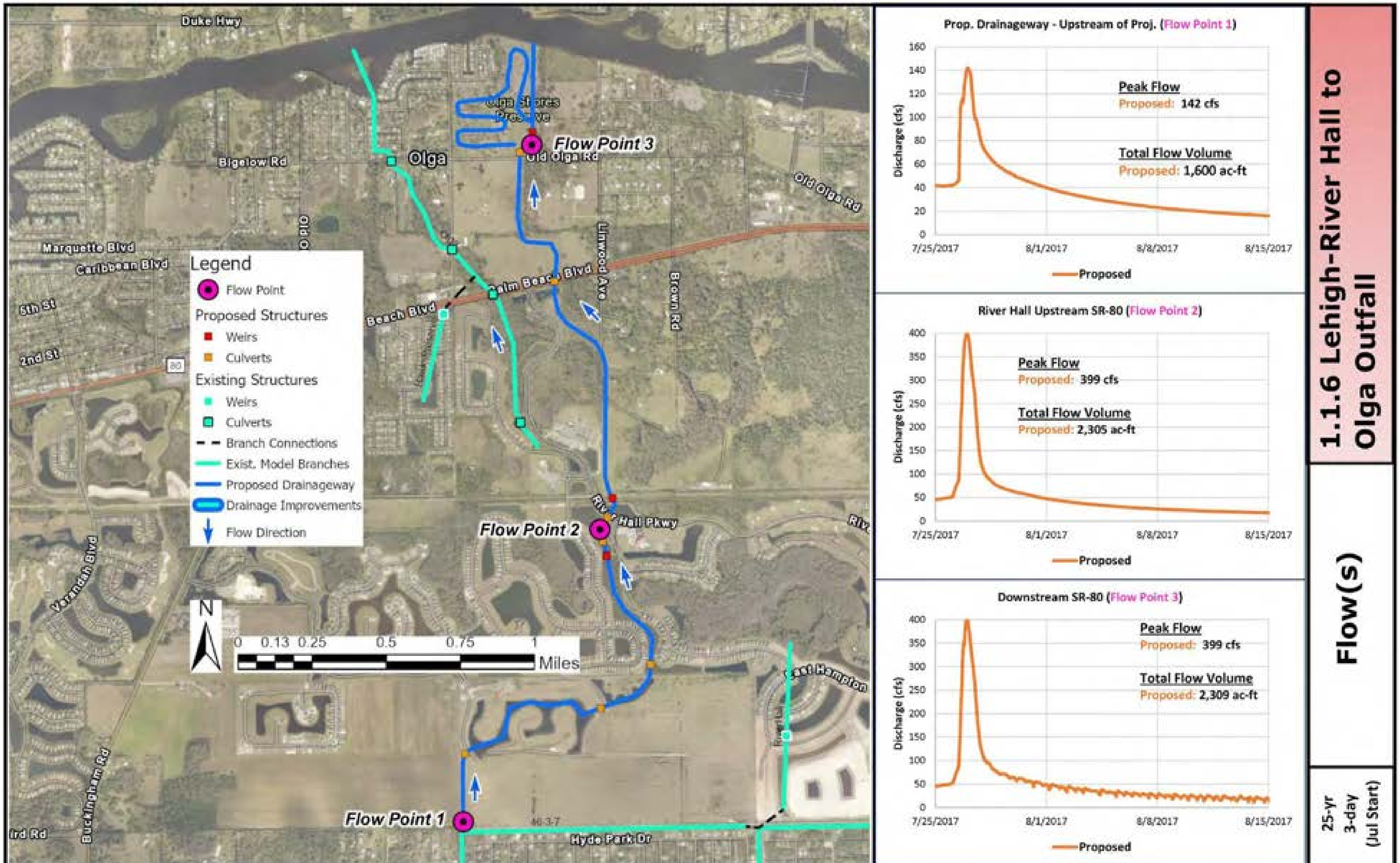

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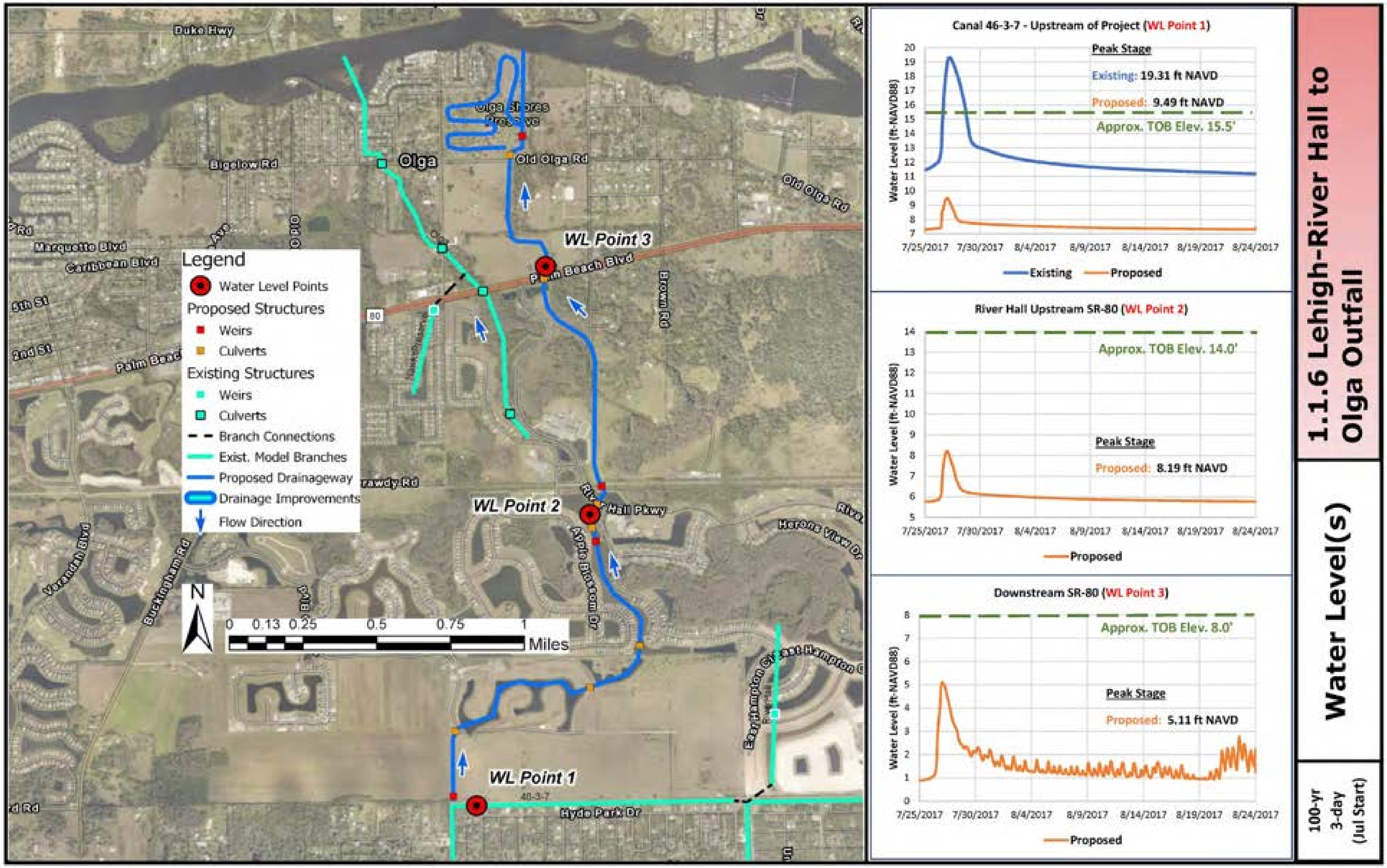

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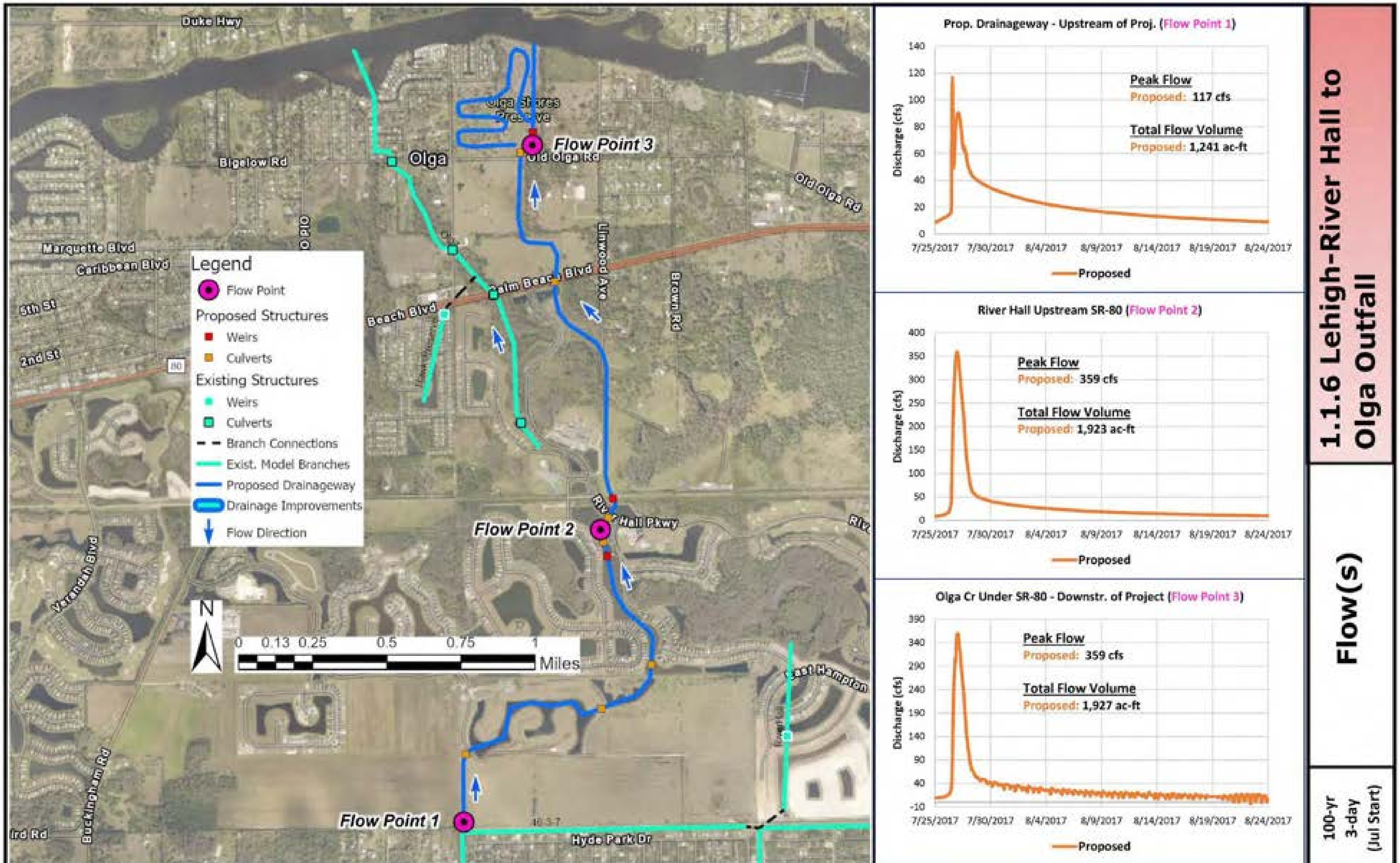

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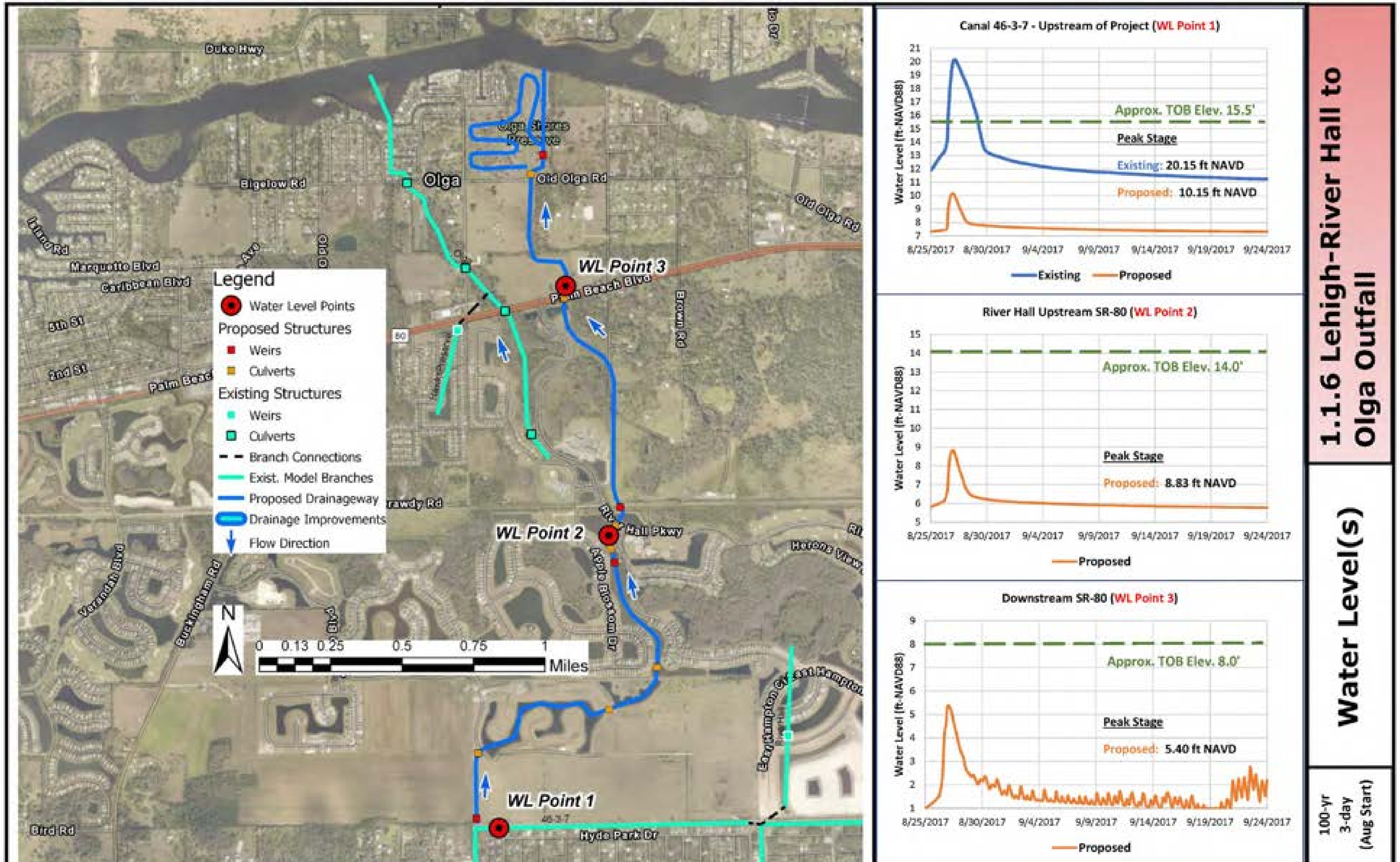


EXHIBIT 1.1.6 (g)

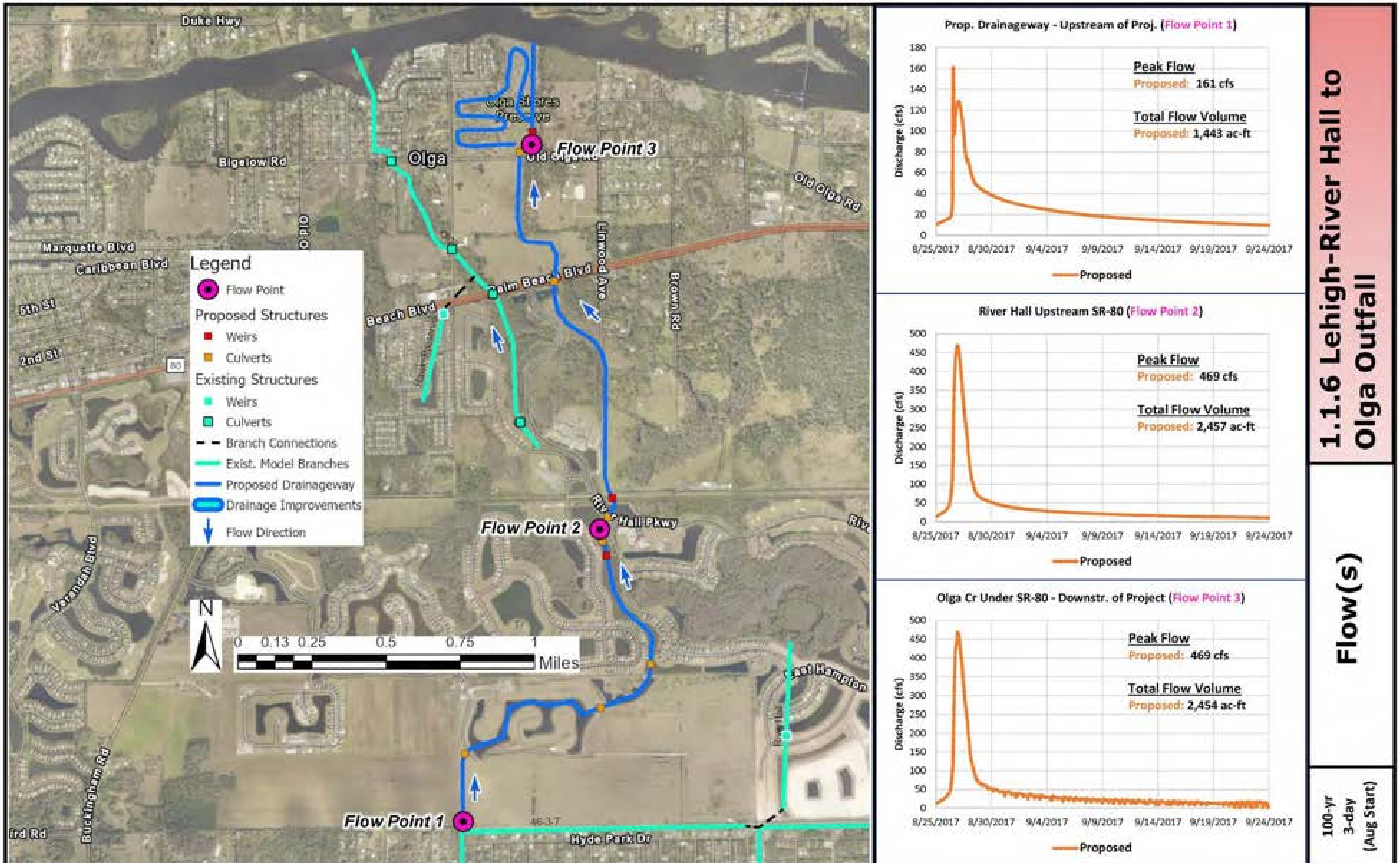


EXHIBIT 1.1.6 (h)

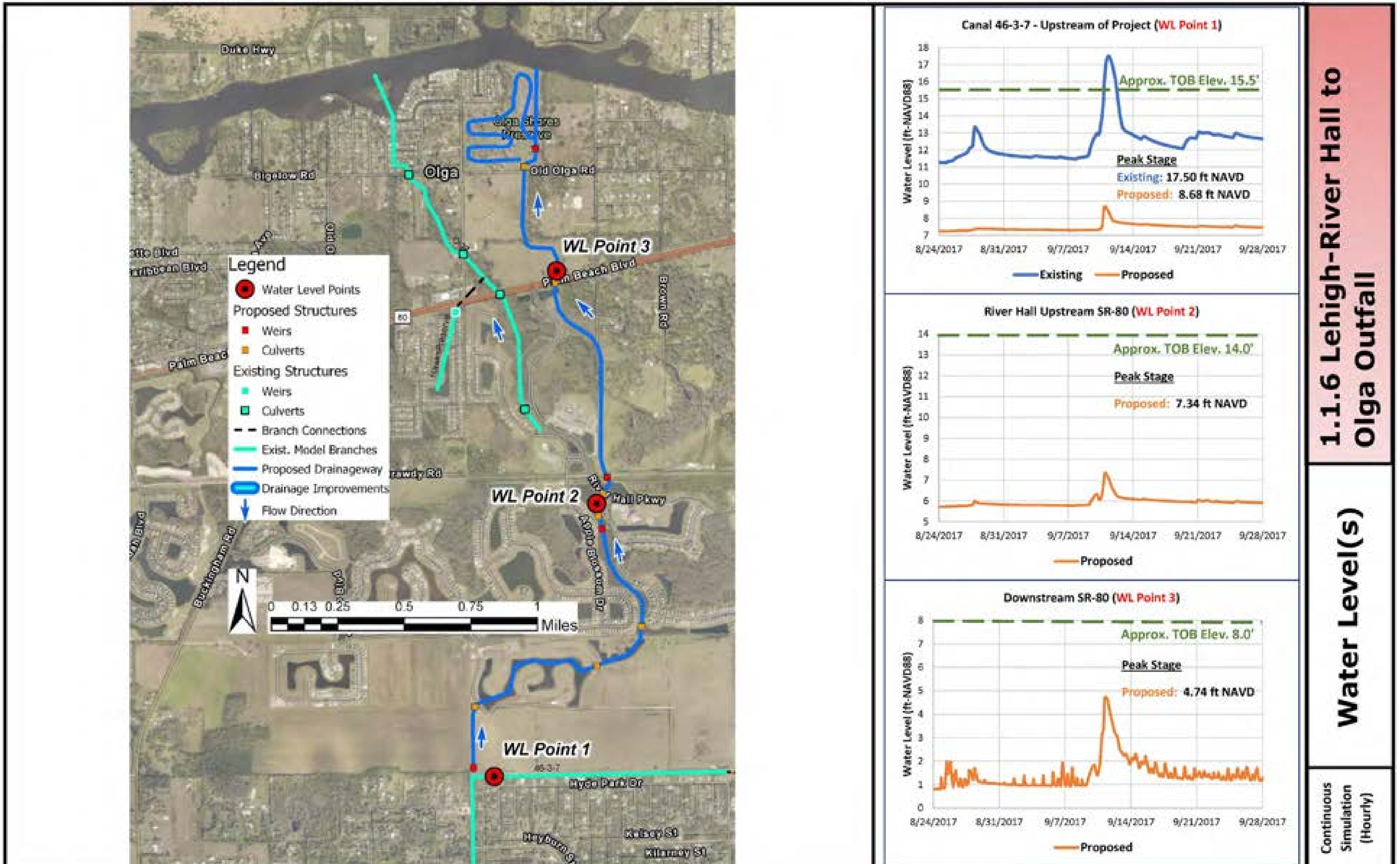
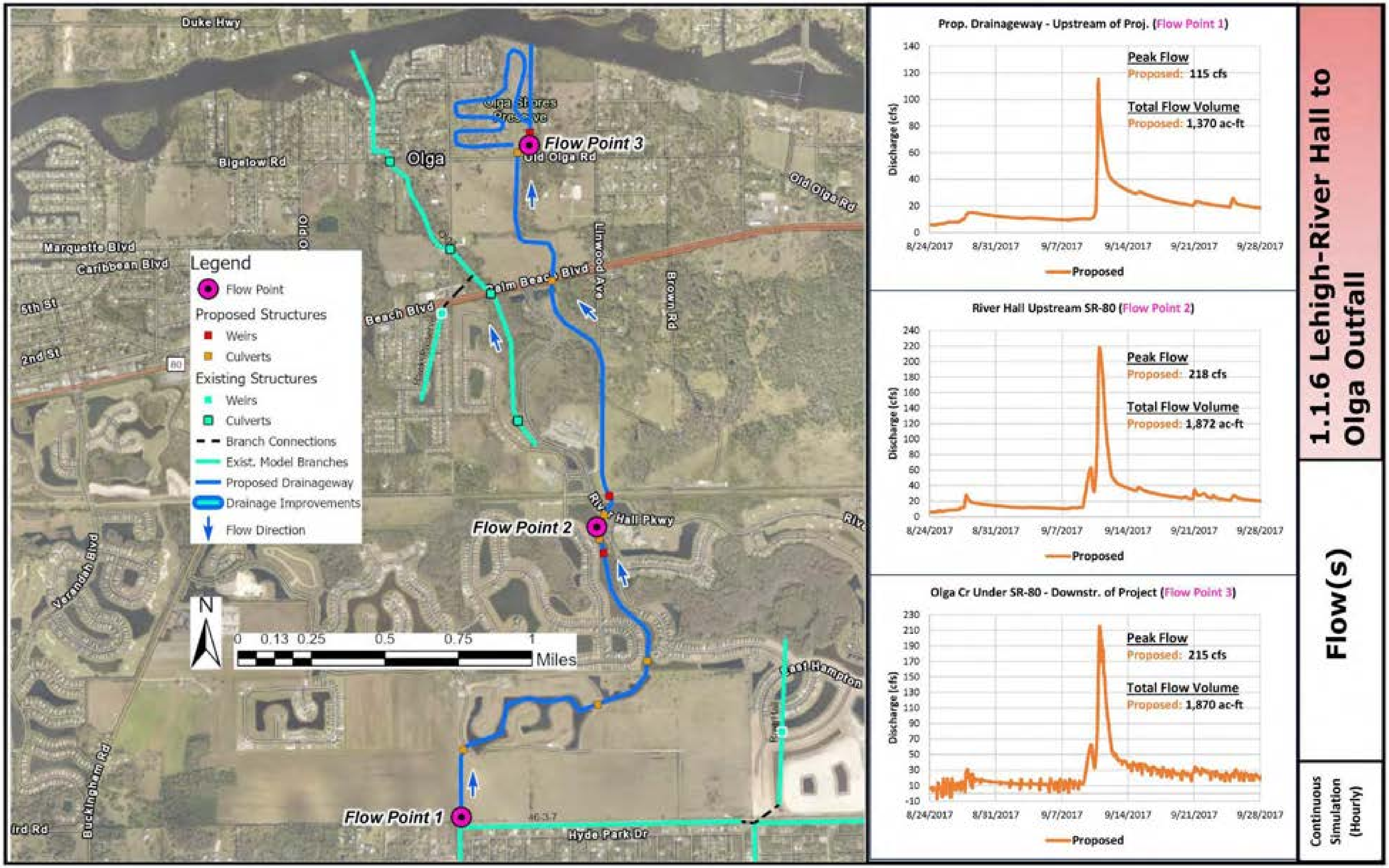


EXHIBIT 1.1.6 (i)



1.1.7 Hickey Creek Overflow Bypass

Background

The Hickey Creek area is a low lying floodplain tributary of the Caloosahatchee River that naturally drains a large watershed to the southeast. Currently, a large drainageway named Hickey Canal connects to the creek and provides a manmade outfall for Lehigh Acres. The area is rural with large home sites and previously farmed lands. The Hickey Creek Mitigation Park designated as a preserve surrounds the area and includes 2020 conservation lands, protected species, and fish and wildlife conservation easements. FDOT has a stormwater management pond for stormwater treatment of SR 80 located along the proposed route. The Hickey Creek area experienced flooding from the 2017 Hurricane Irma.

Location

This concept plan is located near the downstream portion of Hickey Creek in Sections 19 and 30, Township 43 South, and Range 27 East as illustrated in the location map in **Figure 29** below.

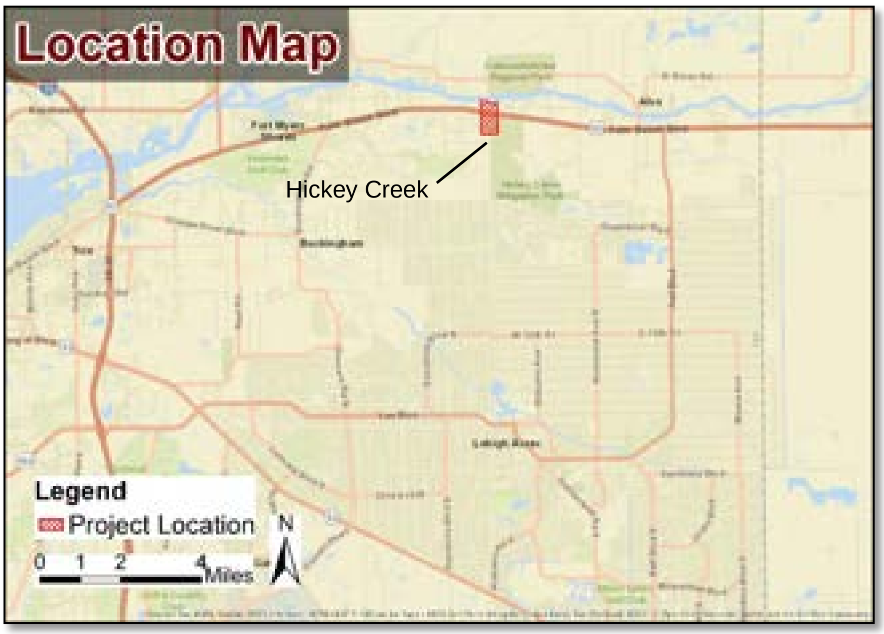


Figure 29 - Location Map, 1.1.7 Hickey Creek Overflow Bypass

Description

This proposed conceptual project extends Hickey Canal directly to the Caloosahatchee River and would convey large storm flows from Lehigh Acres. The Hickey Creek Overflow Bypass is being planned for approximately 35% of the Lehigh Acres excess stormwater runoff removal. Portions of the drainageway may require a seawall with rip-rap rubble shorelines. Land area exists to create filter marshes for water quality and a stormwater storage reservoir.

A control structure on Hickey Creek will allow for the continuation of Hickey Creek baseflow during normal operation conditions divert flow from Hickey Creek to Hickey Bypass during extreme storm events. A new conveyance crossing is required at S.R. 80 with box culverts or bridge structure as illustrated by **Figure 30** below:

Figure 30 - Concept Plan, 1.1.7 Hickey Creek Overflow Bypass

Purpose

This project offers a very significant conveyance of excess stormwater runoff from the Lehigh Acres area and greatly reduces the dependence on natural streams while providing a reduced recovery time between large storm events. Home and roadway flooding in the area would be reduced.

Evaluation

Viability

Constraints associated with this project mainly include acquiring permits for improving Hickeys Creek and for the proposed channels running through conservation 20/20 lands. Land acquisition near existing homes would be necessary. Although increasing the conveyance under S.R. 80 can be a challenging permitting/construction effort, the benefit this project has on the Hickey Creek Drainage basin is essential. With the high benefit flood mitigation value, this project concept is considered to be viable.

Community Considerations

Adverse community impacts south of S.R. 80 are minimal as this region is mostly undeveloped. Where land acquisition is required for parcels north of S.R. 80, water access could be achieved allowing for canoe/kayak access to the Caloosahatchee River from Hickey Creek. The proposed route limits impact to existing residential structures. A seawall with rip-rap rubble shorelines may be necessary in the narrow section for the parcels north of S.R. 80.

Environmental & Permittability Considerations

Providing a water quality component as a secondary benefit to this flood mitigation project may be challenging. This area was established to protect important upland dependent species, including mitigation for gopher tortoise. The site hosts other listed species as well as globally imperiled plant communities per Florida Natural Areas Inventory. The County has received funding from The Nature Conservancy and FWC for scrub jay and gopher tortoise habitat restoration (scrub jay work within the area where the proposed drainage to the DOT pond is located and the gopher tortoise work was completed where the filter marsh is proposed). In addition, the site has recorded conservation easements. The actual layout of this project in these in areas should be designed to not be counterproductive to the years of money and efforts to restore the habitats in these areas for protected species. Hickey's Creek is co-managed by FWC, C20/20 and LCPR staff. Coordination and planning would have to be done with all parties involved. LAMSID has a canal system along the southern and western borders of HCMP and would have to be included in coordination efforts. Coordination with FDOT will be needed for the pond they own adjacent to C20/20 parcels. Any adverse impact to the public use trails and the kayak launch that is part of the Great Calusa Blueway should be mitigated/replaced. Environmental impacts identified as a result of the SFWMD permitting process would require mitigation. Water quality and stormwater storage facilities are possible along the bypass for treatment of flows before discharging into the Caloosahatchee River.

Land Availability

Lee County owns the required parcels south of S.R. 80 with the exception of the S.R. 80 FDOT stormwater storage parcel. Coordination with FDOT and SFWMD is required for a successful partnership in routing conveyance though this FDOT parcel. Land acquisition is required for parcels north of S.R. 80. Coordination with Lee County 2020 Conservation Lands is required.

Opinion of Probable Cost

The cost opinion shown in **Table 8** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 8: Opinion of Probable Cost Breakdown, 1.1.7 Hickey Creek Overflow Bypass

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,441,000	$ 1,441,000
Clearing & Grubbing	12	AC	$ 14,000	$ 168,000
Earthwork	170,000	CY	$ 6	$ 1,020,000
Weir Structure 1.7A (Major)	150	LF	$ 10,000	$ 1,500,000
Weir Structure 1.7B (Standard)	100	LF	$ 5,000	$ 500,000
Weir Structure 1.7C (Major)	150	LF	$ 10,000	$ 1,500,000
Seawall	2,200	LF	$ 250	$ 550,000
Rip-rap along Seawall	1,650	TN	$ 100	$ 165,000
Detour SR. 80	1	LS	$ 220,000	$ 220,000
Box Culvert 1.7-1	1,400	CY	$ 1,200	$ 1,680,000
Arterial Road Pavement Repair SR. 80	800	SY	$ 100	$ 80,000
Electric Supply	1	LS	$ 50,000	$ 50,000
Relocate Ex. Canoe Launch	1	LS	$ 30,500	$ 30,500
Permanent Erosion Control	2,700	SF	$ 25	$ 67,500
Grassing	14,000	SY	$ 2	$ 28,000
Conceptual Construction Costs:				**$ 9,000,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 2,700,000
Land Acquisition				$ 500,000
Project Administration/ CEI (10%)				$ 920,000
Project Unknowns				$ 80,000
Conceptual Project Cost:				**$ 13,200,000**
Contengency (30%)				$ 3,800,000
Conceptual Project Cost (with Contengency):				**$ 17,000,000**

Opportunities for Multiple Benefits & Uses

As Lehigh Acres continues towards full build-out conditions, improving the conveyance of the Hickey Creek Drainage Basin is a critical priority, as this concept project was planned to convey approximately 3,000 CFS being 35% of the Lehigh Acres excess stormwater runoff at a three (3") inch per day removal rate. Providing flood mitigation solutions will also become increasingly difficult as development diminishes the available land. This project has the potential for incorporation of water quality improvement components.

Other Considerations

Alternate flow routes are available; however, this route is the most functional and cost effective. A summary of this concept project is shown below in **Exhibit 1.1.7** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept would successfully convey excess stormwater flows from Hickey Creek to the Caloosahatchee River. The slot weir proposed on Hickey Creek limited high flows and weir on the canal extension controlled normal flow to Hickey Creek. The refined concept plan is shown in **Exhibit 1.1.7 (a)** herein. The concept project was incorporated into the regional model and analyzed the project's effectiveness. Model input data can be found in **Appendix A**. With all the concept projects included in the regional model, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.7 (b) EXHIBIT 1.1.7 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.7 (d) EXHIBIT 1.1.7 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.7 (f) EXHIBIT 1.1.7 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.7 (h) EXHIBIT 1.1.7 (i)

Improvements were shown with dramatic water level reductions along Hickey Creek which experienced flooding during the Hurricane Irma storm event. The overflow bypass was also shown to reroute a significant amount of peak flows and corresponding flow volume from Hickey Creek directly to the Caloosahatchee River during severe storm events. The bypass flood model showed approximately 2,000 cfs discharging to the Caloosahatchee River instead of the planning level 3,000 cfs. Adjusting the design for 2,000 cfs continues to provide significant excess stormwater removal from Lehigh Acres area.

Recommendations

The Hickey Creek stream capacity has historically proved insufficient to handle large runoff from severe storms. Implementing an overflow bypass to the Caloosahatchee River mitigates flooding of structures along Hickey Creek and Lehigh Acres. The implementation of a slotted weir on Hickey Creek limits high flows while allowing normal seasonal flows to proceed downstream. The proposed weir on the canal extension segment also allows for the ability to maintain and regulate normal flow to Hickey Creek. These positive improvements of this project concept warrant further design-level project development.

EXHIBIT 1.1.7

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project extends Hickey Canal directly to the Caloosahatchee River and would convey large storm flows from Lehigh Acres. The Hickey Creek Overflow Bypass is being planned for a very large conveyance of the Lehigh Acres excess stormwater runoff removal. Portions of the drainageway will require a seawall with rip-rap rubble shorelines. Land area exists to create filter marshes for water quality and a stormwater storage reservoir, if desired.

PURPOSE: This project offers a very significant conveyance of excess stormwater runoff from the Lehigh Acres area and greatly reduces the dependence on natural streams while providing a reduced recovery time between large storm events. Home and roadway flooding in the area would be reduced.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and a large drainage structure at S.R. 80 would be required. Environmental impacts will necessitate mitigation along with modification of existing conservation easement agreements.

May 2020

Hickey Creek Overflow Bypass

East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.7

EXHIBIT 1.1.7 (a)

EXHIBIT 1.1.7 (b)

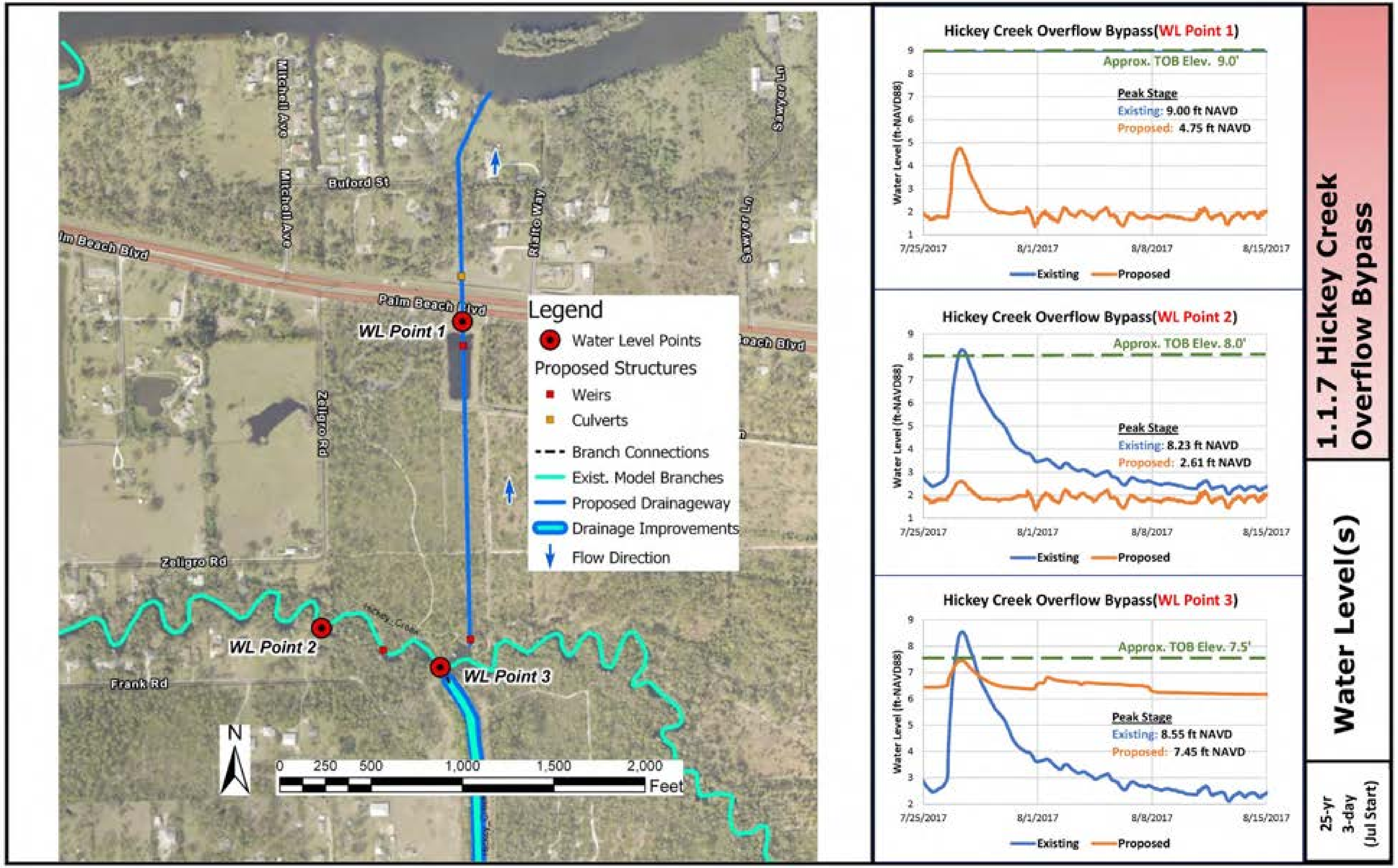
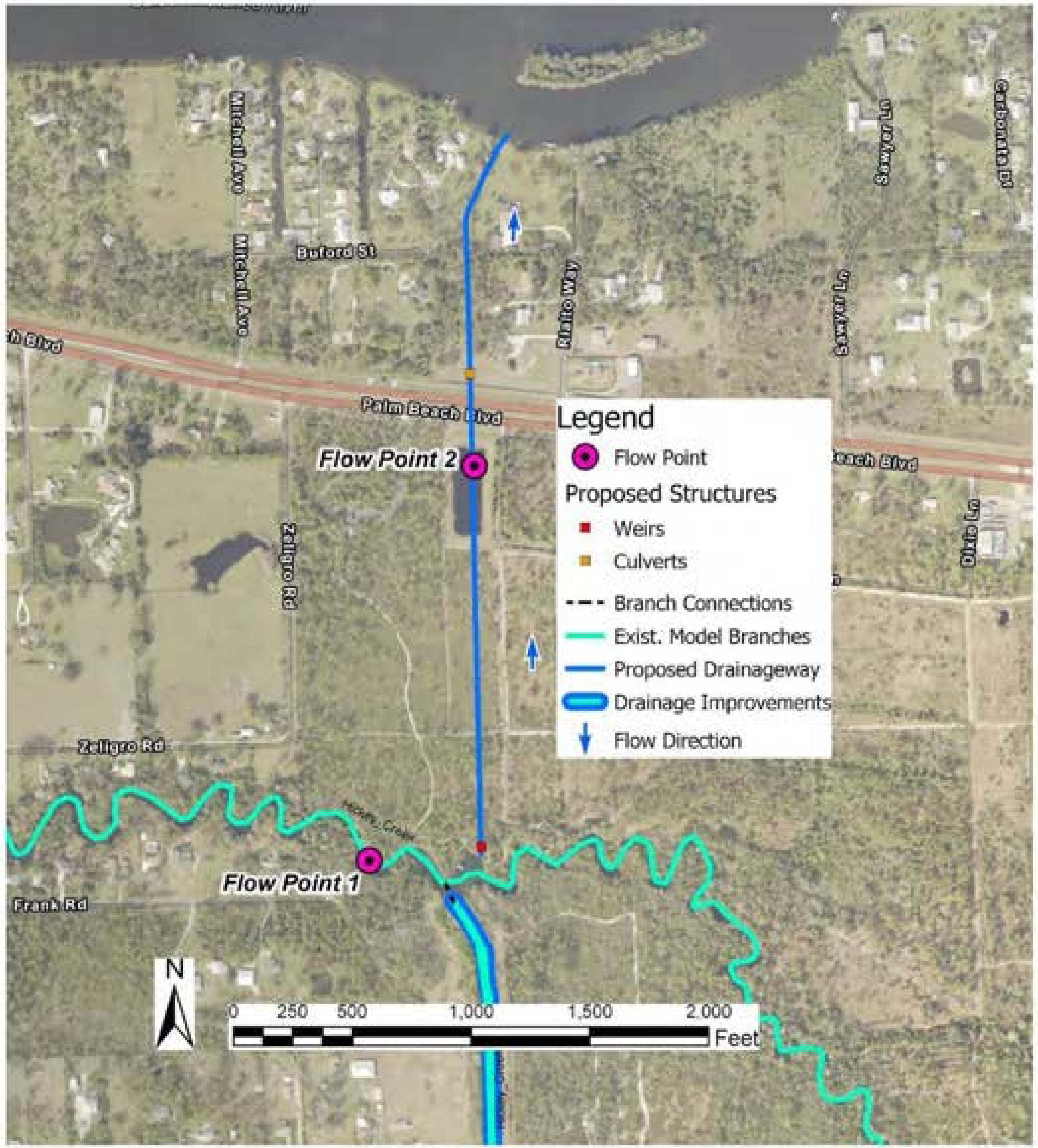
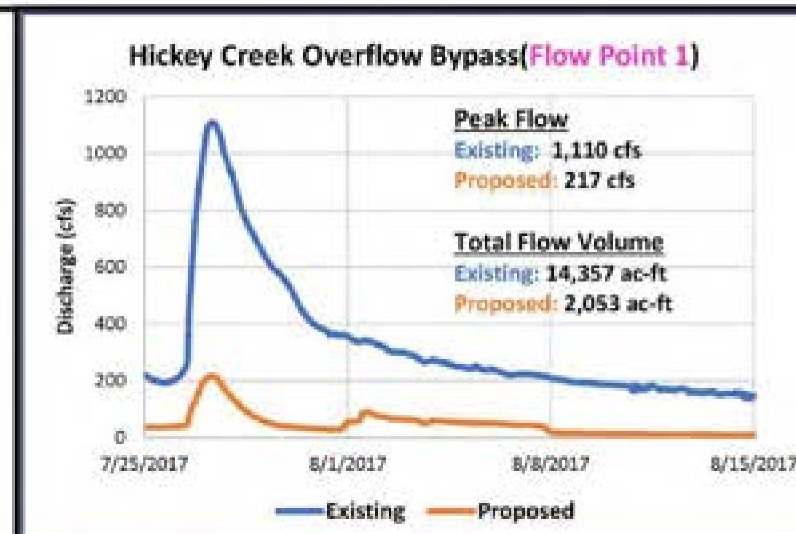
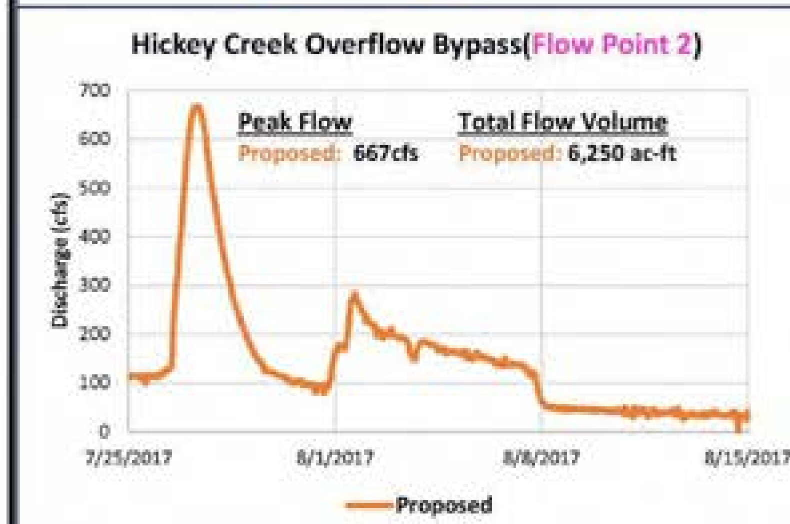


EXHIBIT 1.1.7 (c)







1.1.7 Hickey Creek Overflow Bypass

Flow(s)

25-yr
3-day
(Jul Start)

EXHIBIT 1.1.7 (d)

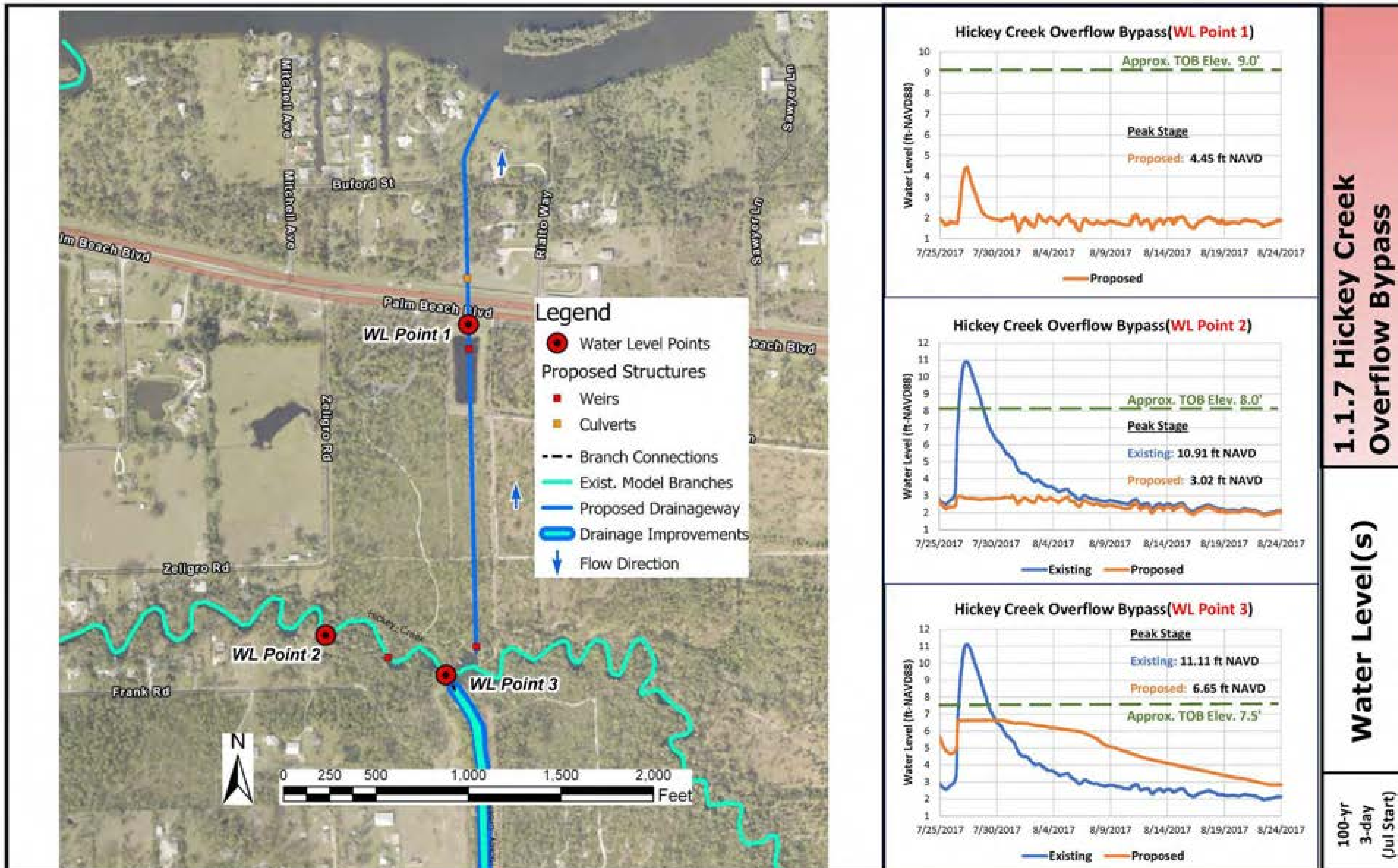
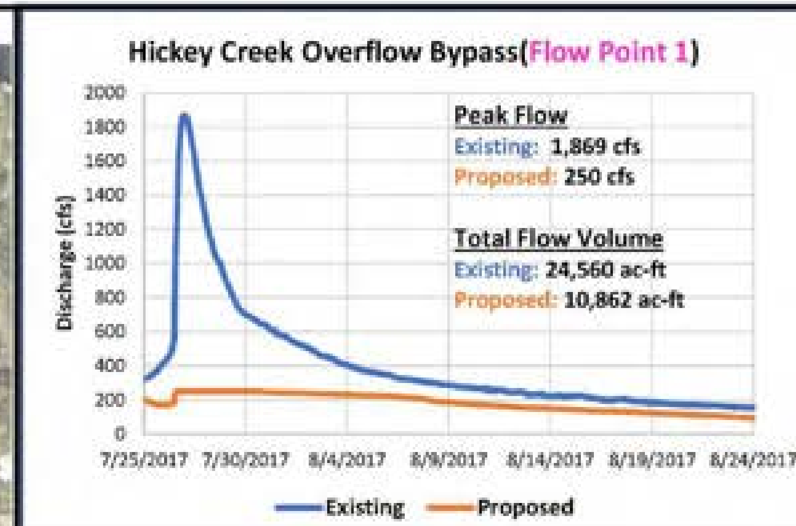
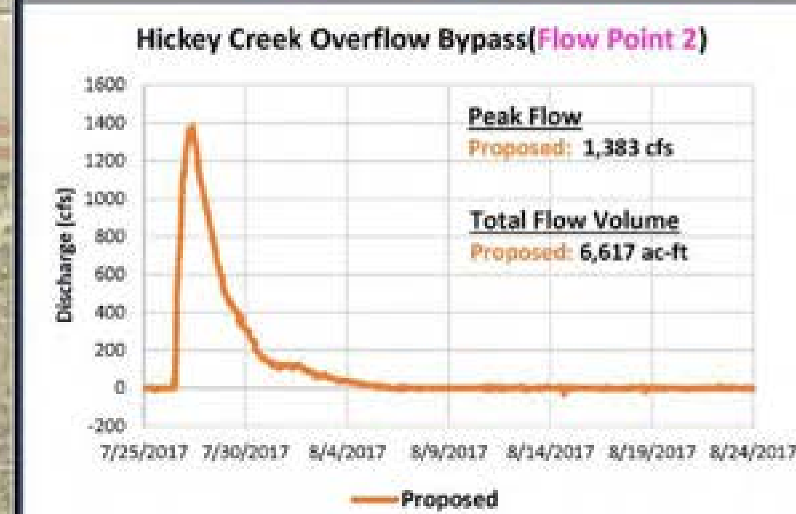


EXHIBIT 1.1.7 (e)





1.1.7 Hickey Creek Overflow Bypass

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.1.7 (f)

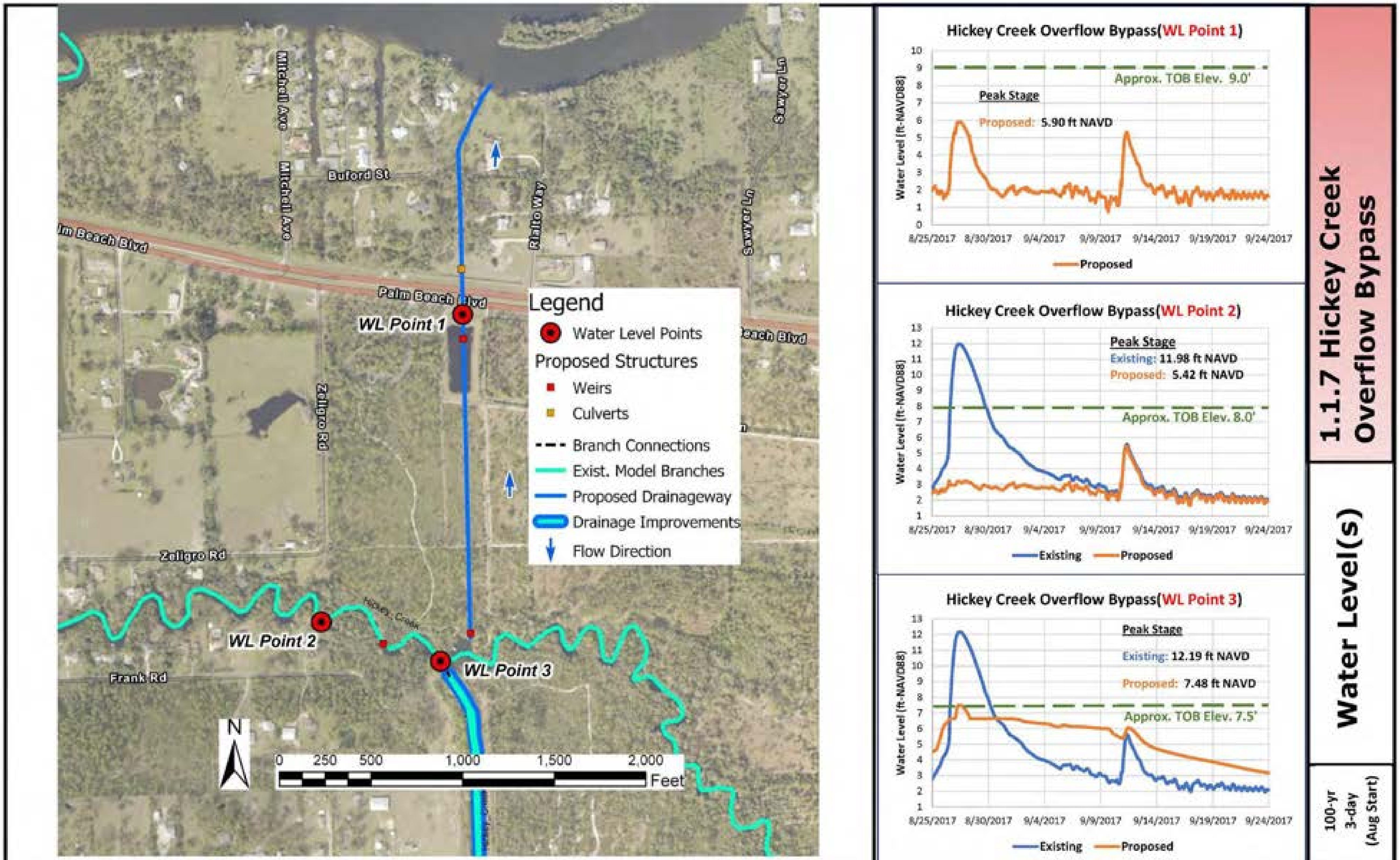
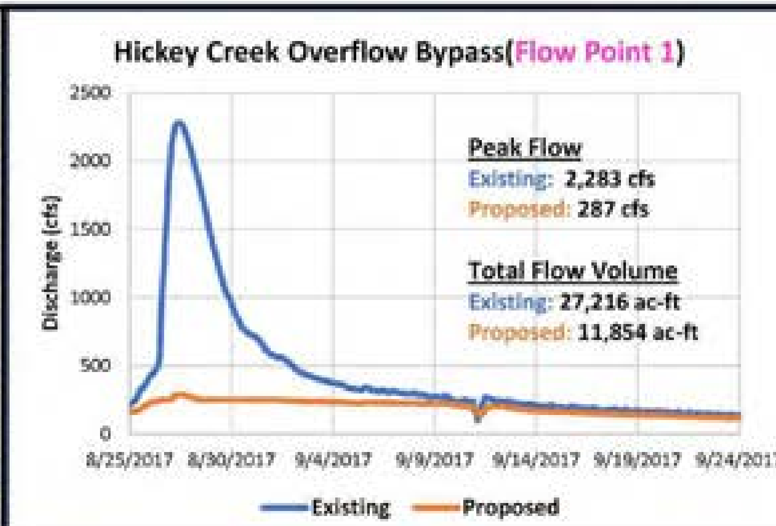
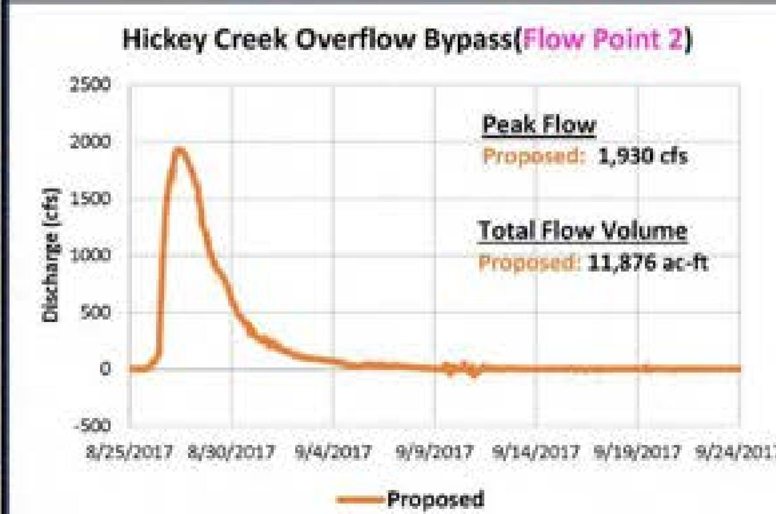


EXHIBIT 1.1.7 (g)





1.1.7 Hickey Creek Overflow Bypass

Flow(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.1.7 (h)

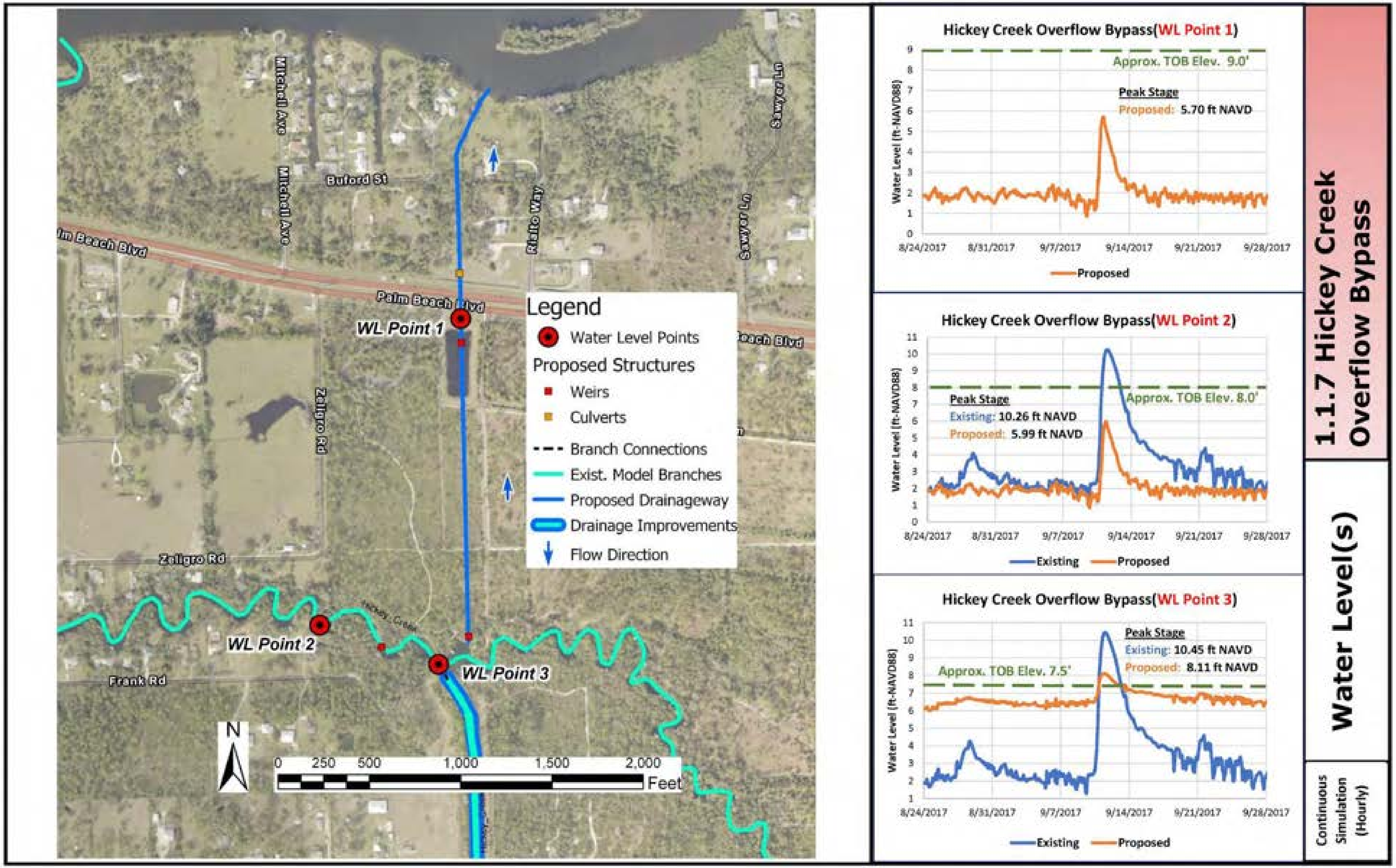
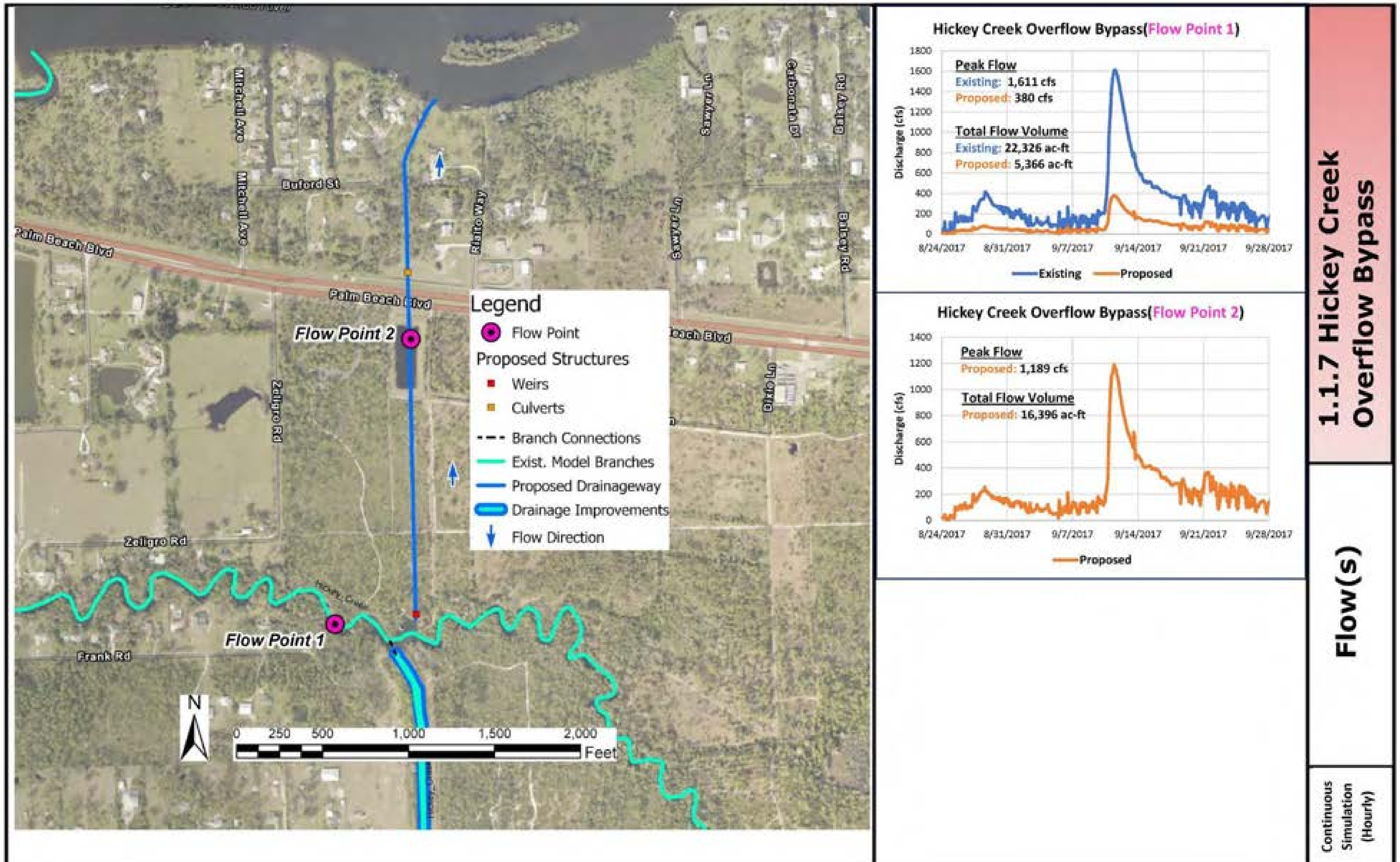


EXHIBIT 1.1.7 (i)



1.1.8 Strayhorn Drainageway

Background

Along the proposed concept drainageway route, there is an existing drainageway with an easement extending southerly from the Orange River to Luckett Road Extension. Historically, the area is sub-divided in 5-acre ranchette type parcels that appear to have been formerly used for cattle ranching operations. The Strayhorn privately-owned airstrip is located along the route. The upstream area at the headwaters of the concept project includes large wetlands with cypress trees. This concept project crossing a large flat plateau area that is part of the Orange River watershed basin. There are very limited drainage facilities in this area.

Location

This concept project is located on the west side of the East Lee County Drainage Area in Sections 1, 12 and 13, Township 44 South and Range 25 East, and Section 36, Township 43 South and Range 25 East as illustrated in the location map in **Figure 31** below:

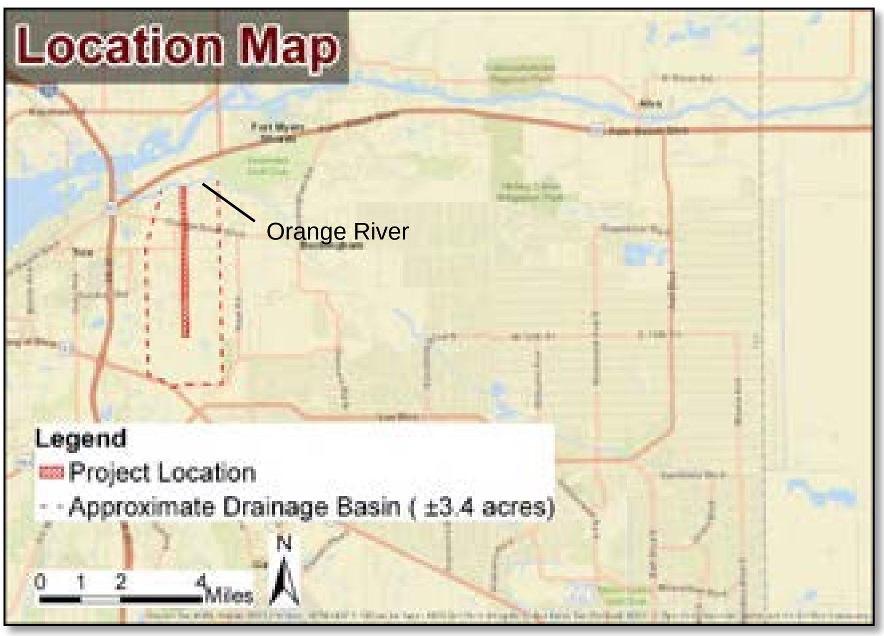


Figure 31 - Location Map, 1.1.8 Strayhorn Drainageway

Description

This proposed conceptual project improves a conveyance in an approximately 3,400 acres watershed area as shown in **Figure 32**. At a three (3”) inch per day removal rate, an approximate peak flow would be 430 CFS. The drainageway would have appropriate planted wetland vegetation for water quality enhancement. Unlike high capacity drainageways, the cross section of this conveyance would be a wide and shallow swale.

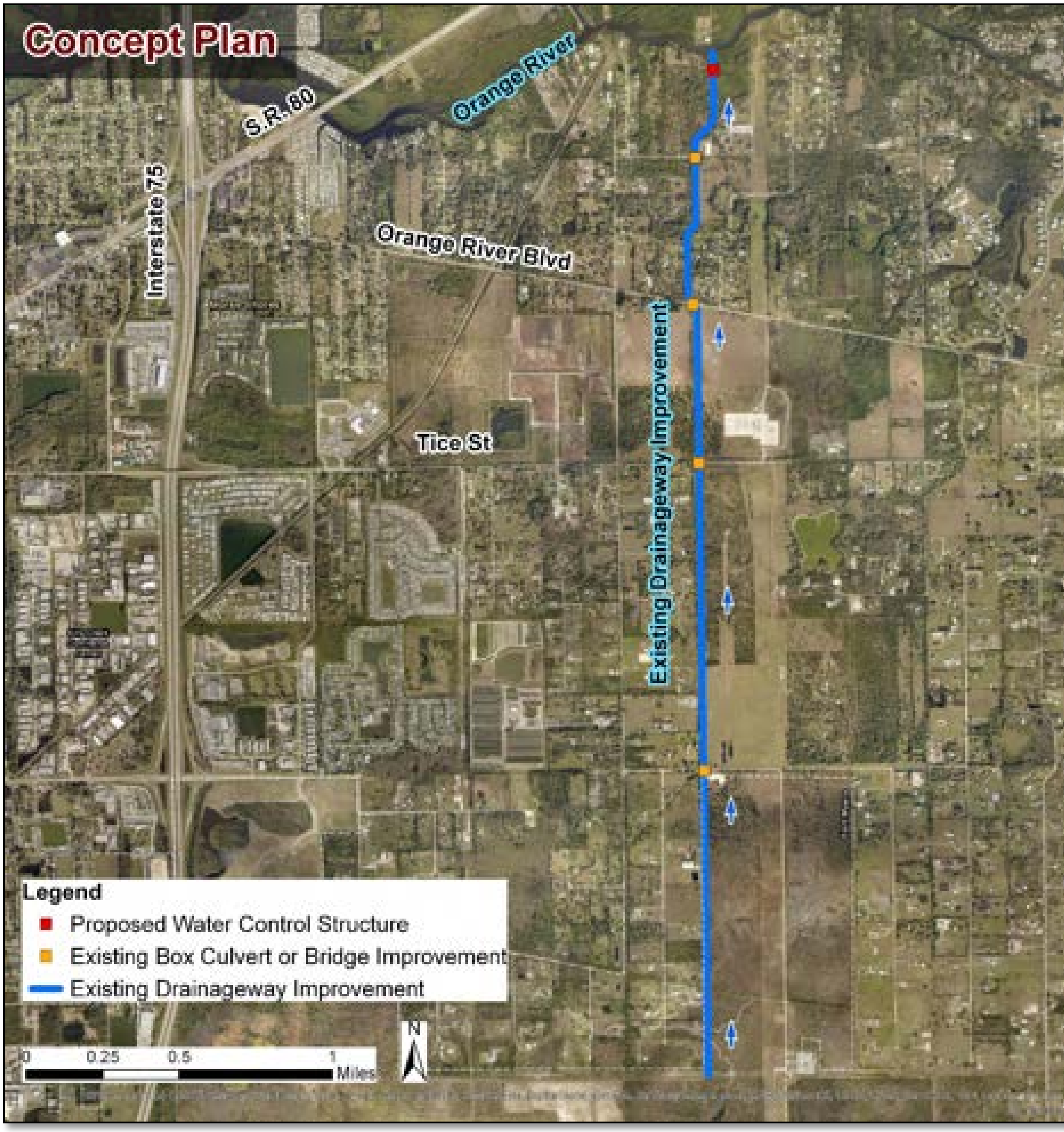


Figure 32 - Concept Plan, 1.1.8 Strayhorn Drainageway

Purpose

Stormwater runoff from this area caused roadway flooding and may have contributed overflow drainage into the Lehigh Acres and the Buckingham area. This project would provide controlled stormwater runoff though a positive outfall to the Orange River, limit roadway flooding, and direct stormwater runoff away from Lehigh Acres and Buckingham. Spoil material from the excavation of the drainageway may be utilized for road projects in the area, such as the Luckett Road Extension.

Evaluation

Viability

As this is an expansion to an existing conveyance, the viability of this project is favorable as a shallow-vegetated drainageway with minimal wetland impacts. This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures are necessary to step down water levels as land topography slopes to the Orange River and drainage structures at road crossings would be required.

Community Considerations

Adverse community impacts are minimal as this region is mostly undeveloped large tracts. The increase conveyance in this region should be welcomed by the community as many homes experienced sustained property and roadway flooding as illustrated in **Figure 33** photo below.

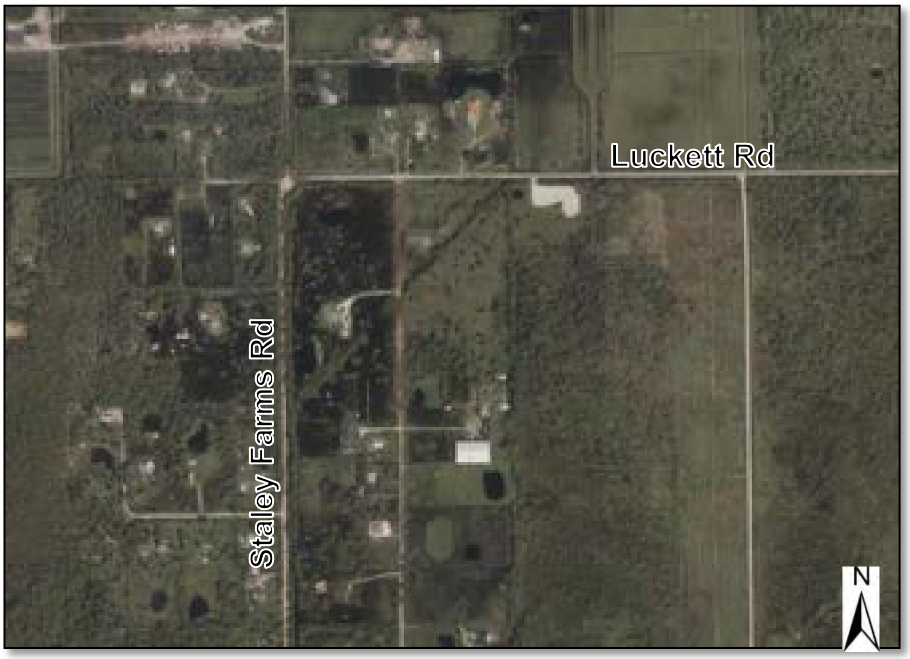


Figure 33 - Imagery of area near the concept plan taken around 9-12-17

Environmental & Permittability Considerations

The Lee County owns the +/-317-acre parcel at the southern end of this concept project. This land is being utilized as a preserve for water quality and storage being the headwaters of the Six Mile Cypress Slough. Protecting this area from over drainage is a concern. This is especially a concern as there are existing mitigation areas in both preserves. During the design phase, further review on how the proposed project would affect the permitted Six Mile North hydrologic restoration project is required (SFWMD Permit 36-07931-P). The design of this project should take into consideration potential impacts to the fluctuation of saltwater and freshwater flows within the Orange River, which is a tidally-influenced tributary of the Caloosahatchee River. Both rivers currently experience impacted fluctuations of freshwater and saltwater flow due to the freshwater release schedule of the C-43 Canal as maintained by the US Army Corps of Engineers. Plant communities along the shoreline of the Orange River preserve, located west of the project area outfall, could be impacted by further alterations to this water salinity fluctuation. The design of this project should include consideration of potential impacts to West Indian manatee which can be frequently found in the river and general area of the outfall. Environmental impacts, if any, would necessitate mitigation.

Land Availability

About two thirds of this drainageway improvement is not in Lee County owned lands. Increasing the width of the existing drainageway cross section, which is generally routed along property lines, is considered a lesser impact where land acquisition or drainage easements are required. Coordination with Conservation 2020 Lands is required.

Opinion of Probable Cost

The cost opinion shown in **Table 9** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 9: Opinion of Probable Cost Breakdown, 1.1.8 Strayhorn Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,095,000	$ 1,095,000
Clearing & Grubbing	40	AC	$ 14,000	$ 560,000
Earthwork	160,000	CY	$ 6	$ 960,000
Construction/ Maintenance Access	5,000	SY	$ 20	$ 100,000
Weir Structure 1.8A (Standard)	70	LF	$ 5,000	$ 350,000
Weir Structure 1.8B (Standard)	70	LF	$ 5,000	$ 350,000
Weir Structure 1.8C (Standard)	70	LF	$ 5,000	$ 350,000
Weir Structure 1.8D (Standard)	70	LF	$ 5,000	$ 350,000
Weir Structure 1.8E (Standard)	70	LF	$ 5,000	$ 350,000
Weir Structure 1.8F (Standard)	70	LF	$ 5,000	$ 350,000
Weir Structure 1.8G (Standard)	70	LF	$ 5,000	$ 350,000
Detours	1	LS	$ 235,000	$ 235,000
Box Culvert 1.8-1	140	CY	$ 1,200	$ 168,000
Box Culvert 1.8-2	240	CY	$ 1,200	$ 288,000
Box Culvert 1.8-3	160	CY	$ 1,200	$ 192,000
Box Culvert 1.8-4	160	CY	$ 1,200	$ 192,000
Electric Supply	0	CY	NA	$ -
Permanent Erosion Control	8,000	SF	$ 15	$ 120,000
Grassing	70,000	SY	$ 2	$ 140,000
Conceptual Construction Costs:				**$ 6,500,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 1,940,000
Land Acquisition				$ 1,150,000
Project Administration/ CEI (10%)				$ 650,000
Project Unknowns				$ 560,000
Conceptual Project Cost:				**$ 10,800,000**
Contengency (30%)				$ 3,200,000
Conceptual Project Cost (with Contengency):				**$ 14,000,000**

Opportunities for Multiple Benefits & Uses

Coordination with Lee County Preserve Lands is this area is an opportunity for finding mutual benefits with this project. Lee County also owns large portions of lands to the south of this project location as illustrated in the purple areas of **Figure 34** below:

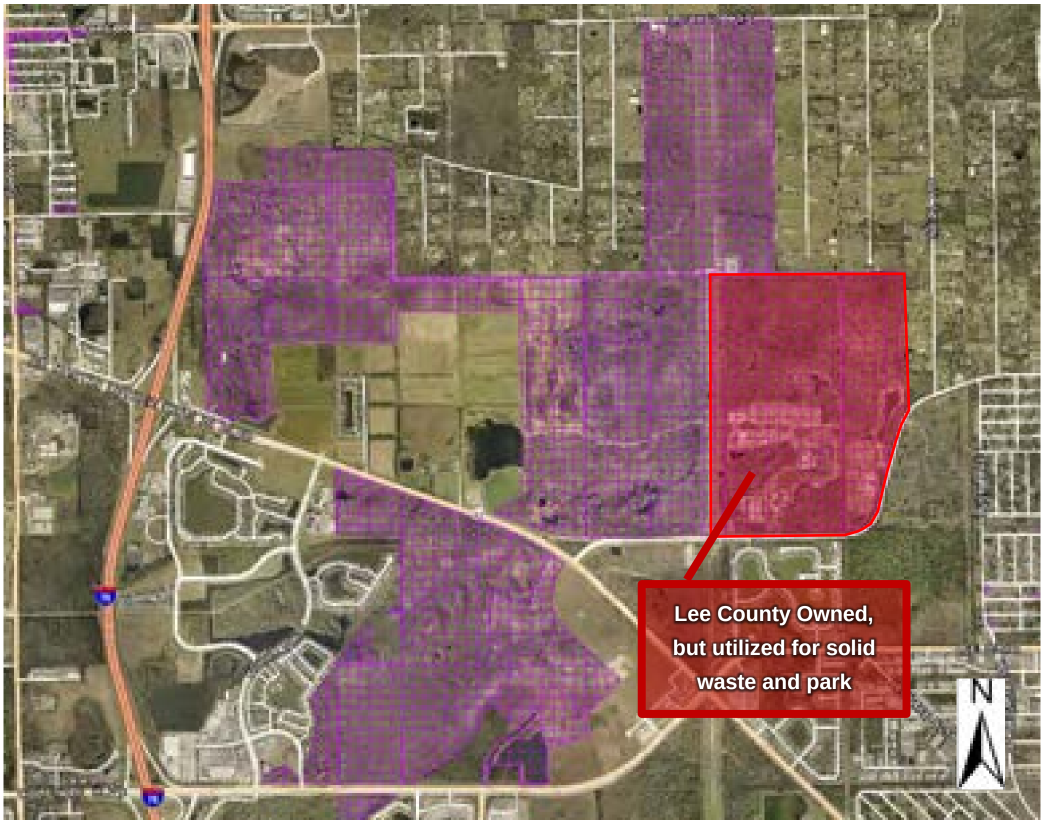


Figure 34 - Map of Lee County Owned Lands

This project allows for potential incorporation of water quality improvement components.

Other Considerations

Protecting the Six Mile Cypress Slough Preserve while providing drainage relief to this area will be a key consideration during the design phase on the placement of the proposed swale. A summary of this concept project is shown below in **Exhibit 1.1.8** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of improving the Strayhorn drainageway to convey excess stormwater flows from the Staley Farms area to the Orange River. The refined concept plan is shown in **Exhibit 1.1.8 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

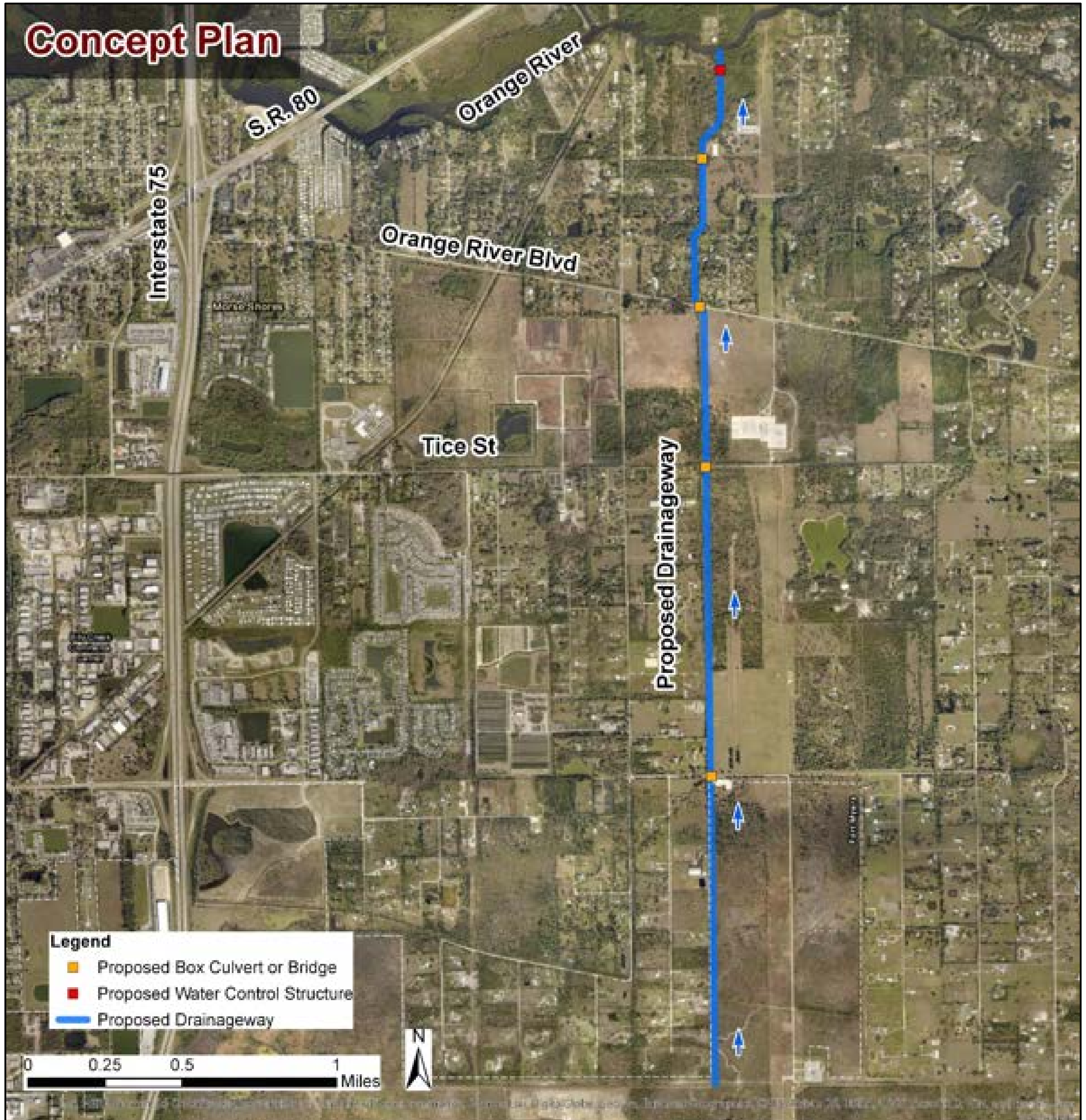
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.8 (b) EXHIBIT 1.1.8 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.8 (d) EXHIBIT 1.1.8 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.8 (f) EXHIBIT 1.1.8 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.8 (h) EXHIBIT 1.1.8 (i)

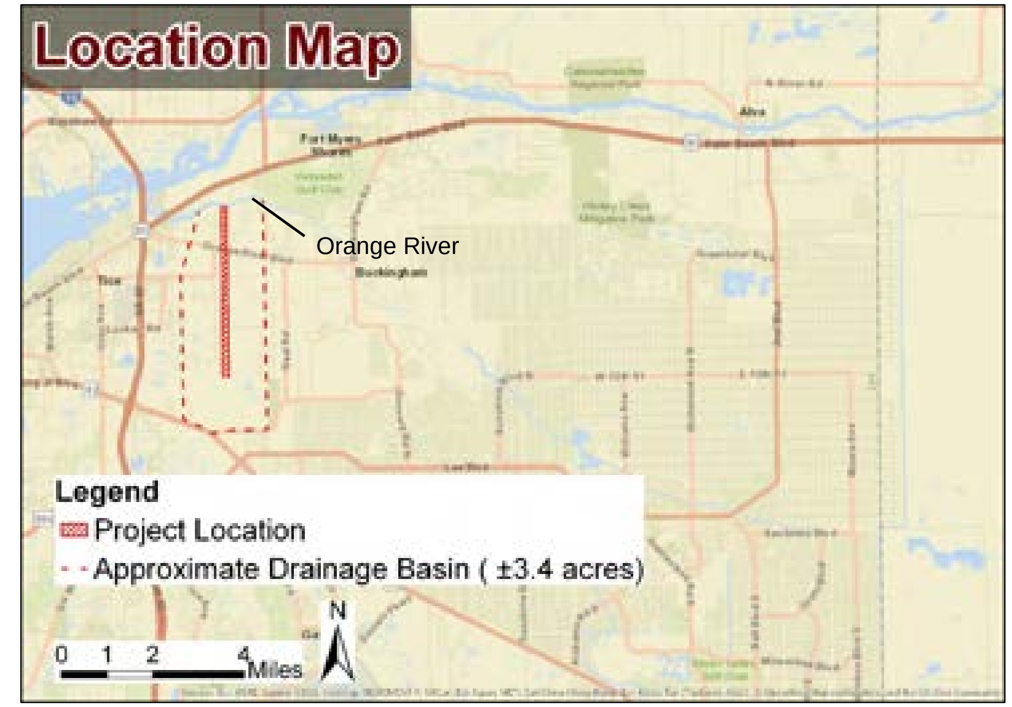
Improvements are realized though providing a major positive outfall for an area with currently limited outfall conveyance capacity. Water levels are shown to decrease from the headwaters to approaching the Orange River.

Recommendations

The proposed Strayhorn drainageway creates improvements to conveying excess stormwater runoff flows from the Staley Farms area to the Orange River. When considered with the Six-Mile Preserve Catchment Reservoir concept project (1.1.11), an additional benefit is gained in supplying a northern outfall for flood headwaters of the Six Mile Cypress Preserve. The positive improvements of this project concept warrant further design-level project development.

EXHIBIT 1.1.8





Project Narrative

DESCRIPTION: This proposed conceptual project improves a conveyance in an approximately 3,400 acres watershed area. At a three (3”) inch per day removal rate, an approximate peak flow would be 430 CFS. The drainageway would have appropriate planted wetland vegetation for water quality enhancement.

PURPOSE: Stormwater runoff from this area caused roadway flooding and may have contributed overflow drainage into the Lehigh Acres and the Buckingham area. This project would provide controlled stormwater runoff though a positive outfall to the Orange River, limit roadway flooding, and direct stormwater runoff away from Lehigh Acres and Buckingham. Spoil material from the excavation of the drainageway may be utilized for road projects in the area.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to step water levels and drainage structures at road crossings would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Strayhorn Drainageway
East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.8

EXHIBIT 1.1.8 (a)

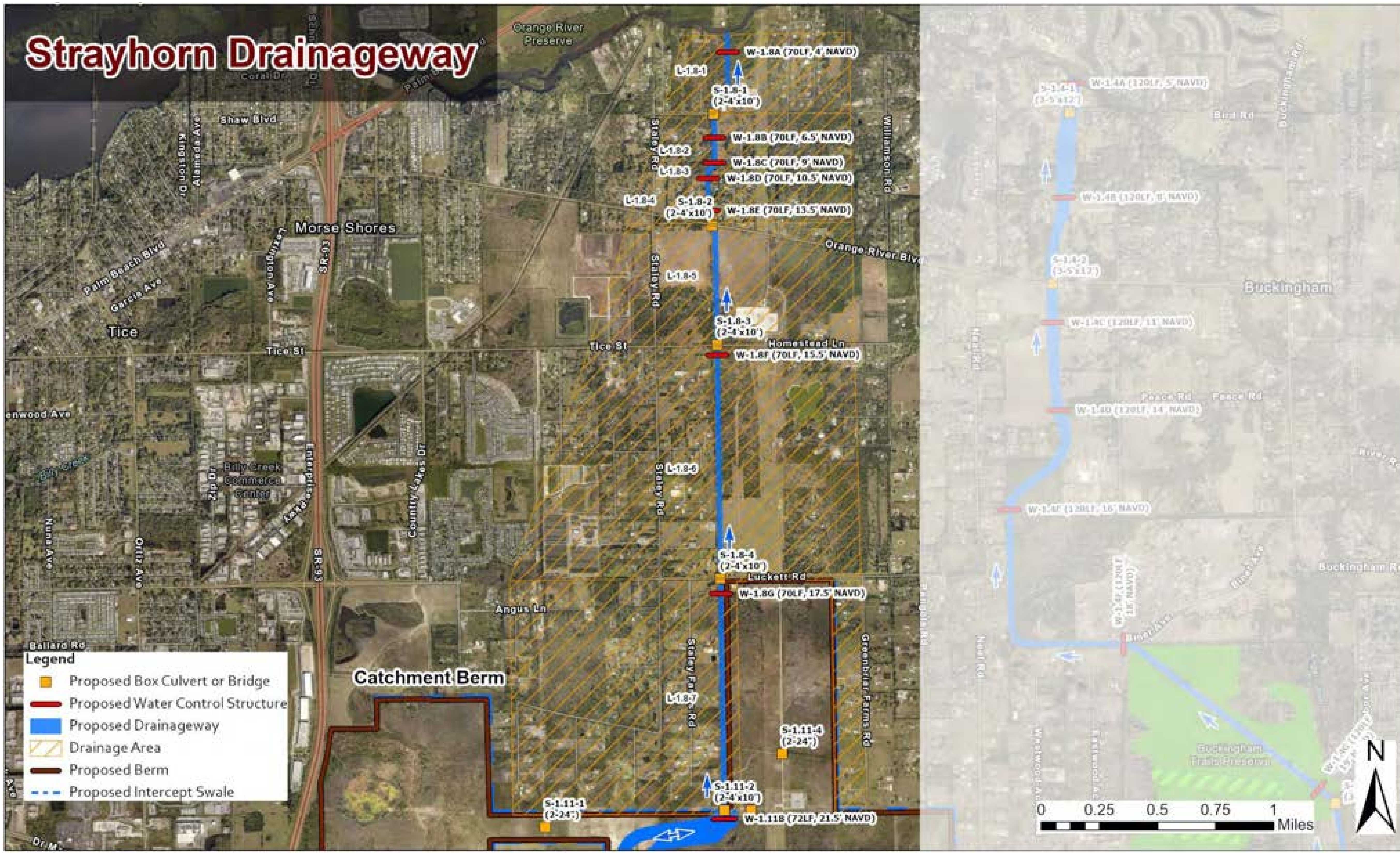
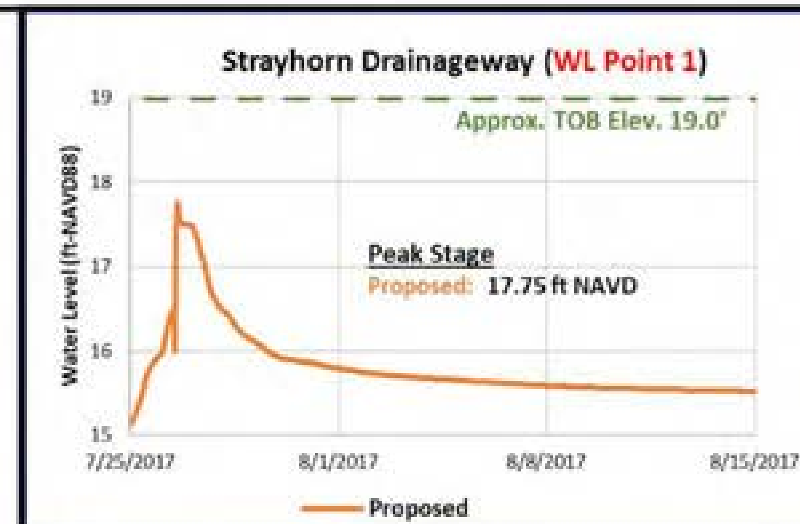
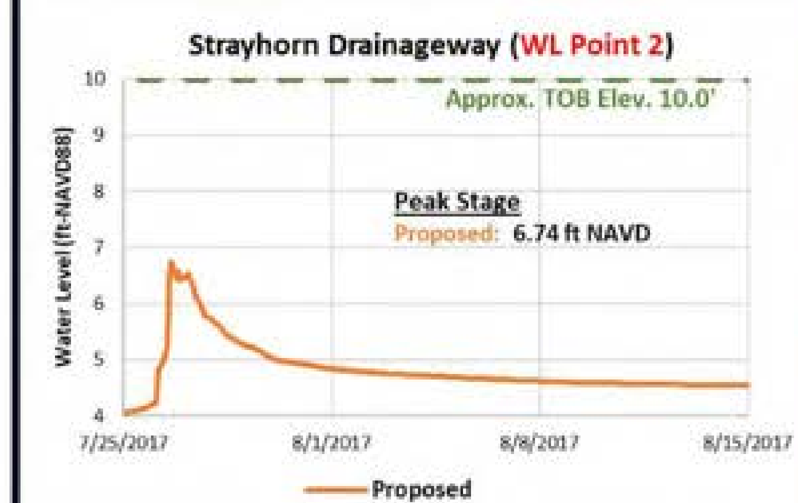


EXHIBIT 1.1.8 (b)



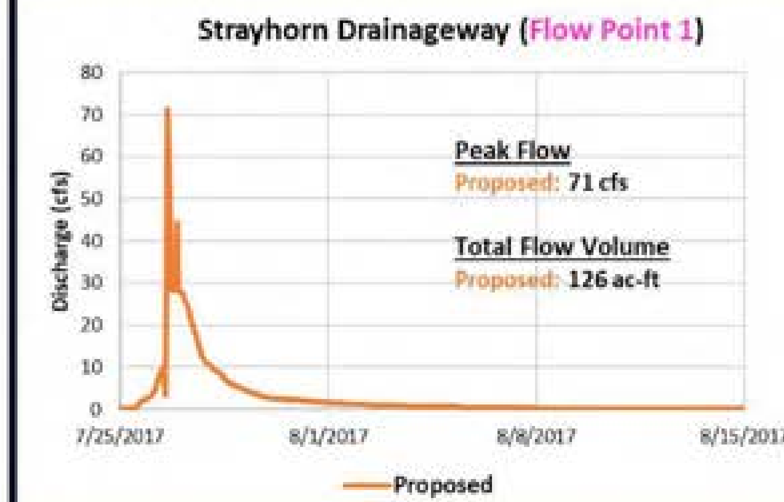


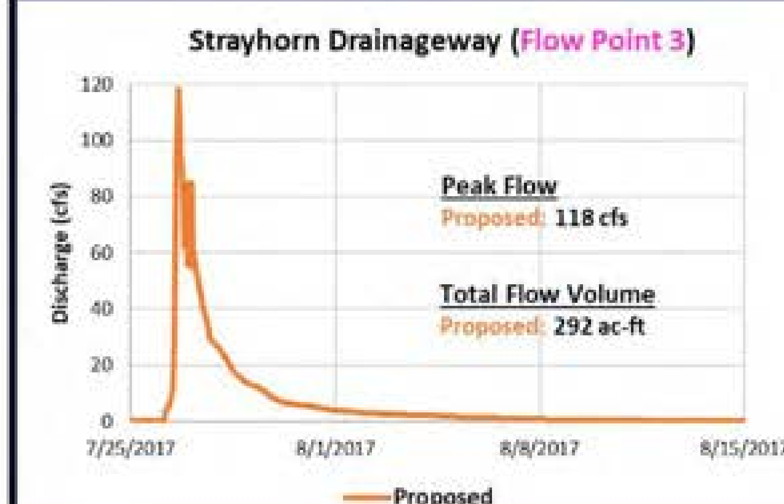
1.1.8 Strayhorn Drainageway

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.1.8 (c)





1.1.8 Strayhorn Drainageway

Flow(s)

25-yr 3-day (Jul Start)

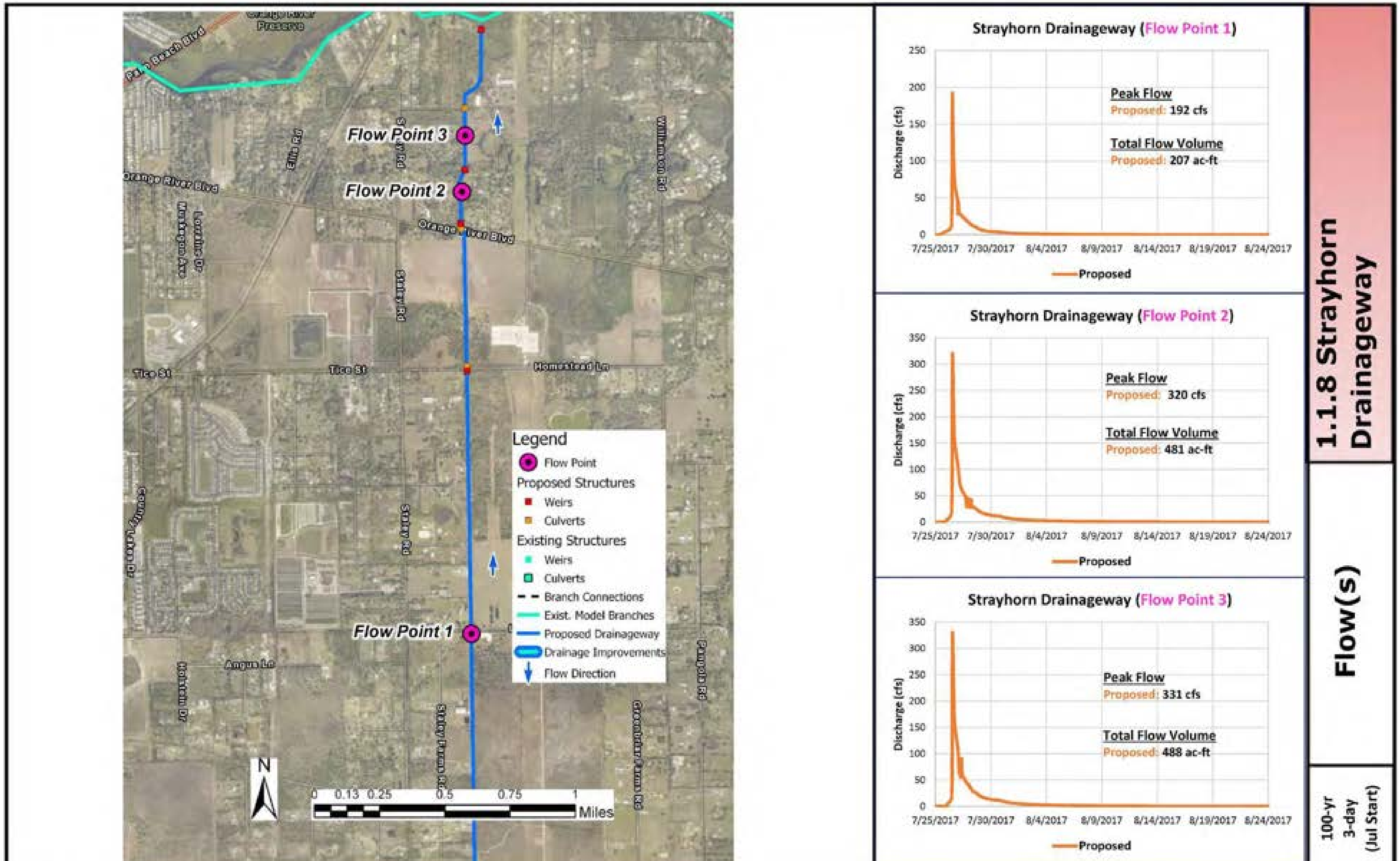
EXHIBIT 1.1.8 (d)

1.1.8 Strayhorn Drainageway

Water Level(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.1.8 (e)



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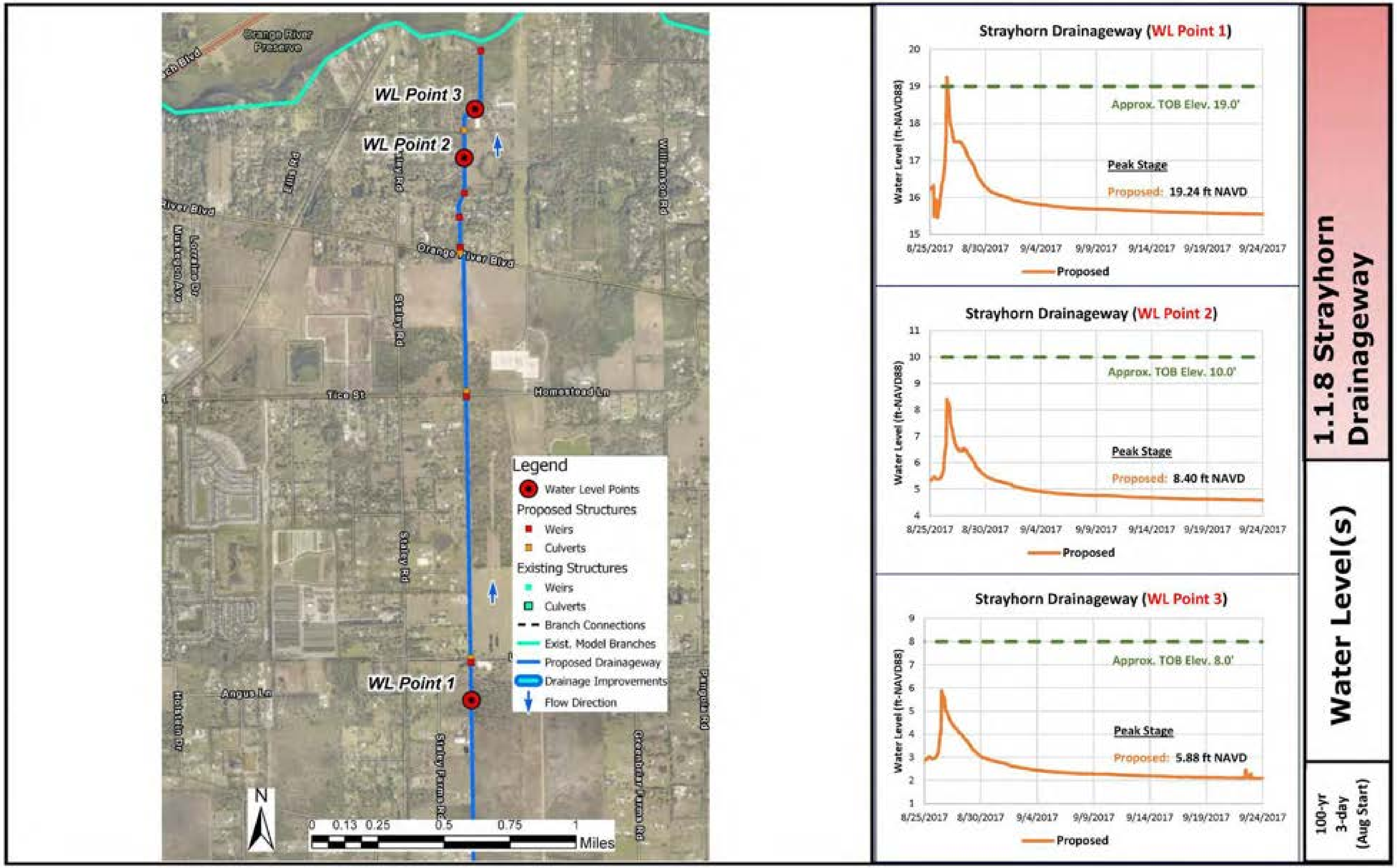

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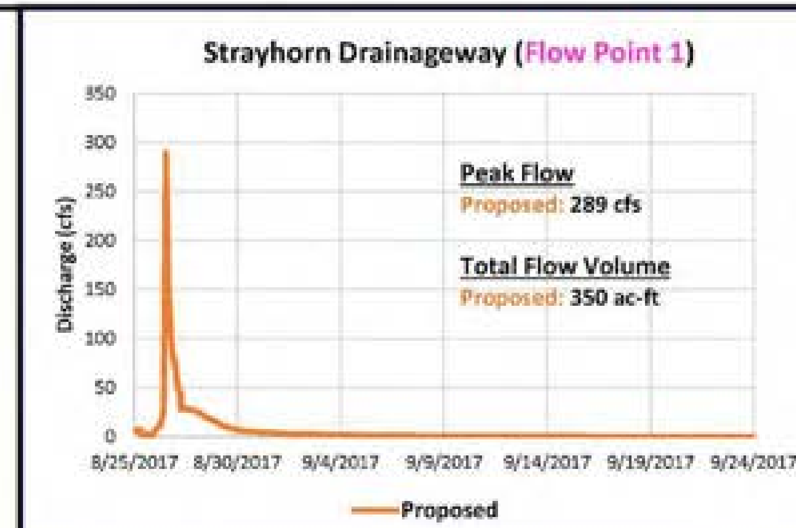
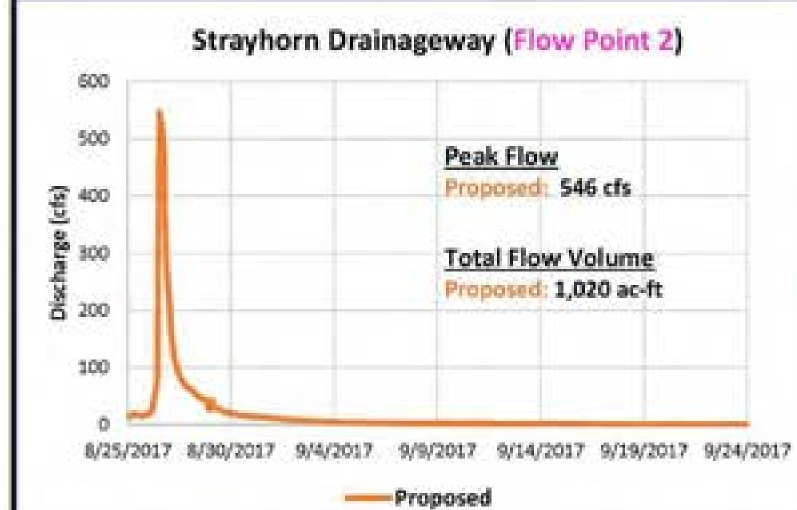
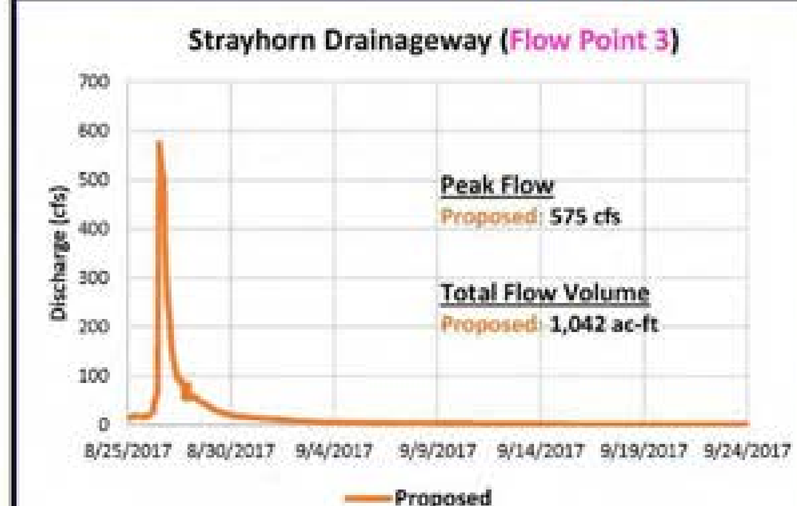






1.1.8 Strayhorn Drainageway

Flow(s)

100-yr 3-day (Aug Start)

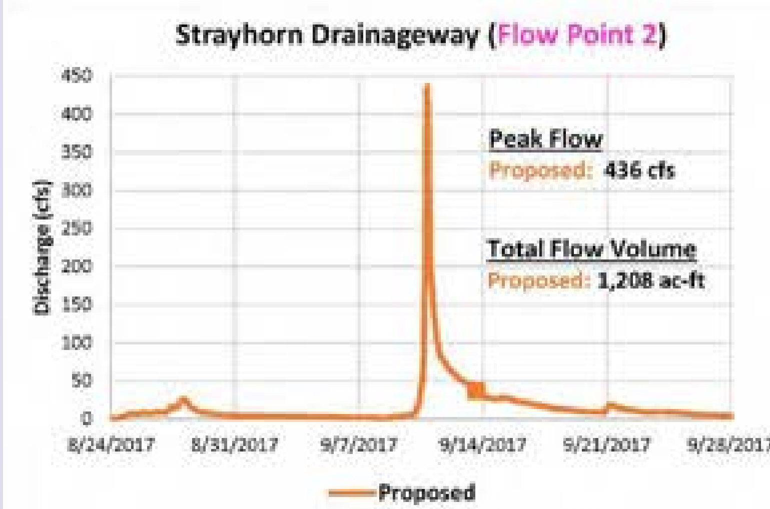
EXHIBIT 1.1.8 (h)

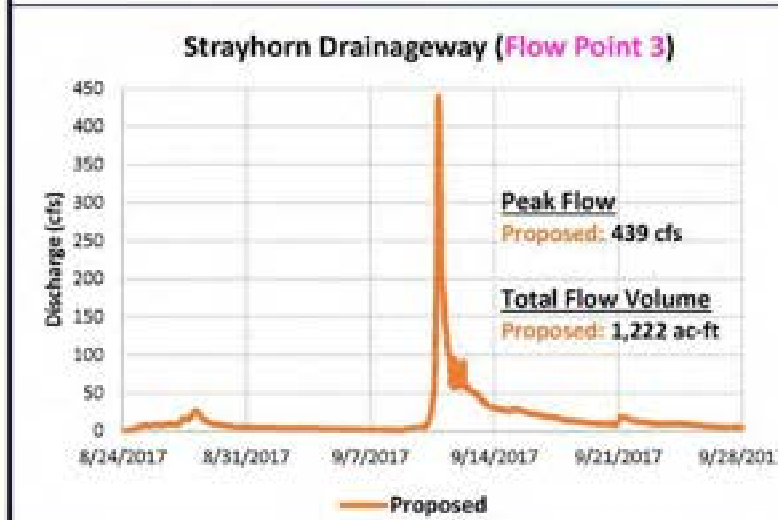
1.1.8 Strayhorn Drainageway

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.1.8 (i)





1.1.8 Strayhorn Drainageway

Flow(s)

Continuous Simulation (Hourly)

1.1.9 Charlie Diversion-Hickey Canal Improvement

Background

This concept project is the expansion of the existing Hickey Canal and Charlie Diversion Canal to transfer more excess stormwater from the Orange River to the Caloosahatchee River with the Hickey Creek Bypass Drainageway. The existing Hickey Canal has a large right of way for the expansion. The weir structures along the drainageway will require modification for the increased flow. The Charlie Diversion will require channel side slope modifications to increase flow capacity. The surrounding areas are mostly developing residential properties with an existing drainageway.

Location

This concept project in located within the Charlie Diversion and Hickey Canal right-of-way in Sections 1, 12, 13 and 24, Township 44 South, Range 26 East, and Sections 25 and 36, Township 43 East, Range 26 East as illustrated in **Figure 35** below.

Figure 35 - Location Map, 1.1.9 Charlie Diversion-Hickey Canal Improvement

Description

This proposed conceptual project transfers high flows from the Able Canal to the Charlie Diversion and Hickey Canal. Included in this project is the widening of the Hickey Canal to the Hickey Creek. Improving weir structures to handle high flows and roadway drainage crossings is required. This project is dependent on the construction of the Hickey Creek Overflow Bypass Concept Plan to the Caloosahatchee River. The Charlie Diversion-Hickey Canal Improvement conveyances would be approximately 150 feet wide. A water quality filter marsh improvement is possible on the 2020 parcel at Hickey Creek Mitigation Park. Permitting should not be contested for this project. This concept plan is illustrated in **Figure 36**:

Figure 36 - Concept Plan, 1.1.9 Charlie Diversion-Hickey Canal Improvement

Purpose

This proposed project provides diversion of high stormwater flows away from the Orange River directly to the Caloosahatchee River. In diverting additional flows to the Hickey Canal, increasing the conveyance capacity and flow controls are proposed as high velocities were observed after Hurricane Irma as illustrated in the **Figure 37** aerial photograph:

Figure 37 - Aerial of high velocity flow in Hickey Creek taken around 9-12-17

Evaluation

Viability

Although the Hickey Canal right-of-way narrows to approximately 200 feet at certain locations, expanding the conveyance capacity to a 150-foot wide cross section is viable. The Charlie Diversion right-of-way is approximately 100 feet wide, so seawalls would be required for sections of the improvement.

Community Considerations

As this is an improvement to an existing canal conveyance, adverse impact to communities is considered minimal.

Environmental & Permittability Considerations

Permit approval should be favorable for this project as improvements are proposed within an existing drainage right-of-way. A water quality filter marsh could be considered for a portion of the 2020 parcel at Hickey Creek Mitigation Park as illustrated in **Figure 38**:

Land Availability

There are many vacant parcels along Charlie Diversion and Hickey Canal. Although the incorporation of seawalls may avoid land acquisition, it may be more cost favorable to purchase lands where available to achieve the 150-foot proposed drainageway cross section. Any projects on 2020 Conservation Lands must be coordinated with Lee County.

Opinion of Probable Cost

The cost opinion shown in **Table 10** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 10: Opinion of Probable Cost Breakdown, 1.1.9 Charlie Diversion-Hickey Canal Improvement

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,812,000	$ 1,812,000
Clearing & Grubbing	1	LS	$ 300,000	$ 300,000
Earthwork	500,000	CY	$ 6	$ 3,000,000
Construction/ Maintenance Access	3,000	SY	$ 20	$ 60,000
Weir Structure 1.9A (Major/ Extension)	75	LF	$ 10,000	$ 750,000
Weir Structure 1.9B (Major/ Extension)	75	LF	$ 10,000	$ 750,000
Weir Structure 1.9C (Major)	150	LF	$ 10,000	$ 1,500,000
Bridge Extensions	1	LS	$ 1,250,000	$ 1,250,000
Detours	1	LS	$ 155,000	$ 155,000
Box Culvert 1.9-4	400	CY	$ 1,200	$ 480,000
Box Culvert 1.9-6	400	CY	$ 1,200	$ 480,000
Electric Supply	1	LS	$ 30,000	$ 30,000
Permanent Erosion Control	10,200	SF	$ 15	$ 153,000
Grassing	140,000	SY	$ 2	$ 280,000
			Conceptual Construction Costs:	**$ 11,000,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 3,300,000
			Land Acquisition	-
			Project Administration/ CEI (10%)	$ 1,100,000
			Project Unknowns	$ 200,000
			Conceptual Project Cost:	**$ 15,600,000**
			Contengency (30%)	$ 4,400,000
			Conceptual Project Cost (with Contengency):	**$ 20,000,000**

Opportunities for Multiple Benefits & Uses

The Hickey Creek Overflow Bypass concept plan was proposed to accomplish 35% of the goals for the East Lee County area. Although the Hickey Creek Overflow Bypass project should be implemented before this concept project, this concept plan provides a substantially larger conveyance for diverting flows from the Orange River. The ability to mitigate impacts to the Orange River Drainage Basin and accomplish a significant conveyance capacity in an existing drainage right-of-way is an outstanding opportunity.

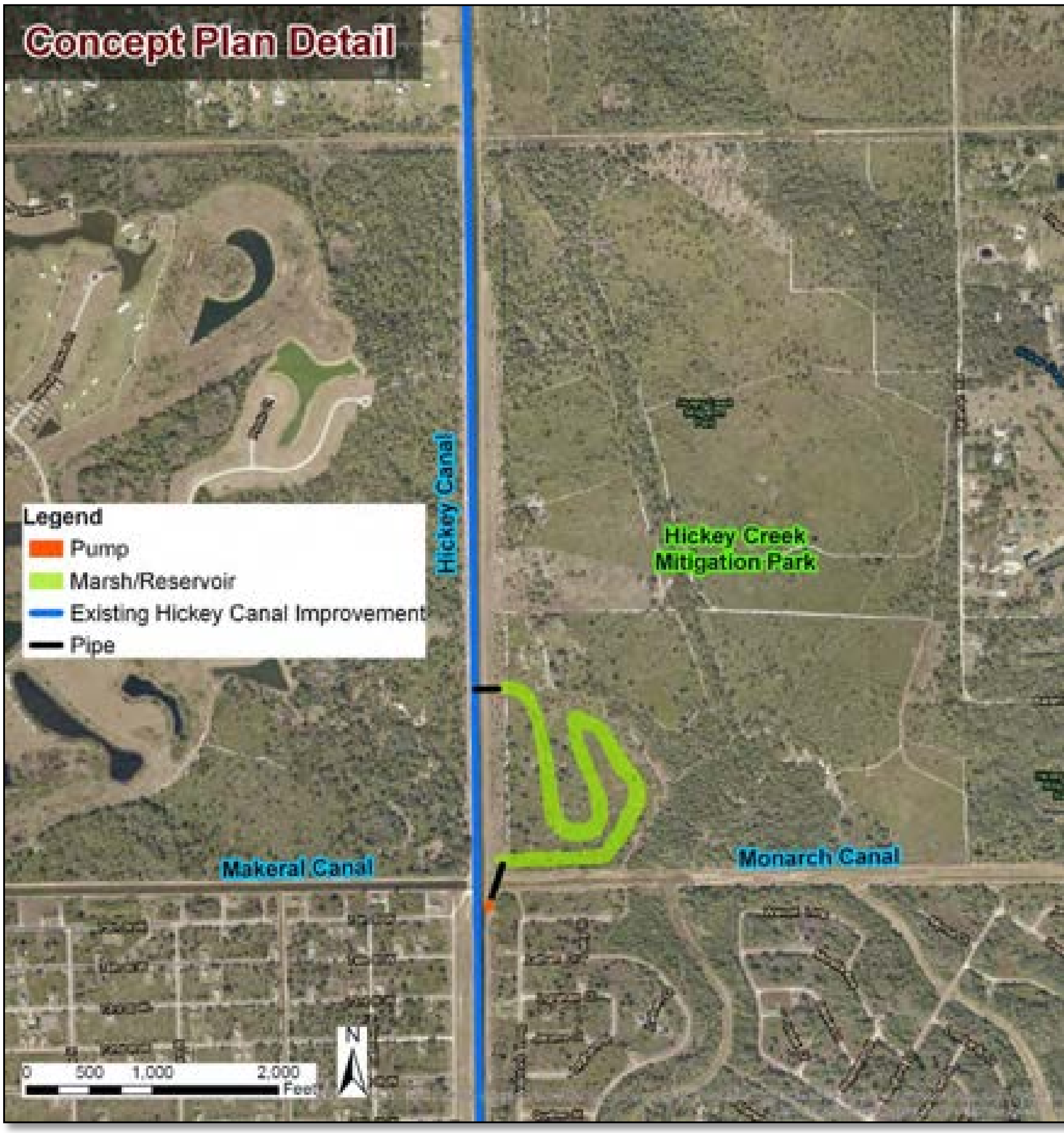


Figure 38 - Example of a water quality filter marsh area, 1.1.9 Charlie Diversion-Hickey Canal Improvement

Other Considerations

Water stages in Harns Marsh were observed to overtop the berms. Diverting flow away from Harns Marsh during severe storm events allows for the water management system to better perform as a storage reservoir attenuating peak flows. A summary of this concept project is shown below in **Exhibit 1.1.9** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of increasing the conveyance capacity on the Charlie Diversion and Hickey Canal to divert excess stormwater flows away from the Orange River towards the Caloosahatchee River. The refined concept plan is shown in **Exhibit 1.1.9 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

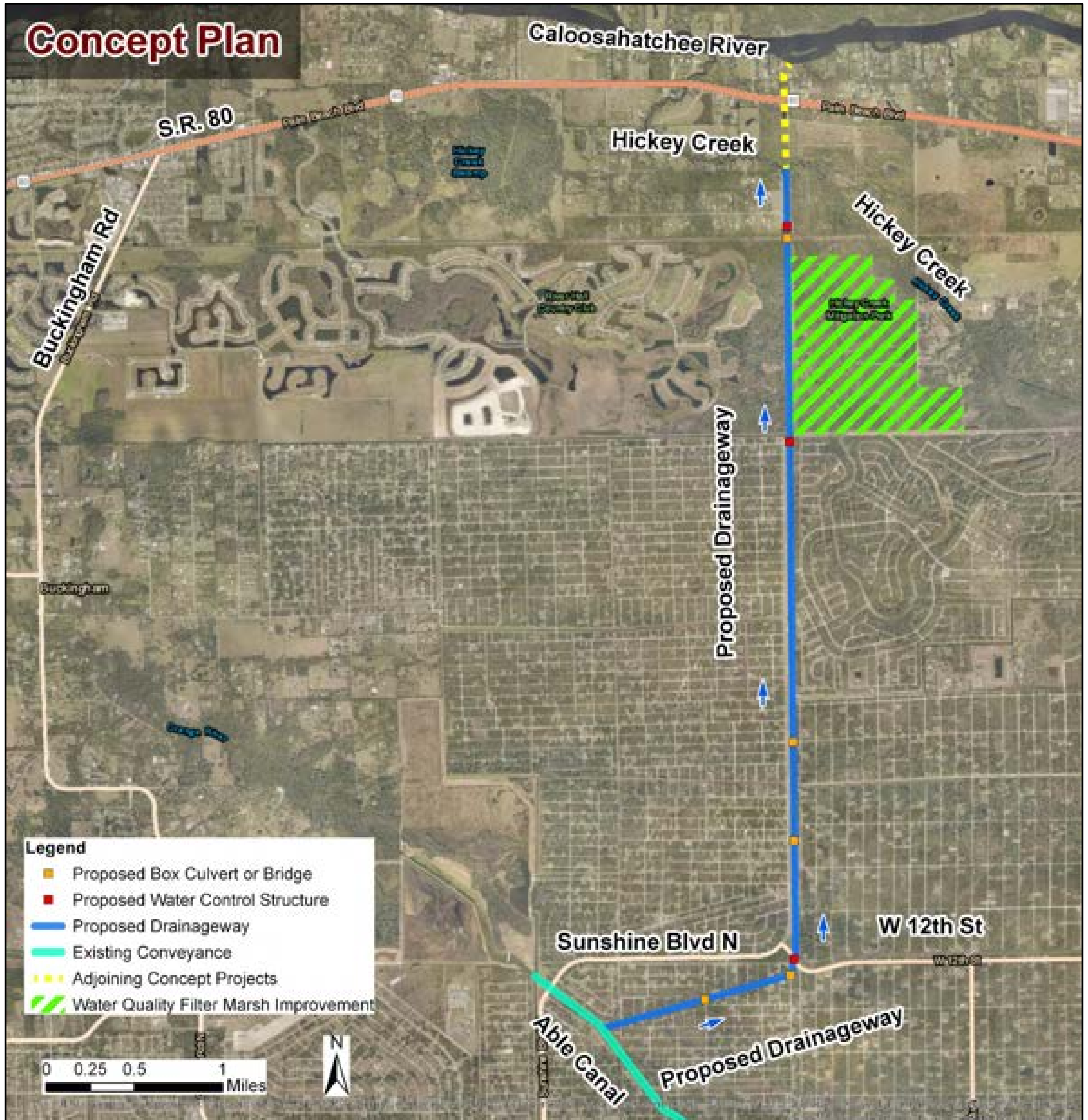
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.9 (b) EXHIBIT 1.1.9 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.9 (d) EXHIBIT 1.1.9 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.9 (f) EXHIBIT 1.1.9 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.9 (h) EXHIBIT 1.1.9 (i)

Improvements were shown with water level reduction along the drainageway. An increase in peak flow and total flow volume were shown at the upstream point of the concept project.

Recommendations

Increasing the conveyance capacity on the Charlie Diversion and Hickey Canal allows for diversion of excess stormwater flows away from the Orange River towards the Caloosahatchee River. During the design phase, the water control structure within the Orange River (S-OR-1) should be raised to along with lower weirs along the conveyance in order gain greater ability and control of diverting flows from the Orange River to the Carlie Diversion and Hickey Canal. To avoid adverse downstream impacts, this concept project should not be constructed until the corresponding downstream concept project is first constructed. The positive improvements of this project concept warrant further design-level project development.

EXHIBIT 1.1.9



Project Narrative

DESCRIPTION: This proposed conceptual project transfers high flows from the Able Canal to the Hickey Canal. Included in this project is the widening of the Hickey Canal to the Hickey Creek. Improving weir structures to handle high flows is required. This project is dependent on the construction of the Hickey Creek Overflow Bypass Concept Plan to the Caloosahatchee River. The Charlie Diversion-Hickey Canal Improvement conveyances would be approximately 150 feet wide. Approximately 200 feet of R/W is available on Hickey Canal.

PURPOSE: This proposed project provides diversion of high stormwater flows from the Orange River directly to the Caloosahatchee River. A water quality filter marsh improvement is possible on the 2020 parcel at Hickey Creek Mitigation Park.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Charlie Diversion-Hickey Canal Improvement

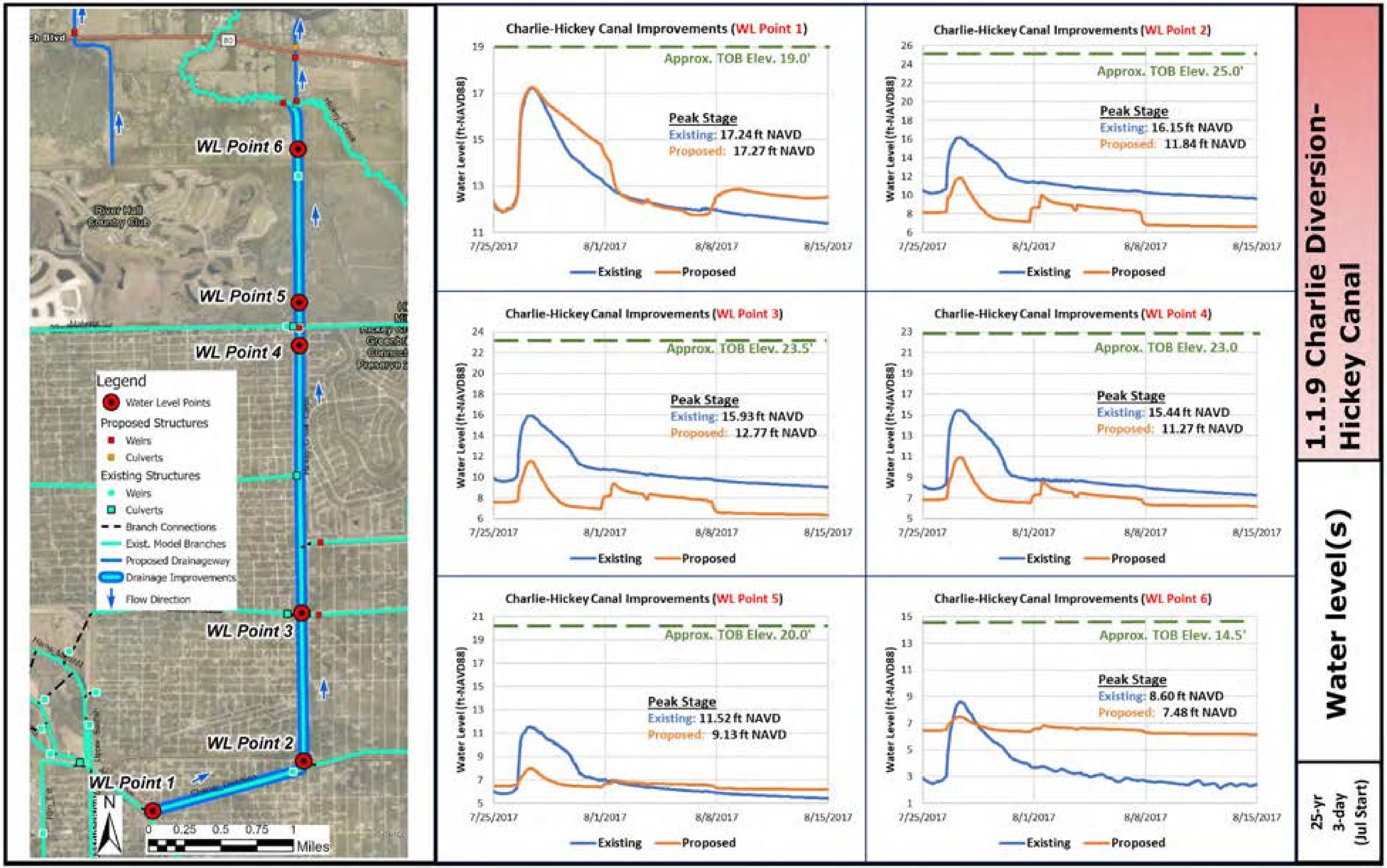
East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.9

EXHIBIT 1.1.9 (a)

EXHIBIT 1.1.9 (b)



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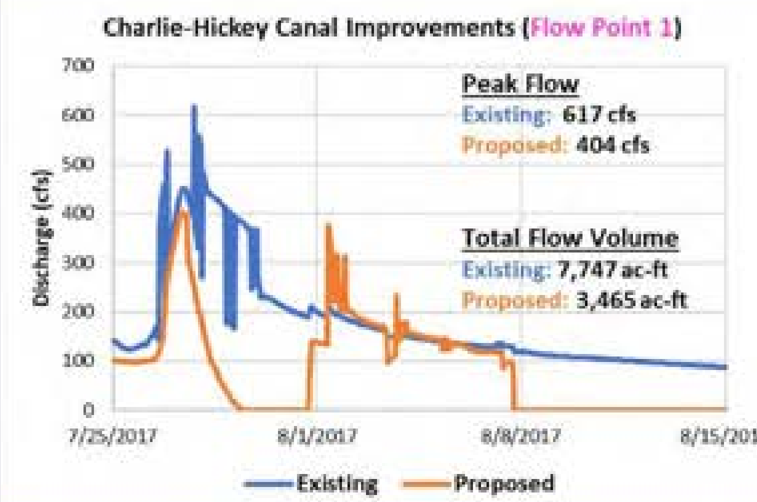
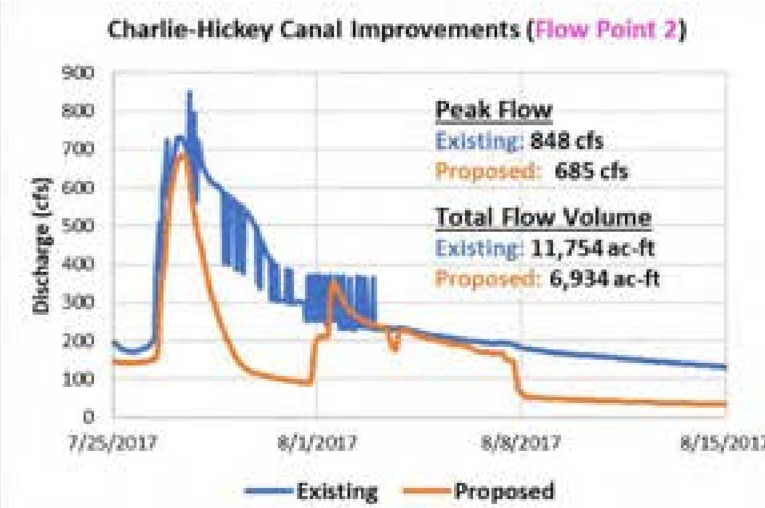
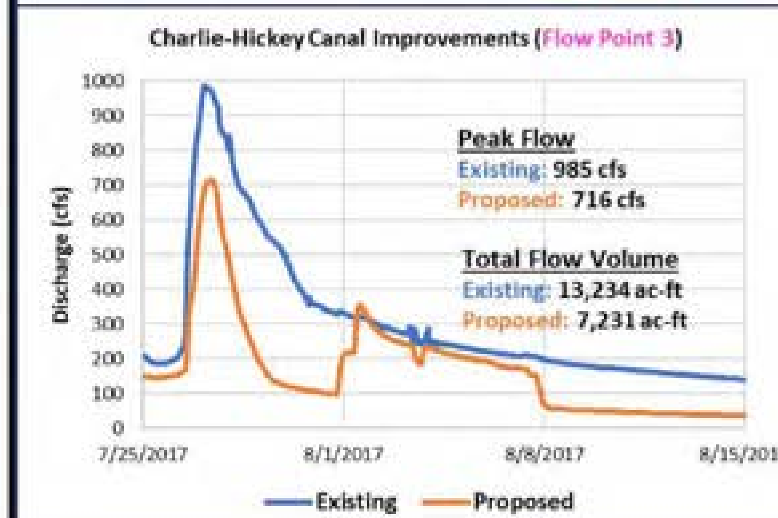




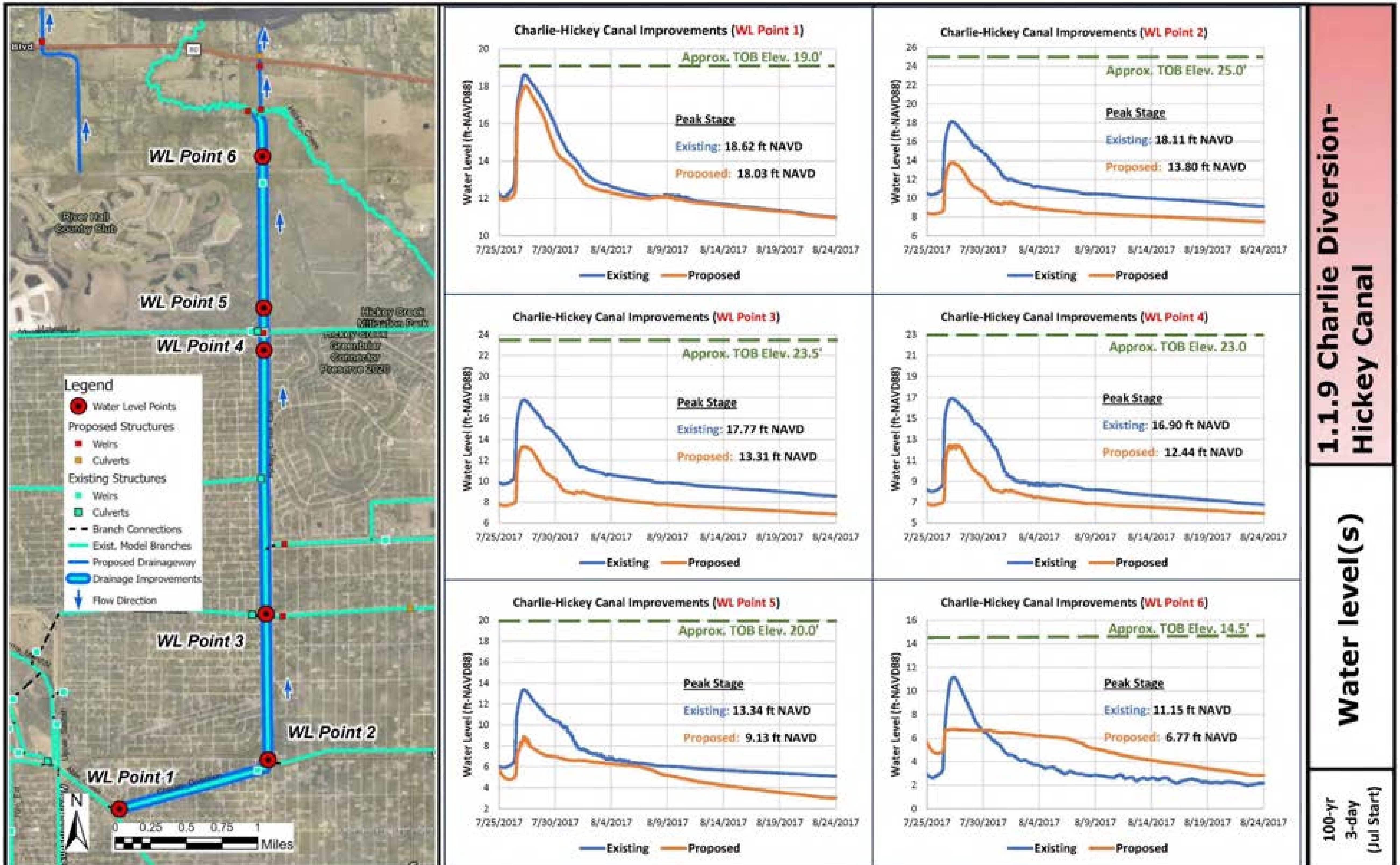


1.1.9 Charlie Diversion-Hickey Canal

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.1.9 (d)



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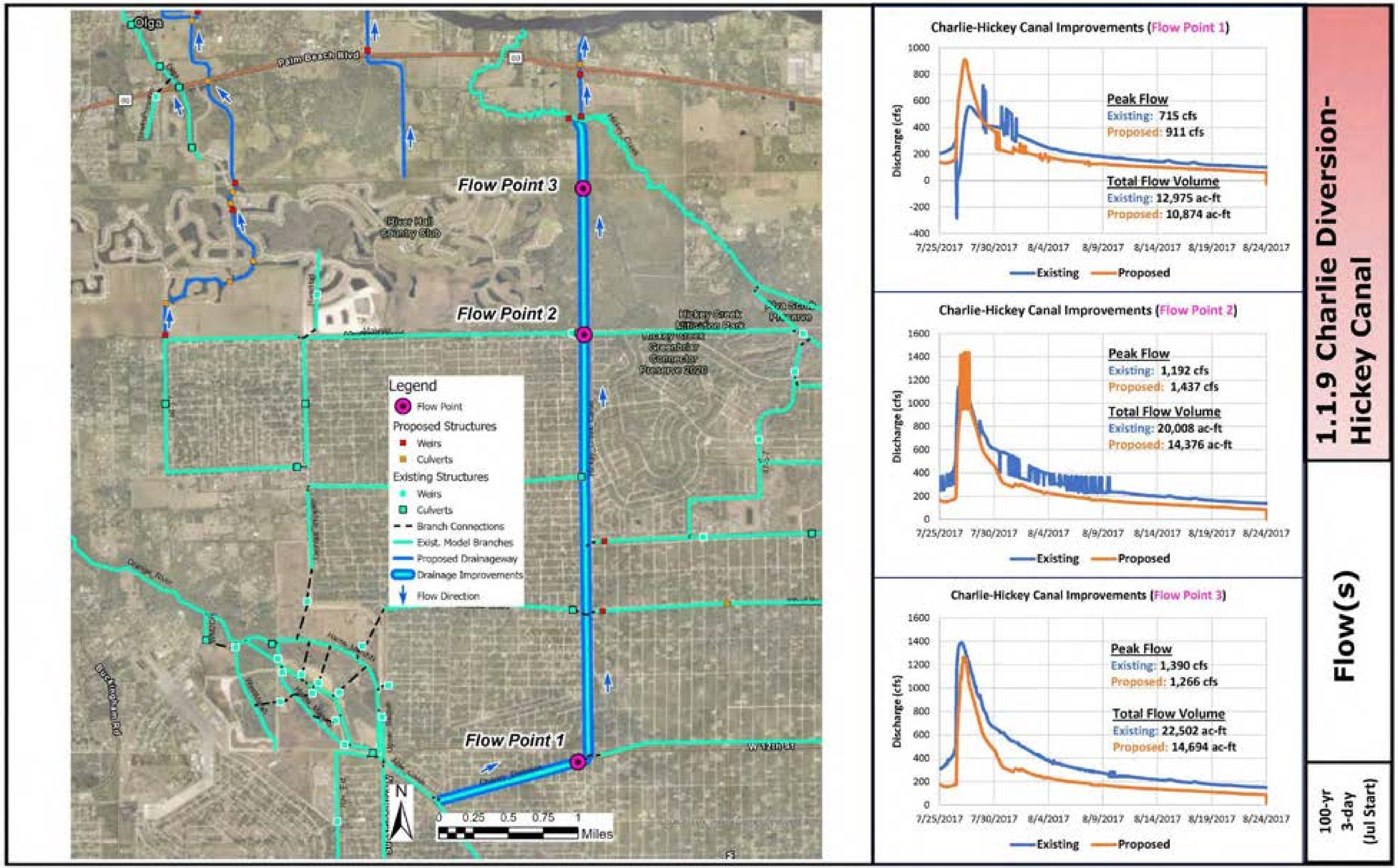

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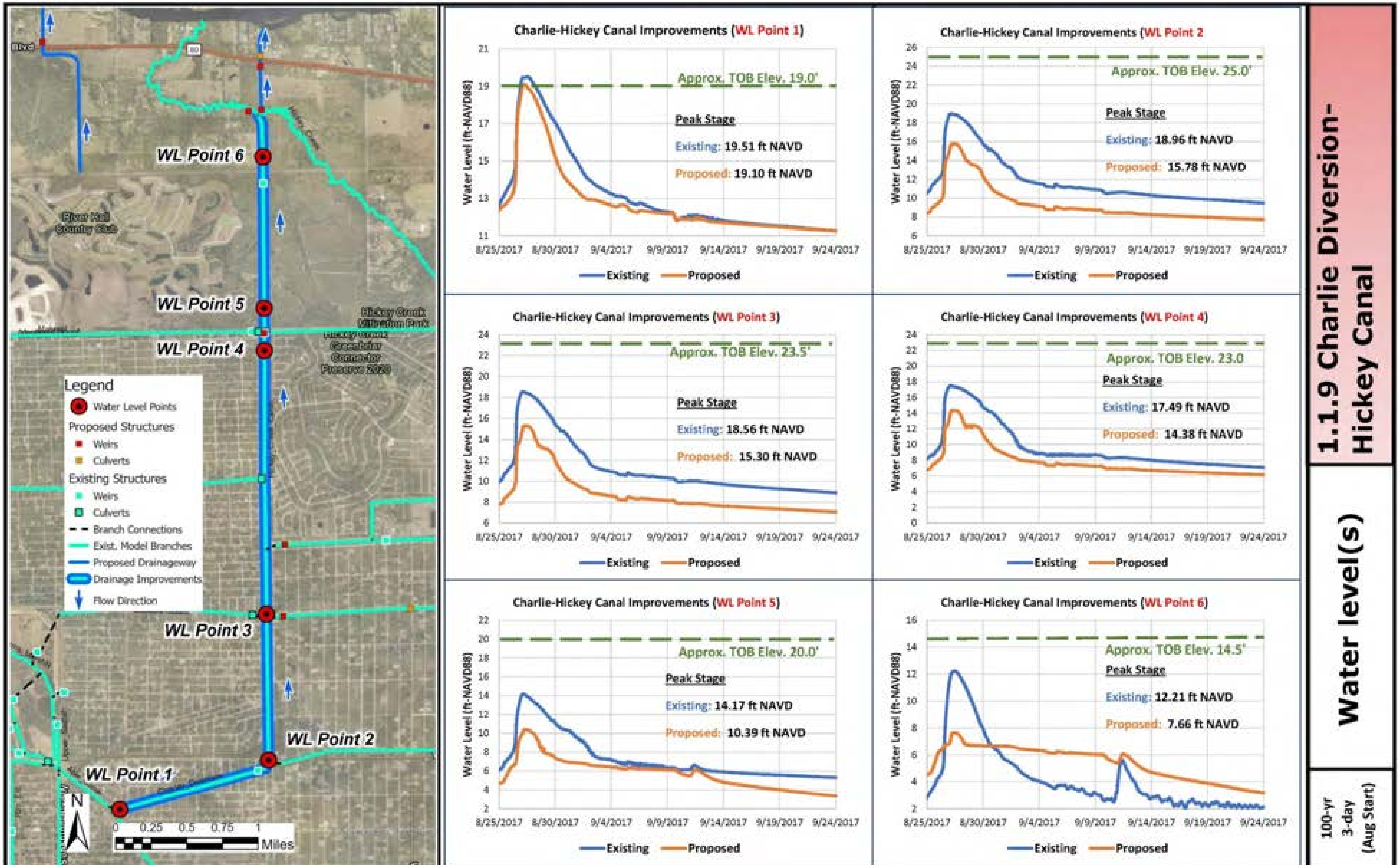

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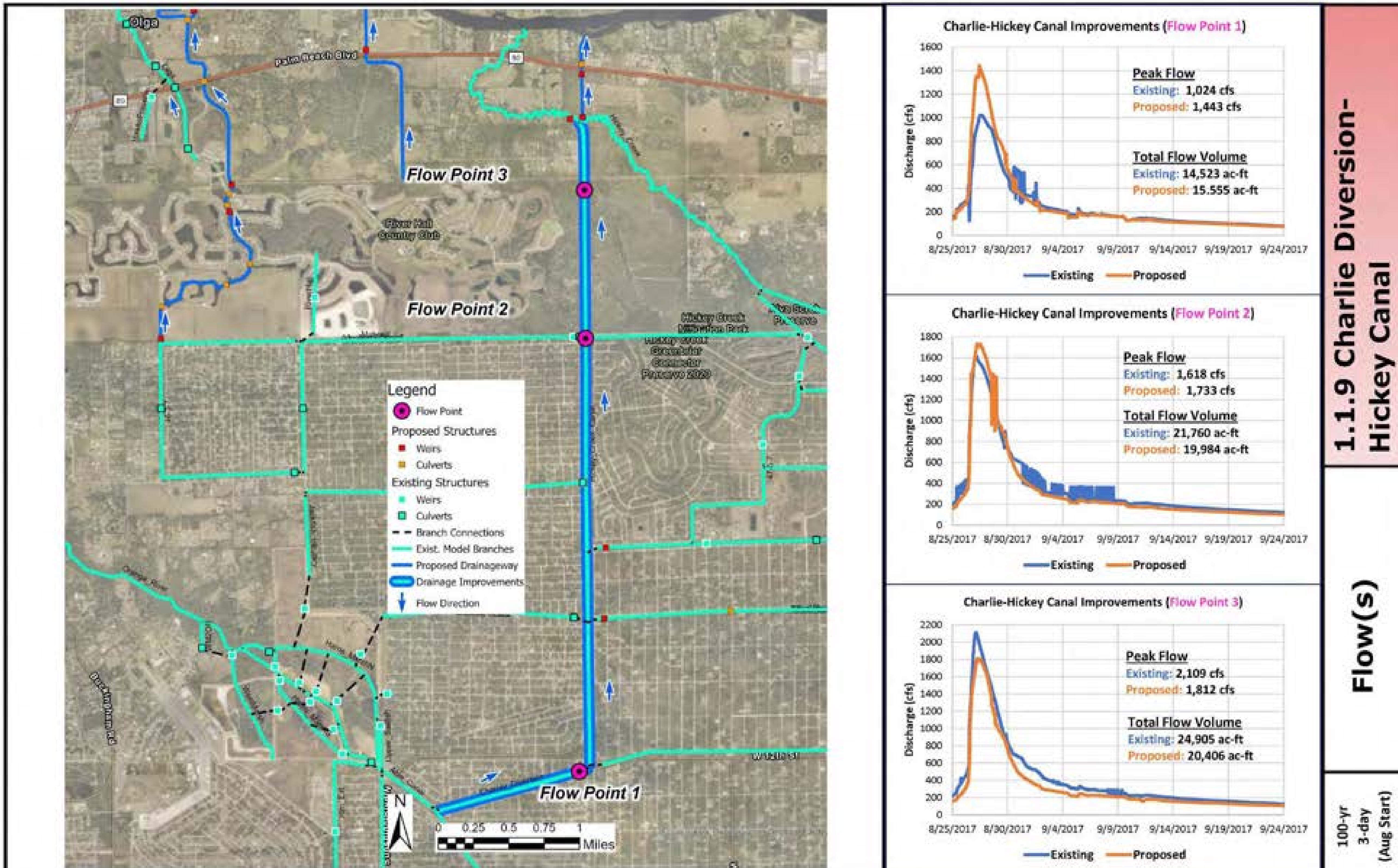


EXHIBIT 1.1.9 (h)

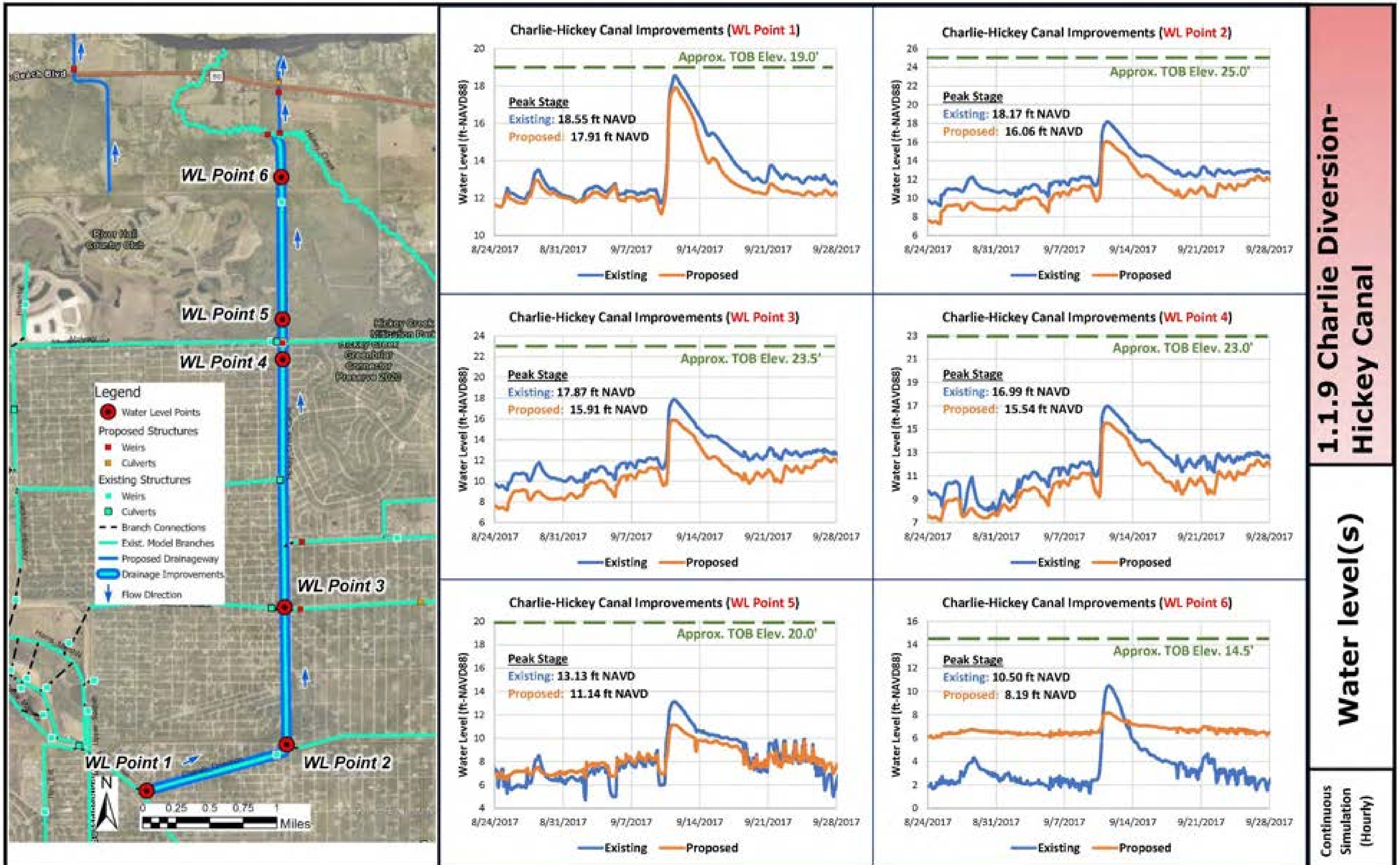
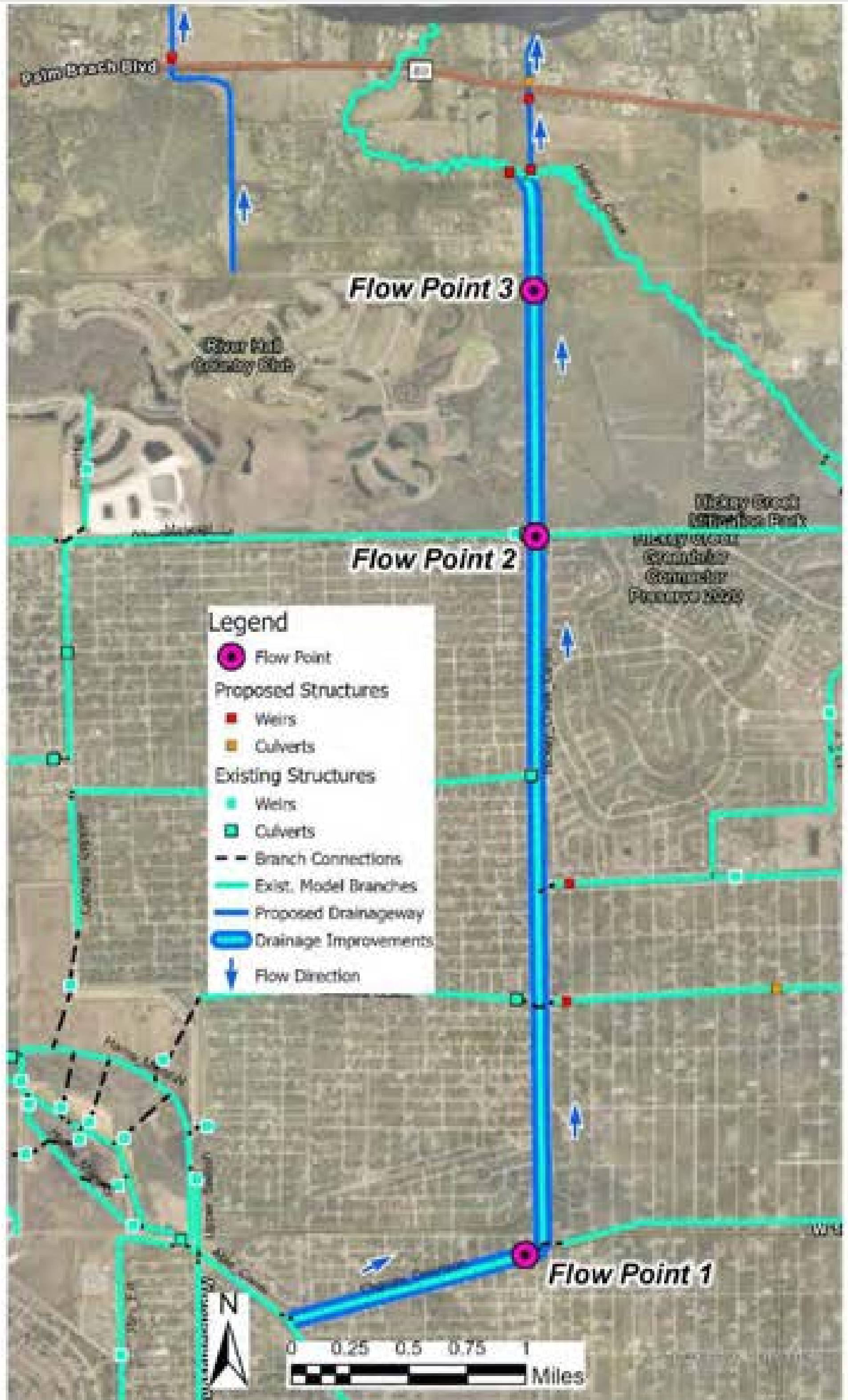
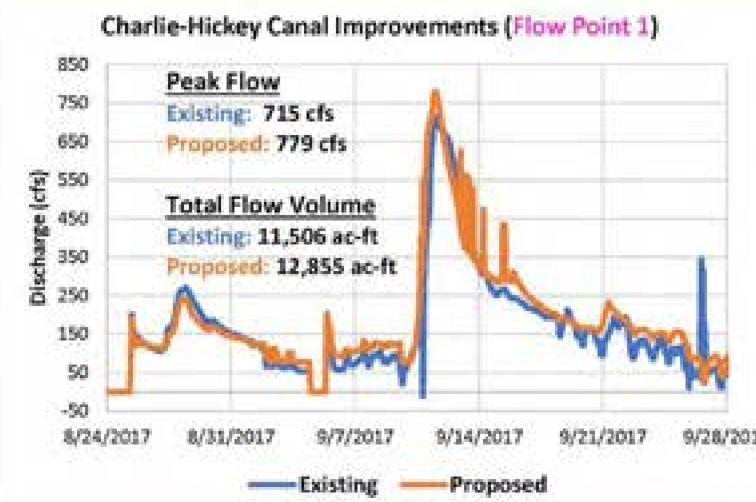
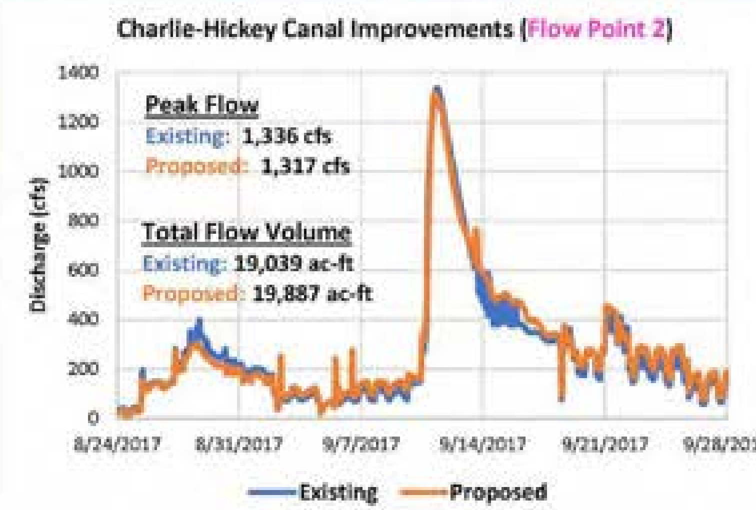
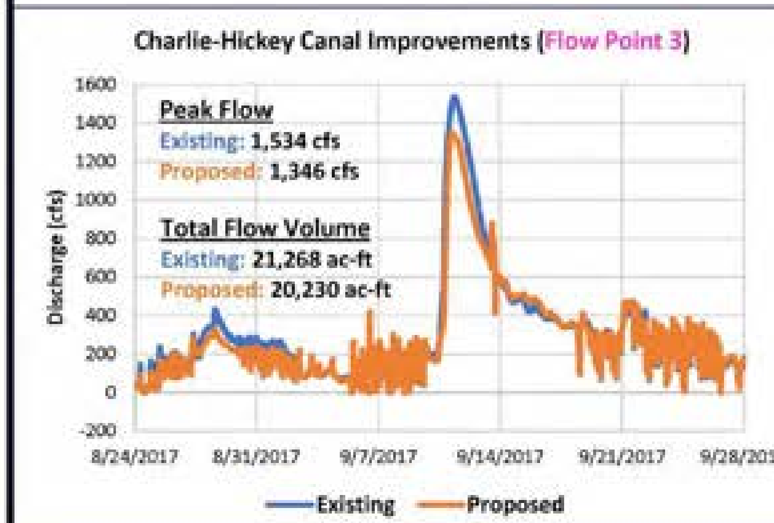


EXHIBIT 1.1.9 (i)









1.1.9 Charlie Diversion-Hickey Canal

Flow(s)

Continuous Simulation (Hourly)

1.1.10 Hickey Creek Swamp Drainageway

Background

The area surrounding this concept project contains very large cypress tree areas and is sometimes referred to as Carter Swamp. This site is typically very wet with ponding that aides in growth of the trees and thriving swamplands. Excess stormwater runoff from higher ground flowed through this site to areas along the Hickey Creek. This low area site has a drainage connection across State Road 80 and on to the Caloosahatchee River. The proposed improvements will limit flow to the Hickey Creek area and better direct flow to the Caloosahatchee River.

Location

This concept project is located within the Hickey Creek Swamp in Sections 23 and 26, Township 43 South, and Range 26 East as illustrated by **Figure 39**:

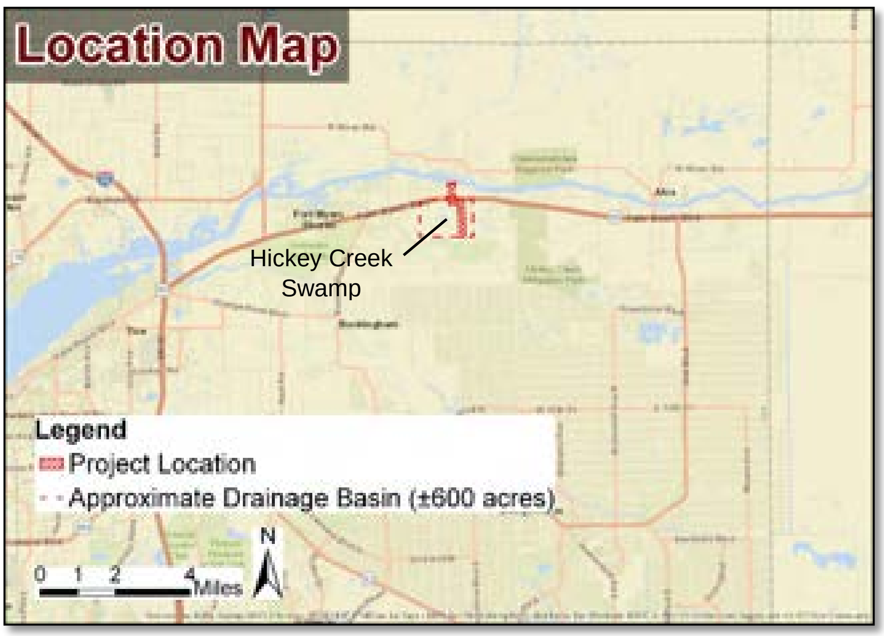


Figure 39 - Location Map, 1.1.10 Hickey Creek Swamp Drainageway

Description

This proposed conceptual project improves the drainage conveyance to the Caloosahatchee River and provides a swale and berm along the easterly boundary to limit flooding in the Hickey Creek area as illustrated by **Figure 40** below.

Figure 40 - Concept Plan, 1.1.10 Hickey Creek Swamp Drainageway

Purpose

This proposed project reduces flooding in the Hickey Creek area and provides water control structures to maintain desirable water levels in the Hickey Creek Swamp.

Evaluation

Viability

The conveyance north of S.R. 80 improves an existing drainageway. A drainage easement would be required for the work in the portion of Hickey Creek Swamp. The fill generated from the excavation for the drainageway could be utilized on site for construction of the berm.

Community Considerations

Residents along Hickey Creek Road reported flows coming from the Hickey Creek Swamp Area causing flooding. Diverting this flow directly to the Caloosahatchee River while maintaining water levels in the swamp should gain local community approval.

Environmental & Permittability Considerations

Hickey Creek Swamp's ecosystem would be protected with a control structure to maintain the wetland hydro periods. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would be mitigated.

Land Availability

This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition or drainage easements. It is reported that property is owned by foreign family members and easement agreement may be difficult to obtain. Cooperation with FDOT is required as the conveyance crossing under S.R. 80 is in the state right-of-way.

Opinion of Probable Cost

The cost opinion shown in **Table 11** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 11: Opinion of Probable Cost Breakdown, 1.1.10 Hickey Creek Swamp Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 107,000	$ 107,000
Clearing & Grubbing	8	AC	$ 14,000	$ 112,000
Earthwork	5,000	CY	$ 8	$ 40,000
Weir Structure 1.10A (Standard)	24	LF	$ 5,000	$ 120,000
Box Culvert 1.10-1	136	LF	$ 250	$ 34,000
Permanent Erosion Control	680	SF	$ 25	$ 17,000
Grassing	35,000	SY	$ 2	$ 70,000
Conceptual Construction Costs:				**$ 500,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 150,000
Land Acquisition				$ 440,000
Project Administration/ CEI (10%)				$ 50,000
Project Unknowns				$ 20,000
Conceptual Project Cost:				**$ 1,160,000**
Contengency (30%)				$ 340,000
Conceptual Project Cost (with Contengency):				**$ 1,500,000**

Opportunities for Multiple Benefits & Uses

The ability to divert flows away from the residents along the Hickey Creek is a beneficial opportunity.

Other Considerations

A summary of this concept project is shown below in **Exhibit 1.1.10** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists a conveyance and berm along the easterly boundary of the Hickey (Carter) Swamp to protect the residents along Hickey Creek that experienced flooding from overland flow from this area. The flow will be directed to Caloosahatchee River with improvements to an existing drainageway. The refined concept plan is shown in **Exhibit 1.1.10 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.10 (b) EXHIBIT 1.1.10 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.10 (d) EXHIBIT 1.1.10 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.1.10 (f) EXHIBIT 1.1.10 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.1.10 (h) EXHIBIT 1.1.10 (i)

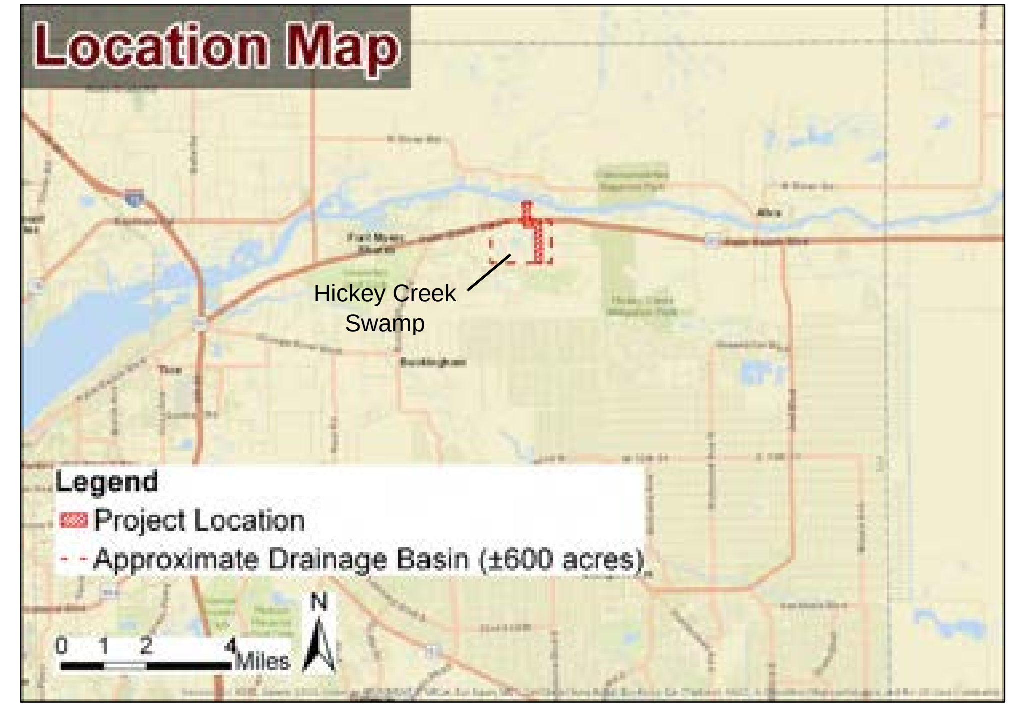
Reasonable water elevations were shown approaching the Caloosahatchee over a 1.5 mile span. A relatively low peak flow was anticipated since this is a smaller project. The proposed drainageway does mitigate flooding by diverting water away from Hickey Creek during large storm events.

Recommendations

Implementing a conveyance and berm along the eastern boundary of the Hickey (Carter) Swamp aids in mitigating flooding impacts to the residents along Hickey Creek that experienced flooding from overland flow from this area. This flow can instead be directed to Caloosahatchee River with improvements to an existing drainageway north of SR 80. These positive improvements of this project concept warrant further design-level project development.

EXHIBIT 1.1.10

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project improves the drainage conveyance to the Caloosahatchee River and provides a swale and berm along the easterly boundary to limit flooding in the Hickey Creek area.

PURPOSE: This proposed project reduces flooding in the Hickey Creek area and provides water control structures to maintain desirable water levels in the Hickey Creek Swamp.

CONSTRAINTS: This project, as planned, crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Hickey Creek Swamp Drainageway

East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.10

EXHIBIT 1.1.10 (a)

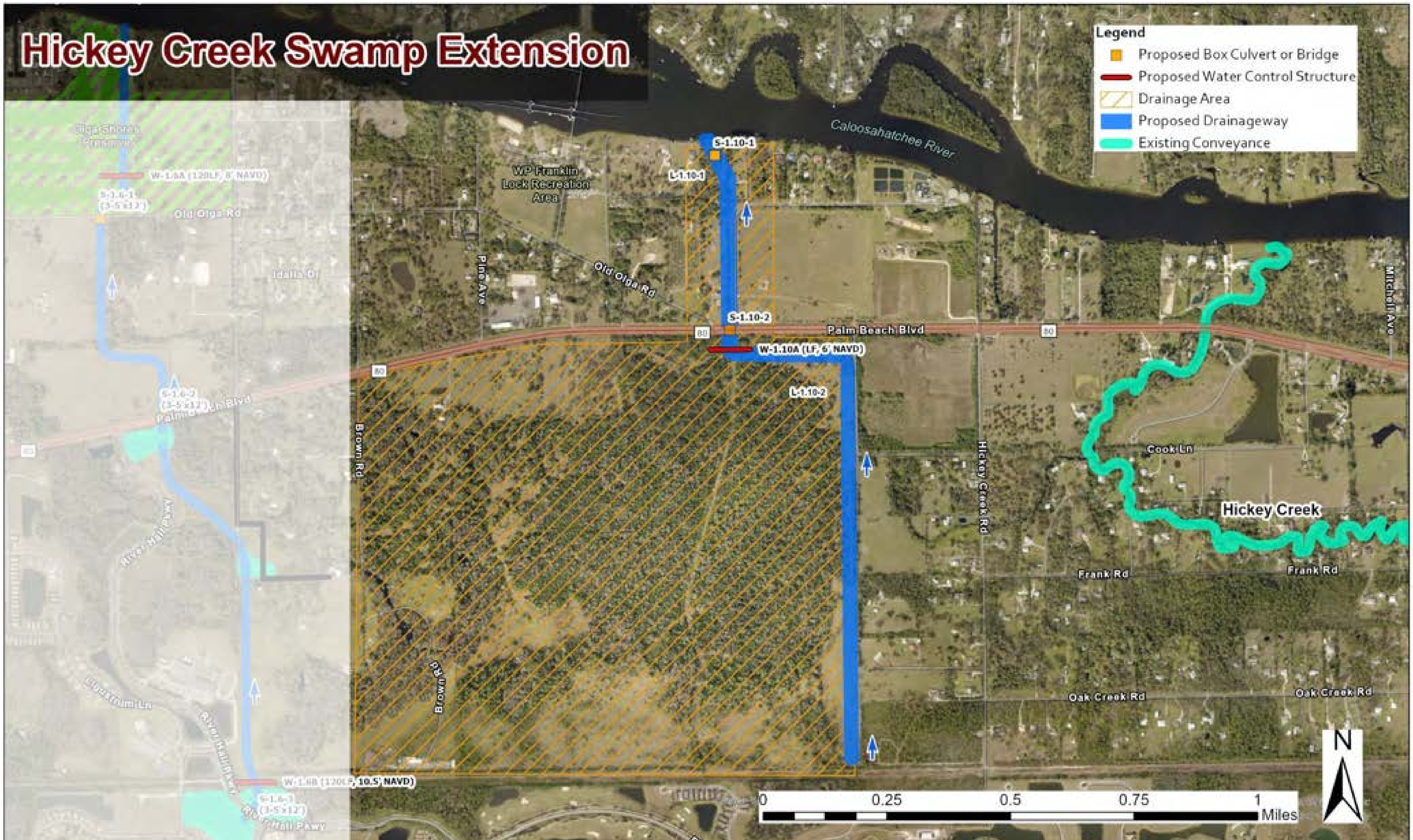


EXHIBIT 1.1.10 (b)

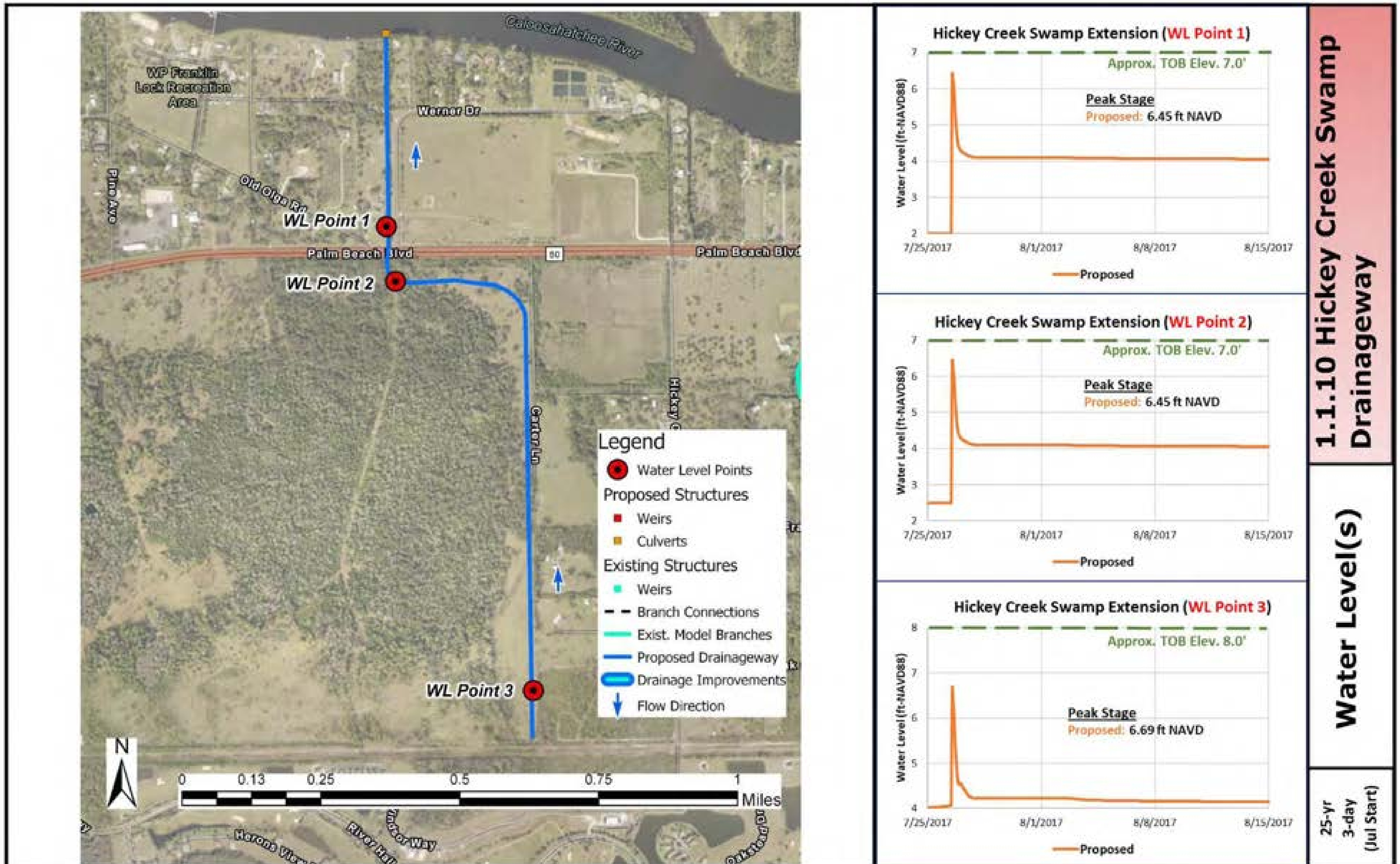
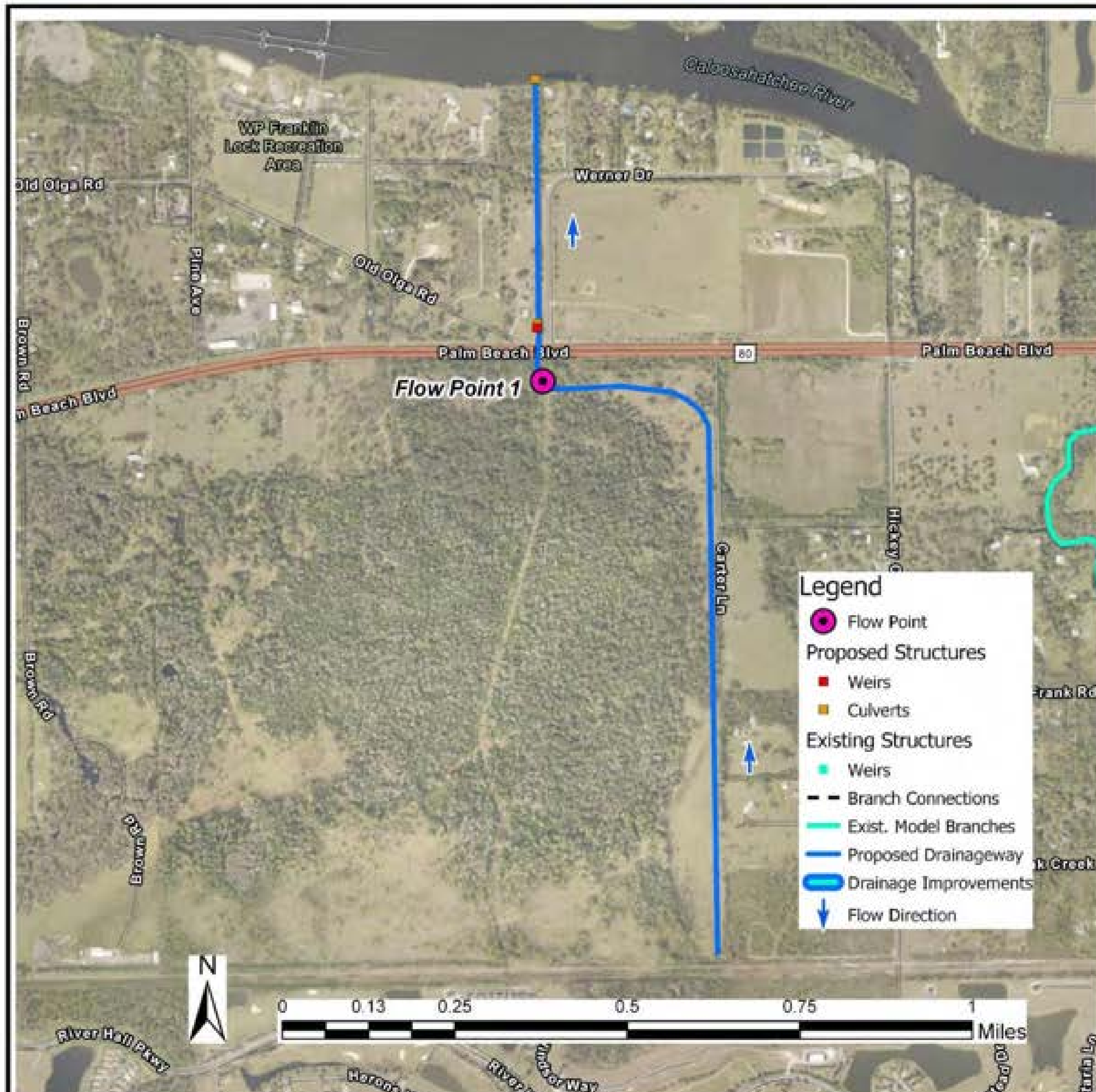
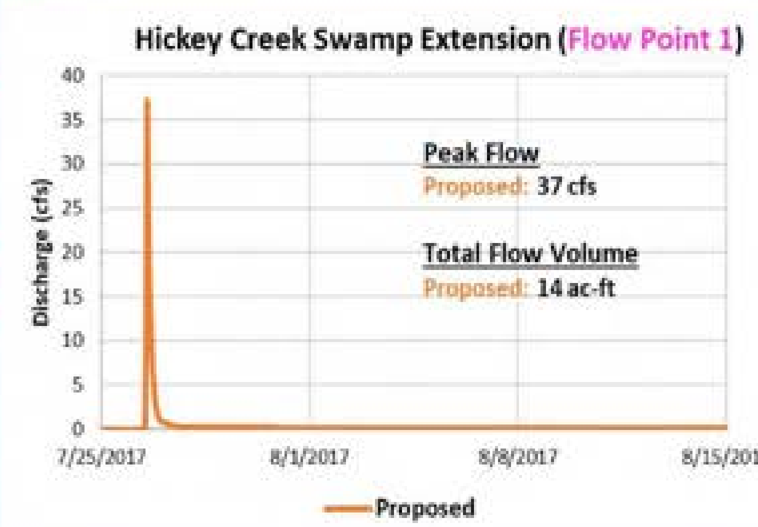


EXHIBIT 1.1.10 (c)





1.1.10 Hickey Creek Swamp Drainageway

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.1.10 (d)

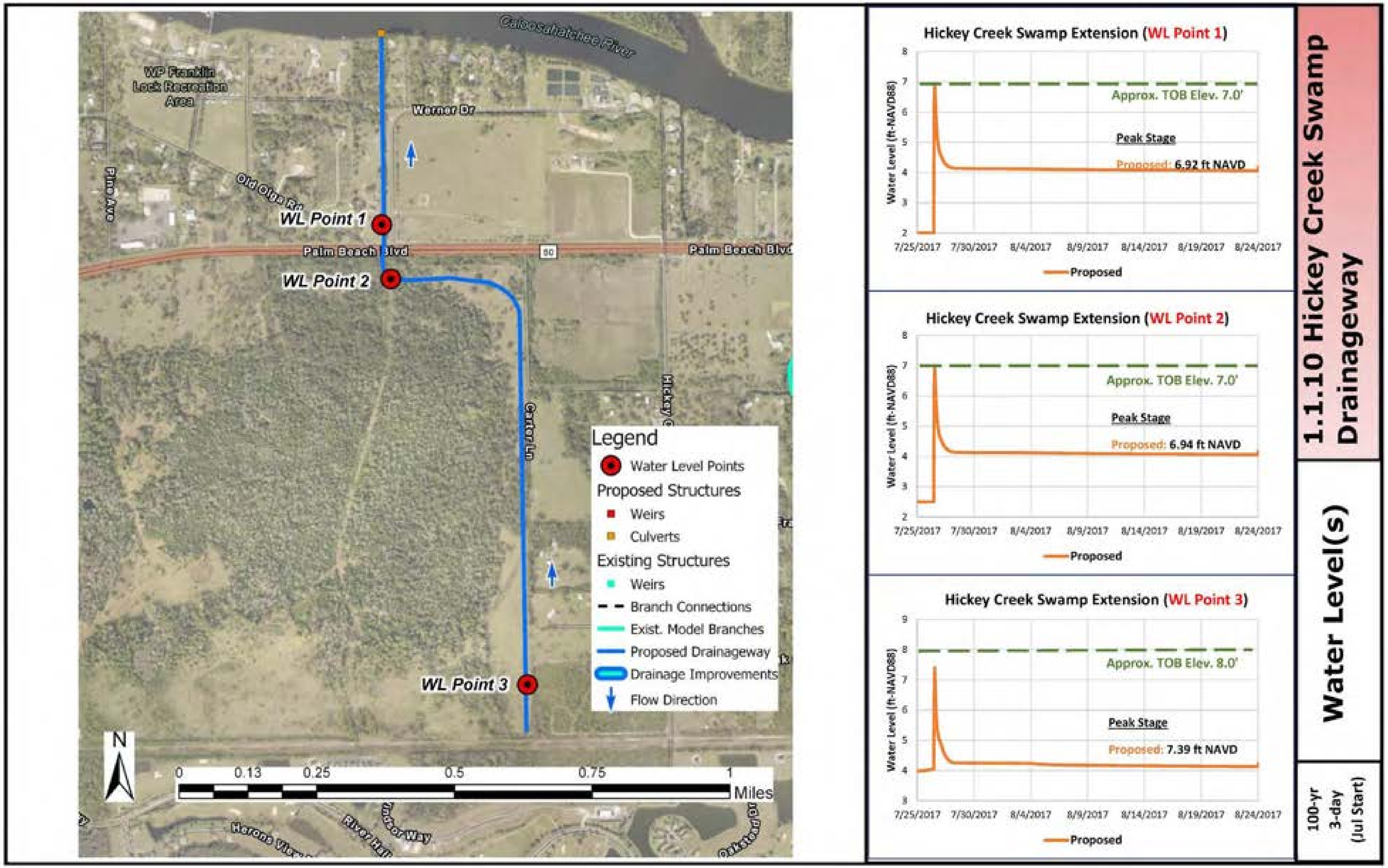
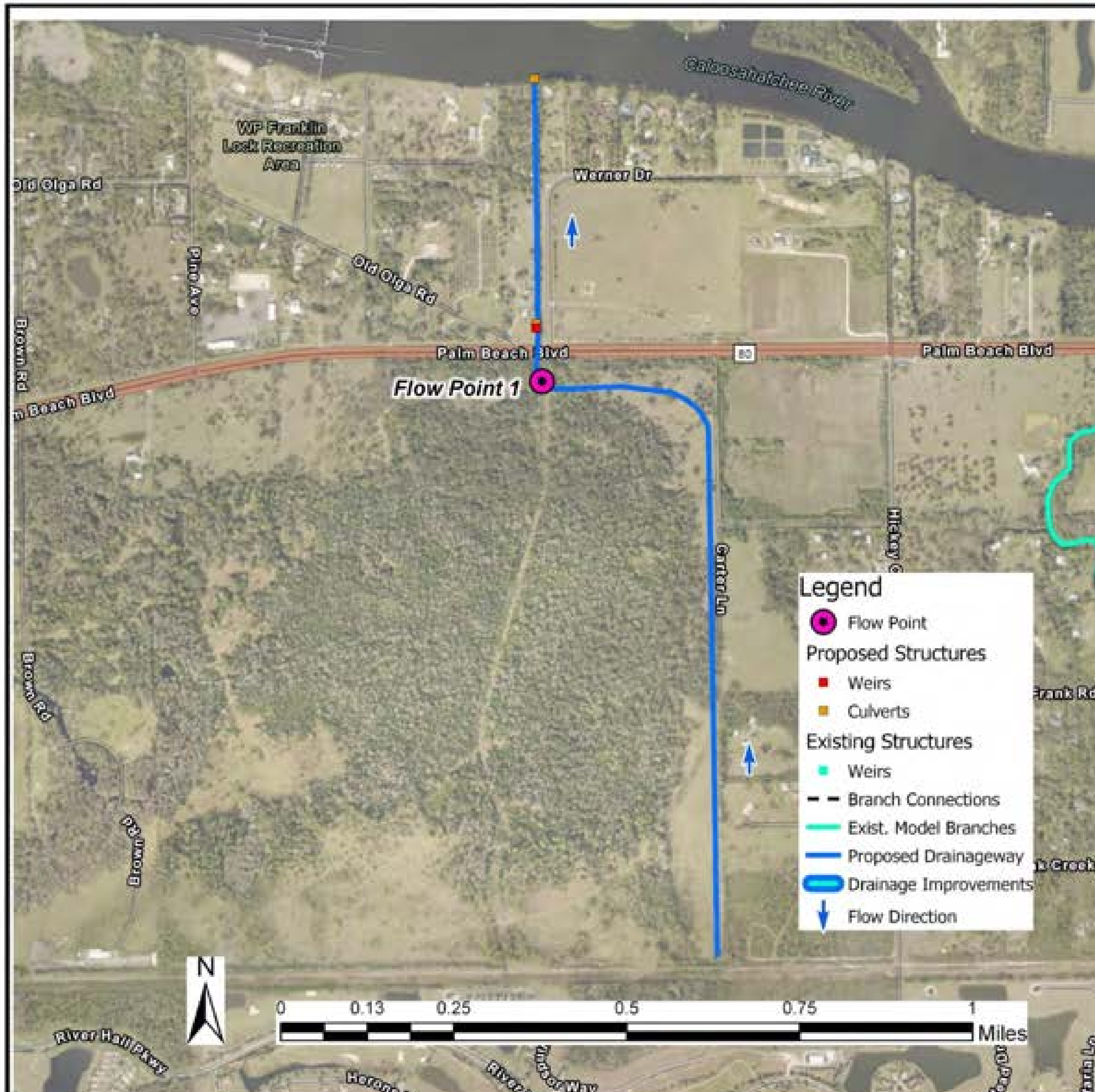
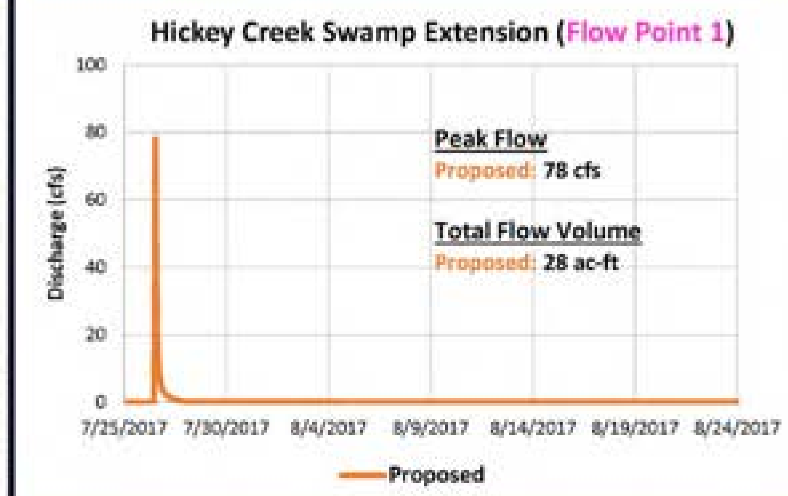


EXHIBIT 1.1.10 (e)



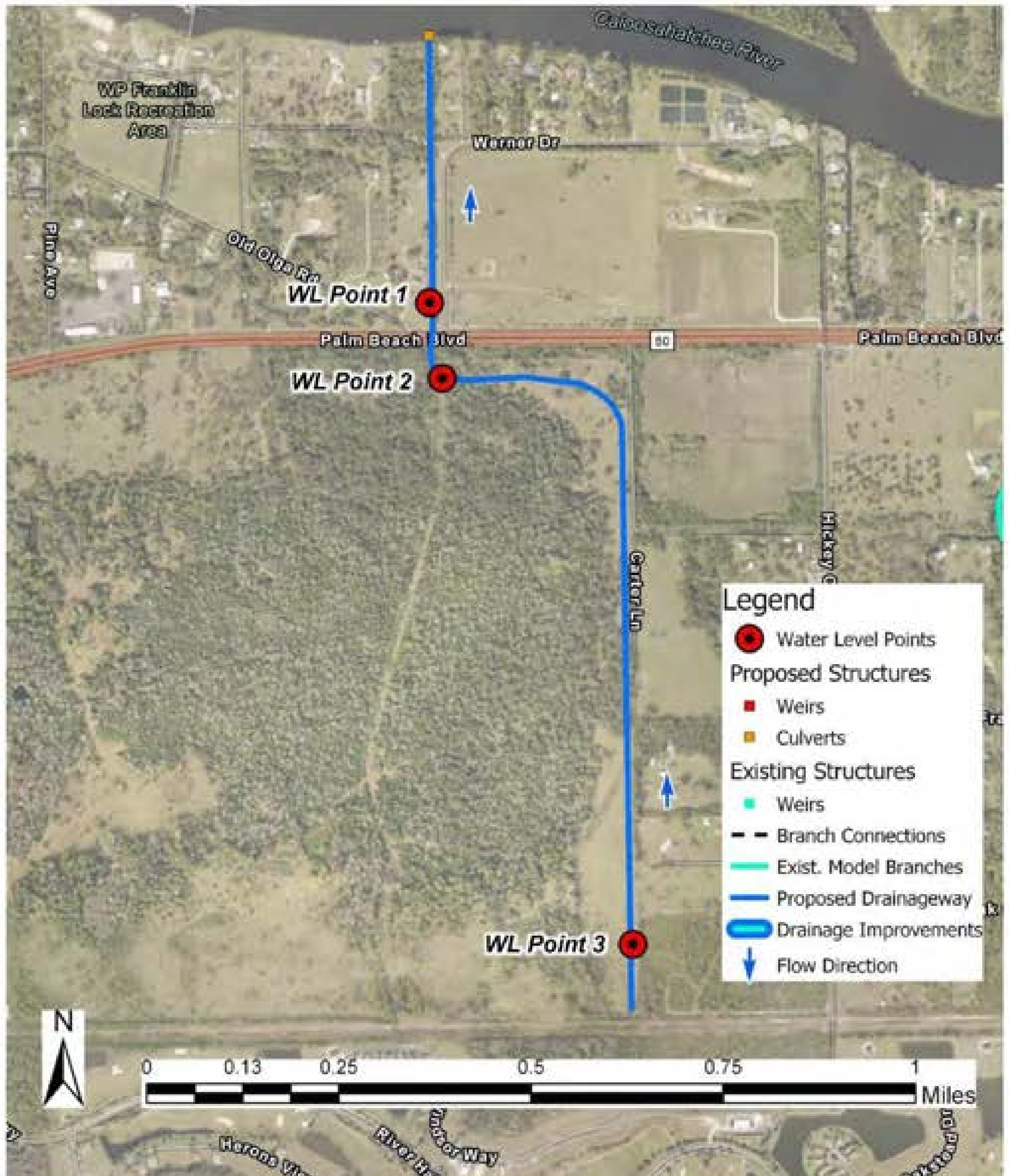


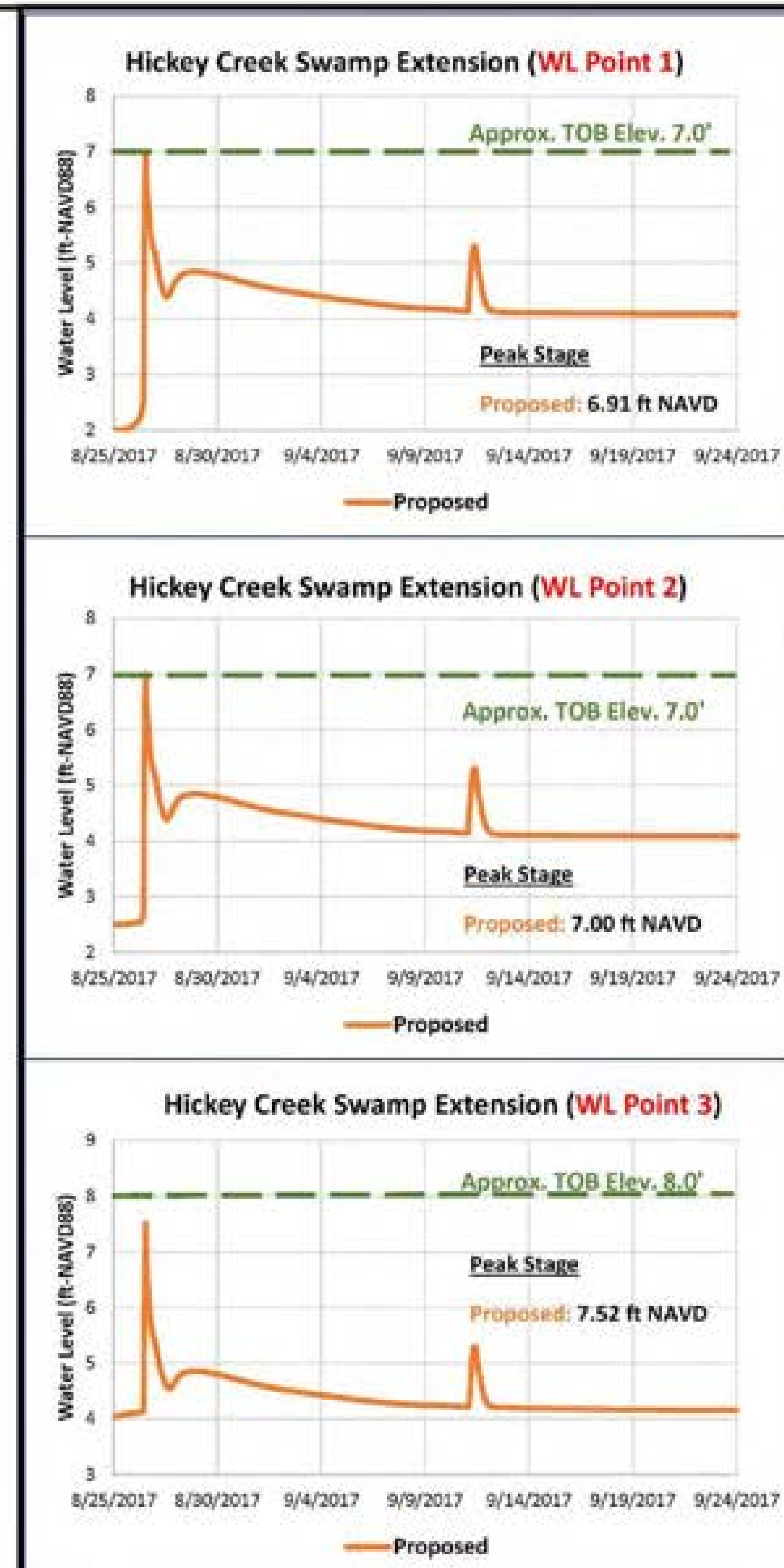
1.1.10 Hickey Creek Swamp Drainageway

Flow(s)

100-yr
3-day
(Jul Start)

EXHIBIT 1.1.10 (f)



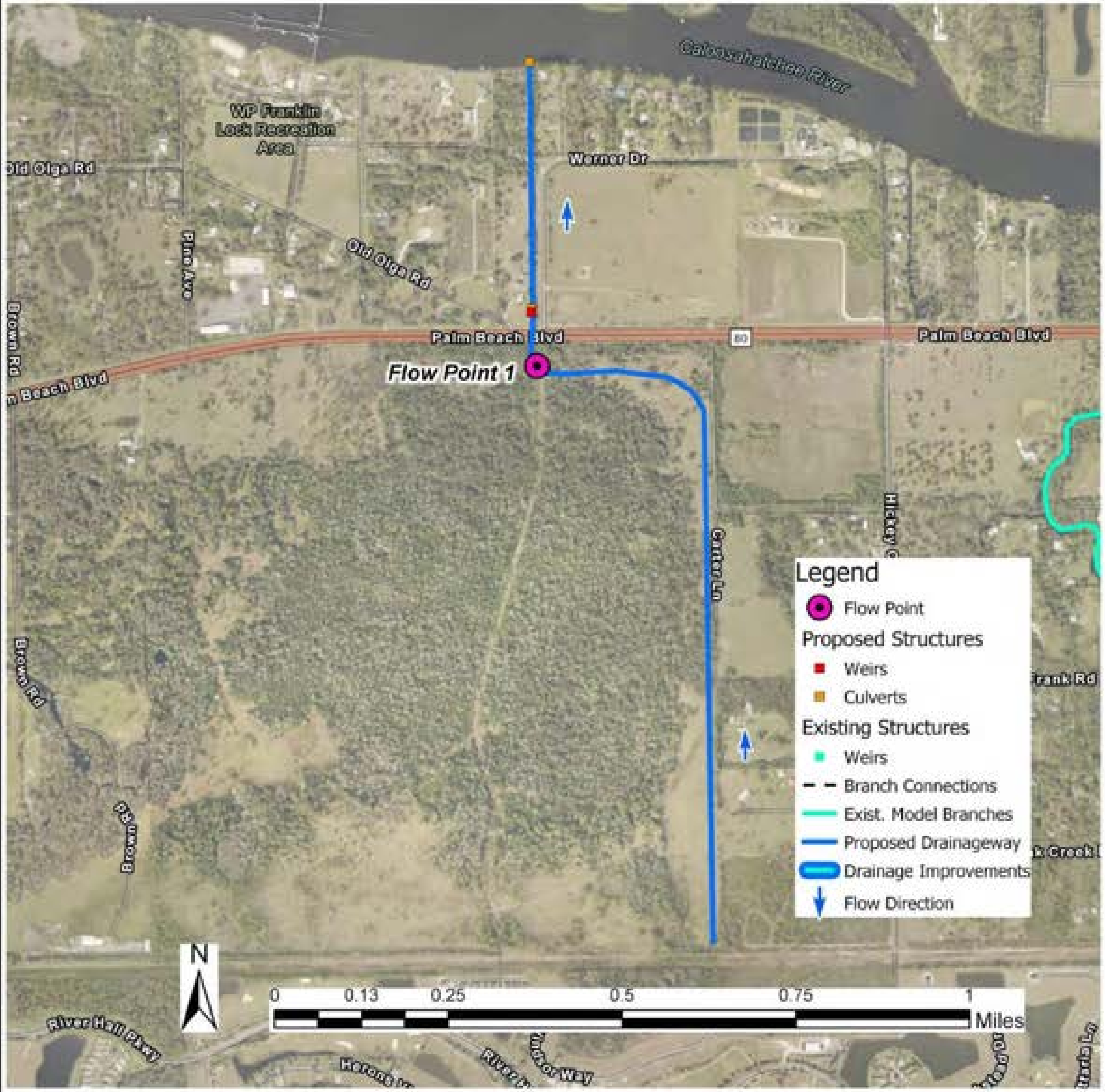


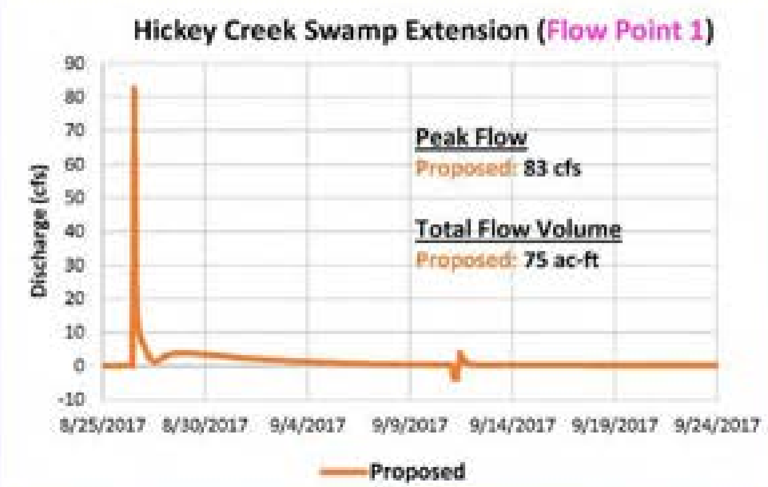
1.1.10 Hickey Creek Swamp Drainageway

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.1.10 (g)



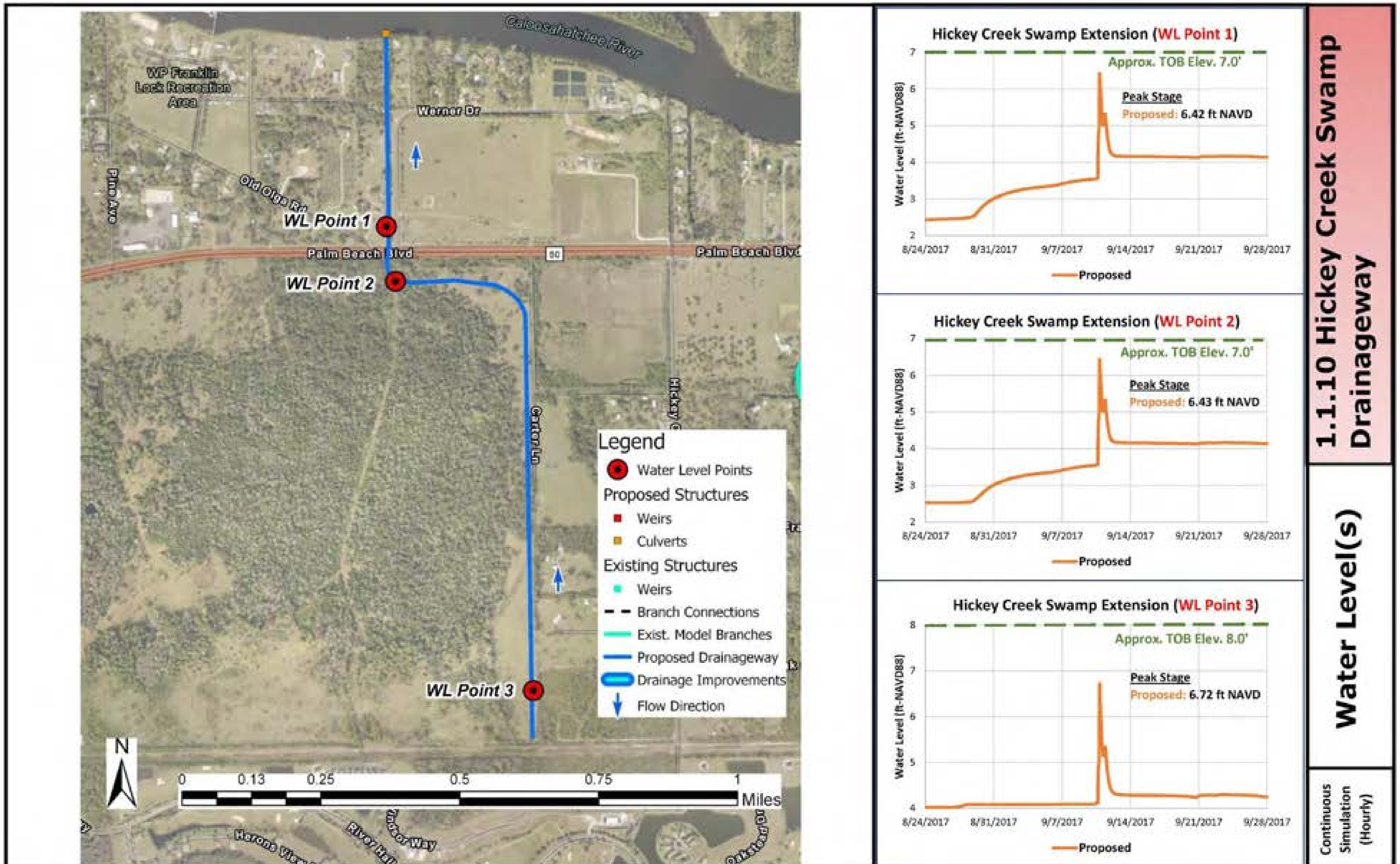


1.1.10 Hickey Creek Swamp Drainageway

Flow(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.1.10 (h)



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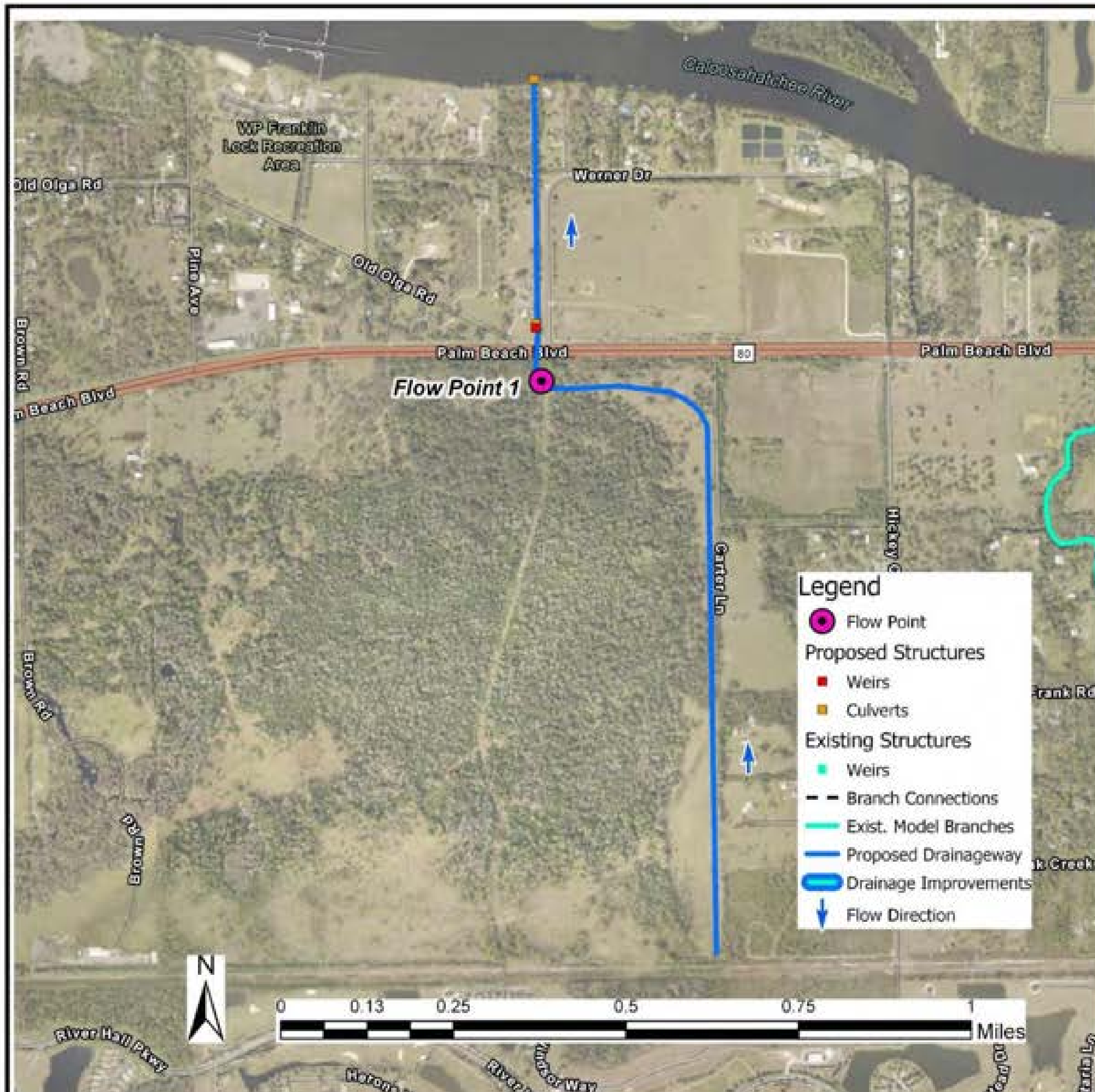
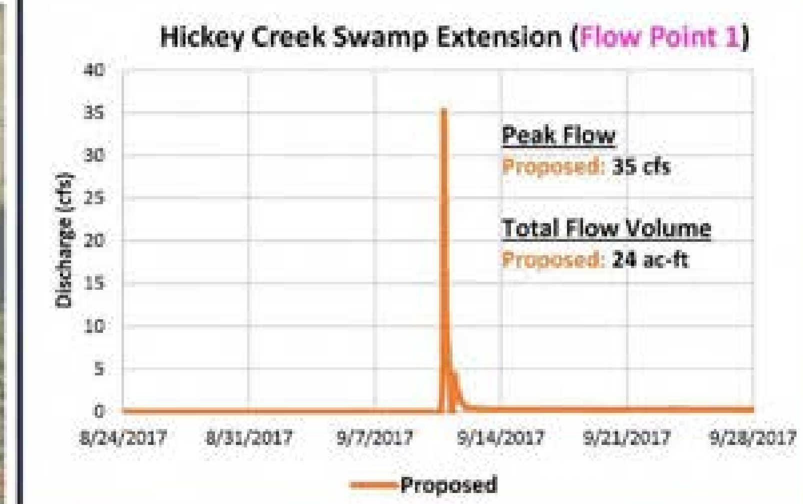




1.1.10 Hickey Creek Swamp Drainageway

Flow(s)

Continuous Simulation (Hourly)

1.1.11 Six-Mile Cypress Preserve North Catchment Reservoir

Background

This 2020 Conservation Lands site lies north of State Road 82 and east of Interstate No. 75 and generally includes a large slough, wetlands, and cypress areas. The topography has a high ground position that allows runoff flow in three directions to Six-Mile Cypress Slough, Billy's Creek and the Orange River. The land use has been preserve areas with old agricultural fields and the adjoining properties have been divided into 5-acre ranchettes. The groundwater is thought to slope towards the Caloosahatchee River even though the ground surface slope varies. The concept project is to berm the site for a rainfall catchment reservoir with discharge to Six-Mile Cypress preserve. A possible high water flow to Orange River is an optional operational component.

Location

This concept project is located in Sections 13, 14, 15, 22, 23, and 24, Township 44 South, and Range 25 East as illustrated in the location map in Figure 41 below:

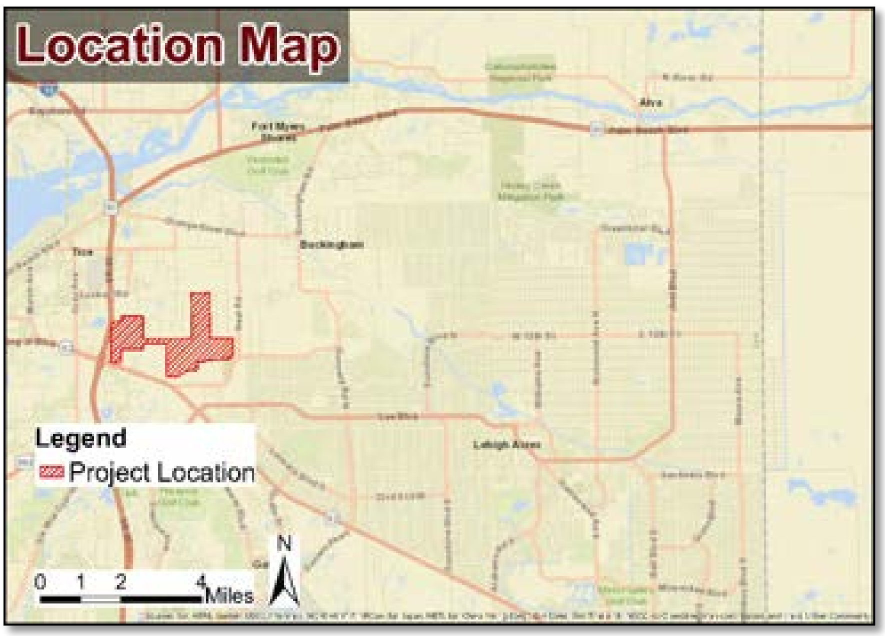


Figure 41 Location Map, 1.1.11 Six-Mile Cypress Preserve North Catchment Reservoir

Description

This concept project includes proposing a rainfall catchment basin along a ridgeline at the headwaters of the Six Mile Cypress Preserve Slough. The land is owned by Lee County and is commonly referred to as Six Mile Cypress Preserve North. A perimeter ditch is proposed to maintain positive drainage outfall for adjacent properties. Multiple emergency outfalls would allow for operational flexibility to discharge flows north to the Strayhorn area or south though the slough as illustrated in **Figure 42** below.

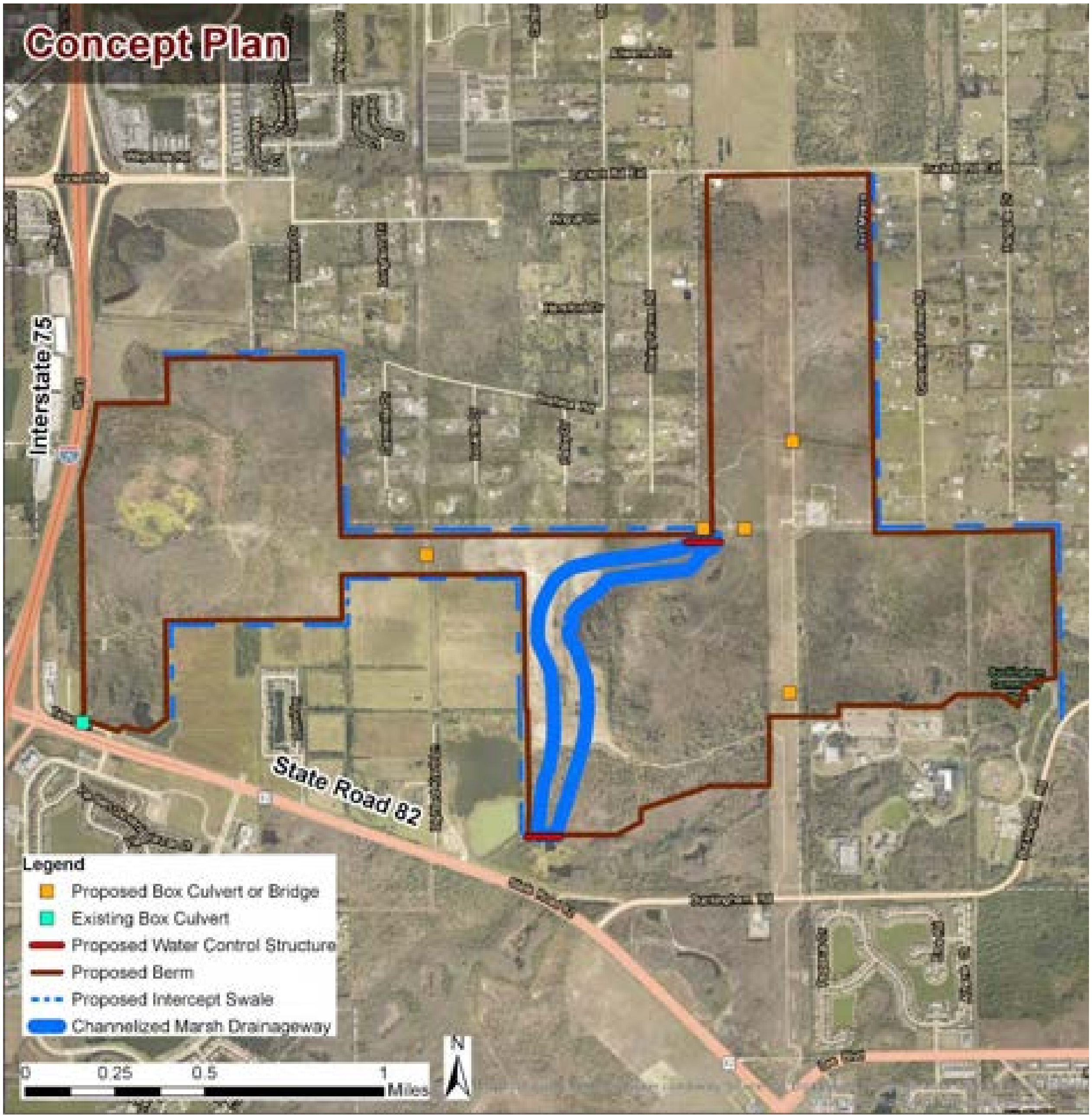


Figure 42 - Concept Plan, 1.1.11 Six-Mile Cypress Preserve North Catchment Reservoir

Purpose

This project concept consists of placing a berm around this large natural area to catch and capture rainfall at the site and to direct controlled releases of excess water down Six-mile Cypress Slough for wetland hydration. Multiple emergency outfalls for release of very high-water levels will be provided along with an intercept swale to protect neighboring at-grade developed properties. This intercept swale would require connection to and completion of project concept 1.1.8 Strayhorn Drainageway to provide an outfall.

Evaluation

Viability

Providing a storage reservoir on the top of the hill does not provide as great an impact as those proposed downstream of conveyance. However, the viability of this concept project is realized with the reservoir serving as a "catchment basin" where improvements are seen outside and downstream of the project area. In order to be a viable project, A perimeter drainage collection ditch should be included to maintain drainage outfall conveyance for adjacent properties.

Community Considerations

The communities located within the Strayhorn area to the north and Six Mile Cypress Preserve area to the south receive the benefit of this area not contributing to flows during extreme storm events. The Strayhorn area in particular.

Environmental & Permittability Considerations

This project allows the operational flexibility of connecting the Six Mile Cypress Preserve and Strayhorn flows. The land use of the Six Mile Cypress Preserve North include mixed rangelands, non-forested uplands, pine flatwoods, upland forests, wet melaleuca, wetlands, wetland hardwood forests, exotic wetland hardwoods, cypress domes/heads, mixed shrubs, and other minor categories. The goals and objectives of Conservation Lands include other factor other than water quality, so there needs to be balance to ensure that the lands set aside as preserves can fulfill each of those goals.

Land Availability

The land is already owned by Lee County and Lee County Conservation 20/20 which is one of the major reasons this project is an attractive pursuit. There was a 417.11-acre portion of the Six Mile Cypress Slough North that was nominated for Conservation 20/20 (Nomination ID 422), but was later withdrawn from consideration. The extent of the current concept project only includes lands already owned by Lee County and others. The 417.11-acres parcel may be considered for future nomination for an opportunity restore hydraulics and/or ecosystem restoration of this agriculture lands.

Opinion of Probable Cost

The cost opinion shown in **Table 12** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project cost are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 12: Opinion of Probable Cost Breakdown, 1.1.11 Six-Mile Cypress Preserve North Catchment Reservoir

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 880,000	$ 880,000
Clearing & Grubbing	80	AC	$ 14,000	$ 1,120,000
Earthwork	200,000	CY	$ 8	$ 1,600,000
Construction/ Maintenance Access	3,900	SY	$ 20	$ 78,000
Weir Structure 1.11A (Standard)	72	LF	$ 5,000	$ 360,000
Weir Structure 1.11B (Standard)	72	LF	$ 5,000	$ 360,000
Box Culvert 1.11-2	200	CY	$ 1,200	$ 240,000
24" ERCP	360	LF	$ 100	$ 36,000
Electric Supply	1	LS	$ 20,000	$ 20,000
Permanent Erosion Control	2,000	SF	$ 15	$ 30,000
Grassing	214,375	SY	$ 2	$ 428,750
Wetland Plantings	47,250	EA	$ 1	$ 47,250
Conceptual Construction Costs:				**$ 5,200,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 1,560,000
Land Acquisition				-
Project Administration/ CEI (10%)				$ 520,000
Project Unknowns				$ 3,720,000
Conceptual Project Cost:				**$ 11,000,000**
Contengency (30%)				$ 3,500,000
Conceptual Project Cost (with Contengency):				**$ 14,500,000**

Opportunities for Multiple Benefits & Uses

Incorporating passive recreational amenities and water quality treatment provisions may generate multi-agency involvement. A facility similar to the Six Mile Cypress Slough Preserve park could provide raised boardwalks and community education and partnerships. A summary of this concept project is shown below in **Exhibit 1.1.11** herein.

Other Considerations

There is a plateau towards the northern end of Six Mile Cypress Preserve that was observed to send flows towards the Orange River during Hurricane Irma. This catchment storage reservoir allows for this flow to be stored and diverted to the Strayhorn project and outfall to the downstream portion of the Orange River which has greater conveyance capacity than the upper reaches which is winding and narrow.

Findings & Recommendations

Regional Modeling Findings

The refined concept plan is shown in **Exhibit 1.1.11 (a)** herein. The concept project was incorporated into the regional model to analyze the project's effectiveness. Model input data can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

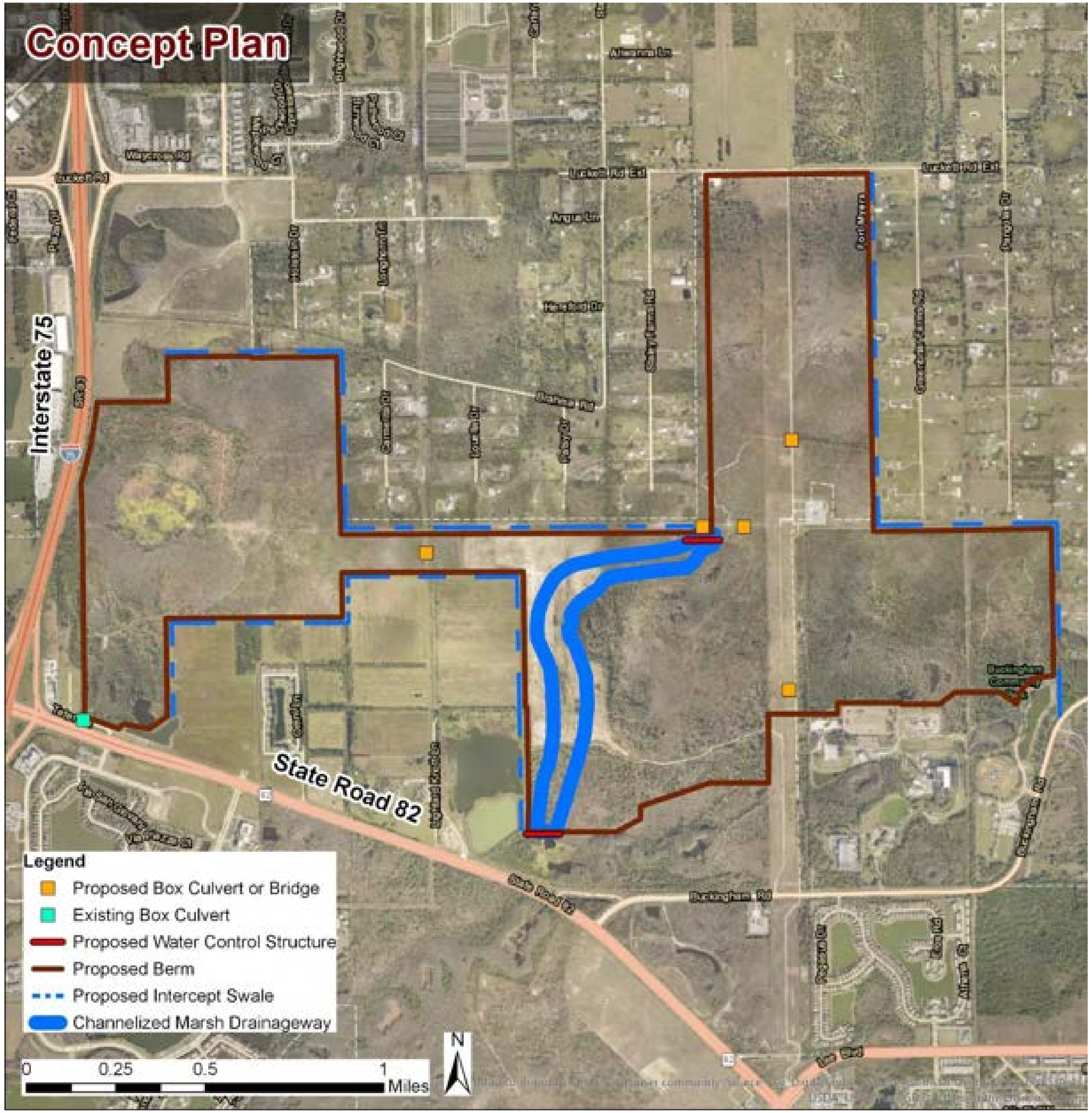
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.1.11 (b)
	Flow(s)	EXHIBIT 1.1.11 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.1.11 (d)
	Flow(s)	EXHIBIT 1.1.11 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.1.11 (f)
	Flow(s)	EXHIBIT 1.1.11 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.1.11 (h)
	Flow(s)	EXHIBIT 1.1.11 (i)

Improvements were shown with water levels increasing in the reservoir which appear satisfactory for the wetland site having general elevations between 18 to 21 feet NAVD and an estimated wet-season water level of 18.5 ft NAVD. Flows are shown to reduce heading towards the Six Mile Cypress Preserve. The results of this project are mostly realized though the benefit of removing this portion of land are from contribution flows both towards the 1.1.8 Strayhorn Drainageway concept project and the Six Mile Cypress Preserve effective decreasing downstream discharge and peak flows.

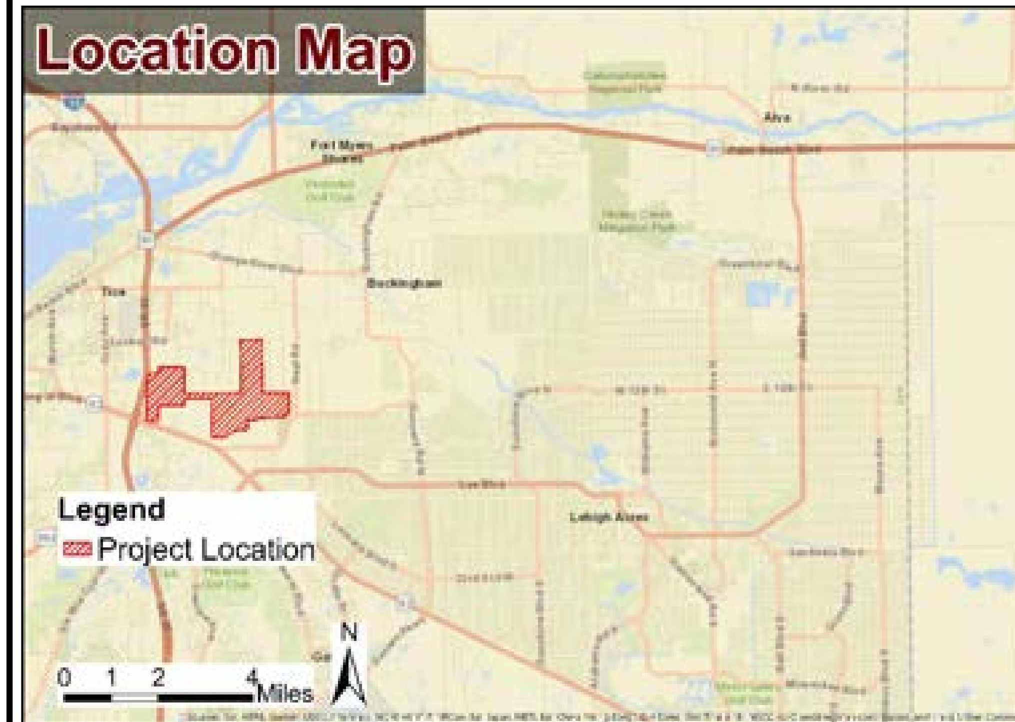
Recommendations

Implementing a berm around this large natural area allows the capture of rainfall at the site and direct control over releases of excess water down Six-mile Cypress Slough for wetland hydration. Multiple emergency outfalls allow for release of very high-water levels should be provided along with an intercept swale allotting the protection of neighboring at-grade developed properties. This intercept swale would require connection 1.1.8 Strayhorn Drainageway concept project to provide an outfall, meaning the construction of the 1.1.8 concept project should proceed this project. The positive improvements of this project concept warrant proceeding to design-level development along with the proceeding project concept 1.1.8 Strayhorn Drainageway.

EXHIBIT 1.1.11



Imagery Date: 2018



Project Narrative

DESCRIPTION: The land is owned by Lee County and is commonly referred to as Six Mile Cypress Preserve North. By-directional outfalls would allow for operational flexibility to discharge flows north to the Strayhorn area or south though the Six Mile Cypress Preserve.

PURPOSE: This project concept consists of placing a berm around this large natural area to catch and capture rainfall at the site and to direct controlled releases of excess water down Six-mile Cypress Slough for wetland hydration. Multiple emergency outfalls for release of very high-water levels will be provided along with an intercept swale to protect neighboring at-grade developed properties.

CONSTRAINTS: The goals and objectives of Conservation Lands include other factor other than water quality. The design will need to balance the flood mitigation goals with the Conservation Lands goals to ensure that the lands set aside as preserves can fulfill each of those goals.

May 2020

Six-Mile Cypress Preserve North
Catchment Reservoir
East Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.1.11

EXHIBIT 1.1.11 (a)

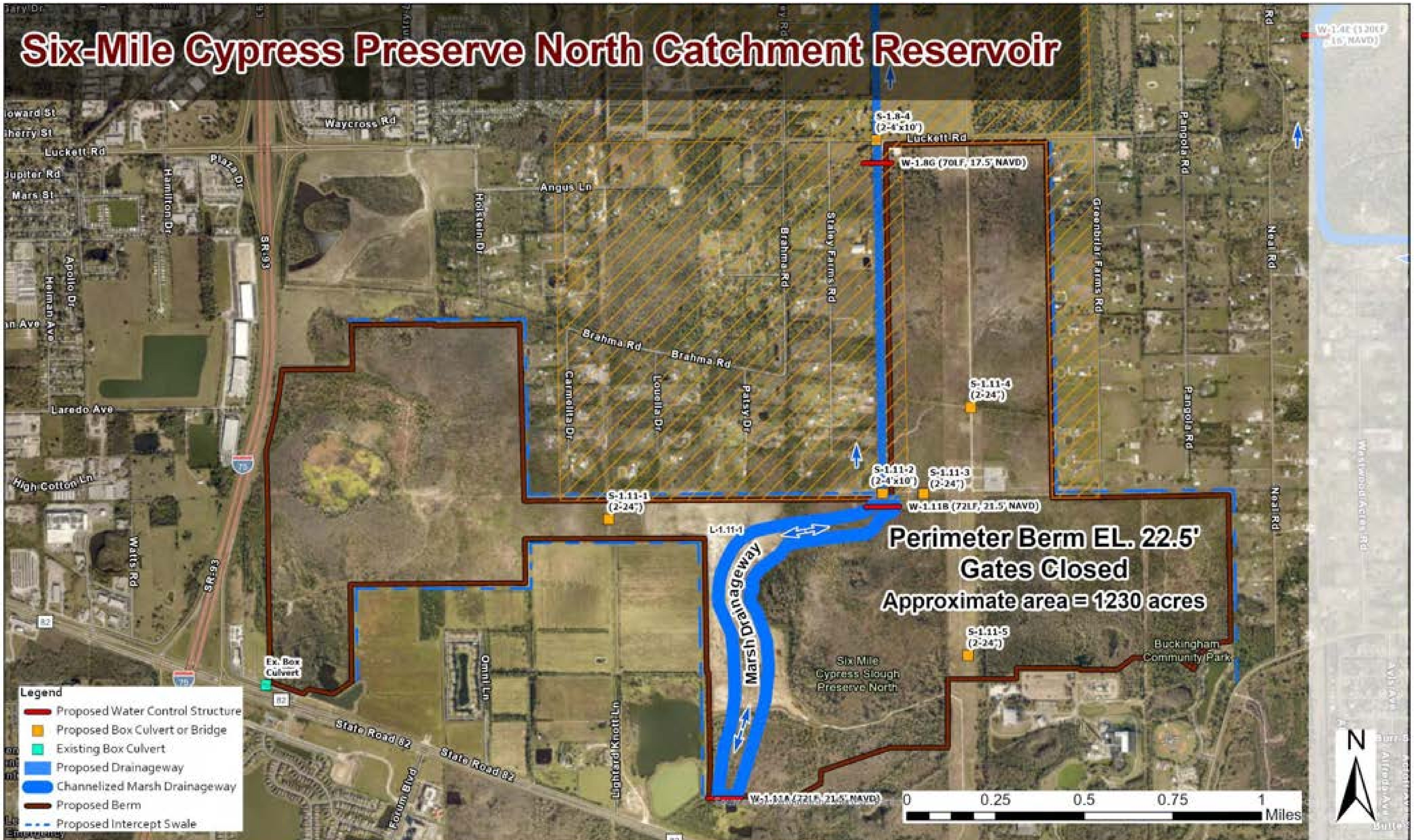


EXHIBIT 1.1.11 (b)

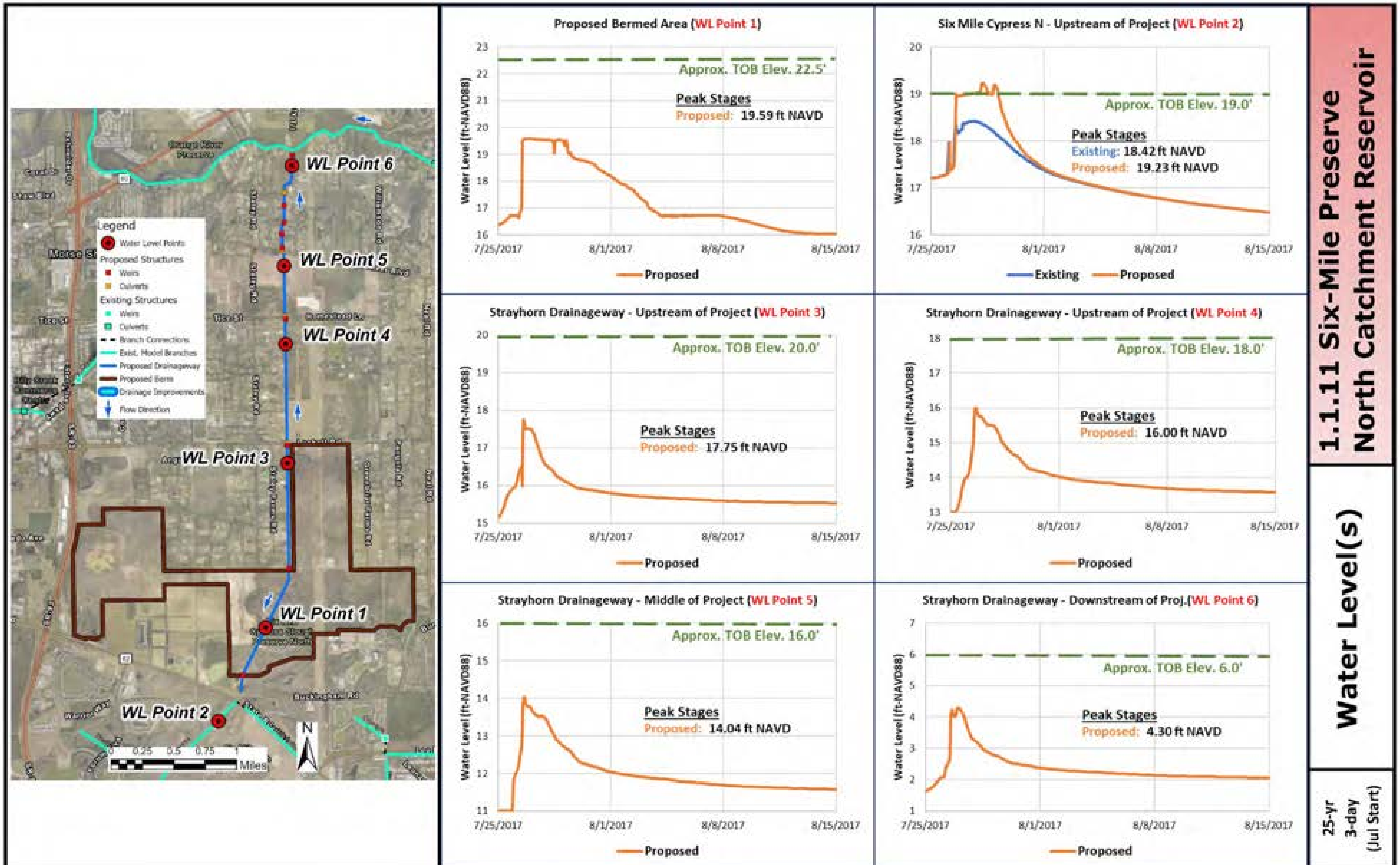


EXHIBIT 1.1.11 (c)

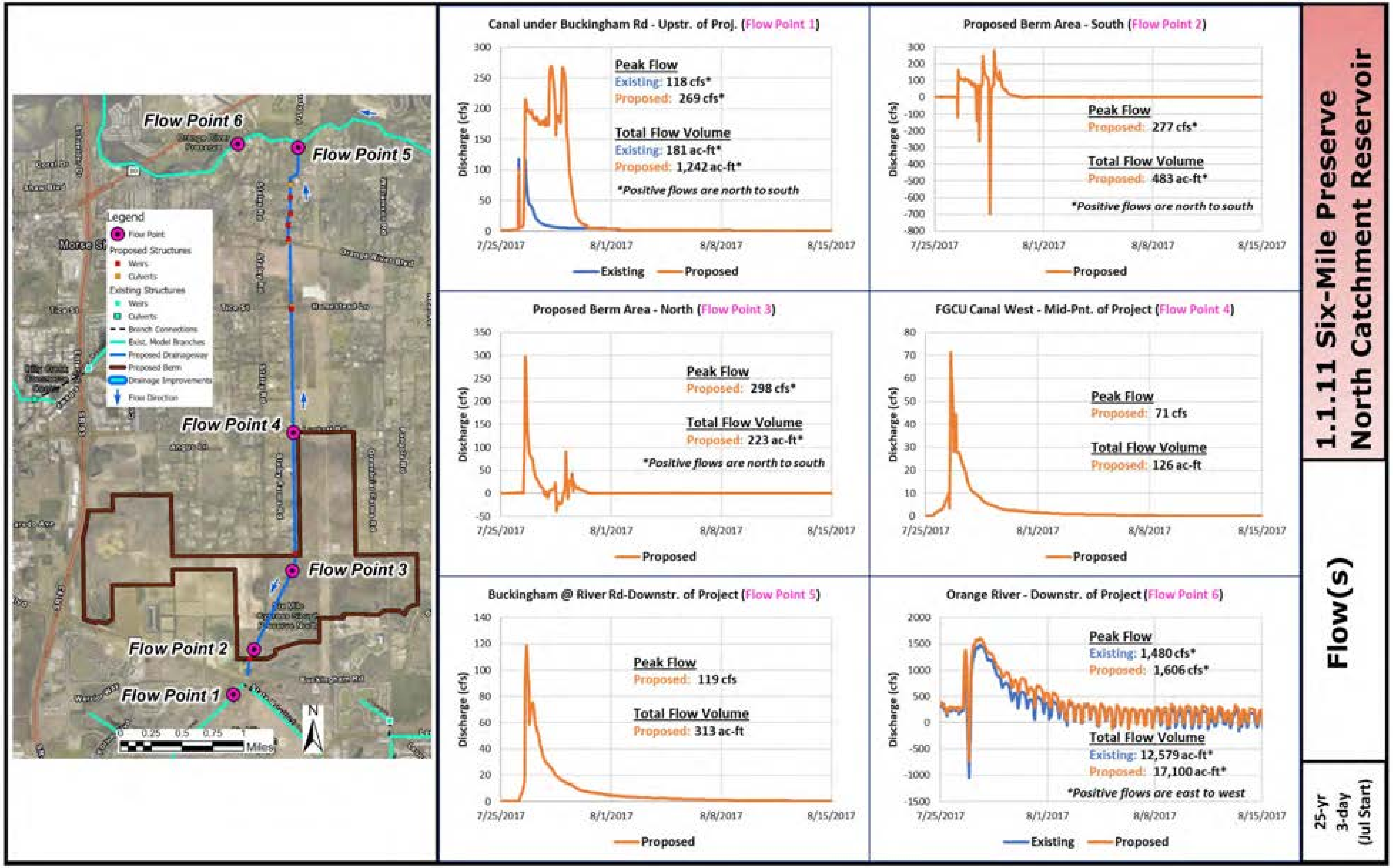


EXHIBIT 1.1.11 (d)

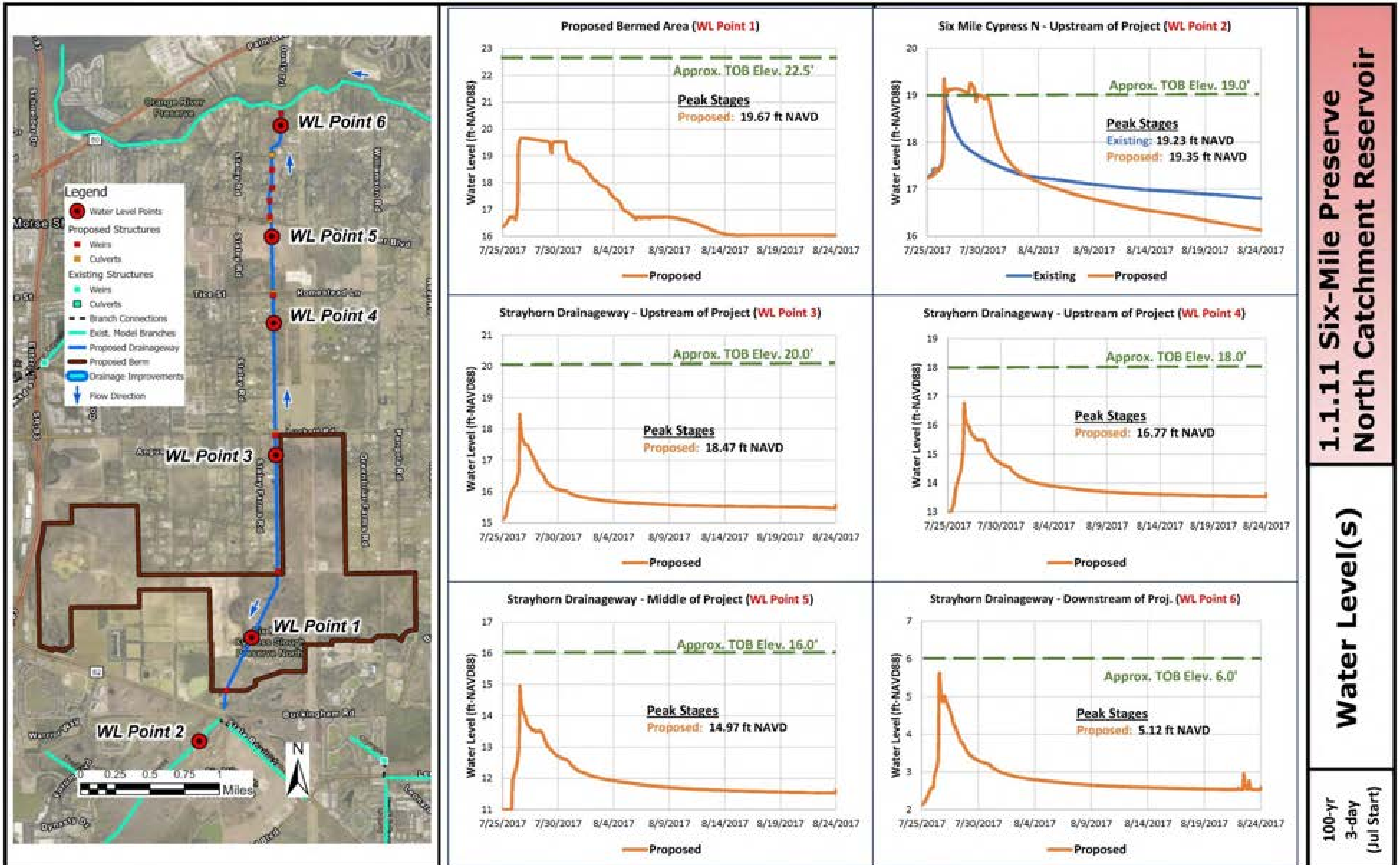
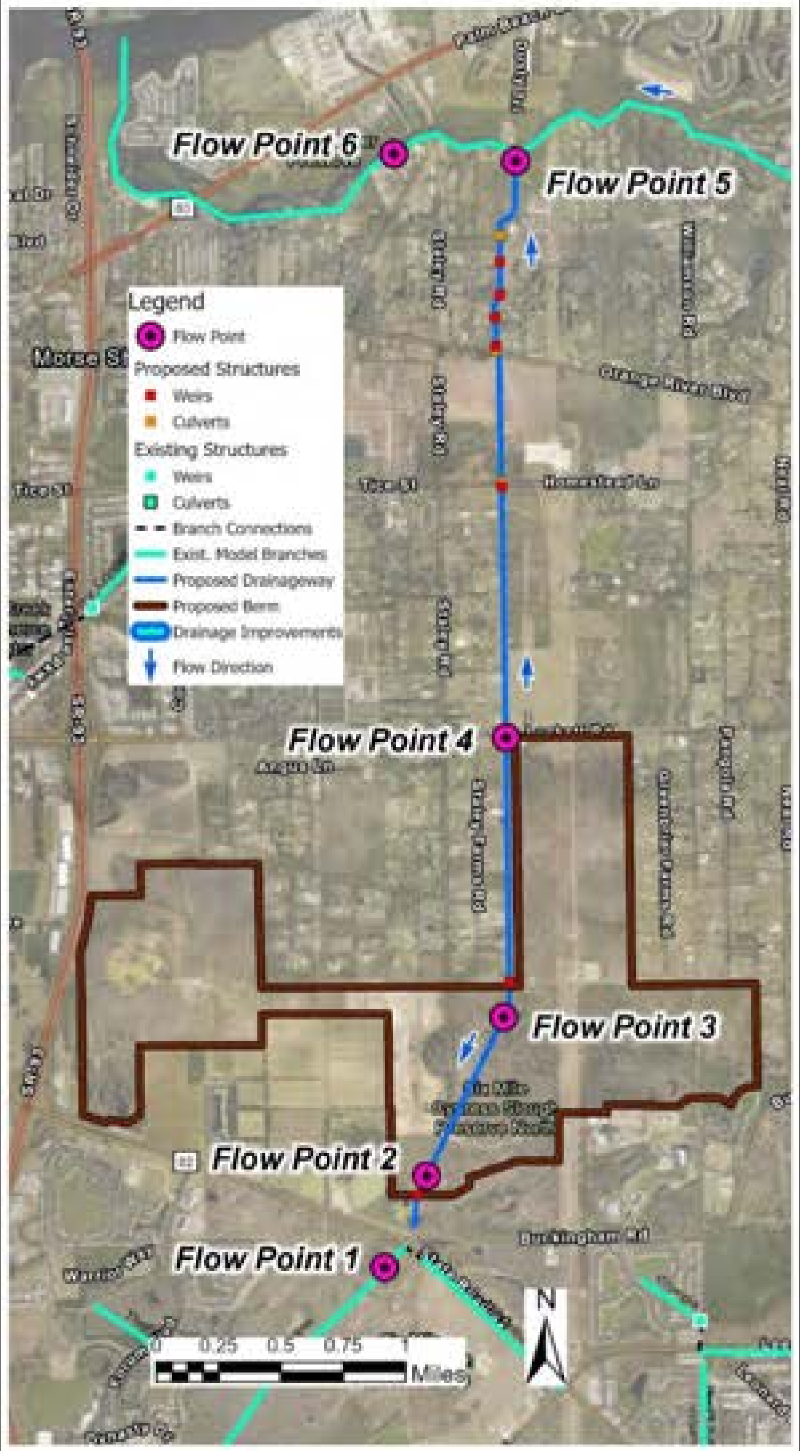
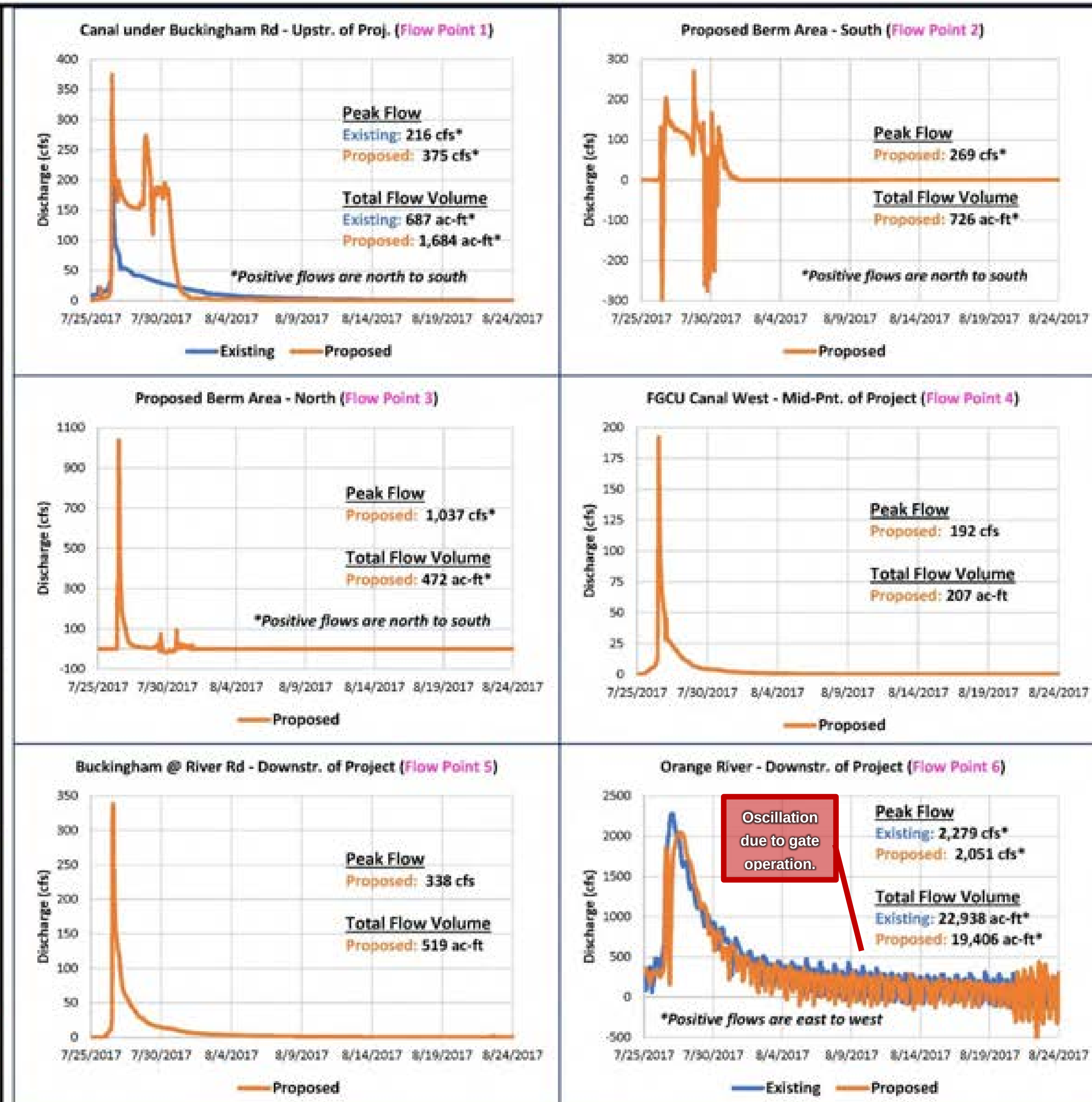


EXHIBIT 1.1.11 (e)





1.1.11 Six-Mile Preserve North Catchment Reservoir

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.1.11 (f)

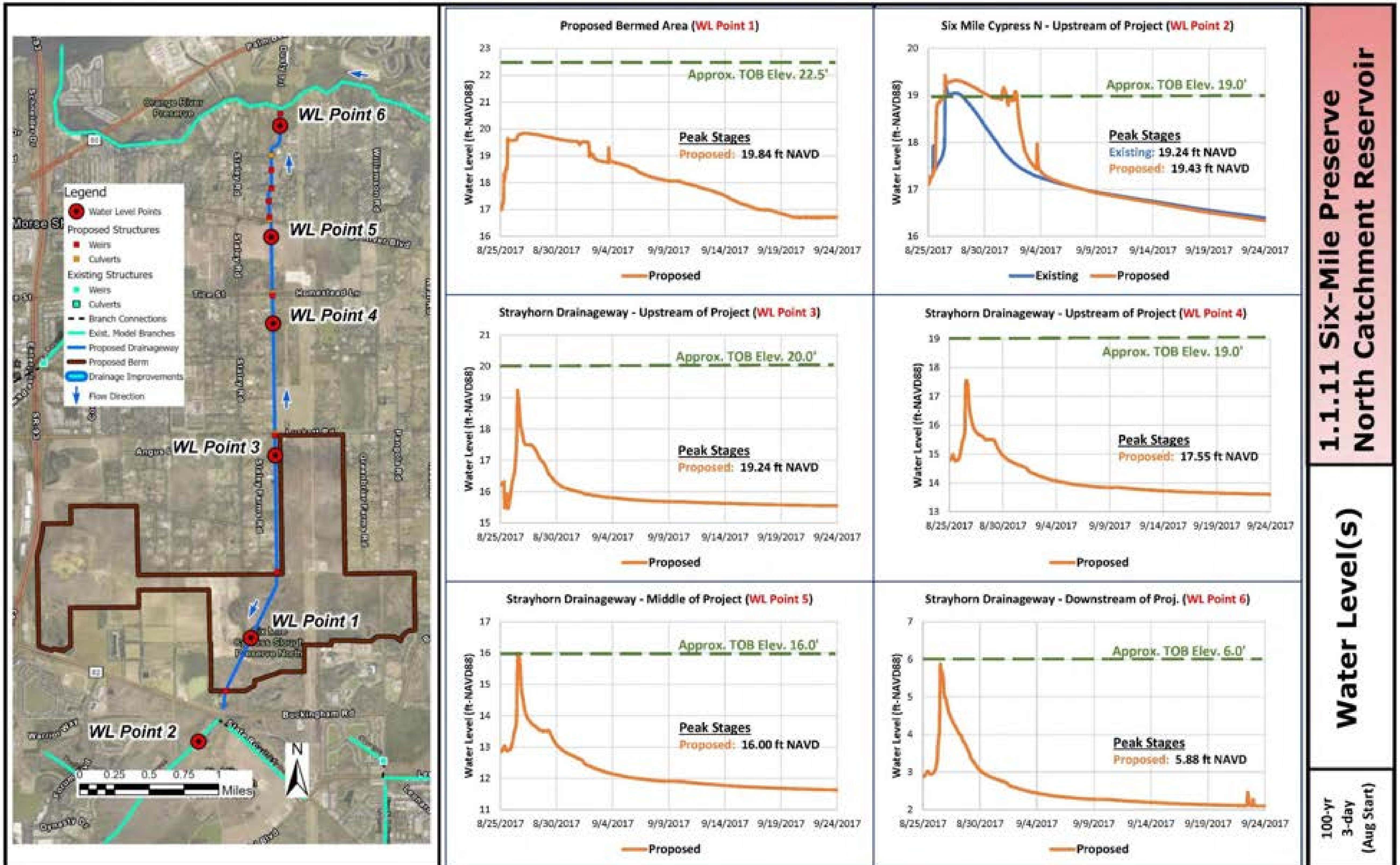


EXHIBIT 1.1.11 (g)

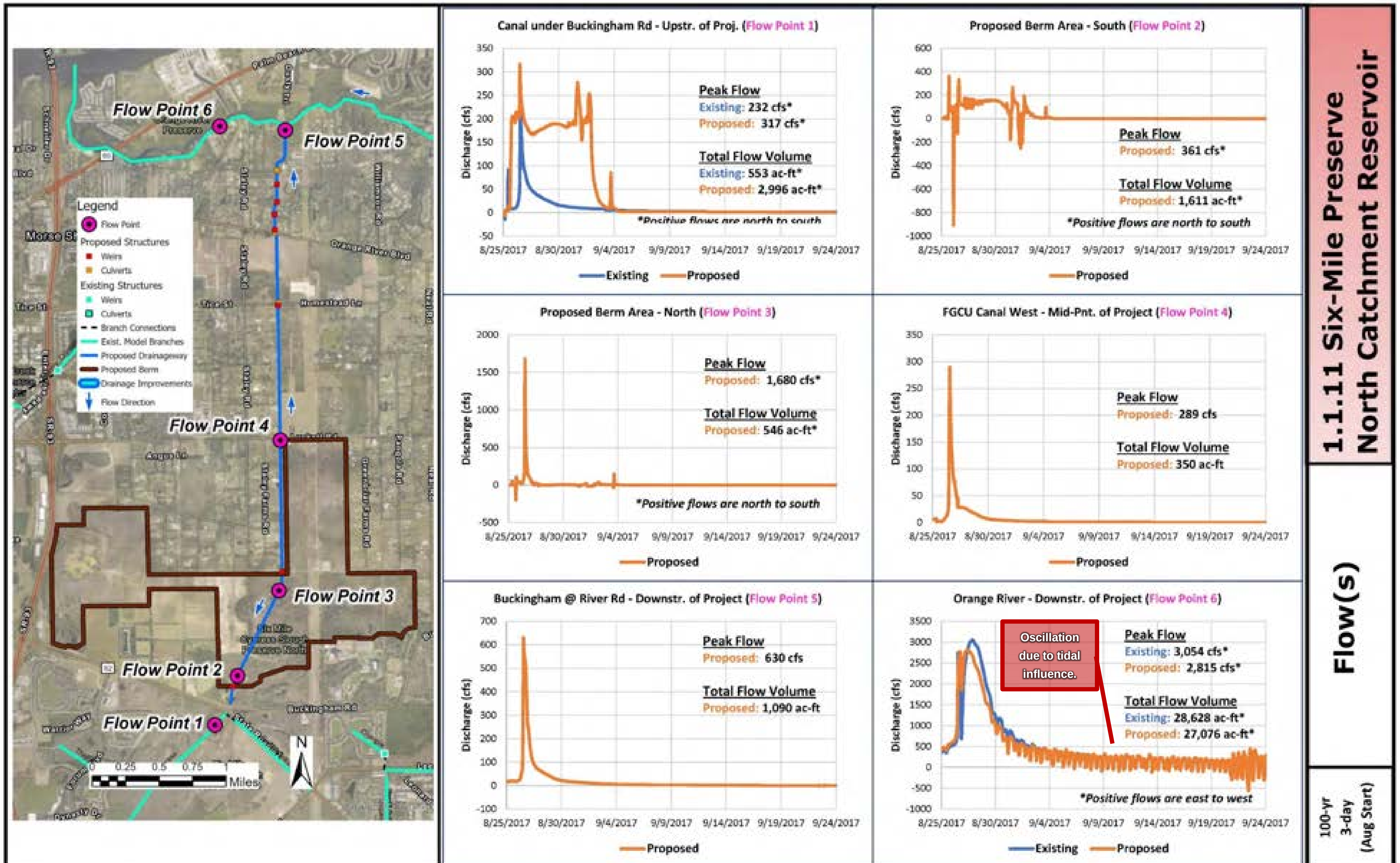


EXHIBIT 1.1.11 (h)

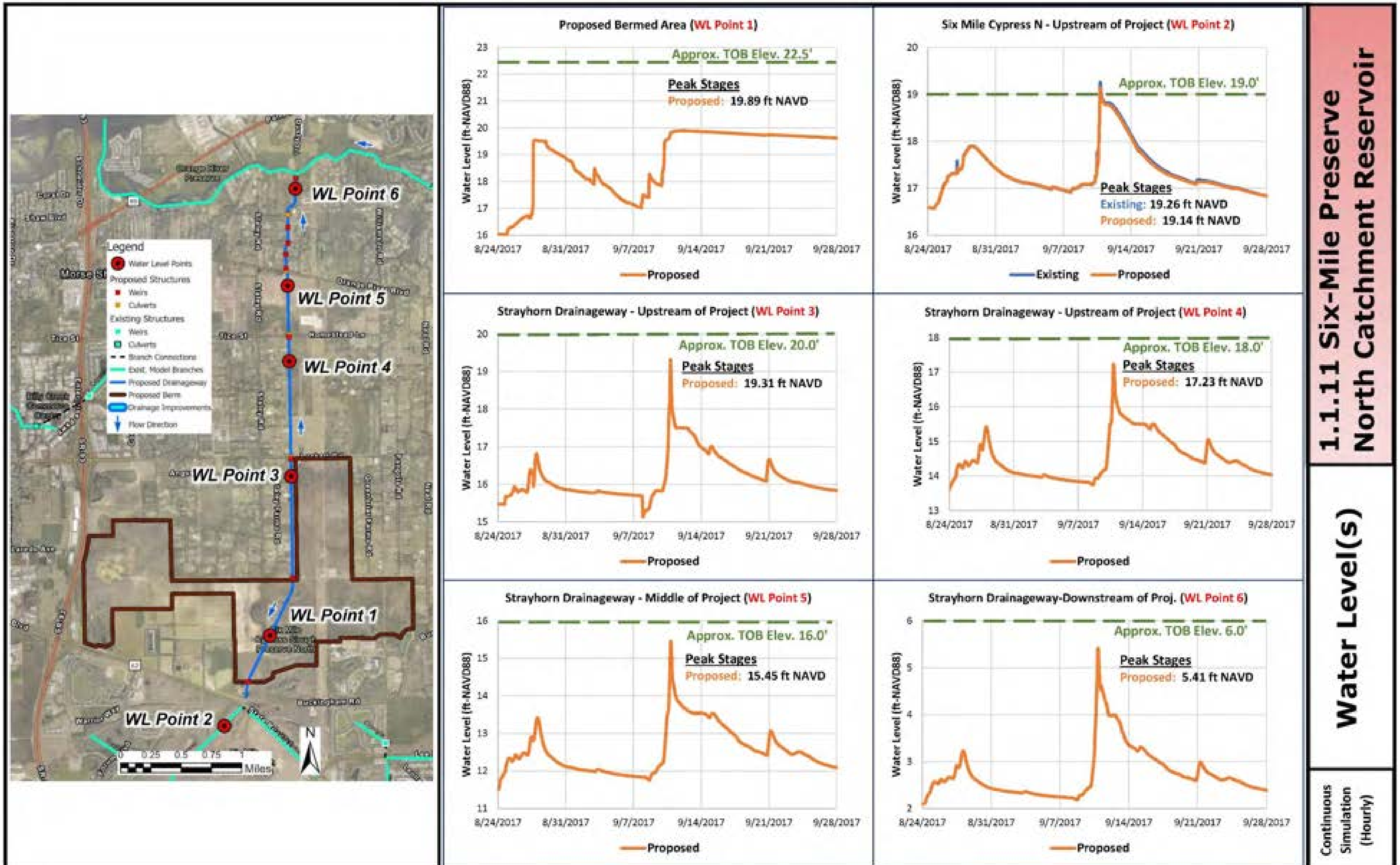
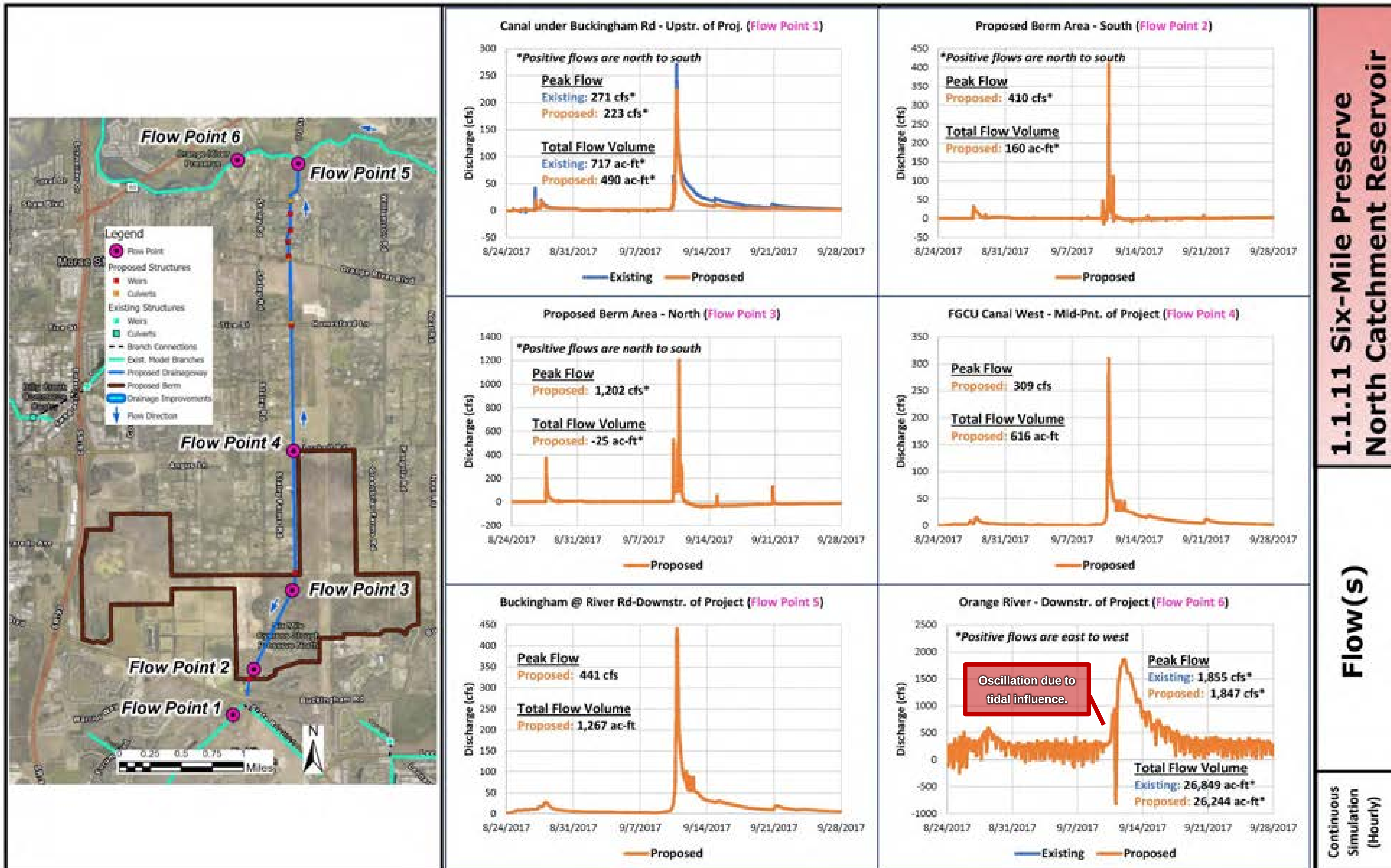


EXHIBIT 1.1.11 (i)



1.2 WHISKEY CREEK IMPROVEMENTS

BACKGROUND AND GENERAL COMMENTARY

Whiskey Creek is a tidal tributary to the Caloosahatchee River in the south-central area of Lee County between the Cape Coral Bridge and the Mid-Point Bridge. The creek extends in a southerly direction off the Caloosahatchee River, and the main portions of the creek are tidal. The Whiskey Creek watershed covers 5,760 acres, with the primary land-uses being high-density commercial and residential (**Figure 1**). The watershed is bordered on the north by Colonial Blvd, the east along Ten-Mile Canal, the south by Cypress Lake Drive and the west by McGregor Boulevard. Elevations in the watershed range from a high of around 20 feet NAVD down to near mean sea level (MSL) in the tidal areas of the creek. Average elevations are on the order of 11 to 12 feet NAVD. There are four primary drainage canals that flow into Whiskey Creek: the L Canal, the Brantley-Dover Canal (BDC), the Park Meadows canal, and the canal that passes through Florida SouthWestern State College (FSW) (Iona Drainage District Canal H-7) and drains areas upstream of the college. Figure 1 presents a plan view showing the primary drainage canals in relation to Whiskey Creek.

In the Final Post Storm Flood Assessment Analysis report (Hole Montes, 2018) the primary causes of flooding throughout the Whiskey Creek watershed revolved around issues of reduced conveyance. The report identified issues associated with maintenance (debris and sediments), as well as undersized culverts and channels in key portions of the watershed. A limited number of design/project recommendations were made in the report beyond the maintenance and debris removal. These are listed below.

<u>L-Canal</u>

1. Canal section narrows between the L-3 north/south canal and US 41 (1200 L.F.). Perform calculations to determine if additional capacity is needed.
2. There is a 42-inch HDPE control gate for Ten-Mile Canal at the east end of the L Canal. Analyze impact of additional drainage from Ten-Mile Canal.
3. Analyze impact of high flood east outfall reliever or equalizer from L Canal to Ten-Mile Canal.

<u>Brantley-Dover Canal</u>

1. Analyze impact of high flood east outfall from The Villas to Ten-Mile Canal.
2. Canal section narrows west of Summerlin Road at the point where the canal alignment becomes winding (900 L.F.). Perform calculations to determine if additional capacity is needed.
3. Perform calculations to determine if additional capacity is needed in Dover Canal. Help relieve N/S canals.
4. Perform calculations to determine if additional capacity is needed culverts (within Dover Canal) at Austin St. and Beacon St.
5. Perform calculations to determine if additional capacity is needed in culvert in the N/S canal along Crest Lane along the south side entering the Dover Canal.
4. Perform calculations to determine if additional capacity is needed in the outfall culvert from Lake Chatham.

<u>Florida South Western State College Canal (Iona Drainage District Canal H-7)</u>

1. Perform calculations to determine if additional capacity is needed in the culvert adjacent to Pinebrook Woods.

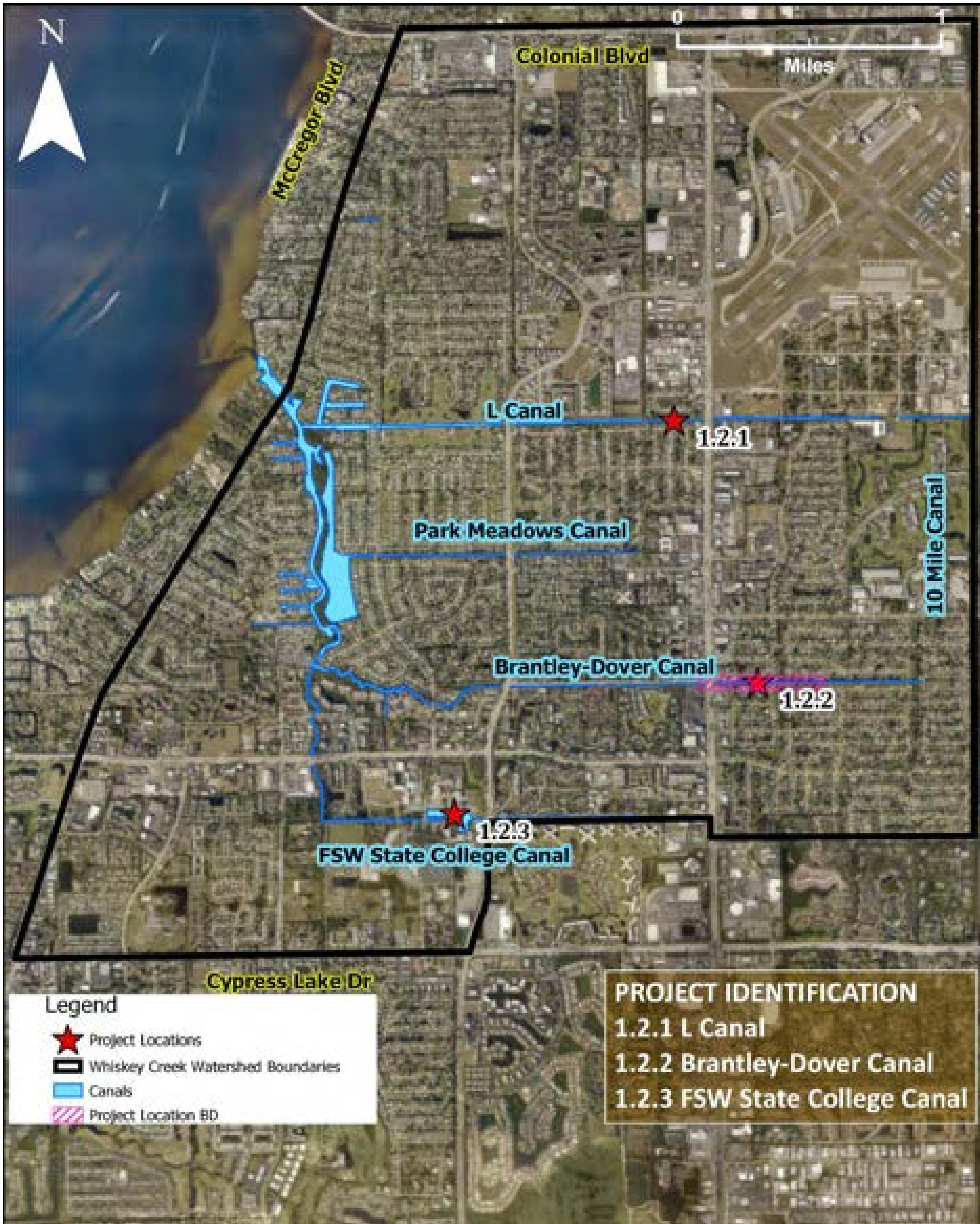


Figure 1 – Whiskey Creek Watershed

These recommendations are primarily related to improving the overall conveyance capacity with some recommendations related to offline storage. Additionally, connections to Ten-Mile canal are identified.

Figure 2 presents a map showing the top 50 ranked flood observation points and lines from the Hole Montes report. The figure shows that the bulk of the top 50 points are within the drainage area for the BDC upstream of the Tamiami Trail (US 41). Additionally, the only highwater marks defined for the post Irma study were in the drainage area for the BDC. The highwater marks ranged from 10.42 feet NAVD up to 11.01 feet NAVD, with a single highwater mark recorded immediately adjacent to the BDC of 10.55 feet NAVD.

Figure 2 – Top 50 Flood Issue Observations in Whiskey Creek Watershed

While the Hole Montes report did not identify key flooding issues along the Florida SouthWestern State College Canal (FSWSCC), issues were reported from a subdivision immediately adjacent to the canal upstream of the college. The issues included significant flooding of the subdivision. **Figure 3** presents photographs showing flooding issues during the events surrounding Hurricane Irma. As with the BDC, the issues raised related to the existing conveyance capacity through the system based upon specific structures.

Figure 3 – Photos of Flooding within Subdivision Adjacent to FSWSCC

The primary focus for Whiskey Creek was evaluation of existing structures (culverts, weirs) and channels in the primary drainageways to address conveyance capacity issues, the potential for additional storage within limited areas, and provision for additional relief to reduce flooding issues along Ten-Mile Canal. The analyses and recommendations are limited to the primary drainageways identified earlier and not along secondary ditches and drainageways. This is due to the nature of the regional modeling (only primary drainageways simulated in MIKE 11), which provided the basis for evaluation of the project alternatives.

PROJECT CONCEPT PROVISIONS

- Flood mitigation is intended to improve drainage to reduce flood levels and post-storm recovery times.
- The approach primarily involves conveyance improvements with limited storage.
- The initial design storm for preliminary concept development was the 25-year, 3-day event with additional 100-year storms run to assess the concept project response.
- The focus is on major flow ways and, therefore, not specific neighborhood drainage issues associated with local conveyance and secondary drainage canals.
- It is anticipated that large flow-way connections will be equipped with water control structures having telemetry, data collectors, remote-operable motorized gates, camera viewing, and standby power facilities.
- A knowledgeable staff will manage the system prior to, during and following large storm events.
- Maintenance of the proposed facilities is required for proper operation.

CONCEPT PROJECT IDENTIFICATION (Figure 1)

1.2.1 L Canal Improvements
1.2.2 Brantley-Dover Canal Improvements
1.2.3 Florida SouthWestern State College Canal Improvements

Flood Mitigation Benefits of Preliminary Concept Level Projects

Flood mitigation benefits are presented here for two of the three projects described in the previous sections (Brantley-Dover Canal and FSW Canal). For the L-canal project, the benefits are more associated with relief for Ten-Mile Canal rather than to abate local flooding, therefore its benefits are included in other sections. Flood mitigation benefits are achieved when water is conveyed and/or stored appropriately to reduce flooding levels and duration. The reduction in flood levels and duration reduces the overall impacts to commercial and private structures along with improving the Level of Service (LOS) for roadways that serve communities. Flooding impacts the health, safety, and welfare of the residents, along with significant economic impact to the community. Within the two project areas presented herein (Brantley-Dover and FSW Canal) the flooding issues are primarily local in nature and associated with limited conveyance.

Section 1.2.3 presented in detail the results of the model simulations along the primary canals from the MIKE-11 simulations. The results focused mainly on the changes in water level along the canals for the 25-year, 100-year and Continuous simulations. Generally, for the purpose of evaluating benefits, the pre- and post-project flooding is depicted in an aerial framework showing areas that are flooded and those that are not.

As discussed previously, the resolution of the MIKE-SHE model outside of primary channels is too coarse to directly provide reasonable pre- versus post-project flooded area. As such, demonstration maps were created by extending the model peak stages within the MIKE-11 channel areas for existing and proposed conditions out within key zones of interest in the project area. In general, key zones were those that were served by secondary drainage pathways off of the primary simulated canals. The projected levels were overlain on local LIDAR topography to define potential depths of flooding. Flooding area maps were then created for areas where flood depths exceeded 6". In order to quantify benefits, the flooded areas were intersected with parcel maps of the area and the number of parcels which experienced flooding were defined for existing and proposed conditions. Later, polygons were developed where elevation changes in the flooded areas reduced by more than a tenth of a foot from existing to proposed model conditions for a 100-yr, 3-day storm event. The approximate value of buildings within these polygon areas was compiled by County staff from Property Appraiser parcel building values for the 2020 tax roll. This value for the Whiskey Creek study area was approximately $186 million.

The maps are not intended for financial decision-making or design-level analysis as the concept plans and model coarseness were developed on a conceptual basis. The contribution or benefits of each project concept is discussed as follows based on modeling results for the 100-Yr, 3-Day storm events.

Brantley-Dover Canal Improvements

The Brantley-Dover project focused on providing flood reduction within the Villas (upstream of Tamiami Trail). Based on this focus, the key zone for the determination of changes in flooding area was defined as seen in Figure 25.

For the 100-year, 3-day simulations the most significant flood reductions were seen for the July simulations. Figure 25 presents the areas of flooding for the existing conditions and the post-project conditions. The potential changes in flooded area are significant.

For the repetitive flooding area adjacent to the Brantley-Dover canal, the improvements mitigate flood waters for approximately 626 parcels based on the 100-year, 3-day modeled storm. Note that the number of approximately benefited parcels that are conceptually shown to be impacted by high peak stages during extreme storm events are limited to the clipped area shown in the maps. The number of parcels impacted could therefore be increased or decreased if the subjective clipped region changes. Localized modeling should be conducted to refine the concepts to gain an increased understanding on how these concept projects benefit the surrounding areas. These figures do not necessarily reflect actual structure flooding, but more of an overall benefit to the area.

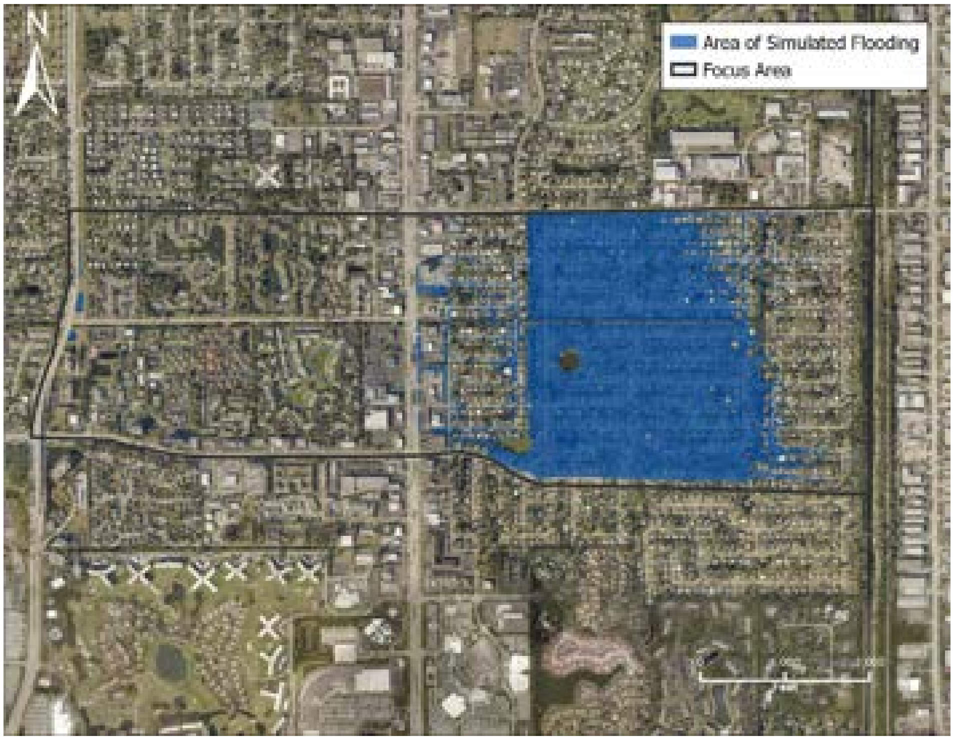


Figure 4 – Flooded Areas within the Villas Existing (top) and Proposed (bottom) Conditions

FSW State College Canal Improvements (Iona Drainage District Canal H-7)

The FSW State College Canal focused on providing flood reduction within neighborhoods upstream of Summerlin Blvd. Based on this focus, the key zone for the determination of changes in flooding area was defined as seen in Figure 26.

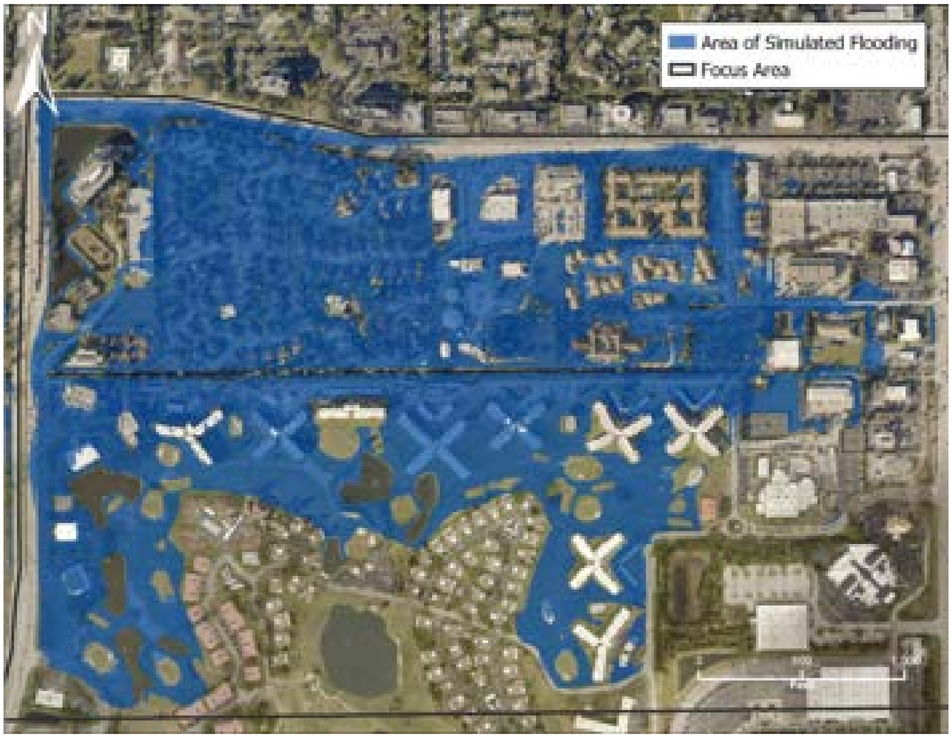
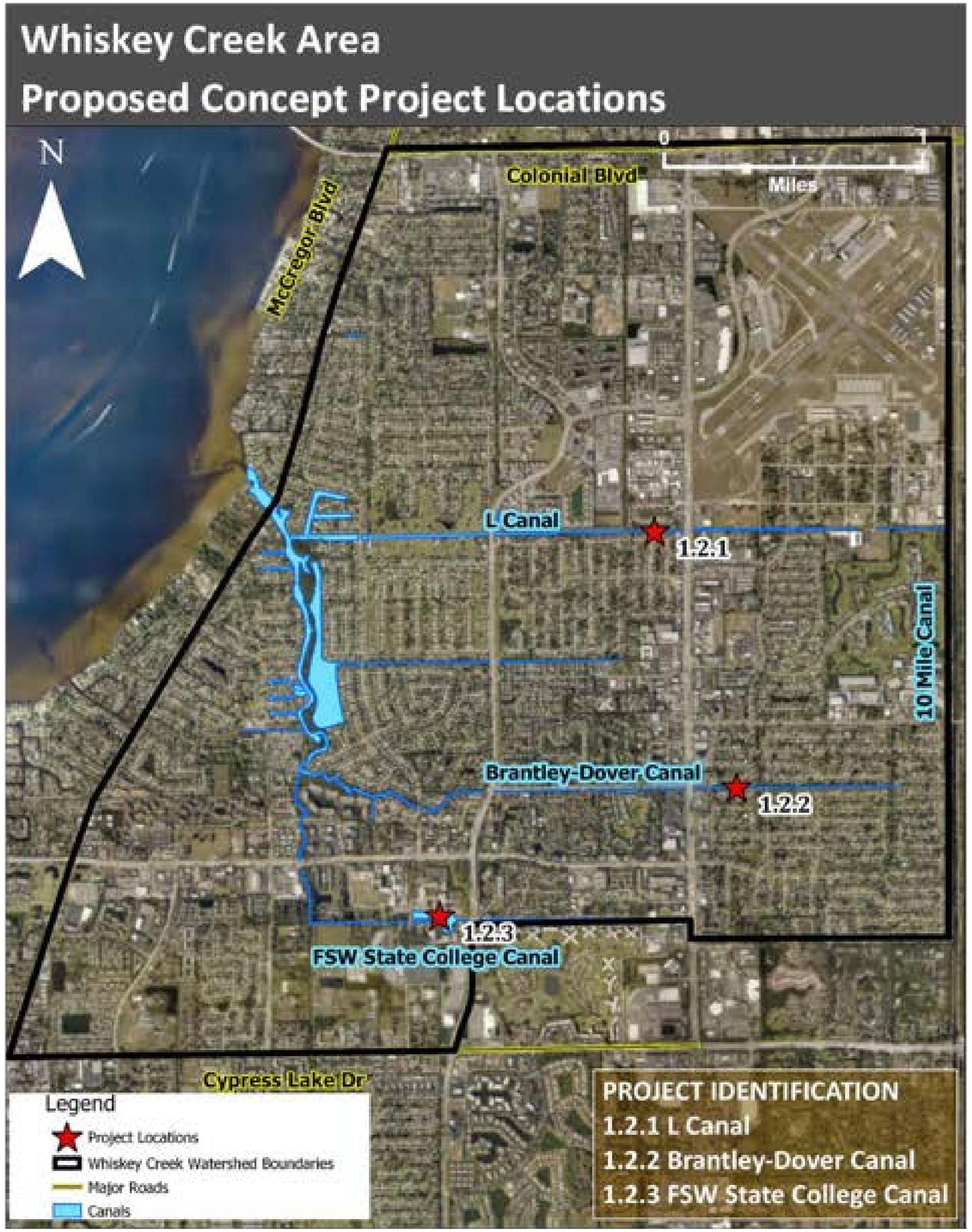
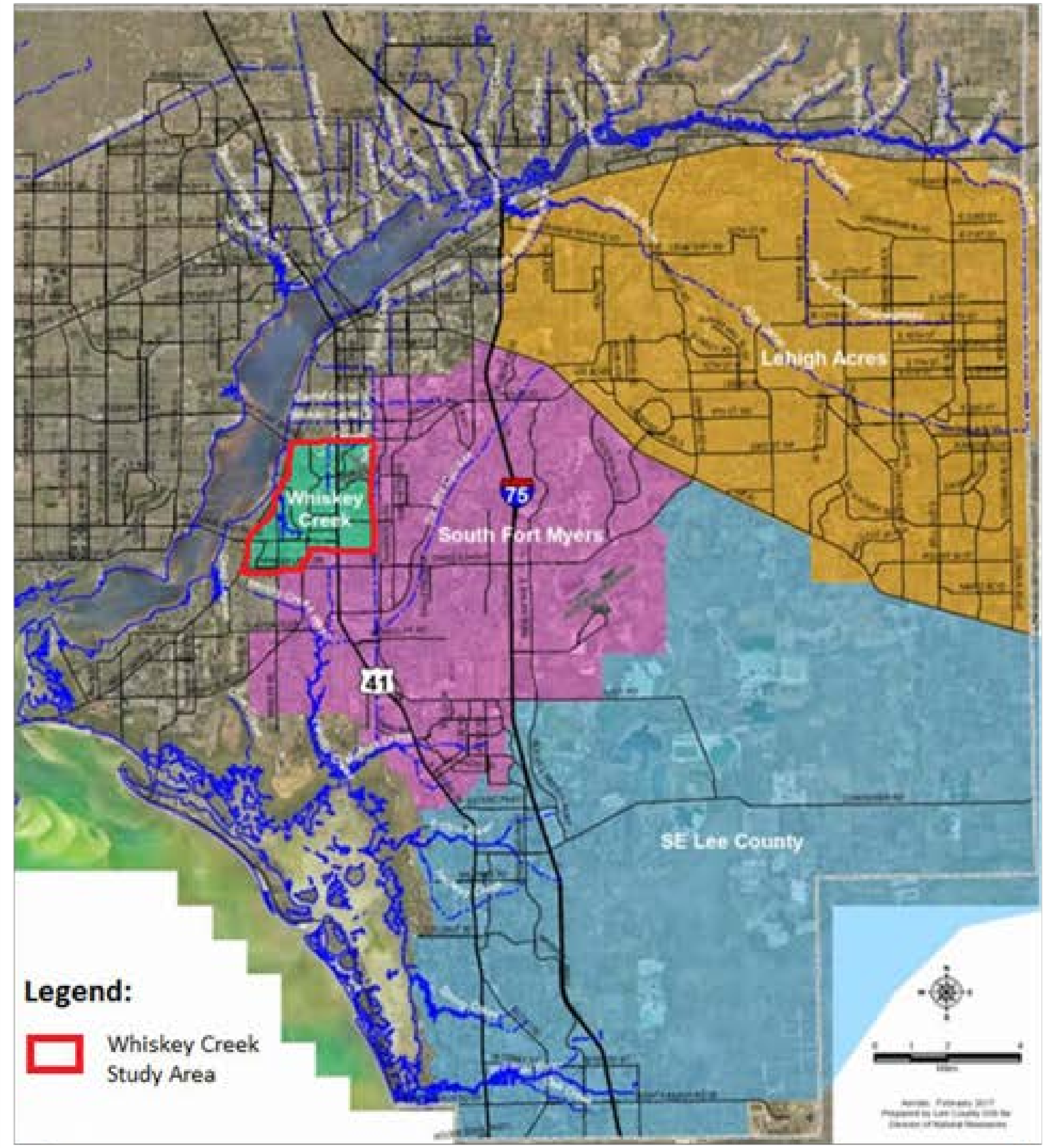


Figure 5 – Flooded Areas Upstream of Summerlin Blvd. Existing (top) and Proposed (bottom) Conditions

For the 100-year, 3-day simulations the most significant flood reductions were seen for the August simulations. Figure 26 presents the areas of flooding for the existing conditions and the post-project conditions. The potential changes in flooded area are significant.

For the repetitive flooding area adjacent to the FSW canal, the improvements mitigate flood waters for approximately 893 parcels based on the 100-year, 3-day modeled storm. Note that the number of approximately benefited parcels that are conceptually shown to be impacted by high peak stages during extreme storm events are limited to the clipped area shown in the maps. The number of parcels impacted could therefore be increased or decreased if the subjective clipped region changes. Localized modeling should be conducted to refine the concepts to gain an increased understanding on how these concept projects benefit the surrounding areas. These figures do not necessarily reflect actual structure flooding, but more of an overall benefit to the area.





Whiskey Creek Area

Proposed Concept Projects

Applied Technology & Management
2201 NW 40th Terr.
Gainesville, FL 32605
(386) 256-1477
www.appliedtm.com

EXHIBIT 1.2

1.2.1 L Canal Improvements

Background

In general, as was shown in the overview of flooding in Whiskey Creek, the flooding along L Canal was more limited in comparison to what occurred in the Brantley-Dover and the Florida Southwest University canal. As such, the concept project provides for improved conveyance along L Canal for the purpose of limiting flooding along the canal, but more importantly, provides for allowance of improved connection to Ten-Mile Canal. This will provide relief to downstream areas along Ten-Mile Canal that experience flooding. Additionally, some side storage is identified along County-owned lands that run parallel to Ten-Mile Canal.

In this section, the write ups, results, and costing focus on the changes in L Canal at key restriction points identified in the Hole Montes report. The design specifics and costing for the pumps, final channel dimensions, and other infrastructure related to the connection between Ten-Mile Canal and L Canal are presented within the South Fort Myers section (1.4). Additionally, a local model of L-Canal was completed which provides greater detail in terms of modeling and design recommendations on channel modifications (Section 4.2).

Location

The L Canal is one of the major tributaries that flow into Whiskey Creek from the approximately 5,760-acre Whiskey Creek Watershed. The L Canal is approximately 2.4 miles in length and runs between Whiskey Creek and Ten-Mile Canal. Elevations in the lower canal are controlled by a structure located at Whiskey Creek Drive. The proposed project area is located in Sections 2, 10, 11 and 12 of Township 45 south, and Range 24 east, as illustrated in **Figure 6:**

Description

Many areas within the Whiskey Creek Watershed experienced flooding due to rainstorms in late August 2017 and Hurricane Irma in September 2017. Lee County, working with Hole Montes, performed a post-event evaluation of this tributary and recognized areas where improvements may alleviate flooding in similar future rainfall events. The report identified that the typical conditions that contributed to flooding during the storm events were vegetation blockage, debris blocking flow-ways, blocked culverts, and siltation. The report findings also recommended that future efforts verify that culverts and other structures within this system were adequately sized for the design flow and identified specific focus areas within L Canal.

Figure 7 presents the primary focus area for the L Canal conceptual project. The goal of the project would be to improve surface water conveyance in the canal by removing a constriction noted in previous studies and during ATM's December 2018 site investigation between where L-3 canal meets L-Canal and the Tamiami Trail (US41). Additionally, the project includes improvements in the channel conveyance capacity upstream of Tamiami Trail through an increase in the cross-sectional area and replacement of a culvert near 4th street. These canal improvements extend from Tamiami Trail to where the canal connects to Ten-mile Canal. These design recommendations are provided in more detail within Section 4.2. Additionally, and as part of the South Lee County projects, the structure at the connection of L-Canal and Ten Mile Canal will be updated to allow flows to be pulled off of Ten-Mile Canal. This will aide in relief of flooding downstream along Ten-Mile Canal. To support this additional flow, the cross-section along L-canal upstream of Tamiami Trail was evaluated relative to the potential to increase capacity. The detailed recommendations are addressed in more detail in Sections 1.4 and 4.2.

As stated, the primary area of focus is the L Canal to the east of the L-3 junction up to where the L Canal meets Ten-Mile Canal. The secondary area of focus is along the western bank of Ten-Mile Canal downstream of the L Canal, on a stretch of land that buffers the Hideaway Golf Course from Ten-Mile Canal. This area could be utilized for off-line storage to provide additional flow attenuation as needed.

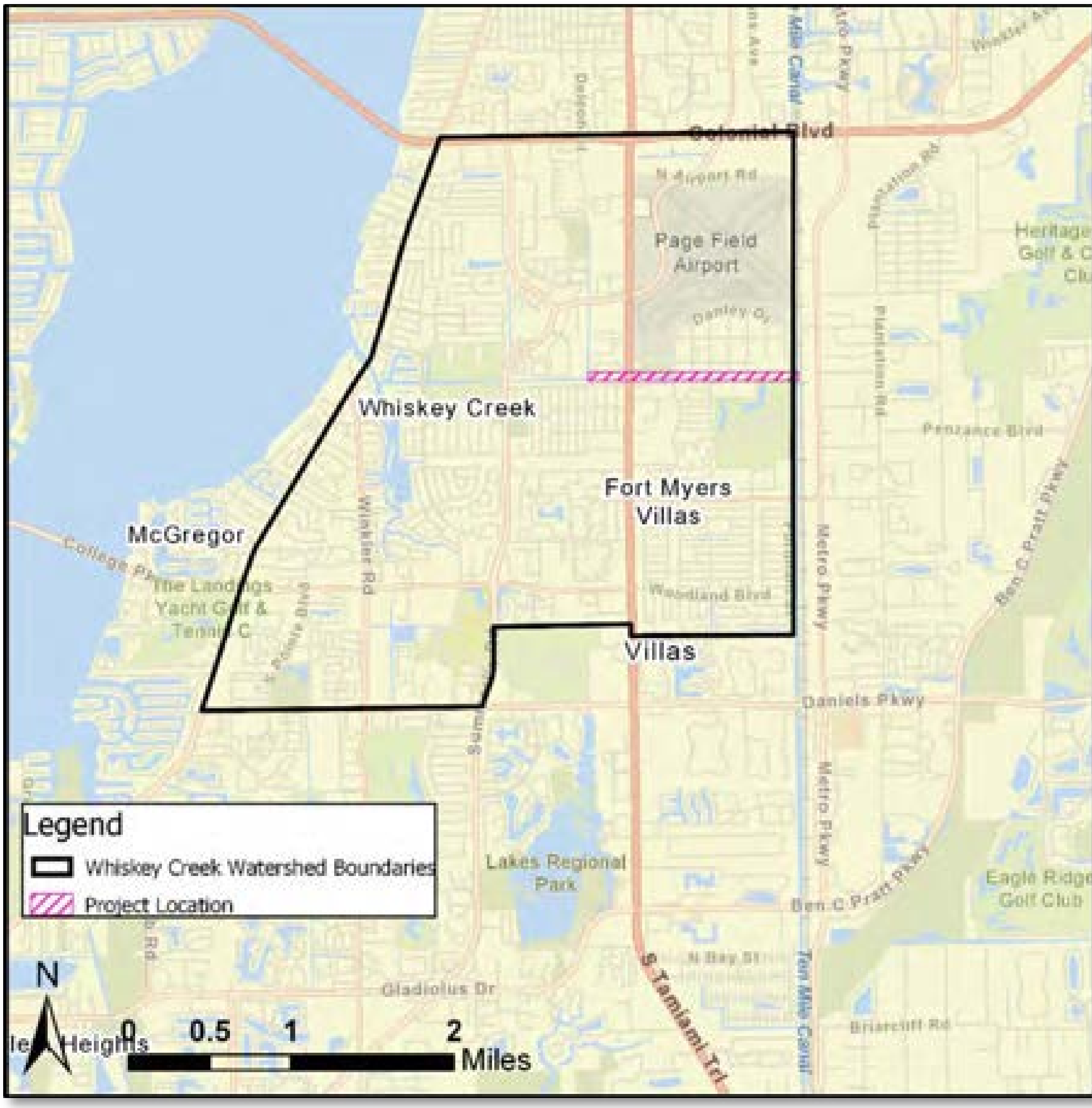


Figure 6. Location Map, 1.2.1 L Canal Improvement Project

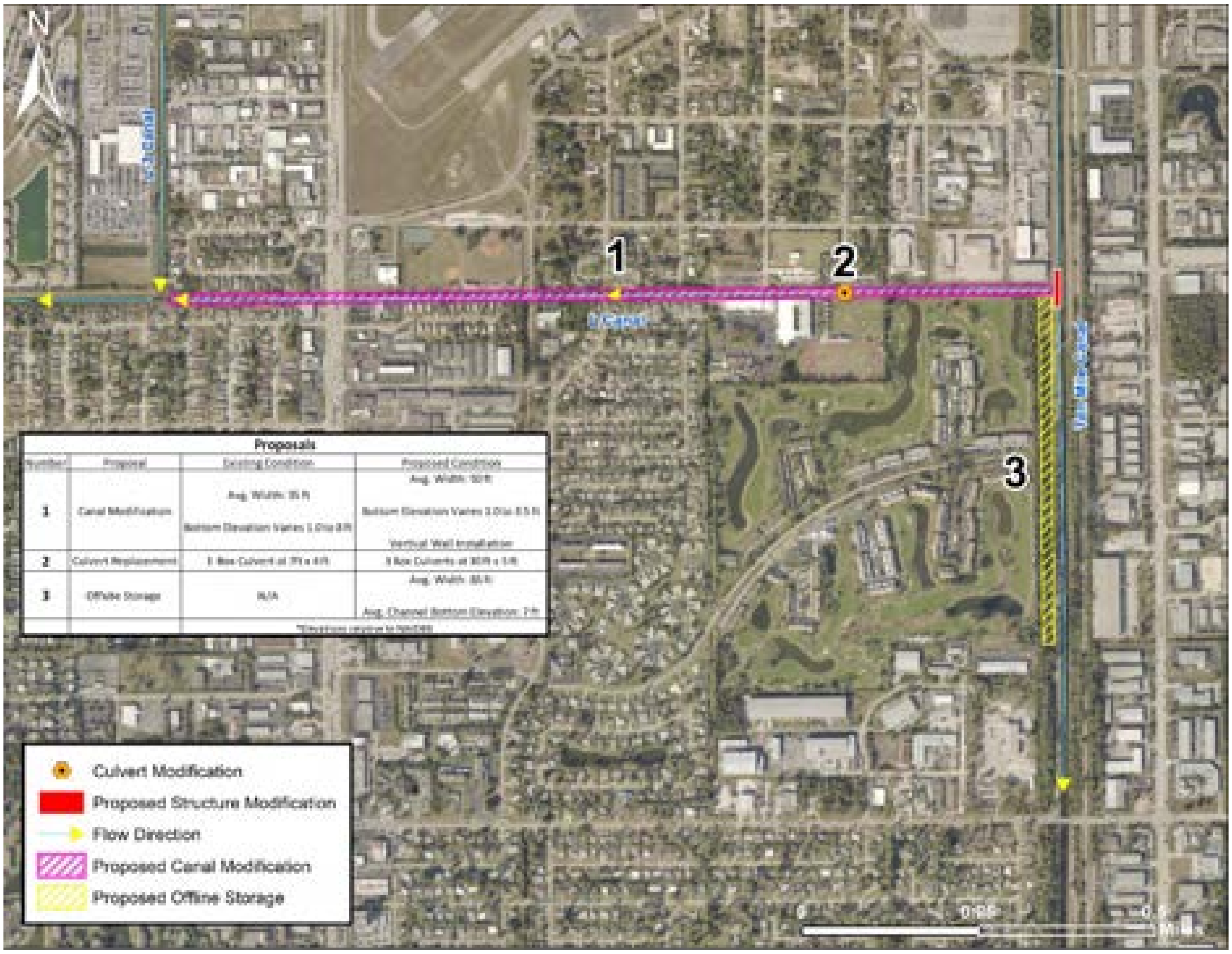


Figure 7. Concept Plan, 1.2.1 L Canal Improvement Project

Purpose

The L Canal exhibits a significant constriction upstream of the L-3 Canal up to the culverts at Tamiami Trail. The images in **Figure 8** show an aerial and ground view at the point of constriction.

The purpose of the project is to eliminate constrictions by increasing the cross-sectional area of the canal to support additional flow from Ten-Mile. Additionally, changes to structures upstream of Tamiami Trail are proposed where those structures restrict flow capacity. Finally, an offsite storage area is available along the County-owned right-of-way that parallels Ten-Mile Canal. This area can provide additional storage. The specifics of the facilities to be constructed to connect L Canal to Ten-Mile Canal are presented in Section 1.4 and details on the design assumptions within the canal and associated structures are presented in Section 4.2. The localized modeling performed for L Canal, presented in Section 4.2, only considered the improvements to the drainageway through canal conveyance capacity increases, it did not evaluate the side storage.

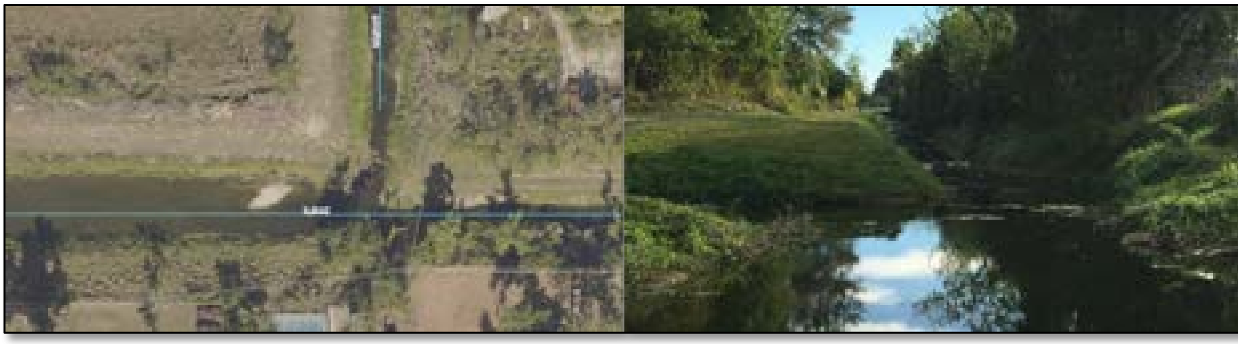


Figure 8. Aerial and Ground Views of the Constricted Area in L Canal between L-3 and Tamiami Trail

Evaluation

Viability

Presently, the right-of-way width available along the L Canal upstream of L-3 is limited to 80 feet. As such, to achieve the desired cross-sectional area, typical channel side slopes may not be feasible. The detailed design of this area (presented in Section 4.2) outlines the limitations and provides alternate recommendations. One key item that needs to be investigated is subsurface conditions (rock) that may hinder the overall deepening and widening.

The property where the offsite storage is proposed is currently owned by Hideaway County Club. Lee County has right-of-way access for Ten-Mile on this property, but the ownership may impede the construction of the offsite storage area.

At present, a connection exists between Ten-Mile Canal and L Canal. This consists of a single culvert opening along the L Canal side and a manually operated gate along the Ten-Mile Canal side. **Figure 9** shows photographs of the culvert and gate structure. The determination of the viability of the connecting infrastructure is presented in Section 1.4.

Figure 9. Photos of the Culvert and Gate Structure Connecting L Canal and Ten-Mile Canal

Community Considerations

Community impacts should be minimal since the work is being done either on rights-of-way or easements and should not impede traffic significantly. The reductions of flood risks may raise community support. Some properties have impinged upon the right-of-way above L-3 which may create issues for the proposed channel modifications.

Environmental & Permittability Considerations

The entirety of the project area is in developed area and will not be impacting any wetlands or preserved natural lands. Permitting should not be an overly difficult effort for this project.

Land Availability

The work for the widening and deepening of L Canal will be done along the existing County right-of-way, therefore, no additional land purchase would be required for that work (**Figure 10**). The offsite storage area will be constructed on a parcel owned by Hideaway Country Club that currently has easement rights for Lee County to access Ten-Mile Canal. Since the project includes the excavation of an approximately 5-acre area, it might also require additional negotiation or land purchasing.

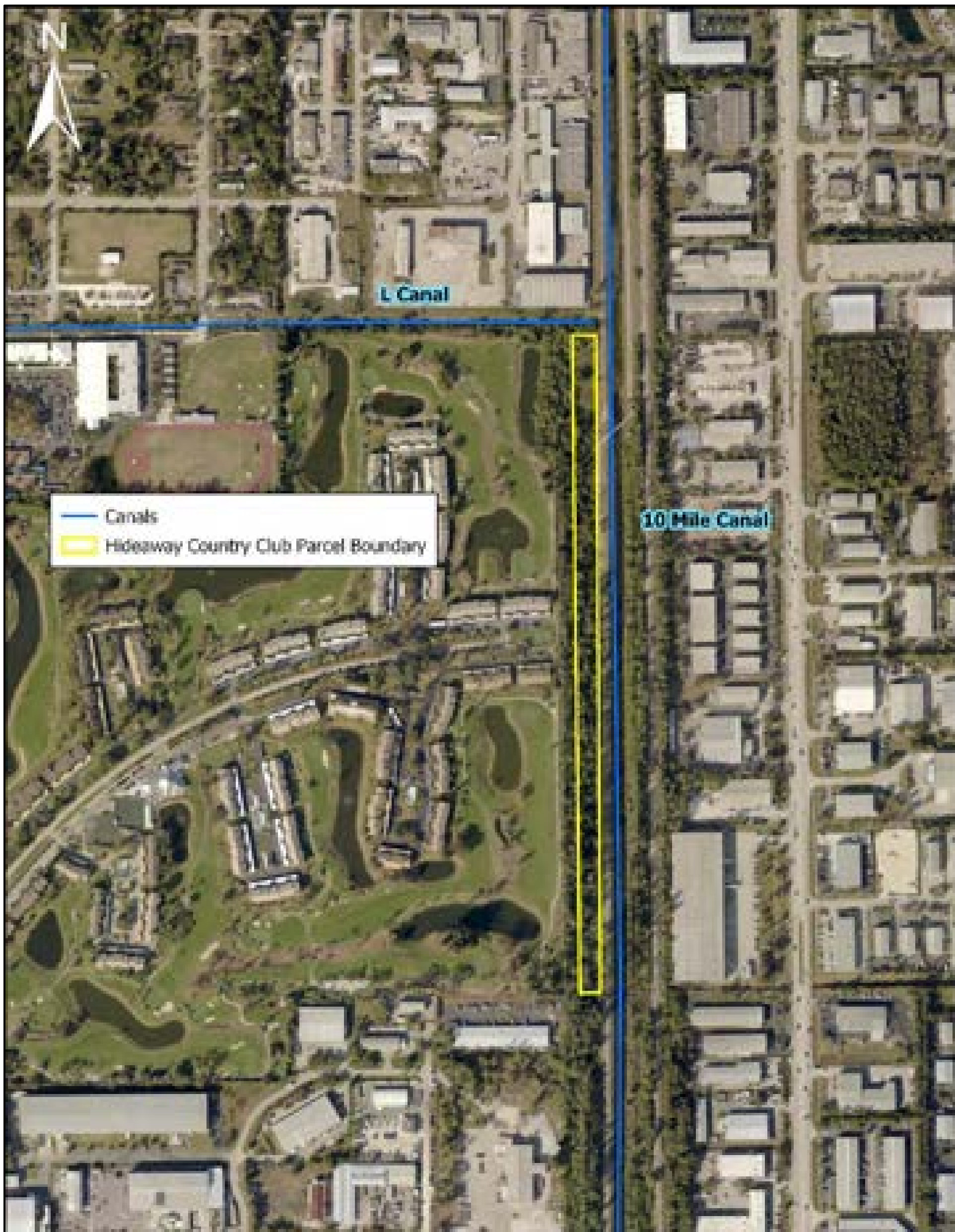


Figure 10 – Parcels on Project Areas along L Canal and Ten-Mile Canal

Opinion of Probable Cost

Table 1 presents the Opinion of Probably Cost (OPC) for the components of the project described above and outlined in detail in Section 4.2. As Section 4.2 presents multiple potential scenarios for channel modification, the OPC presented below represents the most costly of the options (Scenario 3). The cost estimate is preliminary in nature and figures are rounded to the nearest $10,000. The project cost is anticipated to increase with inflation or changes in future market conditions. The OPC presented below does not include the costs of the proposed infrastructure removal and replacement at the connection between L Canal and Ten-Mile Canal. This cost is included within the South Lee County assessments in Section 1.4.

Table 1 – Opinion of Probable Cost breakdown, 1.2.1 L Canal Improvement Project

Construction Costs				
Component	**Quantity**	**Unit**	**Unit Price**	**Cost**
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1.0	LS	$ 164,464.50	$ 164,465
Clearing & Grubbing	15.0	AC	$ 14,000.00	$ 210,000
Erosion Control	18500.0	LF	$ 2.39	$ 44,215
Earthwork	47000.0	CY	$ 6.00	$ 282,000
Grassing	6000.0	SY	$ 2.00	$ 12,000
48-Inch Culvert	50.0	LF	$ 211.35	$ 10,568
Vertical Wall	13000.0	LF	$ 8.72	$ 113,360
Remove Existing Culvert	1.0	LS	$ 83,500.00	$ 83,500
10' x '5' Culvert	195.0	LF	$ 602.32	$ 117,452
- 1 location with three segments of culverts				
			Conceptual Construction Costs:	**$ 1,040,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 320,000
			Project Administration/ CEI (10%)	$ 104,000
			Project Unknowns	$ 80,000
			Conceptual Project Cost:	**$ 1,550,000**
			Contingency (30%)	$ 470,000
			Conceptual Project Cost (with Contingency):	**$ 2,020,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

The project has some potential for water quality credits associated with increased retention in the upper end due to the inclusion of offsite storage and inclusion of a weir as outlined in Section 4.2. This benefit may be somewhat negated by increased flows from Ten-Mile Canal. Additionally, as part of the canal improvements, some small ditch blocks could be installed to provide additional retention of lower level rain events, thus providing some load reduction credits to the Caloosahatchee Estuary.

Other Considerations

As this project concept generates surplus fill material, coordinating the earthwork activity of this project concept with another community project requiring fill may be mutually beneficial.

Findings & Recommendations

Regional Modeling Findings

The concept project was incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.2.1**. **Exhibits 1.2.1(a)** through **Exhibit 1.2.1(h)** present water level and flow results for the various storms run with the Regional Model. **Table 2** presents the Storm Events run along with the results provided and the exhibits where they are shown.

Table 2 – Regional Model Storm Event Conditions and Results

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.2.1 (b) EXHIBIT 1.2.1 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.2.1 (d) EXHIBIT 1.2.1 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.2.1 (f) EXHIBIT 1.2.1 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.2.1 (h) EXHIBIT 1.2.1 (i)

The regional modeling for this project reflected an existing condition with limited operation of the existing gate structure. For the 25-year scenario the gate was not opened. For the 100-year August event and the continuous simulation, the gate was opened intermittently. These conditions can be seen in the flows in the Exhibits at Flow Point 2 and the water level results. Flow Point 2 is at the connection with Ten-Mile Canal. Based on these scenarios, the regional modeling did not show flooding issues associated with locally generated flows. The model did identify that with the gate opened water levels in the upper areas reached levels seen in some of the highwater marks from the Hole Montes study (over 10 feet).

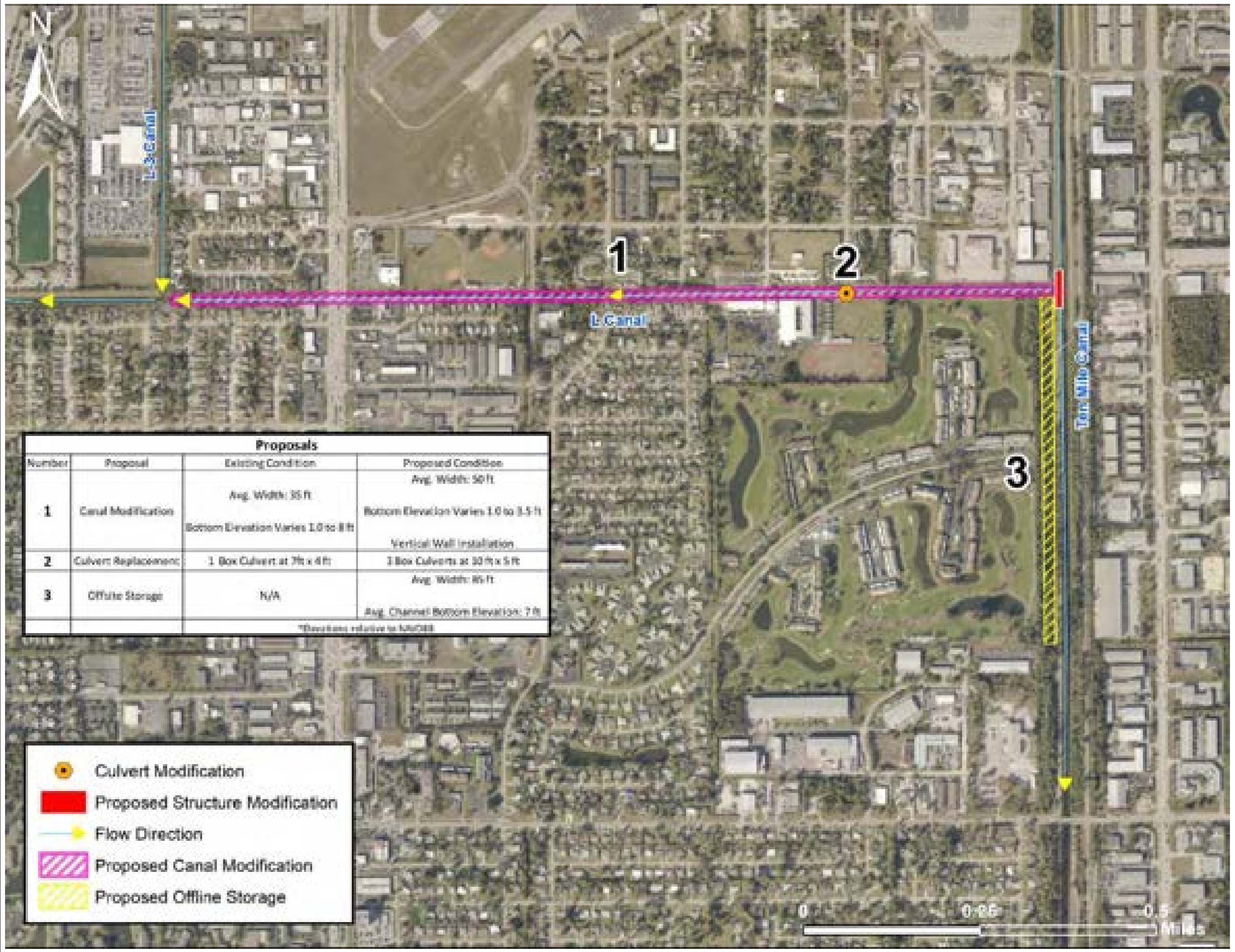
The proposed condition simulations reflect flows and water levels with the structure as proposed in Section 1.4. The general determination is that within the Regional Model the revised L-canal can pass the design flows from Ten-Mile canal. Section 4.2 provides a more refined local model to look in more detail at the post-project conditions with the structure connecting L-canal and Ten-Mile in operation.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by providing for diversion of flows from Ten-Mile Canal. The need for the offsite storage based on the results may be minimal.

EXHIBIT 1.2.1

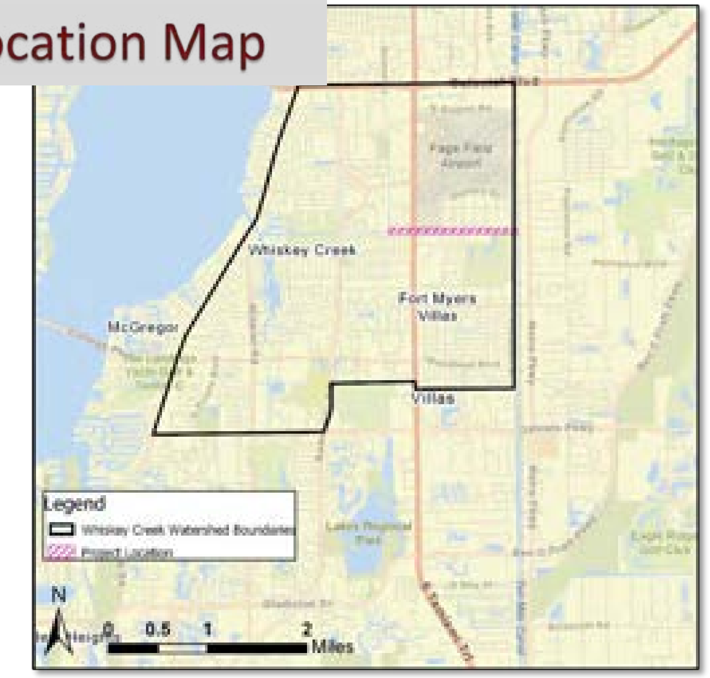
Concept Plan



Proposals

Number	Proposal	Existing Condition	Proposed Condition
1	Canal Modification	Avg. Width: 35 ft Bottom Elevation Varies 1.0 to 8 ft	Avg. Width: 50 ft Bottom Elevation Varies 1.0 to 3.5 ft Vertical Wall Installation
2	Culvert Replacement	1 Box Culvert at 7ft x 4 ft	3 Box Culverts at 10 ft x 5 ft
3	Offsite Storage	N/A	Avg. Width: 85 ft Avg. Channel Bottom Elevation: 7 ft
		*Elevations relative to NAVD88	

Location Map



Project Narrative

DESCRIPTION: The L Canal is approximately 2.4 miles in length between Whiskey Creek and Ten-Mile Canal. The project improves surface water conveyance in the canal by removing constrictions, increasing cross-sections, removing sediment, and replacing an existing structure at Ten-Mile Canal. The new structure is designed to allow flow into or out of Ten-Mile Canal depending on need to provide flood relief for neighboring areas. Retention is provided via linear holding areas along the L Canal for inline water quality treatment to ensure no increase in nutrient loading. Additional flood relief from offline storage will be provided south of the canal along Ten-Mile Canal adjacent to the Hideaway Country Club property.

PURPOSE: The primary purpose is to provide flood relief via increased surface water conveyance in the L Canal, with specific emphasis on the constricted areas upstream of the point at which the L-3 Canal discharges to the L Canal.

CONSTRAINTS: Potential constraints include limitations within the existing right-of-way and transferring water from Ten-Mile Canal to the Caloosahatchee River, which may affect water quality.

February 2019

L Canal Improvements Concept Plan

Whiskey Creek Watershed

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EXHIBIT 1.2.1

EXHIBIT 1.2.1 (a)

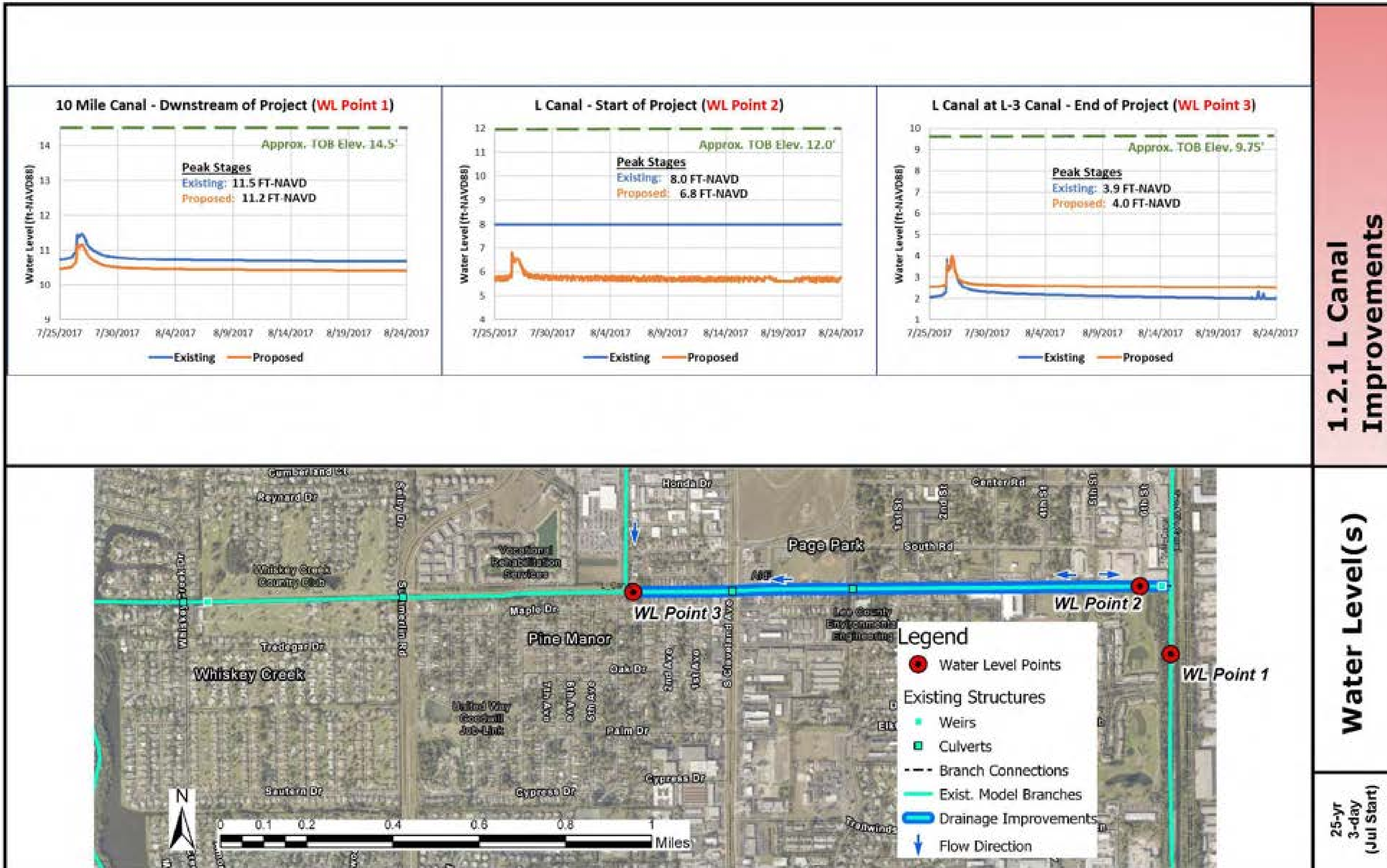
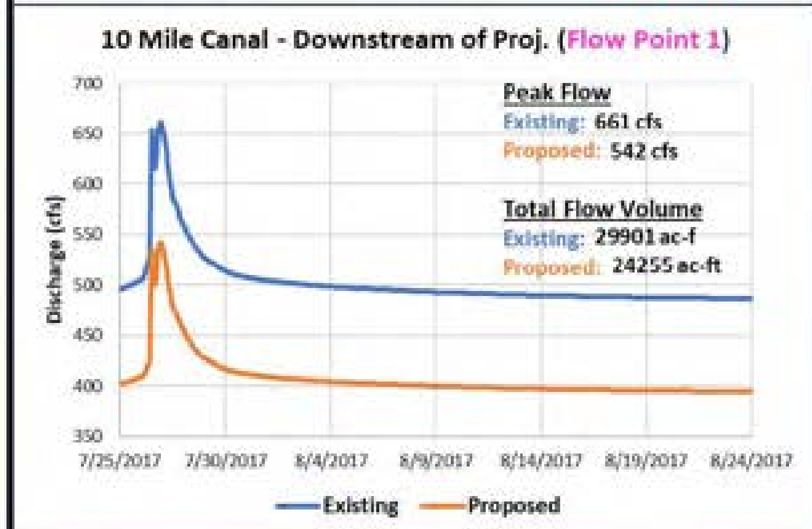
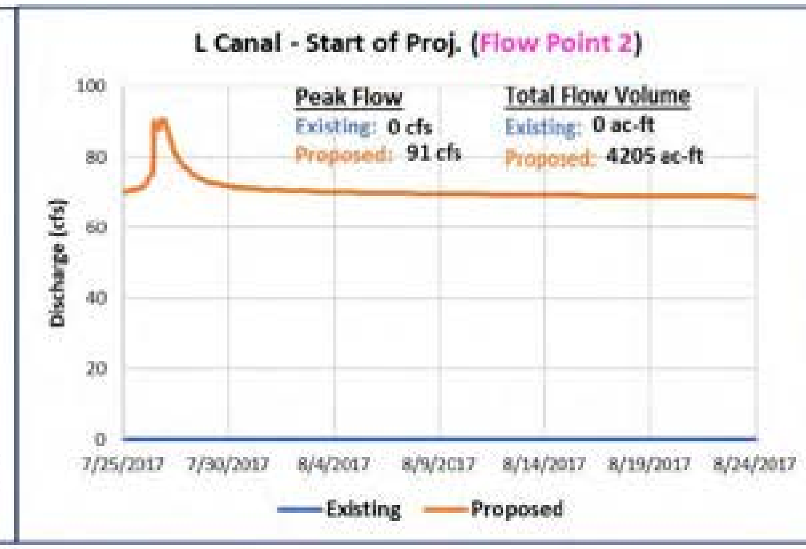
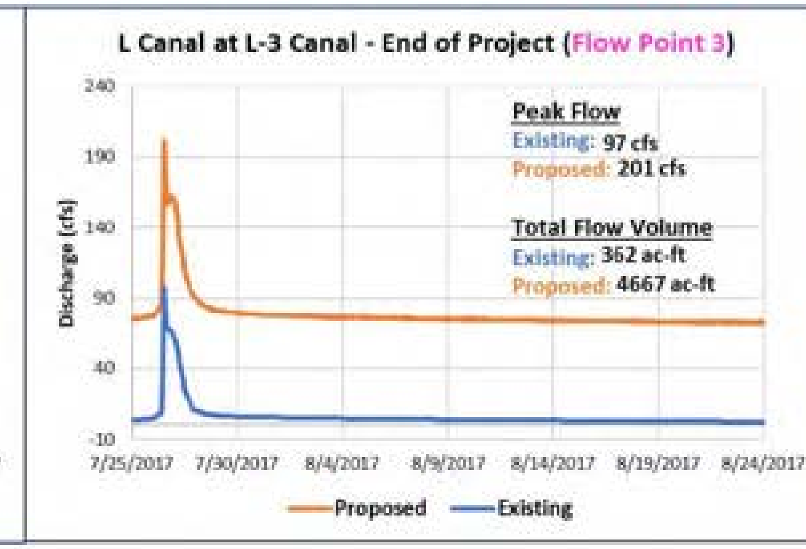


EXHIBIT 1.2.1 (b)

1.2.1 L Canal Improvements







Flow(s)

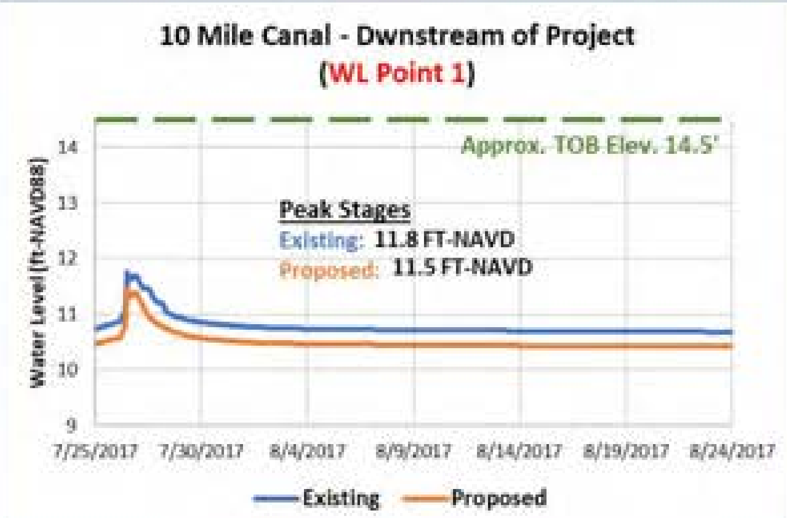
25-yr 3-day (Jul Start)

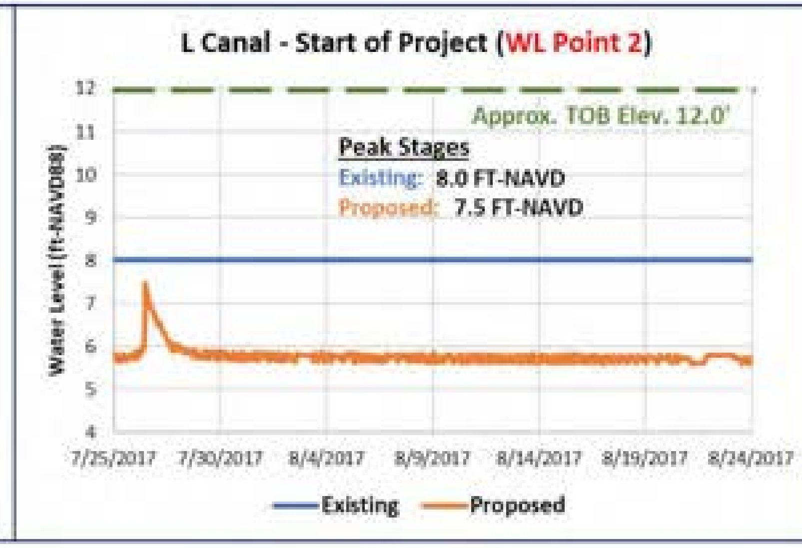
EXHIBIT 1.2.1 (c)

1.2.1 L Canal Improvements

Water Level(s)

100-yr 3-day (Jul Start)





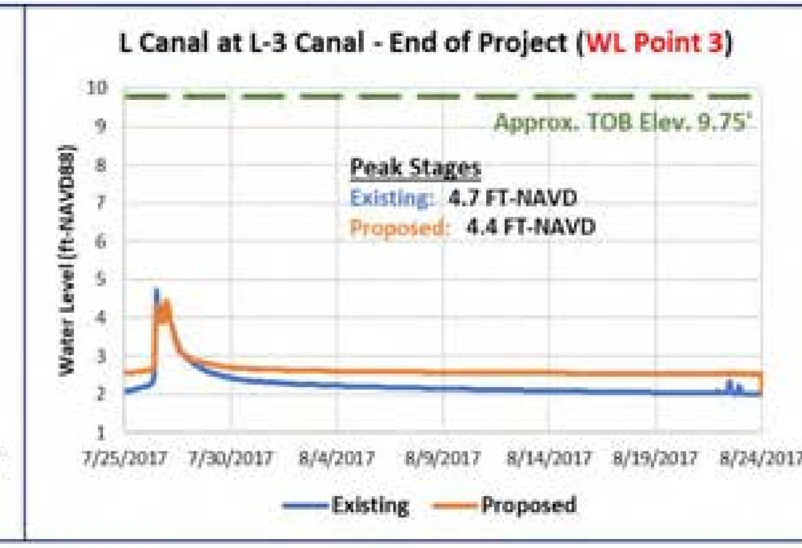
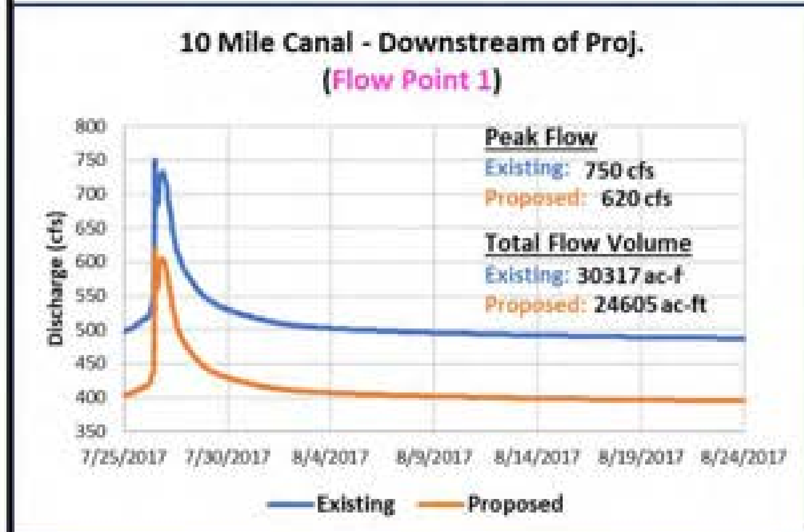
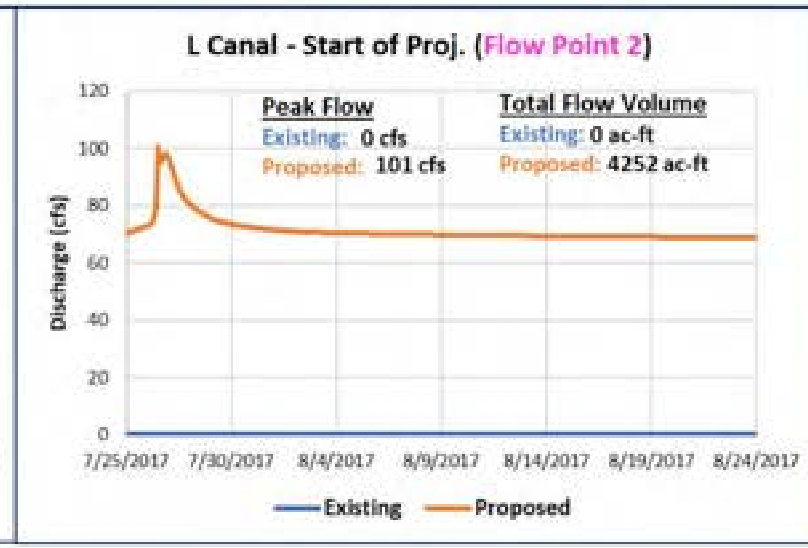
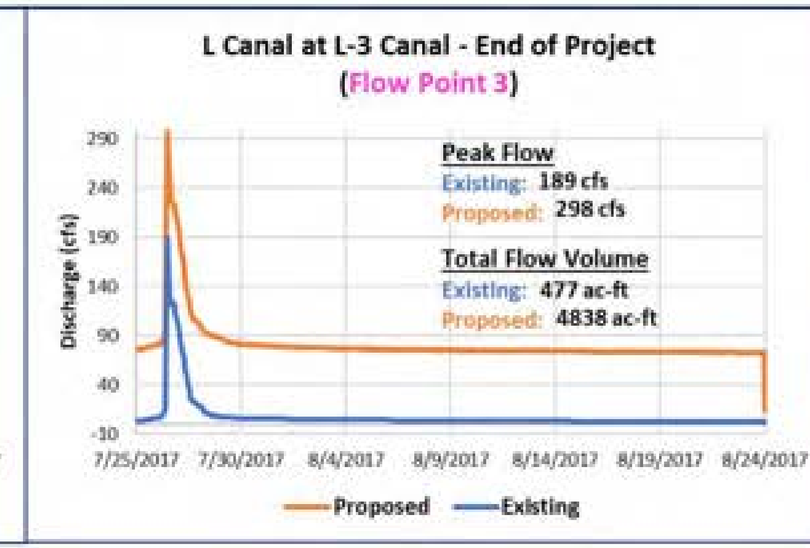


EXHIBIT 1.2.1 (d)

1.2.1 L Canal Improvements







Flow(s)

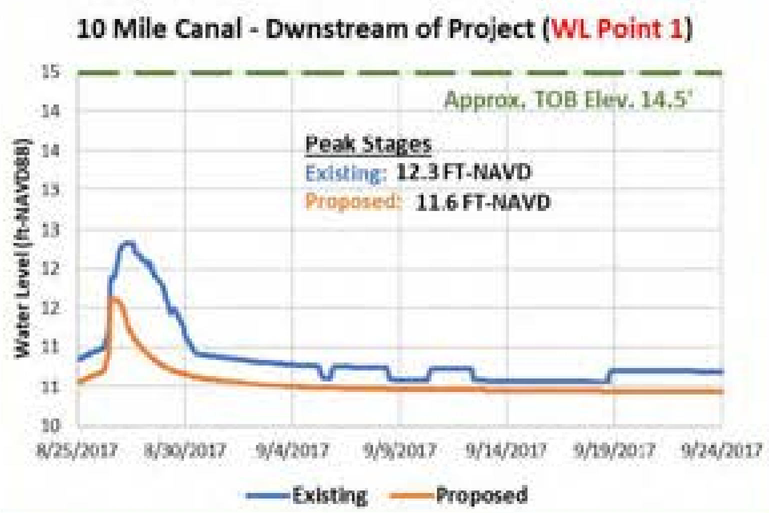
100-yr 3-day (Jul Start)

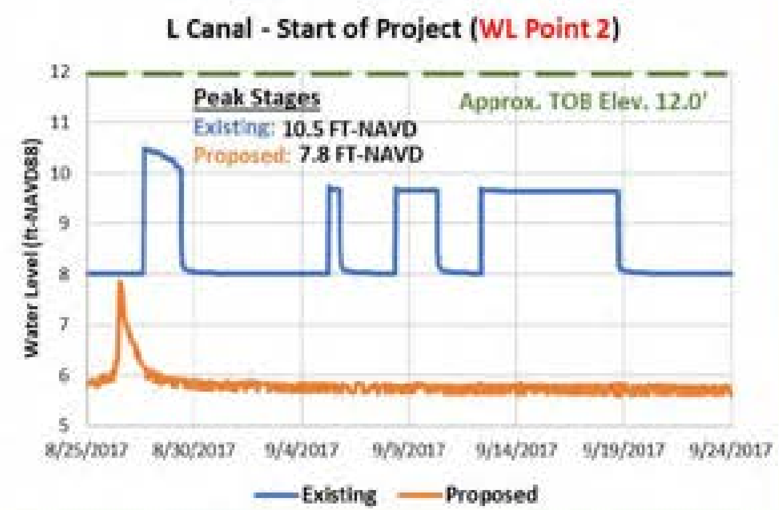
EXHIBIT 1.2.1 (e)

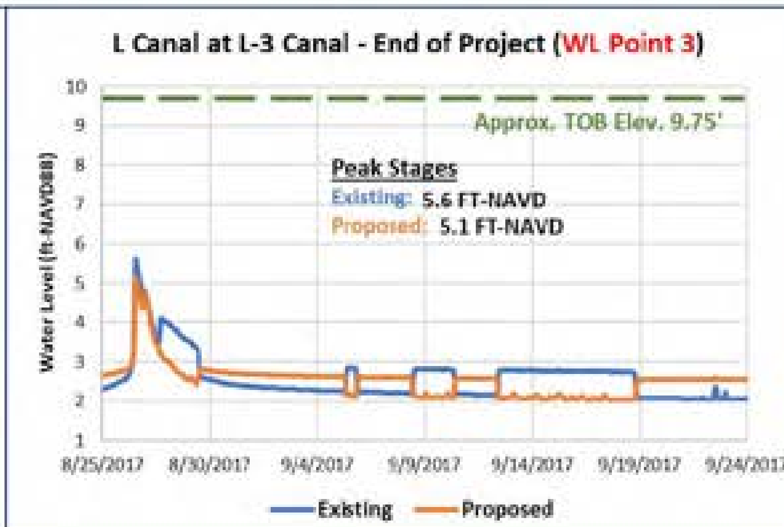
1.2.1 L Canal Improvements

Water Level(s)

100-yr 3-day (Aug Start)







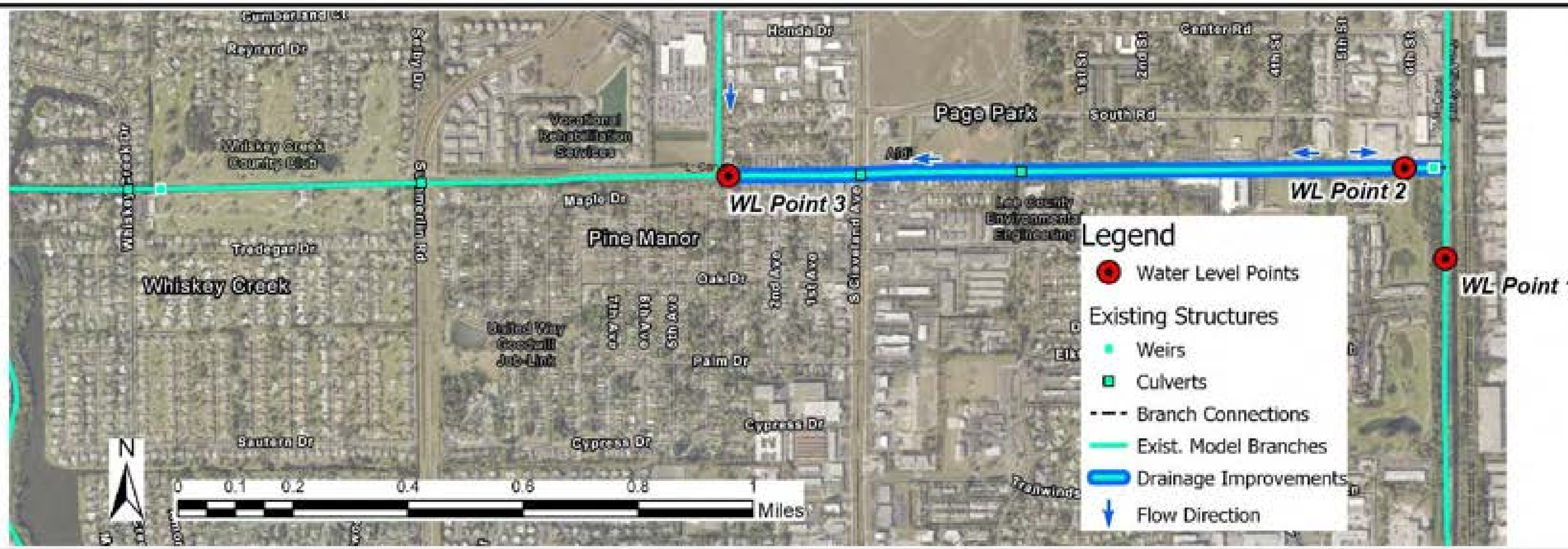
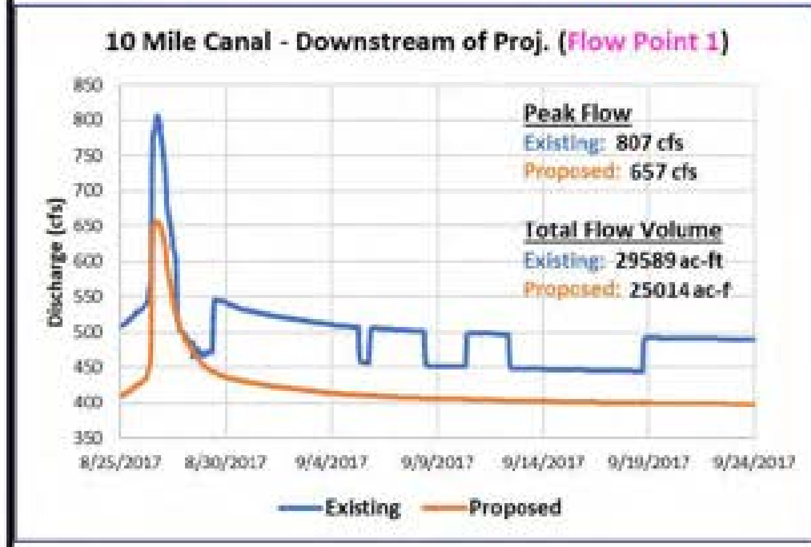
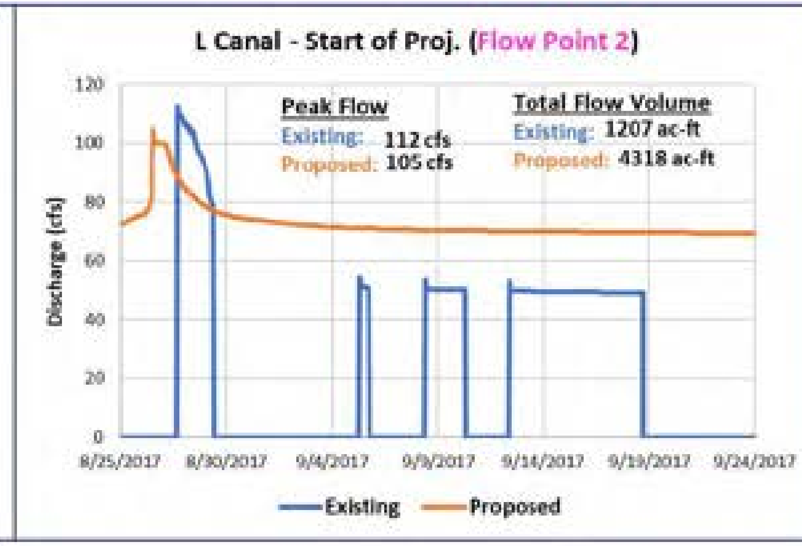
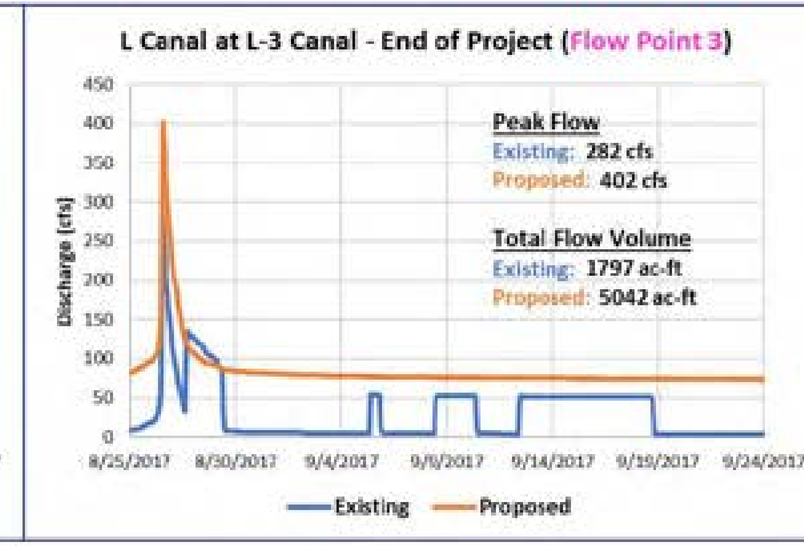


EXHIBIT 1.2.1 (f)

1.2.1 L Canal Improvements







Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.2.1 (g)

1.2.1 L Canal Improvements

Water Level(s)

Continuous Simulation Hourly

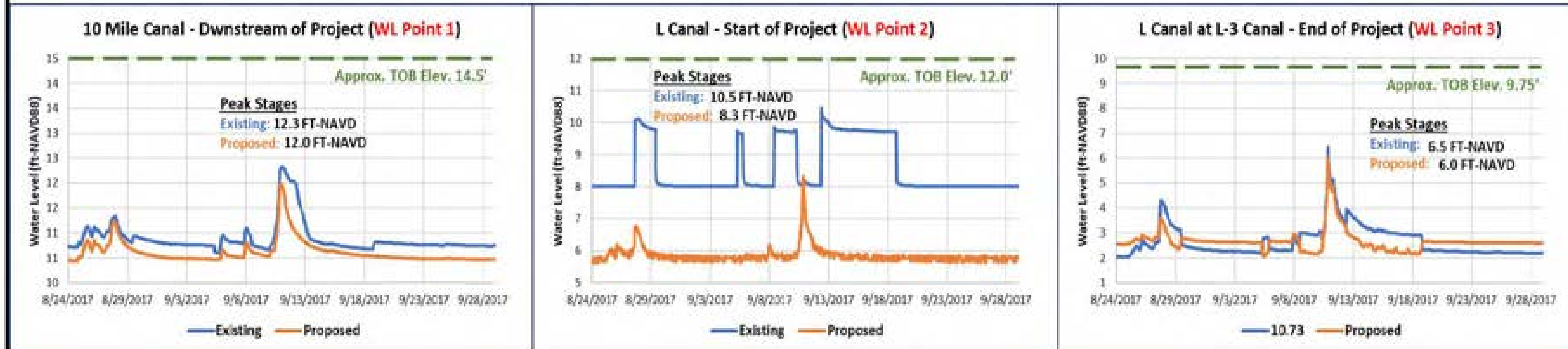
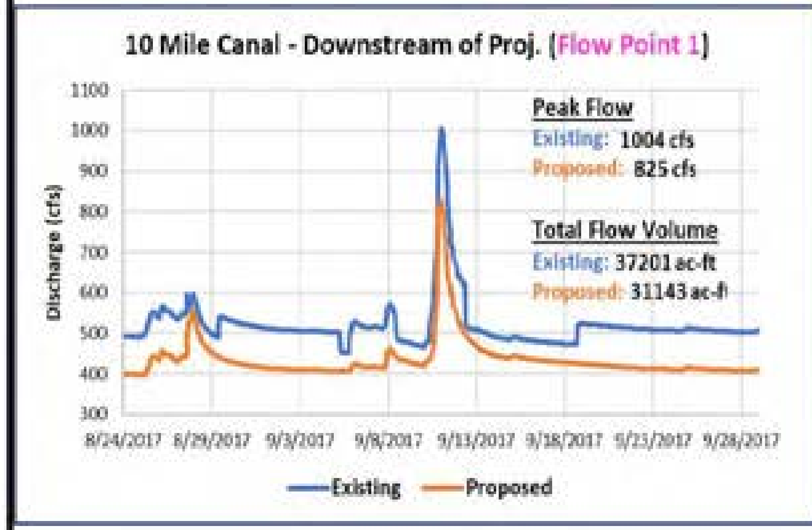
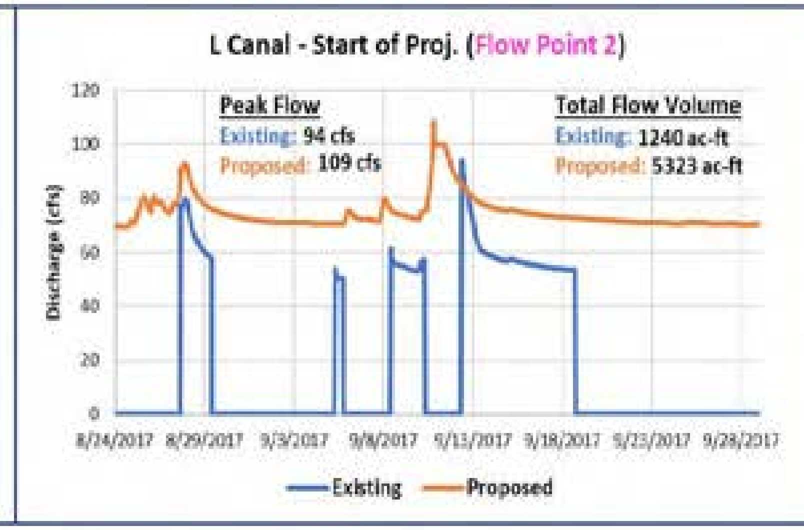
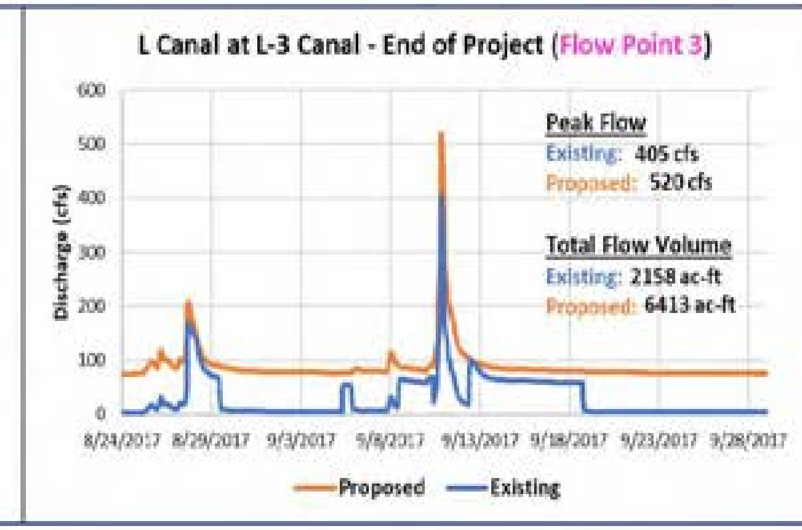


EXHIBIT 1.2.1 (h)

1.2.1 L Canal Improvements







Flow(s)

Continuous Simulation Hourly

1.2.2 Brantley-Dover Canal Improvements

Background

This concept project provides for improvements in the conveyance capacity of BDC in the area upstream of where the canal crosses the Tamiami Trail. Based upon regional model results and reported flooding within The Villas neighborhood as described previously, three culvert crossings were identified as targets to improve conveyance capacity. Due to the urbanized nature of this area, limited opportunity exists for defining offline storage. One recommendation outlined in the Hole Montes report was for a diversion structure to Ten Mile from the Villas. This option would require more localized modeling of the Villas to assess. As such, it was not included in the project recommendations discussed below.

Location

The BDC is one of the major tributaries that flow into Whiskey Creek from the approximately 5,760-acre Whiskey Creek Watershed. The BDC is approximately 1.8 miles in length between Summerlin Road and Ten Mile Canal. The proposed project area is located in Sections 13,14 and 15 of Township 45 south, and Range 24 east, as illustrated in Figure 11:

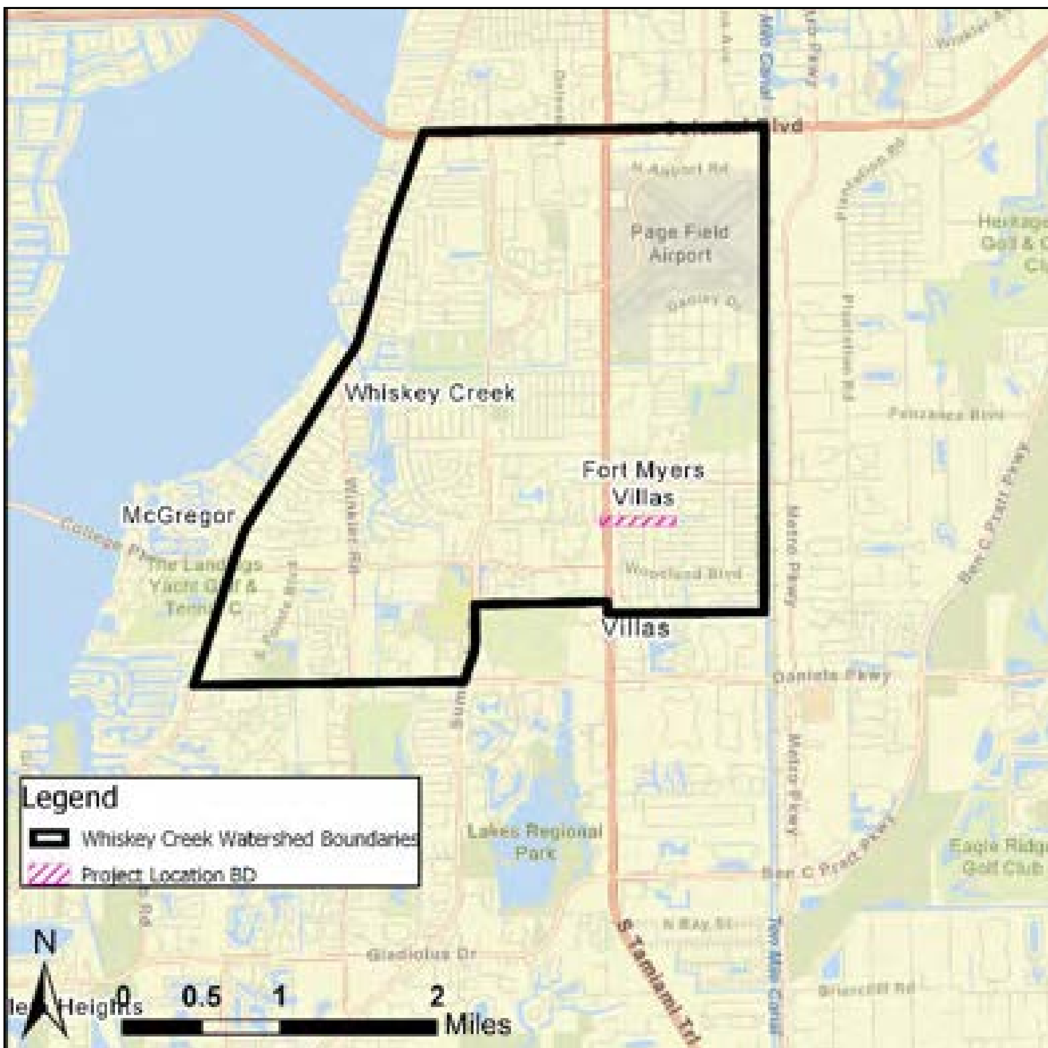


Figure 11 - Location Map, 1.2.2 BDC Improvement Project

Description

Many of the areas within the Whiskey Creek Watershed experienced flooding due to rainstorms in late August 2017 and Hurricane Irma in September 2017. Lee County, working with Hole Montes, performed a post-event evaluation of this tributary and recognized areas where improvements may alleviate flooding in similar future rainfall events. As was commonly found in the Whiskey Creek basin, they found that the typical conditions that contributed to flooding during the storm events were vegetation blockage, debris blocking flow-ways, blocked culverts, and siltation. The report findings also recommended that future efforts verify that culverts and other structures within this system were adequately sized for the design flow. This concept focuses on the improvements of the maintained design conveyance capacity.

Starting upstream of where the BDC meets Summerlin Road, **Figure 12** shows a photo of the canal. This is typical of the conditions in the canal running along Brantley Road up to US 41 (Tamiami Trail). East of US 41, the canal narrows and runs through a right-of-way between the back end of residential properties until it ends at Exeter Street. **Figure 13** shows a photo of the canal east of US 41.

Figure 12 - Photo of BDC Canal East of Summerlin Road

Figure 13 – Photo of BDC Canal East of Tamiami Trail (US 41)

The project seeks to alleviate flooding in The Villas residential area by improving conveyance of surface water in the primary canal. The Villas are located upstream of the Tamiami Trail on either side of the BDC, as shown in **Figure 14**

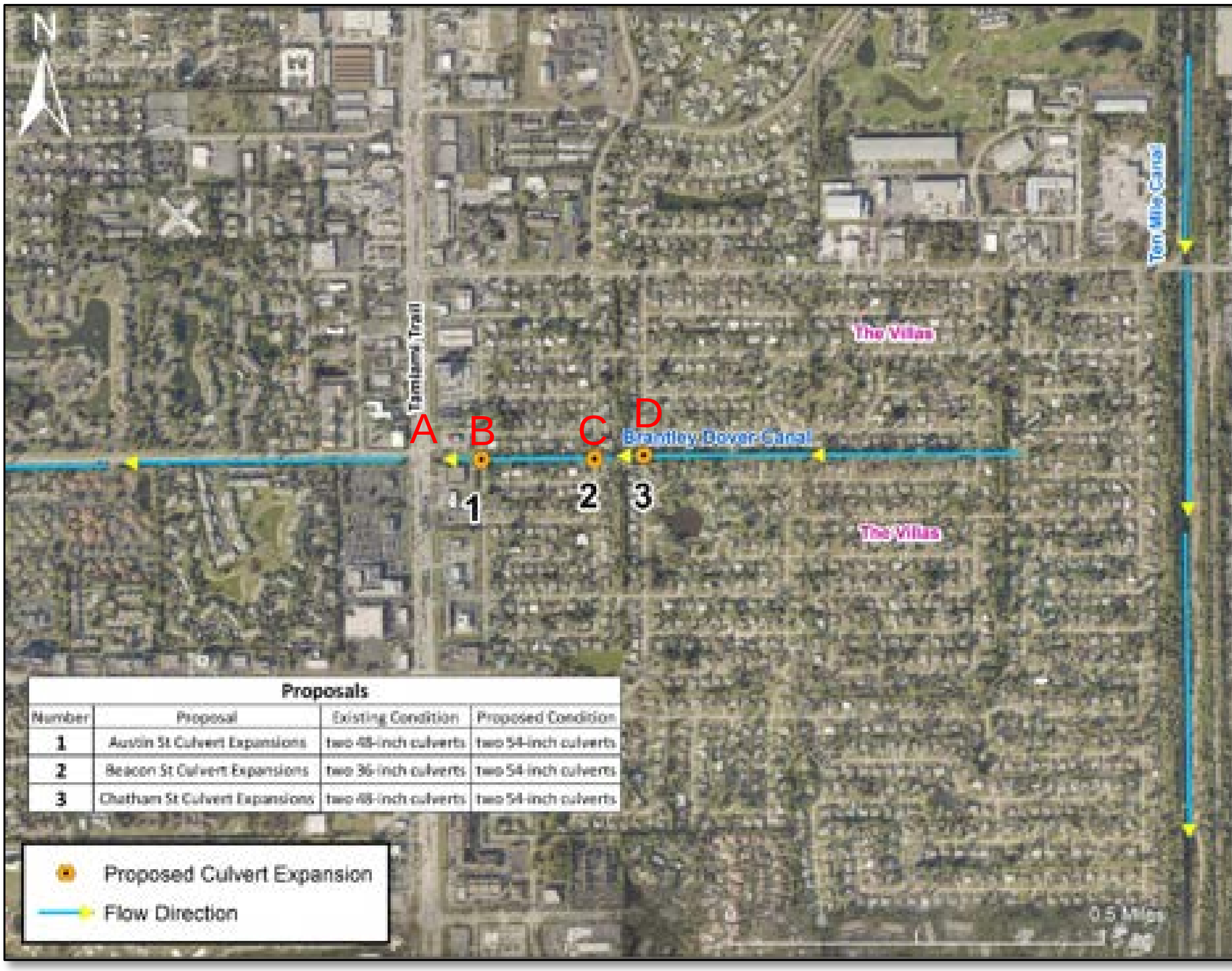


Figure 14 – Concept Plan, 1.2.2 BDC Improvement Project

Purpose

The original recommendation for the BDC was to improve surface water conveyance in the canal through a combination of removing constrictions and potentially widening the canal. This would alleviate flooding in The Villas through improved conveyance. Based on review of the modeling of the BDC in MIKE 11, a significant uptick was identified in the water levels immediately upstream of the Tamiami Trail. Three significant crossings occur upstream of Tamiami Trail (Austin Street, Beacon Street and Chatham Street). The culverts at these three crossings, respectively, are two 48-inch HDPE, two 36-inch HDPE, and two 48-inch concrete. **Figure 15** presents photos of the crossings, along with the box culverts under the Tamiami Trail. The difference in relative conveyance capacity between the crossings and Tamiami Trail are significant. Iterative modeling using MIKE-11 showed that increasing the culvert sizes at all three crossings to 54 inches, along with some improvements in the canal cross-sections in the vicinity of the culverts, improved the conveyance for the 25-year, 3-day storm. This included using consistent materials for the pipe crossings (concrete) to reduce friction. **Figure 14** presents the final recommended Concept Plan. Prior to final determination of the culvert types and sizing, local modeling of the area should be completed to provide a more detailed evaluation of the existing response and the resultant benefits in local flooding. The resolution of the regional model in this area is relatively coarse and does not reflect the more detailed aspects of flow and conveyance in this area, such as backwater flooding up side drainage channels, and overtopping of roadways.

Figure 15.– Photos of Tamiami Trail Box Culverts and Upstream Culverts

Evaluation

Viability

The project is to replace three sets of culverts with larger culverts, and minor modifications to the channel so the concept has a high level of viability. Detailed design considerations would include; localized modeling to more accurately simulate the local hydrology and refine the culvert sizing; evaluation of the need for channel modifications; and evaluation of the pipe size and associated materials related to road cover and clearance for structural integrity. The crossings should be sufficient to accommodate pipes or other culvert configurations to achieve the cross-sectional area and friction as defined by the simulated 54-inch culverts or larger.

Community Considerations

Work done adjacent to residential areas (including work that may block off access roads) or other private property would need to be planned in such a way as to minimize impact to adjacent property owners. Other considerations would include any access or easements required for proposed changes.

Environmental & Permittability Considerations

Future design efforts will need to assess the impact of any modifications to the system that, while improving flow, may reduce retention time needed for water quality treatment. The Caloosahatchee has existing TMDL/BMAP allocations, so that increases in loading, through reductions in retention and residence times, would need to be assessed. The future design may need to consider BMPs such as low ditch blocks, weirs and additional storage to mitigate for the increased loads during flooding events. Permitting is not anticipated to be complicated for this project beyond the considerations noted above.

Land Availability

No work being done will require land acquisitions or easements granted.

Opinion of Probable Cost

The cost estimate in **Table 3** is preliminary in nature and figures are rounded to the nearest $10,000. The project cost is anticipated to increase with inflation or changes in future market conditions.

Table 3 – Opinion of Probable Cost breakdown, 1.2.2 BDC Improvement Project

Construction Costs				
Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1.0	LS	$ 21,703.52	$ 21,704
Clearing & Grubbing	0.5	AC	$ 14,000.00	$ 7,000
Erosion Control	750.0	LF	$ 2.39	$ 1,793
Earthwork	5300.0	CY	$ 6.00	$ 31,800
Grassing	2000.0	SY	$ 2.00	$ 4,000
Road Repair - Per 100 S.F	7.5	Ea.	$ 890.39	$ 6,678
54-Inch Culvert	330.0	LF	$ 283.09	$ 93,420
- 3 locations with two segments of culverts				
Conceptual Construction Costs:				$ 170,000
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 60,000
Project Administration/ CEI (10%)				$ 20,000
Project Unknowns				$ 20,000
Conceptual Project Cost:				$ 270,000
Contingency (30%)				$ 90,000
Conceptual Project Cost (with Contingency):				$ 360,000

Note:
This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

There are no proposed components to this project besides the hydraulic/hydrologic benefits.

Other Considerations

Other considerations include limitations within the existing right-of-way, potentially replacing major road crossings to achieve conveyance, and localized conveyance issues in The Villas.

Findings & Recommendations

Regional Modeling Findings

The concept project was incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.2.2**. Exhibits 1.2.2(a) through 1.2.2(d) present water level results for the various storms run with the Regional Model. **Table 4** presents the Storm Events run along with the results provided and the exhibits where they are shown.

It is important to note that the simulations presented herein, come from a regional model. Significant efforts were made through the model development to update the regional model to simulate some of the key localized issues, but the coarse resolution of the MIKE-SHE grid (typical of a regional model) and the limited representation of side drainage channels which exist in the area, limits the usefulness of the model beyond a screening tool in this area.

Table 4 – Regional Model Storm Event Conditions and Results

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.2.2 (a)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.2.2 (b)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.2.2 (c)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.2.2 (d)

The regional model provides for time series hydrographs of water level through the storm events at three locations. These locations include two locations within The Villas and one in the downstream area of the BDC where it intersects Whiskey Creek. Descriptions of the locations are provided as follows.

- WL Point 1: immediately upstream of Chatham Street, i.e., immediately upstream of the proposed improvements
- WL Point 2: immediately upstream of the connection of BDC with Whiskey Creek
- WL Point 3: between Dartmouth Street and Exeter Street in the upstream portion of The Villas

For the 25-year, 3-day design storm (Exhibit 1.2.2 (a)), the model shows that in the upstream area of The Villas, the peak water levels in the BDC are reduced from 9.4 feet NAVD down to 7.4 feet NAVD, whereas at the station just upstream of the improvements, the water levels are reduced from 9.5 feet NAVD down to 7.6 feet NAVD. These are significant reductions in peak water levels. Additionally, based upon the hydrographs presented, the durations of the high-water levels are reduced. Downstream, in the area where the BDC meets Whiskey Creek, the water levels do not show an appreciable change due to the proposed project. The evaluation of the change in flooding area within the Villas for this storm showed a 96% reduction in the area of potential flooding based upon the peak water levels.

Following the initial design storm iterations using the 25-year storm and the determination of the concept project design components, additional storms were run. These included the three other storm conditions outlined in **Table 4**. These are the 100-year, 3-day storm with a start in July, the 100-year, 3-day storm with a start in August, and finally the continuous hourly simulation that spanned the period from 8/24/2017 through 9/28/2017. The following discusses the results from each.

For the 100-year, 3-day design storm starting in July, the model shows that in the upstream area of The Villas, the peak water levels in the BDC are reduced from 11.3 feet NAVD down to 10.1 feet NAVD, while at the station just upstream of the improvements, the water levels are reduced from 11.2 feet NAVD down to 9.8 feet NAVD. While not as significant as the reductions seen in the 25-year, 3-day storm, these are still significant reductions in peak water levels. A key point is that based on the Top of Bank (TOB) elevation in this area, the proposed project reduces the peak water levels to below the TOB. Additionally, based upon the hydrographs presented, the durations of the high-water levels are significantly reduced. As was seen for the 25-year, 3-day storm, in the area where the BDC meets Whiskey Creek, the water levels do not show an appreciable change due to the proposed project.

For the 100-year, 3-day design storm starting in August, which would have a wetter antecedent condition than the start in July, the model shows that in the upstream area of The Villas, the peak water levels in the BDC are reduced from 11.6 feet NAVD down to 11.4 feet NAVD, while at the station just upstream of the improvements, the water levels are reduced from 11.5 feet NAVD down to 11.1 feet NAVD. The modeling indicates that for the wet antecedent condition there is not a significant reduction in the overall peak water levels, but the durations of high water are significantly reduced.

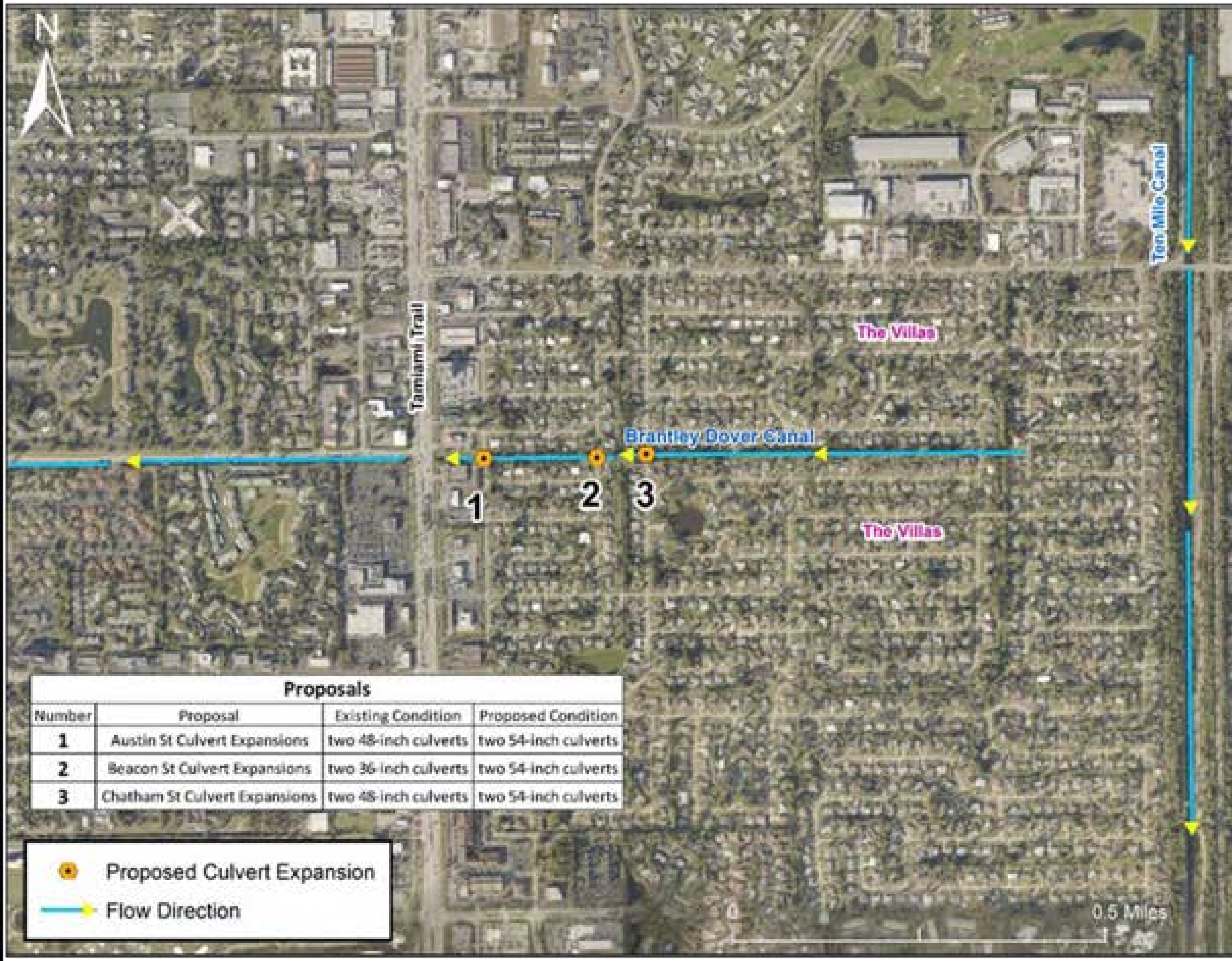
For the continuous simulation, which spans the period of rainfall and storm conditions around Hurricane Irma, the reductions seen in the peak water levels are similar to those seen for the 100-year storm conditions with the two storm peaks, reflecting the dryer antecedent conditions for the first peak and the wetter for the second peak. It should be noted that along the BDC a high-water mark following Irma was identified at 10.6 feet NAVD. The continuous simulations reached upwards of 11.4 feet NAVD in that same area. This is most likely a function of the regional model resolution in the area and the lack of spreading of the flooding off of the channel to unrepresented side channels. As such, the results presented should be examined more in a relative change than absolute flooding levels. The peak water level changes (and the associated potential area of flooding changes) along with the durations reflect what was seen for the dry and wet 100-year 3-day events.

Recommendations

The positive improvements of this project demonstrated by the modeling results warrant proceeding to project development.

EXHIBIT 1.2.2

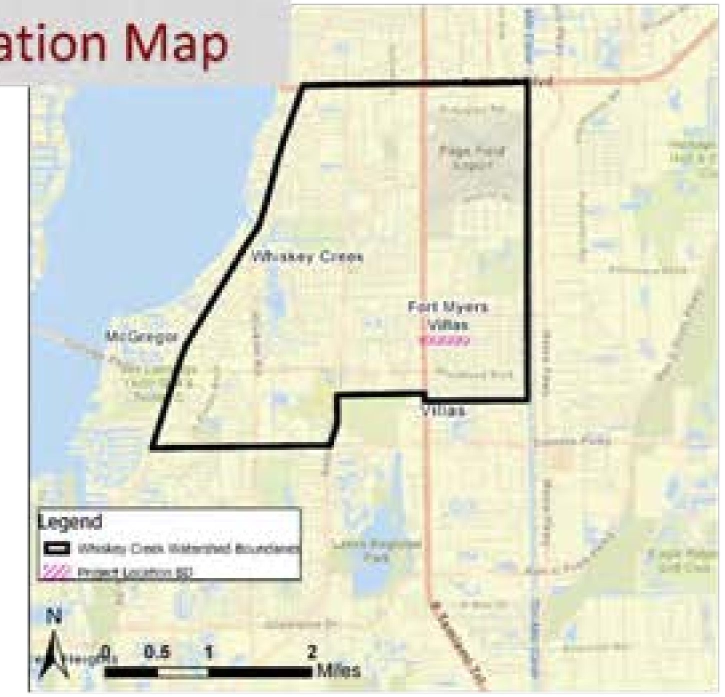
Concept Plan



Proposals

Number	Proposal	Existing Condition	Proposed Condition
1	Austin St Culvert Expansions	two 48-inch culverts	two 54-inch culverts
2	Beacon St Culvert Expansions	two 36-inch culverts	two 54-inch culverts
3	Chatham St Culvert Expansions	two 48-inch culverts	two 54-inch culverts

Location Map



Project Narrative

DESCRIPTION: The Brantley-Dover Canal is approximately 1.8 miles in length between Summerlin Road and Ten-Mile Canal. The project improves surface water conveyance in the canal through installation of larger culverts at three crossings along the canal upstream of Tamiami Trail which showed significant restriction in flows during storm events.

PURPOSE: The primary purpose is to increase surface water conveyance in the Brantley-Dover Canal to alleviate flooding in The Villas residential area.

CONSTRAINTS: Potential constraints include limitations within the existing right-of-way, replacing major road crossings to achieve conveyance, and localized conveyance issues in The Villas.

May 2020

Brantley Canal Area Improvements
Concept Plan
Whiskey Creek Watershed

Applied Technology & Management
2201 NW 40th Terr.
Gainesville, FL 32605
(386) 256-1477
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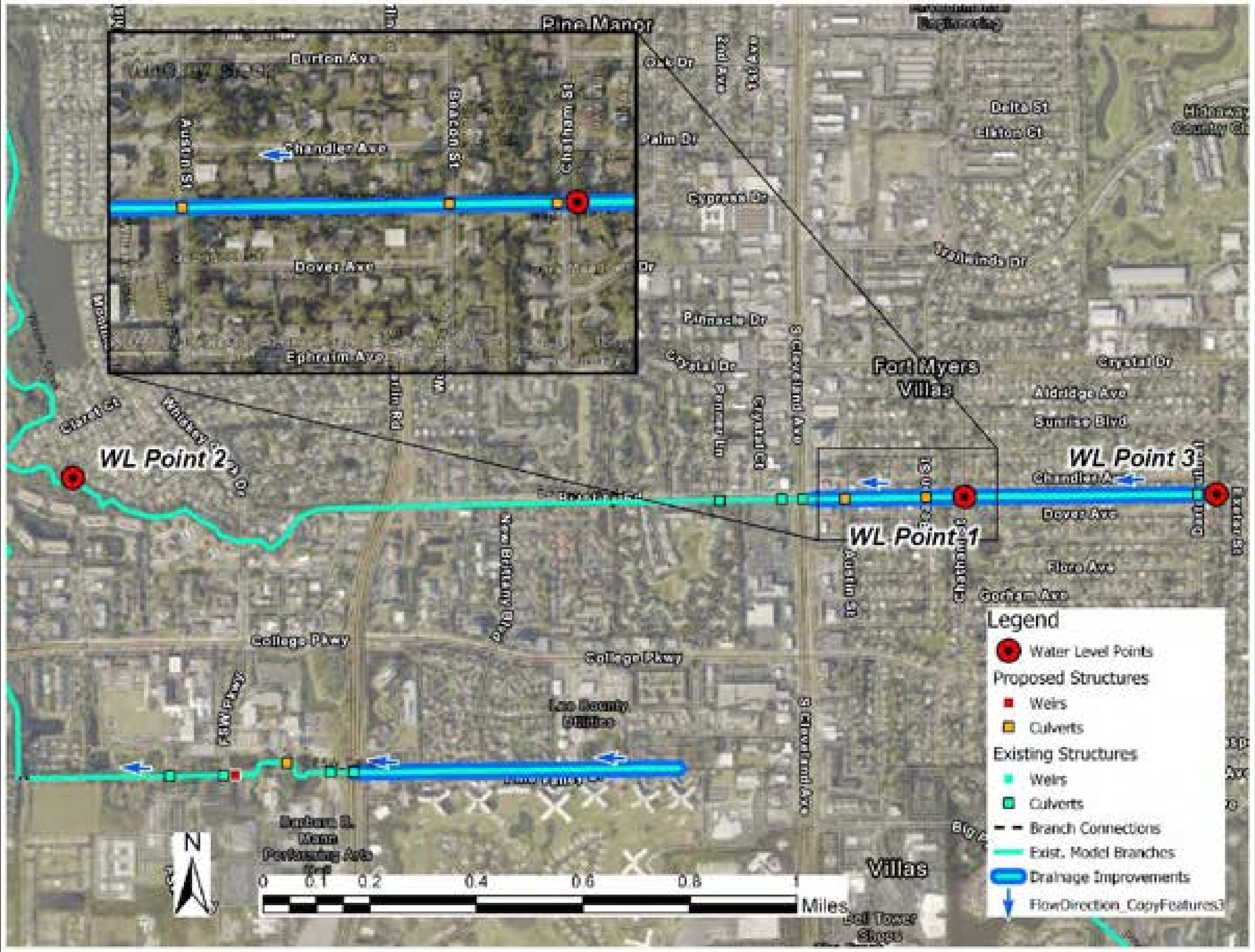
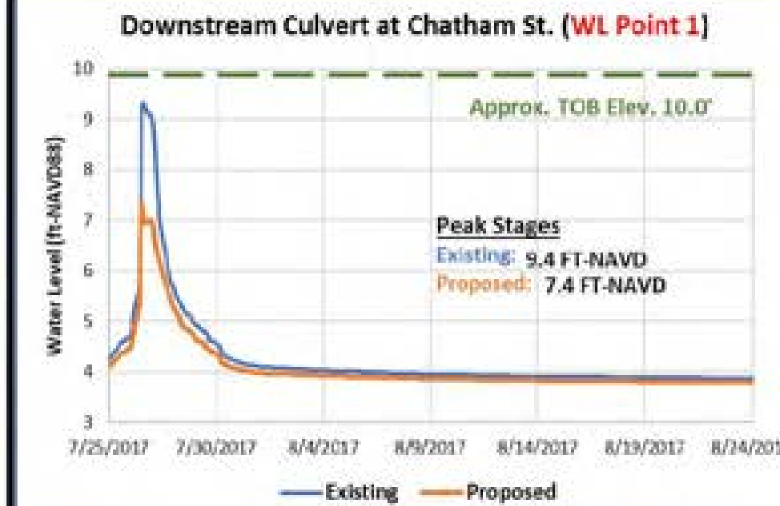
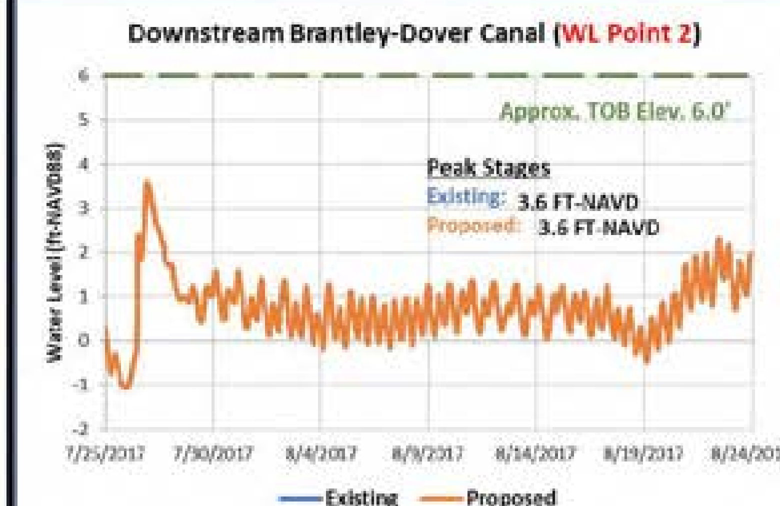
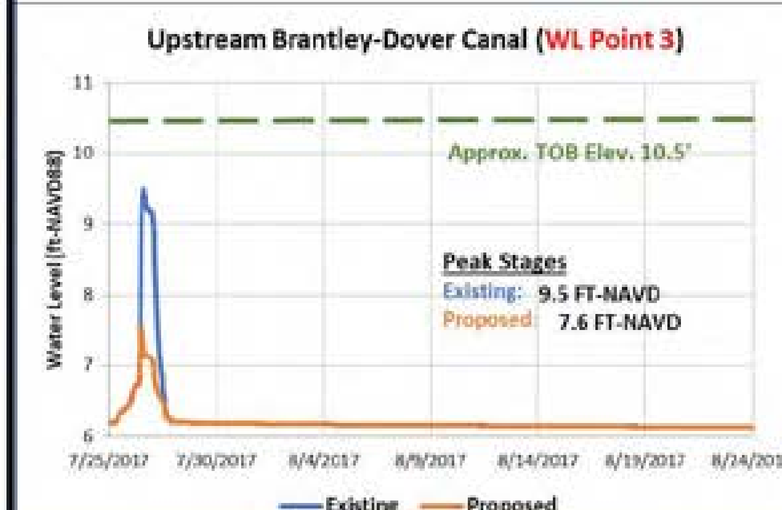
EXHIBIT 1.2.2

EXHIBIT 1.2.2 (a)









1.2.2 Brantley-Dover Canal Improvements

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.2.2 (b)

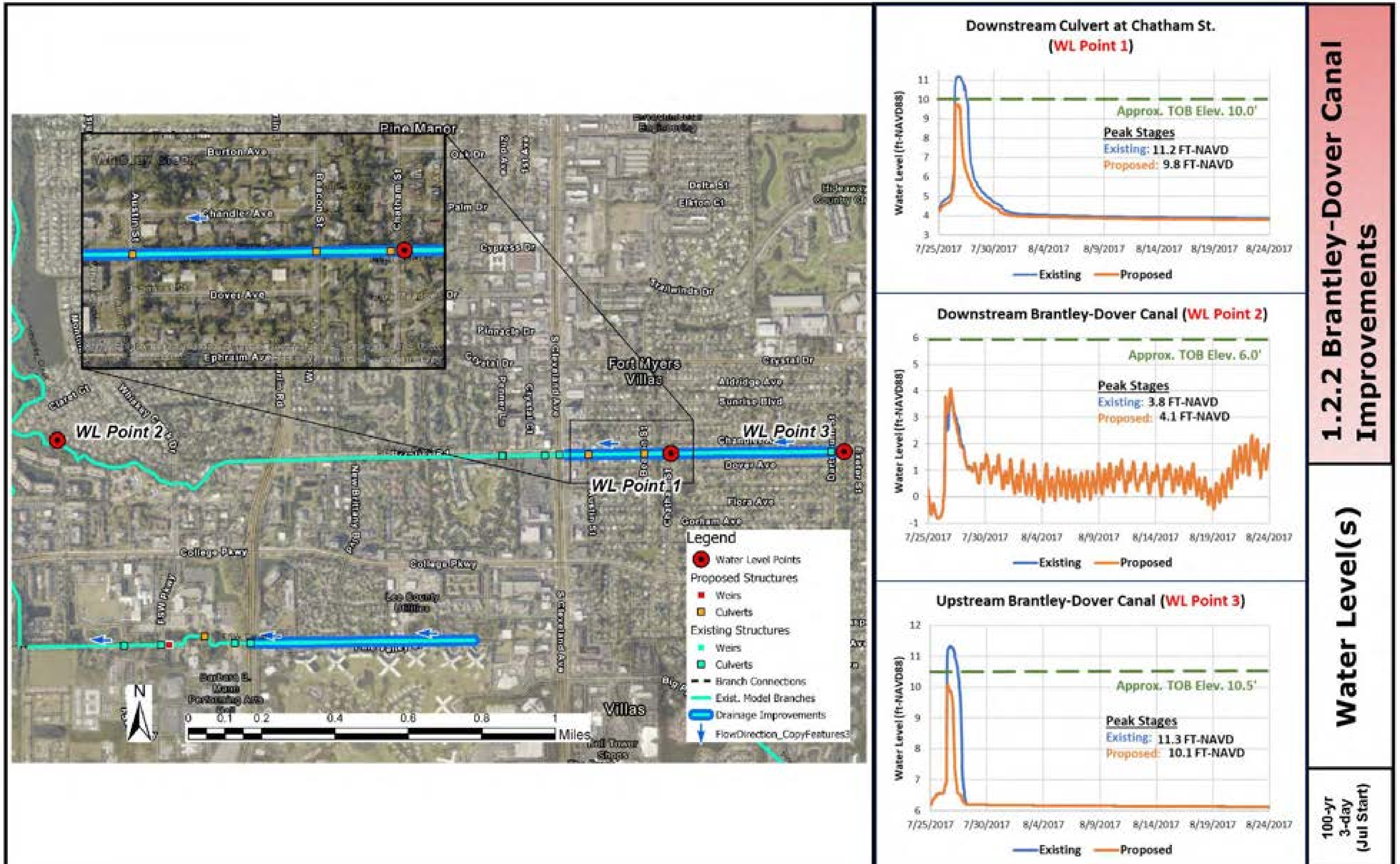
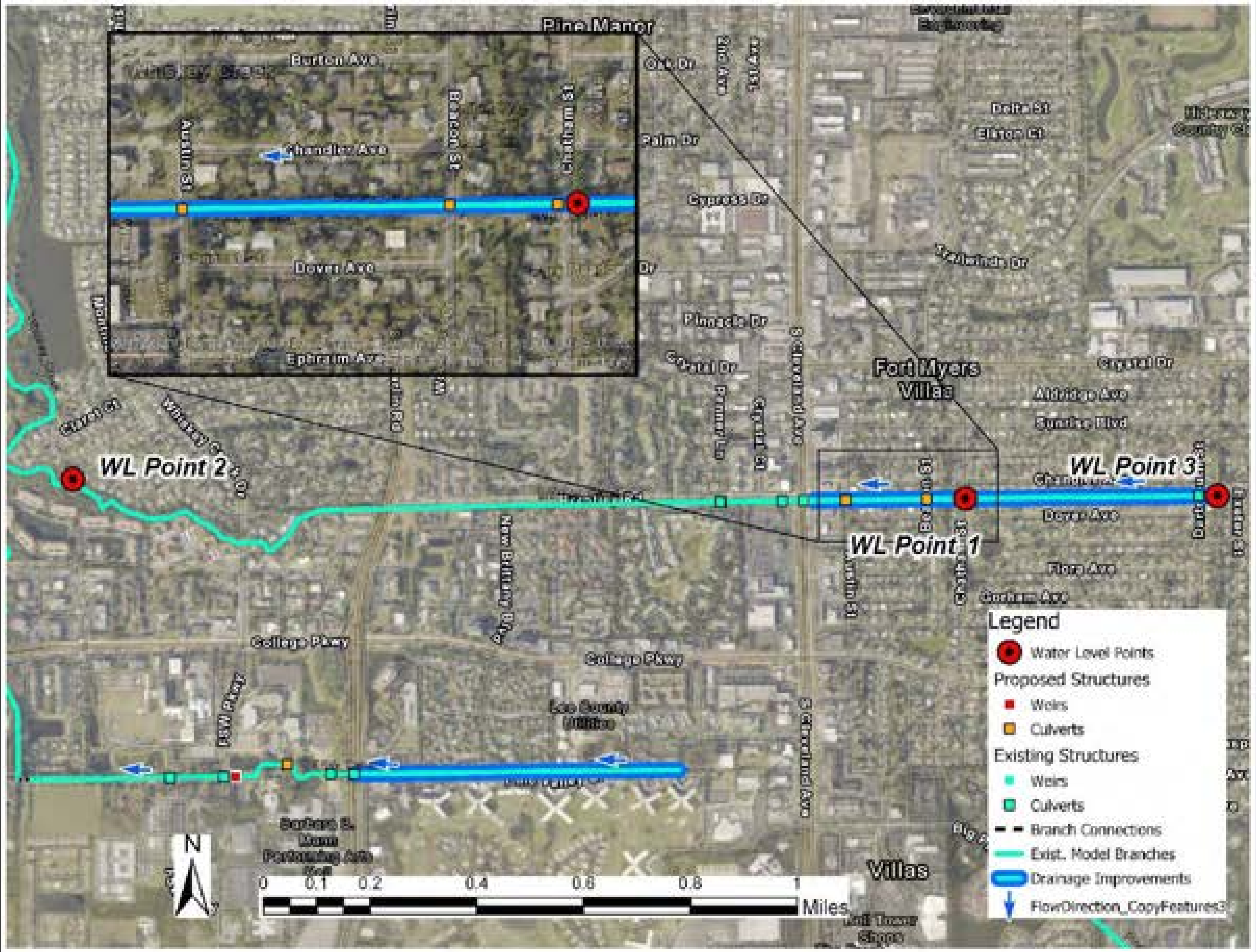
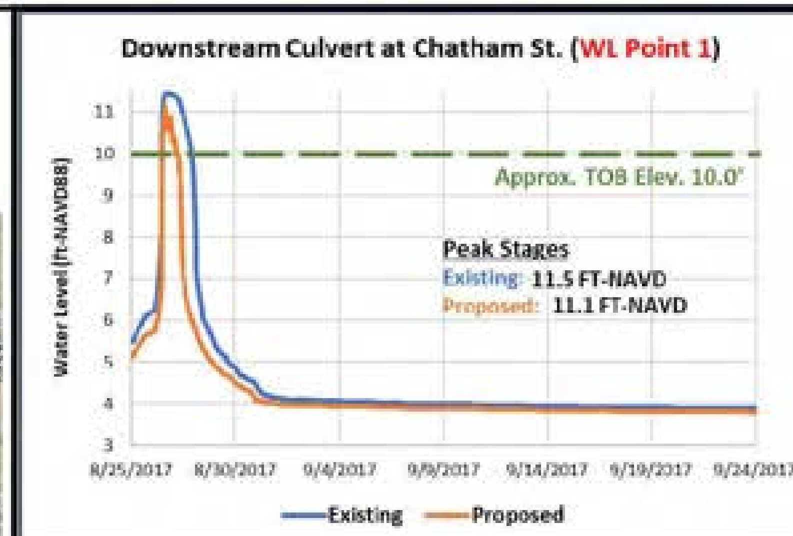
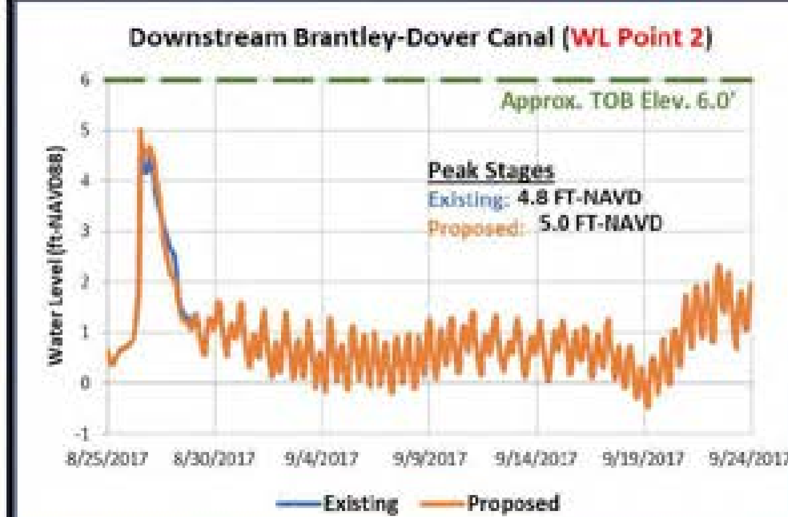
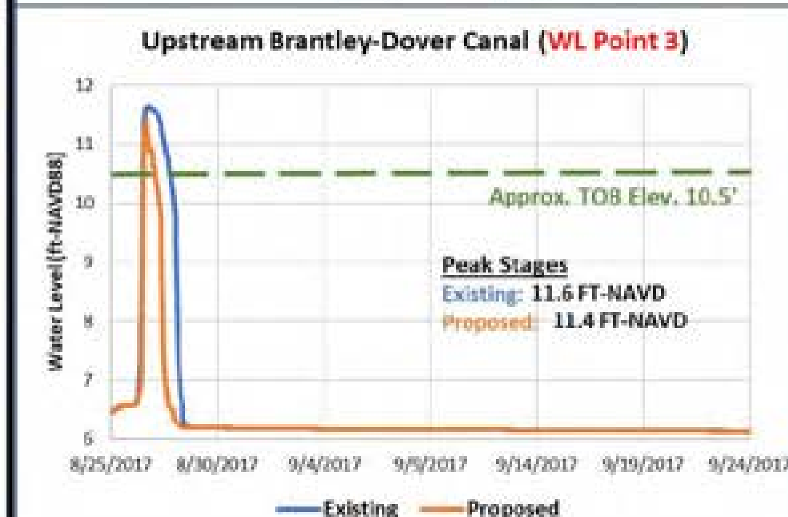


EXHIBIT 1.2.2 (c)







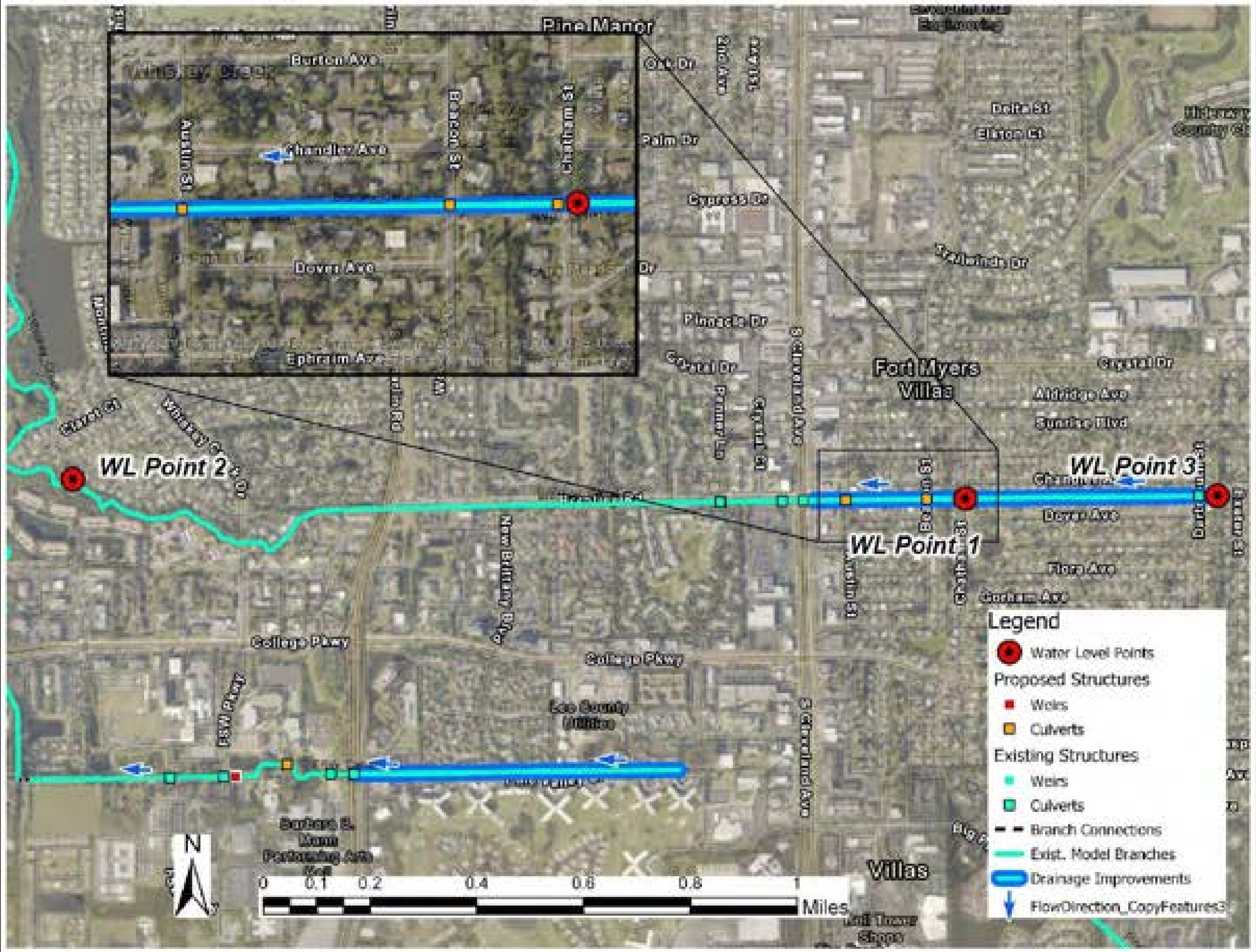


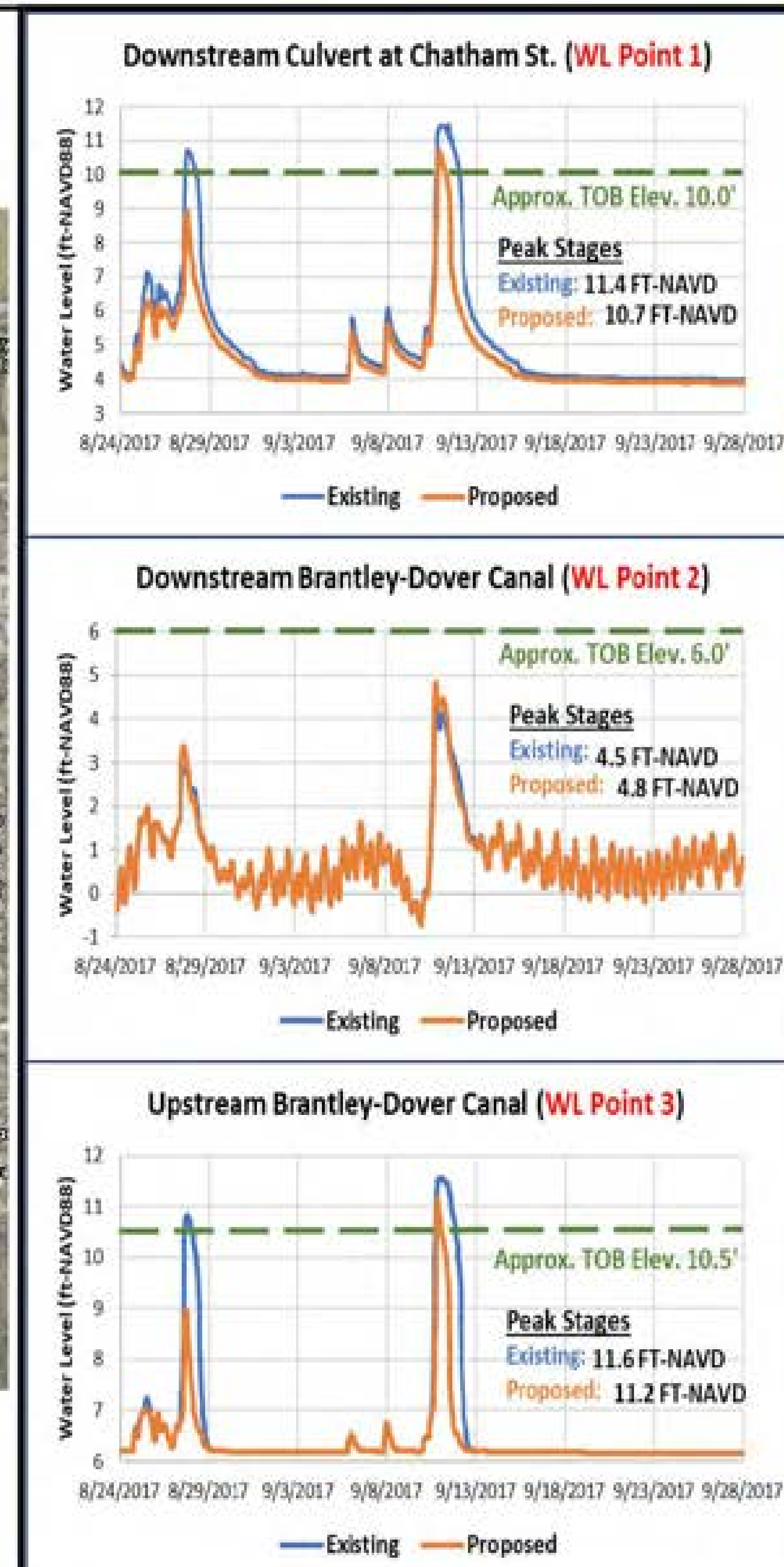
1.2.2 Brantley-Dover Canal Improvements

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.2.2 (d)





1.2.2 Brantley-Dover Canal Improvements

Water Level(s)

Continuous Simulation Hourly

1.2.3 Florida SouthWestern State College Canal Improvements (Iona Drainage District Canal H-7)

Background

This concept project provides for improvements in the conveyance capacity of the Florida SouthWestern State College Canal (FSWSCC) (Iona Drainage District Canal H-7) in the area of the college and areas upstream and creation of additional flood compensation volume in the area of the college. Based upon regional model results and reported flooding within the neighborhood upstream of the college as described previously, a series of structures (including a downstream weir structure) were identified as targets for improvement in the conveyance capacity and flood compensation volume. Due to the urbanized nature of this area, limited opportunity exists for defining offline storage.

Location

The FSWSCC is a primary drainage canal that flows east off the southern end of Whiskey Creek. The FSWSCC is approximately 1.3 miles in length. The proposed project area is in Sections 15, 14, 22 and 23 of Township 45 south, and Range 24 east, as illustrated in **Figure 16**.

Figure 16 – Location Map, 1.2.3 FSWSCC Improvement Project

Description

As described previously, the areas around the FSWSCC were not a significant focus of the post-Irma flooding assessments in the Whiskey Creek watershed. The determination of flooding issues came from reports out of a local neighborhood upstream of FSW that experienced flooding issues. These issues were raised within correspondence, exhibits and a report provided to Lee County.

Based on the materials provided, field visits, evaluation of conditions at the site, and MIKE-11 modeling, it was identified that the weir structure on the FSW campus holds the water in the system up to a level that creates backwater issues in the upstream areas. Additionally, a significant restriction point was identified upstream of the weir structure. This was a single culvert connecting the two ponds (versus multiple same-size culverts at crossings upstream). The images (**Figure 17**) show the drop inlet structure and the culverts upstream of the structure. The locations of the photos are shown on **Figure 17**.

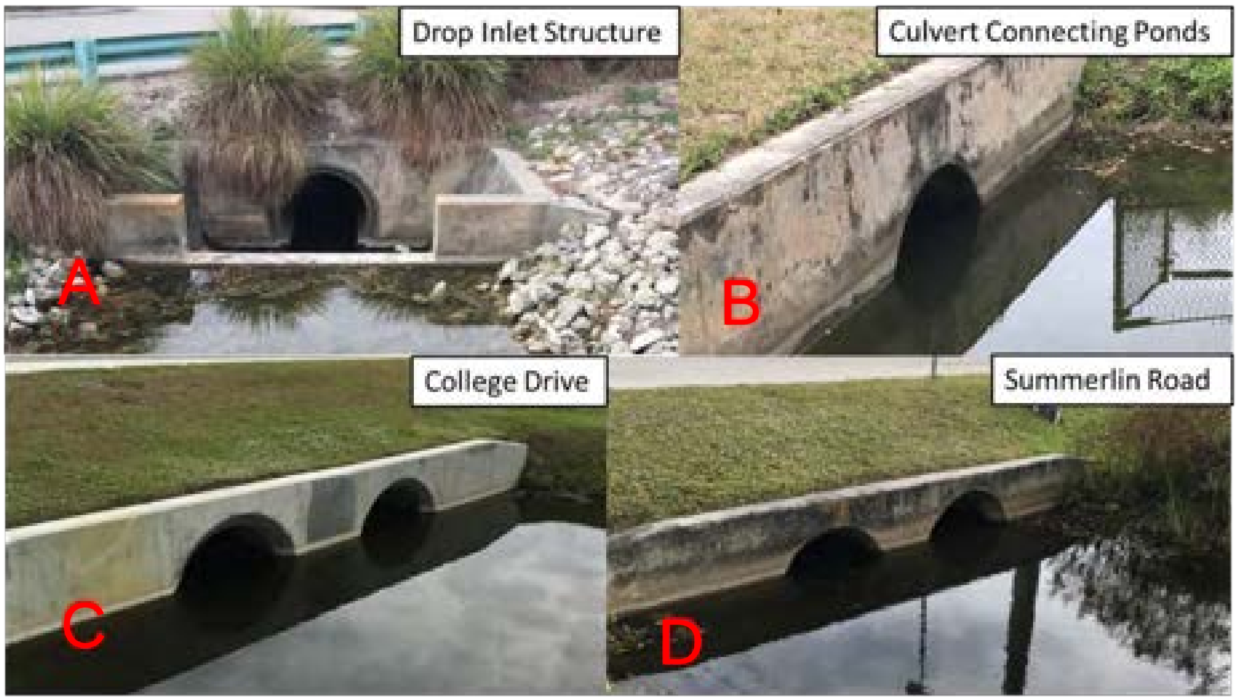


Figure 17 – Photos of Weir Structure and Culverts within FSWSCC Project Area

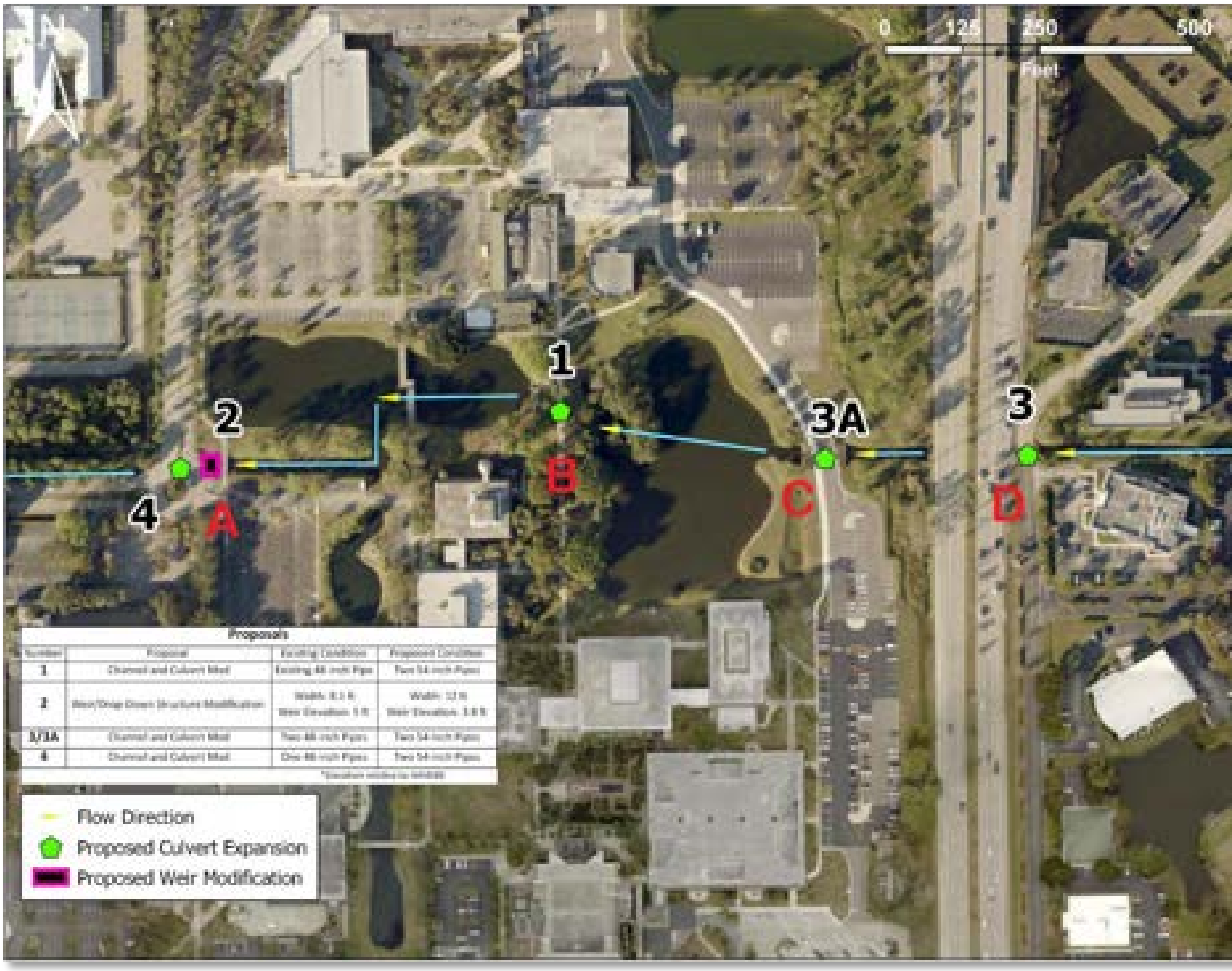


Figure 18 – Concept Plan for FSWSCC

Purpose

Figure 18 presents the proposed concept plan. The concept plan includes modifying the drop inlet structure (including widening and lowering), increasing the size and adding an additional culvert below the weir structure, increasing the number of culverts connecting the ponds to two and increasing the size, increasing the sizes of the culverts upstream of the ponds (at College Drive and Summerlin Road), and minor channel widening near the culvert improvements. For the weir structure, the recommendation would be to have the opportunity to raise and lower the weir to maintain pond levels in the college (for aesthetic reasons) during normal operations while allowing for lowering in preparation for potential storms. These modifications will increase the overall conveyance capacity of the system during storm conditions while maintaining the aesthetic conditions on the ponds during normal operations. Additionally, the size or number of culverts immediately downstream of the weir structure should be evaluated based on the increased capacity upstream and the lowering of the weir.

Prior to final determination of the modifications to the weir structure and culvert types and sizing, local modeling of the area should be completed to provide a more detailed evaluation of the existing response and the resultant benefits in local flooding. The resolution of the regional model in this area is relatively coarse and does not reflect the more detailed aspects of flow and conveyance in this area.

Evaluation

Viability

The project is to modify an existing weir structure and downstream culvert, and replace three culvert crossings upstream with larger culverts, so the concept has a high level of viability. Detailed design considerations would include evaluation of the pipe sizes and associated materials related to road cover and clearance for structural integrity, but the crossings should be sufficient to accommodate pipes or other culvert configurations to achieve the cross-sectional area and friction as defined by the simulated 54-inch culverts.

Community Considerations

The work being done in the ponds at the college will require coordination and planning to minimize unnecessary interruptions and inconveniences for FSW. Additionally, reducing the water level in the ponds may significantly impact the overall aesthetics of the ponds. This may warrant coordination and discussions with FSW. A suggested solution is an adjustable weir in the structure that is dropped down in response to storm events. Additional issues could include access or easements required for proposed improvements and issues of pond aesthetics for the college.

Environmental & Permittability Considerations

Future design efforts will need to assess the impact of any modifications to the system that, while improving flow, may reduce retention time needed for water quality treatment. The Caloosahatchee has existing TMDL/BMAP allocations so that increases in loading, through reductions in retention and residence times, would need to be assessed. The future design may need to consider BMPs such as low ditch blocks and additional storage downstream of the weir to mitigate for the increased loads during flooding events. Permitting is not anticipated to be complicated for this project beyond the considerations noted above.

Land Availability

No work being done will require land acquisitions. An easement for access to the pond might have to be granted by FSW.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $10,000. The project cost is anticipated to increase with inflation or changes in future market conditions.

Opportunities for Multiple Benefits & Uses

There are no proposed components to this project besides the hydraulic/hydrologic benefits.

Other Considerations

Other considerations include limitations in weir modifications; maintaining aesthetics of college lakes; replacing major crossings to achieve conveyance, and localized conveyance and available capacity issues in the upstream neighborhoods.

Table 5 – Opinion of Probable Cost breakdown, 1.2.3 FSW State College Canal Improvement Project

Construction Costs				
Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1.0	LS	$ 41,915.96	$ 41,916
Clearing & Grubbing	0.5	AC	$ 14,000.00	$ 7,000
Erosion Control	1000.0	LF	$ 2.39	$ 2,390
Earthwork	3800.0	CY	$ 6.00	$ 22,800
Grassing	2000.0	SY	$ 2.00	$ 4,000
54-Inch Culvert	850.0	LF	$ 283.09	$ 240,627
- 4 locations with two segments of culverts				
Modify Existing Drainage Structure	1.0	LS	$ 2,623.25	$ 2,623
Canal Structure	1.0	Ea.	$ 29,720.00	$ 29,720
Road Repair - Per 100 S.F	5.0	Ea.	$ 890.39	$ 4,452
Selective Demolition	3000.0	SY	$ 9.53	$ 28,590
Conceptual Construction Costs:				$ 390,000
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 120,000
Project Administration/ CEI (10%)				$ 40,000
Project Unknowns				$ 30,000
Conceptual Project Cost:				$ 580,000
Contingency (30%)				$ 180,000
Conceptual Project Cost (with Contingency):				$ 760,000

Note:

Price of Canal Structure was estimated for a manually controlled gate.

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Findings & Recommendations

Regional Modeling Findings

The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.2.3**. Exhibits 1.2.3(a) through 1.2.3(h) present water level and flow results for the various storms run with the Regional Model. **Table 6** presents the Storm Events run along with the results provided and the exhibits where they are shown.

Table 6– Regional Model Storm Event Conditions and Results

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.2.3 (a) EXHIBIT 1.2.3 (b)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.2.3 (c) EXHIBIT 1.2.3 (d)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.2.3 (e) EXHIBIT 1.2.3 (f)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.2.3 (g) EXHIBIT 1.2.3 (h)

The design recommendations for this concept project were based on the 25-year, 3-day design storm as presented in Exhibits 1.2.3 (a and b). The regional model provides for time series hydrographs of water level through the storm event at three locations and flows at one location. Descriptions of the locations are provided as follows:

- WL Point 1: upstream of Summerlin Road adjacent to the Provincetown subdivision
- WL Point 2: within the FSW ponds
- WL Point 3: at the downstream end of the FSWSCC
- Flow Point 1: immediately downstream of the weir structure

For the 25-year, 3-day design storm, the model shows that upstream of Summerlin Road, the peak water levels reduced from 6.1 feet NAVD down to 3.9 feet NAVD, while at the college ponds, the water levels are reduced from 5.9 feet NAVD down to 3.7 feet NAVD. These are significant reductions in peak water levels. Downstream, at the end of the FSWSCC, the water levels do not show an appreciable change due to the proposed project.

Following the design storm iterations and the determination of the concept project design components, additional storms were run. These included the three other storm conditions outlined in **Table 6**. These are the 100-year, 3-day storm with a start in July, the 100-year, 3-day storm with a start in August, and finally the continuous hourly simulation that spanned the period from 8/24/2017 through 9/28/2017. The following discusses the results from each.

For the 100-year 3-day storm (starting in July), the model shows that upstream of Summerlin Road, the peak water levels reduced from 7.3 feet NAVD down to 4.4 feet NAVD, while at the college ponds, the water levels are reduced from 7.0 feet NAVD down to 4.2 feet NAVD. These are significant reductions in peak water levels. Downstream, at the end of the FSWSCC, the water levels do not show an appreciable change due to the proposed project.

For the 100-year, 3-day storm (starting in August) the model shows that upstream of Summerlin Road, the peak water levels reduced from 8.7 feet NAVD down to 7.4 feet NAVD, while at the college ponds, the water levels are reduced from 8.3 feet NAVD down to 6.6 feet NAVD. The reductions in water level under the wetter antecedent conditions are not as significant as those seen for the dryer antecedent condition. Downstream, at the end of the FSWSCC, there is a slight increase in the post-condition water levels (0.4 foot rise). An additional benefit from the proposed project under this condition are significant reductions in the duration of high water.

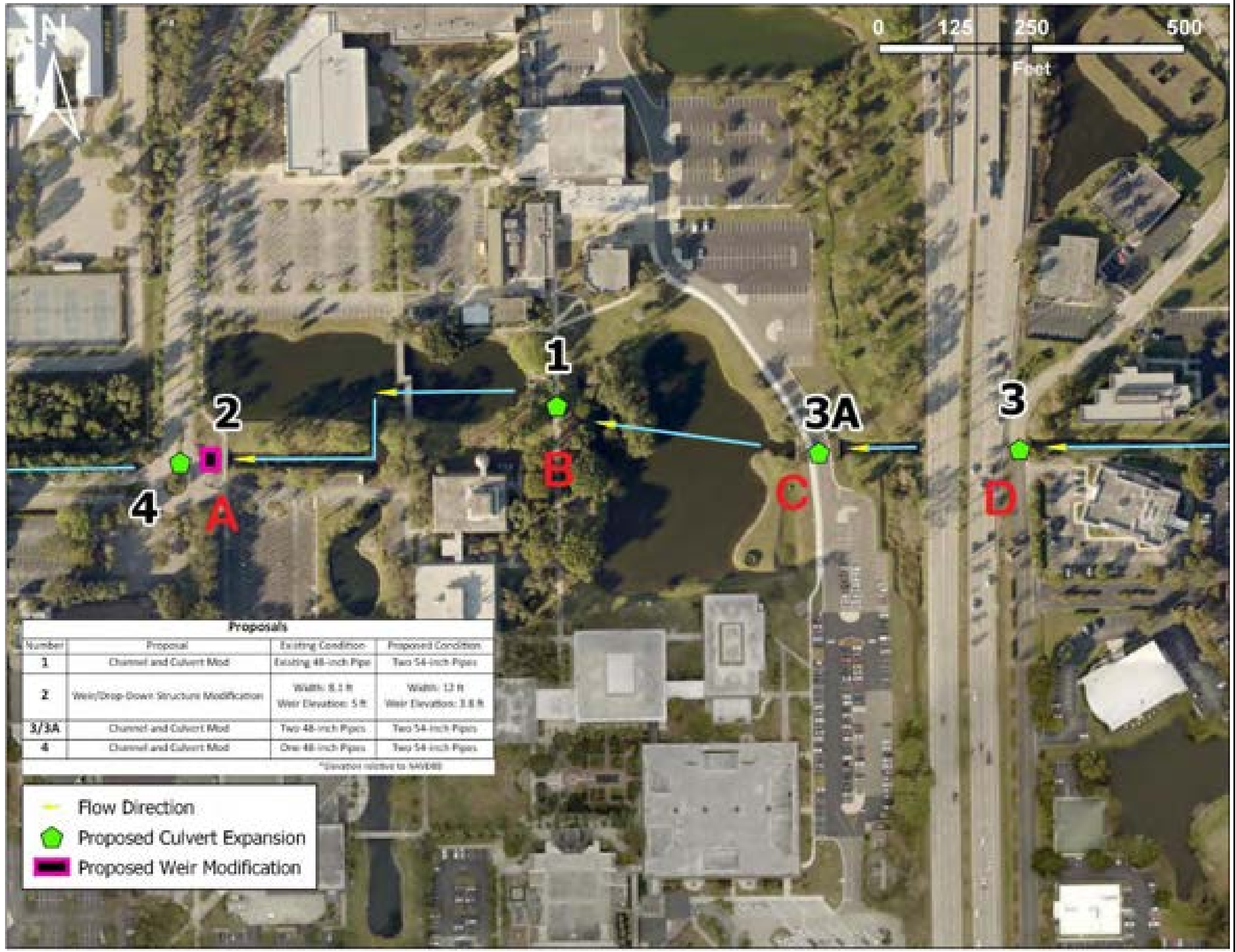
For the continuous simulation, which spans the period of rainfall and storm conditions around Hurricane Irma, the reductions seen in the peak water levels are similar to those seen for the 100-year storm conditions, with the two storm peaks reflecting the dryer antecedent conditions for the first peak and the wetter for the second peak. The peak water level changes (and the associated potential area of flooding changes) along with the durations reflect what was seen for the dry and wet 100-year 3-day events.

Recommendations

The positive improvements of this project demonstrated by the modeling results warrant proceeding to project development.

EXHIBIT 1.2.3

Concept Plan

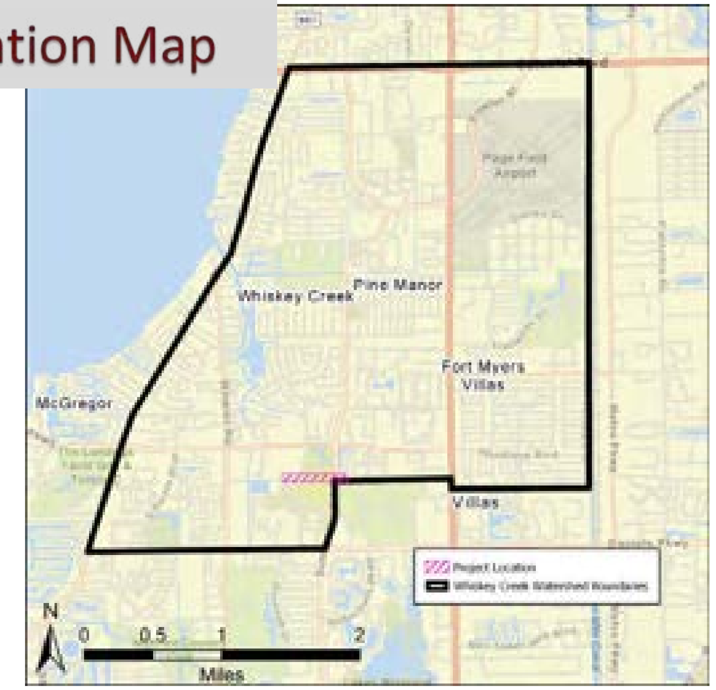


Proposals

Number	Proposal	Existing Condition	Proposed Condition
1	Channel and Culvert Mod	Existing 48-inch Pipe	Two 54-inch Pipes
2	Weir/Drop-Down Structure Modification	Width: 8.1 ft Weir Elevation: 5 ft	Width: 12 ft Weir Elevation: 3.8 ft
3/3A	Channel and Culvert Mod	Two 48-inch Pipes	Two 54-inch Pipes
4	Channel and Culvert Mod	One 48-inch Pipes	Two 54-inch Pipes

*Elevation relative to NAVD88

Location Map



Project Narrative

DESCRIPTION: This project is an evaluation of the canal and pond system (flows and constrictions) within, downstream, and upstream of Florida SouthWestern State College to Provincetown Condominiums to identify remedial actions to alleviate flooding upstream of Summerlin Road (Provincetown area). Potential remedial activities include lowering and enlarging an existing weir and enhancing culverts on the college property. Linear retention options will be explored for water quality treatment to offset any increase in nutrient loading caused by increased conveyance.

PURPOSE: The primary purpose is to improve drainage south of College Parkway that flows east under Summerlin Road, potentially to the Provincetown residential area.

CONSTRAINTS: Potential constraints include limitations in weir modifications, maintaining aesthetics of college lakes, and replacing major crossings to achieve conveyance.

February 2019

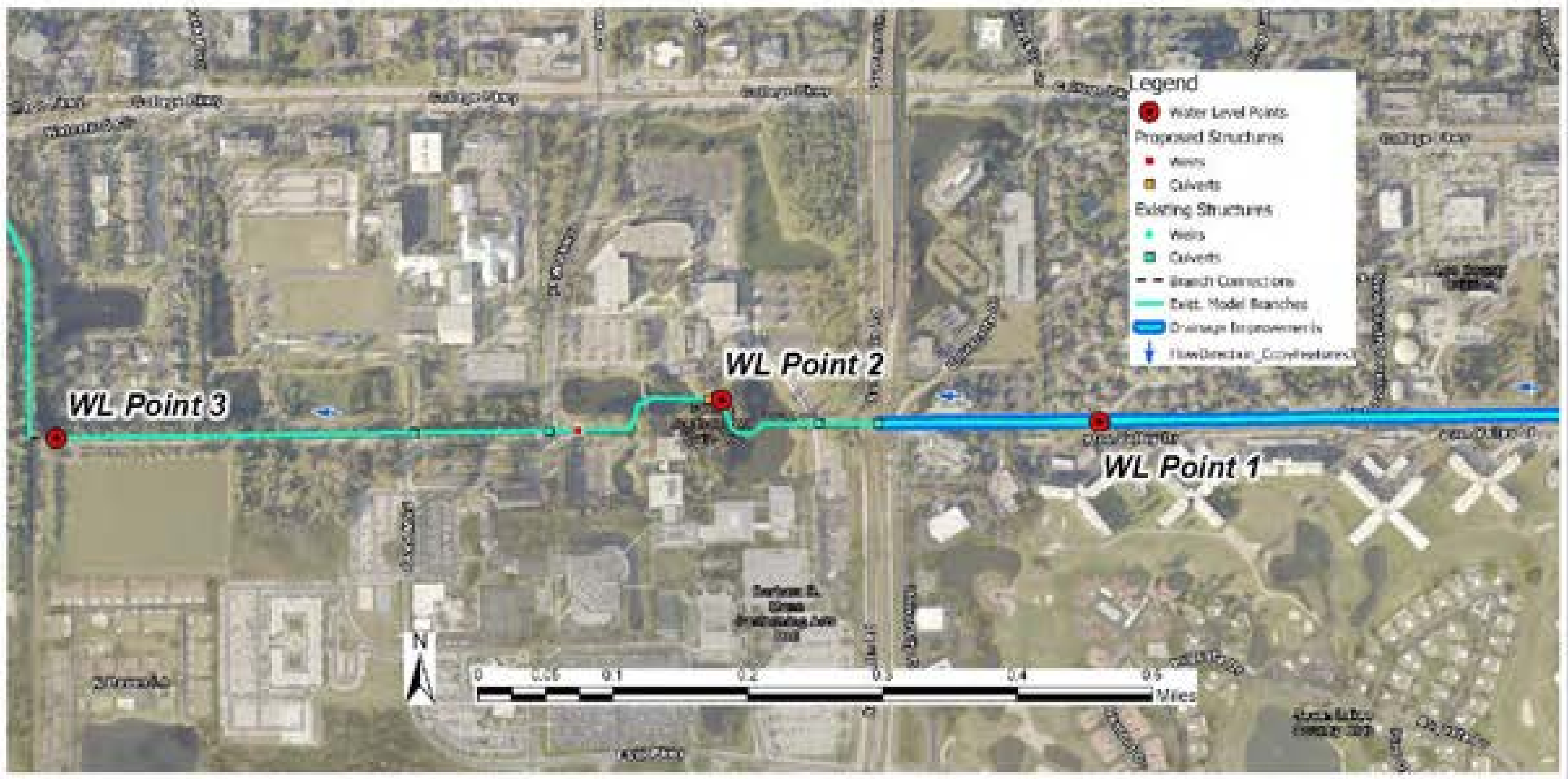
S. Whiskey Creek Drainage Improvements – Concept Plan

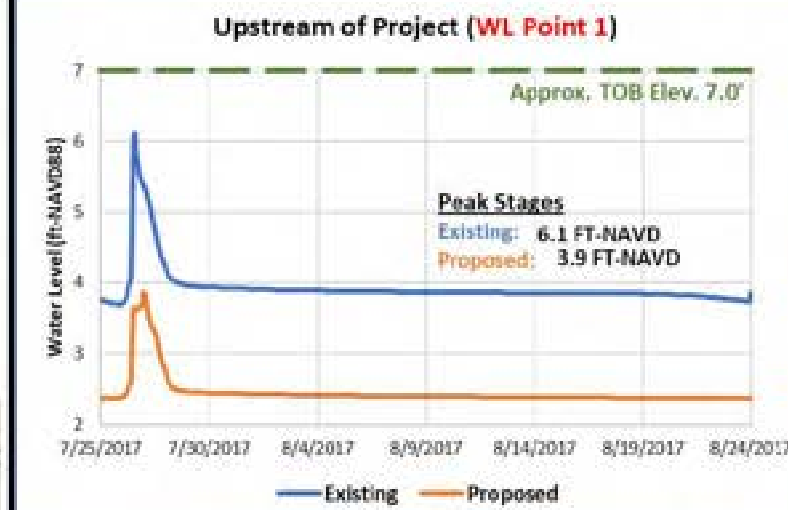
Whiskey Creek Watershed

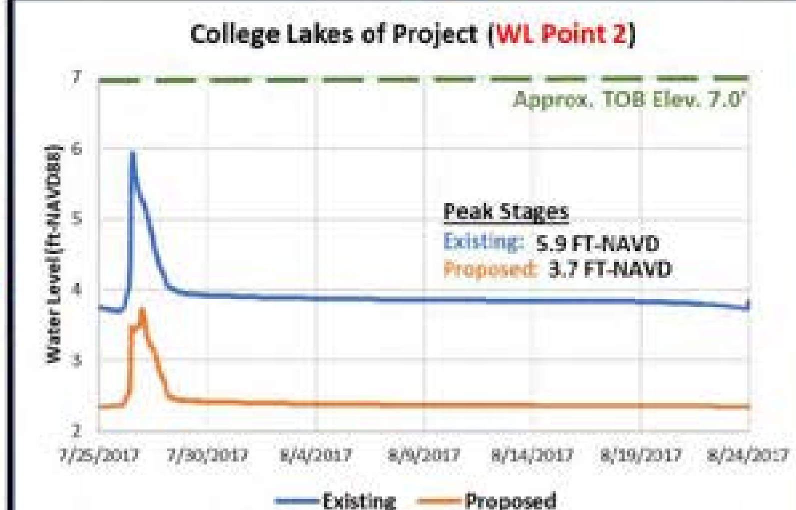
Applied Technology & Management
2201 NW 40th Terr.
Gainesville, FL 32605
(386) 256-1477
www.appliedtm.com
ATM DESIGN ENGINEERING CONSULTING

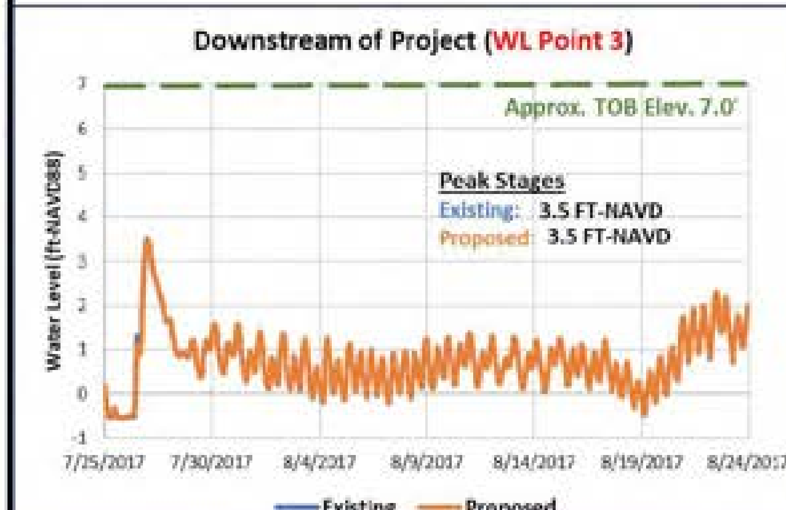
EXHIBIT 1.2.3

EXHIBIT 1.2.3 (a)







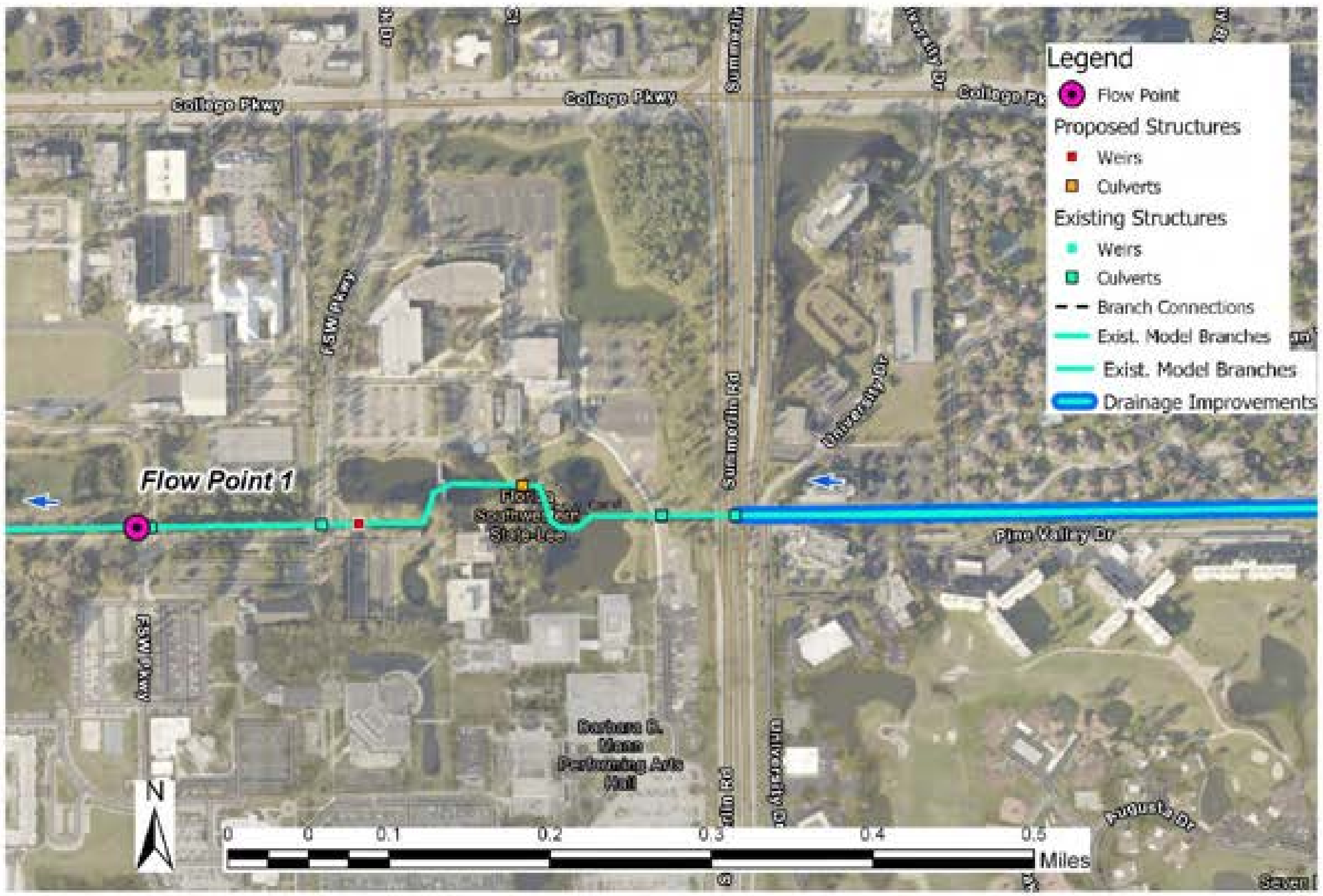


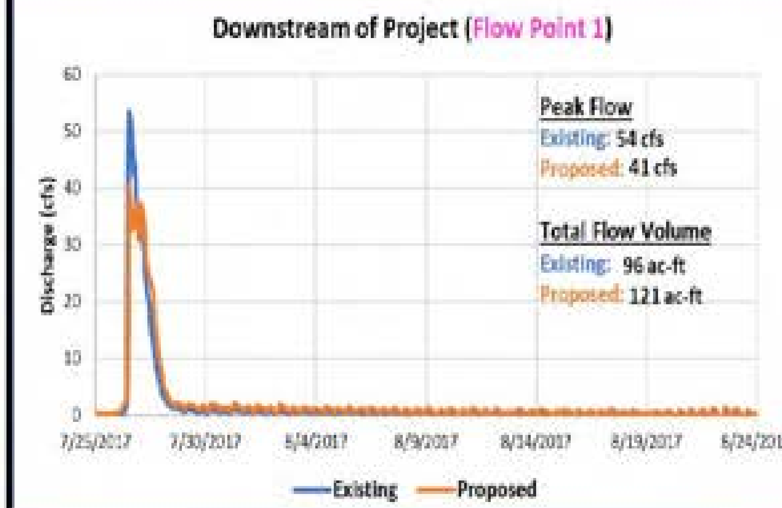
1.2.3 Edison College Branch Improvements

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.2.3 (b)



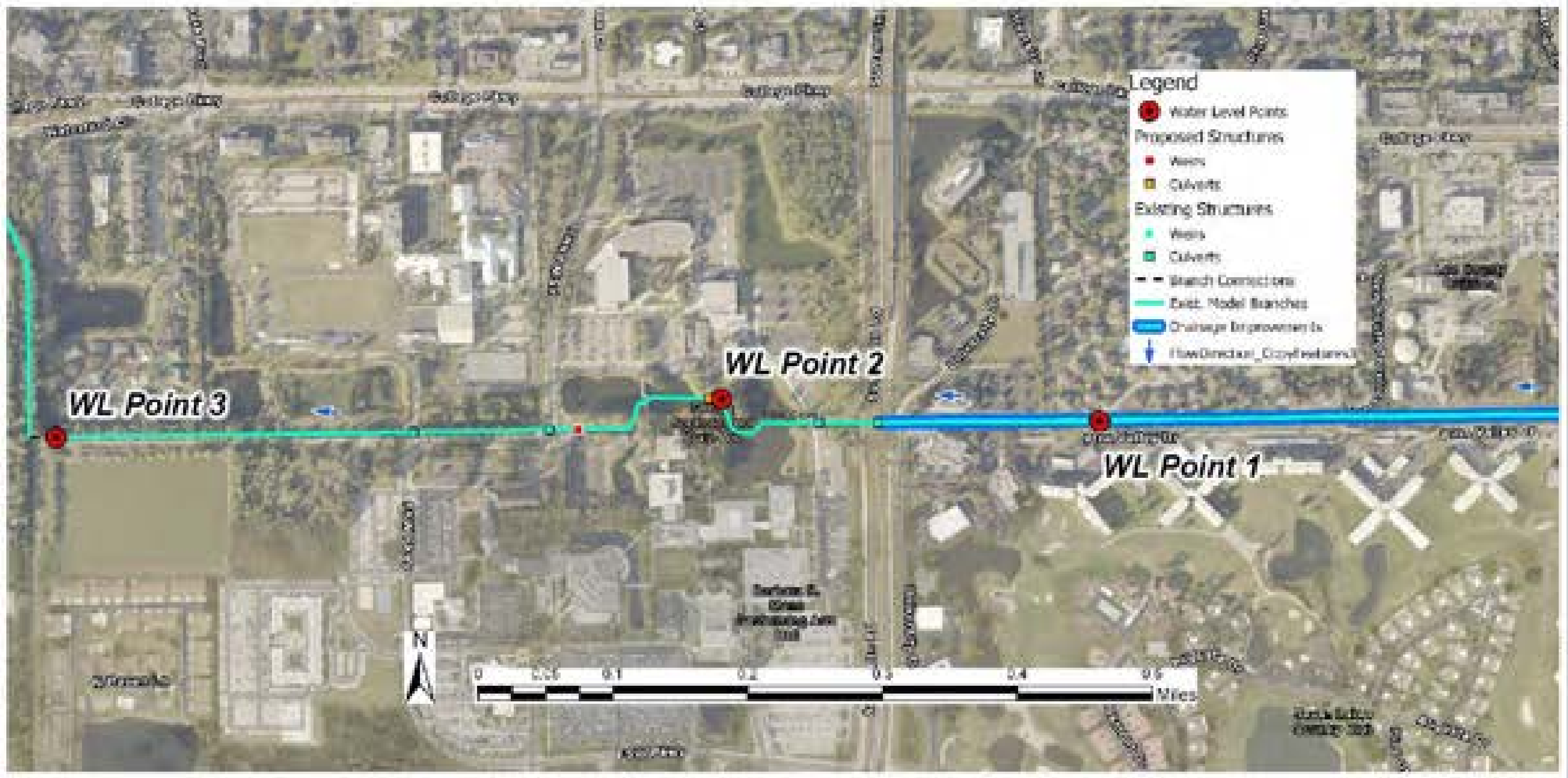


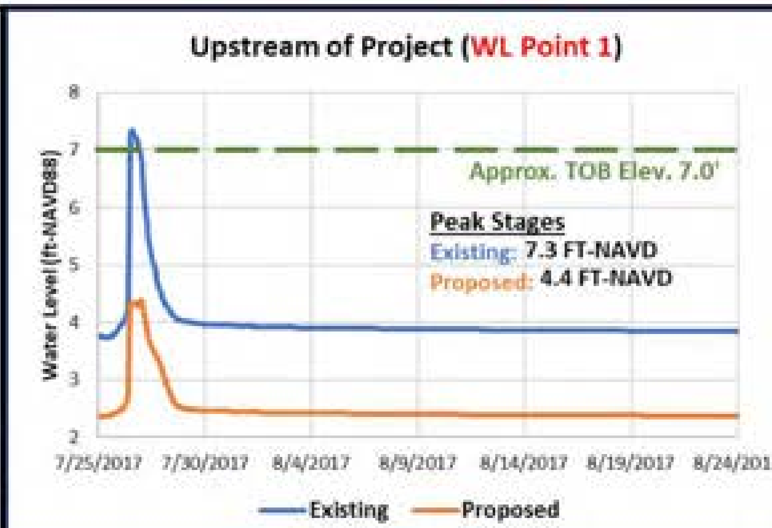
1.2.3 Edison College Branch Improvements

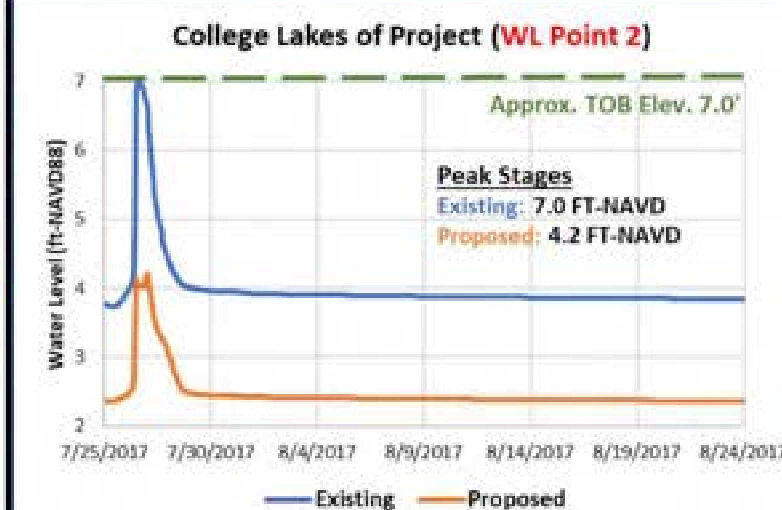
Flow(s)

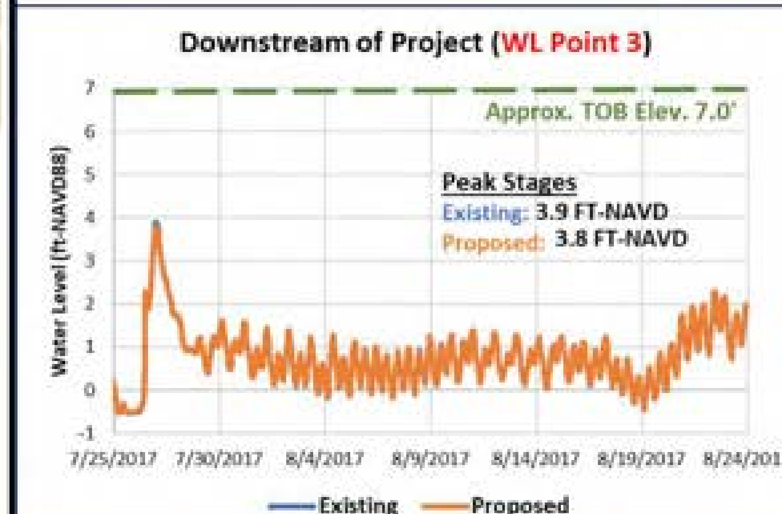
25-yr 3-day (Jul Start)

EXHIBIT 1.2.3 (c)







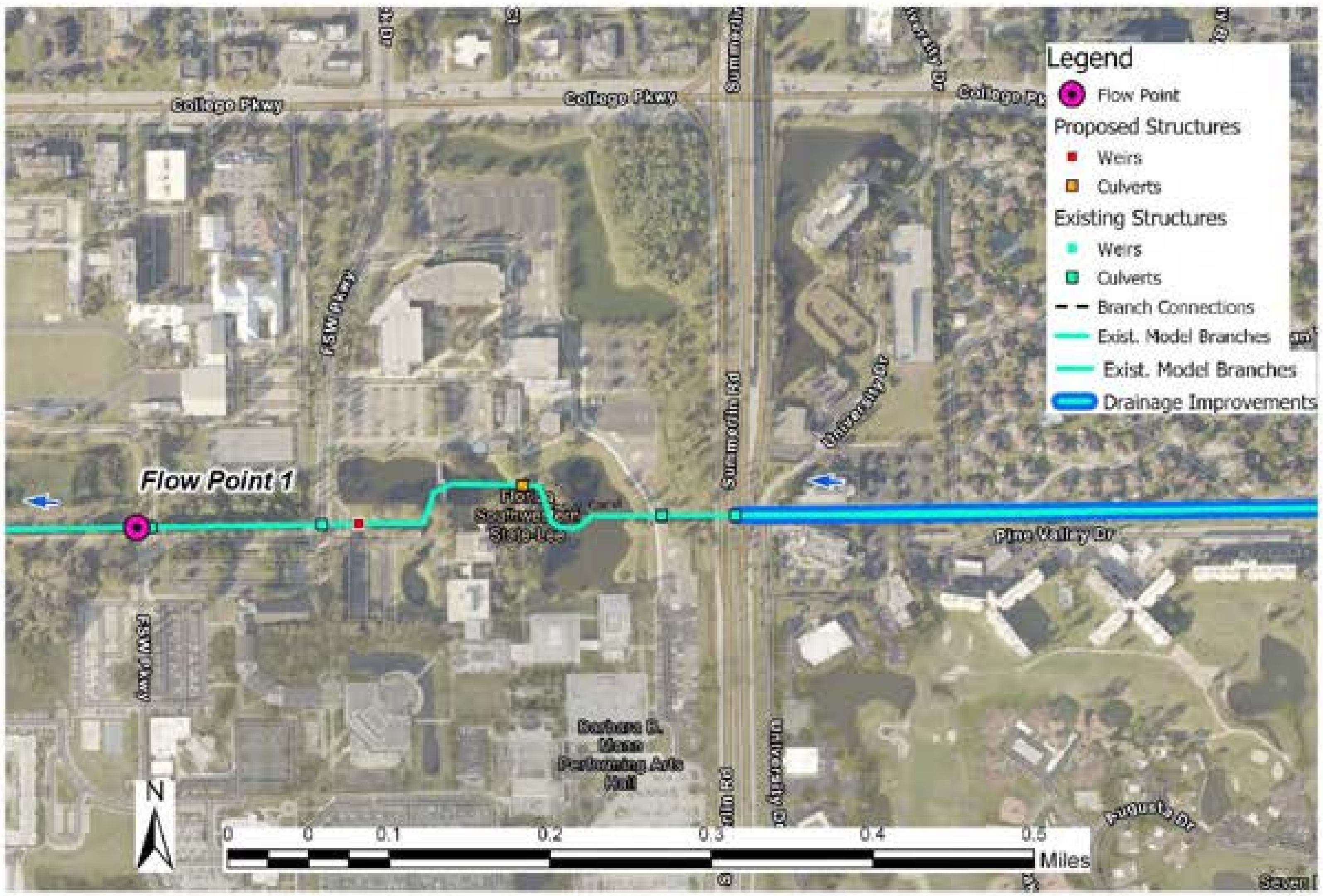


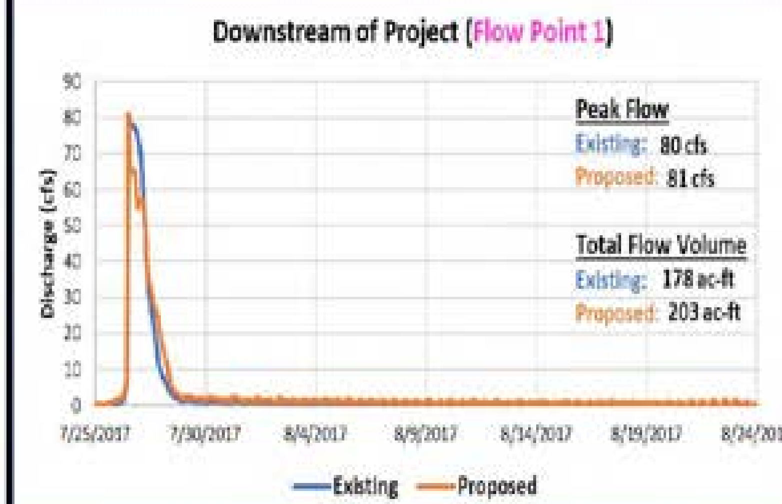
1.2.3 Edison College Branch Improvements

Water Level(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.2.3 (d)





1.2.3 Edison College Branch Improvements

Flow(s)

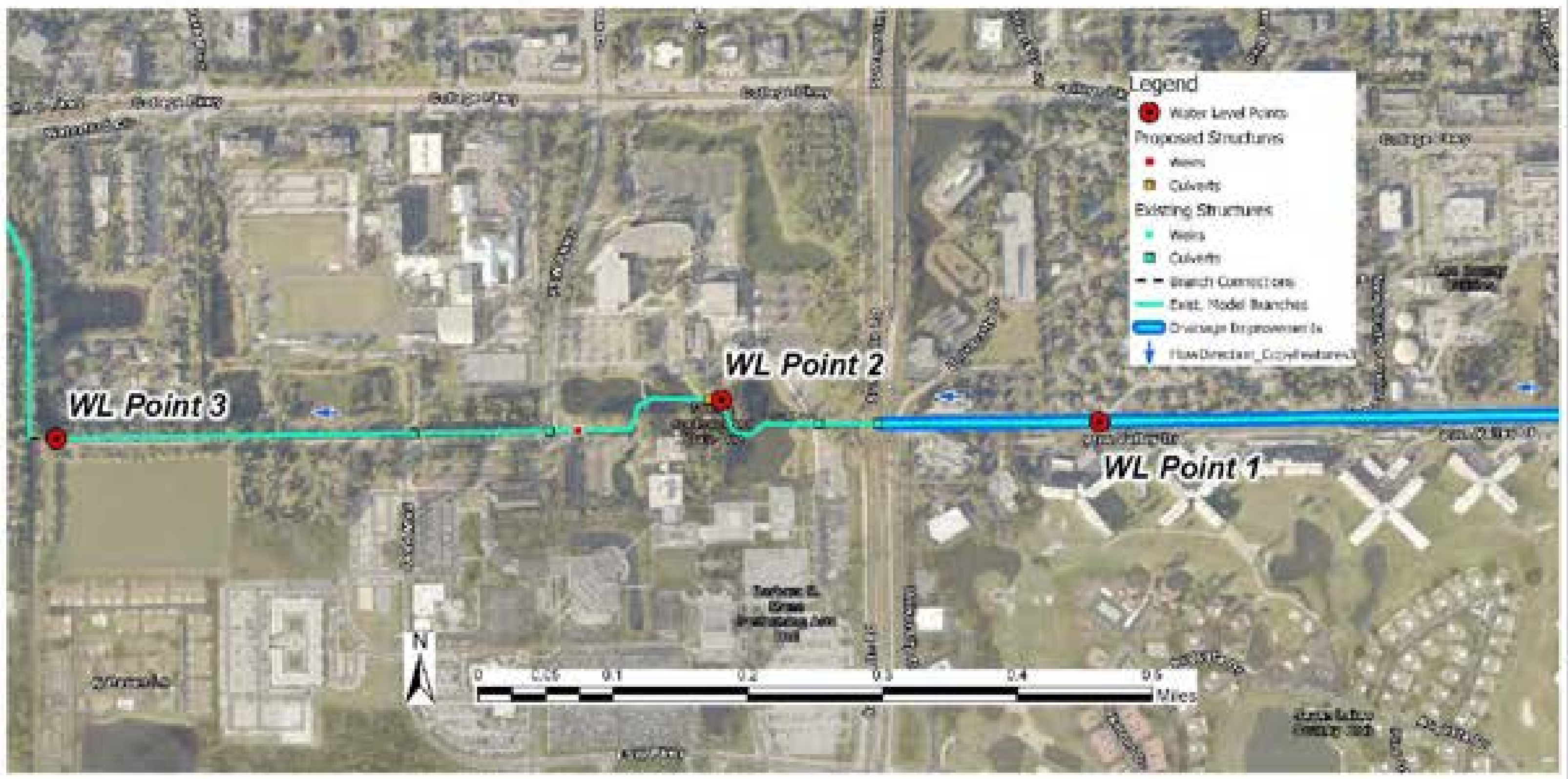
100-yr
3-day
(Jul Start)

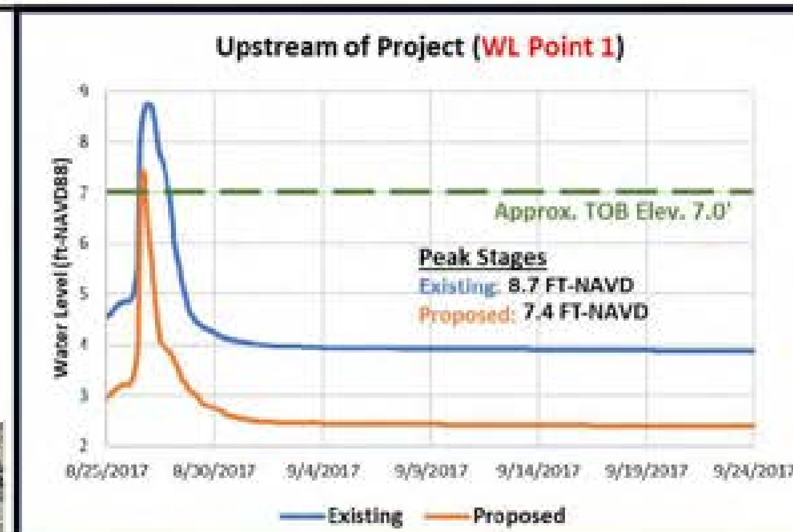
EXHIBIT 1.2.3 (e)

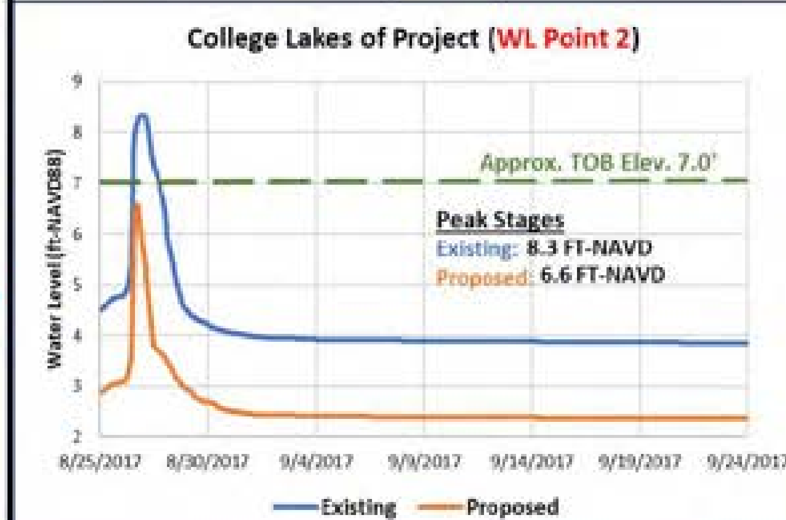
1.2.3 Edison College Branch Improvements

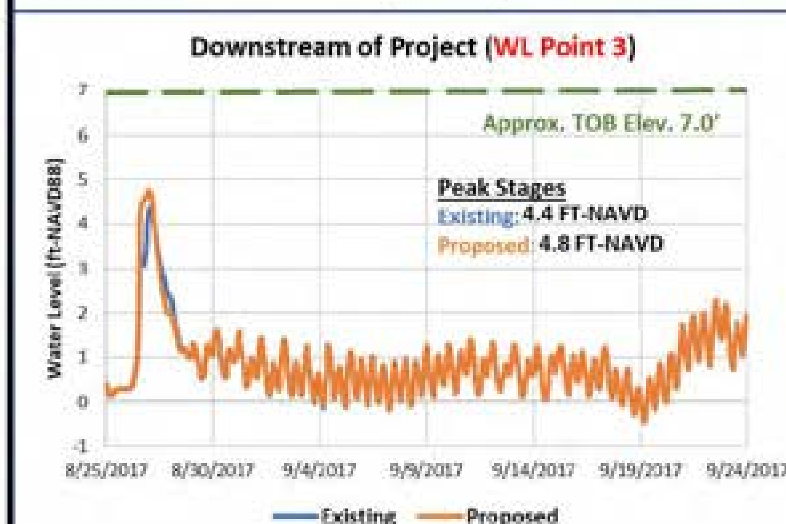
Water Level(s)

100-yr 3-day Aug Start)









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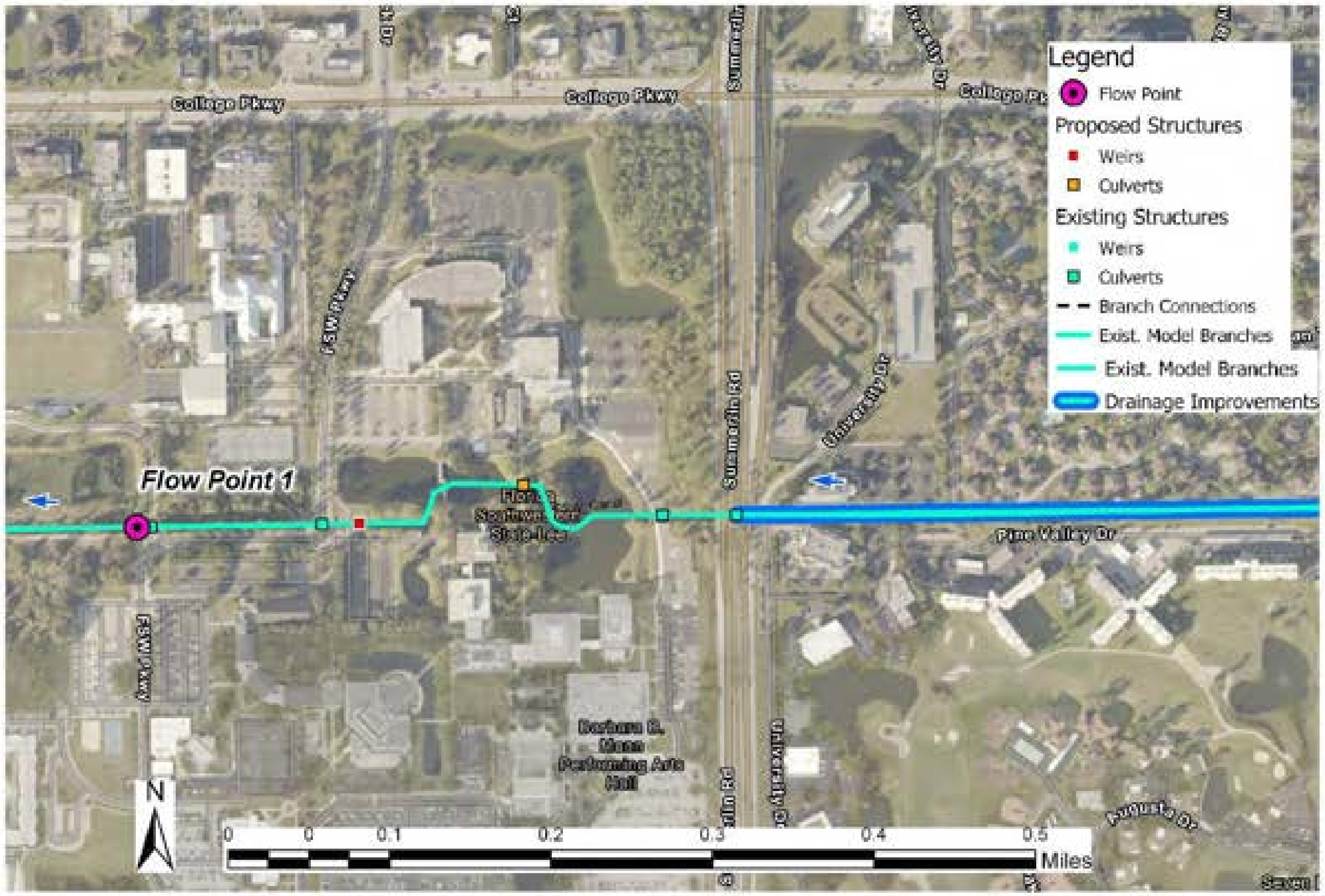
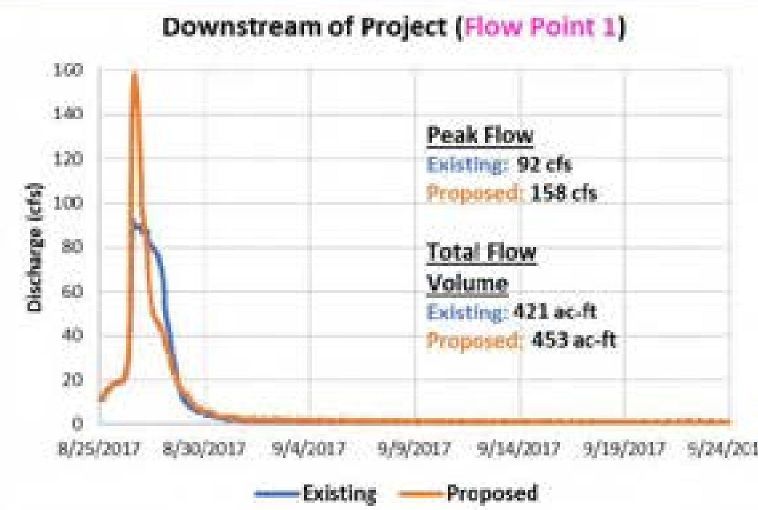


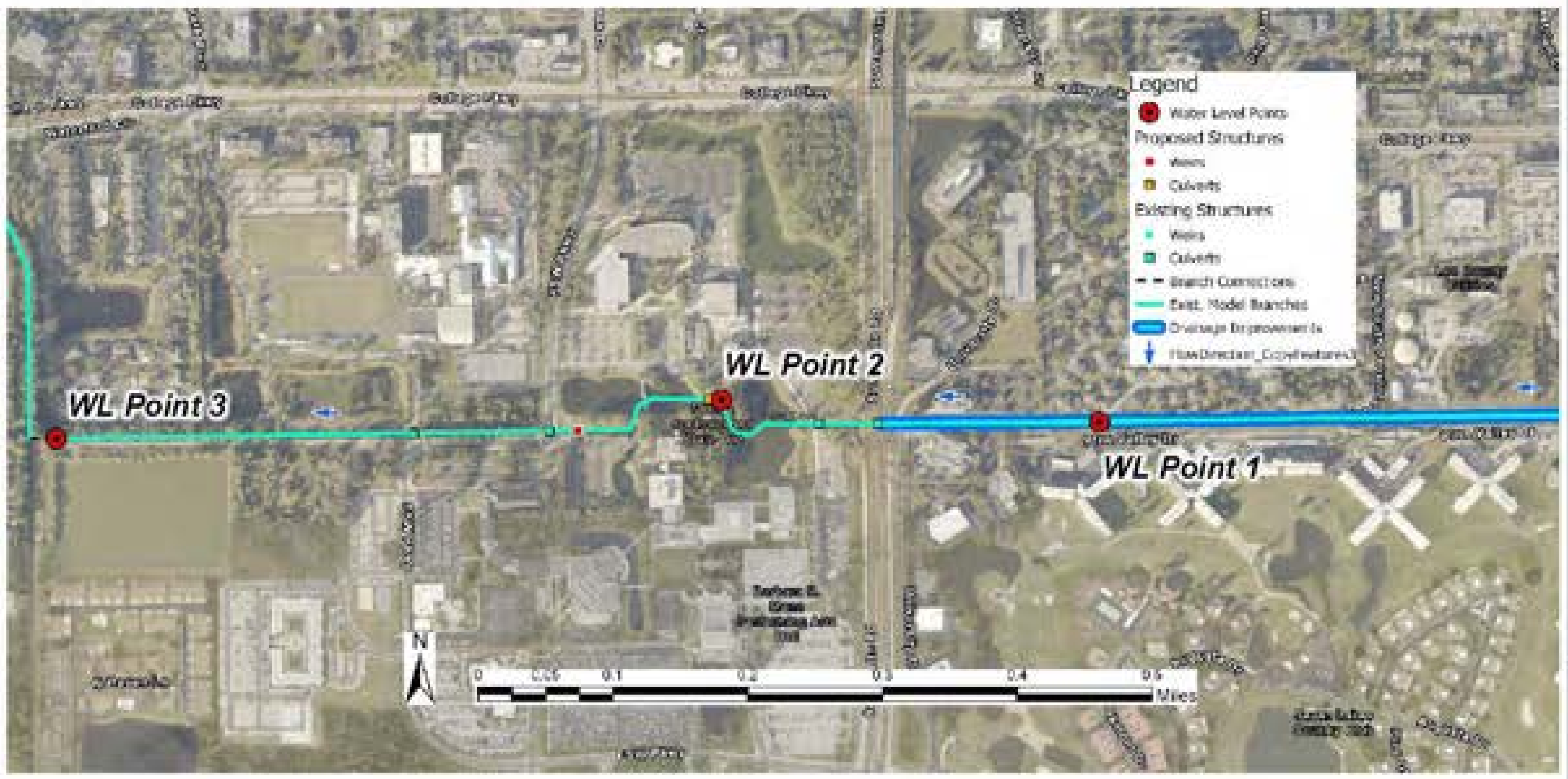


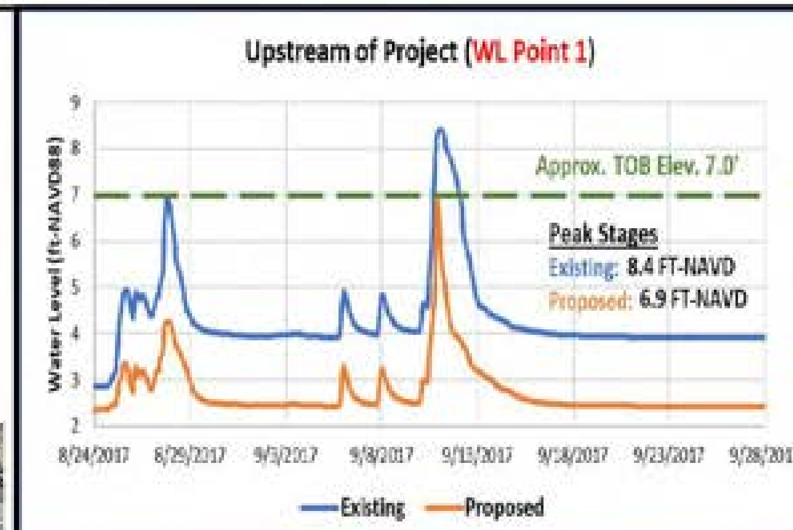
1.2.3 Edison College Branch Improvements

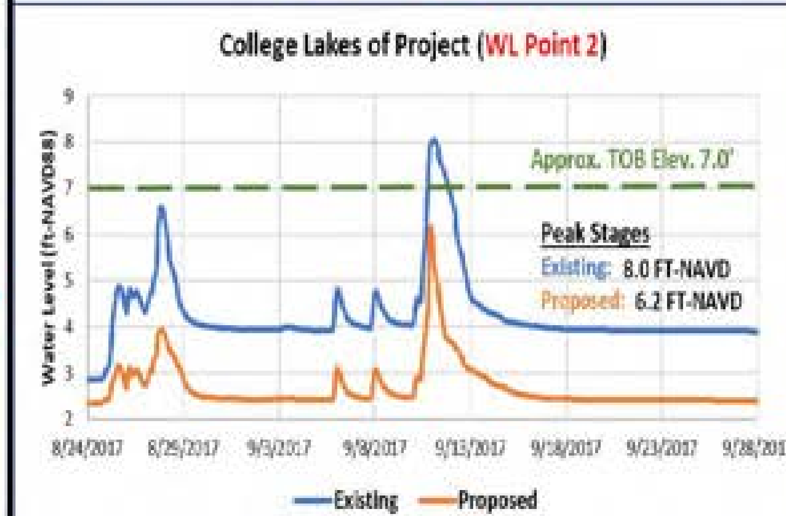
Flow(s)

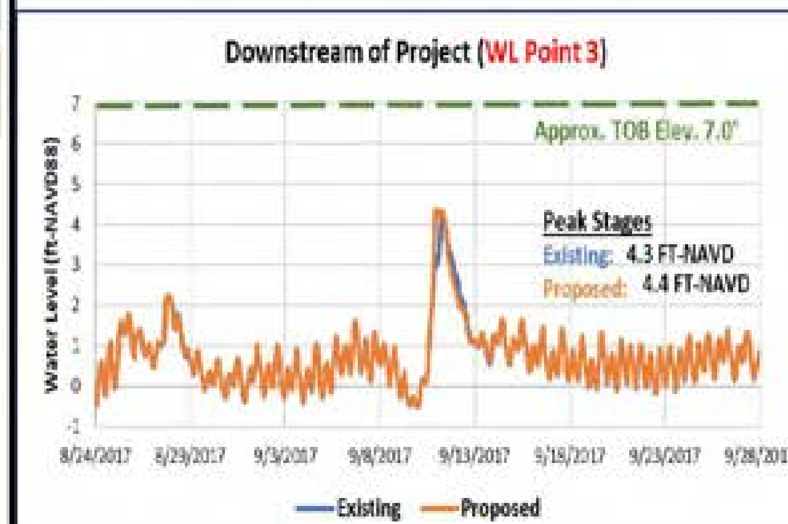
100-yr 3-day (Aug Start)

EXHIBIT 1.2.3 (g)









1.2.3 Edison College Branch Improvements

Water Level(s)

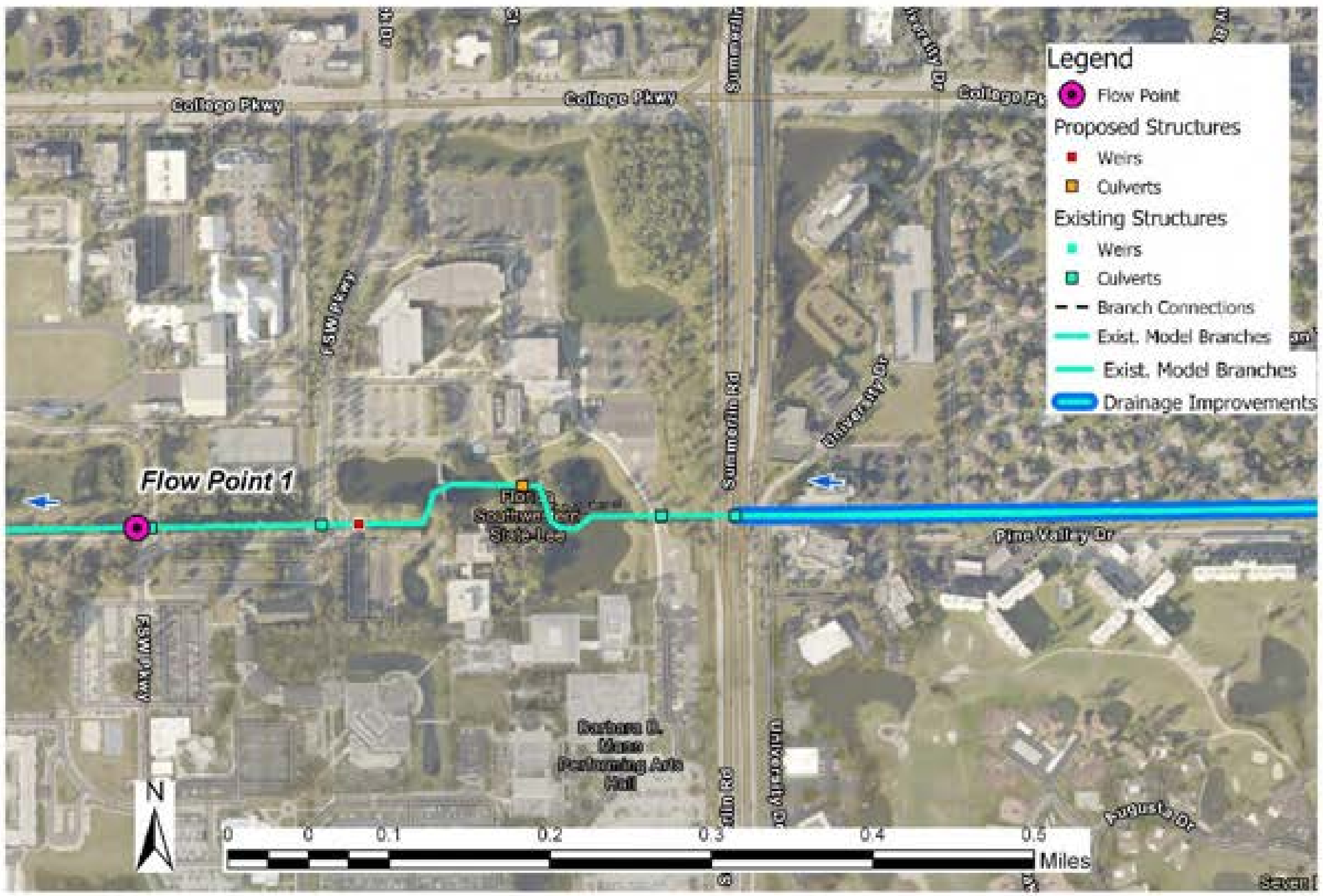
Continuous Simulation Hourly

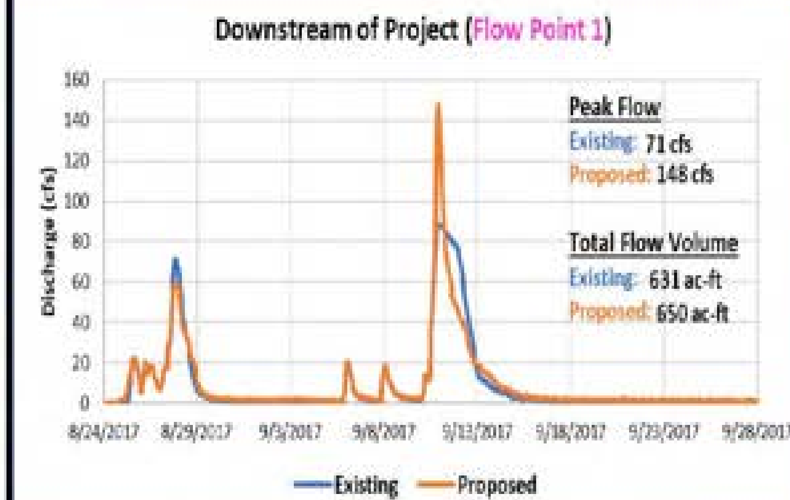
EXHIBIT 1.2.3 (h)

1.2.3 Edison College Branch Improvements

Flow(s)

Continuous Simulation Hourly





1.3 SOUTH EAST LEE COUNTY FLOOD MITIGATION AREA

BACKGROUND

The South East Lee County flood mitigation area is approximately bounded by S.R. 82 on the north, the Lee/Collier County line to the east, the Lee/Collier County line on the south and the Estero Bay to the west. The area is approximately 200 square-miles and contains the Village of Estero, the City of Bonita Springs, the FGCU campus, many golf courses, several existing and proposed mine lakes and vast natural wetlands under governmental ownership. The watershed varies in land elevation from a high of 28 feet above sea level down to tidal waters in the Estero Bay. Drainage in this area is principally dependent on natural overland sheet flow with a few tributaries extending several miles inland from the tidal waters, such as the Estero River, Halfway Creek, Spring Creek, Imperial River and Oak Creek. Linear transportation projects, namely U.S. 41, the railroad and Interstate 75, along with numerous land development projects have interrupted the sheet flow drainage characteristic of this area limiting drainage flow to existing bridges and box culverts that lack connectivity to the tidal waters.

GENERAL COMMENTARY

From the Phase 2 Study of the Invest92L/Hurricane Irma flood impacts in the South East Lee County area, it was generally observed that overland sheet flow from the vast area east of Interstate 75 overwhelmed the small tributaries causing extensive flooding. In addition to having limited flow capacity, the natural systems were impacted with downed trees from high winds, debris, shoaling and other flow impediments that further restricted the water flow resulting in increased flooding levels and extended recovery times for the flood water to recede to normal levels. The high-water levels inundated homes, roads and vehicles thereby affecting the health, safety, and welfare of the public. For flood mitigation, it is proposed that high capacity bypass conveyances and large reservoir storage areas be developed.

To implement the flood mitigation program for this area, a connective approach to link existing drainage structures to one another with a conveyance large enough to handle heavy flows was developed. Normal seasonal flows would continue to the natural systems to maintain the environmental ecosystem of those streams. The focus of the flood mitigation plan is developing a stormwater control system for managing runoff from severe storm events by concentrating on main drainageways in creating a principal outfall system. Minor conveyance connections may be made to the principal drainageways as needed in the future to address localized flow restrictions. Where practical, opportunities to create water storage reservoirs and water quality treatment areas were included in the project concepts.

The project concepts vary from direct flow bypass conveyances to a combination of flow conveyance and stormwater reservoir storage to stormwater reservoir storage only. Flow conveyance capacities are conceptually designed to handle flows at a rate below erosion causing velocities. Flow paths were selected to meet a specific flooding concern while utilizing governmental agency-owned properties to minimize impacts to private property owners, where available. Note that when developing the conveyances, improvements to downstream areas are typically required to precede upstream improvements to avoid overloading a downstream area with increased flow from an upstream improvement.

The potential conceptual projects are preliminary planning ideas that have been presented for modeling input to evaluate the effectiveness and viability of the proposed conveyance and storage components. Some project concepts appear to have an obvious benefit in removal of excess stormwater while other project concepts have complex effects requiring computer modeling for evaluation. A basic volumetric flow analysis has been performed for initial estimation of needed projects. Where practical, project concepts locations were selected in areas of observed flood re-occurrence and areas lacking significant drainageways to convey runoff from severe storm events.

The hydrologic analysis by volumetric removal rate was initially used for pre-planning the number of conveyances and capacity to discharge a large storm event with a reasonable recovery time. This analysis is a basic mass-in, mass out in a reasonable time duration approach. This aspect of hydrologic analysis has been most important with agricultural operations for plant protection aspects per the USDA-NRCS. Often with residential designs, the only concern is handling the peak discharge rate with an acceptable high-water level for a single storm event. A concern with just handling the peak flow is that it does not account for unexpected events, multiple storms, unexpected intensity, developing watersheds and possible mismanaged system operations that would result in higher than expected water levels from a marginal discharge system. The volumetric removal methodology was used by the state drainage engineers in design of the structures under Interstate No. 75. See **Table 1** for available runoff rates.

Table 1 - Flow Discharges under I-75 with Project Concept Improvements (see Figure 6 map)

SOUTH EAST LEE COUNTY AREA (EAST OF INTERSTATE 75)								
Wild Blue / FGCU			**Crew - Flint**			**Bonita Grand**		
Land Area Total:	**15,300**	**AC**		21,900	AC	**Land Area Total:**	**4,100**	**AC**
	100	CFS		12,250	AC		240	CFS
	100	CFS		14,200	AC		170	CFS
	1,000	CFS		10,400	AC		60	CFS
	250	CFS		11,900	AC	**Capacity Total:**	**470**	**CFS**
Capacity Total:	**1,450**	**CFS**		7,300	AC	**0.11 CFS /AC**		
0.094 CFS/AC				2,400	AC			
				3,300	AC			
				4,200	AC			
			Land Area Total:	**87,850**	**AC**			
				2,500	CFS			
				750	CFS			
				240	CFS			
				600	CFS			
				750	CFS			
				1,000	CFS			
			Capacity Total:	**5,840**	**CFS**			
			0.066 CFS/AC					

Since the available removal rates are very low, a very large storage component was added to the flood mitigation project concepts using mine lakes and natural storage areas. These runoff removal rates are limited in reasonably discharging the 100-year, 3-day storm event of 13.6" of rainfall with manageable peak stages and a reasonable recovery time for water levels to return to normal conditions. With large reservoir storage available east of Interstate 75, a two-stage flow control is proposed. Stormwater west of Interstate 75, being the most developed area, would drain first followed by the east side of Interstate 75 after the west side has reached a satisfactory recovery level. Excess rainfall that could not be discharged immediately would be stored to manageable water levels by filling up canals, ponds, reservoirs, roadside swales and residential open spaces.

Areas not having a project concept are generally sloped to drain by existing topography without severe flooding. Complex modeling of the regional area will verify how well the proposed project concepts perform after considering the land topography, geohydrology, overland flow characteristics, impervious areas, and interconnected flow paths.

Unlike the East Lee County study area, the required conveyance capacity for South East Lee County cannot be conceptually accomplished though only utilizing the available undeveloped pathways. To develop concept plans in near fully developed areas where demolition of existing structures is not desirable, conveyance routings were explored though the available space between developments. The actual selected pathway of the proposed conveyance can be further refined during the design phase to be routed around the most environmentally sensitive areas as conceptualized in **Figure 1**. The channels would function as vegetated deep marshes with normal flow during seasonal conditions. Water control structures would control the desired hydroperiod stages while also allowing for large conveyance discharge during extreme storm events. Where additional conveyance capacity is proposed though existing rivers, shallow littoral benches could be created to provide a direct conveyance pathway with increased conveyance capacity during large storm events (**Figure 3**). A 3-D view of this concept is visualized in in **Figure 4**. **Figure 2** demonstrates how seepage barriers can be designed to avoid surface water drawdown to surrounding wetland areas. Excavated fill could be used to benefit road construction.

Figure 1 - Examples of winding high-capacity flow paths functioning as deep marshes during non-emergency conditions.

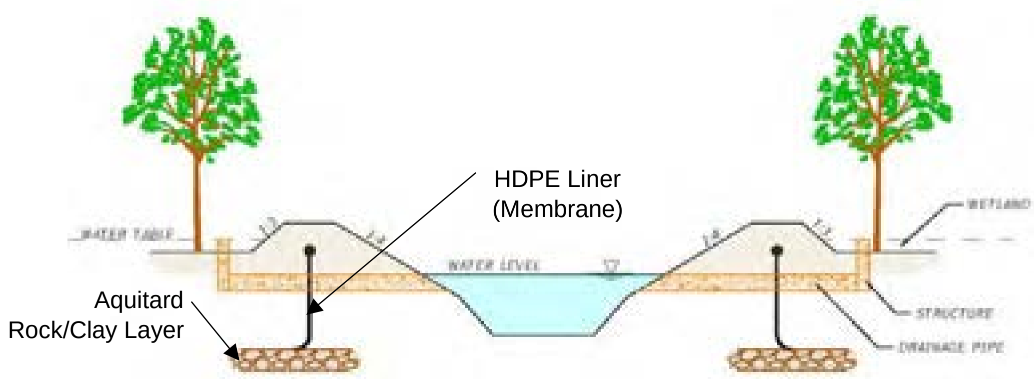


Figure 2 - Example of a seepage barrier concept to avoid water table drawdown in surrounding wetland areas.

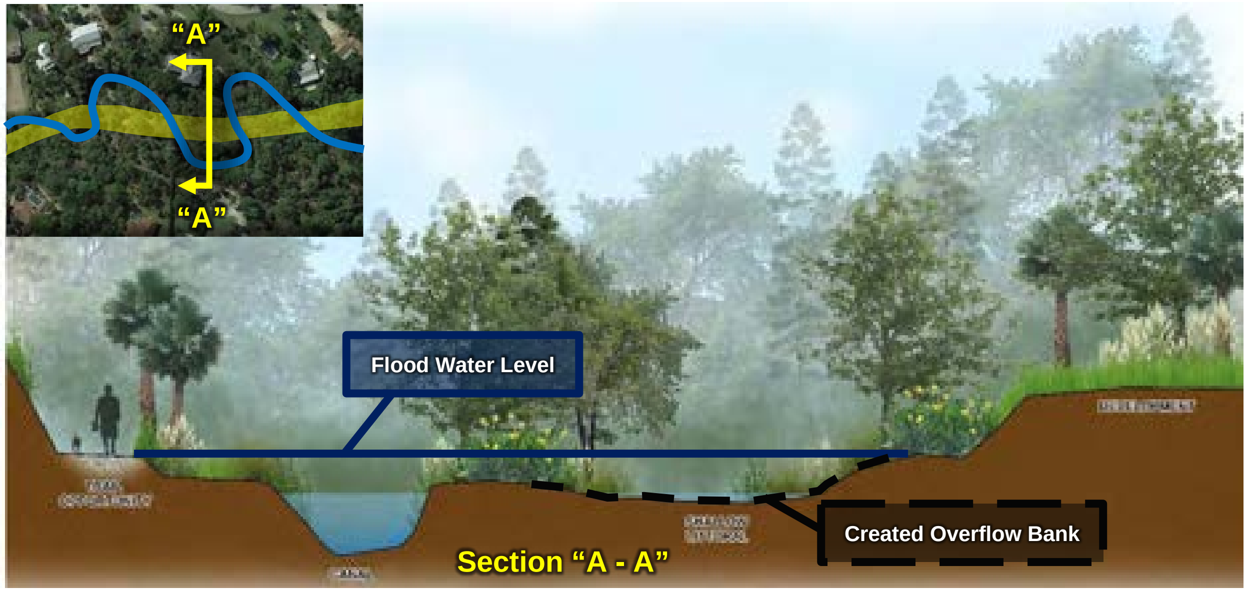


Figure 3 - Example of a shallow littoral bench to provide a direct conveyance pathway with increased conveyance capacity during large storm events.

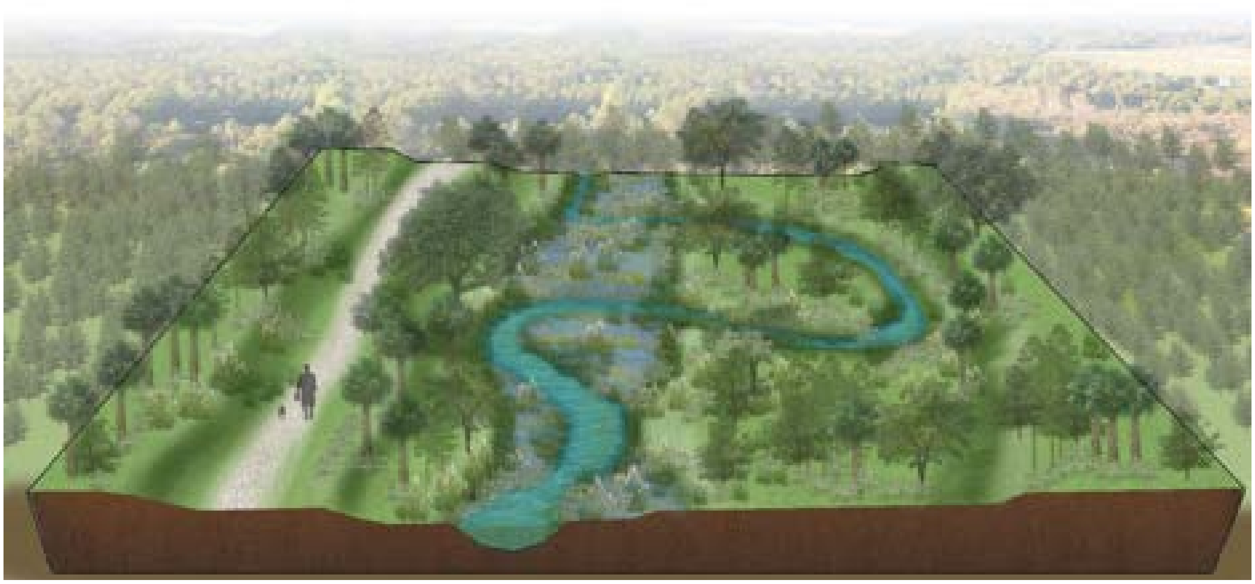


Figure 4 – Three-dimensional representation of a shallow littoral bench to provide a direct conveyance pathway with increased conveyance capacity during large storm events.

In proposing the utilization of large storage components, it is critically important to provide emergency discharge relief capability to avoid potential catastrophic failure resulting from a berm breach. Although the modeling results suggest that the proposed capacity potential of certain downstream drainageways could be refined/reduced, the design of the drainageways that provide potential emergency relief capacity for large storage components should be cautious in limiting this capability. These downstream drainageways were conceptually sized for high flows to allow for very large storm runoff with reasonable recovery time duration and applied to the model results. To avoid potential adverse environmental impacts due to many feet of water being stacked in the storage components for extended periods of time, larger downstream conveyance capacity may also be desired to gain greater functionality and control of the hydro-periods within the storage area. As the watersheds contributing to the proposed large storage areas continue to develop, increased imperviousness and urbanized stormwater systems will only increase the storage system's recovery time duration and desired discharge capacity.

PROJECT CONCEPTS PROVISIONS

- Flood mitigation is intended to improve drainage to reduce flood levels and post storm recovery times
- The approach involves conveyance and storage stormwater management methods
- The initial design storm for preliminary concept development is the 100-year, 3-day event as published by the SFWMD.
- The focus is on major flow-ways and therefore not specific neighborhood drainage issues
- It is anticipated that large flow-way conveyances will be equipped with water control structures having telemetry, data collectors, remote operable motorized gates, camera viewing and standby power facilities
- A knowledgeable staff will manage the system prior to, during and following large storm events
- Maintenance of the proposed facilities is required for proper operation

PROJECT IDENTIFICATION

1.3.1 Halfway Creek Drainageway
1.3.2 Estero River N. Branch Improvements
1.3.3 FGCU Flow-Way Improvements
1.3.4 Alico Mine Lake Interconnects (West)
1.3.5 Alico Mine Lake Interconnects (East)
1.3.6 Alico Road Extension Drainageway
1.3.7 Blackstone Dr to Alico Mine Lakes Drainageway
1.3.8 Alico Mine Lake to Halfway Creek Drainageway
1.3.9 I-75 to Spring Creek Drainageway (North)
1.3.10 I-75 to Spring Creek Drainageway (South)
1.3.11 East I-75 Overland Flow Collection Drainageway
1.3.12 Imperial River Improvements East of I-75
1.3.13 Crew-Flint Pen Hydrologic Restoration
1.3.14 Imperial River Improvements West of I-75
1.3.15 Railway Drainageway Improvements
1.3.16 Corkscrew East Drainageway

Figure 5 hereafter is an 1856 map demonstrating existing conditions of the study area. **Figure 6** indicates the approximate South East Lee County watershed area east of Interstate 75. **Figure 7** indicates the approximate watershed area west of Interstate 75.

FLOOD MITIGATION BENEFITS OF PRELIMINARY CONCEPT LEVEL PROJECTS

Flood mitigation benefits are in general achieved when excess storm water is conveyed and/or stored appropriately to reduce flooding levels and duration that would otherwise inundate structures and have prolonged road flooding. These adverse conditions impact the health, safety, welfare of the residents and have a significant economic impact to the community.

As stated previously in this section, based on the land availability restrictions, the developed system is a two-step process. The downstream conveyances generally west of I-75 are enhanced to provide greater ability to discharge higher volumes of water. Upstream, generally east of I-75, a connected system of storage facilities and conveyances is developed. These upstream improvements are then connected to the improved downstream conveyances and all are controlled with several water control structures. All sixteen concepts were modeled together in one "stitched" model. Therefore, the positive results from the model output reflects the system benefit.

Sixteen preliminary concept projects were developed for the South East Lee County study area. The projects work in concert to develop an overall system improvement to this 150 square mile drainage basin. Targeted areas for reduction in structure flooding included those structures abutting the natural conveyance of the Imperial River. This downstream natural conveyance has been a location of repetitive flooding (See **Figure 8** below depicting FEMA Flood Insurance Claims and Repetitive Loss Areas). Please note that other structures incurred flood damage but were not covered by flood insurance. In addition, flood mitigation was desired due to substantial prolonged flooding of many roadways within the overall SE Lee County study area.

Again, the benefit is seen with implementation of these concept projects as a system. This is reflected in the Regional Model which was run with all concepts stitched together in this system approach. **Figure 9** below depicts the approximate system improvement areas at a high level for South East Lee County where flood mitigation was considered improved when the peak groundwater stage difference is reduced by more than one tenth of a foot from the existing to proposed model condition for a 100-yr, 3-day storm event. The approximate value of the buildings located within these areas was compiled by Lee County staff from the Lee County Property Appraiser parcel building values for the 2020 tax roll. This value for the South East Lee County area was approximately $3 billion. AIM reviewed the Regional Model system output and then noted the concept contribution to this SE system flood mitigation benefit. This was assisted by review of documents such as the Phase 2 reports for this project and Post Irma flooding aerials which showed the potential impact to structures and significant roadway flooding.

As the South East Lee County concepts function so strongly as a system determining an individual projects benefit is somewhat unique in this area. The typical recommended phasing order for this type of system would be to address the downstream projects first. This would provide the best capacity for release of the upstream storage when necessary. However, there may be opportunities based on unique funding to pursue upstream projects first. This may be an option with several of these projects with temporary restrictions on their downstream releases. The downstream projects would be deemed the higher initial benefit based on this; and would be further prioritized based on impact to immediately surrounding flood reduction target areas as well as conveyance capacity. The upstream would be recommended to also occur in a downstream to upstream order and where being compared to other upstream projects the storage volume capability could be considered as a secondary factor.

The contribution or benefit of each project concept is discussed as follows based on modeling results for the August 2017, 100-Yr, 3-Day storm event with gates west of I-75 open at 0 hour, and gates east of I-75 open at 0 hour, closed at the 48th hour and re-opened at 96th hour.

The system of concept projects for SE Lee County provided the following benefits:

Imperial River

The modeling results show a reduction in flood water levels between 1.5 and 4.75 feet with a recovery to normal levels within a few days without increasing the peak flow in the river. This substantial reduction in water levels greatly reduces the flooding potential for those structures previously affected by Hurricane Irma. For the repetitive flooding area adjacent to the Imperial River, these improvements remove flood waters from approximately 821 parcels based on the 100 year 3 day modeled storm (see **Figure 10** below). Note that the number of approximately benefited parcels that are conceptually shown to be impacted by high peak stages during extreme storm events are limited to the clipped area shown in the maps. The number of parcels effected could therefore be greatly increase or decrease if the subjective clipped region changes. Localized modeling should be conducted to refine the concepts to gain an increased understanding on how these concept projects benefit the surrounding areas. These figures do not necessarily reflect actual structure flooding, but more of an overall benefit to the area.

Estero River

The Estero River South Branch experienced significant flooding during Hurricane Irma and the system modeling shows a reduction in the flood levels by approximately 3.5 feet. For the Estero River N. Branch the modeling results show a reduction in flood level of 4.24 feet in the Country Creek neighborhood which was noted to have experienced prolonged roadway flooding. See **Figure 11** below that depicts the reduction in flood area based on the system improvements.

SE Lee County Total Study Area

In this study area road flooding would be reduced in extent and duration. The model generally indicated reductions in water levels and improved recovery times within that would benefit that goal. The model showed a positive reduction in water levels greater than a tenth of a foot for approximately 26,382 acres or about 41 square miles. (see **Figure 9** below).

Below are the individual concept summaries noting the stitched model system benefit:

3.1 ***Halfway Creek Drainageways*** - This conveyance concept project was developed to handle a large portion of the flood flow from east of I-75 and direct excess storm water to Estero Bay. The modeling results show a 419 cfs flow increase to 1,254 cfs. The benefits to directing large flows via this underutilized flow path connected via water control structures to the large preserve areas east of I-75 is to the Estero River North Branch and the Imperial River basins that experienced extreme flooding. Provision to timely recover from high water levels in the preserve areas may warrant a large capacity drainageway.

3.2 ***Estero River N. Branch Improvements*** - This conveyance concept project was developed for mitigation of flooding of the Estero River N. Branch basin, as well as, areas east of I-75. The Estero River N. Branch would be enhanced with overflow bypasses conveyances to better handle high flow conditions. The modeling results show a reduction in flood level of 4.24 feet in Country Creek neighborhood while slightly increasing the flow through this area. The downstream peak flow in the Estero River was reduced from the existing 1,781 cfs to 1,104 cfs with the system of concepts.

3.3 ***FGCU Flow-way Improvements*** - This conveyance concept project was developed to improve flood flow in the FGCU area that has limited flow capacity to reach bridge and box culvert crossings under I-75. The trapped stormwater caused flooding in the NE quadrant of I-75 and Corkscrew Road that extended for many weeks. Under the concept project flow gates would close to utilize the vast wetlands as a storage reservoir and open following the storm. The system modeling results show flows increase by 305 cfs to 640 cfs and that water levels recovered soon after the storm. The area east and north of I-75 and Corkscrew Road residents are the beneficiaries of this project.

3.4 ***Alico Mine Lake Interconnects (West)*** – This conveyance concept project which includes incorporating mine lakes for storm water reservoir storage was developed to direct flow to either the Estero River N. Branch or to the Crew/Flint-Pen/Kiker preserve to mitigate flooding in the vast area extending to the SW Regional Airport and the Wild Turkey Strand. Having water control through conveyance and storage allows limiting peak flows, conservation of water resources and the potential to direct flow south to the large preserve areas. When conditions are favorable the SW Regional Airport excess flows may be directed south to avoid overloading the Briarcliff and Ten-Mile Canal areas. The system modeling results show the potential to direct 279 cfs from the airport, to 186 cfs to the FGCU flow way and increase flow from 108 cfs to 559 cfs to the large Crew-Flint Pen/Kiker preserve areas. Water levels improve significantly in the mine lake near the regional airport from EL 25.44 to EL. 20.81 or a decrease of 4.63 feet and the potential to accept flood flow from the Regional Airport. The beneficiaries of this improvement include residents in the NE Quadrant of I-75 and Corkscrew Road, Ten-Mile Canal area and the hydrologic restoration of the Crew/Flint-Pen/Kiker preserve.

3.5 ***Alico Mine Lake Interconnects (East)*** - This flood reservoir concept project stores excess flood water in mine lakes until the storm event passes. The mine lakes are connected by drainageway conveyances. The system model results show that large quantities of stormwater were satisfactorily stored to natural ground level, attenuated to and released with recovery to normal levels within a few days following the storm event. Approximately, one and one-half feet of vertical storage was achieved between EL. 24.91 and EL. 26.42 in the mine lakes and flows entering the lake system of 1,081 cfs (Blackstone Drive concept project) were reduced to 559 cfs at Corkscrew Road crossing. This concept project develops water control to mitigate flooding, so the Southeast Lee County community is the beneficiary of this project.

3.6 ***Alico Road Extension Drainageway*** – This conveyance concept project was developed to as part of the proposed Alico Road to improve flood flow out the Green Meadows area and avoid flood flow overloading of the Wild Turkey Strand Preserve and the downstream community on Mallard/Devore Roads of Alico Road. The system modeling results show a 144 cfs flood flow concept project drainageway. The two communities are the beneficiaries of this project.

3.7 ***Blackstone Drive to Alico Mine Lakes Drainageway*** - This conveyance concept project was developed to direct flow from Lehigh Acres at Blackstone Drive to the south. Although the flood peak elevations were not high enough to flow south, this area of south of State Road No. 82 directed substantial flows to the south. The system modeling results show the flood flow of 1,081 cfs entering the mine lakes which are attenuated by the mine lake reservoir storage. This concept project develops water control to mitigate flooding, so the Southeast Lee County community is the beneficiary of this project.

3.8 ***Alico Mine Lake to Halfway Creek Drainageway*** - This conveyance concept project was developed to direct flood flow from the Alico Mine Lakes area lying north of Corkscrew Road in a southerly direction to the Crew-Flint Pen/Kiker Preserve. The excess stormwater will be stored in this natural reservoir and eventually released to the Imperial River, Spring Creek and Halfway Creek outfalls to Estero Bay. The system modeling results show increasing the flow to the south side of Corkscrew Road from 108 cfs to 559 cfs or a 451 cfs increase in flood flow. Water levels are increased from EL. 16.60 to EL. 17.39 or an increase of 0.79 feet. The Estero River and Grandezza residents and the business area at the intersection of I-75 and Corkscrew are the beneficiaries of this project. The hydrologic restoration of the Preserve areas is an additional benefit.

3.9 ***I-75 to Spring Creek Drainageway (North)*** - This conveyance concept project was developed to improve flood flow out of the old Bonita Springs Golf & Country Club area to Spring Creek. The system modeling results show a peak water level reduction from EL. 12.72 to EL. 8.57 or a decrease of a 4.15 feet. This concept project was planned to accept flow from the east side of I-75, so flow increased in the golf course area from 42 cfs to 299 cfs. The Bonita Springs Golf Club residents are the main beneficiaries of this project along with Estero and Imperial River residents who benefit by the acceptance of flow from east of I-75.

3.10 ***I-75 to Spring Creek Drainageway (South)*** - This conveyance concept project was developed to direct flow away from the Tropical Acres area lying northwesterly from the Bonita Springs High School. The system modeling results show 97 cfs flood flow towards the Spring Creek outfall with peak water levels at the approximate top of bank with a recovery to normal levels within a few days following the storm event. The Tropical Acres residents of Bonita Springs are the beneficiaries of this project.

3.11 ***East I-75 Overland Flow Collection Drainageway*** - This conveyance concept project was developed to collect flood flow from the area east of I-75 that is being planned as a flood reservoir. This collector drainageway allows a balancing of flows through the various drainage structures under I-75. The residents west of I-75 along the Estero River and Imperial River are the beneficiaries of collecting flood flow and improving the outfall to the west of I-75.

3.12 ***Imperial River Improvements East of I-75*** - This conveyance type concept project was developed to improve flow along the Imperial River. The system modeling results show a reduction in flood water levels between 2.47 feet and 4.75 feet with a recovery to normal levels within a few days without increasing the peak flow in the river. The Bonita Springs residents along the Imperial River are the beneficiaries of this project.

3.13 ***Crew-Flint Pen Hydrologic Restoration*** - This flood reservoir concept project stores flood water on the east side of Interstate No. 75 until the storm event passes. The system modeling shows a reduction in the peak water level on the west side of I-75 from EL. 14.80 to EL. 11.17, or a 3.63-foot decrease in flood levels with a recovery to normal levels within a few days. Additionally, the system model results show a reduction in the peak flow for the Imperial River at Kehl Canal Gate from 526 cfs to 267 cfs or a 259 cfs decrease. The concept project provides an additional benefit with the ability to hold water and provide hydrologic restoration of extensive preserve lands east of I-75. The residents west of I-75 are the beneficiaries of this concept project.

3.14 ***Imperial River Improvements West of I-75*** - This conveyance type concept project was developed to improve flow along the Imperial River. The system modeling results show a reduction in flood water levels between 1.55 feet and 4.33 feet with a recovery to normal levels within a few days following the storm event. The Bonita Springs residents along the Imperial River are the beneficiaries of this project.

3.15 ***Railway Drainageway Improvements*** - This conveyance concept project was developed to improve flow in the Rosemary Canal area of Bonita Springs. The system modeling results show a reduction in flood water levels between 0.94 feet and 1.49 feet with a recovery to normal levels within a few days without increasing the peak flow to the river. The residents in this area of Bonita Springs are the beneficiaries of this project.

3.16 ***Corkscrew East*** - This conveyance concept project was developed to direct flow southerly away from Corkscrew Road and on to the Corkscrew Swamp Sanctuary. These conveyances are intended to carry future flood flow through future development tracts to avoid blocking drainage to the south. The system modeling results show discharges ranging from 119 cfs to 398 cfs in flood flow to the Corkscrew Swamp. The beneficiaries of the planned conveyances will be the residents in this area along with travelers on Corkscrew Road.

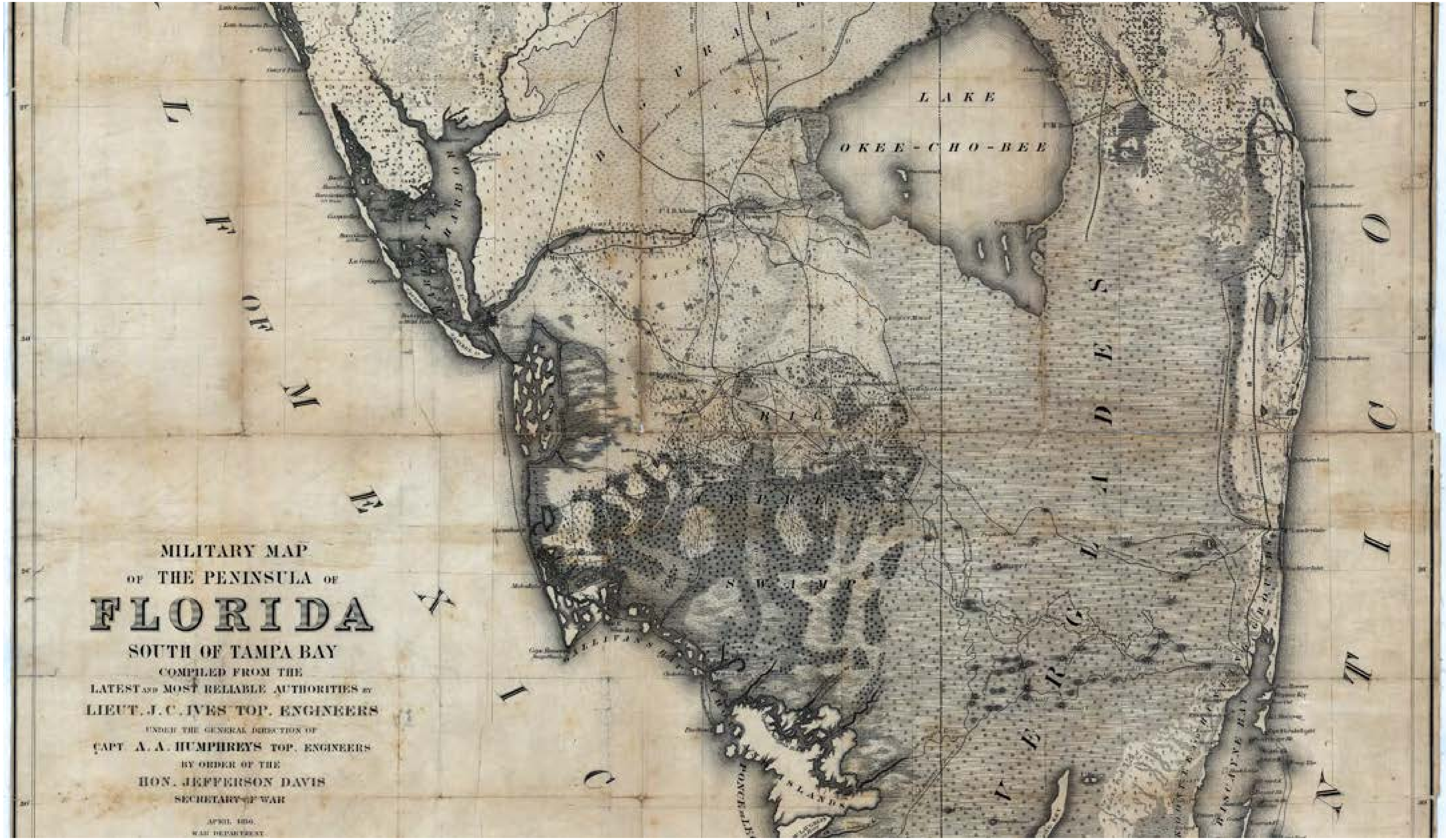


Figure 5 - Existing Conditions map of study area (1856)

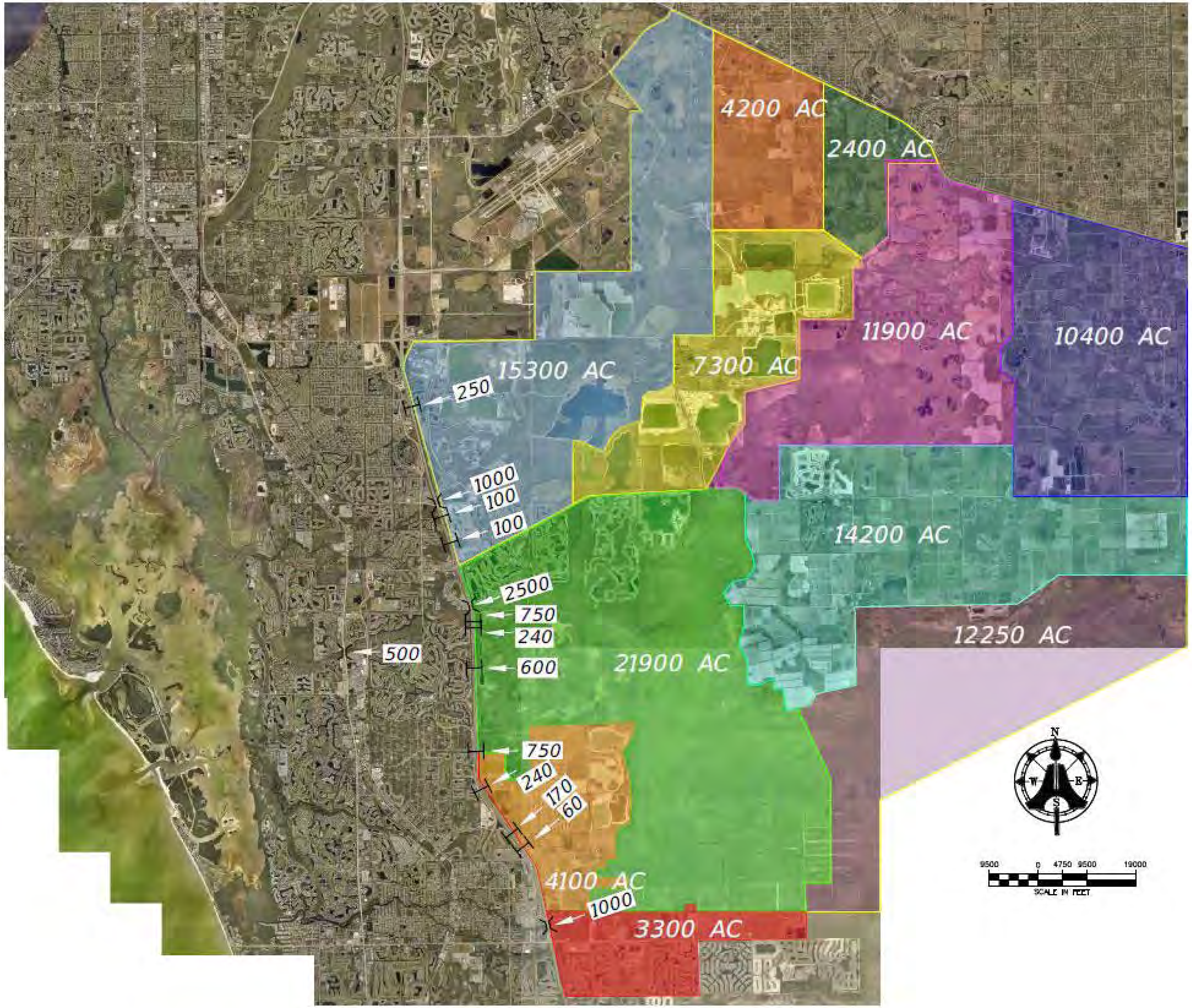


Figure 6 - South East Lee County Watershed Area (east of Interstate 75)

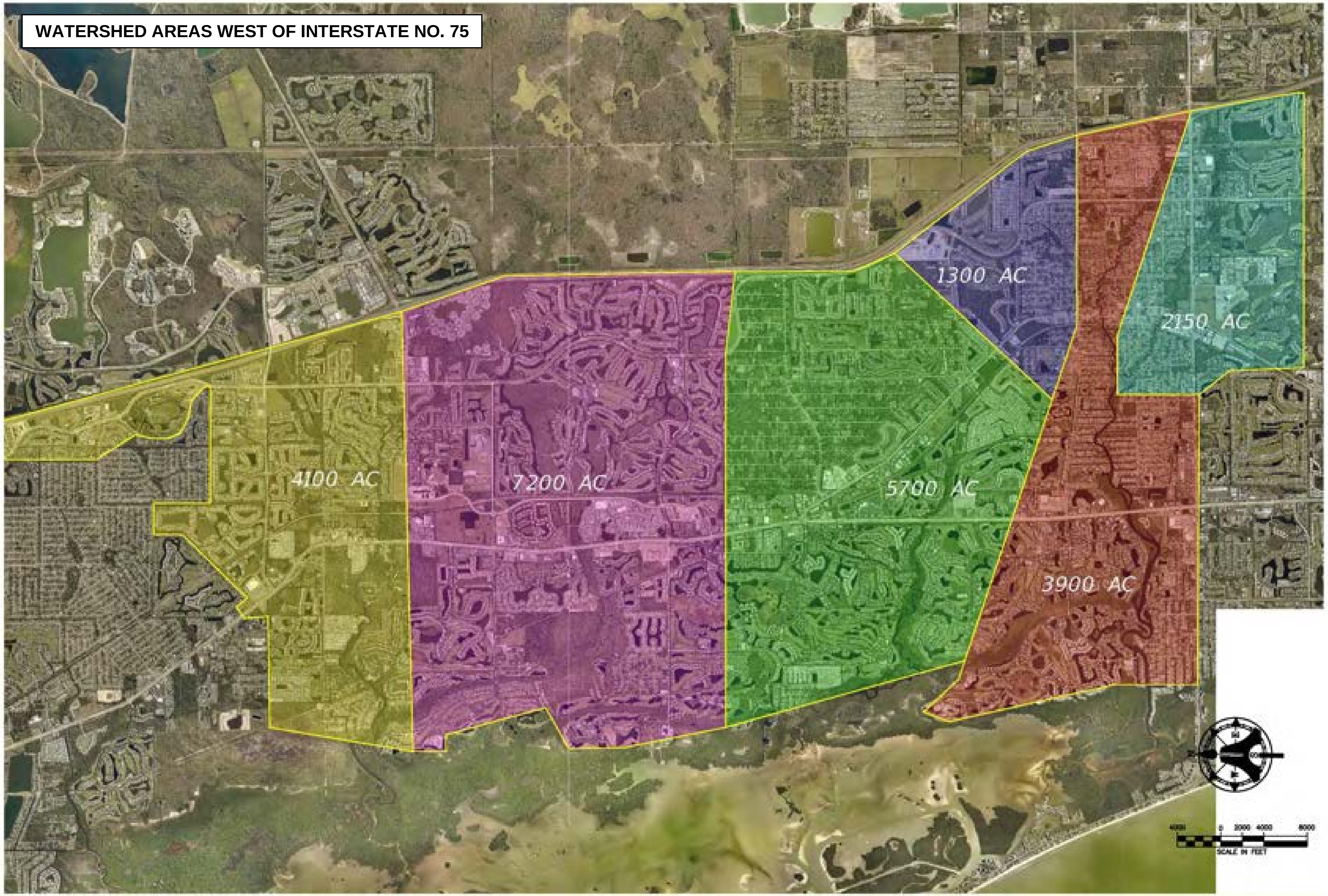
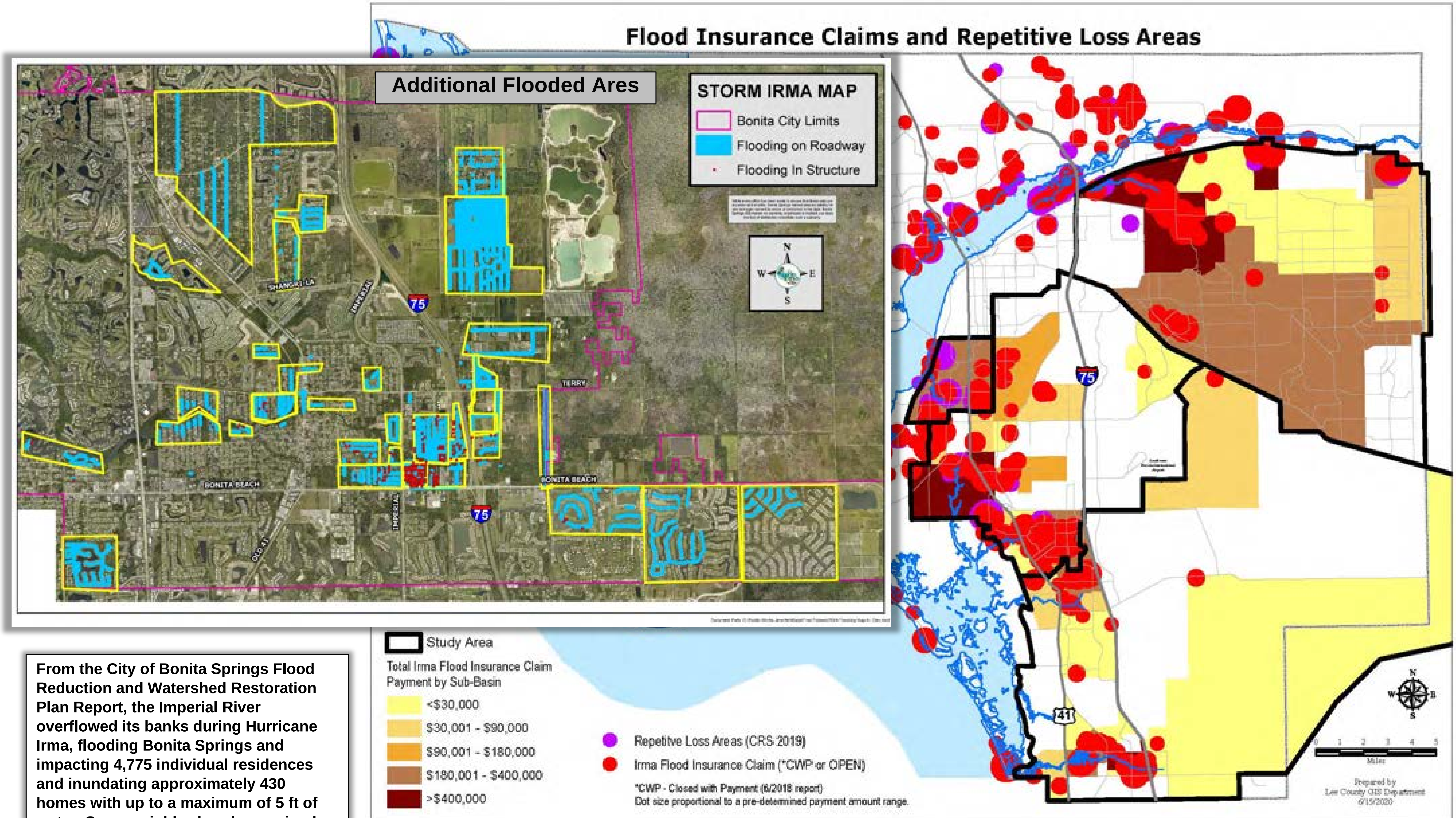


Figure 7 - South East Lee County Watershed Area (west of Interstate 75)



From the City of Bonita Springs Flood Reduction and Watershed Restoration Plan Report, the Imperial River overflowed its banks during Hurricane Irma, flooding Bonita Springs and impacting 4,775 individual residences and inundating approximately 430 homes with up to a maximum of 5 ft of water. Some neighborhoods remained with roads under standing waters for up to 4 - 5 weeks after Hurricane Irma.

Figure 8 - Flood insurance claims and repetitive loss areas.

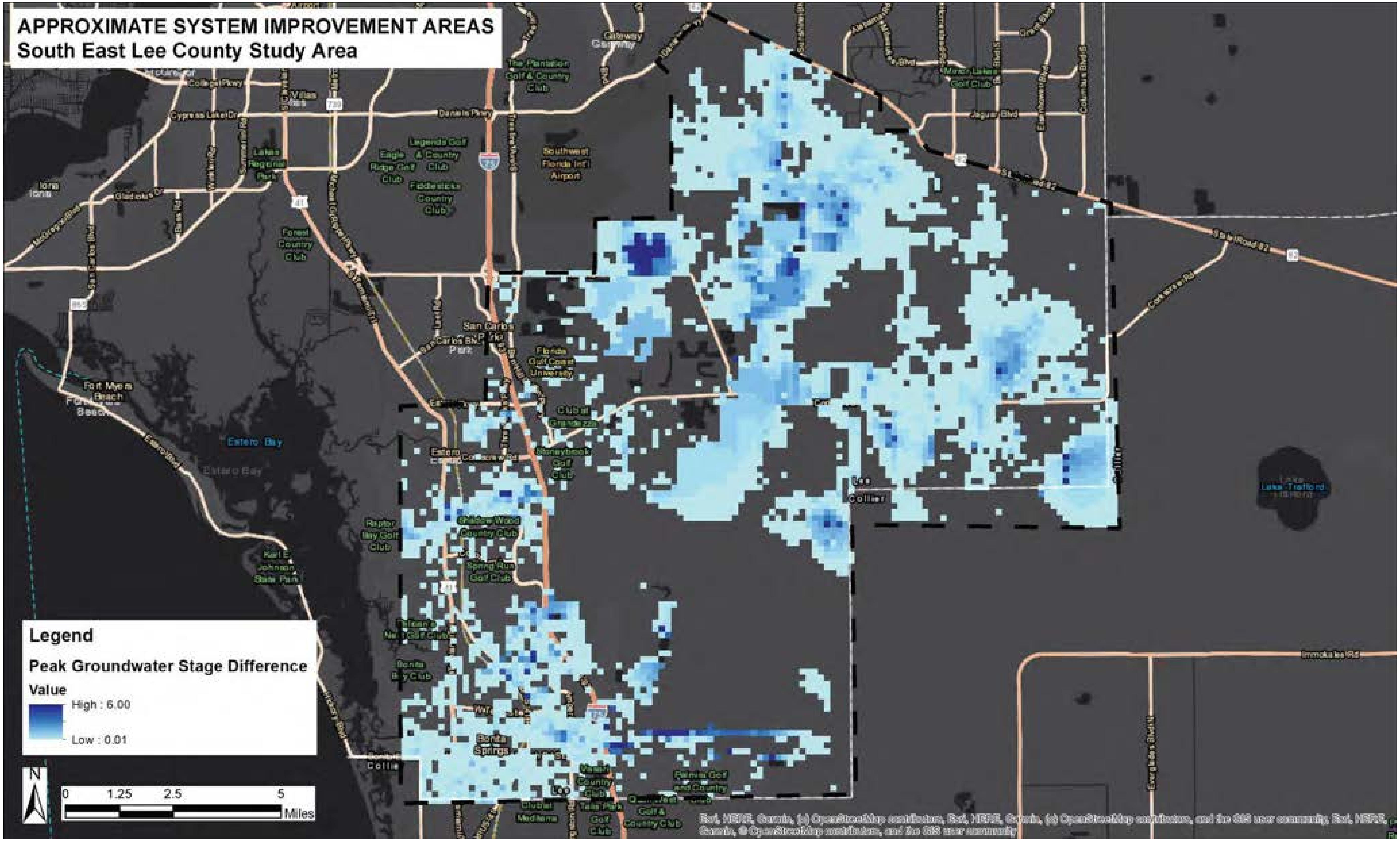


Figure 9 - Approximate system improvement areas for East Lee County Study Area

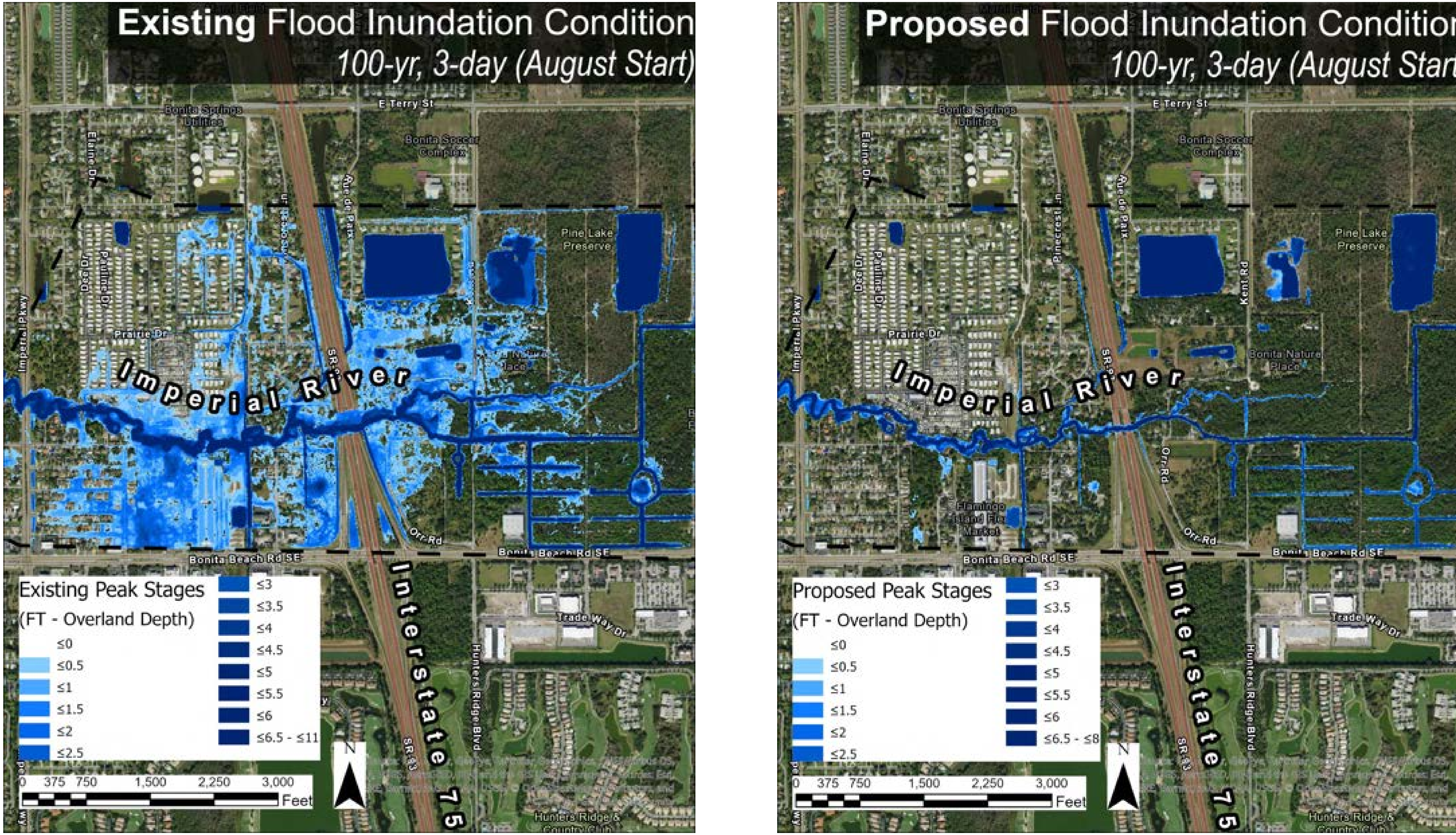
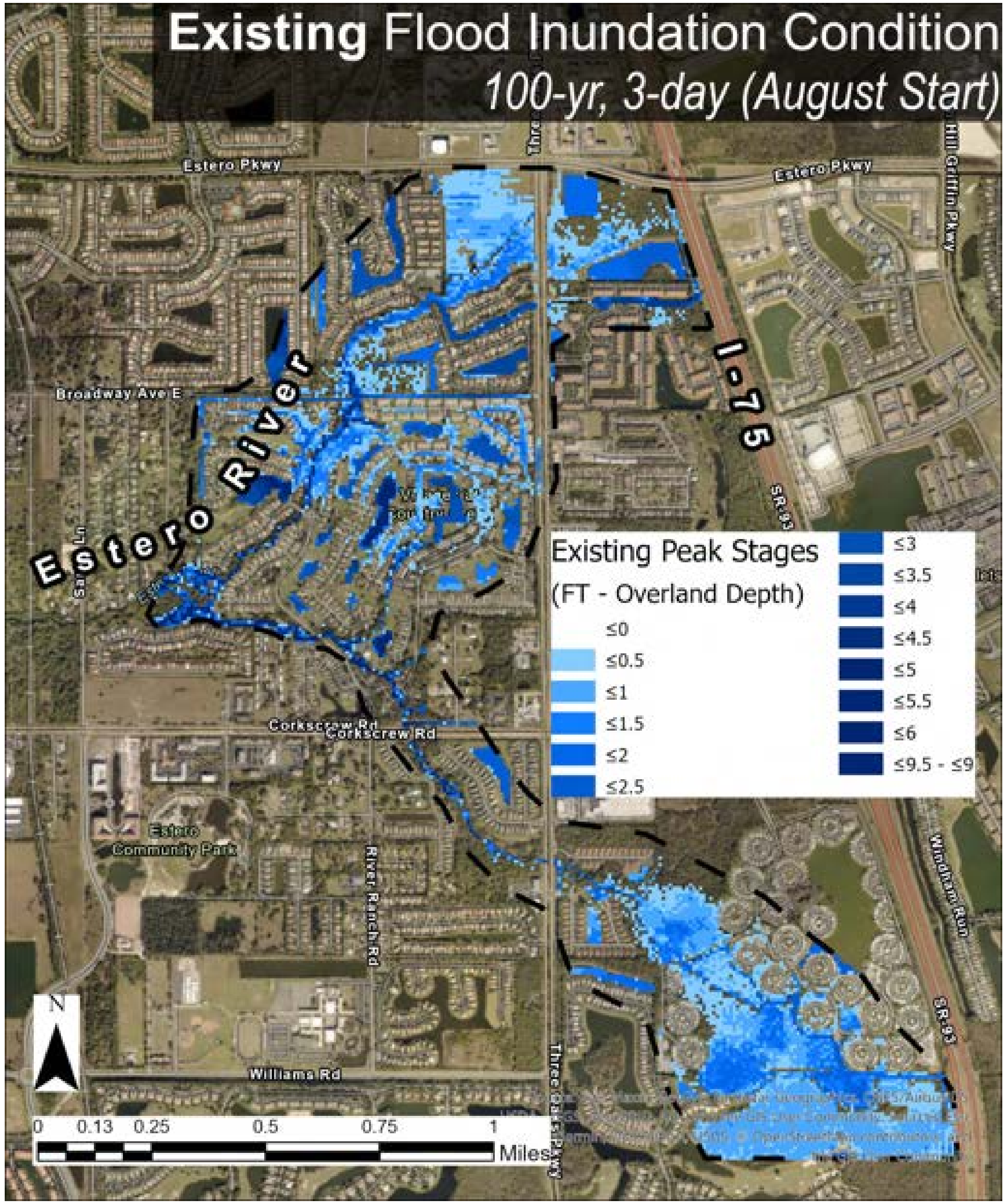


Figure 10 - Example benefited area maps for Imperial River

Conceptual Map Limitations: *These demonstration maps were developed by extending the modeled hydraulic grade line peak stages withing the Imperial River channel for the existing and proposed conditions to the offset shown by the dashed line to demonstrate how the improvements to the reduction in peak stages in a model network translate over LIDAR to benefit the adjacent areas. These maps are not intended for financial decision-making or design-level analysis as the concept plans and model coarseness were developed on a conceptual basis.*



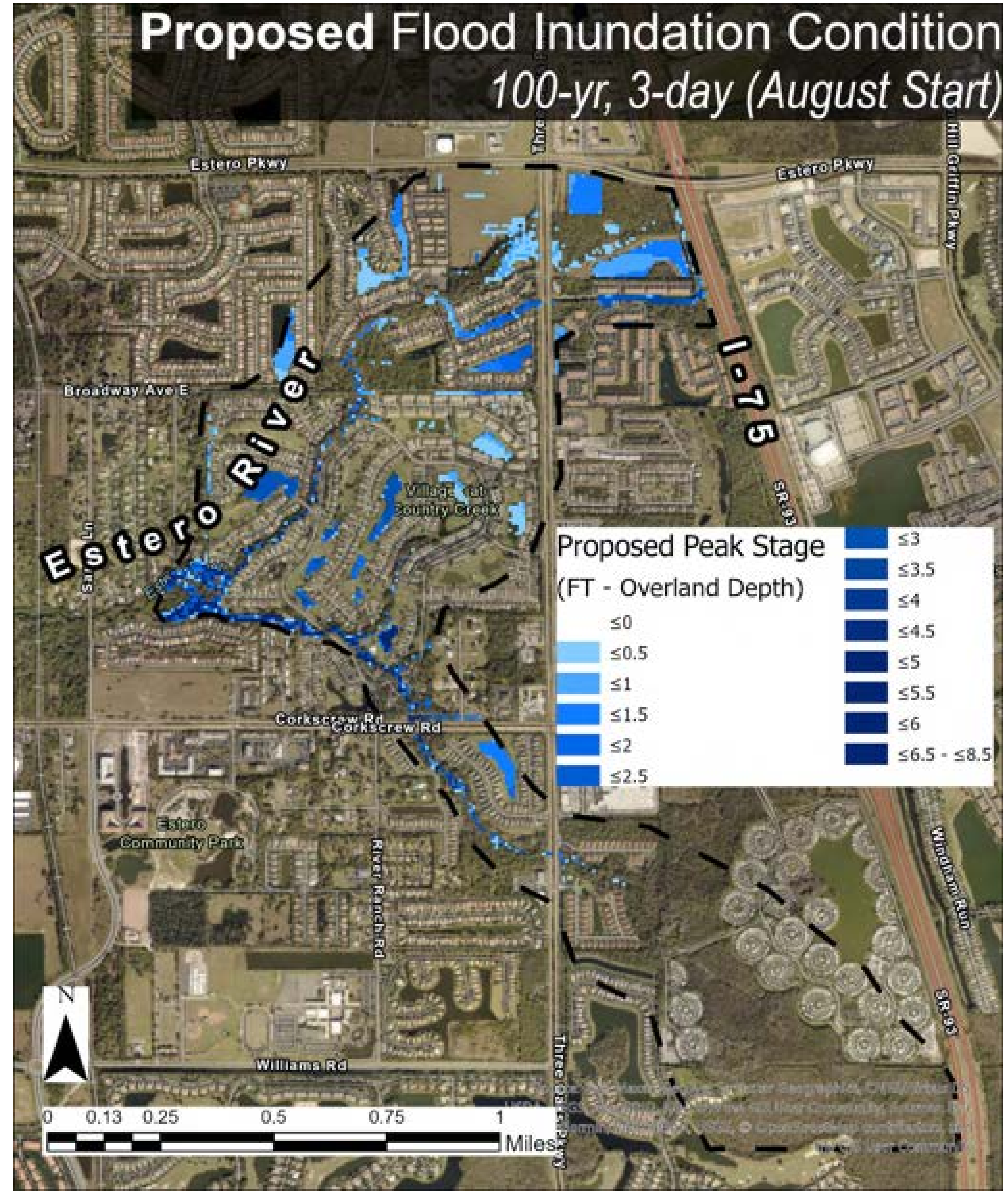
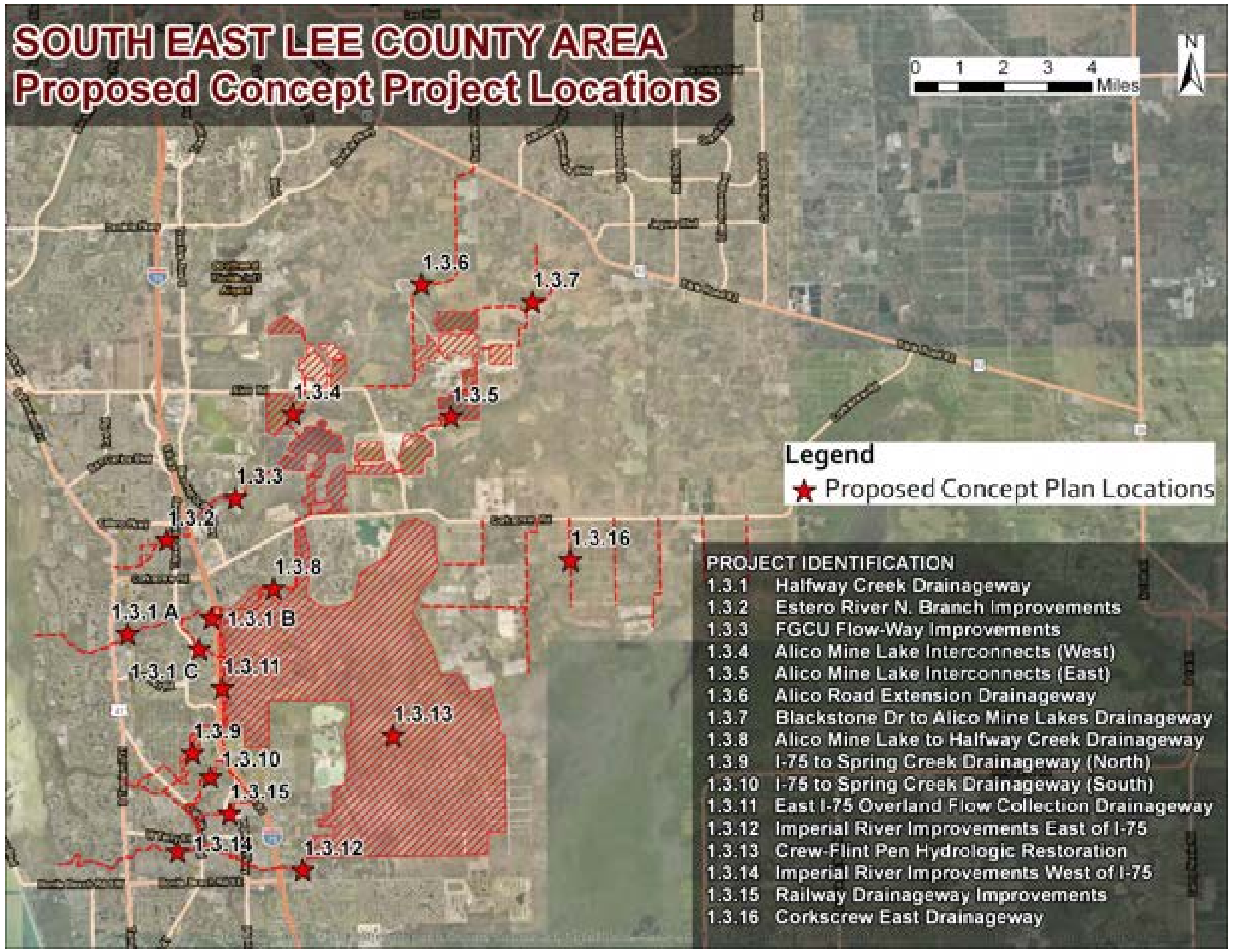


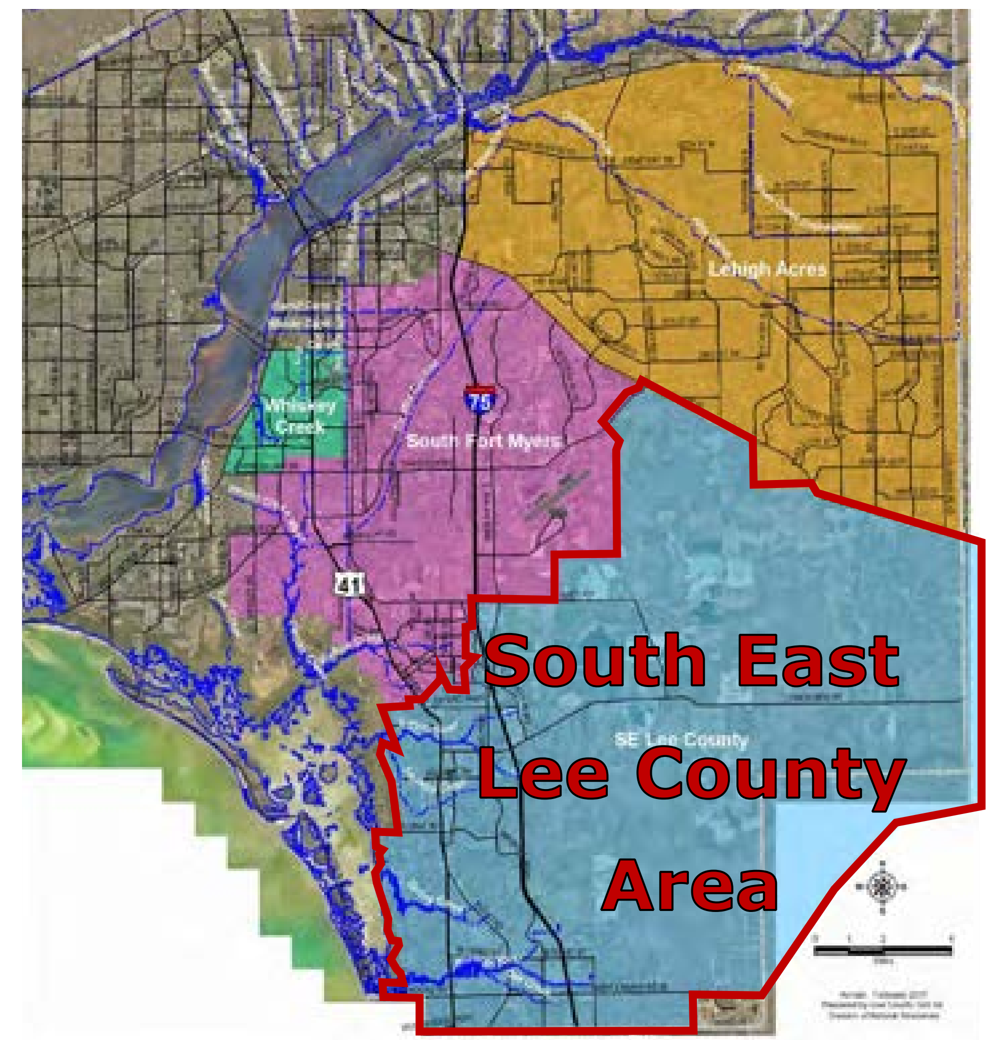
Figure 11 - Example benefited area maps for Estero River

Conceptual Map Limitations: *These demonstration maps were developed by extending the modeled hydraulic grade line peak stages withing the Estero River channel for the existing and proposed conditions to the offset shown by the dashed line to demonstrate how the improvements to the reduction in peak stages in a model network translate over LIDAR to benefit the adjacent areas. These maps are not intended for financial decision-making or design-level analysis as the concept plans and model coarseness were developed on a conceptual basis.*

EXHIBIT 1.3



South East Lee County Area



Proposed Concept Projects

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3

1.3.1 Halfway Creek Drainageways Concept Plan

Background

This concept project extends 3-4 miles inland off the Estero Bay and currently connects to the Estero River through a natural low area behind a coast ridge rise. The connection at the Estero River is a mangrove estuary type flow-way. As the channel continues meandering upstream, it becomes a cypress slough type of environment and at its headwaters is a marsh-type wetland with scattered cypress heads.

Drainage structures along this flow way include a bridge at Williams Road, an opening at the abandoned railroad bridge on the former Atlantic Coastline Railway. Further upstream are box culvert crossings at US-41, a crossing at Via Villagio, Via Coconut Point Road, the seaboard coastline railroad, Knollview Blvd, and Three Oaks Pkwy.

Some of the route has been channelized with lake excavation for land development. Upstream, the channel branches to multiple channel routes extending to Interstate No. 75 area. Historically, this flow-way was a wide dispersed water sheet-flow area. Land development has since blocked, confined, and channelized the once natural sheet-flow condition. Large drainageway structures under I-75 direct flows towards Halfway Creek Drainageway and the Estero River.

Location

The concept project begins approximately one-mile south of Corkscrew Road, just east of I-75 and continues west through the Brooks Community stormwater management system, the Coconut Point DRI property, Pelican Point RPD property and Pelican Landing RPD property to the tidal waters in the Estero Bay at the mouth of Halfway Creek as illustrated in **Figure 12**.

Figure 12 – Location Map, 1.3.1 Halfway Creek Drainageways

Description

This conceptual project conveys excess storm water drainage flow from the existing bridge on Interstate 75 (See **Figure 13**) and 3 other drainage flow crossings under Interstate 75 (See **Figure 13**). These crossings are located approximately one mile south of Corkscrew Road. This drainageway would utilize the Brooks community stormwater management system. This project would also cross the Coconut Point DRI property, the Fountain Lakes PUD property, the Pelican Point RPD property and the Pelican Landing RPD property and include excavated channels, existing lakes and major drainage structures under roadways ultimately discharging to tidal waters in Estero Bay. The drainage area is very large, and the proposed conveyance would be intended for very large flow. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Interconnection conveyances would be approximately 130 feet wide channels provided generally as illustrated in **Figure 13**.

Figure 13 – Concept Plan, 1.3.1 Halfway Creek Drainageways

Purpose

This concept project improves conveyance of excess storm water by returning the area to its historical flow way patterns and re-connecting the flow way to the Estero Bay. This will help to reduce flooding and shorten post-storm recovery of water levels.

Evaluation

Viability

This project is the key outfall conveyance for removing excess storm water from the area east of I-75. The conveyance was initially planned to carry approximately 4,000 CFS which represents 50% of the discharge coming from the east. This flow way has many issues to resolve, however the importance will justify addressing the challenges for this project development. Some major issues are crossing public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures would be required. A proposed land development project at the westerly end of the conveyance may conflict with this high flow conveyance and a spreader swale will be necessary at the end of the flow way to reduce flows to an acceptable level before discharging.

Community Considerations

This drainageway would utilize the Brooks Community stormwater management system, the Coconut Point DRI property, the Fountain Lakes PUD property, the Pelican Point RPD property and the Pelican Landing RPD property and would need approval from all the communities.

Environmental & Permittability Considerations

This project concept will address minimizing impacts and providing mitigation for a large cypress strand blocking the flow path between Marsh Landing and Fountain Lakes developments on the west side of U.S.41. Maintaining a base flow to the Estero River southerly branch should be incorporated. Reducing flow velocity and dispersing the flow by spreader system prior to discharging into Estero Bay will be necessary. There is an existing eagles' nest along the westerly end of the concept project. Water quality treatment could be enhanced by the development of a filter marsh system.

Land Availability

Land acquisition is necessary to construct the Halfway Creek Drainageways Canal conveyance, storage, and water quality features. Coordination between the affected CDD's and HOA's, LCDOT, FDOT, the railroad and the Village of Estero would be required.

Opinion of Probable Cost

The cost opinion shown in **Table 2** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 2 - Opinion of Probable Cost breakdown, 1.3.1 Halfway Creek Drainageways

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 5,086,200	$ 5,086,200
Clearing & Grubbing	65	AC	$ 14,000	$ 910,000
Earthwork	1,000,000	CY	$ 6	$ 6,000,000
Structure Damages	1	LS	$ 350,000	$ 350,000
Flow Dispersion at Bay	1	LS	$ 1,000,000	$ 1,000,000
Construction/ Maintenance Access	16,000	SY	$ 20	$ 320,000
Weir Structure 3.1A (Major)	230	LF	$ 10,000	$ 2,300,000
Weir Structure 3.1B (Major)	230	LF	$ 10,000	$ 2,300,000
Weir Structure 3.1C (Major)	230	LF	$ 10,000	$ 2,300,000
Weir Structure 3.1D (Major)	230	LF	$ 10,000	$ 2,300,000
Weir Structure 3.1E (Major)	230	LF	$ 10,000	$ 2,300,000
Detours	1	LS	$ 800,000	$ 800,000
Box Culvert 3.1-1	600	CY	$ 1,200	$ 720,000
Box Culvert 3.1-2	700	CY	$ 1,200	$ 840,000
Box Culvert 3.1-3	700	CY	$ 1,200	$ 840,000
Box Culvert 3.1-4	700	CY	$ 1,200	$ 840,000
Box Culvert 3.1-5	700	CY	$ 1,200	$ 840,000
Box Culvert 3.1-6	700	CY	$ 1,200	$ 840,000
Box Culvert 3.1-7	750	CY	$ 1,200	$ 900,000
Box Culvert 3.1-8	250	CY	$ 1,200	$ 300,000
Box Culvert 3.1-9	250	CY	$ 1,200	$ 300,000
Box Culvert 3.1-10	250	CY	$ 1,200	$ 300,000
Road Repairs	1	LS	$ 335,000	$ 335,000
Repair Train Tracks	1	LS	$ 100,000	$ 100,000
Electric Supply	1	LS	$ 100,000	$ 100,000
Grassing	64,400	SY	$ 2	$ 128,800
			Construction Cost Sub-Total:	**$ 33,350,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 9,525,000
			Land Acquisition	$ 9,750,000
			Project Administration/ CEI (10%):	$ 3,175,000
			Project Unknowns	$ 5,200,000
			Conceptual Project Cost:	**$ 61,000,000**
			Contingency (30%)	$ 18,000,000
			Conceptual Project Cost (with Contingency):	**$ 79,000,000**

Opportunities for Multiple Benefits & Uses

As south east Lee County continues to reach full build-out conditions, improving the conveyance of the Halfway Creek Drainage Basin is a critical priority. Providing storage solutions will also become increasingly difficult as future development will occupy the available land.

Other Considerations

A summary of this concept project is shown below in **Exhibit 1.3.1** herein. An alternative to the drainageway route, which is currently proposed though undeveloped areas, could require land acquisition and routing though the developed subdivisions.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from east of Interstate No. 75 to Estero Bay by linking existing and proposed conveyances with four existing large drainage structures at Interstate 75 with a proposed connection to open water. This flow route passes through The Brooks and other developments along Halfway Creek. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.1 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.1 (b) EXHIBIT 1.3.1 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.1 (d) EXHIBIT 1.3.1 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.1 (f) EXHIBIT 1.3.1 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.1 (h) EXHIBIT 1.3.1 (i)

Improvements were shown with water level reductions from the existing to the proposed condition with an increase in peak flows. Overall system performance improvements are understood since flow from east of Interstate 75 is delayed allowing the area west of Interstate 75 to recover.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from east of Interstate No. 75 to Estero Bay by linking existing and proposed conveyances with four existing large drainage structures at the interstate with a proposed connection to open water. These positive improvements warrant further design-level project development.

The Halfway Creek outfall to the Estero Bay was planned at over a 4,000 cfs capacity to provide significant water volume removal of flood waters stored east of Interstate No. 75. With the large storage capacity east of Interstate No. 75 and the conceptual level gate operation, the model showed flow rates attenuated to approximately 1,300 cfs for the 100-year, 3-day storm event in August 2017. The creation of a major flow way with direct discharge to Estero Bay is controversial with high cost and a potentially lengthy, challenging permitting process. Therefore, with the understanding that removal of stored water volume in the mine lakes and reservoirs would be very limited with a smaller conveyance, a smaller sized channel improvement on the current alignment to Estero River may be an optional approach to consider for providing flood mitigation for Southeast Lee County. Land acquisition and structure size phasing could be considered for a future expansion of the flow way at a later date. As with most all of concepts, it is important to note that the flows from the model reflect all the improvements being made. The reduction or elimination of any other SE area projects could necessitate revisions, such as capacity increase needs, for other concepts.

EXHIBIT 1.3.1

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from the existing bridge on I-75, located approximately one-mile south of Corkscrew Road, southwesterly towards Halfway Creek. This drainageway would utilize the Brooks Community stormwater management system and includes excavated channels, existing lakes and major drainage structures under roadways, ultimately discharging to tidal waters in Estero Bay. The drainage area is very large, and the proposed conveyance would be intended for very large flow. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Significant environmental impacts would necessitate mitigation.

May 2020

Halfway Creek Drainageways

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.1

EXHIBIT 1.3.1 (a)

EXHIBIT 1.3.1 (b)

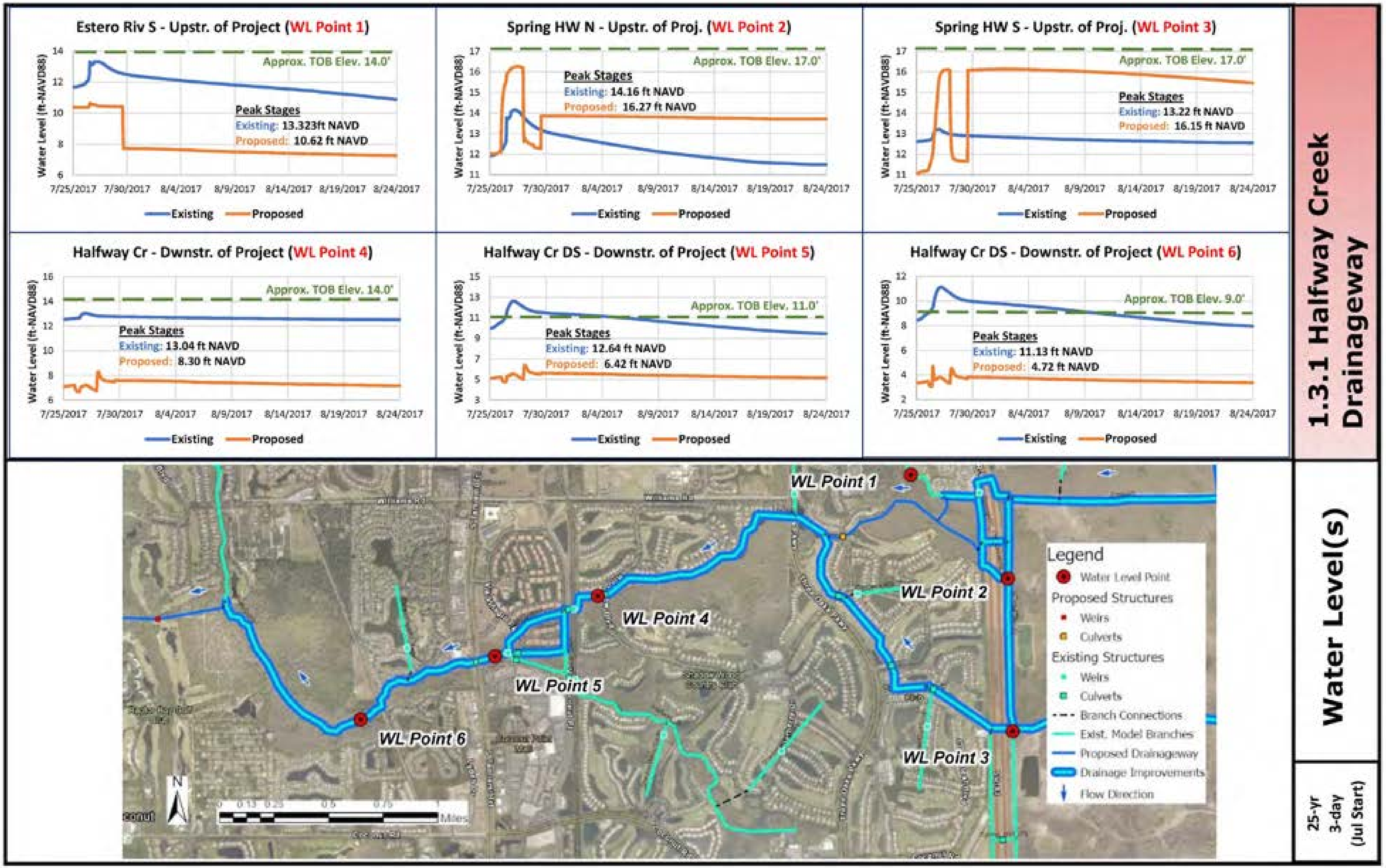
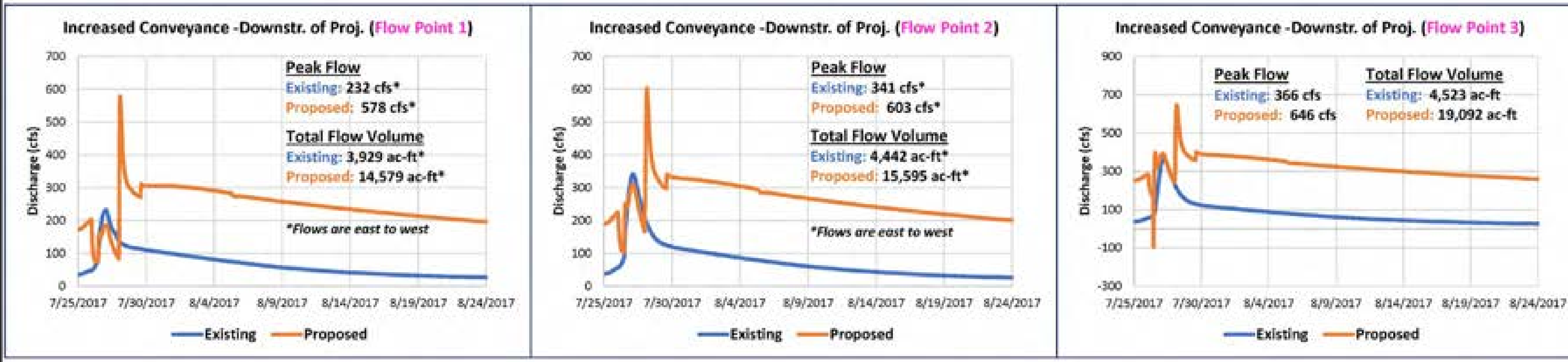
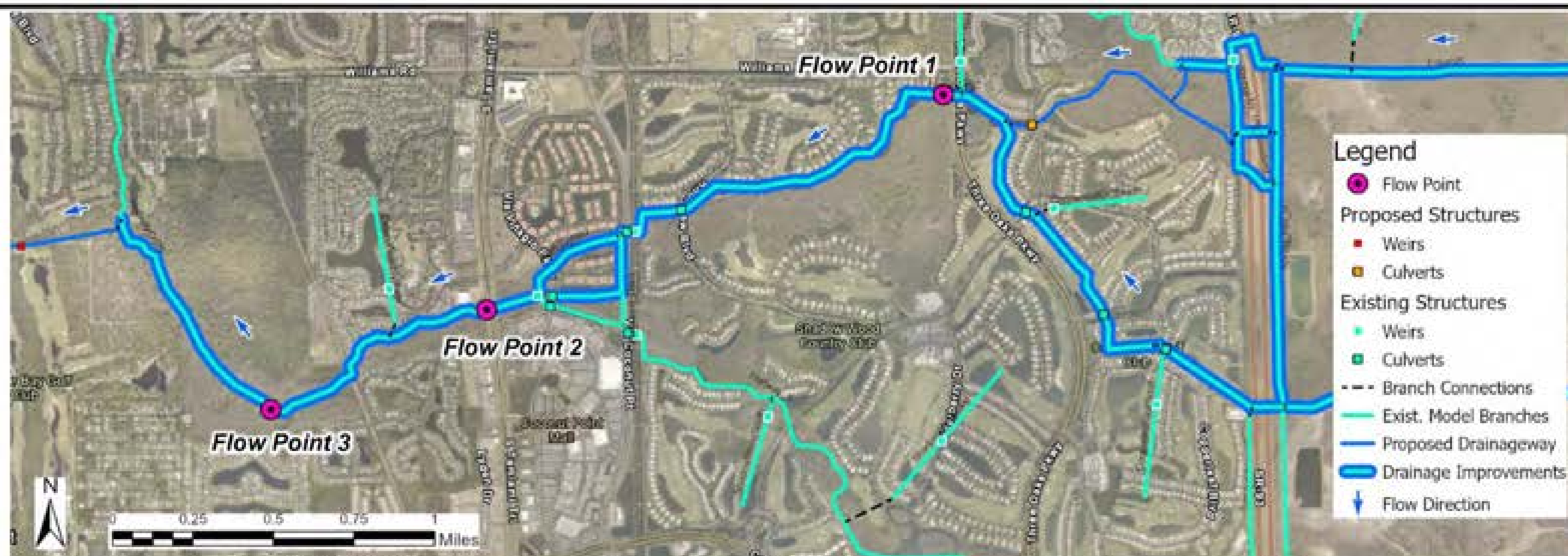


EXHIBIT 1.3.1 (c)

1.3.1 Halfway Creek Drainageway

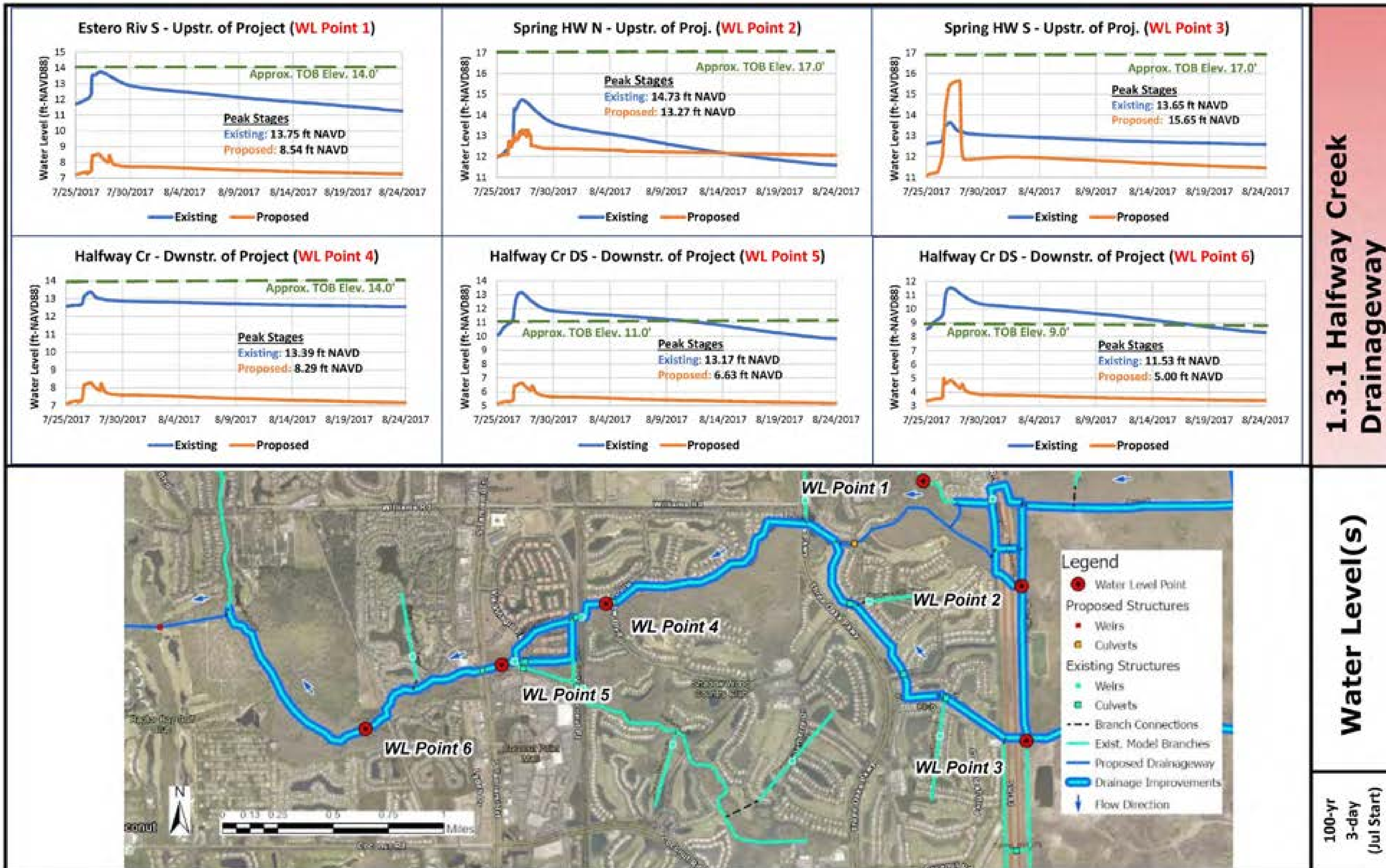


Flow(s)



25-yr 3-day (Jul Start)

EXHIBIT 1.3.1 (d)



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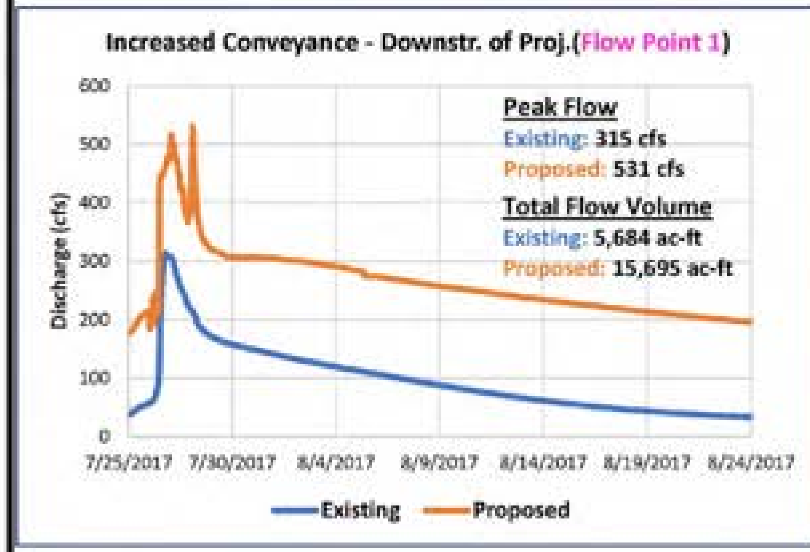
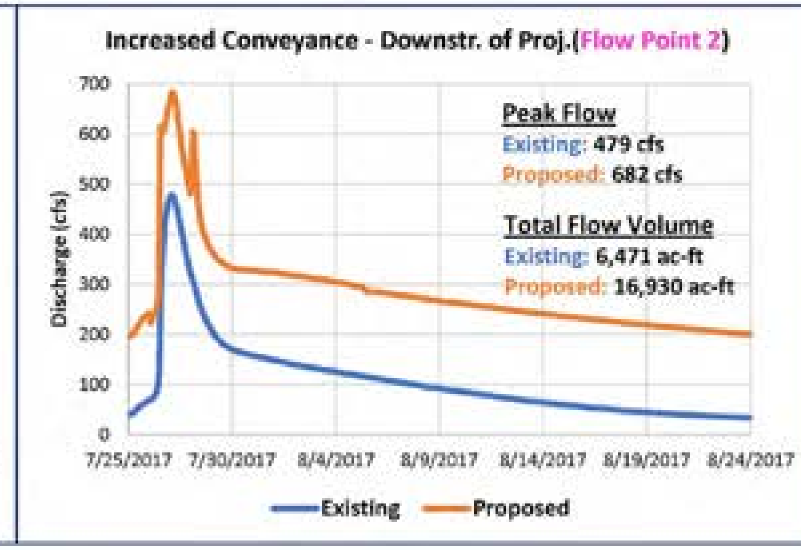
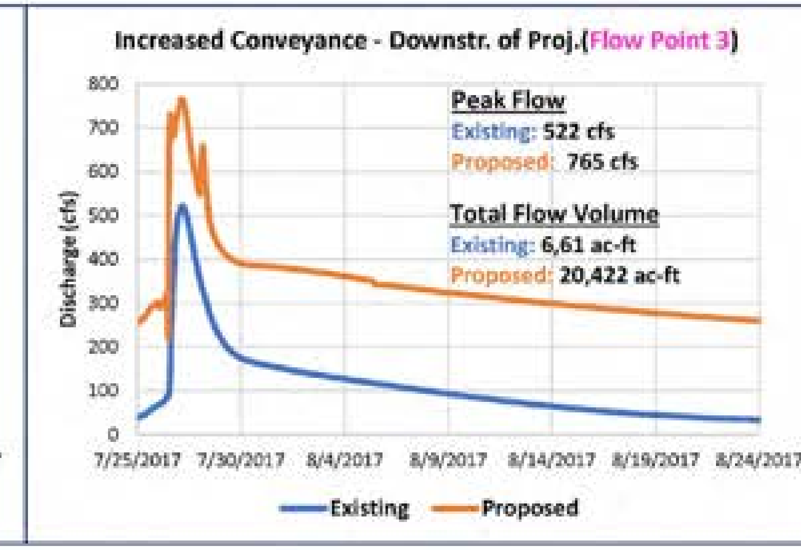






1.3.1 Halfway Creek Drainageway

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.1 (f)

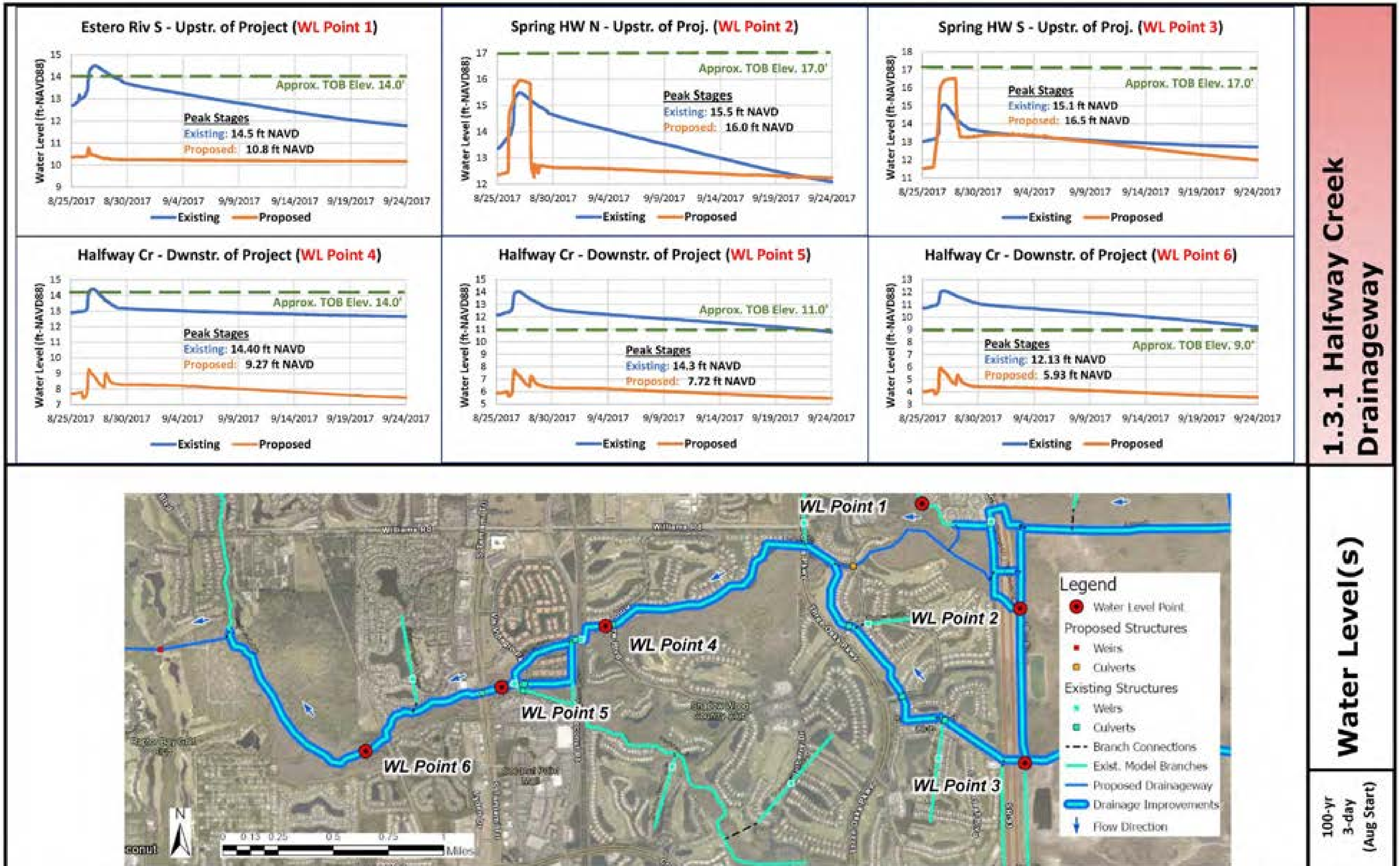
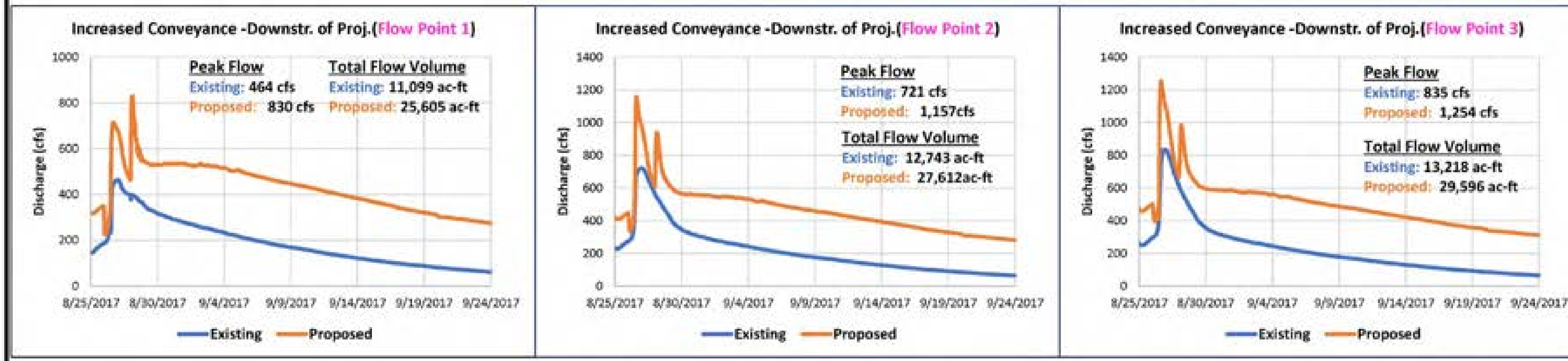


EXHIBIT 1.3.1 (g)

1.3.1 Halfway Creek Drainageway



Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.1 (h)

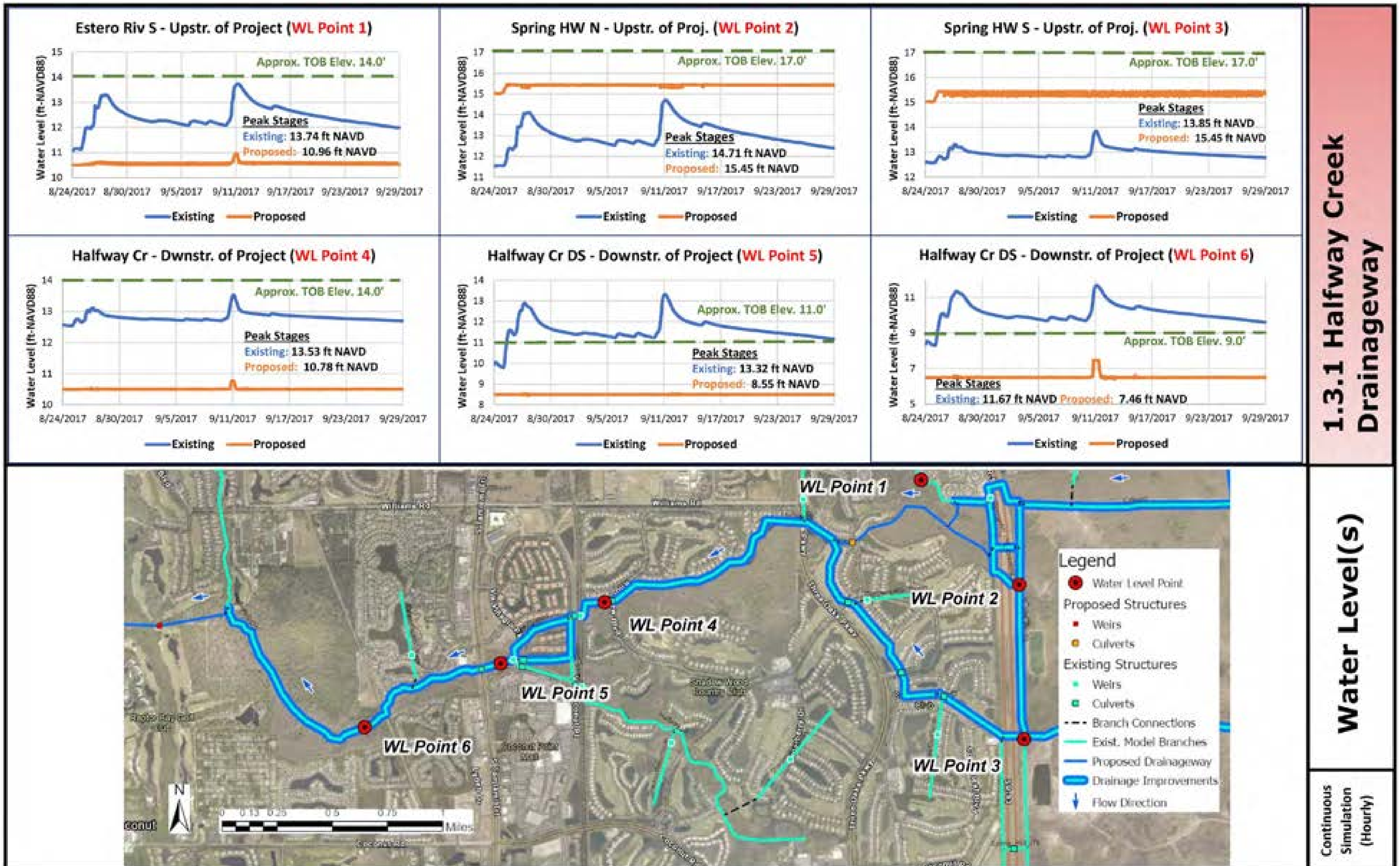
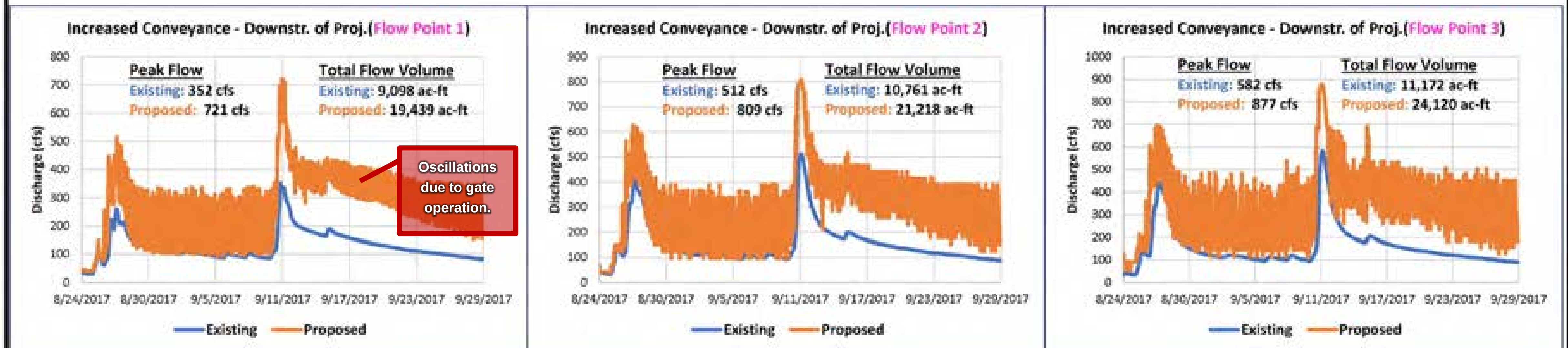


EXHIBIT 1.3.1 (i)

1.3.1 Halfway Creek Drainageway

Flow(s)

Continuous Simulation (Hourly)



1.3.2 Estero River North Branch Improvements

Background

This concept project extends 4-5 miles inland, being narrow natural channel with sharply define banks. Many developments are constructed along the riverbank which have confined flow and restricted the flood plain. The stream channel connects to a large bridge and box culvert under I-75 to link flow from east of Interstate No. 75 to the Estero River. The natural channel has experienced severe flooding and does not adequately handle the stormwater runoff from this very large watershed without severe flooding. This flow way is very picturesque and work in the natural flow-way should be limited to overflow banks, bypass channels and limited weir construction. The Koreshan community were early settlers of this area and many of their historic buildings are located along the river.

Location

The concept project is located at an I-75 bridge crossing just north of the Estero Parkway overpass and continues south west to the Estero River at the box culvert at U.S. 41 just north of Corkscrew Rd as illustrated in **Figure 14**.

Figure 14 – Location Map, 1.3.2 Estero River North Branch Improvements

Description

This concept project enhances conveyance from existing I-75 bridge with flow-way improvements of the Estero River and improvement of channels that re-direct the flow path for extreme storm events. The project would utilize dual paths to allow for better flow conditions, where possible. These conveyances may have remotely operated weir gates to maintain flow and water levels within desirable ranges, where warranted.

Purpose

This concept project enhances the drainage capacity for handling large stormwater flow from the Alico Mine Lakes area. The development of drainage flow-way capacity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels. The concept will help to enhance flow capacity along the Estero River and the North Branch. This project is an opportunity to help drain the basin east of I-75 which contains the FGCU campus and Grandezza Golf Club that has previous flooding issues, by providing approximately 1,000 CFS flow capacity through the project area as illustrated in **Figure 15**.

Figure 15 - Concept Plan, 1.3.2 Estero River North Branch Improvements

Evaluation

Viability

This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Some of the work must be performed within the stream limits to creatively enhance the flows. Weir structures to manage water levels and large drainage structures may be required. This flow-way is an essential flow-way for this area. The critical importance of the flow-way to the region is vitally necessary.

Community Considerations

This drainageway would utilize the Creekside RPD property, the River Oaks Estates property, the Villages at Country Creek RPD property, the Estero on the River MPD and also privately-owned undeveloped properties and all would need approval from all of the communities and property owners.

Environmental & Permittability Considerations

Significant environmental impacts occurring along the route that will necessitate mitigation and creative enhancement to improve flows.

Land Availability

The need for land acquisition and governmental approval is necessary to construct the Estero River North Branch Improvements and water quality features.

Opinion of Probable Cost

The cost opinion shown in **Table 3** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 3 - Opinion of Probable Cost breakdown, 1.3.2 Estero River N. Branch Improvements

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc	1	LS	$ 1,100,000	$ 1,100,000
Clearing & Grubbing/ Demolition	1	LS	$ 600,000	$ 600,000
Earthwork	165,000	CY	$ 8	$ 1,320,000
Structure damages	4	EA	$ 250,000	$ 1,000,000
Construction/ Maintenance Access	7,500	SY	$ 20	$ 150,000
Weir Structure 3.1A (Major)	60	LF	$ 10,000	$ 600,000
Weir Structure 3.2B (Major)	30	LF	$ 10,000	$ 300,000
Seawall	4,400	LF	$ 250	$ 1,100,000
Rip-rap along Seawall	3,300	TN	$ 100	$ 330,000
Detours	1	LS	$ 200,000	$ 200,000
Box Culvert 3.2-4	300	CY	$ 1,200	$ 360,000
Box Culvert 3.2-6	200	CY	$ 1,500	$ 300,000
Electric Supply	1	LS	$ 20,000	$ 20,000
Permanent Erosion Control	10,000	SF	$ 25	$ 250,000
Sod	35,000	SY	$ 2	$ 70,000
			Conceptual Construction Costs:	**$ 7,700,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 2,000,000
			Land Acquisition	$ 2,300,000
			Project Administration/ CEI (10%)	$ 700,000
			Project Unknowns	$ 500,000
			Conceptual Project Cost:	**$ 13,200,000**
			Contingency (30%)	$ 3,800,000
			Conceptual Project Cost (with Contingency):	**$ 17,000,000**

Opportunities for Multiple Benefits & Uses

As south east Lee County continues to reach full build-out conditions, improving the conveyance of the Estero River Drainage Basin is a critical priority. Providing upstream storage solutions will also become increasingly difficult as development acquires the available land.

Other Considerations

A summary of this concept project is shown below in **Exhibit 1.3.2** herein. An alternative to the drainageway route, which is currently proposed though undeveloped areas, could require land acquisition and routing though the developed subdivisions.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from east of Interstate 75 by improving existing conveyances and adding proposed conveyances to increase the flow capacity from a large bridge at Interstate 75 to Estero Bay. Improvements within the stream bed will be limited to overflow banks, channel maintenance, and a proposed weir. The bypass channels will carry most of the flow. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.2 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.2 (b) EXHIBIT 1.3.2 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.2 (d) EXHIBIT 1.3.2 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.2 (f) EXHIBIT 1.3.2 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.2 (h) EXHIBIT 1.3.2 (i)

Improvements were shown with water level reductions from the existing to the proposed condition, and an increase in flow. Adjustments to Country Creek Bypass weir would further lower the water level stage within the proposed bypass. System performance improvements are understood since flows from east of Interstate 75 are delayed allowing the area west of Interstate 75 to recover.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from east of Interstate 75 to the Estero River, and eventually to the Estero Bay. These positive improvements warrant further design-level project development.

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project improves conveyance from existing I-75 bridge crossing at the Estero Parkway overpass to the Estero River with channel widening, excavation of a bypass flow-way and re-directing the flow path for extreme storm events. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project increases drainage capacity for handling large stormwater flow from the Alico Mine Lakes area. The development of drainage flow-way capacity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Working in the natural areas of the Estero River will require special attention to preserve the character of the stream. Environmental impacts would necessitate mitigation.

May 2020

Estero River N. Branch Improvements

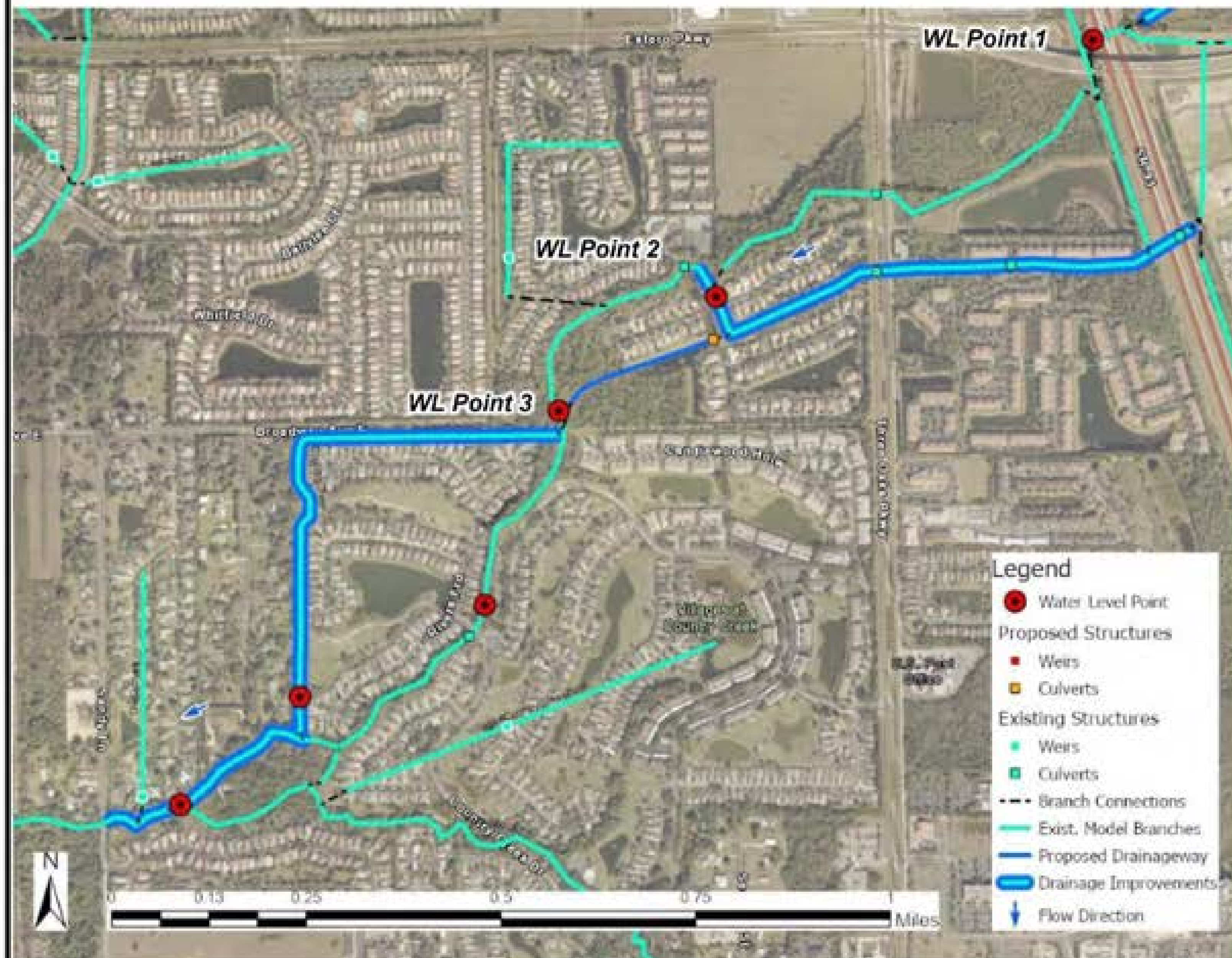
SE Lee County Area

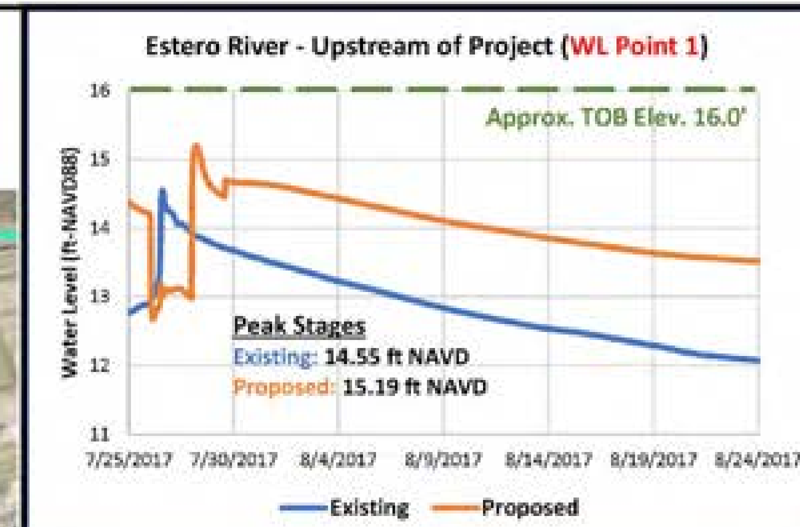
AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

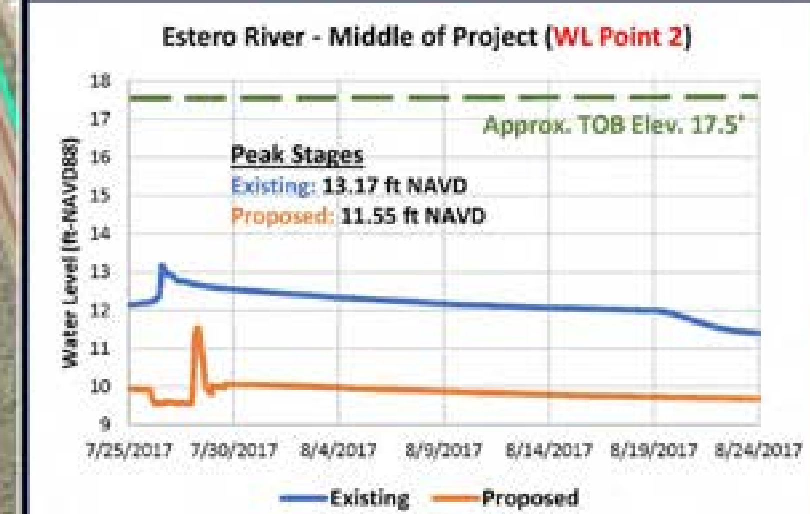
EXHIBIT 1.3.2

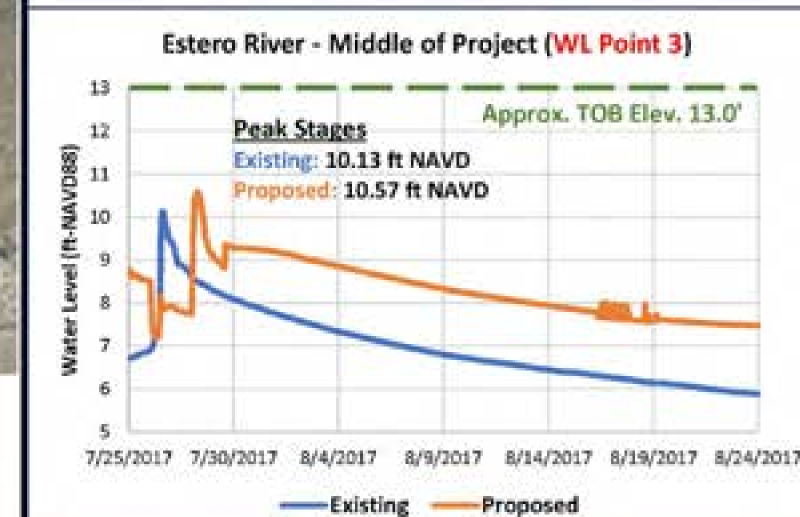
EXHIBIT 1.3.2 (a)

EXHIBIT 1.3.2 (b): 1 of 2









1.3.2 Estero River N. Branch Improvements

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.2 (b): 2 of 2

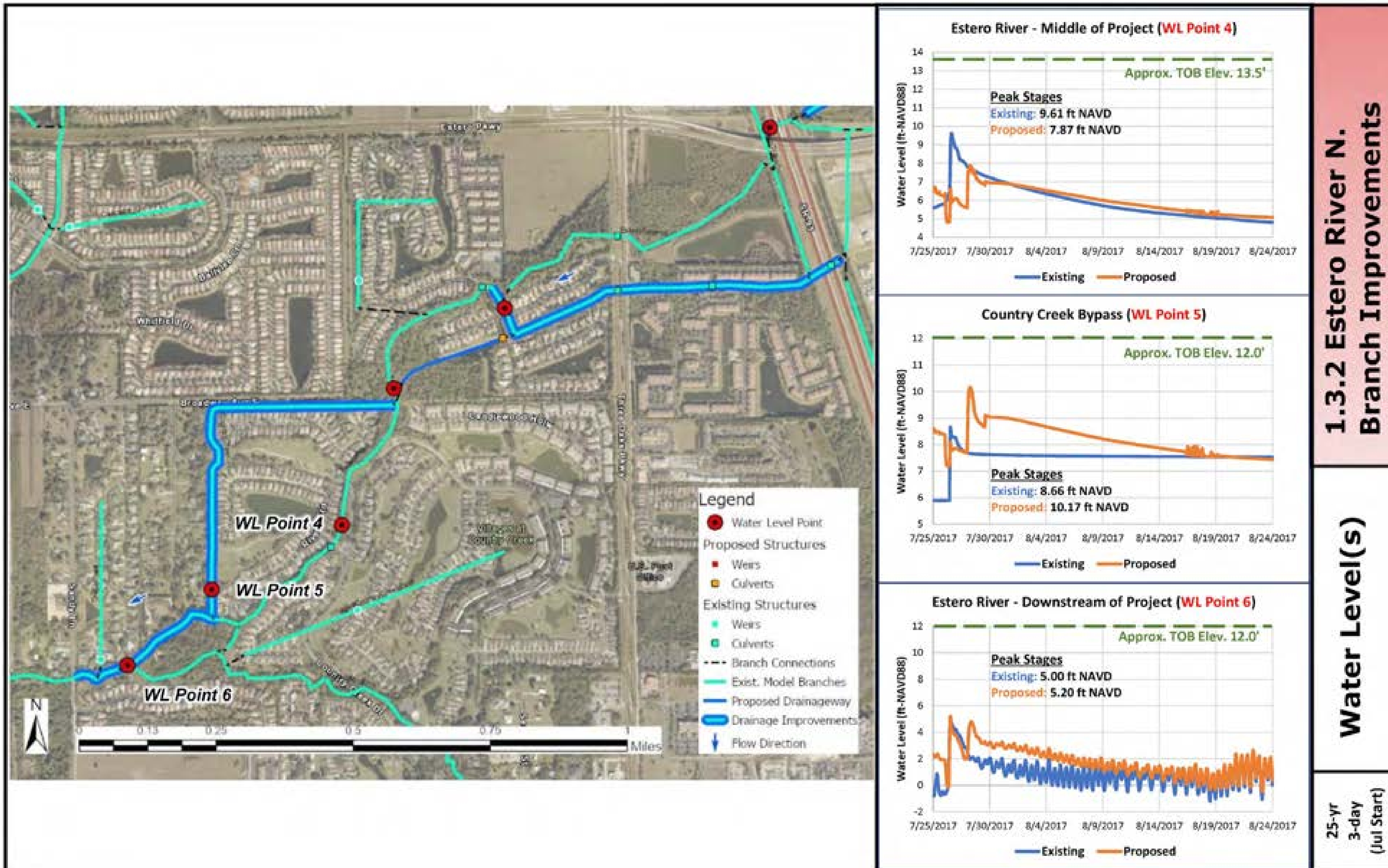


EXHIBIT 1.3.2 (c): 1 of 2

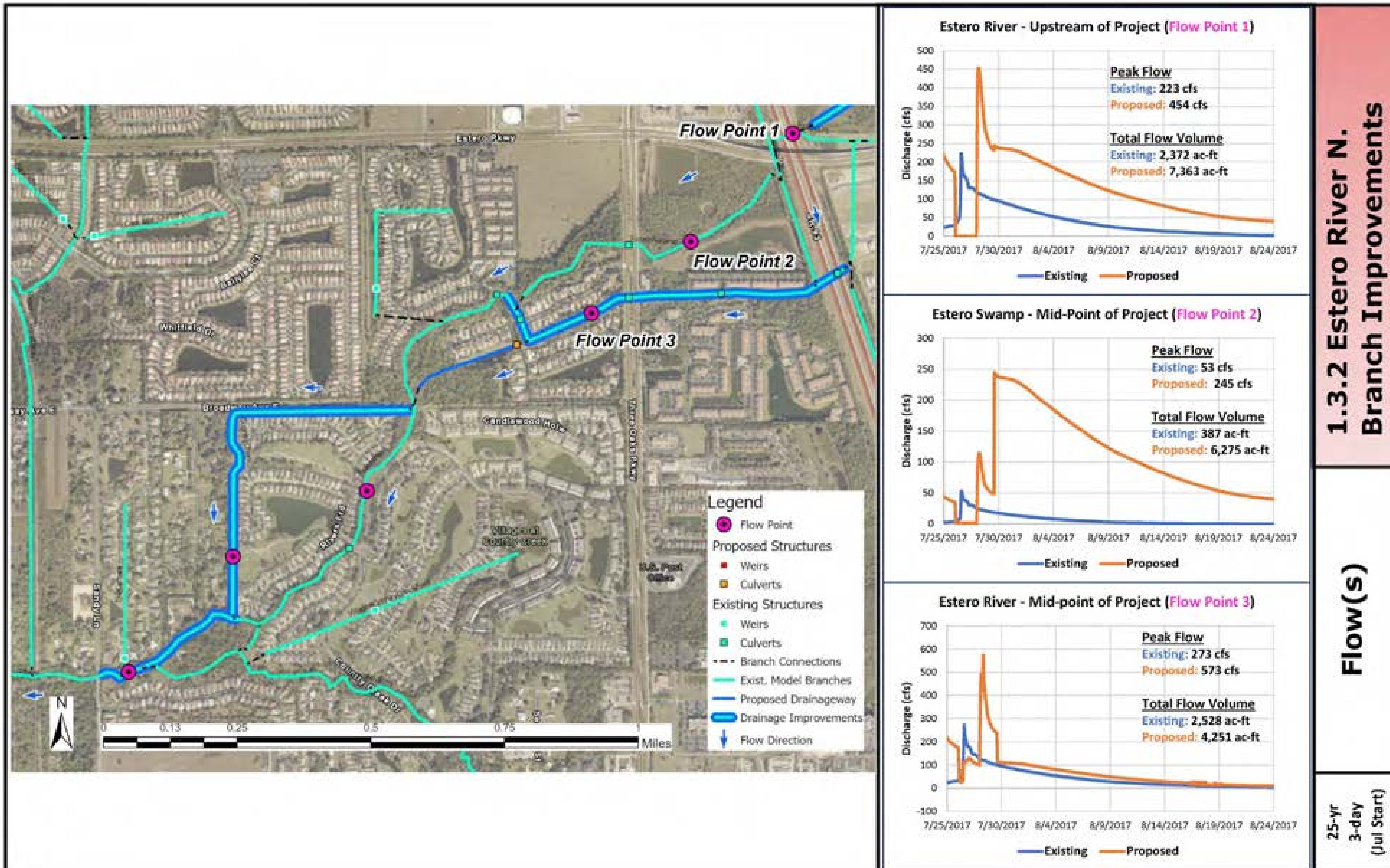
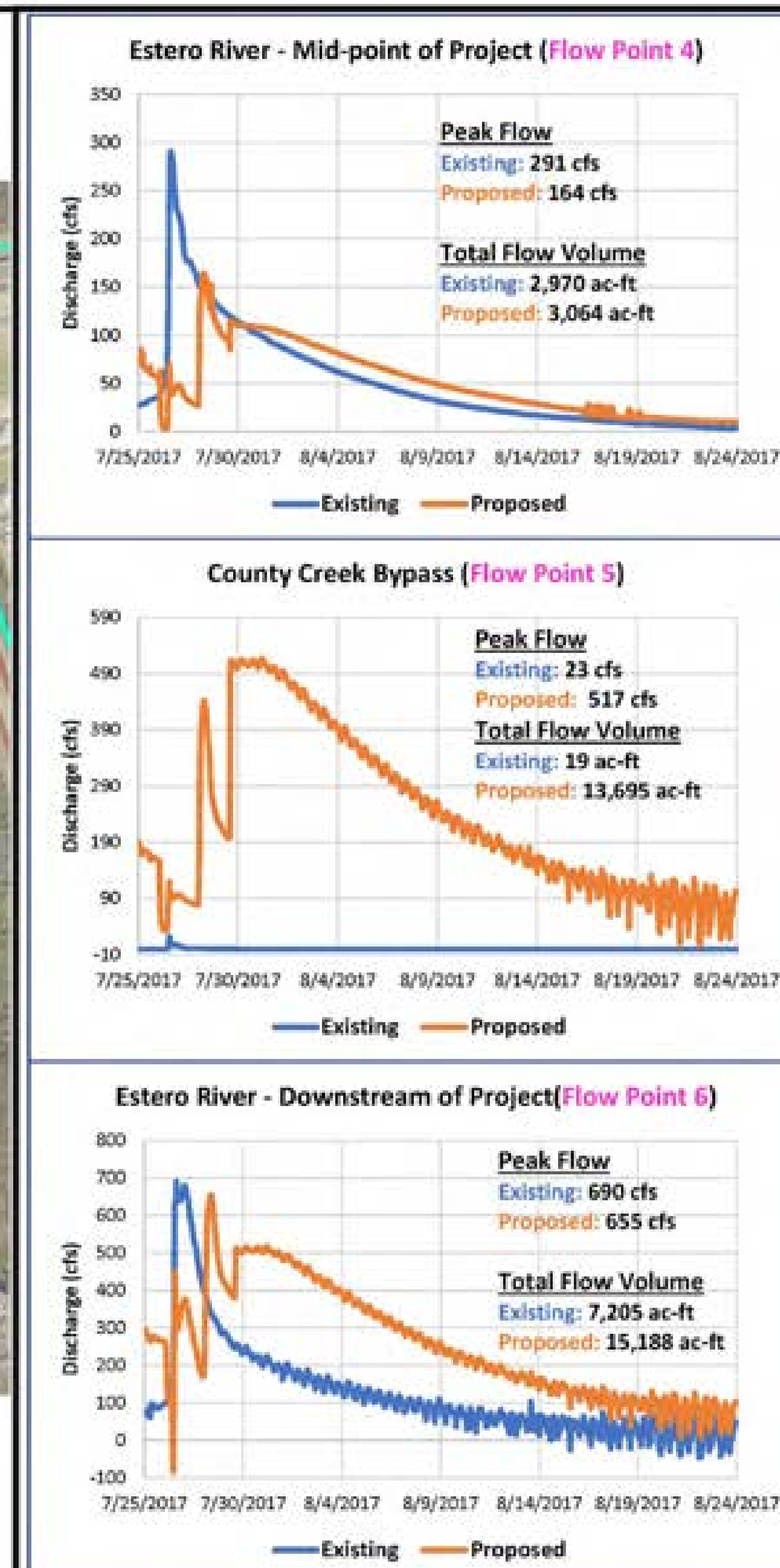


EXHIBIT 1.3.2 (c): 2 of 2

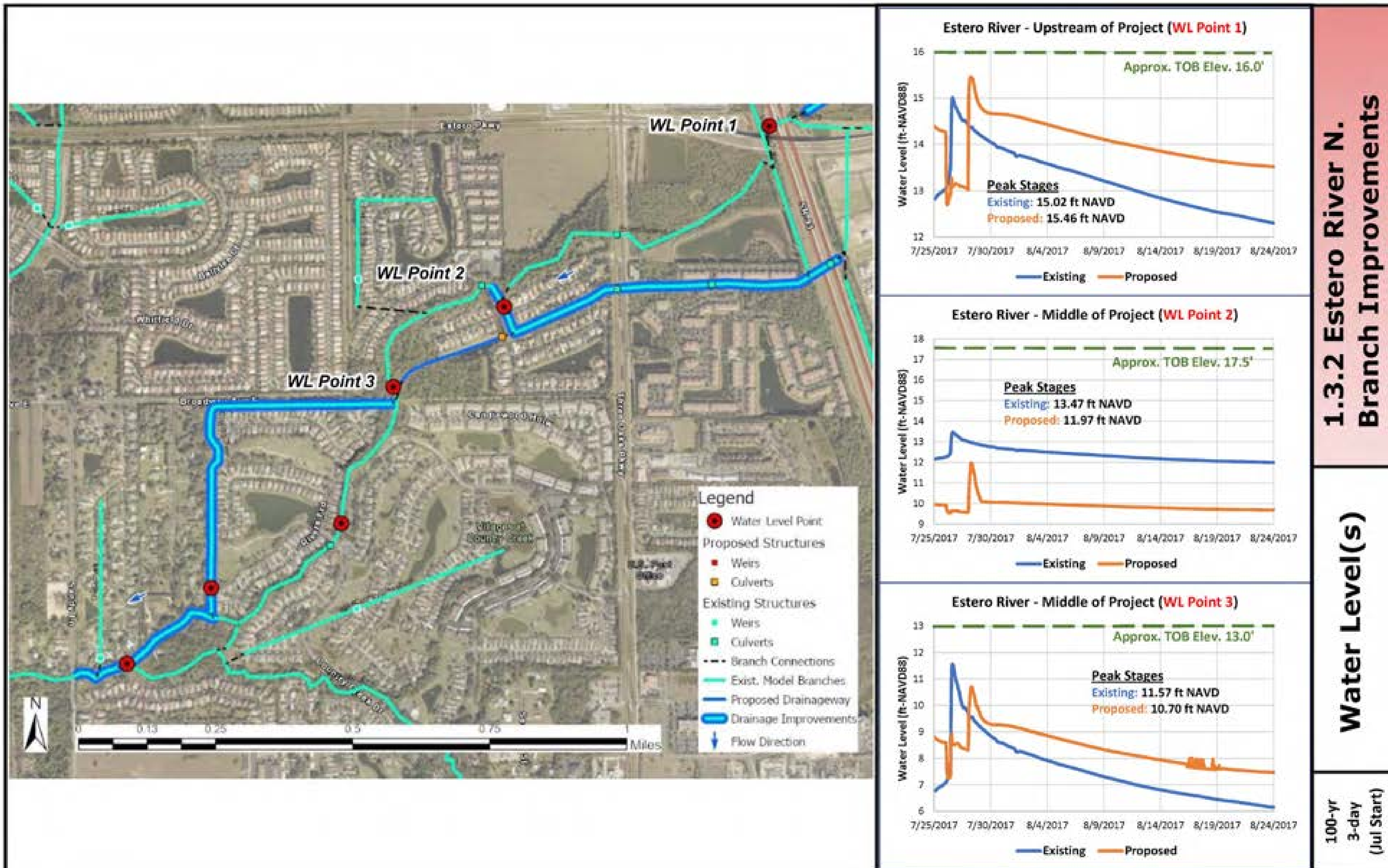


1.3.2 Estero River N. Branch Improvements

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.2 (d): 1 of 2



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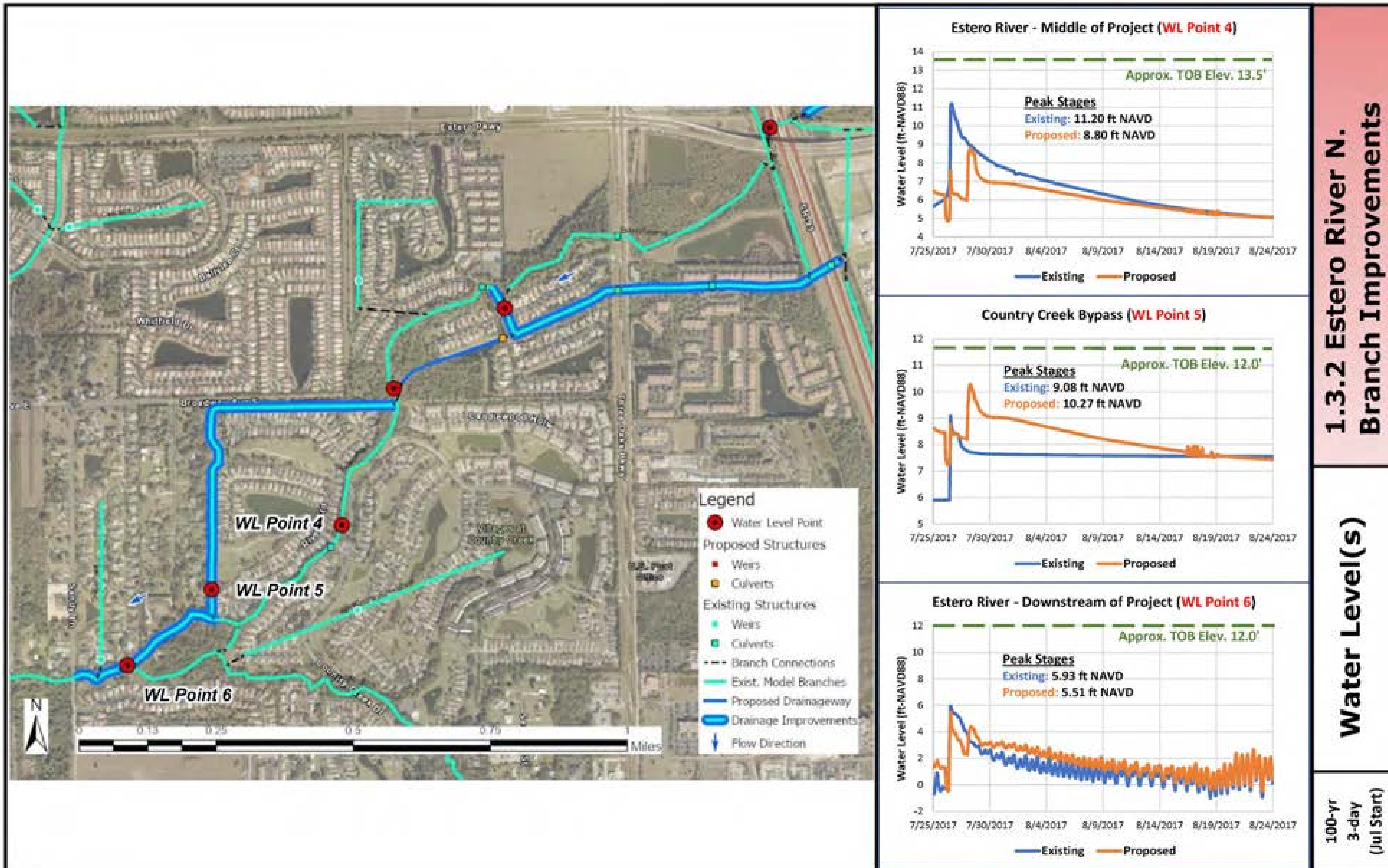

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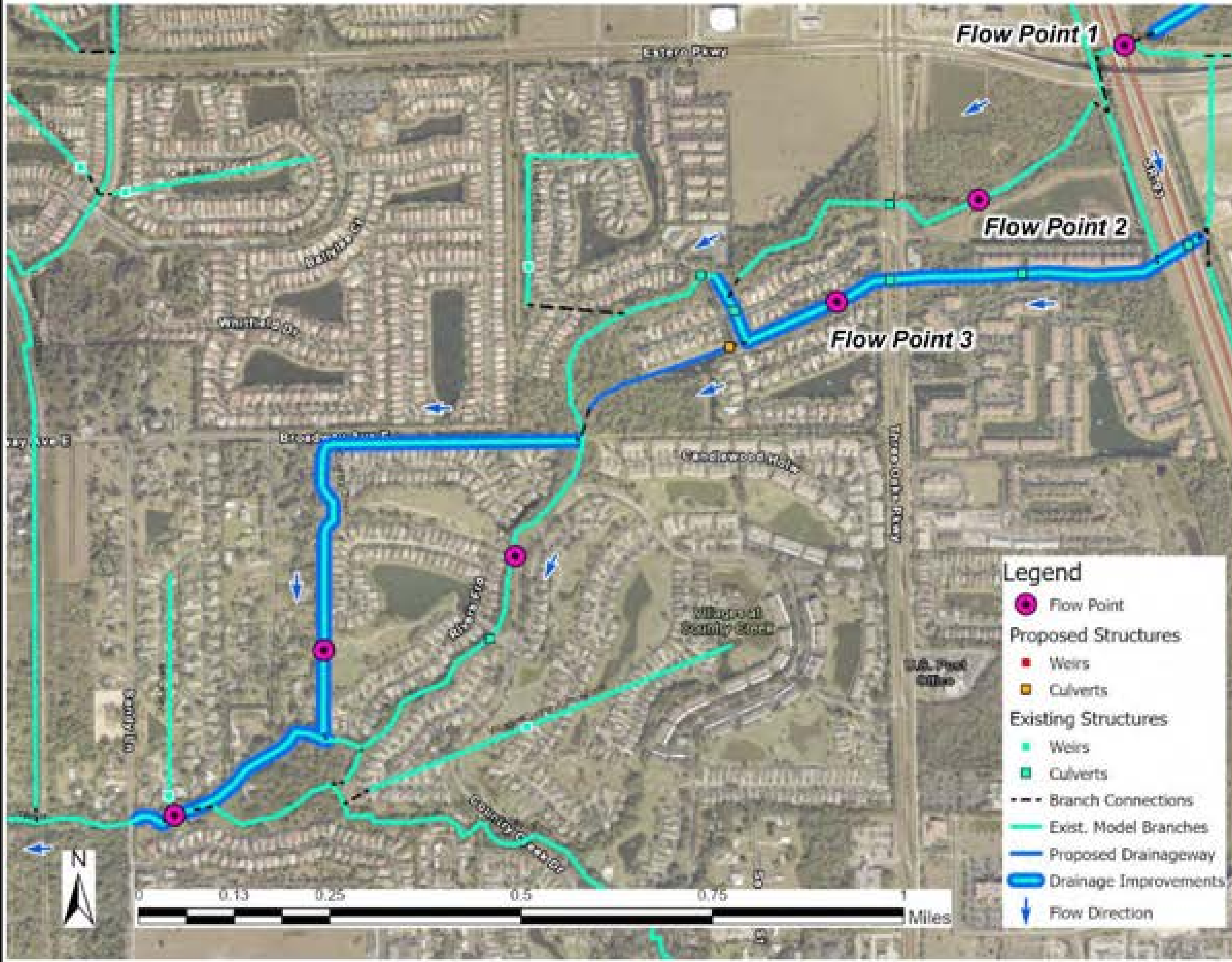
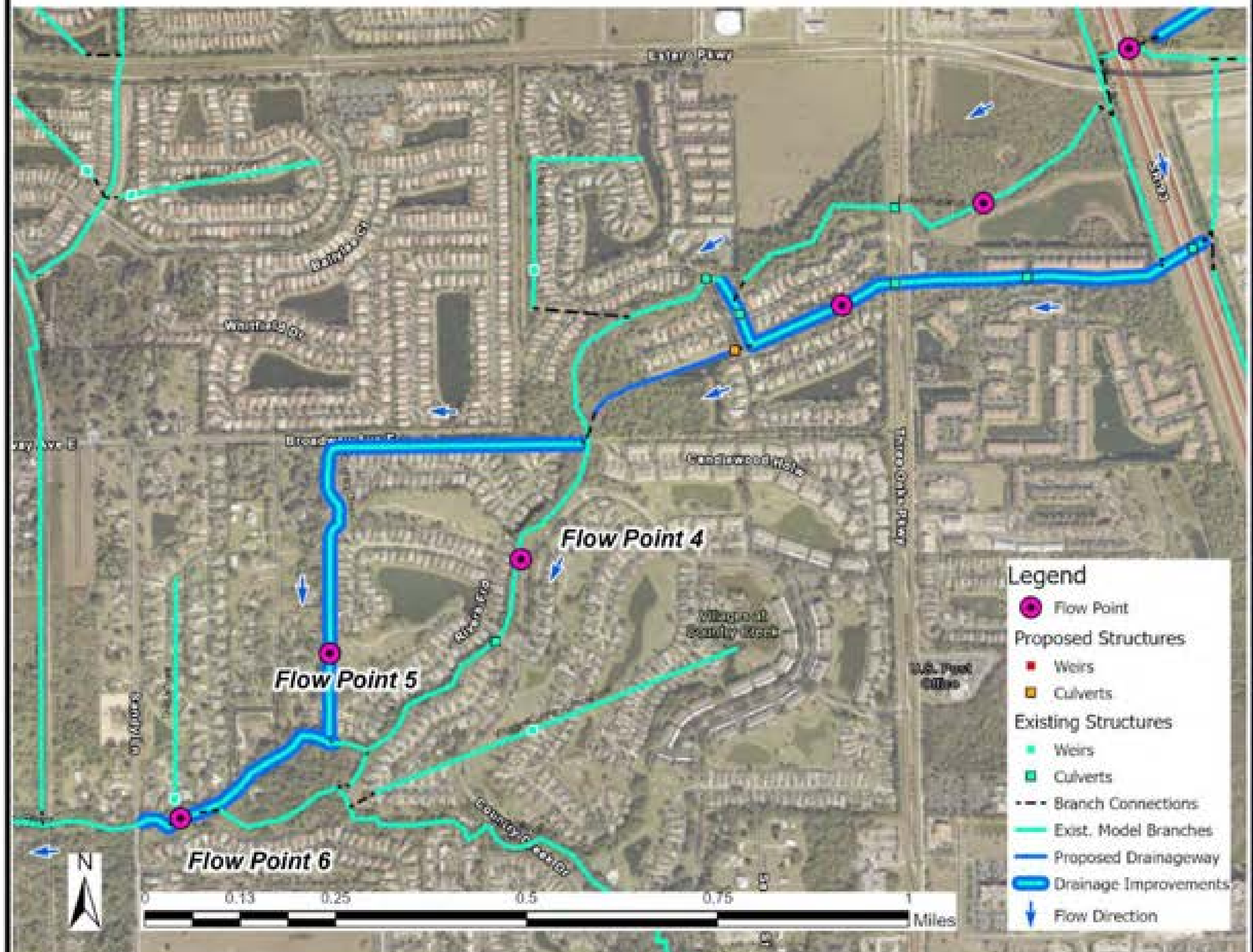


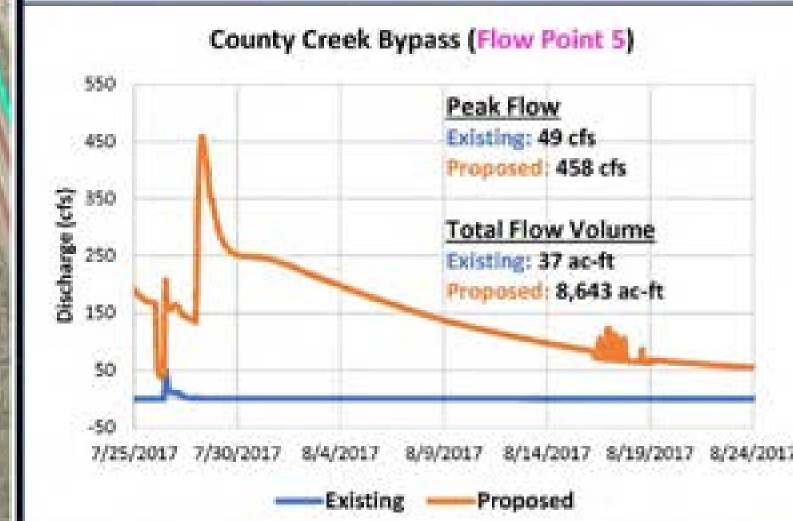
1.3.2 Estero River N. Branch Improvements

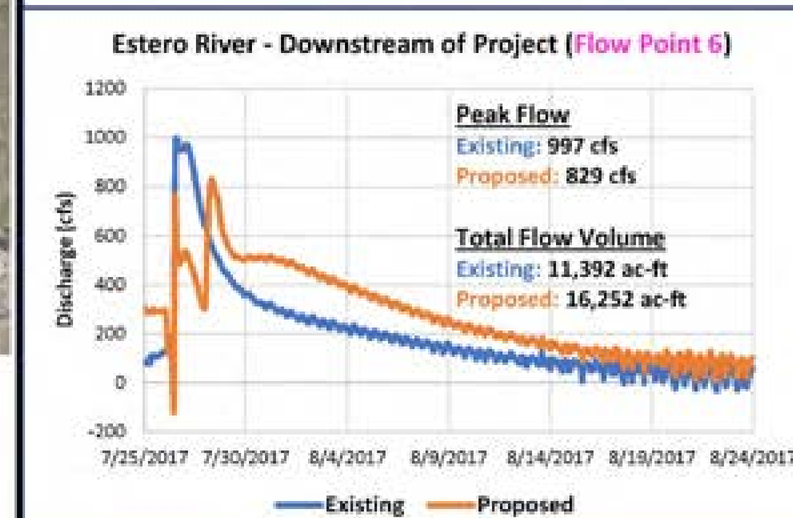
Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.2 (e): 2 of 2





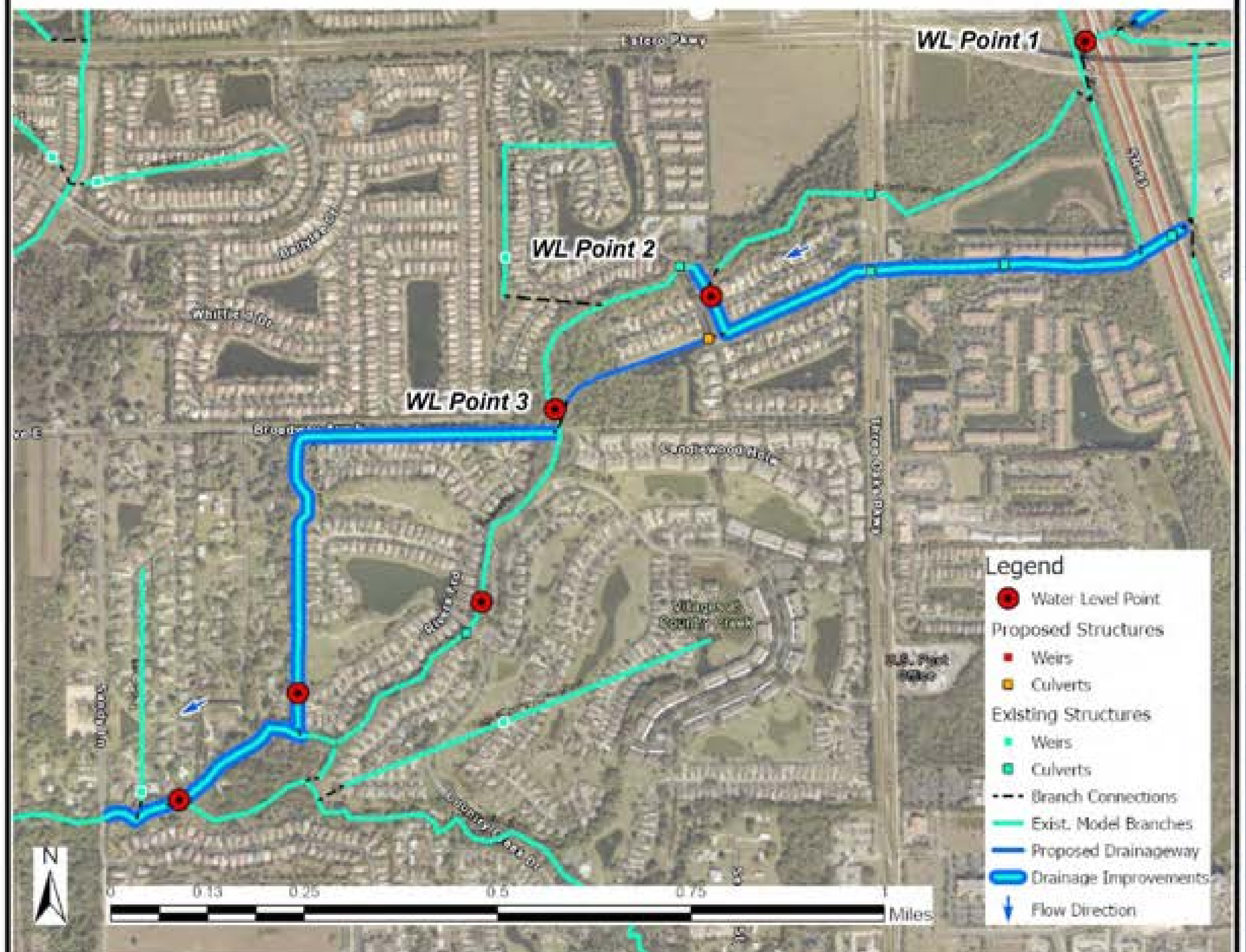


1.3.2 Estero River N. Branch Improvements

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.2 (f): 1 of 2

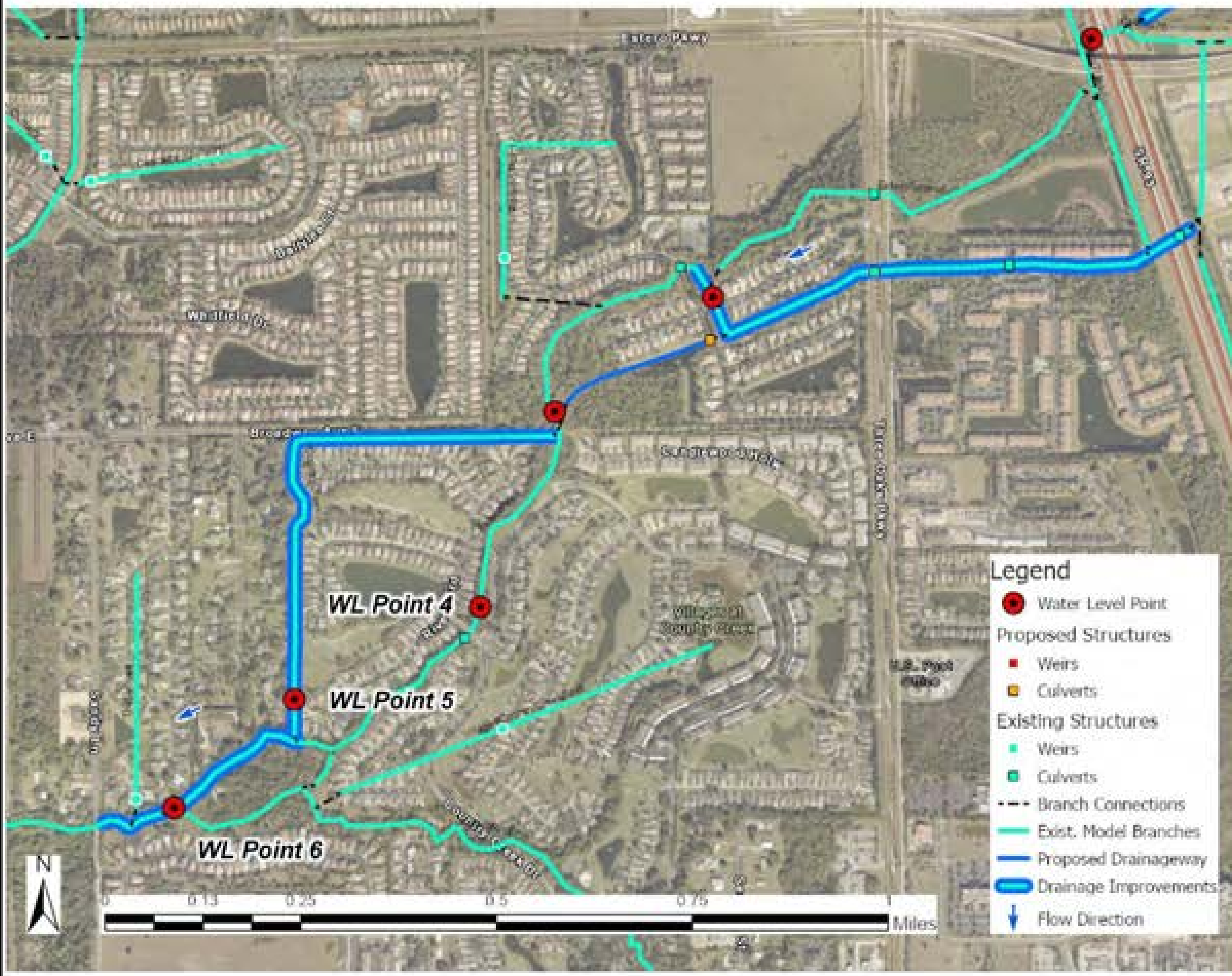


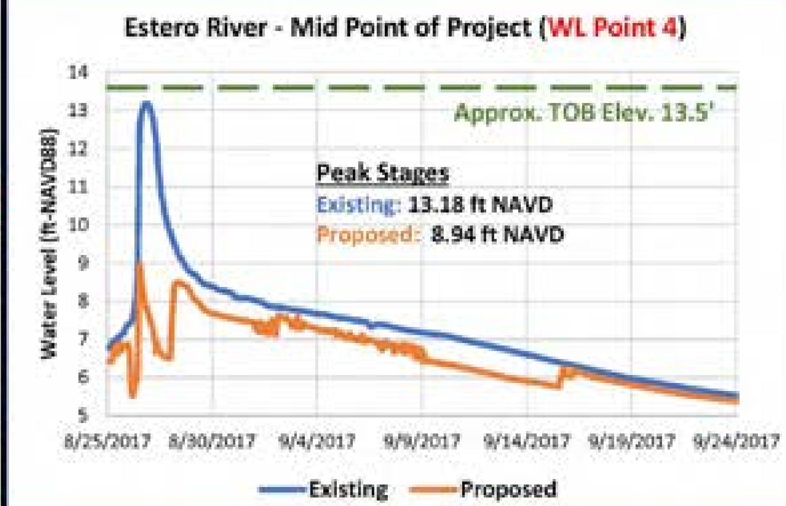
1.3.2 Estero River N. Branch Improvements

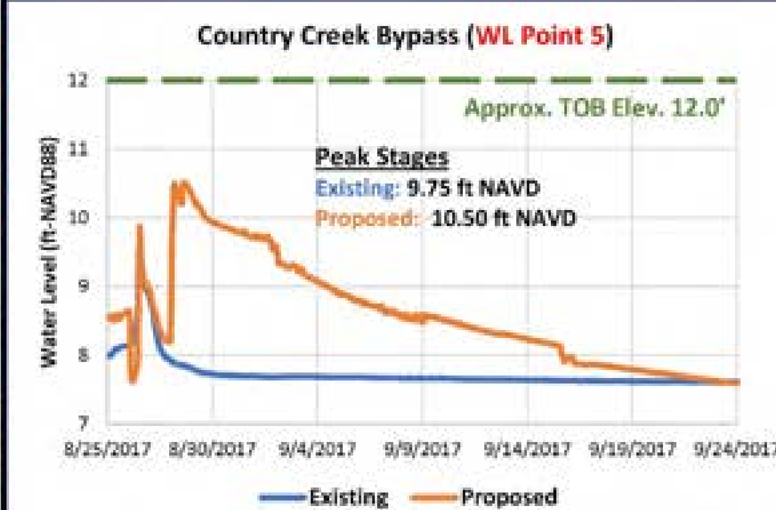
Water Level(s)

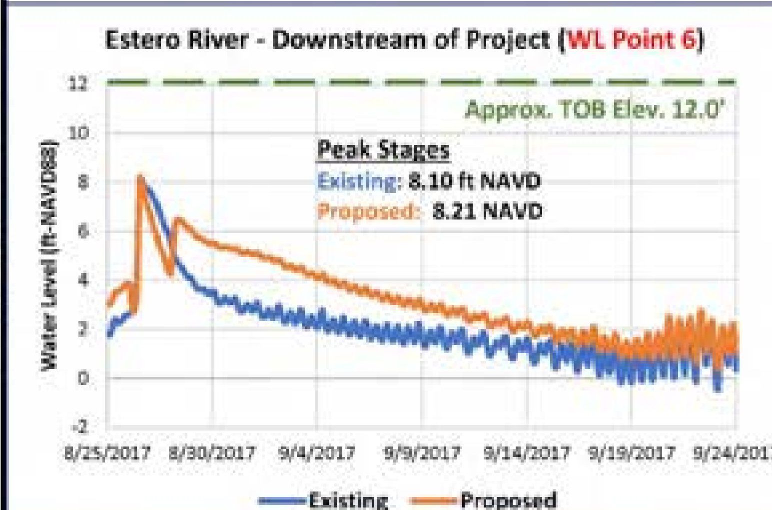
100-yr 3-day (Aug Start)

EXHIBIT 1.3.2 (f): 2 of 2







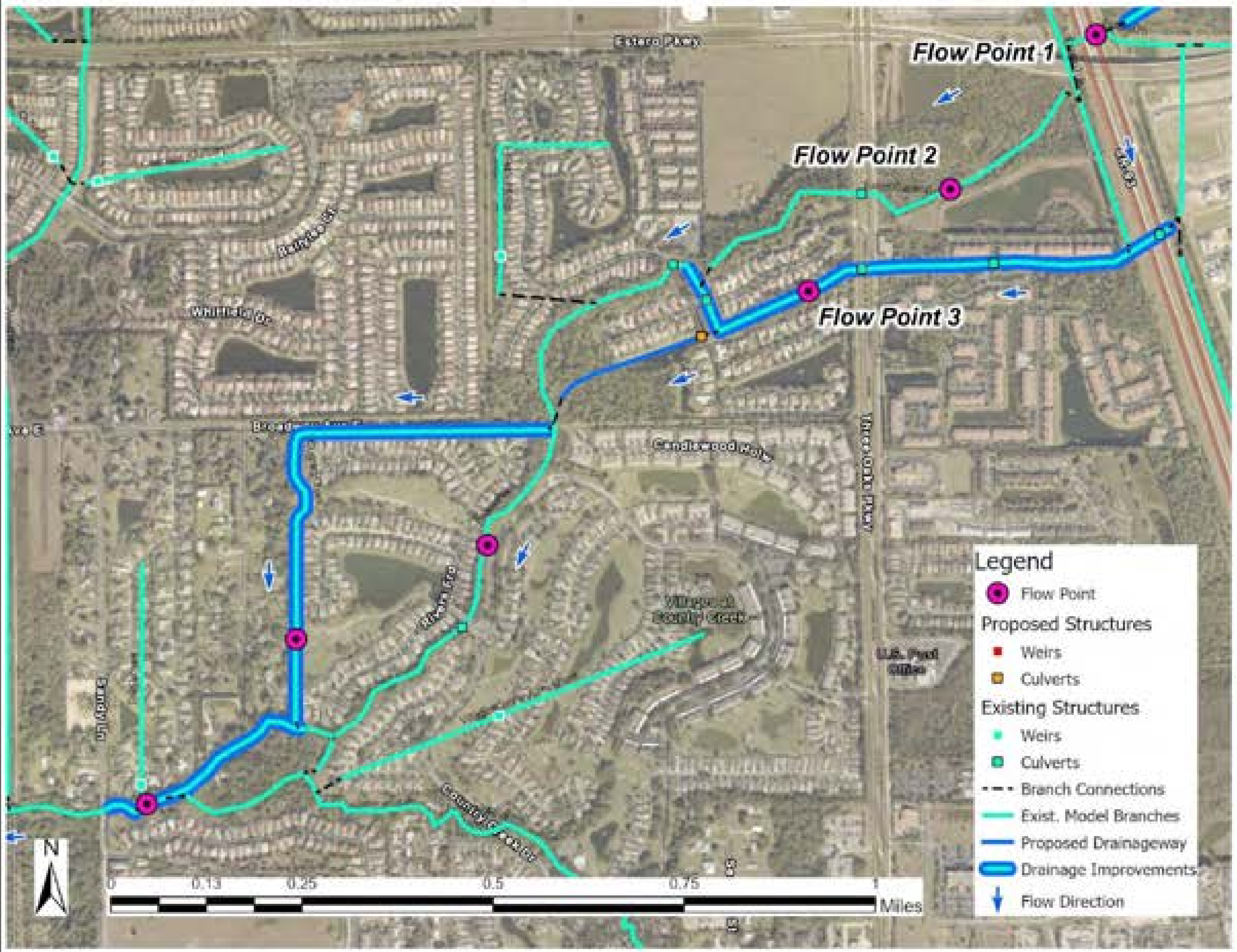


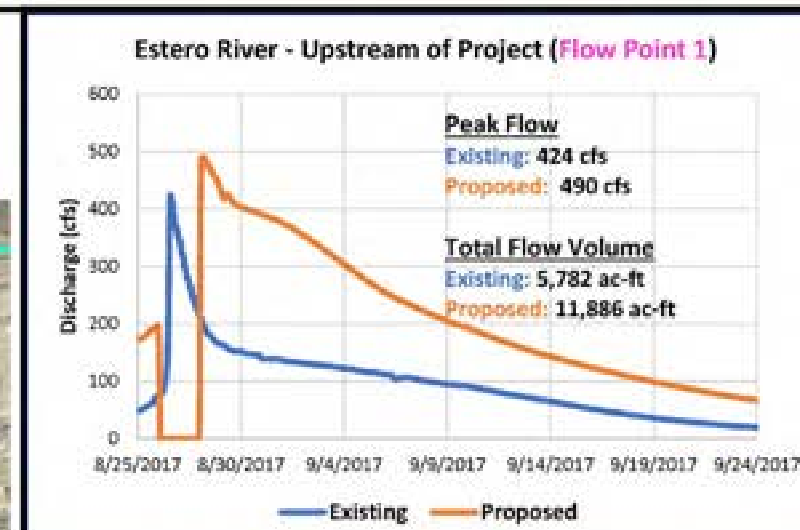
1.3.2 Estero River N. Branch Improvements

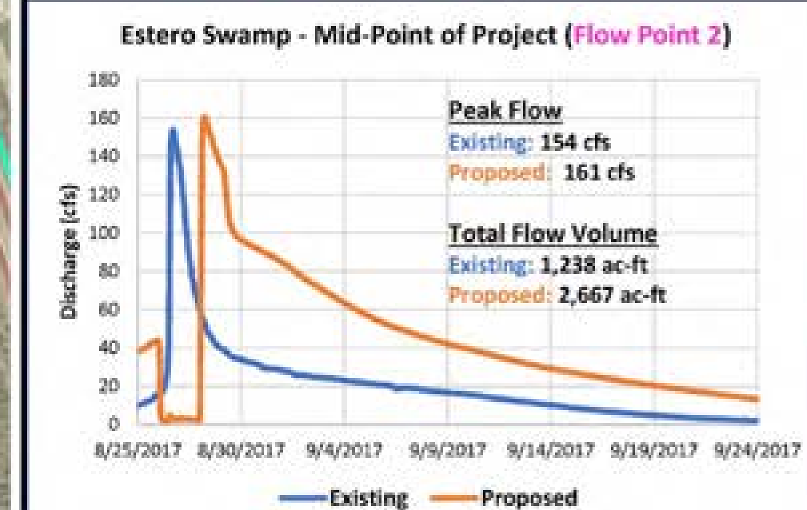
Water Level(s)

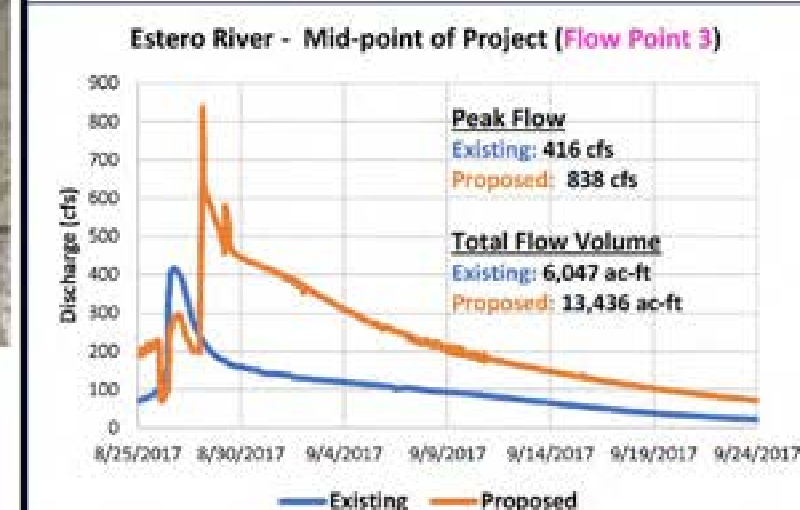
100-yr 3-day (Aug Start)

EXHIBIT 1.3.2 (g): 1 of 2







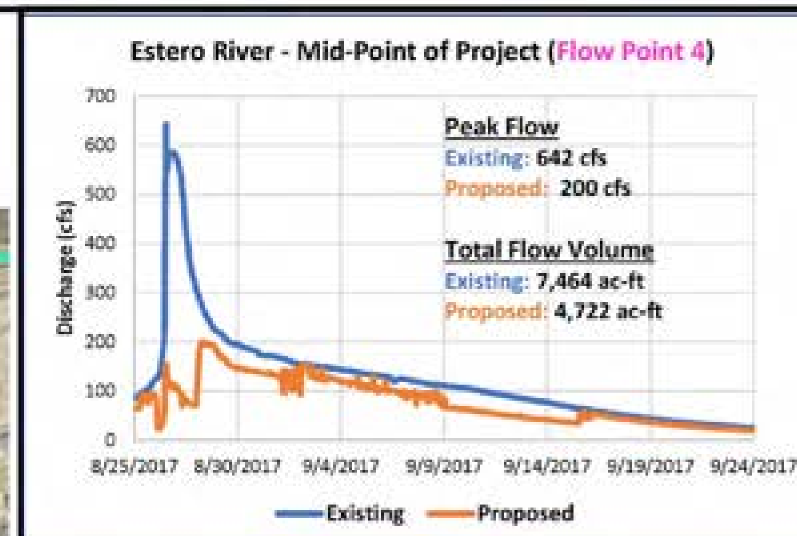


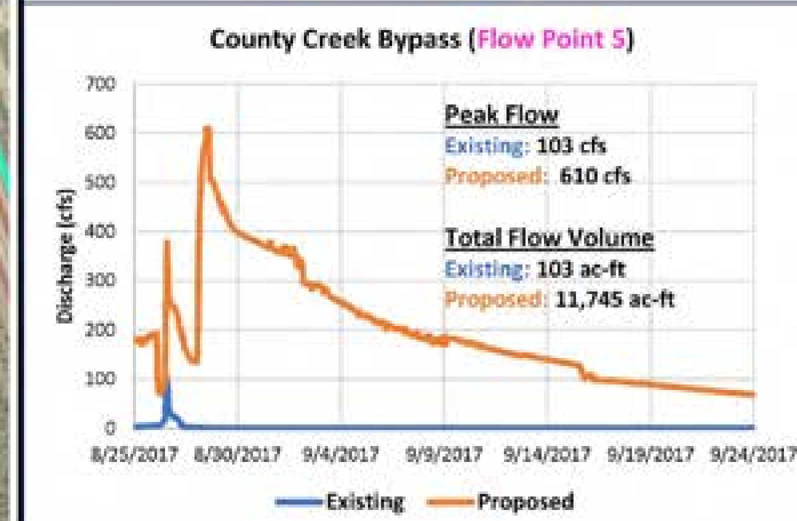
1.3.2 Estero River N. Branch Improvements

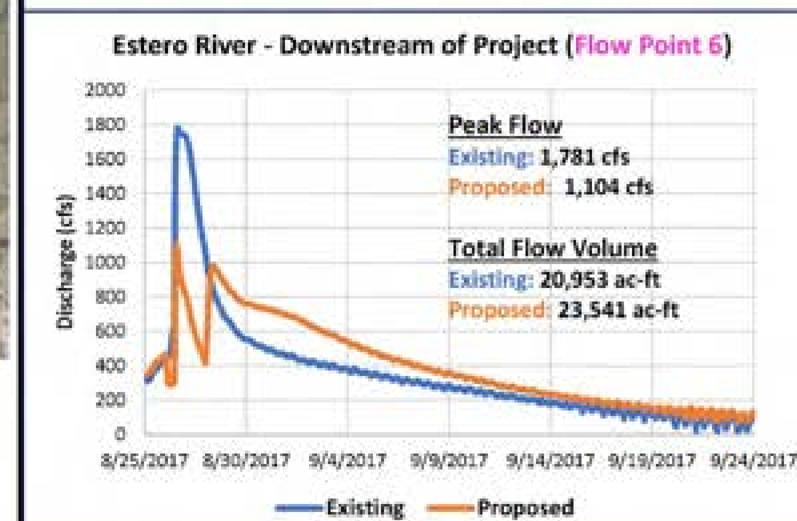
Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.2 (g): 2 of 2







1.3.2 Estero River N. Branch Improvements

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.2 (h): 1 of 2

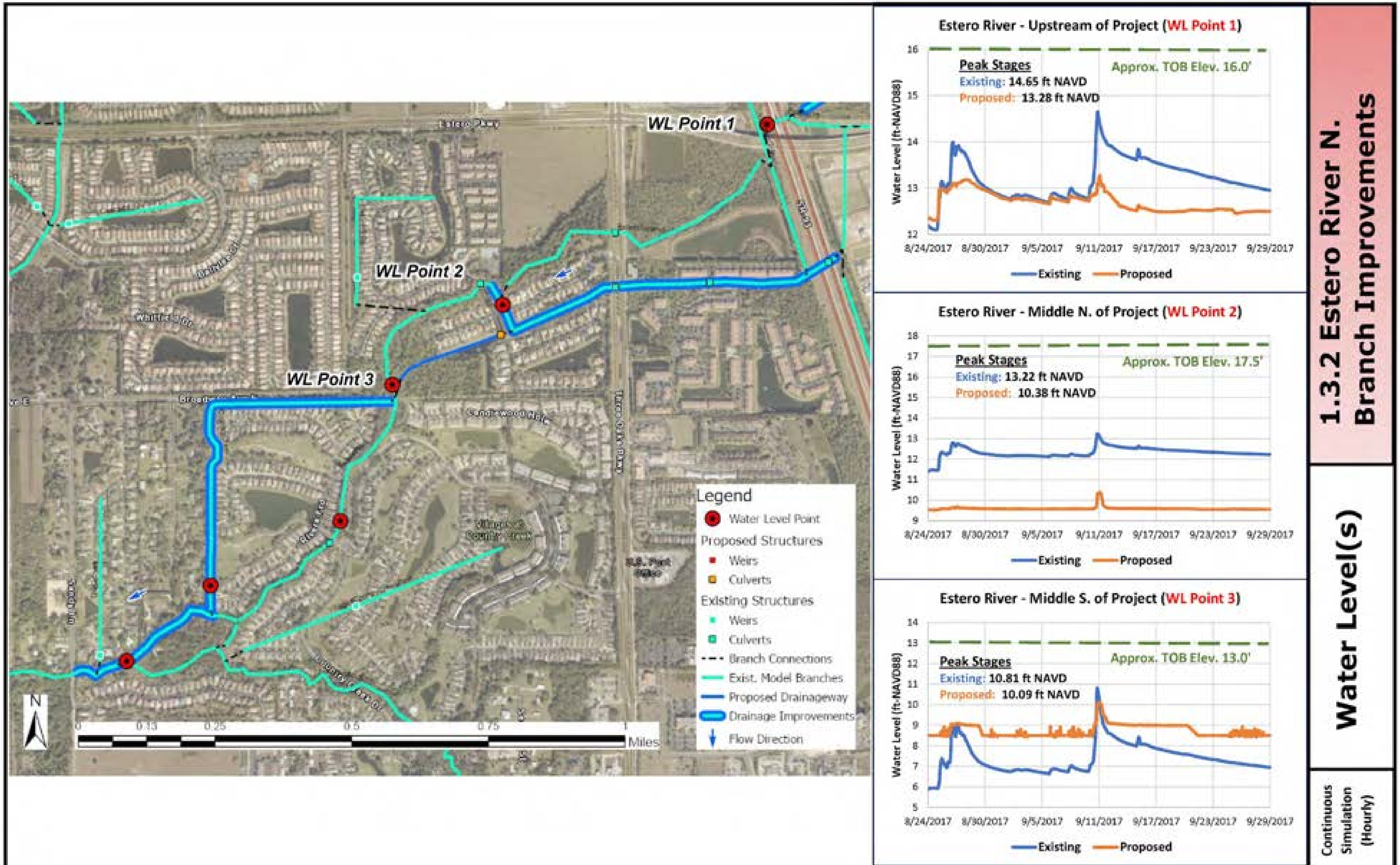


EXHIBIT 1.3.2 (h): 2 of 2

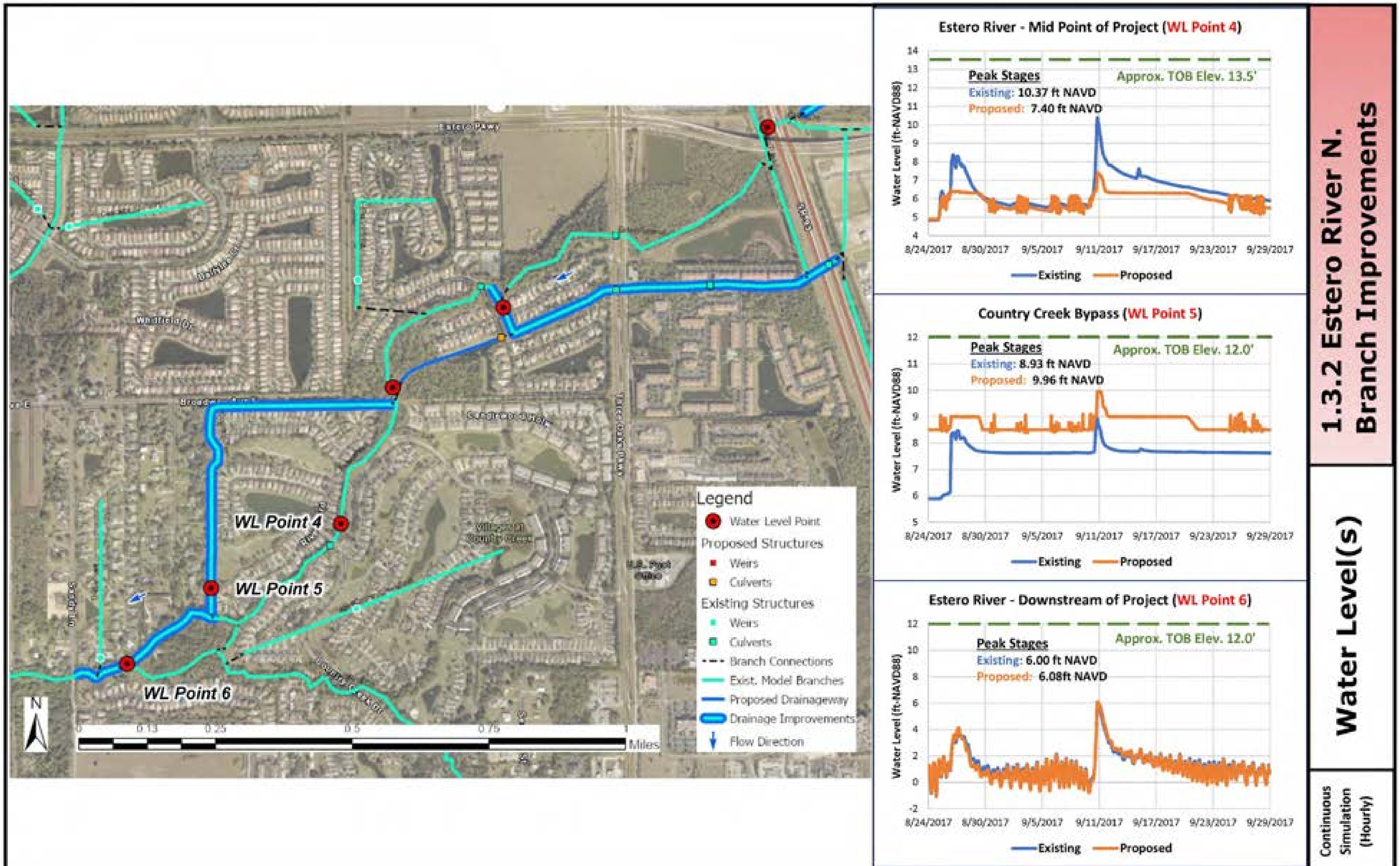
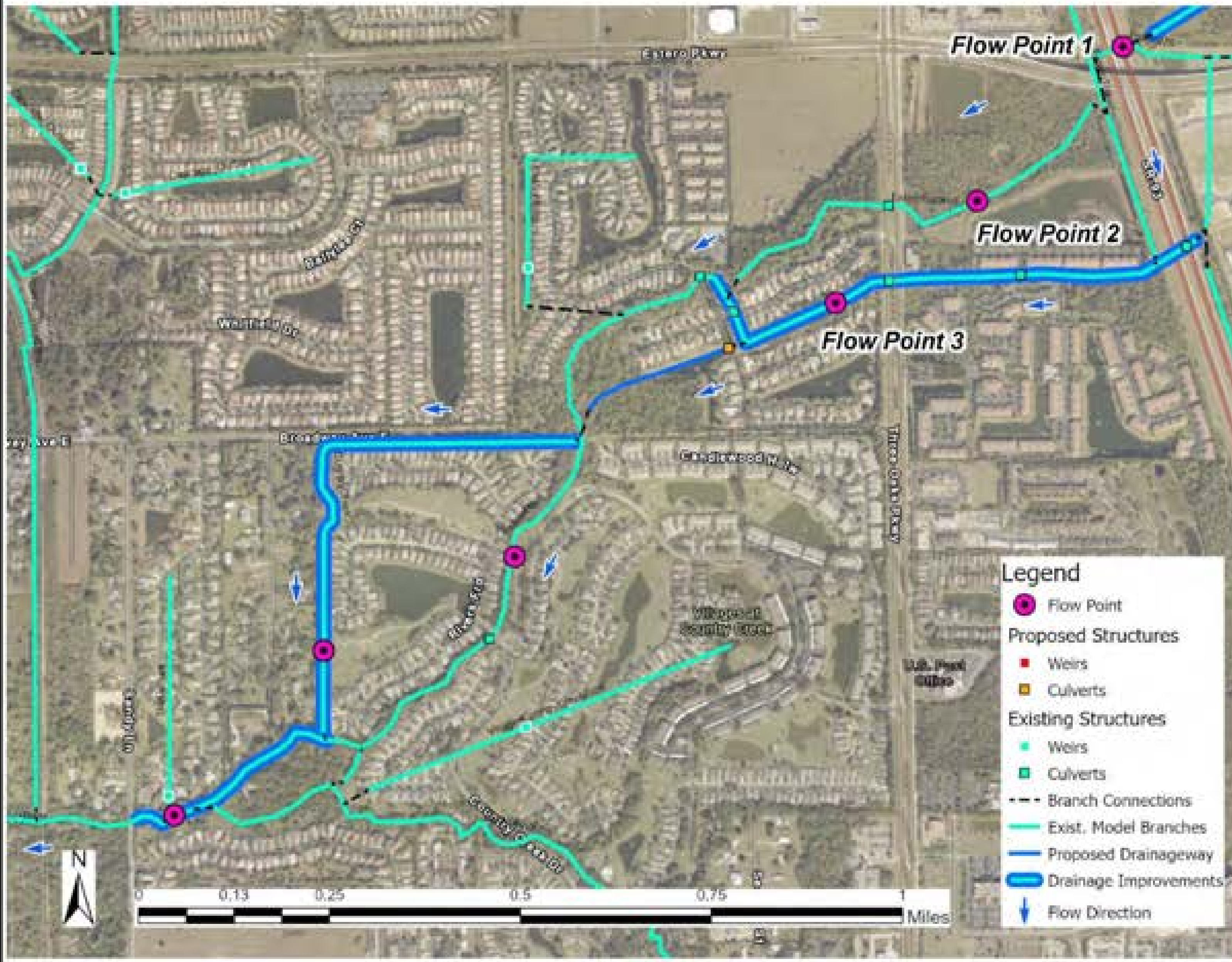
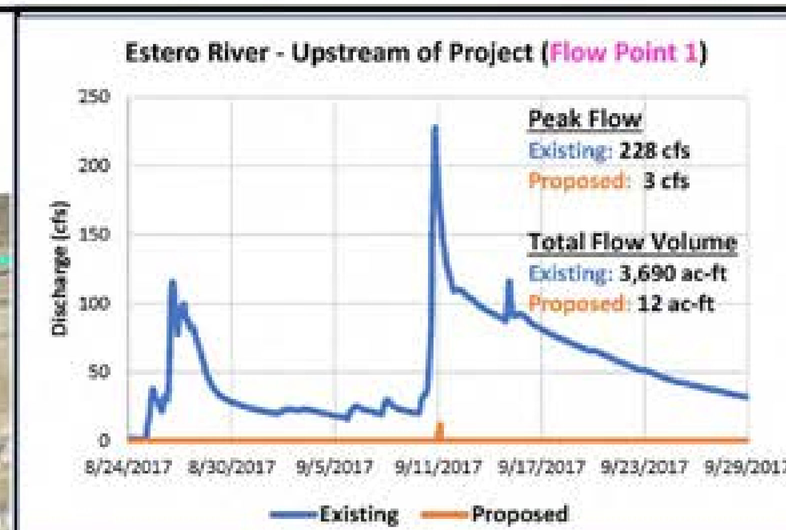
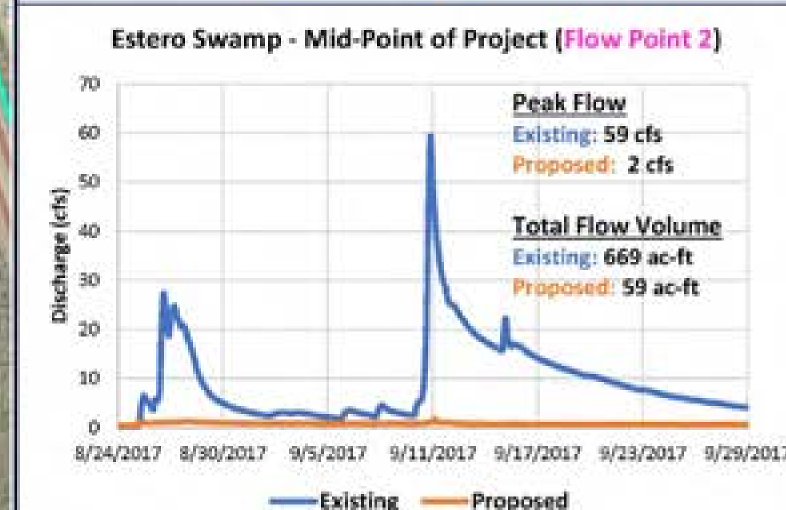
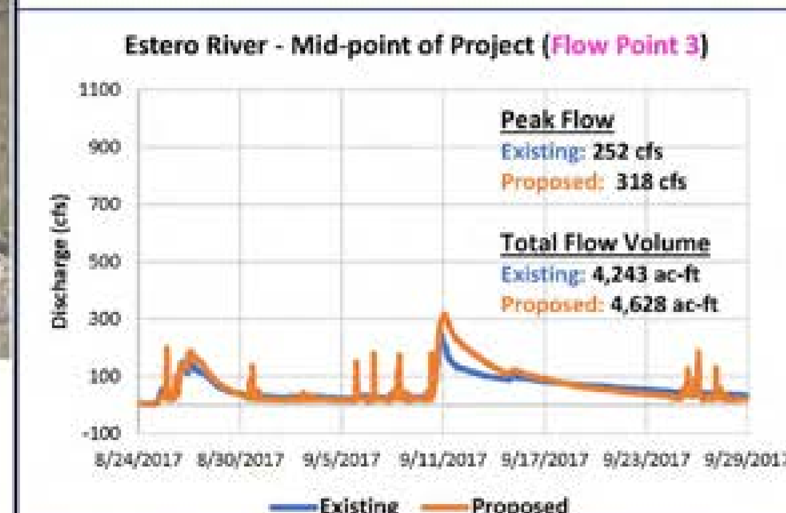


EXHIBIT 1.3.2 (i): 1 of 2







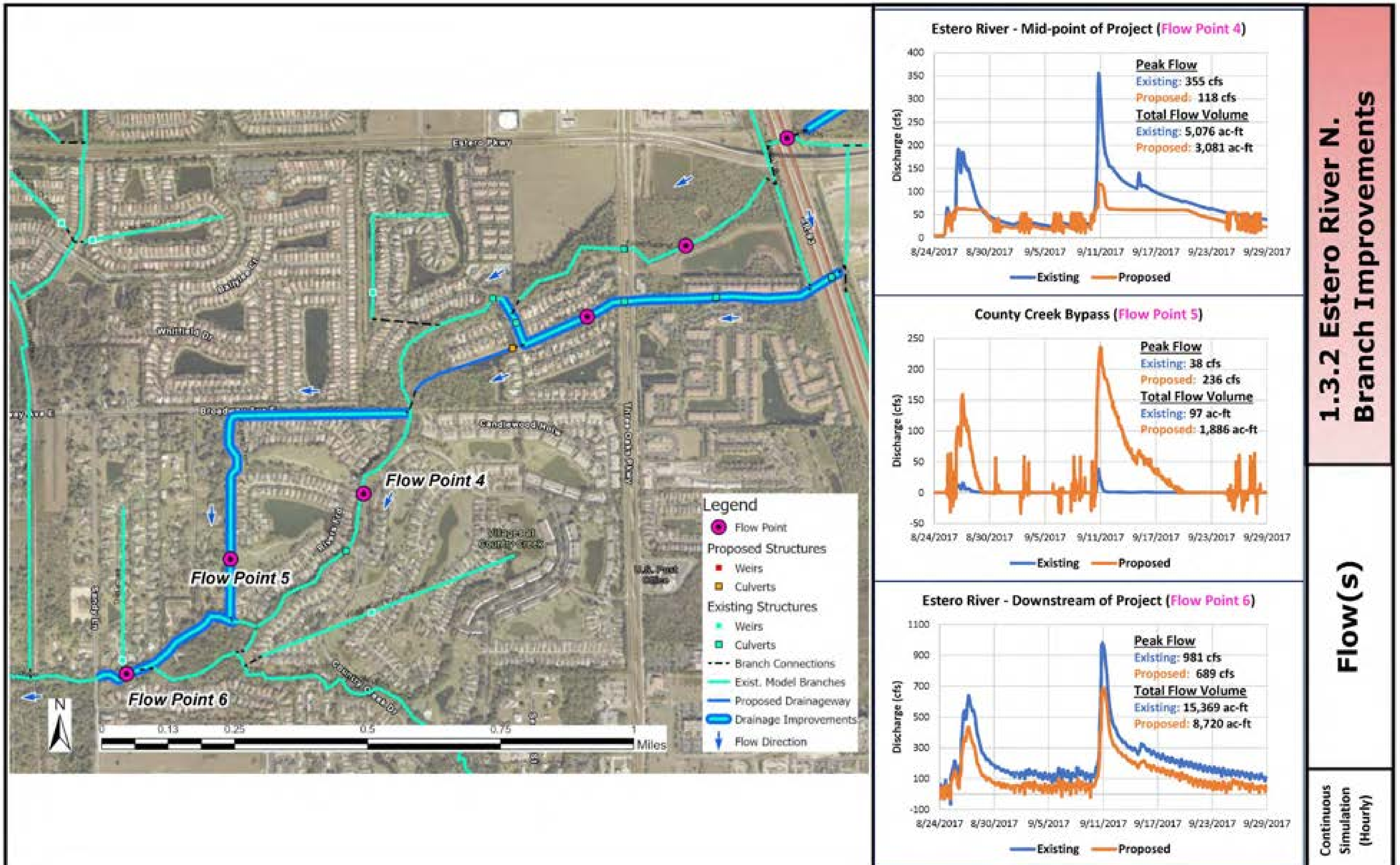


1.3.2 Estero River N. Branch Improvements

Flow(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.2 (i): 2 of 2



1.3.3 FGCU Flow-Way Concept Plan

Background

This concept plan passes through a natural area that is known as Stewart Slough and serves as an extension of the Estero River North Branch. Historically, sheet flow covered this area that flowed unrestricted to the river. The area is largely developed now with shopping centers, roadways, parking lots and residential communities. The remaining flow way extends northeasterly for five to ten miles in a natural flow-way around the Florida Gulf Coast University to an area of mine lakes. Roadway crossings in this area are sufficiently sized to handle very large flows. Prior to development, the area was primarily wetlands and cypress swamps.

Location

The concept project is in SE Lee County and extends drainage control from the Alico Lakes Mines southeast through the Florida Gulf Coast University property terminating at the 120' long bridge at Estero Pkwy and Interstate 75 as illustrated in **Figure 16**.

Figure 16 – Location Map, 1.3.3 FGCU Flow-Way

Description

This concept project provides a flow-way that interconnects the "Wild Blue" existing mine lake in the Alico area to the 120-foot bridge on Interstate 75 at the Estero Parkway overpass with an aesthetically designed conveyance that incorporates the natural system to carry extreme event stormwater flows across the FGCU campus. The flow-way would avoid and minimize environmental impacts, where possible. This flow-way connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Interconnection conveyances would be irregular shaped to appear as ponds with sinuous shorelines to achieve a 1,000 CFS flow from the 15,300 AC drainage basin north and east of the campus. This concept will use the extra storage in the upstream mine lakes for peak flow attenuation of extreme storm events.

Purpose

This proposed project extends regional drainage system functionality into the Alico Mine Lakes area and utilize mine lakes as stormwater storage reservoirs for flow attenuation of large storm events. The development of drainage flow-way connectivity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels as illustrated in **Figure 17**.

Figure 17 - Concept Plan, 1.3.3 FGCU Flow-Way

Evaluation

Viability

This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Coordination with FGCU in creating aesthetically pleasing components, utilizing shallow wide flow ways and enhanced aquatic plantings, curvilinear shorelines and deep pools for eco-diversity. Modern weir structures would be required to manage water levels. This conveyance is critical to stormwater control east of Interstate 75.

Community Considerations

This drainageway would utilize the Wild Blue MPD/DRI property, the Miromar Lakes MPD/DRI property, and the FGCU Campus property, and approval from all communities and property owners would be required

Environmental & Permittability Considerations

Environmental impacts occurring along the route would necessitate mitigation. During the design phase, the specific route can avoid the most environmentally sensitive areas as shown in **Figure 18** below.

Figure 18 – Example of winding flow route to mitigate impacts to environmental areas.

Land Availability

The need for an interlocal agreement between Lee County and FGCU would be required. Land acquisition is necessary to construct the FGCU Flow-way canal conveyance, storage, and water quality features.

Opinion of Probable Cost

The cost opinion in **Table 4** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 4 - Opinion of Probable Cost breakdown, 1.3.3 FGCU Flow-Way

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,444,500	$ 1,444,500
Clearing & Grubbing	38	AC	$ 14,000	$ 532,000
Earthwork	280,000	CY	$ 6	$ 1,680,000
Construction/ Maintenance Access	5,250	SY	$ 20	$ 105,000
Weir Structure 3.3A (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.3B (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.3C (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.3D (Major)	120	LF	$ 10,000	$ 1,200,000
Electric Supply	1	LS	$ 80,000	$ 80,000
Permanent Erosion Control	10,000	SF	$ 25	$ 250,000
Grassing	54,250	SY	$ 2	$ 108,500
			Construction Cost Sub-Total:	**$ 9,000,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 2,700,000
			Land Acquisition	$ 1,800,000
			Project Administration/ CEI (10%):	$ 900,000
			Project Unknowns	$ 2,600,000
			Conceptual Project Cost:	**$ 17,000,000**
			Contingency (30%)	$ 5,000,000
			Conceptual Project Cost (with Contingency):	**$ 22,000,000**

Opportunities for Multiple Benefits & Uses

The bridge crossing located under I-75 does not currently control water levels in natural areas. By constructing water control structures at these locations, wetland hydroperiods may be better controlled for wetland enhancement. Possible nature trails and other environmental enhancements could be incorporated along the proposed route.

Other Considerations

This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. Environmental impacts, if any, would necessitate mitigation. A summary of this concept project is shown below in **Exhibit 1.3.3** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from the Wild Blue mine lake southwesterly across the FGCU natural area to the large bridge at Interstate 75, which connects to the Estero River. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.3 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

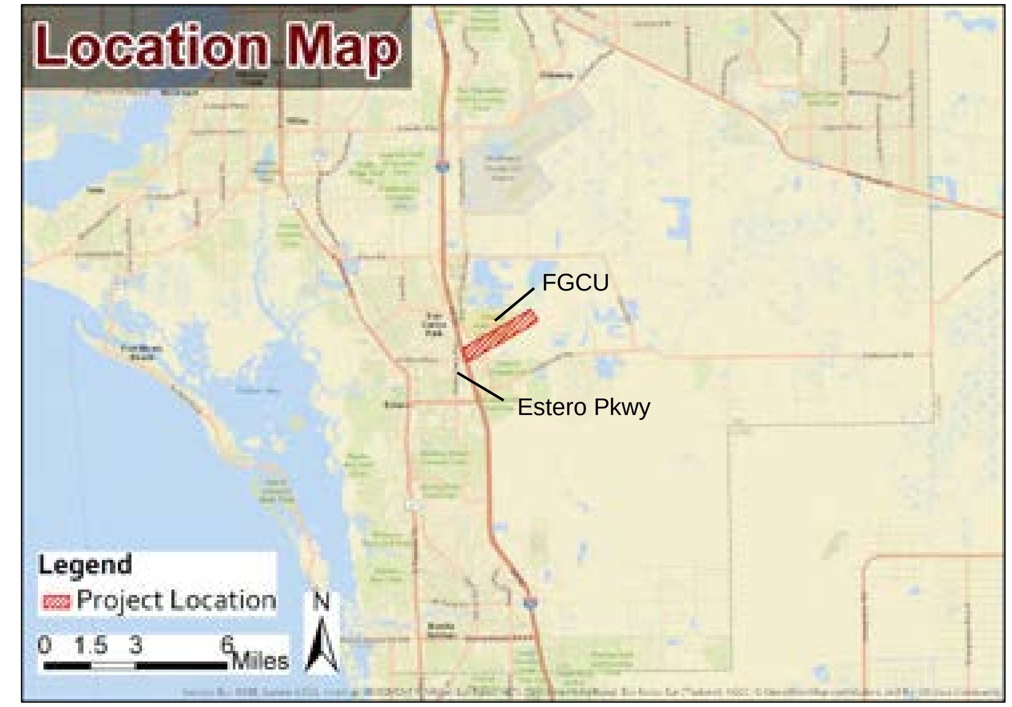
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.3 (b)
	Flow(s)	EXHIBIT 1.3.3 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.3 (d)
	Flow(s)	EXHIBIT 1.3.3 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.3.3 (f)
	Flow(s)	EXHIBIT 1.3.3 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.3.3 (h)
	Flow(s)	EXHIBIT 1.3.3 (i)

Improvements were shown through minimal water level variation and substantial flow increase from the existing to proposed conditions. This conveyance is a key component for moving excess stormwater to the Estero River.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying large increase in excess stormwater flows from the Wild Blue mine lake through the FGCU natural area towards Interstate 75. These positive improvements warrant further design-level project development.

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project interconnects the "Wild Blue" existing mine lake in the Alico area to the Interstate 75 bridge crossing at the Estero Parkway overpass with an excavated channel to carry extreme event stormwater flows across the FGCU campus. This mine lake connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Interconnection conveyances would be approximately 130 feet wide channels which may be irregular shaped to appear as lakes.

PURPOSE: This proposed project extends drainage control into the Alico Mine Lakes area and allows development of storage reservoirs for attenuation of large storm events. The development of drainage flow-way connectivity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. Environmental impacts, if any, would necessitate mitigation.

May 2020

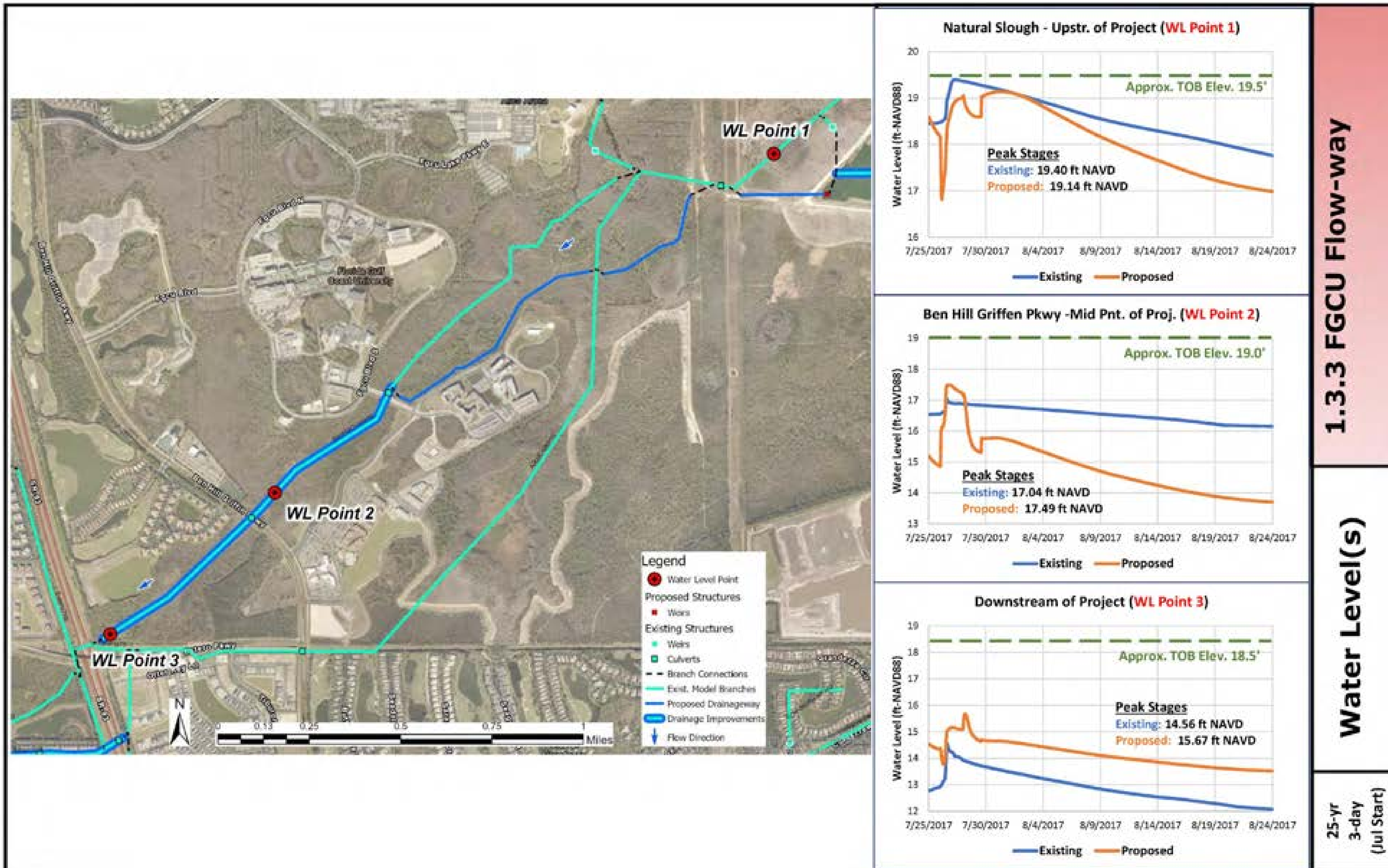
FGCU Flow- Way
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBT 1.3.3

EXHIBIT 1.3.3 (a)

EXHIBIT 1.3.3 (b)



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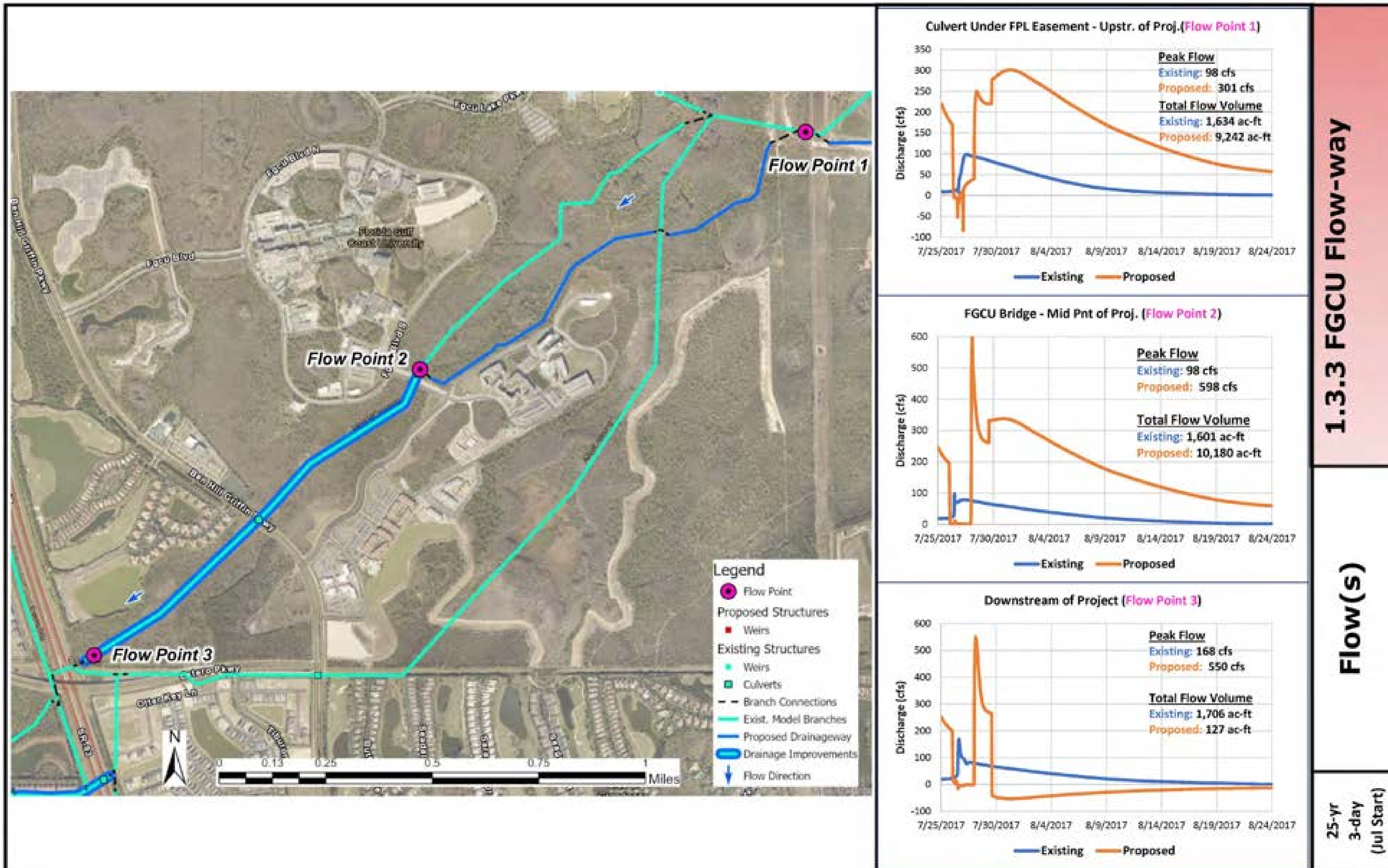

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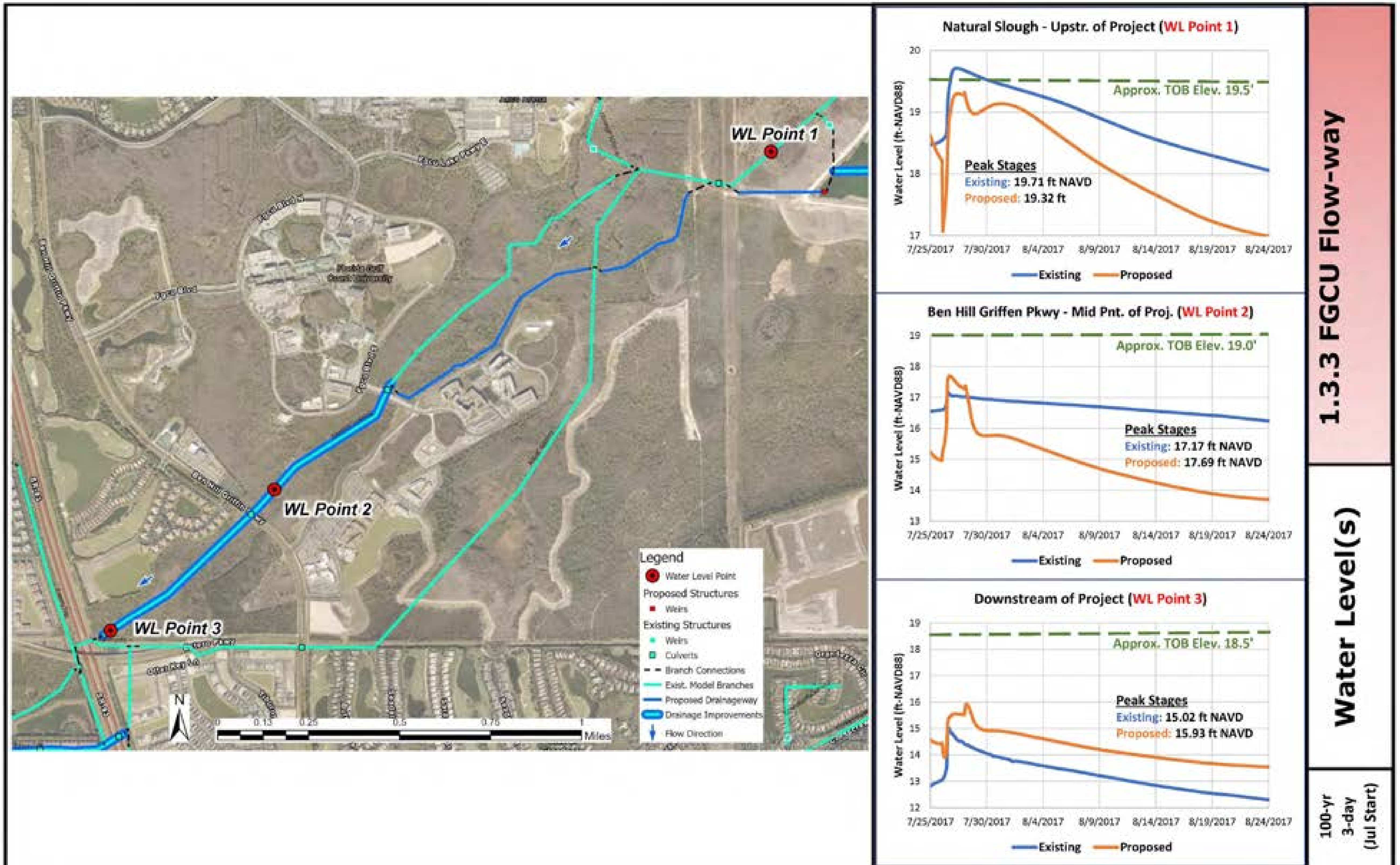

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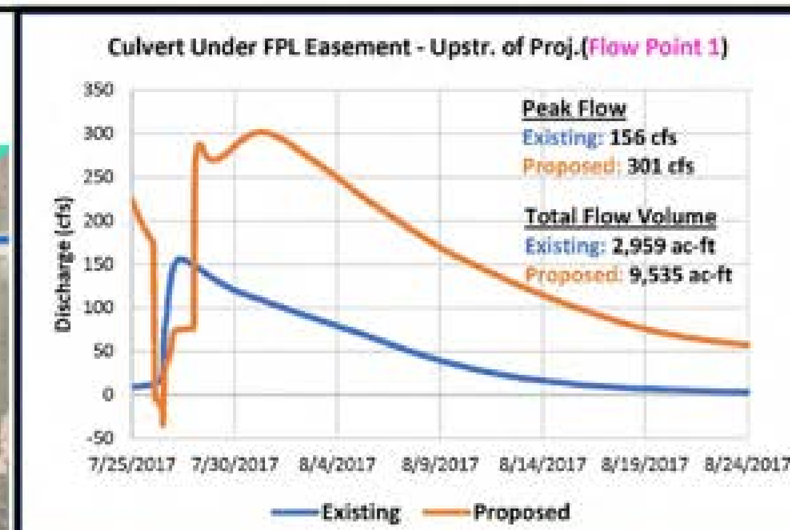
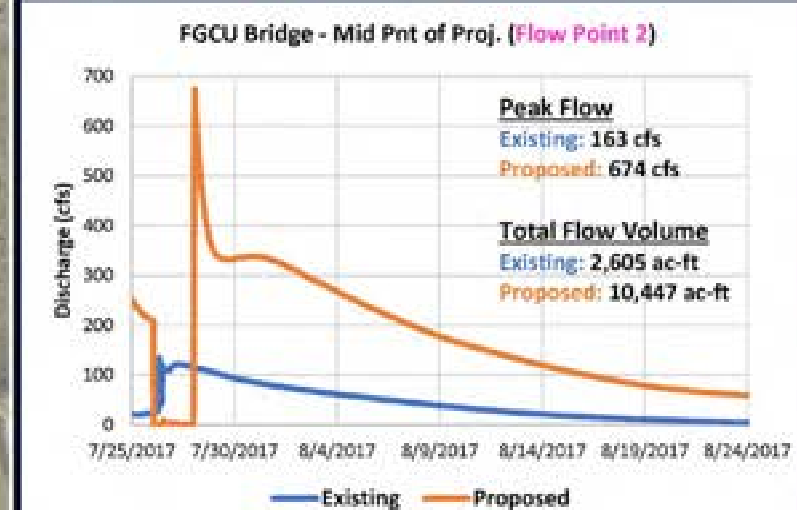
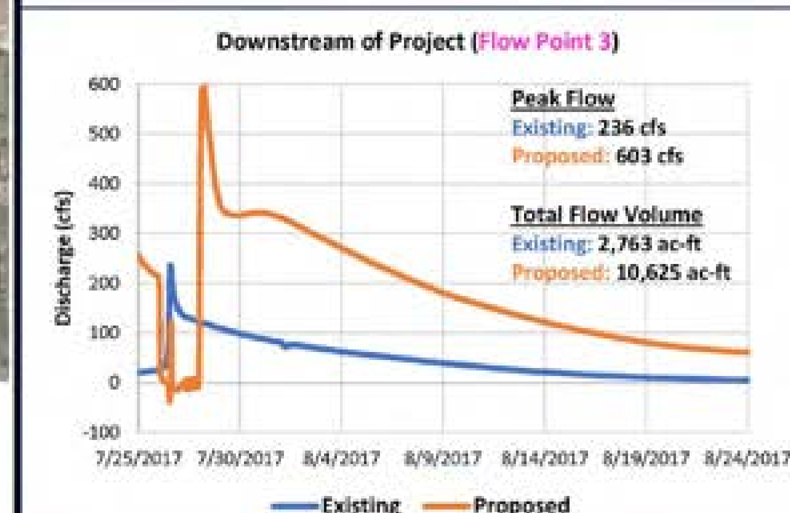




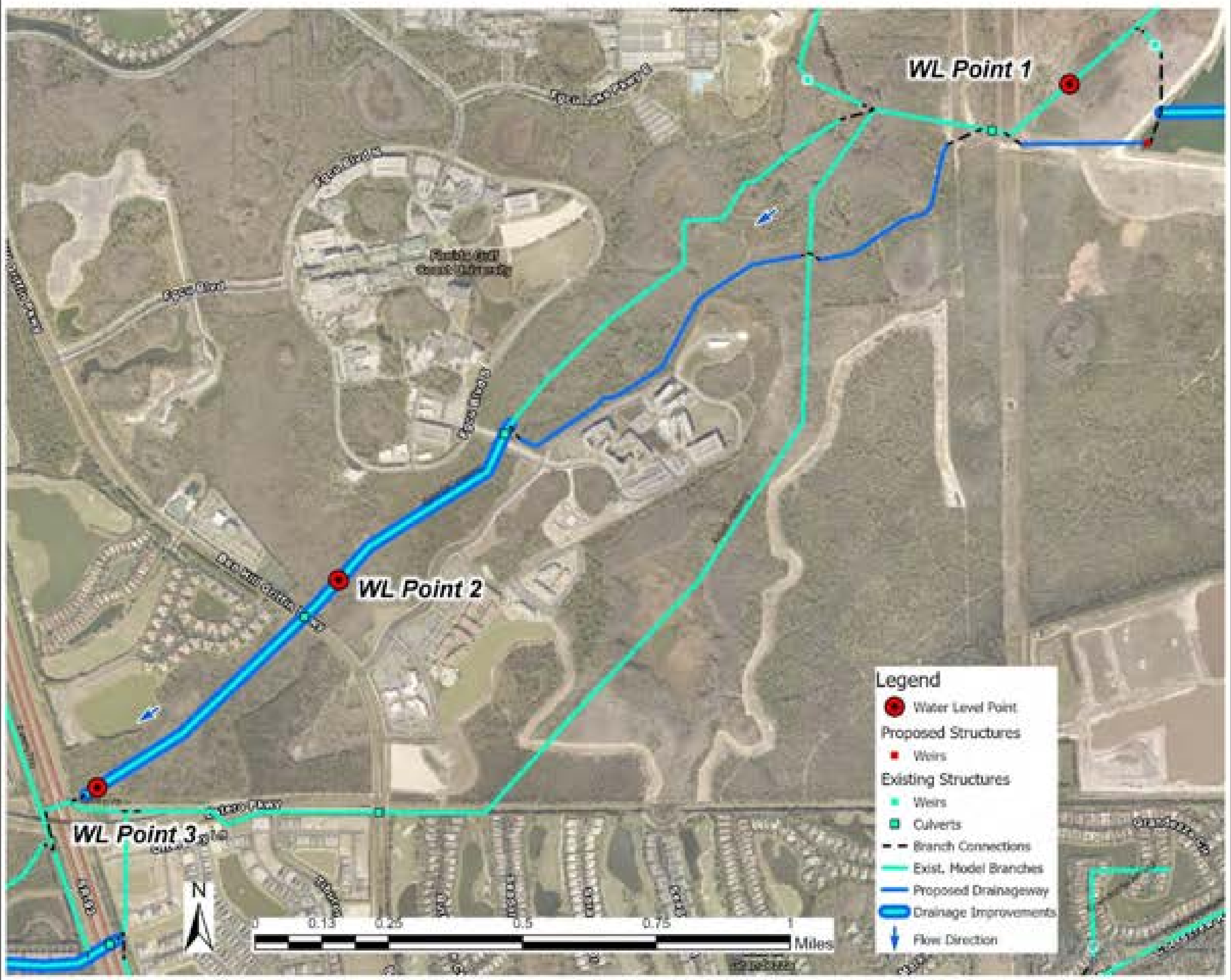


1.3.3 FGCU Flow-way

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.3 (f)



1.3.3 FGCU Flow-way

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.3 (g)

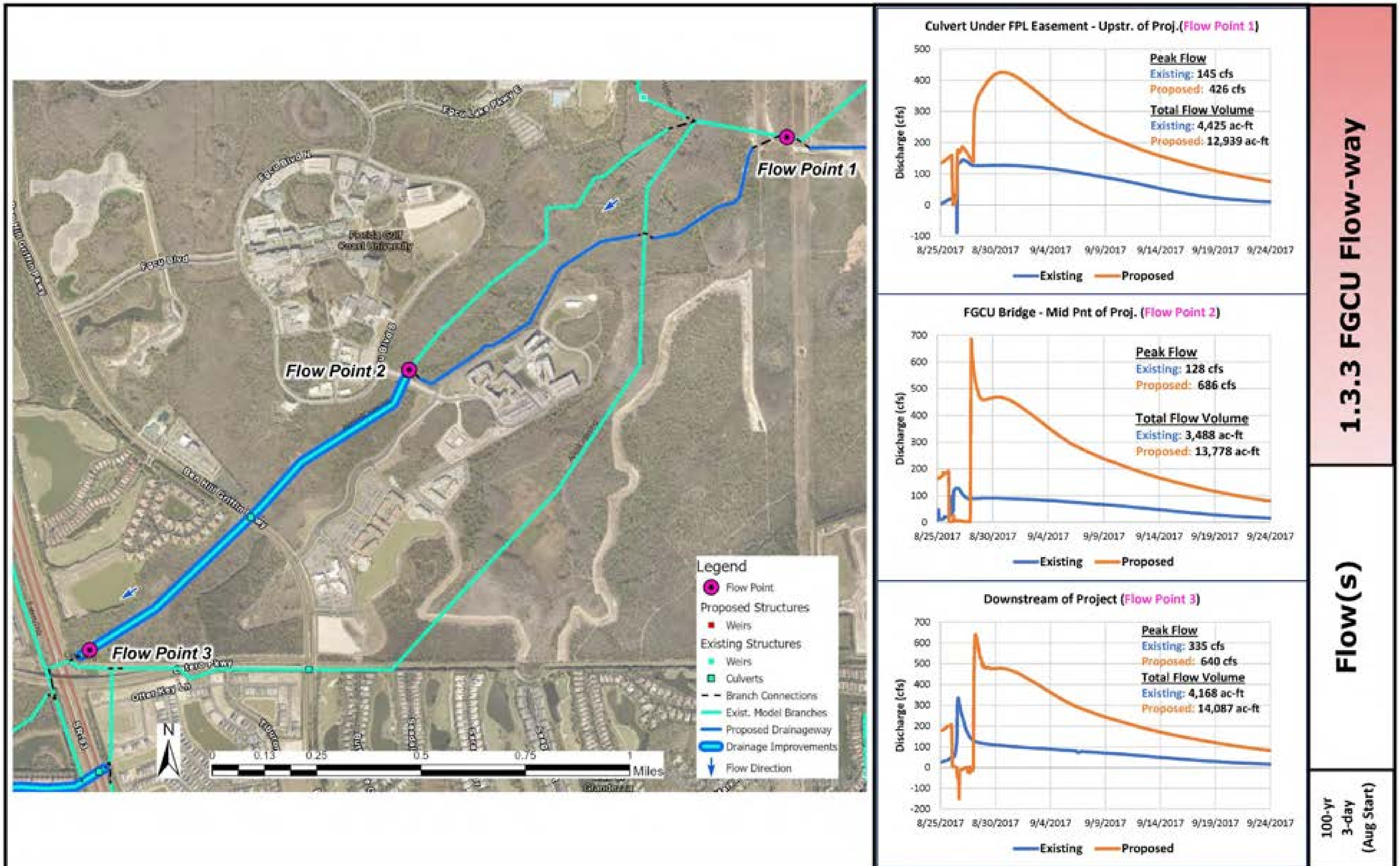


EXHIBIT 1.3.3 (h)

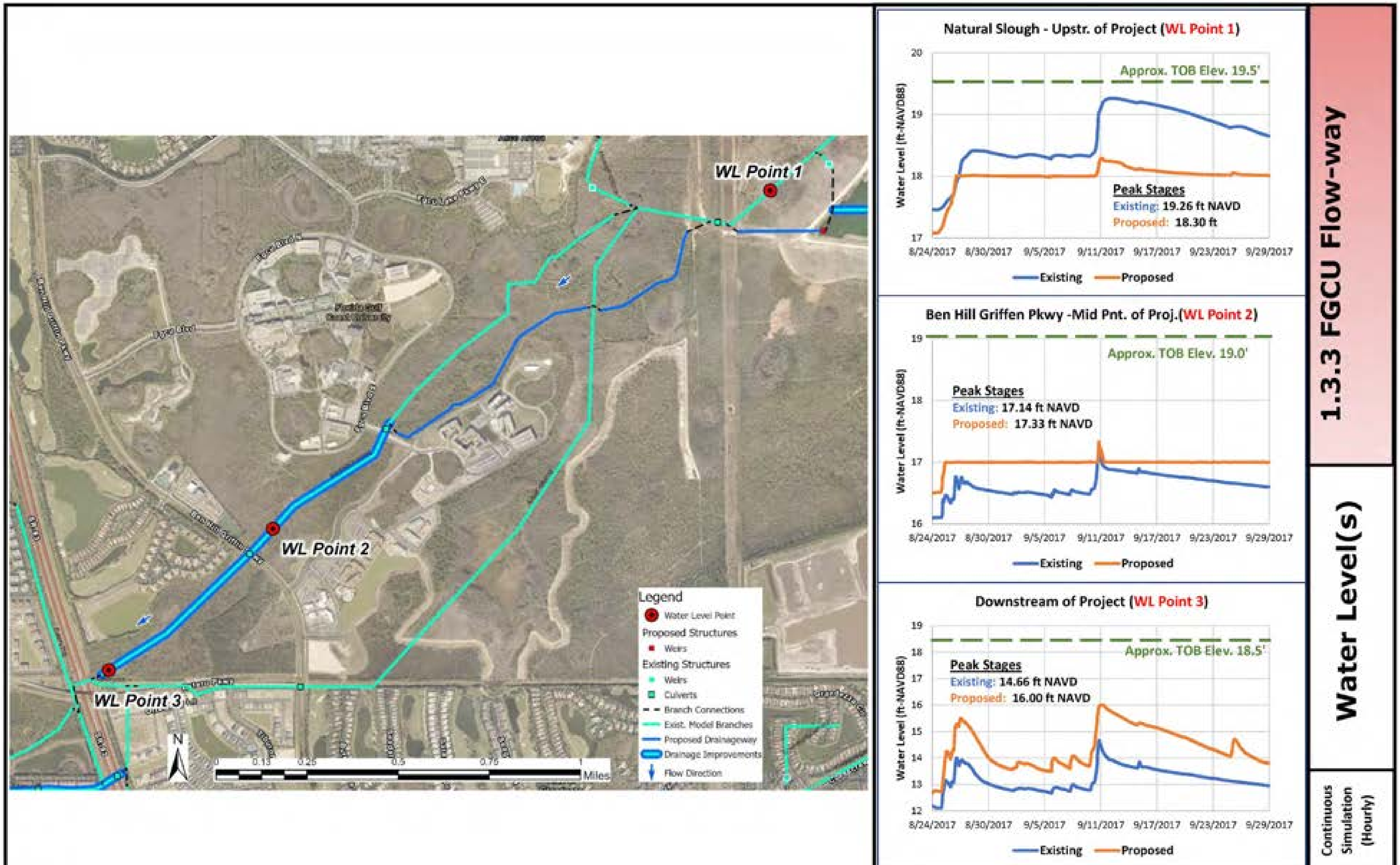
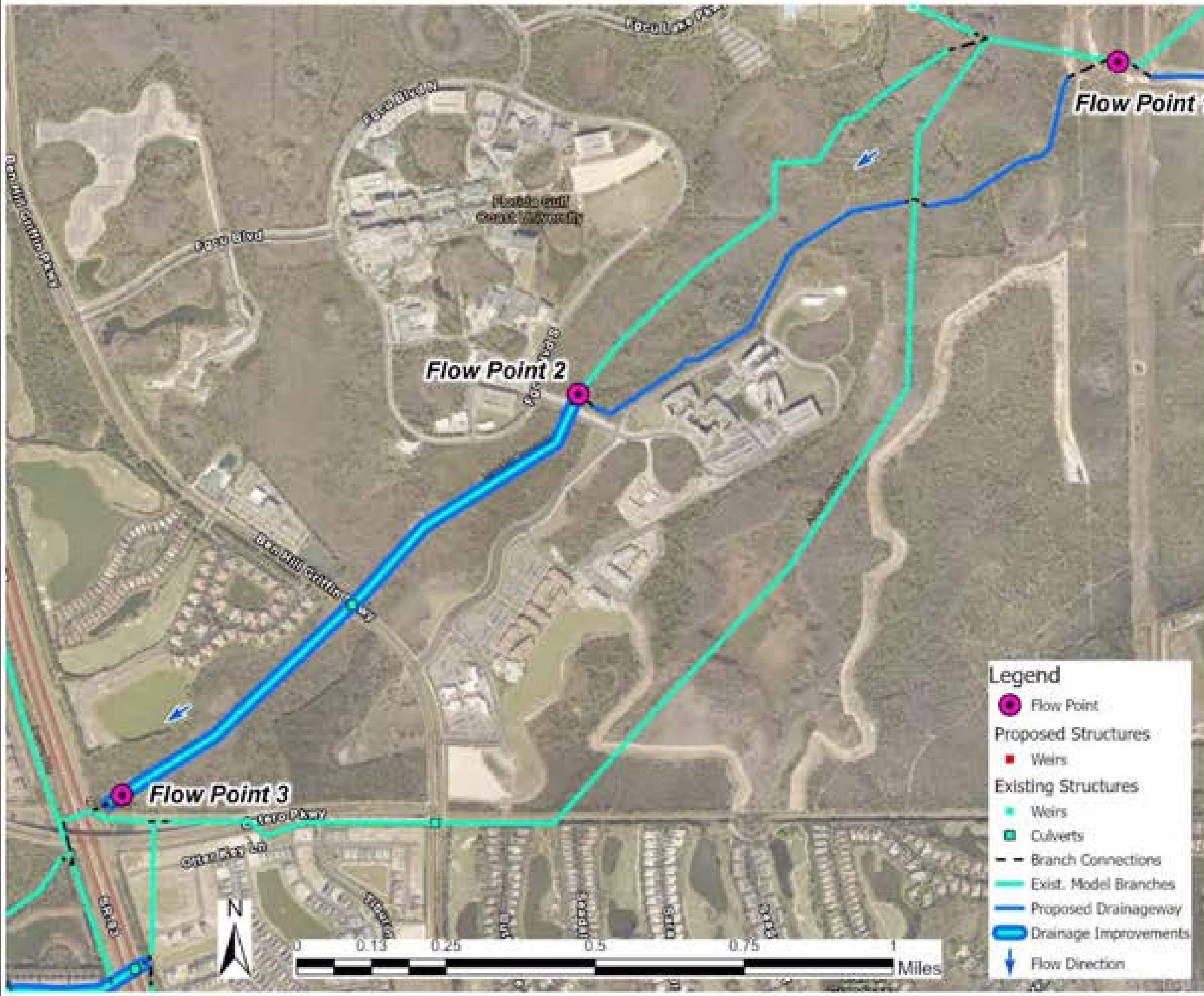
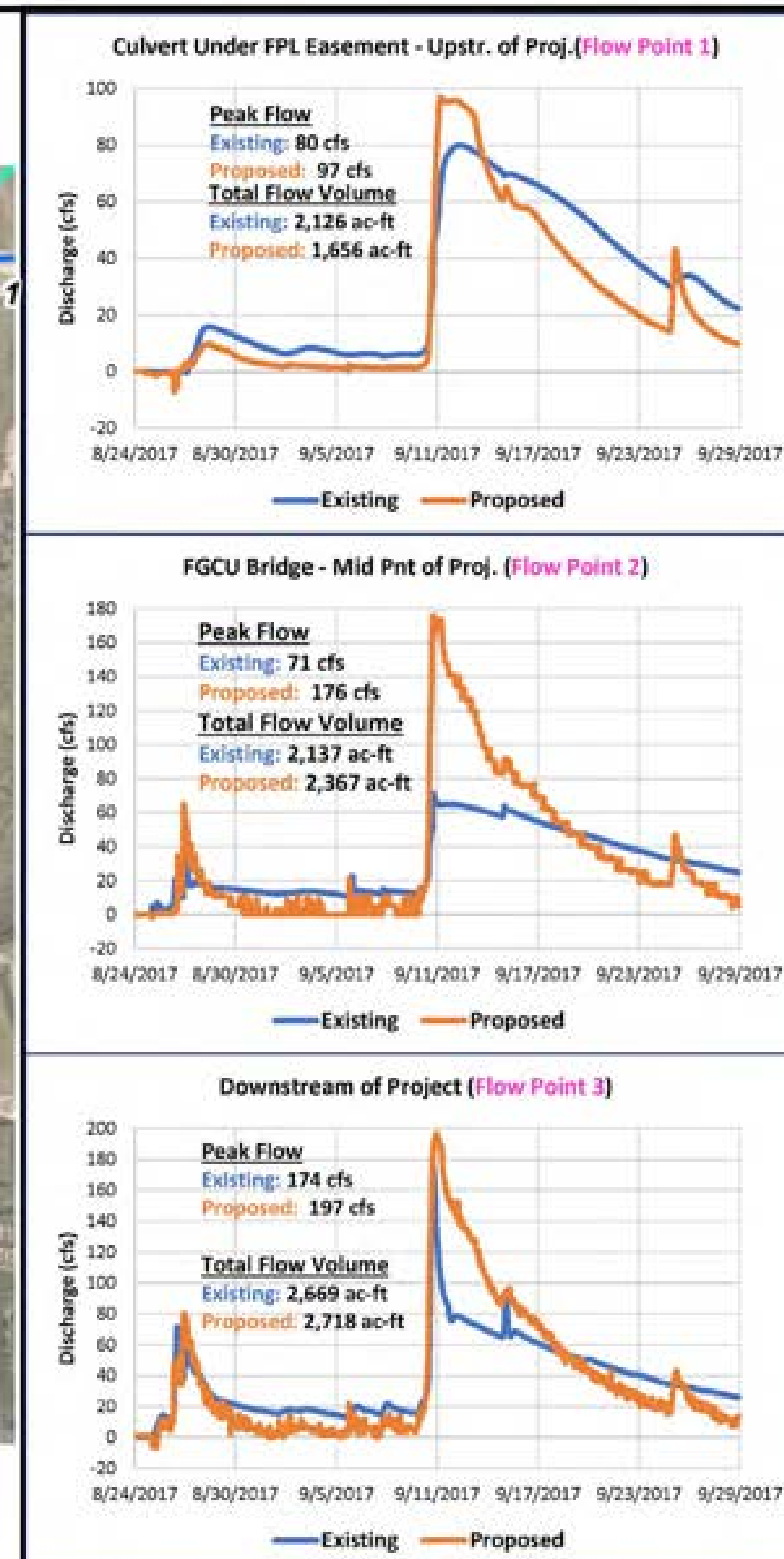


EXHIBIT 1.3. (i)





1.3.3 FGCU Flow-way

Flow(s)

Continuous Simulation (Hourly)

1.3.4 Alico Mine Lake Interconnects (West) Concept Plan

Background

The Alico Road area northeast of the Florida Gulf Coast University has many ongoing and completed mine lakes. Historically, this area was primarily wetlands, cypress swamps, agricultural fields and cattle ranching operations before limerock mining activities started approximately in the 1970s. Materials from these mine lakes were and continue to be used to build parking lots and roadways along with producing gravel for asphalt and concrete. This area was drained by overland sheet flow that has been blocked, confined, and restricted by mining and development activities. There are no apparent provisions to divert impacted sheet flow around the developments. Drainage in the area is limited to remaining wetlands. The mine lakes offer an opportunity to store water runoff and provide a functional floodway path.

Location

This concept project is in SE Lee County begins just south of Southwest Florida International Airport, east of Interstate 75 and Florida Gulf Coast University in the West Alico Mine area, crossing Alico Road as illustrated in **Figure 19**.

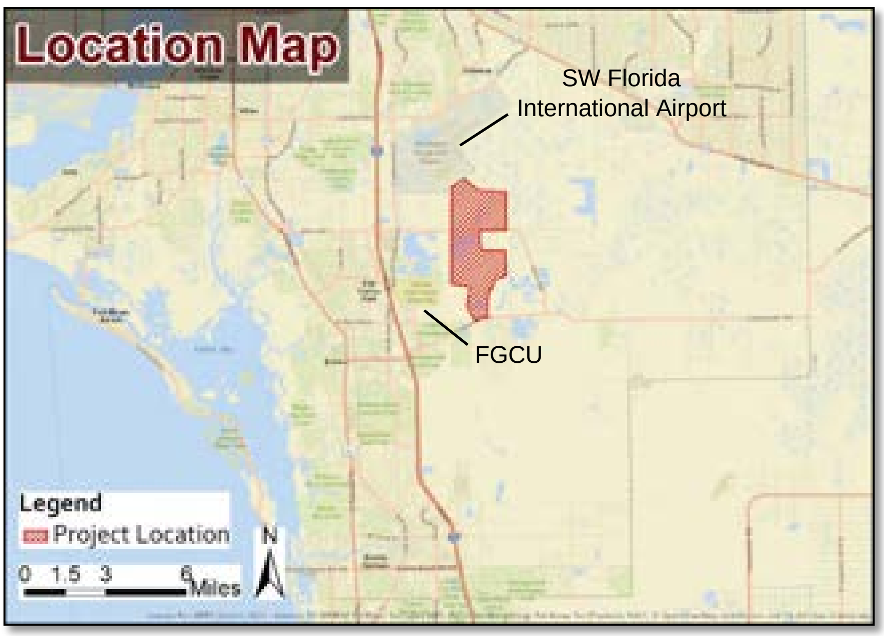


Figure 19 – Location Map, 1.3.4 Alico Mine Lake Interconnects (West)

Description

This concept project interconnects existing mine lakes in the west Alico mine area to store and convey excess stormwater run-off to the south across Corkscrew Road towards the Halfway Creek bridge crossing under I-75. No active mining lakes would be utilized in this project. This interconnection would greatly increase storage which is paramount as the current existing outfalls for this area are so limited that increased storage is necessary. The mine lake connections would have remotely operated weir gates to maintain flow and water levels within desirable ranges as illustrated in **Figure 20**.

Figure 20 - Concept Plan, 1.3.4 Alico Mine Lake Interconnects (West)

Purpose

This proposed project extends drainage control into the Alico Mine Lakes area and provides reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding.

Evaluation

Viability

Viability would be based on the coordination and cooperation of the mine owners, as well as, timely land acquisition for this fast developing area.

Community Considerations

The project would require coordination with the mine owners as well as the Wild Blue MPD/DRI property, Lee County owned property, and the West Lakes Excavation property, all approved storm water management systems and approval from all communities and property owners would be required.

Environmental & Permittability Considerations

This concept plan would allow for wetland hydroperiod control enhancement with pumped water from mine lakes to prevent the over draining of wetlands.

Land Availability

This project as planned crosses public and private properties requiring governmental approvals and land acquisition. The need for, mine flow-way rights and maintenance access is also necessary to construct the Alico Mine Lake Interconnects (West) conveyance, storage, and water quality features.

Opinion of Probable Cost

The cost opinion shown in **Table 5** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 5 - Opinion of Probable Cost breakdown, 1.3.4 Alico Mine Lake Interconnects (West)

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 2,005,600	$ 2,005,600
Clearing & Grubbing	14	AC	$ 14,000	$ 196,000
Earthwork	100,000	CY	$ 6	$ 600,000
Construction/ Maintenance Access	5,250	SY	$ 20	$ 105,000
Weir Structure 3.4A (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.4B (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.4C (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.4D (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.4E (Major)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 3.4F (Major)	120	LF	$ 10,000	$ 1,200,000
Detours	1	LS	$ 240,000	$ 240,000
Box Culvert 3.4-1	300	CY	$ 1,200	$ 360,000
Box Culvert 3.4-2	300	CY	$ 1,200	$ 360,000
Box Culvert 3.4-3	300	CY	$ 1,200	$ 360,000
Box Culvert 3.4-4	300	CY	$ 1,200	$ 360,000
Box Culvert 3.4-5	300	CY	$ 1,200	$ 360,000
Electric Supply	1	LS	$ 60,000	$ 60,000
Permanent Erosion Control	10,000	SF	$ 15	$ 150,000
Grassing	21,700	SY	$ 2	$ 43,400
Natural Flow-way Crossing	1	LS	$ 100,000	$ 100,000
Construction Cost Sub-Total:				**$ 12,500,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 3,750,000
Land Acquisition				$ 2,700,000
Project Administration/ CEI (10%):				$ 1,250,000
Project Unknowns				$ 800,000
Conceptual Project Cost:				**$ 21,000,000**
Contingency (30%)				$ 6,000,000
Conceptual Project Cost (with Contingency):				**$ 27,000,000**

Opportunities for Multiple Benefits & Uses

As south east Lee County continues to reach full build-out conditions, improving the conveyance of the Estero River Drainage Basin is a critical priority. Providing storage solutions will also become increasingly difficult as development diminishes the available land. This project would be very effective methodology to store and treat stormwater. The mining lakes are easy to access and chain together. The project would allow water resources for re-hydrating wetlands year-round.

Other Considerations

Lack of water in the SE Lee County/Crew Flint area is commonly reported. Utilizing mine lake water resources can greatly improve the lack of wetland hydration. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. A summary of this concept project is shown below in **Exhibit 1.3.4** herein.

Findings & Recommendations

Regional Modeling Findings

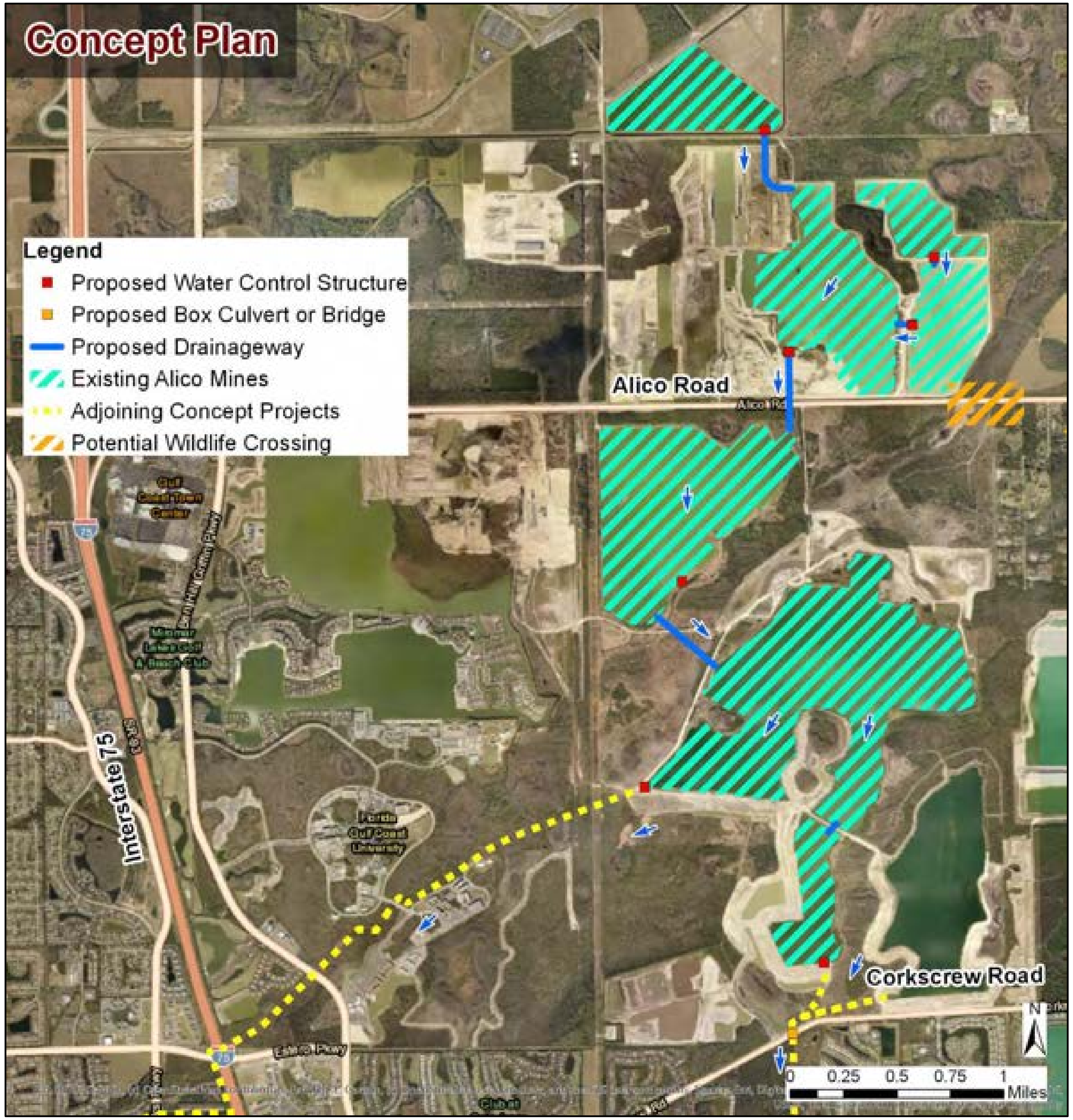
This project concept consists of conveying excess stormwater flows from the eastern Alico mine lakes by interconnecting the lakes, retaining excess stormwater, and conveying flow to the FGCU flow-way, and eventually to the Estero River. When available, excess stormwater may be directed southerly to the Crew-Flint Pen area for wetland re-hydration. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.4 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.4 (b)
	Flow(s)	EXHIBIT 1.3.4 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.4 (d)
	Flow(s)	EXHIBIT 1.3.4 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.3.4 (f)
	Flow(s)	EXHIBIT 1.3.4 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.3.4 (h)
	Flow(s)	EXHIBIT 1.3.4 (i)

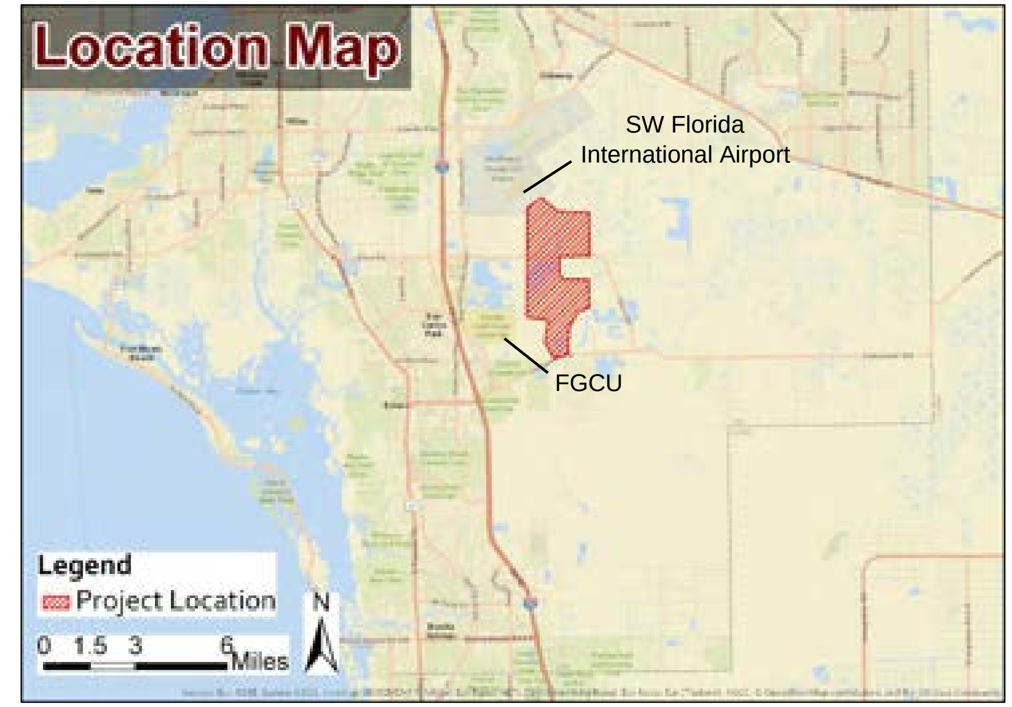
Improvements were shown with water level reductions from the existing to the proposed condition and an increase in water level at the southern connection. Changes in flow are not exceedingly high considering the size of the contributing regional watershed area. This conveyance is a key component for moving excess stormwater to the Estero River.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from the western Alico mine lakes by interconnecting the lakes to store excess stormwater and convey flow to the FGCU flow-way and eventually to the Estero River. These positive improvements warrant further design-level project development.



Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project interconnects existing mine lakes in the west Alico mine area to store and convey excess stormwater run-off to the south across Corkscrew Road towards the halfway creek bridge crossing under I-75. The mine lake connections would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project extends drainage control into the Alico Mine Lakes area and provides reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. Environmental impacts, if any, would necessitate mitigation.

May 2020

Alico Mine Lake Interconnects (West)
SE Lee County Area

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2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
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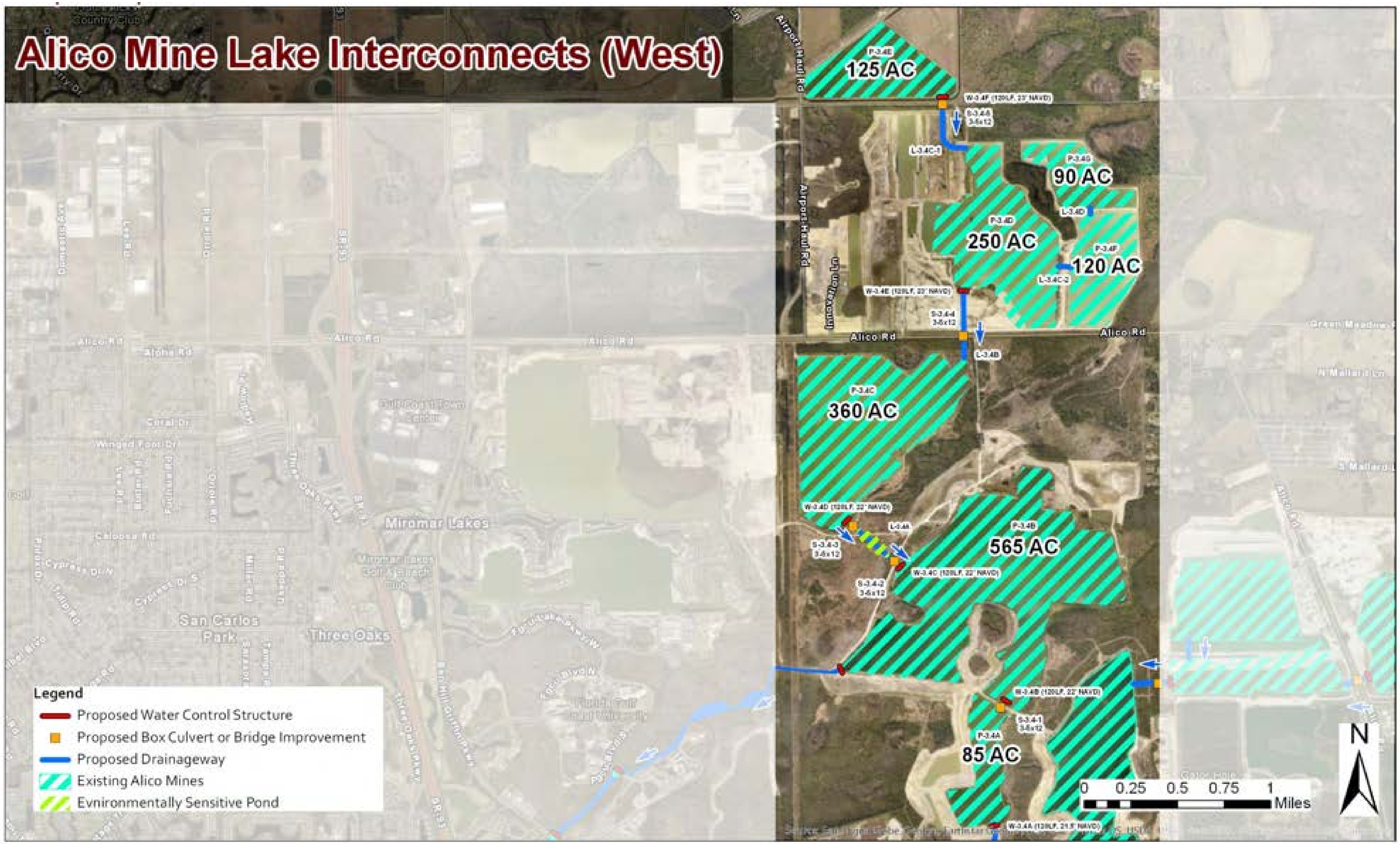
EXHIBIT 1.3.4

EXHIBIT 1.3.4 (a)



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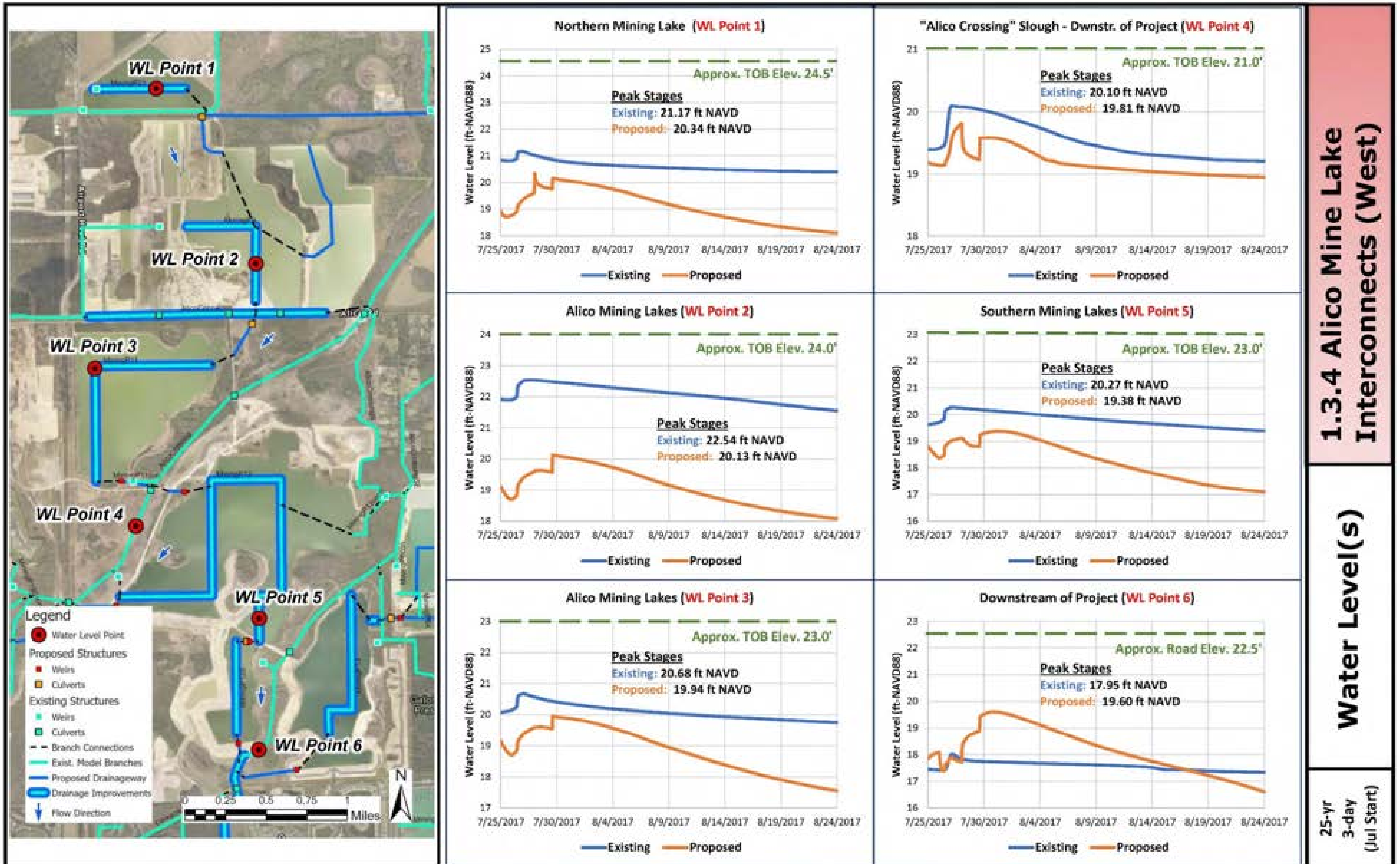

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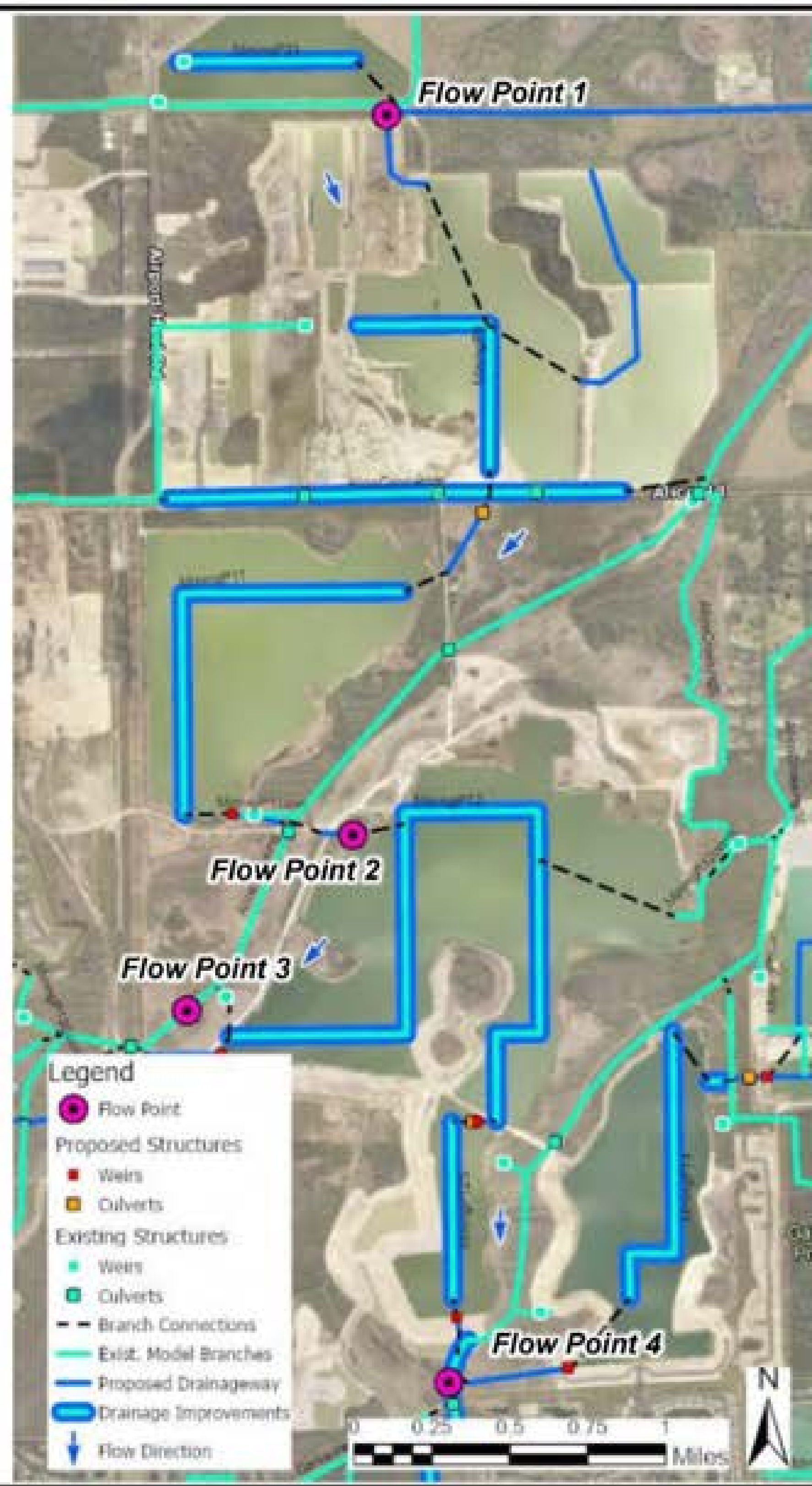
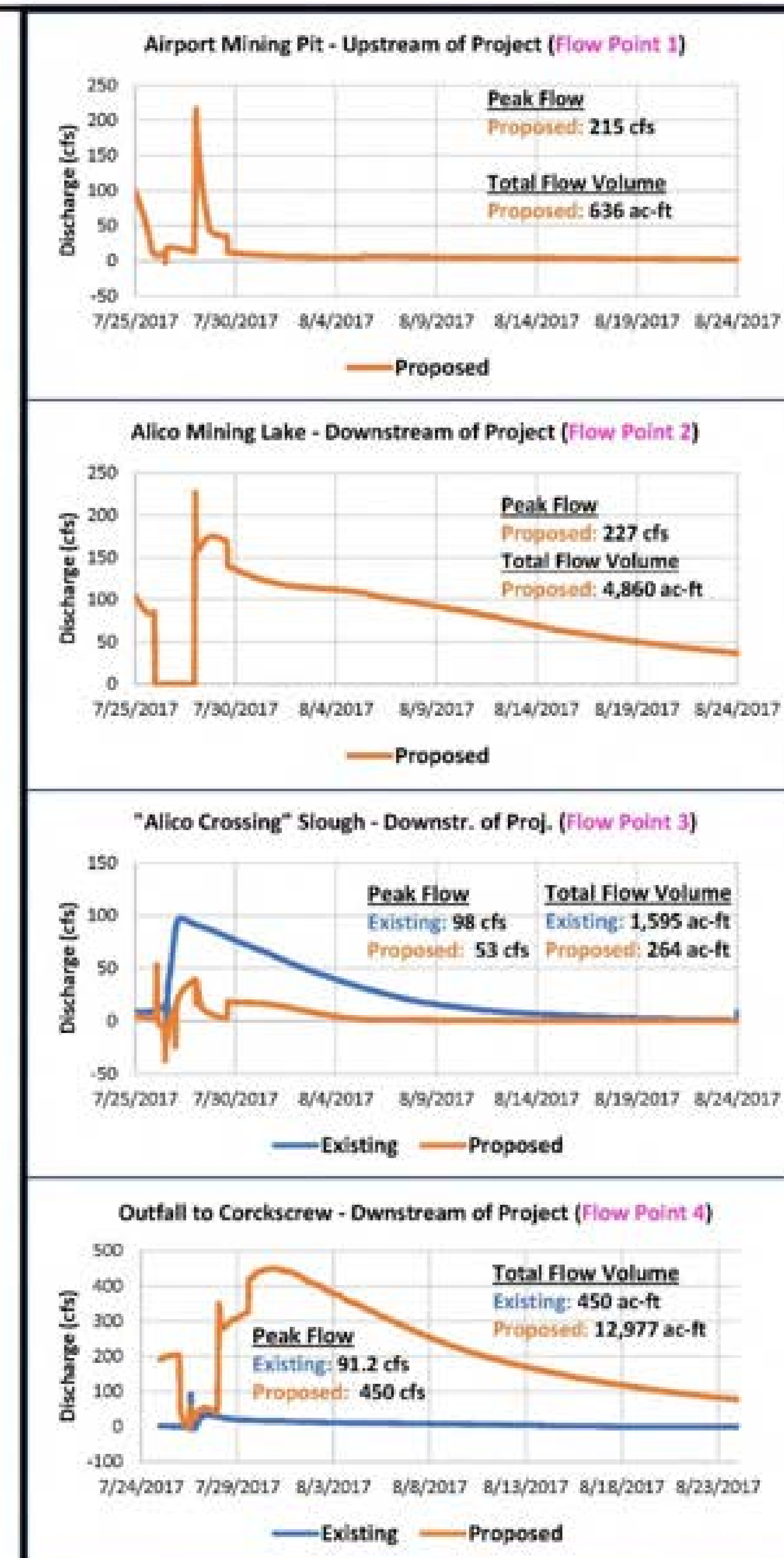


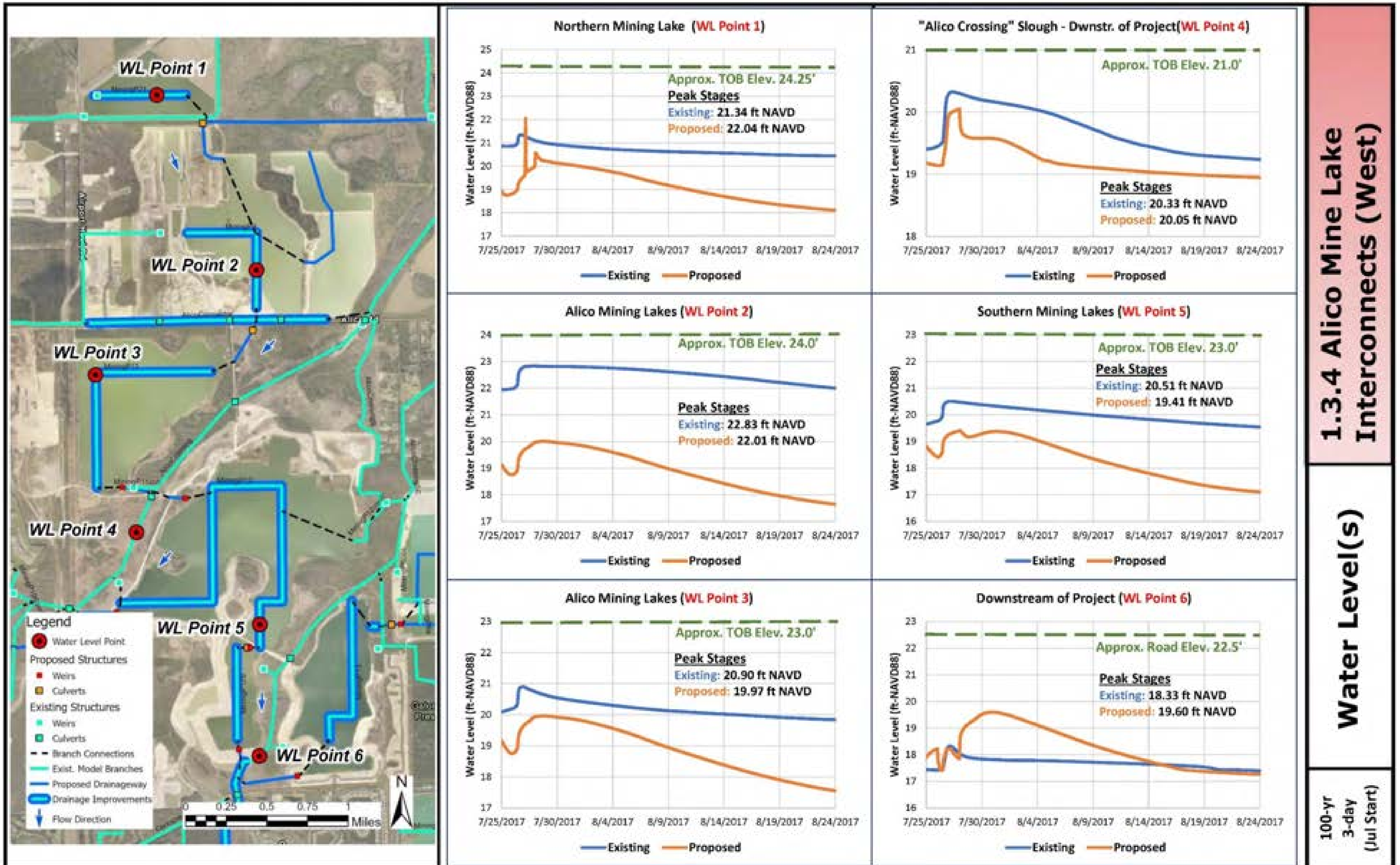


1.3.4 Alico Mine Lake Interconnects (West)

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.4 (d)



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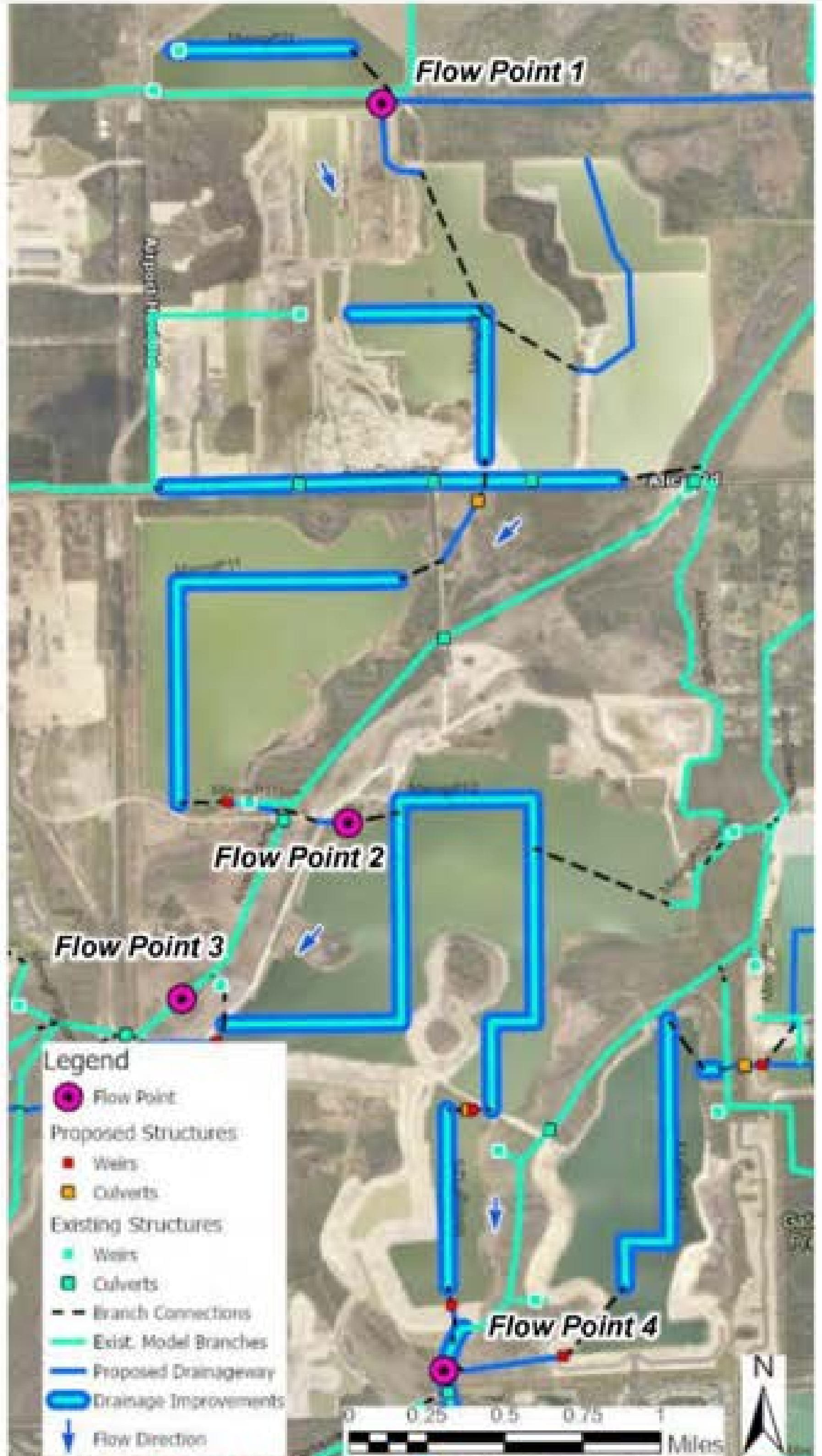
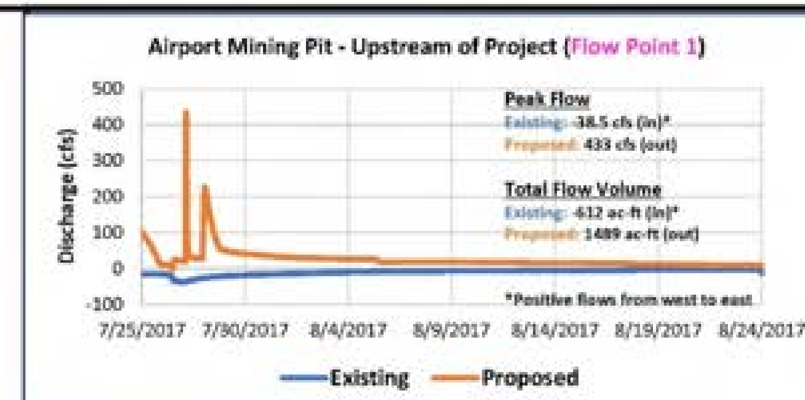
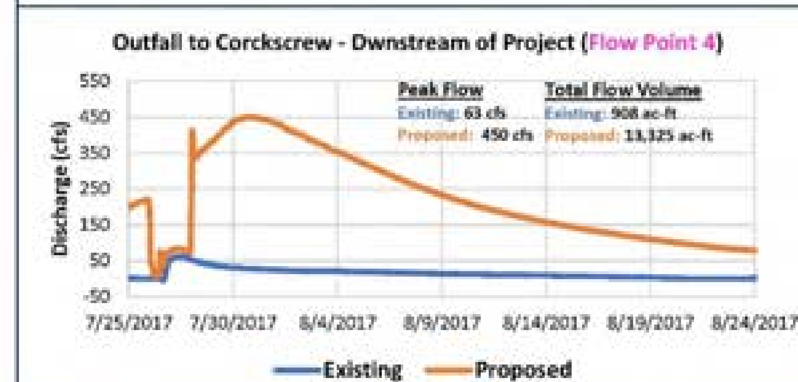




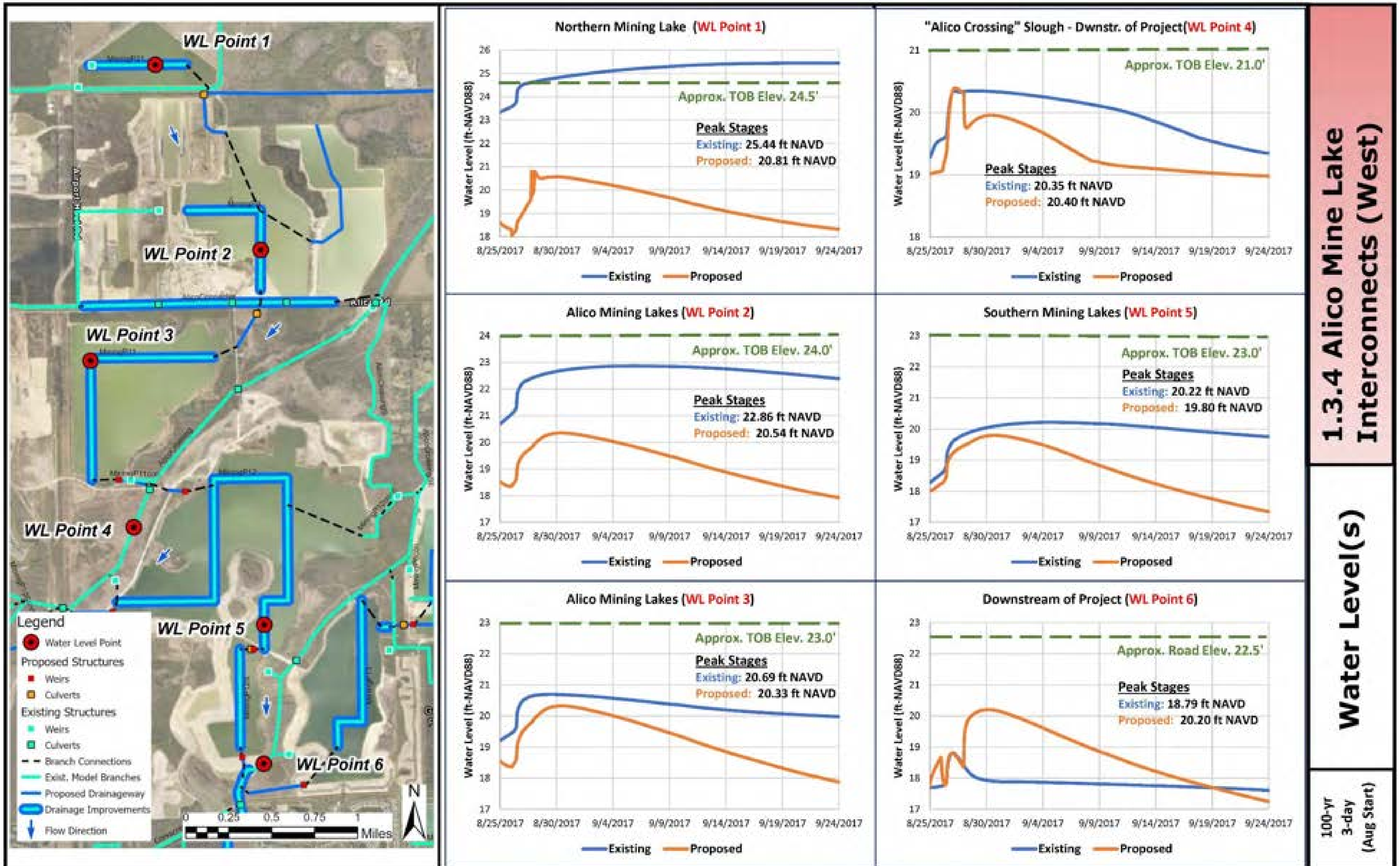


1.3.4 Alico Mine Lake Interconnects (West)

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.4 (f)



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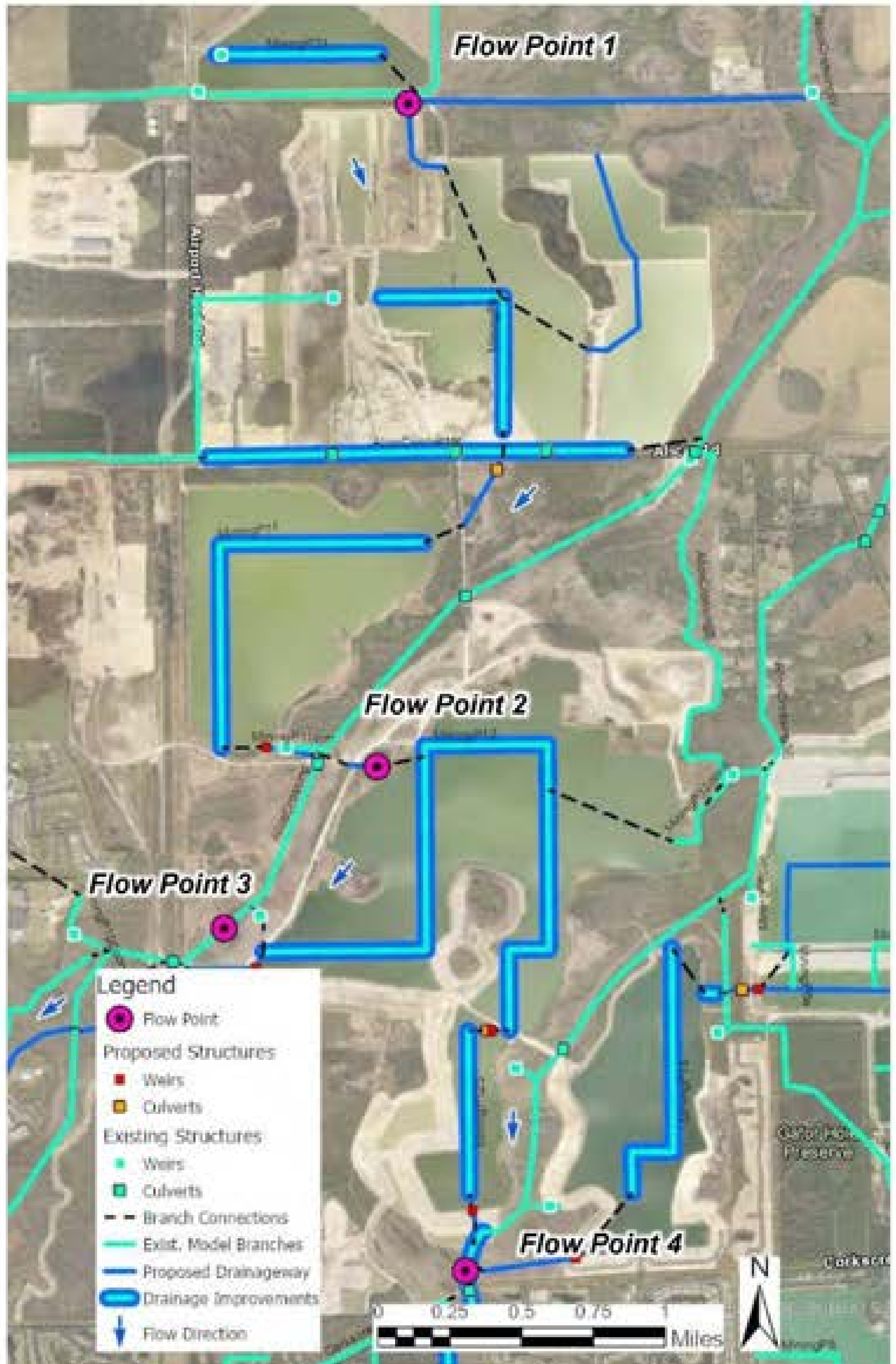
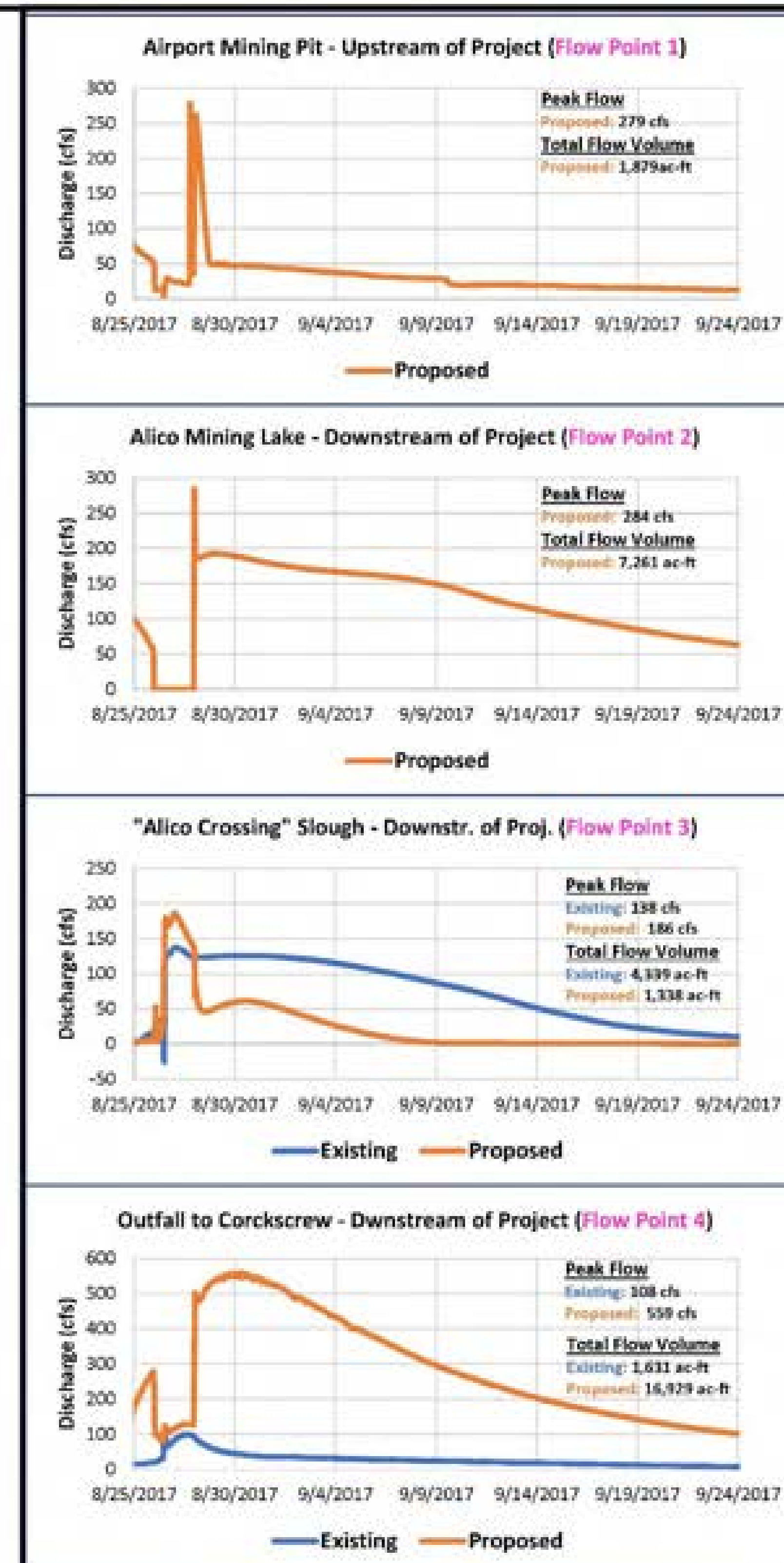




1.3.4 Alico Mine Lake Interconnects (West)

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.4 (h)

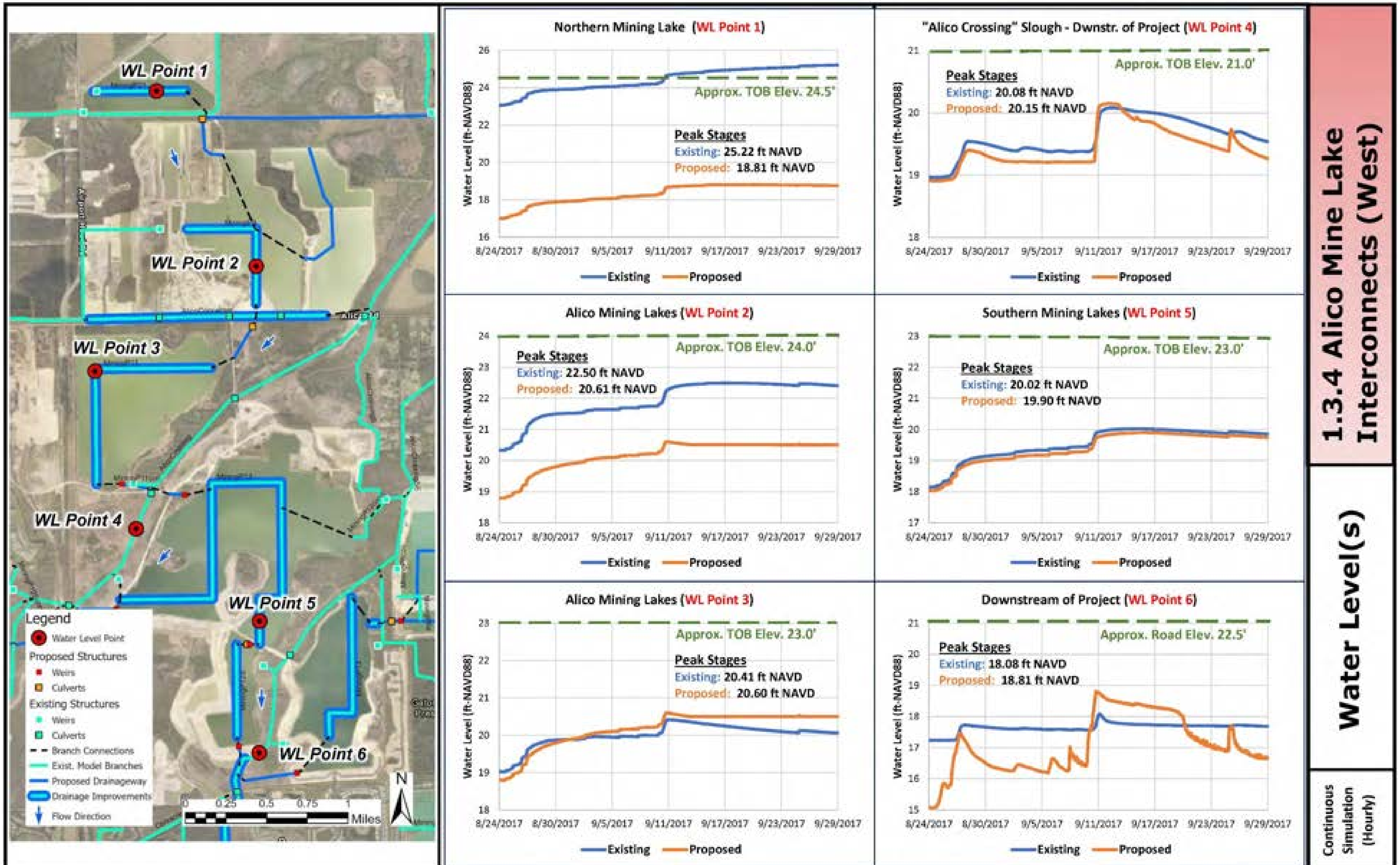
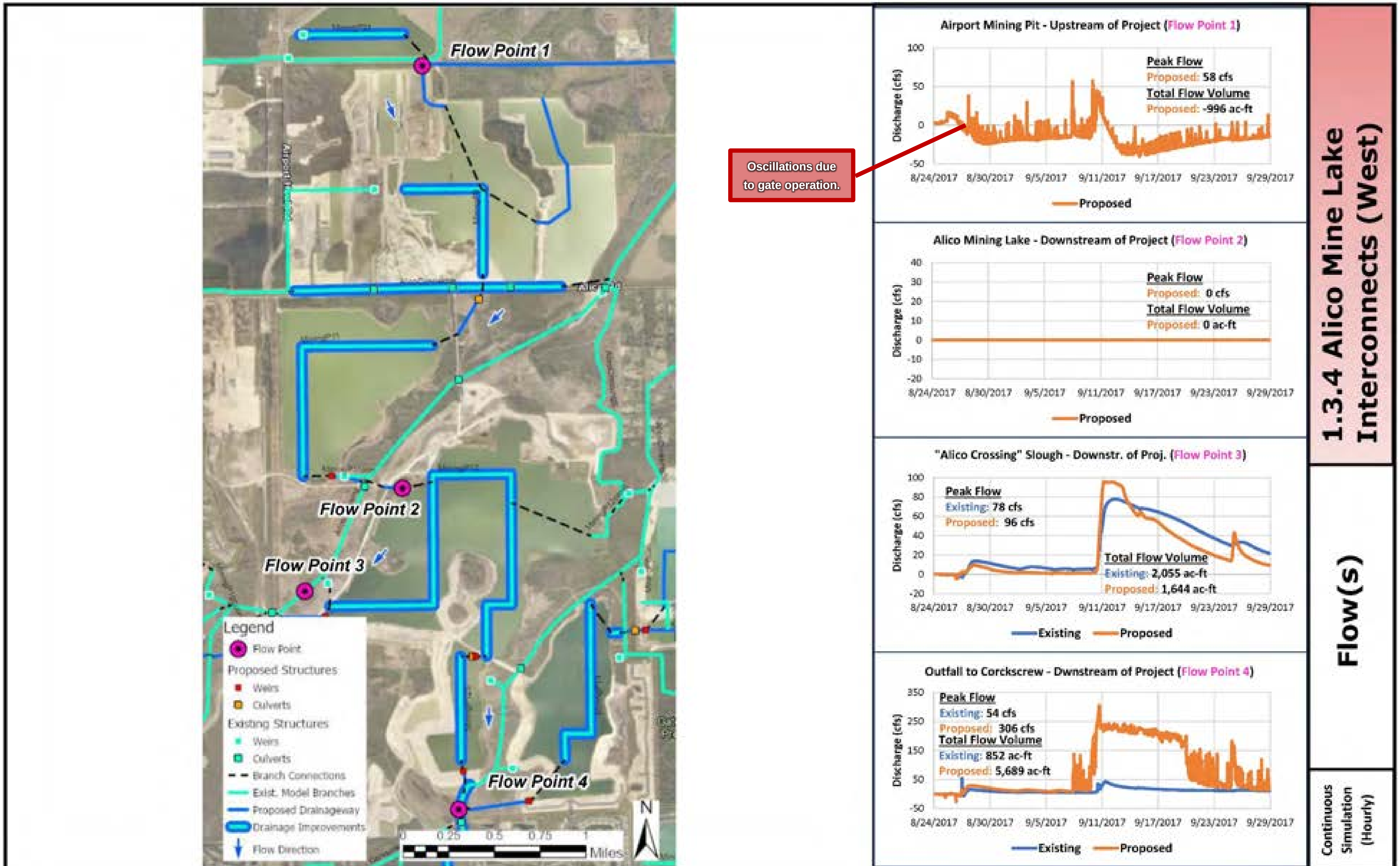


EXHIBIT 1.3.4 (i)



1.3.5 Alico Mine Lake Interconnects (East) Concept Plans

Background

To the northeast of the Alico Road area is a series of mine lakes that are under construction and some that are completed. Prior to mining, this area was generally wetlands, cypress swamps, agricultural fields, and cattle ranching operations. Most of the mine materials were used as limerock for roads and gravel for concrete and asphalt mixes. Originally, overland sheet flow was the only drainage of this area. As the area was improved, sheet flow drainage became blocked, confined and restricted which impacted the natural flow patterns. There are no apparent provisions to properly divert the sheet flow drainage around the mine lakes. The mine lakes offer an opportunity to store excess stormwater runoff and provide a functional floodway drainage path.

Location

This concept project interconnects existing mine lakes in the east Alico area, east of Florida Gulf Coast University to store and convey excess stormwater run-off to the southeast towards Corkscrew Road as illustrated in **Figure 21**.

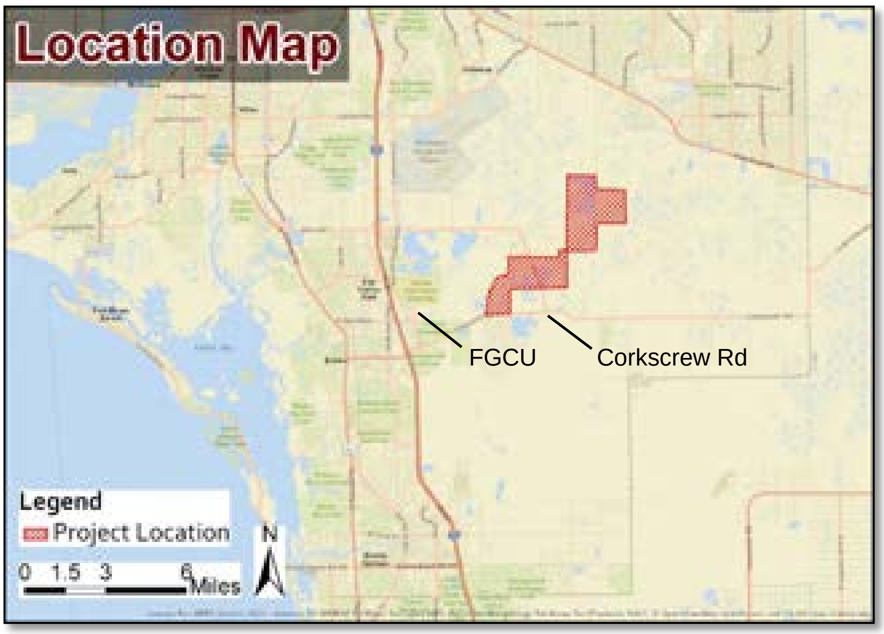


Figure 21 – Location Map, 1.3.5 Alico Mine Lake Interconnects (East)

Description

This concept project interconnects existing mine lakes in the east Alico area to store and convey excess stormwater run-off to the southwest towards Corkscrew Road. The mine lake connections would have remotely operated weir gates to maintain flow and water levels within desirable ranges No active mining lakes would be utilized in this project. This interconnection would greatly increase storage which is paramount as the current existing outfalls for this area are so limited that increased storage is necessary as illustrated in **Figure 22**.

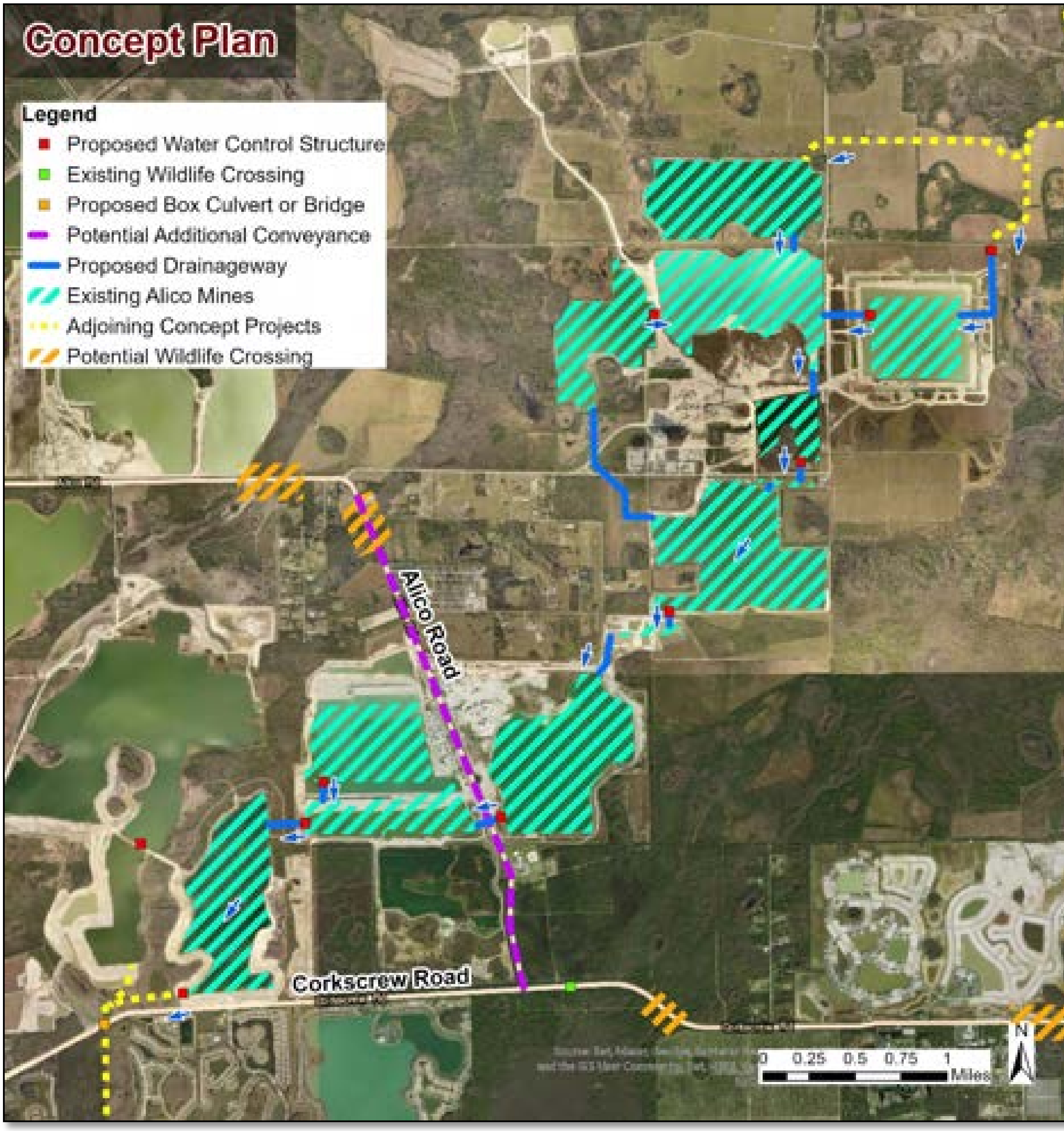


Figure 22 - Concept Plan, 1.3.5 Alico Mine Lake Interconnects (East)

Purpose

This proposed project extends drainageways into the Alico mines area and provides reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding.

Evaluation

Viability

Viability would be based on the coordination and cooperation of the mine owners., as well as, timely land acquisition for this rapidly growing areas of development.

Community Considerations

The project would require co-operation and approval from the Wild Blue MPD/DRI property, Greenmeadow Mine IPD owned property, and the West Lakes Excavation property. As well as from all approved storm water management systems and property owners.

Environmental & Permittability Considerations

This concept plan would allow for wetland hydroperiod enhancement with pumped water from mine lakes to prevent the over draining of wetlands.

Land Availability

This project as planned crosses public and private properties requiring governmental approvals and land acquisition. The need for, mine flow-way rights and maintenance access is also necessary to construct the Alico Mine Lake Interconnects (East) conveyance, storage, and water quality features.

Opinion of Probable Cost

The cost opinion shown in **Table 6** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 6 - Opinion of Probable Cost breakdown, 1.3.5 Alico Mine Lake Interconnects (East)

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$3,697,000	$3,697,000
Clearing & Grubbing	27	AC	$14,000	$378,000
Earthwork	263,000	CY	$6	$1,578,000
Construction/ Maintenance Access	7,500	SY	$15	$112,500
Weir Structure 3.5A (Major)	230	LF	$10,000	$2,300,000
Weir Structure 3.5B (Major)	230	LF	$10,000	$2,300,000
Weir Structure 3.5C (Major)	200	LF	$10,000	$2,000,000
Weir Structure 3.5D (Major)	170	LF	$10,000	$1,700,000
Weir Structure 3.5E (Major)	60	LF	$10,000	$600,000
Weir Structure 3.5F (Major)	130	LF	$10,000	$1,300,000
Weir Structure 3.5G (Major)	90	LF	$10,000	$900,000
Weir Structure 3.5H (Major)	90	LF	$10,000	$900,000
Detours	1	LS	$340,000	$340,000
Box Culvert 3.5-1	670	CY	$1,200	$804,000
Box Culvert 3.5-2	650	CY	$1,200	$780,000
Box Culvert 3.5-3	540	CY	$1,200	$648,000
Box Culvert 3.5-4	485	CY	$1,200	$582,000
Box Culvert 3.5-5	250	CY	$1,200	$300,000
Box Culvert 3.5-6	485	CY	$1,200	$582,000
Box Culvert 3.5-7	425	CY	$1,200	$510,000
Box Culvert 3.5-8	425	CY	$1,200	$510,000
Road Repairs	1	LS	$53,500	$53,500
Electric Supply	1	LS	$80,000	$80,000
Permanent Erosion Control	16,000	SF	$15	$240,000
Grassing	60,000	SY	$1.75	$105,000
Construction Cost Sub-Total:				**$ 23,300,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 6,790,000
Land Acquisition				$ 4,050,000
Project Administration/ CEI (10%):				$ 2,300,000
Project Unknowns				$ 560,000
Conceptual Project Cost:				**$ 37,000,000**
Contingency (30%)				$ 11,000,000
Conceptual Project Cost (with Contingency):				**$ 48,000,000**

Opportunities for Multiple Benefits & Uses

As south east Lee County continues to reach full build-out conditions, improving the conveyance of the Estero River Drainage Basin is a critical priority. Providing storage solutions will also become increasingly difficult as development diminishes the available land. This project would be a very effective methodology to store and treat stormwater. The mining lakes are easy to access and chain together. The project would allow water resources for re-hydrating wetlands year-round. An additional potential conveyance along Alico Road (shown in purple on Fig. 22), was identified later in the process and could be further evaluated for improvements within the area.

Other Considerations

Lack of water in the SE Lee County/Crew Flint area is commonly reported. Utilizing mine lake water resources can greatly improve the lack of wetland hydration. Water quality corrections for dissolved oxygen levels may be necessary for the discharge of water from deep lakes. A summary of this concept project is shown below in **Exhibit 1.3.5** herein.

Findings & Recommendations

Regional Modeling Findings

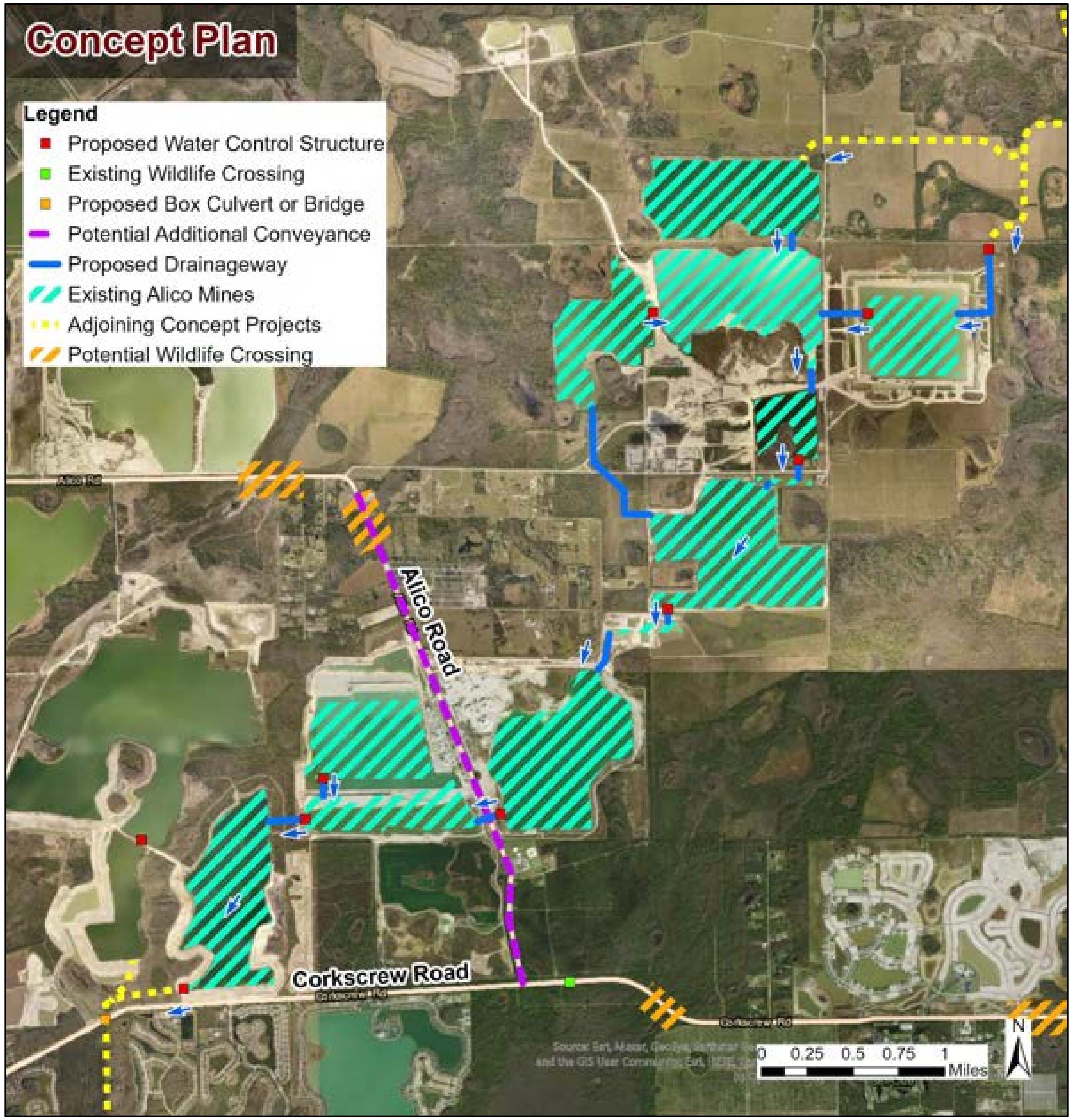
This project concept consists of conveying excess stormwater flows from the eastern Alico mine lakes by inter-connecting the lakes, retaining excess stormwater, and conveying flow to the Crew-Flint Pen Hydrologic Restoration area. When available, excess stormwater may be directed southerly to the Crew-Flint Pen area for wetland re-hydration. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.5 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.5 (b) EXHIBIT 1.3.5 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.5 (d) EXHIBIT 1.3.5 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.5 (f) EXHIBIT 1.3.5 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.5 (h) EXHIBIT 1.3.5 (i)

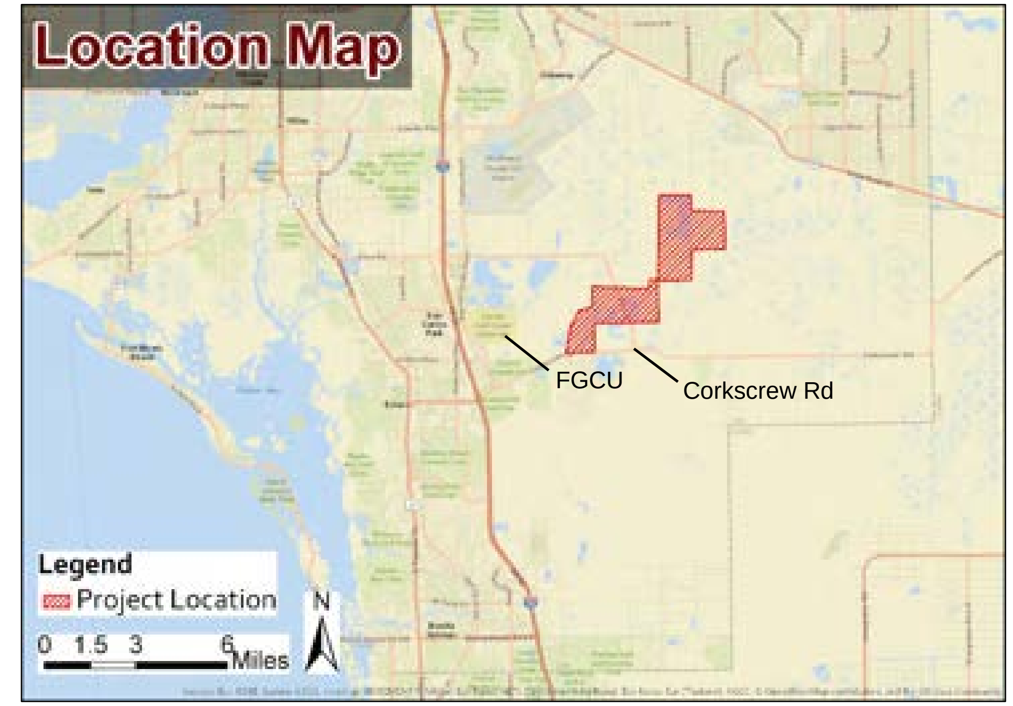
Improvements were shown with water level reductions from the existing to the proposed condition in the upper lakes with an increase in water level in the southern lakes at Corkscrew Road. Changes in flow are not exceedingly high considering the size of the contributing regional watershed area. A substantial increase in flow was observed towards the Crew/Flint Pen area. This conveyance is a key component for moving excess stormwater to the Halfway Creek Drainageway.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes through conveying excess stormwater flows from the eastern Alico mine lakes, interconnecting the lakes to store excess stormwater, and conveying flow to the Crew Flint Pen Hydrologic Restoration area. These positive improvements warrant further design-level project development.



Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project interconnects existing mine lakes in the east Alico area to store and convey excess stormwater run-off to the southwest towards Corkscrew Road. The mine lake connections would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project extends drainageways into the Alico mines area and provides reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Alico Mine Lake Interconnects (East)

SE Lee County Area

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2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.5

EXHIBIT 1.3.5 (a)

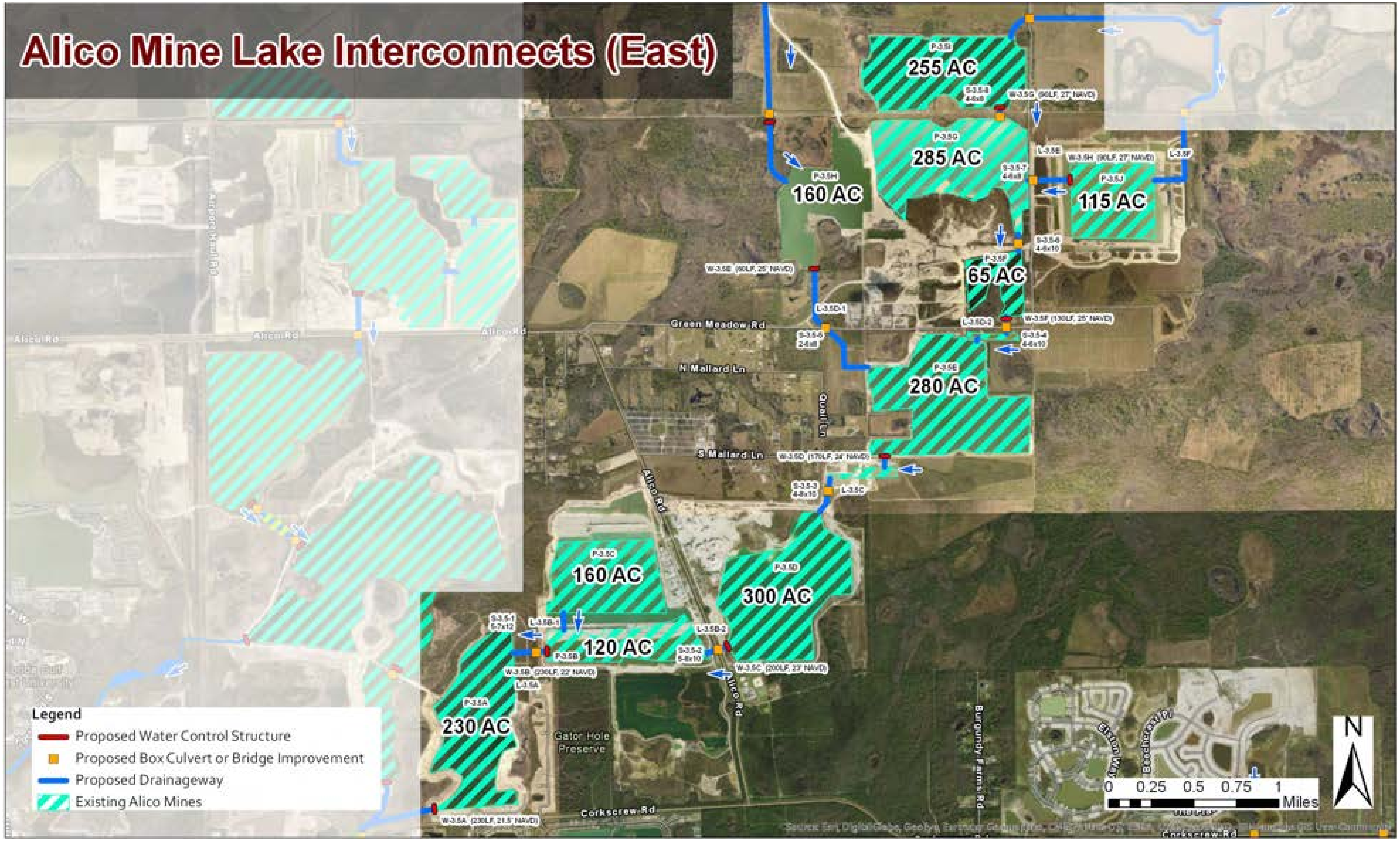


EXHIBIT 1.3.5 (b): 1 of 2

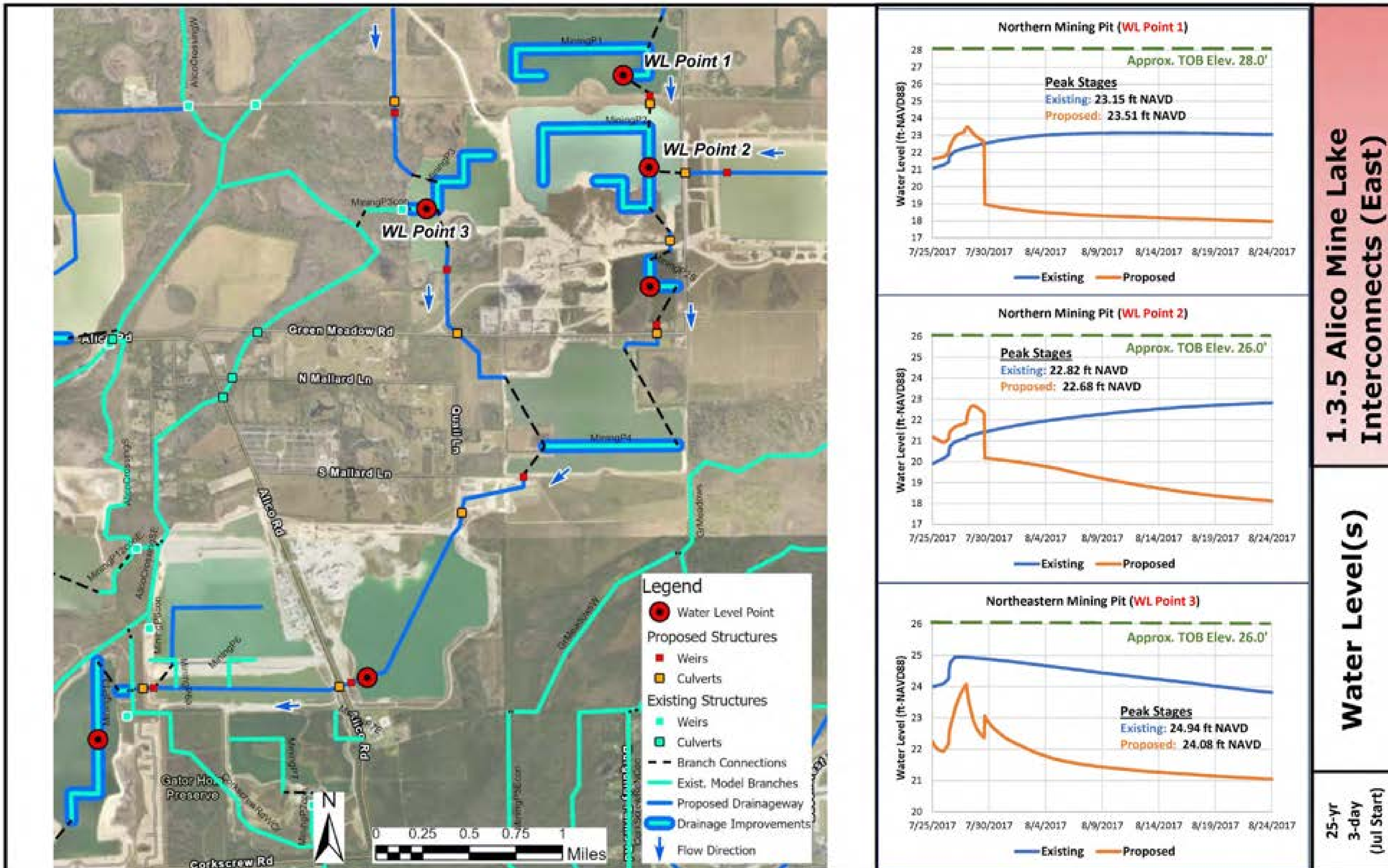


EXHIBIT 1.3.5 (b): 2 of 2

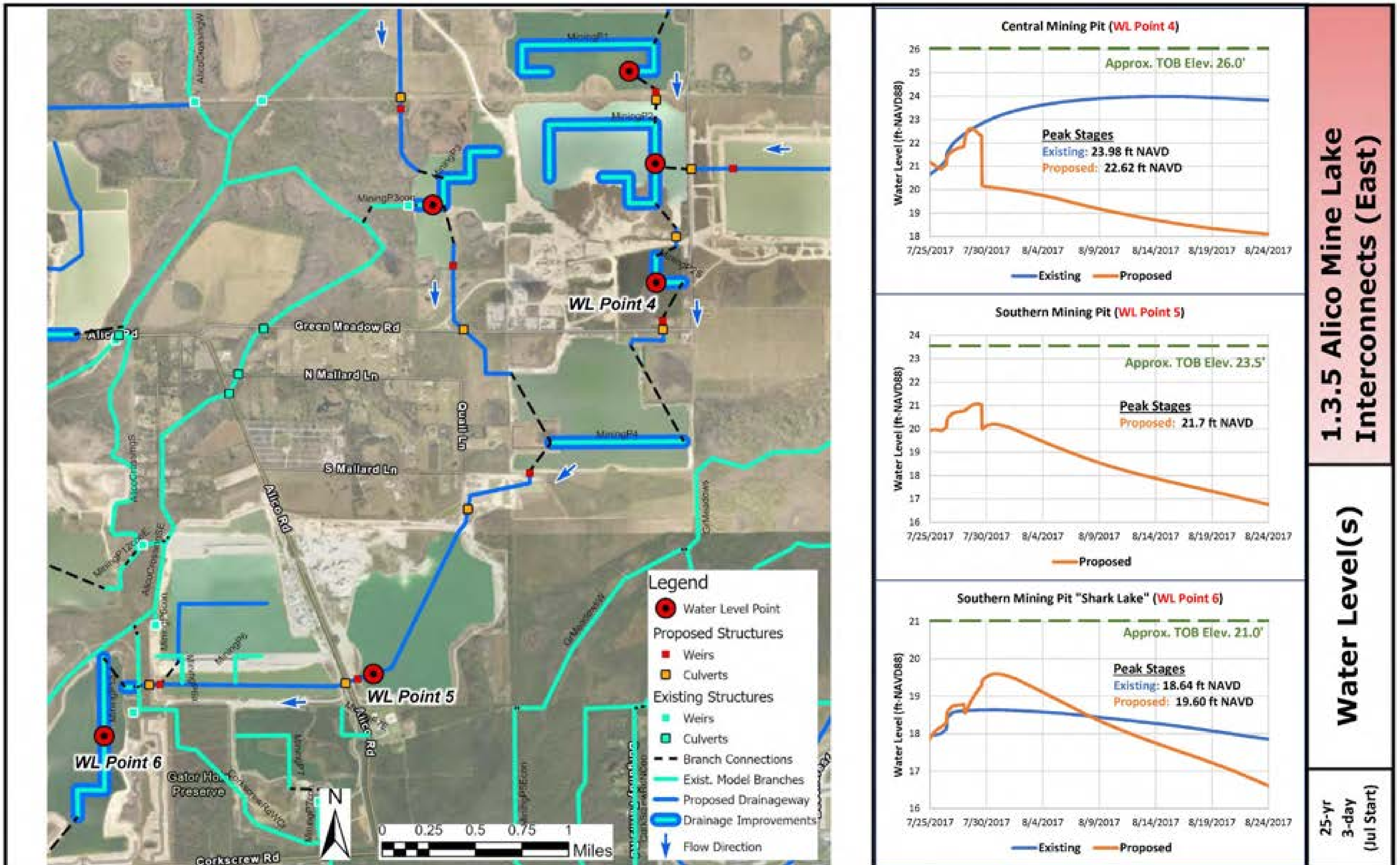
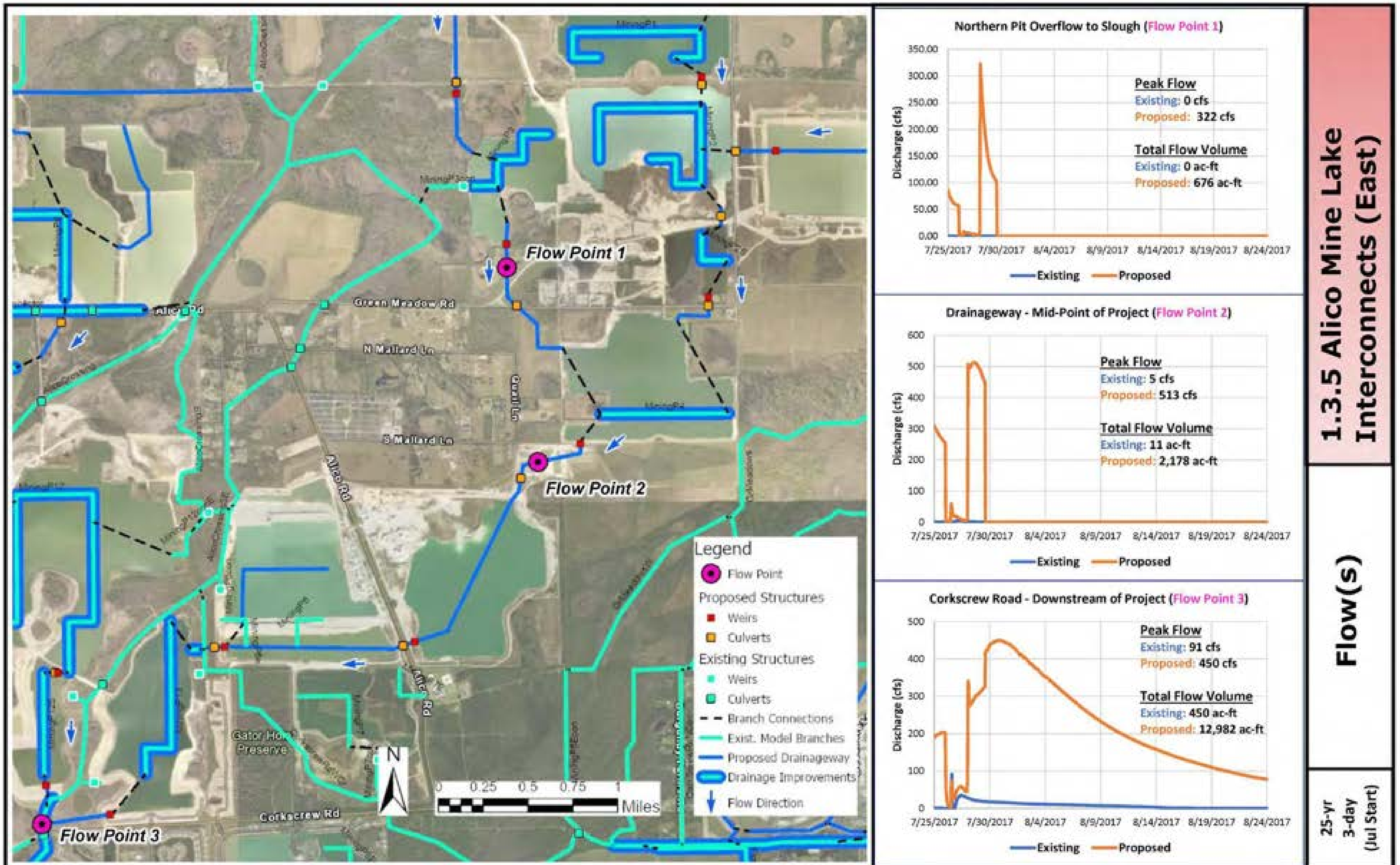


EXHIBIT 1.3.5 (c)



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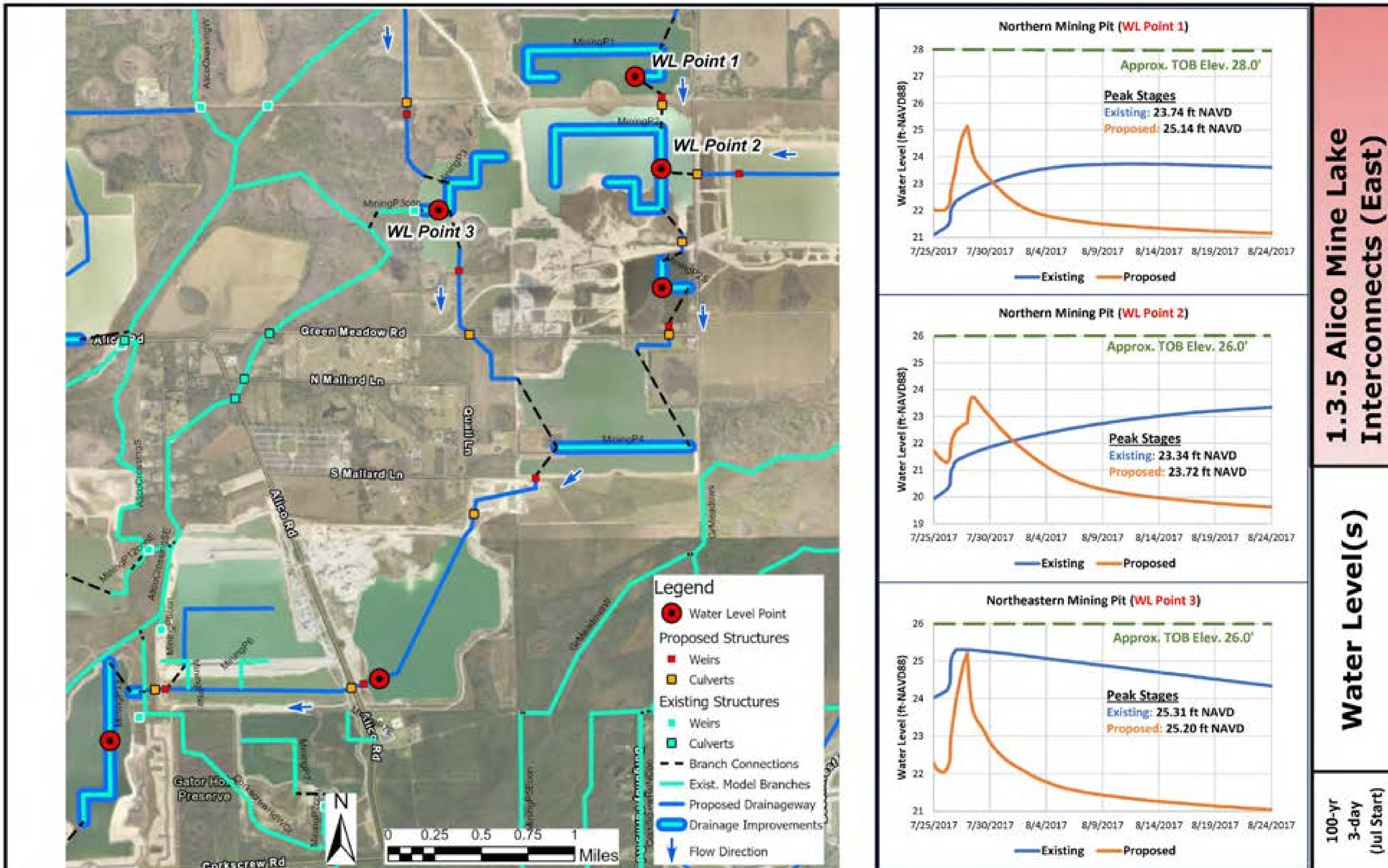

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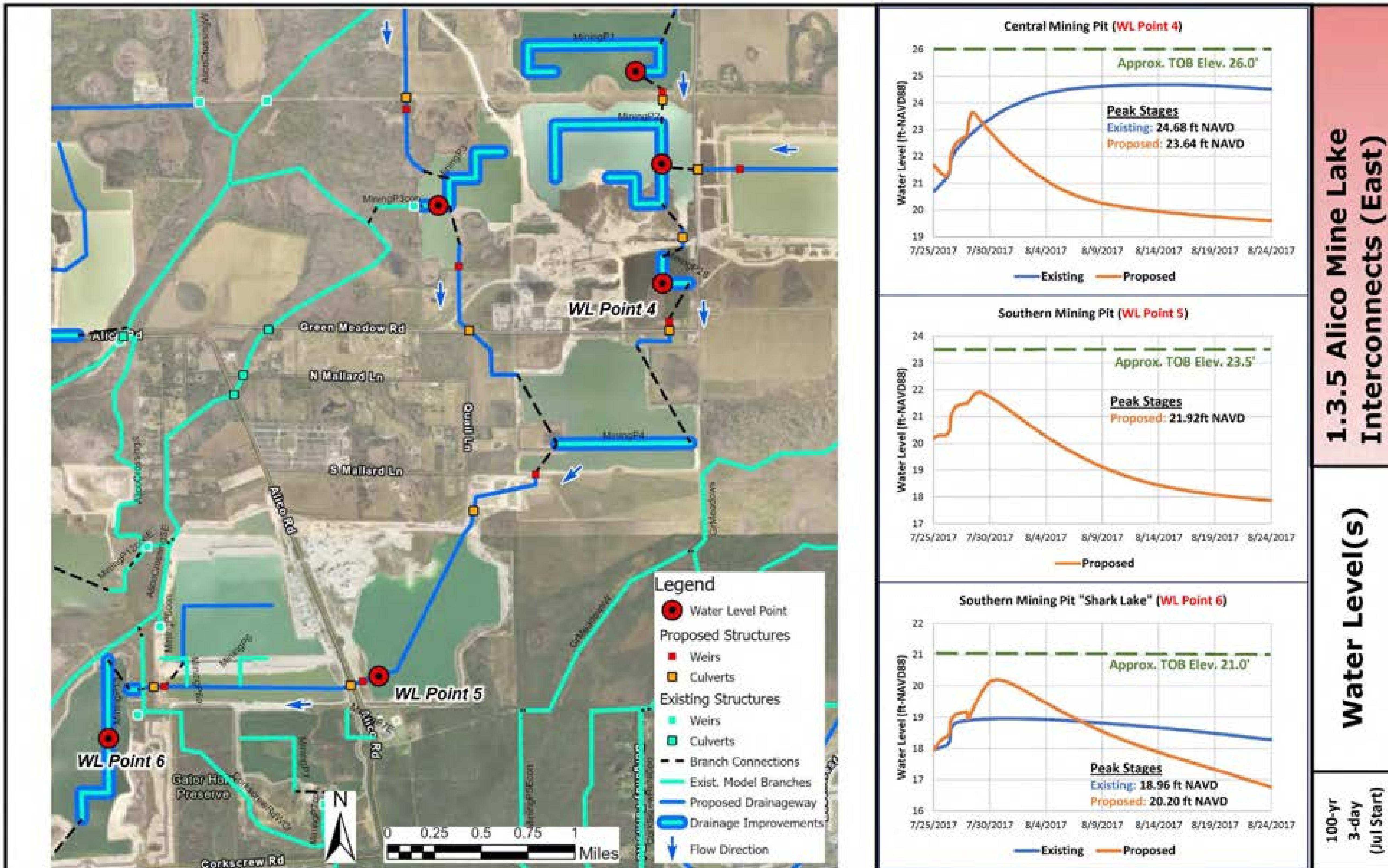

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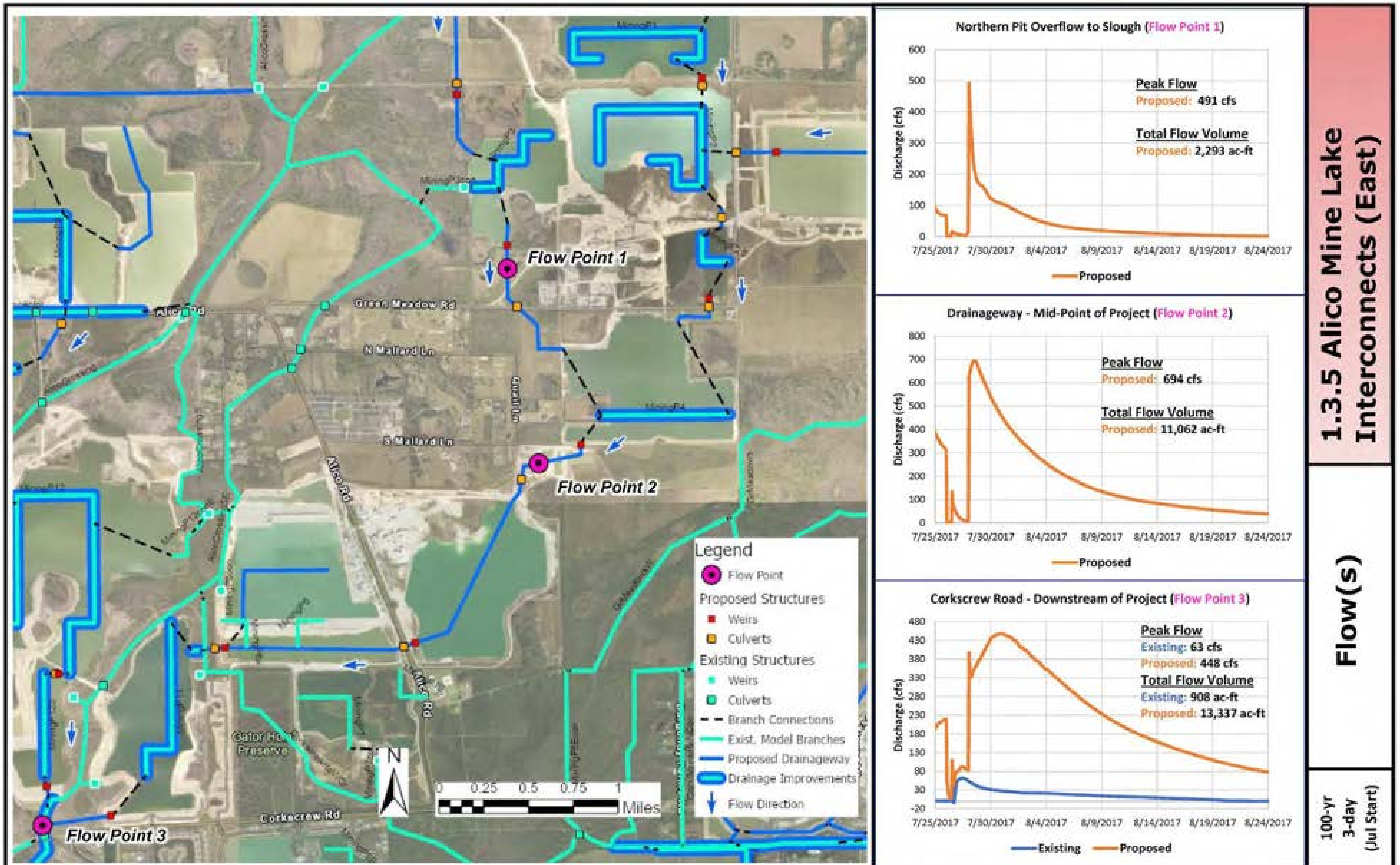

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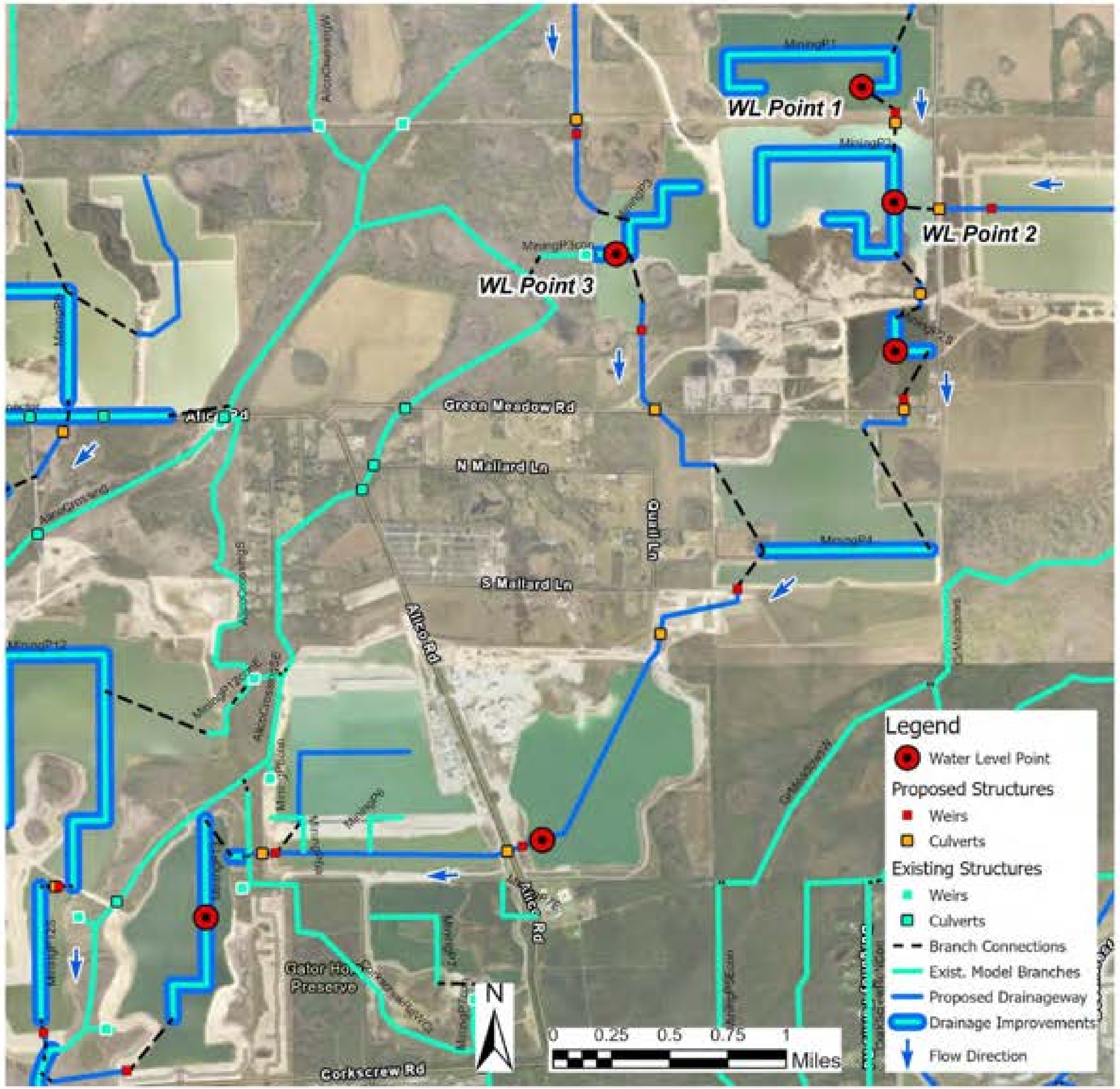
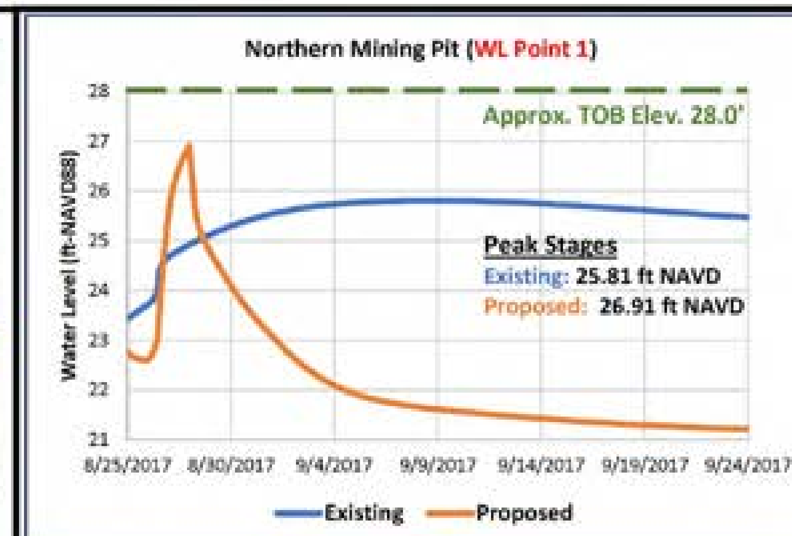
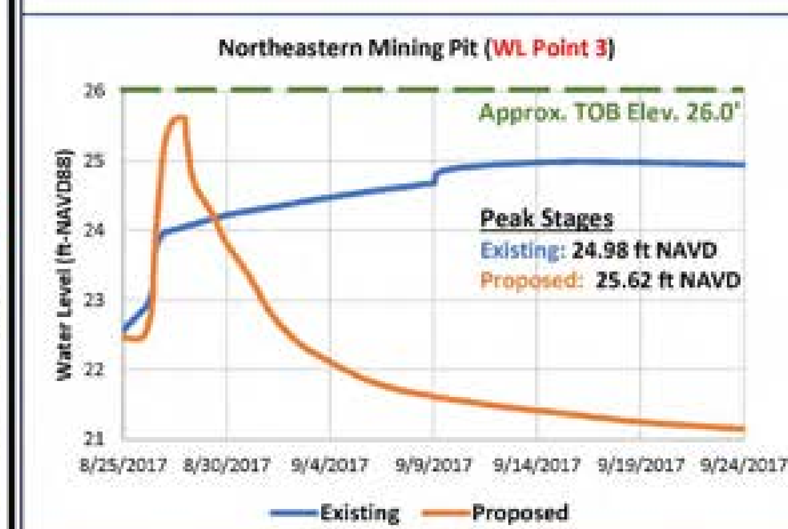




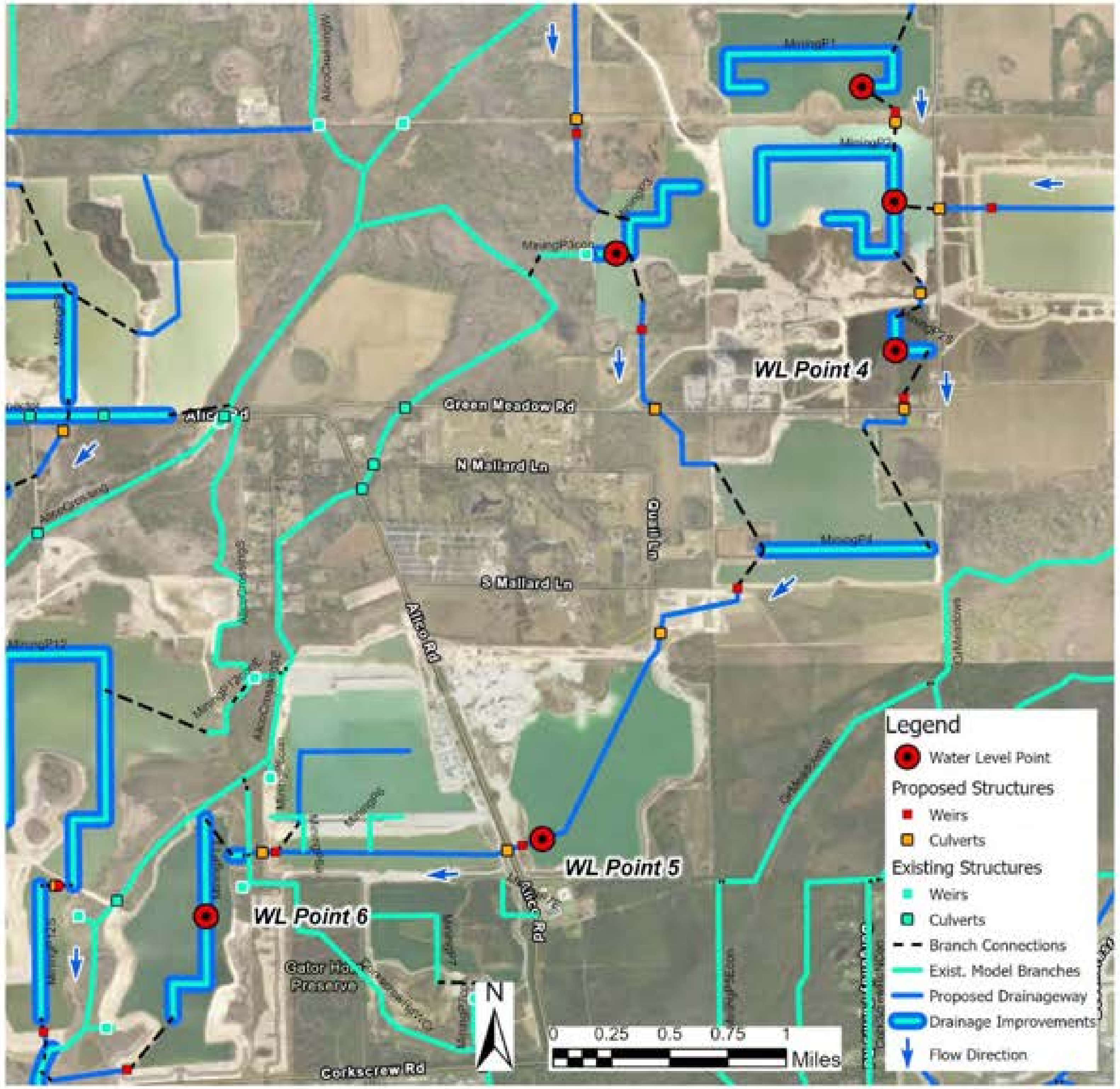


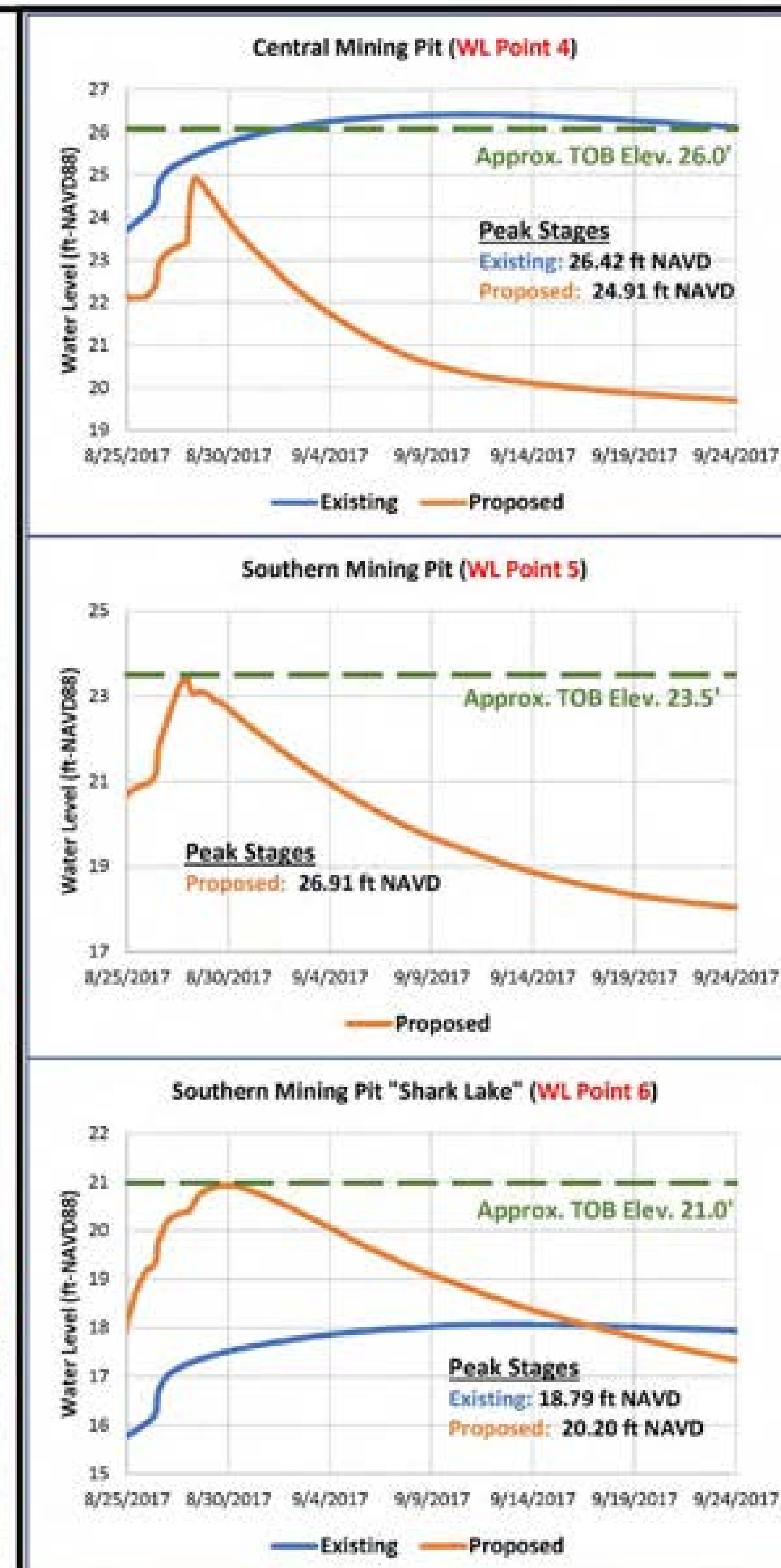
1.3.5 Alico Mine Lake Interconnects (East)

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.5 (f): 2 of 2



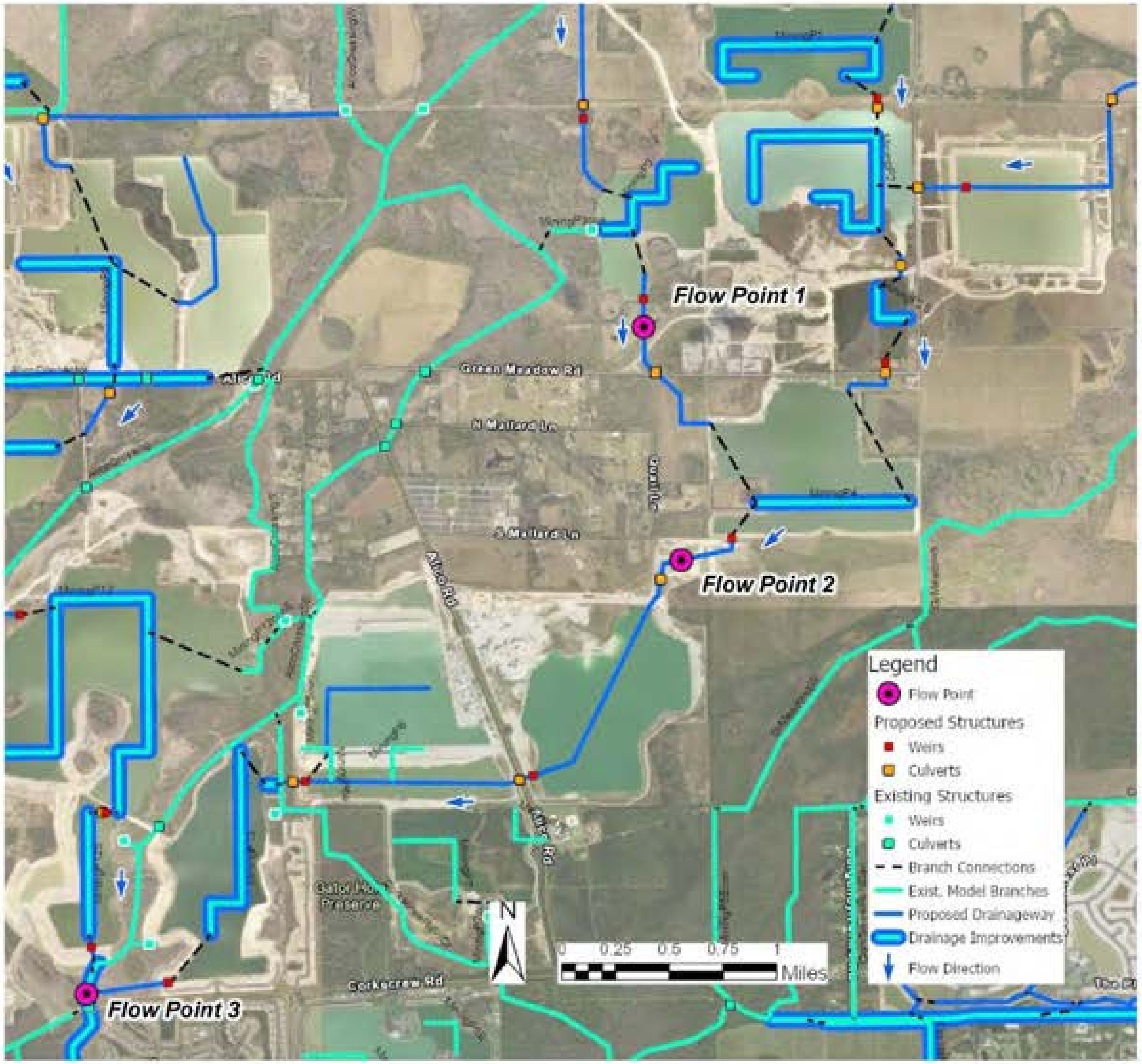


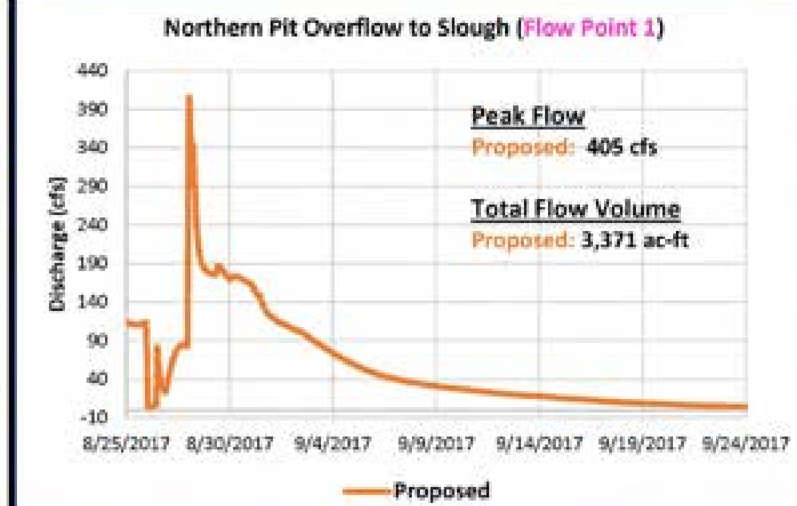
1.3.5 Alico Mine Lake Interconnects (East)

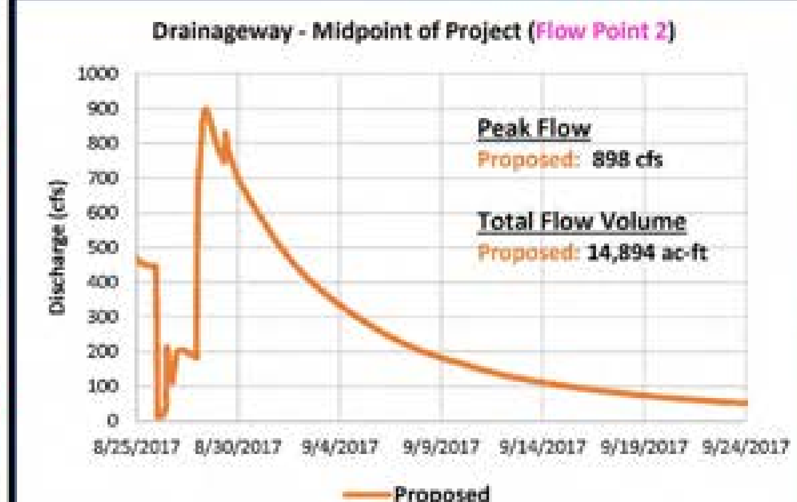
Water Level(s)

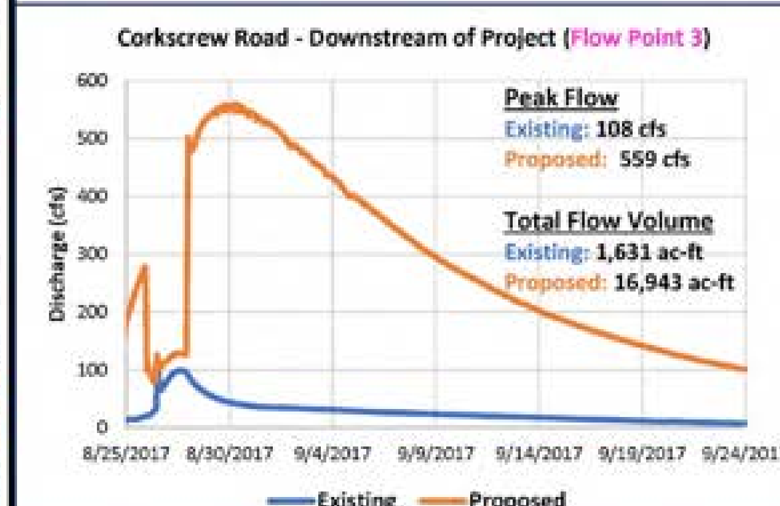
100-yr 3-day (Aug Start)

EXHIBIT 1.3.5 (g)







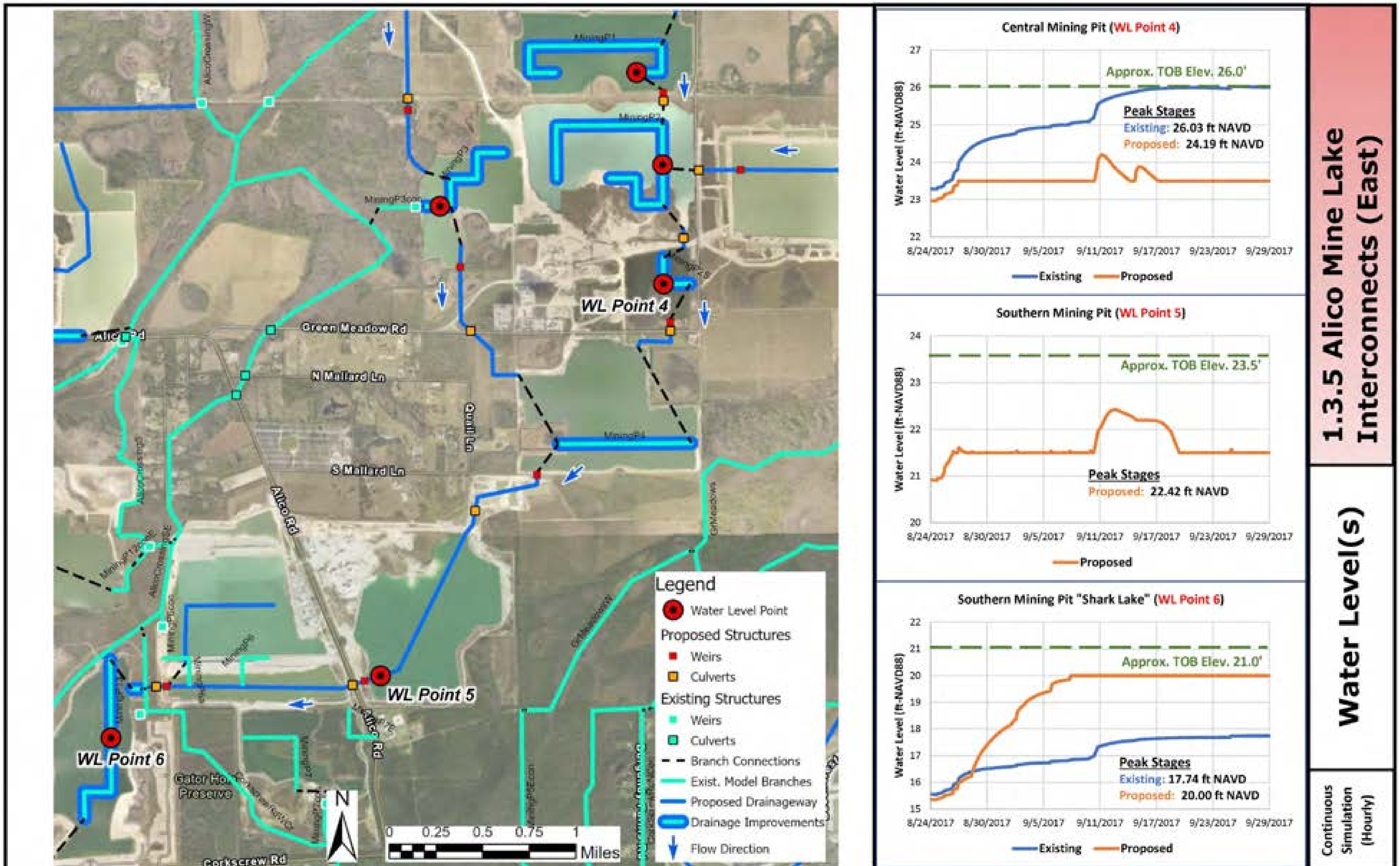


1.3.5 Alico Mine Lake Interconnects (East)

Flow(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.3.5 (h): 1 of 2



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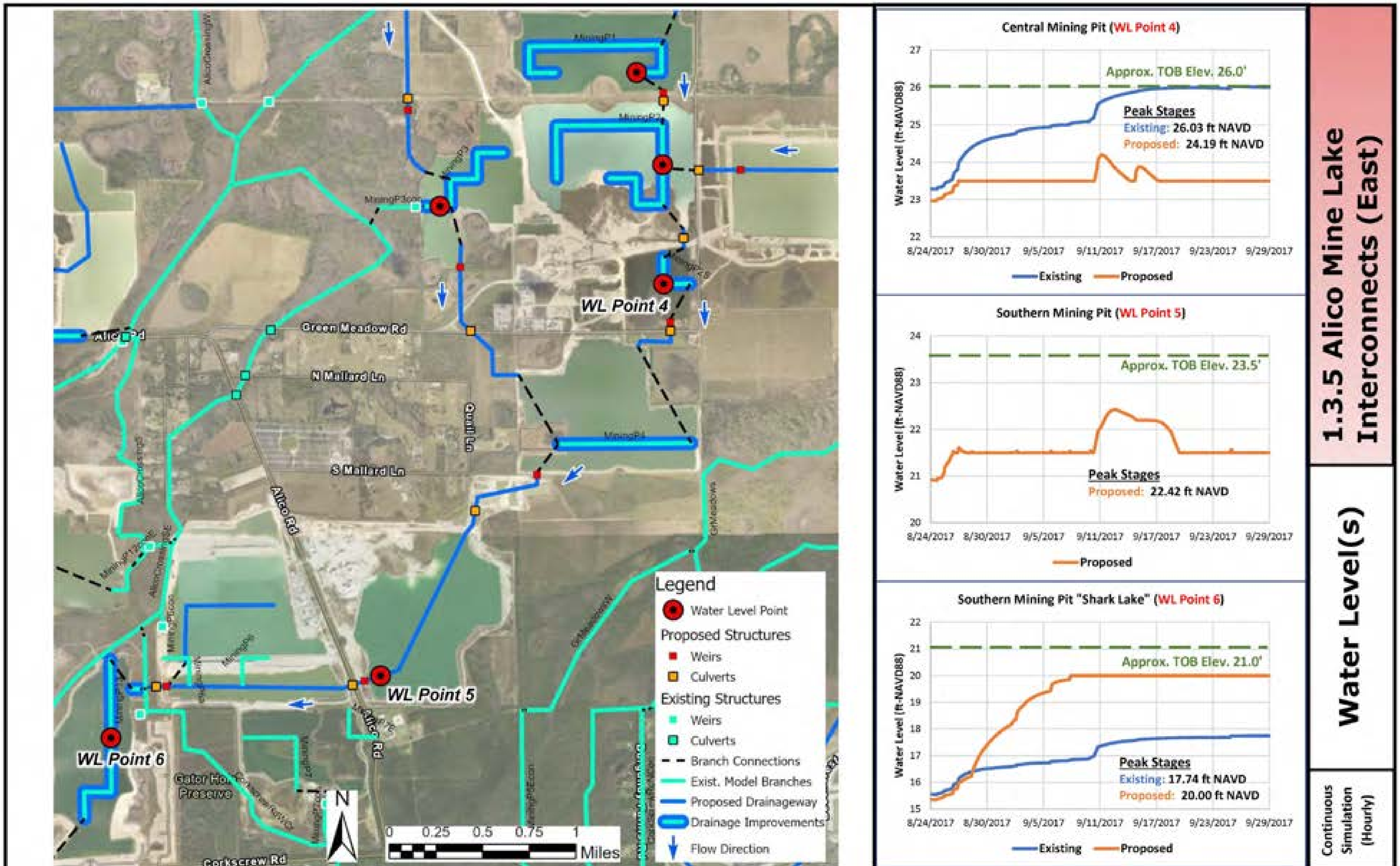
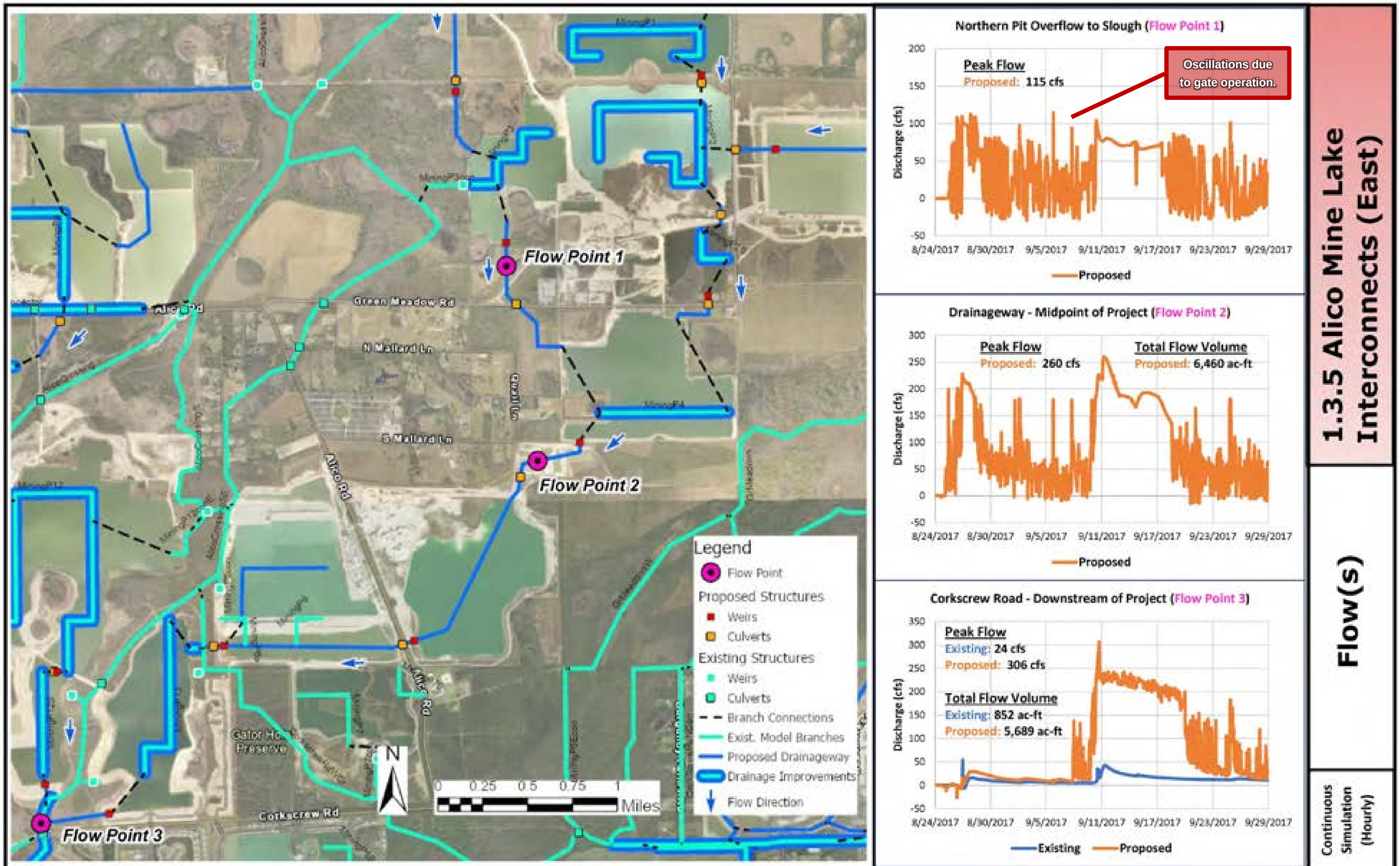


EXHIBIT 1.3.5 (i)



1.3.6 Alico Road Extension Drainageway Concept Plan

Background

This project concept is located along the proposed Alico Road Extension to Lehigh Acres at the intersection of Sunshine Boulevard and State Road No. 82. A drainageway along the proposed road would allow collection of excess stormwater in this area and direct flow southerly to a series of mine lakes in the existing Alico Road area. This area contains dense cypress swamps, large residential tracts and agricultural operations. Natural flow would continue to the wetland areas and the excess stormwater diverted to mine lakes. The concept project drainageway may be used for stormwater quality treatment and runoff attenuation.

Location

This concept project is located in SE Lee County east of Interstate 75 and Southwest Florida International Airport, south of State Road 82 and generally follows the proposed alignment of the Alico Road extension as illustrated in **Figure 23**.

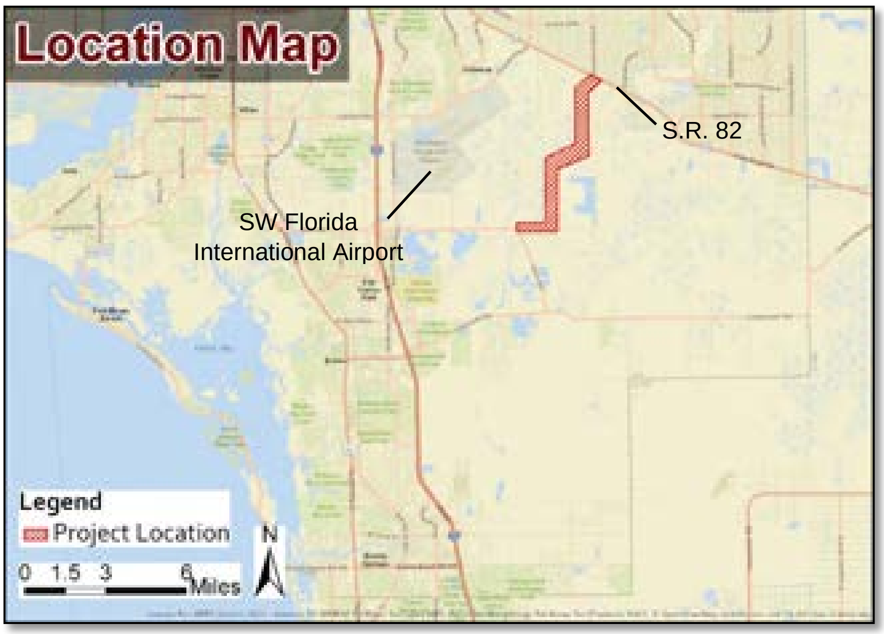


Figure 23 – Location Map, 1.3.6 Alico Road Extension Drainageway

Description

This concept project is for a drainageway running south from SR 82 along the east boundary of the RSW International Airport lands and generally following the proposed Alico Road extension to SR 82. This drainageway would convey excess stormwater from large storm events to the existing Alico Mine Lakes as illustrated in **Figure 24**.

Figure 24 – Concept Plan, 1.3.6 Alico Road Extension Drainageway

Purpose

This proposed project provides routing of excess stormwater run-off away from the Ten-Mile Canal which is experiencing severe over loading. The drainageway would provide fill material for roadway embankment, as well as, road drainage outfall and water quality treatment. A wide conveyance swale along the proposed Alico Roadway extension route could extend storm water management control on the east side of the SW Florida Regional Airport. This swale can be planted with aquatic vegetation and water control structures can be placed along the project to avoid over drainage of the wetland. **Figure 25** demonstrates how seepage barriers can be designed to avoid surface water drawdown to surrounding wetland areas. Excavated fill could be used to benefit road construction.

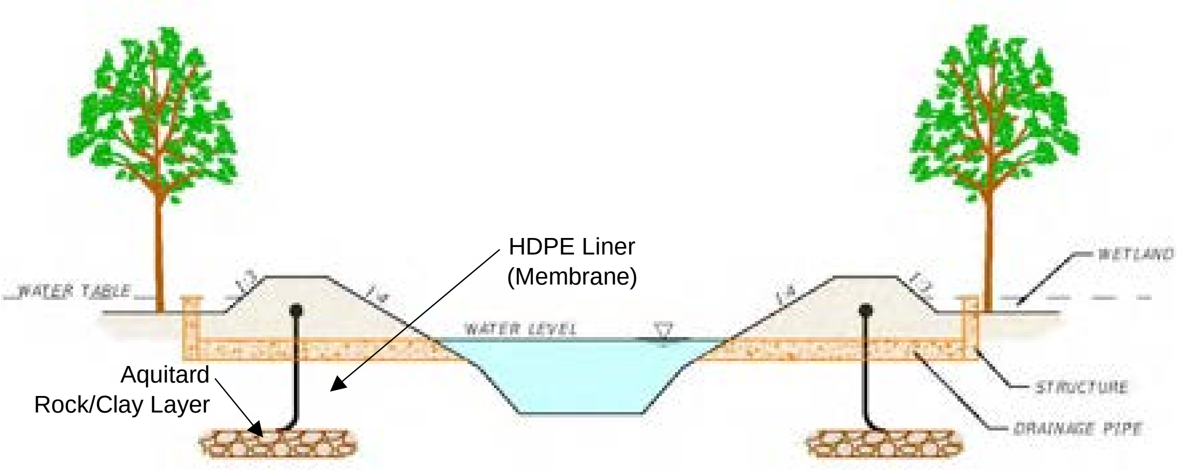


Figure 25 - Example of a seepage barrier concept to avoid water table drawdown in surrounding wetland areas.

Evaluation

Viability

This project is viable due to the Alico Road extension project requirements. Careful consideration of wetland avoidance, minimization and mitigation is a viable way to manage storm water in this area.

Community Considerations

This drainageway would utilize Green Meadow IPD and Florida Rock Mine properties.

Environmental & Permittability Considerations

This concept plan should avoid, minimize and mitigate any wetland impacts. Maintaining wetland water levels shall be key a key consideration for this project.

Land Availability

The need for land acquisition is necessary to construct the Alico Road Extension Drainageway conveyance, storage, and water quality features. Coordination with LCDOT and the mine lake owners will be required.

Opinion of Probable Cost

The cost opinion shown in **Table 7** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 7 - Opinion of Probable Cost breakdown, 1.3.6 Alico Road Extension Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 699,000	$ 699,000
Clearing & Grubbing	42	AC	$ 14,000	$ 588,000
Earthwork	105,000	CY	$ 6	$ 630,000
Construction/ Maintenance Access	12,000	SY	$ 20	$ 240,000
Weir Structure 3.6A (Standard)	48	LF	$ 5,000	$ 240,000
Weir Structure 3.6B (Standard)	48	LF	$ 5,000	$ 240,000
Weir Structure 3.6C (Standard)	48	LF	$ 5,000	$ 240,000
Box Culvert 3.6-1	135	CY	$ 1,200	$ 162,000
Box Culvert 3.6-2	135	CY	$ 1,200	$ 162,000
Box Culvert 3.6-3	135	CY	$ 1,200	$ 162,000
Box Culvert 3.6-4	120	CY	$ 1,200	$ 144,000
Electric Supply	1	LS	$ 30,000	$ 30,000
Permanent Erosion Control	4,000	SF	$ 15	$ 60,000
Grassing	101,500	SY	$ 2	$ 203,000
			Construction Cost Sub-Total:	**$ 3,800,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 1,140,000
			Land Acquisition	$ 2,000,000
			Project Administration/ CEI (10%):	$ 380,000
			Project Unknowns	$ 1,680,000
			Conceptual Project Cost:	**$ 9,000,000**
			Contingency (30%)	$ 2,600,000
			Conceptual Project Cost (with Contingency):	**$ 11,600,000**

Opportunities for Multiple Benefits & Uses

The project could provide fill for road construction, water quality treatment and drainage for the road project.

Other Considerations

This project could alleviate some flooding on the Ten Mile Canal by sending water south to the Crew-Flint Strand area. A summary of this concept project is shown below in **Exhibit 1.3.6** herein.

Findings & Recommendations

Regional Modeling Findings

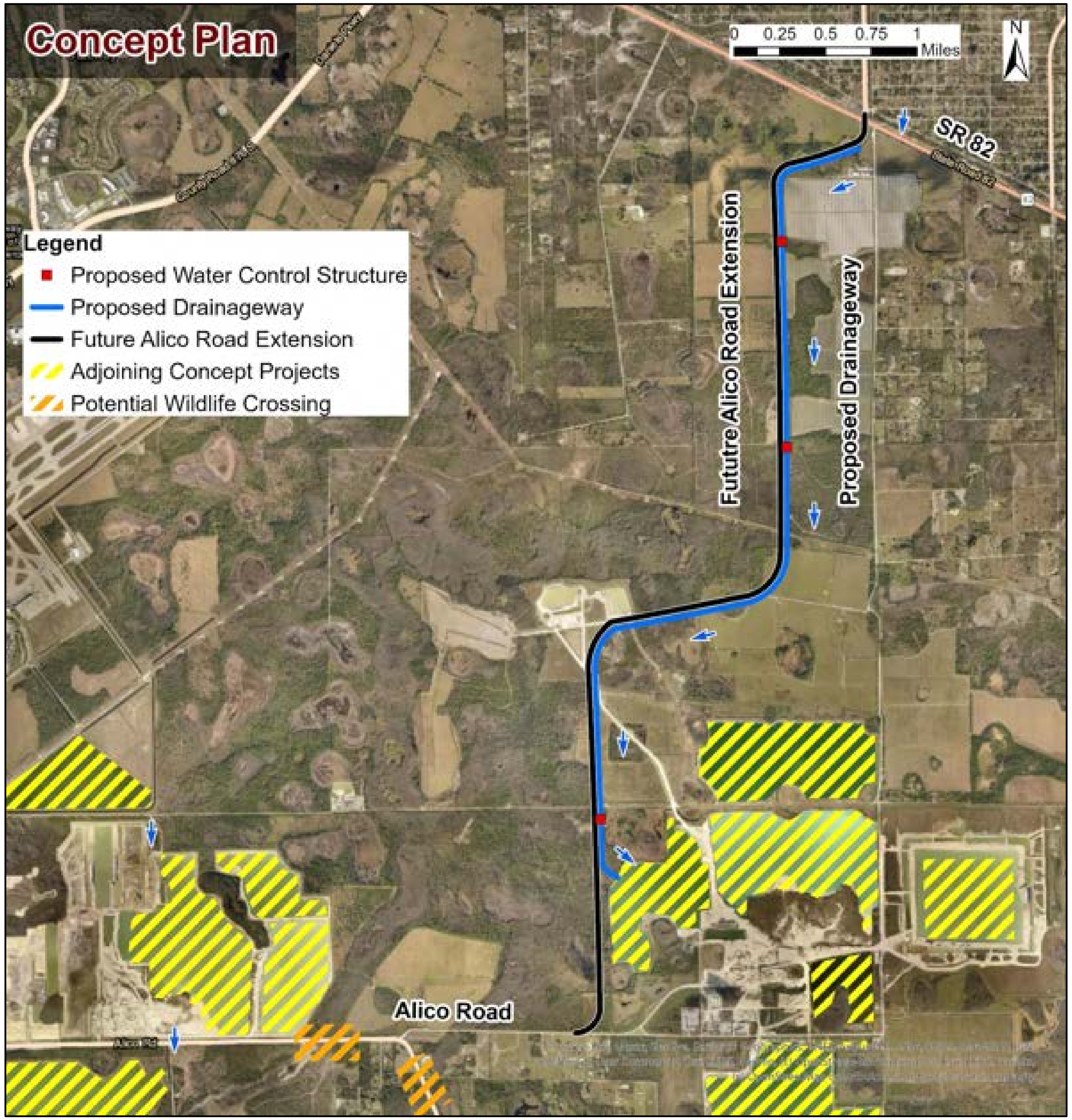
This project concept consists of conveying excess stormwater flows from the Wild Turkey Slough area along the proposed Alico Road Extension southerly to convene with the eastern Alico Mine Lakes. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.6 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.6 (b) EXHIBIT 1.3.6 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.6 (d) EXHIBIT 1.3.6 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.6 (f) EXHIBIT 1.3.6 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.6 (h) EXHIBIT 1.3.6 (i)

Improvements were shown as water levels in nearby marsh areas varied from slightly lower to slightly higher along the route, and flows increased southernly from the existing to proposed condition.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from the Wild Turkey Slough area along the proposed Alico Road Extension southerly to convene with the eastern Alico mine lakes. These positive improvements warrant further design-level project development.



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project is for a drainageway running south from SR 82 along the east boundary of the RSW International Airport lands and generally following the proposed Alico Road extension to SR 82. This drainageway would convey excess stormwater from large rainfall events to the existing Alico Mine Lakes.

PURPOSE: This proposed project provides routing of excess stormwater run-off away from the Ten-Mile Canal which is experiencing severe over loading. The drainageway would provide fill material for roadway embankment, as well as, road drainage outfall and water quality treatment.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Coordination with the road extension would be required to utilize fill spoil material. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts would necessitate mitigation.

May 2020

Alico Road Extension Drainageway

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.6

EXHIBIT 1.3.6 (a)

EXHIBIT 1.3.6 (b)

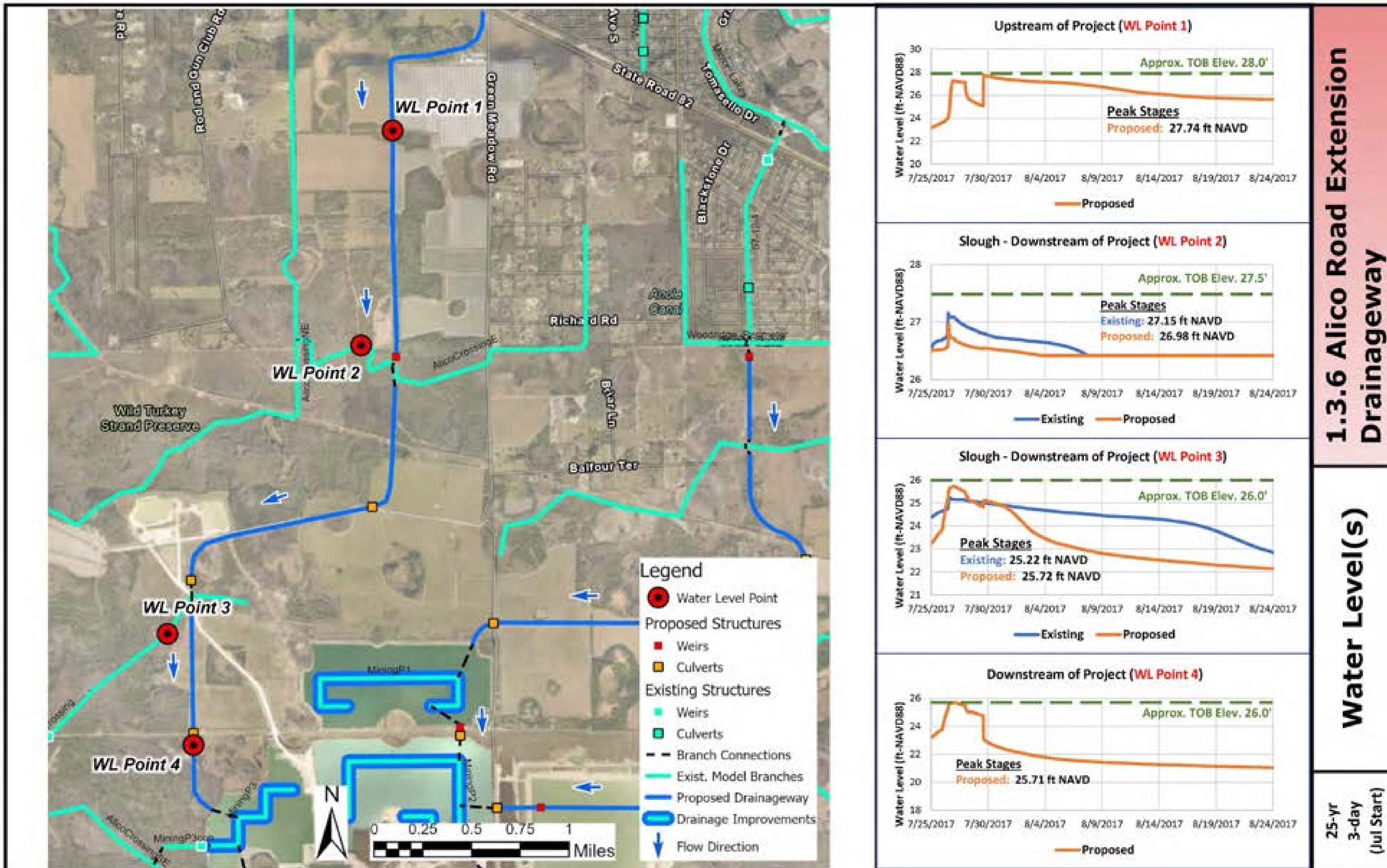
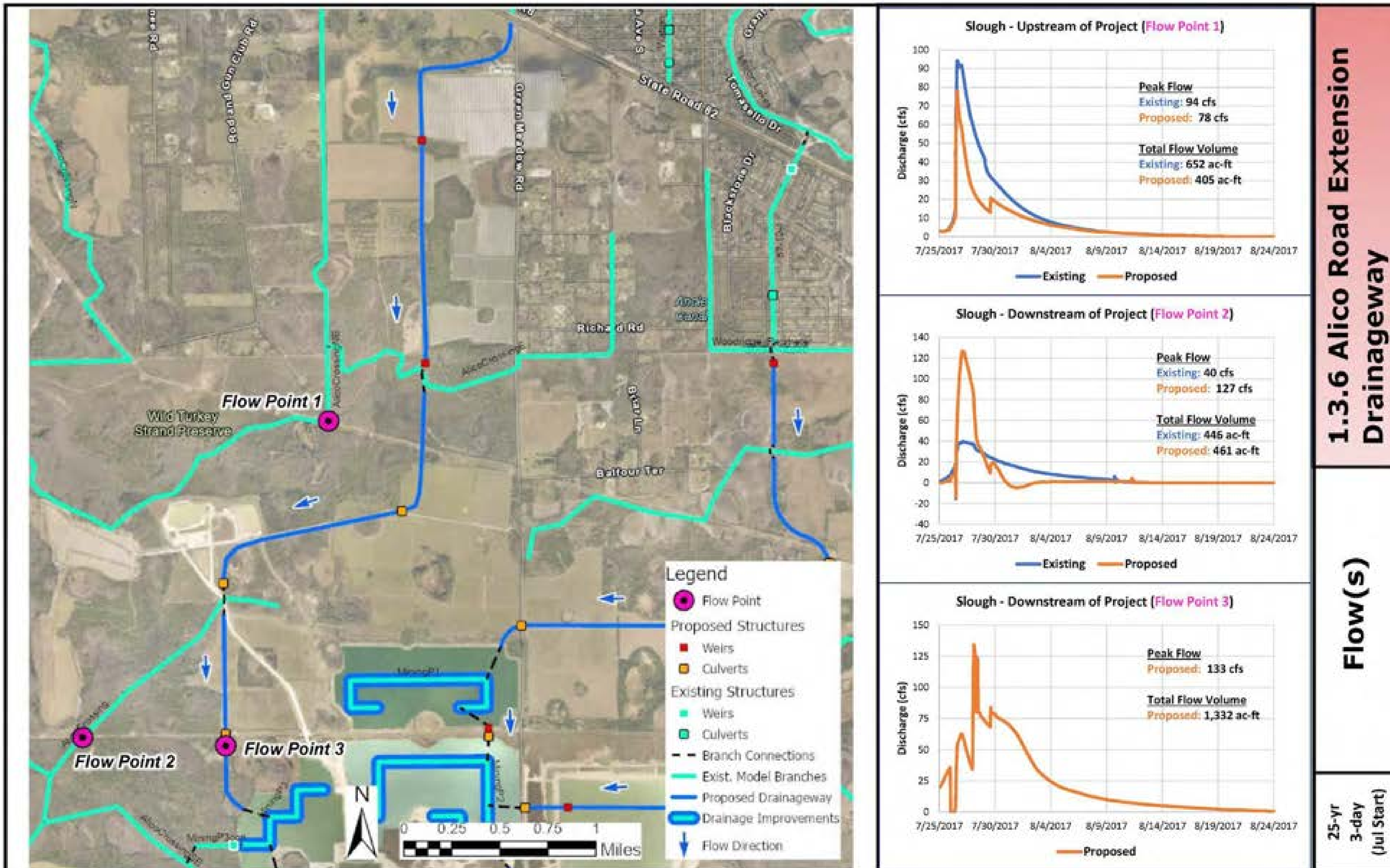


EXHIBIT 1.3.6 (c)



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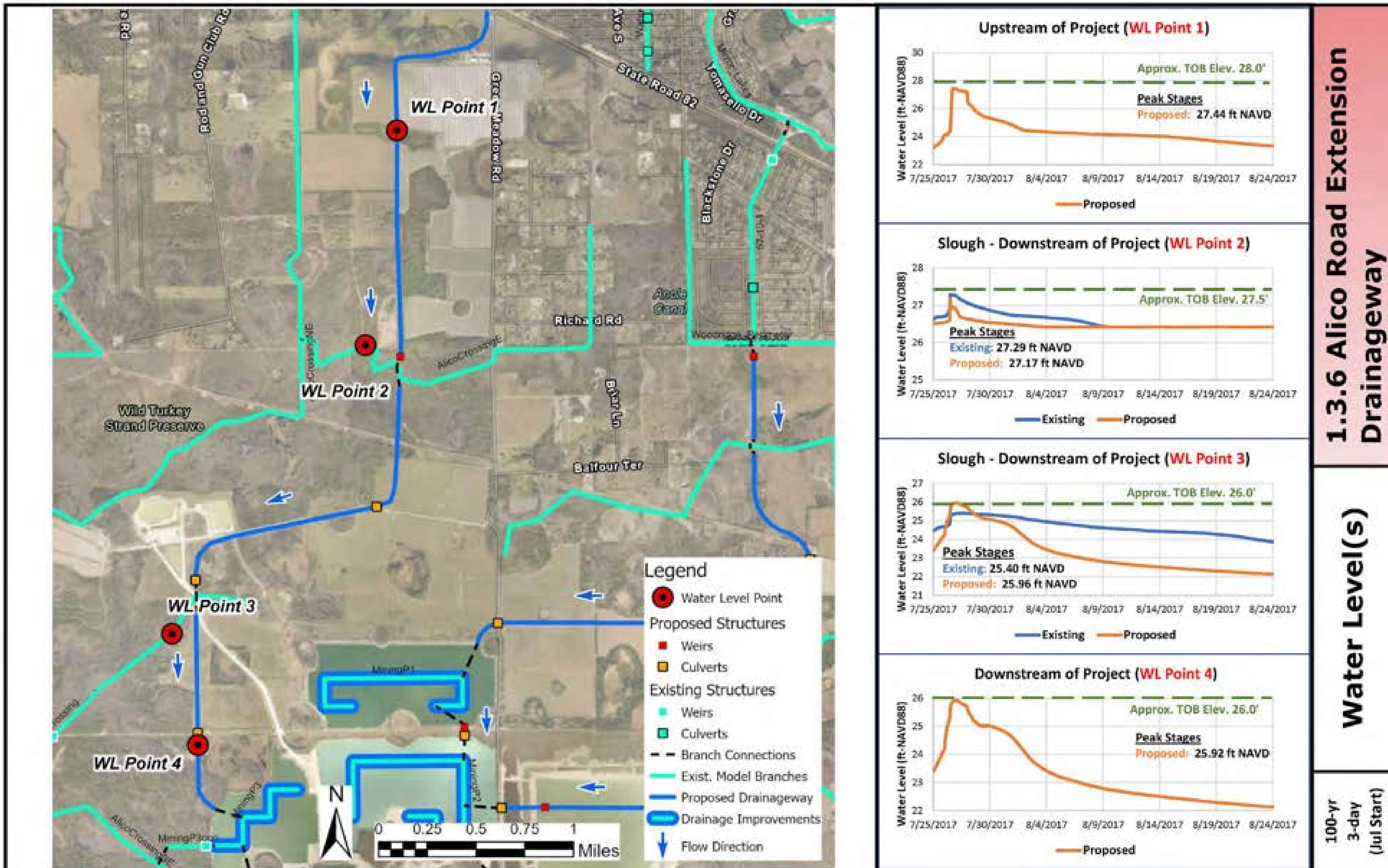

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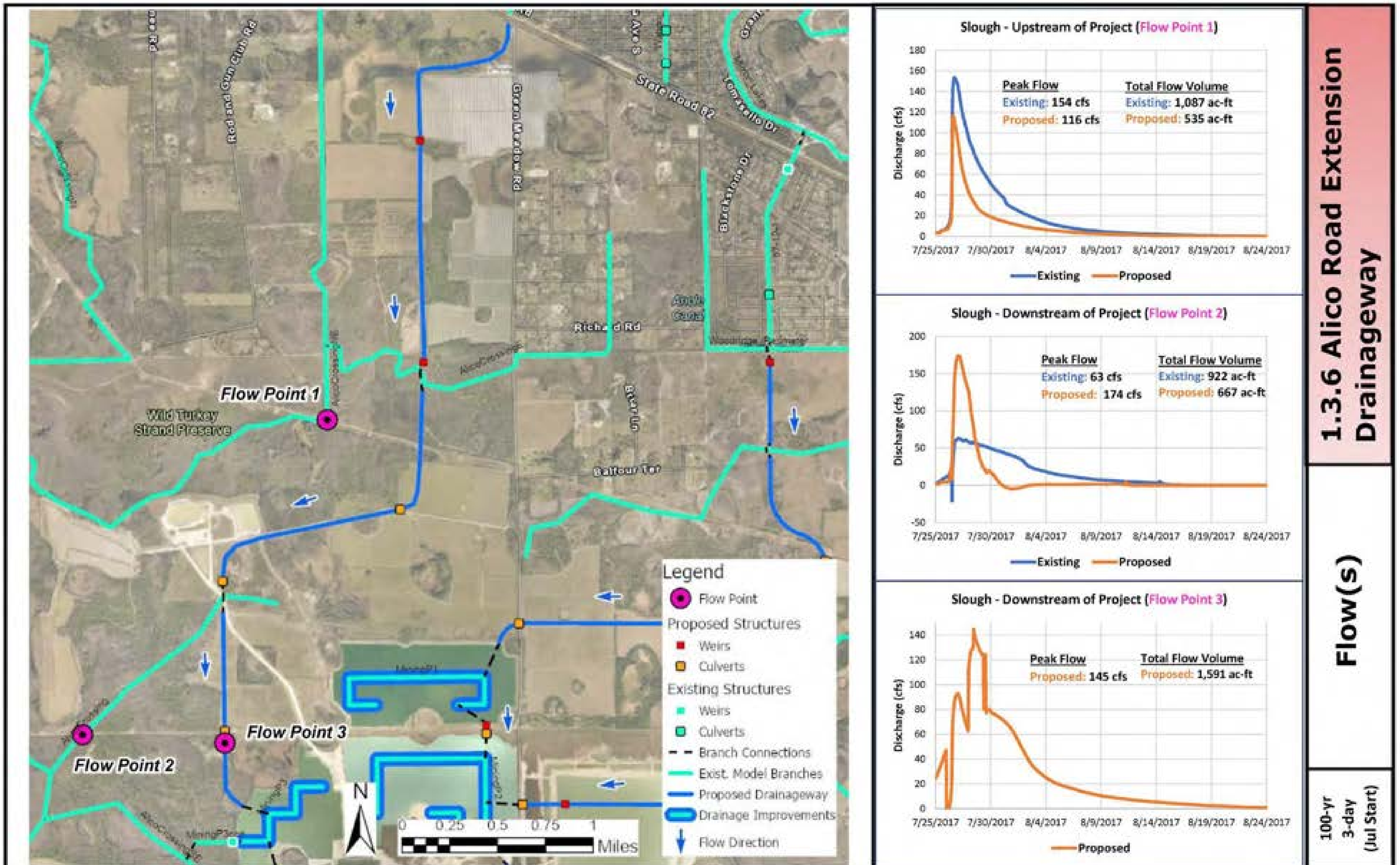

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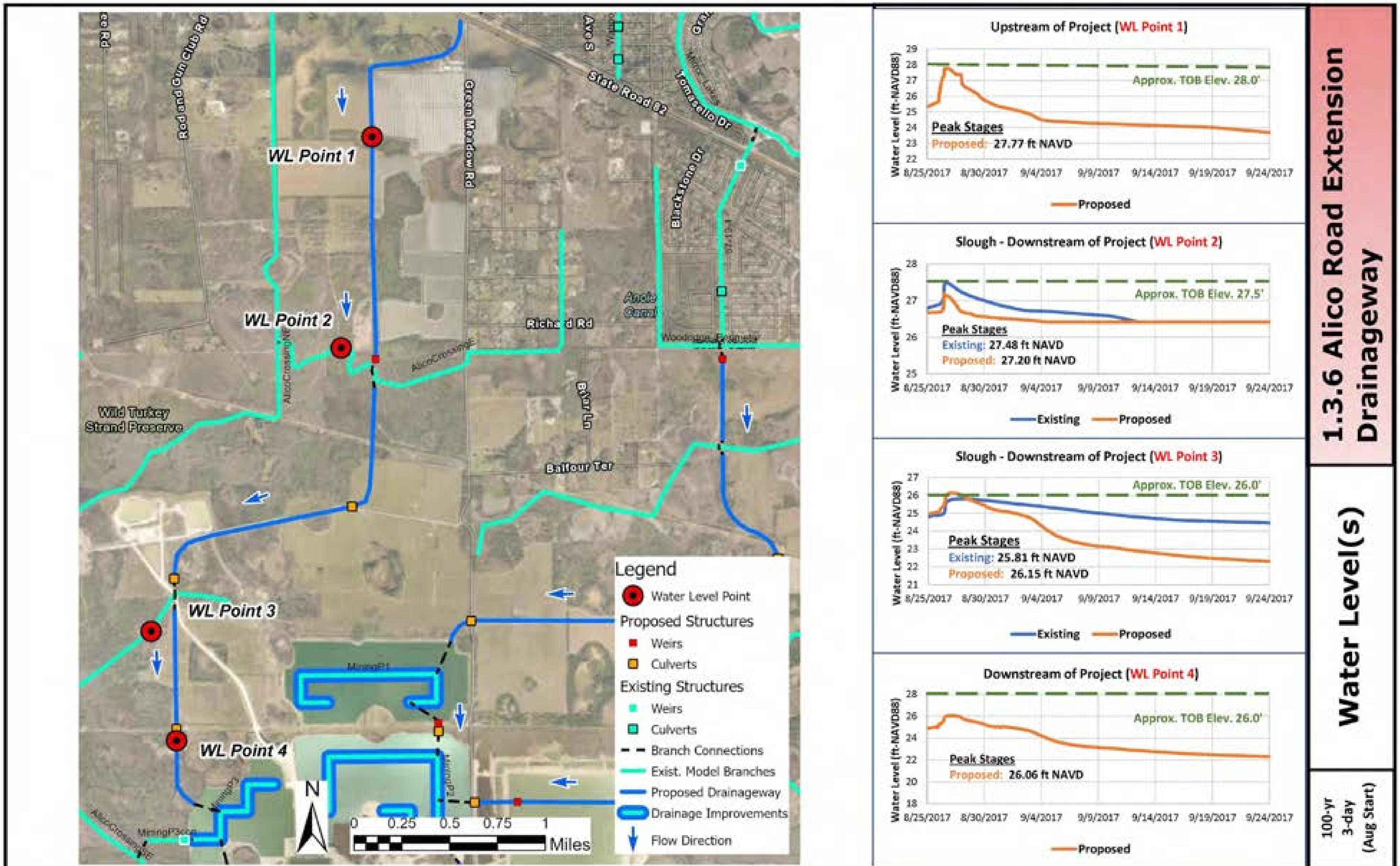
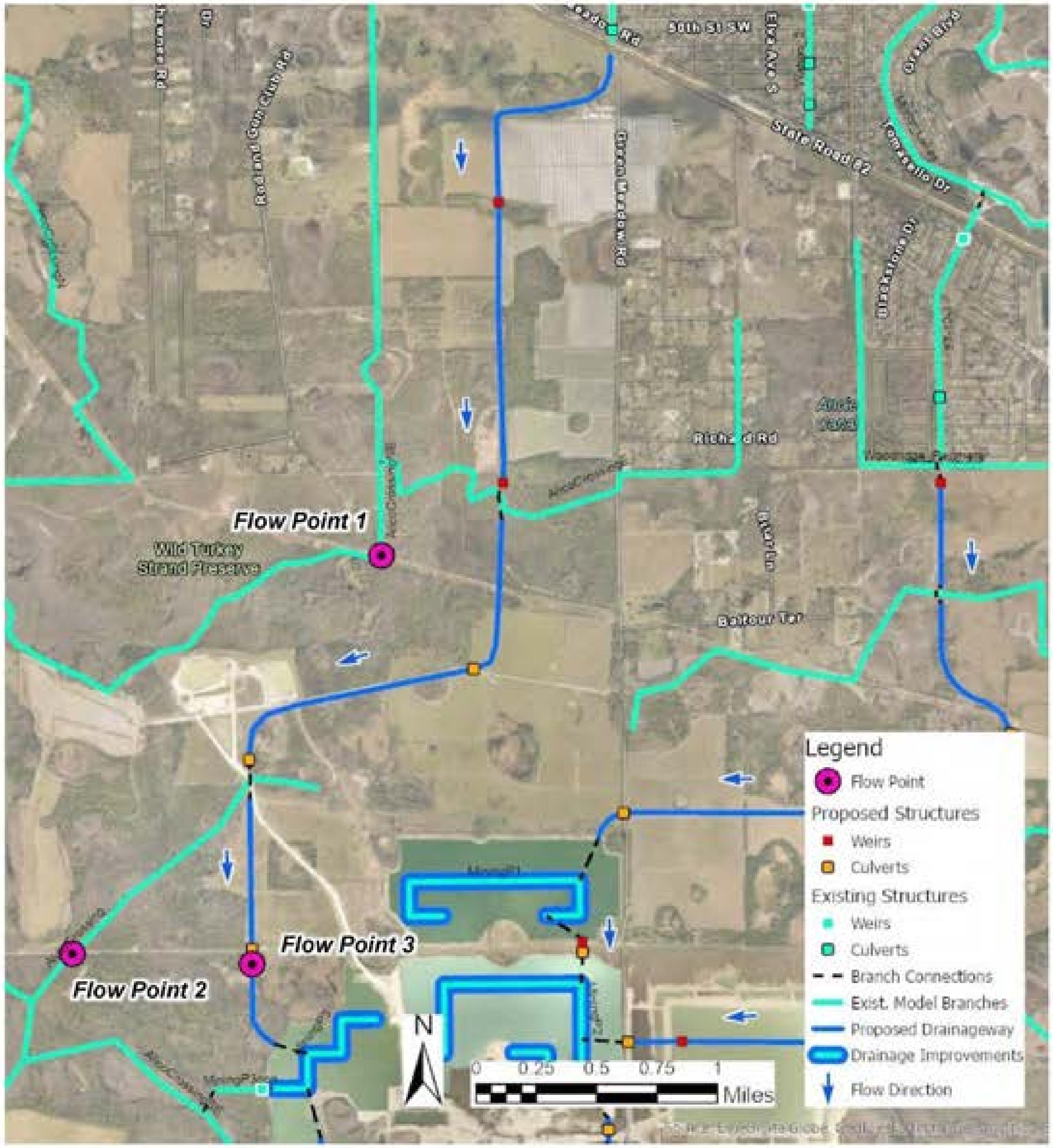
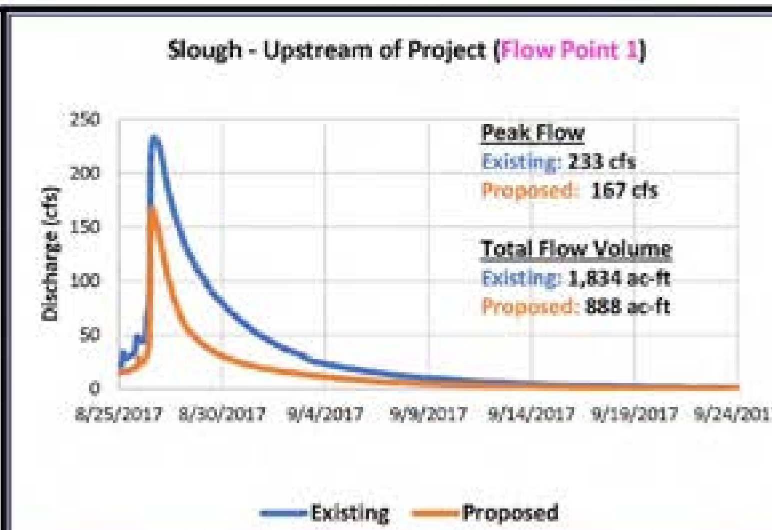


EXHIBIT 1.3.6 (g)





1.3.6 Alico Road Extension Drainageway

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.6 (h)

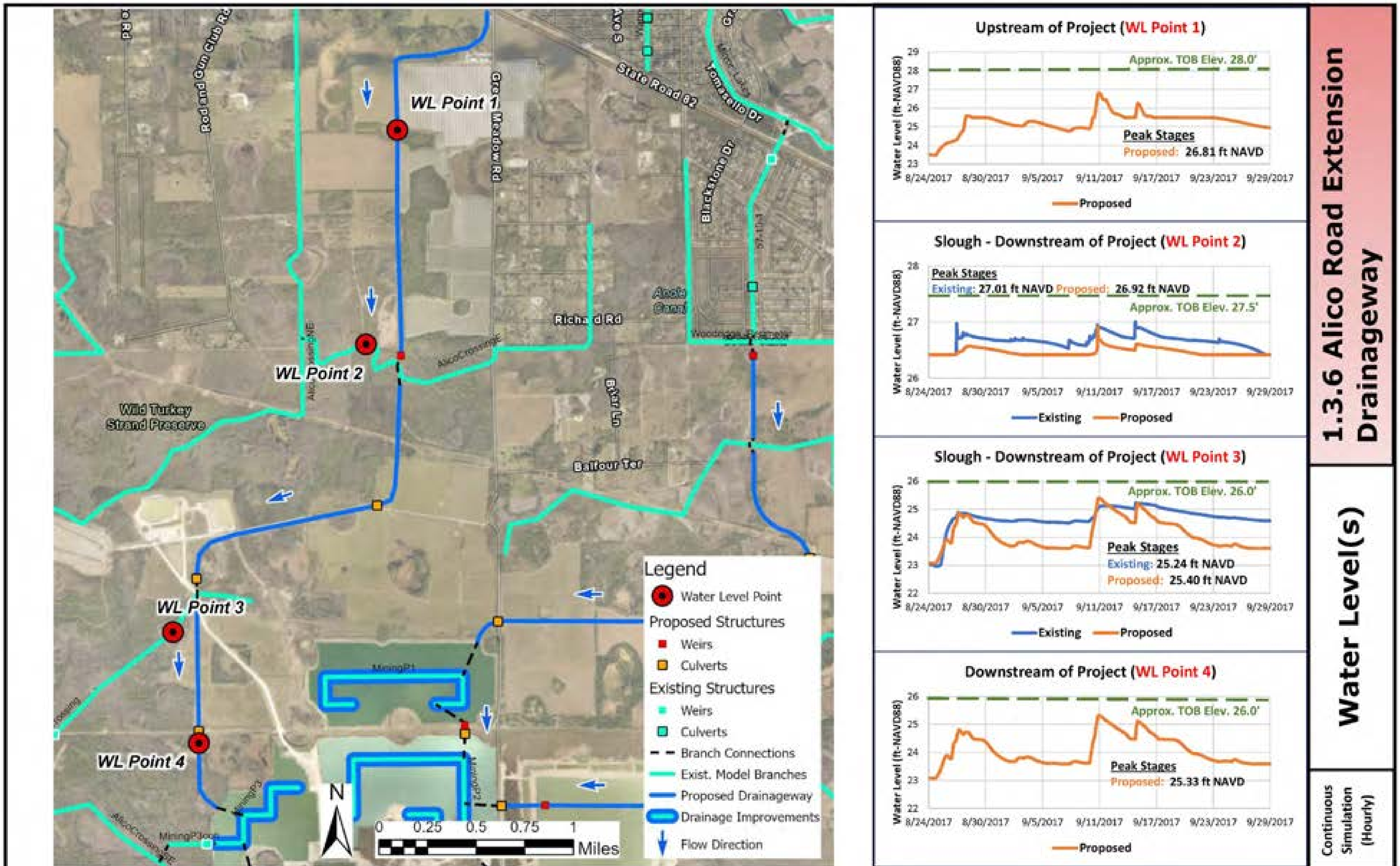
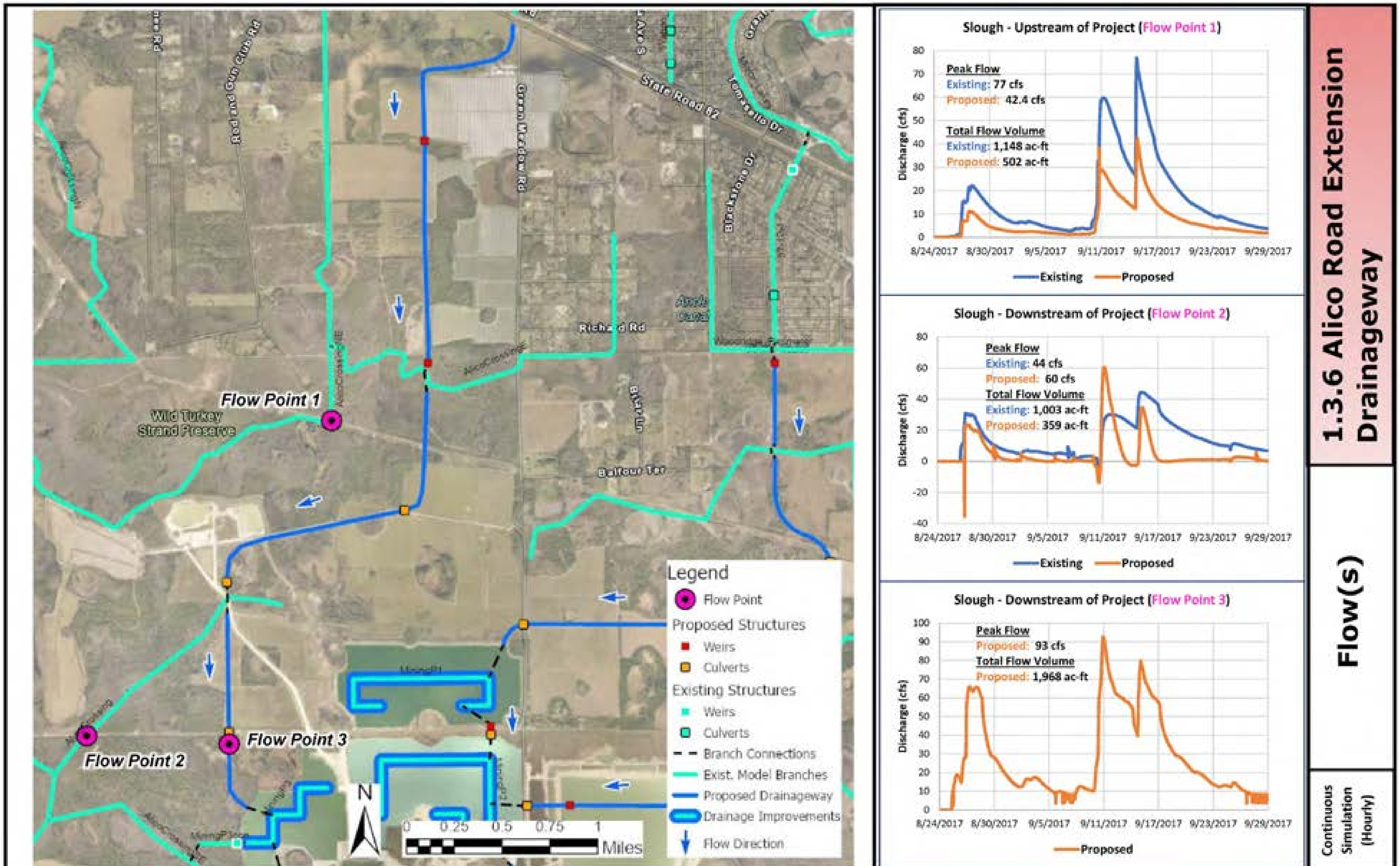


EXHIBIT 1.3.6 (i)



1.3.7 Blackstone Dr to Alico Mine Lakes Drainageway Concept Plan

Background

This concept project was proposed to transfer excess stormwater from the Lehigh Acres canal system to large preserve areas located south of State Road 82 as conditions allowed. This area contains cypress swamps, wetland areas, cattle ranching operations and future mine lake excavation and operations. This would be an alternate route for discharging Lehigh Acres stormwater south.

Location

This concept project is located in SE Lee County east of Interstate 75, and Southwest Florida International Airport, south of State Road 82 and north of the Flint Pen preserve as illustrated in **Figure 26**.

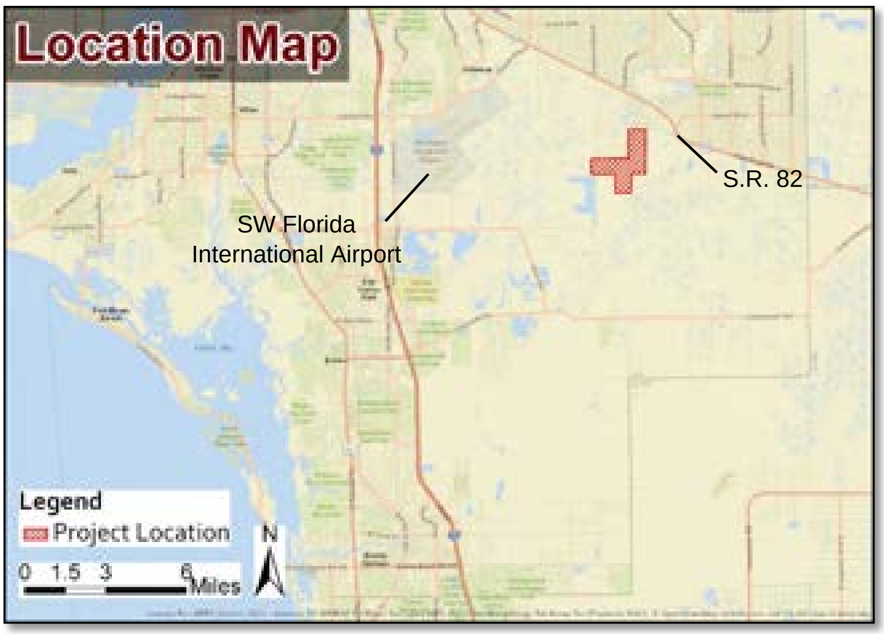


Figure 26 – Location Map, 1.3.7 Blackstone Dr. to Alico Mine Lakes Drainageway

Description

This proposed conceptual project conveys excess stormwater drainage flow from Blackstone Drive area in Lehigh Acres lying south of SR 82 to the existing Alico Mining Lakes and/or the Flint Pen Preserve. This project is part of a larger project that includes the Alico Mine Lakes East and west Projects. The project would also restore some of the historical drainage flow ways coming out of the Lehigh Acres area. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges illustrated in **Figure 27**.

Figure 27 - Concept Plan, 1.3.7 Blackstone Dr. to Alico Mine Lakes Drainagway

Purpose

This proposed project improves conveyance of excess stormwater to the south to reduce flooding and improving hydrologic restoration of the Flint Pen area.

Evaluation

Viability

Viability of this route is a part of a much larger project in an effort to move water south. Land acquisition and governmental approvals would be necessary, and the project is located along the eastern side of the airport mitigation lands.

Community Considerations

This drainageway would utilize Lee County owned and Florida Rock Mine properties. This area has very few residents.

Environmental & Permittability Considerations

The work is near environmentally sensitive lands and consideration would need to be taken for wetland avoidance and drawdown of the water table.

Land Availability

The need for land acquisition and governmental approval as well as coordination with the Lehigh Acres Municipal Improvement District for the connection at the Gecko Canal is necessary to construct the Blackstone Dr to Alico Mine Lakes Drainageway conveyance, storage, and water quality features.

Opinion of Probable Cost

The cost opinion shown in **Table 8** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 8 - Opinion of Probable Cost breakdown, 1.3.7 Blackstone Dr. to Alico Mine Lakes Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,225,000	$ 1,225,000
Clearing & Grubbing	55	AC	$ 14,000	$ 770,000
Earthwork	350,000	CY	$ 6	$ 2,100,000
Construction/ Maintenance Access	25,000	SY	$ 20	$ 500,000
Weir Structure 3.7A (Major)	90	LF	$ 10,000	$ 900,000
Weir Structure 3.7B (Major)	90	LF	$ 10,000	$ 900,000
Box Culvert 3.7-1	230	CY	$ 1,200	$ 276,000
Box Culvert 3.7-2	140	CY	$ 1,200	$ 168,000
Box Culvert 3.7-3	230	CY	$ 1,200	$ 276,000
Electric Supply	1	LS	$ 60,000	$ 60,000
Permanent Erosion Control	6,000	SF	$ 25	$ 150,000
Grassing	87,500	SY	$ 2	$ 175,000
Construction Cost Sub-Total:				**$ 7,500,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 2,250,000
Land Acquisition				$ 2,000,000
Project Administration/ CEI (10%):				$ 750,000
Project Unknowns				$ 1,200,000
Conceptual Project Cost:				**$ 13,700,000**
Contingency (30%)				$ 4,000,000
Conceptual Project Cost (with Contingency):				**$ 17,700,000**

Opportunities for Multiple Benefits & Uses

As the mine lake operations are proceeding, there is an opportunity to coordinate some of this work with the mine owners to see if this project could be incorporated into their mining projects.

Other Considerations

There is an opportunity with the available lands to incorporate the filter marsh into the project. The project could then treat the water coming from Lehigh and improve the water quality for the area. A summary of this concept project is shown below in **Exhibit 1.3.7** herein.

Findings & Recommendations

Regional Modeling Findings

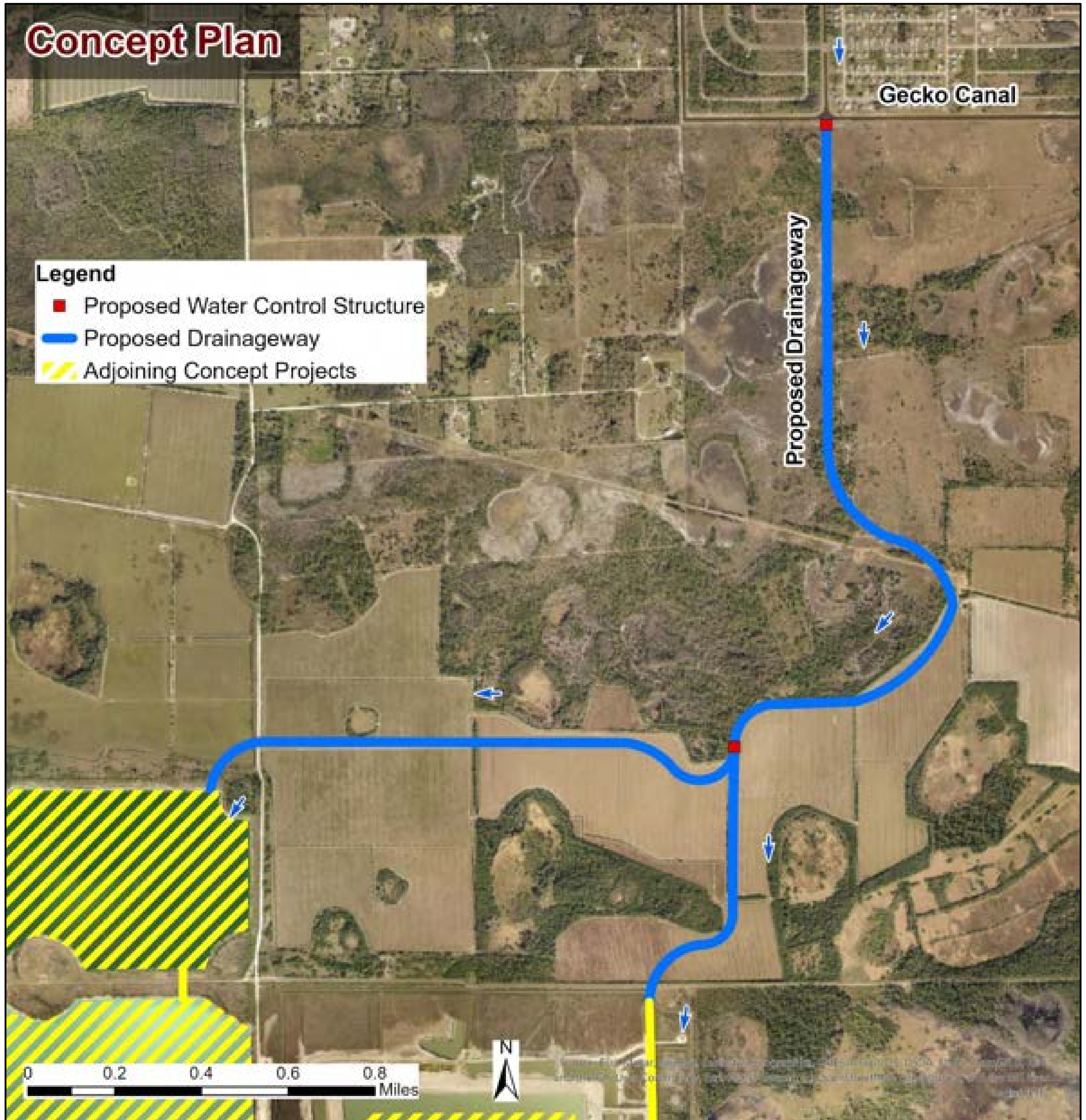
This project concept allows for regional system functionality improvements though conveyance of excess stormwater flows within Lehigh Acres, when practical, from the Blackstone Drive area near SR 82 southerly to convene with the eastern Alico Mine Lakes. The connection would be gate-controlled which could be opened when conditions warranted. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.7 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.7 (b) EXHIBIT 1.3.7 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.7 (d) EXHIBIT 1.3.7 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.7 (f) EXHIBIT 1.3.7 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.7 (h) EXHIBIT 1.3.7 (i)

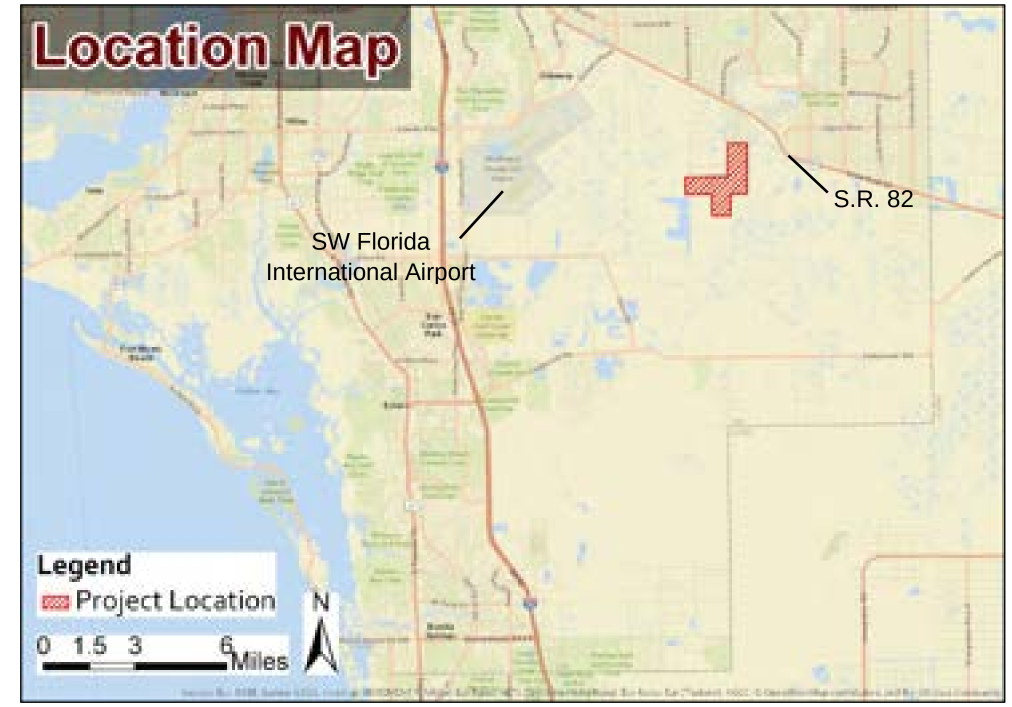
Improvements were shown with water level reductions and an increased southerly flow at the mine lakes from the existing to the proposed condition. The results did not show an ability to move water south from Lehigh Acres.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets outcomes of conveying excess stormwater flows from the area south of Lehigh Acres to the Alico Mine Lakes. Since modeling did not show significant flow out of Lehigh Acres, this connection would serve only as an alternate route as conditions allow. The improvements warrant further design-level project implementation as the area develops.



Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from Blackstone Drive area in Lehigh Acres lying south of SR 82 to the existing Alico Mining Lakes and/or the Flint Pen Preserve. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to the south to reduce flooding and improving hydrologic restoration of the Flint Pen area.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Blackstone Dr to Alico Mine Lakes Drainageway

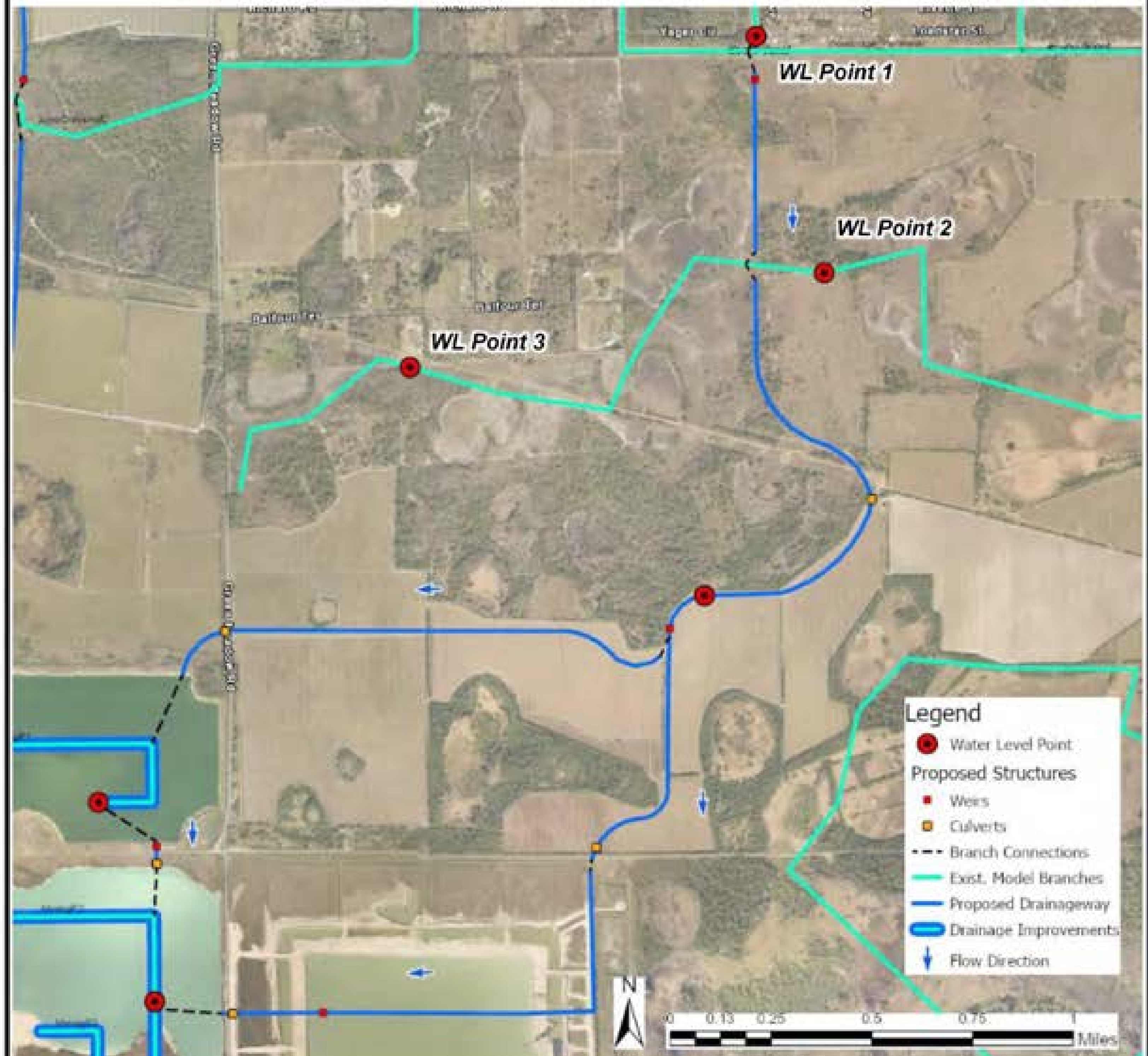
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.7

EXHIBIT 1.3.7 (a)

EXHIBIT 1.3.7 (b): 1 of 2

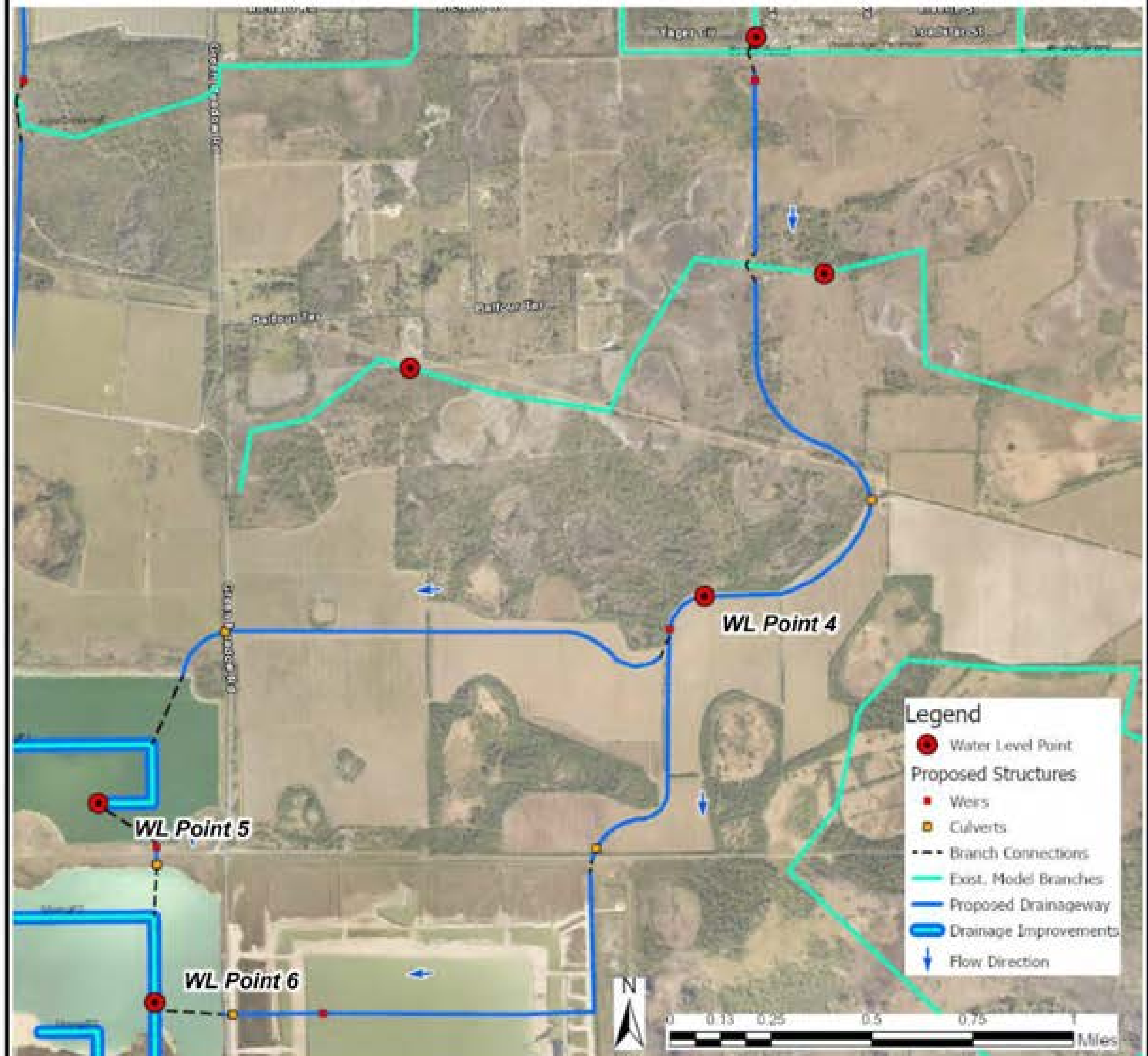


1.3.7 Blackstone Dr to Alico Mine Lakes Drain.

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.7 (b): 2 of 2

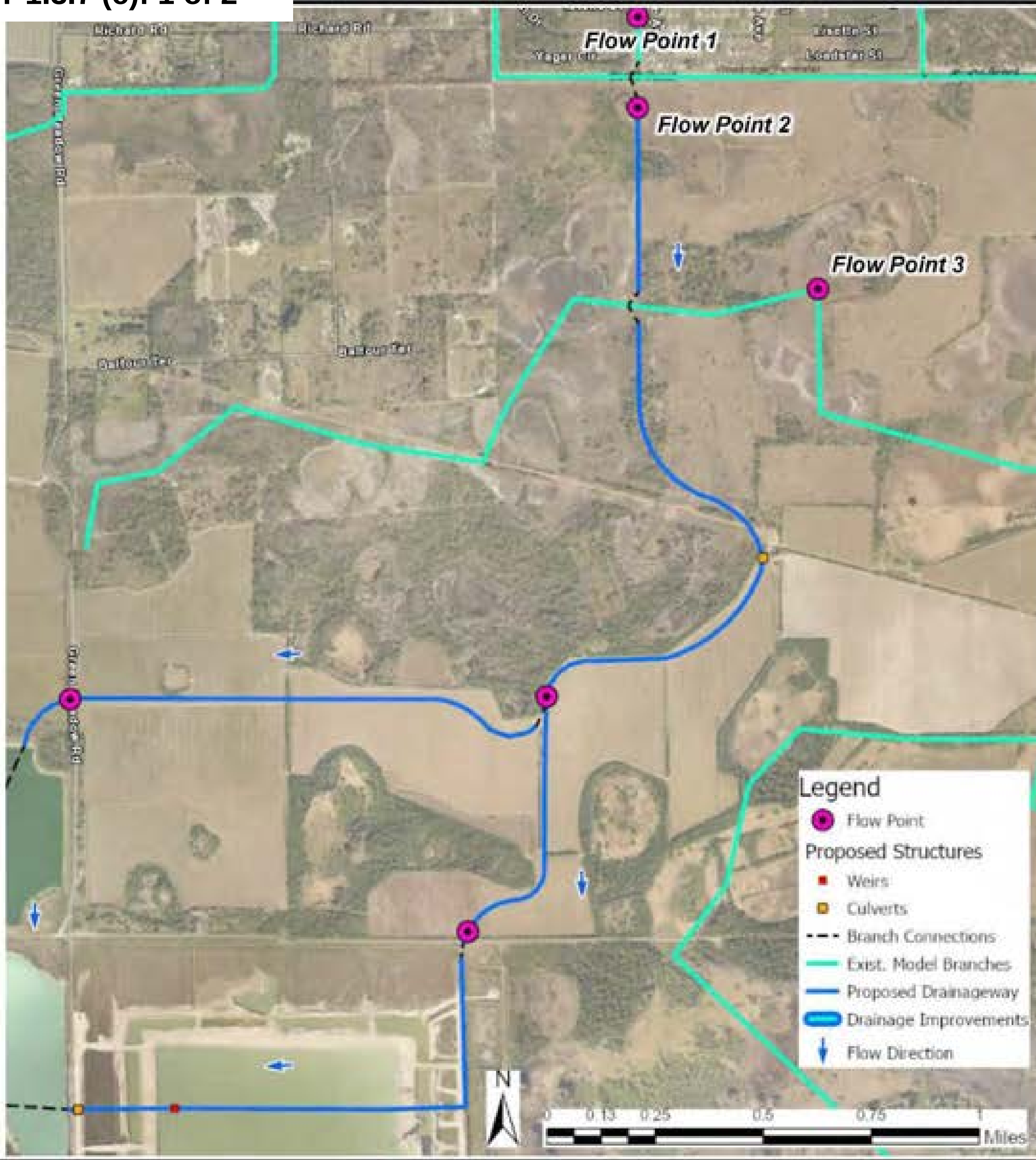


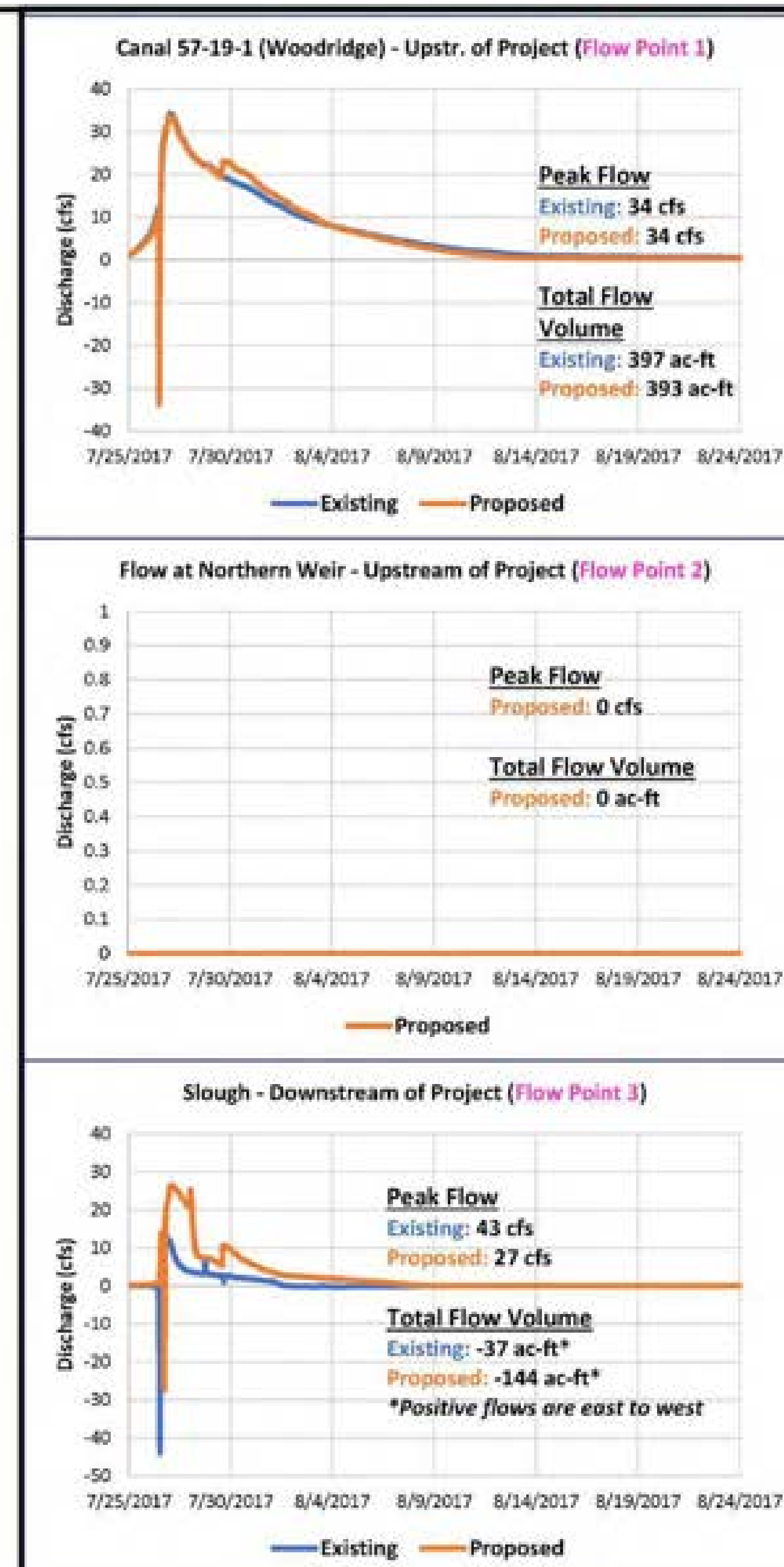
1.3.7 Blackstone Dr to Alico Mine Lake Drain.

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.7 (c): 1 of 2



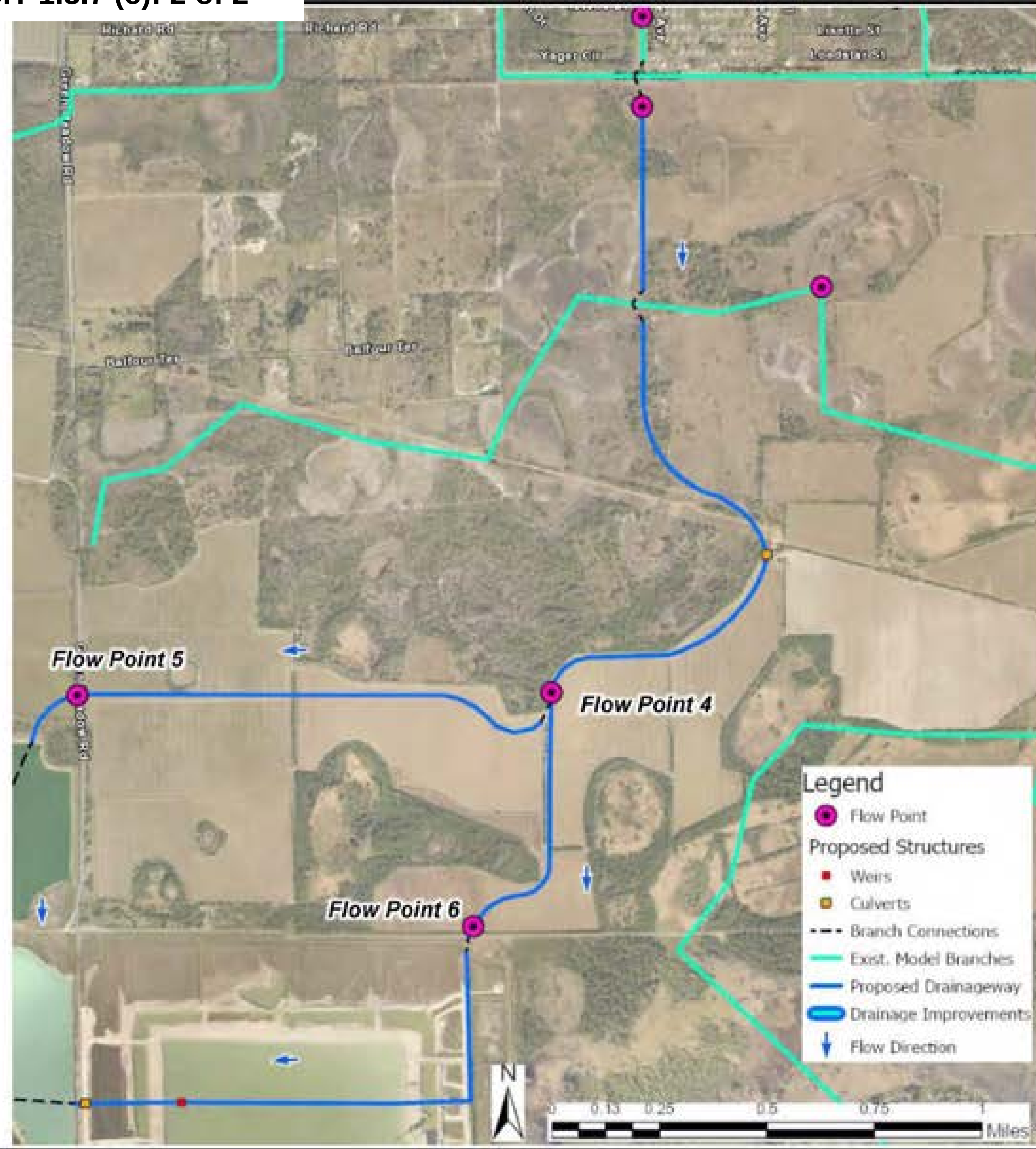


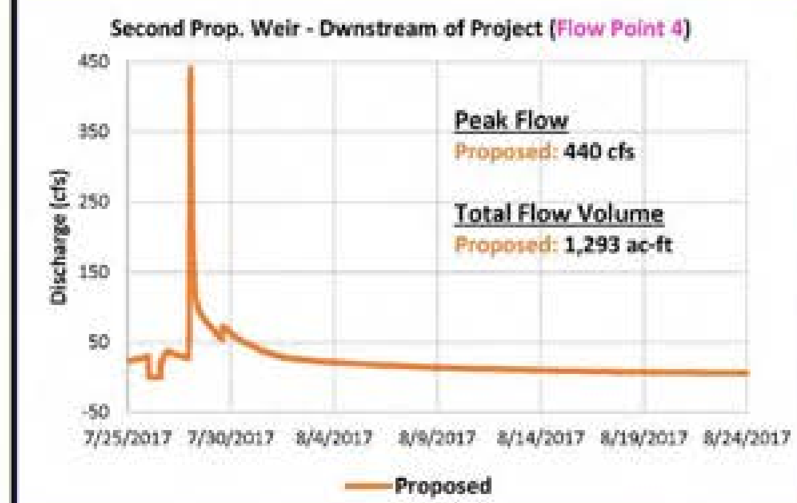
1.3.7 Blackstone Dr to Alico Mine Lake Drain.

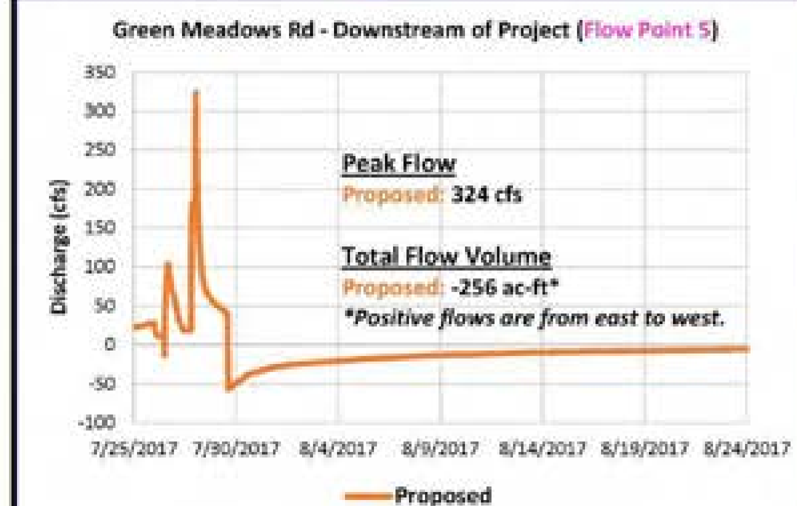
Flow(s)

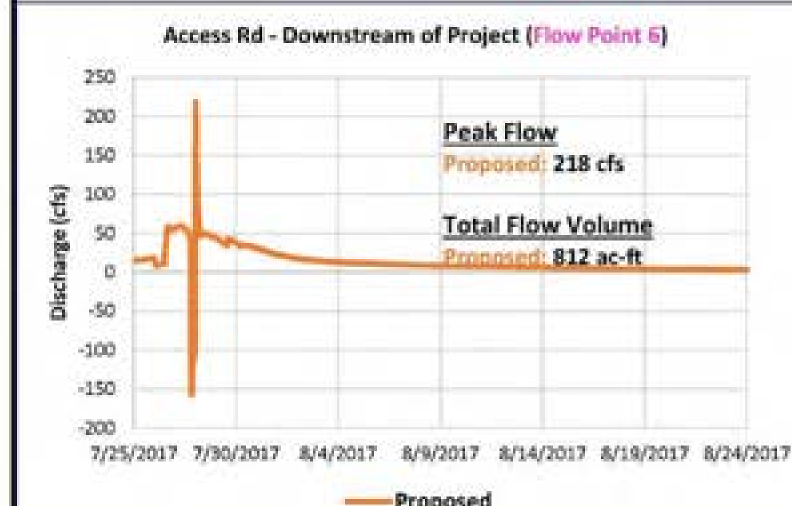
25-yr 3-day (Jul Start)

EXHIBIT 1.3.7 (c): 2 of 2







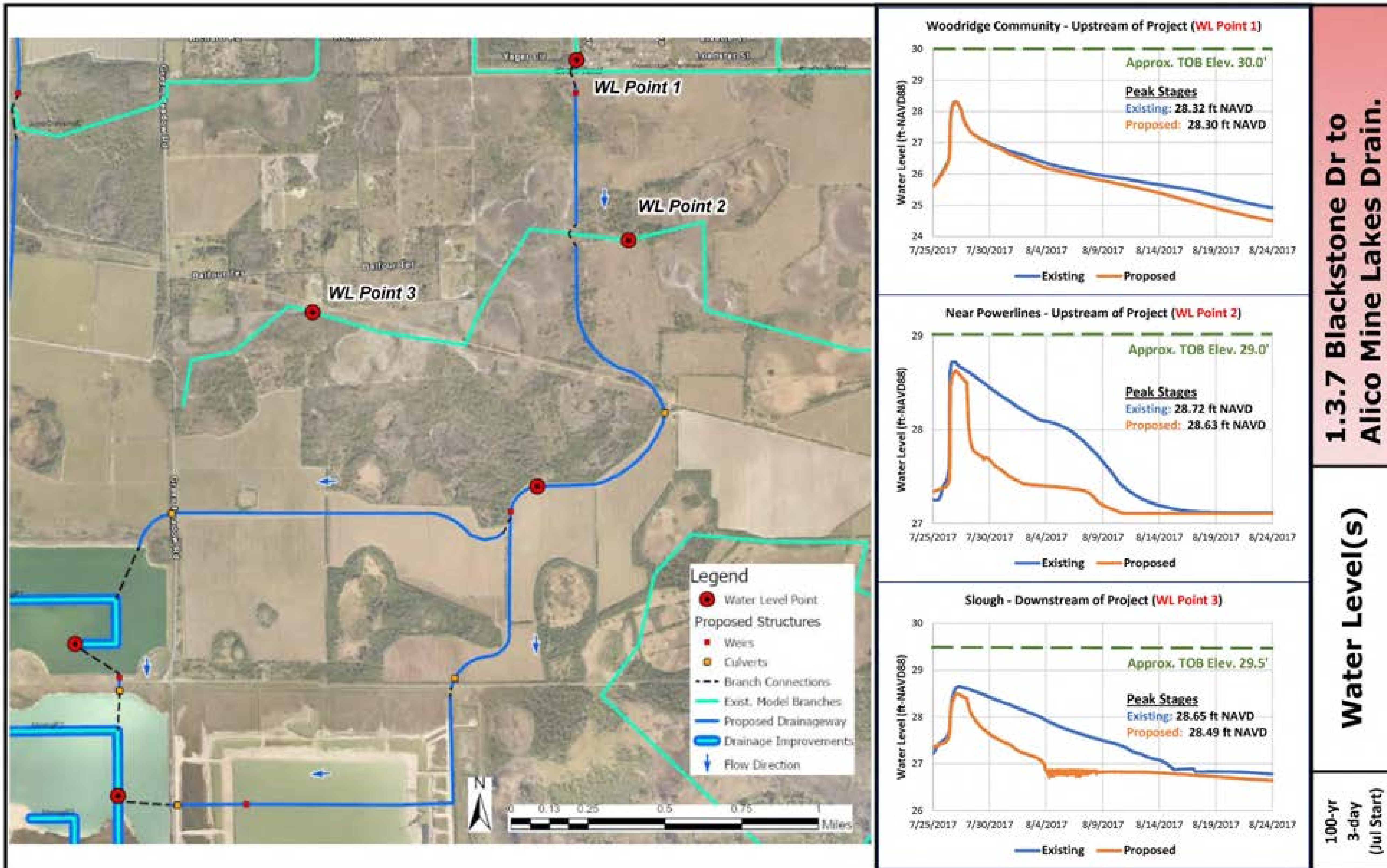


1.3.7 Blackstone Dr to Alico Mine Lake Drain.

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.7 (d): 1 of 2



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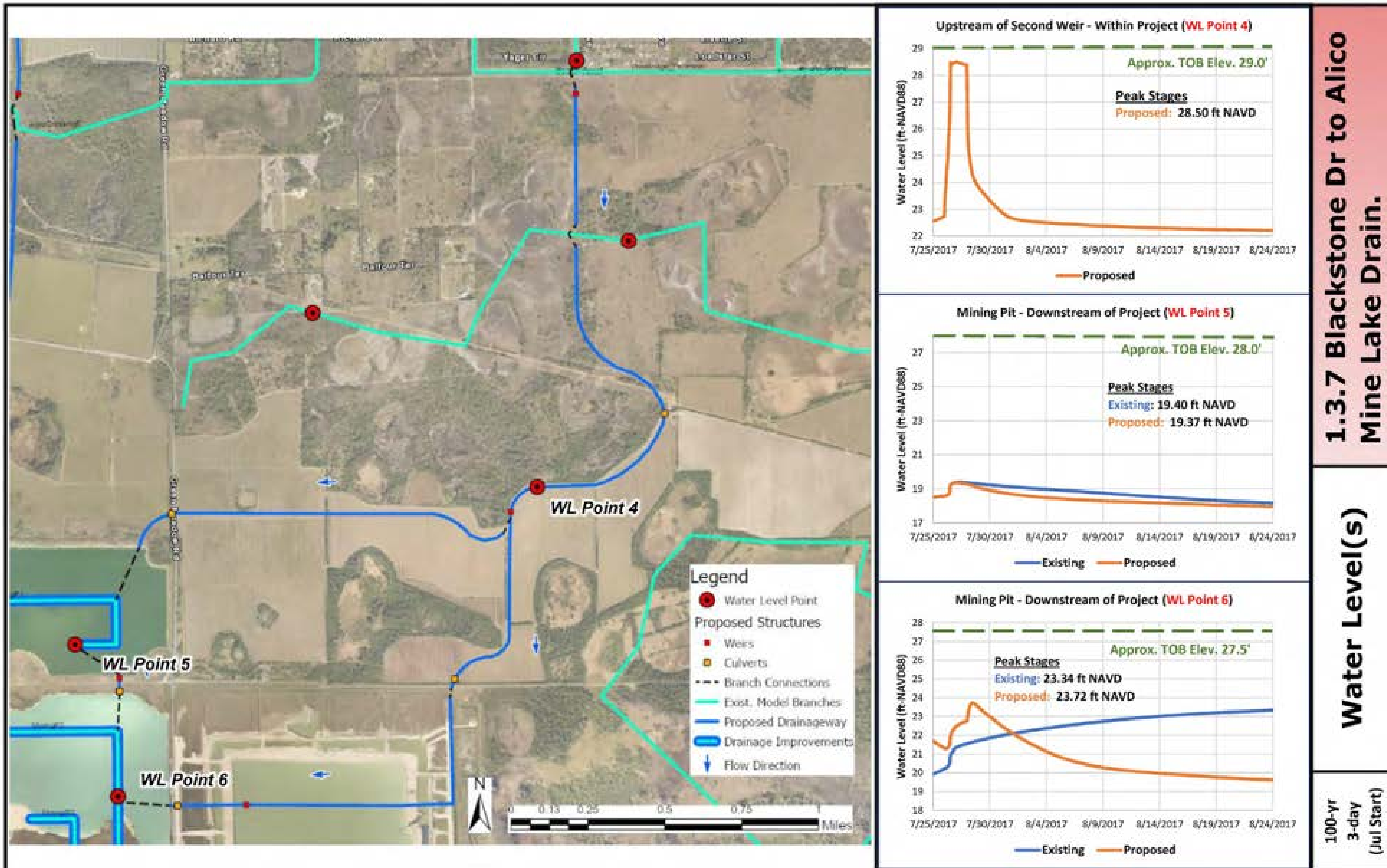

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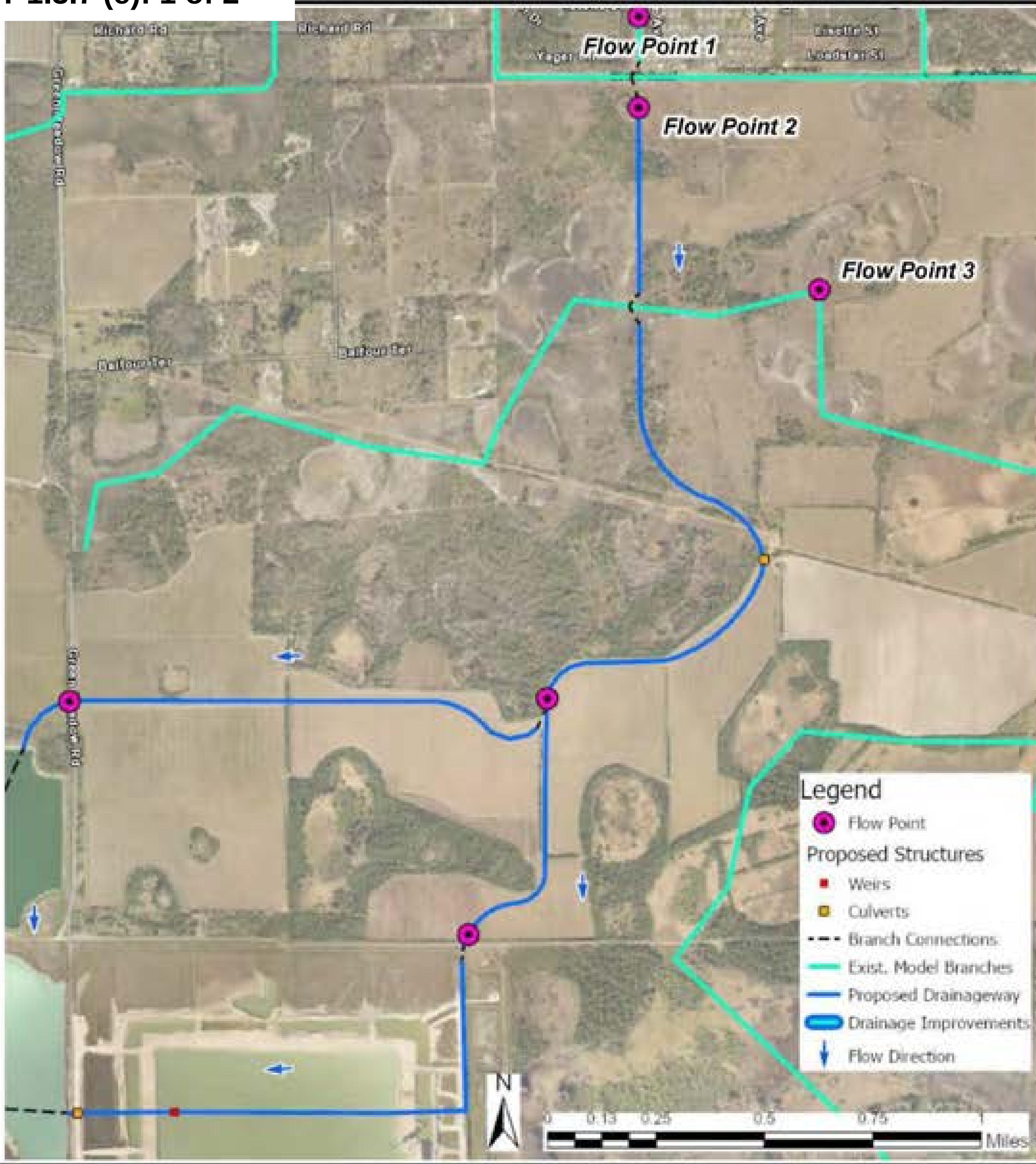
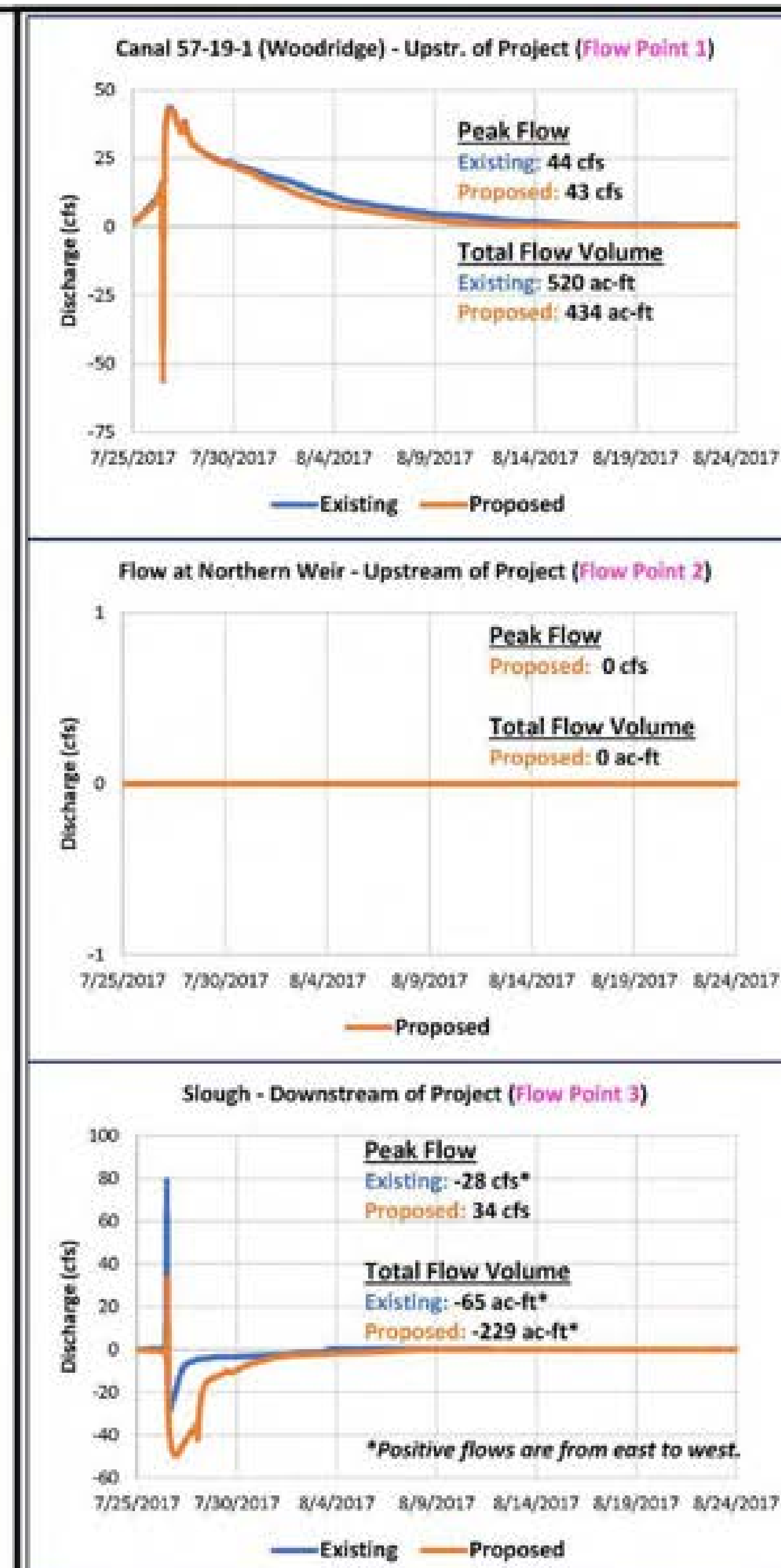


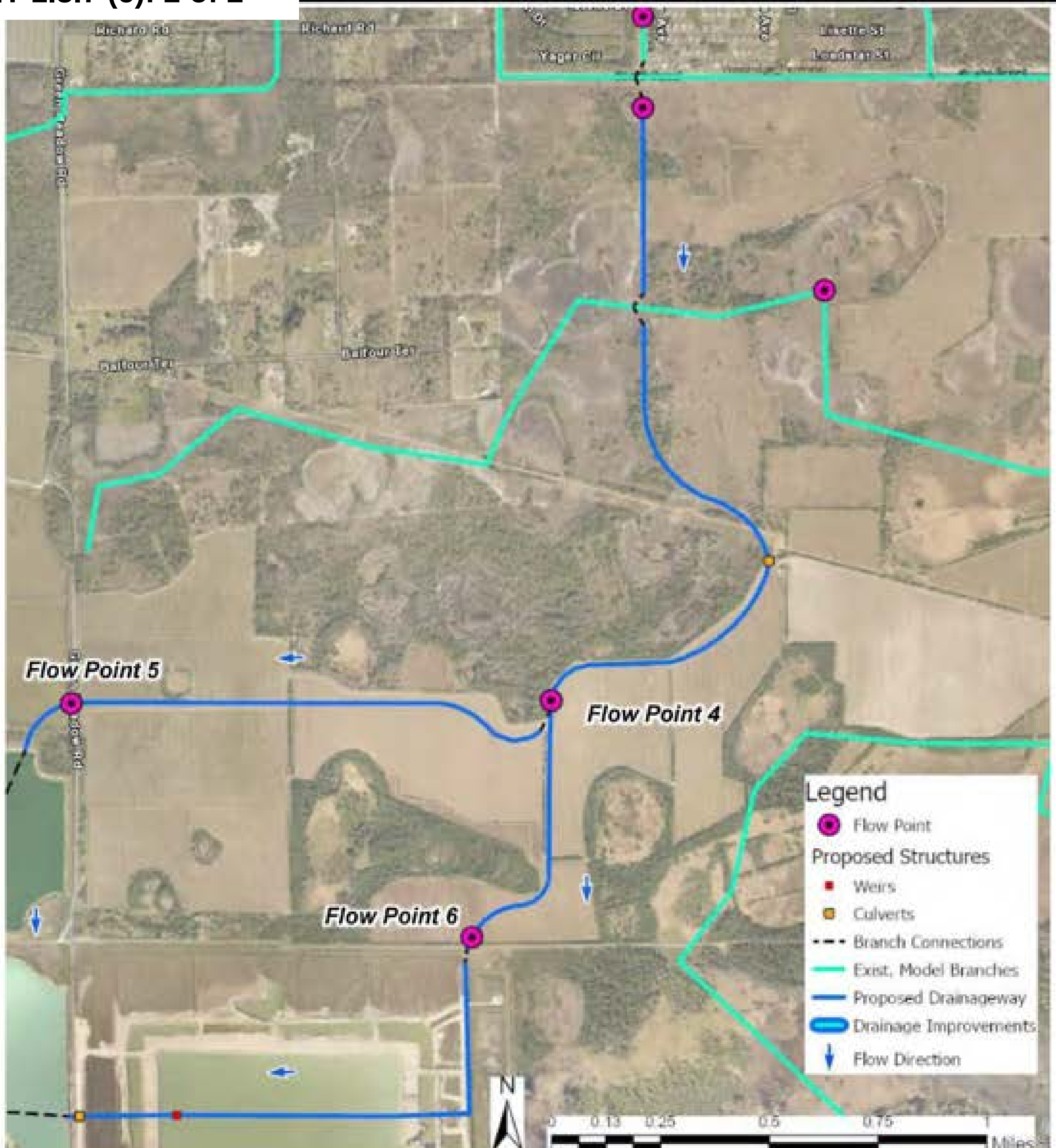


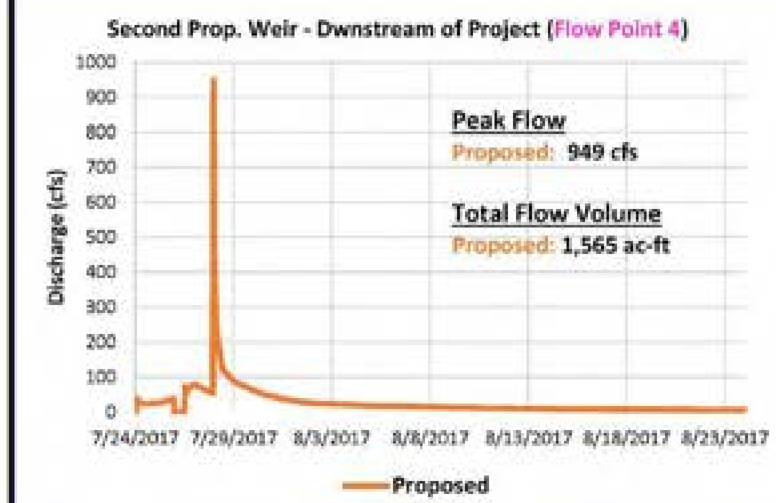
1.3.7 Blackstone Dr to Alico Mine Lake Drain.

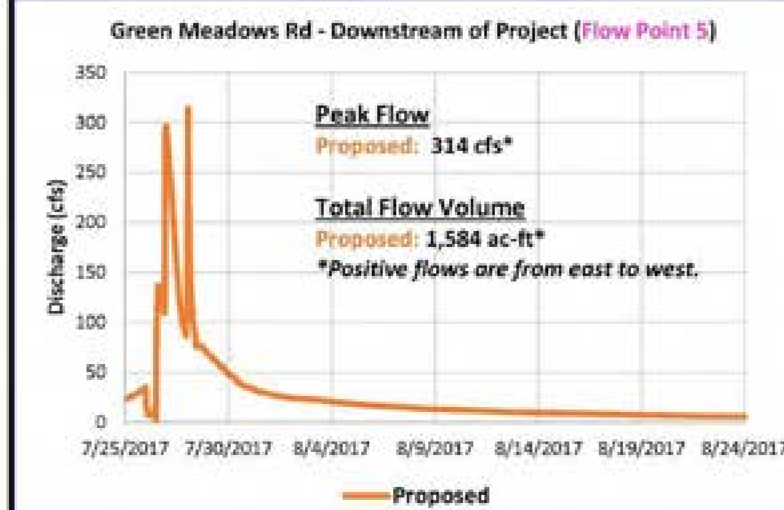
Flow(s)

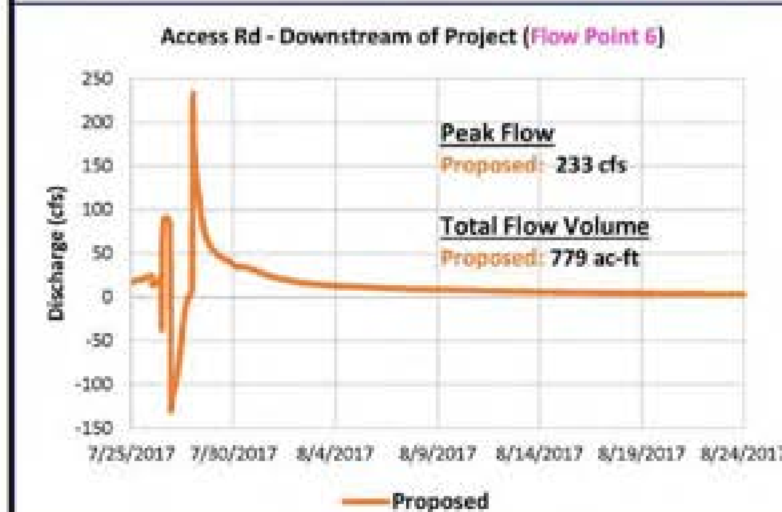
100-yr
3-day
(Jul Start)

EXHIBIT 1.3.7 (e): 2 of 2







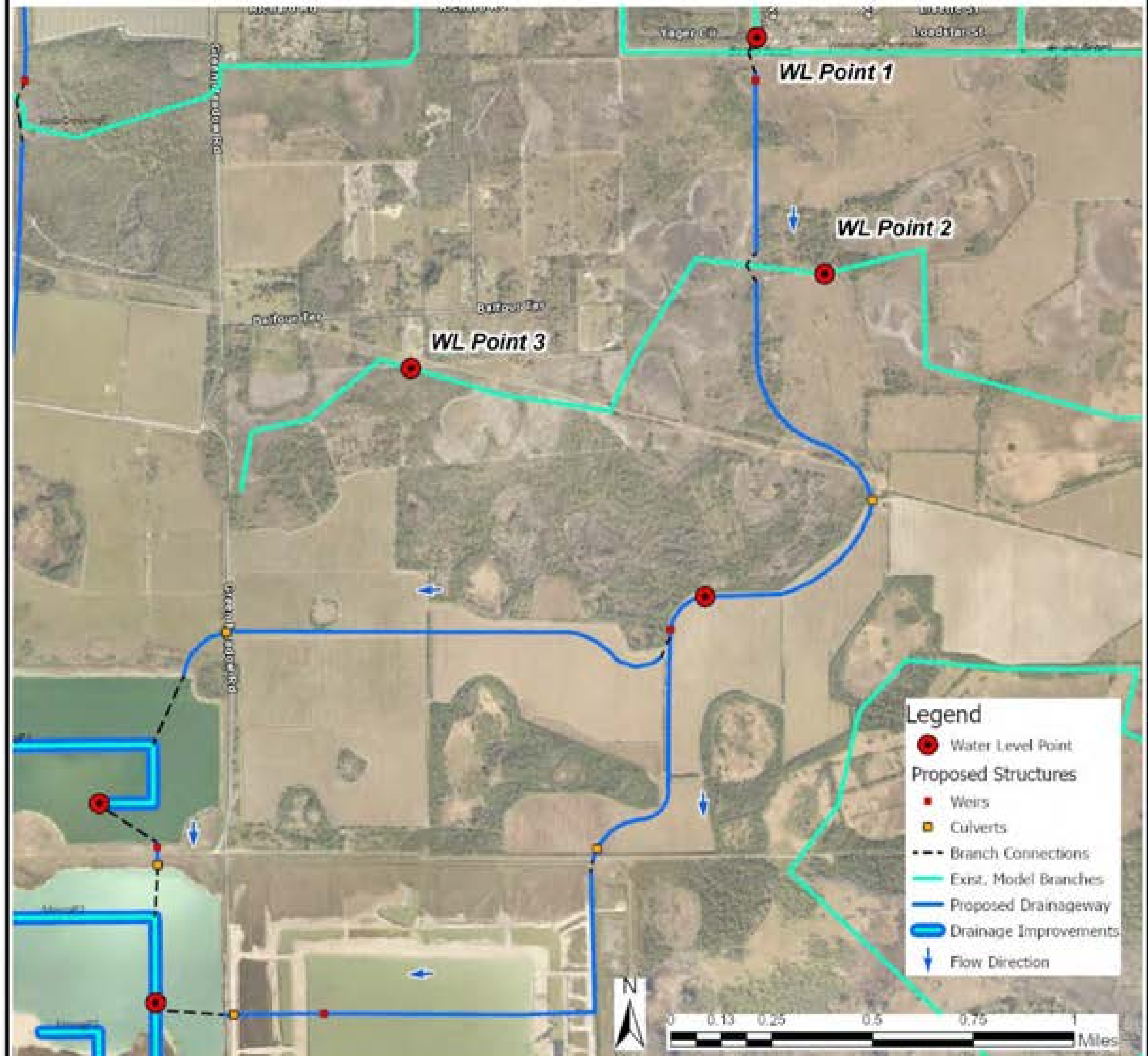


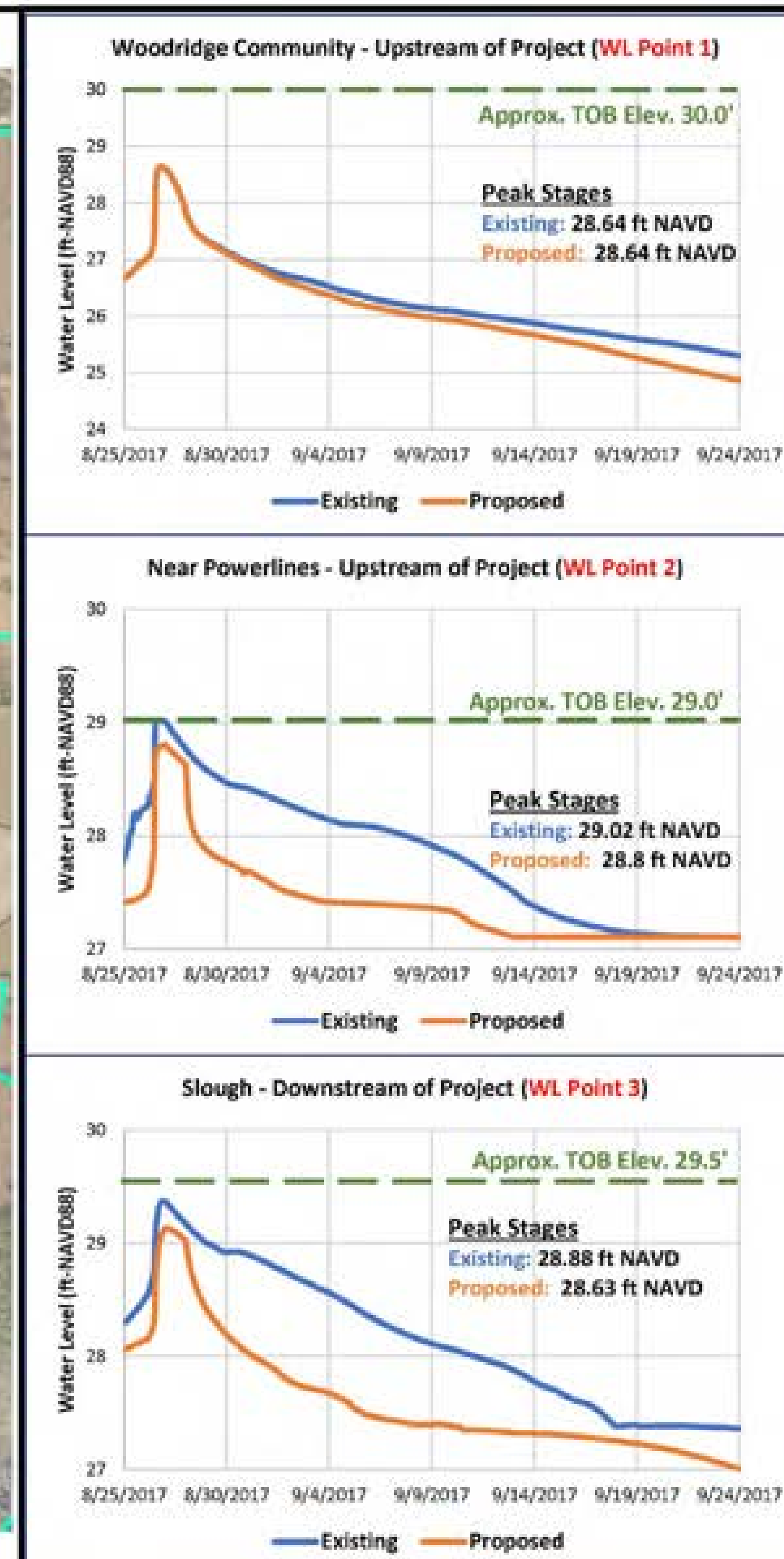
1.3.7 Blackstone Dr to Alico Mine Lake Drain.

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.7 (f): 1 of 2





1.3.7 Blackstone Dr to Alico Mine Lakes Drain.

Water Level(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.3.7 (f): 2 of 2

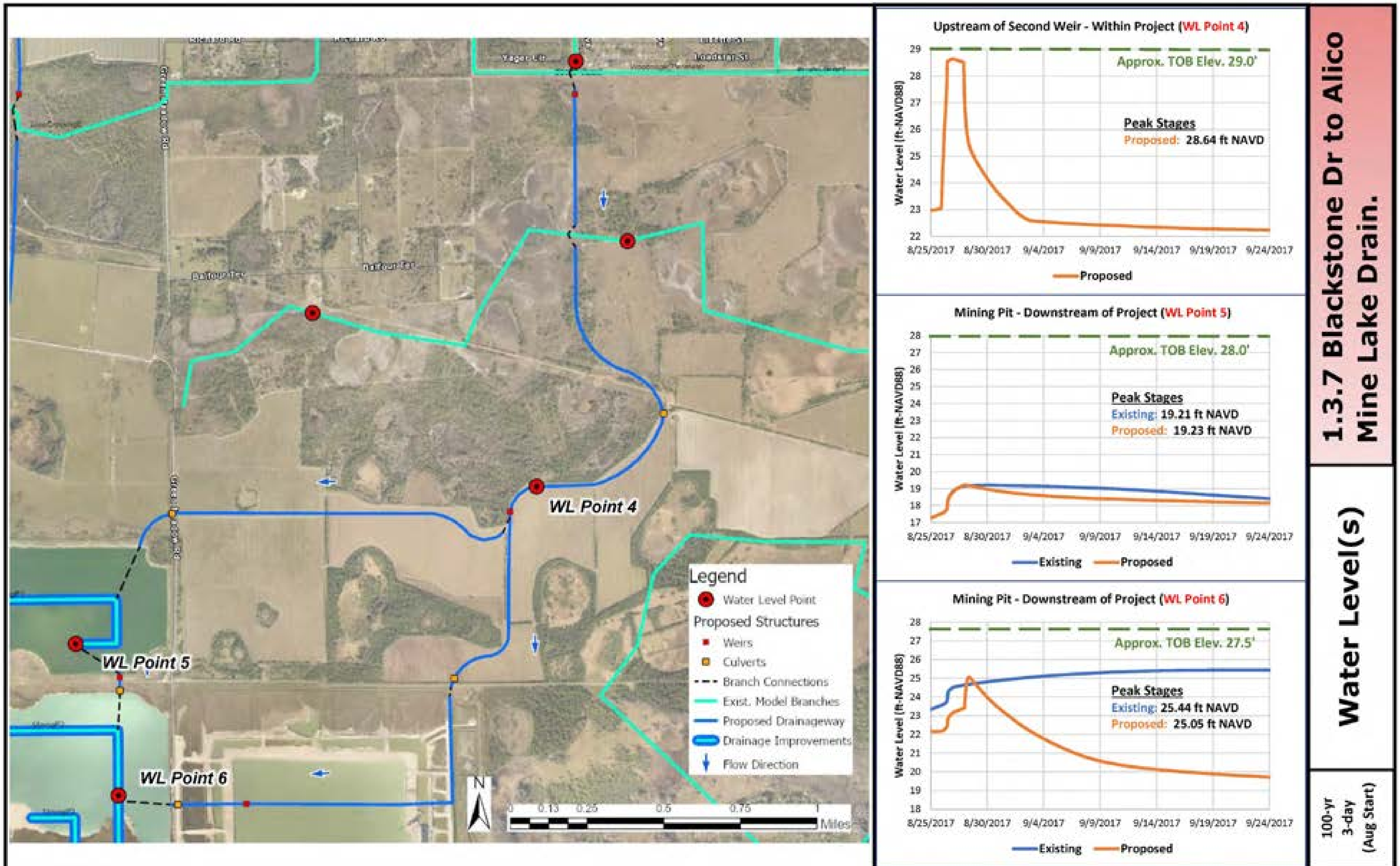
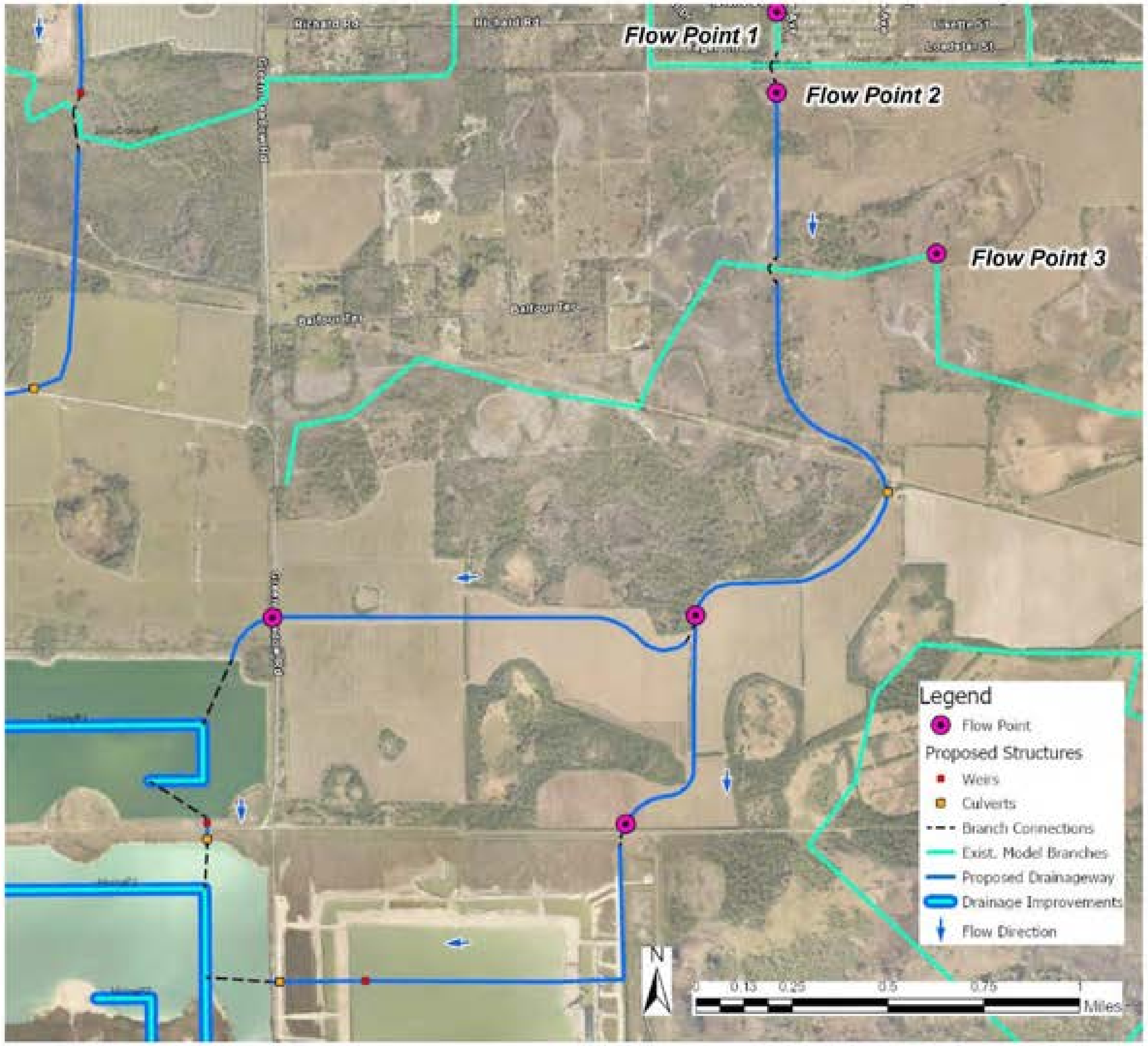
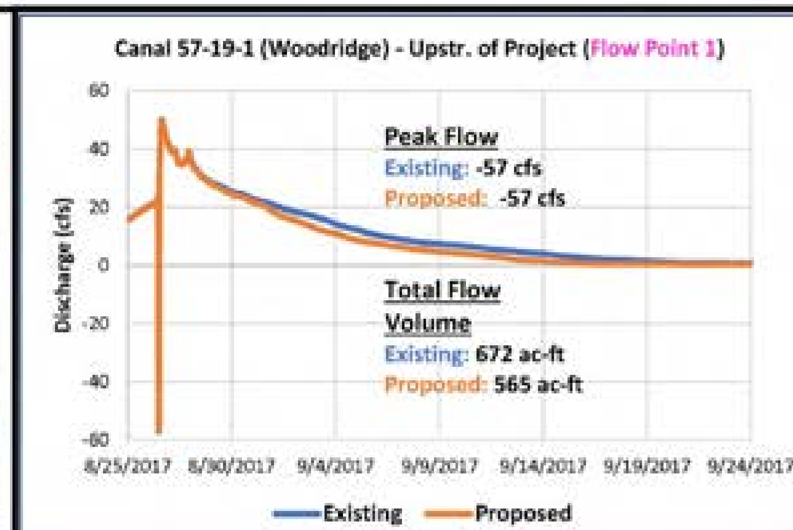
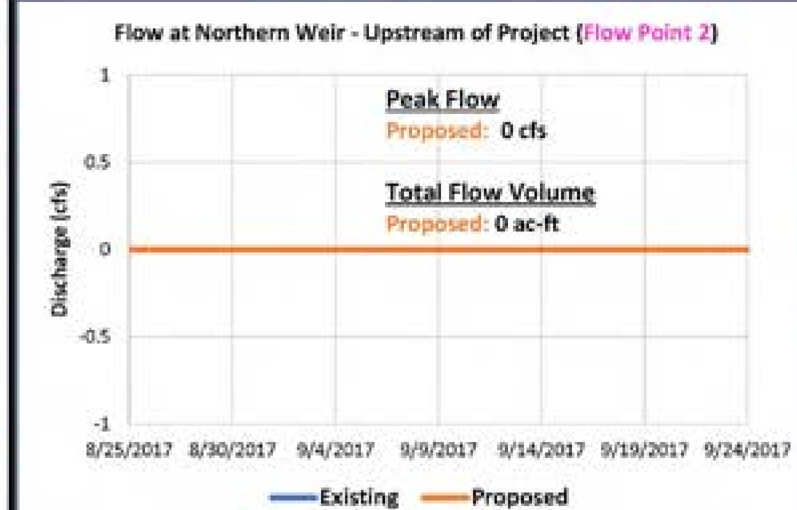
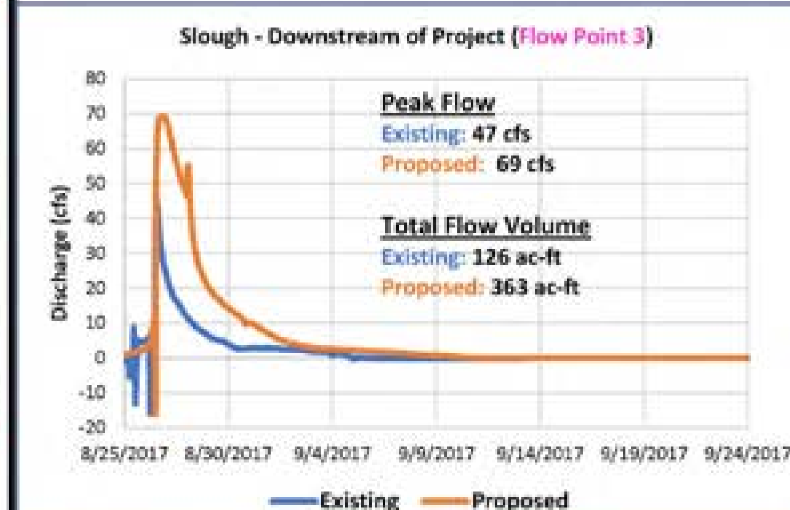


EXHIBIT 1.3.7 (g): 1 of 2







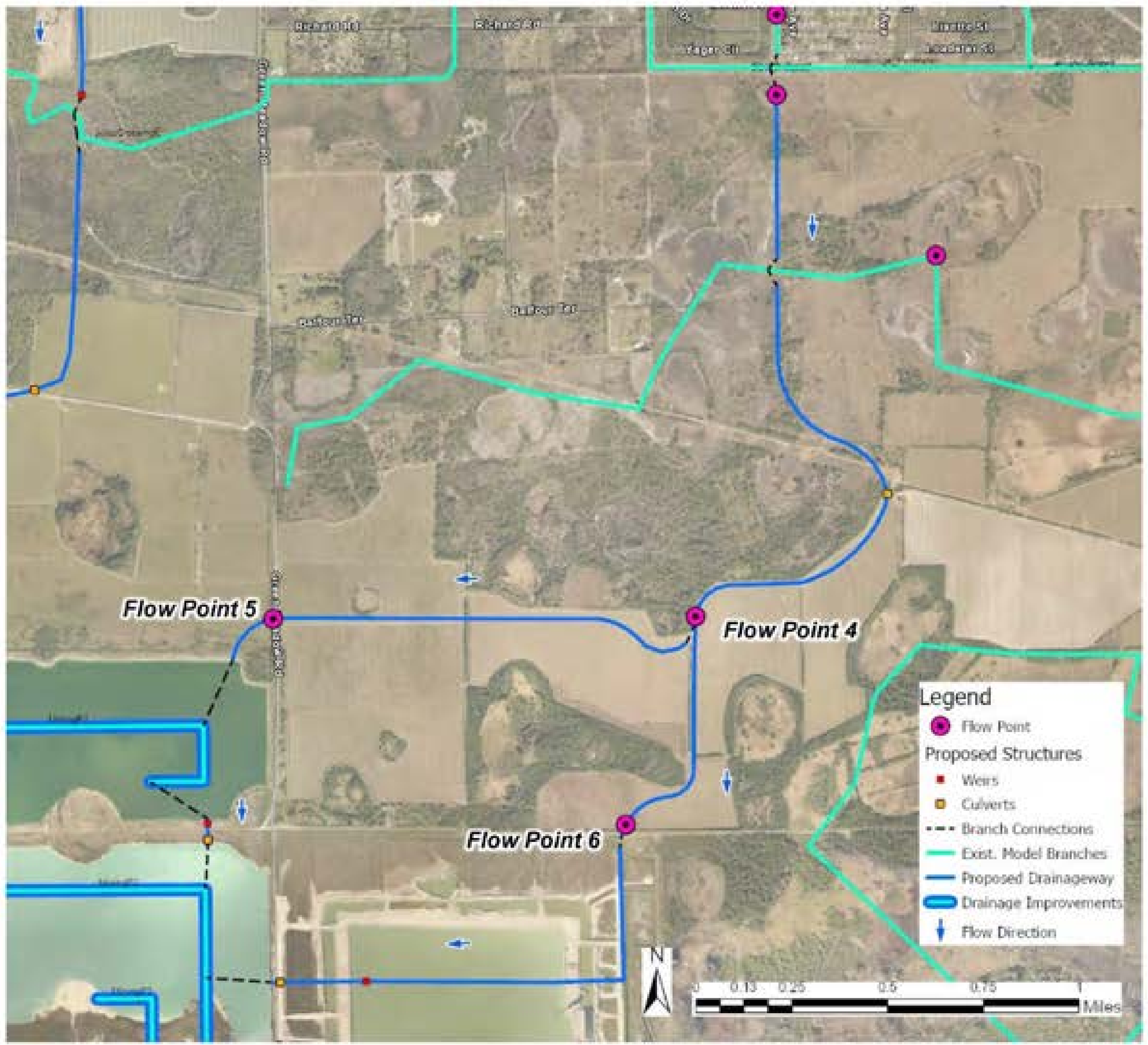


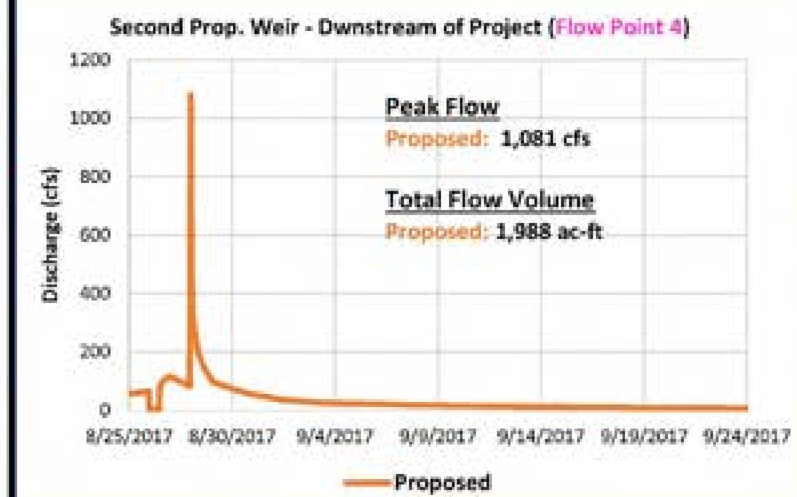
1.3.7 Blackstone Dr to Alico Mine Lake Drain.

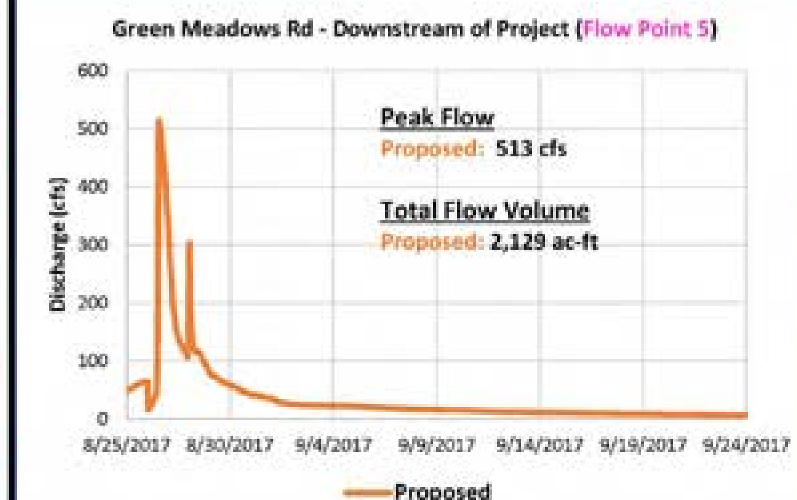
Flow(s)

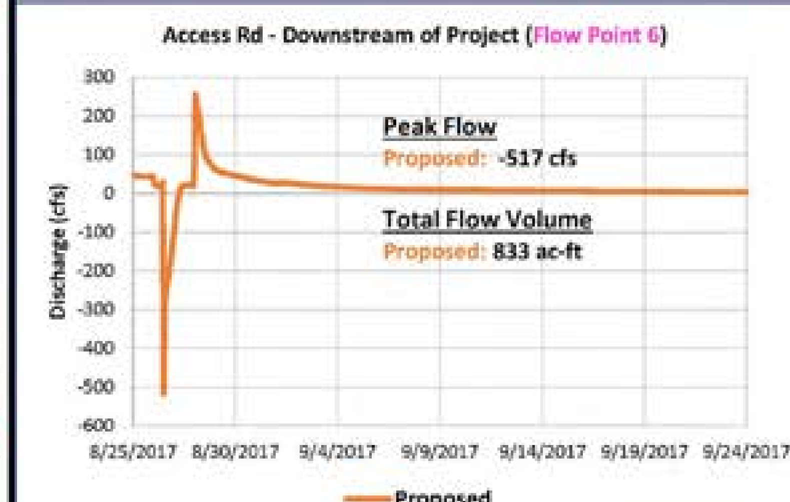
100-yr 3-day (Aug Start)

EXHIBIT 1.3.7 (g): 2 of 2







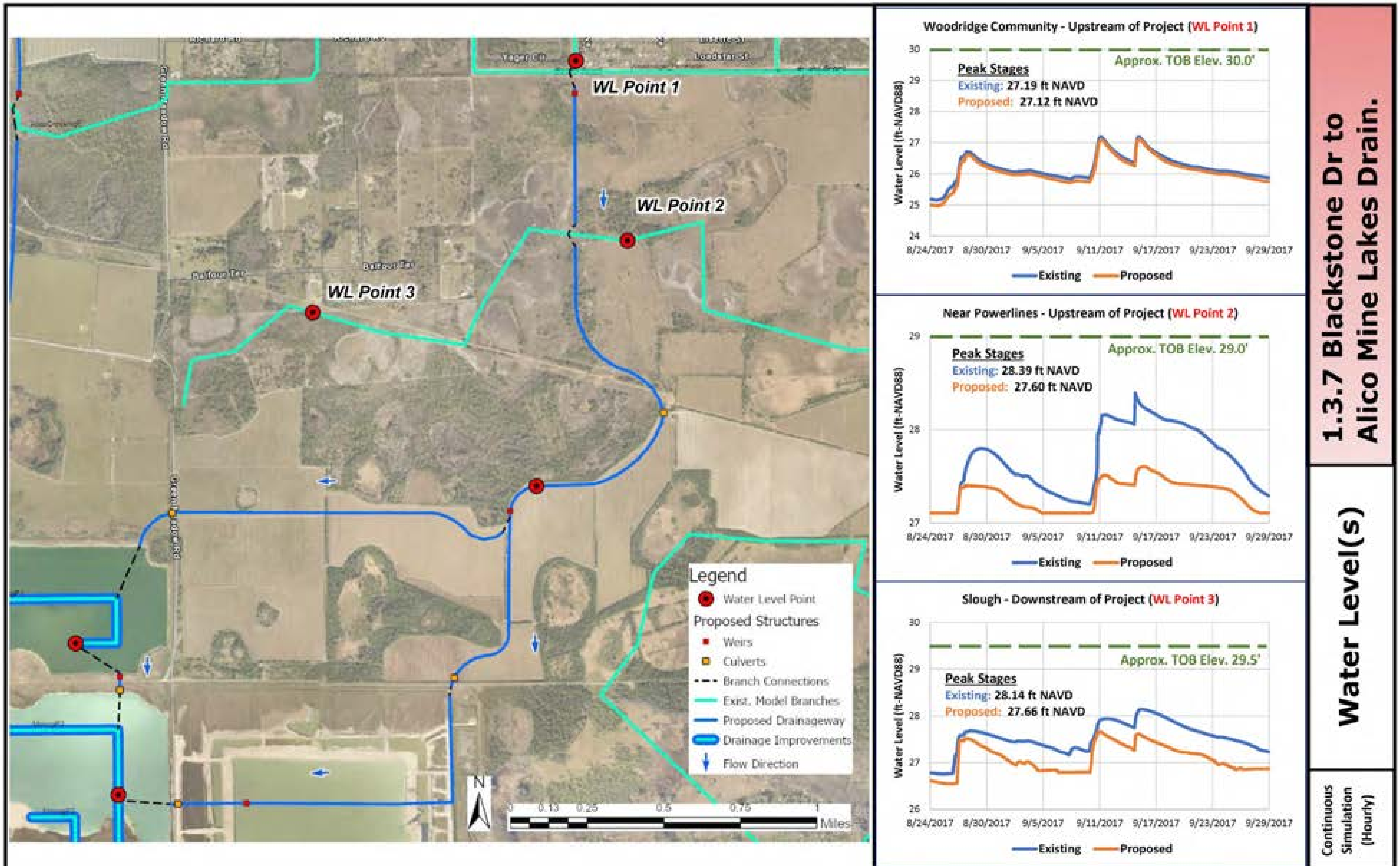


1.3.7 Blackstone Dr to Alico Mine Lake Drain.

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.7 (h): 1 of 2



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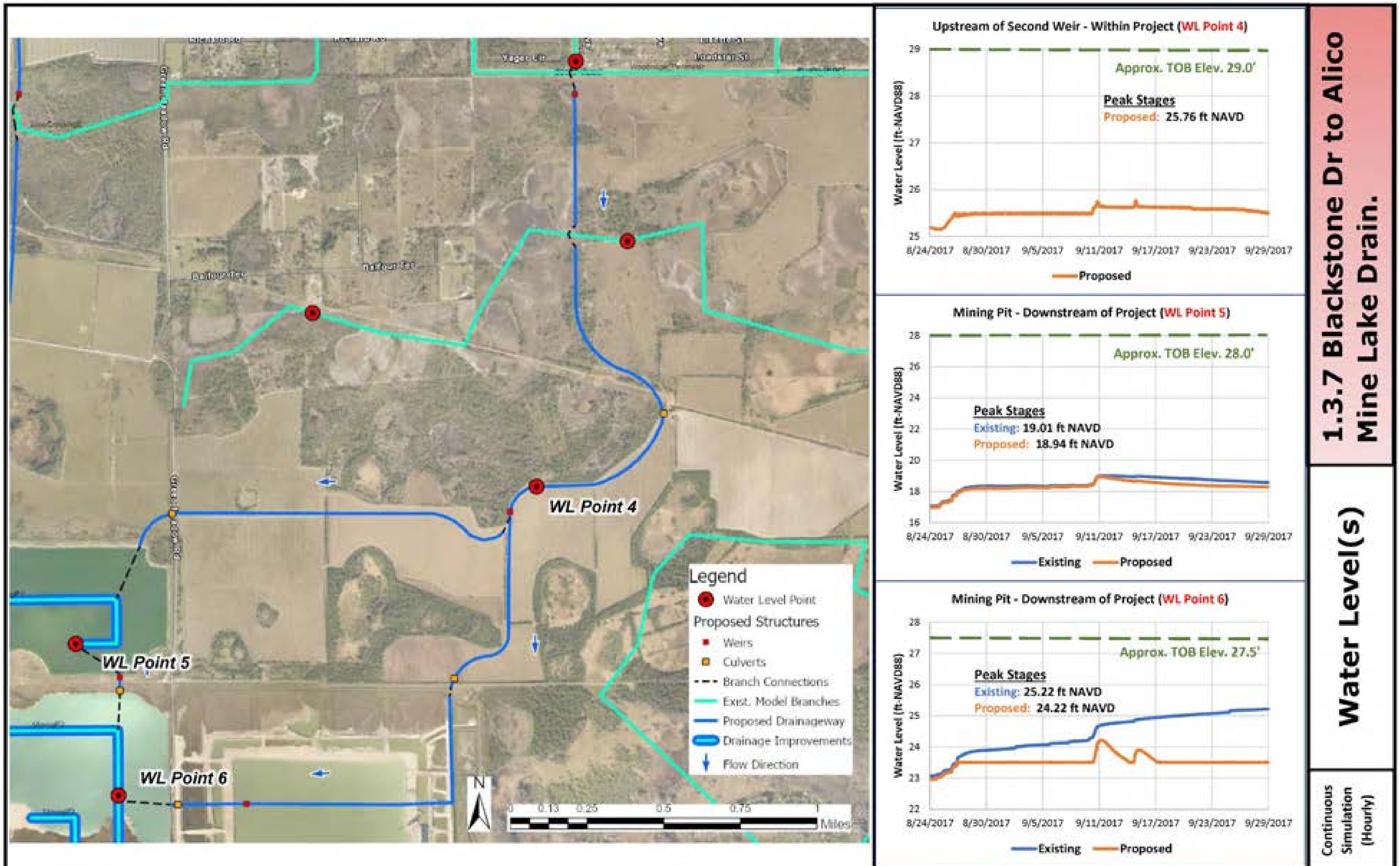
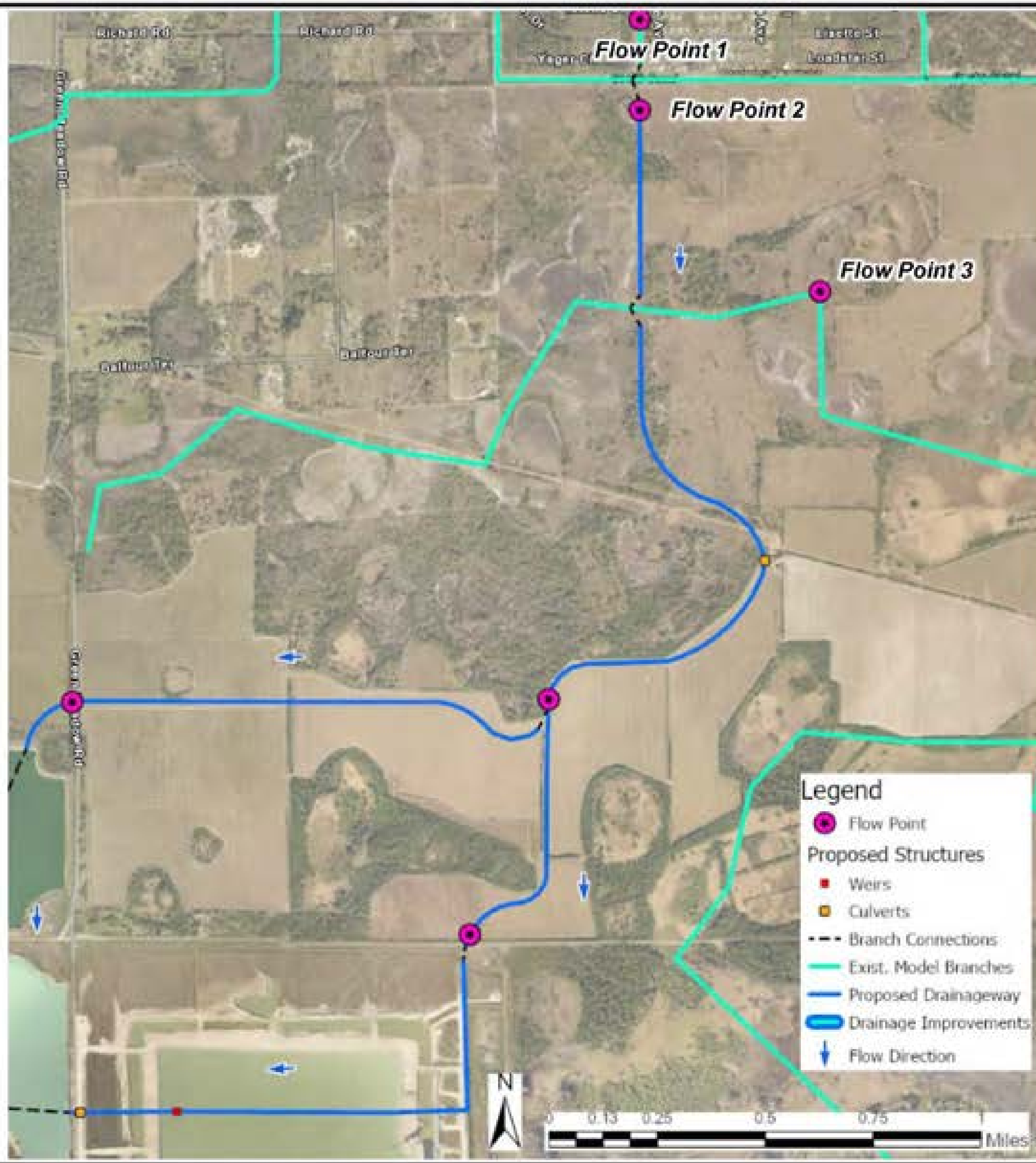
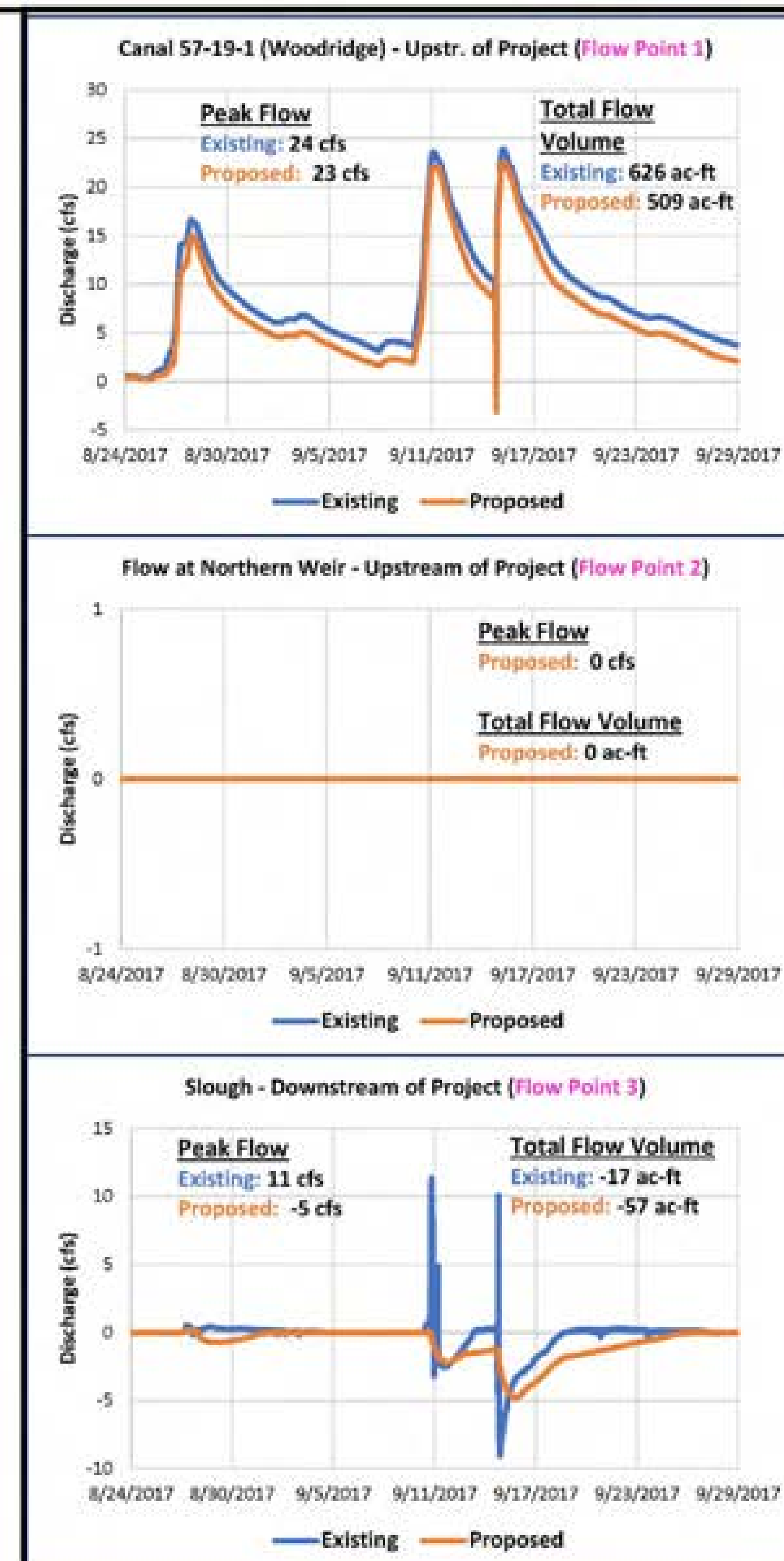


EXHIBIT 1.3.7 (i): 1 of 2



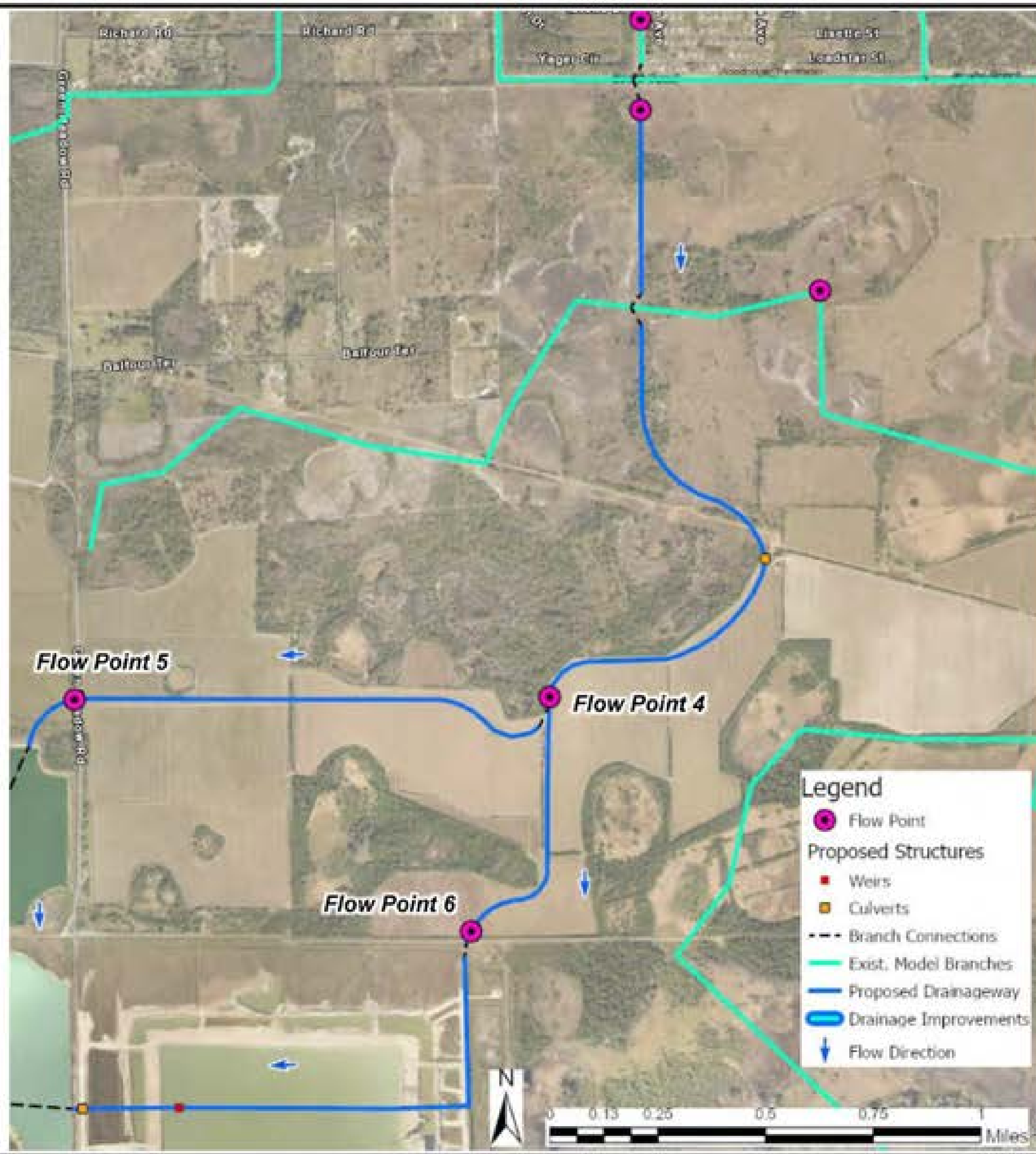


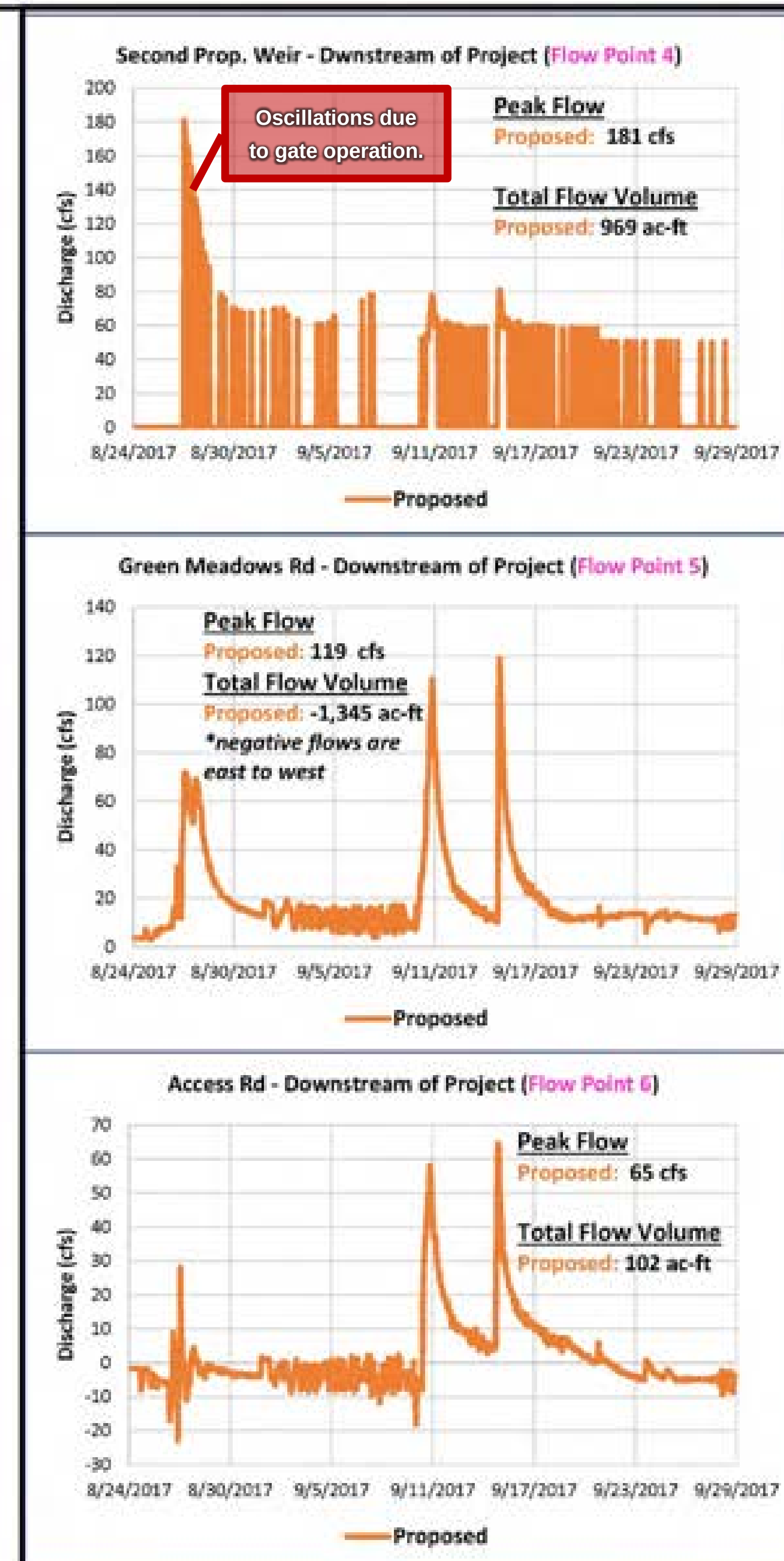
1.3.7 Blackstone Dr to Alico Mine Lake Drain.

Flow(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.7 (i): 2 of 2





1.3.7 Blackstone Dr to Alico Mine Lake Drain.

Flow(s)

Continuous Simulation (Hourly)

1.3.8 Alico Mine Lake to Halfway Creek Drainageway Concept Plan

Background

This concept project area is known as the Crew-Flint Pen/Kiker Preserve area and contains dense cypress swamps, sloughs, and wetlands. This area routinely experiences overland sheet flow directed westerly and southwesterly to Interstate No. 75. Land developments and roadways have impacted the natural sheet flow characteristics of the area. Large watershed areas lying north of Corkscrew Road require flow provisions to reach the many structures existing under Interstate No. 75 to avoid overloading the Estero River N. Branch flow way.

Location

This proposed conceptual project is located in SE Lee County east of Interstate 75, south of the Miromar Outlets and crosses Corkscrew Road then follows southeast to Interstate 75 as illustrated in **Figure 28**.

Figure 28 – Location Map, 1.3.8 Alico Mine Lake to Halfway Creek Drainageway

Description

This proposed conceptual project conveys the existing mine lakes in the Alico area lying north of Corkscrew Road into the Crew Flint preservation area and directs excess flow towards the Halfway Creek bridge under I-75. The route south of Corkscrew Rd will be along a recent land development project approved by the South Florida Water Management District. The route will generally go south, south west and connect to the Halfway Creek. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges as illustrated in **Figure 29**.

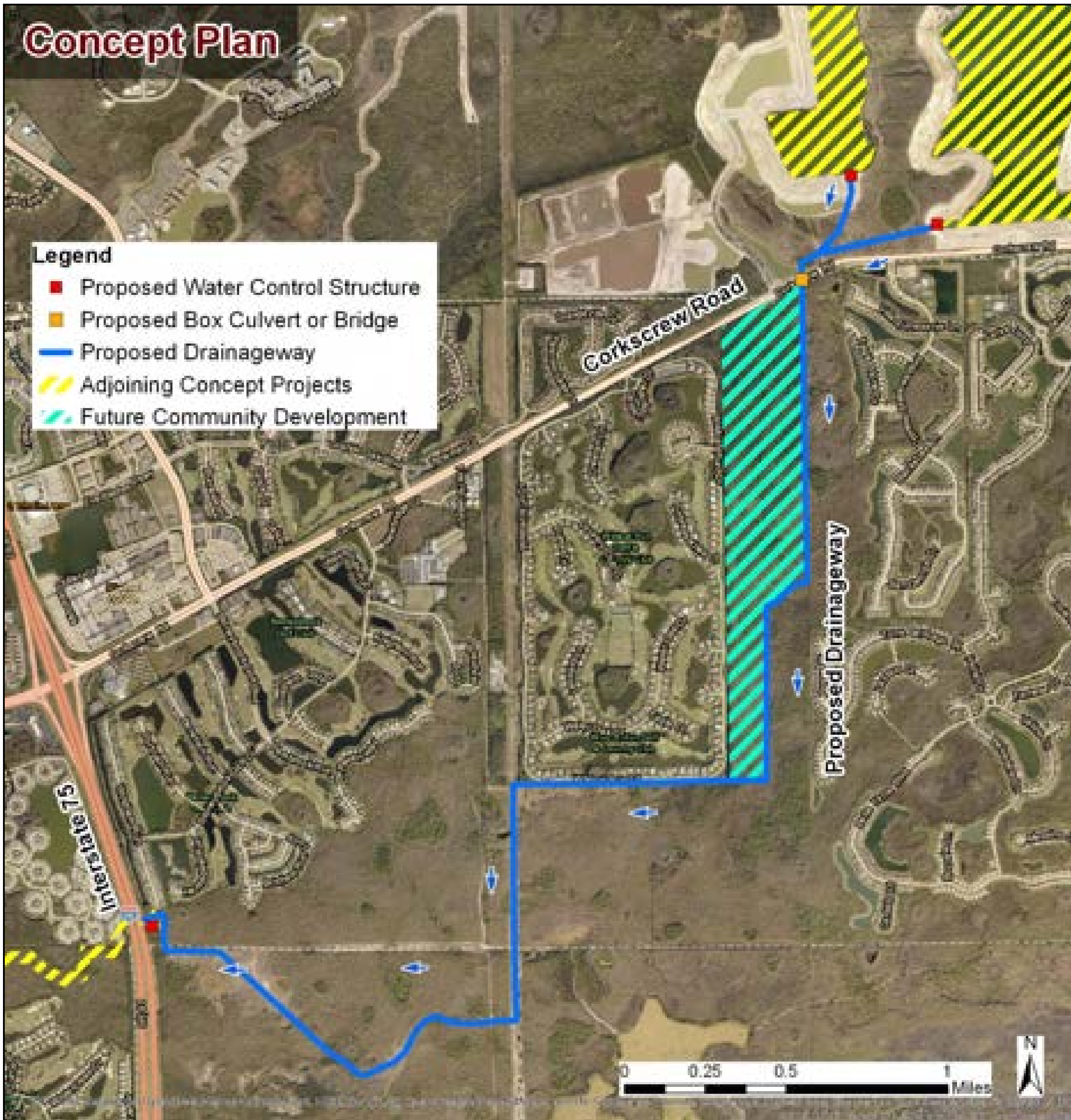


Figure 29 – Concept Plan, 1.3.8 Alico Mine Lake to Halfway Creek Drainageway

Purpose

This proposed project extends drainage control into the Alico Mine Lakes area and allows reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding. Water flow is directed to the Crew Flint preservation area which improves natural system hydrology in this area.

Evaluation

Viability

This project is a critical component for water management control of the large areas north of Corkscrew road leading to an outfall in the Halfway Creek conveyance. Currently the flow paths are constricted between planned developments and a functional channel is necessary to carry this very large flow to the outfall.

Community Considerations

The pathway for this flow way conveyance is in environmentally sensitive lands requiring approvals from Lee County 20/20 conservation lands and other governmental agencies in the area. Some land acquisition from private property owners may be necessary. This drainageway would utilize Lee County owned properties and mine lakes.

Environmental & Permittability Considerations

Environmental impacts shall be considered along the path with provisions to minimize water draw down where practical and possible. The wetland impacts will be either avoided, minimized and mitigated, as practical.

Land Availability

The conveyance passes through mostly public lands and extensive governmental agency approval will be required. The modification of the conservation lands requirements may be necessary for crossing the 20/20 conservation land properties. Approvals from the water Utilities may be necessary for work close to their well field to avoid impacts that might occur to their facilities.

Opinion of Probable Cost

The cost opinion shown in **Table 9** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 9 - Opinion of Probable Cost breakdown, 1.3.8 Alico Mine Lake to Halfway Creek Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,866,000	$ 1,866,000
Clearing & Grubbing	100	AC	$ 14,000	$ 1,400,000
Earthwork	1,000,000	CY	$ 6	$ 6,000,000
Construction/ Maintenance Access	30,000	SY	$ 20	$ 600,000
Detours	1	LS	$ 140,000	$ 140,000
Box Culvert 3.8-1	250	CY	$ 1,200	$ 300,000
Box Culvert 3.8-2	250	CY	$ 1,200	$ 300,000
Box Culvert 3.8-3	650	CY	$ 1,200	$ 780,000
Permanent Erosion Control	6,000	SF	$ 15	$ 90,000
Grassing	112,000	SY	$ 2	$ 224,000
			Construction Cost Sub-Total:	**$11,700,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 3,485,000
			Land Acquisition	$ 2,750,000
			Project Administration/ CEI (10%):	$ 1,165,000
			Project Unknowns	$ 8,000,000
			Conceptual Project Cost:	**$27,100,000**
			Contingency (30%)	$ 7,900,000
			Conceptual Project Cost (with Contingency):	**$35,000,000**

Opportunities for Multiple Benefits & Uses

This conveyance flow way may be incorporated into the natural features of the land and create an interesting path that may offer a canoe or hiking trail possibility.

Other Considerations

A possible filter marsh opportunity may be possible along this route, so that any runoff from the future Corkscrew Road improvements may be treated. The excavated material from this conveyance may be beneficial to future highway construction. A summary of this concept project is shown below in **Exhibit 1.3.8** herein.

Findings & Recommendations

Regional Modeling Findings

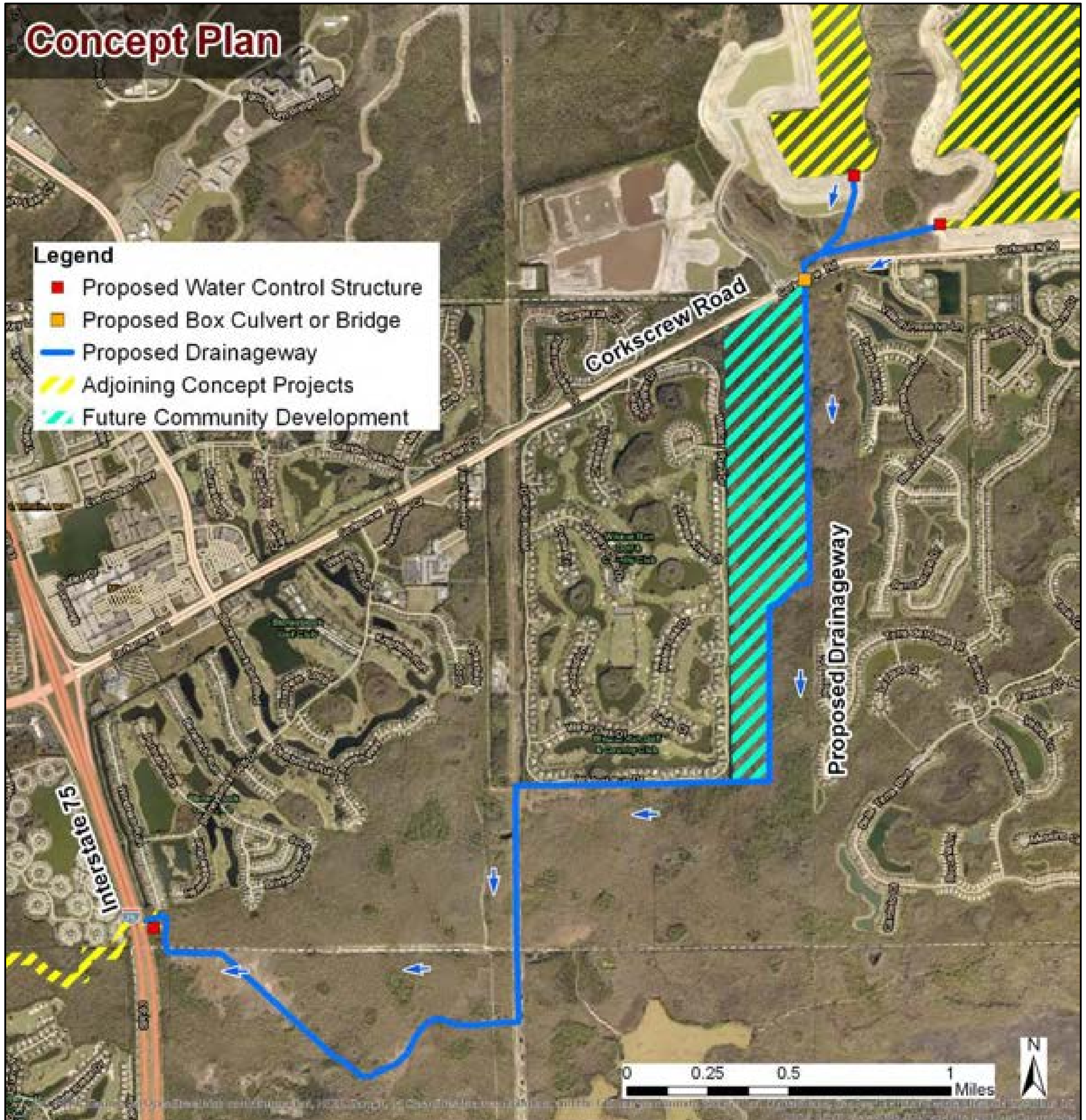
This project concept consists of joining conveyances from both the East and West Alico mine lakes to discharge excess storage and flow to convene with the downstream project concept at Interstate 75. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.8 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.8 (b) EXHIBIT 1.3.8 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.8 (d) EXHIBIT 1.3.8 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.8 (f) EXHIBIT 1.3.8 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.8 (h) EXHIBIT 1.3.8 (i)

Improvements were shown with only minimal variation of the water levels within the drainageway route, and a substantial increase in the proposed peak flow from the existing to the proposed conditions.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by joining conveyances from both East and West Alico Mine Lakes to discharge excess storage and flow to join with the downstream project at Interstate 75. These positive improvements warrant further design-level project development.



Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project conveys the existing mine lakes in the Alico area north of Corkscrew Road into the Crew Flint preservation area and directs excess flow towards the Halfway Creek bridge under I-75. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project extends drainage control into the Alico Mine Lakes area and allows reservoir storage in the mine lakes for attenuation of large storm events. The development of mine lake storage is critical to attenuating excess stormwater peak runoff rates for this area to reduce flooding. Water flow is directed to the Crew Flint preservation area which improves natural system hydrology in this area.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Alico Mine Lake to Halfway Creek Drainageway

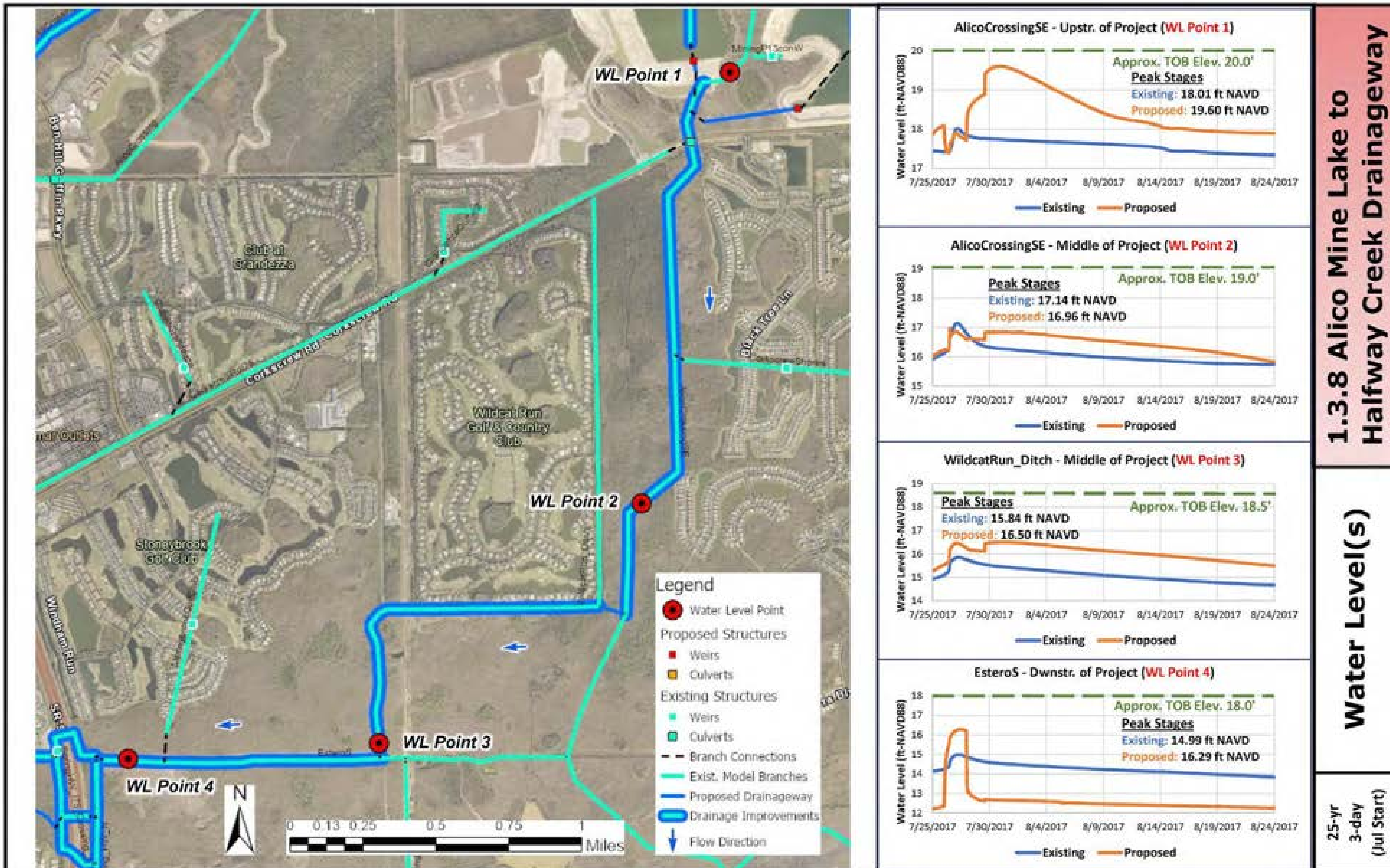
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.8

EXHIBIT 1.3.8 (a)

EXHIBIT 1.3.8 (b)



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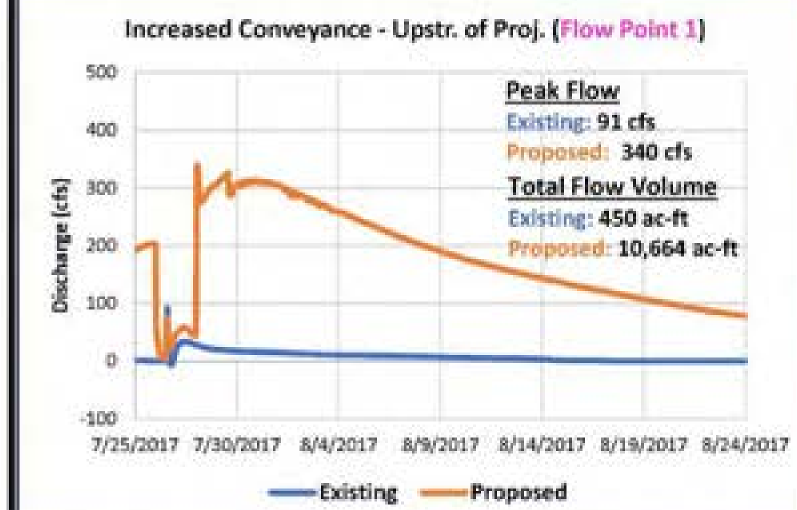
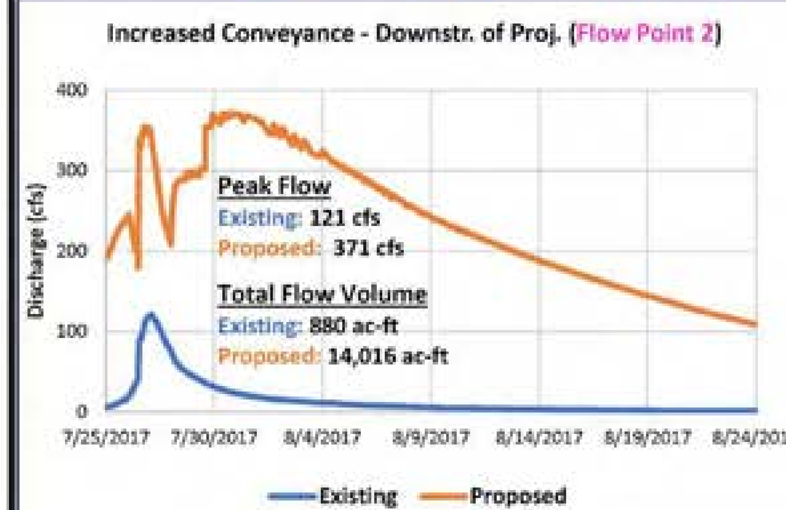
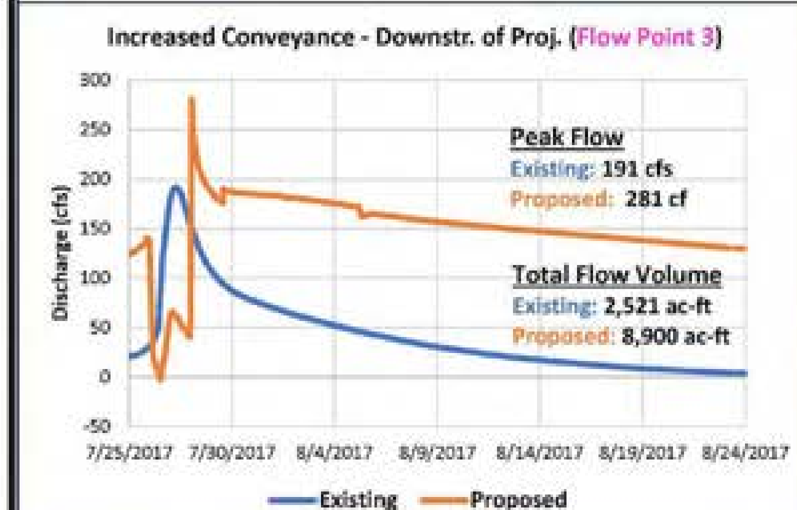




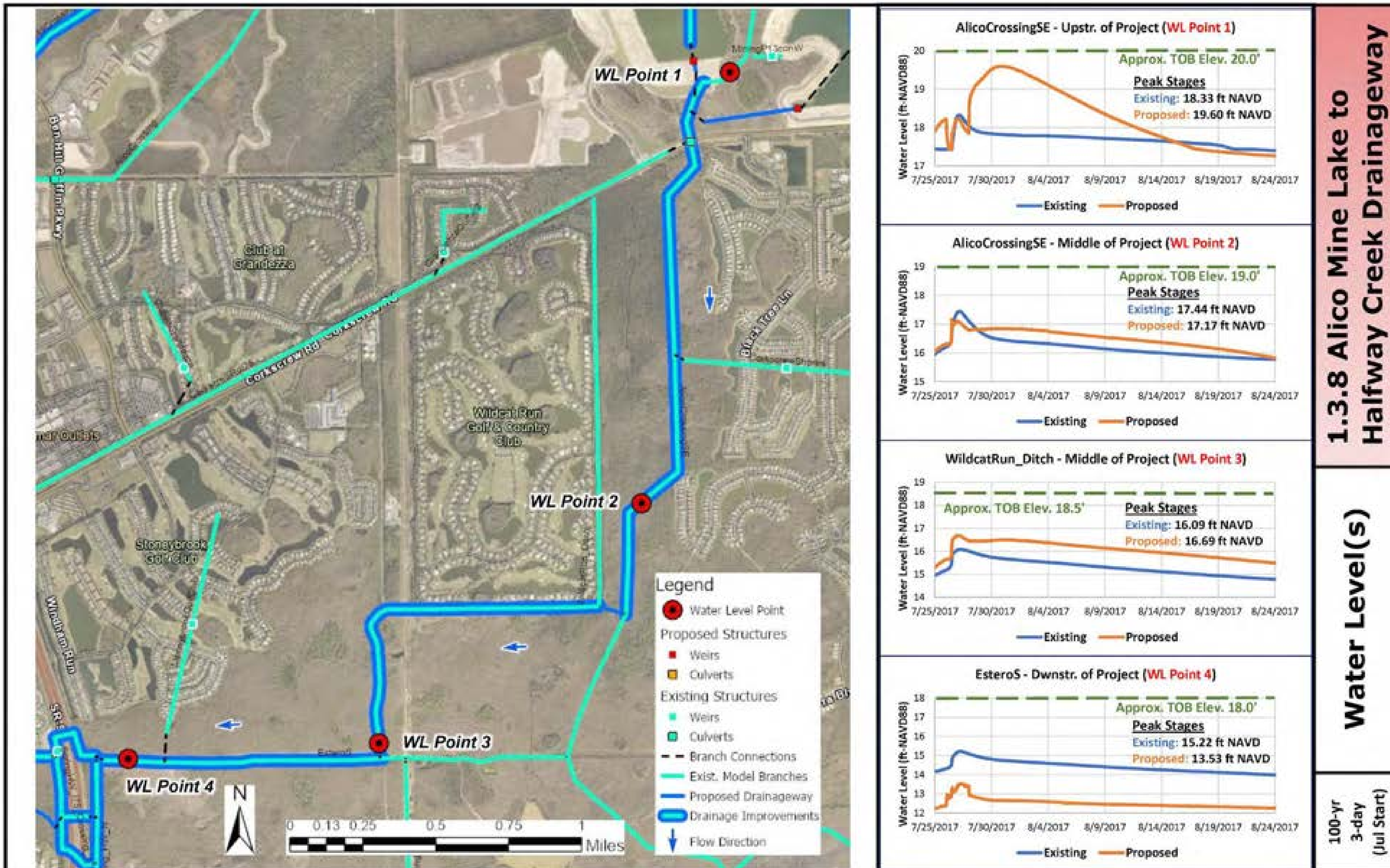


1.3.8 Alico Mine Lake to Halfway Creek Drainageway

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.8 (d)



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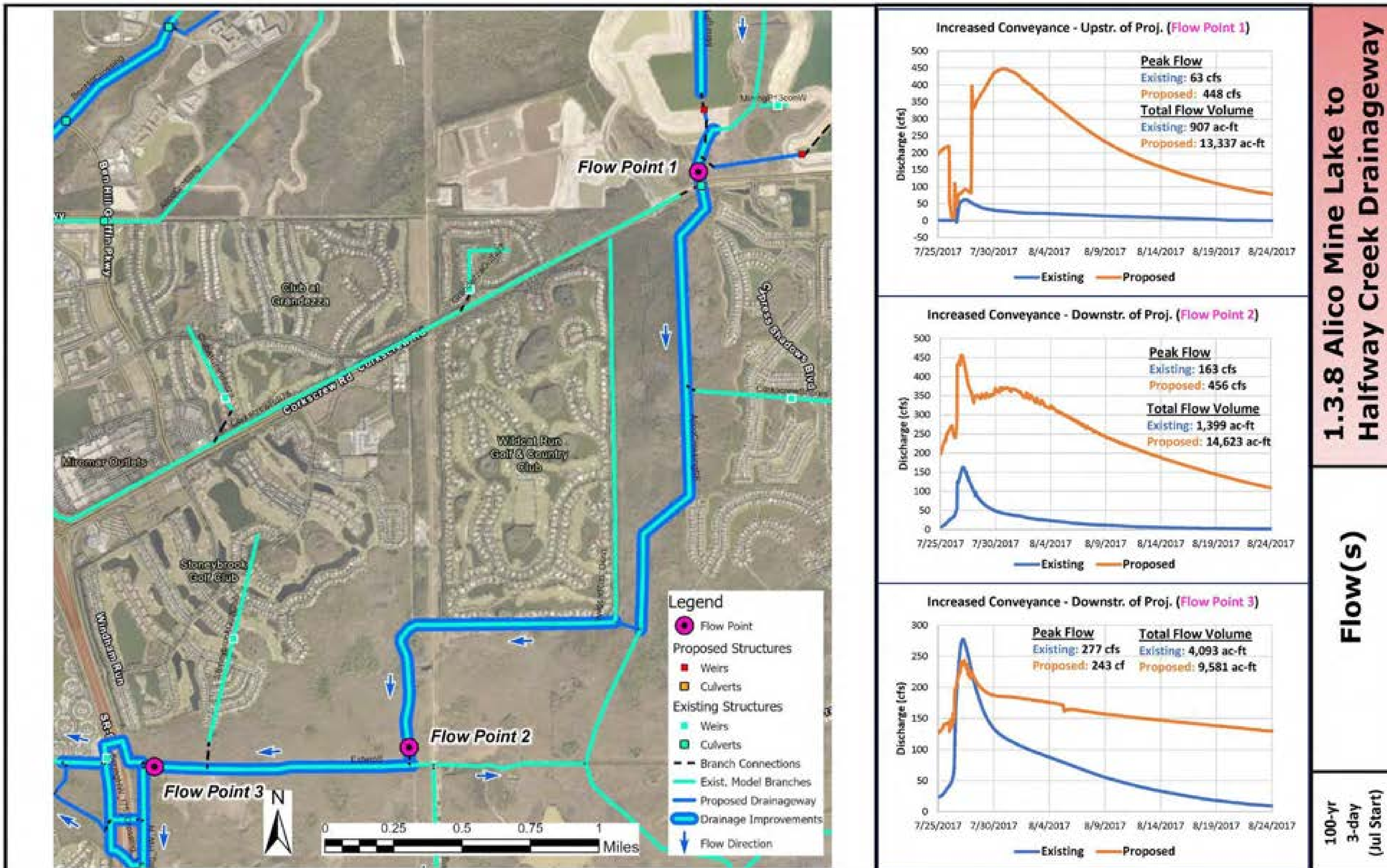

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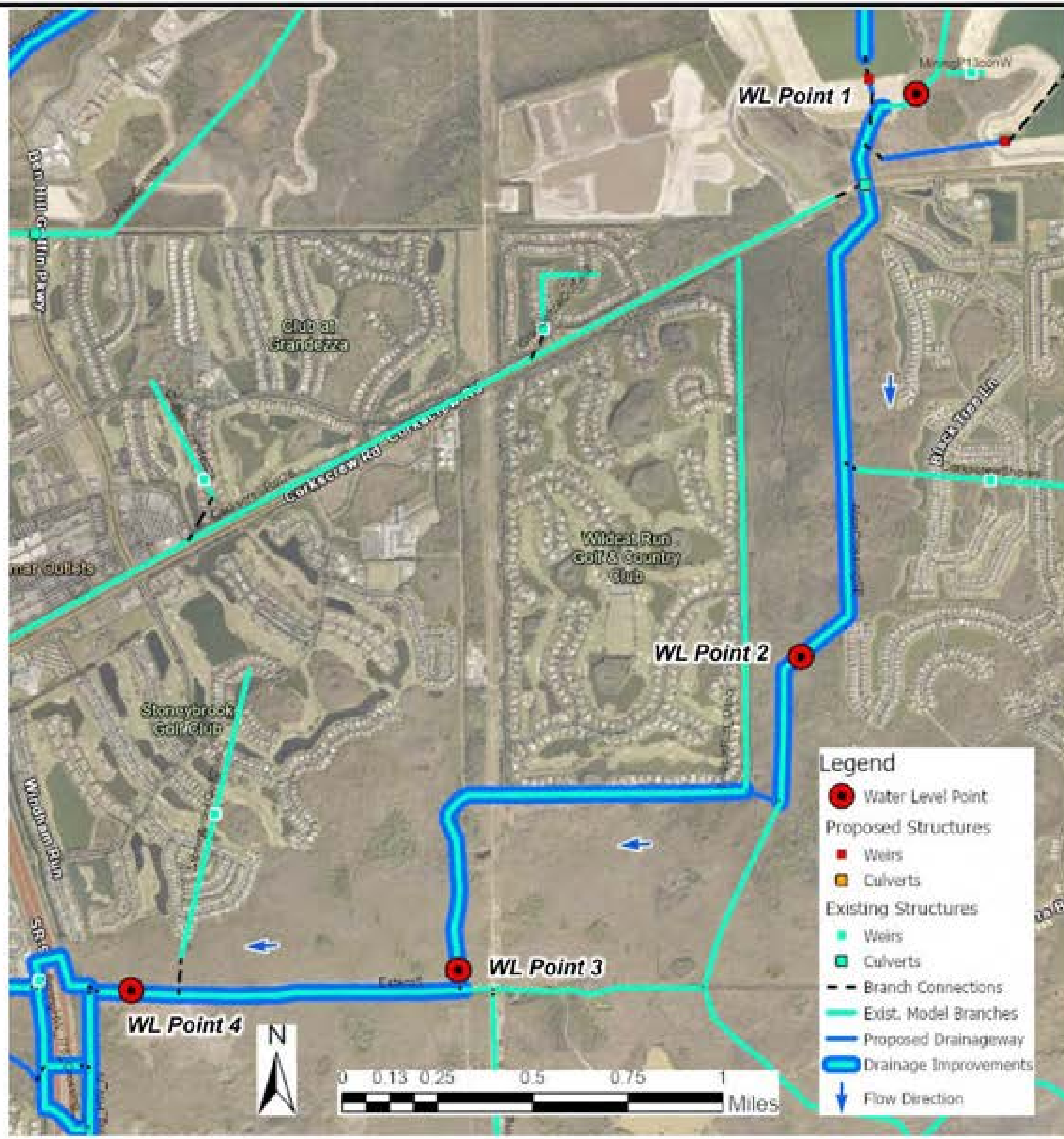
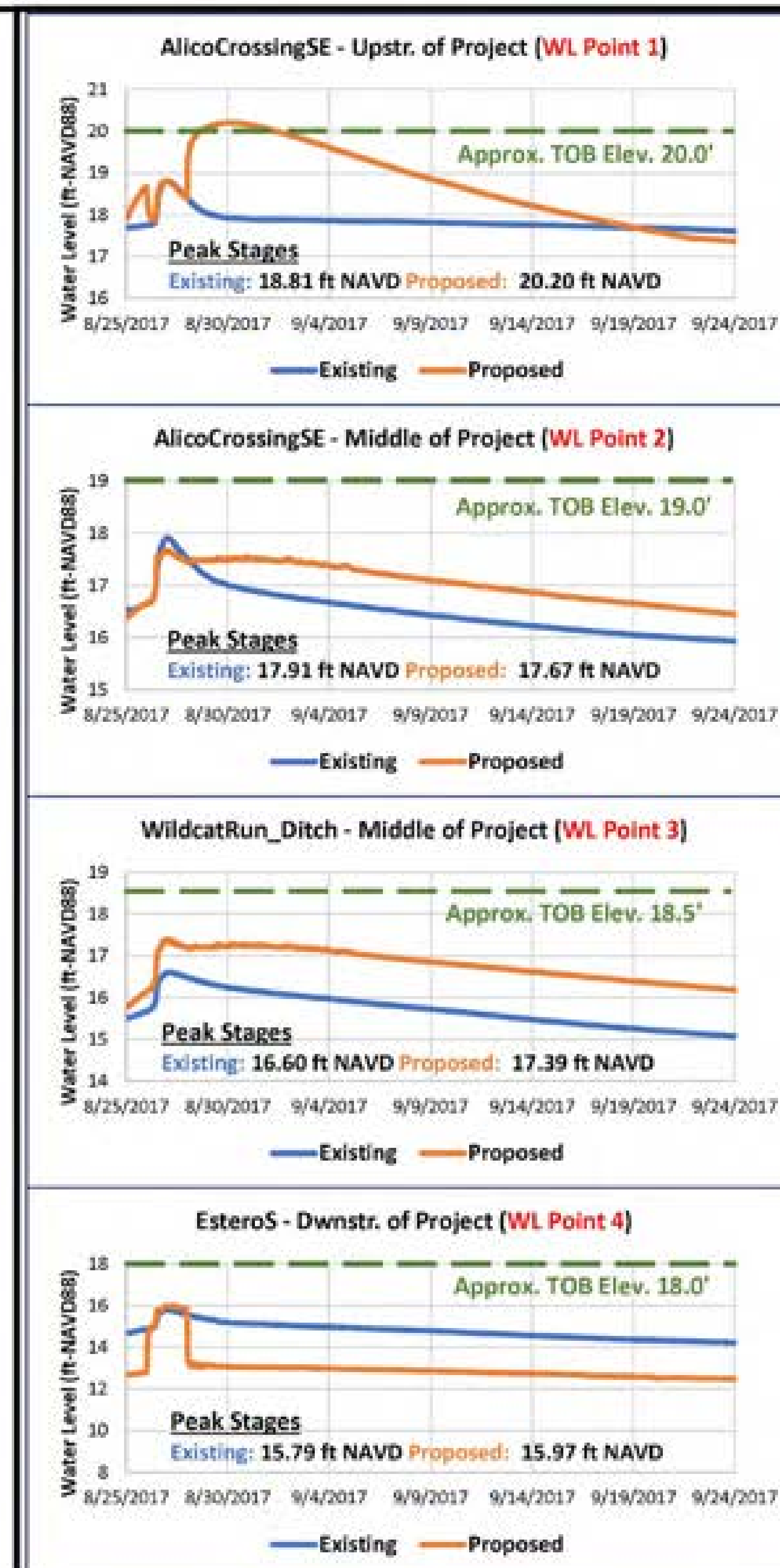


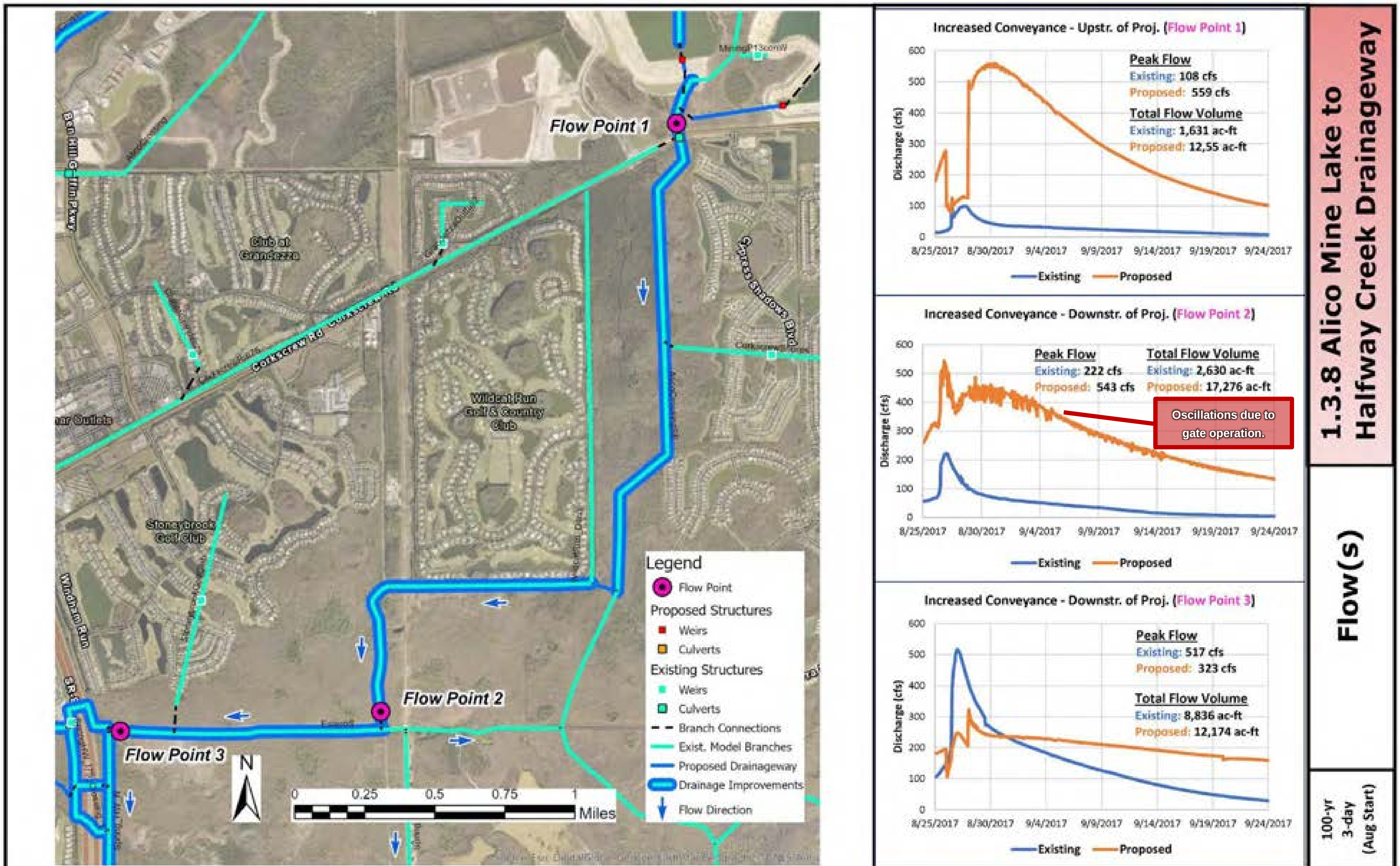


1.3.8 Alico Mine Lake to Halfway Creek Drainageway

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.8 (g)



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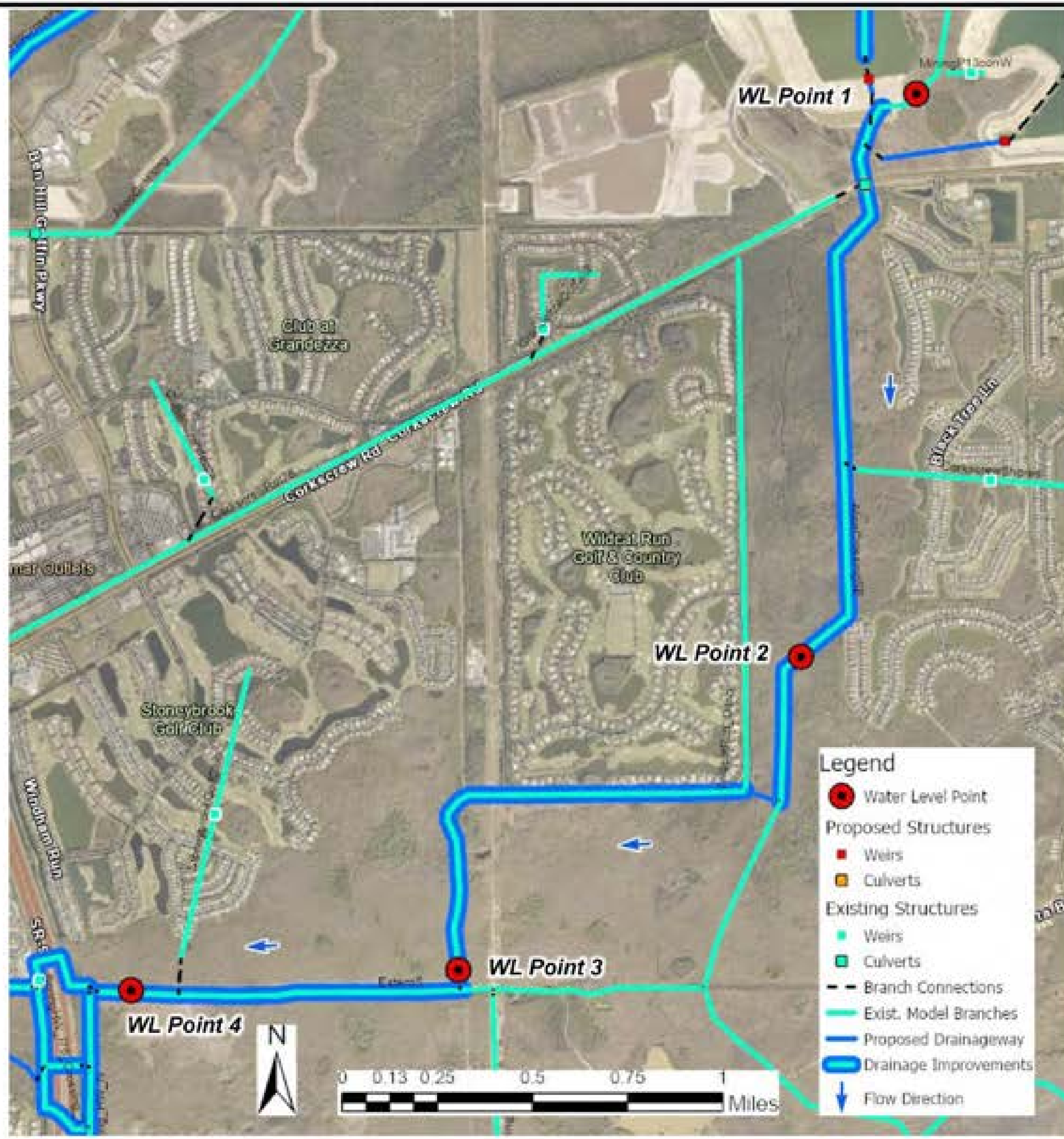
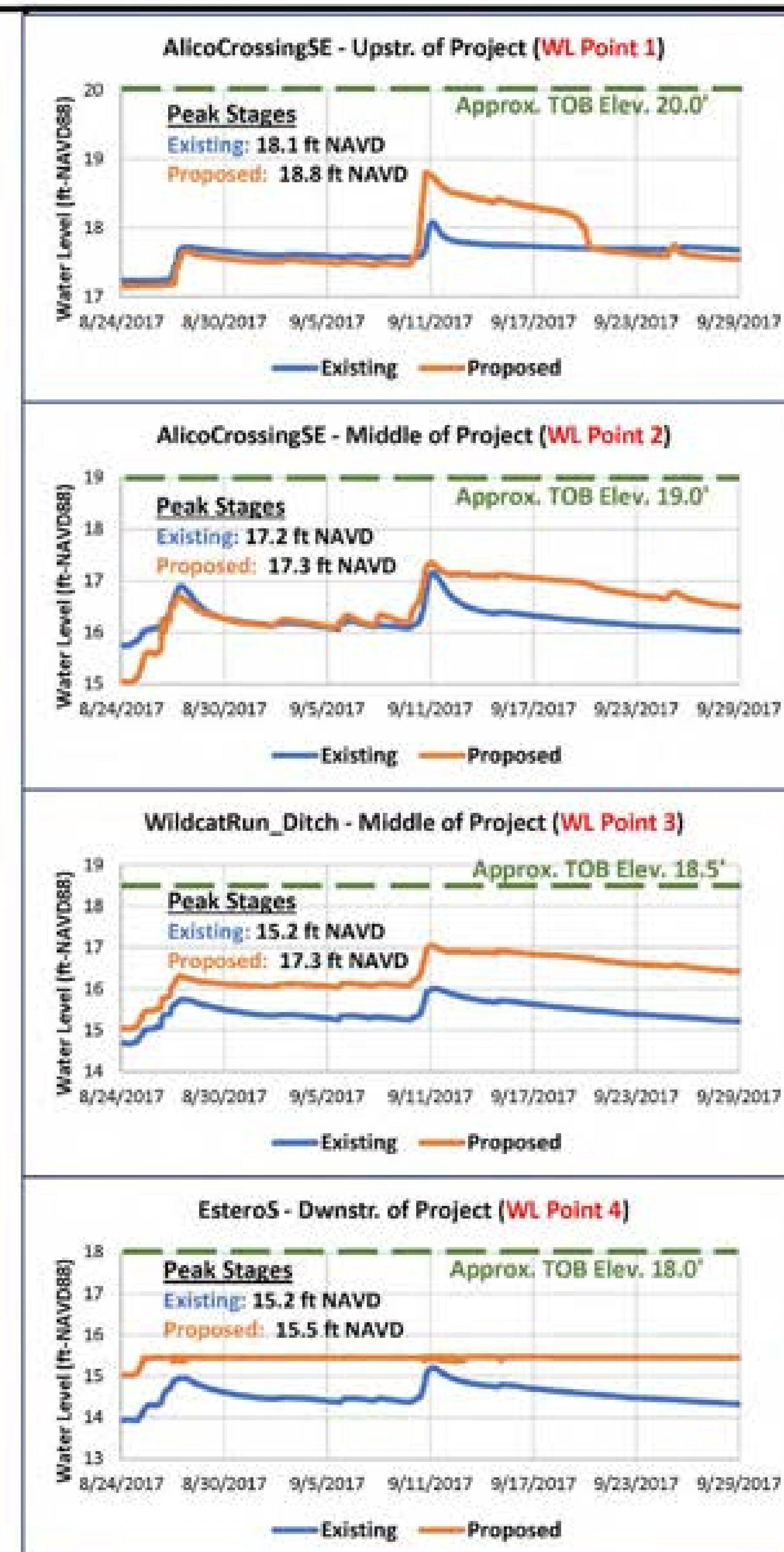


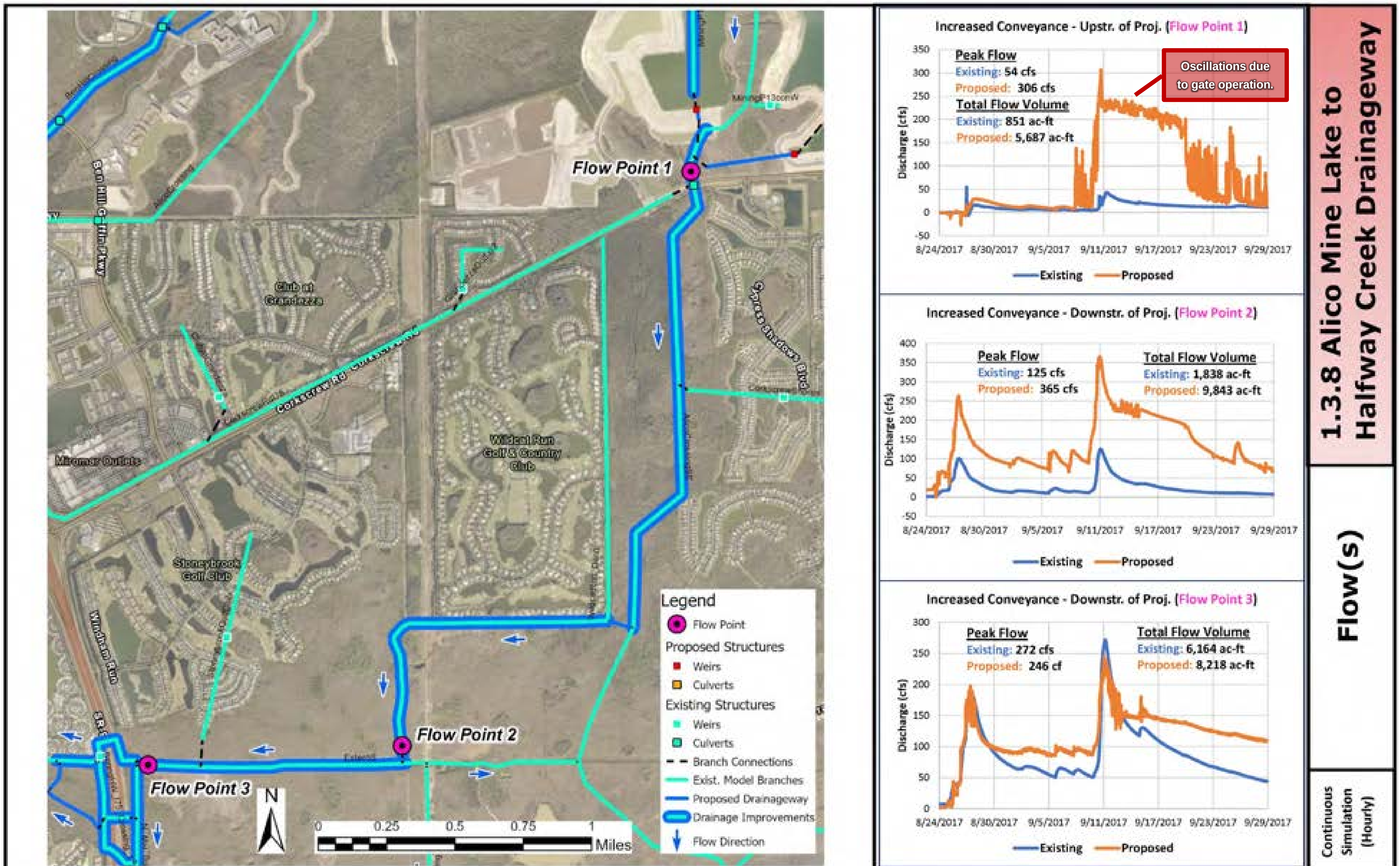


1.3.8 Alico Mine Lake to Halfway Creek Drainageway

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.8 (i)



1.3.9 I-75 to Spring Creek Drainageway (North) Concept Plan

Background

This concept project extends a drainageway 3-4 miles inland from the natural mangrove lined Spring Creek to connect a proposed box culvert crossing at Interstate No. 75. The route is branched and travels through developed areas, crosses roads, railroads, highways, and an abandoned golf course while utilizing existing drainageways where practical to link drainage east of the interstate to Estero Bay. Historically, this poorly drained area relied on overland sheet flow drainage. Railroad and road construction along with land development has blocked, confined, and restricted the natural sheet-flow conditions.

Location

This proposed conceptual project is in SE Lee County west of Interstate 75 between Corkscrew Road, Bonita Beach Road and east of U.S. 41 as illustrated in **Figure 30**.

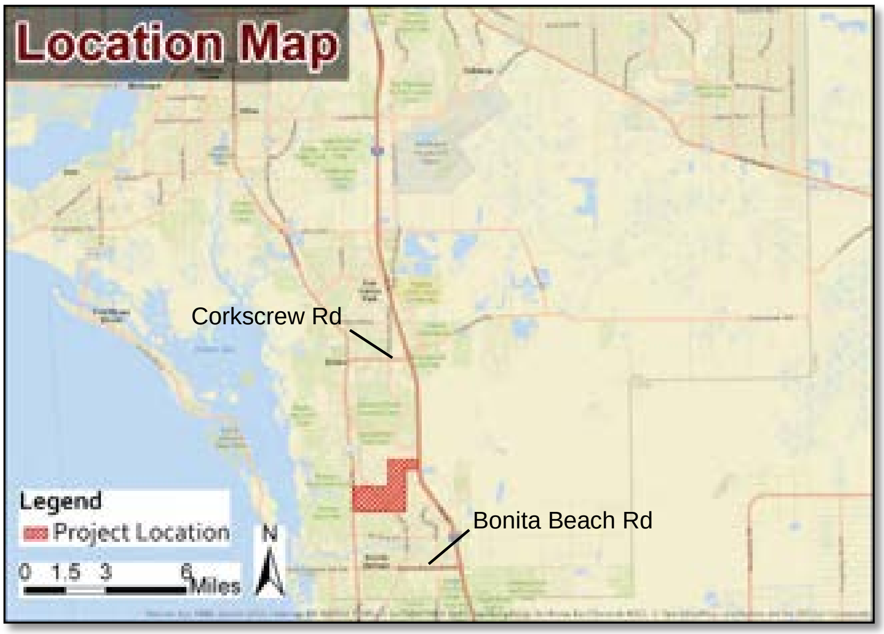


Figure 30 – Location Map, 1.3.9 I-75 to Spring Creek Drainageway (North)

Description

This proposed conceptual project conveys excess stormwater drainage flow from a proposed drainage structure under I-75 through the Spring Creek Drainageway extension. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Utilizing an abandoned golf course for conveyance and water quality treatment is possible as illustrated in **Figure 31**.

Figure 31 – Concept Plan, 1.3.9 I-75 to Spring Creek Drainageway (North)

Purpose

This proposed concept project improves conveyance of excess stormwater to reduce flooding and shorten post-storm recovery of water levels.

Evaluation

Viability

This project concept has challenges with the new drainage structure under Interstate 75 and with acquisition of the abandoned golf course and other private properties. The potential exists in working on an abandoned golf course that special soil handling techniques may be required. This is an important conveyance carrying high flows that would justify the involved project development.

Community Considerations

Construction of this conveyance would involve extensive earthwork and traffic delays on Interstate 75 that would be disruptive to residents and drivers in the area. After construction of these facilities, the filter marsh may provide a passive recreational nature park that is aesthetically pleasing. This drainageway would utilize Bonita 120 RPD, Platinum Coast Financial Corp. Villages of Bonita RPD, Bernwood IPD/CPD and Spring Creek PUD/DRI owned properties.

Environmental & Permittability Considerations

Environmental wetland impacts are not obvious; however, all wetland impacts would require mitigation that may be included in the filter marsh work construction.

Land Availability

The conveyance would be through private properties and require land acquisition. This project concept is located within the City of Bonita Springs and their approval may be necessary.

Opinion of Probable Cost

The cost opinion shown in **Table 10** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 10 - Opinion of Probable Cost breakdown, 1.3.9 I-75 to Spring Creek Drainageway (North)

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,630,000	$ 1,630,000
Clearing & Grubbing	37	AC	$ 14,000	$ 518,000
Earthwork	200,000	CY	$ 6	$ 1,200,000
Construction/ Maintenance Access	5,250	SY	$ 20	$ 105,000
Weir Structure 3.9A (Major)	100	LF	$ 10,000	$ 1,000,000
Weir Structure 3.9B (Major)	100	LF	$ 10,000	$ 1,000,000
Seawall	1,500	LF	$ 250	$ 375,000
Rip-rap along Seawall	1,100	TN	$ 100	$ 110,000
Detours	1	LS	$ 295,000	$ 295,000
Box Culvert 3.9-1	150	CY	$ 1,200	$ 180,000
Box Culvert 3.9-2	150	CY	$ 1,200	$ 180,000
Box Culvert 3.9-3	310	CY	$ 1,200	$ 372,000
Box Culvert 3.9-4	310	CY	$ 1,200	$ 372,000
Box Culvert 3.9-5	310	CY	$ 1,200	$ 372,000
Box Culvert 3.9-6	580	CY	$ 1,200	$ 696,000
Electric Supply	1	LS	$ 20,000	$ 20,000
Permanent Erosion Control	12,000	SF	$ 25	$ 300,000
Grassing	87,500	SY	$ 2	$ 175,000
			Construction Cost Sub-Total:	**$ 8,900,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 2,670,000
			Land Acquisition	$ 3,250,000
			Project Administration/ CEI (10%):	$ 900,000
			Project Unknowns	$ 1,280,000
			Conceptual Project Cost:	**$ 17,000,000**
			Contingency (30%)	$ 5,000,000
			Conceptual Project Cost (with Contingency):	**$ 22,000,000**

Opportunities for Multiple Benefits & Uses

This conveyance route is a unique opportunity to collect flow from the east of Interstate 75 and direct flow to the tidal waters of Estero Bay. The filter marsh would provide water quality treatment and storm water reservoir storage to attenuate peak flows.

Other Considerations

This flow way conveyance may result in a natural park like setting for the residents previously located on the golf course. A summary of this concept project is shown below in **Exhibit 1.3.9**.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from east of Interstate 75 to Estero Bay via Spring Creek. Existing drainageways would be improved and new drainageways are proposed to increase flow capacity and connectivity. A portion of the conveyance may include a stormwater storage pond. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.9 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

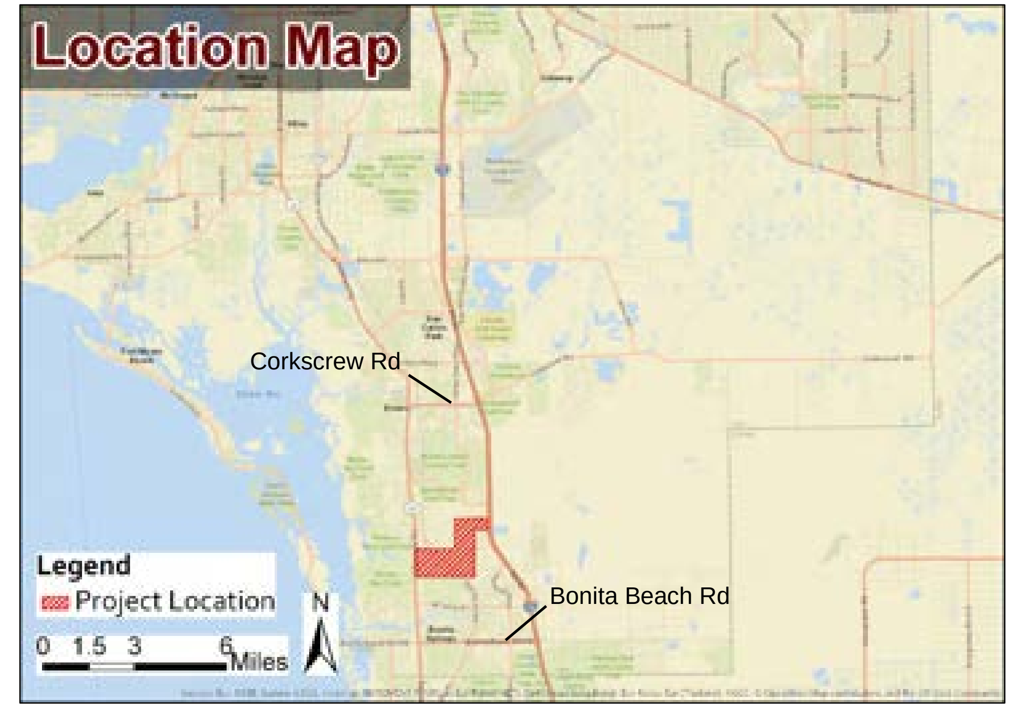
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.9 (b) EXHIBIT 1.3.9 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.9 (d) EXHIBIT 1.3.9 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.9 (f) EXHIBIT 1.3.9 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.9 (h) EXHIBIT 1.3.9 (i)

Improvements were shown with a reduction in water levels at certain locations and an increase in proposed peak flows. Where an increase in propose water elevations were observed, the peak stages were shown to be retained within the approximate drainageway top of bank.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from east of Interstate 75 through Spring Creek to Estero Bay. These positive improvements warrant further design-level project development.

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from a proposed drainage structure under I-75 through the Spring Creek Drainageway extension. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges. Utilizing an abandoned golf course for conveyance and water quality treatment is possible.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Utilization of the golf course has the potential of special soil handling. Environmental impacts, if any, would necessitate mitigation.

May 2020

I-75 to Spring Creek Drainageway (North)

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.9

EXHIBIT 1.3.9 (a)

EXHIBIT 1.3.9 (b): 1 of 2

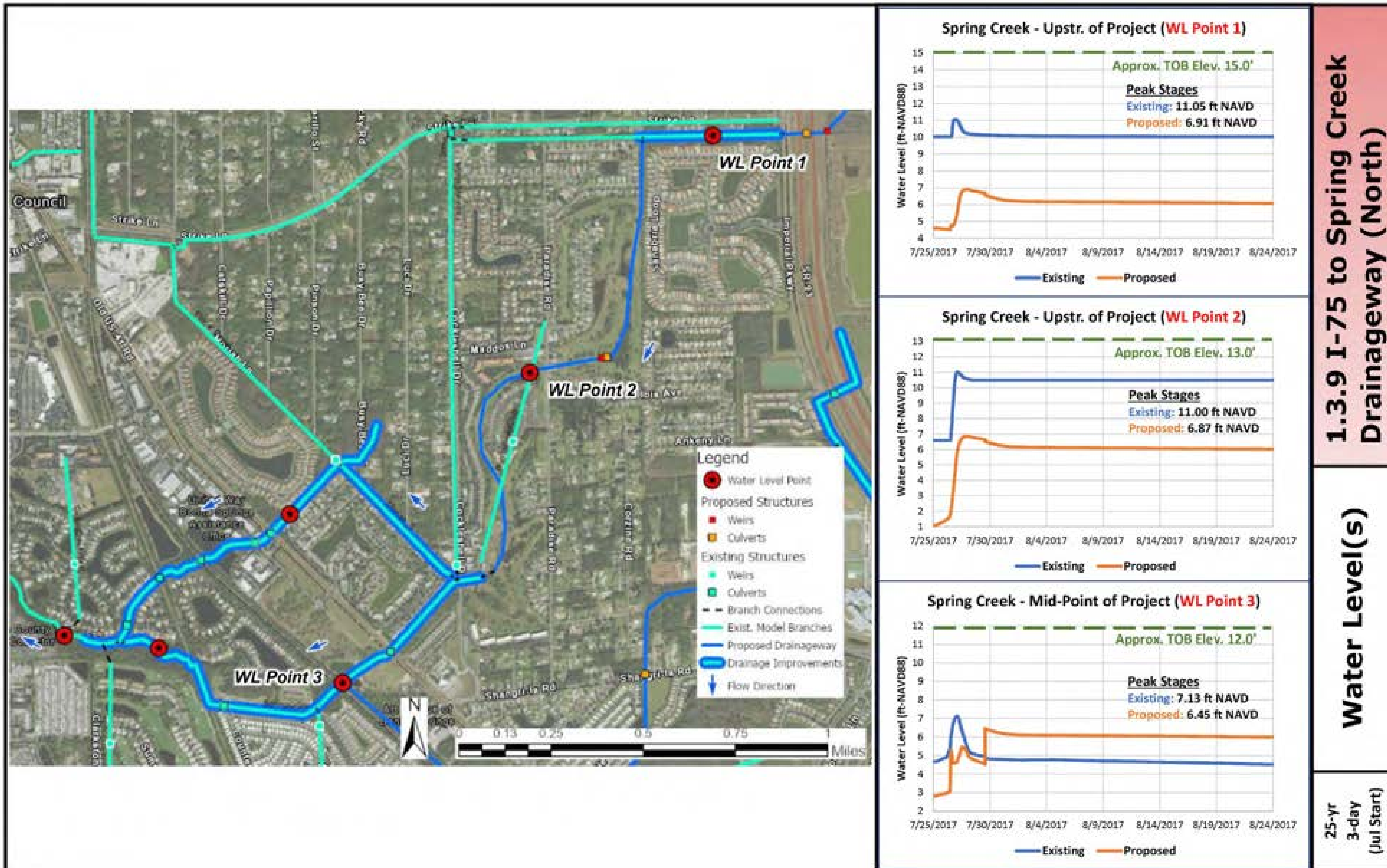


EXHIBIT 1.3.9 (b): 2 of 2

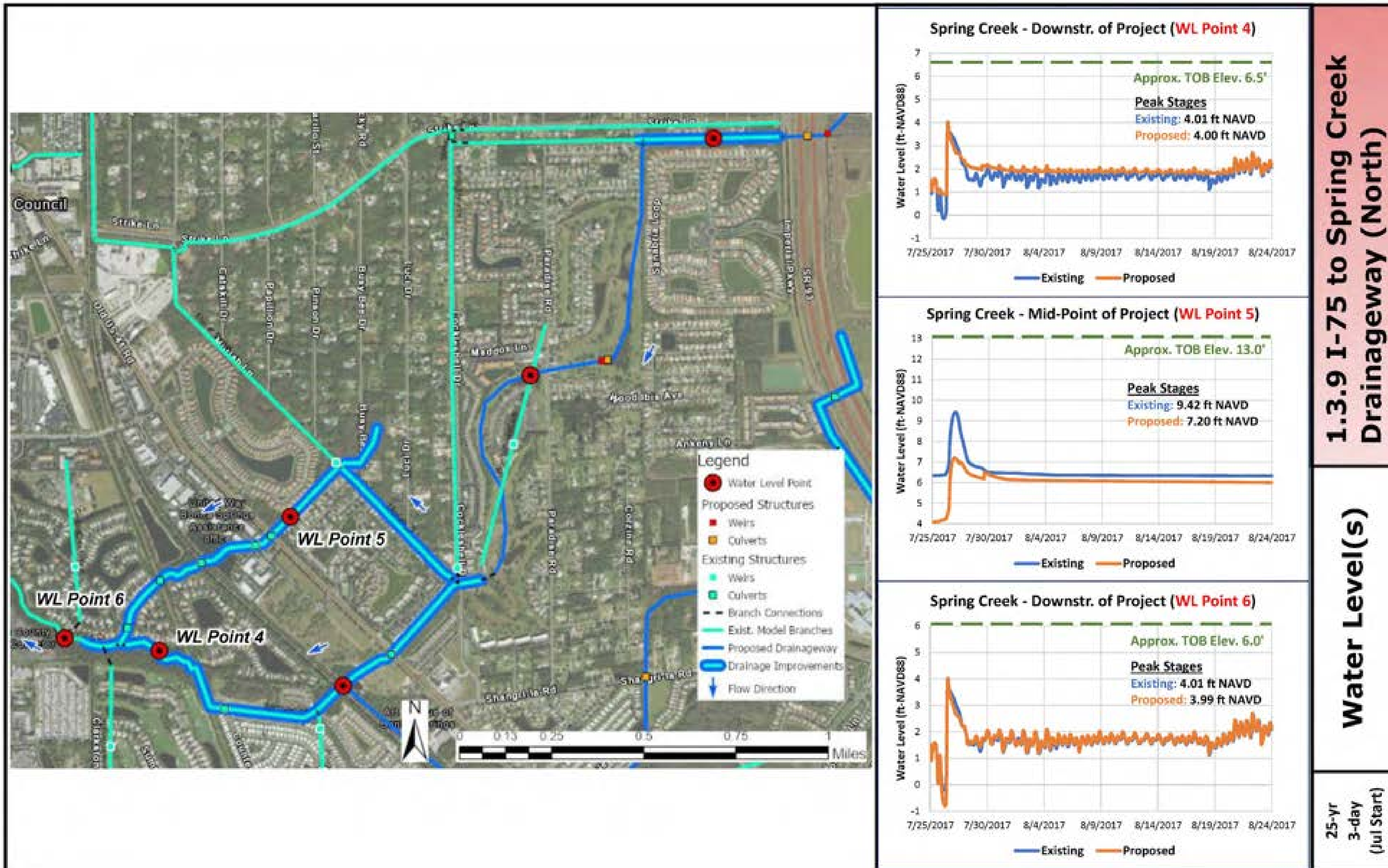
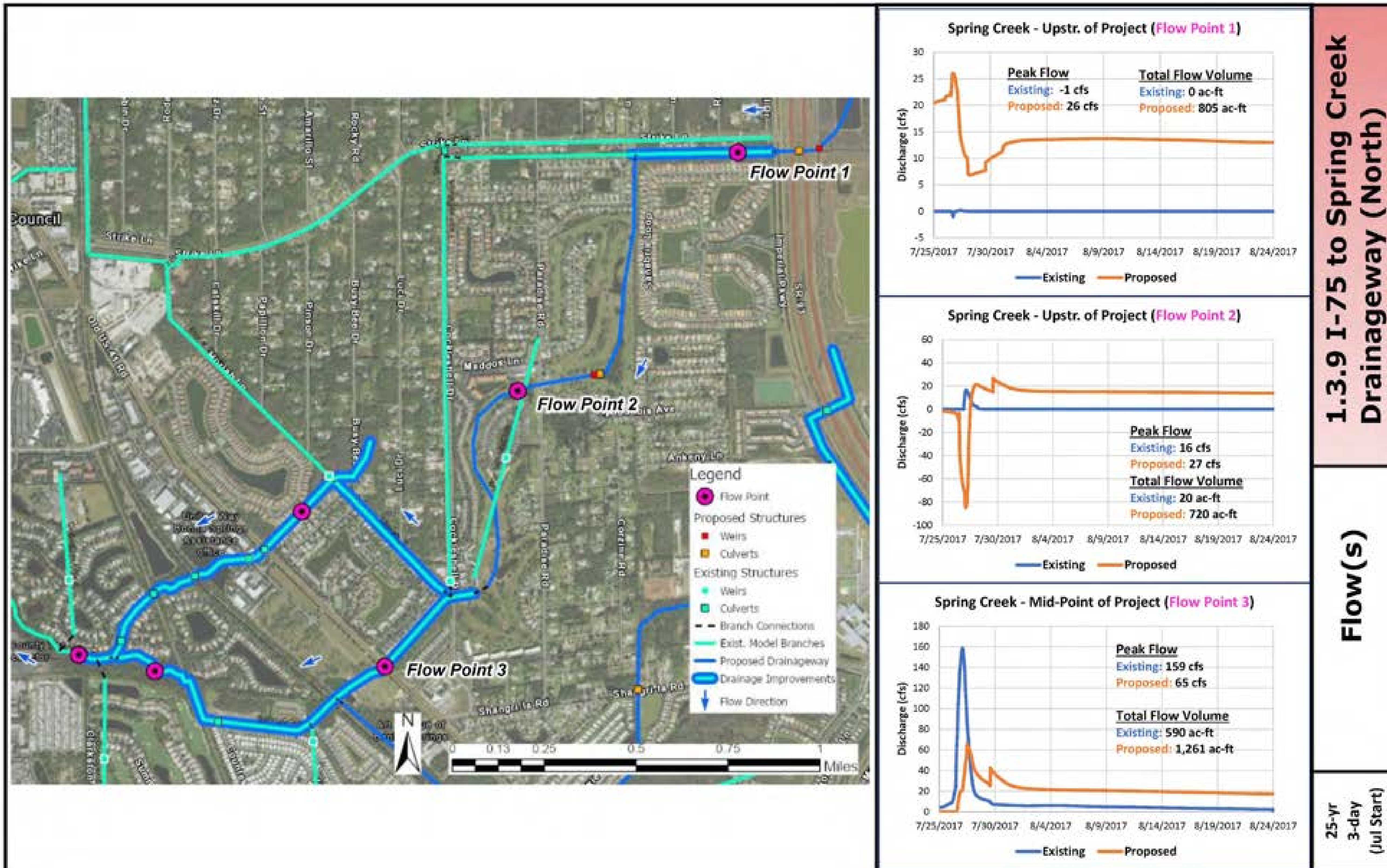


EXHIBIT 1.3.9 (c): 1 of 2



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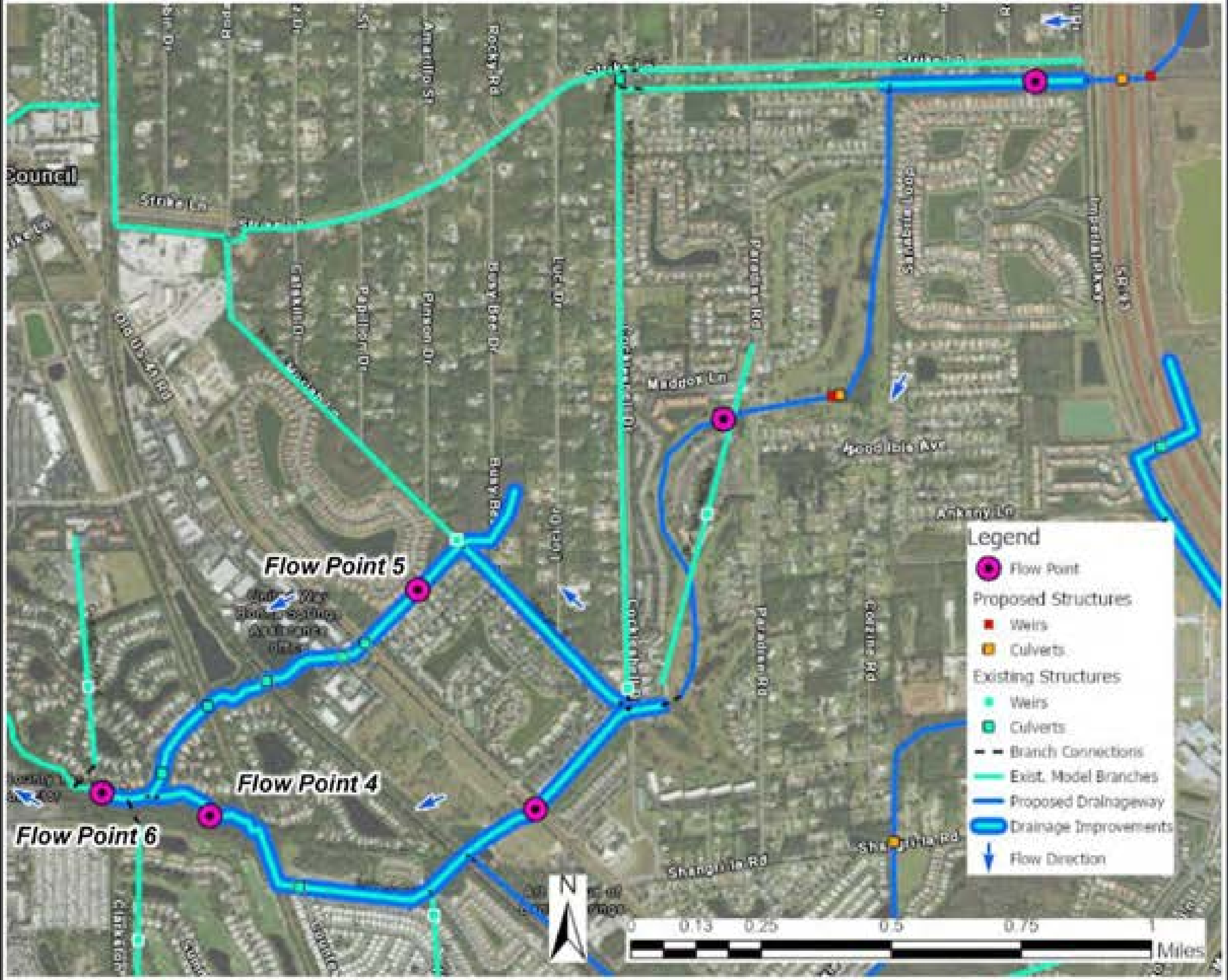
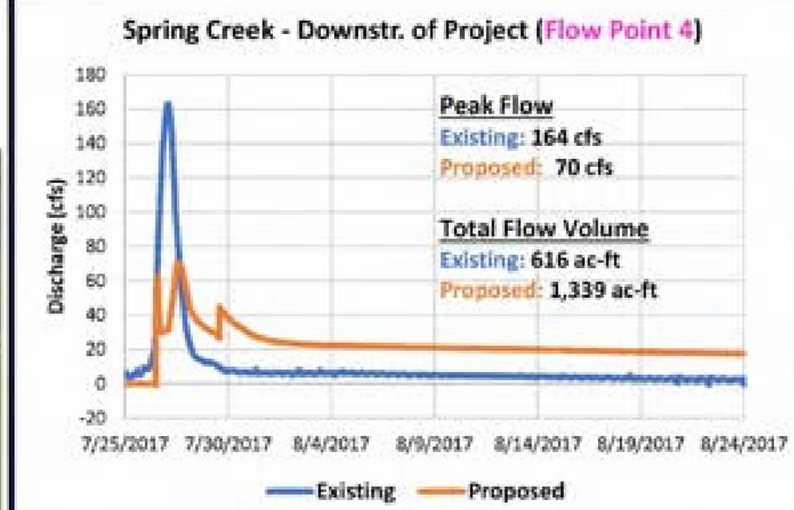
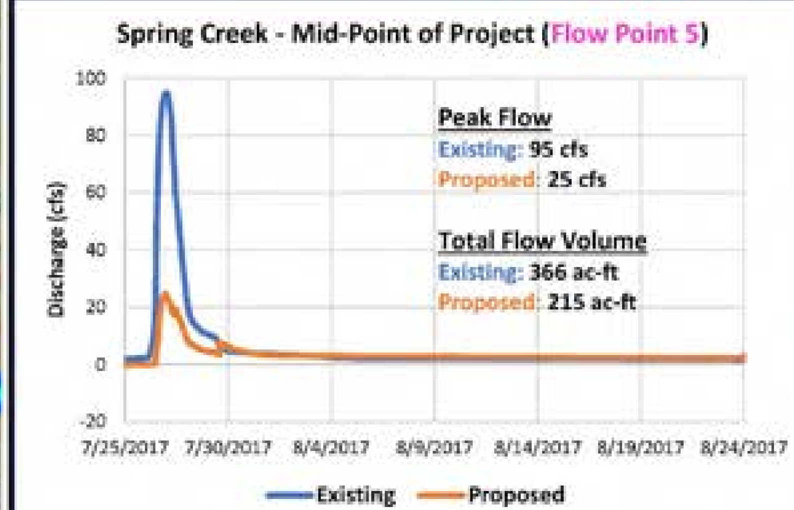
1.3.9 I-75 to Spring Creek Drainageway (North)

Flow(s)

25-yr 3-day (Jul Start)







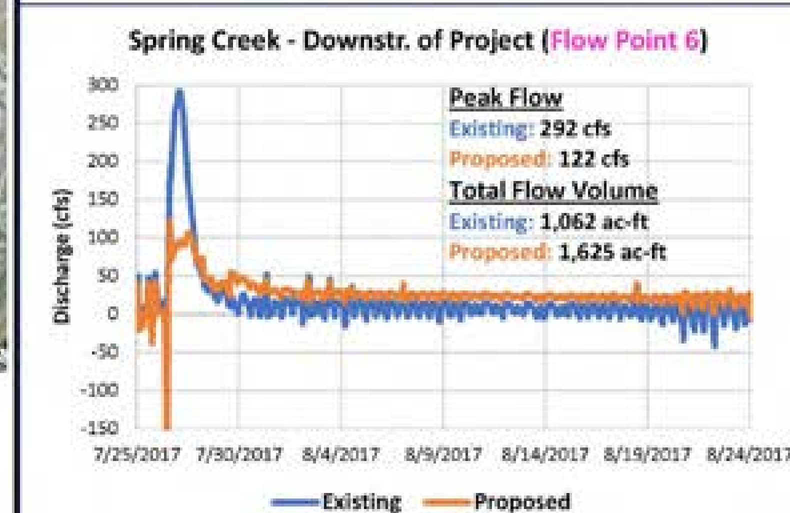
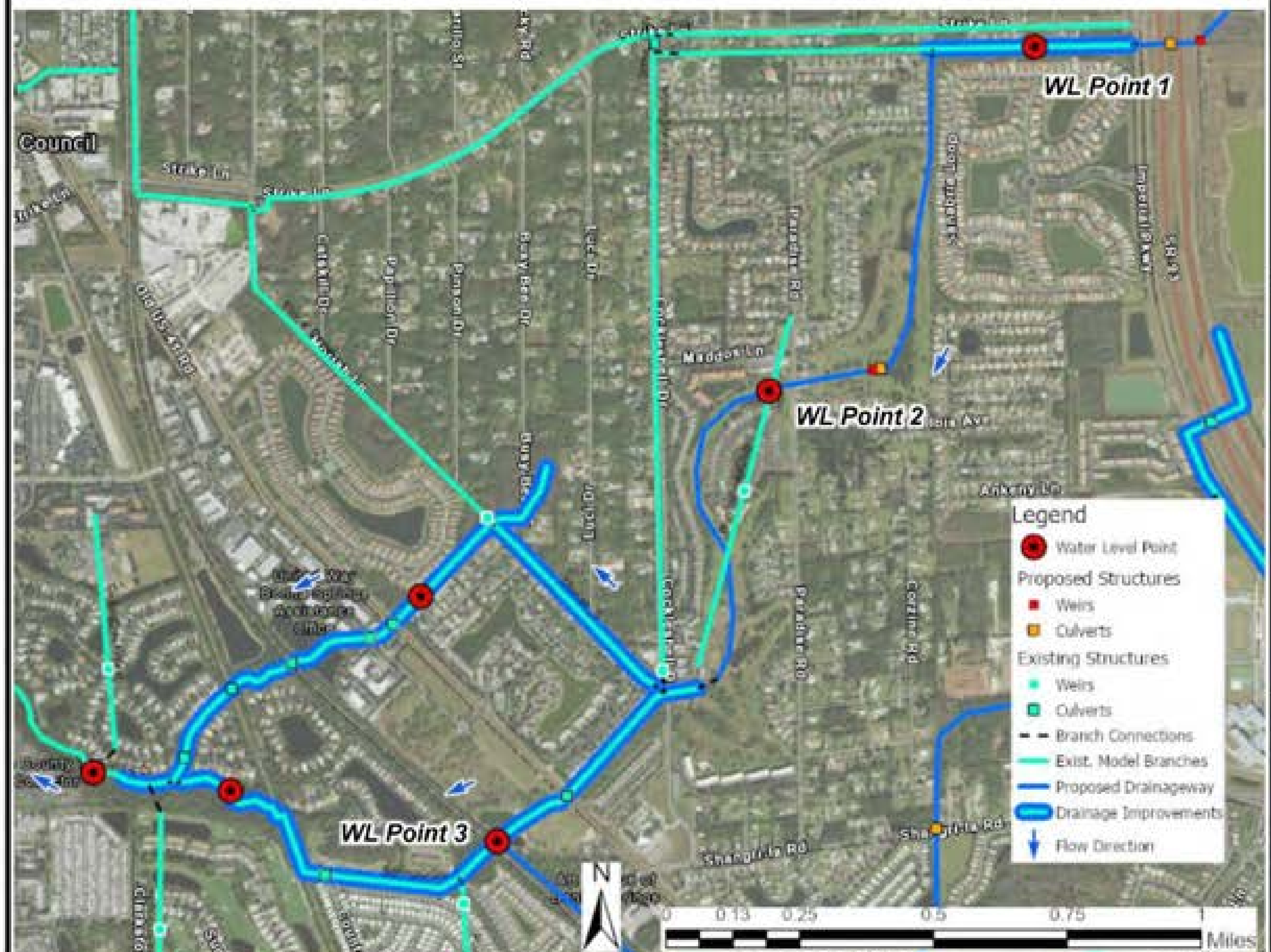


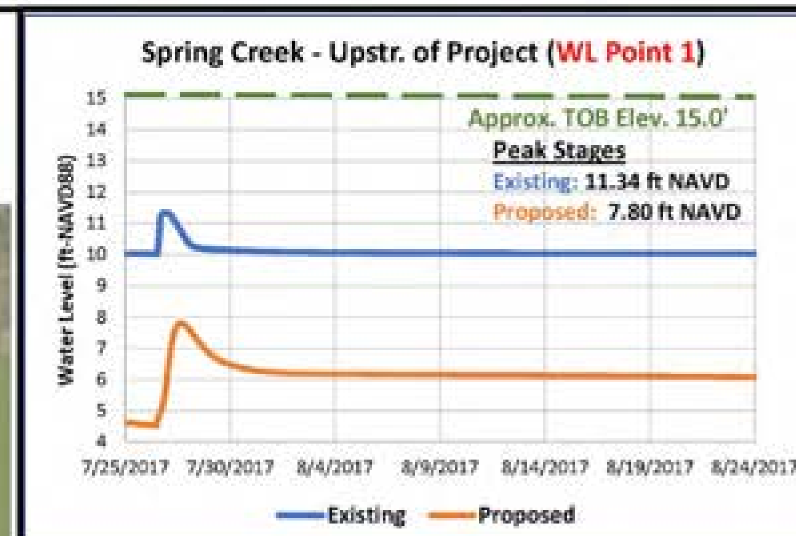
EXHIBIT 1.3.9 (d): 1 of 2

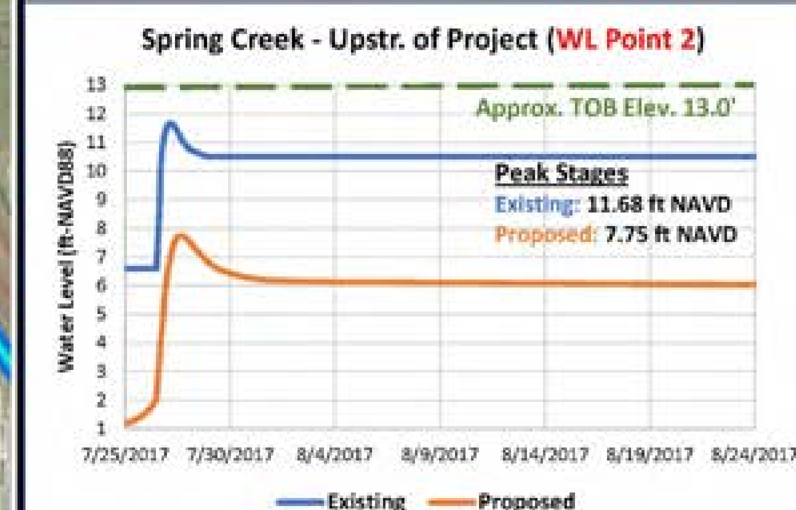
1.3.9 I-75 to Spring Creek Drainageway (North)

Water Level(s)

100-yr 3-day (Jul Start)







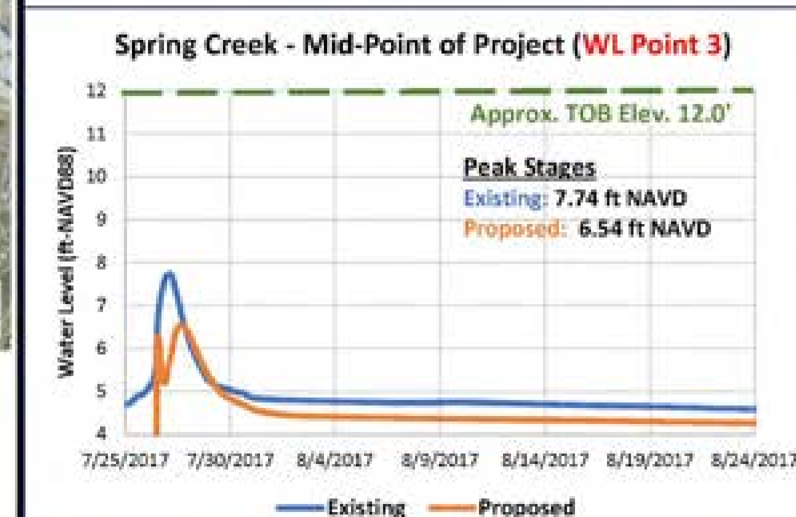
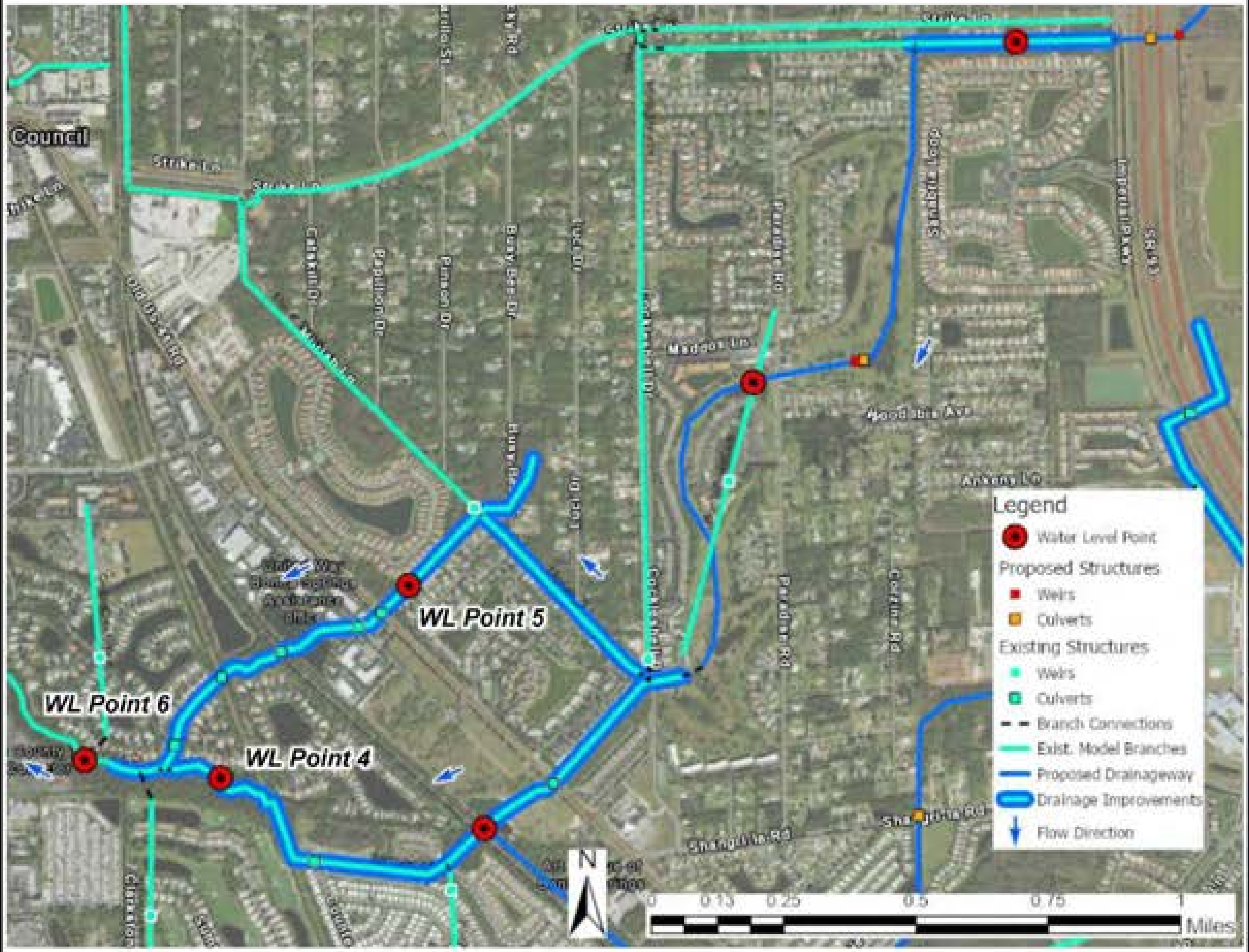
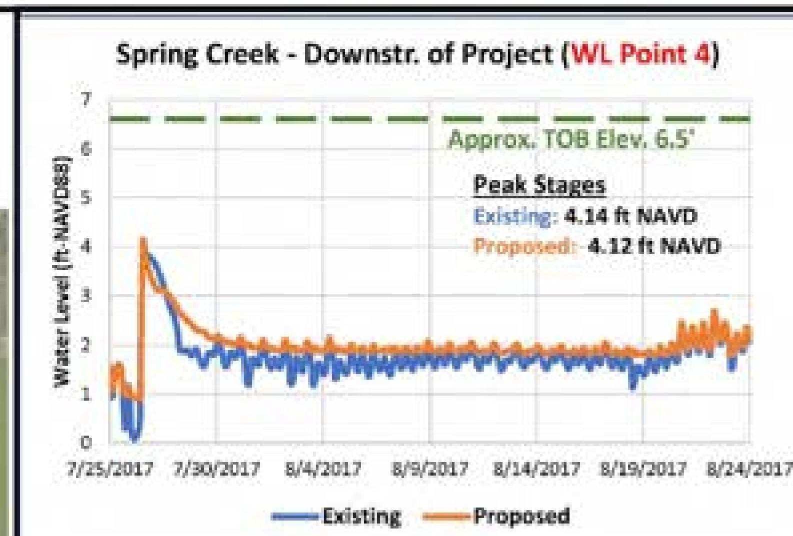
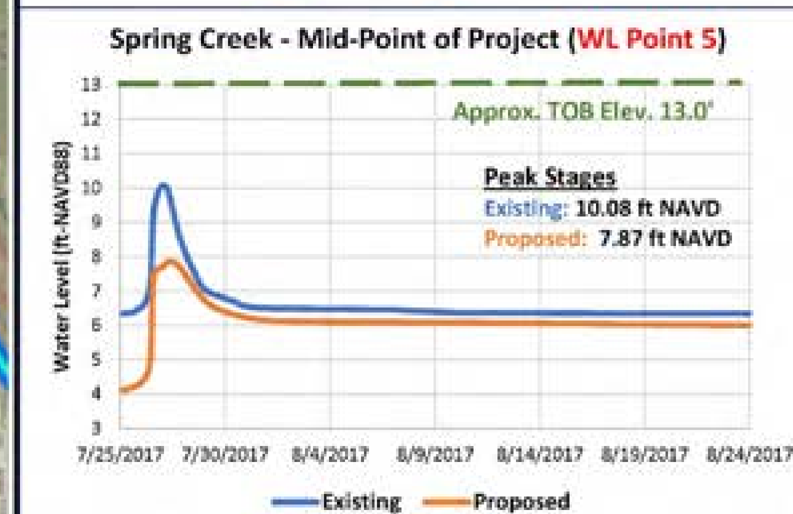
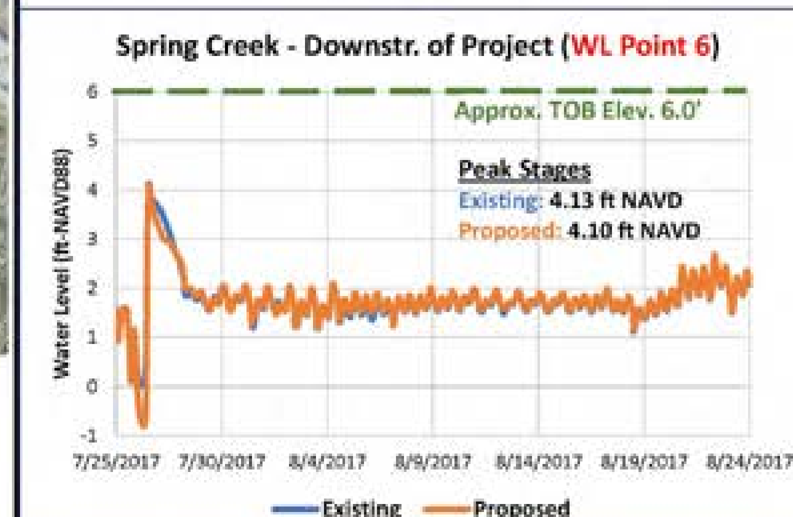


EXHIBIT 1.3.9 (d): 2 of 2









1.3.9 I-75 to Spring Creek Drainageway (North)

Water Level(s)

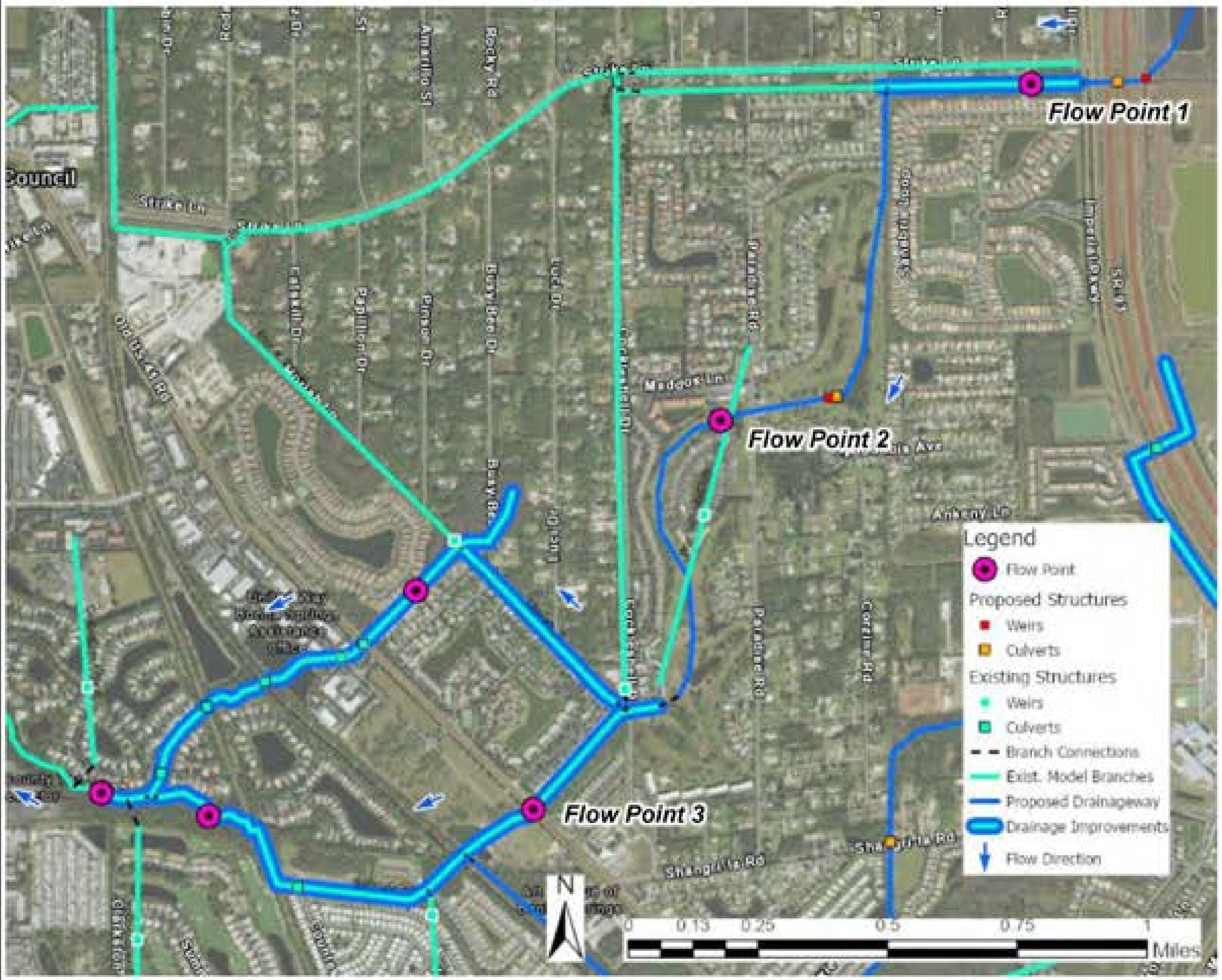
100-yr 3-day (Jul Start)

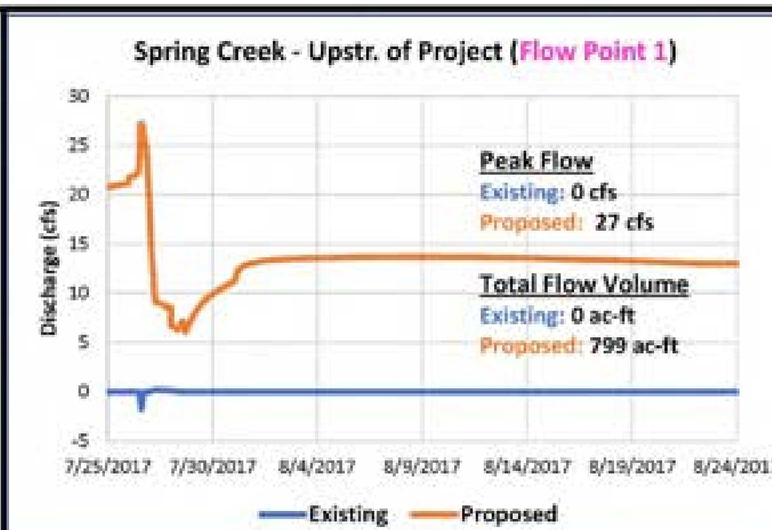
EXHIBIT 1.3.9 (e): 1 of 2

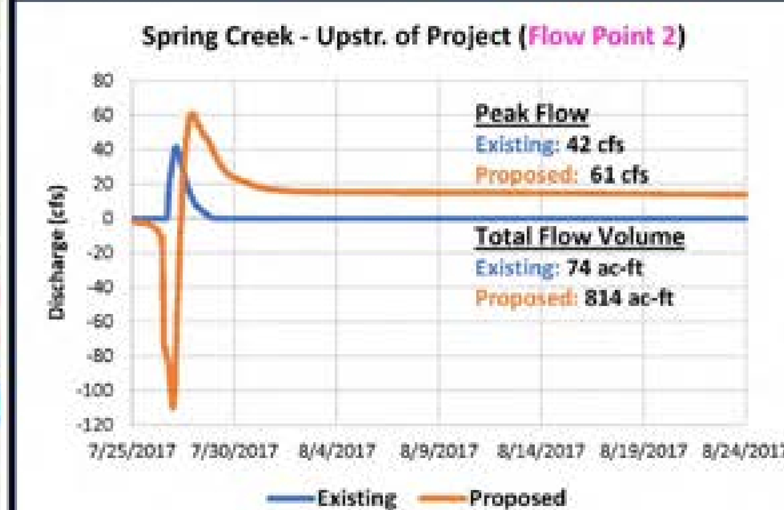
1.3.9 I-75 to Spring Creek Drainageway (North)

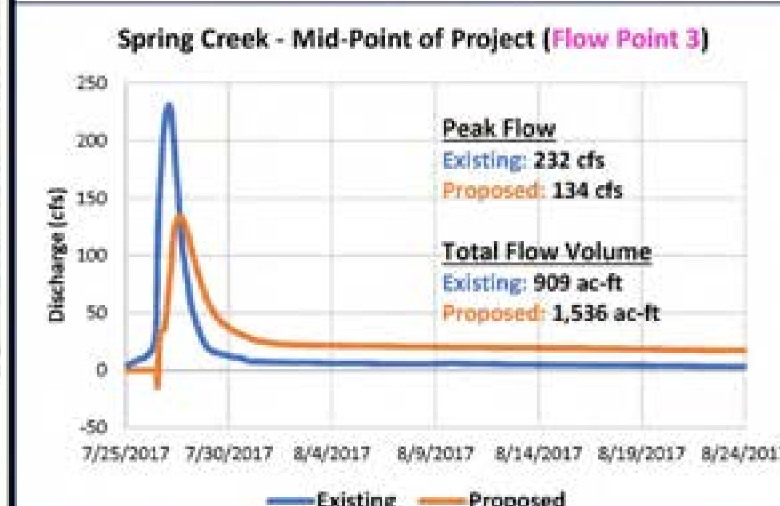
Flow(s)

100-yr 3-day (Jul Start)









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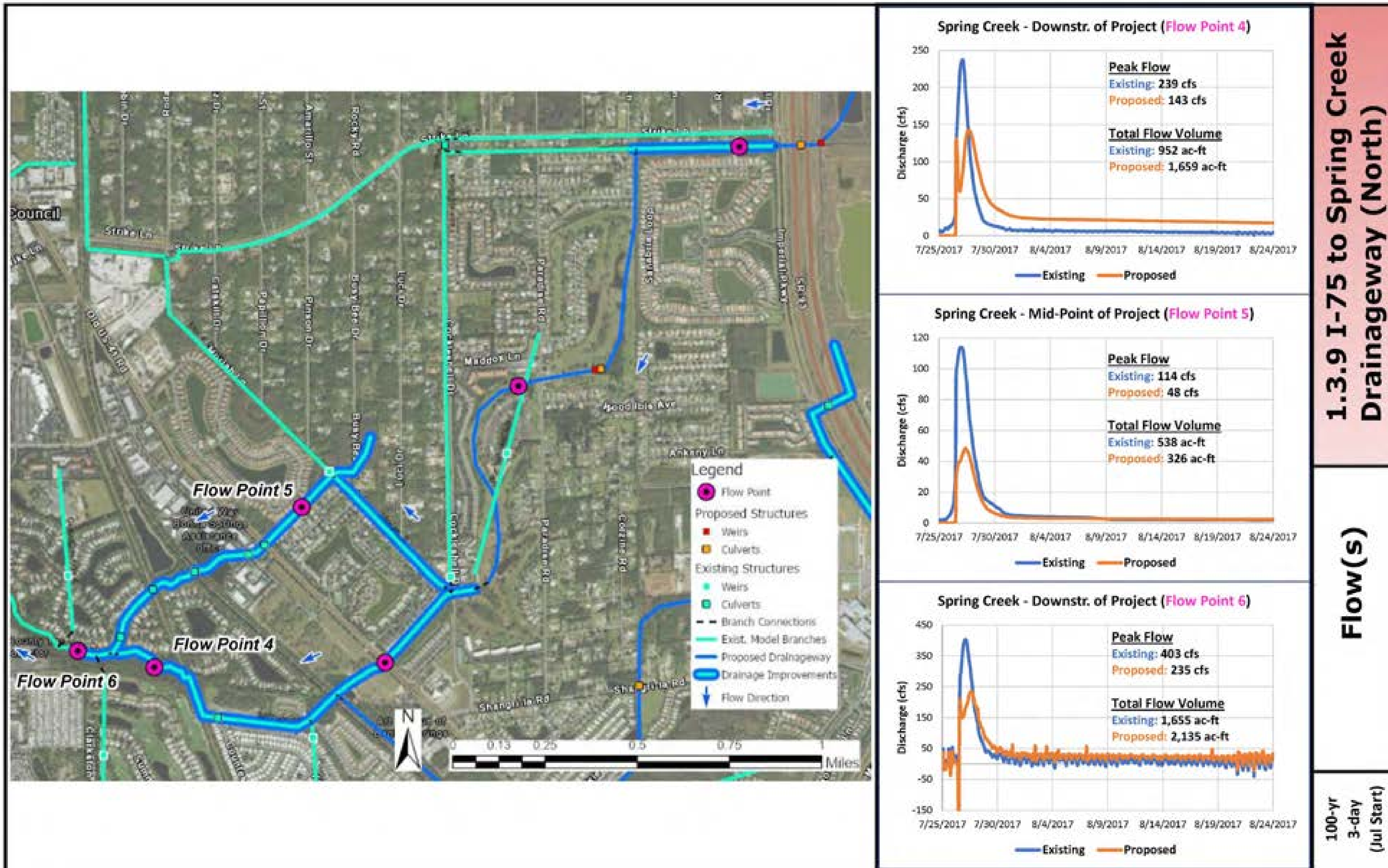
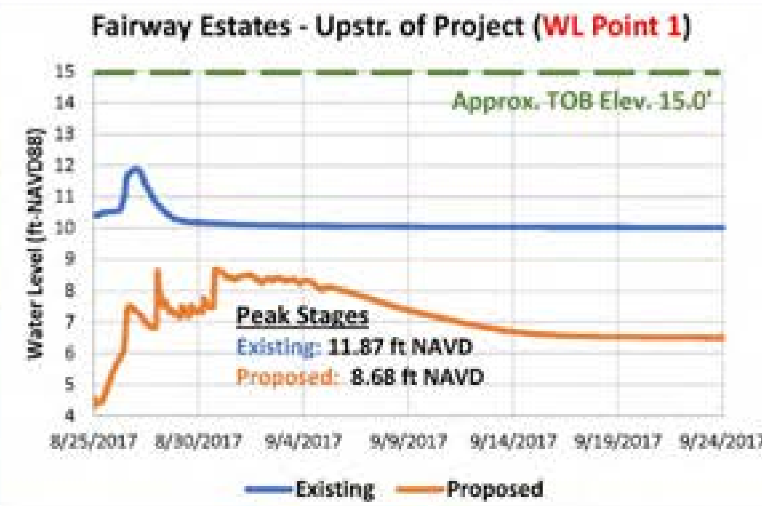
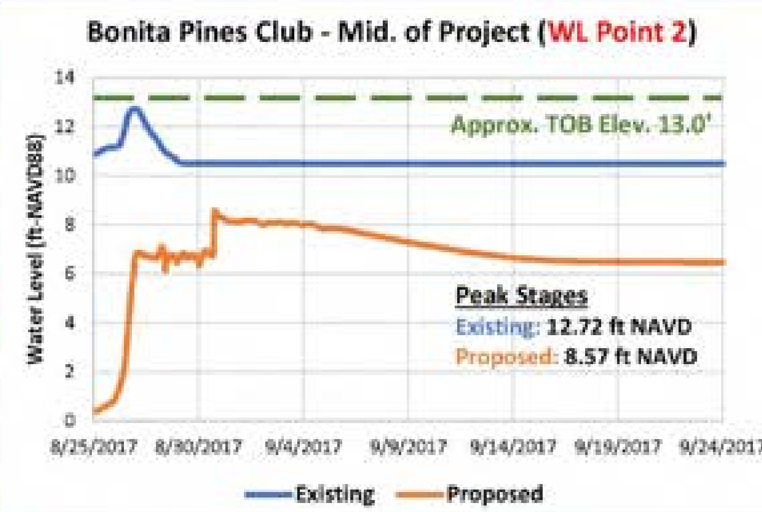
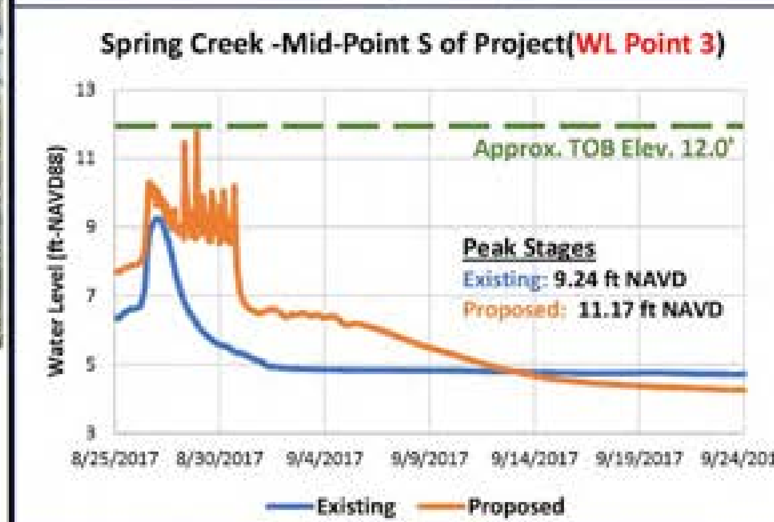


EXHIBIT 1.3.9 (f): 1 of 2







1.3.9 I-75 to Spring Creek Drainageway (North)

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.9 (f): 2 of 2

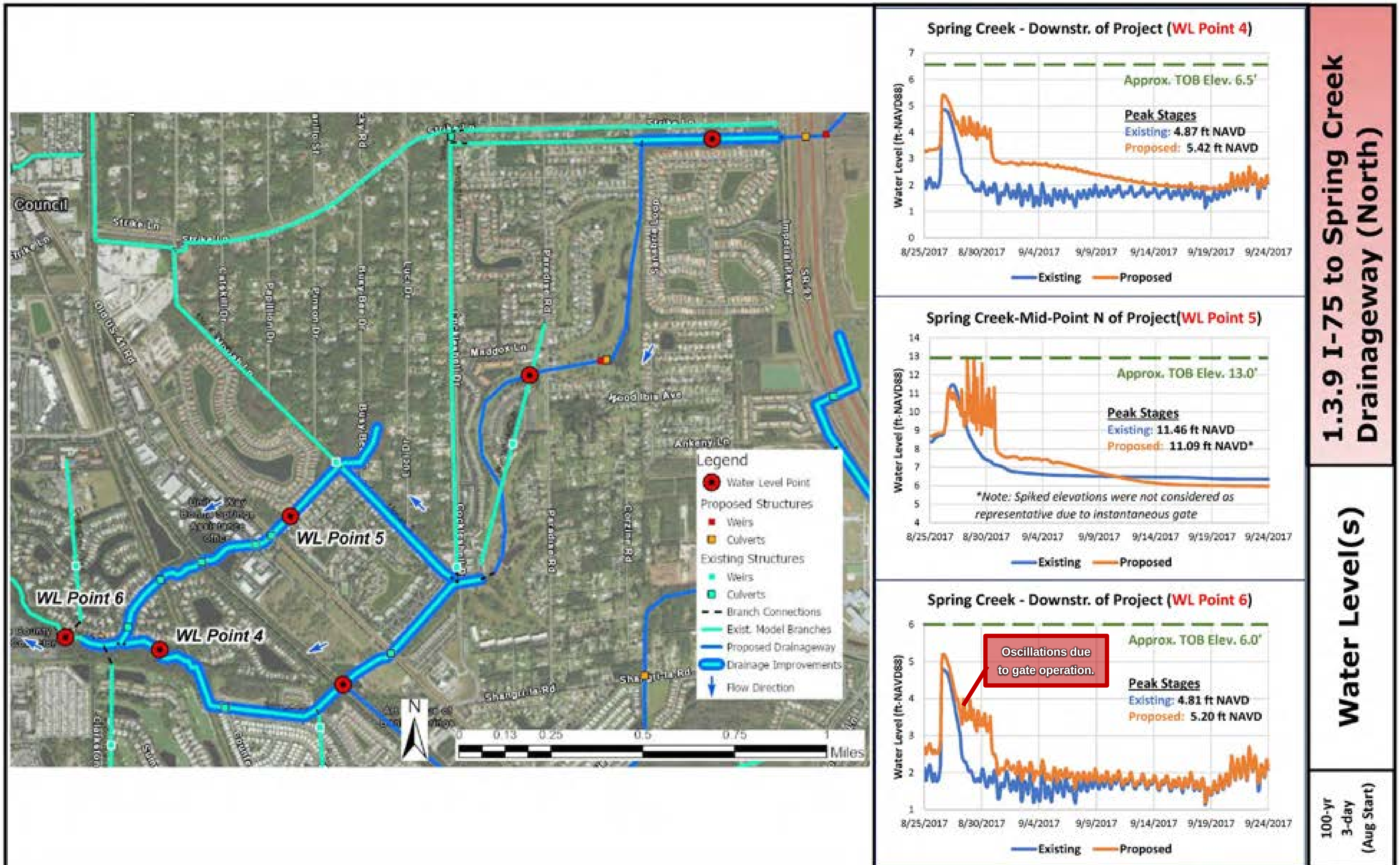
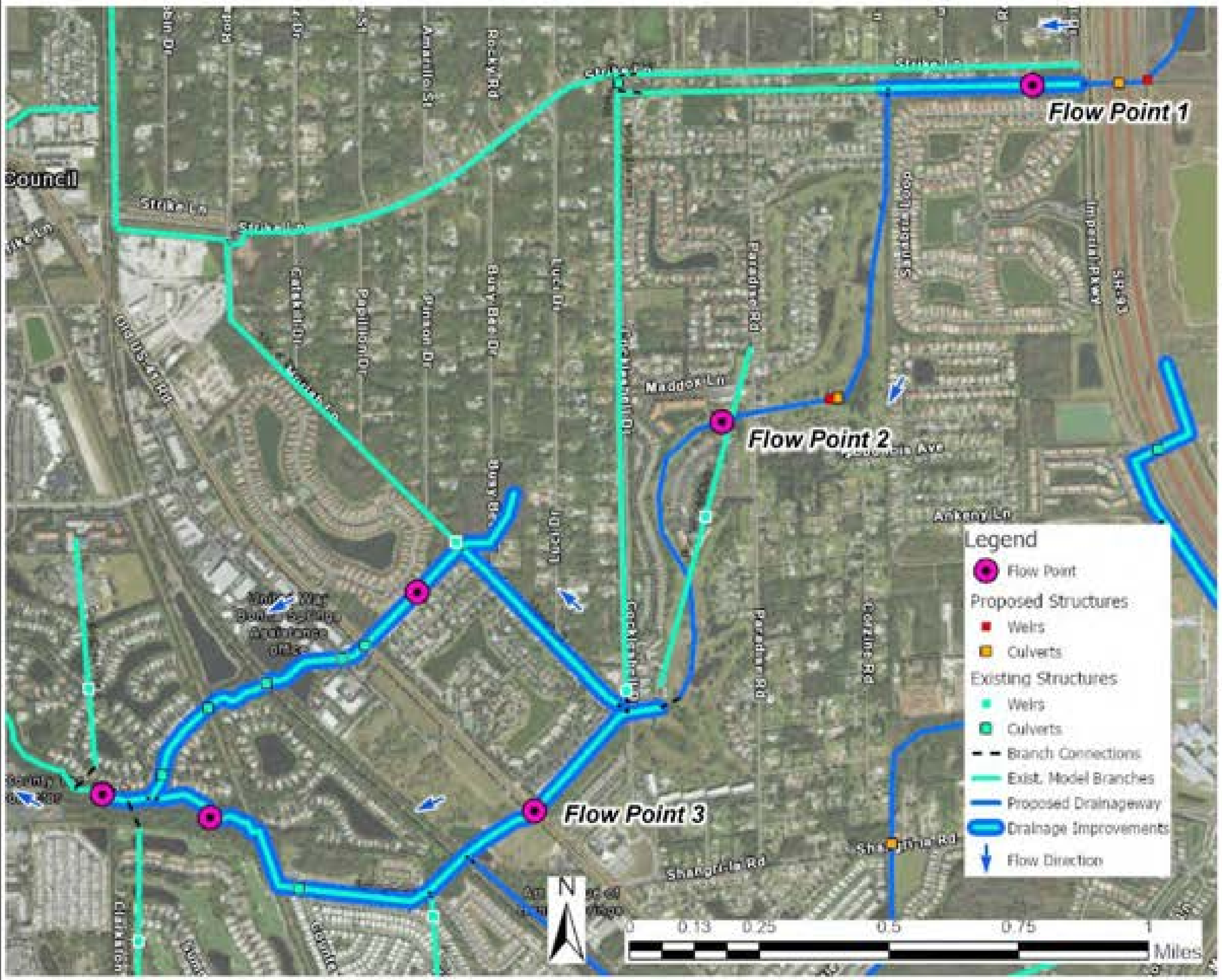
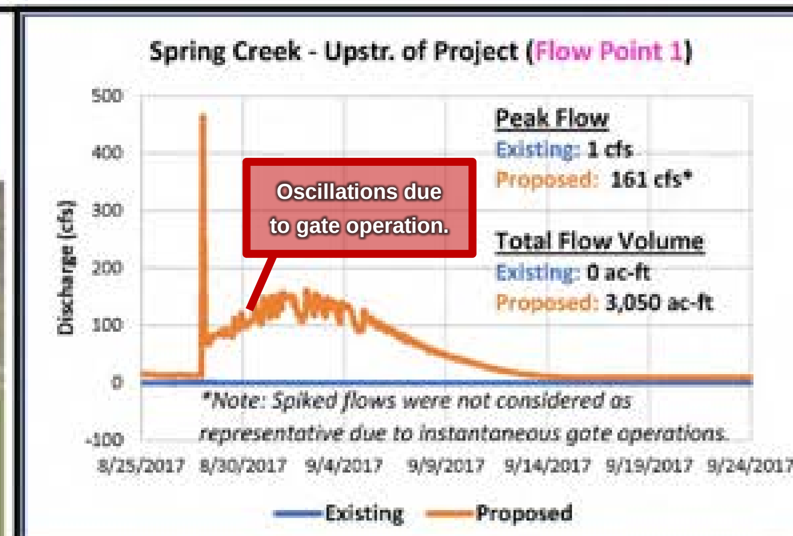
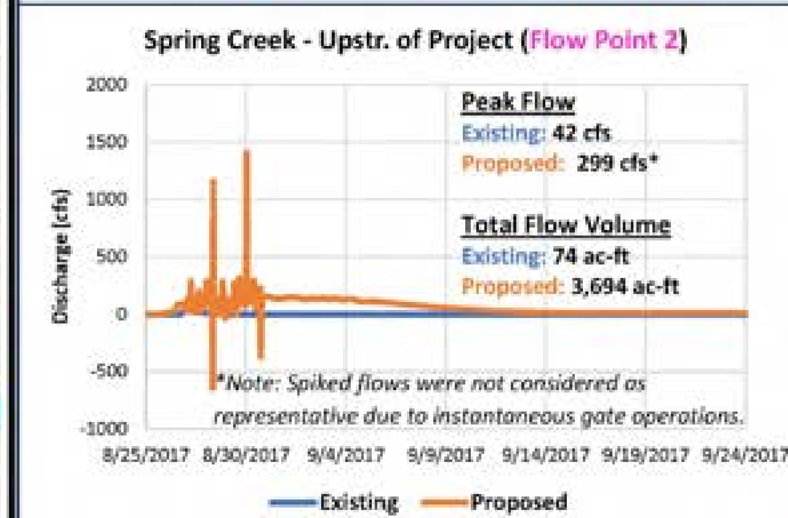
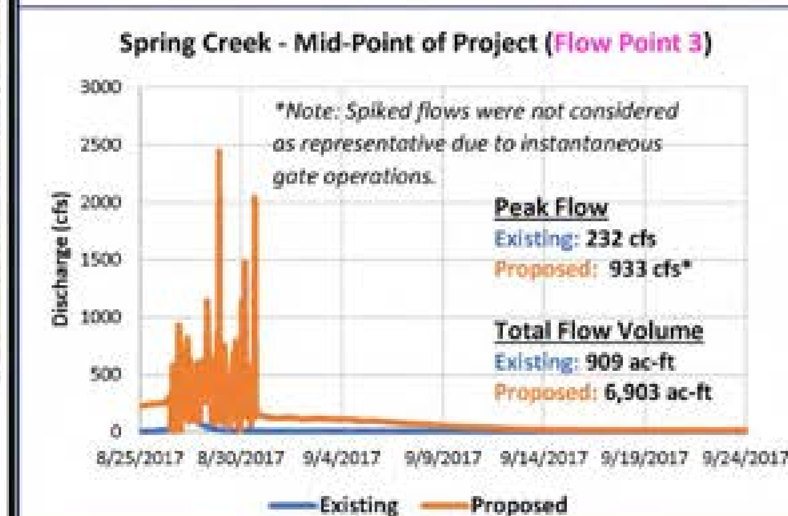


EXHIBIT 1.3.9 (g): 1 of 2







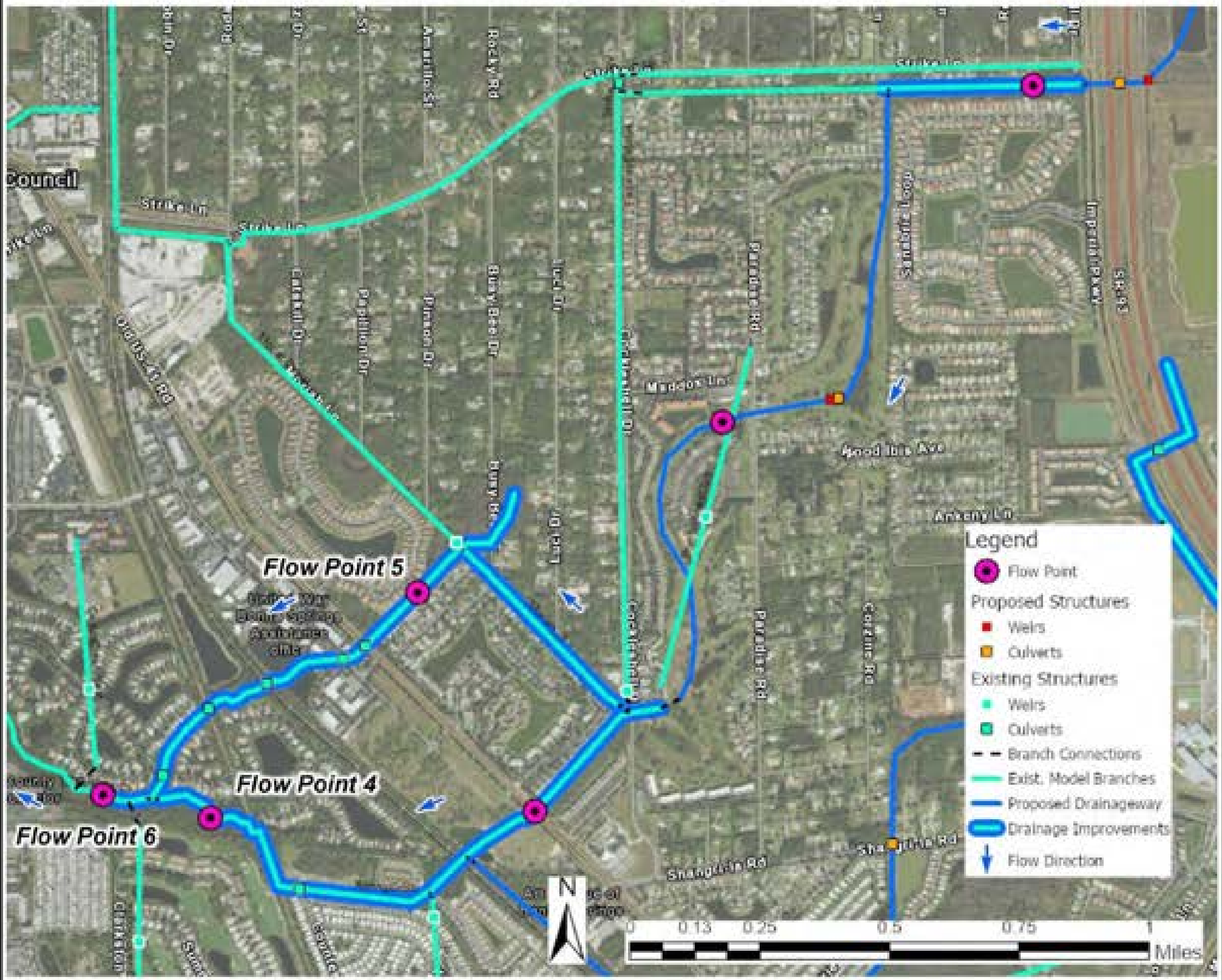


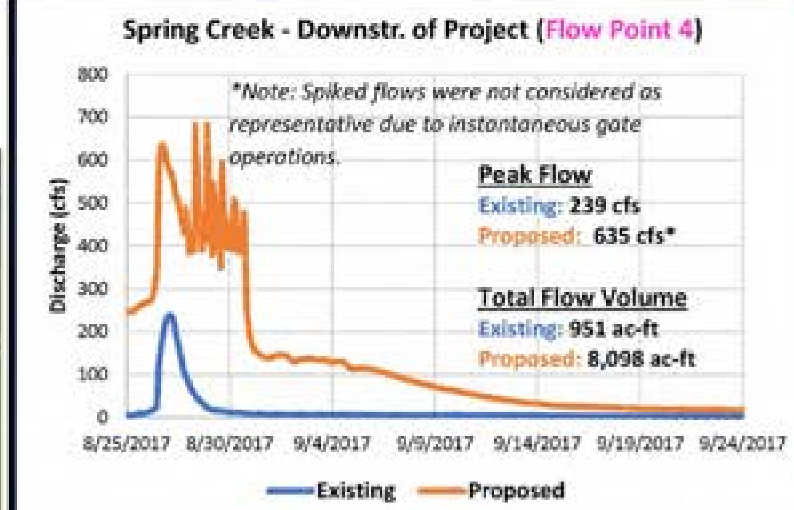
1.3.9 I-75 to Spring Creek Drainageway (North)

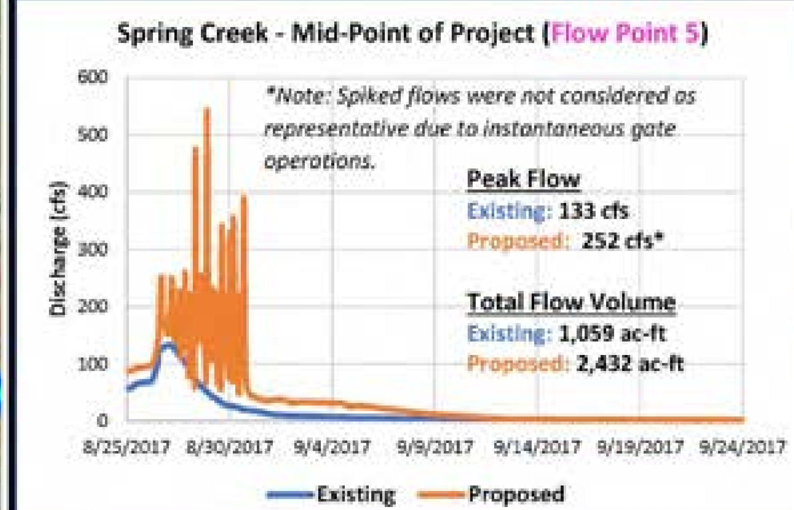
Flow(s)

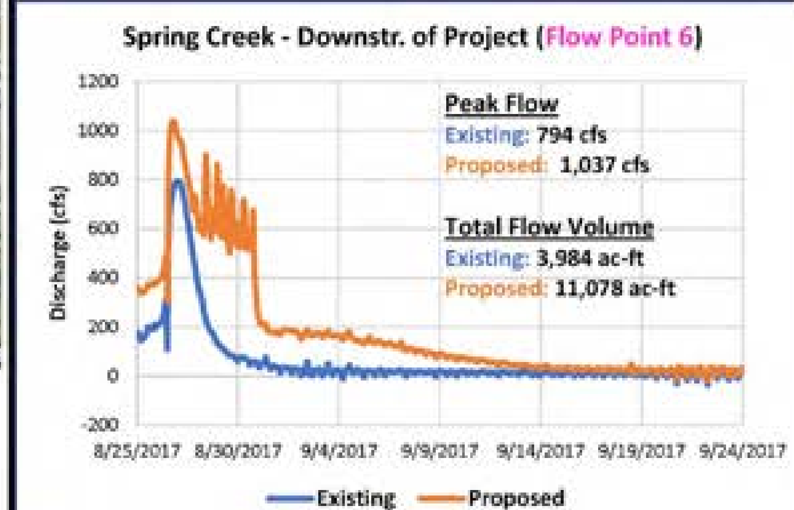
100-yr 3-day (Aug Start)

EXHIBIT 1.3.9 (g): 2 of 2









1.3.9 I-75 to Spring Creek Drainageway (North)

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.9 (h): 1 of 2

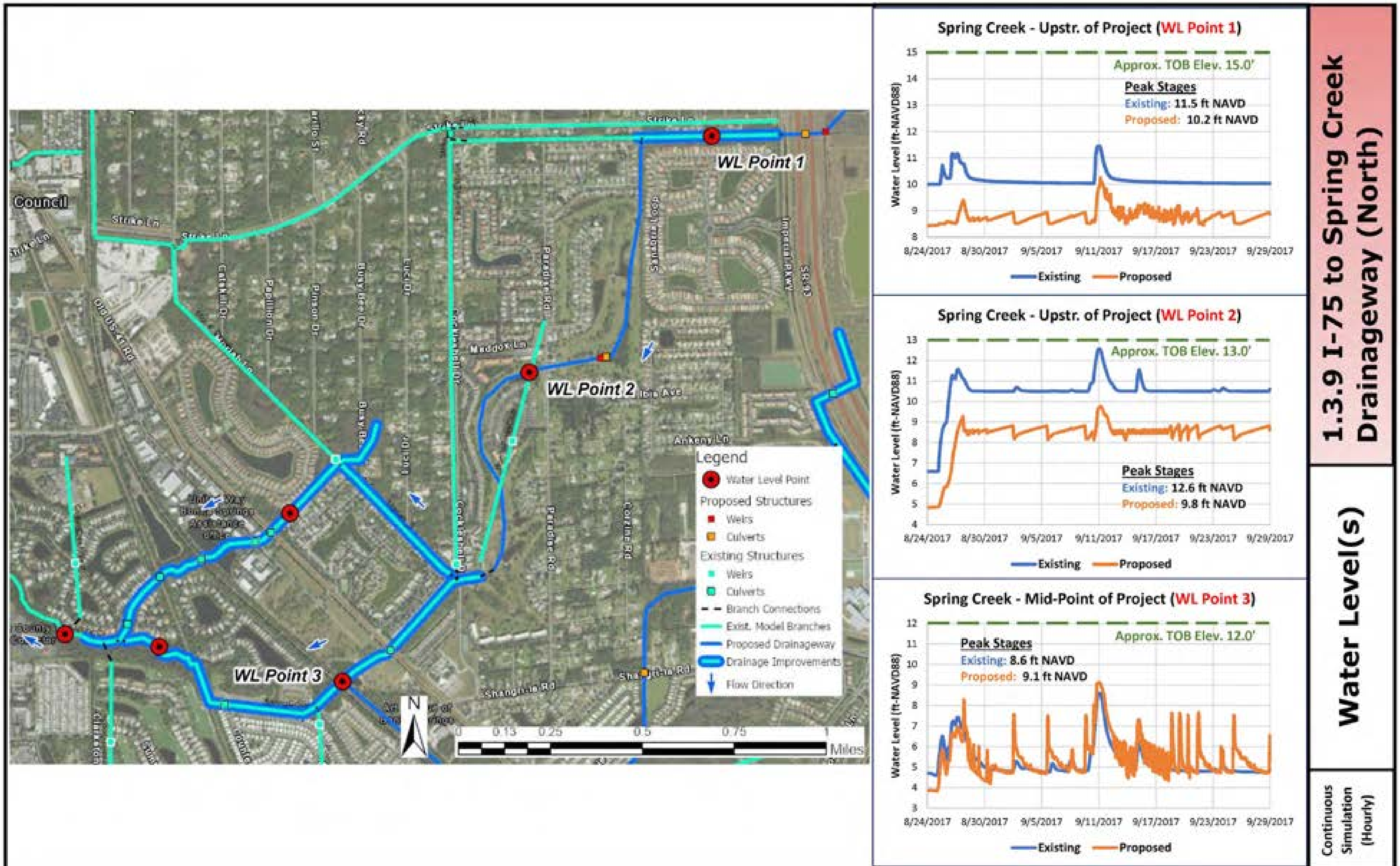
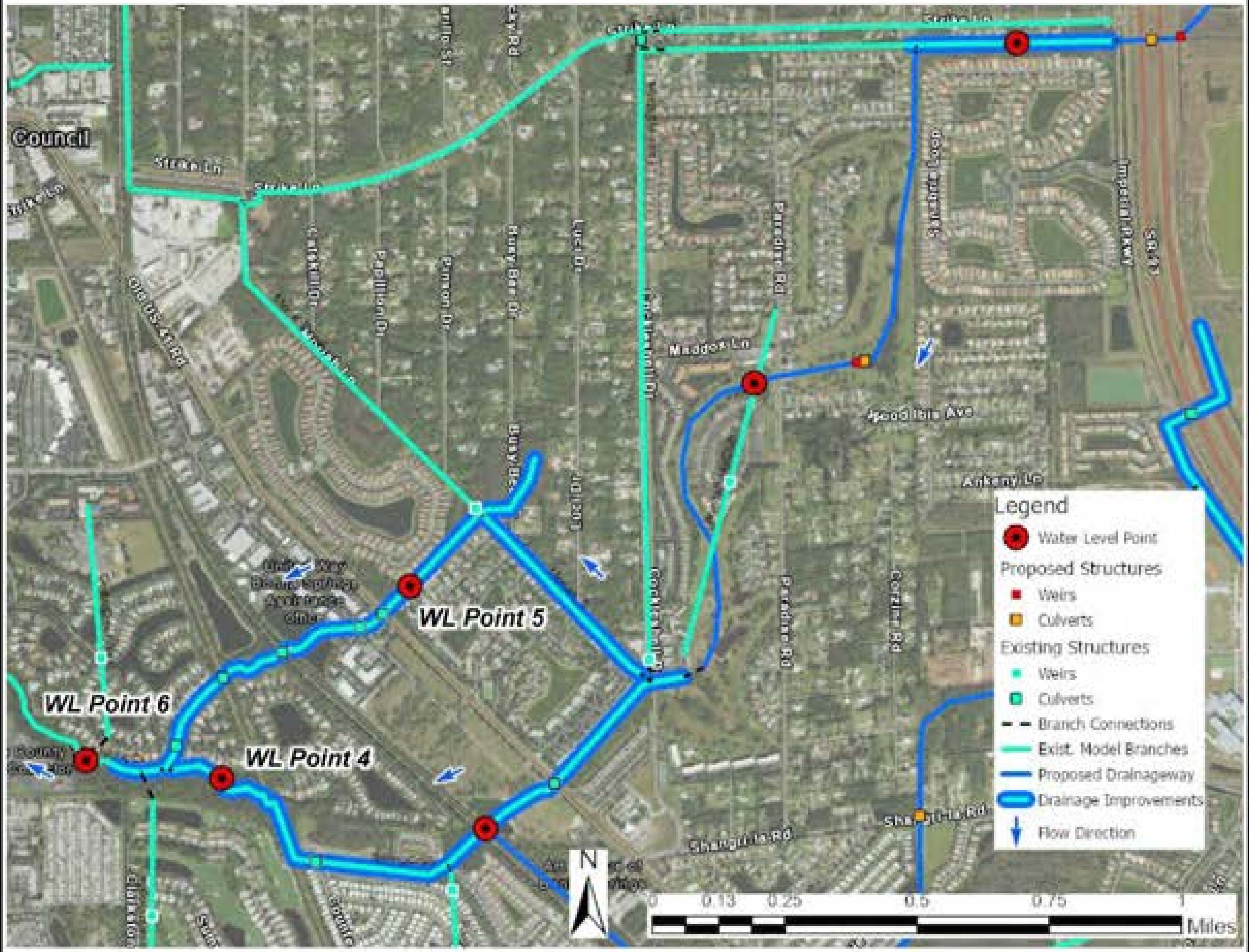


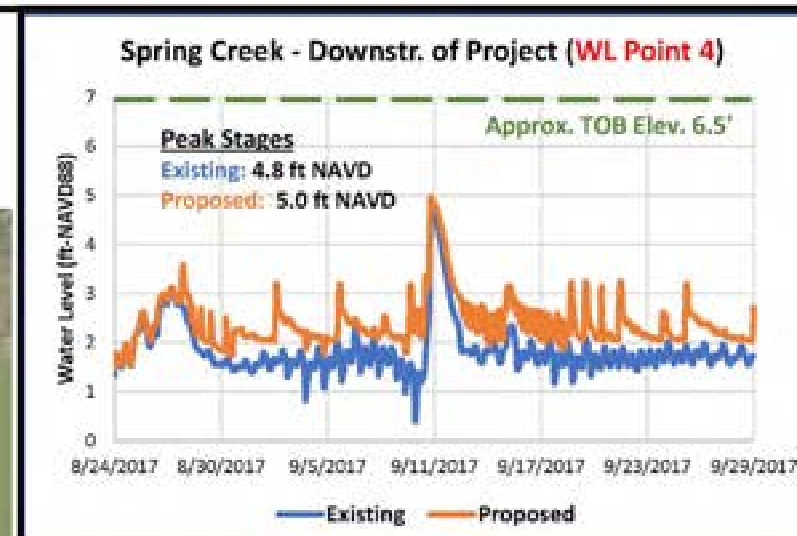
EXHIBIT 1.3.9 (h): 2 of 2

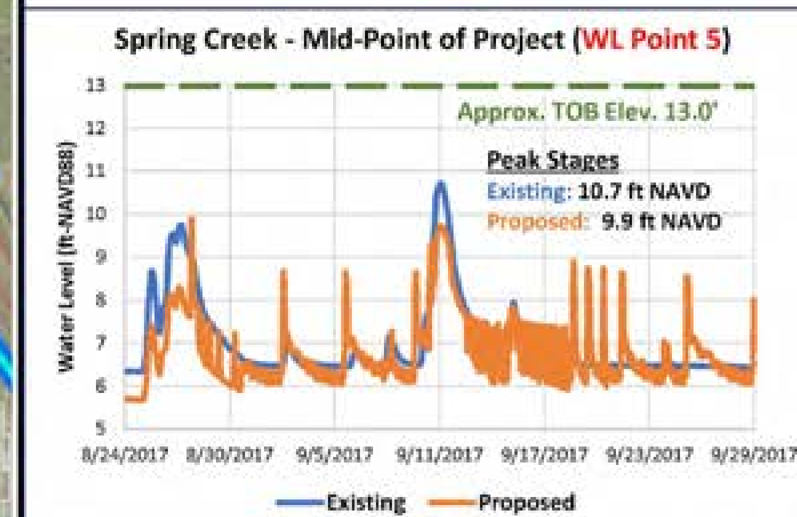
1.3.9 I-75 to Spring Creek Drainageway (North)

Water Level(s)

Continuous Simulation (Hourly)







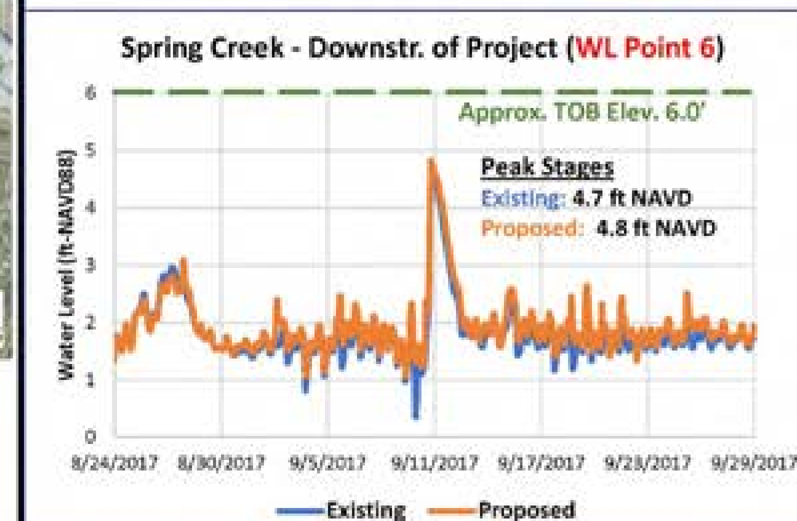
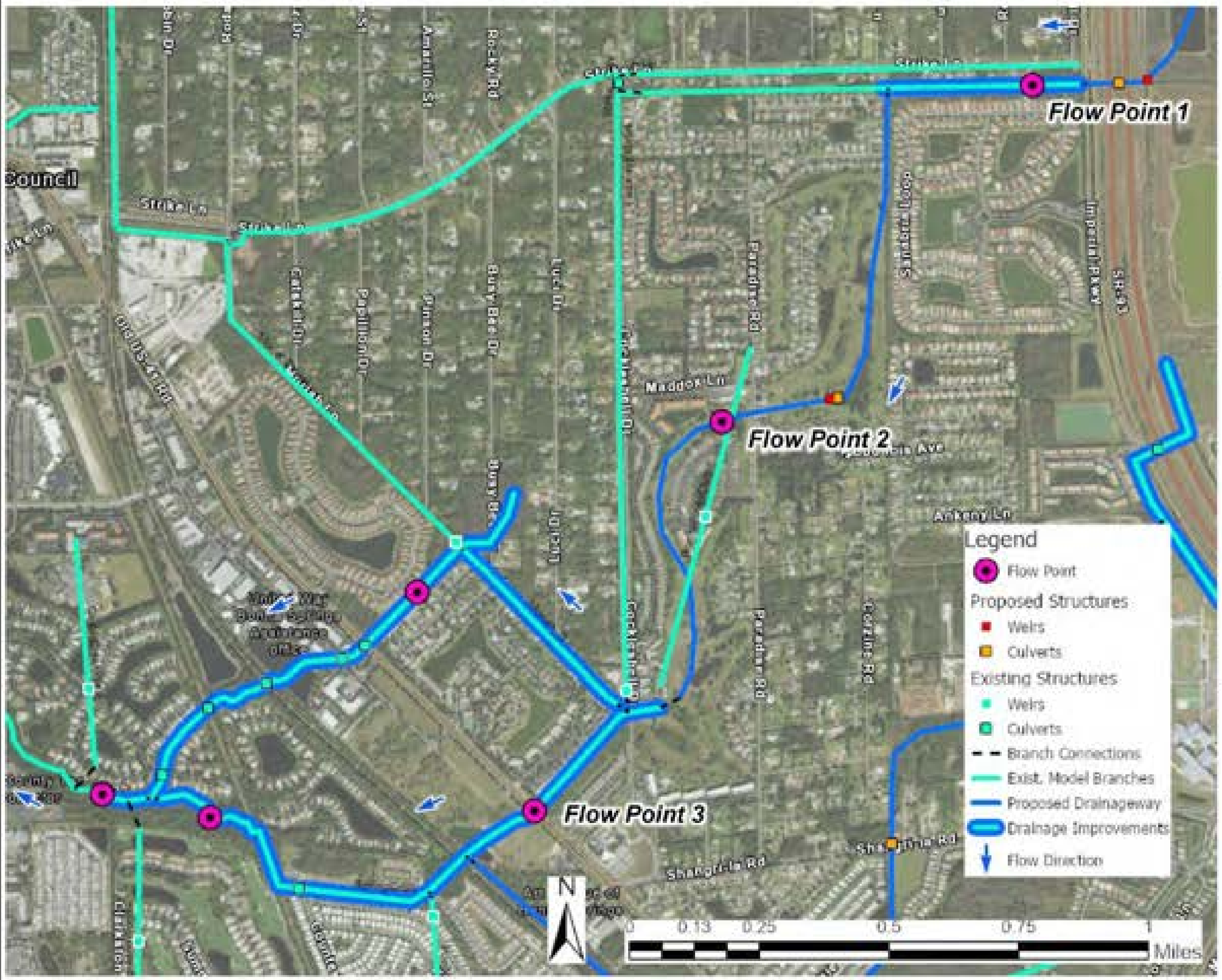
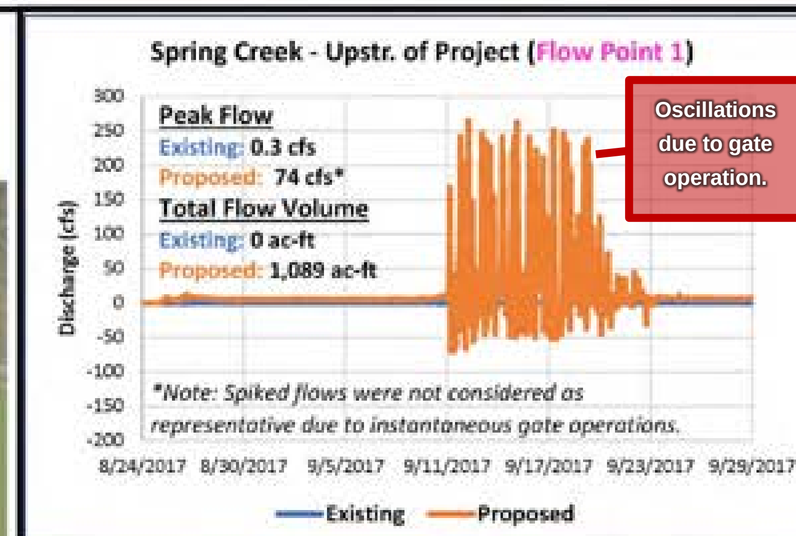
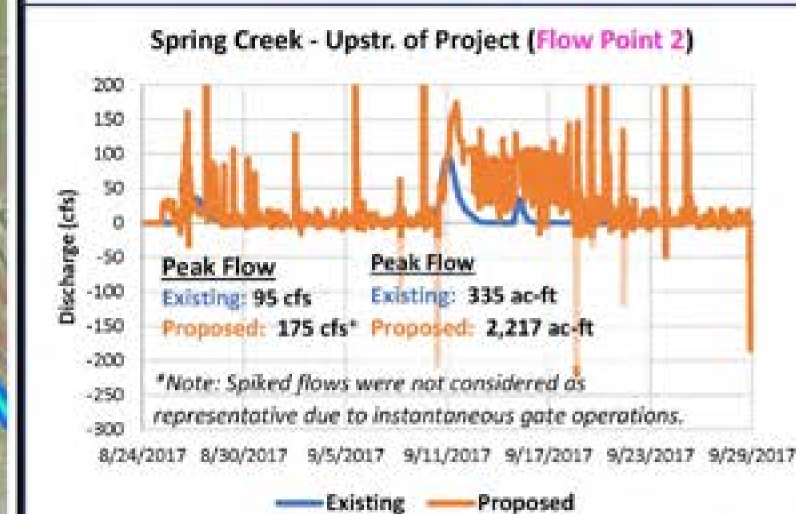
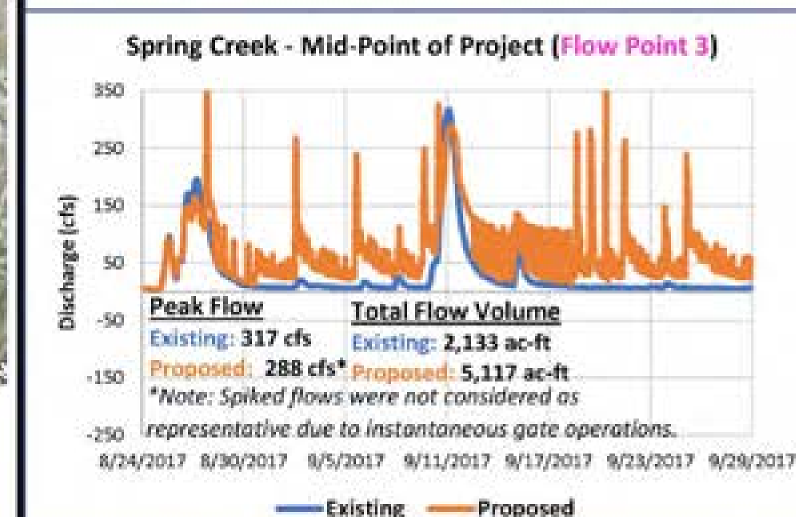


EXHIBIT 1.3.9 (i): 1 of 2







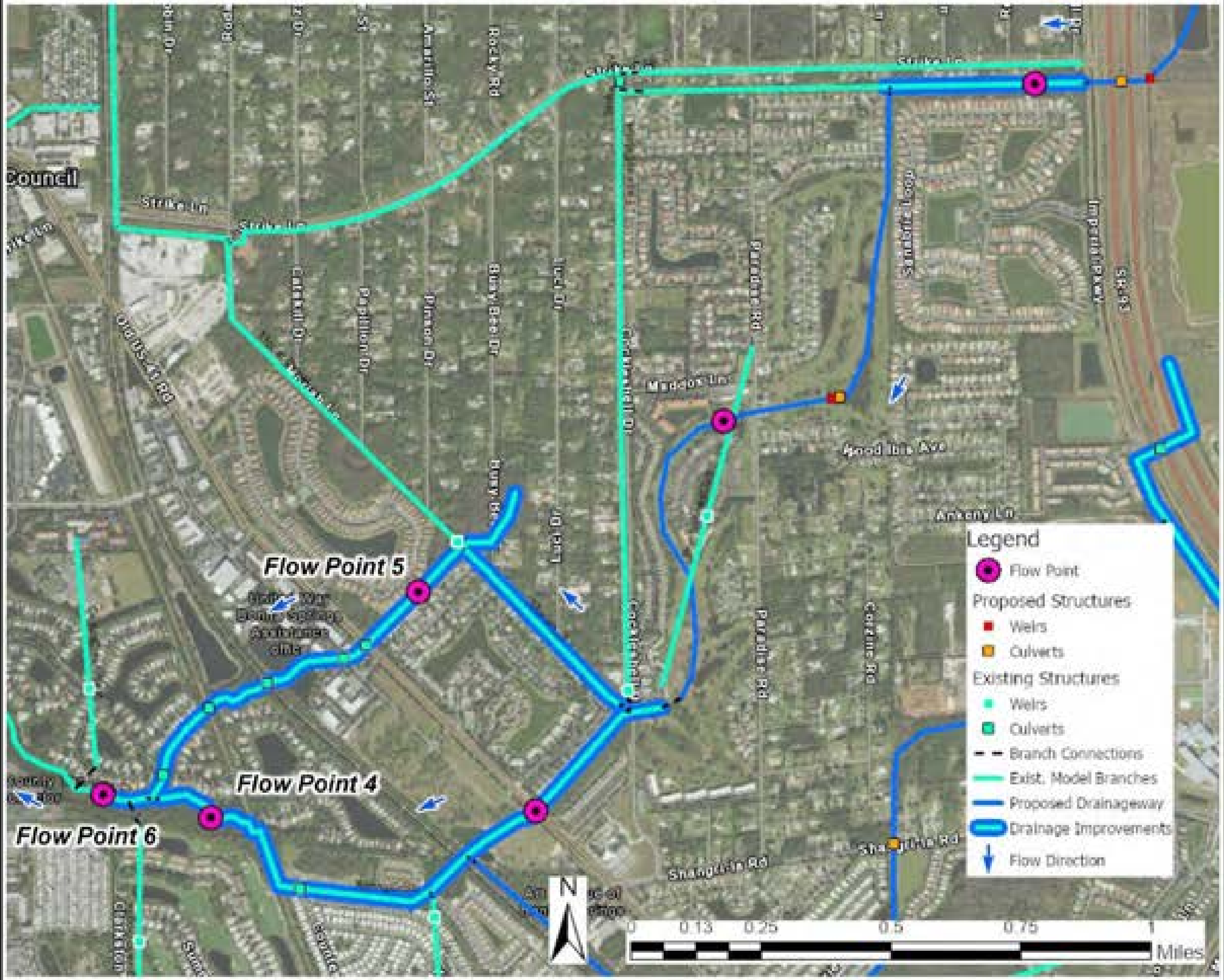


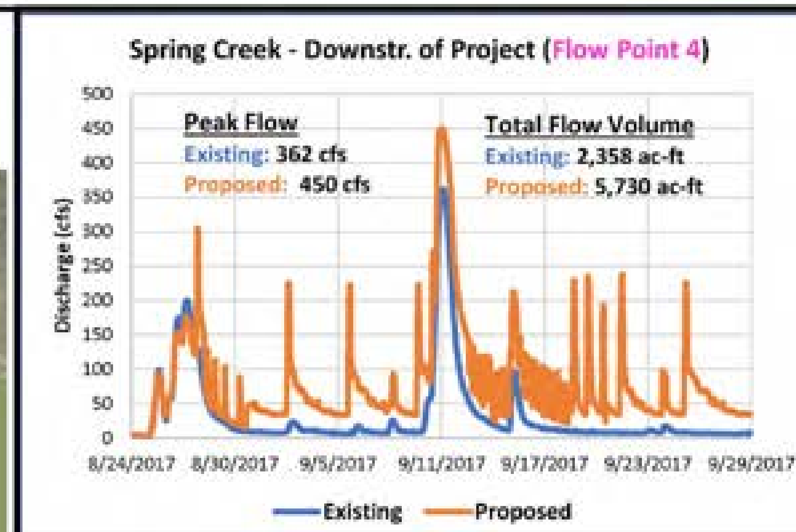
1.3.9 I-75 to Spring Creek Drainageway (North)

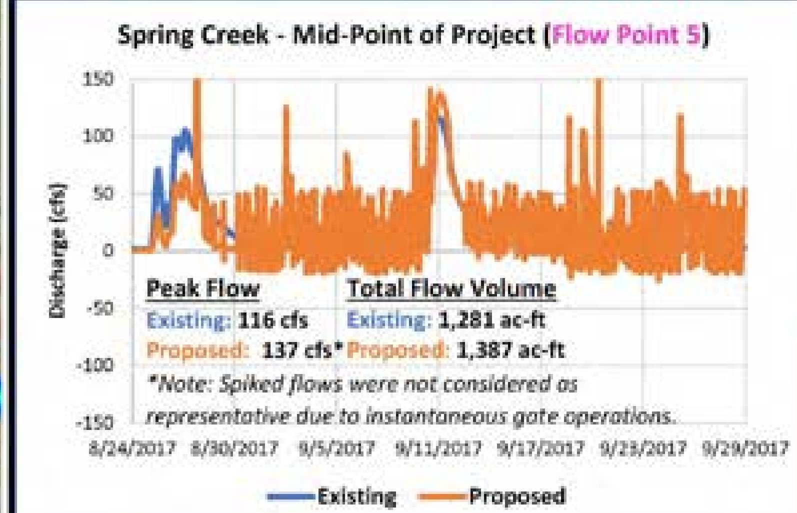
Flow(s)

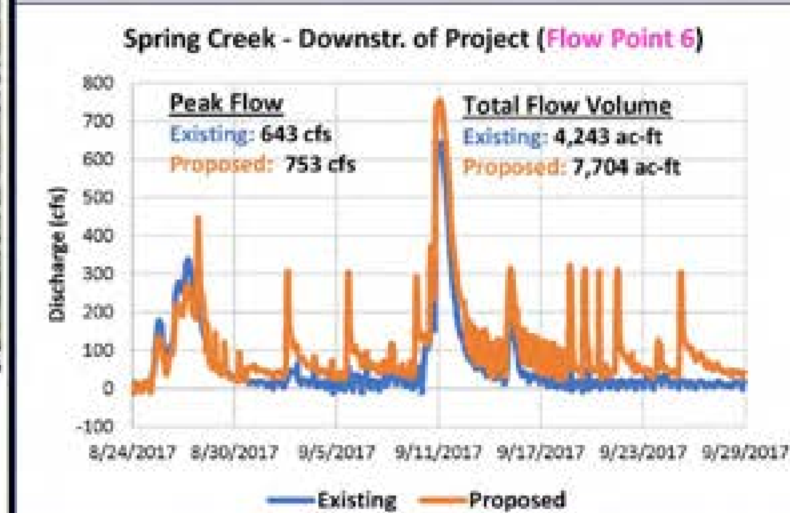
Continuous Simulation (Hourly)

EXHIBIT 1.3.9 (i): 2 of 2









1.3.9 I-75 to Spring Creek Drainageway (North)

Flow(s)

Continuous Simulation (Hourly)

1.3.10 I-75 to Spring Creek Drainageway (South) Concept Plan

Background

This concept project extends a drainageway 3-4 miles inland from the natural mangrove lined Spring Creek along the railroad, traveling through developed areas, crossing roads, highways and through large residential tracts utilizing existing drainageways where practical to reach an existing box culvert to link drainage east of the Interstate No. 75 to Estero Bay. Historically, this poorly drained area relied on overland sheet flow drainage. Railroad and road construction along with land development has blocked, confined, and restricted the natural sheet-flow without adequate replacement drainage conveyances.

Location

This proposed conceptual project is in SE Lee County beginning at Interstate 75 north of Bonita Beach Road, crosses Old U.S. 41. and continues to the Spring Creek Drainageway as illustrated in **Figure 32**.

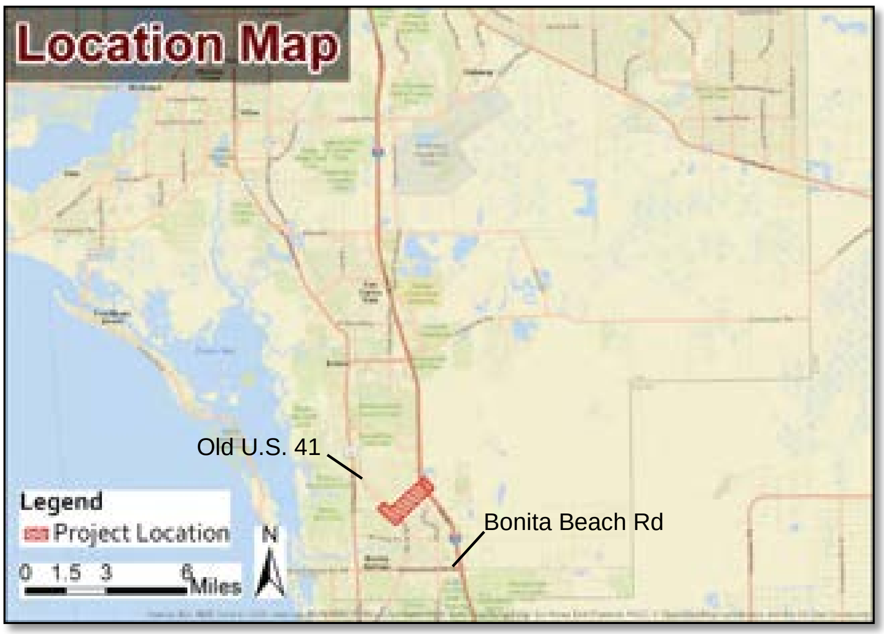


Figure 32 – Location Map, 1.3.10 I-75 to Spring Creek Drainageway (South)

Description

This proposed conceptual project conveys excess stormwater drainage flow from an existing drainage structure under I-75 to Spring Creek Drainageway extension. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges as illustrated in **Figure 33**.

Figure 33 - Concept Plan, 1.3.10 I-75 to Spring Creek Drainageway (South)

Purpose

This proposed project improves conveyance of excess stormwater to reduce flooding and shorten post-storm recovery of water levels.

Evaluation

Viability

This project concept provides an alternate flow way from Interstate 75 drainage crossing heading southwest and eventually reaching a drainage way along the rail road. This project has challenges in obtaining rights of way. This is an important flow way for handling flows from the east of Interstate 75 in a more direct manner that justifies the project's complexities.

Community Considerations

This conveyance is located along property lines and should not be a detriment to the residents in this area. This conveyance provides a drainage opportunity for improvement in the area. This drainageway would utilize Lee County owned properties, Bonita 30 RPD, Bonita St. James, Bonita Lake LLC, the U.S. Postal Service and numerous privately-owned properties.

Environmental & Permittability Considerations

The conveyance is routed to utilize existing drainage ways where possible and avoid obvious wetland areas. Water control structures would be used to maintain water levels along the conveyance route. During the design phase, the specific route can avoid the most environmentally sensitive areas as shown in **Figure 34** below.

Figure 34 - Example of winding flow route to mitigate impacts to environmental areas.

Land Availability

This project requires land acquisition from private property owners and requires approval from the City of Bonita Springs. Working along the railroad requires coordination with the railroad and possibly agreements, should work be required in the railroad right of way.

Opinion of Probable Cost

The cost opinion shown in **Table 11** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 11 - Opinion of Probable Cost breakdown, 1.3.10 I-75 to Spring Creek Drainageway (South)

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPP/ Misc.	1	LS	$ 554,000	$ 554,000
Clearing & Grubbing	24	AC	$ 14,000	$ 336,000
Earthwork	56,500	CY	$ 8	$ 452,000
Construction/ Maintenance Access	10,000	SY	$ 20	$ 200,000
Weir Structure 3.10A (Standard)	48	LF	$ 5,000	$ 240,000
Weir Structure 3.10B (Standard)	48	LF	$ 5,000	$ 240,000
Detours	1	LS	$ 300,000	$ 300,000
Box Culvert 3.10-1	75	CY	$ 1,200	$ 90,000
Box Culvert 3.10-2	75	CY	$ 1,200	$ 90,000
Box Culvert 3.10-3	75	CY	$ 1,200	$ 90,000
Box Culvert 3.10-4	75	CY	$ 1,200	$ 90,000
Electric Supply	1	LS	$ 20,000	$ 20,000
Grassing	49,000	SY	$ 2	$ 98,000
			Construction Cost Sub-Total:	**$ 2,800,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 845,000
			Land Acquisition	$ 1,475,000
			Project Administration/ CEI (10%):	$ 280,000
			Project Unknowns	$ 200,000
			Conceptual Project Cost:	**$ 5,600,000**
			Contingency (30%)	$ 1,700,000
			Conceptual Project Cost (with Contingency):	**$ 7,300,000**

Opportunities for Multiple Benefits & Uses

The incorporation of the hiking/walking trails along the conveyance may be a beneficial amenity to the residents in this area.

Other Considerations

Incorporation of a stormwater treatment area, such as a filter marsh would be a very beneficial component for water quality and reservoir storage. Environmental impacts, if any, would necessitate mitigation. A summary of this concept project is shown below in **Exhibit 1.3.10** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of conveying excess stormwater flows from east of Interstate 75 in the Bonita Grande area towards Spring Creek. The conveyances would link flow from a box culvert structure under Interstate 75, routing flow through Tropic Acres, along St. James Village, Bonita Lake RV Resort, and the railroad. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.10 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.10 (b) EXHIBIT 1.3.10 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.10 (d) EXHIBIT 1.3.10 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.10 (f) EXHIBIT 1.3.10 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.10 (h) EXHIBIT 1.3.10 (i)

Improvements were shown though an increase peak flow from the existing condition to the proposed condition, while peak water levels remained below the approximate top of bank elevation.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from east of Interstate 75 in the Bonita Grande area towards Spring Creek. These positive improvements warrant further design-level project development.

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project conveys excess stormwater drainage flow from an existing drainage structure under I-75 to Spring Creek Drainageway extension. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding and shorten post-storm recovery of water levels.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

I-75 to Spring Creek Drainageway (South)

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.10

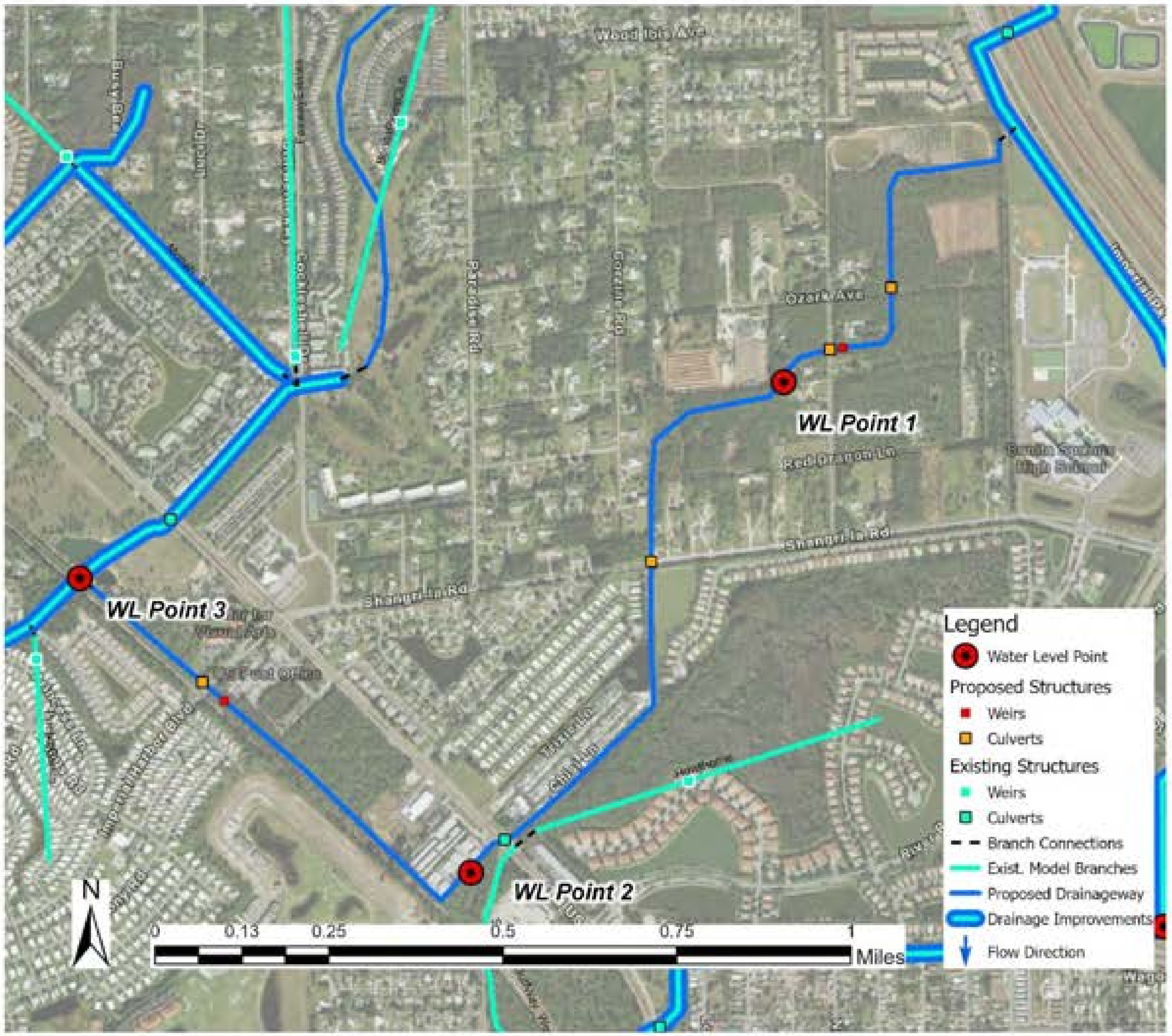
EXHIBIT 1.3.10 (a)

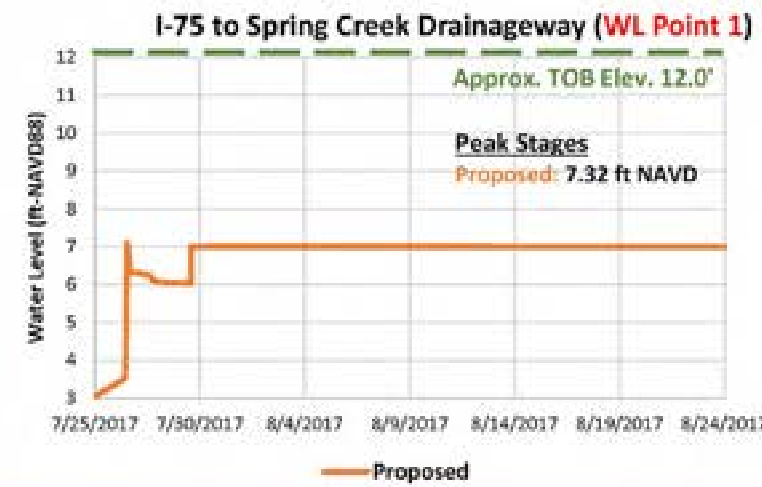
EXHIBIT 1.3.10 (b)

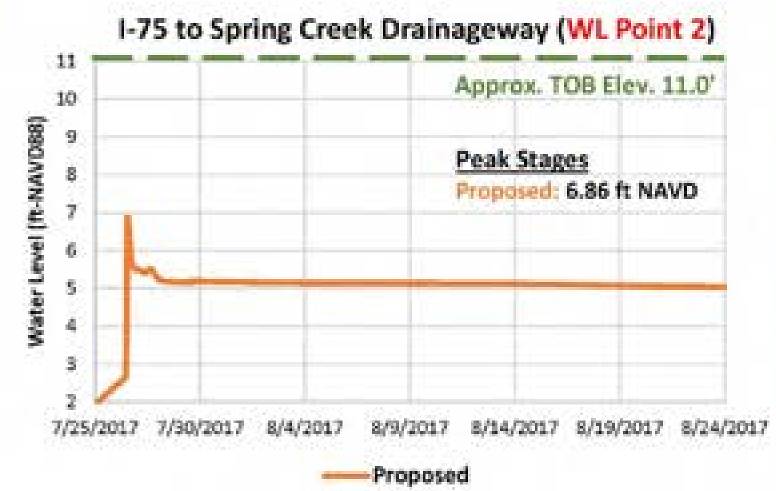
1.3.10 I-75 to Spring Creek Drainageway (South)

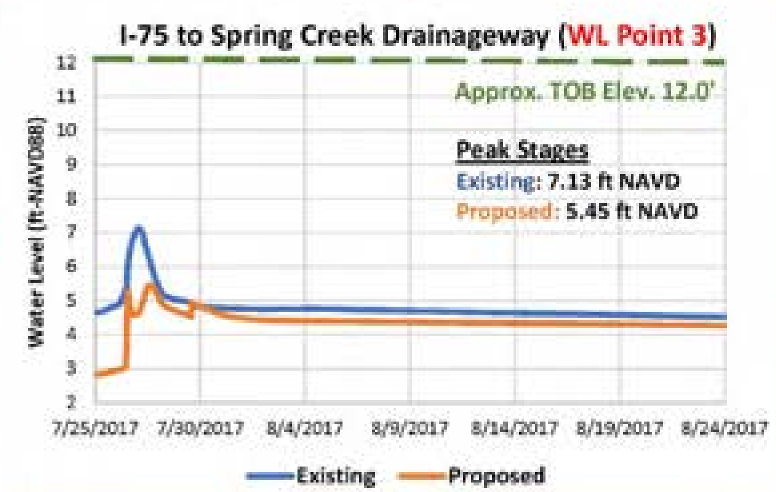
Water Level(s)

25-yr 3-day (Jul Start)









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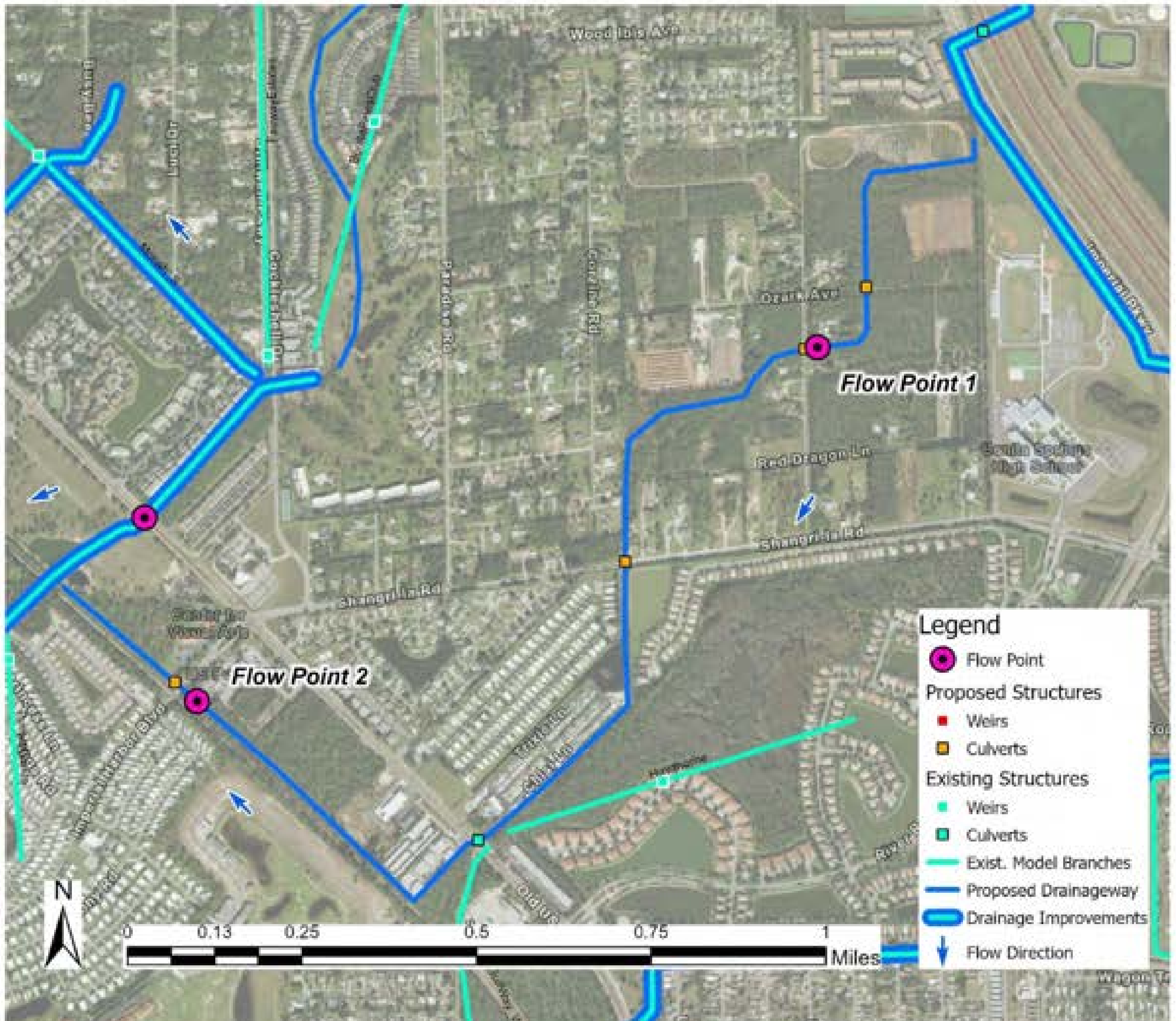
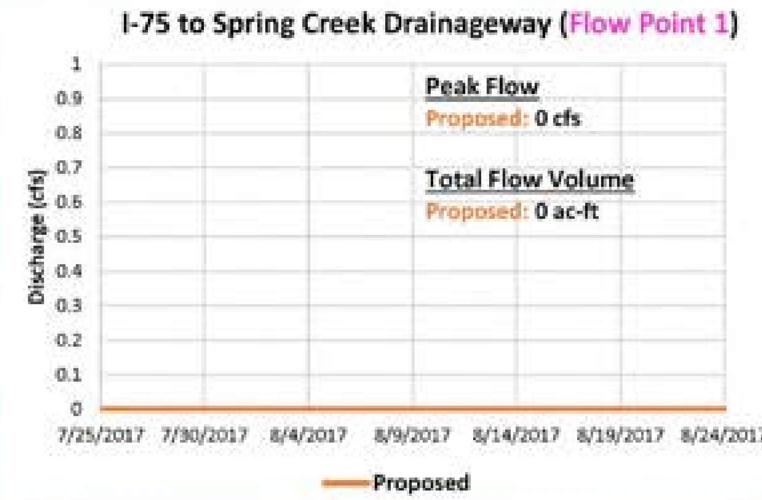
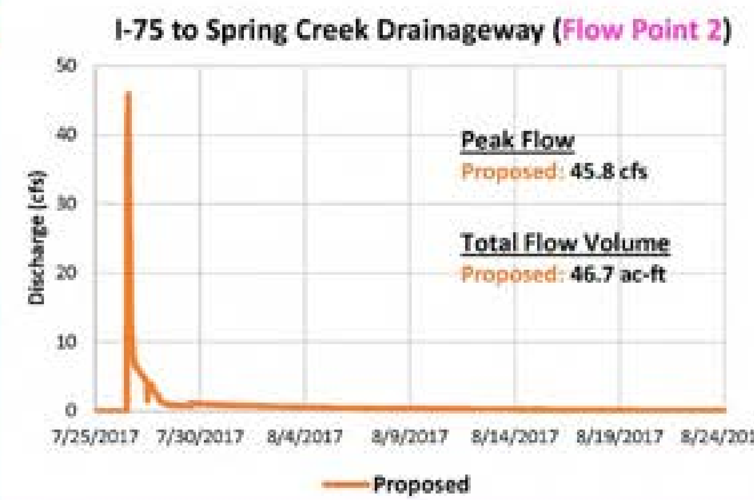






1.3.10 I-75 to Spring Creek Drainageway (South)

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.10 (d)

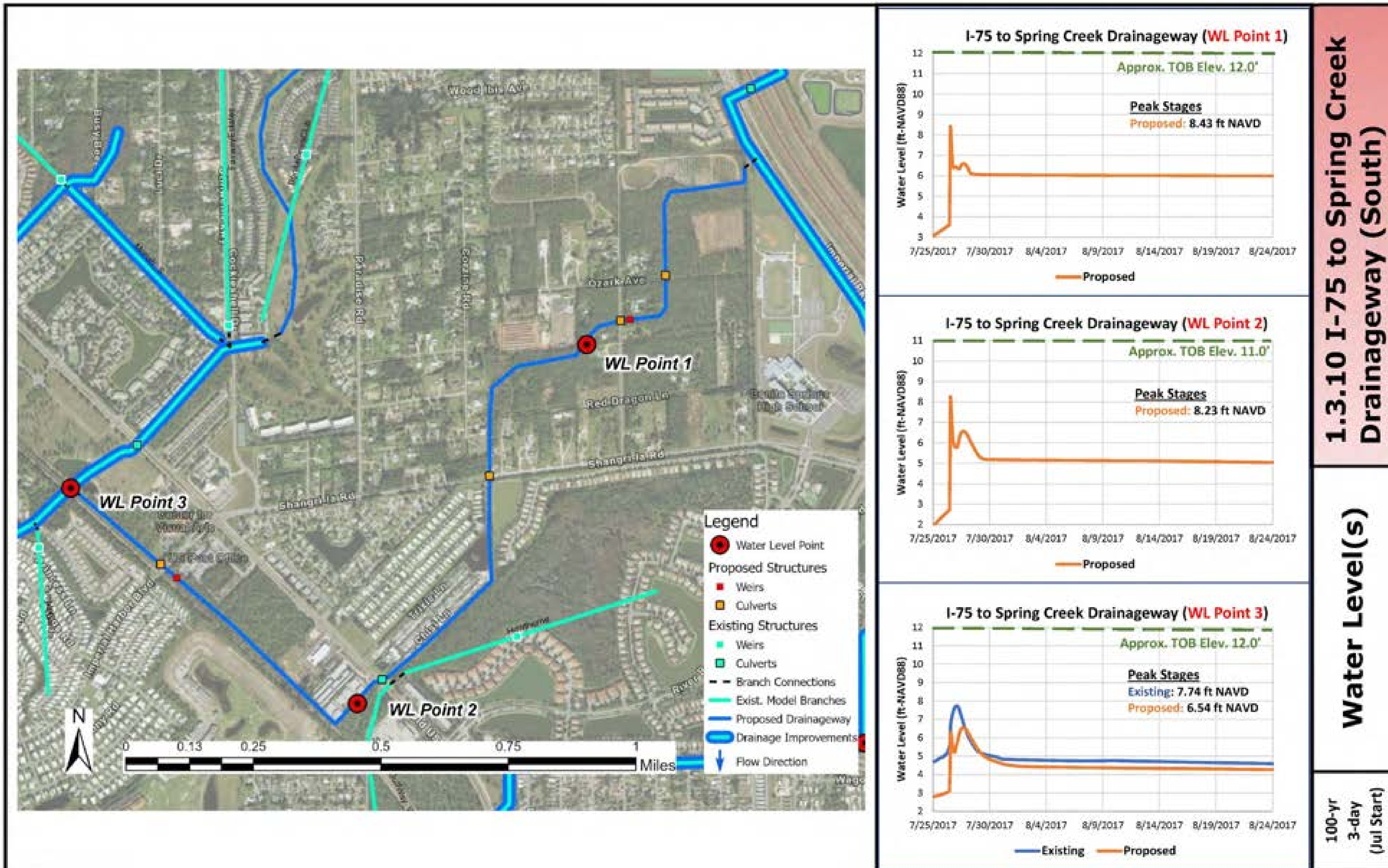
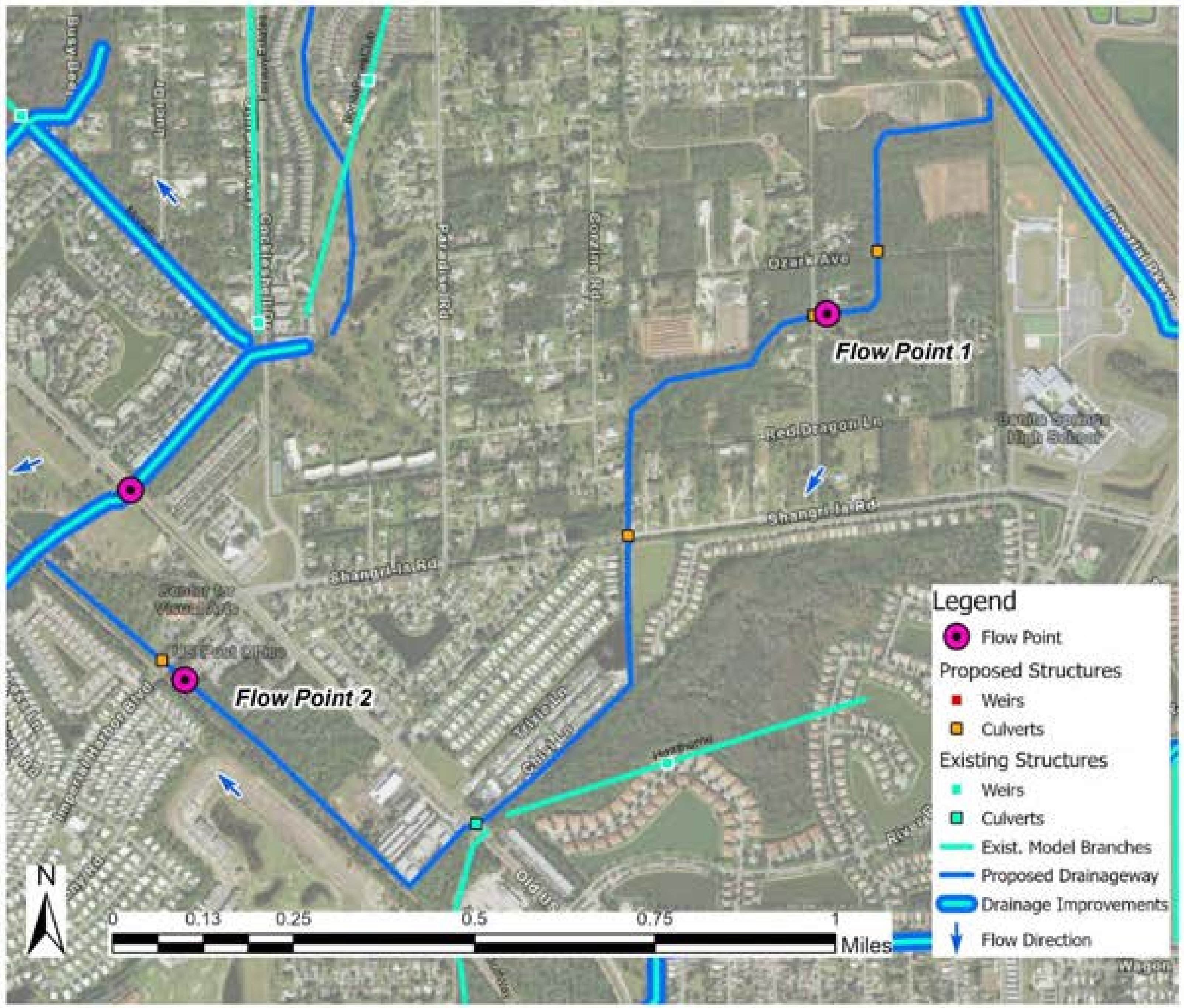


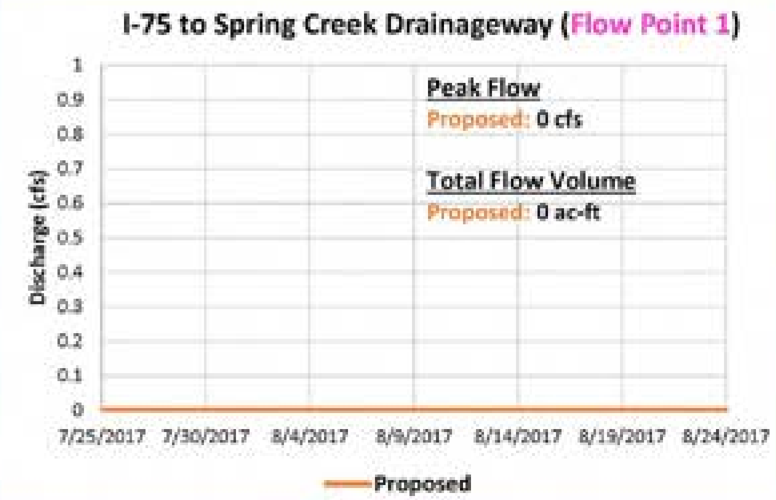
EXHIBIT 1.3.10 (e)

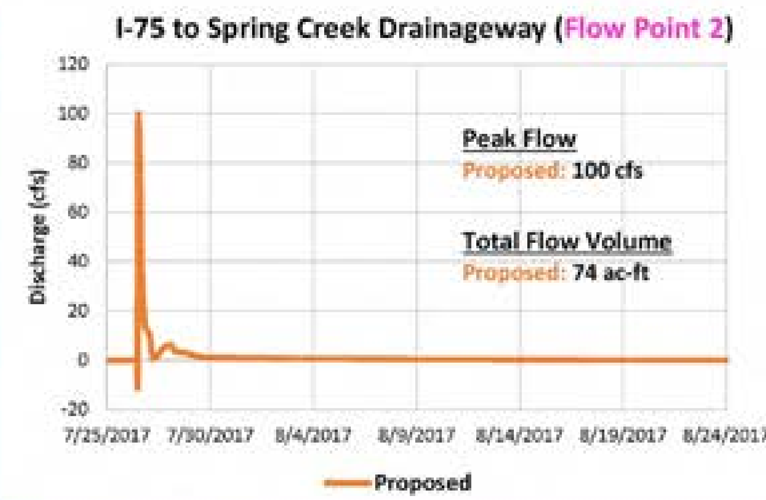
1.3.10 I-75 to Spring Creek Drainageway (South)

Flow(s)

100-yr 3-day (Jul Start)







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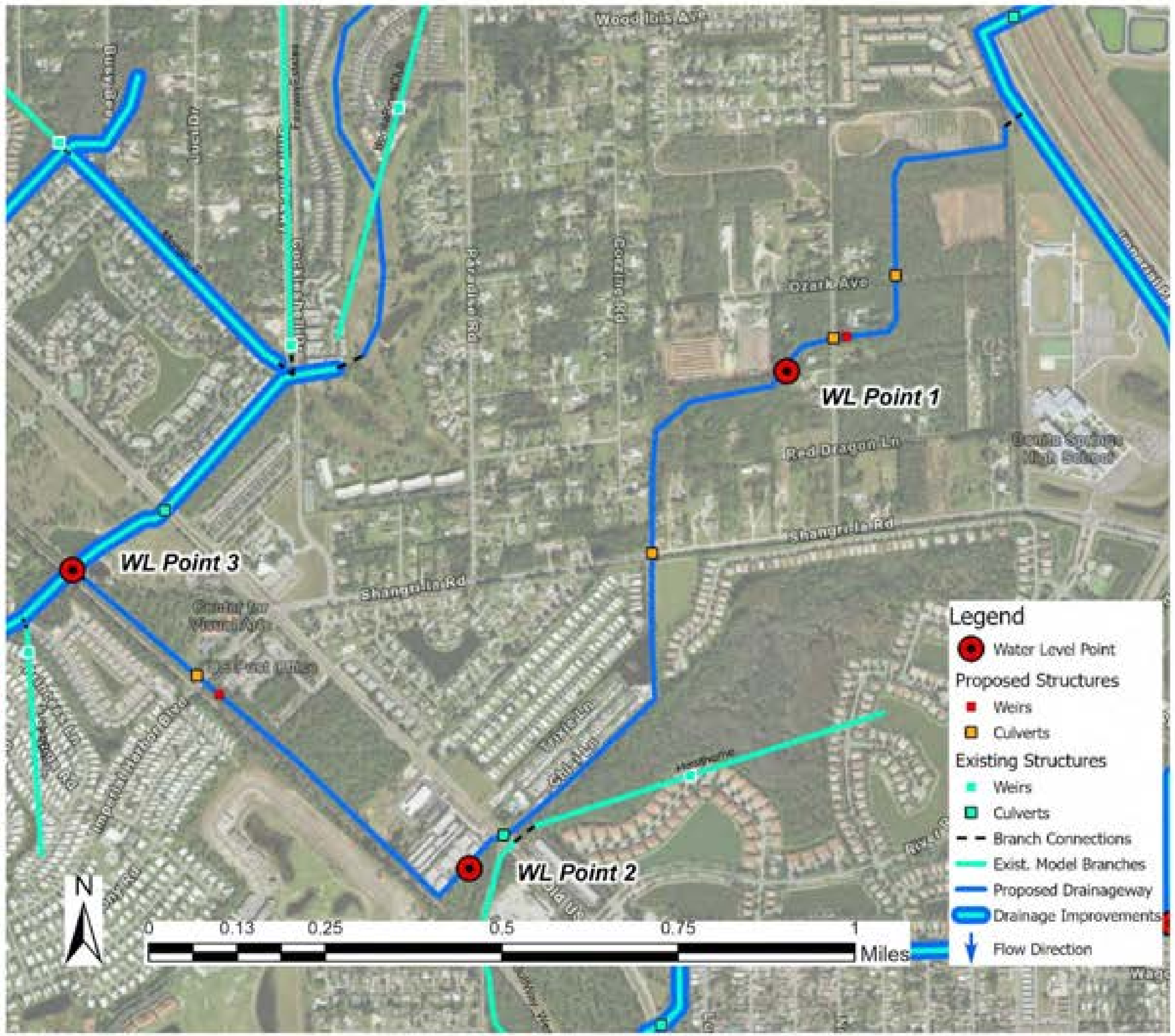
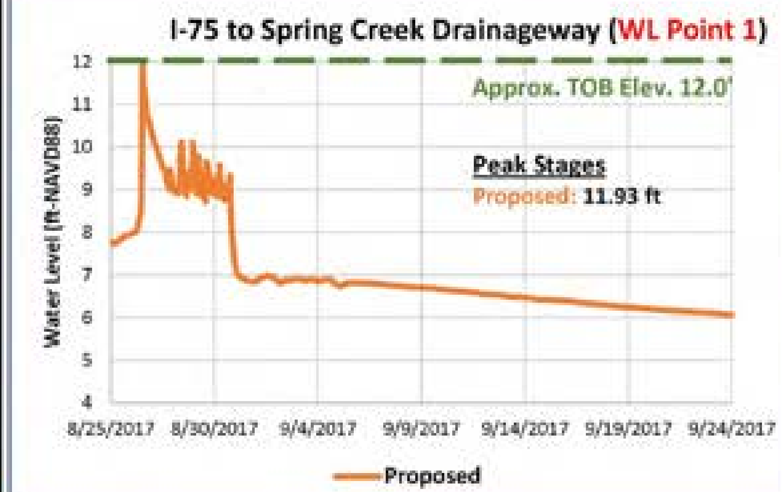
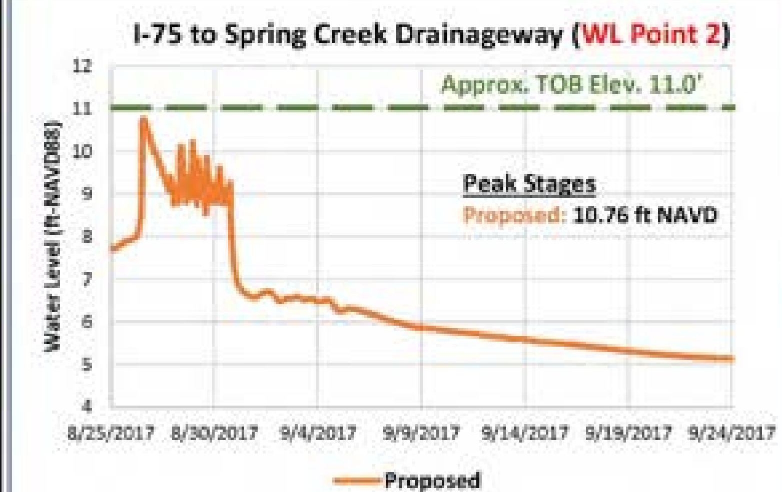
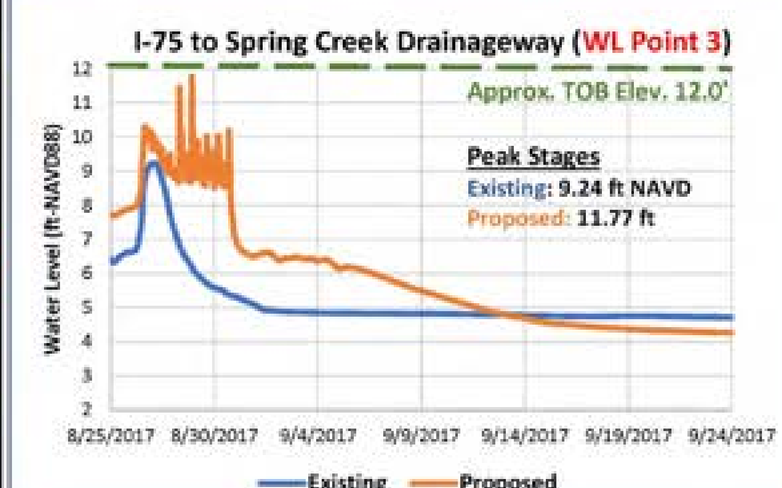






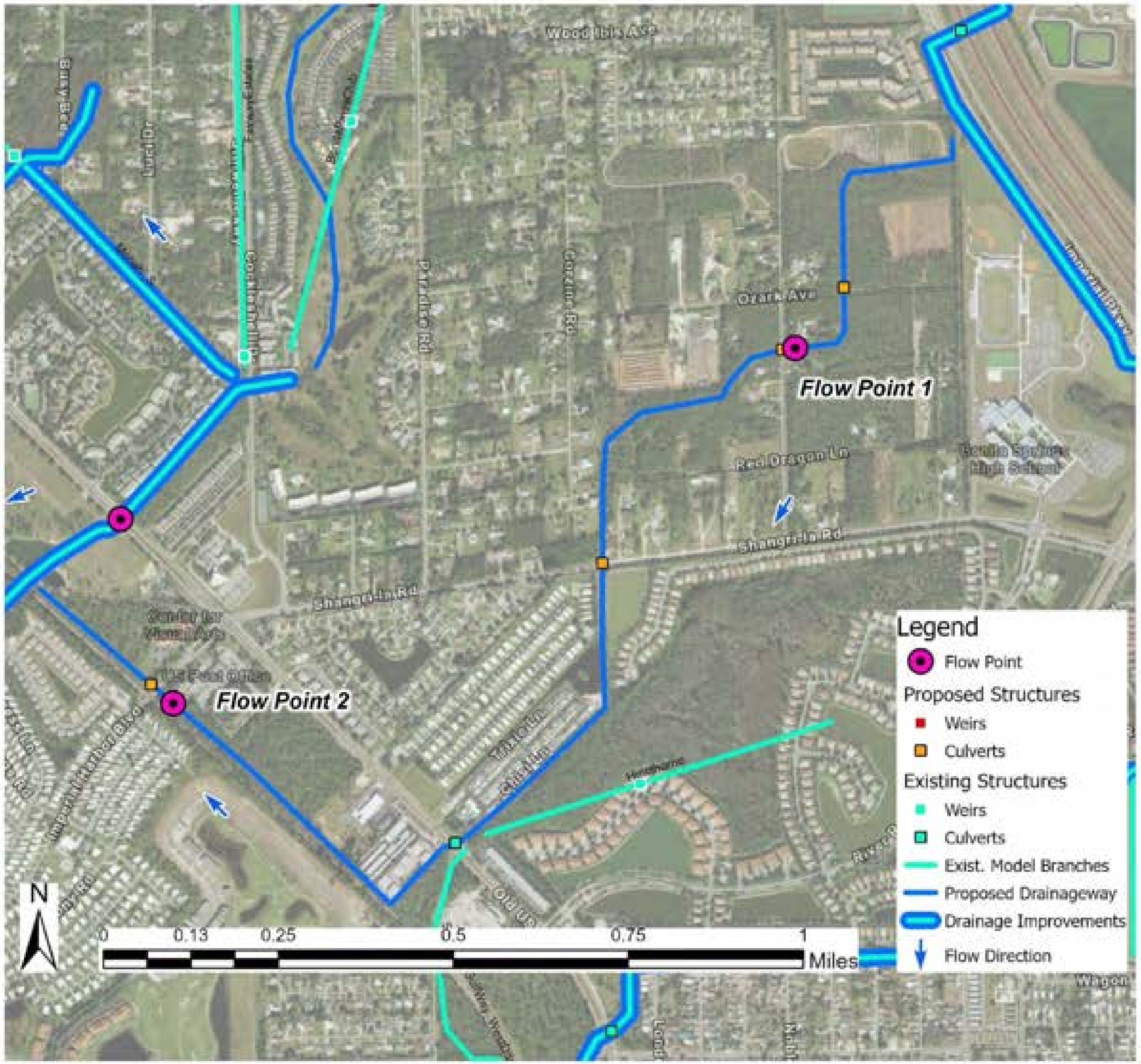


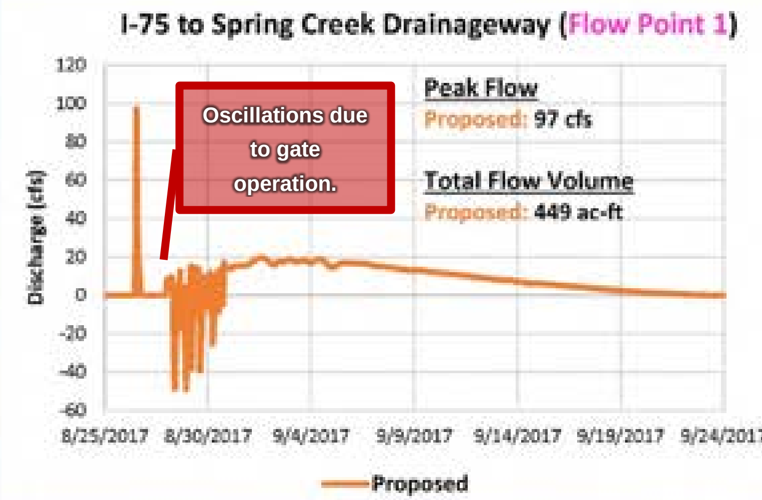
1.3.10 I-75 to Spring Creek Drainageway (South)

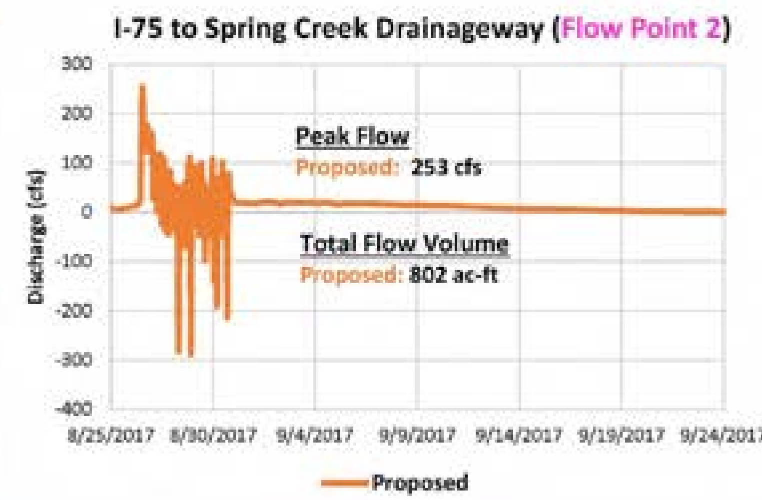
Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.10 (g)







1.3.10 I-75 to Spring Creek Drainageway (South)

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.10 (h)

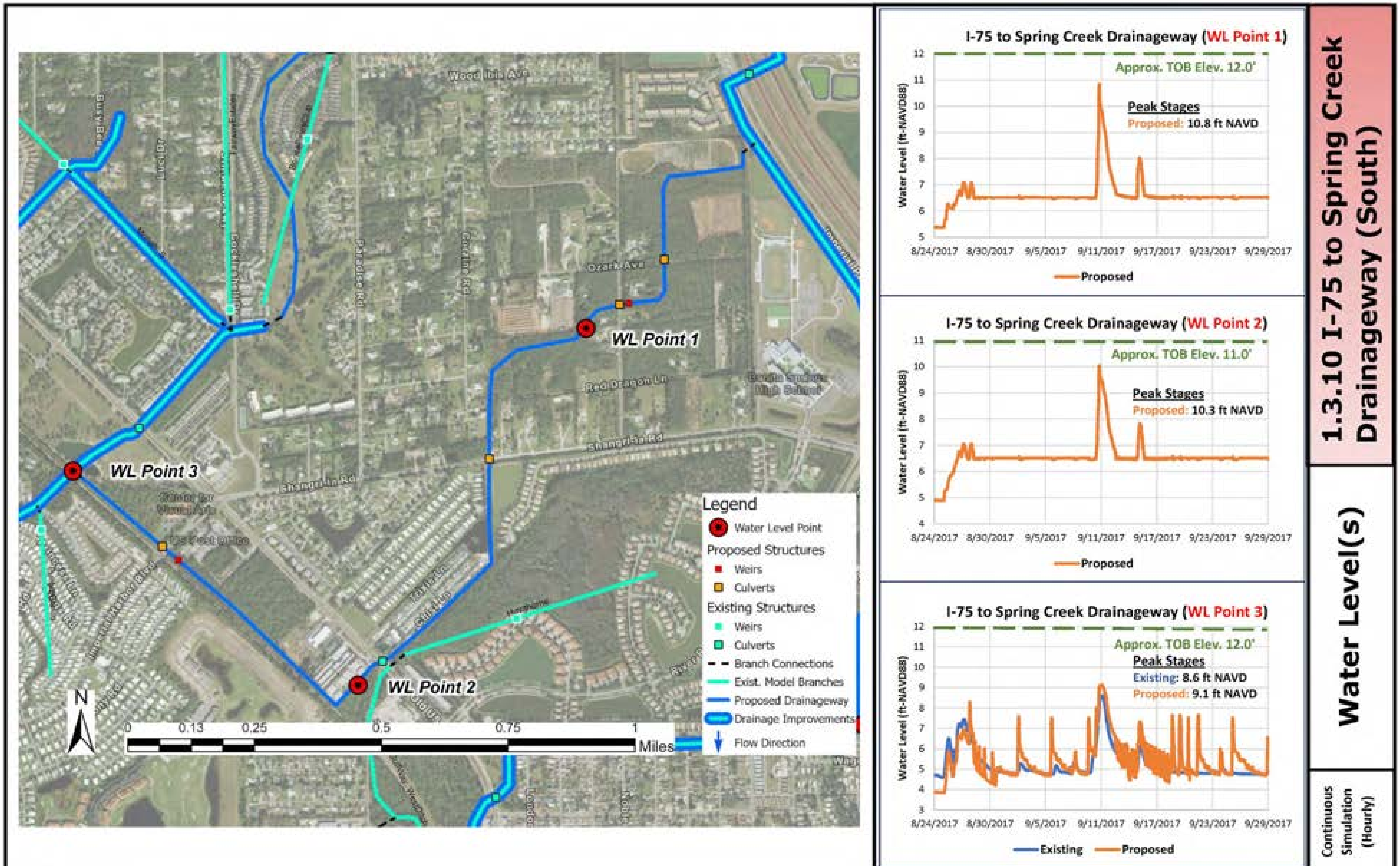
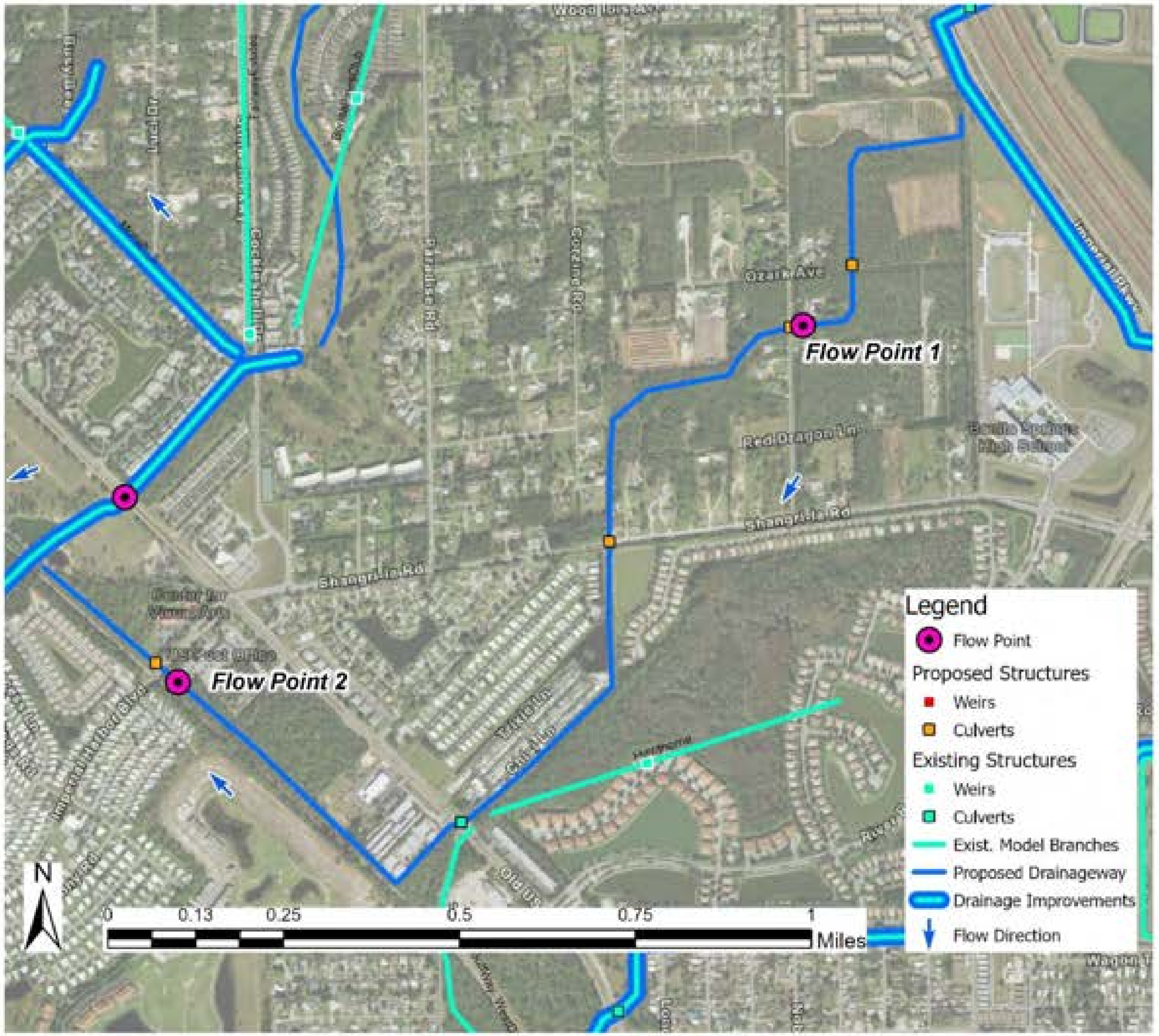
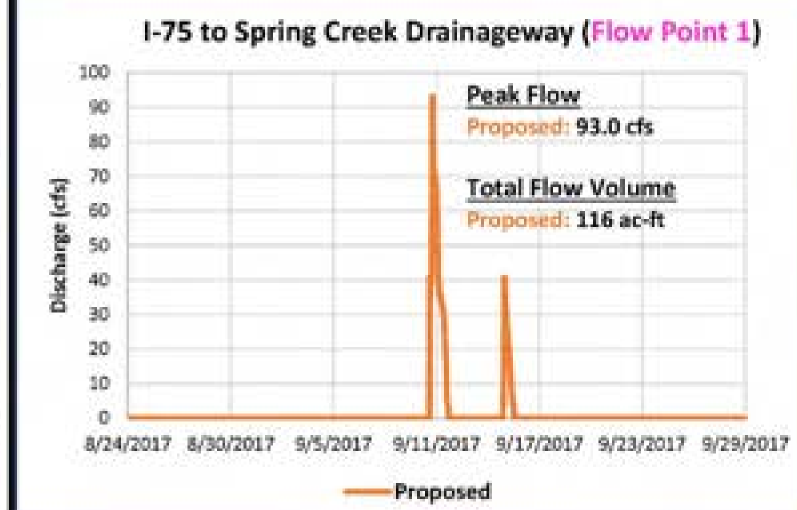


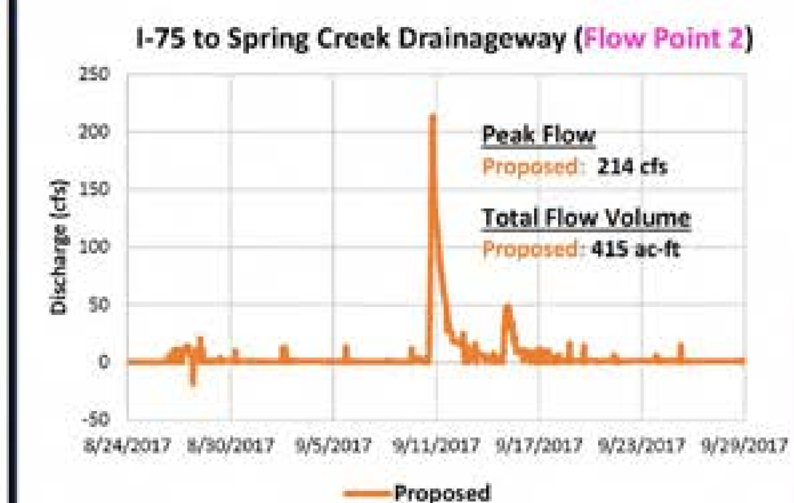
EXHIBIT 1.3.10 (i)

1.3.10 I-75 to Spring Creek Drainageway (South)



Flow(s)





Continuous Simulation (Hourly)

1.3.11 East I-75 Overland Flow Collection Drainageway Concept Plan

Background

This concept project parallels Interstate No. 75 (I-75) and serves to collect overland sheet flow from the Crew-Flint Pen/Kiker Preserve and direct flow to the multiple drainage structures under the interstate. The land cover in this area is cypress with hydric pine forest. This area east of I-75 is a very large watershed that is routinely covered in standing water during the late summer months. Located along the collection drainageway are rectangular shaped borrow pits used for providing fill material for the interstate construction.

Location

This proposed conceptual project is in SE Lee County and runs along the east side Interstate 75 between Corkscrew Road and Bonita Beach Road as illustrated in **Figure 35**.

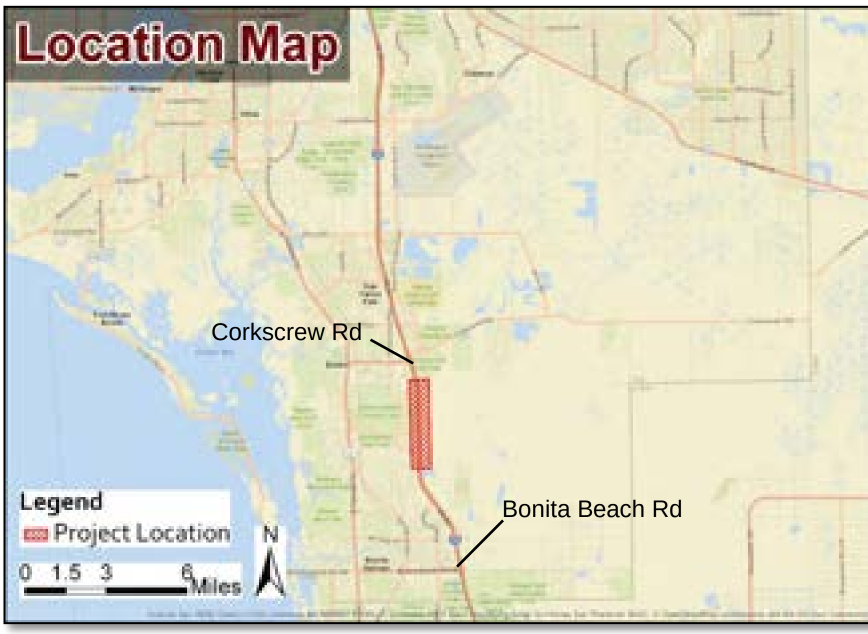


Figure 35 – Location Map, 1.3.11 East I-75 Overland Flow Collection Drainageway

Description

This proposed conceptual project connects existing borrow pit lakes to the conveyance structures under I-75. This collector drainageway would direct overland flow and equalize water levels at each I-75 road crossing to fully utilize each structure. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges as illustrated in **Figure 36**.

Figure 36 - Concept Plan, 1.3.11 East I-75 Overland Flow Collection Drainageway

Purpose

This proposed project improves conveyance of excess stormwater to reduce flooding.

Evaluation

Viability

Managing a large overland sheet flow from the Crew-Flint natural area requires a conveyance to collect the overland flow and collect stormwater to crossings underneath Interstate 75. This project would require coordination from the Lee County 20/20 conservation lands and the FDOT. A berm would be constructed on the west side of this equalizer flow way to protect drainage systems along the interstate. This collector conveyance is an important component for managing water on the east side of Interstate 75 which justifies the complex project development.

Community Considerations

The area around this proposed improvement is undeveloped and should not adversely impact the community.

Environmental & Permittability Considerations

This equalizer conveyance/ interceptor swale will have some wetland impacts that will need to be avoided, minimized, or mitigated, where practical. This improvement would provide some water quality treatment. The berm proposed to separate the collector flow way from the FDOT highway 75 drainage system may also have sound attenuating properties.

Land Availability

This project concept is located on the Lee County conservation lands requiring their approval, as well as the approval of the FDOT.

Opinion of Probable Cost

The cost opinion shown in **Table 12** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 12 - Opinion of Probable Cost breakdown, 1.3.11 East I-75 Overland Flow Collection Drainageway

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,718,000	$ 1,718,000
Clearing & Grubbing	23	AC	$ 14,000	$ 322,000
Earthwork	144,000	CY	$ 6	$ 864,000
Construction/ Maintenance Access	42,000	SY	$ 20	$ 840,000
Weir Structure 3.6A (Major)	50	LF	$ 15,000	$ 750,000
Weir Structure 3.6B (Major)	42	LF	$ 15,000	$ 630,000
Weir Structure 3.6C (Major)	40	LF	$ 15,000	$ 600,000
Weir Structure 3.6D (Major)	50	LF	$ 15,000	$ 750,000
Weir Structure 3.6E (Major)	100	LF	$ 15,000	$ 1,500,000
Detours	1	LS	$ 1,030,000	$ 1,030,000
Box Culvert 3.11-1	1,220	CY	$ 1,200	$ 1,464,000
Road Repairs	1	LS	$ 295,000	$ 295,000
Electric Supply	1	LS	$ 100,000	$ 100,000
Permanent Erosion Control	4,000	SF	$ 15	$ 60,000
Grassing	38,500	SY	$ 2	$ 77,000
			Construction Cost Sub-Total:	**$ 11,000,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 3,200,000
			Land Acquisition	$ -
			Project Administration/ CEI (10%):	$ 1,000,000
			Project Unknowns	$ 1,800,000
			Conceptual Project Cost:	**$ 17,000,000**
			Contingency (30%)	$ 5,000,000
			Conceptual Project Cost (with Contingency):	**$ 22,000,000**

Opportunities for Multiple Benefits & Uses

The collector conveyance may provide hiking trails and canoe/kayak use opportunities.

Other Considerations

The fill material generated from this project may be used for future highway improvements in the area. A summary of this concept project is shown below in **Exhibit 1.3.11** herein.

Findings & Recommendations

Regional Modeling Findings

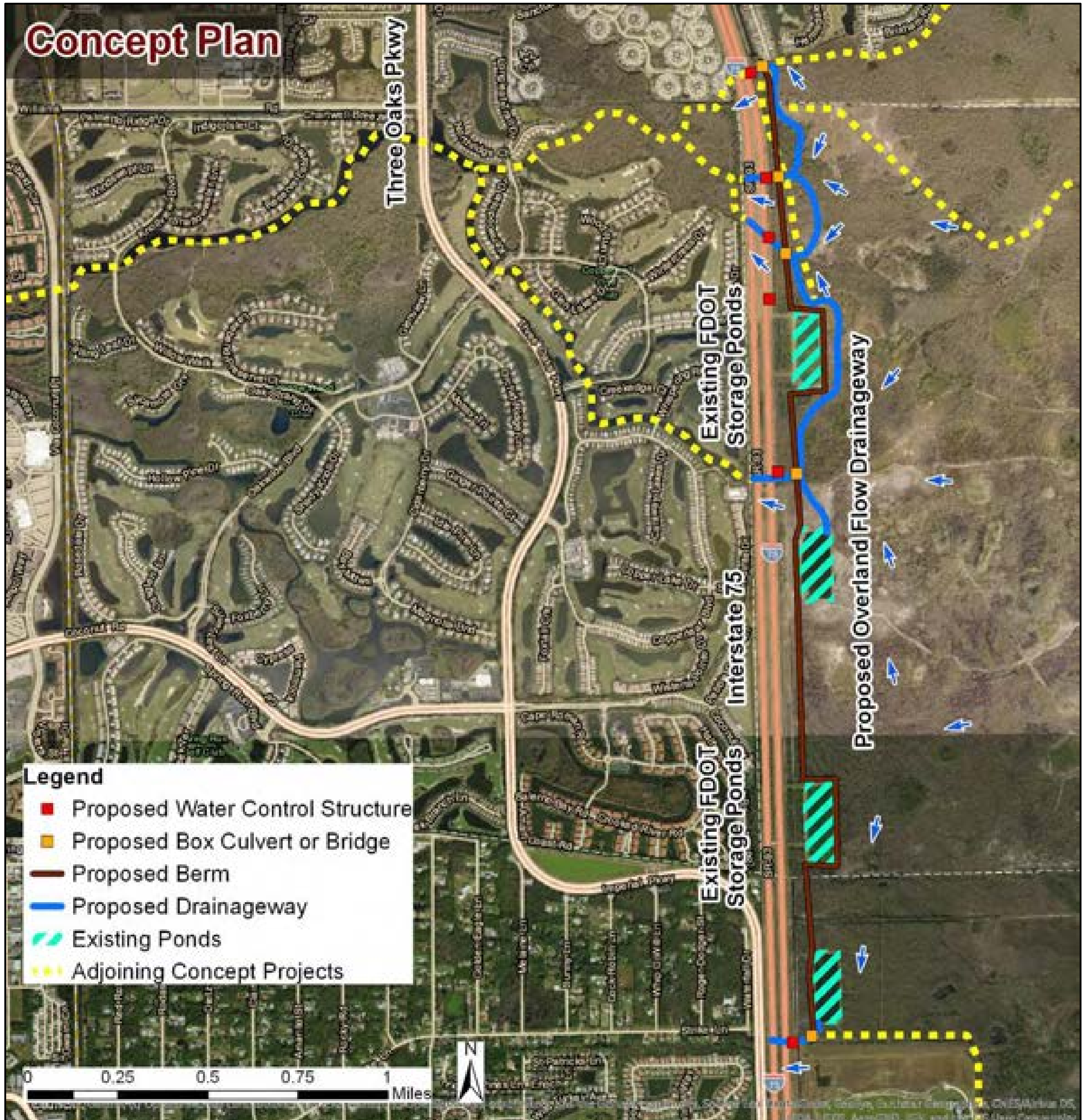
This project concept consists of an intercept collection drainageway along Interstate 75 to capture overland flow from the area east of I-75, and to direct runoff towards control structures for managed flow at multiple outfall locations. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.11 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.11 (b)
	Flow(s)	EXHIBIT 1.3.11 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.11 (d)
	Flow(s)	EXHIBIT 1.3.11 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.3.11 (f)
	Flow(s)	EXHIBIT 1.3.11 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.3.11 (h)
	Flow(s)	EXHIBIT 1.3.11 (i)

Improvements are shown with an increase of the storage capacity and water levels east of Interstate 75, a reduction of peak stages west of Interstate 75, and an increase in flow capacity east of Interstate 75 from the existing and proposed conditions. Conservation of water levels were shown as a benefit of controlling stormwater discharge from the reservoir. This conveyance is a key component for moving excess stormwater to the Estero Bay.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by capturing overland flow from east of Interstate 75 into an intercept collection drainageway that flows to multiple controlled outfalls. These positive improvements warrant further design-level project development.



Imagery Date: 2018

May 2020

East I-75 Overland Flow Collection Drainageway

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.11

Project Narrative

DESCRIPTION: This proposed conceptual project connects existing borrow pit lakes to the conveyance structures under I-75. This collector drainageway would collect overland flow and equalize water levels at each I-75 road crossing to fully utilize each structure. This connection would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves conveyance of excess stormwater to reduce flooding.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts would necessitate mitigation.

EXHIBIT 1.3.11 (a)

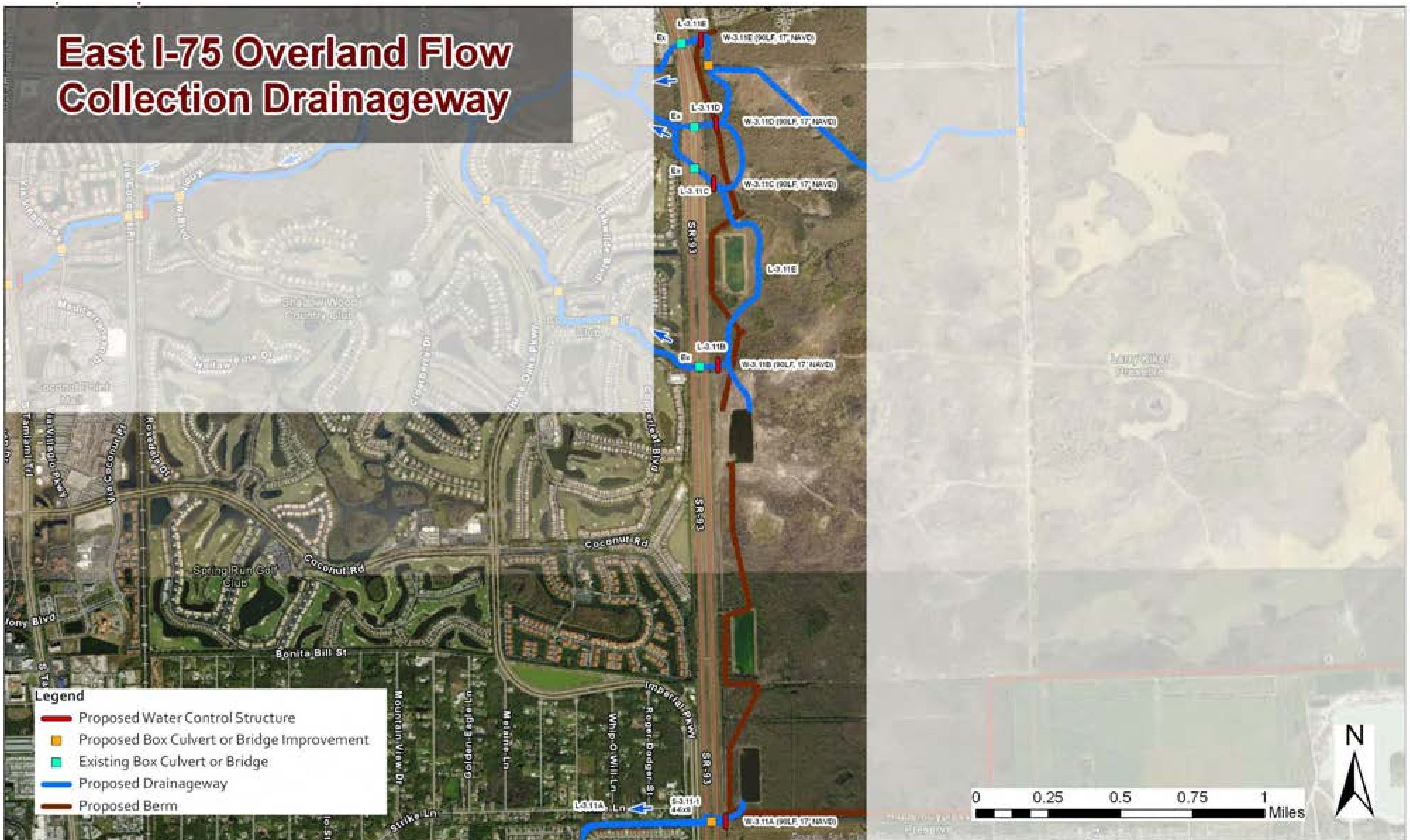


EXHIBIT 1.3.11 (b)

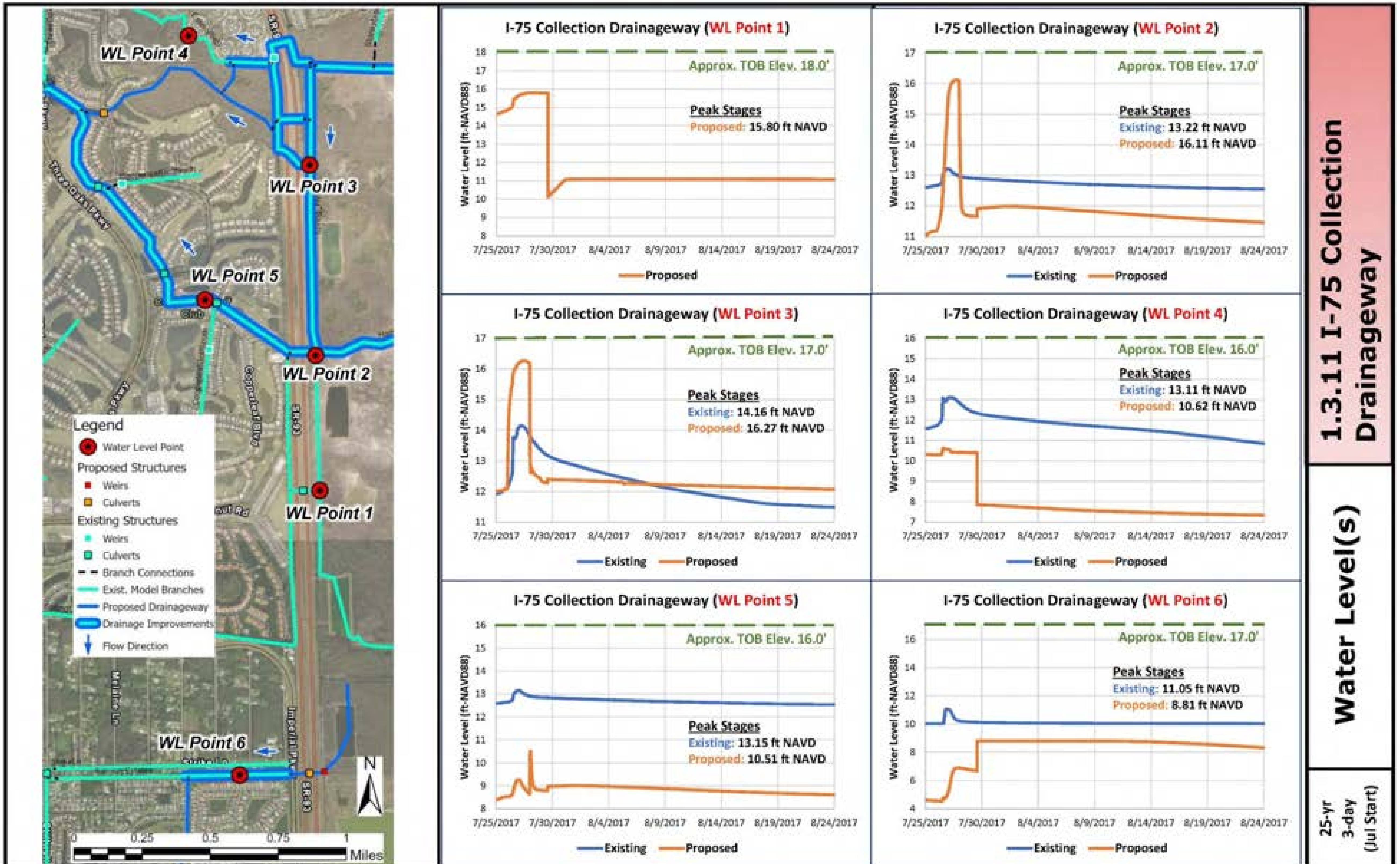


EXHIBIT 1.3.11 (c)

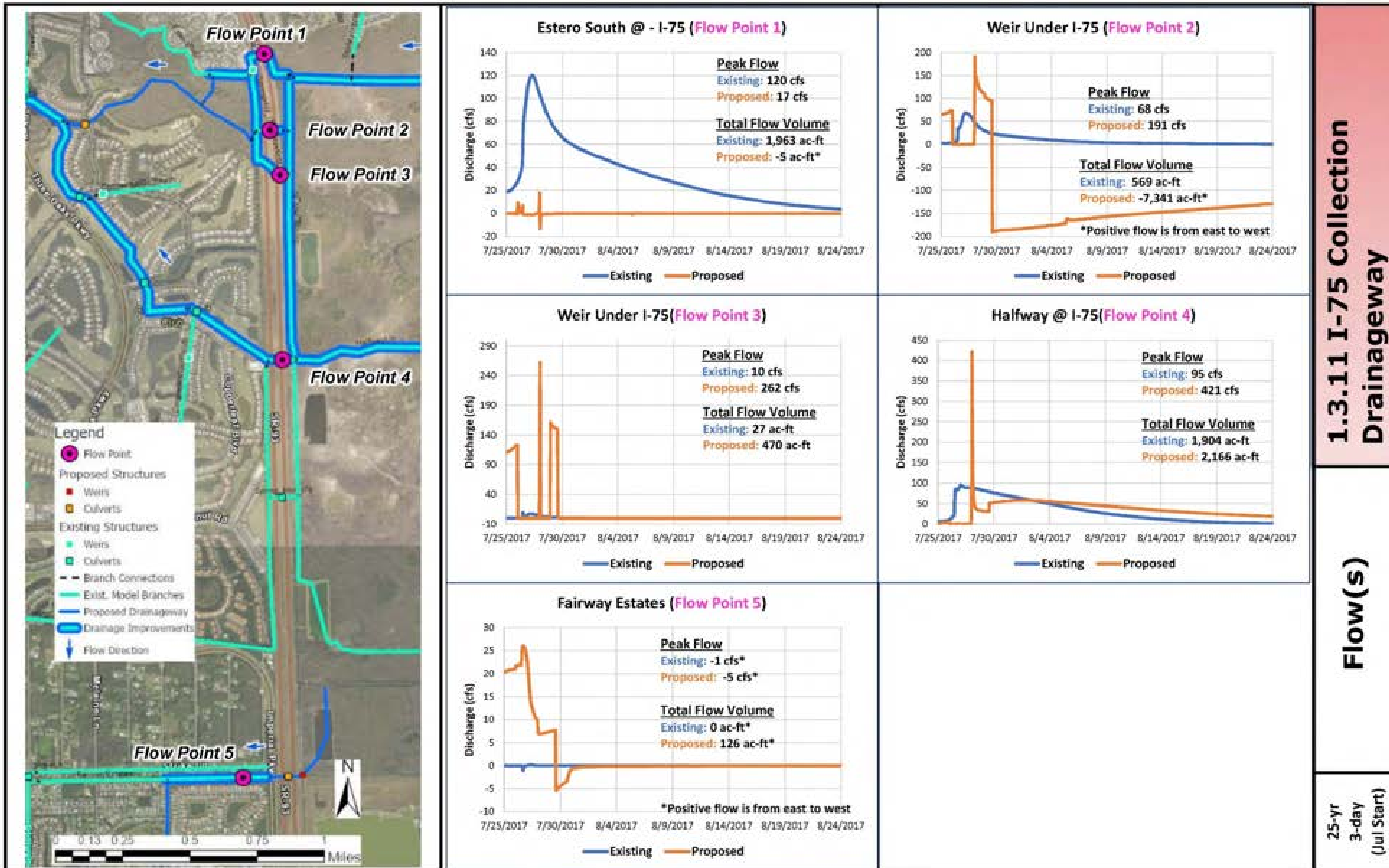


EXHIBIT 1.3.11 (d)

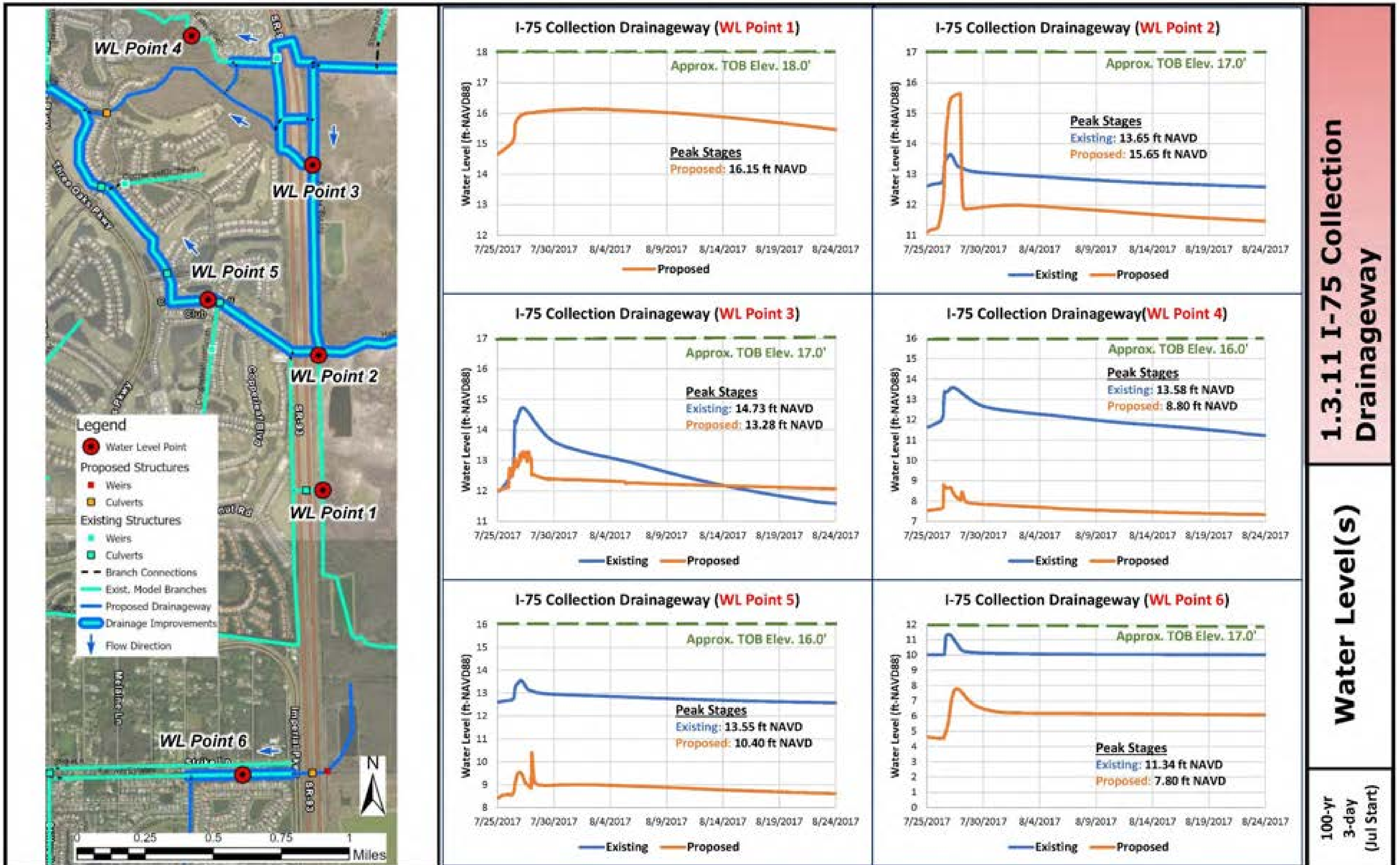


EXHIBIT 1.3.11 (e)

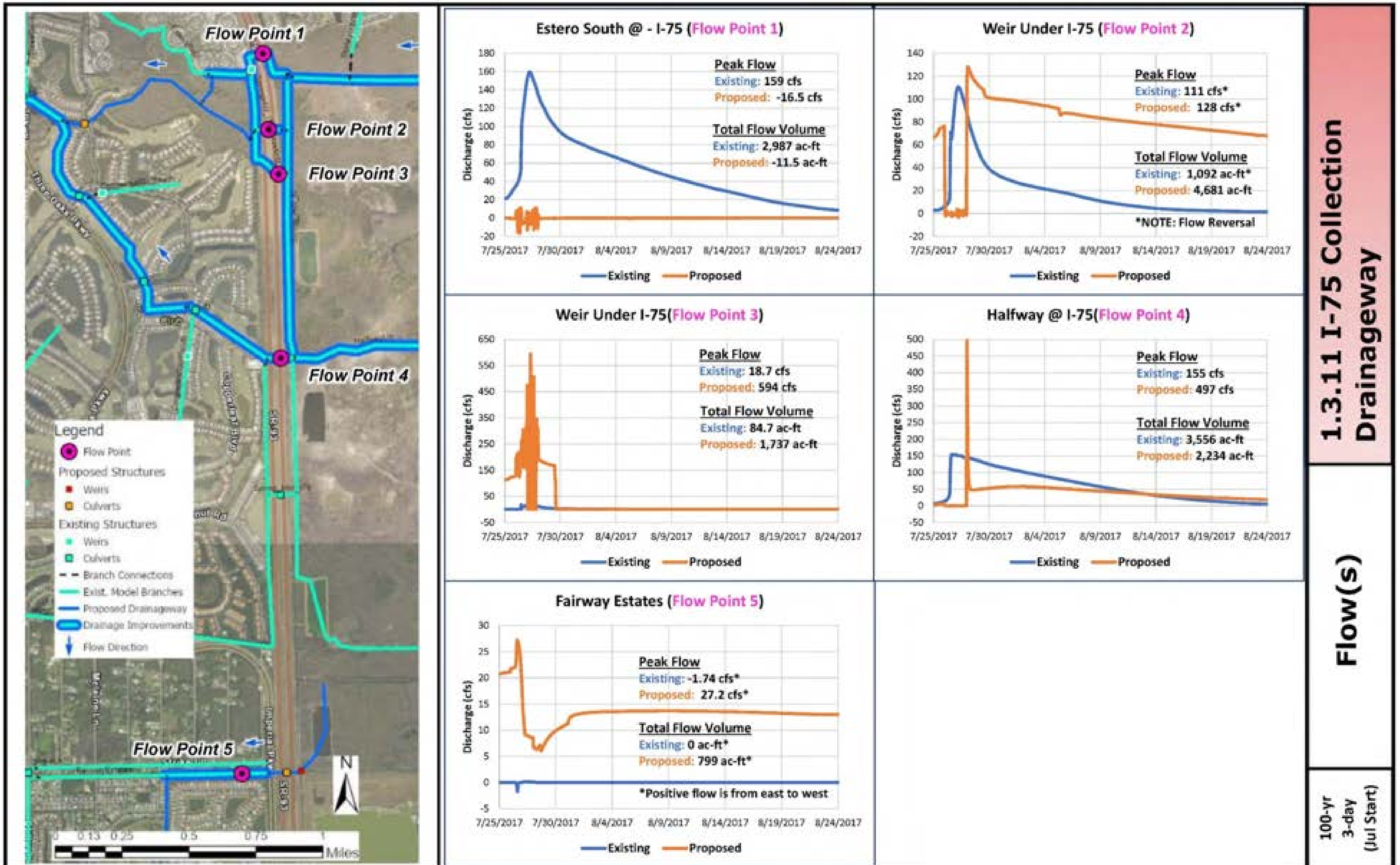


EXHIBIT 1.3.11 (f)

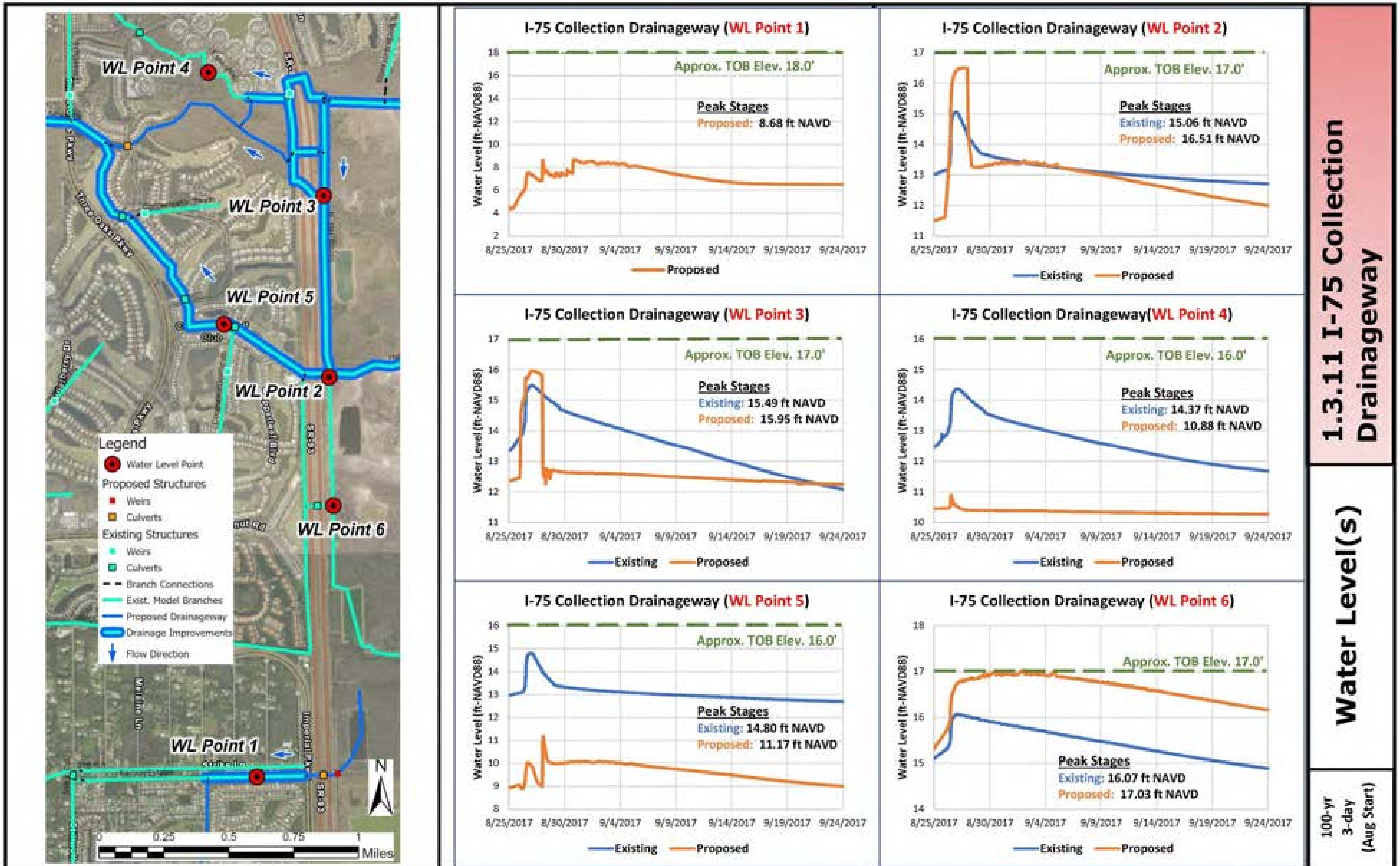


EXHIBIT 1.3.11 (g)

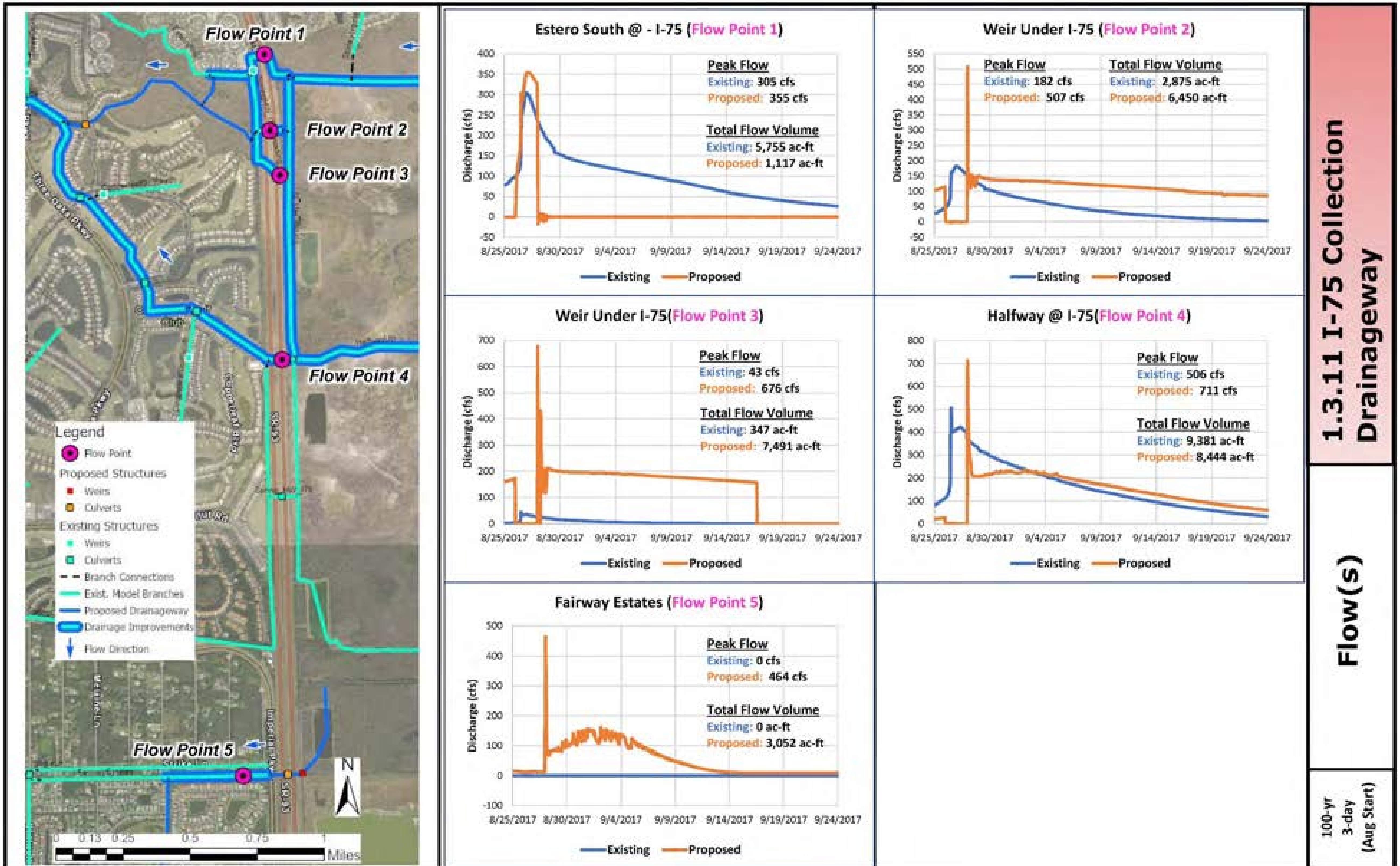


EXHIBIT 1.3.11 (h)

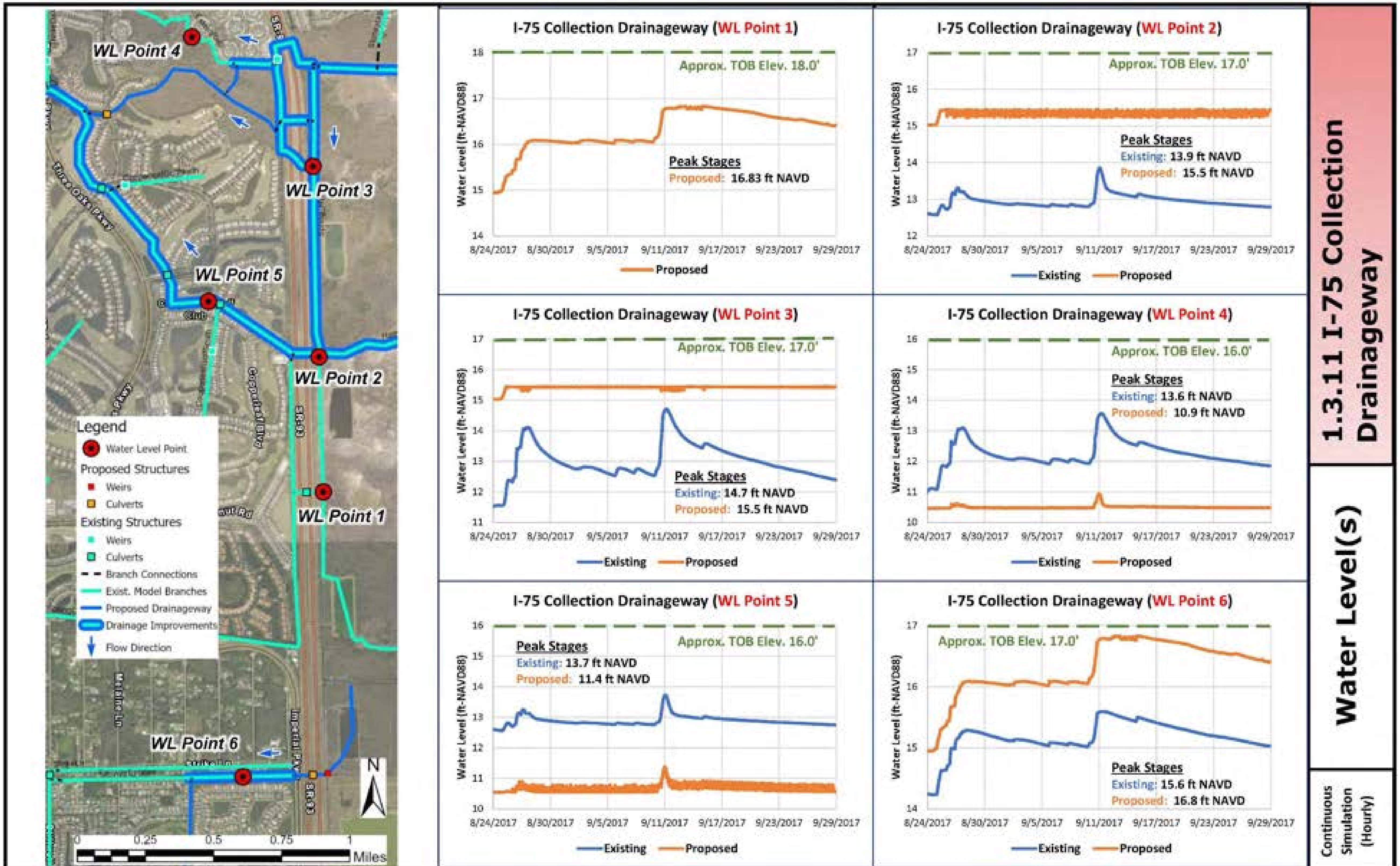
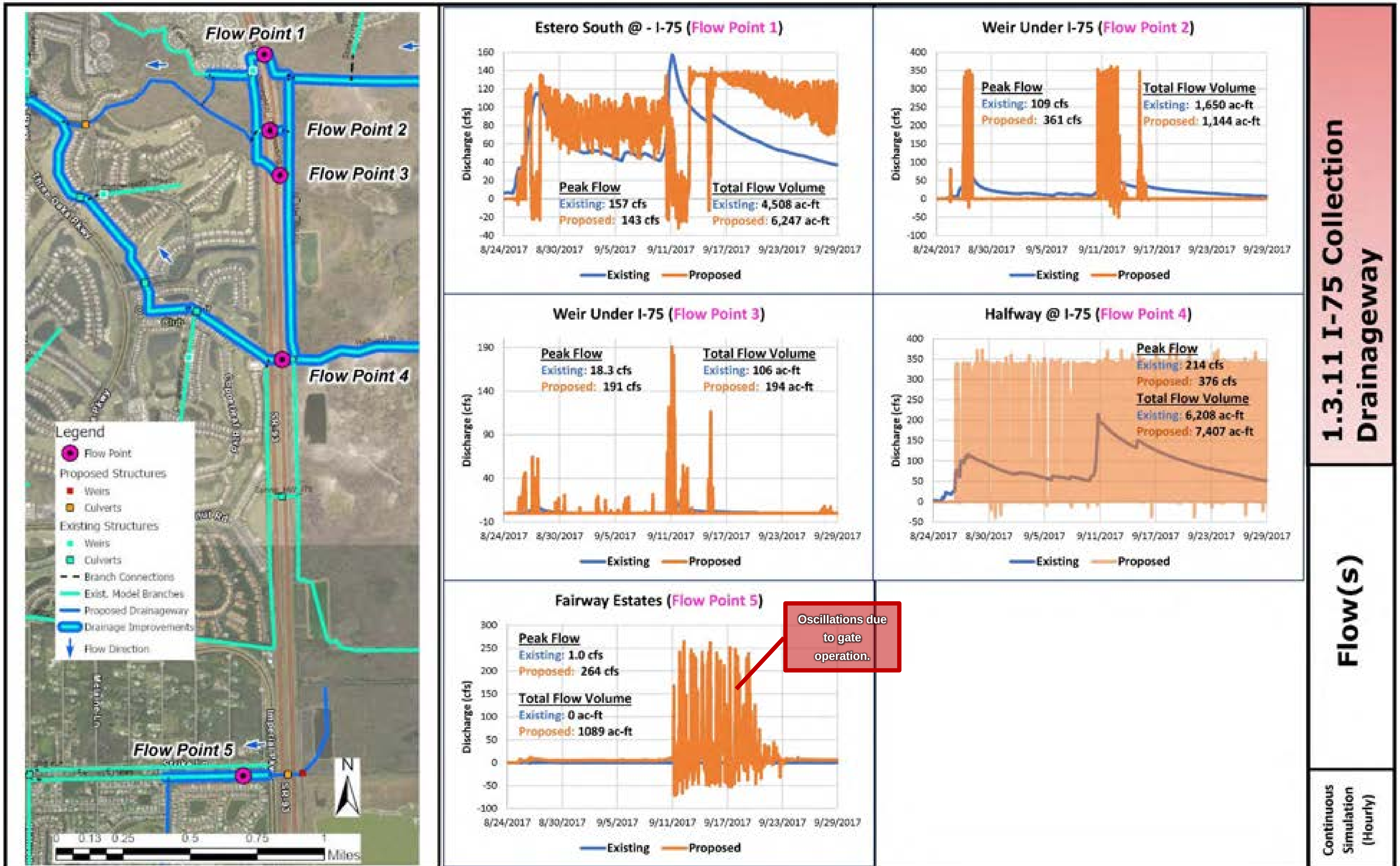


EXHIBIT 1.3.11 (i)



1.3.12 Imperial River Improvements East of I-75 Concept Plan

Background

This concept project is located at the headwaters of the Imperial River and is intended to improve the hydraulic capacity on the approximately one-mile long segment of the Kehl Canal on the east side of Interstate No. 75. The manmade canal is routed near the original Imperial River natural creek. This area receives large runoff flows from a very large watershed known as Crew-Flint Pen Preserve that extends to Collier County.

Location

This proposed conceptual project is in SE Lee County beginning at the Kehl Canal weir running west under Bonita Grande Dr. and continues south and west to the 300-foot long bridge at Interstate 75 as illustrated in **Figure 37**.

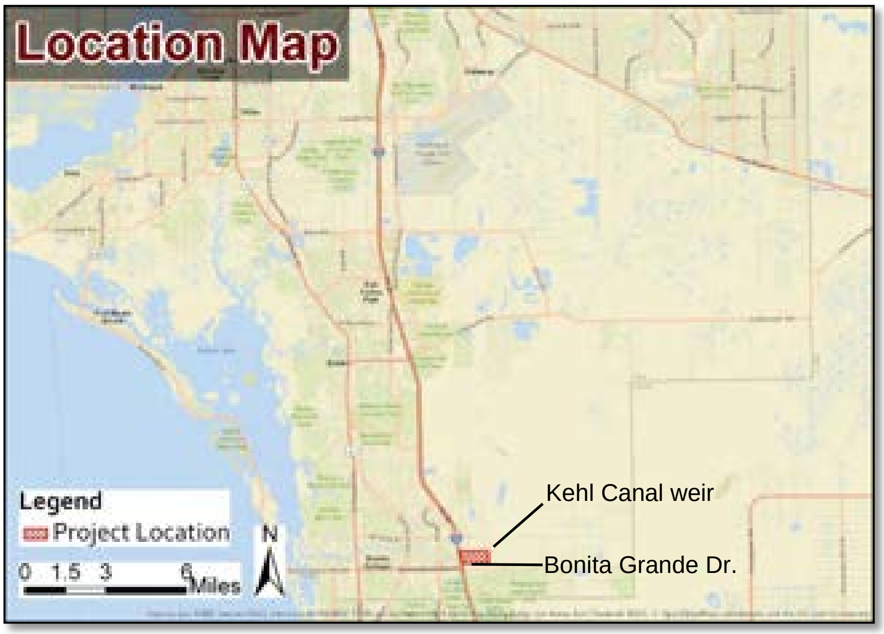


Figure 37 – Location Map, Imperial River Improvements East of I-75

Description

This proposed conceptual project improves conveyance from Kehl Canal weir westerly to the I-75 bridge crossing at the Imperial River and includes channel flow enhancements for conveying flow from extreme storm events. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges as illustrated in **Figure 38**.

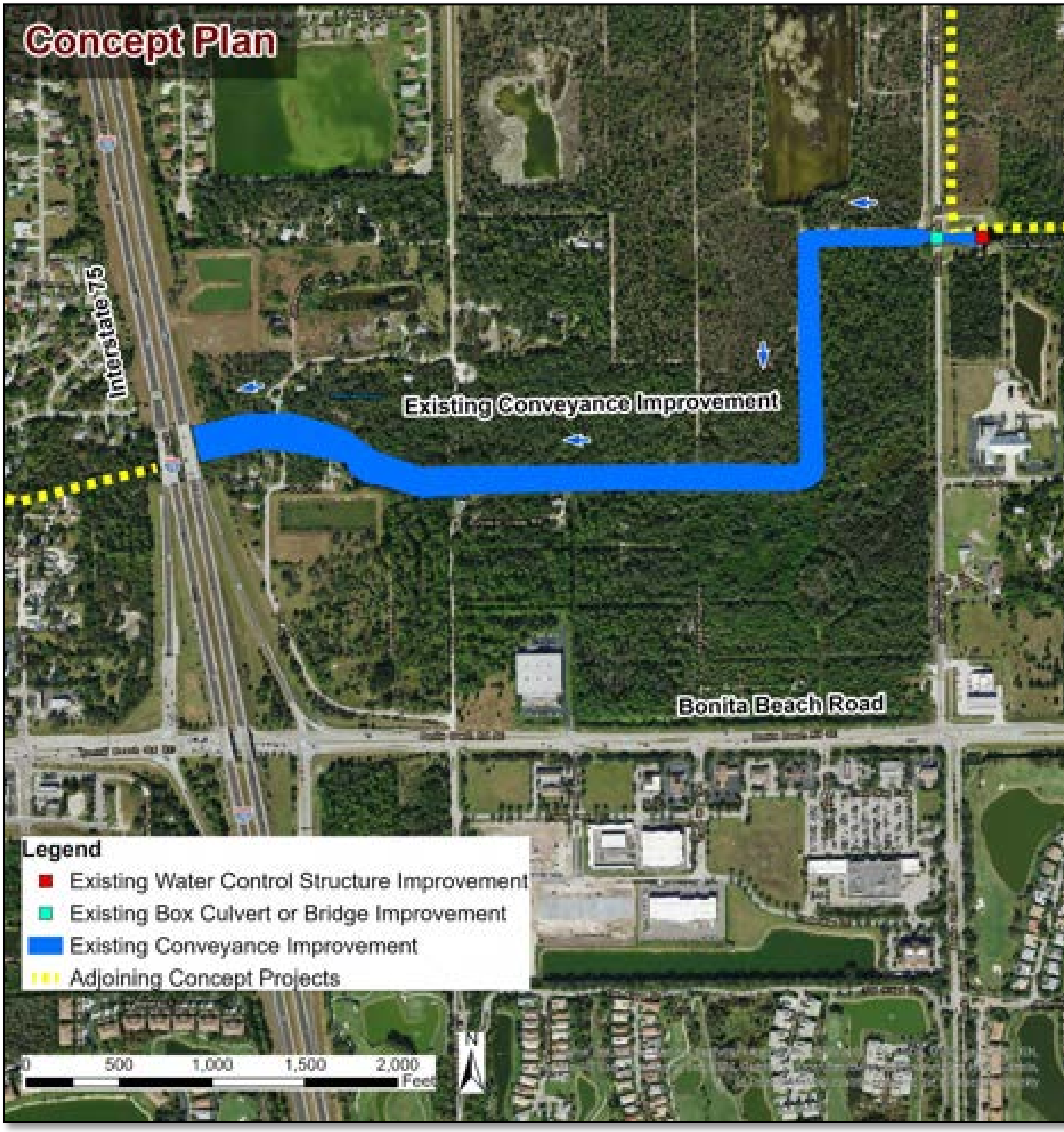


Figure 38 - Concept Plan, Imperial River Improvements East of I-75

Purpose

This concept project enhances drainage capacity for handling large stormwater flow from the Crew-Flint-Edison Farms. The development of drainage flow-way capacity is critical to handling excess stormwater runoff to reduce flooding and shorten post-storm recovery of water levels. The concept will help to enhance flow capacity along the Imperial River. This project is an opportunity to help drain excess stormwater from the basin east of I-75 which has experienced previous flooding issues.

Evaluation

Viability

This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. The work must be done within the stream areas to creatively enhance the flow conditions. Weir structures to manage water levels and large drainage structures would be required. Enhancing this existing flow-way appears viable with careful environmental considerations.

Community Considerations

The flow way enhancements require the coordination with the City of Bonita Springs.

Environmental & Permittability Considerations

Significant environmental impacts occurring along the route would necessitate mitigation and creative enhancement to improve flows. This work may include overflow bank areas planted with low aquatic plants or planted overflow shelves expanded along the stream banks. The addition of a filter marsh storage reservoir would benefit this project concept.

Land Availability

The need for land acquisition and governmental approval is necessary to construct the Imperial River flow enhancements, increased storage, and water quality features.

Opinion of Probable Cost

The cost opinion shown in **Table 13** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project.

Table 13 - Opinion of Probable Cost breakdown, 1.3.12 Imperial River Improvements East of I-75

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,220,000	$ 1,220,000
Clearing & Grubbing	10	AC	$ 14,000	$ 140,000
Earthwork	85,000	CY	$ 8	$ 680,000
Construction/ Maintenance Access	3,000	SY	$ 20	$ 60,000
Weir Structure 3.12A (Major/ Extension)	100	LF	$ 10,000	$ 1,000,000
Bonita Grande Bridge Extension	1	LS	$ 500,000	$ 500,000
Permanent Erosion Control	10,000	SF	$ 15	$ 150,000
Grassing	25,000	SY	$ 2	$ 50,000
Construction Cost Sub-Total:				**$ 3,800,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)				$ 1,140,000
Land Acquisition				$ 1,500,000
Project Administration/ CEI (10%):				$ 380,000
Project Unknowns				$ 480,000
Conceptual Project Cost:				**$ 7,300,000**
Contingency (30%)				$ 2,200,000
Conceptual Project Cost (with Contingency):				**$ 9,500,000**

Opportunities for Multiple Benefits & Uses

As southeast Lee County continues to reach full build-out conditions, improving the conveyance of the Imperial River Drainage Basin is a critical priority. Providing better conveyance capacity and storage solutions will also become increasingly difficult as development diminishes the available land.

Other Considerations

Enhancements to the riverbanks may make the flow way more accessible for canoe/kayak enthusiasts. A summary of this concept project is shown below in **Exhibit 1.3.12** herein.

Findings & Recommendations

Regional Modeling Findings

Purpose:

This project concept consists of improving the flow way capacity of the Imperial River east of Interstate 75 to better convey high flows resulting from large storm events. This flow way improvement is intended to lower flood levels and increase the conveyance of excess stormwater from east of Interstate 75. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.12 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.12 (b) EXHIBIT 1.3.12 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.12 (d) EXHIBIT 1.3.12 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.12 (f) EXHIBIT 1.3.12 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.12 (h) EXHIBIT 1.3.12 (i)

Improvements were shown with water level reductions from the existing condition to the proposed condition.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flows from the Imperial River to Interstate 75. These positive improvements warrant further design-level project development.

Imagery Date: 2018

Project Narrative

DESCRIPTION: This proposed conceptual project improves conveyance from Kehl Canal weir westerly to the I-75 bridge crossing at the Imperial River and includes channel flow enhancements for conveying flow from extreme storm events. This conveyance would have remotely operated weir gates to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project increases drainage capacity for handling large storm events and resulting excess stormwater flow from the Corkscrew Swamp, Flint Pen, Crew Flint and Edison Farms areas. The development of drainage flow-way capacity is critical to avoid excess water in the preserve.

CONSTRAINTS: This project as planned crosses public and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Working in the natural areas of the headwaters of Imperial River will require special attention to preserve the character of the stream. Environmental impacts would necessitate mitigation.

May 2020

Imperial River Improvements East of I-75

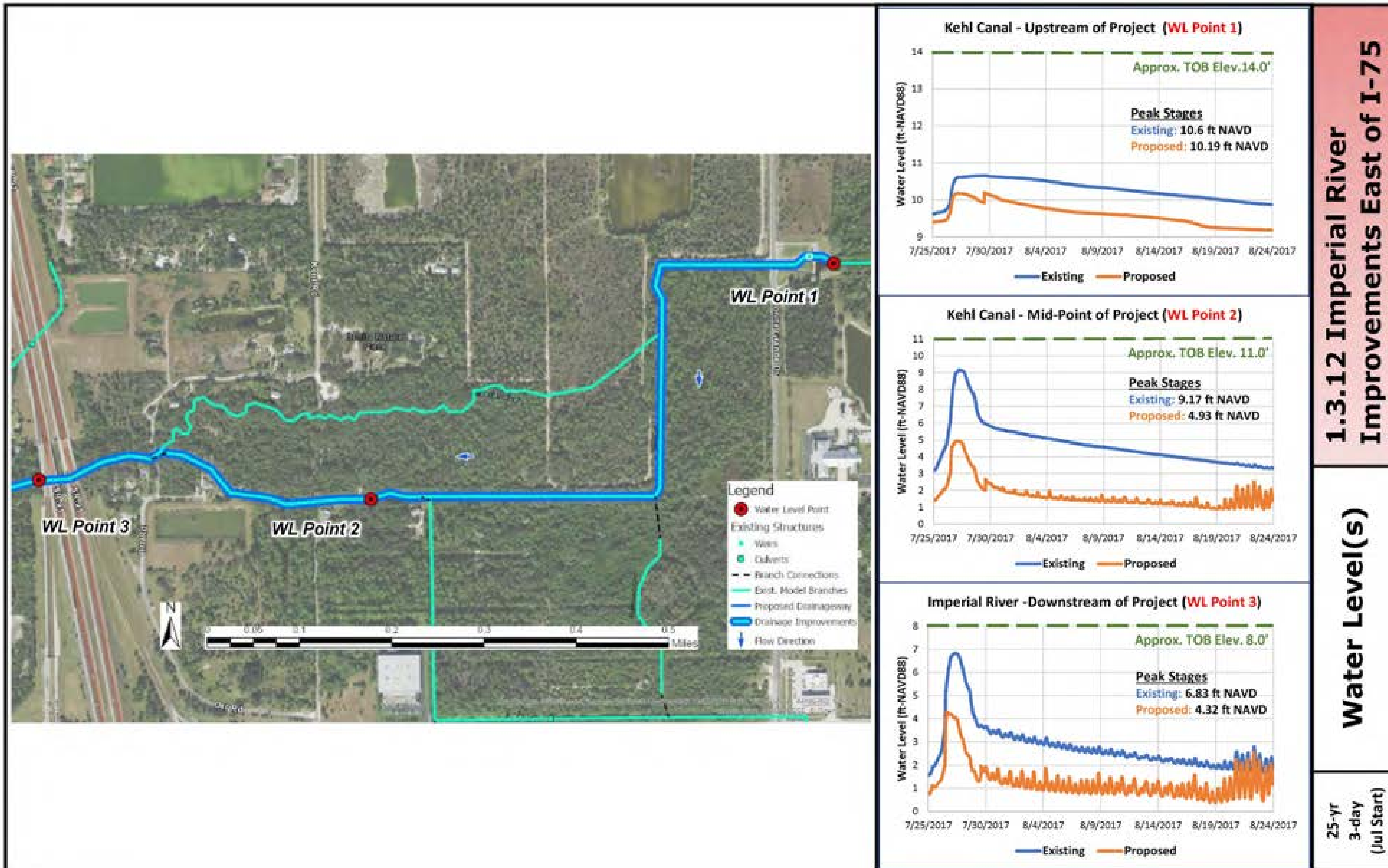
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.12

EXHIBIT 1.3.12 (a)

EXHIBIT 1.3.12 (b)



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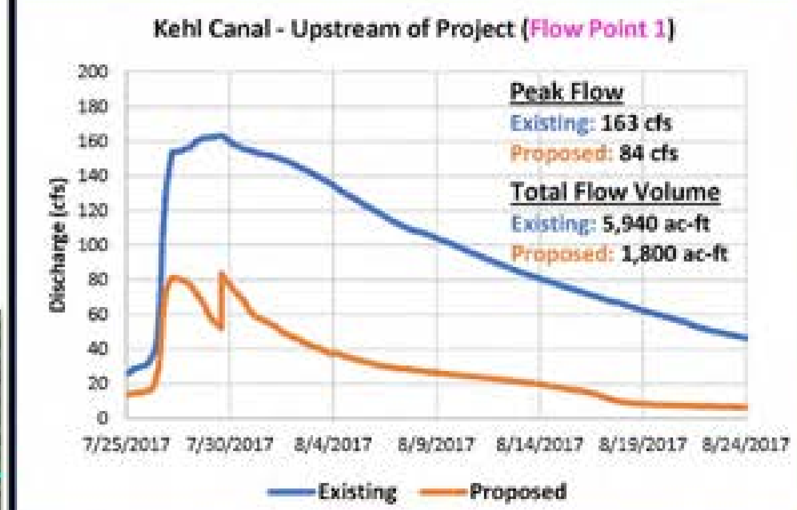
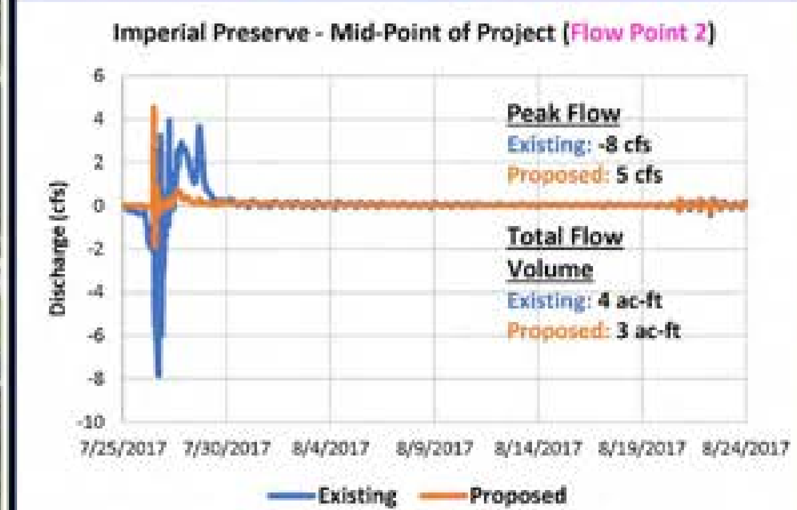
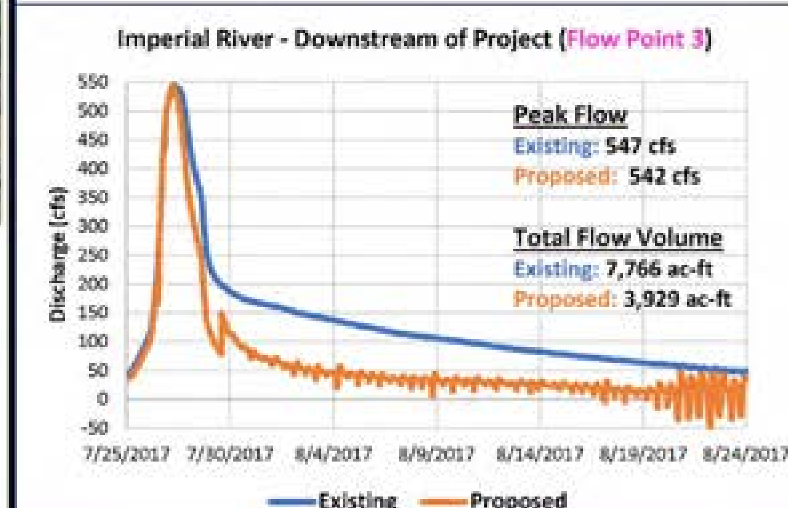






1.3.12 Imperial River Improvements East of I-75

Flow(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.12 (d)

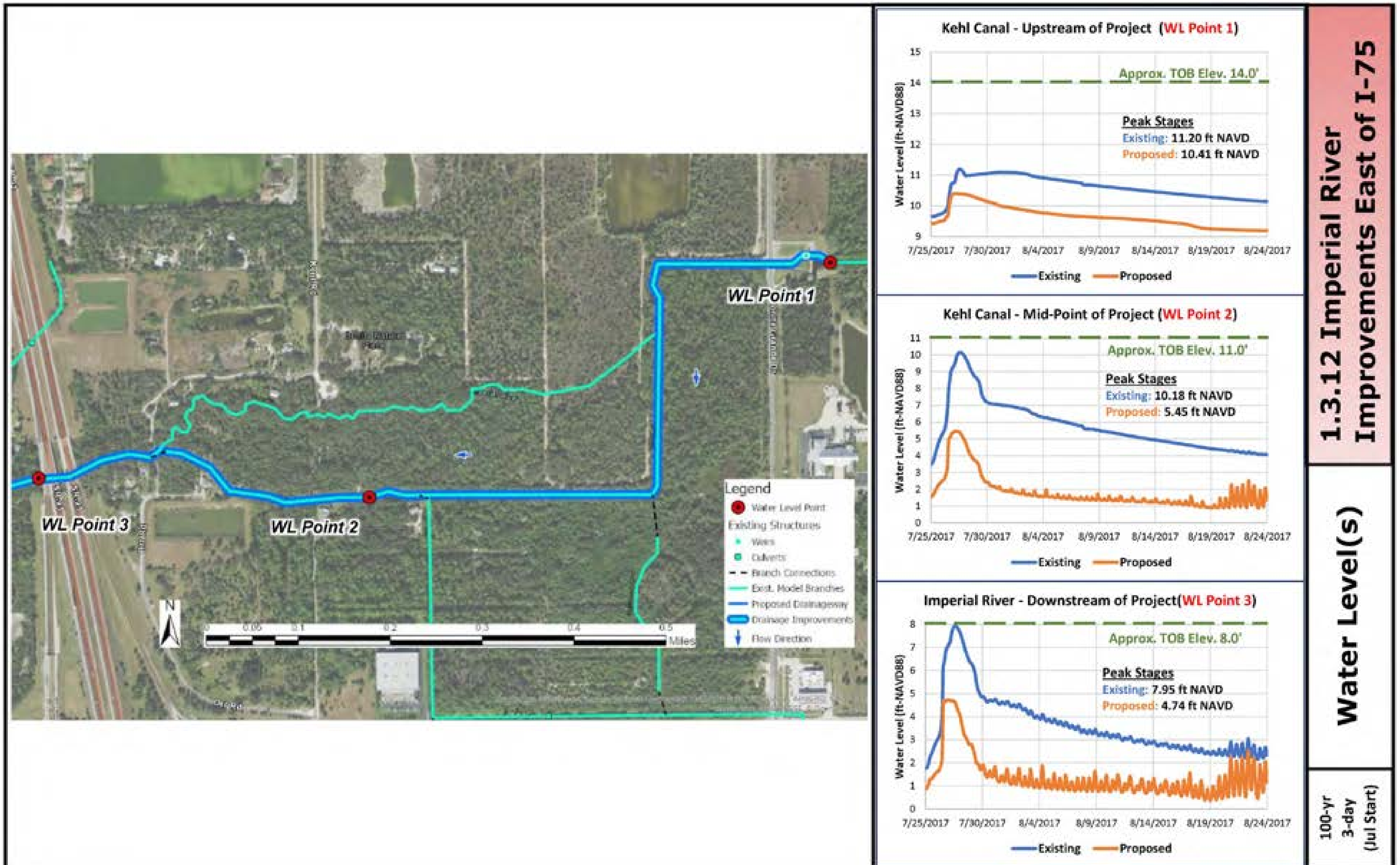
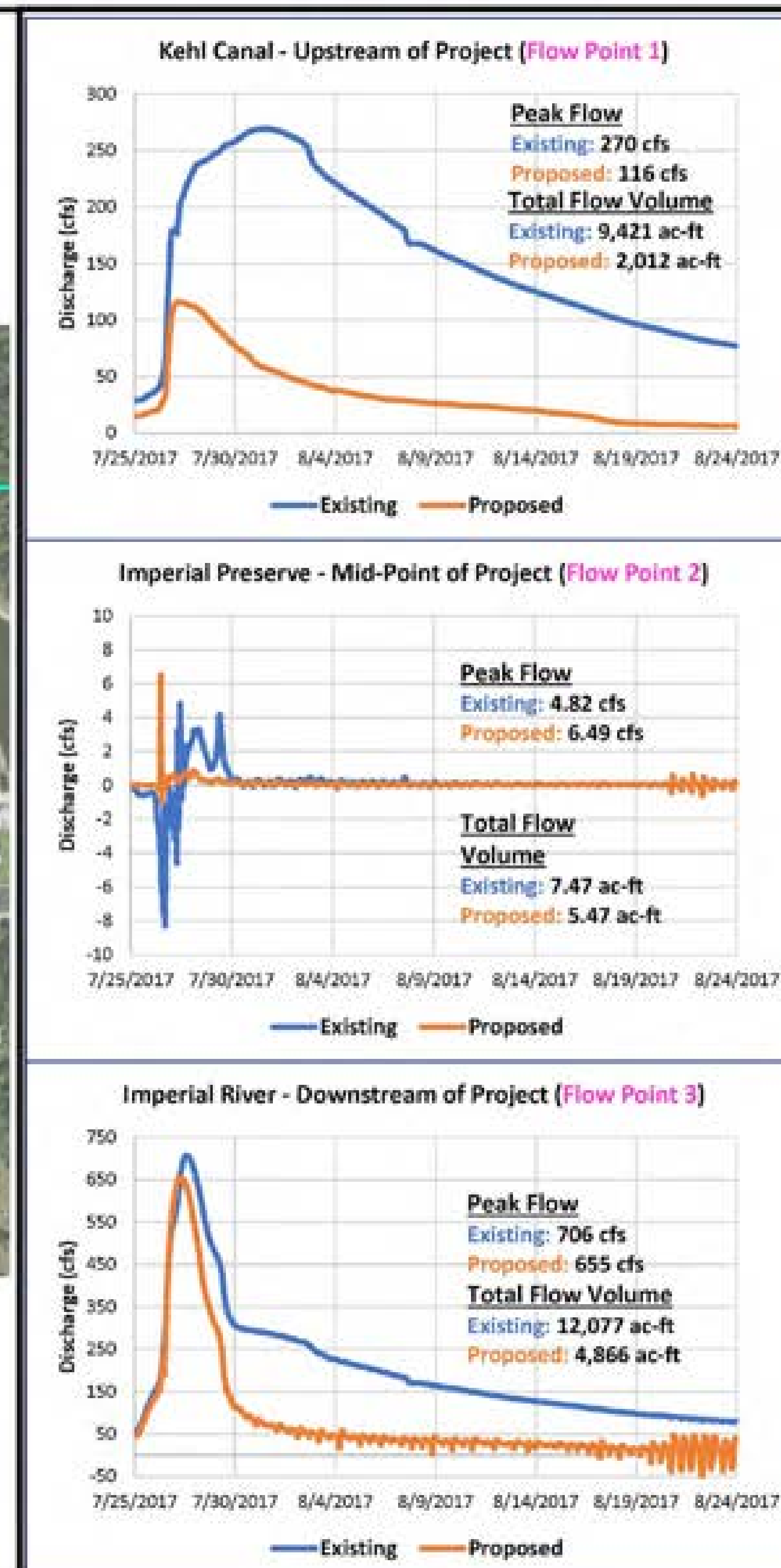


EXHIBIT 1.3.12 (e)

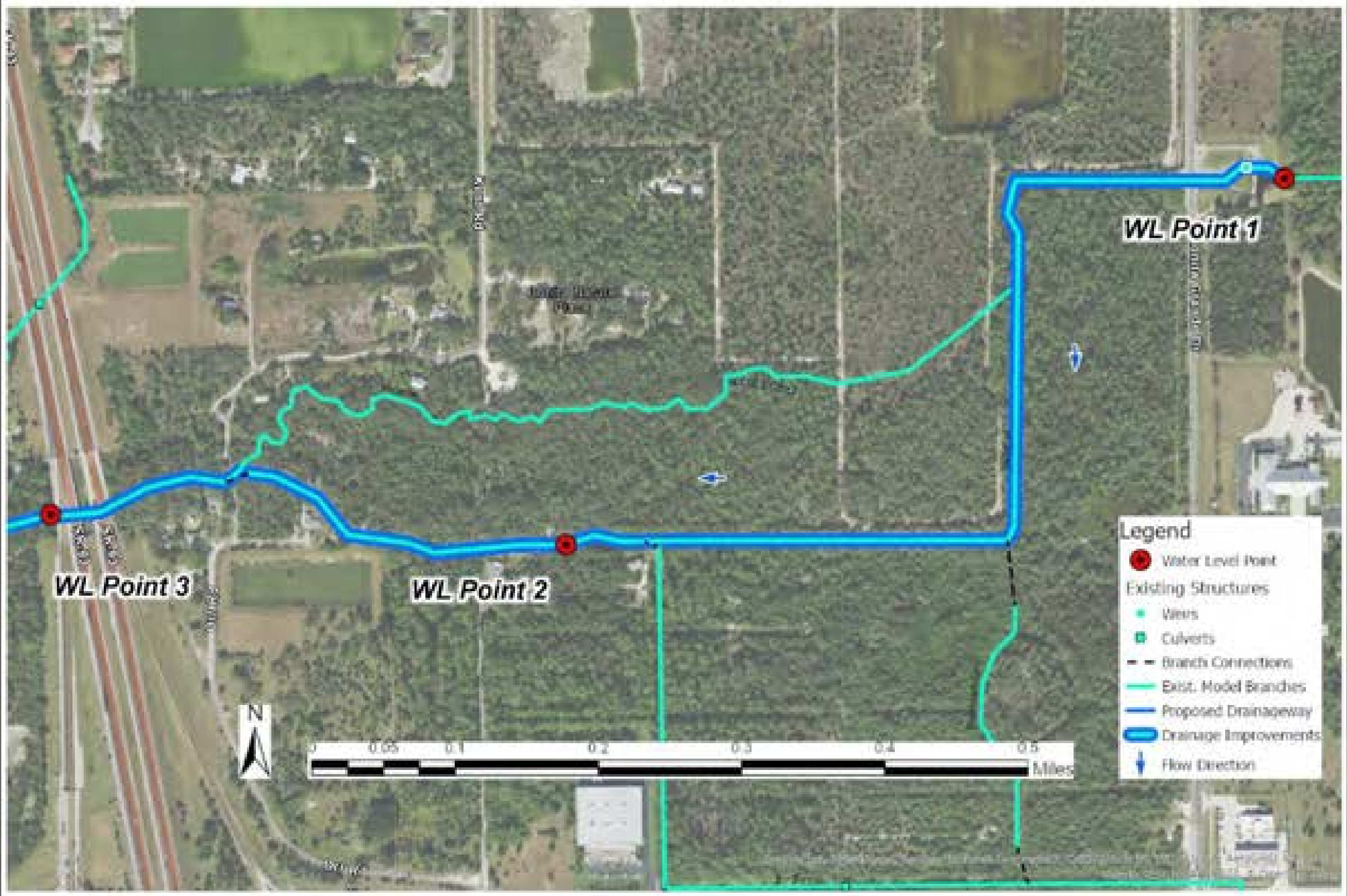


1.3.12 Imperial River Improvements East of I-75

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.12 (f)

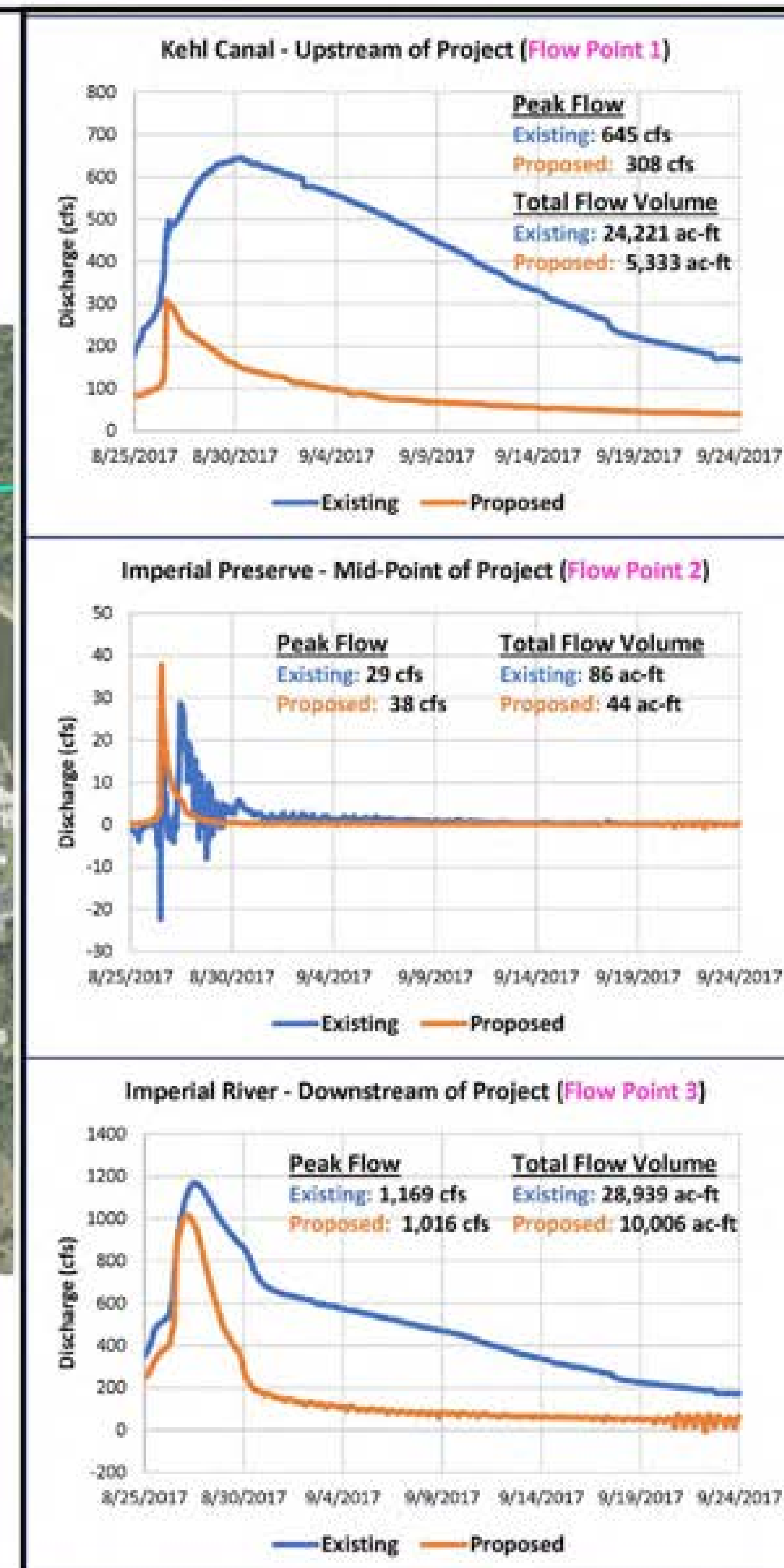


1.3.12 Imperial River Improvements East of I-75

Water Level(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.3.12 (g)

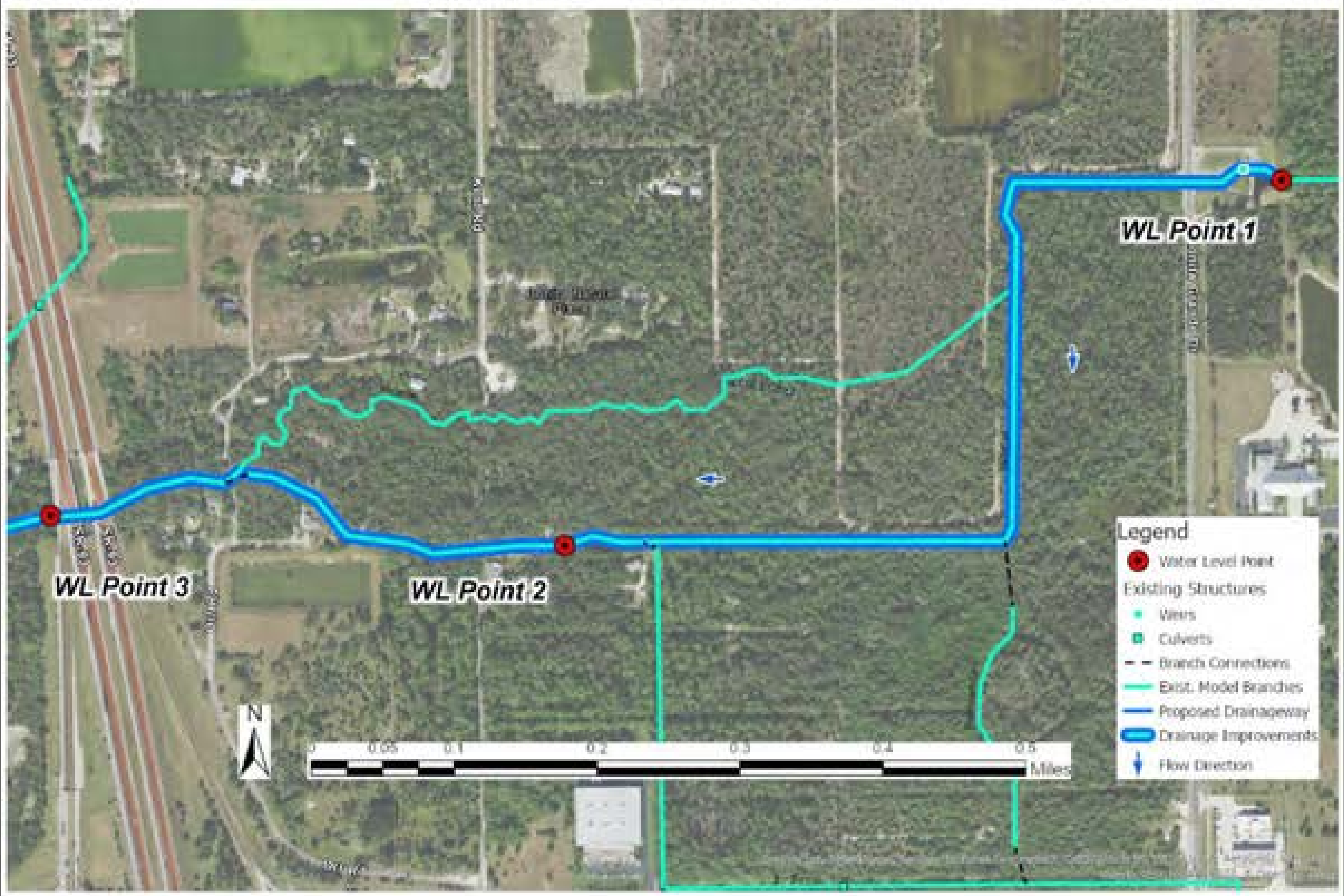


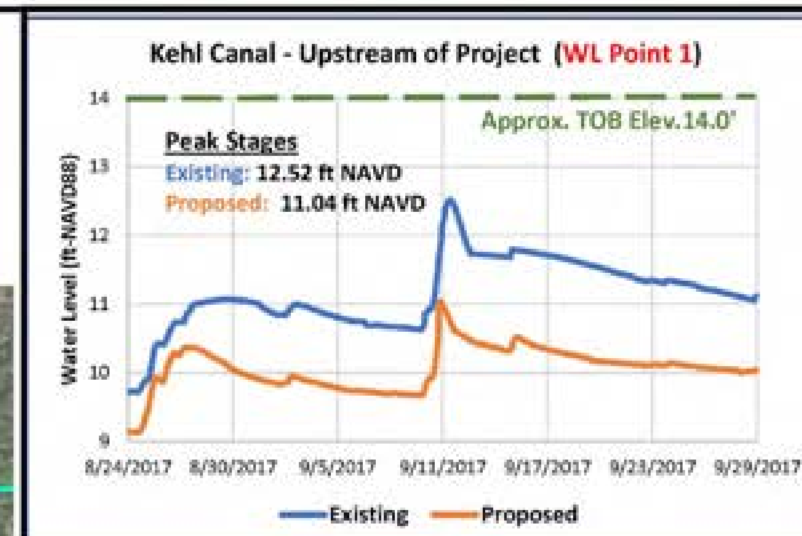
1.3.12 Imperial River Improvements East of I-75

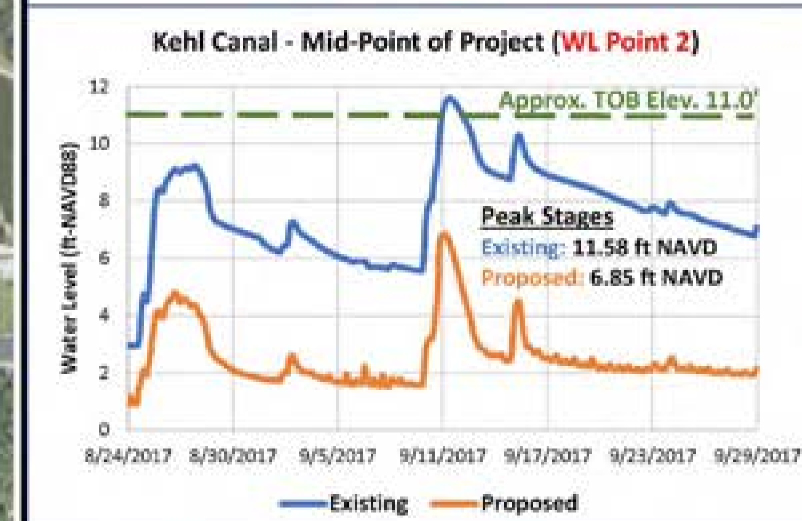
Flow(s)

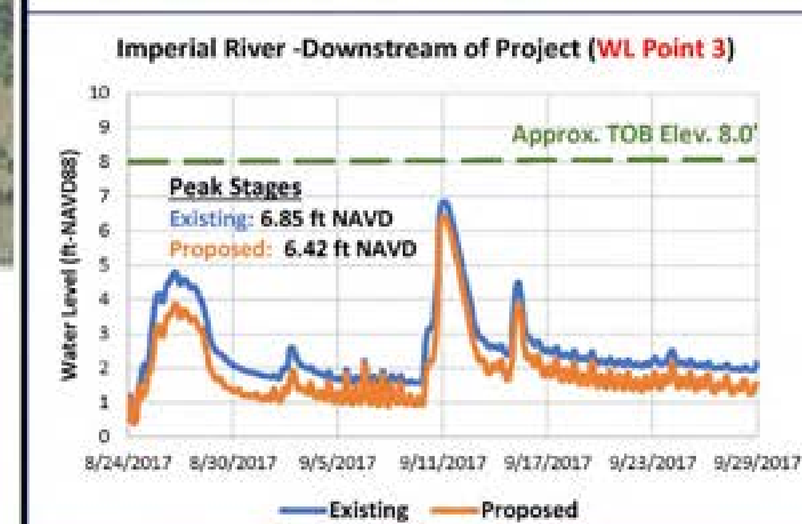
100-yr 3-day (Aug Start)

EXHIBIT 1.3.12 (h)







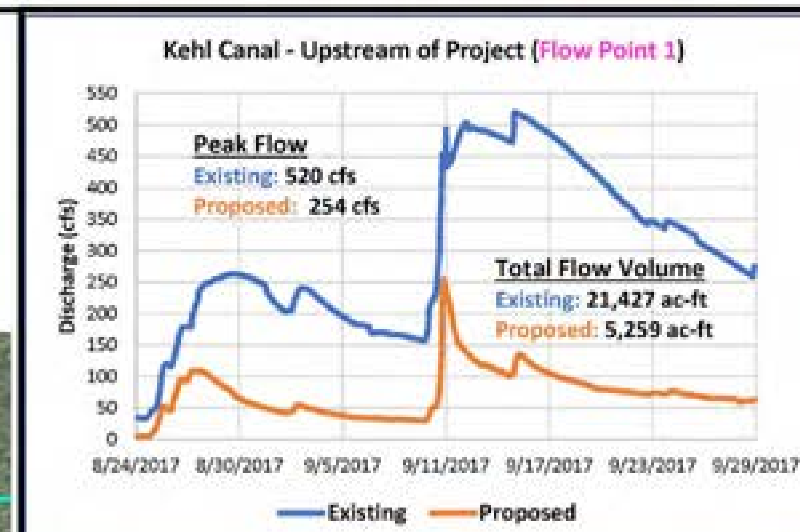


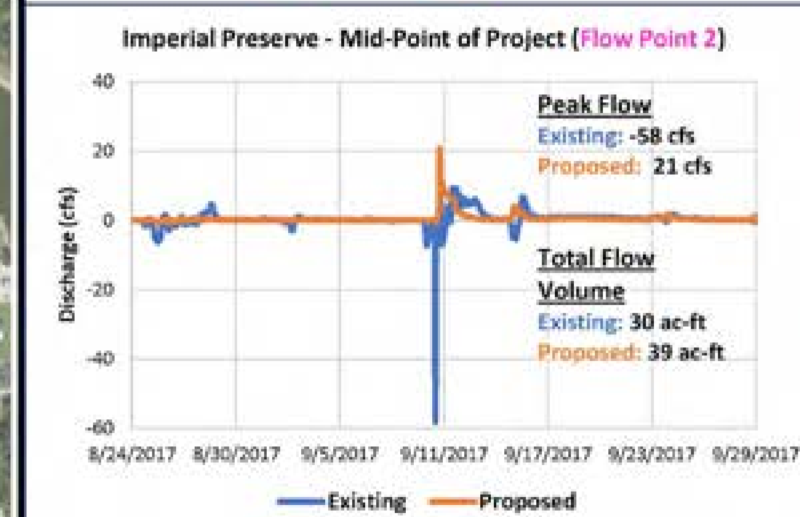
1.3.12 Imperial River Improvements East of I-75

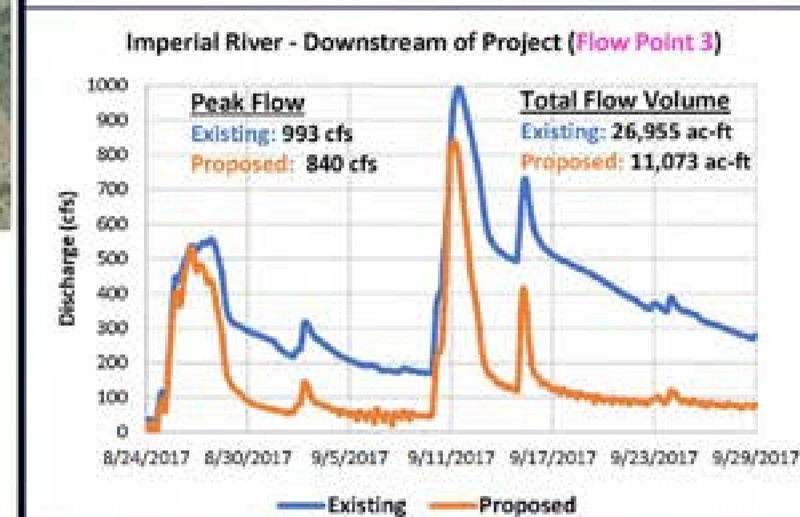
Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.12 (i)







1.3.12 Imperial River Improvements East of I-75

Flow(s)

Continuous Simulation (Hourly)

1.3.13 Crew-Flint Pen Hydrologic Restoration Concept Plan

Background

This concept plan is intended to create a reservoir on the very large area of Crew-Flint Preserve that lies east of Interstate No. 75 and drains to the Imperial River. The land is sloped westerly and southwesterly towards Bonita Springs. The land cover is mostly wetlands, cypress swamps with limited residents and some other uses. There are well fields in the area, power transmission lines and a drainageway that intercepts large overland sheet flow. Land development and other improvements have blocked, confined, and restricted the natural overland flow in the area. The reservoir area slopes from EL 17+ down to EL 13+. With a flood water level near el 17+, the average depth of water in the reservoir would be approximately two (2'+) deep. This depth would be a flood level and not an annual water level.

Location

This proposed conceptual project is in SE Lee County beginning at the eastern Lee County Line and continuing west to Interstate 75 between Corkscrew Road and Bonita Beach Road as illustrated in **Figure 39**.

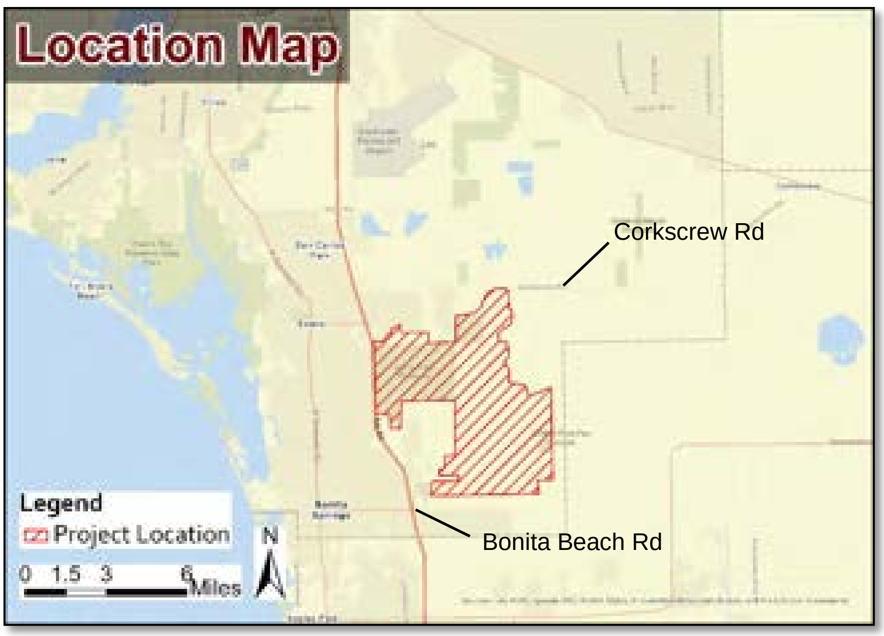


Figure 39 – Location Map, 1.3.12 Crew-Flint Pen Hydrologic Restoration

Description

This proposed conceptual project would develop a reservoir area on the Crew/Flint–Pen/Kiker Preserve area to hold excess stormwater until downstream developed areas have drained following a large storm event. This area would be contained within a perimeter berm and remotely operated weir gates would be necessary to maintain flow and water levels within desirable ranges as illustrated in **Figure 40**.

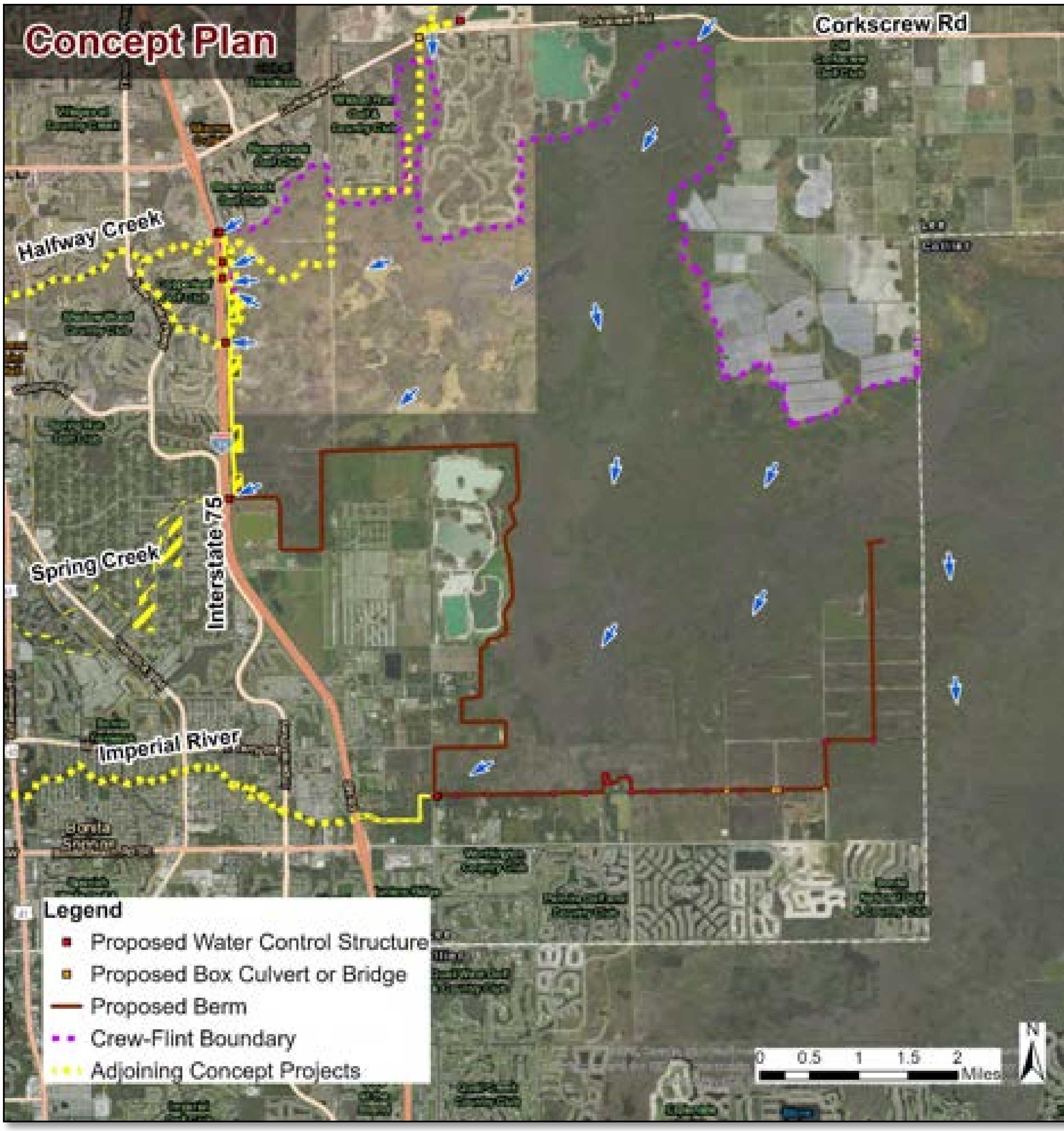


Figure 40 – Concept Plan, Crew-Flint Pen Hydrologic Restoration

Purpose

This proposed project improves storage of excess stormwater to reduce flooding downstream and improves hydrologic conditions in the preserve by controlling runoff during non-storm periods.

Evaluation

Viability

The stormwater control project concept of creating a stormwater reservoir storage area on the Crew/Flint/Kiker Preserve nature area is a key component of staging flow east of Interstate 75 while the areas west of Interstate 75 would drain first. This hydrologic reservoir warrants the complexity of project development.

Community Considerations

This area is undeveloped with only a few residents and entities utilizing the natural area. Construction of a partial perimeter berm would have some temporary impact on residents.

Environmental & Permittability Considerations

The construction of the partial perimeter berm and modern water control structures may lead to an enhanced hydrology in this natural area. Currently there are some drainage connections to this area that may be causing drawdown of water tables during the dry season. The wetland impact areas would be avoided, minimized or mitigated.

Land Availability

This project would require possible private property acquisition and governmental agency approval for the work. Coordination with the City of Bonita Springs would be required.

Opinion of Probable Cost

The cost opinion shown in **Table 14** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project. Note that there is a cost provision for structure demolition which is indicated by the "structure damages" component. The wetland mitigation costs were not specifically identified, but rather generally accounted for in the "project unknowns" component.

Table 14 - Opinion of Probable Cost breakdown, 1.3.13 Crew-Flint Pen Hydrologic Restoration

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPP/ Misc.	1	LS	$ 2,976,000	$ 2,976,000
Clearing & Grubbing	104	AC	$ 14,000	$ 1,456,000
Earthwork	1,120,000	CY	$ 8	$ 8,960,000
Structure Damages	20	EA	$ 100,000	$ 2,000,000
Construction/ Maintenance Access	250,000	SY	$ 20	$ 5,000,000
Detours	1	LS	$ 100,000	$ 100,000
Road Repairs	2,700	SY	$ 40	$ 108,000
			Construction Cost Sub-Total:	**$ 20,600,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 5,600,000
			Land Acquisition	$ 1,000,000
			Project Administration/ CEI (10%):	$ 1,800,000
			Project Unknowns	$ 18,000,000
			Conceptual Project Cost:	**$ 47,000,000**
			Contingency (30%)	$ 14,000,000
			Conceptual Project Cost (with Contingency):	**$ 61,000,000**

Opportunities for Multiple Benefits & Uses

The partial perimeter Berm may also serve as a hiking and biking trail for nature enthusiast.

Other Considerations

Fill material for constructing the partial perimeter berm may be supplied from on-site or other projects in the flood mitigation program may be utilized. A summary of this concept project is shown below in **Exhibit 1.3.13** herein.

Findings & Recommendations

Regional Modeling Findings

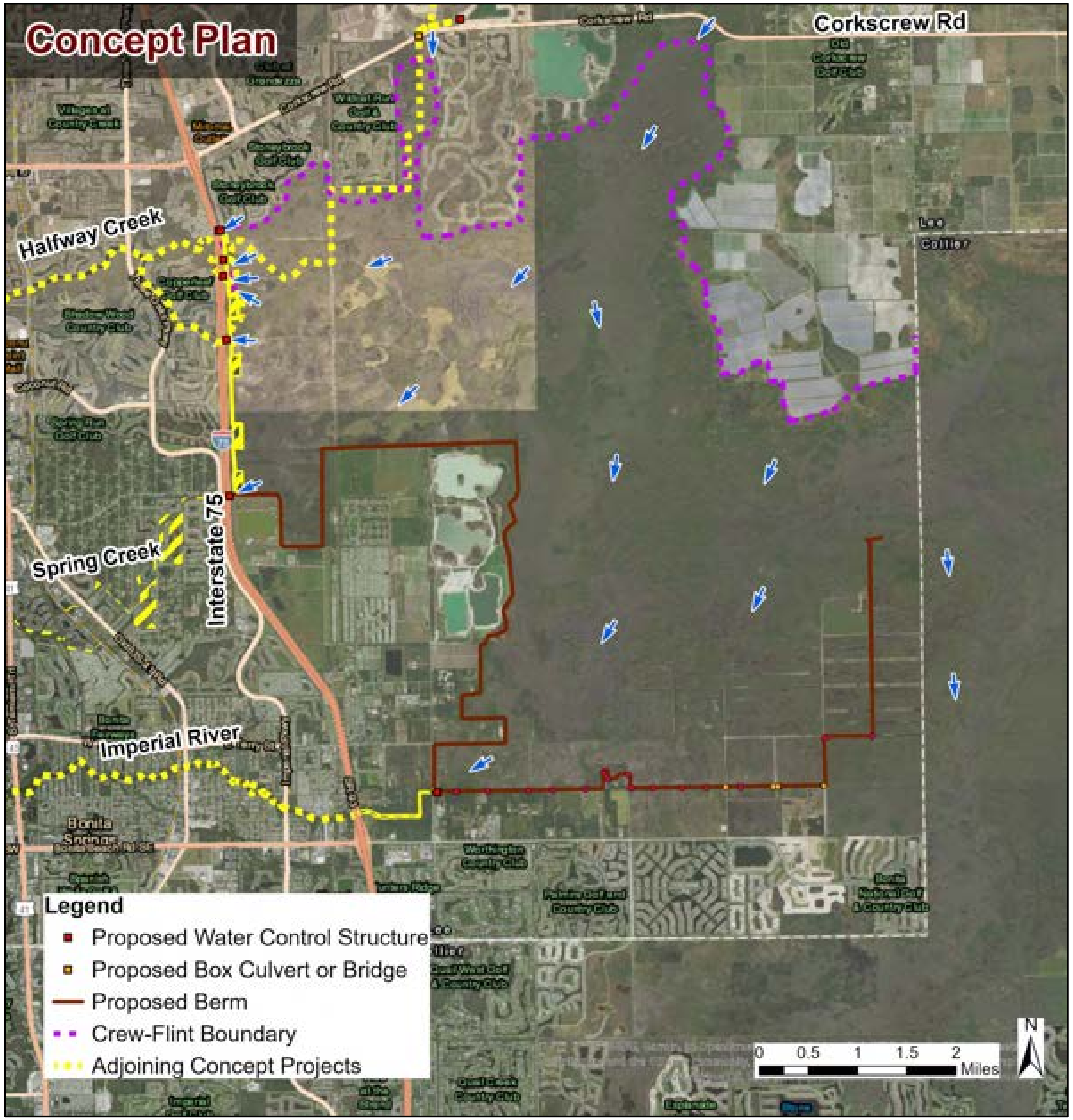
This project concept consists of holding excess stormwater on the east side of Interstate 75 in the Crew Flint Pen/Kiker Preserve area and delaying the release of the stored runoff until the water levels in the areas west of Interstate 75 are sufficiently recovered from a large storm event. These flows will be released through large control structures to manage flow through multiple outfalls towards open water. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.13 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.13 (b)
	Flow(s)	EXHIBIT 1.3.13 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.13 (d)
	Flow(s)	EXHIBIT 1.3.13 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.3.13 (f)
	Flow(s)	EXHIBIT 1.3.13 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.3.13 (h)
	Flow(s)	EXHIBIT 1.3.13 (i)

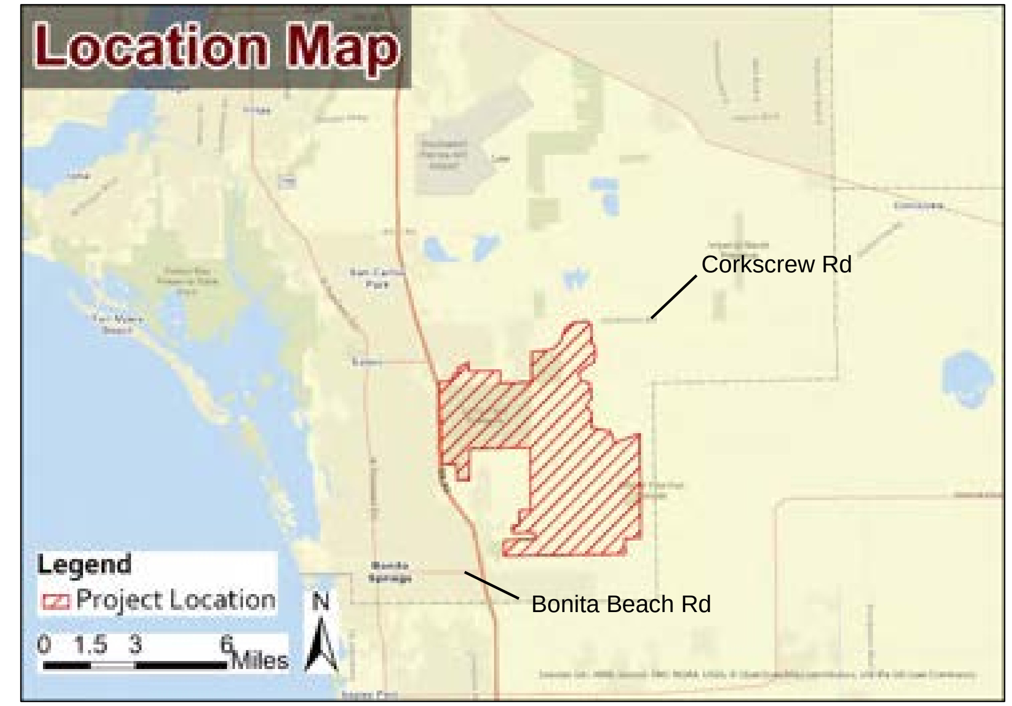
Improvements were shown such that the water levels within the reservoir berm without raising the water level in the Corkscrew Swamp. Water levels downstream of the reservoir were reduced. These results show that with properly managed water levels, the reservoir can conceptually store a severe storm event.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by storing excess stormwater on the east side of I-75 in the Crew Flint Pen/Kiker Preserve area, and delaying the release of the stored runoff until the conveyances west of I-75 are capable of handling the flow. These positive improvements warrant further design-level project development.



Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project would develop a reservoir area on the Crew Flint–Edison Farms area to hold excess stormwater until downstream developed areas have drained following a large storm event. This area would be contained within a perimeter berm and remotely operated weir gates would be necessary to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project improves storage of excess stormwater to reduce flooding downstream and improves hydrologic conditions in the preserve by controlling runoff during non-storm periods.

CONSTRAINTS: This project as planned crosses public, community and private properties requiring governmental approvals and land acquisition. Weir structures to manage water levels and large drainage structure would be required. Environmental impacts, if any, would necessitate mitigation.

May 2020

Crew-Flint Pen Hydrologic Restoration

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.13

EXHIBIT 1.3.13 (a)

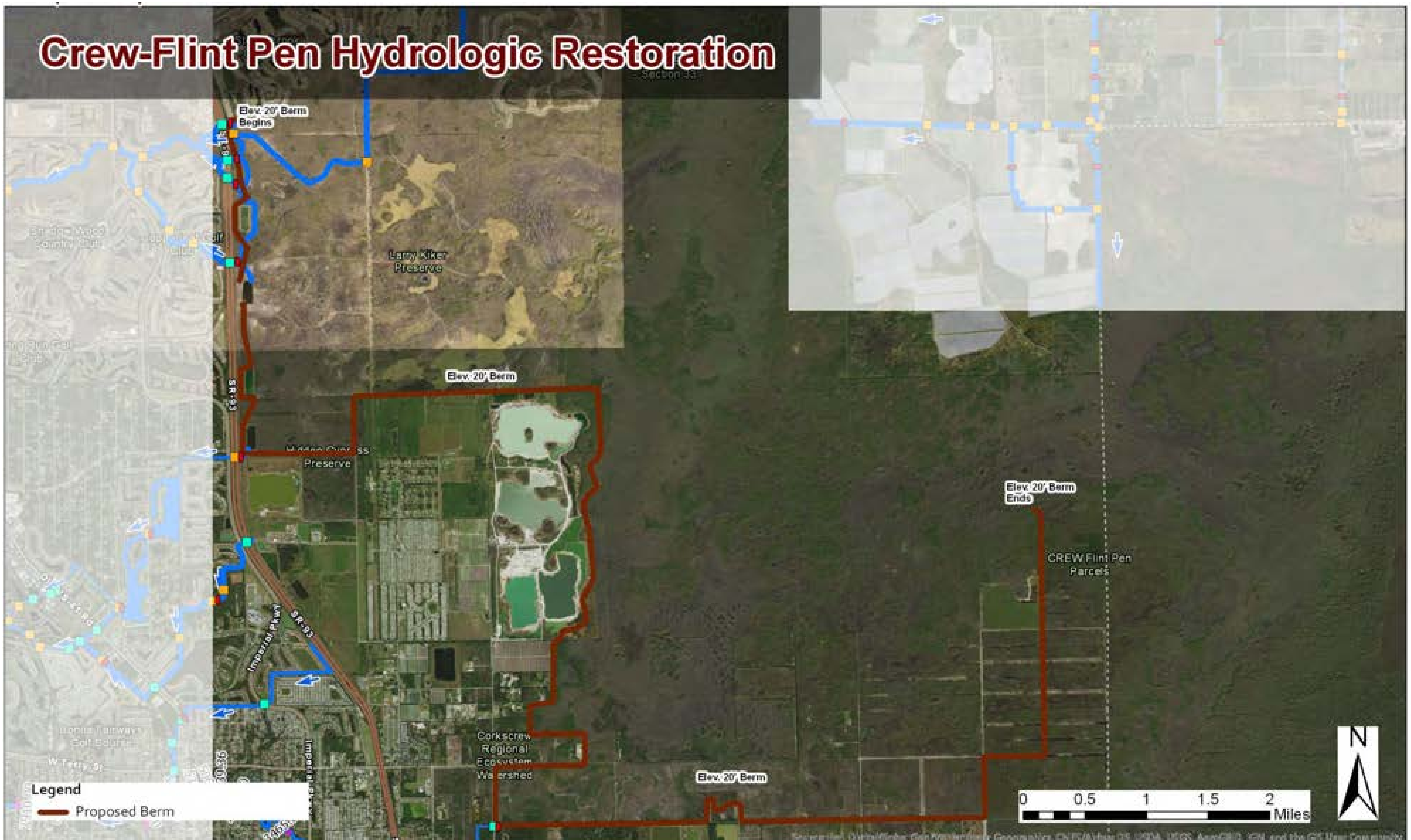


EXHIBIT 1.3.13 (b): 1 of 2

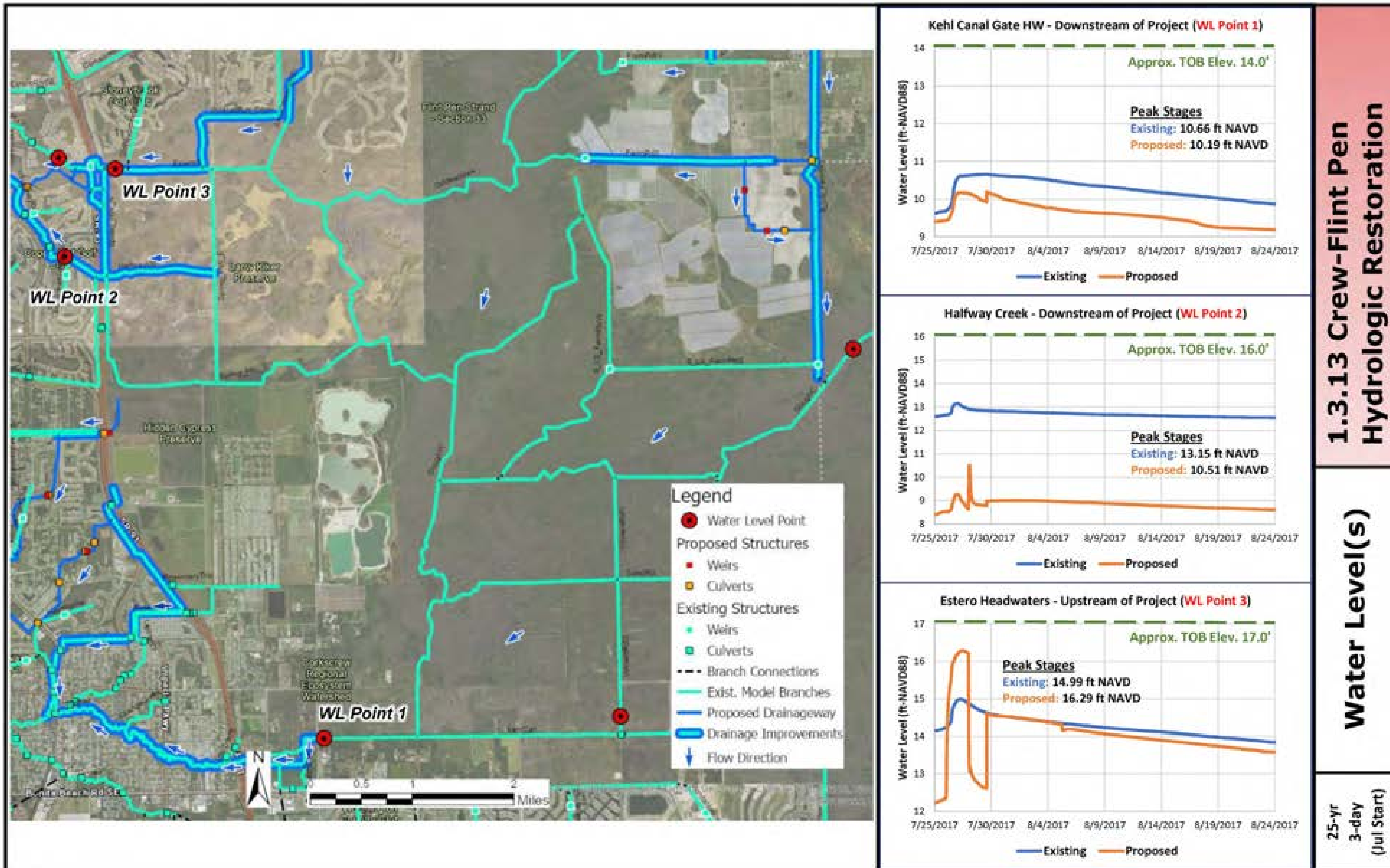
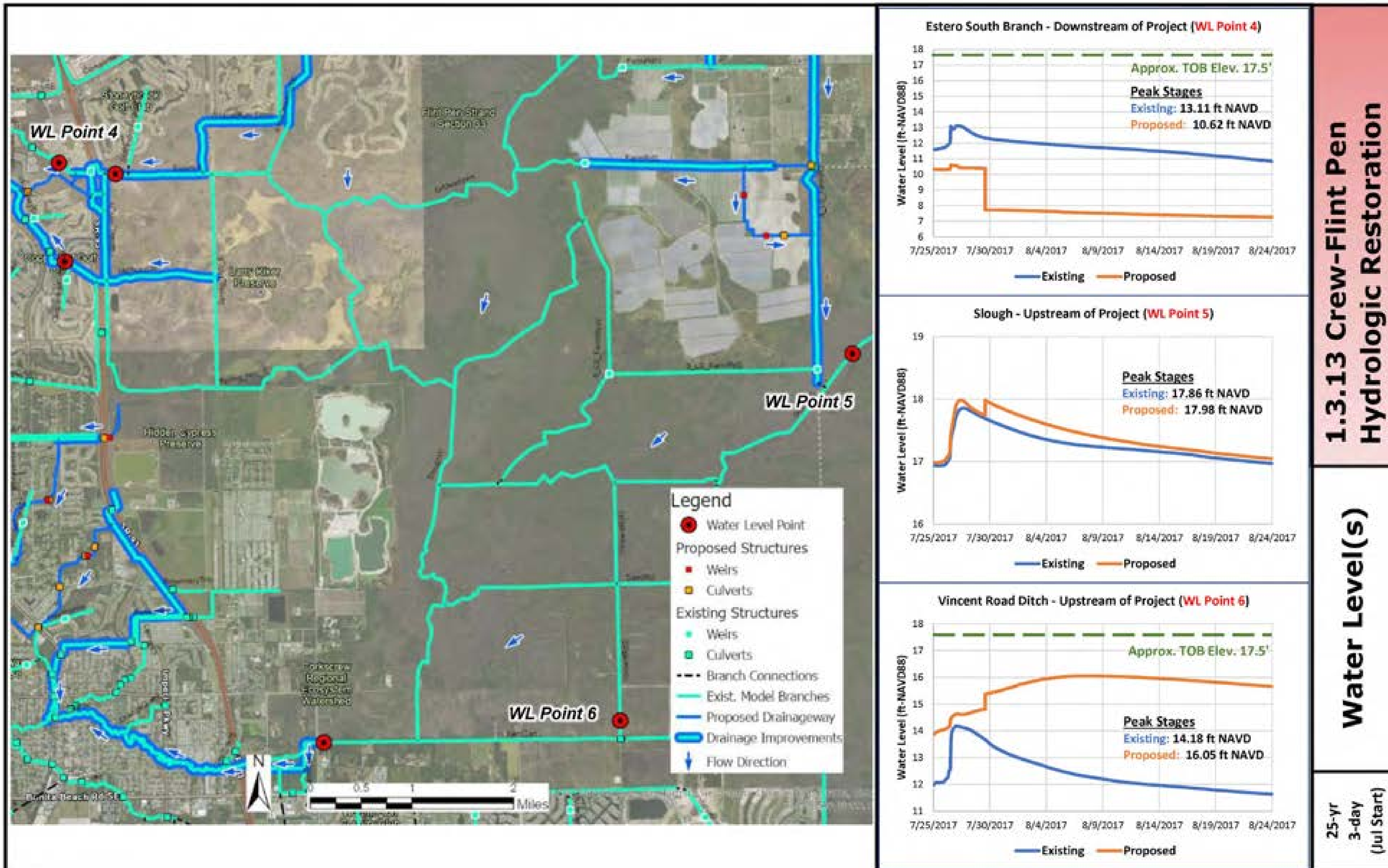


EXHIBIT 1.3.13 (b): 2 of 2



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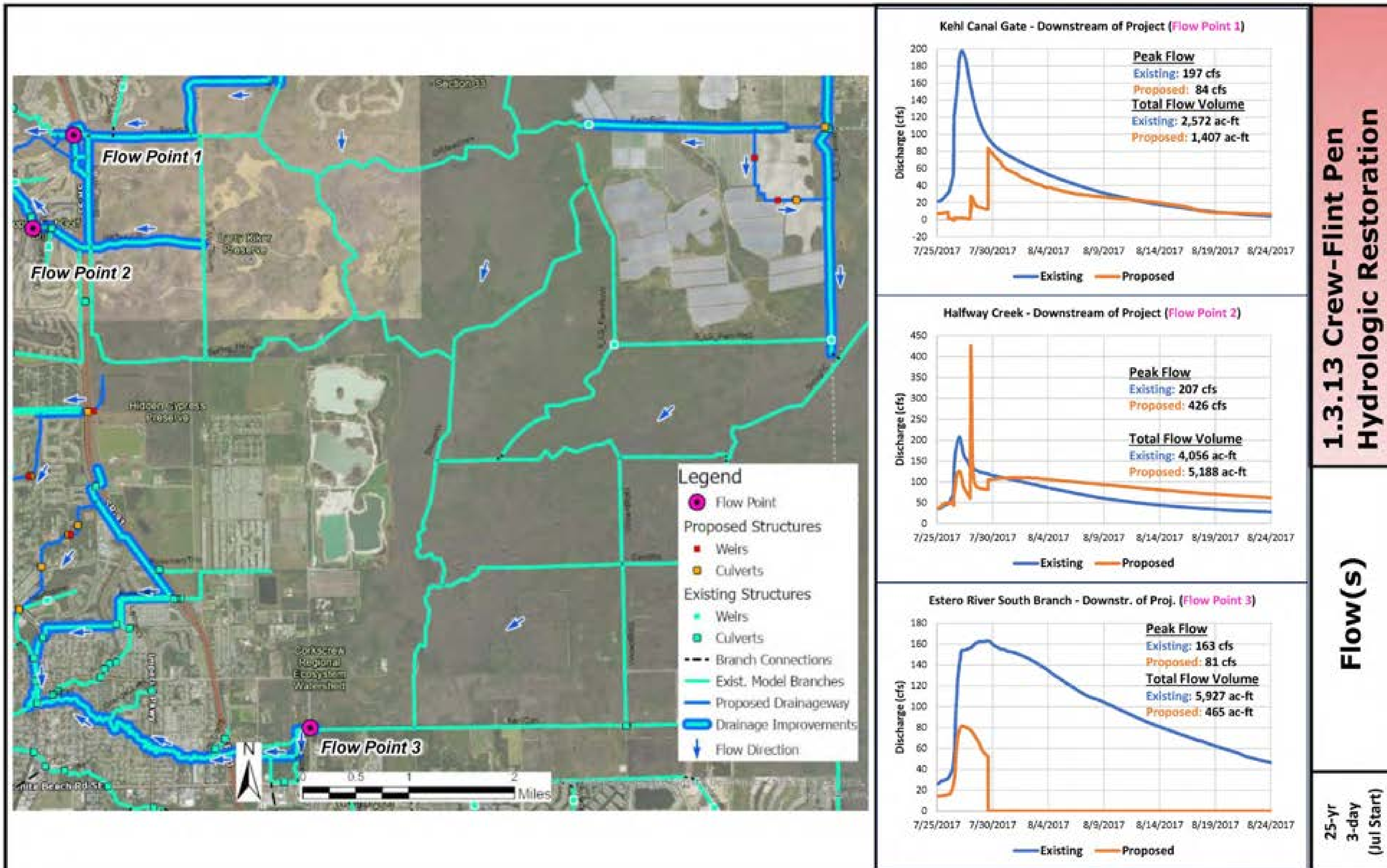

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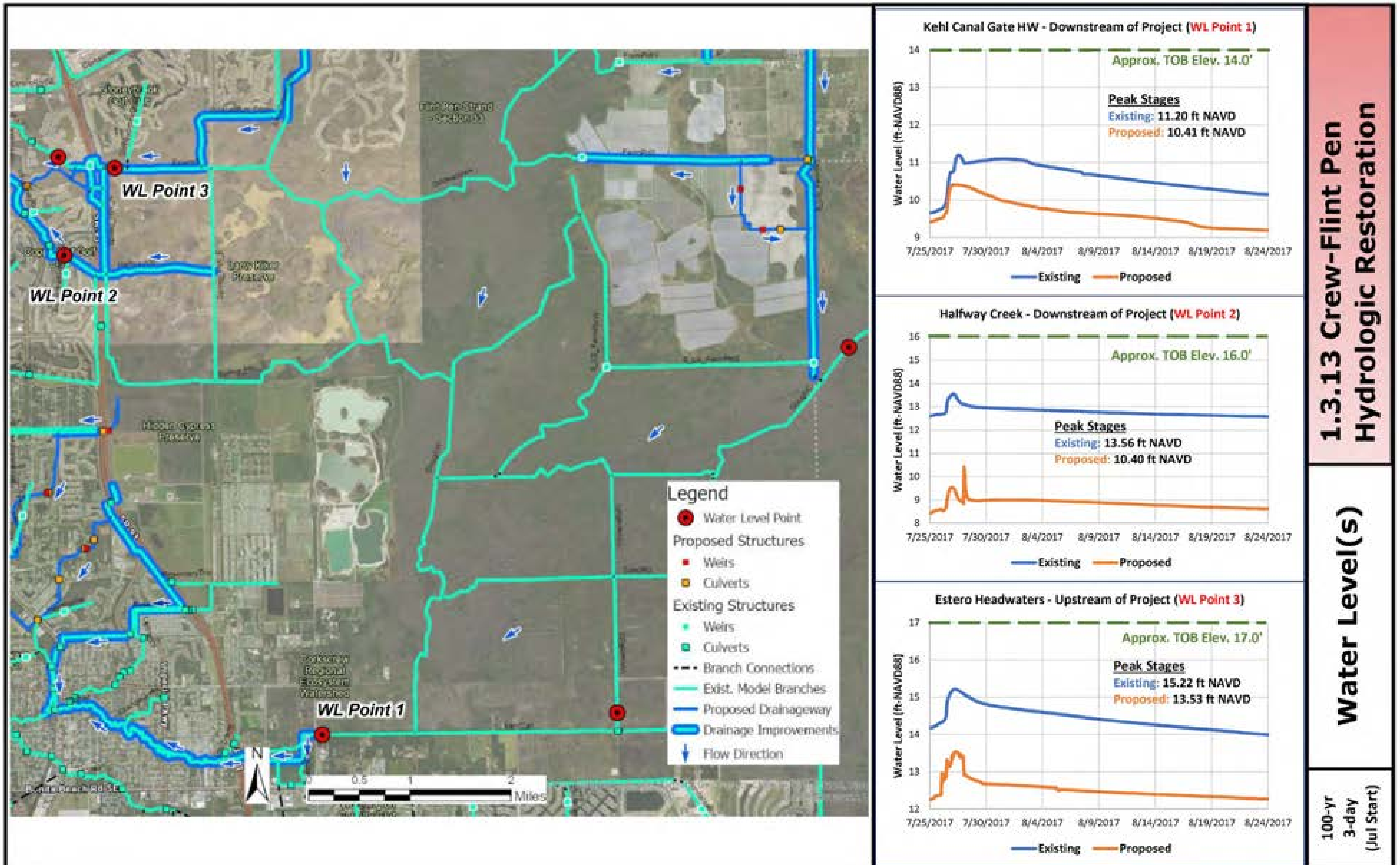

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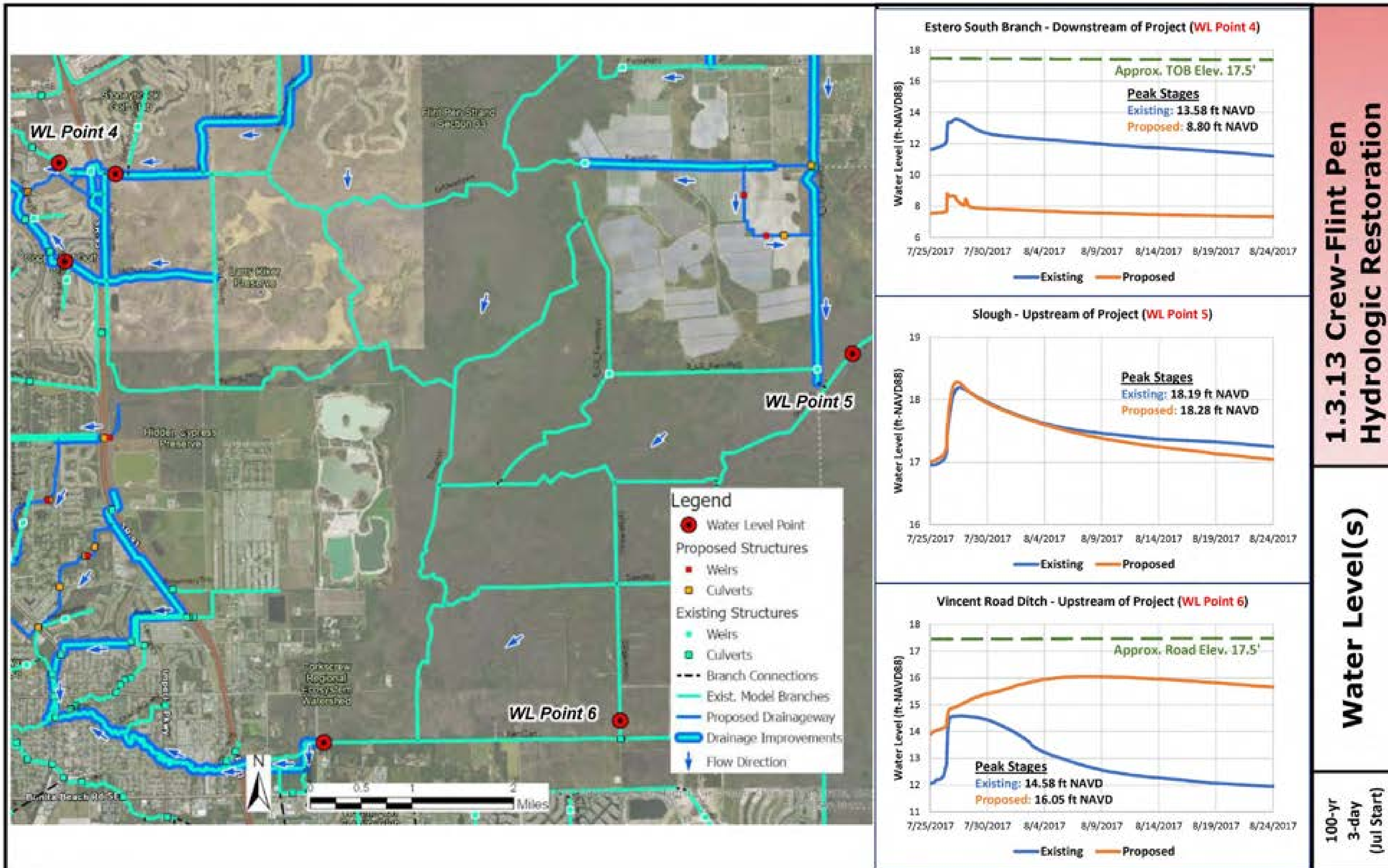

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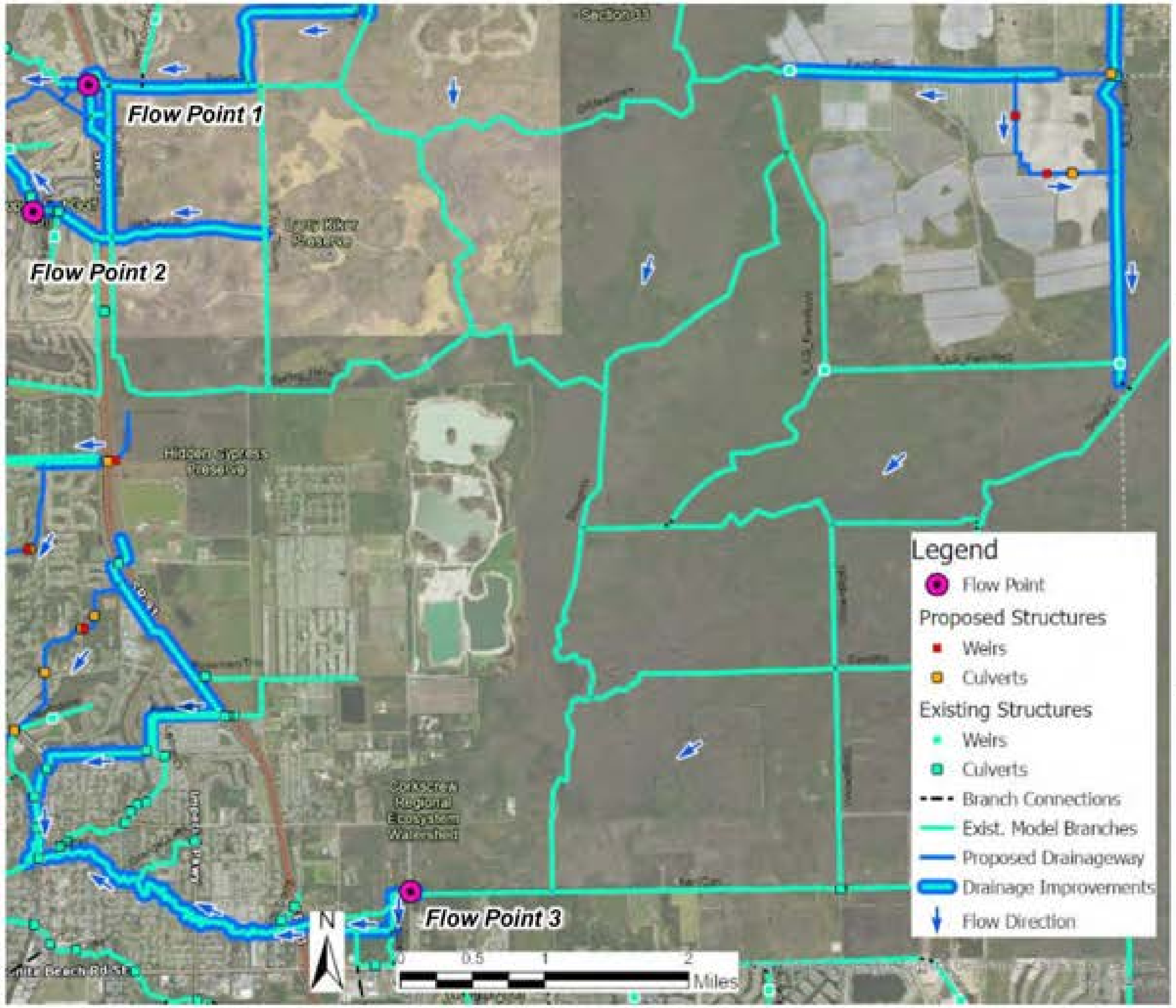
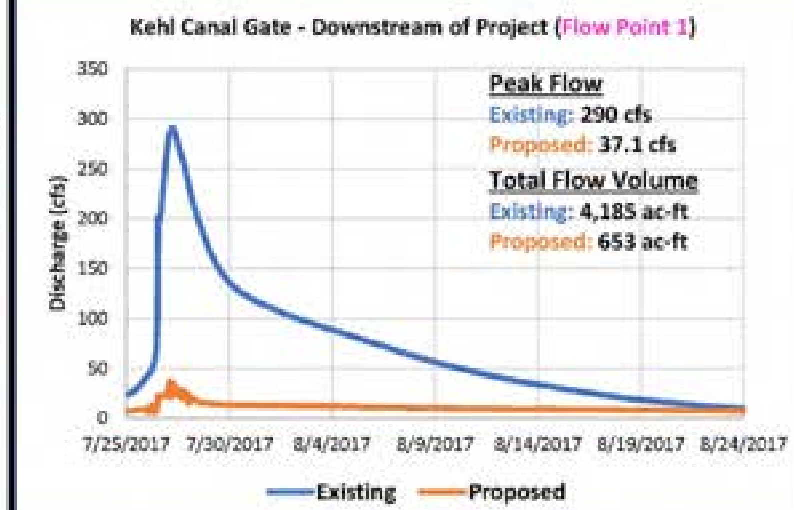
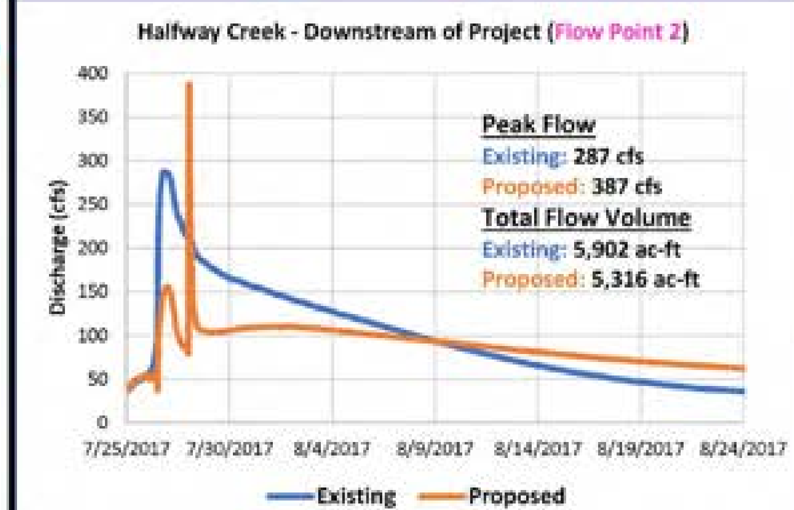
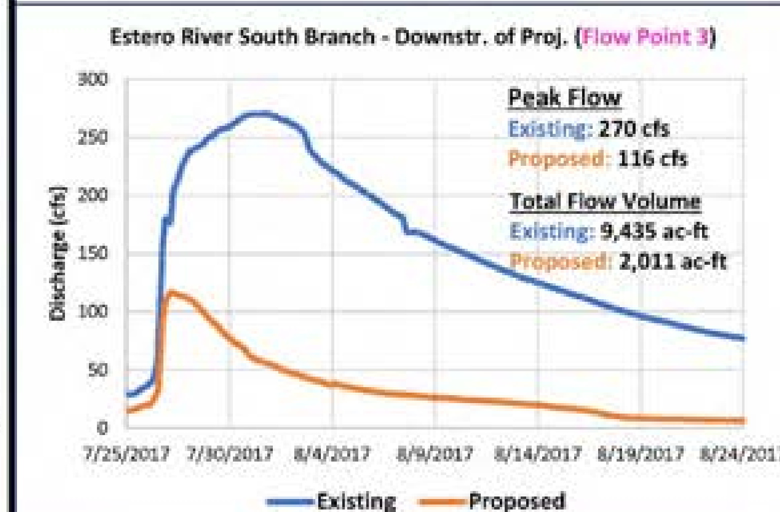






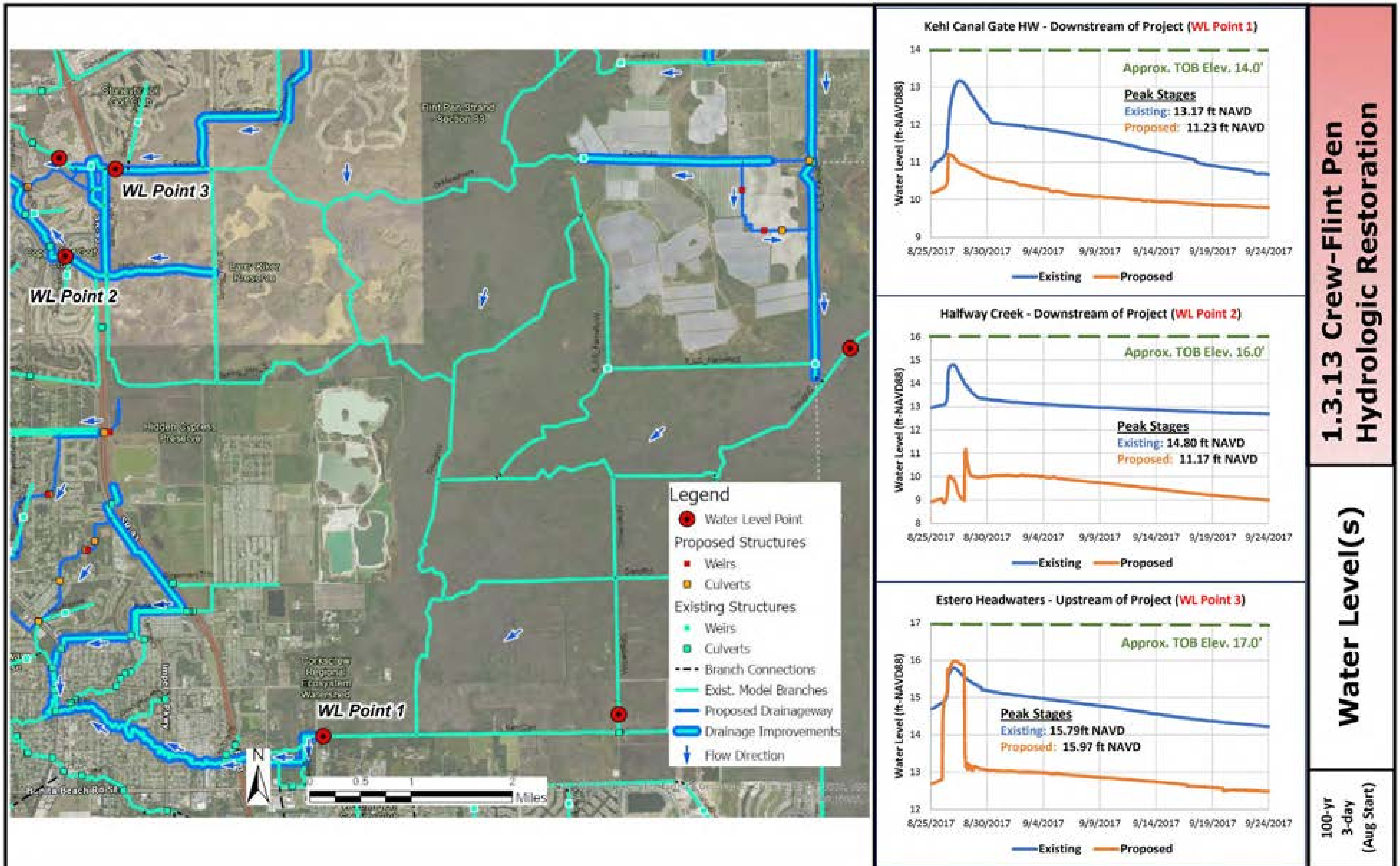


1.3.13 Crew-Flint Pen Hydrologic Restoration

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.13 (f): 1 of 2



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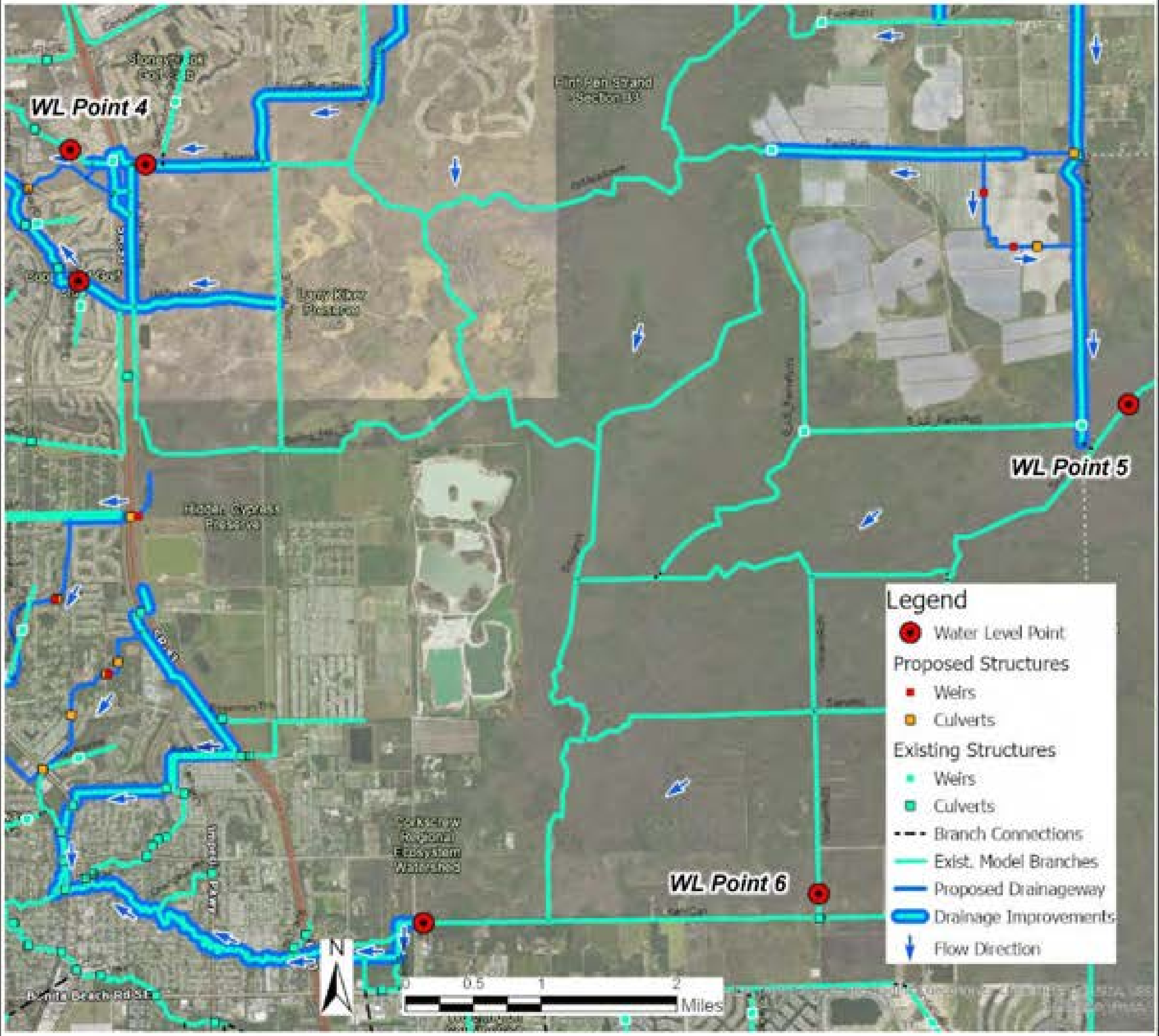
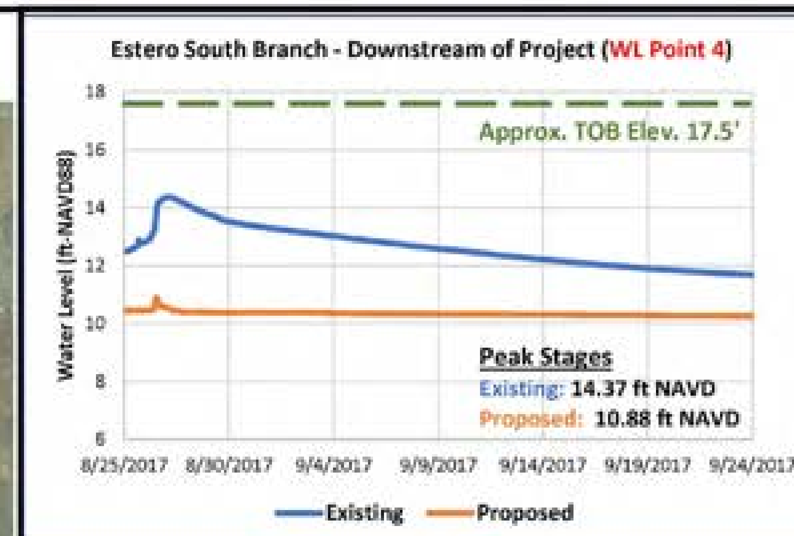
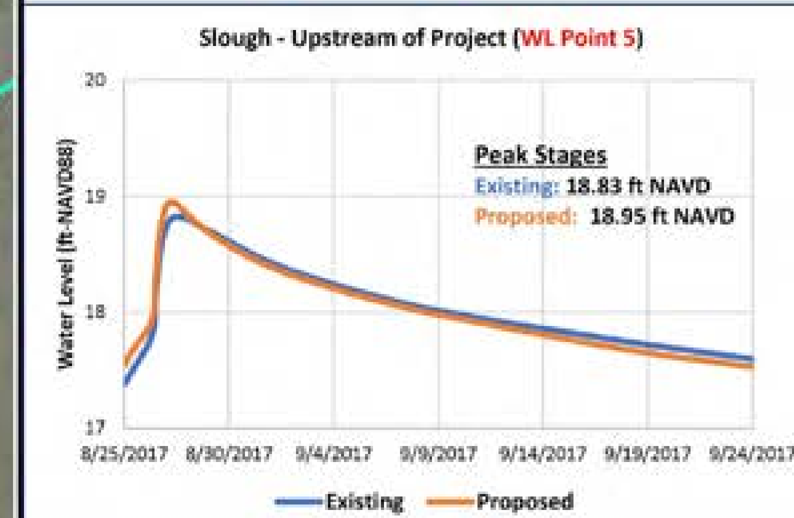
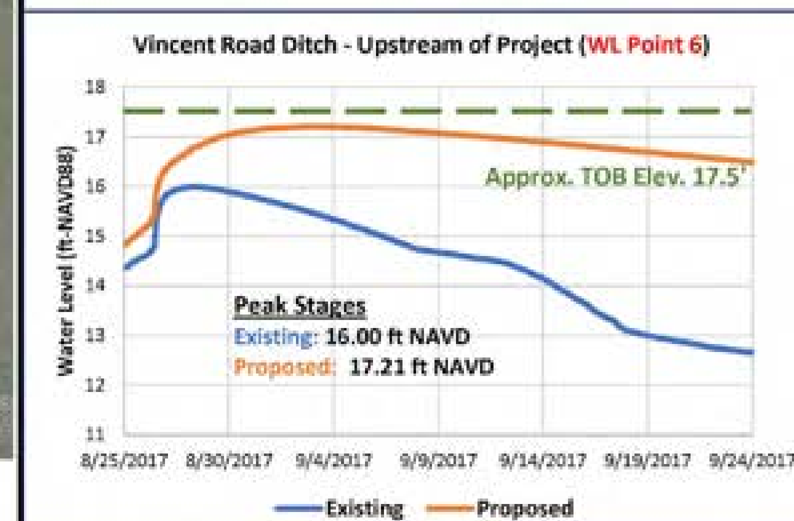






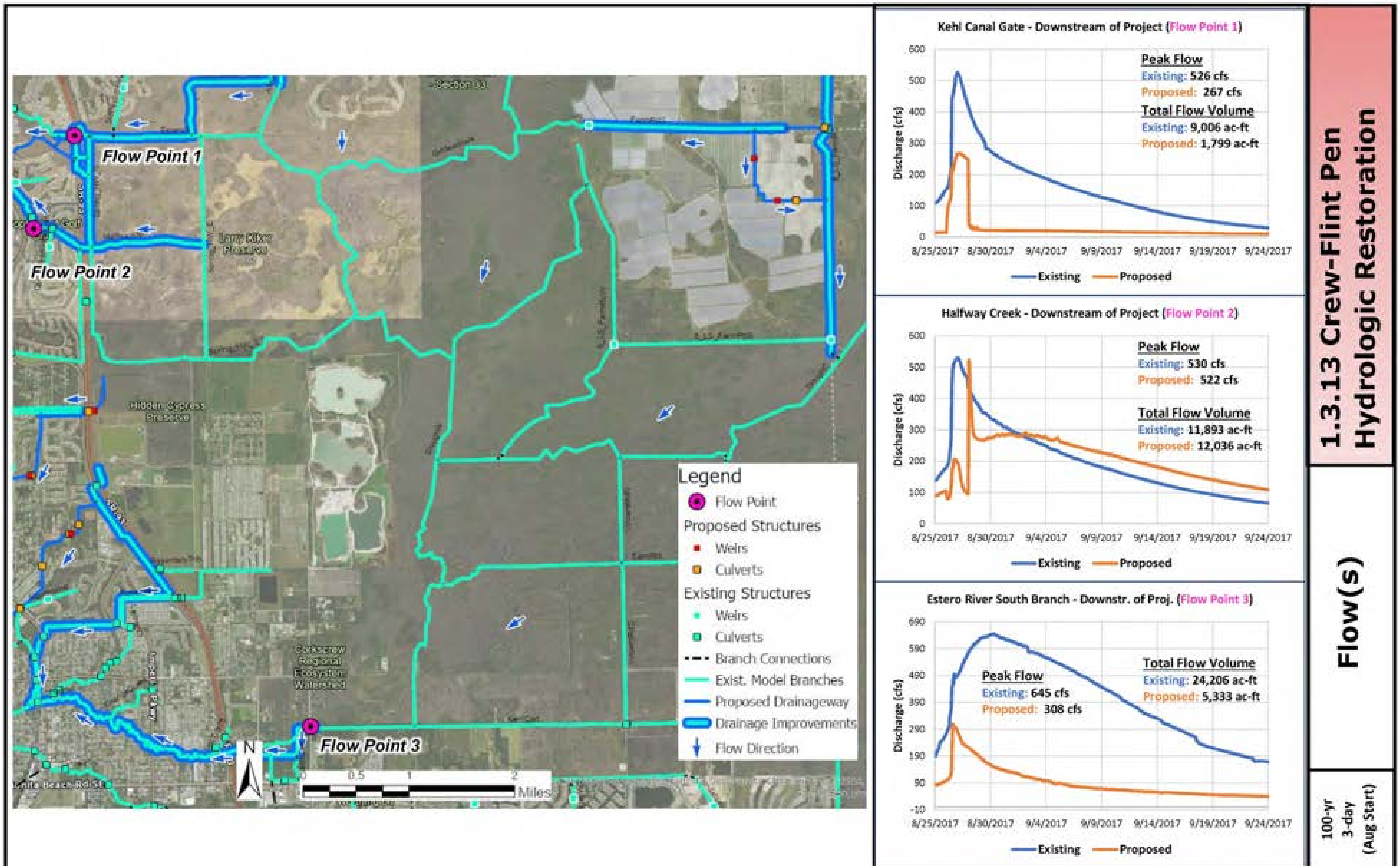


1.3.13 Crew-Flint Pen Hydrologic Restoration

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.13 (g)



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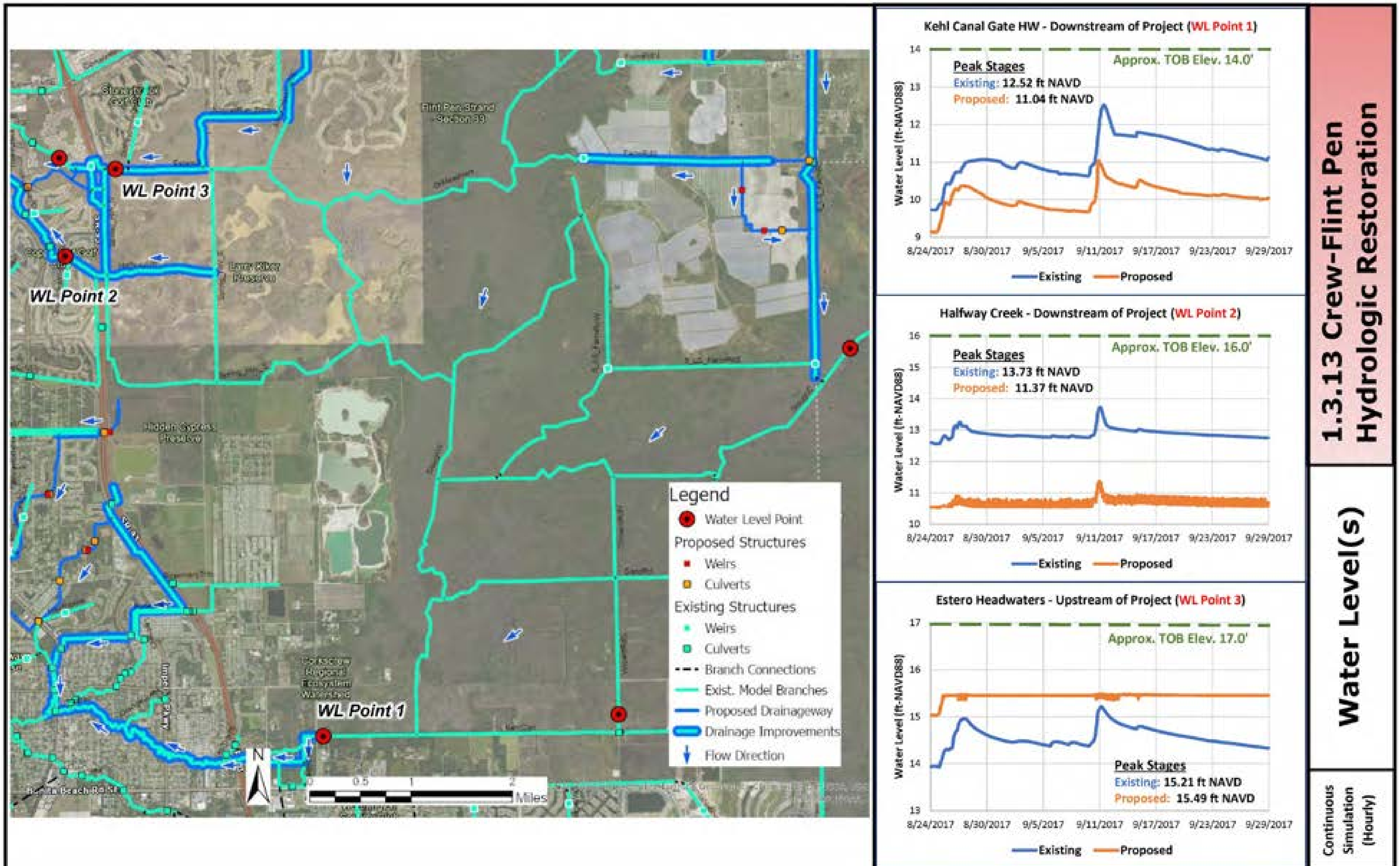
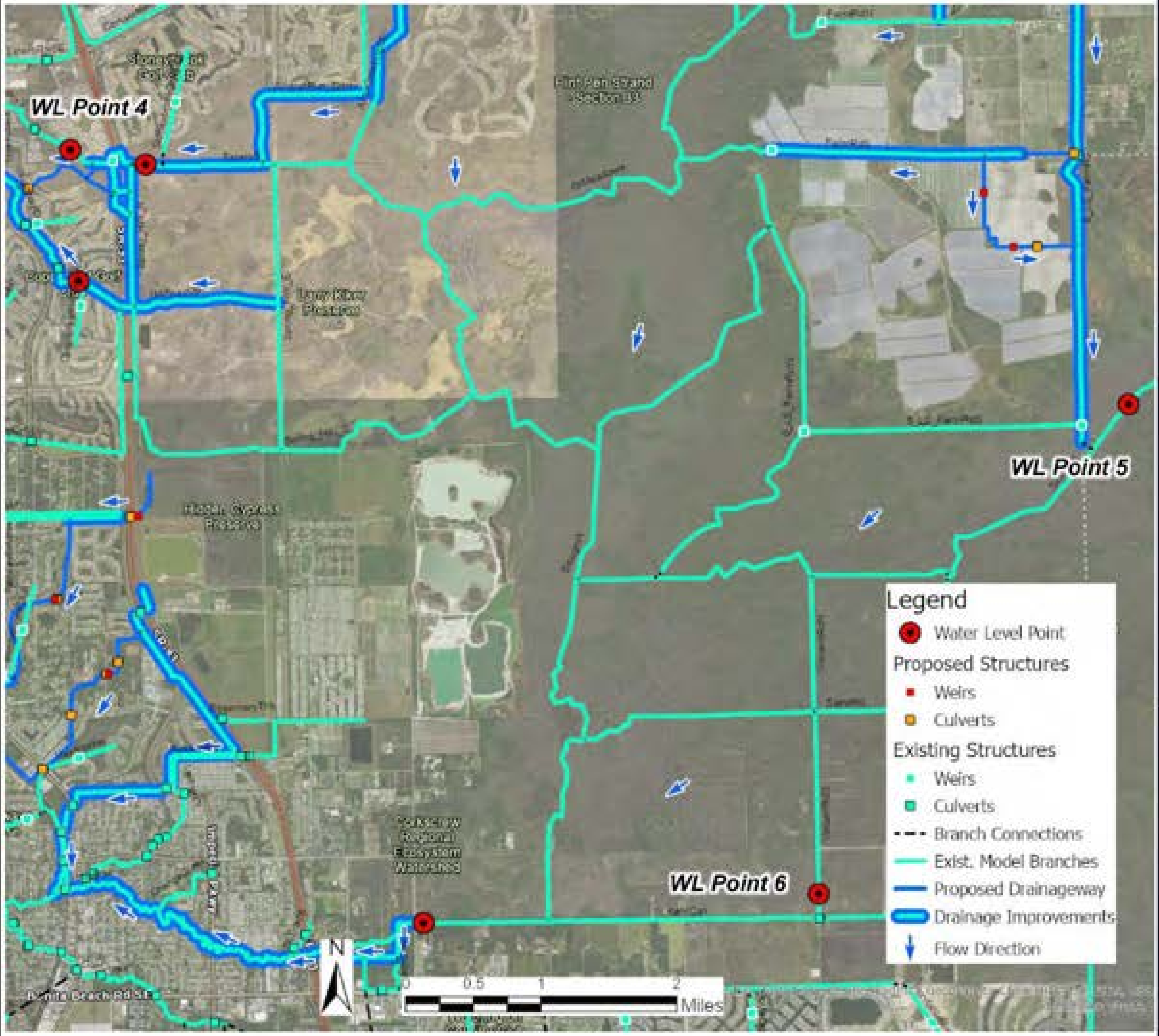
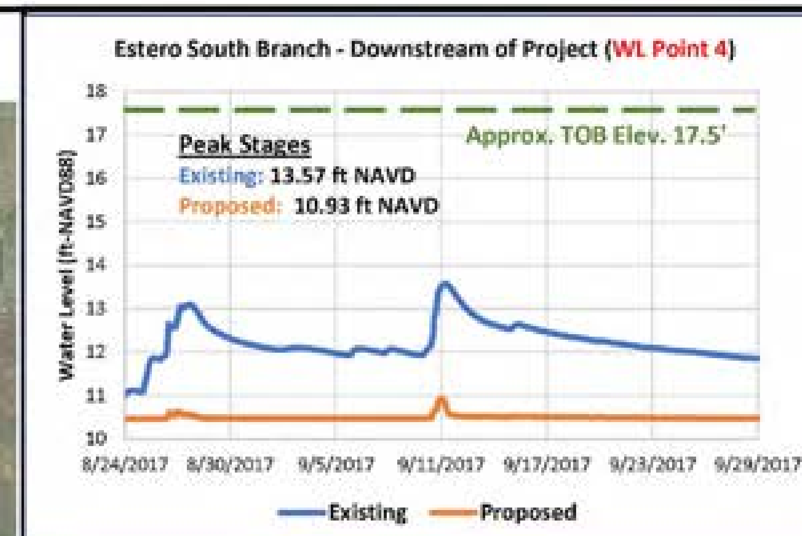
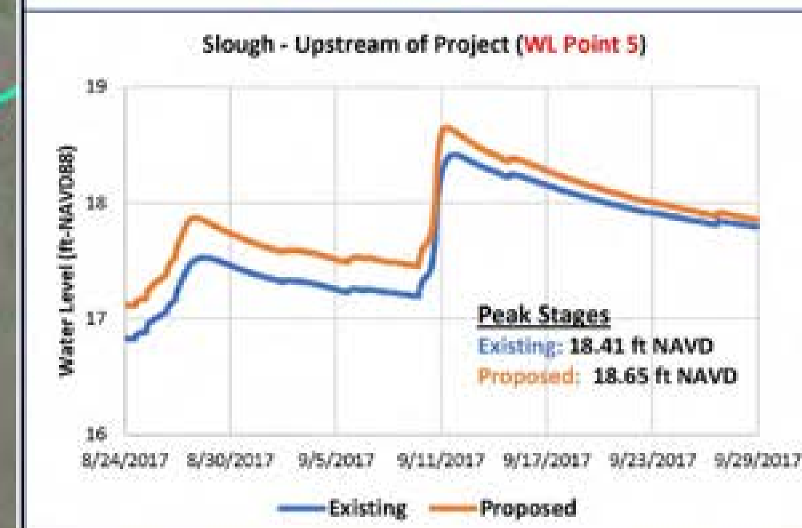
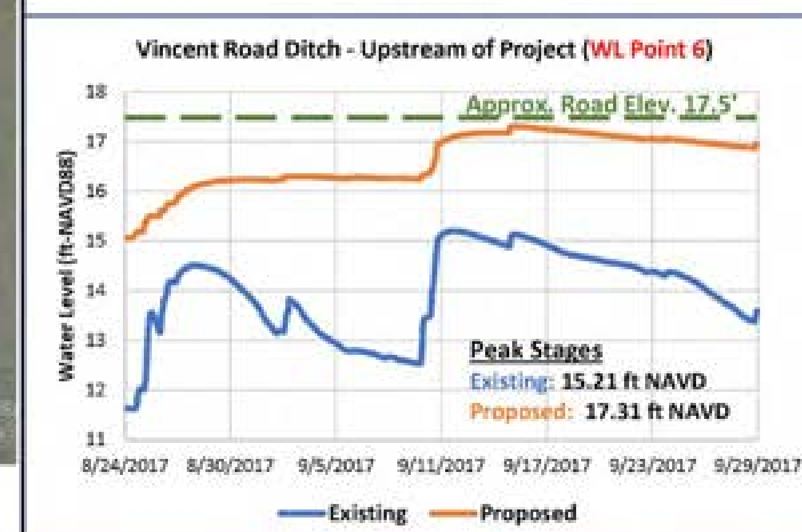


EXHIBIT 1.3.13 (h): 2 of 2







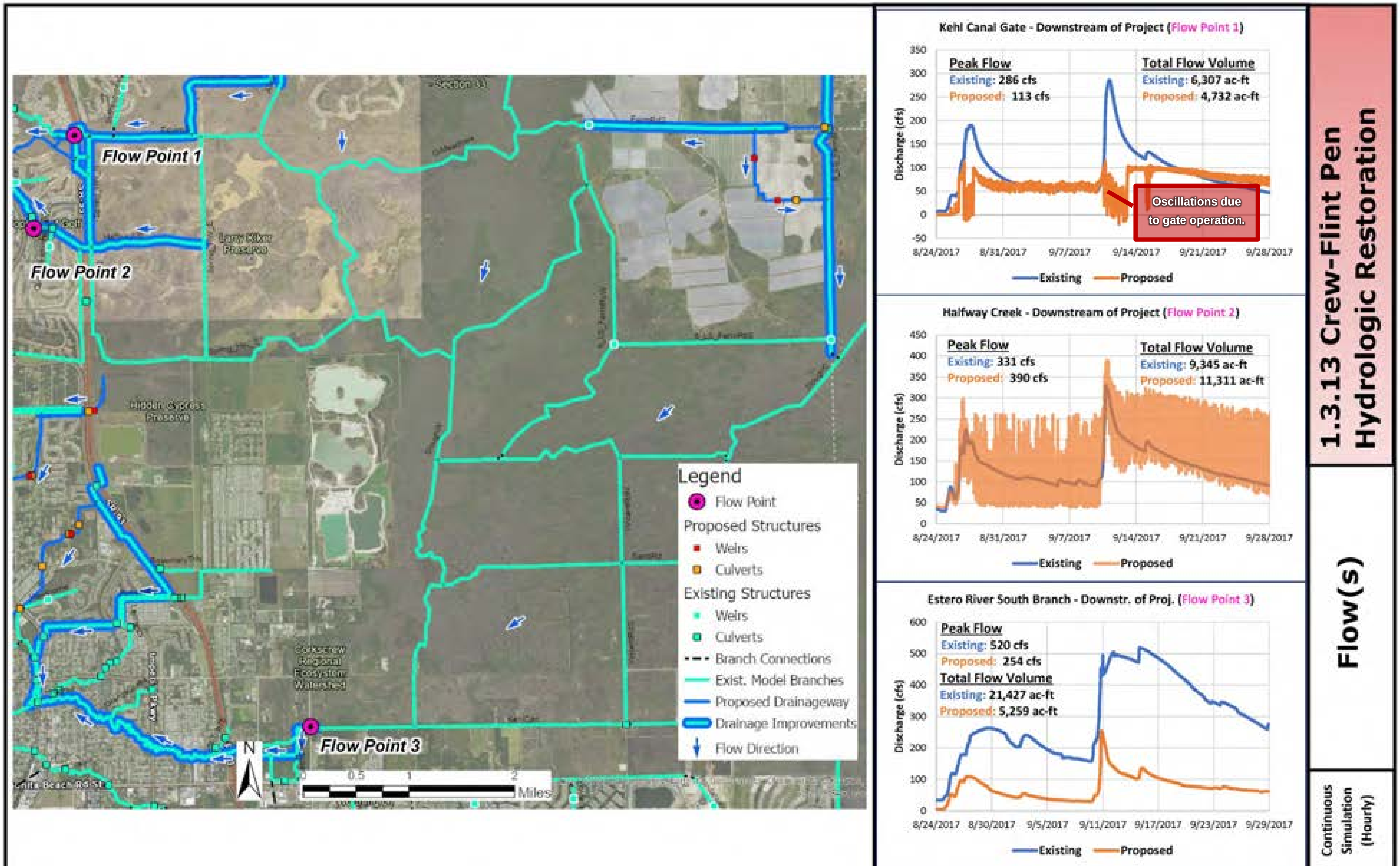


1.3.13 Crew-Flint Pen Hydrologic Restoration

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.13 (i)



1.3.14 Imperial River Improvements West of I-*75* Concept Plan

Background

The Imperial River west of Interstate No. 75 is a narrow, high-banked, natural flow-way stream, consisting of many twists and turning oxbows. This flow way conveyance experiences very large runoff flows from the Crew-Flint Pen Preserve. The river is very picturesque with large overhanging trees. This concept plan is to improve the hydraulic capacity of the river by creating overflow banks above the stream level. The natural stream would remain, but in high water conditions the overflow banks would allow more water to pass. There are several homes constructed in the river flood plain that are subject to flood impacts. Portions of the river appear to be tidally influenced and homes constructed on very low ground may be subject to storm surge flooding.

Location

This proposed conceptual project is in SE Lee County beginning at Interstate 75 just north of Bonita Beach Road and continuing west to the tidal Imperial River as illustrated in **Figure 41**.

Figure 41 – Location Map, 1.3.13 Imperial River Improvements West of I-75

Description

This proposed conceptual project improves the Imperial River conveyance downstream of the I-75 bridge crossing. These improvements would include sandbar and shoaling deposits, removal of debris and overhanging vegetation that would impede flow and enlarge channel constrictions on the Imperial River that restrict river channel flow during extreme storm events as illustrated in **Figure 42**.

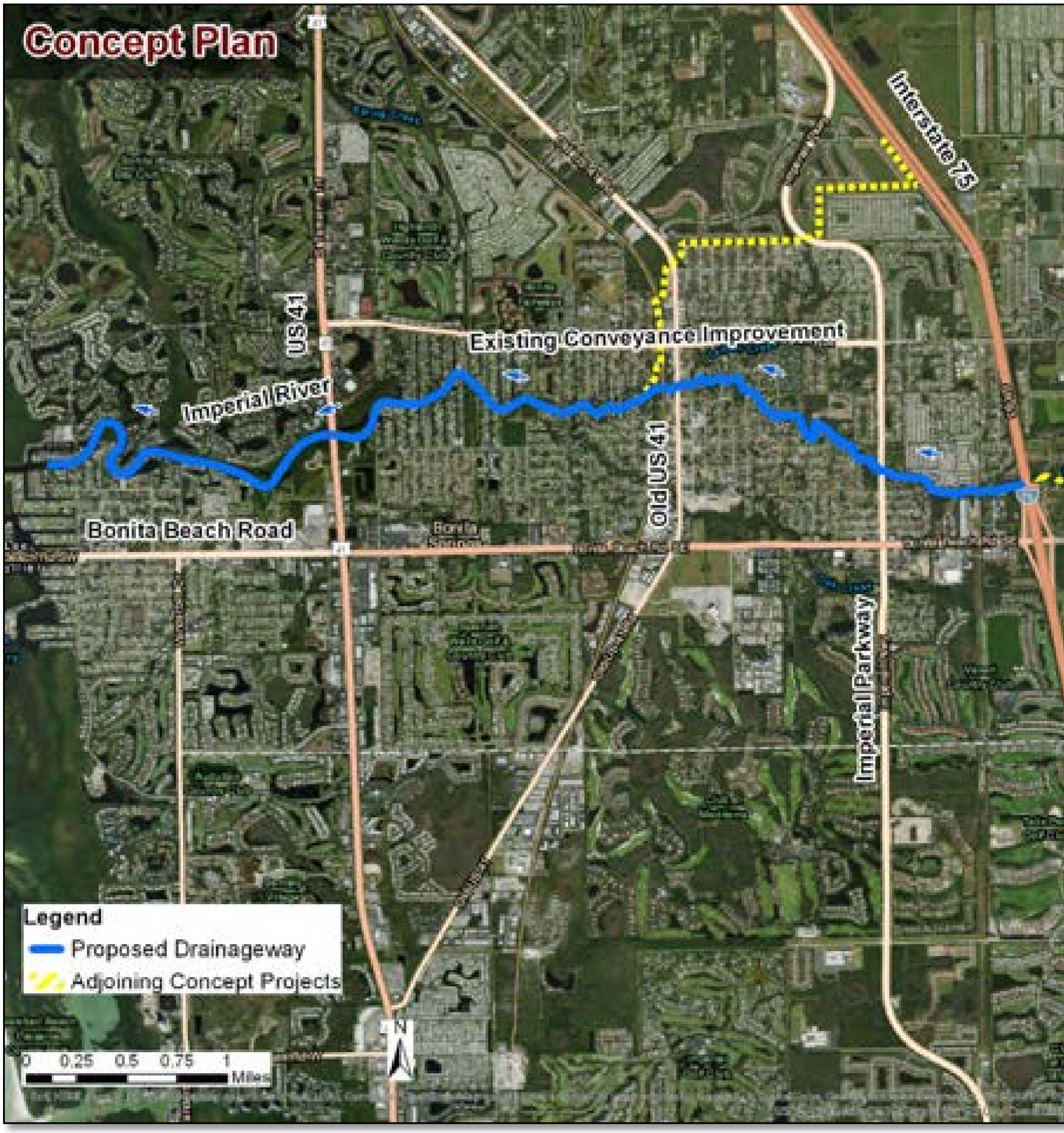


Figure 42 - Concept Plan, 1.3.14 Imperial River Improvements West of I-75

Purpose

This proposed project increases drainage capacity for handling large storm events and resulting excess stormwater flow from the Corkscrew Swamp, Flint Pen, Crew Flint and Edison Farms areas. The development of drainage flow-way capacity is critical to avoid excess water in the preserve.

Evaluation

Viability

This project as planned is in a sovereign natural waterway requiring extensive permitting that is of critical importance for flood mitigation that warrants the complex involvement for project development.

Community Considerations

The removal of sand bars, shoaling and overhanging vegetation to improve the channel flow in the Imperial River should not significantly impact residents in the area.

Environmental & Permittability Considerations

Maintenance work is often considered an ongoing activity to do at regular intervals. Turbidity control is very important along with manatee protection. A designated upland offload spoil disposal area would aid in the work. Significant environmental impacts occurring along the route would necessitate mitigation and creative enhancement.

Land Availability

Land acquisition or flow way easements would be required for overflow bank creation. Any channel improvements in the river would require obtaining dredging permits from the FDEP/USACOE and coordination with the City of Bonita Springs are required.

Opinion of Probable Cost

The cost opinion shown in **Table 15** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project. There is an allowance for some downstream maintenance/sedimentation removal in the navigable portion of the river included in the "project unknows" component since it has been previously dredged and may need it again.

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 1,600,000	$ 1,600,000
Clearing & Grubbing	1	LS	$ 375,000	$ 375,000
Earthwork	225,000	CY	$ 8	$ 1,800,000
Structure damages	12	EA	$ 250,000	$ 3,000,000
Construction/ Maintenance Access	15,000	SY	$ 20	$ 300,000
Seawall	1,000	LF	$ 250	$ 250,000
Rip-rap along Seawall	750	TN	$ 100	$ 75,000
Permanent Erosion Control	10,000	SF	$ 25	$ 250,000
Grassing & Plantings	175,000	SY	$ 2	$ 350,000
			Construction Cost Sub-Total:	**$ 8,000,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 1,500,000
			Land Acquisition	$ 6,000,000
			Project Administration/ CEI (10%):	$ 500,000
			Project Unknowns	$ 1,000,000
			Conceptual Project Cost:	**$ 17,000,000**
			Contingency (30%)	$ 5,000,000
			Conceptual Project Cost (with Contingency):	**$ 22,000,000**

Table 15 - Opinion of Probable Cost breakdown, 1.3.14 Imperial River Improvements West of I-75

Opportunities for Multiple Benefits & Uses

As southeast Lee County continues to reach full build-out conditions, improving the conveyance of the Imperial River Drainage Basin is a critical priority.

Other Considerations

Dredging organic material from the river bottom may generate TMDL credits for nutrient removal benefits. A summary of this concept project is shown below in **Exhibit 1.3.14** herein.

Findings & Recommendations

Regional Modeling Findings

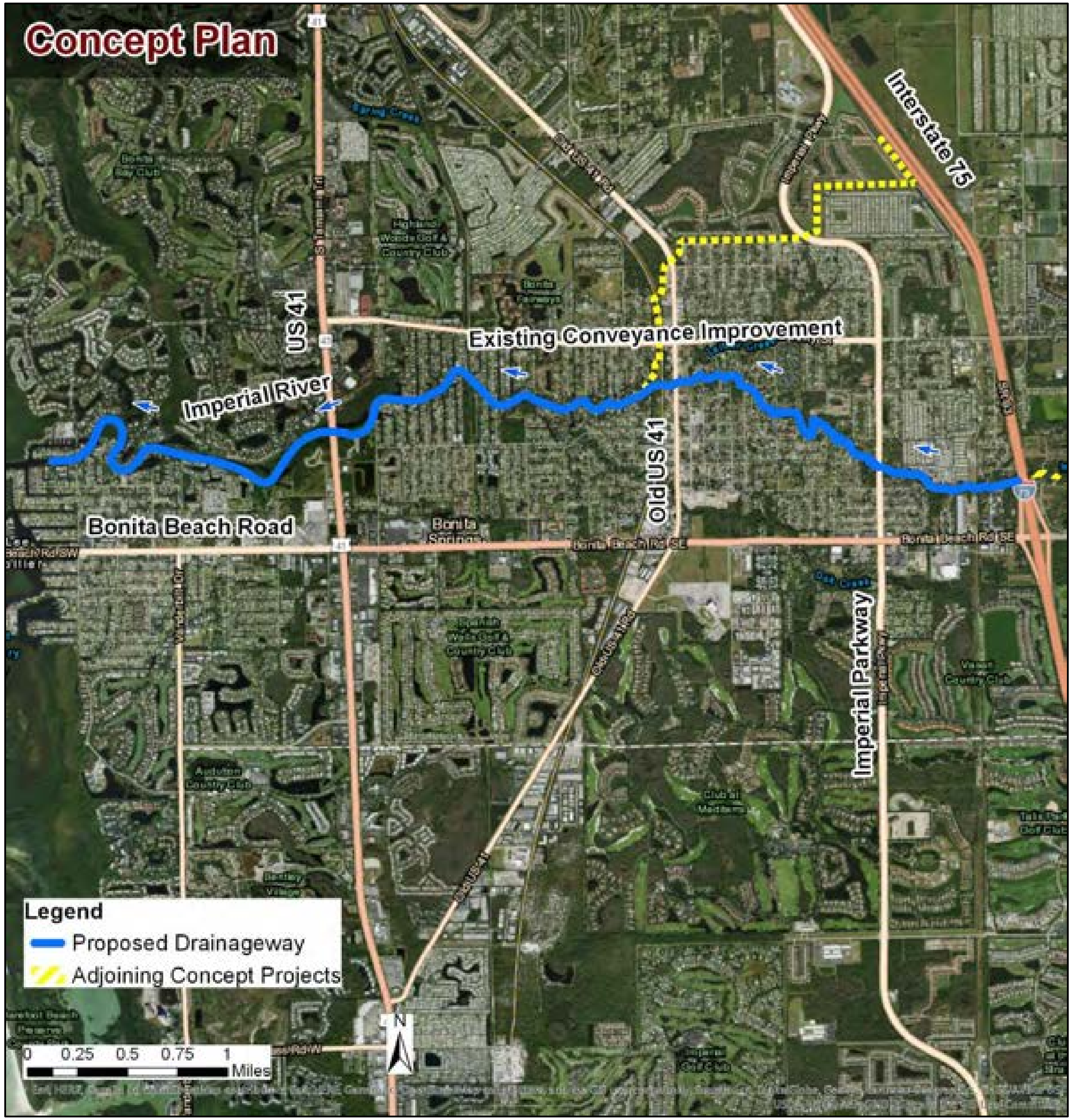
This project concept consists of improving the flow way capacity of the Imperial River by creating overflow banks, oxbow overflow areas, and shortening the overall length of the conveyance in a flood level event. Overflow bank elevations should not significantly impact the natural stream or bank vegetation. The flow way improvements are intended to lower flood levels and increase the conveyance of excess stormwater from east of Interstate 75 westerly towards open water. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.14 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.14 (b) EXHIBIT 1.3.14 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.14 (d) EXHIBIT 1.3.14 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.14 (f) EXHIBIT 1.3.14 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.14 (h) EXHIBIT 1.3.14 (i)

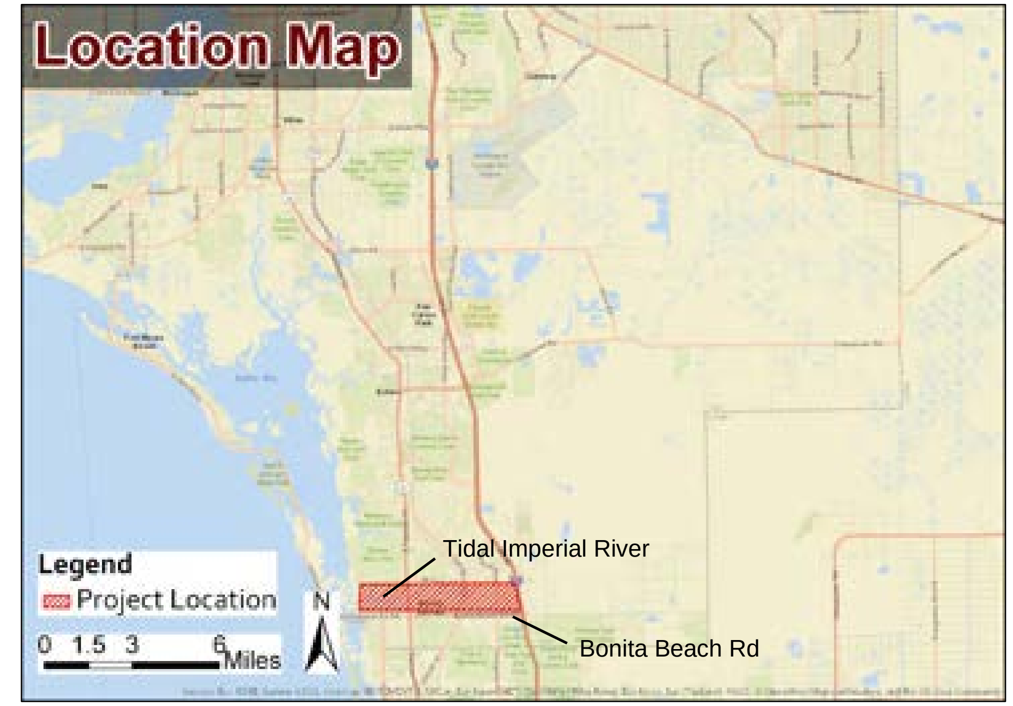
Improvements were shown with water level reductions from the existing condition to the proposed condition. Flow results demonstrate a reduction in the system recovery duration following a severe storm event.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcome by conveying excess stormwater flow from east of Interstate 75 through the improved Imperial River toward the Estero Bay. These positive improvements warrant further design-level project development.



Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project improves the Imperial River conveyance downstream of the I-75 bridge crossing. These improvements would include sandbar and shoaling deposits, removal of debris and overhanging vegetation that would impede flow and enlarge channel constrictions on the Imperial River that restrict river channel flow during extreme storm events.

PURPOSE: This proposed project increases drainage capacity for handling large storm events and resulting excess stormwater flow from the Corkscrew Swamp, Flint Pen, Crew Flint and Edison Farms areas. The development of drainage flow-way capacity is critical to avoid excess water in the preserve.

CONSTRAINTS: This project as planned requires access across public and private properties requiring governmental approvals and land acquisition. Working in the natural areas of the Imperial River will require special attention to preserve the natural character. Environmental impacts would necessitate mitigation.

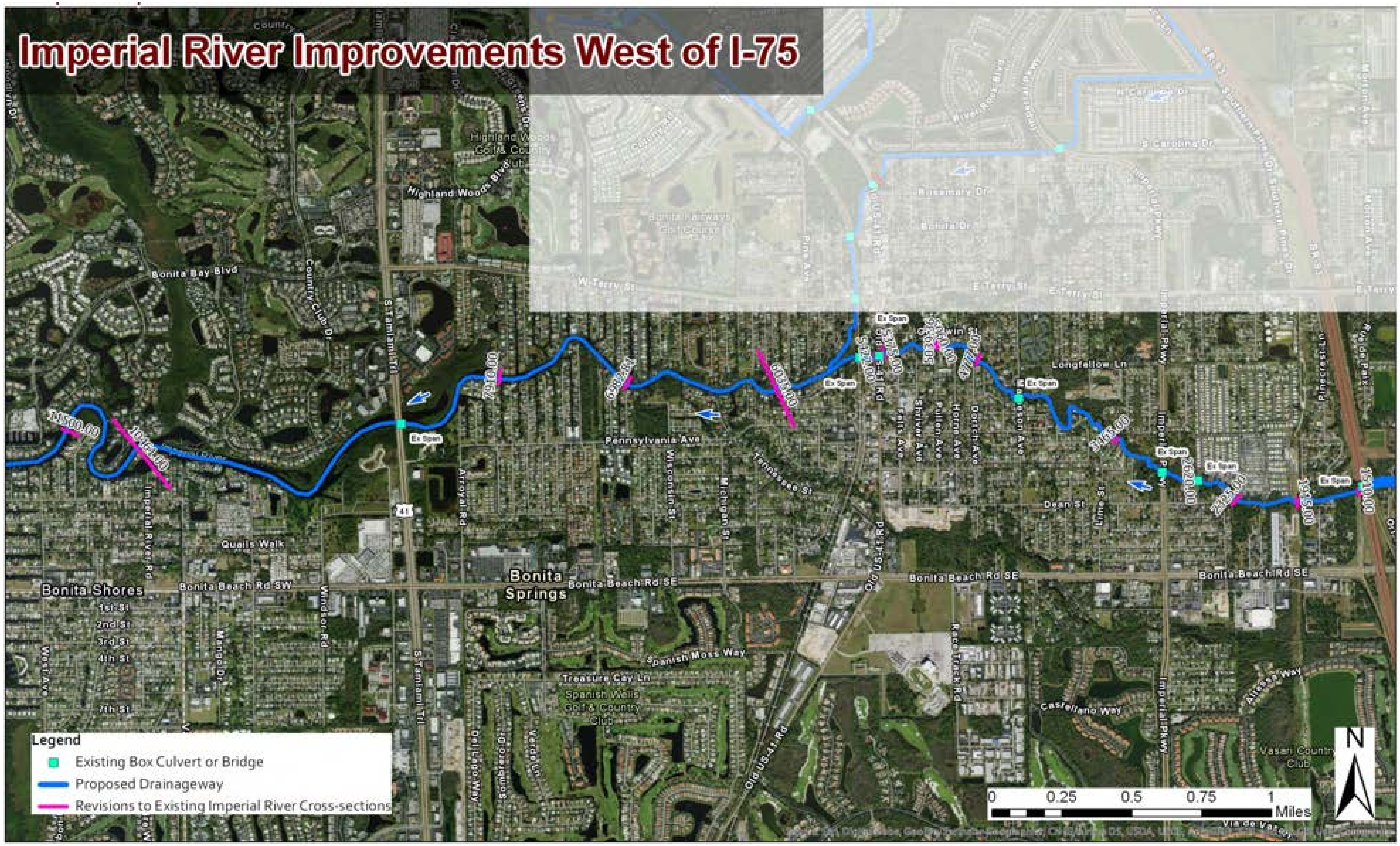
May 2020

Imperial River Improvements
West of I-75
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.14

EXHIBIT 1.3.14 (a)



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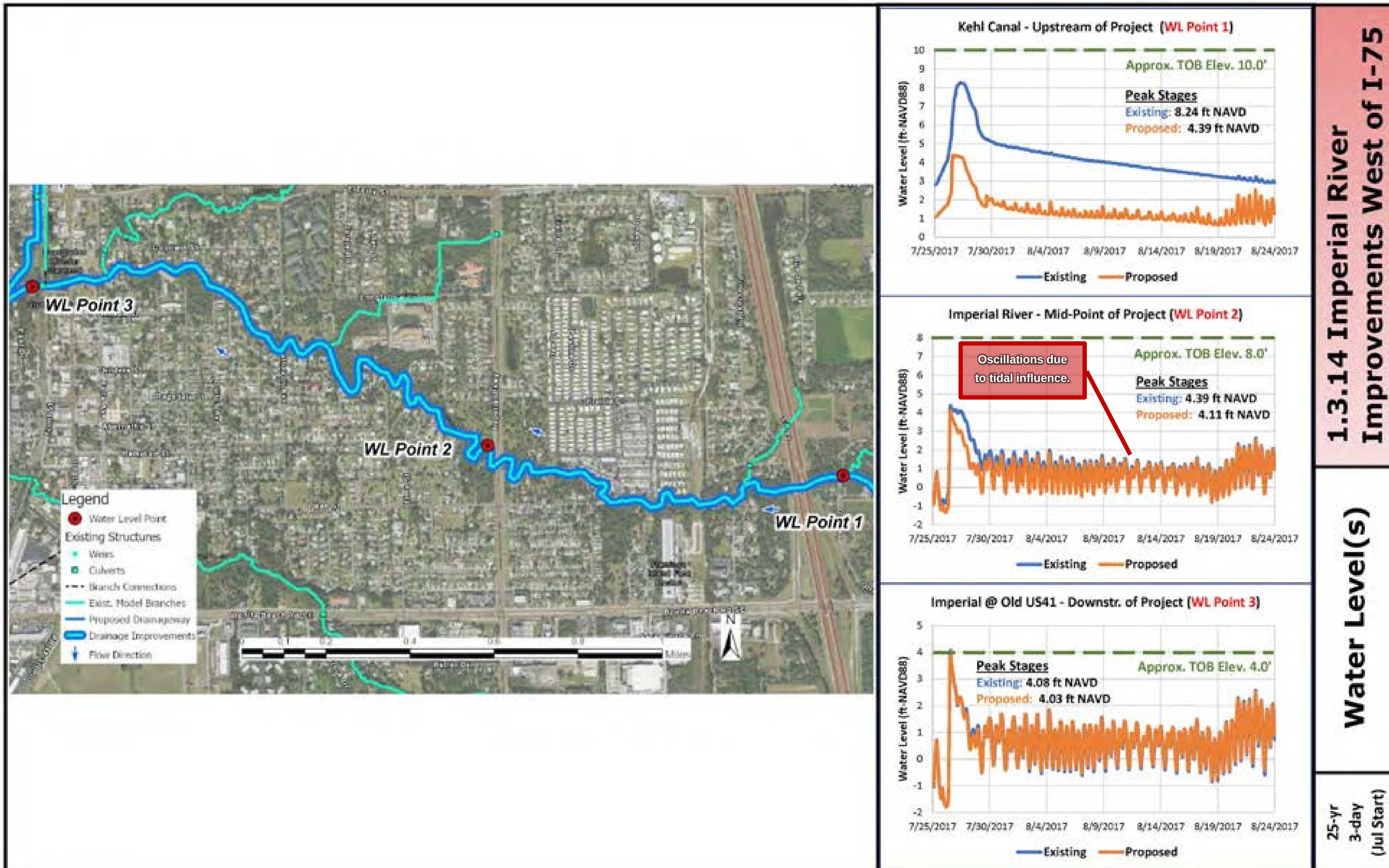

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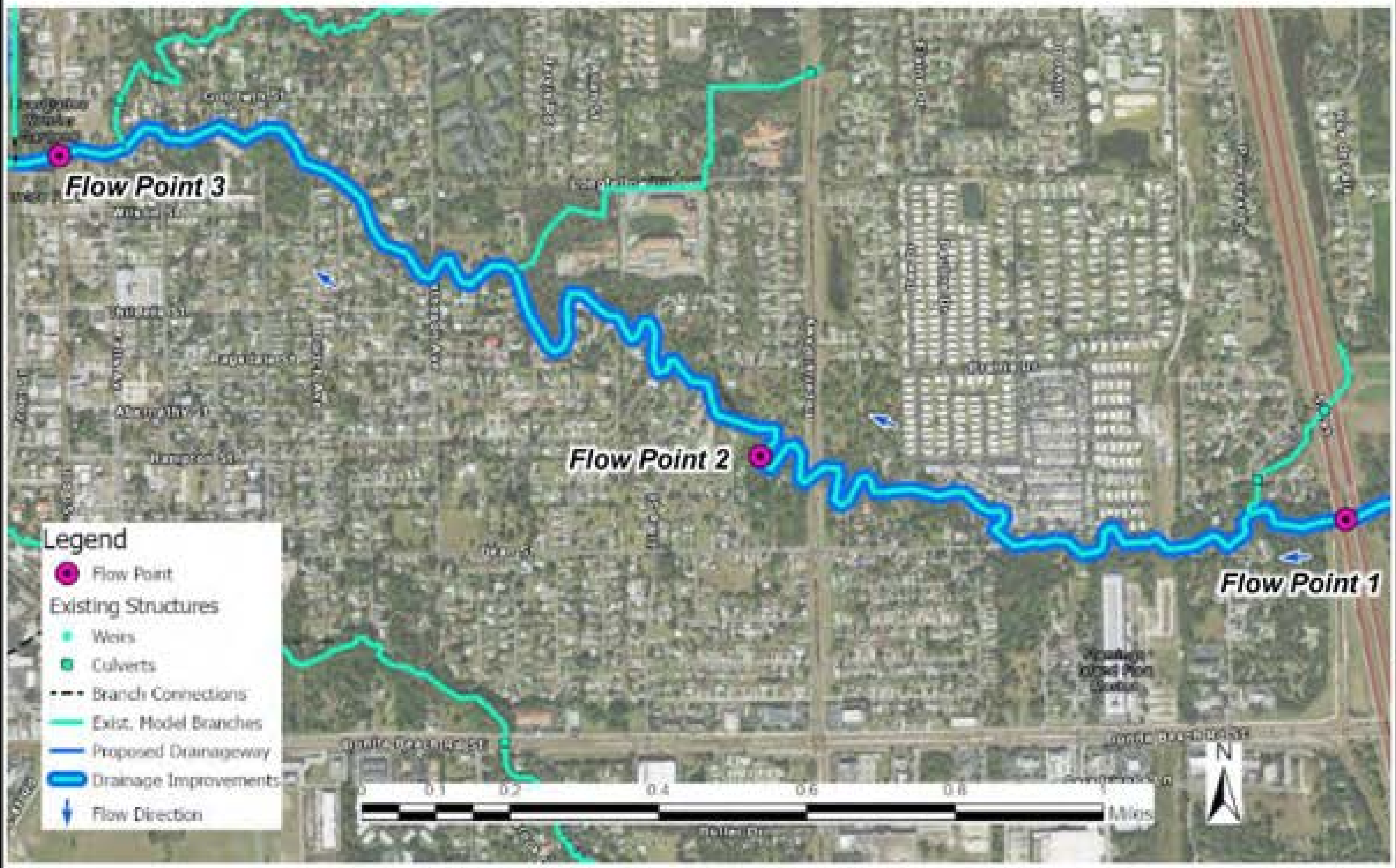
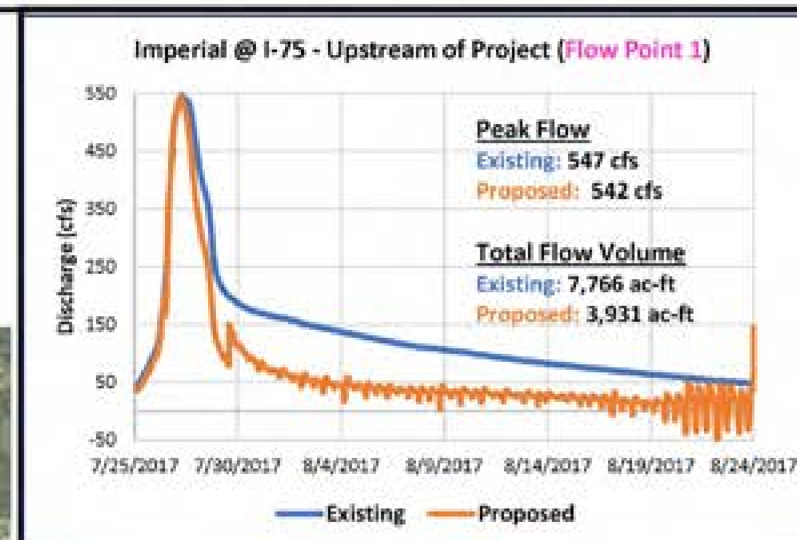
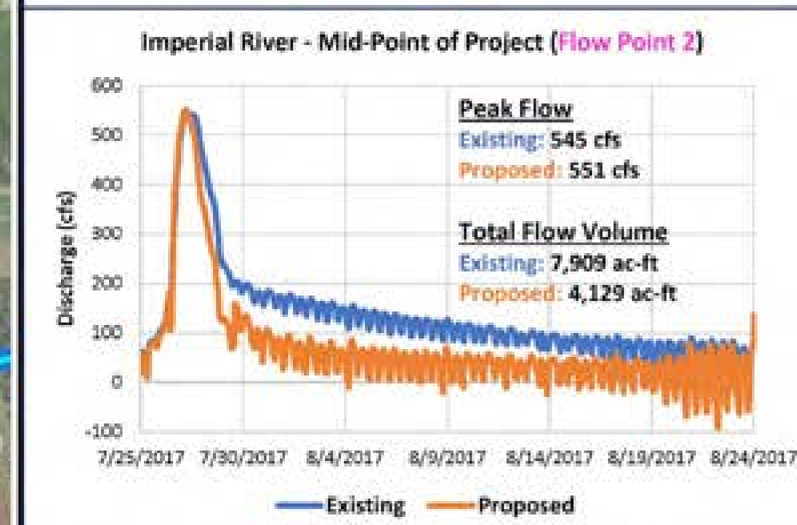
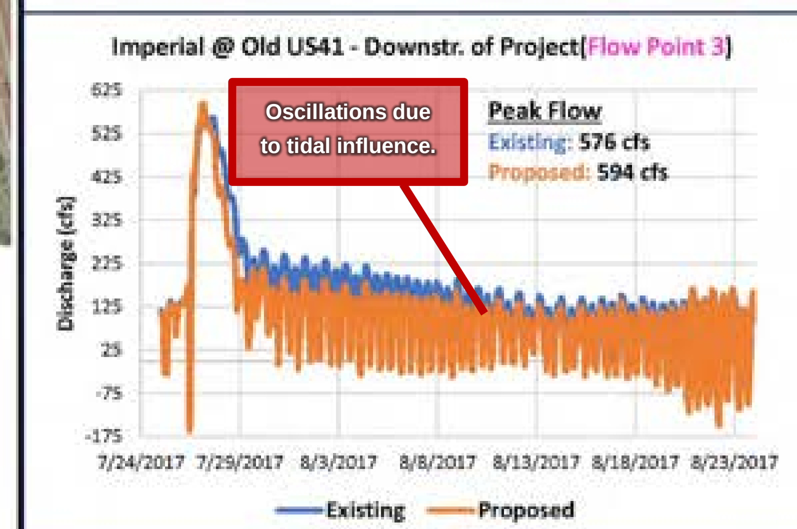






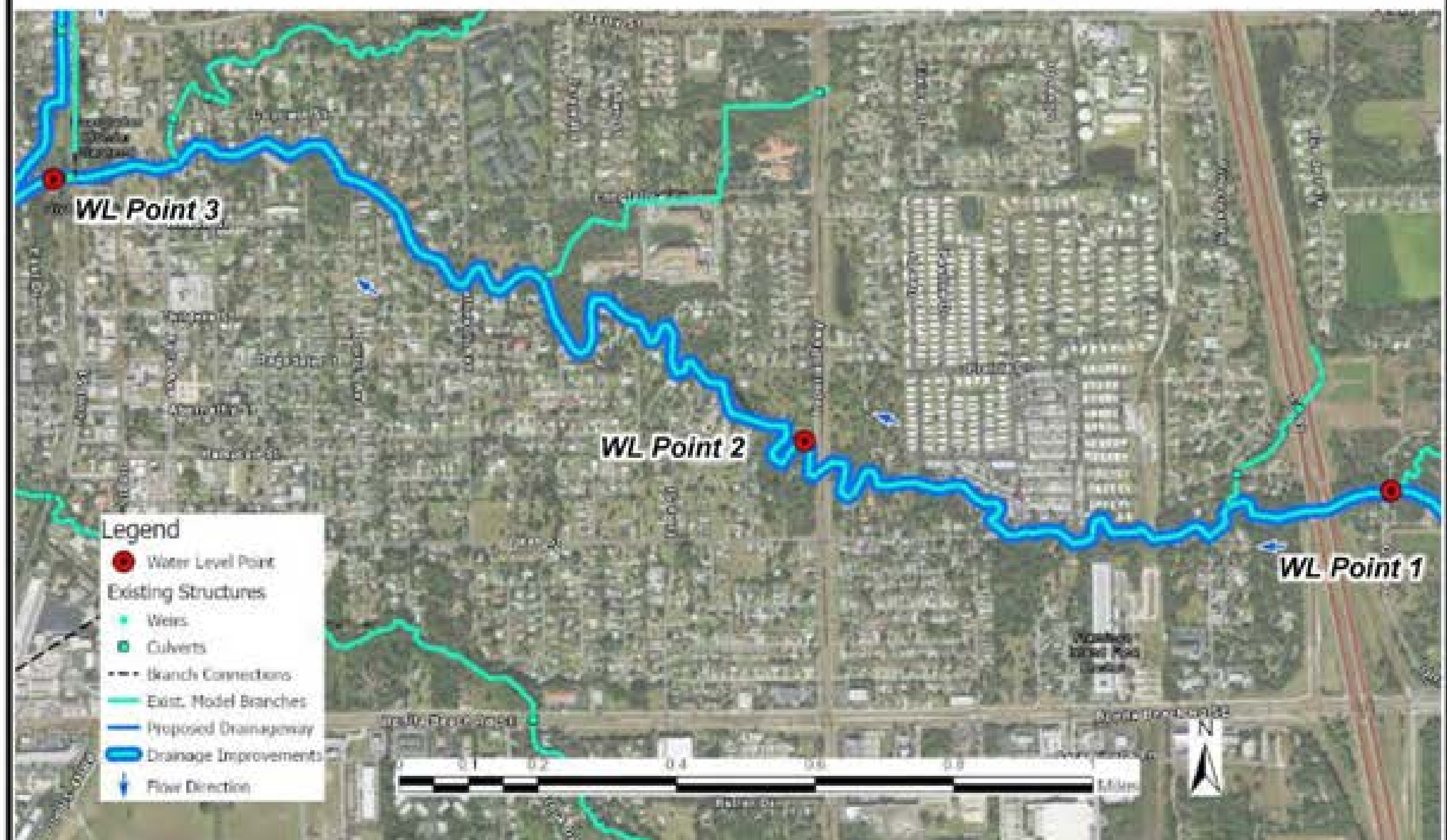


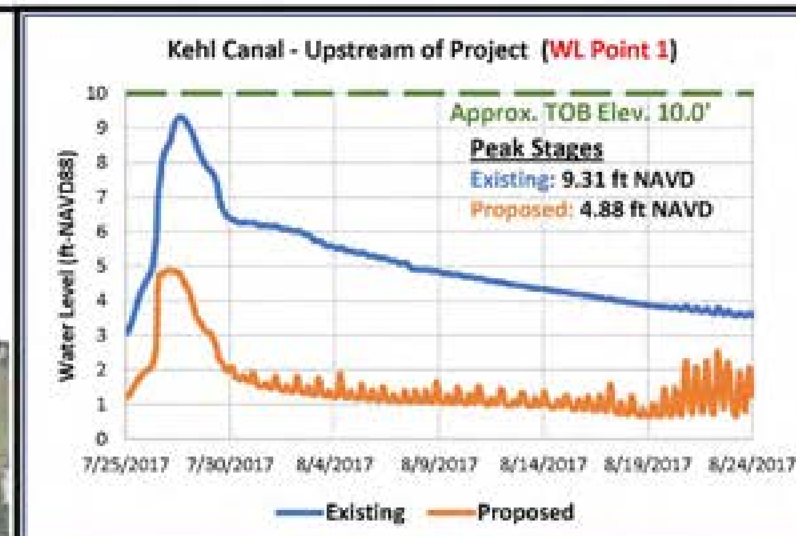
1.3.14 Imperial River Improvements West of I-75

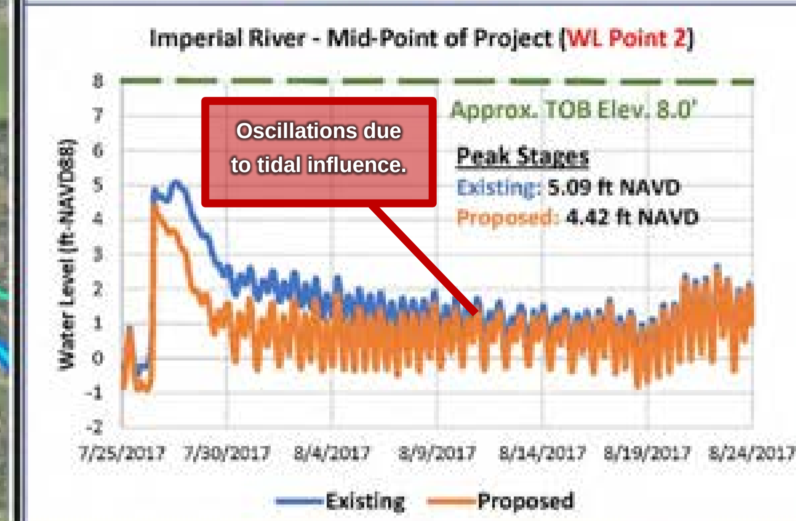
Flow(s)

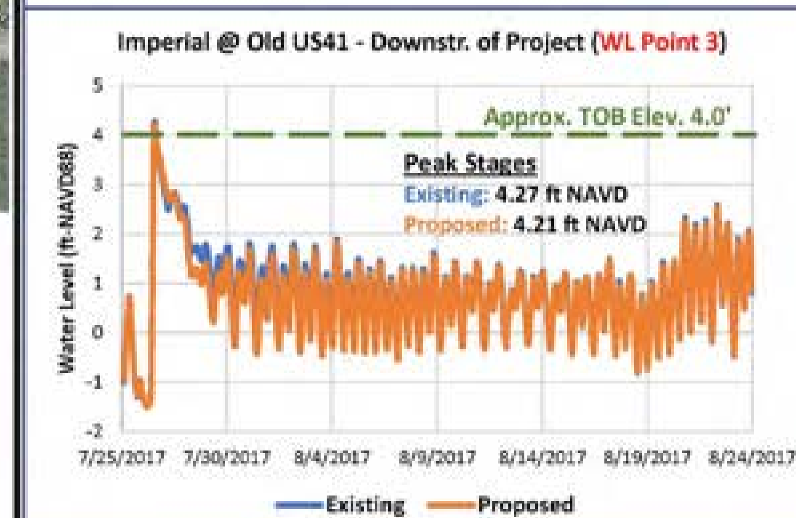
25-yr 3-day (Jul Start)

EXHIBIT 1.3.14 (d)







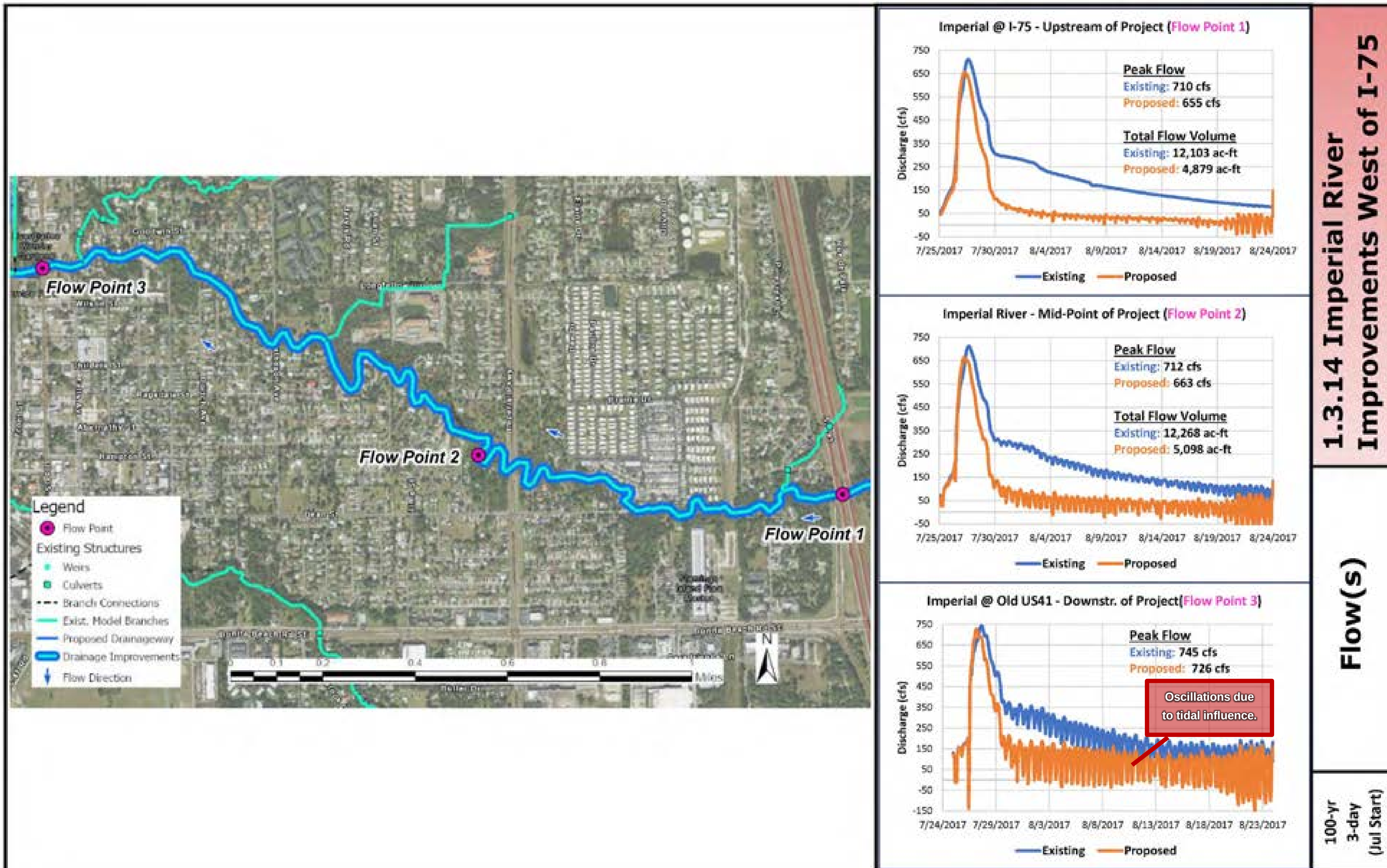


1.3.14 Imperial River Improvements West of I-75

Water Level(s)

100-yr
3-day
(Jul Start)

EXHIBIT 1.3.14 (e)



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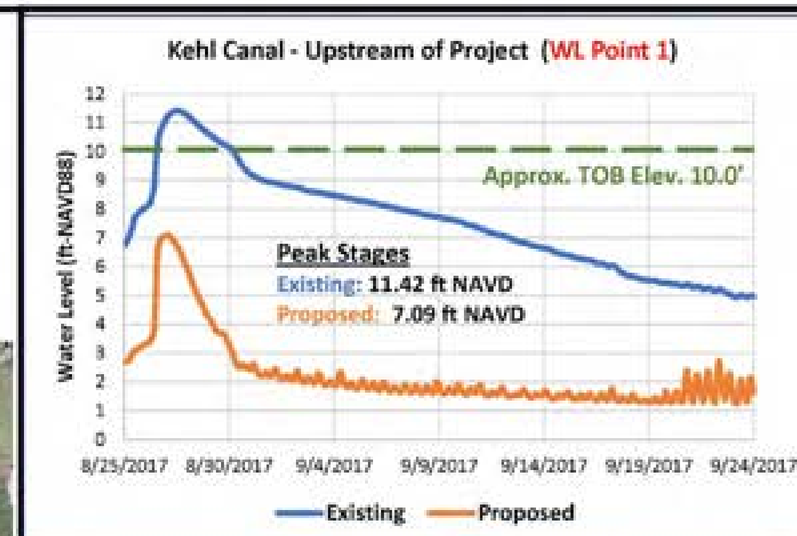
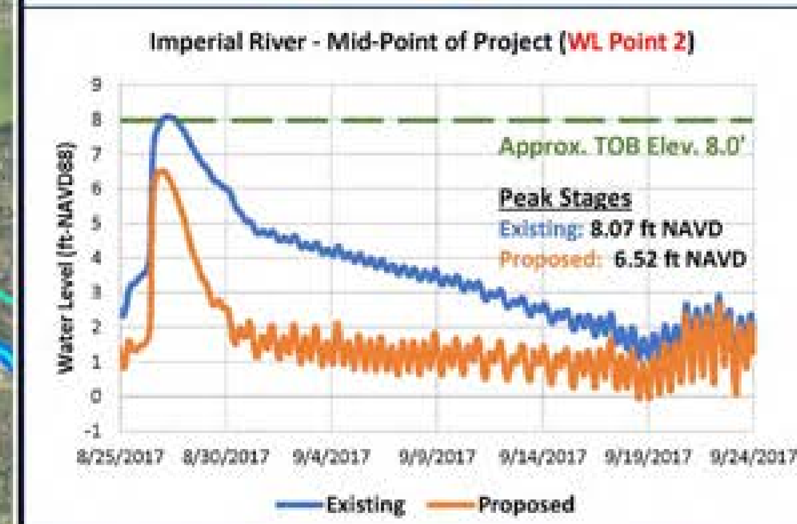
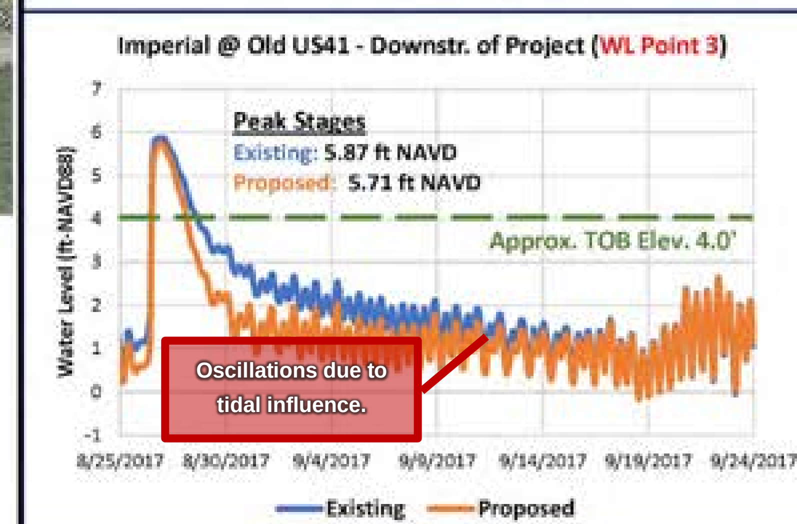






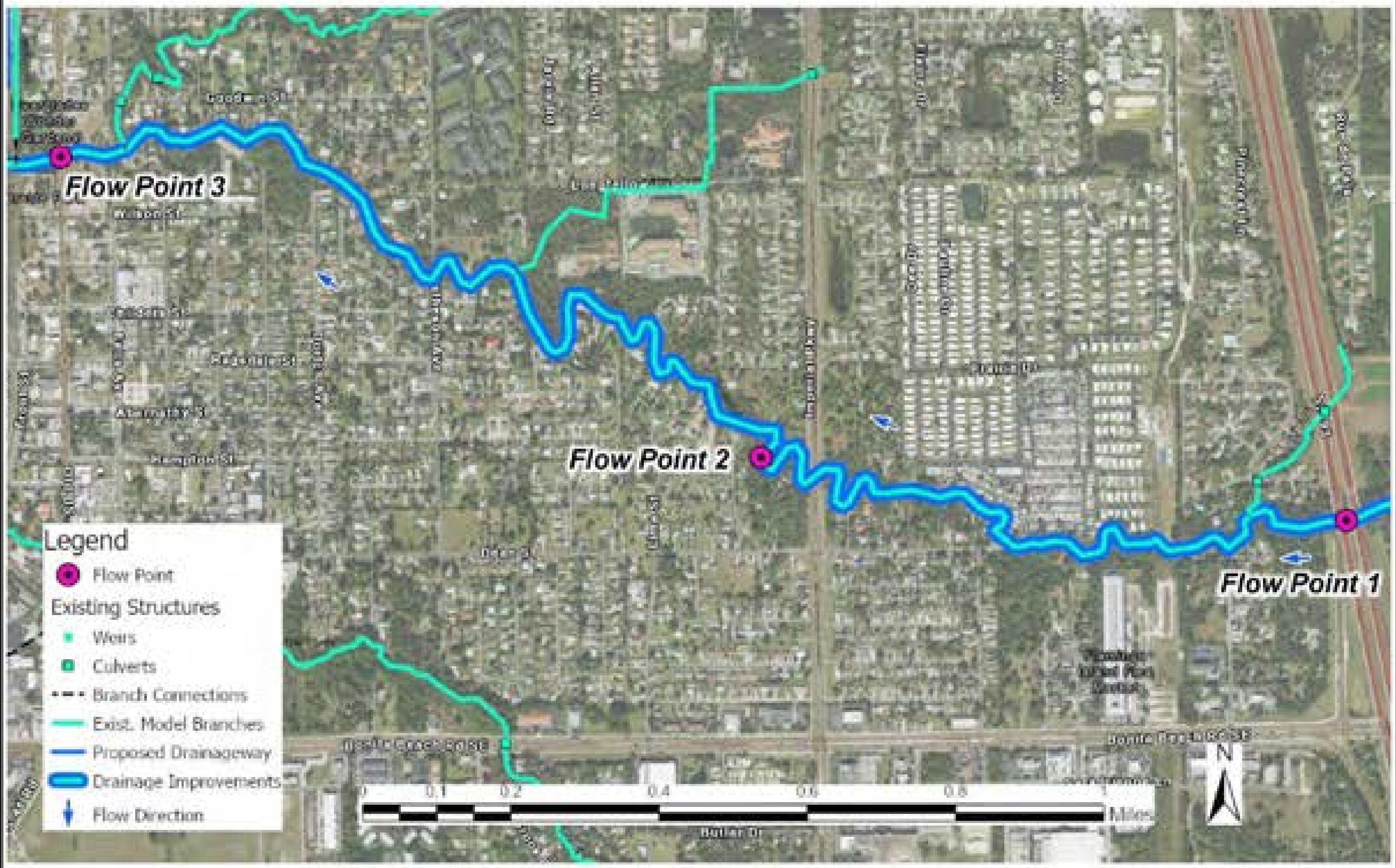
1.3.14 Imperial River Improvements West of I-75

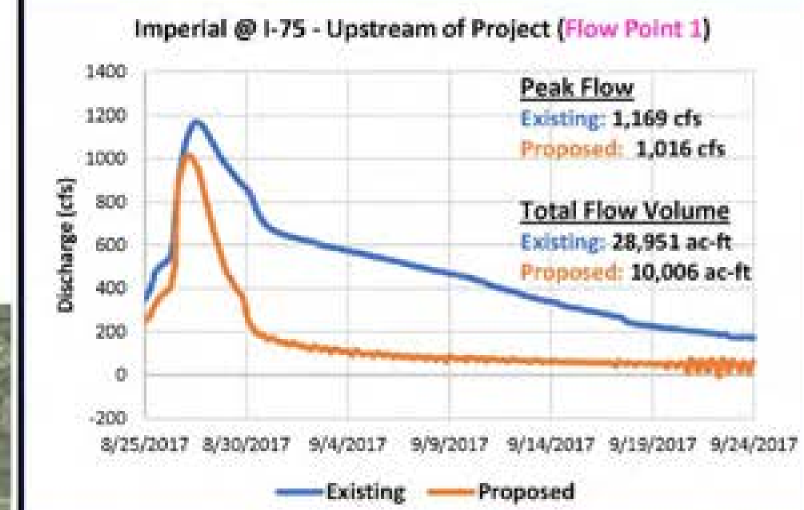
Water Level(s)

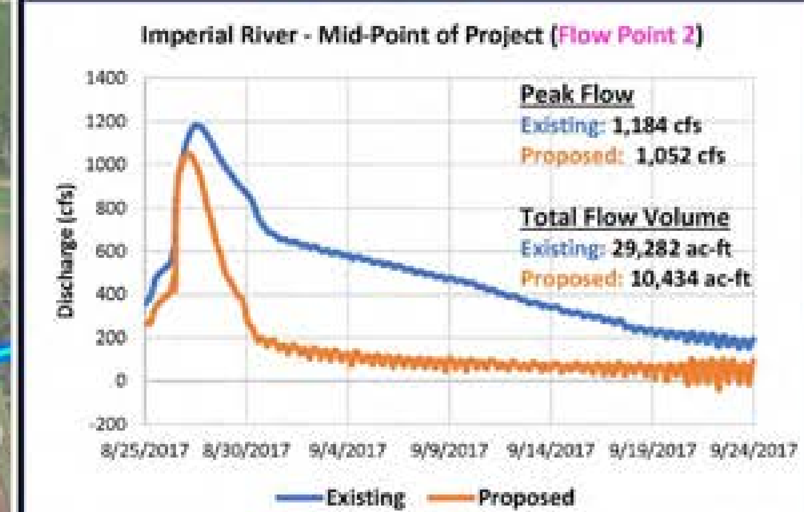
100-yr 3-day (Aug Start)

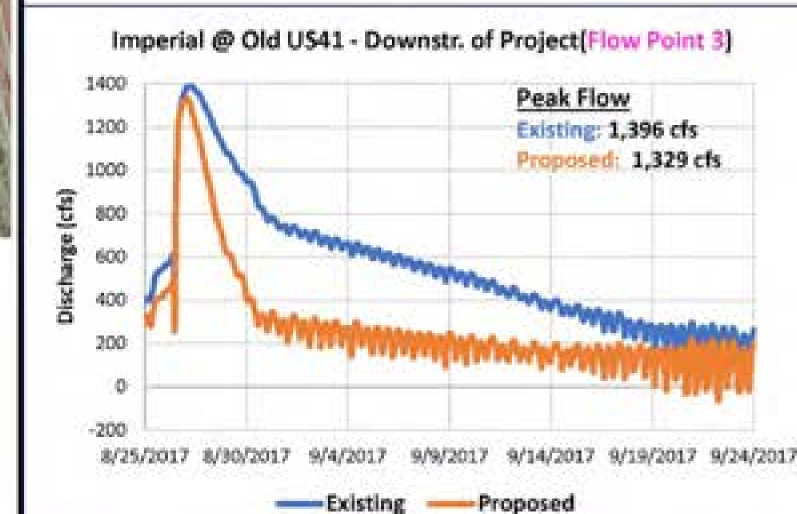
EXHIBIT 1.3.14 (g)

1.3.14 Imperial River Improvements West of I-75









Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.14 (h)

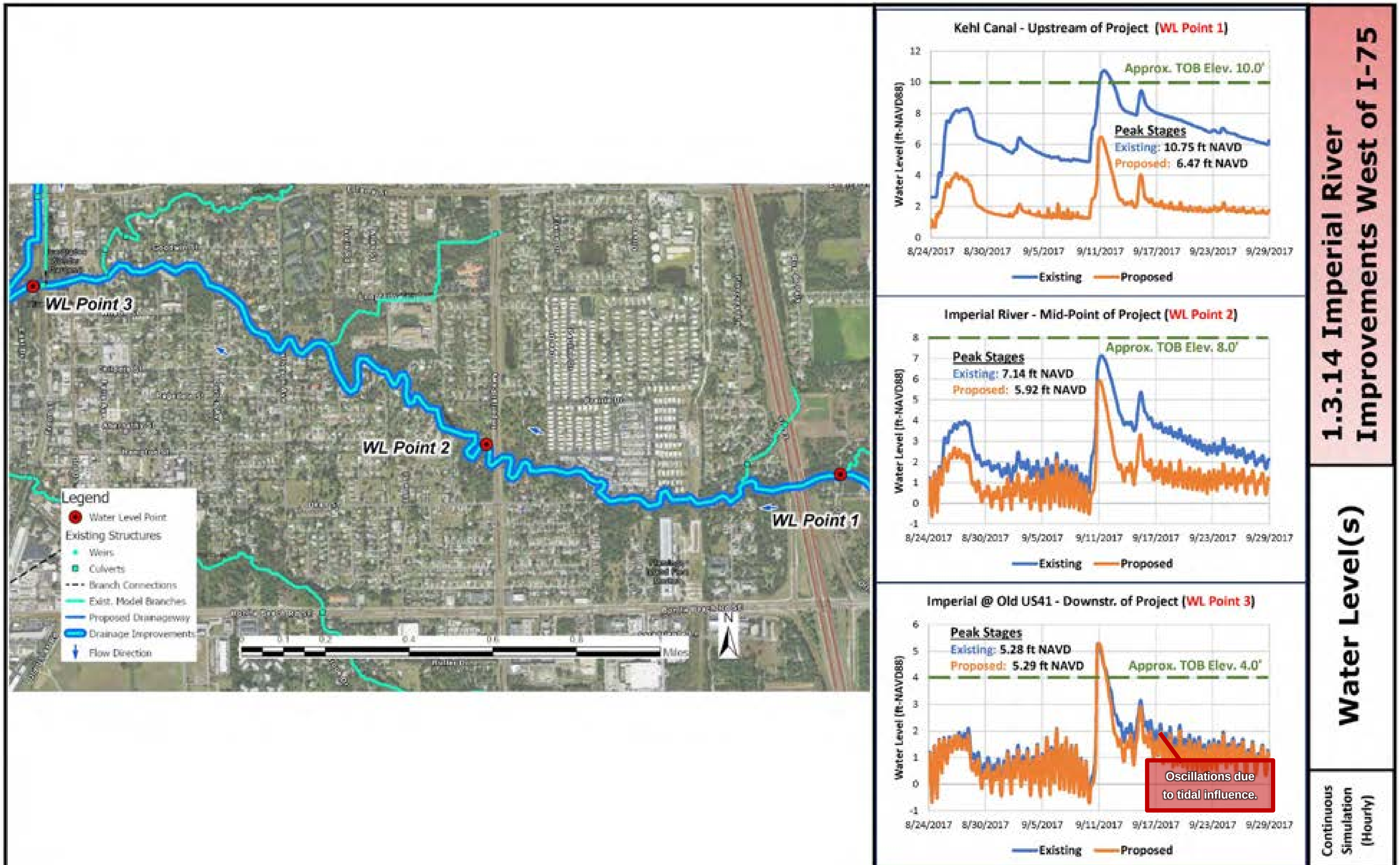
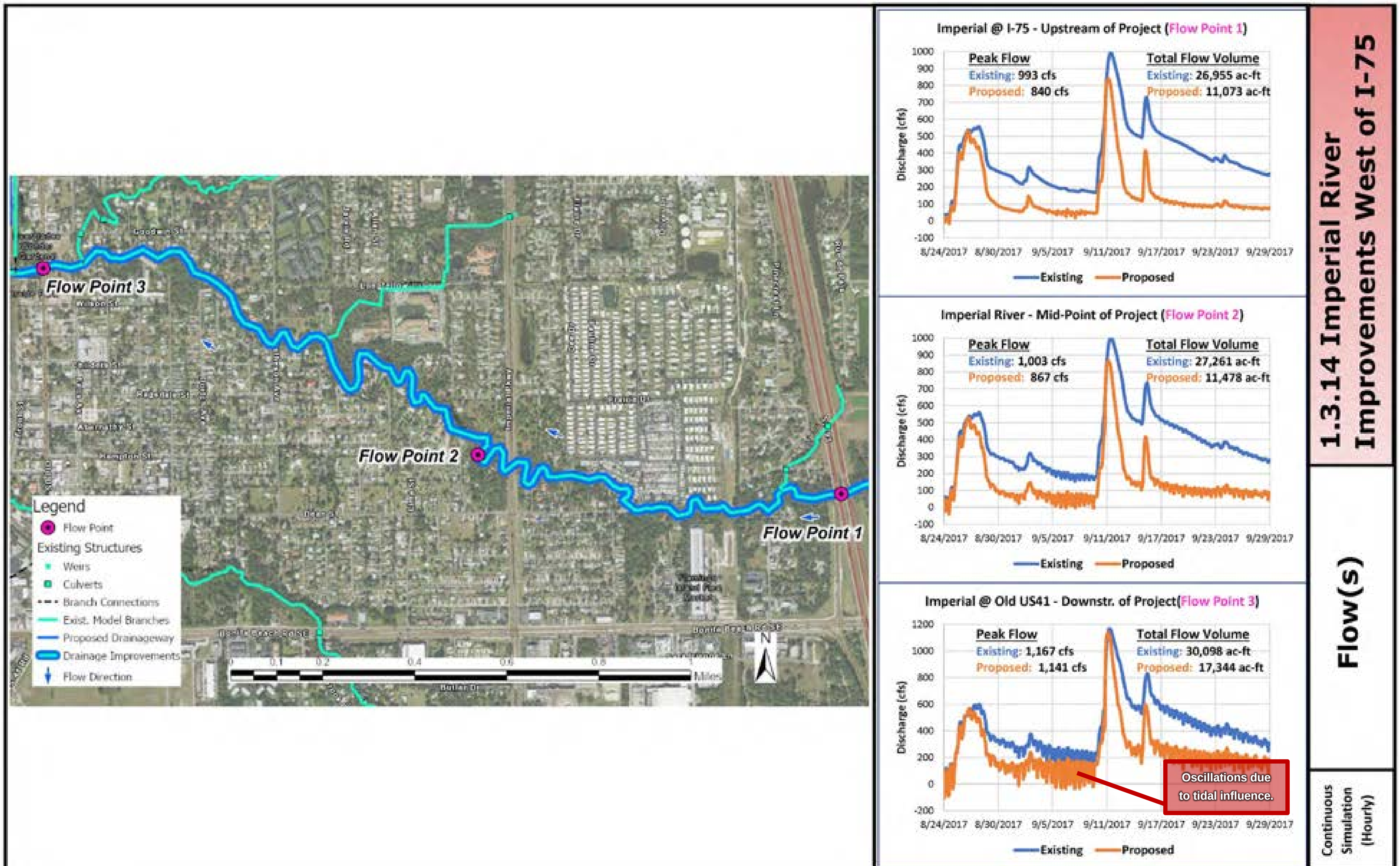


EXHIBIT 1.3.14 (i)



1.3.15 Railway Drainage Improvements

Background

The concept project improves an existing manmade drainageway in the Rosemary Canal area to the Imperial River. The drainageway is located in the central Bonita Springs area and fully developed. Portions of the drainageway are located along the railroad and the City River Park on the north side of the river.

Location

This proposed conceptual project is in Bonita Springs beginning just north of at Bonita Beach at Imperial Parkway and Interstate 75 and continuing southwest to the Imperial River as illustrated in **Figure 43**.

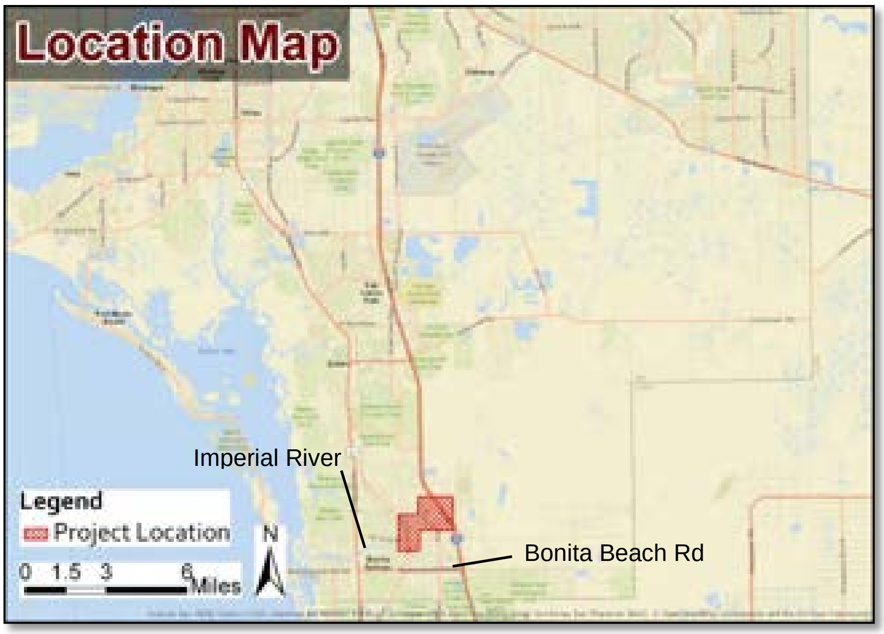


Figure 43 – Location Map, 1.3.15 Railway Drainage Improvements

Description

This proposed conceptual project improves conveyance from the drainageway along the westerly side of I-75 to the Imperial River with a focus on the conveyance along the railway approaching the Imperial River. This conveyance may have weirs and structures to manage flow conditions and water levels within desirable ranges as illustrated in **Figure 44**.

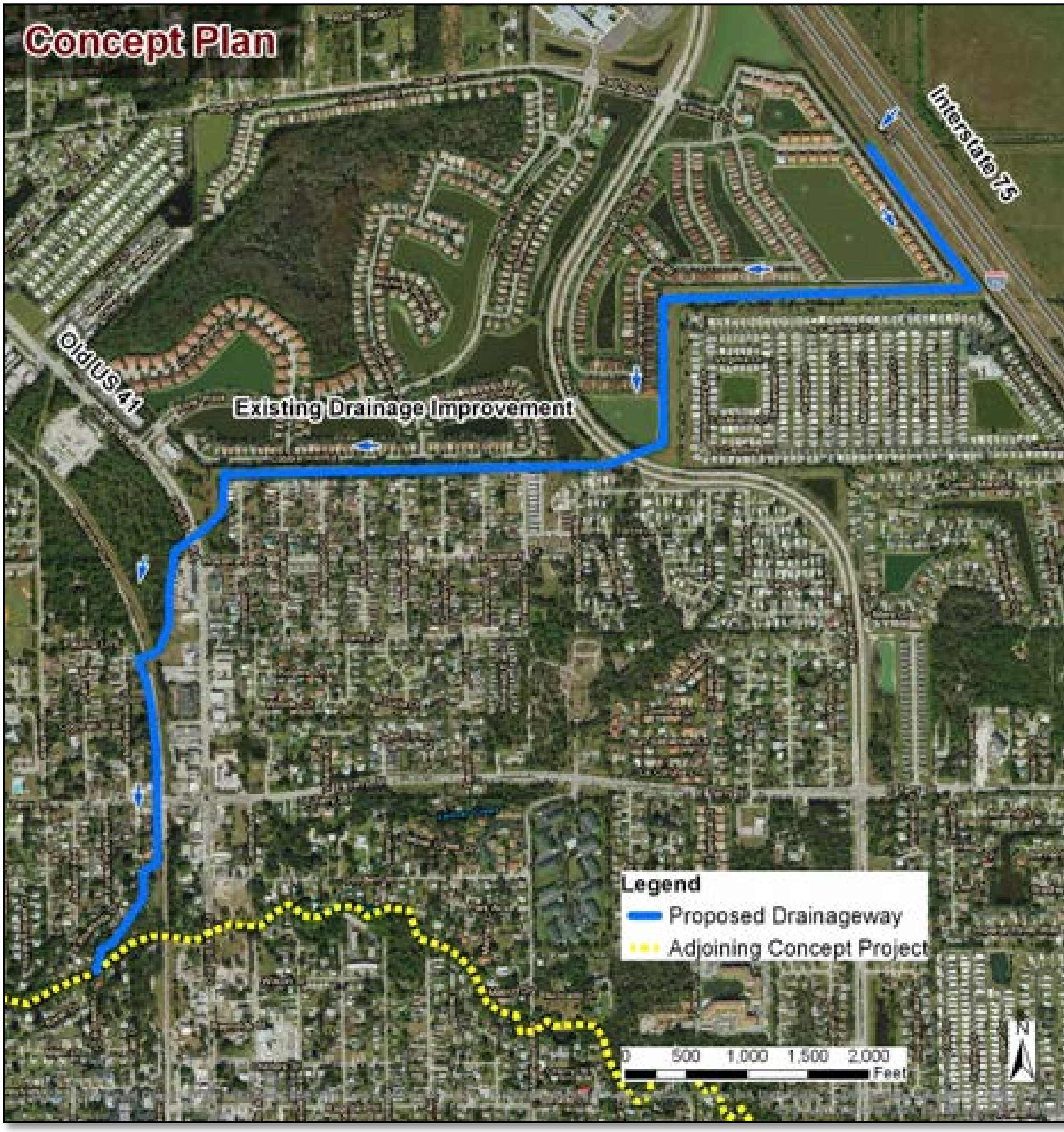


Figure 44 - Concept Plan, 1.3.15 Railway Drainage Improvements

Purpose

This proposed project increases drainage capacity for handling large storm excess runoff from the area and would provide a drainage outfall for the Bonita Grand Lakes area on the easterly side of I-75.

Evaluation

Viability

Since this project concept is along existing drainageways, improving the conveyance should not be controversial. Land acquisition and working with the railroad property may present some challenges. This project should not have significant permitting issues and appears to be a viable project concept for improving drainage in the subject area.

Community Considerations

This drainage conveyance improvement along an existing drainageway should not be disruptive to the community other than the temporary construction disturbances.

Environmental & Permittability Considerations

No significant environmental impacts are anticipated along the route. Wetland impacts, if any would necessitate mitigation.

Land Availability

The need for land acquisition is necessary to expand and construct the Railway Drainage Improvements west of I -75 along with working out agreements with the railroad.

Opinion of Probable Cost

The cost opinion shown in **Table 16** below is at a budgetary conceptual level with generalized prices, basic quantities and limited information. Project costs are anticipated to increase with inflation or changes in future market conditions. Land acquisition budgets are for private land property only with other land needs being met with joint-use flow-way agreements. Environmental assessment for wetland and wildlife impact mitigation costs were not addressed as a part of this report. A category for project unknowns was included to allow for project aspects that could not be defined at this time. The project has been presumed to plan, schedule, and pursue activities as cost-effectively as possible, which may include multi-purposes projects, such as coordinating earthwork excavation with fill material demands of another project. There is an allowance for some downstream maintenance/sedimentation removal in the navigable portion of the river included in the "project unknows" component since it has been previously dredged and may need it again.

Table 16 - Opinion of Probable Cost breakdown, 1.3.15 Railway Drainageway Improvements

Component	Quantity	Unit	Unit Price	Cost
Construction Costs				
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Misc.	1	LS	$ 362,000	$ 362,000
Clearing & Grubbing	20	AC	$ 14,000	$ 280,000
Earthwork	30,000	CY	$ 8	$ 240,000
Weir Structure 3.15A (Standard)	30	LF	$ 5,000	$ 150,000
Detours	1	LS	$ 100,000	$ 100,000
Box Culvert 3.15, West Terry	140	CY	$ 1,200	$ 168,000
Electric Supply	1	LS	$ 10,000	$ 10,000
Permanent Erosion Control	8,000	SF	$ 15	$ 120,000
Grassing	35,000	SY	$ 2	$ 70,000
			Construction Cost Sub-Total:	**$ 1,500,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 440,000
			Land Acquisition	$ 750,000
			Project Administration/ CEI (10%):	$ 150,000
			Project Unknowns	$ 160,000
			Conceptual Project Cost:	**$ 3,000,000**
			Contingency (30%)	$ 900,000
			Conceptual Project Cost (with Contingency):	**$ 3,900,000**

Opportunities for Multiple Benefits & Uses

As southeast Lee County continues to reach full build-out conditions, improving the conveyance of the Bonita Springs Drainage Basin is a critical priority. Providing conveyances for large storm events will be vitally important for the community. Land acquisition storage solutions will also become increasingly difficult as development diminishes the available land.

Other Considerations

This project concept may provide possible additional drainage connections that could benefit the areas adjacent to the proposed conveyance improvement. A summary of this concept project is shown below in **Exhibit 1.3.15** herein.

Findings & Recommendations

Regional Modeling Findings

This project concept consists of improving the conveyances within the Rosemary Park area of Bonita Springs to alleviate high water levels during large storm events. Flow is directed to the Imperial River via proposed improvements within existing drainageways. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.15 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

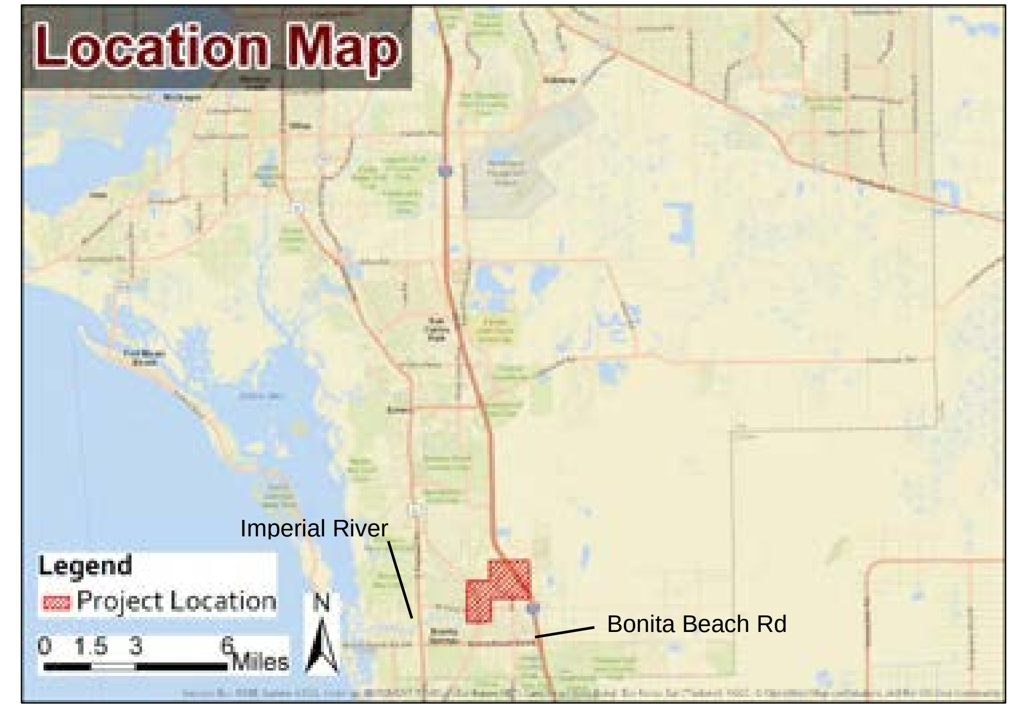
Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.15 (b)
	Flow(s)	EXHIBIT 1.3.15 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.3.15 (d)
	Flow(s)	EXHIBIT 1.3.15 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.3.15 (f)
	Flow(s)	EXHIBIT 1.3.15 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.3.15 (h)
	Flow(s)	EXHIBIT 1.3.15 (i)

Improvements were shown with water level reductions from the existing to the proposed condition, and. A reduction in peak flows is observed due to the storage reservoir east of Interstate 75 temporarily retaining a portion of the contributing conveyance.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flow from east of Interstate 75 through the improved Rosemary Park area of Bonita Springs towards the Imperial River. These positive improvements warrant further design-level project development.

Imagery Date: 2018



Project Narrative

DESCRIPTION: This proposed conceptual project improves conveyance from the drainageway along the westerly side of I-75 to the Imperial River with a focus on the conveyance along the railway approaching the Imperial River. This conveyance may have weirs and structures to manage flow conditions and water levels within desirable ranges.

PURPOSE: This proposed project increases drainage capacity for handling large storm excess runoff from the area and would provide a drainage outfall for the Bonita Grand Lakes area on the easterly side of I-75.

CONSTRAINTS: This project as planned crosses private properties requiring approvals and land acquisition. Weir structures to manage water levels and large drainage structures at road crossings would be required. Working near natural areas will require special attention and environmental impacts would necessitate mitigation.

May 2020

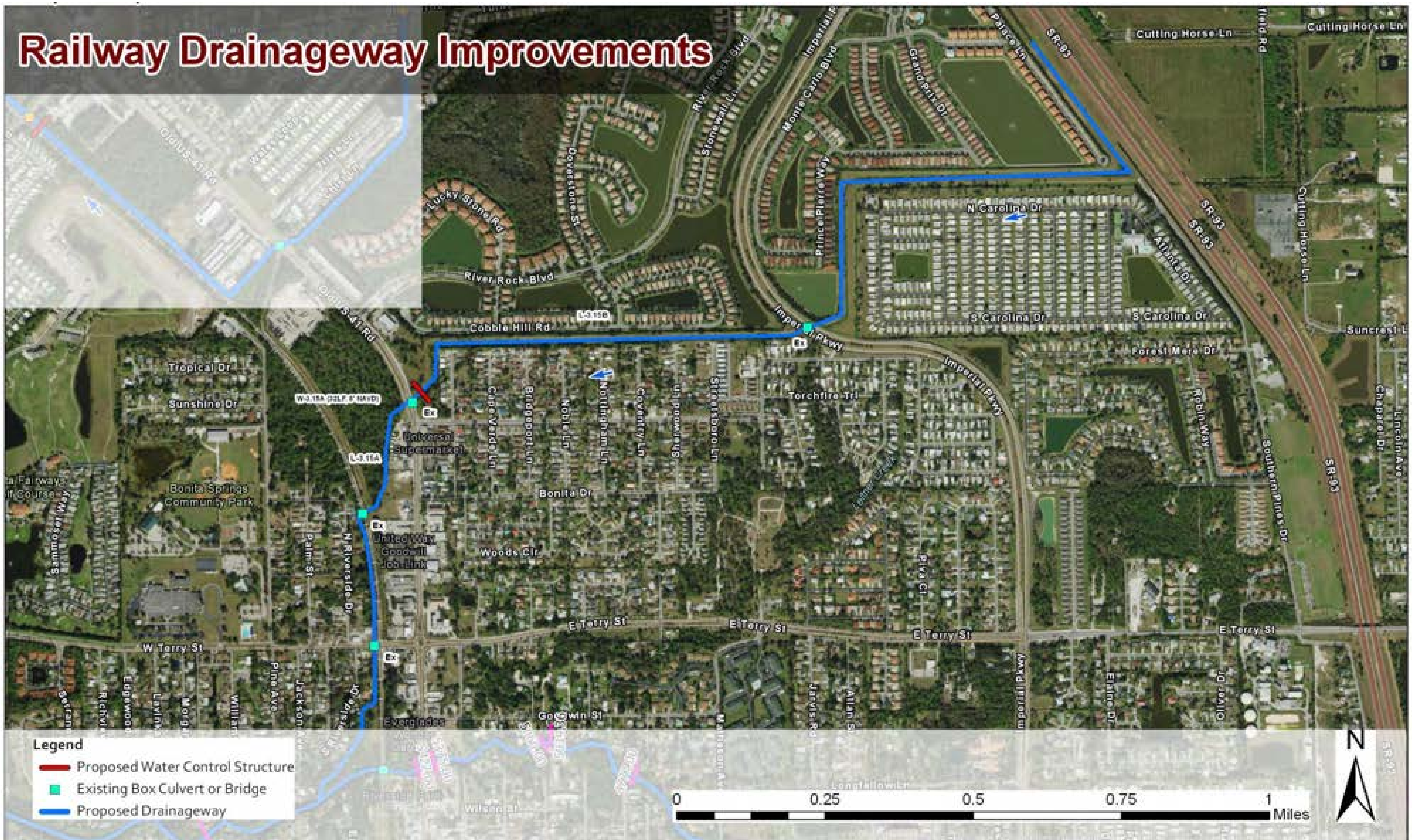
Railway Drainageway Improvements

SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.15

EXHIBIT 1.3.15 (a)



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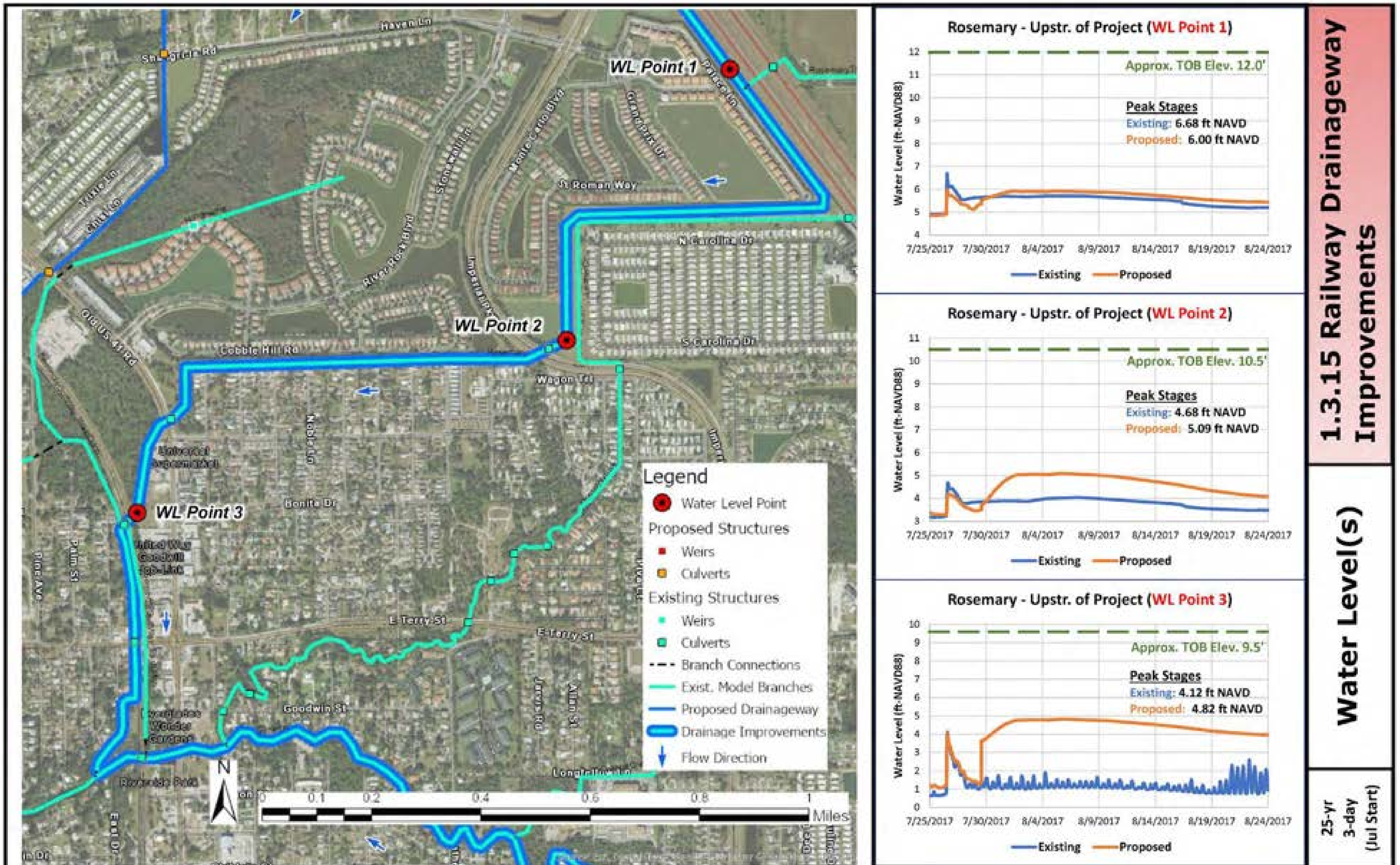

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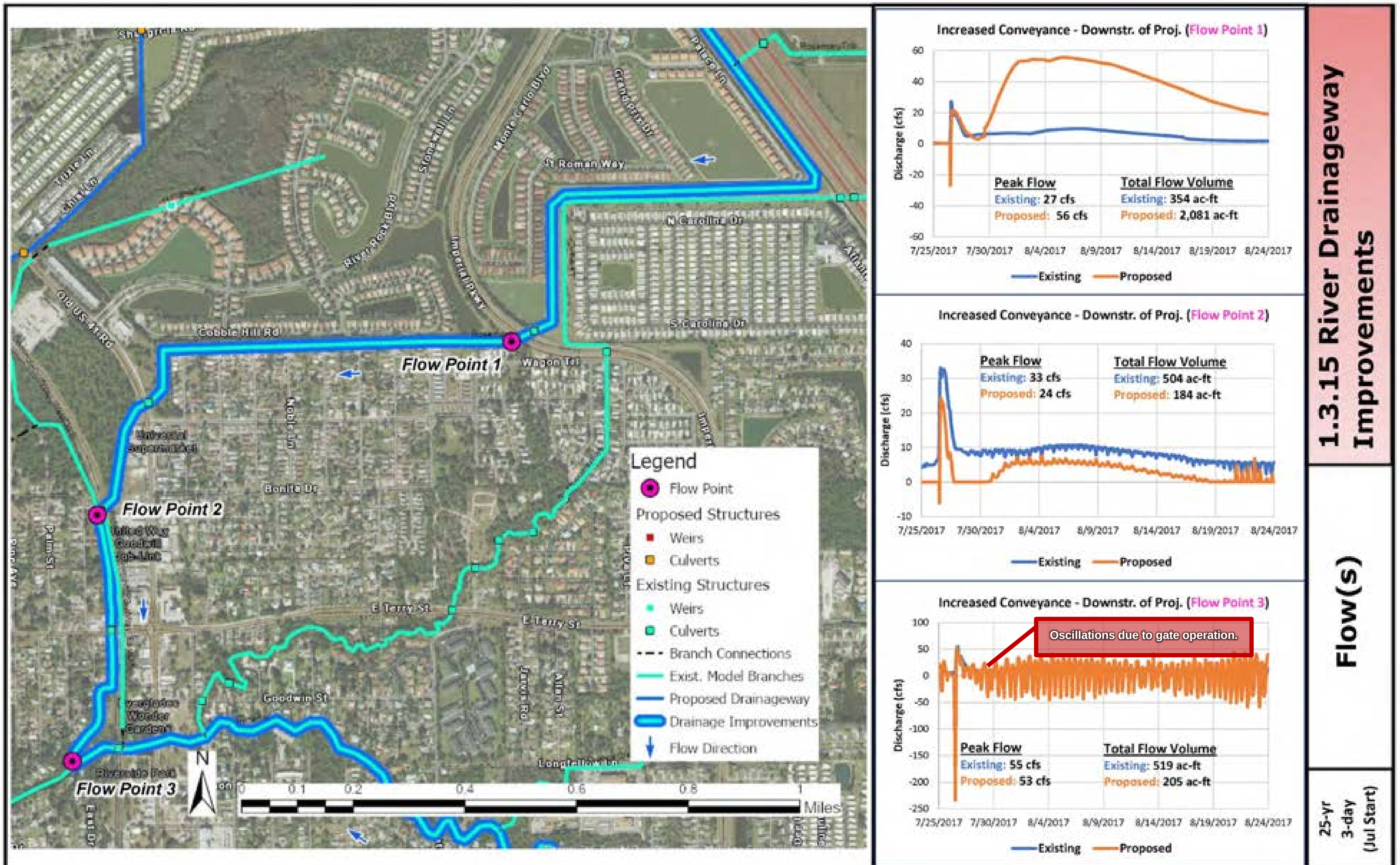

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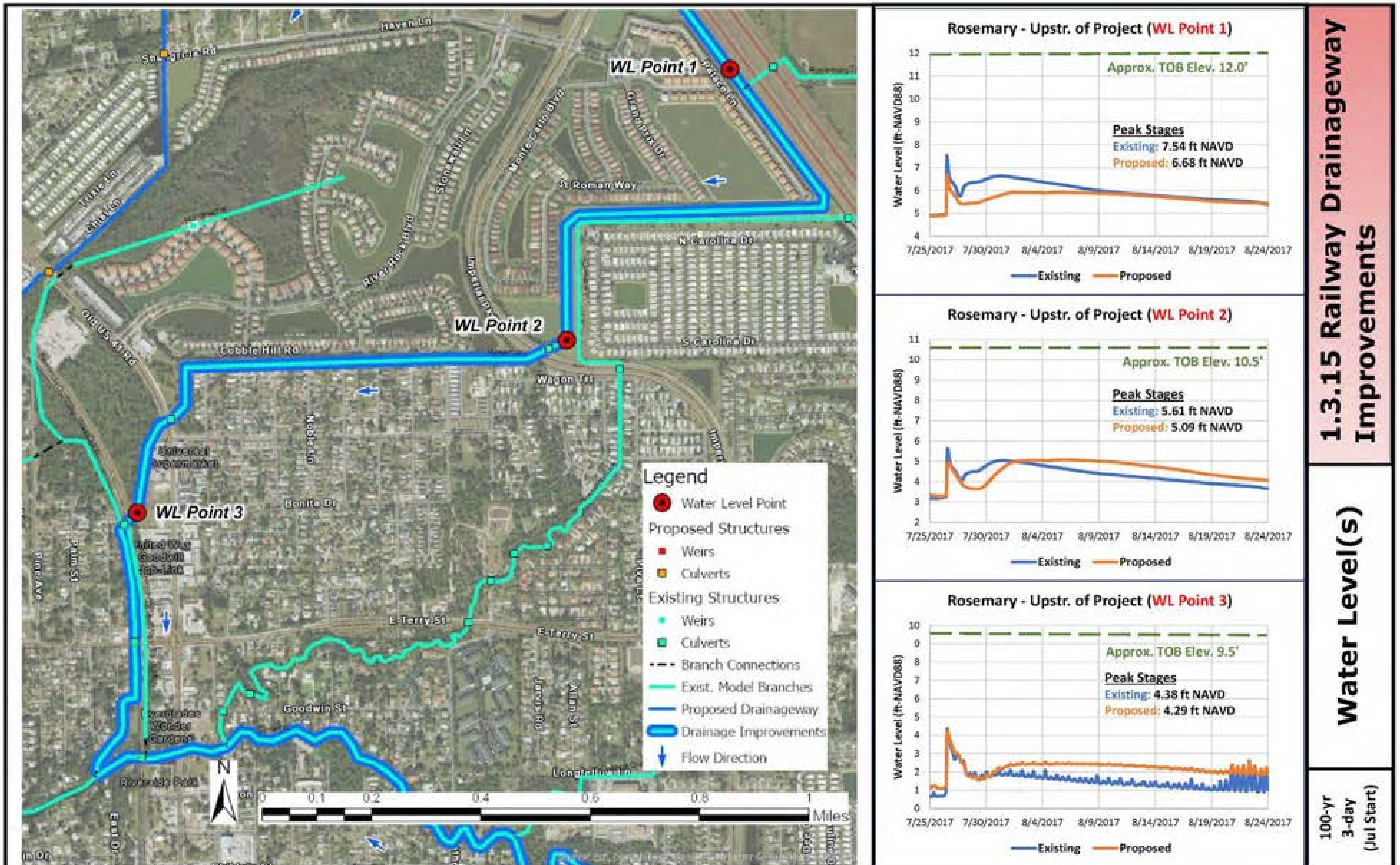
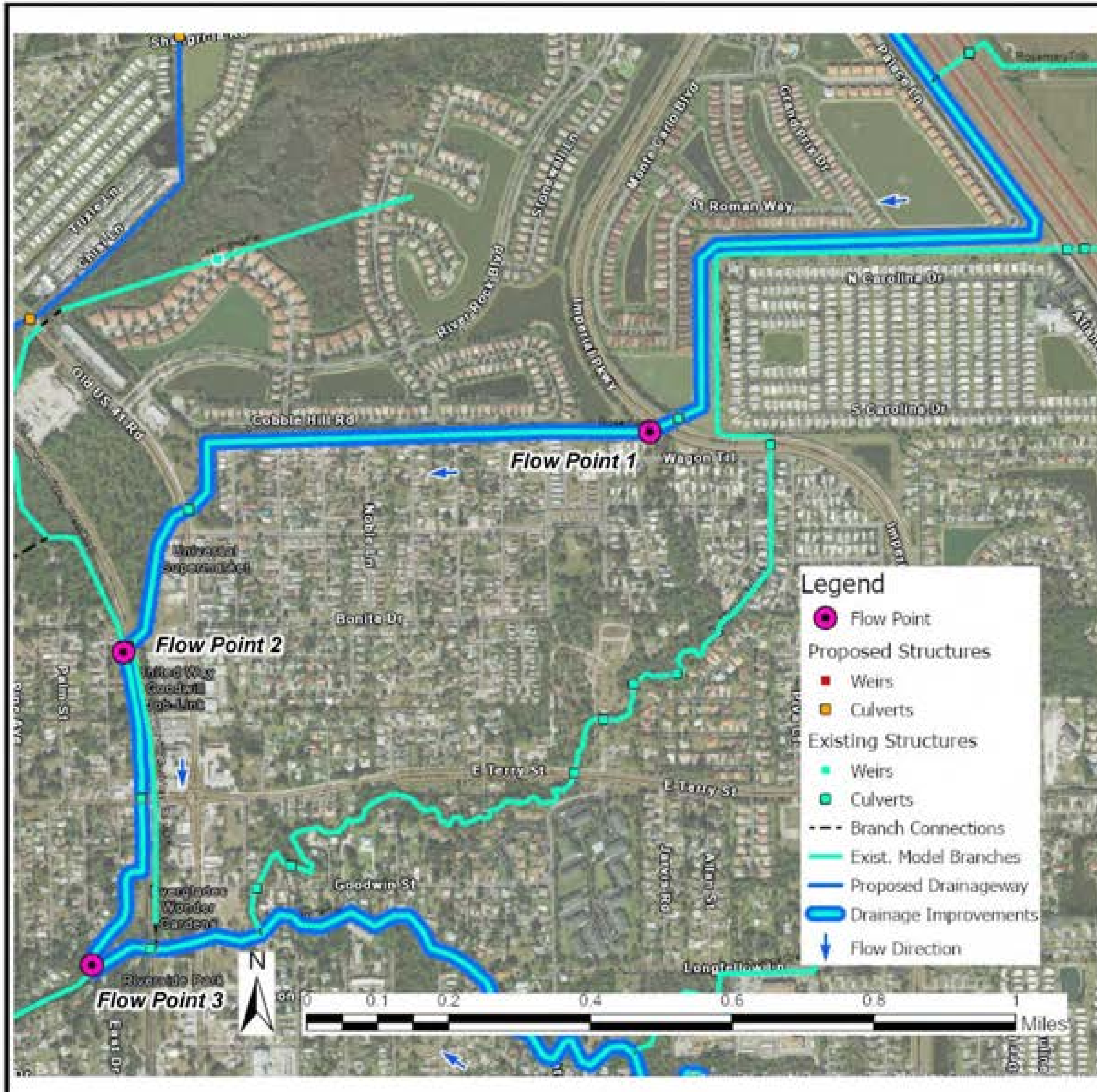
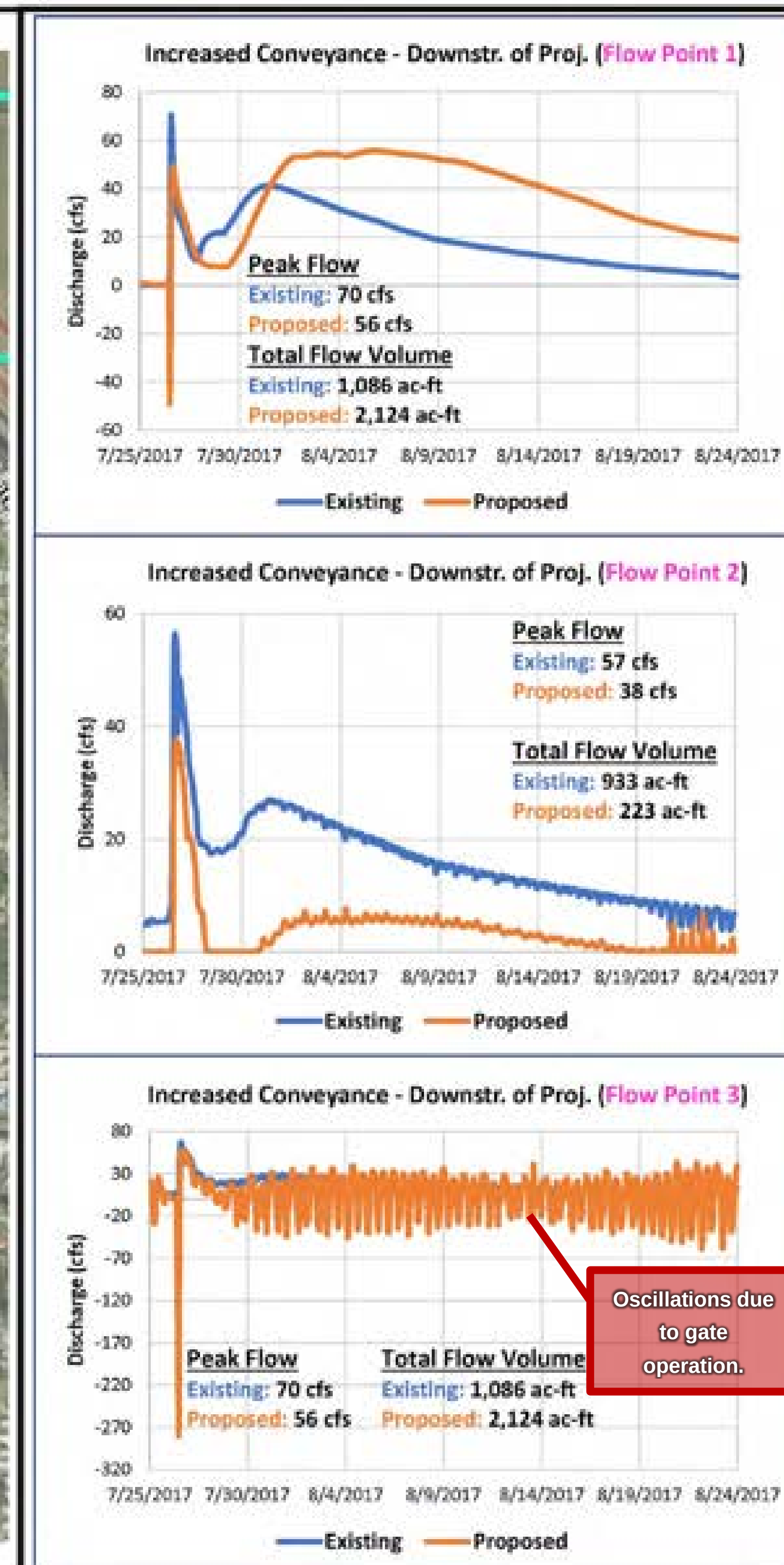


EXHIBIT 1.3.15 (e)



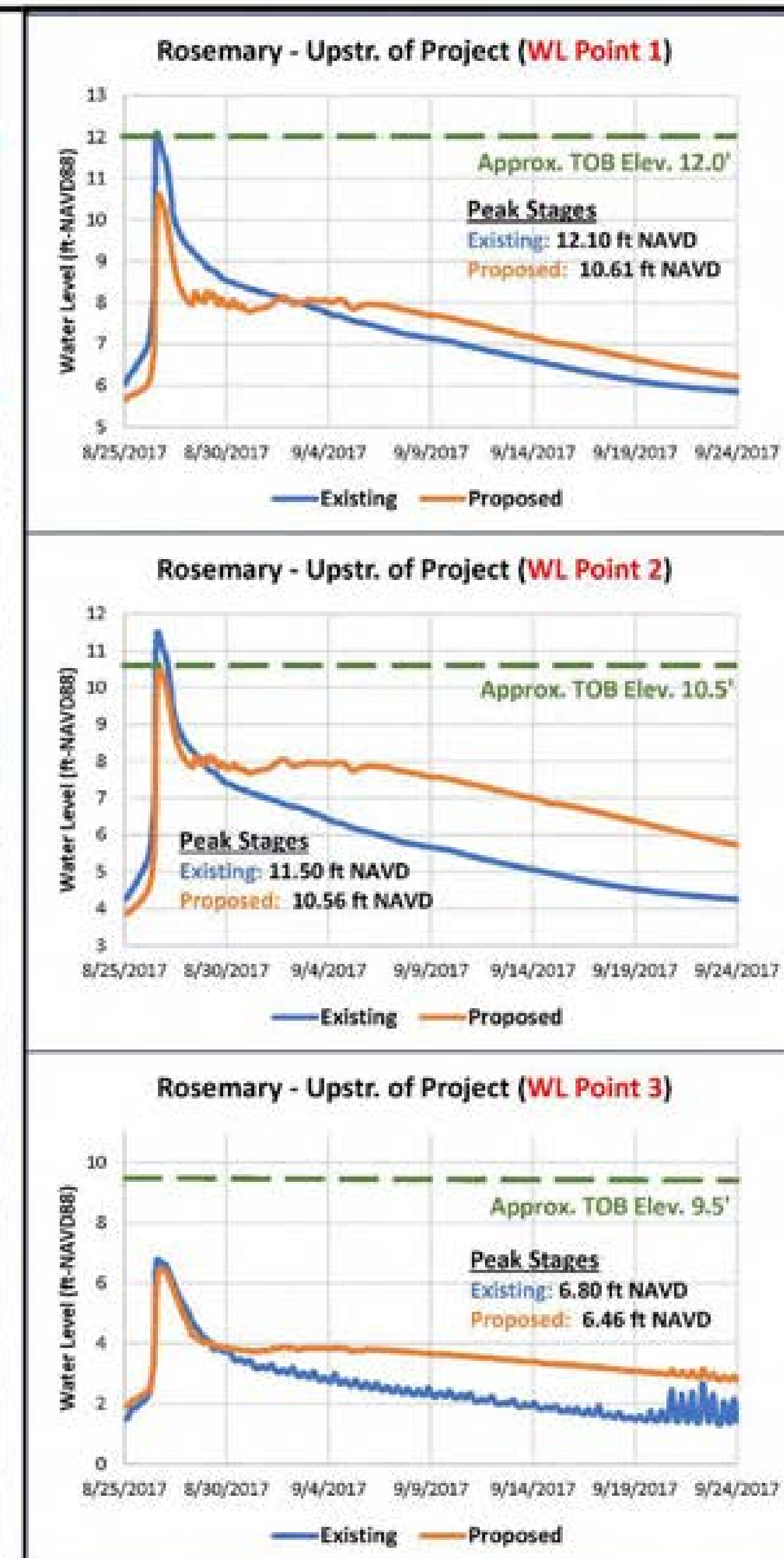


1.3.15 River Drainageway Improvements

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.15 (f)

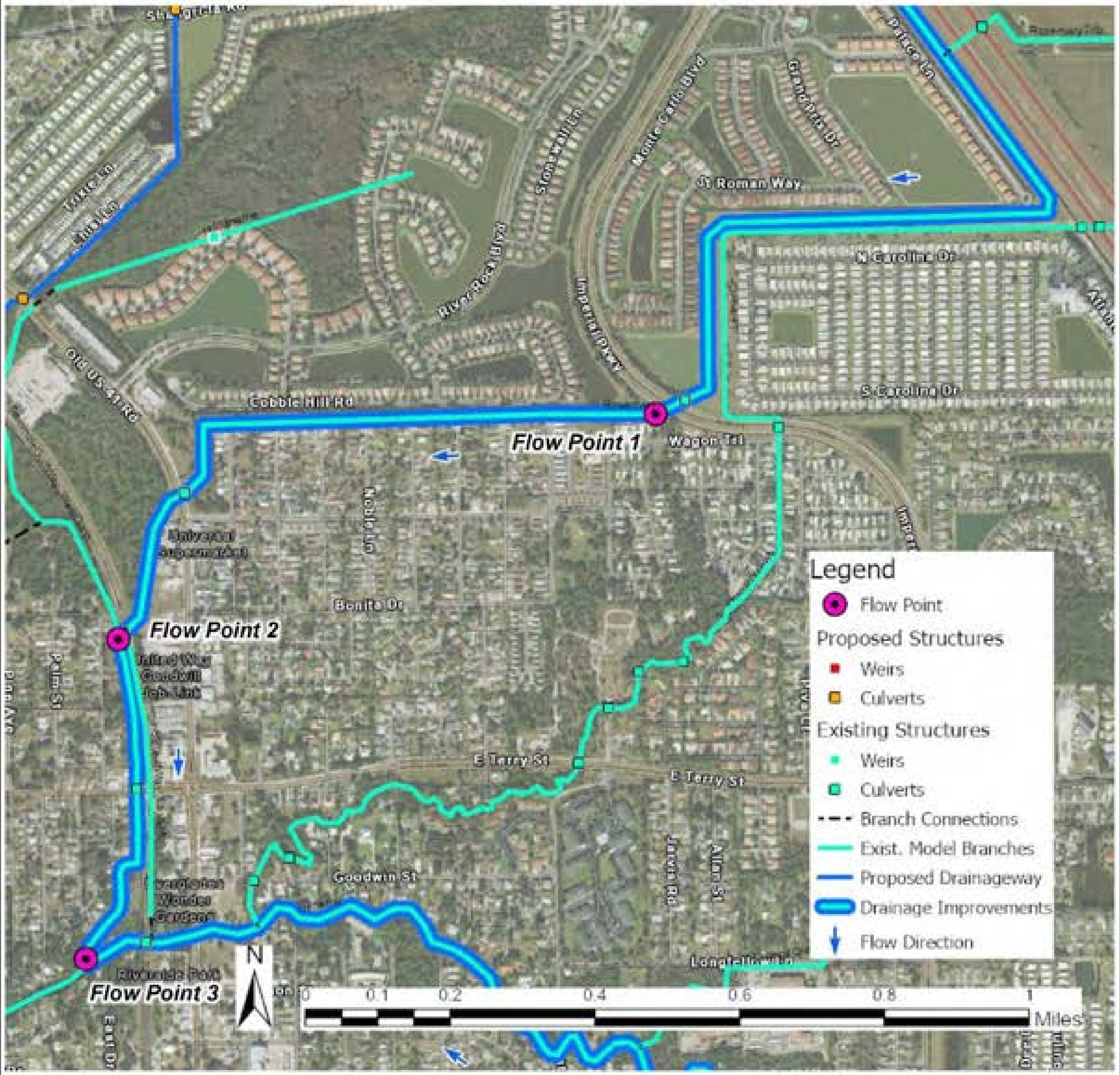


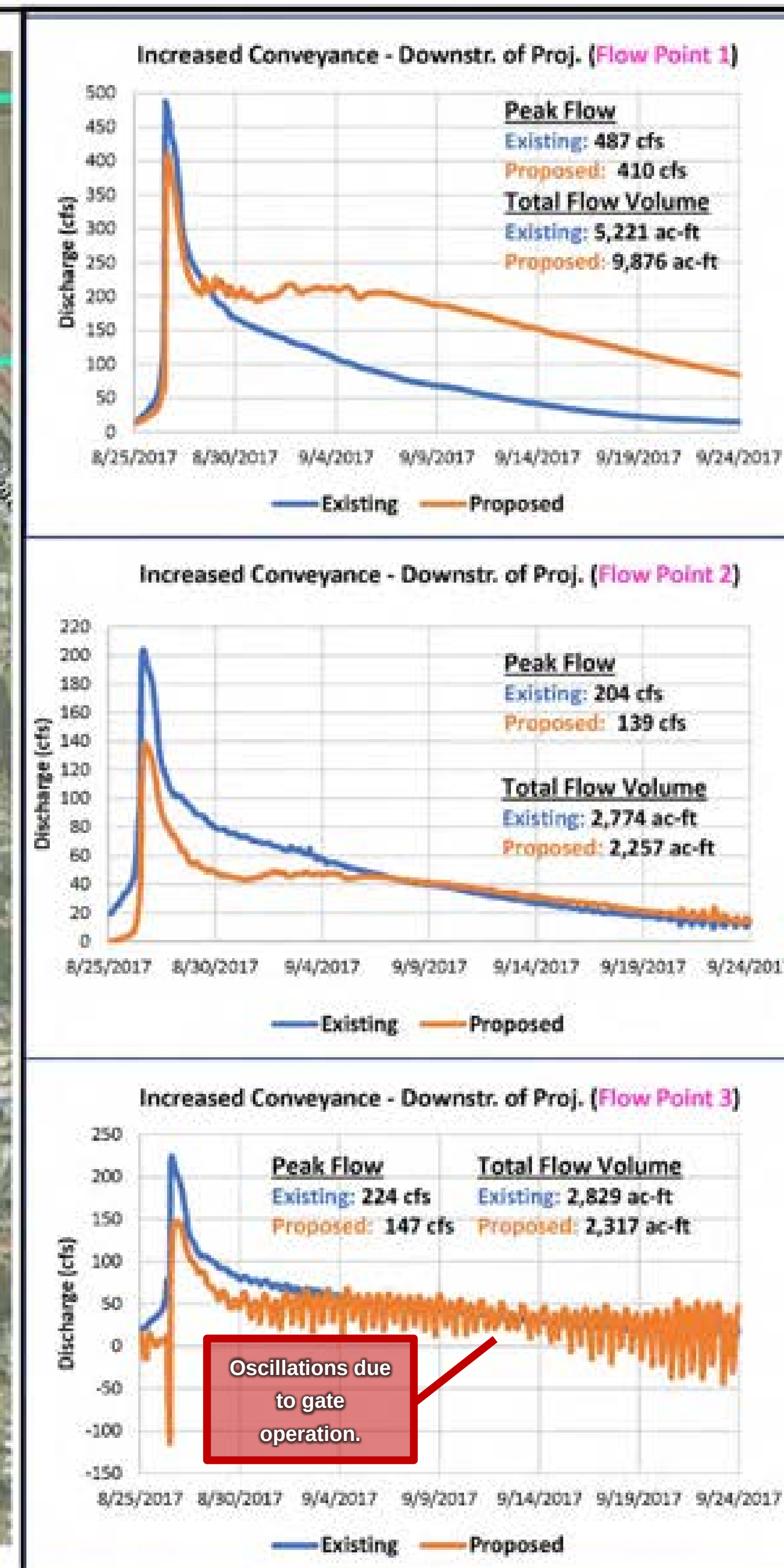
1.3.15 Railway Drainageway Improvements

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.15 (g)



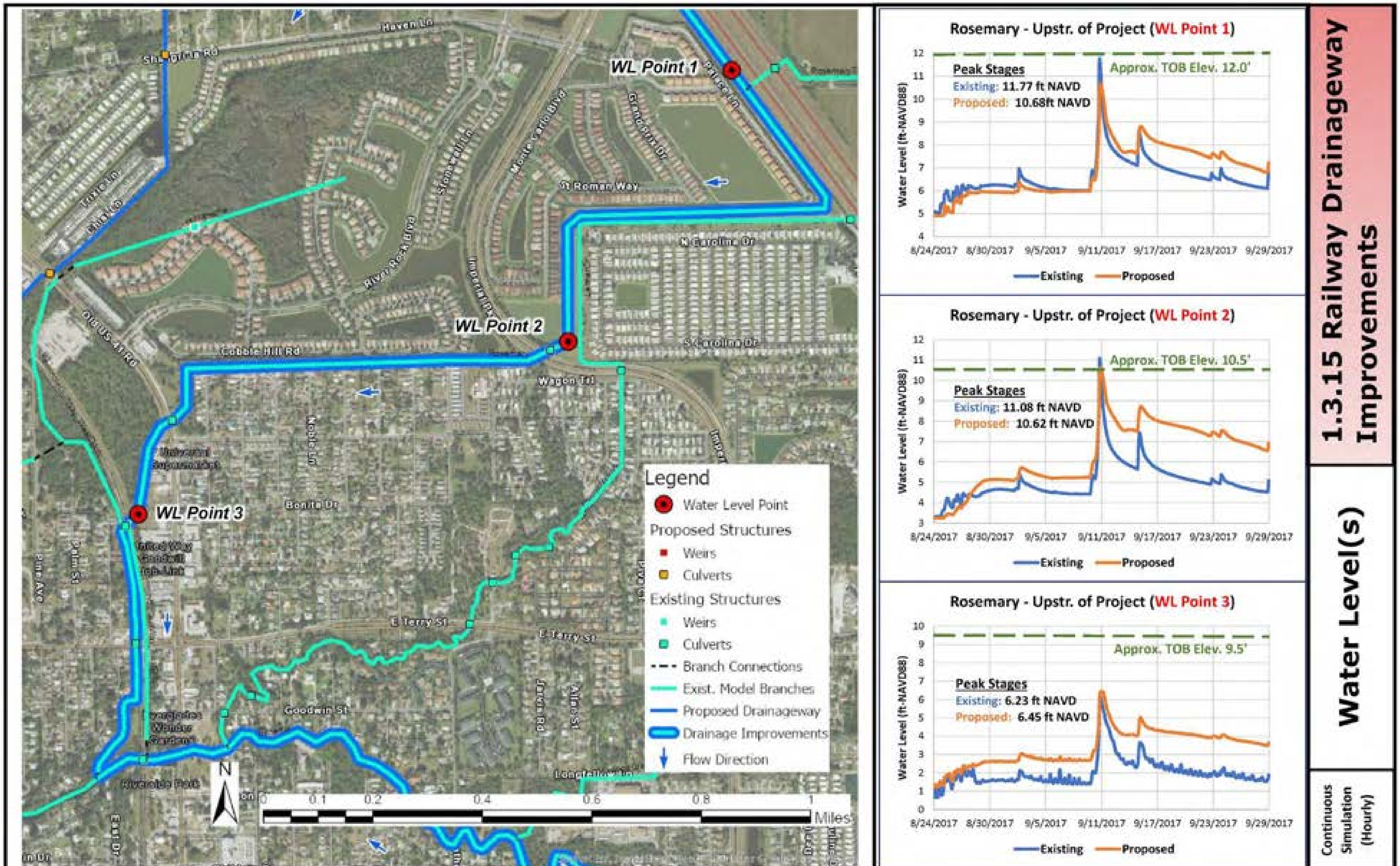


1.3.15 River Drainageway Improvements

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.15 (h)



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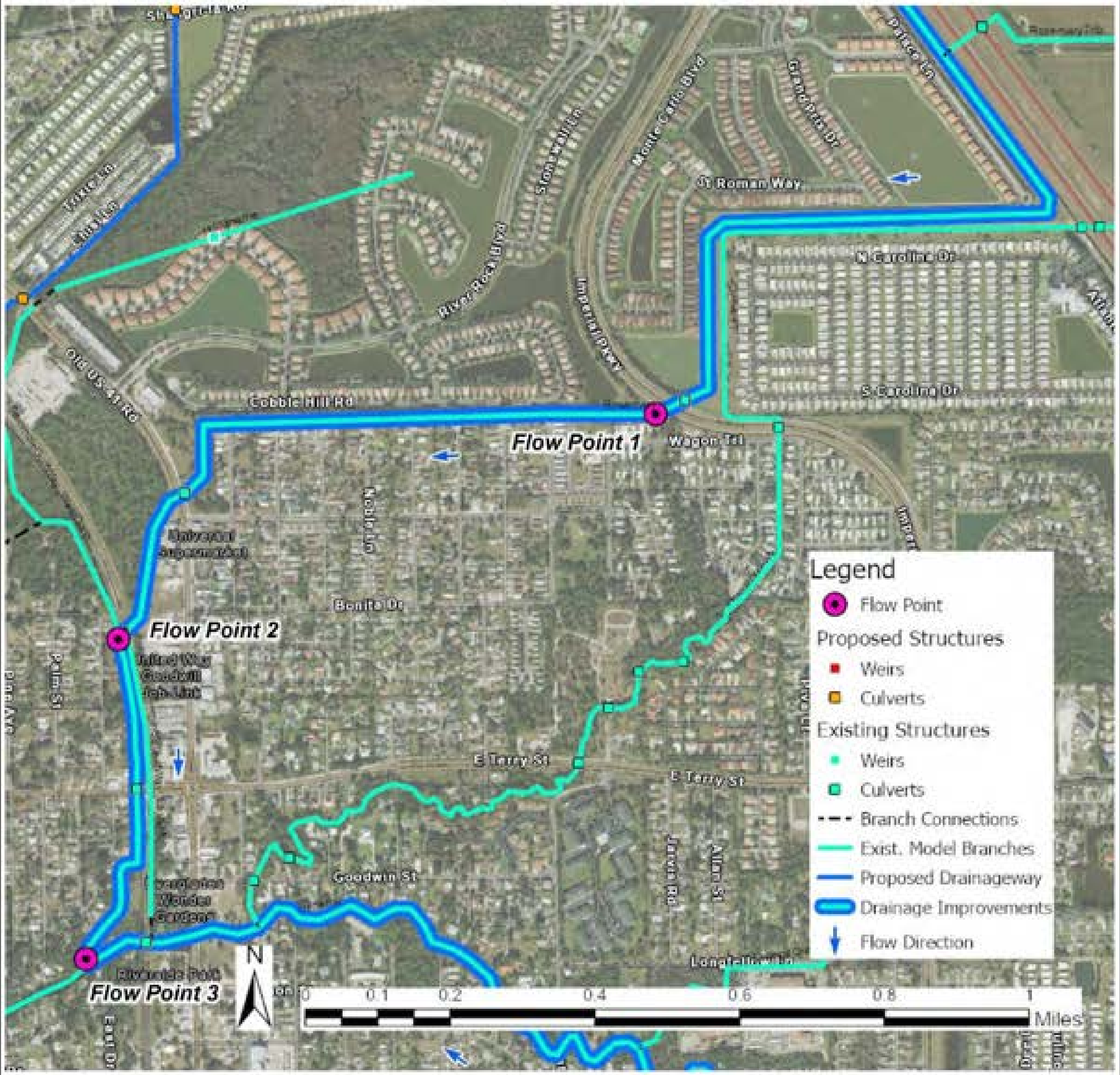
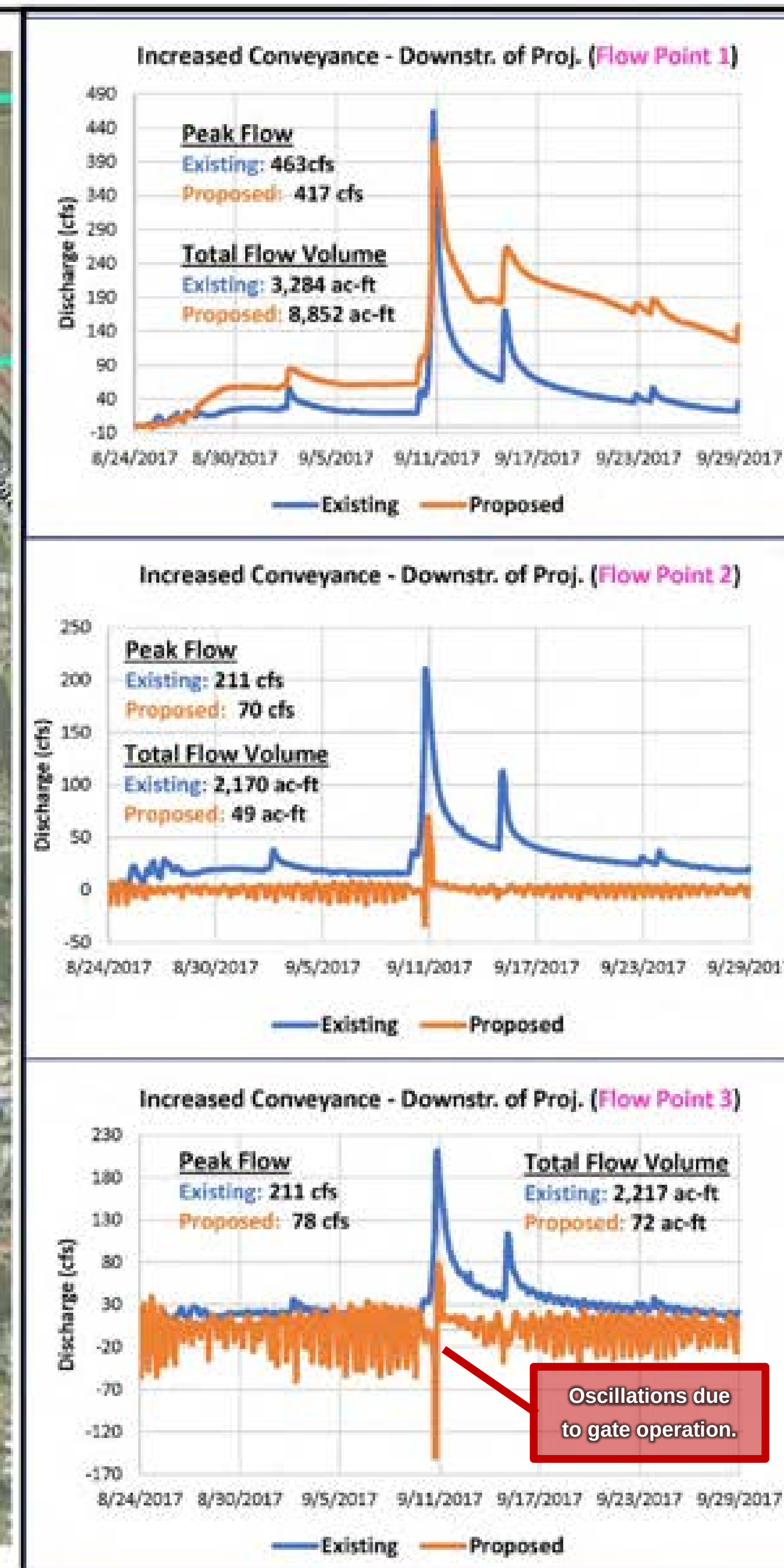




1.3.15 River Drainageway Improvements

Flow(s)

Continuous Simulation (Hourly)

1.3.16 Corkscrew East Drainageway Concept Plan

Background

The area at the east end of Corkscrew Road near the County line has been primarily used for agricultural purposes with some large tract residential properties. This area is currently developing farmlands to major land developments. This concept project provided information for flow ways between land developments to pass water from naturally sloped lands north of Corkscrew Road southerly to Corkscrew Swamp to avoid flow blockages. The land cover consists of cypress, wetlands, remnant sloughs and agricultural fields.

Location

This proposed conceptual project is in SE Lee County beginning just west of the intersection of Corkscrew Road and Alico Road and continuing east to the Lee and Collier County line as illustrated in **Figure 45**.

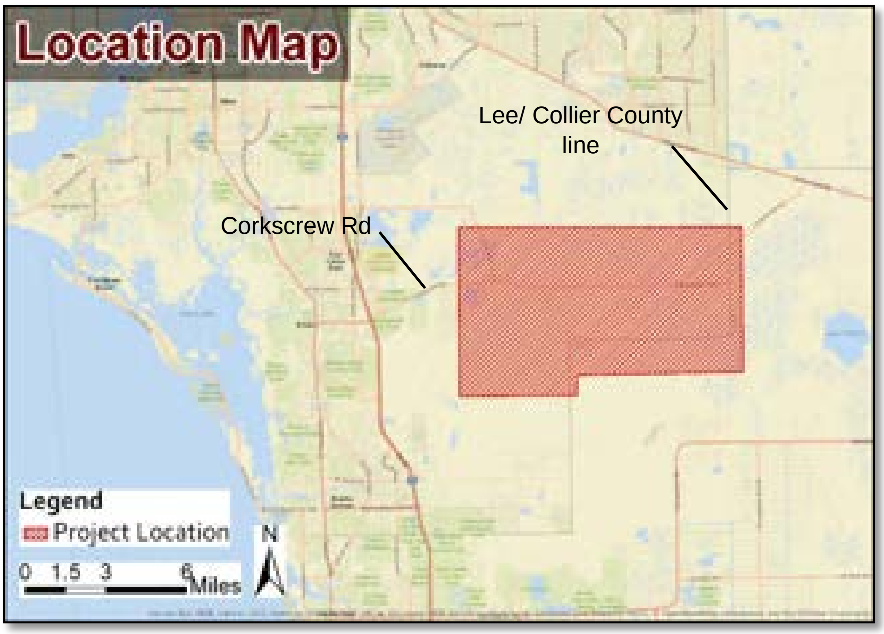


Figure 45 –Location Map, 1.3.16 Corkscrew East Drainageway

Description

This proposed conceptual project would provide natural and manmade drainage conveyances for the upcoming development of this area to account for surface water runoff from the lands north of Corkscrew Road flowing southerly to the Corkscrew Swamp. These conveyances would utilize natural flow paths and have drainageways with weirs to maintain flow and water levels within desirable ranges as illustrated in **Figure 46**.

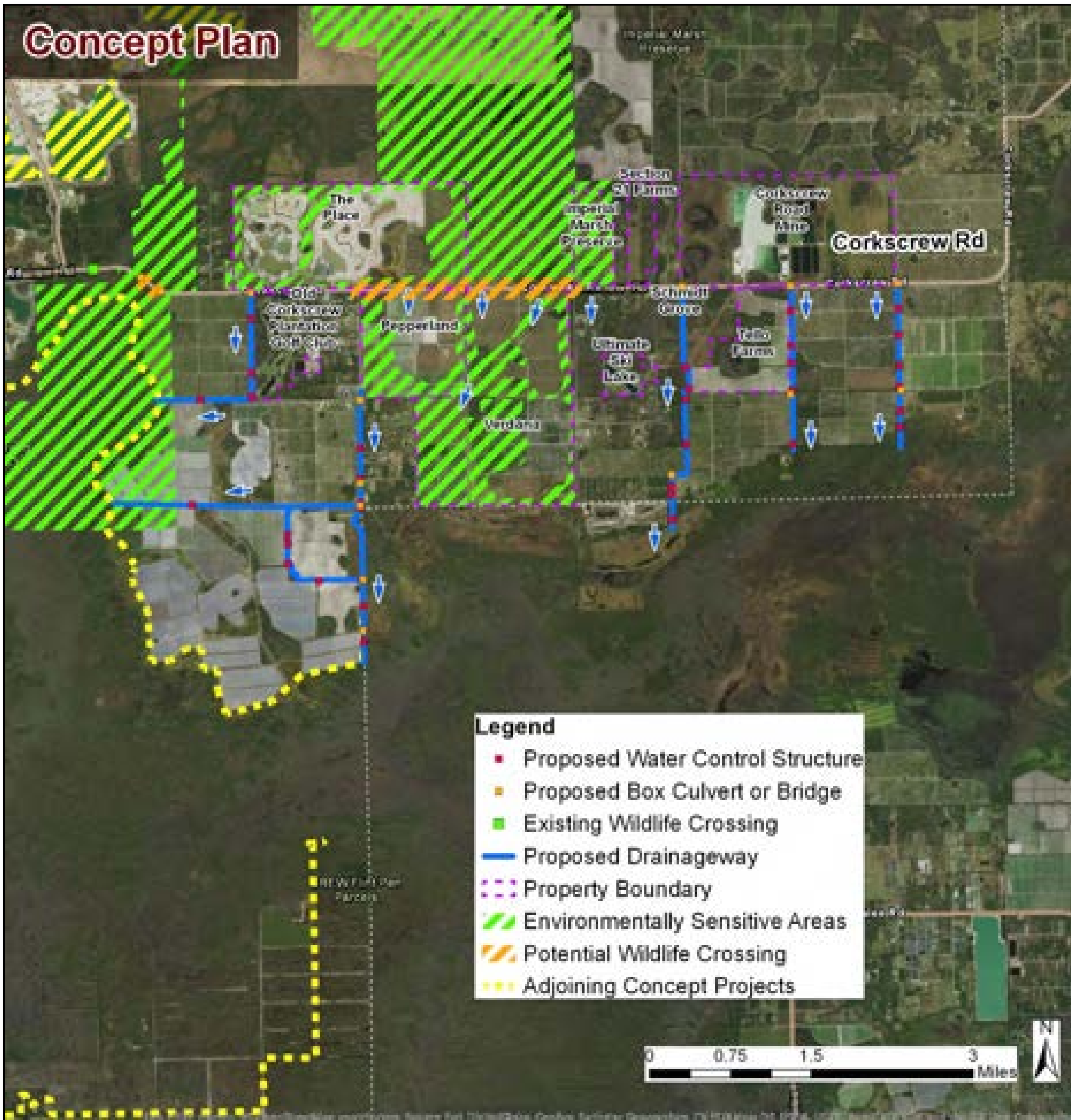


Figure 46 - Concept Plan, 1.3.16 Corkscrew East Drainageway

Purpose

This proposed project would make provisions for drainage through proposed developments in this area to handle runoff from large storm events.

Evaluation

Viability

This project concept is intended to focus awareness of the rapid development ongoing in this area, so that conveyance opportunities can be preserved. Addressing this issue will avoid land development blocking the natural flow to Corkscrew Swamp and minimize flood management problems in the future.

Community Considerations

This drainageway would require landowners to provide land areas as part of the development projects.

Environmental & Permittability Considerations

Significant environmental impacts occurring along the possible routes may necessitate mitigation.

Land Availability

The need for land acquisition is necessary to construct the Corkscrew East Drainageway conveyance, storage, and water quality features.

Opinion of Probable Cost

The costs for these improvements are intended to be provided by future developments and by the Lee County DOT as part of future highway improvements.

Opportunities for Multiple Benefits & Uses

As south east Lee County continues to reach full build-out conditions, improving the conveyance in the Corkscrew East drainage area is a critical priority. Providing reservoir storage solutions would be an additional benefit, since available land is becoming increasingly difficult to obtain as development progresses.

Other Considerations

This project as planned involves private properties and requires planning provisions during project reviews. A summary of this concept project is shown below in **Exhibit 1.3.16** herein.

Findings & Recommendations

Regional Modeling Findings

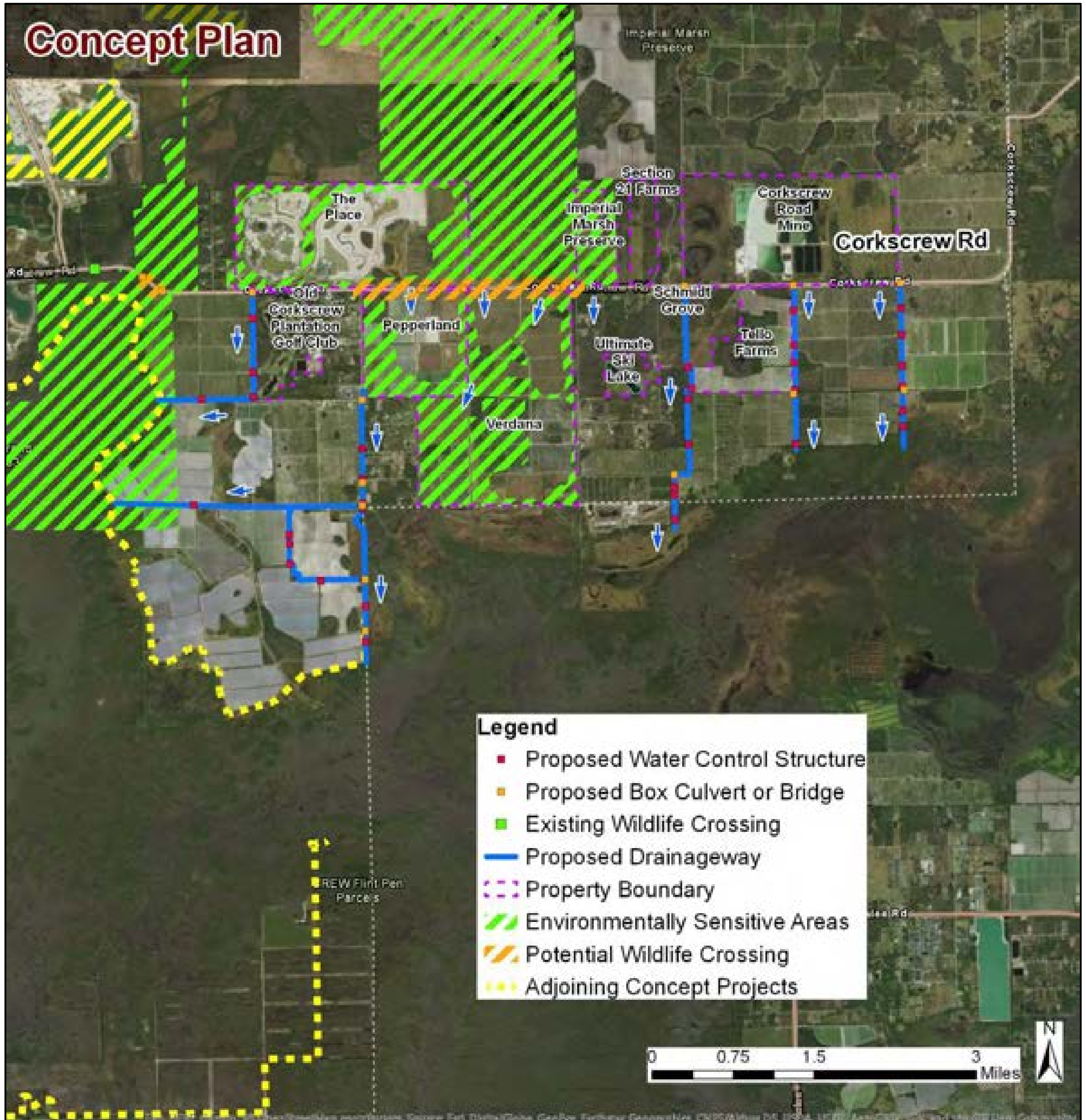
This project concept consists of multiple conveyances to route excess stormwater flows from the large area north of Corkscrew Road southerly to Corkscrew Swamp. This area is largely undeveloped and is being planned for proposed flow ways between land development projects to convey overland flow southernly. The conveyances generally link with proposed structures under Corkscrew Road and are routed along main property lines spaced at one-half to one-mile intervals to distribute flow. An interceptor swale along the northern side of Corkscrew Road would collect and distribute runoff. The concept project was further refined and incorporated into the regional model to analyze the project's effectiveness. The refined concept plan is shown in **Exhibit 1.3.16 (a)** herein. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. All the concept projects are included in the regional model; meaning, the indicated results are reflective of the entire system functionality. Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.16 (b) EXHIBIT 1.3.16 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.16 (d) EXHIBIT 1.3.16 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.3.16 (f) EXHIBIT 1.3.16 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.3.16 (h) EXHIBIT 1.3.16 (i)

The results generally showed minor changes in water levels which is indicative of the proposed structures to protect groundwater levels. Flows varied from minimal to high change in the proposed conveyances. The minimal flows that were shown in some conveyances may reflect the undeveloped area and the non-channelized flow that currently exists but may change in the future. Planning for the larger flow in all the conveyances should be considered for future development. The modeling shows a high flows in certain conveyances indicating that planning flow ways between land development properties will be an essential improvement to protect this area from blocking future flood flows in a rapidly changing watershed.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by conveying excess stormwater flow from a large area north of Corkscrew Road southerly towards the Corkscrew Swamp. This is achieved by utilizing multiple conveyances spaced out from one-half to one-mile intervals along Corkscrew Road. These positive improvements warrant further design-level project development. The planned flows shown herein appear to conceptually provide a satisfactory planned flow capacity.



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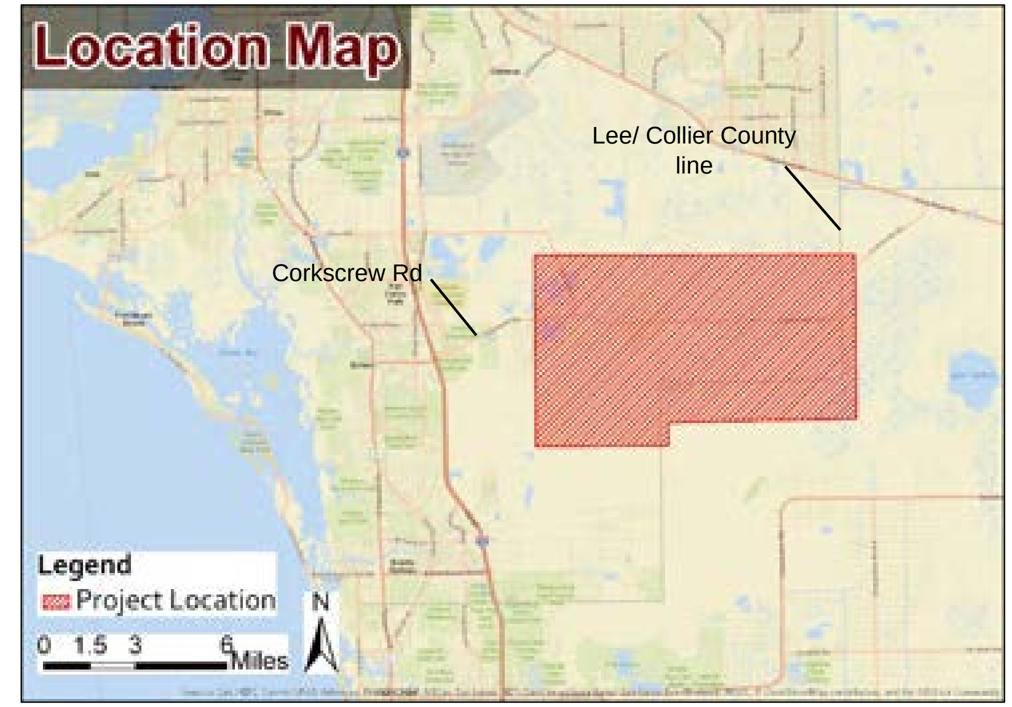


Project Narrative

DESCRIPTION: This proposed conceptual project would provide natural and manmade drainage conveyances for the upcoming development of this area to account for surface water runoff from the lands north of Corkscrew Road flowing southerly to the Corkscrew Swamp. These conveyances would utilize natural flow paths and have drainageways with weirs to maintain flow and water levels within desirable ranges.

PURPOSE: This proposed project would make provisions for drainage through proposed developments in this area to handle runoff from large storm events.

CONSTRAINTS: This project as planned involves private properties and requires planning provisions during project reviews.

May 2020

Corkscrew East Drainageway

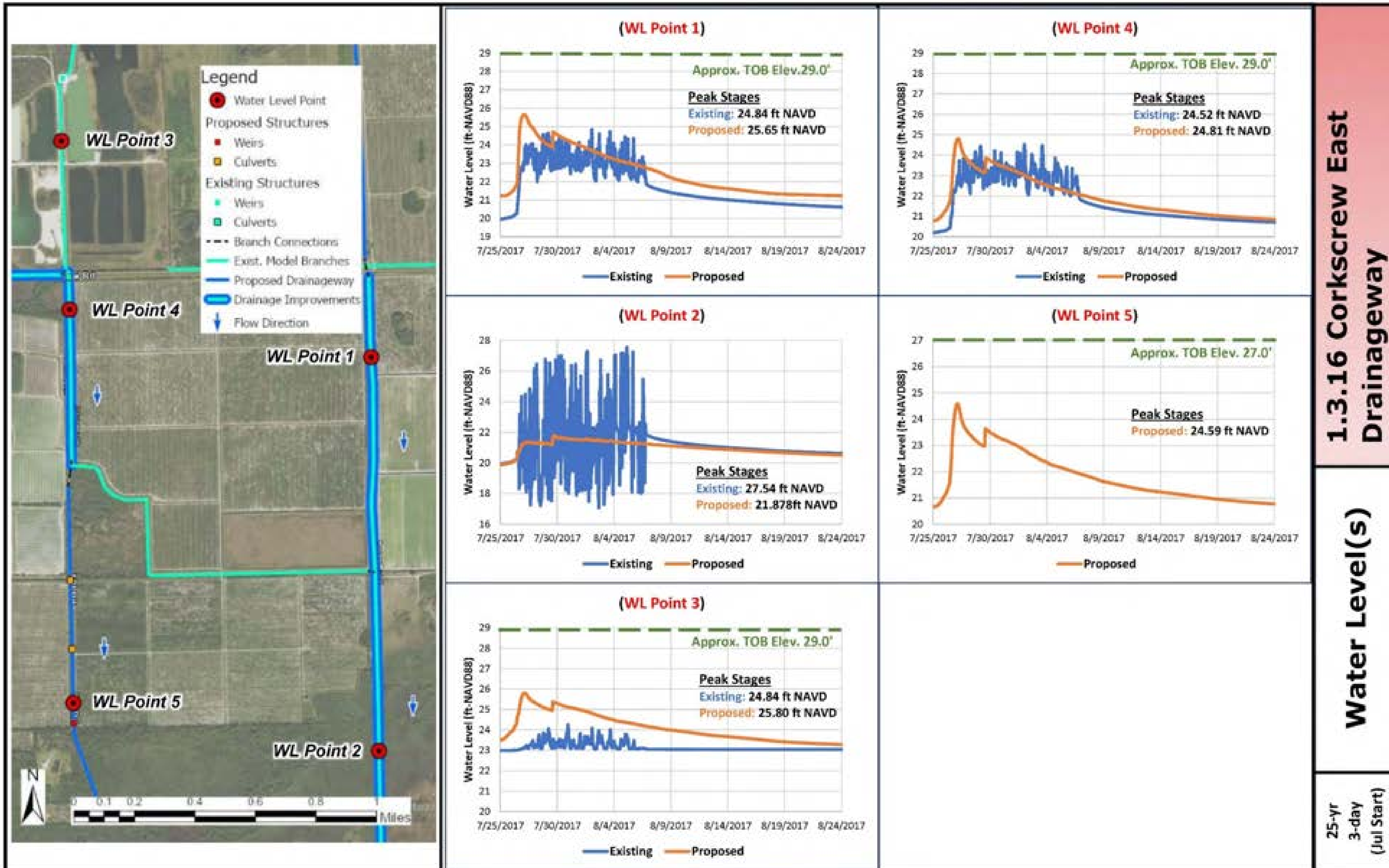
SE Lee County Area

AIM Engineering & Surveying, Inc.
2161 Fowler Street
Fort Myers, Florida 33901
(239) 332-4569
www.aimengr.com

EXHIBIT 1.3.16

EXHIBIT 1.3.16 (a)

EXHIBIT 1.3.16 (b): 1 of 3



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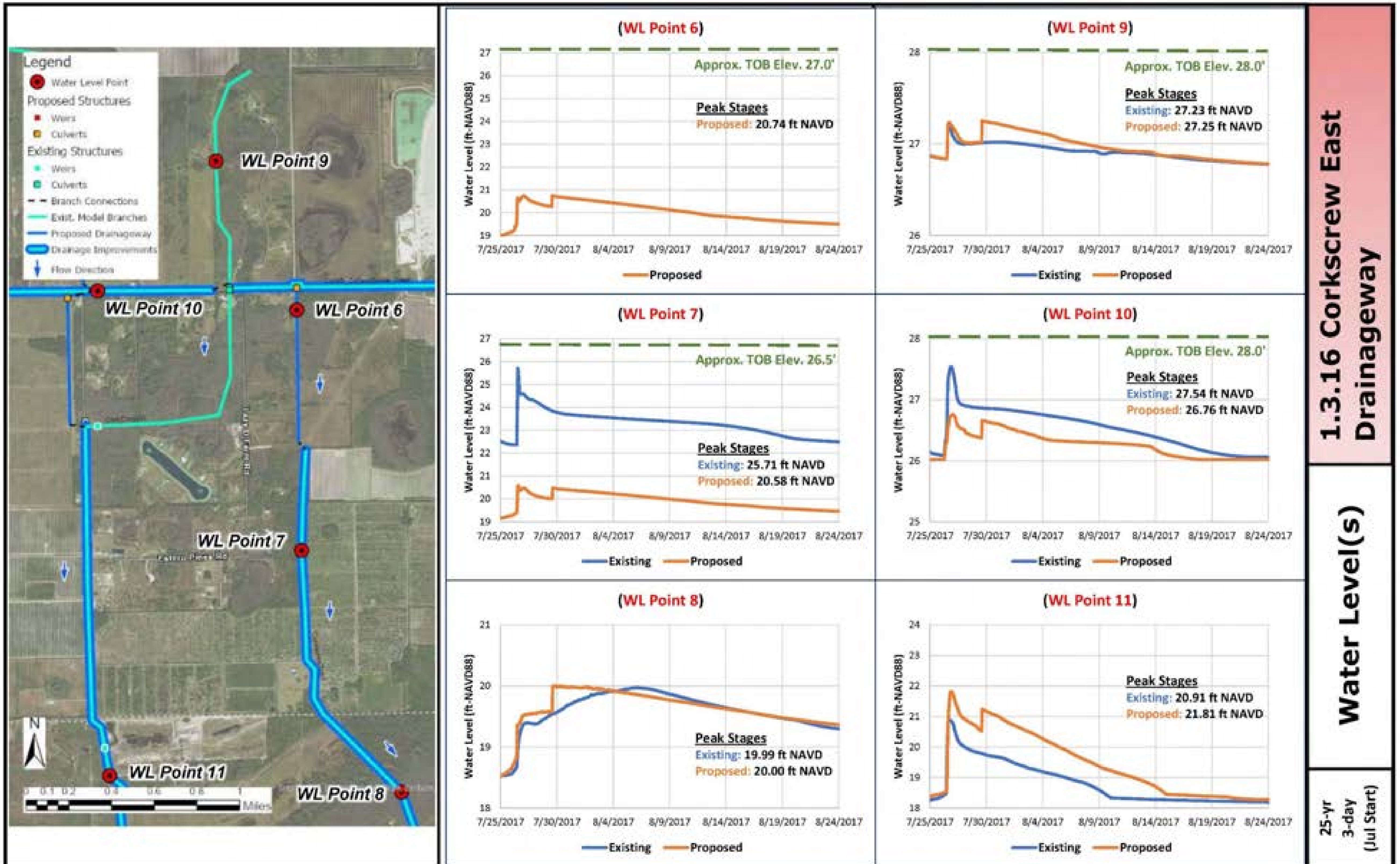

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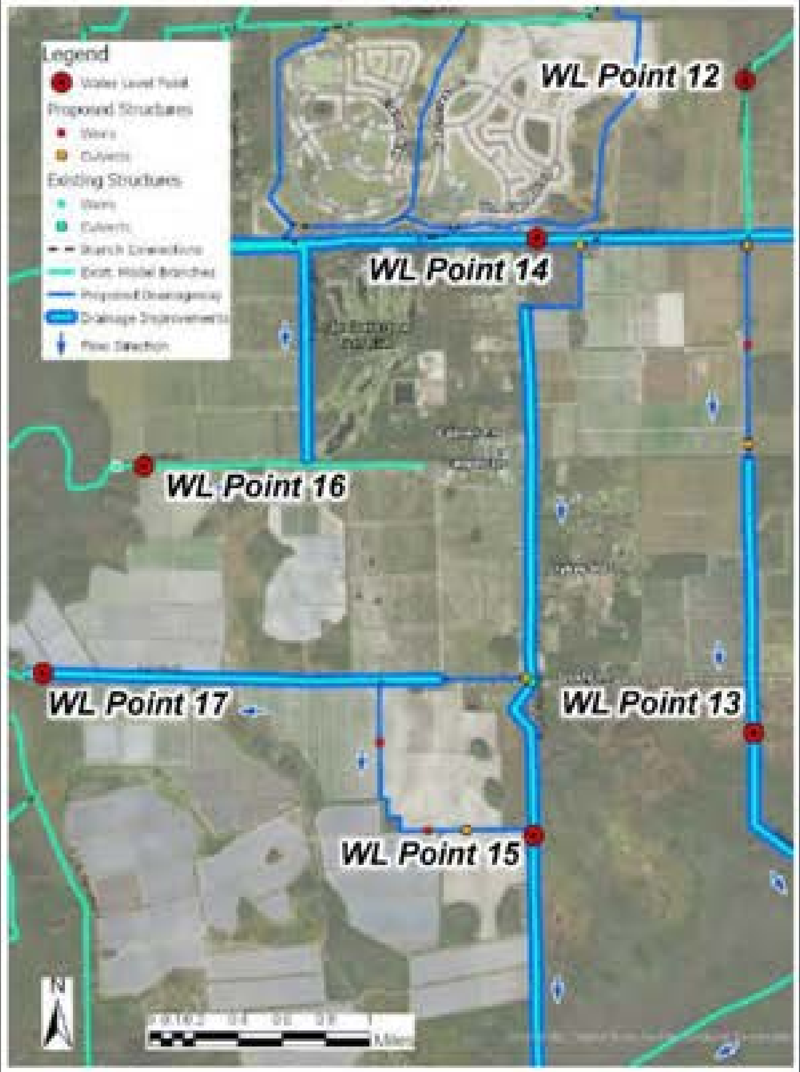
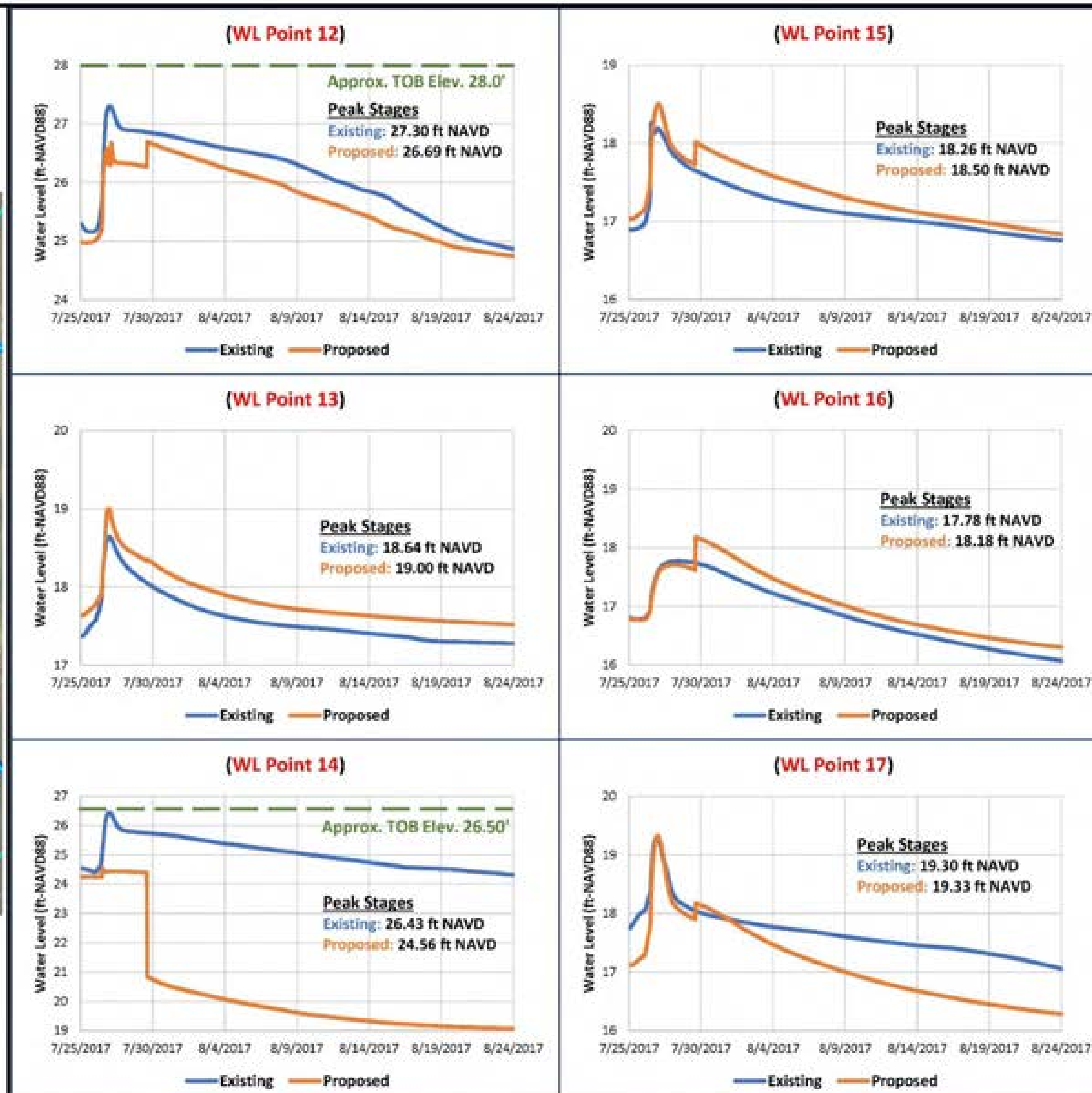


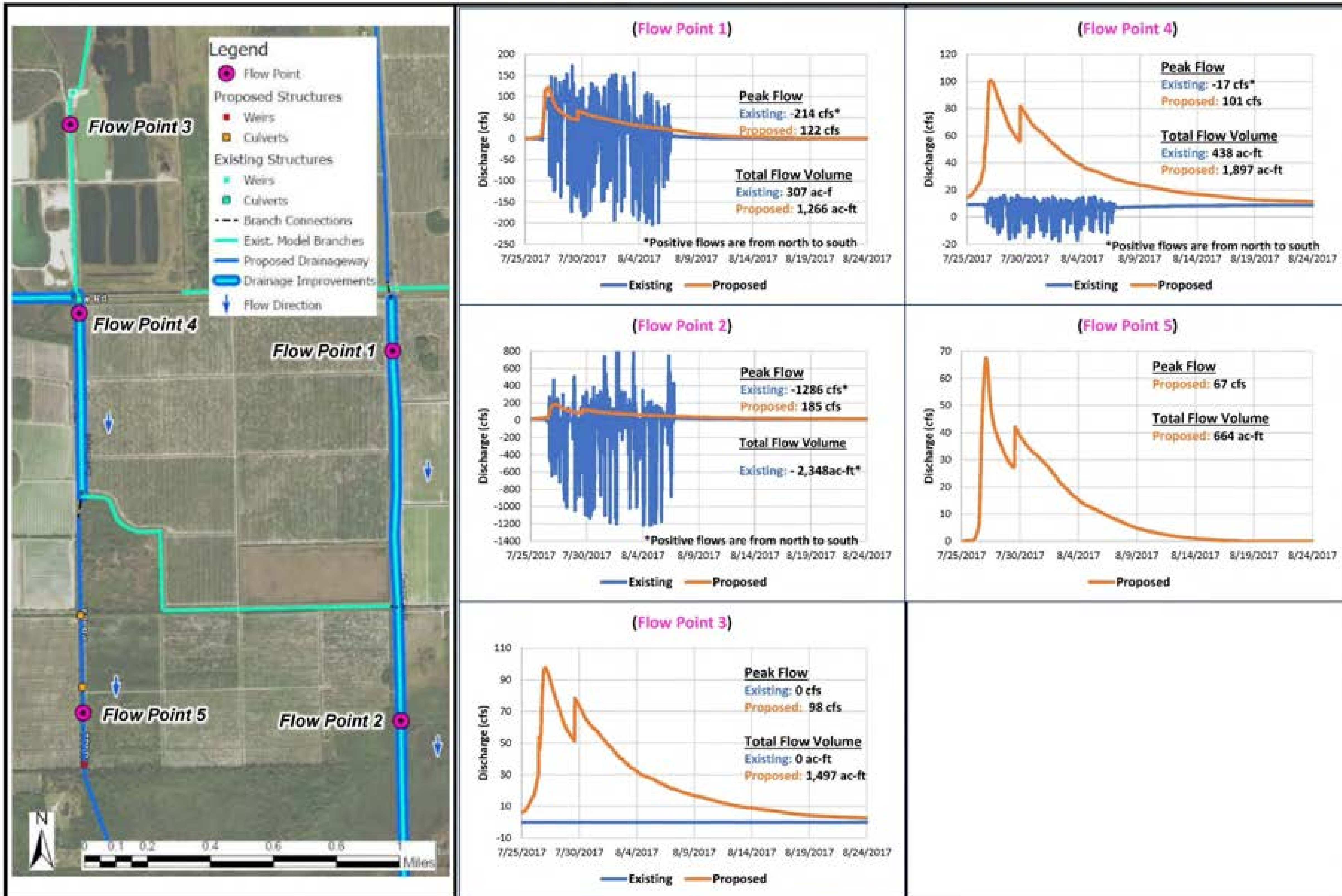


1.3.16 Corkscrew East Drainageway

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.3.16 (c): 1 of 3



1.3.16 Corkscrew East Drainageway

Flow(s)

25-yr 3-day (Jul Start)

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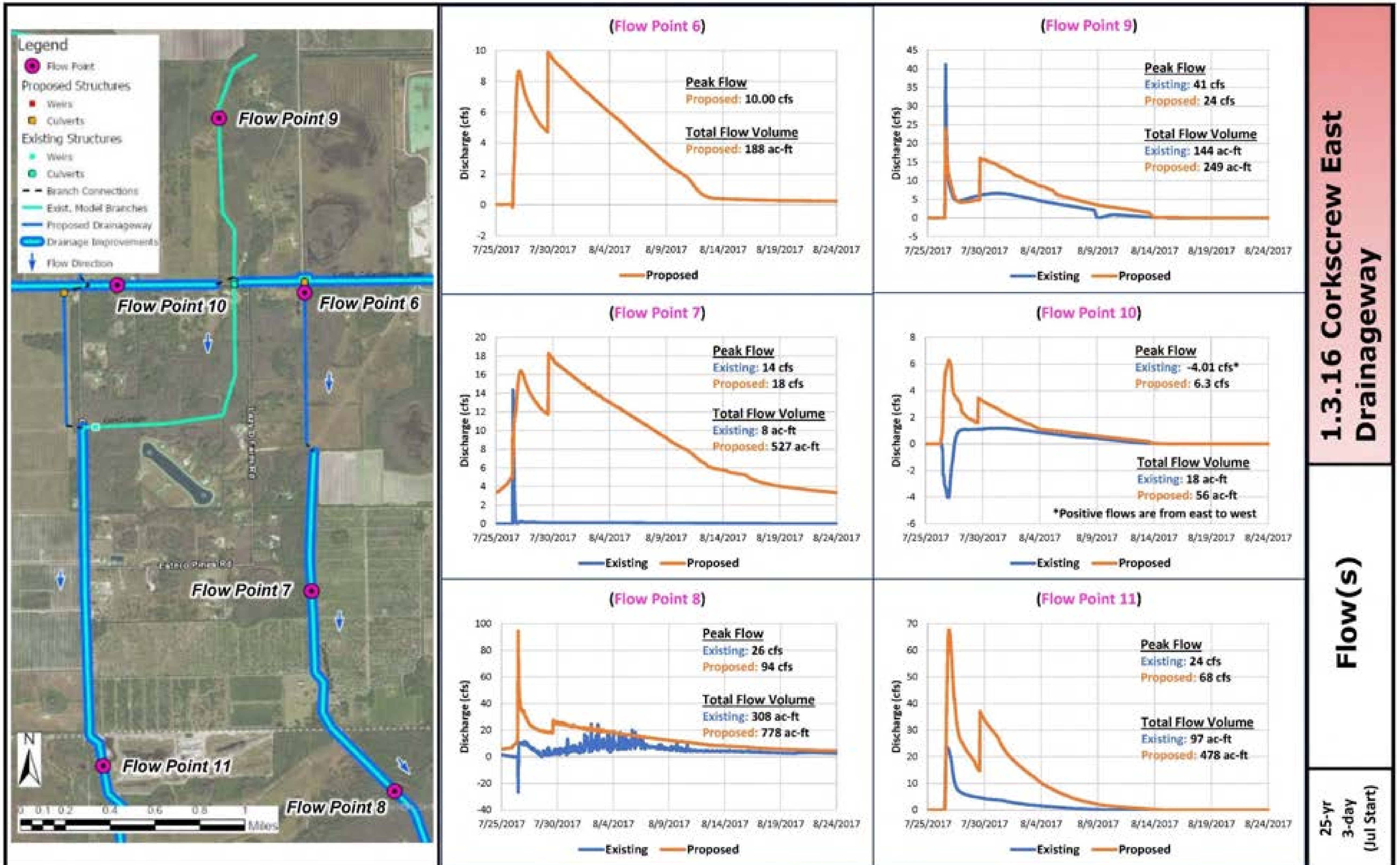
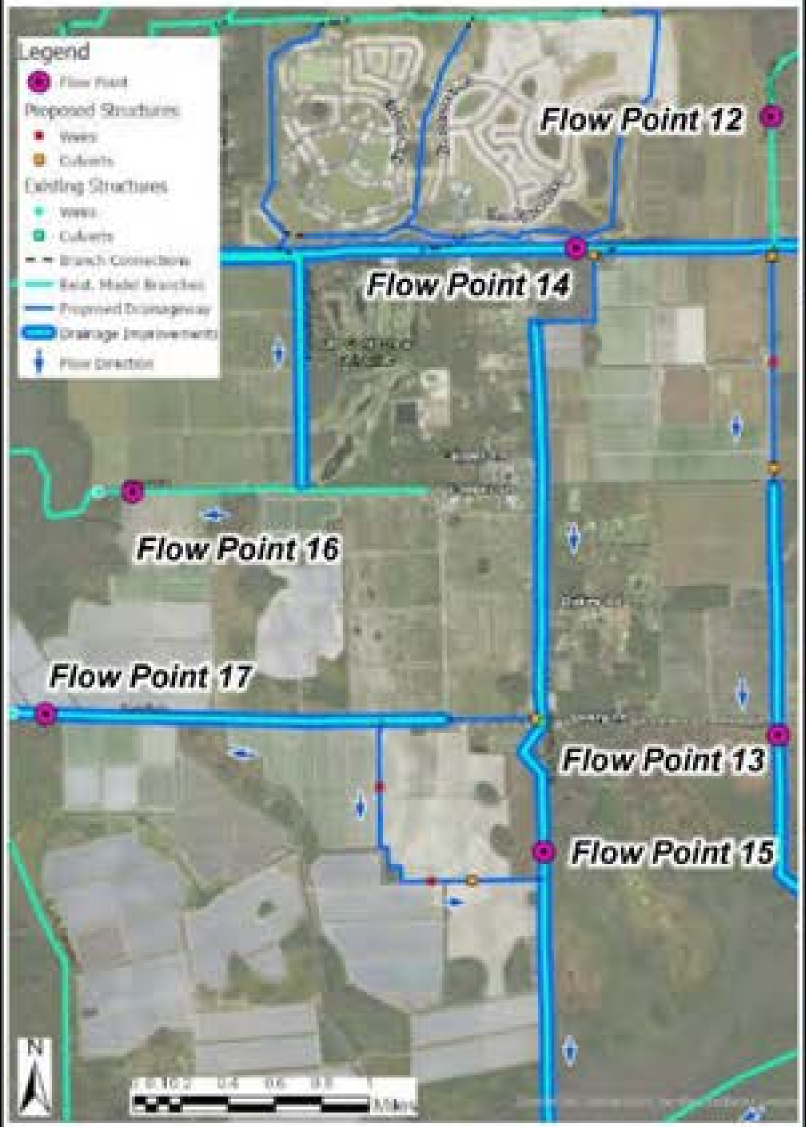


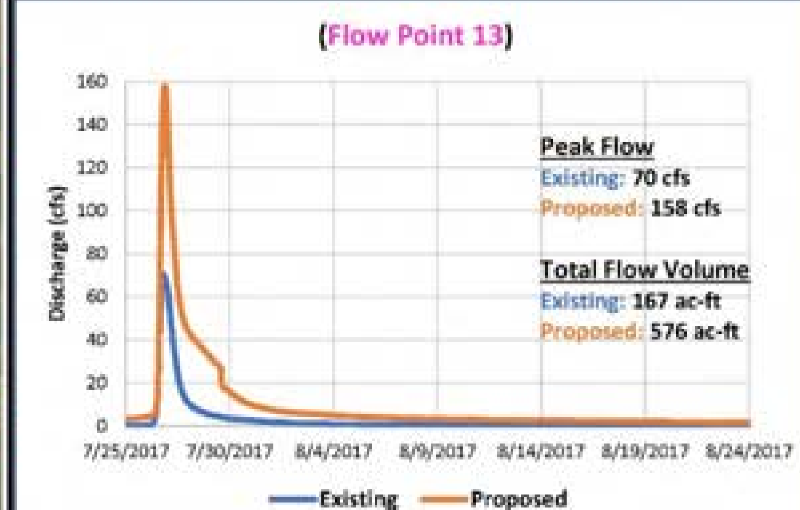
EXHIBIT 1.3.16 (c): 3 of 3

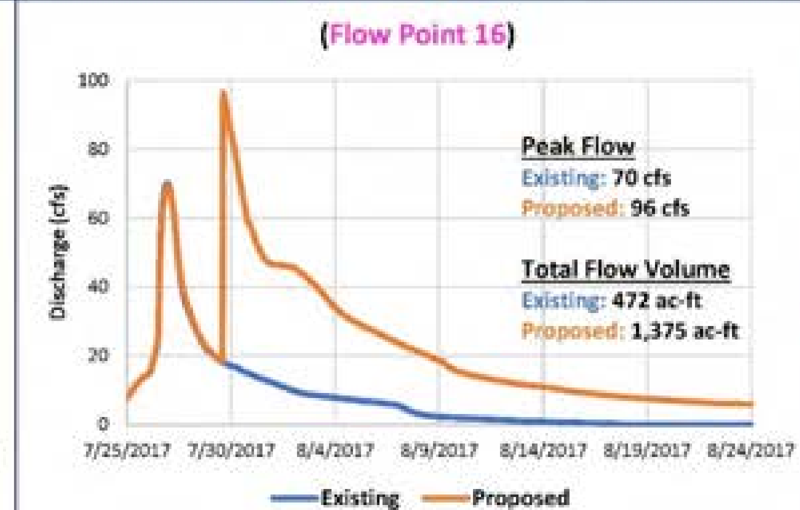
1.3.16 Corkscrew East Drainageway

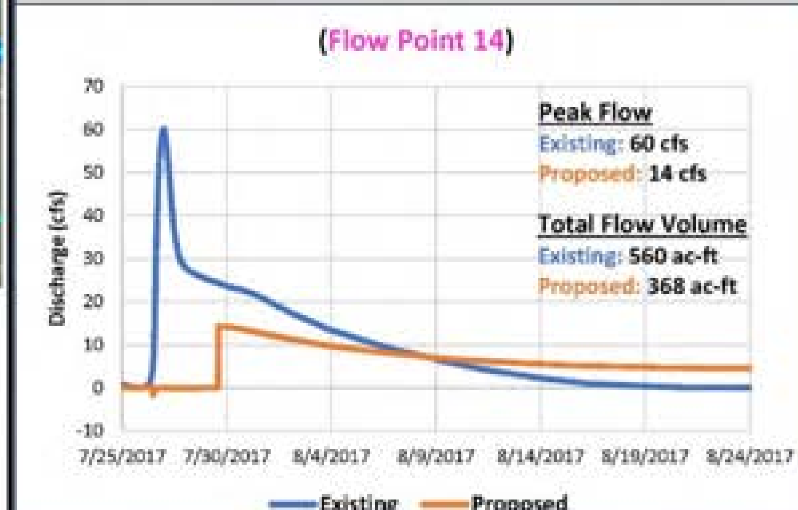
Flow(s)

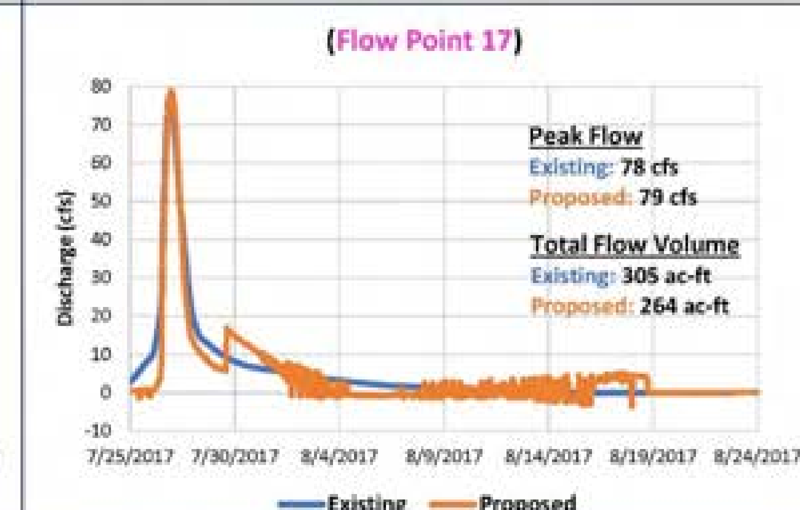
25-yr 3-day (Jul Start)











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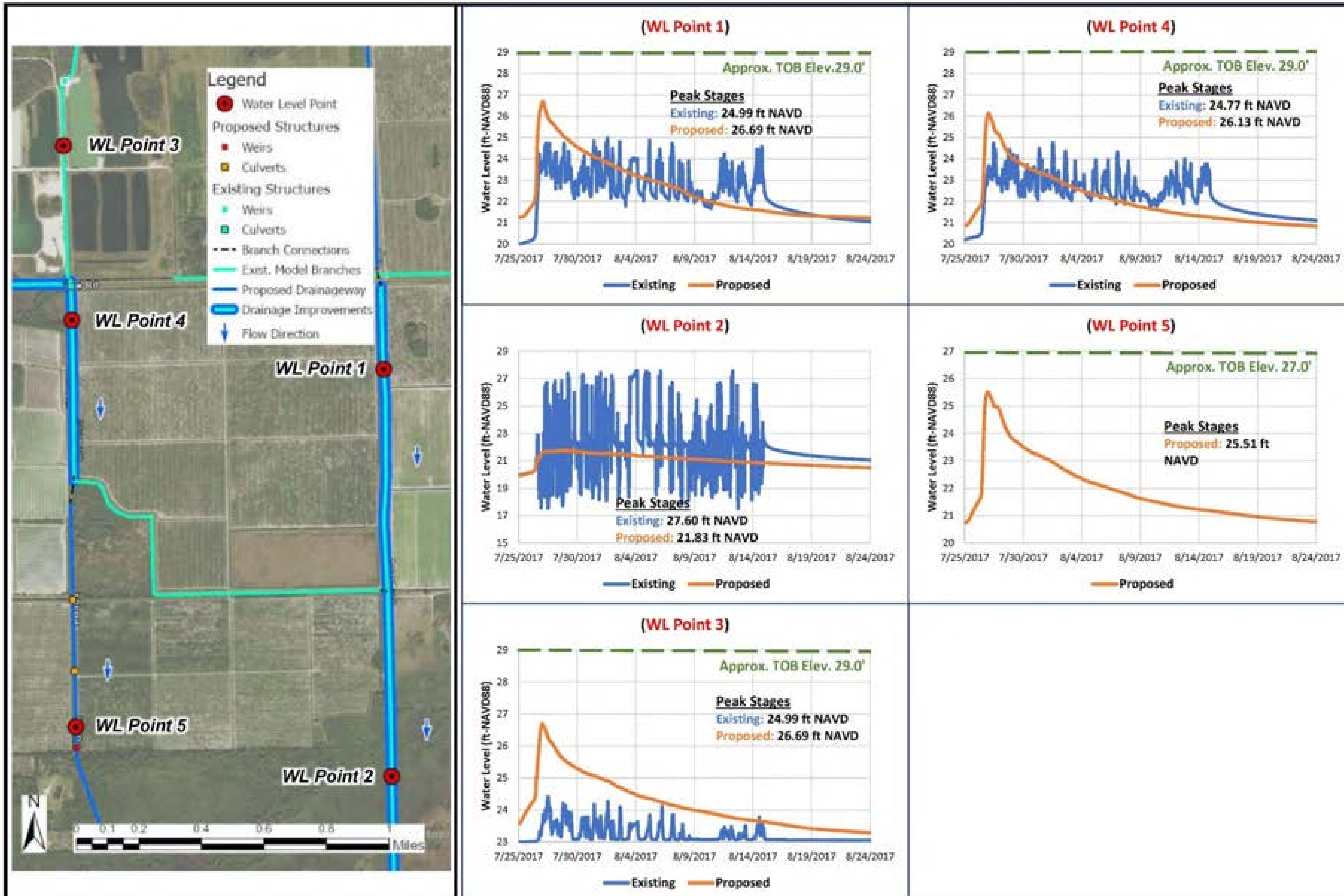

1.3.16 Corkscrew East Drainageway

Water Level(s)

100-yr 3-day (Jul Start)

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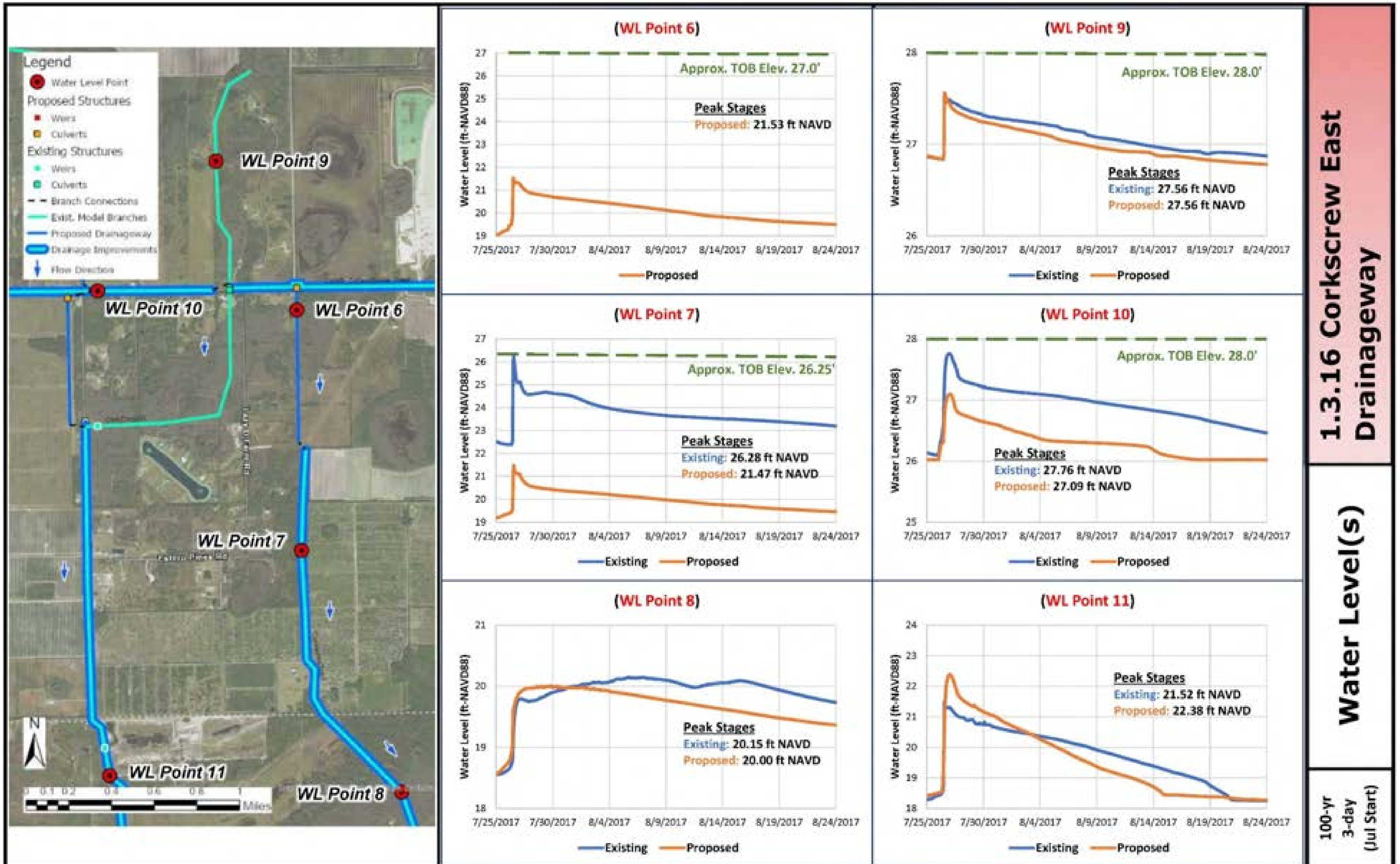

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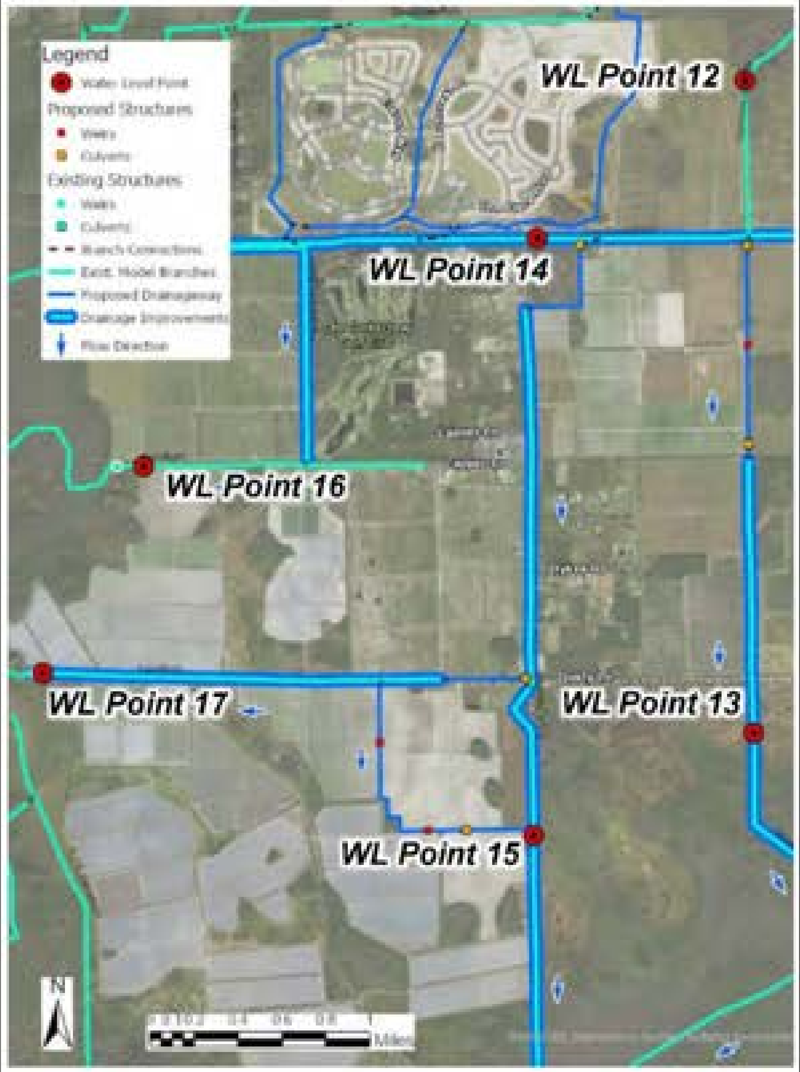
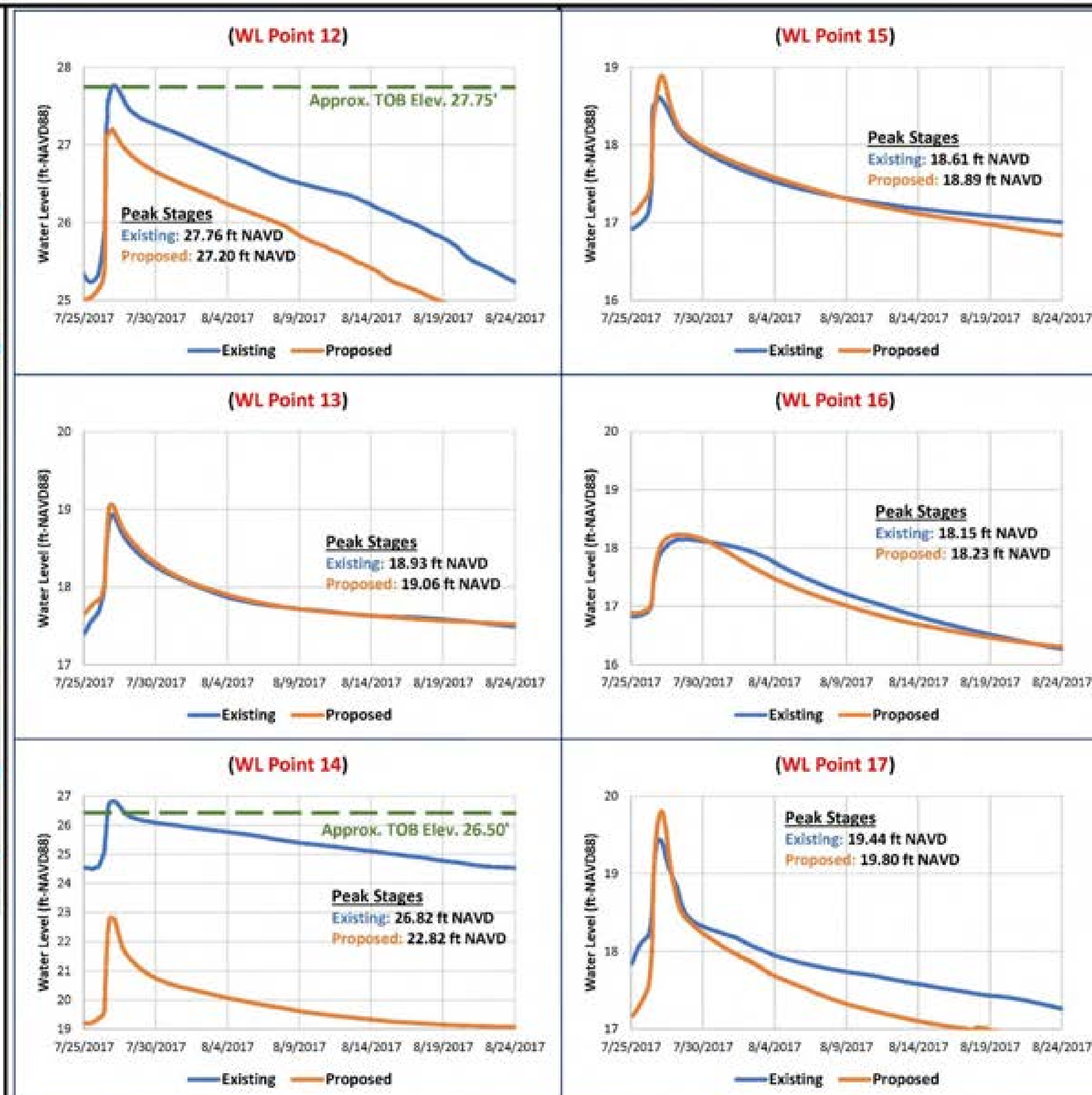


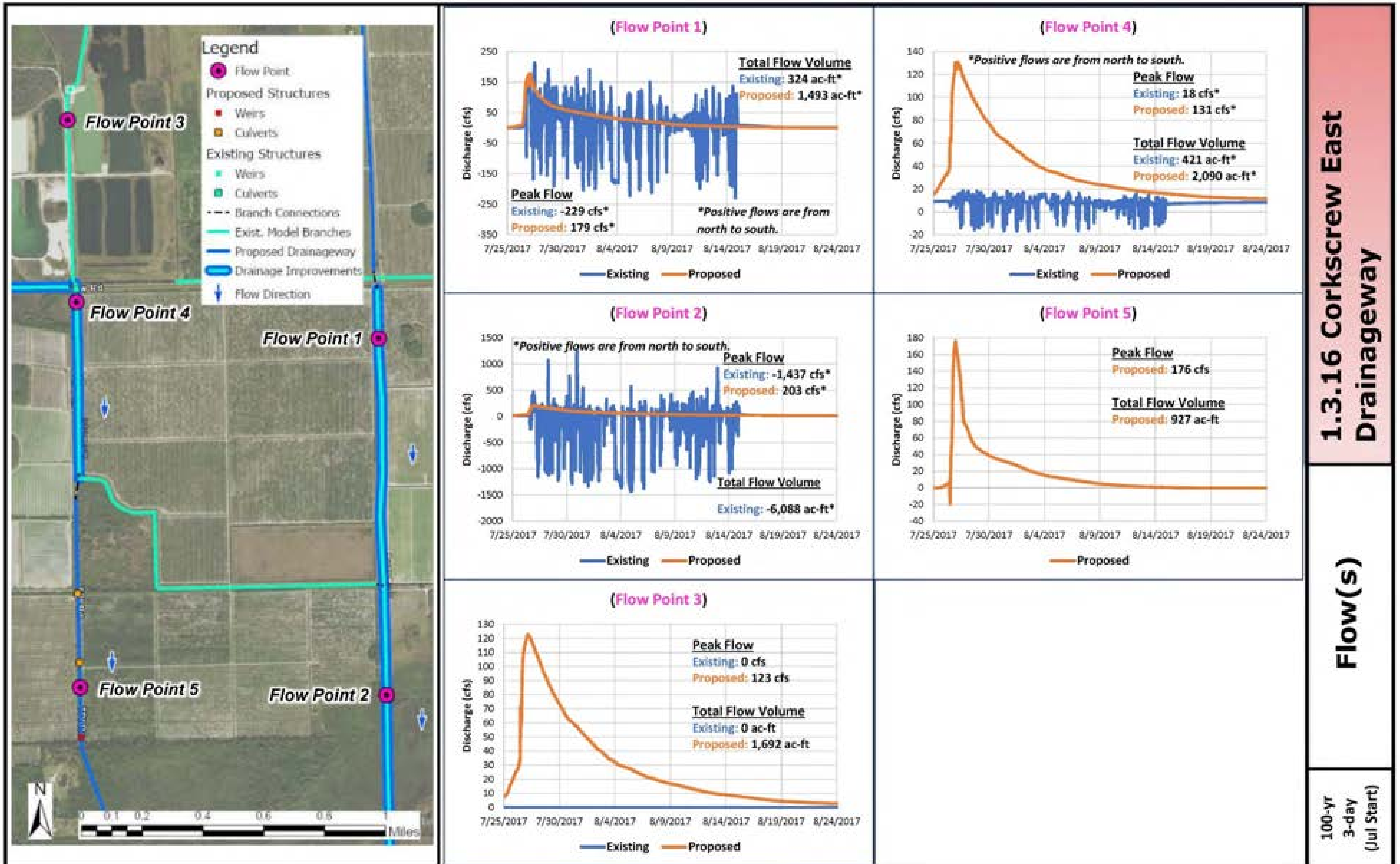


1.3.16 Corkscrew East Drainageway

Water Level(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.3.16 (e): 1 of 3



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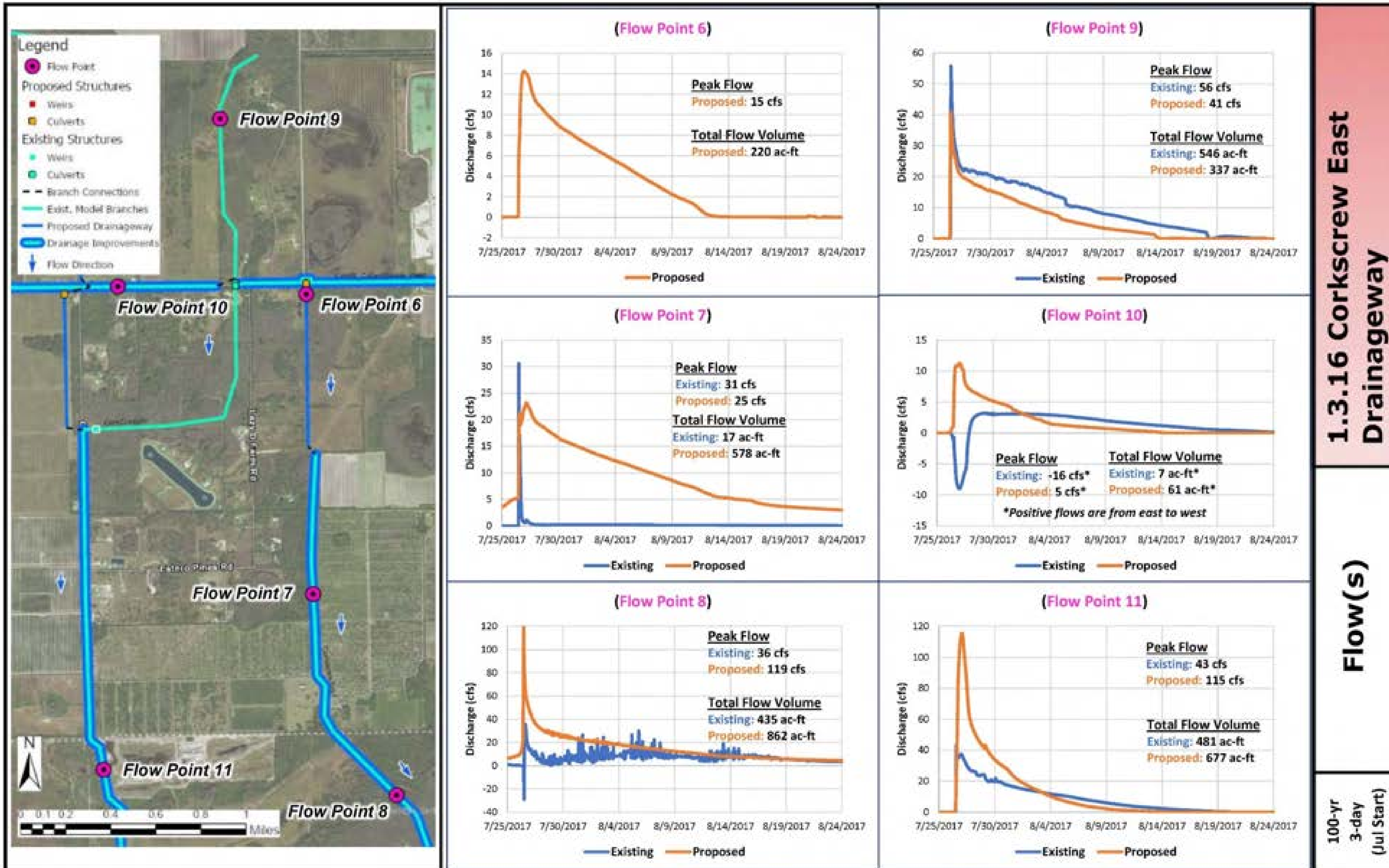

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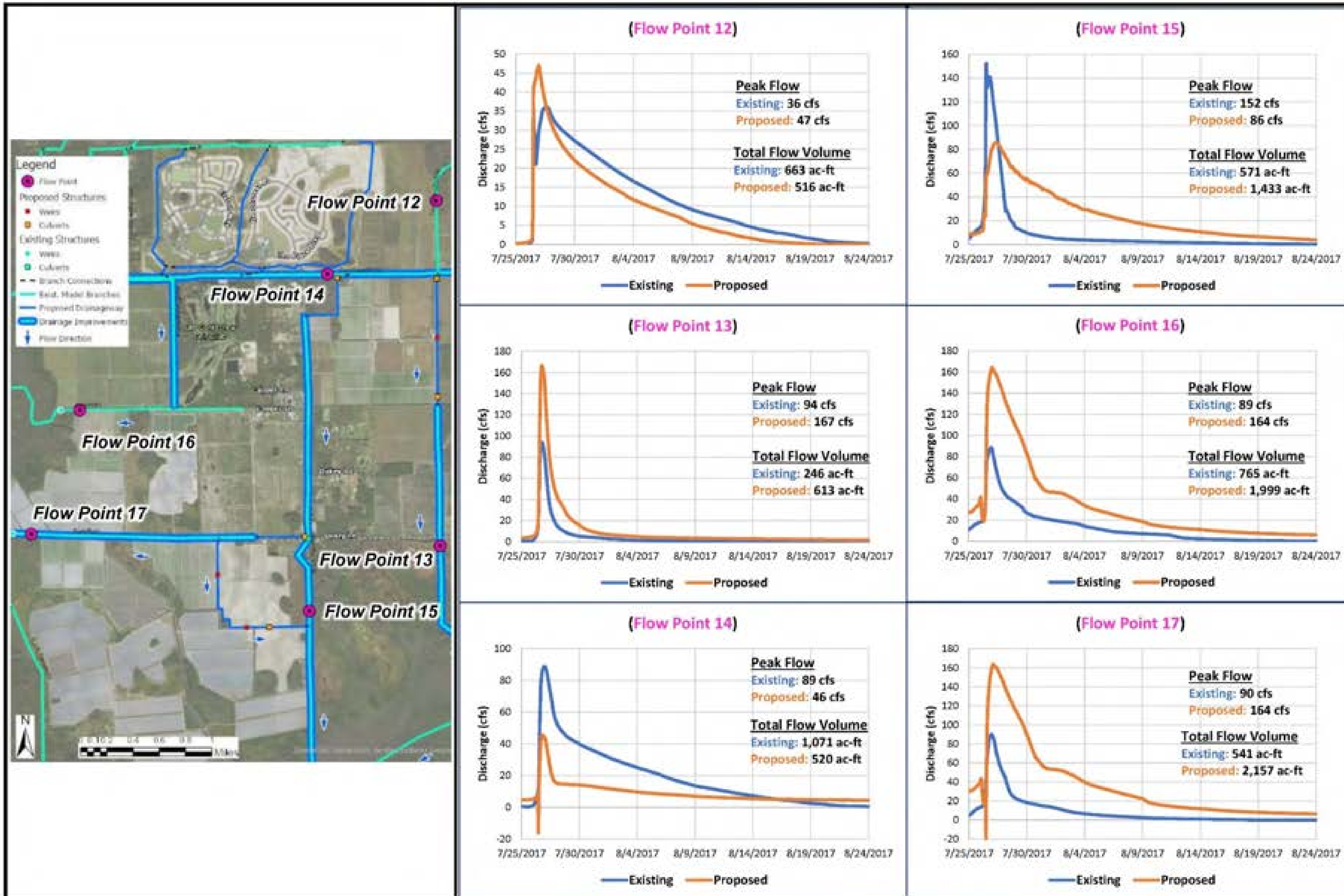

1.3.16 Corkscrew East Drainageway

Flow(s)

100-yr 3-day (Jul Start)

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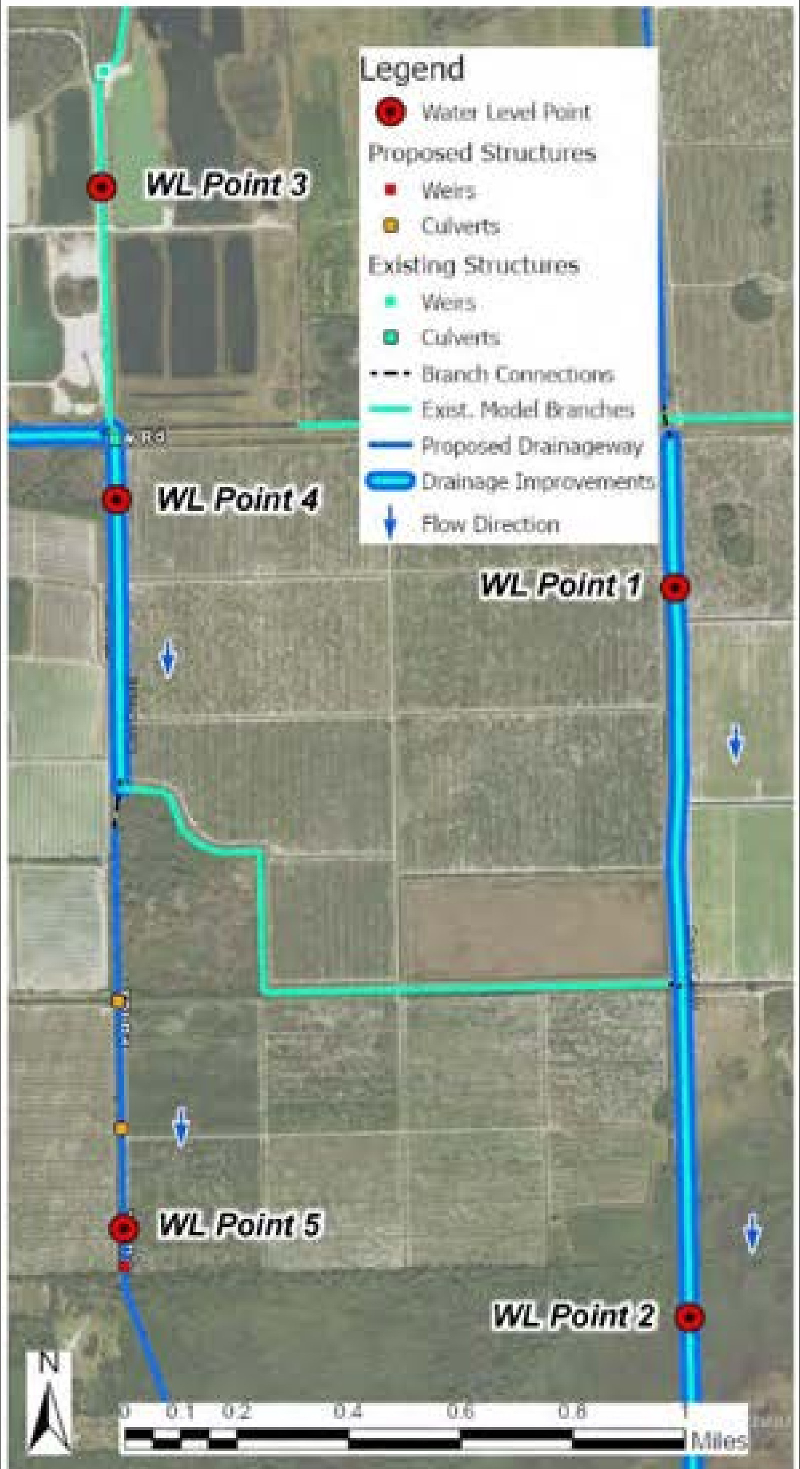
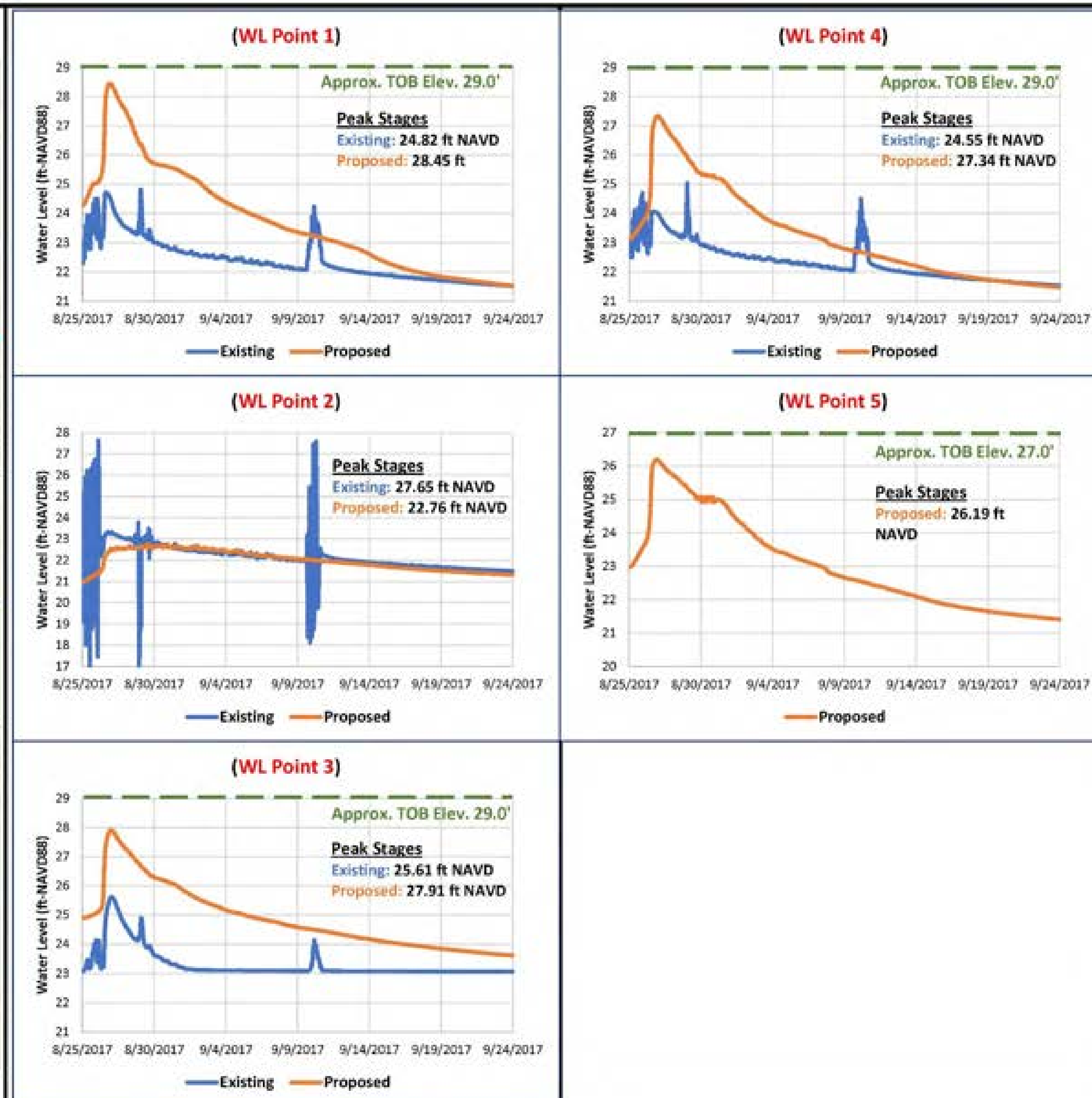


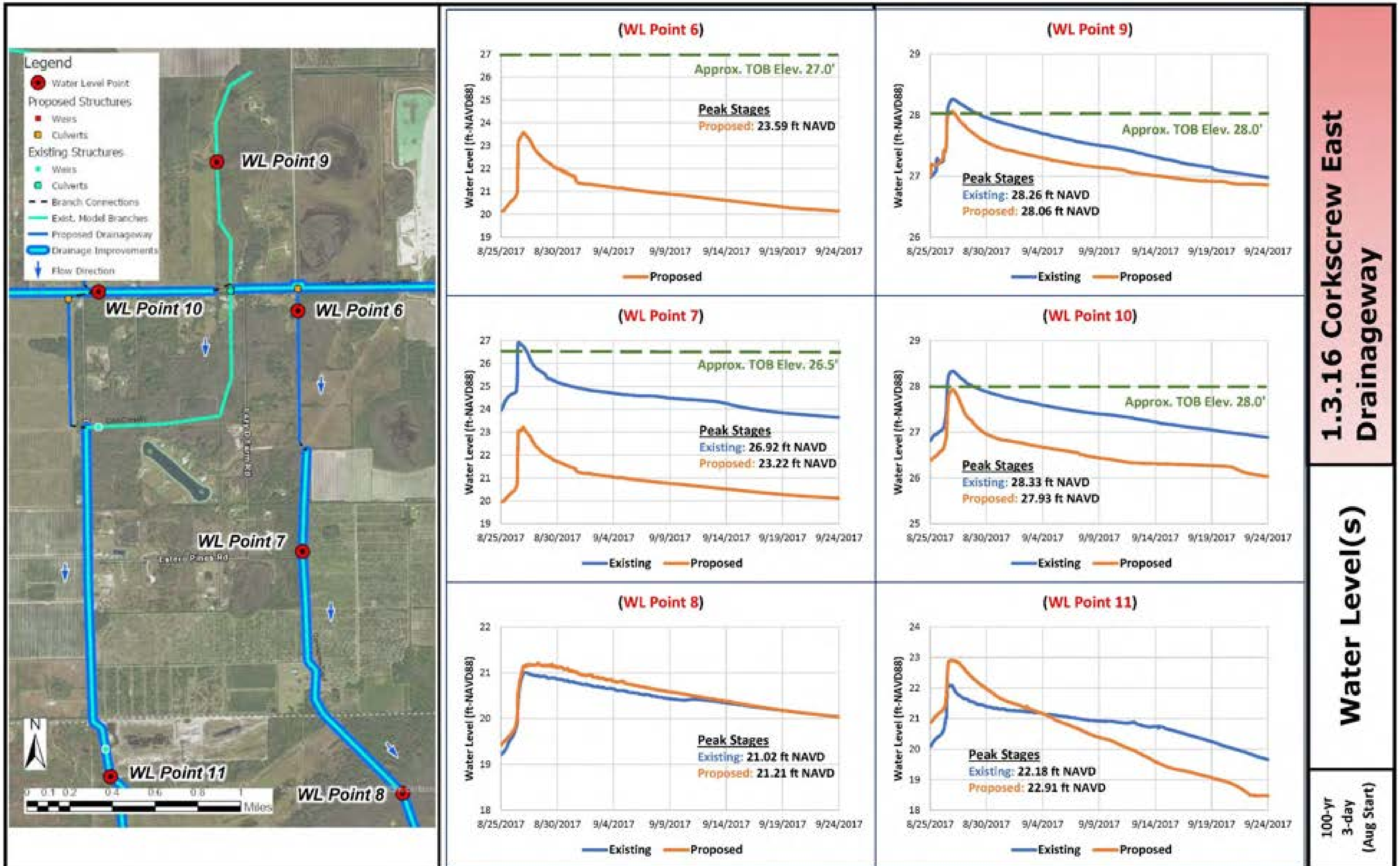


1.3.16 Corkscrew East Drainageway

Water Level(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.3.16 (f): 2 of 3



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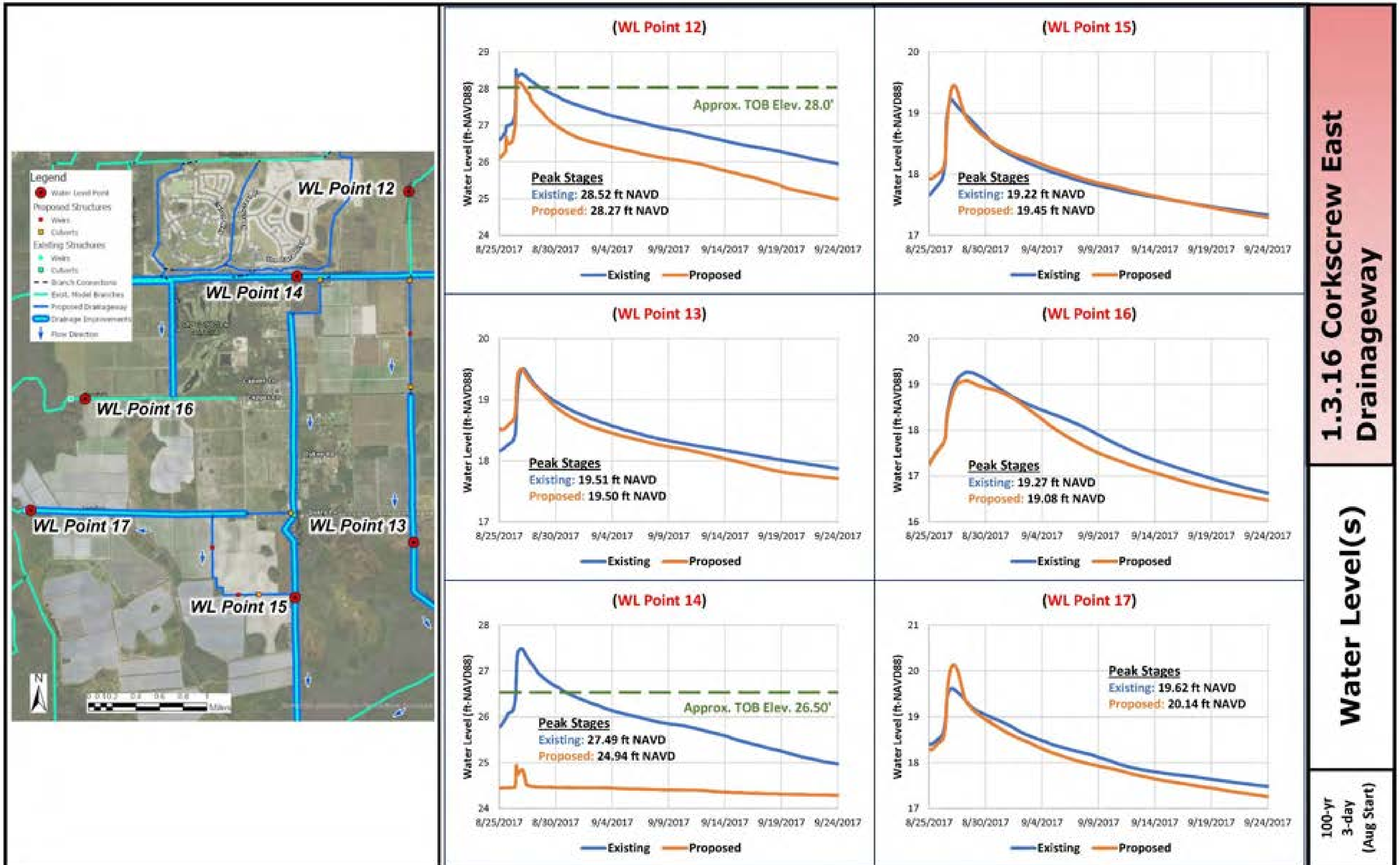

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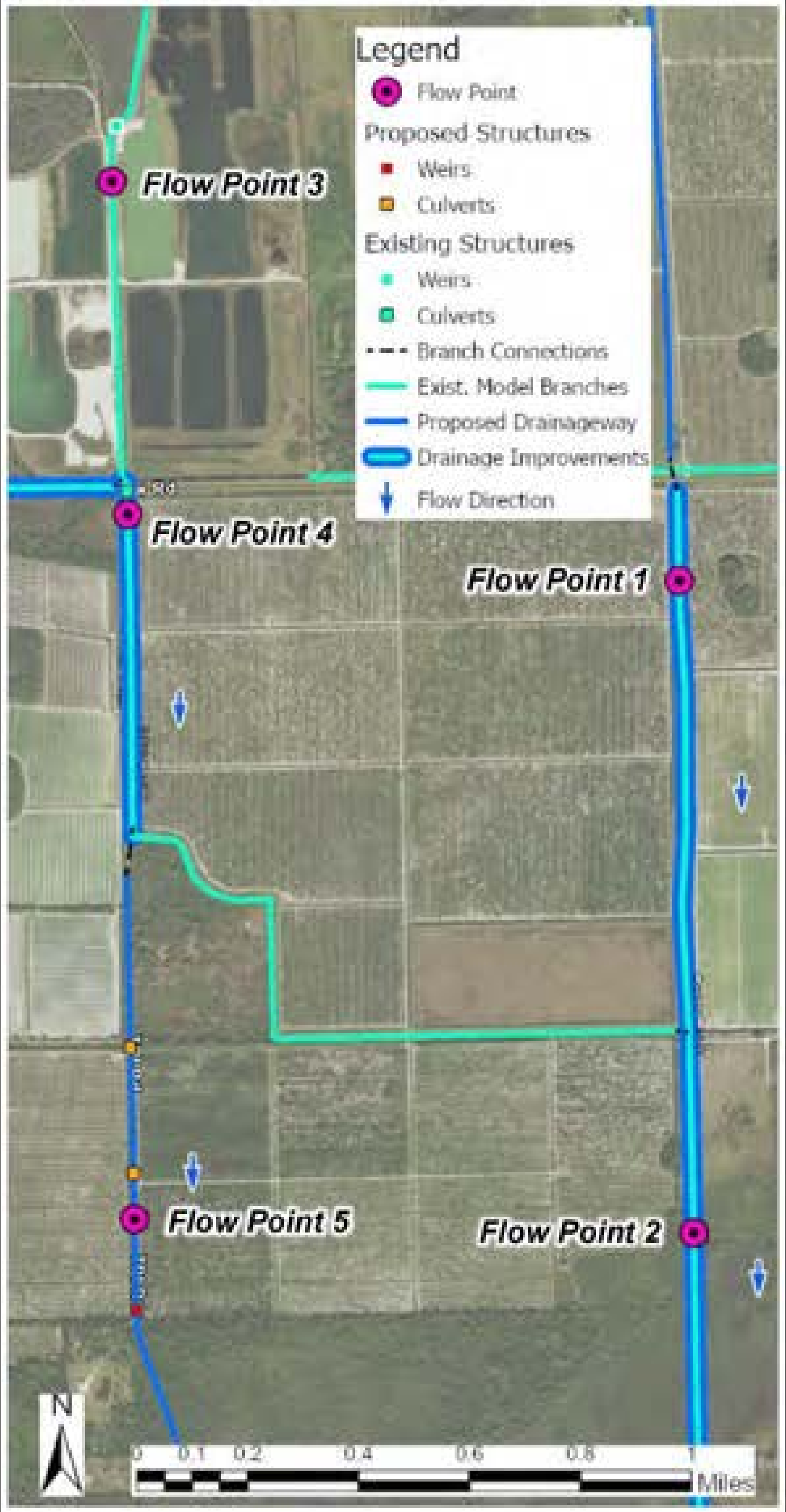
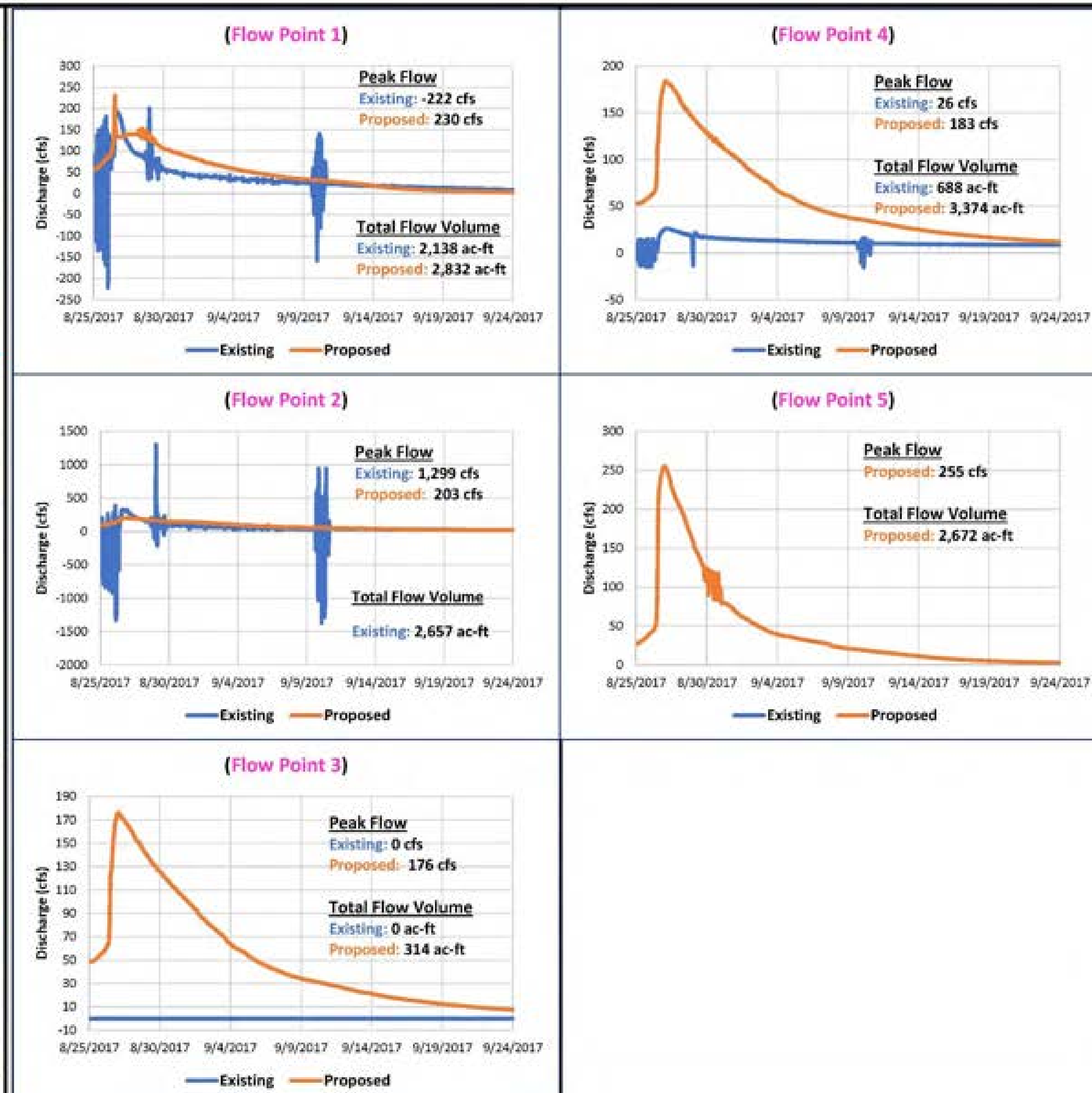


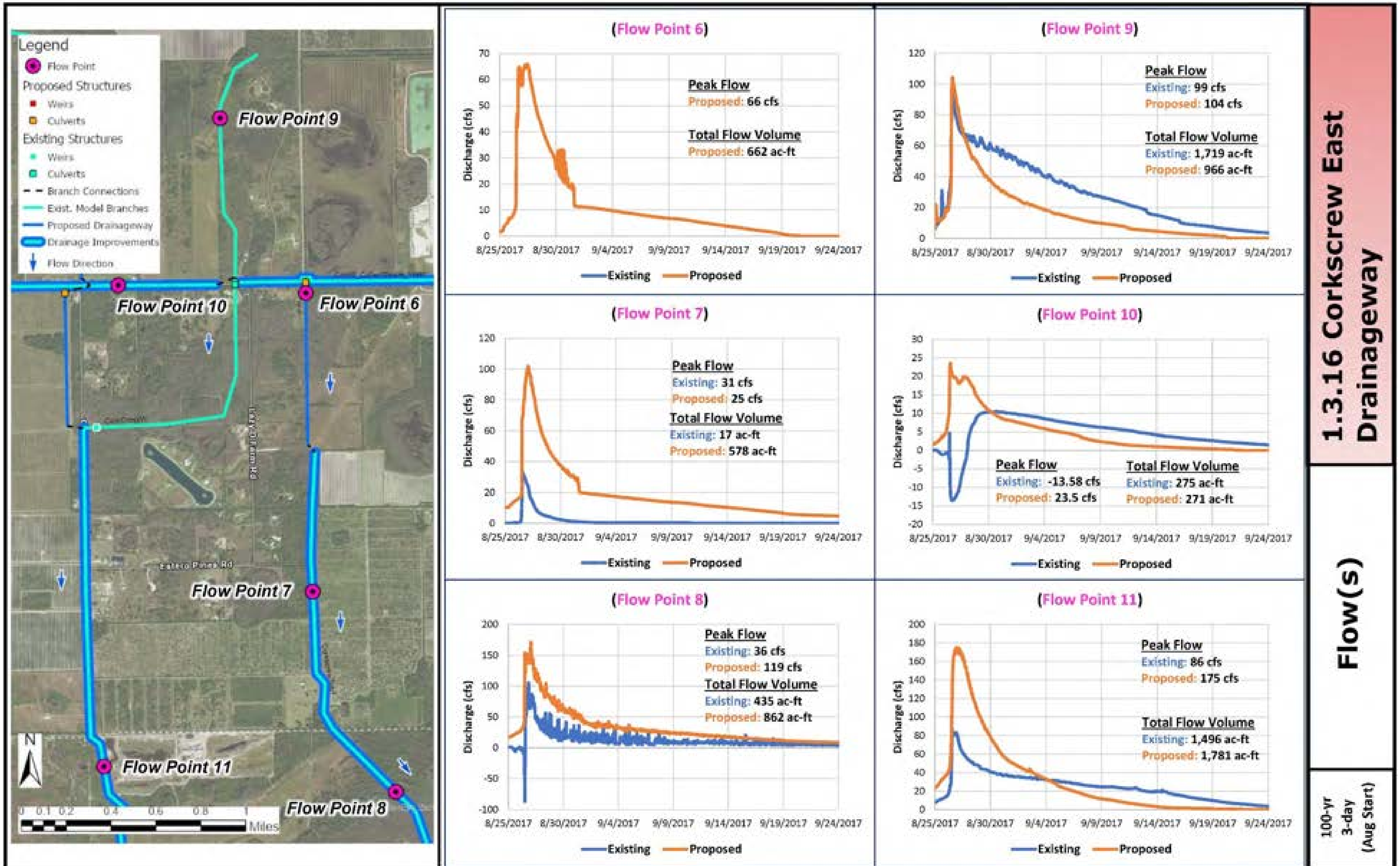


1.3.16 Corkscrew East Drainageway

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.16 (g): 2 of 3



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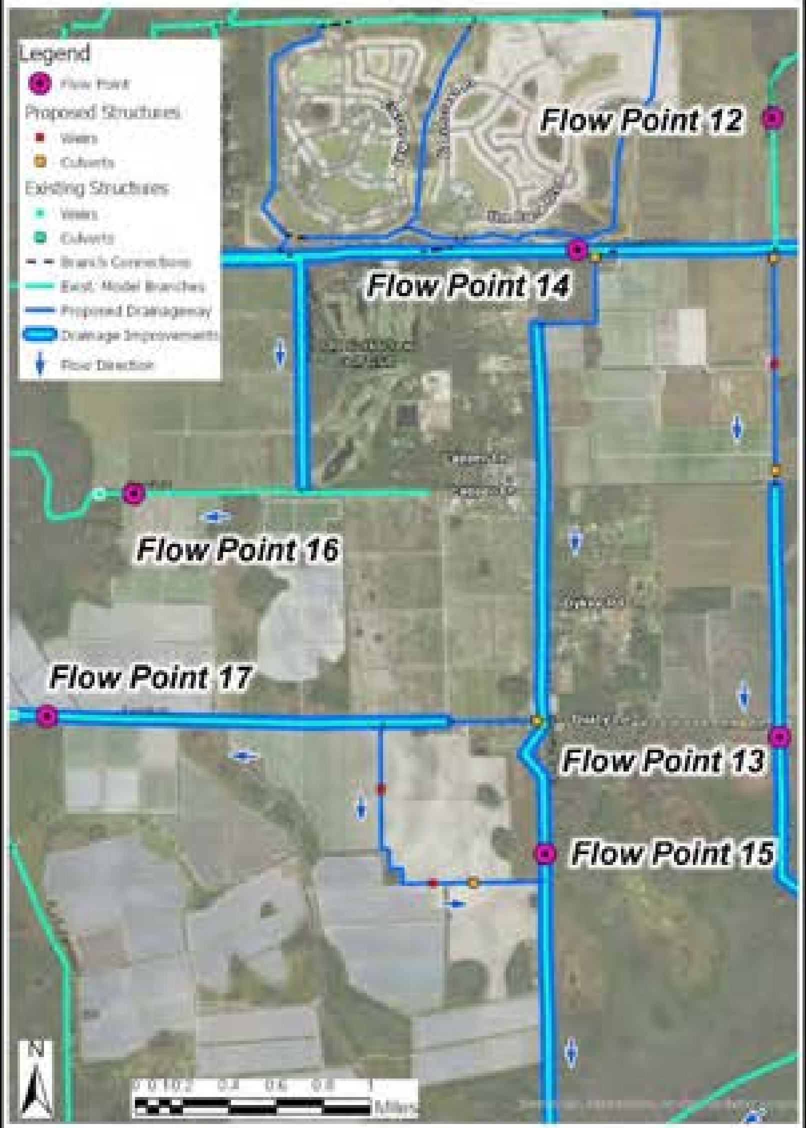
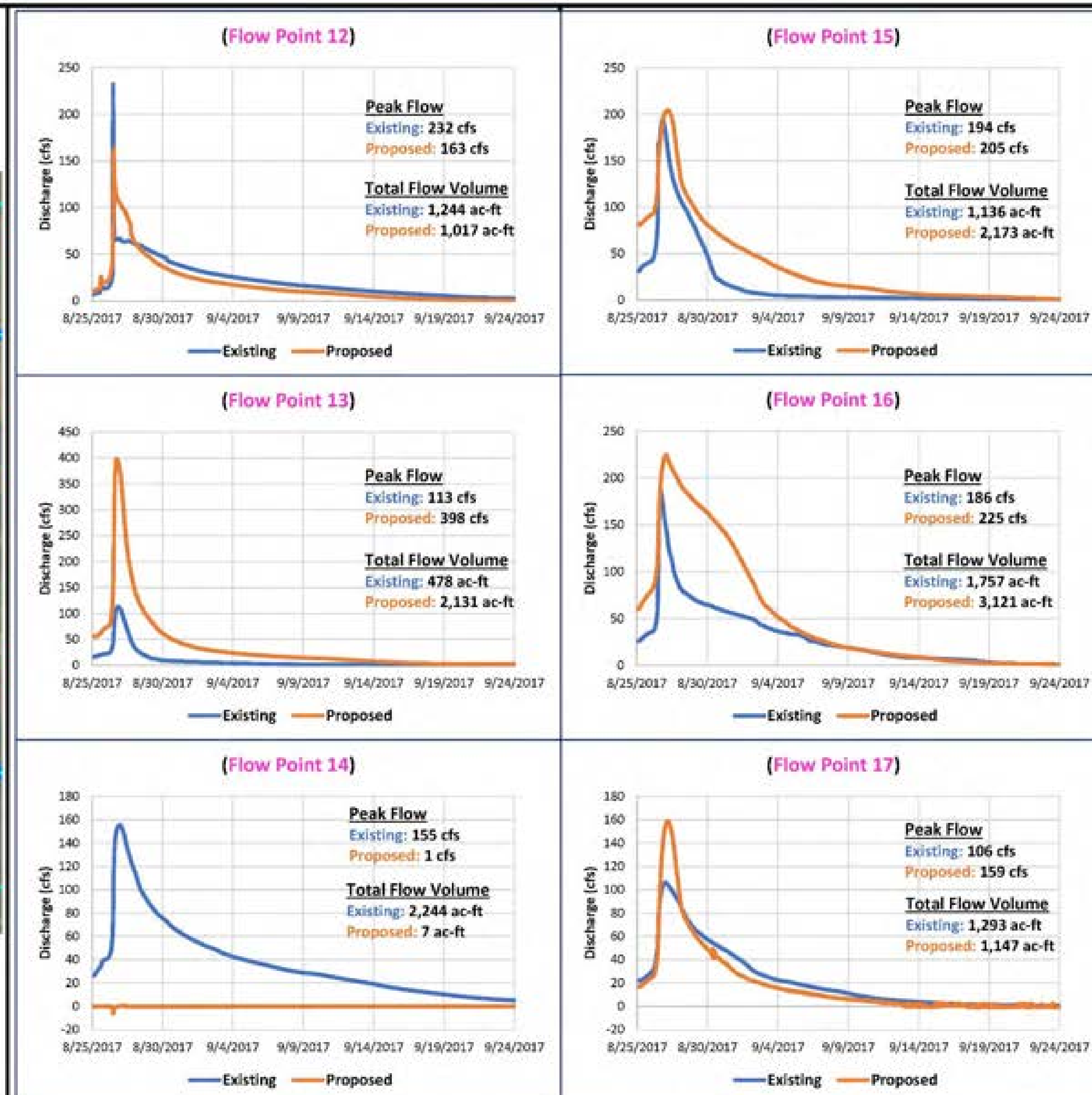


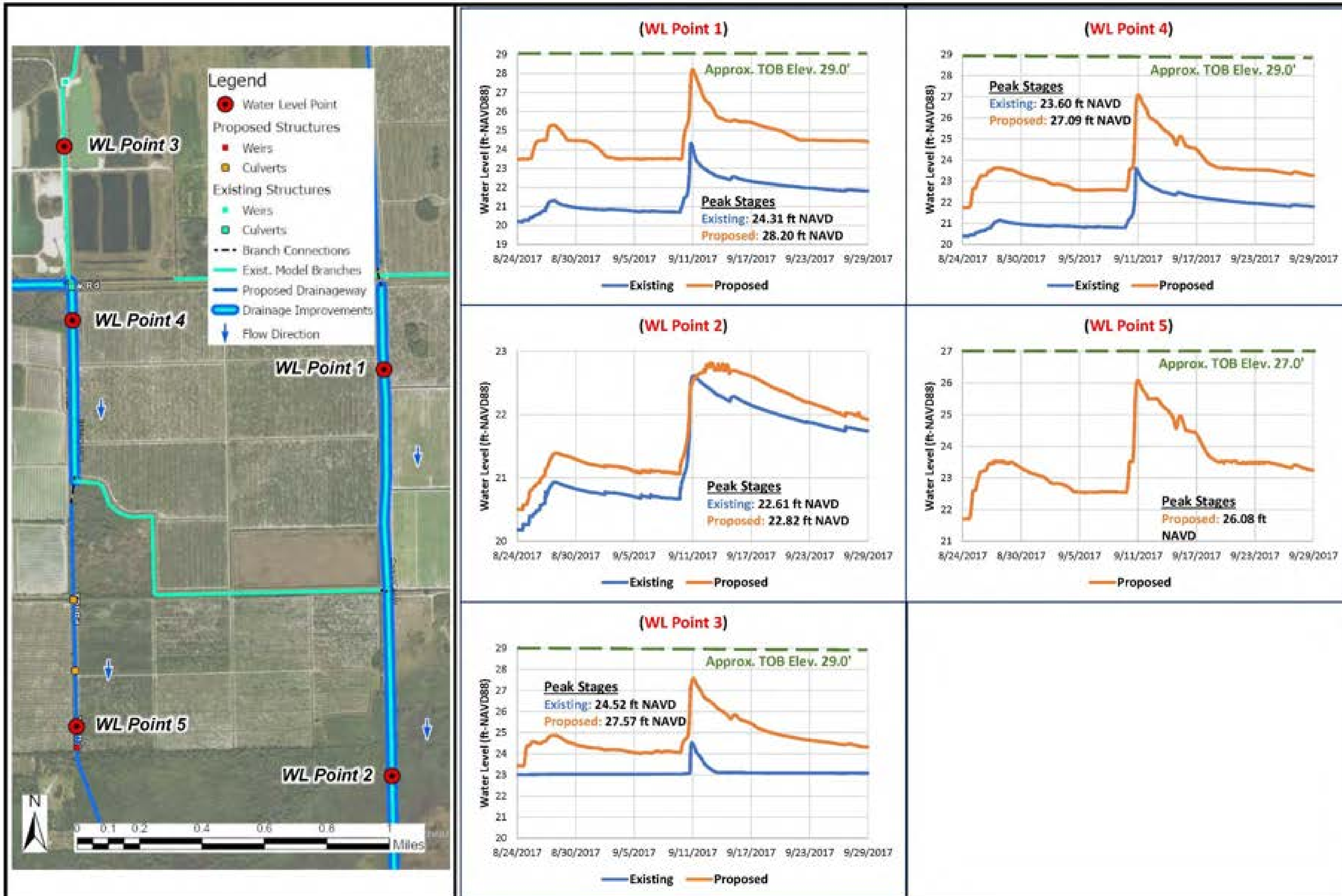


1.3.16 Corkscrew East Drainageway

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.3.16 (h): 1 of 3



1.3.16 Corkscrew East Drainageway

Water Level(s)

Continuous Simulation (Hourly)

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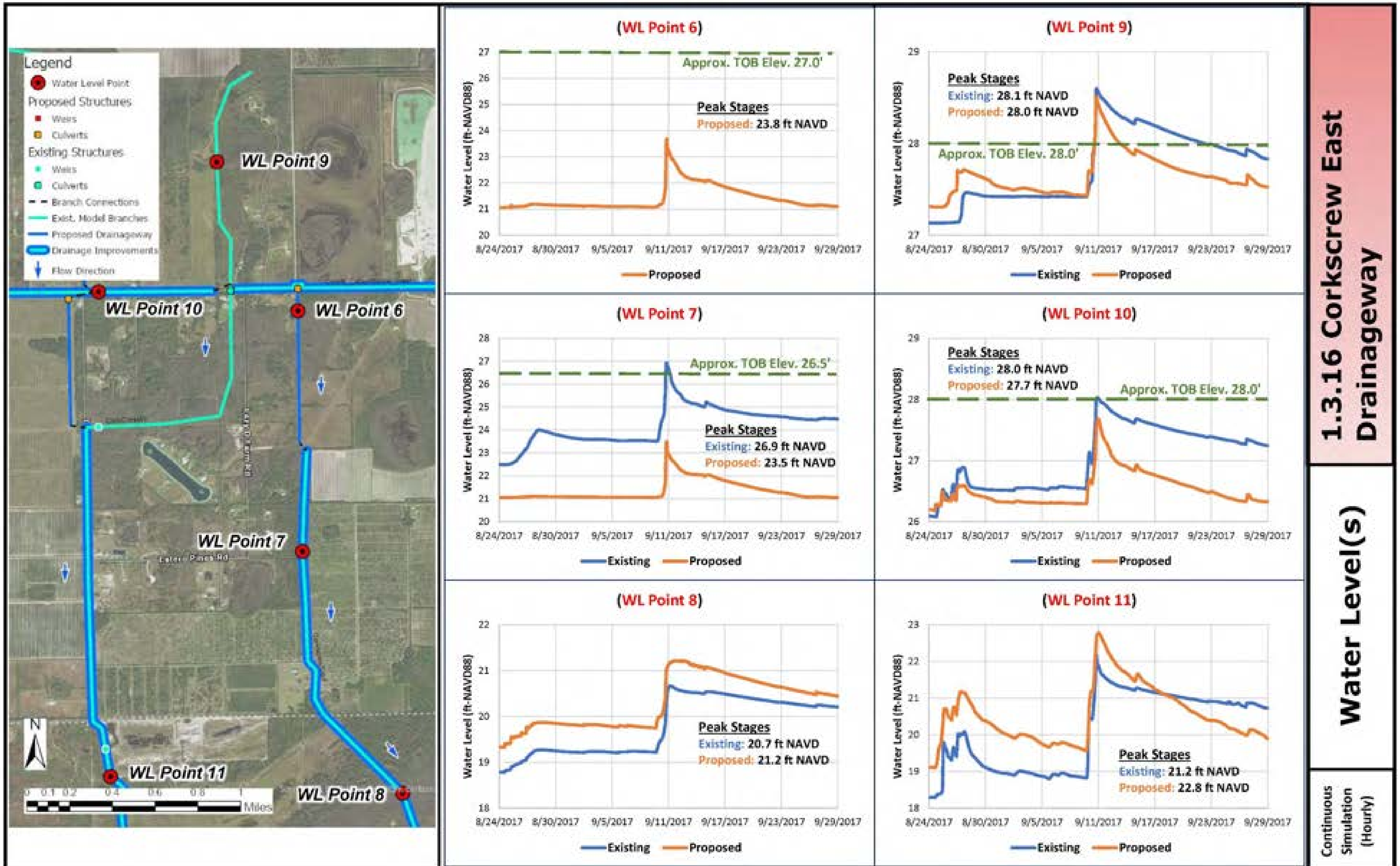

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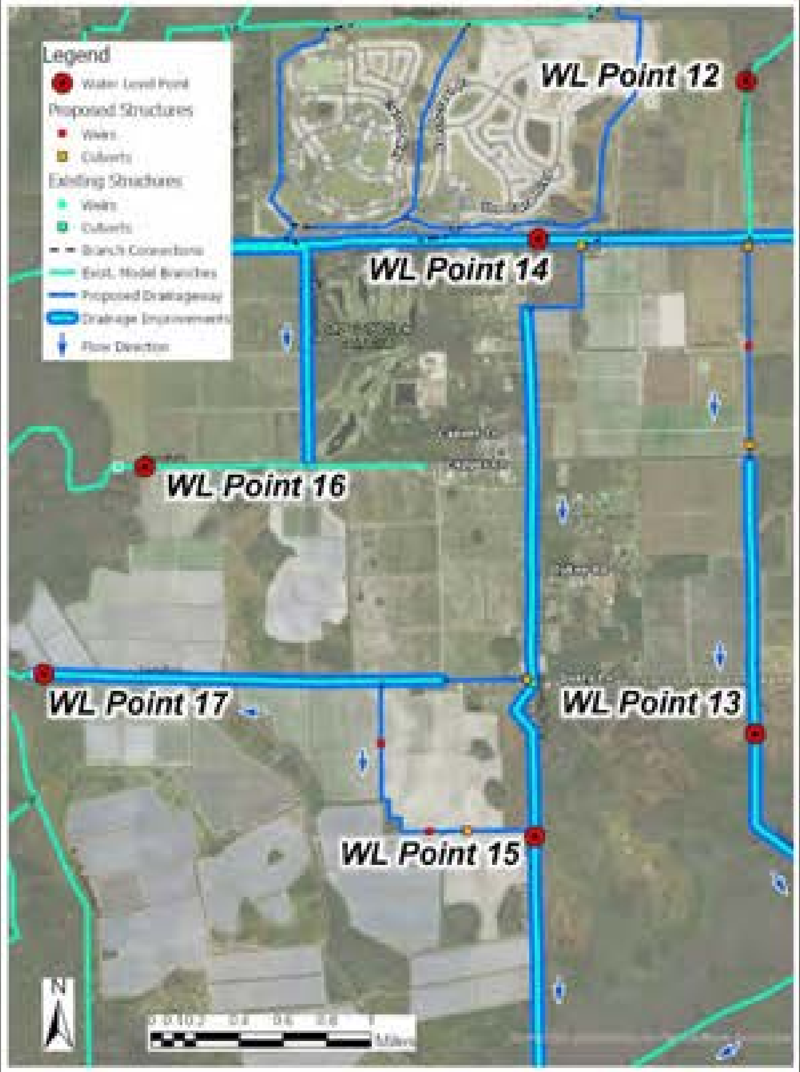
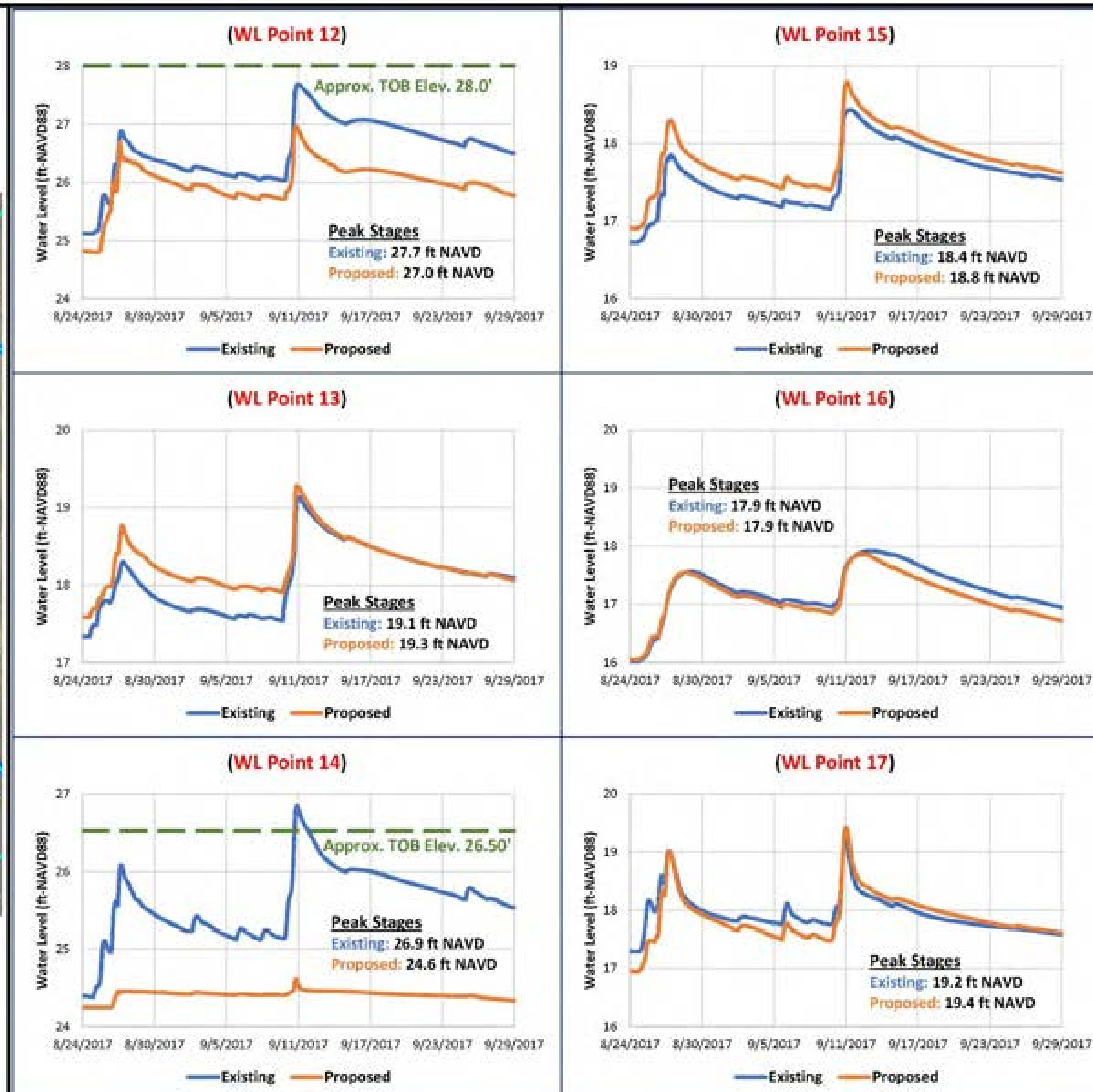


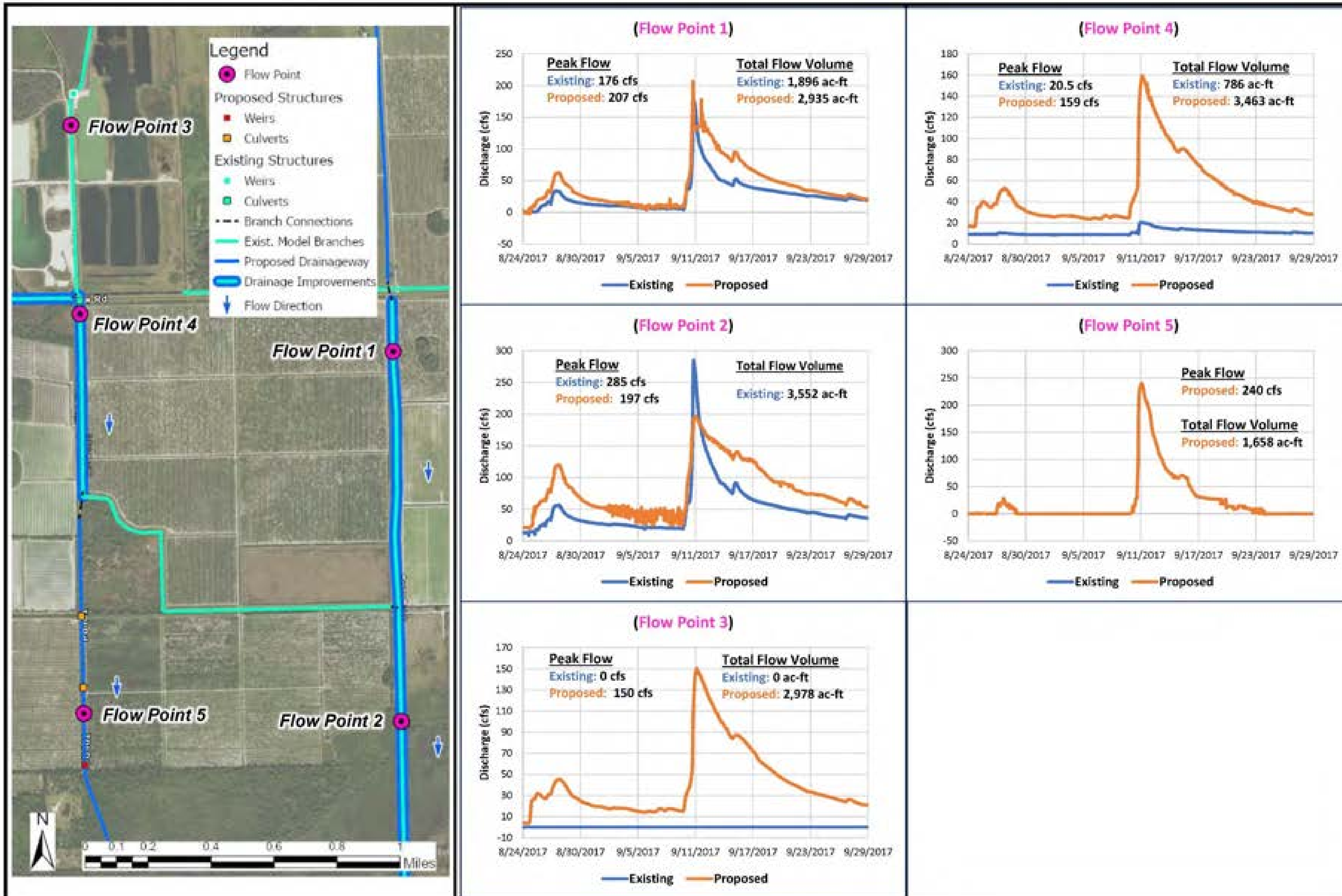


1.3.16 Corkscrew East Drainageway

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.16 (i): 1 of 3

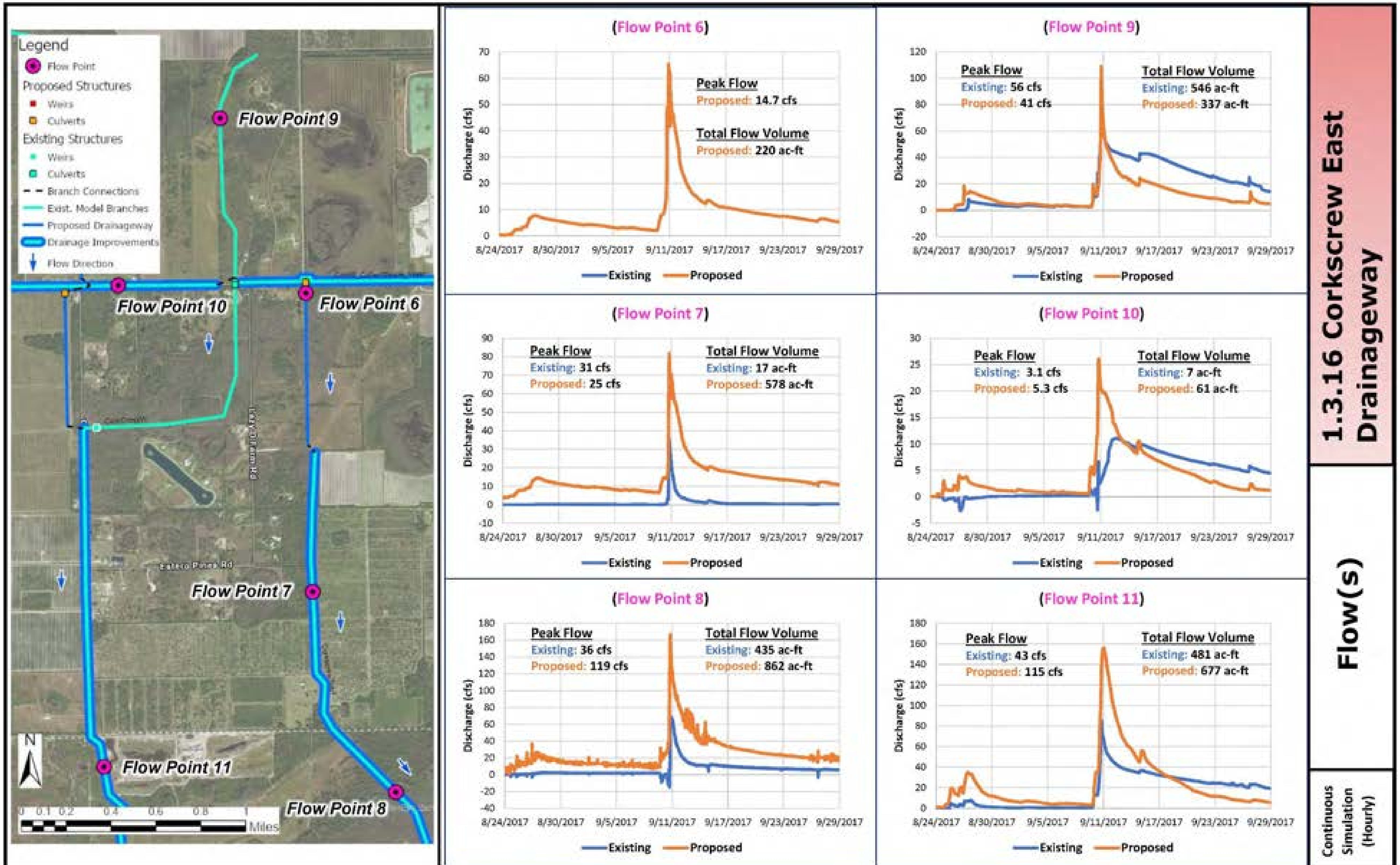


1.3.16 Corkscrew East Drainageway

Flow(s)

Continuous Simulation (Hourly)

EXHIBIT 1.3.16 (i): 2 of 3



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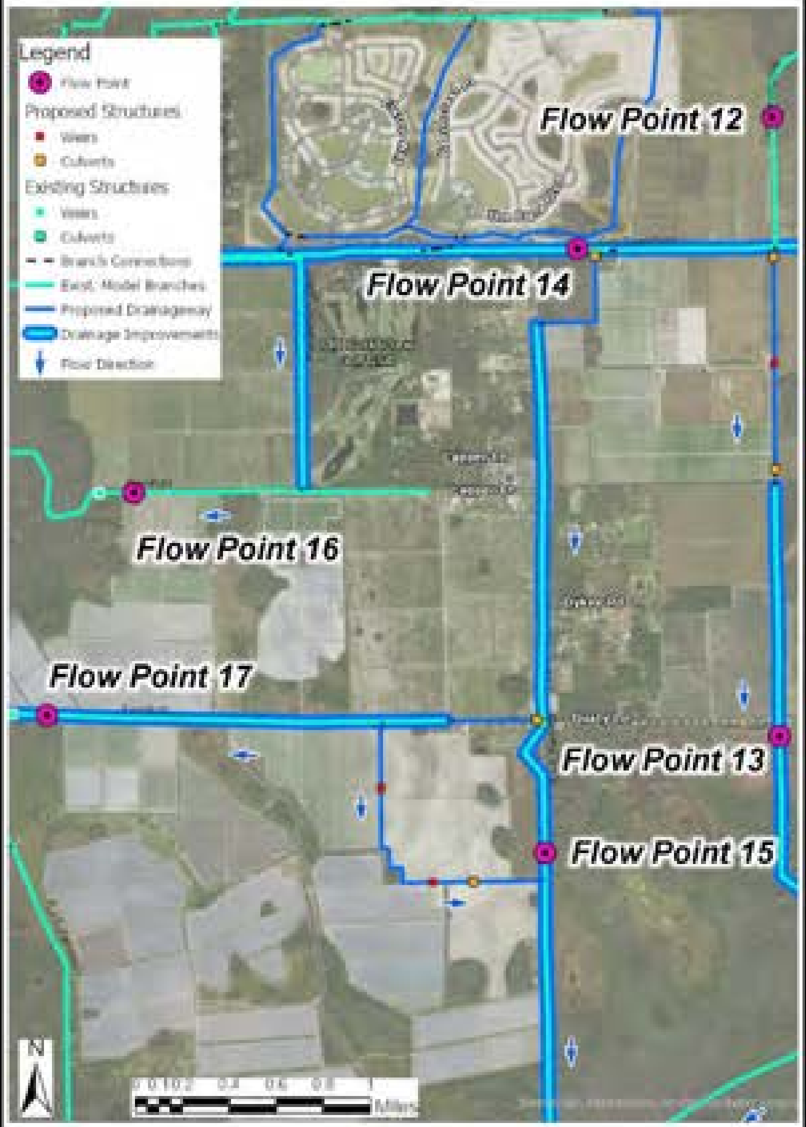
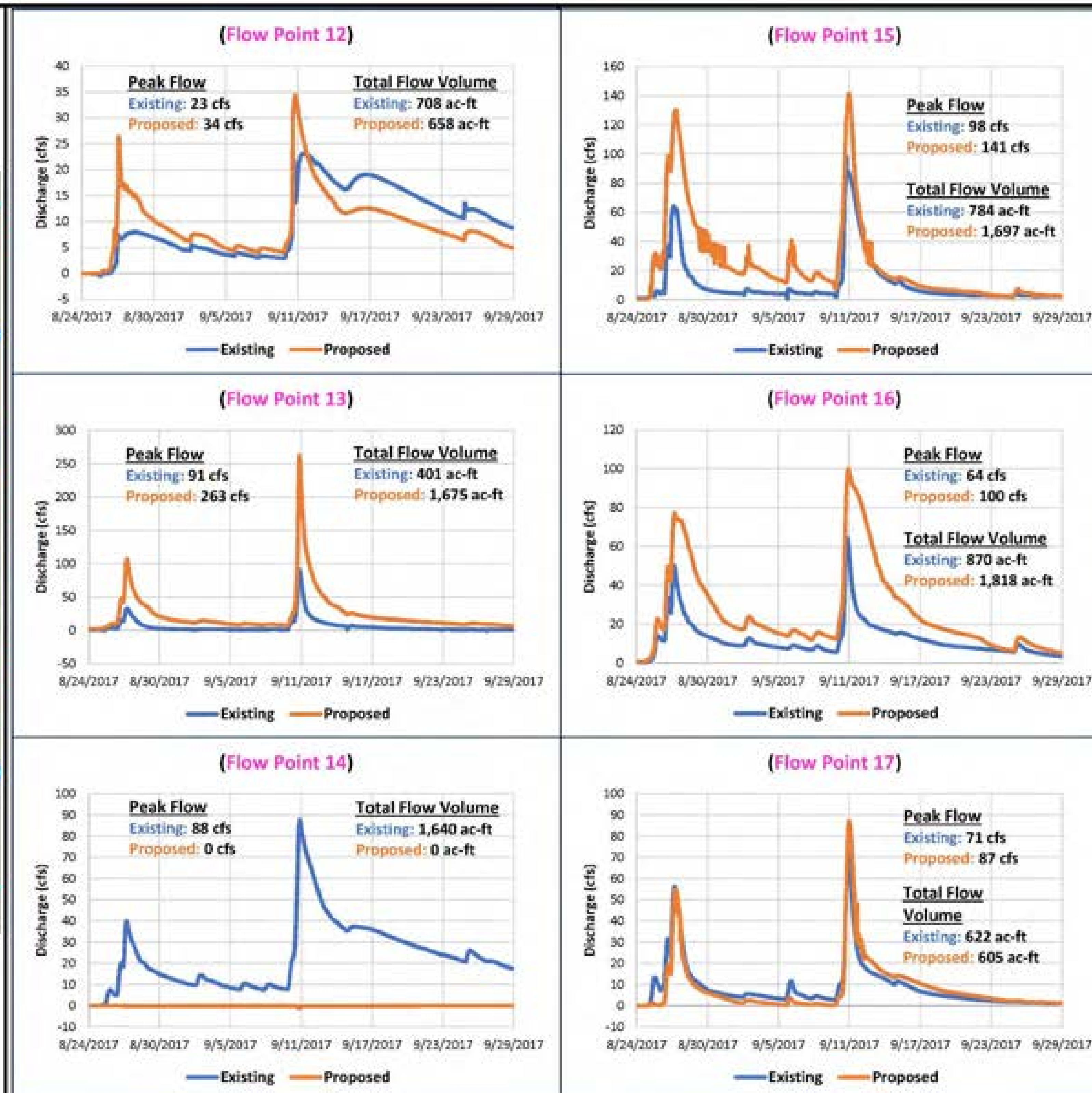




1.3.16 Corkscrew East Drainageway

Flow(s)

Continuous Simulation (Hourly)

1.4 SOUTH FORT MYERS FLOOD MITIGATION AREA

BACKGROUND

The South Fort Myers flood mitigation areas included in this study are the Ten Mile Canal, Six Mile Cypress, Mullock Creek, and Hendry Creek watersheds, as shown in **Figure 1**. The Ten Mile Canal and Six Mile Cypress combined watershed area of 68 square miles. The Ten Mile Canal watershed is divided into two parts, a northern area (12 square miles) and a southern area (1 square mile), which are separated by the Six Mile Cypress watershed (55 square miles).

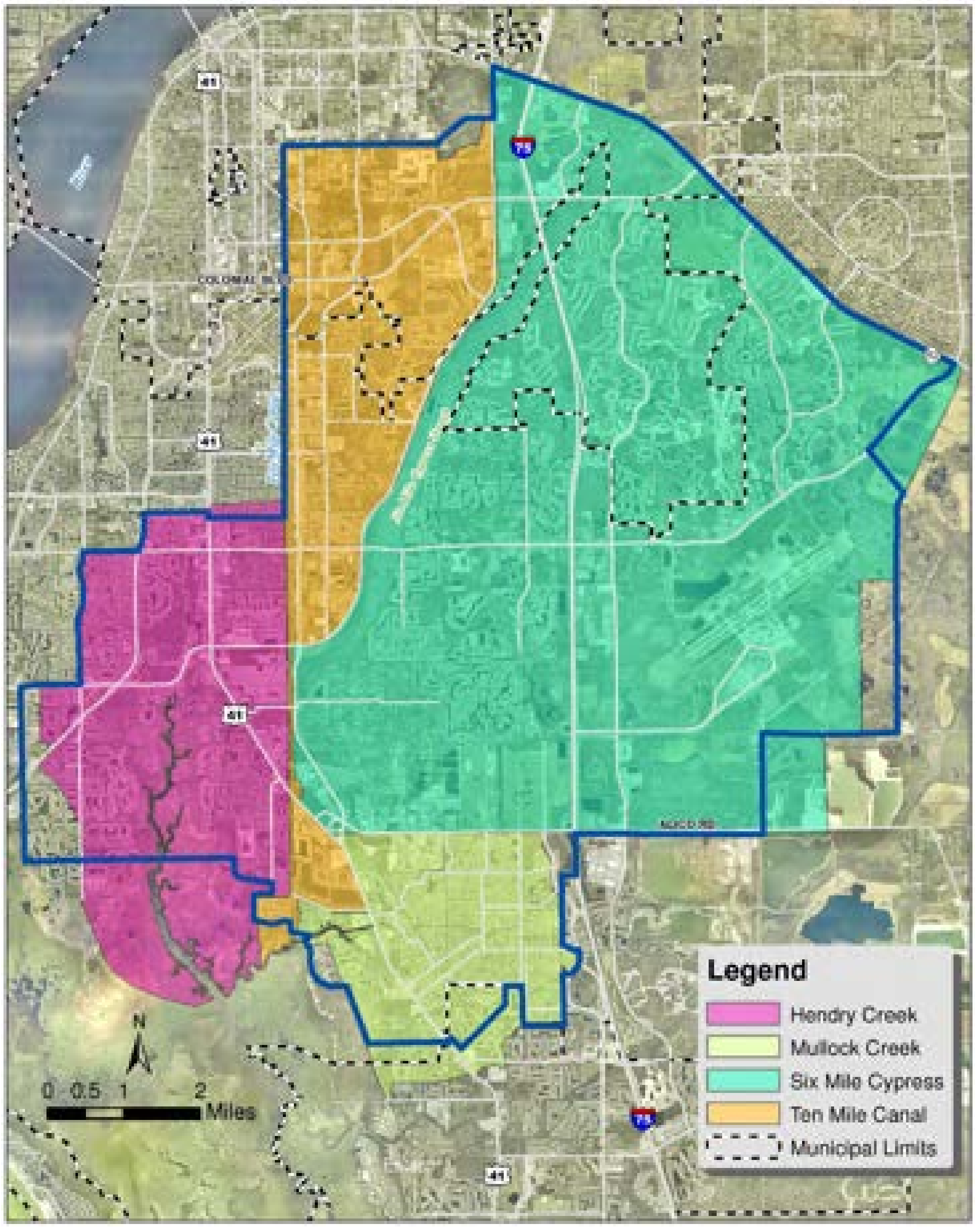


Figure 1 – South Fort Myers Drainage Basin Areas. The basin boundaries are shown according to the governing allowable discharge criteria.

A portion of the Six Mile Cypress watershed no longer drains into the Slough but is connected directly to Ten Mile Canal. This portion is about 17 square miles. It is important to keep this area assigned to the Six Mile Cypress basin due to the difference in allowable discharge differential

(Six Mile Cypress is 37 cubic feet per second per square mile (csm) and Ten Mile Canal is 69 csm) so as not to overload the downstream system.

The Mullock Creek watershed (7 sq. miles) is primarily composed of the San Carlos Park area and a few other adjacent communities. Drainage in San Carlos Park is under the jurisdiction of the East Mulloch Water Control District (EMWCD), which is now a dependent special district of Lee County under Chapter 189, Florida Statutes. The Hendry Creek watershed (14 sq. miles) is west of Ten Mile Canal and includes communities that had some of the highest numbers of FEMA claims per square mile, including the Island Park and Royal Woods areas.

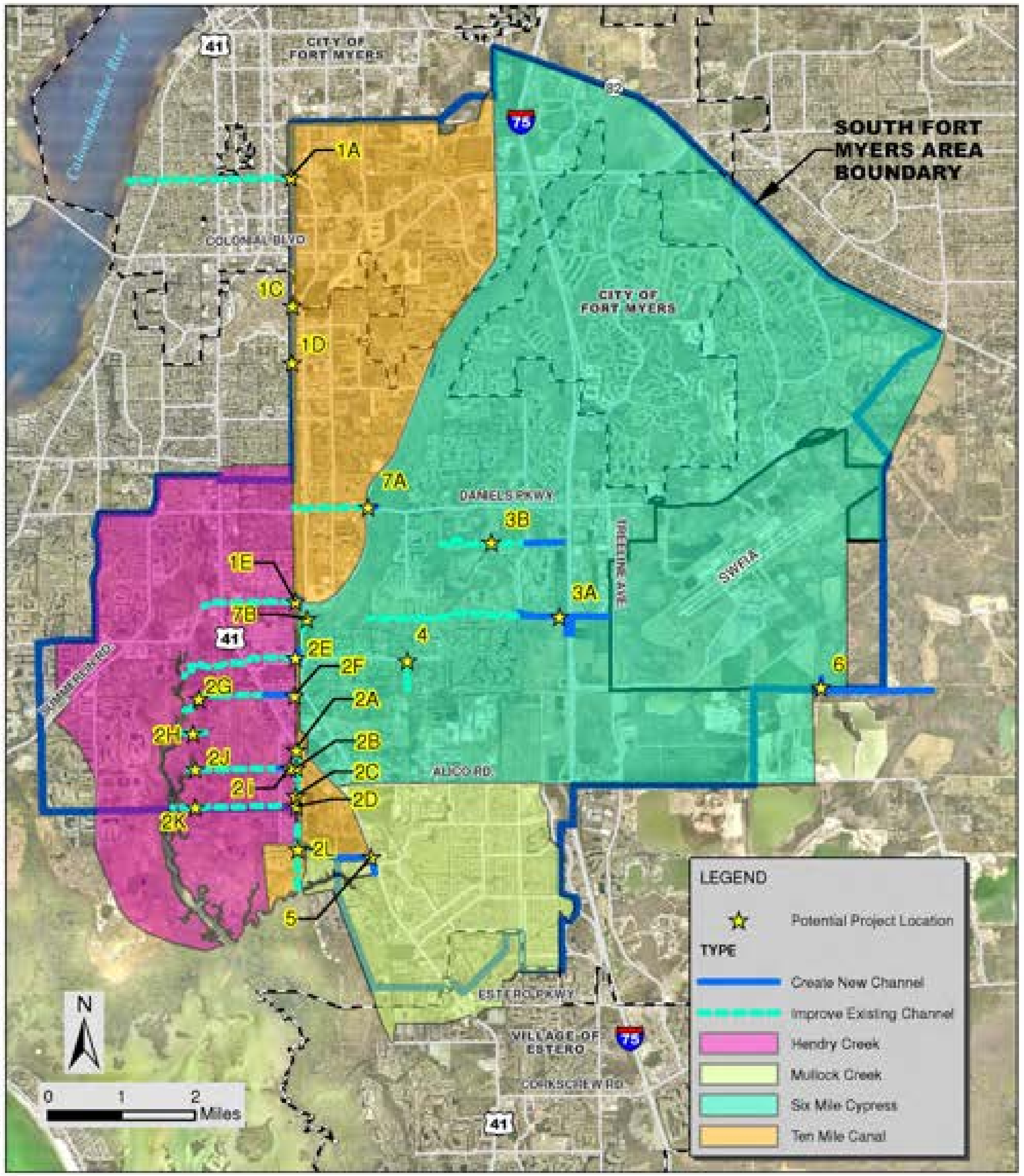
Most of the areas in the south Fort Myers watersheds included in this study are developed areas. The Six Mile Cypress watershed also includes natural wetland areas throughout the watershed that are in addition to the Six Mile Cypress Slough. Most of these wetland areas are under protective conservation easements and serve multiple functions in the watershed. In addition to providing wildlife habitat, these natural systems convey normal seasonal flows, reduce peak discharges to downstream receiving waters, and reduce levels of pollutants in the surface waters.

As a result of the flooding impacts from Invest 92L in August 2017 and Hurricane Irma on September 10, 2017, Johnson Engineering, Inc., conducted a review of the flooded locations in the South Fort Myers drainage area. The review included data collection and field activities which identified locations where impediments to flow existed that could be remedied quickly and locations with deficiencies in structural components that may have facilitated flooding. From that review and further review based on knowledge of the area and other pertinent documents, seven conceptual projects are proposed for long-term flood hazard mitigation in the South Fort Myers area. These were screened through the regional model developed under this contract.

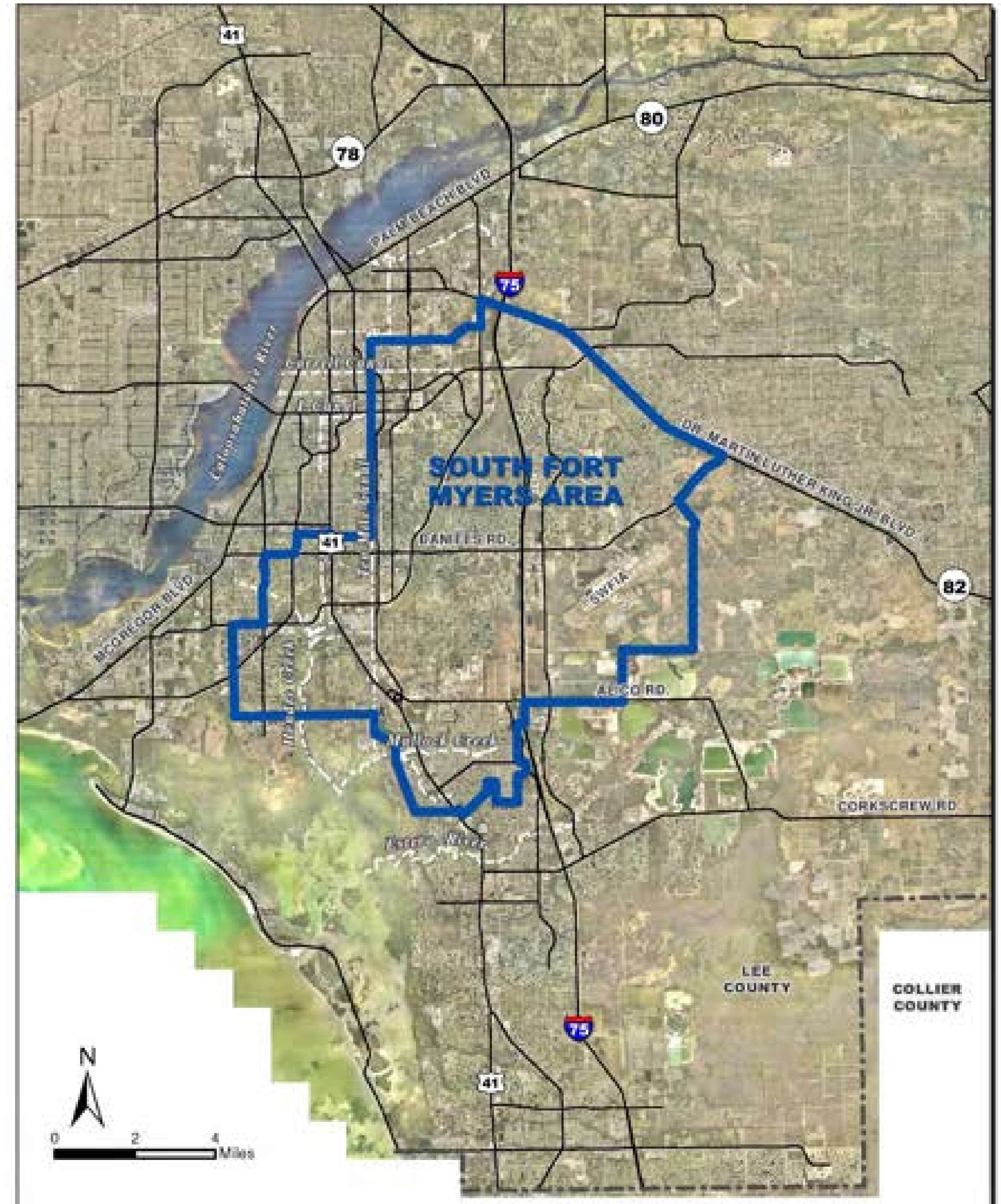
The discussions for each conceptual project below include several facets of each project, including known easements and their potential impacts to the projects. Before a project continues to the design/permitting phase, an exhaustive title search is recommended to identify all easements on each parcel within the project area.

PROJECT IDENTIFICATION

1.4.1 Ten Mile Canal-North
1.4.2 Ten Mile Canal-South
1.4.3 Daniels Parkway-South Area
1.4.4 Briarcliff Area
1.4.5 Park Road Area
1.4.6 LCPA Diversion to Estero Basin
1.4.7 Six Mile Cypress Slough-South



NOTES:
1. The aerial imagery was provided by Lee County government and was flown in 2019.
2. The major basins and conveyances were provided by Lee County government.



South Fort Myers Area

MAY 2020

Proposed Concept Projects
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4

FLOOD MITIGATION BENEFITS OF PRELIMINARY CONCEPT LEVEL PROJECTS

Adverse flooding conditions impact the health, safety, and welfare of residents and have significant economic impact to the community. Primary flood mitigation benefits are achieved when water levels on roadways and inside building structures are reduced. A reduction in flooding duration is also beneficial, but to a lesser extent than a reduction in flood water levels. These two objectives are achieved when increased stormwater is carried through existing conveyances (culverts, rivers, canals, wetlands, etc.), diverted out of the upstream portion of the watershed, and/or stored appropriately within the watershed. The concept projects in the South Fort Myers Flood Mitigation Area are designed to provide flood mitigation benefits to areas throughout the study area that have known historical regional flooding issues.

This regional approach to meeting the flood mitigation goals is necessary since many flooding problems are not solvable on a local level. For instance, if a primary drainage canal does not have sufficient capacity to convey the required flows, then the adjacent communities relying on the canal will experience adverse tailwater conditions that inhibit and/or prevent outflow that was anticipated in the original design of the community.

Seven preliminary concept projects are proposed for the South Fort Myers study area as shown in **Exhibit 1.4**. The projects generally work in concert to develop an overall plan to reduce flooding in the region. Targeted areas for reduction in structure flooding included the communities abutting the southern portion of Ten Mile Canal. **Figure 2** shows this subbasin is within the highest category of total FEMA flood insurance claims after Hurricane Irma in 2017 and has known repetitive loss areas (please note that other structures in Lee County incurred flood damage but were not covered by flood insurance and were therefore not represented on the map).

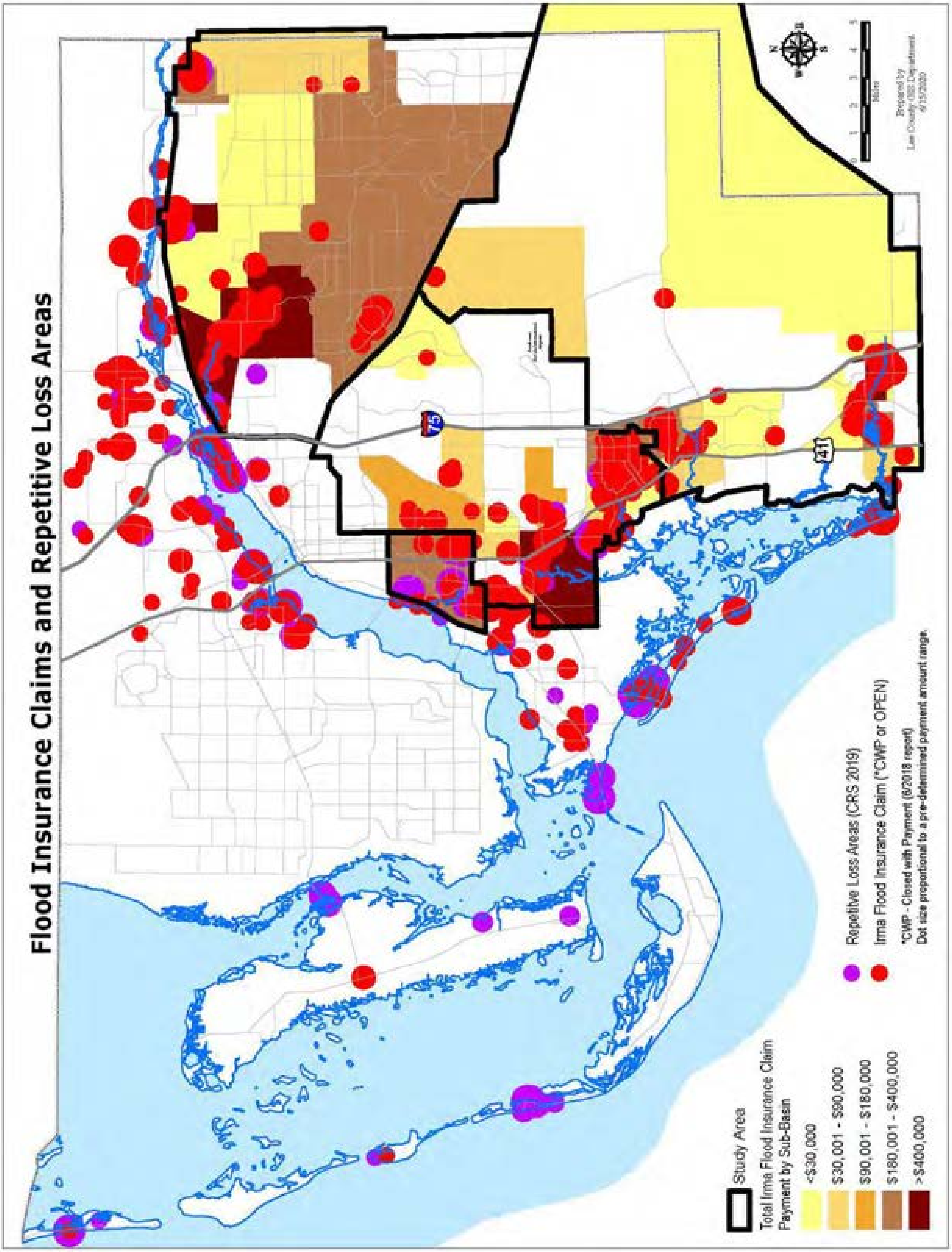


Figure 2 – Hurricane Irma flood insurance claim map and countywide repetitive loss areas.

A prerequisite of some of the upstream projects is that downstream improvements must occur first so that flooding problems are not simply transferred from one area to another. The regional model was therefore run with all conceptual projects stitched together to demonstrate the regional effects of the proposed projects. **Figure 3** depicts the approximate regional improvement areas at a high level for South Fort Myers. The individual conceptual projects were modeled independently in the previous interim project screening report. The results from the previous modeling are not shown graphically in this report but are mentioned occasionally. The following discussion of each project is based on the modeling results from the 100-year, 3-day design storm event.

Projects 1.4.1 and 1.4.2 collectively benefit the Island Park Road area. The projects work together to reduce flood stages in south Ten Mile Canal and the surrounding communities by diverting flow, controlling overflow, and improving the conveyance capacity of Ten Mile Canal. The two projects combined to reduce the peak flood level at the US 41 crossing of Ten Mile Canal by nearly three feet. This substantial reduction in water levels greatly reduces the flooding potential for those communities previously affected by Hurricane Irma.

For the communities adjacent to the southern end of Ten Mile Canal, the existing and proposed peak water levels of the canals in the Island Park community were extracted from the model results for the 100-year, 3-day storm event (August 2017 start) to create a map of the approximate overland flood depth. The estimated effects of the proposed projects can be quantified and displayed across an area by subtracting the existing from the proposed peak water levels. **Figure 3** shows a spatial representation of the approximate peak water level reductions due to the proposed projects for the communities adjacent to the southern end of Ten Mile Canal. The peak water levels were reduced by six inches or more for approximately 6,000 acres in this area or approximately 1,470 parcels. It should be noted that this is a simplistic way to present graphical results for a region and does not include local-level complexities unique to each community. In this same figure the area where flood mitigation was considered improved when the peak groundwater stage difference is reduced by more than one tenth of a foot from the existing to proposed model condition for a 100-yr, 3-day storm event is depicted. The approximate value of the buildings located within these areas was compiled by Lee County staff from the Lee County Property Appraiser parcel building values for the 2020 tax roll. This value for the South Fort Myers study area was approximately $1.2 billion.

Project 1.4.3 is designed to benefit the communities directly south of Daniels Parkway between Six Mile Cypress Slough and Interstate 75. The project provides flood mitigation benefit through increased conveyance capacity of existing east-to-west flow ways. Reductions in peak water levels by six inches or more were observed in the regional modeling results on only a limited number of parcels (approximately 92), but the peak flows into the Six Mile Cypress Slough were increased and the area had a reduction in flood duration.

Due to their small scale relative to the model, the final version of the regional model did not include projects 1.4.4 or 1.4.5, which are designed to provide flood mitigation benefit for the Briarcliff and Park Road areas, respectively. However, the individual conceptual projects were modeled independently in a previous interim project screening report and were shown to provide increased conveyance capacity for areas that have limited outfall options today.

The wetland areas east of the Southwest Florida International Airport currently flow to the west and contribute to flows in the southern portion of Ten Mile Canal. In conjunction with construction of the second runway, the airport received authorization to divert a portion of the flows to the east and south to the Estero River. Project 1.4.6 is designed to store additional water in the wetlands north of Green Meadows Road and thereby reduce the peak flows in Estero River.

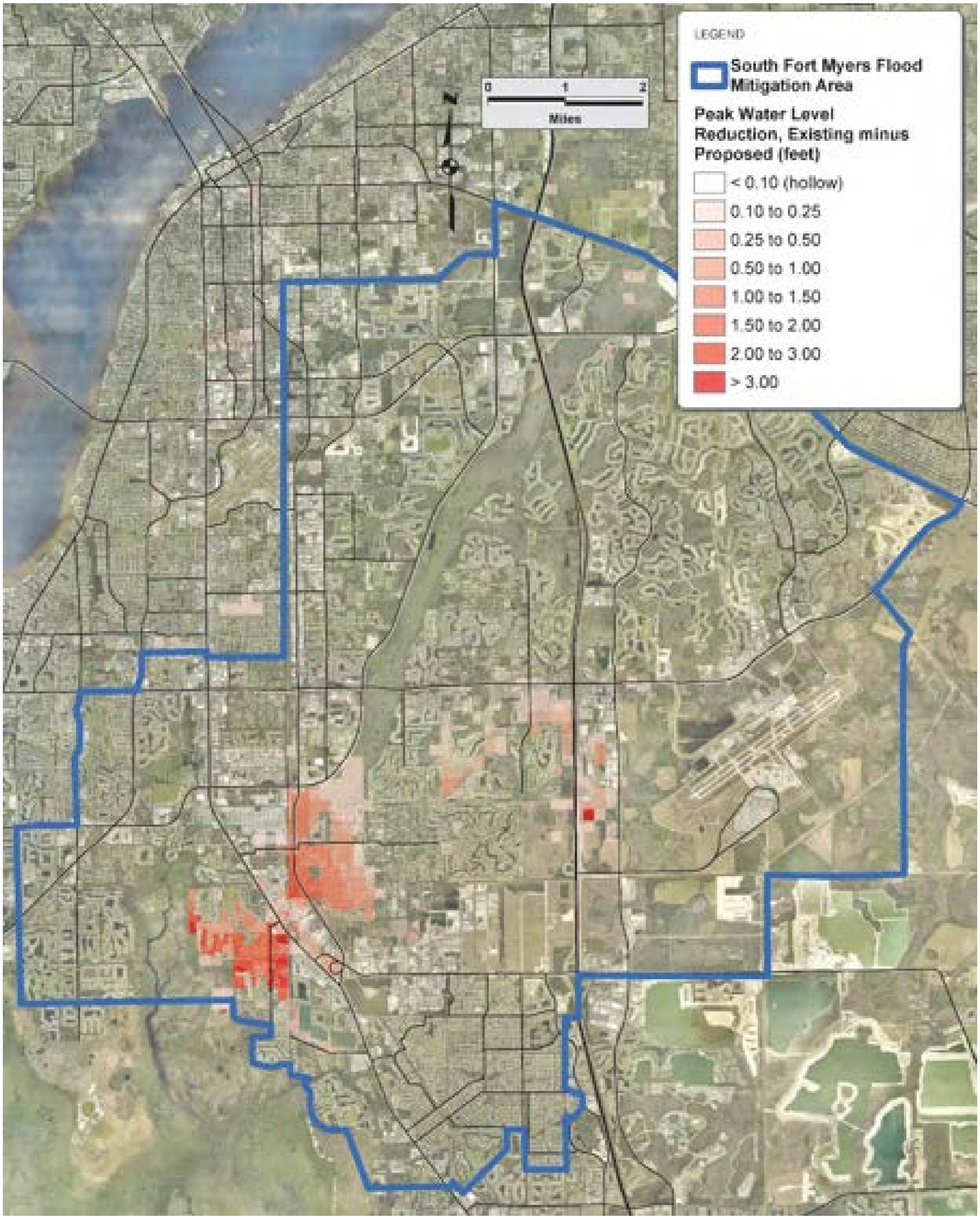


Figure 3 – Regional flood reduction map based on the Existing minus Proposed groundwater layers from the regional modeling results.

Limited regional stormwater management capabilities exist in the middle and southern portions of the Six Mile Cypress Slough. Project 1.4.7 proposes to provide additional storage capacity in the Slough ahead of a major storm event to reduce peak flows in the lower reaches of Ten Mile

Canal. While the regional model did not include a gate operations schedule to instruct the gate to open, the individual conceptual project was modeled independently previously in the interim project screening report and the gate operation schedule allowed the gate to open before and after the design storm event. The previous model results demonstrated a reduced recovery time following the peak of the storm event by more than 20 days, but it did not reduce the peak stages in the Slough upstream or downstream of Daniels Parkway. In the previous modeling the transfer of flow from the Slough to Ten Mile Canal did not increase the peak stages in Ten Mile Canal and the project did not affect the recovery time of Ten Mile Canal south of Daniels Parkway.

The following are concept project summaries of the anticipated flood mitigation benefit for each project.

1.4.1 ***Ten Mile Canal-North*** - This flow diversion and storage concept project was developed to direct flood flow away from the southern end of Ten Mile Canal. The modeling results show a 100 cfs upstream diversion into Carrell Canal, 200 cfs upstream diversion into Canal L, and 50 cfs upstream diversion into the Six Mile Cypress Parkway roadside swale. These combine to a total flow diversion of approximately 21,000 acre-feet over a 30-day period. An increase in upstream storage was proposed through redesigning the existing weir adjacent to Page Field Airport, but the increased storage volume was not quantified in the regional model.

1.4.2 ***Ten Mile Canal-South*** - This flow diversion and conveyance improvement concept project was developed to provide flood mitigation for the Island Park Road area. The modeling results show a 400 cfs diversion into Canal J, 200 cfs diversion into Canal K, 100 cfs diversion into Canal T, and a 1,100-cfs increase in capacity for Ten Mile Canal. These combine to a total flow diversion and conveyance increase of approximately 47,000 acre-feet.

1.4.3 ***Daniels Parkway-South Area*** - This conveyance improvement concept project was developed for flood mitigation of the communities south of Daniels Parkway, between Six Mile Cypress Slough and Interstate 75. The modeling results show 540 acre-feet of increased capacity in the swale north of the Legends community and a capacity increase of 1,100 acre-feet in the swale south of the Eagle Ridge community.

1.4.4 ***Briarcliff Area*** - This conveyance improvement concept project was developed for flood mitigation in the Briarcliff area. While this project was not included in the regional modeling, it is anticipated the project could provide up to 150 acre-feet of increased capacity for an existing area that has limited existing outfall options.

1.4.5 ***Park Road Area*** - This conveyance improvement concept project was developed for flood mitigation in the Park Road area. While this project was not included in the regional modeling, it is anticipated the project could provide up to 180 acre-feet of increased capacity for an existing area that has limited existing outfall options.

1.4.6 ***LCPA Diversion to Estero Basin*** - This flow diversion and storage concept project was developed for flood mitigation of the downstream portions of Ten Mile Canal and Estero River. The regional modeling results show the project could provide up to 800 acre-feet of increase storage in the wetland areas east of the airport. This project has a secondary benefit of increased wetland hydration.

1.4.7 ***Six Mile Cypress Slough-South*** - This flow diversion concept project was developed to provide increase stormwater management in the Six Mile Cypress Slough watershed.

While the gate operations were not included in the regional modeling, the model results from the interim project screening report showed this project could provide up to 5,300 acre-feet of increased water management flexibility in the watershed. This project has a secondary benefit of increased wetland hydration.

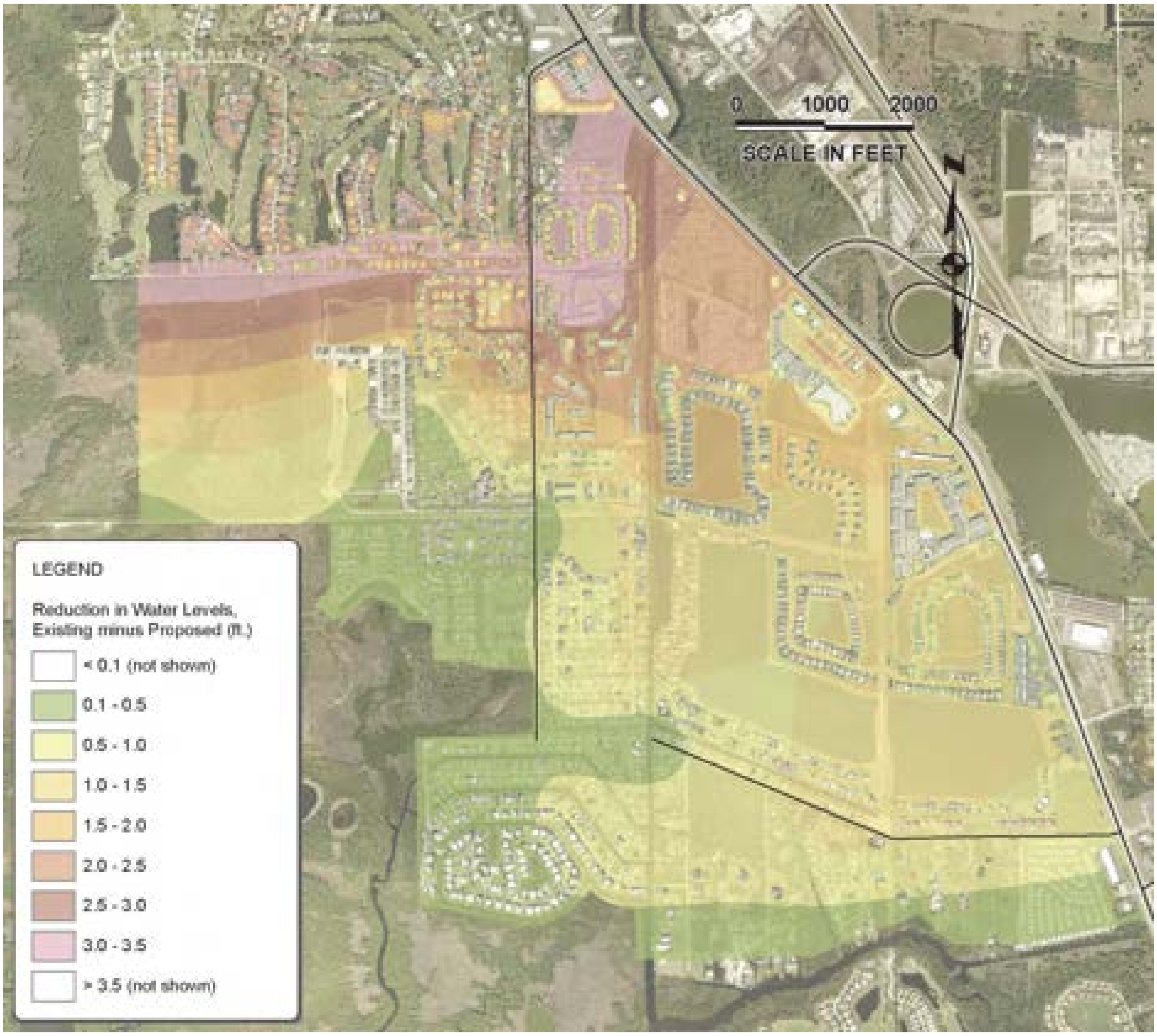


Figure 4 – Island Park community flood reduction map based on regional model results. Depths were calculated by subtracting the existing peak water levels of the 100-year, 3-day storm event (August 2017 start date) from the proposed peak water levels based on all proposed projects being implemented.

1.4.1 Ten Mile Canal-North

Background

Prior to the construction of the Ten Mile Canal, runoff east of Fort Myers proceeded westerly toward the Caloosahatchee River or Hendry Creek. The Iona Drainage District (IDD) constructed a series of canals in the 1920s to provide drainage and flood protection for areas west of Ten Mile Canal (formerly known as the Line A Dike). Spoil material from excavating the Ten Mile Canal was placed on the western bank of the canal to create a north-south berm and divert the water south to Estero Bay. Most of the canals constructed west of Ten Mile Canal still exist today and continue to serve as the primary conveyances for west Fort Myers.

Location

The northern area of the Ten Mile Canal is a triangular-shaped watershed bounded to the north by Hanson Street, to the east and southeast by Ortiz Avenue and Six Mile Cypress Parkway, and to the west by the Ten Mile Canal. Approximately half of the watershed is within the City of Fort Myers and the remainder is in unincorporated Lee County. Carrell Canal and IDD Canal L are outside the watershed, begin immediately west of Ten Mile Canal and continue west to the Caloosahatchee River.

Description

Three diversion points are proposed that will function as side-bank spillways from Ten Mile Canal into the upstream end of adjacent canals to the west. Carrell Canal and IDD Canal L are existing east-west canals that originate near Ten Mile Canal and terminate at the tidal Caloosahatchee. The third flow diversion point conveys water from Ten Mile Canal to Hendry Creek downstream of Lakes Regional Park, flowing parallel to Six Mile Cypress Parkway. This project proposes new interconnect structures at the upstream end of each canal to divert time- and stage-dependent flows west out of the Ten Mile Canal watershed.

The watersheds for Carrell Canal, IDD Canal L, and the north swale for Six Mile Cypress Parkway have relatively short times of concentration; as a result, the water levels in the canals/swale rise and fall rapidly following intense rain events. By contrast, the Ten Mile Canal watershed has a much longer time of concentration. An opportunity exists to take advantage of these differences by constructing automated, motorized gates with telemetry control at the canal intersections. The addition of pumps at these diversion points and retrofitting other weirs in the vicinity (such as upstream in the North Colonial Waterway and downstream in Ten Mile Canal) to include motorized gates with telemetry control can further assist in water management of Ten Mile Canal before and after a storm event.

The three receiving conveyances to the west lack enough capacity to convey water from Ten Mile Canal during a major storm event. The proposed gates will be open when the water levels west of Ten Mile Canal are higher than the water level in Ten Mile Canal to allow flow into the canal and provide relief for the areas to the west. After the storm event, the water level in Ten Mile Canal will be higher than the canals to the west, and the flow through the gates will reverse, providing relief for the Ten Mile Canal watershed. If the water level in Ten Mile Canal is higher than that of the canals to the west and the water levels to the west are above a pre-set elevation (e.g., streets are submerged), the gates will remain shut so that flooding west of Ten Mile Canal is not worsened.

Conveyance improvements of Carrell Canal, Canal L, and the north swale for Six Mile Cypress Parkway are needed to allow the additional flow from Ten Mile Canal. Additional discussions on increasing the conveyance of IDD Canal L are provided in Sections 1.2 and 4.1 of this report.

Smaller canal interconnect structures currently exist at Ten Mile Canal's intersection with Carrell Canal and IDD Canal L, as shown in **Figure 5**. Larger gates with lower invert elevations will allow for more flexible management of the Ten Mile Canal watershed ahead of a major storm.

Figure 5 – Existing Canal Interconnect Structures at Carrell Canal (left) and IDD Canal L (right).

Additional storage in the Ten Mile Canal watershed can be made available through the modification of the existing weir in Ten Mile Canal, east of the Page Field Airport, shown in **Figure 6**. Raising the weir crest slightly provides additional storage across the upstream watershed. In conjunction with raising the weir, the weir length needs to be increased to ensure the existing conveyance capacity is not reduced and gates are proposed to allow flexible water management.

Figure 6 – Existing Weir in Ten Mile Canal West of Page Field Airport.

Installation of a new weir in Ten Mile Canal at Park Windsor Drive (upstream of the existing weir east of Page Field Airport) was considered briefly. However, it was determined that modifying the existing weir east of Page Field Airport could achieve the same benefits as the addition of a new weir near Park Windsor Drive so this component of the project was not further investigated.

Objectives

This series of interrelated projects restores some of the historical flows to the Caloosahatchee River and Hendry Creek and reduces high-flow contributions to Ten Mile Canal through upstream diversions and storage. Advanced weir control features, including motorized gates with local or telemetry control allow for greater flexibility of water management to develop storage capacity ahead of a storm and divert water at high stages, all while protecting downstream communities that are receiving the diverted water.

Evaluation

Viability

The proposed storage and flow diversion projects are not overly challenging from a technical standpoint and the additional structures and conveyance capacity needed will be straightforward to design and permit once the modeling support and community support have been accomplished. These simple changes to existing infrastructure will provide significant benefits to a large, developed area.

Community Considerations

There could be some concern from the City of Fort Myers residents, fearing that flooding in the south end of the Ten Mile Canal Watershed will be moved to them. However, with the appropriate structure and operating protocol this issue can be addressed. Well managed, the system should relieve potential flooding in Ten Mile Canal and parts of the Hendry Creek Watershed by using capacity in these canals when they are not being used. Communities along the southern portions of Ten Mile Canal will benefit by increased upstream storage and diversions, resulting in decreased flows following major storm events.

Environmental & Permitting Considerations

The proposed work is all within existing, maintained stormwater facilities. The permitting effort will most likely focus on operational schedules rather than disturbance of the environment.

Land Availability

Existing drainage easements encompass most, if not all the proposed work areas. However, these easements have been granted to various governmental organizations. Collaboration effort are possible with these projects between the State, County, and City governments.

Discussions with the City of Fort Myers have resulted in interest in determining the existing capacity and possible improvements within the City as part of the connection project. No commitment on funding of the project has been determined.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements.

Table 1 – Opinion of Probable Cost breakdown, 1.4.1 Ten Mile Canal-North

Construction Costs

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 1,200,000	$ 1,200,000
Clearing & Grubbing	12	AC	$ 14,000	$ 168,000
Earthwork	25,375	CY	$ 10	$ 254,000
Weir Structure 1.4.1A (Carrell Canal Interconnect)	20	LF	$ 10,000	$ 200,000
Weir Structure 1.4.1C (Ten Mile Canal at Airport)	120	LF	$ 10,000	$ 1,200,000
Weir Structure 1.4.1D (Canal L Interconnect)	40	LF	$ 10,000	$ 400,000
Weir Structure 1.4.1E (Gladiolus Swale Interconnect)	20	LF	$ 10,000	$ 200,000
Culvert-RCP 48"	530	LF	$ 215	$ 114,000
Pumps (25 cfs)	4	EA	$ 310,000	$ 1,240,000
Pumps (50 cfs)	2	EA	$ 700,000	$ 1,400,000
Permanent Erosion Control	14,000	SF	$ 25	$ 350,000
Grassing	19,738	SY	$ 3	$ 60,000
			Conceptual Construction Costs:	**$ 6,800,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 2,040,000
			Land Acquisition	$ 150,000
			Project Administration/ CEI (10%)	$ 680,000
			Conceptual Project Cost:	**$ 9,700,000**
			Contengency (30%)	$ 2,900,000
			Conceptual Project Cost (with Contengency):	**$ 12,600,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

The opportunity exists to route the stormwater flows through designated stormwater quality treatment areas, helping Lee County achieve their Basin Management Action Plan (BMAP) goals for Total Nitrogen reduction for the Tidal Caloosahatchee. The inclusion of stormwater runoff east of Ten Mile Canal through Carrel Canal can potentially allow the City of Fort Myers to expand the existing redevelopment area boundary further to the east, promoting infill within the City.

The Hideaway golf community is located at the upstream end of IDD Canal L. If the community is willing, a collaboration effort is possible to incorporate the community's stormwater management lake system into the regional stormwater management of IDD Canal L by removing the outfall structure to the community and replacing it with a weir structure further downstream in the canal. This can provide regional water quality and flood control benefits for the City of Fort Myers and portions of unincorporated Lee County.

Findings & Recommendations

Regional Modeling Findings

The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.1 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**.

Modeled results demonstrating the water levels and discharges over time are included for the following design storm events:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.1 (b) EXHIBIT 1.4.1 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.1 (d) EXHIBIT 1.4.1 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.1 (f) EXHIBIT 1.4.1 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.4.1 (h) EXHIBIT 1.4.1 (i)

At Ten Mile Canal downstream of Six Mile Cypress Parkway, the model output showed a reduction in peak stage, reduction in peak flow, and reduction in total flow volume for each storm event modeled. Increased peak stages were observed in some of the three western receiving canals. To protect downstream communities along the canals, conveyance improvements and careful management of the diversion structures will be required. Significant noise is depicted in the flow output graphs for some of the receiving canals due to rapid starting and stopping of the proposed pumps. This issue can be addressed with further refinements of the model input parameters, but these modifications will likely not significantly affect the overall results. Therefore, further model refinements are not needed for this conceptual analysis.

The project concept model results demonstrate a significant reduction in the peak stage of Ten Mile Canal. The recovery time following the peak stage was also reduced significantly as was the total flow volume to the southern half of Ten Mile Canal. When paired with the projects described in 1.4.2, the projects should reduce regional flood stages and durations in the communities around the southern portion of Ten Mile Canal. The positive improvements of this project concept warrant further project development.

Recommendations

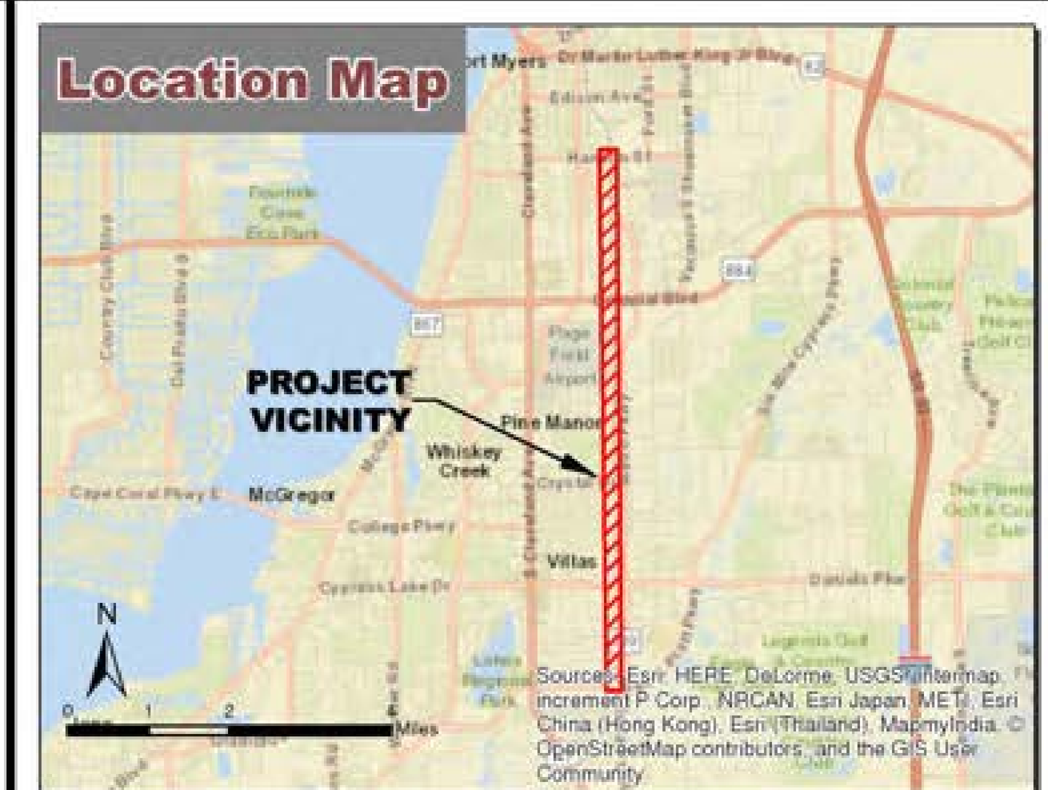
The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by diverting flow from Ten Mile Canal to the smaller conveyances to the west, which reduces flow to the south Ten Mile Canal area. The preliminary flow diversion out of Ten Mile Canal into Carrell Canal is 100 cfs, into Canal L is 200 cfs, and into the Six Mile Cypress Parkway roadside swale is 50 cfs. The model output highlighted the need for a detailed analysis of the existing conveyance capacities of Carrell Canal, Canal L, and the Six Mile Cypress Parkway roadside swale. It is likely that downstream conveyance improvements will be required for all three conveyances. As discussed in Section 4.1, the local modeling of Canal L included three flow scenarios of 100 cfs, 300 cfs and 400 cfs. Additional local modeling of the other canals is recommended to further investigate the recommended flowrates and associated conveyance modifications. The regional model output also emphasized the need for careful management of the flows at the diversion points to ensure flows are not being discharged into the western canals until after the canals have recovered from the storm event. For the greatest benefit, the projects described in 1.4.1 should be constructed along with the projects in 1.4.2, described later.

For simplicity, the conceptual model utilized only pumps for flow diversions and did not incorporate advanced weir control features. With the approximate design flows and stages developed in this regional modeling effort, additional local modeling will be needed in the detailed design phase to refine the flows, stages, and designs of the downstream conveyances, gate sizes and elevations, and pump setpoints. It is recommended that all proposed pumps include a Variable Frequency

Drive (VFD) for better control of flow and to reduce the number of starts and stops of the pumps. All proposed gates should be automated with telemetry-controlled gates for greater operational flexibility.

The preliminary modeling results showed no increase in the upstream peak water levels despite raising the existing weir crest in Ten Mile Canal east of Page Field Airport by six inches to provide additional storage in the upstream watershed. Additional local modeling efforts are recommended for this area to verify these findings and refine the design of the weir and gates.

NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.



Project Narrative

DESCRIPTION: Prior to the construction of Ten Mile Canal and its west berm, runoff east of Fort Myers proceeded westerly towards the Caloosahatchee River. This project restores a portion of that historical flow via diversion from Ten Mile Canal into Carrell Canal, IDD Canal L, and along Six Mile Cypress Parkway to downstream of Lakes Regional Park. Additional storage is proposed to be created by slightly raising the crest elevation of the existing weir in Ten Mile Canal, east of Page Field airport.

PURPOSE: This series of interrelated projects restores some of the historical flows to the tidal Caloosahatchee and Hendry Creek and reduces high-flow contributions to Ten Mile Canal through diversions and storage.

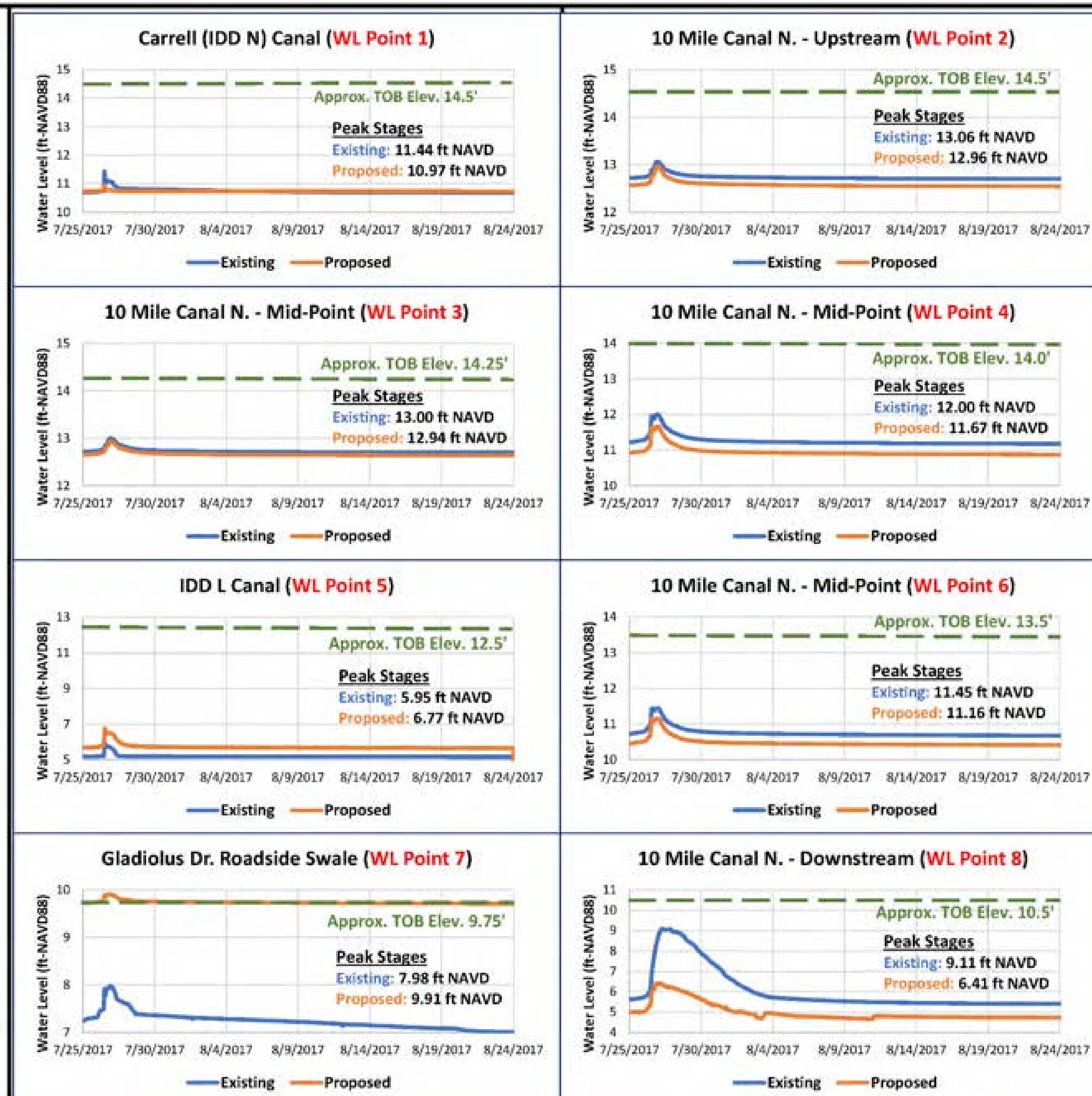
CONSTRAINTS: The northerly diversion project will require coordination with the City of Fort Myers. Preliminary meetings with City staff have indicated a willingness to consider these projects. In conjunction with these flow diversions, the downstream conveyances may need to be improved, determined by later studies.

MAY 2020

Ten Mile Canal - North
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.1(a)

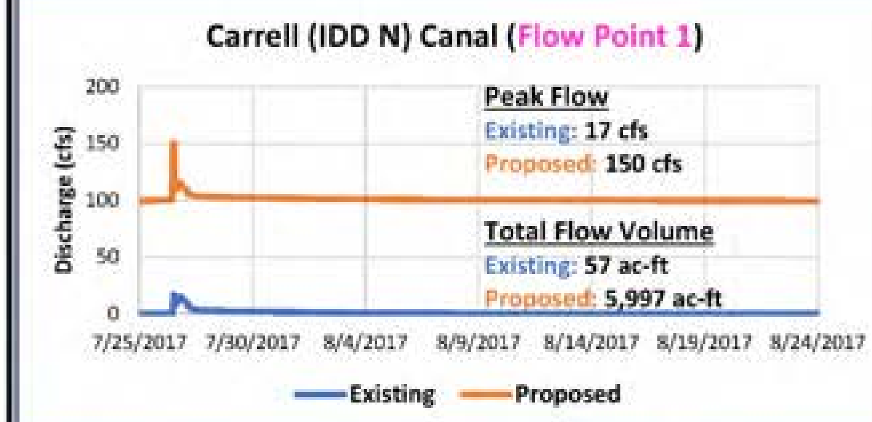


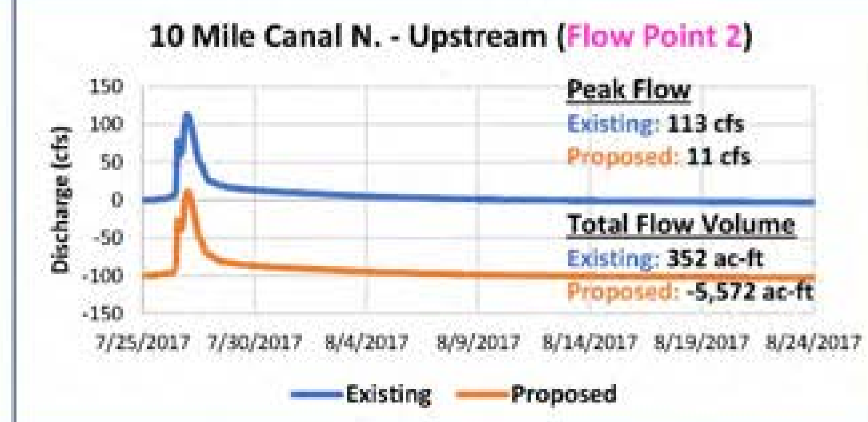
1.4.1 Ten Mile Canal-North

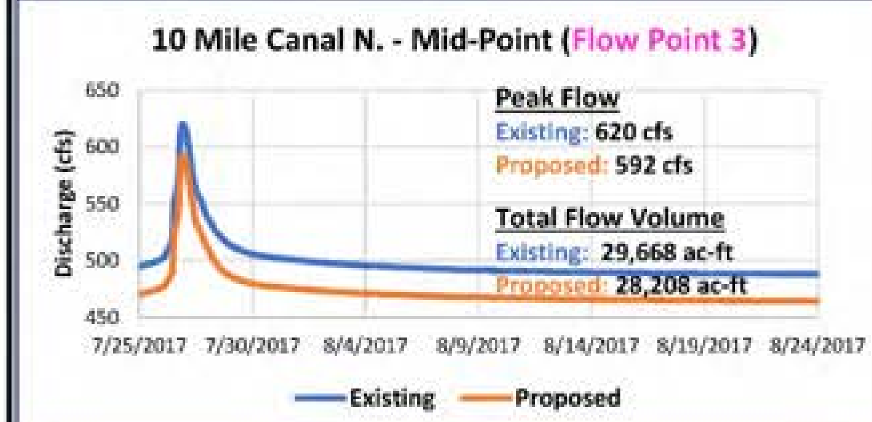
Water Level(s)

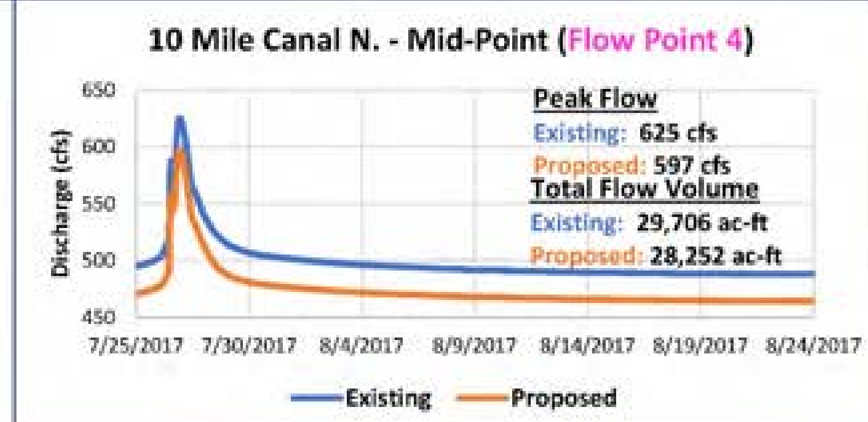
25-yr 3-day (Jul Start)

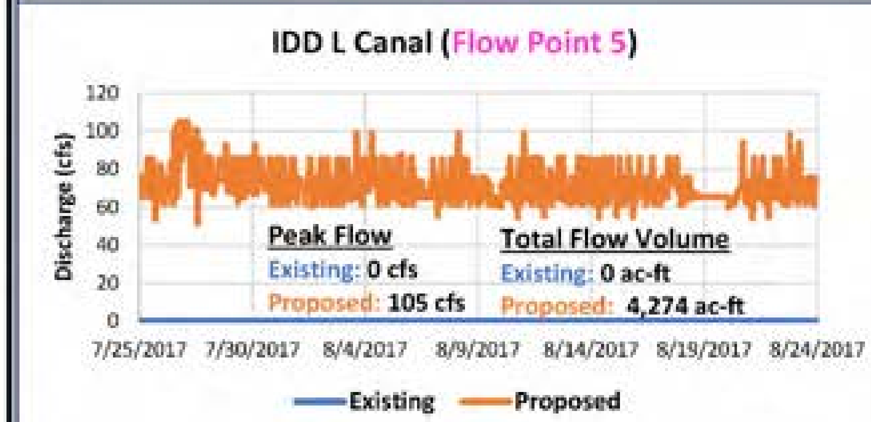
EXHIBIT 1.4.1 (b)

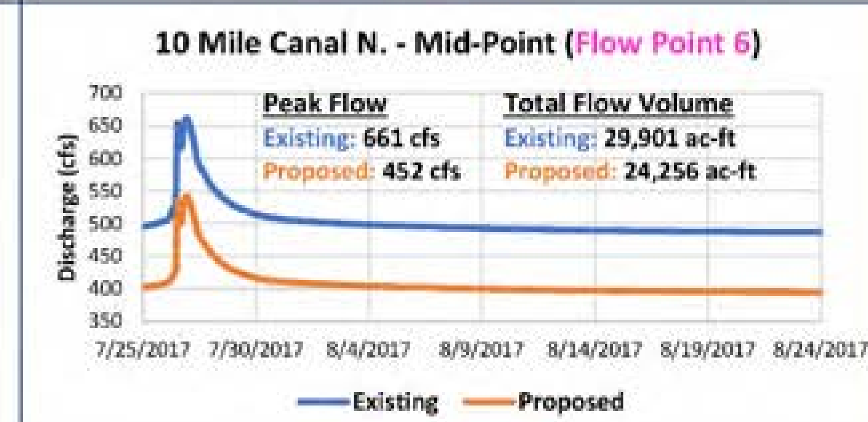


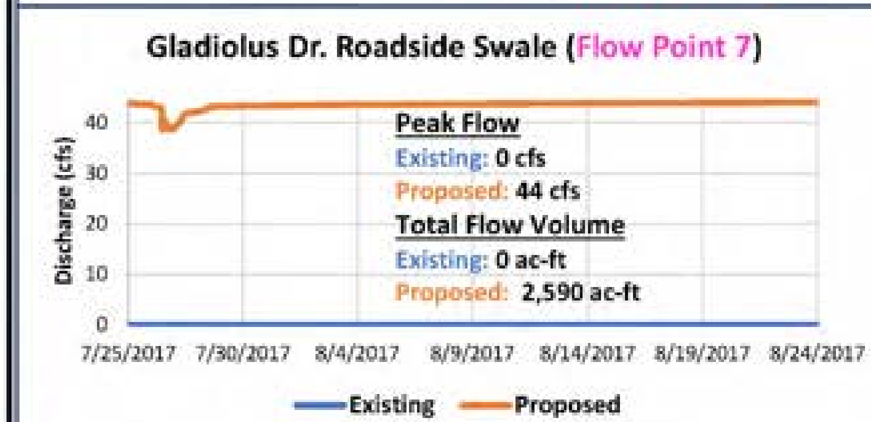


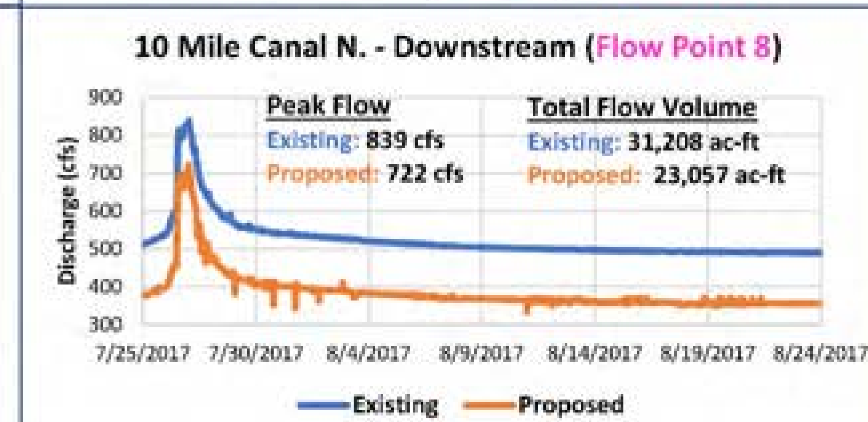










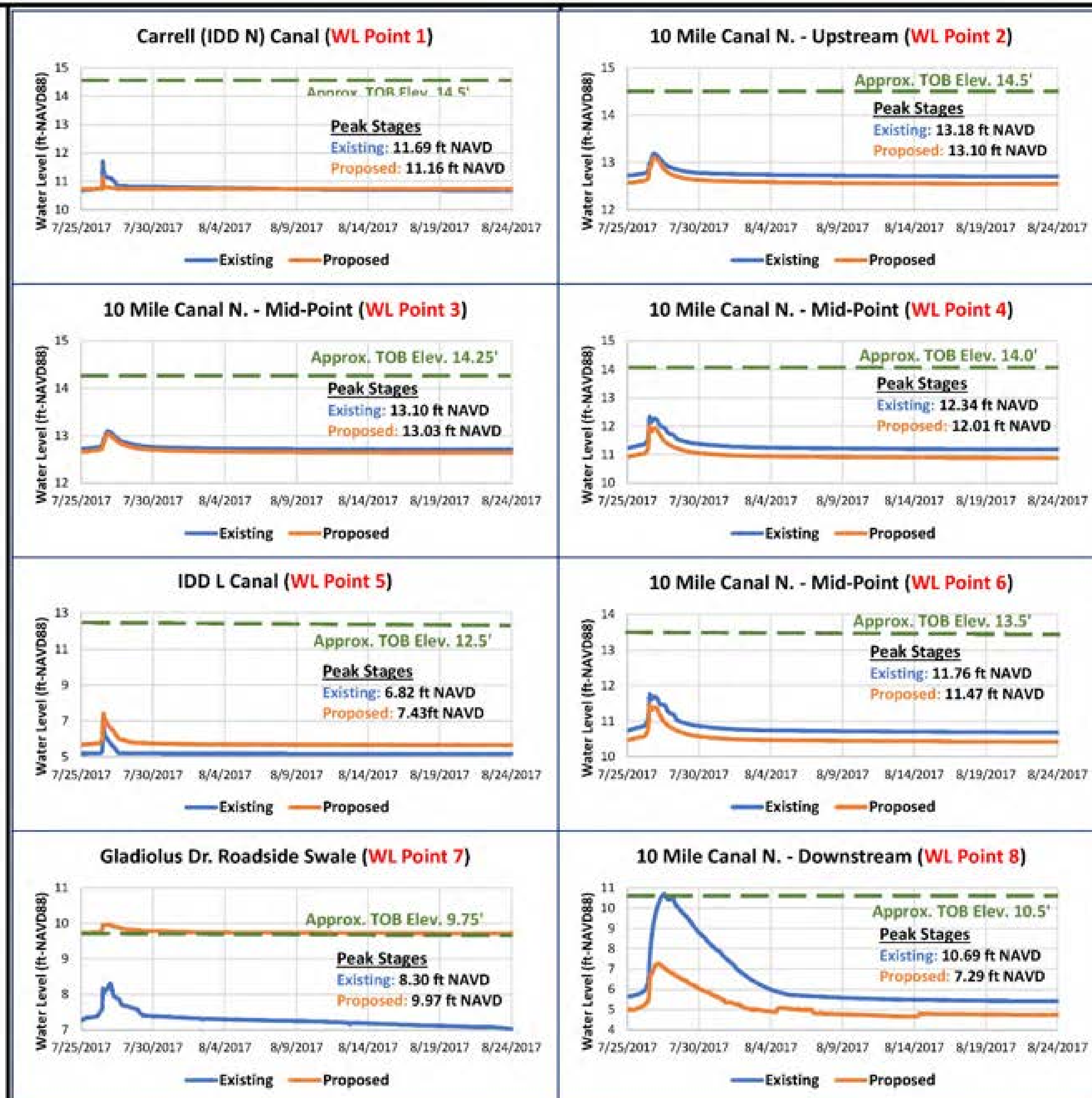


1.4.1 Ten Mile Canal-North

Flow(s)

25-yr
3-day
(Jul Start)

EXHIBIT 1.4.1 (c)

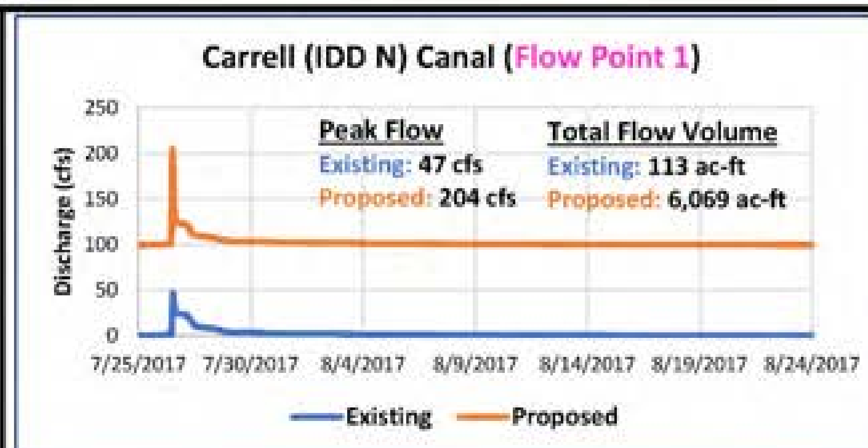


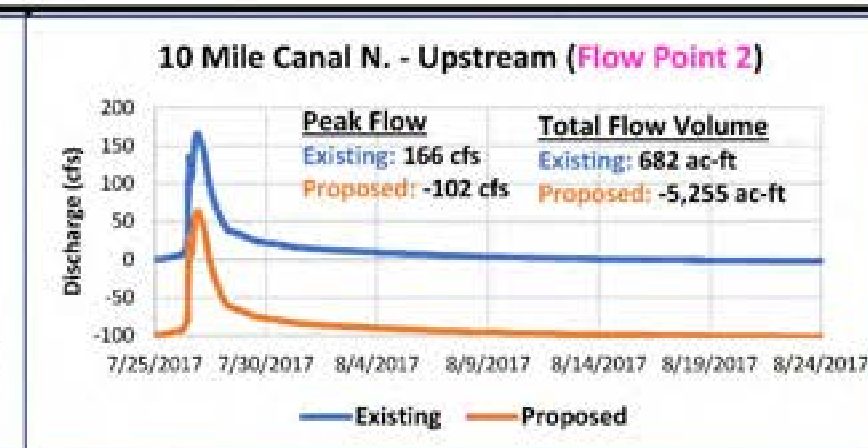
1.4.1 Ten Mile Canal-North

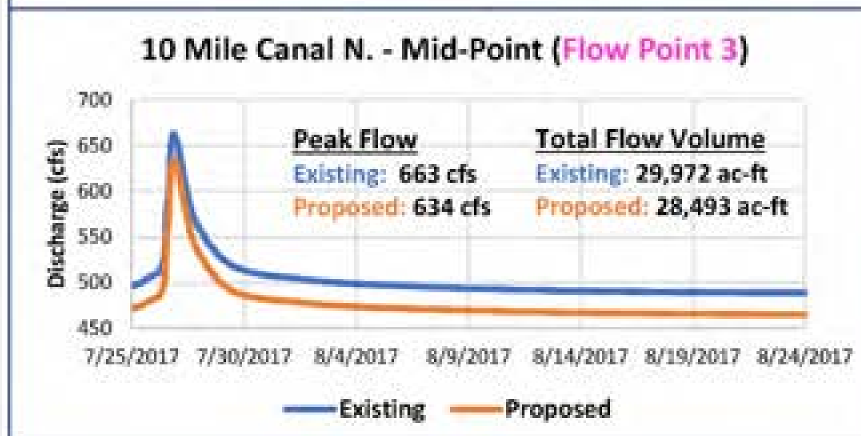
Water Level(s)

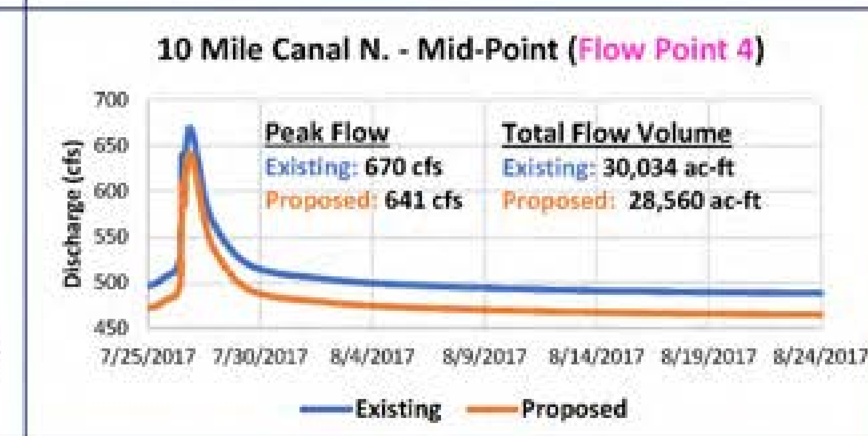
100-yr 3-day (Jul Start)

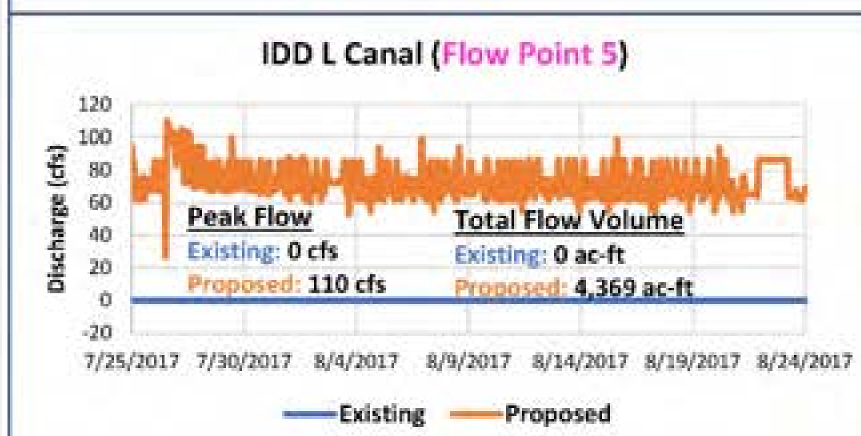
EXHIBIT 1.4.1 (d)

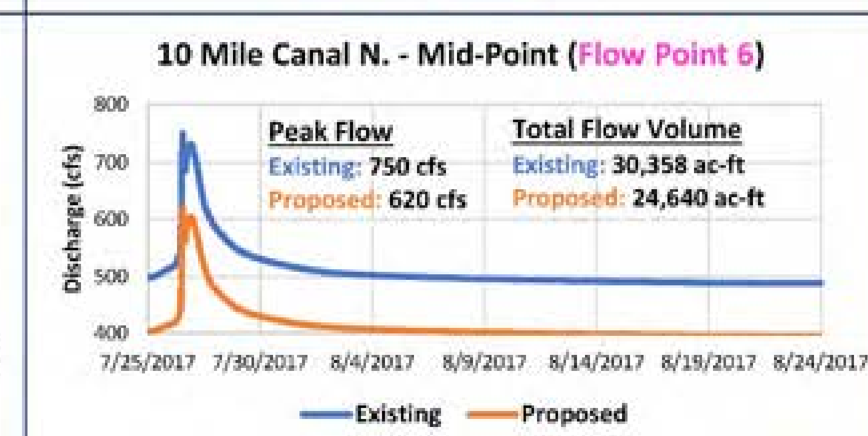


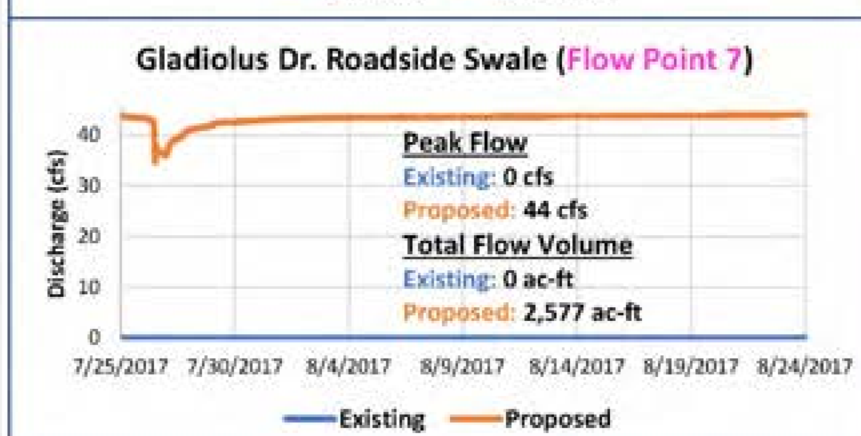


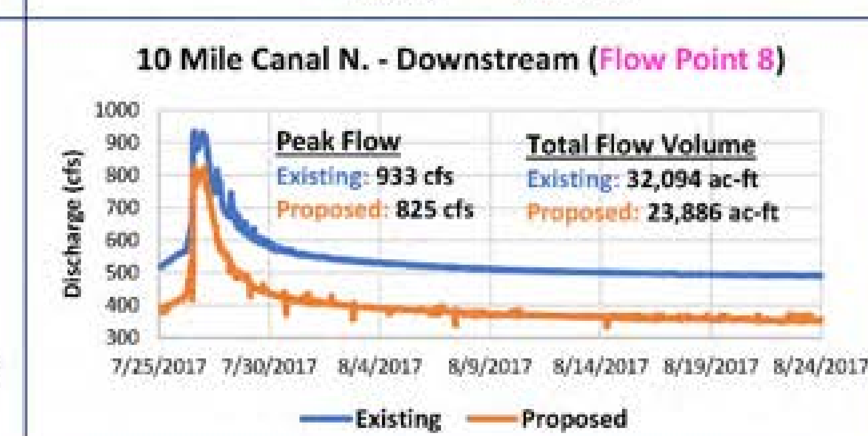












1.4.1 Ten Mile Canal-North

Flow(s)

100-yr
3-day
(Jul Start)

EXHIBIT 1.4.1 (e)

1.4.1 Ten Mile Canal-North

Water Level(s)

100-yr 3-day (Aug Start)

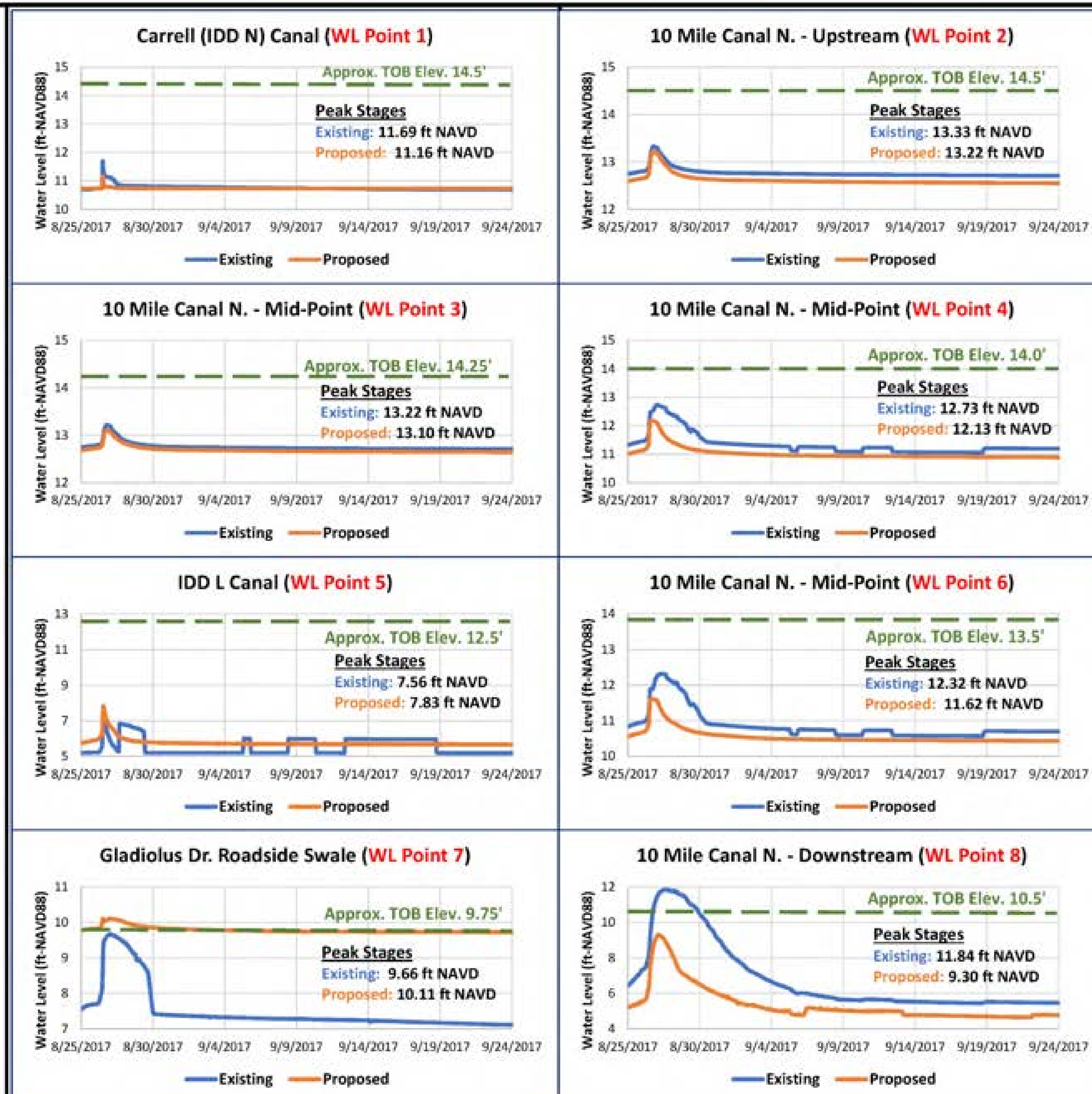
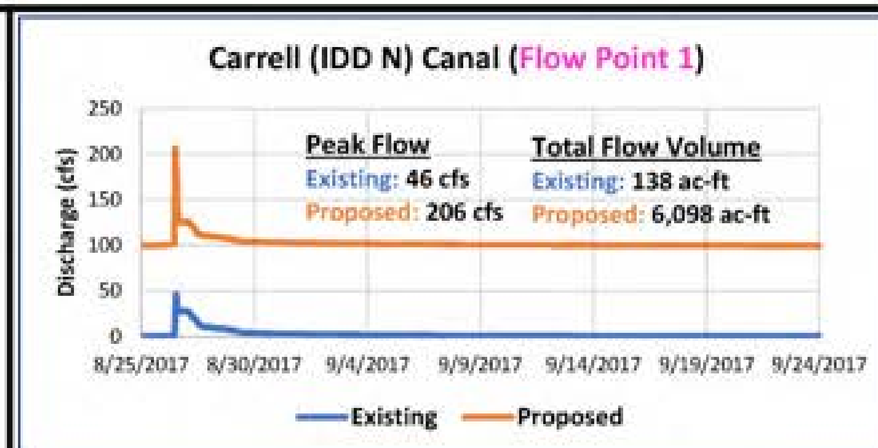
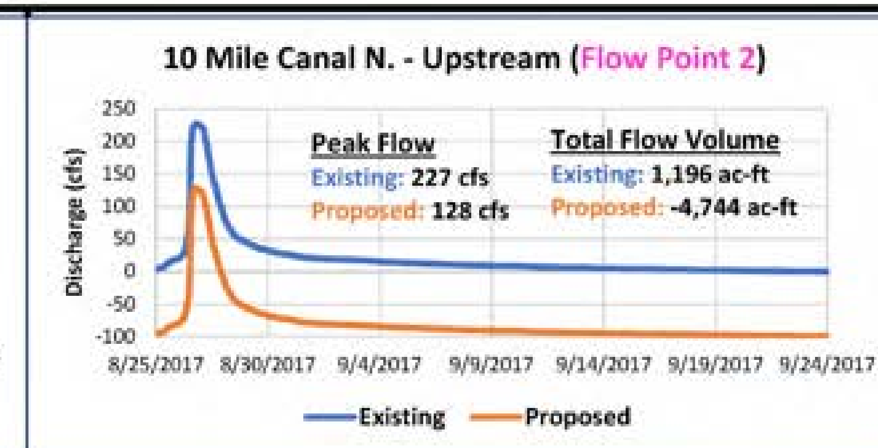
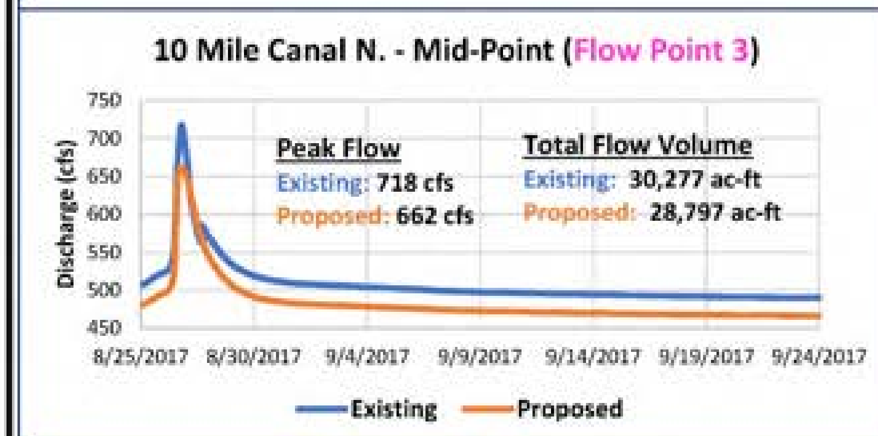
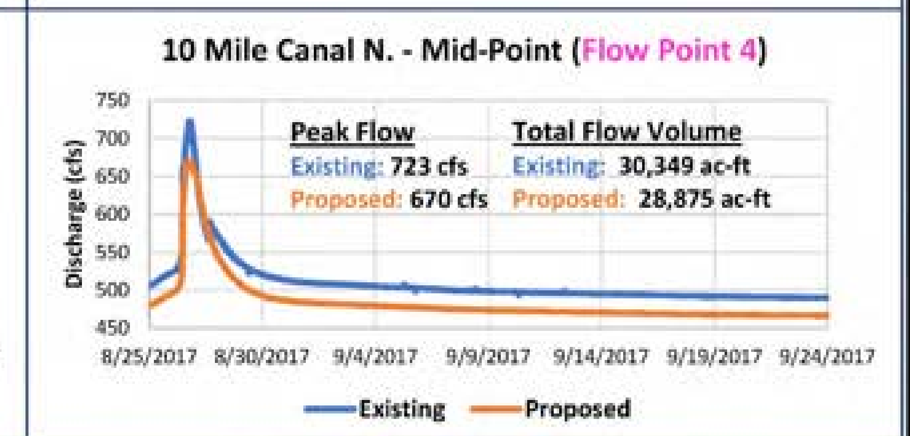


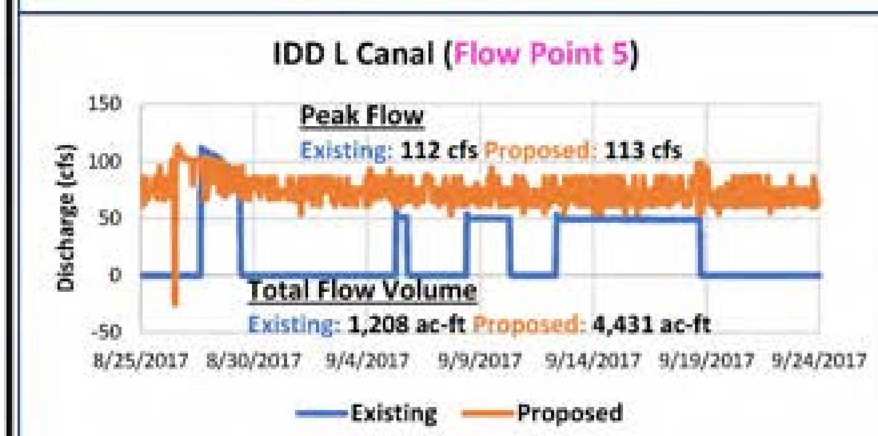
EXHIBIT 1.4.1 (f)

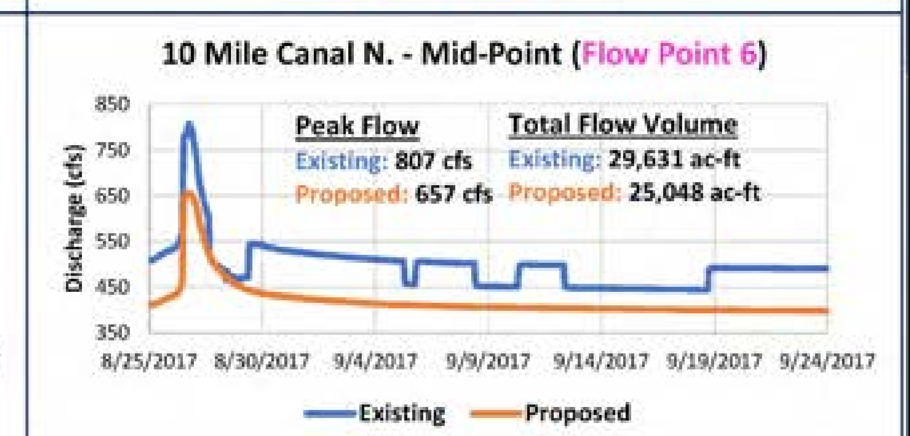


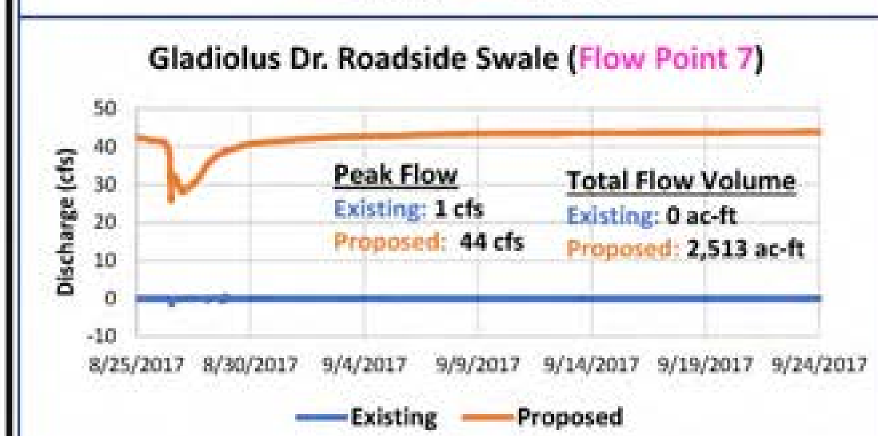


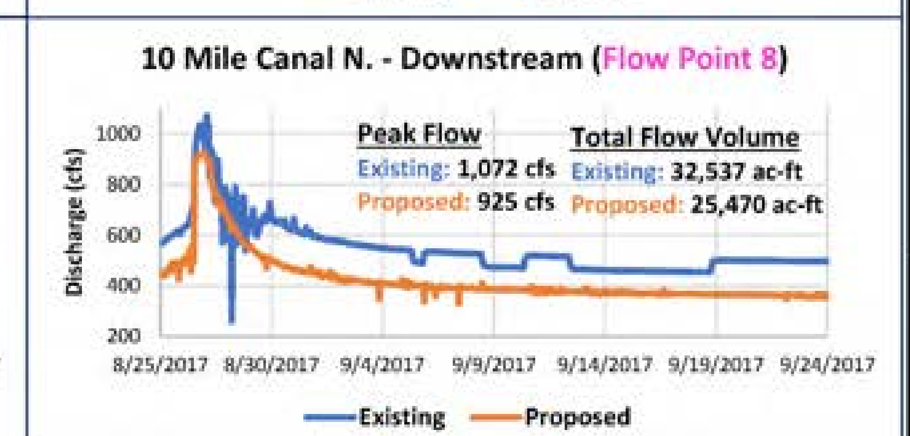










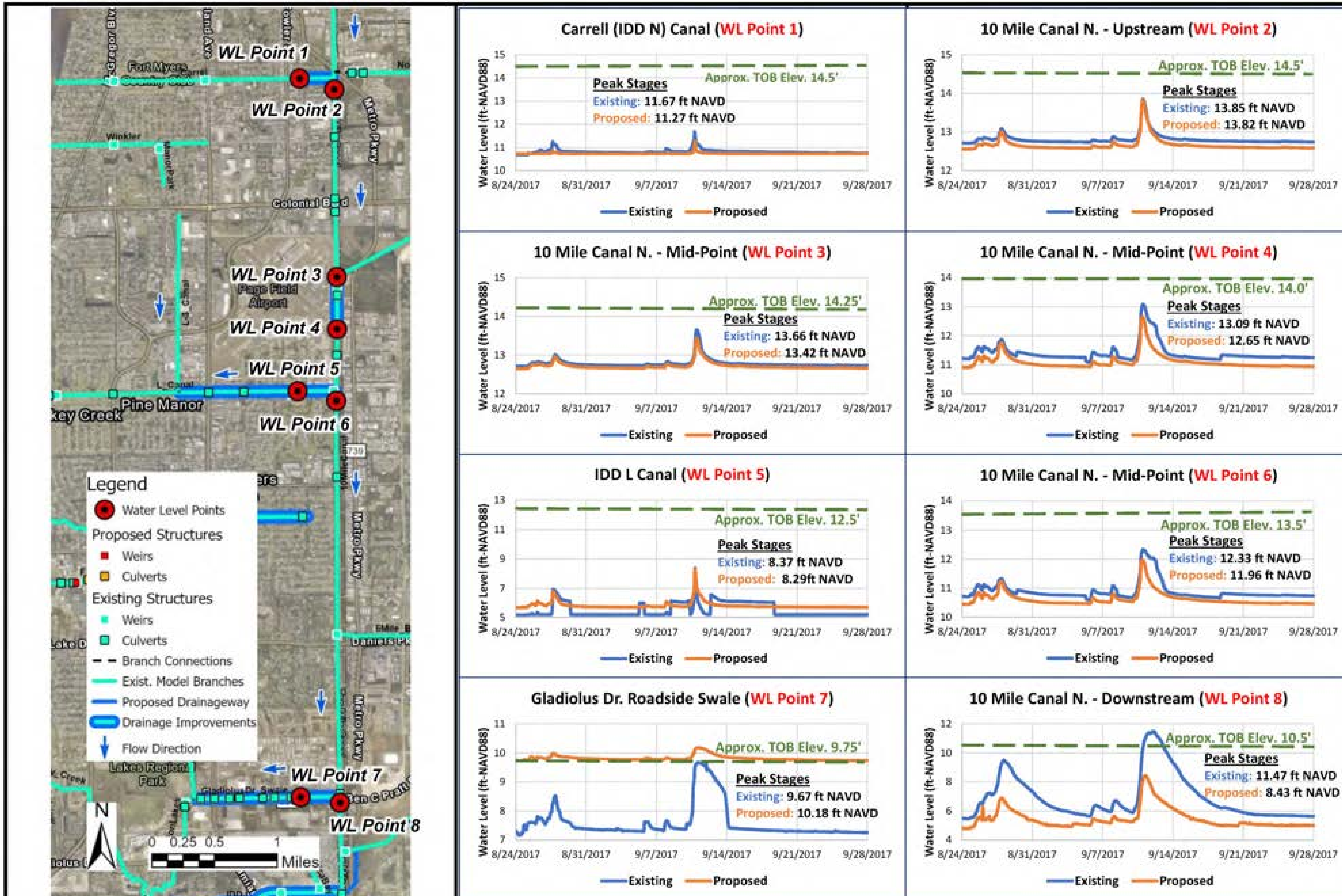


1.4.1 Ten Mile Canal-North

Flow(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.4.1 (g)



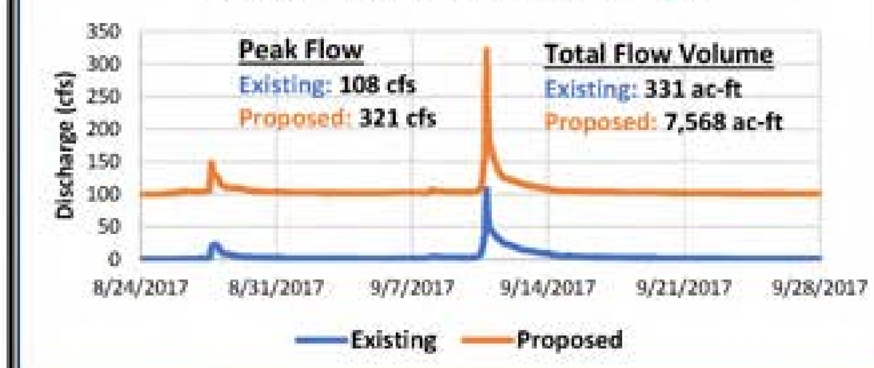
1.4.1 Ten Mile Canal-North

Water Level(s)

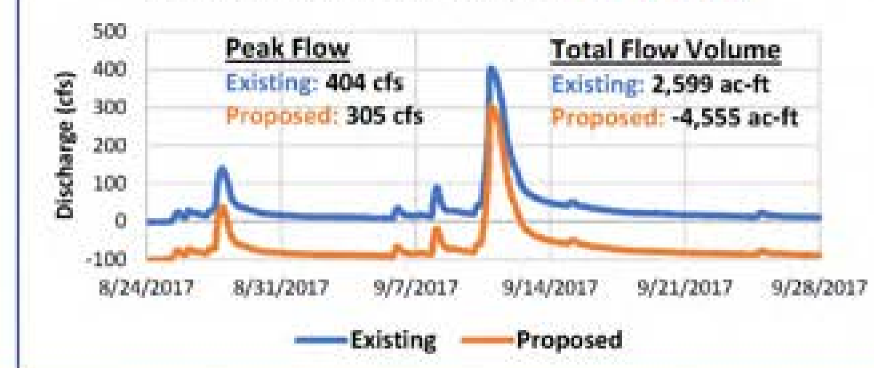
Continuous Simulation (Hourly)

EXHIBIT 1.4.1 (h)

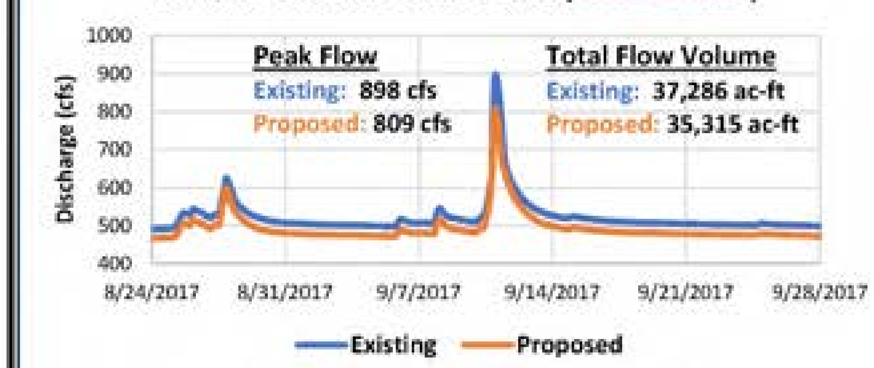
Carrell (IDD N) Canal (Flow Point 1)



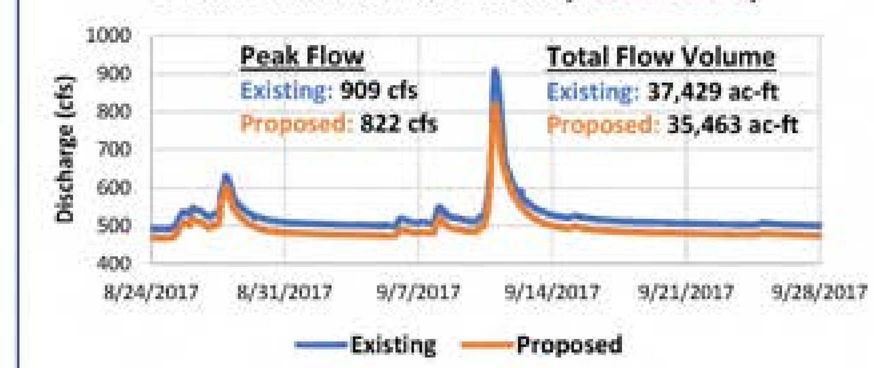
10 Mile Canal N. - Upstream (Flow Point 2)



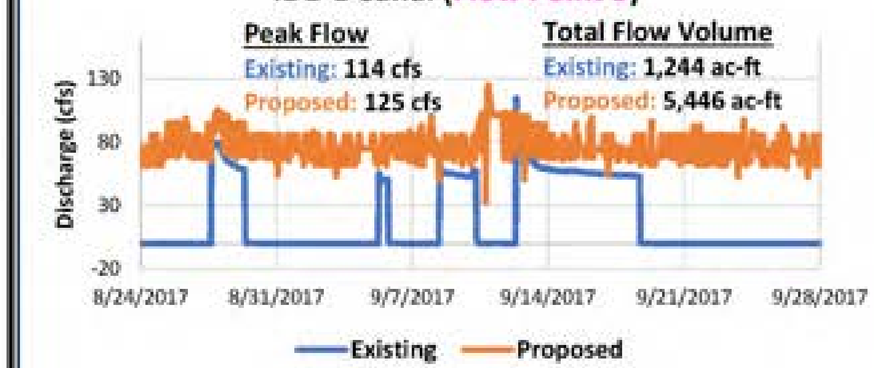
10 Mile Canal N. - Mid-Point (Flow Point 3)



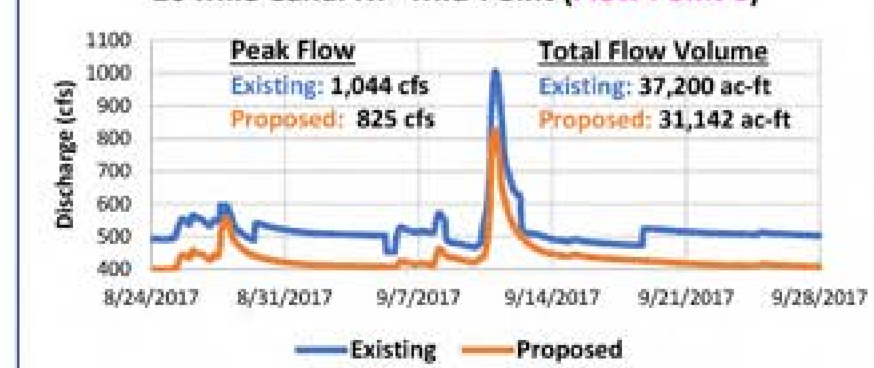
10 Mile Canal N. - Mid-Point (Flow Point 4)



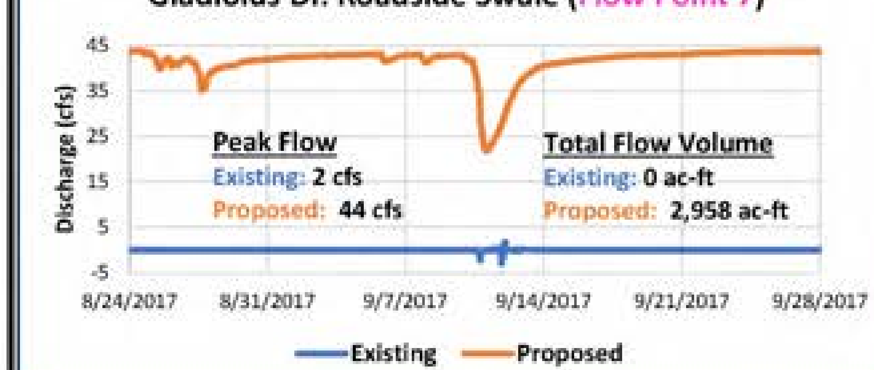
IDD L Canal (Flow Point 5)



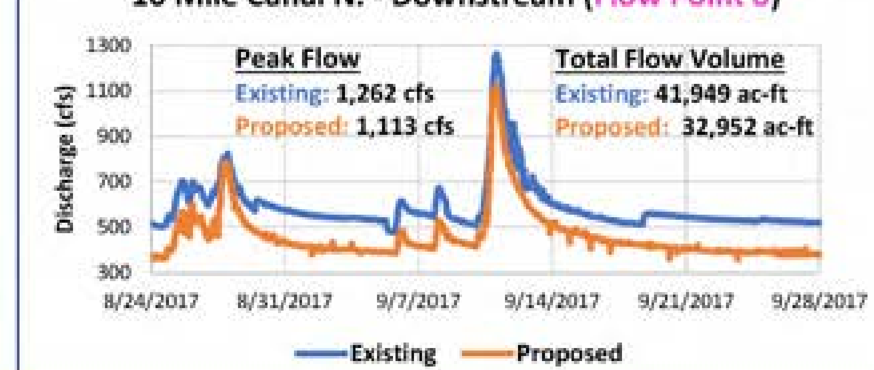
10 Mile Canal N. - Mid-Point (Flow Point 6)



Gladiolus Dr. Roadside Swale (Flow Point 7)



10 Mile Canal N. - Downstream (Flow Point 8)



1.4.1 Ten Mile Canal-North

Flow(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.1 (i)

1.4.2 Ten Mile Canal-South

Background

The Six Mile Cypress Slough was historically a tributary to Hendry Creek, passing through the present-day Jamaica Bay community. The construction of the Line A Dike in the 1920s by the Iona Drainage District intercepted this flow and instead routed it south to Mullock Creek. This redirection was further enhanced by the widening and deepening of the borrow ditch (Ten Mile Canal) for the Line A Dike that began in the 1970s. In addition to the 38-square mile Six Mile Cypress Slough watershed, the Ten Mile Canal collects water from the Ten Mile Canal north watershed (12 square miles) and the Ten Mile Canal south watershed (1 square mile) along with the portion of the Six Mile Cypress watershed that drains directly to Ten Mile Canal (17 square miles).

The original intent of the Line A Dike was not to provide drainage to the lands to the east of it, but to protect lands to the west. There was little to no emphasis placed on designing the Ten Mile Canal to adequately convey drainage from the upstream areas. The 1977 Ten Mile Water Management Plan included a new design cross section for Ten Mile Canal so that it could better-serve the lands within the Ten Mile Canal watershed. However, portions of the canal south of US 41 do not match the design cross section and a number of boat docks have been added within the narrowest portion of the canal. As a result, sections of the Ten Mile Canal at its outfall into Mullock Creek are not sufficient to convey the required flows. Today the relatively narrow outfall of Ten Mile Canal into Mullock Creek creates undesirable head loss conditions during periods of high flows and the backwater profile increases rapidly in the southernmost mile and a half of the canal. This adverse tailwater condition stores water in the lower portion of the watershed for several days following major storm events. The increased stages also force the water to find alternate outfalls that were not designed to convey large amounts of runoff.

Original IDD plans from the 1920s indicated construction of a spoil berm on the west bank of the Ten Mile Canal. Most of this berm still exists today, either as a conventional berm appearance or has been blended into construction fill pads. However, the west side of Ten Mile Canal south of US 41 has several boat ramps that provide access to the drainage conveyance for recreation. The tops of the boat ramps were constructed too low, effectively creating breaches in the berm that allow water to flow westerly into the Island Park area when water levels in Ten Mile Canal are high enough to overflow the banks. Also, the berm does not connect to the southern US 41 bridge embankment, providing an additional opportunity for flood waters to overflow the canal bank and make its way to Island Park Road through an undeveloped parcel.

Location

Improvements to Ten Mile Canal are recommended from Briarcliff Road south to its outfall into Mullock Creek. Improvements are also recommended to several IDD canals between Ten Mile Canal and Hendry Creek, all south of Six Mile Cypress Parkway.

Description

Diversion points proposed to convey stage-dependent flows west out of both Ten Mile Canal and Six Mile Cypress Slough into existing IDD Canals J, K, and T (see **Exhibit 1.4.2 (a)**). The three proposed diversion points will function as side-bank spillways from Ten Mile Canal into the upstream ends of the canals similar to the example shown in **Figure 7**, but with gates, pumps, and a higher weir crest that will force most if not all of the flow through the gates to allow greater control over the timing of the flow diversions. The IDD Canal watersheds have relatively short times of concentration and as a result the water levels in the canals rise and fall rapidly following intense rain events. By contrast, the Ten Mile Canal watershed has a much longer time of concentration. An opportunity exists to take advantage of these differences by constructing automated, motorized gates with telemetry control at the canal intersections. The addition of pumps at these diversion pumps can further assist in water management of Ten Mile Canal before and after a storm event.

Figure 7 – Example Side-Bank Overflow Spillway Perpendicular to a Canal.

Two flow connections are proposed into Canal J. The first diversion point is a direct connection from Six Mile Cypress Slough to IDD Canal J. The southern end of the Six Mile Cypress Slough is controlled at elevation 9.8 feet NAVD 88 and during times of high flow the peak stage can be in excess of 11 feet NAVD 88. Installing approximately 700 feet of 72-inch diameter culvert under Ten Mile Canal (bypassing the canal) into IDD Canal J, which is controlled at elevation 5.4 feet NAVD 88, can likely divert a significant flowrate using gravity alone. As described in Section 4.1 of this report, conveyance improvements of IDD Canal J will be required to allow the additional flow, including the modification of the existing weir at the southwest corner of the Jamaica Bay community. The proposed flow bypass will not lower the existing control elevation of the Six Mile Cypress Slough of 9.8 feet NAVD 88. Water delivered directly from Six Mile Cypress Slough to IDD Canal J without going through Ten Mile Canal will decrease the discharge from the weirs at the south end of the Six Mile Cypress Slough that would normally continue south in Ten Mile Canal. This reduces the flood potential at the downstream end of Ten Mile Canal and, to a small extent, provides restoration of flows to Hendry Creek.

The potential also exists to divert up to 50 cfs from the Slough directly into IDD Canal I-1. However, this option was dropped early in the conceptual design phase due to its relative lack of benefit compared with the cost, as it would require approximately 2,400 feet of 42-inch pipe that would cross several major infrastructure features and would require additional improvements further downstream. The potential also exists to divert up to 40 cfs from the Slough directly into IDD Canal K with 4,000 feet of 42-inch pipe. However, this option was also dropped early in the conceptual design phase due to its relative lack of benefit compared with the cost.

Lee County maintenance staff performs routine maintenance in the portions of the IDD canals that are adjacent to developed lands. However, significant portions of the canals pass through preserve and conservation lands and are not maintained, resulting in sediment and vegetation buildup. Maintenance clearing and dredging of the IDD canals to Hendry Creek are recommended to significantly improve the conveyance capacities of the canals. For conceptual modeling purposes only, the widths of these canals were widened to the maximum extent possible given the existing right of way (ROW) width to ensure the canals were non-limiting in the model and determine the maximum potential reduction in peak stage due to the proposed projects. Once the regional model results identify the peak flows and peak stages, the IDD canals west of Ten Mile Canal can be reexamined and reduced in size to the smallest-allowable width in the detailed design phase.

To restore the west berm of Ten Mile Canal south of US 41, three existing boat ramps need to be modified to raise the peak elevation of the ramps. The west berm also needs to be reconstructed adjacent to an undeveloped parcel immediately downstream from US 41 (see **Exhibit 1.4.2 (a)**). Closing these breaches minimizes potential routes for water to overflow out the Ten Mile Canal into the Island Park Road area.

The County has initiated maintenance dredging of sediment buildup in the southern portion of Ten Mile Canal. In addition to this work, further conveyance capacity is needed downstream of US 41 to reduce flooding impacts from major storm events, as described in Section 4.1 of this report.

This conceptual project also investigated removing the existing boat docks within the channel that are causing restrictions to flow, as shown in **Figure 8**, and replacing them with a different form of access. Of greatest concern are the docks in the canal sections that are narrower than 100 feet, south of US 41. Some homes adjacent to the Ten Mile Canal already have off-channel docking/storage for their boats, also shown in **Figure 8**. This design is one of multiple alternatives for homes adjacent to the Ten Mile Canal to maintain boat access to individual lots.

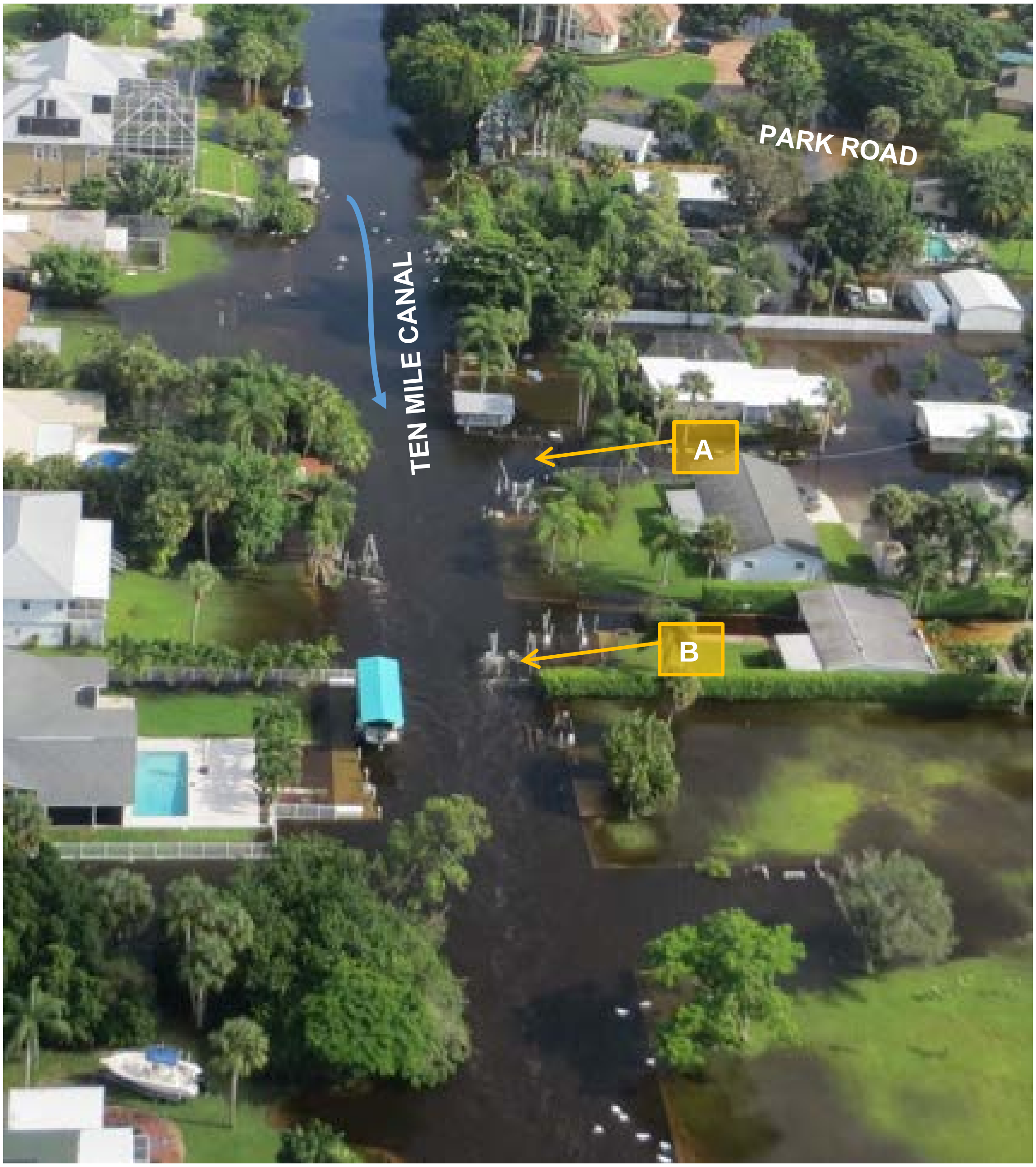


Figure 8 – A comparison of boat dock design alternatives. Location "A" is an example of an off-channel dock that is not causing a constriction in flow. Location "B" is an example of a dock with pilings in the main channel that are causing flow restrictions. Photograph taken by SFWMD on August 29, 2017.

Objectives

This project reduces flood stages in south Ten Mile Canal and the surrounding communities by diverting flow, controlling overflow, and improving the conveyance capacity of Ten Mile Canal.

Evaluation

Viability

Success of the flow diversion projects depends largely on the extent to which downstream conveyances are improved in order to handle the increased flows. The proposed berm improvements along the west bank of Ten Mile Canal are only recommended if combined with upstream flow diversion and/or downstream conveyance improvements in Ten Mile Canal. As a stand-alone project, it will likely only move a flooding problem from one neighborhood to another. Detailed modeling of the lower reach of Ten Mile Canal is required to quantify the reduction of flooding impacts due to the downstream conveyance improvements.

Community Considerations

Taken together, the proposed projects will benefit many communities both east and west of the canal. The proposed rehabilitation of the western portions of IDD Canals T and U will reduce flooding impacts in the Island Park Road community. The proposed widening of Ten Mile Canal and removal of boat docks currently within the primary flow channel may result in some homes that no longer have recreational boat access to the canal, unless provided by other means, and some homes may need to be removed altogether.

Environmental & Permitting Considerations

Many of the existing canals that discharge to tidal waters have mangroves growing on both banks. Restoration and/or widening of the canals will likely require mitigation of impacts to the existing plants. IDD canal restoration to the original design cross section within the existing canal ROWs would generally be considered a maintenance activity. However, the canals discharge directly to an Outstanding Florida Water and some of the proposed work area is within preserve and conservation lands, making this type of capacity restoration difficult. Access to some of the work areas is limited, compounding the effort needed to accomplish some of the projects.

The western portion of IDD Canal U was incorporated in the Island Park Regional Mitigation Area, in South Florida Water Management District (SFWMD) Environmental Resource Permit (ERP) Number 36-05430-P, issued in October 2005. This presents a legal and/or permitting challenge, as there are now two conflicting easements over the same area.

Land Availability

The original rights of way for IDD Canals J, K, and T stop approximately ¼ mile west of Ten Mile Canal. New drainage easements will need to be acquired by the County if these canals are used for flow diversion purposes out of Ten Mile Canal. New drainage easements may also be required for widening the Ten Mile Canal to 100 feet. Current existing legal validity of the original IDD Canal rights of way will need to be verified for any easement vacations that may have occurred.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements.

Table 2 – Opinion of Probable Cost breakdown, 1.4.2 Ten Mile Canal-South

Construction Costs

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 7,300,000	$ 7,300,000
Clearing & Grubbing	44	AC	$ 14,000	$ 616,000
Earthwork	203,310	CY	$ 10	$ 2,034,000
Dredging	133,008	CY	$ 75	$ 9,976,000
Weir Structure 1.4.2 E-1 (TMC Interconnect)	50	LF	$ 10,000	$ 500,000
Weir Structure 1.4.2 E-2 (SMCS Interconnect)	30	LF	$ 10,000	$ 300,000
Weir Structure 1.4.2 E-3 (J. Bay Redesign)	50	LF	$ 10,000	$ 500,000
Weir Structure 1.4.2 F (Canal K Interconnect)	30	LF	$ 10,000	$ 300,000
Weir Structure 1.4.2 i (Canal T Interconnect)	30	LF	$ 10,000	$ 300,000
Culvert-RCP 42"	100	LF	$ 160	$ 16,000
Culvert-RCP 48"	1,345	LF	$ 215	$ 290,000
Culvert-RCP 72"	700	LF	$ 435	$ 305,000
Pumps (25 cfs)	2	EA	$ 310,000	$ 620,000
Pumps (50 cfs)	12	EA	$ 700,000	$ 8,400,000
Seawall	10,890	LF	$ 850	$ 9,257,000
Regrade Ex. Boat Ramps	3	LS	$ 30,500	$ 92,000
Remove/Redesign Ex. Boat Docks	50	EA	$ 15,000	$ 750,000
Permanent Erosion Control	38,260	SF	$ 20	$ 766,000
Grassing	64,160	SY	$ 3	$ 193,000
			Conceptual Construction Costs:	**$ 42,600,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 12,780,000
			Land Acquisition	$ 2,431,150
			Project Administration/ CEI (10%)	$ 4,260,000
			Conceptual Project Cost:	**$ 62,100,000**
			Contengency (30%)	$ 18,600,000
			Conceptual Project Cost (with Contengency):	**$ 80,700,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

The diversion and conveyance improvement projects also may enable the ability to construct other improvement further up in the watershed without causing increased flood stages in the lower watershed. This project helps restore some of the historical flows that previously reached Hendry Creek from Six Mile Cypress Slough, prior to the construction of Ten Mile Canal.

An added benefit to the proposed conveyance between Ten Mile Canal and the upstream end of IDD Canal K (which begins at the west ROW edge of US 41) is that it can serve the industrial areas that were impacted by flooding after Hurricane Irma. Additional flows down IDD Canal T can have a secondary benefit of providing additional hydration to the northeast corner of the Island Park Regional Mitigation Area, permitted by SFWMD ERP Number 36-05430-P.

Other Considerations

The Royal Woods community experienced some of the worst impacts of flooding from the late August and Hurricane Irma events in 2017, in terms of the density of FEMA flood claims. The community is uniquely positioned and boxed in by newer, and higher, developments on all sides. A new entry roadway was constructed to the development to the west and the previously-open IDD Canal U is now a piped system, limiting the ability for Royal Woods to discharge runoff as they have in the past. Several solutions are proposed to alleviate the flooding impacts in the community, including the construction of a pumped discharge system with associated controls and discharge piping to the previous IDD Canal U.

Findings & Recommendations

Regional Modeling Findings

The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.2 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. Modeled results demonstrating the water levels and discharges over time are included for the following design storm events:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.2 (b-c) EXHIBIT 1.4.2 (d-e)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.2 (f-g) EXHIBIT 1.4.2 (h-i)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.2 (j-k) EXHIBIT 1.4.2 (l-m)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.4.2 (n-o) EXHIBIT 1.4.2 (p-q)

At the Ten Mile Canal crossing of US 41, the model output showed a reduction in peak stage, reduction in peak flow, and reduction in total flow volume of Ten Mile Canal. The increase in peak stages and/or water levels exceeding the top of bank elevations of the western receiving canals that received higher inflows demonstrates the need for additional detailed local modeling of the proposed conveyance improvements. Maintenance cleaning was shown to reduce the peak stage in Canal U. The noise depicted in the proposed conditions in some of the water level output graphs when the water level is near elevation 0 feet is due to daily tidal fluctuations.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes of reducing the peak flood stage and duration in the southern end of Ten Mile Canal. The positive improvements of this project concept warrant further development of all aspects of the project, particularly when paired with the improvements described in 1.4.1. For simplicity, the conceptual model utilized only pumps for flow diversions and did not incorporate advanced weir control features. With the approximate design flows and stages developed in this regional modeling effort, additional local modeling will be needed to refine the flows, stages, and designs of the downstream conveyance modifications, gate sizes and elevations, and pump setpoints. Further refinements are also needed to the model to limit increases in downstream stages in the receiving canals and other observed issues with the model output results. It is recommended that all proposed pumps include a VFD for better control of flow and to reduce the number of starts and stops of the pumps. All proposed gates should be automated with telemetry-controlled gates for greater operational flexibility. These refinements will likely not significantly affect the overall results.

Based on the regional modeling, the preliminary recommended flow diversion out of Six Mile Cypress Slough into IDD Canal J is 200 cfs. The recommended flow diversion out of Ten Mile Canal into IDD Canal J is also 200 cfs, for a total combined inflow rate of 400 cfs from the two watersheds. The recommended flow diversion out of Ten Mile Canal into IDD Canal K is up to 200 cfs, and into Canal T is up to 50 cfs. For the greatest benefit, the projects described in 1.4.2 should be constructed along with the projects in 1.4.1, described previously.

The model output highlighted the need for a detailed analysis of the existing conveyance capacities of IDD Canal K and Canal T, as was done for Canal J in Section 4.1 of this report. It is likely that downstream conveyance improvements will be required for all conveyances, including canal widening and deepening at select locations, redesign of existing weirs, and canal bank stabilization. The model output also emphasized the need for careful management of the flows at the diversion points to ensure flows are not being discharged into the western canals until after the canals have recovered from the storm event.

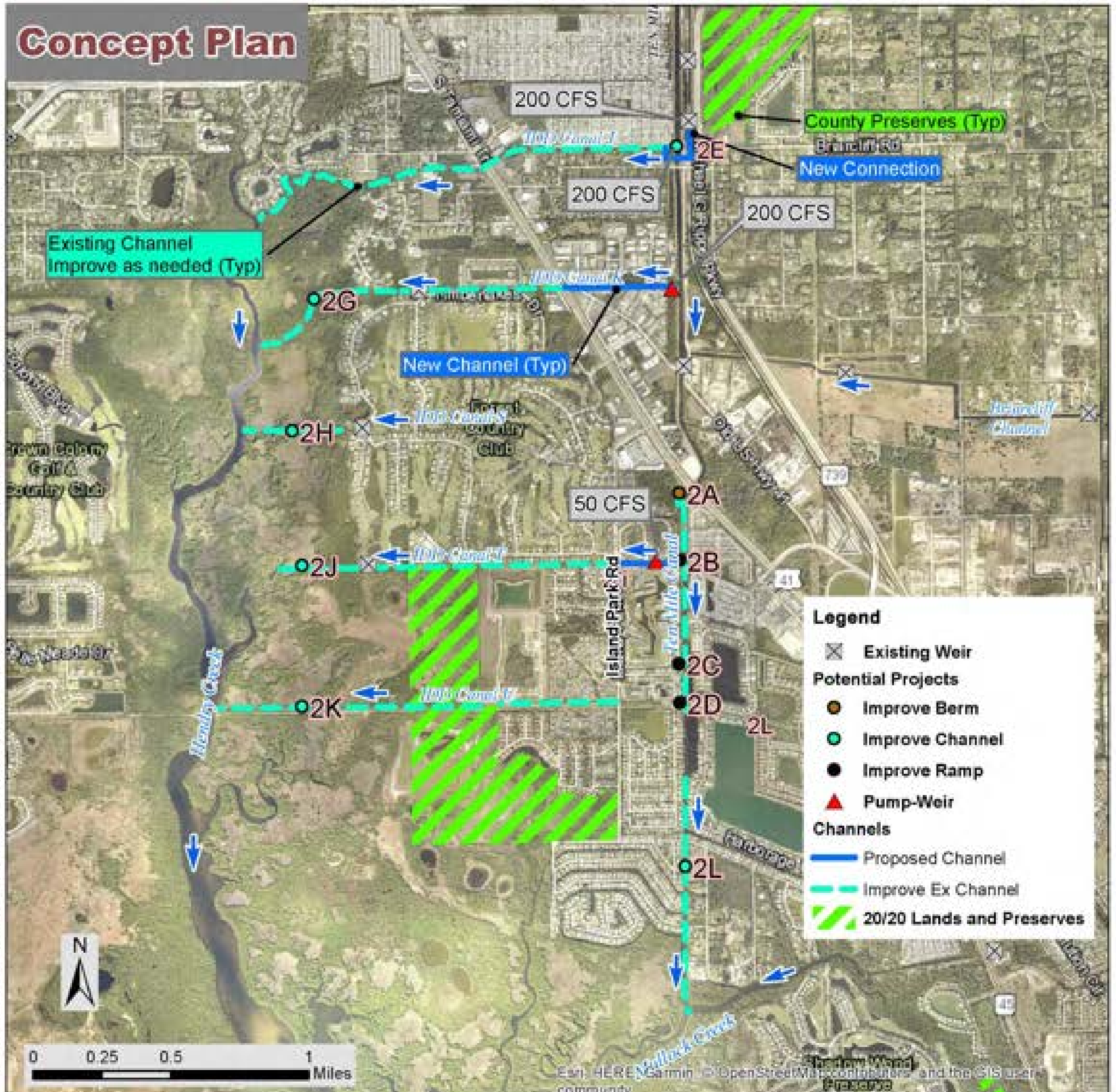
It is recommended Lee County maintenance staff continue to perform routine maintenance in the portions of the IDD canals that are adjacent to developed lands. Maintenance clearing and dredging of the IDD canals to Hendry Creek is also recommended to significantly improve the conveyance capacities of the canals, particularly IDD Canal U.

Restoration is recommended for the west berm of Ten Mile Canal south of US 41. The three existing boat ramps should be modified to raise the peak elevation of the ramps or removed altogether, if acceptable to the adjacent communities. The west berm also should be reconstructed adjacent to an undeveloped parcel immediately downstream from US 41. Closing these breaches minimizes potential routes for water to overflow out the Ten Mile Canal into the Island Park Road area.

The County has initiated maintenance dredging of sediment buildup in the southern portion of Ten Mile Canal. In addition to this work, further conveyance capacity is needed downstream of US 41 to reduce flooding impacts from major storm events, as described in the local modeling section of this report.

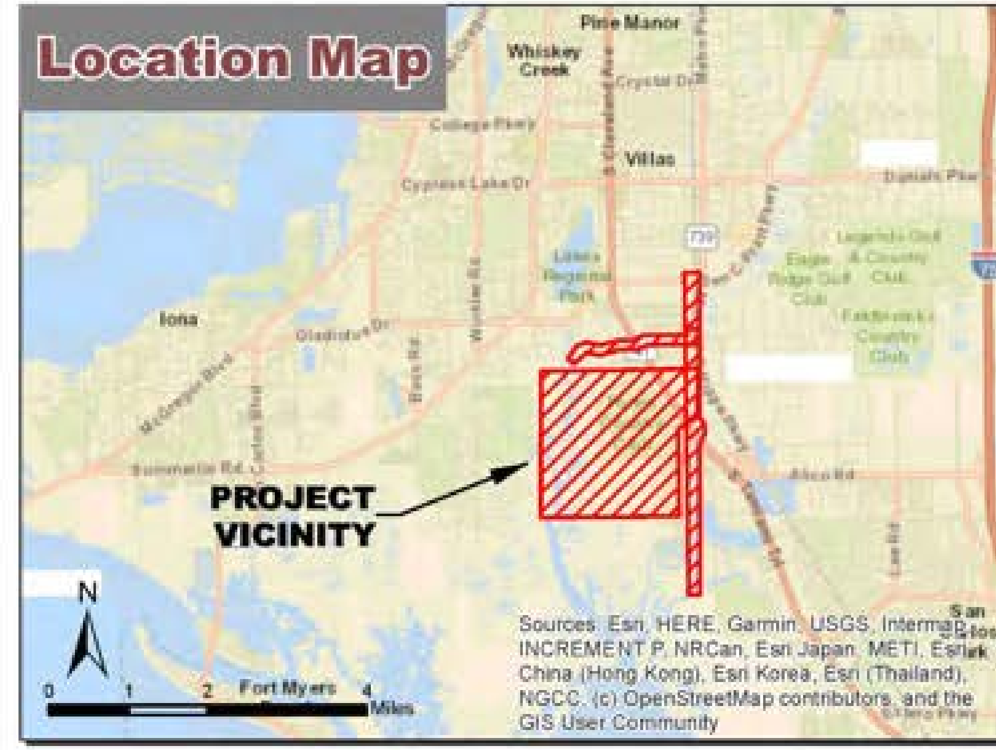
It is recommended the existing boat docks within the channel of Ten Mile Canal be removed and replaced with a different form of access, particularly in the canal sections that are narrower than 100 feet. As shown in **Figure 8**, some homes adjacent to the Ten Mile Canal already have off-channel docking/storage for their boats that do not impede flow. This design is one of multiple alternatives for homes adjacent to the Ten Mile Canal to maintain boat access to individual lots.

Concept Plan



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Location Map



Project Narrative

DESCRIPTION: Prior to the construction of Ten Mile Canal, Hendry Creek was hydrologically connected to Six Mile Cypress Slough. This project partially restores this connection using a series of interrelated projects to divert flows out of the Ten Mile Canal and Six Mile Crpress Slough to Hendry Creek via IDD Canals K, J, and T. The project also proposes to restore the Ten Mile Canal west berm in the Island Park Road area, improve existing IDD canals west of Island Park Road and improve the conveyance capacity of the southern end of Ten Mile Canal.

PURPOSE: This project reduces high-flow contributions to south Ten Mile Canal and improves the conveyance capacity of Ten Mile Canal, while partially restoring historical flows to Hendry Creek.

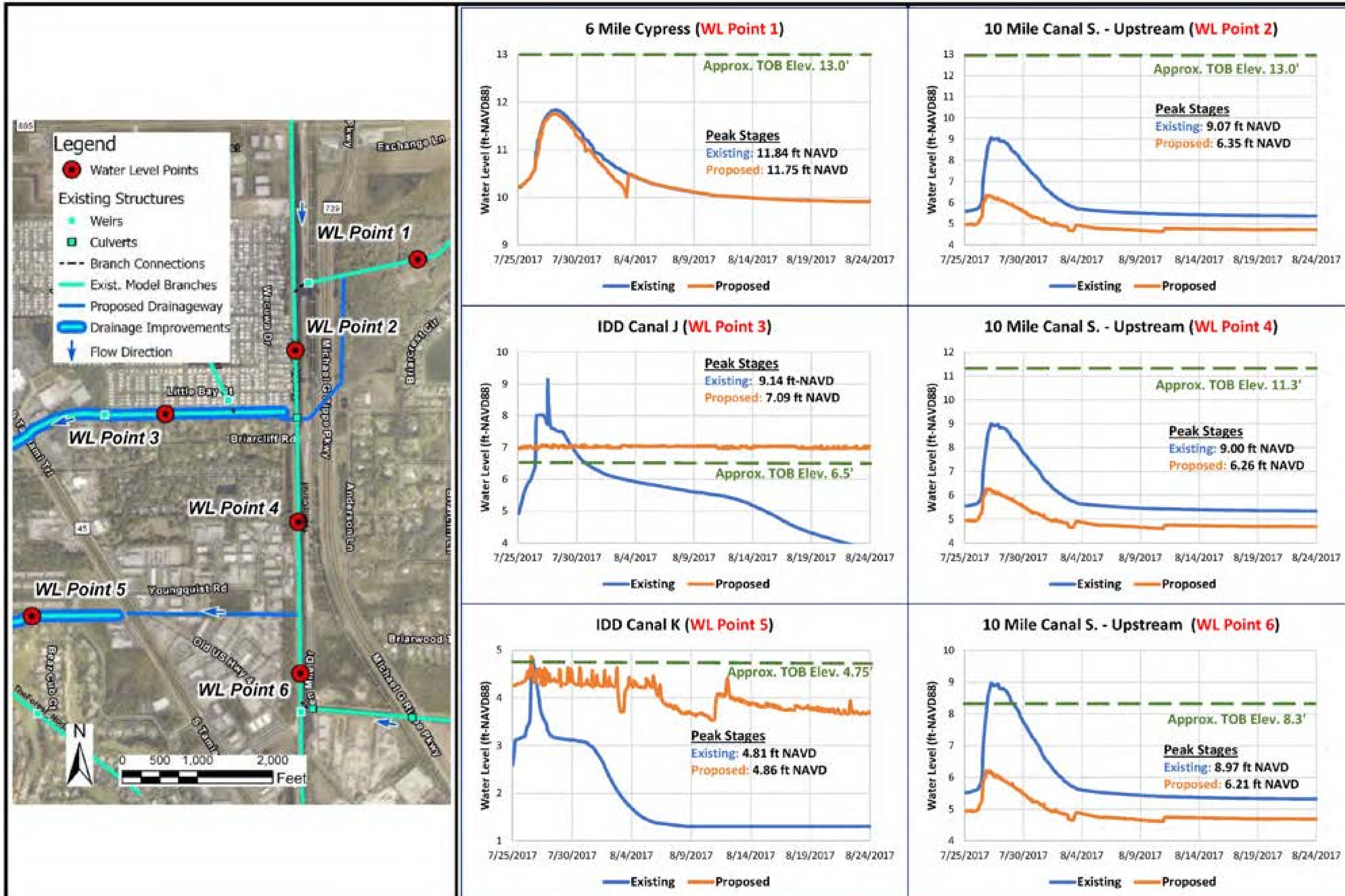
CONSTRAINTS: The conveyance capacity of the IDD canals will need to be increased to accept the diverted flow, which will potentially require the acquisition of drainage easements. Improving the conveyance at the south end of Ten Mile Canal will be expensive. To restore the Ten Mile Canal west berm, work may require acquisition of construction easements.

MAY 2020

Ten Mile Canal South \ Island Park Rd
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.2 (a)

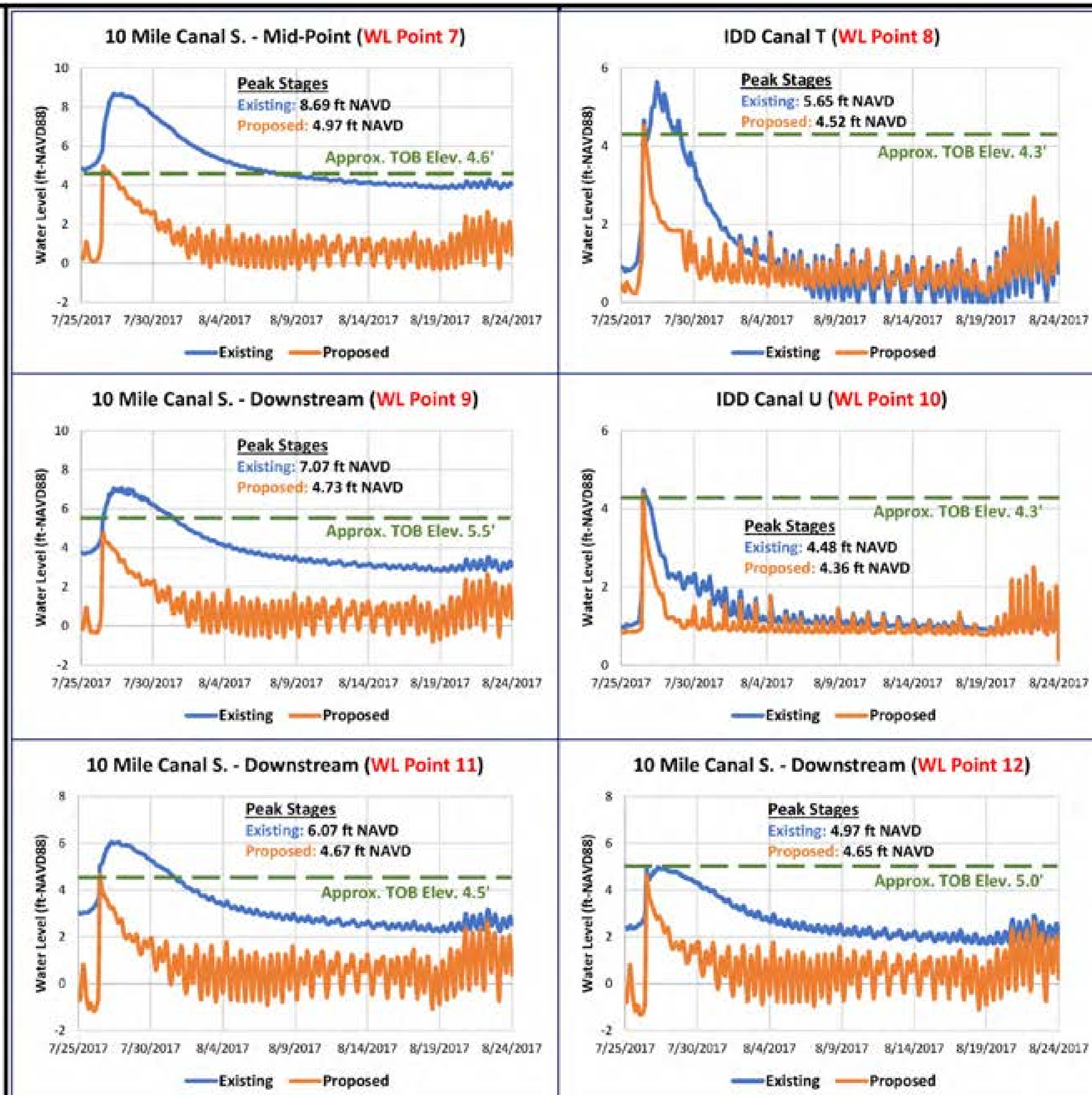


1.4.2 Ten Mile Canal-South

Water Level(s)

25-yr
3-day
(Jul Start)

EXHIBIT 1.4.2 (b)



1.4.2 Ten Mile Canal-South

Water Level(s)

25-yr 3-day (Jul Start)

EXHIBIT 1.4.2 (c)

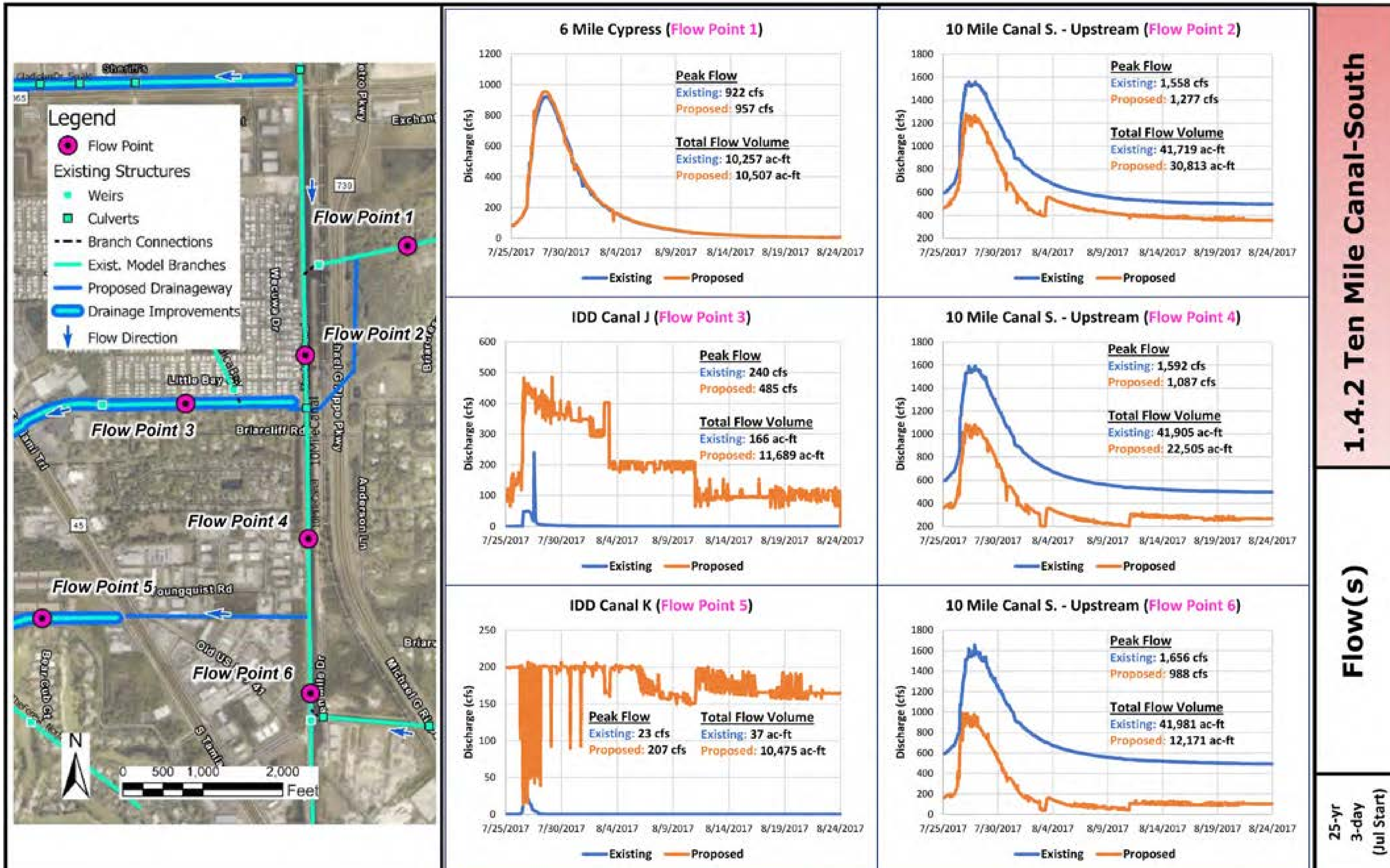
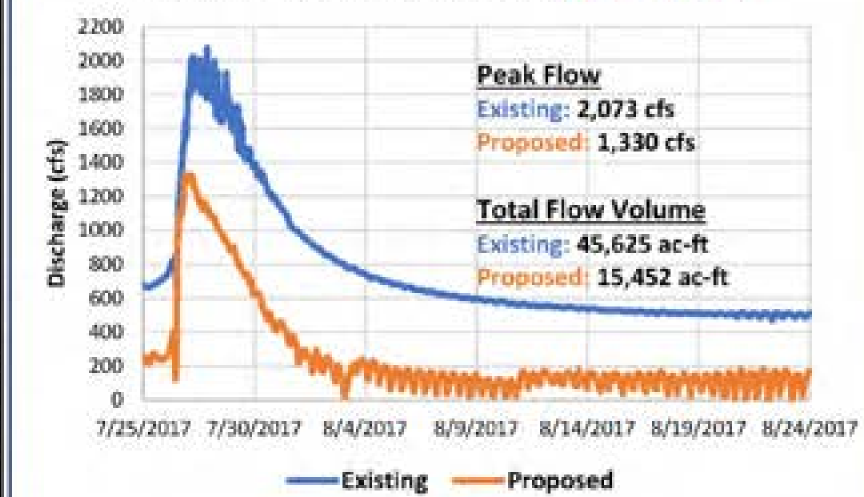
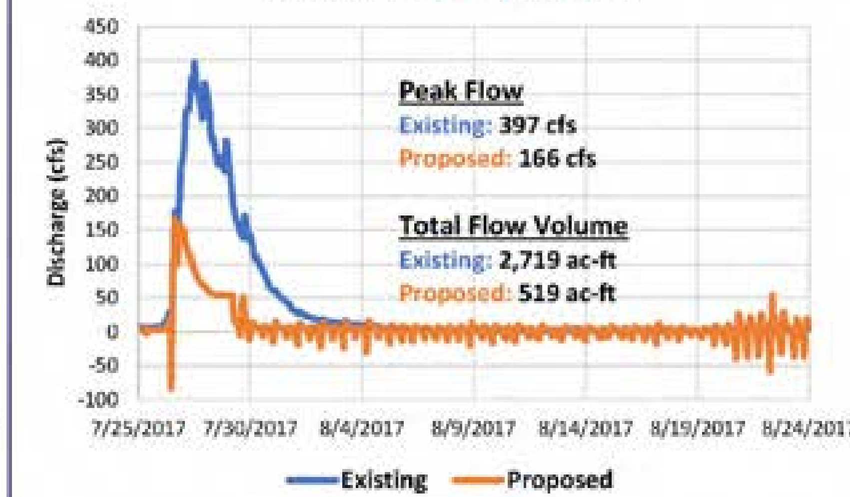


EXHIBIT 1.4.2 (d)

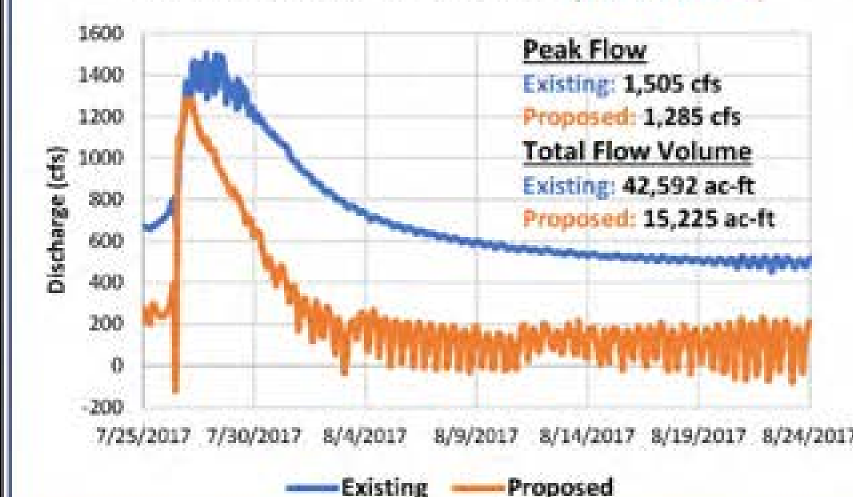
10 Mile Canal S. - Mid-Point (Flow Point 7)



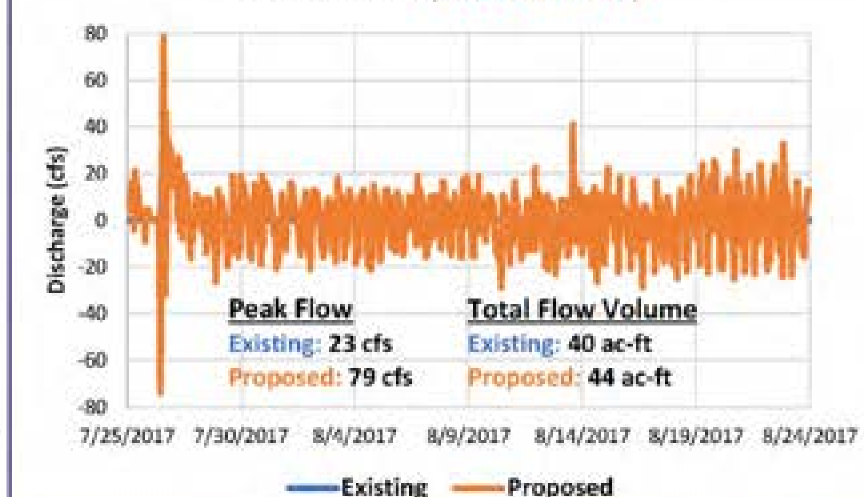
IDD Canal T (Flow Point 8)



10 Mile Canal S. - Downstream (Flow Point 9)



IDD Canal U (Flow Point 10)



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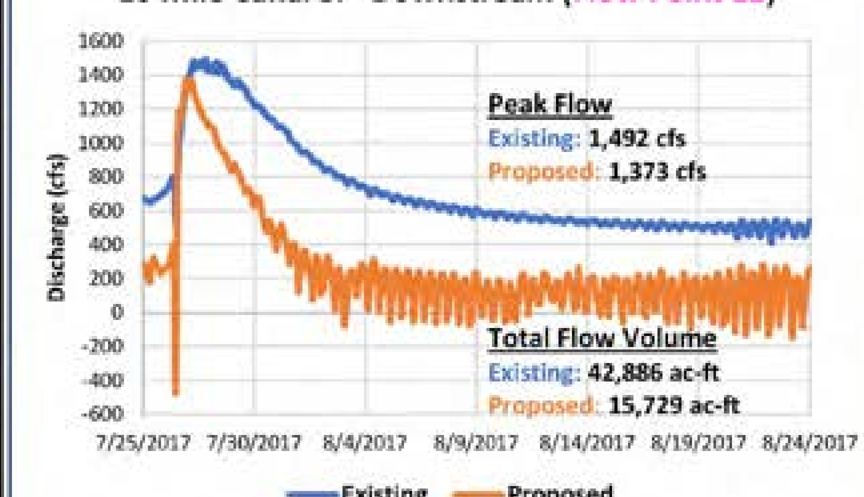
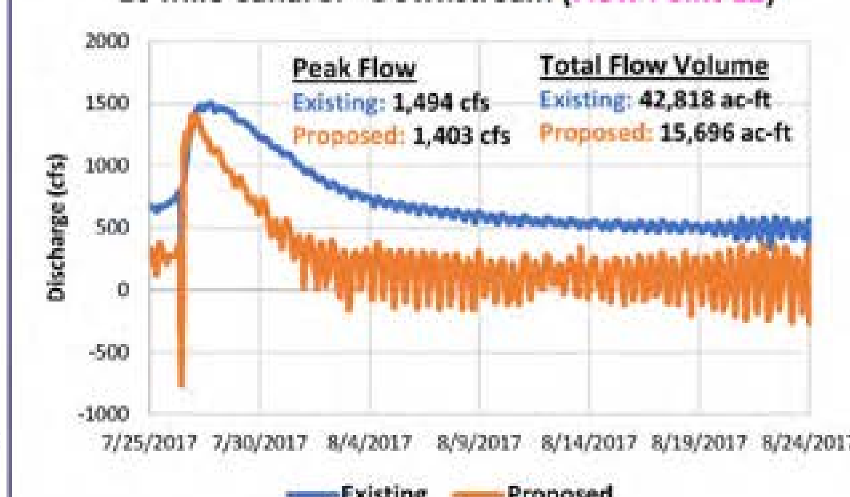


10 Mile Canal S. - Downstream (Flow Point 12)

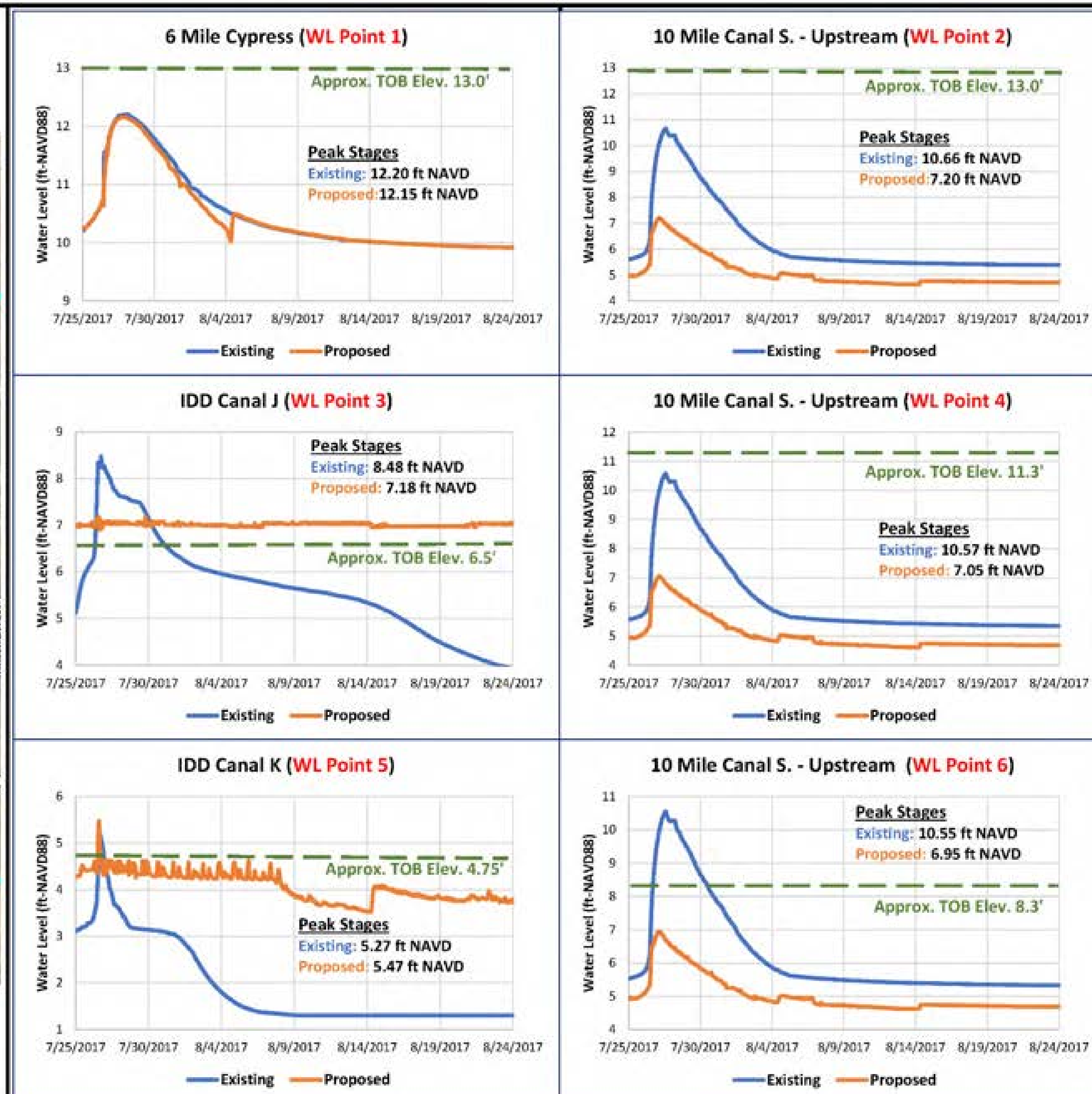


1.4.2 Ten Mile Canal-South

Flow(s)

25-yr
3-day
(Jul Start)

EXHIBIT 1.4.2 (e)



1.4.2 Ten Mile Canal-South

Water Level(s)

100-yr
3-day
(Jul Start)

EXHIBIT 1.4.2 (f)

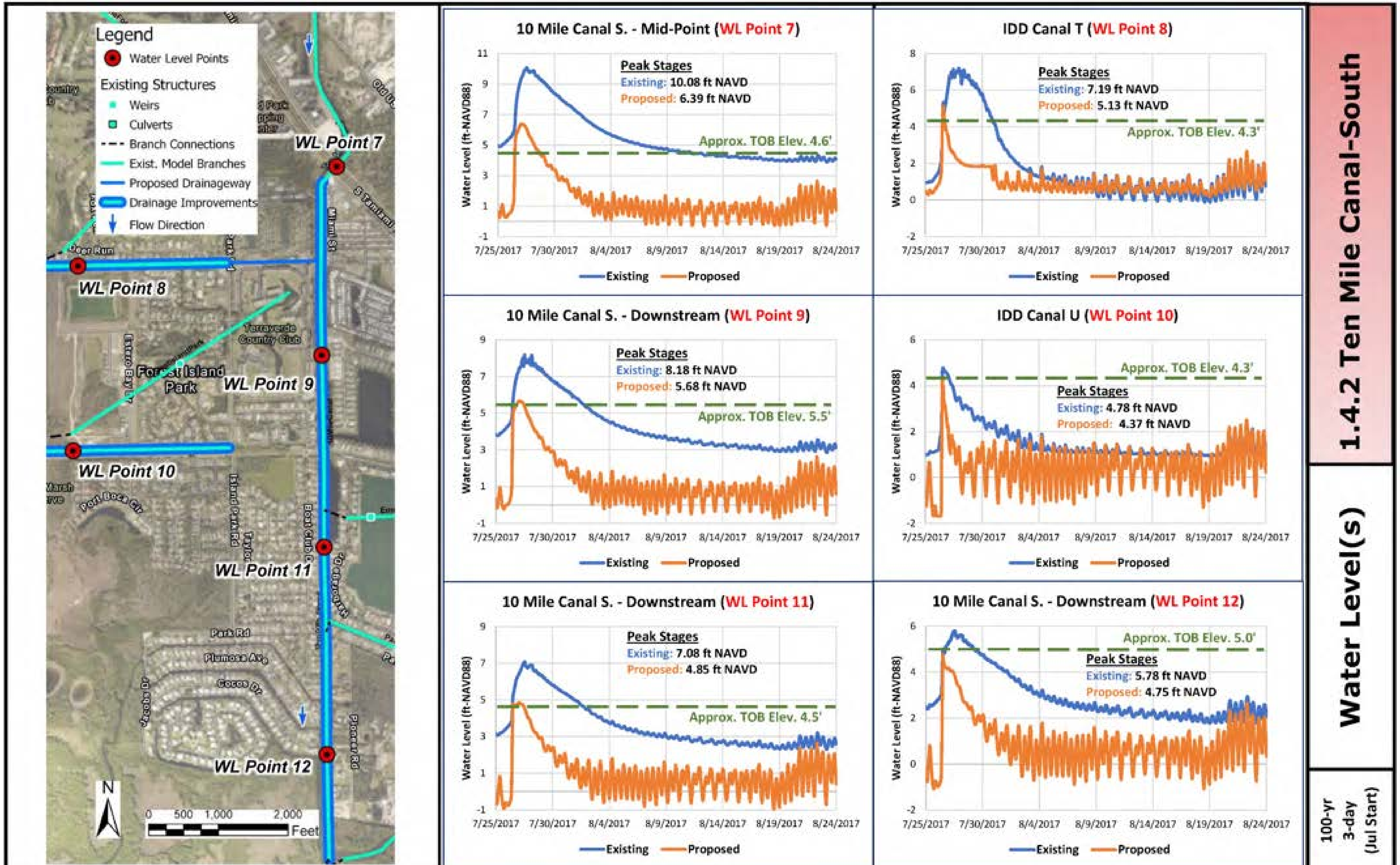
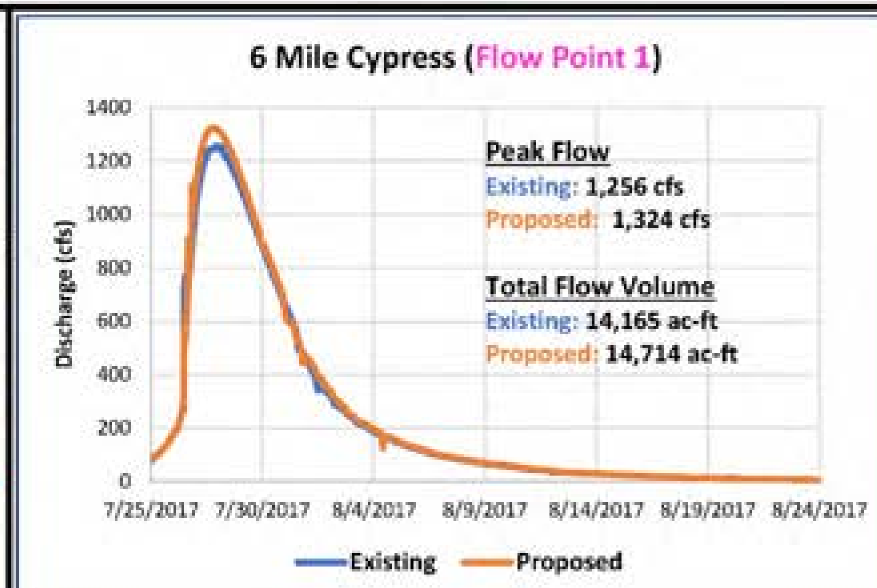


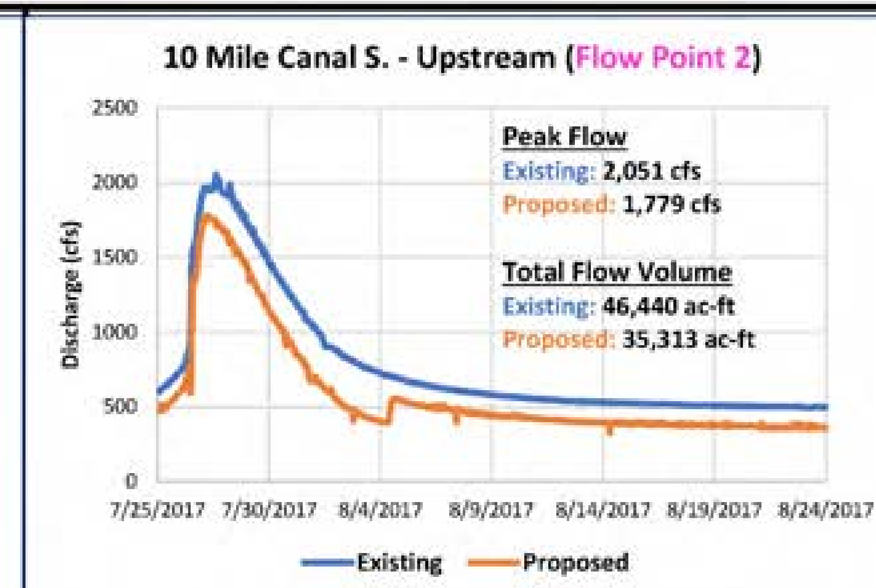
EXHIBIT 1.4.2 (g)

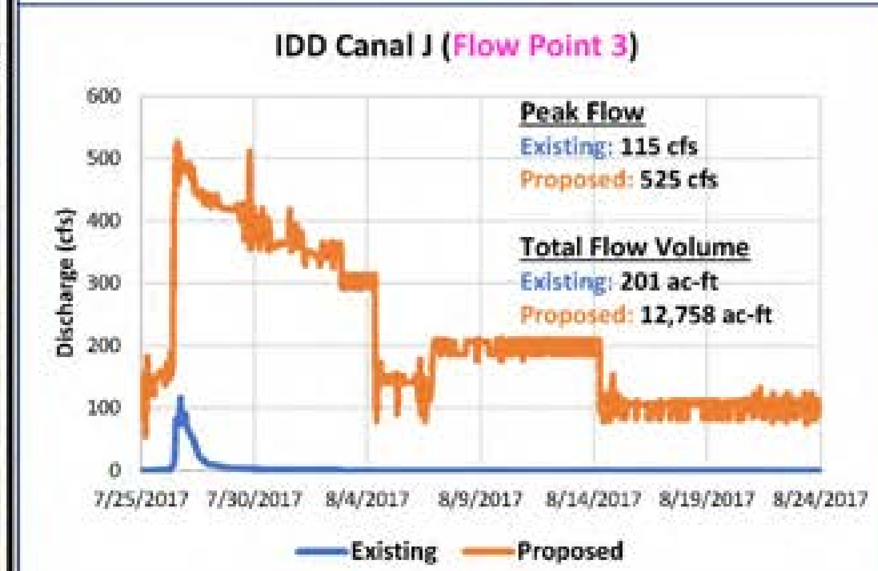
1.4.2 Ten Mile Canal-South

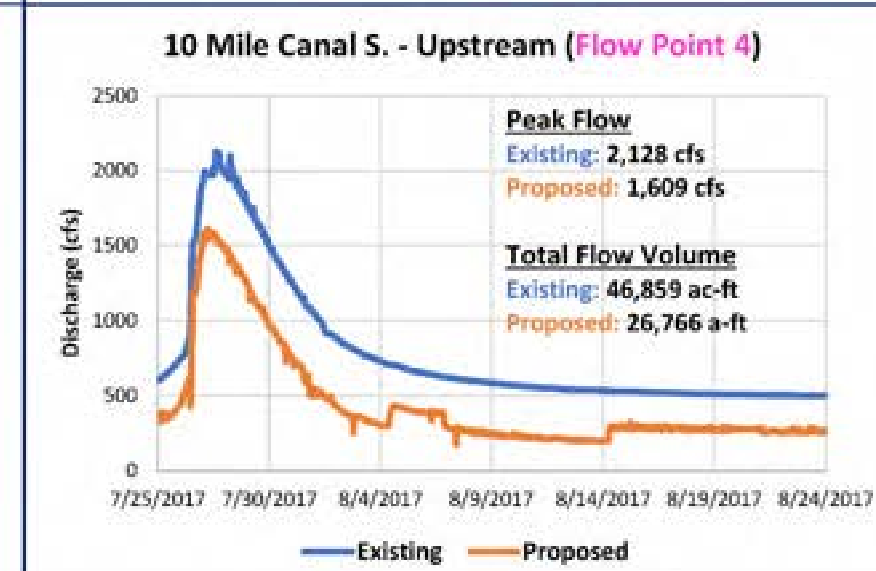
Flow(s)

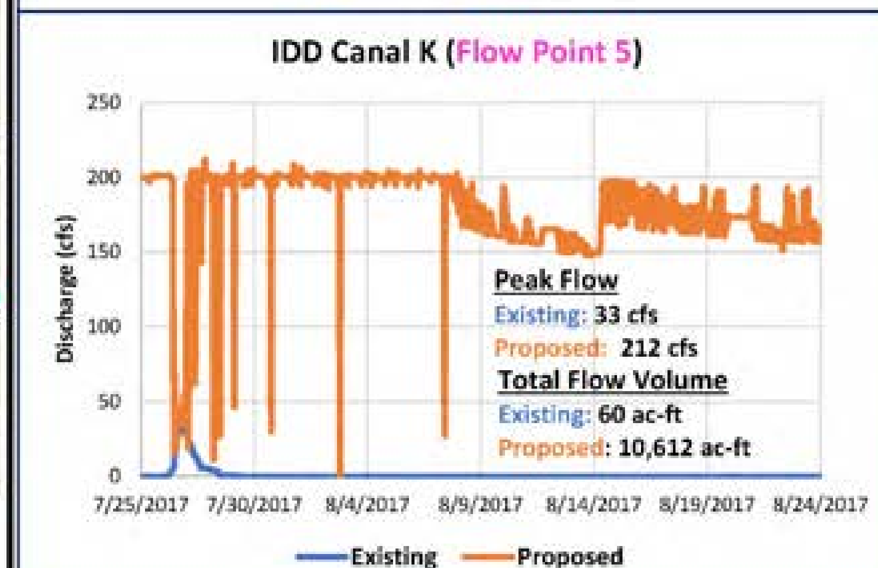
100-yr 3-day (Jul Start)

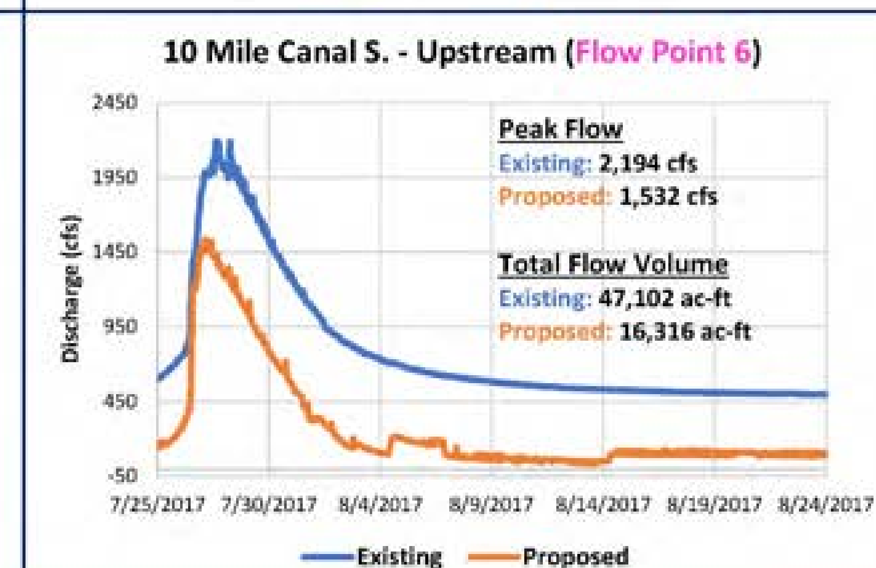












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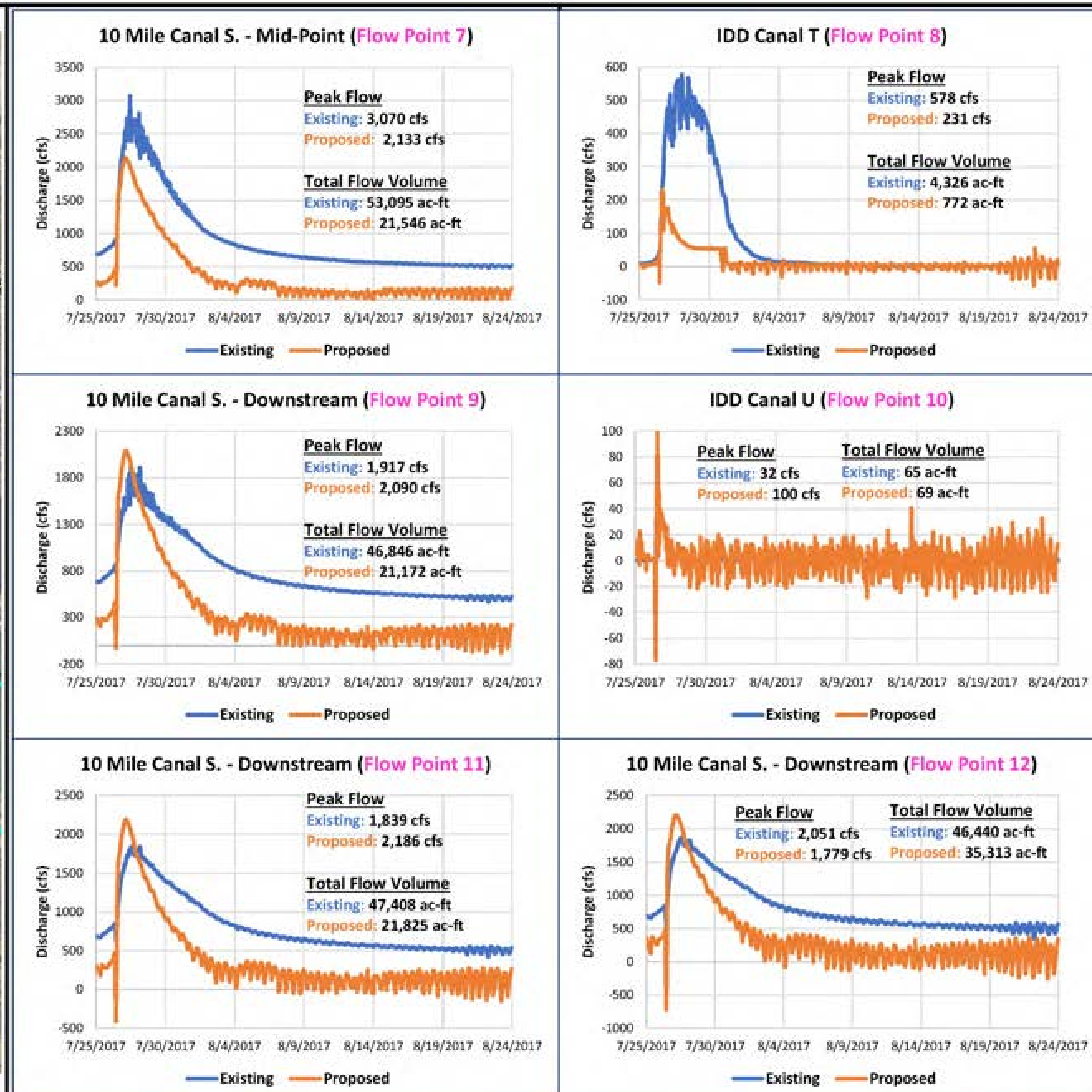
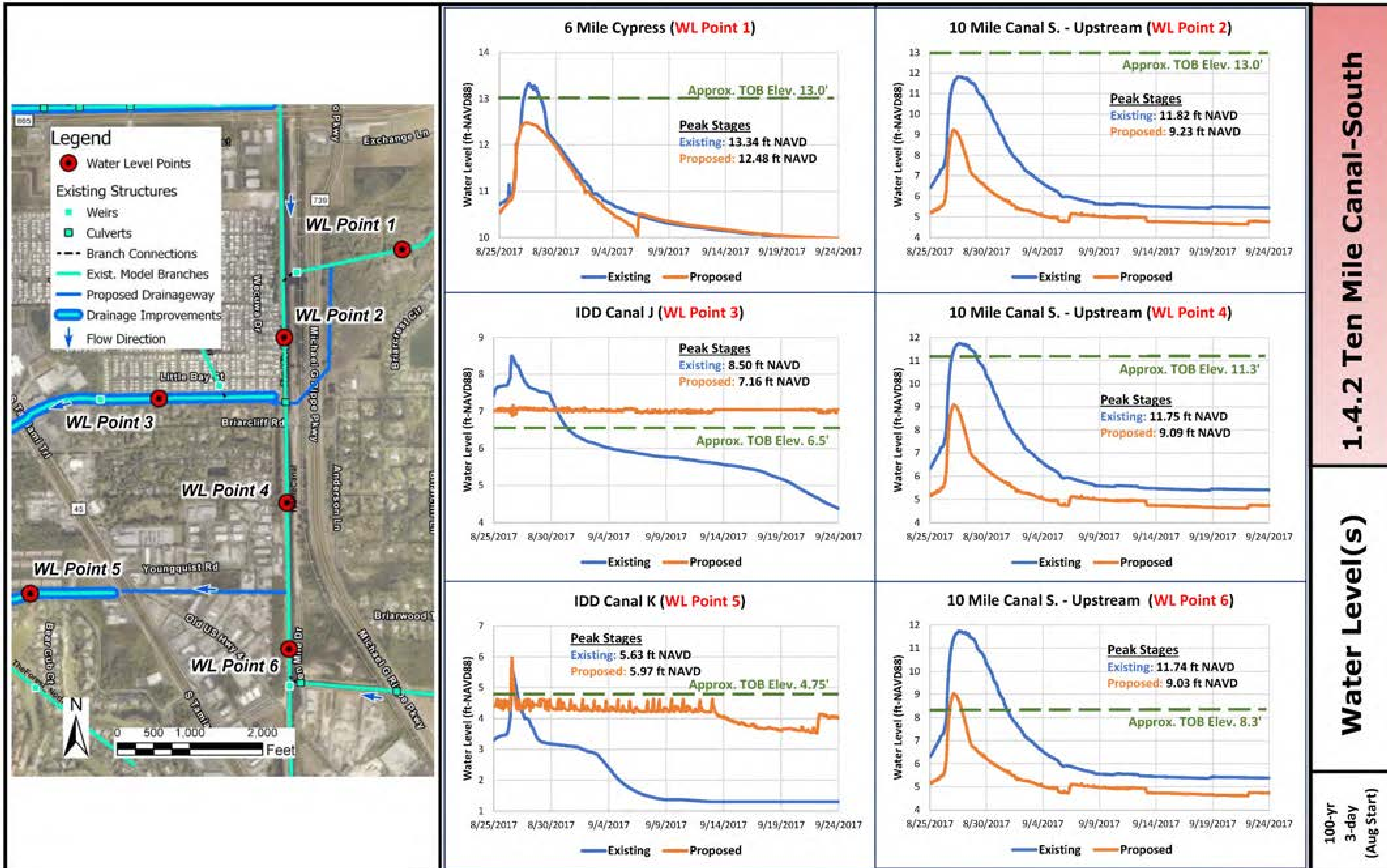


1.4.2 Ten Mile Canal-South

Flow(s)

100-yr
3-day
(Jul Start)

EXHIBIT 1.4.2 (i)



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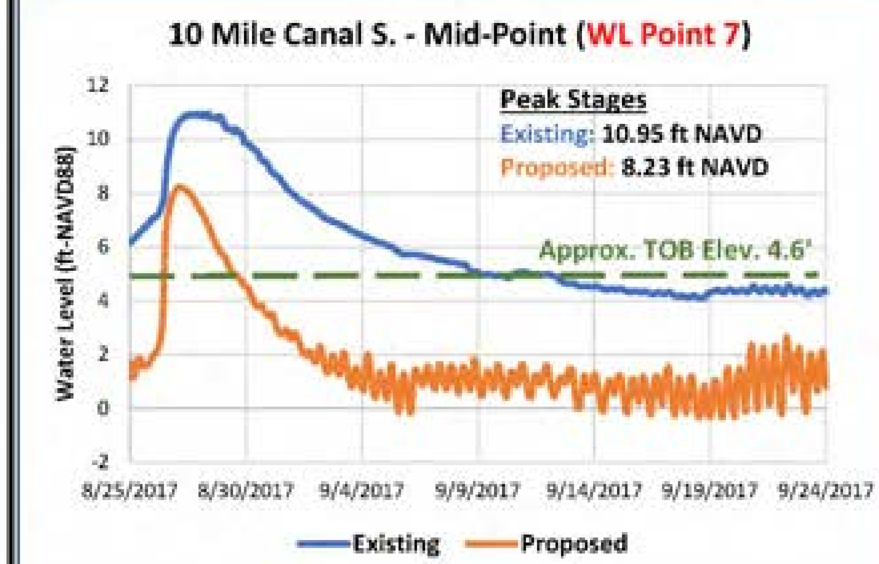
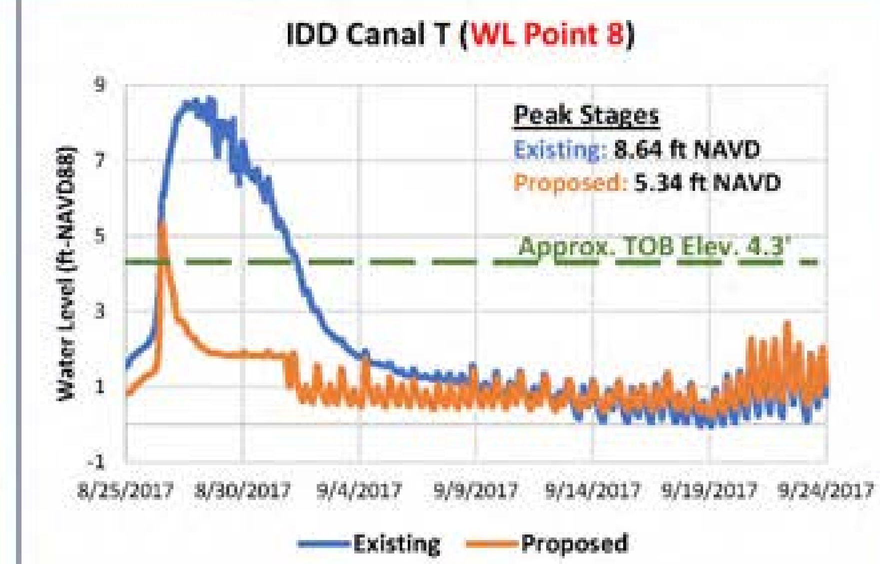
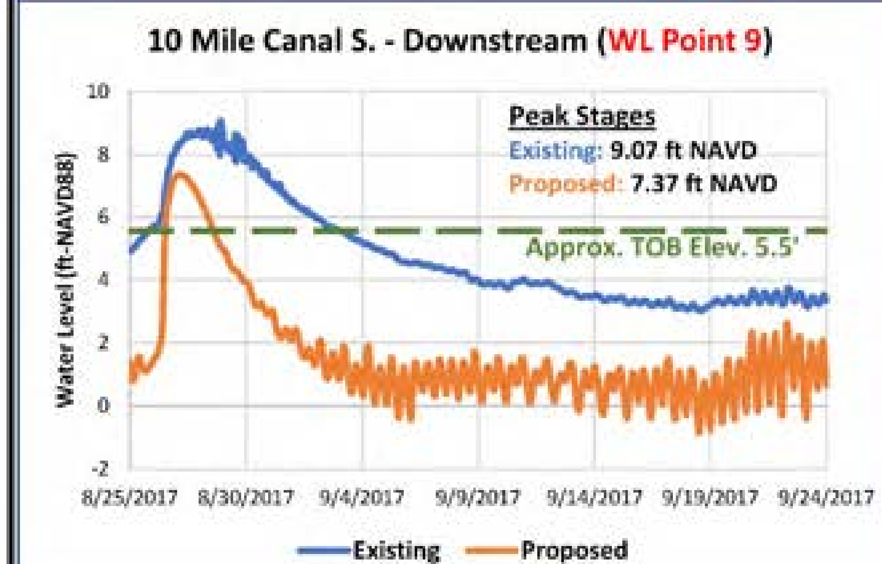
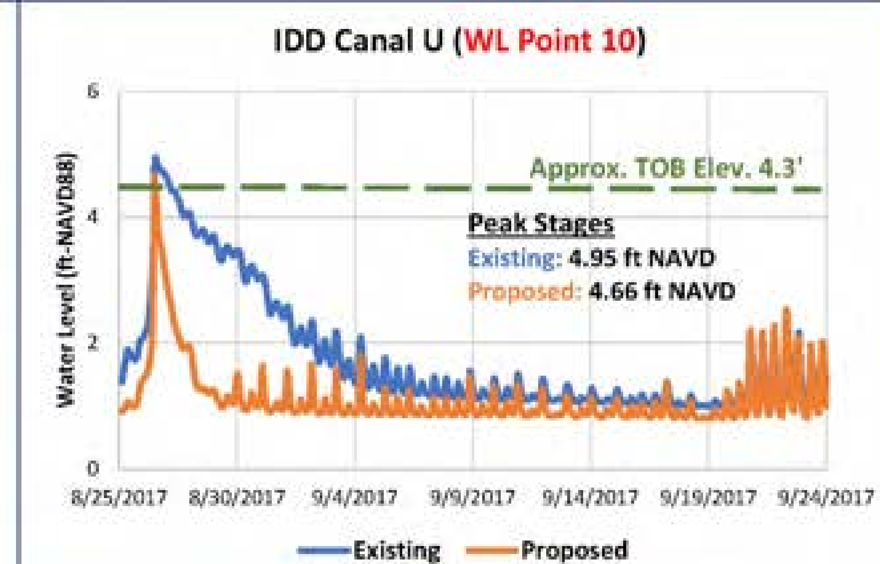
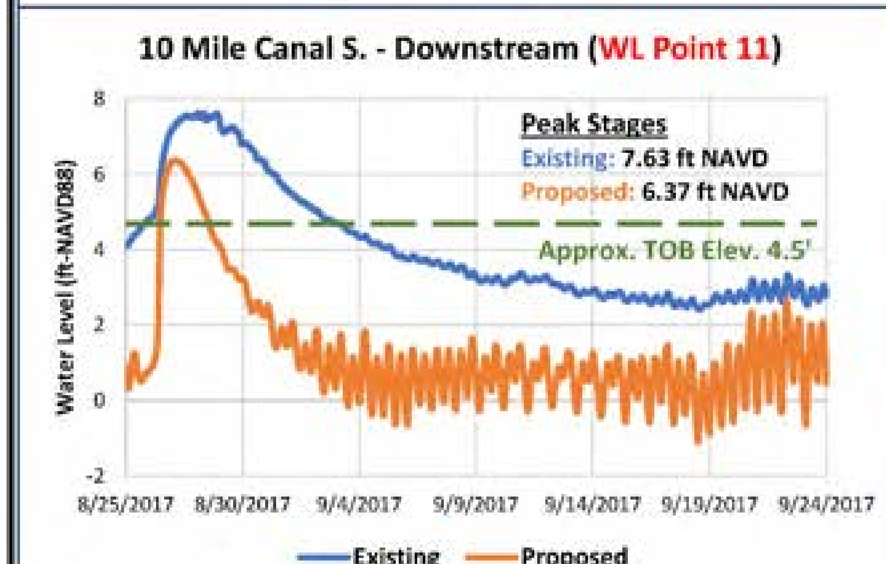
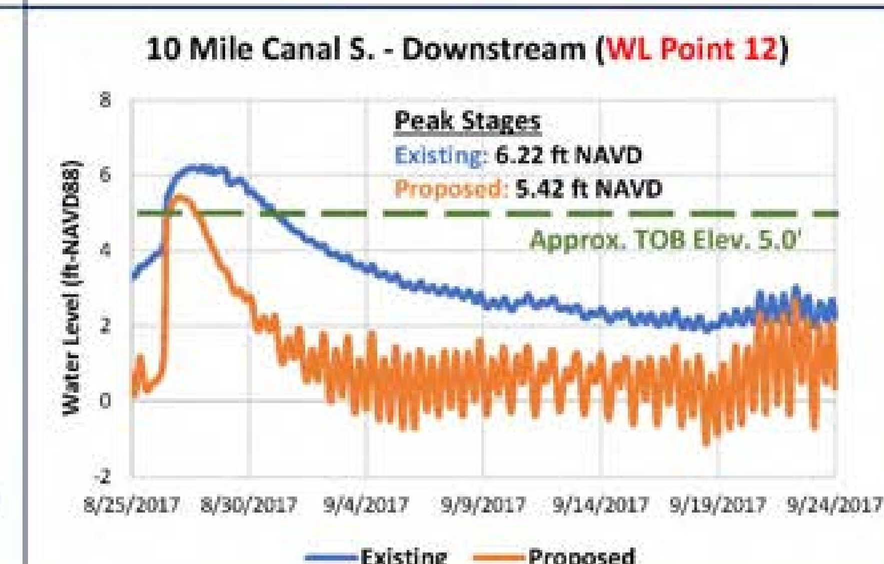










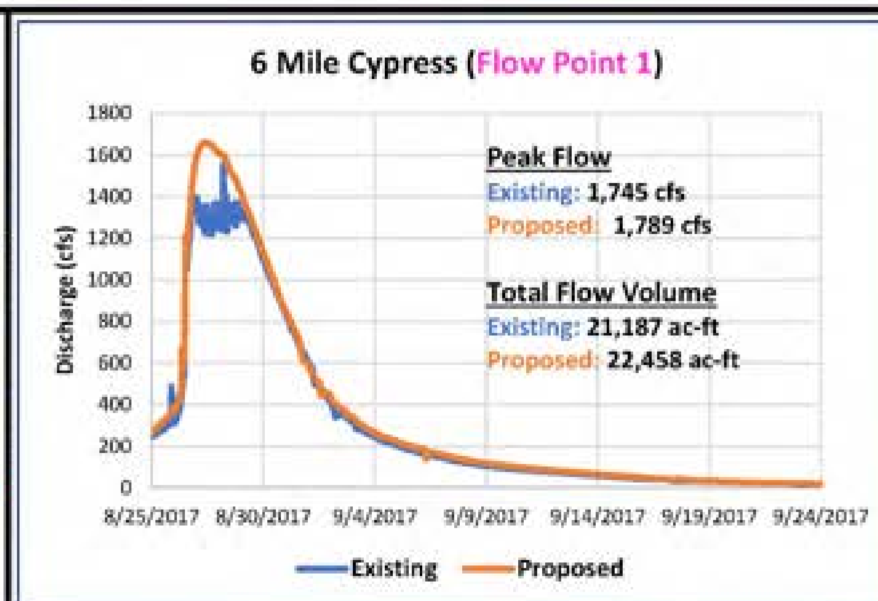


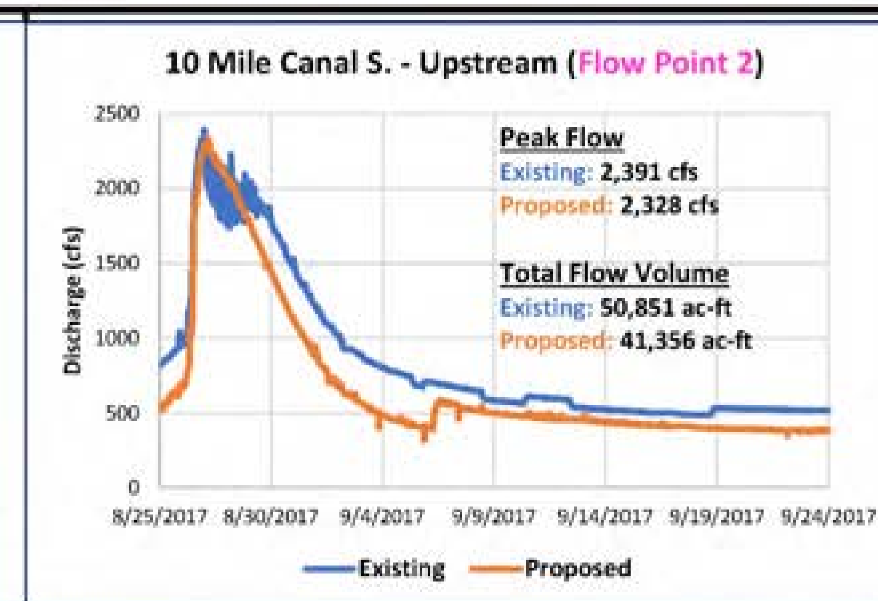
1.4.2 Ten Mile Canal-South

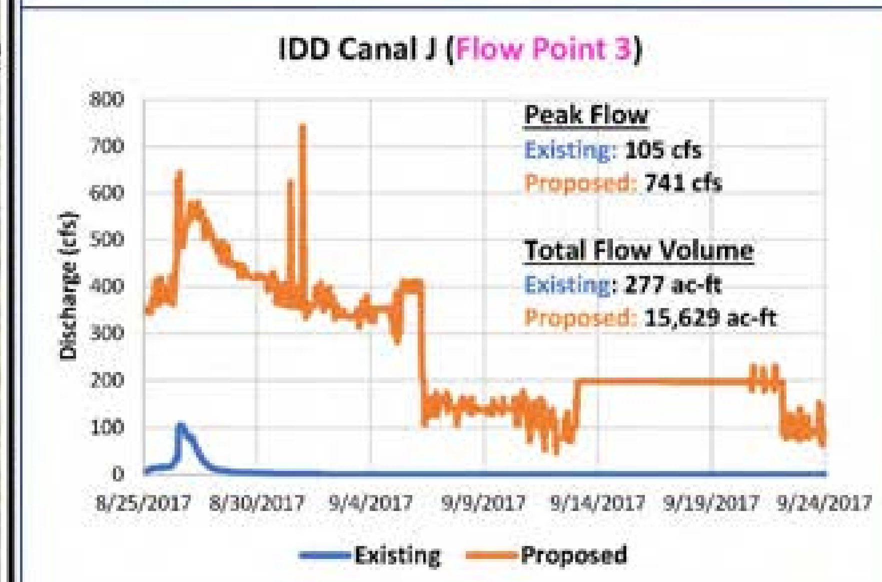
Water Level(s)

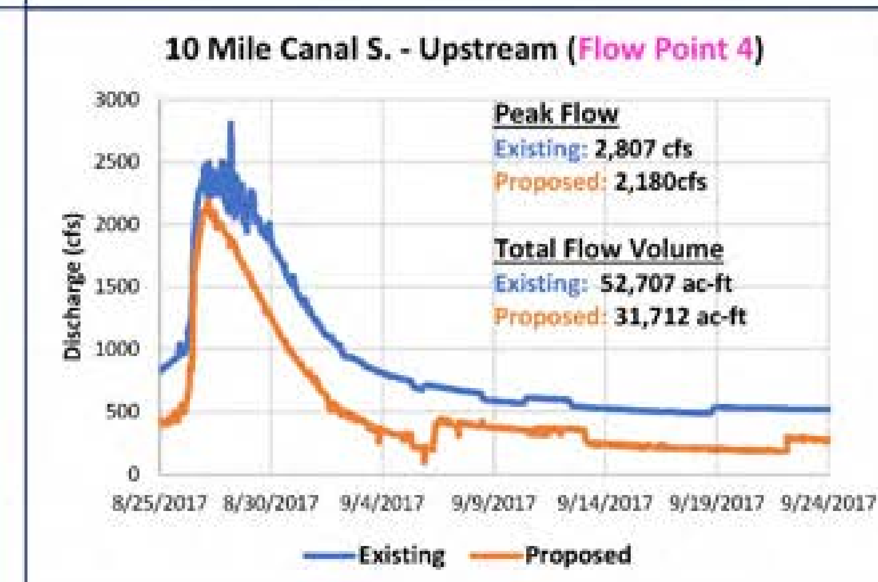
100-yr
3-day
(Aug Start)

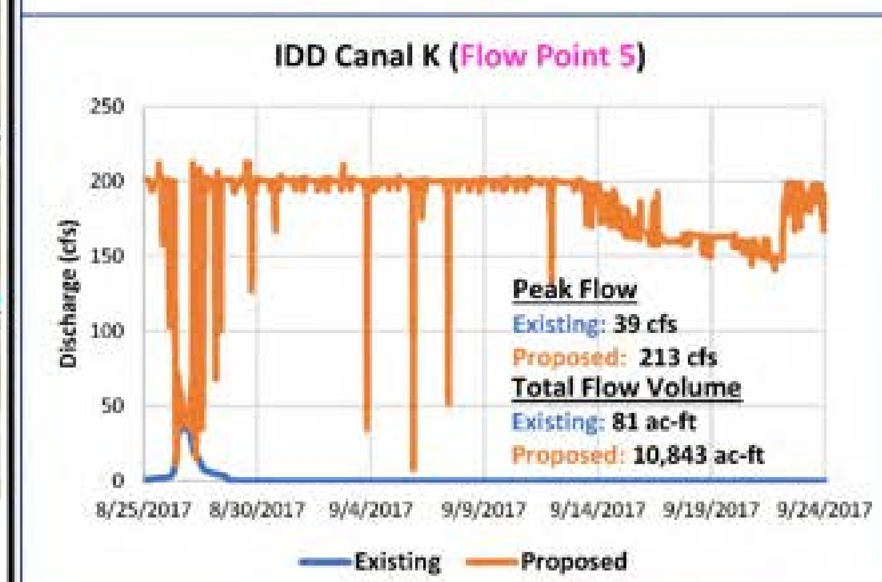
EXHIBIT 1.4.2 (k)

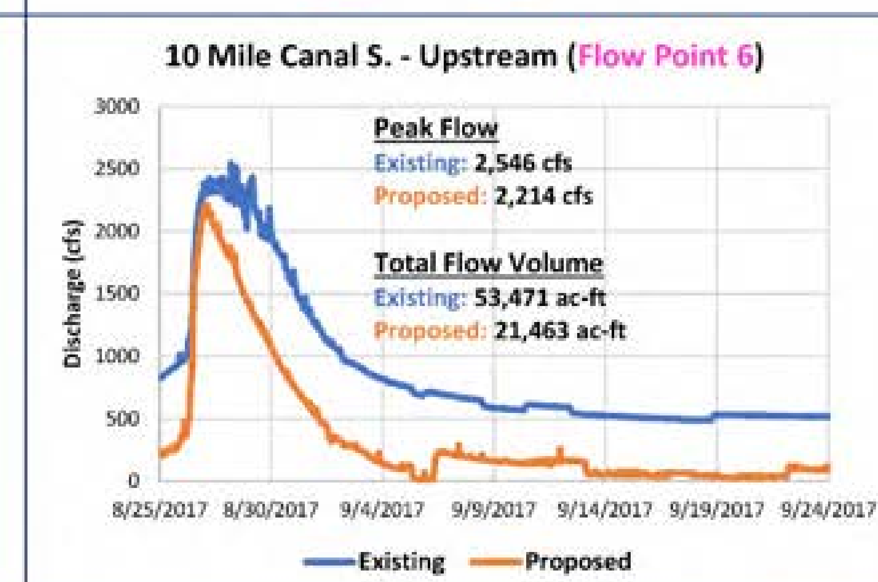










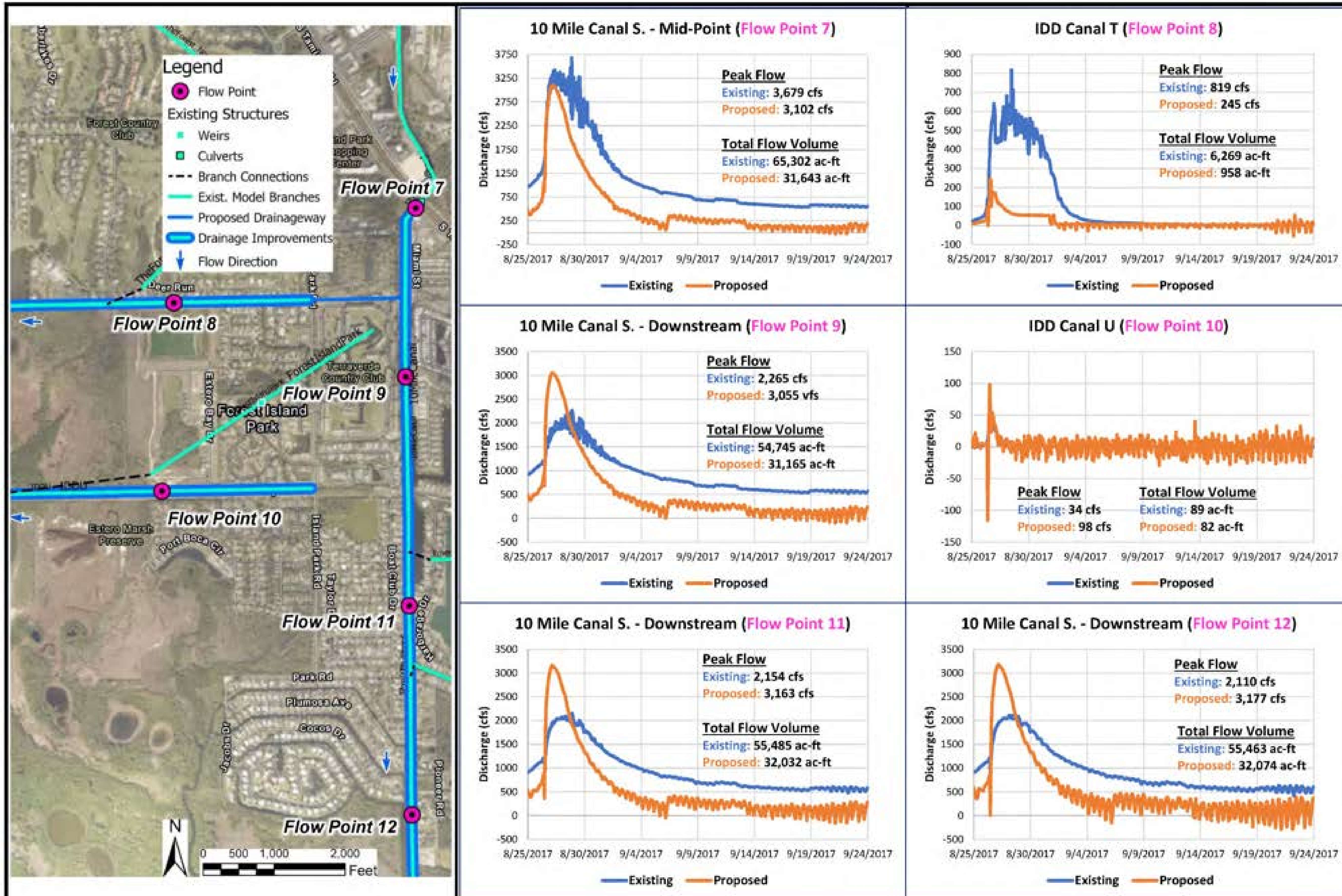


1.4.2 Ten Mile Canal-South

Flow(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.4.2 (I)

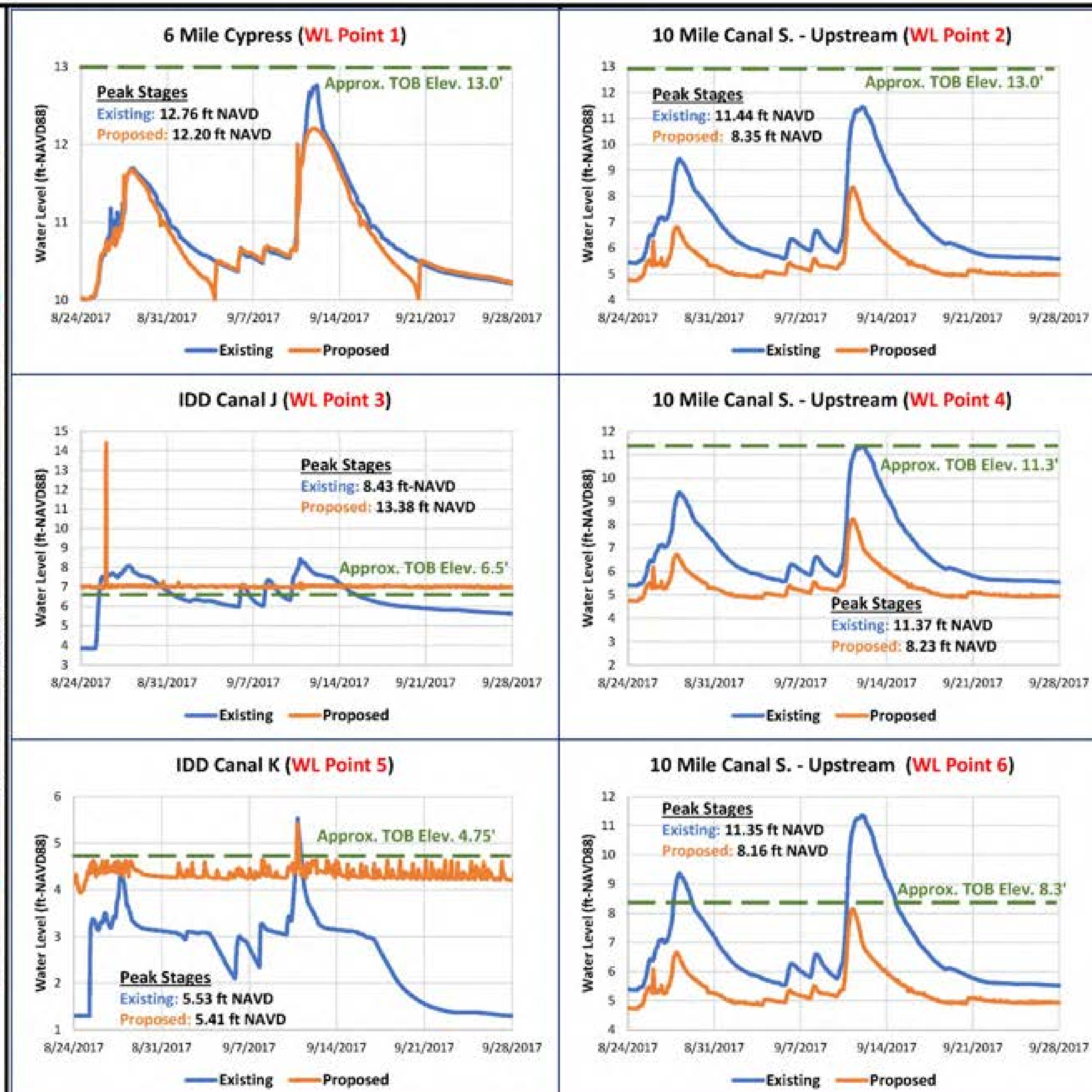


1.4.2 Ten Mile Canal-South

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.4.2 (m)

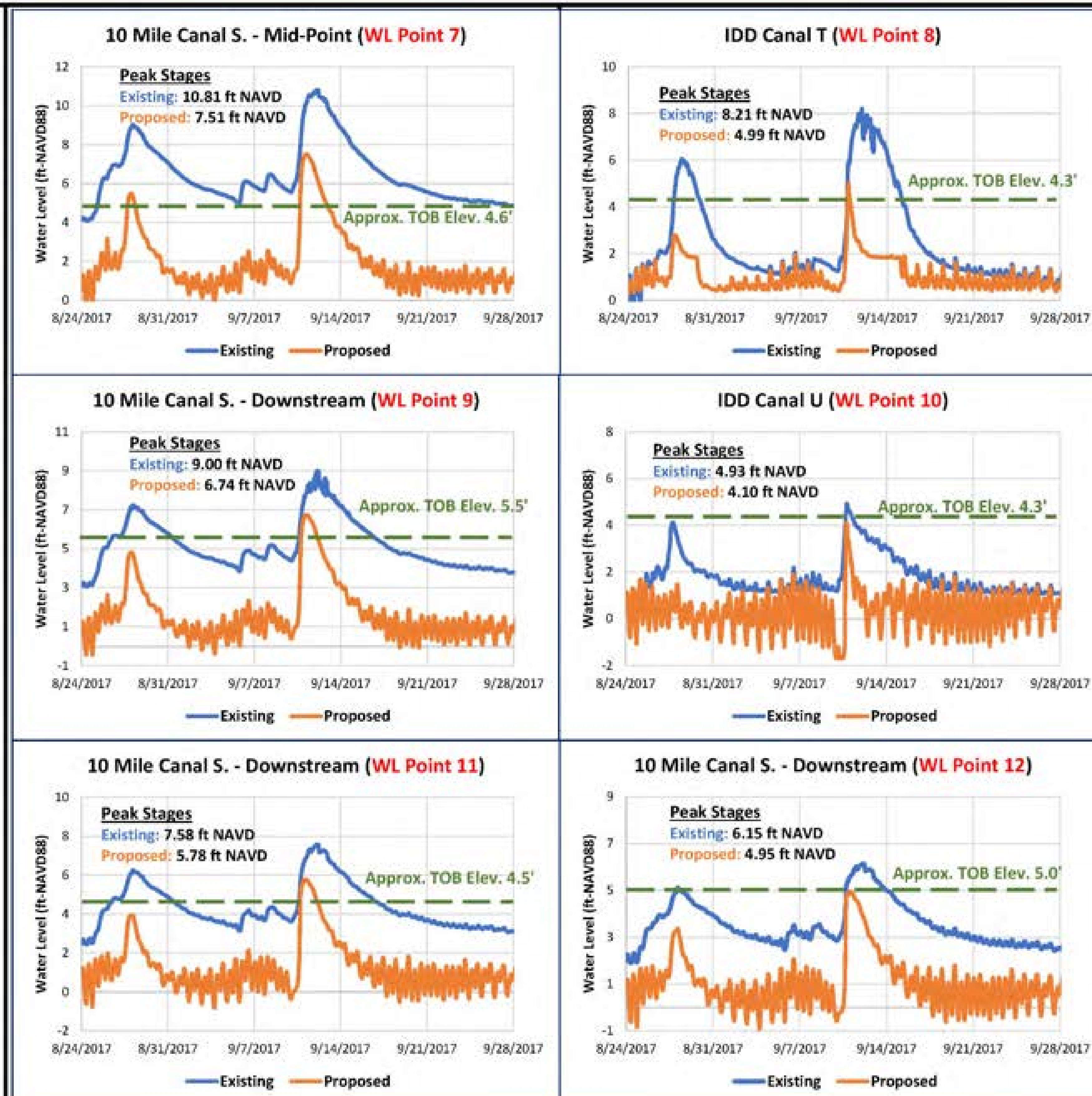


1.4.2 Ten Mile Canal-South

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.2 (n)

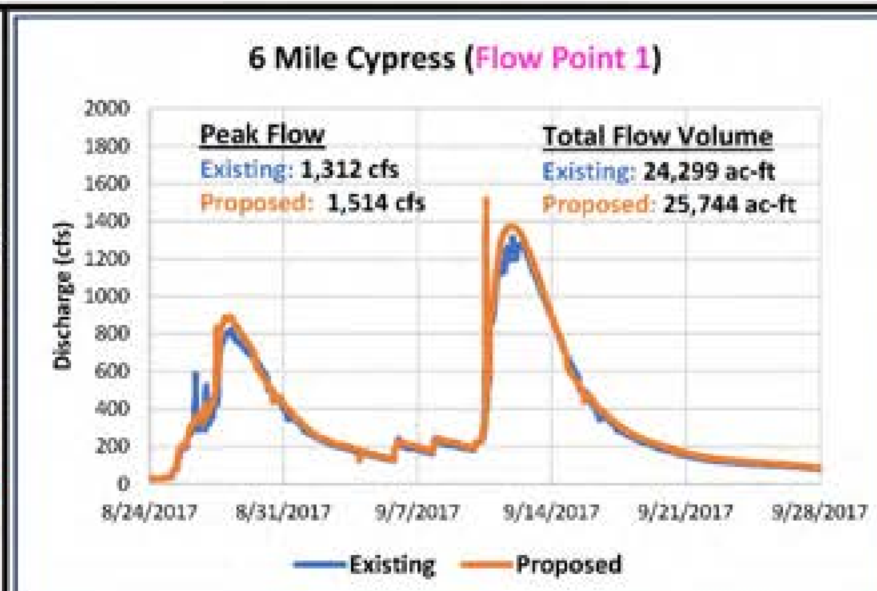


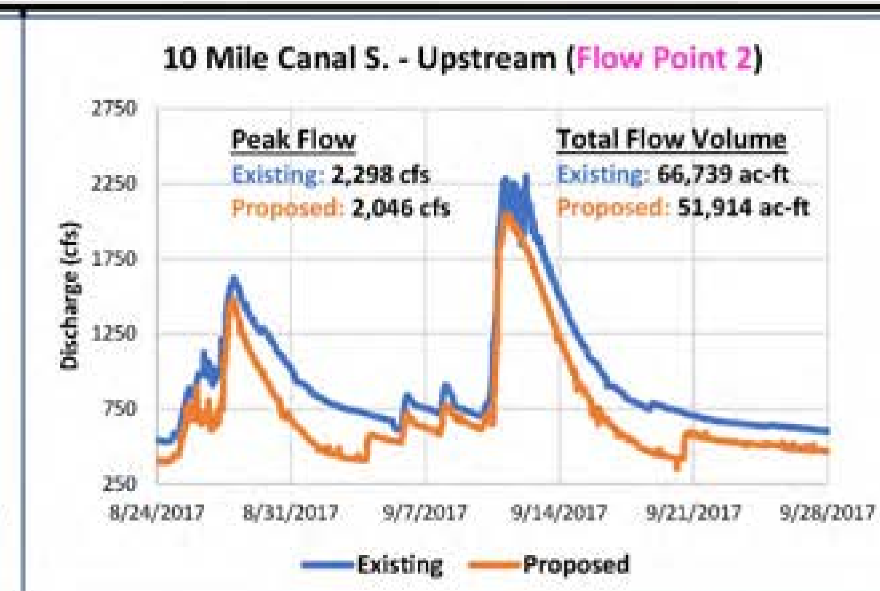
1.4.2 Ten Mile Canal-South

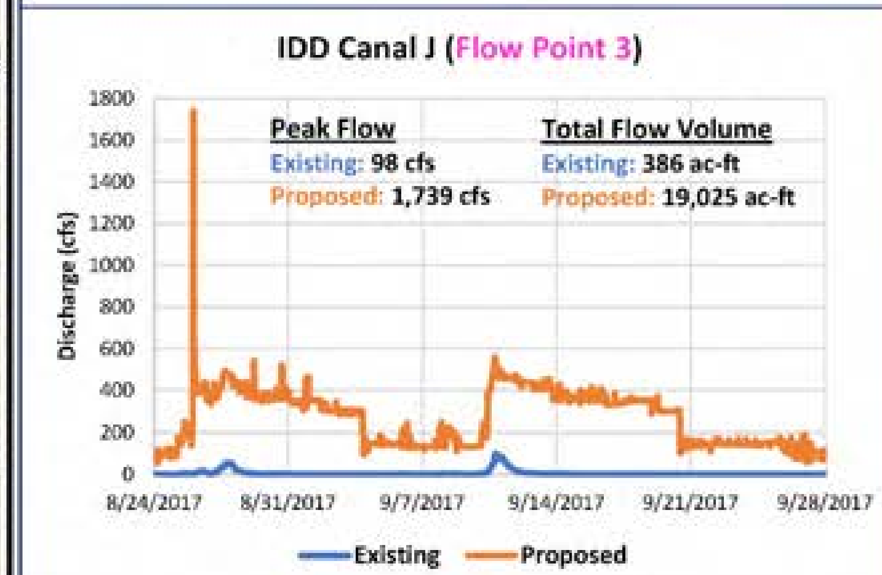
Water Level(s)

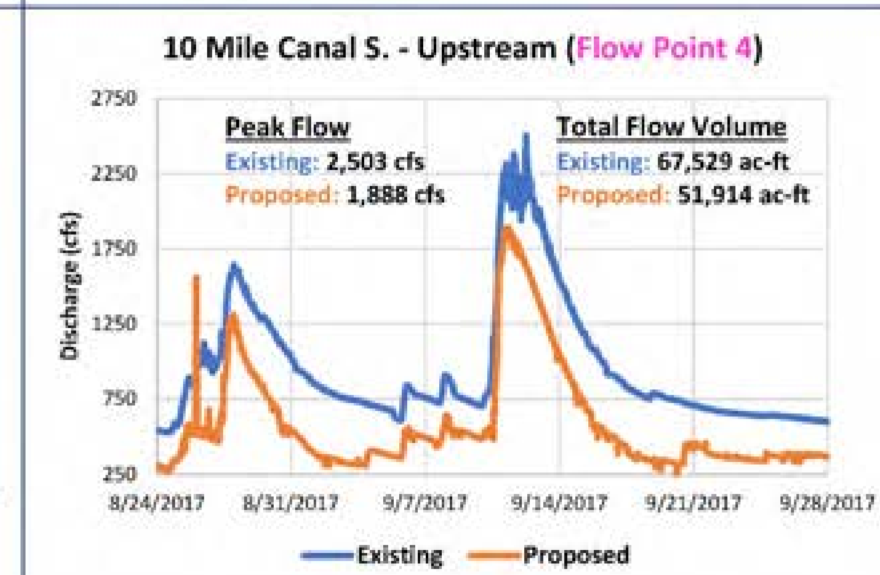
Continuous Simulation (Hourly)

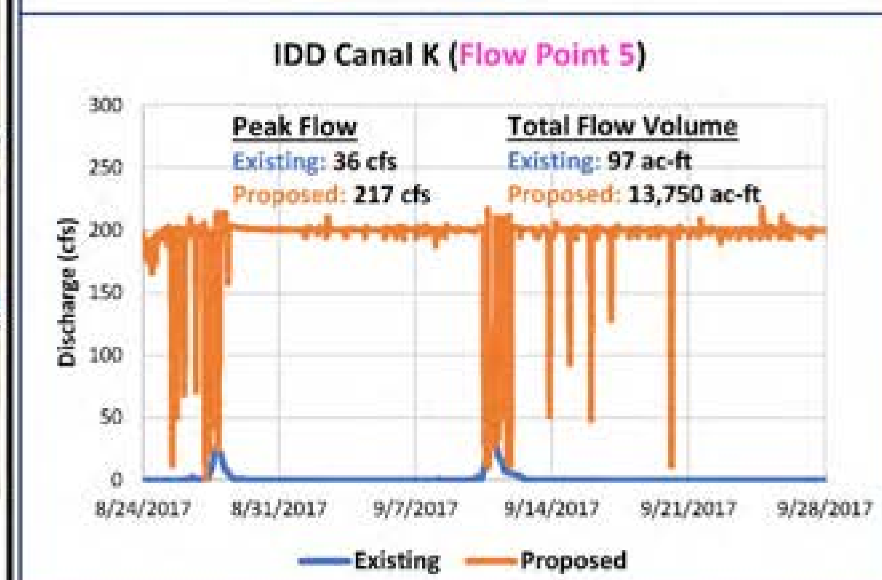
EXHIBIT 1.4.2 (o)

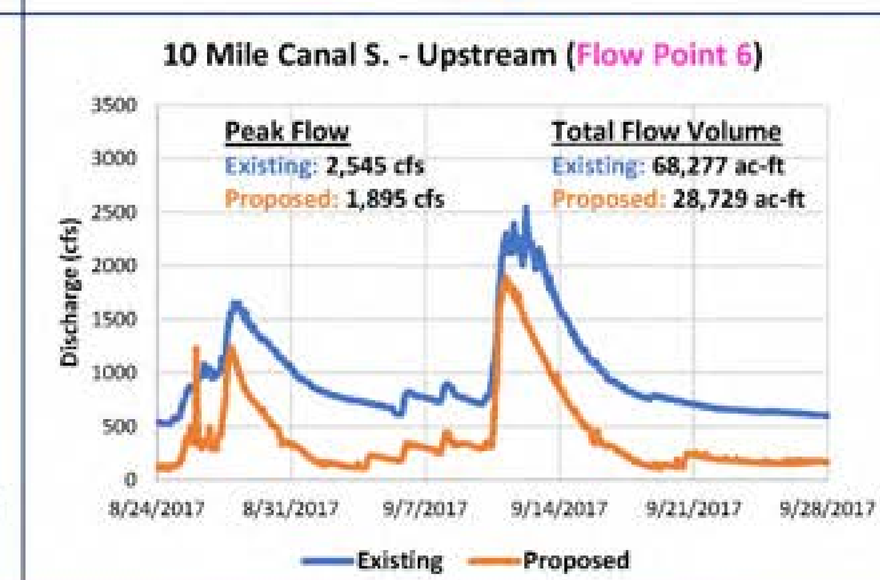










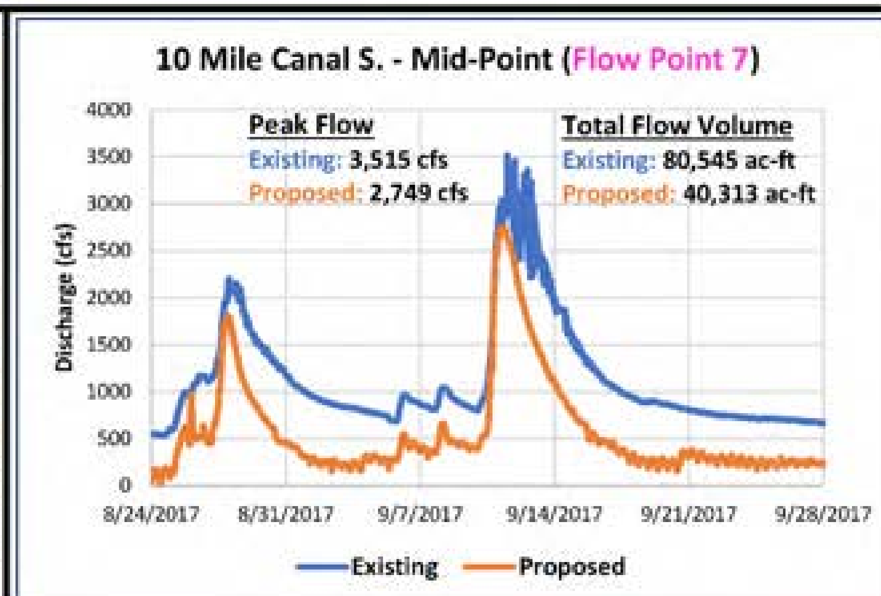


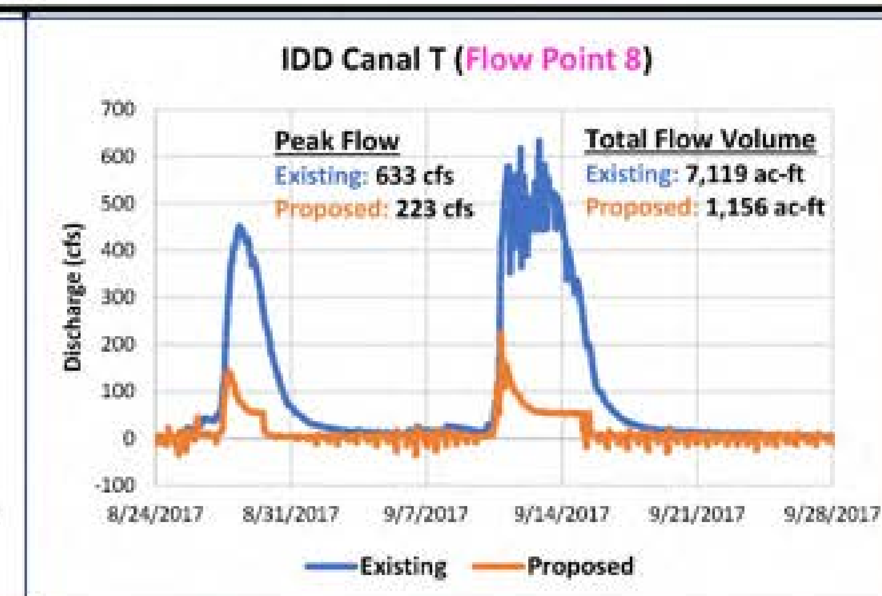
1.4.2 Ten Mile Canal-South

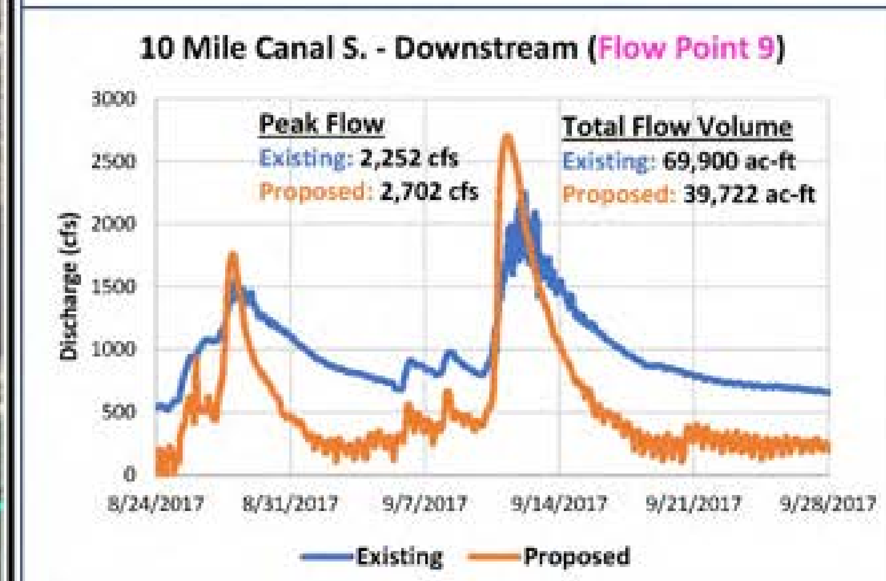
Flow(s)

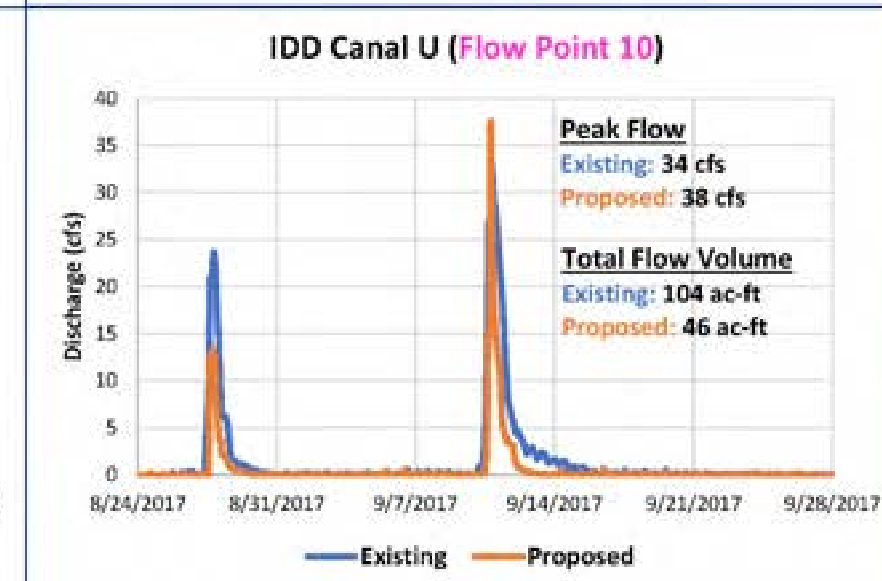
Continuous Simulation (Hourly)

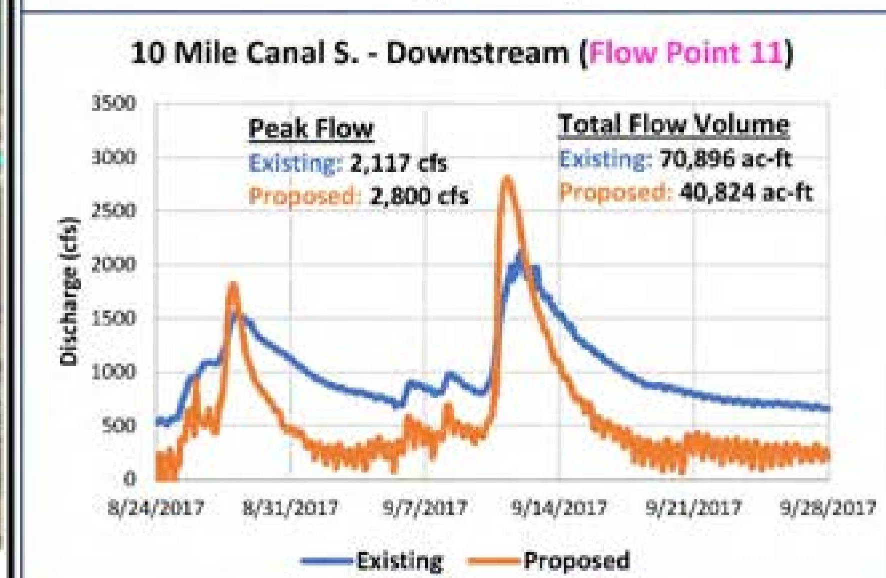
EXHIBIT 1.4.2 (p)

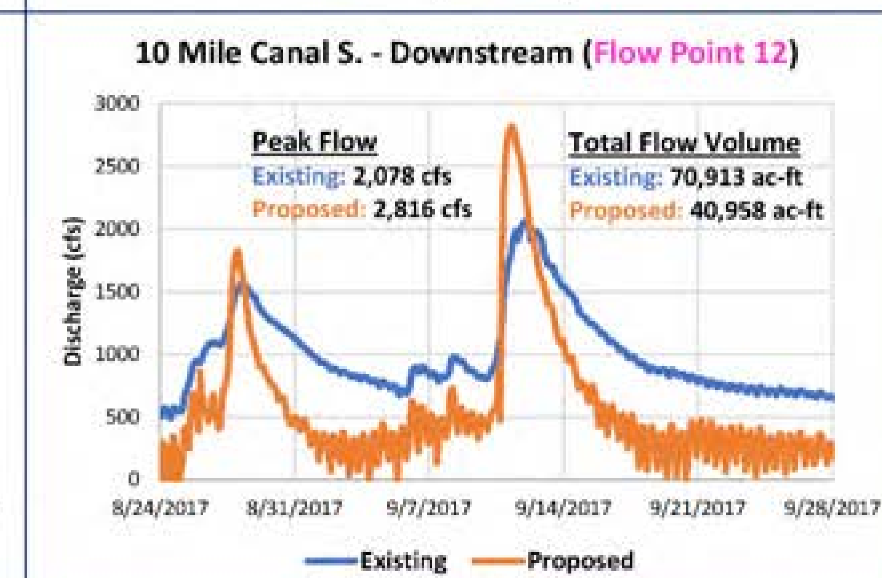












1.4.2 Ten Mile Canal-South

Flow(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.2 (q)

1.4.3 Daniels Parkway-South Area

Background

During the original design and permitting of the Legends Golf and Country Club, a perimeter swale was required along the northern boundary of development to convey offsite flows west to Eagle Ridge Drive. Lack of maintenance of this swale over the years has caused it to become highly vegetated, resulting in reduced capacity to convey stormwater flows.

Further south, stormwater west of Treeline Avenue passes through culverts under I-75, flows overland through and south of the Old Hickory community, continues under Fiddlesticks Boulevard and passes through wetland and lake systems in the Legends golf community. The water then enters wetland systems in the Eagle Ridge community before entering one of two swales that convey the water west to the Six Mile Cypress Slough. Lacking a well-defined conveyance route, the flow path cannot sufficiently convey stormwater from major storm events.

Location

Two existing, parallel flow ways convey stormwater west from Fiddlestick Boulevard to the Six Mile Cypress Slough. The northern corridor is an existing swale along the northern boundary of the Legends Golf and Country Club. The southern corridor passes through wetland and lake systems in the Legends and Eagle Ridge golf communities.

Description

This project proposes conveyance improvements along two east-to-west corridors south of Daniels Parkway. Improvements are recommended along the northern corridor to return the existing conveyance swale to its original design, as required by the SFWMD ERP issued for the initial development of the community. The eastern (upstream) end of the conveyance stops at a land section corner and does not continue to Fiddlesticks Boulevard. The conveyance needs to be extended east to the road. Also needed is to enlarge the culvert capacity under the road and improve the conveyance along Indian Pony Road. An enlargement of the Legends perimeter swale may be needed in addition to the remedial maintenance if further capacity is required to serve the planned developments east of Fiddlesticks Boulevard, north of Indian Pony Drive. An enlargement of the swale should also benefit the neighborhoods around Freshman Lane, an area of known repeated flooding. Further stormwater management benefits may be achieved by adding gates to the existing weir structure at the northwest corner of the Legends community.

The original conceptual design of the Legends community included significant reliance on the southern lake system to convey high flows from large storm events, with the flows continuing west along the southern edge of the Eagle Ridge community. The flow path was later cut off and all discharge was rerouted through wetland systems within both communities. It is recommended to reconnect the southern lake system of the Legends community with the existing drainage easement in the southeast corner of the Eagle Ridge community for additional conveyance capacity when the water levels are elevated. New weir structures will likely be required at the existing interconnect with the Treeline Avenue parallel canal, at the southeast corner of the Legends community, and at the southwest corner of the Legends community to maintain wet season water table elevations and provide enhanced stormwater management capabilities within the system.

Objectives

The conveyance improvements are recommended to provide adequate and well-defined outfall routes for the surrounding communities and the new developments currently planned in conjunction with the Three Oaks Parkway extension.

Evaluation

Viability

The proposed conveyance improvements will provide a dedicated drainage path for a large area that currently lacks adequate downstream conveyances. Collaboration between the County and the existing private community organizations will be necessary to achieve the maximum conveyance benefits.

Community Considerations

Both the northern and southern routes will benefit a large area of homes and businesses, once improvements are completed. The projects will also require the cooperation and coordination with the neighboring homeowners' associations for modifications to systems within or adjacent to the existing developments.

Environmental & Permitting Considerations

The extension of the northern flow path to the east will most likely impact wetlands and require mitigation. The southern path may also incur wetland impacts and thus require wetland mitigation.

Land Availability

Indian Pony Road may require acquisition of an easement or additional ROW for drainage purposes if the existing ROW width is insufficient to convey the required flows. The southern route may necessitate a revision of the drainage easement along the southeastern boundary of the Eagle Ridge community and a revision of the Environmental Resource Permit for the Legends community.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements.

Table 3 – Opinion of Probable Cost breakdown, 1.4.3 Daniels Parkway-South Area

Construction Costs

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 700,000	$ 700,000
Clearing & Grubbing	33	AC	$ 14,000	$ 462,000
Earthwork	123,653	CY	$ 10	$ 1,237,000
Weir Structures (3) 1.4.3A (Major)	60	LF	$ 10,000	$ 600,000
Weir Structure 1.4.3B (Major)	40	LF	$ 10,000	$ 400,000
Permanent Erosion Control	10,500	SF	$ 25	$ 263,000
Grassing	53,815	SY	$ 3	$ 162,000
			Conceptual Construction Costs:	**$ 3,900,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 1,170,000
			Land Acquisition	$ 4,200,000
			Project Administration/ CEI (10%)	$ 390,000
			Conceptual Project Cost:	**$ 9,700,000**
			Contengency (30%)	$ 2,900,000
			Conceptual Project Cost (with Contengency):	**$ 12,600,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

The northern route will provide a defined and legal outfall for the northern end of the proposed Three Oaks Parkway extension. The southern route will provide an improved route for properties east and west of the interstate. Both routes provide opportunities for cooperation between agencies within Lee County governance and with private developments.

Other Considerations

A community involvement/education program will be critical to project success in this area, as in others. This largely residential area has historically been active in protecting what they perceive as being in their best interests.

Findings & Recommendations

Regional Modeling Findings

The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.3 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. Modeled results demonstrating the water levels and discharges over time are included for the following design storm events:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.4.3 (b)
	Flow(s)	EXHIBIT 1.4.3 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.4.3 (d)
	Flow(s)	EXHIBIT 1.4.3 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.4.3 (f)
	Flow(s)	EXHIBIT 1.4.3 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.4.3 (h)
	Flow(s)	EXHIBIT 1.4.3 (i)

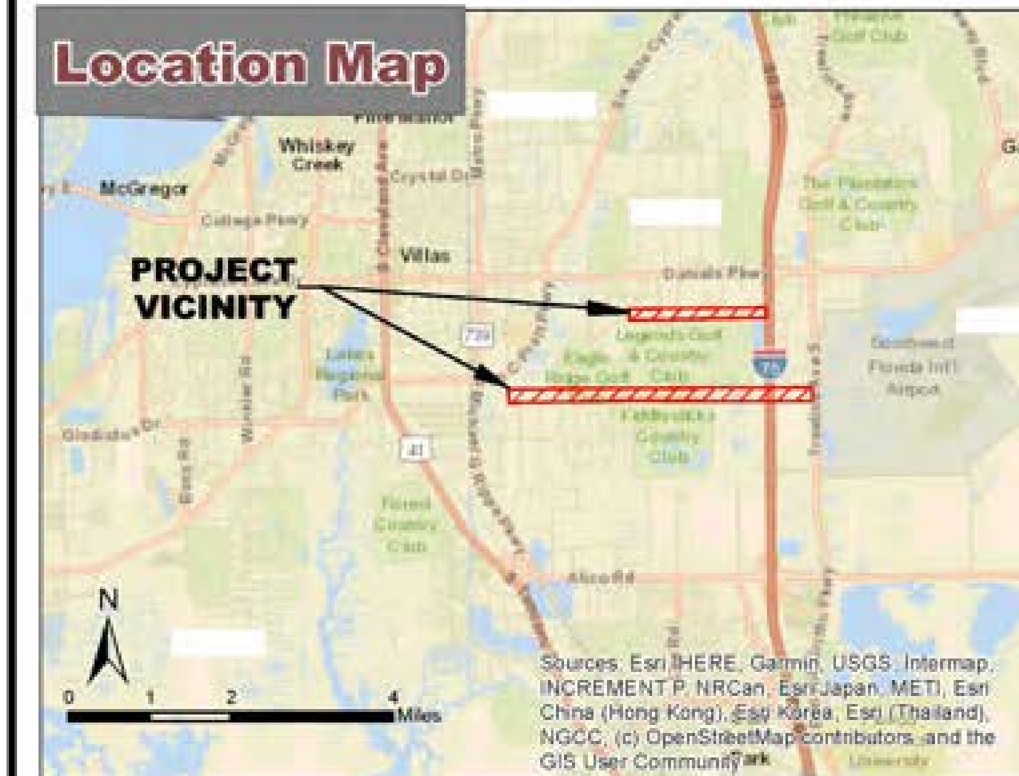
The regional modeling showed very little changes in peak stages in all but one location in the watershed (Water Level Point 5). There is likely an issue with the existing cross section information used in the regional model downstream of this point being more constrictive than it is, artificially representing a constriction in flow. The model output generated proposed flowrates that were similar to the existing flowrates at half of the locations. For some storm events, significantly higher flowrates were shown at Flow Points 3, 5, and 6. The higher flows through Points 3 and 5 were largely due to the proposed connection east of Fiddlesticks Boulevard. At Point 6, the model is indicating higher flowrates will enter the Six Mile Cypress Slough.

Recommendations

The modeling results demonstrate that this proposed conceptual project meets the desired outcomes by providing additional conveyance capacity during times of peak flooding through the area south of Daniels Boulevard. Detailed local modeling will be required during the design phase to accurately simulate the existing conveyances and refine the sizes of the proposed conveyance modifications based on the water level and flowrate boundary conditions from the regional model output.

The model results highlight the need for a restrictive allowable peak discharge rate for all new development to protect the existing communities in the area. The recommended allowable peak discharge rate for that sub-part to the watershed will likely be lower than for the watershed for the Six Mile Cypress Slough.

NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.



Project Narrative

DESCRIPTION: This project proposes conveyance improvements along two corridors south of Daniels Parkway to address existing flood concerns and prepare for new developments currently planned in conjunction with the Three Oaks Parkway extension.

PURPOSE: Improvements along the north side of The Legends returns the existing conveyance swale to its original design or enlarge, if needed. The implementation of both projects will reduce flooding impacts to the surrounding communities and the airport (SWFIA) by providing adequate and well-defined outfall routes.

CONSTRAINTS: Close coordination with surrounding communities and LCPA staff would be required for these improvements, with modifications to existing permits and review of applicable ordinances. This project relies on the completion of other improvement projects to achieve maximum results in reduced peak flows to Ten Mile Canal.

MAY 2020

Daniels Parkway South Area
South Fort Myers Area

JOHNSON ENGINEERING

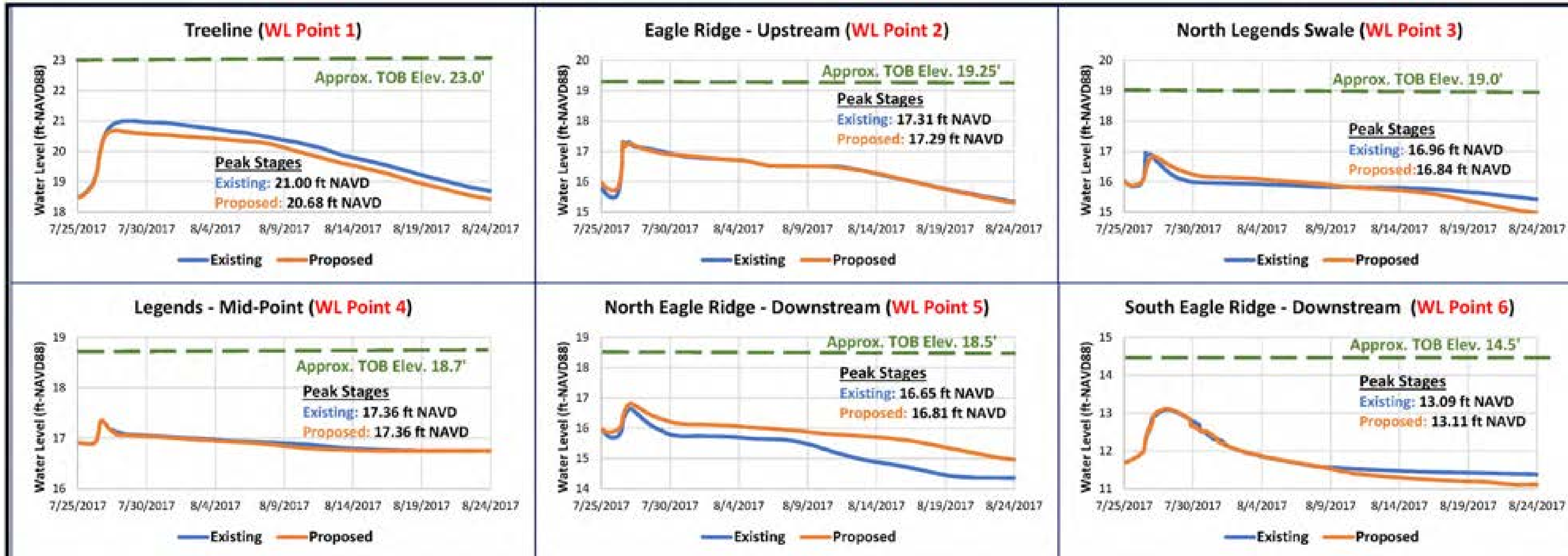
EXHIBIT 1.4.3(a)

EXHIBIT 1.4.3 (b)

1.4.3 Daniels Parkway South-Area

Water Level(s)

25-yr 3-day (Jul Start)

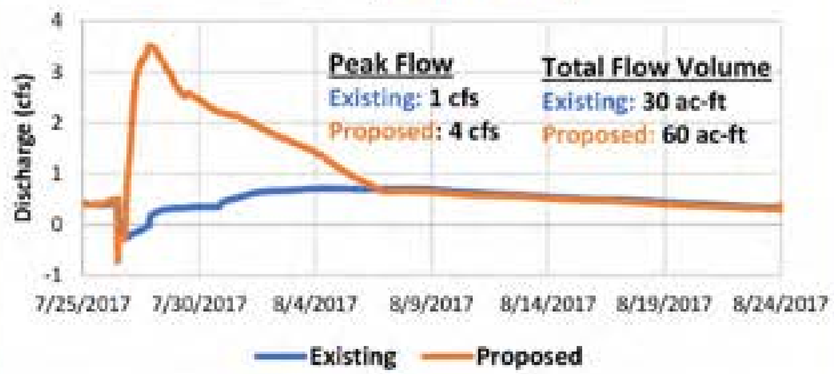


1.4.3 Daniels Parkway South-Area

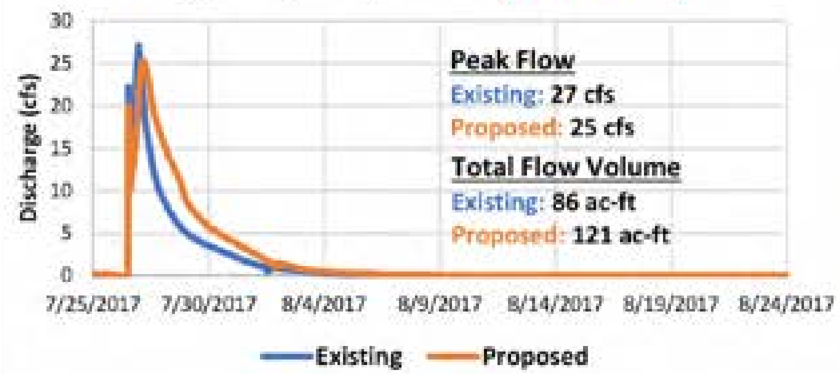
Flow(s)

25-yr 3-day (Jul Start)

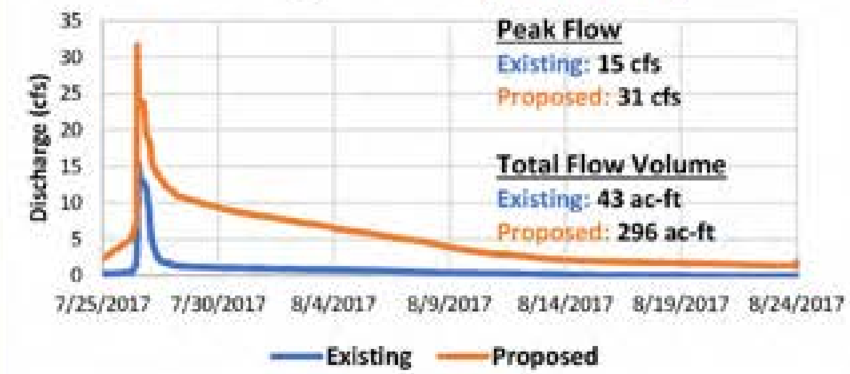
Treeline (Flow Point 1)



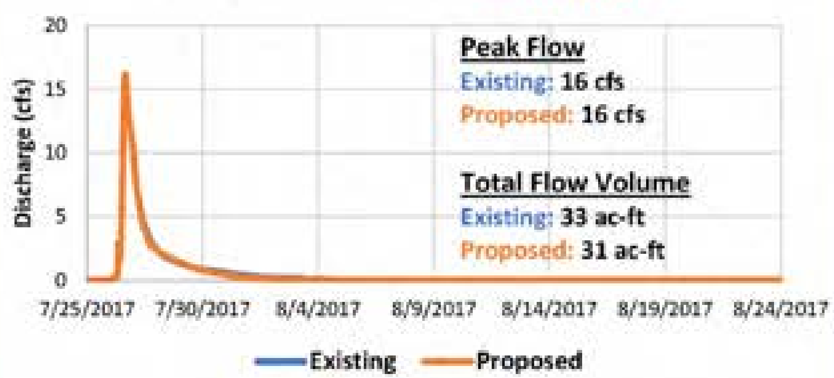
Eagle Ridge - Upstream (Flow Point 2)



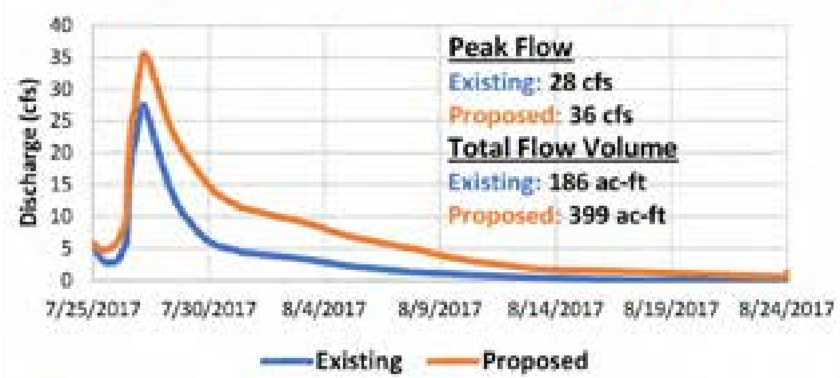
North Legends Swale (Flow Point 3)



Legends - Mid-Point (Flow Point 4)



North Eagle Ridge - Downstream (Flow Point 5)



South Eagle Ridge - Downstream (Flow Point 6)

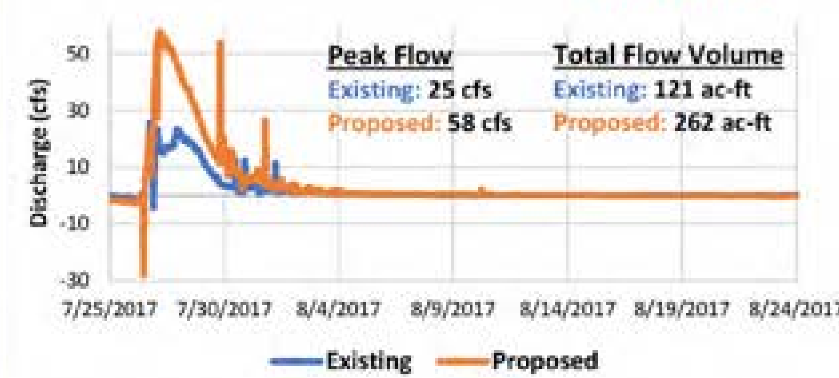
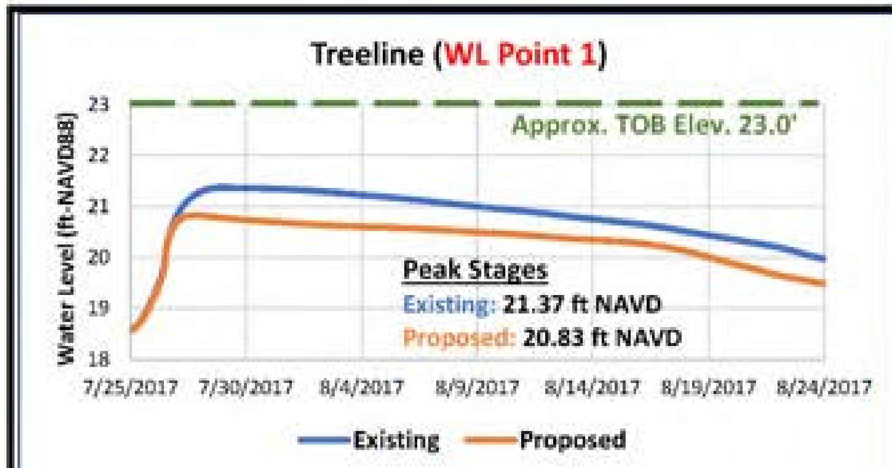


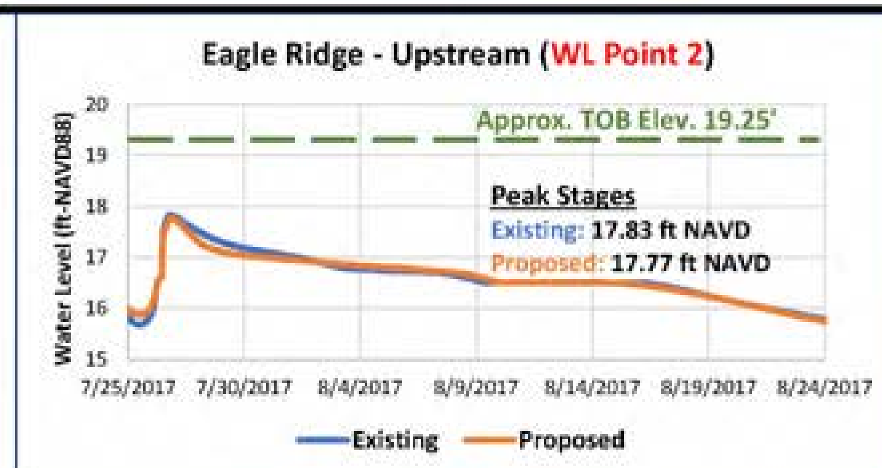
EXHIBIT 1.4.3 (c)

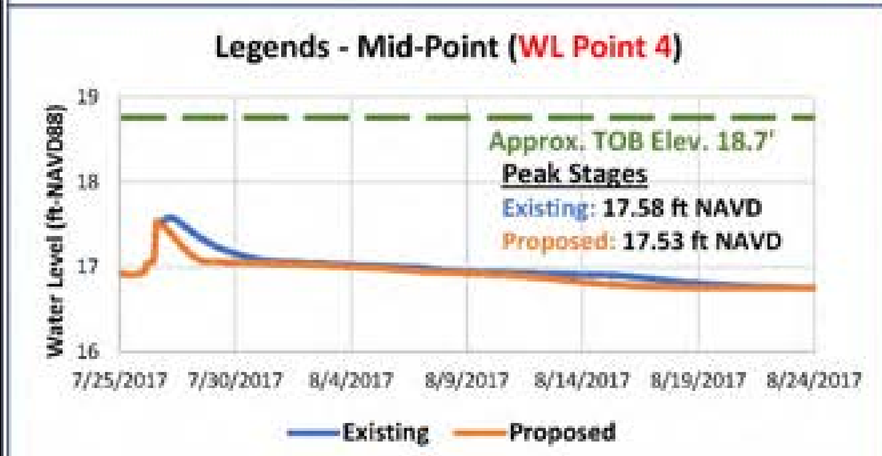
1.4.3 Daniels Parkway South-Area

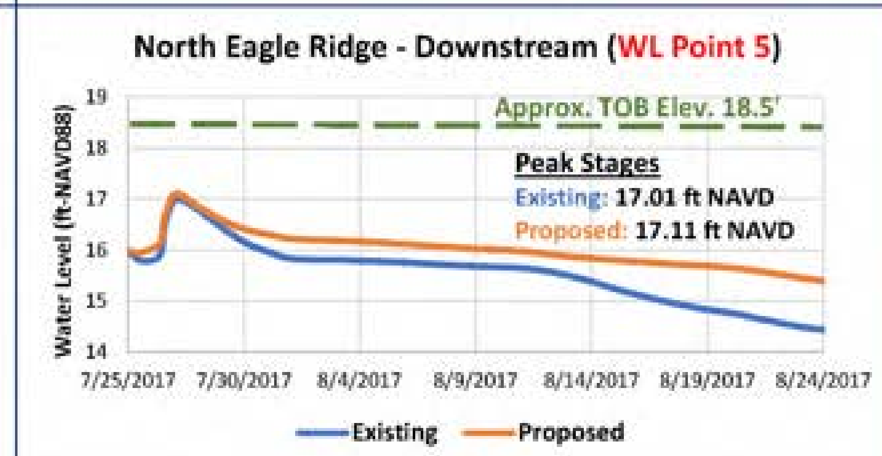
Water Level(s)

100-yr 3-day (Jul Start)









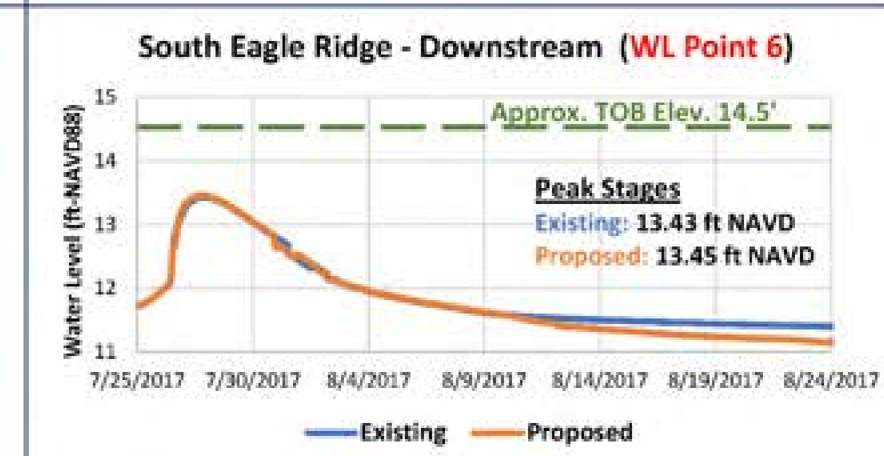
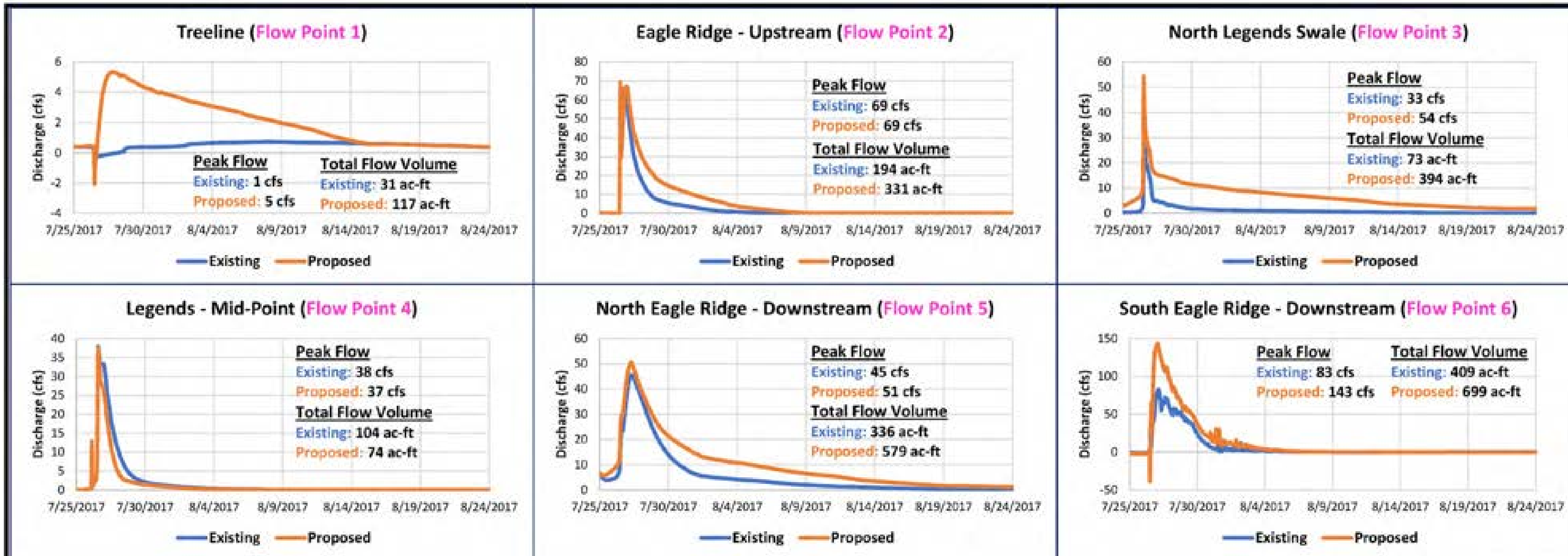


EXHIBIT 1.4.3 (d)

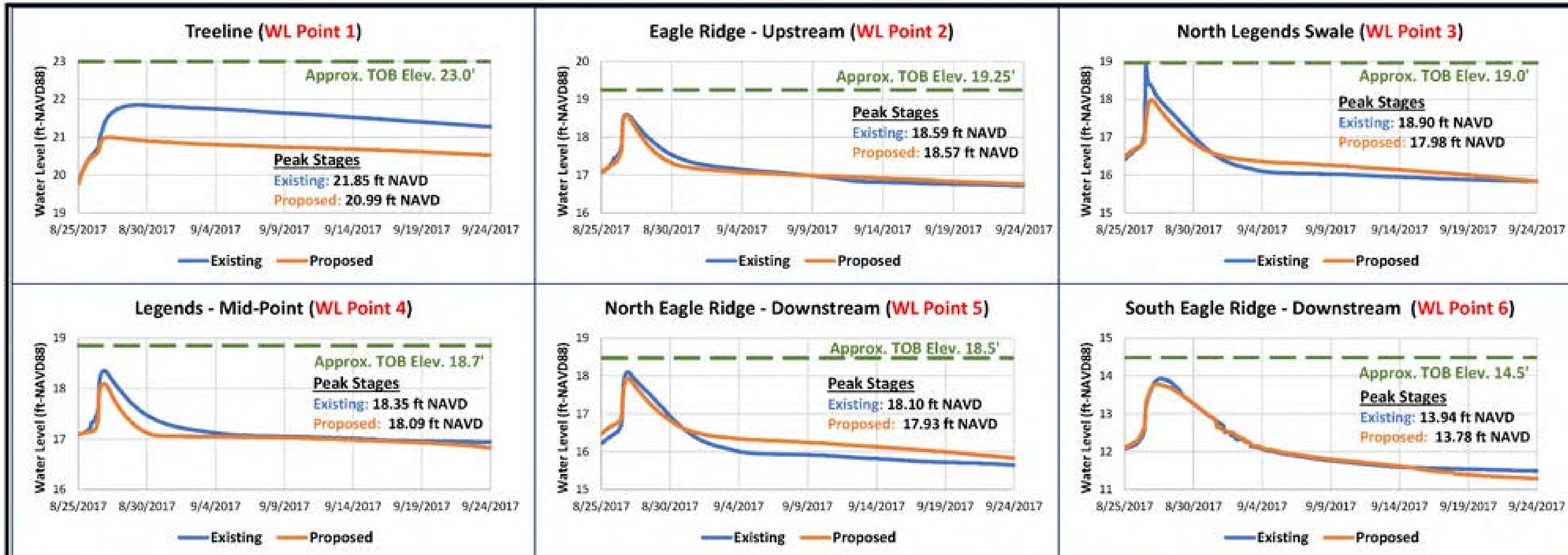


1.4.3 Daniels Parkway South-Area

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.4.3 (e)



1.4.3 Daniels Parkway South-Area

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.4.3 (f)

1.4.3 Daniels Parkway South-Area

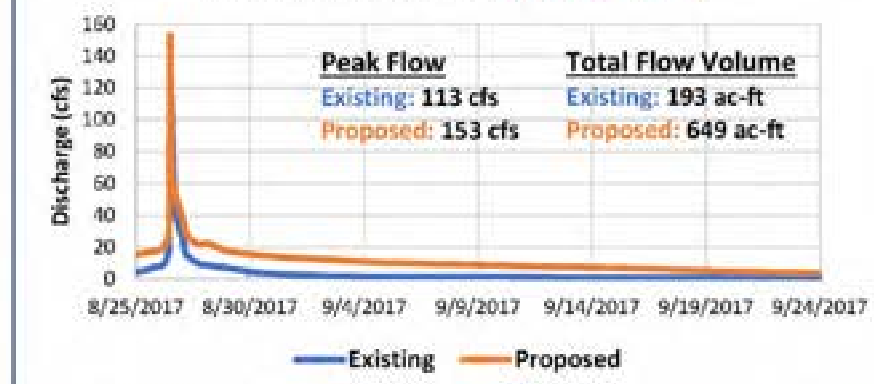
Flow(s)

100-yr 3-day (Aug Start)

Treeline (Flow Point 1)

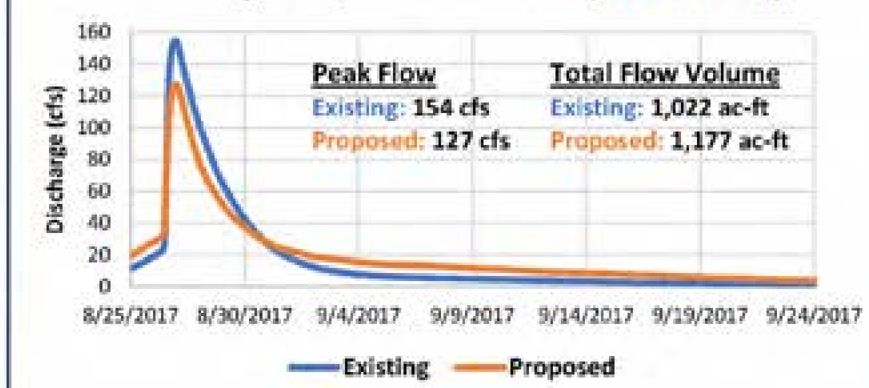
Eagle Ridge - Upstream (Flow Point 2)

North Legends Swale (Flow Point 3)



Legends - Mid-Point (Flow Point 4)

North Eagle Ridge - Downstream (Flow Point 5)



South Eagle Ridge - Downstream (Flow Point 6)

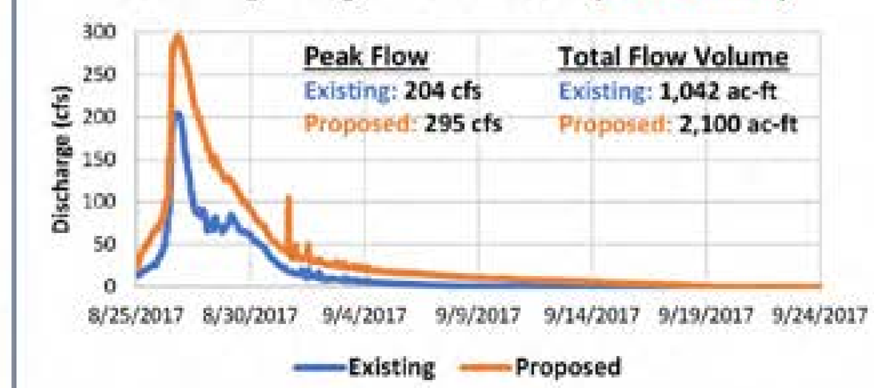
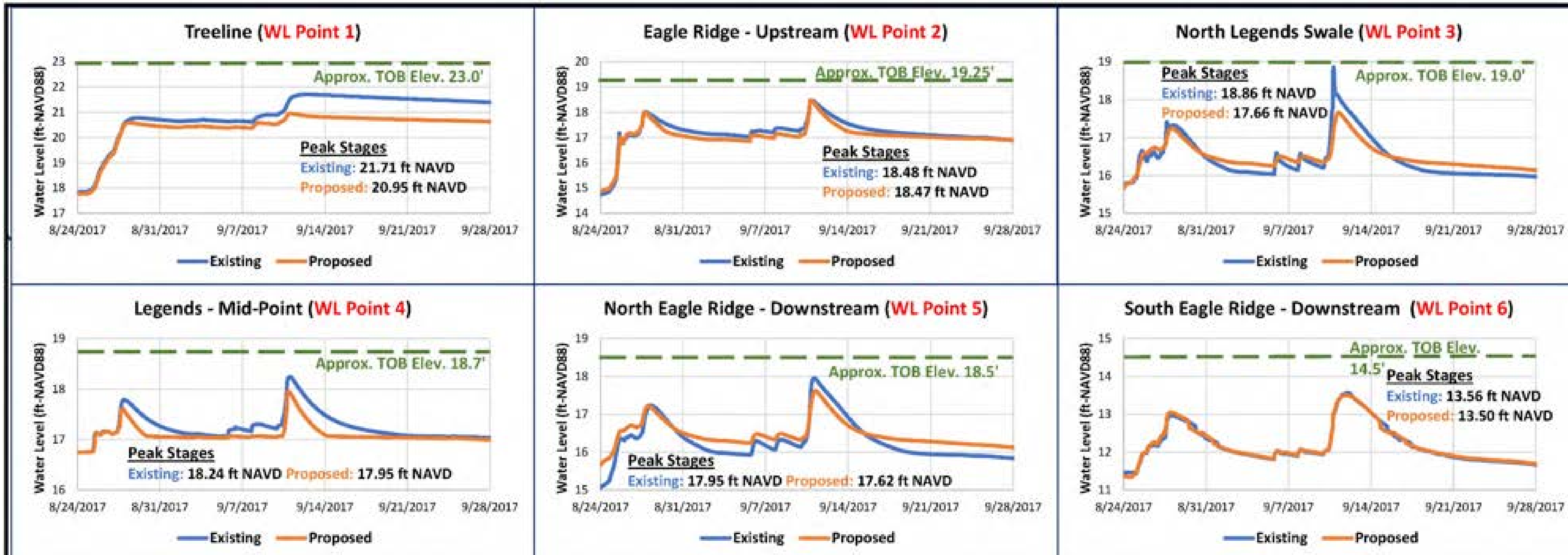


EXHIBIT 1.4.3 (g)



1.4.3 Daniels Parkway South-Area

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.3 (h)

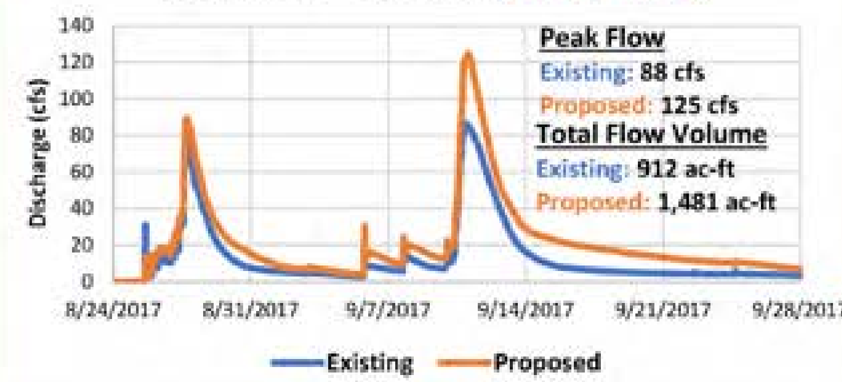
1.4.3 Daniels Parkway South-Area

Flow(s)

Continuous Simulation (Hourly)

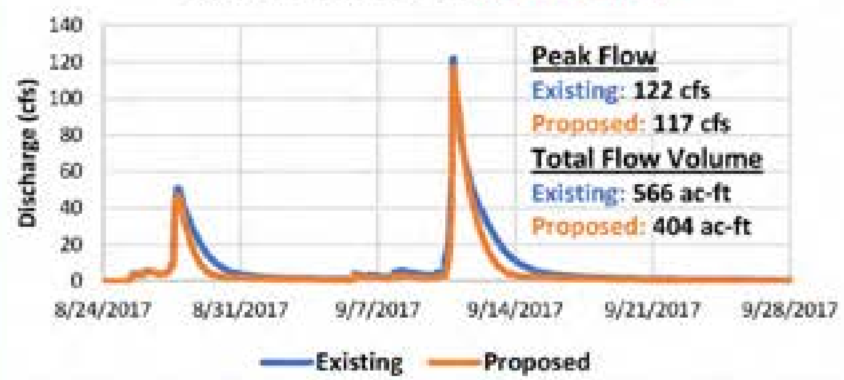
Treeline (Flow Point 1)

Eagle Ridge - Upstream (Flow Point 2)

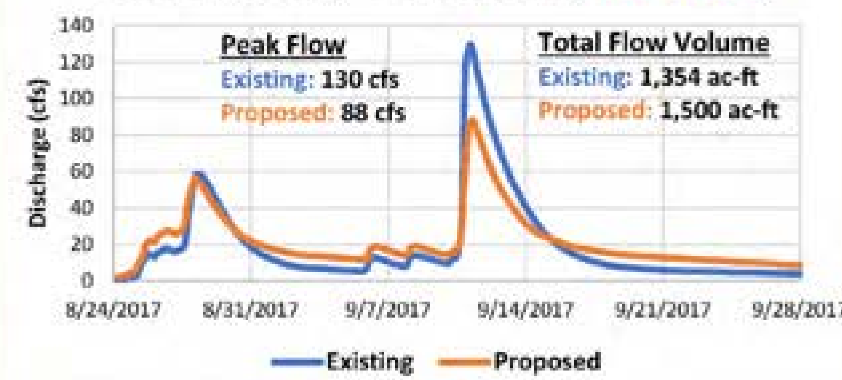


North Legends Swale (Flow Point 3)

Legends - Mid-Point (Flow Point 4)



North Eagle Ridge - Downstream (Flow Point 5)



South Eagle Ridge - Downstream (Flow Point 6)

EXHIBIT 1.4.3 (i)

1.4.4 Briarcliff Area

Background

The Briarcliff community is a residential area with limited existing stormwater management infrastructure. Development east of Ten Mile Canal began a decade or more before there were any stormwater management system requirements and prior to widening of the Ten Mile Canal. Access was a one-lane wooden bridge over the borrow ditch for the Line A Dike. Widening of Ten Mile Canal resulted in a longer and wider bridge for two-lane access in the late 1970s or early 1980s. This community benefitted greatly from past Lee County projects to berm off the Six Mile Cypress Slough on the north side of the community in the 1990's, thereby reducing sheet flow through the area from seasonal rains and large storm events. Fast forward to the Lee County 2017 Flood Study Report, many of the primary drainage swales were found to have reduced conveyance capacity due to sediment, debris, and vegetation. Lee County maintenance staff have since cleared most of the swales in the western area of Briarcliff, however the need remains to improve the existing swales in the eastern area of Briarcliff.

Location

The Briarcliff community's drainage area is bordered to the north by Eagle Ridge, to the west by the Six Mile Cypress Slough and Ten Mile Canal, to the south by the Briarcliff Channel, and to the east by the Fiddlesticks Country Club.

Description

Enhancements are proposed along a conveyance in the eastern area of Briarcliff, starting near the intersection of Briarcliff Road and Quail Trail. The route is an enhancement of the existing roadside swale along Quail Trail to its intersection with Monarch Lane. The swale then continues due south along property lines to its outfall into Briarcliff Channel. The existing ground and roadway elevations along the proposed route is higher than the existing top of bank elevation for Briarcliff Channel further downstream. Therefore, backflow from Briarcliff Channel into the Briarcliff neighborhood to the north is not expected as a result of this proposed conveyance improvement. The Blackhawk and Briar Ridge subdivisions along with areas south of Briarcliff Road will have lessened flood conditions with this improvement.

Objectives

This project provides general drainage improvements in the Briarcliff area to reduce roadway flooding and reduce the potential for high water to enter residences in the project area.

Evaluation

Viability

The proposed swale improvements will aid in the recovery of water levels following back-to-back storm events. However, the Briarcliff area has limited existing improvements for storage and water quality treatment. This project relies on the completion of other downstream improvement projects to achieve the required results without causing increased flood stages in downstream communities.

Community Considerations

Due to the interconnected nature of the existing swales within the Briarcliff community, conveyance improvements within one area of Briarcliff will likely benefit a much larger area than the properties immediately adjacent to the work area. However, many homes have existing landscaping and fences up to or within the road rights of way which may be impacted by the proposed projects if the selected flow enhancements are adjacent to their property. As with all proposed improvement projects, community involvement, participation and education will be an important component of project success.

Environmental & Permitting Considerations

The proposed project is an improvement of existing stormwater management facilities located within uplands; therefore, it is not anticipated this project will affect wetlands or protected species. It is likely there are wetlands adjacent to some of the work areas, therefore additional analyses are recommended to identify and reduce potential secondary wetland impacts.

Land Availability

It appears that most ditches and swales in the Briarcliff area have County easements. However, there are some that appear to not have easements, according to the information provided. It is recommended the County review the primary flow paths in the Briarcliff community to ensure all necessary easements are in place to perform maintenance and improvements of the existing drainage infrastructure.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements.

Table 4 – Opinion of Probable Cost breakdown, 1.4.4 Briarcliff Area

Construction Costs

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 100,000	$ 100,000
Clearing & Grubbing	2	AC	$ 14,000	$ 28,000
Earthwork	6,019	CY	$ 10	$ 61,000
Permanent Erosion Control	7,000	SF	$ 25	$ 175,000
Grassing	5,556	SY	$ 3	$ 17,000
			Conceptual Construction Costs:	**$ 400,000**
			Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 120,000
			Land Acquisition	$ 300,000
			Project Administration/ CEI (10%)	$ 40,000
			Conceptual Project Cost:	**$ 900,000**
			Contengency (30%)	$ 300,000
			Conceptual Project Cost (with Contengency):	**$ 1,200,000**

Note:
This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Findings & Recommendations

Regional Modeling Findings

The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.4 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**.

Due to the small scale of the project in relation to the size of the regional model, the model output could not provide existing stages of the Quail Trail roadside swale. Therefore, the regional model does not accurately reflect the potential for improvements from this project and an output exhibit could not be prepared.

Recommendations

Known needs for improvements of the existing stormwater conveyance infrastructure in the area warrant further project development. The existing ground and roadway elevations along the proposed route are at least two feet above the peak stage from the 100-year, 3-day storm event Briarcliff Channel, and backflow from Briarcliff Channel into the Briarcliff neighborhood to the north is not expected as a result of this proposed conveyance improvement. Therefore, additional local modeling is recommended for the Briarcliff community to determine the recommended sizing of the proposed conveyance improvements.

NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Project Narrative

DESCRIPTION: This project consists of general drainage improvements in the Briarcliff area with an enhanced conveyance running north and south, delivering runoff to Briarcliff Channel to the south.

PURPOSE: This project results in less roadway flooding and reduced potential for high water to enter residences in the project area. Berms in the 1990s along the northern project area adjacent to Six Mile Cypress Slough provided substantial relief to residents from sheet flow out of the slough running south through the Briarcliff area. This project continues those benefits while providing additional well-defined conveyances for runoff with the opportunities for water quality treatment.

CONSTRAINTS: This is a residential area with limited existing improvements for storage and water quality treatment. Downstream communities may raise concerns if the project results in additional peak flows from this sub-watershed. By ordinance, the Briarcliff area is in the Six Mile Cypress watershed.

MAY 2020

Briarcliff Area
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.4 (a)

1.4.5 Park Road Area

Background

The roadside swale along the northern portion of Park Road has minimal conveyance capacity and is not connected to a dedicated outfall, causing a bottleneck for runoff from Park Road. The roadside swale along the western portion of US 41 near the Park Road intersection also has limited conveyance and lacks a dedicated outfall. In addition to the roadways, a few dozen homes and businesses drain to the roadside swales and their stormwater management systems are currently unable to recover between repeated storm events. Following Hurricane Irma in 2017, water levels in the swales increased until Park Road was inundated, and the roadway became the conveyance system to carry the water to the Park Road Canal.

Location

Park Road is located in south Lee County, west of US 41 and north of Mullock Creek. It is the sole evacuation route for numerous residences.

Description

Two improvement options are available to connect the roadside drainage systems to a dedicated outfall. The first begins at an existing culvert under US 41 and involves improving the existing swales and culverts along the west side of US 41 to Park Road, and then along the north side of Park Road to the Park Road Canal. The shortest path requires the acquisition of a drainage easement to connect the Park Road roadside swale to the upstream end of Park Road Canal. The second option also begins at an existing culvert under US 41 and involves improving the existing swales and culverts along the west side of US 41 to Mullock Creek to the south.

Objectives

The project aims to provide a downstream stormwater conveyance for developed and undeveloped areas that have been partially blocked off by surrounding development. Both project options attempt to route stormwater to runoff into the Park Road Canal or Mullock Creek without first overtopping a roadway, which should reduce the frequency of roadway flooding.

Evaluation

Viability

The proposed swale improvements will aid in the recovery of water levels for many area homes and businesses following back-to-back storm events. However, this project requires collaboration with the Florida Department of Transportation (FDOT) and likely the acquisition of a drainage easement on private property. Special attention to coordination and communication with FDOT staff will need to be made.

Community Considerations

Residential and commercial properties along the west side of US 41 and north of Park Road between US 41 and the east end of the Park Road Canal will benefit from improved downstream conveyances.

Environmental & Permitting Considerations

The proposed project is an improvement of existing stormwater management facilities located within uplands, therefore it is not anticipated this project will affect wetlands or protected species. The project area of the first route is almost entirely within roadway ROW and will likely require minimal permitting efforts. The second route, entirely along US 41, passes through a detention area fronting some businesses. A modification to this permit will likely be required unless the proposed conveyance is culverted and passes under the detention area.

Land Availability

Most of the project areas are located within roadway ROWs owned by Lee County and FDOT. If the decision is made to improve the roadside swale along Park Road, the acquisition of a short drainage easement on private property will be required to connect the drainage to Park Road Canal. The proposed improvements within the US 41 right of way will require coordination with FDOT.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements.

Table 5 – Opinion of Probable Cost breakdown, 1.4.5 Park Road Area

Construction Costs

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 300,000	$ 300,000
Clearing & Grubbing	2	AC	$ 14,000	$ 28,000
Culvert-RCP 48"	4,200	LF	$ 215	$ 903,000
Permanent Erosion Control	7,000	SF	$ 25	$ 175,000
Grassing	9,333	SY	$ 3	$ 28,000

Conceptual Construction Costs:	**$ 1,500,000**
Professional Services: Eng, Survey, Environ, Geotech (30%)	$ 450,000
Land Acquisition	$ 30,000
Project Administration/ CEI (10%)	$ 150,000
Conceptual Project Cost:	**$ 2,200,000**
Contengency (30%)	$ 700,000
Conceptual Project Cost (with Contengency):	**$ 2,900,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

Given the project's ability to improve the roadway drainage of roads maintained by two separate governmental agencies, a collaboration effort is possible with this project between the Departments of Transportation at the County and State levels.

Findings & Recommendations

Regional Modeling Findings

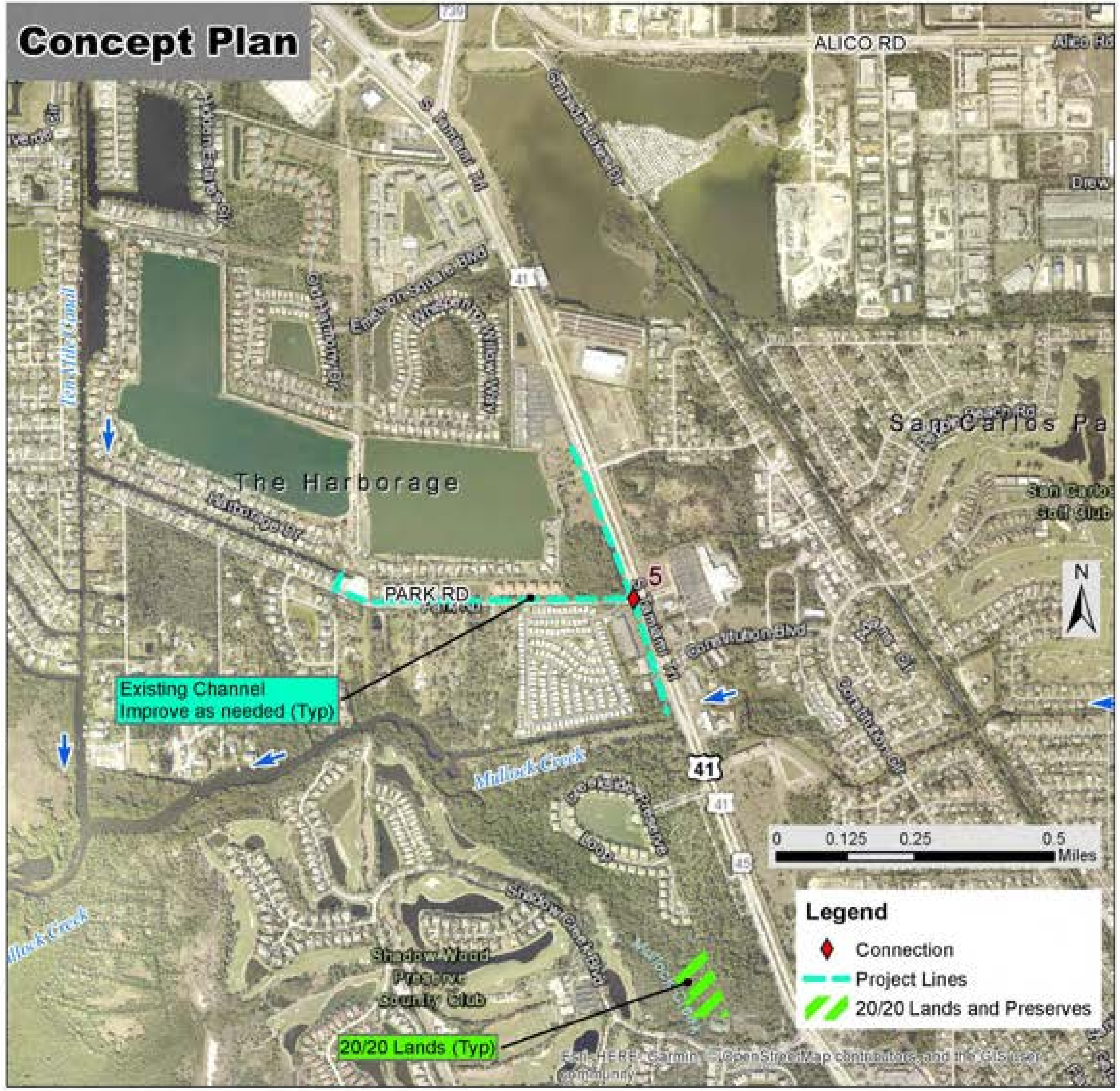
The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.5 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**.

Due to the small scale of the project in relation to the size of the regional model, the model output could not provide existing stages of the roadside swales. Therefore, the regional model does not accurately reflect the potential for improvements from this project and an output exhibit could not be prepared.

Recommendations

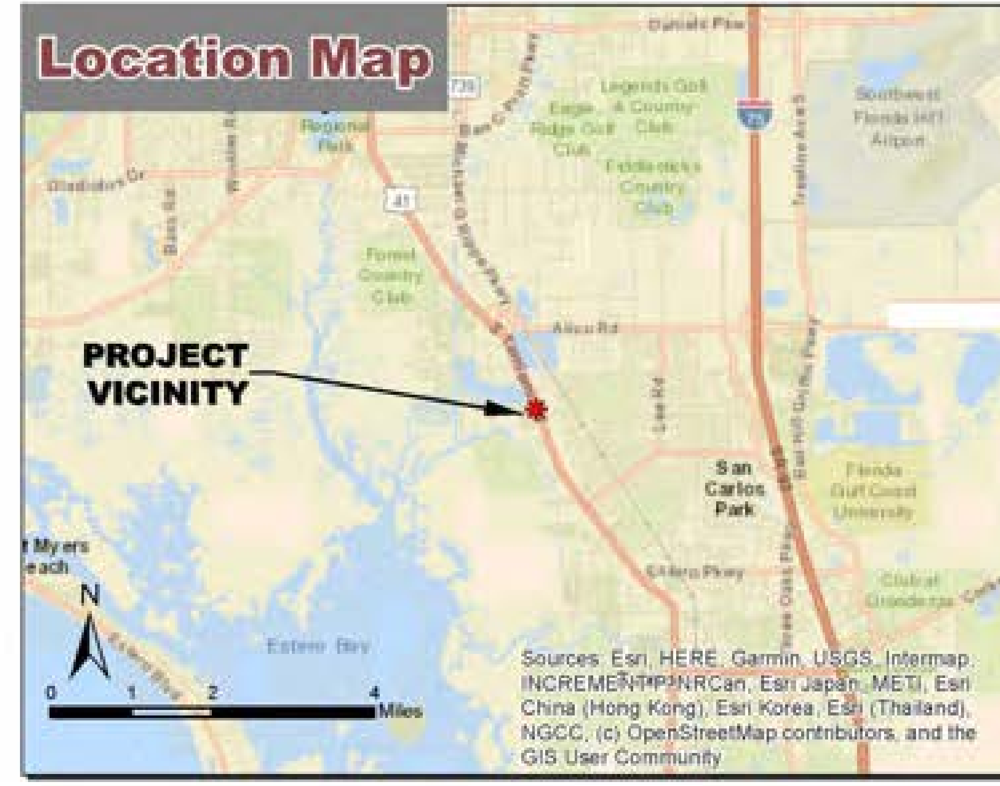
Known needs for improvements of the existing stormwater conveyance infrastructure in the area warrant further project development. Therefore, additional local modeling is recommended for the US 41 and Park Road area to determine the recommended sizing of the proposed conveyance improvements.

Concept Plan



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands and 20/20 Lands were provided by Lee County GIS.

Location Map



Project Narrative

DESCRIPTION: The roadside swale along the northern portion of Park Road has minimal conveyance capacity and is not connected to a dedicated outfall, causing a bottleneck for runoff from Park Road and a portion of US 41. This project consists of general roadway drainage improvements in the Park Road area.

PURPOSE: An improved conveyance along Park Road reduces flooding and allows surrounding drainage systems to recover between repeated storm events.

CONSTRAINTS: The acquisition of a drainage easement will be required to connect the drainage to Park Road Canal. Work within US 41 right of way will require coordination with FDOT staff, but may also offer an opportunity to seek some funding from FDOT.

MAY 2020

Park Road Area
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.5(a)

1.4.6 LCPA Diversion to Estero Basin

Background
The southeast corner of the Southwest Florida International Airport (SWFIA) was historically within the Estero River watershed. Permitting in the early 2000s allowed this area to continue to flow south to the Estero River or west into the SWFIA stormwater management system, which ultimately discharges to Ten Mile Canal via the Briarcliff Channel. The master stormwater management system for SWFIA was modified in the past few years as a part of the parallel runway project and the area to the east that previously discharged to both the Six Mile Cypress Slough and Estero River will only flow to the Estero River. While permitting is complete, this construction has not occurred.

Location
The proposed project affects the surface water flows in the southeast corner of SWFIA and the southern end of the Wild Turkey Strand Preserve, north of Lee County Utilities' Green Meadows Water Treatment Plant.

Description
This project proposes berms and weirs on County-owned lands east of SWFIA to create additional storage and direct additional water around SWFIA into the Estero River watershed, reducing runoff volumes to Ten Mile Canal. A small proposed conveyance will carry the attenuated water to another proposed storage project in the northern reaches of the Estero River watershed. This project is described in further detail in Section 1.3 of this report.

Objectives
The project goal is to create additional storage in the upper reaches of the watershed to reduce the peak rate of runoff to the Estero River and thereby reduce downstream peak flood stages from major storm events. The partial restoration of some flows to the Estero Watershed from lands east of SWFIA will reduce total flows through the Briarcliff Channel and to Ten Mile Canal, thereby lessening downstream impacts to the lower Ten Mile Canal watershed.

Evaluation
Viability
Developments along the North Branch of the Estero River already experience flooding and delivery of more water to this region will test the storage capacity needed to not move flooding from one location to another. Detailed modeling is required to ensure the additional flows to the Estero River are within the system capacities.

Community Considerations
The Lee County Port Authority (LCPA) may have concerns about expanding wetlands by the impoundment of water, which will have the potential of attracting wildlife (primarily large water birds). These are a hazard to air traffic and something LCPA has been actively working to reduce for the past several years.

Residents downstream along the upper reaches of the Estero River may complain about additional water reaching locations that already have their own flooding challenges. Businesses and residents towards the south end of Ten Mile Canal may see reduced stages of water in the canal with upstream water stored/diverted and would likely be in favor of these improvements.

Environmental & Permitting Considerations

Portions of the proposed berm are potentially within existing wetland preserve areas. Mitigation of impacts to these areas will be required and can potentially be provided onsite.

Land Availability

The proposed project is located on lands owned by Lee County, although different parcels are managed by different agencies within the County. Collaboration between the agencies will be required for successful completion of the project.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements. Due to the proximity of environmentally-sensitive areas and the relatively low construction costs compared with the other projects, a higher fee percentage was used for the professional services for conceptual cost purposes.

Table 6 – Opinion of Probable Cost breakdown, 1.4.6 LCPA Diversion to Estero Basin

Construction Costs

Component	Quantity	Unit	Unit Price	Cost
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$ 200,000	$ 200,000
Clearing & Grubbing	12	AC	$ 14,000	$ 168,000
Earthwork	46,667	CY	$ 10	$ 467,000
Permanent Erosion Control	3,500	SF	$ 25	$ 88,000
Grassing	18,667	SY	$ 3	$ 57,000
			Conceptual Construction Costs:	**$ 1,000,000**
			Professional Services: Eng, Survey, Environ, Geotech (50%)	$ 500,000
			Land Acquisition	$ -
			Project Administration/ CEI (10%)	$ 100,000
			Conceptual Project Cost:	**$ 1,600,000**
			Contengency (30%)	$ 500,000
			Conceptual Project Cost (with Contengency):	**$ 2,100,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

The project has the potential to lengthen the hydroperiod of upstream wetlands within the Wild Turkey Strand Preserve, enhancing existing wetland habitat.

Other Considerations

The success of this project depends in part on the completion of downstream improvements in the Estero River Watershed covered in more detail in Section 1.3 of this report.

Findings & Recommendations

Regional Modeling Findings

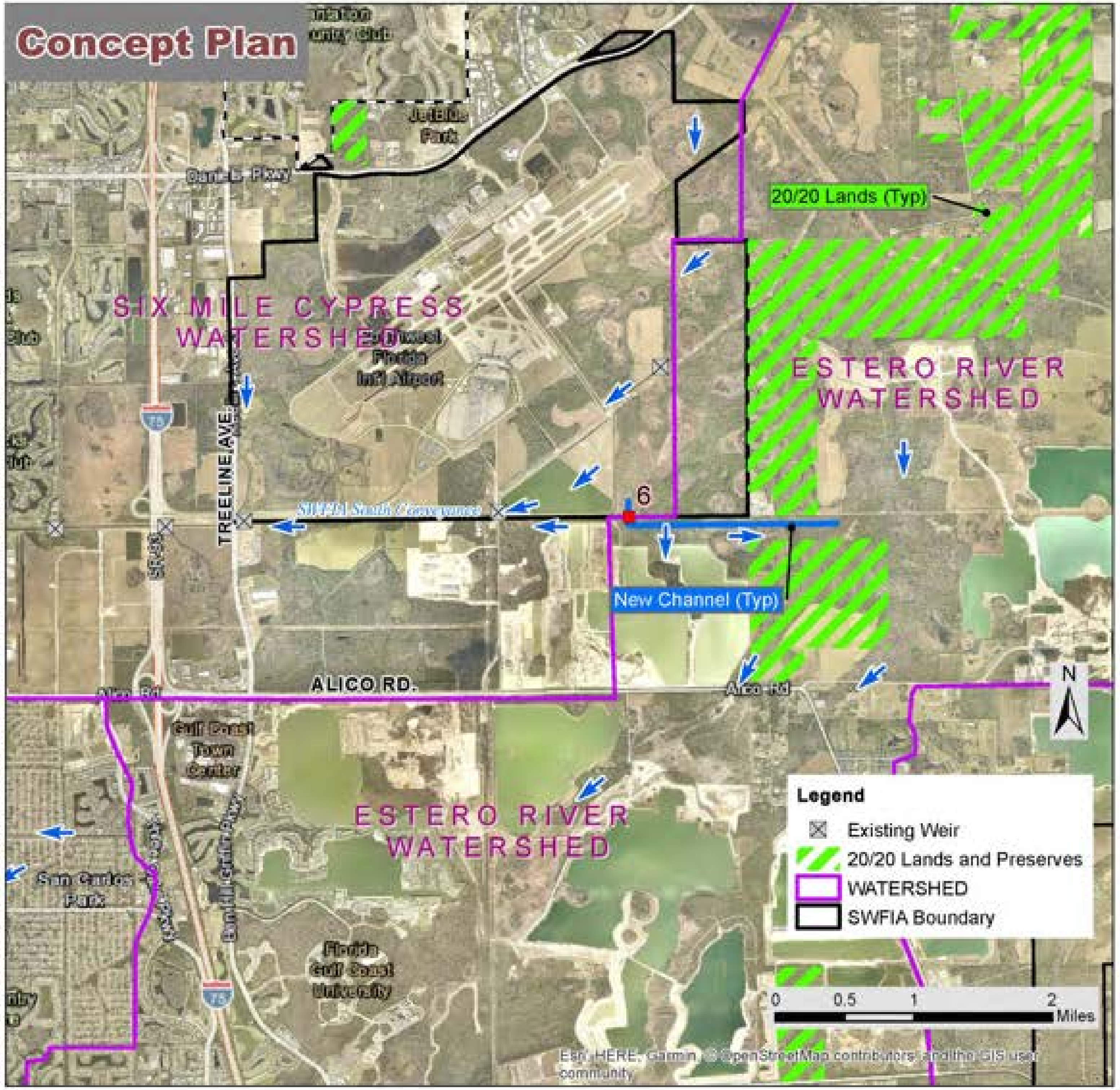
The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.6 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. Modeled results demonstrating the water levels and discharges over time are included for the following design storm events:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.4.6 (b)
	Flow(s)	EXHIBIT 1.4.6 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s)	EXHIBIT 1.4.6 (d)
	Flow(s)	EXHIBIT 1.4.6 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.4.6 (f)
	Flow(s)	EXHIBIT 1.4.6 (g)
Continuous Simulation (Hourly 2017)	Water Level(s)	EXHIBIT 1.4.6 (h)
	Flow(s)	EXHIBIT 1.4.6 (i)

The model results showed increased water levels in the wetlands east of SWFIA (Water Level Point 5) and showed less flow going into the upstream end of the Estero River watershed.

Recommendations

The positive improvements of this project concept warrant further project development. The proposed conveyance can be reduced in size, if not eliminated from the project entirely, given the small flows shown in the model. These adjustments could greatly reduce project construction costs.



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands and 20/20 Lands were provided by Lee County GIS.

Project Narrative

DESCRIPTION: The southeast corner of SWFIA was historically within the Estero River watershed. Permitting in the early 2000s allowed this area into the SWFIA water management system, which ultimately discharges to Ten Mile Canal via the Briarcliff Channel.The master stormwater management system for SWFIA was modified in the past few years to instead direct this discharge to the Estero River watershed as a part of the parallel runway project. This project proposes berms and weirs on County-owned lands east of SWFIA.

PURPOSE: This project creates additional storage and redirects additional water to the Estero River watershed, reducing runoff volumes to Ten Mile Canal.

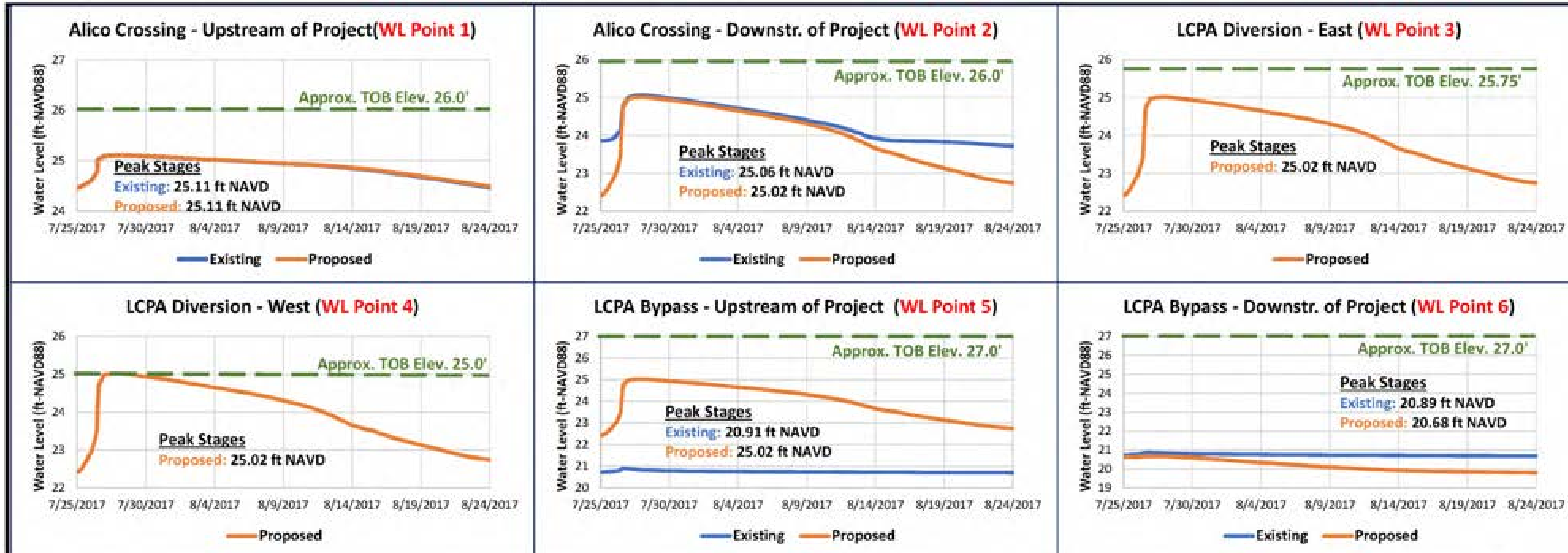
CONSTRAINTS: Permits currently support this downstream route, but modeling to ensure additional flows to Estero are within system capacities is required. Existing and proposed mine operations immediately to the south have the potential to negatively or positively impact conveyance capacity and storage volume. Developments along the North Branch of the Estero River already experience flooding and delivery of more water to this region will test the storage capacity needed to not move flooding from one location to another.

MAY 2020

LCPA Diversion to Estero Basin
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.6(a)



1.4.6 LCPA Diversion to Estero Basin

Water Level(s)

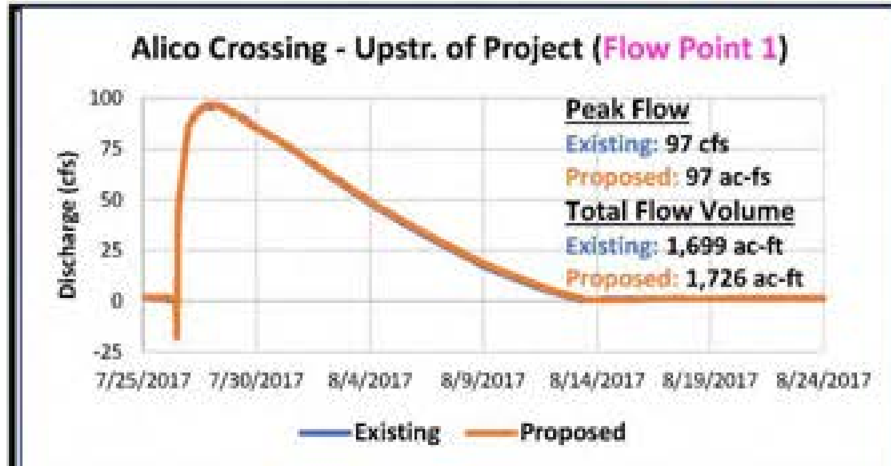
25-yr 3-day (Jul Start)

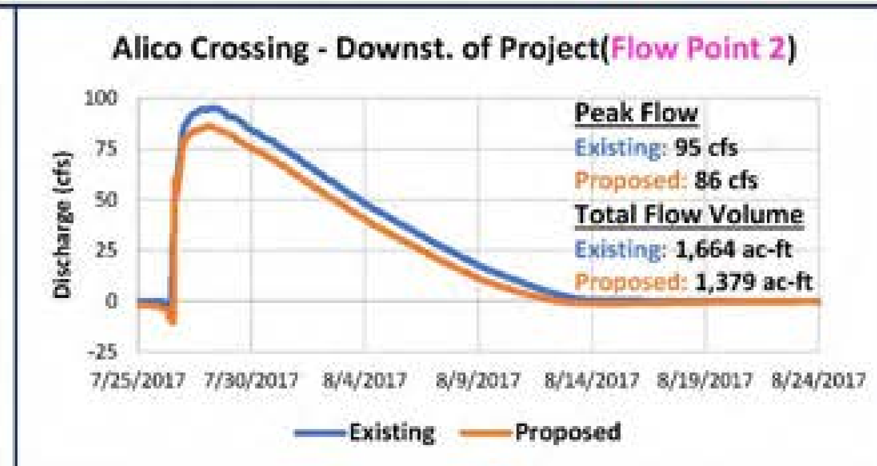
EXHIBIT 1.4.6 (b)

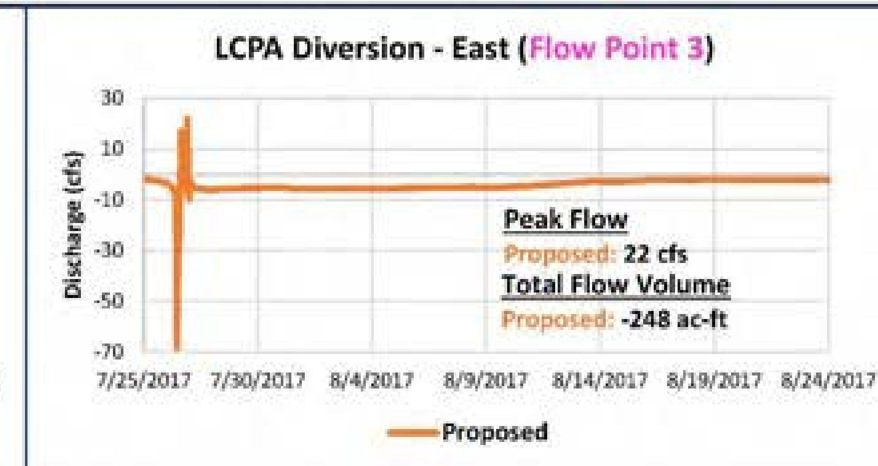
1.4.6 LCPA Diversion to Estero Basin

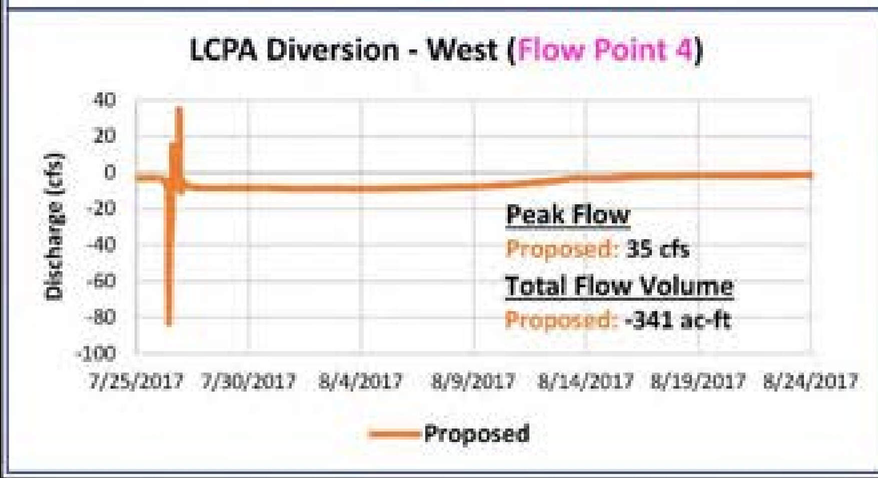
Flow(s)

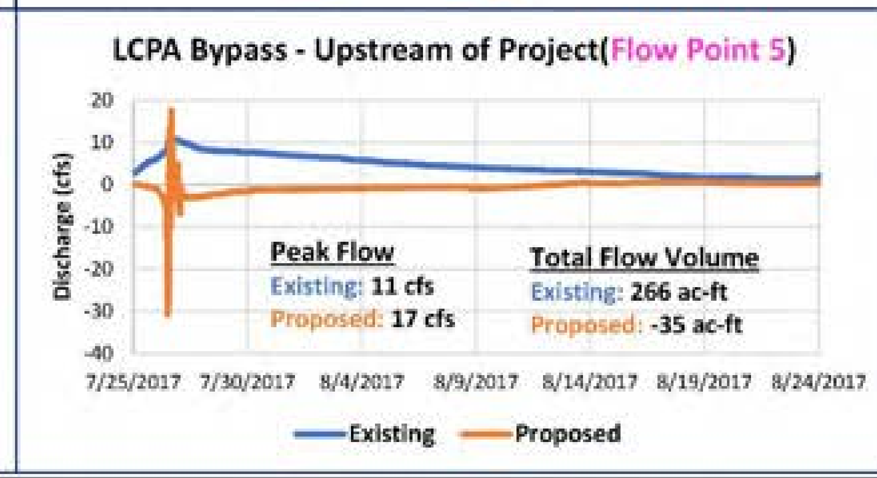
25-yr 3-day (Jul Start)











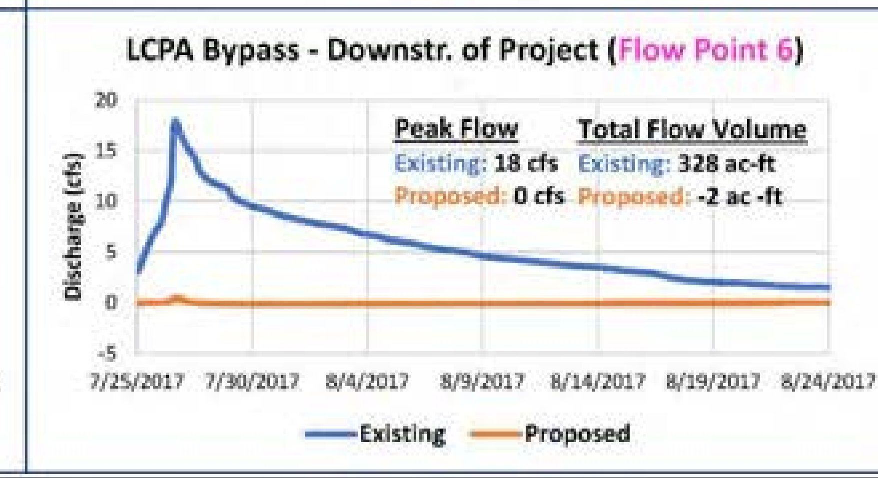


EXHIBIT 1.4.6 (c)

1.4.6 LCPA Diversion to Estero Basin

Water Level(s)

100-yr 3-day (Jul Start)

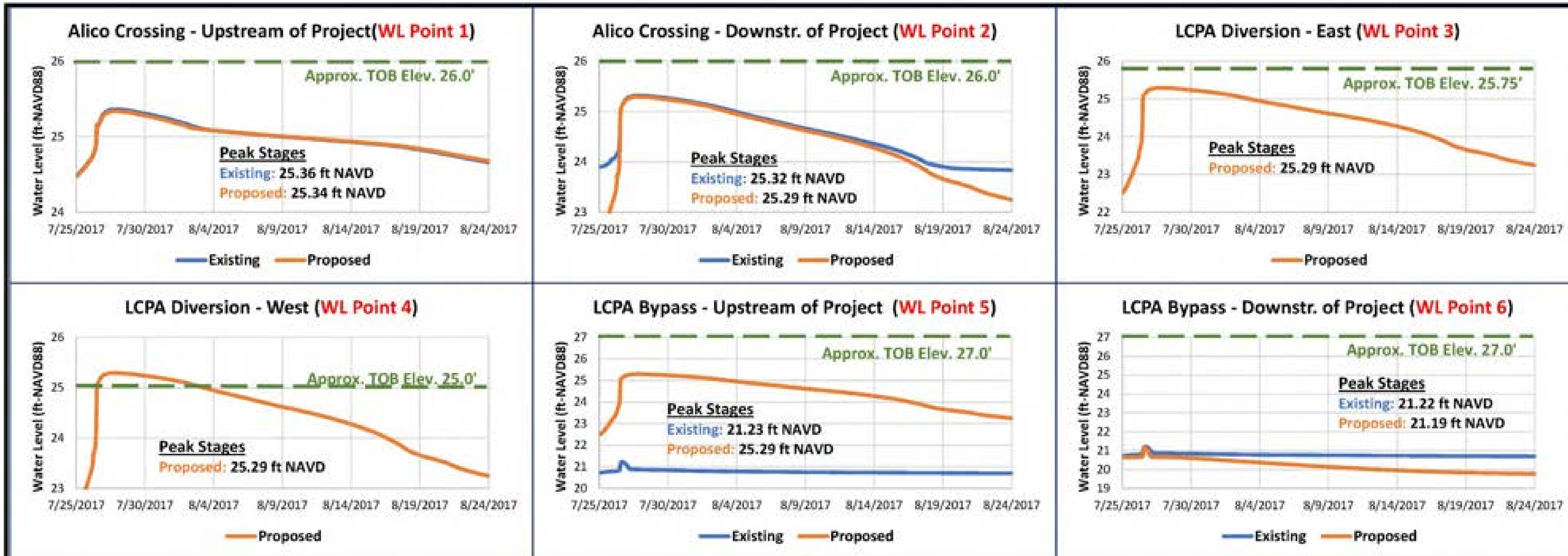
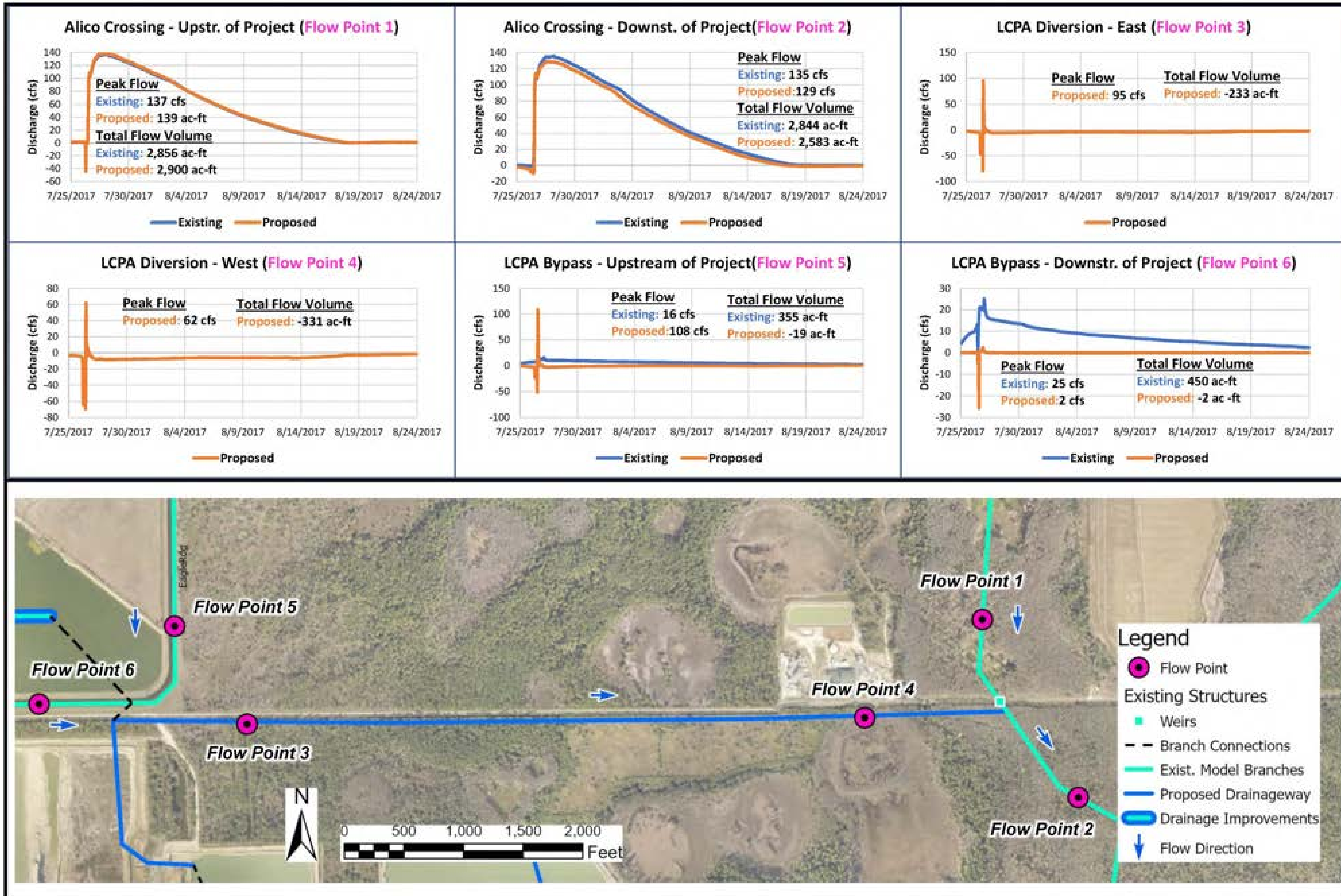


EXHIBIT 1.4.6 (d)

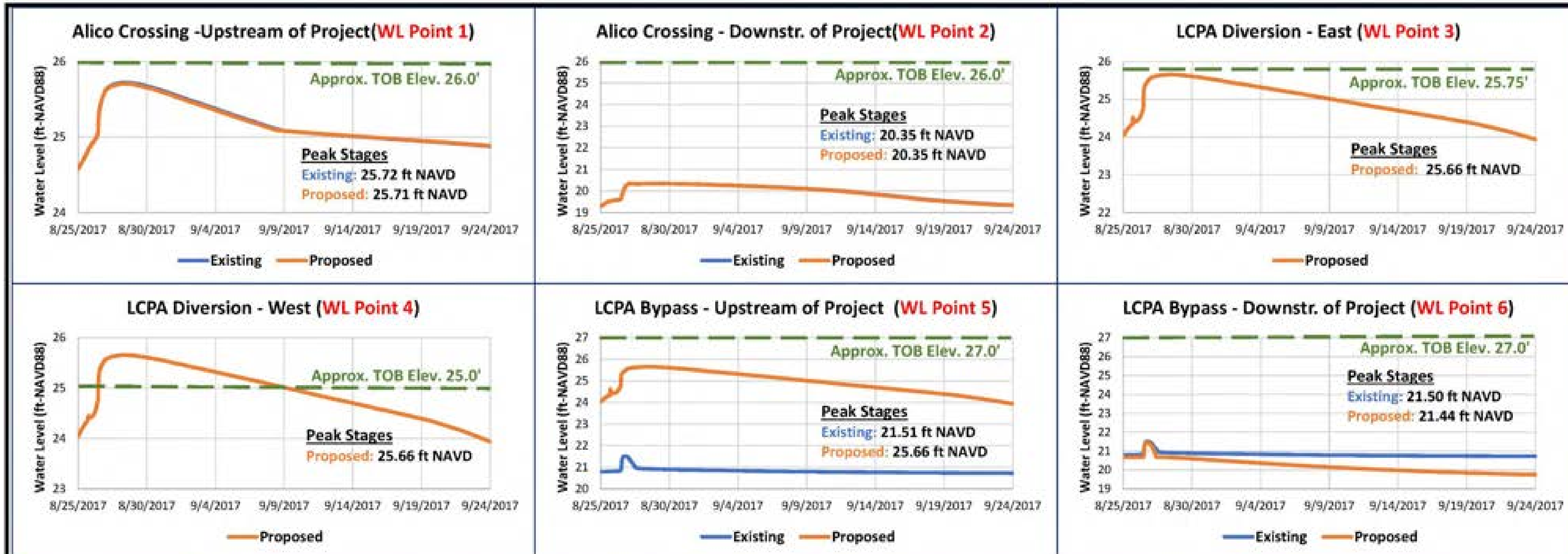


1.4.6 LCPA Diversion to Estero Basin

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.4.6 (e)



1.4.6 LCPA Diversion to Estero Basin

Water Level(s)

100-yr 3-day (Aug Start)

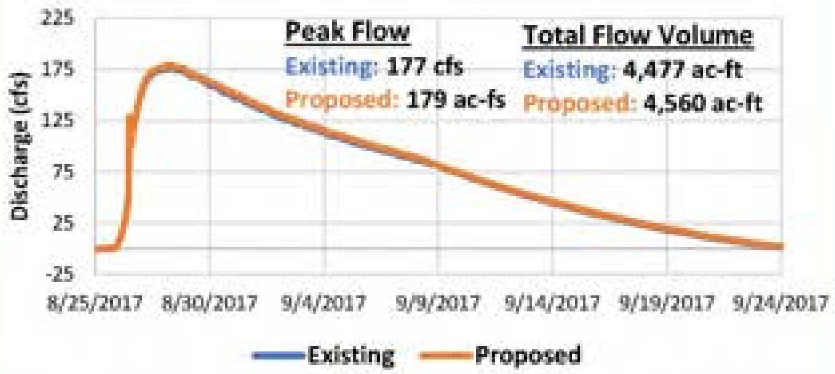
EXHIBIT 1.4.6 (f)

1.4.6 LCPA Diversion to Estero Basin

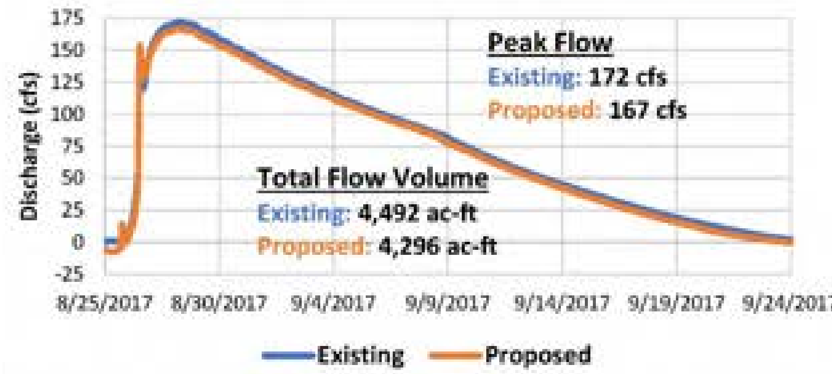
Flow(s)

100-yr 3-day (Aug Start)

Alico Crossing - Upstr. of Project (Flow Point 1)



Alico Crossing -Downst. of Project(Flow Point 2)



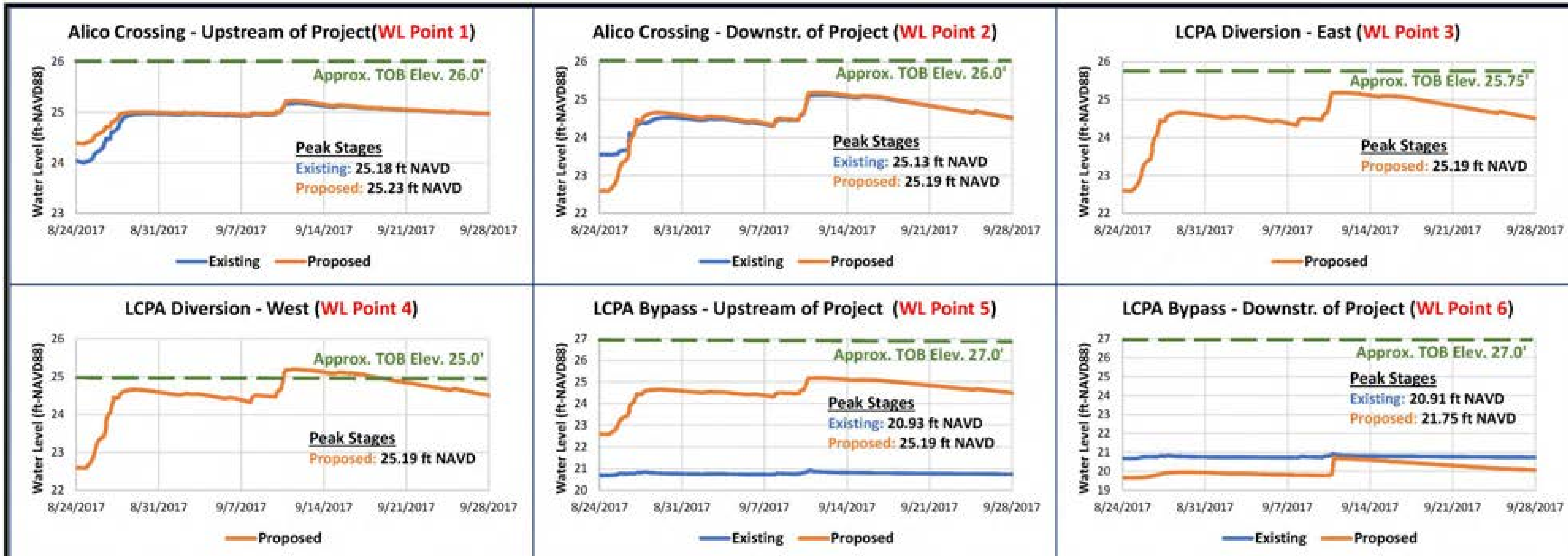
LCPA Diversion - East (Flow Point 3)

LCPA Diversion - West (Flow Point 4)

LCPA Bypass -Upstream of Project(Flow Point 5)

LCPA Bypass - Downstr. of Project (Flow Point 6)

EXHIBIT 1.4.6 (g)

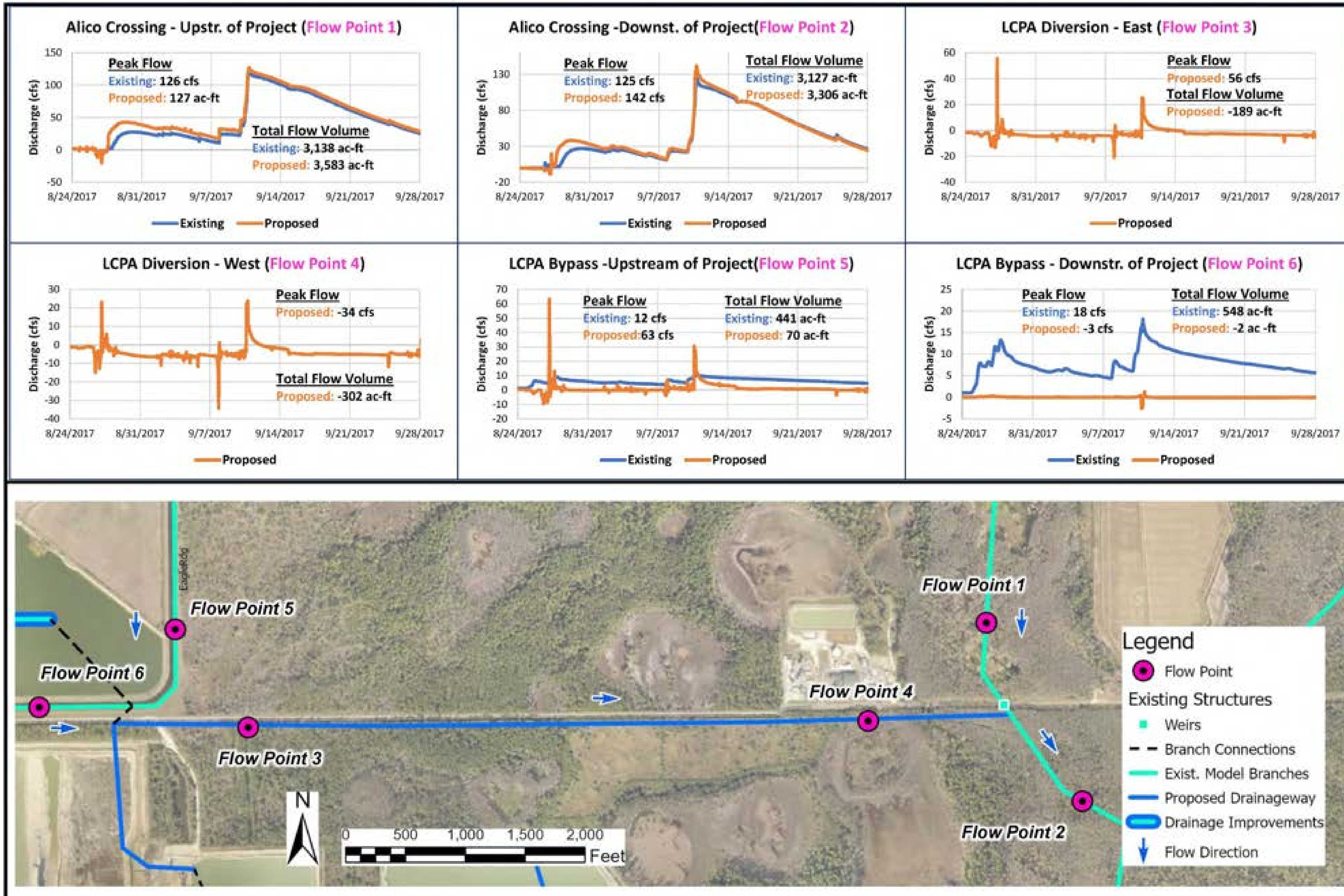


1.4.6 LCPA Diversion to Estero Basin

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.6 (h)



1.4.6 LCPA Diversion to Estero Basin

Flow(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.6 (i)

1.4.7 Six Mile Cypress Slough-South

Background

Water levels in the Six Mile Cypress Slough are controlled by existing weirs at Daniels Parkway and at the interface with the Ten Mile Canal. The weirs are used to lengthen the hydroperiod of the Slough and have operable gates that provide the ability to lower the water levels in the Slough in low frequency situations ahead of a major storm to provide additional storage capacity in the basin. The existing weirs immediately north of Daniels Parkway were constructed in the late 1970s and early 1980s, in conjunction with Daniels Parkway. Lee County DOT staff report that opening the gates in the weir at the interface with the Ten Mile Canal ahead of a major storm event can successfully lower the water levels upstream for approximately 1.3 miles, however, it does not cause a measurable change in water levels or increase in flow in the Slough under Daniels Parkway (approximately 2.3 miles upstream from Ten Mile Canal). This lack of operational flexibility is not due to tailwater condition in Ten Mile Canal, as the downstream weir crest elevation in Ten Mile Canal is elevation 4.3 feet NAVD 88 while the weir crest elevation of the Six Mile Cypress Slough at the interface with Ten Mile Canal is elevation 9.8 feet NAVD 88, meaning the tailwater is nonlimiting.

During the construction of Six Mile Cypress Parkway in the early 1990s, an interconnect running east and west under Six Mile Cypress Parkway on the north side of Daniels Parkway was built with the anticipation of a need to rehydrate the Slough by back-pumping from Ten Mile Canal. This has rarely, if ever, been instituted but creates an opportunity, as described below, for more flexible management the Six Mile Cypress watershed ahead of a large storm event.

Location

The proposed projects are in the southern region of the Six Mile Cypress Slough, from just upstream of Daniels Parkway to the interface with Ten Mile Canal.

Description

A group of projects is proposed to improve the ability to manage the water levels in the Slough in emergency situations. Understory cleaning of debris that has fallen and been carried downstream over the past couple decades is recommended in the furthest downstream mile of the Slough to reduce the overland flow roughness coefficient. An alternative to understory cleaning is to allow the upstream communities with stormwater management systems to install pumps to overcome the adverse tailwater conditions, when water levels in the Six Mile Cypress Slough exceed the levels in the communities. The pumping systems should be designed to not exceed the allowable discharge rate of the community.

Construction of Metro Parkway Extension in the early 1990s included a horseshoe area at the furthest downstream end of the Six Mile Cypress Slough that was excavated to serve as a flow equalizer between the two outfall weir structures from the Slough into Ten Mile Canal. Historical imagery indicates the flow equalization area has gradually filled in with sediment and vegetation. Maintenance cleaning of the area is recommended.

During construction of the Metro Parkway Extension (Michael G. Rippe Parkway), the original design plans included a perimeter swale along the eastern edge of the right of way. The perimeter swale was built and is shown as being lined with rip-rap in the 2014 as-built drawings. However, Lee County DOT staff report that the rip-rap potentially also resulted in a small berm on the eastern edge of the swale that prevents flow from entering the swale from the Six Mile Cypress Slough. Restoration of this swale is recommended to remove any impediments of flow into the swale.

The existing interconnect under Six Mile Cypress Parkway on the north side of Daniels Parkway is proposed to be modified to allow for more flexible management the Six Mile Cypress watershed before and after a large storm event. Advanced weir control features, including motorized gates with local or telemetry control, allow for greater flexibility of water management to develop storage capacity ahead of a storm and divert water at high stages, all while protecting downstream communities that are receiving the diverted water. This would need to be done well in advance (up to five days) of a known large storm event, as it will likely stage up water levels in Ten Mile Canal which will be viewed as undesirable in the downstream reaches of Ten Mile Canal later in the storm development process. Once the storage was created in the watershed ahead of the expected storm event, the interconnect would be closed. Additional flexibility can be incorporated into the redesign of the existing interconnect structure under Six Mile Cypress Parkway on the north side of Daniels Parkway to allow the pump to send flow in the opposite direction and hydrate the Six Mile Cypress Slough during drier periods using water from Ten Mile Canal.

Objectives

Taken together, the proposed projects provide additional storage capacity in the Slough ahead of a major storm event and provide increased conveyance capacity. This will also reduce flows to the lower reaches of Ten Mile Canal, helping to mitigate impacts of larger storm events.

Evaluation

Viability

Success of the conveyance improvement projects will rely in part on the completion of other downstream improvement projects in Ten Mile Canal to achieve the required results without causing increased flood stages in downstream areas. The flow diversion project would not be overly challenging from a technical standpoint and the structure modifications will be straightforward to design. Modeling will be required to demonstrate the operation schedule of the modified structure that conveys water under Six Mile Cypress Parkway will not result in increased flood stages downstream.

Community Considerations

This project relies on the completion of other downstream improvement projects in the Ten Mile Canal to achieve the required results without causing increased flood stages in downstream communities. The roadside swales will have higher than normal water levels during periods of diversion, and levels of service will need to be analyzed to ensure safety of the traveling public will need to be considered.

Environmental & Permitting Considerations

Most of the proposed work area is within or adjacent to preserve and environmentally-sensitive lands, making this type of flow capacity restoration challenging. Most storm events cannot be predicted more than five days in advance with any type of certainty. When considering water management actions more than five days in advance, a Professional Wetland Scientist should be consulted regarding any impacts that a drawdown may have on the natural communities within the slough.

Land Availability

The proposed projects are within existing roadway rights of way or County-owned properties. However, work within areas with existing conservation easements will be limited to the stipulations of the easements, unless modified.

Opinion of Probable Cost

The cost estimate is preliminary in nature and figures are rounded to the nearest $100,000. The project cost is anticipated to increase with inflation or changes in future market conditions. Earthwork unit cost is anticipated to be advantageous as excavated fill can be utilized to fill low spots within the work area, thereby reducing trucking distance requirements.

Table 7 – Opinion of Probable Cost breakdown, 1.4.7 Six Mile Cypress Slough-South

Construction Costs

Component	Quantity	Unit	Unit Price		Cost	
Mobilization/ Demobilization/ MOT/ Layout/ SWPPP/ Access/ Misc.	1	LS	$	200,000	$	200,000
Clearing & Grubbing	1	AC	$	14,000	$	14,000
Earthwork	8,429	CY	$	10	$	85,000
Weir Structure 1.4.7 A (Major)	15	LF	$	10,000	$	150,000
Pumps (25 cfs)	1	EA	$	310,000	$	310,000
Permanent Erosion Control	3,500	SF	$	25	$	88,000
Grassing	2,766	SY	$	3	$	9,000
				Conceptual Construction Costs:	**$**	**900,000**
				Professional Services: Eng, Survey, Environ, Geotech (30%)	$	270,000
				Land Acquisition	$	-
				Project Administration/ CEI (10%)	$	90,000
				Conceptual Project Cost:	**$**	**1,300,000**
				Contengency (30%)	$	400,000
				Conceptual Project Cost (with Contengency):	**$**	**1,700,000**

Note:

This budgetary conceptual Opinion of Probable Cost was prepared without the benefit of detailed plans, surveys, geotechnical soil investigations, environmental assessments, land boundaries, title research, utility locates, etc. and used limited and generalized information. The project has been presumed to schedule, plan and pursue activities as cost effectively as possible. Cost effectiveness may include multi-purposes, such as coordinating earthwork excavation with other project's fill material demands, providing wetland creation, where practical to offset mitigation cost, combining land acquisition with other community land needs, working with the land development owners for inclusion of flood mitigation in their project plans for joint benefit and pursuing other cost saving opportunities as may occur.

Opportunities for Multiple Benefits & Uses

The project has the potential to provide additional hydration of Six Mile Cypress Slough, lengthening the wetland hydroperiod and enhancing existing wetland habitat. The project could also assist Lee County achieve their BMAP goals for Total Nitrogen reduction for the Tidal Caloosahatchee by routing water from Ten Mile Canal through the southern end of Six Mile Cypress Slough.

Findings & Recommendations

Regional Modeling Findings

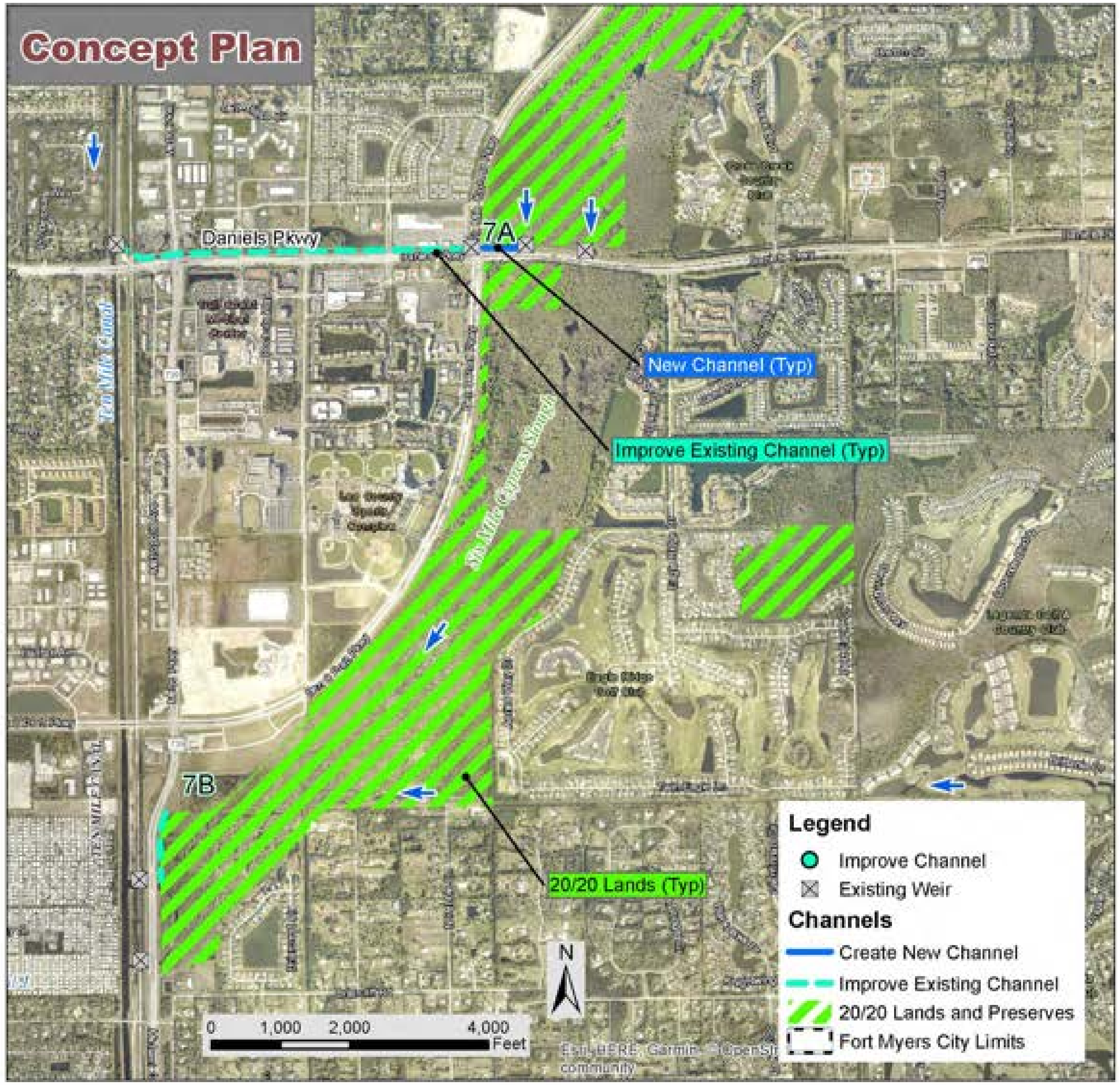
The concept project was incorporated into the regional model to analyze the project's effectiveness. The concept plan is shown in **Exhibit 1.4.7 (a)**. Model input data, concept refinement map, and initial concept project screening results can be found in **Appendix A**. Modeled results demonstrating the water levels and discharges over time are included for the following design storm events:

Storm Event	Description	Exhibit Nomenclature
25-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.7 (b) EXHIBIT 1.4.7 (c)
100-Year, 3-Day (July 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.7 (d) EXHIBIT 1.4.7 (e)
100-Year, 3-Day (August 2017 Start)	Water Level(s) Flow(s)	EXHIBIT 1.4.7 (f) EXHIBIT 1.4.7 (g)
Continuous Simulation (Hourly 2017)	Water Level(s) Flow(s)	EXHIBIT 1.4.7 (h) EXHIBIT 1.4.7 (i)

The current model results do not show flow through the modified interconnect structure because the gate operations schedule in the model did not instruct the gate to open. However, when the individual conceptual projects were modeled independently previously in the interim project screening report, the gate operation schedule allowed the gate to open be before and after the design storm event. The previous model results demonstrated a reduced recovery time following the peak of the storm event by more than 20 days, but it did not reduce the peak stages in the Slough upstream or downstream of Daniels Parkway. In the previous modeling the transfer of flow from the Slough to Ten Mile Canal did not increase the peak stages in Ten Mile Canal and the project did not affect the recovery time of Ten Mile Canal south of Daniels Parkway.

Recommendations

With the design flows and stages developed in this regional modeling effort, additional local modeling is recommended to refine the designs of the downstream conveyance modifications, gate sizes and elevations, and pump setpoints. The reduced recovery time following the peak stage demonstrated in previous modeling warrants further project development even though the project concept screening did not demonstrate reduction of peak stages in the Slough. It is recommended the proposed pump station be capable of working in both directions to provide additional hydration from Ten Mile Canal to the Six Mile Cypress Slough during dry periods.



NOTES:
1. The aerial photographs shown were provided by Lee County government and were taken in 2019.
2. The County Lands, 20/20 Lands and County Preserves were provided by Lee County GIS.

Project Narrative

DESCRIPTION: Water levels in the Six Mile Cypress Slough are controlled by existing weirs at Daniels Parkway and at the interface with the Ten Mile Canal. The weirs are used to lengthen the hydroperiod of the Slough and have operable gates that can lower the water levels in the Slough ahead of a major storm to provide additional storage capacity in the basin. Projects to improve stormwater management of the southern portion of the Slough include restoration of the perimeter swale along the Metro Parkway Extension (Michael G. Rippe Parkway), and an enhancement of the existing westward flow diversion point at Daniels Parkway.

PURPOSE: The proposed projects provide additional stormwater management flexibility in the Slough ahead of a major storm event.

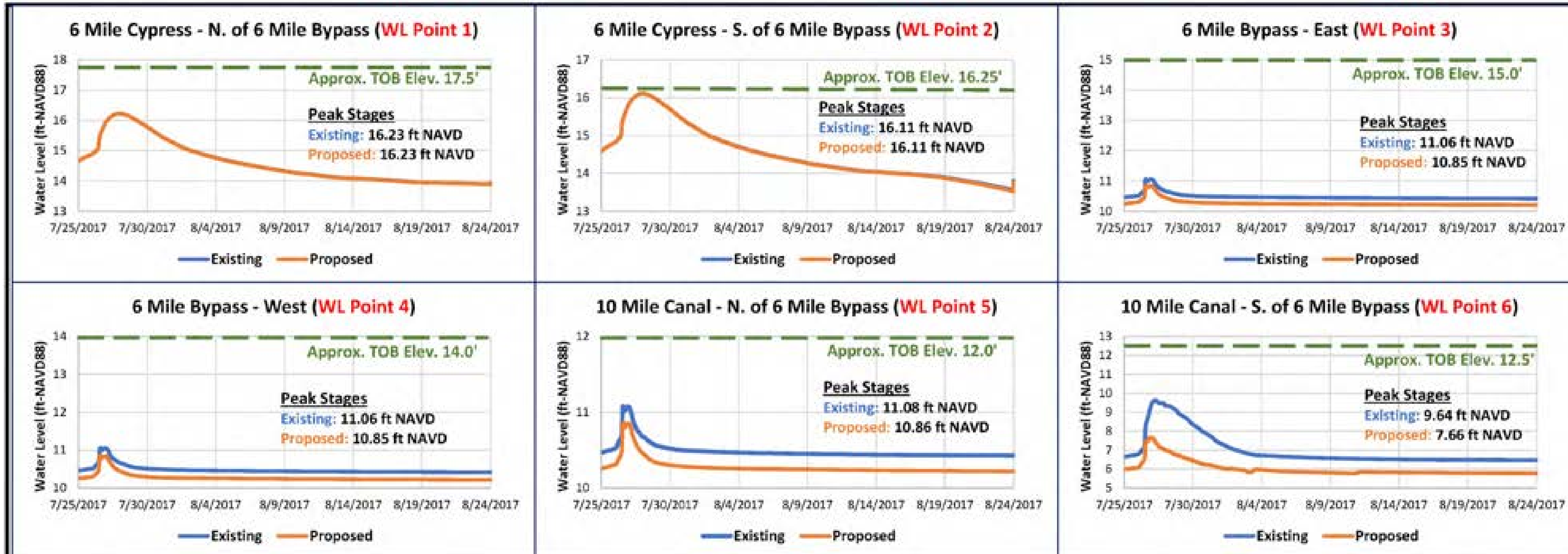
CONSTRAINTS: Most of the proposed work area is within or adjacent to preserve and conservation lands, making this type of flow capacity restoration challenging.

MAY 2020

Six Mile Cypress Slough - South
South Fort Myers Area

JOHNSON ENGINEERING

EXHIBIT 1.4.7(a)



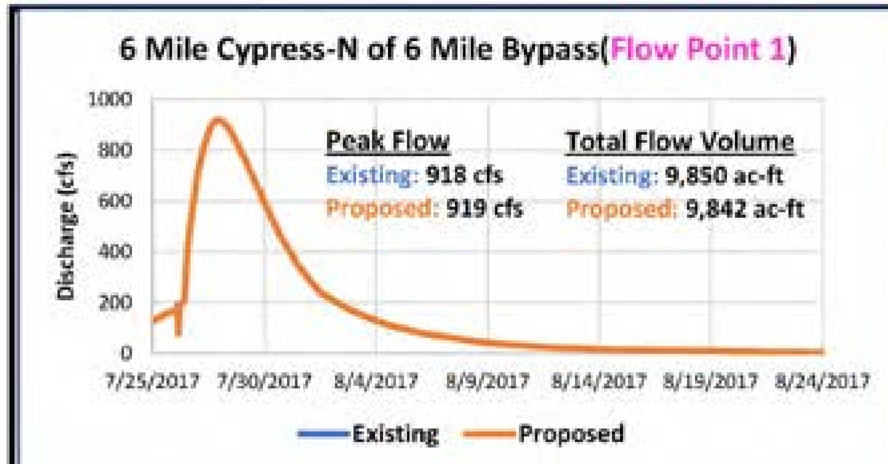
1.4.7 Six Mile Cypress Slough-South

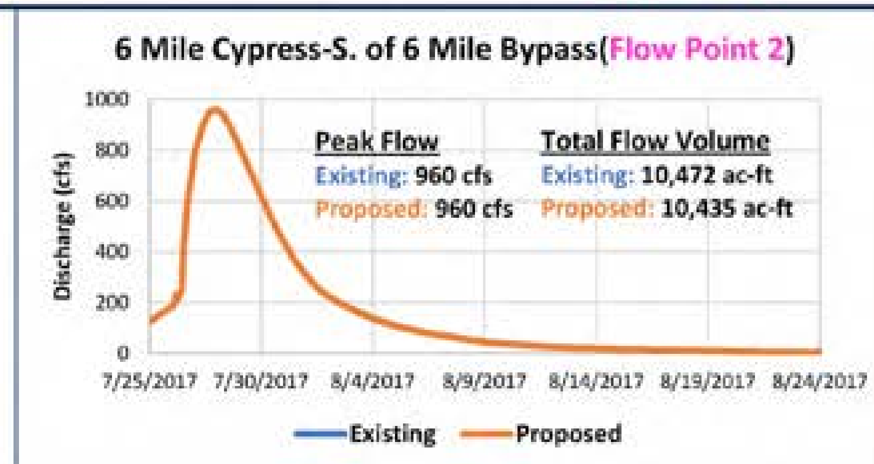
Water Level(s)

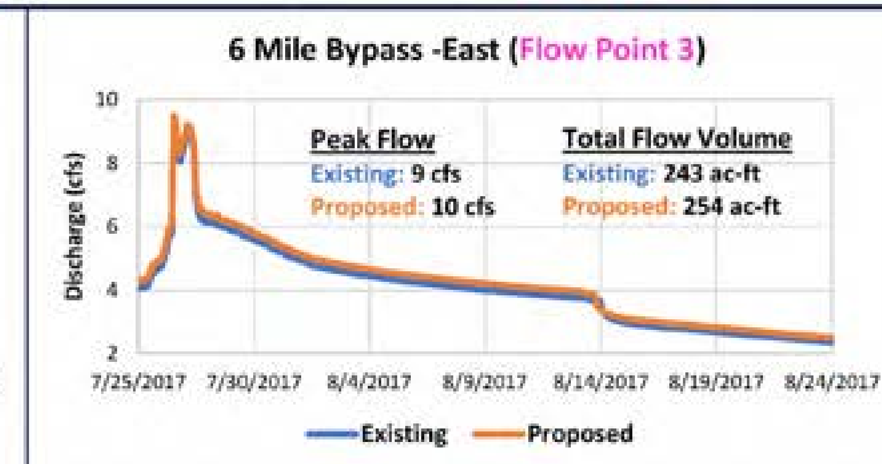
25-yr 3-day (Jul Start)

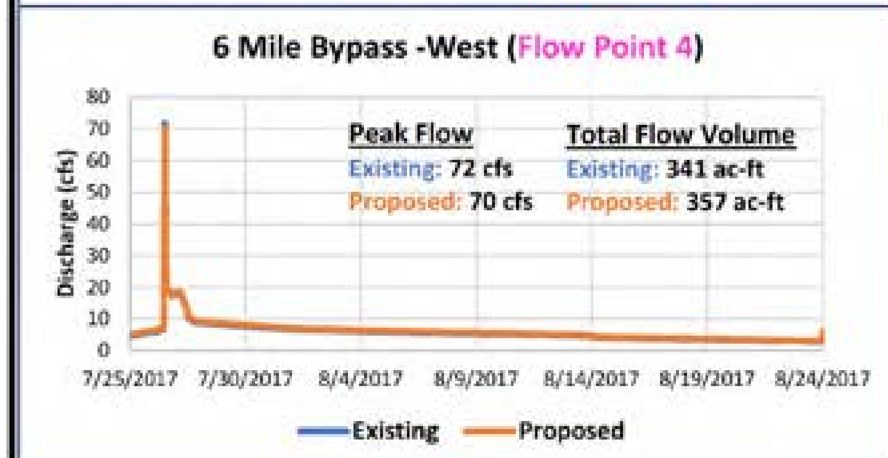
EXHIBIT 1.4.7 (b)

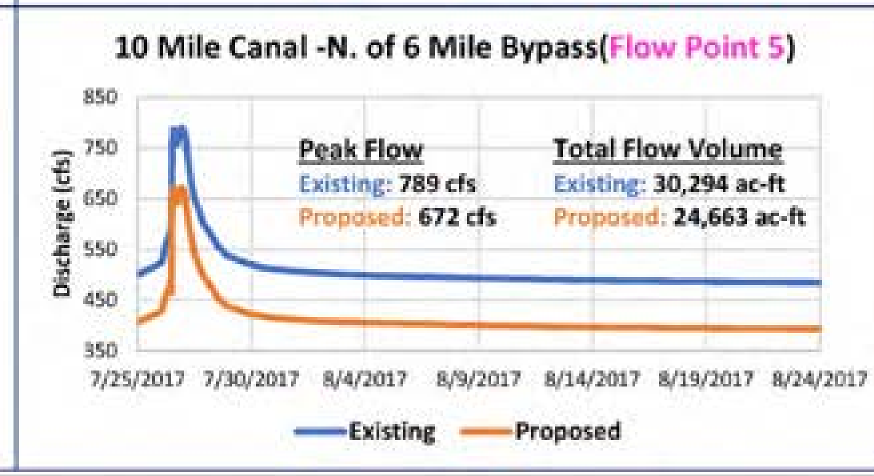
1.4.7 Six Mile Cypress Slough-South

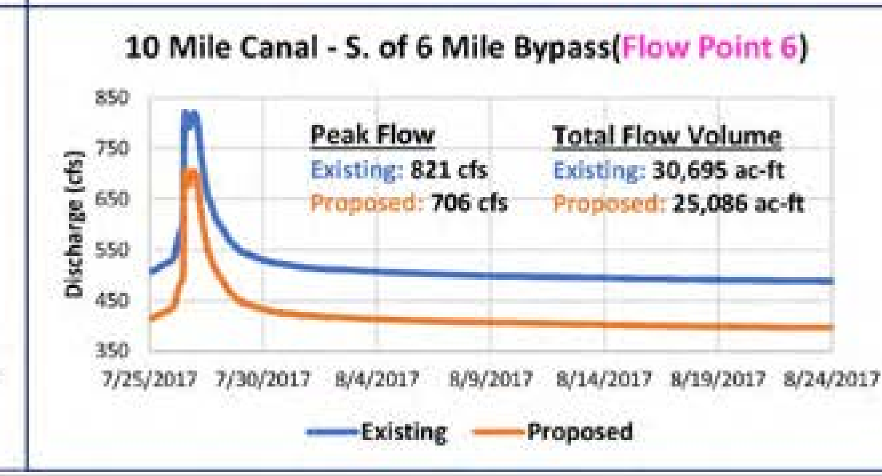








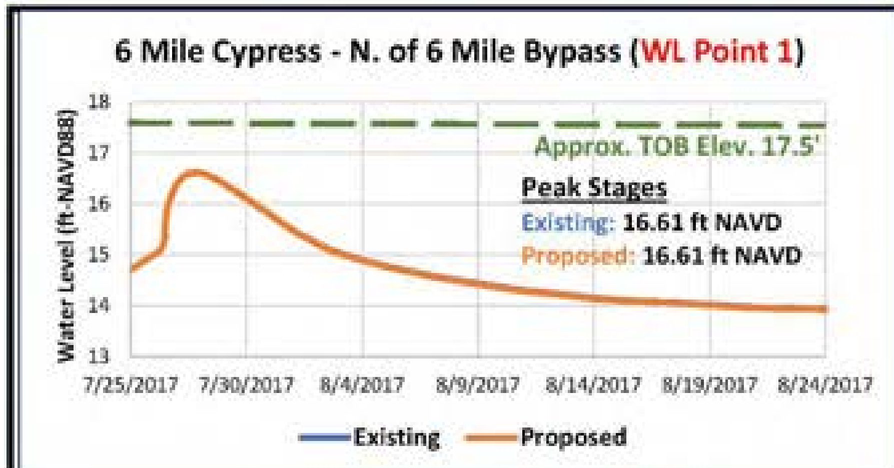


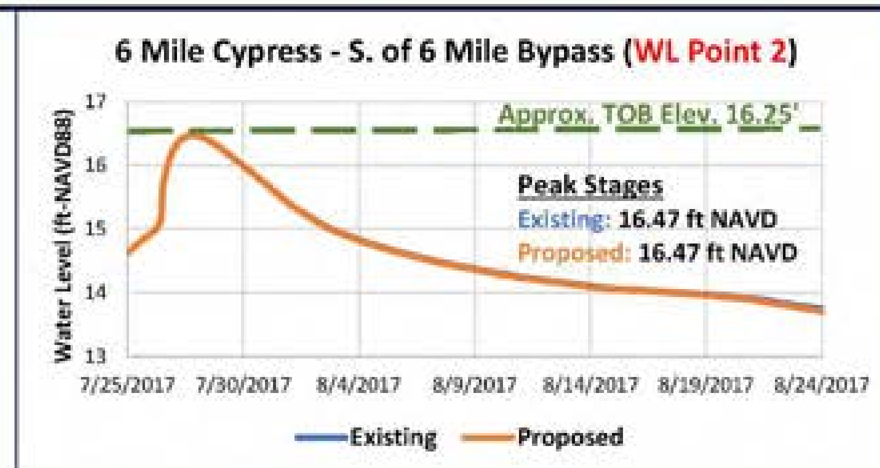


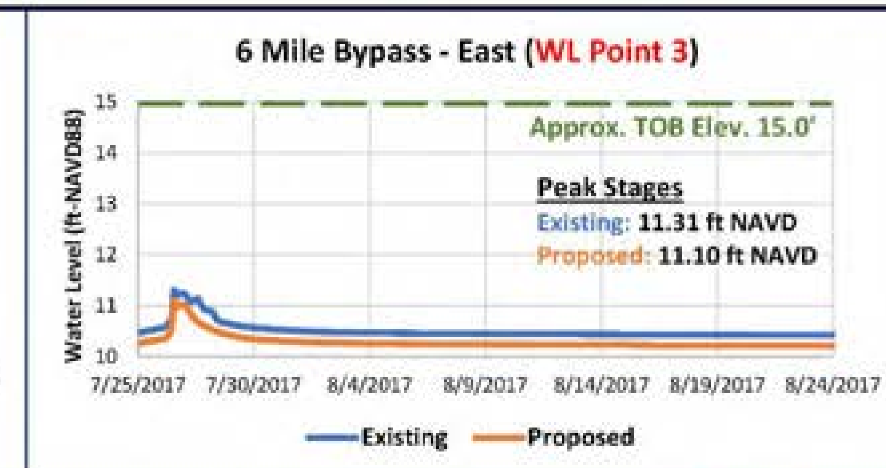
Flow(s)

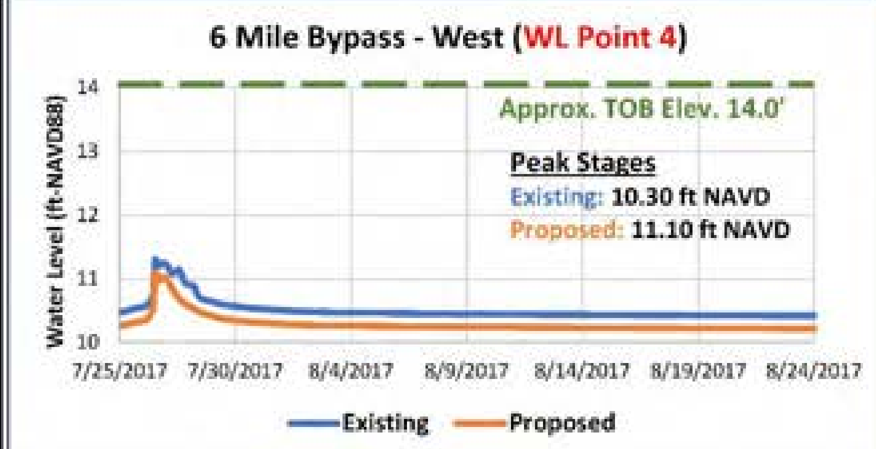
25-yr 3-day (Jul Start)

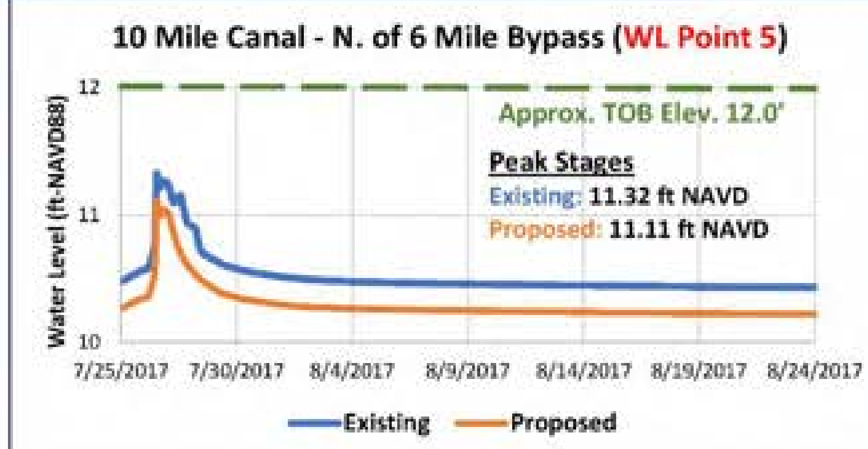
EXHIBIT 1.4.7 (c)

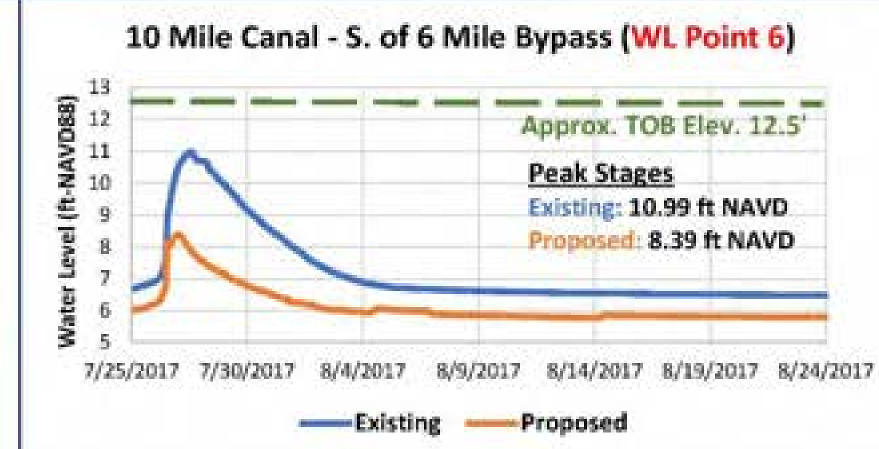










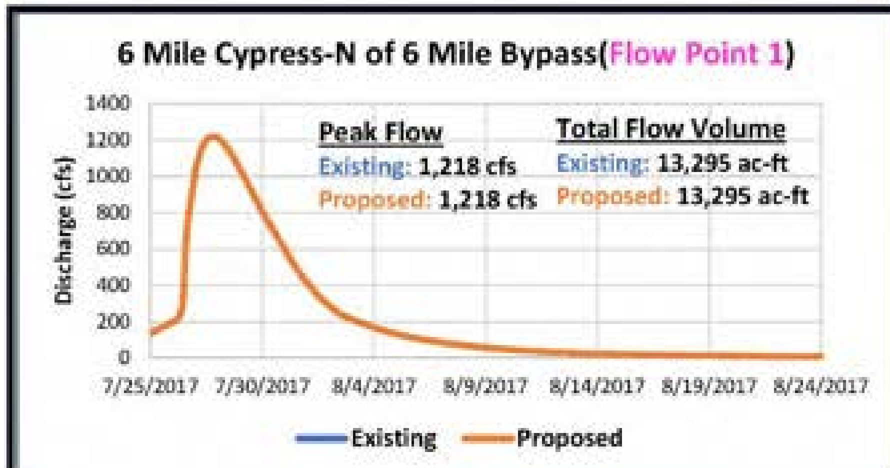


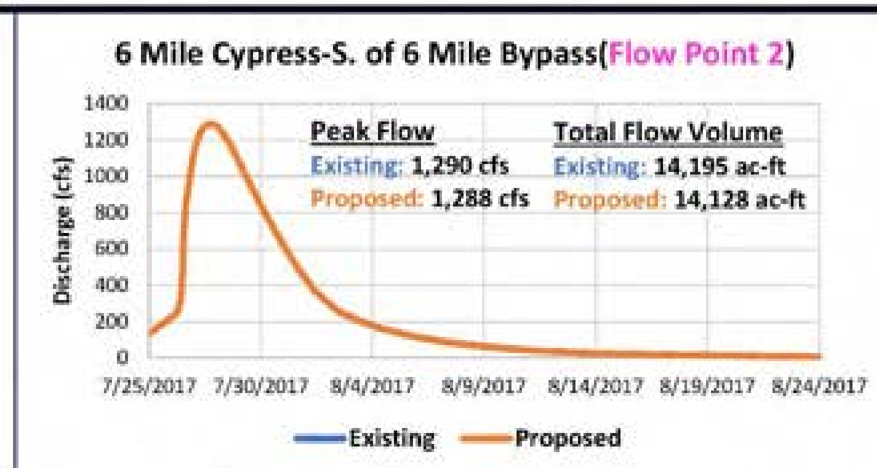
1.4.7 Six Mile Cypress Slough-South

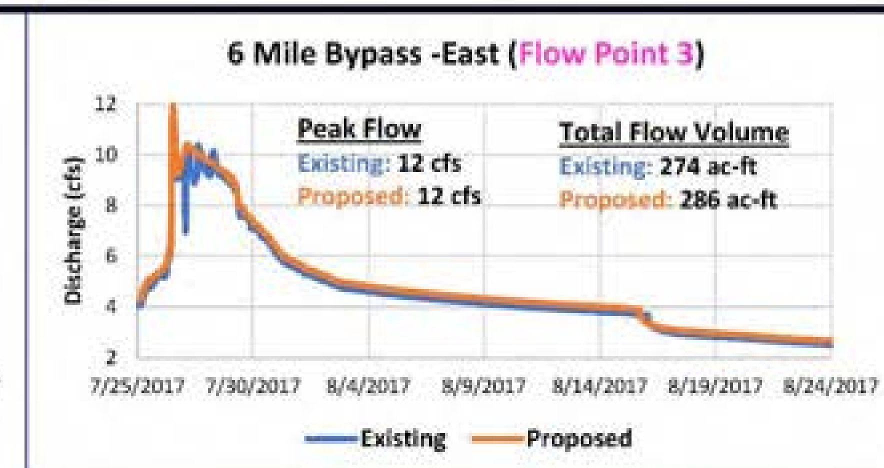
Water Level(s)

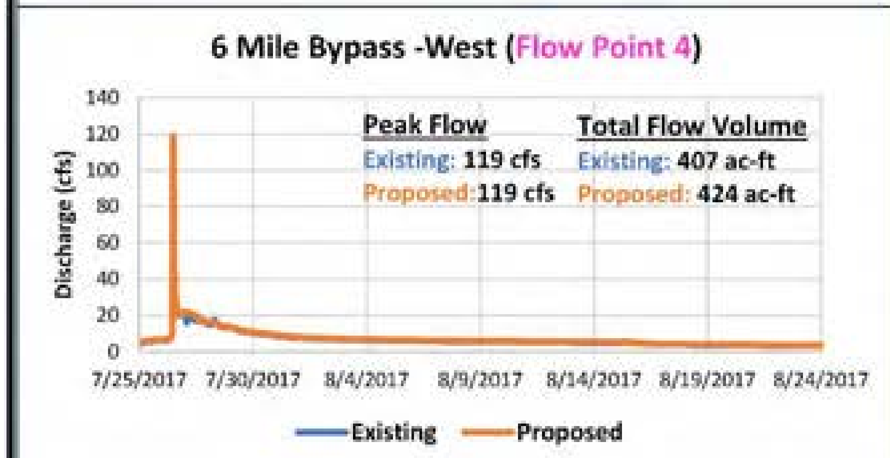
100-yr 3-day (Jul Start)

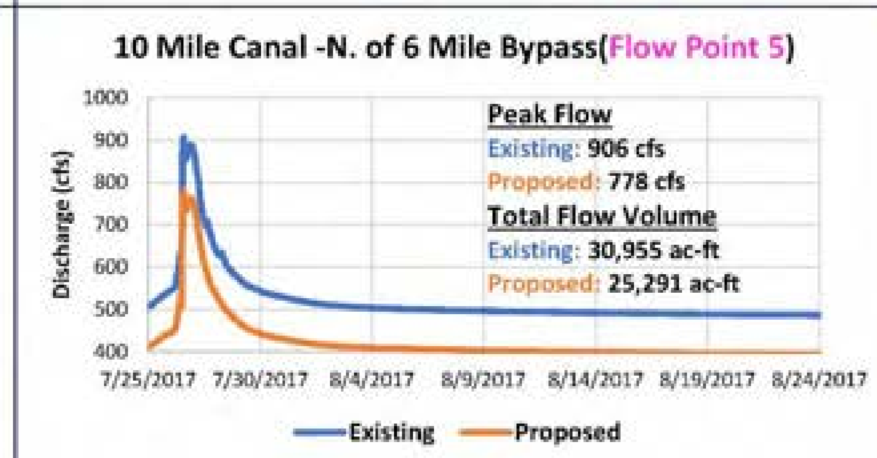
EXHIBIT 1.4.7 (d)

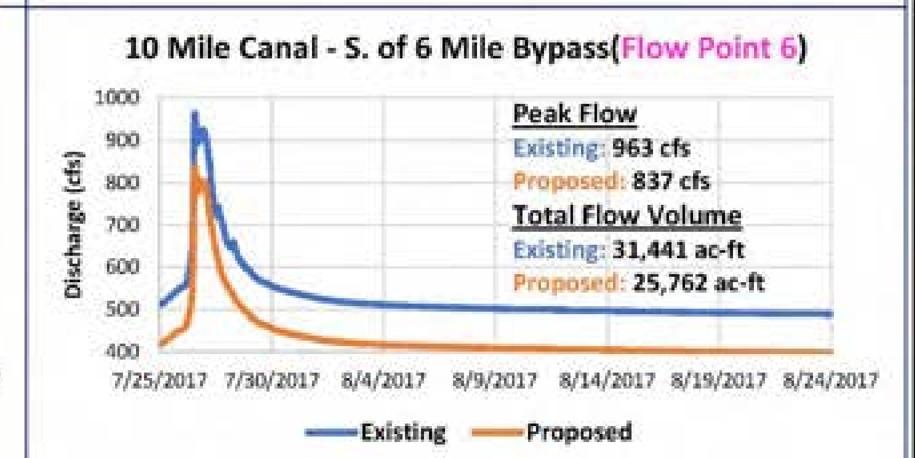












1.4.7 Six Mile Cypress Slough-South

Flow(s)

100-yr 3-day (Jul Start)

EXHIBIT 1.4.7 (e)

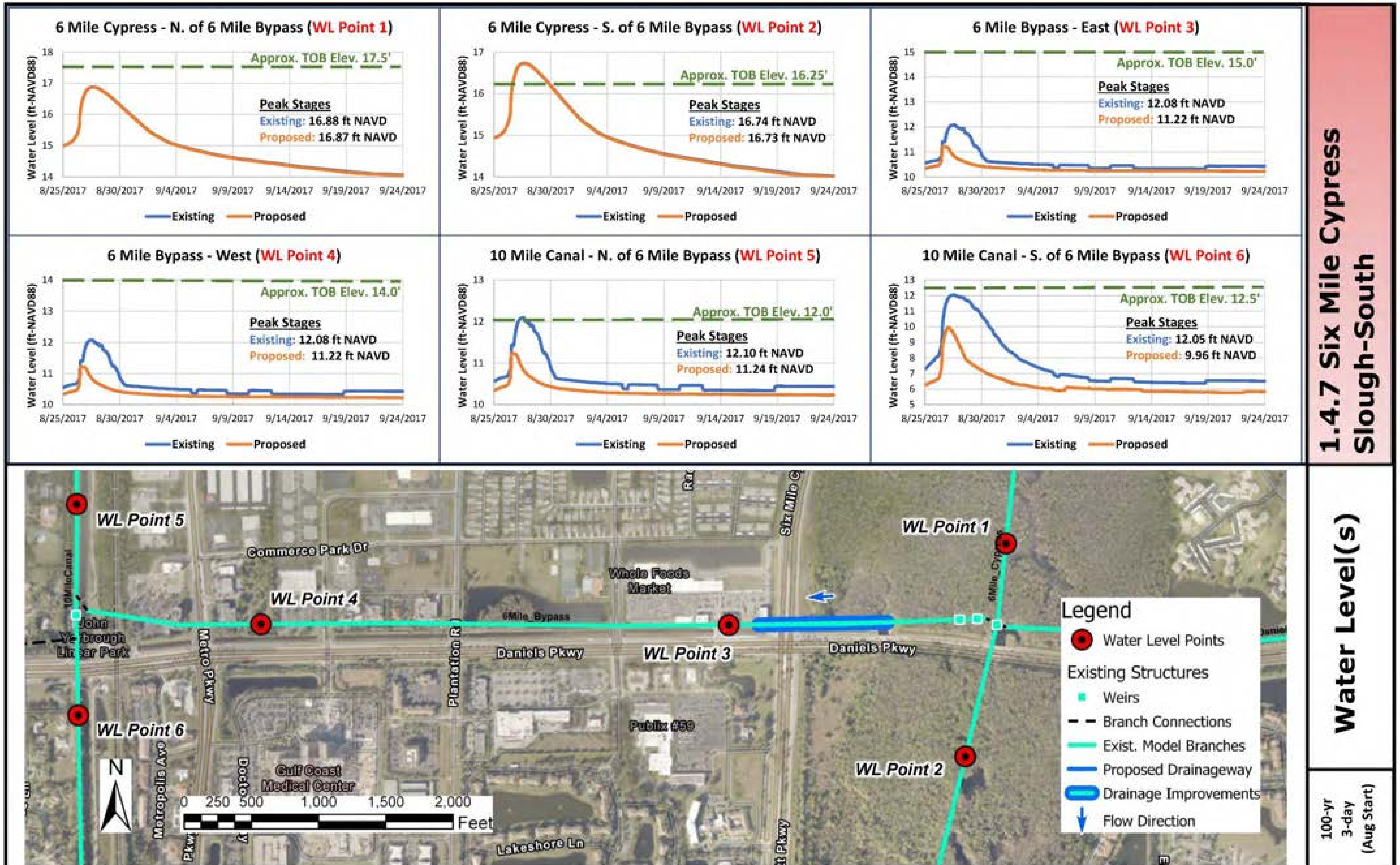
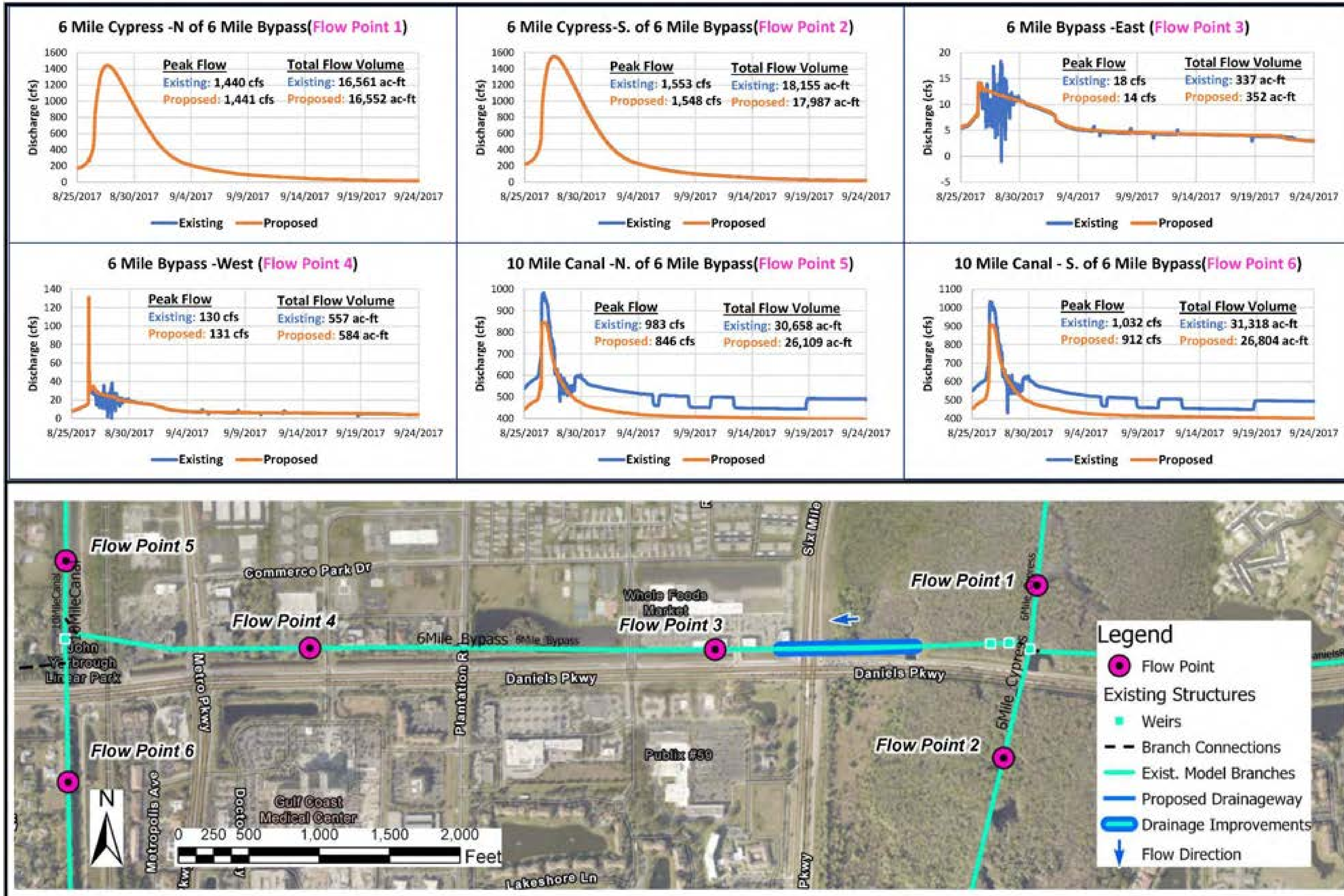


EXHIBIT 1.4.7 (f)

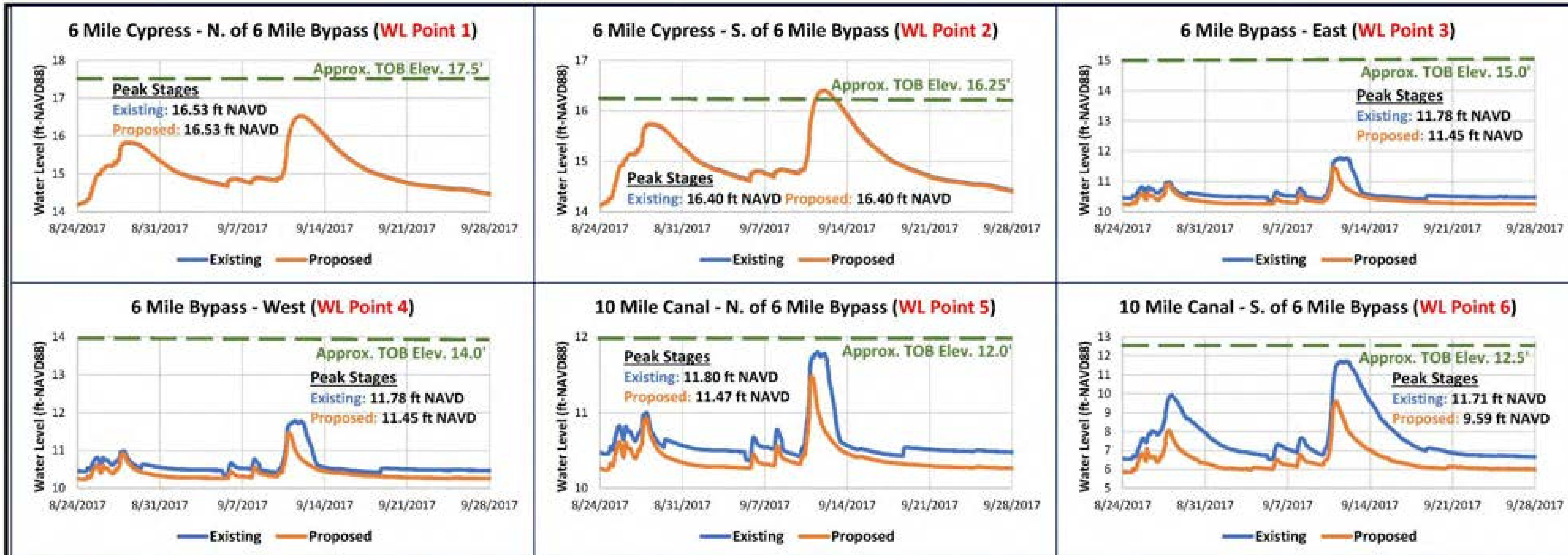


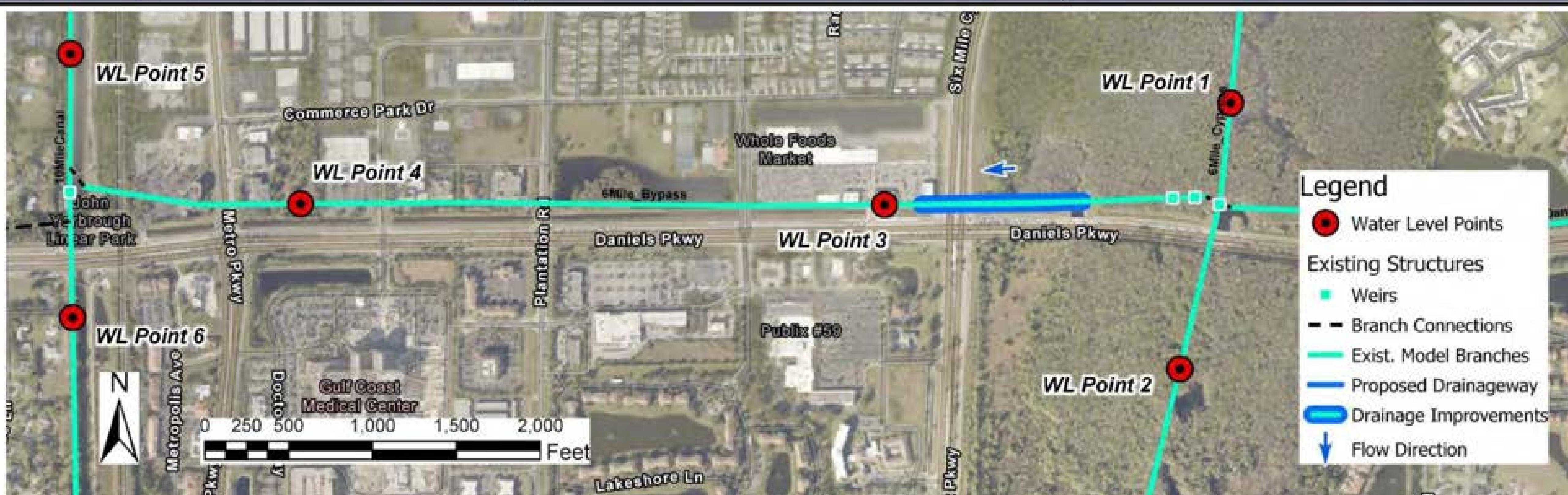
1.4.7 Six Mile Cypress Slough-South

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.4.7 (g)





1.4.7 Six Mile Cypress Slough-South

Water Level(s)

Continuous Simulation (Hourly)

EXHIBIT 1.4.7 (h)

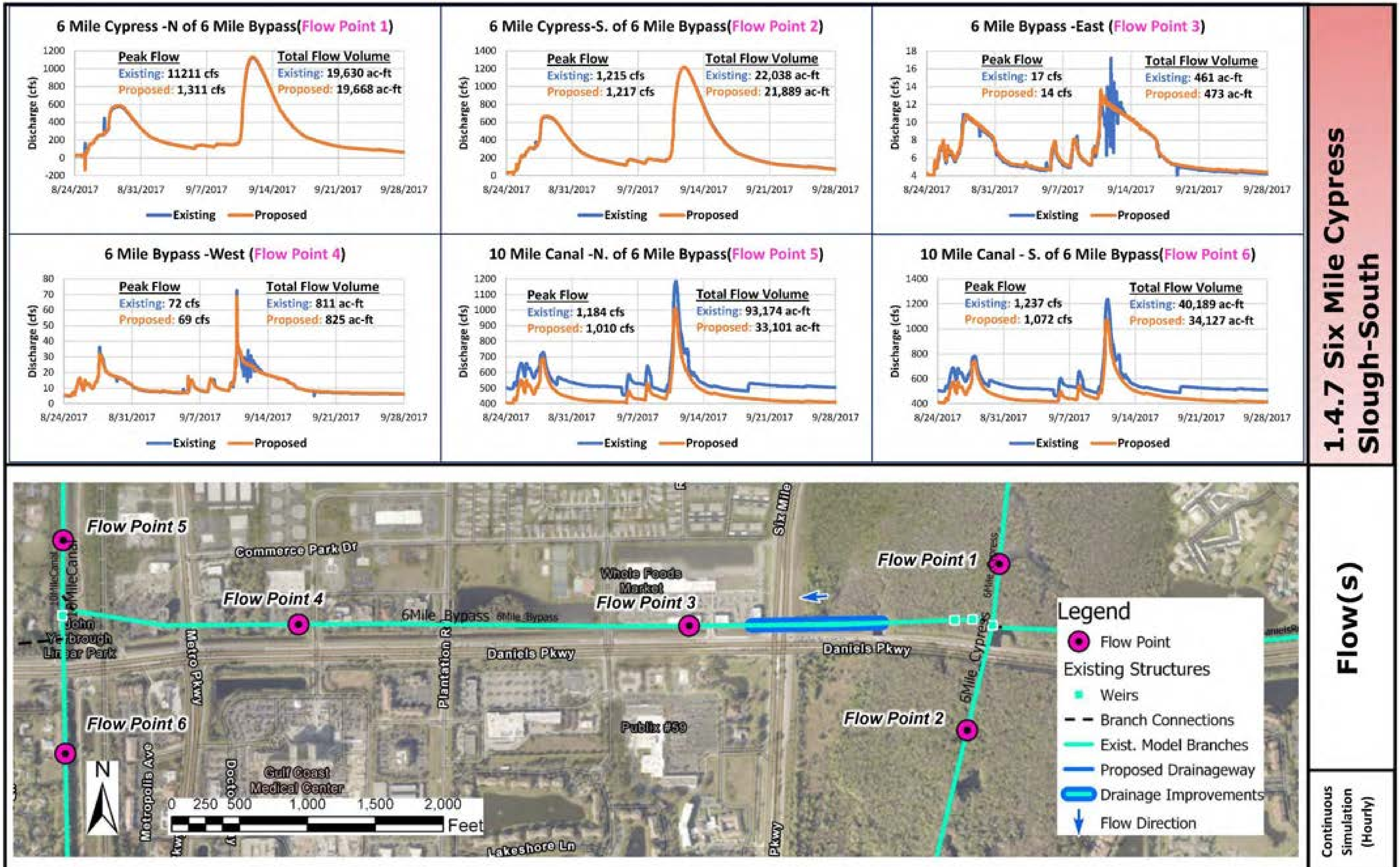


EXHIBIT 1.4.7 (i)

1.5 ENHANCED MAINTENANCE CONDITION SCENARIO

BACKGROUND

In many areas of Lee County, development growth over the past 100 years has fundamentally changed the characteristics of the historical natural system. A contrast of pre-development conditions to current conditions aids in understanding the limitation of the remaining natural flow ways. From the Phase 2 study, the existing stormwater network consisting of manmade and natural conveyances was found to be inadequate in conveying extreme storm event flows. Natural river and creek conveyances are inherently narrow with broad flood plains. The conveyance capacity of natural conveyances is often reduced due to vegetation across the conveyance section. Certain vegetation, such as cypress knees, are challenging to maintain from a permitting standpoint and may have other impacts to the natural environment. is neither permitted nor desirable to remove since the natural system would be negatively impacted.

PURPOSE

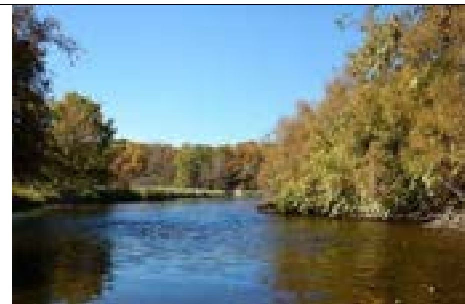
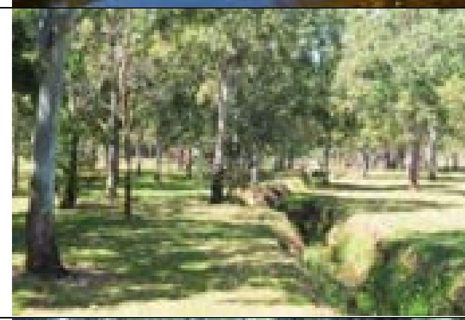
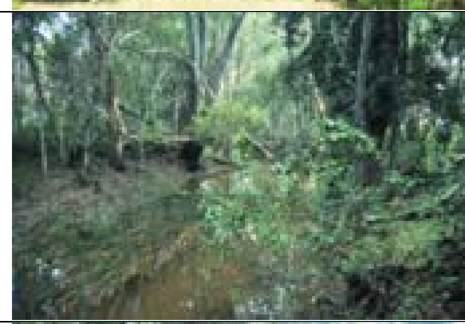
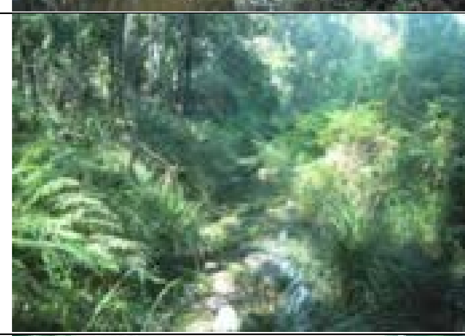
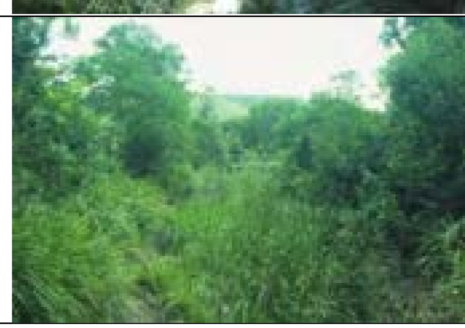
The intention of Project 1.5 was to illustrate the impact of clearing canals of underbrush, dead trees, and branches, and maintaining canals for increased flow capability. Roughness values within the model flow ways were adjusted from those in the Existing Conditions model to simulate this maintained condition.

MODELING ADJUSTMENTS FOR MAINTAINED CHANNEL CONDITION

MIKE 11 provides a user input option for variable channel roughness based on location. Hydraulic roughness within the river branches is expressed by the Manning's roughness coefficient (n), which represents the resistance to flow exerted by land surface features and conditions. The coefficient is empirical in nature and can be difficult to quantify; thus, sound engineering judgment and prior experience was referred to when selecting values.

For the Existing Conditions modeling, a standard uniform value of 0.035 was assigned for the primary flow section of each river, which typically spans from top-of-bank (TOB) to top-of-bank. This value was selected based on literature review and assessment of river conditions. Roughness values of 0.050, 0.100, 0.125 and 0.150 were then applied to the riverbanks, where appropriate. These values were assigned based on manual inspection of aerial photography and review of land use information for each river branch. **Table 1** provides descriptions and visual references for all roughness values utilized in the network.

Table 1. Channel Roughness Coefficients

Manning's *n*	Description	Visual Reference
0.035	Natural channel, somewhat irregular side slopes, fairly even, clear and regular bottom, little variation in cross-section	
0.050	Banks consist of single trunk trees with no low branches or shrubs	
0.100	Banks with sparse trees and a few woody shrubs	
0.125	Banks with trees and flexible understory plants, some low branches and shrubs, slow to walk through	
0.150	Banks with thick shrub growth, low branches, fallen trees, difficult and slow to walk through	

The starting point for the maintained channel condition scenario was the Existing Conditions Model. To simulate the clearing of underbrush, dead trees and maintenance of channels, the Manning's n values for the following branches were edited:

- Bedman Creek
- Hickey Creek
- Olga Creek
- Orange River
- Ten Mile Canal (south of Daniel's Pkwy)
- Brantley Canal
- Whiskey Creek
- Hendry Creek
- Mullock Creek
- Estero River North Branch
- Estero River South Branch
- Halfway Creek
- Spring Creek (main and south branches)
- Kehl Canal
- Imperial River
- Rosemary

Manning's n values were adjusted for both the channel bottom and the embankments. The formula for adjusting the values was as follows:

Channel Bottoms:

Reduce the value by 0.05 if the existing value is greater than or equal to 0.075.

If value is less than 0.075, leave as existing.

Channel Embankments:

Reduce the n value by 0.025 to a minimum of 0.10.

This level of reduction ensures that a realistic level of vegetation removal and dredging occurs. **Figure 1** and **Figure 2** show the existing and proposed bottom and embankment Manning's n values for the channels that were evaluated for a maintained condition.

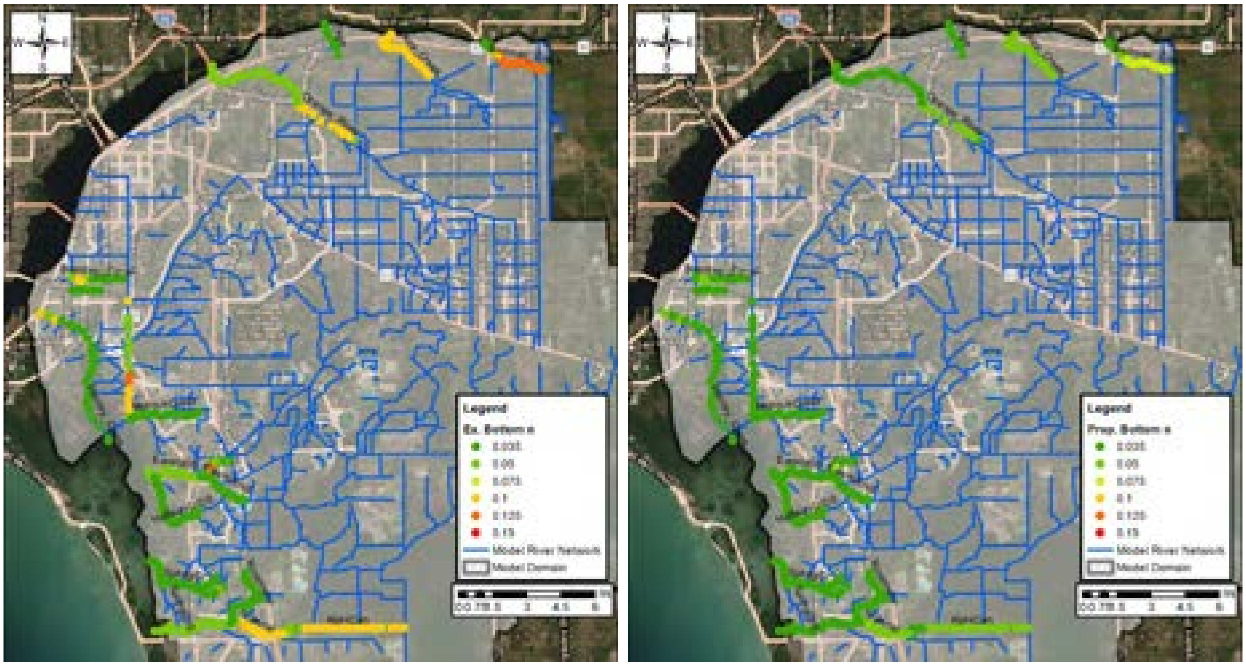


Figure 1. Existing and Proposed Manning's n values for the bottom of the channels

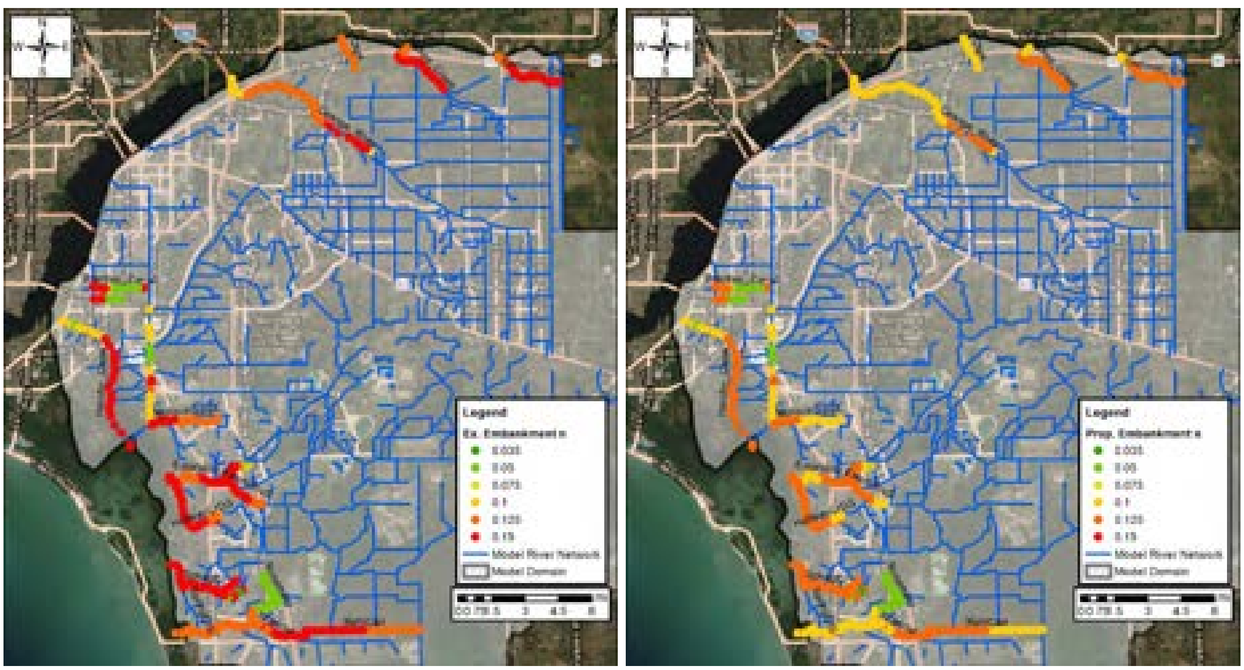


Figure 2. Existing and Proposed Manning's n for the channel embankments

MODELING RESULTS

Peak stages during the 100 yr Design storm, with the modified start date of 8/24/2017, were extracted for the existing conditions and 1.5 proposed maintained conditions models as shown in the Figures below. The proposed conditions results are shown in red and the existing conditions results are shown in black.

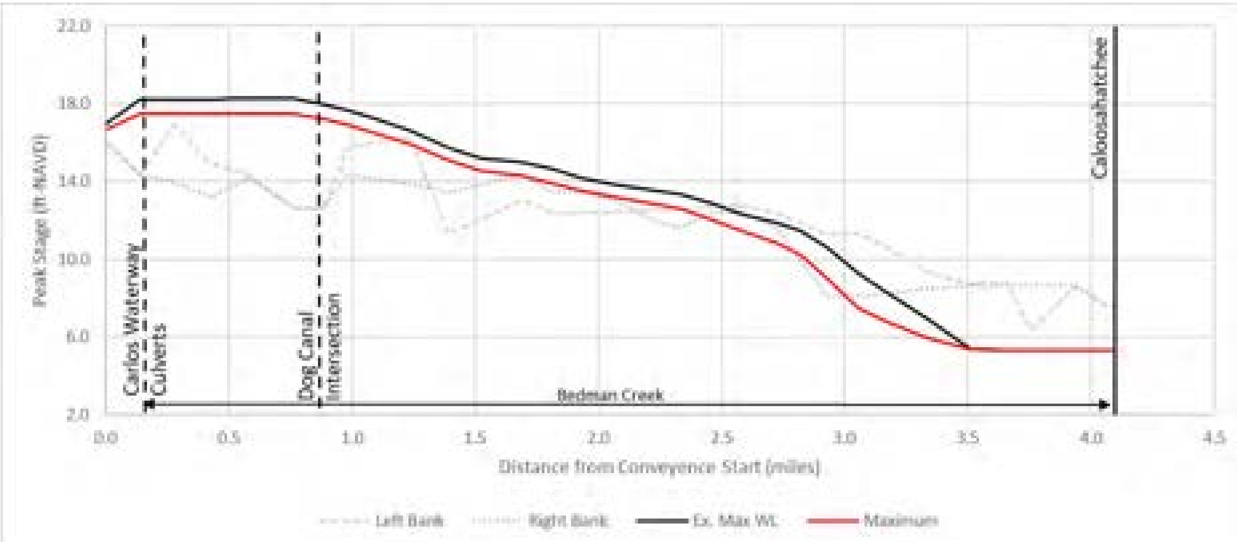


Figure 3. Peak Stage Comparison for Bedman Creek

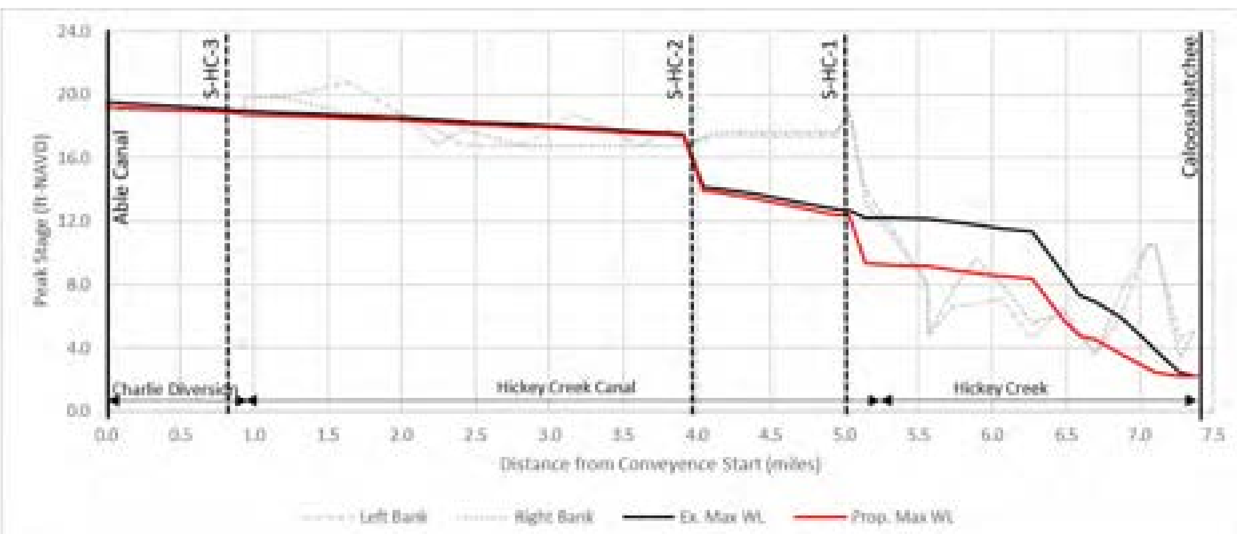


Figure 4. Peak Stage Comparison for Hickey's Creek Canal

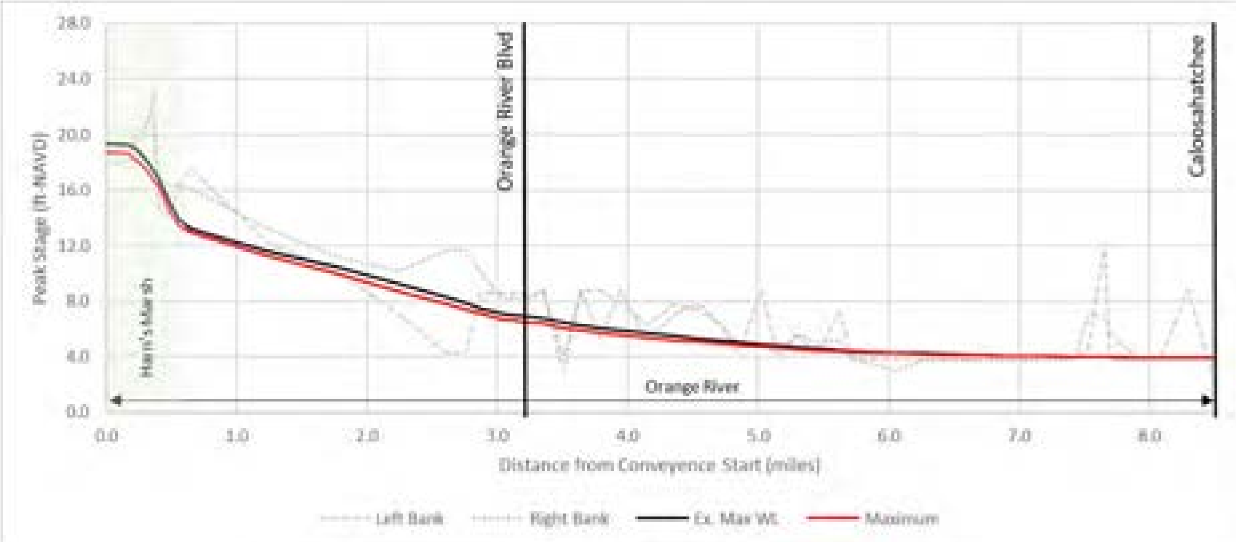


Figure 5. Peak Stage Comparison for Orange River

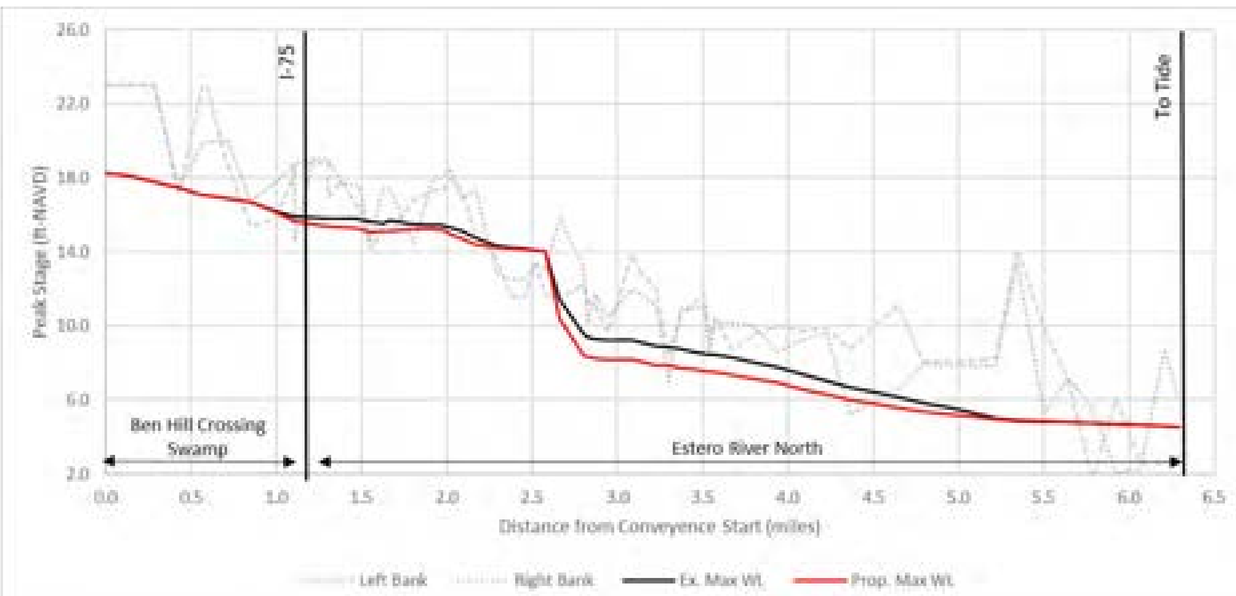


Figure 6. Peak Stage Comparison for Estero River North Branch

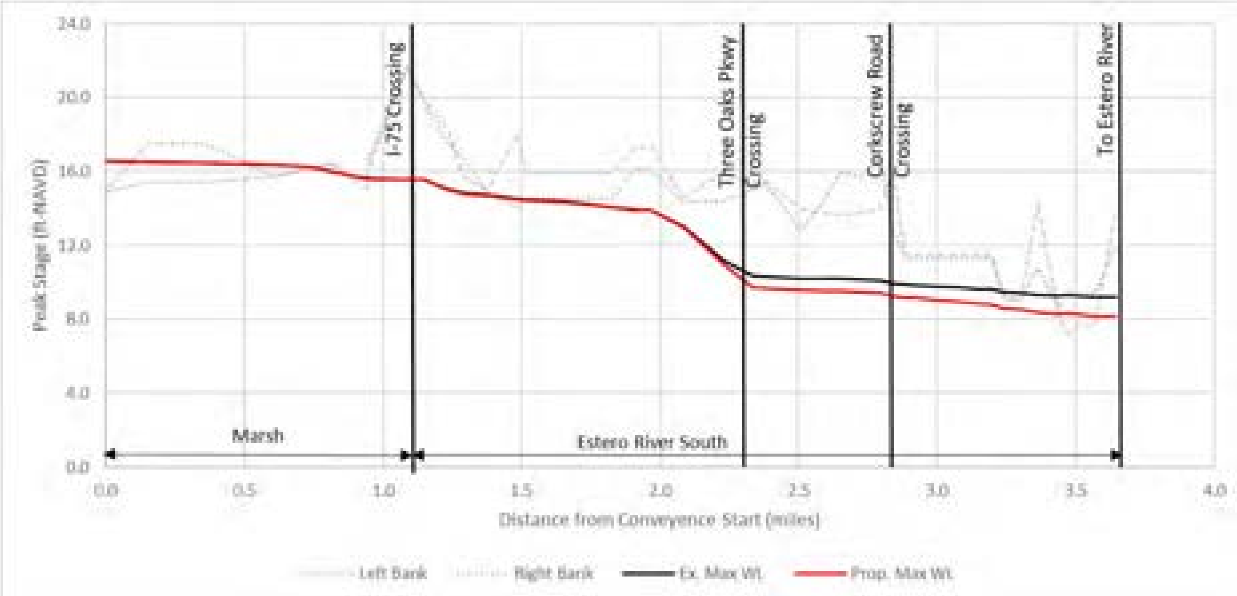


Figure 7. Peak Stage Comparison for Estero River South Branch

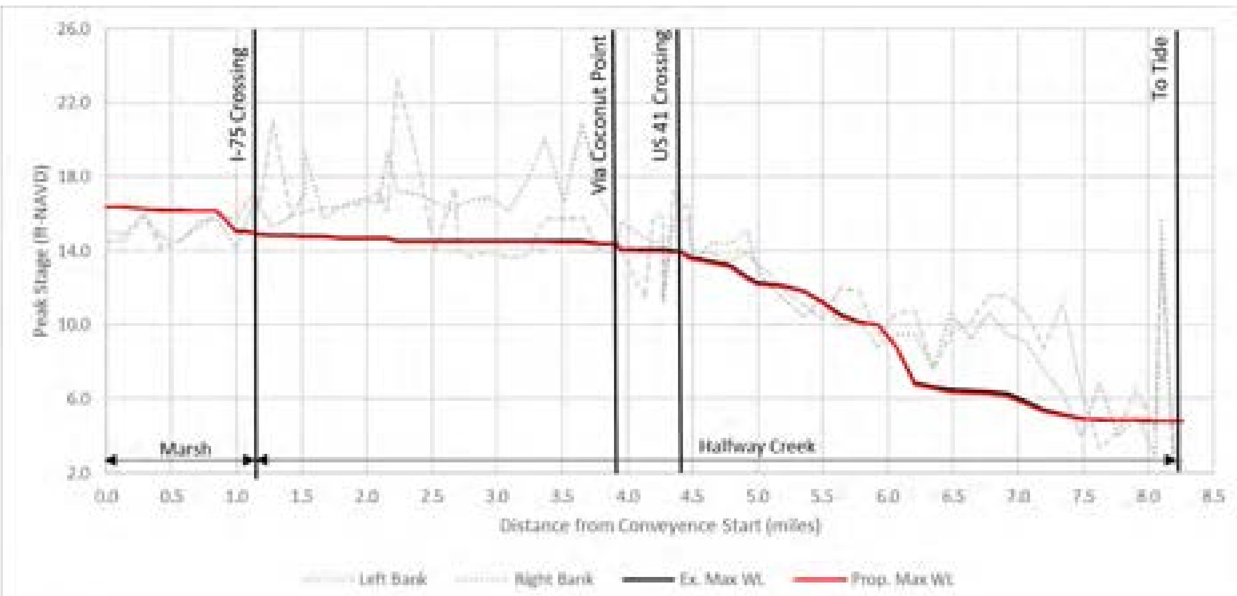


Figure 8. Peak Stage Comparison for Halfway Creek

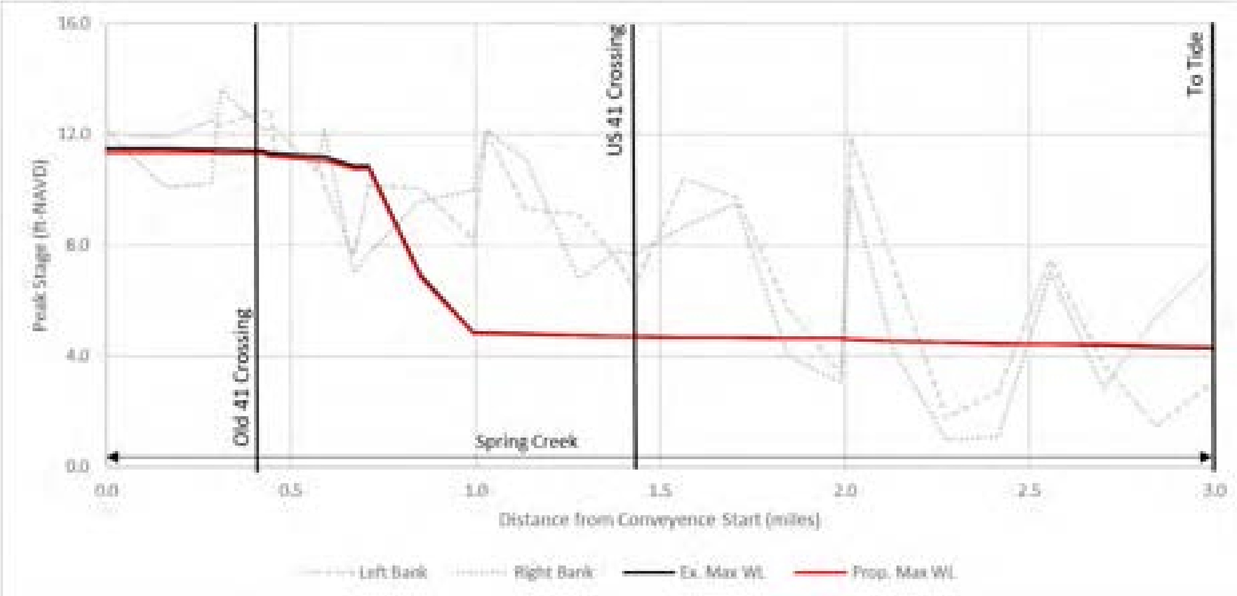


Figure 9. Peak Stage Comparison for Spring Creek

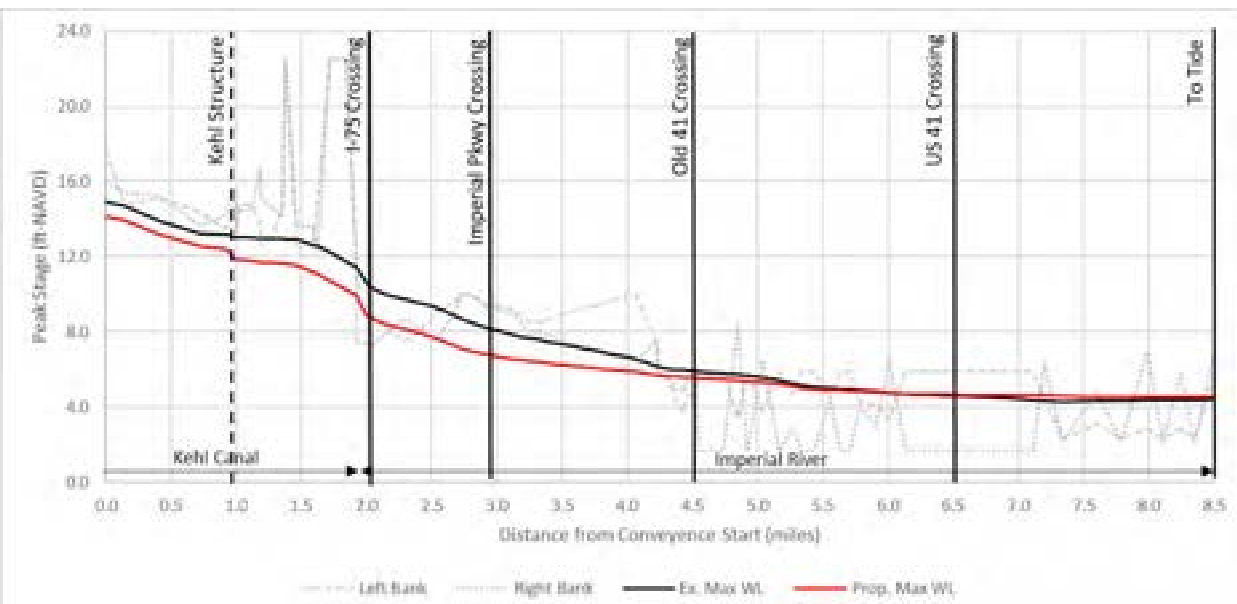


Figure 10. Peak Stage Comparison for Kehl Canal/Imperial River

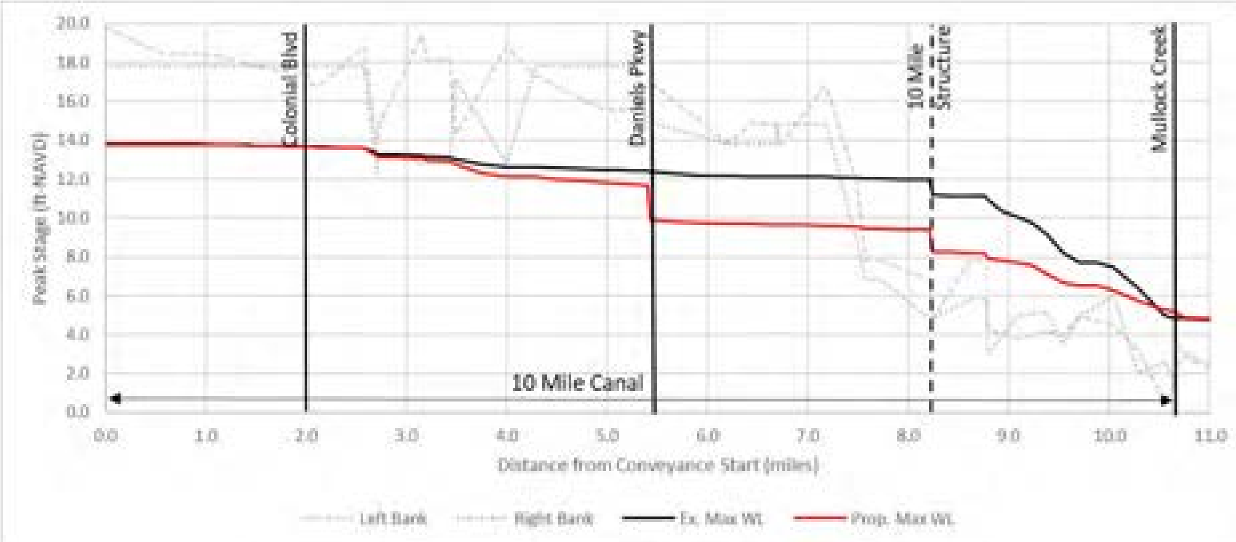


Figure 11. Peak Stage Comparison for Brantley Canal

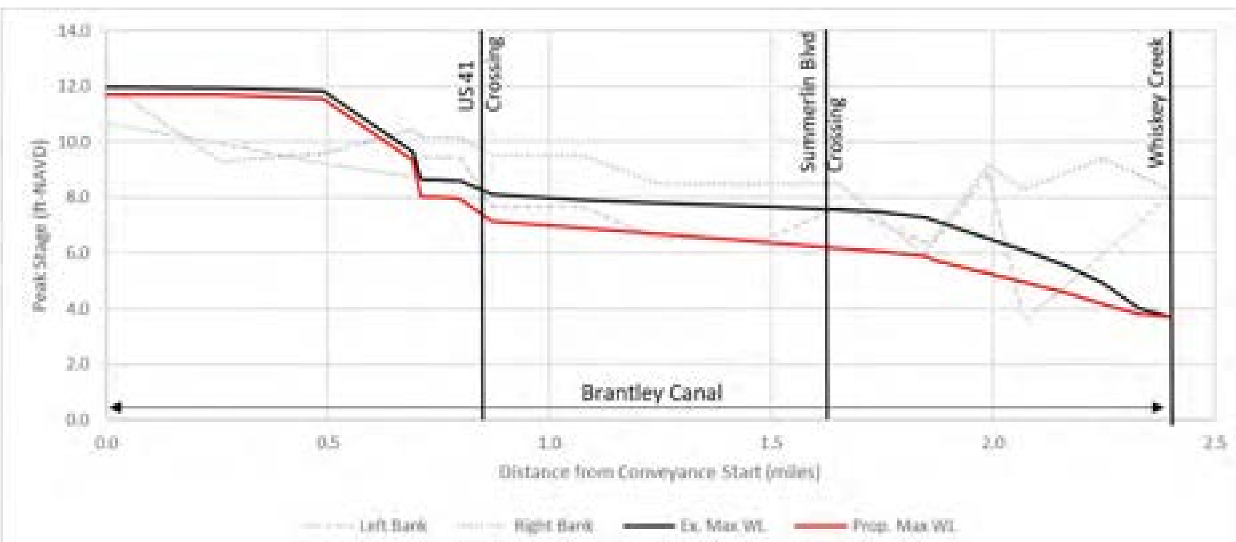


Figure 12. Peak Stage Comparison for Brantley Canal

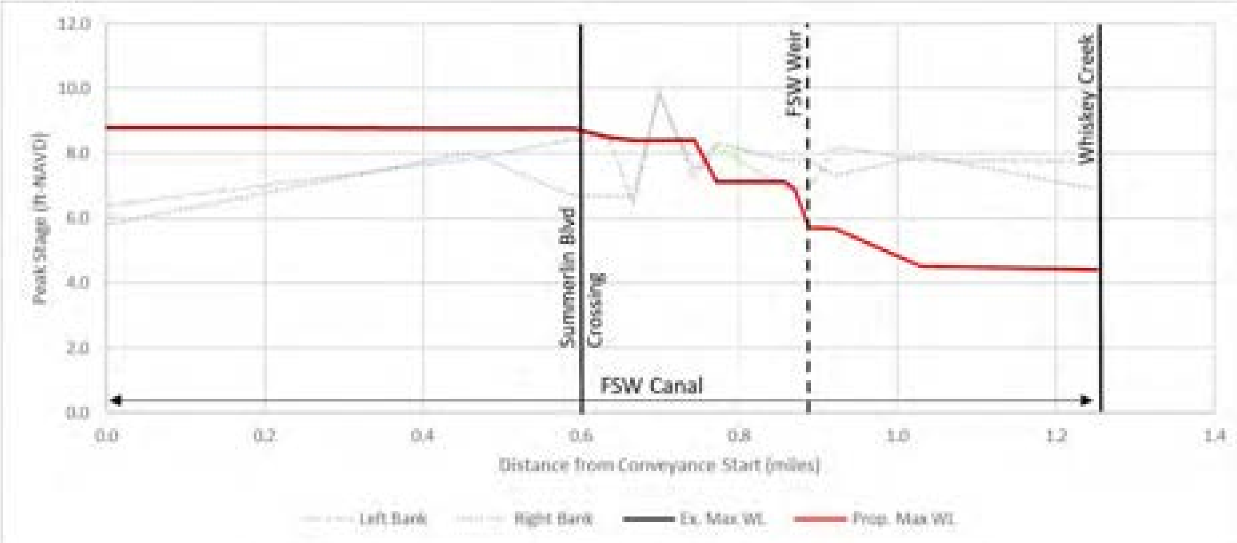


Figure 13. Peak Stage Comparison for FSW Canal

DISCUSSION

As a result of increased channel maintenance represented by reduced Manning's n, the model results show peak stage reductions in Orange River, Bedman Creek, Hickey Creek, Imperial River, Ten Mile Canal, and Brantley Canal. **Table 2** shows the maximum reduction in each channel.

Table 2. Maximum Peak Stage Reduction in Specific Branches

	Maximum Peak Stage Reduction in Channel (ft)
Orange River	0.822
Bedman Creek	1.752
Hickey Creek	2.976
Estero North	1.109
Estero South	1.036
Halfway Creek	0.141
Spring Creek	0.138
Imperial River	1.702
Ten Mile Canal	3.019
Brantley Canal	1.429
FSW Canal	0.027

In the model, natural channels such as Hickey Creek, Bedman Creek, Imperial River, etc. have higher Manning's roughness values to represent the vegetation that has grown in and around the channel, but also other factors such as siltation and the minor bends in the river that may not have been picked up in the development of the network. However, channel roughness in Ten Mile was calibrated to attempt to reach the peak of Irma during the calibration effort. Higher values of channel roughness, particularly in the bottom of the channel, may be artificially high, and therefore lowering the values creates a large drop in the peak stages. It is recommended that a channel study is done to understand the benefits of clearing and dredging channels such as Ten Mile Canal.

Generally, the results showed improvements in reduction of peak water levels and corresponding improvements to flow capacity. Significant water level reductions occurred in the Orange River, Bedman Creek, Hickey Creek, Imperial River, Ten Mile Canal, and Brantley Canal. These improvements show the value of improved maintenance on lower water levels and increasing flow capacity.

RECOMMENDATION

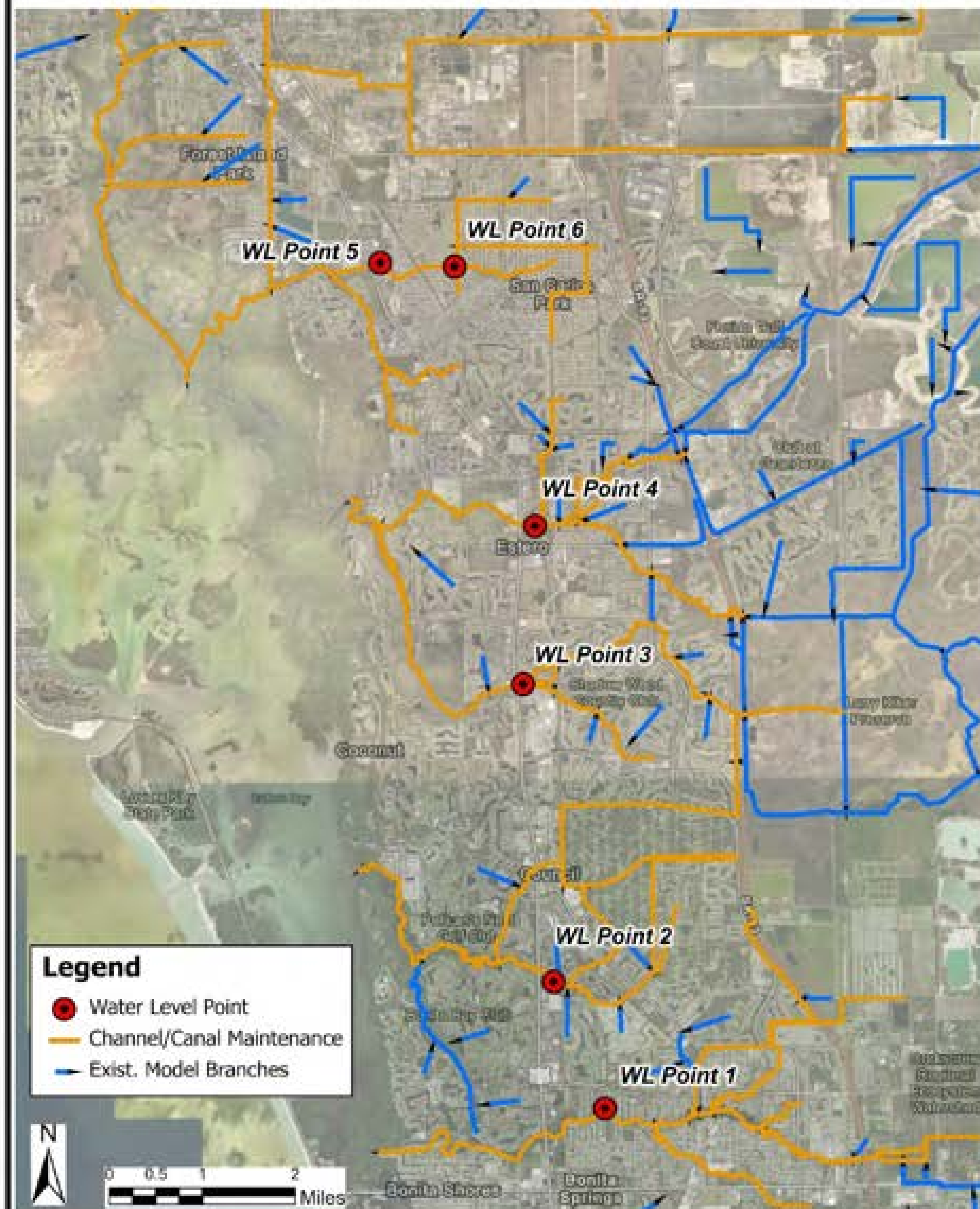
Although improved maintenance to flow-ways is shown to be significant in some areas, the improvements are not sufficient to provide flood mitigation by this single activity. As modeling results are only one of the tools in the decision-making process, the viability of modifying a natural stream/river into a highly maintained conveyance may not be desirable or permissibly feasible to the fullest extent expressed in this concept project. Other concept projects included in this study discuss a more environmentally sustainable approach, such as creating overflow littoral benches though river oxbows. Additionally, the natural creeks, streams, and rivers are often attractive for residential development with so many homes having been constructed in nature’s floodplain. To mitigate flooding of these homes, bypassing flood flows to manmade conveyances is a practical alternative to convey excess flows. Even when the vegetation in natural flow ways is maintained within permitting guidelines, the destructive nature of extreme storm events causes downed trees and other impediments to further impede the conveyance capacity. Even if these conveyances were cleared of all vegetation and manmade blockades, the narrow, shallow, and winding geometry of the main channel of natural rivers/streams provide limited capacity to convey flood flows, resulting in flooding of the adjacent floodplain. Additional flood mitigation project concepts are therefore warranted.

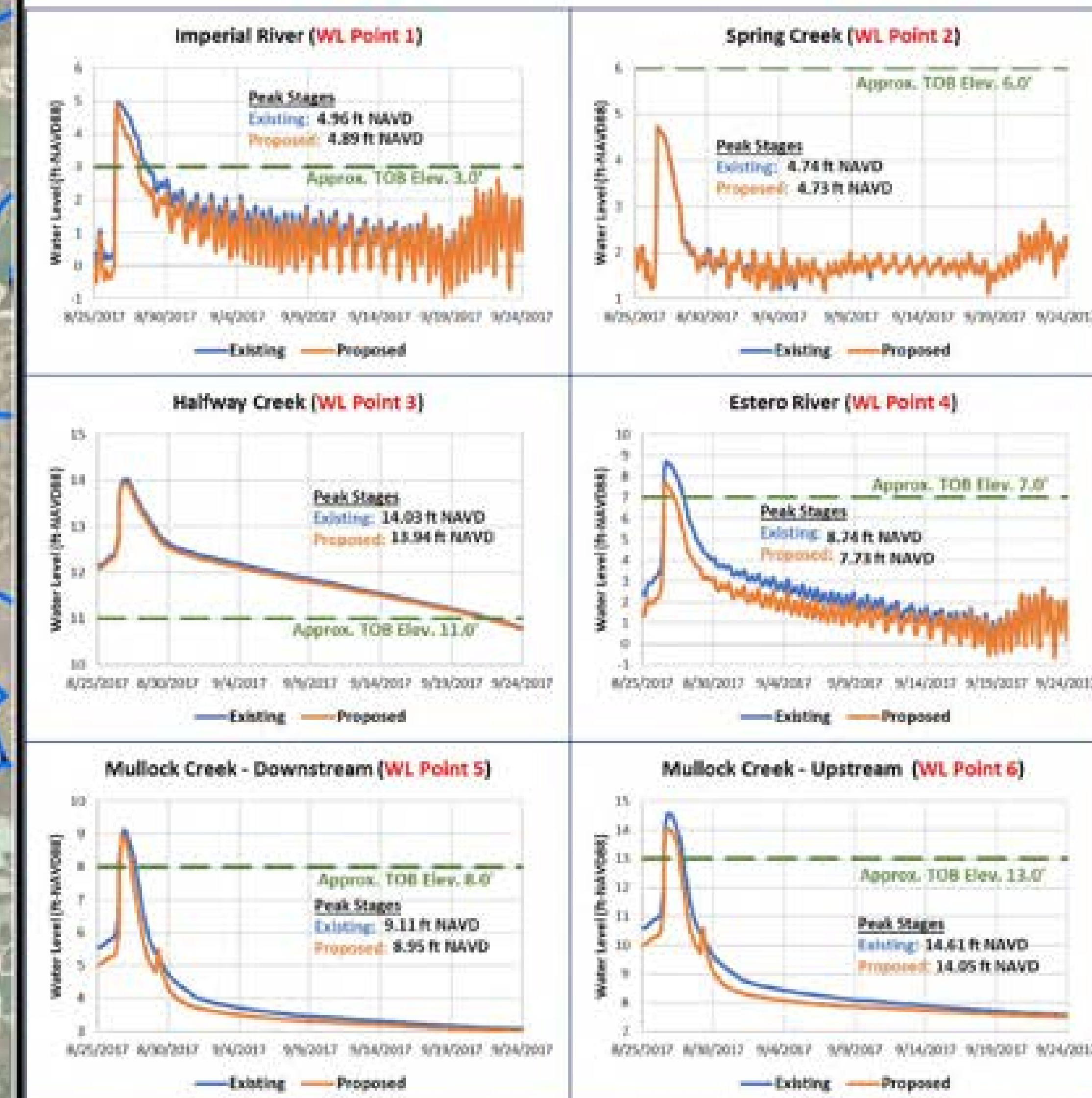
Regional Modeling Findings

Modeled results demonstrating the water level(s) and discharge(s) over time are included for the following design storms:

Storm Event	Description	Exhibit Nomenclature
100-Year, 3-Day (August 2017 Start)	Water Level(s)	EXHIBIT 1.5.1 (a)
	Flow(s)	EXHIBIT 1.5.1 (b)

EXHIBIT 1.5.1 (a): 1 of 3





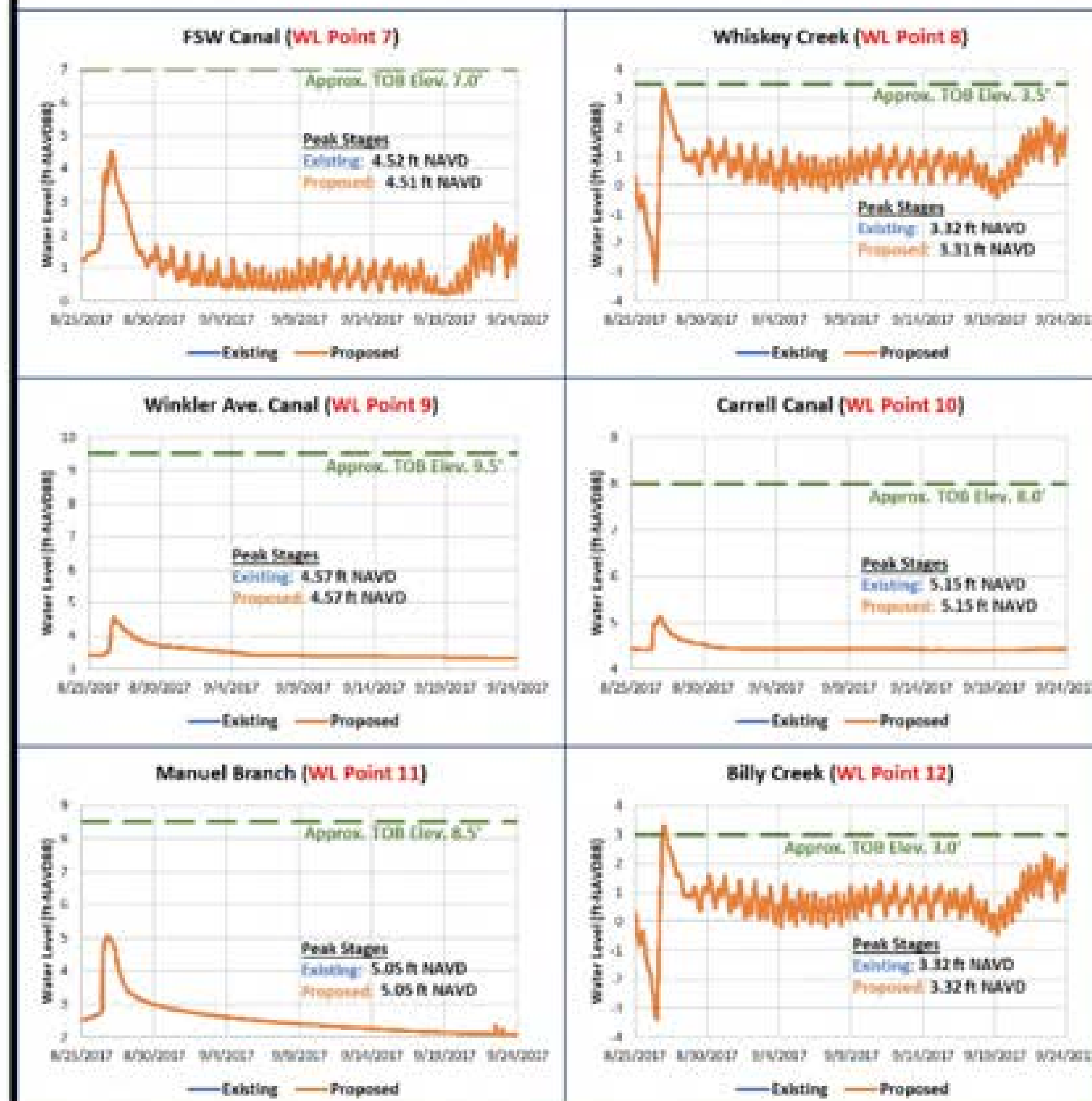
Note: WL Points 5 & 6 reflect results developed by Lago Consulting, who modified the existing conditions model (LCSWMP_021820_100yrDS_n_S2.she) such that the mannings n in the center of Mullock Creek branch (low flow value) was increased from 0.035 to 0.08.

1.5.1 Maintained Channel/ Canal Conditions

Water Level(s)

100-yr
3-day
(Aug Start)

EXHIBIT 1.5.1 (a): 2 of 3

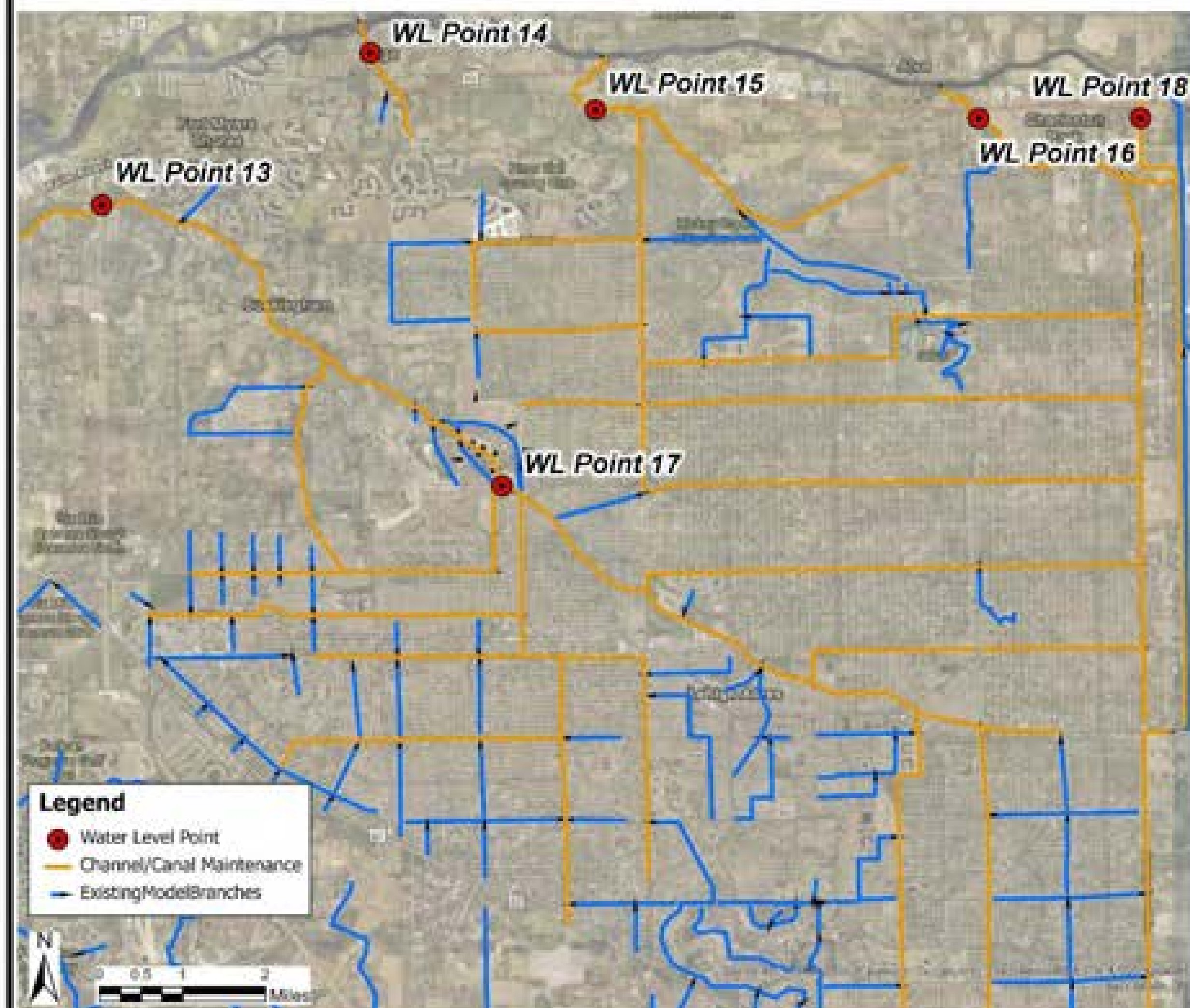


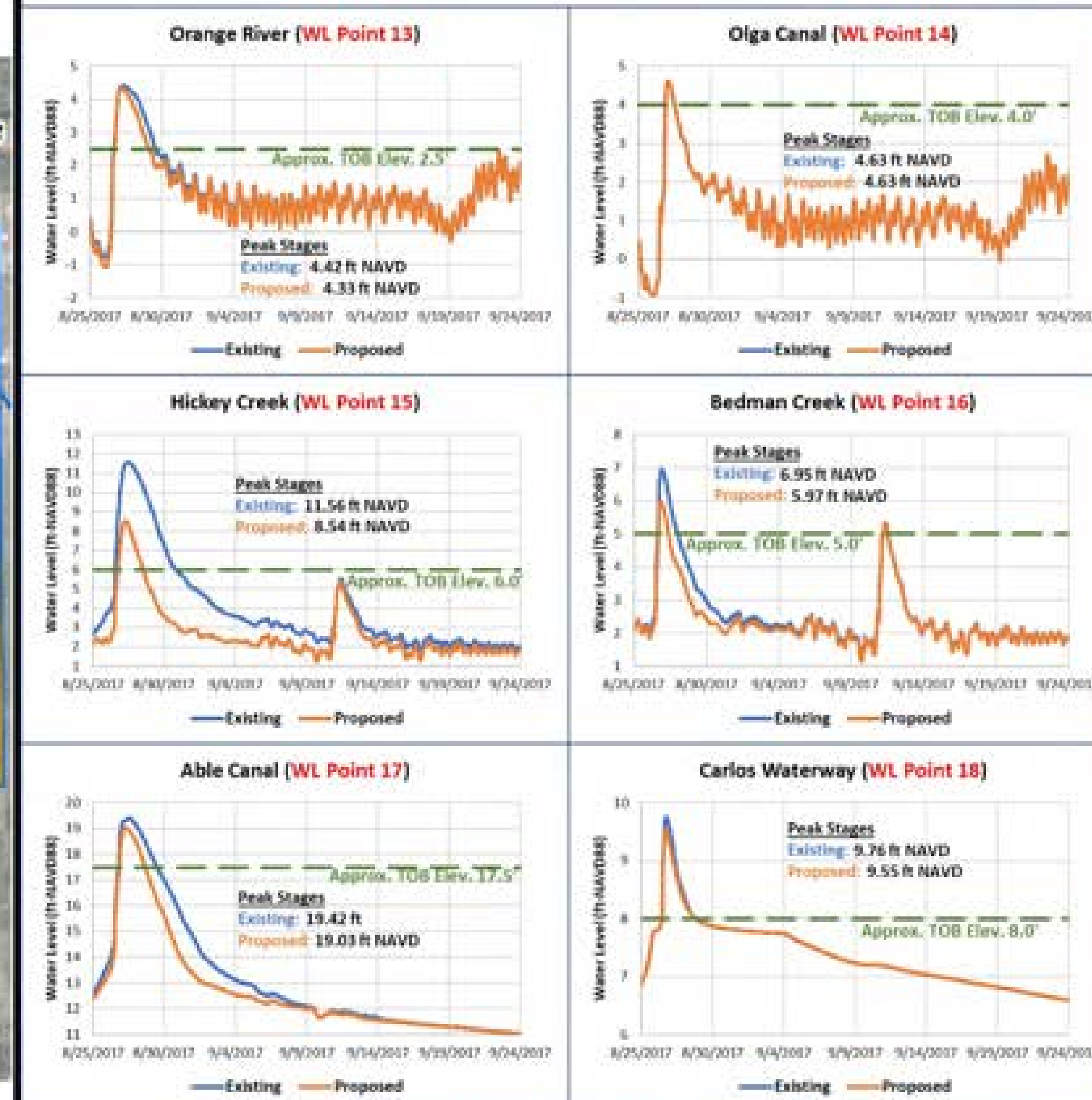
1.5.1 Maintained Channel/ Canal Conditions

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.5.1 (a): 3 of 3



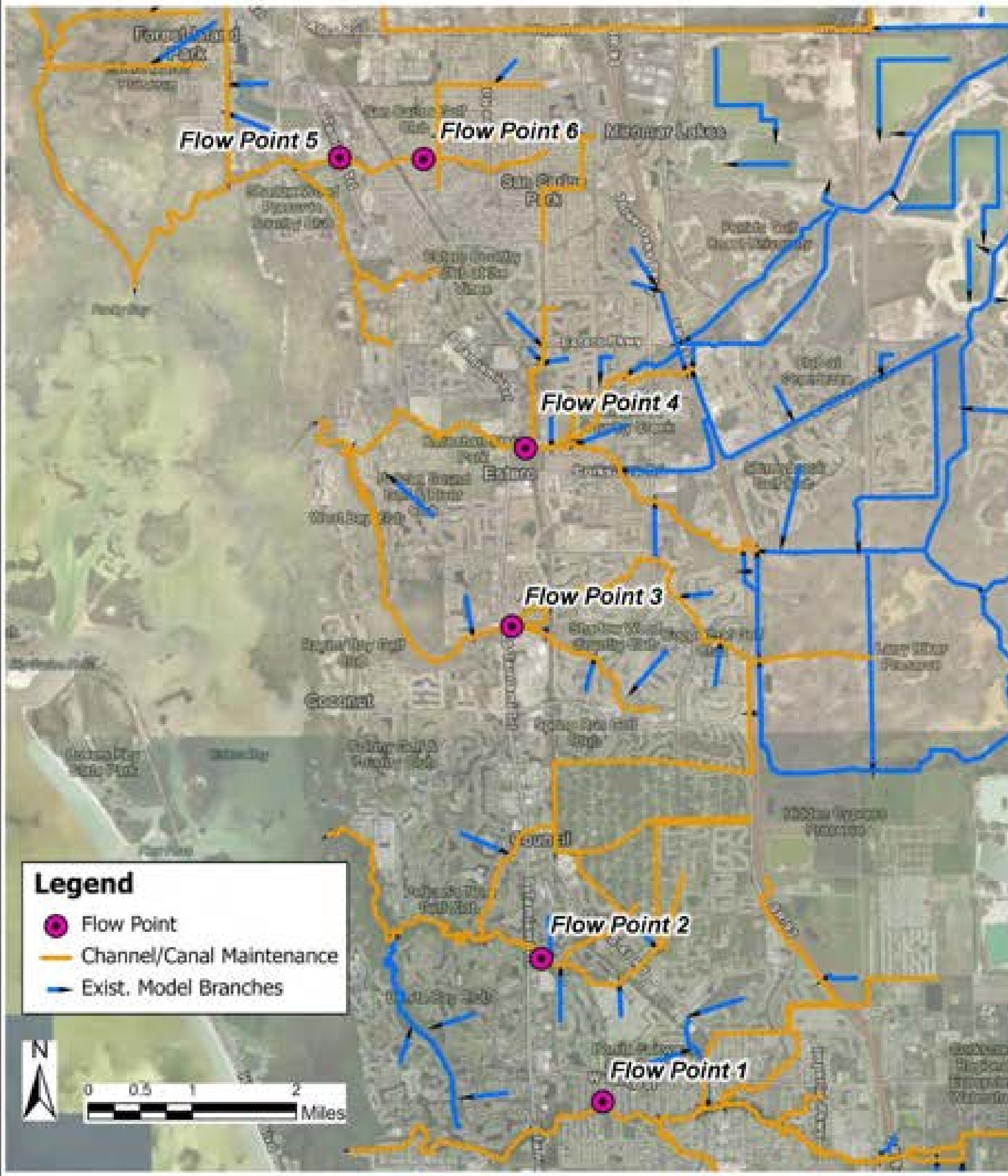


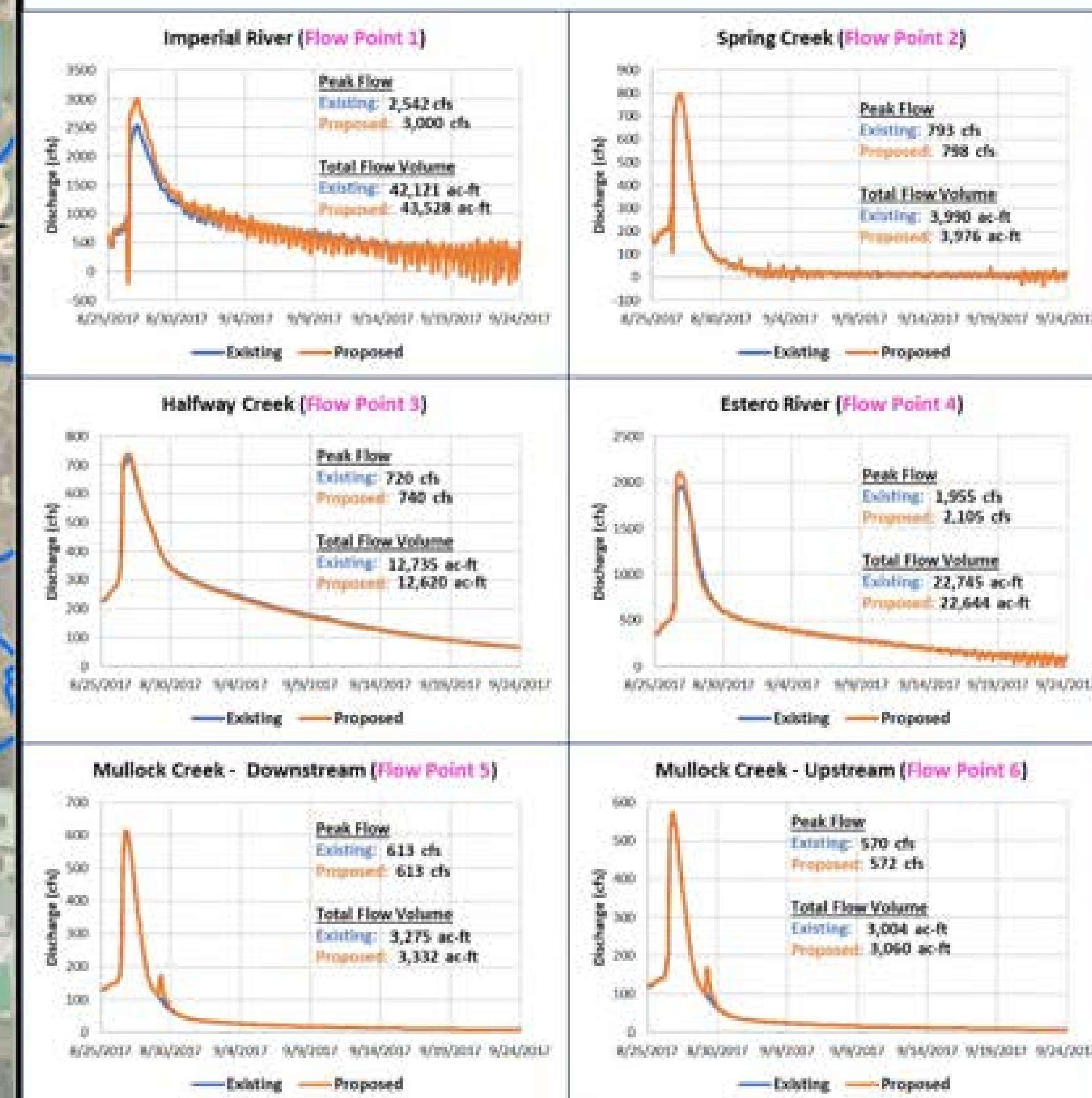
1.5.1 Maintained Channel/ Canal Conditions

Water Level(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.5.1 (b): 1 of 3



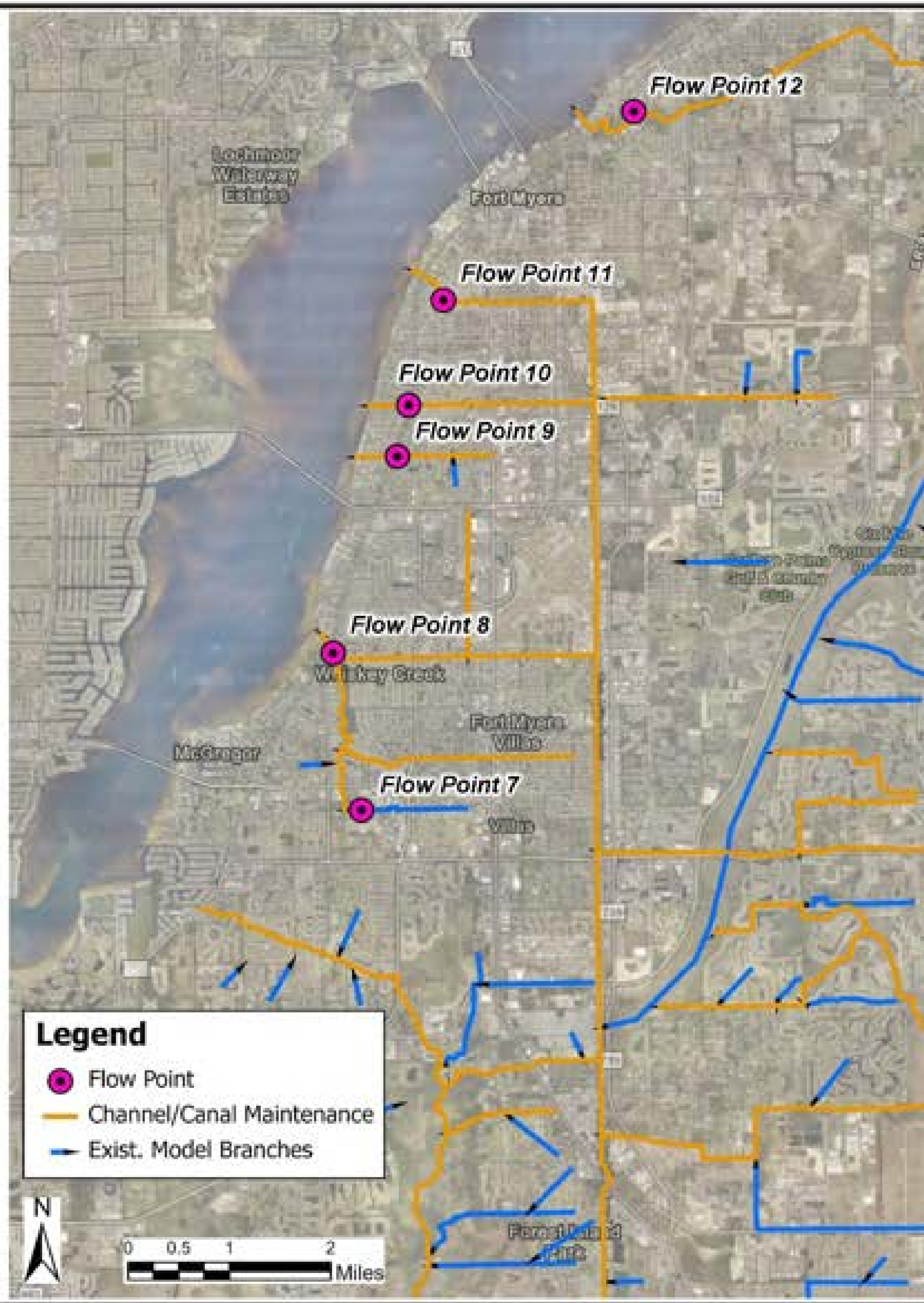


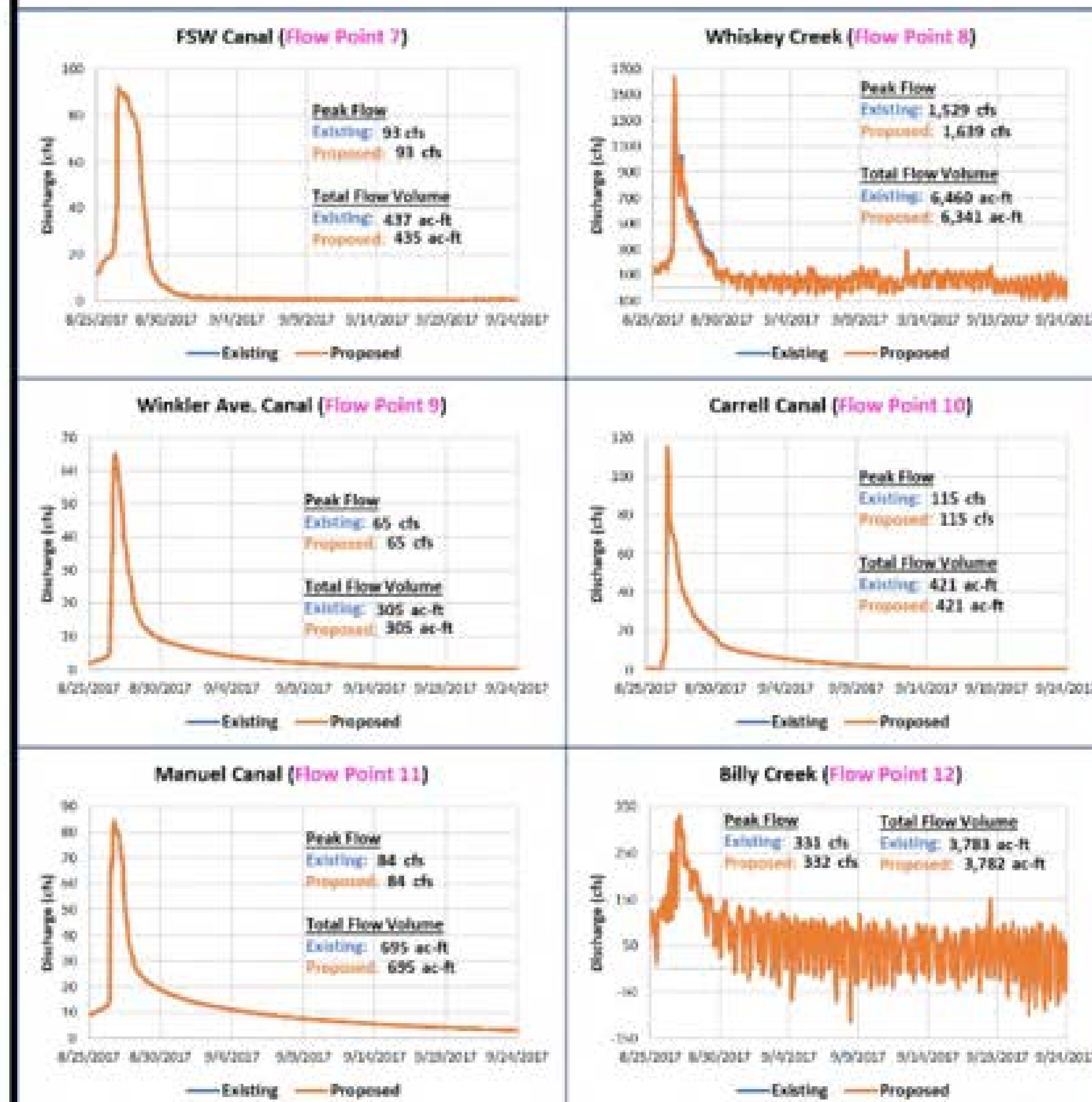
1.5.1 Maintained Channel / Canal Conditions

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.5.1 (b): 2 of 3



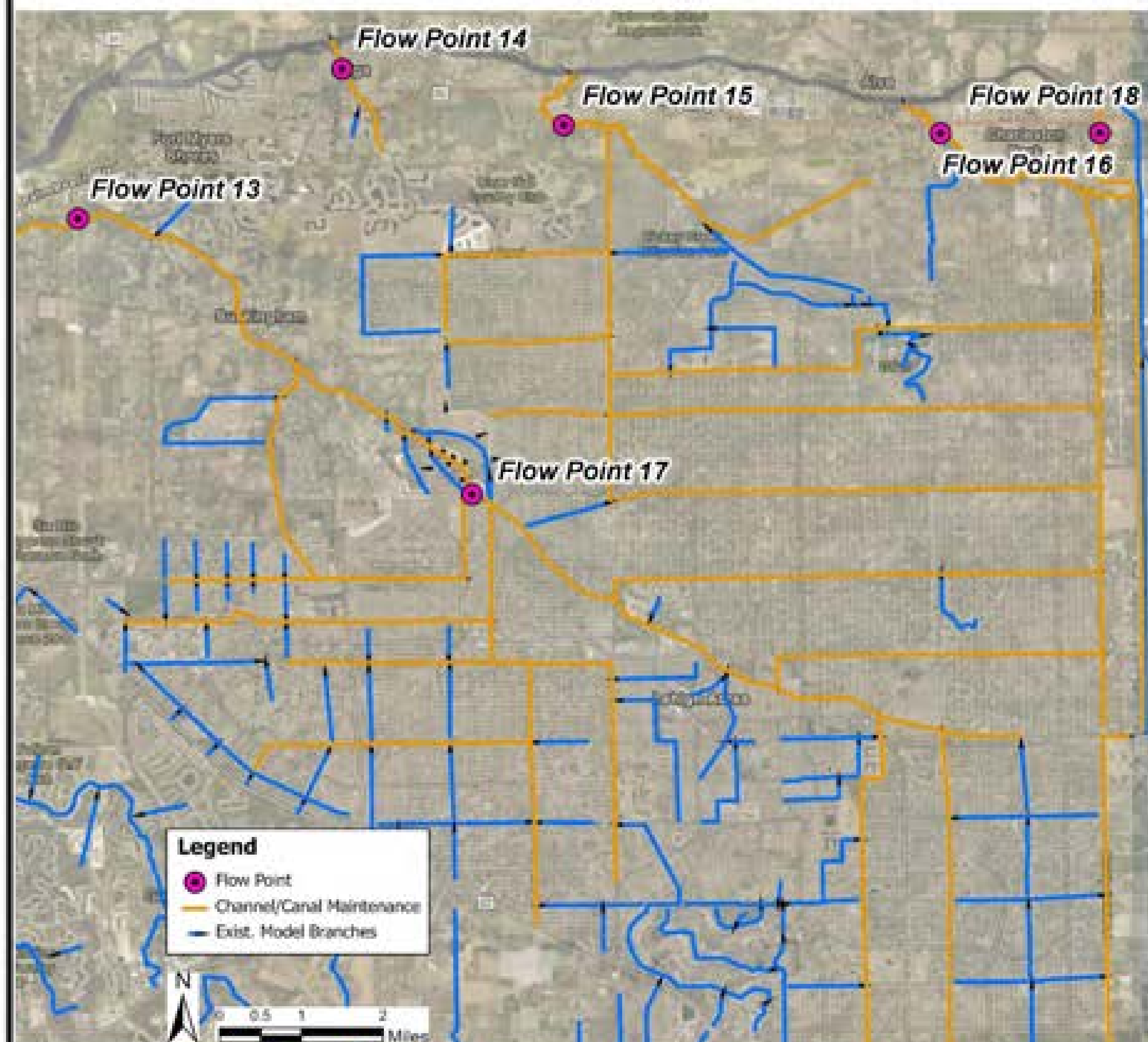


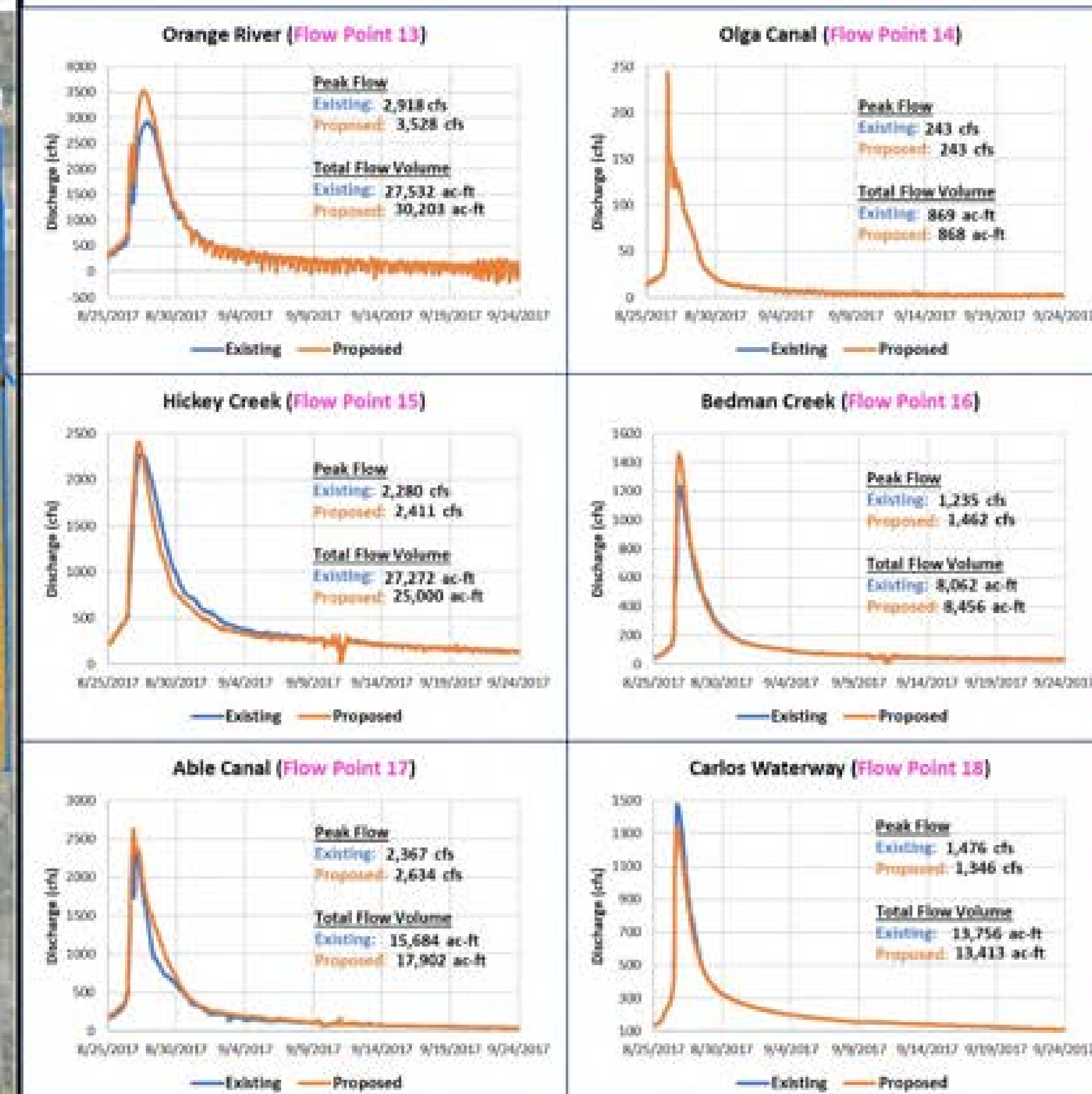
1.5.1 Maintained Channel/ Canal Conditions

Flow(s)

100-yr 3-day (Aug Start)

EXHIBIT 1.5.1 (b): 3 of 3





1.5.1 Maintained Channel / Canal Conditions

Flow(s)

100-yr 3-day (Aug Start)

Part 2

Project Prioritization Matrix

2.1 PROJECT PRIORITIZATION MATRIX

PURPOSE

While every concept provides benefits, a project prioritization matrix provides a useful tool for Lee County to evaluate the developed preliminary concepts considering several important criteria. This prioritization matrix can serve as a planning guide for long-term implementation of regional project needs. Due to the scale of the regional stormwater system improvements proposed in the concept projects, the design and construction of the projects is anticipated to be accomplished over a significant timeframe, such as thirty years or more. While this matrix can assist in determining desired implementation priorities, there may be other future issues arise that could revise timing for moving certain projects forward. This could include opportunities where grouping of projects is beneficial from a design/construction standpoint.

As shown in **Figure 1** below, there are known areas which repeatedly experience damages and loss. This Figure also demonstrates the reported FEMA Flood Claims for structures that flooded as a result of the Hurricane Irma storm event. Note that this heat map does not represent all structure flooding since structures without flood insurance are not reported.

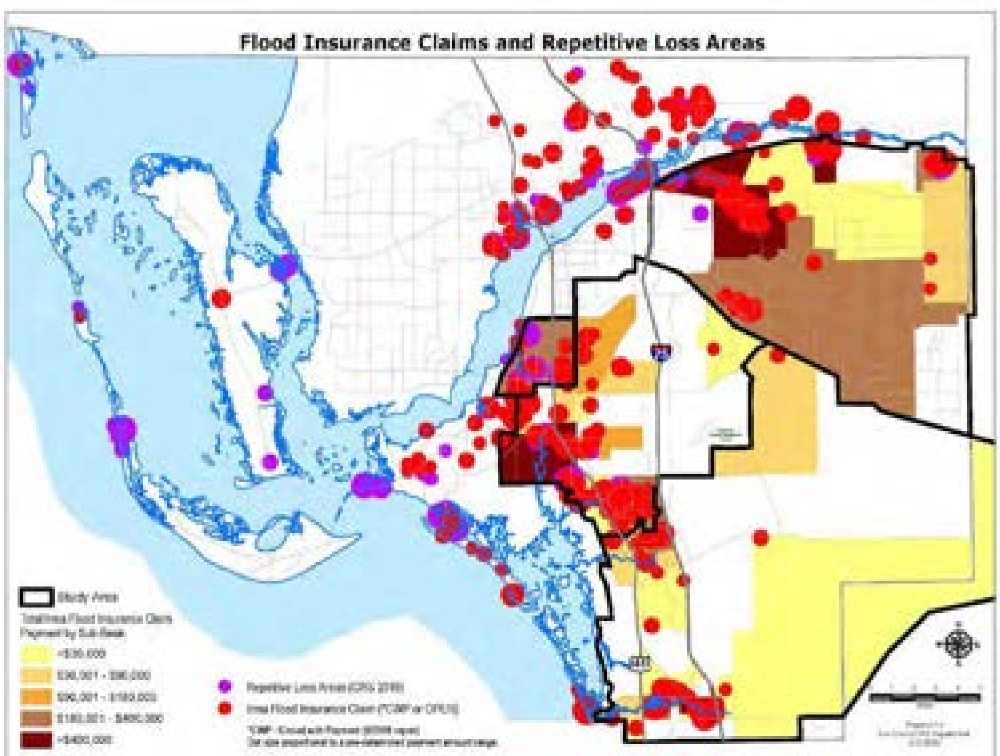


Figure 1 - Heat map representing reported FEMA flood claims.

CRITERIA

An example of the priority matrix is shown in **Table 1** below. This priority matrix includes five criteria that help to analyze each project and show the subsequent attributes of each one. Descriptions of each criterion assist in determining and scoring each project. The criteria are as follows:

- Cost and Flood Mitigation Benefit
- Existing Drainage Level of Service
- Multiple Benefits
- Land Availability
- Permittability

Additionally, each criterion has a scoring system which allows the user to promote the importance of each project's specific goal within that criterion.

Table 1: Example of Priority Matrix

Priority Matrix (Weighted Factor Ranking) Identification of Flood Mitigation Projects East Lee County (1.1)												
Criteria	Cost/Flood Mitigation Benefit			Existing Drainage Level of Service					Multiple Benefits	Land Cost	Permittability	
Weight	35%			30%					10%	10%	15%	
Description	Estimated project cost and flood mitigation benefit			Current level of drainage conditions					Project contains alternative benefits	How much of the land is currently available	Expected to reduce delays from permitting	
Reference	Table 2			Table 3					Table 4	Table 5	Table 6	
Project	Project Cost	Project Benefit	Total	Structure Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	Weighted Summary

Cost/Flood Mitigation Benefit

The cost and flood mitigation benefit criterion (**Table 2**) are the preliminary conceptual opinion of probable cost of a project and that project's flood mitigation benefit. The flood mitigation benefit is understood to include a variety of improvements such as positively addressing stormwater flow, reducing storm related water levels/duration, or storing stormwater to reduce downstream flooding. This is important to note as the benefit of some concept projects is realized though a reduction in peak stages, while other projects benefit the surrounding area by reducing the duration or recovery time post storm event. Each project contributes to flood mitigation and is crucial to the overall impact with varying individual costs. Projects that have a lower construction cost and greater flood benefits are ranked higher than those that cost more and only demonstrate minor flood benefits.

The development of the flood mitigation criteria was dependent upon the data provided by the Regional Modeling effort and the Concept Projects Reports. The Regional Modeling report provided hydraulic grade lines depicting peak water levels of various storm events for conditions both before and after implementation of the preliminary concept projects. These graphics also provided adjacent top of bank elevations. This information allowed for evaluation of the reduction in peak water levels as well as the potential impact on adjacent properties. These reductions are reflected in key areas that incurred structure damages as a result of Invest 92L/Hurricane Irma.

The Concept Projects Reports provided additional data with time series graphs at key locations near the concept project. These graphs depicted regional model output for various storms both with and without preliminary concept projects as well as adjacent top of bank elevations. These graphs provided water levels over time as well as flows over time. Again, this data is important in that some concept projects focus on increasing flows to positively affect other areas where water level may be the key indicator.

In addition, the peak groundwater reductions were obtained from the regional model and the number of acres improved for the pertinent system of concepts was tabulated. This is an indicator of overall flood mitigation. It is especially beneficial when considering the widespread extended duration road flooding.

Also, targeted special areas of concern were evaluated in further detail with graphics depicting the areal extent of flood waters before and after implementation of the concept projects. From these graphics, the number of parcels positively benefitted was tabulated. The cumulative data coupled with senior engineering evaluation, allowed for scoring of the Flood Mitigation Benefit. As each of the four study areas have some unique characteristics, a more detailed project benefit scoring definition is provided on each area's respective Priority Matrix exhibit below.

It is important to note that typically all these charts and graphics reflect the improvement realized by the system of preliminary concept projects within that study area.

Table 2: Cost per Flood Mitigation Benefit

Table 2 (Cost/Flood Mitigation Benefit, 35% weight)		**35%**
Project Cost	* Very High = 1, High = 2, Medium = 3, Low = 4, Very Low = 5	
Project Benefit	** Very High = 5, High = 4, Medium = 3, Low = 2, Very Low = 1	
***Project cost definition:** Very High = greater than $30M, High = between $15M and $30M, Medium = between $5M and $15M, Low = between $1M and $5M, Very Low = less than $1M		

Existing Drainage Level of Service

The existing drainage level of service criterion (**Table 3**) is representative of how severe the current drainage condition is in the area of a project. Areas that have historically shown significant flooding issues reflect a higher score for this criterion.

The existing drainage level of service has been sub-categorized into four classifications: structure flooding, road flooding, extended duration, and repetitive flooding. This minimizes opportunity for discrepancies when defining "existing drainage level of service," allowing for individual projects to have a more defined existing drainage level of service.

Structure (building) flooding is considered of high importance and received a greater variance in score (0 to 4) over the other three sub-categories which have a scoring of 0 to 2. This reflects Lee County's current Flood Protection Level of Service (FPLOS) which dictates a higher LOS for structures (100-year, 3-day storm) compared to evacuation routes (25-year, 3-day storm) or local roads. Data such as Lee County's database of FEMA flood claims from Hurricane Irma, post-Irma flooding aerials, and Phase 2 reports for this project were used in this consideration. In addition, data provided by the Regional Modeling effort, as well as the Concept Projects Reports was used to develop this criterion.

Table 3: Example of Existing Drainage Level of Service

Table 3 (Existing Drainage Level of Service, 30% weight)		**30%**
All other	Scale 0 - 2 (0 being none to 2 being severe)	
Strucutre Flooding	* Adjusted scale, 0 - 4 (0 being none to 4 being severe)	

Multiple Benefits

Certain projects possess potential for having more than just the intended flood mitigation benefit. A project that included the opportunity for an environmental enhancement or storage of water may also facilitate the opportunity for a conservation area. Many of these projects are large and span across watersheds which allows for numerous secondary improvements including conservation areas, water quality enhancement, wildlife preservation, or provision of drainage for planned roadway extensions. In **Table 4**, the provision of any one of the individual items scores two points while multiple benefits receive additional points. The Concepts Project Reports were used to assist in this effort.

Table 4: Multiple Benefits

Table 4 (Multiple Benefits, 10% weight)	10%
Criteria	Score
Serves solely the prime motivation of flood mitigation	0
Ability to implement connecting roads	2
Ability to implement a conservation area	2
Ability to implement water quality enhancement	2
Ability to perform 2 of the 3 multiple benefits	5
Ability to perform 3 of the 3 multiple benefits	10

Land Availability

Although the proposed conceptual projects were designed to utilize land owned by Lee County as much as possible, portions of the proposed projects are on privately-owned land or land requiring acquisition. Projects on lands which do not need to be acquired are given higher priority. Conversely, projects that may require land acquisition are ranked lower as shown in **Table 5** below. Since land acquisition can take a considerable amount of time, a project requiring land acquisition may also require an extended implementation schedule. The data for this criterion can be found in the individual Concept Projects Reports.

Table 5: Land Availability

Table 5 (Land Cost, 10% weight)	10%
Criteria	Score
Greater than $5M	1
Land costs between $3M to $5M	2
Land costs between $2M to $3M	3
Land costs between $1M to $2M	4
Land costs between $500K to $1M	5
Land costs between $250K to $500K	6
Land costs between $100K to $250K	7
Land costs between $50K to $100K	8
Less than $50K	9
No land cost	10

Permittability

Some of the proposed projects will require extensive permitting and permission from various regulatory agencies. As a result, projects that will need little to no permitting are be given a higher priority ranking rather than projects which require considerably more permitting efforts as detailed in **Table 6** below. Permits from agencies such as the United States Army Corp of Engineers (USACE), Florida Fish and Wildlife Conservation Commission (FWC), and United States Fish and Wildlife Service (USFWS) require a considerable amount of time to be processed and granted, which greatly influences the project's cost and schedule. This item is briefly discussed in each of the Concept Projects Reports.

Table 6: Permittability

Table 6 (Permittability, 15% weight)	15%
Criteria	Score
Extensive permitting required	1
Moderate permitting required	2
Limited permitting required	5
Minimal permitting required	8
No permitting required	10

Weighted Factor Analysis

This analysis allows for the criteria to be weighted based on a percentage scale that sums to 100 percent. Each of the five criteria have a designated percentage based on a comprehensive view of the County's priorities. The aim is to reduce damage occurred from future storm events by proposing conceptual projects specifically designed to accommodate severe storm events such as Hurricane Irma and Invest 92L. The interest of the community and environment should also be considered. With these principles, the Existing Drainage Level of Service and Cost/Flood Mitigation Benefit hold the highest weight.

Description	Weight (100%)
• Cost and Flood Mitigation Benefit	35%
• Existing Drainage Level of Service	30%
• Multiple Benefits	10%
• Land Availability	10%
• Permittability	15%

This Priority Matrix can serve as a valuable planning level tool. In addition, the matrix specifies projects that may compete well for potential grant funding although their ranking may not be the highest. It also highlights opportunities to coordinate with other opportunities such as planned major roadways by providing the needed drainage, stormwater treatment, and fill material. The Alico Road Connector and Luckett Road Extension projects are two noted possibilities recognized at this time. Opportunities to advance certain projects may also be incentivized based upon private sector development coordination and potential partnerships.

The developed Priority Matrix for each of the four project study areas, as well as an overall combined Priority Matrix is included herein.

Study Area	Exhibit Nomenclature
• East Lee County	EXHIBIT 2.1.1
• Whiskey Creek	EXHIBIT 2.1.2
• South East Lee County	EXHIBIT 2.1.3
• South Fort Myers	EXHIBIT 2.1.4
• OVERALL CONCEPT PROJECT MATRIX	EXHIBIT 2.1.5

EXHIBIT 2.1.1

Priority Matrix (Weighted Factor Ranking)
Identification of Flood Mitigation Projects
East Lee County (1.1)

Criteria		Cost/Flood Mitigation Benefit			Existing Drainage Level of Service					Multiple Benefits	Land Cost	Permittability		
Weight		35%			30%					10%	10%	15%		
Description		Estimated project cost and flood mitigation benefit			Current level of drainage conditions					Project contains alternative benefits	How much of the land is currently available	Expected to reduce delays from permitting		
Reference		Table 2			Table 3					Table 4	Table 5	Table 6		
Project		Project Cost	Project Benefit	Total	Strucutre Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	Weighted Summary	Prelim. Total Proj. Cost (with contingency)
1.3	GS-10 Stormwater Quality Reservoir	3	4	7	3	2	1	2	8	5	10	8	75.5	$6,000,000
1.9	Charlie Diversion- Hickey Canal Imp.	2	5	7	4	1	2	2	9	2	10	2	66.5	$20,000,000
1.1	Dog to Hendry Drainageway (CREST)	4	3	7	1	1	1	1	4	5	10	8	63.5	$2,700,000
1.7	Hickey Creek Overflow Bypass	2	5	7	4	2	2	2	10	2	5	1	63	$17,000,000
1.4	Buckingham Bypass Drainageway	1	4	5	3	2	2	2	9	2	4	2	53.5	$31,000,000
1.5	Buckingham Trails Water Quality Res.	2	2	4	1	1	1	1	4	5	6	5	44.5	$16,000,000
1.6	Lehigh River hall to Olga Outfall	2	2	4	2	2	1	1	6	5	2	2	42	$26,000,000
1.11	Six Mile Cypress Preserve N. Catch. Res.	3	2	5	0	1	0	1	2	5	10	2	41.5	$14,500,000
1.2	Bedman Creek Overflow Bypass	2	3	5	1	1	1	1	4	2	3	2	37.5	$17,000,000
1.8	Strayhorn Drainageway	3	3	6	0	1	1	1	3	0	4	2	37	$14,000,000
1.10	Hickey Creek Swamp Drainageway	4	1	5	0	1	0	1	2	0	5	2	31.5	$1,500,000

Table 2 (Cost/Flood Mitigation Benefit, 35% weight)		35%
Project Cost	* Very High = 1, High = 2, Medium = 3, Low = 4, Very Low = 5	
Project Benefit	** Very High = 5, High = 4, Medium = 3, Low = 2, Very Low = 1	
***Project cost definition:** Very High = greater than $30M, High = between $15M and $30M, Medium = between $5M and $15M, Low = between $1M and $5M, Very Low = less than $1M		
****Project Benefit Definition:** Very High = Substantial benefits for two targeted basins including the largest basin (Orange River), High = Substantial benefits for two targeted basins, Medium = Substantial benefits for one targeted basin, Low = Moderate benefits to one targeted basin, Very Low = Benfits to more localized area		

**Project systems providing benefit are ranked based on the overall benefit to targeted areas of structure flooding and roadway flooding. The indicators of improvement are the acreage of reduction in peak groundwater as this provides guidance to the size of the area benefitted. In addition the number of parcels positively impacted by at the downstream target areas is considered. Secondarily, a project's beneficial cfs rerouting/reduction is considered. Based on previous flooding the target areas are Orange River Basin, Hickey Creek Basin, and Bedman Basin. Please note that as Hickey Basin is interconnected with Orange River Basin, this is also considered in the area benefitted.

Table 3 (Existing Drainage Level of Service, 30% weight)		30%
All other	Scale 0 - 2 (0 being none to 2 being severe)	
Strucutre Flooding	* Adjusted scale, 0 - 4 (0 being none to 4 being severe)	

Table 4 (Multiple Benefits, 10% weight)	10%
Criteria	Score
Serves solely the prime motivation of flood mitigation	0
Ability to implement connecting roads	2
Ability to implement a conservation area	2
Ability to implement water quality enhancement	2
Ability to perform 2 of the 3 multiple benefits	5
Ability to perform 3 of the 3 multiple benefits	10

Table 5 (Land Cost, 10% weight)	10%
Criteria	Score
Greater than $5M	1
Land costs between $3M to $5M	2
Land costs between $2M to $3M	3
Land costs between $1M to $2M	4
Land costs between $500K to $1M	5
Land costs between $250K to $500K	6
Land costs between $100K to $250K	7
Land costs between $50K to $100K	8
Less than $50K	9
No land cost	10

Table 6 (Permittability, 15% weight)	15%
Criteria	Score
Extensive permitting required	1
Moderate permitting required	2
Limited permitting required	5
Minimal permitting required	8
No permitting required	10

EXHIBIT 2.1.2

Priority Matrix (Weighted Factor Ranking)
Identification of Flood Mitigation Projects
Whiskey Creek (1.2)

Criteria		Cost/Flood Mitigation Benefit			Existing Drainage Level of Service					Multiple Benefits	Land Cost	Permittability		
Weight		35%			30%					10%	10%	15%		
Description		Estimated project cost and flood mitigation benefit			Current level of drainage conditions					Project contains alternative benefits	How much of the land is currently available	Expected to reduce delays from permitting		
Reference		Table 2			Table 3					Table 4	Table 5	Table 6		
Project		Project Cost	Project Benefit	Total	Structure Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	Weighted Summary	Prelim. Total Proj. Cost (with contingency)
2.2	Brantley-Dover Canal Improvements	5	5	10	3	2	1	2	8	2	10	8	83	$360,000
2.3	FSW State Canal Improvements	5	5	10	2	1	1	1	5	2	10	8	74	$760,000
2.1	L-Canal Improvements	4	3	7	1	1	1	1	4	2	9	5	55	$2,020,000

Table 2 (Cost/Flood Mitigation Benefit, 35% weight)		35%
Project Cost	* Very High = 1, High = 2, Medium = 3, Low = 4, Very Low = 5	
Project Benefit	** Very High = 5, High = 4, Medium = 3, Low = 2, Very Low = 1	
Project cost definition: Very Low = less than $1M, Low = between $1M and $5M, Medium = between $5M and $15M, High = between $15M and $30M, Very High = greater than $30M		

Table 3 (Existing Drainage Level of Service, 30% weight)		30%
All other	Scale 0 - 2 (0 being none to 2 being severe)	
Structure Flooding	* Adjusted scale, 0 - 4 (0 being none to 4 being severe)	

Table 4 (Multiple Benefits, 10% weight)	10%
Criteria	Score
Serves solely the prime motivation of flood mitigation	0
Ability to implement connecting roads	2
Ability to implement a conservation area	2
Ability to implement water quality enhancement	2
Ability to perform 2 of the 3 multiple benefits	5
Ability to perform 3 of the 3 multiple benefits	10

Table 5 (Land Cost, 10% weight)	10%
Criteria	Score
Greater than $5M	1
Land costs between $3M to $5M	2
Land costs between $2M to $3M	3
Land costs between $1M to $2M	4
Land costs between $500K to $1M	5
Land costs between $250K to $500K	6
Land costs between $100K to $250K	7
Land costs between $50K to $100K	8
Less than $50K	9
No land cost	10

Table 6 (Permittability, 15% weight)	15%
Criteria	Score
Extensive permitting required	1
Moderate permitting required	2
Limited permitting required	5
Minimal permitting required	8
No permitting required	10

Note: As noted in Section 1.2, the primary benefits for L-canal are associated with flood relief for Ten-Mile Canal rather than for local flooding. Benefits scoring herein relates to local flooding. Overall benefits are included in other projects.

** The benefits for the Brantley-Canal and FSW Canal projects are based upon reduction in flooded area as outlined in Section 1.2.4 along with reductions in duration of flooding shown on Exhibits presented within Section 1.2. Significant reductions in flooding of local structures (through analysis of parcel flooding) were acheived along with reductions in extent and duration of roadway flooding. Based on this, these two projects rate as very high for Project Flood Mitigation Benefit.

EXHIBIT 2.1.3

Priority Matrix (Weighted Factor Ranking)
Identification of Flood Mitigation Projects
South East Lee County (1.3)

Criteria		Cost/Flood Mitigation Benefit			Existing Drainage Level of Service					Multiple Benefits	Land Cost	Permittability		
Weight		35%			30%					10%	10%	15%		
Description		Estimated project cost and flood mitigation benefit			Current level of drainage conditions					Project contains alternative benefits	How much of the land is currently available	Expected to reduce delays from permitting		
Reference		Table 2			Table 3					Table 4	Table 5	Table 6		
Project		Project Cost	Project Benefit	Total	Strucutre Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	Weighted Summary	Prelim. Total Proj. Cost (with contingency)
3.12	Imperial River Improvements East	3	4	7	4	2	2	2	10	0	4	1	60	$9,500,000
3.14	Imperial River Improvements West	2	5	7	4	2	2	2	10	2	1	1	59	$22,000,000
3.16	Corkscrew East Drainageway	5	2	7	0	1	1	1	3	0	10	10	58.5	$0
3.11	East I-75 Overland Flow Collection	2	4	6	3	2	2	1	8	0	10	2	58	$22,000,000
3.10	I-75 to Spring Creek Drainageway S.	3	4	7	2	2	2	2	8	0	4	2	55.5	$7,300,000
3.2	Estero River N. Branch Improvements	2	5	7	2	2	2	2	8	0	3	2	54.5	$17,000,000
3.13	Crew Flint Pen Hydrologic Restoration	1	4	5	3	2	2	1	8	5	4	2	53.5	$61,000,000
3.9	I-75 to Spring Creek Drainageway N.	2	4	6	2	2	2	2	8	0	2	2	50	$22,000,000
3.3	FGCU Flow-way Improvements	2	4	6	0	2	2	2	6	0	3	2	45	$22,000,000
3.1	Halfway Creek Drainageway	1	5	6	0	2	2	2	6	0	1	1	41.5	$79,000,000
3.15	Railroad Drainageway Improvements	4	2	6	1	1	1	1	4	0	5	2	41	$3,900,000
3.4	Alico Mine Lake Interconnects (West)	2	3	5	0	1	1	1	3	0	2	5	36	$27,000,000
3.6	Alico Road Extensin Drainageway	3	3	6	0	0	0	0	0	2	3	5	33.5	$11,600,000
3.5	Alico Mine Lake Interconnects (East)	1	3	4	0	1	1	1	3	0	1	5	31.5	$48,000,000
3.8	Alico Mine Lake to Halfway Creek	1	4	5	0	1	1	1	3	0	2	1	30	$35,000,000
3.7	Blackstone Dr to Alico Mine Lakes	2	1	3	0	0	0	0	0	0	3	2	16.5	$17,700,000

Table 2 (Cost/Flood Mitigation Benefit, 35% weight)		**35%**
Project Cost	* Very High = 1, High = 2, Medium = 3, Low = 4, Very Low = 5	
Project Benefit	** Very High = 5, High = 4, Medium = 3, Low = 2, Very Low = 1	
***Project cost definition:** Very High = greater than $30M, High = between $15M and $30M, Medium = between $5M and $15M, Low = between $1M and $5M, Very Low = less than $1M		
****Project Benefit Definition:** Very High = High capacity downstream conveyances, High = Moderate capacity downstream conveyances, first upstream east of I-75 storage components, and high capacity east of I-75 conveyances, Medium = Further upstream storage with slightly more moderate storage capacity, and further upstream conveyances of moderate capacity, Low = More localized improvement, Very Low = Farthest upstream conveyance with limited current demand		

**As SE Lee County concepts function as a system, determining individual project benefit is somewhat unique in this area. The typical recommended phasing order for this system is to address high capacity downstream projects first. This provides the best capacity for release of upstream storage when necessary. The downstream projects would be deemed the higher initial benefit based on this; and are further prioritized based on impact to immediately surrounding flood reduction target areas as well as conveyance capacity. Upstream concepts are recommended to also occur in a downstream to upstream order and where being compared to other upstream projects the storage volume capability is considered as a secondary factor. Note, there may be opportunities based on unique funding to pursue upstream projects first. This may be an option with several of these projects with temporary restrictions on their downstream releases.

Table 3 (Existing Drainage Level of Service, 30% weight)		**30%**
All other	Scale 0 - 2 (0 being none to 2 being severe)	
Structure Flooding	* Adjusted scale, 0 - 4 (0 being none to 4 being severe)	

Table 4 (Multiple Benefits, 10% weight)	**10%**
Criteria	Score
Serves solely the prime motivation of flood mitigation	0
Ability to implement connecting roads	2
Ability to implement a conservation area	2
Ability to implement water quality enhancement	2
Ability to perform 2 of the 3 multiple benefits	5
Ability to perform 3 of the 3 multiple benefits	10

Table 5 (Land Cost, 10% weight)	**10%**
Criteria	Score
Greater than $5M	1
Land costs between $3M to $5M	2
Land costs between $2M to $3M	3
Land costs between $1M to $2M	4
Land costs between $500K to $1M	5
Land costs between $250K to $500K	6
Land costs between $100K to $250K	7
Land costs between $50K to $100K	8
Less than $50K	9
No land cost	10

Table 6 (Permittability, 15% weight)	**15%**
Criteria	Score
Extensive permitting required	1
Moderate permitting required	2
Limited permitting required	5
Minimal permitting required	8
No permitting required	10

EXHIBIT 2.1.4

Priority Matrix (Weighted Factor Ranking)
Identification of Flood Mitigation Projects
South Fort Myers (1.4)

Criteria		Cost/Flood Mitigation Benefit			Existing Drainage Level of Service					Multiple Benefits	Land Cost	Permittability		
Weight		35%			30%					10%	10%	15%		
Description		Estimated project cost and flood mitigation benefit			Current level of drainage conditions					Project contains alternative benefits	How much of the land is currently available	Expected to reduce delays from permitting		
Reference		Table 2			Table 3					Table 4	Table 5	Table 6		
Project		Project Cost	Project Benefit	Total	Strucutre Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	Weighted Summary	Prelim. Total Proj. Cost (with contingency)
4.2	Ten Mile Canal-South	1	5	6	4	2	2	2	10	5	2	2	61	$80,700,000
4.7	Six Mile Cypress Slough-South	4	4	8	0	0	2	1	3	5	10	5	59.5	$1,700,000
4.1	Ten Mile Canal-North	3	4	7	2	1	2	1	6	2	7	5	59	$12,600,000
4.5	Park Road Area	4	1	5	1	1	1	2	5	0	9	8	53.5	$2,900,000
4.4	Briarcliff Area	4	1	5	1	1	1	2	5	0	6	8	50.5	$1,200,000
4.6	LCPA Diversion to Estero Basin	4	2	6	0	0	1	0	1	2	10	2	39	$2,100,000
4.3	Daniels Parkway-South Area	3	3	6	0	1	1	0	2	2	1	2	33	$12,600,000

Table 2 (Cost/Flood Mitigation Benefit, 35% weight)		**35%**
Project Cost	* Very High = 1, High = 2, Medium = 3, Low = 4, Very Low = 5	
Project Benefit	** Very High = 5, High = 4, Medium = 3, Low = 2, Very Low = 1	
Project Cost Definition: >$30M = 1, $30M-$15M = 2, $15M-$5M = 3, $5M-$1M = 4, <$1M = 5		
****Project Benefit Definition:** Volume of water diverted upstream, volume of increased storage, and/or volume of increased flow passed due to increased conveyance capacity. Based on regional model results of the 100-year, 3-day storm event with August 2017 start date.		
Project Benefit scale: >25K ac-ft = 5, 25K-5K ac-ft = 4, 5K-1K ac-ft = 3, 1k-500 ac-ft = 2, <500 ac-ft = 1		

Table 3 (Existing Drainage Level of Service, 30% weight)		**30%**
All other	Scale 0 - 2 (0 being none to 2 being severe)	
Structure Flooding	* Adjusted scale, 0 - 4 (0 being none to 4 being severe)	

Table 4 (Multiple Benefits, 10% weight)	**10%**
Criteria	Score
Serves solely the prime motivation of flood mitigation	0
Ability to implement connecting roads	2
Ability to implement a conservation area	2
Ability to implement water quality enhancement	2
Ability to perform 2 of the 3 multiple benefits	5
Ability to perform 3 of the 3 multiple benefits	10

Table 5 (Land Cost, 10% weight)	**10%**
Criteria	Score
Greater than $5M	1
Land costs between $3M to $5M	2
Land costs between $2M to $3M	3
Land costs between $1M to $2M	4
Land costs between $500K to $1M	5
Land costs between $250K to $500K	6
Land costs between $100K to $250K	7
Land costs between $50K to $100K	8
Less than $50K	9
No land cost	10

Table 6 (Permittability, 15% weight)	**15%**
Criteria	Score
Extensive permitting required	1
Moderate permitting required	2
Limited permitting required	5
Minimal permitting required	8
No permitting required	10

EXHIBIT 2.1.5

Priority Matrix (Weighted Factor Ranking)

Identification of Flood Mitigation Projects

ALL PROJECTS

Criteria			Cost/Flood Mitigation Benefit			Existing Drainage Level of Service					Multiple Benefits	Land Cost	Permittability		
Weight			35%			30%					10%	10%	15%		
Description			Estimated project cost and flood mitigation benefit			Current level of drainage conditions					Project contains alternative benefits	How much of the land is currently available	Expected to reduce delays from permitting		
Reference			Table 2			Table 3					Table 4	Table 5	Table 6		
Project	Section	Name	Project Cost	Project Benefit	Total	Structure Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	**Weighted Summary**	**Prelim. Total Proj. Cost (with contingency)**
1.3	East Lee Cty 1.1	GS-10 Stormwater Quality Reservoir	3	4	7	2	2	1	2	7	5	10	8	**72.5**	**$ 6,000,000**
1.9	East Lee Cty 1.1	Charlie Diversion- Hickey Canal Imp.	2	5	7	4	1	2	2	9	2	10	2	**66.5**	**$ 20,000,000**
1.1	East Lee Cty 1.1	Dog to Hendry Drainageway (CREST)	4	3	7	1	1	1	1	4	5	10	8	**63.5**	**$ 2,700,000**
1.7	East Lee Cty 1.1	Hickey Creek Overflow Bypass	2	5	7	4	2	2	2	10	2	5	1	**63**	**$ 17,000,000**
1.4	East Lee Cty 1.1	Buckingham Bypass Drainageway	1	4	5	3	2	2	2	9	2	4	2	**53.5**	**$ 31,000,000**
1.5	East Lee Cty 1.1	Buckingham Trails Water Quality Res.	2	2	4	1	1	1	1	4	5	6	5	**44.5**	**$ 16,000,000**
1.6	East Lee Cty 1.1	Lehigh River hall to Olga Outfall	2	2	4	2	2	1	1	6	5	2	2	**42**	**$ 26,000,000**
1.11	East Lee Cty 1.1	Six Mile Cypress Preserve N. Catch. Res.	3	2	5	0	1	0	1	2	5	10	2	**41.5**	**$ 14,500,000**
1.2	East Lee Cty 1.1	Bedman Creek Overflow Bypass	2	3	5	1	1	1	1	4	2	3	2	**37.5**	**$ 17,000,000**
1.8	East Lee Cty 1.1	Strayhorn Drainageway	3	3	6	0	1	1	1	3	0	4	2	**37**	**$ 14,000,000**
1.10	East Lee Cty 1.1	Hickey Creek Swamp Drainageway	4	1	5	0	1	0	1	2	0	5	2	**31.5**	**$ 1,500,000**
Project	Section	Name	Project Cost	Project Benefit	Total	Structure Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	**Weighted Summary**	**Prelim. Total Proj. Cost (with contingency)**
2.2	Whiskey Creek1.2	Brantley-Dover Canal Improvements	5	5	10	3	2	1	2	8	2	10	8	**83**	**$ 360,000**
2.3	Whiskey Creek1.2	FSW State Canal Improvements	5	5	10	2	1	1	1	5	2	10	8	**74**	**$ 760,000**
2.1	Whiskey Creek1.2	L-Canal Improvements	4	3	7	1	1	1	1	4	2	9	5	**55**	**$ 2,020,000**
Project	Section	Name	Project Cost	Project Benefit	Total	Structure Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	**Weighted Summary**	**Prelim. Total Proj. Cost (with contingency)**
3.12	SE Lee Cty 1.3	Imperial River Improvements East	3	4	7	4	2	2	2	10	0	4	1	**60**	**$ 9,500,000**
3.14	SE Lee Cty 1.3	Imperial River Improvements West	2	5	7	4	2	2	2	10	2	1	1	**59**	**$ 22,000,000**
3.16	SE Lee Cty 1.3	Corkscrew East Drainageway	5	2	7	0	1	1	1	3	0	10	10	**58.5**	**$ -**
3.11	SE Lee Cty 1.3	East I-75 Overland Flow Collection	2	4	6	3	2	2	1	8	0	10	2	**58**	**$ 22,000,000**
3.10	SE Lee Cty 1.3	I-75 to Spring Creek Drainageway S.	3	4	7	2	2	2	2	8	0	4	2	**55.5**	**$ 7,300,000**
3.2	SE Lee Cty 1.3	Estero River N. Branch Improvements	2	5	7	2	2	2	2	8	0	3	2	**54.5**	**$ 17,000,000**
3.13	SE Lee Cty 1.3	Crew Flint Pen Hydrologic Restoration	1	4	5	3	2	2	1	8	5	4	2	**53.5**	**$ 61,000,000**
3.9	SE Lee Cty 1.3	I-75 to Spring Creek Drainageway N.	2	4	6	2	2	2	2	8	0	2	2	**50**	**$ 22,000,000**
3.3	SE Lee Cty 1.3	FGCU Flow-way Improvements	2	4	6	0	2	2	2	6	0	3	2	**45**	**$ 22,000,000**
3.1	SE Lee Cty 1.3	Halfway Creek Drainageway	1	5	6	0	2	2	2	6	0	1	1	**41.5**	**$ 79,000,000**
3.15	SE Lee Cty 1.3	Railroad Drainageway Improvements	4	2	6	1	1	1	1	4	0	5	2	**41**	**$ 3,900,000**
3.4	SE Lee Cty 1.3	Alico Mine Lake Interconnects (West)	2	3	5	0	1	1	1	3	0	2	5	**36**	**$ 27,000,000**
3.6	SE Lee Cty 1.3	Alico Road Extensin Drainageway	3	3	6	0	0	0	0	0	2	3	5	**33.5**	**$ 11,600,000**
3.5	SE Lee Cty 1.3	Alico Mine Lake Interconnects (East)	1	3	4	0	1	1	1	3	0	1	5	**31.5**	**$ 48,000,000**
3.8	SE Lee Cty 1.3	Alico Mine Lake to Halfway Creek	1	4	5	0	1	1	1	3	0	2	1	**30**	**$ 35,000,000**
3.7	SE Lee Cty 1.3	Blackstone Dr to Alico Mine Lakes	2	1	3	0	0	0	0	0	0	3	2	**16.5**	**$ 17,700,000**
Project	Section	Name	Project Cost	Project Benefit	Total	Structure Flooding	Road Flooding	Extended Duration	Repetitive Flooding	Total	Total	Total	Total	**Weighted Summary**	**Prelim. Total Proj. Cost (with contingency)**
4.2	South 1.4	Ten Mile Canal-South	1	5	6	4	2	2	2	10	5	2	2	**61**	**$ 80,700,000**
4.7	South 1.4	Six Mile Cypress Slough-South	4	4	8	0	0	2	1	3	5	10	5	**59.5**	**$ 1,700,000**
4.1	South 1.4	Ten Mile Canal North	3	4	7	2	1	2	1	6	2	7	5	**59**	**$ 12,600,000**
4.5	South 1.4	Park Road Area	4	1	5	1	1	1	2	5	0	9	8	**53.5**	**$ 2,900,000**
4.4	South 1.4	Briarcliff Area	4	1	5	1	1	1	2	5	0	6	8	**50.5**	**$ 1,200,000**
4.6	South 1.4	LCPA Diversion to Estero Basin	4	2	6	0	0	1	0	1	2	10	2	**39**	**$ 2,100,000**
4.3	South 1.4	Daniels Parkway-South Area	3	3	6	0	1	1	0	2	2	1	2	**33**	**$ 12,600,000**

*As each of the four study areas have unique characteristics, the scoring on a number of criteria reflects the relative value within that study area.

Part 3

Regional Modeling

3.1 - DEVELOPMENT AND CALIBRATION OF THE SOUTHERN LEE COUNTY REGIONAL MODEL

1 INTRODUCTION

The 2017 Atlantic hurricane season was the costliest tropical cyclone season on record. Following a heavy rainfall event in August that caused flooding in many areas, Florida's southwestern coast was further impacted by Hurricane Irma in early September. During the storm, many parts of Lee County experienced bursts of heavy rainfall over a relatively short period of time. These intervals of intense rainfall in combination with the already exacerbated saturated groundwater conditions, resulted in inundation of many parts of Lee County, including Lehigh Acres, Eastern Lee County, Whiskey Creek and Bonita Springs.

After the initial post-Irma clean-up, Lee County mobilized several teams of surveyors to measure high-water marks, identify flow obstructions within canals (i.e. clean, full of debris, highly vegetated, etc.), and assess operational status of water control structures. Using this information, Lee County identified four (4) study areas south of the Caloosahatchee River that are to be evaluated for potential flood mitigation projects. These areas include Whiskey Creek, South Fort Myers, Lehigh Acres (herein referred to as East Lee County), and Southeast Lee County (See Figure 1). Each region has unique hydrological features that will require distinctive projects to manage proper storage and conveyance of stormwater.

To test the effectiveness of each of the proposed mitigation projects, a regional model of Southern Lee County was envisioned. Several smaller regional models have been previously developed for other projects within the area, including the Lehigh Acres Municipal Services Improvement District (LA-MSID) Stormwater Model and the Village of Estero (VOE) Regional Model. These models were developed using the MIKE SHE/MIKE 11 software, which is an integrated hydrological numerical modeling tool that links 1-dimensional (1D) surface water hydraulics to 3-dimensional (3D) groundwater movement. Accordingly, the latest version (2017) of this software was selected for the assessment of the projects, due in part to its regional modeling capabilities and historical usage within the area. This model is herein referred to as the Southern Lee County Regional Model (SLCRM).

In addition to assessing the proposed drainage improvements; the objective of this project is to develop a comprehensive understanding of the impacts caused by Hurricane Irma. For this purpose, the calibration period for the model was determined to be from June 1st, 2017 to October 31st, 2017, as this period captures the majority of the rain and hurricane season. Nonetheless, the model was developed for a full two (2) year simulation period, spanning from January 1st, 2016 to December 31st, 2017. The objective of this report is to provide a detailed discussion on the development and calibration of the SLCRM.

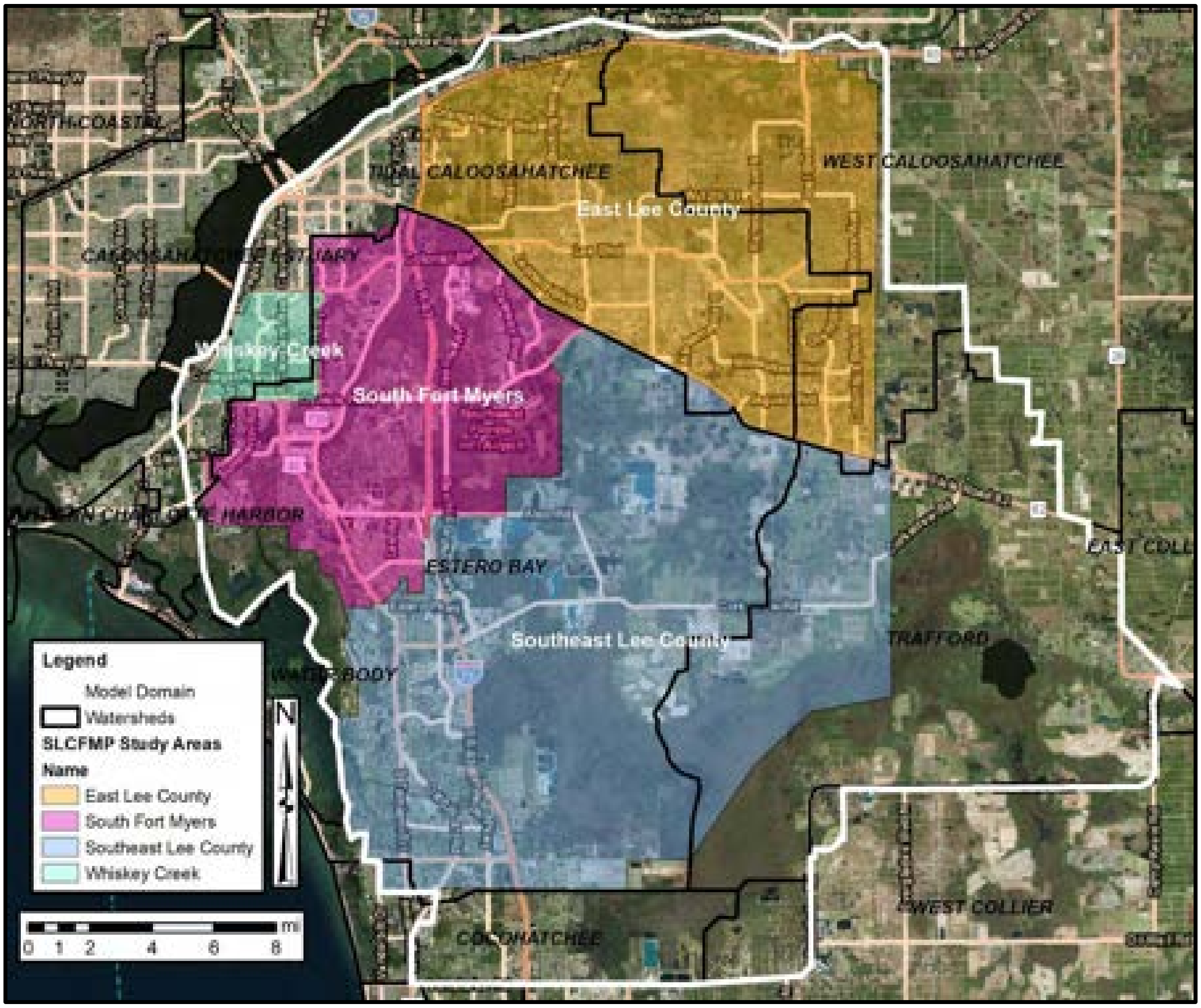


Figure 1. Study areas identified by Lee County.

2 DATA COLLECTION

A systematic approach was followed to gather the data required to develop the SLCRM. All existing models were obtained with relevant data being extracted for the new model. Extracted model input parameters include: river branches, cross-section data, and surface water features, such as culverts and gates. In addition, permit data, as-built drawings, and existing survey data was obtained, where available, to fill missing data. Additional survey work was also conducted, particularly in study areas that had either missing or outdated information.

Furthermore, the following additional input parameters were sourced for model development: rainfall, reference evapotranspiration (ET), land use information, topography/bathymetry, soil maps and parameters, aquifer bottom elevations, measured data for aquifer boundary conditions and public supply well pumping data. Moreover, measured surface water and groundwater data was sourced for means of model calibration. This data was obtained from a variety of sources, including Lee County Natural Resources Department, Lee County Port Authority, LA-MSID, the U.S. Geological Survey (USGS), South Florida Water Management District (SFWMD), and the National Oceanic and Atmospheric Administration (NOAA). The Data Collection Memorandum, provided in the Appendix, offers additional details of the data collection process.

3 MODEL DEVELOPMENT

The following sections provide details for each component of the MIKE SHE/11 hydrological model:

- Model Domain and Grid – defines the spatial extent of the model and the size of the grid cell for the entire model
- Topography – defines the averaged topography for each grid cell
- Climate – defines the time-varying spatial maps of Rainfall and Reference Evapotranspiration data for the simulation period
- Land Use – defines the various vegetation types and their Leaf Area Index and Root Depths, which contribute to the calculation of Actual Evapotranspiration
- River Network – defines the extent, dimensions and features of the canals and rivers using the 1D network tool MIKE 11, which is then linked to MIKE SHE via groundwater interactions
- Overland Flow – defines the ways in which water flows over the land surface by determining the roughness values, impervious surfaces, and overland drainage areas.
- Unsaturated Flow – defines the soil types, their spatial distribution and physical properties such as water content at saturation
- Saturated Zone – defines the hydrostratigraphy by determining the layering system, depth of each layer, and layer properties such as hydraulic conductivity.

3.1 Model Domain and GRID

The model domain was chosen based on several criteria. The extent of the four (4) study areas were of primary concern. Thus, it was critical to ensure that Whiskey Creek, East Lee County, South Fort Myers, and Southeast Lee County were all properly represented within the model domain. Secondly, the SFWMD basins and sub-basin boundaries were utilized to define the outer extent of the model domain, which extends beyond the study areas, see Figure 1. Moreover, for District boundaries that may have extended beyond the focus area, or would have caused the model to become exceedingly large, natural or man-made flow divides such as rivers, roads, or canals were used to reduce the domain size in a way that made sense hydrologically.

The MIKE SHE model uses a uniform square grid cell for the entire model domain, and calculations for overland, unsaturated zone, and saturated zone hydrological processes are made at each grid cell. With such a large spatial extent as selected for this model, it is important to select a grid cell size that will be able to capture important land surface features while still keeping computation times relatively low. A range of model cell sizes were tested, ranging from 750 to 1,500 feet, for the selected model domain. The number of grid cells produced for the map will control the computational time during model simulations. It was determined that the grid cell size of 750 ft x 750 ft produces a map with 33,121 computational cells for each layer. For comparison, the Cape Coral Stormwater MIKE SHE Model grid size is 750 ft and has 25,757 cells. The Cape Coral model runs the full two (2) year simulation in about four (4) to five (5) hours. This computational time was considered low enough to work with efficiency during model development and calibration.

3.2 Topography

The developed model domain covers three (3) counties, including Lee, Collier and Hendry. Digital Elevation Models (DEMs) for the first two (2) were directly sourced from the counties. Both datasets have a cell size of 5 feet and are in the North American Vertical Datum of 1988 (NAVD88). No LiDAR information was available directly from Hendry County; thus, SFWMD LiDAR data was sourced for the area, which has a cell size of 25 feet and is also in NAVD88. In turn, all three (3) DEMs were merged and clipped to the model domain. The topography was then aggregated to a cell size of 750 ft using the average value of the input cell. Figure 2 shows the coverage of each elevation dataset and their respective topography.

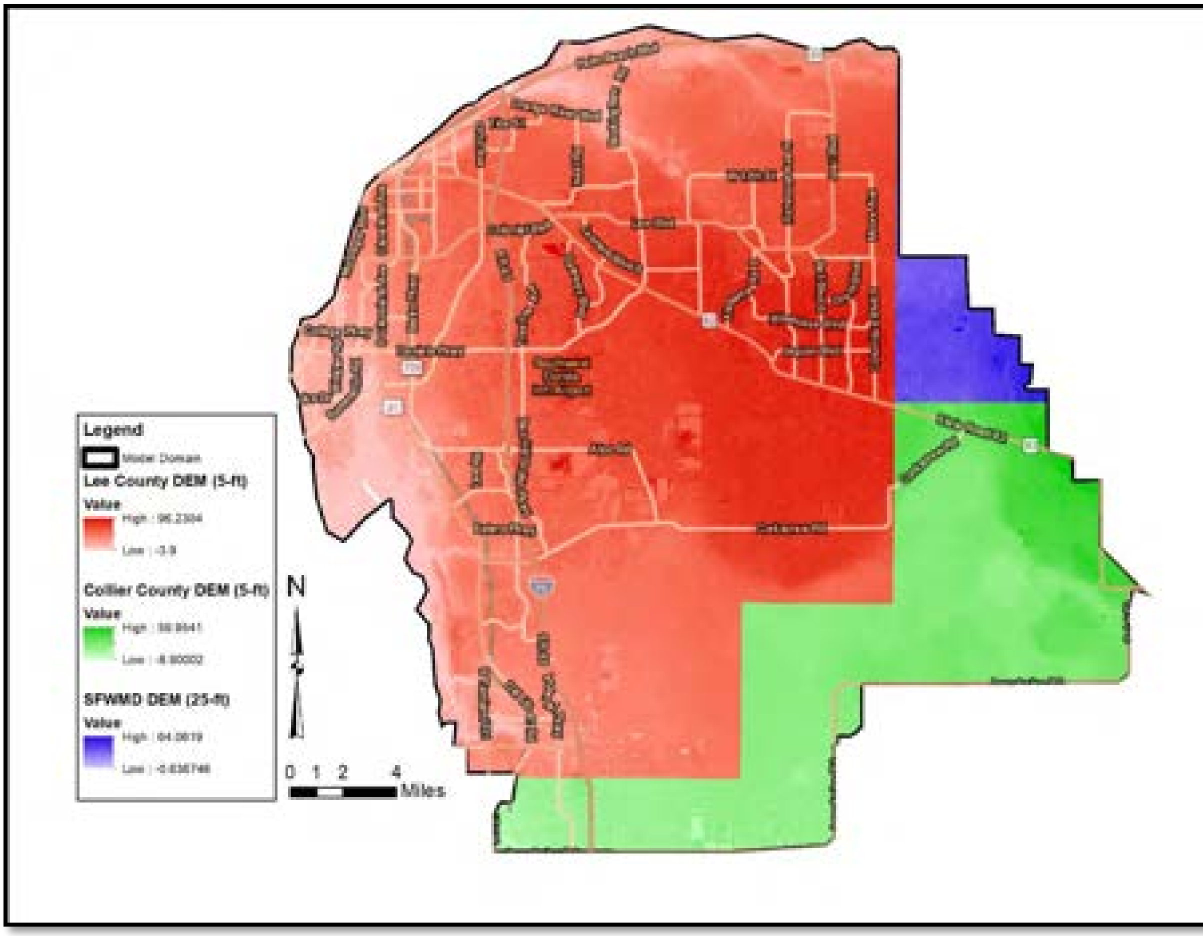


Figure 2. Coverage of Sourced Digital Elevation Models (DEMs)

The topography of the watershed generally slopes east to west, with a ridgeline being observed along the eastern basin boundary (See Figure 3). This ridgeline runs south to north and acts as the principal high point within the study area, having elevations around 38 to 40 feet relative to the NAVD88. Elevations taper off as the terrain mildly slopes westerly towards the center of the watershed. More defined gradients are observed running south-westerly and westerly towards Estero Bay, as well as north-westerly towards the Caloosahatchee River.

The LiDAR topography does not penetrate water surfaces and thus does not account for the bathymetry of open water bodies. To accommodate this limitation for filled mining pits; the elevations of the mine sites were "burned" into the topography by manually modifying the mine bottom depths within the topography file. The modified bottom depths are based on the elevations provided in the VOE Regional Model. The extent of these mine sites does not exactly match the VOE model, due to the difference in cell size. Nonetheless, great care was taken to properly represent the current extent of the larger mines using current land use information and aerial photography.

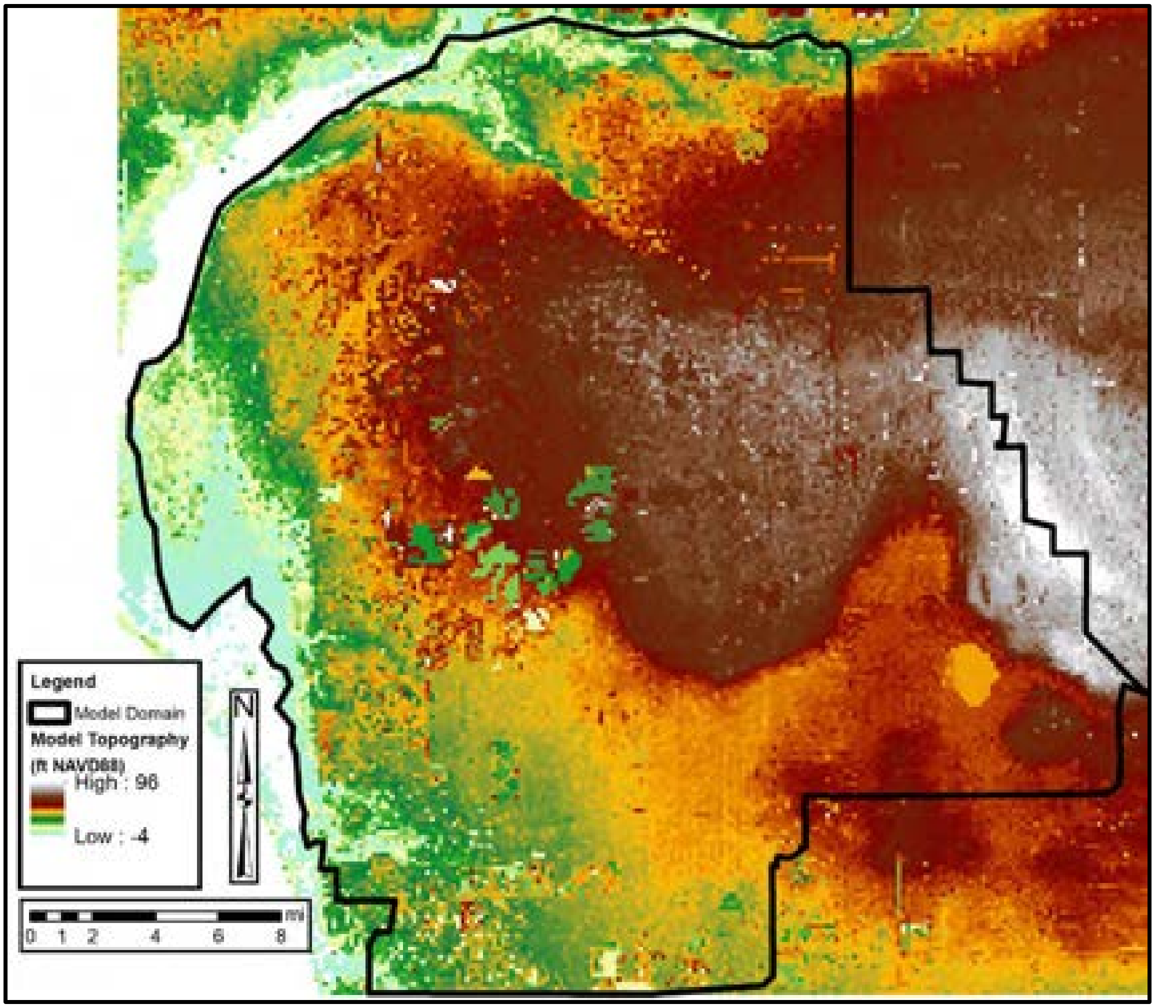


Figure 3. Model Topography at 750ft Resolution

3.3 Rainfall and Evapotranspiration

To provide the optimal rainfall estimates for the 2017 storm season, which featured record amounts of rainfall fell over a relatively short period of time, both the gridded "One Rain" NEXRAD data and the measured data were obtained for comparison. While the gridded data can provide a much better spatial resolution over measured data at an individual station; measured data can be more accurate and reliable at smaller record frequencies.

Several rain gauge stations were compared with the gridded "One Rain" NEXRAD data. Figure 4 shows measured data at the LEHIGH W_R station (in blue) compared with the gridded data at the same location (grid cell 984). Over the 3-day period, covering Hurricane Irma from 9/9/2017 through 9/11/2017, the LEHIGH W_R station measured 10.1 inches of rainfall, whereas the gridded data showed 9.375 inches of rainfall. The difference between these two (2) measurements during this extreme weather event is considered small. The majority of the stations that were reviewed showed a similar discrepancy in the data.

Figure 5 shows the comparison of a LA-MSID rain gauge with the gridded data. The LA-MSID station S-H-3 measured 18.8 inches during the same 3-day period, while the gridded data showed only 8.37 inches during that time. This discrepancy in the data is significant and could possibly be explained by a localized cloud-burst, data recorder errors, or a lack of refinement in the gridded data.

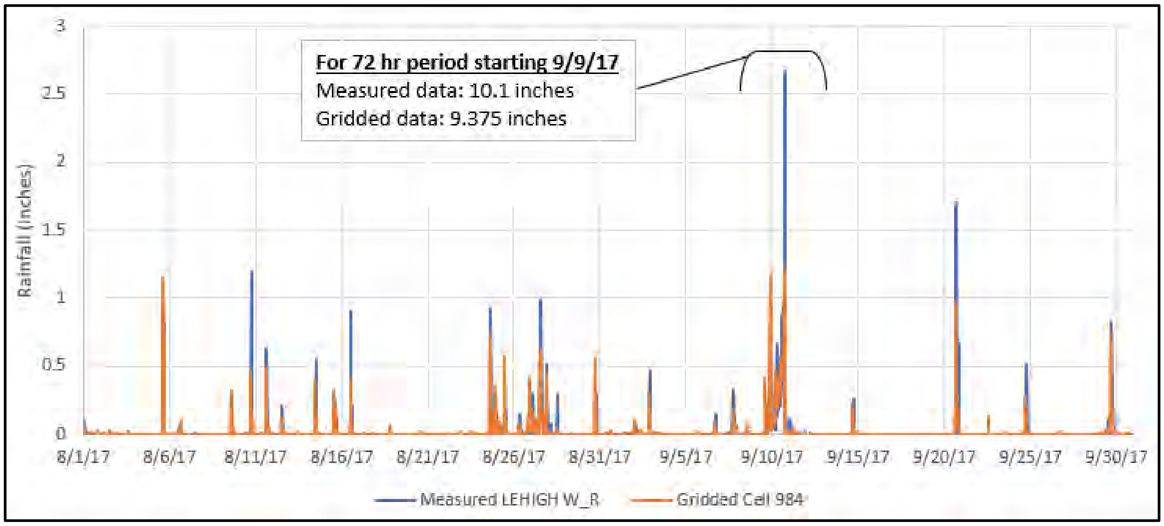


Figure 4. Comparison of measured data at SFWMD's LEHIGH W_R station with the gridded data at the same location.

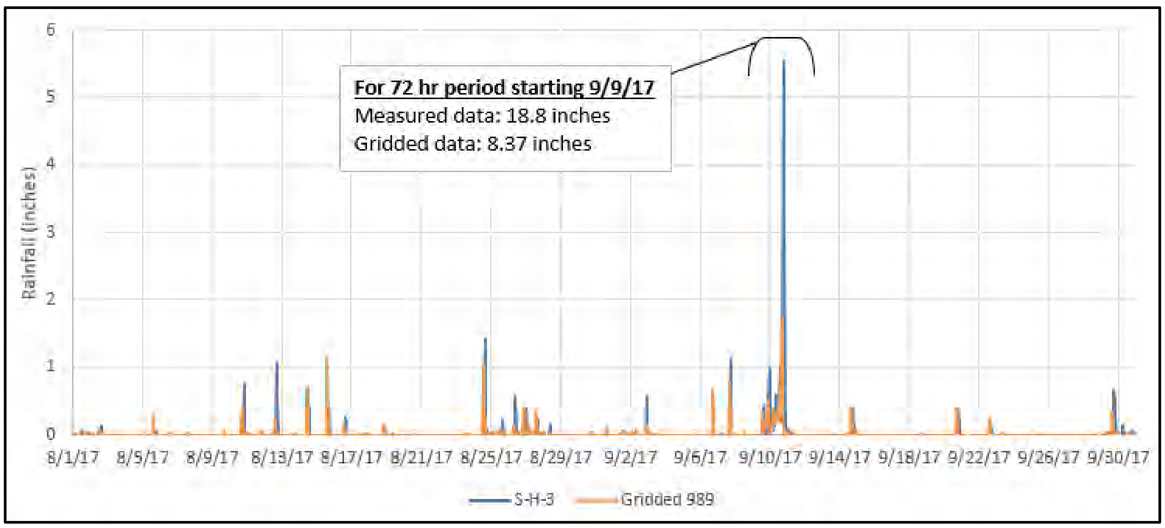


Figure 5. Comparison of measured data at LA-MSID's S-H-3 station with the gridded data at the same location.

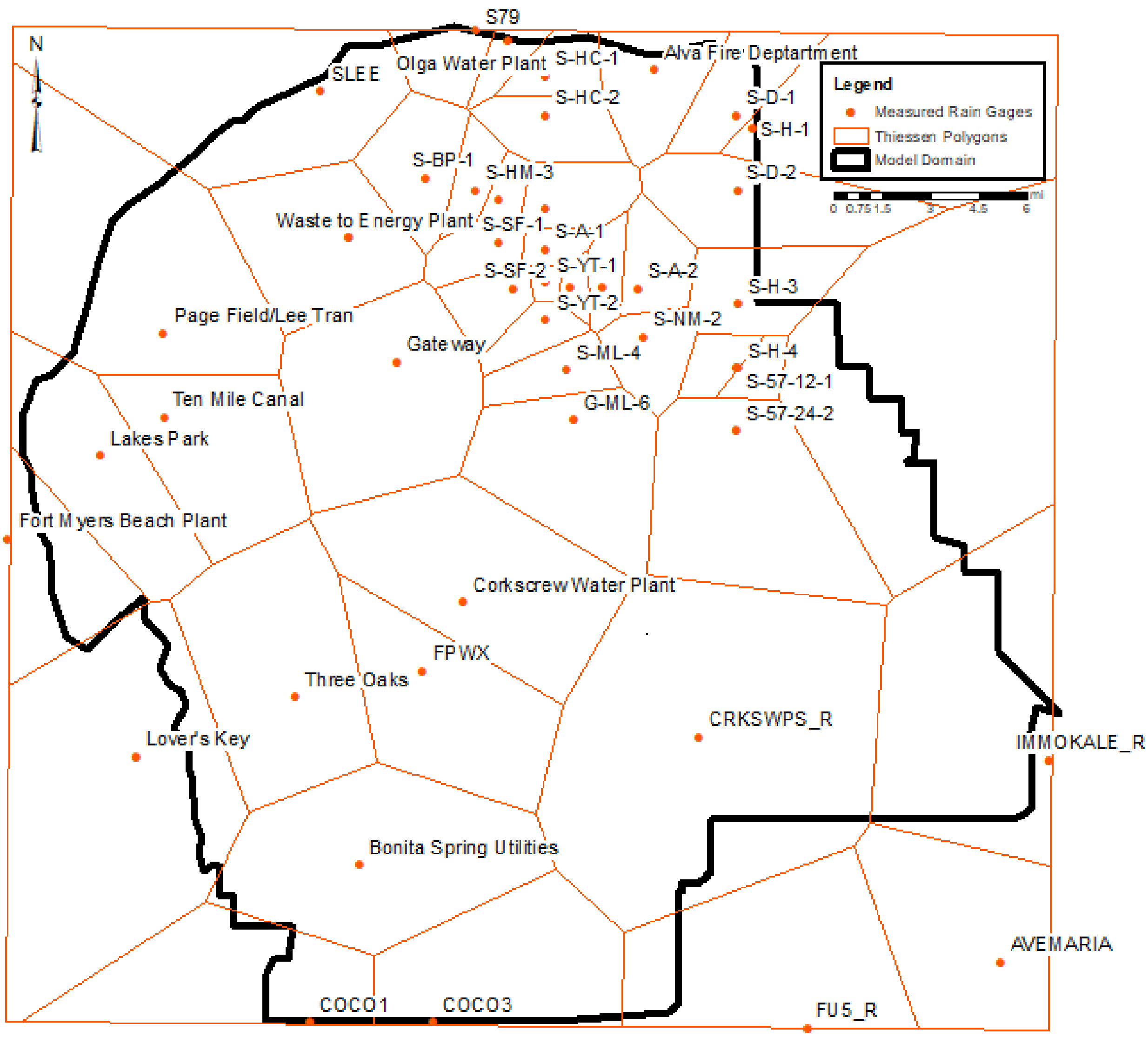


Figure 6. Theissen Polygons used to implement the measured station-based data over the model domain.

Initially, the "One Rain" data was used for the model rainfall; however, a test was performed on several sub-basins within Lehigh Acres using their measured data stations. Peak stages improved at several locations, including S-A-1 and S-A-2, when compared with the gridded rainfall results. It was concluded that the measured rainfall captures the peaks of the large storm events much better than the gridded data.

All rain gages from LA-MSID, SFWMD, and Lee County were combined into a single shapefile and Thiessen Polygons were developed based on their locations, as shown in Figure 5. Some rain gages showed some missing data gaps during critical rainfall events, likely due to gage errors. The procedure for these gaps was to fill the missing data with that of the nearest rain gage that has recorded data. For example, the following Lee County rain gages had missing data:

- Hendry County Landfill – missing 9/10/2017 through 10/2/1017 15:30
    - Filled with S-H-4 rainfall data
- Three Oaks – missing 9/10/2017 14:00 through 9/11/2017 5:00
    - Filled with FPWX rainfall data
- Gateway – missing 5/31/17 17:45 through 6/5/17 12:15, 6/19/17 11:45 through 6/20/17 8:15, and 8/25/2017 21:30 through 8/28/2017 11:15
    - Filled with Waste to Energy Plant rainfall data

Gridded data for Reference Evapotranspiration (ET) was obtained from USGS for 2016 through 2017. This data has a daily frequency. The model calculates actual ET based on simulated water availability and vegetation parameters, such as Root Depth and Leaf Area Index, which are specified within the model.

3.4 River Network

The river network is included within the MIKE 11 component of the SLCRM and is discussed in detail below.

3.4.1 Initial River Network

The MIKE 11 River Network originates from the following models:

1. ***Village of Estero (VOE) regional model*** – The Village of Estero regional MIKE SHE/11 model, completed in September of 2018, was obtained from the Village of Estero. The southern section of the SLCRM utilizes the river and canal network developed in the Estero model (shown in green in Figure 7), including all cross-sections and structure data.
2. ***LA-MSID Model*** – Lehigh Acres Municipal Services Improvement District has an updated regional MIKE SHE/11 model that ADA developed in 2015 and refined twice more for use in the GS-10 project in the summer of 2016 and the SR-82 Expansion project in fall of 2016. ADA worked on all three (3) of these refinements and has access to all the relevant model files. The river and canal network developed in the LA-MSID model was used to fill in canal data, including cross-section and structure data, for the north east section of the SLCRM (shown in yellow in Figure 7).
3. ***Tidal Caloosahatchee River Basin (TCRB) model*** – A 2009 version of the TCRB MIKE SHE/11 model was used to evaluate the design of Harn's Marsh in the former East County Water Control District (ECWCD) in 2011. This river and canal network developed in the TCRB model (shown in aqua in Figure 7) was used to fill in canal data, including cross-section and structure data, for the northwestern area of the SLCRM.

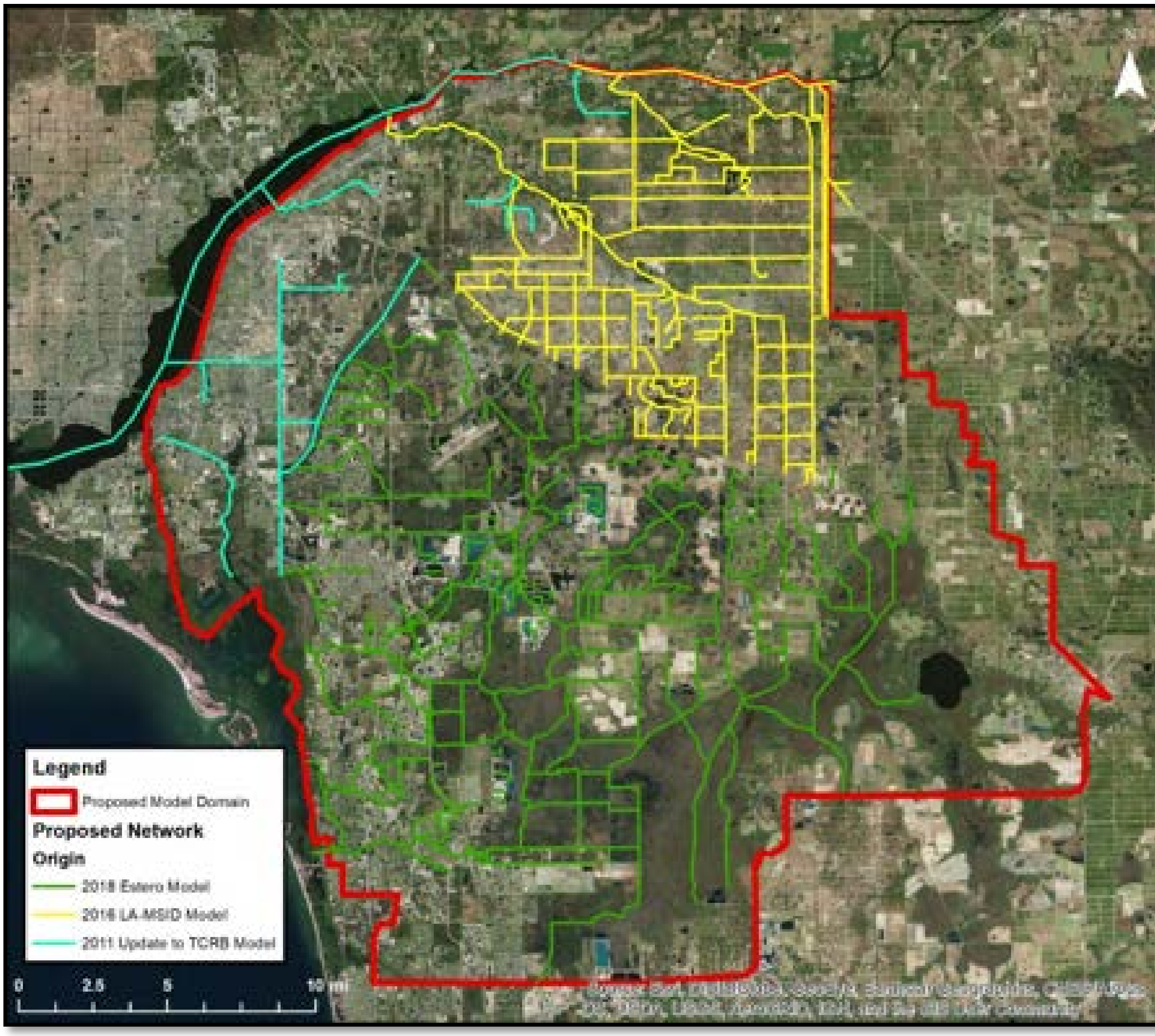


Figure 7. Origins of the river network file.

The MIKE 11 networks from these models were merged into a single file, including the cross-section information, boundary conditions, and structure data. The river branches pulled from each prior model are shown in Figure 7.

3.4.2 Quality Control for Existing M11 Models

The original model river network was comprised of 14 branches from the previous TCRB model, 129 branches from the previous LA-MSID model, and 156 branches from the previous VOE model. Each of these existing branches had cross-section information at about every 1,000 to 2,000 feet, on average. All branches, cross-sections, and structures (i.e. weirs and culverts) were pulled into the model and reviewed, with particular attention being paid to the older model that required updates. The initial model inputs sourced from the previous models are outlined in Table 1. In total, over 3,500 cross-sections and 700 structures were reviewed to ensure that model input process was complete and that the existing data was up-to-date and relevant to the study.

Table 1. Data extracted from the three (3) main existing models.

MODEL	*BRANCHES*	*CROSS-SECTIONS*	*WEIRS*	*CULVERTS*	*GATED STRUCTURES*
VOE	156	1969	158	125	5
LA-MSID	129	1333	172	124	57
TCRB	14	202	40	39	17

During the quality control (QC) process of the existing data, two (2) major issues were discovered. Initially, some cross-sections did not transfer correctly to the new model. The software's built-in import/export tool, which was used to transfer the data, created occasional vertical and horizontal unit conversion issues. This was likely a system bug, associated with software versioning. Cross-sections with this conversion issue were deleted and re-imported manually.

Secondly, many cross-sections were originally developed for other models using a methodology that didn't require a definition of the channel center, and therefore placed the markers for the left and right embankments very close together, rather than to the left and right of the center of the channel. Figure 8 shows a sample cross-section with left and right bank markers (thick red line) very close together. It should be noted that this cross-section was initially updated, but then finally omitted as the Corkscrew branch was removed from the model. The placement of these bank markers is critical for ADA's method of using a land use-based Manning's n value for the embankments. Thus, all cross-sections had to be reviewed with bank markers revised to represent the left and right channel embankments.

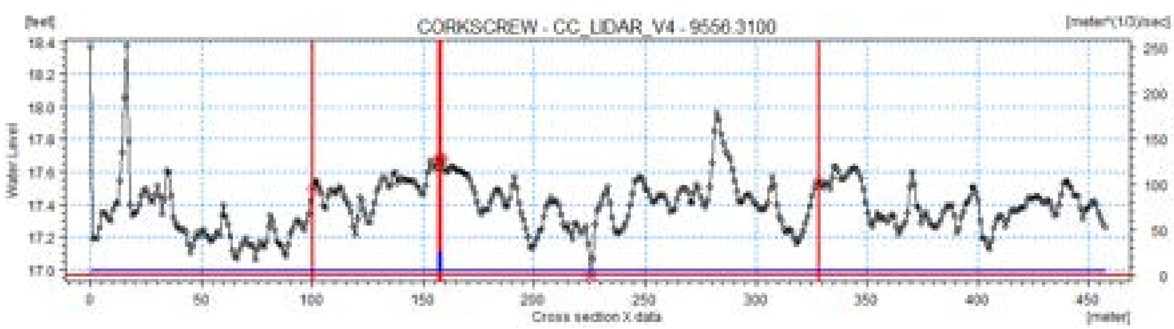


Figure 8. Sample Cross-section from VOE Model

3.4.3 Other External Data

Cross-sections and structure data were also acquired from additional data sources such as surveys, plans, as-built drawings, and previous Stormwater Master Plans (SMPs) and models. For example, forty (40) cross-sections and four (4) culverts were added to the model from the 2018 survey performed by Banks Engineering for the Sunniland & Nine Mile Run Drainage Improvements project. Furthermore, five (5) cross-sections and dimensions for about six (6) structures were extracted from the Provincetown and Edison College permits. In addition, permit data for the Hawk's Haven community was used to extract structure dimensions for the culvert within Olga Canal and running under SR 80, which was used to estimate the canal bottom depths. The City of Fort Myers EPA SWMM model was also mined for cross-section and relevant structure information. In total, ninety-two (92) cross-sections were entered into the M11 model for Manuel's Branch, Carrel Canal, and Winkler Canal from the Fort Myers Model.

3.4.4 River Network Updates

Once the three (3) existing M11 model networks were compiled into a single network, the model was further refined to add detail in hydraulically simplified areas (particularly Whiskey Creek and Ft Myers), update any older model information (e.g. the Hendry Creek and Mulloch Creek area), correct any flow-way inconsistencies or model short-cuts that might have been used in the previous models (e.g. changing Bedman Creek and Hickey Creek from straight-line representation to the actual meandering pathway), reduce unnecessary complexity where appropriate, and re-thinking model boundary information. The final model network is shown in Figure 9.The following updates were made to the merged MIKE 11 network:

Caloosahatchee as a boundary: The Caloosahatchee/C-43 branches were removed and replaced with the appropriate 15-minute (or higher frequency) measured data as boundary conditions at the connecting branches (i.e. Hickey Creek, Orange River, Billy's Creek, Whiskey Creek, and Hendry Creek).

Slough representation: Branches that represented large, natural areas, such as wetlands and sloughs, were removed from the M11 network. The Overland flow module of MIKE SHE is able to properly represent the flow through these areas based on topography and overland roughness. Adding branches that do not have a clearly defined channel, may over-drain the slough, or cause unrealistically high flows. Consequently, the following branches were removed from the network:

- *CorkscrewSE*
- *CorkscrewTrib2*
- *CorkscrewTrib3*
- *Corkscrew (from 4225 m through 31482 m)*
- *CorkIrrCanE (from 2187 m to 3358 m)*
- *SloughS*
- *WildcatRun4*

Mine representation: Branches representing isolated mines, i.e. mines not hydraulically connected to any network branch, were removed from the network to reduce unnecessary model complexity and improve computational time. These mines were still represented in the MIKE SHE component of the model as water features and by modifying the topography to represent the bottom depth of the mines (as estimated from the mine cross-sections and topography from the VOE model). The following mine branches were removed: MiningP1, MiningP14, MiningP15, MiningP16, MiningP17, MiningP17E, MiningP18, MiningP18S, MiningP19, MiningP2, MiningP20, MiningP22, MiningP23, MiningP24, MiningP25, MiningP26, MiningP2S, MiningP4, MiningP7E, MiningP8, and MiningP8E. Authors of the VOE model have stated that Mining Pits were originally represented in the MIKE 11 portion of the VOE model to remove numerical instabilities that were observed in the Saturated Zone. No such instabilities have been observed in or near mine sites in the SLCRM.

Additional branches: Additional rivers and canals (i.e. branches) were added to the MIKE 11 network to ensure that:

1) the main drainages for each subbasin are well represented,
2) areas of flooding concern were correctly represented, and
3) proposed project areas were properly represented with the existing canals.

These branches were added based on the Drainage Flowways Geographic Information System (GIS) shapefile obtained from the Lee County Drainage Geodatabase, as well as aerial photography and LiDAR topography. As a result, the following additions were made to the model:

- FGCU/Buckingham
- The 10 Mile to Hendry cut through canals (IDD J, IDD U) and existing drainage ditches in The Forest community
- Fiddlesticks (Treeline Ave S)
- Brantley
- L-3 Canal
- Edison College ditch – culverts and cross-sections extracted from permit data and as-builts
- Winkler Canal – cross-sections added from the City of Fort Myers HEC model
- Carrel Canal (Fort Myers Golf Club) – cross-sections added from the City of Fort Myers HEC model
- Manuel's Branch – cross-sections added from the City of Fort Myers HEC model
- Olga Creek – cross-sections from plans
- Canals south of Buckingham Road (Alvin N and Alvin S, Albert N and Albert S, Anza N and Anza S, 46-20-2 and 46-29-2, and Champion N) – cross-sections added from new survey by AIM
- Country Creek – the ditch running along the west side of County Creek community that outfalls to the Estero River was added
- WildcatRun Ditch – new survey data was requested to provide cross-sections for this branch
- Florida Farms Ditch – new survey data was requested to provide cross-sections for this branch
- SeminoleGulfWay West Ditch – new survey data was requested to provide cross-sections for this branch
- Eleven (11) Overland drainage connections were made to Kehl Canal to represent places where the canal embankment had eroded and overland water flows into the river.
- East Mulloch area – branch information added from the EMDD model and from new survey (Laurel Valley, San Carlos, Useppa Rd, and Baruch Rd)
- Reflection Lakes – the drainage outfall from Reflection Lakes has been added to the model based on permit data
- Subsurface Drainage branches (additional details area provided in Section 3.8.4) – shown in red in Figure 9.

Channel complexity: Bedman Creek and Hickey's Creek were originally represented by simplified, straight-line, channels; however, this representation could under-estimate storage, the drainage time, and channel roughness. Therefore, both Creeks were re-entered into the model with all their existing bends and curves.

Bridges and large culverts: All bridges were removed from the MIKE 11 network as these are typically large and do not represent a flow constriction; however, they do add model complexity and increase computational time. Culverts that have a sufficiently large cross-sectional area (i.e. large diameter or length and width) and do not represent a flow constriction were also generally omitted from the model development or removed from the existing data where deemed unnecessary.

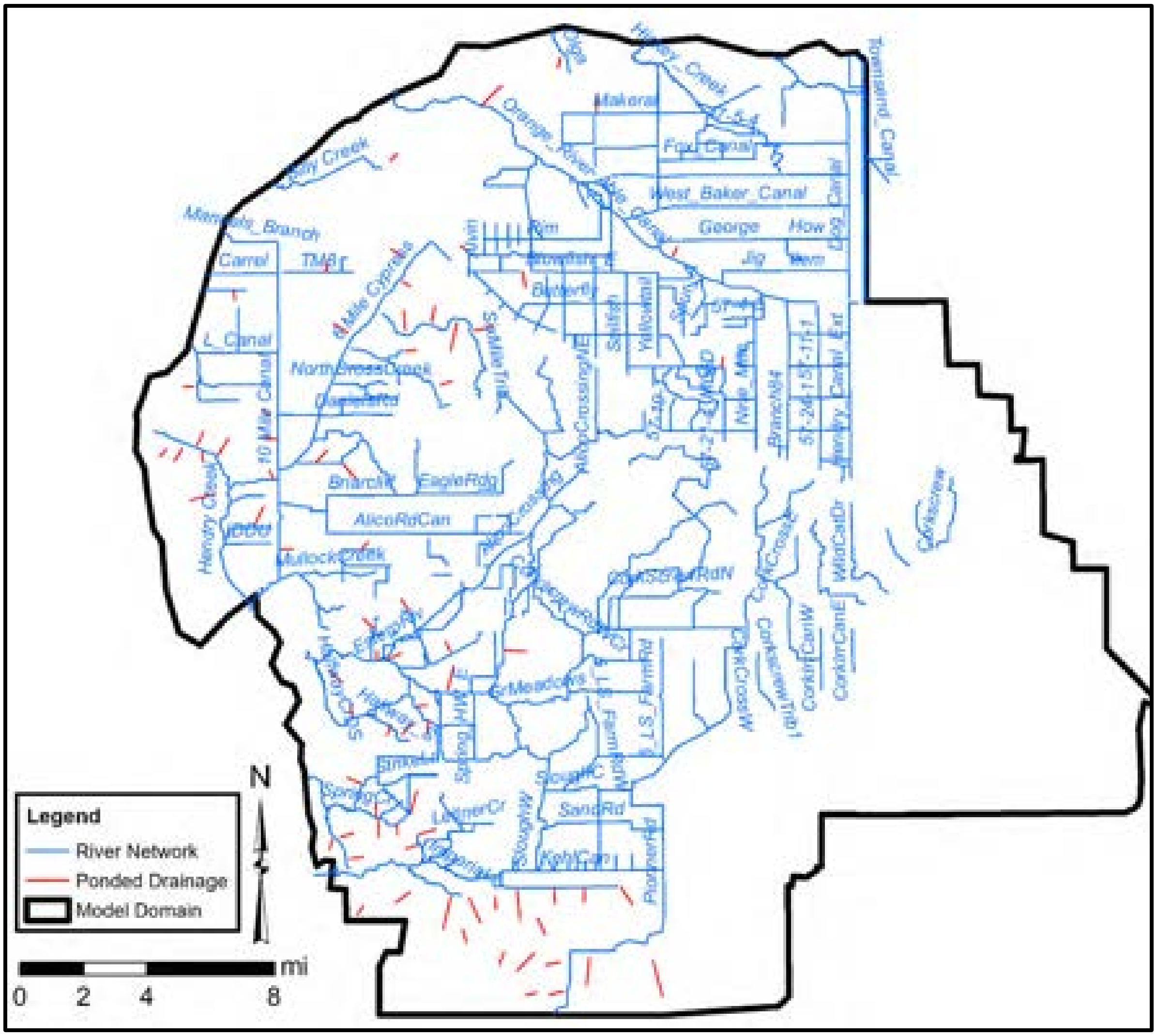
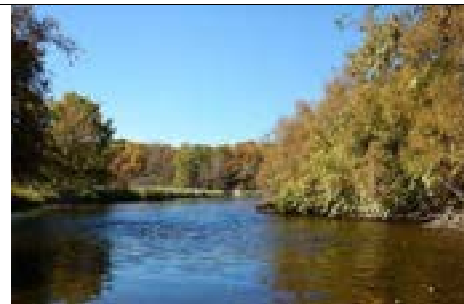
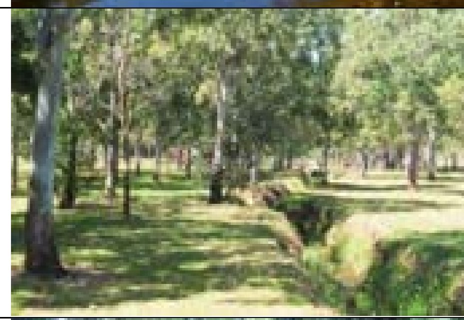
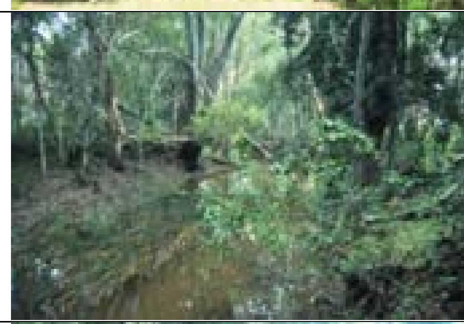
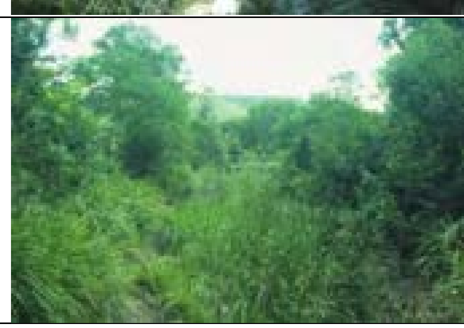


Figure 9. Final Model River Network

3.4.5 Channel Roughness

MIKE 11 provides a user input option for variable channel roughness based on location. Hydraulic roughness within the river branches is expressed by the Manning's roughness coefficient (*n*), which represents the resistance to flow exerted by land surface features and conditions. The coefficient is empirical in nature and can be difficult to quantify; thus, sound engineering judgment and prior experience was referred to when selecting values.

Table 2. Channel Roughness Coefficients

Manning's *n*	Description	Visual Reference
0.035	Natural channel, somewhat irregular side slopes, fairly even, clear and regular bottom, little variation in cross-section	
0.050	Banks consist of single trunk trees with no low branches or shrubs	
0.100	Banks with sparse trees and a few woody shrubs	
0.125	Banks with trees and flexible understory plants, some low branches and shrubs, slow to walk through	
0.150	Banks with thick shrub growth, low branches, fallen trees, difficult and slow to walk through	

A standard uniform value of 0.035 was assigned for the primary flow section of each river, which typically spans from top-of-bank (TOB) to top-of-bank. This value was selected based on literature review and assessment of river conditions. Table 2 provides a list of the Manning's values that were used to define channel roughness throughout the model. These values were assigned based on manual inspection of aerial photography and review of land use information for each river branch.

3.4.6 Flood Codes

Overland flow can pass into the 1D MIKE 11 river network if the water is high enough to flow over the embankment specified in the river dimensions (i.e. cross-section information). Flood Codes are used in the model to allow for overland flooded areas to flow into the nearby channels with flood codes without consideration of the channel embankment specified in the cross-section files.

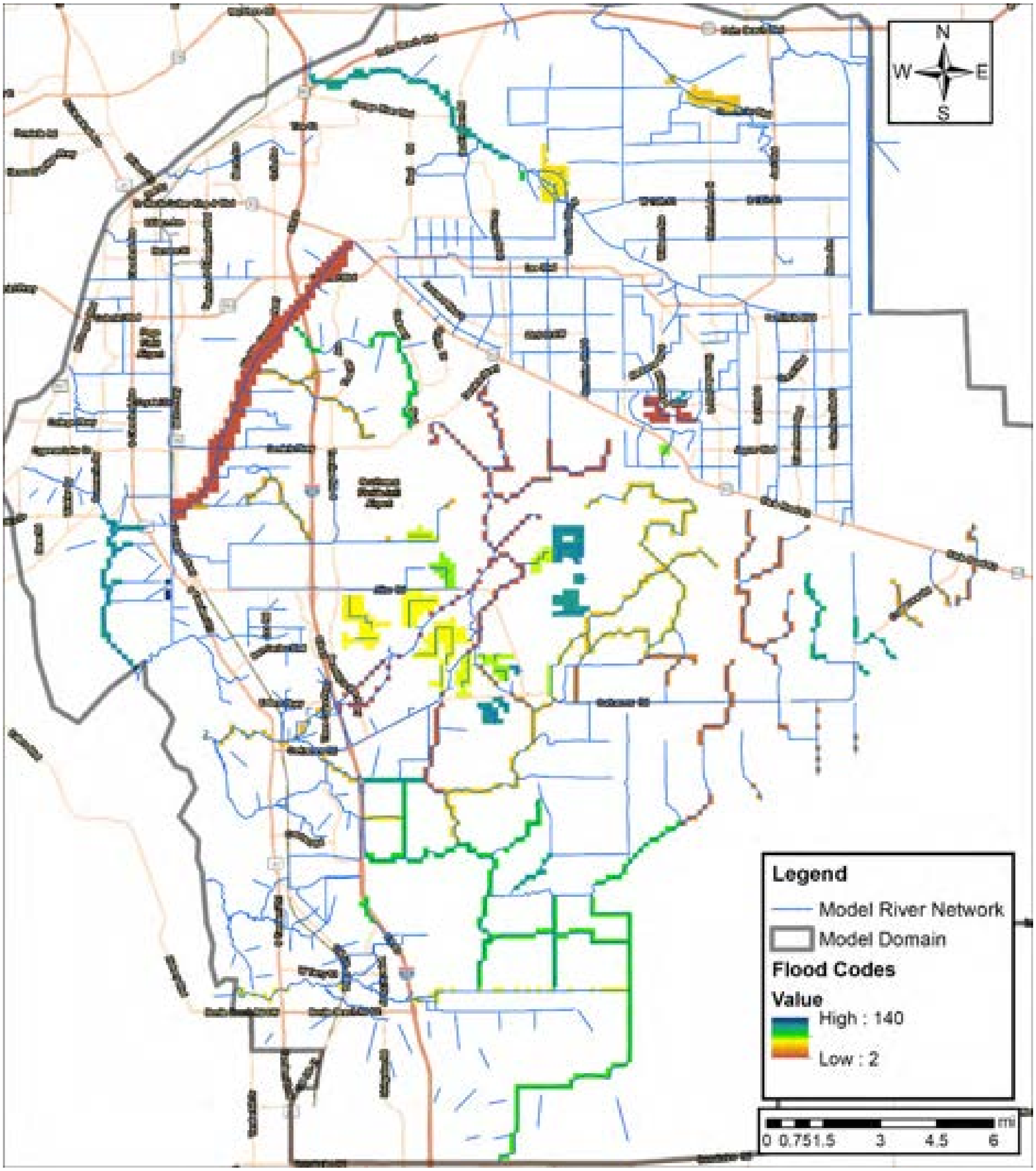


Figure 10. Flood Codes

3.4.7 Cross-section Updates

Updates to the network cross-sections have been made based on 1) existing survey found from permit data or other sources, 2) new survey data, 3) LiDAR data using the Lee Couty or Collier County 5ft data, 4) and rating curves from gaging stations.

Rating curves were downloaded for USGS flow measurement stations for Estero North Branch, Estero South Branch, and Imperial River. These rating curves were then used to adjust the cross-section bottom depths, widths (if the cross-section was established from LiDAR), and roughness coefficients. An example of the flow rating curve is shown in Figure 11 for the Imperial River gaging station. Not all stations lined up with USGS rating curves, typically due to lack of survey data at these locations.

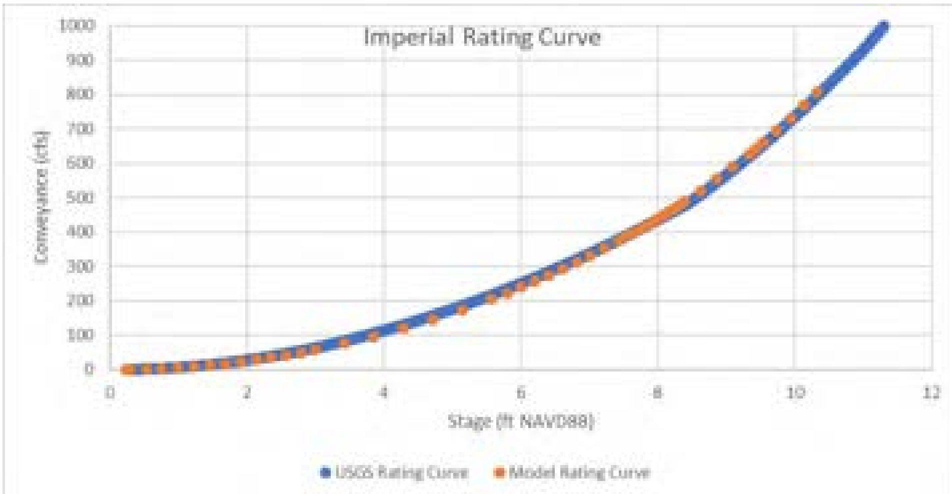


Figure 11. Flow Rating curves for Imperial River

3.5 Land Use

2014-2016 Land use data was obtained from the District in the form of a GIS shapefile. The data was clipped to the model extent and grouped using the Florida Land Use Classification Codes (FLUCCS) descriptions of each land use type (at the highest level). The land use groups were also assigned an integer value for the corresponding MIKE SHE code that is to be used within the model. Table 3 lists all of the FLUCCS codes that were used for each model land use type. There were three (3) codes that did not appear within the model domain and thus were not included in the model (shown in grey).

Table 3. Florida Land Use Classification Codes for each model Land Use type.

MSHE Code	Model Land Use Type	Florida Land Use Classification Code
1	Citrus	2200, 2220, 2230, 2210
2	Pasture	1423, 2100, 2110, 2120, 2130, 2320, 2510, 2520, 8115, 8320
3	Sugar Cane	2156
4	Sod	2420
5	Truck Crops	2140, 2150, 2160, 2430
6	Golf Course	1820
7	Bare Ground	1600, 1610, 1620, 1630, 1670, 2300, 2610, 7400, 7420, 7440, 8350, 7450, 7470
8	Mesic Flatwood	1900, 1910, 1940, 2240, 2600, 3100, 3210, 3300, 4100, 4110, 4140, 4290, 4350, 4400, 4410, 4430, 7100, 7200, 7410
9	Mesic Hammock	4200, 4220, 4230, 4260, 4270, 4271, 4340, 4370, 4380, 4390
10	Xeric Flatwood	4120, 4130
11	Xeric Hammock	1650, 3200, 3220, 4210, 4300, 4320
12	Hydric Flatwood	4119, 4190, 6240, 6250
13	Hydric Hammock	3290, 4240, 4250, 4280, 4330, 6100, 6110, 6191, 7430
14	Wet Prairie	2540, 6430, 6439
15	Dwarf Cypress	6219
16	Marsh	6171, 6172, 6180, 6400, 6410, 6411, 6412, 6440
17	Cypress	6200, 6210, 6212, 6215, 6216, 6218
18	Swamp Forest	6130, 6140, 6150, 6160, 6170, 6300
19	Mangrove	6120, 6420
20	Water	1660, 5000, 5100, 5110, 5120, 5200, 5230, 5240, 5330, 5340, 5300, 5320, 5410, 5420, 5430, 5600, 6510, 6530, 8160
41	Urban Low Density	1100, 1110, 1130, 1120, 1180, 1190, 1230, 1350, 1480, 1850, 1890, 1920, 1930, 2400, 2410, 2430, 2450, 2460, 2500, 8310
42	Urban Medium Density	1009, 1200, 1210, 1220, 1290, 1330, 1350, 1440, 1710, 1860, 8110, 8330, 8340
43	Urban High Density	1300, 1310, 1320, 1340, 1390, 1400, 1410, 1411, 1423, 1430, 1460, 1470, 1490, 1500, 1510, 1520, 1530, 1540, 1550, 1560, 1590, 1700, 1870, 2310, 8100, 8120, 8140, 8200, 8300

A Willow extent map for Corkscrew and CREW was provided by the Audubon Society. The area shown within the map was sprayed to kill the willow; however, the plant communities that grew in have similar ET rates to the original willow (e.g. cattail, primrose willow, and buttonbush). Consequently, this extent was defined in the model as a separate land use type (# 21). All land use types used in the model are shown in Figure 11.

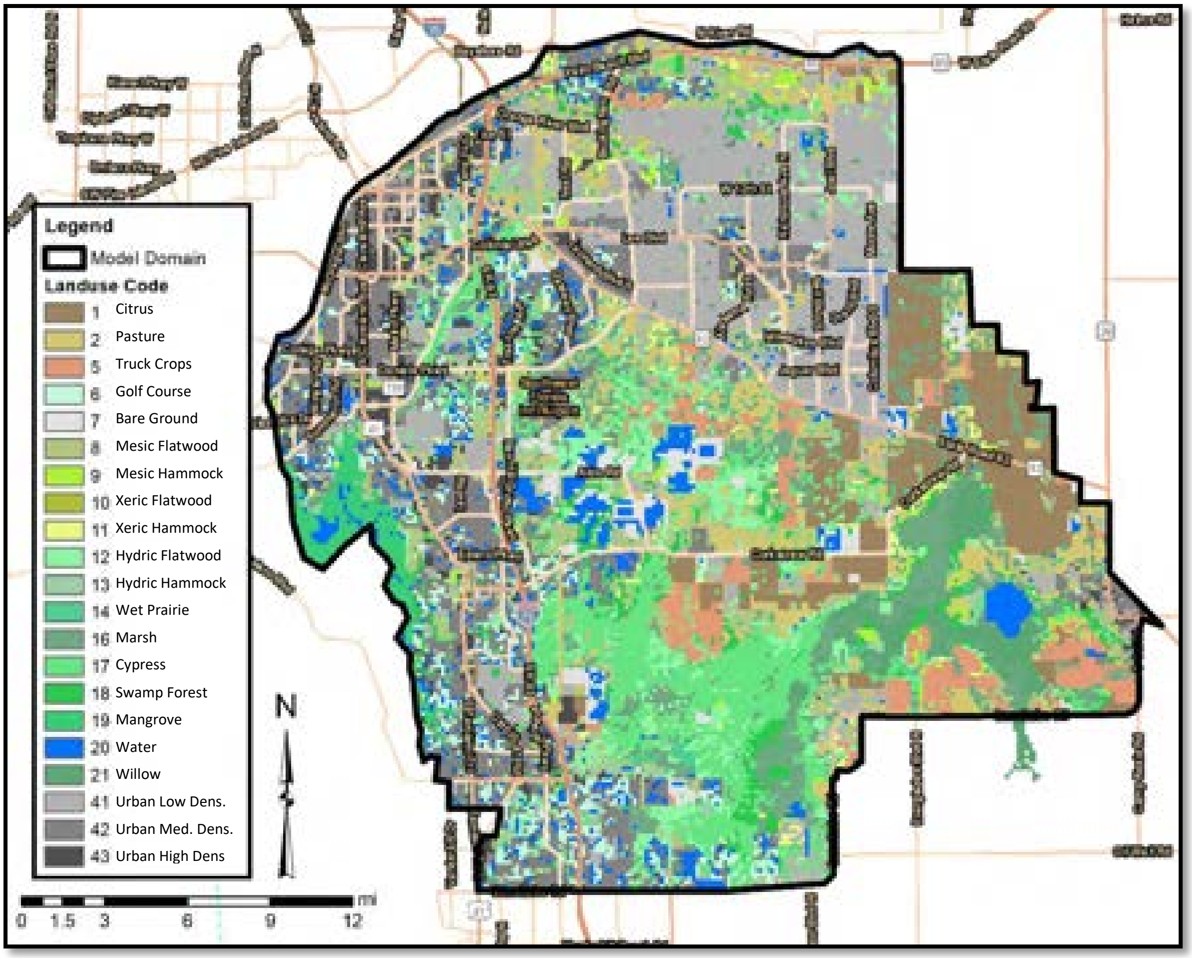


Figure 12. Land use map

Each vegetation type has time-varying parameters, which are used to internally calculate actual ET: Leaf Area Index (LAI), Root Depth (RD), and Crop Coefficient (K_c). These values were extracted from previously developed regional MIKE SHE models in west central Florida (i.e. LA-MSID, City of Cape Coral, etc.). Table 4, Table 5, and Table 6 provide the LAI, RD, and K_c values, respectively, for all land use types used within the model domain.

Table 4. Leaf Area Index values (inches) for all land use types in the model

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	2	2	2	2	2	2	2	2	2	2	2	2
Pasture	0.1	0.4	0.6	0.4	1.4	1.5	1.4	1.2	0.8	0.4	0.15	0.05
Truck Crops	4.5	4.5	4.5	4.5	1.5	1.5	1.5	1.5	4.5	4.5	4.5	4.5
Golf Course	2	2	3	3	3	3	3	3	3	3	2	2
Bare Ground	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mesic Flatwood	1.5	1.5	1.5	1.5	1.5	2	3	3	2.5	2	1.5	1.5
Mesic Hammock	2.5	3	3	3	3.5	4	4	4	3.5	3.5	3	2.5
Xeric Flatwood	1	1	1	1	1.5	2	2	2	2	1.5	1.5	1
Xeric Hammock	2	2	2	2	2.5	3	3	3	2.5	2.5	2	2
Hydric Flatwood	1.5	1.5	2	2	2.5	3	3	3	2.5	2	1.5	1.5
Hydric Hammock	2.5	3	3	3	3.5	4	4	4	3.5	3.5	3	2.5
Wet Prairie	1.5	1.5	2	2	2.5	3	3	3	2.5	2	1.5	1.5
Dry Prairie	0.4	0.1	0.1	0.1	0.4	0.4	0.6	1.4	1.5	1.4	1.2	0.8
Marsh	2	2	3	3	3	3.5	4	4	3.5	3	2.5	2
Cypress	2	2	3	3	3.5	4	4	4	3.5	3	2.5	2
Swamp Forest	3	3	4	4	4.5	5	5	5	4.5	4	3.5	3
Willow	3	3	4	4	4.5	5	5	5	4.5	4	3.5	3
Mangrove	3	3	3	3	3.5	4	4	4	3.5	3.5	3	3
Water	2	2	2	2	2	2	2	2	2	2	2	2
Residential Underdeveloped	0.1	0.4	0.6	0.4	1.4	1.5	1.4	1.2	0.8	0.4	0.15	0.05
Urban Low Density	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Urban Medium Density	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Urban High Density	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25

Table 5. Root Depth values (inches) for all land use types within the model.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	30	2	2	2	2	2	2	2	2	2	2	2
Pasture	0.3	1.9	3	1.9	7.4	8	7.4	6.3	4.1	1.9	0.6	0
Truck Crops	29.5	29.5	29.5	29.5	5.91	5.91	5.91	5.91	29.5	29.5	29.5	29.5
Golf Course	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Bare Ground	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94
Mesic Flatwood	48	48	48	48	48	48	48	48	48	48	48	48
Mesic Hammock	48	48	48	48	48	48	48	48	48	48	48	48
Xeric Flatwood	48	48	48	48	48	48	48	48	48	48	48	48
Xeric Hammock	48	48	48	48	48	48	48	48	48	48	48	48
Hydric Flatwood	48	48	48	48	48	48	48	48	48	48	48	48
Hydric Hammock	48	48	48	48	48	48	48	48	48	48	48	48
Wet Prairie	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Dry Prairie	20	18	18	18	20	22	23	24	24	23	22	21
Marsh	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Cypress	60	60	60	60	60	60	60	60	60	60	60	60
Swamp Forest	60	60	60	60	60	60	60	60	60	60	60	60
Willow	60	60	60	60	60	60	60	60	60	60	60	60
Mangrove	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8
Water	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Residential Underdeveloped	18	39.5	47.9	46	60	60	53.5	53.5	48.8	52.5	24.5	18
Urban Low Density	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6
Urban Medium Density	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6
Urban High Density	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6

Table 6. Crop Coefficient values (K_c) for all land use types within the model.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	0.86	0.93	0.97	1.05	1.03	1.03	1.05	0.95	1	0.79	0.87	0.79
Pasture	1	1	1	1	1	1	1	1	1	1	1	1
Truck Crops	0.4	0.8	1.25	1.25	1.25	1.25	1.25	1.25	1.25	0.75	0.58	0.4
Golf Course	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Bare Ground	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Mesic Flatwood	1	1	1	1	1	1	1	1	1	1	1	1
Mesic Hammock	1	1	1	1	1	1	1	1	1	1	1	1
Xeric Flatwood	1	1	1	1	1	1	1	1	1	1	1	1
Xeric Hammock	1	1	1	1	1	1	1	1	1	1	1	1
Hydric Flatwood	1	1	1	1	1	1	1	1	1	1	1	1
Hydric Hammock	0.8	1	1.1	1.2	1.2	1.2	8	1.2	1.1	1.1	1	0.8
Wet Prairie	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Dry Prairie	1	1	1	1	1	1	1	1	1	1	1	1
Marsh	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Cypress	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Swamp Forest	1	1	1	1	1	1	1	1	1	1	1	1
Willow	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Mangrove	1	1	1	1	1	1	1	1	1	1	1	1
Water	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Residential Underdeveloped	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Urban Low Density	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Urban Medium Density	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Urban High Density	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

The Irrigation module in MIKE SHE was not used in the development of this model. Data suggests that individual users of irrigation water use less water in the wet season It was assumed that the amount of water contributing to wet season flooding, which is the focus of this study, would not significantly contribute to flows and was therefore omitted from the model. This may be a limitation of the model in the future if it is utilized for other purposes, such as water quality or dry season investigations.

3.6 Overland Flow

3.6.1 Manning's Roughness

The Manning's Roughness values were determined for each land use type based on channel roughness values from the reference shown in Figure 12 (Chow, 1959). For example, areas classified as pasture were given a roughness value equivalent to pasture with high grass. Likewise, golf courses were given a roughness value equal to that of a pasture with low grass. All areas classified as urban were also given a low grass roughness value.

The referenced values are specifically for natural streams with widths less than 100 ft; in turn, the roughness does not translate exactly to flow over the land surface with a cell size of 750 ft. At this scale, the model can have instabilities if the roughness values (or Manning's n values) are too low (or smooth). To mitigate these instabilities, the roughness values were scaled up by a factor of 5. All roughness values that were utilized for overland flow are provided in Table 7 with their respective spatial distribution being shown in Figure 13.

Manning's n for Channels (Chow, 1959)

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1. short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160

Figure 13. Reference for Manning's values

Table 7. Manning's n values used in the model

Land use Type	Channel type	Manning's n	Adjusted Manning's n
Agriculture (Citrus and Truck Crops)	--	NA	NA
Pasture	Pasture: high grass (max)	0.035	0.175
Golf Course	Pasture: short grass (min)	0.025	0.125
Bare Ground	Cultivated areas: no crop	0.020	0.100
Mesic and Xeric Forests	Trees: heavy stand of timber (max)	0.120	0.600
Hydric and Wetland Forests	Trees: heavy stand of timber (min)	0.080	0.400
Willow	Trees: dense willows	0.150	0.750
Water	--	NA	NA
Urban areas	Pasture: short grass	0.03	0.150

For areas classified as agriculture, the Manning's M roughness was set to zero to turn off overland flow for these areas. For agricultural areas, water will instead drain using the subsurface drainage feature to represent crop drainage via ditches with controlled elevations. Manning's M was also set to zero for all water bodies. Manning's M is the reciprocal of Manning's n, which is shown in Figure 14.

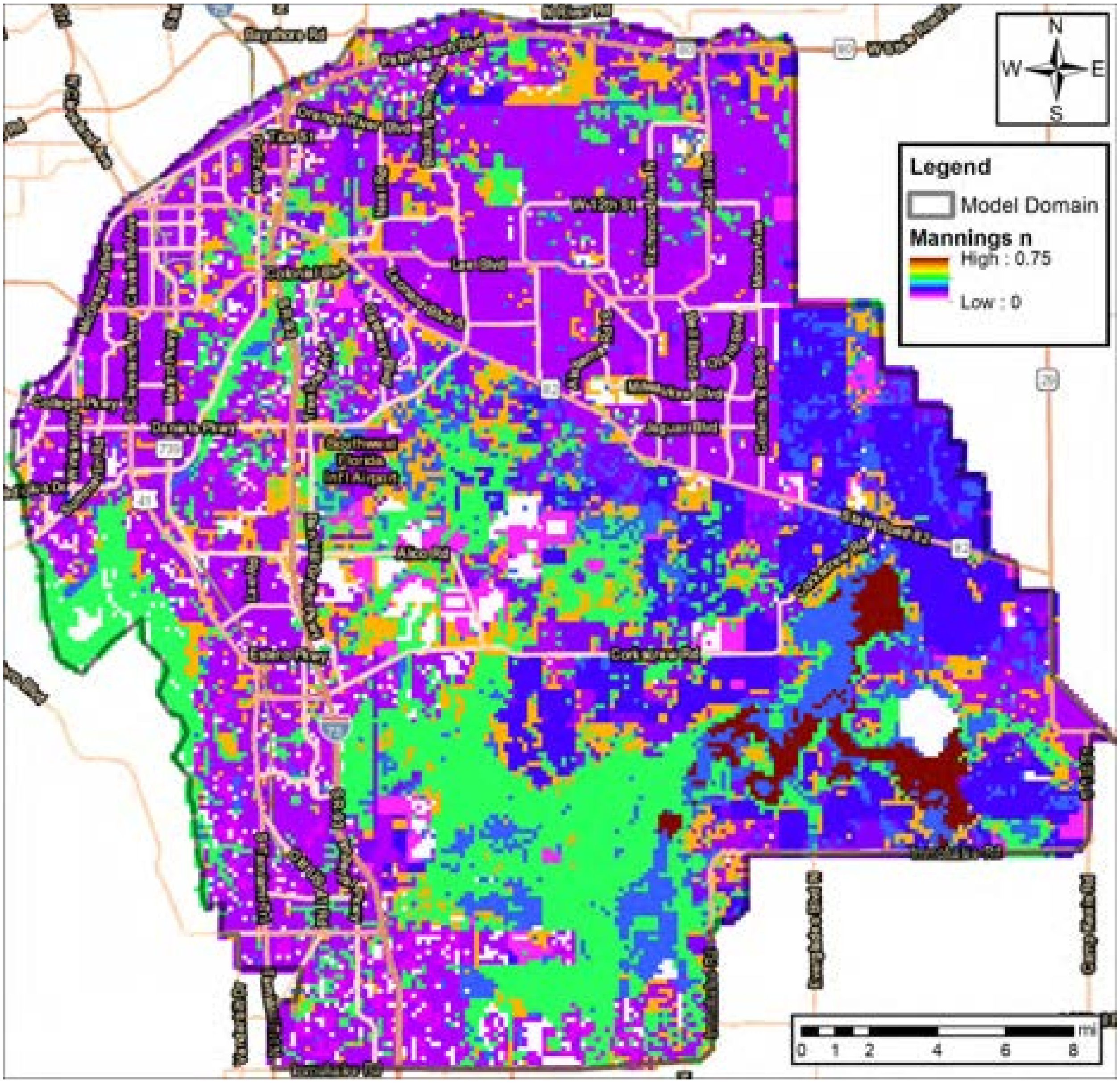


Figure 14. Manning's n Roughness Values

3.6.2 Paved Area Coefficient

Paved Area coefficient values were developed based on the impervious areas encountered within each model grid cell. A shapefile of roads and streets were obtained from the Lee County Land Use data. Building footprints were obtained from a Lee County shapefile as well. The total area of roads and buildings were summed for each cell and divided by the total cell area to determine the percent of impervious areas (ranging from 0 to 100%). All values were then divided by two, to provide a more realistic representation of the impervious nature of the area. The percent impervious map, shown in Figure 14, provides a spatial overview of the percentages used to define the runoff coefficient.

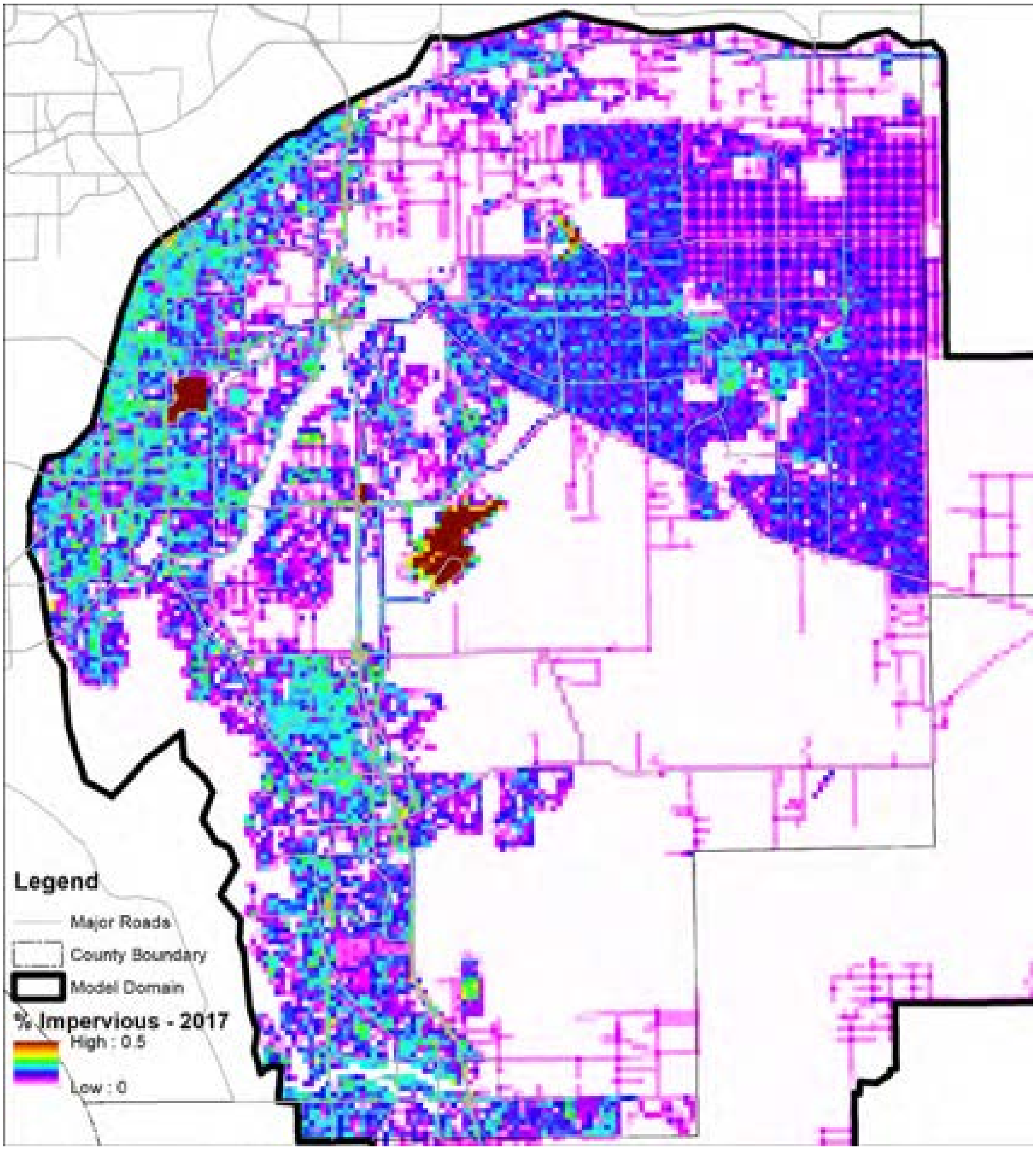


Figure 15. Map of Percent Impervious Used to Define the OL Runoff Coefficient

3.6.3 Separated Overland Flow Areas

By specifying separated overland flow areas within the model, blockages to overland flow such as roads, embankments, levees, etc., can be input. This is beneficial for models with low resolution topography that may not be able to pick up levees and roads thinner than the width of the model cell. Figure 15 shows the individual grid codes for the separated overland flow areas used in the model. The actual number of the code is not important information, only that there is a unique value for each separated area. In addition to major roads, communities used in the Subsurface Drainage feature are also separated into individual grid codes.

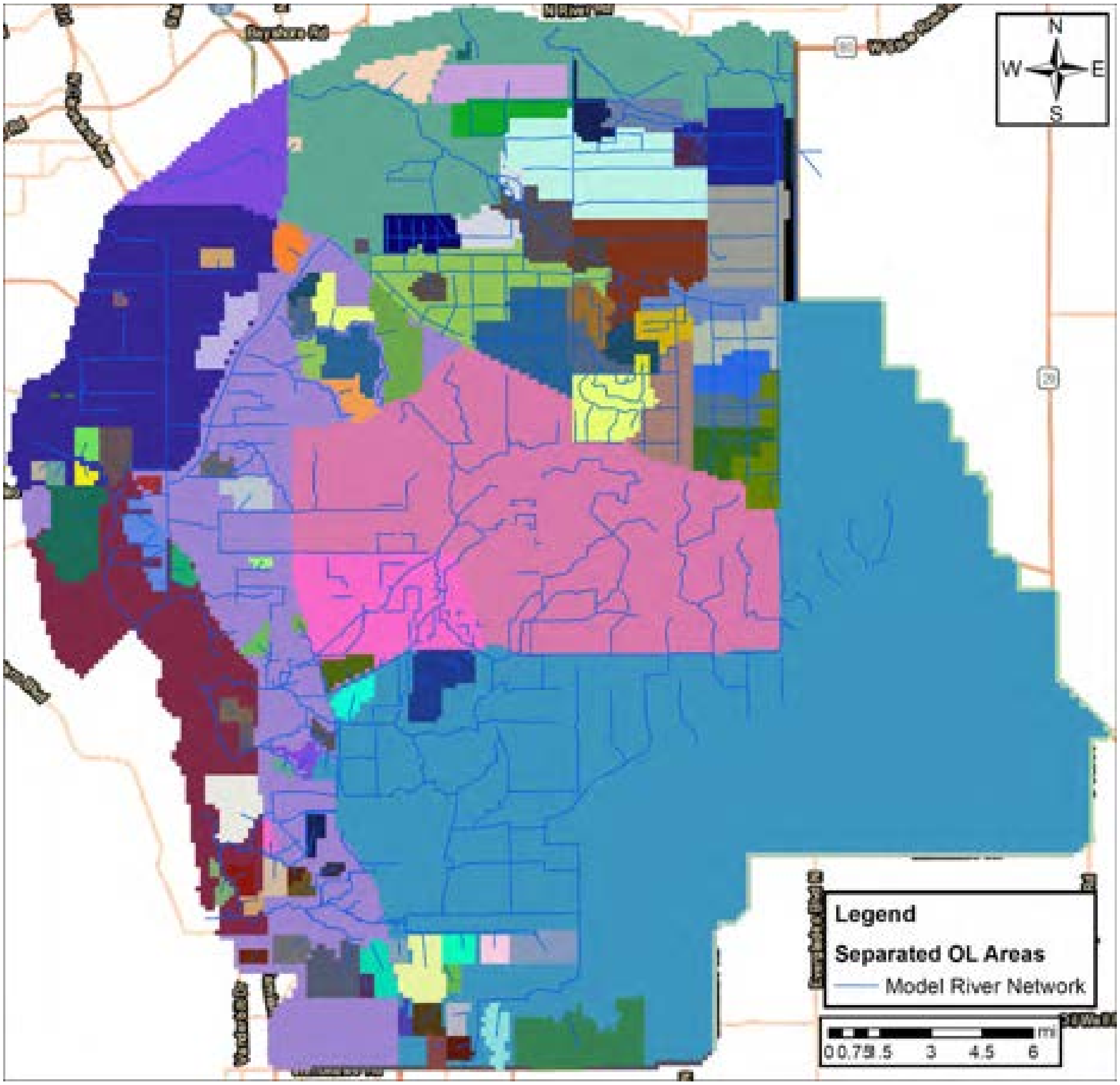


Figure 16. Separated Overland Areas

3.7 Unsaturated Zone

The 2-Layer Water Balance method was used to calculate the actual evapotranspiration and the amount of water that recharges the saturated zone. This module simplifies the soil column into two (2) zones: the root zone and the zone between the roots and the water table. This method is considered appropriate for areas where the water table is shallow and groundwater recharge is influenced by evapotranspiration.

3.7.1 Soil Types

Soil information was sourced for the study area from the NRCS soil database. Soils were reviewed and classified by their MUKey designation, or "parent" soil type. As is shown in Table 8, twenty (20) different soil types are encountered within the study area (See Figure 16).

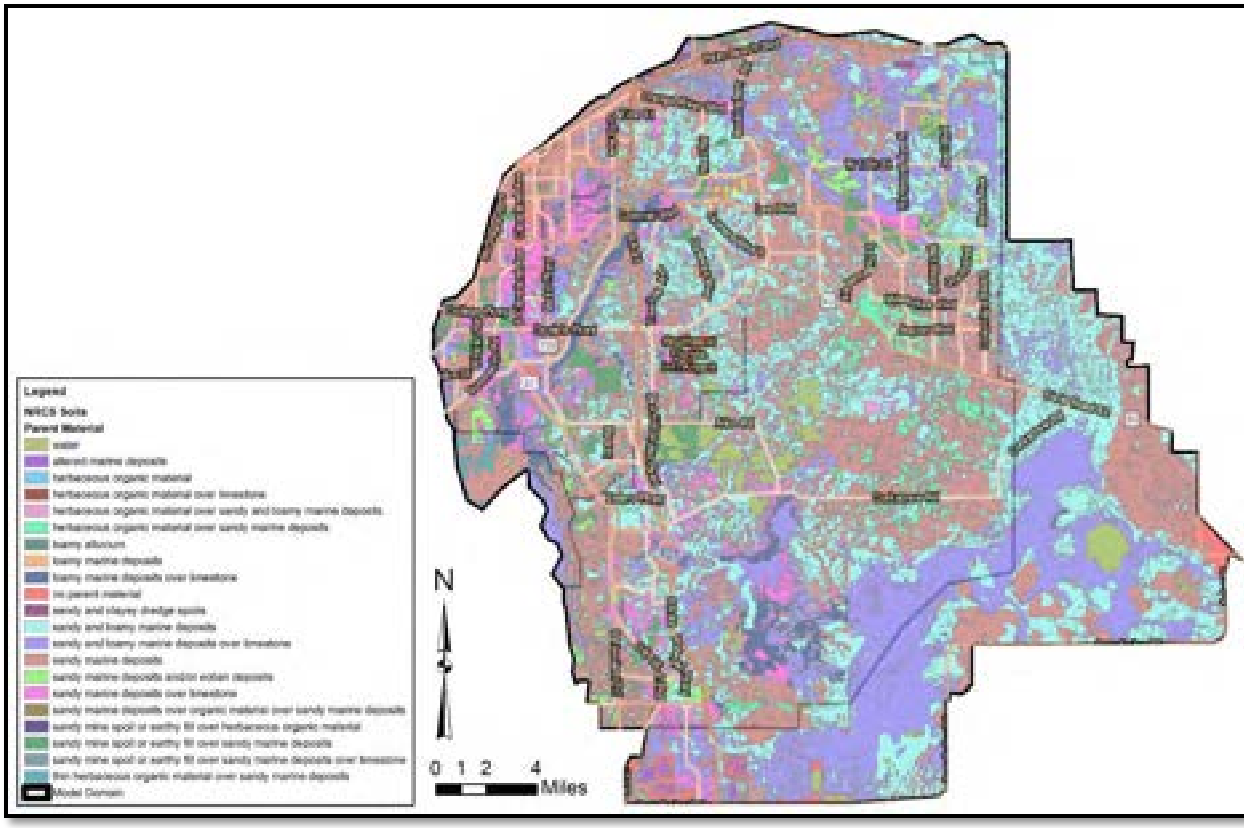


Figure 17. Soil Distribution

Soils were aggregated from the master list of soil types based on their Parent Material. The soils shapefile was then resampled to a 750 ft grid resolution using nearest neighbor interpolation.

Table 8 provides a list of the soil types and their total acreage throughout the domain. For example, the parent material called "sandy marine deposits", one of the most prevalent soil types within the model domain, is an aggregate of soil types such as Basinger sand and fine sand, Pomello fine sand, Immokalee sand and fine sand, Satellite fine sand, Myakka sand and fine sand, etc.

Table 8. Soil Distribution within Model Domain

Soil Parent Material	Area (acres)
altered marine deposits	821
herbaceous organic material	73
herbaceous organic material over limestone	17
herbaceous organic material over sandy and loamy marine deposits	1,121
herbaceous organic material over sandy marine deposits	11,102
loamy alluvium	5
loamy marine deposits	3
loamy marine deposits over limestone	10,457
no parent material	5,504
sandy and clayey dredge spoils	640
sandy and loamy marine deposits	121,958
sandy and loamy marine deposits over limestone	89,016
sandy marine deposits	131,551
sandy marine deposits and/or eolian deposits	6,524
sandy marine deposits over limestone	25,724
sandy marine deposits over organic material over sandy marine deposits	11
sandy mine spoil or earthy fill over herbaceous organic material	191
sandy mine spoil or earthy fill over sandy marine deposits	9,051
sandy mine spoil or earthy fill over sandy marine deposits over limestone	109
thin herbaceous organic material over sandy marine deposits	1,354

3.7.2 Soil Parameters

Various soil properties specific to the study area were processed utilizing the Soil Data Viewer add-on for ArcGIS. These parameters included:

- Percent Clay (%)
- Percent Sand (%)
- Organic Matter Content (%)
- Bulk Density, One-Third Bar (g/cm^3)
- Saturated Hydraulic Conductivity (µm/s)
- Water Content, One-Third Bar (%)
- Moisture Content, 15 Bar (%)
- Depth to Water Table (cm)

The Green-Ampt spreadsheet sourced from the ICPRv4 reference documents was used to calculate the 2-layer UZ soil properties required for the unsaturated flow of the MIKE SHE model component. The following soil parameters were averaged for each parent soil type and used as initial parameter inputs. Table 9 provides the initial values utilized for each parameter and parent soil type:

- Water content at saturation (θ_s)
- Water content at field capacity (θ_{fc})
- Water content at wilting point (θ_{wp})
- Saturated hydraulic conductivity (K_{sat})

Table 9. Initial Parameters for each Soil Type.

MIKE CODE	Parent Soil Type	Average θ_s	Average θ_{fc}	Average θ_{wp}	Average K_{sat} (ft/day)
1	alluvium	0.50	0.009	0.004	15.22
2	altered marine deposits	0.47	0.066	0.030	25.89
3	herbaceous organic material	0.77	0.428	0.099	24.52
4	herbaceous organic material over limestone	0.67	0.434	0.121	19.85
5	herbaceous organic material over sandy and loamy marine deposits	0.67	0.259	0.099	12.45
6	herbaceous organic material over sandy marine deposits	0.70	0.403	0.171	25.28
7	loamy alluvium	0.50	0.225	0.118	4.20
8	loamy marine deposits	0.50	0.209	0.124	6.16
9	loamy marine deposits over limestone	0.65	0.150	0.065	17.01
10	no parent material	0.48	0.069	0.026	28.47
11	sandy and clayey dredge spoils	0.84	0.230	0.167	10.84
12	sandy and loamy marine deposits	0.56	0.139	0.067	16.22
13	sandy and loamy marine deposits over limestone	0.55	0.129	0.061	18.61
14	sandy marine deposits	0.60	0.081	0.026	29.96
15	sandy marine deposits and/or eolian deposits	0.69	0.071	0.018	59.67
16	sandy marine deposits over limestone	0.60	0.092	0.030	20.56
17	sandy marine deposits over organic material over sandy marine deposits	0.52	0.154	0.066	25.45
18	sandy mine spoil or earthy fill over herbaceous organic material	0.69	0.219	0.066	25.10
19	sandy mine spoil or earthy fill over sandy marine deposits	0.74	0.095	0.032	21.67
20	sandy mine spoil or earthy fill over sandy marine deposits over limestone	0.74	0.097	0.034	16.84
21	thin herbaceous organic material over sandy marine deposits	0.73	0.112	0.032	21.92

The specific Green-Ampt parameter, known as soil suction at the wetting front, was estimated based on the porosity, percent clay, and percent sand, which were averaged for each parent soil type. Table 10 provides the average soil parameters that were used to calculate the wetting front suction head for each parent soil type (Rawls, et al., 1992).

Table 10. Suction Head at Wetting Front Calculated from Soil Parameters

MIKE CODE	Parent Soil Type	Porosity	% Clay	% Sand	Wetting Front Suction (ft)
1	alluvium	0.538	7.8	89.8	**0.084**
2	altered marine deposits	0.506	8.5	89.6	**0.083**
3	herbaceous organic material	0.833	8.4	85.2	**0.285**
4	herbaceous organic material over limestone	0.719	8.1	86.0	**0.138**
5	herbaceous organic material over sandy and loamy marine deposits	0.719	10.5	80.6	**0.125**
6	herbaceous organic material over sandy marine deposits	0.758	2.6	95.4	**0.289**
7	loamy alluvium	0.543	19.4	70.7	**0.105**
8	loamy marine deposits	0.535	18.6	70.1	**0.115**
9	loamy marine deposits over limestone	0.702	7.3	78.1	**0.148**
10	no parent material	0.518	3.0	95.8	**0.103**
11	sandy and clayey dredge spoils	0.906	29.4	45.3	**0.162**
12	sandy and loamy marine deposits	0.606	8.3	84.9	**0.099**
13	sandy and loamy marine deposits over limestone	0.595	7.4	87.1	**0.097**
14	sandy marine deposits	0.649	2.4	96.8	**0.144**
15	sandy marine deposits and/or eolian deposits	0.741	2.7	97.5	**0.257**
16	sandy marine deposits over limestone	0.648	2.2	94.5	**0.148**
17	sandy marine deposits over organic material over sandy marine deposits	0.554	5.4	92.6	**0.093**
18	sandy mine spoil or earthy fill over herbaceous organic material	0.743	2.2	96.7	**0.269**
19	sandy mine spoil or earthy fill over sandy marine deposits	0.793	3.1	95.2	**0.379**
20	sandy mine spoil or earthy fill over sandy marine deposits over limestone	0.799	3.6	94.0	**0.372**
21	thin herbaceous organic material over sandy marine deposits	0.790	1.6	97.3	**0.445**

3.7.3 Testing of Soil Parameters

To test model performance with varying soil parameter values, the water content at saturation was reduced by 10%, 20% and 50%. Results showed that groundwater calibration improved with the larger reduction. Consequently, values for water content at saturation and water content at field capacity were reduced by 50% for all parent soil types, with the exception of soil type no. 6 (herbaceous organic material over sandy marine deposits) which are shown as highlighted in the table below. Model instabilities were encountered when reducing the respective soil parameters by 50%. Accordingly, values for this soil type were only reduced by 25%. Overall, the revised values increased infiltration to the saturated zone and increased groundwater levels. Table 11 shows the final soil parameters used in the model.

Table 11. Reduced Soil Parameters for Water Content at Saturation and at Field Capacity

MIKE CODE	Parent Soil Type	Average WC @ Sat	Average WC @ Field	Reduced WC @ Sat	Reduced WC @ Field
1	alluvium	0.50	0.009	0.25	0.0045
2	altered marine deposits	0.47	0.066	0.24	0.0328
3	herbaceous organic material	0.77	0.428	0.39	0.2142
4	herbaceous organic material over limestone	0.67	0.434	0.33	0.2170
5	herbaceous organic material over sandy and loamy marine deposits	0.67	0.259	0.33	0.1297
6	herbaceous organic material over sandy marine deposits	0.70	0.403	0.53	0.3021
7	loamy alluvium	0.50	0.225	0.25	0.1125
8	loamy marine deposits	0.50	0.209	0.25	0.1043
9	loamy marine deposits over limestone	0.65	0.150	0.33	0.0749
10	no parent material	0.48	0.069	0.24	0.0344
11	sandy and clayey dredge spoils	0.84	0.230	0.42	0.1150
12	sandy and loamy marine deposits	0.56	0.139	0.28	0.0695
13	sandy and loamy marine deposits over limestone	0.55	0.129	0.28	0.0646
14	sandy marine deposits	0.60	0.081	0.30	0.0407
15	sandy marine deposits and/or eolian deposits	0.69	0.071	0.34	0.0356
16	sandy marine deposits over limestone	0.60	0.092	0.30	0.0458
17	sandy marine deposits over organic material over sandy marine deposits	0.52	0.154	0.26	0.0770
18	sandy mine spoil or earthy fill over herbaceous organic material	0.69	0.219	0.35	0.1095
19	sandy mine spoil or earthy fill over sandy marine deposits	0.74	0.095	0.37	0.0473
20	sandy mine spoil or earthy fill over sandy marine deposits over limestone	0.74	0.097	0.37	0.0485
21	thin herbaceous organic material over sandy marine deposits	0.73	0.112	0.37	0.0560

3.8 Saturated Zone

The Lee County area is underlain by three (3) aquifer systems, as defined by the Hydrologic Unit Mapping Update for the Lower West Coast Water Supply Planning Area (Geddes, et al. 2015). These aquifers, shown in Figure 17, are the Surficial, Intermediate, and Floridan. Within these layer systems are productive (transmissive) zones overlain with less transmissive confining units.

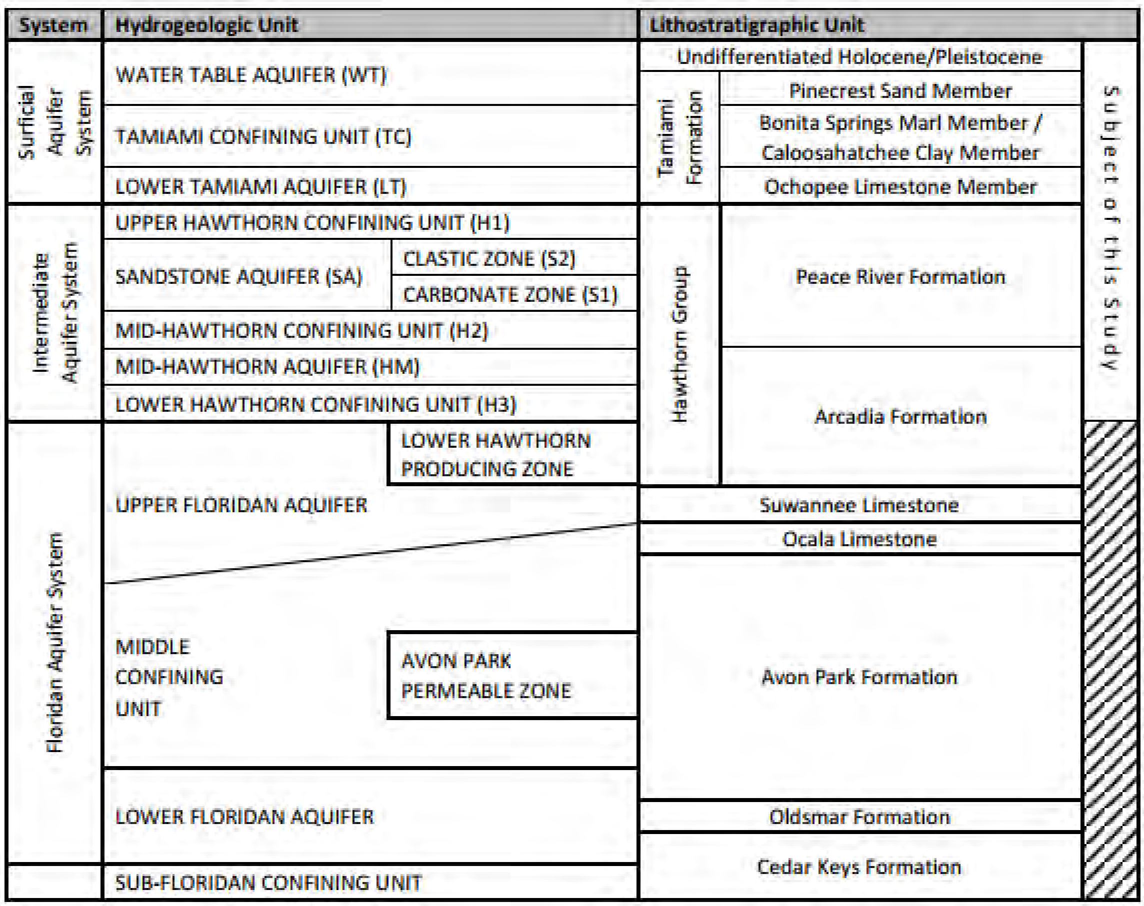


Figure 18. Generalized Hydrogeology from the LWC Water Supply Planning Area.

For the purposes of the Lee County study, the model was set up to represent the saturated zone from the land surface down to the top of the Mid-Hawthorn Confining Unit, which is present throughout Lee County and acts as a zero-flux boundary for modeling purposes. The layering was simplified to represent the three (3) productive zones that are present in Lee County, the Water Table Aquifer (WT), the Lower Tamiami Aquifer (LT), and the Sandstone Aquifer (SA). In addition, two (2) confining units were used in the model: 1) the Tamiami Confining Unit (T_CU), which separates the Water Table and the Lower Tamiami, and 2) the Upper Hawthorn Confining Unit (H_CU), which separates the Lower Tamiami and the Sandstone (See Figure 18).

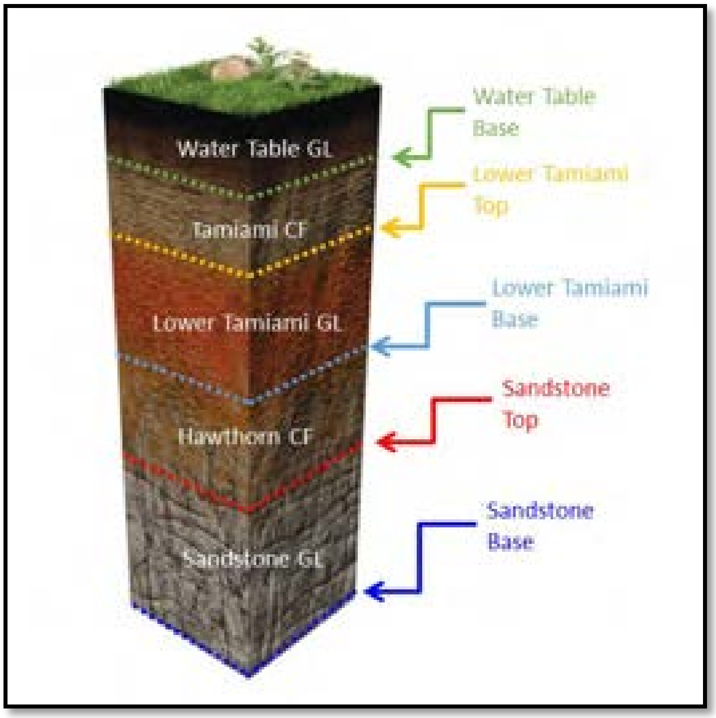


Figure 19. Geological Layers & Confining Units

3.8.1 Layer Thickness

Elevations for each layer were provided by the Lower West Coast Water Supply Planning Area model data from 2015. The recent update to the LWC model for 2018 was not available for public use at the time of this model development and was therefore not included in the development of the model layers. Figure 19 through Figure 28 provide the bottom elevation and thickness of each layer.

Figure 20 shows a thinning of the Water Table layer near the Caloosahatchee, where the land surface slopes down to the river, and in western Lehigh Acres and down to the Estero River watershed, where the base of the Water Table is closer to the land surface.

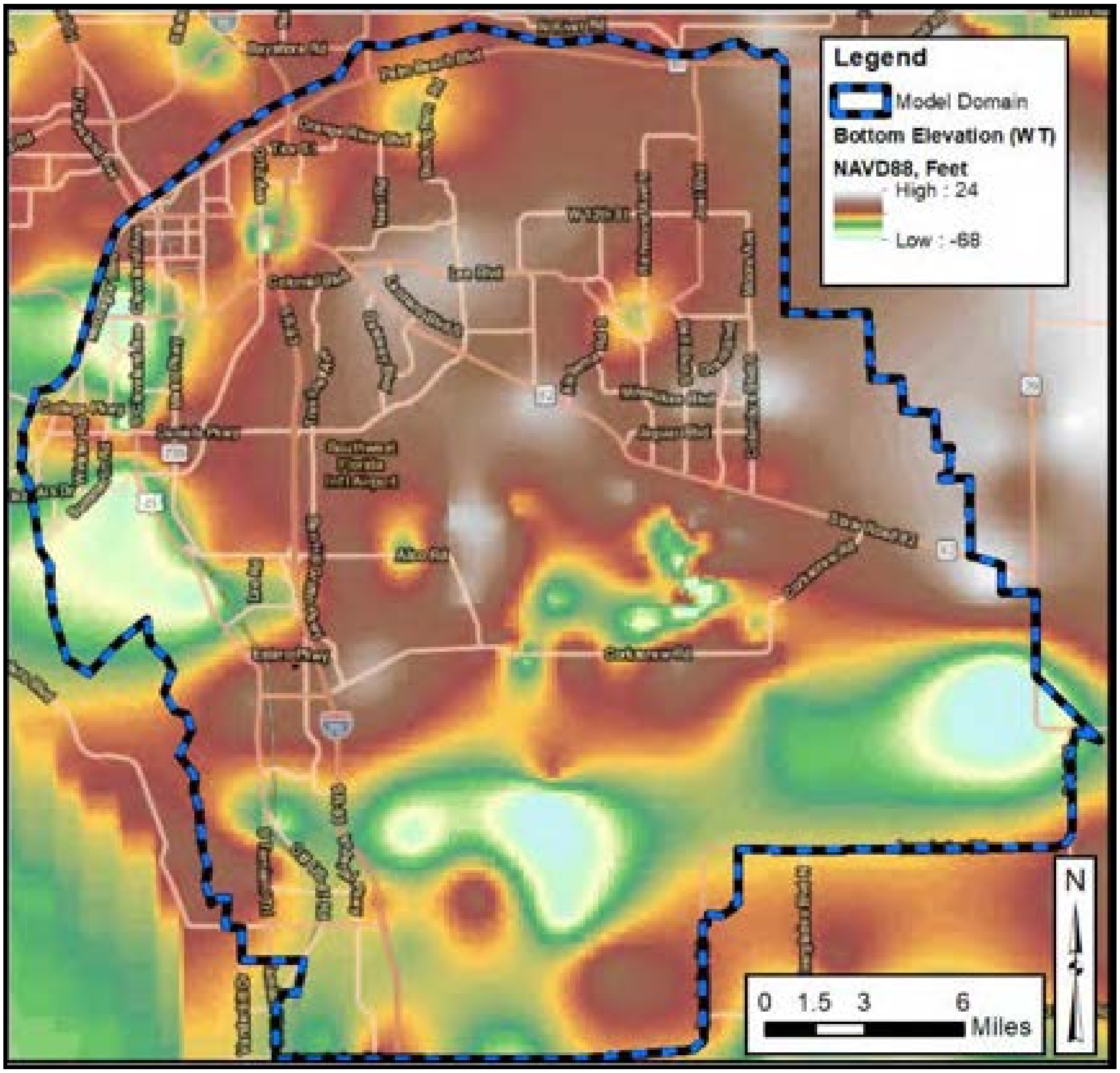


Figure 20. Water Table (WT) Geological Layer Bottom Elevation

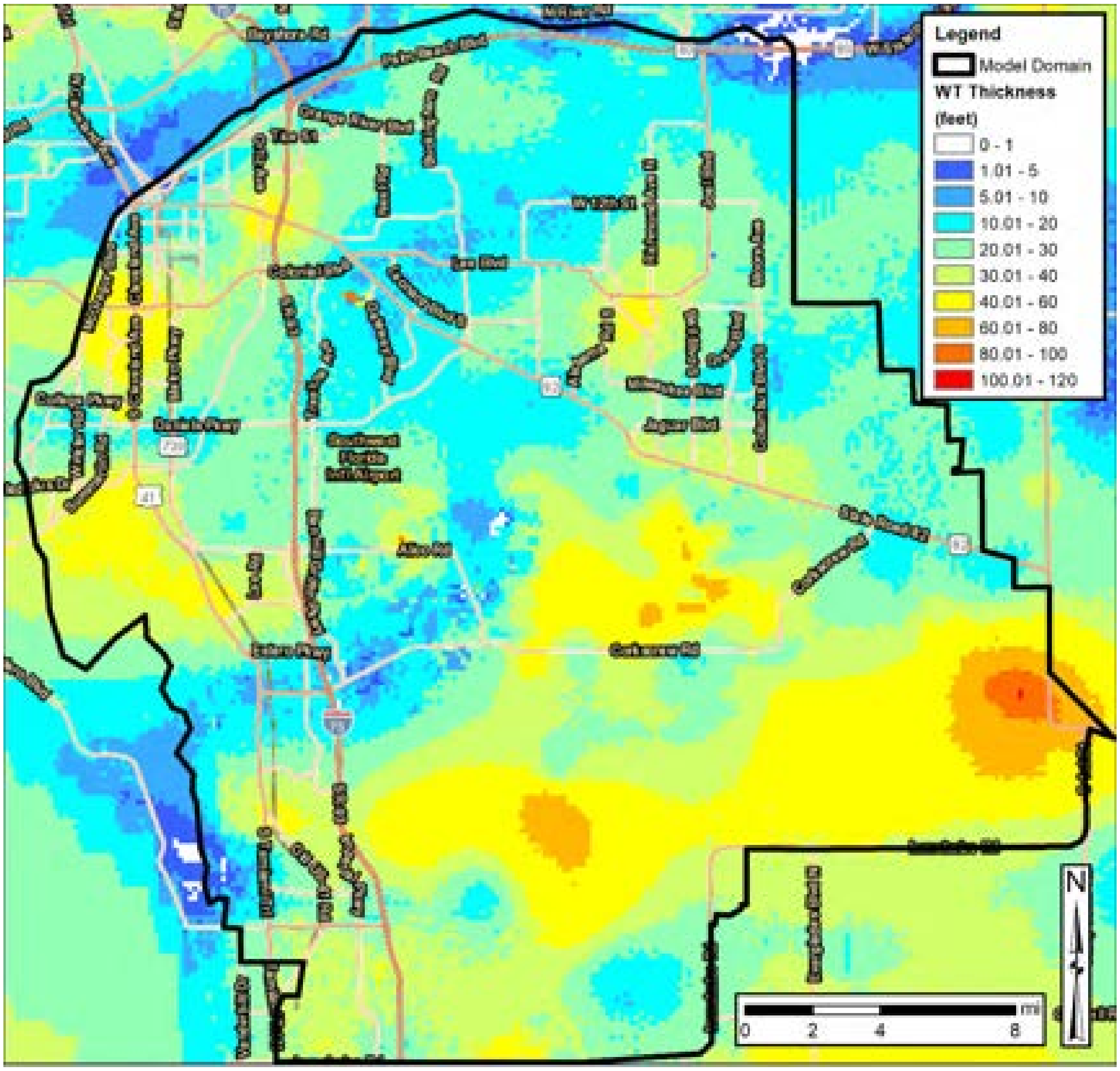


Figure 21. Thickness of the Water Table (WT) Aquifer

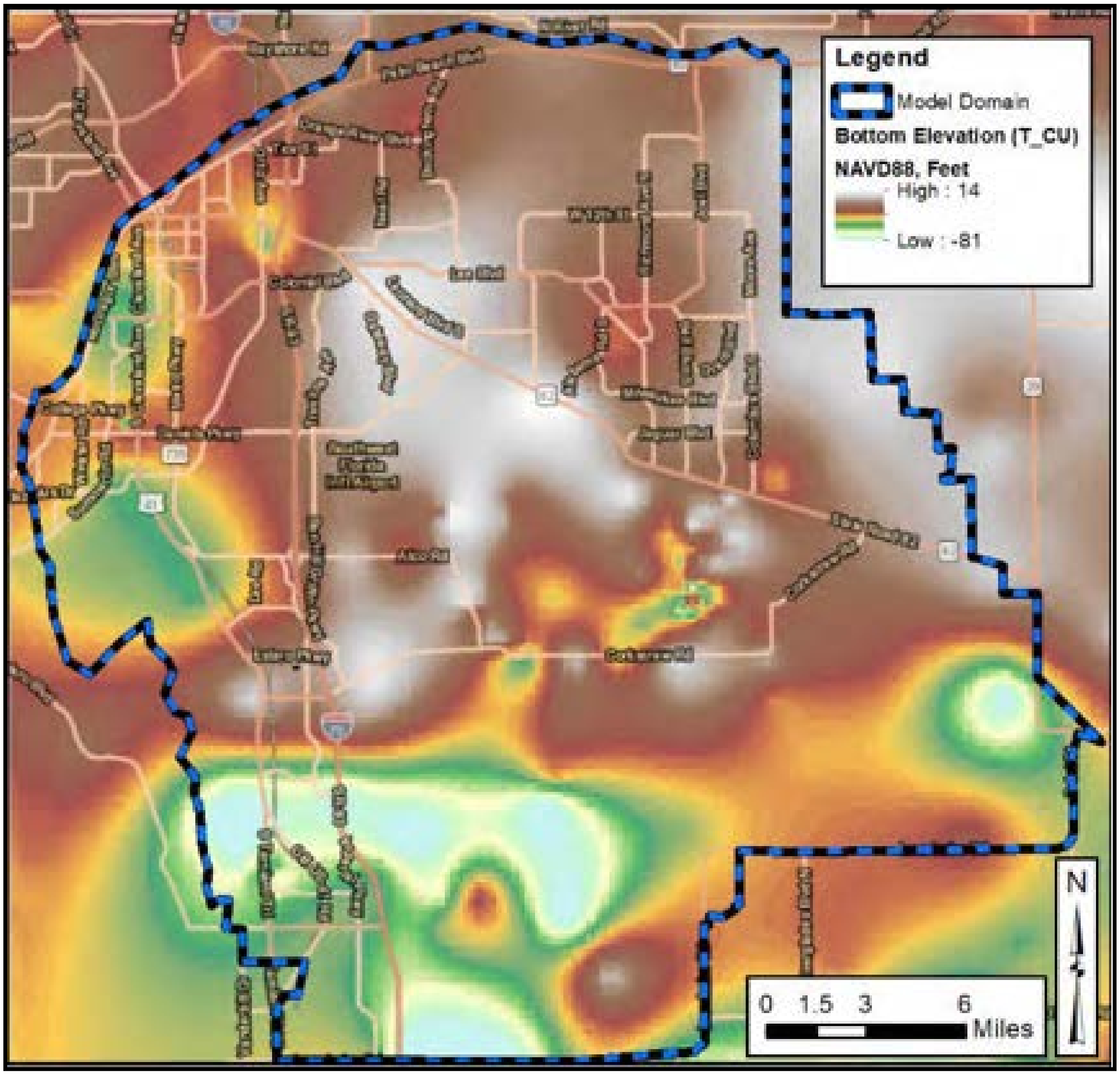


Figure 22. Tamiami Confining Unit (T_CU) Geological Lens Bottom Elevation

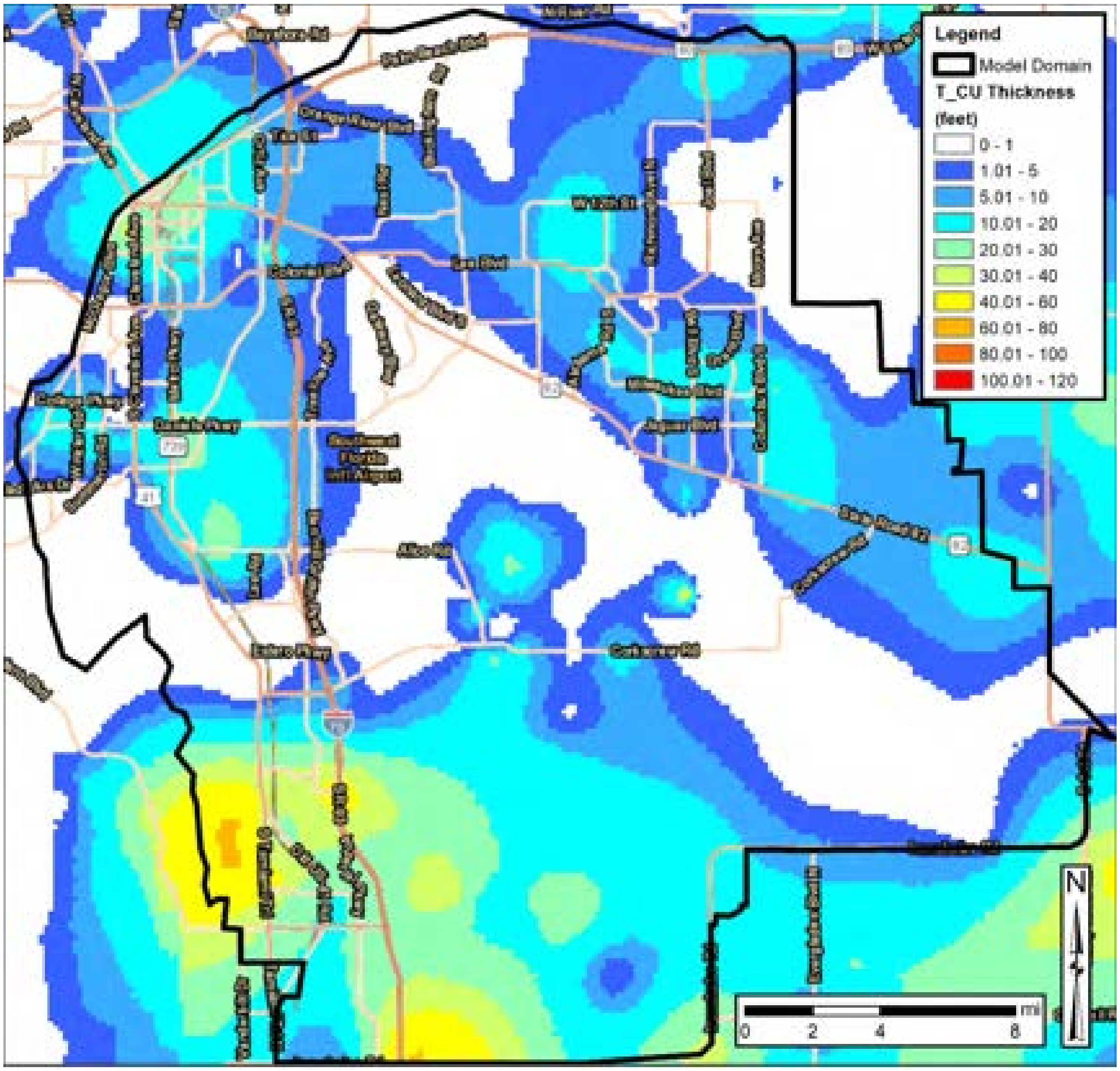


Figure 23. Thickness of the Tamiami Confining Unit (T_CU)

Figure 22 illustrates how the Tamiami Confining Unit (T_CU) thins in the center of the model domain. This layer is thickest in the southern portion of the model, i.e. Bonita Springs area. The Lower Tamiami (LT) Aquifer is also thickest in the southern portion of the model, as shown in Figure 24, and is not present in most of the northern part of the model, near the Caloosahatchee River.

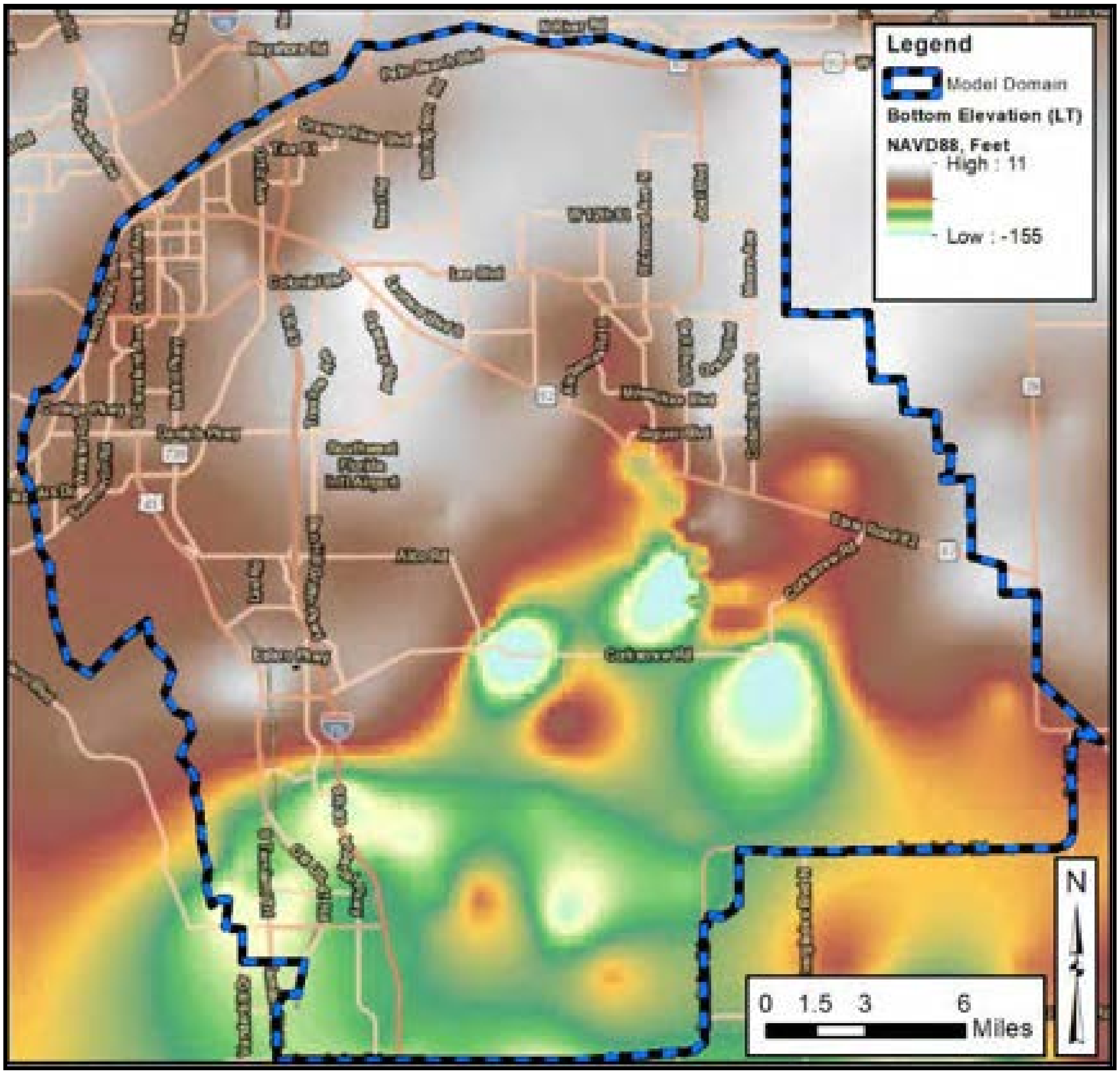


Figure 24. Lower Tamiami (LT) Geological Layer Bottom Elevation

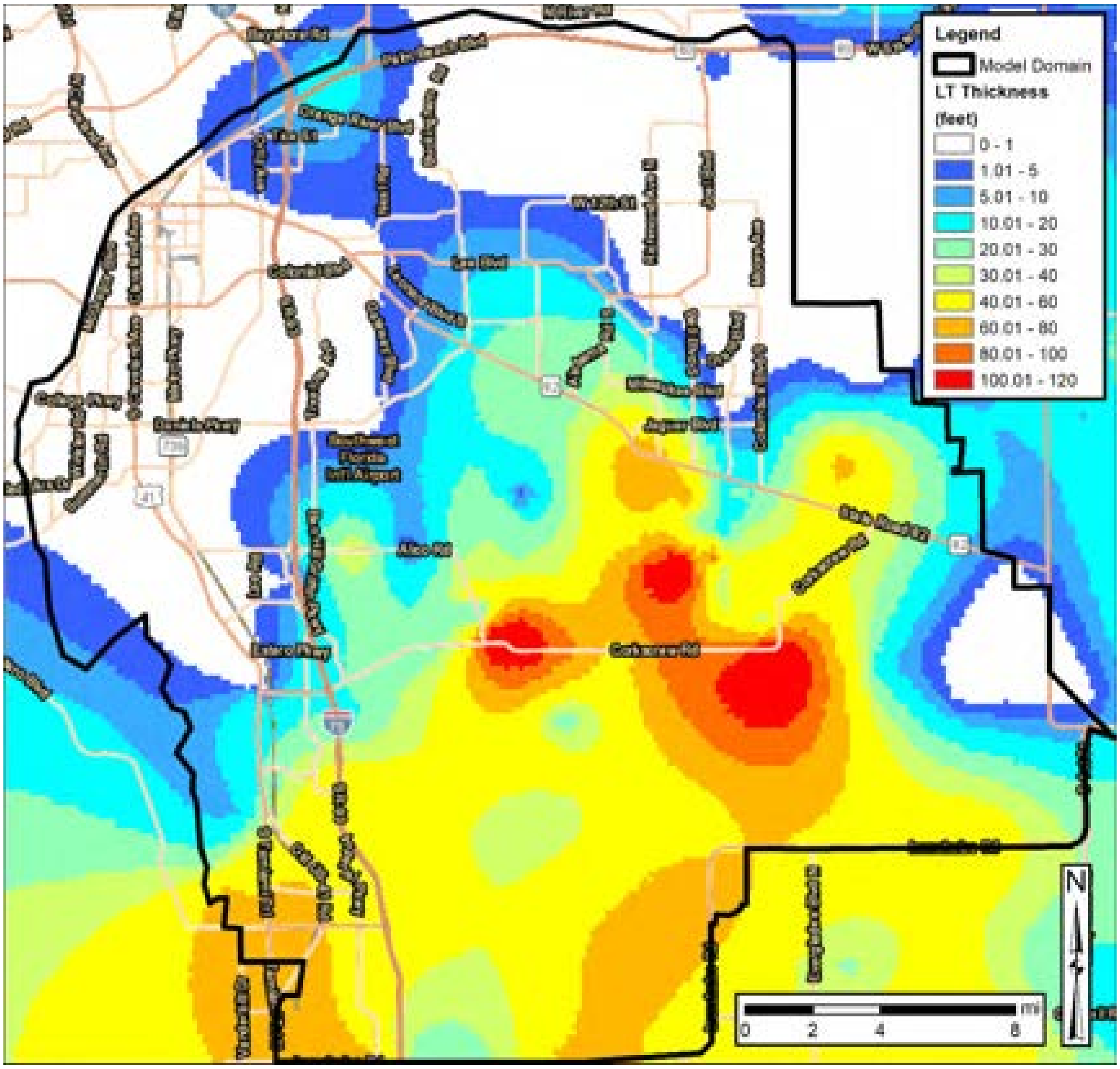


Figure 25. Thickness of the Lower Tamiami (LT) Aquifer

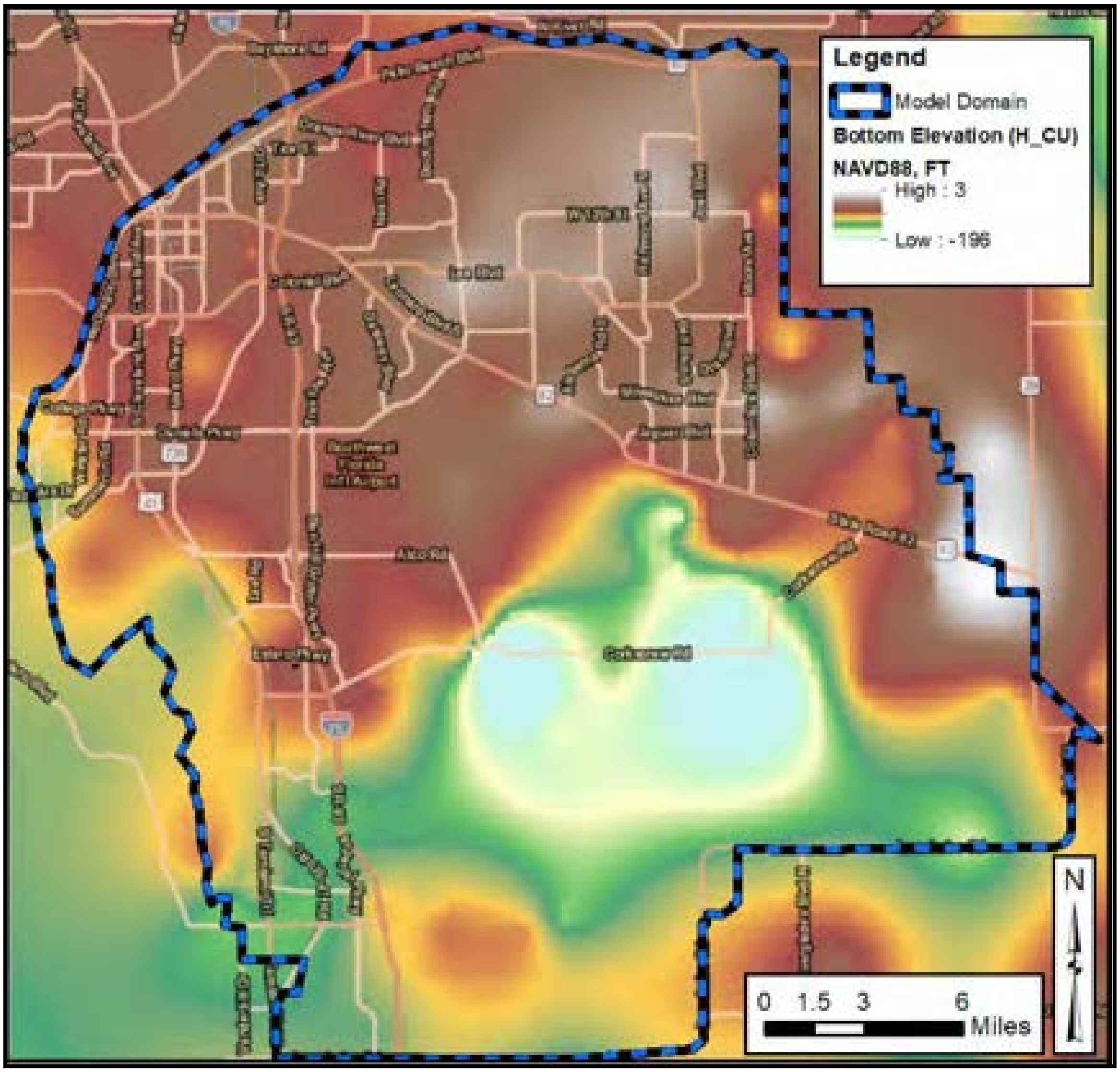


Figure 26. Hawthorn Confining Unit (H_CU) Geological Lens Bottom Elevation

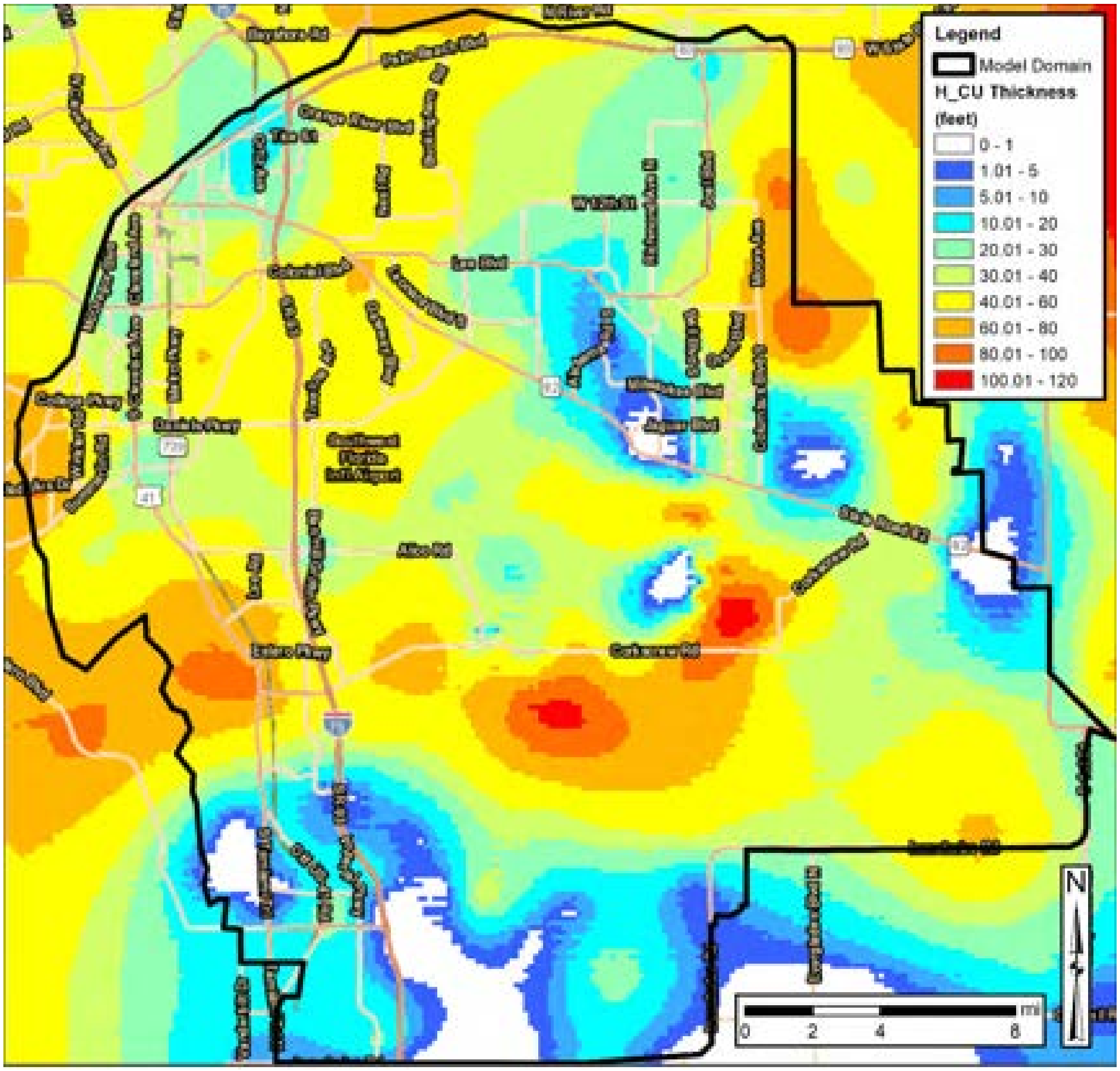


Figure 27. Thickness of the Hawthorn Confining Unit (H_CU)

The Hawthorn Confining Unit (H_CU), shown in Figure 25 and Figure 26, is present throughout most of the model domain, with the exception of some areas in southern Lehigh Acres and Bonita Springs.

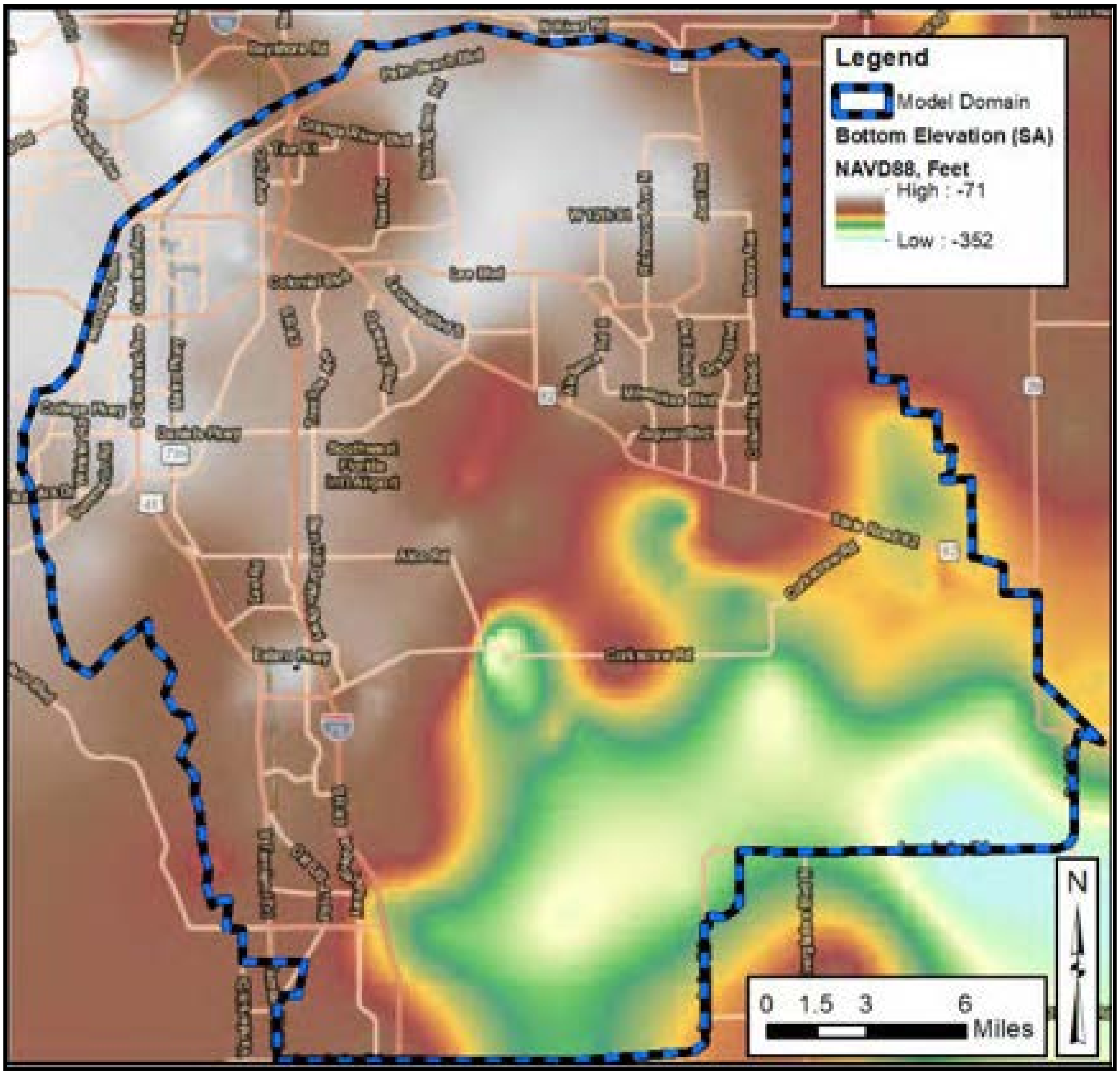


Figure 28. Sandstone (SA) Geological Layer Bottom Elevation

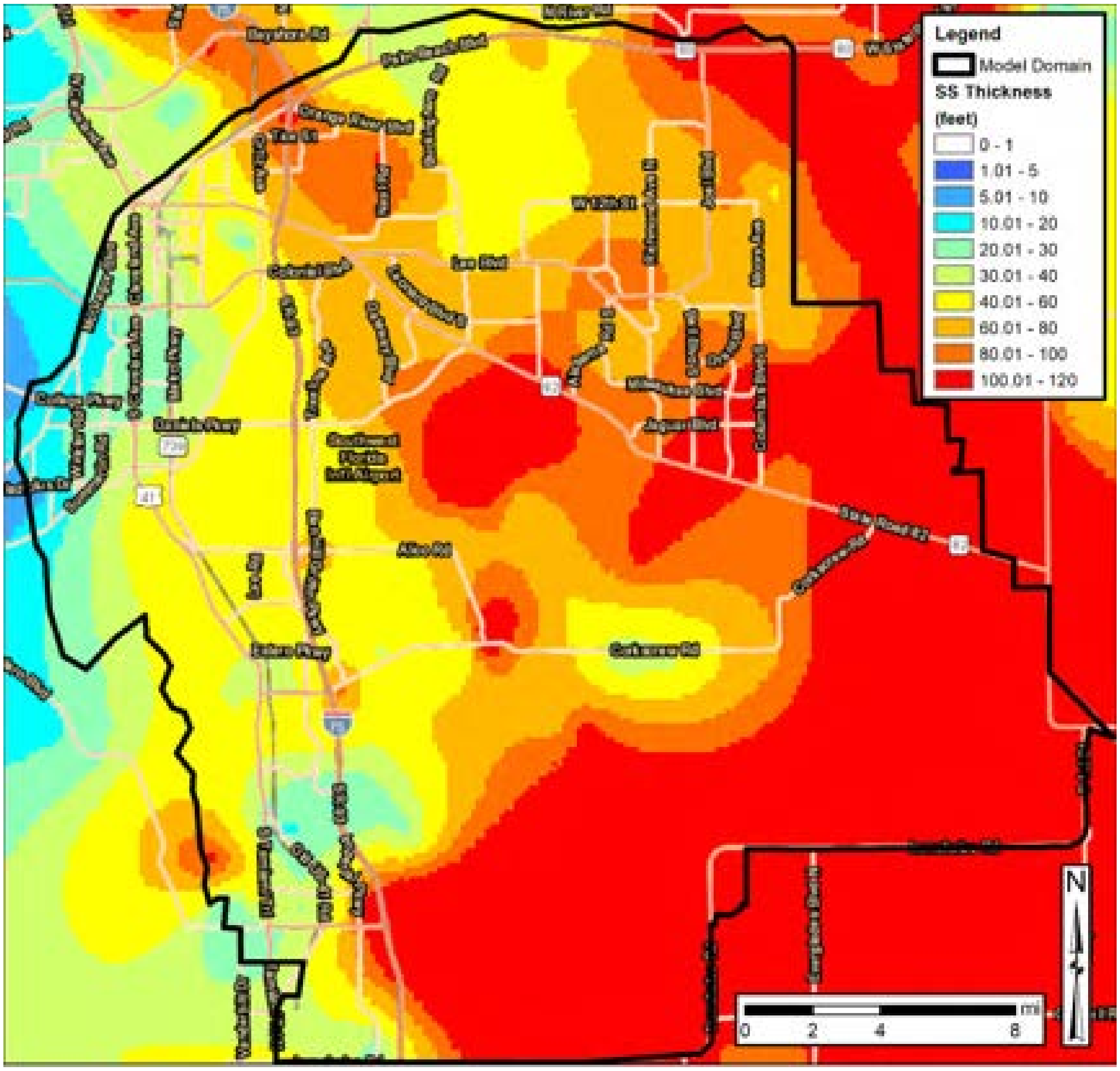


Figure 29. Thickness of the Sandstone Aquifer (SA)

3.8.2 Boundary Conditions

Boundary conditions for this model were established based on the nearest measured water level stations. Particular care was taken to ensure that the boundaries for the surficial aquifer were as accurate as possible, as this layer most directly impacts wet season conditions, which is the focus of this study.

3.8.2.1 Water Table Boundaries

Tidal data for the Caloosahatchee River was obtained from the District's DBHydro database and USGS. Stations S-79 T, VALI75, 8725520, and MARKH were used to create an interpolated tidal surface for the entire tidal portion of the Caloosahatchee on an hourly basis. Figure 29 shows the boundary condition map for the tidal portion of the Caloosahatchee River. This was used as the water table boundary condition for the northwestern boundary of the model.

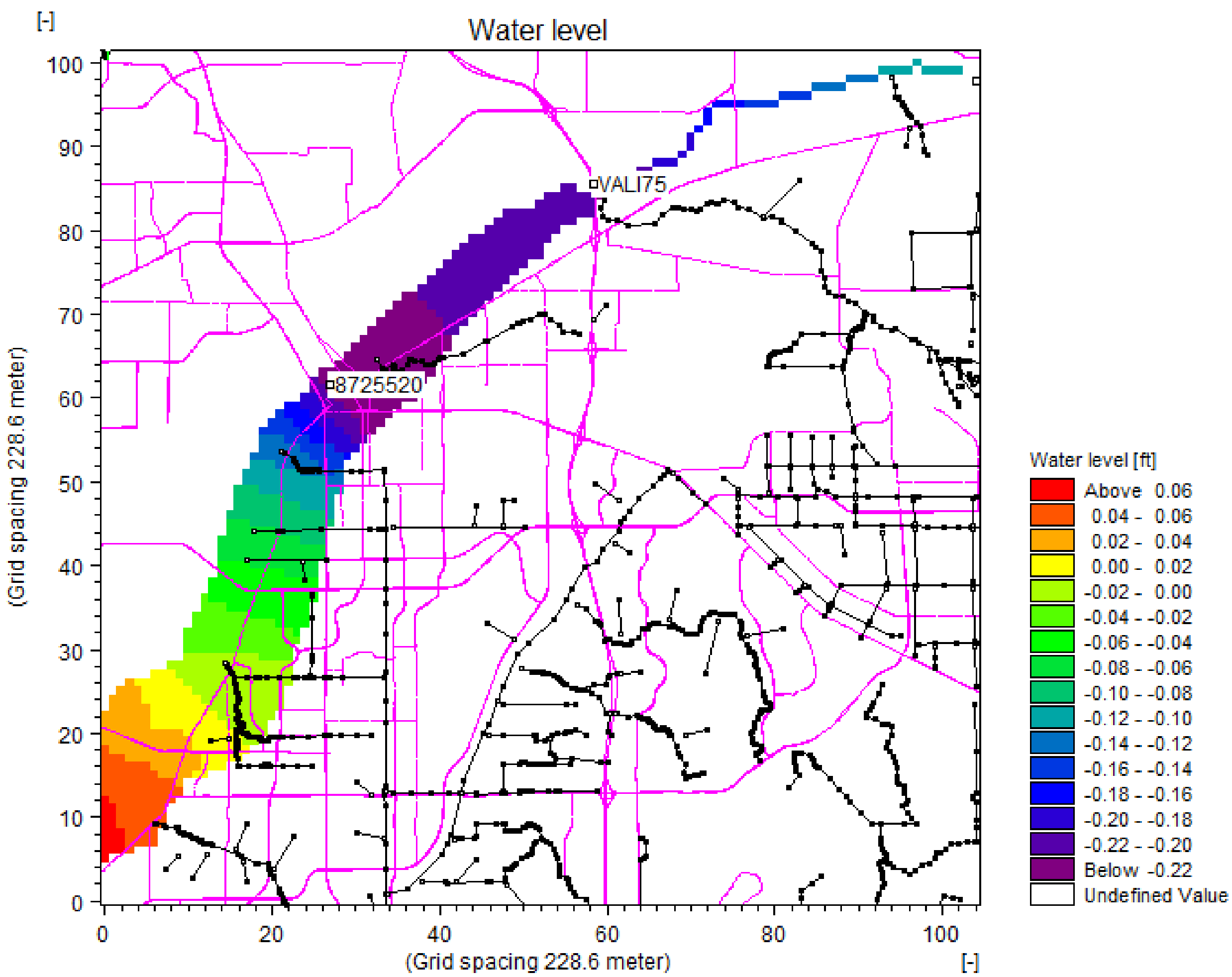


Figure 30. Time-Varying Boundary Conditions for the Tidal Portion of the Caloosahatchee River

Measured data from the 2016-2017 period was used to fill the surficial aquifer boundary conditions, including the Water Table Aquifer and the Tamiami Confining Unit. The northern boundary of the model domain, west of the S-79 structure, was set to measured instantaneous data for the S-79 headwaters. Figure 30, shows the locations of the boundaries and their associated measured data station. No canal data is available for the Townsend or DUDA Canals on the eastern boundary of the model, so surficial aquifer levels from station HE558 were used for the northeast portion, closest to the Caloosahatchee River. Farther away from the Caloosahatchee, the HE558 data was modified using average monthly values from the LA-MSID station SGW10. Measured data from station L730 and C1075 make up the remainder of the western boundary. The southern boundary consists of measured surface water data from KEAIS846, GOLD846, COCO3, COCO2, and tidal data at the tailwater for the COCO1 structure. MARKH was used for the remainder of the tidal boundary along Lee County's coastline, as this is the closest tidal gauge available.

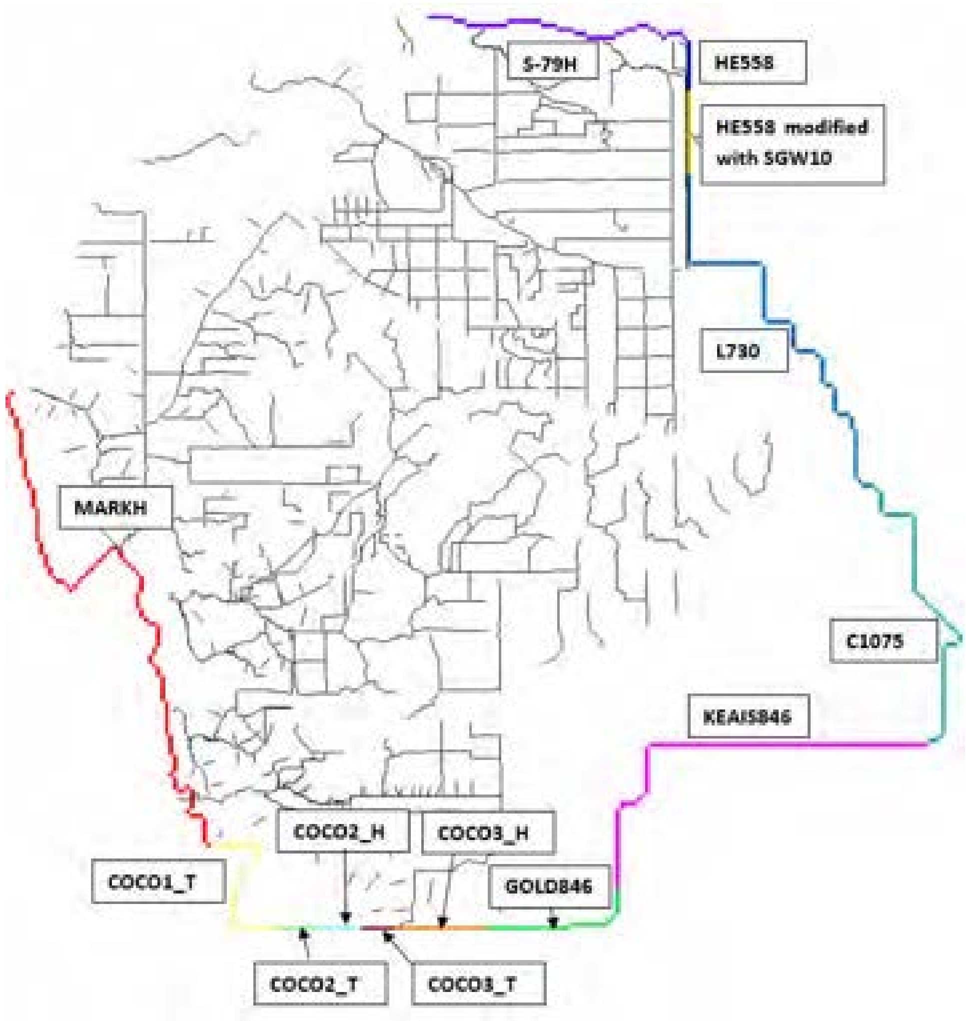


Figure 31. Location of External Boundary Conditions for the Water Table Aquifer

Internal Boundary Condition

Water levels in Lake Trafford were defined as an internal boundary condition for the Water Table Aquifer layer, assuming the measured lake levels (shown in Figure 31) represented about the same elevation over the entire surface of the lake. The location of the Lake boundary is shown in Figure 32.

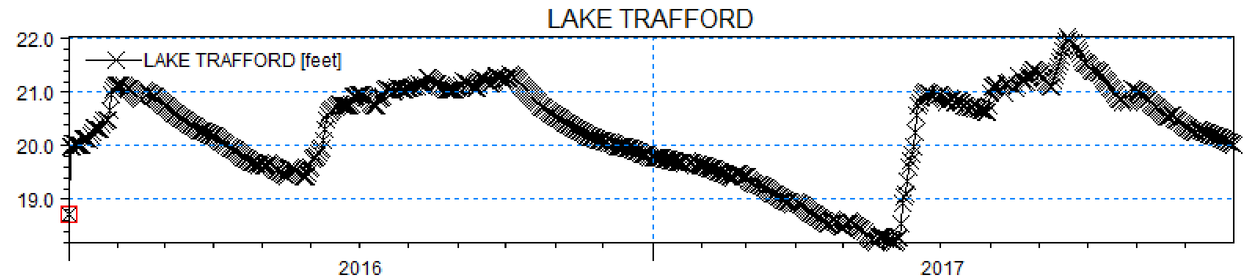


Figure 32. Lake Trafford Internal Boundary Time Series

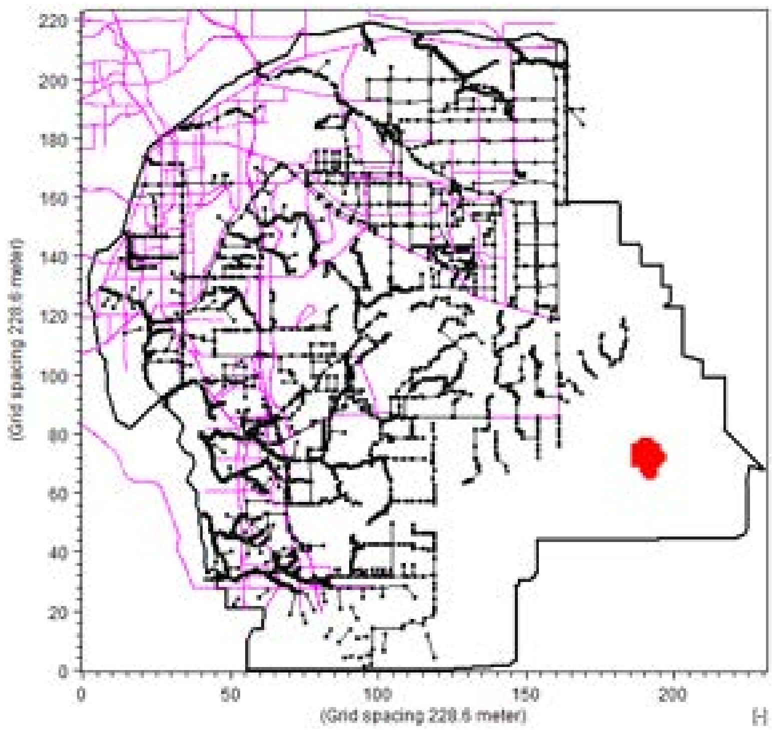


Figure 33. Boundary Condition Location for Lake Trafford

3.8.2.2 Lower Tamiami Boundaries

Measured data from the 2016-2017 period was used to fill the Lower Tamiami boundary conditions. The same tidal Caloosahatchee boundary previously described and shown in Figure 29 was used for the Lower Tamiami. The northern boundary of the model domain, west of the S-79 structure, was set to measured instantaneous data for the S-79 headwaters, as shown in Figure 33. Surficial aquifer levels from station HE558 were used for the portion closest to the Caloosahatchee River. Farther away from the Caloosahatchee, the HE558 data was modified using average monthly values from the LA-MSID station SGW10, and farther south the HE558 files were modified with SGW11 data. Measured data from station C462 was used to fill the western border, with C982 filling the southwestern corner of the model boundary. The southern boundary consists of measured data from C1245, C1279, and C1004R. MARKH was used for the remainder of the tidal boundary along Lee County's coastline, as this is the closest tidal gauge available.

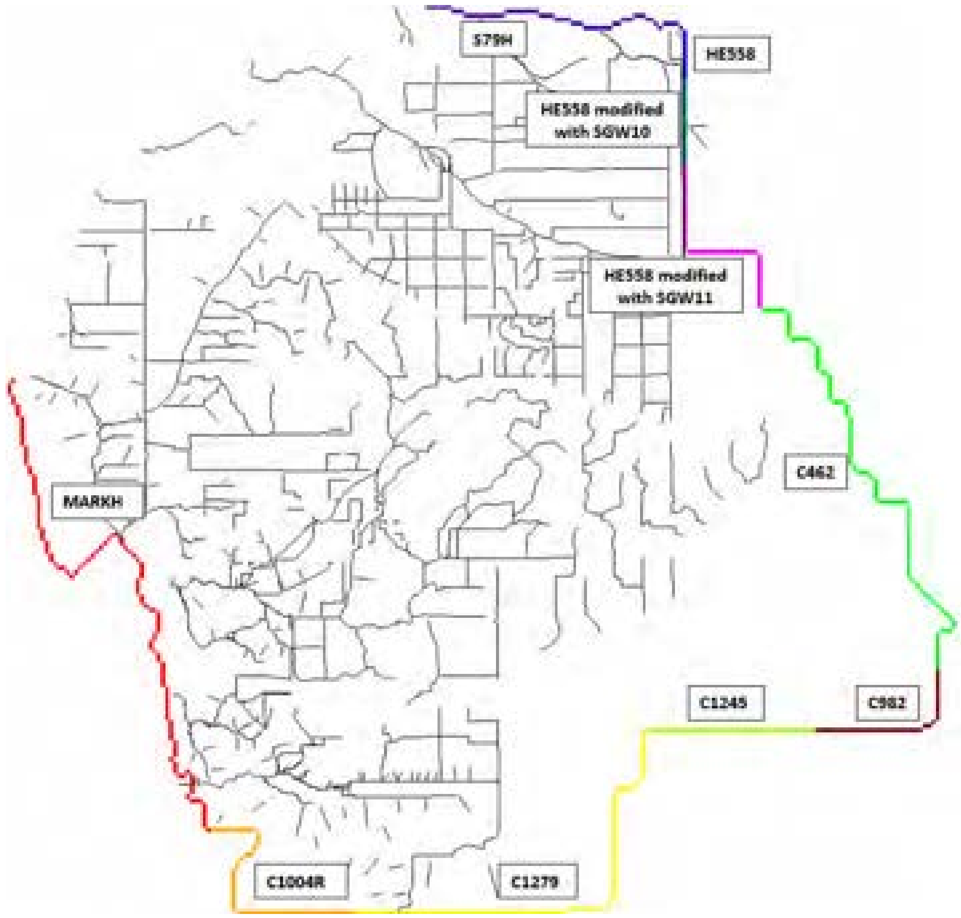


Figure 34. Location of the External Boundary Conditions for the Lower Tamiami Aquifer

3.8.2.3 Sandstone Boundaries

There are very few measured groundwater levels for the Sandstone Aquifer outside the model domain that have daily data for the 2016 to 2017 period. Four stations were used to define the model boundaries for this layer (See Figure 34). For the most coastal extent, the station C688 was used. In the northeastern corner of the model station HE557 was used as a boundary. The easternmost boundary was defined by station L2215, and the southeastern boundary was defined by station C1079. The lack of boundary data for the Sandstone is not viewed as a limitation for the purposes of this study, as this study focuses primarily on wet season conditions and flooding of the surficial layers.

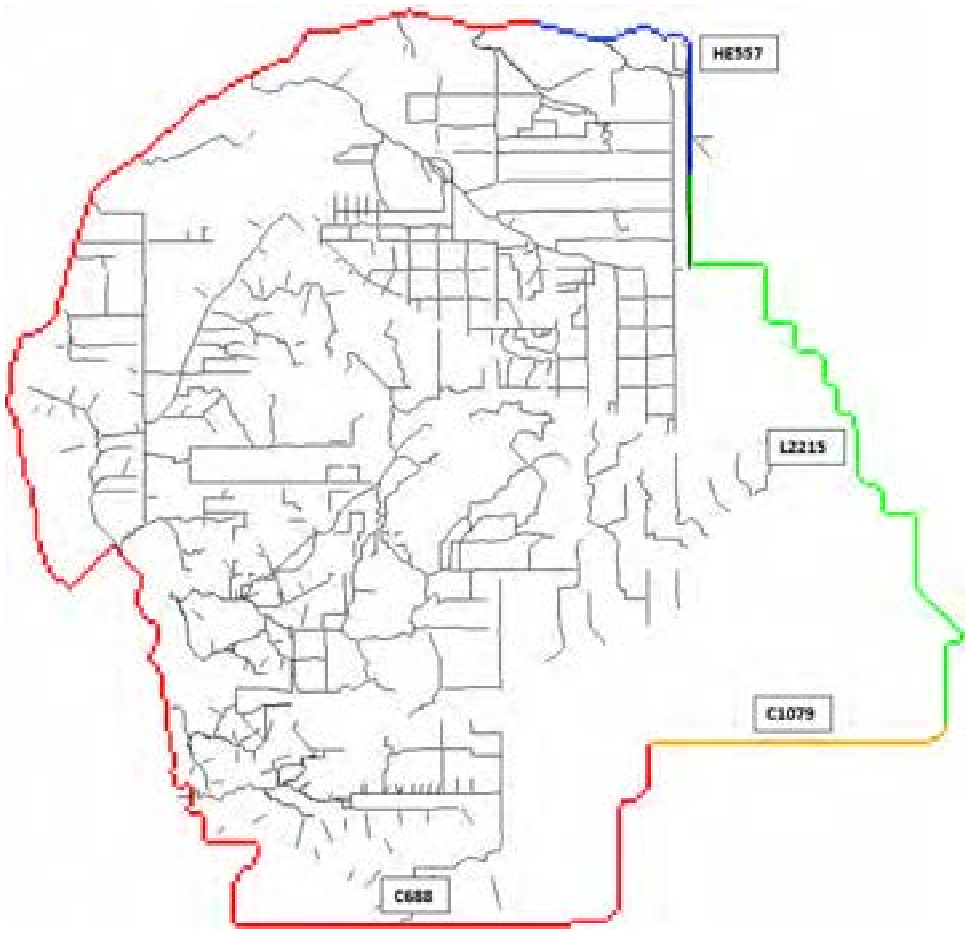


Figure 35. Location of the External Boundary Conditions for the Sandstone Aquifer

3.8.3 Pumping

Pumping data from public supply wells was requested from the District and from Lee County; however, transient data was not available. Thus, the model uses estimated values for all public supply wells taken from the Village of Estero model (WSA, 2018). Wellfield locations are shown in Figure 35.

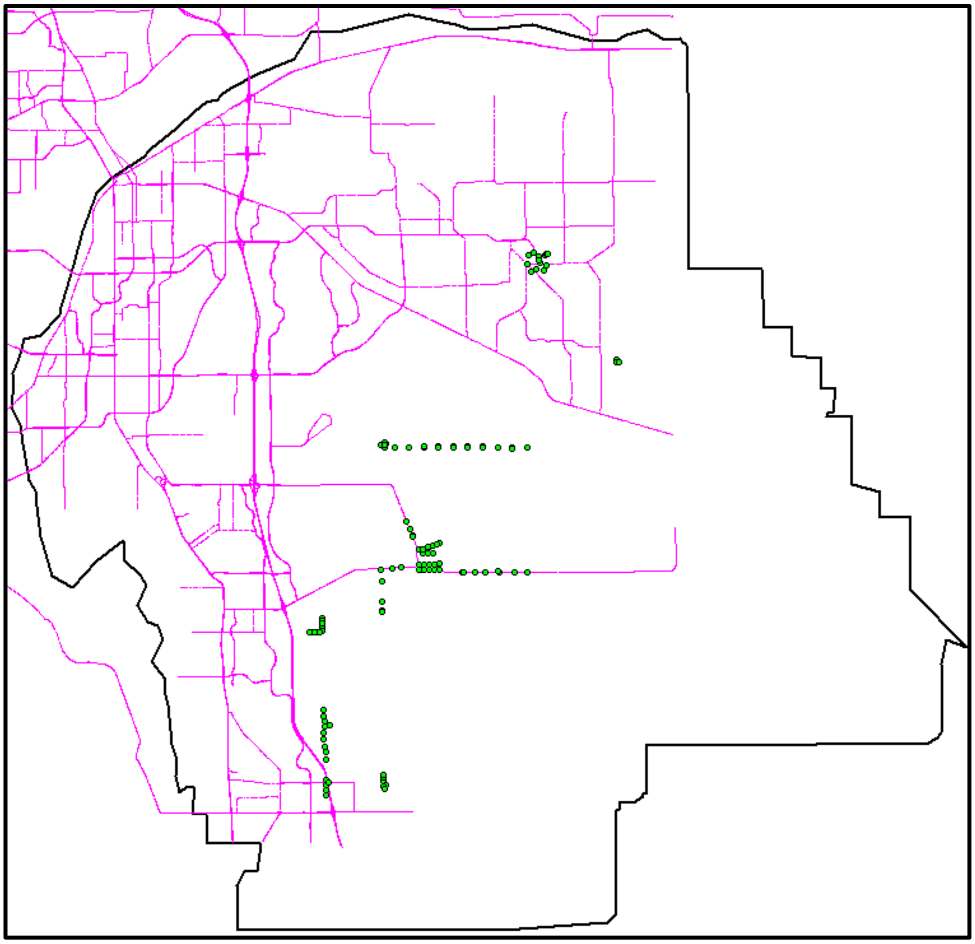


Figure 36. Wellfield Locations

3.8.4 Subsurface Drainage

The Subsurface Drainage component in MIKE SHE is used to represent drainage systems that are not defined in the river network. Agricultural areas, defined in the land use map, were set to drain using the adjacent down gradient cells (i.e., drainage option = 1). This drainage option used in the model represents general agricultural drainage practices, such as controlled ditches that help prevent over-saturation of the farm. All agricultural areas drain to a level 2.0 feet below the land surface to the nearest river branch or boundary. All areas classified as urban (low-density, medium-density, and high-density) were given a drainage level of 1.0 feet below the land surface to represent urban drainage features, such as roadside drainage swales, ditches, catch basins, storm sewers, and other stormwater treatment facilities. These specific features are typically not represented in large regional models due to their coarse resolution. To account for this, the drain level is used to represent the urban drainage. Figure 36 shows the drain depth map for the model domain.

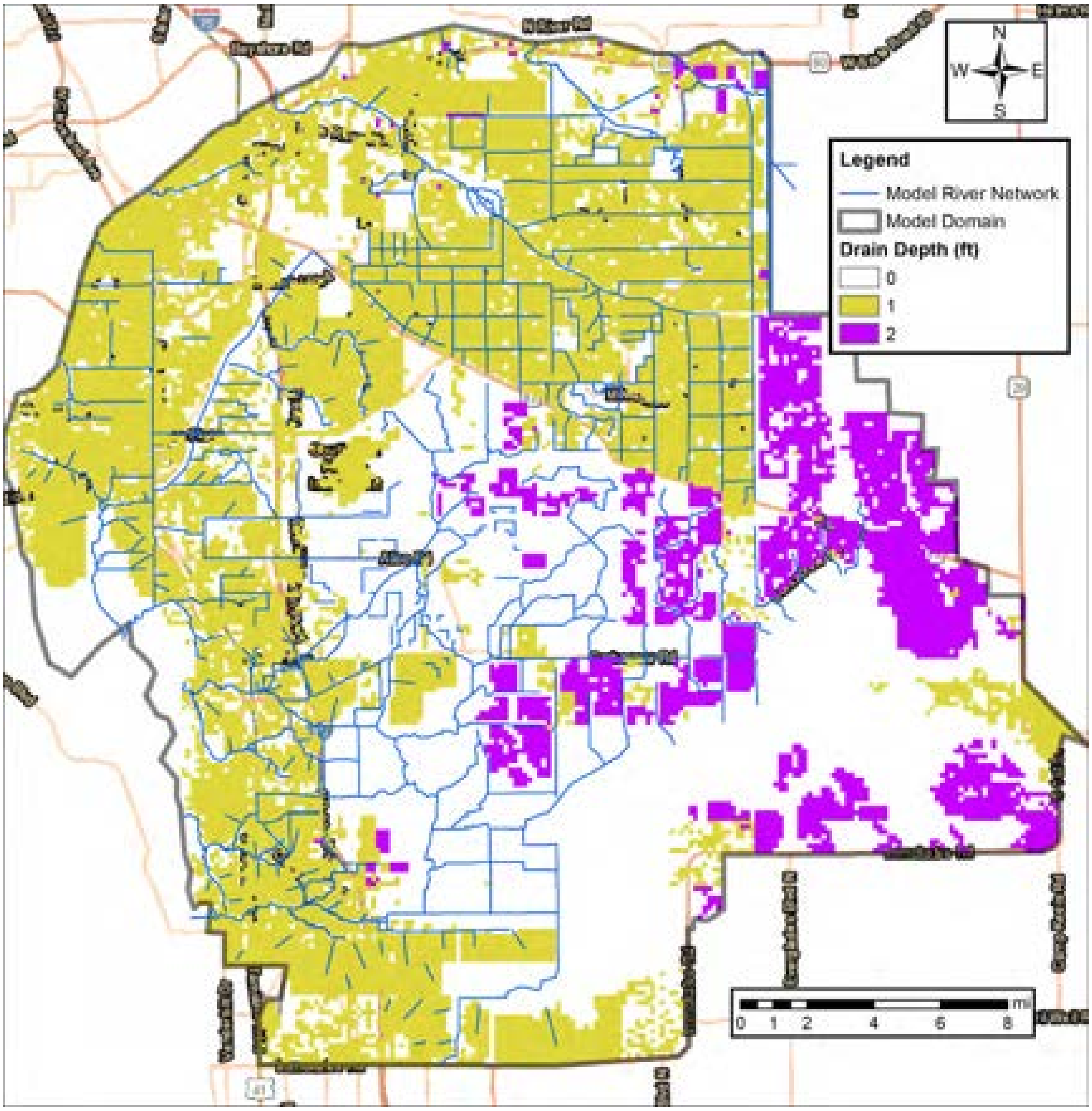


Figure 37. Drain Level Depth Below the Land Surface (feet)

The Lee County watershed is characterized by moderately to highly urbanized areas within the southern, western and northern bounds of the basin. The majority of these urban regions are composed of residential sub-divisions, which range in size from smaller mobile home parks to larger medium/low-density golf course neighborhoods. These sub-divisions typically feature stormwater management facilities that provide attenuation (i.e. storage) to accommodate the increased stormwater runoff associated with the post-development state. Moreover, these facilities generally include interconnected man-made drainage systems that route runoff to a central point, which typically correspond to the gradient of the surrounding lands. Consequently, these facilities need to be accounted for during model development to properly simulate the hydraulic conditions of the watershed.

To account for drainage from large communities, the specified subsurface drainage component (by using Drainage Option = 3), along with representative drainage branches for the major communities, were used. Branches were added along with cross-section information and weir data to represent the drainage characteristics of each subdivision. Two (2) cross-sections were provided for each branch, with the most upstream section including additional storage for the stormwater pond(s). Moreover, one (1) weir structure was added to each branch to represent the discharge capabilities of the outfall structure and top-of-bank overflow.

Storage values for each sub-division (i.e. specified drainage area) were tabulated using the SFWMD's GIS land use shapefile. Land use types such as reservoirs, lakes, and holding ponds were extracted from the District's shapefile and amended, as necessary, to include more recent developments/improvements. Boundaries for each ponded drainage area were manually drawn in GIS and are based on property lines, existing infrastructure information, and topographic data. These boundaries were then intersected and clipped with the aforementioned water features to determine the on-site storage of each drainage area (see Figure 37).

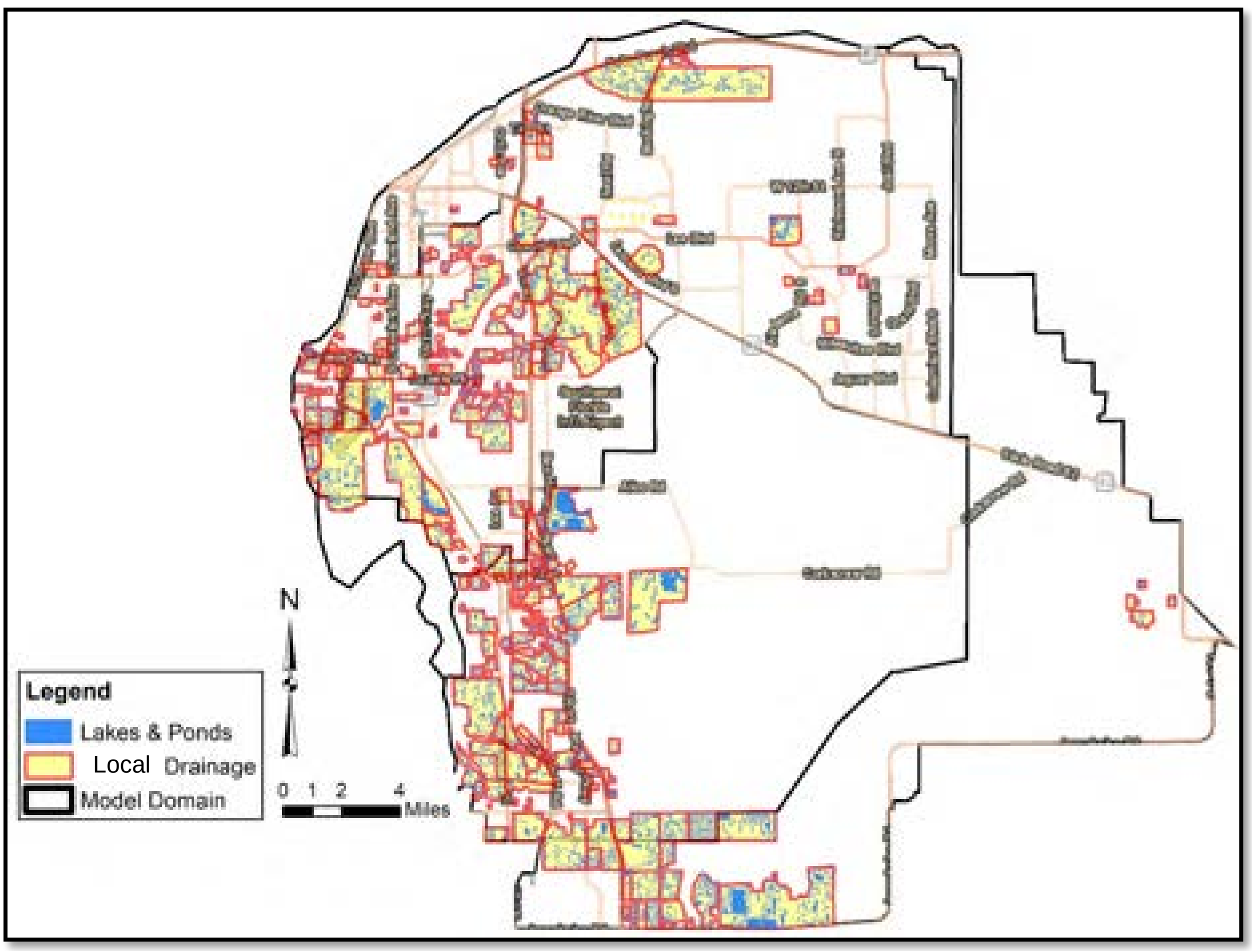


Figure 388. Community Drainage Areas

Discharge parameters for each drainage area are based on previously designed and permitted stormwater management systems within the watershed. Numerous construction drawings were reviewed throughout the study area, with close attention being paid to the outfall structure of each drainage system. During the review, it was noted that the majority of the systems had design water levels (i.e. control elevations) situated two (2) feet below the top-of-bank (TOB). Moreover, most sub-divisions were observed as having one (1) control structure within the system that would function as the final outfall, prior to discharging into a downstream branch. In turn, the below listed assumptions were made to develop a two-stage weir representing typical discharge rates for each ponded drainage area.

- Control structure width: *FDOT Ditch Bottom Inlet (DBI) Type-G*
- Control structure elevation: *Two (2) feet below the top-of-bank (TOB)*
- Top-of-bank (TOB) width: *500 feet*
- Top-of-bank (TOB) elevation: *DEM derived*

Overall, 265 drainage areas were originally derived using this approach. However, to limit model complexity and to keep simulation run times low, the largest sub-divisions were selected from these 265, which condensed the final ponded drainage areas to 75. It should be noted that the remaining areas may be incorporated at a later point on an as-needed basis to add more detail in particular areas of interest, such as proposed project locations.

3.8.4.1 Specified Drainage Areas

The 75 specified drainage areas each have a unique code in the MIKE SHE Drainage module (shown in Figure 38). These codes are used to link the sub-division area in MIKE SHE with the receiving river branch and discharge weir in MIKE 11. Rainfall that falls onto these areas is routed to the river network where it is stored until it overtops the control weir. All other areas in the model will drain normally using topographic gradients to route the water to the nearest river or boundary cell. Any water remaining on the land surface after either the grid codes or the topography has routed the water will undergo 1) evaporation, 2) infiltration to the unsaturated zone, and finally 3) lateral overland flow to adjacent cells.

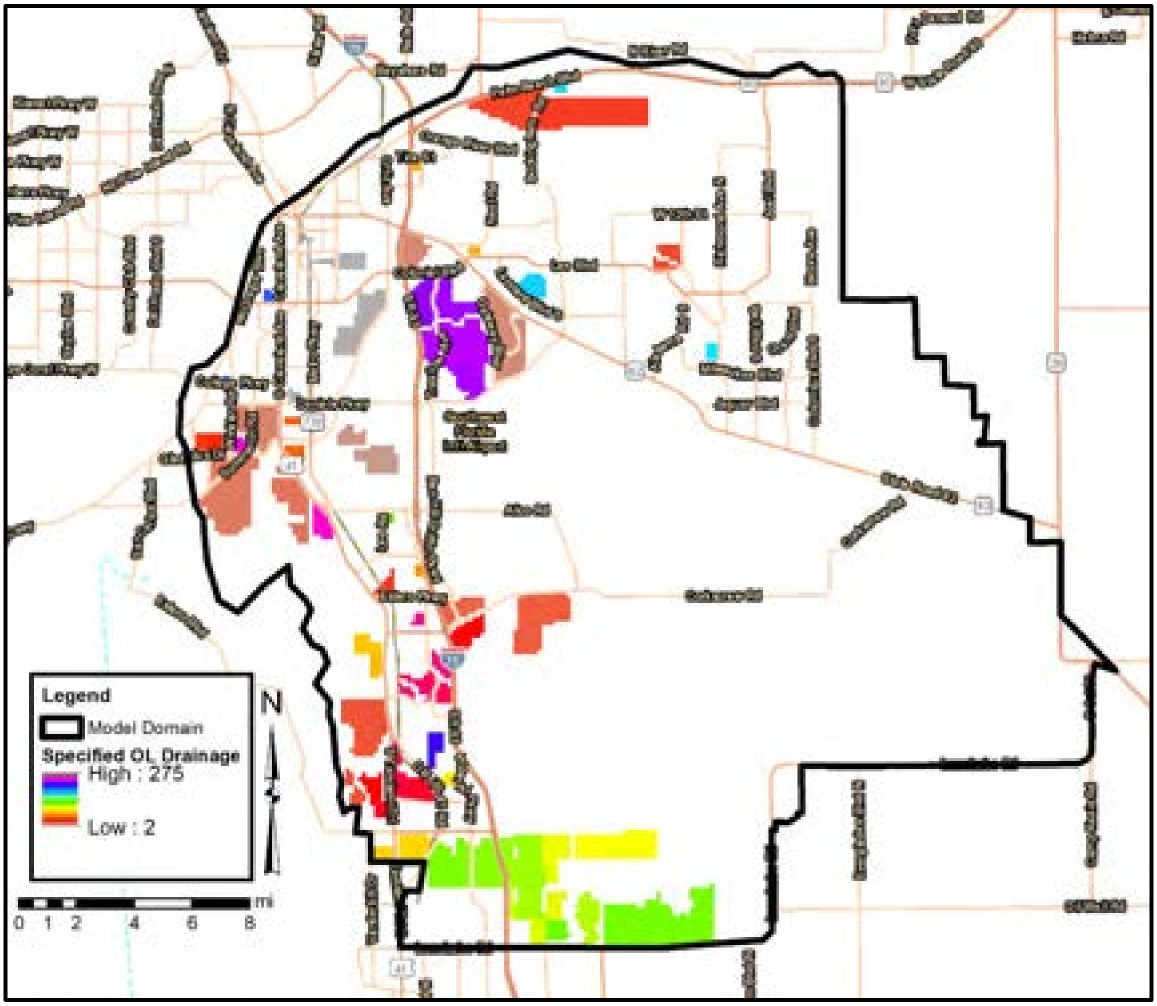


Figure 39. Map of Specified Overland Drainage Areas

3.8.5 Aquifer Parameters

Analyses were performed to test model performance sensitivity to varying values of horizontal hydraulic conductivity (Kh) of the water table aquifer (WT), the vertical hydraulic conductivity (Kv) of the Tamiami Confining Unit (T_CU), and the horizontal hydraulic conductivity of the Lower Tamiami Aquifer (LT).

The horizontal hydraulic conductivity of the Water Table Aquifer was tested using a wide range of values (50, 1000, and 5000 ft/day), over the 2017 wet season (5/25/2017 through 10/31/2017). Measured horizontal hydraulic conductivity values for the Water Table Aquifer range from about 30 to about 6,500 ft/day for the study area (Shoemaker and Edwards, 2003). The water table aquifer groundwater results for these three tests were compared against measured data by reviewing the calibration plots and calibration statistics, such as Mean Absolute Error and the R Correlation (See Table 12). The best Kh values associated with these calibration points were selected and used in the model. The average results for the WT aquifer calibration stations improved across the model when using these values.

Table 12. Testing Kh Values for the WT aquifer.

	Kh Value (ft/day)	MAE	R(Correlation)
Test 01	50	2.13	0.55
Test 02	1000	1.92	0.56
Test 03	5000	2.14	0.60
Test 04	Best Values	1.72	0.61

Hydraulic conductivity values for the confining units were set to uniform values throughout the model domain, based on estimates from literature. The Tamiami Confining Unit was set to a vertical hydraulic conductivity (Kv) of 0.013 ft/day and the Hawthorn Confining Unit was set to a Kv of 0.01 ft/day (Shoemaker and Edwards, 2003).

Tests were performed on the vertical conductivity of the Tamiami Confining Unit by varying the value from 0.001, 10, and 1000 ft/day. Few calibration sites showed a sensitivity to varying this parameter; thus, it was determined that the value from literature worked the best throughout the study area (Kv = 0.013 ft/day).

Additional testing was performed on Kh value for the Lower Tamiami Aquifer with a range of 100 ft/day to 5,000 ft/day. Areas where the model varied significantly during this test, matched well with areas where the Lower Tamiami is thickest in the model.

The final calibrated hydraulic conductivity values for the water table aquifer are shown in Table 13.

Table 13. Horizontal and Vertical Hydraulic Conductivity Values

	Kh (ft/d)	Kv (ft/d)
Water Table Aquifer	See map (Figure 39)	Kh/10
Tamiami Confining Unit	See map (Figure 40)	Kh/10
Lower Tamiami Aquifer	500	100
Hawthorn Confining Unit	0.01	0.001
Sandstone Aquifer	100	10

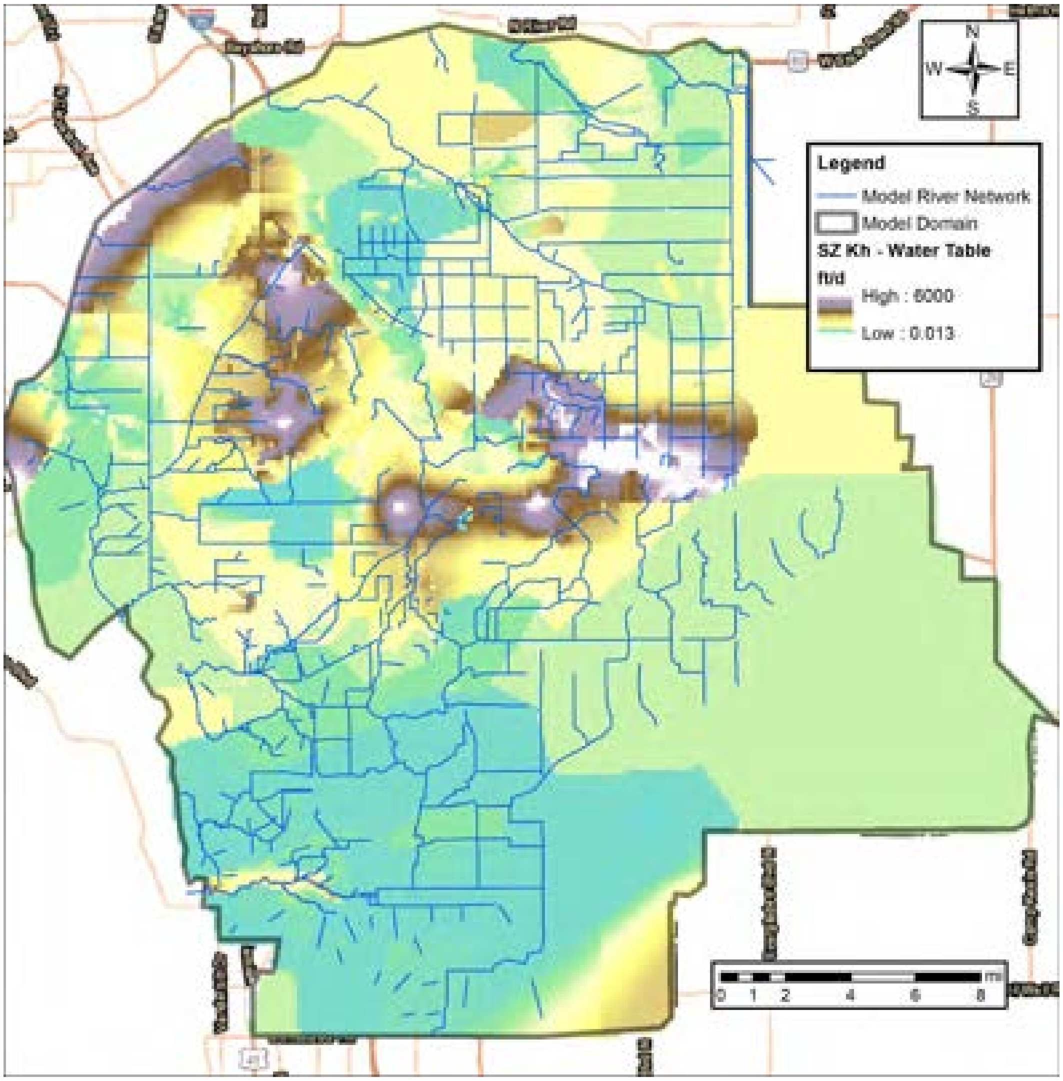


Figure 40. Horizontal Conductivity Map for the Water Table Aquifer

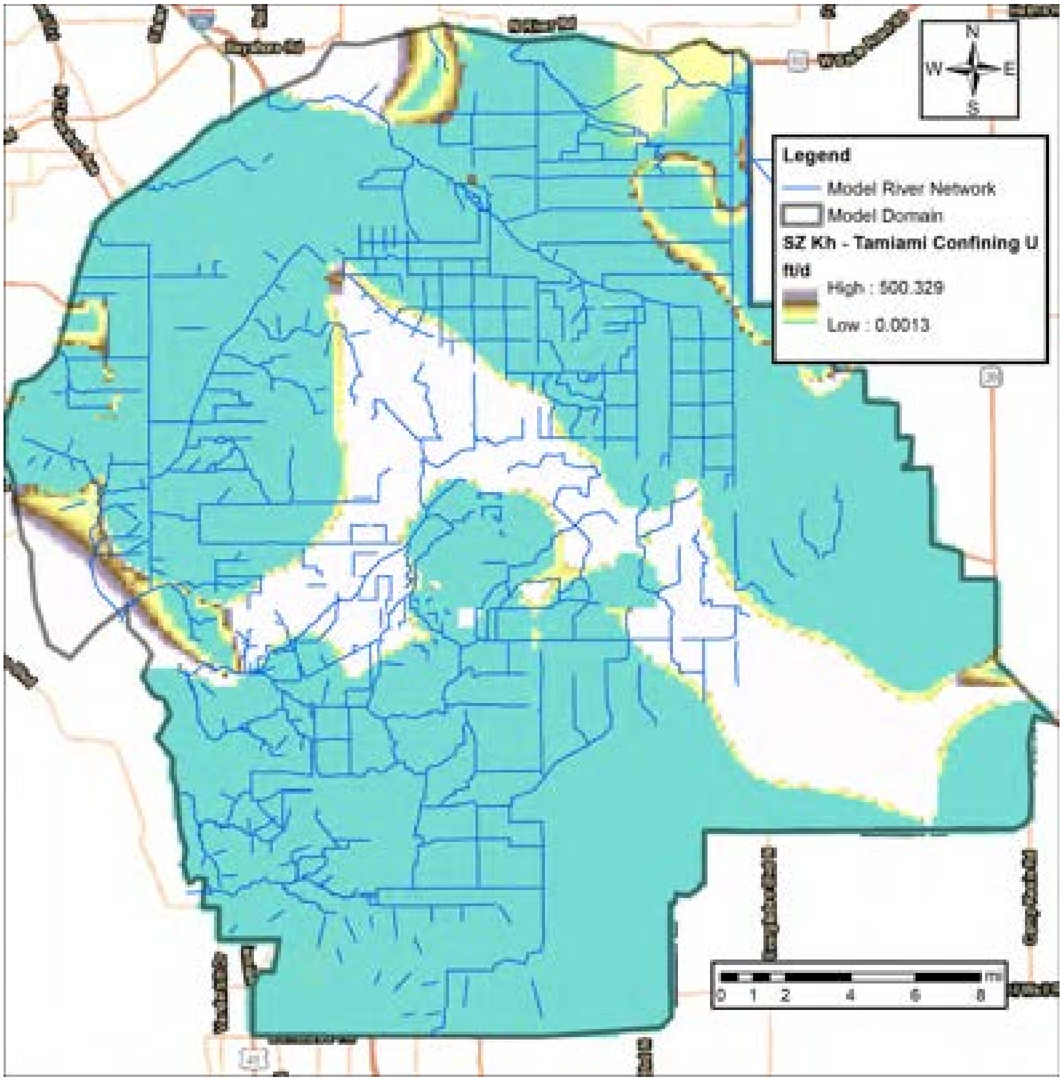


Figure 41. Horizontal Conductivity Map for the Tamiami Confining Unit

3.9 Model Limitations

This model provides a reasonable representation of the regional hydrology of southern Lee County and is useful for analyzing the impacts of regional hydraulic improvement projects. Due to the regional scale of the model, the results represent averaged conditions over a 750ft x 750ft grid cell, with 1D hydraulic results for only major rivers and canals. Therefore, local scale conditions, such as flooding due to secondary or tertiary drainage should be evaluated with a more refined scale model. In addition to scale, model calibration may have been impacted by the selection of the calibration period, the lack of gate operations, and the continual improvement of the model without additional refinements, due to time constraints.

Calibration period:

The model calibration period focused on the wet months of 2017 (i.e. July through October). However, dry season conditions may not be accurately calibrated to using this short, extreme wet season. In fact, when the longer period was run using these calibrated results, the 2016 period under-performed in the surface water calibration locations.

In addition, the model calibration period included two major storm events: Invest 92L in August and Hurricane Irma in September. Both storms produced a large amount of rainfall for the region, and Hurricane Irma was a high wind event, which downed trees and structures and led to heavy debris in the downstream drainage areas. The debris sometimes led to temporary flow constrictions and elevated stages that could not be modeled. In some areas, particularly Orange River and Imperial River, it is believed that the highest peak of Irma was a result of debris blockages and it is therefore considered acceptable that the peak stages for these events do not always match.

Missing Information:

Gate operations are critical for modeling correct water levels and flows; however, gate operations for the Lee County water control structures were not available during the time this model was developed. This led to assumptions about generalized gate operations (i.e. either always closed or always open) for most gates, and detailed assumptions of daily operations based on calibration results. In particular, assumptions on the closed gates at Ten Mile at Daniels, Six Mile Cypress at Ten Mile, Ten Mile at US 41, and Kehl Canal could be incorrect, and more informed gate operations should be included in the model, once the information becomes available.

Continual Updates:

It was recommended to add several updates to the model to represent drainages, modify culvert sizes, etc. during the project implementation phase. During this phase, the calibrated model was used as a base model and the proposed projects were added into the model individually. Due to the detailed analysis that was then performed during these 38 individual proposed project model evaluations, additional information was found that would improve the representation of the existing conditions and these changes were made to the model. With every change, a new existing conditions model was created. Final calibration of the Ten Mile Canal portion of the model will occur during detailed design of the proposed projects.

3.10 Model Recommendations

Several final tests were performed over the 2 year simulation period (1/1/2016 through 2017) to enhance the model's ability to perform during dry season conditions, and improve calibration around the early wet season, when water levels begin to rise. Model performance improved about 14% for the surface water stations and 8% for the water table aquifer calibration stations. Some key items should be evaluated for future use of this model:

- The ET parameters for each land use type were not a focus of this modeling study due to the fact that it was a wet season model, when ET is not a typical hydrological driver. However, groundwater ramp-up times, or the time to stage up to wet season levels after a period of drought were impacted by the ET parameters (i.e. Leaf Area Index, Root Depth, and Crop Coefficient). Testing these parameters, by reverting to similar parameters used in the Kissimmee model study, showed a marked improvement of surface water conditions. A list of the suggested ET parameters are provided in the Table 25, Table 26, and Table 27 of Appendix A.
- Modifications to the way communities discharge to Ten Mile Canal were made to the final model upon the suggestion of experts with intricate knowledge of the area., This raised water levels above measured in Ten Mile Canal north of the Daniel's Parkway gated structure. Since these gates were assume closed during the simulation period, calibration will be improved by opening and closing this gate according to the measured stages in the canal during detailed design phase(s). It is recommended that in lieu of actual recorded gate operations, the gate operations in the model are adjusted to account for this change in flows to Ten Mile Canal.
- The Overland module of MIKE SHE uses a Manning's M map to account for variations in surface roughness caused by land use. A value of zero was used to account for areas where the Overland Flow module should be "turned off" due to lakes and other water bodies. However, in low lying depressional areas, this can lead to water getting "stuck" in the cell with no option to leave the depression. It is recommended that the Manning's M values that equal zero are modified to match the nearest cell or interpolated from nearby cells.

4 Model Calibration Results

The model was calibrated using the period of May 25th, 2017 through October 31st, 2017. This period includes the end of the 2017 dry season, which was drier on average, and two (2) large rainfall events: the August storm and the Hurricane Irma. Initial groundwater elevations of the surficial aquifer system were interpolated from measured groundwater levels for 5/25/2017 from the Lee County and Lee County Port Authority monitoring wells.

During model calibration, the following strategy was utilized: exhaust all possible physical data issues with the model before adjusting parameters such as hydraulic conductivities. This data-focused strategy prioritized how the model is used to represent drainage of the systems, over fine-tuning parameters that may be highly variable. Particular attention was paid to surface water drainage features, how they may be over or under-representing drainage and/or storage. Observation of vegetation, siltation and debris in channels was also used to adjust roughness parameters, where needed.

Once the physical parameters, or a representative approximation of the physical features such as the ponded or subsurface drainage features, have been thoroughly represented in the model, multiple tests were performed using a range of values modified uniformly over the entire domain. Sections 3.7.3 and 3.8.5 provide details on the tests that were performed for unsaturated zone and saturated zone parameters, respectively.

The following sections show the groundwater calibration results for each hydrostratigraphic layer of the model and the surface water calibration results for each study area of the model. Statistics are provided for the averaged Mean Absolute Error (MAE) in feet and cfs and the R Correlation Coefficient. Table 14 and Table 15 provides the guidelines that were used to determine the "fit" of the model at each surface water station for stages and flows, respectively. Groundwater metrics are shown in Table 16. These performance metrics will be used in the Calibration section to describe how the model performed.

Table 14. Model Performance Metrics for Surface Water Stages

Model Performance	Mean Abs Error	R Correlation Coeff.
Good	MAE ≤ 1.0 ft	≥ 0.75
Okay	MAE ≤ 1.5 ft	≥ 0.60
Poor	MAE > 1.5 ft	< 0.60

Table 15. Model Performance Metrics for Surface Water Flows

Model Performance	Mean Abs Error	R Correlation Coeff.
Good	MAE ≤ 50 cfs	≥ 0.75
Okay	MAE ≤ 100 cfs	≥ 0.60
Poor	MAE > 100 cfs	< 0.60

Table 16. Model Performance Metrics for Groundwater Levels

Model Performance	Mean Abs Error	R Correlation Coeff.
Good	MAE ≤ 1.0 ft	≥ 0.75
Okay	MAE ≤ 1.5 ft	≥ 0.60
Poor	MAE > 1.5 ft	< 0.60

4.1 Surface Water Calibration

Measured water level and flow data for rivers and canals in the study area were obtained from Lee County, LA-MSID, SFWMD, and USGS. Station locations were obtained from coordinates and visual inspection of aerials.

4.1.1 Eastern Lee County

Surface water monitoring stations in Eastern Lee County are comprised of LA-MSID telemetry stations located at each water control structure. Table 17 provides a summary of the model performance based on the performance metrics. A map of the surface water calibration stations for East Lee County is shown in Figure 41. In addition, calibration plots for these stations (excluding the data points with monthly datasets) are shown in the preceding graphics. The monitoring station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 17. Model Performance for Surface Water Stations in Eastern Lee County

	Water Levels	Discharge
# of Gages	**57**	**1**
Good	47%	0%
Okay	28%	0%
Poor	25%	100%

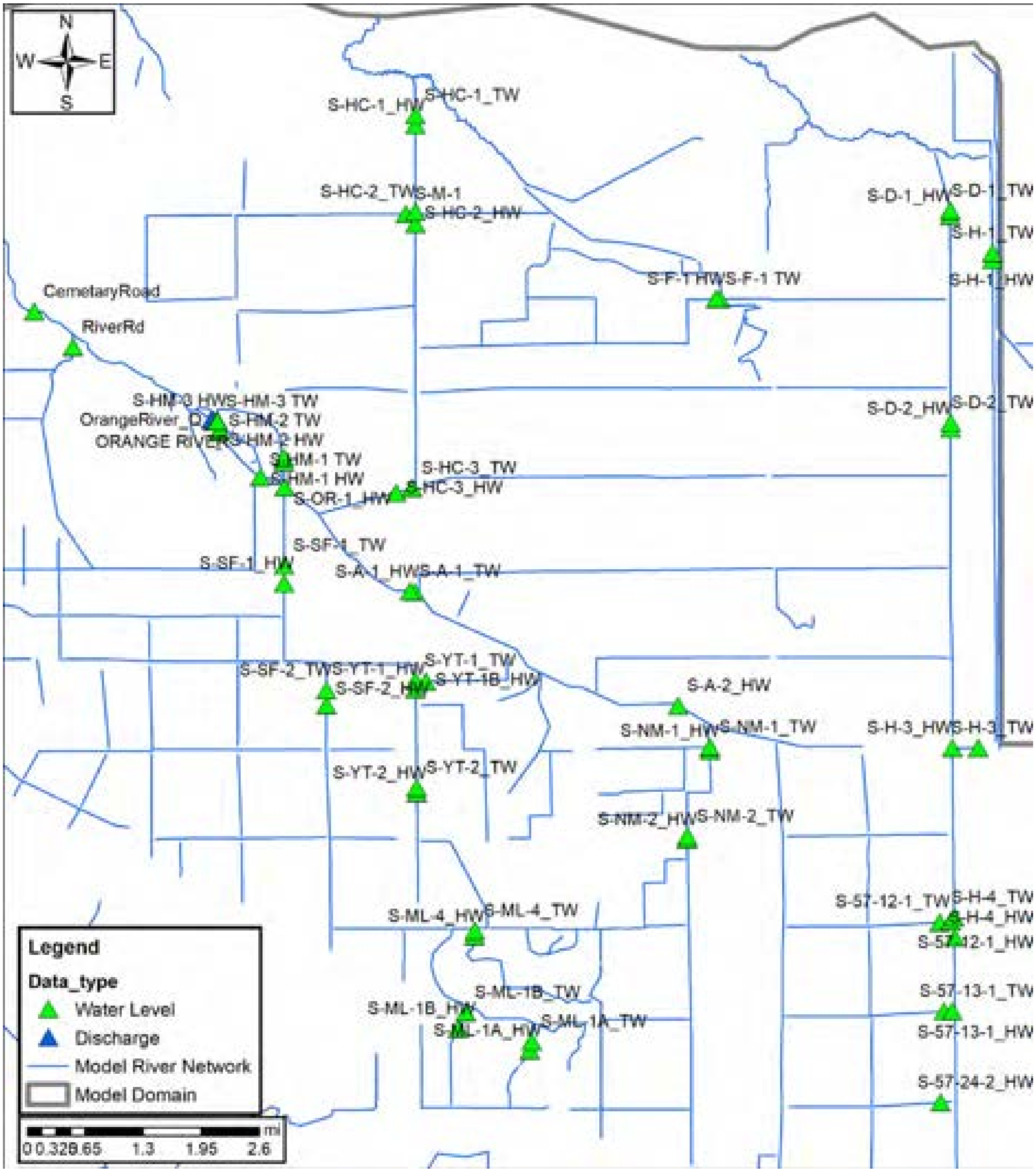
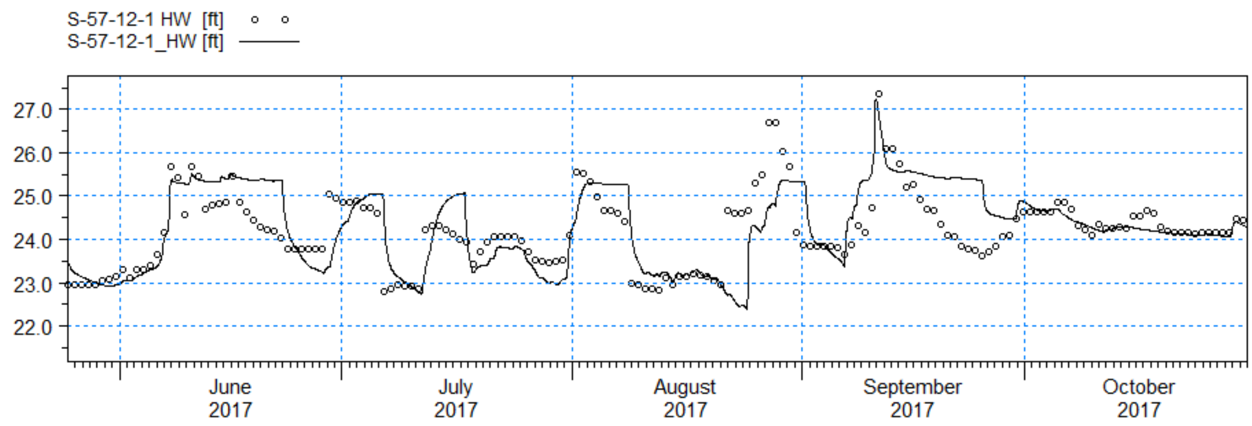
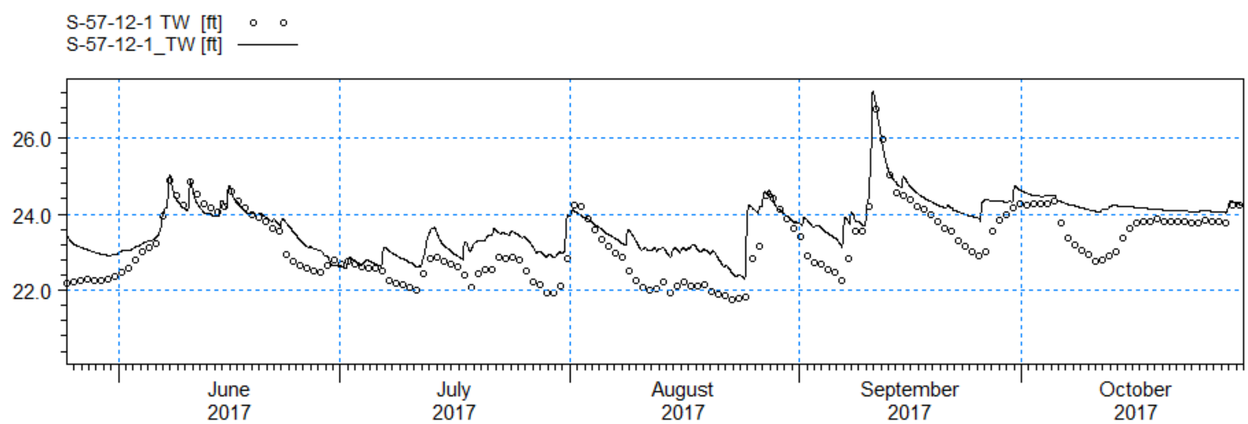
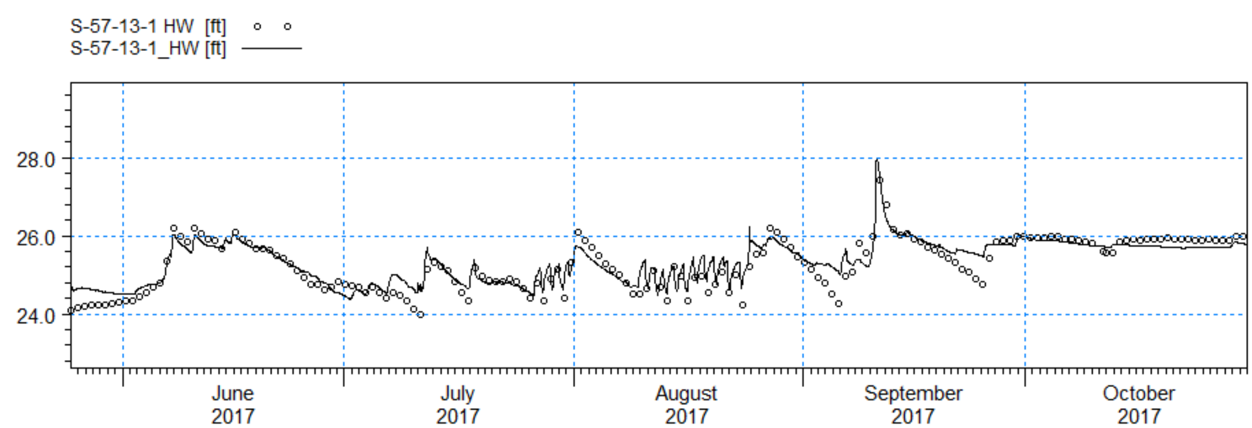
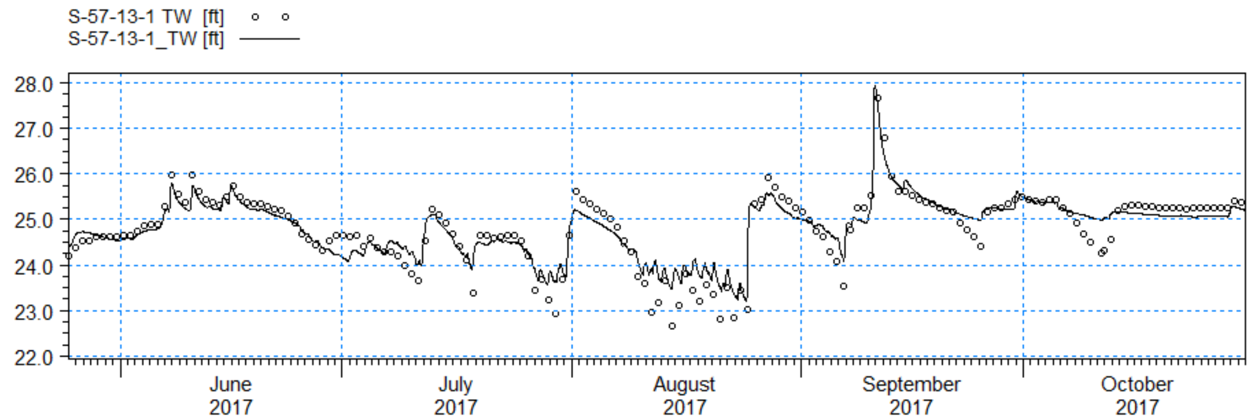


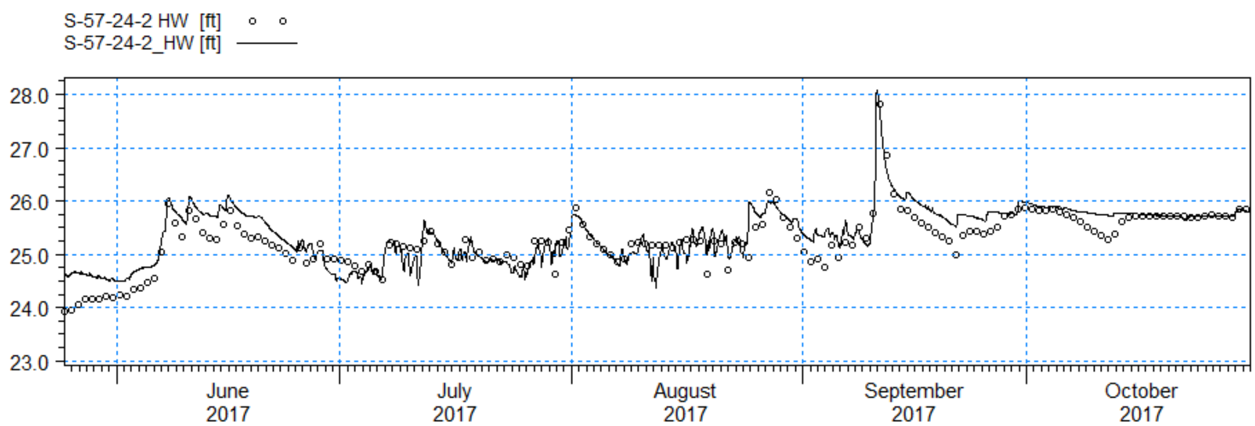
Figure 42. Surface Water Calibration Points for Eastern Lee County

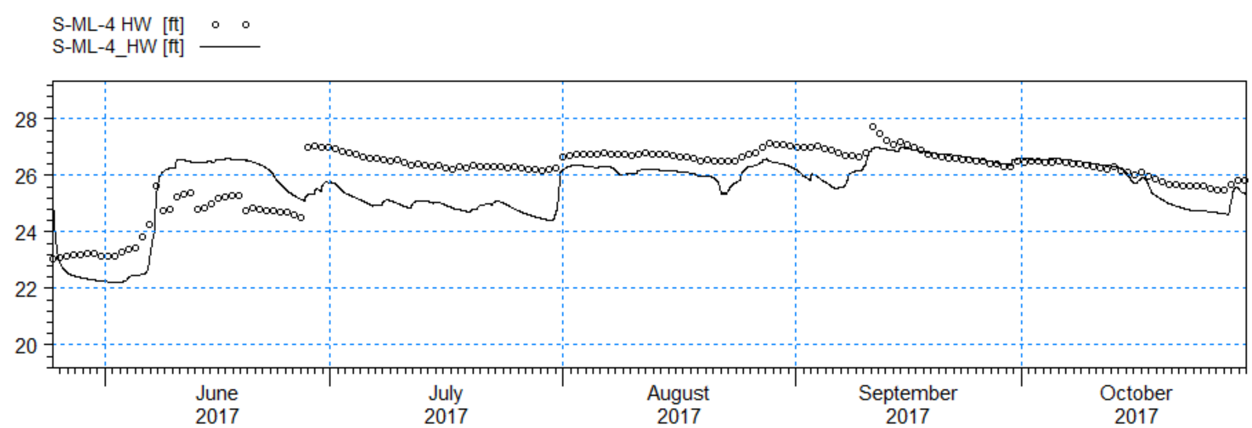

S-57-12-1 HW [ft]
S-57-12-1_HW [ft]
27.0
26.0
25.0
24.0
23.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017

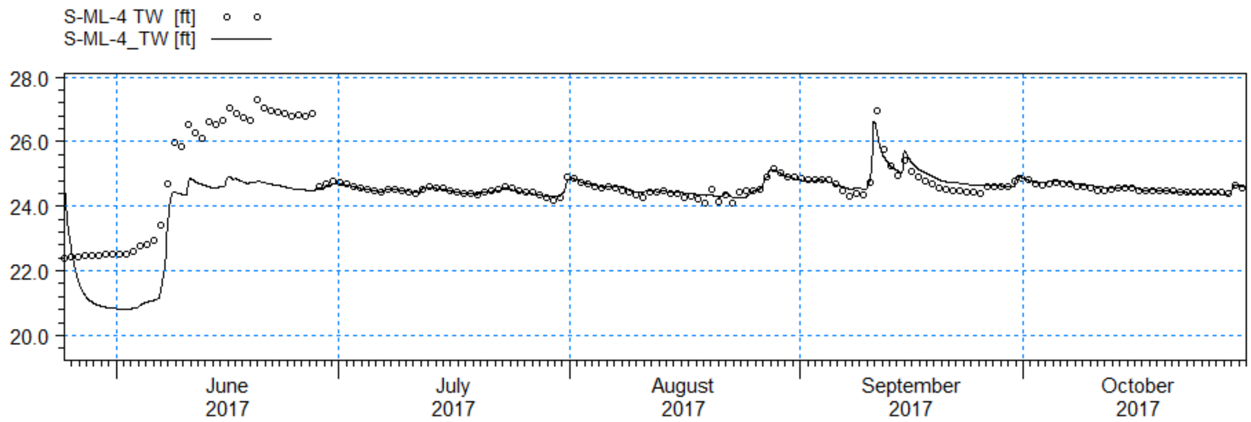

S-57-12-1 TW [ft]
S-57-12-1_TW [ft]
26.0
24.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017

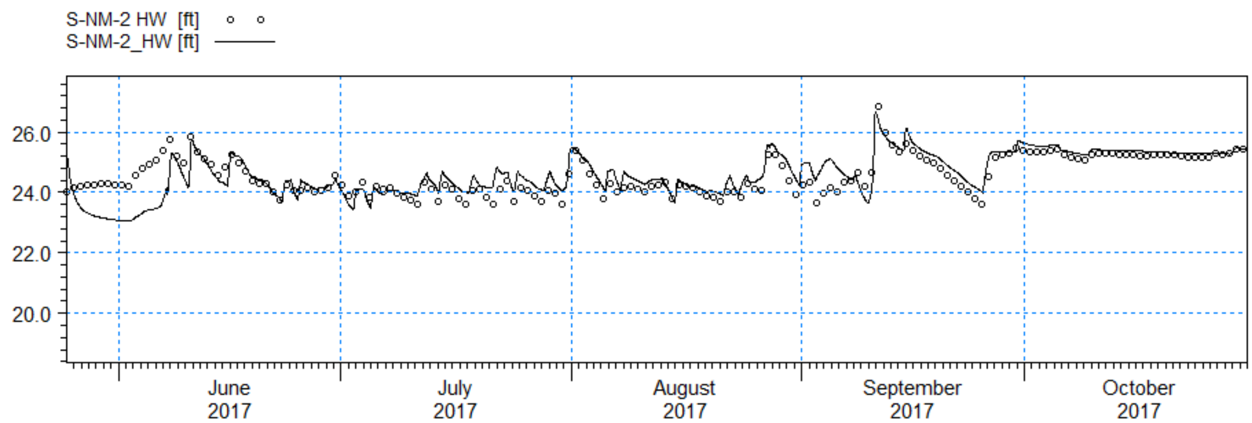

S-57-13-1 HW [ft]
S-57-13-1_HW [ft]
28.0
26.0
24.0
June 2017
July 2017
August 2017
September 2017
October 2017

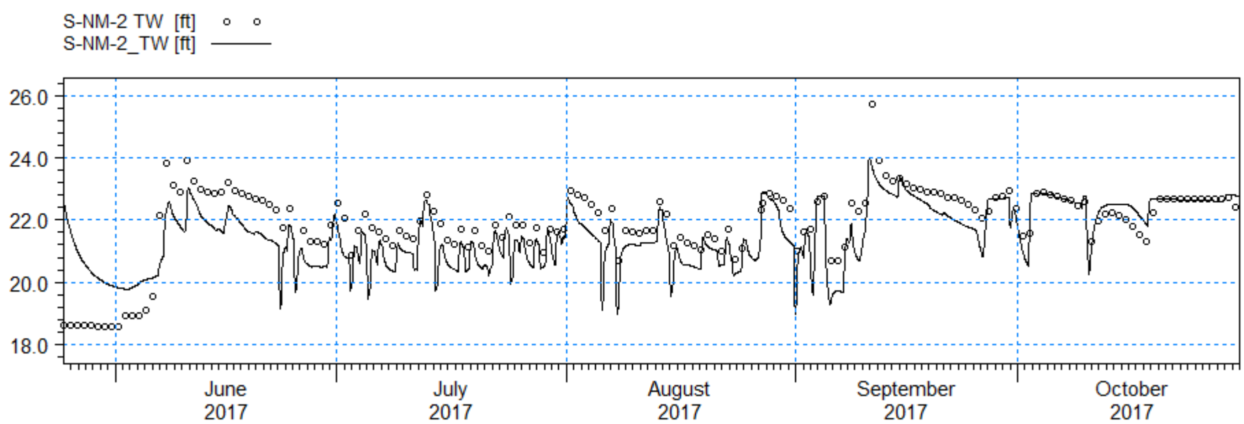

S-57-13-1 TW [ft]
S-57-13-1_TW [ft]
28.0
27.0
26.0
25.0
24.0
23.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017

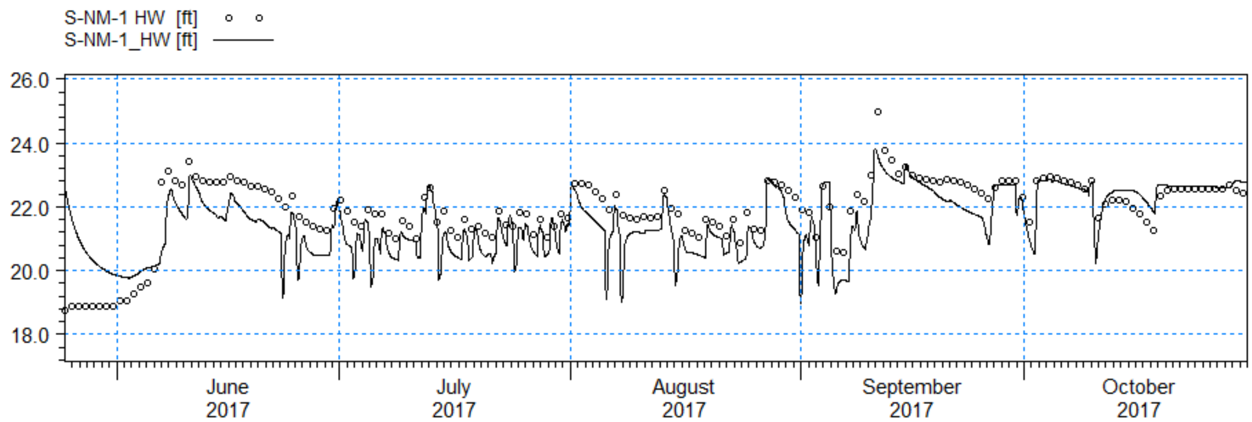

S-57-24-2 HW [ft]
S-57-24-2_HW [ft]
28.0
27.0
26.0
25.0
24.0
23.0
June 2017
July 2017
August 2017
September 2017
October 2017

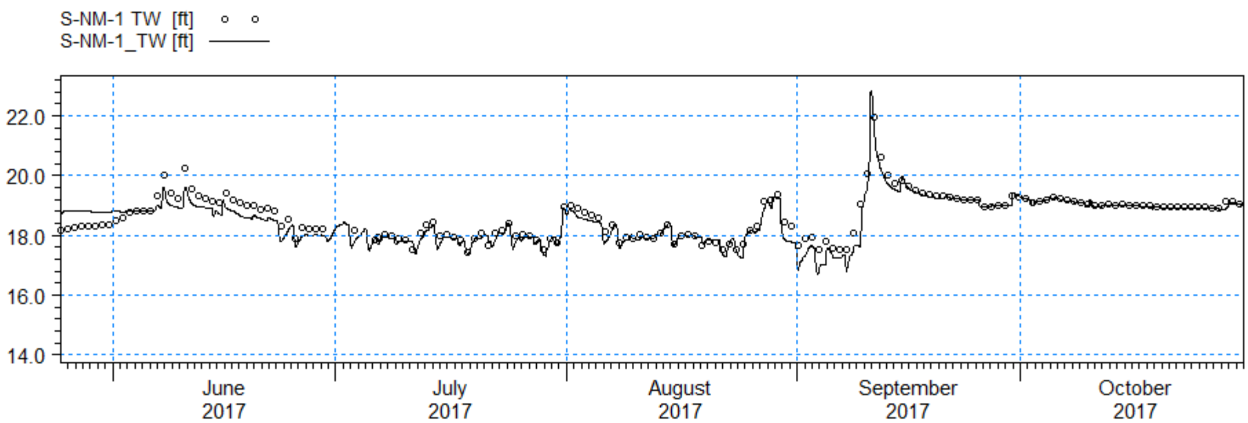

S-ML-4 HW [ft]
S-ML-4_HW [ft]
28
26
24
22
20
June 2017
July 2017
August 2017
September 2017
October 2017

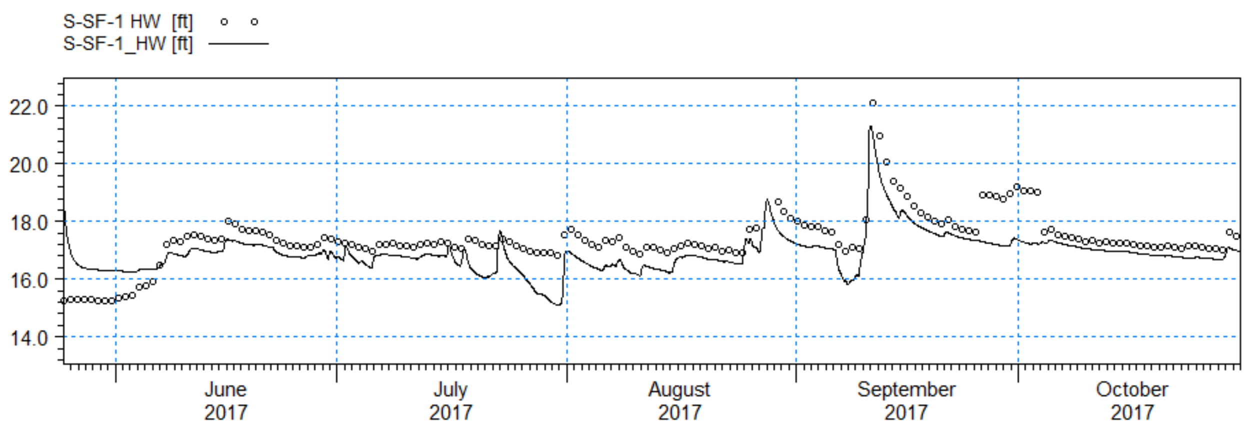

S-ML-4 TW [ft]
S-ML-4_TW [ft]
28.0
26.0
24.0
22.0
20.0
June 2017
July 2017
August 2017
September 2017
October 2017

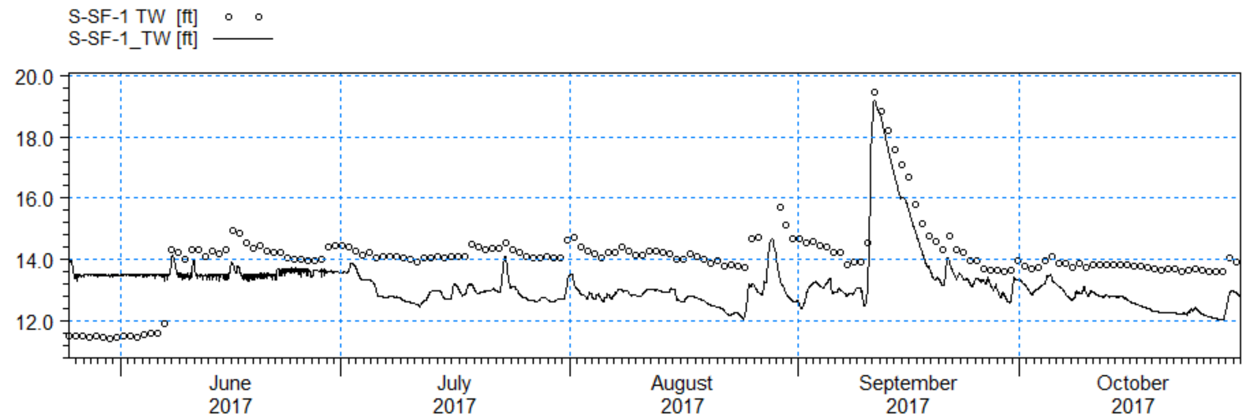

S-NM-2 HW [ft]
S-NM-2_HW [ft]
26.0
24.0
22.0
20.0
June 2017
July 2017
August 2017
September 2017
October 2017

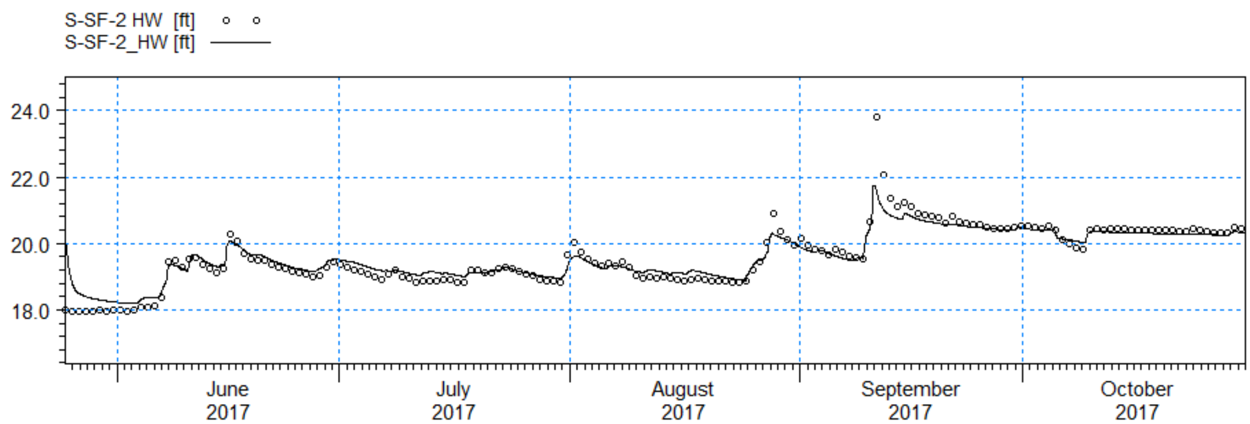

S-NM-2 TW [ft]
S-NM-2_TW [ft]
26.0
24.0
22.0
20.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

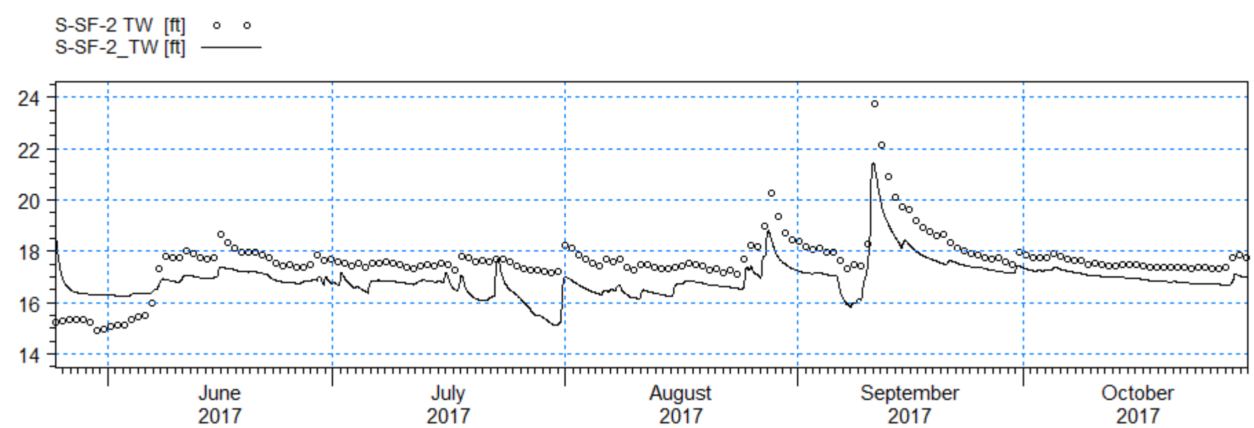

S-NM-1 HW [ft]
S-NM-1_HW [ft]
26.0
24.0
22.0
20.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

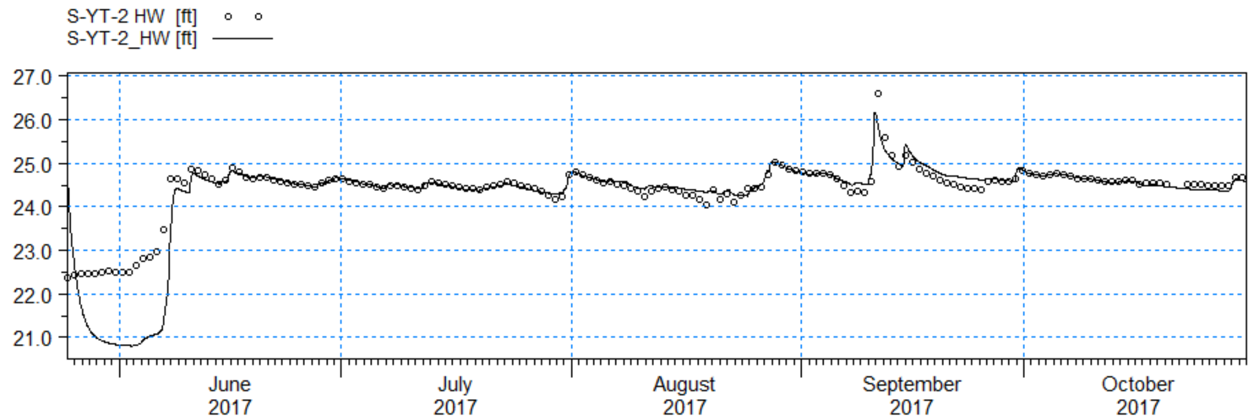

S-NM-1 TW [ft]
S-NM-1_TW [ft]
22.0
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

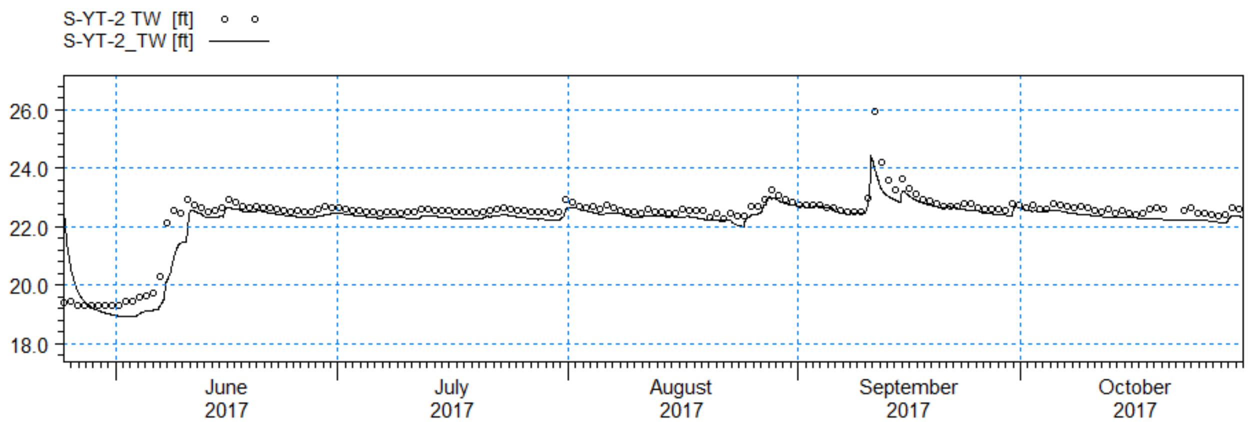

S-SF-1 HW [ft]
S-SF-1_HW [ft]
22.0
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

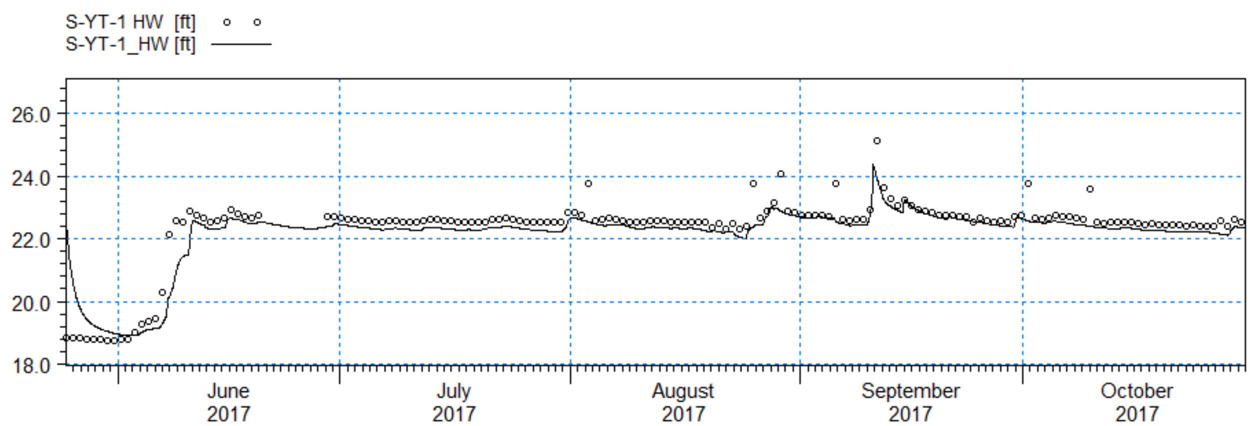

S-SF-1 TW [ft]
S-SF-1_TW [ft]
20.0
18.0
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

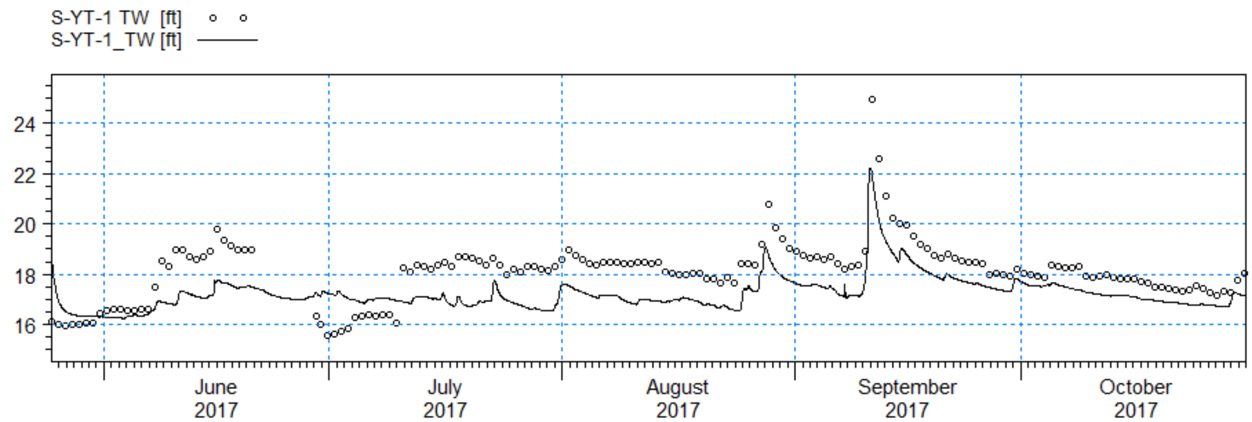

S-SF-2 HW [ft]
S-SF-2_HW [ft]
24.0
22.0
20.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

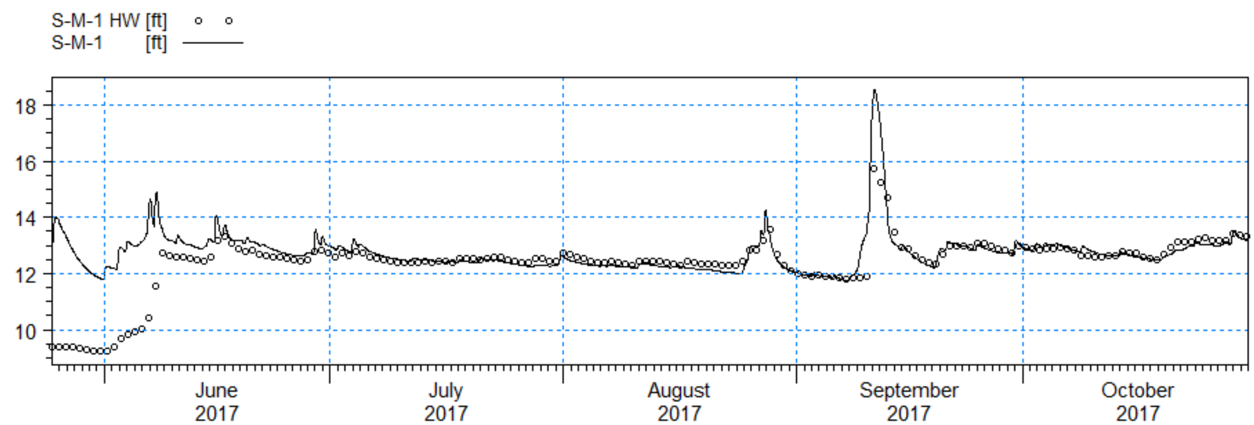

S-SF-2 TW [ft]
S-SF-2_TW [ft]
24
22
20
18
16
14
June 2017
July 2017
August 2017
September 2017
October 2017

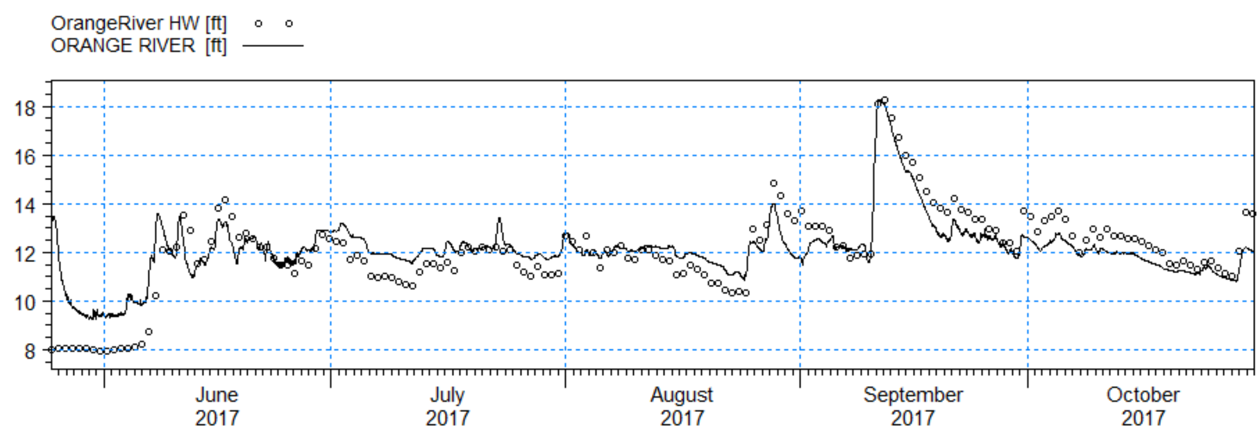

S-YT-2 HW [ft]
S-YT-2_HW [ft]
27.0
26.0
25.0
24.0
23.0
22.0
21.0
June 2017
July 2017
August 2017
September 2017
October 2017

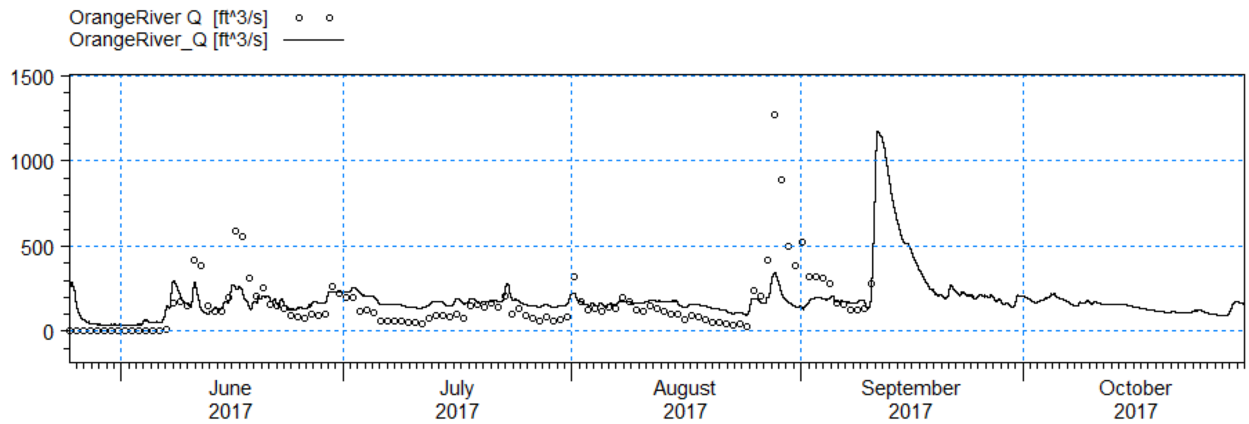

S-YT-2 TW [ft]
S-YT-2_TW [ft]
26.0
24.0
22.0
20.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

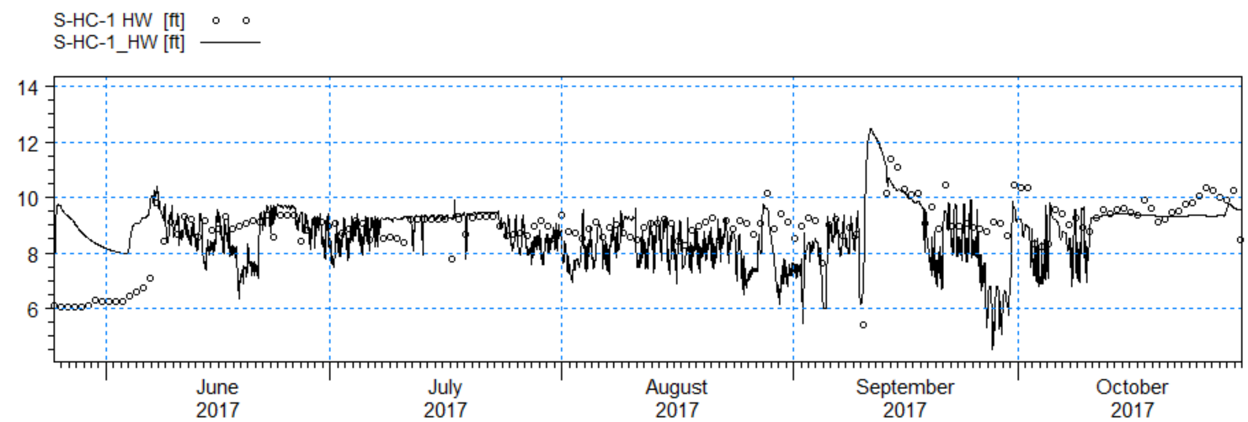

S-YT-1 HW [ft]
S-YT-1_HW [ft]
26.0
24.0
22.0
20.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

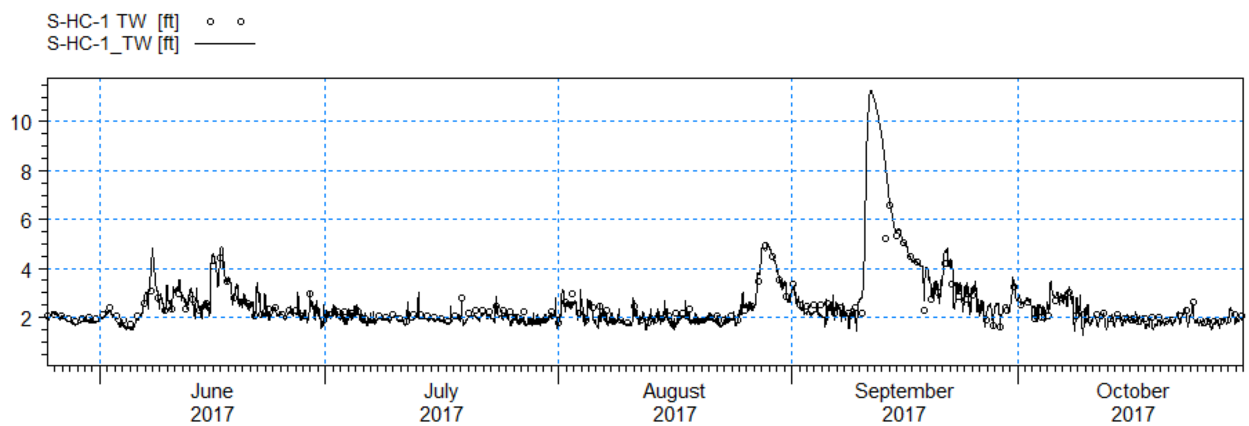

S-YT-1 TW [ft]
S-YT-1_TW [ft]
24
22
20
18
16
June 2017
July 2017
August 2017
September 2017
October 2017

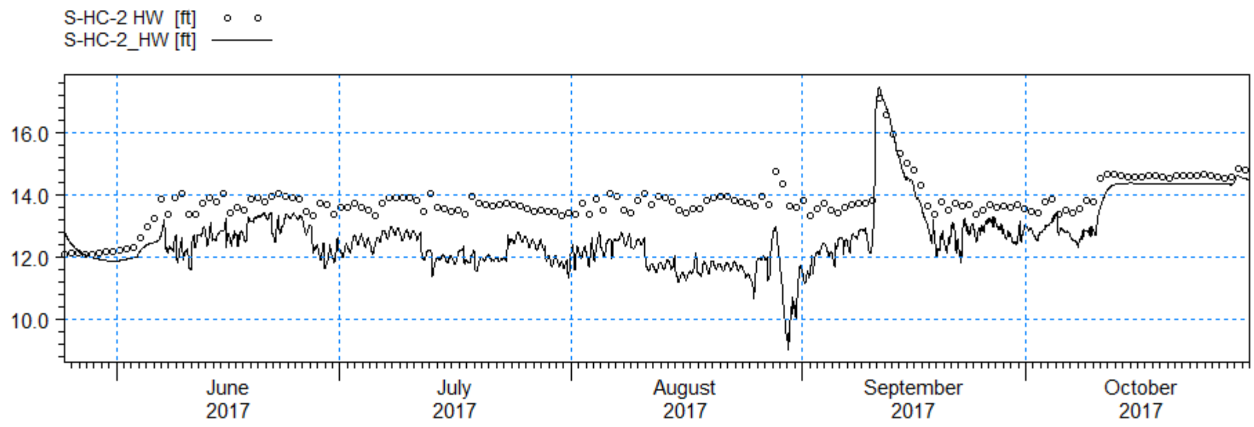

S-M-1 HW [ft]
S-M-1 [ft]
18
16
14
12
10
June 2017
July 2017
August 2017
September 2017
October 2017

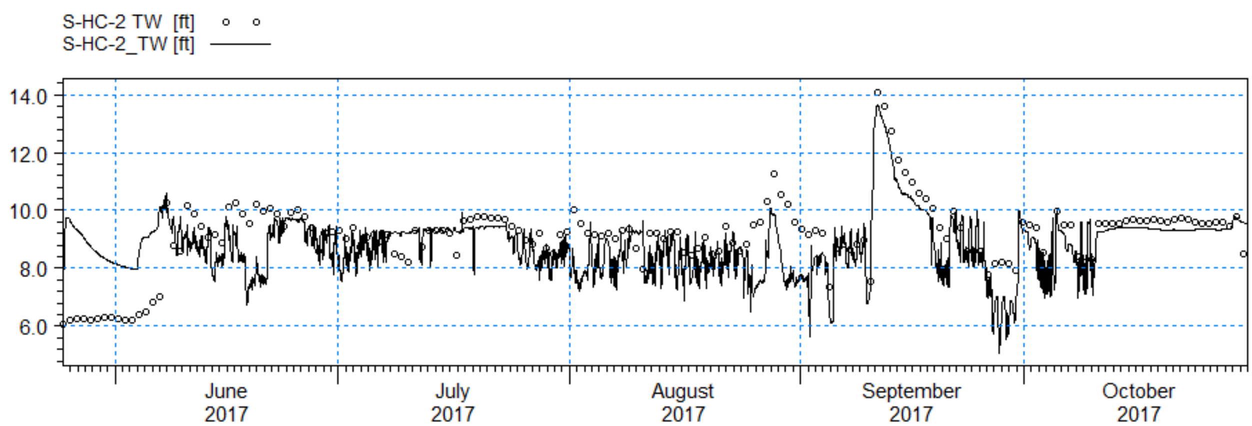

OrangeRiver HW [ft]
ORANGE RIVER [ft]
18
16
14
12
10
8
June 2017
July 2017
August 2017
September 2017
October 2017

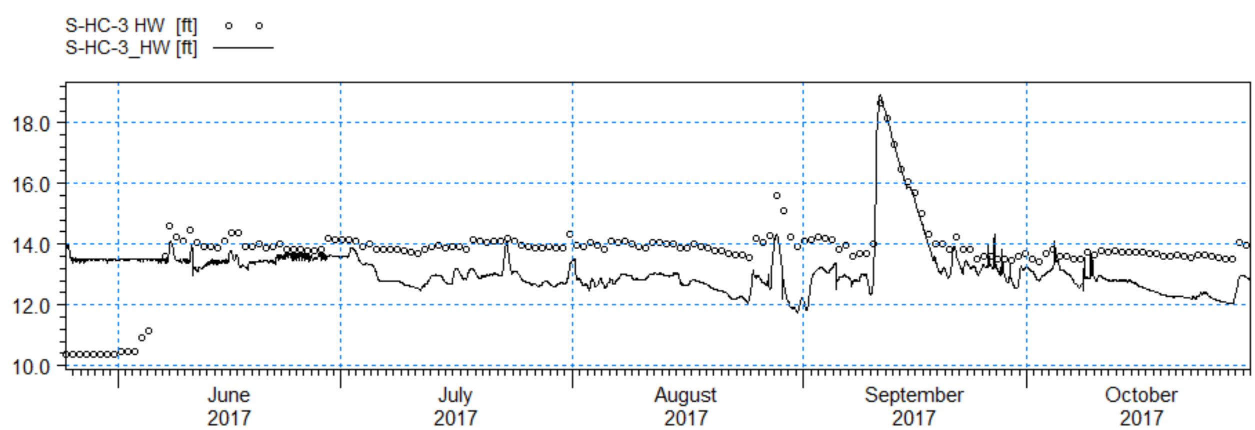

OrangeRiver Q [ft^3/s]
OrangeRiver_Q [ft^3/s]
1500
1000
500
0
June 2017
July 2017
August 2017
September 2017
October 2017

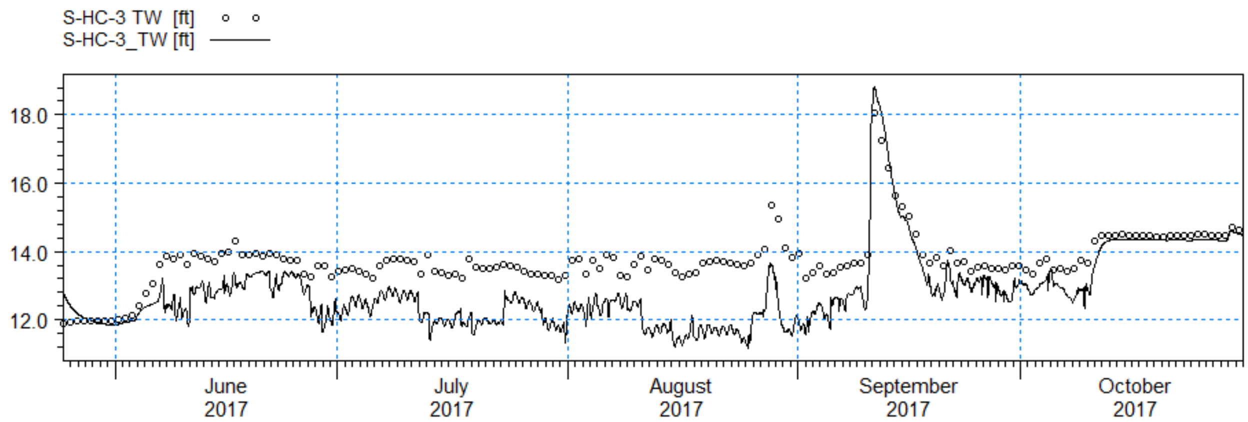

S-HC-1 HW [ft]
S-HC-1_HW [ft]
14
12
10
8
6
June 2017
July 2017
August 2017
September 2017
October 2017

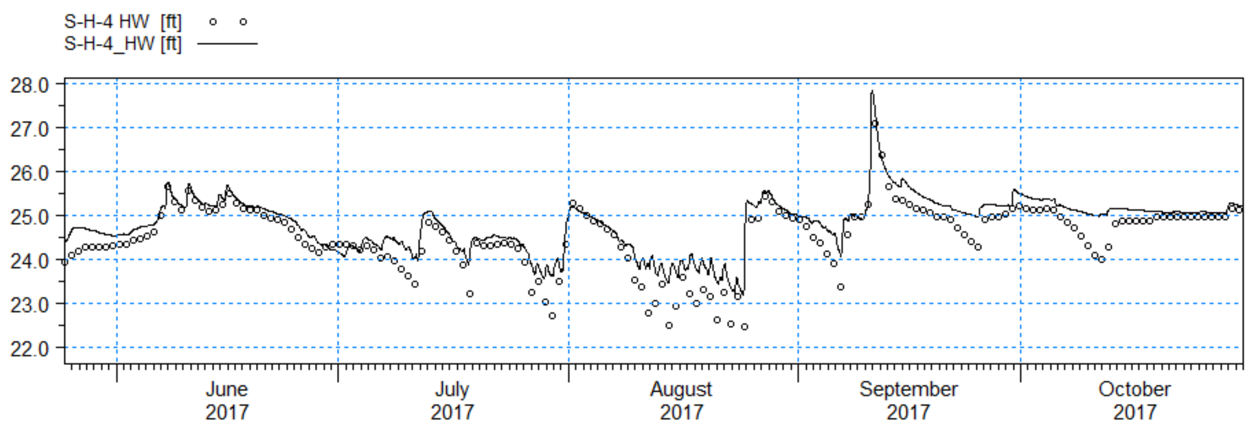

S-HC-1 TW [ft]
S-HC-1_TW [ft]
10
8
6
4
2
June 2017
July 2017
August 2017
September 2017
October 2017

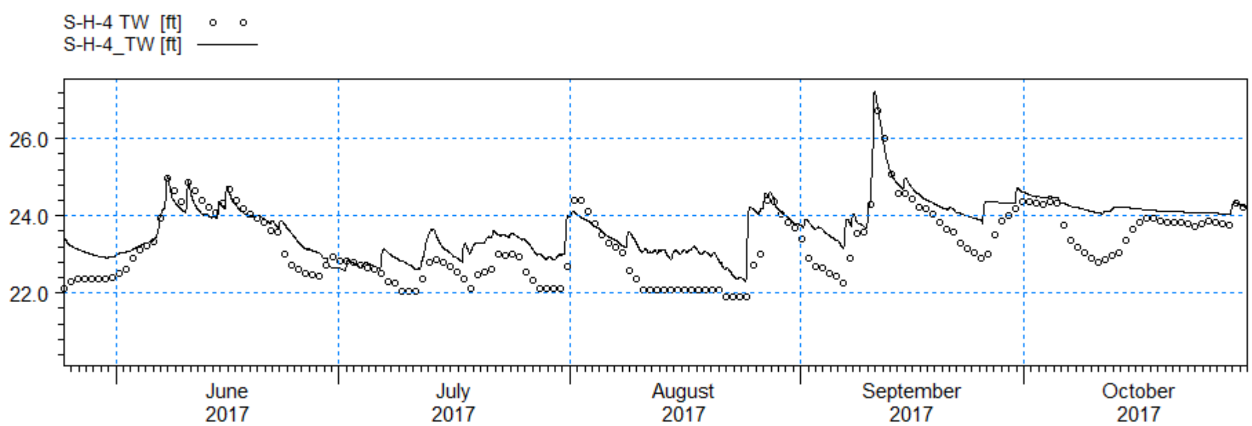

S-HC-2 HW [ft]
S-HC-2_HW [ft]
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

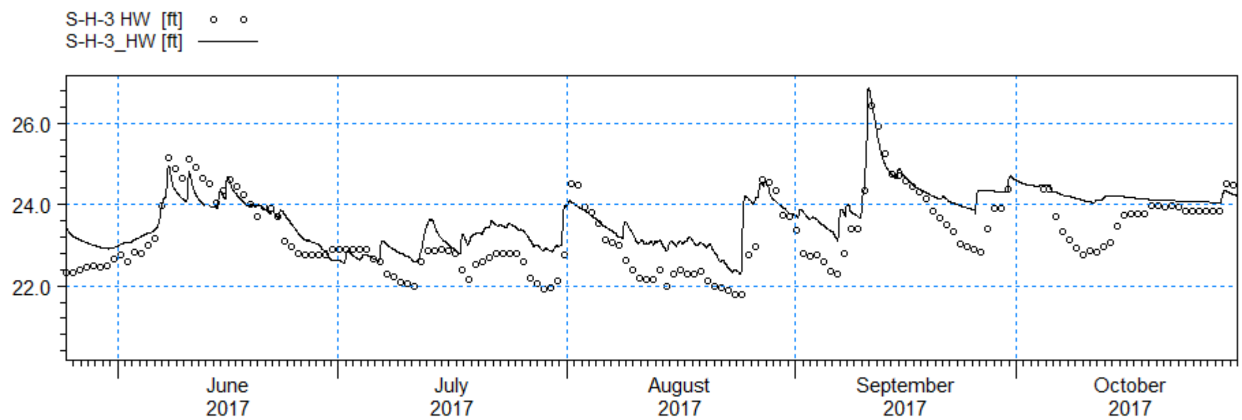

S-HC-2 TW [ft]
S-HC-2_TW [ft]
14.0
12.0
10.0
8.0
6.0
June 2017
July 2017
August 2017
September 2017
October 2017

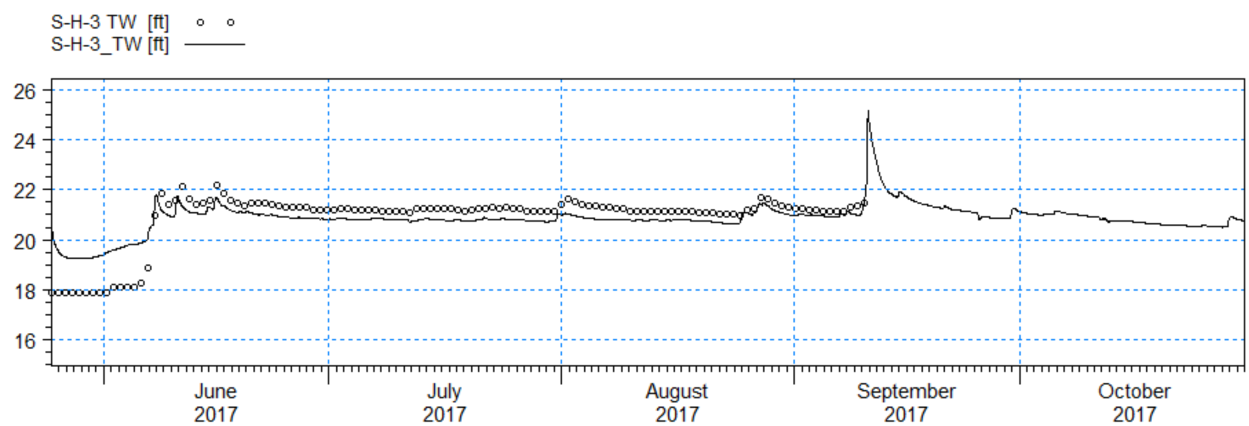

S-HC-3 HW [ft]
S-HC-3_HW [ft]
18.0
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

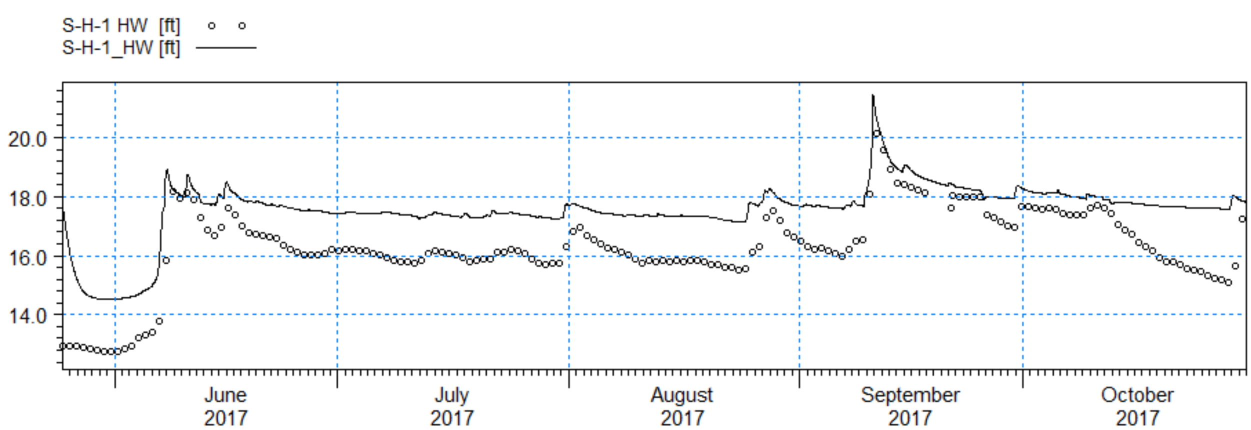

S-HC-3 TW [ft]
S-HC-3_TW [ft]
18.0
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

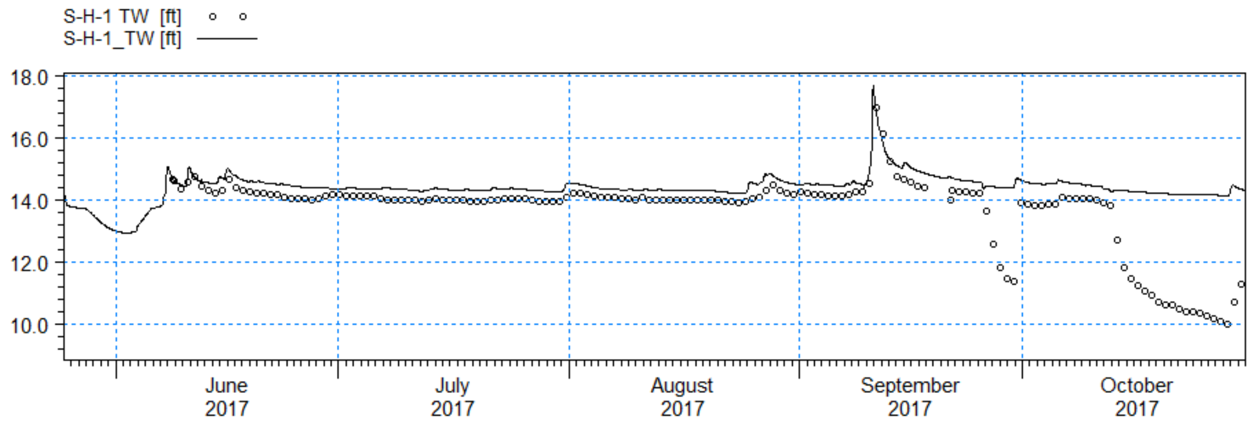

S-H-4 HW [ft]
S-H-4_HW [ft]
28.0
27.0
26.0
25.0
24.0
23.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017

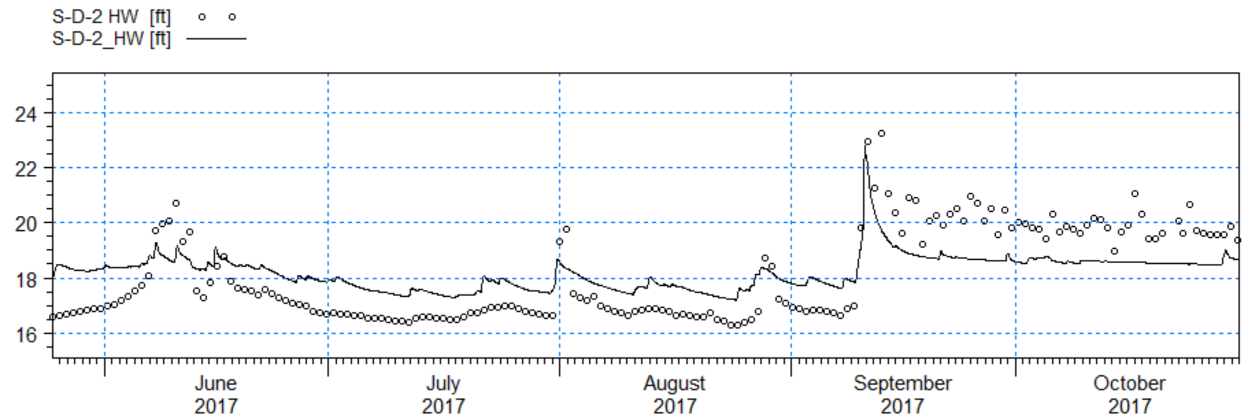

S-H-4 TW [ft]
S-H-4_TW [ft]
26.0
24.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017

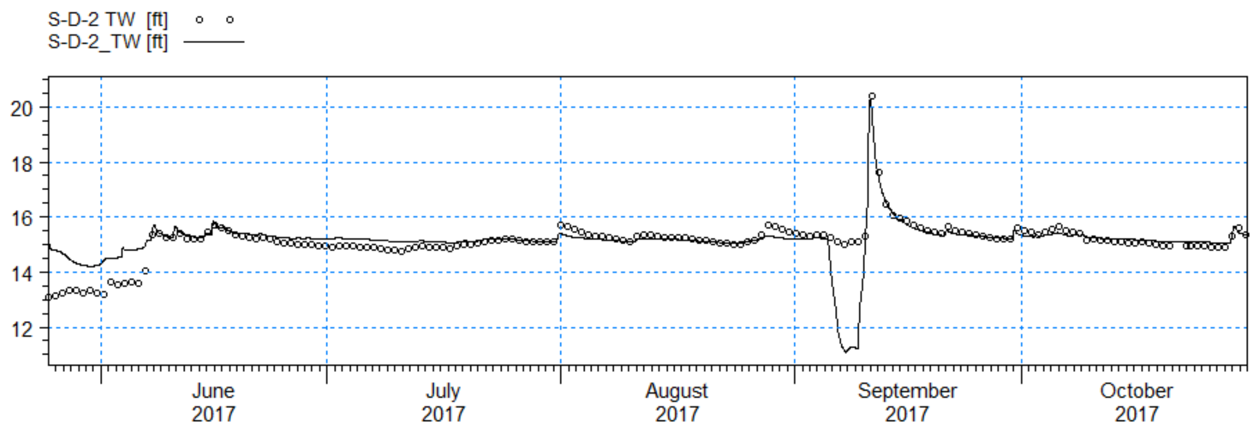

S-H-3 HW [ft]
S-H-3_HW [ft]
26.0
24.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017

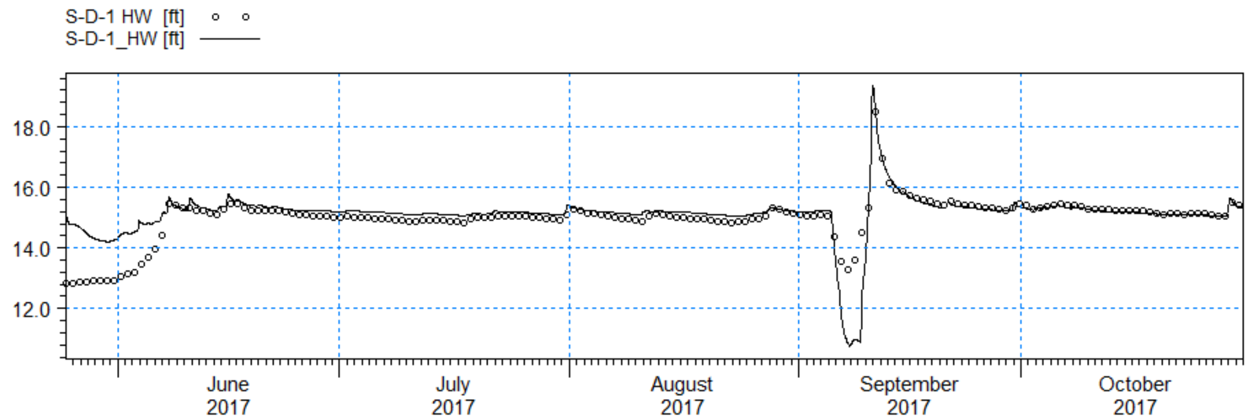

S-H-3 TW [ft]
S-H-3_TW [ft]
26
24
22
20
18
16
June 2017
July 2017
August 2017
September 2017
October 2017

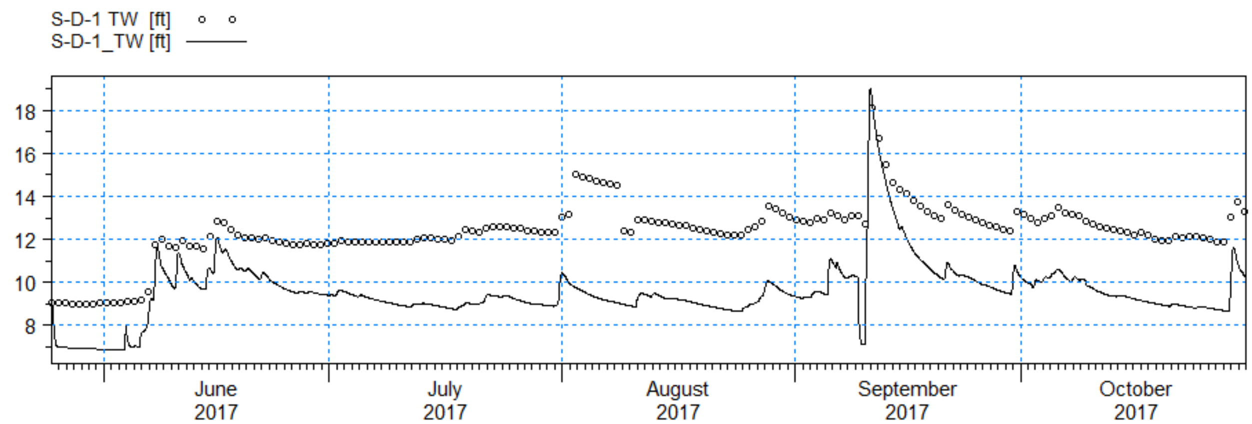

S-H-1 HW [ft]
S-H-1_HW [ft]
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

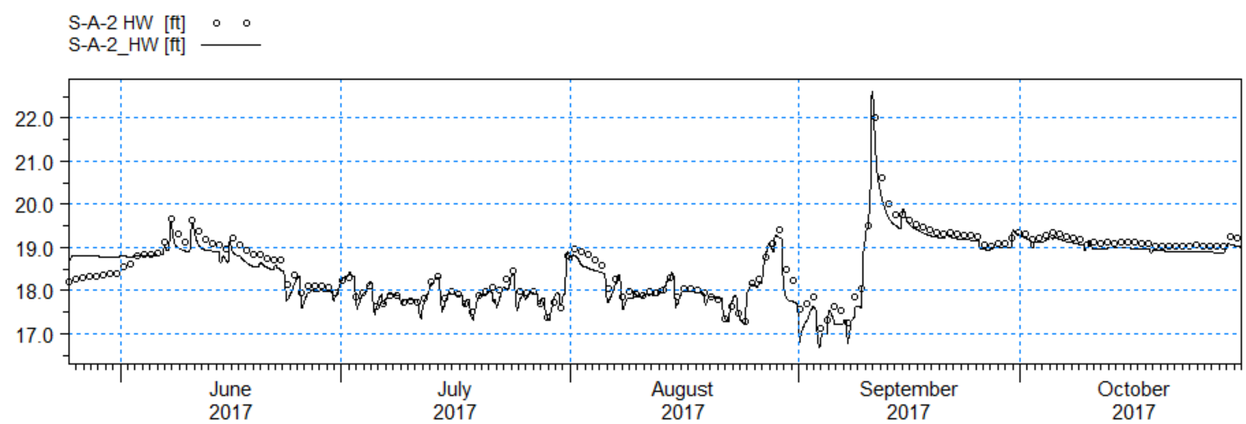

S-H-1 TW [ft]
S-H-1_TW [ft]
18.0
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

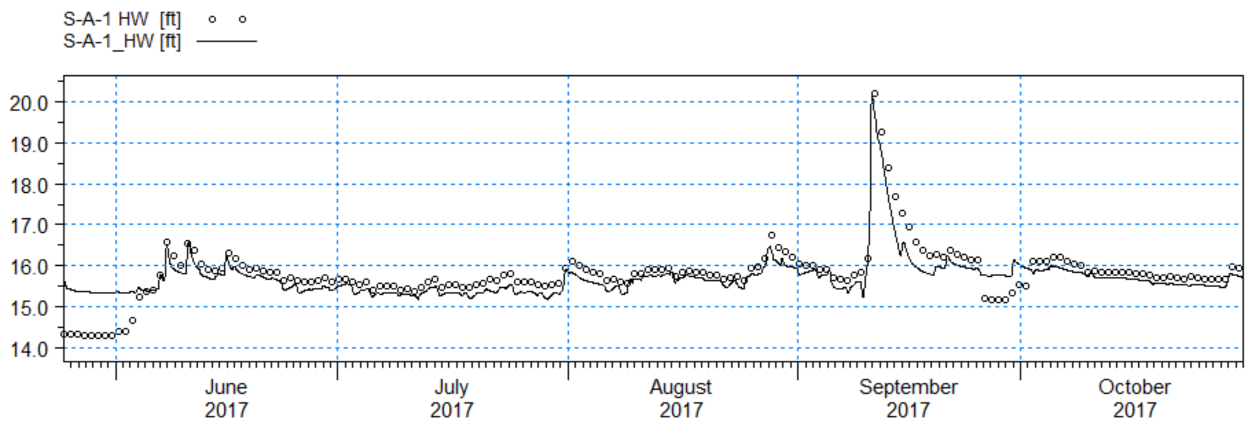

S-D-2 HW [ft]
S-D-2_HW [ft]
24
22
20
18
16
June 2017
July 2017
August 2017
September 2017
October 2017

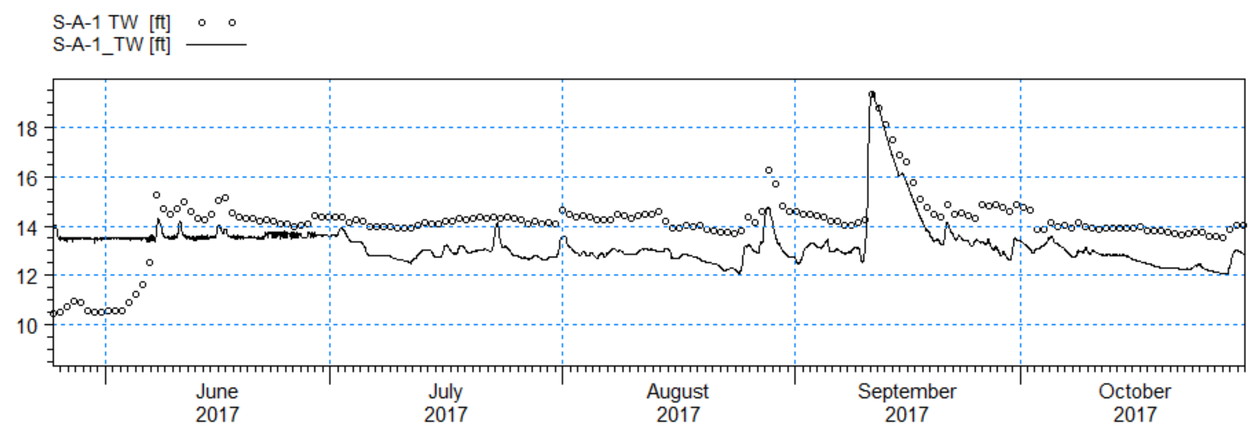

S-D-2 TW [ft]
S-D-2_TW [ft]
20
18
16
14
12
June 2017
July 2017
August 2017
September 2017
October 2017

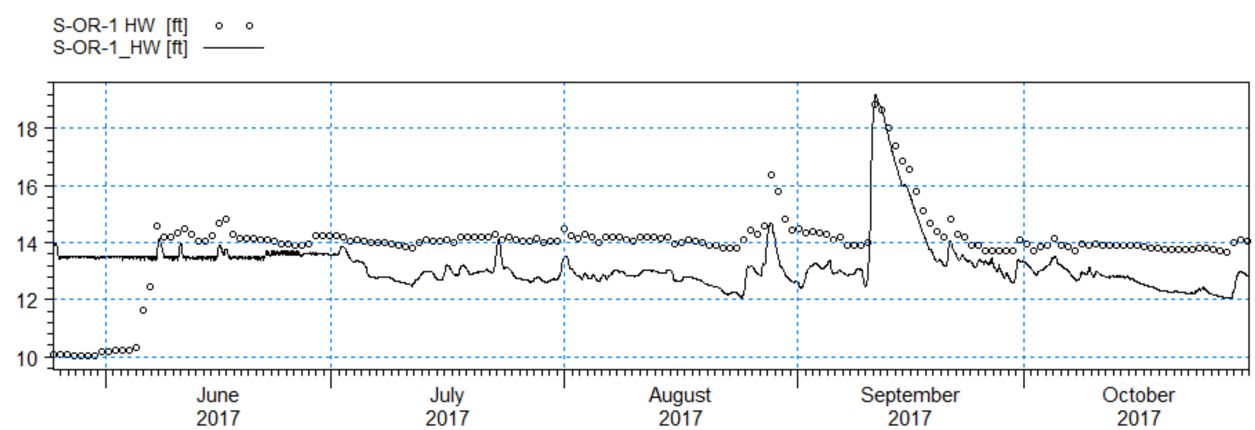

S-D-1 HW [ft]
S-D-1_HW [ft]
18.0
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

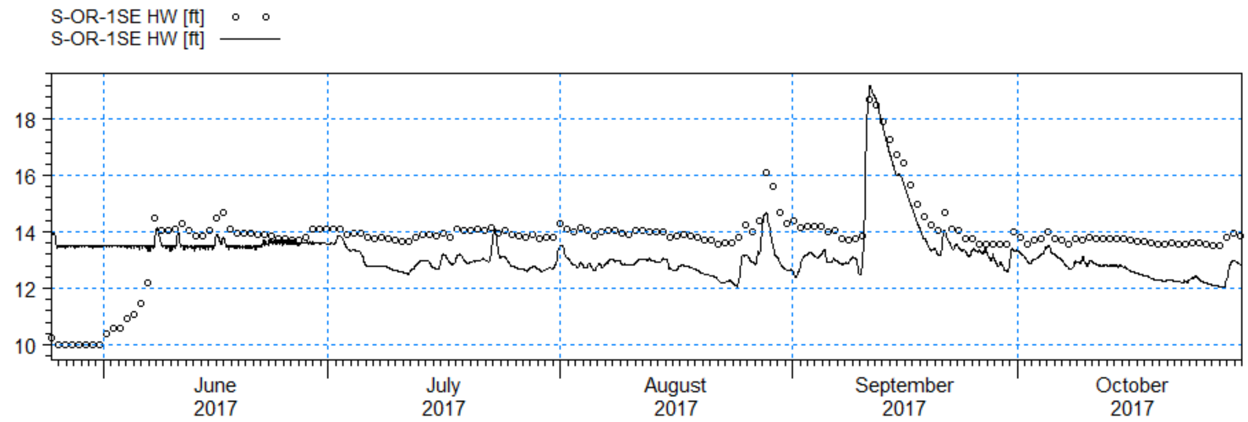

S-D-1 TW [ft]
S-D-1_TW [ft]
18
16
14
12
10
8
June 2017
July 2017
August 2017
September 2017
October 2017

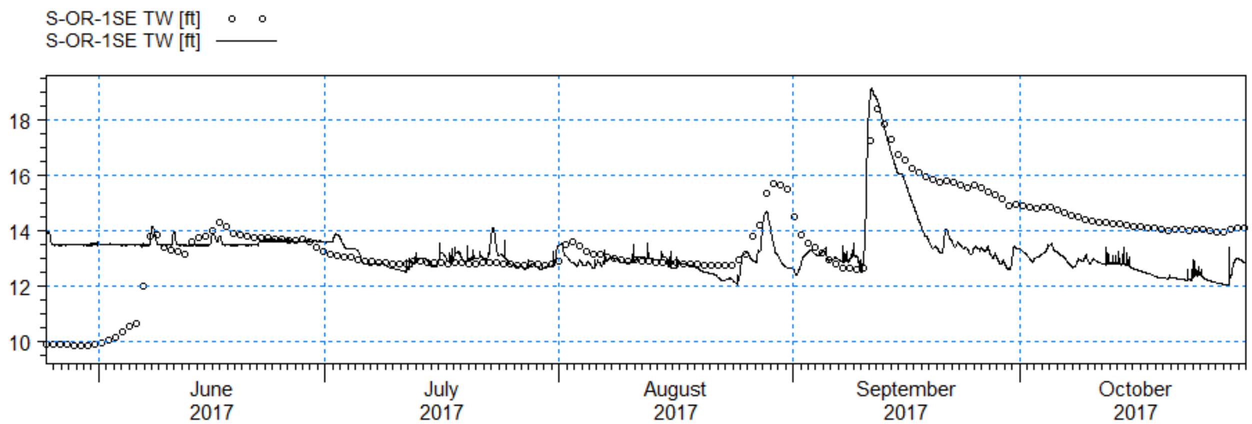

S-A-2 HW [ft]
S-A-2_HW [ft]
22.0
21.0
20.0
19.0
18.0
17.0
June 2017
July 2017
August 2017
September 2017
October 2017

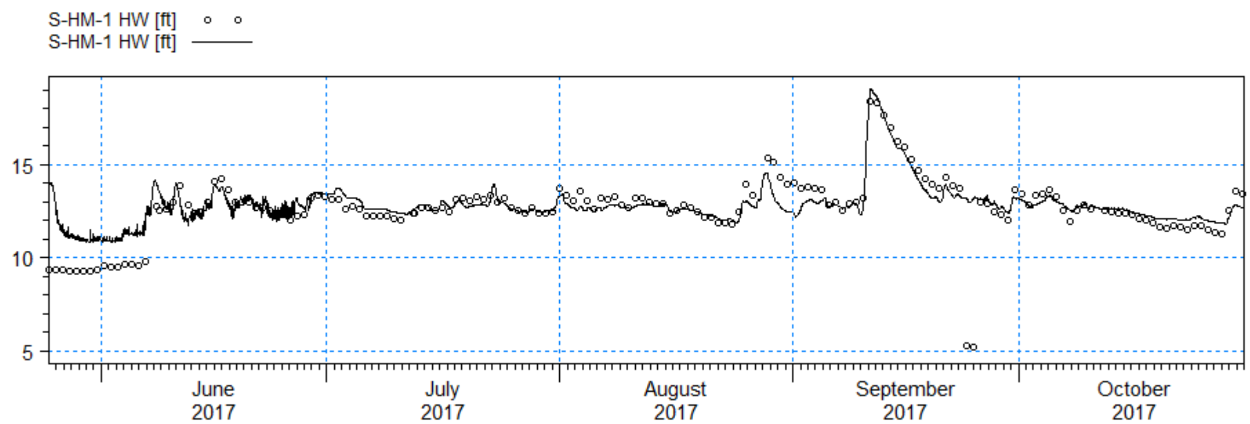

S-A-1 HW [ft]
S-A-1_HW [ft]
20.0
19.0
18.0
17.0
16.0
15.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

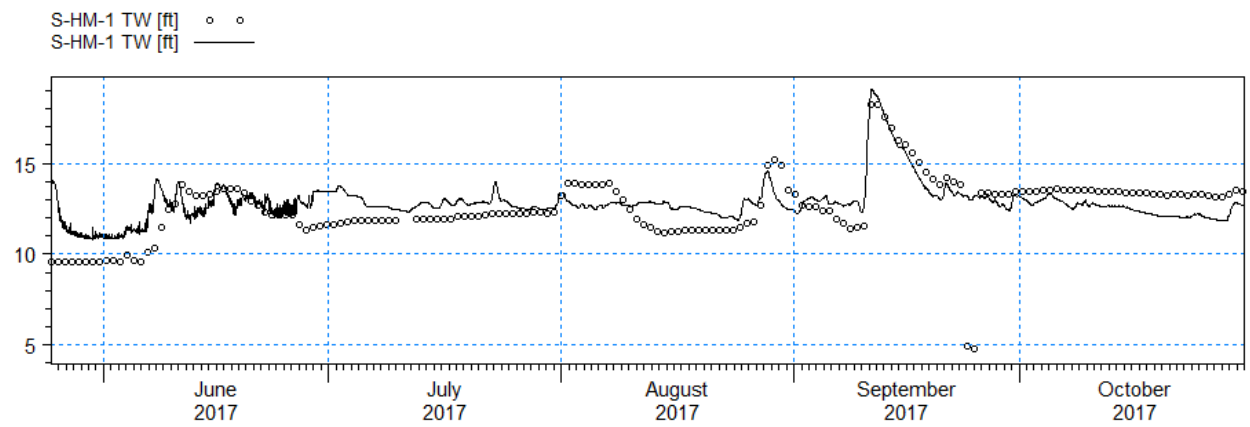

S-A-1 TW [ft]
S-A-1_TW [ft]
18
16
14
12
10
June 2017
July 2017
August 2017
September 2017
October 2017

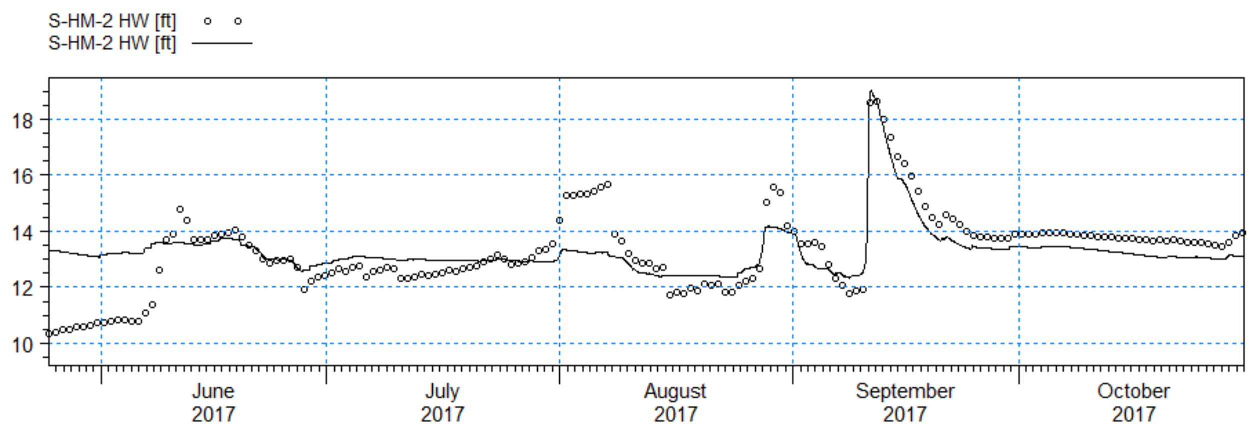

S-OR-1 HW [ft]
S-OR-1_HW [ft]
18
16
14
12
10
June 2017
July 2017
August 2017
September 2017
October 2017

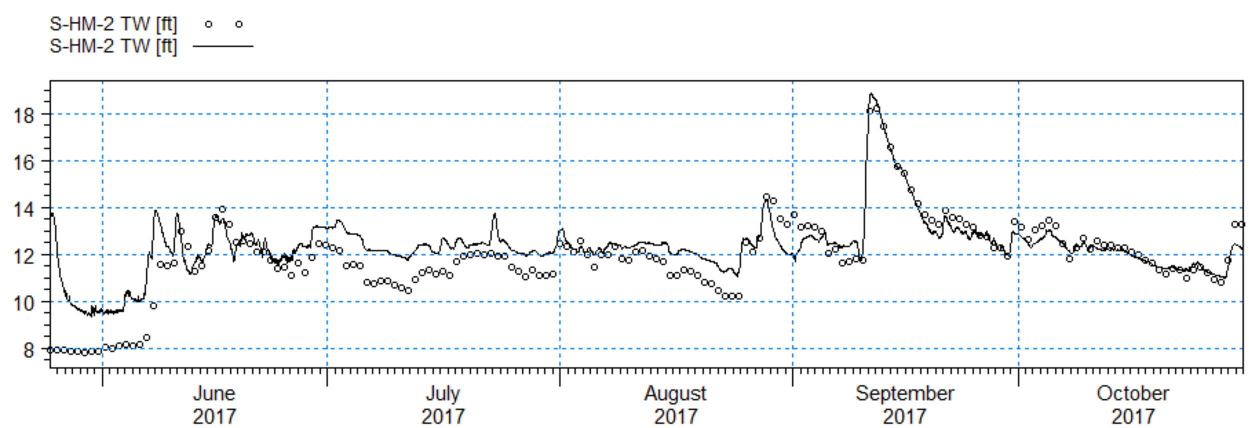

S-OR-1SE HW [ft]
S-OR-1SE HW [ft]
18
16
14
12
10
June 2017
July 2017
August 2017
September 2017
October 2017

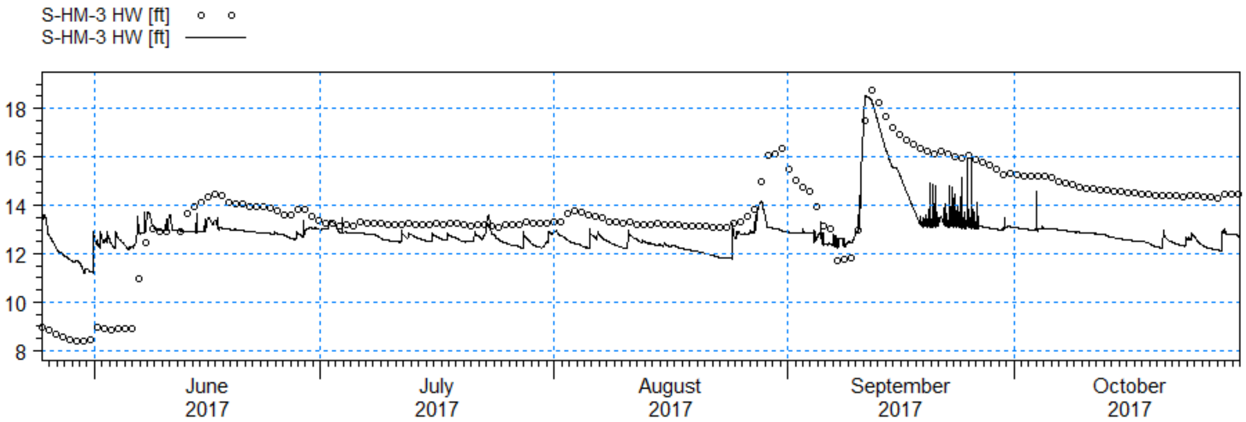

S-OR-1SE TW [ft]
S-OR-1SE TW [ft]
18
16
14
12
10
June 2017
July 2017
August 2017
September 2017
October 2017

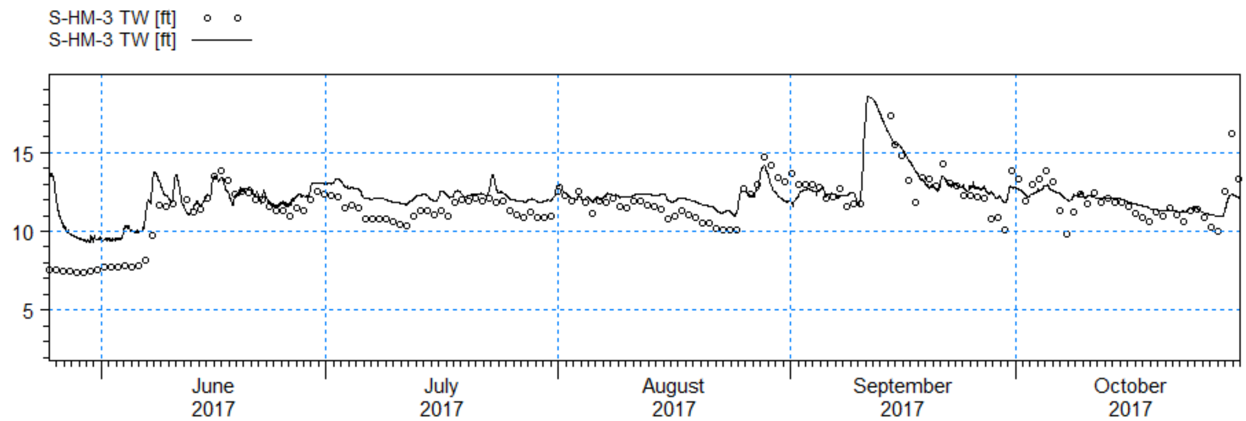

S-HM-1 HW [ft]
S-HM-1 HW [ft]
15
10
5
June 2017
July 2017
August 2017
September 2017
October 2017

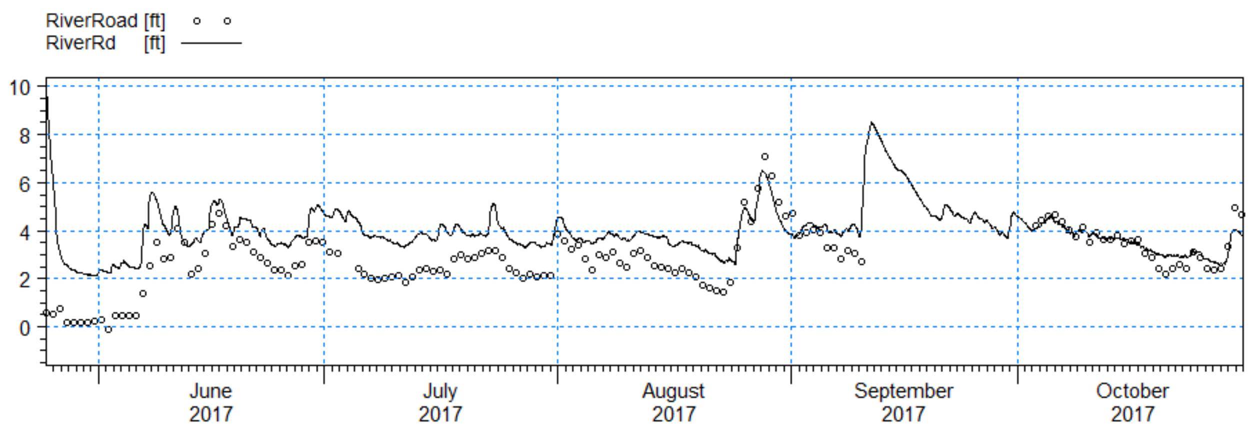

S-HM-1 TW [ft]
S-HM-1 TW [ft]
15
10
5
June 2017
July 2017
August 2017
September 2017
October 2017

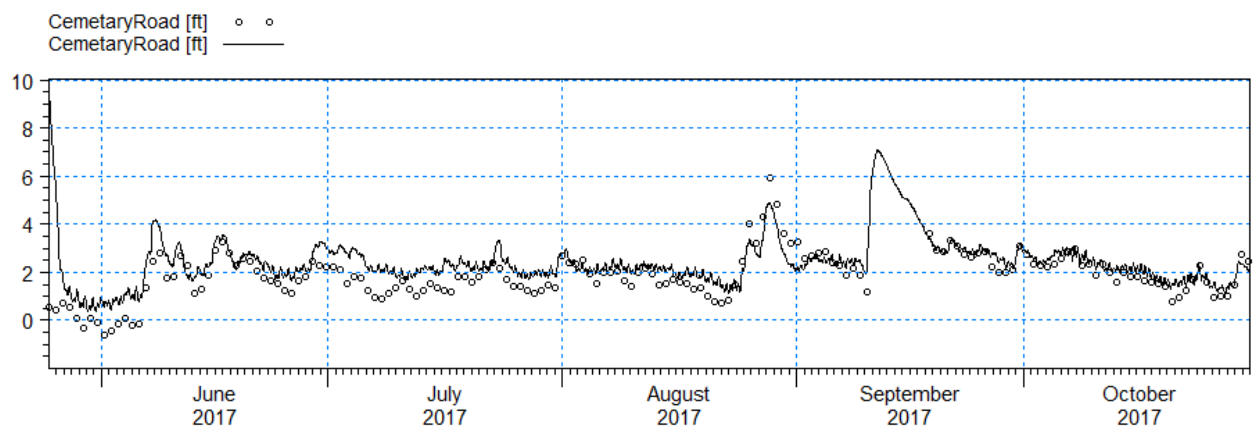

S-HM-2 HW [ft]
S-HM-2 HW [ft]
18
16
14
12
10
June 2017
July 2017
August 2017
September 2017
October 2017


S-HM-2 TW [ft]
S-HM-2 TW [ft]
18
16
14
12
10
8
June 2017
July 2017
August 2017
September 2017
October 2017


S-HM-3 HW [ft]
S-HM-3 HW [ft]
18
16
14
12
10
8
June 2017
July 2017
August 2017
September 2017
October 2017


S-HM-3 TW [ft]
S-HM-3 TW [ft]
15
10
5
June 2017
July 2017
August 2017
September 2017
October 2017


RiverRoad [ft]
RiverRd [ft]
10
8
6
4
2
0
June 2017
July 2017
August 2017
September 2017
October 2017



4.1.2 Whiskey Creek

There is only one monitoring station in the Whiskey Creek study area; water level and discharge is monitored at the L Canal gated water control structure. Table 18 provides a summary of the model performance for Whiskey Creek. There was no known gate operation data for this structure, however, there is evidence that this structure operated during the 2017 wet season. Further investigation of the measured water levels may provide insight as to the gate operations for this structure and improve calibration statistics for the water levels. A map of the Whiskey Creek monitoring station is shown in Figure 42. In addition, calibration plots for this station is shown in the preceding graphics. The monitoring station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 18.Model Performance for the Surface Water Station in Whiskey Creek

	Water Levels	Discharge
# of Gages	**1**	**1**
Good	0%	0%
Okay	100%	100%
Poor	0%	0%

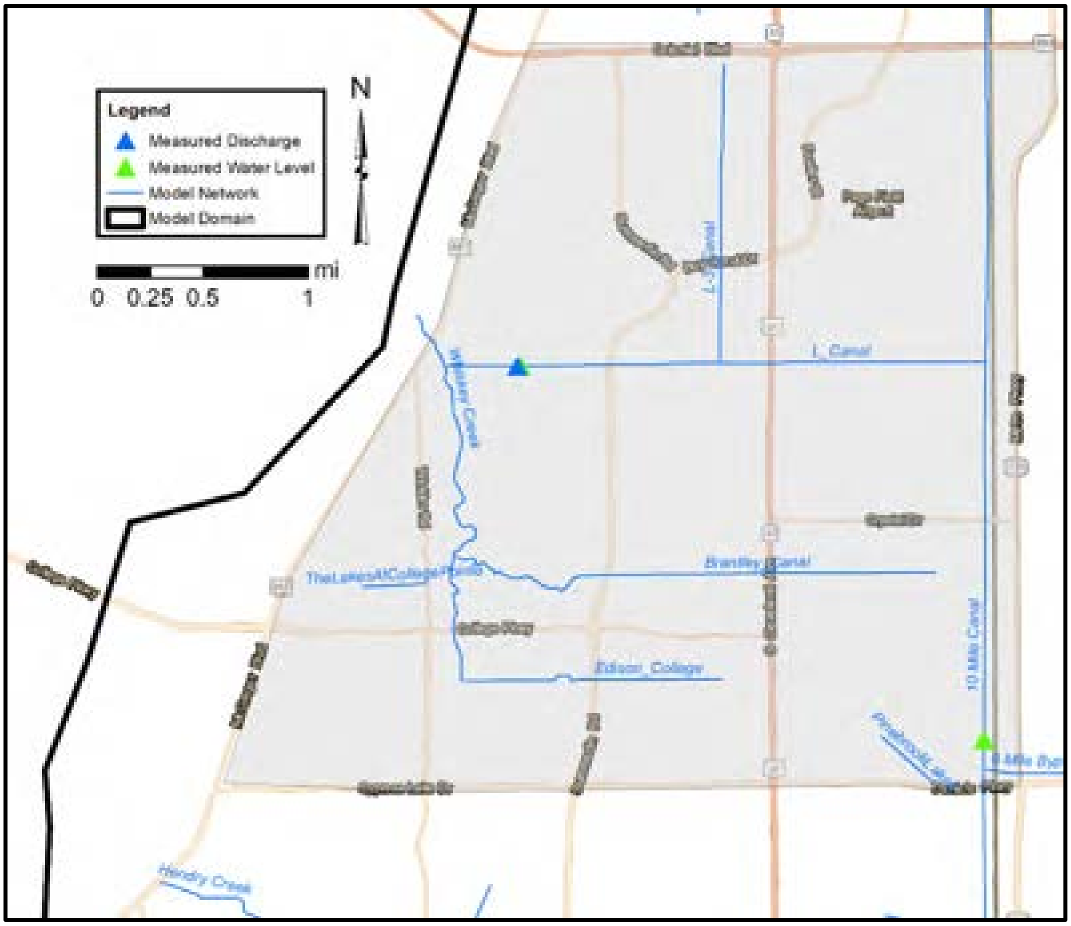
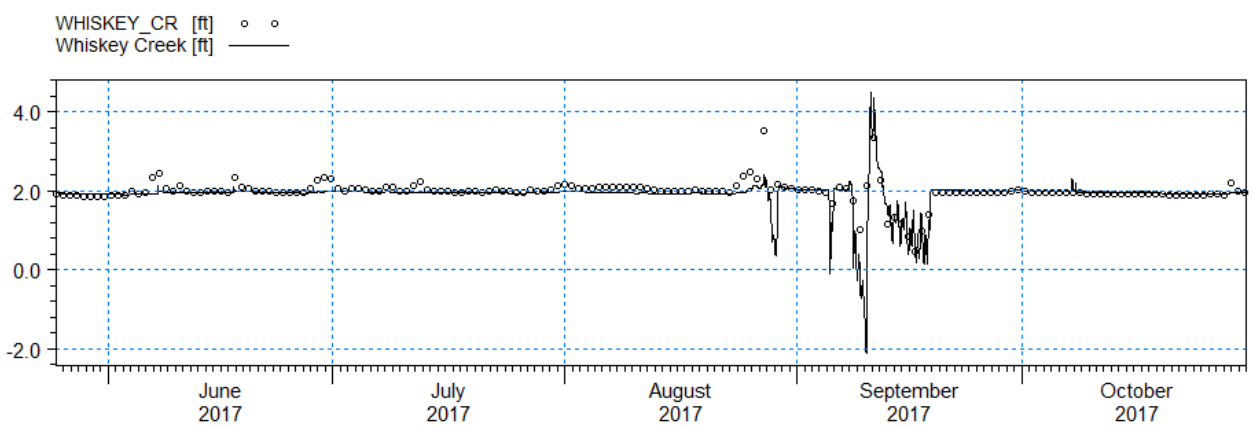
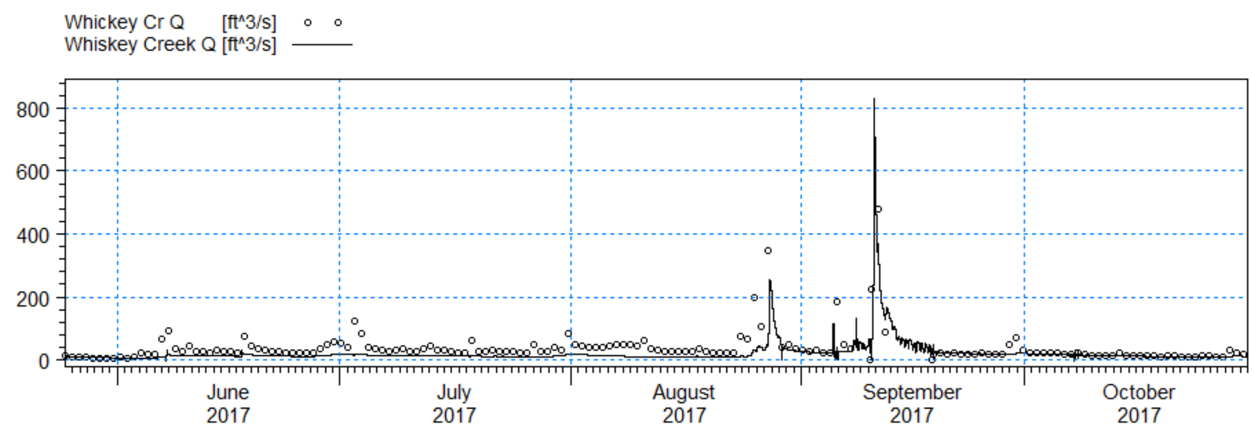


Figure 393. Surface Water Calibration Points for Whiskey Creek





4.1.3 South Fort Myers

There are six (6) stations in the South Ft. Myers study area. Table 19 provides a measure of the model performance for the surface water stations in the area. A map of the surface water calibration stations for South Ft Myers is shown in Figure 43. In addition, calibration plots for these stations (excluding the data points with monthly datasets) are shown in the preceding graphics. The monitoring station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 19. Model Performance for the Surface Water Stations in South Ft Myers

	Water Levels	Discharge
# of Gages	**10**	**3**
Good	80%	0%
Okay	10%	67%
Poor	10%	33%

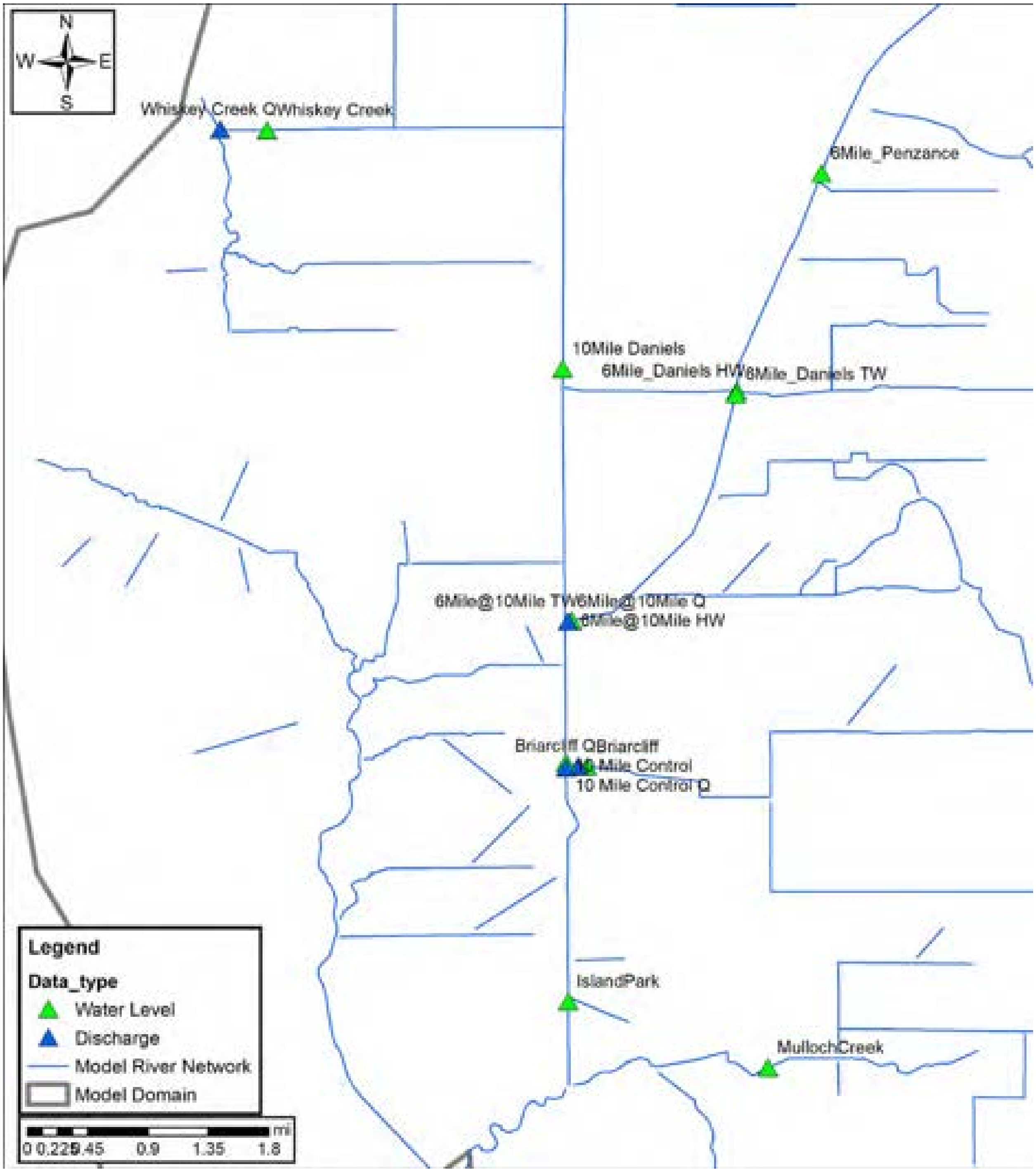
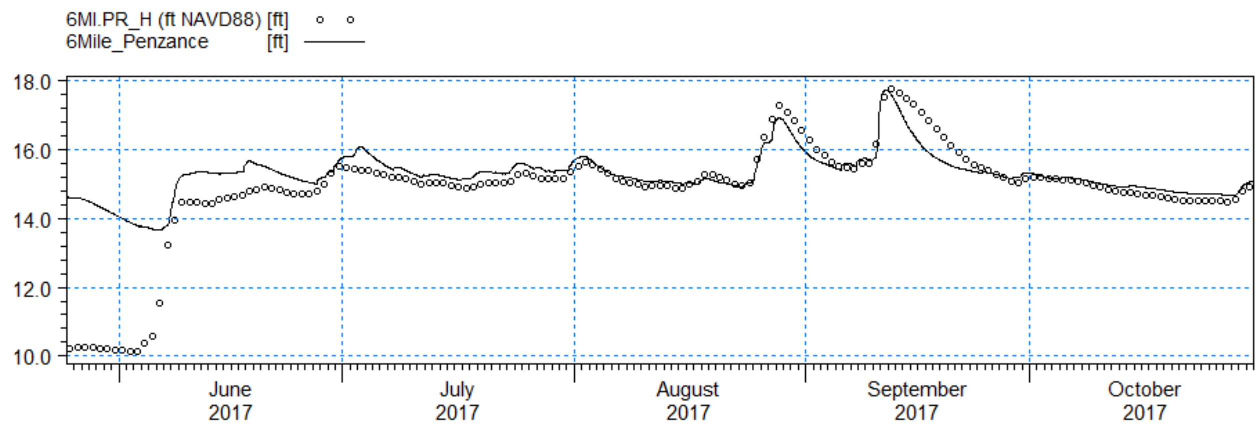
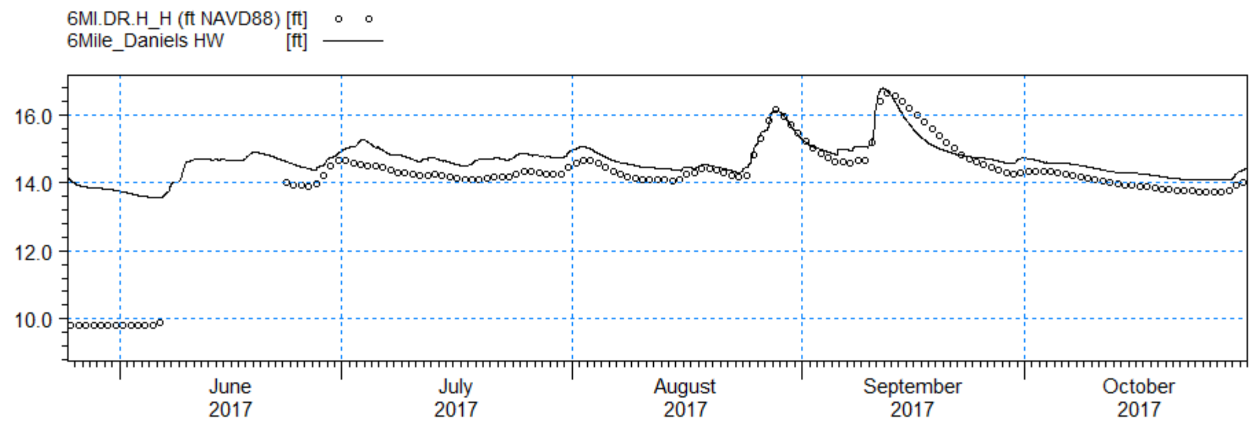
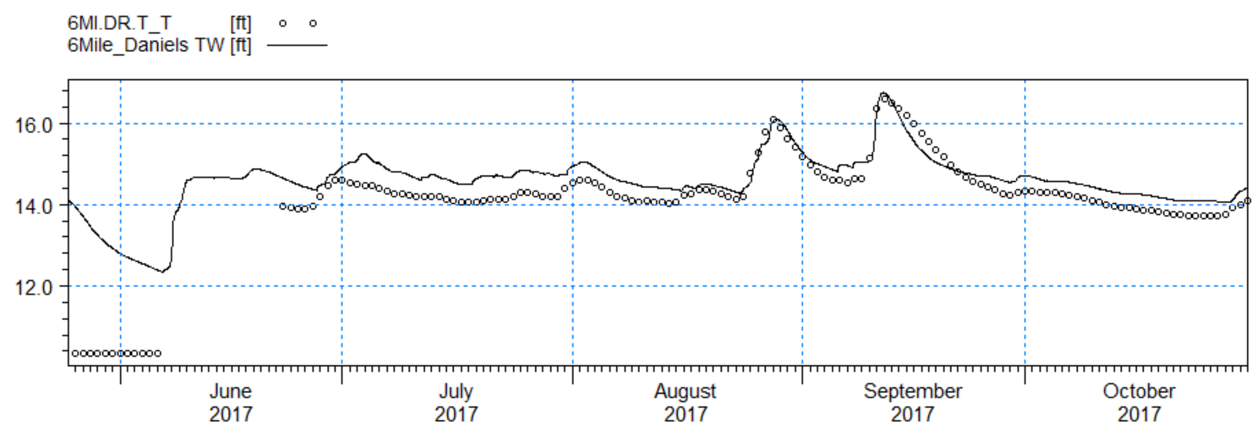
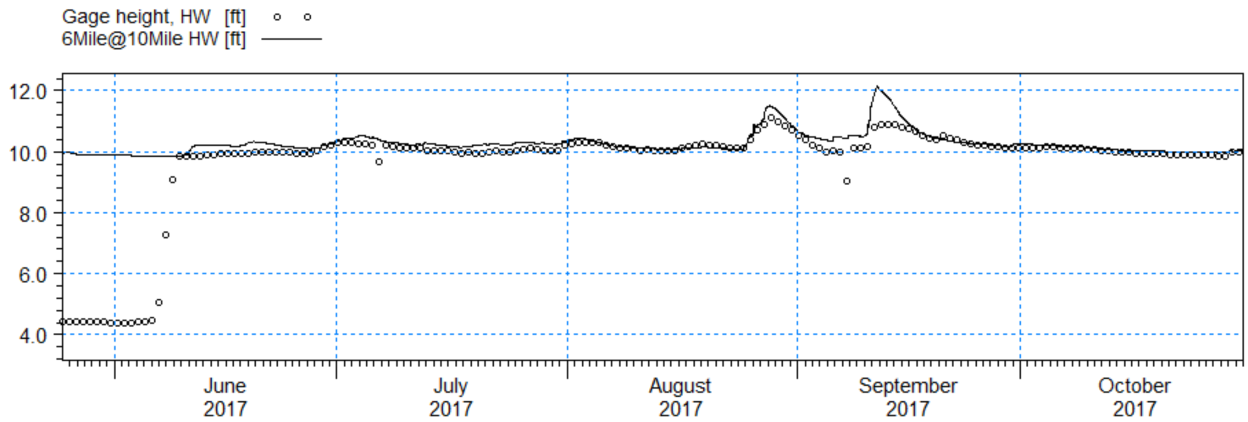


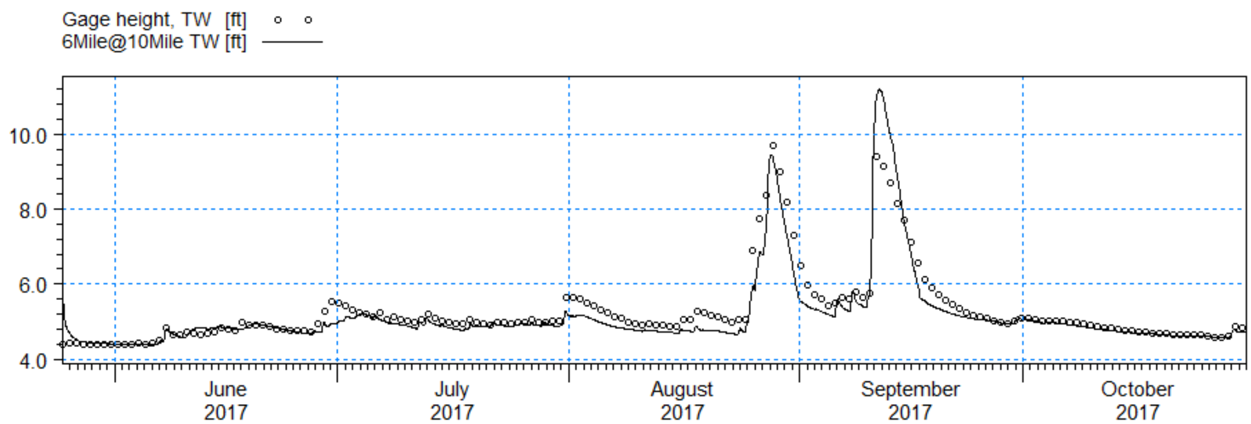
Figure 404. Surface Water Calibration Points for South Fort Myers

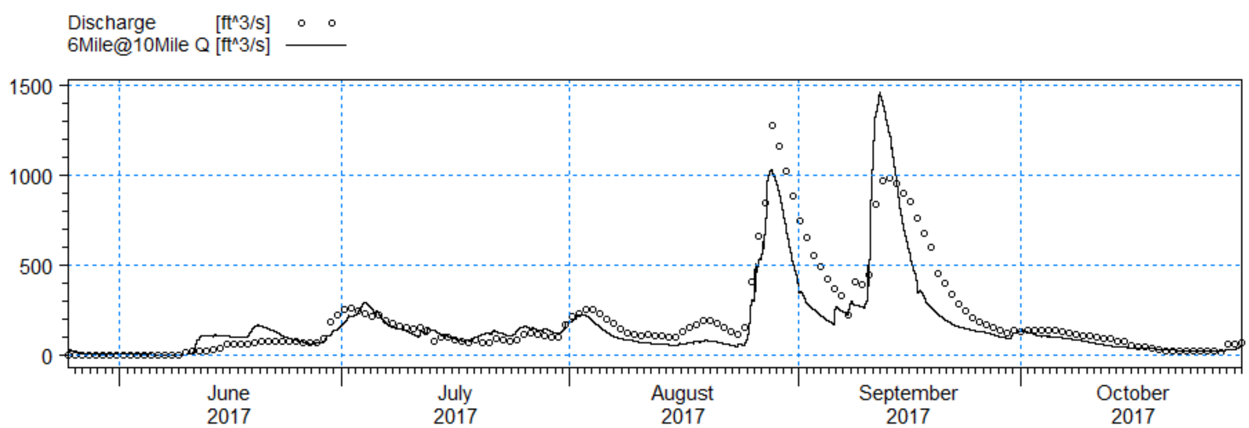

6MI.PR_H (ft NAVD88) [ft]
6Mile_Penzance [ft]
18.0
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

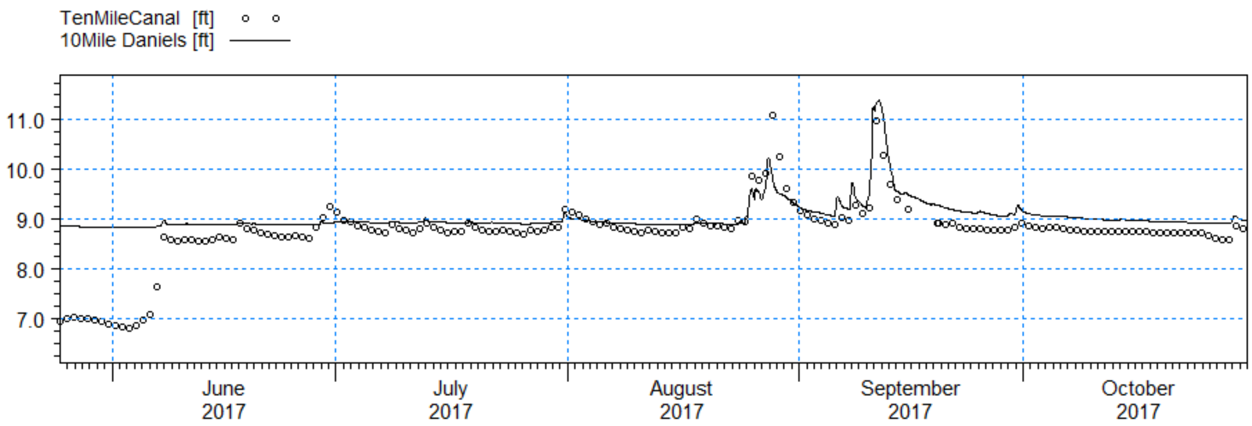

6MI.DR.H_H (ft NAVD88) [ft]
6Mile_Daniels HW [ft]
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

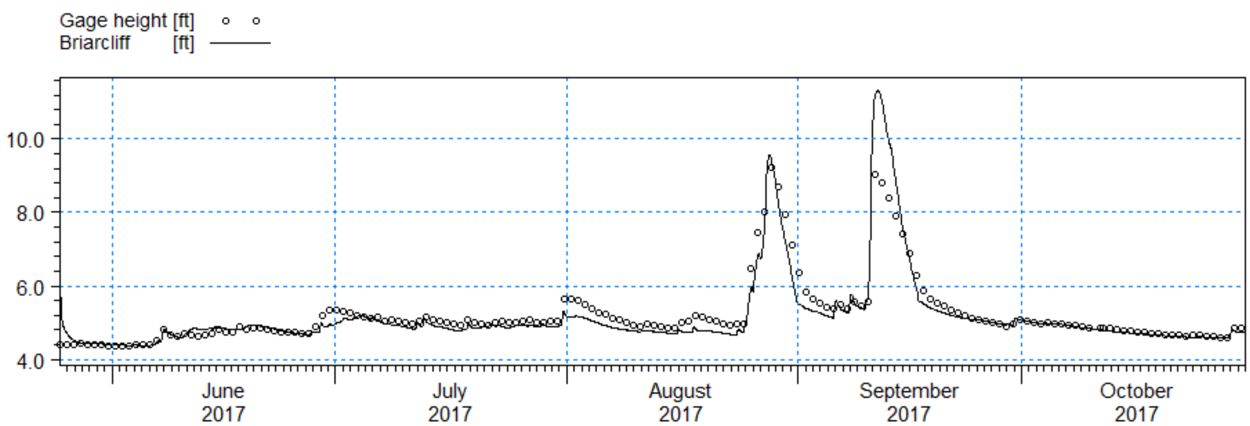

6MI.DR.T_T [ft]
6Mile_Daniels TW [ft]
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

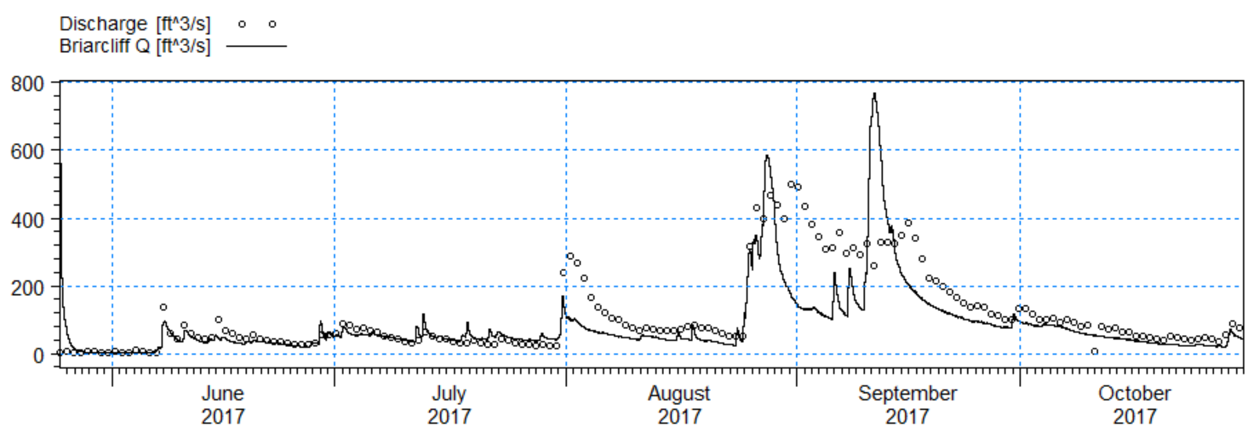

Gage height, HW [ft]
6Mile@10Mile HW [ft]
12.0
10.0
8.0
6.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017

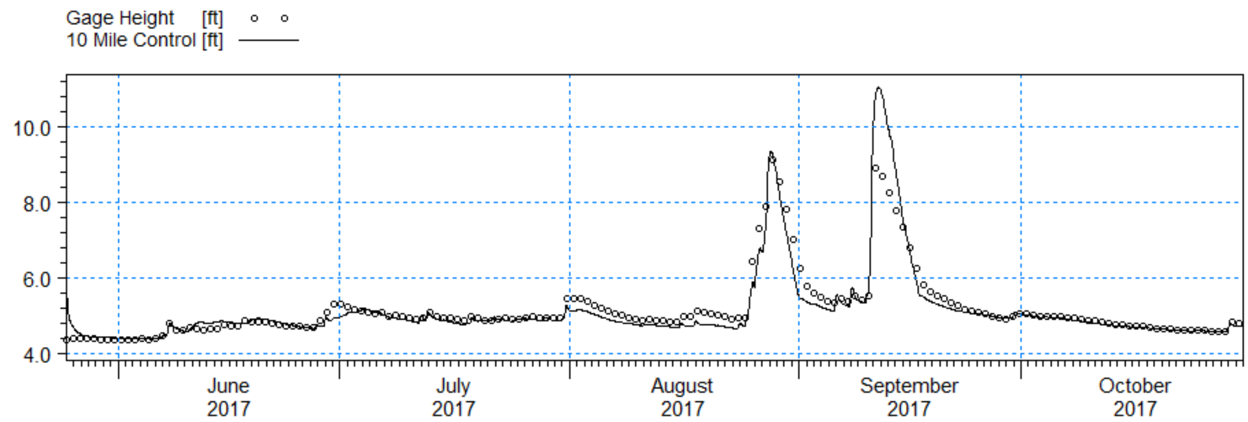

Gage height, TW [ft]
6Mile@10Mile TW [ft]
10.0
8.0
6.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017

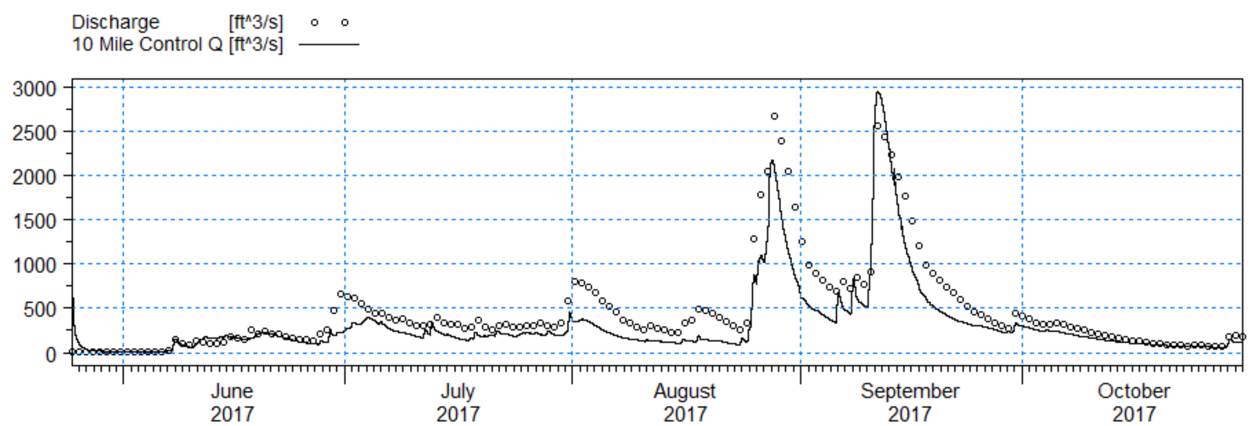

Discharge [ft^3/s]
6Mile@10Mile Q [ft^3/s]
1500
1000
500
0
June 2017
July 2017
August 2017
September 2017
October 2017

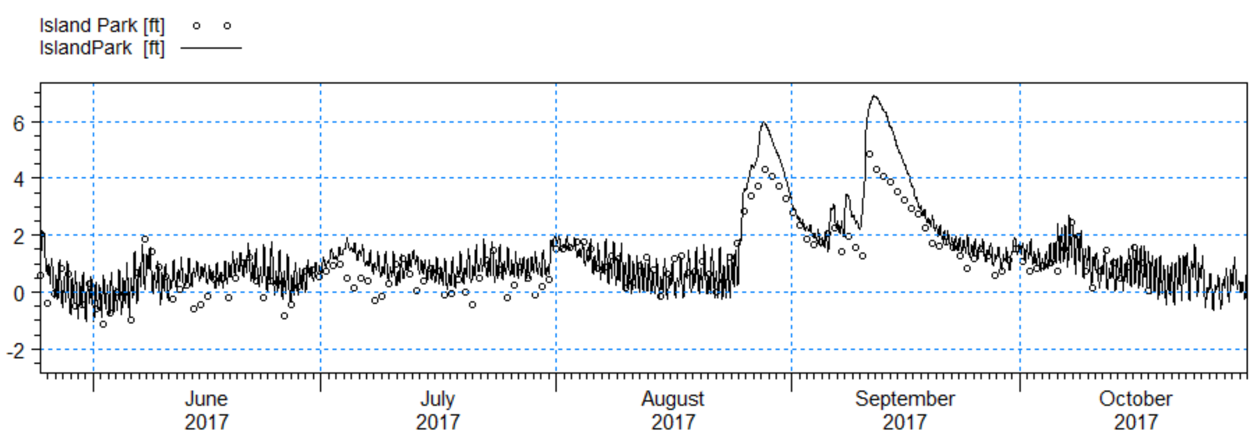

TenMileCanal [ft]
10Mile Daniels [ft]
11.0
10.0
9.0
8.0
7.0
June 2017
July 2017
August 2017
September 2017
October 2017

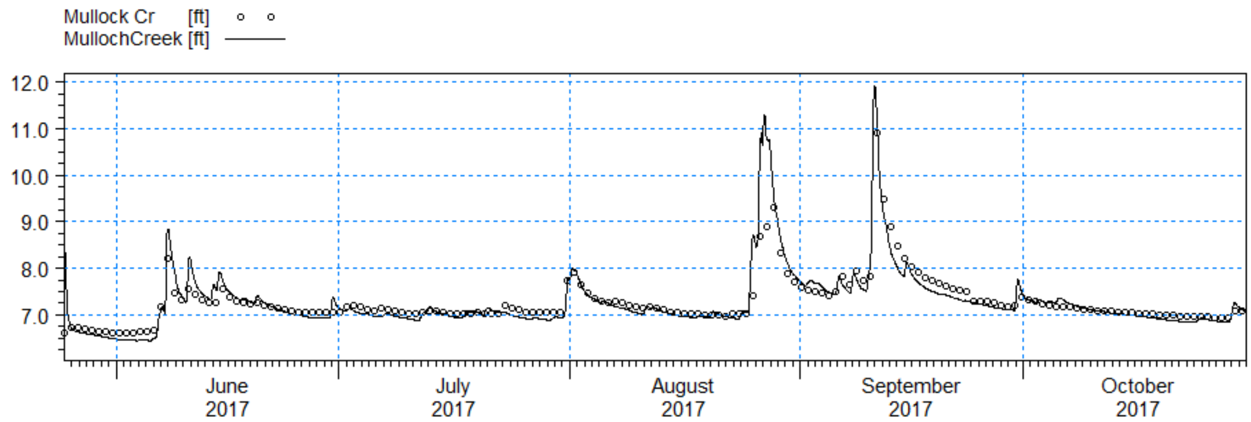

Gage height [ft]
Briarcliff [ft]
10.0
8.0
6.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017


Discharge [ft^3/s]
Briarcliff Q [ft^3/s]
800
600
400
200
0
June 2017
July 2017
August 2017
September 2017
October 2017


Gage Height [ft]
10 Mile Control [ft]
10.0
8.0
6.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017


Discharge [ft^3/s]
10 Mile Control Q [ft^3/s]
3000
2500
2000
1500
1000
500
0
June 2017
July 2017
August 2017
September 2017
October 2017


Island Park [ft]
IslandPark [ft]
6
4
2
0
-2
June 2017
July 2017
August 2017
September 2017
October 2017



4.1.4 Southeastern Lee County

Surface water monitoring stations in Southeastern Lee County are District and Lee County stations located at the major outfalls, including the Estero River, Spring Creek, and the Imperial River. There are eleven (11) water level monitoring stations and four (4) discharge monitoring gages located in this study area. The model performance metrics are shown in Table 20. A map of the surface water calibration stations for East Lee County is shown in Figure 44. In addition, calibration plots for these stations (excluding the data points with monthly datasets) are shown in the preceding graphics. The monitoring station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 20. Model Performance for Surface Water Stations in Southeast Lee County

	Water Levels	Discharge
# of Gages	**11**	**4**
Good	55%	75%
Okay	9%	0%
Poor	36%	25%

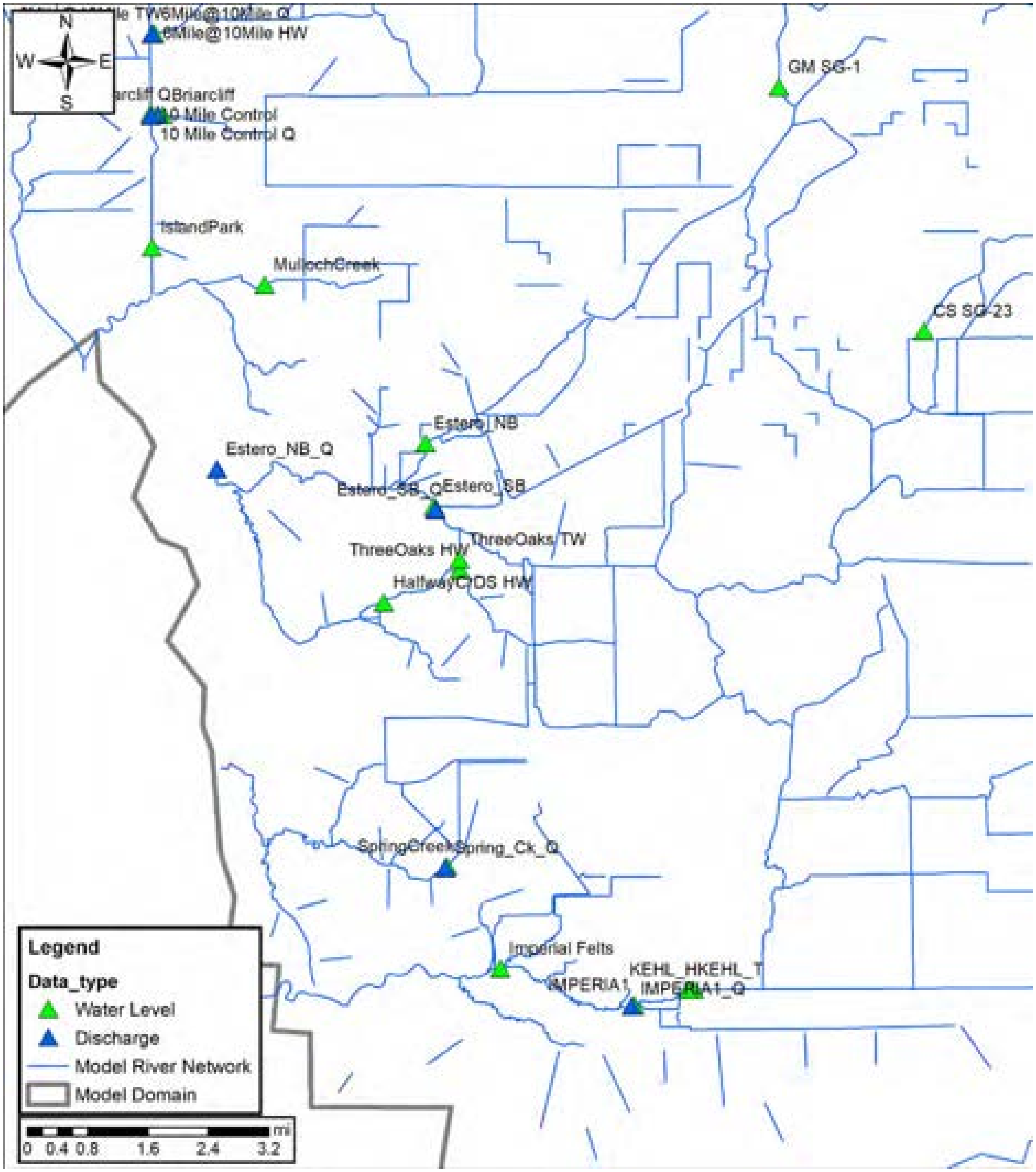
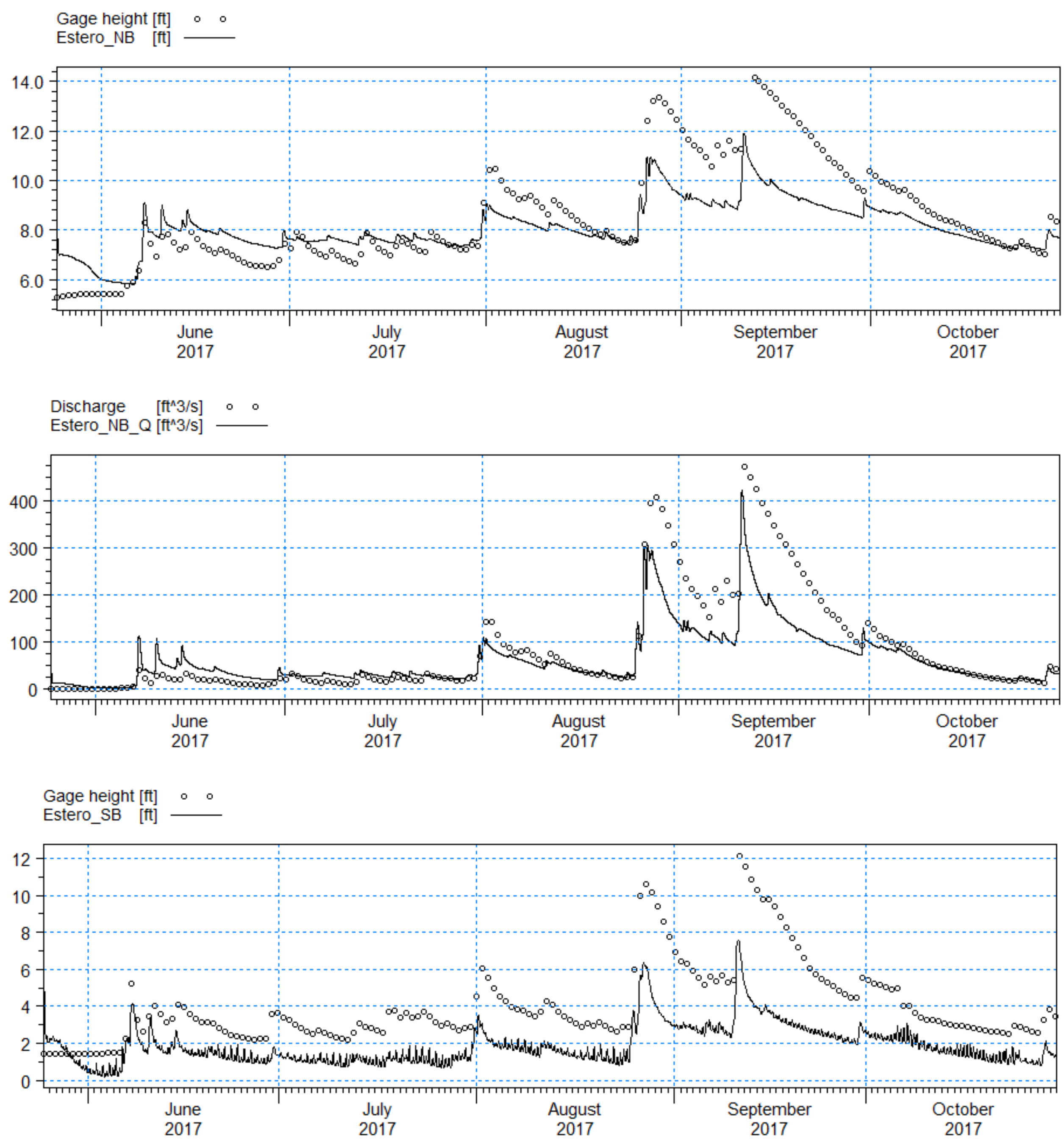
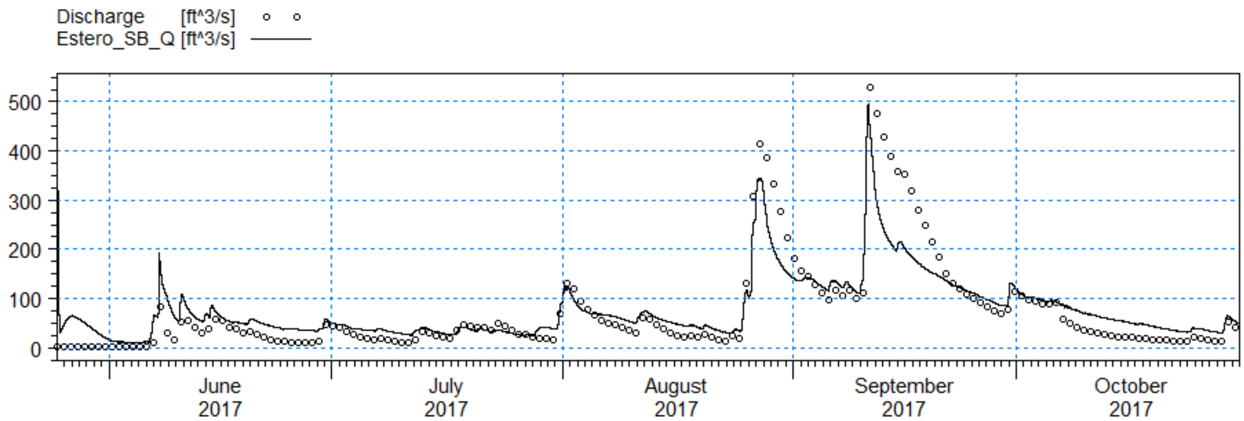
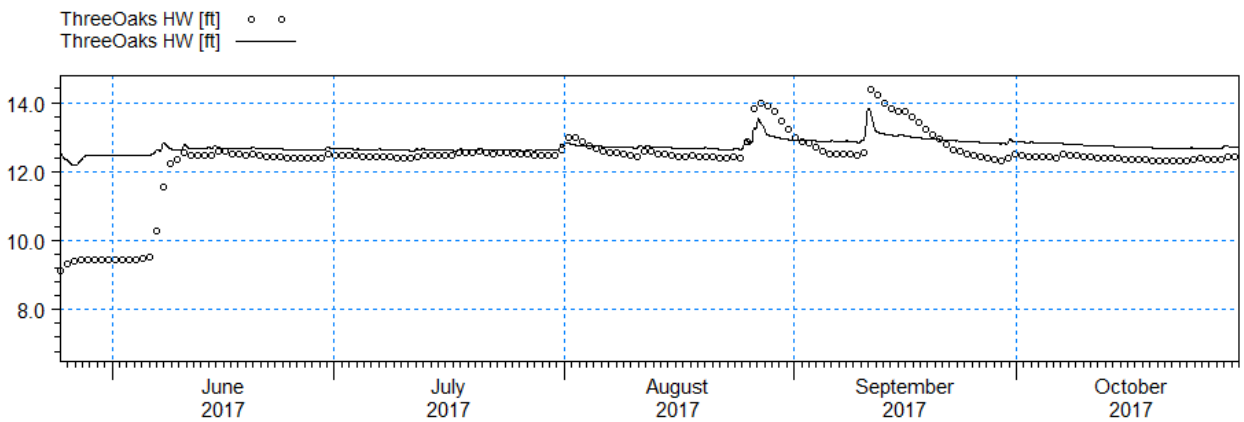
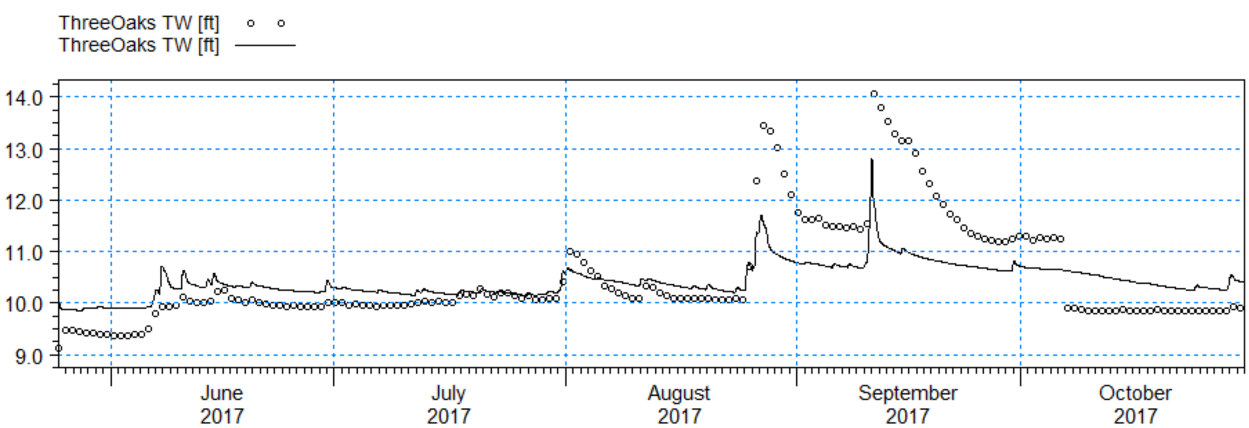


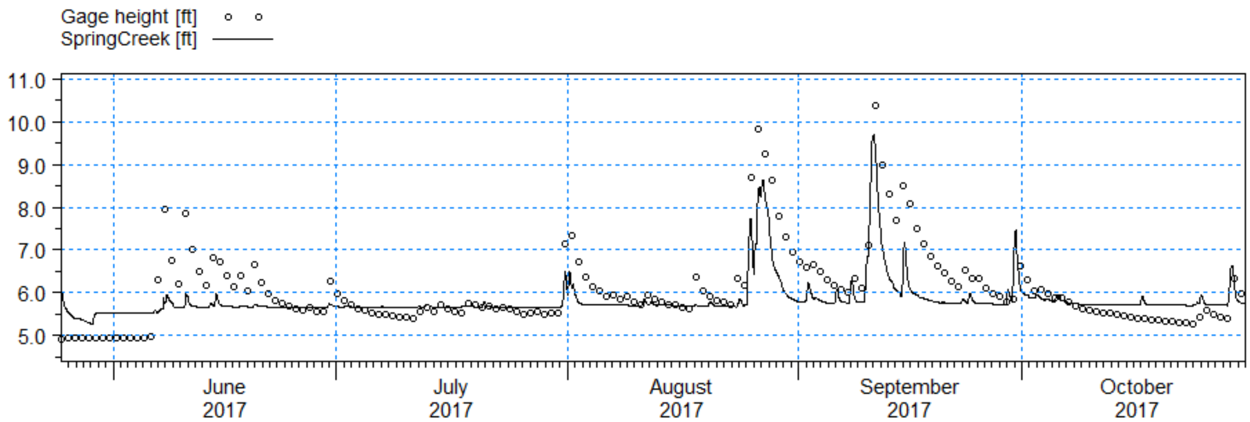
Figure 415. Surface Water Calibration Points for Southeastern Lee County

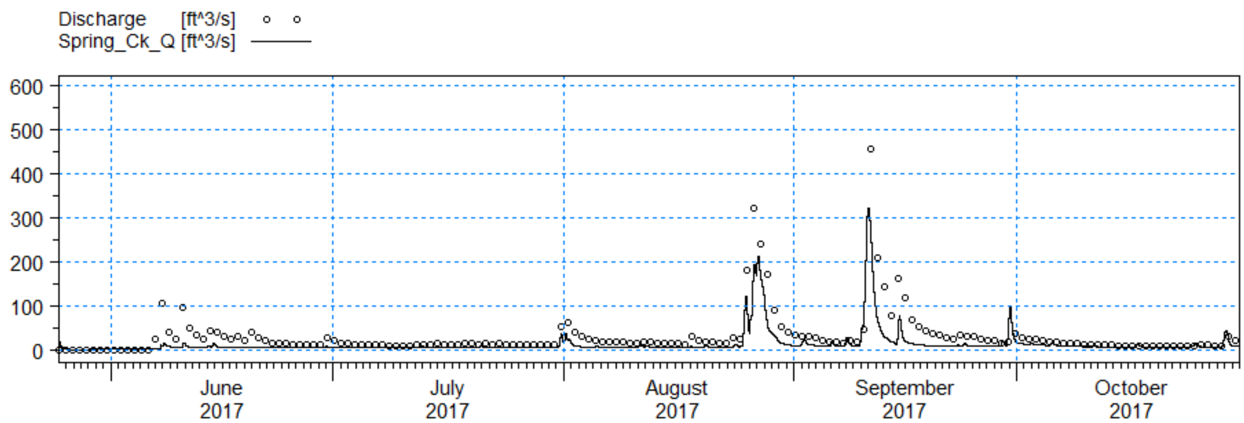

Gage height [ft]
Estero_NB [ft]
14.0
12.0
10.0
8.0
6.0
June 2017
July 2017
August 2017
September 2017
October 2017
Discharge [ft^3/s]
Estero_NB_Q [ft^3/s]
400
300
200
100
0
June 2017
July 2017
August 2017
September 2017
October 2017
Gage height [ft]
Estero_SB [ft]
12
10
8
6
4
2
0
June 2017
July 2017
August 2017
September 2017
October 2017

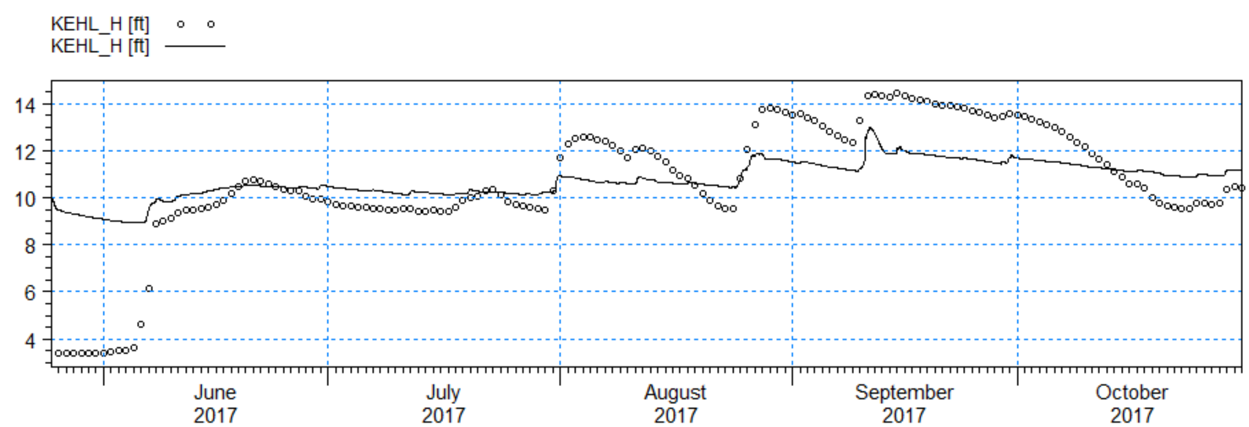

Discharge [ft^3/s]
Estero_SB_Q [ft^3/s]
500
400
300
200
100
0
June 2017
July 2017
August 2017
September 2017
October 2017

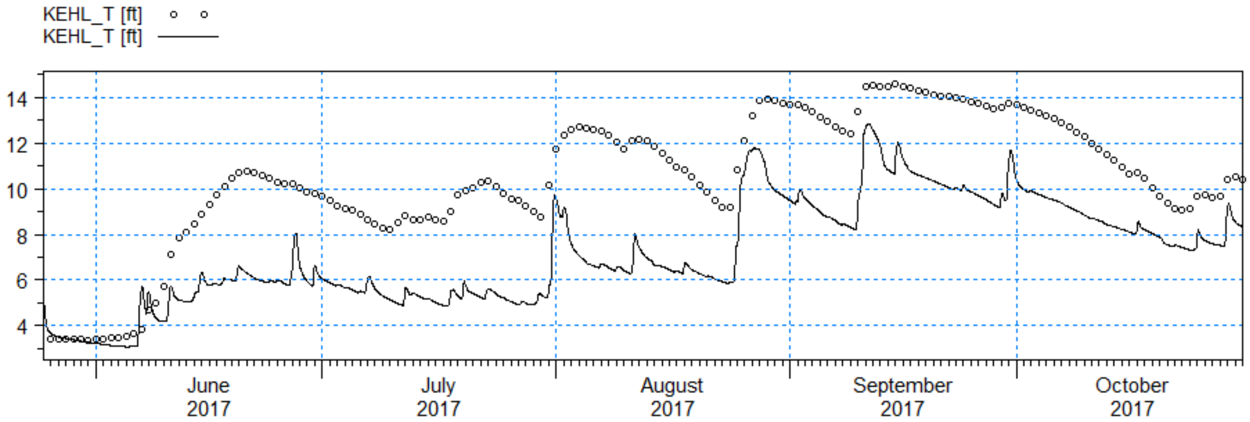

ThreeOaks HW [ft]
ThreeOaks HW [ft]
14.0
12.0
10.0
8.0
June 2017
July 2017
August 2017
September 2017
October 2017

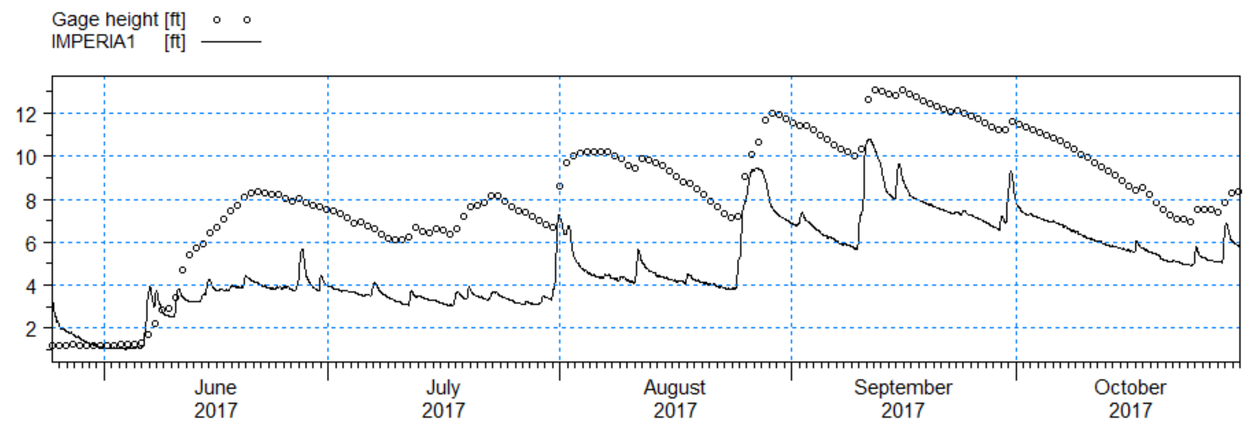

ThreeOaks TW [ft]
ThreeOaks TW [ft]
14.0
13.0
12.0
11.0
10.0
9.0
June 2017
July 2017
August 2017
September 2017
October 2017

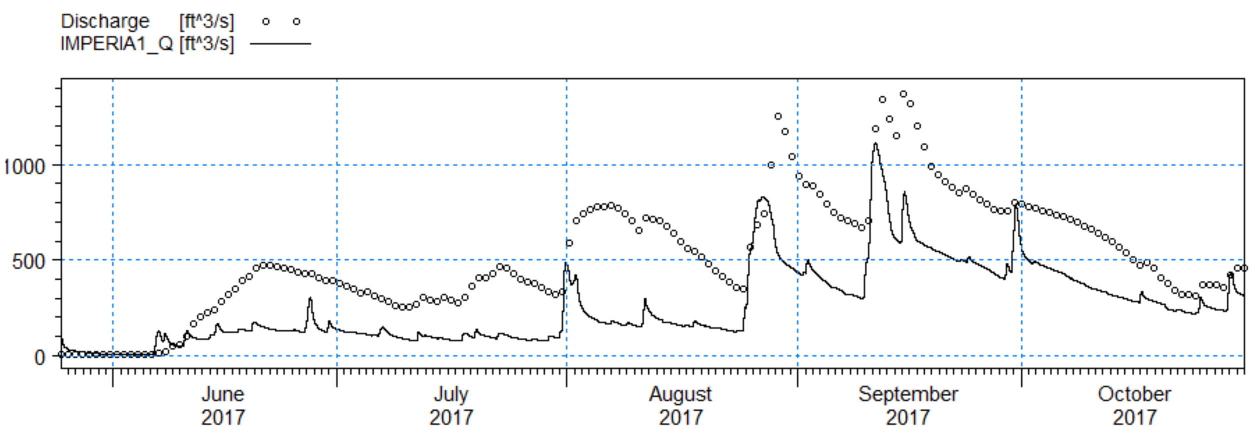

Gage height [ft]
SpringCreek [ft]
11.0
10.0
9.0
8.0
7.0
6.0
5.0
June 2017
July 2017
August 2017
September 2017
October 2017


Discharge [ft^3/s]
Spring_Ck_Q [ft^3/s]
600
500
400
300
200
100
0
June 2017
July 2017
August 2017
September 2017
October 2017


KEHL_H [ft]
KEHL_H [ft]
14
12
10
8
6
4
June 2017
July 2017
August 2017
September 2017
October 2017


KEHL_T [ft]
KEHL_T [ft]
14
12
10
8
6
4
June 2017
July 2017
August 2017
September 2017
October 2017


Gage height [ft]
IMPERIA1 [ft]
12
10
8
6
4
2
June 2017
July 2017
August 2017
September 2017
October 2017


Discharge [ft^3/s]
IMPERIA1_Q [ft^3/s]
1000
500
0
June 2017
July 2017
August 2017
September 2017
October 2017

4.2 Groundwater Calibration Results

4.2.1 Water Table Aquifer

The majority of the data stations in the model are from the water table aquifer, primarily due to the large amount of Lee County measured data for the surficial aquifer. Table 21 provides a measure of the model's ability to simulate the groundwater levels in the water table aquifer for each study area, Table 22 provides the same but for the Tamiami Confining Unit. A map of the groundwater calibration stations for the water table aquifer and Tamiami Confining Unit are shown in Figure 45. In addition, groundwater calibration plots for these stations (excluding the data points with monthly datasets) are shown in the preceding graphics. The station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 21. Model Performance Per Study Area for the WT Aquifer

	East Lee County	Whiskey Creek	South Ft Myers	Southeast Lee County	All Study Areas
# of Stations	33	1	19	30	83
Good	55%	0%	84%	50%	59%
Okay	42%	0%	11%	17%	25%
Poor	3%	100%	5%	33%	16%

Table 22. Model Performance Per Study Area for the Tamiami CU

	East Lee County	Whiskey Creek	South Ft Myers	Southeast Lee County	All Study Areas
# of Stations	1	0	1	2	4
Good	0%	--	100%	0%	25%
Okay	100%	--	0%	50%	50%
Poor	0%	--	0%	50%	25%

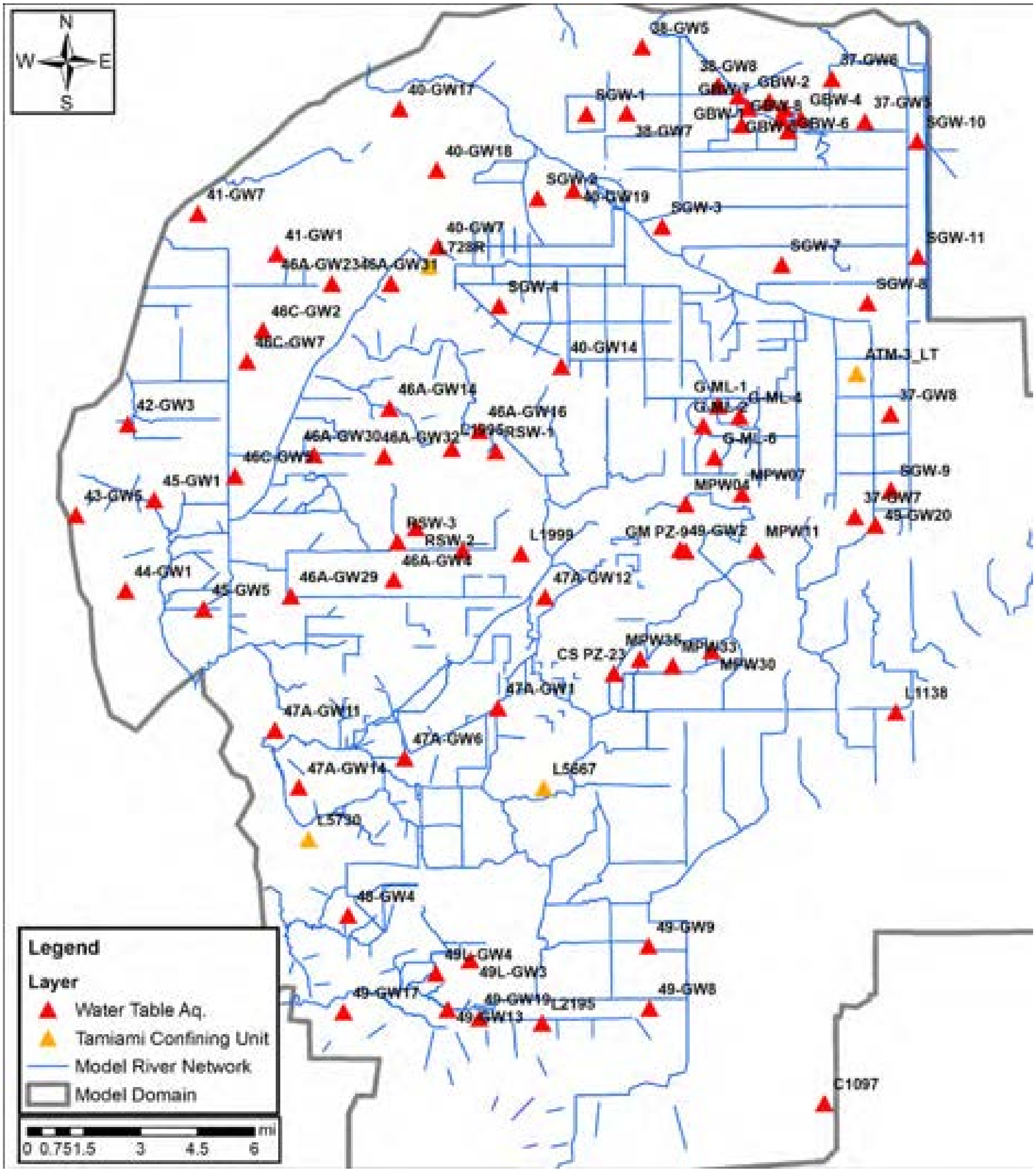
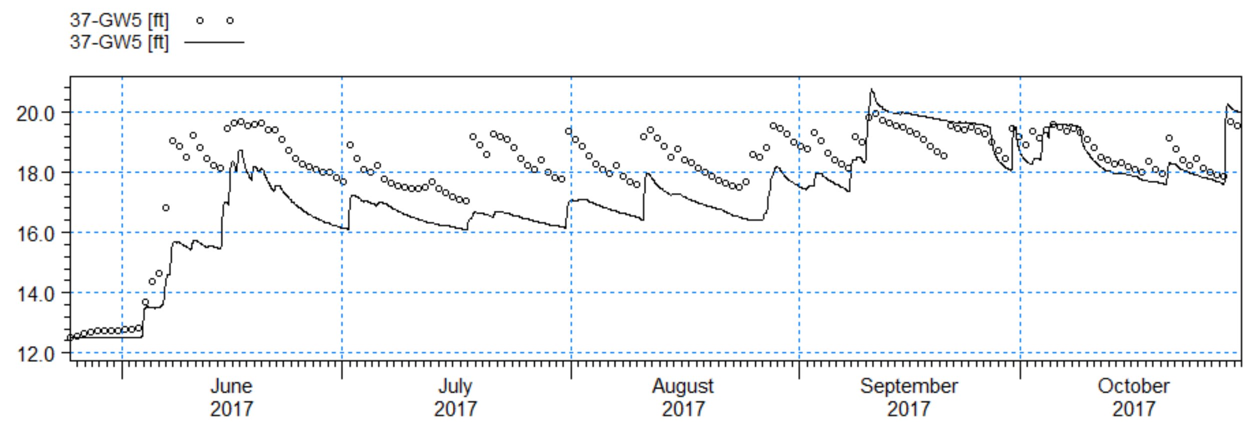
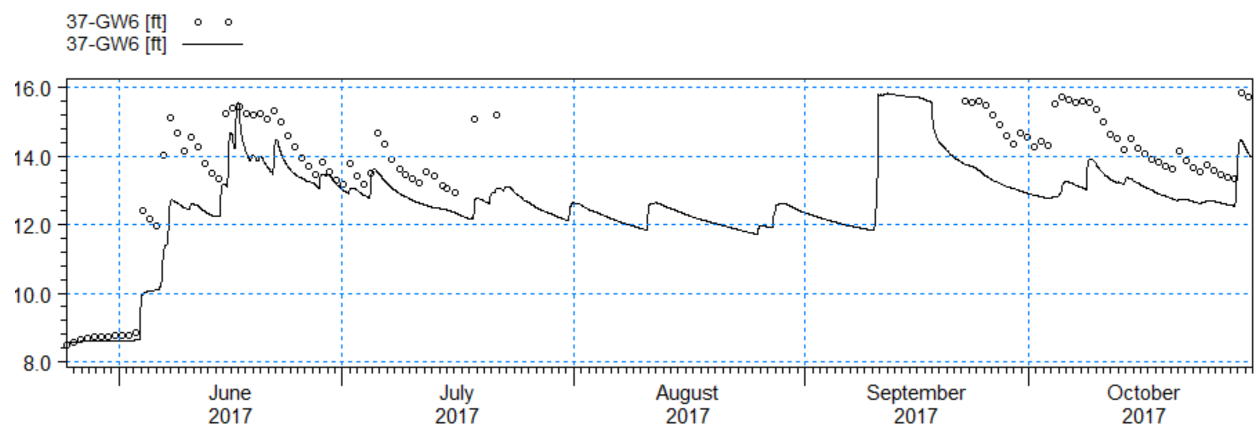
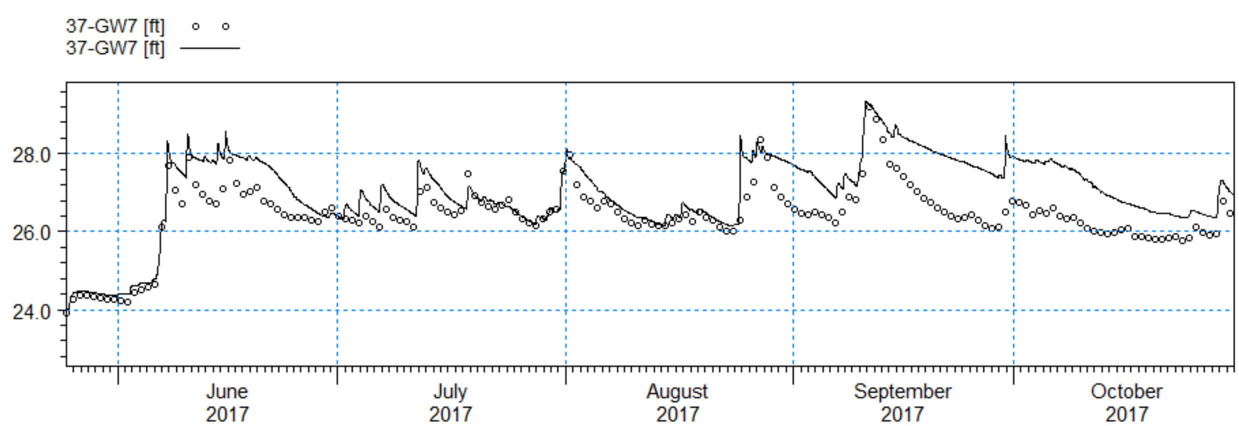
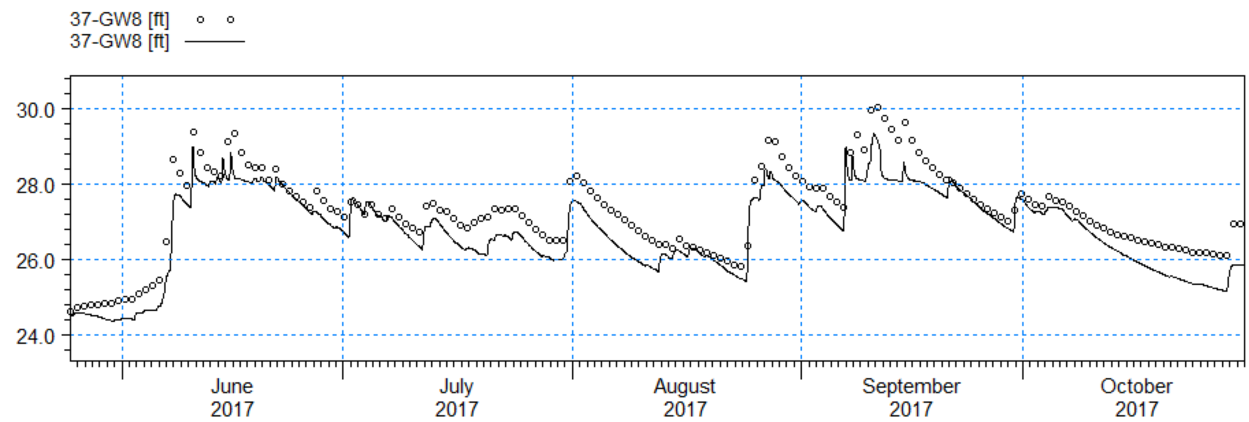


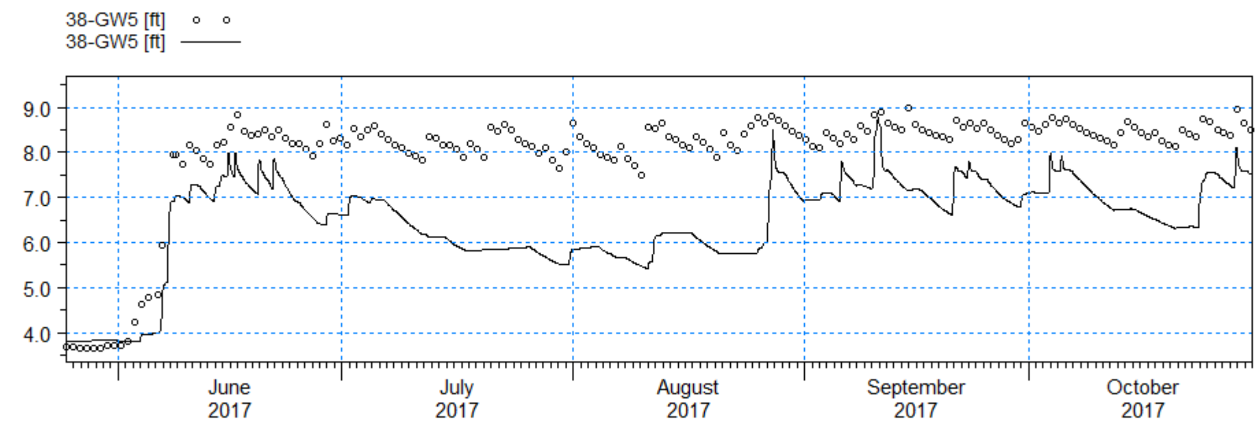
Figure 426. Map of Groundwater Calibration Points for the Water Table Aquifer and Tamiami Confining Unit

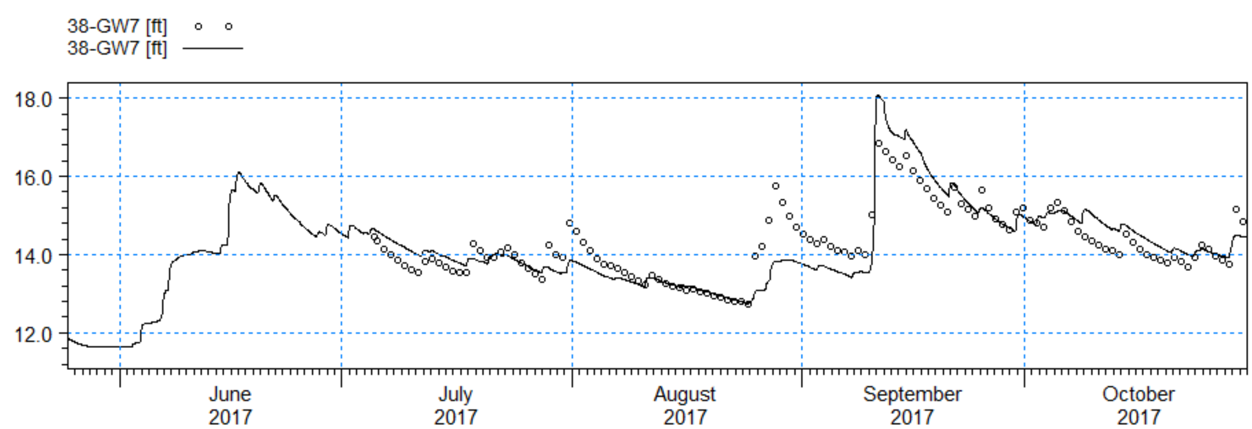

37-GW5 [ft]
37-GW5 [ft]
20.0
18.0
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

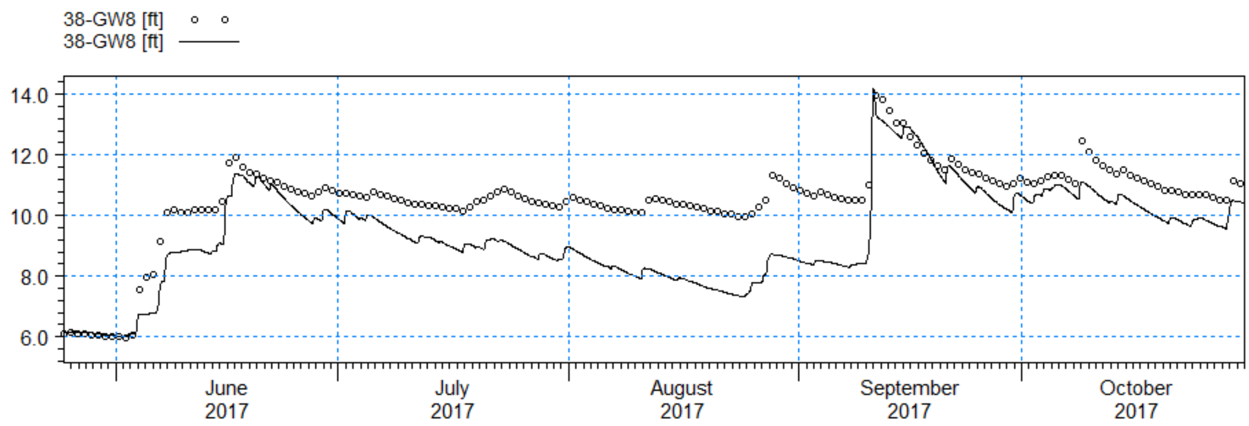

37-GW6 [ft]
37-GW6 [ft]
16.0
14.0
12.0
10.0
8.0
June 2017
July 2017
August 2017
September 2017
October 2017

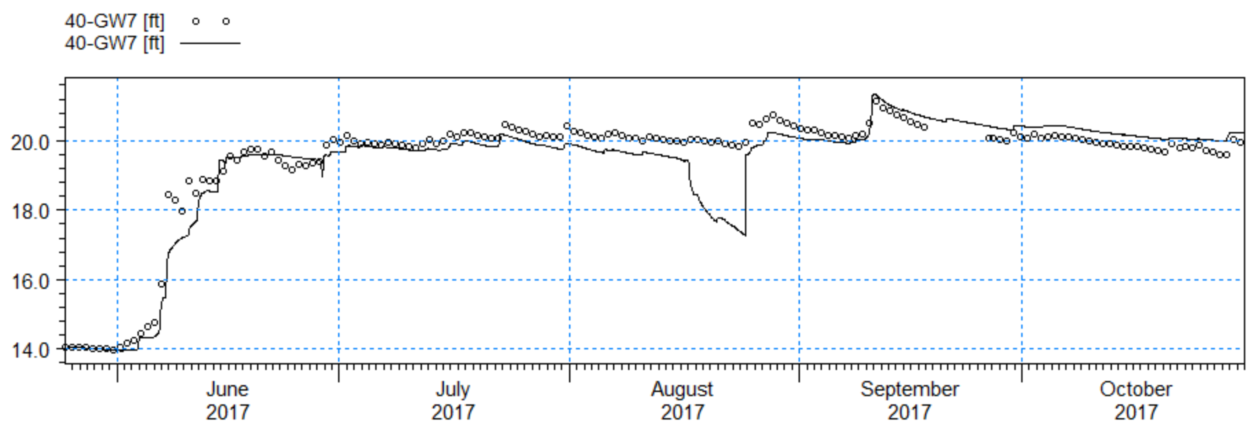

37-GW7 [ft]
37-GW7 [ft]
28.0
26.0
24.0
June 2017
July 2017
August 2017
September 2017
October 2017

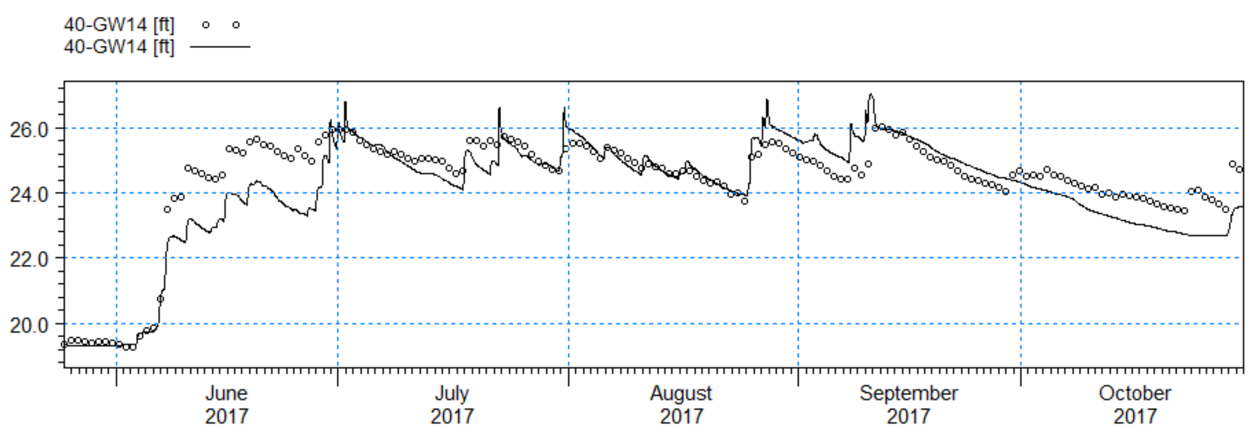

37-GW8 [ft]
37-GW8 [ft]
30.0
28.0
26.0
24.0
June 2017
July 2017
August 2017
September 2017
October 2017

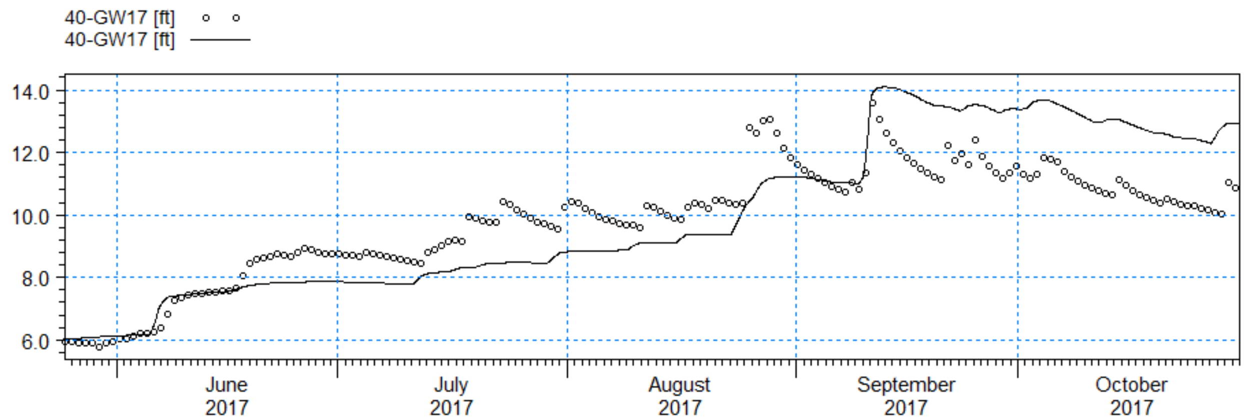

38-GW5 [ft]
38-GW5 [ft]
9.0
8.0
7.0
6.0
5.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017

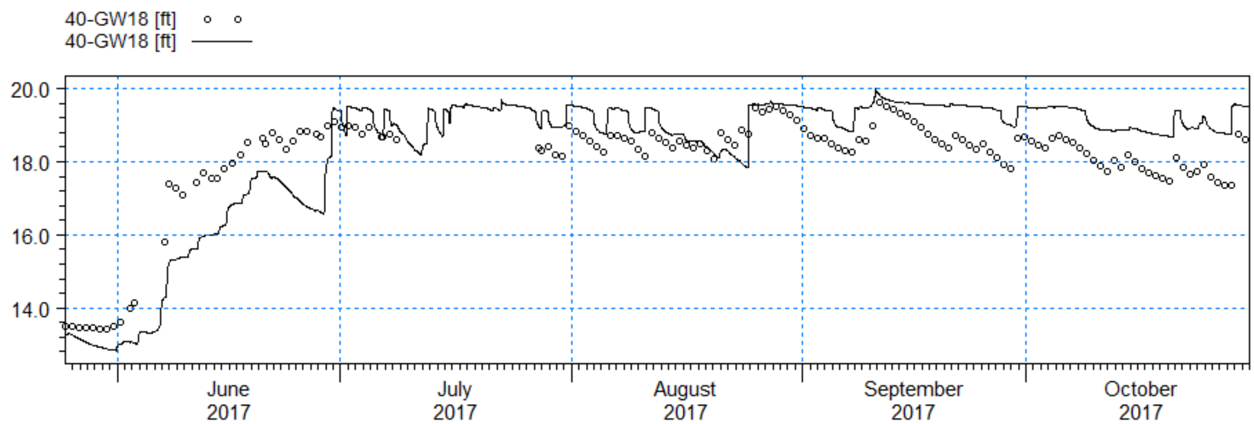

38-GW7 [ft]
38-GW7 [ft]
18.0
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

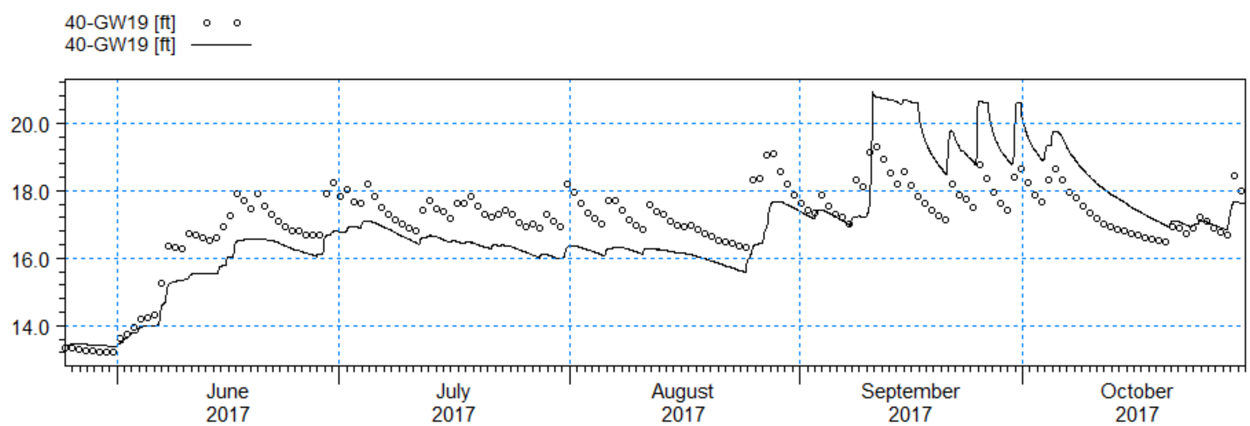

38-GW8 [ft]
38-GW8 [ft]
14.0
12.0
10.0
8.0
6.0
June 2017
July 2017
August 2017
September 2017
October 2017

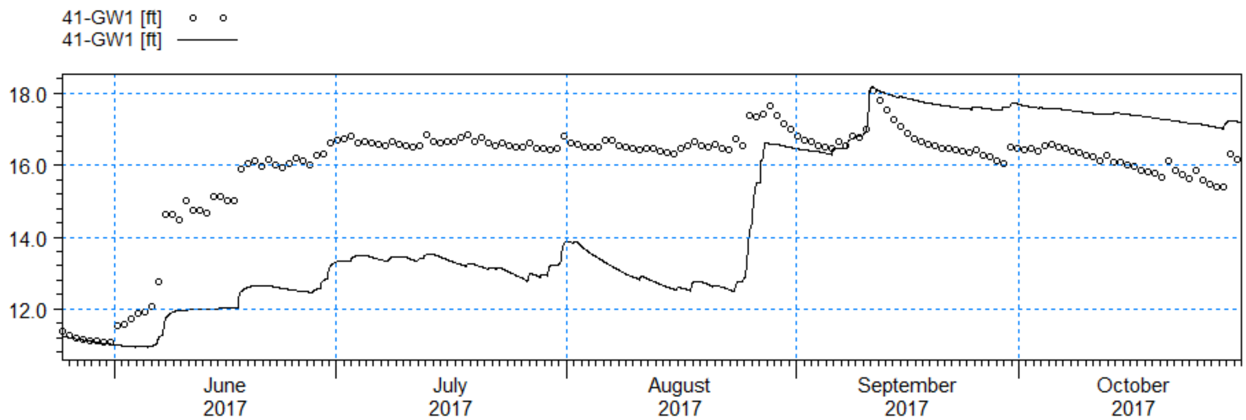

40-GW7 [ft]
40-GW7 [ft]
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

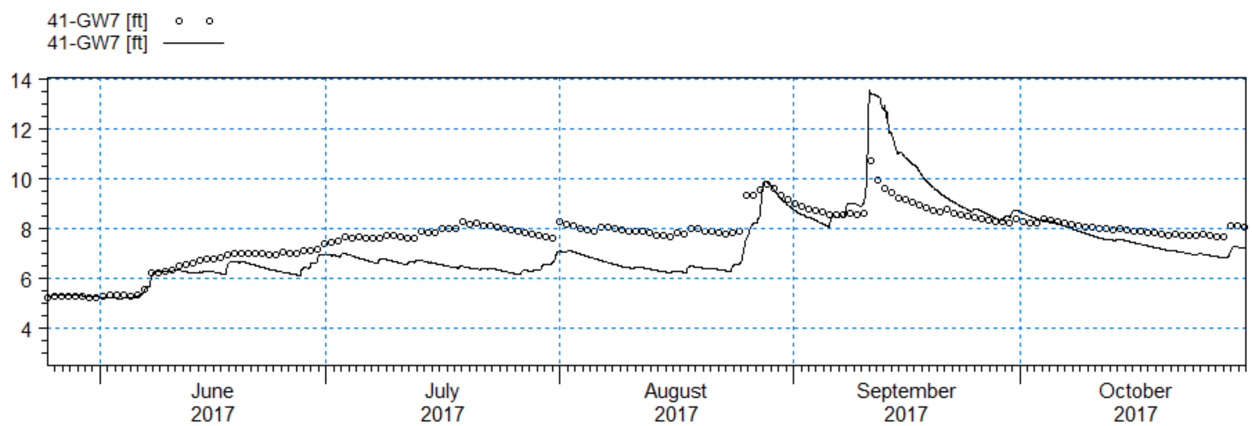

40-GW14 [ft]
40-GW14 [ft]
26.0
24.0
22.0
20.0
June 2017
July 2017
August 2017
September 2017
October 2017

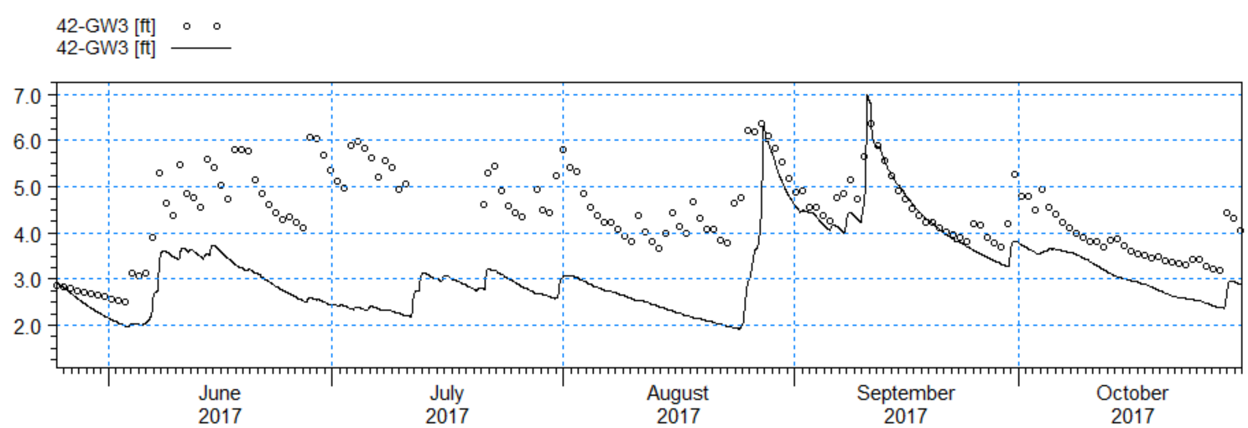

40-GW17 [ft]
40-GW17 [ft]
14.0
12.0
10.0
8.0
6.0
June 2017
July 2017
August 2017
September 2017
October 2017

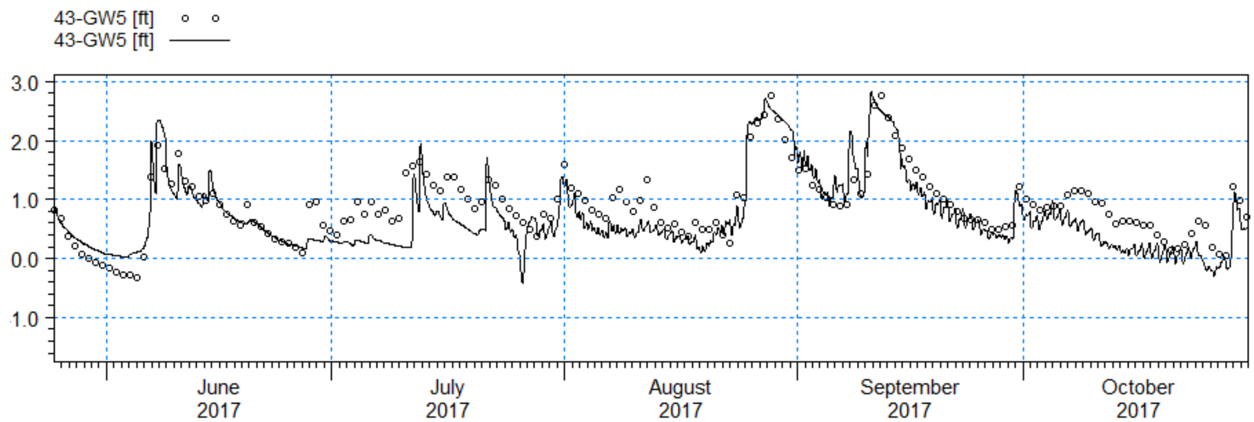

40-GW18 [ft]
40-GW18 [ft]
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

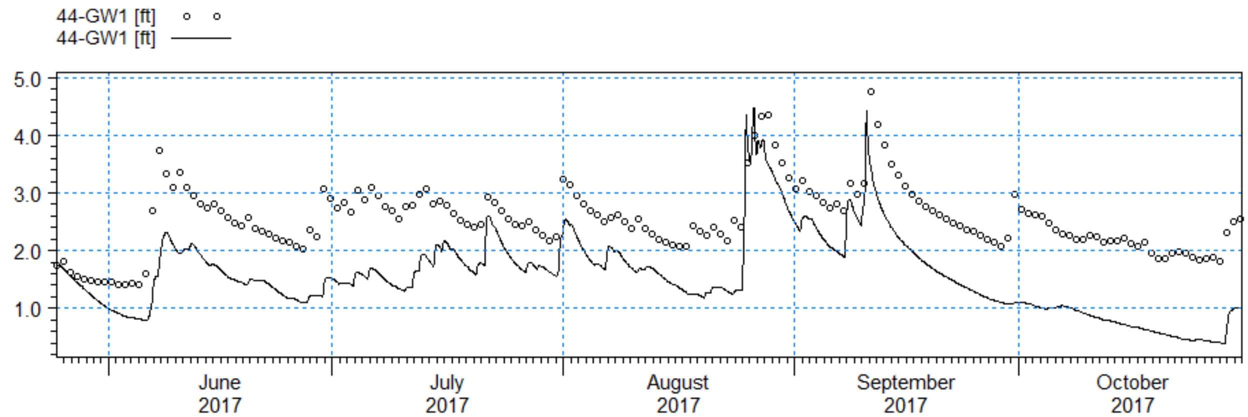

40-GW19 [ft]
40-GW19 [ft]
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

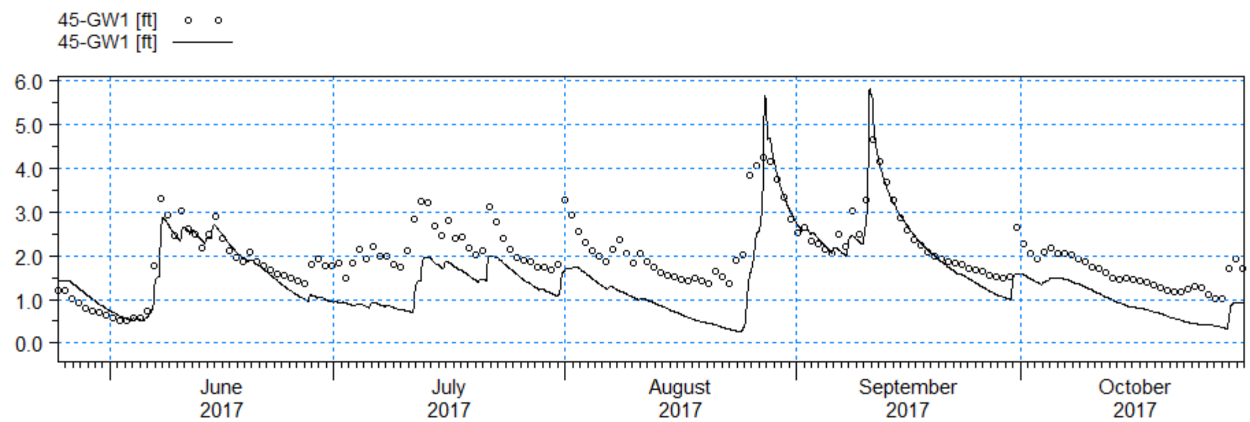

41-GW1 [ft]
41-GW1 [ft]
18.0
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

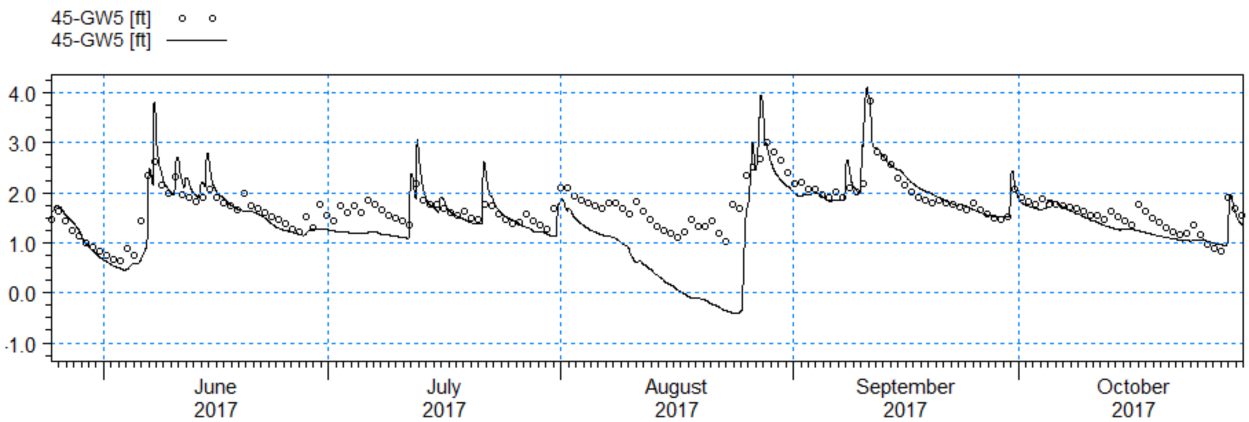

41-GW7 [ft]
41-GW7 [ft]
14
12
10
8
6
4
June 2017
July 2017
August 2017
September 2017
October 2017

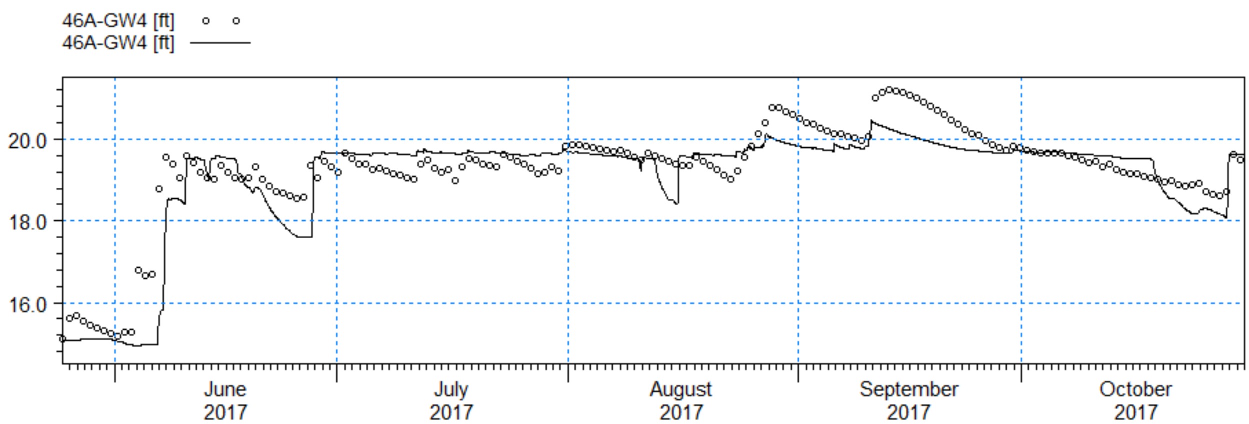

42-GW3 [ft]
42-GW3 [ft]
7.0
6.0
5.0
4.0
3.0
2.0
June 2017
July 2017
August 2017
September 2017
October 2017

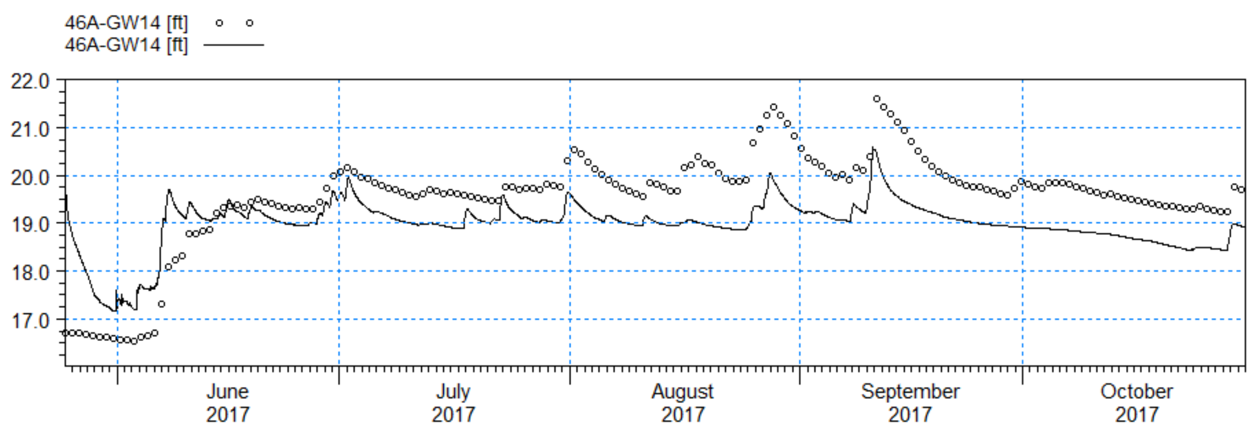

43-GW5 [ft]
43-GW5 [ft]
3.0
2.0
1.0
0.0
1.0
June 2017
July 2017
August 2017
September 2017
October 2017

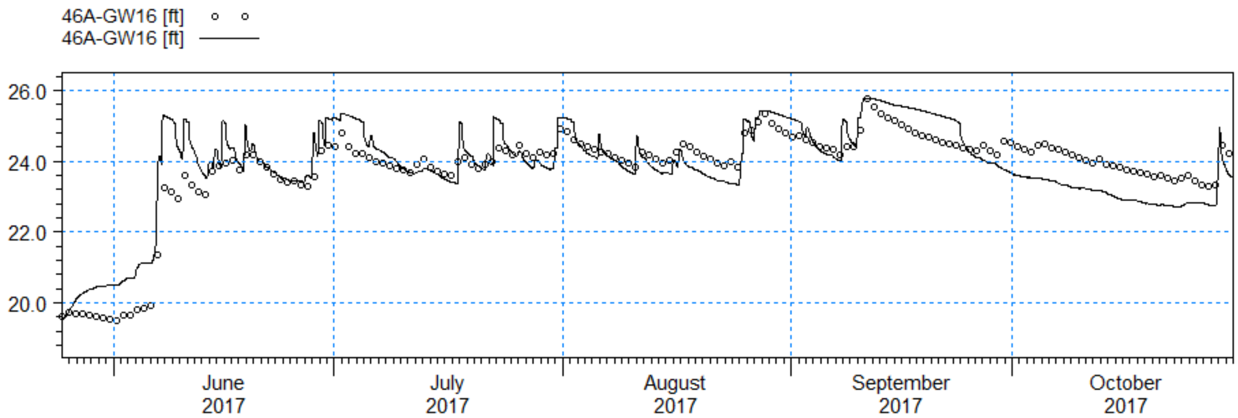

44-GW1 [ft]
44-GW1 [ft]
5.0
4.0
3.0
2.0
1.0
June 2017
July 2017
August 2017
September 2017
October 2017

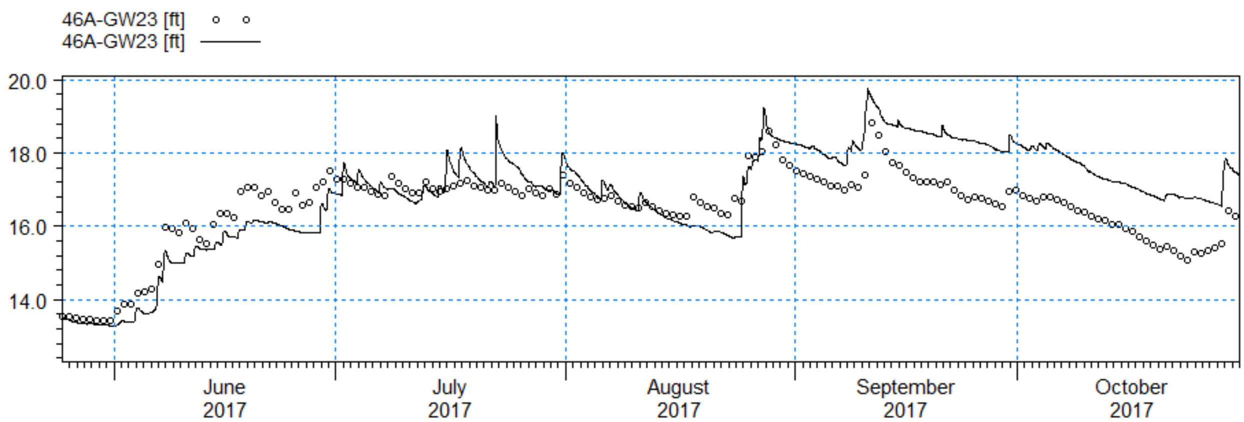

45-GW1 [ft]
45-GW1 [ft]
6.0
5.0
4.0
3.0
2.0
1.0
0.0
June 2017
July 2017
August 2017
September 2017
October 2017

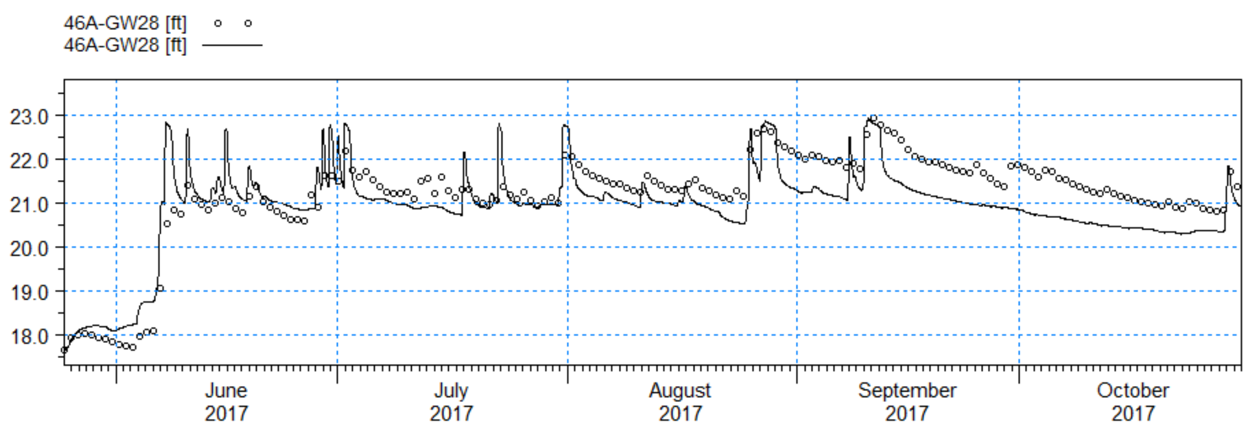

45-GW5 [ft]
45-GW5 [ft]
4.0
3.0
2.0
1.0
0.0
-1.0
June 2017
July 2017
August 2017
September 2017
October 2017

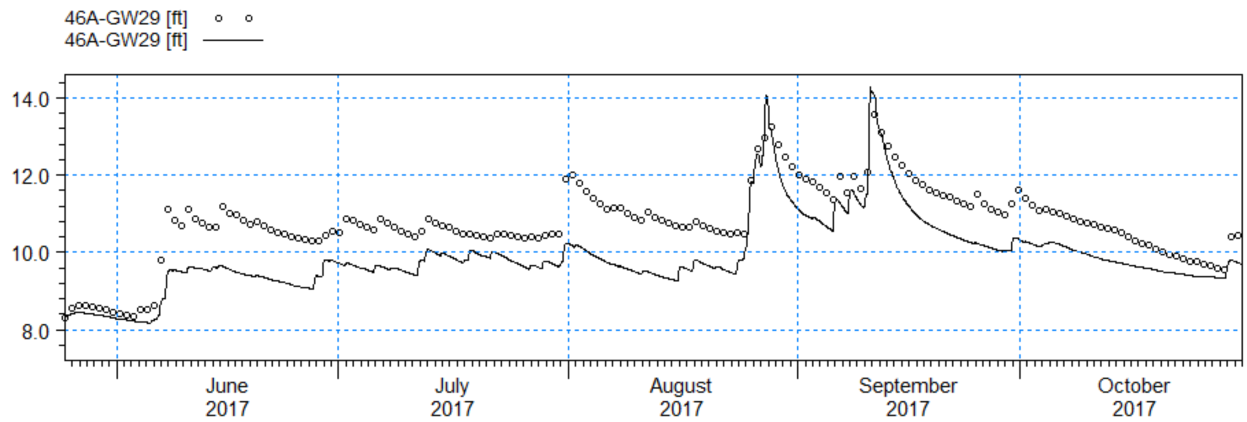

46A-GW4 [ft]
46A-GW4 [ft]
20.0
18.0
16.0
June 2017
July 2017
August 2017
September 2017
October 2017


46A-GW14 [ft]
46A-GW14 [ft]
22.0
21.0
20.0
19.0
18.0
17.0
June 2017
July 2017
August 2017
September 2017
October 2017

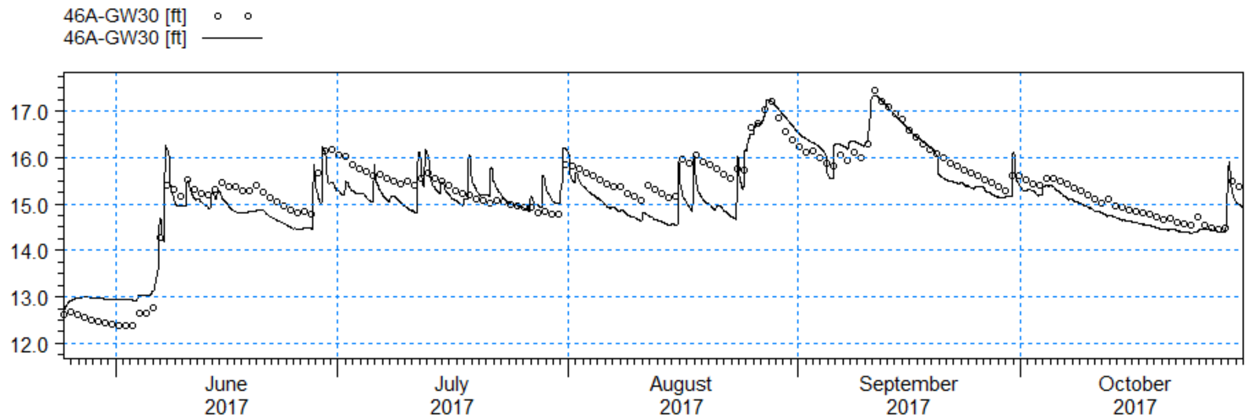

46A-GW16 [ft]
46A-GW16 [ft]
26.0
24.0
22.0
20.0
June 2017
July 2017
August 2017
September 2017
October 2017


46A-GW23 [ft]
46A-GW23 [ft]
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

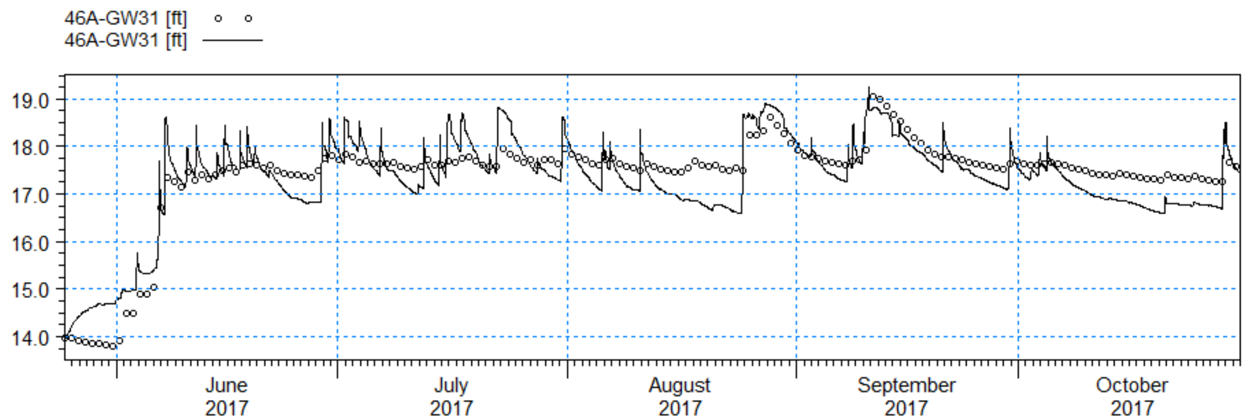

46A-GW28 [ft]
46A-GW28 [ft]
23.0
22.0
21.0
20.0
19.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017



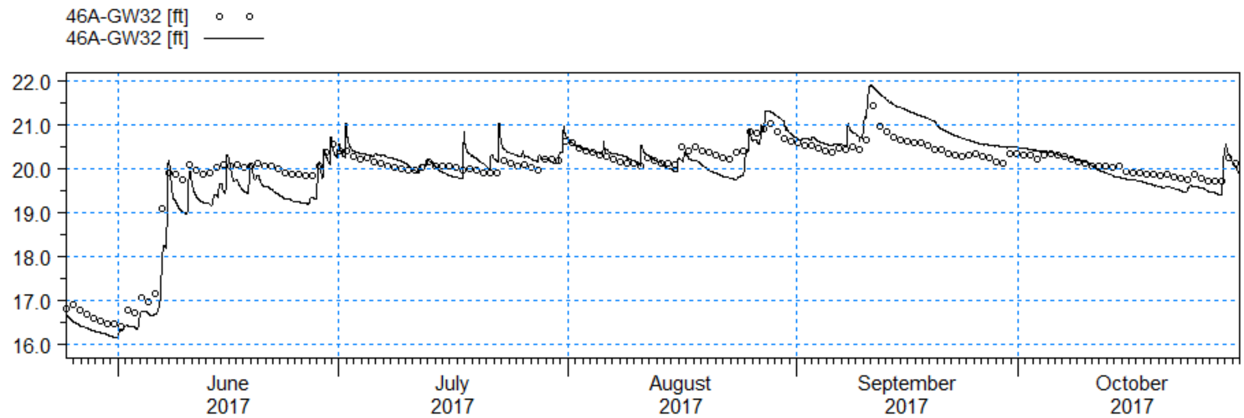
46A-GW29 [ft]
46A-GW29 [ft]
14.0
12.0
10.0
8.0
June 2017
July 2017
August 2017
September 2017
October 2017



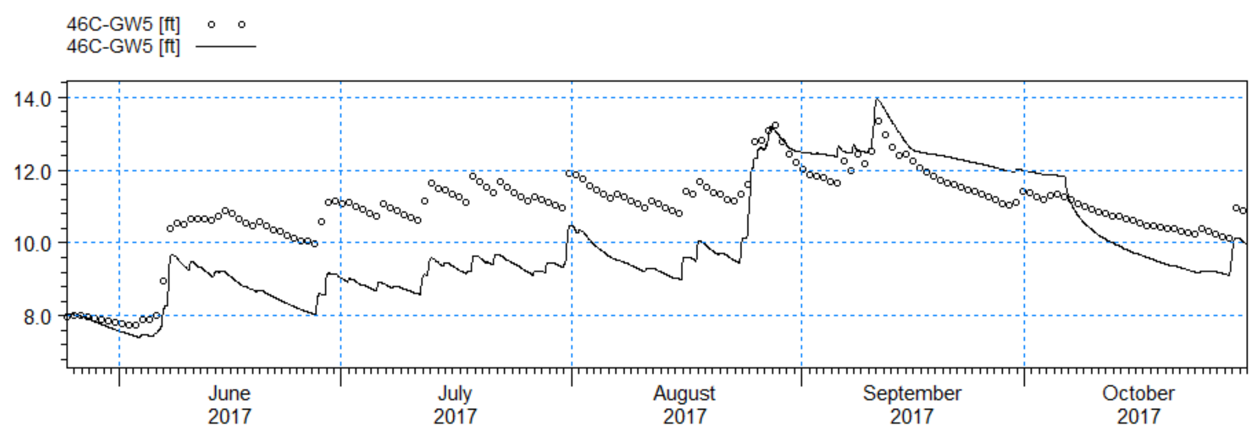
46A-GW30 [ft]
46A-GW30 [ft]
17.0
16.0
15.0
14.0
13.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

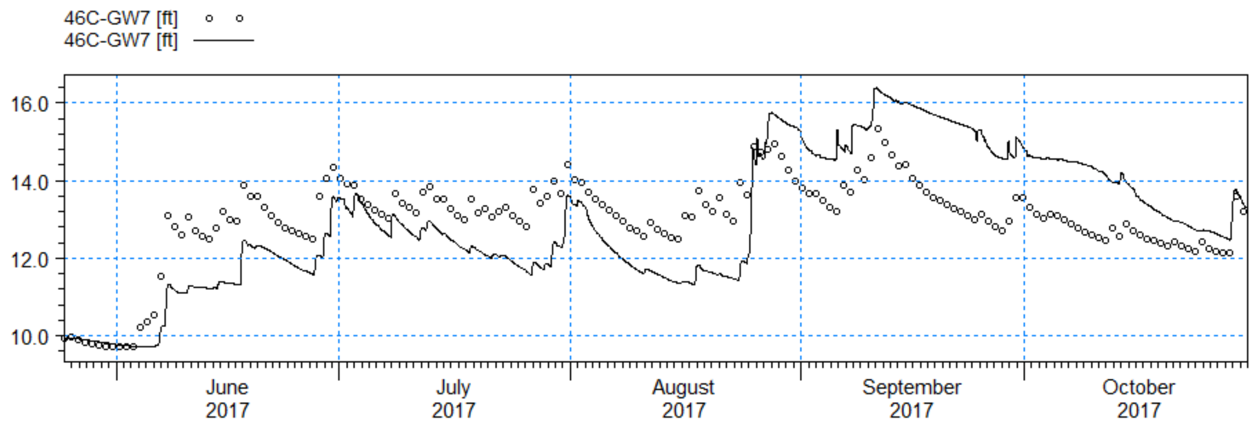


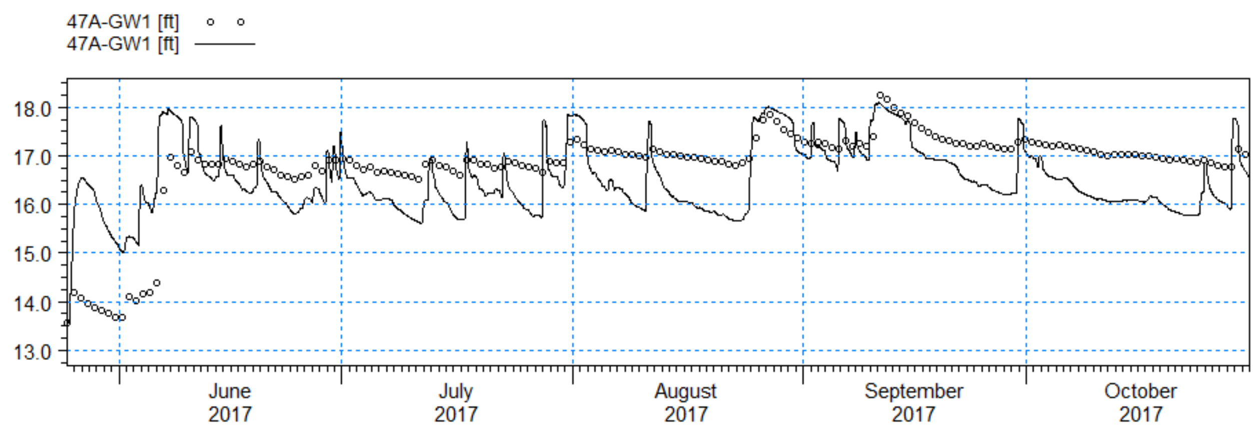
46A-GW31 [ft]
46A-GW31 [ft]
19.0
18.0
17.0
16.0
15.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

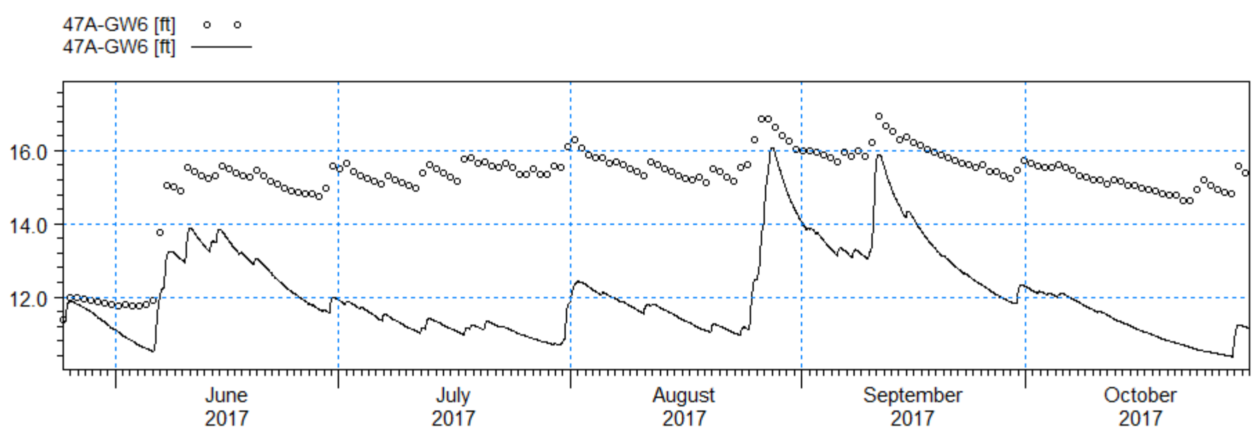

46A-GW32 [ft]
46A-GW32 [ft]
22.0
21.0
20.0
19.0
18.0
17.0
16.0
June 2017
July 2017
August 2017
September 2017
October 2017

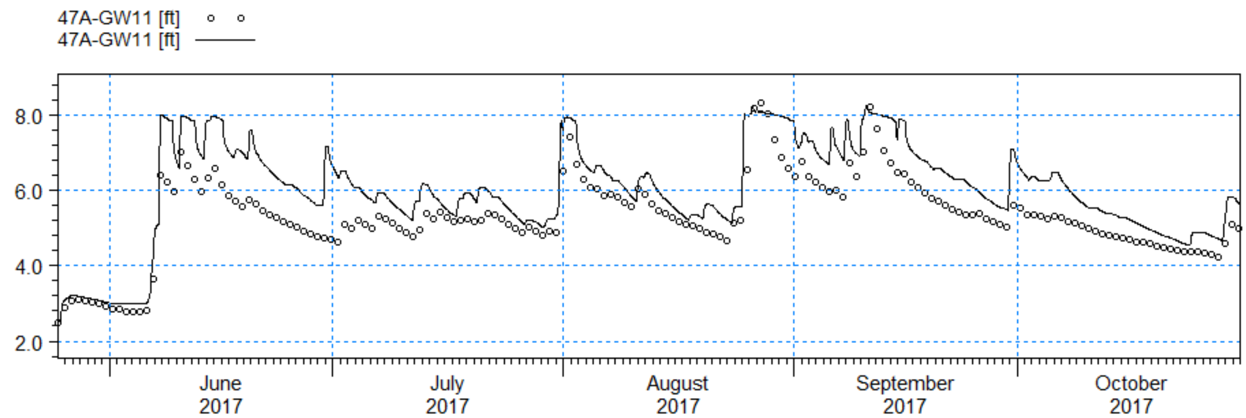

46C-GW2 [ft]
46C-GW2 [ft]
17.0
16.0
15.0
14.0
13.0
12.0
11.0
June 2017
July 2017
August 2017
September 2017
October 2017

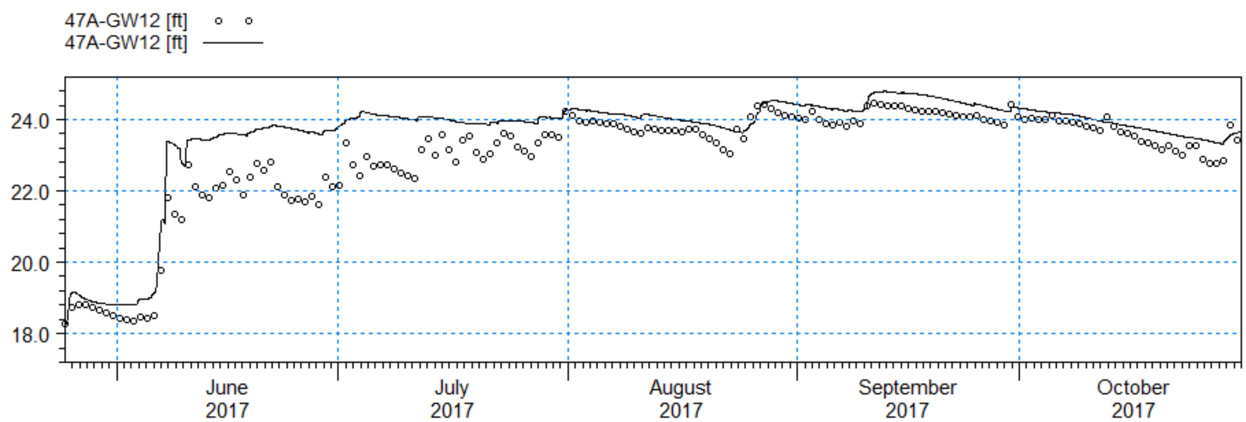

46C-GW5 [ft]
46C-GW5 [ft]
14.0
12.0
10.0
8.0
June 2017
July 2017
August 2017
September 2017
October 2017

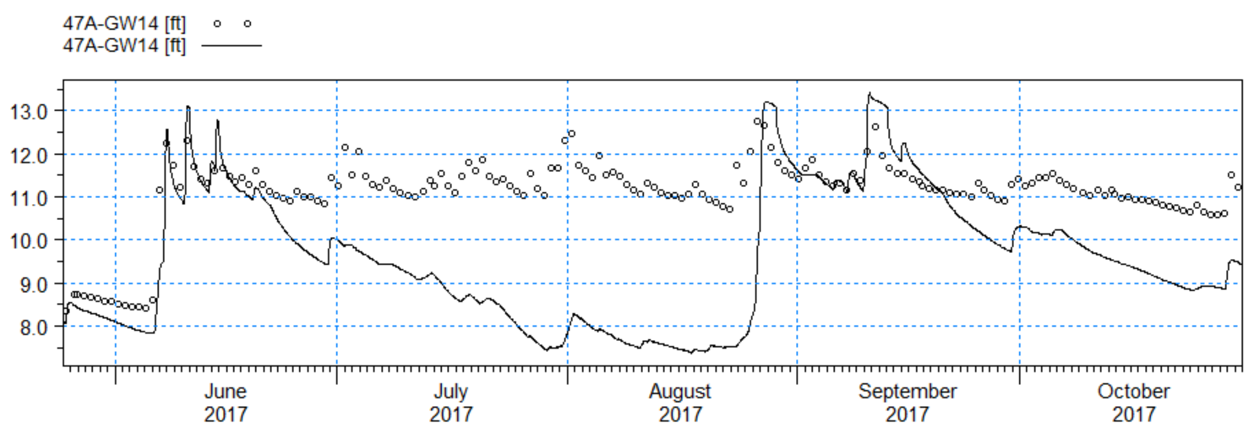

46C-GW7 [ft]
46C-GW7 [ft]
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

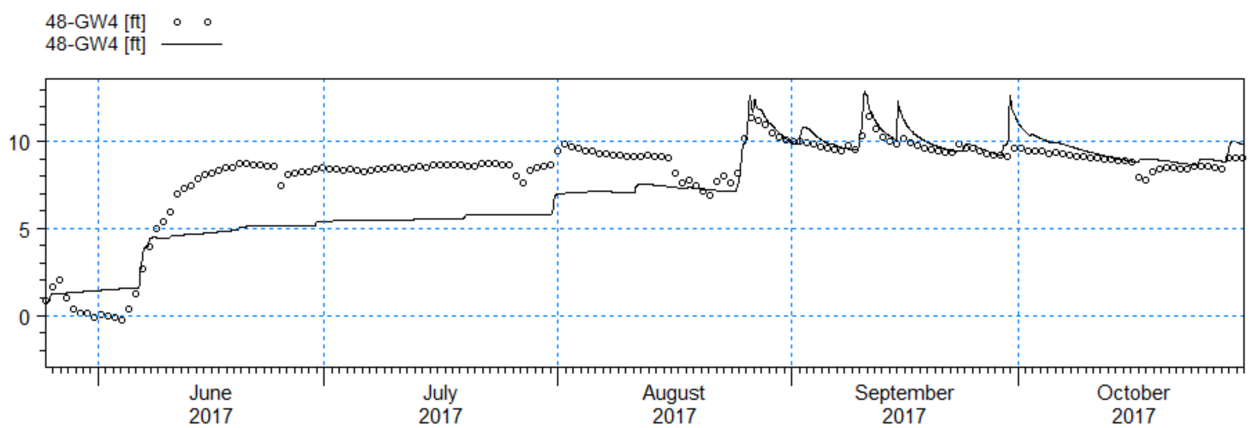

47A-GW1 [ft]
47A-GW1 [ft]
18.0
17.0
16.0
15.0
14.0
13.0
June 2017
July 2017
August 2017
September 2017
October 2017

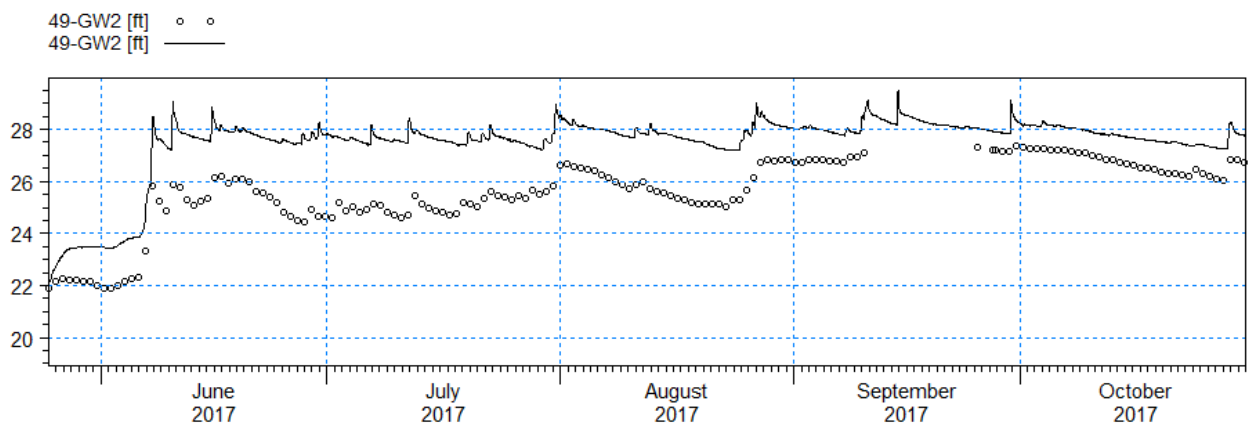

47A-GW6 [ft]
47A-GW6 [ft]
16.0
14.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

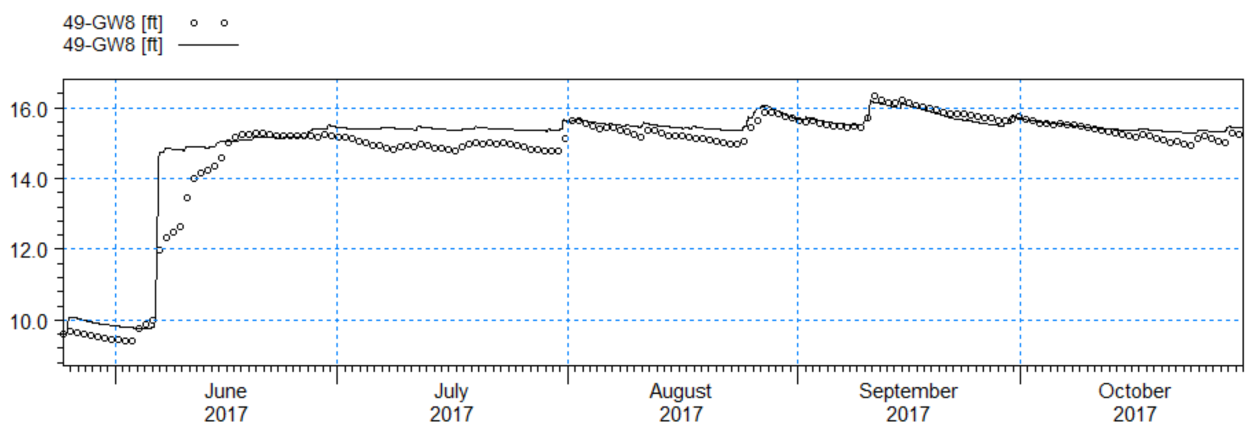

47A-GW11 [ft]
47A-GW11 [ft]
8.0
6.0
4.0
2.0
June 2017
July 2017
August 2017
September 2017
October 2017

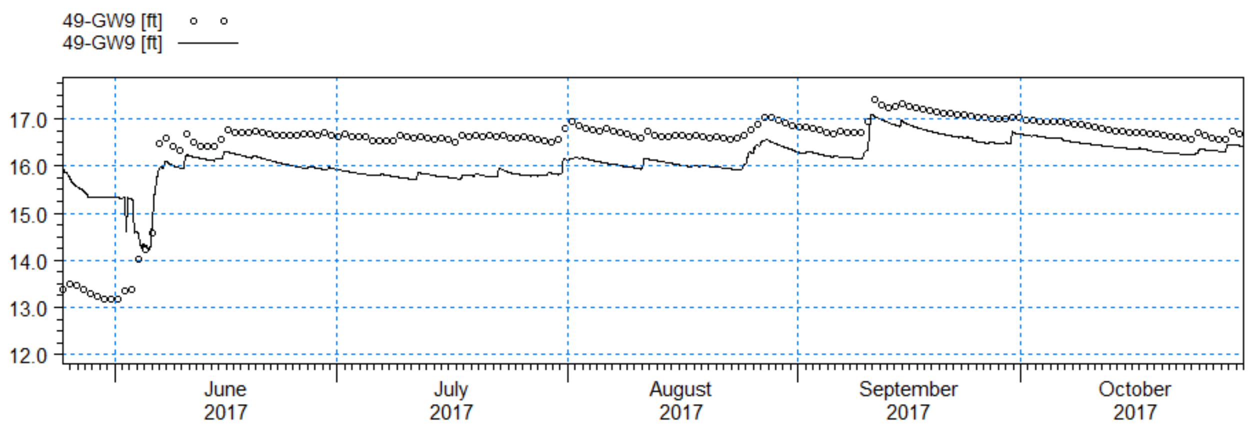

47A-GW12 [ft]
47A-GW12 [ft]
24.0
22.0
20.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

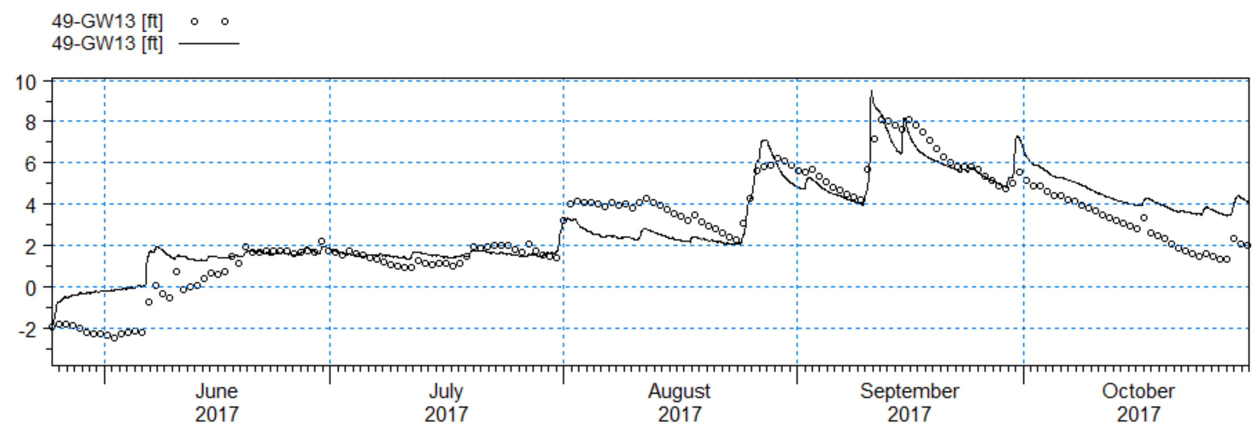

47A-GW14 [ft]
47A-GW14 [ft]
13.0
12.0
11.0
10.0
9.0
8.0
June 2017
July 2017
August 2017
September 2017
October 2017

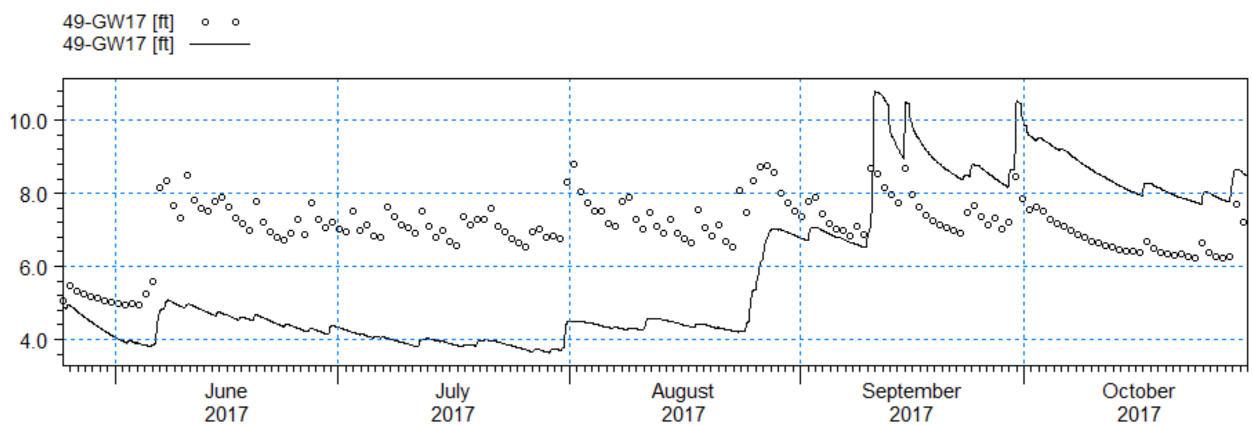

48-GW4 [ft]
48-GW4 [ft]
10
5
0
June 2017
July 2017
August 2017
September 2017
October 2017

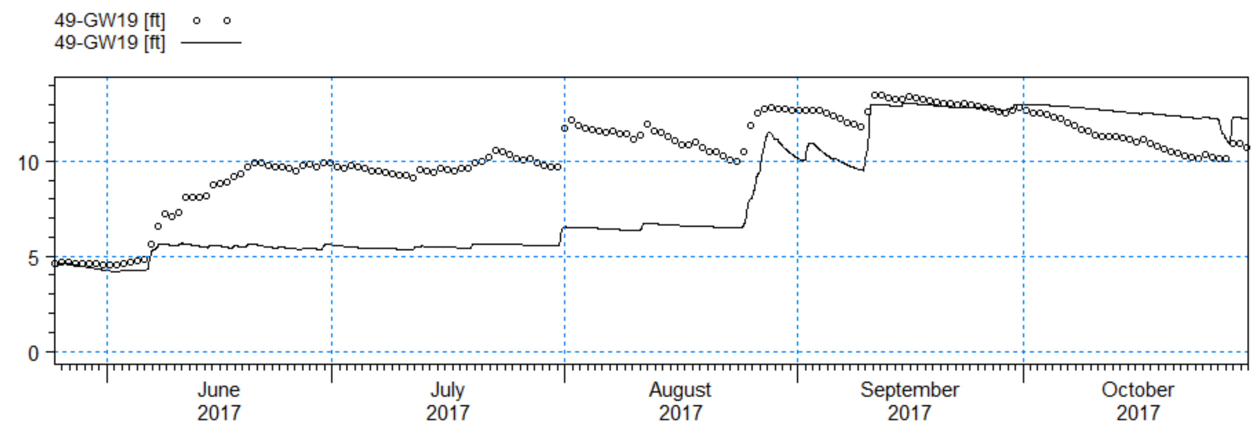

49-GW2 [ft]
49-GW2 [ft]
28
26
24
22
20
June 2017
July 2017
August 2017
September 2017
October 2017

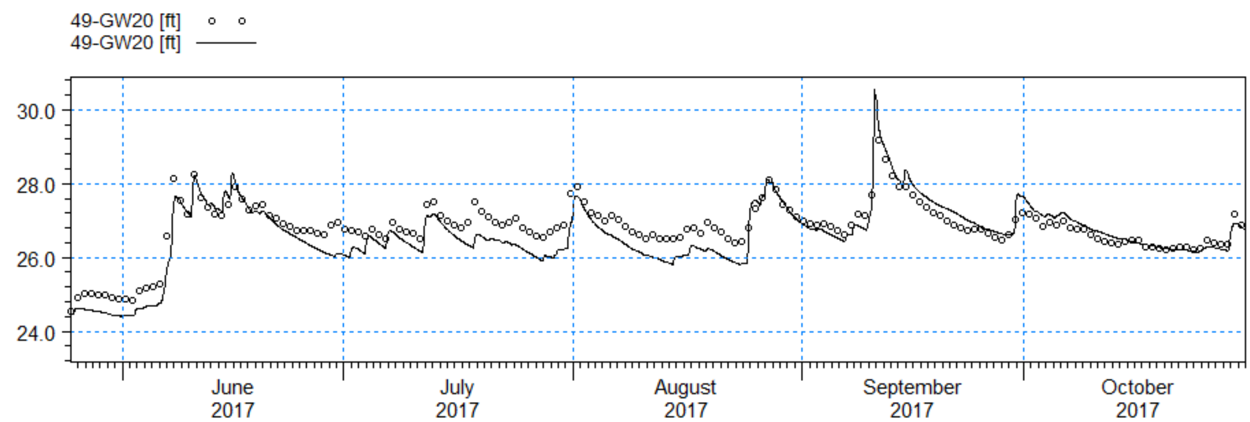

49-GW8 [ft]
49-GW8 [ft]
16.0
14.0
12.0
10.0
June 2017
July 2017
August 2017
September 2017
October 2017

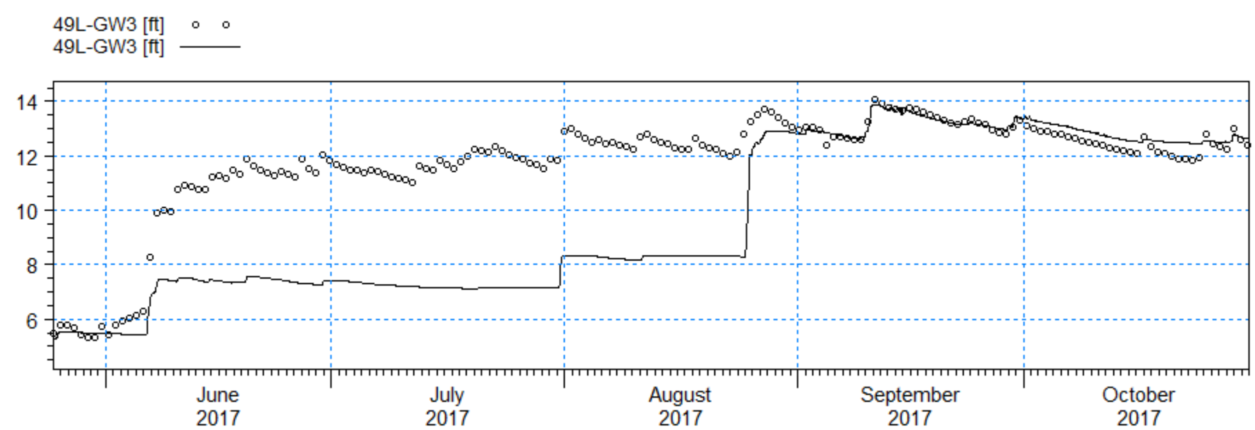

49-GW9 [ft]
49-GW9 [ft]
17.0
16.0
15.0
14.0
13.0
12.0
June 2017
July 2017
August 2017
September 2017
October 2017

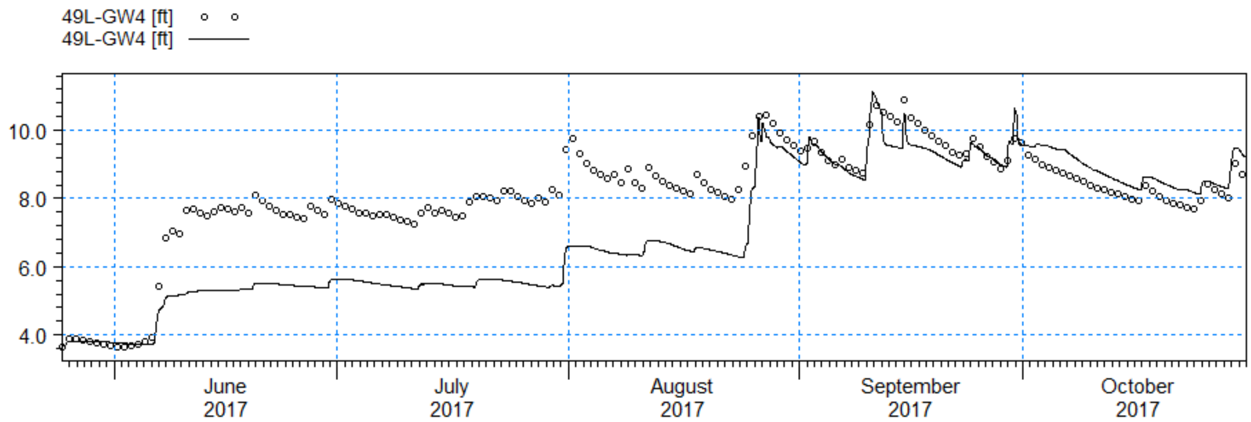

49-GW13 [ft]
49-GW13 [ft]
10
8
6
4
2
0
-2
June 2017
July 2017
August 2017
September 2017
October 2017

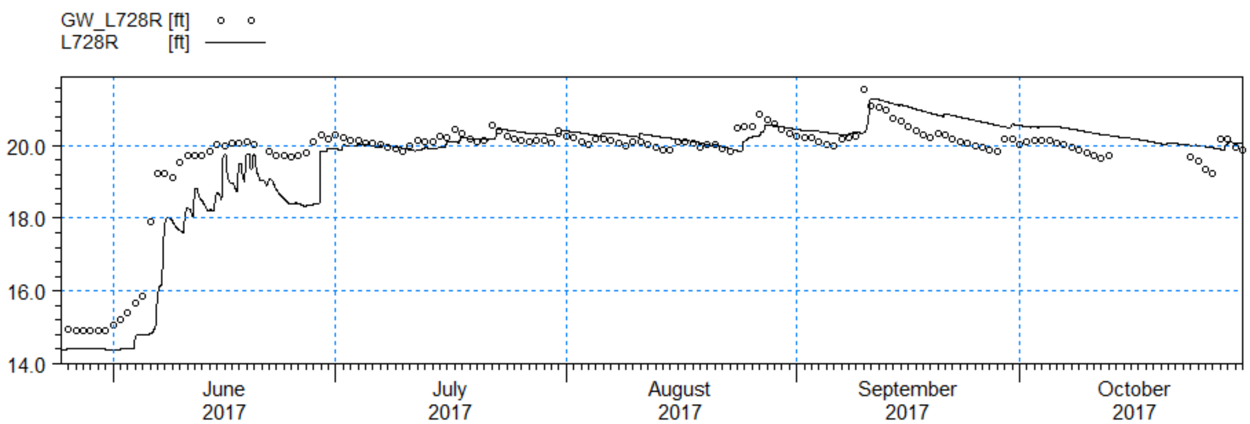

49-GW17 [ft]
49-GW17 [ft]
10.0
8.0
6.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017

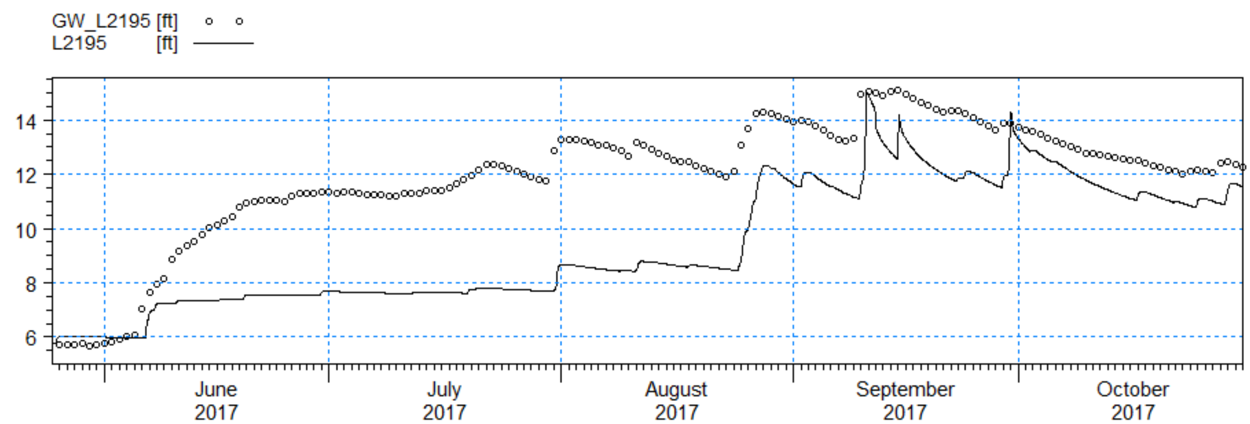

49-GW19 [ft]
49-GW19 [ft]
10
5
0
June 2017
July 2017
August 2017
September 2017
October 2017

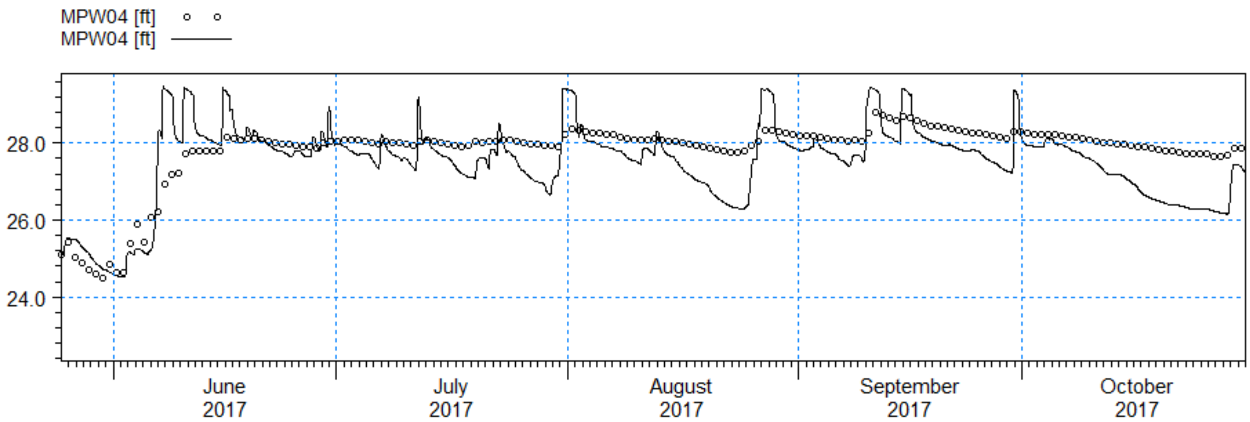

49-GW20 [ft]
49-GW20 [ft]
30.0
28.0
26.0
24.0
June 2017
July 2017
August 2017
September 2017
October 2017


49L-GW3 [ft]
49L-GW3 [ft]
14
12
10
8
6
June 2017
July 2017
August 2017
September 2017
October 2017

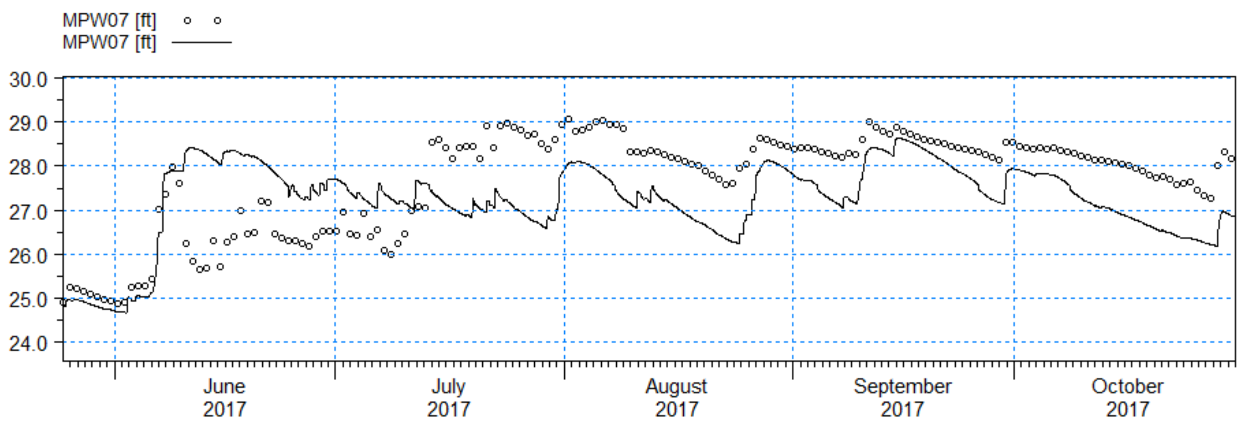

49L-GW4 [ft]
49L-GW4 [ft]
10.0
8.0
6.0
4.0
June 2017
July 2017
August 2017
September 2017
October 2017


GW_L728R [ft]
L728R [ft]
20.0
18.0
16.0
14.0
June 2017
July 2017
August 2017
September 2017
October 2017

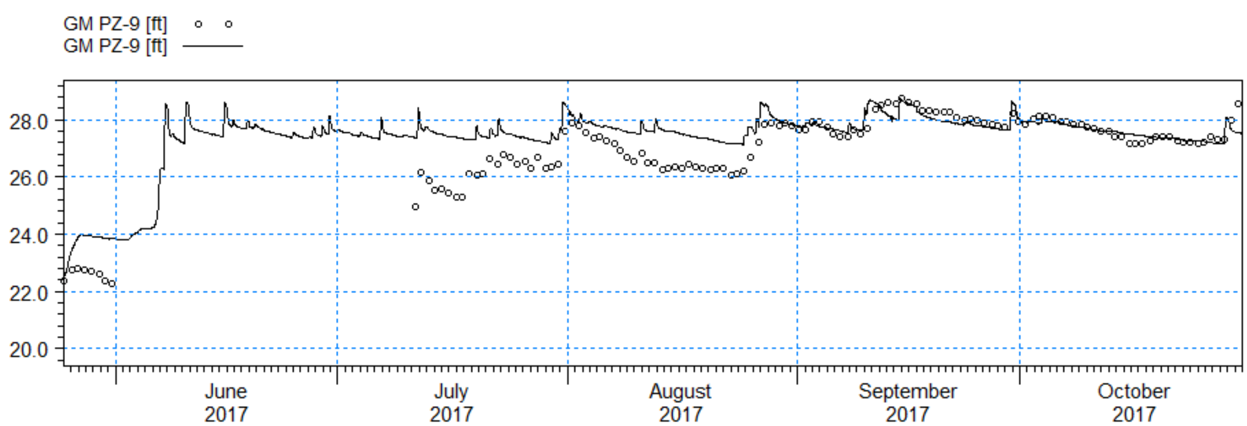

GW_L2195 [ft]
L2195 [ft]
14
12
10
8
6
June 2017
July 2017
August 2017
September 2017
October 2017



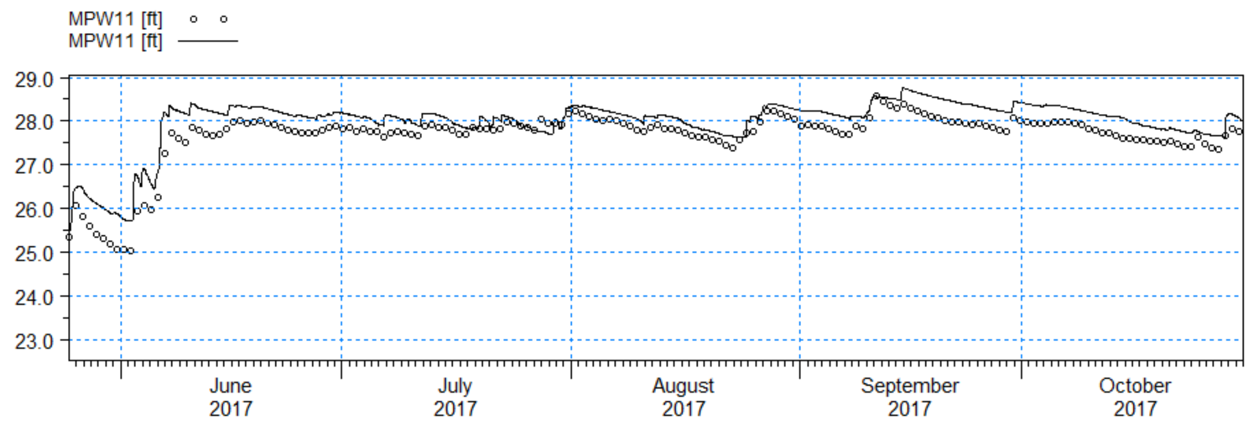
MPW04 [ft]
MPW04 [ft]
28.0
26.0
24.0
June 2017
July 2017
August 2017
September 2017
October 2017

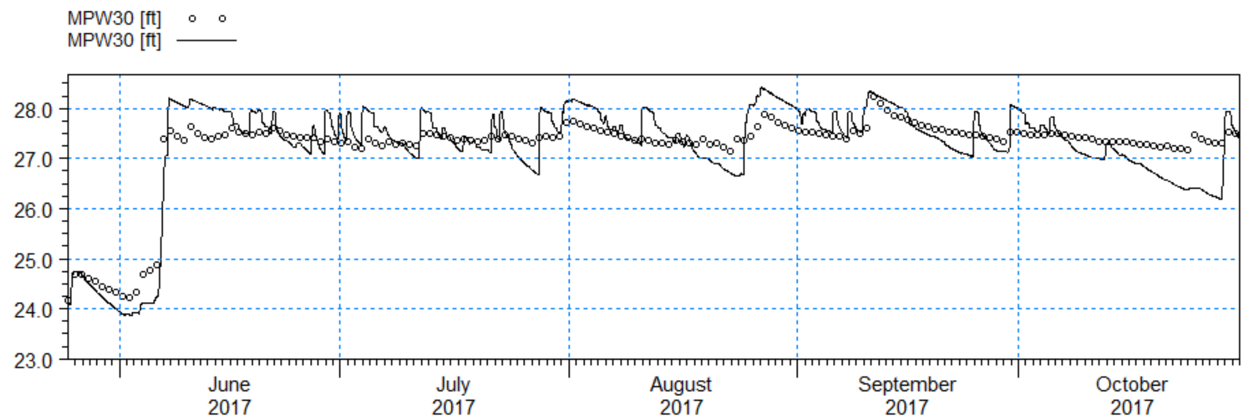


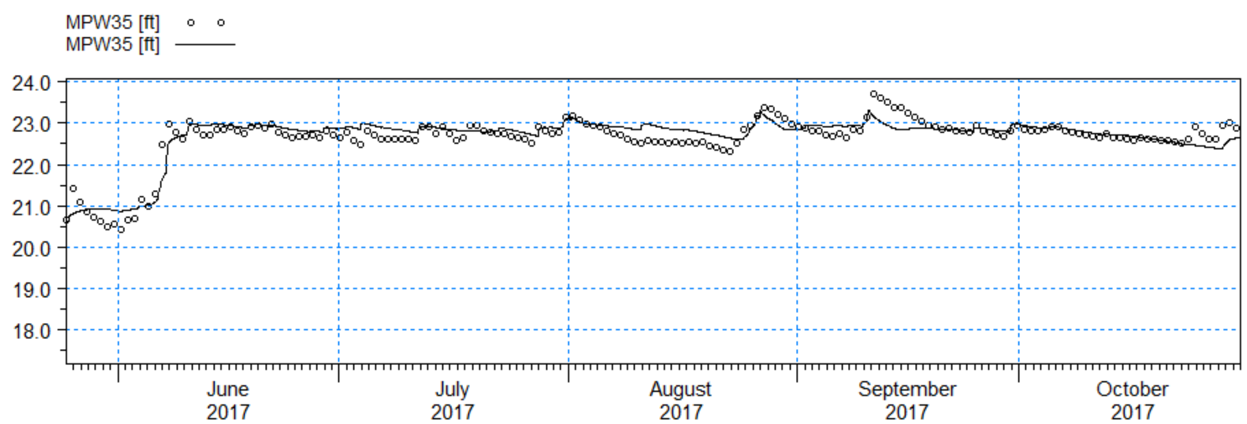
MPW07 [ft]
MPW07 [ft]
30.0
29.0
28.0
27.0
26.0
25.0
24.0
June 2017
July 2017
August 2017
September 2017
October 2017

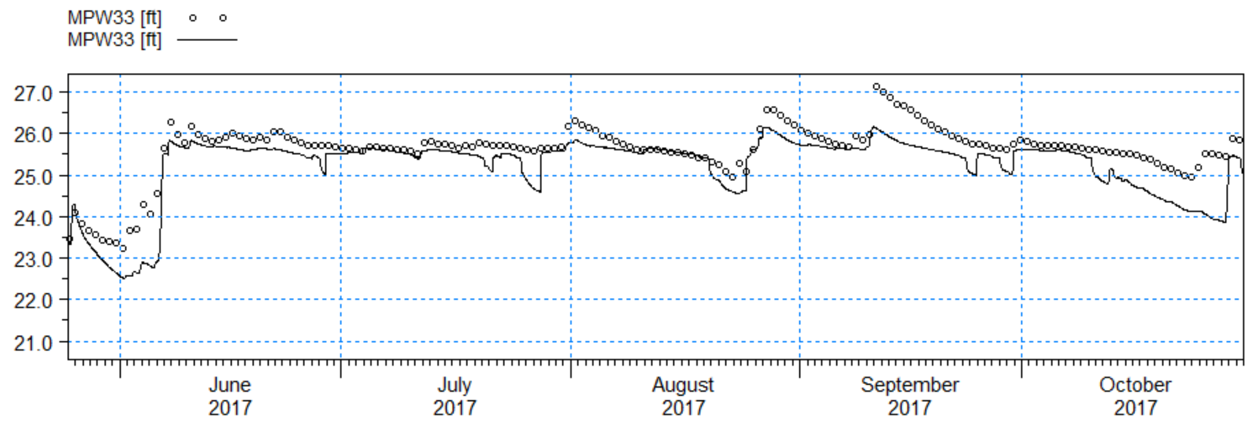


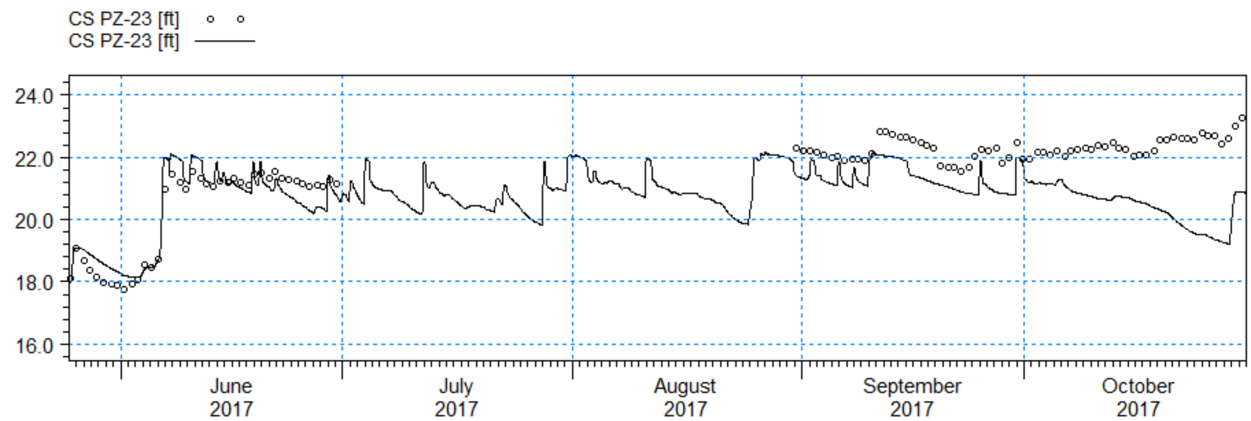
GM PZ-9 [ft]
GM PZ-9 [ft]
28.0
26.0
24.0
22.0
20.0
June 2017
July 2017
August 2017
September 2017
October 2017

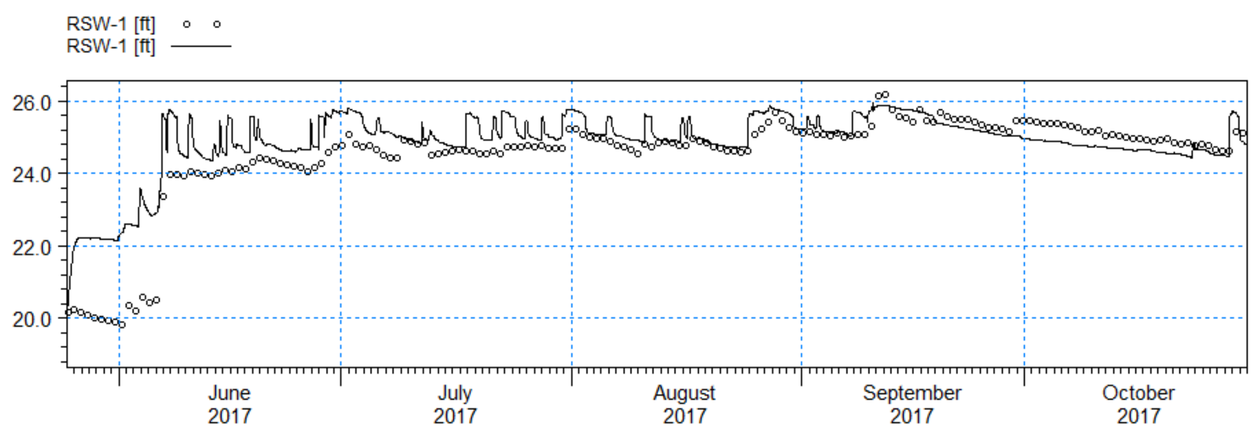

MPW11 [ft]
MPW11 [ft]
29.0
28.0
27.0
26.0
25.0
24.0
23.0
June 2017
July 2017
August 2017
September 2017
October 2017

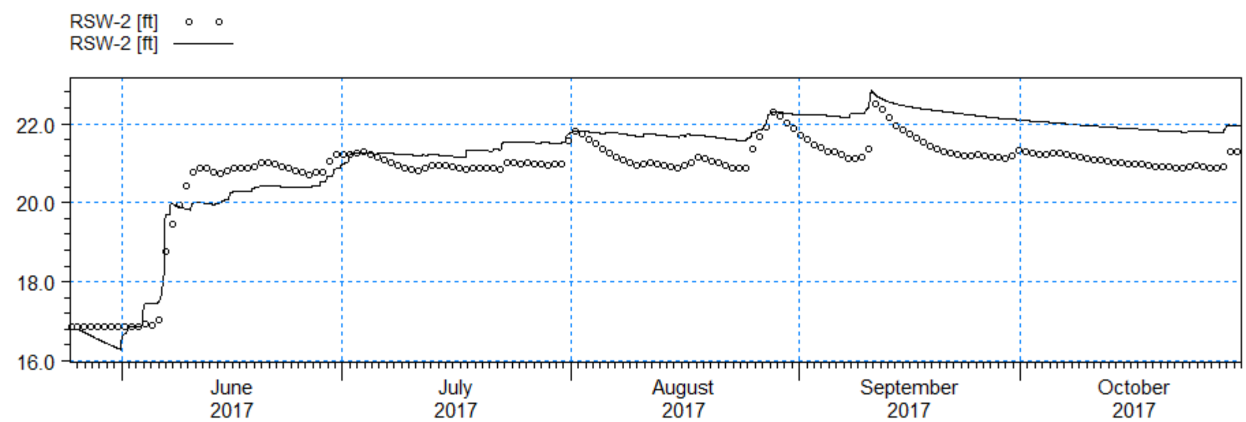

MPW30 [ft]
MPW30 [ft]
28.0
27.0
26.0
25.0
24.0
23.0
June 2017
July 2017
August 2017
September 2017
October 2017

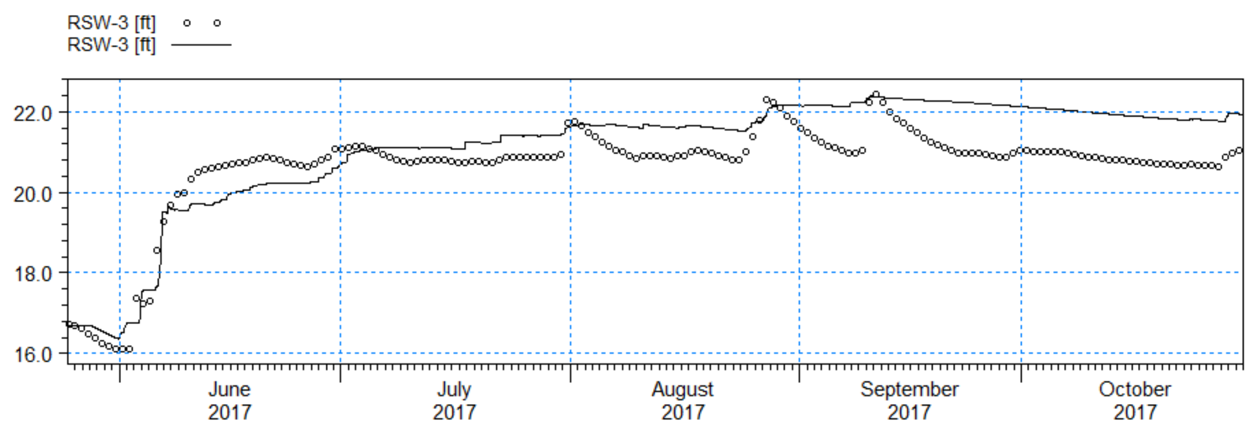

MPW35 [ft]
MPW35 [ft]
24.0
23.0
22.0
21.0
20.0
19.0
18.0
June 2017
July 2017
August 2017
September 2017
October 2017

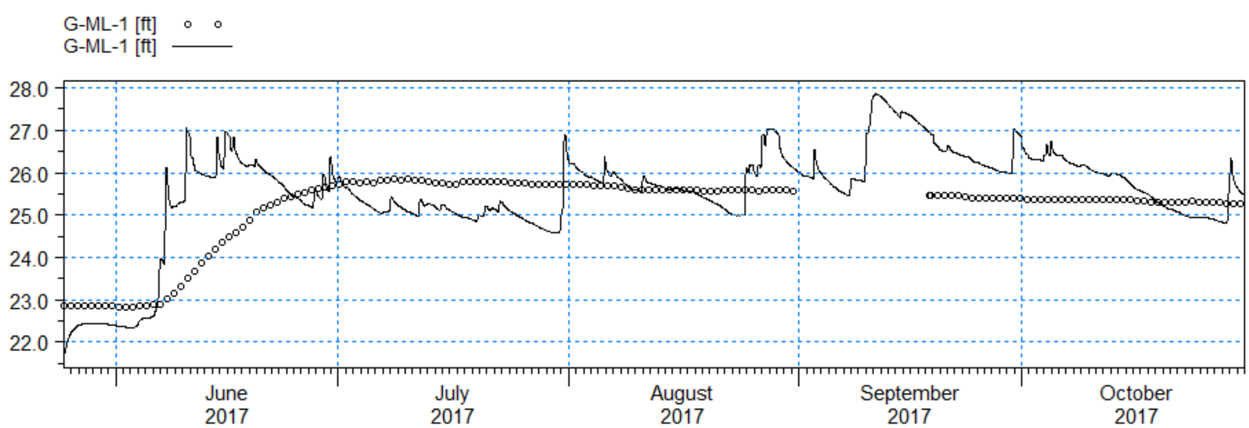

MPW33 [ft]
MPW33 [ft]
27.0
26.0
25.0
24.0
23.0
22.0
21.0
June 2017
July 2017
August 2017
September 2017
October 2017

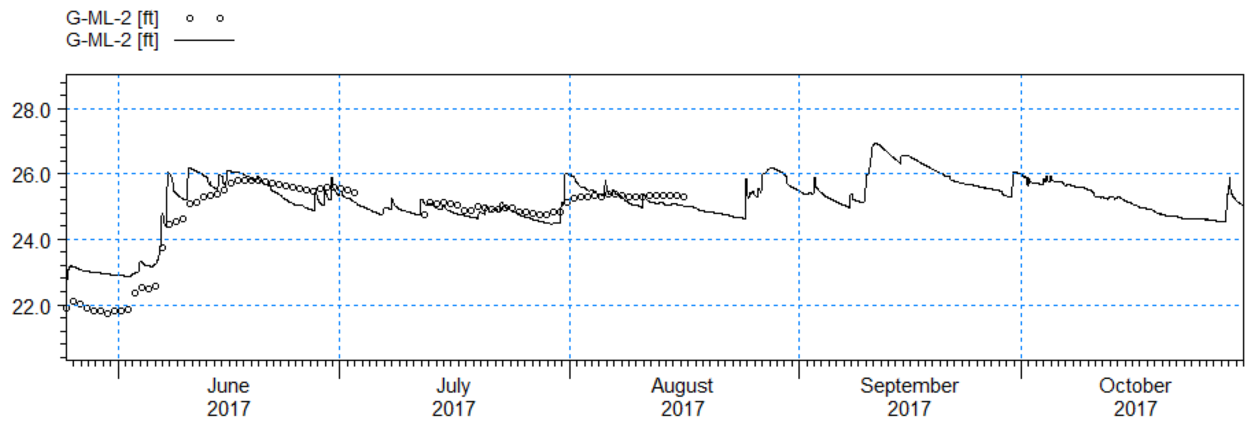

CS PZ-23 [ft]
CS PZ-23 [ft]
24.0
22.0
20.0
18.0
16.0
June 2017
July 2017
August 2017
September 2017
October 2017

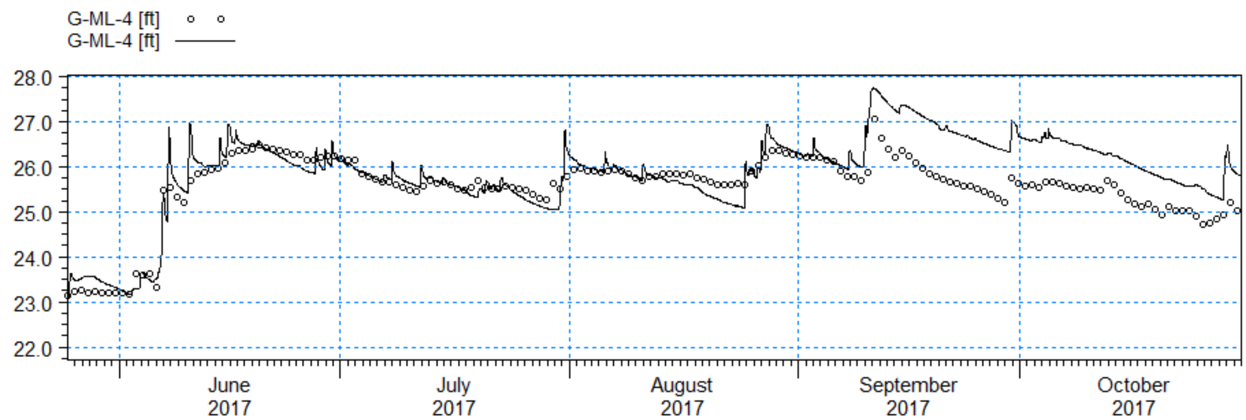

RSW-1 [ft]
RSW-1 [ft]
26.0
24.0
22.0
20.0
June 2017
July 2017
August 2017
September 2017
October 2017

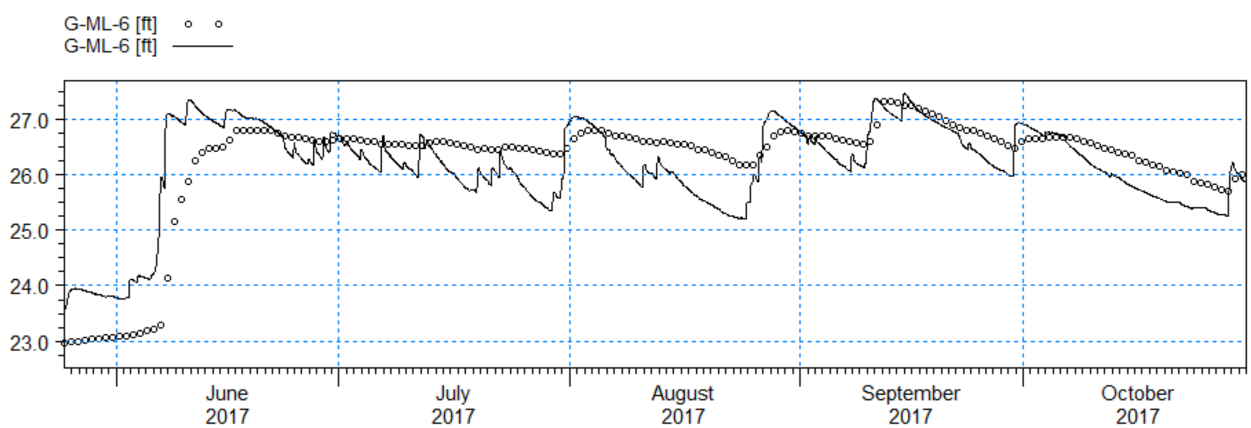

RSW-2 [ft]
RSW-2 [ft]
22.0
20.0
18.0
16.0
June 2017
July 2017
August 2017
September 2017
October 2017


RSW-3 [ft]
RSW-3 [ft]
22.0
20.0
18.0
16.0
June 2017
July 2017
August 2017
September 2017
October 2017


G-ML-1 [ft]
G-ML-1 [ft]
28.0
27.0
26.0
25.0
24.0
23.0
22.0
June 2017
July 2017
August 2017
September 2017
October 2017







4.2.2 Lower Tamiami

The Lower Tamaimi aquifer is represented by only a few stations throughout the model. Table 23 provides a summary of the model performance within the Lower Tamiami aquifer. A map of the groundwater calibration stations for the Lower Tamiami is shown in Figure 46. In addition, groundwater calibration plots for these stations (excluding the data points with monthly datasets) are shown in the preceding graphics. The station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 23.Model Performance Per Study Area for the Lower Tamiami aquifer

	East Lee County	Whiskey Creek	South Ft Myers	Southeast Lee County	All Study Areas
# of Stations	6	0	0	5	11
Good	33%	--	--	60%	45%
Okay	50%	--	--	40%	45%
Poor	17%	--	--	0%	9%

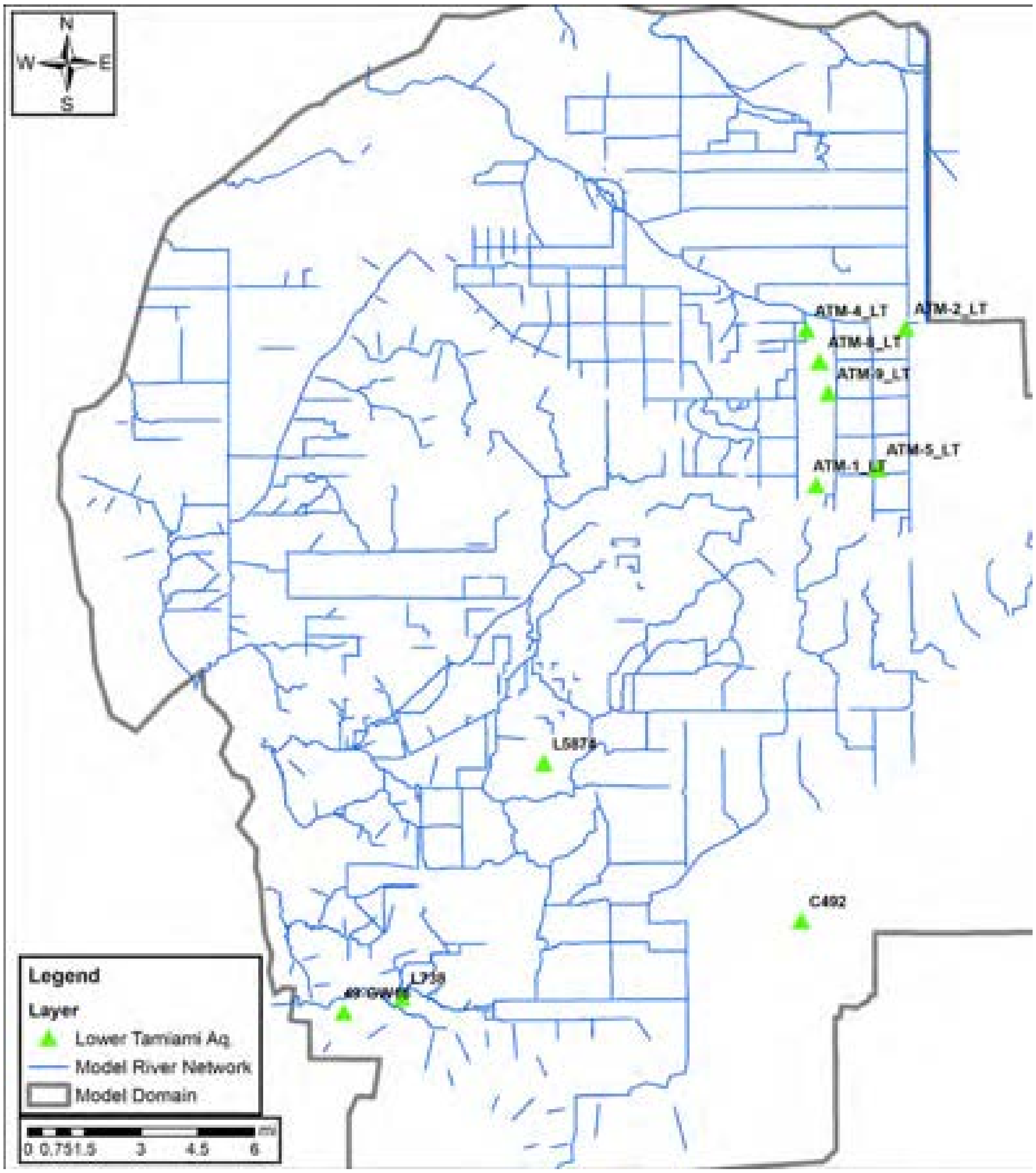
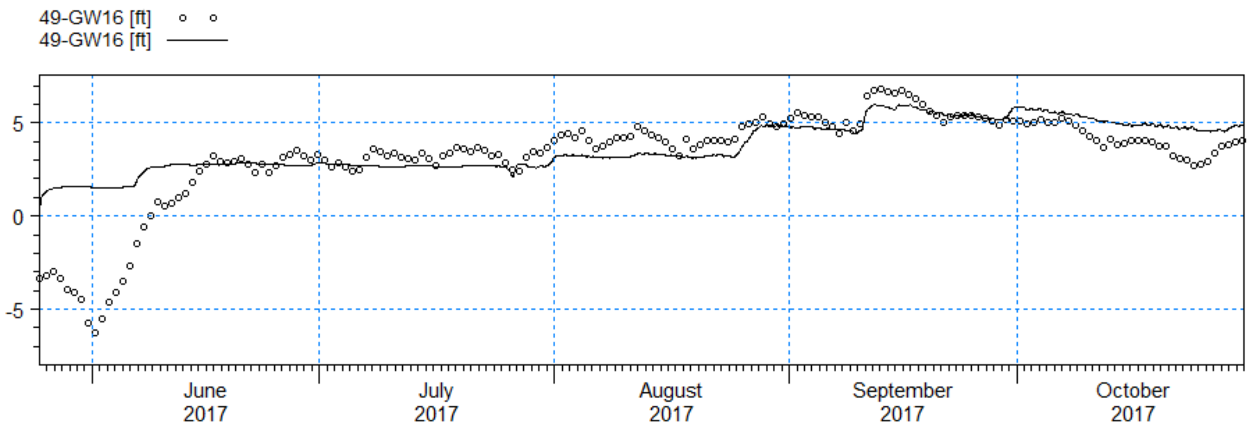
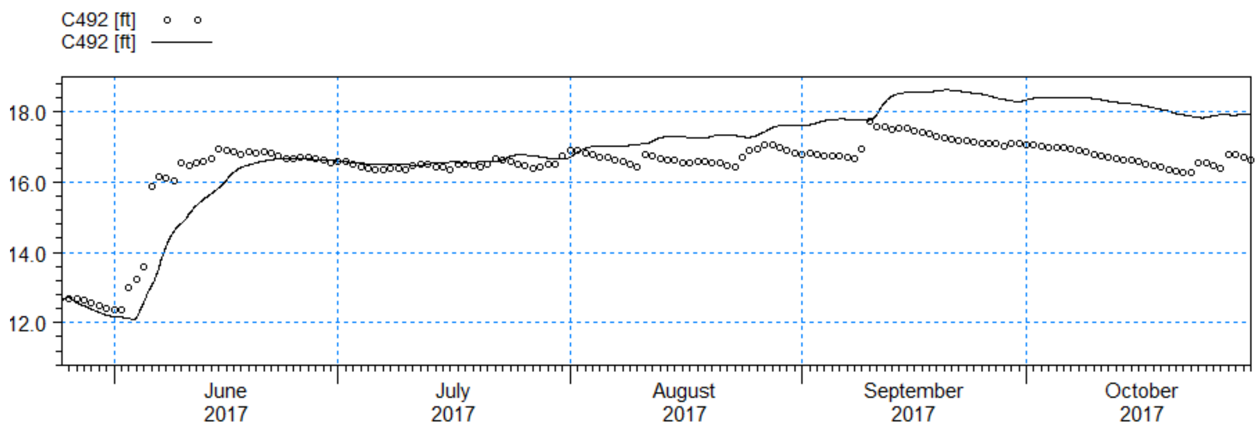


Figure 437. Map of Groundwater Calibration Points for the Lower Tamiami Aquifer


49-GW16 [ft]
49-GW16 [ft]
5
0
-5
June 2017
July 2017
August 2017
September 2017
October 2017


C492 [ft]
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18.0
16.0
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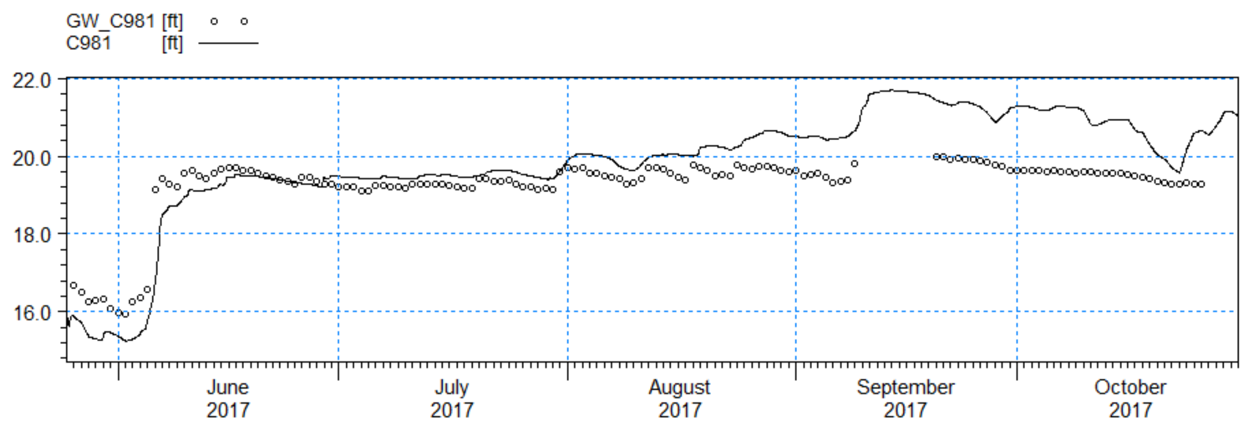
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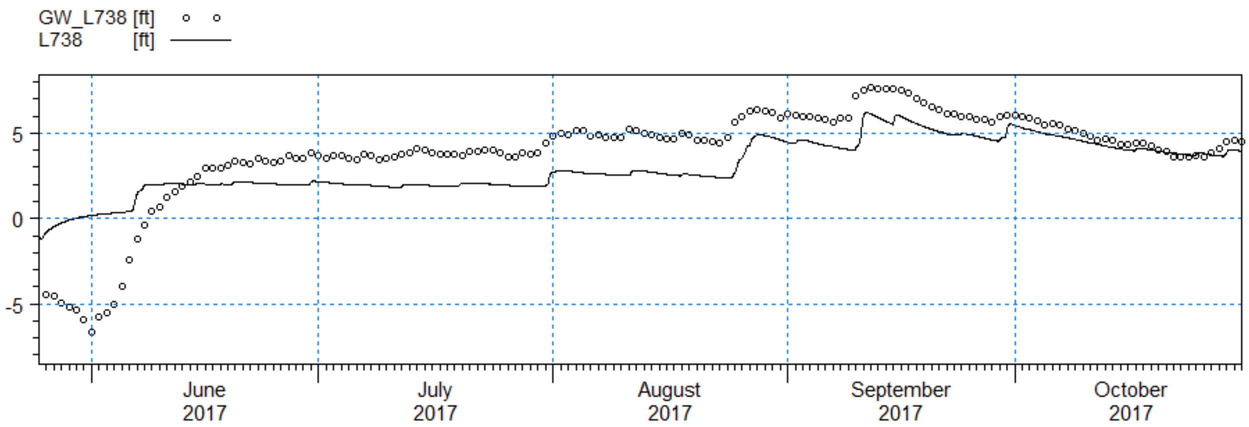
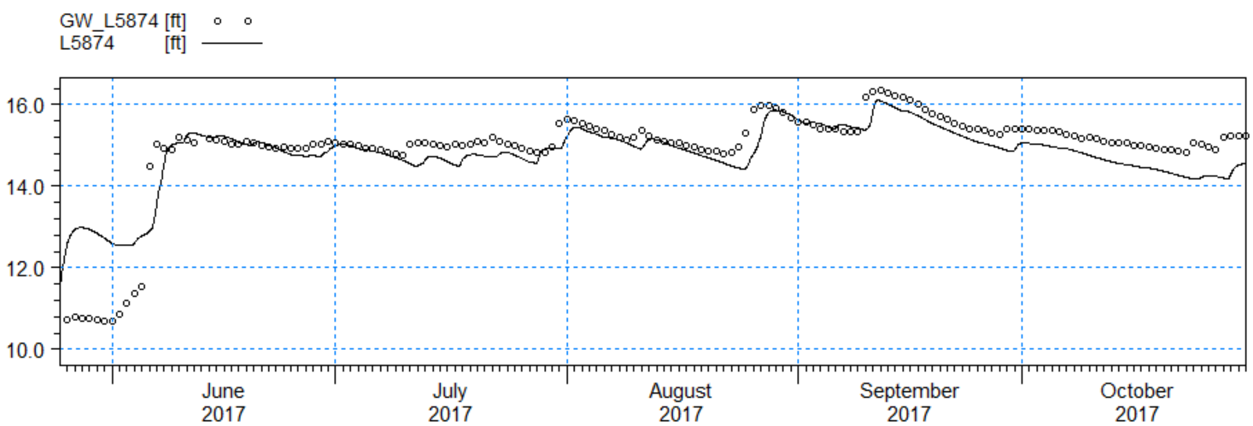




4.2.3 Sandstone Aquifer

No measured stations were shown to be within the Hawthorn Confining Unit. Table 24 provides a measure of the model's ability to simulate the groundwater levels in the Sandstone aquifer for each study area. A map of the groundwater calibration stations for the sandstone aquifer is shown in Figure 47. In addition, groundwater calibration plots for these stations (excluding the data points with monthly datasets) are shown in the preceding graphics. The station number is shown in top left of the graphic, with measured data as circles and modeled data as a solid line.

Table 24. Model Performance Per Study Area for the Sandstone aquifer

	East Lee County	Whiskey Creek	South Ft Myers	Southeast Lee County	All Study Areas
# of Stations	8	0	0	1	9
Good	0%	--	--	0%	0%
Okay	13%	--	--	0%	11%
Poor	88%	--	--	100%	89%

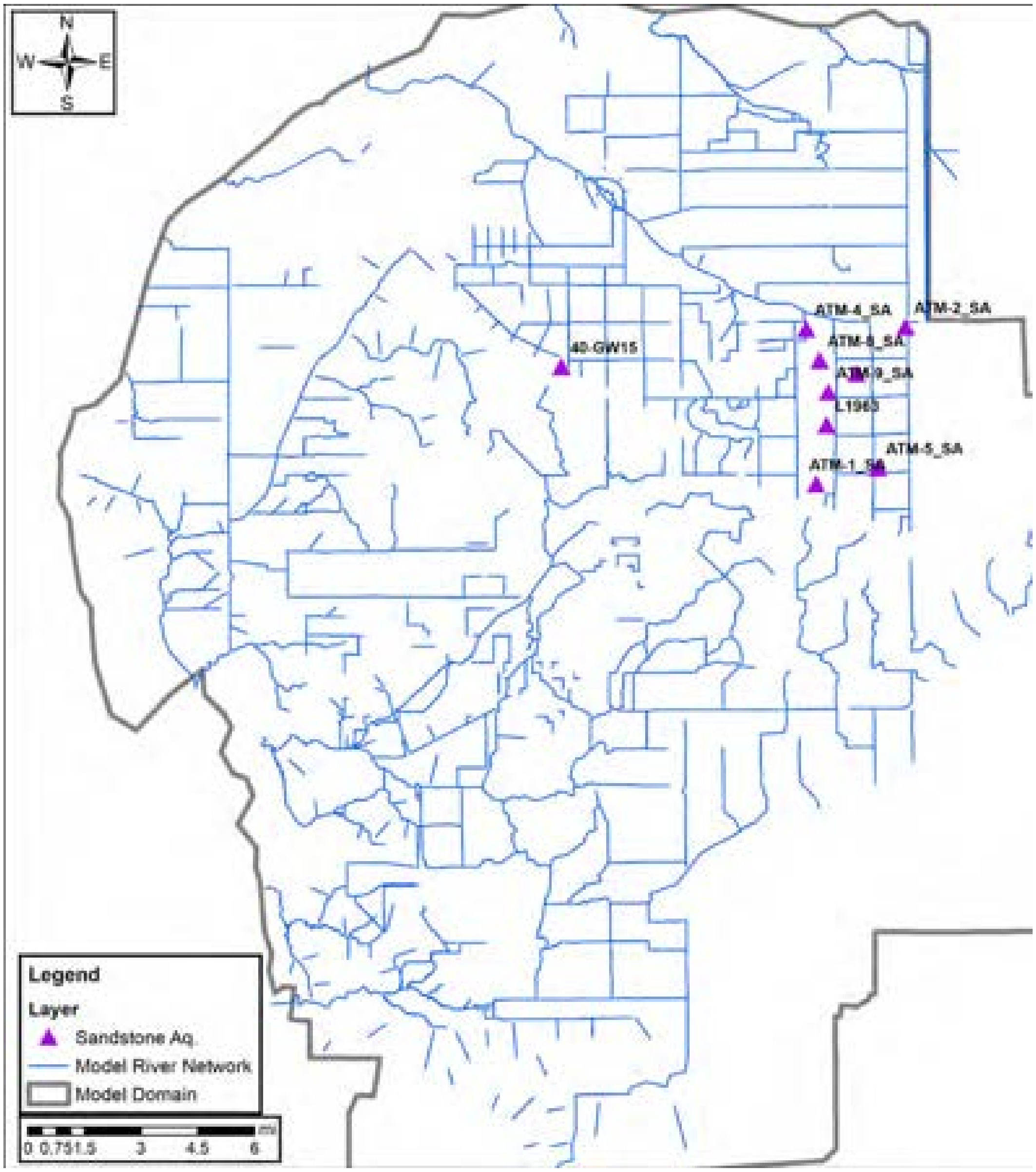
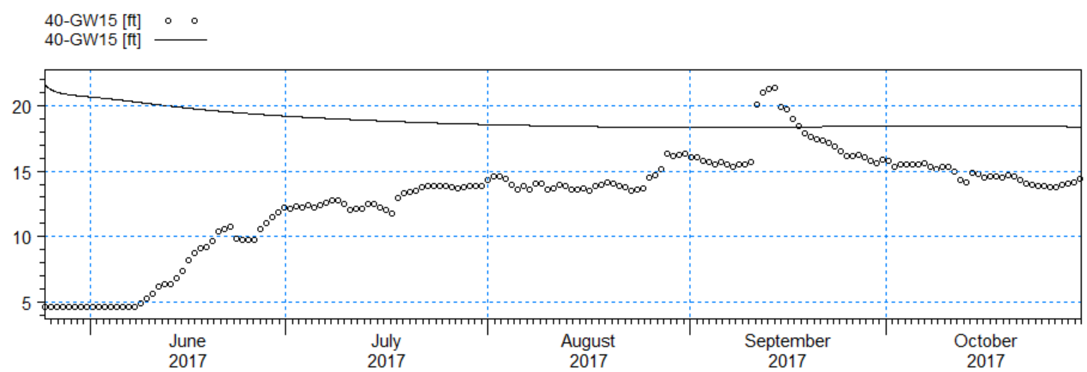


Figure 48. Map of Groundwater Calibration Points for the Sandstone Aquifer



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Appendix A – Suggested Model Parameters

The following parameters were tested over the 2 year simulation period (1/1/2016 through 12/31/2017) after the modeling effort was completed and were therefore not included in the modeling analysis. However, they are suggested modifications to the model that may improve calibration in the dry months.

Table 25. Suggested LAI values

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	3.38	3.75	4.12	4.5	4.5	4.5	4.5	4.5	4.5	3.75	3.38	3.38
Pasture	3.5	4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4	3.5
Truck Crops	3.75	4.5	3	3.75	4.5	3	3	3	3	3	3	3
Golf Course	2	2.5	3	3	3	3	3	3	3	3	3	2
Bare Ground	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mesic Flatwood	1.5	1.5	1.5	1.5	1.5	2	3	3	2.5	2	1.5	1.5
Mesic Hammock	2.5	3	3	3	3.5	4	4	4	3.5	3.5	3	2.5
Xeric Flatwood	1	1	1	1	1.5	2	2	2	2	1.5	1.5	1
Xeric Hammock	2	2	2	2	2.5	3	3	3	2.5	2.5	2	2
Hydric Flatwood	1.5	1.5	2	2	2.5	3	3	3	2.5	2	1.5	1.5
Hydric Hammock	2.5	3	3	3	3.5	4	4	4	3.5	3.5	3	2.5
Wet Prairie	1.5	1.5	2	2	2.5	3	3	3	2.5	2	1.5	1.5
Dry Prairie	0.4	0.1	0.1	0.1	0.4	0.4	0.6	1.4	1.5	1.4	1.2	0.8
Marsh	2	2	3	3	3	3.5	4	4	3.5	3	2.5	2
Cypress	2	2	3	3	3.5	4	4	4	3.5	3	2.5	2
Swamp Forest	4.5	3.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	4.5	3.5
Willow	3	3	4	4	4.5	5	5	5	4.5	4	3.5	3
Mangrove	3	3	3	3	3.5	4	4	4	3.5	3.5	3	3
Water	0	0	0	0	0	0	0	0	0	0	0	0
Residential Underdeveloped	1.0	1.4	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.0
Urban Low Density	0.9	1.25	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.9
Urban Medium Density	0.8	1.13	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.8
Urban High Density	0.7	0.98	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	0.98	0.7

Table 26. Suggested RD values (inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2
Pasture	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Truck Crops	17.7	29.5	6.0	17.7	29.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Golf Course	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Bare Ground	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94	3.94
Mesic Flatwood	48	48	48	48	48	48	48	48	48	48	48	48
Mesic Hammock	24	24	24	24	24	24	24	24	24	24	24	24
Xeric Flatwood	48	48	48	48	48	48	48	48	48	48	48	48
Xeric Hammock	24	24	24	24	24	24	24	24	24	24	24	24
Hydric Flatwood	48	48	48	48	48	48	48	48	48	48	48	48
Hydric Hammock	24	24	24	24	24	24	24	24	24	24	24	24
Wet Prairie	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Dry Prairie	20	18	18	18	20	22	23	24	24	23	22	21
Marsh	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Cypress	60	60	60	60	60	60	60	60	60	60	60	60
Swamp Forest	60	60	60	60	60	60	60	60	60	60	60	60
Willow	60	60	60	60	60	60	60	60	60	60	60	60
Mangrove	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8
Water	0	0	0	0	0	0	0	0	0	0	0	0
Residential Underdeveloped	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Urban Low Density	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Urban Medium Density	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Urban High Density	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9

Table 27. Suggested Kc, crop coefficients

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	0.69	0.69	0.74	0.82	0.91	0.99	1.03	1.03	1.03	1.03	0.91	0.74
Pasture	0.67	0.72	0.86	0.98	1.00	1.01	1.01	0.98	0.92	0.88	0.75	0.65
Truck Crops	0.71	0.86	1.03	1.06	0.96	0.88	0.92	0.97	0.97	0.96	0.91	0.76
Golf Course	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Bare Ground	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Mesic Flatwood	0.67	0.68	0.70	0.72	0.73	0.74	0.76	0.76	0.75	0.73	0.71	0.69
Mesic Hammock	0.67	0.68	0.70	0.72	0.73	0.74	0.76	0.76	0.75	0.73	0.71	0.69
Xeric Flatwood	0.67	0.68	0.70	0.72	0.73	0.74	0.76	0.76	0.75	0.73	0.71	0.69
Xeric Hammock	0.67	0.68	0.70	0.72	0.73	0.74	0.76	0.76	0.75	0.73	0.71	0.69
Hydric Flatwood	0.67	0.68	0.70	0.72	0.73	0.74	0.76	0.76	0.75	0.73	0.71	0.69
Hydric Hammock	0.67	0.68	0.70	0.72	0.73	0.74	0.76	0.76	0.75	0.73	0.71	0.69
Wet Prairie	0.78	0.78	0.82	0.86	0.87	0.87	0.89	0.90	0.87	0.84	0.79	0.78
Dry Prairie	1	1	1	1	1	1	1	1	1	1	1	1
Marsh	0.77	0.78	0.80	0.80	0.81	0.81	0.82	0.83	0.81	0.78	0.77	0.78
Cypress	0.82	0.83	0.84	0.92	1.00	1.01	1.03	1.04	0.92	0.80	0.79	0.80
Swamp Forest	0.70	0.71	0.74	0.76	0.82	0.89	0.94	0.96	0.95	0.89	0.79	0.73
Willow	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Mangrove	1	1	1	1	1	1	1	1	1	1	1	1
Water	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Residential Underdeveloped	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Urban Low Density	0.54	0.53	0.55	0.57	0.58	0.61	0.69	0.72	0.71	0.66	0.59	0.57
Urban Medium Density	0.47	0.46	0.47	0.48	0.49	0.52	0.56	0.59	0.59	0.56	0.51	0.49
Urban High Density	0.39	0.38	0.39	0.40	0.41	0.42	0.44	0.46	0.47	0.45	0.42	0.41

3.2 PROJECT ANALYSIS – REPORT

INTRODUCTION

The 2017 Atlantic hurricane season was the costliest tropical cyclone season on record. For Lee County alone, cleanup and repair costs topped $40M. Following a heavy rainfall event in August that caused flooding in many areas, Florida's southwestern coast was further impacted by Hurricane Irma in early September. During the storm, many parts of Lee County experienced bursts of heavy rainfall over a relatively short period of time. These intervals of intense rainfall in combination with the already exacerbated saturated groundwater conditions, resulted in inundation of many parts of Lee County, including Lehigh Acres, Eastern Lee County, Whiskey Creek and Bonita Springs.

The AIM Team has developed flood mitigation projects for Southern Lee County in four distinct areas, including Whiskey Creek, South Fort Myers, Lehigh Acres (herein referred to as East Lee County), and Southeast Lee County. Each region has unique hydrological features that will require distinctive projects to manage proper storage and conveyance of stormwater.

To test the effectiveness of each of the proposed mitigation projects, a regional model of Southern Lee County was developed by the modeling team. Several smaller regional models have been previously developed for other projects within the area, including the Lehigh Acres Municipal Services Improvement District (LA-MSID) Stormwater Model and the Village of Estero (VOE) Regional Model. These models were developed using the MIKE SHE/MIKE 11 software, which is an integrated hydrological numerical modeling tool that links 1-dimensional (1D) surface water hydraulics to 3-dimensional (3D) groundwater movement. This model is herein referred to as the Southern Lee County Regional Model (SLCRM).

The proposed conditions, outlined for each proposed project by the project development team, were then implemented into the model as additional 1D branches, weirs, culverts, gated water control structures, pumps, and berms. The proposed condition models were then compared with existing conditions to assess their effectiveness at reducing peak stages and/or duration of peak stages.

1 EXISTING CONDITIONS MODEL DEVELOPMENT SUMMARY

The existing conditions model was calibrated using the 2017 wet season as a shortened period for comparison with measured data. A full description of the calibration effort was detailed in the Development and Calibration of the Southern Lee County Regional Model Report.

Model development included:

- domain and grid sizing,
- resampling of the DEM,
- evaluation of the appropriate rainfall inputs,
- collection and combination of existing model data for the development of the 1D river network (including cross-sections, water control structures, etc),
- establishing appropriate ET parameters for each landuse type,
- developing the appropriate Manning's Roughness,
- establishing the paved area fraction of the cell based on the building footprint and roadways shapefiles,
- creating soil maps

An external peer review process was performed by Lago Consulting & Services on model development and the Model Development Report.

2.1 DESIGN STORM SETUP

Design storm simulations were established using the existing conditions model for the 100-year 3-day and 25-year 3-day rainfall hydrographs. To simulate a storm surge event along with the rainfall event, long-term measured tidal data at the NOAA Naples Pier station was evaluated to determine the appropriate surge event to use as the tidal boundary conditions for the MIKE 11 model. It was determined that the Irma surge event would be an appropriate, if conservative, tidal condition to pair with the design storm events. To do this, the peak of the Irma storm surge was matched with the peak of the rainfall hydrograph by changing the start date of the Irma tidal timeseries. Figure 2.1 illustrates the 100 yr and 25 yr design storm rainfall along with the tidal conditions at the Naples Pier and Caloosahatchee Tidal Gages.

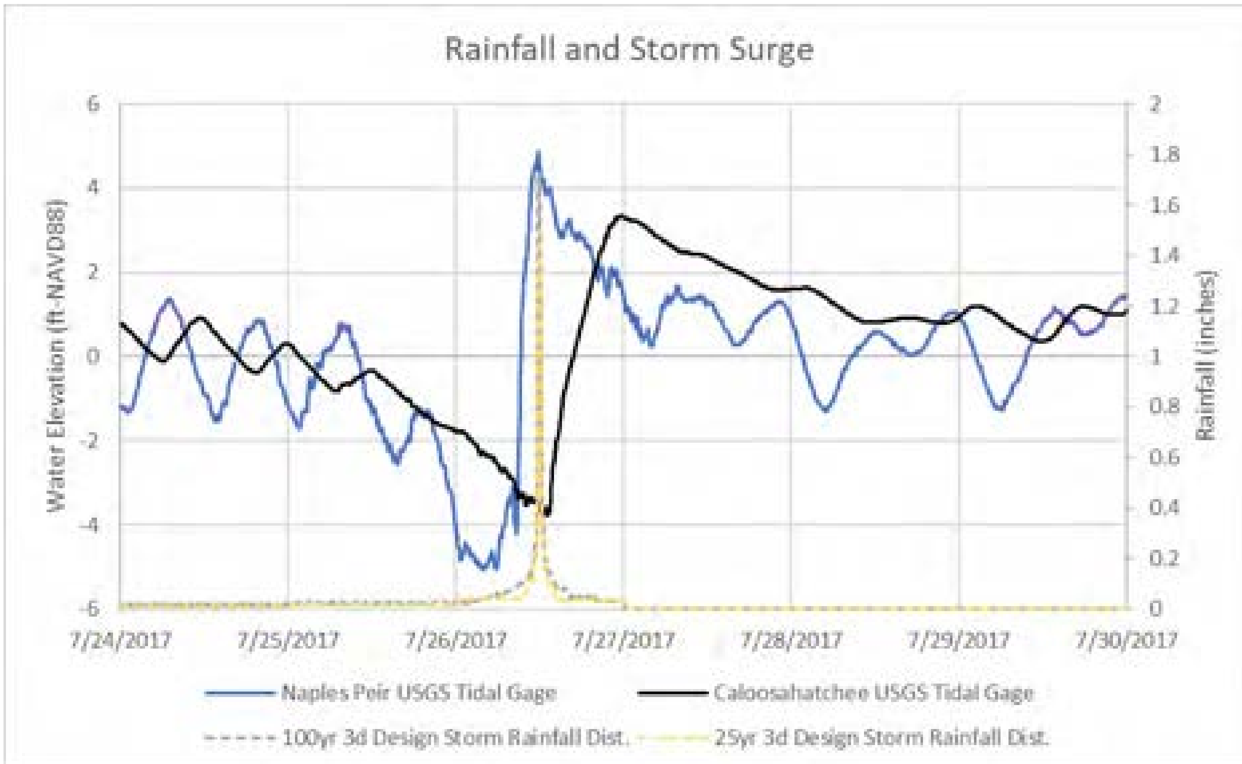


Figure 2.1. Rainfall Distribution and Storm Surge for 100 yr and 25 yr Design Storm Simulations

To establish the antecedent stages and groundwater level for these design storm simulations, the initial start date was chosen to be 7/24/2017, which represented a "typical" wet season condition at several measured groundwater sites. Overland water depths, groundwater elevations, and surface water stages on this date were extracted from the existing conditions continuous simulation and used as starting conditions for all the 100-year design storm simulations. However, external review of the antecedent conditions revealed that the conditions starting a month later were more conservative approach, which could be considered more appropriate for this modeling effort focused on the effects of severe storm events, such as Hurricane Irma. Therefore, a secondary modified 100 yr Design Storm simulation was also developed with the start date and antecedent conditions from 8/24/2017.

2 PROJECT MODEL DEVELOPMENT

3.1 PROJECTS OVERVIEW

The proposed projects were developed for each divided area within the county (East Lee County, Whiskey Creek, Southeast Lee County, and South Fort Myers) as specified below:

1.1. East Lee County
- 1.1.1. Dog Canal to Hendry Canal (CREST)
- 1.1.2. Bedman Creek Overflow Bypass
- 1.1.3. GS-10 Stormwater Quality Reservoir
- 1.1.4. Buckingham Bypass Drainageway
- 1.1.5. Buckingham Trails Water Quality Reservoir
- 1.1.6. Lehigh-River Hall to Olga Outfall
- 1.1.7. Hickey Creek Overflow Bypass
- 1.1.8. Strayhorn Drainageway
- 1.1.9. Charlie Diversion-Hickey Canal Improv.
- 1.1.10. Hickey Creek Swamp Drainageway
- 1.1.11. Six-Mile Cypress Preserve North Catchment Reservoir

1.2. Whiskey Creek
- 1.2.1. L Canal Improvements
- 1.2.2. Brantley Canal Area Improvements
- 1.2.3. South Whiskey Creek Drainage Improvements

1.3. Southeast Lee County
- 1.3.1. Halfway Creek Drainageway
- 1.3.2. Estero River N. Branch Improvements
- 1.3.3. FGCU Flow-Way Improvements
- 1.3.4. Alico Mine Lake Interconnects (West)
- 1.3.5. Alico Mine Lake Interconnects (East)
- 1.3.6. I-75 to Spring Creek Drainageway (North)
- 1.3.7. I-75 to Spring Creek Drainageway (South)
- 1.3.8. Alico Mine Lake to Halfway Creek Drainageway
- 1.3.9. I-75 to Spring Creek Drainageway (North)
- 1.3.10. I-75 to Spring Creek Drainageway (South)
- 1.3.11. East I-75 Overland Flow Collection Drainageway
- 1.3.12. Imperial River Improvements East of I-75
- 1.3.13. Crew-Flint Pen Hydrologic Restoration
- 1.3.14. Imperial River Improvements West of I-75
- 1.3.15. Railway Drainageway Improvements
- 1.3.16. Corkscrew East Drainageway

1.4. South Fort Myers
- 1.4.1. Ten Mile Canal North Improvements
- 1.4.2. Ten Mile Canal South and Island Park Improvements
- 1.4.3. Daniels South Drainage Areas Improvements

1.4.4. Briarcliff Drainage Improvements
1.4.5. Park Road Drainage Improvements
1.4.6. LCPA Diversion to Estero Basin
1.4.7. Six Mile Cypress South Improvements

In addition to the study areas listed above, a general enhanced maintenance project was evaluated (Project 1.5), which evaluated the impacts of clearing channels of excessive vegetation by reducing channel roughness estimates.

A full description of the proposed projects is defined in the Task 4 Screening Report. For each project region, the project development teams developed lists of proposed structures with dimensions, elevations, and general gate operations for the modeling team to translate into the 1D MIKE 11 model. They also provided GIS files of proposed channels and their cross-sections or general dimensions. Any proposed changes to channel depths, embankments, and/or bottom widths were also supplied in the form of proposed channel dimensions or cross-sections.

The project development teams and the model development team worked together to ensure the proposed project plan was implemented into the model in the most appropriate representation. This included establishing appropriate gate operations and timing, pump trigger elevations, overflow elevations, channel cross-sections, storage elements, etc. through an iterative and involved process of trial and error.

The modeling team developed a numbering system for implementing proposed changes to the existing conditions model for each project. This numbering system used the project numbers, as listed above. Using project 1.3.1 Halfway Creek Drainageway as an example of the naming convention, the following components were named in this manner:

- Proposed channels or drainageways: Branch Name → 1_3_1_Drainageway1
- Proposed channel dimension changes: Cross-section TopoID → 1_3_1_Proposed
- Proposed weirs, culverts, gated structures: Structure ID → 1_3_1_StructureName

3.2 INITIAL PROJECT SCREENING

Each individual model was developed as a proposed condition into the existing condition base model. The 100-year design storm was used to compare the peak stages from the existing and the proposed conditions. After optimizing the proposed models to represent the project as designed by the project development team, exhibits for the individual models were developed that illustrated existing versus proposed water levels and flows at various key locations throughout the proposed project area. The project summaries and preliminary screening exhibits were presented in the Task 4 Screening Report.

The purpose of the initial project screening phase was to establish those projects which demonstrate significant regional impacts to peak stage and flow reductions in vulnerable areas and/or demonstrate a reduction in the time of inundation during a storm event.

The results of the initial screening revealed that all the proposed projects presented a viable option for flood mitigation; however, it was determined that projects 4.4 (the Briarcliff Drainage Improvements) and 4.5 (the Park Road Drainage Improvements) would be better evaluated with a local-scale model that captures more drainage details, rather than the larger regional model that was used for this analysis. Therefore, these projects were eliminated from the combined project analysis.

4 PROJECT COMBINATIONS MODELING

4.1 COMBINED MODEL DEVELOPMENT

To continue the project evaluation process, the models were combined into three proposed condition models. The eleven (11) proposed project conditions were merged into one model for East Lee County (Region 1). The sixteen (16) proposed project conditions were merged into one model for Southeast Lee County (Region 3). The three (3) proposed project conditions from Whiskey Creek (Region 2) and the five (5) remaining projects from South Ft Myers (Region 4) were merged into one model. The numbering convention was maintained to keep track of the origin of each new proposed feature.

4.1.1 East Lee County

The East Lee County proposed conditions model combined projects 1.1.1 through 1.1.11 (see above list) by merging weirs, culverts, gates, channels, cross-sections, flood codes, and separated overland areas from the individually developed models. The proposed conditions included:

- Approximately 17 miles of new flow-ways (including drainageways, bypass channels, and reservoirs)
- 81 new or modified weirs/gates
- 31 new or modified culverts
- Modifications to approximately 9 miles of existing channels

The proposed conditions are shown in Figure 4.1, below.

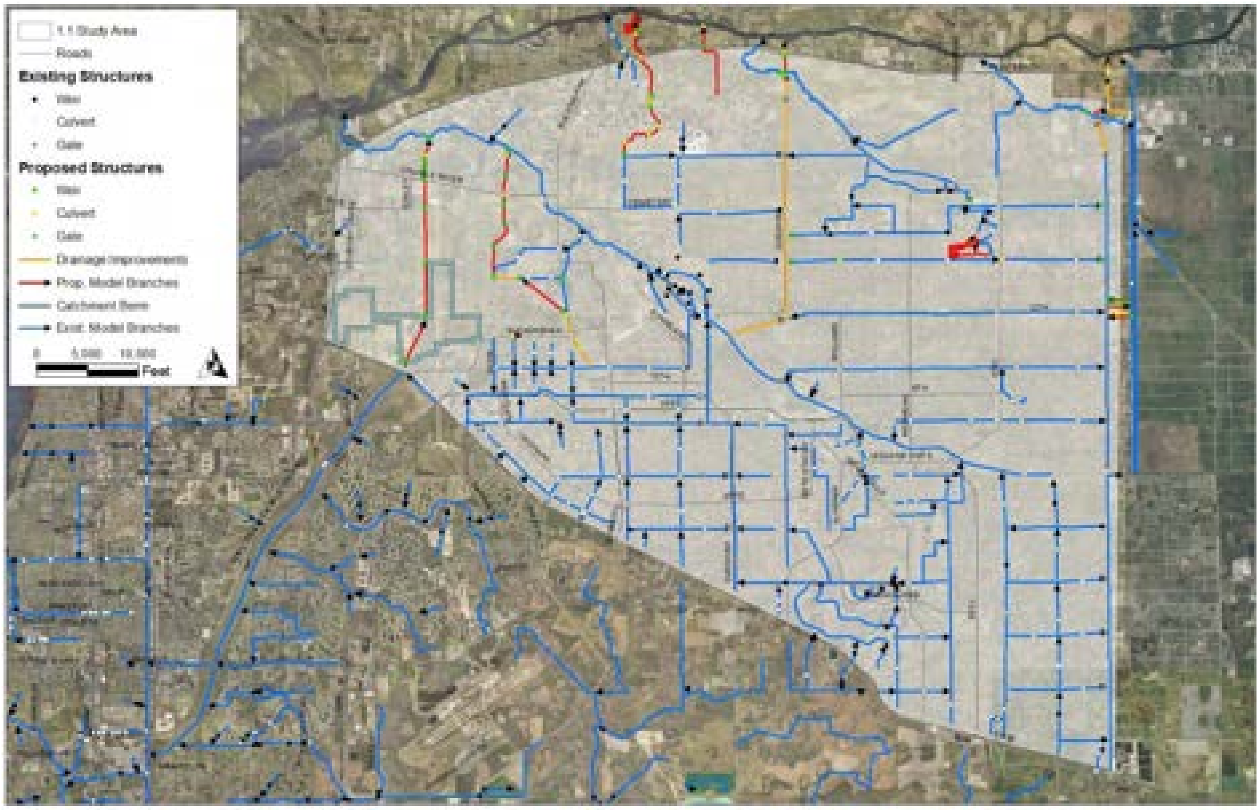


Figure 4.1. Proposed Conditions for the 1.1 Study Area

For this proposed conditions model, the newly constructed S-H-2 gated structure in Hendry Canal was represented in its current location and with its current dimensions. Because this gate was not yet constructed during the summer of 2017, the original location and dimensions (including a small culvert representing the leaks through the aging weir) were used in the existing conditions model.

It should be noted that Project 1.1.5 did not include the addition of any hydraulic components, just the use of a separated flow area to represent the proposed Water Quality Reservoir that would link with the proposed drainageways in Project 1.1.4 – Buckingham Bypass Drainageway.

In addition, flood codes have been created for four (4) project areas, including the Bedman Creek Overflow Bypass area, Buckingham Trails water quality reservoir, Olga outfall marsh, and the Six Mile Cypress Preserve North Catchment Reservoir.

Three (3) project areas have been designed as separated by embankments, which requires the use of a unique code for the separated overland area map. These areas are the Bedman Creek Overflow Bypass area, Buckingham Trails water quality reservoir, and the Six Mile Cypress Preserve North Catchment Reservoir.

4.1.2 Southeast Lee County

The Southeast Lee County proposed conditions model combined projects 1.3.1 through 1.3.16 (see above list) by merging weirs, culverts, gates, channels, cross-sections, flood codes, and separated overland areas from the individually developed models. The proposed conditions included:

- Approximately 66 miles of new flow-ways (including drainageways, bypass channels, and reservoirs)
- 57 new or modified weir or gated structures
- 35 new or modified culverts
- Modifications to approximately 63 miles of existing channels

The proposed conditions are shown in Figure 4.2, below.

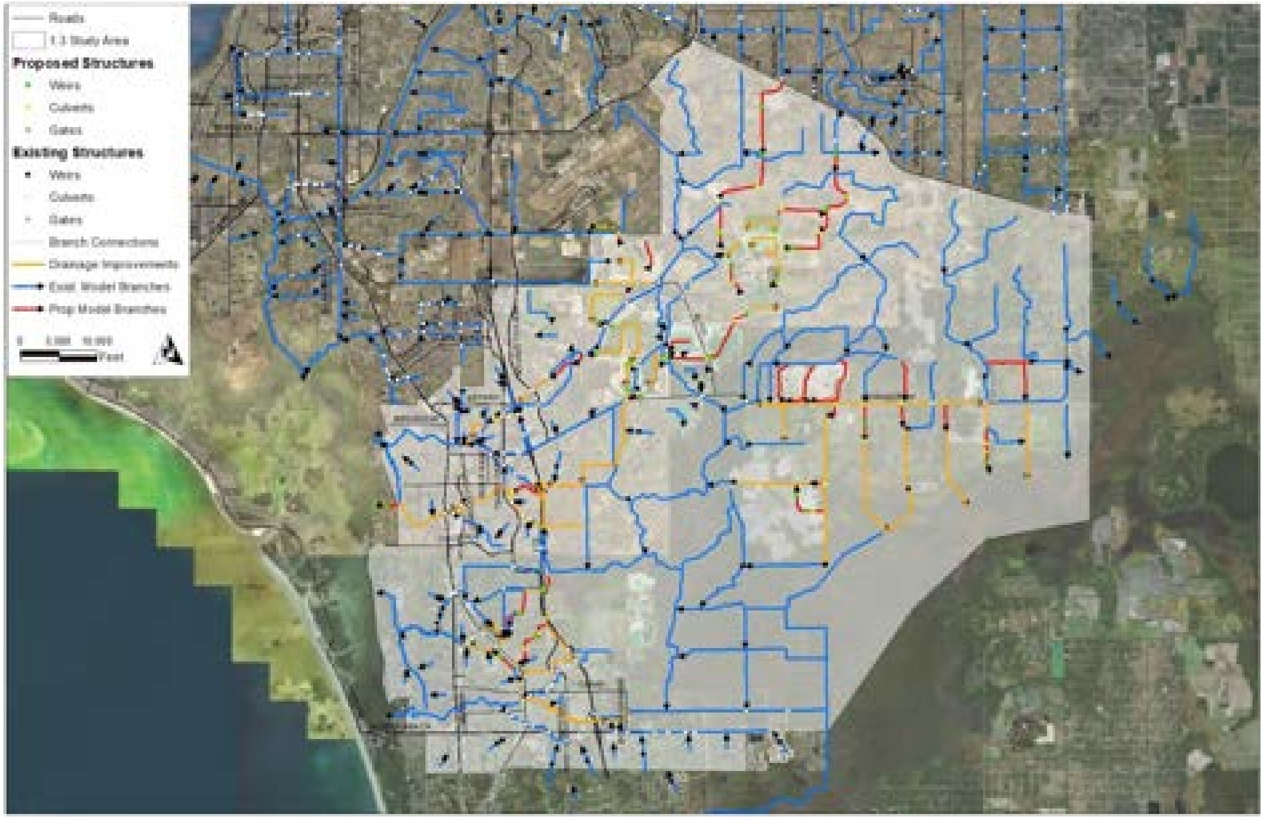


Figure 4.2. Proposed Conditions for the 1.3 Project Area

In this proposed conditions model, the under-construction community called The Place (located just north of Corkscrew Road and east of Alico Rd) was represented in the form of drainageways and weirs, which connect the wetland to the north with the Corkscrew roadside swale south of the community. This community is in the proposed conditions model, but not represented in the existing conditions model.

This proposed condition included the operation of 57 gated water control structures. For appropriate implementation of gate operations, guidance on operations was required from the project development team and they needed feedback of the results from the modeling team. In general, gates east of I-75 would be used to store water during a design storm event to allow flood waters west of I-75 to drain from the urban regions first. Then, after the storm passes, the gates will open and release the flooding in the marshes to the west. In practice, an operational procedure should be developed for gate operations, which establishes the appropriate headwater (HW) and tailwater (TW) stages for opening each gate to reach regional water management goals. However, for the purposes of this preliminary regional study, gate operations were generalized based on the timing of the design storm simulation. A summary of these gate operations is shown inTable 4.1. Simplified headwater (HW) stage-based operations for the continuous simulations were also established to allow for both dry season storage and wet season flood protection, as shown in Table 4.2. As shown in the table, the gates are meant to open as stages upstream of the gates rise during storm events. The gates will remain closed when the HW is lower than 1.5 ft below the crest of the weir. Above that target, gates will begin to open by one foot, and then 2 feet when stages rise 0.5 ft below the crest of the weir. Above that, the gates are opened fully (fully opened gate height varies depending on the project, purpose, and location of the gate).

Table 4.1. General Operations for Proposed 1.3 Gates for Design Storm Events

Hours After Start	Gates East of I-75*	Gates West of I-75
0	Open	Open
24	Close	Open
96	Open	Open

Table 4.2. Gate Operations for Proposed 1.3 Gates for Continuous Simulation

Gate Operation	HW Stage
Fully Open	0.5 ft Above Crest
Opens 2 ft	0.5 ft Below Crest
Opens 1 ft	1.5 ft Below Crest
Closed	>1.5 ft Below Crest

In addition, seven (7) new flood codes have been created for several project areas, including the three (3) newly proposed connections to mine lakes, three (3) separate flood codes in the Corkscrew East Drainageway area that help represent the overland connection to various shallow channels, and one (1) new flood code representing The Place (a community under construction with marsh-type flowways).

The separated overland area map was also modified to include the proposed bermed area east of I-75 (between Corkscrew Road to the north and Kehl Canal to the south) for Project 3.13 – Crew-Flint Pen Hydrologic Restoration.

4.1.3 South Ft Myers/Whiskey Creek

The South Ft Myers/Whiskey Creek proposed conditions model combined projects 1.2.1 through 1.2.3, 1.4.1, 1.4.2, 1.4.3, 1.4.6, and 1.4.7 (see above list) by merging weirs, culverts, gates, channels, cross-sections, flood codes, and separated overland areas from the individually developed models. The proposed conditions included:

- Approximately 4 miles of new flow-ways (including drainageways, bypass channels, and reservoirs)
- 41 new or modified weirs/gates

- 18 new or modified culverts
- Modifications to approximately 15 miles of existing channels

The proposed conditions are shown in Figure 4.3, below.

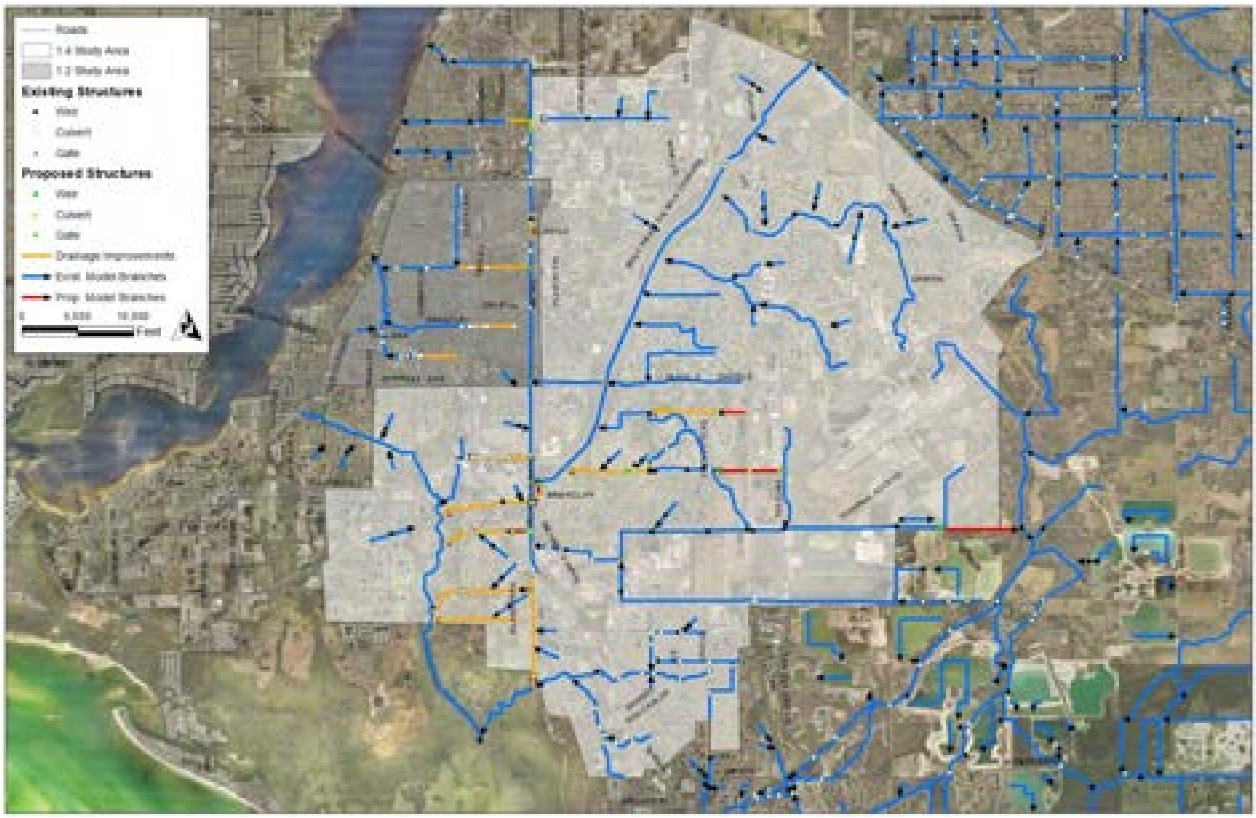


Figure 4.3. Proposed Conditions for the 1.2 and 1.4 Project Areas

No overland flow or flood code files were modified to implement the projects represented in this model.

Late-phase corrections were applied to the model to provide better representation of drainage from individual communities, such as Heritage Palms, Pinebrook Lakes, and Bell Tower Park.

4.2 RESULTS

The following simulations were run for the existing conditions model and all three (3) proposed conditions models to be use for peak stage and flow comparisons during design storm events, inundation mapping during Hurricane Irma, Level of Service (LOS) analysis, etc:

- 100 yr Design Storm

- 100 yr Design Storm with modified start date
- 25 yr Design Storm
- Continuous simulation for the period 1/1/2017 through 12/31/2017
- Continuous simulation, with reduced simulation period and hourly timestep

Flow and stage comparison exhibits, for each project area, will be provided in the Task 7 Report.

4.1.4 1.1 Projects

Peak stages during the 100 yr 3 day design storm, with the modified start date of 8/24/2017, were extracted for the existing conditions and 1.1 proposed conditions model for Hendry Canal/Carlos Waterway, Dog Canal, Bedman Creek, Hickey's Creek Canal, Able Canal, and Orange River, as shown in the Figures below. The proposed conditions results are shown in red and the existing conditions results are shown in black.

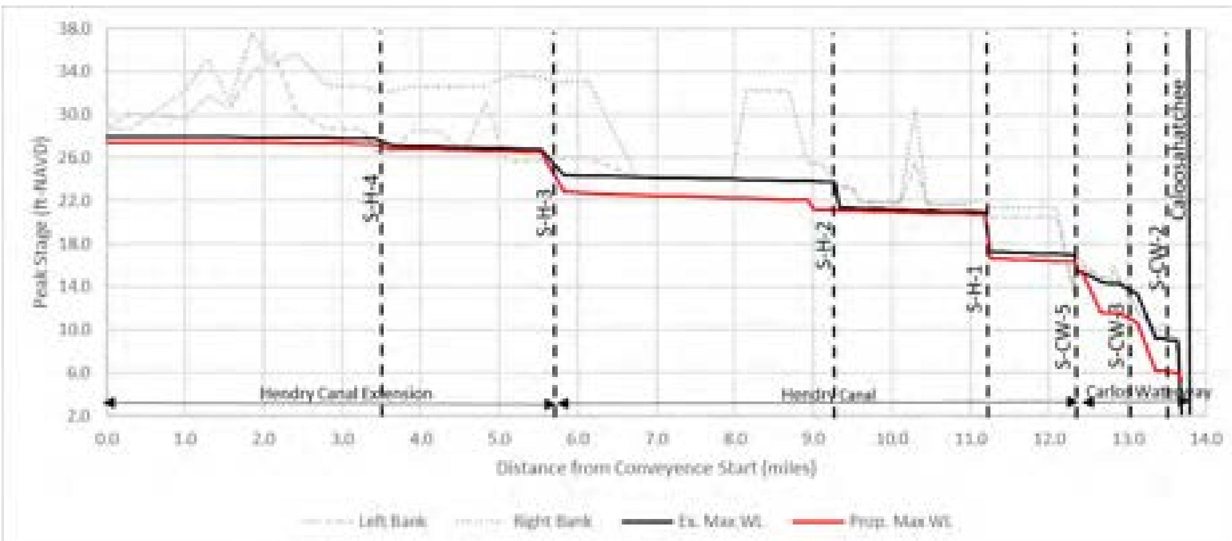


Figure 4.4. Peak Stage Comparison for Hendry Canal/Carlos Waterway for 100yr DS

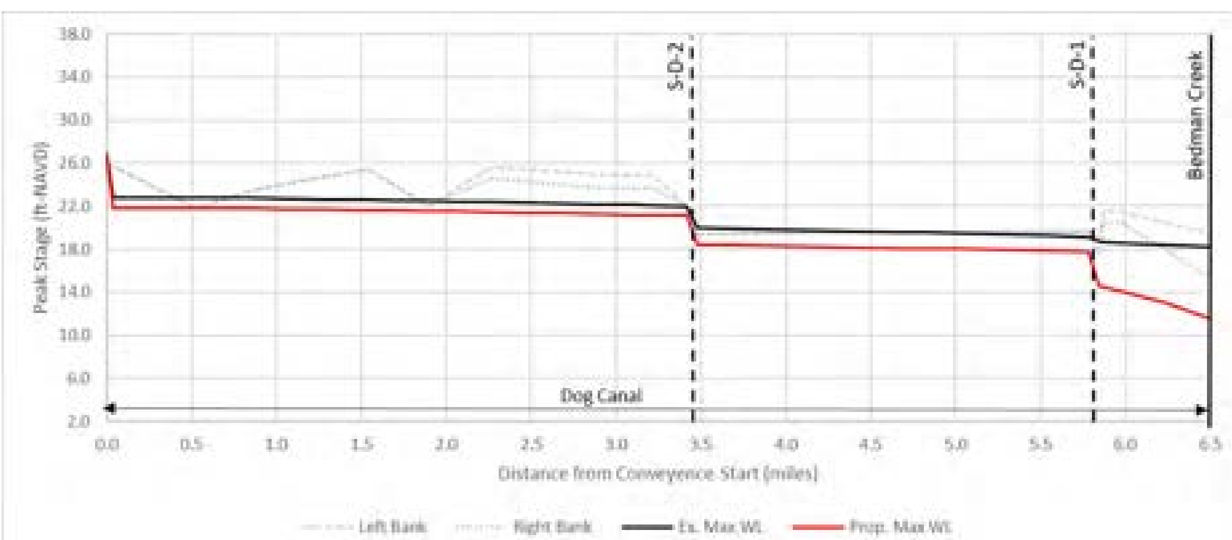


Figure 4.5. Peak Stage Comparison for Dog Canal for 100yr DS

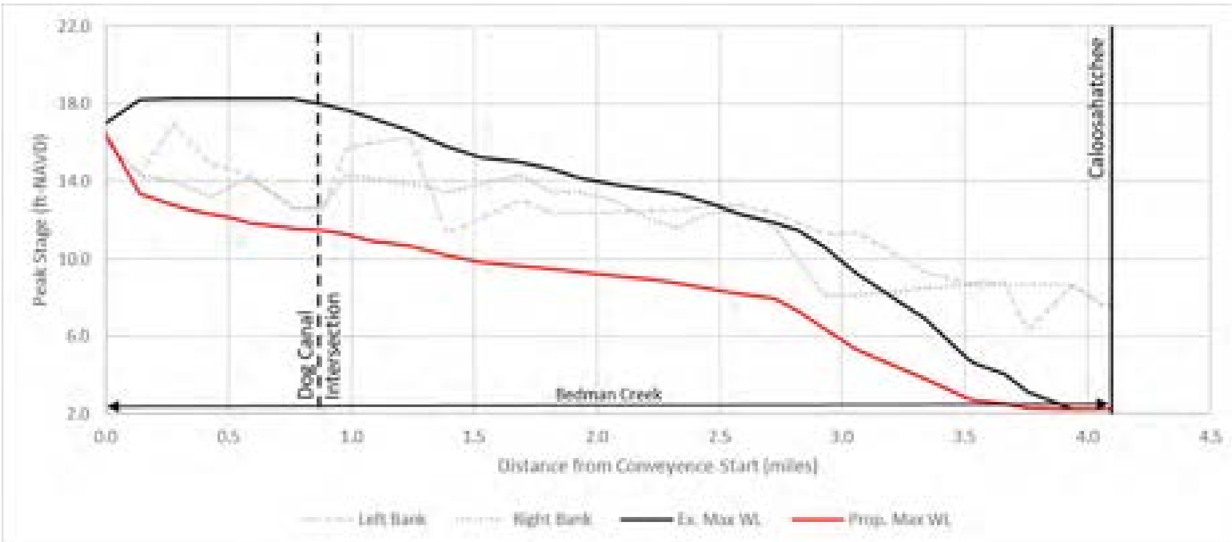


Figure 4.6. Peak Stage Comparison for Bedman Creek for 100yr DS

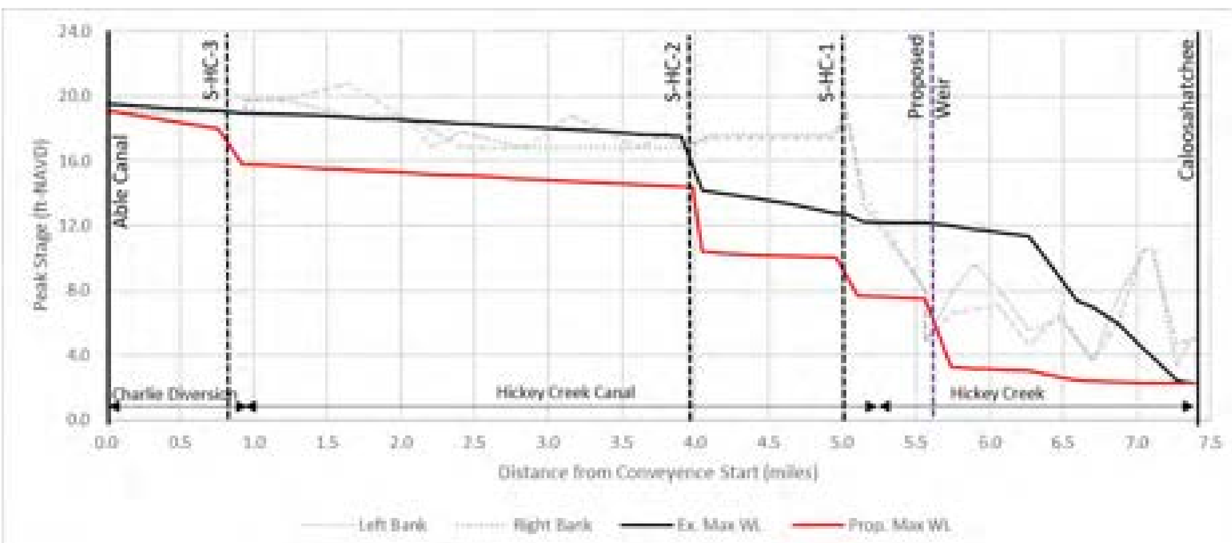


Figure 4.7. Peak Stage Comparison for Hickey's Creek Canal for 100yr DS

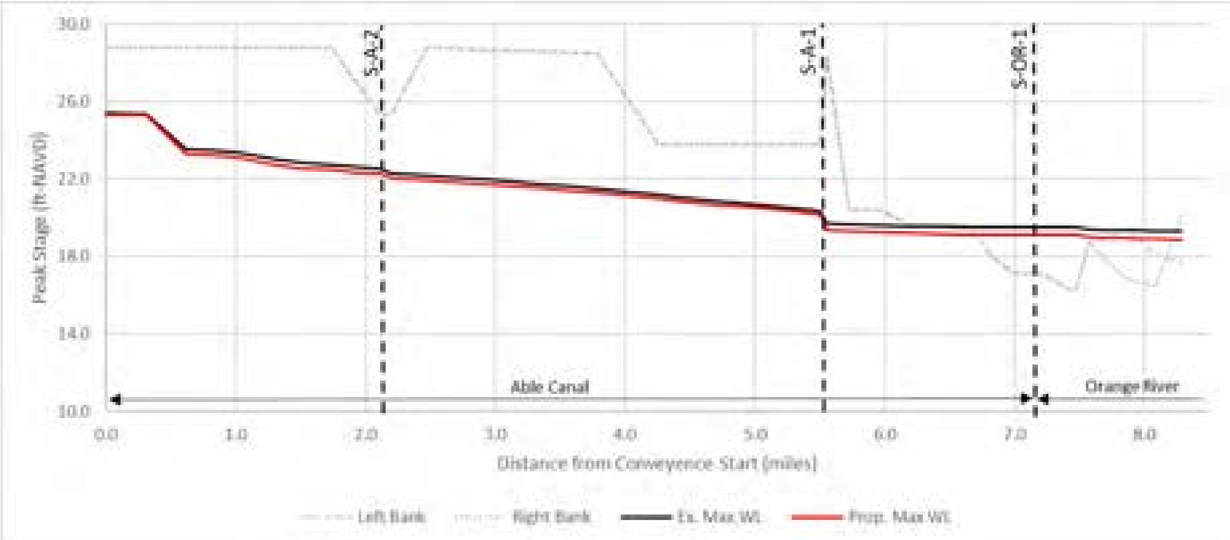


Figure 4.8. Peak Stage Comparison for Able Canal for 100yr DS

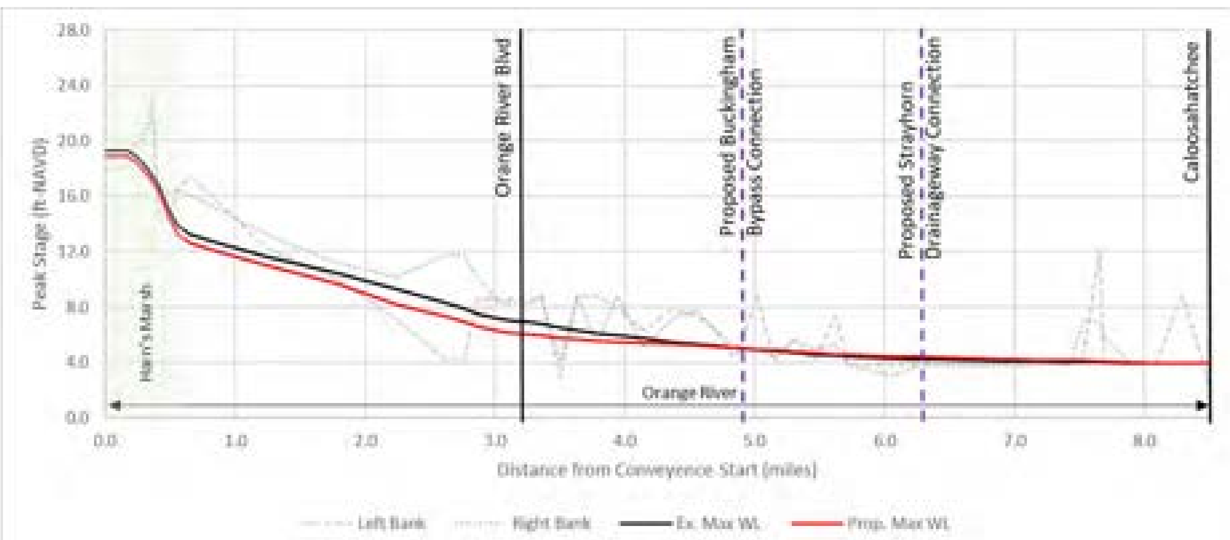


Figure 4.9. Peak Stage Comparison for Orange River for 100yr DS

In addition, the overland water depth maps were extracted for the peak of the Irma event and added to the model topography to produce a 750ft resolution peak elevation of overland water. This was then imported to GIS and subtracted from the 5ft Lee County topography to illustrate the detailed overland water depth. Figure 4.10 illustrates the peak overland depth for the 1.1 East Lee County Proposed conditions model. Figure 4.11 illustrates the overland water depth difference from the existing conditions results for the peak of the Irma event, and Figure 4.12 shows the depth difference at a more detailed scale. The depth difference maps show the values of the Existing Conditions water surface minus the values of the Proposed Conditions water surface. Thus, the greater the positive number value for the region, the greater the flood reduction in that region. Areas of notable overland flood reduction are those north of Buckingham Road and south of Orange River Boulevard. Some areas, including the GS-10 and Greenbriar Swamp areas, showed an increase in overland depths, indicating the potential storage capabilities of the proposed projects.

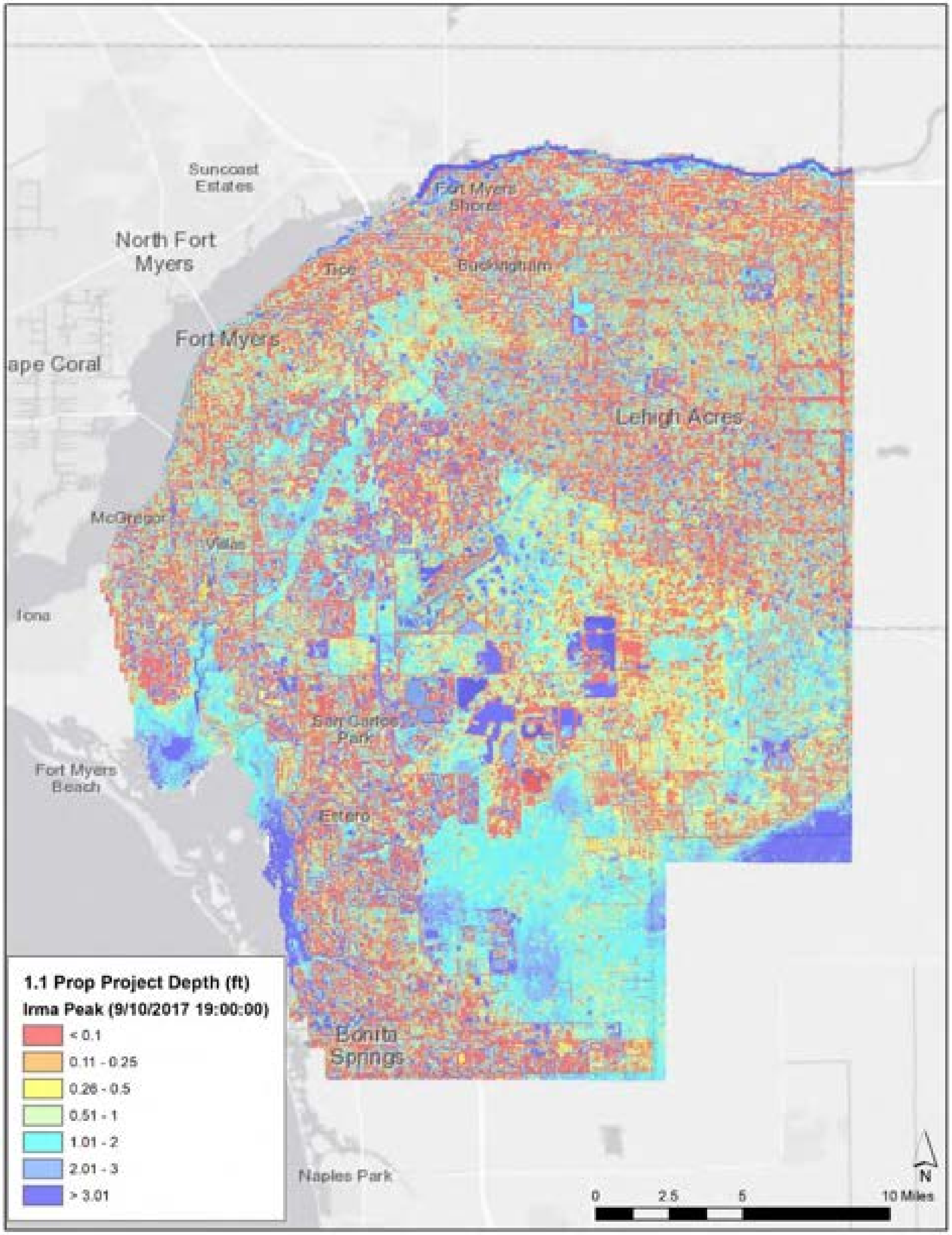


Figure 4.10. Peak Water Depth for Proposed 1.1 Projects during Hurricane Irma

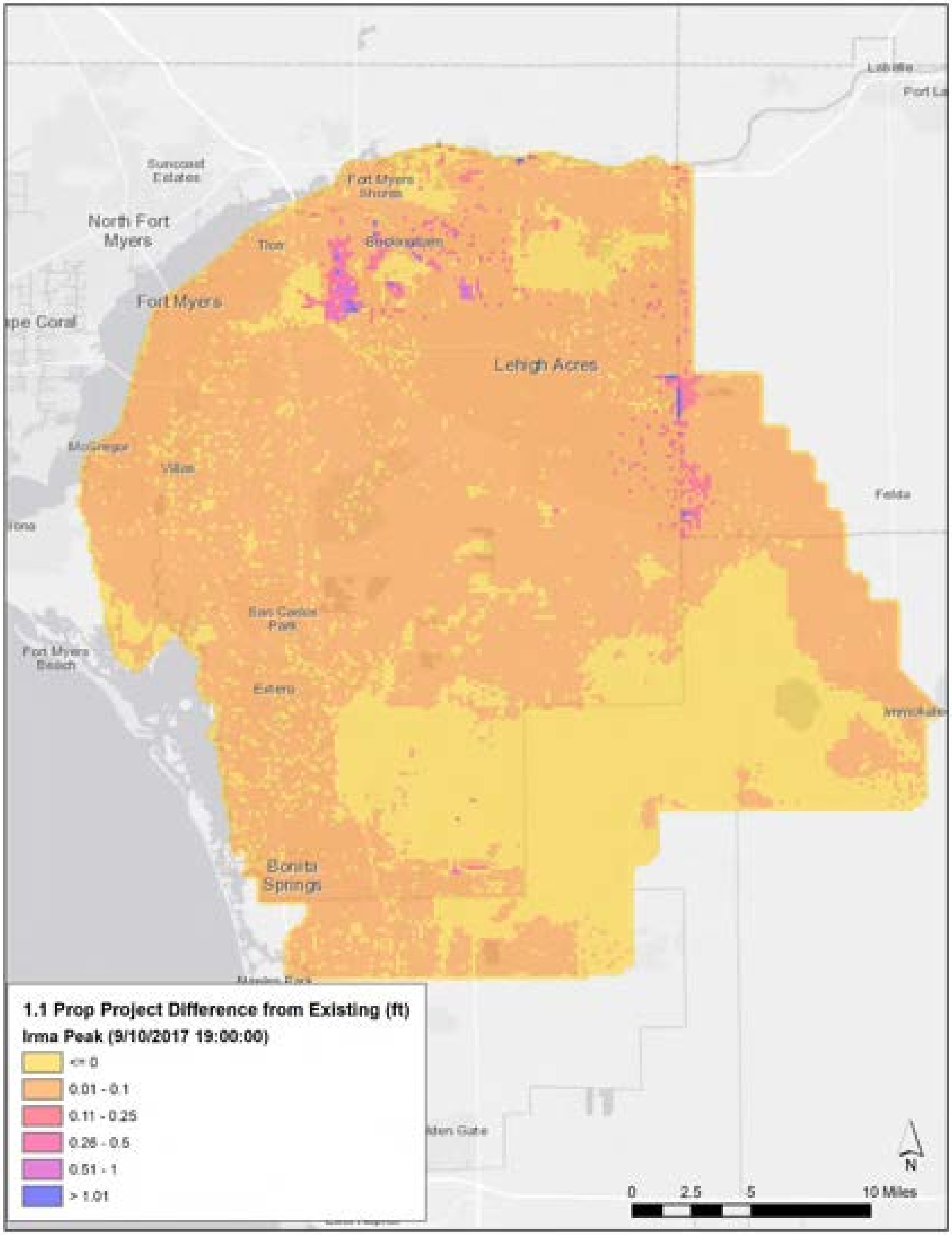


Figure 4.11. Difference between Existing Conditions Stage and Proposed 1.1 Projects Stage during Hurricane Irma

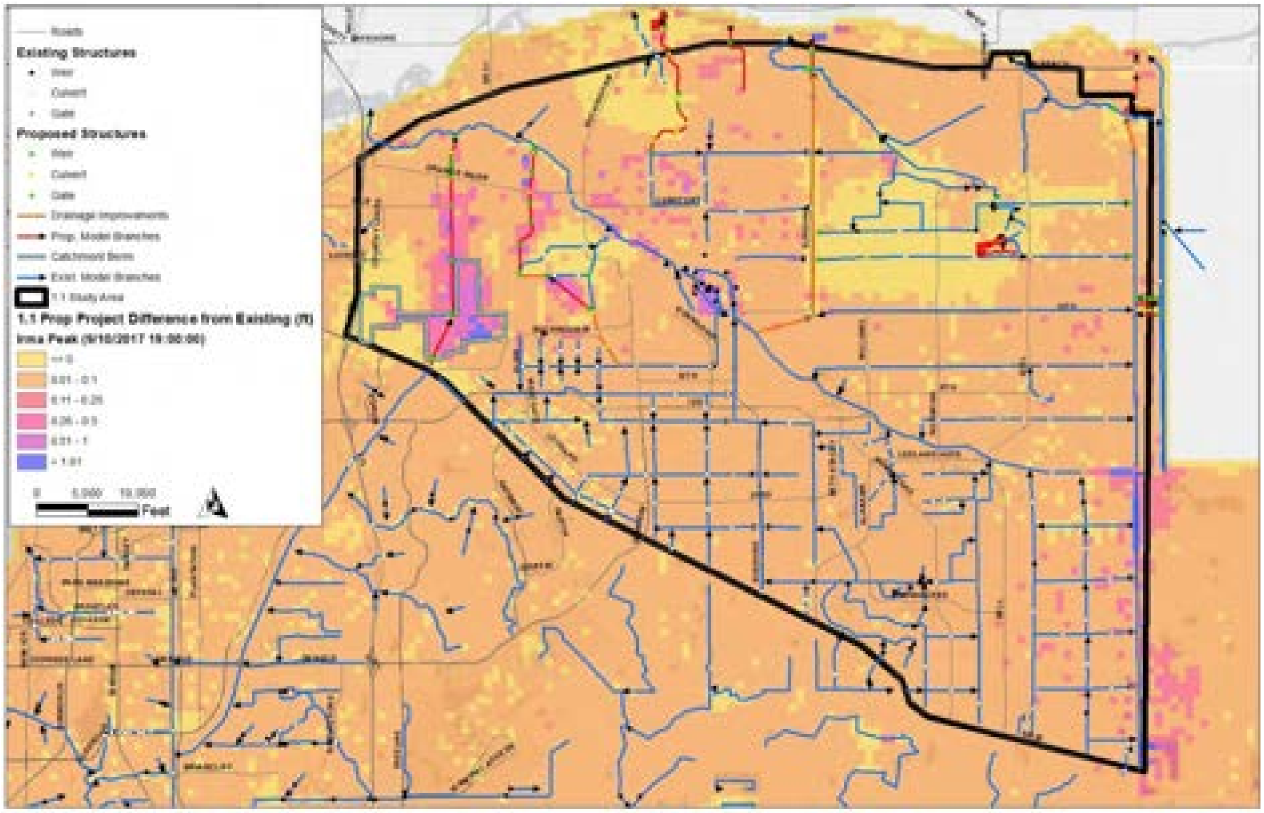


Figure 4.12. Detailed Difference between Existing Conditions Stage and Proposed 1.1 Projects Stage during Hurricane Irma

4.1.5 1.3 Projects

Peak stages during the 100 yr Design storm, with the modified start date of 8/24/2017, were extracted for the existing conditions and 1.3 Southeast Lee County proposed conditions model for Estero River North Branch, Estero River South Branch Halfway Creek, Spring Creek, and Imperial River, as shown in the Figures below.

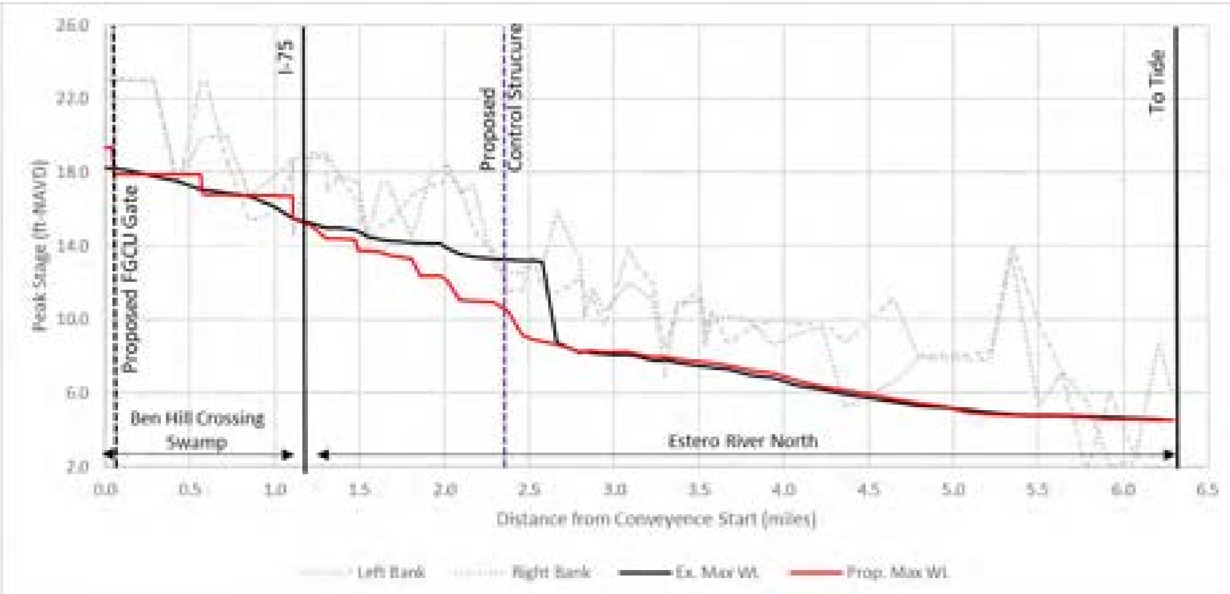


Figure 4.13. Peak Stage Comparison for Estero River North Branch for 100yr DS

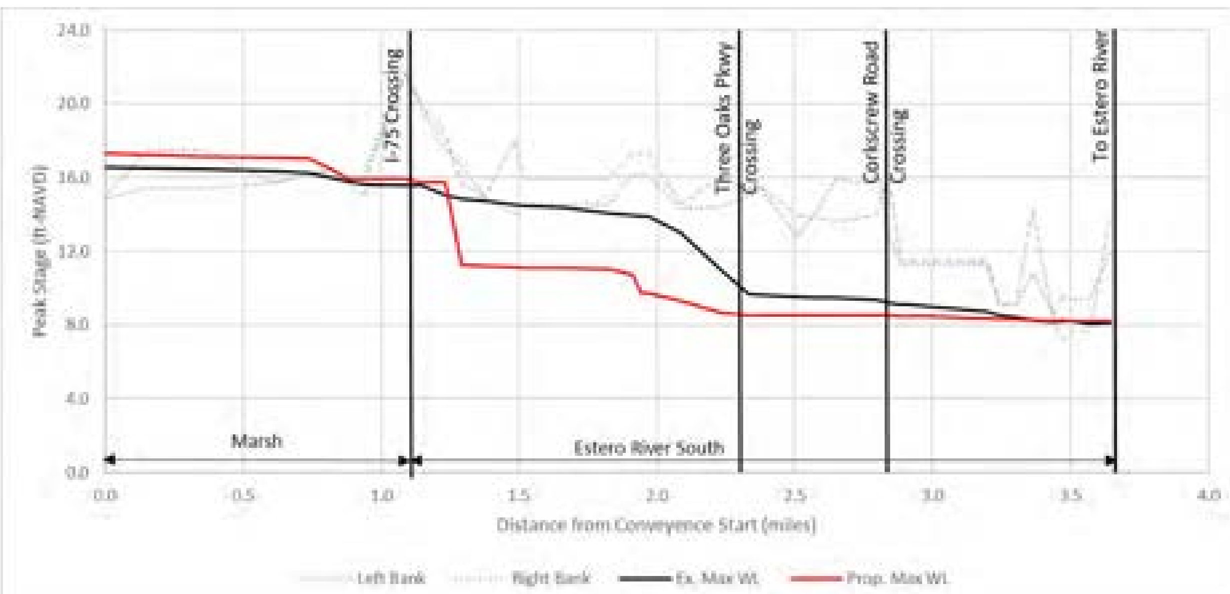


Figure 4.14. Peak Stage Comparison for Estero River South Branch for 100yr DS

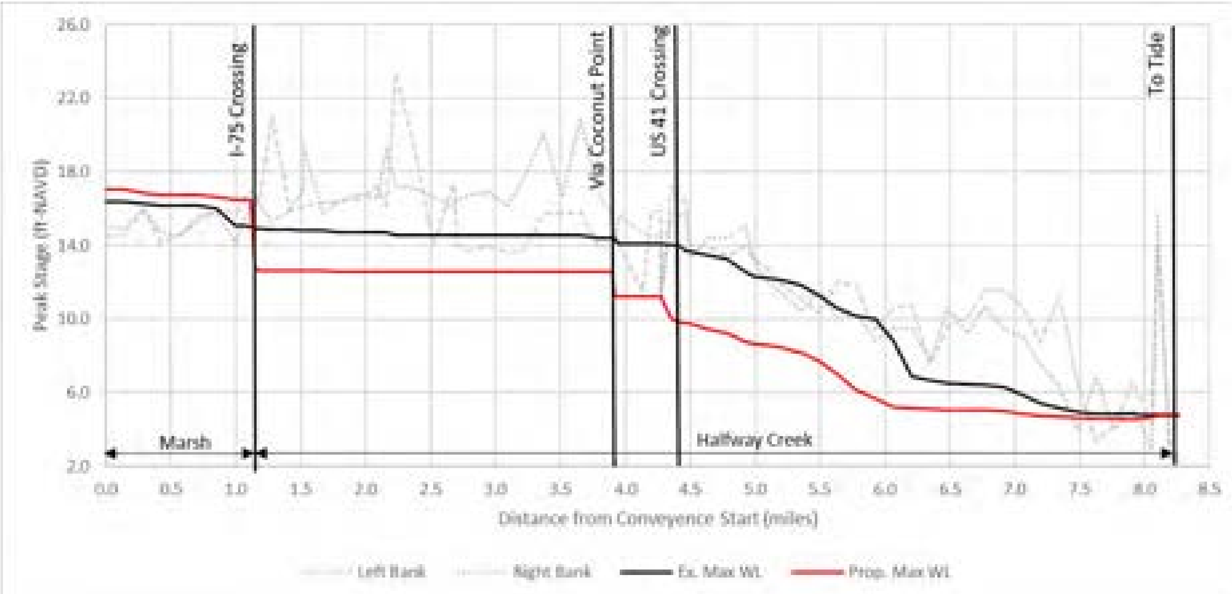


Figure 4.15. Peak Stage Comparison for Halfway Creek for 100yr DS

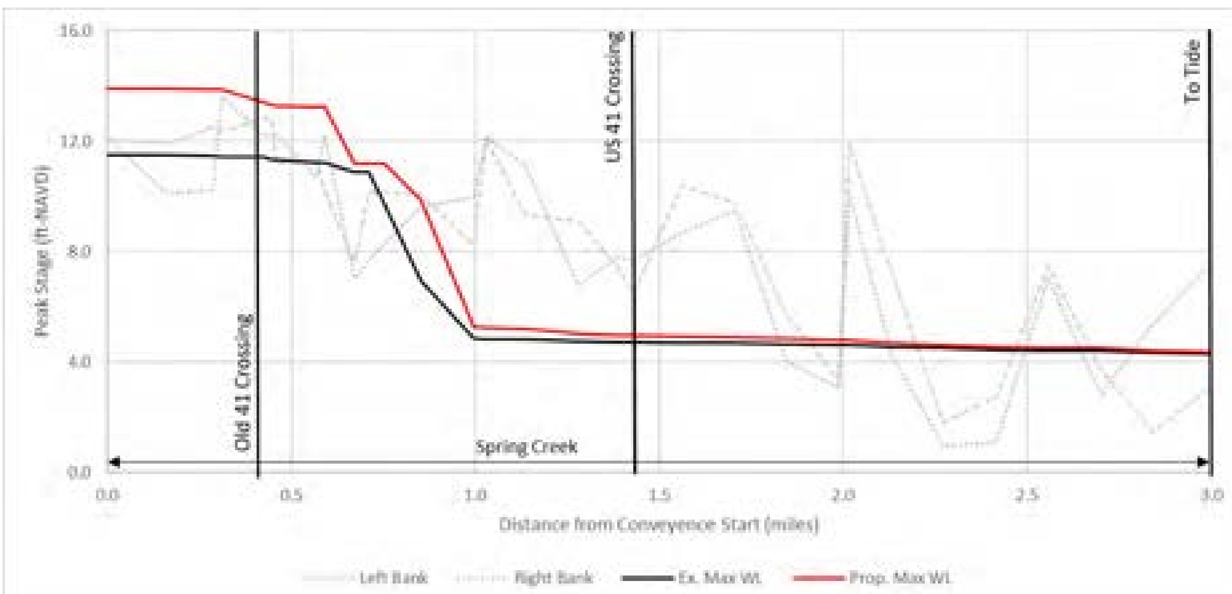


Figure 4.16. Peak Stage Comparison for Spring Creek for 100yr DS

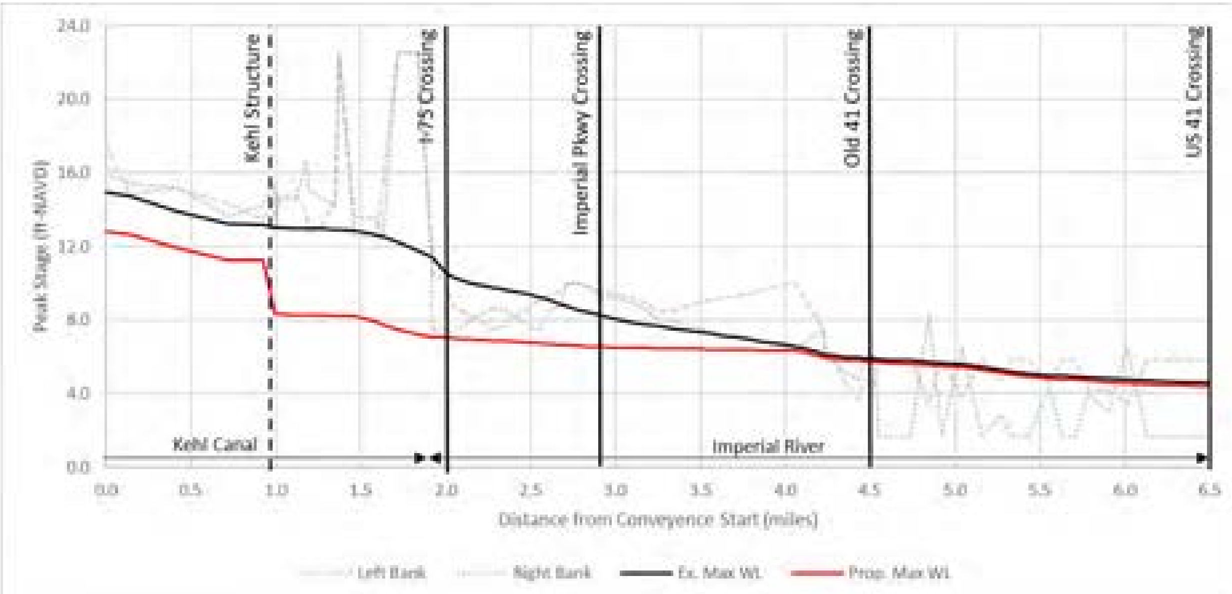


Figure 4.17. Peak Stage Comparison for Kehl Canal/Imperial River for 100yr DS

Figure 4.18 illustrates the peak overland depth for the 1.3 Southeast Lee County Proposed conditions model. Figure 4.19 illustrates the overland water depth difference from the existing conditions results for the peak of the Irma event, and Figure 4.20 shows the depth difference at a more detailed scale. The depth difference maps show the values of the Existing Conditions water surface minus the values of the Proposed Conditions water surface. Thus, the greater the positive number value for the region, the greater the flood reduction in that region. Areas of notable overland flood reduction occur throughout the northern part of the study area improvements are apparent from the blue/pink areas in Figure 4.20.

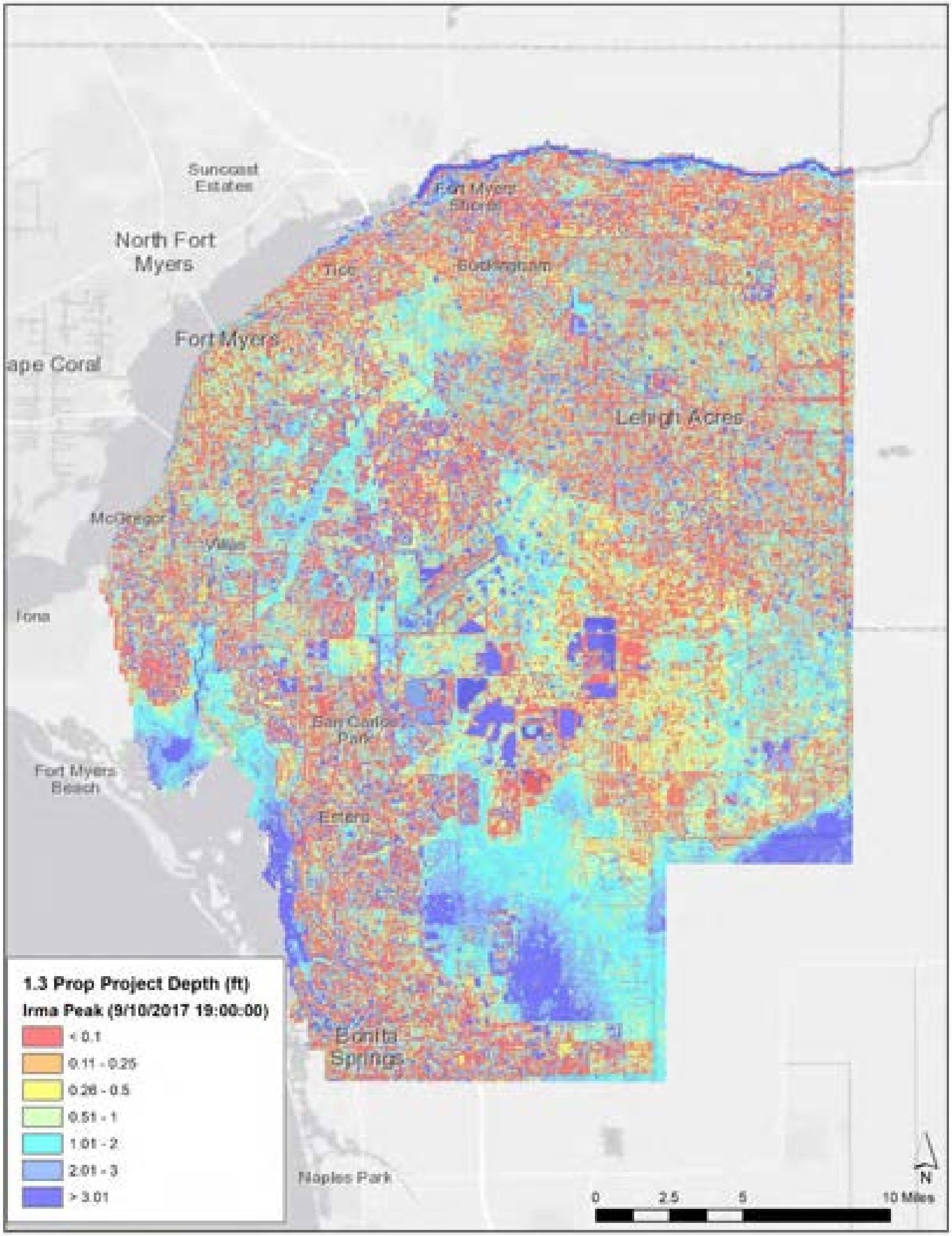


Figure 4.18. Peak Water Depth for Proposed 1.3 Projects during Hurricane Irma

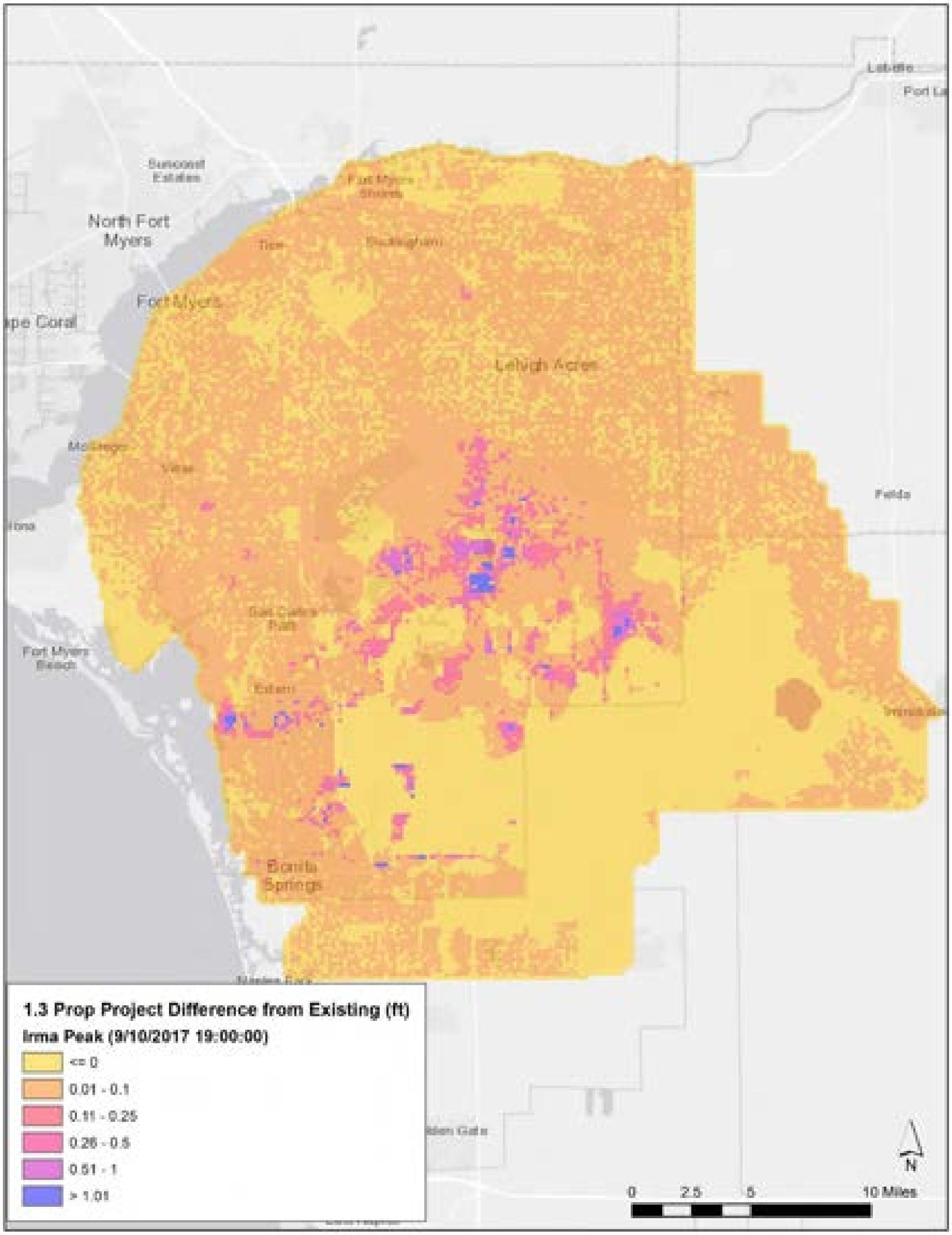


Figure 4.19. Difference between Existing Conditions Stage and Proposed 1.3 Projects Stage during Hurricane Irma

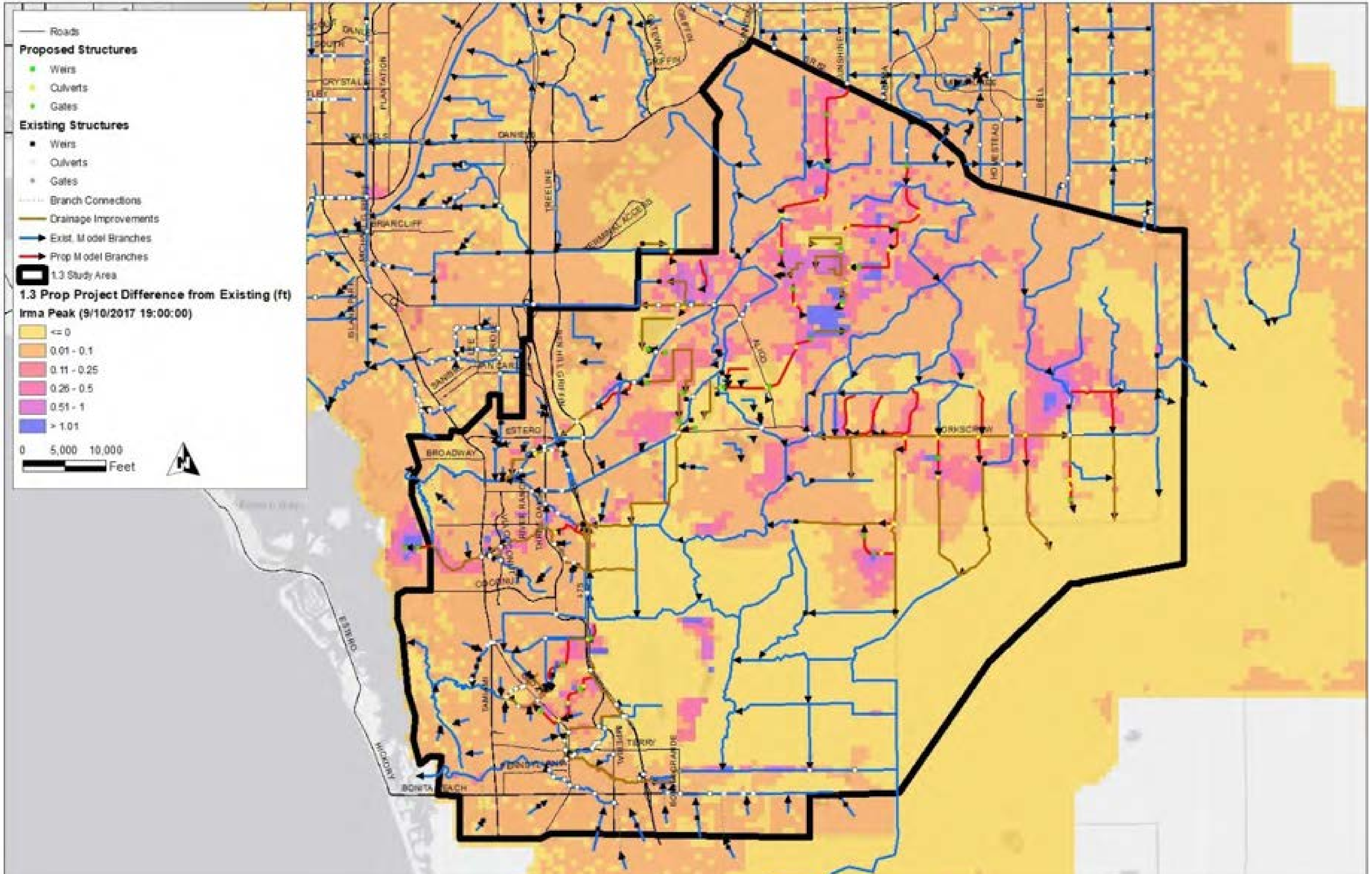


Figure 4.20. Detailed Difference between Existing Conditions Stage and Proposed 1.3 Projects Stage during Hurricane Irma

4.1.6 1.4 and 1.2 Projects

Peak stages during the 100 yr Design Storm, with the modified start date of 8/24/2017, were extracted for the existing conditions and 1.4 and 1.2 South Ft Myers/Whiskey Creek Proposed conditions model for 10 Mile Canal, Six Mile Cypress, L Canal, Brantley Canal, and FSW Canal, as shown in the Figures below.

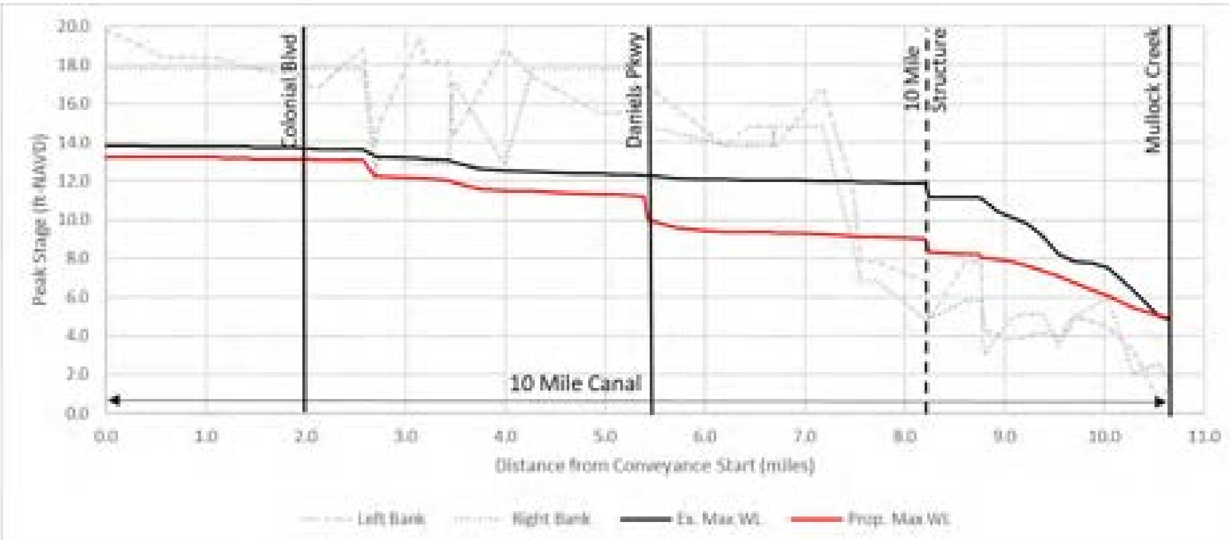


Figure 4.21. Peak Stage Comparison for 10 Mile Canal for 100yr DS

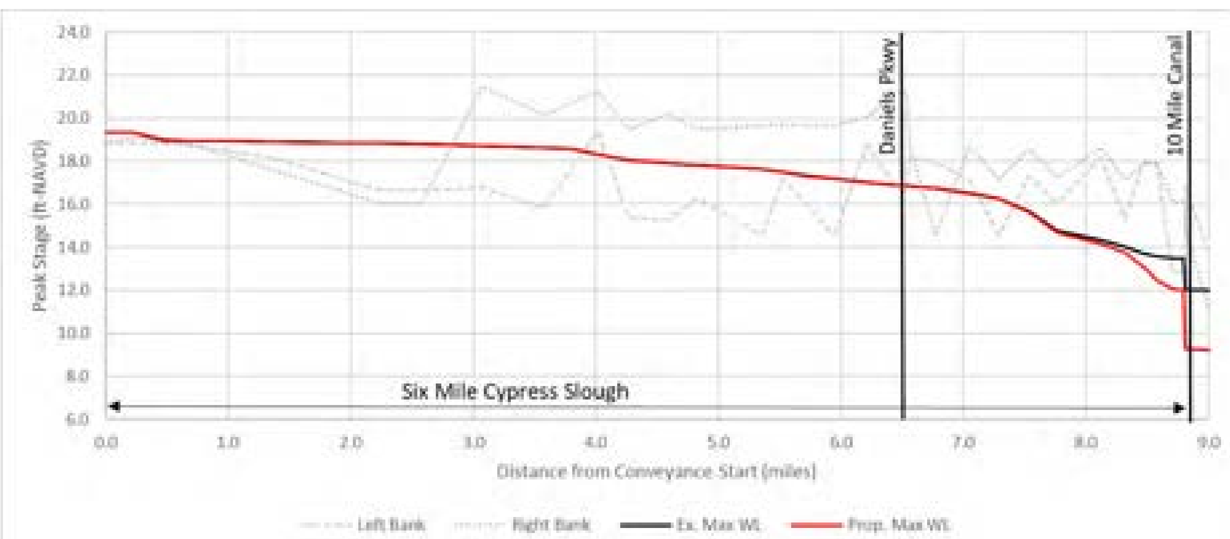


Figure 4.22. Peak Stage Comparison for Six Mile Cypress Slough for 100yr DS

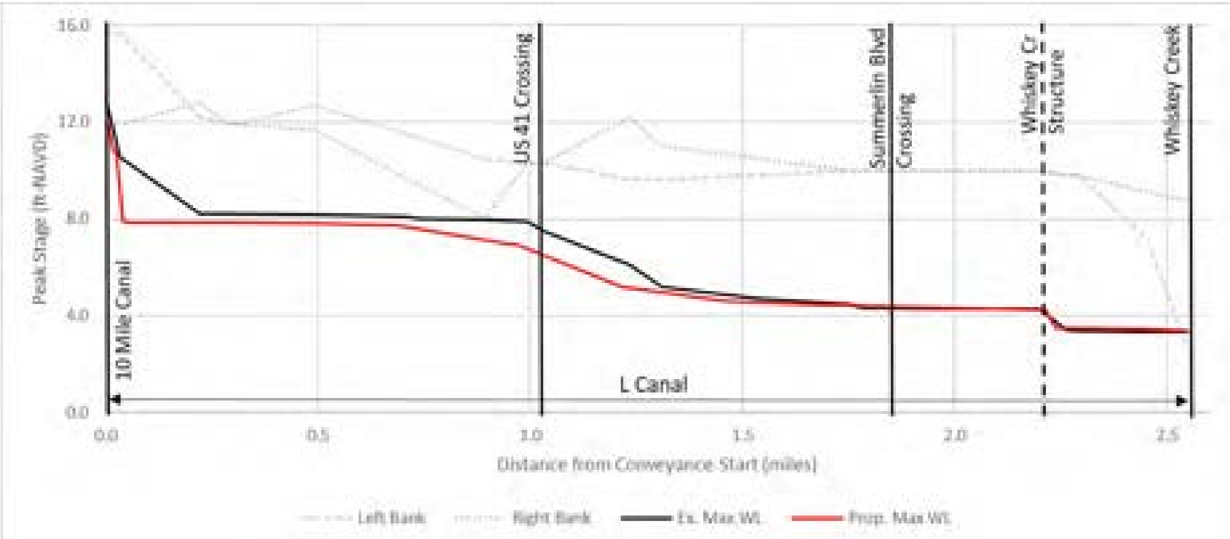


Figure 4.23. Peak Stage Comparison for L Canal for 100yr DS

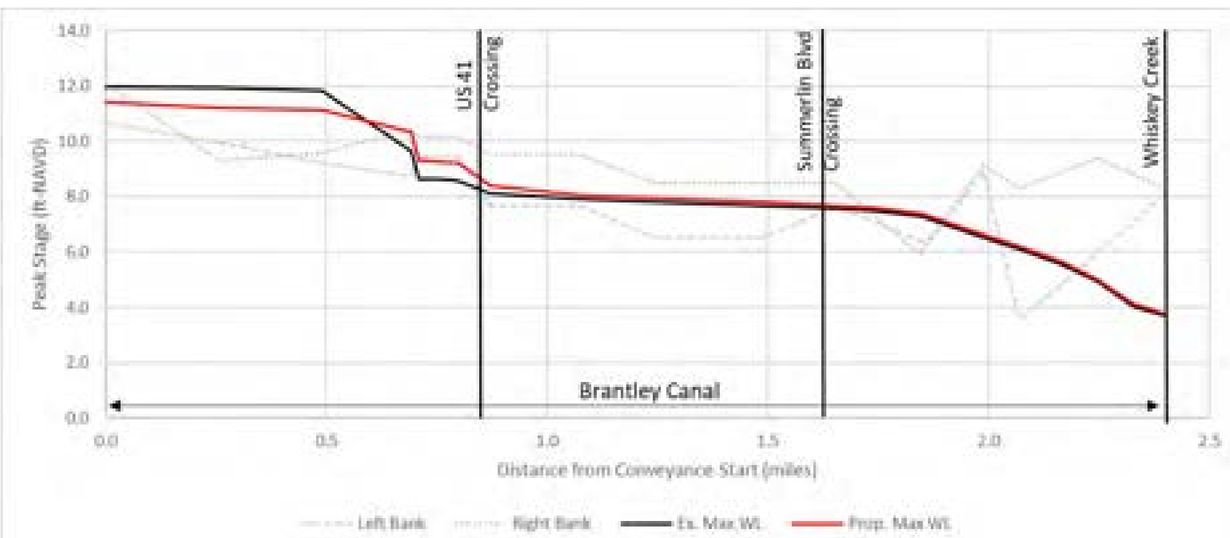


Figure 4.24. Peak Stage Comparison for Brantley Canal for 100yr DS

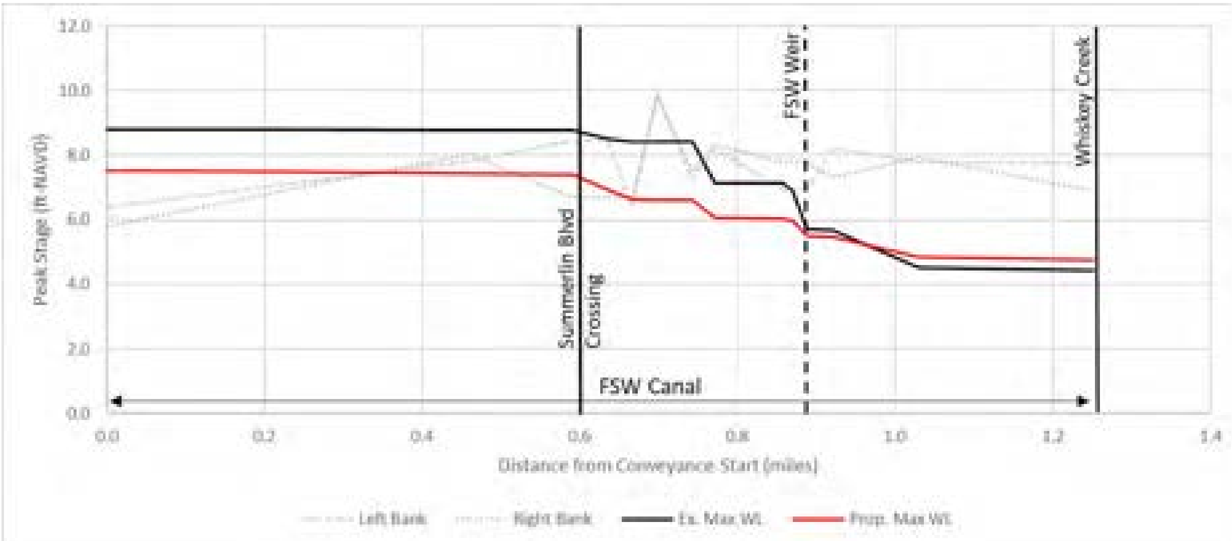


Figure 4.25. Peak Stage Comparison for FSW Canal for 100yr DS

Figure 4.26 illustrates the peak overland depth for the 1.4 and 1.2 South Ft Myers/Whiskey Creek Proposed conditions model. Figure 4.27 illustrates the overland water depth difference from the existing conditions results for the peak of the Irma event, and Figure 4.28 shows the depth difference at a more detailed scale. The depth difference maps show the values of the Existing Conditions water surface minus the values of the Proposed Conditions water surface. Thus, the greater the positive number value for the region, the greater the flood reduction in that region. Areas of notable flood reduction occur south of Daniels Parkway, and west of Treeline Avenue South. In addition, there is notable flood reduction along Island Park Road.

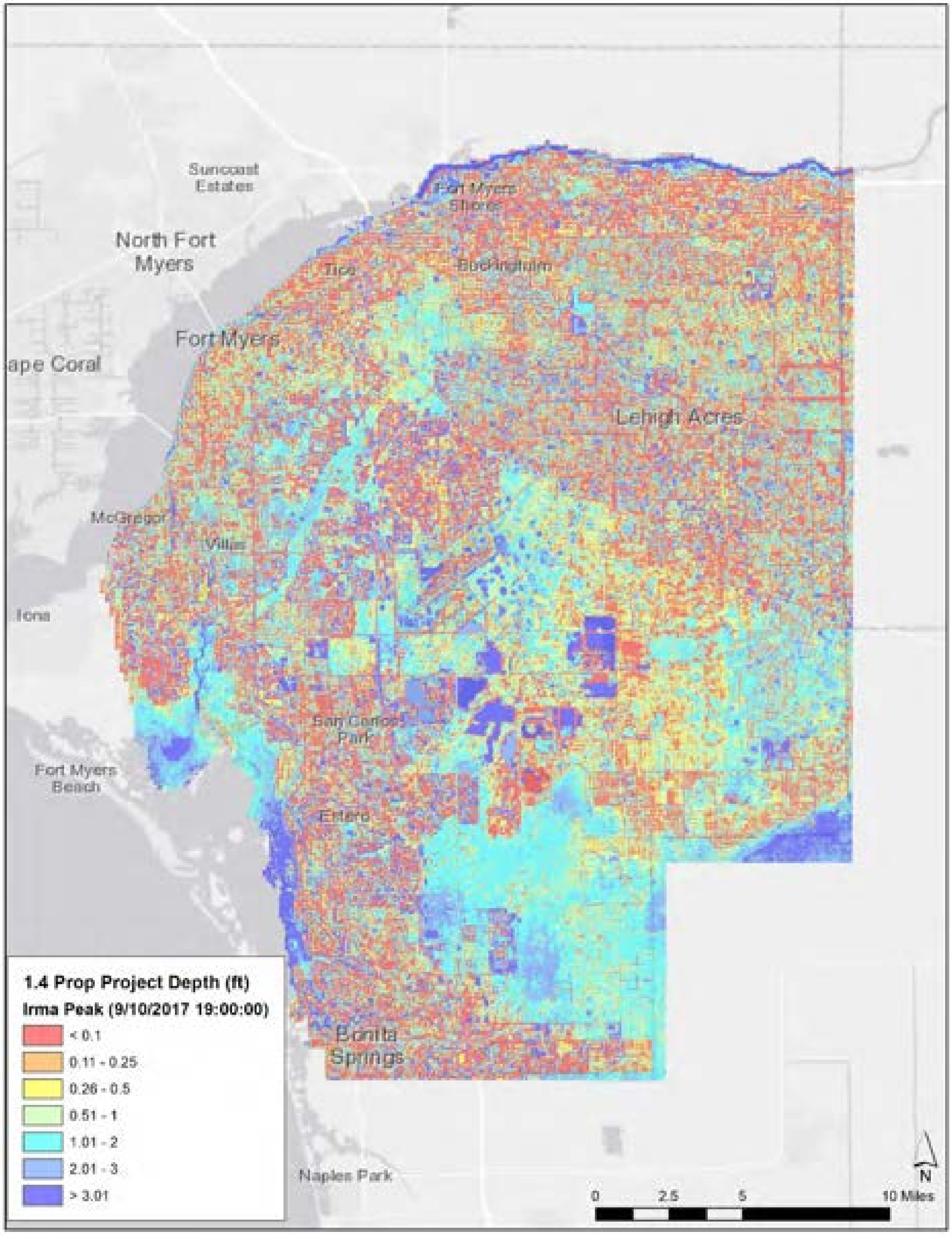


Figure 4.26. Peak Water Depth for Proposed 1.4 and 1.2 Projects during Hurricane Irma

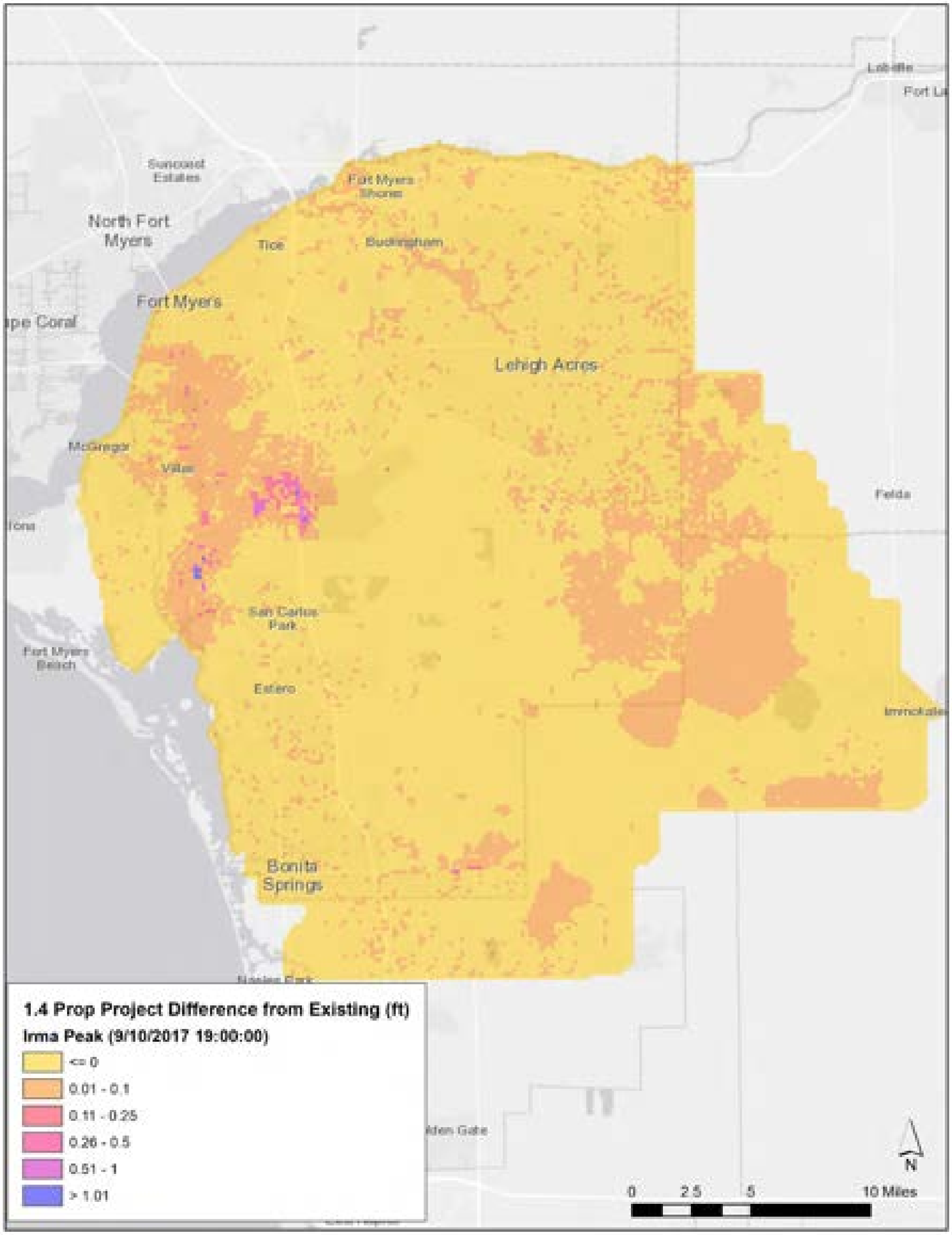


Figure 4.27. Difference between Existing Conditions Stage and Proposed 1.4 and 1.2 Projects Stage during Hurricane Irma

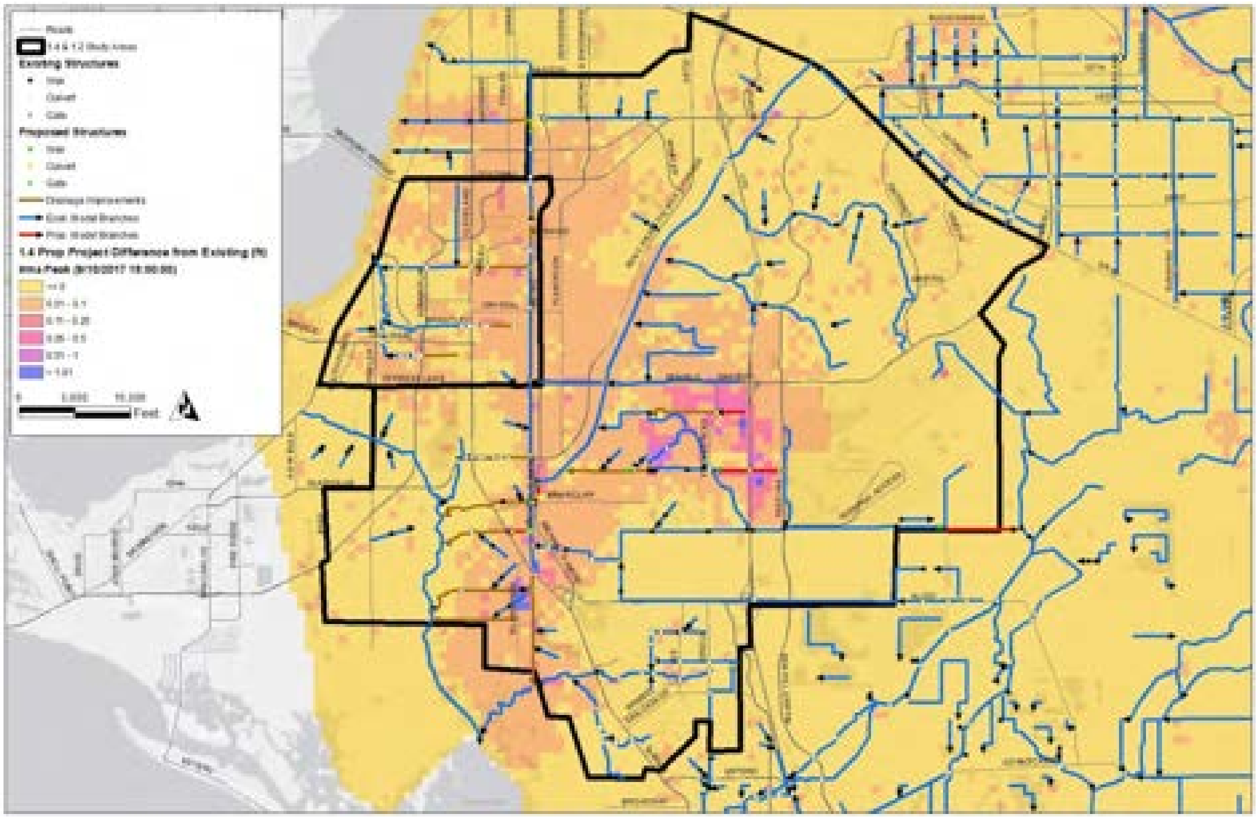


Figure 4.28. Detailed Difference between Existing Conditions Stage and Proposed 1.4 and 1.2 Projects Stage during Hurricane Irma

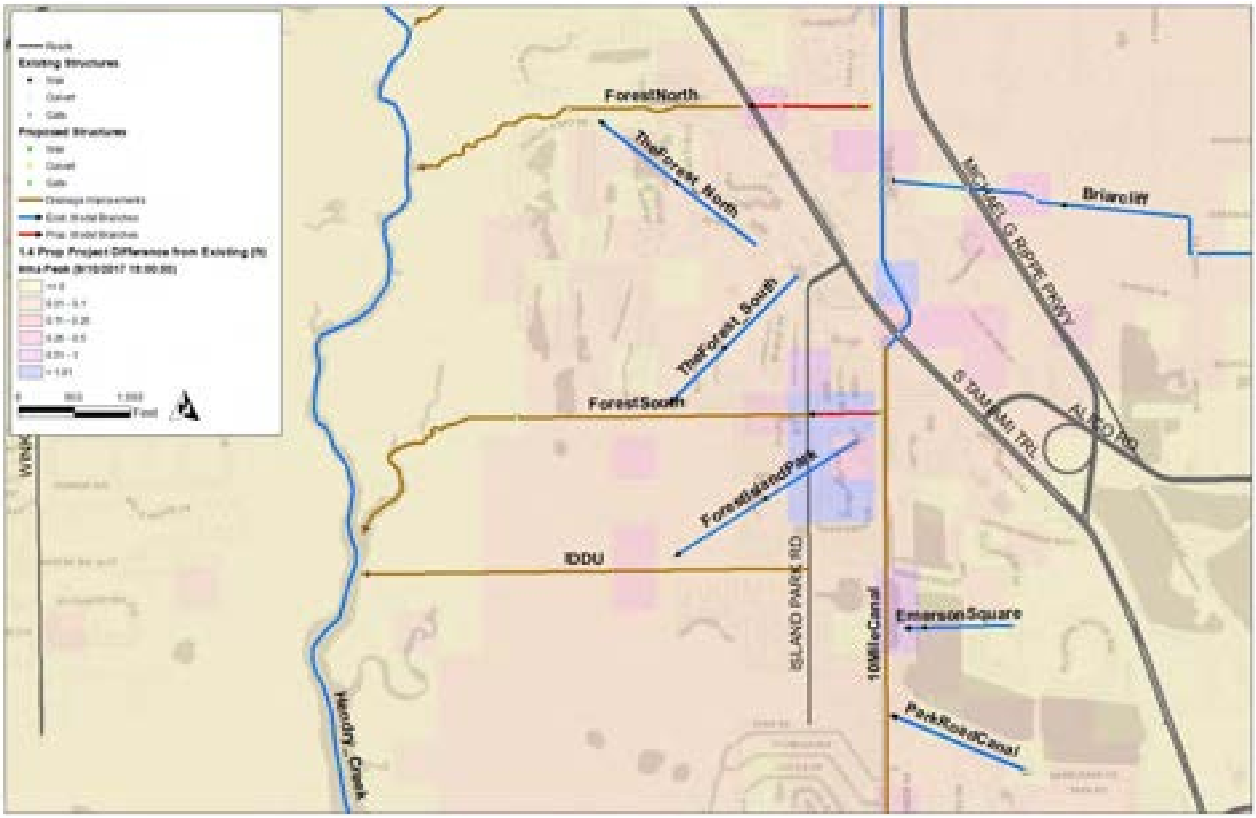


Figure 4.29. Detailed Difference between Existing Conditions Stage and Proposed Projects Stage during Hurricane Irma for the Island Park Road Area

5 FPSS ANALYSIS

To determine the effects of the projects on the overland flooding, a Level of Service (LOS) analysis was performed for each proposed condition. This analysis evaluated the severity of flooding throughout each defined basin by the calculation of a flooding problem severity score (FPSS), which is a function of several “severity indicators”. These severity indicators were based on the FPLOS criteria and were modified to adhere to Lee County’s standards.

Per the Lee Plan Policy 60.3 and 95.1.3, the County’s stormwater management facilities shall provide the following LOS for roadways and structures:

- No flooding of designated evacuation routes for the 25-Year 3-Day storm event for more than 24 hours within the unincorporated areas of the County
- Trunk conveyance crossing of arterial roads to be free of flooding from the 25-Year 3-Day storm event
- Major collector and arterial roadways to have no more than 6 inches of standing water for the 25-Year 3-Day storm event
- No flooding from a 100-Year, 3-Day storm event for private and public structures that are situated a minimum of one (1) foot above the 100-Year, 3-Day floodplain

As noted previously, the roadway LOS criteria were primarily concerned with evacuation routes as well as major collector and arterial roadways. In turn, the FPLOS analysis focused on these three (3) types of roadways for the 25-Year 3-Day storm event with minor collector roads and local roads being omitted from the evaluation. Furthermore, all structures/buildings were considered equivalent for the analysis, regardless of their ownership entity, size or value.

Per the County’s LOS criteria, the maximum allowable water depths for both roadways and structures were as follows:

- Evacuation Routes – 0-inch (applies to 25-Year, 3-Day event only)
- Arterial Roads – 6-inch (applies to 25-Year, 3-Day event only)
- Major Collector Roads – 6-inch (applies to 25-Year, 3-Day event only)
- Private/Public Structures – 0-inch (applies to 100-Year, 3-Day event only)

The modified severity indicators are defined and summarized below.

1. NS - Number of structures anticipated to flood for a 100-Year 3-Day design storm event, which can include commercial, residential, and public buildings. All structures and/or buildings are considered equivalent, regardless of their size or value.
2. MER - Miles of designated evacuation routes anticipated to flood for a 25-Year 3-Day design storm event. Evacuation routes are considered flooded if the depth of inundation exceeds the County’s LOS criteria of 0-inch.
3. MAR - Miles of arterial roadways anticipated to flood for a 25-Year 3-Day design storm event. Arterial roads are considered flooded if the depth of inundation exceeds the County’s LOS criteria of 6-inch.
4. MMCR - Miles of major collector roadways anticipated to flood for a 25-Year 3-Day design storm event. Major collector roads are considered flooded if the depth of inundation exceeds the County’s LOS criteria of 6-inch.

5.1 BASIN MAP FOR VISUALIZATION

The various severity indicators were extracted and reported on per basin. The basin map was developed using a combination of the SFWMD's basin map, Lee County basin delineations, and LA-MSID basin delineations and was further refined to provide better representation of basin divides where obvious changes to the topography and flow paths have taken place. As a way to simplify the reporting process a system of codes was created as short-hand for the basin names/numbers and new sub-basin that were created. The Figure below provides a detailed map of the basins and their abbreviated names used in this process.

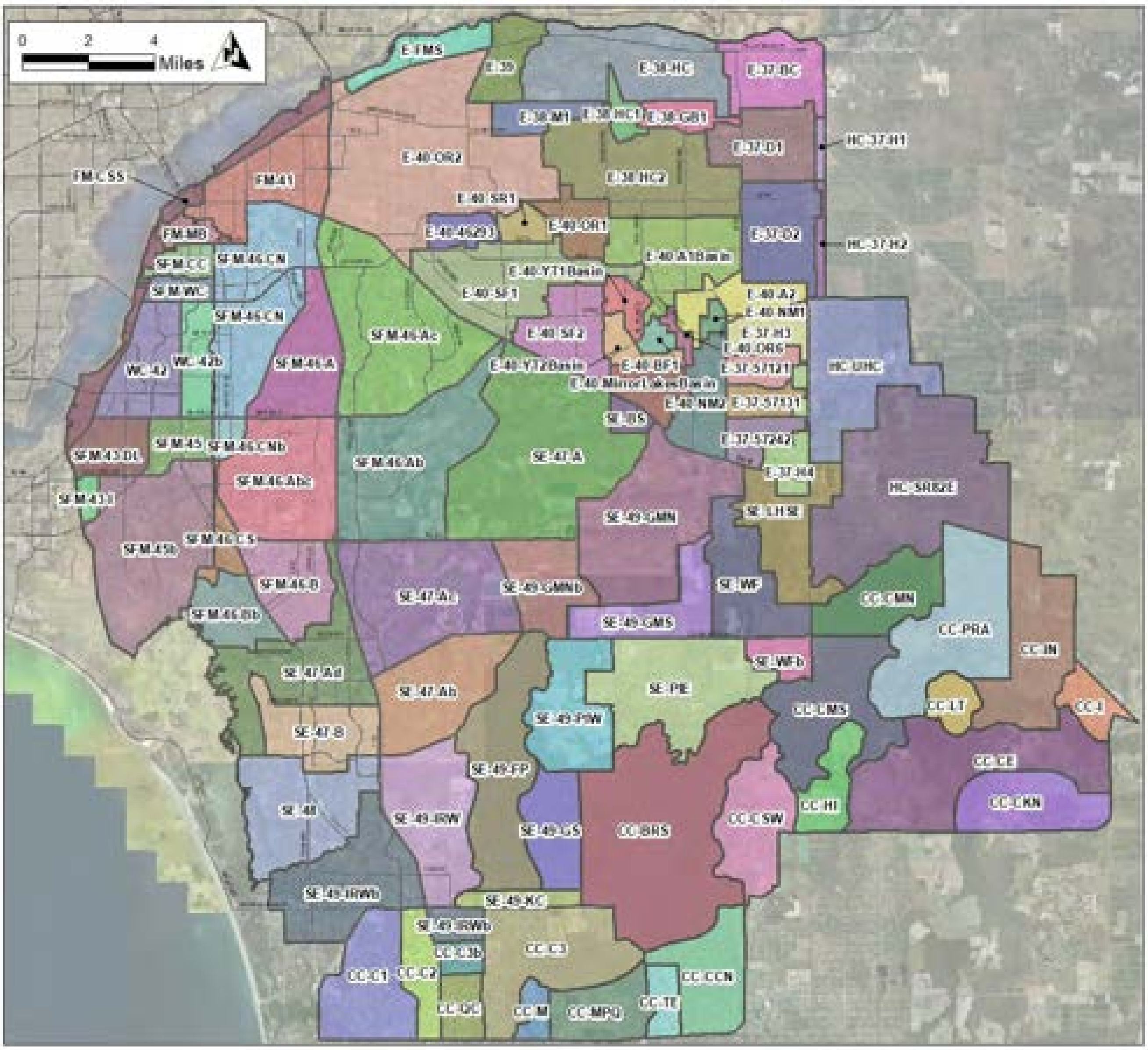


Figure 5.1. Lee County Basin Map for Visualization

5.2 QUANTIFICATION OF MER, MAR, MMCR SEVERITY INDICATORS

Polyline GIS shapefiles for the major roads were be sourced from the County's 'Open Data portal', which include linework for the centerlines of the roads. For purposes of this study, minor collector and local roads were removed from the dataset of these shapefiles. A shapefile with points each representing a 25- foot section of roadway was created. Moreover, maximum overland depths for the 25-year Design Storm simulations were extracted from the existing and proposed condition models and added to the model topography to develop a surface water level raster file. This raster was then intersected with the aforementioned roadway shapefile to determine a depth of flooding and an exceedance value approximated for each section of roadway. Furthermore, the length of roadway experiencing inundation above the maximum allowable water depth was be determined.

The miles of roads that exceeded the inundation criteria for Evacuation Routes, Arterial Roads, and Major Collector Roads was summed and extracted per basin. The miles of roads exceeding the criteria were then compared for the existing and proposed conditions, as shown inTable 3, Table 4, and Table 5 below.

Table 5.1. Miles of Roads Exceeding the Criteria for All Roads within East Lee County (Region 1.1)

Subbasin	Existing Cond. - Miles of Roads Exceeding Criteria	1.1 Proposed Cond. - Miles of Roads Exceeding Criteria	Existing Minus Proposed (mi)
E-40-46293	0.59	0.47	0.12
E-38-HC2	4.16	4.13	0.02
E-37-BC	1.60	1.59	0.00
E-37-D1	0.75	0.74	0.00
E-37-57121	0.00	0.00	0.00
E-37-D2	1.11	1.11	0.00
E-38-HC	0.16	0.16	0.00
E-38-M1	0.12	0.12	0.00
E-39	0.12	0.12	0.00
E-40-A1Basin	2.60	2.60	0.00
E-40-A2	0.79	0.79	0.00
E-40-BF1	0.20	0.20	0.00
E-40-MirrorLakesBasin	0.75	0.75	0.00
E-40-NM1	0.83	0.83	0.00
E-40-NM2	4.15	4.15	0.00
E-40-OR1	0.79	0.79	0.00
E-40-OR2	2.33	2.33	0.00
E-40-OR6	0.05	0.05	0.00
E-40-SF1	3.18	3.18	0.00
E-40-SF2	1.17	1.17	0.00
E-40-SR1	0.66	0.66	0.00
E-40-YT1Basin	0.03	0.03	0.00
E-40-YT2Basin	0.58	0.58	0.00
E-FMS	0.20	0.20	0.00
FM-41	4.89	4.89	0.00

Basin E-40-46293 showed some flood improvement on Alvin Avenue as shown by Figure 5.2 where increases green sections of roadway and decreases in red sections of roadway indicate that greater portions of the road are meeting LOS Criteria for the 25-year design storm with the improvements for Region 1.1.

Figure 5.2. Flood Improvements on Roadway in Basin E-40-46293

Table 5.2. Miles of Roads Exceeding the Criteria for All Roads within (or in proximity to) Southeast Lee County (Region 1.3)

Subbasin	Existing Cond. - Miles of Roads Exceeding Criteria	1.3 Proposed Cond. - Miles of Roads Exceeding Criteria	Existing Minus Proposed (mi)
SE-47-Ac	2.55	2.57	-0.02
CC-C1	0.11	0.11	0.00
E-37-57121	0.00	0.00	0.00
E-37-D2	1.11	1.11	0.00
E-FMS	0.20	0.20	0.00
SE-47-A	1.72	1.72	0.00
SE-47-Ab	0.27	0.27	0.00
SE-48	0.14	0.14	0.00
SE-49-FP	0.01	0.01	0.00
SE-49-GMN	0.07	0.07	0.00
SE-49-GMNb	0.17	0.17	0.00
SE-49-GMS	0.08	0.08	0.00
SE-49-IRW	0.23	0.23	0.00
SE-49-IRWb	1.80	1.80	0.00
SE-49-KC	0.51	0.51	0.00
SE-49-PIW	0.00	0.00	0.00

SE-WFb	0.13	0.13	0.00
SFM-46-A	2.85	2.85	0.00
SFM-46-Ab	3.20	3.20	0.00
SFM-46-B	3.00	3.00	0.00
SE-47-B	1.69	1.69	0.00
E-37-D1	0.75	0.74	0.00
E-37-BC	1.60	1.59	0.00

Table 5.3. Miles of Roads Exceeding the Criteria for All Roads within (or in proximity to) South Ft Myers/Whiskey Creek (Region 1.4/1.2)

Subbasin	Existing Cond. - Miles of Roads Exceeding Criteria	1.4 Proposed Cond. - Miles of Roads Exceeding Criteria	Existing Minus Proposed (mi)
E-40-OR2	2.33	2.33	0.00
E-40-SF1	3.18	3.18	0.00
FM-41	4.89	4.89	0.00
FM-CSS	3.78	3.78	0.00
FM-MB	1.49	1.49	0.00
SE-47-A	1.72	1.72	0.00
SE-47-Ab	0.27	0.27	0.00
SE-47-Ac	2.55	2.55	0.00
SE-47-B	1.69	1.69	0.00
SFM-43-DL	1.61	1.61	0.00
SFM-43-I	0.02	0.02	0.00
SFM-45	0.32	0.32	0.00
SFM-45b	2.58	2.02	0.56
SFM-46-A	2.85	2.85	0.00
SFM-46-Ab	3.20	3.20	0.00
SFM-46-B	3.00	3.00	0.00
SFM-46-CN	4.73	4.73	0.00
SFM-46-CNb	0.31	0.31	0.00
SFM-46-CS	0.07	0.07	0.00
SFM-CC	1.33	1.33	0.00
SFM-WC	1.28	1.28	0.00
WC-42	5.87	5.87	0.00
WC-42b	0.58	0.58	0.00

Basin SFM-45b showed some road flooding improvement on Island Park Road as shown in Figure 5.3 where increases green sections of roadway and decreases in red sections of roadway indicate that greater portions of the road are meeting LOS Criteria for the 25-year design storm with the improvements for Region 1.4.

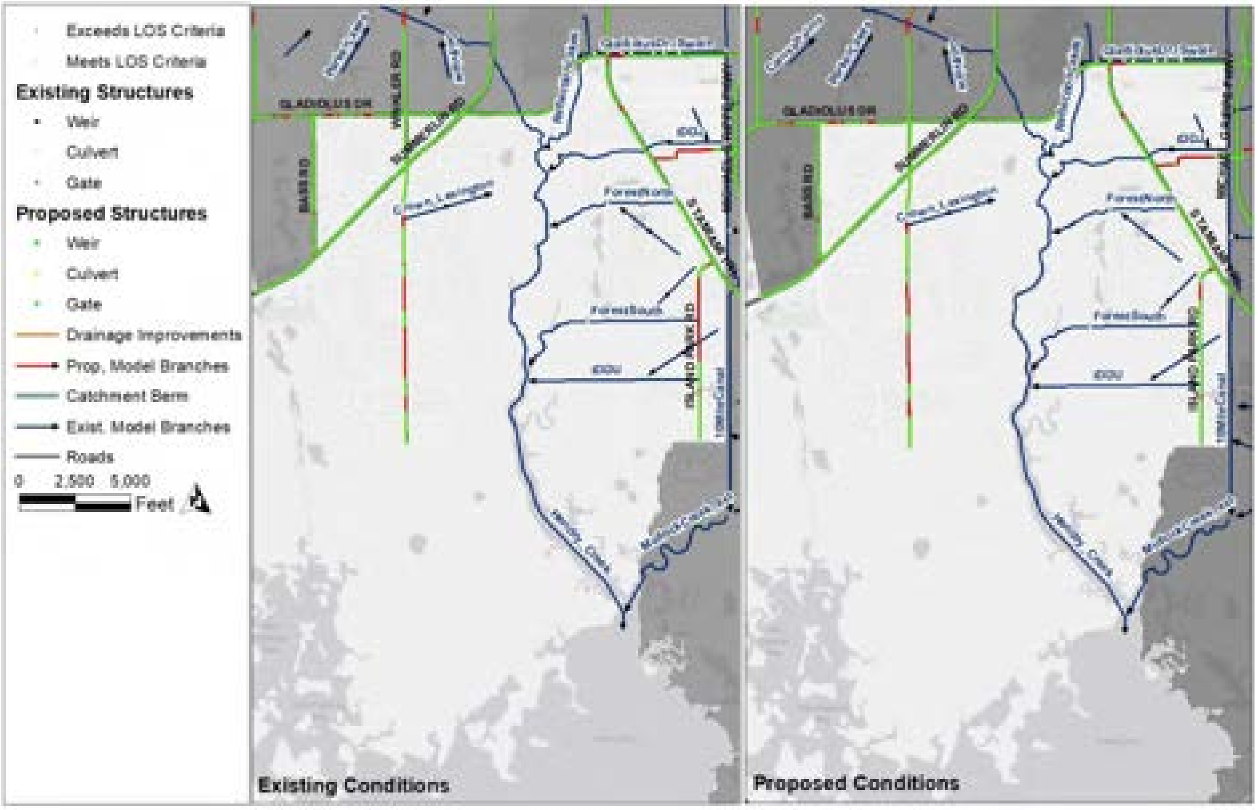


Figure 5.3. Flood Improvements on Roadway in Basin SFM-45b

5.3 QUANTIFICATION OF NS SEVERITY INDICATOR

To properly evaluate the FPLOS of structures within the County, the Finished Floor Elevations (FFE) was determined. Polygon GIS shapefiles for the building footprints were sourced from the County's 'Open Data portal', which consist of the structure envelopes of all the buildings located within the County. The polygon boundaries of the structures were intersected with the 2017 DEM. For each structure, the maximum and minimum elevations were extracted from the DEM. In turn, the average of the two (2) values was determined and 1.0 foot was added to obtain the estimated FFE. For mobile and manufactured homes, the average value was increased by 2.0 feet. The 1.0 foot and 2.0 feet elevation increases are included to account for the thickness of the concrete slab and elevated nature of manufactured homes, respectively. The polygon shapefile with the estimated FFE assigned to each building footprint was then further intersected with the previously developed peak stage rasters to determine which structures are at risk of flooding.

The number of structures in each basin that were below the criteria were extracted and are shown in Table 5.5 and Table 5.6 below. An increase in the number of structures below the FFE criteria is shown in red and a decrease is shown in green. Very few basins showed a decrease in the number of structures that could be inundated in the event of a large rainfall with the proposed projects, with the exception of SFM-45b (see Basin Map in Figure 5.1 for location). Figure 5.4 shows SFM-45b improvements in pink (i.e. structures that were flooded in the Existing scenario, but not in the Proposed scenario are pink in the figure). Structural flooding improvements are primarily seen around Island Park Road.

Table 5.4. Number of Structures Below Finished Floor Elevation Criteria (FFE) for Existing and 1.1 Proposed Conditions in the East Lee County Study Area

		Number of Structures Below the FFE Criteria	
Basin ID	**Total NS**	**Ex 100 yr DS Max**	**Prop 1.1 100 yr DS Max**
E-37-57121	496	3	3
E-37-57131	365	10	10
E-37-57242	436	2	2
E-37-BC	360	36	36
E-37-D1	642	33	33
E-37-D2	1600	35	35
E-37-H3	526	20	20
E-37-H4	554	3	3
E-38-GB1	203	0	0
E-38-HC	1190	82	89
E-38-HC1	51	0	0
E-38-HC2	2820	33	33
E-38-M1	762	3	3
E-39	1355	64	64
E-40-46293	1832	90	90
E-40-A1Basin	5095	99	99
E-40-A2	2725	99	99
E-40-BF1	605	30	30
E-40-MirrorLakesBasin	475	13	13
E-40-NM1	334	33	33
E-40-NM2	1301	78	78
E-40-OR1	1453	22	22
E-40-OR2	5556	210	210
E-40-OR6	33	1	1
E-40-SF1	7021	254	254
E-40-SF2	3009	53	53
E-40-SR1	887	14	14
E-40-YT1Basin	1981	37	37
E-40-YT2Basin	597	7	7
E-FMS	2259	156	173
FM-41	6940	470	471
FM-CSS	5300	988	988

Table 5.5. Number of Structures Below Finished Floor Elevation Criteria (FFE) for Existing and 1.3 Proposed Conditions in and around the Southeast Lee County Study Area

		Number of Structures Below the FFE Criteria	
Basin ID	**Total NS**	**Ex 100 yr DS Max**	**Prop 1.3 100 yr DS Max**
CC-BRS	3	0	0
CC-C1	509	9	9
CC-C2	416	26	26
CC-C3	3771	20	20
SE-47-A	2051	93	94
SE-47-Ab	3900	93	93
SE-47-Ac	8685	606	600
SE-47-B	3445	191	191
SE-48	6156	449	449
SE-49-FP	21	0	0
SE-49-GMN	15	0	0
SE-49-GMNb	44	1	1
SE-49-GMS	374	0	0
SE-49-GS	3	0	0
SE-49-IRW	1886	17	17
SE-49-IRWb	12643	580	579
SE-49-KC	79	0	0
SE-49-PIW	49	1	1
SE-BS	606	3	3
SE-LHSE	150	2	2
SE-PIE	114	3	2
SE-WF	9	0	0
SE-WFb	8	3	1

Table 5.6. Number of Structures Below Finished Floor Elevation Criteria (FFE) for Existing and 1.4/1.2 Proposed Conditions in and around the South Ft Myers and Whiskey Creek Study Areas

		Number of Structures Below the FFE Criteria	
Basin	**Total NS**	**Ex 100 yr DS Max**	**Prop 1.4 100 yr DS Max**
FM-41	6940	470	470
FM-CSS	5300	988	988
FM-MB	1576	80	80
SFM-43-DL	3622	35	35
SFM-43-I	872	6	6
SFM-45	1427	56	56
SFM-45b	6738	215	159
SFM-46-A	13295	557	564
SFM-46-Ab	3358	81	80
SFM-46-B	8203	518	518
SFM-46-Bb	1016	50	50
SFM-46-CN	6174	142	142
SFM-46-CNb	184	7	7
SFM-46-CS	1211	55	54
SFM-CC	1789	67	64
SFM-WC	1564	45	45
WC-42	7440	400	400
WC-42b	2721	148	144

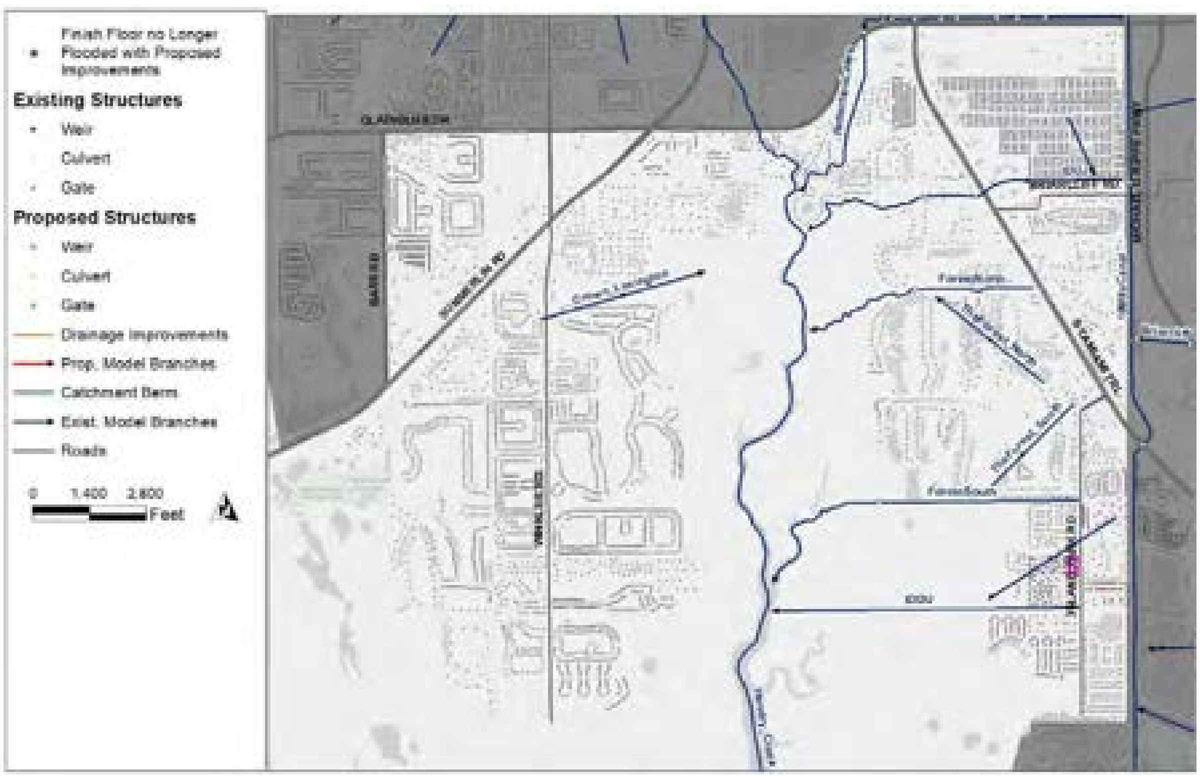


Figure 5.4. Improvements to Number of Structures Flooded

The difference between these projects and the projects' impacts to the system are better defined by the water levels and flows comparison. The 100 yr design storm did not show substantial flooding. The number of structures flooded with the base existing conditions simulation is largely due to the model topography averaging over a 750 ft grid. So, for example if there are 100 houses within one grid cell, the topography of that cell may be at a higher elevation than the base elevation of some of the houses. The overland depth is added to the model topography to get the Water Surface Elevation (WSE), which means areas with zero overland flooding could be higher than the FFE if the topography is higher. Therefore, many basins experiencing no change in the number of structures flooded may be due to 1) very little flooding occurring during the 100 yr 3 day design storm and 2) average topography being higher for many houses within one grid cell.

6 CONCLUSIONS

Flood mitigation projects were developed for the Southern Lee County Flood Mitigation Plan in four (4) distinct regions: 1) East Lee County (developed by AIM Engineering), 2) Whiskey Creek (developed by ATM Engineering), 3) Southeast Lee County (developed by AIM Engineering), and 4) South Ft Myers (developed by Johnson Engineering). These projects were then summarized by their hydraulic components and implemented into the calibrated model by the model development team.

Project implementation was separated into the Screening Phase and the Combined Project Phase. The Screening Phase involved implementing each proposed project into a separate model, running the 100 yr DS simulation, and comparing with the existing conditions results. This purpose of this phase was to create an understanding of how each proposed project will impact the system and decide which projects should be included in the second phase. Projects that showed a reduction in the peak stages, flows, or time of inundation were considered to have a positive impact to the system.

For the Combined Project Phase, all projects that showed a positive impact to the hydraulics during the 100 yr Design Storm were then implemented into the larger regional combined project files for 1.1 East Lee County (11 projects), 1.3 Southeast Lee County (16 projects), and 1.4/1.2 South Ft Myers and Whiskey Creek (10 projects). The only projects that were left out of the Combined Projects Phase were 1.4.4 and 1.4.5, which showed little to no impacts due to the scale difference between the proposed projects and the large regional model cell size.

For these simulations the following conditions were simulated:

1. Continuous simulation – from 1/1/2017 through 12/31/2017
2. Continuous simulation with hourly output – from 7/30/2017 through 9/30/2017
3. 100 yr Design Storm –antecedent conditions from 7/24/2017
4. 25 yr Design Storm – antecedent conditions from 7/24/2017
5. 100 yr Design Storm with modified start date - antecedent conditions from 8/24/2017

While the Level of Service analysis was not an effective tool for evaluating project impacts with this model scale and selected Design Storm, the peak stage and flow analysis showed significant improvements in many areas as a result of project implementation. In general, projects produce reduced stages in impacted areas, and may increase stages where storage is being encouraged via the implementation of weir and gated structures. While this methodology didn't produce usable results, we were able to produce some great data for the individual projects that will greatly reduce flooding impacts. The data used in the Level of Service exercise can be input into local models to refine more localized benefits.

Due to the regional nature of this model, it was shown that many proposed urban projects, such as shallow swales and roadside ditches to improve drainage/storage in areas, may be better represented with a scaled-down model that can focus on the individual projects and allow for more detail in specific areas.

3.3 FUTURE CONDITIONS ANALYSIS

1. BACKGROUND

The Southern Lee County Flood Mitigation Plan was developed using the most up-to-date landuse information for 2017. However, growth and development of the region is expected to increase in the next 20+ years. While Lee County is encouraging smart or low-impact growth that won't negatively impact natural flows, any increase in growth means an increase in impervious surfaces. When impervious surface coverage increases in an area, this typically decreases the amount of water that will be infiltrate and reduces the time it takes for water to reach the receiving channel. These effects can therefore increase peak stages during a storm event, which may exacerbate existing flooding conditions. In addition, the future conditions for areas connected to or impacted by tide will be impacted by rising seas due to sea level rise.

This report section provides a detailed review of the changes that have been implemented into the existing conditions model to project future conditions. Under direction from the County, the model was projected to the year 2040, representing 23 years of increased growth and sea level rise for Southern Lee County.

2. PROJECTED 2040 CONDITIONS

The county provided projections for the 2040 land use coverage. This was used to reflect the increasing development within Lee County for the year 2040 in the form of land use coverage changes. In the model, the runoff friction coefficients were adjusted to reflect how the land stores rainfall runoff during a storm event, as more land surfaces will be converted from vegetated to impervious areas. The decrease in vegetation coverage and consequently in the runoff friction coefficient also impact evapotranspiration calculations and overland flow rates, respectively.

Impervious Surface Changes

Lee County provided a geodatabase feature class file with an estimation of the lots that were projected to be built upon by the year 2040. These lots were then assigned a percent imperviousness by dividing the number of units (houses) per acre. For the purpose of this model, the following rules were applied to the lots:

- Lots greater than or equal to 8 units/acre = 65% impervious
- Lots between 2 and 8 units/acre = 38% impervious
- Lots between 0.5 and 2 units/acre = 25% impervious
- Lots less than 2 units/acre = 12% impervious

The data was then converted to raster format and compared to the 2017 existing conditions impervious map (raster file) that was created during model development. The resulting impervious map was then aggregated over a 750 ft grid to match the model grid and imported into the model. The 2017 impervious percentage coverage is shown in Figure 1. The future 2040 impervious percentage is shown in Figure 2.

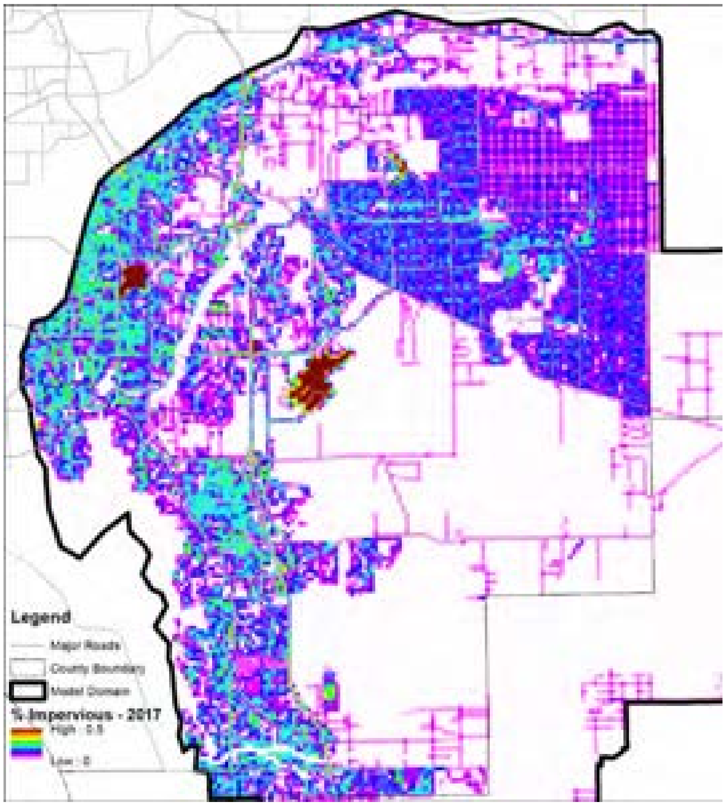


Figure 1. Existing 2017 Impervious Surface Coverage

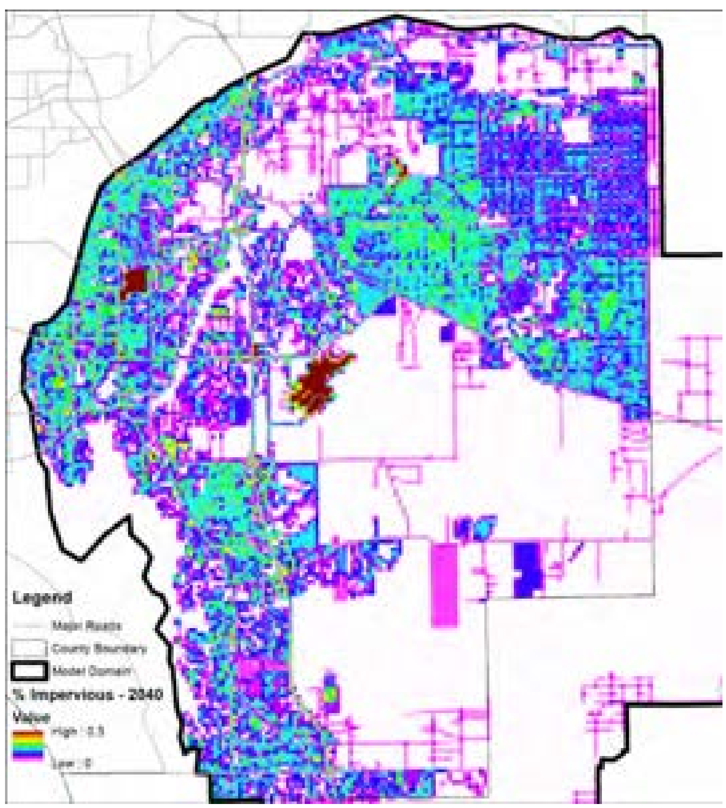


Figure 2. Future 2040 Impervious Surface Coverage

Manning's Change

The percent increase in imperviousness from 2017 to 2040 was used to increase the Manning's M (equivalent to 1/n) for the overland flow module in MIKE SHE.

- The impervious percentage for 2017 was subtracted from the 2040 imperviousness
- One was added to the impervious increase, to get the correct multiplier.
- The percent increase was then multiplied by the Manning's M values to get the estimated change in roughness.

The Manning's M values for the existing 2017 conditions and the future 2040 conditions are shown in Figure 1 and Figure 2, respectively.

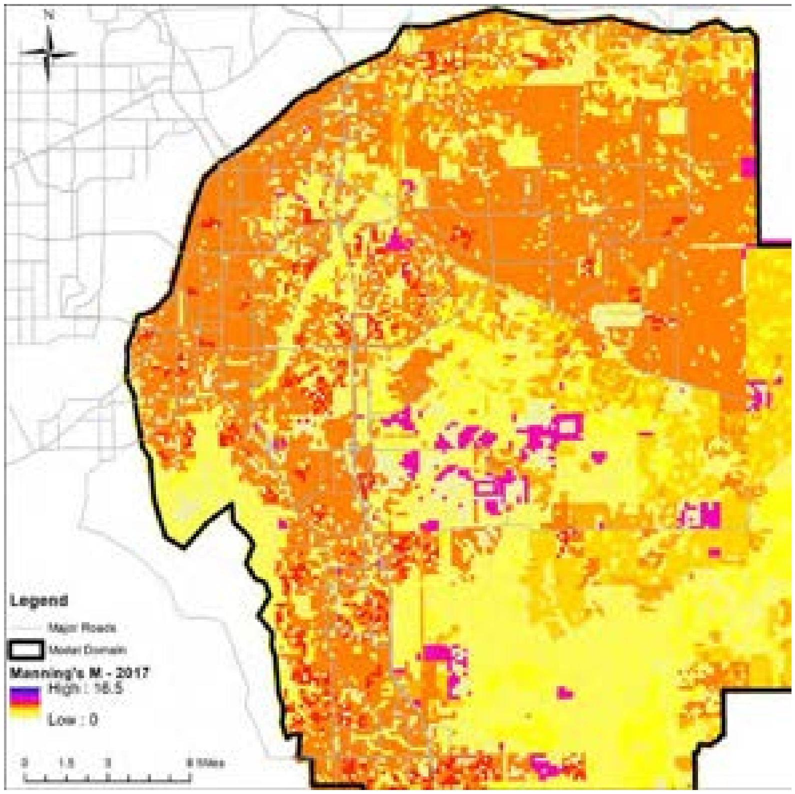


Figure 3. Existing Manning's M roughness values for Overland Flow

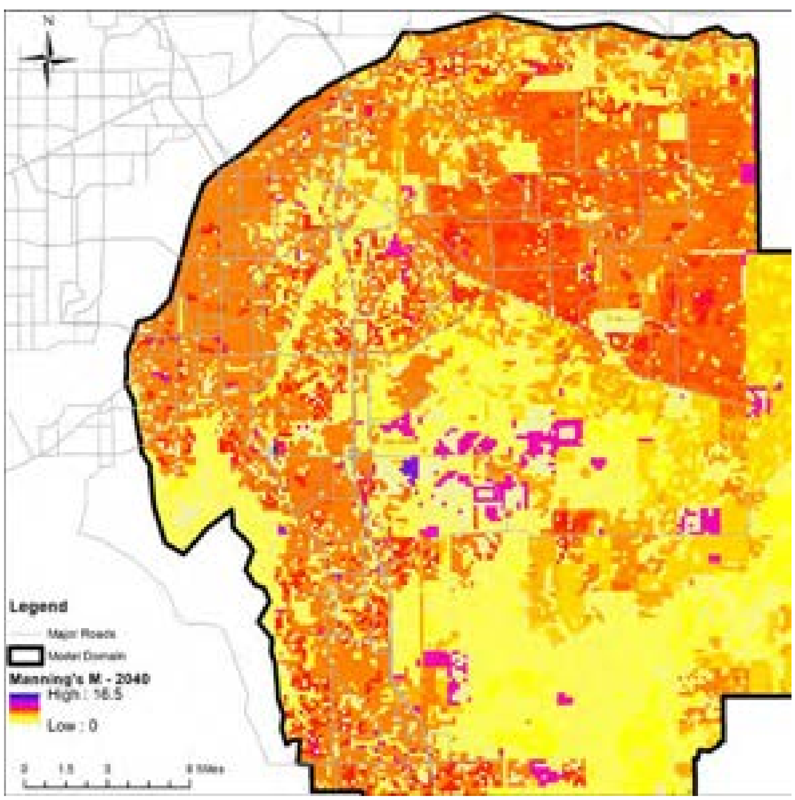


Figure 4. Future Manning's M roughness values for Overland Flow

Landuse change

Landuse or vegetation coverage in the MIKE SHE model plays a role in the calculation of evapotranspiration. To modify the vegetation coverage in the model, the following procedure was taken:

- Previously undeveloped areas (vegetated, cropland, barren, etc.) that show an increase in imperviousness were modified to “Low Density Urban”.
- Areas that were previously classified as “Low Density Urban” that show an increase in imperviousness were modified to “Medium Density Urban”.
- Areas that were previously classified as “Medium Density Urban” that show an increase in imperviousness were modified to “High Density Urban”.

The existing and future conditions landuse maps used in the model are shown in Figure 3 and Figure 4, respectively.

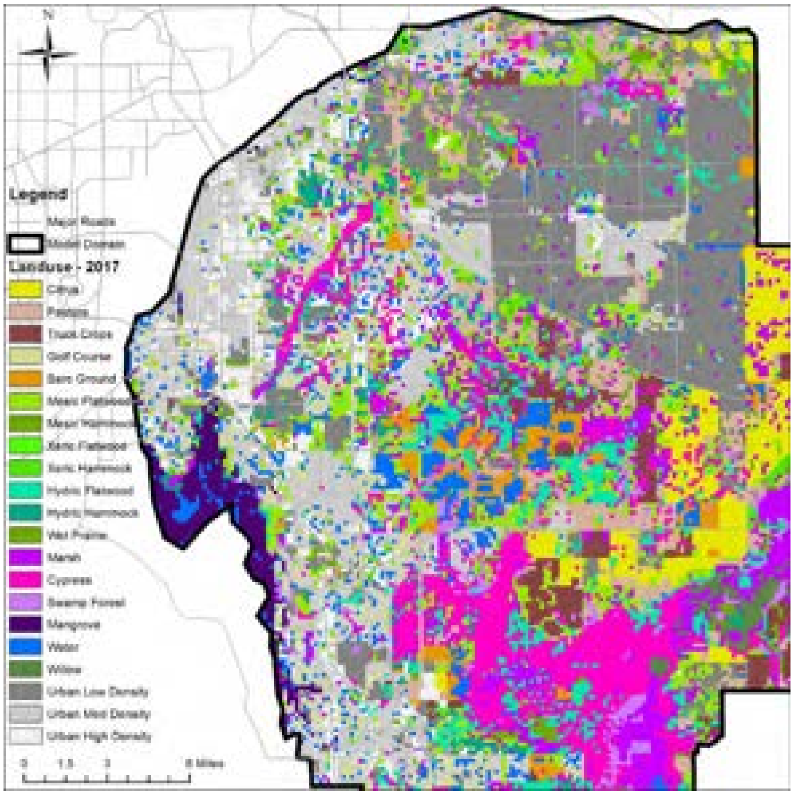


Figure 5. Existing landuse coverage for 2017

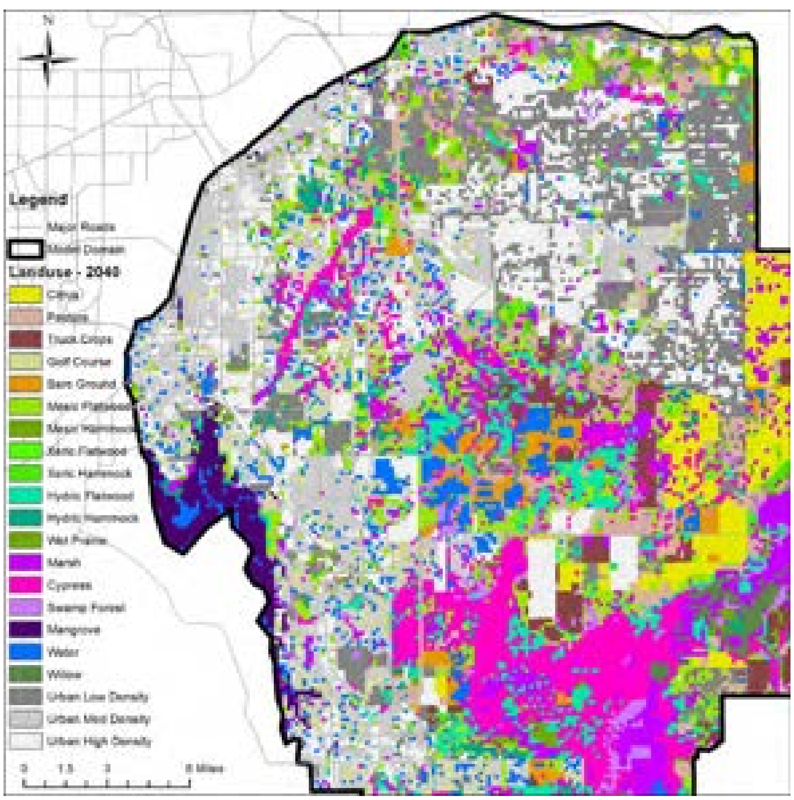


Figure 6.Future landuse coverage for 2040

3. CHANGING BOUNDARY CONDITIONS

Sea Level Trends

As with the increasing impervious surfaces, a scenario evaluating the 2040 conditions should also include the effects of a rising sea level. Rising sea levels may impact the boundary conditions and tidal outfalls for several branches within Lee County.

The NOAA tidal gauge at Naples Pier has been recording sea levels since 1965. Over the 54 year period of record, the data shows increasing sea levels with a linear sea level trend of 3.02 ± 0.45 mm/year based on monthly mean sea level according to NOAA (Figure 1). This is equivalent to 0.99 feet over a 100 year period (NOAA, 2019).

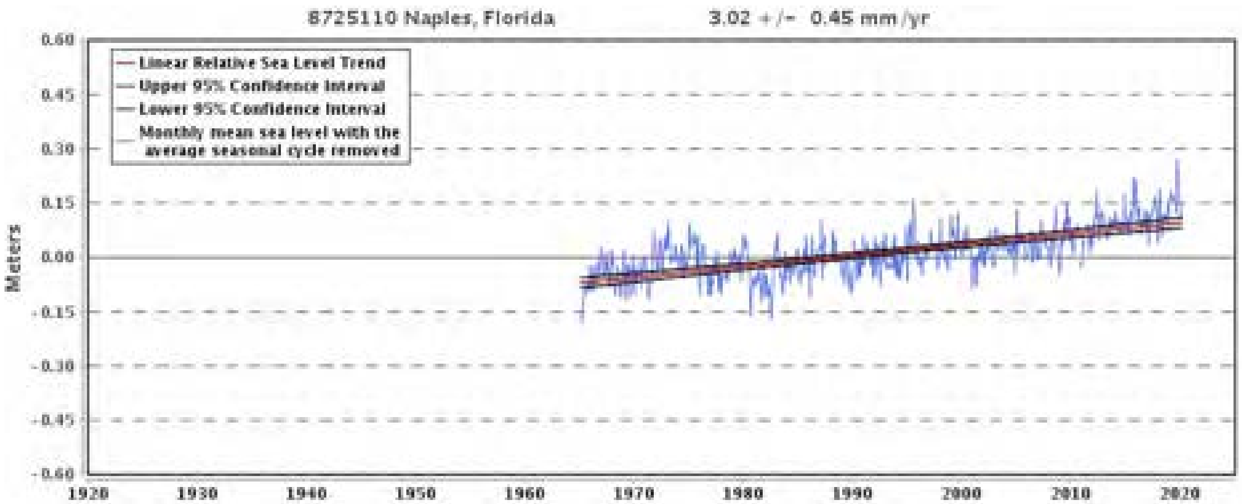


Figure 7. NOAA Sea Level Trend for the Naples Pier (NOAA, 2019)

This increase is similar to other tidal gages along the Gulf Coast of Florida, and is close to the mean trend for this area, as shown in Figure 2. The Fort Myers station, located within the Caloosahatchee estuary, shows a SLR trend of 3.22 mm/yr (NOAA, 2019), but may also experience influence from freshwater flows.

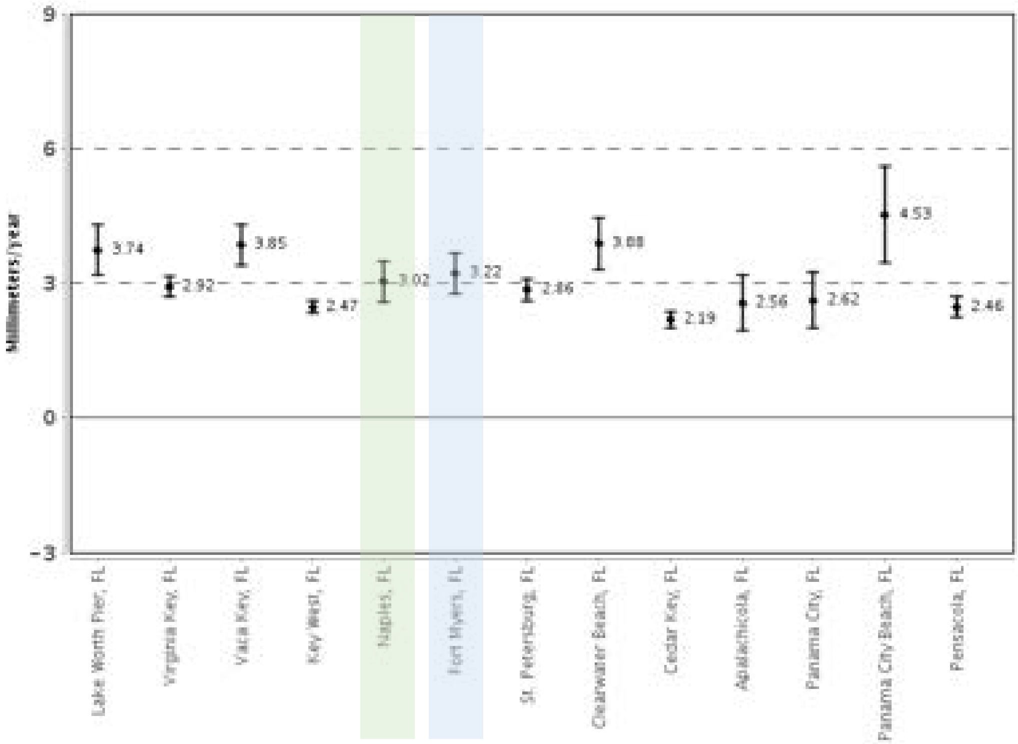


Figure 8. Relative Sea Level Trends for a sampling of tidal gages along the Gulf Coast of Florida (NOAA, 2019)

This trend suggests that, at a minimum, the sea level will rise from 2017 to 2040 by about 3 inches. This only considers recent linear gauge data and does not incorporate future conditions such as the effects of rising sea temperatures and melting ice sheets, which could significantly increase sea levels above this current linear trend. Other projections should be taken into account when evaluating the effects of sea level rise for engineering design purposes.

Sea Level Rise Projections

NOAA has established six (6) global sea level rise scenarios, ranging from low to extreme, that project the global rise in sea levels. Research has shown that the likelihood of the "Low" scenario being exceeded is highly likely (94% to 100% depending on the scenario). The "Intermediate-Low" scenario is also likely to occur (probability ranges from 50% to 96%). The "Intermediate" scenario is considered less likely, with probability of exceedance ranging from 2% to 17%. However, the report discusses the fact that new evidence regarding the Antarctic ice sheet, which may significantly increase these probabilities, have not yet been incorporated into the probabilistic analysis for Global Mean Sea Level (Sweet, et al., 2017).

The USACE has developed a Sea Level Change Curve Calculator (Huber and White, 2017), which adapts various sea level change curves for each NOAA tidal gage location. The Naples Pier location was used to determine the sea level change for this 2040 projection. Figure 3 shows the six (6) NOAA scenarios and the three (3) USACE scenarios for sea level change. The NOAA Intermediate scenario, which lies between the USACE Intermediate and High scenarios, will be used for the purposes of this analysis and the graph shows the confidence interval for the scenario.

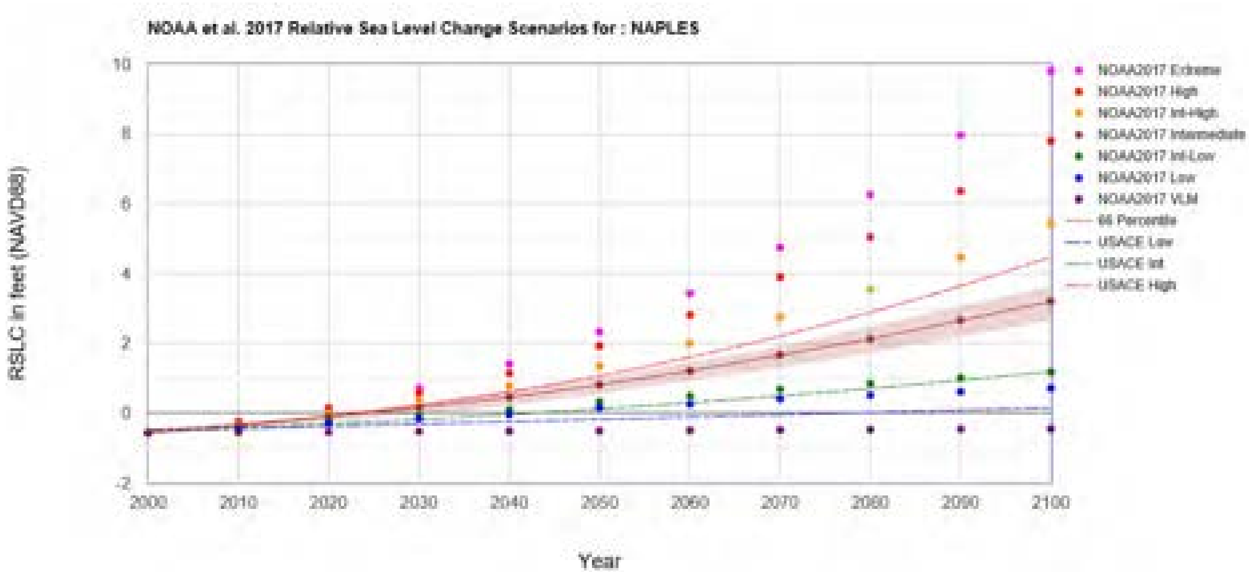


Figure 9. Sea Level Change for various scenarios in Naples.

Using the NOAA Intermediate scenario projection published on the USGS Sea Level Change Curve Calculator, the projected rise for the Naples tidal gage is 0.64 ft from 2017 to 2040. This value was added to all the 2040 tidal boundary conditions in the model, including those along the Caloosahatchee.

4. MODEL RESULTS

The existing conditions and proposed projects were simulated with current (2017) and future (2040) conditions to determine the effects of build-out and whether the projects will improve the conditions for the future. The results provided in this section show the 100-year design storm conditions (with antecedent conditions from Aug 24th). For results from the Irma event, please see the Appendix. The following simulations were run:

2017 Conditions:

- Existing Conditions
- Proposed 1.1 Project Conditions
- Proposed 1.3 Project Conditions
- Proposed 1.4 Project Conditions

2040 Conditions:

- Proposed 1.1 Project Future Conditions
- Proposed 1.3 Project Future Conditions
- Proposed 1.4 Project Future Conditions

Proposed 1.1 Future Conditions

The proposed conditions for the 1.1 project are shown in comparison to the existing conditions in Figure 10 through Figure 15, below. Many areas within East Lee County showed an increase in the imperviousness due to the development predicted for 2040. However, the area did not show as significant increase in the channel peak stages during the 100-year Design Storm event. This is likely due to the existing water control structures that manage water elevations. Hendry Canal (Figure 10) and Dog Canal (Figure 11) are good examples of canals that will likely not see impacts of increased development in 2040 due to the highly managed system.

It should be noted that boundary conditions along the Caloosahatchee upstream of the S-79 structure were not modified, as were the boundary conditions downstream of the S-79, to simulate the sea level change. It is assumed that water levels upstream of the structure will be managed and will therefore not immediately suffer the effects of sea level rise. Because of this, tailwaters along natural channels such as Bedman Creek and Hickey's Creek do not change with this new future conditions scenario. However, Orange River, being downstream of S-79, did see an impact from the rising sea levels.

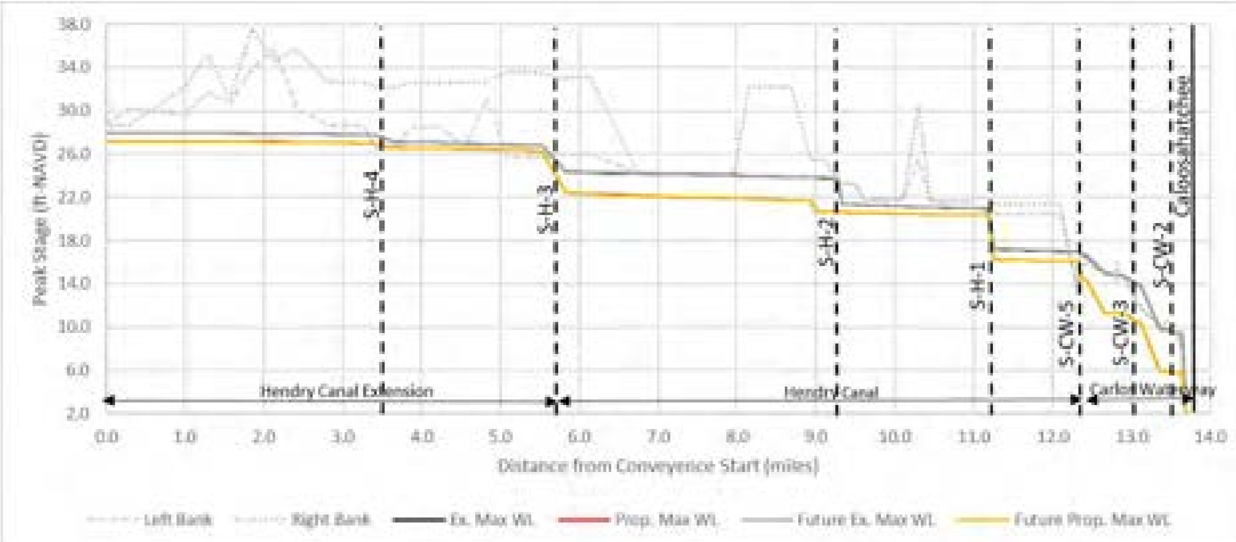


Figure 10. Peak stages during the 100 yr Design Storm within Hendry Canal and Carlos Waterway

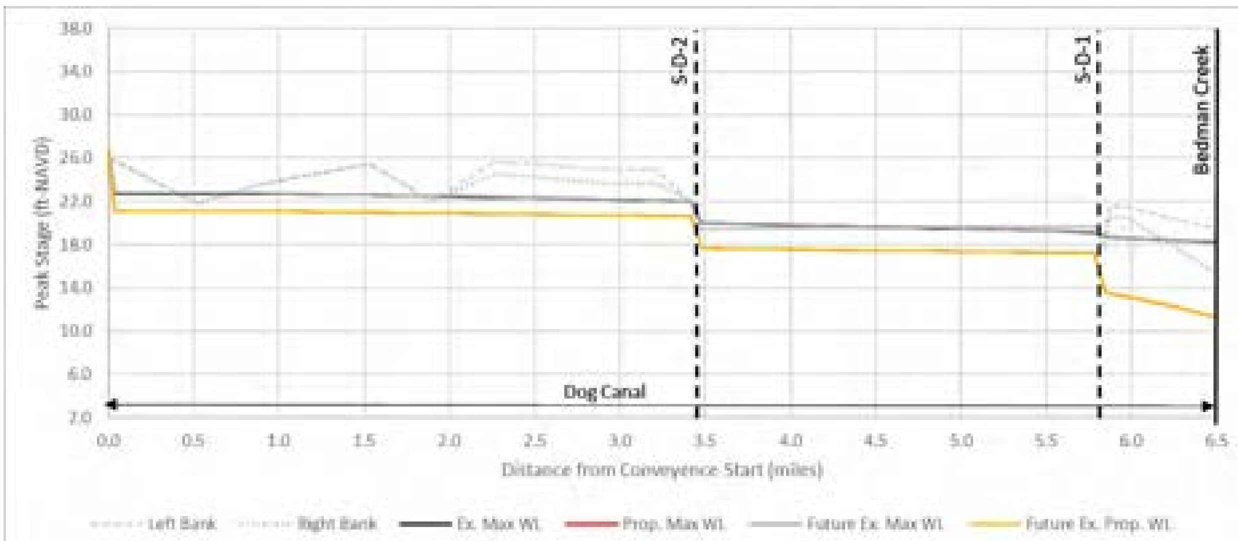


Figure 11. Peak stages during the 100 yr Design Storm within Dog Canal

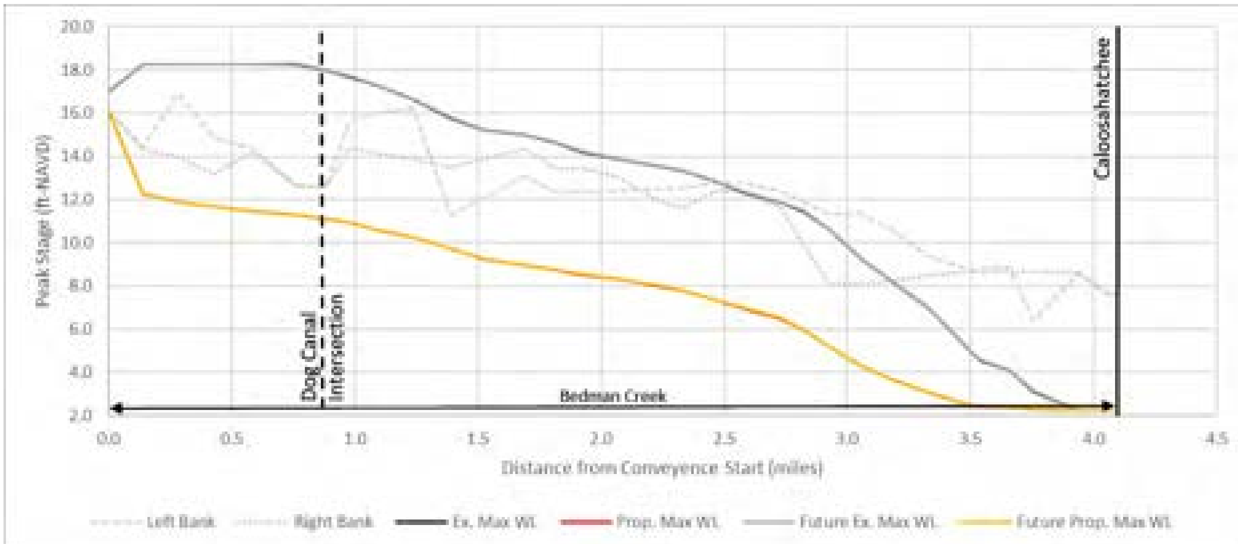


Figure 12.Peak stages during the 100 yr Design Storm within Bedman Creek

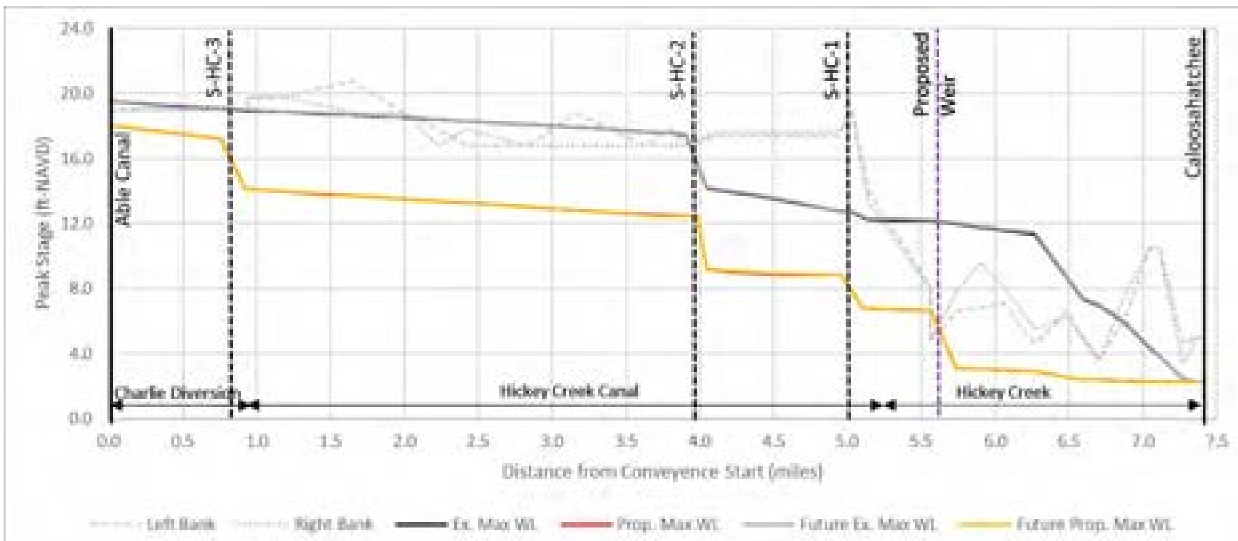


Figure 13. Peak stages during the 100 yr Design Storm within Hickey's Creek

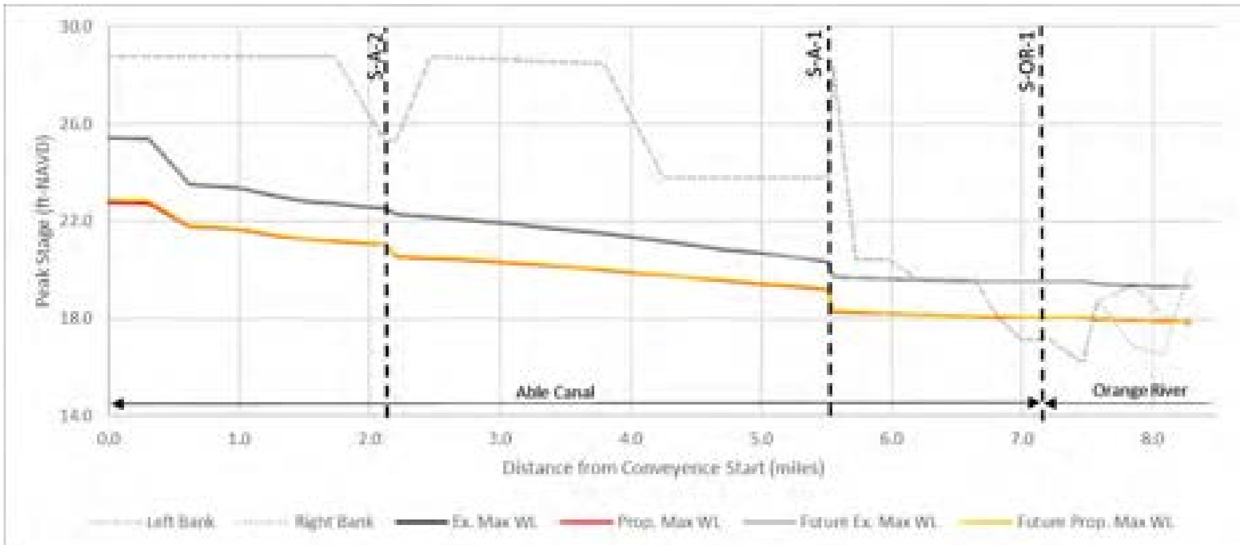


Figure 14. Peak stages during the 100 yr Design Storm within Able Canal

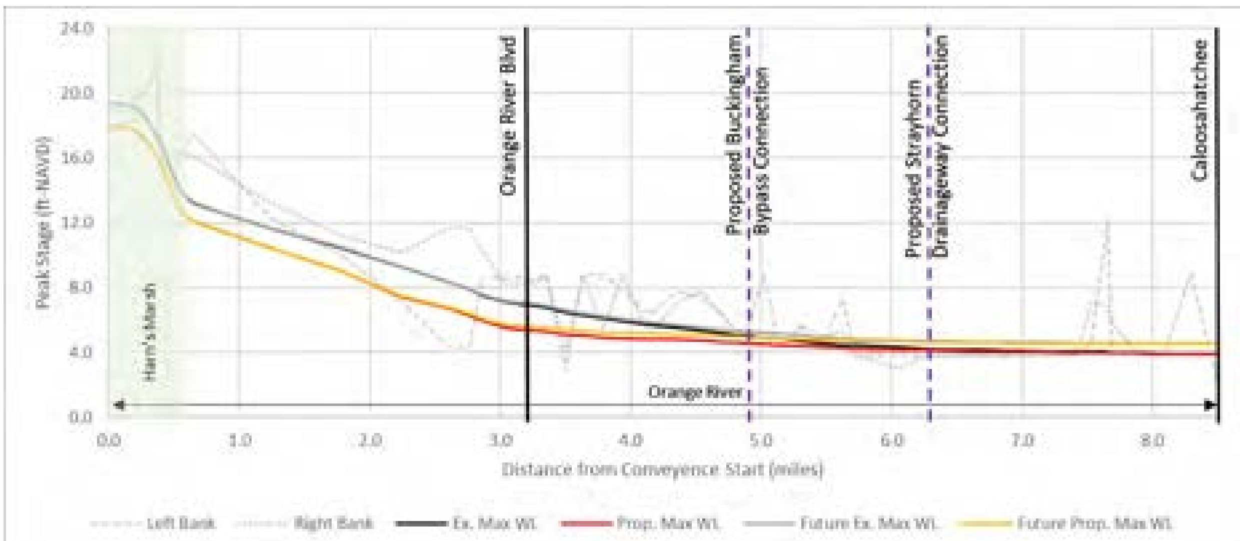


Figure 15. Peak stages during the 100 yr Design Storm within Orange River

Proposed 1.3 Future Conditions

The proposed conditions for the 1.3 project are shown in comparison to the existing conditions in Figure 16 through Figure 20, below. The Southeast Lee County seems to show minimal impact from development in 2040 on the overall water levels in the various rivers and creeks that drain to the Gulf. However, increasing sea levels will impact tidal areas and areas that may experience backwater effects from increasing tidal boundary.

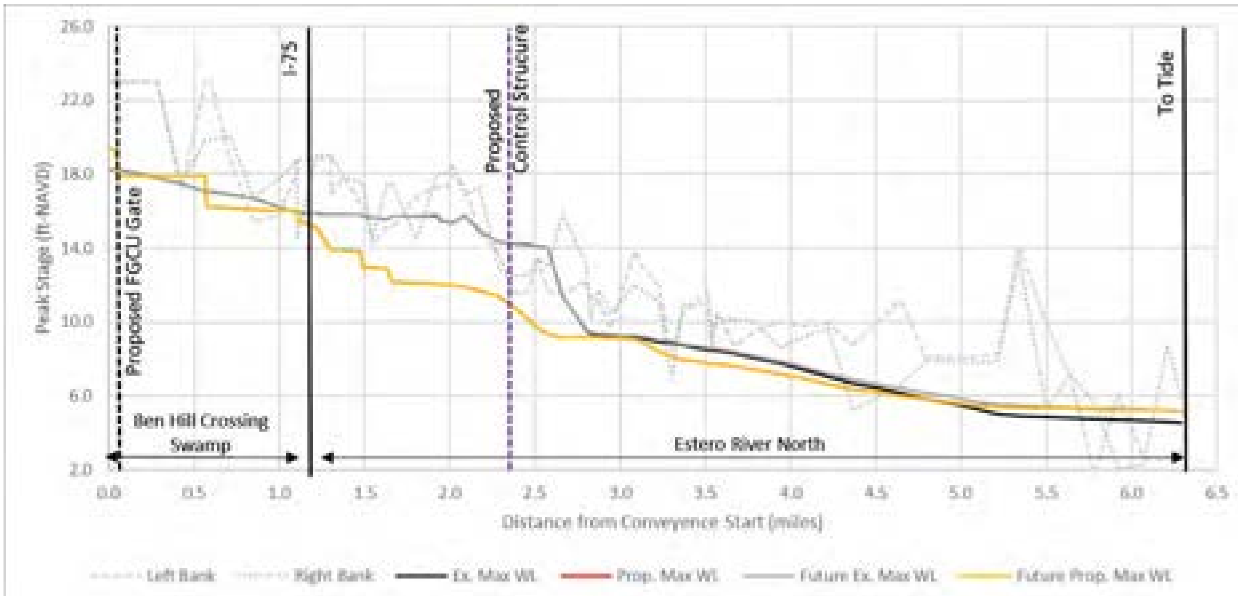


Figure 16. Peak stages during the 100 yr Design Storm within Estero River North Branch

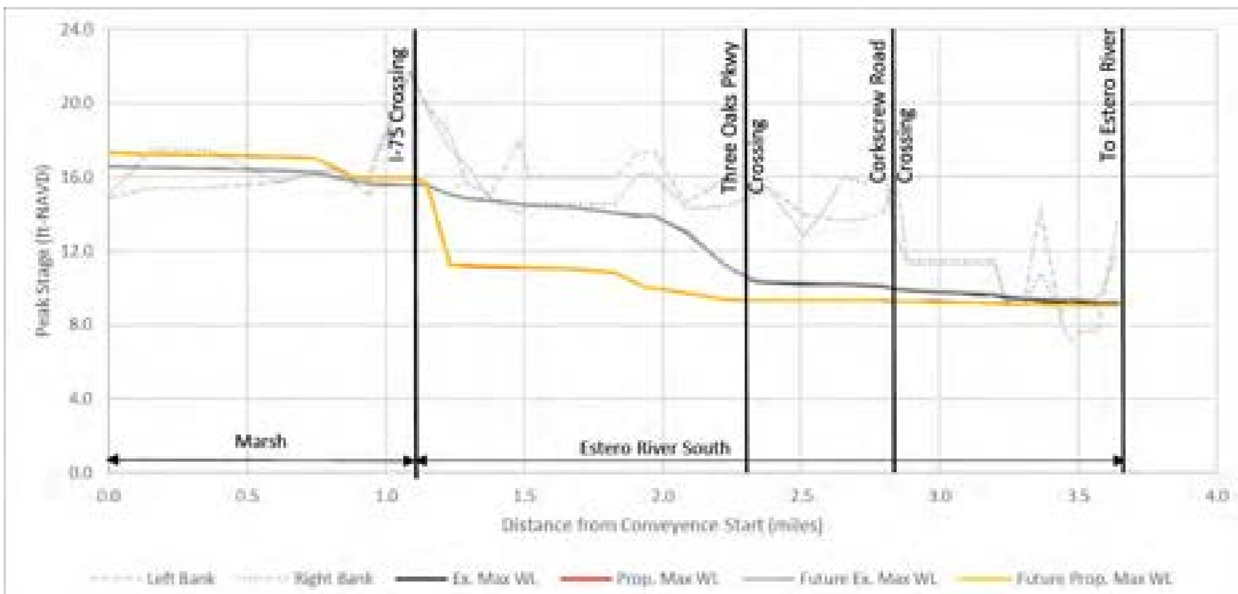


Figure 17. Peak stages during the 100 yr Design Storm within Estero River South Branch

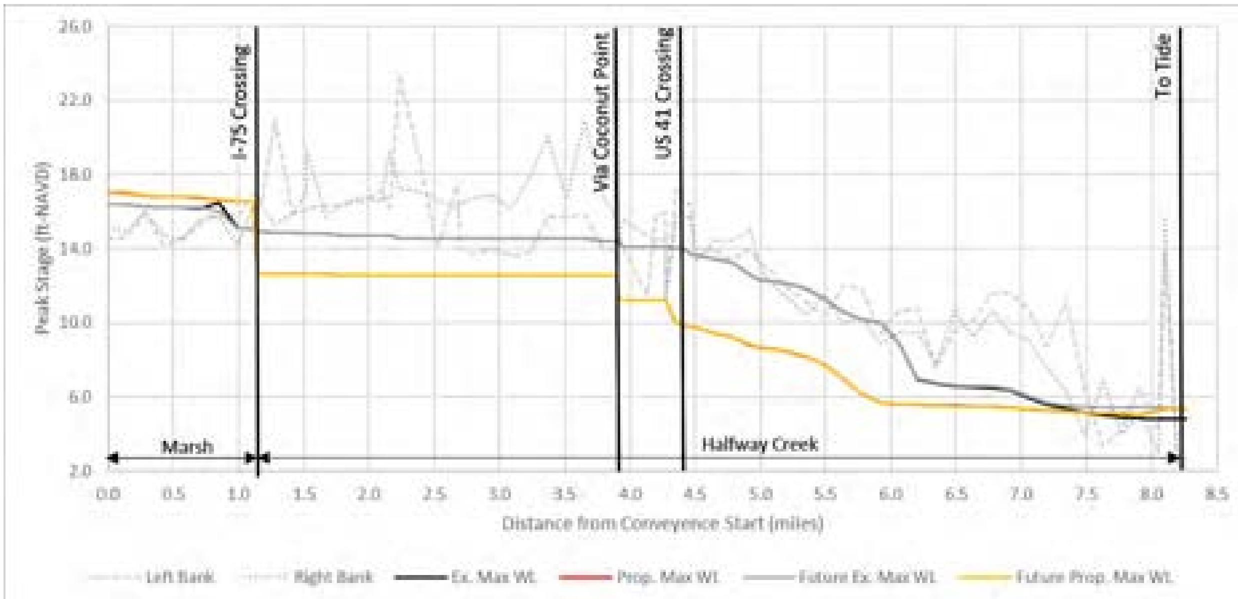


Figure 18. Peak stages during the 100 yr Design Storm within Halfway Creek

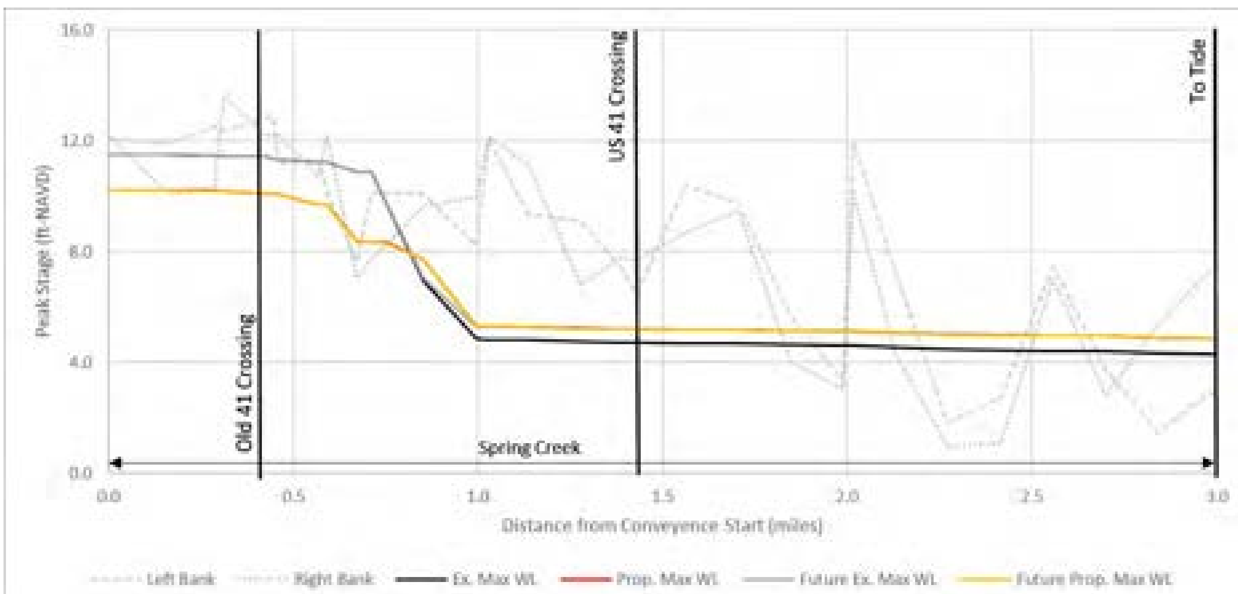


Figure 19. Peak stages during the 100 yr Design Storm within Spring Creek

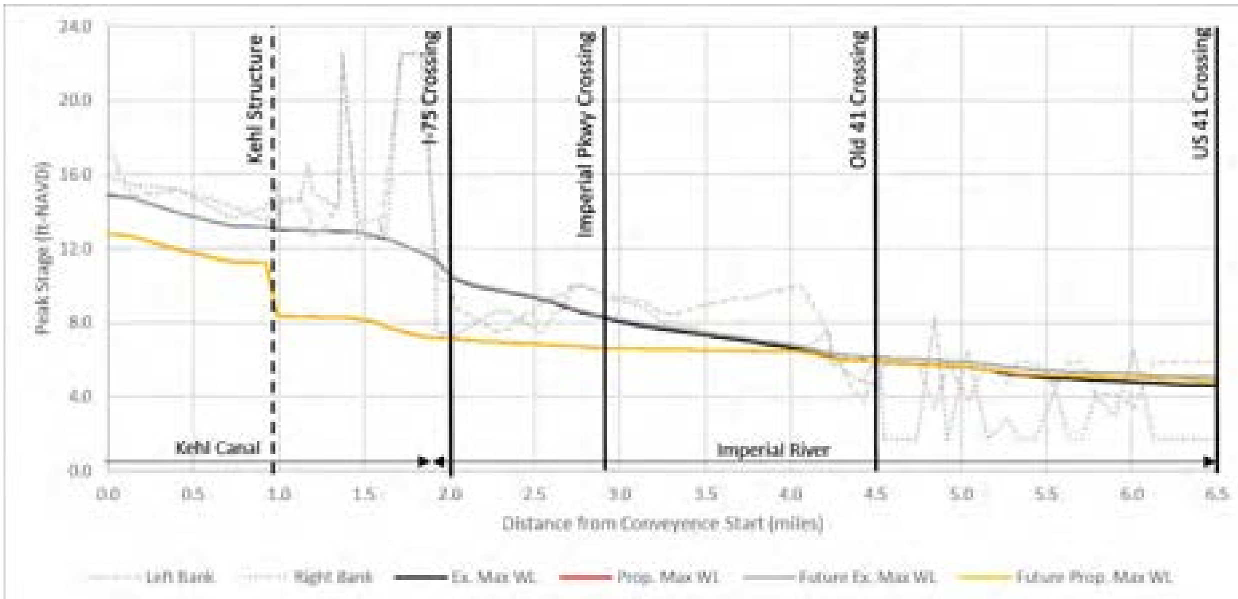


Figure 20. Peak stages during the 100 yr Design Storm within Kehl Canal and the Imperial River

Proposed 1.4 Future Conditions

The proposed conditions for the 1.4 project are shown in comparison to the existing conditions in Figure 21 through Figure 24, below. Increased stages as a result of increased runoff from the impervious surfaces are seen in the South Ft Myers and Whiskey Creek region for the 2040 projection. However, the proposed project conditions show that the future conditions with project will provide peak stage reduction relief for upstream impacted areas. For example, in the FSW Canal upstream of the weir (Figure 24), the largest increase in peak stages is about 4 inches. Despite the increase in both the existing and proposed conditions, the future conditions with project will still be much lower upstream of the weir than without project. Ten Mile Canal shows only minimal impact in peak stages (Figure 21) to both proposed and existing conditions.

L Canal shows an increase in peak stages upstream of the Whiskey Creek control structure (Figure 22). Peak stages in both the future without and future with project increase almost a foot above 2017 conditions and for about a mile upstream of the Whiskey Creek control structure. Gate operations at this structure were unknown and were simulated as closed for these 100 yr Design Storm simulations. Opening gates at this structure may alleviate some increase.

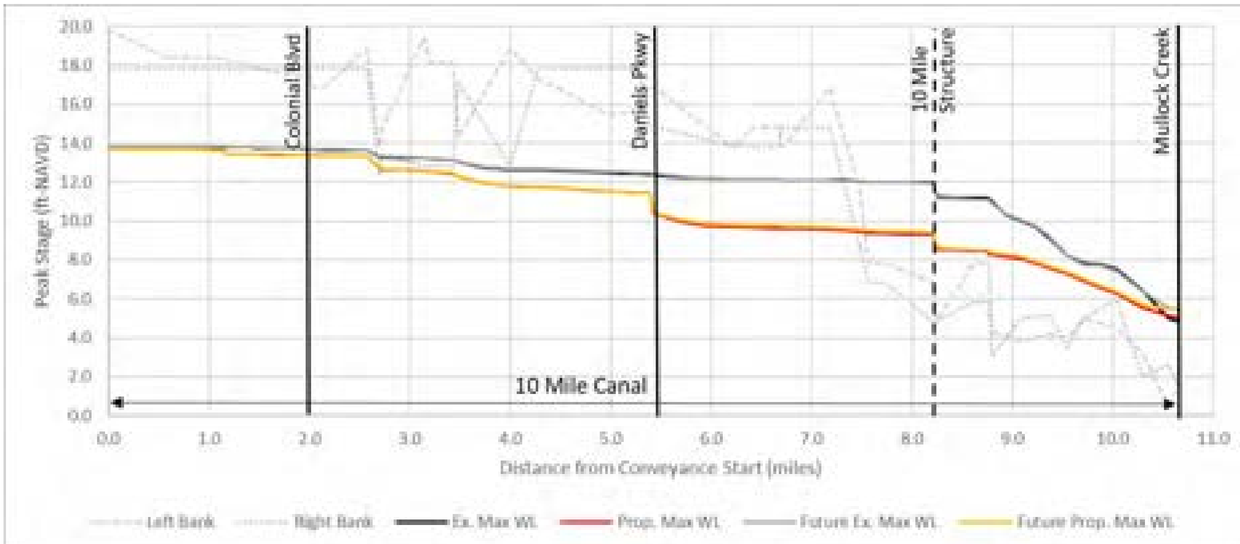


Figure 21. Peak stages during the 100 yr Design Storm within Ten Mile Canal

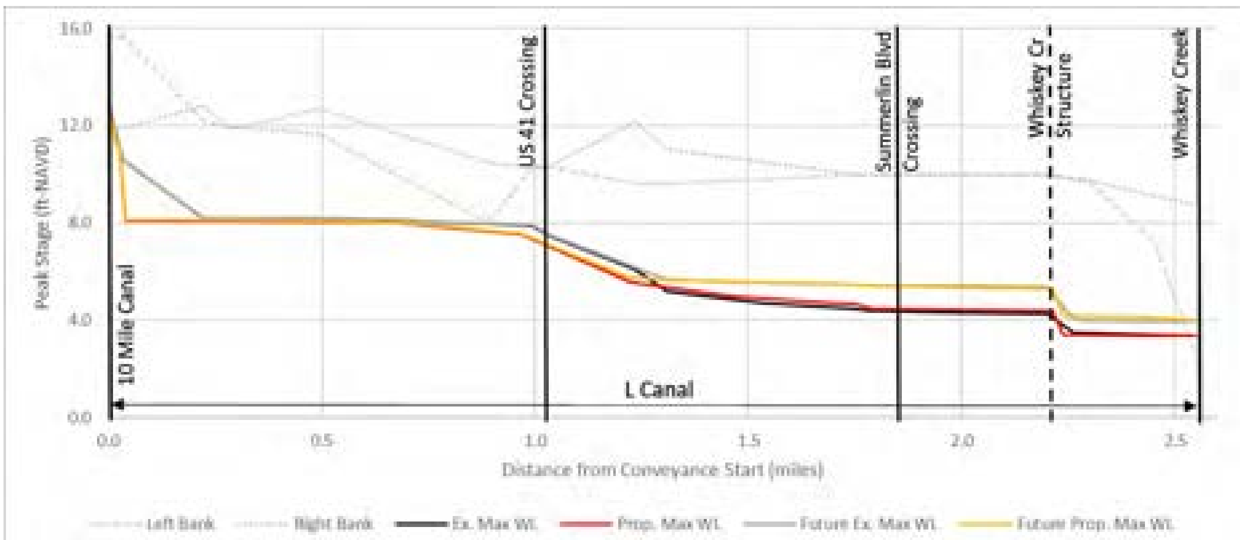


Figure 22. Peak stages during the 100 yr Design Storm within L Canal

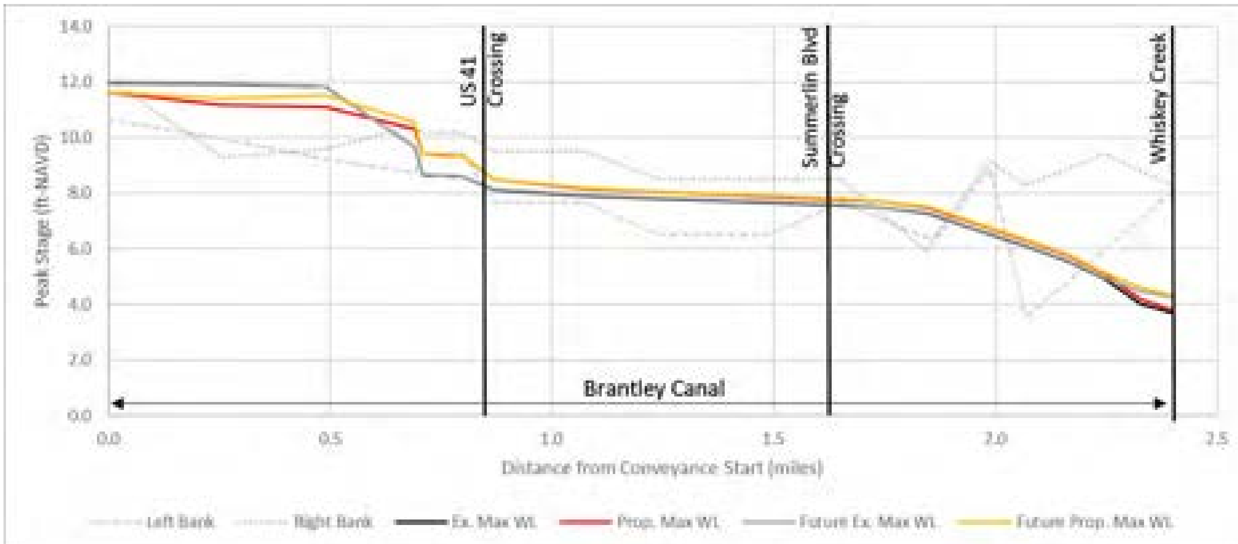


Figure 23. Peak stages during the 100 yr Design Storm within Brantley Canal

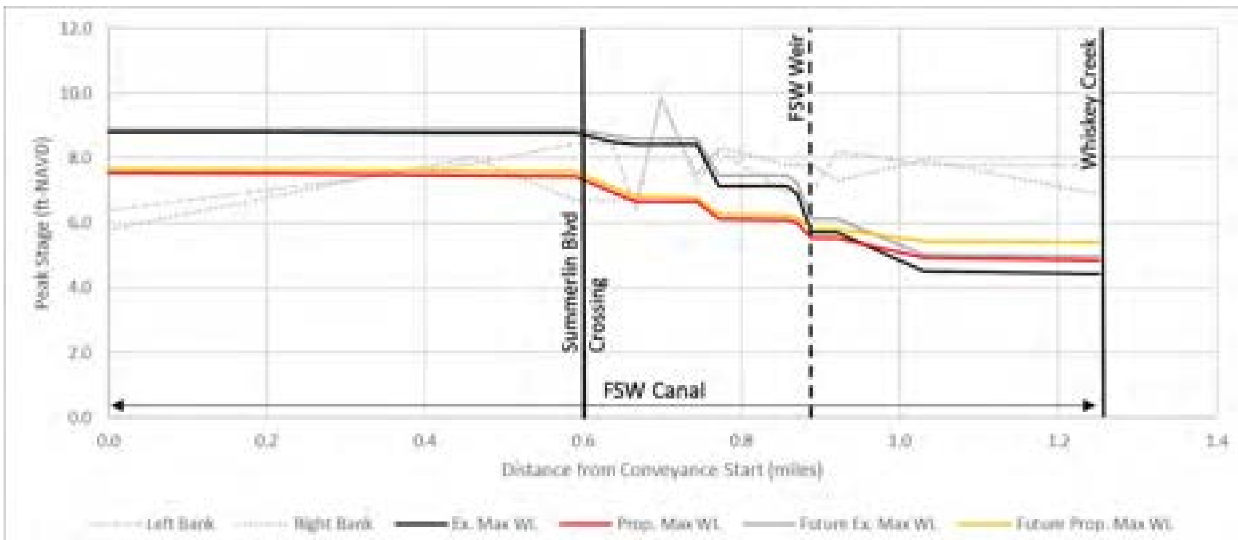


Figure 24. Peak stages during the 100 yr Design Storm within FSW Canal

5. CONCLUSIONS

The Southern Lee County Flood Mitigation existing and proposed conditions were evaluated under future conditions given the expected growth in Lee County for the year 2040. A rise in sea levels of 0.64 feet were also applied to the tidal boundaries as projected by the NOAA Intermediate projection. While some rise in peak stages during the 100 yr Design Storm event was shown for the future conditions, the impacts were minor for this short-term, 23 year projection. In addition, the effects of the projects in the proposed conditions showed that a future conditions with the projects will likely help alleviate any in peak stages impacts to the areas.

6. REFERENCES

Huber, Mark, White, Kate. Sea Level Change Curve Calculator (2017.55) User Manual. USACE Responses to Climate Change Program. July 2017 (Link: http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html)

NOAA Center for Operational Oceanographic Products and Services. (n.d.) Sea level trends. (Link: https://tidesandcurrents.noaa.gov/sltrends/) Accessed November 18, 2019.

Sweet, W.V., Kopp, R.E., Weaver, C.P., Obeysekera, T., Horton, R.M., Thieler, E.R., and Zervas, C. (2017). Global and Regional Sea Level Rise Scenarios for the United States. NOAA Tech. Rep. NOS CO-OPS 083. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD. 75pp. (Link: https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

7. APPENDIX

To get a snapshot of how the peak stages during the Irma event would be impacted by future conditions, the Continuous Simulation was also run for each of the existing and proposed conditions under both current (2017) and future conditions (2040). The following simulations were run for the continuous simulation:

2017 Conditions:

- Existing Conditions
- Proposed 1.1 Project Conditions
- Proposed 1.3 Project Conditions
- Proposed 1.4 Project Conditions

2040 Conditions:

- Existing Conditions
- Proposed 1.1 Project Conditions
- Proposed 1.3 Project Conditions
- Proposed 1.4 Project Conditions

Proposed 1.1 Future Conditions – Irma

This section provides the peak stages during the modeled Irma event for existing and proposed conditions with the proposed 1.1 projects. The current (2017) and future (2040) conditions are shown in the same graph for comparison.

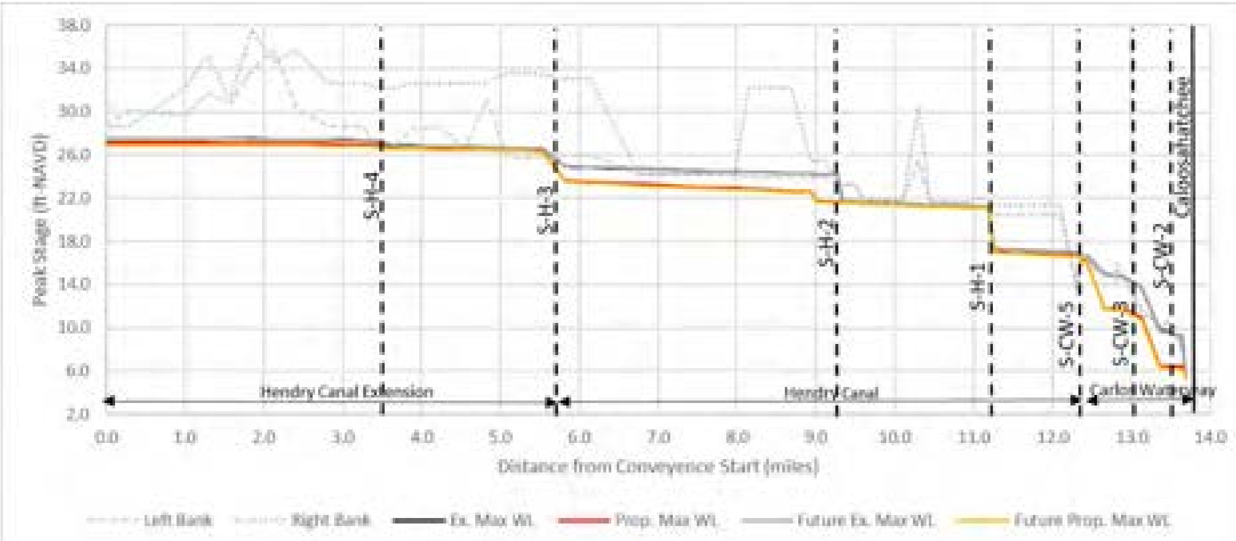


Figure 25. Peak stages during Irma within Hendry Canal and Carlos Waterway

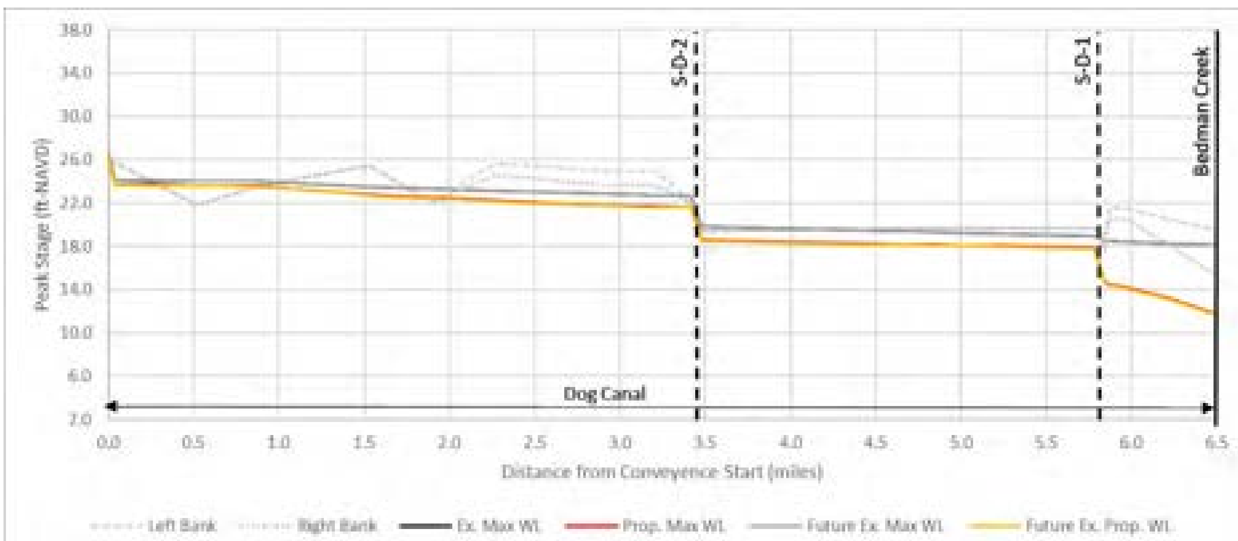


Figure 26. Peak stages during Irma within Dog Canal

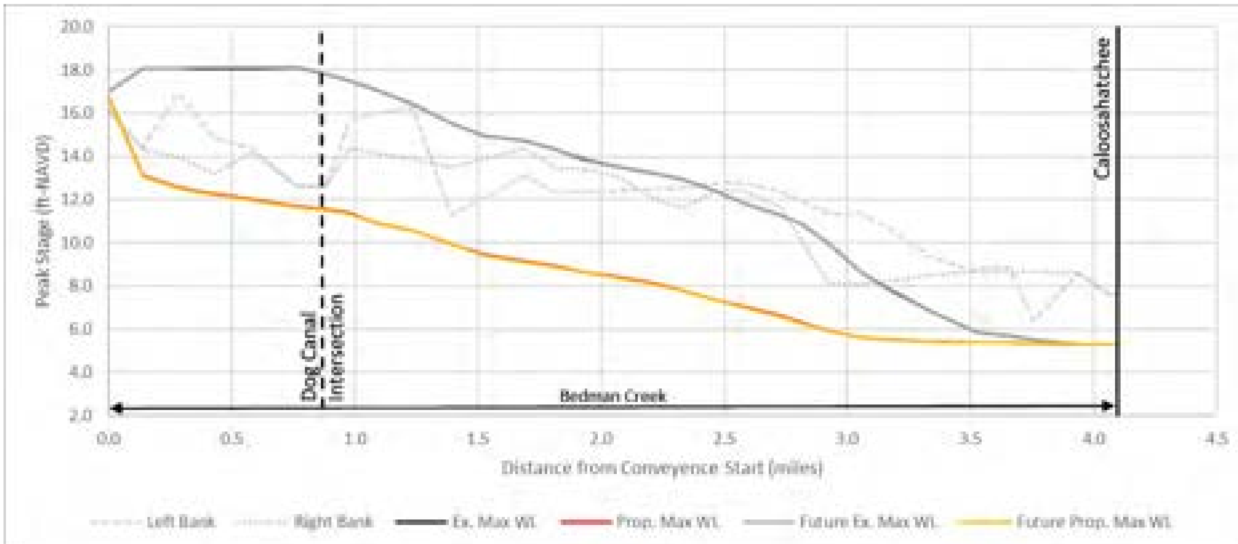


Figure 27. Peak stages during Irma within Bedman Creek

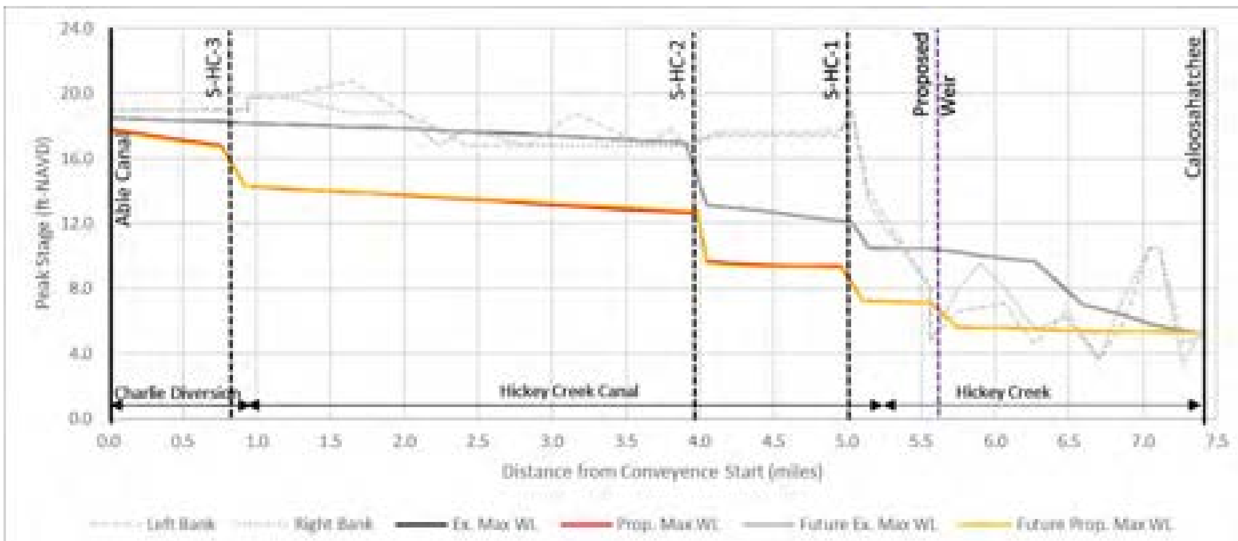


Figure 28. Peak stages during Irma within Hickey Creek

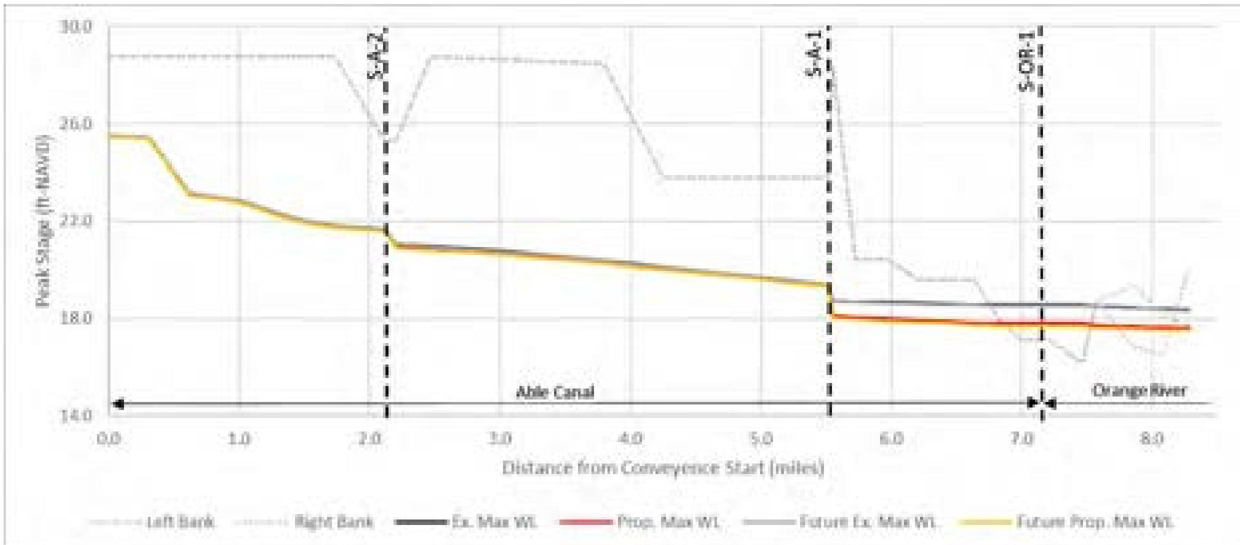


Figure 29. Peak stages during Irma within Able Canal

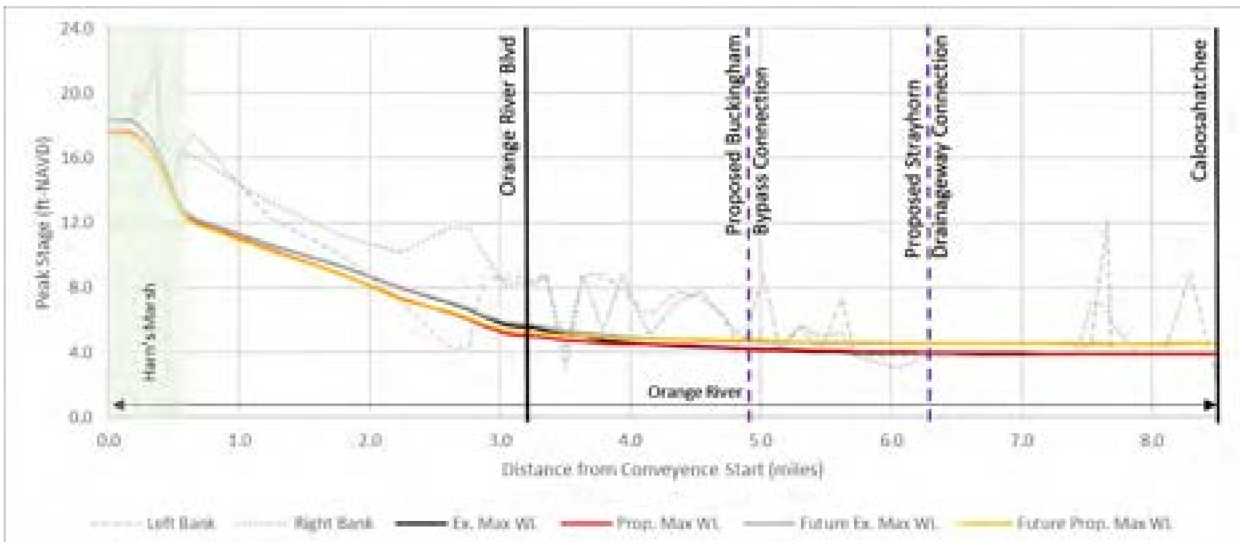


Figure 30. Peak stages during Irma within Orange River

Proposed 1.3 Future Conditions – Irma

This section provides the peak stages during the modeled Irma event for existing and proposed conditions with the proposed 1.3 projects. The current (2017) and future (2040) conditions are shown in the same graph for comparison.

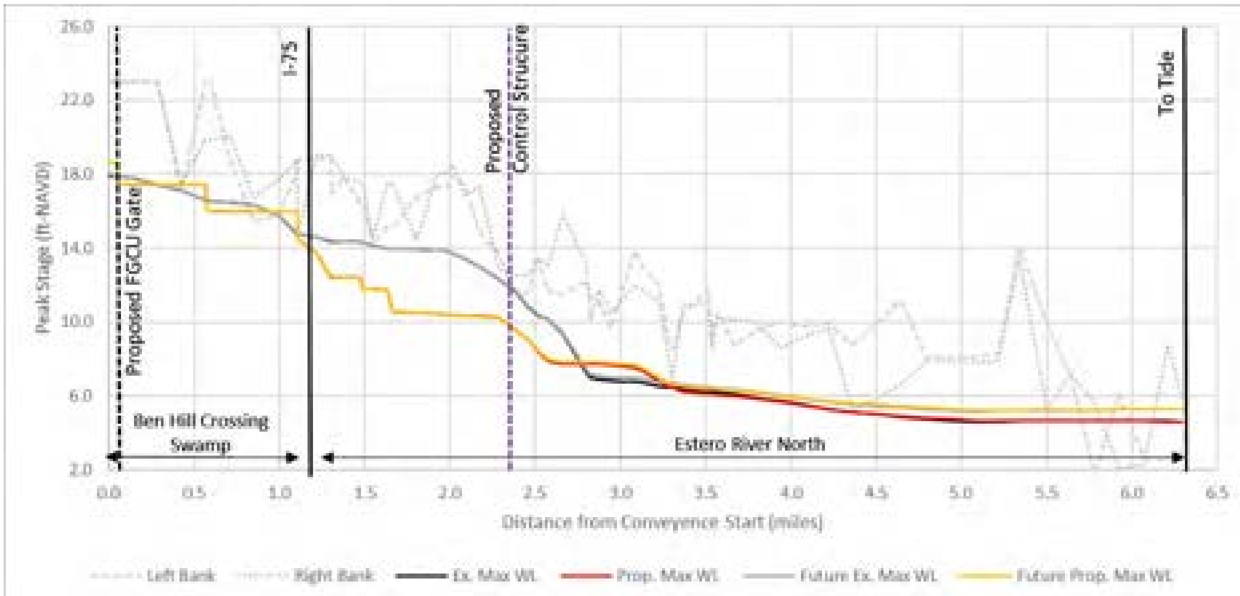


Figure 31. Peak stages during Irma within Estero River North Branch

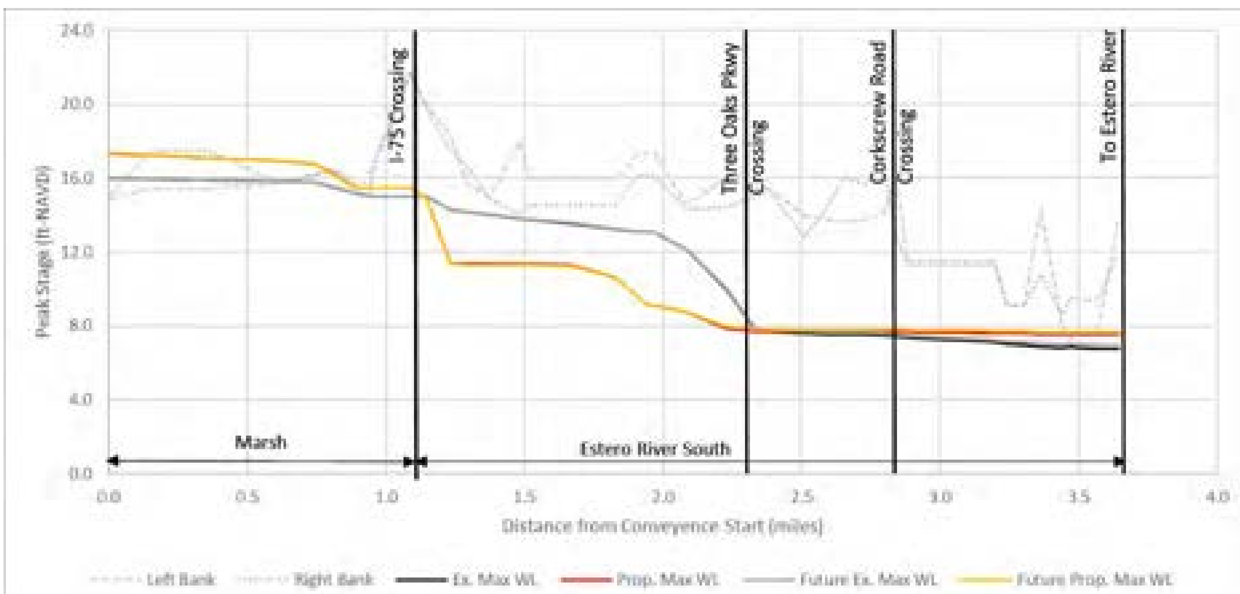


Figure 32. Peak stages during Irma within Estero River South Branch

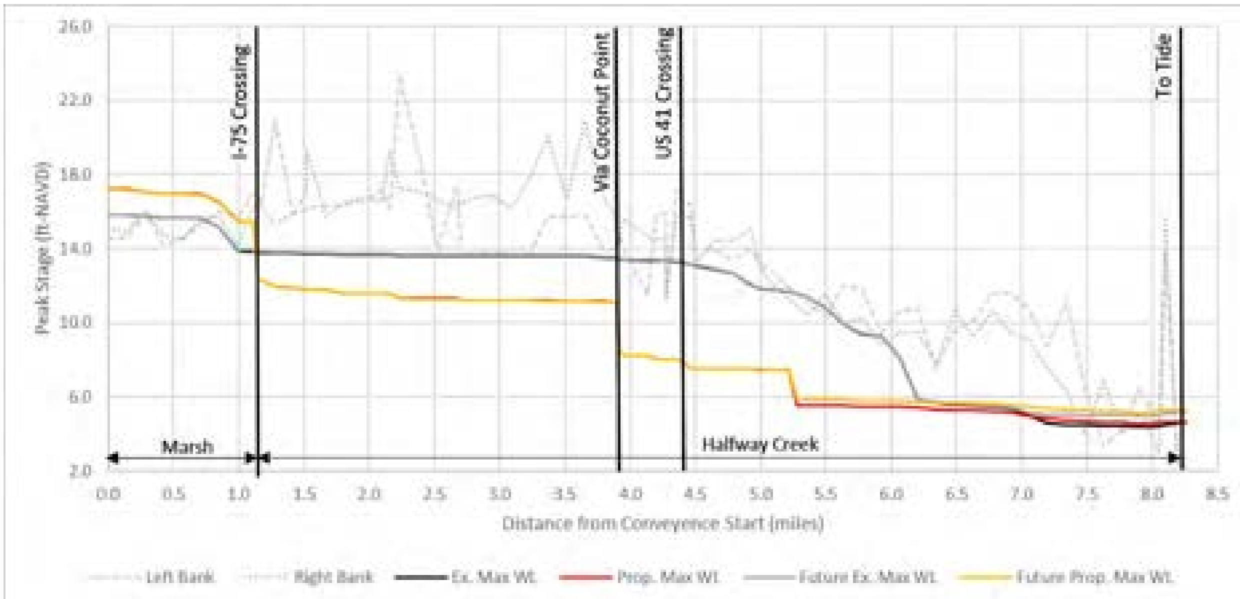


Figure 33. Peak stages during Irma within Halfway Creek

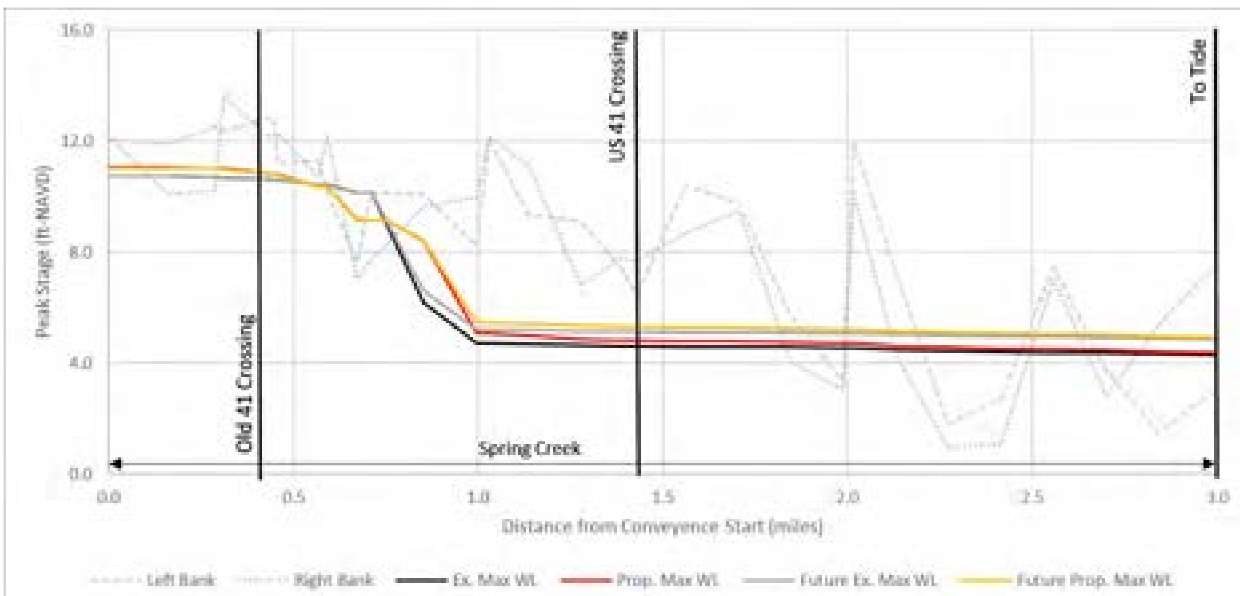


Figure 34. Peak stages during Irma within Spring Creek

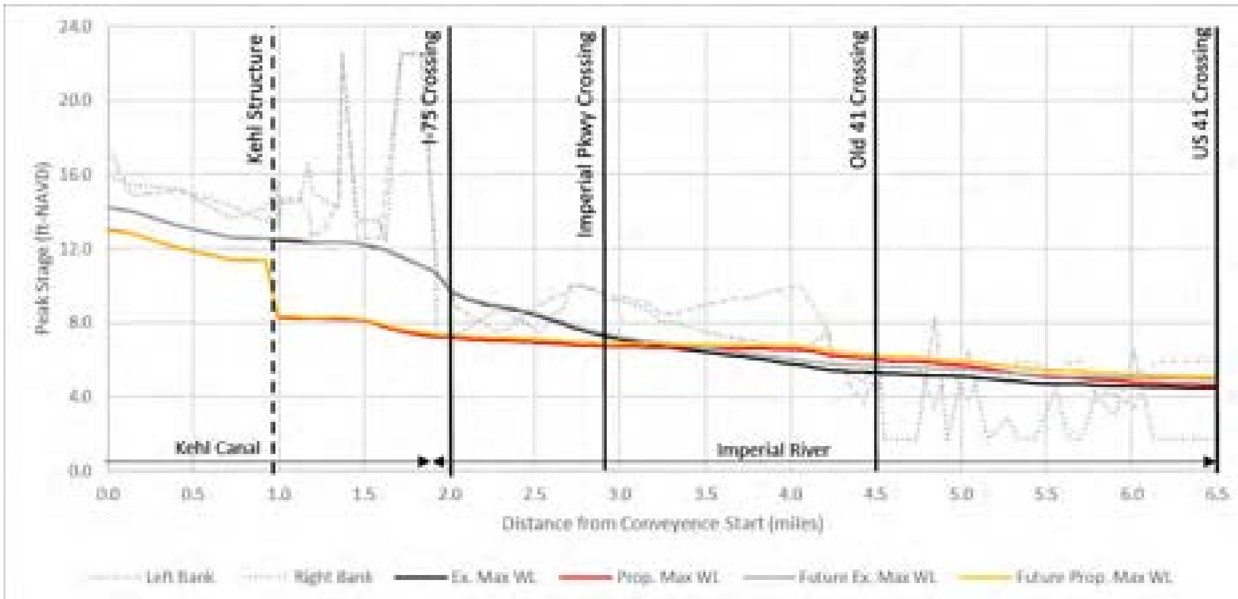


Figure 35. Peak stages during Irma within Kehl Canal and the Imperial River

Proposed 1.4 Future Conditions – Irma

This section provides the peak stages during the modeled Irma event for existing and proposed conditions with the proposed 1.4 projects. The current (2017) and future (2040) conditions are shown in the same graph for comparison.

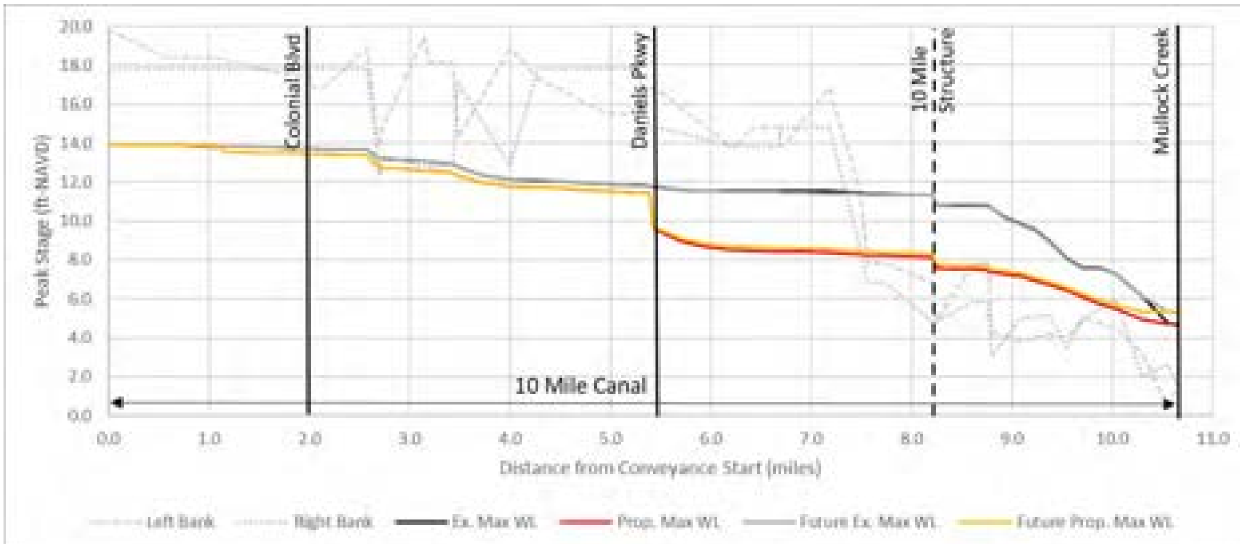


Figure 36. Peak stages during Irma within Ten Mile Canal

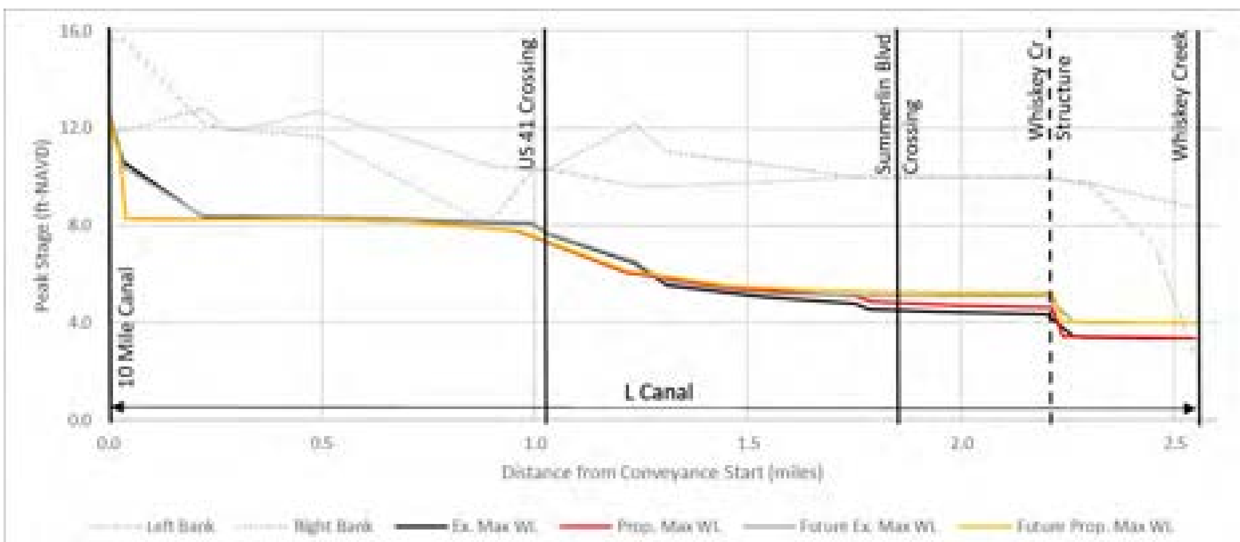


Figure 37. Peak stages during Irma within L Canal

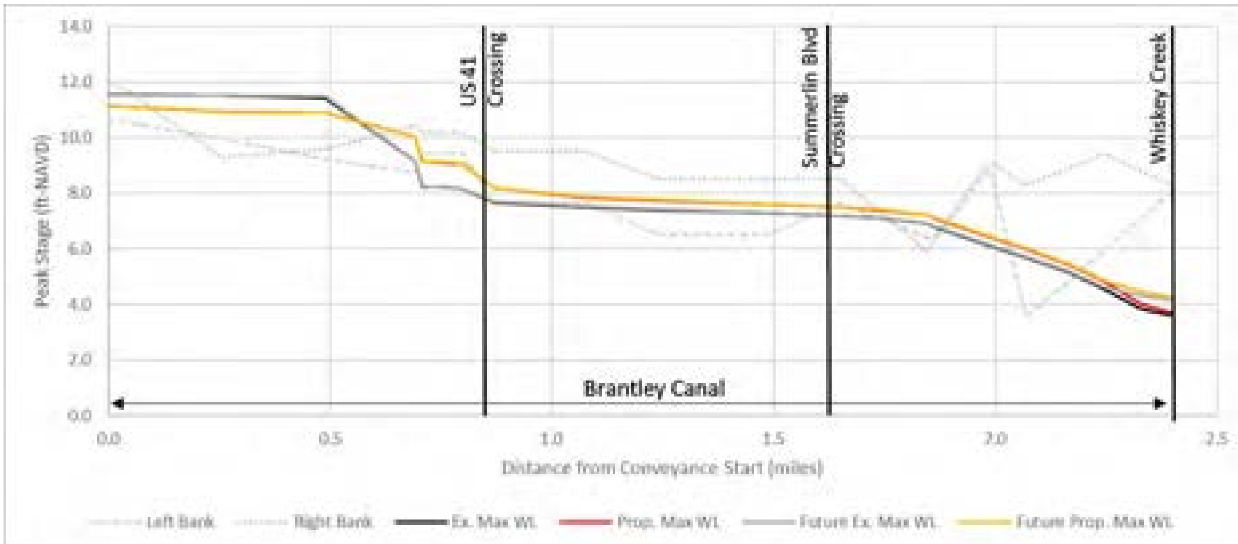


Figure 38. Peak stages during Irma within Brantley Canal

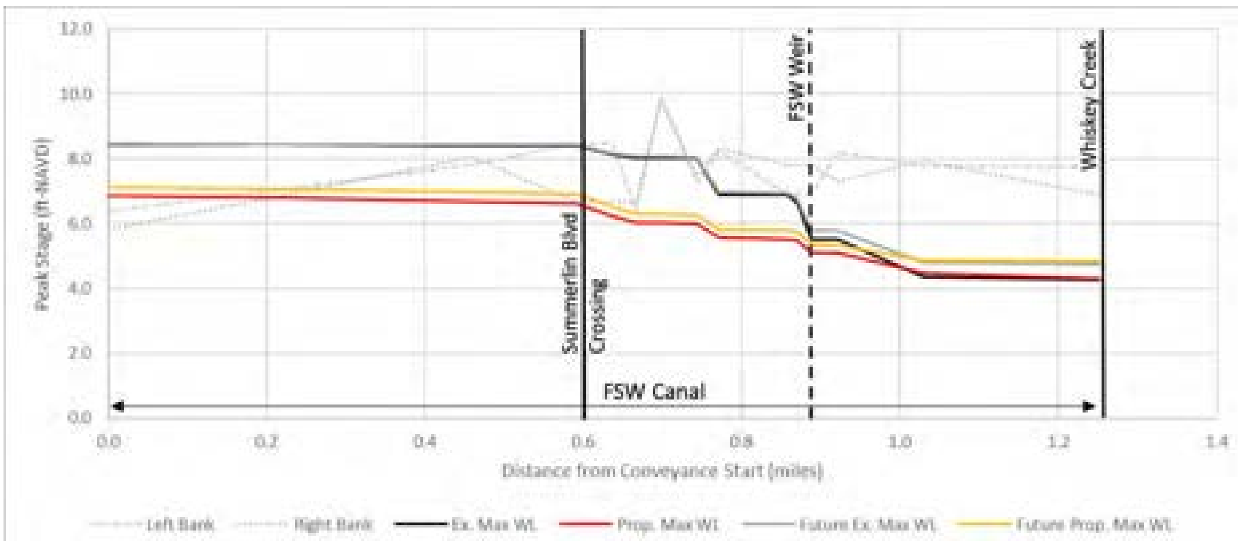


Figure 39. Peak stages during Irma within FSW Canal

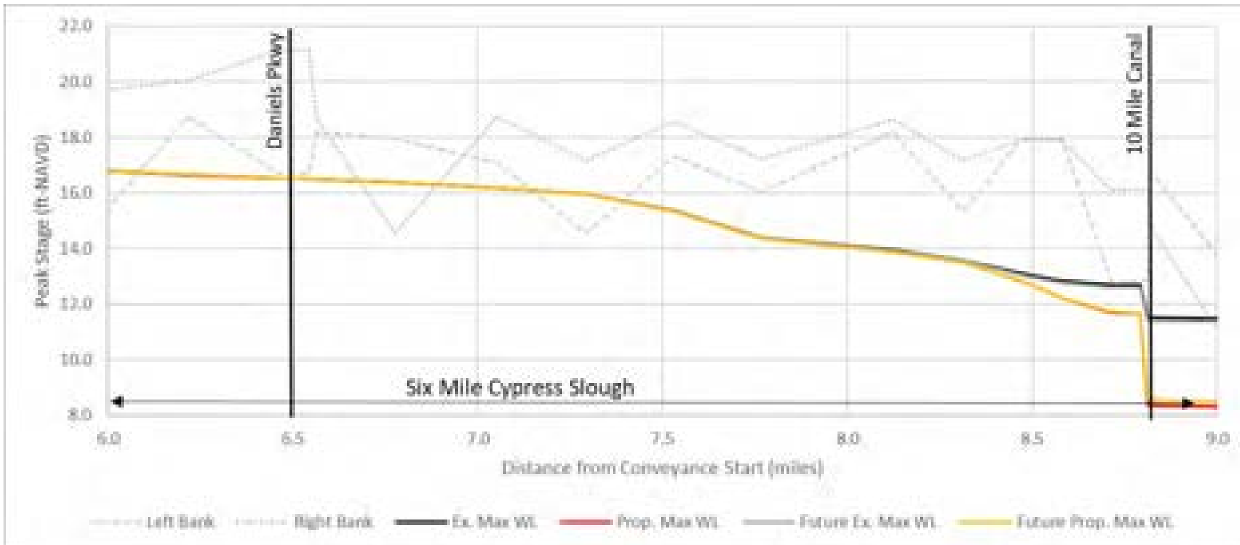


Figure 40. Peak stages during Irma within Six Mile Cypress Slough

3.4 BASIN STORAGE AND ALLOWABLE DISCHARGE REPORT

BACKGROUND

Land use changes in Lee County, as a result of development, may impact the hydrology of the region by decreasing the available ground surface over which water can infiltrate and by decreasing the time it takes for water to reach the discharge point in a watershed. Therefore, it is important to establish maximum discharge coming from each watershed during extreme rainfall events, such that standards for future development account for discharge beyond this rate.

SUB-WATERSHEDS

The MIKE SHE/11 model that was used to develop the SLCFMP uses a physics-based approach for calculating channel flow, overland flow, and flow through the groundwater. Therefore, the model does not use the basin-based approach that many other modeling tools utilize to summarize flows and levels at pre-determined locations. Water movement over the land surface, as well as subsurface flows, is calculated at each cell for each timestep. Therefore, water is free to cross over watershed divides, as long as the topography and water surface elevation supports that movement. In this regard, the traditional definition of basins was not followed in the model, which instead allowed topography to largely control runoff, with the exception of user-defined boundaries such as major roads, berms, or levees that are known impediments to sheet flow.

The SFWMD sub-basin map, the Lee County basin map, and the Lehigh Acres basin map were combined and modified to improve the representation of the regional basins (for the purposes of this study, the delineated basins will be herein referred to as sub-watersheds to avoid confusion with the basin modeling approach).

The sub-watersheds were then fine-tuned in specific areas to 1) split the sub-watershed to include major boundaries such as roads, 2) refine the boundary to match existing roads and watershed divides that may not have existed when the original maps were developed, and 3) to develop a naming system useful for this study.

In total, 98 sub-watersheds were identified. The final sub-watershed map is shown in **Figure 1**, below.

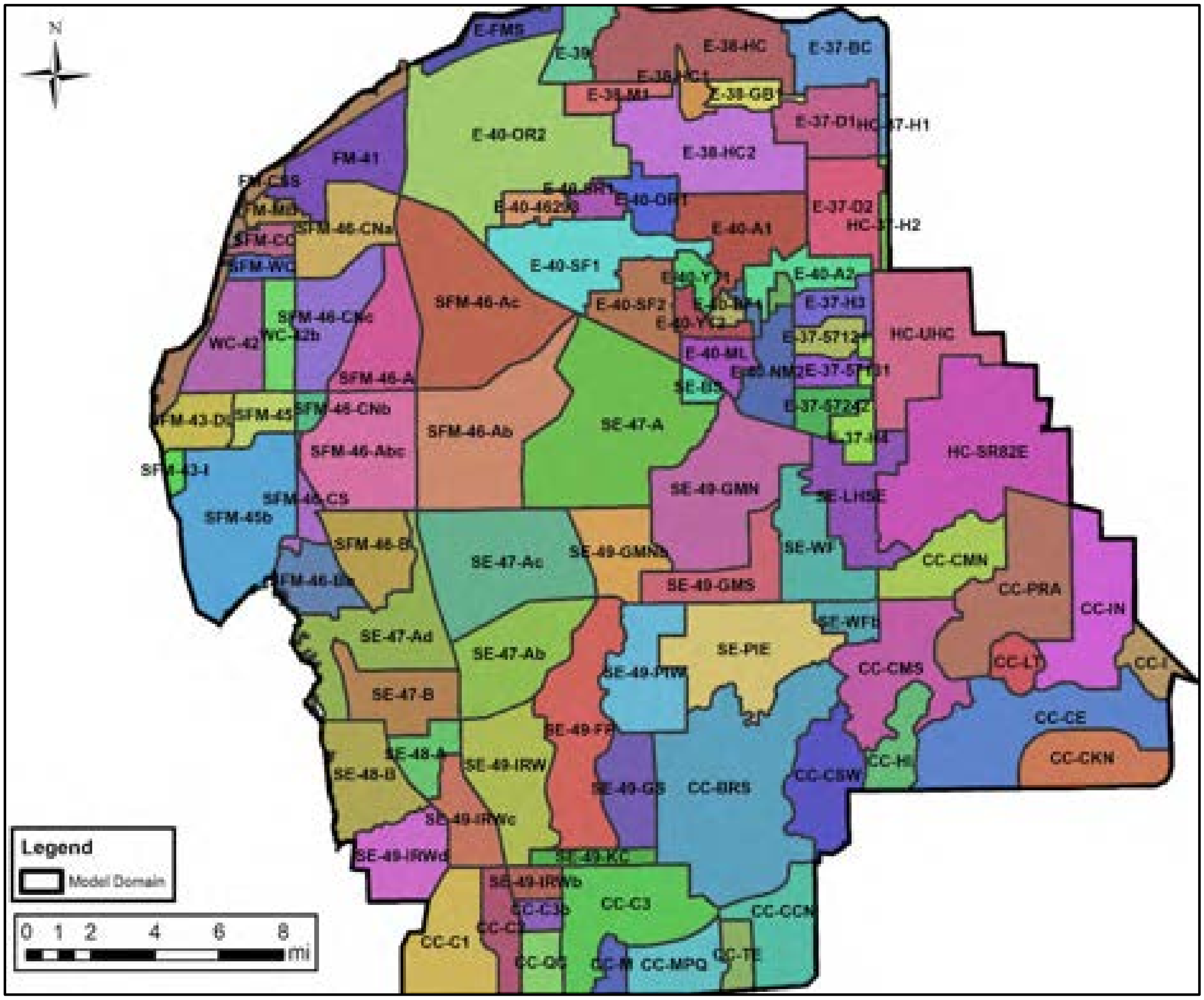


Figure 1. Sub-Watersheds for Study

MAXIMUM DISCHARGE

The Lee County Surface Water Management Master Plan (LCSWMMP) and Volume IV of the District's Permit Information Manual were reviewed to determine the appropriate methodology for determining maximum allowable discharge for the SLCFMP. The LCSWMMP produced basin allowable discharges using the results from the 25-year 72-hour design storm, simulated for each basin with a HEC-1 interconnected hydrologic and hydraulic model.

Following the previous methodology, the 25-year, 72-hour design storm event was modeled for the existing and future conditions using the MIKE SHE/MIKE 11 Southern Lee County flood model, developed as part of the SLCFMP. Using the sub-watershed map, shown in **Figure 1,** hydrographs were extracted from the model at each flow point that crosses the sub-watershed boundary. The following sections provide details on the process and results for the entire domain, broken into the focus areas of East Lee County, South Fort Myers/Whiskey Creek Area, and Southeast Lee County.

East Lee County

The sub-watersheds within eastern Lee County that were evaluated for this study are shown in **Figure 2**. Outflow points, shown as green dots, were selected along sub-watershed boundaries, using structure locations as a guide (i.e. culvert outfall points, etc.). The points were then used to extract flow hydrographs from the model for each location and to determine the total inflows and outflows for each sub-watershed.

The total flow volume (acre-feet) and the peak discharge in cubic feet per second (cfs) was extracted from the results and summed for all the inflow and outflows for each sub-watershed, as summarized in **Table 1**. The change in the peak stages, or the outflow minus the inflow, is the gross contribution of inflow to the channels from overland and subsurface within the sub-watershed. For example, E-40-NM2 has no inflows from other sub-watersheds, and therefore the peak discharge (322 cfs) leaving that sub-watershed is originating within the sub-watershed via runoff and/or exchange with the groundwater. Conversely, E-40-NM1, which discharges 327 cfs at the peak, receives a peak inflow of 299 cfs from E-40-NM2, therefore this sub-watershed is only contributing 28 cfs to the total peak outflow leaving that sub-watershed.

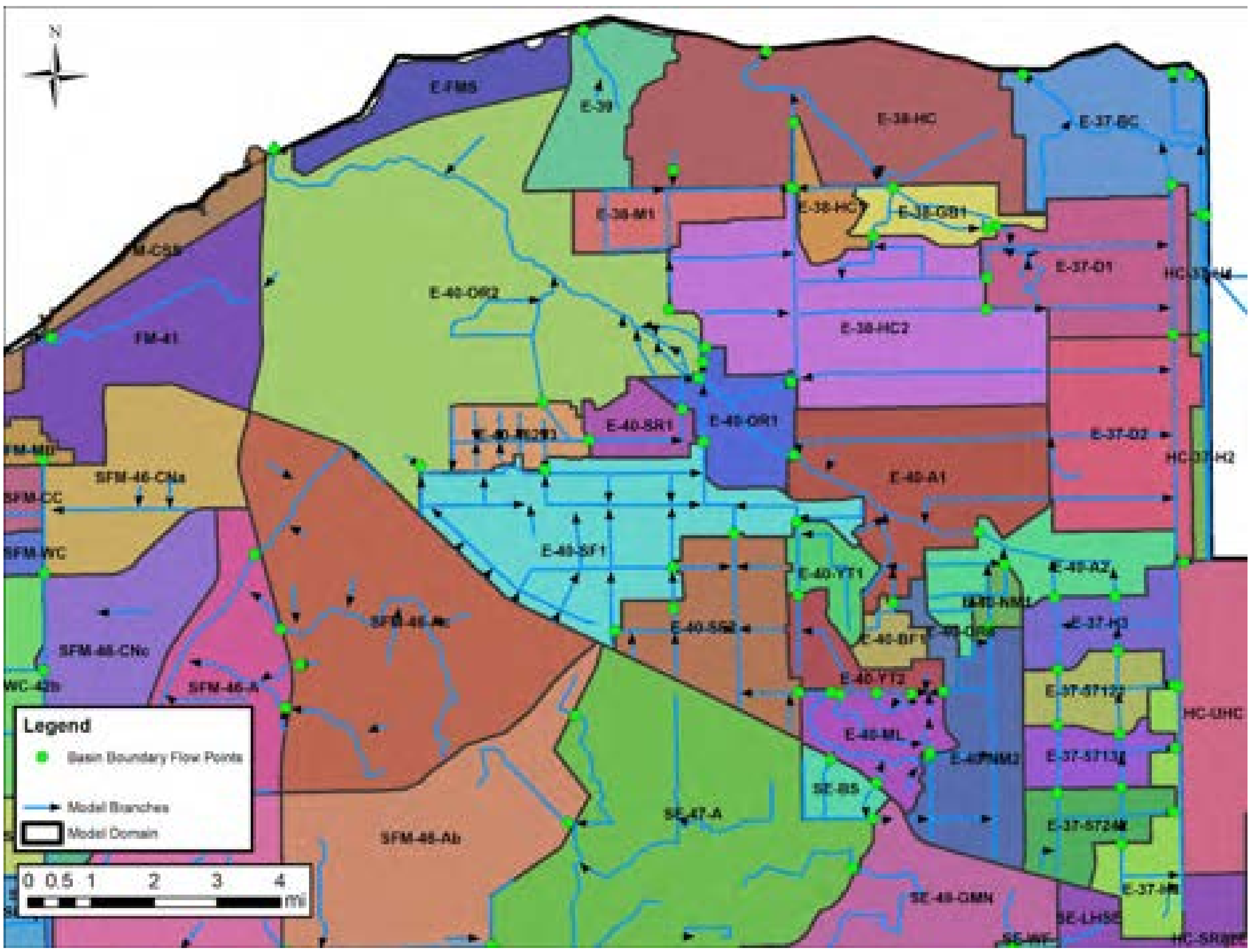


Figure 2. Sub-Watersheds and outflow points for Eastern Lee County

Table 1. Summary of Inflows and Outflows for Eastern Lee County

	Inflows		Outflows		
Name	Total Volume (ac-ft)	Peak Discharge (cfs)	Total Volume (ac-ft)	Peak Discharge (cfs)	Peak CFS Change (Out - In)
E-37-57121	91.2	22.1	650.3	178.1	156.1
E-37-57131	297.6	-108.0	1435.8	134.0	242.1
E-37-57242	0.0	0.0	1747.7	84.3	84.3
E-37-BC	22004.9	1751.8	44302.8	2603.9	852.0
E-37-D1	3334.3	555.6	4637.1	744.5	188.9
E-37-D2	0.0	0.0	3181.3	560.4	560.4
E-37-H3	7302.2	727.1	9604.1	1005.1	278.0
E-37-H4	2794.7	304.3	6651.9	548.9	244.7
E-38-GB1	0.0	0.0	623.8	172.1	172.1
E-38-HC	20633.9	1660.9	23559.5	2041.9	381.0
E-38-HC1	19741.8	1507.8	20097.2	1524.6	16.8
E-38-HC2	12203.7	900.1	17833.4	1238.4	338.3
E-38-M1	0.0	0.0	2076.0	299.7	299.7
E-39	0.0	0.0	773.1	240.6	240.6
E-40-46293	-690.1	199.9	1679.3	301.4	101.5
E-40-A1	6216.4	956.3	10066.1	1561.1	604.8
E-40-A2	4527.9	585.6	6054.3	897.9	312.3
E-40-BF1	0.0	0.0	162.1	58.4	58.4
E-40-ML	884.5	29.3	2225.8	230.0	200.6
E-40-NM1	3489.7	298.7	3748.7	326.6	27.9
E-40-NM2	0.0	0.0	3488.3	322.3	322.3
E-40-OR1	22271.3	2968.6	23564.2	3065.3	96.7
E-40-OR2	12957.5	2417.4	34392.8	2679.5	262.1
E-40-OR6	0.0	0.0	0.0	0.0	0.0
E-40-SF1	6878.4	760.3	11515.0	1607.4	847.2
E-40-SF2	299.2	74.9	3102.6	272.8	197.8
E-40-SR1	184.1	120.2	0.0	0.0	-120.2
E-40-YT1	3108.4	329.1	3663.0	451.1	122.0
E-40-YT2	1921.3	153.0	3029.3	310.7	157.7
E-FMS	0.0	0.0	0.0	0.0	0.0
HC-37-H1	11791.4	870.6	17367.8	1007.3	136.7
HC-37-H2	8824.9	746.1	11791.4	870.6	124.6
HC-SR82E	0.0	0.0	4236.6	775.5	775.5
HC-UHC	0.0	0.0	0.0	0.0	0.0

South Fort Myers/Whiskey Creek Area

The sub-watersheds within South Fort Myers and the Whiskey Creek area that were evaluated for this study are shown in **Figure 3**. Outflow points, shown as green dots, were selected along sub-watershed boundaries, using structure locations as a guide (i.e. culvert outfall points, etc.). The points were then used to extract flow hydrographs from the model for each location and to determine the total inflows and outflows for each sub-watershed.

The total flow volume (acre-feet) and the peak discharge (cfs) was extracted from the results and summed for all the inflow and outflows for each sub-watershed, as summarized in **Table 2**. The change in the peak stages, or the outflow minus the inflow, is the gross contribution of inflow to the channels from overland and subsurface within the sub-watershed.

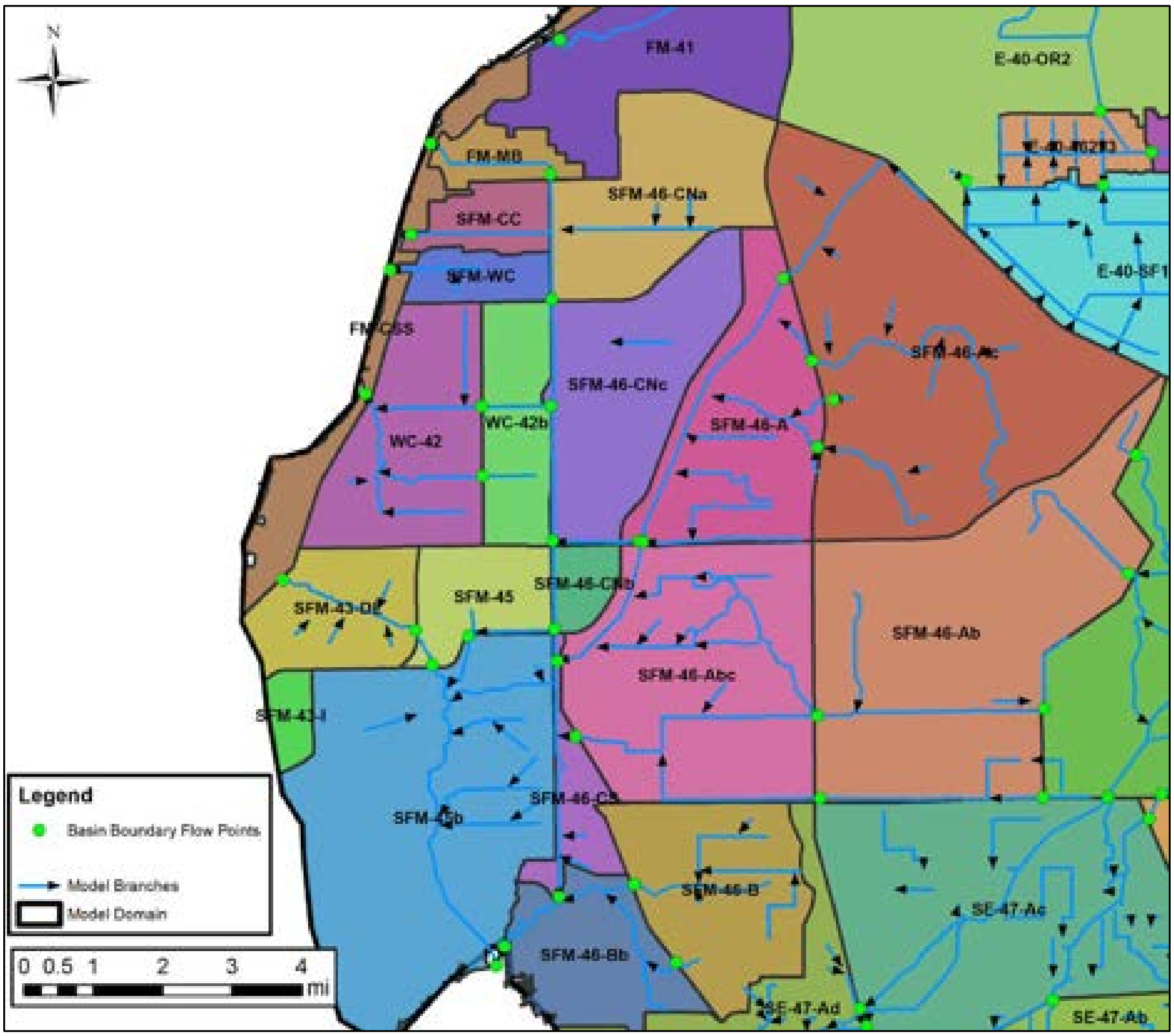


Figure 3. Sub-Watersheds and outflow points for South Ft. Myers/Whiskey Creek

Table 2. Summary of Inflows and Outflows for South Ft Myers/Whiskey Creek

	Inflows		Outflows		
Name	Total Volume (ac-ft)	Peak Discharge (cfs)	Total Volume (ac-ft)	Peak Discharge (cfs)	Peak CFS Change (Out - In)
FM-41	0.0	0.0	3914.5	268.8	268.8
FM-CSS	0.0	0.0	0.0	0.0	0.0
FM-MB	0.0	0.0	1008.6	114.6	114.6
SFM-43-DL	19.8	6.8	1359.3	653.7	646.9
SFM-43-I	0.0	0.0	0.0	0.0	0.0
SFM-45	1359.3	653.7	2597.9	987.9	334.3
SFM-45b	2597.9	987.9	86008.7	8874.0	7886.1
SFM-46-A	9860.8	1203.0	14466.4	1220.8	17.8
SFM-46-Ab	1742.9	55.2	5133.5	276.1	220.9
SFM-46-Abc	4637.7	325.9	7825.2	660.4	334.4
SFM-46-Ad	14466.4	1220.8	15531.3	1532.4	311.6
SFM-46-Ac	0.0	0.0	9860.8	1203.0	1203.0
SFM-46-B	0.0	0.0	3061.8	491.8	491.8
SFM-46-Bb	58871.4	2476.5	61231.9	2936.6	460.1
SFM-46-CNa	0.0	0.0	1378.6	269.1	269.1
SFM-46-CNb	36335.6	1013.7	37077.1	1007.5	-6.3
SFM-46-CNc	1378.6	269.1	37624.1	1108.1	839.0
SFM-46-CS	60433.6	3200.3	55809.6	1984.7	-1215.5
SFM-CC	0.0	0.0	567.3	69.8	69.8
SFM-WC	0.0	0.0	389.7	79.9	79.9
WC-42	2659.4	365.6	5587.9	966.2	600.6
WC-42b	1288.5	94.3	2659.4	365.6	271.3

Southeast Lee County

The sub-watersheds within Southeast Lee County that were evaluated for this study are shown in **Figure 4**. Outflow points, shown as green dots, were selected along sub-watershed boundaries, using structure locations as a guide (i.e. culvert outfall points, etc.). The points were then used to extract flow hydrographs from the model for each location and to determine the total inflows and outflows for each sub-watershed. For Southeast Lee County, there are several sub-watersheds that do not have M11 branches represented in the model, as flow in these areas is mostly dominated as overland flow or sheet flow, with the exception of minor road and farm ditches and swales. Discharges from these sub-watersheds will not be reported for this study. In addition, the shallow farm ditch discharging to sub-watershed CC-CMS caused some minor instabilities (which did not affect the rest of the model) and the results for this sub-watershed were therefore removed from this analysis. However, the full results are provided to the County for detailed review of this area.

The total flow volume (acre-feet) and the peak discharge (cfs) was extracted from the results and summed for all the inflow and outflows for each sub-watershed, as summarized in Table 3. The change in the peak stages, or the outflow minus the inflow, is the gross contribution of inflow to the channels from overland and subsurface within the sub-watershed. A negative contribution means that there is more flow entering the sub-watershed than leaving. There are several reasons the sub-watershed contribution would be negative:

1. Channelized Flow to Sheet Flow: If the sub-watershed is receiving flows from channels that end in that watershed, water from the channels will overflow into the Overland and become sheetflow which can then either infiltrate into the groundwater table, leave the water cycle via evapotranspiration, or continue on as sheetflow out of the sub-watershed. For example, sub-watersheds CC-CMN and CC-CMS receive water from upstream agricultural ditches that simply end into the Corkscrew Swamp area. This water is then processed as overland and groundwater flows.

2. Storage: If the sub-watershed shows greater inflow than outflow, some storage may be assumed for the area. For example, sub-watershed SE-49-FP receives flow from many channelized agricultural areas to the north and east, but only outfalls at Kehl Canal via a shallow slough. Other sub-watersheds that may present storage are SE-49-GS and SE-49-IRW.

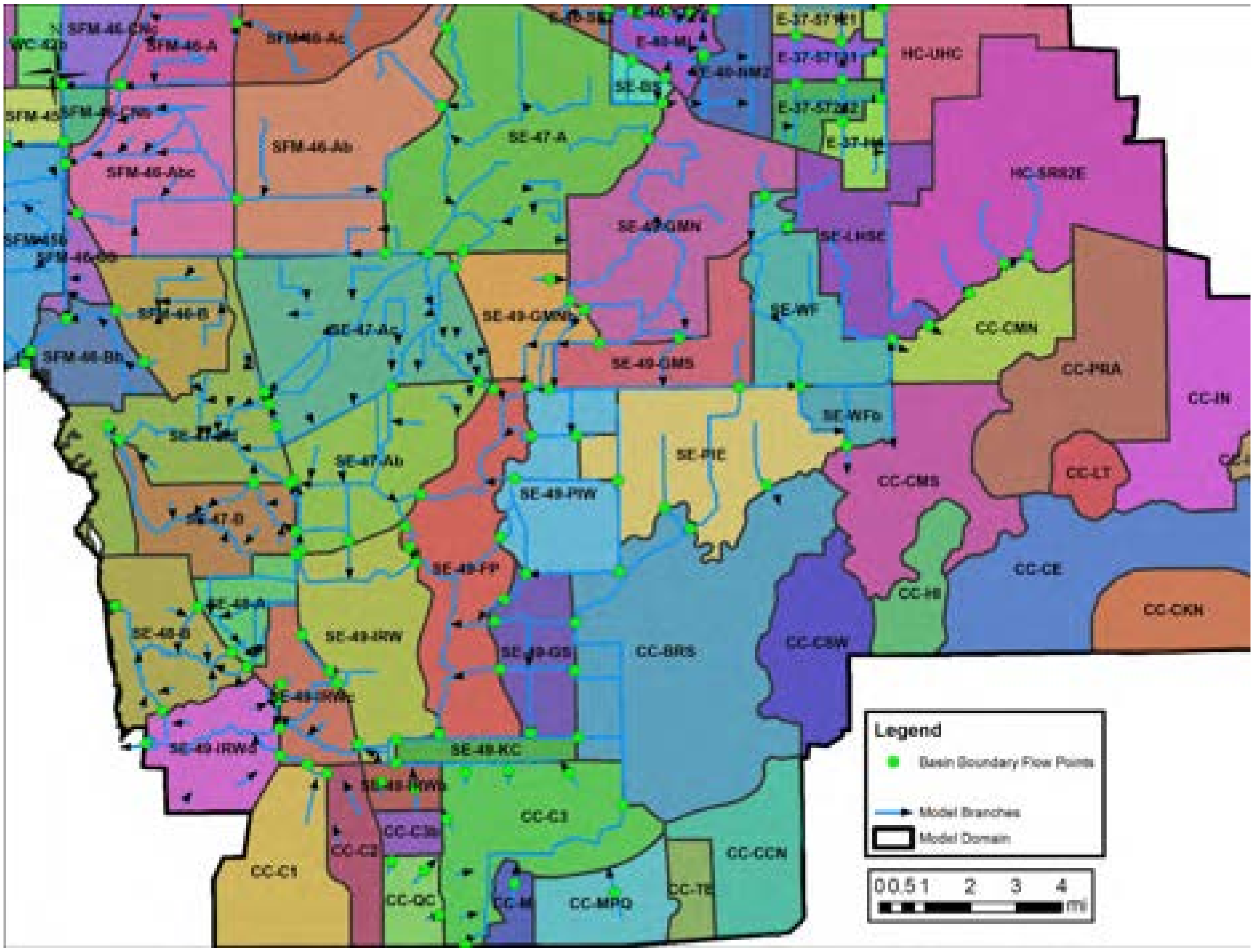


Figure 4. Sub-Watersheds and outflow points for South Ft. Myers/Whiskey Creek

Table 3. Summary of Inflows and Outflows for Southeastern Lee County

	Inflows		Outflows		
Name	Total Volume (ac-ft)	Peak Discharge (cfs)	Total Volume (ac-ft)	Peak Discharge (cfs)	Peak CFS Change (Out - In)
CC-BRS	5526.6	379.0	13312.5	370.9	-8.0
CC-C1	584.9	150.5	1548.6	342.8	192.3
CC-C2	0.0	0.0	584.9	150.5	150.5
CC-C3	10851.6	1481.2	19024.4	1651.1	169.9
CC-CMN	5469.3	1032.7	0.0	0.0	-1032.7
CC-M	0.0	0.0	697.2	355.4	355.4
CC-MPQ	0.0	0.0	8890.2	1026.4	1026.4
CC-QC	0.0	0.0	530.4	149.3	149.3
HC-SR82E	0.0	0.0	4236.6	775.5	775.5
SE-47-A	495.8	-49.8	5183.4	144.9	194.7
SE-47-Ab	17032.8	663.3	23464.4	1243.3	580.0
SE-47-Ac	3713.3	133.4	6740.0	797.4	664.0
SE-47-Ad	25776.4	2154.9	33717.0	3105.9	951.0
SE-47-B	6978.4	325.2	10832.1	981.1	655.8
SE-48-A	-2219.6	-51.2	2870.9	506.2	557.5
SE-48-B	2796.3	608.2	125700.3	3515.9	2907.7
SE-49-FP	18244.5	1211.5	29311.4	999.8	-211.6
SE-49-GMN	-138.4	86.5	4143.7	343.9	257.4
SE-49-GMNb	7953.5	698.1	9327.8	767.6	69.5
SE-49-GMS	815.5	41.0	5358.4	392.0	351.0
SE-49-GS	14986.7	556.7	11164.2	420.2	-136.5
SE-49-IRW	34441.0	1656.5	13204.3	729.0	-927.4
SE-49-IRWb	1230.2	355.1	133.9	46.1	-308.9
SE-49-IRWc	6524.7	811.8	31625.7	2014.7	1202.9
SE-49-IRWd	31625.7	2014.7	33873.4	2584.3	569.6
SE-49-KC	18604.7	1216.9	24291.5	1457.6	240.8
SE-49-PIW	3185.0	206.6	1369.8	217.6	11.0
SE-BS	84.3	-5.7	959.8	22.0	27.8
SE-LHSE	0.0	0.0	2688.1	309.2	309.2
SE-PIE	1723.5	82.9	7682.7	431.6	348.7
SE-WF	1976.6	15.7	748.8	28.7	13.0
SE-WFb	748.8	28.7	0.0	0.0	-28.7

FUTURE CONDITIONS

During Task 10, the Future Conditions for 2040 were considered and modeled to determine how projected development in Lee County would impact the hydraulics of the system. Increased land development can increase runoff and impact peak stages in canals during storm events. The future 2040 conditions include changes to the model to indicate the increased landuse, such as increased imperviousness and decreased roughness in the future developed areas. No proposed projects were included for this sub-watershed allowable discharge study and all reference to future conditions only includes the projected 2040 landuse and sea level rise changes.

For this study, the future 2040 conditions discharge was evaluated in the same way as the existing conditions, summing the inflows and outflows for each sub-watershed and subtracting to get the peak discharge contribution from each sub-watershed.

In addition, the peak discharge (cubic feet per second) was normalized using the area of the sub-watershed (square miles), to get units of CSM (cubic feet per second per square mile).

Figure 5 and **Figure 6** show the peak discharge in CSM for each sub-watershed for existing and future projected conditions, respectively. Sub-watersheds without channel representations do not have results for this analysis and are shown as white. **Figure 7** shows the difference between the future and existing conditions, also in CSM for each sub-watershed.

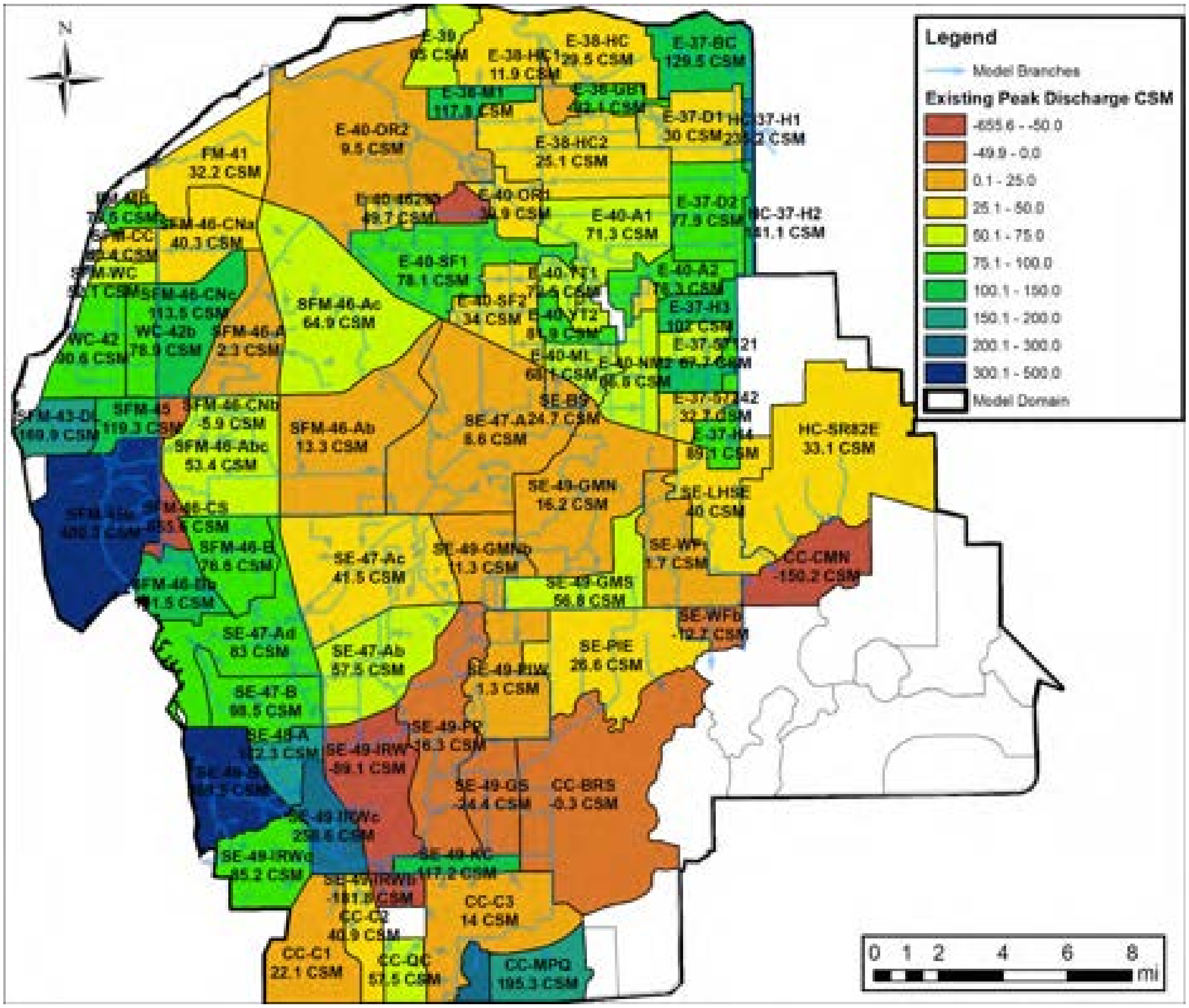


Figure 5. Peak Discharge Per Sub-Watershed in CSM for Existing 2017 Conditions

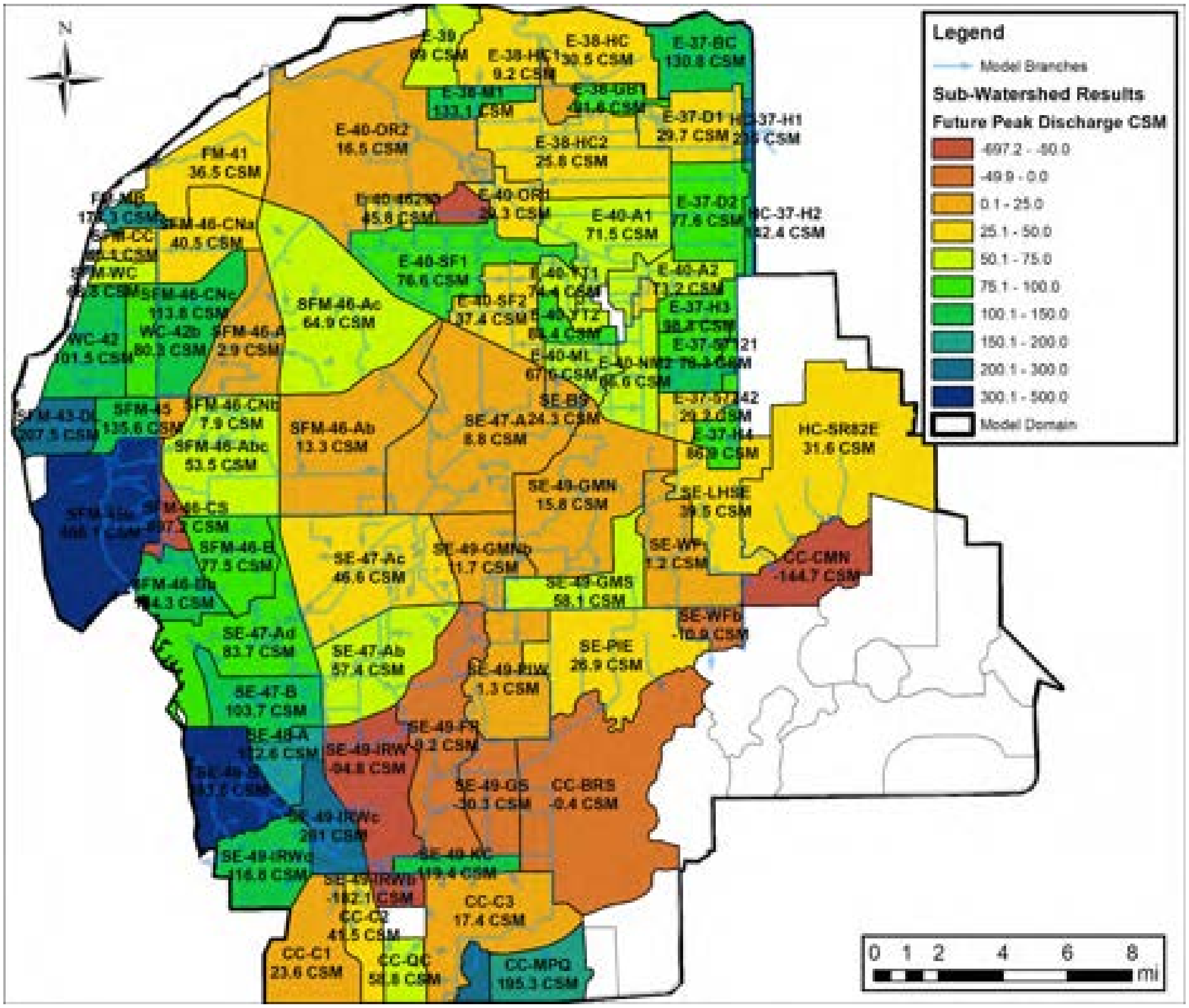


Figure 6. Peak Discharge Per Sub-Watershed in CSM for Future 2040 Conditions

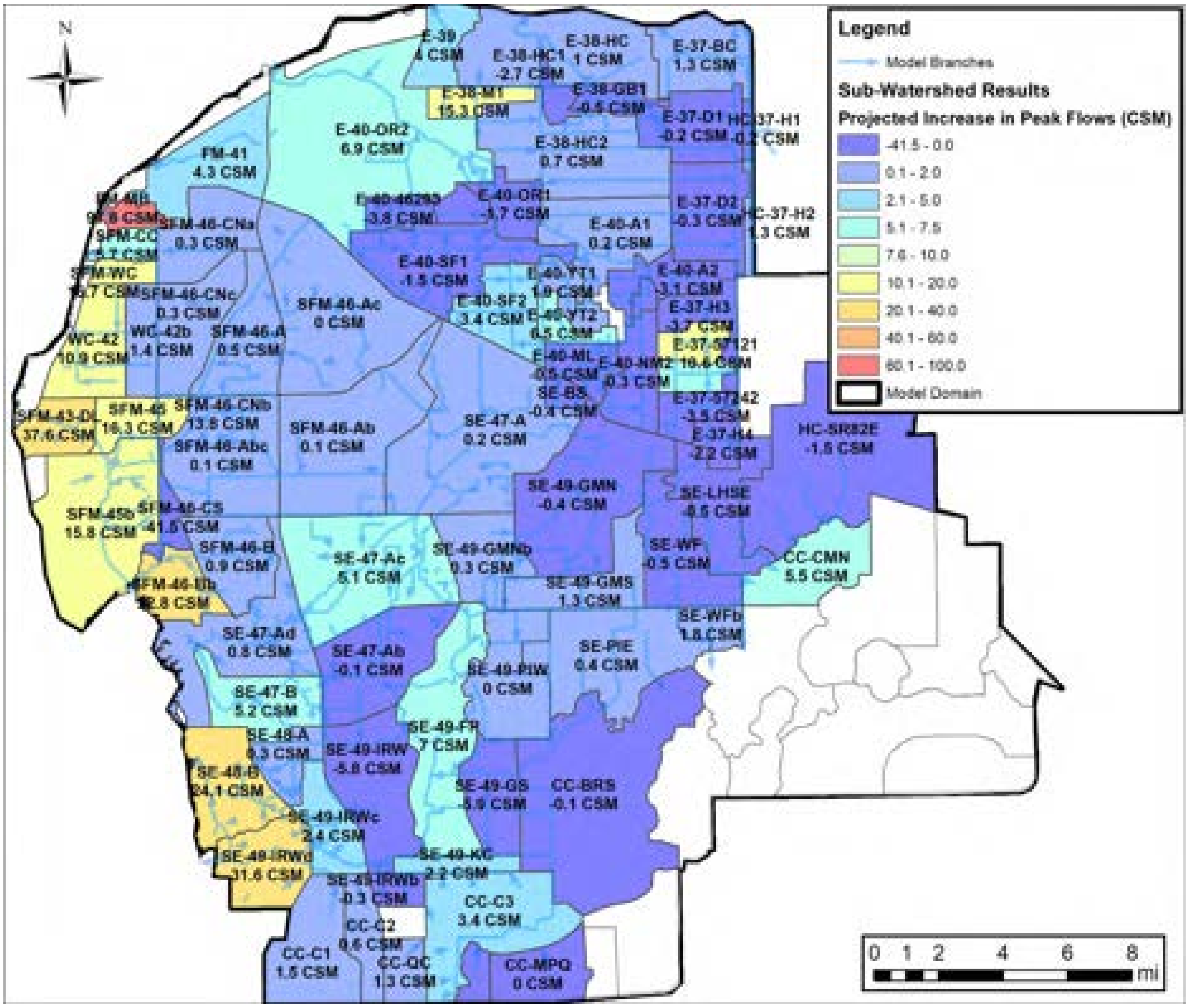


Figure 7. Increase in Peak Discharges with the Future Projected Conditions

The values shown in the figures above are provided in the tables in the following sections, broken out by each study area.

East Lee County

The peak discharges for existing and proposed conditions for sub-watersheds within East Lee County are shown in **Table 4**, below. The peak discharges in and out of the sub-watershed are shown in cfs. The calculated peak discharge change is converted to CSM, or cubic feet per second per square mile, by dividing by the sub-watershed area.

Table 4. Peak Discharges for Existing and Future Projected Conditions for East Lee County

	Existing 2017 Conditions			Future 2040 Conditions		
Sub-Watershed Name	Peak Discharge IN (cfs)	Peak Discharge OUT (cfs)	Peak CSM Change (OUT - IN)	Peak Discharge IN (cfs)	Peak Discharge OUT (cfs)	Peak CSM Change (OUT - IN)
E-37-57121	22.1	178.1	67.7	22.0	202.4	78.3
E-37-57131	-108.0	134.0	119.0	-115.1	138.9	124.9
E-37-57242	0.0	84.3	32.7	0.0	75.1	29.2
E-37-BC	1751.8	2603.9	129.5	1746.8	2607.5	130.8
E-37-D1	555.6	744.5	30.0	554.4	741.8	29.7
E-37-D2	0.0	560.4	77.9	0.0	557.9	77.6
E-37-H3	727.1	1005.1	102.0	748.1	1016.0	98.3
E-37-H4	304.3	548.9	89.1	307.1	545.7	86.9
E-38-GB1	0.0	172.1	82.1	0.0	171.0	81.6
E-38-HC	1660.9	2041.9	29.5	1704.8	2099.3	30.5
E-38-HC1	1507.8	1524.6	11.9	1555.1	1568.0	9.2
E-38-HC2	900.1	1238.4	25.1	900.8	1248.6	25.8
E-38-M1	0.0	299.7	117.8	0.0	338.7	133.1
E-39	0.0	240.6	65.0	0.0	255.3	69.0
E-40-46293	199.9	301.4	49.7	208.3	302.1	45.8
E-40-A1	956.3	1561.1	71.3	958.9	1565.8	71.5
E-40-A2	585.6	897.9	76.3	599.0	898.7	73.2
E-40-BF1	0.0	58.4	63.1	0.0	60.1	64.9
E-40-ML	29.3	230.0	68.1	28.6	227.6	67.6
E-40-NM1	298.7	326.6	41.4	298.0	325.9	41.3
E-40-NM2	0.0	322.3	66.8	0.0	321.1	66.6
E-40-OR1	2968.6	3065.3	30.9	2981.6	3073.1	29.3
E-40-OR2	2417.4	2679.5	9.5	2423.4	2875.6	16.5
E-40-OR6	0.0	0.0	0.0	0.0	0.0	0.0
E-40-SF1	760.3	1607.4	78.1	793.2	1624.2	76.6
E-40-SF2	74.9	272.8	34.0	73.8	291.4	37.4
E-40-SR1	120.2	0.0	-73.5	121.0	0.0	-73.9
E-40-YT1	329.1	451.1	72.5	340.1	465.3	74.4
E-40-YT2	153.0	310.7	81.9	151.7	321.9	88.4
E-FMS	0.0	0.0	0.0	0.0	0.0	0.0
HC-37-H1	870.6	1007.3	235.2	868.5	1005.1	235.0
HC-37-H2	746.1	870.6	141.1	742.8	868.5	142.4
HC-SR82E	0.0	775.5	33.1	0.0	741.0	31.6
HC-UHC	0.0	0.0	0.0	0.0	0.0	0.0

In addition to changes in peak discharge expected with the projected development for 2040, the total discharge volumes are also expected to rise for some sub-watersheds evaluated in this region. **Table 5** shows the total flow volumes for existing and future conditions. For sub-watersheds that indicate an increase in total flow volume, the projected storage increase is provided in acre-feet.

Table 5. Total Flow Volumes for Existing and Future Conditions for East Lee County

	Existing 2017 Conditions			Future 2040 Conditions			
Sub-watershed Name	Total Volume IN (ac-ft)	Total Volume OUT (ac-ft)	Sub-Watershed Volume (ac-ft)	Total Volume IN (ac-ft)	Total Volume OUT (ac-ft)	Sub-Watershed Volume (ac-ft)	Projected Storage Increase (ac-ft)
E-37-57121	91.2	650.3	559.1	90.8	646.1	555.3	--
E-37-57131	297.6	1435.8	1138.2	298.9	1436.1	1137.2	--
E-37-57242	0.0	1747.7	1747.7	0.0	1748.0	1748.0	0.3
E-37-BC	22004.9	44302.8	22297.9	22023.1	44323.3	22300.2	2.3
E-37-D1	3334.3	4637.1	1302.8	3344.5	4651.6	1307.0	4.2
E-37-D2	0.0	3181.3	3181.3	0.0	3188.2	3188.2	7.0
E-37-H3	7302.2	9604.1	2301.9	7299.5	9605.6	2306.1	4.3
E-37-H4	2794.7	6651.9	3857.2	2794.3	6653.4	3859.1	1.9
E-38-GB1	0.0	623.8	623.8	0.0	622.3	622.3	--
E-38-HC	20633.9	23559.5	2925.6	20937.4	23967.9	3030.5	104.9
E-38-HC1	19741.8	20097.2	355.4	20105.4	20401.3	295.9	--
E-38-HC2	12203.7	17833.4	5629.7	12273.6	18051.5	5777.9	148.3
E-38-M1	0.0	2076.0	2076.0	0.0	2224.5	2224.5	148.4
E-39	0.0	773.1	773.1	0.0	828.5	828.5	55.5
E-40-46293	-690.1	1679.3	2369.4	-710.6	1700.1	2410.7	41.3
E-40-A1	6216.4	10066.1	3849.7	6257.5	10125.7	3868.3	18.6
E-40-A2	4527.9	6054.3	1526.4	4552.0	6088.4	1536.4	10.0
E-40-BF1	0.0	162.1	162.1	0.0	169.1	169.1	6.9
E-40-ML	884.5	2225.8	1341.3	895.0	2260.8	1365.8	24.5
E-40-NM1	3489.7	3748.7	258.9	3500.5	3773.5	273.0	14.0
E-40-NM2	0.0	3488.3	3488.3	0.0	3499.0	3499.0	10.7
E-40-OR1	22271.3	23564.2	1292.9	22480.6	23763.2	1282.6	--
E-40-OR2	12957.5	34392.8	21435.3	13103.1	34545.0	21441.9	6.5
E-40-OR6	0.0	0.0	0.0	0.0	0.0	0.0	--
E-40-SF1	6878.4	11515.0	4636.7	6973.6	11644.2	4670.6	33.9
E-40-SF2	299.2	3102.6	2803.4	305.3	3132.4	2827.1	23.6
E-40-SR1	184.1	0.0	-184.1	187.2	0.0	-187.2	--
E-40-YT1	3108.4	3663.0	554.5	3158.2	3730.6	572.4	17.9
E-40-YT2	1921.3	3029.3	1108.0	1950.1	3077.8	1127.7	19.7
E-FMS	0.0	0.0	0.0	0.0	0.0	0.0	--
HC-37-H1	11791.4	17367.8	5576.3	11795.0	17371.5	5576.5	0.2
HC-37-H2	8824.9	11791.4	2966.5	8827.1	11795.0	2967.9	1.4
HC-SR82E	0.0	4236.6	4236.6	0.0	4124.0	4124.0	--
HC-UHC	0.0	0.0	0.0	0.0	0.0	0.0	--

South Fort Myers/Whiskey Creek Area

The peak discharges for existing and proposed conditions for sub-watersheds within South Ft Myers/Whiskey Creek Area are shown in **Table 6**, below. The peak discharges in and out of the sub-watershed are shown in cfs. The calculated peak discharge change is converted to CSM, or cubic feet per second per square mile, by dividing by the sub-watershed area.

Table 6. Peak Discharges for Existing and Future Projected Conditions for South Ft Myers/Whiskey Creek Area

	Existing 2017 Conditions			Future 2040 Conditions		
Sub-Watershed Name	Peak Discharge IN (cfs)	Peak Discharge OUT (cfs)	Peak CSM Change (OUT - IN)	Peak Discharge IN (cfs)	Peak Discharge OUT (cfs)	Peak CSM Change (OUT - IN)
FM-41	0.0	268.8	32.2	0.0	304.6	36.5
FM-CSS	0.0	0.0	0.0	0.0	0.0	0.0
FM-MB	0.0	114.6	79.5	0.0	255.7	177.3
SFM-43-DL	6.8	653.7	169.9	7.7	797.8	207.5
SFM-43-I	0.0	0.0	0.0	0.0	0.0	0.0
SFM-45	653.7	987.9	119.3	797.8	1177.8	135.6
SFM-45b	987.9	8874.0	480.3	1177.8	9323.1	496.1
SFM-46-A	1203.0	1220.8	2.3	661.1	1225.4	74.0
SFM-46-Ab	55.2	276.1	13.3	55.3	277.1	13.3
SFM-46-Abc	325.9	660.4	49.2	326.0	663.5	49.7
SFM-46-Ad	1220.8	1532.4	58.8	1225.4	1534.6	58.3
SFM-46-Ac	0.0	1203.0	64.9	0.0	1203.4	64.9
SFM-46-B	0.0	491.8	76.6	0.0	497.4	77.5
SFM-46-Bb	2476.5	2936.6	101.5	2429.7	2993.2	124.3
SFM-46-CNa	0.0	269.1	40.3	0.0	271.0	40.5
SFM-46-CNb	1013.7	1007.5	-5.9	1018.1	1026.6	7.9
SFM-46-CNc	269.1	1108.1	113.5	271.0	1111.9	113.8
SFM-46-CS	3200.3	1984.7	-655.6	3224.7	1932.2	-697.2
SFM-CC	0.0	69.8	40.4	0.0	79.6	46.1
SFM-WC	0.0	79.9	52.1	0.0	105.5	68.8
WC-42	365.6	966.2	90.6	370.0	1042.6	101.5
WC-42b	94.3	365.6	78.9	93.8	370.0	80.3

In addition to changes in peak discharge expected with the projected development for 2040, the total discharge volumes are also expected to rise for some sub-watersheds evaluated in this region. **Table 7** shows the total flow volumes for existing and future conditions. For sub-watersheds that indicate an increase in total flow volume, the projected storage increase is provided in acre-feet.

Table 7. Total Flow Volumes for Existing and Future Conditions for South Ft Myers/Whiskey Creek Area

	Existing 2017 Conditions			Future 2040 Conditions			
Sub-watershed Name	Total Volume IN (ac-ft)	Total Volume OUT (ac-ft)	Sub-Watershed Volume (ac-ft)	Total Volume IN (ac-ft)	Total Volume OUT (ac-ft)	Sub-Watershed Volume (ac-ft)	Projected Storage Increase (ac-ft)
FM-41	0.0	3914.5	3914.5	0.0	3900.7	3900.7	--
FM-CSS	0.0	0.0	0.0	0.0	0.0	0.0	--
FM-MB	0.0	1008.6	1008.6	0.0	1086.1	1086.1	77.5
HC-37-H1	11791.4	17367.8	5576.3	11795.0	17371.5	5576.5	0.2
HC-37-H2	8824.9	11791.4	2966.5	8827.1	11795.0	2967.9	1.4
HC-SR82E	0.0	4236.6	4236.6	0.0	4124.0	4124.0	--
HC-UHC	0.0	0.0	0.0	0.0	0.0	0.0	--
SFM-43-DL	19.8	1359.3	1339.5	34.9	1660.4	1625.5	286.1
SFM-43-I	0.0	0.0	0.0	0.0	0.0	0.0	--
SFM-45	1359.3	2597.9	1238.6	1660.4	2960.8	1300.4	61.8
SFM-45b	2597.9	86008.7	83410.7	2960.8	84336.5	81375.6	--
SFM-46-A	9860.8	14466.4	4605.6	9887.1	14565.0	4678.0	72.4
SFM-46-Ab	1742.9	5133.5	3390.6	1750.9	5191.2	3440.3	49.6
SFM-46-Abc	4637.7	7825.2	3187.5	4642.3	7873.0	3230.6	43.1
SFM-46-Ad	14466.4	15531.3	1064.9	14565.0	15606.1	1041.1	--
SFM-46-Ac	0.0	9860.8	9860.8	0.0	9887.1	9887.1	26.3
SFM-46-B	0.0	3061.8	3061.8	0.0	3093.3	3093.3	31.5
SFM-46-Bb	58871.4	61231.9	2360.5	58855.6	61185.1	2329.4	--
SFM-46-CNa	0.0	1378.6	1378.6	0.0	1416.2	1416.2	37.6
SFM-46-CNb	36335.6	37077.1	741.5	36430.7	37172.7	741.9	0.4
SFM-46-CNc	1378.6	37624.1	36245.5	1416.2	37716.9	36300.7	55.2
SFM-46-CS	60433.6	55809.6	-4624.0	60651.8	55762.3	-4889.5	--
SFM-CC	0.0	567.3	567.3	0.0	678.2	678.2	110.9
SFM-WC	0.0	389.7	389.7	0.0	698.8	698.8	309.0
WC-42	2659.4	5587.9	2928.5	2660.6	5809.2	3148.6	220.1
WC-42b	1288.5	2659.4	1370.9	1286.2	2660.6	1374.4	3.5

Southeast Lee County

The peak discharges for existing and proposed conditions for sub-watersheds within East Lee County are shown in **Table 8**, below. The peak discharges in and out of the sub-watershed are shown in cfs. The calculated peak discharge change is converted to CSM, or cubic feet per second per square mile, by dividing by the sub-watershed area.

Table 8. Peak Discharges for Existing and Future Projected Conditions for Southeast Lee County

	Existing 2017 Conditions			Future 2040 Conditions		
Sub-Watershed Name	Peak Discharge IN (cfs)	Peak Discharge OUT (cfs)	Peak CSM Change (OUT - IN)	Peak Discharge IN (cfs)	Peak Discharge OUT (cfs)	Peak CSM Change (OUT - IN)
CC-BRS	379.0	370.9	-0.3	384.7	374.5	-0.4
CC-C1	150.5	342.8	22.1	152.8	357.8	23.6
CC-C2	0.0	150.5	40.9	0.0	152.8	41.5
CC-C3	1481.2	1651.1	14.0	1438.9	1650.0	17.4
CC-CMN	1032.7	0.0	-150.2	994.8	0.0	-144.7
CC-M	0.0	355.4	235.1	0.0	308.3	203.9
CC-MPQ	0.0	1026.4	195.3	0.0	1026.2	195.3
CC-QC	0.0	149.3	57.5	0.0	152.7	58.8
HC-SR82E	0.0	775.5	33.1	0.0	741.0	31.6
SE-47-A	-49.8	144.9	8.6	-48.9	151.1	8.8
SE-47-Ab	663.3	1243.3	57.5	670.4	1249.1	57.4
SE-47-Ac	133.4	797.4	41.5	133.5	878.2	46.6
SE-47-Ad	2154.9	3105.9	83.0	2274.5	3234.2	83.7
SE-47-B	325.2	981.1	98.5	328.0	1018.5	103.7
SE-48-A	-51.2	506.2	172.3	-51.3	507.3	172.6
SE-48-B	608.2	3515.9	369.5	697.0	3794.6	393.6
SE-49-FP	1211.5	999.8	-16.3	1198.4	1078.0	-9.2
SE-49-GMN	86.5	343.9	16.2	92.3	343.9	15.8
SE-49-GMNb	698.1	767.6	11.3	706.2	777.6	11.7
SE-49-GMS	41.0	392.0	56.8	40.9	400.0	58.1
SE-49-GS	556.7	420.2	-24.4	563.5	393.9	-30.3
SE-49-IRW	1656.5	729.0	-89.1	1726.2	738.5	-94.8
SE-49-IRWb	355.1	46.1	-181.8	355.4	46.0	-182.1
SE-49-IRWc	811.8	2014.7	258.6	834.1	2048.2	261.0
SE-49-IRWd	2014.7	2584.3	85.2	2048.2	2829.4	116.8
SE-49-KC	1216.9	1457.6	117.2	1217.1	1462.3	119.4
SE-49-PIW	206.6	217.6	1.3	209.4	220.7	1.3
SE-BS	-5.7	22.0	24.7	-5.8	21.6	24.3
SE-LHSE	0.0	309.2	40.0	0.0	305.4	39.5
SE-PIE	82.9	431.6	26.6	83.0	436.4	26.9
SE-WF	15.7	28.7	1.7	183.8	24.6	-20.2

SE-WFb	28.7	0.0	-12.7	24.6	0.0	-10.9

In addition to changes in peak discharge expected with the projected development for 2040, the total discharge volumes are also expected to rise for some sub-watersheds evaluated in this region. **Table 9** shows the total flow volumes for existing and future conditions. For sub-watersheds that indicate an increase in total flow volume, the projected storage increase is provided in acre-feet.

Table 9. Total Flow Volumes for Existing and Future Conditions for Southeast Lee County

	Existing 2017 Conditions			Future 2040 Conditions			
Sub-watershed Name	Total Volume IN (ac-ft)	Total Volume OUT (ac-ft)	Sub-Watershed Volume (ac-ft)	Total Volume IN (ac-ft)	Total Volume OUT (ac-ft)	Sub-Watershed Volume (ac-ft)	Projected Storage Increase (ac-ft)
CC-BRS	5526.6	13312.5	7785.9	5454.7	13239.5	7784.8	--
CC-C1	584.9	1548.6	963.8	593.7	1637.2	1043.6	79.8
CC-C2	0.0	584.9	584.9	0.0	593.7	593.7	8.8
CC-C3	10851.6	19024.4	8172.8	10854.3	19024.1	8169.7	--
CC-CMN	5469.3	0.0	-5469.3	5340.9	0.0	-5340.9	--
CC-M	0.0	697.2	697.2	0.0	713.0	713.0	15.7
CC-MPQ	0.0	8890.2	8890.2	0.0	8873.0	8873.0	--
CC-QC	0.0	530.4	530.4	0.0	532.0	532.0	1.6
HC-SR82E	0.0	4236.6	4236.6	0.0	4124.0	4124.0	--
SE-47-A	495.8	5183.4	4687.6	548.8	5228.1	4679.3	--
SE-47-Ab	17032.8	23464.4	6431.6	17218.1	23636.4	6418.4	--
SE-47-Ac	3713.3	6740.0	3026.7	3742.6	6760.2	3017.6	--
SE-47-Ad	25776.4	33717.0	7940.7	25893.1	33733.2	7840.1	--
SE-47-B	6978.4	10832.1	3853.6	7037.1	10883.9	3846.8	--
SE-48-A	-2219.6	2870.9	5090.4	-2219.5	2882.0	5101.6	11.1
SE-48-B	2796.3	125700.3	122903.9	2784.4	124258.6	121474.2	--
SE-49-FP	18244.5	29311.4	11066.9	18331.9	29590.3	11258.4	191.6
SE-49-GMN	-138.4	4143.7	4282.1	-127.8	4141.3	4269.1	--
SE-49-GMNb	7953.5	9327.8	1374.2	7983.6	9369.3	1385.7	11.4
SE-49-GMS	815.5	5358.4	4542.9	813.6	5378.7	4565.1	22.1
SE-49-GS	14986.7	11164.2	-3822.5	14942.6	11117.2	-3825.4	--
SE-49-IRW	34441.0	13204.3	-21236.6	34584.7	13359.6	-21225.1	--
SE-49-IRWb	1230.2	133.9	-1096.3	1233.1	133.2	-1099.9	--
SE-49-IRWc	6524.7	31625.7	25101.0	6721.8	31971.5	25249.8	148.8
SE-49-IRWd	31625.7	33873.4	2247.7	31971.5	34144.3	2172.8	--
SE-49-KC	18604.7	24291.5	5686.8	18642.5	24354.3	5711.7	24.9
SE-49-PIW	3185.0	1369.8	-1815.2	3201.7	1451.7	-1750.0	--
SE-BS	84.3	959.8	875.5	84.9	971.6	886.7	11.2
SE-LHSE	0.0	2688.1	2688.1	0.0	2670.7	2670.7	--
SE-PIE	1723.5	7682.7	5959.2	1725.2	7565.6	5840.4	--
SE-WF	1976.6	748.8	-1227.9	2002.2	737.4	-1264.8	--
SE-WFb	748.8	0.0	-748.8	737.4	0.0	-737.4	--

UNDERSTANDING TIDAL INFLUENCE

The MIKE SHE/MIKE 11 Southern Lee County flood model uses tidal boundary conditions at coastal boundaries (including surficial groundwater boundaries and river outfalls to tide) from the Hurricane Irma storm event to represent extreme tailwater stages in combination with large storm events. The tidal surge at the two tidal gaging stations used along the coastal boundaries in the model (NOAA's Naples Pier and Caloosahatchee) and the 25 yr 72 hr and 100 yr 72 hr design storm rainfall hydrographs are shown in **Figure 8**.

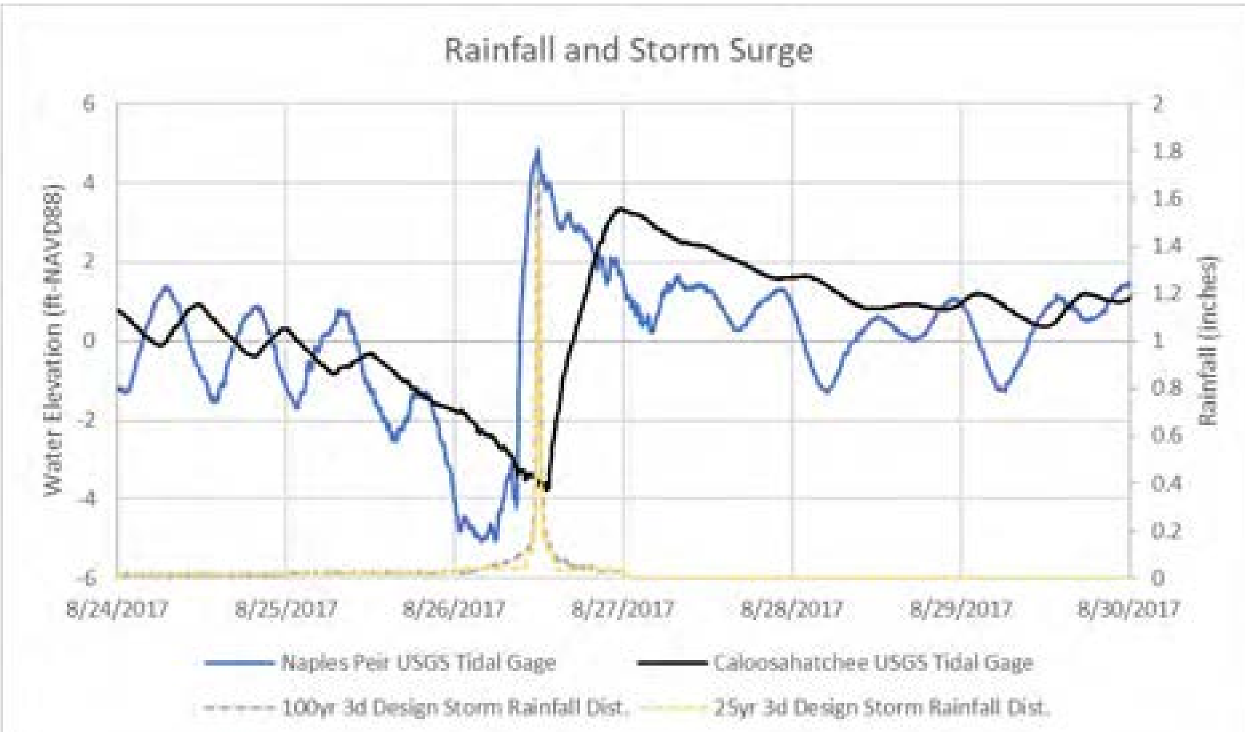


Figure 8. Design Storm Rainfall Hydrographs and Tidal Surge Boundary Conditions

Due to the effect of the tidal boundaries, flows can reverse at some tidal discharge locations, creating a negative flow in the model and counting towards the total sub-watershed inflow, rather than outflow. **Figure 9** shows the tidal signature at several tidal boundaries. Negative flows, or reversal of flow direction, are present at all tidal boundary locations, with the exception of Carrell Canal, which may be due to the higher bottom of the canal at the outfall location in the model.

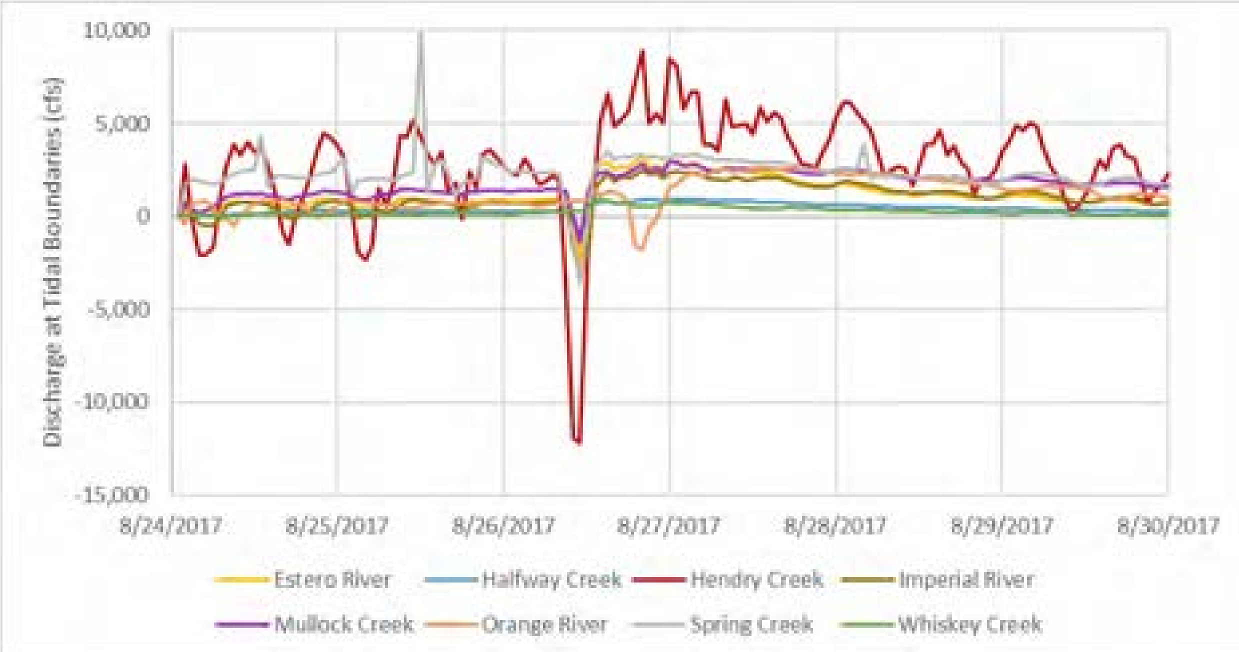


Figure 9. Discharge at Tidal Boundaries

Tidal boundaries increase by 0.64 ft for all boundaries for the 2040 projected future conditions, which can increase flows upstream into the channels. **Table 10** provides the peak discharges in both directions for each channel. Peak discharge upstream is the "negative" flow, shown in the table as the absolute value. Discharge (in both directions) increases for the Future 2040 Conditions as a result of increased development and tidal conditions.

Table 10. Discharge to Tide and Upstream for Existing and Future Conditions

		Existing 2017 Conditions		Future 2040 Conditions	
River Name	Sub-Watershed Name	Peak Discharge to Tide (cfs)	Peak Discharge Upstream (cfs)	Peak Discharge to Tide (cfs)	Peak Discharge Upstream (cfs)
Orange River	E-40-OR2	2,643.1	1,779.6	2,839.3	2,785.4
Carrell Canal	SFM-CC	69.8	0.0	79.6	0.0
Whiskey Creek	WC-42	966.2	120.6	1,042.6	154.1
Hendry Creek @ McGregor	SFM-43-DL	0.8	6.8	3.5	7.7
Hendry Creek	SFM-45b	8,874.0	12,192.3	9,323.1	13,987.5
Mulloch Creek	SFM-46-Bb	2,936.6	1,346.7	2,993.2	1,661.6
Estero River	SE-47-Ad	3,105.9	2,398.2	3,234.2	3,033.0
Halfway Creek	SE-47-B	912.0	923.2	949.0	1,245.2
Spring Creek	SE-48-B	3,515.9	3,715.0	3,794.6	4,819.7
Imperial River	SE-49-IRWd	2,482.3	3,015.7	2,639.7	3,642.2

MAXIMUM STAGES

Peak stages from the 100 yr design storm were already presented in Task 10, but are summarized for each sub-watershed as the maximum and minimum peak stage for the existing 2017 and future 2040 conditions in **Table 11**. The values presented in the table show maximum and minimum of the peak elevations for each MIKE11 stage output location within each sub-watershed, so the max and min provide the range of stages that are found within a sub-watershed. With the exception of sub-watersheds that experience tidal influence, there are no significant increases in peak stages seen throughout the domain. However, the minimum peak stage within the sub-watershed is often slightly higher with the future 2040 conditions than existing 2017 conditions, indicating that the range of values within the sub-watershed, and therefore the possible available storage, is decreasing with future conditions.

Table 11. Peak stages for the 100 yr Design Storm for all sub-watersheds

Sub-Watershed Name	Max of Peak Stage Ex. 2017(ft-NAVD)	Max of Peak Stage Fut. 2040 (ft-NAVD)	Min of Peak Stage Ex. 2017 (ft-NAVD)	Min of Peak Stage Fut. 2040 (ft-NAVD)
CC-BRS	21.121	21.083	16.522	16.524
CC-C1	14.312	14.331	9.92	10.03
CC-C2	11.948	11.963	11.042	11.123
CC-C3	27.409	27.426	12.08	12.08
CC-CMN	25.543	25.537	23.572	23.57
CC-CMS	30.952	30.481	23.054	22.979
CC-M	17.022	17.021	17.009	17.008
CC-MPQ	18.012	18.012	18.003	18.003
CC-QC	16.732	16.725	16.353	16.349
E-37-57121	28.029	28.141	27.118	27.124
E-37-57131	28.9	28.91	27.857	27.857
E-37-57242	29.086	29.09	27.966	27.965
E-37-BC	18.713	18.74	5.309	5.309
E-37-D1	19.971	20.034	16.092	16.101
E-37-D2	26.76	26.767	21.996	22
E-37-H3	27.371	27.404	26.76	26.767
E-37-H4	28.099	28.094	27.748	27.749
E-38-GB1	18.24	18.252	13.762	13.793
E-38-HC	20.424	20.423	5.31	5.31
E-38-HC1	14.164	14.223	12.208	12.287
E-38-HC2	19.411	19.587	17.483	17.496
E-38-M1	20.194	20.318	19.962	20.067
E-39	7.716	7.721	4.57	5.21
E-40-46293	24.119	24.13	23.059	23.075
E-40-A1	24.375	24.541	20.308	20.341
E-40-A2	25.774	25.813	22.524	22.576
E-40-BF1	24.42	24.584	24.406	24.571
E-40-ML	28.358	28.365	27.379	27.421
E-40-NM1	24.275	24.282	24.053	24.059

E-40-NM2	28.614	28.66	26.967	26.973
E-40-OR1	19.709	19.718	18.959	18.97
E-40-OR2	24.083	24.085	3.904	4.544
E-40-SF1	26.169	26.225	22.276	22.275
E-40-SF2	27.252	27.289	22.684	22.699
E-40-SR1	22.776	22.784	19.637	19.655
E-40-YT1	25.508	25.523	25.063	25.107
E-40-YT2	29.062	29.063	26.814	26.858
FM-41	14.015	14.026	3.306	3.946
FM-CSS	3.313	3.951	3.305	3.945
FM-MB	13.814	13.834	3.306	3.946
HC-37-H1	22.001	22.001	5.334	5.334
HC-37-H2	24.39	24.41	22.003	22.003
HC-SR82E	29.362	29.361	24.178	24.174
HC-UHC	24.39	24.41	22.003	22.003
SE-47-A	29.034	29.034	21.505	21.507
SE-47-Ab	21.018	21.018	5.463	5.463
SE-47-Ac	24.373	24.374	15.861	15.863
SE-47-Ad	19.029	19.026	4.541	5.181
SE-47-B	16.893	16.895	4.787	5.39
SE-48-A	14.93	14.939	10.424	10.44
SE-48-B	14.838	14.839	4.107	4.657
SE-49-FP	19.615	19.635	14.723	14.735
SE-49-GMN	29.682	29.675	26.275	26.275
SE-49-GMNb	26.649	26.649	17.333	17.336
SE-49-GMS	28.531	28.531	23.222	23.255
SE-49-GS	18.319	18.338	15.703	15.712
SE-49-IRW	16.626	16.635	9.992	10.045
SE-49-IRWb	15.365	15.368	12.548	12.559
SE-49-IRWc	12.904	12.905	5.947	6.211
SE-49-IRWd	10.819	10.992	4.257	4.759
SE-49-KC	27.385	27.402	13.175	13.185
SE-49-PIW	25.053	25.063	17.447	17.462
SE-BS	28.649	28.651	28.365	28.372
SE-LHSE	29.828	29.827	24.118	24.104
SE-PIE	28.37	28.371	19.307	19.324
SE-WF	29.936	29.936	26.851	27.017
SE-WFb	28.71	28.608	23.055	22.98
SFM-43-DL	6.232	6.268	4.178	4.75
SFM-45	9.847	9.848	4.195	4.751
SFM-45b	9.108	9.048	4.035	4.496
SFM-46-A	20.559	20.559	12.471	12.481
SFM-46-Ab	26.371	26.428	17.759	17.761
SFM-46-Abc	20.791	20.79	12.731	12.75
SFM-46-Ac	27.103	27.1	18.861	18.865

SFM-46-B	16.766	16.77	4.945	5.5
SFM-46-Bb	11.513	11.536	4.546	5.183
SFM-46-CNa	19.189	19.199	13.716	13.736
SFM-46-CNb	12.28	12.292	12.117	12.143
SFM-46-CNc	19.457	19.455	10.585	10.585
SFM-46-CS	13.52	13.516	5.027	5.572
SFM-CC	12.614	12.614	3.306	3.946
SFM-WC	11.546	11.551	3.306	3.946
WC-42	8.809	8.95	3.314	3.952
WC-42b	11.964	11.997	7.878	7.919

CONCLUSIONS

Due to the modeling process, and because watershed boundaries were not defined in the model, the analysis of discharges through the watersheds is purely a post-processing tool to evaluate how water moves through channelized areas and is not a cleanly separated flow area in the model. The MIKE SHE model allows for exchange through these areas via overland and groundwater, depending on the gradient at each model 750x750ft grid cell at each time step. Therefore, the sub-watersheds defined in this report can pass flows from the river, through the overland or saturated zone, and into other sub-watersheds, given the right conditions. Rural areas with only minor drainage that is not represented as 1D flow in the model will *only* exchange via overland and groundwater flow, and therefore, these sub-watersheds were not evaluated for discharges.

The methodology utilized for this report evaluates the channel flow at the major outfalls for each sub-watershed, taking into account the incoming flows from upstream sub-watersheds. The 25-year 72-hour design storm was used to determine the peak discharge through each sub-watershed. To compare the 1992 Lee County Stormwater Master Plan allowable discharges with the current model results, sub-watersheds were aggregated to match similar areas analyzed in 1992 report. The following table provides the allowable discharge (CSM) from the 1990's studies and the current values from the 2017 study.

Summary of Results

In general, the current results show an increase in discharges above the 1992 study, which is an expected result considering 25 years of increased development in the region. The 1992 study identified an allowable discharge for the Orange River watershed of 55 CSM; however, within LA-MSID boundaries the allowable discharge from all basins is set at 30 CSM via LA-MSID permits. Comparing the current results to the LA-MSID allowable discharge, there is an increase in the discharge. In addition, the 1991 study separated discharge from the Whiskey Creek basin into north (108 CSM) and south (40 CSM) of College Pkwy. While the current discharge for Whiskey Creek (96 CSM) is lower than the north area, it is higher for the south area. While most basins show an increase in discharge, it is recommended that the existing allowable discharge is maintained for these areas. One exception is the Imperial River watershed east of Bonita Grande Drive. This region shows a decrease in discharge with the current results, which may be explained by changes to storage in the area after the 1991 study. It is recommended that for all future developments, the new discharge rate of 12.4 CSM is used if there was not a previously permitted rate. There are also two exceptions for Orange River and Hickey Creek watersheds downstream from the LA-MSID boundaries where a reduction is recommended. Please see **Table 12** for a summary of the recommendations.

In addition, a look into the future 2040 projected conditions evaluated how much discharge from each sub-watershed may increase with increasing development and rising sea levels. We are expected to see a general increase in peak discharges throughout southern Lee County with the projected increase in land development. Total discharge volumes tend to increase in the proposed future conditions, due to the backwater effects of rising sea levels. However, when we remove tidally influenced sub-watersheds, the total discharge volume increases with the future conditions by 1,130 ac-ft throughout southern Lee County (less tidal sub-watersheds shown in **Table 10**). This volume of water should be taken into consideration when planning improvements to the watershed.

Table 12. Recommended Allowable Discharges

Watershed Name	Current Allowable Discharge Rates (CSM)	SLCFMP (CSM)	% Change	Recommended Allowable Discharge (CSM)
Six Mile Cypress****	37.1	69.7	88%	37.1
Bedman Creek	58* (30 LA-MSID)	80.2	38%	58 (30 LA-MSID)
Hickey Creek	65* (30 LA-MSID)	62.9	-3%	62.9 (30 LA-MSID)
Orange River	55* (30 LA-MSID)	39.5	-28%	39.5 (30 LA-MSID)
Mulloch Creek	69	119.1	73%	69
Estero River	42	51.5	23%	42
Halfway Creek	60	147.3	146%	60
Spring Creek	81	316.6	291%	81
Imperial River west of Bonita Grande Dr.	59	85.2	44%	59
Imperial River east of Bonita Grande Dr.	25	12.4	-50%	12.4
Ten Mile Canal **	64			
Ten Mile Canal (Harper Brothers Farm Permit #36-00736-S)	43	NA		
Ten Mile Canal (North)		73.2	14%	64
Ten Mile Canal (South)		78.4	22%	37.1
Hendry Creek	131	312.1	138%	131
Hendry Creek (Upstream of Lakes Park weir)	102	NA		102
Whiskey Creek (north of College Pkwy)	108	96.0	-11%	108
Whiskey Creek (south of College Pkwy) ***	40	NA		40

*Allowable Discharge within the LA-MSID area is set at 30 CSM in LA-MSID permits
**Some studies separate the Ten Mile Canal area into the entire area and the Harper Brother Farm; however, the Lee County basin map uses "North" and "South".
***The Whiskey Creek area is separated into north of College Pkwy and south of College Pkwy in the 1991 study, but these areas are combined in the existing sub-watershed boundary.
****HNTB study for citing of Southwest Florida International Airport in the 1970's established the 37.1 CSM.

Future Conditions

Analysis of the Existing and Future Conditions modeling results (in both Task 10 and Task 11) indicate that projected future development does not show a substantial impact on flooding and sub-watershed discharges. Therefore, by only addressing future developments, existing flooding conditions will not be improved or mitigated. However, the data provided in this task could be used when reviewing large future development's impacts on peak discharge rates and discharge volumes. These future development projects could be modeled within the developed program with a focus on minimizing increases to peak discharges and total volumes from the respective sub-watershed above existing conditions.

Figure 10 below provides a comparison of the original watershed basins listed in **Table 12** as contrasted to the modified model domain basins listed in **Table 11**.

Sub-Basin Delineation

Since the early 1990’s, southern Lee County has undergone immense growth and development, resulting in a change of subbasin flow patterns to receiving watersheds and water bodies. During model development and calibration, subbasins were defined to best represent current flow conditions. This report identifies the regionally refined subbasins, which utilized the following criteria:

- Best known subbasin and watershed delineations from the Lee County, SFWMD, and LA-MSID.
- Updated 2019 LIDAR topography.
- Observed subsequent subbasin divides, such as new road and levee construction.

Subbasins were merged to delineate the corresponding watersheds. Further subbasin and watershed refinement was conducted to reflect changes in development, such as major roadway construction, new subdivisions, and known regional conveyance alterations. While subbasin and watershed delineation has been further enhanced through this SLCFMP project, these revised delineations should not be adopted by governing agencies without further refinement. This process should include localized review of critical drainage patterns that could not be analyzed as a part of this regionally scaled analysis. However, the refined subbasins and watersheds identified herein are an excellent first step towards updating drainage boundary delineation and can be utilized for high-level planning purposes. It is recommended that the currently adopted watershed boundaries are updated through subsequent localized refinement efforts to further reflect new localized drainage patterns, topography alterations, and developmental urbanization. In cooperation with SFWMD, updating the subbasins and corresponding watershed delineation would allow for a better understanding, tracking, and management of the stormwater system.

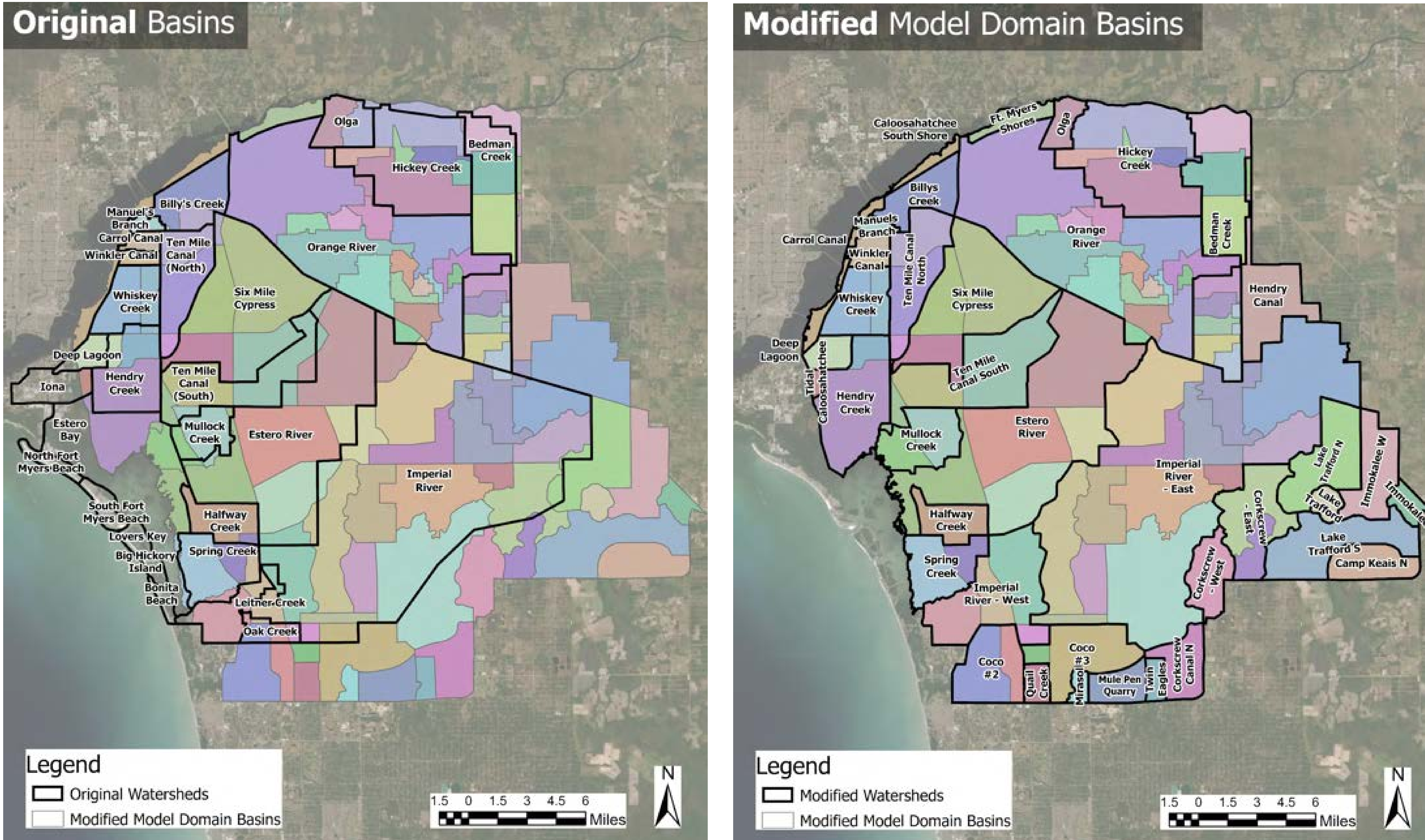
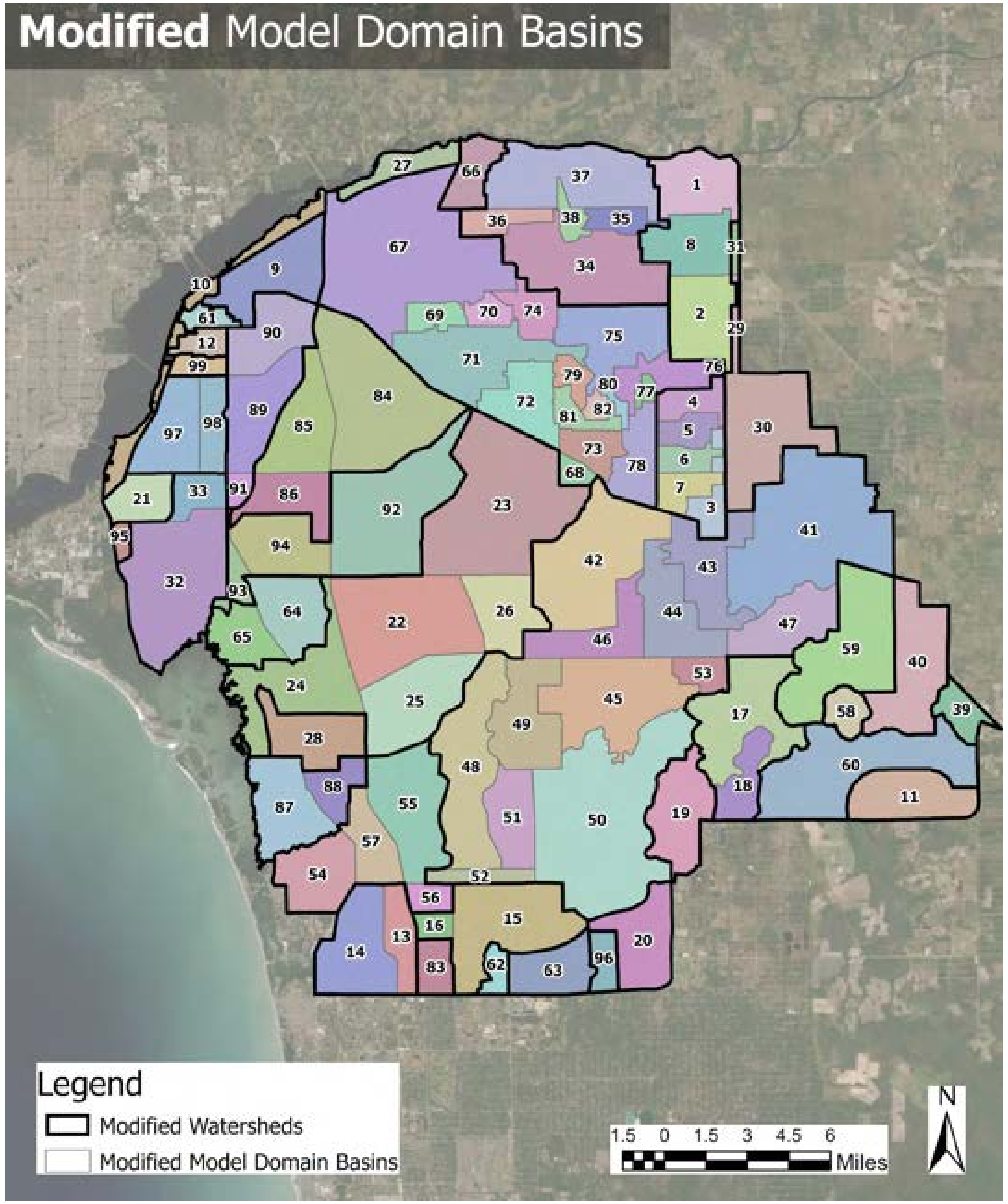


Figure 10. Original Basins vs. Modified Model Domain Basins.



Map Index

Modified Model Domain Basins		Watershed	Modified Model Domain Basins		Watershed	Modified Model Domain Basins		Watershed
No.	Name		No.	Name		No.	Name	
1	E-37-BC	Bedman Creek	34	E-38-HC2	Hickey Creek	67	E-40-OR2	Orange River
2	E-37-D2	Bedman Creek	35	E-38-GB1	Hickey Creek	68	SE-BS	Orange River
3	E-37-H4	Bedman Creek	36	E-38-M1	Hickey Creek	69	E-40-46293	Orange River
4	E-37-H3	Bedman Creek	37	E-38-HC	Hickey Creek	70	E-40-SR1	Orange River
5	E-37-57121	Bedman Creek	38	E-38-HC1	Hickey Creek	71	E-40-SF1	Orange River
6	E-37-57131	Bedman Creek	39	CC-I	Immokalee	72	E-40-SF2	Orange River
7	E-37-57242	Bedman Creek	40	CC-IN	Immokalee W	73	E-40-ML	Orange River
8	E-37-D1	Bedman Creek	41	HC-SR82E	Imperial River - East	74	E-40-OR1	Orange River
9	FM-41	Billys Creek	42	SE-49-GMN	Imperial River - East	75	E-40-A1	Orange River
10	FM-CSS	Caloosahatchee S Shore	43	SE-LHSE	Imperial River - East	76	E-40-A2	Orange River
11	CC-CKN	Camp Keais N	44	SE-WF	Imperial River - East	77	E-40-NM1	Orange River
12	SFM-CC	Carrol Canal	45	SE-PIE	Imperial River - East	78	E-40-NM2	Orange River
13	CC-C2	Coco #2	46	SE-49-GMS	Imperial River - East	79	E-40-YT1	Orange River
14	CC-C1	Coco #2	47	CC-CMN	Imperial River - East	80	E-40-OR6	Orange River
15	CC-C3	Coco #3	48	SE-49-FP	Imperial River - East	81	E-40-YT2	Orange River
16	CC-C3b	Coco #3	49	SE-49-PIW	Imperial River - East	82	E-40-BF1	Orange River
17	CC-CMS	Corkscrew - East	50	CC-BRS	Imperial River - East	83	CC-QC	Quail Creek
18	CC-HI	Corkscrew - East	51	SE-49-GS	Imperial River - East	84	SFM-46-Ac	Six Mile Cypress
19	CC-CSW	Corkscrew - West	52	SE-49-KC	Imperial River - East	85	SFM-46-A	Six Mile Cypress
20	CC-CCN	Corkscrew Canal N	53	SE-WFb	Imperial River - East	86	SFM-46-Ad	Six Mile Cypress
21	SFM-43-DL	Deep Lagoon	54	SE-49-IRWd	Imperial River - West	87	SE-48-B	Spring Creek
22	SE-47-Ac	Estero River	55	SE-49-IRW	Imperial River - West	88	SE-48-A	Spring Creek
23	SE-47-A	Estero River	56	SE-49-IRWb	Imperial River - West	89	SFM-46-CNc	Ten Mile Canal North
24	SE-47-Ad	Estero River	57	SE-49-IRWc	Imperial River - West	90	SFM-46-CNa	Ten Mile Canal North
25	SE-47-Ab	Estero River	58	CC-LT	Lake Trafford	91	SFM-46-CNb	Ten Mile Canal North
26	SE-49-GMNb	Estero River	59	CC-PRA	Lake Trafford N	92	SFM-46-Ab	Ten Mile Canal South
27	E-FMS	Ft. Myers Shores	60	CC-CE	Lake Trafford S	93	SFM-46-CS	Ten Mile Canal South
28	SE-47-B	Halfway Creek	61	FM-MB	Manuels Branch	94	SFM-46-Abc	Ten Mile Canal South
29	HC-37-H2	Hendry Canal	62	CC-M	Mirasol	95	SFM-43-I	Tidal Caloosahatchee
30	HC-UHC	Hendry Canal	63	CC-MPQ	Mule Pen Quarry	96	CC-TE	Twin Eagles
31	HC-37-H1	Hendry Canal	64	SFM-46-B	Mullock Creek	97	WC-42	Whiskey Creek
32	SFM-45b	Hendry Creek	65	SFM-46-Bb	Mullock Creek	98	WC-42b	Whiskey Creek
33	SFM-45	Hendry Creek	66	E-39	Olga	99	SFM-WC	Winkler Canal

Figure 10 (continued). Original Basins vs. Modified Model Domain Basins.

Part 4

Appendixes

SLCFMP DATA/RESOURCES CATALOG			
Provider	**Title**	**Accessed (Y/N)**	**Commentary**
AIM Engineering & Surveying Inc.	DesignPhase_Report_ver6 (word doc)	Y	
	LCEEPO Env Summary Memo-Final-2018 0619 (pdf)	Y	
	Olga Watersged	Y	
	*12020000 SR 80_Bus US 41 (pdf)	Y	
	*Olga Regional Drainage Info (pdf)	Y	
	*Olga Regional Drainage Narative (pdf)	Y	
	*Olga LiDAR (jpeg)	Y	
	Panther Canal Pictures	Y	
	*18 jpeg pictures taken on 5-16-19	Y	
Audubon Society	Willow Shapefile (Corkscrew and CREW)	Y	Refined landuse shapefile
City of Bonita Springs	Bonita Springs Flood Reduction Plan	Y	
	*City of Bonita Springs Flood Reduction and Watershed Restoration Plan	Y	
City of Fort Myers	AdICPR model	Y	Extracted cross-sections, weirs, culverts, etc.
	CFM-WeirStruct-Set (pdf)	Y	
	ICPR	Y	
	*City of Fort Myers	Y	
	*10-yr event	Y	
	*25-yr event	Y	
	*100-yr event	Y	
	Profiles_Static & 25-yr (pdf)	Y	
	Stormwater Facilities (pdf)	Y	
Collier County	BCB LOS - The Collier County Watershed Management Plan MIKE SHE/11 model (2011)	Y	Compared with Estero model (structure dimensions and operations, etc)
	CalculatedScoringWorksheet_MASTER(08052014) (excel)	Y	
	Coco 1 Weir During Hurr Irma Eye Passage (jpeg)	Y	
	NRCS Soils Data	Y	Used for soils data
	Stormwater Planning Program Guide 10-14-14 (word doc)	Y	
	Stormwater Priority Matrix xls (excel)	Y	
FEMA	Region IV Coastal Flood Hazard (pdf)	Y	
Hendry County	Hendry County Bridge Alignment (pdf)	Y	Reviewed, but not used
	NRCS Soils Data	Y	Used for soils data
LA-MSID	Control Structure Operations (gate levels)	Y	Reviewed and processed for control structure operations
	Groundwater Monitoring Data	Y	Reviewed and processed for calibration or boundary data
	Measured Rainfall Data	Y	
	*S-A-1, S-A-2, S-D-1, S-D-2, S-H-1, S-H-3, S-H-4, S-HC-1, S-HC-2, S-HC-3, S-HM-1, S-HM-3, S-ML-4, S-NM-2, S-SF-1, S-SF-2, S-YT-1, S-YT-2, G-ML-6, S 57-12-1, S 57-24-2, S-LC-1	Y	Reviewed and processed for rainfall comparison and input
	Surface Water Monitoring Data	Y	Reviewed and processed for calibration or boundary data
	SW Weirs final plan sheets (pdfs)	Y	
Lee County	Elevation Certificates	Y	
	*http://www.leegov.com/dcd/eServ/searchec	Y	
	*https://maps.floridadisaster.org/portal/apps/GeoForm/index.html?appid=d5642b277af24b7191107524b390bada	Y	
Lee County DNR	10_Mile_Filter_Marsh_Project folder (mostly autocad)	Y	Used to modify cross-sections and Manning's
	Alico Mines (Future)	Y	
	*Master Mine Plan/Culvert Location Map (pdf plan set)	Y	
	AllocationsForModpath-041219 (excel file)	Y	Reviewed, but required more detailed data. This was provided in subsequent emails.
	Bedman Creek & Dog Canal LOMR HECRAS	Y	Used to modify cross-sections and Manning's
	East Mulloch Drainage District Model (ICPR3)	Y	Used to modify cross-sections, culverts and weirs
	EMDD ICPR Model Files	Y	Used to modify cross-sections, culverts and weirs

SLCFMP			
DATA/RESOURCES CATALOG			
Provider	**Title**	**Accessed (Y/N)**	**Commentary**
Lee County DNR	FGCU Buckingham Canal Topo	Y	Used to include new branch, cross-sections, culverts and weirs
	GIS Layers	Y	
	*1% Stillwater Elevations (Raster File)	Y	This file was reviewed for comparison with the Irma peak stage. Will not be used in the model.
	*ArcGIS_HighWaterMark (jpeg)	Y	Reviewed.
	*Flood Questioners (gdb)	Y	Reviewed.
	*Flooded Areas_Watersheds	Y	Reviewed.
	*http://leegis.maps.arcgis.com/apps/webappviewer/index.html?id=5159446cf7264c35ab9bc446a55e5a1a	Y	Used to understand the flooding concerns.
	*https://www.leegov.com/gis/data/gis-data.	Y	Downloaded shapefiles necessary for the model and FPLOS processing (i.e. land records, rivers, lakes, watersheds, major roads, etc.)
	Groundwater Monitoring Data	Y	Groundwater data processed and input as calibration or boundary data
	Hickey Swamp Conveyance (Pages from 991012-3_ComplianceEngHistoryMaps1_674412) (pdf)	Y	Reviewed for missing model data
	Hidden Cypress-Edison Farms Preserves_Survey SOW with Detail Sheets_22Jul2018_reduced (pdf)	Y	Reviewed for missing model data
	Hydrological-Monitoring (http://www.leegov.com/naturalreources/hydrological-monitoring)	Y	Station information downloaded from this site.
	Irma Aerials (Taken around September 12th): http://www.arcgis.com/apps/webappviewer/index.html?id=02a763300e1d49fd9332b863f5b29983	Y	Used to confirm flooding extent
	Island Park (Estero Marsh) As-Built Drawing	Y	Not used in existing condition model. Will be conceptualized as a flood code in a "maintained" condition simulation.
	Island Park Mitigation Site Photo 1	Y	Reviewed.
	Island Park Mitigation Site Photo 2	Y	Reviewed.
	L3 Canal Data	Y	
	*18063 L-3 CANAL TOPO (autocad file)	Y	
	*18063 L-3 CANAL TOPO (excel)	Y	
	Lee County Phase II Flood Assessment	Y	Reviewed and used to understand flooding
	Lee County Rain Data	Y	
	*Alva Fire Department, Bonita Springs Utilities, Corkscrew Water Plant, Fort Myers Beach Plant, Gateway, Hendry County Landfill, Lake Fairways, Lakes Park, Lehigh Utilities, Lover's Key, Olga Water Plant, Paige Field/Lee Tran, Ten Mile Canal, Three Oaks, Waste to Energy Plant	Y	Reviewed and processed for rainfall input
	Lee DNR Hydrological Monitoring	Y	WL data processed and input as calibration data
	New Evacuation Zone (post Irma) (pdf)	Y	Reviewed.
	NOAA Tides and Currents	Y	Reviewed.
	*Fort Myers (https://tidesandcurrents.noaa.gov/waterlevels.html?id=8725520&units=standard&bdate=20170901&edate=20170920&timezone=GMT&datum=NAVD&interval=6&action=)	Y	Used as boundary conditions
	*Naples (https://tidesandcurrents.noaa.gov/waterlevels.html?id=8725110)	Y	Used as boundary conditions
	NRCS Soils Data	Y	Used for soils data
	Olga Watershed	Y	
	*Hawk's Haven (pdf)	Y	
	Other Sources	Y	
	*Bob Howard's Research/Report	Y	Reviewed.
	*Island Parks Citizen.org	Y	Reviewed.
	Post Irma Aerials	Y	Used to confirm flooding extent
	Post Irma Articles	Y	Used to confirm flooding extent
	Post Irma Phase 2 Reports and Flood Assessment Rank Maps *(Only used South of the River)*	Y	

SLCFMP DATA/RESOURCES CATALOG			
Provider	**Title**	**Accessed (Y/N)**	**Commentary**
Lee County DNR	*Lehigh Acres	Y	Reviewed to understand the extent of flooding.
	*North Fort Myers	N	Not geographically relevant
	*Southeast Lee County	Y	Reviewed to understand the extent of flooding.
	*South Fort Myers	Y	Reviewed to understand the extent of flooding.
	*Whiskey Creek	Y	Reviewed to understand the extent of flooding.
	*44471_SURVEYORS_REPORT_FINAL (pdf)	Y	Reviewed to understand the extent of flooding.
	*http://www.leegov.com/irma/flood	Y	Reviewed to understand the extent of flooding.
	Provincetown Information	Y	
	*Culverts	Y	Reviewed and used to update M11 model
	*LCDOT Spot Elevations	Y	Reviewed and used to update M11 model
	*SFWMD Permit #971006-19	Y	Reviewed and used to update M11 model
	*SFWMD Permit Map	Y	Reviewed and used to update M11 model
	*Part1-SFWMD Research Provincetown-H7	Y	Reviewed and used to update M11 model
	*Part2-SFWMD Research Provincetown-H7	Y	Reviewed and used to update M11 model
	*Part3-SFWMD Research Provincetown-H7	Y	Reviewed and used to update M11 model
	RepetitiveLossArea MAPS 5-30-19 (pdf)	Y	Reviewed and will be used during FPLOS task
	Surface Water Levels (2016-2017)	Y	Reviewed, processed, and input into the model as calibration data
	Surface Water Publications (South of the Caloosahatchee River)	Y	
	*Danish Hydraulic Institute (DHI) Surface Water Quality Model of Estero Bay Watershed (February 2002)	Y	Reviewed for relevant information (i.e. structures, canals, etc.)
	*East Mulloch Report (July 2008)	Y	Reviewed for relevant information (i.e. structures, canals, etc.)
	*Lakes Park Water Quality Testing With Alum Injection (2011)	N	No relevant model inputs
	*Lee County Best Management Practices Final Report (November 2009)	Y	Reviewed for relevant information (i.e. structures, canals, etc.)
	*Lee County Culvert Map *(Major culvert crossing within watersheds)*	Y	Used to verify culvert locations
	*Lee County Conservation 2020 Preserves *(South of the River)* (https://www.leegov.com/conservation2020/preserves)	Y	
	*Alva Scrub Preserve, Billy Creek Preserve, Bob Janes Preserve, Buckingham Trails Preserve, Corkscrew Regional Ecosystem Watershed, Deep Lagoon Preserve, Estero Marsh Preserve, Flag Pond Preserve, Gator Hole Preserve, GS-10, Hickey Creek Greenbriar Cinnector, Hickey Creek Mitigation Park, Hickory Swamp Preserve, Hidden Cypress Preserve, Imperial Marsh Preserve, Imperial River Preserve, Koreshan Preserve, Larry Kiker Preserve, Mullock Pass Preserve, Oak Creek Preserve, Olga Shores Preserve, Orange River Preserve, Pine Lake Preserve, San Carlos Bay - Bunche Beach Preserve, Six Mile Cypress Slough Preserve, Six Mile Cypress Slough Preserve North, West Marsh Preserve, Wild Turkey Strand Preserve	Y	Used to understand the extent of various preserves.

SLCFMP			
DATA/RESOURCES CATALOG			
Provider	**Title**	**Accessed (Y/N)**	**Commentary**
Lee County DNR	*Buttonwood Preserve, Caloosahatchee Creeks Preserve, Carver Preserve, Cayo Costa Preserve, Cayo Pelau Preserve, Charlotte Harbor Buffer Preserve, Columbus G. McLeod Preserve, Daniels Preserve at Spanish Creek, Ding Darling Preserve, Galt Preserve, Matanzas Pass Preserve, Pine Island Flatwoods Preserve, Pineland Site Complex, Pop Ash Creek Preserve, Powell Creek Preserve, Prairie Pines Preserve, Smokehouse Bay Preserve, Telegraph Creek Preserve, Yellow Fever Creek Preserve, Yucca Pens Preserve	N	No relevant model inputs
	*Lee County Surface Water Management Plan (CAD dwgs, reports, HECRAS--from 1991-1996)	Y	Used to fill missing data such as culvert, gate, and weir dimensions.
	*Progress Report: Nitrogen Reduction Phase One Pilot Testing at Lakes Park (November 2013)	Y	Reviewed for relevant information
	*South Lee County Watershed Plan Final Reccommendations (January 2011)	Y	Reviewed to fill missing information gaps
	*South Lee County Watershed Plan Update Final Report (May 2009)	Y	Reviewed to fill missing information gaps
	*Ten Mile Canal Filter Marsh Final Report (10/24/07)	Y	Used to modify cross-sections and Manning's
	*The Lee County Southeastern Density Reduction Groundwater Resource DR/GR Area (September 2009)	Y	Reviewed for relevant information (i.e. structures, canals, groundwater parameters, etc.)
	SFWMD Permit App 190725-2 Pipe Under Estero Parkway (pdf)	Y	Reviewed.
	USGS Flood Irma Viewer (https:\\stn.wim.usgs.gov/FEV/#IrmaSeptember2017)	Y	Reviewed.
	Watershed Master Plan Credit CRS Manual (pdf)	Y	Reviewed to fill missing information gaps
	Well Data (Available Surficial, Lower Tamiami, and Sandstone Well Data *(South of the River))*	Y	
	*Shared Files 1, 3, & 4 (separate folders of excel file data)	Y	Groundwater data processed and input as calibration or boundary data
	Wellfiled Pumping Rates (LCU) 1-16 to 12-17 (6 excel files)	Y	Processed and input to update the pumping files through 2017
Lee County Port Authority	Groundwater Monitoring Data (on wells) (2016-2018)	Y	Groundwater data processed and input as calibration data
	LCPA Water Level Data	Y	
	*LCPA Mit Park	Y	
	*2018-Mit Park Hydrographs (pdf)	Y	
	*Data Logger History Mit Park-11X17 (pdf)	Y	
	*LCPA Onsite	Y	
	*2018-Onsite Hydrographs_Rev1 (pdf)	Y	
	*Data Logger Locations Mit Park TNB 8x11 NE (pdf)	Y	
	*Data Logger Locations Mit Park TNB 8x11 SW (pdf)	Y	
	*Fig 1 - S-16-Sample Location Map (pdf)	Y	
	*Figure 3 - S16 Water Level and Flow (pdf)	Y	
Lee County Utilities Data	LCU Monitoring Data (1 excel file)	Y	Processed in GIS and reviewed for relevance. Used a few surface water stations for calibration
	Monitoring Data (Green Meadows & Corkscrew Wellfields) (pdf)	Y	Processed and input to update the pumping files through 2017
SFWMD	2003 25-ft SWFFS LiDAR dataset	Y	Used to to develop topography input and fill Hendry County topography gap
	2007 f-ft Collier County LiDAR dataset	Y	Used to develop topography input and fill Collier County topography
	2007 5-ft Lee County LiDAR dataset	Y	Used to develop topography input
	2014-2016 Land Use	Y	Used to develop landuse (vegetation) map, and as a basis for other input such as manning's
	Approved Permits	Y	

SLCFMP			
DATA/RESOURCES CATALOG			
Provider	**Title**	**Accessed (Y/N)**	**Commentary**
SFWMD	*Bonita National_LtrMod, Corkscrew Crossing Permit, Ginn Development (Pre-Wilod Blue), Imperial Marsh Preserve, Pepperland Approved Permit, Pepperland Narrative, Pepperland Pre-Post Outfall Ditch Exhibit, Pepperland Stormwater Calcs, The Place Calculations, The Place Plans, University Village Calculations, University Village Nutrient Removal Calculations, University Village Plans, Waldrop Wildblue Comments, Wild Blue_PetitionAdminHearing_20150924, Wild Blue_sfwmd nutrient analysis, Wild Blue_Stormwater Plans, Wild Blue-Topo and Seasonal Storm Water Elevations Exhibit, Wildblue Stormwater Calcs **(all pdfs)**	Y	
	Groundwater Monitoring Data	Y	
	*DBHYDRO online database	Y	Groundwater data processed and input as calibration or boundary data
	Rainfall Data	Y	
	*DBHYDRO online database	Y	
	*Cocohatchee Canal, Corkscrew Swamp Sanctuary Rain, Flint Pen Strand Weather Station, Immokalee Landfill, Lee County Tower, Ft Myers at Orange River, Lehigh Acres Waste Water Treatment Okant, S-79 Spillway & lock on Caloosahatchee River near Olga, Spillway on Cocohatchee Canal at Palm River Rd.	Y	Rainfall data downloaded and input into model
	Surface Water Monitoring Data	Y	
	*DBHYDRO online database	Y	Surface water data processed and input as calibration or boundary data
SWFRPC	Bonita Springs Flood Reduction Plan	Y	
	*City of Bonita Springs Flood Reduction and Watershed Restoration Plan	Y	
Village of Estero	Exec Summary (word doc)	Y	
	Local Scale Study	Y	
	*00 Report	Y	
	*Volume 1	Y	
	*VOE_SWMP_REPORT Final Oct 2018 (pdf)	Y	
	*Volume 2	Y	
	*22 different maps pertaining to report (pdf)	Y	
	*01 Models	Y	
	*HEC-RAS	Y	
Village of Estero	*Estero River GeoHECRAS & HECRAS	Y	
	*Halfway Creek GeoHECRAS & HECRAS	Y	
	*ICPR	Y	
	*VOE_SWMP_BO	Y	
	*VOE_SWMP_Ex_2017	Y	
	*VOE_SWMP_Prop	Y	
	*Projects 1-14	Y	
	*02 Main Data	Y	
	*Supporting Data	Y	
	Lower West Coast Surficial and Intermediate Aquifer Systems Model	Y	Reviewed to understand the regional groundwater parameters
	Pages from VOE_SWMP_REPORT Final Oct 2018 (word doc)	Y	
	Regional Study	Y	
	*Final_VOE_Model	Y	
	The Village of Estero regional MIKE SHE/11 model (2018)	Y	Used as a starting point for the model (M11 and other input data)
USGS	Groundwater Monitoring Data	Y	Groundwater data processed and input as calibration or boundary data
	Surface Water Monitoring Data	Y	
	*USGS Waterdata Online	Y	Surface water data processed and input as calibration or boundary data

4.2 LOCAL MODELING OF TEN MILE, J, AND L CANALS

PURPOSE

Task 2 of the Southern Lee County Flood Mitigation Plan identified over 40 conceptual projects that had the potential to mitigate regional flooding impacts from significant storm events. A multi-dimensional, interconnected regional model was developed in Task 4.1 to determine the effects of the proposed conceptual projects at a regional level. From the list of conceptual projects included in the regional model, three local projects were identified and modeled at a local level to provide an increased level of design detail for each project.

BACKGROUND

The conceptual flood hazard mitigation projects developed for the South Fort Myers area include a number of sub-projects aimed at reducing flooding impacts to the areas along the southern end of Ten Mile Canal, including communities along Island Park Road. To alleviate the amount of flow in Ten Mile Canal downstream of US 41, multiple flow diversion points are proposed that will function as side-bank spillways from Ten Mile Canal into the upstream end of the adjacent canals to the west created by the former Iona Drainage District (IDD). Maintenance of the canals within the unincorporated areas of Lee County is currently performed by the County and the canals within the City of Fort Myers are maintained by the City.

The IDD canal watersheds have relatively short times of concentration, and as a result the water levels in the canals rise and fall rapidly following intense rain events. By contrast, the watershed for Ten Mile Canal has a much longer time of concentration and water levels in the canal rise and fall more slowly. Installing motorized gates with telemetry control at the canal intersections can take advantage of these differences and allow time- and stage-dependent flows west out of Ten Mile Canal. The addition of pumps at the flow diversion points can further assist water management efforts before and after a storm event. Of the six flow diversion projects included in the regional model, IDD Canals J and L were selected for the local modeling effort to further refine the proposed flow diversions, canal stages, and conveyance reconfigurations.

The regional modeling effort confirmed the need for increased conveyance capacity of Ten Mile Canal downstream of US 41 to reduce flooding impacts from major storm events to the Island Park Road area. Options to increase the conveyance capacity of Ten Mile Canal that are discussed in the regional modeling section of this report include additional maintenance dredging of sediment buildup to obtain the design cross section, relocation of existing boat docks within the channel to off-channel docking, removal of vegetation within the channel at select locations, and selective widening of the canal. Together with restoring a consistent berm on the west side of Ten Mile Canal, the proposed conceptual projects will reduce the rate of overflow out of Ten Mile Canal into the Island Park Road area.

Given the local modeling's focus on identifying the optimal improvements to increase the conveyance capacity of Ten Mile Canal, the local modeling of the canal did not need to recreate the time-stage graphs of the design storm events that were simulated in the regional modeling. This allowed the use of a constant peak flowrate for Ten Mile Canal to calculate the resulting water surface elevations of the chosen scenarios. The watershed of Ten Mile Canal south of US 41 has a much shorter time of concentration than the watershed north of US 41 and discharge from many of the the stormwater management systems that drain into the canal south of US 41 are reduced to zero when the water level of Ten Mile Canal is at its peak. Therefore, the contributions to peak flow from the watershed south of US 41 are estimated to be negligible which allows for the input of uniform flow rates into the model software.

The primary focus of the local model for Canals J and L is identifying conveyance improvement options to convey side-bank flow diversions from Ten Mile Canal into the upstream end of the canals before and after a storm event. Therefore, the local modeling did not need to include the contributions from the surrounding watershed that were calculated in the regional model. Like the modeling of Ten Mile Canal, this allowed for the input of a constant flowrate into the local model to calculate the resulting water surface elevations of the chosen scenarios.

Backwater profiles were calculated using the HEC-RAS software developed by the U.S. Army Corps of Engineers (USACE). This is a well-established backwater profile analysis program that is designed to calculate the water surface elevations along rivers and channels given a known or estimated flowrate (as opposed to other commonly-used programs that are designed to calculate flow given a known rain depth and other inputs). The software is in the public domain, is widely accepted across the nation for one-dimensional modeling of water surface elevations with user-defined, constant flowrates, and has been used in Lee County for decades. The model software was updated by USACE as recently as March 2019. All profiles began at creek intersections that are near tidal waters, with a tailwater condition of 3.0 feet NAVD 88, which assumes some degree of coastal flooding and is consistent with the tailwater assumptions used in the regional model.

TEN MILE CANAL

Model Input

To confirm agreement of peak water levels and flows between the regional model software (multi-dimensional MIKE SHE with one-dimensional MIKE 11) and the local model software (one-dimensional HEC-RAS), the local model for Ten Mile Canal from US 41 to its intersection with Mullock Creek was initially built using the same input information and peak flows as the regional model. The differences in water surface elevations of the backwater profiles for the two models were between 0.1 feet and 0.5 feet throughout the two-mile segment of the canal, which is within generally-accepted tolerances given the large scale of the conceptual model and confirmed the suitability of using the HEC-RAS software.

Further refinements to the local model for Ten Mile Canal included the addition of cross sections at locations where the canal width changes and a refinement of the Manning's "n" roughness values across each cross section for the existing conditions simulation. The additional cross sections were generated using the bathymetric survey data collected by AIM Engineering & Surveying, Inc., in December 2017, before commencement of the post-storm canal dredging. The center of every cross section had an "n" value of 0.035 to represent the sandy-bottom canal, which is a commonly-used value in Lee County[1,2] and is consistent with published text values[3,4,5]. The side banks varied between 0.1 and 10, depending on the extent of the existing flow obstructions. The "n" value of 10 is a conservatively-high value and was selected to represent situations with near-total blockage of flow. An example of this is shown in **Figures 1** through **3**, where boat docks and vegetation within the channel at Station 127+00 were causing a near-total blockage of flow near the banks after the Invest 92L storm event in late August 2017 (**Figure 1**). Upon closer inspection at the same location, dense vegetation was found protruding into the main channel (**Figure 2**). Similar conditions were found at several locations nearby, which led to the decision to apply an "n" value of 10 to both banks along the stretch of the canal upstream and downstream of STA 127+00 (**Figure 3**). This approach was used for all cross sections of Ten Mile Canal downstream of US 41 in the existing conditions local model.

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[1] The FEMA Flood Insurance Study for Lee County (2008, revised 2018) used channel roughness values from 0.03 to 0.06 for most river/canal channels in Lee County.

[2] The 1991 Lee County Master Watershed Plan used a Manning's "n" factor of 0.03 for well-maintained channels in tidal reaches.

[3] Appendix 19.A, Manning's roughness coefficients for design use. Civil Engineering Reference Manual for the PE Exam, 15th Ed. (2015), by Michael Lindeburg.

[4] Open-Channel Hydraulics (1959) by Ven te Chow.

[5] Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains (1989), by George Arcement and Verne Schneider. U.S. Geological Survey.

Figure 1 - Example of vegetation and boat dock obstructions within the main channel of Ten Mile Canal at STA 127+00 causing restrictions to flow. Also shown are two off-channel boat access designs that do not cause flow restrictions. Photograph taken by Mark White, SFWMD.

Figure 2 - Example of vegetation obstructions within the channel at STA 127+00, looking south.

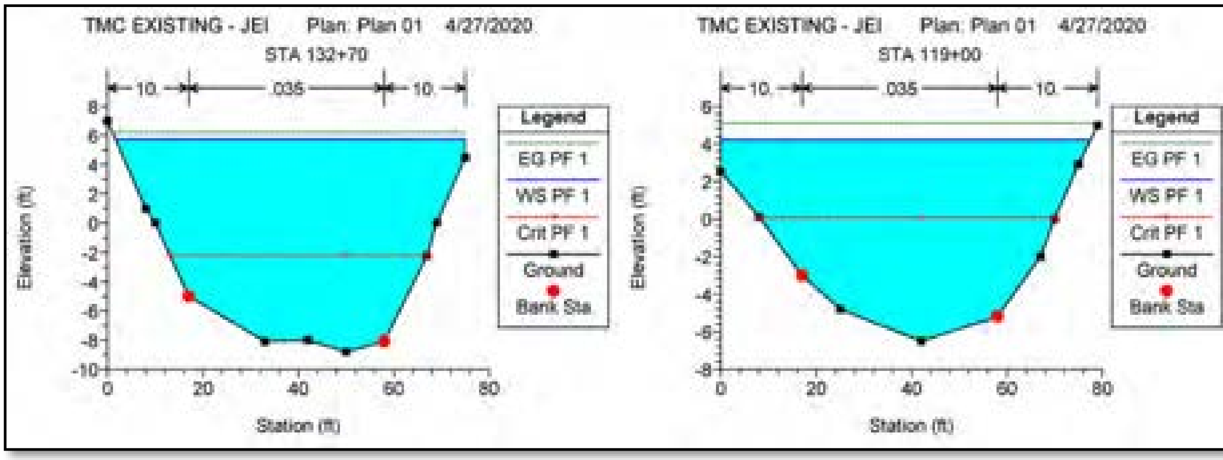


Figure 3 - Cross section information of sections immediately upstream and downstream of STA 127+00, with high Manning's "n" roughness coefficients applied to both banks to simulate the effects of the existing boat docks and vegetation within the channel. In the legend, EG=Energy Grade, WS=Water Surface, Crit.=Critical Depth, and PF=Profile.

After the storm events of August and September 2017, Lee County collected peak water level measurements throughout the county, including the areas around Ten Mile Canal. To check the accuracy of the existing conditions local model for Ten Mile Canal south of US 41, a model simulation was performed using the peak flow from the 2017 storm events and the resulting backwater profile elevations were compared with the measured elevations. The U.S. Geological Survey operates a stage and flow gaging station at the southernmost weir in Ten Mile Canal (USGS 02291673) that recorded a peak flow of approximately 2,600 cfs on August 28, 2017, and a total of six days above 2,000 cfs from the two storm events. Knowing that downstream of the weir the canal exceeded both banks in several locations in 2017 and flow exited the canal and entered the surrounding communities, the peak flowrate in the portion of the canal downstream of US 41 was likely lower than the peak flowrate measured at the weir upstream of US 41. For this model, a reduced flowrate of 2,300 cfs was selected as the estimated peak flowrate from the 2017 storm events for the portion of the canal downstream of US 41. As shown in **Figure 4**, the model results calibrated well with the peak water levels from the 2017 storm events.

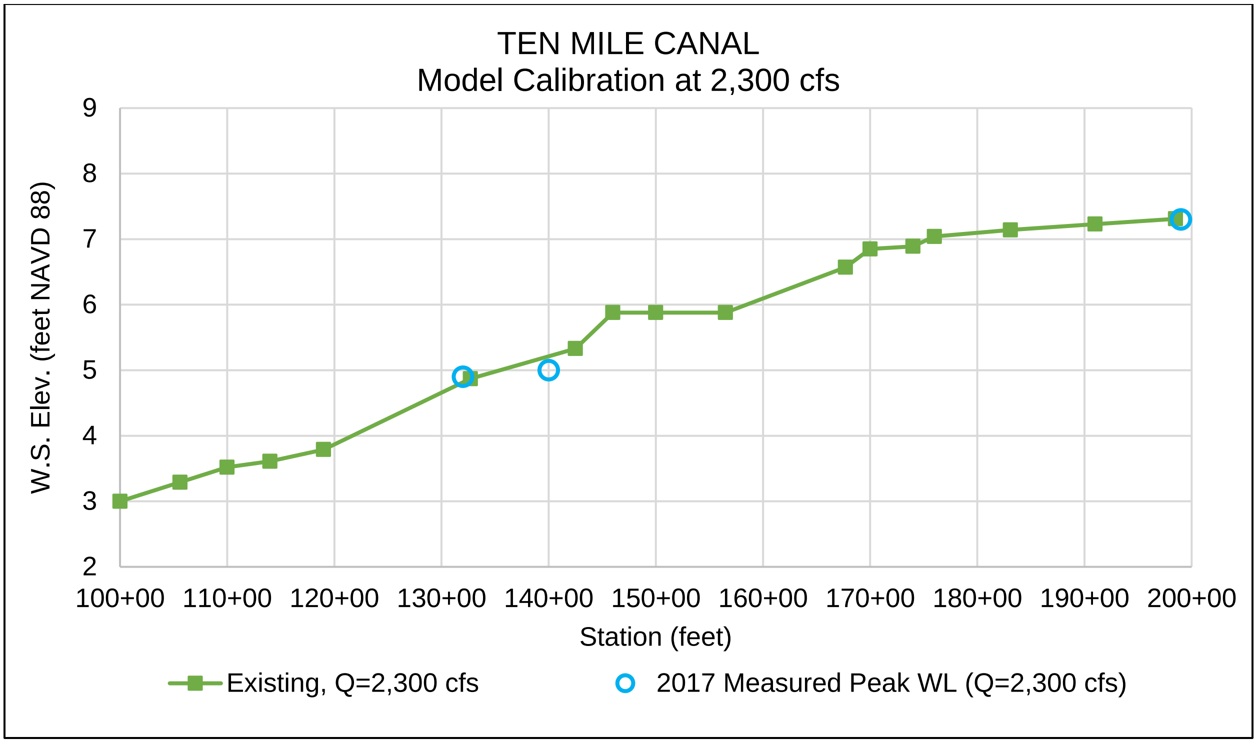


Figure 4 - Model calibration verification for Ten Mile Canal, downstream of US 41, comparing the flows and water levels from the 2017 storms events. The outlet into Mullock Creek is at STA 100+00 and the crossing with US 41 is at STA 198+00.

The local modeling of Ten Mile Canal downstream of US 41 included an investigation of three proposed scenarios aimed at mitigating flood impacts from major storm events. The scenarios are summarized as follows:

- Scenario 1: Remove all flow obstructions from both canal banks.
- Scenario 2: Deepen canal bottom and increase canal width at select locations but allow existing flow obstructions to remain.
- Scenario 3: Perform both Scenario 1 and Scenario 2.

The first scenario investigated the anticipated effects of removing all flow obstructions from both banks. To simulate this change, the roughness coefficients of both banks were reduced to 0.035, resulting in a uniform roughness coefficient across every cross section. The canal cross section geometry was not modified in the first scenario and remained identical to the cross sections in the existing conditions simulation. The second scenario maintained the high bank roughness coefficients of the existing conditions simulation, but the canal geometry was modified by deepening the canal bottom in several locations, as shown in **Figure 5**, and modifications to the width by cutting an opening in the existing east berm at STA 169+00 to allow flow into the parallel borrow lake and widening by approximately 20 feet from STA 159+00 through 156+00 (near the existing high-voltage electrical transmission line crossing). The third scenario incorporated the modifications from scenarios one and two, with modified cross section geometry and a uniform roughness coefficient of 0.035. A conceptual map of the three proposed scenarios for Ten Mile Canal downstream of US 41 is shown in **Sheet A**.

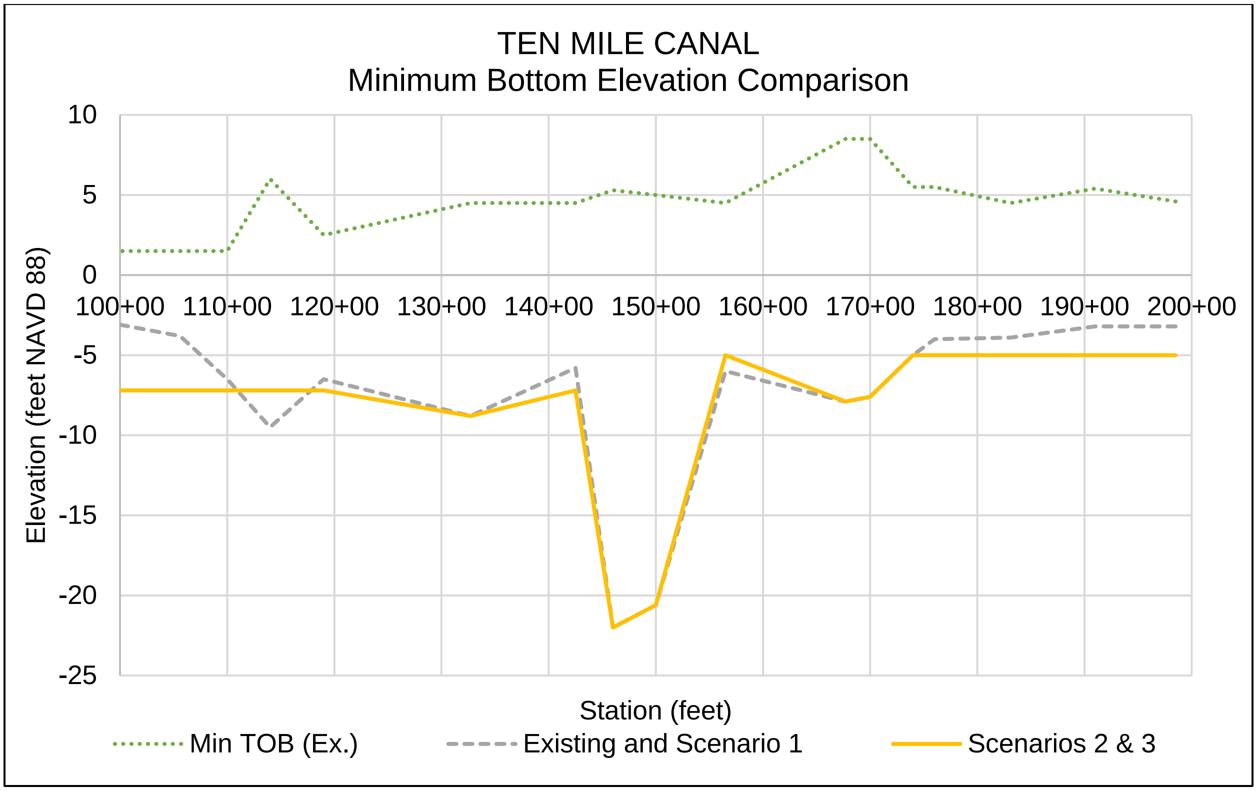
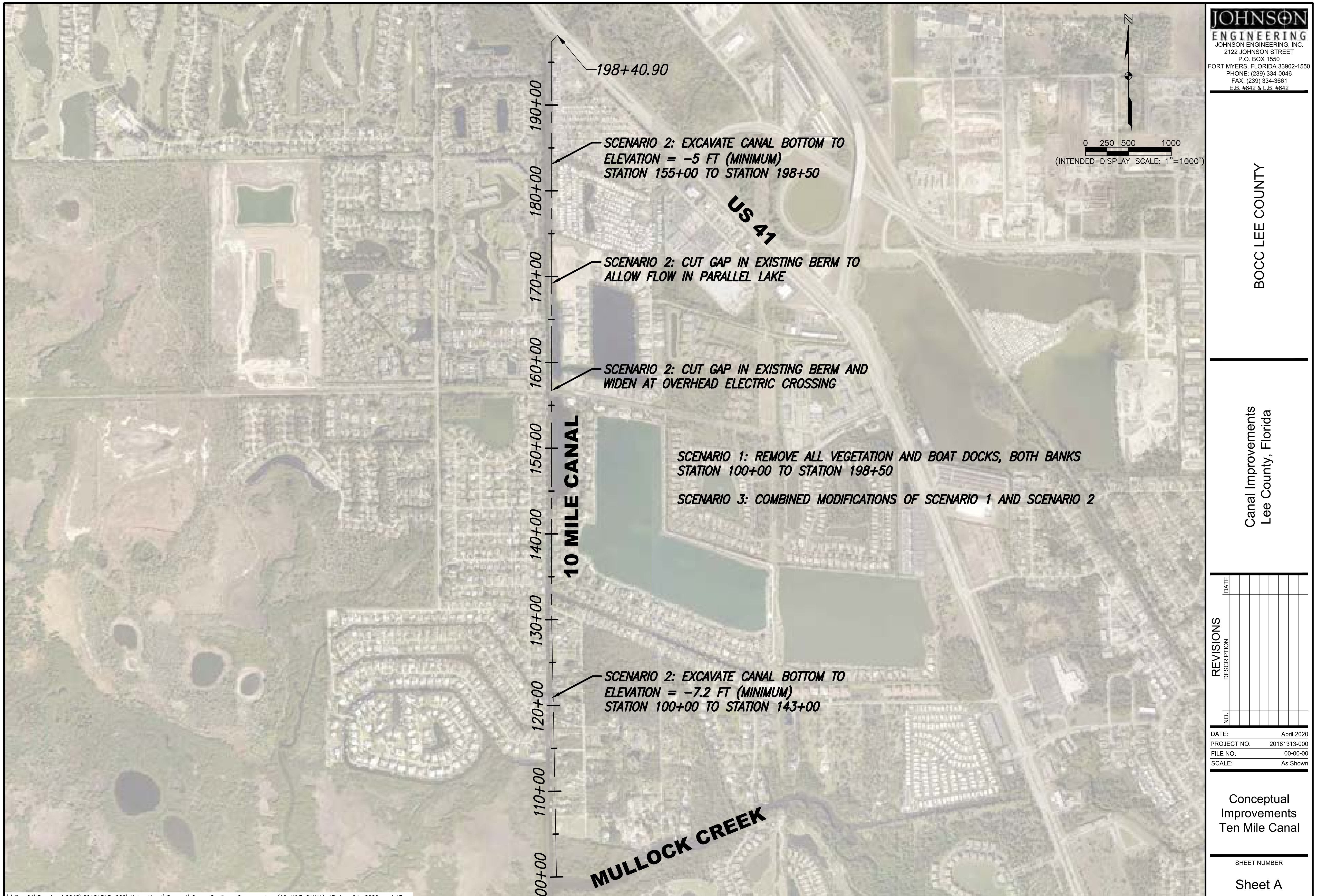


Figure 5 - Comparison of existing and proposed canal bottom elevations of Ten Mile Canal downstream of US 41. Also shown is existing minimum top of bank (TOB) elevations derived from 2019 LiDAR information, which typically represent adjacent roadway elevations. The outlet into Mullock Creek is at STA 100+00 and the crossing with US 41 is at STA 198+00.


198+40.90
190+00
180+00
170+00
160+00
150+00
140+00
130+00
120+00
110+00
100+00
10 MILE CANAL
US 41
MULLOCK CREEK
SCENARIO 2: EXCAVATE CANAL BOTTOM TO ELEVATION = -5 FT (MINIMUM) STATION 155+00 TO STATION 198+50
SCENARIO 2: CUT GAP IN EXISTING BERM TO ALLOW FLOW IN PARALLEL LAKE
SCENARIO 2: CUT GAP IN EXISTING BERM AND WIDEN AT OVERHEAD ELECTRIC CROSSING
SCENARIO 1: REMOVE ALL VEGETATION AND BOAT DOCKS, BOTH BANKS STATION 100+00 TO STATION 198+50
SCENARIO 3: COMBINED MODIFICATIONS OF SCENARIO 1 AND SCENARIO 2
SCENARIO 2: EXCAVATE CANAL BOTTOM TO ELEVATION = -7.2 FT (MINIMUM) STATION 100+00 TO STATION 143+00
N
0 250 500 1000
(INTENDED DISPLAY SCALE: 1"=1000')
\\ftms01\Drawings\2018\20181313-000\Water Mgmt\Support\Cross Sections_Compare.dwg (10 MILE CANAL) AP Aug 04, 2020 - 4:47pm
JOHNSON ENGINEERING
JOHNSON ENGINEERING, INC.
2122 JOHNSON STREET
P.O. BOX 1550
FORT MYERS, FLORIDA 33902-1550
PHONE: (239) 334-0046
FAX: (239) 334-3661
E.B. #642 & L.B. #642
BOCC LEE COUNTY
Canal Improvements
Lee County, Florida
REVISIONS
NO.
DESCRIPTION
DATE
DATE: April 2020
PROJECT NO. 20181313-000
FILE NO. 00-00-00
SCALE: As Shown
Conceptual Improvements Ten Mile Canal
SHEET NUMBER
Sheet A

Model Results and Discussion

The scenarios described previously were compared primarily based on backwater profile results from the HEC-RAS model simulations. The existing and proposed simulations for Ten Mile Canal were compared using the same flowrate to quantify estimated impact of each proposed scenario.

The backwater profile comparison shown in **Figure 13** shows the water surface elevation exceeding both banks in several locations in the existing conditions simulation at 2,300 cfs. This is consistent with flooding documented in the communities east and west of the canal after the 2017 storm events caused by flows exiting the canal and entering the surrounding communities. The backwater profile for the first proposed scenario demonstrates the anticipated reduction in peak water levels if all boat dock and vegetation overgrowth restrictions were removed from the channel. The peak water level was reduced by approximately one foot in the canal segment between The Harborage community and US 41. However, the peak water level continued to meet or exceed the east and west top of bank elevations at several locations.

The second scenario estimated the reduction in peak water levels in the canal due to dredging and widening at select locations, as described previously. The backwater profile for the second scenario is similar to the first, reducing the peak water level by approximately one foot in the one-mile section downstream of US 41, but is not able to maintain all flows within the canal.

The combined effects of the first and second scenarios is presented in the backwater profile for the third scenario. As shown in **Figure 13**, combining the two scenarios results in peak water levels that are at or below the adjacent top of bank elevations at most locations. The third scenario also highlights that modifications made to the canal alone are not likely to prevent all canal bank overtopping into the surrounding communities after storm events like those seen in 2017. If built in conjunction with the canal modifications, increasing the west berm elevation downstream of US 41 (including redesigning the existing boat ramps) will further mitigate the flood risk to the communities west of Island Park Road. The minimum berm elevation on the west side of the canal would need to be higher than the water level elevation shown in the graph to prevent water from leaving the canal and flowing through the communities to the west.

Sandy bottom canals in southwest Florida are typically designed with a maximum allowable velocity of two to three feet per second to reduce the potential for erosion, unless additional bank and bottom reinforcement measures are included in the design. **Figure 14** shows that the estimated channel velocities for all scenarios at 2,300 cfs exceed this threshold at several locations. The existing banks of the canal currently have seawalls and/or dense vegetation throughout. The higher velocities of the proposed scenarios highlight the importance that clearing the existing flow obstructions should be accompanied by bank stabilization measures to reduce the erosion potential. Given the size of Ten Mile Canal, installation of riprap or other stabilization measures along the canal bottom are not cost effective and impractical. Regular maintenance dredging will help to return the canal bottom to its design elevation.

Also added to **Figure 13** for comparison purposes is the preliminary Federal Emergency Management Agency (FEMA) base flood elevation of 11 feet along this section of Ten Mile Canal. The FEMA floodplain in this area is an extension of the coastal flooding from the Gulf of Mexico. The canal modifications investigated in this study are not likely to mitigate flood impacts from the design storm event used in the FEMA modeling that resulted in the coastal flood elevation of 11 feet.

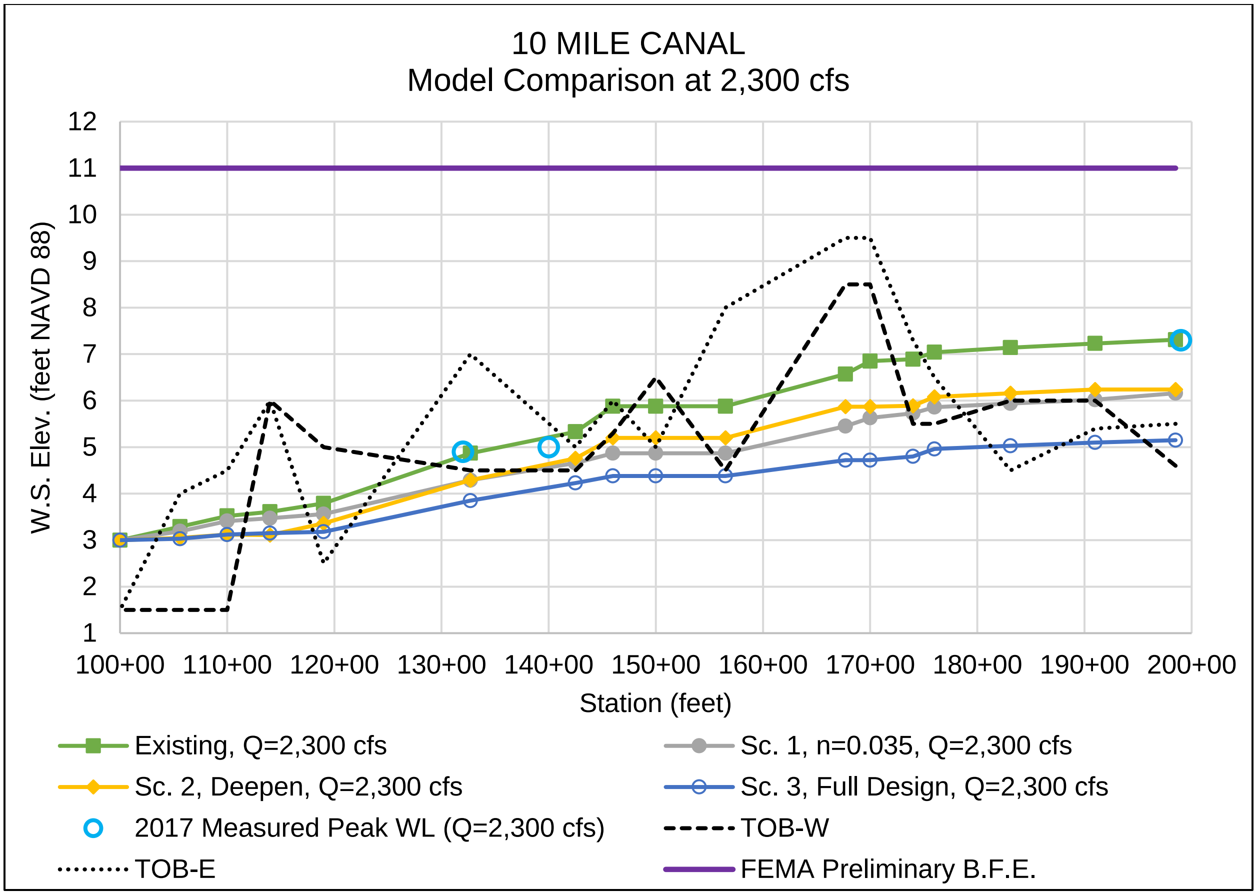


Figure 13 - Model results of three proposed scenarios of Ten Mile Canal downstream of US 41. The outlet into Mullock Creek is at STA 100+00 and the crossing with US 41 is at STA 198+00. The east and west top of bank (TOB) elevations were derived from 2019 LiDAR information and typically represent adjacent roadway elevations. A flow of 2,300 cfs was selected based on the approximate peak flows from the 2017 storm events.

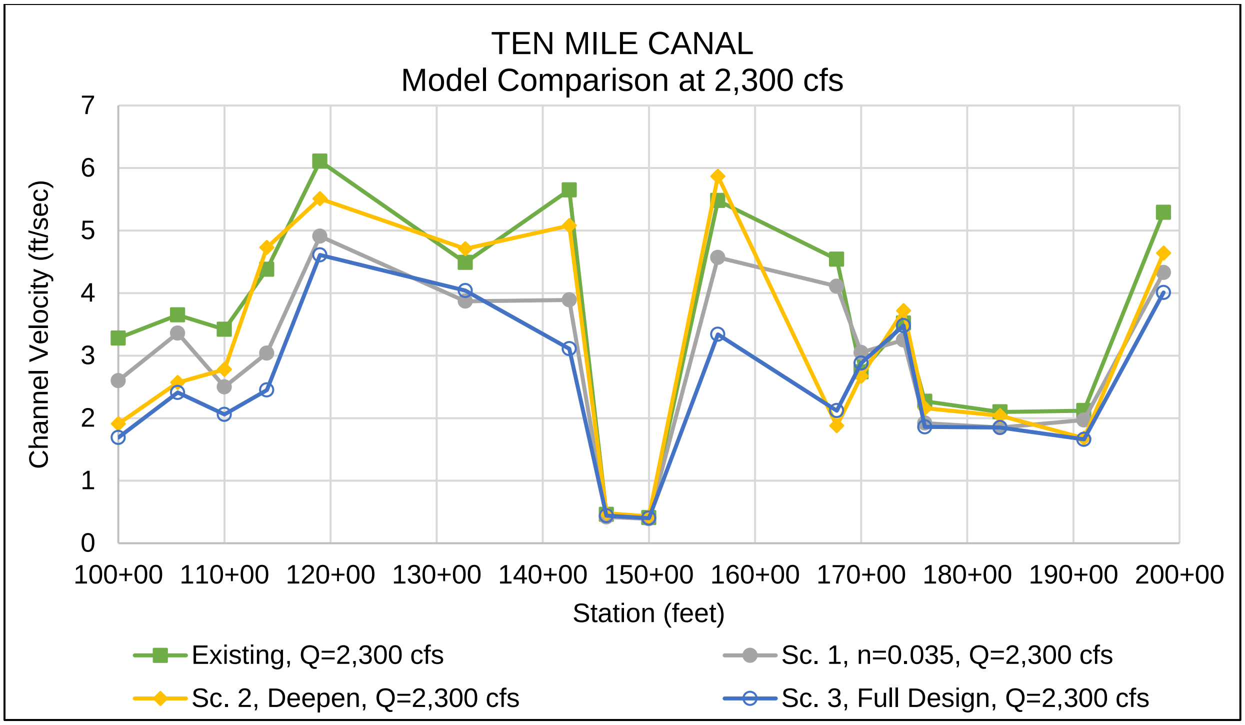


Figure 14 - Comparison of channel velocities for the four model simulations at 2,300 cfs.

Backwater profile comparisons were also made at flowrates of 1,600 cfs (**Figure 15**) and 3,100 cfs (**Figure 16**). The first flowrate approximates the anticipated water level reduction if upstream side-bank discharges were able to decrease the peak flow in Ten Mile Canal downstream of US 41 by 700 cfs. The water surface elevation at US 41 in the existing conditions scenario was reduced by approximately 1.5 feet, which nearly eliminates westward overflows into the Island Park community without raising the west berm elevation. Scenarios one and two further reduced the peak water levels at the 1,600 cfs flowrate by up to 0.9 feet. The third scenario reduced the water surface elevation at US 41 by 1.6 feet below the existing conditions water surface elevation at the 1,600 cfs flowrate.

The regional modeling results indicate increasing the conveyance capacity of Ten Mile Canal will increase the peak flowrate from the 100-year design storm event to approximately 3,100 cfs. **Figure 16** compares the backwater profiles of the three proposed scenarios. The existing conditions model results are not included, as the results would not be realistic given the depth of overbank exceedance. The water surface elevations of the first and second scenarios at this higher flowrate are within the range of peak water levels measured after the 2017 storm events and exceed the existing top of bank elevations at several locations. The third scenario reduced the water surface elevation at US 41 by approximately one foot below the 2017 measured peak water level, but the water surface profile also exceeds the existing top of bank elevations at several locations. The minimum berm elevation on the west side of the canal would need to be higher than the water level elevation shown in the graph to prevent water from leaving the canal and flowing through the communities to the west.

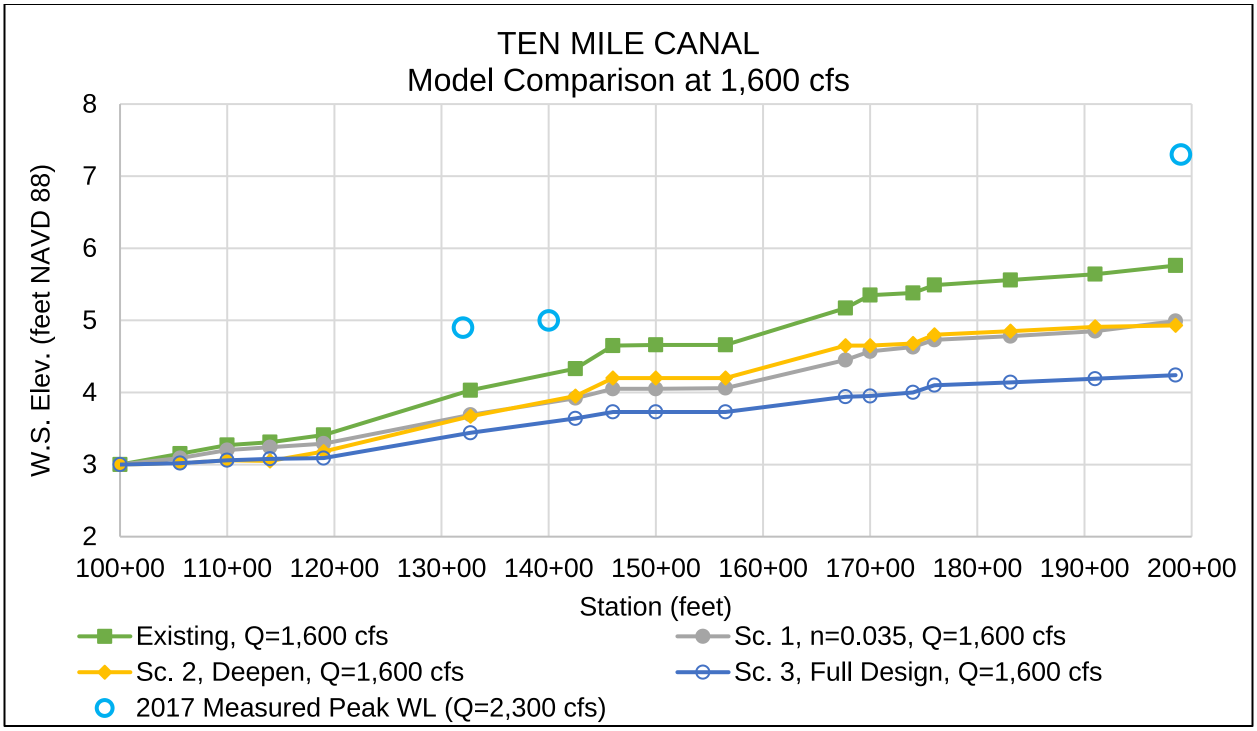


Figure 15 - Model results of three proposed scenarios of Ten Mile Canal downstream of US 41. A flow of 1,600 cfs was selected based on the approximate reduction in peak flows due to upstream side-bank discharge proposed by projects 1.4.1 and 1.4.2, discussed elsewhere in this report.

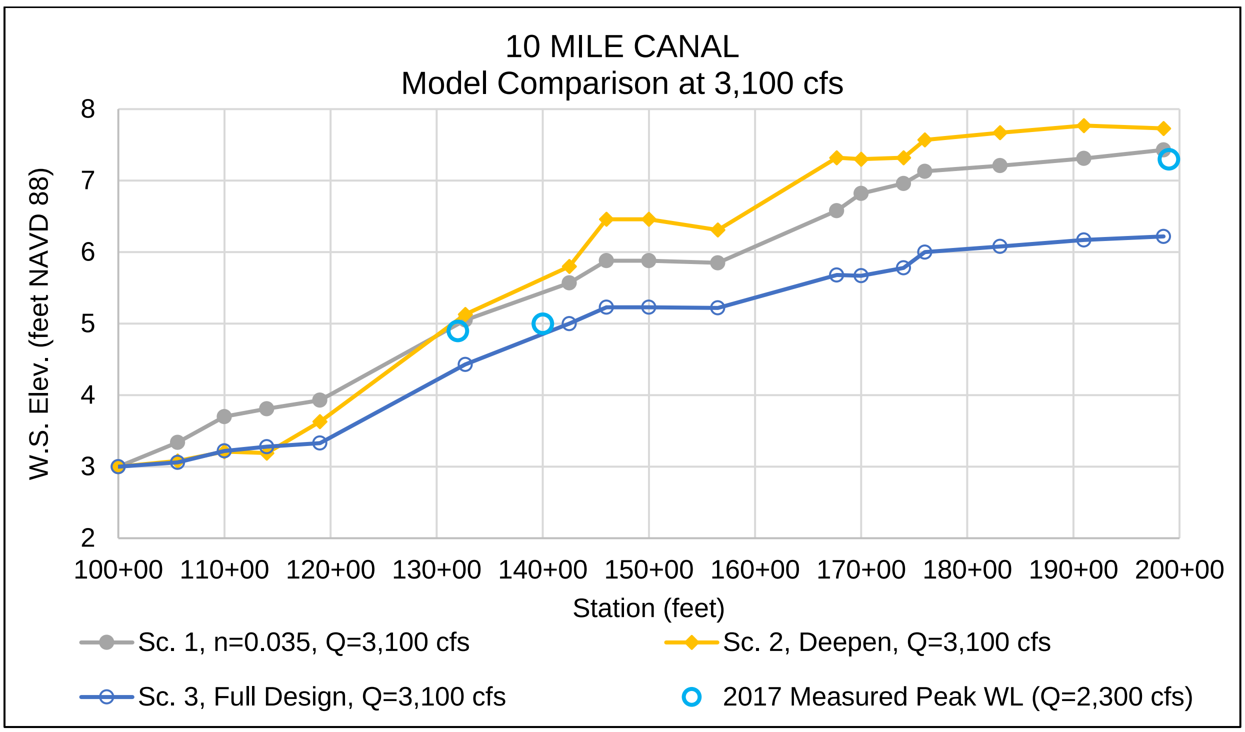


Figure 16 - Model results of three proposed scenarios of Ten Mile Canal downstream of US 41. A flow of 3,100 cfs was selected to estimate the resulting water surface elevations after increasing the capacity of the canal.

CANAL J

Model Input

Also originally created by the Iona Drainage District to provide drainage for agricultural lands, the watershed for Canal J today is mostly developed and includes a variety of urban land uses. Canal J generally lies along the historical path of the Six Mile Cypress Slough, when it provided freshwater flows into Hendry Creek over 100 years ago. The original ROW width for Canal J was 80 feet and extended from the East Branch of Hendry Creek to a point one-quarter mile west of Ten Mile Canal. The flow path of Canal J today deviates significantly from the historical design, with the furthest upstream quarter mile incorporated into the stormwater management system for the Jamaica Bay community. Downstream of the outfall weir for the Jamaica Bay community the flow path meanders between commercial and residential properties, is largely overgrown, and begins to be tidally influenced downstream of US 41. Upstream of the historical ROW extent, the lake system for the Jamaica Bay community continues to the west berm of Ten Mile Canal.

The local model for Canal J was created using the one-dimensional HEC-RAS software using cross sectional survey data collected in July 2019. A base model was initially created to simulate the existing conditions of the canal, with Manning's "n" roughness coefficients based on recent field observations. With the primary focus of the local model for Canal J being side-bank flow diversion from Ten Mile Canal into the upstream end of Canal J before and after a storm event, a design assumption is diversion into Canal J will not occur during times of peak flow in Canal J. This assumption allows for a simplification of the local model, using a uniform flowrate that is equal to the upstream flow diversion.

Initial model runs highlighted two significant existing flow restrictions in Canal J. The 30-inch diameter culvert under the frontage road east (upstream) of US 41 is significantly smaller than the double 6-foot by 4-foot box culverts under US 41 (**Figure 10**). Also, the existing weir at the southwest corner of the Jamaica Bay community (**Figure 11**) was designed to serve only that community and needs to be modified before conveying additional flow.

Figure 10 - Existing culverts in Canal J under the east frontage road (left) and US 41 (right).

Figure 11 - Existing outfall weir for the Jamaica Bay community.

The local modeling of Canal J included an investigation of three proposed scenarios aimed at side-bank flow diversion from Ten Mile Canal into the upstream end of Canal J before and after a storm event to mitigate flood impacts to communities within the watershed for Ten Mile Canal. In addition to the modifications described below, all scenarios included gates added to the existing outfall weir for the Jamaica Bay community that were modeled in the open position and replacing the existing culvert under the US 41 frontage road with box culverts extended from the existing culverts under US 41. The three scenarios are summarized as follows:

- Scenario 1: 50 cfs via gravity; install one 4-foot by 3-foot gate to existing weir.
- Scenario 2: 300 cfs via pump; install two 8-foot by 4-foot gates to existing weir; install vertical walls within existing canal (3,300-foot canal length); deepen canal (2,900-foot canal length).
- Scenario 3: 400 cfs via pump; install three 6-foot by 5-foot gates to existing weir; install vertical walls within existing canal (3,300-foot canal length); deepen canal (2,900-foot canal length); widen canal (7,400-foot canal length).

The first scenario investigated minimum canal modifications to convey flow via gravity alone. After several iterations, the optimized design included the addition of a 4-foot by 3-foot gate to the existing outfall weir at the southwest corner of the Jamaica Bay community. The design flowrate for the first scenario was 50 cfs.

The aim of the second scenario was to identify the highest potential diversion from Ten Mile Canal into Canal J based on canal improvements made only within the existing canal width (limited by existing developments on both sides of the canal). The selected alterations reduced the canal bottom elevation upstream of the existing outfall weir (see **Figure 12**), added two 8-foot by 4-foot gates to the weir at the southwest corner of the Jamaica Bay community, installed vertical walls from STA 157+00 to STA 190+00 (from US 41 to Ten Mile Canal) with a 30-foot bottom width, and required canal bank cleaning from STA 118+00 to STA 152+00. The design flowrate for the second scenario was 300 cfs, which would require installation of a pump station at the canal intersection. Due to insufficient upstream head conditions, gravity flow alone cannot divert 300 cfs pre-storm or for a prolonged period.

The third scenario investigated the maximum potential diversion flowrate based on modifications that utilized the entire historical 80-foot ROW width. The design included reducing the canal bottom elevation upstream of the existing outfall weir (see **Figure 12**), adding three 6-foot by 5-foot gates to the weir at the southwest corner of the Jamaica Bay community, installation of vertical walls from STA 157+00 to STA 190+00 (from US 41 to Ten Mile Canal) with a 50-foot bottom width, and canal widening to a 30-foot minimum bottom width from STA 118+00 to STA 152+00. The design flowrate for the third scenario was 400 cfs, which would require installation of a pump station at the canal intersection. A conceptual map of the three proposed scenarios for Canal J is shown in **Sheet B**.

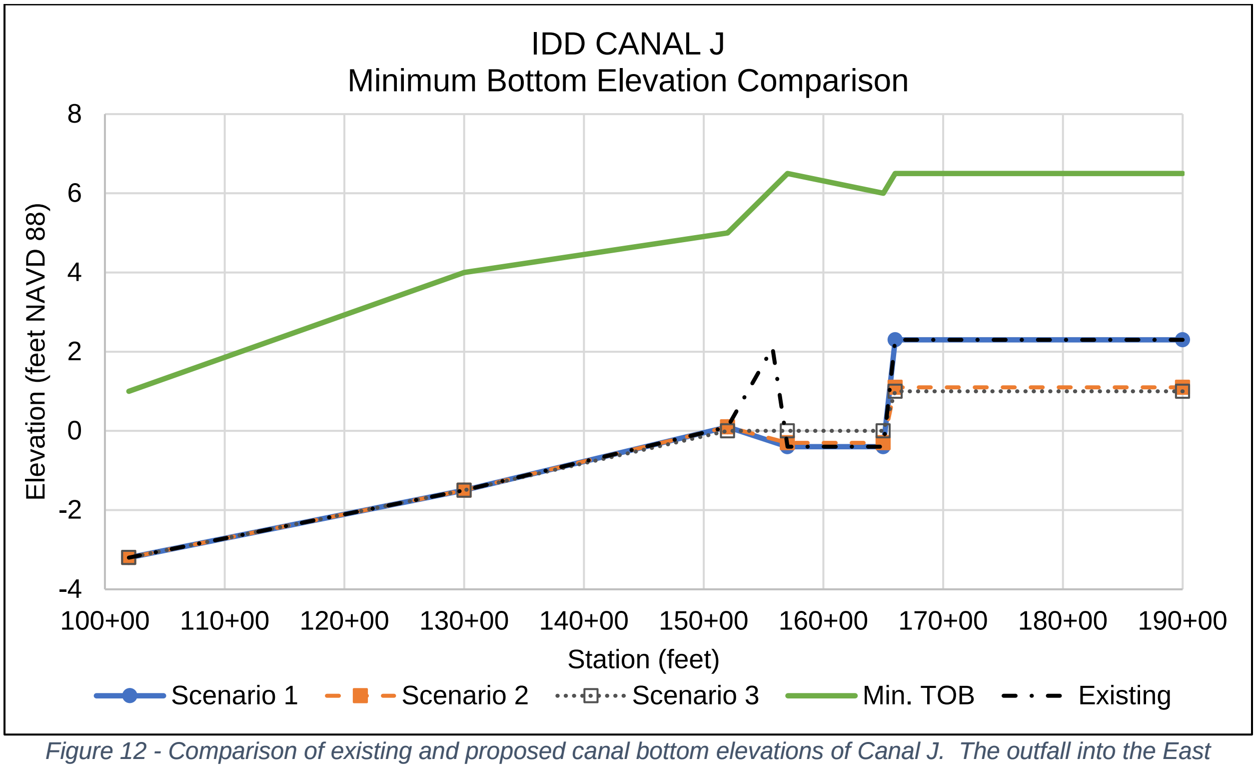
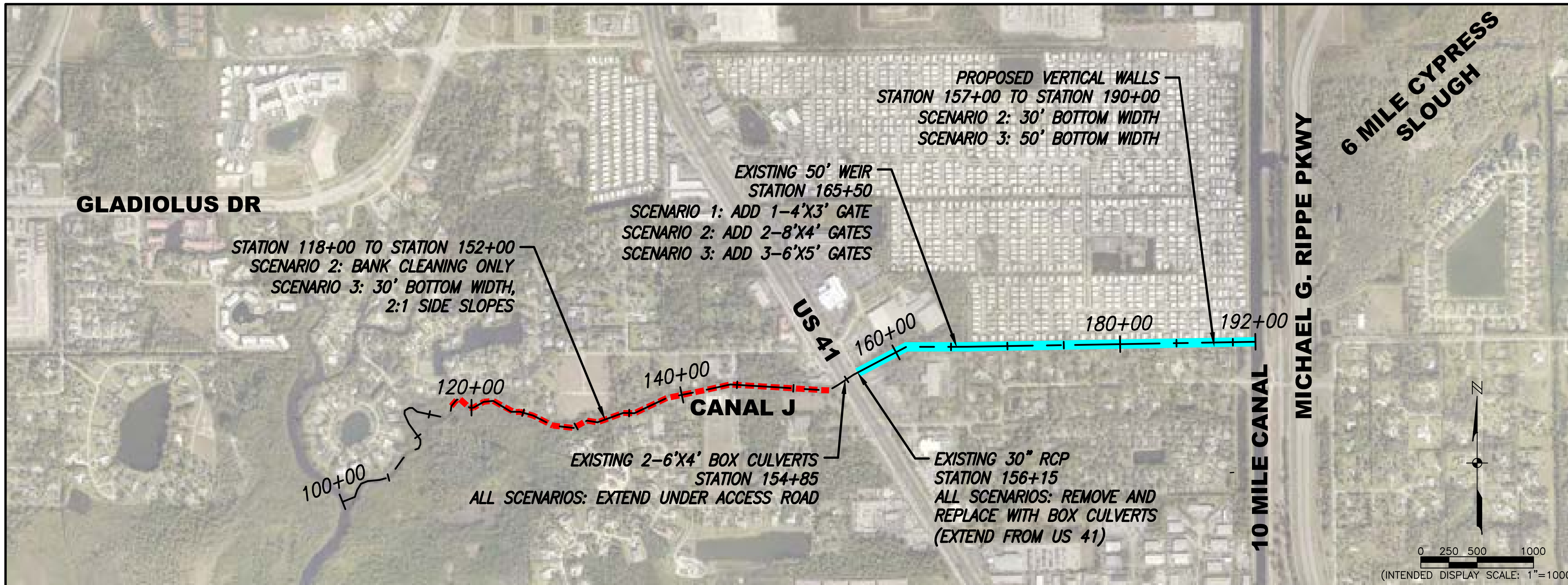
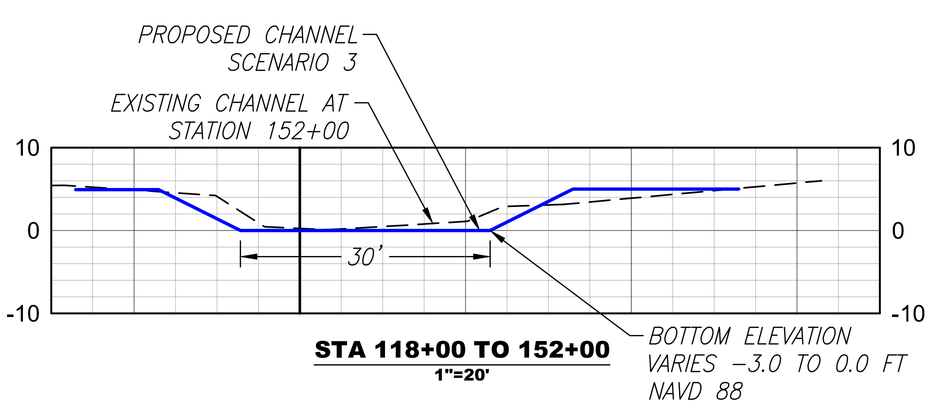


Figure 12 - Comparison of existing and proposed canal bottom elevations of Canal J. The outfall into the East Branch of Hendry Creek is at STA 100+00, US 41 is at STA 153+00, the existing weir is at STA 165+50 and the intersection with Ten Mile Canal is at STA 190+00.





STA 118+00 TO 152+00
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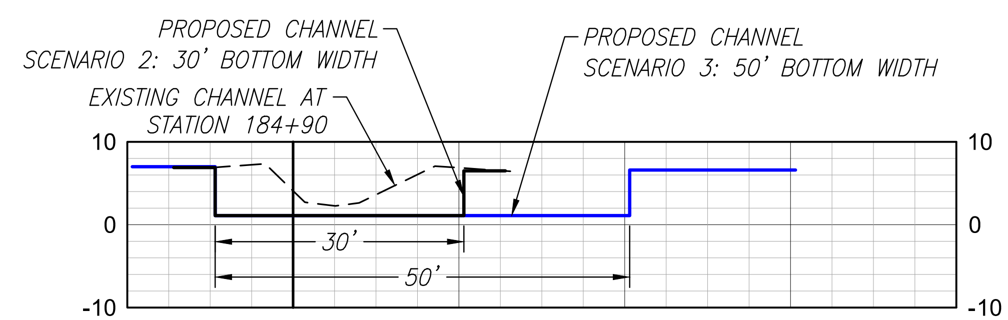

STA 157+00 TO 190+00
1"=20'

NOTE: CHANNEL WIDENING MAY REQUIRE THE RELOCATION OF EXISTING UTILITIES.

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BOCC LEE COUNTY

Canal Improvements
Lee County, Florida

REVISIONS

NO.	DESCRIPTION	DATE

DATE:	April 2020
PROJECT NO.	20181313-000
FILE NO.	00-00-00
SCALE:	As Shown

Conceptual Improvements Canal J

SHEET NUMBER
Sheet B

Model Results and Discussion

The scenarios described previously were compared primarily based on backwater profile results from the HEC-RAS model simulations. The flowrates for Canal J were selected based on an iterative process to estimate the highest potential flow diversion out of Ten Mile Canal based on the constraints of each proposed scenario.

The existing neighborhoods along Canal J are older and significantly lower in elevation than current requirements for new developments. As such, there is only approximately three feet of allowable headloss along the canal to convey the proposed flow diversions out of Ten Mile Canal and not cause roadway flooding. **Figure 19** demonstrates the water surface elevations of the three proposed scenarios are within a few tenths of a feet of the adjacent top of bank elevations at several locations. At the furthest downstream end, the top of bank elevation of 1 foot represents the LiDAR-derived elevation of a wetland area and is shown to be temporarily inundated due to coastal flooding. The channel velocities of each scenario shown in **Figure 20** are relatively low in each scenario and are not anticipated to cause erosion of the channel bank or bottom.

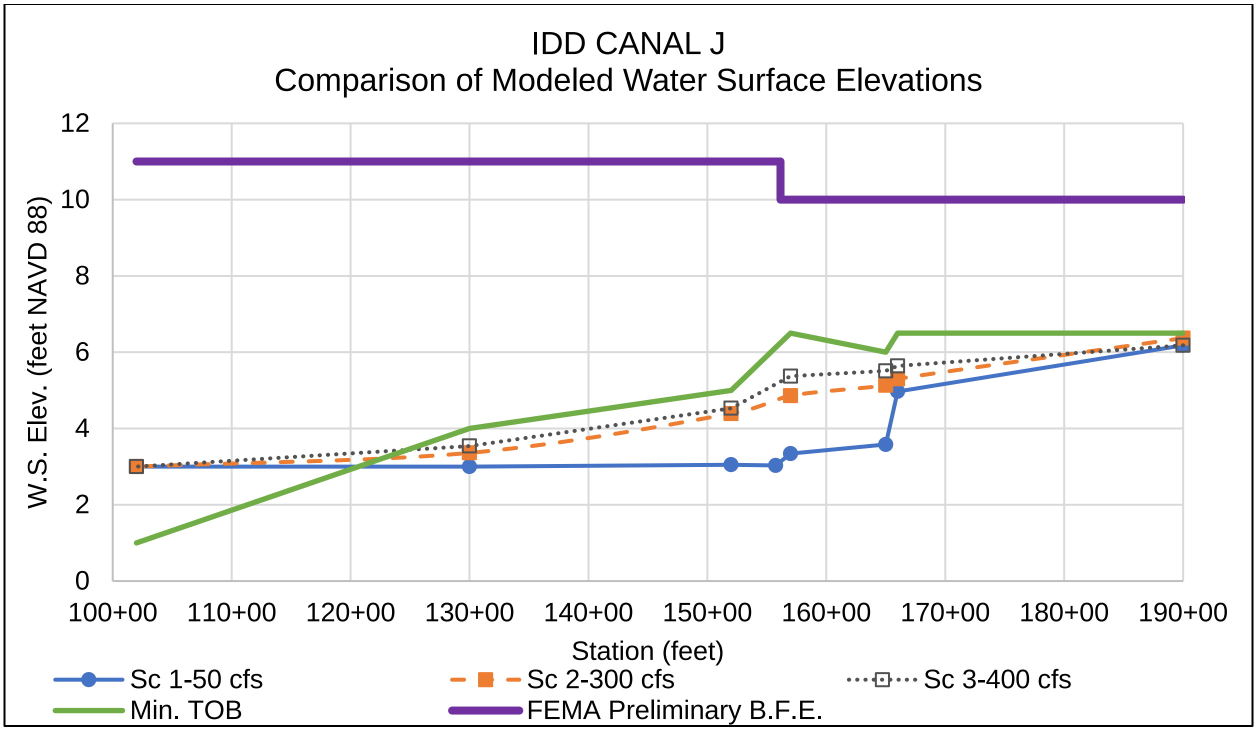


Figure 19 - Model results of three proposed scenarios of Canal J. The outfall into the East Branch of Hendry Creek is at STA 100+00, US 41 is at STA 153+00, the existing weir is at STA 165+50, and the intersection with Ten Mile Canal is at STA 190+00. The top of bank (TOB) elevations were derived from survey information and/or 2019 LiDAR information and typically represent adjacent roadway/parking elevations.

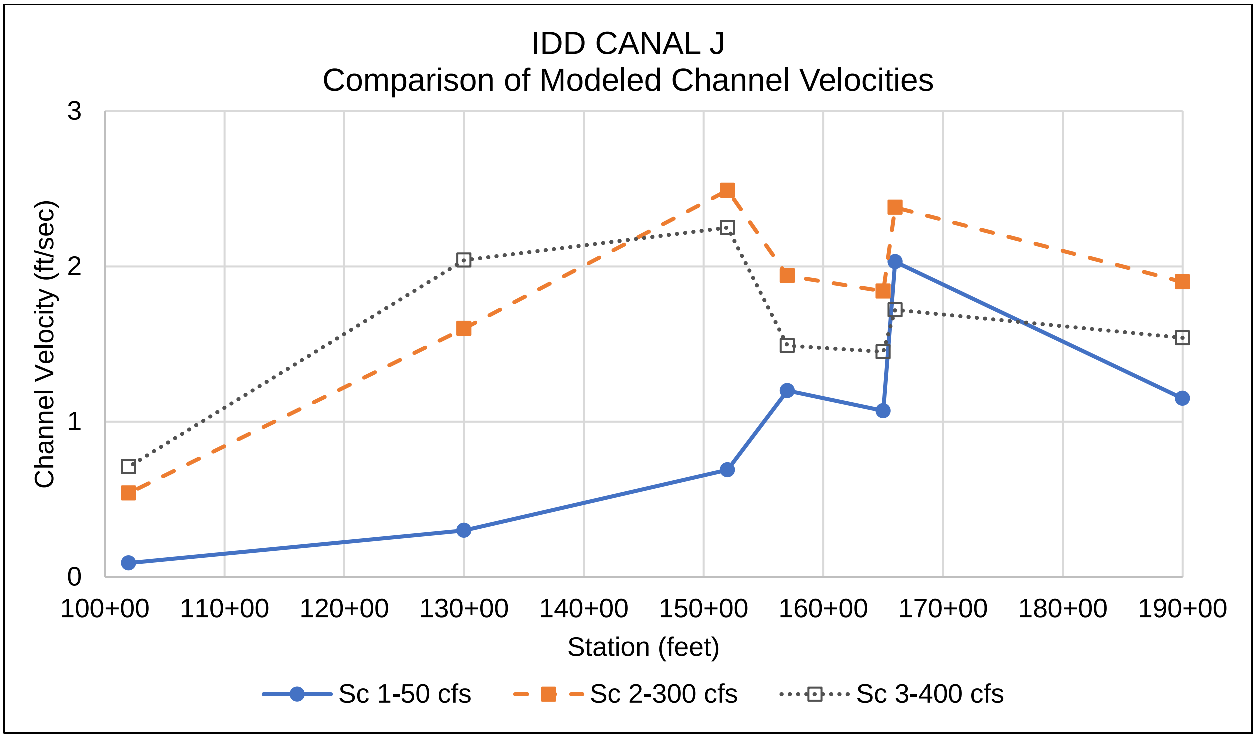


Figure 20 - Comparison of channel velocities for the three model simulations of Canal J.

CANAL L

Model Input

Originally created by the Iona Drainage District to provide drainage for agricultural lands, Canal L is a sub-watershed of Whiskey Creek's watershed. Today the areas upstream of Canal L are mostly developed and include a variety of urban land uses. Much of the development within the watershed is older and was accomplished without the use of stormwater detention areas, resulting in a relatively short time of concentration and the water level in the canal rises and falls rapidly following intense rain events. From the Canal L Watershed Water Management Study prepared for Lee County by Johnson Engineering, Inc., in 1988, the canal's right of way (ROW) width is 120 feet at the downstream end, from Whiskey Creek Drive upstream to its intersection with Canal L-3. The ROW width is then reduced to 80 feet and continues upstream to its intersection with Ten Mile Canal. Based on aerial imagery and historical permit records, development has encroached into the canal's ROW at several locations upstream of the Canal L-3 intersection, reducing the canal's width and conveyance capacity. The sole water control structure within Canal L is a weir immediately upstream of Whiskey Creek Drive. The weir's original design flowrate was 1,000 cfs from the 25-year design storm event. Another water control structure exists at the upstream end of Canal L at its intersection with Ten Mile Canal.

The local model for Canal L was created using the one-dimensional HEC-RAS software using cross sectional survey data collected in June 2019. A base model was initially created to simulate the existing conditions of the canal, with Manning's "n" roughness coefficients based on recent field observations. With the primary focus of the local model for Canal L being side-bank flow diversion from Ten Mile Canal into the upstream end of Canal L before and after a storm event, a design assumption is diversion into Canal L will not occur during times of peak flow in Canal L. This assumption allows for a simplification of the local model, using a uniform flowrate that is equal to the upstream flow diversion. This design assumption is also a critical component of the overall design modifications to the canal; as stated in the 1988 Study, "This controlled connection [from Ten Mile Canal into Canal L] is advantageous although an uncontrolled connection would be disastrous to the area west of Ten Mile Canal."

Initial model runs highlighted several significant existing flow restrictions at the upstream end of the canal. The box culvert under the 4th Street crossing is 7 feet by 4 feet (see **Figure 6**), which is significantly smaller than the design recommendation from the 1988 Study that all proposed structures above Danley Drive have a minimum cross-sectional area of 80 square feet. Historical permit records indicate the invert elevation of the box culvert under the 4th Street crossing is 6.4 feet NAVD 88, which is only 0.4 feet lower than the upstream control elevation for the Hideaway Golf Course. Initial model runs also identified restrictions to flow upstream of 4th Street due to a rapid rise in the canal bottom, heavy vegetation overgrowth on the south canal bank (**Figure 7**), and the invert elevation of the existing canal interconnect is too high if it is to be retrofitted for water management purposes ahead of a known storm event.

Figure 6 - Existing 7'x4' box culvert crossing of Canal L under 4th Street.

Figure 7 - Heavy vegetation overgrowth shown on south bank of Canal L upstream of 4th Street.

The local modeling of Canal L included an investigation of three proposed scenarios aimed at side-bank flow diversion from Ten Mile Canal into the upstream end of Canal L before and after a storm event to mitigate flood impacts to communities within the watershed for Ten Mile Canal. The three scenarios are summarized as follows:

- Scenario 1: 100 cfs via gravity; replace existing box culvert with one 8-foot by 5-foot box culvert; deepen canal (1,600-foot canal length).
- Scenario 2: 300 cfs via pump; replace existing box culvert with two 8-foot by 5-foot box culverts; deepen canal (1,600-foot canal length); install vertical walls within existing canal (2,600-foot canal length).
- Scenario 3: 400 cfs via pump; replace existing box culvert with three 10-foot by 5-foot box culverts; deepen canal (2,600-foot canal length); install vertical walls within canal (6,700-foot canal length); widen canal (6,700-foot canal length).

The first scenario investigated minimum canal modifications to convey flow via gravity alone. After several iterations, the optimized design included a reduced canal bottom elevation upstream of 4th Street (see **Figure 8**) and replacing the existing 7-foot by 4-foot box culvert under 4th Street with a minimum 8-foot by 5-foot box culvert with an invert elevation of 5.0 feet NAVD 88. The design flowrate for the first scenario was 100 cfs.

The second scenario was developed to identify the highest potential diversion from Ten Mile Canal into Canal L based on canal improvements made only within the existing canal width (limited by existing developments on both sides of the canal). The selected alterations included reducing the canal bottom elevation upstream of 4th Street, installing vertical walls from STA 210+00 (between 2nd Street and 3rd Street) to STA 236+00 with a 25-foot bottom width, and replacing the existing box culvert under 4th Street with double 8-foot by 5-foot box culverts with an invert elevation of 5.0 feet NAVD 88. The design flowrate for the second scenario was 300 cfs, which would require installation of a pump station at the canal intersection. Due to insufficient upstream head conditions, gravity flow alone cannot divert 300 cfs pre-storm or for a prolonged period.

The third scenario investigated the maximum potential diversion flowrate based on modifications that utilized the entire historical 80-foot ROW width. The design included reducing the canal bottom elevation upstream of Danley Drive, installing vertical walls from STA 169+00 (at the intersection with Canal L-3) to STA 236+00 with a 50-foot bottom width, and replacing the existing box culvert under 4th Street with triple 10-foot by 5-foot box culverts with an invert elevation of 5.0 feet NAVD 88. The design flowrate for the third scenario was 400 cfs, which would require installation of a pump station at the canal intersection. A conceptual map of the three proposed scenarios for Canal L is shown in **Sheet C**.

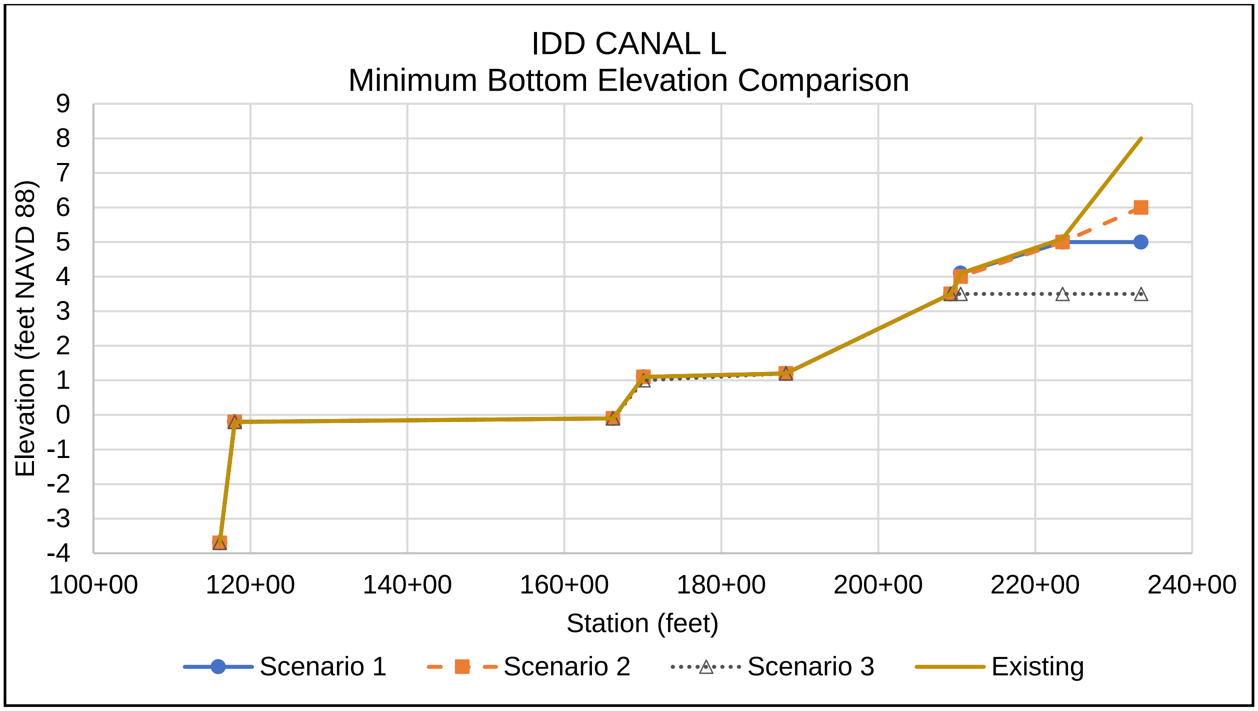
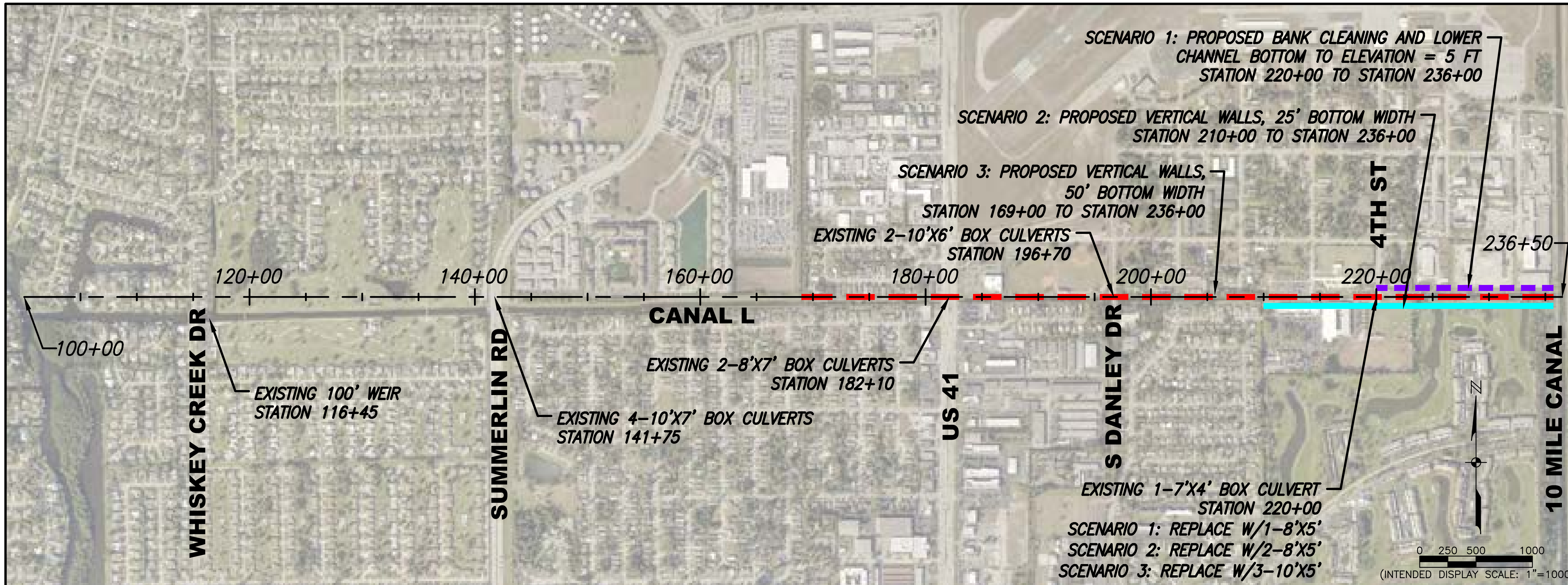
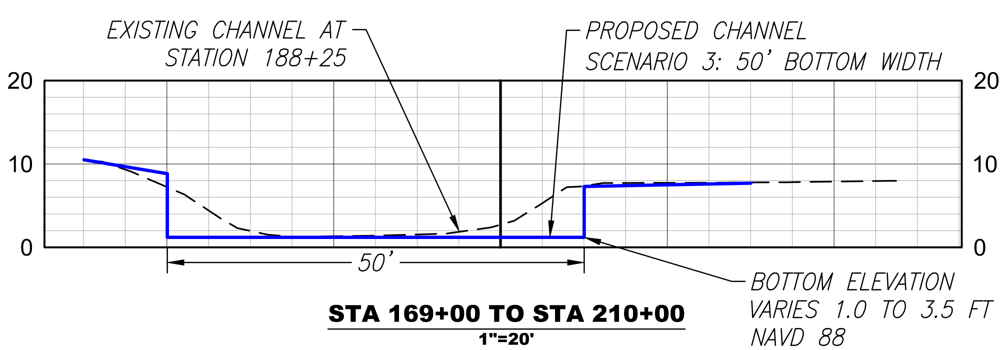
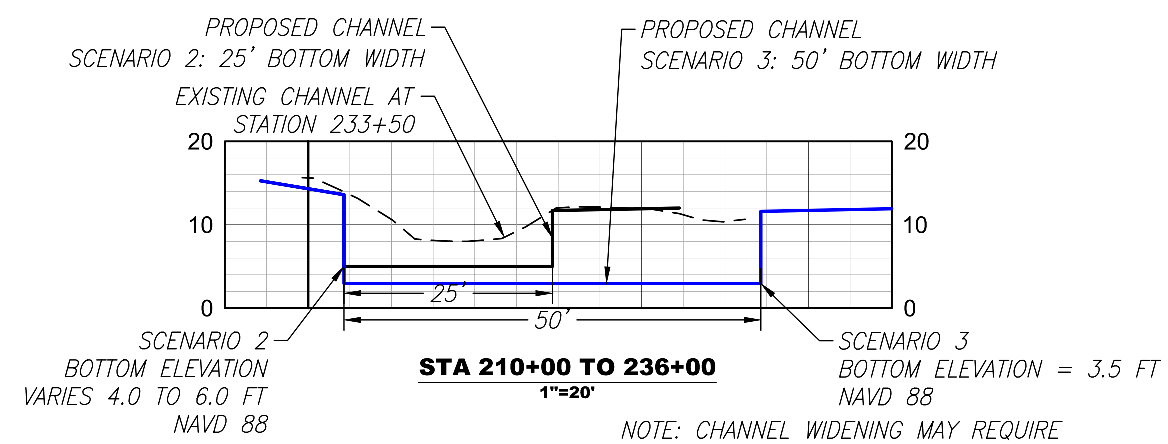


Figure 8 - Comparison of existing and proposed canal bottom elevations of Canal L. The elevations downstream of STA 166+20 are approximately only, have not been recently surveyed, and should not be used for purposes other than this conceptual study. The existing weir upstream of Whiskey Creek Drive is at STA 116+50 and the interconnect at Ten Mile Canal is at STA 236+00.





STA 169+00 TO STA 210+00
1"=20'



STA 210+00 TO 236+00
1"=20'

NOTE: CHANNEL WIDENING MAY REQUIRE THE RELOCATION OF EXISTING UTILITIES.

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BOCC LEE COUNTY

Canal Improvements
Lee County, Florida

REVISIONS

NO.	DESCRIPTION	DATE

DATE:	April 2020
PROJECT NO.	20181313-000
FILE NO.	00-00-00
SCALE:	As Shown

Conceptual Improvements Canal L

SHEET NUMBER
Sheet C

Model Results and Discussion

The scenarios described previously were compared primarily based on backwater profile results from the HEC-RAS model simulations. The flowrates for Canal L were selected based on an iterative process to estimate the highest potential flow diversion out of Ten Mile Canal based on the constraints of each proposed scenario.

A comparison of backwater profiles for the three proposed scenarios for Canal L are shown in **Figure 17**. The water surface elevations for each scenario remain below the existing minimum top of bank elevations along the canal. The slope of the water surface elevation below Canal L-3 (STA 166+00) is negligible, indicating there are no concerns with the lower portion of the canal conveying the proposed flows. The water surface elevation slope for the first and second scenarios is steepest upstream of STA 210+00 (from a point between 2nd Street and 3rd Street to its interconnection with Ten Mile Canal). The water surface elevation slope of the third scenario is steepest between Canal L-3 (STA 166+00) and Brooks Community Park (STA 188+00).

The highest channel velocities in each scenario, as shown in **Figure 18**, are located at the downstream ends of the proposed improvements, at the transition points back to the existing canal configuration. The elevated velocities in these locations indicate the need for canal bank and bottom stabilization to reduce the potential for erosion.

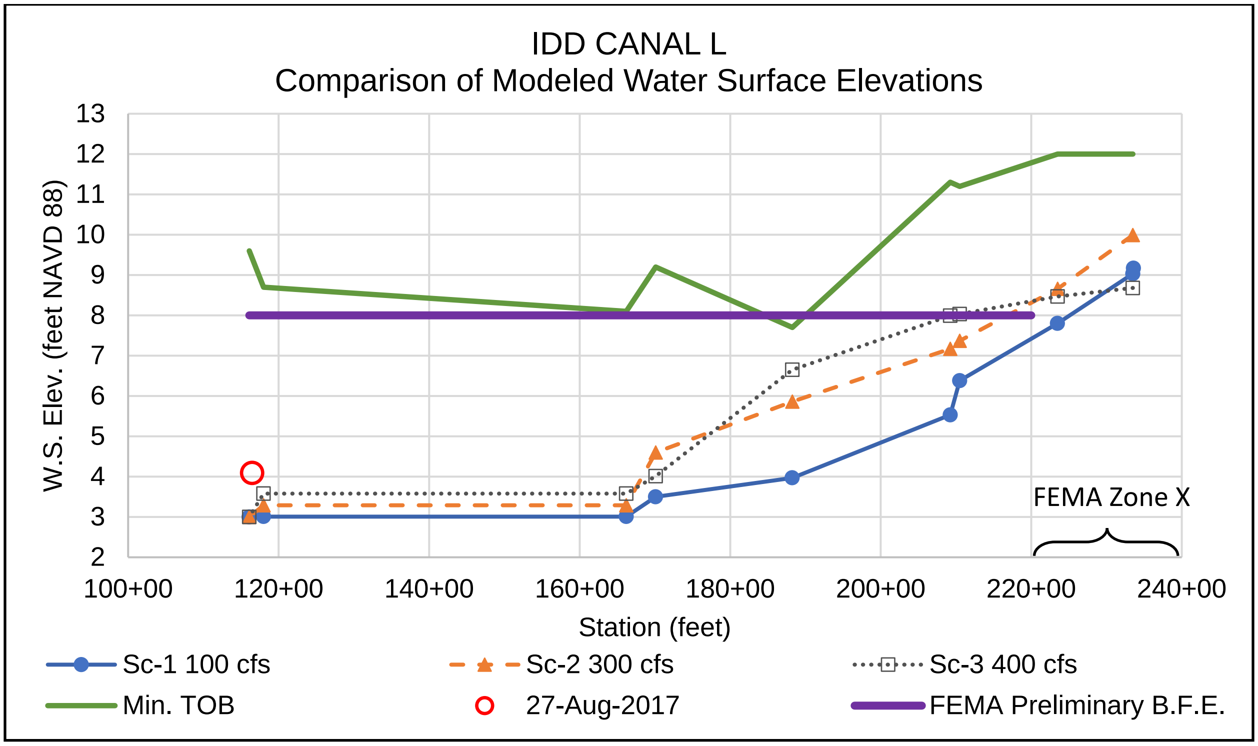

Figure 17 - Model results of three proposed scenarios of Canal L. The existing weir upstream of Whiskey Creek Drive is at STA 116+50 and the interconnect at Ten Mile Canal is at STA 236+00. The top of bank (TOB) elevations were derived from survey information and/or 2019 LiDAR information and typically represent adjacent roadway/parking elevations.

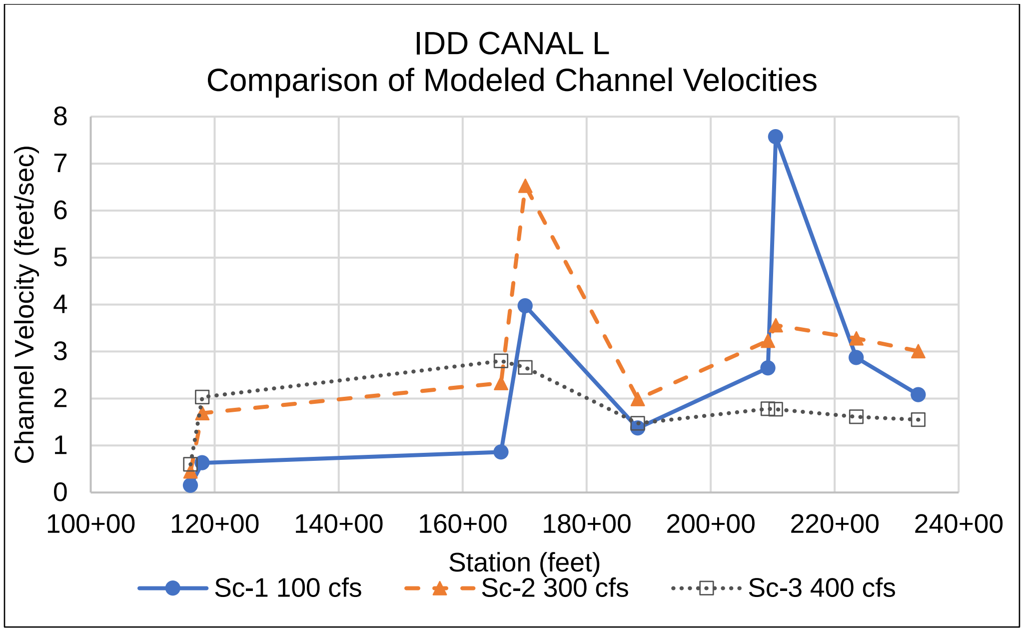

Figure 18 - Comparison of channel velocities for the three model simulations of Canal L.

While not included in the model, the three scenarios of conceptual modifications to Canal L will likely need to include the addition of a weir in the canal to maintain existing groundwater levels in the area. It is expected the weir location would be immediately upstream of 4th Street. If the Hideaway Golf Course community was willing to partner with Lee County, the potential exists to remove the community's outfall control structure and utilize the proposed weir near 4th Street as its replacement. This would enable the community's lake system to be interconnected with the canal and provide attenuation volume for the upper portion of the watershed.

Several other secondary benefits are possible with improvements to Canal L. A recreational trail can be co-located within the canal's maintenance path. By taking advantage of the existing pedestrian bridge over Ten Mile Canal located 500 feet south of the interconnect with Canal L, the proposed trail along Canal L can connect two Lee County parks, the John Yarbrough Linear Park Trail and the Brooks Community Park. Increasing the ROW width would also allow the opportunity to excavate a shallow littoral shelf to provide a treatment marsh along the length of the canal, as shown in **Figure 9**.

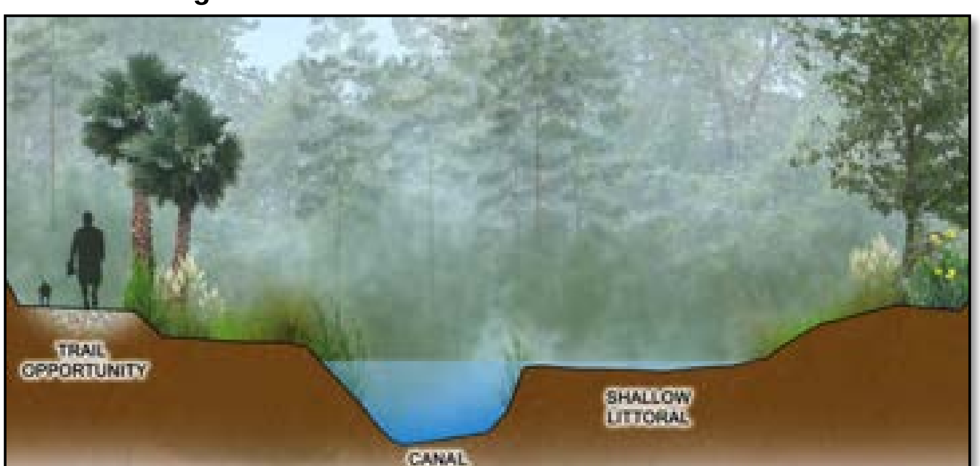

Figure 9 - Conceptual alternative cross section design with water quality and recreational benefits added within the canal ROW.

CONCLUSIONS AND RECOMMENDATIONS

The three local models discussed previously were created to provide additional levels of detail regarding flows, stages, and canal conveyance modifications. All three projects have the aim of mitigating flood impacts to communities in the Ten Mile Canal area. Each project included three alternative design scenarios that varied in anticipated impact, cost, and complexity to help identify the most cost-effective solution and were compared based on resulting backwater profiles calculated by the HEC-RAS software. A comparison the anticipated requirements and effects of each scenario is presented in **Table 1**. Simple sections with vertical sides were used to simplify the modeling effort and a myriad of potential improvements exist for varying side slopes. Only two former IDD canals were modeled. It is likely that other canals would show similar results of being able to divert water from Ten Mile Canal by gravity and pumps and reduce the overall peak flow and stages within Ten Mile Canal.

The model results for Ten Mile Canal indicate that Scenario 3 (performing the improvements described in both Scenarios 1 and 2) provides a combined benefit of the first two scenarios, indicating a linear relationship between the amount of improvement performed and the amount of benefit observed. It is therefore recommended that the improvements described in Scenarios 1 and 2 be completed for Ten Mile Canal. The minimum berm elevation on the west side of the canal will need to be higher than the water level elevation for Scenario 3 shown in **Figure 16** to prevent water from leaving the canal and flowing through the communities to the west.

Increasing the conveyance capacity of Ten Mile Canal downstream of US 41 will also likely result in increased flowrates in the canal following a major storm event. This is because the watershed is relatively flat, and thousands of acre-feet of storage is provided within the watershed for every one or two feet of elevation difference. The increased flowrates will in turn reduce the anticipated improvements from the proposed modifications to Ten Mile Canal. It is therefore recommended that additional improvements are made elsewhere in the watershed to provide increased storage in the upstream watershed (such as increased water management operations before and after major storm events as being proposed in other projects in this study) and upstream diversions occur to reduce the flowrate and flow volume to the southern end of Ten Mile Canal. The model results showed that a target peak flow reduction of 700 cfs from upstream diversions is recommended to protect the Island Park community from overflows from Ten Mile Canal.

Canal J model results show that a moderate amount of flow (50 cfs) can be diverted from Ten Mile Canal via gravity with minimal required downstream conveyance improvements. Performing improvements within the existing canal cross section and adding a pump station increases the allowable flow diversion by threefold, while maximizing the improvements to the greatest extent practical only increases the allowable flow diversion by an additional 33%. This indicates that the inflection point between amount of improvement made and project benefit occurs at roughly 300 cfs, making Scenario 2 the recommended conceptual design for Canal J.

The model results for Canal L lead to similar conclusions as those observed for Canal J. A gravity structure can divert up to 100 cfs from Ten Mile Canal with minimal required downstream conveyance improvements. The ideal design that provides significant benefit to the Island Park community is a flow diversion of approximately 300 cfs, making Scenario 2 the recommended conceptual design for Canal L. The combined flow from the recommended scenarios for Canals J and L is 600 cfs, which is short of the targeted upstream diversion rate of 700 cfs. It is therefore recommended that one or more additional upstream diversion points are explored to increase the upstream diversion capacity by at least 100 cfs.

The three local models and the subsequent analyses show that improvements can be made to mitigate flood risks along the southern end of Ten Mile Canal, including communities along Island Park Road. Additional detailed modeling should be performed to optimize which improvements should be made to improve Ten Mile Canal. There are potentially other canals that can be easily improved and also provide flood mitigation.

Table 1 - Comparison of design scenarios for each local model.

Scenario No.	Scenario Summary	Flood Mitigation Benefit	Land Availability
Ten Mile Canal			
Sc. 1	Remove all flow obstructions from both canal banks.	Reduces peak stage by approx. 1 foot	Reconfiguration of boat docks may present legal challenges
Sc. 2	Deepen canal bottom and increase canal width at select locations but allow existing flow obstructions to remain.	Same as Scenario 1	Canal widening at select locations will require legal review
Sc. 3	Perform both Scenario 1 and Scenario 2.	Combines the benefits of Scenarios 1 & 2	Same as Scenarios 1 and 2
Canal J			
Sc. 1	50 cfs via gravity; install one 4-foot by 3-foot gate to existing weir.	Diverts 50 cfs from Ten Mile Canal	Requires operational agreement with private community
Sc. 2	300 cfs via pump; install two 8-foot by 4-foot gates to existing weir; install vertical walls within existing canal (3,300-foot canal length); deepen canal (2,900-foot canal length).	Diverts 300 cfs from Ten Mile Canal	Same as above, plus work within environmentally-sensitive areas
Sc. 3	400 cfs via pump; install three 6-foot by 5-foot gates to existing weir; install vertical walls within existing canal (3,300-foot canal length); deepen canal (2,900-foot canal length); widen canal (7,400-foot canal length).	Diverts 400 cfs from Ten Mile Canal	Same as above, plus easement acquisition
Canal L			
Sc. 1	100 cfs via gravity; replace existing box culvert with one 8-foot by 5-foot box culvert; deepen canal (1,600-foot canal length).	Diverts 100 cfs from Ten Mile Canal	Within existing ROW
Sc. 2	300 cfs via pump; replace existing box culvert with two 8-foot by 5-foot box culverts; deepen canal (1,600-foot canal length); install vertical walls within existing canal (2,600-foot canal length).	Diverts 300 cfs from Ten Mile Canal	Within existing ROW
Sc. 3	400 cfs via pump; replace existing box culvert with three 10-foot by 5-foot box culverts; deepen canal (2,600-foot canal length); install vertical walls within canal (6,700-foot canal length); widen canal (6,700-foot canal length).	Diverts 400 cfs from Ten Mile Canal	May require easement acquisition

Southern Lee County Flood Mitigation Plan

ICPR4 Modeling of East of I-75 Overland Collection Drainageway Concept Project and Crew-Flint Pen Hydrologic Restoration Concept

- Final Report -

Prepared by

STREAMLINE TECHNOLOGIES

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Winter Springs, Florida 32708

For

AIM Engineering & Surveying, Inc.

2161 Fowler Street
Fort Myers, Florida 33901

August 21, 2020

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1. Introduction

Streamline Technologies, Inc. (SLT) was contracted by AIM Engineering & Surveying, Inc. on behalf of Lee County to model two conceptual projects in southeastern Lee County using ICPR4. Brief descriptions of these projects are provided in the following two sections.

1.1 East I-75 Overland Flow Collection Drainageway Project

This project is in southeastern Lee County at Interstate 75 south of Corkscrew Road and is intended to improve conveyance of excess stormwater to reduce flooding. It connects existing borrow pit lakes to the conveyance structures under I-75. This collector drainageway is intended to direct overland flow and equalize water levels at each I-75 road crossing to fully utilize each structure. It will also include remotely operated weir gates to maintain flow and water levels within desirable ranges. The general improvements are illustrated in Figure 1. Proposed conceptual projects west of I-75 and north of Corkscrew Road were not included SLT's scope of work.

Figure 1 East I-75 Overland Flow Collection Drainageway Project

1.2 Crew-Flint Pen Hydrologic Restoration Project

This project is also in southeastern Lee County beginning at the eastern Lee County line and continuing west to I-75 between Corkscrew Road and Bonita Beach Road. The purpose of this plan is to develop a reservoir area on the Crew Flint – Edison Farms area to hold excess stormwater until downstream developed areas have drained following a large storm event. This area is to be contained within a perimeter berm and will include operable weir gates to maintain flow and water levels within desirable ranges. The proposed conceptual improvements are depicted in Figure 2. Note that flow patterns at the southeastern end of the project area are assumed to split on both sides of the north-south portion of the proposed berm. This assumption is examined later through particle tracing and flow pattern analysis.

Figure 2 Crew-Flint Pen Hydrologic Restoration Project

2. Model Setup

2.1 Horizontal and Vertical Datums

The NAD83(HARN) / Florida West (ftUS) is used as the horizontal datum for this project. The NAVD88 (ft) vertical datum is also used.

2.2 The Study Area

The study area for the Southern Lee County (SLC) ICPR4 model is shown below in Figure 3. Approximately 250 square miles is modeled using 2D overland flow. Also, the City of Bonita Springs ICPR Model west of Interstate 75 (Figure 4), prepared by (Lago Consulting & Services, 2019), was incorporated into the overall SLC ICPR4 model. Although the hydraulics portion of the Bonita Springs model was left mostly "as is", the Green-Ampt method for infiltration and soil moisture accounting was used instead of the curve number method. This was necessary for continuous simulation purposes.

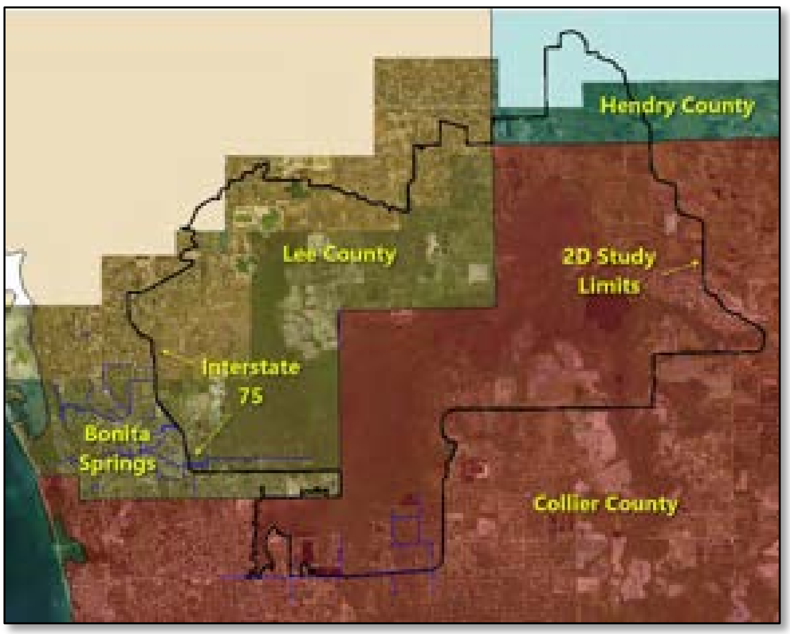


Figure 3. Study limits for the Southern Lee County (SLC) ICPR4 Model

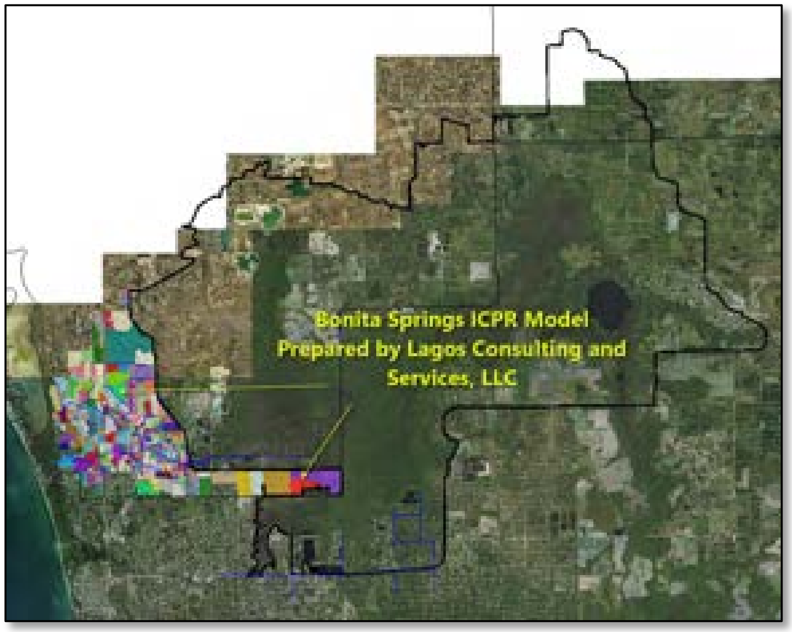


Figure 4. Extents of the Bonita Springs ICPR4 Model Incorporated into the SLC ICPR4 Model

2.3 Ground Surface Digital Elevation Model (DEM)

The ground surface is a composite of three LiDAR-based products: (1) Lee County – 2018 LiDAR at a 1-meter grid (3.281-ft); (2) Collier County – 2007 LiDAR at a 5-ft grid; and (3) Hendry County – 2015 LiDAR at a 50-ft grid. The Collier and Hendry surfaces were obtained from the SFWMD and were resampled for purposes of this investigation. The composite DEM is at a 3.281-ft (1m) grid and is shown in Figure 5.

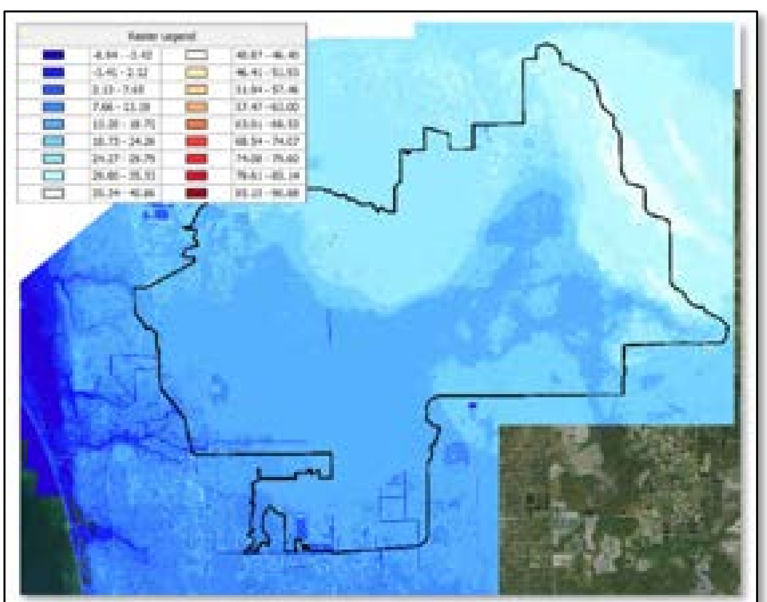


Figure 5 Composite Ground Surface DEM (ft NAVD88)

2.4 Basin Map Layer

The basin map layer for the Bonita Springs ICPR4 model is shown on the left side of Figure 6. Basins within the 2D study limits were deleted as shown on the right side of Figure 6. A few new basins were added at the northwest corner near the Halfway Creek and Estero outfall system.

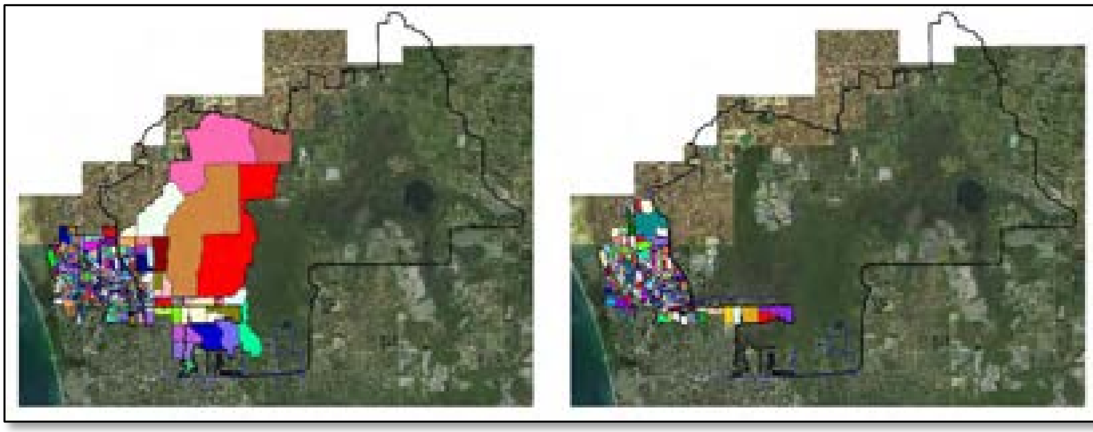


Figure 6 Original (Left) and Modified (Right) Bonita Springs Basins

2.5 Land Use Map Layer

Spatial land use data based on the Florida Land Use, Cover and Forms Classification System (FLUCCS) were obtained from the Florida Department of Environmental Protection (FDEP) in digital form and represent conditions between 2012 and 2016. It was imported to ICPR4 from a shapefile as a polygon map layer and was rasterized using a 2-foot grid. A generalized form of the land use map is shown in Figure 7. A breakdown of areas by generalized land use designation is provided in Table 1.

A detailed land use map layer was used to parameterize: (1) percent impervious and percent directly connected impervious area (DCIA); (2) crop coefficients and root depths; and, (3) shallow and deep Manning's n values and depth ranges. Details of these parameters are included in Sections 2.5.1, 2.5.2, and 2.5.3, respectively.

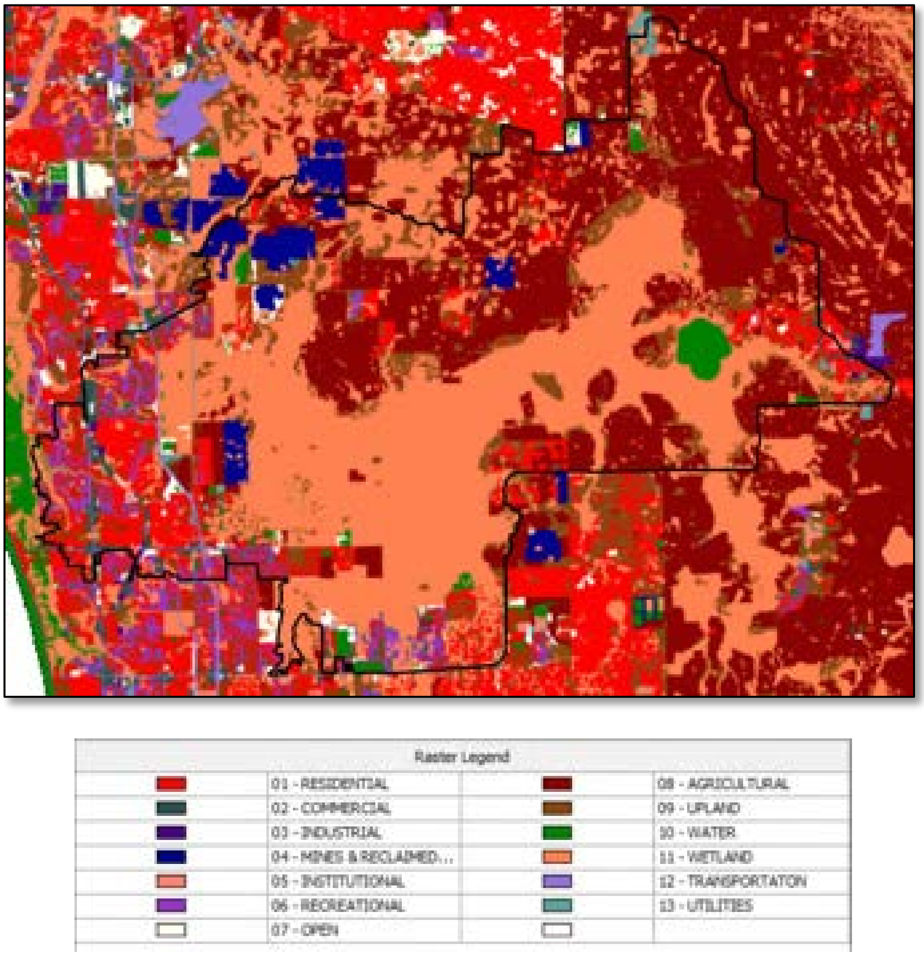


Figure 7 Generalized Land Use Map Layer

Land Use Designation	Area (mi^2/%)	Land Use Designation	Area (mi^2/%)
01 - Residential	26.8 / 9.6%	08 - Agricultural	74.2 / 26.6%
02 - Commercial	2.6 / 0.9%	09 - Upland	24.8 / 8.9%
03 - Industrial	0.3 / 0.0%	10 - Water	9.0 / 3.2%
04 – Mines & Reclaimed Lands	7.1 / 2.5%	11 - Wetland	123.0 / 44.0%
05 - Institutional	0.6 / 0.2%	12 - Transportation	1.3 / 0.5%
06 – Recreational	6.3 / 2.2%	13 - Utilities	1.2 / 0.4%
07 - Open	2.8 / 1.0%		
Total			280.0 / 100.0%

Table 1 Areas by Land Use Designation

2.5.1 Percent Impervious and Percent DCIA

Directly Connected Impervious Areas (DCIAs) are impervious areas that are hydraulically connected to the conveyance system and then to the basin outlet point without flowing over pervious areas. ICPR4 separates DCIAs from other impervious areas by specifying the total percentage of impervious area (%

IMP) and the percentage DCIA (% DCIA). The impervious percentage that flows across pervious areas and consequently subject to infiltration is the (% IMP) minus the (% DCIA). A look-up table was used in ICPR4 that specifies these percentages by FLUCCS code. These are summarized in Table 2. Land use names by FLUCCS code are provided in Appendix A.

FLUCCS CODE	%IMP/ %DCIA	FLUCCS CODE	%IMP/ %DCIA	FLUCCS CODE	%IMP/ %DCIA	FLUCCS CODE	%IMP/ %DCIA
1110	38/20	1610	10/0	2430	0/0	6191	0/0
1120	50/30	1620	0/0	2500	0/0	6200	0/0
1130	42/27	1630	0/0	2510	0/0	6210	0/0
1180	12/0	1660	0/0	2540	0/0	6215	0/0
1190	38/20	1700	0/0	2610	0/0	6216	0/0
1210	50/30	1710	50/30	3100	0/0	6240	0/0
1220	60/40	1820	10/0	3200	0/0	6250	0/0
1230	38/20	1840	25/10	3210	0/0	6300	0/0
1290	65/45	1850	15/0	3300	0/0	6410	0/0
1310	65/45	1900	0/0	4110	0/0	6430	0/0
1320	72/55	1920	20/0	4200	0/0	6440	0/0
1330	72/55	2110	0/0	4220	0/0	7400	0/0
1340	85/70	2120	0/0	4240	0/0	7430	0/0
1350	72/55	2130	0/0	4280	0/0	8115	10/0
1390	72/55	2140	0/0	4340	0/0	8140	65/45
1400	85/70	2150	0/0	4410	0/0	8200	0/0
1411	85/70	2160	0/0	5120	0/0	8310	0/0
1423	50/30	2210	0/0	5200	0/0	8320	0/0
1460	50/30	2230	0/0	5300	0/0	8330	50/30
1480	10/0	2240	0/0	6170	0/0	8340	50/30
1550	65/45	2410	0/0	6172	0/0	8350	25/15

Table 2 Percent Impervious and Percent DCIA by FLUCCS Code

2.5.2 Crop Coefficient and Root Depth

ICPR4 uses a reference evapotranspiration (ET) methodology to calculate ET losses. Reference ET is the evapotranspiration that would occur for an idealized turf grass. Daily reference ET values (see 2.8 Rainfall and Evapotranspiration Data) on a 2-km grid for the period 1995 – 2017 were obtained from the United States Geological Survey (USGS). The USGS discontinued this service after 2017.

Potential ET is the maximum possible ET at a given point in time and is calculated as the product of reference ET and a crop coefficient. In ICPR4, ET is satisfied in this order: (1) rainfall; (2) irrigation; (3) ponded water; and, (4) soil moisture in the root zone. Actual ET never exceeds potential ET and is often less.

A look-up table was created for crop coefficients and root depths by FLUCCS code. A summary is provided in Table 3. Land use names by FLUCCS code are provided in Appendix A. Although the crop coefficients and root depths can be varied with time in ICPR4, results were not sensitive to these seasonal variations and consequently, they were held constant for all simulations.

FLUCCS CODE	CC/ RD (ft)	FLUCCS CODE	CC/ RD (ft)	FLUCCS CODE	CC/ RD (ft)	FLUCCS CODE	CC/ RD (ft)
1110	1.0/1.5	1610	1.0/1.5	2430	1.0/1.5	6191	0.7/3.0
1120	1.0/1.5	1620	1.0/1.5	2500	0.7/3.0	6200	0.7/3.0
1130	1.0/1.5	1630	1.0/1.5	2510	1.0/1.5	6210	0.7/3.0
1180	1.0/1.5	1660	1.0/1.5	2540	1.0/1.5	6215	0.7/3.0
1190	1.0/1.5	1700	1.0/1.5	2610	1.0/1.5	6216	0.7/3.0
1210	1.0/1.5	1710	1.0/1.5	3100	0.7/2.0	6240	0.7/3.0
1220	1.0/1.5	1820	1.0/1.5	3200	0.7/2.0	6250	0.7/3.0
1230	1.0/1.5	1840	1.0/1.5	3210	0.7/2.0	6300	0.7/3.0
1290	1.0/1.5	1850	1.0/1.5	3300	0.7/2.0	6410	1.0/1.5
1310	1.0/1.5	1900	1.0/1.5	4110	0.7/3.0	6430	1.0/1.5
1320	1.0/1.5	1920	1.0/1.5	4200	0.7/3.0	6440	1.0/1.5
1330	1.0/1.5	2110	1.0/1.5	4220	0.7/3.0	7400	1.0/1.5
1340	1.0/1.5	2120	1.0/1.5	4240	0.7/3.0	7430	1.0/1.5
1350	1.0/1.5	2130	0.7/3.0	4280	0.7/3.0	8115	1.0/1.5
1390	1.0/1.5	2140	1.0/1.5	4340	0.7/3.0	8140	1.0/1.5
1400	1.0/1.5	2150	1.0/1.5	4410	0.7/3.0	8200	1.0/1.5
1411	1.0/1.5	2160	1.0/1.5	5120	1.0/1.5	8310	1.0/1.5
1423	1.0/1.5	2210	0.7/3.0	5200	1.0/1.5	8320	1.0/1.5
1460	1.0/1.5	2230	0.7/3.0	5300	1.0/1.5	8330	1.0/1.5
1480	1.0/1.5	2240	0.7/3.0	6170	0.7/3.0	8340	1.0/1.5
1550	1.0/1.5	2410	0.7/3.0	6172	0.7/2.0	8350	1.0/1.5

Table 3 Crop Coefficient (CC) and Root Depth (RD) by FLUCCS Code

2.5.3 Shallow Manning's n, Deep Manning's n, and Depth Range

Roughness parameters for 2D overland flow include a shallow condition Manning's n-value, a deep condition Manning's n-value and a depth range for the transition from shallow to deep. ICPR4 uses an exponential decay function for this transition as shown in Figure 8. The shallow n-value begins at the surface and the deep n-value occurs at the user-specified depth range. The shallow n-value, deep n-value, and depth range for the example in Figure 8 are 0.8, 0.1 and 3 feet, respectively.

A look-up table was created for roughness parameters by FLUCCS code. Land use names by FLUCCS code are provided in Appendix A. A summary is provided in Table 4.

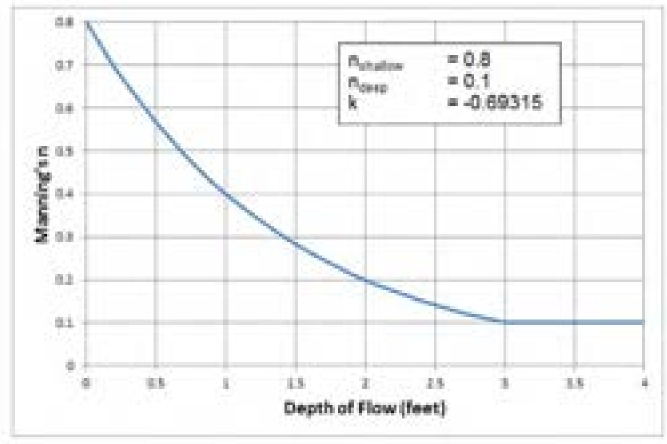


Figure 8 Exponential Decay Function for Manning's n in 2D Overland Flow

FLUCCS CODE	SN/DN/ RNG (ft)	FLUCCS CODE	SN/DN/ RNG (ft)	FLUCCS CODE	SN/DN/ RNG (ft)	FLUCCS CODE	SN/DN/ RNG (ft)
1110	.12/.06/1	1610	.12/.06/1	2430	.12/.06/1	6191	.6/.6/1.5
1120	.12/.06/1	1620	.12/.06/1	2500	.12/.06/1	6200	.6/.6/1.5
1130	.12/.06/1	1630	.12/.06/1	2510	.12/.06/1	6210	.6/.6/1.5
1180	.12/.06/1	1660	.12/.06/1	2540	.12/.06/1	6215	.6/.6/1.5
1190	.12/.06/1	1700	.12/.06/1	2610	.12/.06/1	6216	.6/.6/1.5
1210	.12/.06/1	1710	.12/.06/1	3100	.2/.1/1.5	6240	.6/.6/1.5
1220	.12/.06/1	1820	.12/.06/1	3200	.3/.15/1.5	6250	.6/.6/1.5
1230	.12/.06/1	1840	.12/.06/1	3210	.3/.15/1.5	6300	.6/.6/1.5
1290	.12/.06/1	1850	.12/.06/1	3300	.3/.15/1.5	6410	.6/.6/1.5
1310	.12/.06/1	1900	.12/.06/1	4110	.3/.15/1.5	6430	.6/.6/1.5
1320	.12/.06/1	1920	.12/.06/1	4200	.3/.15/1.5	6440	.6/.6/1.5
1330	.12/.06/1	2110	.12/.06/1	4220	.3/.15/1.5	7400	.12/.06/1
1340	.12/.06/1	2120	.12/.06/1	4240	.3/.15/1.5	7430	.12/.06/1
1350	.12/.06/1	2130	.12/.06/1	4280	.3/.15/1.5	8115	.12/.06/1
1390	.12/.06/1	2140	.12/.06/1	4340	.3/.15/1.5	8140	.12/.06/1
1400	.12/.06/1	2150	.12/.06/1	4410	.3/.15/1.5	8200	.12/.06/1
1411	.12/.06/1	2160	.12/.06/1	5120	.06/.06/1.5	8310	.12/.06/1
1423	.12/.06/1	2210	.12/.06/1	5200	.06/.06/1.5	8320	.12/.06/1
1460	.12/.06/1	2230	.12/.06/1	5300	.06/.06/1.5	8330	.12/.06/1
1480	.12/.06/1	2240	.12/.06/1	6170	.6/.6/1.5	8340	.12/.06/1
1550	.12/.06/1	2410	.12/.06/1	6172	.6/.6/1.5	8350	.12/.06/1

Table 4 Shallow n (SN), Deep n (DN) and Depth Range (RNG) by FLUCCS Code

2.6 Soils Map Layer

Digital soil maps for Lee, Collier, and Hendry counties were downloaded from the Natural Resources Conservation Service (NRCS) web soil survey and merged into a single map. The composite soils map was then imported to ICPR4 as a map layer and rasterized using a 2-foot grid. A generalized soils map depicting hydrologic groups is shown in Figure 9. A breakdown of areas by hydrologic soil group is provided in Table 5. The corresponding NRCS SSURGO database was also downloaded and used to develop the Green-Ampt parameters needed for ICPR4 by unique soil designations referred to as “MUKEY”.

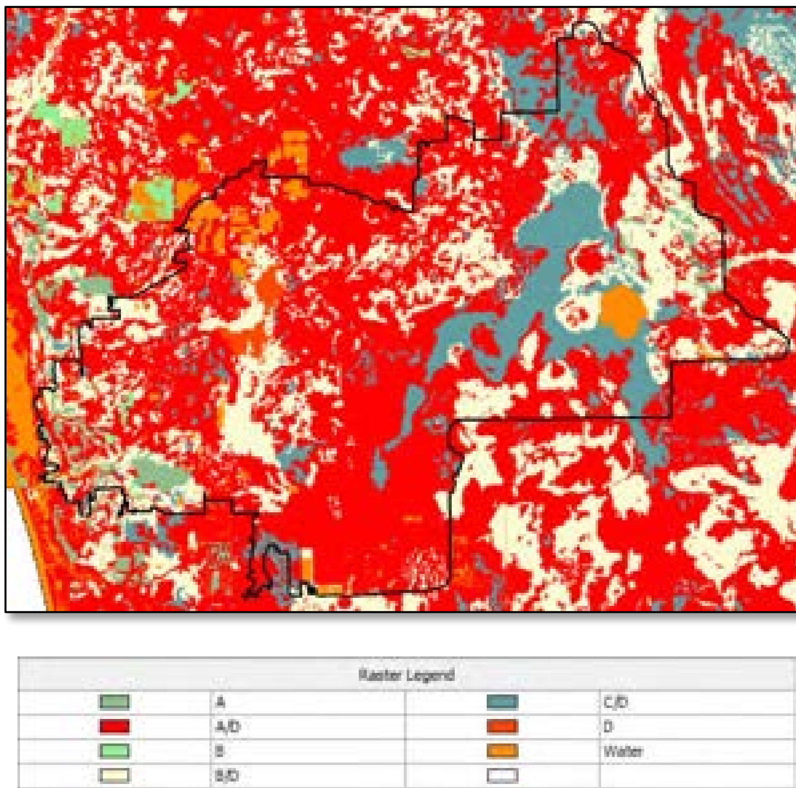


Figure 9 NRCS Soils by Hydrologic Group

Hydrologic Soil Group	Area (sqmi)	Percent of Total
A	6.2	2.2%
A/D	155.4	55.5%
B	0.9	0.3%
B/D	68.7	24.6%
C/D	37.0	13.2%
D	3.1	1.1%
Water	8.7	3.1%
Total	**280.0**	**100.0%**

Table 5 Areas by Hydrologic Soil Group

The Green-Ampt parameters are weighted averages for the upper 6 feet (approximately) of the soil column. These include: (1) saturated vertical conductivity, K_v (fpd); (2) saturated moisture content, MC Sat (dec); (3) initial moisture content, MC Init (dec); (4) moisture content at field capacity, MC FC (dec); (5) moisture content at wilting point, MC Wilt (dec); (6) residual moisture content, MC Res (dec); (7) pore size index, PSI (dec); (8) bubble pressure, BP (in); and, (9) water table depth, WT (ft). All moisture contents are by volume. The SSURGO database in conjunction with procedures outlined in the ICPR4 technical reference were used to develop the first iteration of these parameters. Adjustments were made during the calibration process (3.1.4 Calibration Process and Model Adjustments). The calibrated parameters are provided in Table 6 by MUKEY designation. Soil names by MUKEY are provided in Appendix B. "K_v Sat" includes a factor of safety of 2.0. "MC Init Dry" is equal to the calibrated "MC FC" and represents a dry initial condition, used for all continuous simulations. "MC Init Wet" is equal to 50% of the moisture content between "MC FC" and "MC Sat" and represents a wet initial condition. This was used for all single storm event simulations. Soil moisture can fluctuate between "MC Wilt" and "MC Sat".

MUKEY	Kv Sat (fpd)	MC Sat (dec)	MC Init Dry (dec)	MC Init Wet (dec)	MC FC (dec)	MC Wilt (dec)	MC Res (dec)	Pore Size Index (dec)	Bubble Pressure (in)	WT Depth (ft)
1151405	10.03	0.45	0.16	0.31	0.16	0.03	0.01	0.50	1.89	0.66
1151406	7.85	0.42	0.16	0.29	0.16	0.05	0.02	0.47	1.94	0.26
1151407	6.74	0.34	0.20	0.27	0.20	0.11	0.05	0.45	3.48	0.98
1151408	5.71	0.34	0.21	0.28	0.21	0.11	0.05	0.44	3.69	0.98
1151409	10.20	0.37	0.16	0.26	0.16	0.05	0.02	0.59	1.96	0.98
1151410	9.80	0.35	0.18	0.27	0.18	0.07	0.03	0.53	2.73	0.49
1151412	8.04	0.36	0.18	0.27	0.18	0.07	0.03	0.53	2.26	0.49
1151415	9.71	0.45	0.19	0.32	0.19	0.06	0.03	0.47	2.78	0.98
1151416	11.11	0.36	0.15	0.26	0.15	0.04	0.01	0.60	2.26	1.02
1151417	13.00	0.36	0.16	0.26	0.16	0.04	0.01	0.59	1.95	0.49
1151419	4.25	0.44	0.30	0.37	0.30	0.14	0.05	0.41	4.64	0.26
1151420	13.04	0.66	0.60	0.63	0.60	0.36	0.02	0.37	4.92	0.01
1151421	8.29	0.35	0.19	0.27	0.19	0.08	0.03	0.49	3.01	0.49
1151424	15.36	0.37	0.15	0.26	0.15	0.04	0.01	0.60	1.85	2.00
1151429	3.69	0.33	0.22	0.27	0.22	0.13	0.06	0.38	6.43	0.26
1151430	8.29	0.35	0.19	0.27	0.19	0.08	0.03	0.49	3.01	0.26
1151440	11.10	0.36	0.19	0.27	0.19	0.07	0.03	0.53	2.56	0.98
1151444	8.35	0.37	0.16	0.27	0.16	0.05	0.02	0.55	1.88	0.01
1151445	3.06	0.32	0.22	0.27	0.22	0.13	0.05	0.38	7.09	0.26
1151446	8.80	0.36	0.16	0.26	0.16	0.04	0.01	0.59	1.99	0.01
1413456	11.10	0.36	0.19	0.27	0.19	0.07	0.03	0.52	2.42	2.00
1413459	10.26	0.37	0.16	0.27	0.16	0.05	0.02	0.60	1.84	2.00
1413460	11.11	0.38	0.17	0.28	0.17	0.05	0.02	0.58	1.66	2.00
1413462	10.84	0.63	0.20	0.41	0.20	0.02	0.01	0.40	3.61	2.00
1413463	8.21	0.44	0.20	0.32	0.20	0.08	0.03	0.44	3.07	2.00
1413464	15.36	0.37	0.15	0.26	0.15	0.04	0.01	0.60	1.85	2.00
1413465	6.32	0.37	0.21	0.29	0.21	0.11	0.05	0.44	2.66	2.00
1413466	13.04	0.38	0.15	0.26	0.15	0.03	0.01	0.60	1.79	2.00
1413469	11.13	0.51	0.18	0.34	0.18	0.04	0.01	0.46	2.67	2.00
1413470	3.02	0.44	0.29	0.37	0.29	0.15	0.06	0.36	2.33	0.01
1413472	9.70	0.44	0.18	0.31	0.18	0.06	0.02	0.45	2.43	0.01
1413473	11.00	0.36	0.19	0.27	0.19	0.07	0.03	0.52	2.45	2.00
1413475	11.19	0.36	0.21	0.28	0.21	0.10	0.04	0.49	2.63	2.00
1413476	8.38	0.44	0.19	0.31	0.19	0.06	0.02	0.44	1.96	1.02
1413477	12.08	0.41	0.16	0.29	0.16	0.04	0.01	0.56	1.99	2.00
1413478	5.71	0.34	0.21	0.28	0.21	0.11	0.05	0.44	3.69	2.00
1413479	5.71	0.34	0.21	0.28	0.21	0.11	0.05	0.44	3.69	2.00
1413482	7.70	0.39	0.21	0.30	0.21	0.09	0.04	0.42	2.25	1.02
1413483	5.71	0.34	0.21	0.28	0.21	0.11	0.05	0.44	3.69	2.00
1413488	4.45	0.38	0.21	0.30	0.21	0.10	0.04	0.36	2.21	0.01

MUKEY	Kv Sat (fpd)	MC Sat (dec)	MC Init Dry (dec)	MC Init Wet (dec)	MC FC (dec)	MC Wilt (dec)	MC Res (dec)	Pore Size Index (dec)	Bubble Pressure (in)	WT Depth (ft)
1413490	4.74	0.52	0.25	0.38	0.25	0.10	0.04	0.35	8.84	0.49
1413500	11.13	0.43	0.21	0.32	0.21	0.08	0.03	0.53	1.69	0.01
1483406	13.00	0.38	0.14	0.26	0.14	0.02	0.01	0.60	1.77	2.00
1483408	11.11	0.38	0.17	0.28	0.17	0.05	0.02	0.58	1.66	2.00
1483409	12.12	0.37	0.17	0.27	0.17	0.05	0.02	0.55	1.96	2.00
1483410	11.13	0.51	0.18	0.34	0.18	0.04	0.01	0.46	2.67	2.00
1483411	13.00	0.37	0.15	0.26	0.15	0.03	0.01	0.60	1.88	2.00
1483416	4.25	0.44	0.30	0.37	0.30	0.14	0.05	0.41	4.64	0.49
1483423	8.04	0.36	0.18	0.27	0.18	0.07	0.03	0.53	2.26	2.00
1483424	13.04	0.38	0.15	0.27	0.15	0.03	0.01	0.60	1.76	1.51
1483425	10.20	0.37	0.16	0.26	0.16	0.05	0.02	0.59	1.96	2.00
1483427	6.74	0.34	0.20	0.27	0.20	0.11	0.05	0.45	3.48	2.00
1483428	11.10	0.36	0.19	0.27	0.19	0.07	0.03	0.52	2.42	2.00
1483429	5.71	0.34	0.21	0.28	0.21	0.11	0.05	0.44	3.69	2.00
1483431	29.76	0.38	0.13	0.26	0.13	0.02	0.00	0.61	1.80	2.00
1483435	12.99	0.36	0.15	0.25	0.15	0.04	0.01	0.61	2.06	1.51
1483437	9.71	0.45	0.19	0.32	0.19	0.06	0.03	0.47	2.78	2.00
1483439	11.10	0.36	0.19	0.27	0.19	0.07	0.03	0.53	2.56	1.51
1483442	11.67	0.36	0.17	0.26	0.17	0.06	0.02	0.55	2.21	1.51
1483445	4.20	0.32	0.24	0.28	0.24	0.16	0.07	0.34	7.56	0.49
1483446	11.35	0.38	0.17	0.27	0.17	0.05	0.02	0.58	1.69	1.51
1483451	9.91	0.63	0.19	0.41	0.19	0.02	0.01	0.40	3.61	2.00
1483454	11.10	0.36	0.19	0.27	0.19	0.07	0.03	0.53	2.56	2.00
1483458	9.06	0.37	0.16	0.27	0.16	0.04	0.01	0.58	1.79	2.00
1483462	7.51	0.36	0.18	0.27	0.18	0.08	0.03	0.52	2.35	1.51
1483466	8.21	0.44	0.20	0.32	0.20	0.08	0.03	0.44	3.07	2.00
1483469	10.52	0.35	0.19	0.27	0.19	0.08	0.03	0.52	2.59	2.00
1483470	11.13	0.43	0.21	0.32	0.21	0.08	0.03	0.53	1.69	0.01
3045908	11.96	0.45	0.16	0.31	0.16	0.03	0.01	0.52	2.17	1.51
3045922	11.96	0.45	0.16	0.31	0.16	0.03	0.01	0.52	2.17	2.00
3045924	8.66	0.44	0.20	0.32	0.20	0.08	0.03	0.43	3.12	2.00
3045925	8.66	0.44	0.20	0.32	0.20	0.08	0.03	0.43	3.12	2.00
3045926	11.59	0.37	0.17	0.27	0.17	0.05	0.02	0.56	1.99	2.00
3045927	8.04	0.36	0.18	0.27	0.18	0.07	0.03	0.53	2.26	2.00
3045928	10.84	0.63	0.20	0.41	0.20	0.02	0.01	0.40	3.61	2.00
3102832	29.76	0.38	0.13	0.26	0.13	0.02	0.00	0.61	1.78	2.00
3102839	4.64	0.51	0.26	0.39	0.26	0.13	0.06	0.35	4.90	1.51
3102841	4.64	0.51	0.26	0.39	0.26	0.13	0.06	0.35	4.90	1.51
3102852	11.67	0.36	0.17	0.26	0.17	0.06	0.02	0.55	2.21	1.51
3102853	12.12	0.37	0.17	0.27	0.17	0.05	0.02	0.55	1.96	2.00
3102854	4.20	0.32	0.24	0.28	0.24	0.16	0.07	0.34	7.44	0.49
3102857	9.91	0.63	0.19	0.41	0.19	0.02	0.01	0.40	3.61	2.00
3102867	7.34	0.44	0.20	0.32	0.20	0.08	0.03	0.44	3.44	2.00
3102870	7.34	0.44	0.20	0.32	0.20	0.08	0.03	0.44	3.44	2.00
3102873	11.10	0.36	0.19	0.28	0.19	0.07	0.03	0.52	2.42	2.00
3102874	11.10	0.36	0.19	0.28	0.19	0.07	0.03	0.52	2.42	1.51
3102878	9.06	0.37	0.16	0.27	0.16	0.04	0.01	0.58	1.79	2.00
3102880	11.11	0.38	0.17	0.27	0.17	0.05	0.02	0.58	1.70	2.00
3102881	11.35	0.38	0.17	0.27	0.17	0.05	0.02	0.58	1.69	1.51
3102883	8.56	0.45	0.19	0.32	0.19	0.07	0.03	0.47	2.37	2.00
3102885	8.56	0.45	0.19	0.32	0.19	0.07	0.03	0.47	2.37	2.00
3102888	6.74	0.34	0.20	0.27	0.20	0.11	0.05	0.45	3.48	2.00
3102889	35.01	0.37	0.15	0.26	0.15	0.03	0.01	0.60	1.89	2.00
3102894	8.04	0.36	0.18	0.27	0.18	0.07	0.03	0.53	2.26	2.00
3102895	7.51	0.36	0.18	0.27	0.18	0.08	0.03	0.52	2.35	1.51
3102898	13.00	0.38	0.14	0.26	0.14	0.02	0.01	0.60	1.77	2.00
3102899	13.04	0.38	0.15	0.27	0.15	0.03	0.01	0.60	1.76	1.51
3102906	29.76	0.39	0.14	0.26	0.14	0.02	0.00	0.61	1.72	2.00
3102912	13.00	0.37	0.15	0.26	0.15	0.03	0.01	0.60	1.88	2.00
3102913	5.71	0.34	0.21	0.28	0.21	0.11	0.05	0.44	3.69	2.00

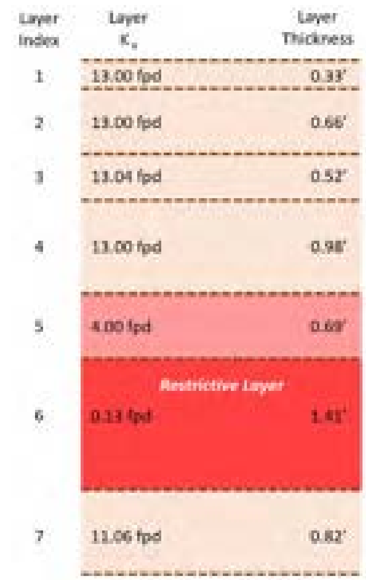
MUKEY	Kv Sat (fpd)	MC Sat (dec)	MC Init Dry (dec)	MC Init Wet (dec)	MC FC (dec)	MC Wilt (dec)	MC Res (dec)	Pore Size Index (dec)	Bubble Pressure (in)	WT Depth (ft)
3102914	9.71	0.45	0.19	0.32	0.19	0.06	0.03	0.47	2.78	2.00
3102920	3.76	0.31	0.23	0.27	0.23	0.14	0.06	0.37	9.00	1.51
3102936	11.13	0.51	0.18	0.34	0.18	0.04	0.01	0.46	2.67	2.00
3102937	11.13	0.51	0.18	0.34	0.18	0.04	0.01	0.46	2.67	2.00
3102943	9.91	0.63	0.19	0.41	0.19	0.02	0.01	0.40	3.61	2.00
3102944	9.91	0.63	0.19	0.41	0.19	0.02	0.01	0.40	3.61	2.00
3102947	13.04	0.37	0.15	0.26	0.15	0.03	0.01	0.60	1.89	1.51
3102948	13.04	0.37	0.15	0.26	0.15	0.03	0.01	0.60	1.89	1.51
3102949	12.99	0.36	0.15	0.25	0.15	0.04	0.01	0.61	2.06	1.51
3102950	11.13	0.51	0.18	0.35	0.18	0.04	0.01	0.46	2.64	2.00
3102952	10.20	0.37	0.16	0.26	0.16	0.05	0.02	0.59	1.96	2.00
3102953	8.21	0.44	0.20	0.32	0.20	0.08	0.03	0.44	3.07	2.00

Table 6 Calibrated Green-Ampt Parameters by NRCS MUKEY

As mentioned above, the Green-Ampt parameters represent a weighted average of the soil properties in the upper 6 feet (+/-) of the soil column. An example calculation is shown in Table 7 for soil zone (MUKEY) 1413463. There are 7 layers for this soil type and the saturated vertical conductivities range from 0.13 – 13.0 fpd – two orders of magnitude difference. The restrictive layer can cause a perched water table condition. The weighted average K_v is 8.21 fpd, 63 times higher than K_v for the restrictive layer. If groundwater recharge (i.e., the flux between the vadose zone and the saturated groundwater table) is permitted for this soil zone, then the restrictive layer will be missed because of the high weighted average K_v (8.21 fpd versus 0.13 fpd). Consequently, the available soil storage will be overestimated and the runoff volume under-predicted. This is an important concept, especially when interacting with the groundwater module of ICPR4, and is discussed further in 3.1.4 Calibration Process and Model Adjustments.

Layer Index	K_v (fpd)	Thickness, T (ft)	T x K_v
1	13.00	0.33	4.27
2	13.00	0.66	8.53
3	13.04	0.52	6.84
4	13.00	0.98	12.80
5	4.00	0.69	2.75
6	0.13	1.41	0.18
7	11.06	0.82	9.07
Total		5.51	44.45
Weighted Avg			8.21 fpd

Table 7 Example K_v Weighted Average Calculation for Soil Zone 1413463



A review of the SSURGO data indicates that there are restrictive (K_v < 1 fpd) and semi-restrictive (K_v 1-2 fpd) layers in the upper 6 feet of the soil column for large expanses of the study area. These are depicted in Figure 10 (the K_v ranges include a factor of safety of 2.0). A breakdown of the areas of the most restrictive layers categorized by K_v are provided in Table 8. Approximately 63% of the 2D study area includes restrictive and semi-restrictive layers.

Kv (fpd)	Area (sqmi)	Area (%)
< 1 fpd	61.9	24.8
1 – 2 fpd	95.5	38.2
> 2 fpd	92.5	37.0
Total	249.9	100

Table 8 Areas Based on Most Restrictive Layers Categorized by K_v

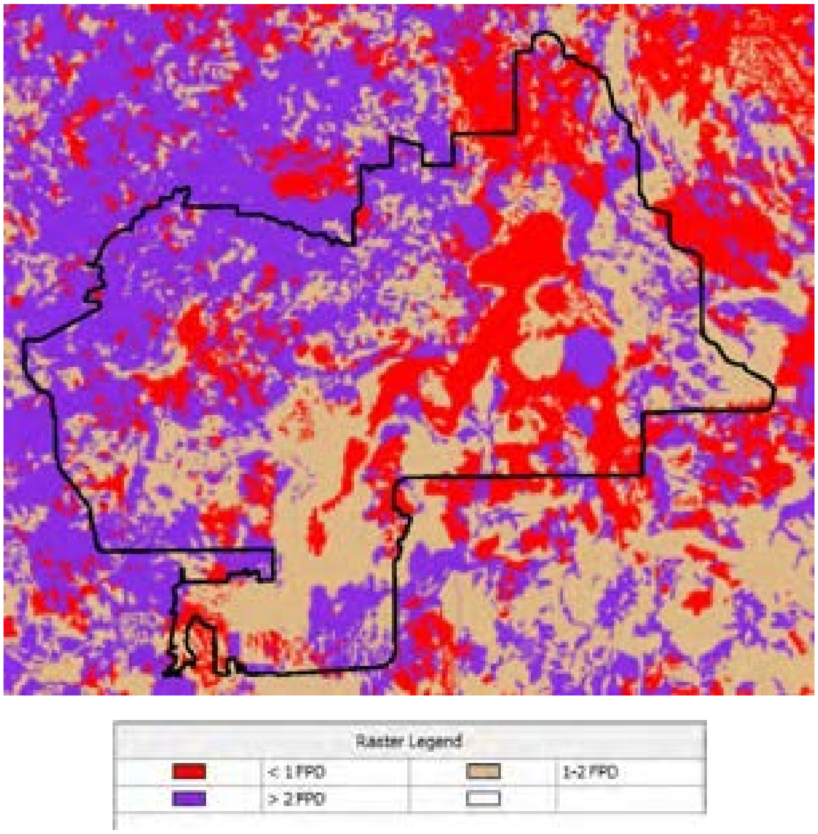


Figure 10 Saturated Vertical Conductivity (K_v) of the Most Restrictive Layer in the Upper 6 feet (+/-) of the Soil Column

2.7 NEXRAD Map Layer

The NEXRAD rainfall pixels were imported to ICPR4 as a polygon map layer and rasterized using a 10-foot grid size. Each NEXRAD pixel is approximately 2-km by 2-km in size. This map layer (Figure 11) was used to spatially distribute historical rainfall and the USGS reference ET described in 2.5.2 Crop Coefficient and Root Depth. A unique rainfall text file and a unique reference ET text file is required for each pixel in the NEXRAD map layer. Rainfall and ET data are discussed in 2.8 Rainfall and Evapotranspiration Data.

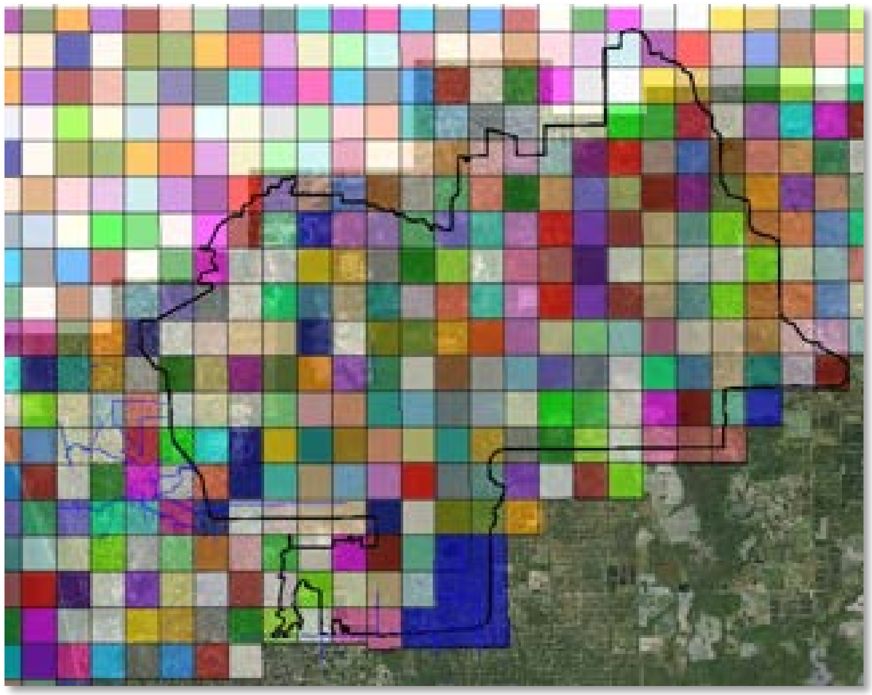


Figure 11 NEXRAD Rainfall Map Layer

2.8 Rainfall and Evapotranspiration Data

Although the study area is in the South Florida Water Management District (SFWMD), NEXRAD rainfall data was obtained from the Southwest Florida Water Management District (SWFWMD). A single vendor provides calibrated NEXRAD rainfall data to both water management districts, so it should be the same. However, SWFWMD makes that data available in 15-minute increments whereas SFWMD provides it in 1-hour increments. SWFWMD also provides the data in the requisite ICPR4 text file format. The period of record for the NEXRAD data is 1995 to present with a 2- to 3-month lag for the calibrated data.

The USGS daily reference ET data is available for the same NEXRAD pixels for the period 1995 – 2017. SLT has preprocessed these data for the State of Florida into individual ICPR4 text files for each NEXRAD pixel in the study area.

The NEXRAD rainfall data and the USGS reference ET data were used for the 5-month calibration period (June 1 to November 1, 2017) and the 5-year verification period (2013 – 2017). The cumulative rainfall amount for the calibration period are shown in Figure 12 and total approximately 65 inches for the study area. Potential ET and actual ET are about 21.5 inches and 20 inches, respectively.

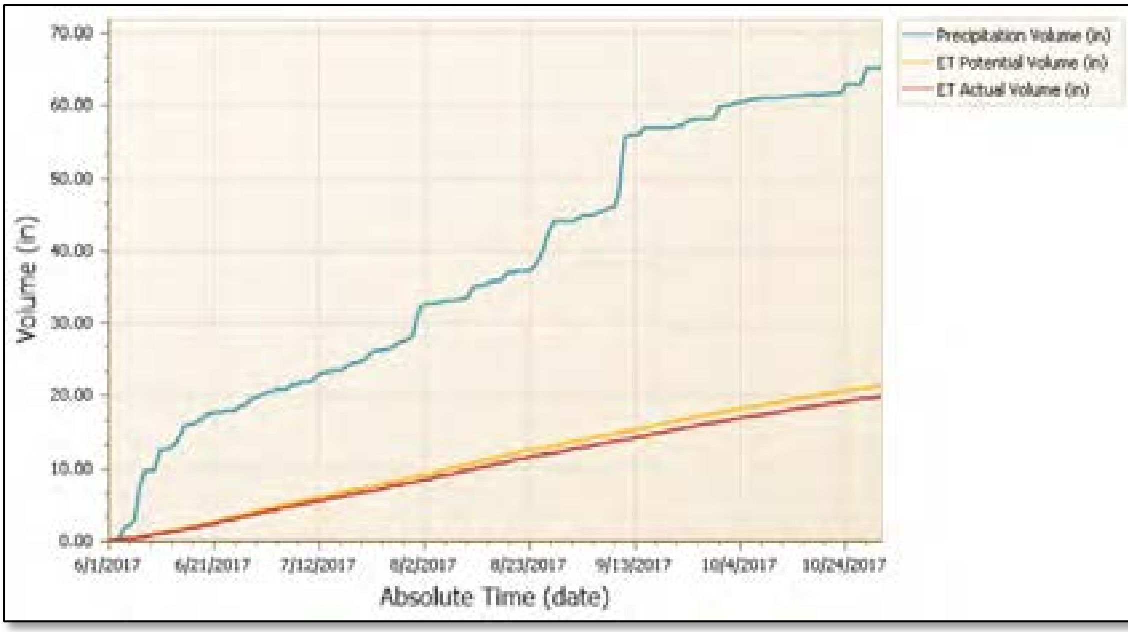


Figure 12 Cumulative Rainfall, Potential ET, and Actual ET (June 1 – November 1, 2017)

Discrete synthetic storm events were also modeled including 72-, 168- and 240-hour storm durations for 25- and 100-year return intervals. NOAA Atlas 14 at the Kehl Canal structure was used to determine rainfall amounts. These are provided in Table 9 with their respective temporal distributions.

	72-Hour	168-Hour	240-Hour
25-Year	11.2	13.5	14.7
100-Year	14.9	17.4	18.4
Distribution	SFWMD – 72hr	FDOT – 168hr	FDOT – 240hr

Table 9 Rainfall Totals and Distributions for Discrete Storm Event Analysis

2.9 Overland Flow Computational Mesh Development

ICPR4 uses a flexible triangular computational mesh for 2D overland flow that is constructed from various graphical elements that: (1) characterize the terrain; (2) interface with 1D model components; and, (3) establish boundary conditions.

2.9.1 Overland Flow Region

The overland flow region boundary is the modeling domain for 2D surface flow and corresponds to the 2D study limits shown in Figure 3. Vertical walls are assumed along the perimeter of the region boundary. Surface flow can pierce this wall via 1D links and or with 2D boundary stage points or lines. Only 1D links were used in this investigation to pierce the region boundary.

The overland flow region manager is used to specify the various surface DEMs and map layers for parameterizing the computational mesh. The region manager settings for the calibration and verification simulations is shown in Figure 13.

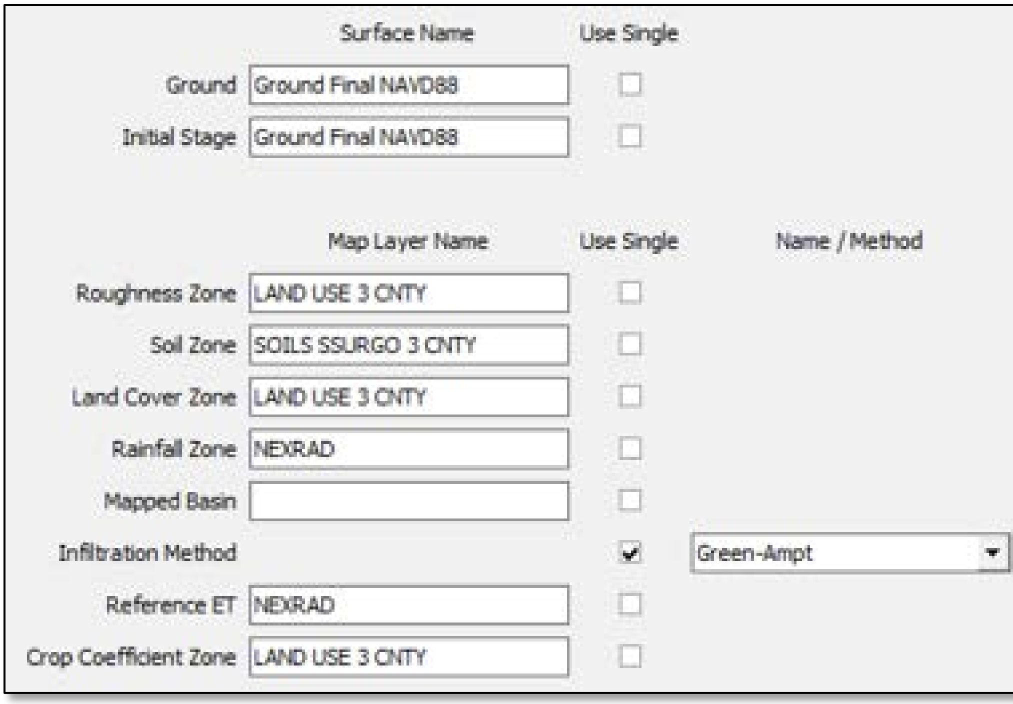


Figure 13 Overland Flow Region Manager used for Calibration and Verification Simulations

2.9.2 Channel Control Volumes

Channel control volumes (CCVs) form interfaces between 2D overland flow and 1D channel links. They are closed polygons referenced to a 1D node and generally extend halfway upstream and downstream of channel links attached to the referenced node. An example is shown in Figure 14 at the Imperial River just east of I-75. The blue lines represent 1D channel links, the yellow solid circles are 1D nodes, and the magenta polygons are the channel control volumes. The green diamond mesh is formed along the sides of the triangles and represent the areas where 2D overland flow occurs. Water can move into or out of the CCVs depending on water surface elevations in the floodplain and along the 1D channel links at specific points of connection. The water surface inside the CCV is sloped and interpolation functions are used to determine the water surface elevation at points of connection with the 2D mesh. A total of 87 CCVs are used in the existing condition model.

Figure 14 Example of Channel Control Volumes

2.9.3 Pond Control Volumes

Pond control volumes (PCVs) are like CCVs except the water surface inside the PCV is assumed to be a level pool (i.e., flat) and they are not related to 1D channel links. Water can move into and out of the PCV. These are typically used for stormwater ponds and lakes.

Figure 15 Example of Pond Control Volumes

An example using PCVs is shown in Figure 15. This is a subdivision with various stormwater detention ponds and wetland depressions. There are 4 control structures modeled as 1D weir links. Several ponds are interconnected with equalizer pipes (not included in the model) behind each of the structures. The assumption in this model setup is that the group of ponds behind a weir will behave as a level pool. The PCVs encompass each group of ponds. A stage-area table is extracted from the ground surface DEM at 0.25-ft vertical increments. These include storage in the ponds as well as in the streets. In addition to the weir connections, water can be exchanged with the 2D computational mesh (green diamonds) if water levels permit. There are 242 PCVs in the existing condition model.

2.9.4 1D Node Interfaces

The 1D node interface allows communication and transfer of water between 1D model components and the 2D computational mesh. An example is shown in Figure 16 where 1D node interfaces are placed at the downstream end of discharge points for a variety of 1D links (e.g., pipes, weirs, drop structures). The detention ponds are represented as PCVs and discharge to the large adjacent wetland system. Water entering the 1D node interface points combine with other flows in the 2D overland flow computational mesh. There are 290 1D node interface points in the existing condition model.

Figure 16 Example of 1D Node Interfaces

2.9.5 2D Weirs

A 2D weir is a tool that allows roadway embankments, berms, and levees to be incorporated into the 2D computational mesh. It consists of 3 polylines: (1) the centerline; (2) an upstream offset; and, (3) a downstream offset. The polylines can be edited independent of one another. This allows the centerline to be placed precisely along the crown of a roadway and the offsets can be placed at the bottom of a roadside swale. 2D overland flow can occur parallel to the weir feature, but it cannot overtop the weir. Instead, 1D weir links are created at each centerline vertex. The geometry of the individual 1D weir links are extracted from the underlying ground surface DEM.

An example of a 2D weir is shown in Figure 17. This is along a portion of Corkscrew Road. There are numerous culvert crossings at this location that are modeled as pipe links. 1D node interfaces are placed along the 2D weir offset vertices. The combination of node interfaces, pipe links, and the 2D weir feature allow for flow both under the road and over the top of it should water surfaces exceed the roadway elevation. There are 47 weir features in the existing condition model that get converted to 2,150 1D weir links.

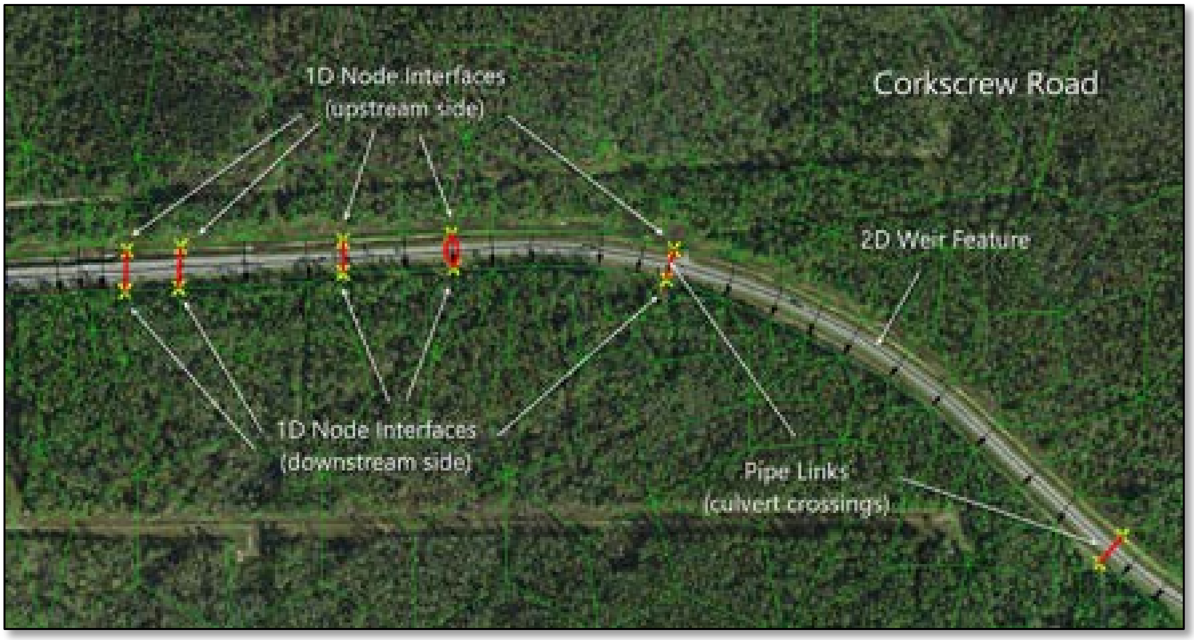


Figure 17 Example of a 2D Weir

2.9.6 Breaklines

ICPR4 calculates flows along the edges of triangles. Breaklines are polylines and triangle edges are guaranteed along their lengths. They can be used to incorporate local flow paths and ridges, which in flat areas like the Corkscrew Swamp, can be very subtle. Square-celled 2D models resample the DEM to an average ground elevation based on the cell size. Since the average elevation in these types of models will never be at the lowest point, subtle flow paths can be inadvertently blocked causing large volumes of water to be shunted in a wrong direction. An example of this is depicted in Figure 18. The square-cell approach is shown on the left with the average ground elevations included next to the cell names. A depression is located mostly in cell E with an average ground elevation of 15.7’. The natural flow pattern is from east to west out of this depression at elevation 14’. However, based on the average ground elevations of the cells, flow will be directed to the south. Breaklines can be used in ICPR4 to overcome this limitation (middle image). Water flows along the edges of the triangles and triangle edges are guaranteed along breaklines. Consequently, flow moves in the correct direction – from east to west. The computational mesh is shown on the right.

A total of 2,322 breaklines were used in the existing condition model.

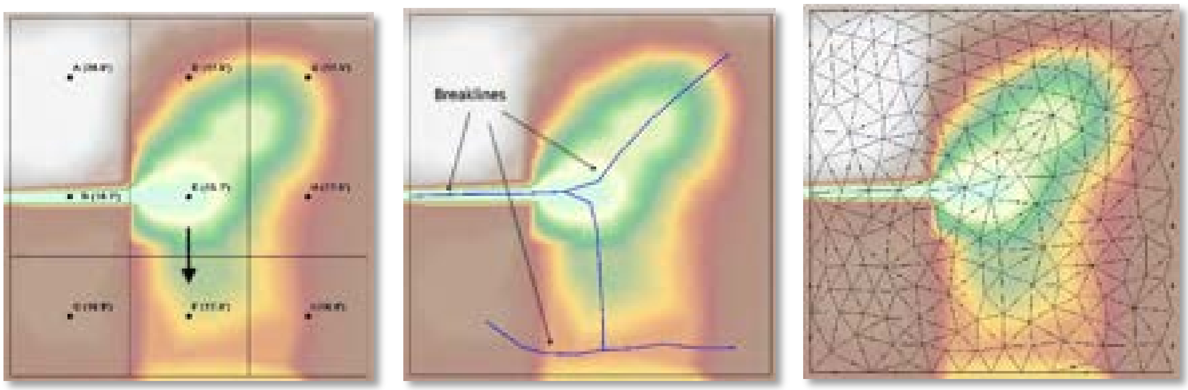


Figure 18 Example of Breakline Placement: (Left) Square Cell Approach with Average Ground Elevations; (Middle) Breaklines in Valleys & Ridges; (Right) Resulting Computational Mesh

2.9.7 Breakpoints

Triangle vertices are guaranteed at breakpoints. These are used to further characterize the terrain and refine the mesh. A total 6,736 breakpoints were used in the existing condition model of varying densities.

2.9.8 Mesh Construction

ICPR4 automatically constructs the computational meshes (triangle, honeycomb, and diamond) from the various graphic elements, the surface DEMs, and the map layers. The process is illustrated in Figure 19. The triangular mesh is developed from the graphic elements. Irregular shaped polygons (the honeycomb) are formed around the triangle vertices. The diamond mesh is formed along the triangle edges. Ground elevations and initial water surface elevations are set at each triangle vertex.

The honeycomb mesh is intersected with soils, land use, and the NEXRAD rainfall map layers. Each of the sub-polygons formed by this intersection have soil (MUKEY), land cover (impervious zone), and rainfall (NEXRAD pixel) attributes. Rainfall, ET, infiltration, current soil moisture, and runoff are calculated for each sub-polygon. Runoff from all sub-polygons within a given honeycomb are summed and delivered to the corresponding triangle vertex (2D surface node) for subsequent 2D overland flow surface hydraulic computations. The final existing condition honeycomb mesh is shown in Figure 20.

The diamond mesh is intersected with the land use map layer (roughness zones). Area weighted average roughness coefficients and various edge properties are determined for each triangle edge.

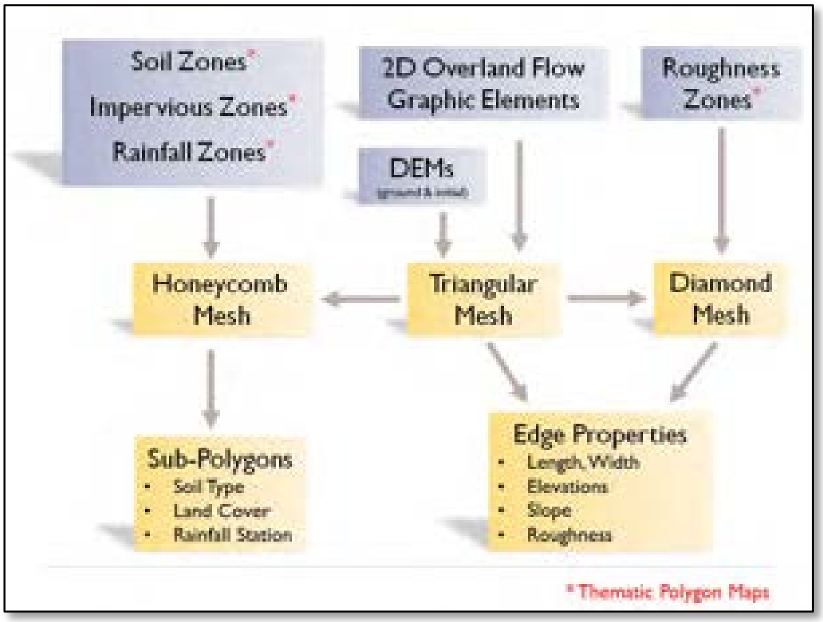


Figure 19 Development and Parameterization of the Computational Meshes

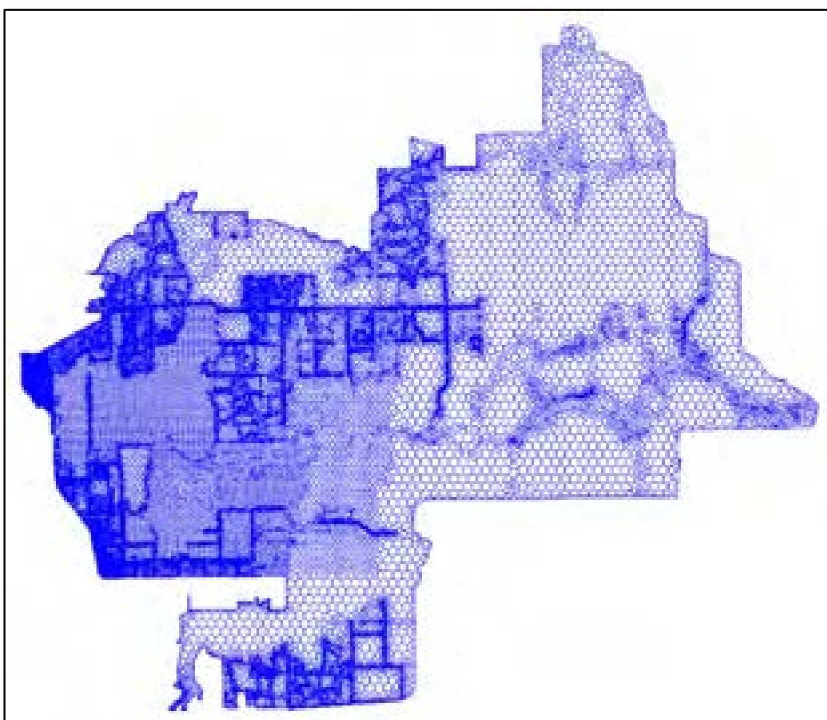


Figure 20 Final Existing Condition Honeycomb Mesh

2.10 Initial Conditions

2.10.1 Calibration and Verification Simulation Periods

The initial water surface elevations for the 2D overland computational mesh were set to the ground surface for the calibration and verification simulation periods. Initial water surfaces for 1D nodes were based on water control structures where appropriate. Initial soil moisture contents were set to the calibrated field capacities.

2.10.2 Discrete Storm Events

The initial water surface elevations for the discrete storm events were based on simulated water levels for August 24, 2017 (during the calibration period), just prior to the Invest 92L storm system. Initial soil moisture contents for the discrete storms were set to a “wet” condition which was assumed to be 50% between the calibrated field capacity and saturated conditions.

2.11 Boundary Stage Conditions

2.11.1 Calibration and Verification Periods

The recorded tidal elevations at the Naples NOAA tide gage (8725110) were used for outlets discharging into Estero Bay for the calibration and verification periods. The USGS South Branch Estero River at Estero, Florida (02291597) was used where the Estero River South Branch flows under Corkscrew Road.

2.11.2 Discrete Storm Events

The same historical gage data were used for the discrete storm events except the peak Irma stage was set at hours 60, 150 and 180 for the 72-hour, 168-hour and 240-hour storms, respectively. These times correspond to the maximum rainfall intensities.

3. Model Calibration and Verification

3.1 Calibration

3.1.1 Calibration Period

The summer of 2017 (June 1 to November 1) was used as the calibration period. As previously discussed in 2.8 Rainfall and Evapotranspiration Data, NEXRAD rainfall data (15-minute increments) obtained from the SWFWMD was used to distribute the rainfall spatially and temporally across the model domain for the calibration period.

3.1.2 Observed Data

Observed water levels at the eight locations shown in Figure 21 were used to test model calibration. Stations #1, #2 and #3 are along the Kehl Canal and Imperial River. Stations #4, #5, #7 and #8 are in wetland systems. And station #6 is in a Lake Trafford.

Figure 21 Calibration Points

3.1.3 Statistical Metrics

The statistical metrics presented in Table 10 were used for a study of the Myakka River (Interflow Engineering, LLC, 2008).

METRIC	Good	Fair	Poor
Coefficient of Determination (R^2)	0.6 <= COD <= 1.0	0.4 <= COD < 0.6	COD < 0.4
Nash-Sutcliffe Efficiency (NSE)	0.0 <= NSE <= 1.0	-1.0 <= NSE < 0.0	NSE < -1.0
Mean Error (ME) ft	|ME| <= 0.50'	0.50' < |ME| <= 1.00'	|ME| > 1.00'
Mean Absolute Error (MAE) ft	0.00' <= MAE <= 0.75'	0.75' < MAE <= 1.50'	MAE > 1.50'
Root Mean Square Error (RMSE) ft	0.00' <= RMSE <= 1.00'	1.00' < RMSE <= 2.00'	RMSE > 2.00'

Table 10 Calibration Metrics for the Myakka River Watershed Initiative

Since the Myakka River Watershed is similar in many respects to this study area, the same metrics are used with exception of the Nash-Sutcliffe Efficiency (NSE) as highlighted Table 11. Additionally, ratings of “good”, “fair” and “poor” are used if at least 2, 1 or 0 of ME, MAE and RMSE are within ½ of the standard deviation of the observed, respectively.

METRIC	Good	Fair	Poor
Coefficient of Determination (R^2)	0.6 <= COD <= 1.0	0.4 <= COD < 0.6	COD < 0.4
Nash-Sutcliffe Efficiency (NSE)	0.5 <= NSE <= 1.0	0.0 <= NSE < 0.5	NSE < 0.0
Mean Error (ME) ft	|ME| <= 0.50'	0.50' < |ME| <= 1.00'	|ME| > 1.00'
Mean Absolute Error (MAE) ft	0.00' <= MAE <= 0.75'	0.75' < MAE <= 1.50'	MAE > 1.50'
Root Mean Square Error (RMSE) ft	0.00' <= RMSE <= 1.00'	1.00' < RMSE <= 2.00'	RMSE > 2.00'
1/2 Standard Deviation (Observed) ft	2+ |ME|, MAE, RMSE	1 |ME|, MAE, RMSE	0 |ME|, MAE, RMSE

Table 11 Calibration Metrics for the SLC ICPR4 Modeling Effort

3.1.4 Calibration Process and Model Adjustments

The 2D groundwater component of ICPR4 addresses interactions between the surficial aquifer system and surface water bodies. It does not include complex three-dimensional geological layering, confined or semi-confined aquifer systems. Although it can calculate leakage across a confining layer based on user-defined pressures below the confining layer, it cannot calculate the pressures in confined systems such as in the Lower Tamiami Aquifer or changes in those pressures caused by well pumping.

When the first pass of the 2D groundwater module for most of the study area west of I-75 was constructed, unacceptably poor results were obtained even after going through the typical parameter adjustments phase (e.g., fillable porosity, saturated horizontal conductivity).

To understand the processes that might have caused the poor results, the groundwater system was analyzed for smaller areas and then incrementally increased, expanding land use coverages. This analysis is explained in a calibration memo dated February 25, 2020 from Pete Singhofen (SLT) to Steve Neff (AIM). The results deteriorated as the large agricultural areas between Corkscrew Road and the preserve were added. It was hypothesized that perhaps there are factors in the actual internal operation of these agricultural systems that were affecting not only the groundwater computations, but also runoff volumes. For example, water levels of internal canals are usually carefully maintained for these types of operations to provide both drainage and irrigation. The water table is maintained low enough to not saturate the root zone, but high enough to provide a water source via capillary action to the roots. Without all the details of the internal workings of these large agricultural systems (pump stations, water control structures and their operations such as flash boards, etc.) the model was likely over-predicting groundwater drawdowns in these areas.

Another factor contributing to the poor results is the influence of restrictive and semi-restrictive soil layers discussed in

2.6 Soils Map Layer. Approximately 63% of the study area (see Figure 10) has restrictive or semi-restrictive soil layers in the upper 6 feet (+/-) of the soil column. Weighted averages of the saturated vertical conductivities (K_v) are used in the Green-Ampt parameters and consequently the flux from the vadose zone to the saturated water table is over-predicted for these restrictive and semi-restrictive layers when the groundwater module is in play. ICPR4 includes an option to discretize the soil column into vertical layers with each layer having its set of parameters. This would allow the restrictive layers to be included and would work well if the water table is below the upper 6 feet (+/-) of the soil column. However, when the water table is within this upper zone, the recharge flux is based on unsaturated vertical conductivity in whatever layer the water table happens to fall within. Recall that the saturated vertical conductivities varied by a factor of 100 for the example presented in Table 7.

As a check, the available MIKE SHE/11 modeling effort calibration/verification results (provided to SLT from AIM Engineering & Surveying in May 2020) were reviewed. In that model, the complex groundwater system is modeled in three dimensions and includes the surficial aquifer system as well as various confined aquifer systems and well fields. In both the ICPR4 model with 2D groundwater included and the MIKE SHE/11 work, simulated water surface levels were underpredicted along the Kehl Canal and the Imperial River east of I-75. This is typically a volumetric problem. If there are expanses of hardpan or clay near the surface with perched water tables that are not included in the normal sources of soil parameters, or if water management practices in the agricultural areas intentionally maintain higher water tables, then there would be less soil storage overall and more runoff than the models indicate.

To test this hypothesis, the 2D groundwater component in ICPR4 was eliminated from the model. Instead, the thickness of the vadose zone was controlled, and various scenarios were tested. The distance between the ground surface and the seasonal highwater tables (SHWT) available through the SSURGO data from the NRCS. However, the maximum depths were limited, testing max depths of 1.5', 2.0' and 2.5'. For example, if the NRCS SHWT was 1.1' for a given soil type, then that value was retained. But if it was 3.5', it was limited to 1.5, 2.0' or 2.5' for each of those scenarios, respectively. A maximum depth of 2.0' was optimum, producing the most accurate results. Figure 22 is an example of a restrictive layer in the soil column that creates a perched water table. The right side of this figure is how it is idealized in the SLC ICPR4 Model.

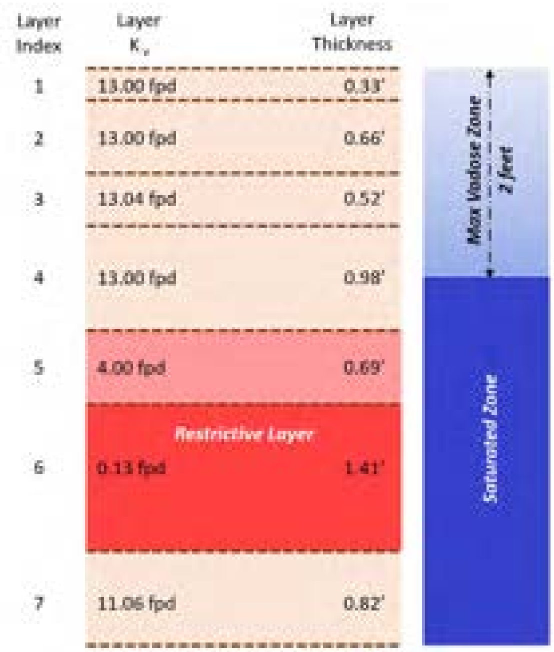


Figure 22 Example of a Restrictive Layer in the Soil Column and How it is Idealized in the SLC ICPR4 Model (Soil Zone 1413463, see Table 7 for additional details)

These results are more accurate than the ICPR4 model with 2D saturated groundwater included and they are more accurate than the MIKE SHE/11 results (see Figure 23, Figure 24, Figure 25 and Figure 26). Increased model complexity does not guarantee better results.

The following adjustments were made during the calibration process.

1. The maximum depth to the water table was set to 2.0 feet in the Green-Ampt parameters. This adjustment increased the surface runoff and better matched observed volumes.
2. Moisture contents for field capacity and wilting point were increased by 25% above the weighted averages originally computed from the NRCS SSURGO data.
3. A high Manning's n roughness coefficient (0.60) was needed through the swamp areas to adequately attenuate flows. Prior to this adjustments, simulated stage hydrographs peaked higher and receded faster than observed data.

The maximum depth to water table of 2 feet is a "calibrated" value. Soil moisture is tracked continuously in the soil column for the simulation period. Infiltration adds water to the soil column and evapotranspiration depletes it. Although saturated horizontal groundwater flow is not included in the final calibrated model, water can move horizontally above the ground surface when the soil column becomes saturated. As it moves overland, further infiltration can take place as unsaturated soils are encountered. There is likely interflow in the wetland system – the slow horizontal movement of water through the densely vegetated and mucky surface of the wetland system. This has been incorporated into the model by assigning high Manning's n coefficients (0.60) for the wetland system.

3.1.5 Calibration Results

A summary of the statistical metrics at the eight observation points is provided in Table 12. Stations #1, #4, #5, #6 and #8 (5 of the 8 stations) are considered "good" for all 6 of the statistical metrics. Stations #2 and #3 are "good" for R^2, NSE, and the ½ standard deviation criteria, and "fair" for ME, MAE and RMSE. These "fair" values lean closer to "good" than "poor". Station #7 is considered "good" for ME, MAE, RMSE, and the ½ standard deviation criteria and "fair" for R^2 and NSE. Overall, the calibration of the SLC ICPR4 model is considered "good".

STATIONS -->	#1	#2	#3	#4	#5	#6	#7	#8
METRIC	KEHL-H	KEHL-T	IMPERIAL	HF1	KEA846	L TRAFFO	ST2	49-GW9
Coefficient of Determination (R^2)	0.90	0.87	0.85	0.88	0.85	0.93	0.56	0.78
Nash-Sutcliffe Efficiency (NSE)	0.87	0.81	0.78	0.69	0.80	0.90	0.31	0.63
Average Calculated ft NAVD88	10.63	10.17	7.98	19.72	19.58	19.79	27.77	16.63
Average Observed ft NAVD88	11.03	10.78	8.61	19.90	19.71	19.68	27.81	16.65
Mean Error (ME) ft	0.39	0.62	0.63	0.18	0.05	-0.11	0.04	0.07
Mean Absolute Error (MAE) ft	0.54	0.87	0.97	0.22	0.26	0.18	0.07	0.10
Root Mean Square Error (RMSE) ft	0.80	1.13	1.24	0.27	0.36	0.22	0.10	0.14
Standard Deviation (Observed) ft	2.21	2.57	2.62	0.48	0.79	0.71	0.12	0.23
1/2 Standard Deviation (Observed) ft	1.10	1.29	1.31	0.24	0.40	0.35	0.06	0.11

STATIONS
#1 Kehl Canal Structure (Upstream)
#2 Kehl Canal Structure (Downstream)
#3 USGS 02291500 Imperial River Near Bonita Springs
#4 SFWMD Gage HF1
#5 SFWMD Gage KEA846
#6 SFWMD Gage L TRAFFO
#7 SFWMD Gage ST2
#8 Lee County 49-GW9

Table 12 Calibration Results – Statistical Metrics

Charts are provided on the following pages and compare calculated and observed water surface elevations at the various gages for the 5-month simulation period.

The ICPR4 results at the upstream side of the Kehl Canal structure (location #1, Figure 23) correlate well with observed data in terms of matching timing and shape of the stage hydrograph. Calculated stages at the four local maximums for the calibration period are within about 6 inches of observed levels. Water levels recover quicker for the ICPR4 stage hydrographs following the Invest 92L Storm (August 24-26) and Hurricane Irma (September 10-11), but the slopes of the recession legs generally follow the observed data. The MIKE SHE calibrated model results are shown in Figure 23 for comparison purposes.

The separation grows at the downstream side of the Kehl Canal structure (location #2, Figure 24) and at the USGS 02291500 gage (location #3, Figure 25) farther downstream. The MIKE SHE calibrated model results are shown in these two figures for comparison purposes. The USGS gage is located on the Imperial River just east of Interstate 75. Recall that the Bonita Springs ICPR model was incorporated mostly "as is" west of I-75. It might be possible to adjust the model west of I-75 to improve the match of peak elevations at USGS gage for late August into September. For example, channel cross sections along the Imperial River west of I-75 extend only to the top of bank and overbank conveyance is handled with weirs links. Weirs do not include friction terms and move water instantaneously from node to node. A more realistic treatment of the hydraulics west of I-75 might improve the results east of I-75 for higher flow conditions.

A comparison of ICPR4 and observed discharges at the USGS 02291500 gage is provided in Figure 26. The MIKE SHE calibrated model results are shown in this figure for comparison purposes. The observed peak discharges for the Invest 92L storm and Hurricane Irma are higher than the ICPR4 peaks. The observed recession legs for these two storms appear steeper than ICPR4. There is also an unusual outward "bowing" of the observed recession leg beginning about October 1.

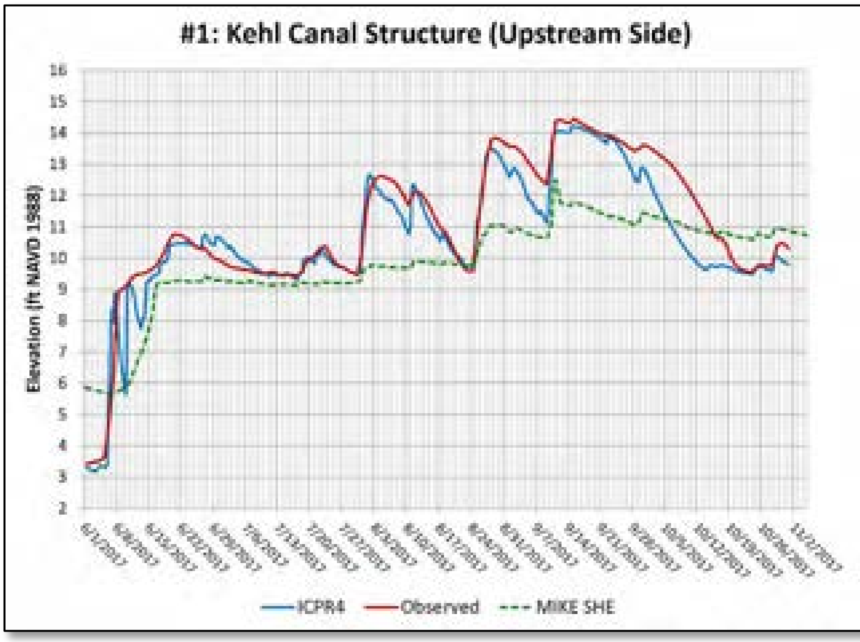


Figure 23 Stage Comparison at Kehl Canal Structure (Upstream Side)

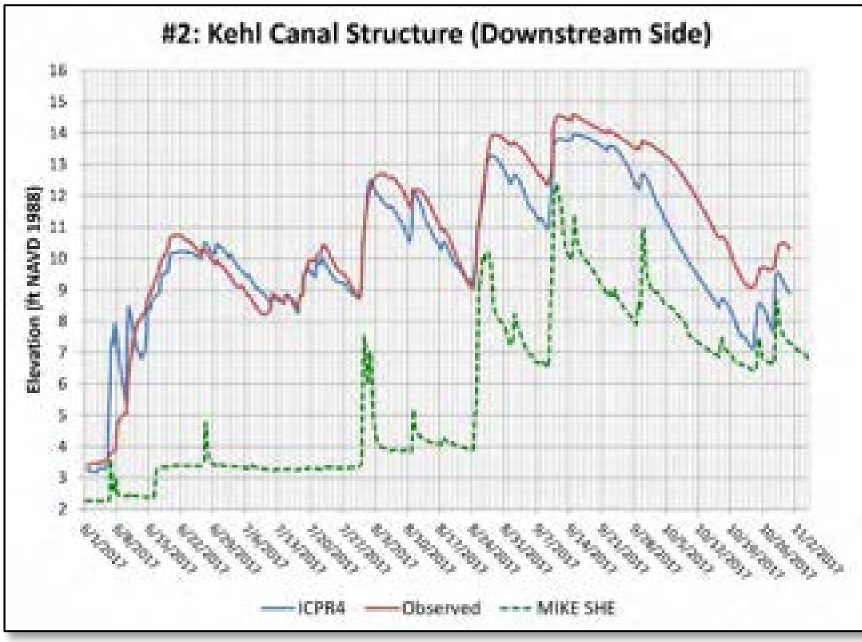


Figure 24 Stage Comparison at Kehl Canal Structure (Downstream Side)

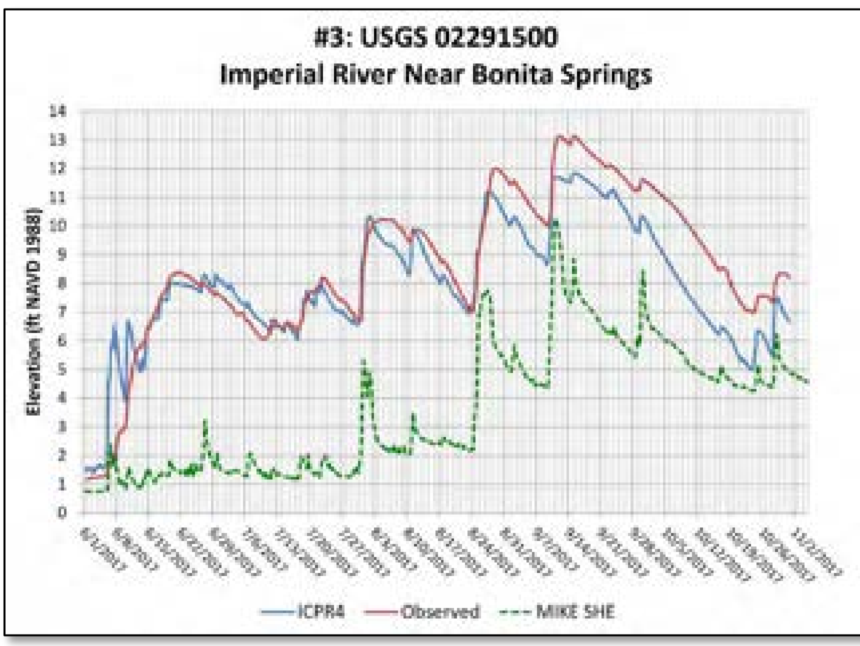


Figure 25 Stage Comparison at USGS Gage 02291500, Imperial River near Bonita Springs

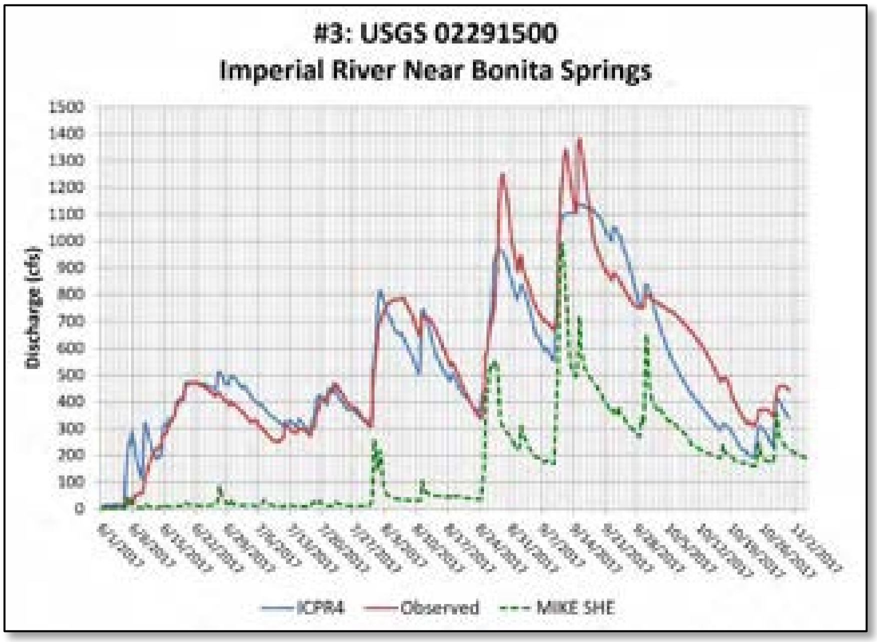


Figure 26 Discharge Comparison at USGS Gage 02291500, Imperial River near Bonita Springs

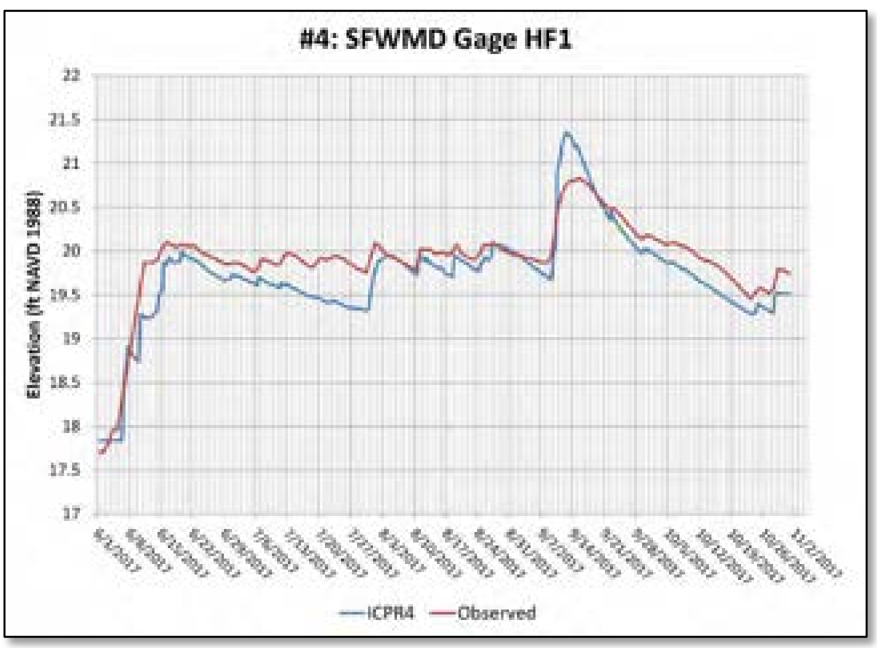


Figure 27 Stage Comparison at SFWMD Gage HF1

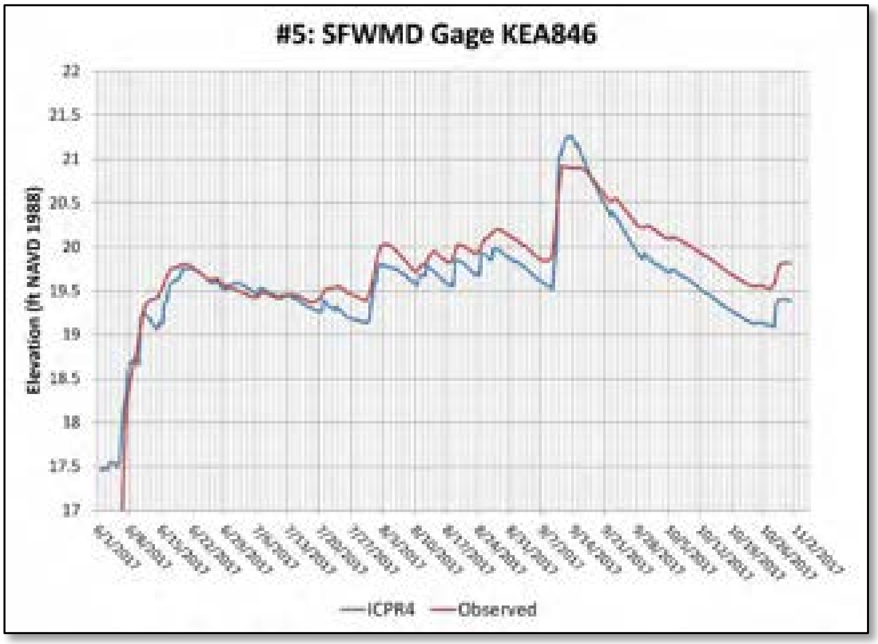


Figure 28 Stage Comparison at SFWMD Gage KEA846

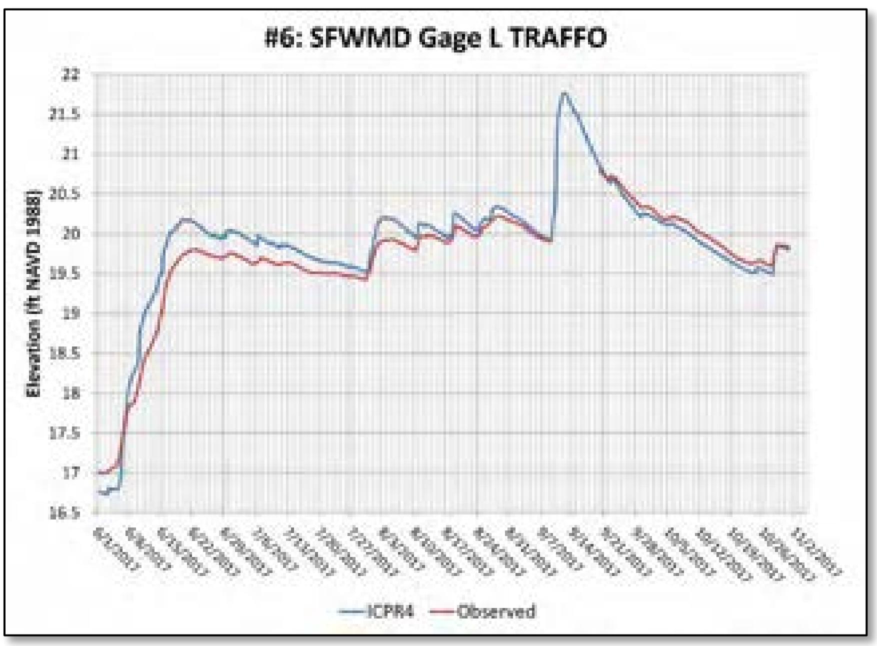


Figure 29 Stage Comparison at SFWMD Gage L Traffo

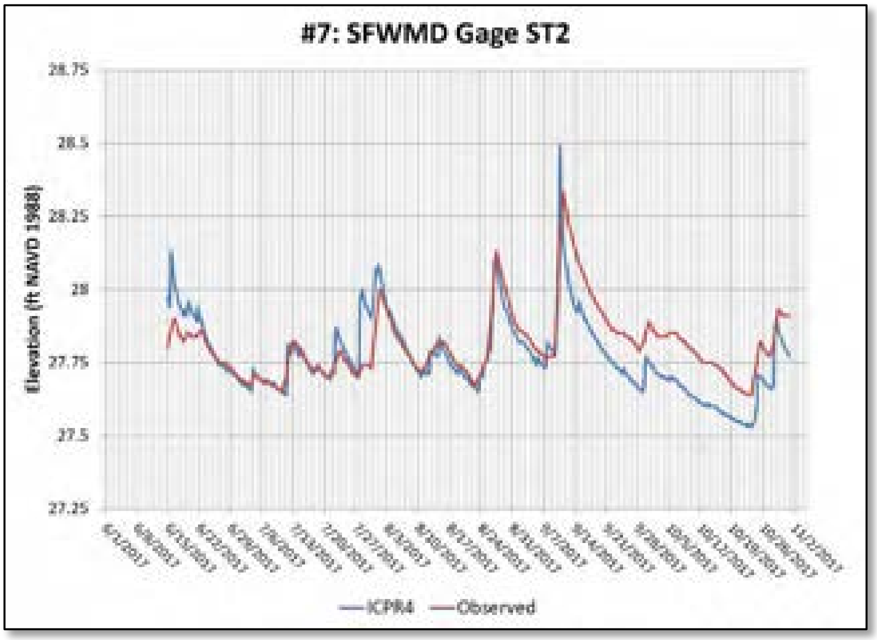


Figure 30 Stage Comparison at SFWMD Gage ST2

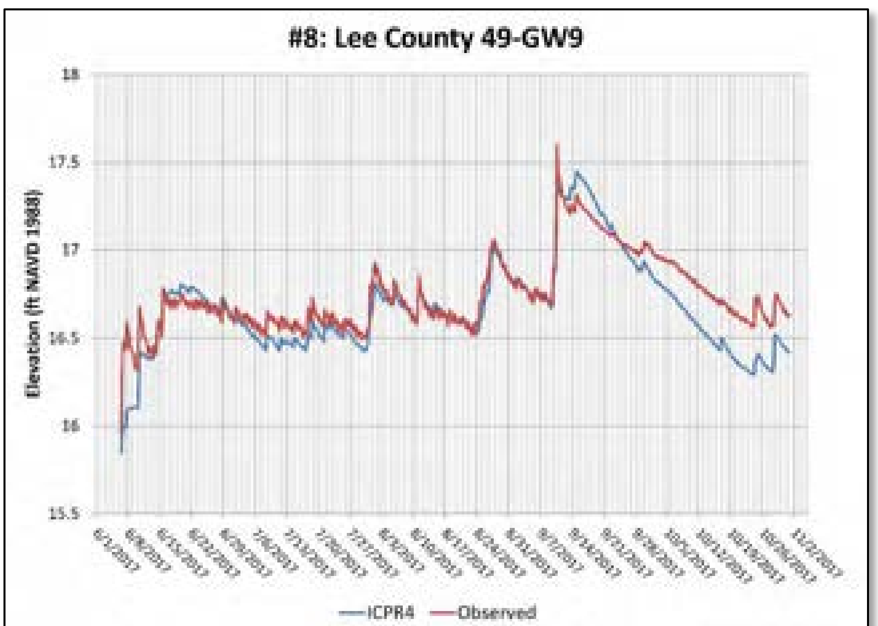


Figure 31 Stage Comparison at Lee County 49-GW9

3.2 Verification

The calibration period for the Southern Lee County ICPR4 model is June 1 to November 1, 2017, an unusually wet period. It includes two back-to-back major storm systems – Invest 92L and Hurricane Irma. A 5-year simulation from January 1, 2013 to December 31, 2017 is used for verification purposes and allows testing of numerous wet and dry cycles.

3.2.1 Imperial River Near Bonita Springs (USGS 02291500)

A summary of the statistical metrics for water surface elevations of the 5-year simulation period at the Imperial River Near Bonita Springs(location #3 in Figure 21) is presented in Table 13. The coefficient of determination (R^2), the Nash-Sutcliffe Efficiency (NSE), the Mean Error (ME), and the ½ standard deviation criteria are considered "good". The mean absolute error (MAE) and the root mean square error (RMSE) are "fair".

5-Year Simulation (Existing Conditions)			
USGS 02291500	Coefficient of Determination (R^2)	0.83	<-- Good
Imperial River	Nash-Sutcliffe Efficiency (NSE)	0.76	<-- Good
Near Bonita Springs	Average Calculated ft NAVD88	3.53	
	Average Observed ft NAVD88	3.47	
	Mean Error (ME) ft	-0.06	<-- Good
	Mean Absolute Error (MAE) ft	1.01	<-- Fair
	Root Mean Square Error (RMSE) ft	1.34	<-- Fair
	Standard Deviation (Observed) ft	2.72	
	1/2 Standard Deviation (Observed) ft	1.36	<-- Good

Table 13 Verification Statistical Metrics at USGS Gage 02291500, Imperial River near Bonita Springs

A comparison of the observed and calculated stage hydrographs for the "Imperial River Near Bonita Springs" is shown in Figure 32. Timing of peaks and recession legs match well. The rising legs of the calculated stage hydrographs at the beginning of the wet seasons for years 2014 and 2015 precedes the observed rising legs somewhat. This is believed to be caused by the assumed gate operations of the Kehl Canal gates for modeling purposes (all 3 gates were left open 1.3 feet for the entire simulation period) versus the actual gate operations. It is likely that one or more of the gates were either closed or not opened the full 1.3 feet used in the model. The model could be improved by incorporating actual gate operations for the simulation period although the results are considered "good" overall.

The observed levels are consistently higher (generally less than 12 inches) than the simulated levels for dry periods, which could be attributed to groundwater base flow. The differences could also be caused by gate operations (simulated vs. observed) or by a bump in the bottom of the channel downstream of the gage (between computational nodes) that is not included in the model or differences in roughness between assumed and actual. Regardless, these are relatively minor.

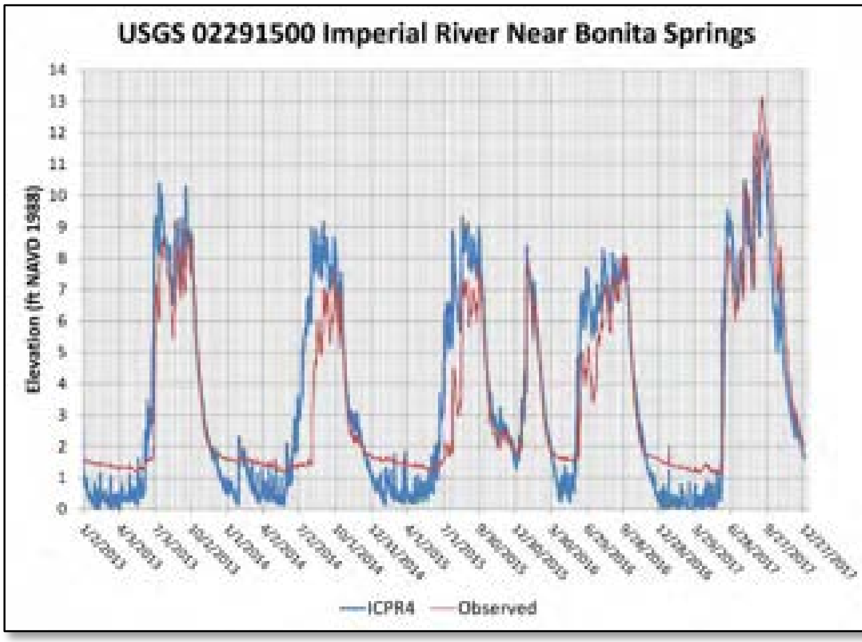


Figure 32 Verification Stage Comparison at USGS Gage 02291500, Imperial River near Bonita Springs

A comparison of the observed and calculated discharge hydrographs for the “Imperial River Near Bonita Springs” is shown in Figure 33.

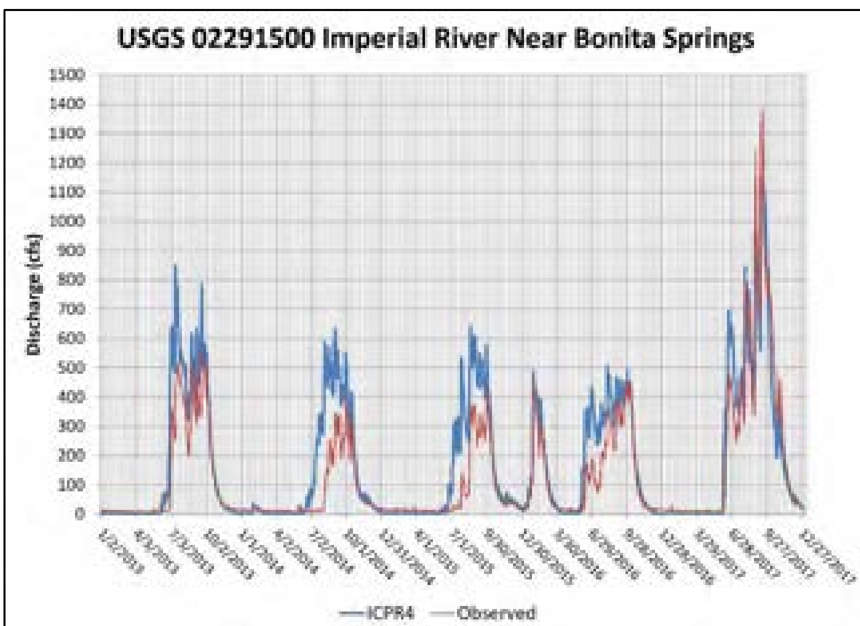


Figure 33 Verification Discharge Comparison at USGS Gage 02291500, Imperial River near Bonita Springs

3.2.2 SFWMD Gage HF1

The South Florida Water Management District (SFWMD) surface water gage "HF1" is located southwest of Lake Trafford in Collier County (location #4 in Figure 21) and is in a wetland system.

A summary of the statistical metrics based on water surface elevations is provided in Table 14. R^2 and NSE are 0.83 and 0.76, respectively, both considered "good". These are coincidently the same as for the Imperial River. The ME, MAE, RMSE, and the ½ standard deviation criteria are also considered "good" based on the statistical targets used for this study.

5-Year Simulation (Existing Conditions)			
SFWMD Gage HF1	Coefficient of Determination (R^2)	0.83	<-- Good
	Nash-Sutcliffe Efficiency (NSE)	0.76	<-- Good
	Average Calculated ft NAVD88	3.53	
	Average Observed ft NAVD88	3.47	
	Mean Error (ME) ft	-0.23	<-- Good
	Mean Absolute Error (MAE) ft	0.36	<-- Good
	Root Mean Square Error (RMSE) ft	0.47	<-- Good
	Standard Deviation (Observed) ft	0.95	
	1/2 Standard Deviation (Observed) ft	0.48	<-- Good

Table 14 Verification Statistical Metrics at SFWMD Gage HF1

A chart comparing observed and calculated stage hydrographs for the verification period is shown in Figure 34. ICPR4 matches the timing and magnitude of the peak water surface elevations each year with one exception – a winter storm in 2016. Calculated rising legs match the observed rising legs closely. The calculated recession legs are flatter than the observed and are likely caused by local drainage patterns not captured in the model.

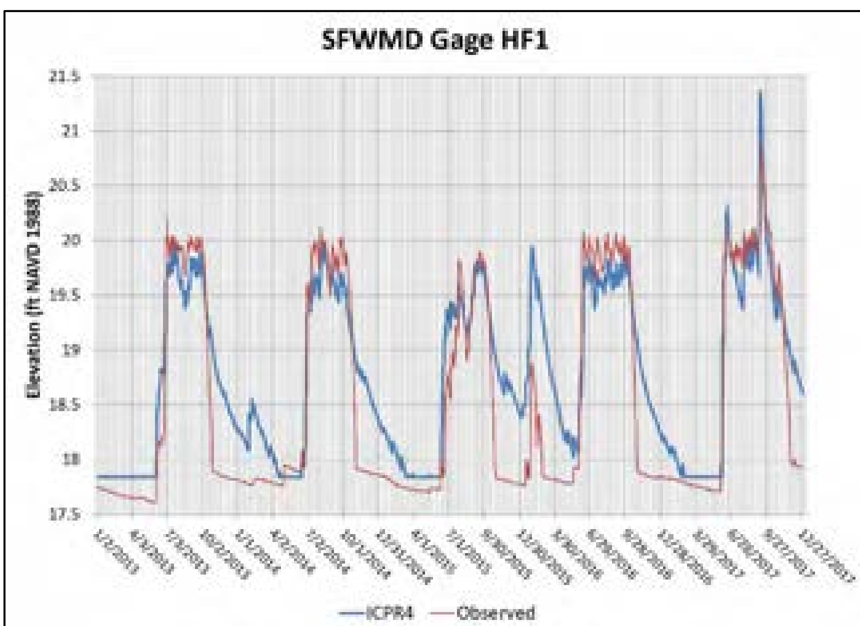


Figure 34 Verification Stage Comparison at SFWMD Gage HF1

3.2.3 Lee County 49-GW9

Lee County 49-GW9 (location #8 in Figure 21) is a groundwater monitoring well maintained by Lee County and water levels are recorded both below and above the ground surface (approximately elevation 15.45 feet NAVD88). The data appears to be suspect for all of 2013. An elevation of 14.5 feet NAVD88 was reported for the entire year without variation. A comparison of water levels above the ground surface are shown in Figure 35. The maximum calculated water surface elevations are within about 6 inches for years 2014 – 2017. The simulated maximums for years 2014 and 2017 are less than about an inch different than observed. The accuracy of LiDAR data for ground surfaces is typically (+/-) 6 inches.

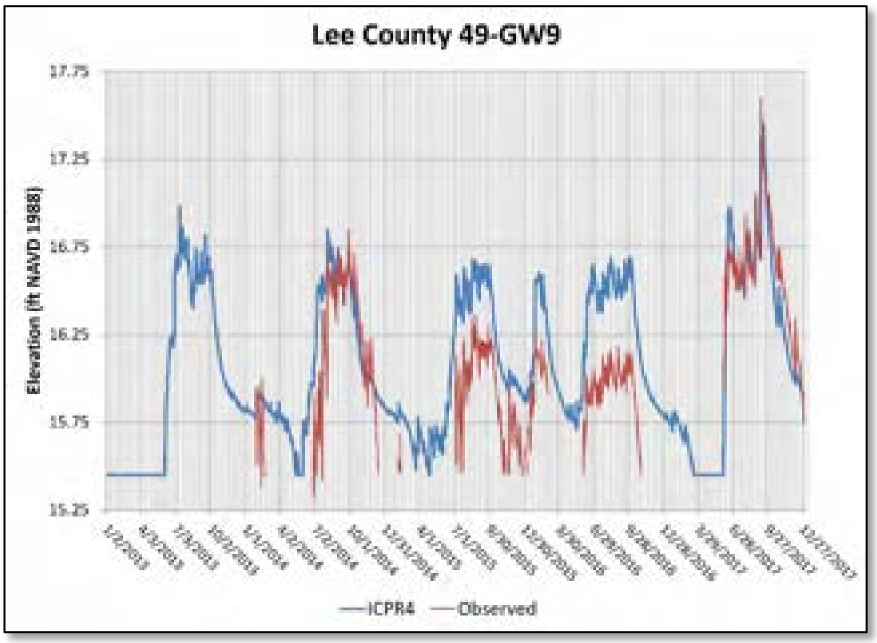


Figure 35 Verification Stage Comparison at Lee County 49-GW9

3.2.4 Lee County 49-GW10

Lee County 49-GW10 is located on the east side of Radio Tower Road about midway between the Kehl Canal and Bonita Beach Road. Observed monthly water levels are shown in Figure 36. Data was not available for years 2015 and 2016. Also, the gage was unable to record water surfaces above elevation 14.98 feet NAVD88, which occurred several times in 2017.

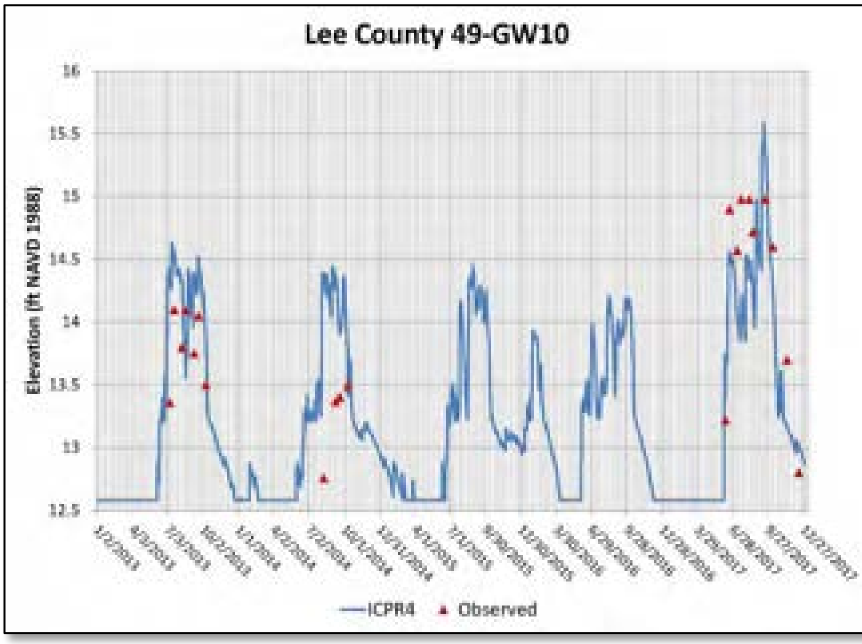


Figure 36 Verification Stage Comparison at Lee County 49-GW10

3.2.5 Lee County 49-GW6

Lee County 49-GW6 is located about 2.25 miles south of Corkscrew Road on the west edge of a large agricultural operation (see Figure 37). A comparison of monthly observed water levels (above the surface) are shown in Figure 38. ICPR4 does not match the observed water levels at this location as well as at the others. The simulated maximum water surfaces are about 6 – 9 inches lower than the observed levels for 2016 and 2017. The local drainage patterns in this area are complex. More detail in the ICPR4 model would be needed to capture these subtleties. But, given that the accuracy of the LiDAR ground elevations is (+/-) 6 inches, the simulated elevations are within reasonable ranges.

Figure 37 Location of Lee County 49-GW6

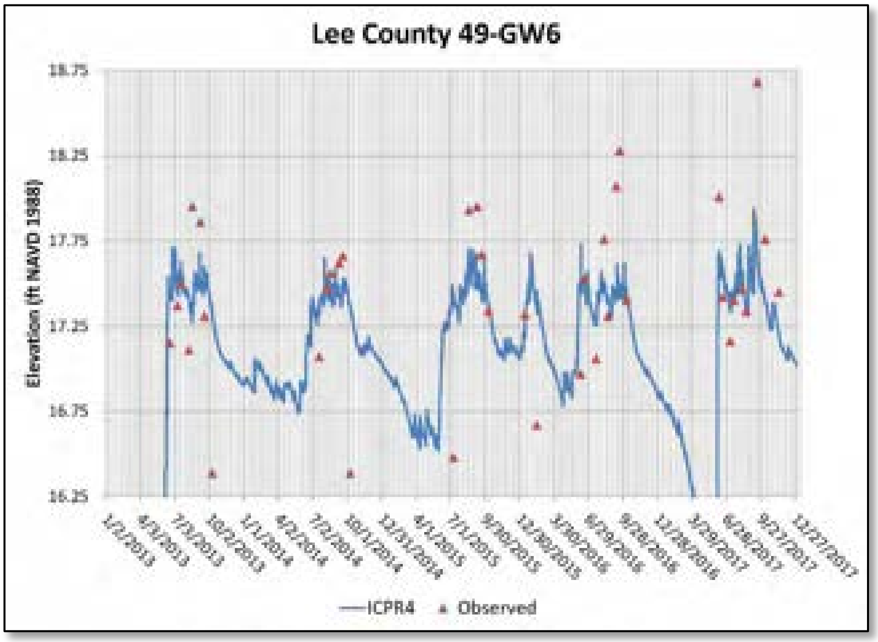


Figure 38 Verification Stage Comparison at Lee County 49-GW6

3.2.6 Hidden Cypress and Larry Kiker Preserves Monitoring Wells

There are 13 monitoring wells located in the Kiker Preserve as shown in Figure 39. Wells “MW1”, “MW2” and “MW3” are 12 feet deep and the others are 3 feet deep. Daily water levels at each well between June 1, 2019 and December 15, 2019 were provided to SLT. This period includes the end of the 2019 dry season, continues through the wet season, and then ends at the beginning of the next dry season. County staff indicated at a December 18, 2019 meeting that this period was wetter than average. The data includes depths below ground (negative values) and depths above ground (positive values). The ground elevations of the wells were not surveyed and are therefore unavailable, so it is not possible to compare water surface elevations at these wells.

To test the reasonableness of the “maximum vadose zone thickness of 2 feet” assumption in the calibrated ICPR4 model, the range of water level fluctuations at 13 monitoring wells in the Kiker Preserve were compared to the model results of the 5-year existing condition simulations.

Figure 39 Hidden Cypress and Larry Kiker Preserves Groundwater Monitoring Wells

The maximum and minimum depths at each of the wells were extracted for the 5½-month period and are shown in Figure 40. Also shown on the chart are the maximum and minimum depths determined from the 5-year ICPR4 simulation at the same locations. Although these comparisons are from different time periods, the depth ranges are typical for this area. The water level ranges are similar for all wells except MW1 and MW2. The minimum observed depths are greater for these wells by about 1.7 feet and 1.0 foot, respectively. Overall, 11 of the 13 wells experienced groundwater depths less than about 2.25 feet below the ground surface. This demonstrates that the underlying assumption of a maximum vadose zone thickness of 2 feet is reasonable.

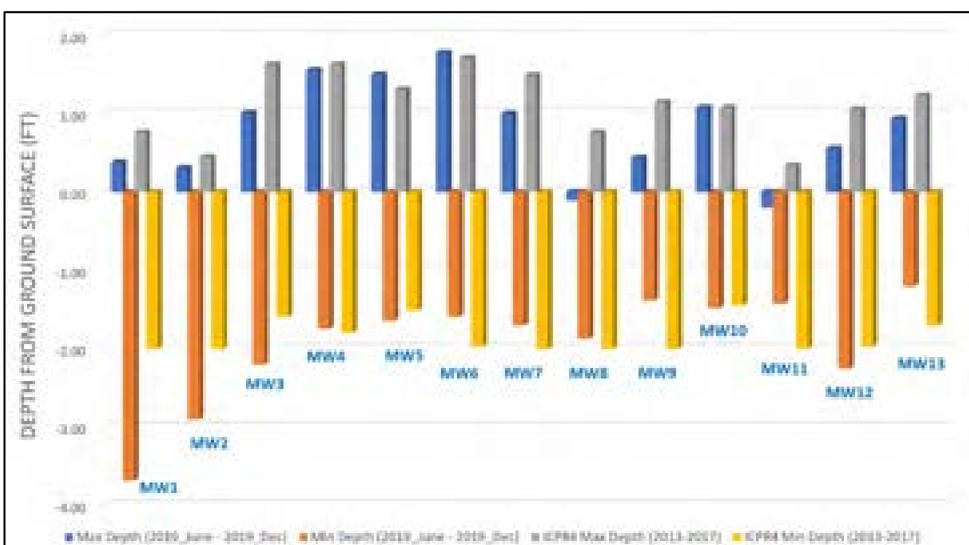


Figure 40 Comparison of Water Fluctuations at 13 Groundwater Monitoring Wells in the Kiker Preserve

3.2.7 Summary

The verification process includes comparisons with observed data from two characteristically different surface water gages (USGS 02291500 and SFWMD HF1) for the 5-year simulation period. The USGS gage is located on the Imperial River just east of I-75. A large portion of the study area drains past this gage. The SFWMD HF1 gage is in a wetland system in the upper watershed area. R^2 and NSE values of 0.83 and 0.76, respectively, were obtained at both gages (coincidently the same) and indicate a “good” correlation with observed data.

The 5-year ICPR4 simulations were also compared to 13 groundwater monitoring wells in the Kiker Preserve. The range of groundwater and surface water depths were extracted from the daily recorded values from June 1 to December 15, 2019 for each well. Ranges were also determined from the ICPR4 model results for the 5-year simulation period. The observed maximum depth to the water table for 11 of the 13 wells was less than 2.25 feet which is close to the maximum allowable water table depth of 2.0 feet used in the final calibration model.

The maximum depth to water table of 2 feet is a “calibrated” value. Soil moisture is tracked continuously in the soil column for the simulation period. Infiltration adds water to the soil column and evapotranspiration depletes it. Although saturated horizontal groundwater flow is not included in the final calibrated model, water can move horizontally above the ground surface when the soil column becomes saturated. As it moves overland, further infiltration can take place as unsaturated soils are encountered. There is likely interflow in the wetland system – the slow horizontal movement of water through the densely vegetated and mucky surface of the wetland system. This has been incorporated into the model by assigning high Manning’s n coefficients (0.60) for the wetland system.

Flood control is the primary focus of this investigation and it has been demonstrated that the model is accurate in predicting timing and magnitude of flooding of this complex system. A secondary focus is the potential environmental consequences from wetland hydroperiod alterations. It has been demonstrated that the model accurately simulates wet and dry cycles and that hydroperiods can be determined from long term simulations for both existing and project conditions.

4. Assessment of Existing Conditions

4.1 Particle Tracing Analysis

An existing condition particle tracing analysis was performed using flow velocities on September 13, 2017, two days after Hurricane Irma had passed over the study area. This tool works by placing a starting point anywhere in the watershed. A flow path is then traced from the starting point based on velocity magnitudes and directions. The path ends when a zero velocity is encountered. Seventeen (17) starting points were used for this analysis (e.g., A, B, … Q) and the resulting flow paths (A – A', B – B', … Q – Q') are shown in Figure 41. The length, travel time and average velocity for each of the flow paths are provided in

Table *15*. For example, if a particle is placed at point F, it will reach point F' in 329 hours, traveling 39,615 feet following the flow path F – F' at an average velocity of 2,890 fpd. The weighted average velocity of all flow paths is 2,369 fpd or 0.027 fps, which is quite slow as expected.

Note that the flow paths north of and including K – K' move in a generally northeast to southwest direction, from Collier County into the southeast corner of Lee County at the Kehl Canal. This is a significant drainage area that must be considered relative to the berm alignments and flood mitigation projects.

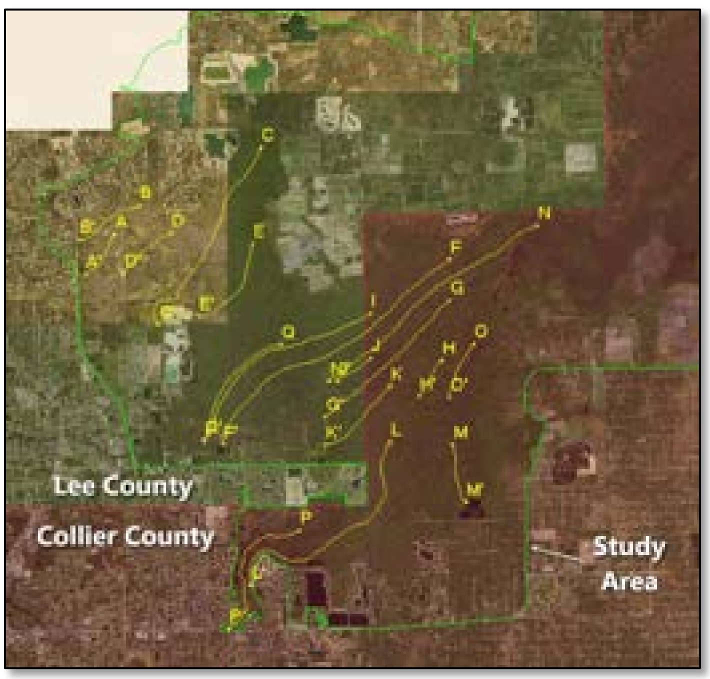


Figure 41 Flow Paths Derived from Particle Tracing Analysis

Water surface profiles for Hurricane Irma superimposed with the 25- and 100-year storms (72-, 168-, and 240-hour durations) are shown for flow paths A' – A, D' – D, G' – G, I' – I, K' – K, and L' – L in Figure 42 through Figure 59.

Flow Path	Length (ft)	Travel Time (hrs)	Avg Velocity (fpd)
A – A’	6,784	643	253
B – B’	9,425	3,957	57
C – C’	29,474	368	1,922
D – D’	8,309	80	2,493
E – E’	12,899	133	2,328
F – F’	39,615	329	2,890
G – G’	22,469	196	2,751
H – H’	5,674	59	2,308
I – I’	29,361	274	2,572
J – J’	5,337	39	3,284
K – K’	11,705	113	2,486
L – L’	32,266	580	1,335
M – M’	7,867	71	2,659
N – N’	34,336	240	3,434
O – O’	7,749	55	3,381
P – P’	19,463	197	2,371
Q – Q’	17,362	204	2,043
Weighted Average			2,369

Table 15 Travel Times and Average Velocities Based on Particle Tracing Analysis

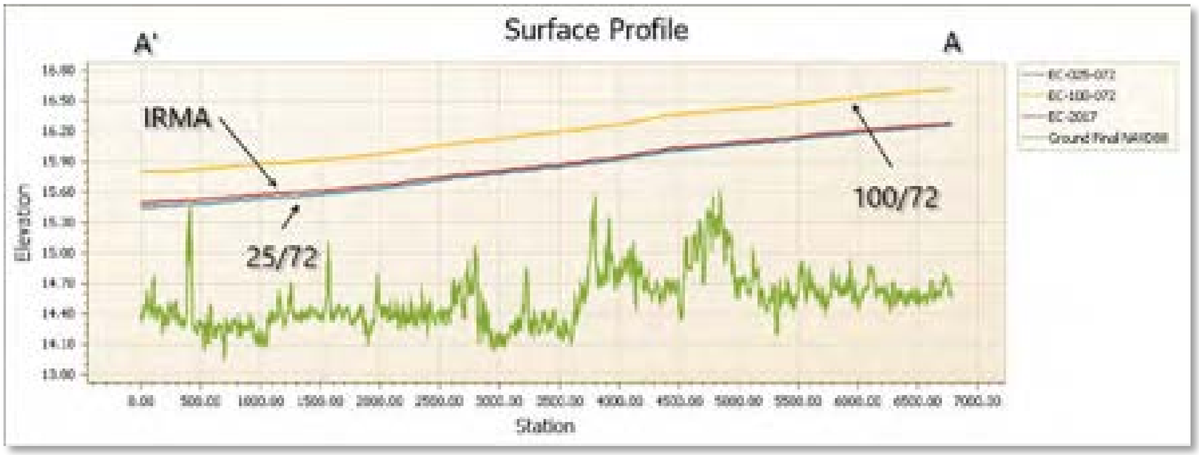


Figure 42 Existing Condition (EC) Water Surface Profiles for Path A'-A: Irma, 25-yr & 100-yr 72-hr Storms

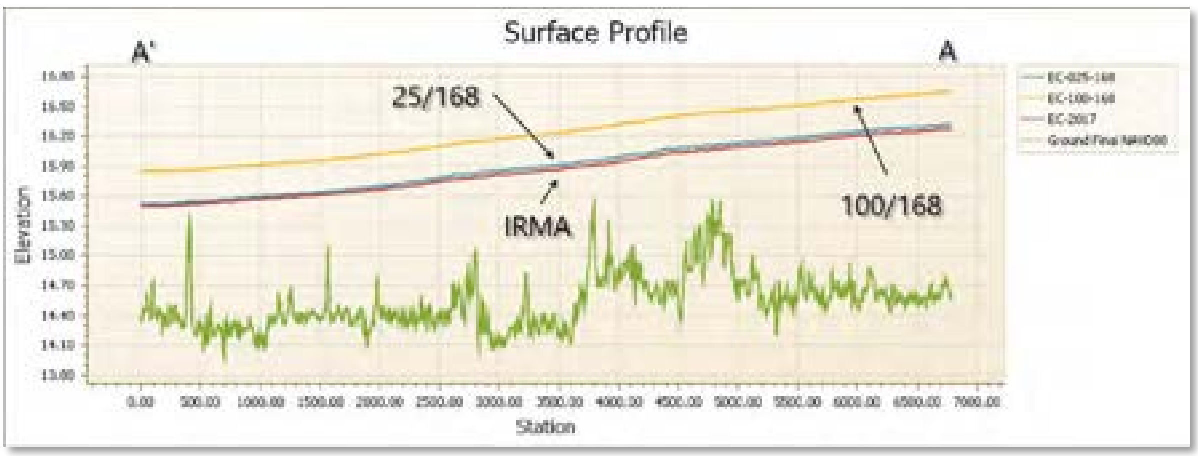


Figure 43 Existing Condition (EC) Water Surface Profiles for Path A'-A: Irma, 25-yr & 100-yr 168-hr Storms

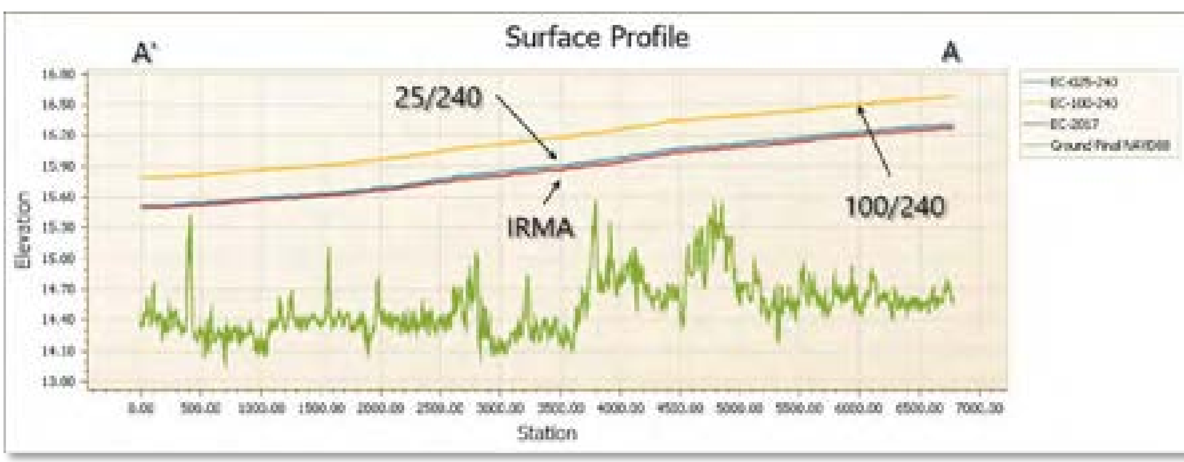


Figure 44 Existing Condition (EC) Water Surface Profiles for Path A'-A: Irma, 25-yr & 100-yr 240-hr Storms

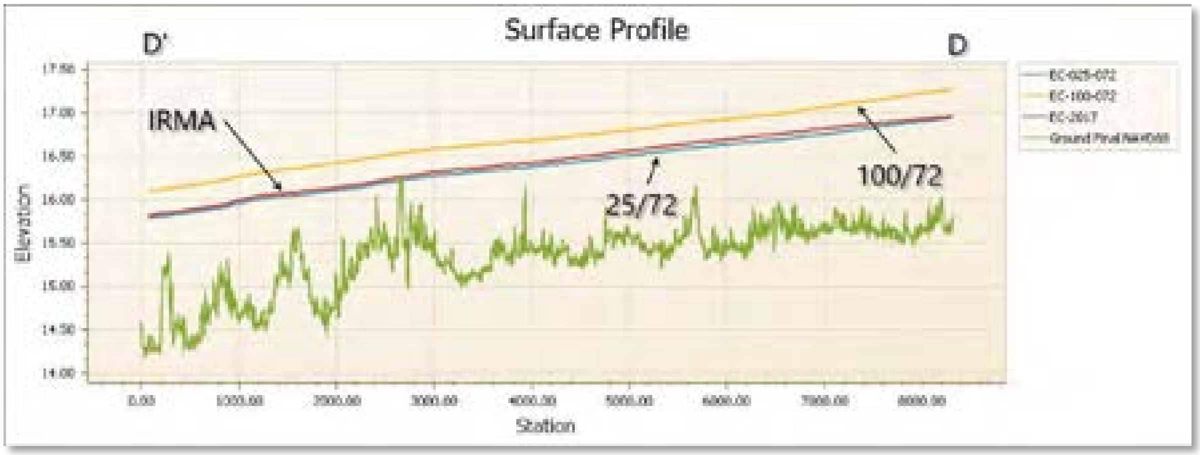


Figure 45 Existing Condition (EC) Water Surface Profiles for Path D'-D: Irma, 25-yr & 100-yr 72-hr Storms

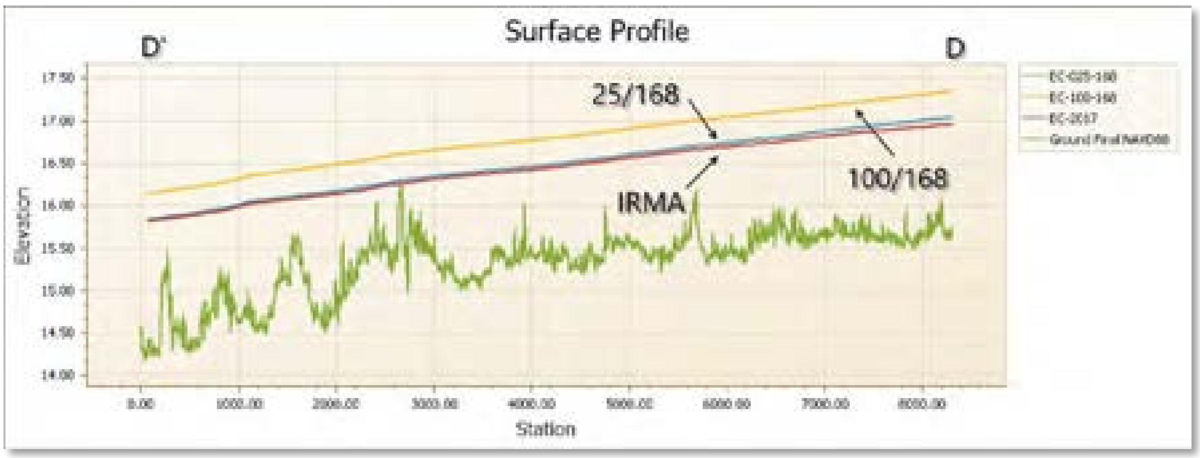


Figure 46 Existing Condition (EC) Water Surface Profiles for Path D'-D: Irma, 25-yr & 100-yr 168-hr Storms

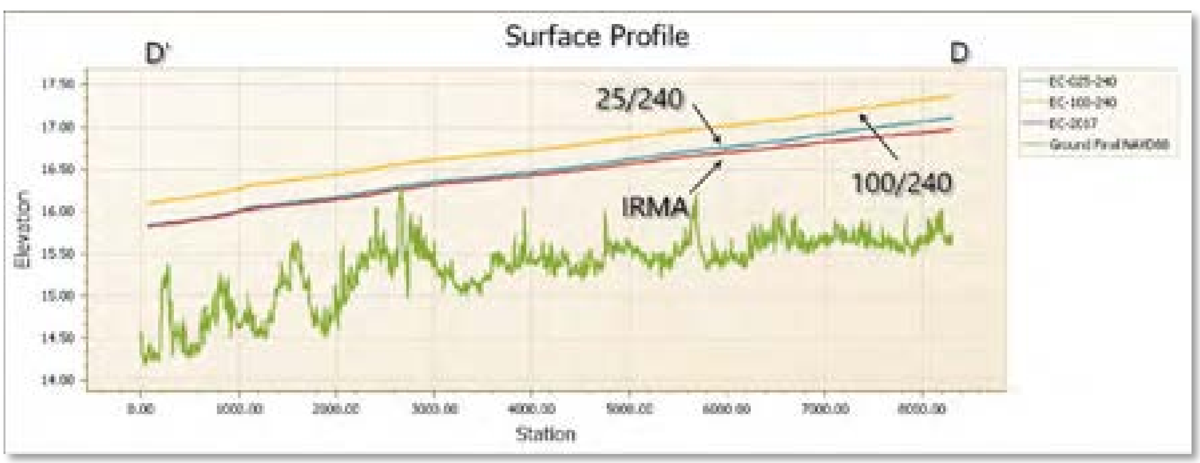


Figure 47 Existing Condition (EC) Water Surface Profiles for Path D'-D: Irma, 25-yr & 100-yr 240-hr Storms

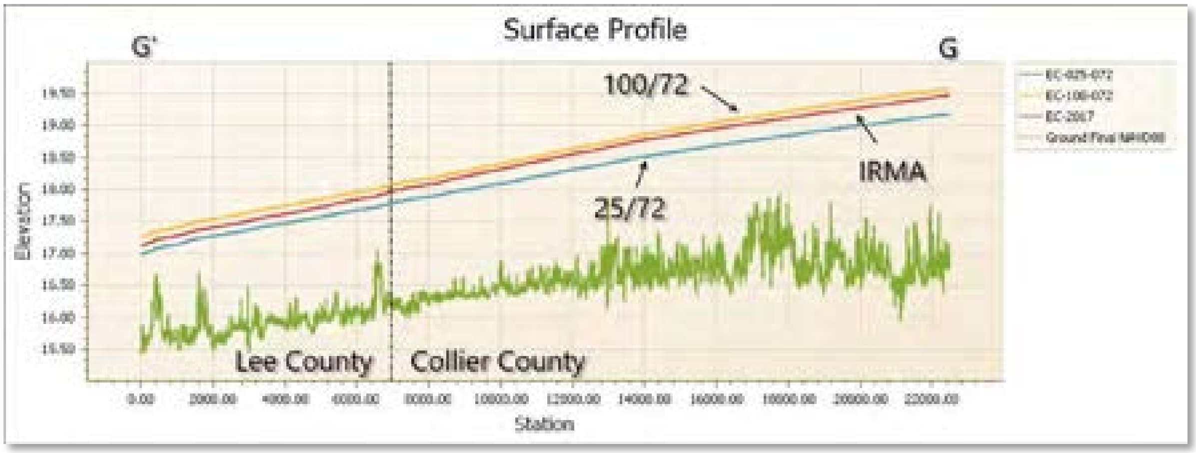


Figure 48 Existing Condition (EC) Water Surface Profiles for Path G'-G: Irma, 25-yr & 100-yr 72-hr Storms

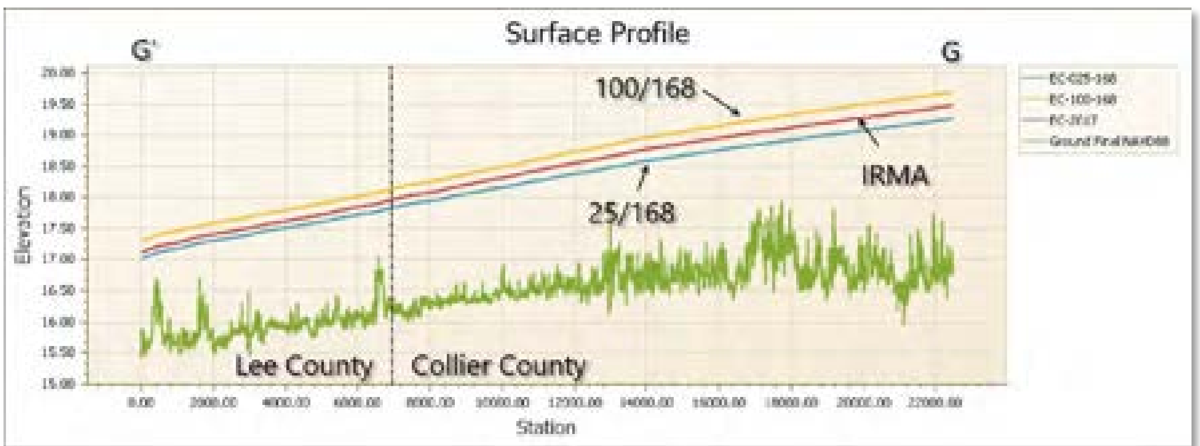


Figure 49 Existing Condition (EC) Water Surface Profiles for Path G'-G: Irma, 25-yr & 100-yr 168-hr Storms

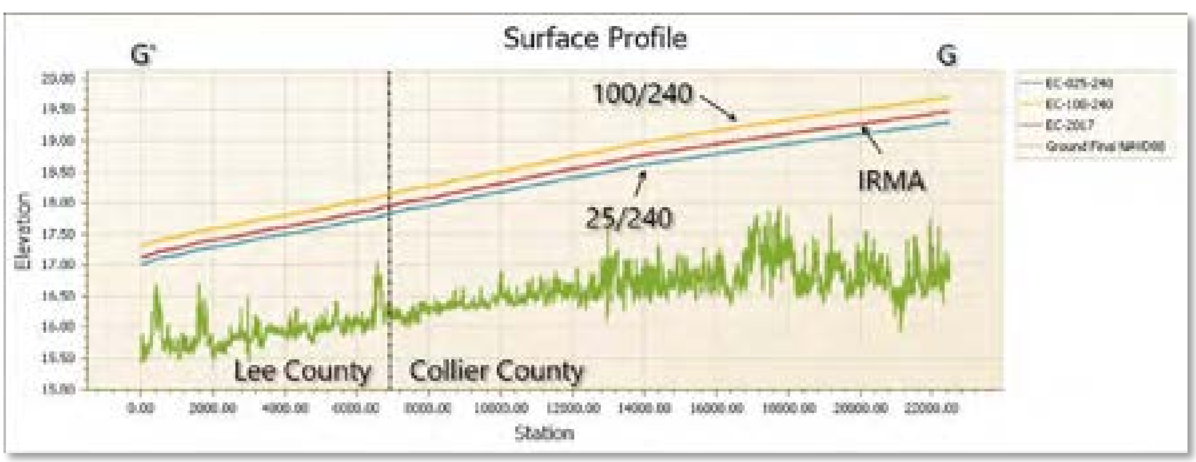


Figure 50 Existing Condition (EC) Water Surface Profiles for Path G'-G: Irma, 25-yr & 100-yr 240-hr Storms

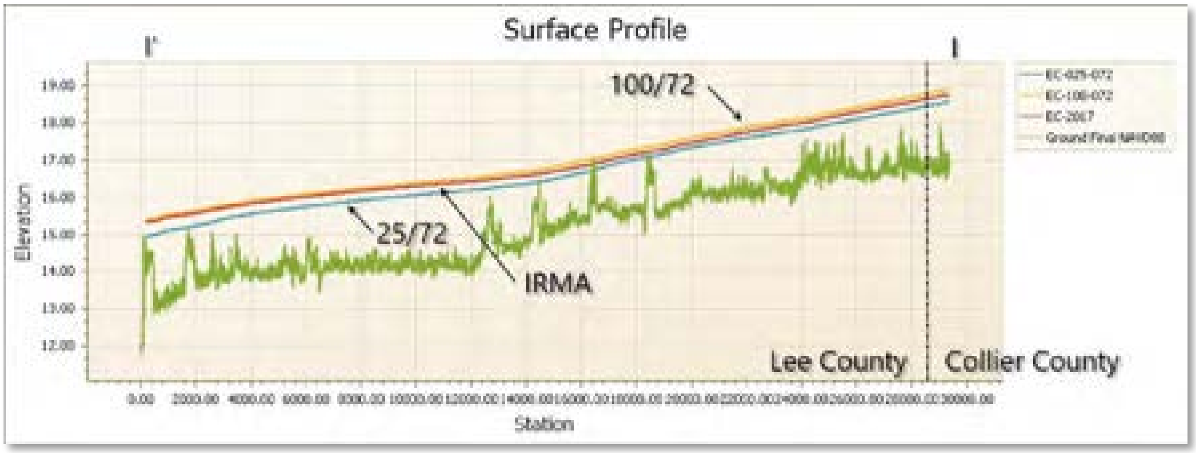


Figure 51 Existing Condition (EC) Water Surface Profiles for Path I'-I: Irma, 25-yr & 100-yr 72-hr Storms

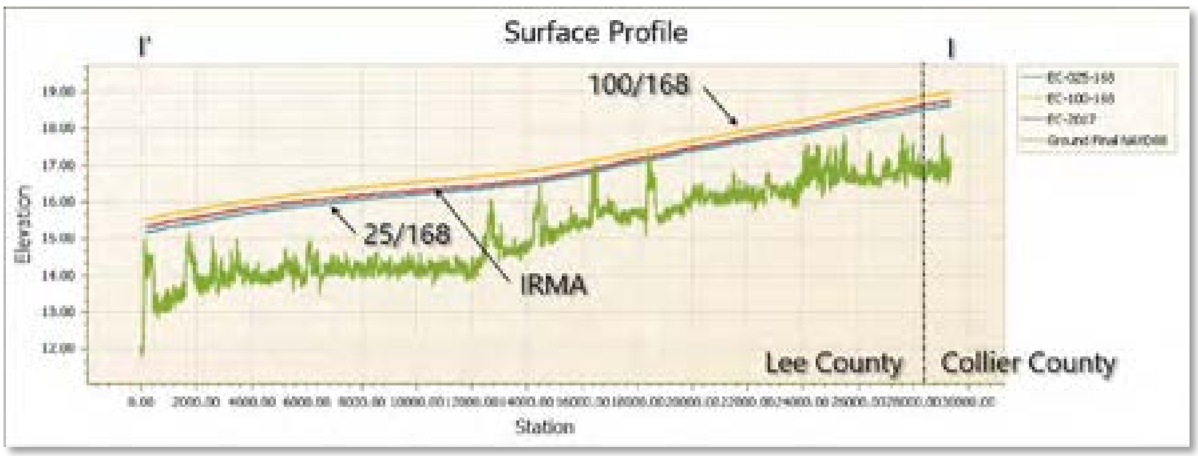


Figure 52 Existing Condition (EC) Water Surface Profiles for Path I'-I: Irma, 25-yr & 100-yr 168-hr Storms

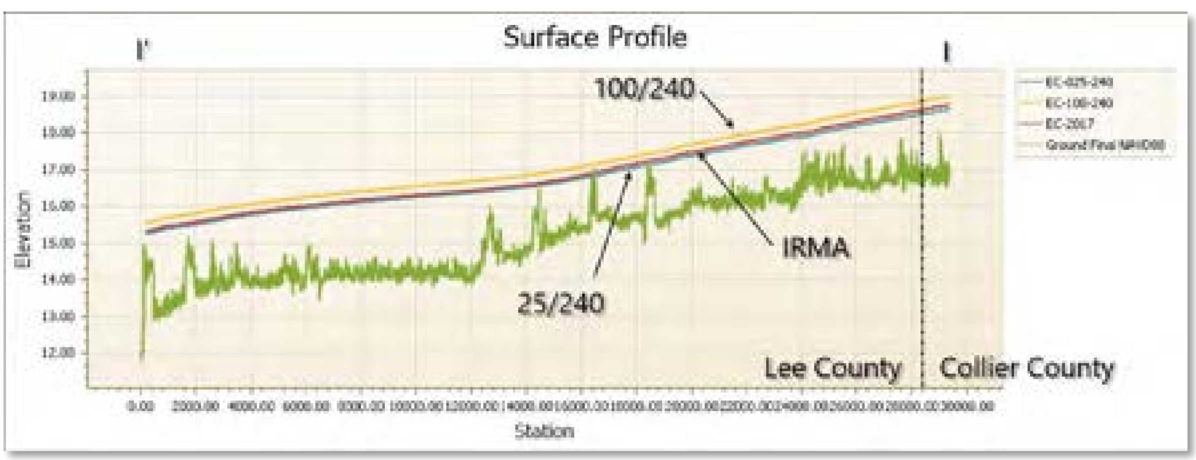


Figure 53 Existing Condition (EC) Water Surface Profiles for Path I'-I: Irma, 25-yr & 100-yr 240-hr Storms

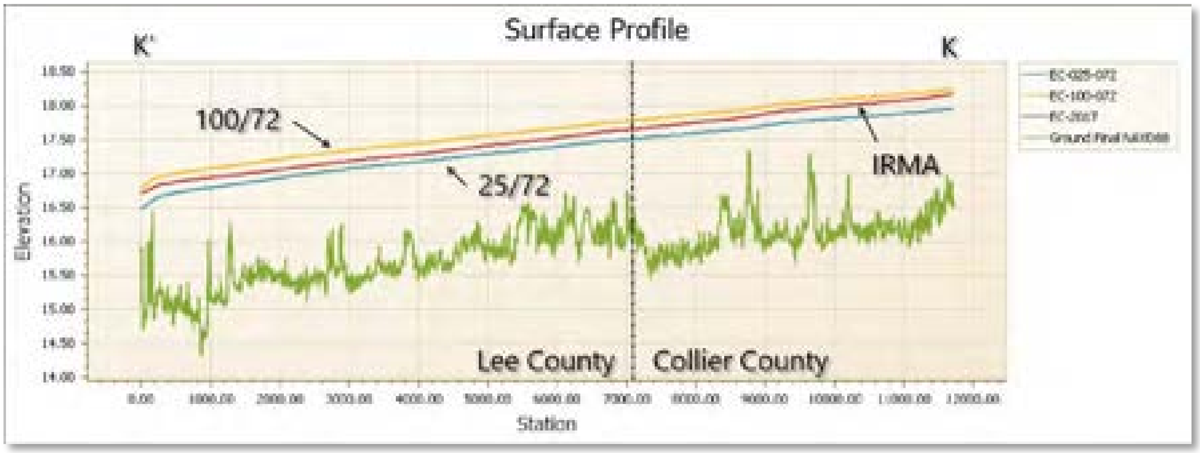


Figure 54 Existing Condition (EC) Water Surface Profiles for Path K'-K: Irma, 25-yr & 100-yr 72-hr Storms

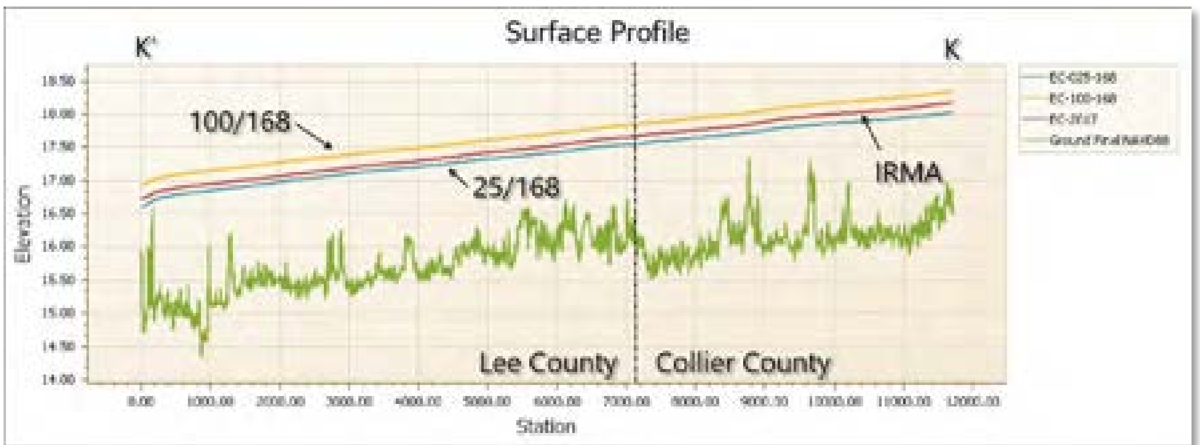


Figure 55 Existing Condition (EC) Water Surface Profiles for Path K'-K: Irma, 25-yr & 100-yr 168-hr Storms

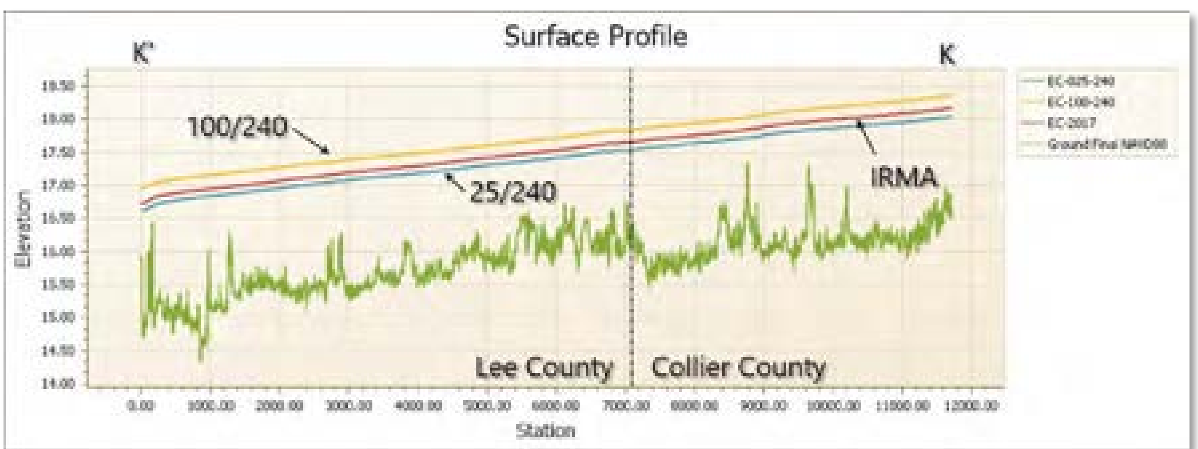


Figure 56 Existing Condition (EC) Water Surface Profiles for Path K'-K: Irma, 25-yr & 100-yr 240-hr Storms

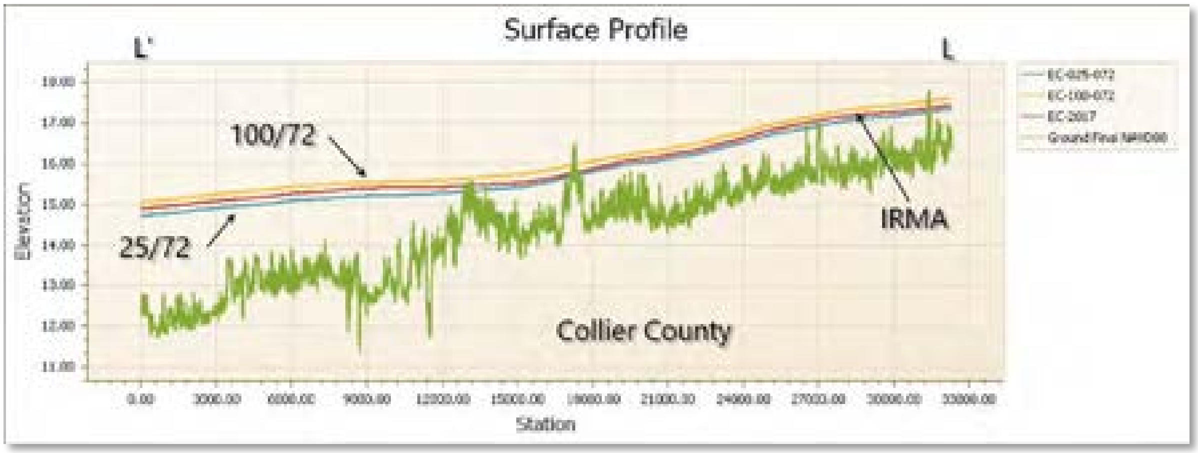


Figure 57 Existing Condition (EC) Water Surface Profiles for Path L'-L: Irma, 25-yr & 100-yr 72-hr Storms

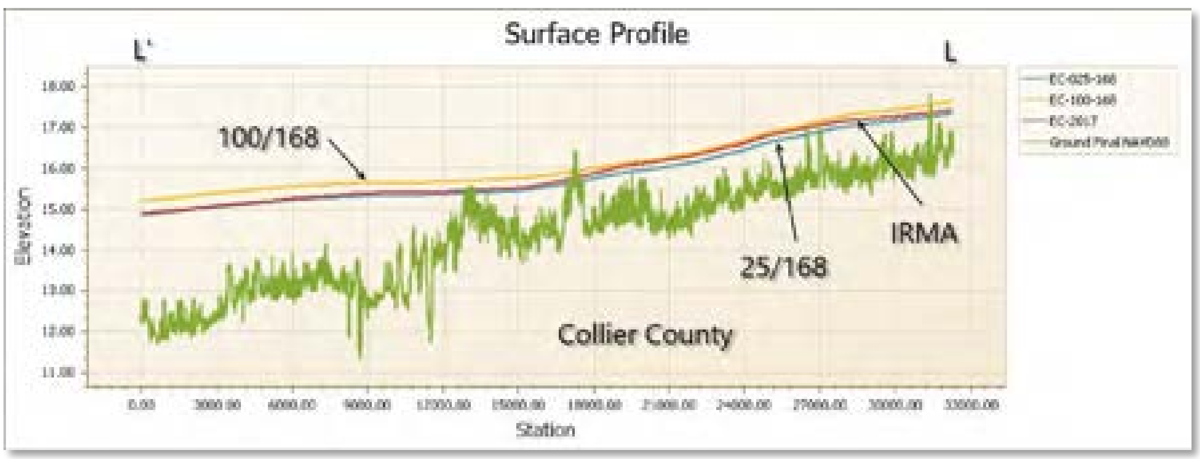


Figure 58 Existing Condition (EC) Water Surface Profiles for Path L'-L: Irma, 25-yr & 100-yr 168-hr Storms

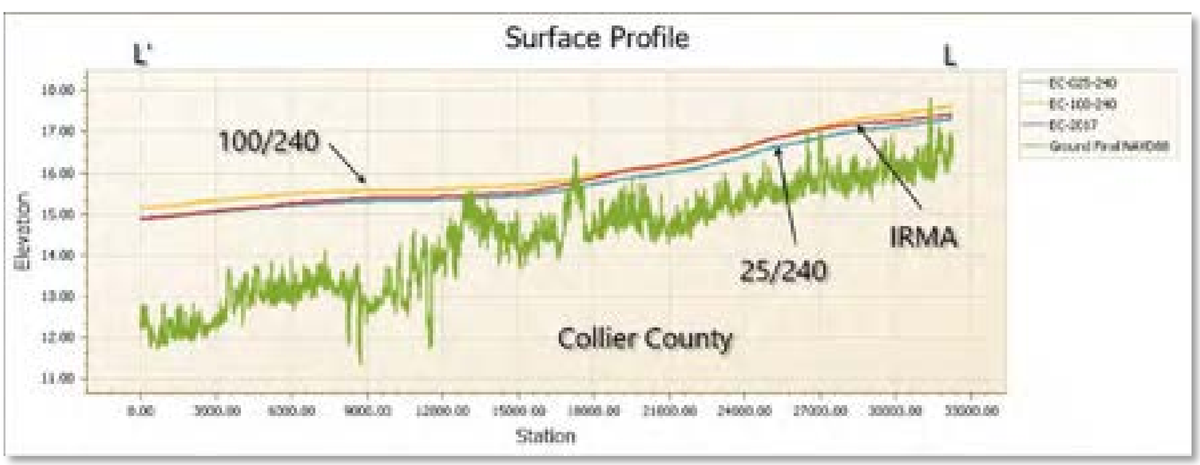


Figure 59 Existing Condition (EC) Water Surface Profiles for Path L'-L: Irma, 25-yr & 100-yr 240-hr Storms

4.2 Discrete Storm Analysis

As discussed in 2.11.2 Discrete Storm Events, a matrix of 6 discrete storms were simulated. These include the 25- and 100-year events for 72-, 168-, and 240-hour durations. Results are presented at selected locations in the 2D study area for these storms. Results from the calibration period (June 1 to November 1, 2017) are included for comparison purposes.

Figure 60 Area Between I-75 and the Proposed Berm

4.2.1 USGS Station 02291500, Imperial River: PT-02

PT-02 is located at the USGS Station 02291500 on the Imperial River (see Figure 60). The top of bank (T.O.B.) here is about elevation 11 feet NAVD88. Discharge rates and volumes presented in this section are under I-75 rather than at PT-02 because there is significant out-of-bank flooding.

A summary of maximum elevations, maximum discharge rates, discharge volumes, and the number of hours for out-of-bank conditions are presented in Table 16. Maximum elevations at PT-02 are within 0.02 feet for the 100-year 168- and 240-hour storms. These 2 storms are about 0.2 feet higher than the 100-year 72-hour storm. The 25-year 240-hour maximum elevation is 0.16 and 0.12 feet higher than the 25-year 72- and 168-hour storms.

The maximum discharge rates for the 25-year 168- and 240-hour storms are about 70 cfs higher (~7%) than the 25-year 72-hour storm. The 100-year 72-, 168-, and 240-hour maximum discharge rates are within a few percent of one another and only slightly higher than the 25-year storms. However, out-of-bank flooding is protracted by 6.8, 5.2, and 3.9 days for the 100-year storms, respectively.

	25yr/72hr	25yr/168hr	25yr/240hr	100yr/72hr	100yr/168hr	100yr/240hr
Sim Dur (hrs)	720	840	840	720	840	840
Volume (af)	38,515	46,131	48,297	46,875	54,353	55,316
Max Q (cfs)	1,043	1,103	1,120	1,137	1,170	1,169
Max Z (ft NAVD)	11.65	11.69	11.81	12.25	12.45	12.43
Hours > T.O.B.	129	191	231	292	317	323
Days > T.O.B.	5.4	8.0	9.6	12.2	13.2	13.5

Table 16 Summary of Max Elevations, Max Discharges, Volumes, and Flood Durations at PT-02

Discharge hydrographs for the 25-year and 100-year storms are presented in Figure 61 and Figure 62, respectively. Stage hydrographs for the calibration period, the 25-year storms, and the 100-year storms are shown in Figure 63, Figure 64, and Figure 65, respectively.

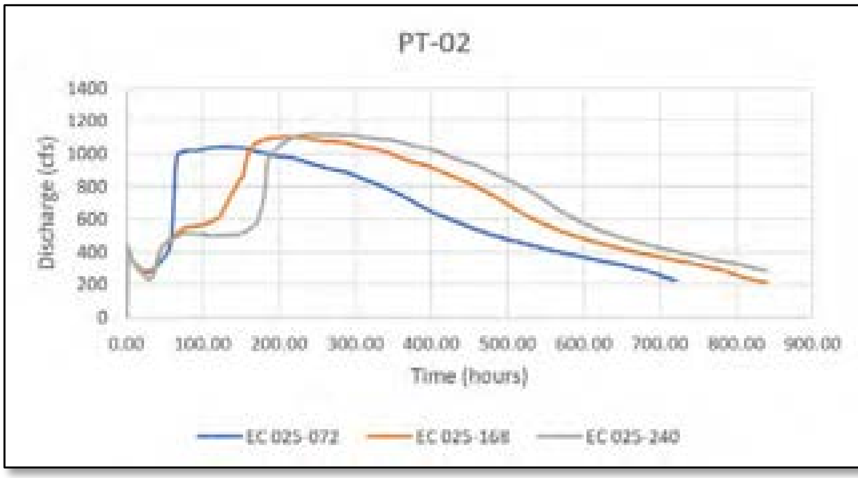


Figure 61 Existing Condition (EC) Discharge Hydrographs at Location PT-02 for 25-year 72-, 168-, and 240-hour Storms

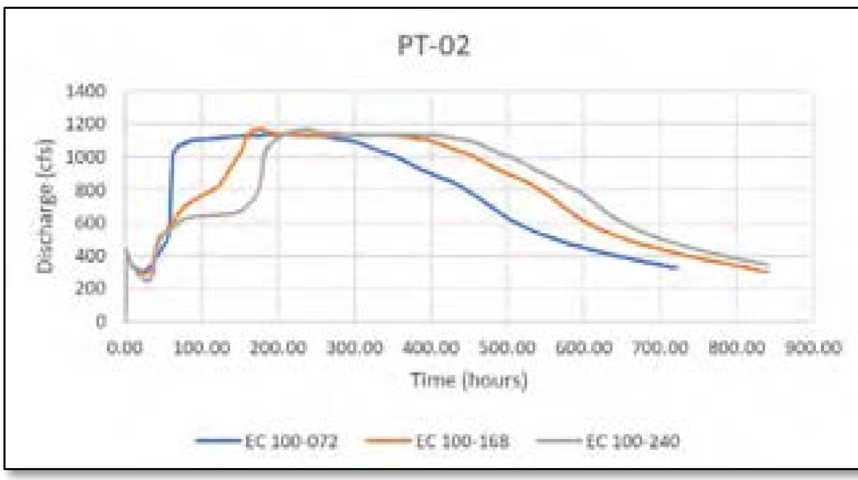


Figure 62 Existing Condition (EC) Discharge Hydrographs at Location PT-02 for 100-year 72-, 168-, and 240-hour Storms

Figure 63 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-02 for Calibration Period

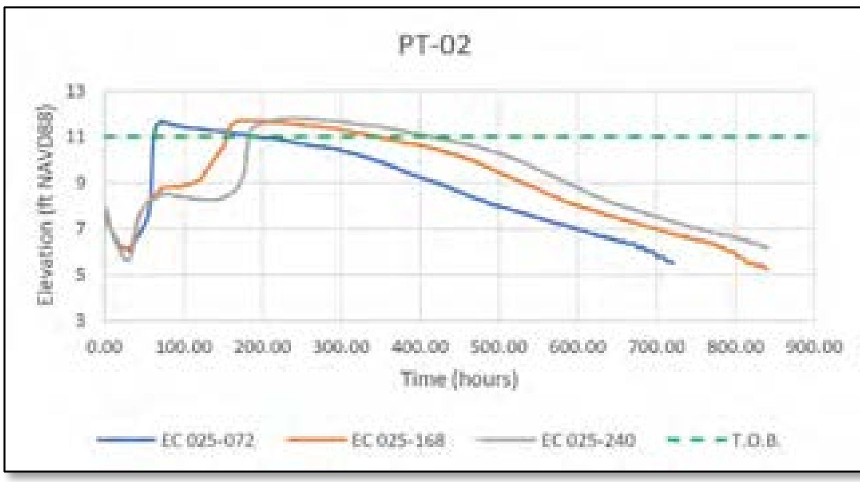


Figure 64 Existing Condition (EC) Stage Hydrographs at Location PT-02 for 25-year 72-, 168-, and 240-hour Storms

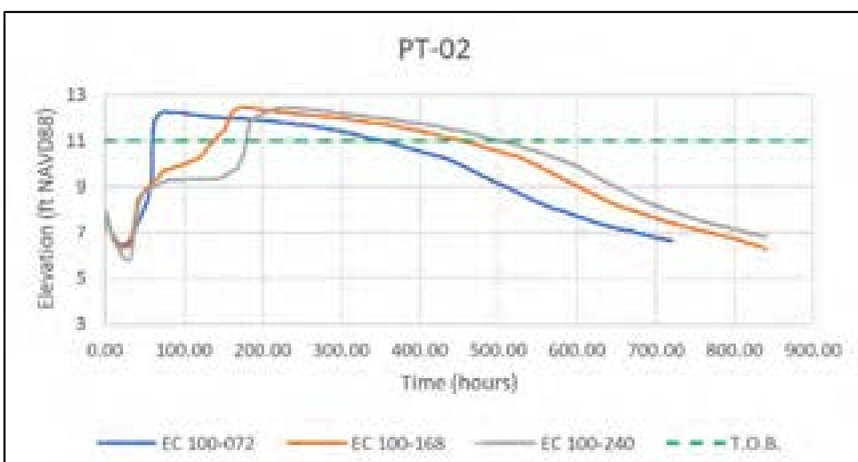


Figure 65 Existing Condition (EC) Stage Hydrographs at Location PT-02 for 100-year 72-, 168-, and 240-hour Storms

4.2.2 Kehl Canal Structure (Upstream Side): PT-03

PT-03 is on the upstream side of the Kehl Canal structure (see Figure 60). The T.O.B. elevation at that location is 13.5 feet NAVD88, but varies substantially farther upstream and is considerably lower in many locations. Overland flow can occur around the structure during extreme flooding conditions. Table 17 provides a summary of maximum water surface elevations for the storm maxtrix and the durations of out-of-bank flooding. Figure 66 depicts the relationship between maximum simulated elevation and duration of out-of-bank flooding.

	25yr/72hr	25yr/168hr	25yr/240hr	100yr/72hr	100yr/168hr	100yr/240hr
Sim Dur (hrs)	720	840	840	720	840	840
Max Z (ft NAVD)	13.79	14.05	14.15	14.31	14.46	14.49
Hours > T.O.B.	164	219	256	313	334	344
Days > T.O.B.	6.8	9.1	10.7	13.0	13.9	14.3

Table 17 Summary of Maximum Elevations and Flood Durations at PT-03

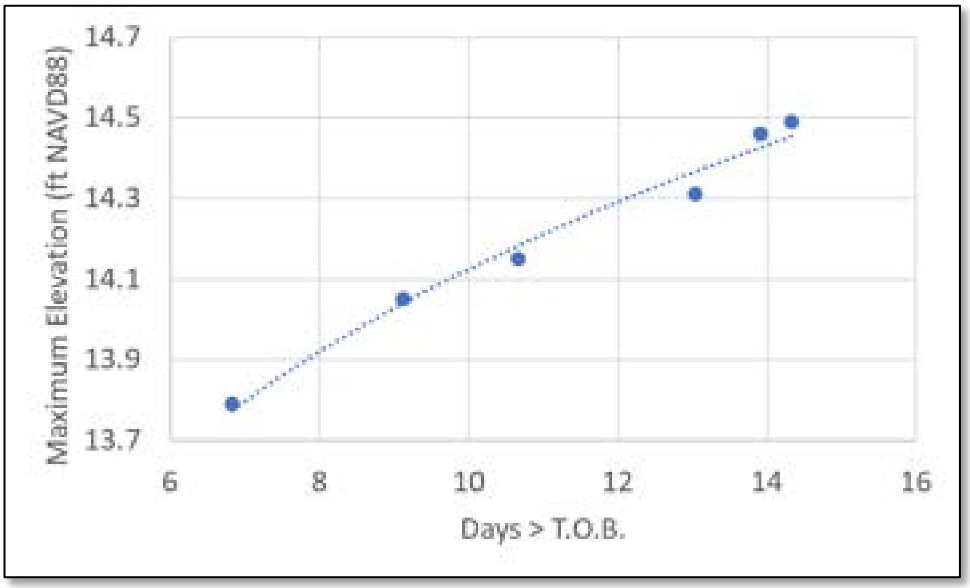


Figure 66 Relationship Between Maximum Simulated Water Surface Elevation and the Number of Days Above the Top of Bank at the Kehl Canal Structure (Upstream Side) PT-03

Stage hydrographs for the calibration period, the 25-year storms, and the 100-year storms are shown in Figure 67, Figure 68, and Figure 69, respectively.

Figure 67 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-03 for Calibration Period

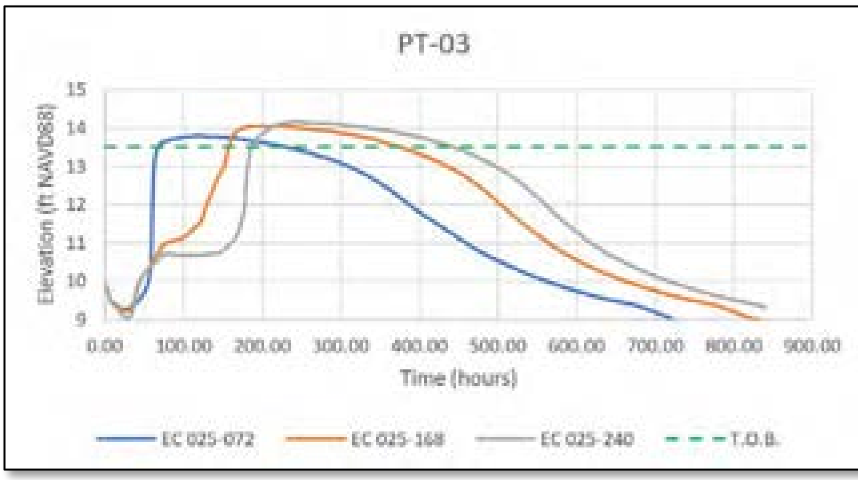


Figure 68 Existing Condition (EC) Stage Hydrographs at Location PT-03 for 25-year 72-, 168-, and 240-hour Storms

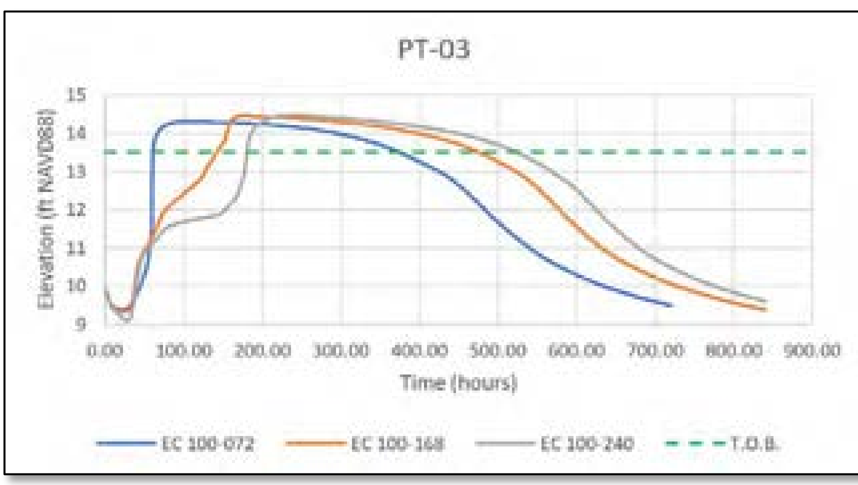


Figure 69 Existing Condition (EC) Stage Hydrographs at Location PT-03 for 100-year 72-, 168-, and 240-hour Storms

4.2.3 Citrus Park Neighborhood: PT-04

PT-04 is located in the Citrus Park neighborhood (see Figure 60) which experienced severe and prolonged flooding from Invest 92L and Hurricane Irma. (Waldrop Engineering, 2018) estimated the flood elevation at the south end of this neighborhood to be 14.2 feet NAVD88 on September 14, 2017 (after Irma). ICPR4 calculated flood elevations within +/- 0.1 feet of this on the same date. Simulated flooding extents for Hurricane Irma are shown in Figure 70.

The low road elevation in this neighborhood is approximately 13 feet NAVD88. Stage hydrographs for the calibration period, the 25-year storms, and the 100-year storms are provided in Figure 71, Figure 72, and Figure 73, respectively.

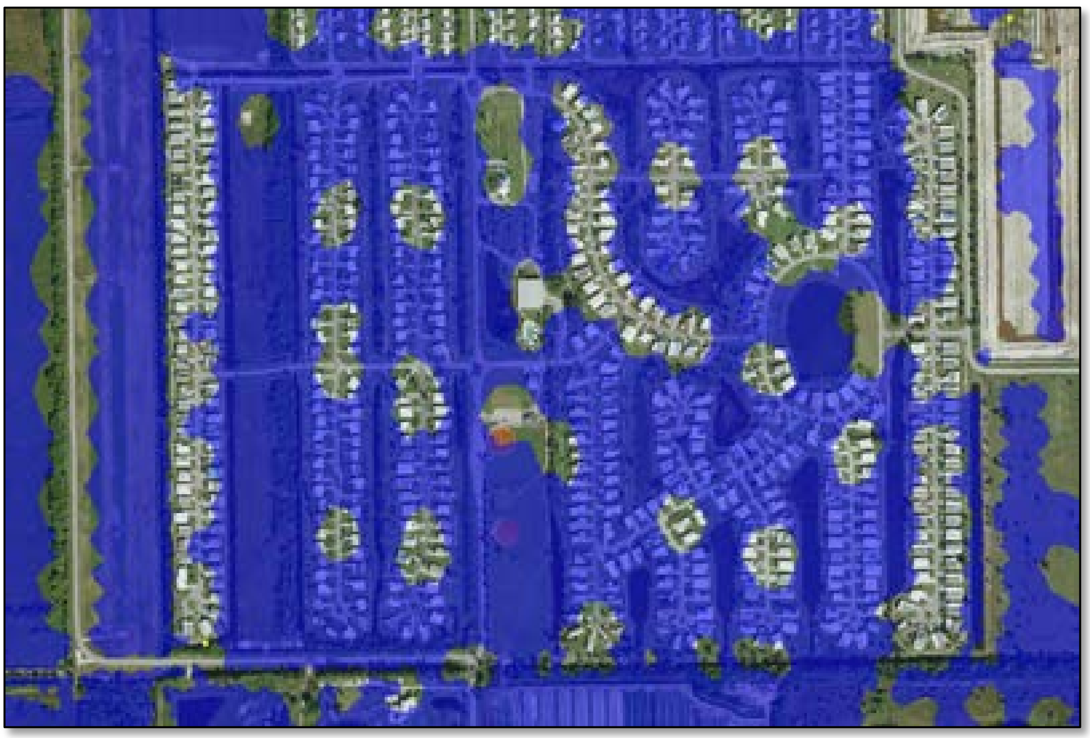


Figure 70 Simulated Flooding Extents in the Citrus Park Neighborhood (Hurricane Irma)

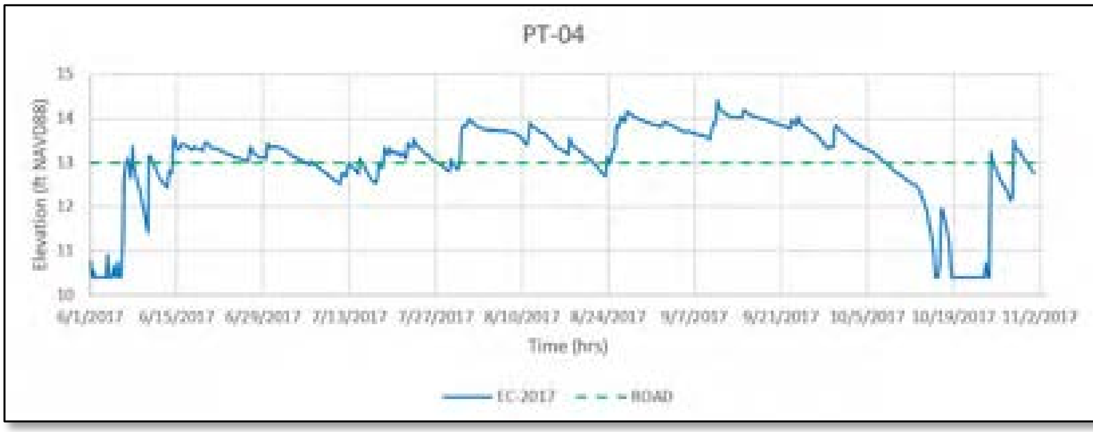


Figure 71 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-04 for Calibration Period

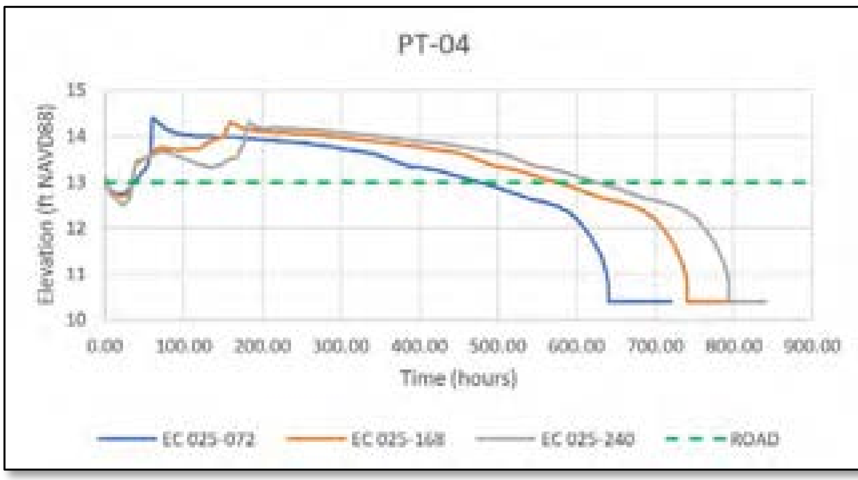


Figure 72 Existing Condition (EC) Stage Hydrographs at Location PT-04 for 25-year 72-, 168-, and 240-hour Storms

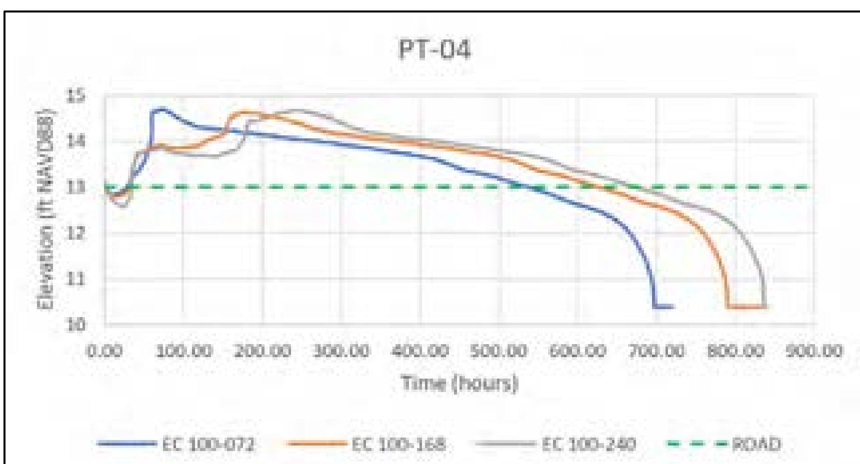


Figure 73 Existing Condition (EC) Stage Hydrographs at Location PT-04 for 100-year 72-, 168-, and 240-hour Storms

4.2.4 Halfway Creek at Three Oaks Parkway: PT-05

Flow patterns west of I-75 in the vicinity of Halfway Creek are shown in Figure 74. Location PT-05 is on the upstream (east) side of the Three Oaks Parkway at Halfway Creek. The flow splits at this location with a portion going west along Halfway Creek and the remainder flowing north through a gated bypass structure. For purposes of this investigation, one gate was set as a 4.5-foot wide by 6.0-foot high rectangular opening at an invert elevation of 10.8 feet NAVD88. The other gate was set as a 4.5-foot wide by 4.36-foot high opening at an invert elevation of 12.44 feet NAVD88. These were used for all simulations.

There is a 200-foot fixed crest (PT-06) at elevation 12.4 feet NAVD88 located along Halfway Creek on the east side of Via Coconut Point. This controls normal water levels at PT-05 and, depending on how the bypass structure is operated, base flows can be directed to the north and into the South Branch of the Estero River.

Figure 74 Flow Patterns in the Vicinity of Halfway Creek

Maximum flows under Three Oaks Parkway and maximum elevations at PT-05 are included in Table 18. The low road elevation near PT-05 is approximately 15.3 feet NAVD88, which is above the maximum water surface elevation for all 6 storms. (Waldrop Engineering, 2018) indicated a maximum water level of 14.2 feet NAVD88 at this location during Hurricane Irma. The ICPR4 simulations indicate a lower elevation (approximately 0.8 feet lower) for Hurricane Irma (see Figure 77). The assumed versus actual gate operations of the bypass structure could explain the differences.

The maximum discharge rates for the 72-hour storms are significantly higher than the 168- and 240-hour storms, but the discharge volumes are higher for the longer duration storms. The highest rainfall intensities in SFWMD 72-hour rainfall distribution occur near hour 60 in the storm and are much higher than the highest intensities of the FDOT 168-hour and FDOT 240-hour rainfall distributions. The higher maximum discharge rates and maximum elevations for the 72-hour storms imply local runoff conditions are significant in this area.

	25yr/72hr	25yr/168hr	25yr/240hr	100yr/72hr	100yr/168hr	100yr/240hr
Sim Dur (hrs)	720	840	840	720	840	840
Volume (af)	1,820	2,270	2,425	2,387	2,954	3,074
Max Q (cfs)	1,241	162	200	1,653	205	230
Max Z (ft NAVD)	13.83	13.42	13.48	14.39	13.84	13.81

Table 18 Summary of Max Elevations, Max Discharges, and Volumes at PT-05

Discharge hydrographs for the 25-year and 100-year storms are presented in Figure 75, and Figure 76, respectively. Stage hydrographs for the calibration period, the 25-year storms, and the 100-year storms are shown in Figure 77, Figure 78, and Figure 79, respectively.

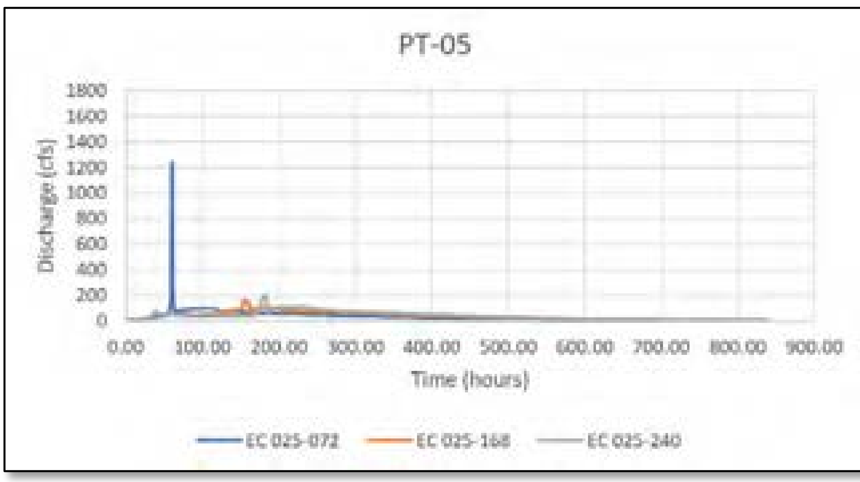


Figure 75 Existing Condition (EC) Discharge Hydrographs at Location PT-05 for 25-year 72-, 168-, and 240-hour Storms

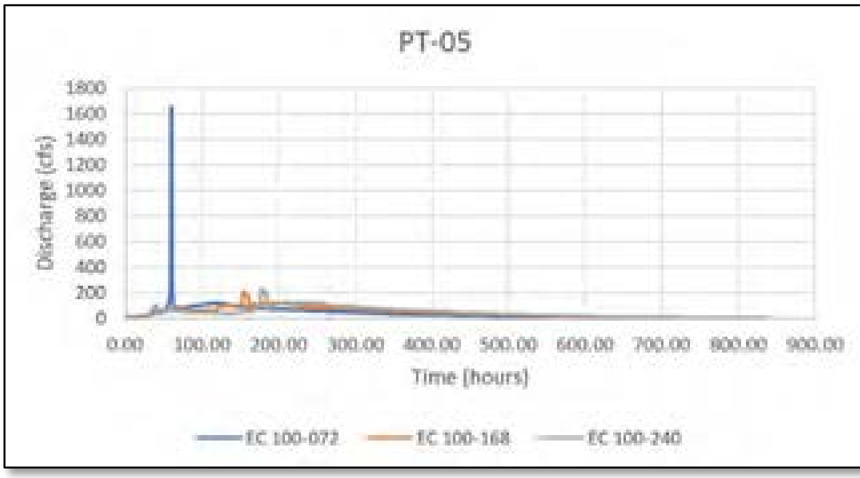


Figure 76 Existing Condition (EC) Discharge Hydrographs at Location PT-05 for 100-year 72-, 168-, and 240-hour Storms

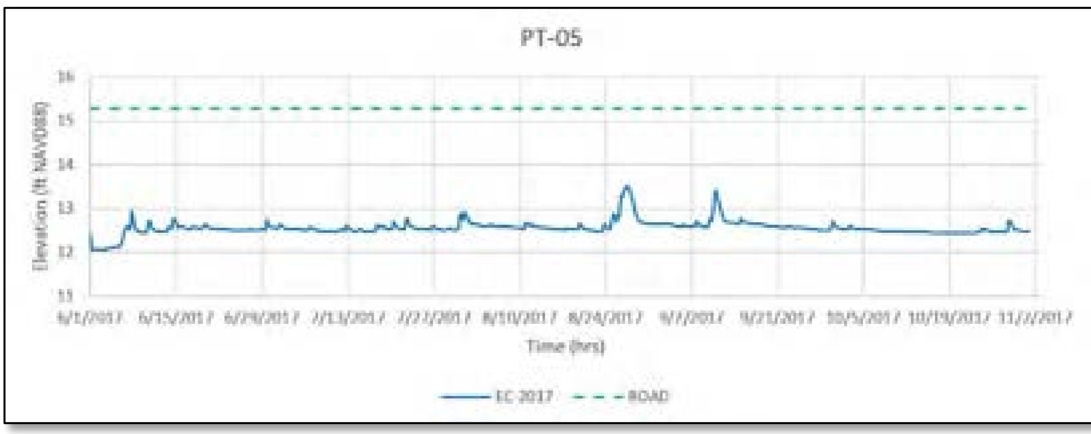


Figure 77 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-05 for Calibration Period

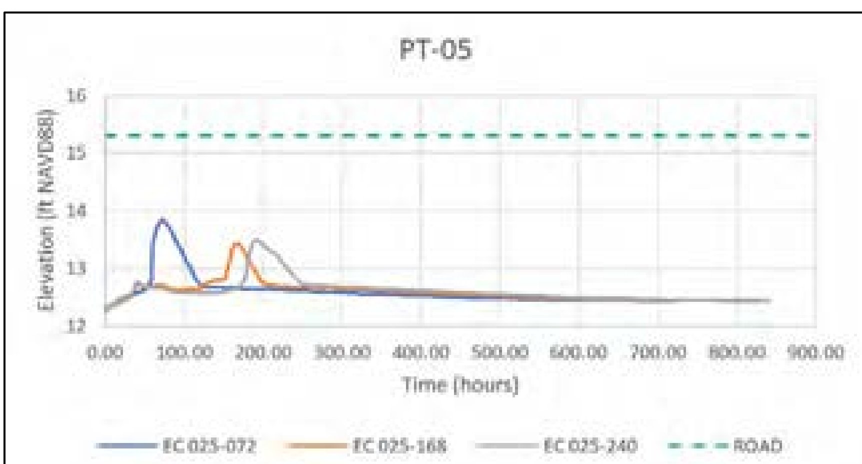


Figure 78 Existing Condition (EC) Stage Hydrographs at Location PT-05 for 25-year 72-, 168-, and 240-hour Storms

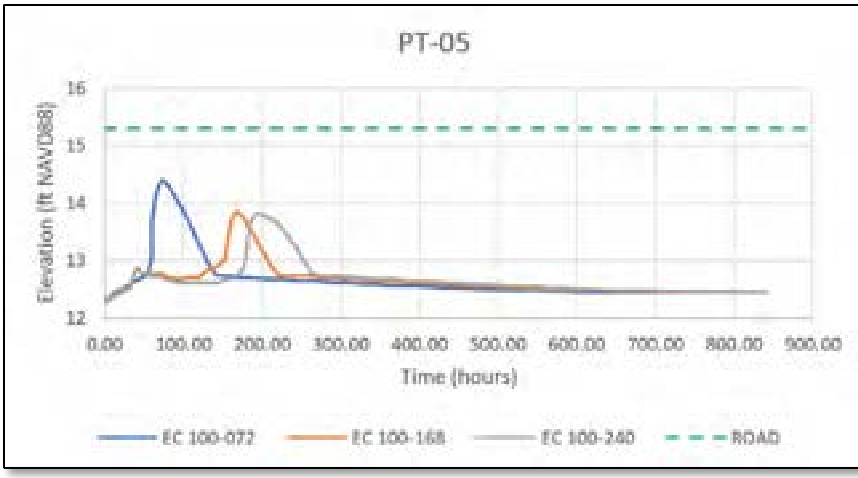


Figure 79 Existing Condition (EC) Stage Hydrographs at Location PT-05 for 100-year 72-, 168-, and 240-hour Storms

4.2.5 Halfway Creek at Weir Structure East of Via Coconut Point: PT-06

PT-06 is located on the upstream side of a 200-foot weir east of Via Coconut Point (see Figure 74) along Halfway Creek. This structure controls normal water levels in Halfway Creek upstream as far as I-75. There is a large wetland system south of Halfway Creek between this weir and Three Oaks Parkway.

Table 19 includes maximum stages, maximum flows, and discharge volumes across the weir. The low road elevation is approximately 15.3 feet NAVD88. There is about 1 foot of freeboard for all 6 storms. The maximum flow rates for the 72-hour storms are 2-3 times lower than those at Three Oaks Parkway (PT-05). This is because of the expansive detention storage system between the weir and Three Oaks Parkway.

	25yr/72hr	25yr/168hr	25yr/240hr	100yr/72hr	100yr/168hr	100yr/240hr
Sim Dur (hrs)	720	840	840	720	840	840
Volume (af)	2,123	2,674	2,861	2,832	3,510	3,656
Max Q (cfs)	555	212	311	533	209	320
Max Z (ft NAVD)	13.79	13.38	13.43	14.35	13.79	13.77

Table 19 Summary of Max Elevations, Max Discharges, and Volumes at "PT-06"

Discharge hydrographs for the 25- and 100-year storms are included in Figure 80 and Figure 81, respectively. Stage hydrographs for the calibration period, the 25-year, and the 100-year storms can be found in Figure 82, Figure 83, and Figure 84, respectively.

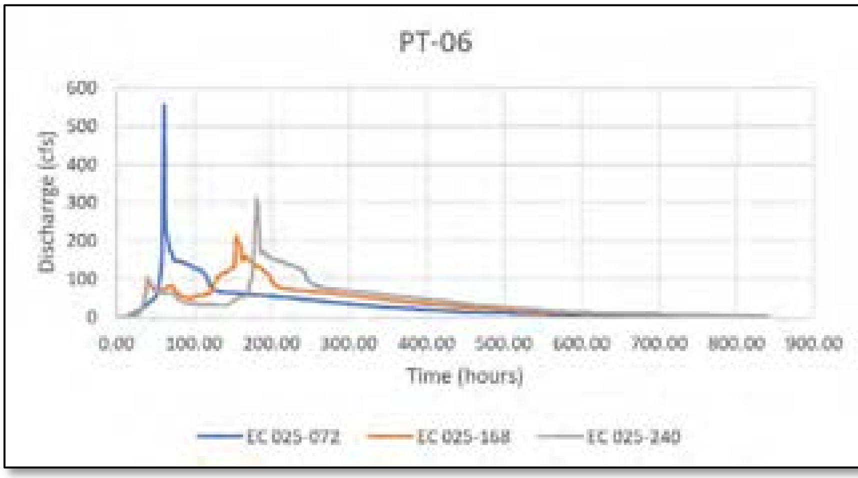


Figure 80 Existing Condition (EC) Discharge Hydrographs at Location PT-06 for 25-year 72-, 168-, and 240-hour Storms

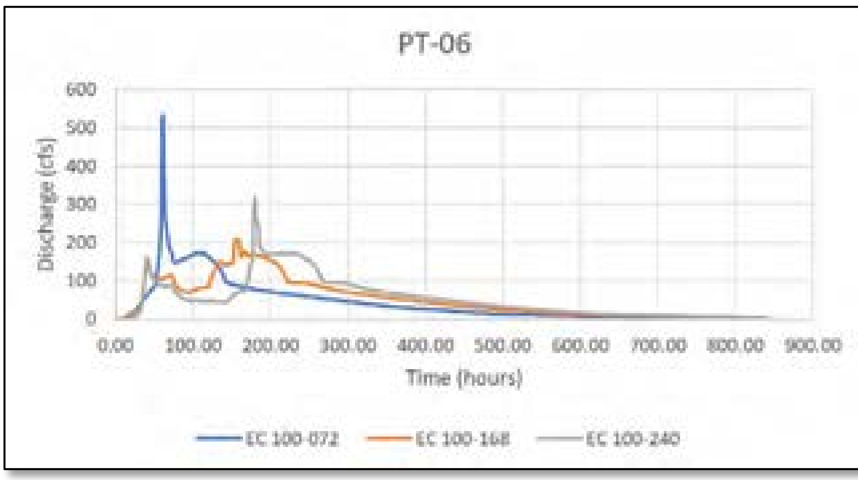


Figure 81 Existing Condition (EC) Discharge Hydrographs at Location PT-06 for 100-year 72-, 168-, and 240-hour Storms

Figure 82 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-06 for Calibration Period

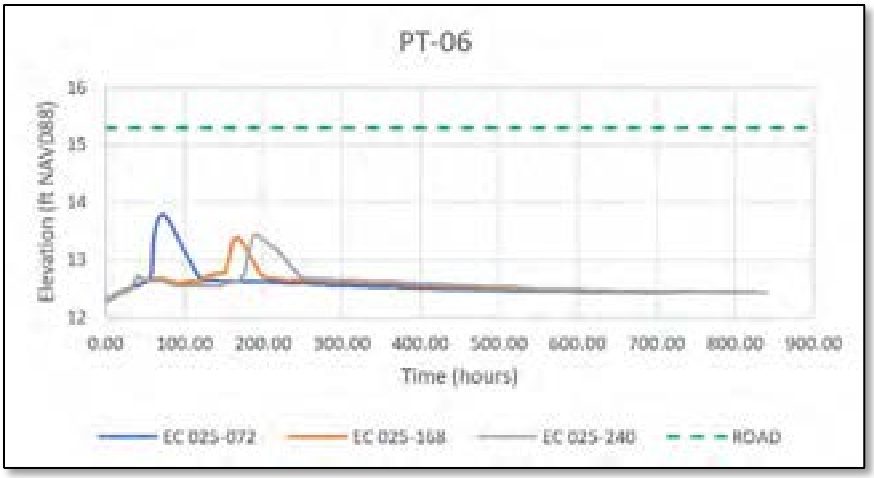


Figure 83 Existing Condition (EC) Stage Hydrographs at Location PT-06 for 25-year 72-, 168-, and 240-hour Storms

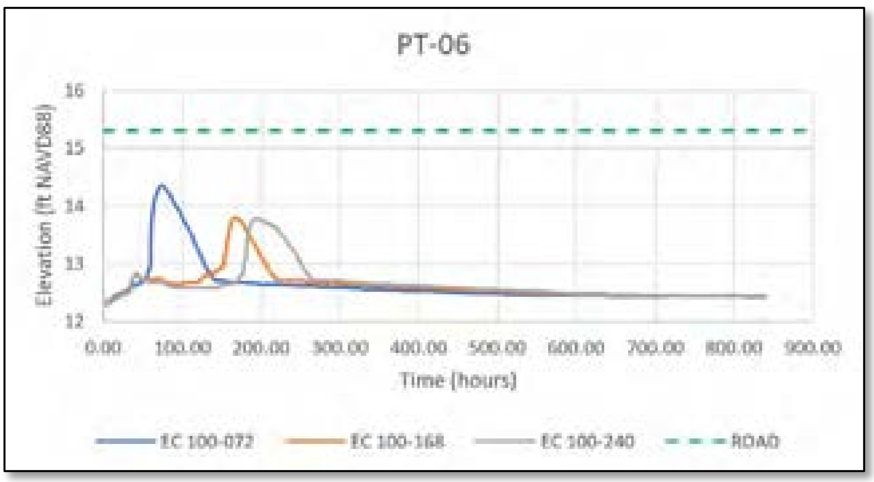


Figure 84 Existing Condition (EC) Stage Hydrographs at Location PT-06 for 100-year 72-, 168-, and 240-hour Storms

4.2.6 Halfway Creek at Rapallo: PT-06B

PT-06B is located along Halfway Creek west of Via Coconut Point and east of Via Villagio (Figure 74 and Figure 85). The Rapallo neighborhood is located on the north side of Halfway Creek. Waldrop Engineering, 2018 reported extensive roadway flooding in this community during Hurricane Irma, but Piazza Del Lago Circle did not flood. Flood elevations were not available. It is unclear if the flooding was a result of highwater in Halfway Creek or a local drainage problem inside the development. (SWFRPC, 2018) cites a recommendation in the South Lee County Watershed Update Plan (a report prepared by Boyle Engineering dated January 20, 2011 for SFWMD and Lee County) to connect Halfway Creek and the Rapallo Lake. This seems to imply that there might have been some local drainage issues.

Figure 85 Halfway Creek at Rapallo

Maximum stages at PT-06B for the 6 storm events are included in Table 20. Stage hydrographs for the calibration period, the 25-year storms, and the 100-year storms are shown in Figure 86, Figure 87, and Figure 88, respectively. The low road elevation in Rapallo is approximately 14 feet NAVD88. The 100-year 72-hour storm is the only event that is higher than the minimum road elevation in the Rapallo neighborhood. However, as discussed in 4.2.4 Halfway Creek at Three Oaks Parkway: PT-05, the modeled gate operation of the bypass structure might have been different than the actual gate operation during Hurricane Irma. The actual flood elevations at PT-06B during Hurricane Irma might have been higher than the calculated values.

	25yr/72hr	25yr/168hr	25yr/240hr	100yr/72hr	100yr/168hr	100yr/240hr
Sim Dur (hrs)	720	840	840	720	840	840
Max Z (ft NAVD)	13.70	13.28	13.34	14.26	13.70	13.68

Table 20 Summary of Max Elevations at "PT-06B"

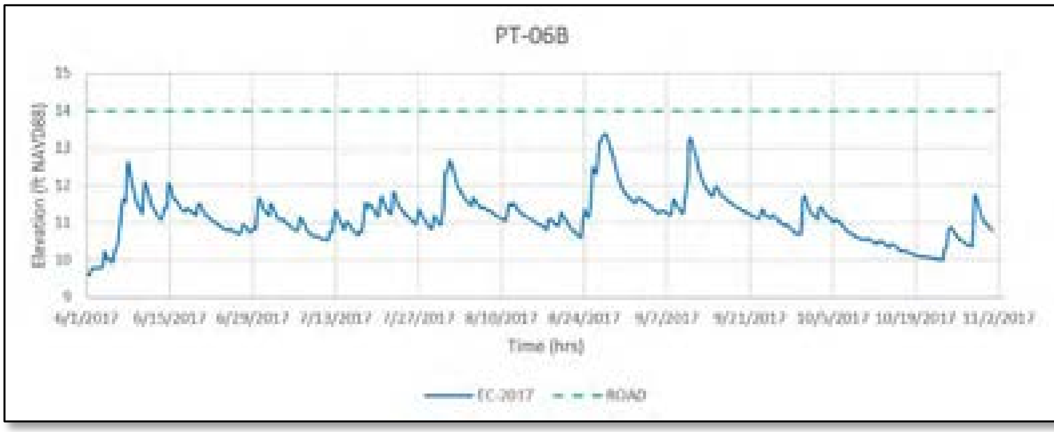


Figure 86 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-06B for Calibration Period

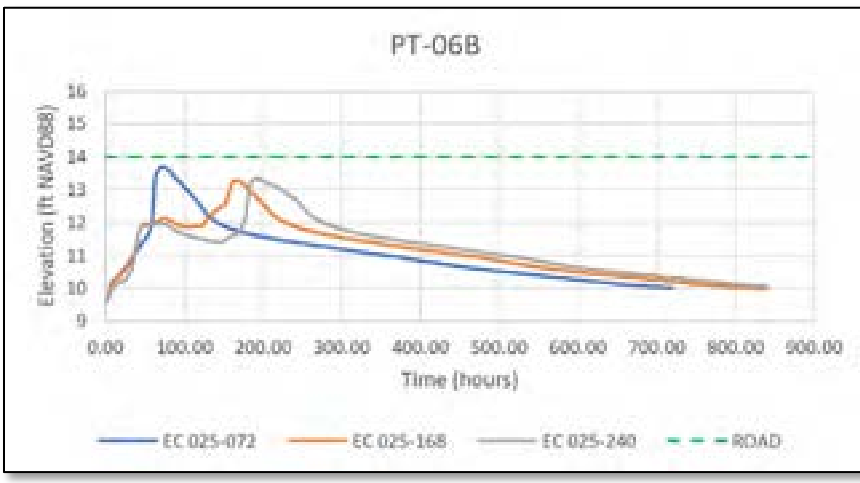


Figure 87 Existing Condition (EC) Stage Hydrographs at Location PT-06B for 25-year 72-, 168-, and 240-hour Storms

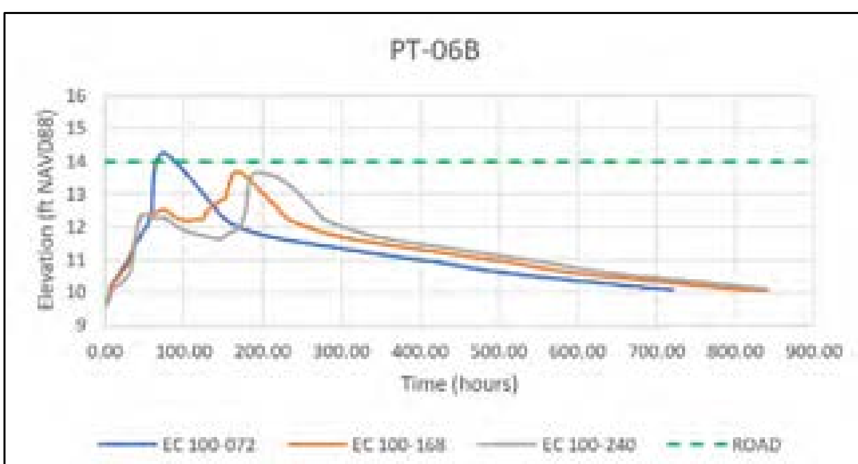


Figure 88 Existing Condition (EC) Stage Hydrographs at Location PT-06B for 100-year 72-, 168-, and 240-hour Storms

4.2.7 Island Club at Corkscrew: PT-07

PT-07 is in a wetland slough near the Island Club at Corkscrew development (see Figure 74). Water flows north through this slough to the South Branch of Estero River as shown by the velocity vectors in Figure 89. (Waldrop Engineering, 2018) reported extensive roadway flooding in this community during Hurricane Irma based on an analysis of aerial photographs dated September 14, 2017 (about 3 days after Hurricane Irma) and estimated elevations of 14.6 and 14.9 feet NAVD88 in this slough on that date. These are consistent with the ICPR4 model results for the calibration period (Figure 90).

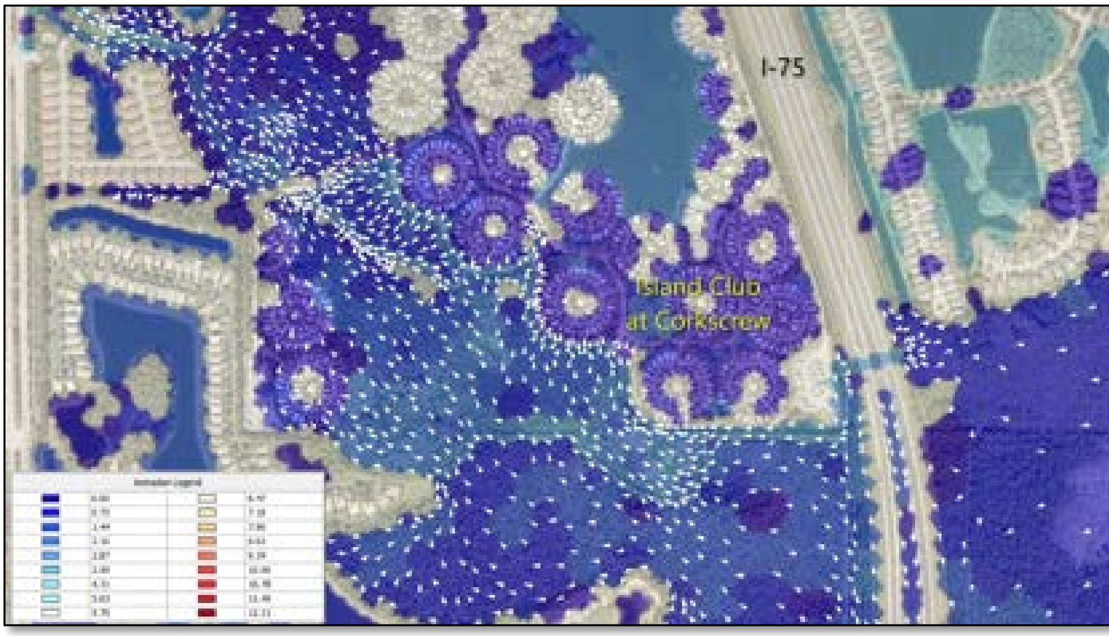


Figure 89 Simulated Flooding Extents and Velocity Vectors – Island Club at Corkscrew (Hurricane Irma)

Maximum stages at PT-07 for the 6 storm events are included in Table 21. Stage hydrographs for the calibration period, the 25-year storms, and the 100-year storms are shown in Figure 90, Figure 91, and Figure 92, respectively. The low road elevation in Island Club is approximately 14.6 feet NAVD88. All storm events, including Hurricane Irma, exceed this elevation.

	25yr/72hr	25yr/168hr	25yr/240hr	100yr/72hr	100yr/168hr	100yr/240hr
Sim Dur (hrs)	720	840	840	720	840	840
Max Z (ft NAVD)	15.22	15.23	15.18	15.51	15.43	15.37

Table 21 Summary of Max Elevations at "PT-07"

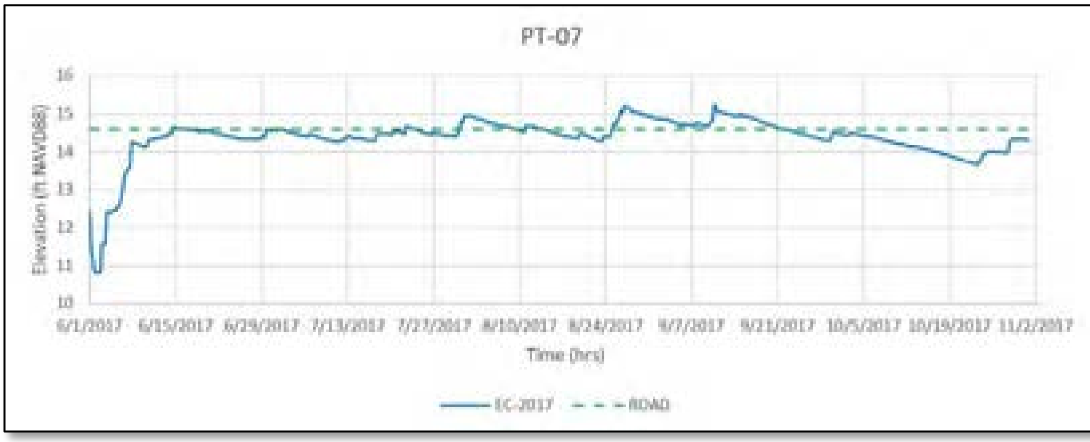


Figure 90 Existing Condition (EC) Simulated Stage Hydrograph at Location PT-07 for Calibration Period

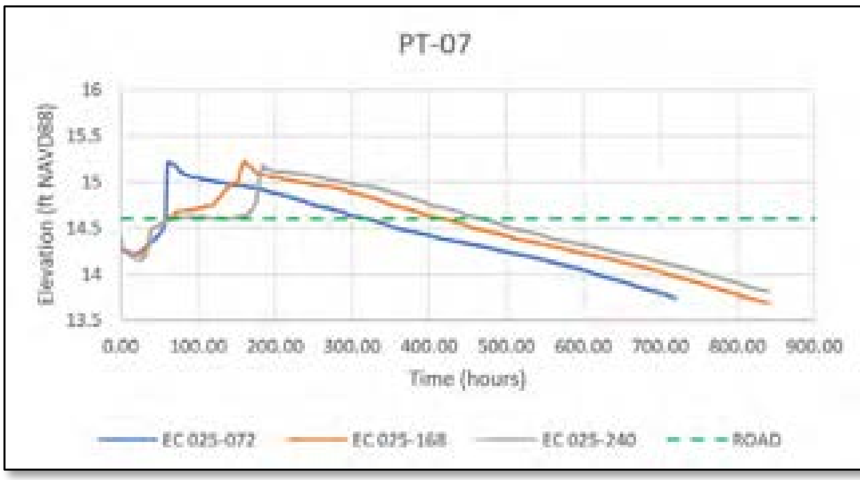


Figure 91 Existing Condition (EC) Stage Hydrographs at Location PT-07 for 25-year 72-, 168-, and 240-hour Storms

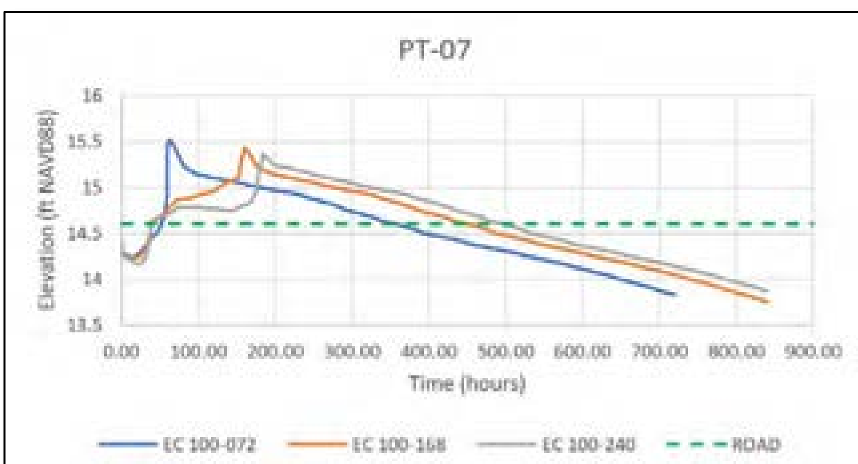


Figure 92 Existing Condition (EC) Stage Hydrographs at Location PT-07 for 100-year 72-, 168-, and 240-hour Storms

4.3 Hydroperiod Assessment

Hydroperiods are defined by the relationship between surface inundation and time. The verification simulations described in 3.2 Verification were based on a 5-year period (2013 – 2017). Time series charts can be created at any node (1D or 2D) in the model like the example shown in Figure 93.

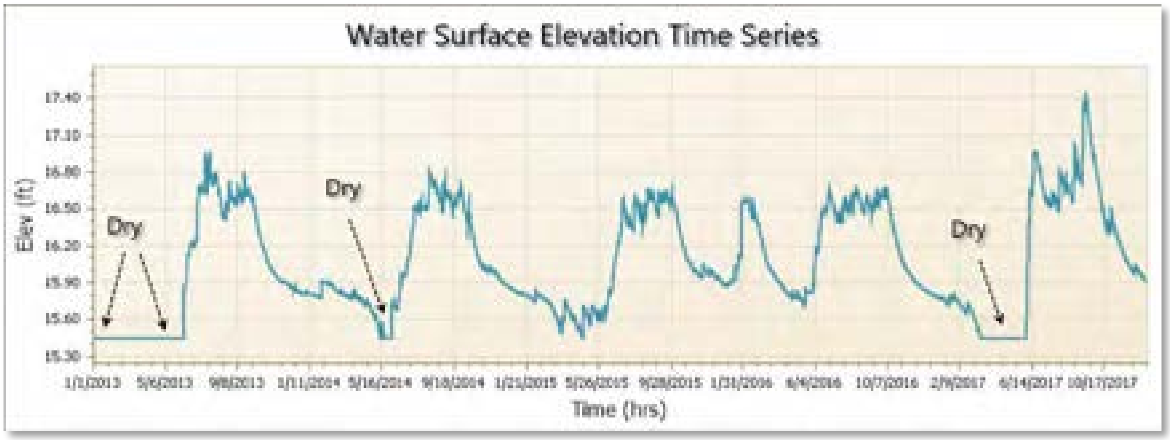


Figure 93 Example Water Surface Elevation Time Series Chart for Verification Period

The elevation time series data can also be viewed in raster form as shown in Figure 94. The scale on the right is the range of water surface elevations from the overall minimum (15.45 feet NAVD88) to the maximum (17.46 feet NAVD88). The depth range in this example is 2.01 feet over the 5-year simulation period. The colors are coded based on the elevation. The wetter periods occur between about days 160 and 300 (June – October).

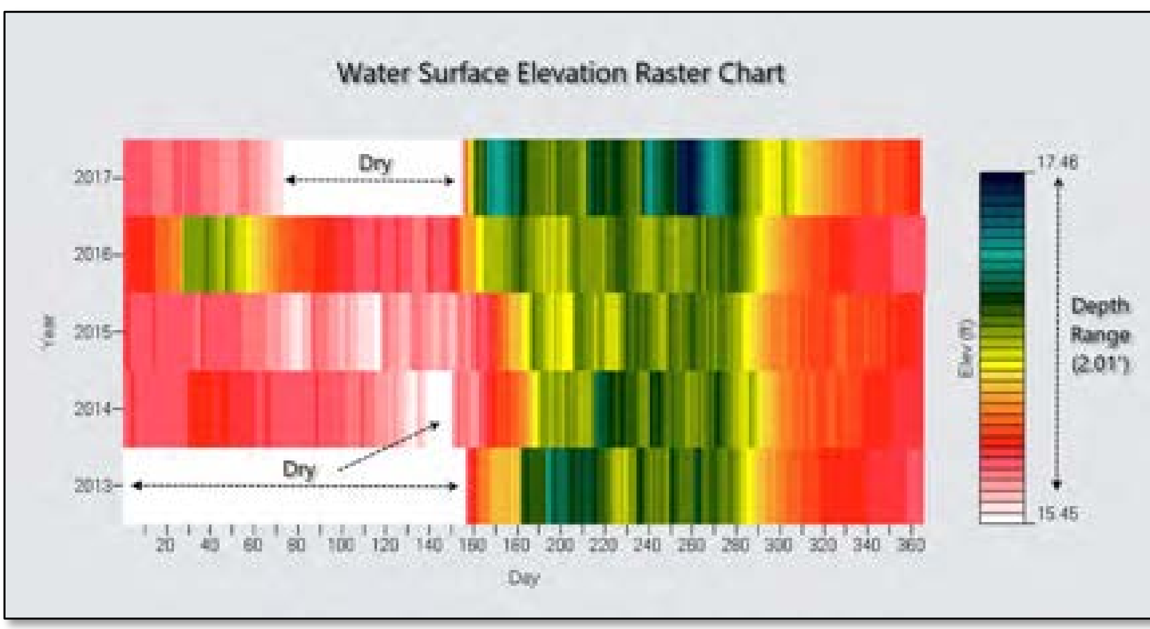


Figure 94 Example Water Surface Elevation Raster Chart for Verification Period

The stage-duration curve is a typical tool for defining hydroperiod. The example shown in Figure 95 is derived from the time series data presented in Figure 93 and Figure 94. Elevation 16.5 feet NAVD88 is exceeded 25% of the time at this location, which is 3 months per year on average. The depth is 1.05 feet.

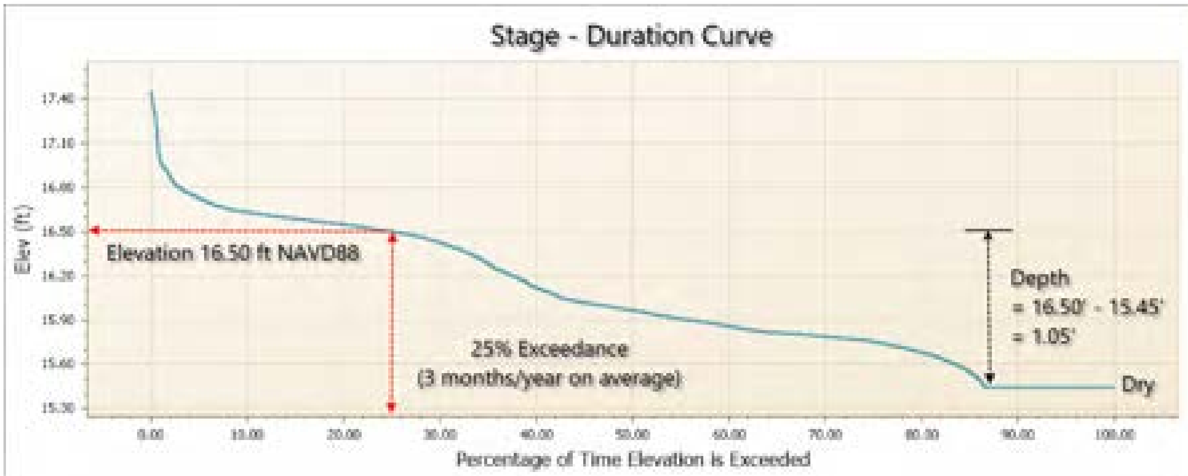


Figure 95 Example Stage-Duration Curve for Verification Period

It is also possible to "animate" the exceedance probability for depth or elevation for the 2D study area. Snapshots of 8%, 17%, 25%, 50% and 75% exceedance probabilities of depth of inundation are shown in Figure 96, Figure 97, Figure 98, Figure 99, and Figure 100 for the 2D study area. These correspond to 1, 2, 3, 6, and 9 months of inundation on average, respectively.

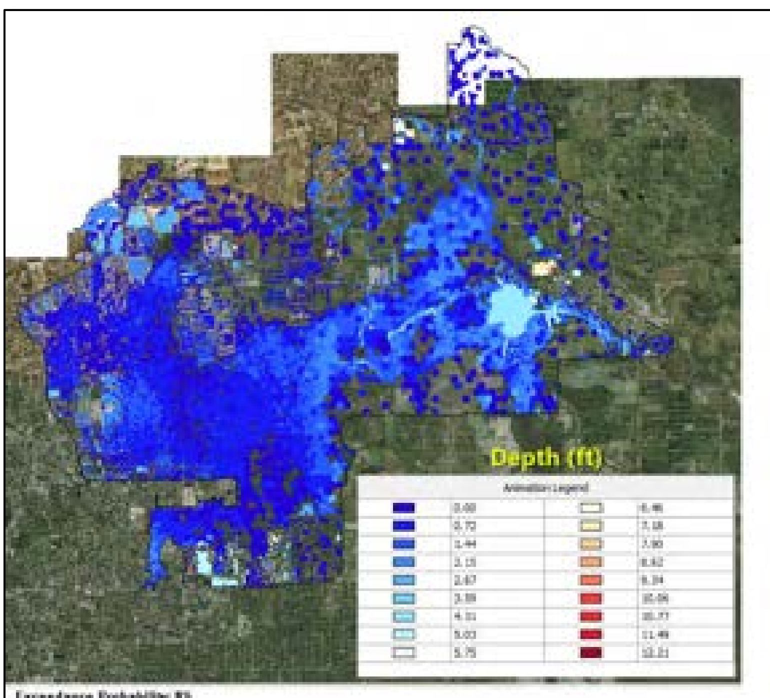


Figure 96 Extents of Inundated Areas within 2D Study Area for 1 Month per Year on Average

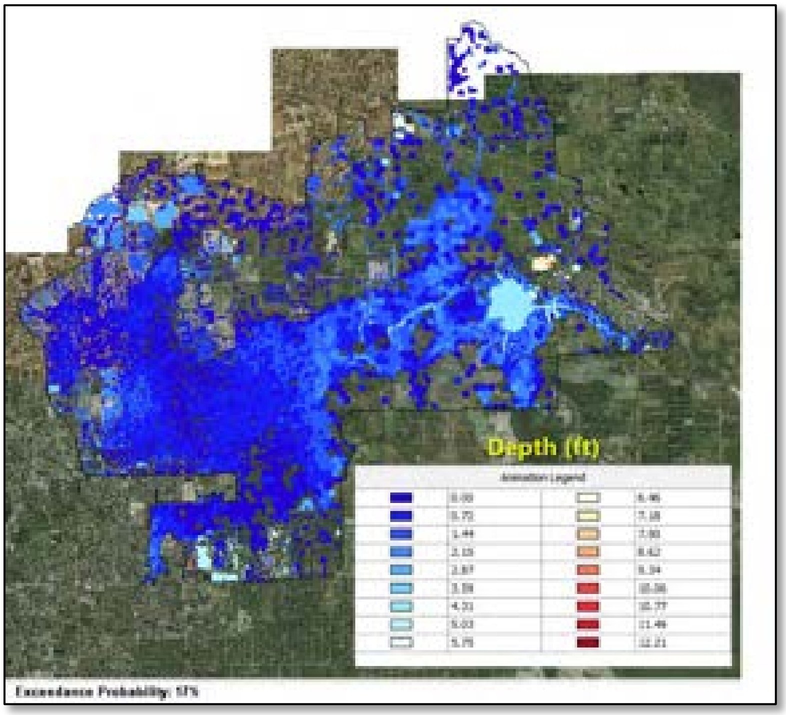


Figure 97 Extents of Inundated Areas within 2D Study Area for 2 Months per Year on Average

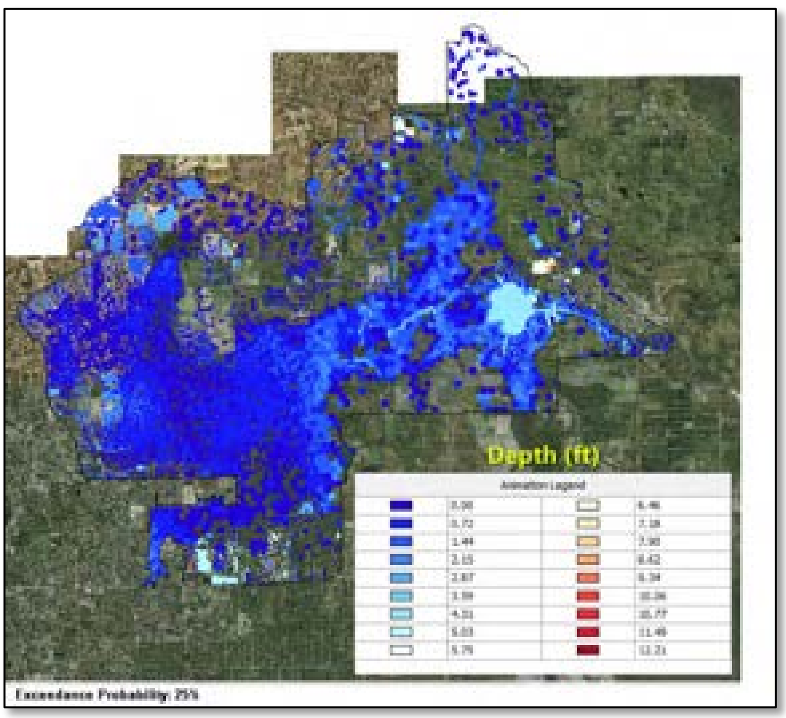


Figure 98 Extents of Inundated Areas within 2D Study Area for 3 Months per Year on Average

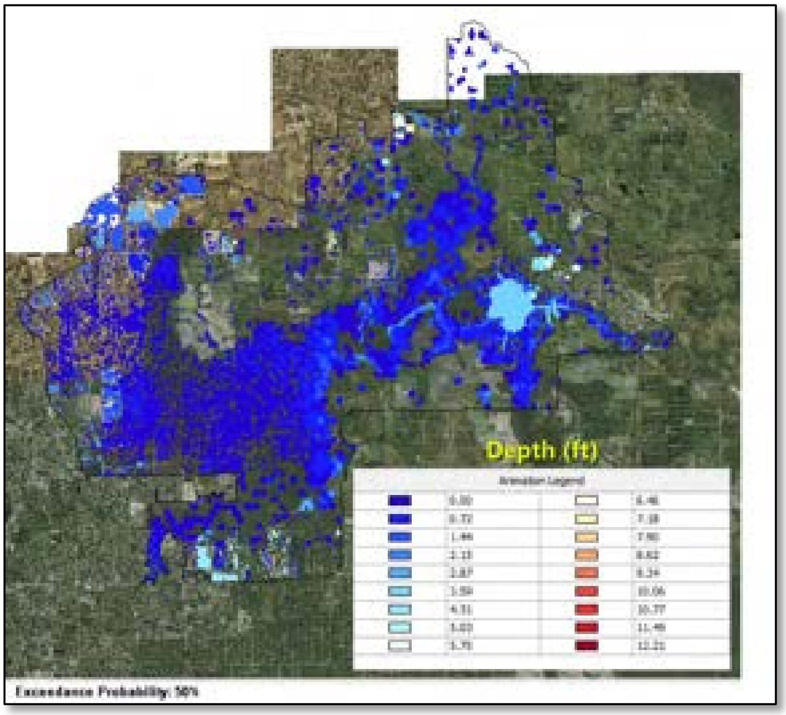


Figure 99 Extents of Inundated Areas within 2D Study Area for 6 Months per Year on Average

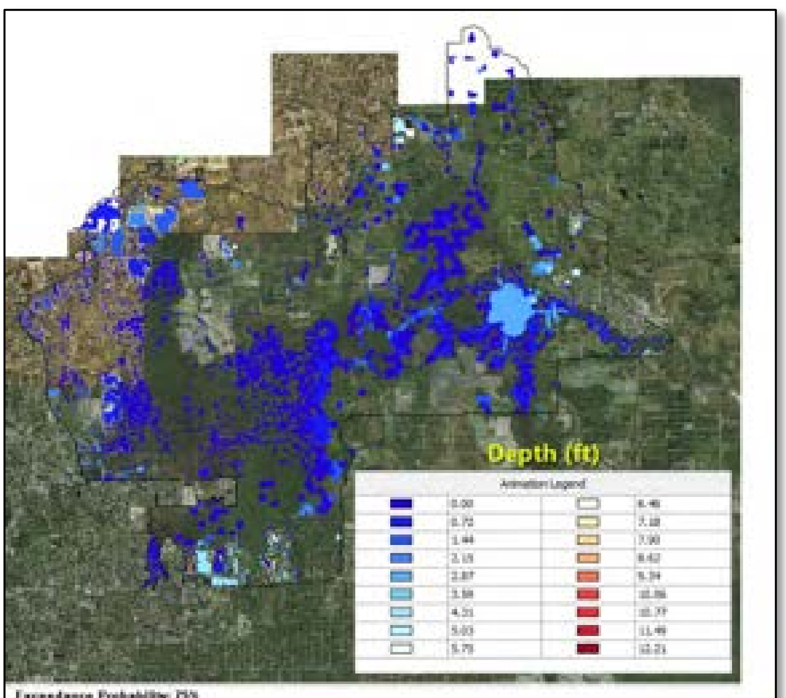


Figure 100 Extents of Inundated Areas within 2D Study Area for 9 Months per Year on Average

4.3.1 Larry Kiker and Hidden Cypress Preserves

Snapshots of 8%, 17%, 25%, 50% and 75% exceedance probabilities of inundated extents (on average) are shown in Figure 101, Figure 102, Figure 103, Figure 104, and Figure 105 for the Larry Kiker and Hidden Cypress Preserves. These correspond to 1, 2, 3, 6, and 9 months of inundation, respectively.

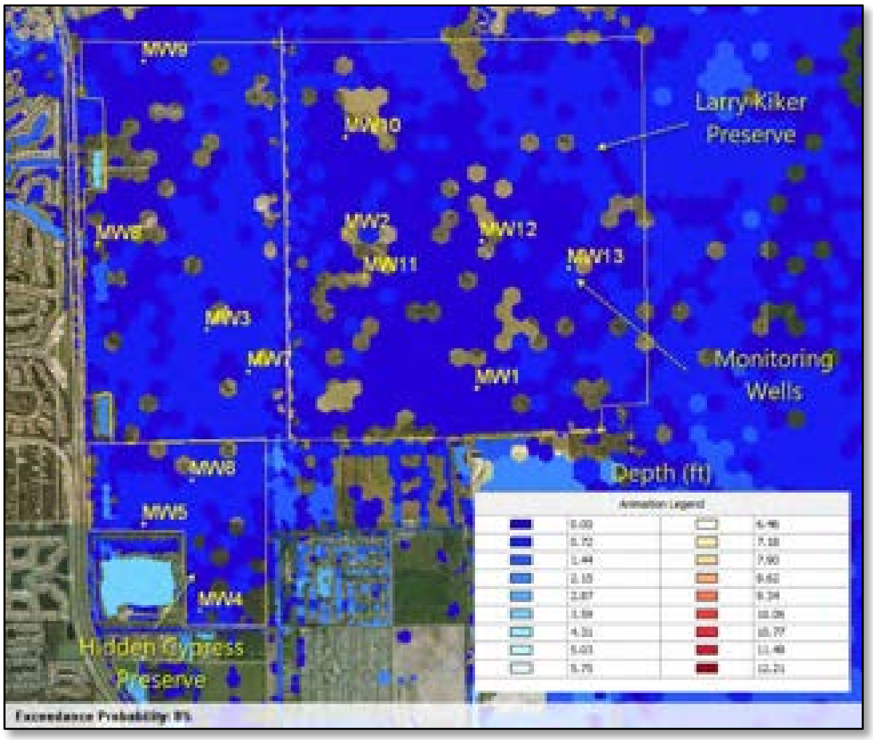


Figure 101 Extents of Inundated Areas within the Kiker and Hidden Cypress Preserves for 1 Month per Year on Average

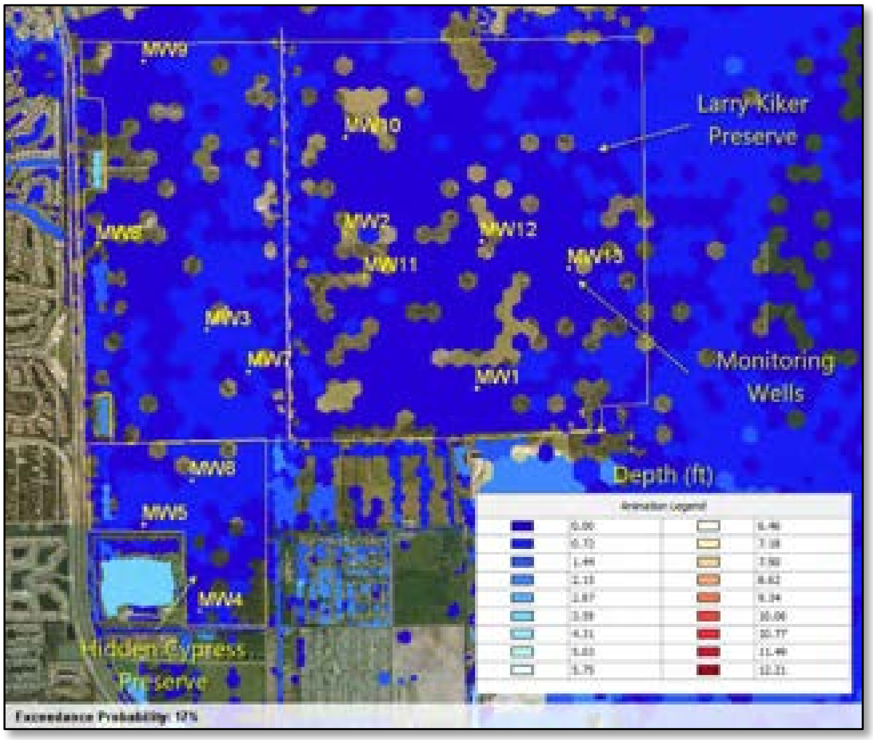


Figure 102 Extents of Inundated Areas within the Kiker and Hidden Cypress Preserves for 2 Months per Year on Average

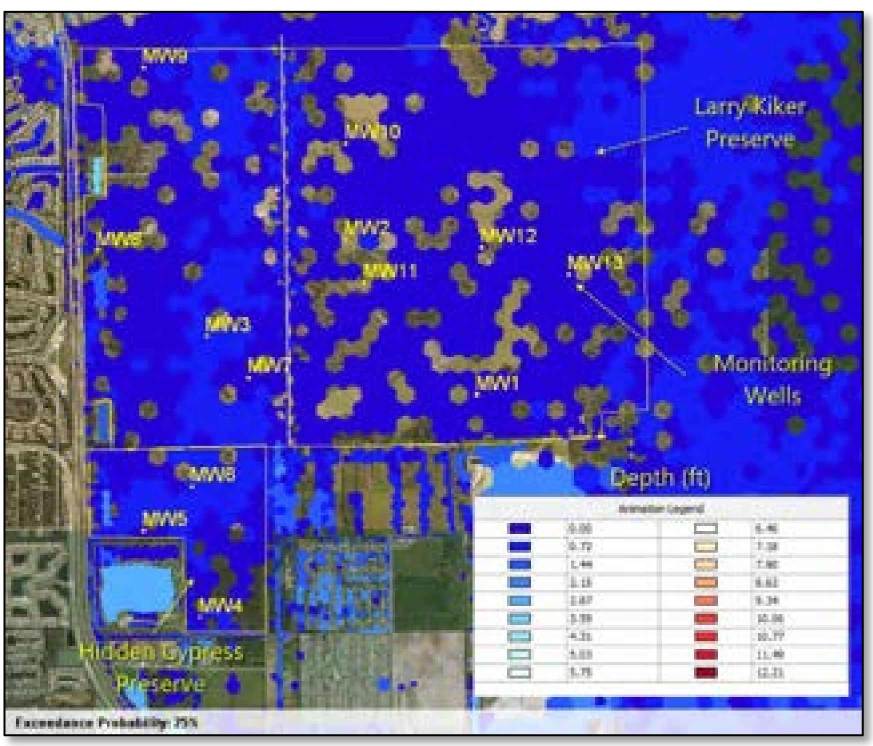


Figure 103 Extents of Inundated Areas within the Kiker and Hidden Cypress Preserves for 3 Months per Year on Average

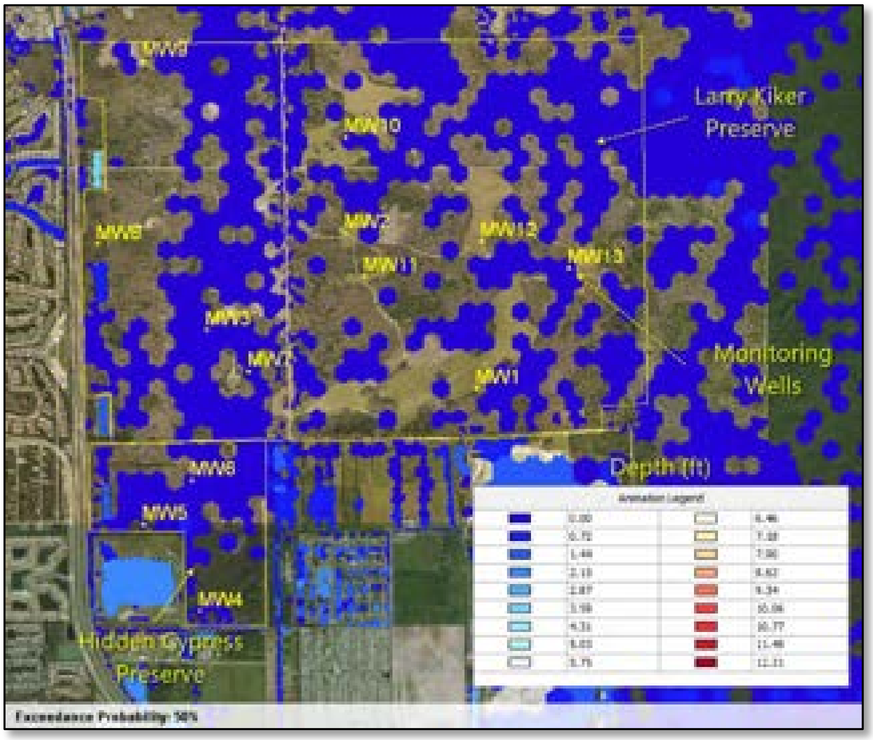


Figure 104 Extents of Inundated Areas within the Kiker and Hidden Cypress Preserves for 6 Months per Year on Average

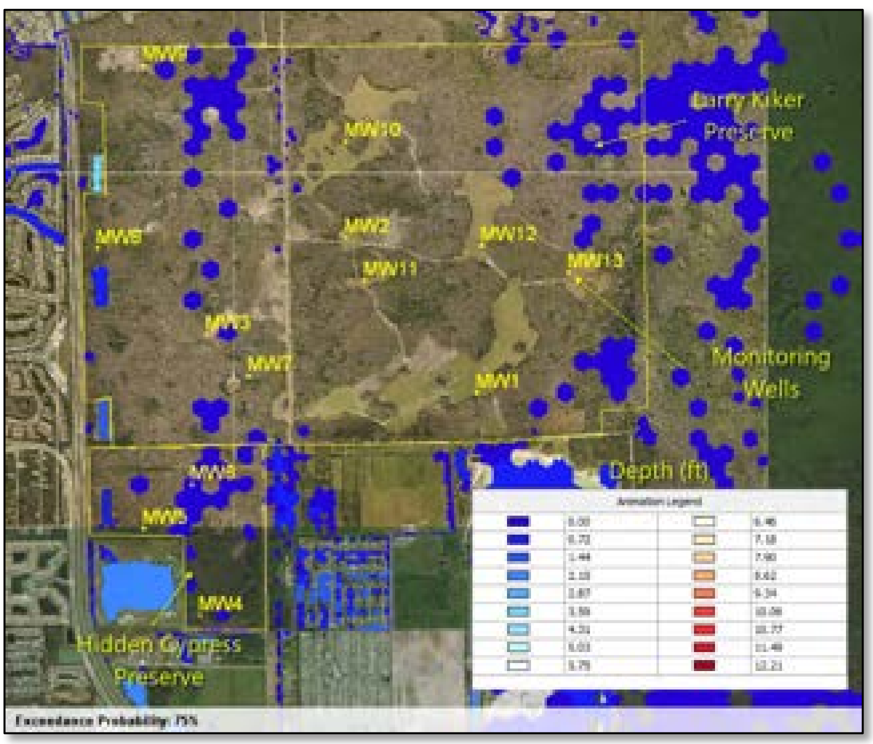


Figure 105 Extents of Inundated Areas within the Kiker and Hidden Cypress Preserves for 9 Months per Year on Average

5. Other Projects of Interest

There is one imminent project and two others in the early planning stages that were evaluated. The first is along Corkscrew Road and involves replacing a series of horizontal elliptical culverts with twin 6’x12’ box culverts. A wildlife crossing will also be added at this location. A second project under consideration by the City of Bonita Springs is the diversion of flows from the Kehl Canal south to the Logan Boulevard channel and eventually into a wetland slough that flows to the Cocohatchee Canal. The third project is also under consideration by the City of Bonita Springs and involves a major new crossing of I-75 and some improvements west of I-75 to accommodate the additional flows.

A copy of the existing condition scenario was made in ICPR4, and these 3 projects were added. The 25- and 100-year 72-hour storms were simulated. Although each of these projects is discussed individually in the following sections, they were combined in a single scenario and run together. However, they were not included with the proposed berm and reservoir simulations described in 6. Assessment of Regional Berm and Reservoir System.

5.1 Corkscrew Road Culvert Upsizing and Wildlife Crossing

Horizontal elliptical pipes (29”x45”) are currently used as cross drains for Corkscrew Road at the 6 locations shown in Figure 106. Existing pipes at locations #2, #3, #4, and #5 were removed from the model. Twin 6’x12’ box culverts were added at location #3 (invert elevation of 13.8 feet NAVD88). Also, a wildlife crossing was added to the model as an 8’x24’ box culvert at location #4 (invert elevation 17.0 feet NAVD88).

Figure 106 Existing Cross Drains Along Corkscrew Road

A summary of maximum flows for the existing and proposed cross drains are presented in Table 22. The maximum flow rates at each crossing occur at slightly different times, so the total maximum flows presented in the table are the worst case. The proposed maximum flows increase by 11.67 cfs (9.1%) and 35.1 cfs (20.0%) for the 25- and 100-year 72-hour storms, respectively. The maximum upstream stages decrease slightly for the proposed condition (-0.01’ and -0.08’ for the 25- and 100-year storms, respectively). The maximum downstream stages increase by 0.14’ and 0.20’ for the 25- and 100-year storms, respectively. These differences are localized and do not propagate upstream or downstream as indicated in Figure 107.

Location	25yr/72hr Existing	25yr/72hr Proposed	100yr/72hr Existing	100yr/72hr Proposed
#2 Q_{max} (cfs)	44.60	0.00	58.10	0.00
#3 Q_{max} (cfs)	41.97	79.47	55.46	123.30
#4 Q_{max} (cfs)	23.75	60.24	31.07	87.43
#5 Q_{max} (cfs)	17.72	0.00	31.00	0.00
Total (cfs)	**128.04**	**139.71**	**175.63**	**210.73**
#3 U/S Z_{max} (NAVD)	19.80	19.79	20.21	20.13
#3 D/S Z_{max} (NAVD)	19.63	19.77	19.91	20.11

Table 22 Comparison of Existing and Proposed Max Discharges and Elevations for the Corkscrew Road Culvert Upsizing

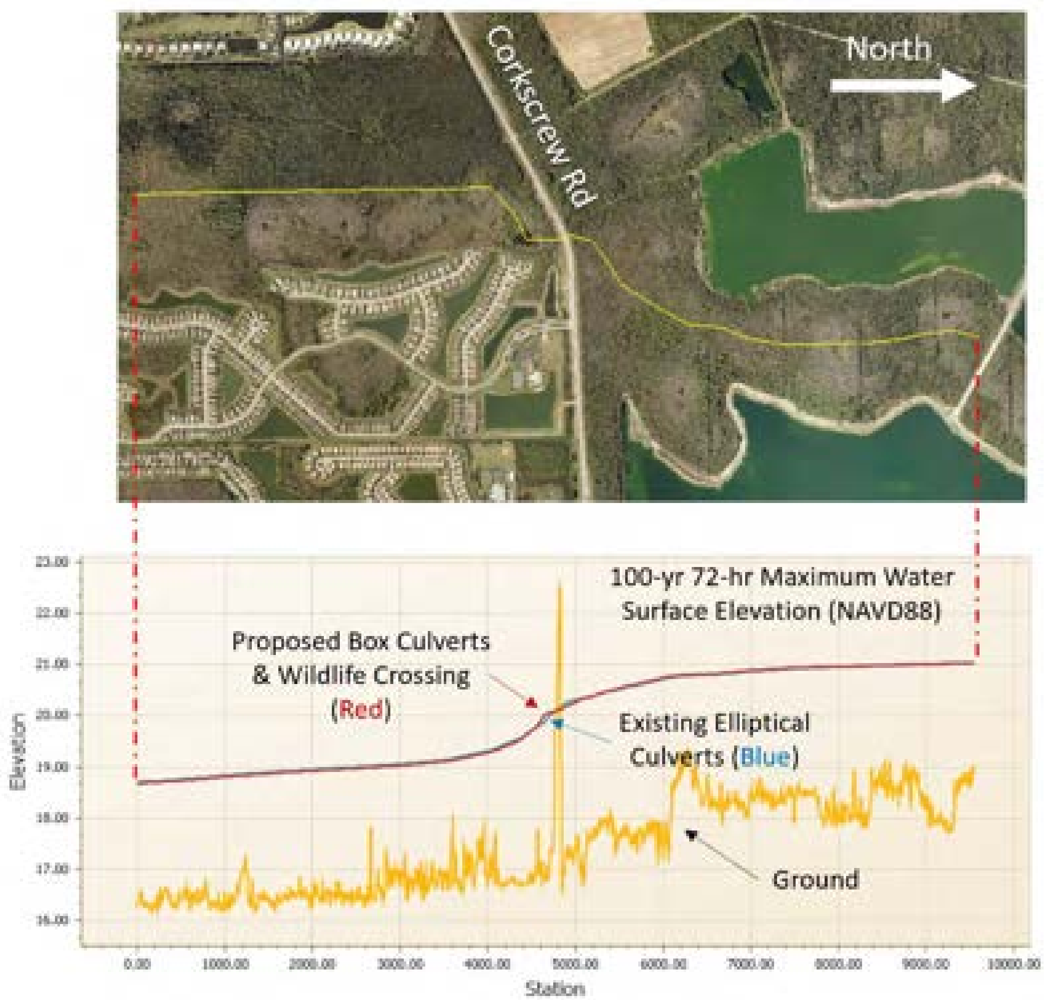


Figure 107 Comparison of Water Surface Profiles at Corkscrew Road Culvert Upsizing for the 100-year 72-hour Storm

5.2 Logan Boulevard Channel

(Lago Consulting & Services, 2019) presented several alternatives to connect the Kehl Canal at Radio Tower Road to the Logan Boulevard channel and ultimately to a wetland slough and the Cocohatchee Canal. Alternative L4a as described in that document was incorporated into the SLC ICPR4 model for this investigation as shown in Figure 108. The model changes include two new channel links, a new box culvert under Bonita Beach Road, a 77-cfs pump station, a 200-cfs pump station, and a new weir at the downstream end of the Logan Blvd. channel. The 77-cfs pump station is to help drainage along the south side of Bonita Beach Road. The on/off level switches are set to 9.8’ and 8.8’ (NAVD), respectively. The 200-cfs pump station is used to “lift” water from the Logan Blvd. channel and discharge it into the slough at the south end of the channel. The on/off level switches are set to 12.3’ and 10.8’, respectively. Furthermore, this pump station should not operate when water levels at SFWMD structure COCO3_H is greater than elevation 11.3’ NAVD. Examination of stage data at this location for Hurricane Irma indicated 4 or 5 days above this elevation. For purposes of this ICPR4 modeling effort, the pump was shut off between hours 72 and 168 for the 72-hour duration storms. This is a 4-day period following the storms. Flap gates are also proposed at the northwest end of the triple 60-inch culverts that cross the intersection of Bonita Beach Road and Bonita Grande Drive.

Figure 108 Lago Consulting Alternative L4a Improvements

5.2.1 Impact of Logan Boulevard Improvements at the Kehl Canal Structure

A comparison of stage hydrographs at the upstream side of the Kehl Canal structure (model node NF0000) for the 25- and 100-year 72-hour storms are shown in Figure 109 and Figure 110, respectively. The maximum water surface elevations decrease slightly: 0.1 feet for the 25-year storm and 0.03 feet for the 100-year storm. The duration of out-of-bank flooding is reduced by 39 hours and 27 hours for the 25- and 100-year storms, respectively.

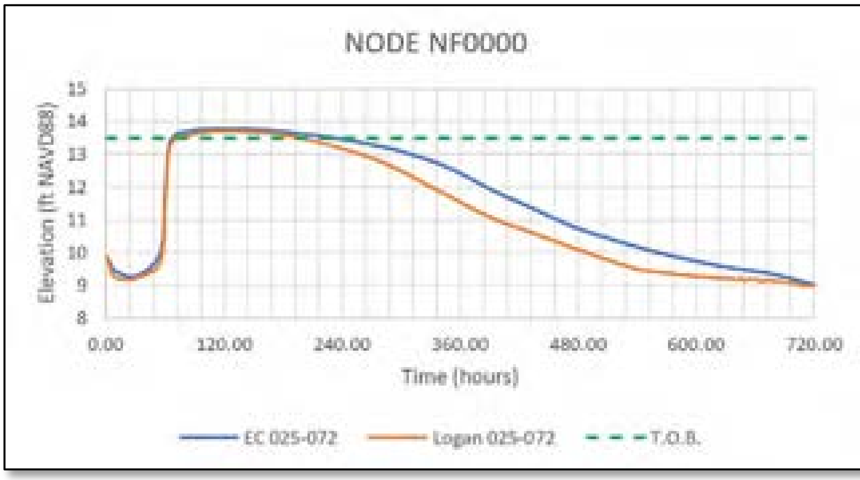


Figure 109 Logan Blvd Improvements: Stage Hydrograph Comparison at KEHL-H for the 25-year 72-hour Storm

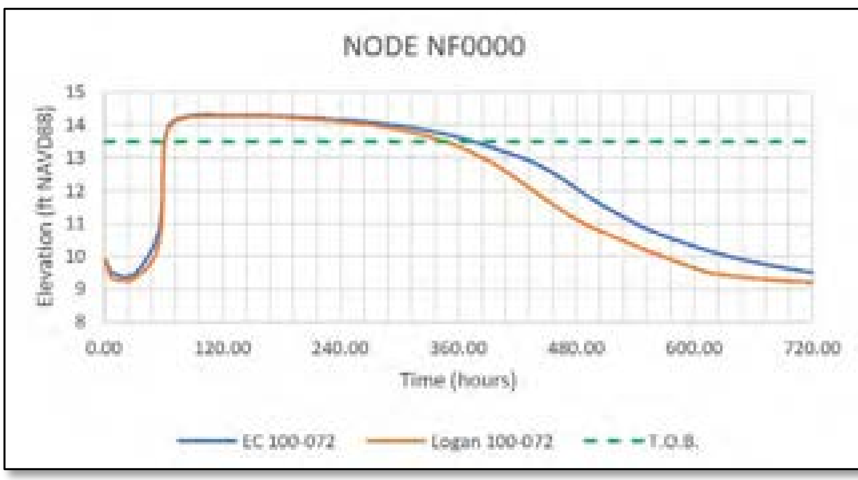


Figure 110 Logan Blvd Improvements: Stage Hydrograph Comparison at KEHL-H for the 100-year 72-hour Storm

5.2.2 Impact of Logan Boulevard Improvements on the South Bonita Beach Road Canal

Most of the developments along the south side of Bonita Beach Road east of I-75 drain into the south Bonita Beach Road canal. Consequently, water levels in the canal have a direct effect on drainage for these developments. A comparison of stage hydrographs along the Bonita Beach Road south canal, approximately 4,600 feet east of Bonita Grande Drive (model node NE0292), for the 25- and 100-year 72-hour storms are shown in Figure 111 and Figure 112, respectively. Durations above an arbitrary target elevation of 11 feet NAVD88 are reduced by 226 hours and 300 hours for the 25- and 100-year storms, respectively. These reductions are due to the proposed 77 cfs pump station at Logan Boulevard in combination with the proposed flap gates to be added to the triple 60-inch culverts at the intersection of Bonita Beach Road and Bonita Grande Drive.

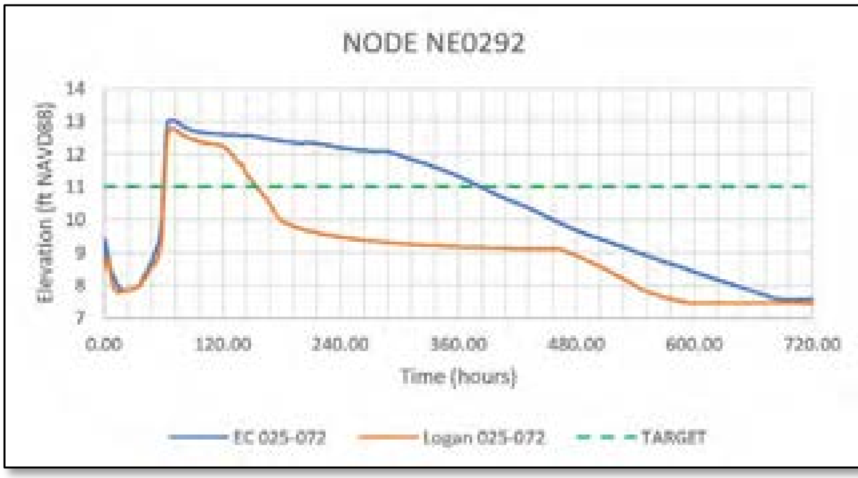


Figure 111 Logan Blvd Improvements: Stage Hydrograph Comparison Along South Bonita Beach Rd Canal for the 25-year 72-hour Storm

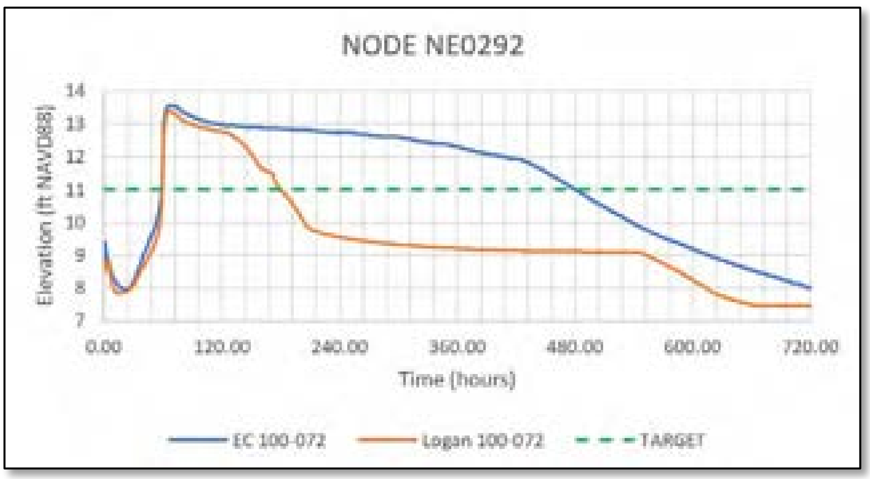


Figure 112 Logan Blvd Improvements: Stage Hydrograph Comparison Along South Bonita Beach Rd Canal for the 100-year 72-hour Storm

5.2.3 Impact of Logan Boulevard Improvements on Wetland Slough at Discharge Point

The 25-year 72-hour stage and discharge hydrographs at the Logan Blvd channel outlet are shown in Figure 113 and Figure 114, respectively. Maximum stages increase from 15.06 feet NAVD88 to 15.42 feet NAVD88 (a 0.36-foot increase). The discharge hydrographs depict the flow for the weir and pump station separately. The flow over the weir is reversed when the pump station is engaged and indicates that water flows from the slough into the Logan Blvd channel, negating some of the capacity of the pump station. The net flow (weir plus pump station) is much less than the full 200 cfs capacity of the pump station.

Similar behavior occurs for the 100-year 72-hour simulation (Figure 115 and Figure 116). The maximum stage in the slough immediately downstream of the pump station increases from 15.42 feet NAVD88 to 15.73 feet NAVD88 (a 0.31-foot increase). A comparison of the 100-year 72-hour maximum water surface elevations in the wetland slough between the Logan Blvd channel outlet and the Cocohatchee Canal are shown in Figure 117. The impact diminishes with distance away from the outlet point.

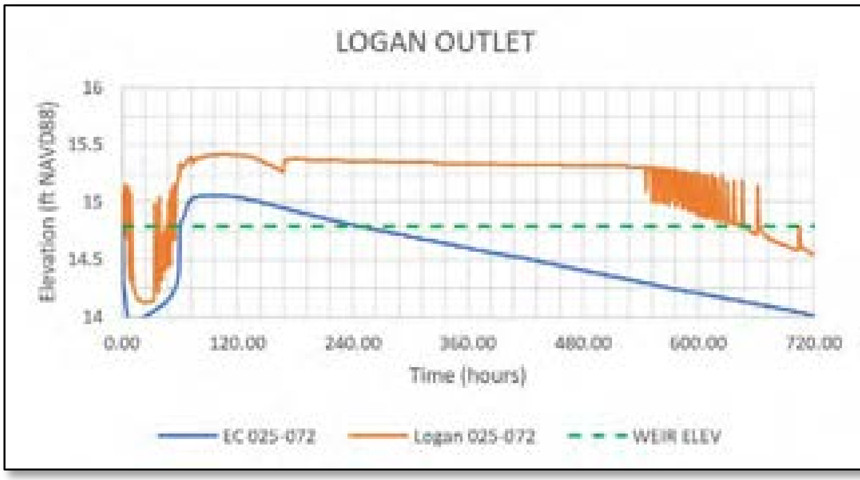


Figure 113 Logan Blvd Improvements: Stage Hydrograph Comparison in Wetland Slough South of the Logan Blvd Channel for the 25-year 72-hour Storm

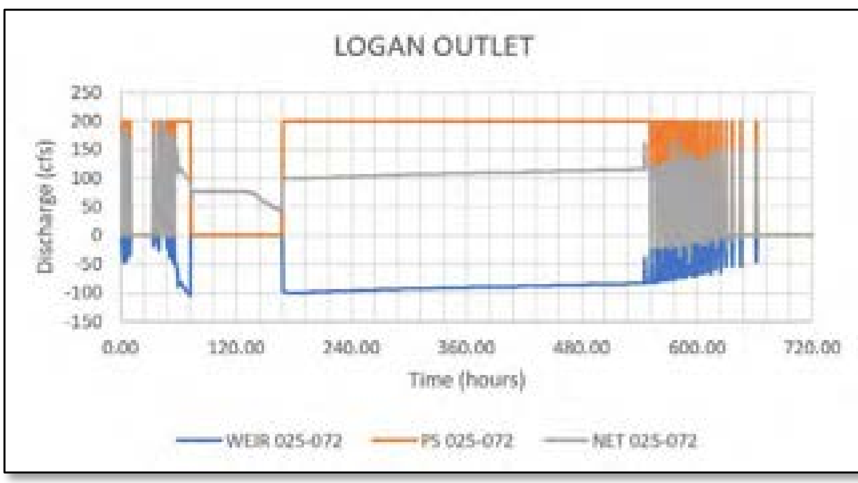


Figure 114 Logan Blvd Improvements: Discharge Hydrographs to Wetland Slough South of the Logan Blvd Channel for the 25-year 72-hour Storm

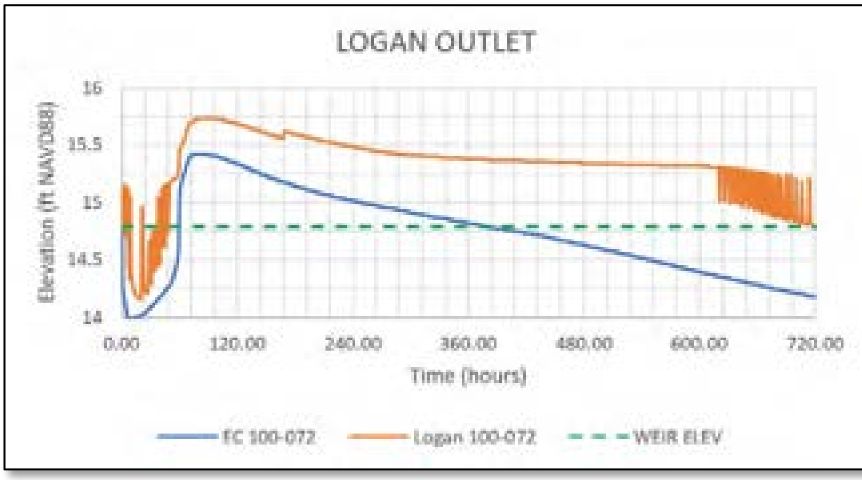


Figure 115 Logan Blvd Improvements: Stage Hydrograph Comparison in Wetland Slough South of the Logan Blvd Channel for the 100-year 72-hour Storm

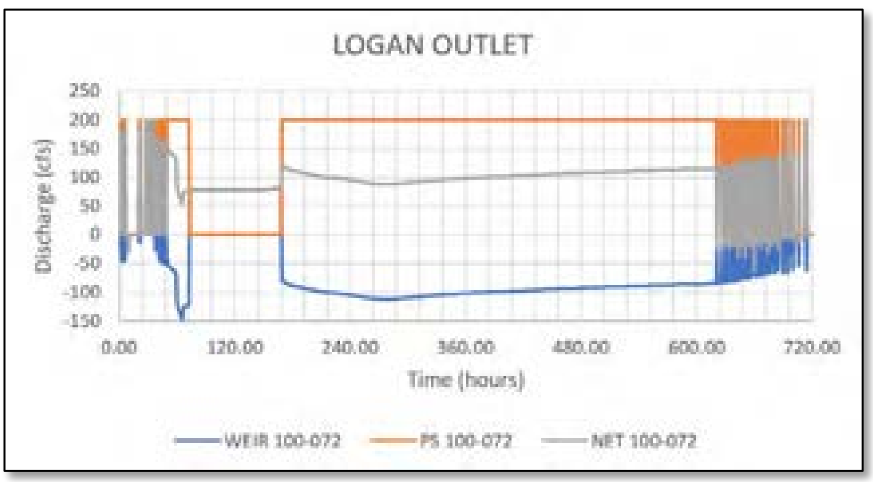


Figure 116 Logan Blvd Improvements: Discharge Hydrographs to Wetland Slough South of the Logan Blvd Channel for the100-year 72-hour Storm

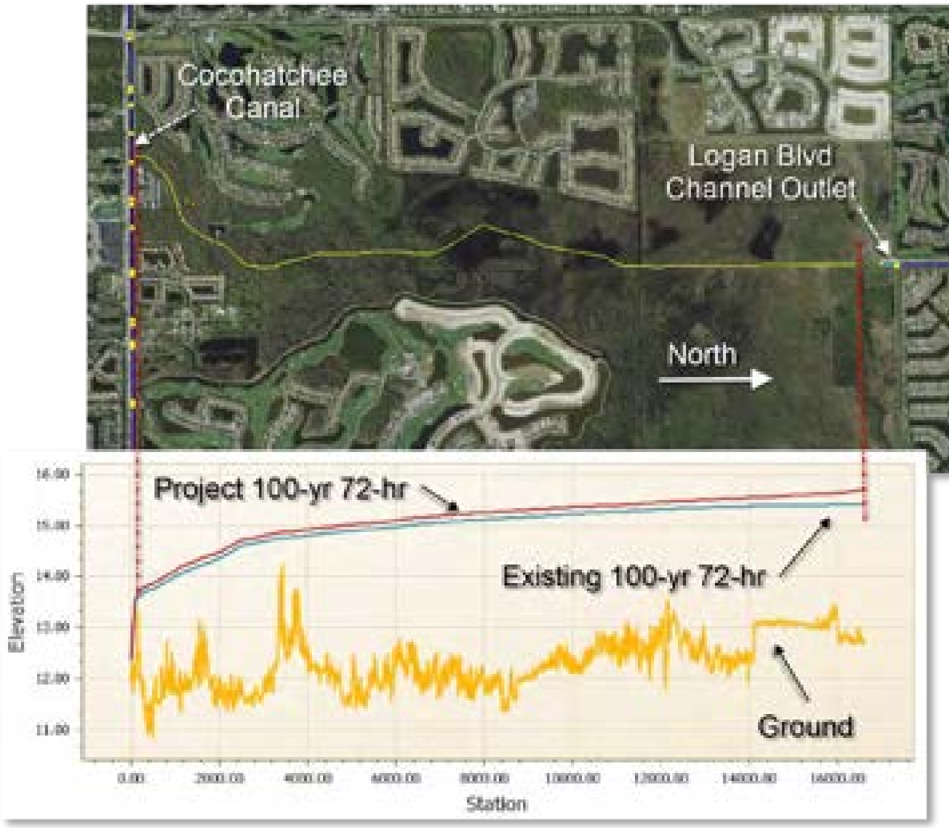


Figure 117 Comparison of Water Surface Profiles in Wetland Slough South of Logan Blvd Outlet for the 100-year 72-hour Storm

5.3 Proposed New I-75 Crossing at Bonita Springs Golf Course

(Lago Consulting & Services, 2019) presented five (5) alternatives near the Bonita Fairways Golf Course to reduce flooding during extreme storm events like Hurricane Irma. The first, GC1, addressed local flooding issues near the Bonita Springs Golf Course. Alternatives GC2 through GC5 were mostly concerned with lowering flood elevations east of I-75 by creating a new connection across I-75. Many of the improvements west of I-75 included in these alternatives were needed to accommodate the increased and prolonged flows from east of I-75. According to (Lago Consulting & Services, 2019), alternatives G4 and G5 provide the greatest reduction in peak flood stages east of I-75, approximately 0.75 feet (at the intake structures) for Hurricane Irma conditions.

Alternative GC4 was incorporated into the SLC ICPR4 model. The proposed improvements are depicted in Figure 118 and Table 23 includes some of the proposed features.

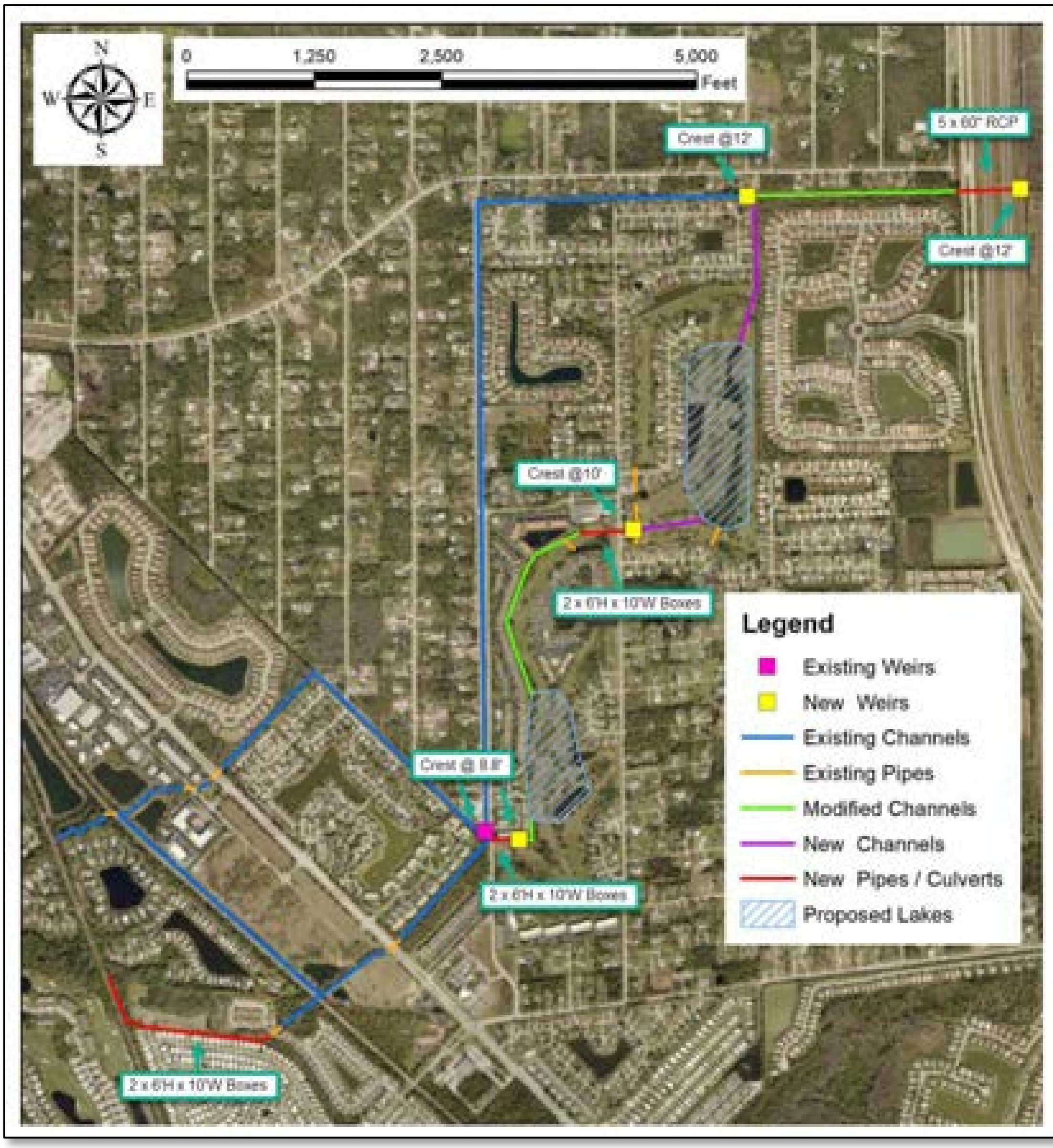


Figure 118 Sketch of Existing and Proposed Features of Golf Course Scenario Alternative GC4 (Lago Consulting & Services, 2019)

Feature	Description
Modified channels	Trapezoidal cross section: bottom width = 20', side slope = 2H:1V, and depth ≅ 6'
5 x 60" RCPs crossing I-75	Invert elevation = 7.5' and 7' NAVD88 for up- and down-stream ends of the pipes, respectively, as in previous GC2 and GC3 alternatives
Weir for each 60" RCP crossing I-75	FDOT Type H Ditch Bottom Inlet: horizontal rectangle = 6.58' x 3', and crest elevation = 12' NAVD88, as in previous GC2 and GC3 alternatives
New weir blocking Strike Ln Canal	Transversal: length= 20', crest elevation= 12' NAVD88
New weir for each 6' H x 10' W box culvert	Vertical rectangular slot: depth= 0.8', width= 10', and invert elevation shown in Figure 15 (= 10' or 8.8' NAVD88). Horizontal rectangle: width= 10', depth= 6', and invert elevation= 1' above slot invert Operable rectangular gate: width= 2', depth= 3', and invert elevation= 4' below slot invert

Table 23 Some Proposed Features for Golf Course Scenario Alternative GC4 (Lago Consulting & Services, 2019)

Discharge hydrographs at the proposed I-75 crossing for alternative GC4 are shown in Figure 119 for the 25- and 100-year 72-hour storms. The peak rates of flow are 133 cfs and 202 cfs, respectively. A comparison of stage hydrographs on the intake side of the proposed I-75 cross drain for existing conditions (EC) and alternative GC4 for the 25- and 100-year 72-hour storms are shown in Figure 120 and Figure 121, respectively. The differences in peak elevations are 0.48 and 0.51 feet for the 25- and 100-year storms, respectively. These are a little lower than the 0.75-foot difference reported by (Lago Consulting & Services, 2019) for Hurricane Irma.

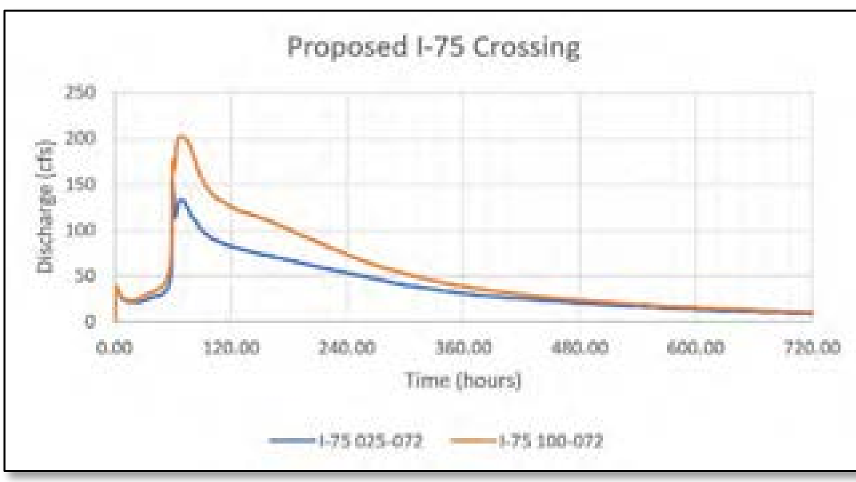


Figure 119 Discharge Hydrographs for the 25- and 100-year 72-hour Storms at the Proposed I-75 Cross Drain

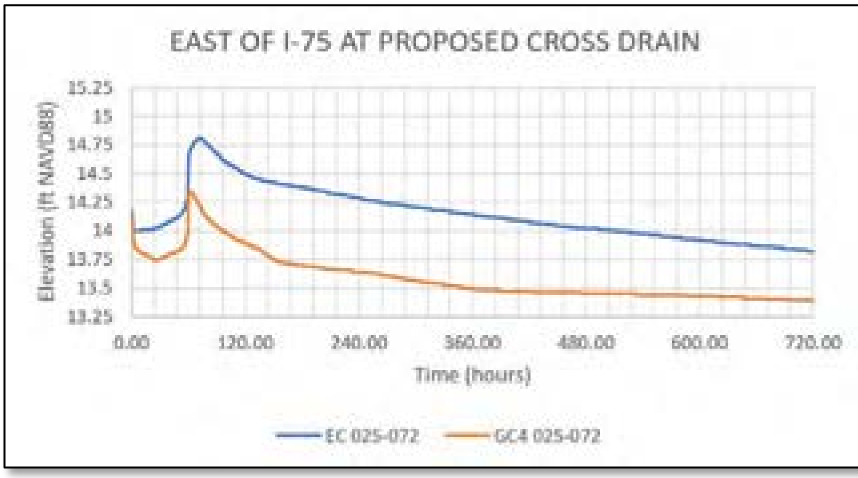


Figure 120 Comparison of Stage Hydrographs for the 25-year 72-hour Storms on the Intake Side of the Proposed I-75 Cross Drain

Figure 121 Comparison of Stage Hydrographs for the 100-year 72-hour Storms on the Intake Side of the Proposed I-75 Cross Drain

As described in 4.2.3 Citrus Park Neighborhood: PT-04, the Citrus Park neighborhood experienced severe and prolonged flooding from Invest 92L and Hurricane Irma. A comparison of stage hydrographs for existing conditions (EC) and alternative GC4 are shown in Figure 122 and Figure 123 for the 25- and 100-year 72-hour storms, respectively. The proposed I-75 cross drain has almost no impact on flooding in Citrus Park.

The impact of alternative GC4 is mostly diminished within a 1-mile radius as seen in Figure 124 and Figure 125.

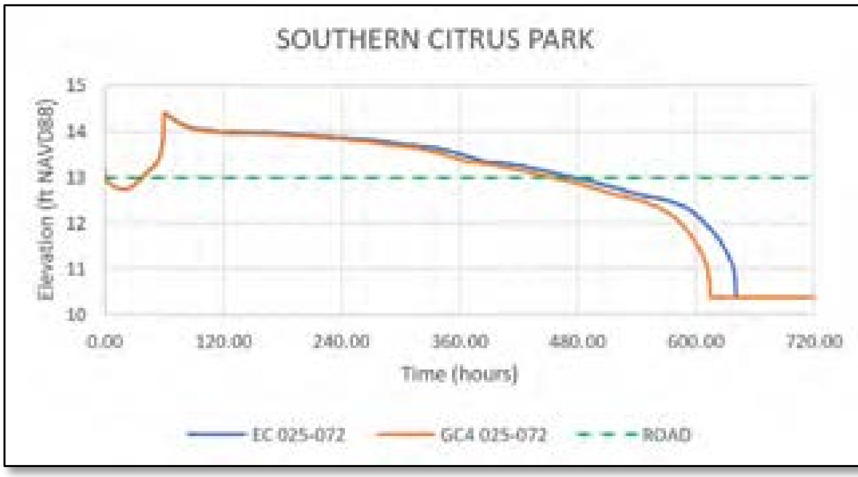


Figure 122 Comparison of Stage Hydrographs for the 25-year 72-hour Storm in the Southern Citrus Park Neighborhood

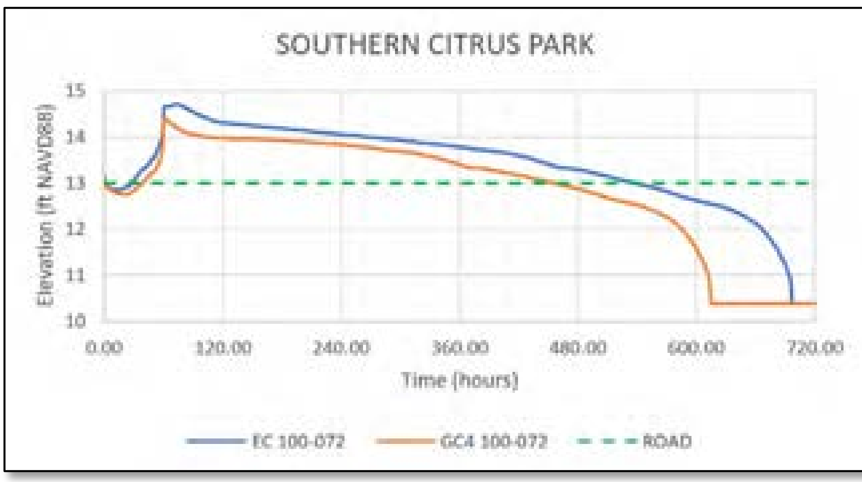


Figure 123 Comparison of Stage Hydrographs for the 100-year 72-hour Storm in the Southern Citrus Park Neighborhood

Figure 124 Radius of Influence for the Proposed I-75 Cross Drain

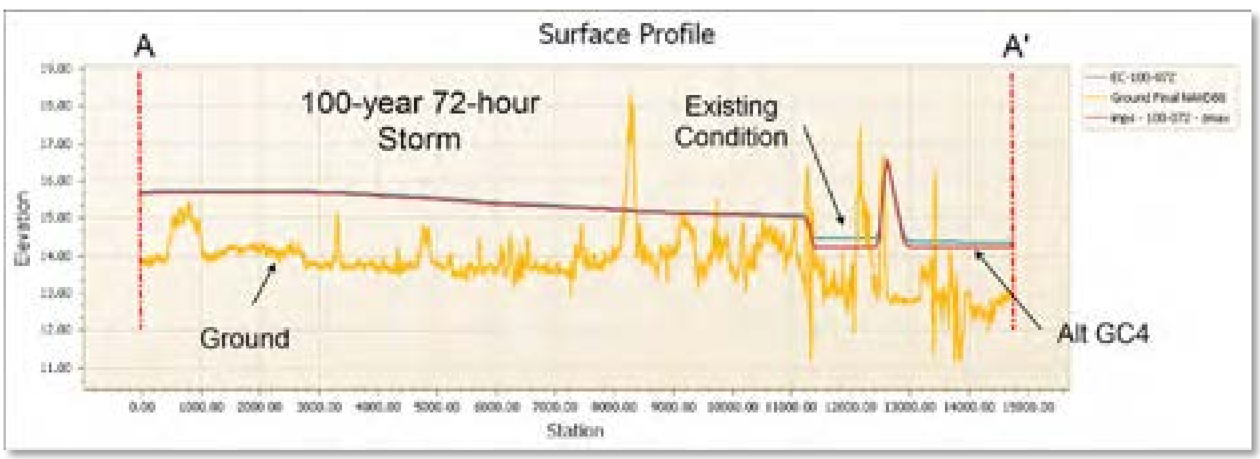


Figure 125 Comparison of Water Surface Profiles at the 1-mile Radius of Influence for Existing Conditions and Alternative GC4 for the 100-year 72-hour Storm

6. Assessment of Regional Berm and Reservoir System

The projects described in 5. Other Projects of Interest were not included in the assessment of the regional berm and reservoir system.

6.1 Proposed Berm Alignments and Appurtenant Works

6.1.1 Flow Patterns at the Southeastern Corner of Lee County

Velocity vectors at the southeast corner of Lee County are shown in Figure 126 for September 13, 2017 of the calibration period existing condition simulation. Also shown in this figure are the proposed original berm alignment and a possible alternate alignment. These alignments are discussed in detail later in 6.1.2 Berm Alignments. The blue shaded area shows overland flow contributions from Collier County into Lee County and the Kehl Canal. Placing the berm along the original alignment can “shunt” water into the Kehl Canal through a “back door” south of the original proposed berm alignment. Understanding these flow patterns is important when considering berm alignments.

Figure 126 Flow Patterns at the Southeastern Corner of Lee County

6.1.2 Berm Alignments

Two berm alignments, B1 and B2, were evaluated and are shown in Figure 127. Both are set at elevation 20 feet NAVD. Alignment B1 follows the original proposed alignment closely except a shift is proposed at its eastern end in the SFWMD Southern C.R.E.W. Project Area. This will minimize environmental impacts in that area. Bonita Grande Road and East Terry Street could serve as the berm if elevated to 20 feet NAVD.

B2 follows Radio Tower Road south to Bonita Beach Road instead of paralleling the north side of the eastern half of the Kehl Canal into the SFWMD Southern C.R.E.W. Project Area. It then parallels the north side of Bonita Beach Boulevard to the east. This alignment would involve elevating Radio Tower Road to 20 feet NAVD. Bonita Beach Road could be used as the berm if it is at or above elevation 20 feet NAVD. The B2 alignment follows the B1 alignment between Radio Tower Road and I-75. But, B2 ties into I-75 instead of paralleling it in the Kiker Preserve area. Smaller local berms are placed at the various I-75 crossings.

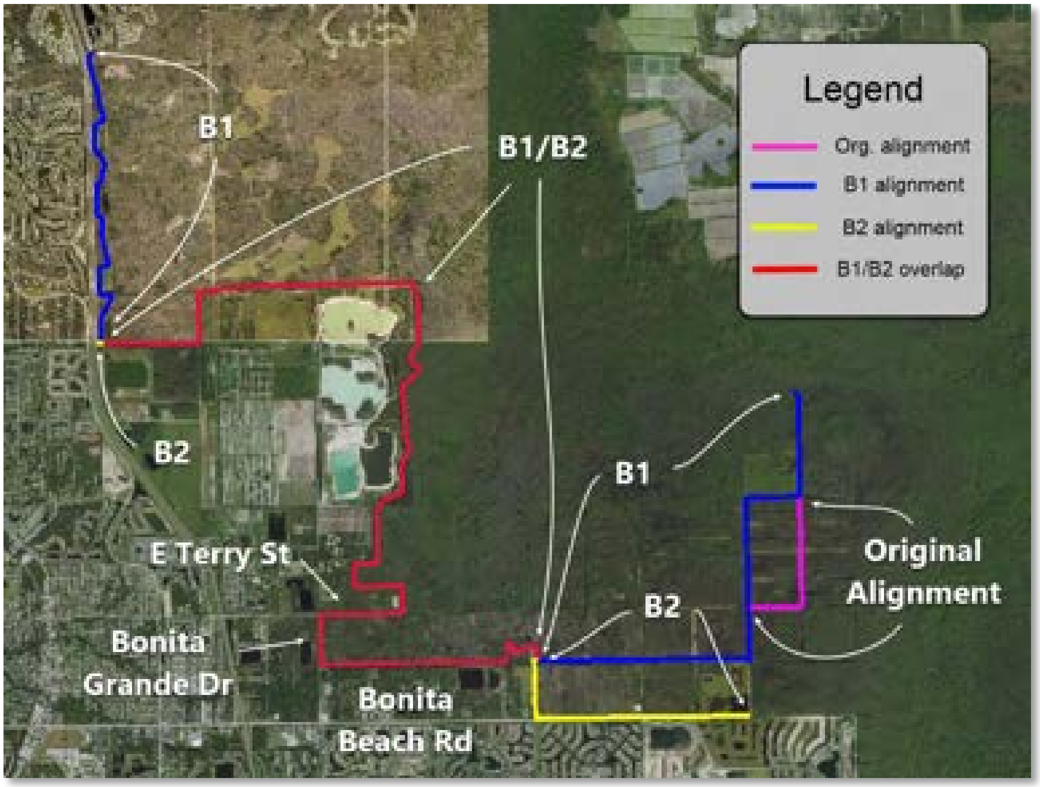


Figure 127 Berm Alignments

B1 and B2 include approximately 101,000 feet and 75,000 feet of berm construction, respectively. Much of the 26,000-foot difference would likely be in environmentally sensitive areas. Also, B1 could potentially disrupt some of the recent restoration work done in the SFWMD Southern C.R.E.W. project area. Profiles of each berm alignment are shown in Figure 128 and Figure 129.

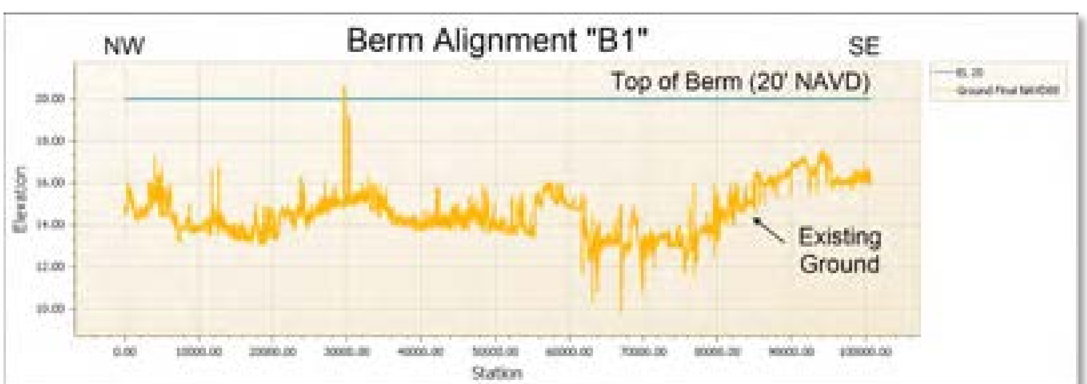


Figure 128 Existing Ground Surface Profile for Berm Alignment B1

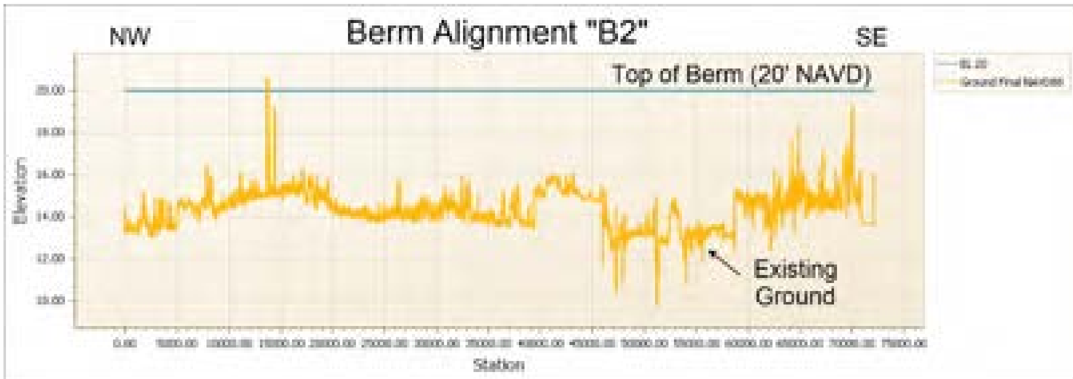


Figure 129 Existing Ground Surface Profile for Berm Alignment B2

Water elevations behind each on the berm alignments are not flat surfaces. Water levels are expected to increase above existing conditions farther upstream for extreme storm events beyond the limits of the berms. Water movement and patterns through the reservoirs was modeled using 2D overland flow. The approximate surface area behind berm alignments B1 and B2 are 27.4 and 28.6 square miles, respectively. The approximate stored volumes during the 100-year 240-hour storm event are shown in Figure 130. The maximum storage volumes for B1 and B2 for this storm are approximately 29,000 acre-feet and 33,000 acre-feet, respectively. The average depths at maximum storage for B1 and B2 are 1.66 feet and 1.80 feet, respectively.

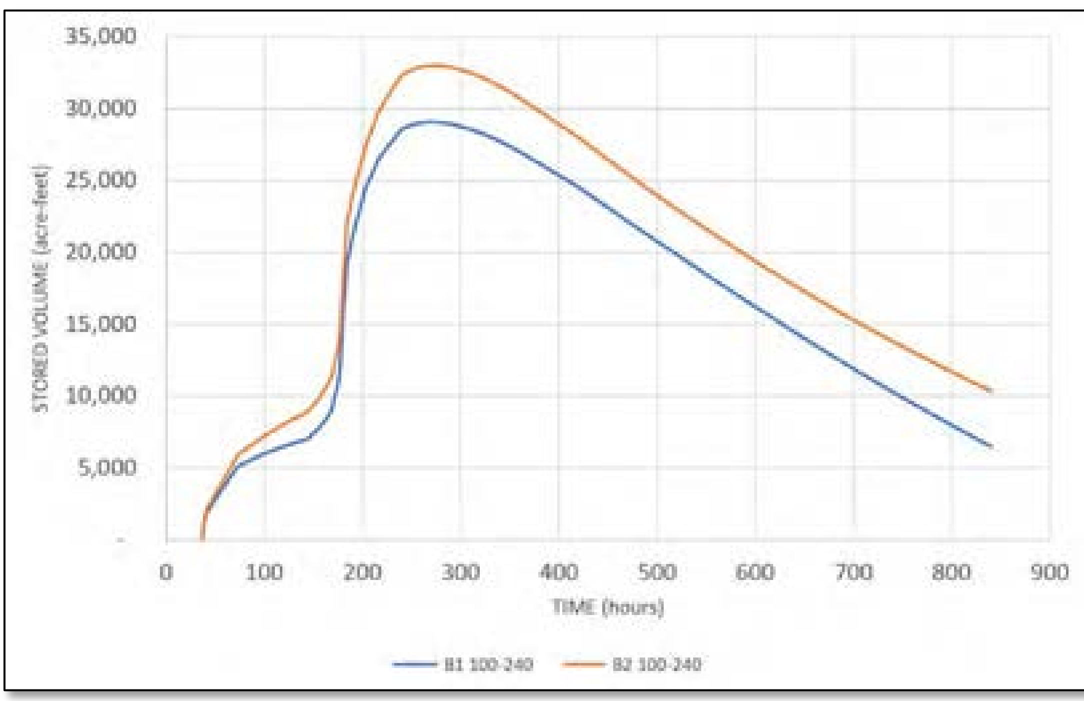


Figure 130 Reservoir Storage for Berm Alignments B1 and B2 (100-year 240-hour Storm)

6.1.3 Appurtenant Works

Project works west of I-75 were outside the scope of work for this study. However, some improvements were necessary to determine reasonable performance aspects of the proposed reservoir system. These were kept to a minimum with an emphasis on: (1) minimizing environmental impacts; (2) reducing flooding in the Island Club at Corkscrew neighborhood; and, (3) utilizing apparent excess capacity along Halfway Creek in The Brooks neighborhood (located within the Village of Estero). The improvements west of I-75 along Halfway Creek should be considered a starting point.

A new “manifold” ditch (30’ BW, 3:1 SS) was placed parallel to and on the west side of I-75 (see Figure 131). A north-south berm was included along the northern end of this ditch on the west side to prevent overtopping and to reduce flooding impacts to the Island Club at Corkscrew development. Although not included in the SLC ICPR4 model, a gated structure could be placed in this berm to allow some regulated flow through the Island Club slough. For purposes of this modeling effort, flow is directed to a flow-way in The Brooks development that consists of several detention ponds connected with quadruple box culverts (6’x10’). A 200-foot fixed crest weir upstream of a railroad crossing on the east side of Via Coconut Point was lowered 1 foot to elevation 11.4 feet NAVD. This was necessary to decrease tailwater conditions on The Brooks flow-way and the cross connections along I-75. Although not included in the SLC ICPR4 model, another option would be to configure a gate system to lower water levels prior to large storm systems if water table issues are a concern.

The Halfway Creek and Brooks flow-way appears to have been designed for relatively large offsite flows from the east side of I-75. Bathymetry of the detention ponds along the flow-way was not available. If this option is ultimately selected for implementation, the conveyance through the flow-way and all structures will have to be field surveyed and the model refined/rerun to confirm hydraulic performance.

Figure 131 Conceptual Improvements Included in the ICPR4 Model for Berm Alignment B1

The improvements depicted west of I-75 in Figure 131 are for berm alignment B1. Structures "W-3 11B", "W-3 11C", W-3 11D" and "W-3 11E" each include a 90-foot fixed crest weir at elevation 17 feet NAVD and (4) 6'x6' operable gates with invert elevations at 11 feet NAVD. The gates are intended to be closed prior to the arrival of large storm systems and then opened the full 6 feet after the storm has passed and downstream drainage systems have recovered from local runoff. A fourth structure ("W-3 11A") was proposed at the south end of the Larry Kiker Preserve in the concept plan but was not included in the model. The "W-3 11A" improvements might not be necessary if the other improvements described for The Brooks and Halfway Creek are implemented. The "W-3 11A" improvements are like the Bonita Springs Golf Course alternatives GC4 and GC5.

Figure 132 Conceptual Improvements Included in the ICPR4 Model East of I-75 for Berm Alignment B2

Improvements east of I-75 for the B2 berm alignment are shown in Figure 132. Local berms at each structure are used instead of a long linear berm parallel to I-75.

A total of (4) single gate (6' wide by 4' high) structures ("Kehl-01", "Kehl-02", Kehl-03" and "Kehl-04") with invert elevations at 12 feet NAVD are proposed along the north side of the Kehl Canal for the B1 berm alignment as shown in Figure 133. These gates are to be operated similar to the proposed I-75 gates in that they are to be closed during major storm systems and opened 2 feet after the storm has passed. The culvert under Radio Tower Road at the Kehl Canal should also be upgraded to a single 10' wide by 6' high box culvert for the B1 berm alignment.

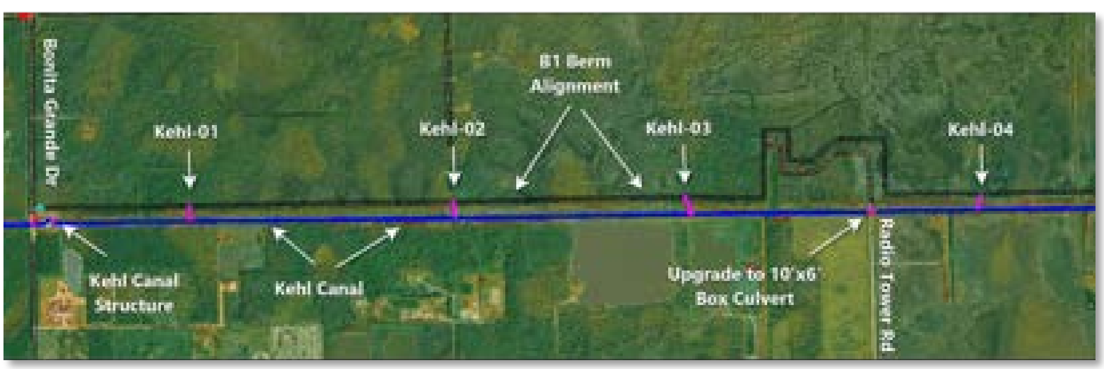


Figure 133 Proposed Berm and Structure Placement for Berm Alignment "B1"

Gates "Kehl-01", "Kehl-02" and "Kehl-03" for berm alignment B2 are the same as B1. Gate "Kehl-04" is placed at the Radio Tower Road crossing of the Kehl Canal as shown in Figure 134.

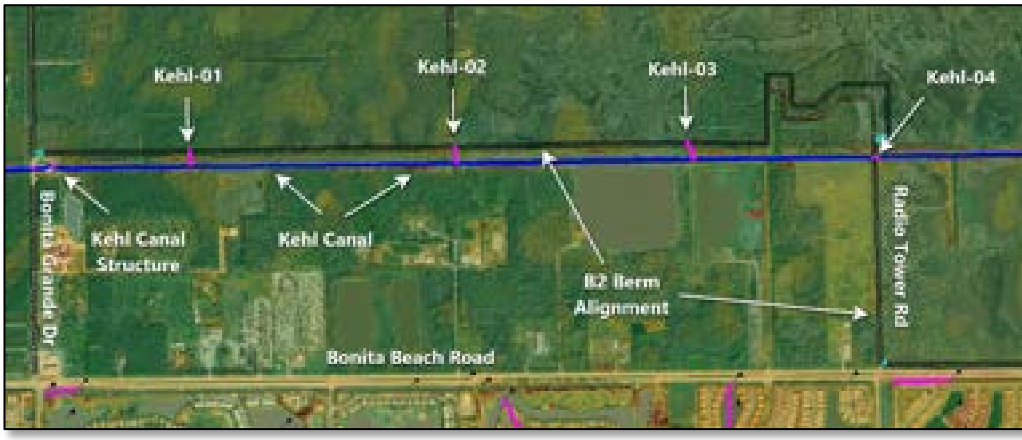


Figure 134 Proposed Berm and Structure Placement for Berm Alignment "B2"

6.1.4 Gate Operating Criteria

The I-75 and Kehl Canal lateral gates are operated using time dependent top clip operating tables in ICPR4. The maximum gate opening is specified in the weir link data form (e.g., 6-foot maximum depth). Top clips are measured downward from the maximum opening. A top clip of 6 feet with a maximum depth of 6 feet is the same as the gate being closed. The gate operations for the discrete and historical storms are provided in Table 24. The I-75 gates were either fully opened or fully closed. The Kehl Canal gates were either half opened or fully closed.

	Gate Closure Periods
Discrete Storm Simulations	
SFWMD 72-Hour	Hours 48 – 96
FDOT 168-Hour	Hours 126 – 174
FDOT 240-Hour	Hours 156 – 204
Historical Simulations	6/30/2013 – 7/4/2013
	1/27/2016 – 1/31/2016
	6/6/2017 – 6/10/2017
	7/31/2017 – 8/3/2017
	8/23/2017 – 8/29/2017
	9/9/2017 – 9/12/2017

Table 24 Gate Closure Times and Dates for the Proposed I-75 and Kehl Canal Structures

6.2 Analysis of Results

Stage hydrographs for reference points PT-02, PT-03, PT-03B, PT-04, PT-05, PT-06, PT-06B, PT-07, PT-09, PT-10, PT-11, PT-12, PT-24, PT-32 and PT-33 (see Figure 135) are presented in the following sections. Existing conditions are compared with berm alignments B1 and B2 for the calibration period (summer of 2017) simulations and the 25- and 100-year 72-, 168- and 240-hour simulations. Maximum water surface profiles are also presented for flow paths A' – A, D' – D, G' – G, I' – I, K' – K and L' – L (see Figure 136) for Hurricane Irma and the 25- and 100-year 240-hour simulations. Initial conditions for the B1 and B2 single event simulations were based on the August 24, 2017 water levels from their respective summer of 2017 simulations.

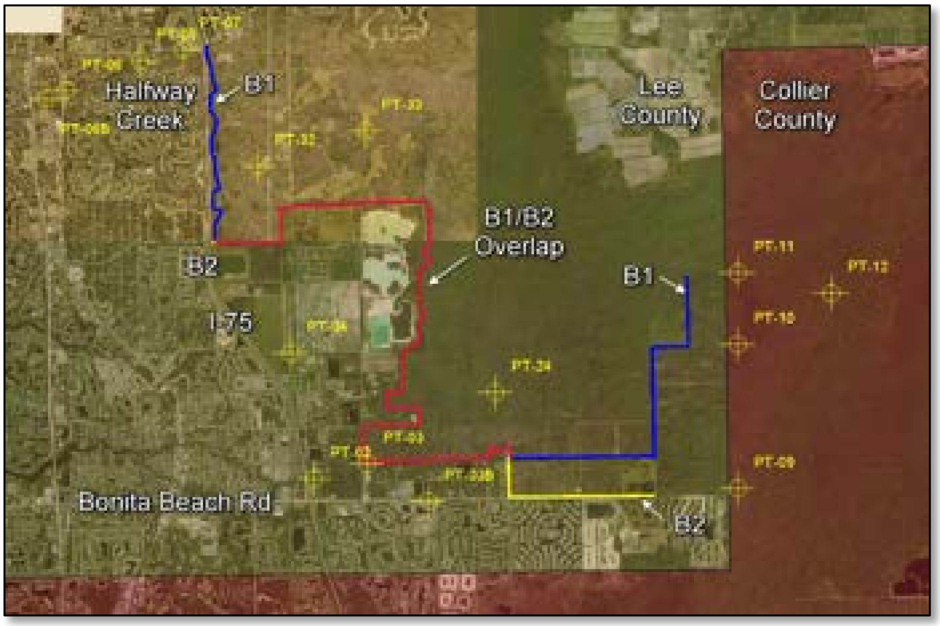


Figure 135 Reference Point Locations for Reporting Purposes

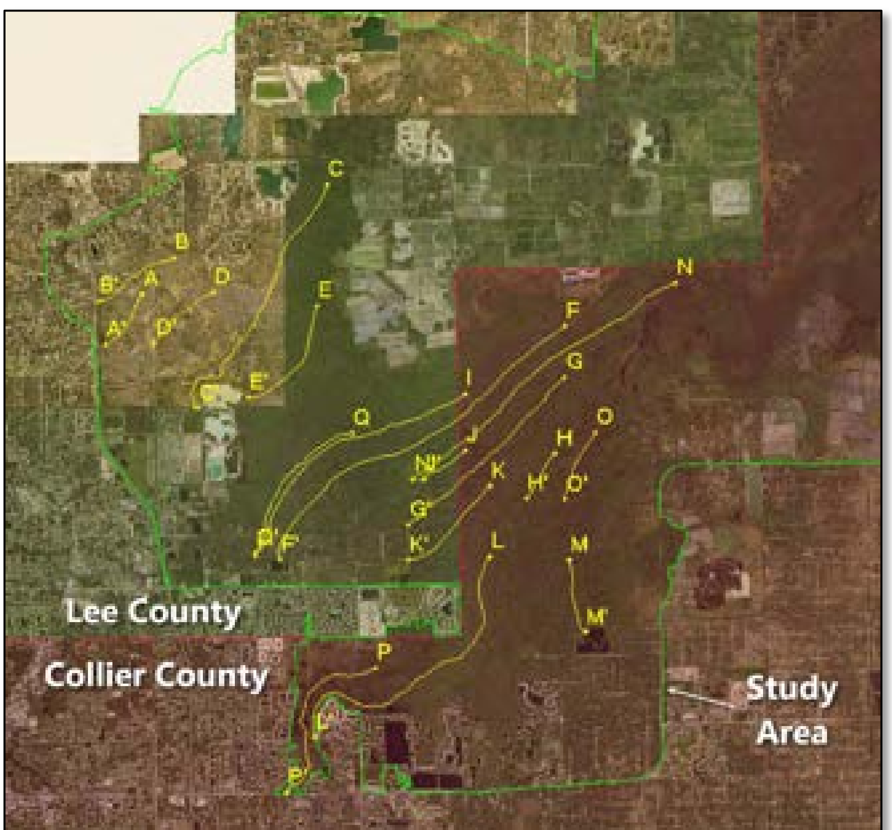


Figure 136 Water Surface Profile Locations

6.2.1 USGS Station 02291500, Imperial River: PT-02

A summary of maximum water surface elevations for existing conditions (EC) and berm alignments B1 and B2 are included in Table 25. Berm alignment B1 lowers maximum water surface elevations between 0.60 feet (100yr-72hr) and 1.76 feet (25yr-168hr) at reference point PT-02. Berm alignment B2 lowers the maximum stages even further – between 0.97 feet (100yr-72hr) and 2.67 feet (Summer 2017). As shown in Figure 137, water levels remain in-bank for B1 and B2 for all simulations except during a brief period for the 100-year 72-hour storm.

Maximum Water Surface Elevations at PT-02					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	11.85	10.25	9.18	-1.60	-2.67
025-072	11.65	10.78	10.11	-0.87	-1.54
025-168	11.69	9.93	9.18	-1.76	-2.51
025-240	11.81	10.2	9.56	-1.61	-2.25
100-072	12.25	11.65	11.28	-0.60	-0.97
100-168	12.45	11	9.92	-1.45	-2.53
100-240	12.43	10.99	10.28	-1.44	-2.15

Table 25 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-02 for Existing Conditions (EC), and Berm Alignments B1 and B2

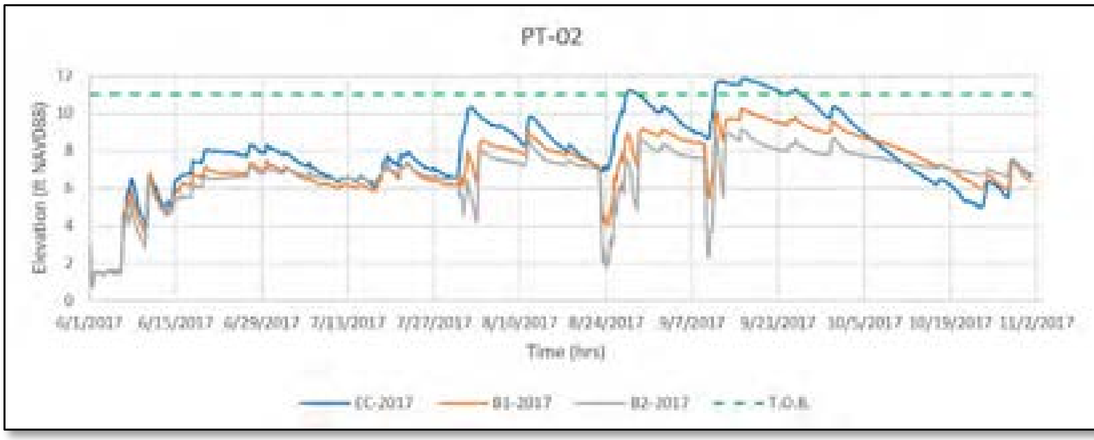
Maximum discharge rates and volumes for the various simulation periods are provided in Table 26 and Table 27, respectively. Significant reductions in maximum flow rates and volumes result for both berm alignments. Berm alignment B1 reduces maximum discharge rates by 240 cfs (100yr-72hr) to 362 cfs (25yr-168hr). B2 reduces maximum discharge rates even further with ranges from 395 cfs (100yr-72hr) to 548 cfs (Summer 2017). The volume reductions for B2 are almost double that of B1. Discharge hydrographs are presented in Figure 138. The discharges and volumes are slightly downstream of PT-02, at Imperial River under I-75, because of overbank flooding at PT-02.

Maximum Discharge Rates (cfs) at PT-02					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	1,142	811	594	-331	-548
025-072	1,043	703	557	-340	-486
025-168	1,103	741	593	-362	-510
025-240	1,120	775	635	-345	-485
100-072	1,137	897	742	-240	-395
100-168	1,170	862	667	-308	-503
100-240	1,169	894	700	-275	-469

Table 26 Comparison of Maximum Discharge Rates (cfs) at PT-02 for Existing Conditions (EC), and Berm Alignments B1 and B2

Volumes (acft) at PT-02					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	158,017	125,566	106,926	-32,451	-51,091
025-072	38,515	31,485	25,449	-7,030	-13,066
025-168	46,131	37,587	26,431	-8,544	-19,700
025-240	48,297	38,795	30,649	-9,502	-17,648
100-072	46,875	37,583	27,741	-9,292	-19,134
100-168	54,353	44,202	32,607	-10,151	-21,746
100-240	55,316	44,790	32,909	-10,526	-22,407

Table 27 Comparison of Volumes (acft) at PT-02 for Existing Conditions (EC), and Berm Alignments B1 and B2



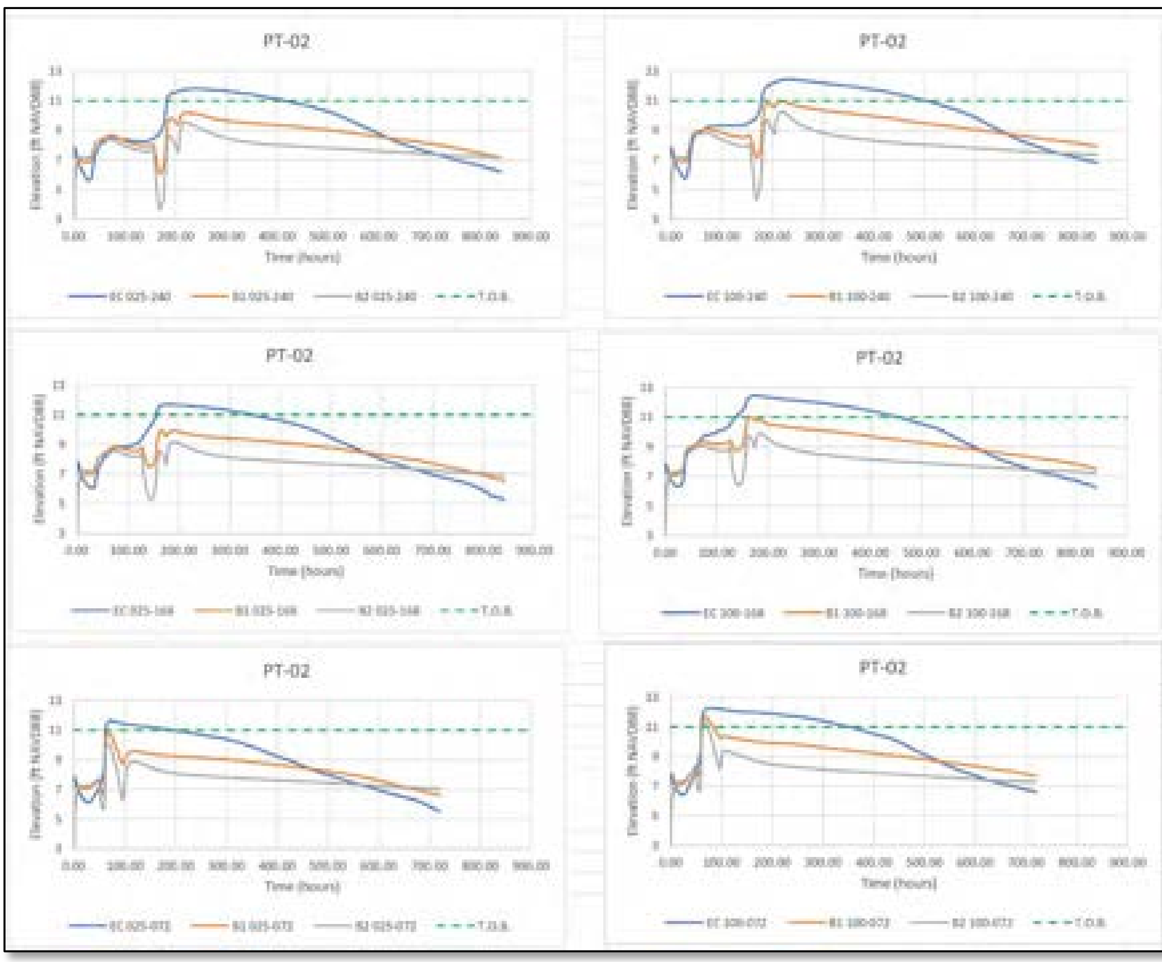


Figure 137 Comparison of Stage Hydrographs at PT-02 for Existing Conditions (EC), and Berm Alignments B1 and B2

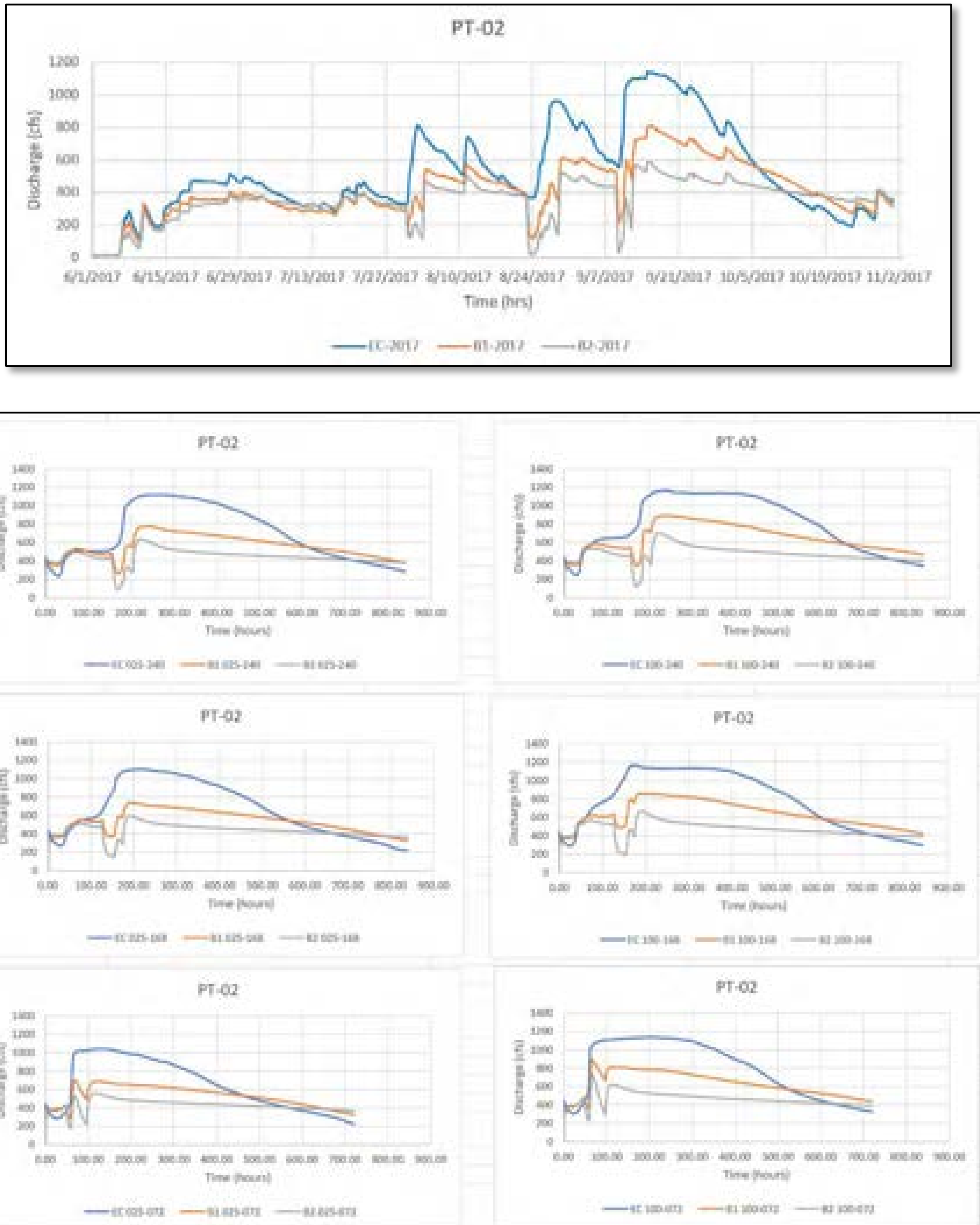


Figure 138 Comparison of Discharge Hydrographs at PT-02 for Existing Conditions (EC), and Berm Alignments B1 and B2

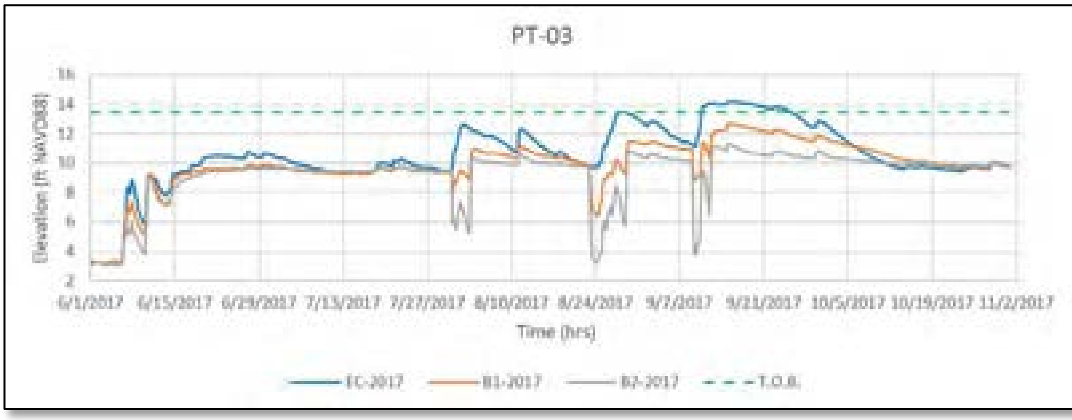
6.2.2 Kehl Canal Structure (Upstream Side): PT-03

A summary of maximum water surface elevations for existing conditions (EC) and berm alignments B1 and B2 are included in Table 28. Berm alignment B1 lowers maximum water surface elevations between 1.38 feet (100yr-72hr) and 1.81 feet (25yr-168hr) at reference point PT-03. Berm alignment B2 lowers the maximum stages even further – between 2.05 feet (100yr-72hr) and 2.87 feet (Summer 2017). As shown in Figure 139, water levels remain in-bank for B1 and B2 for all simulations.

Maximum Water Surface Elevations at PT-03

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	14.21	12.70	11.34	-1.51	-2.87
025-072	13.79	12.07	11.03	-1.72	-2.76
025-168	14.05	12.24	11.3	-1.81	-2.75
025-240	14.15	12.46	11.57	-1.69	-2.58
100-072	14.31	12.93	12.26	-1.38	-2.05
100-168	14.46	12.93	11.84	-1.53	-2.62
100-240	14.49	13.07	12.1	-1.42	-2.39

Table 28 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-03 for Existing Conditions (EC), and Berm Alignments B1 and B2



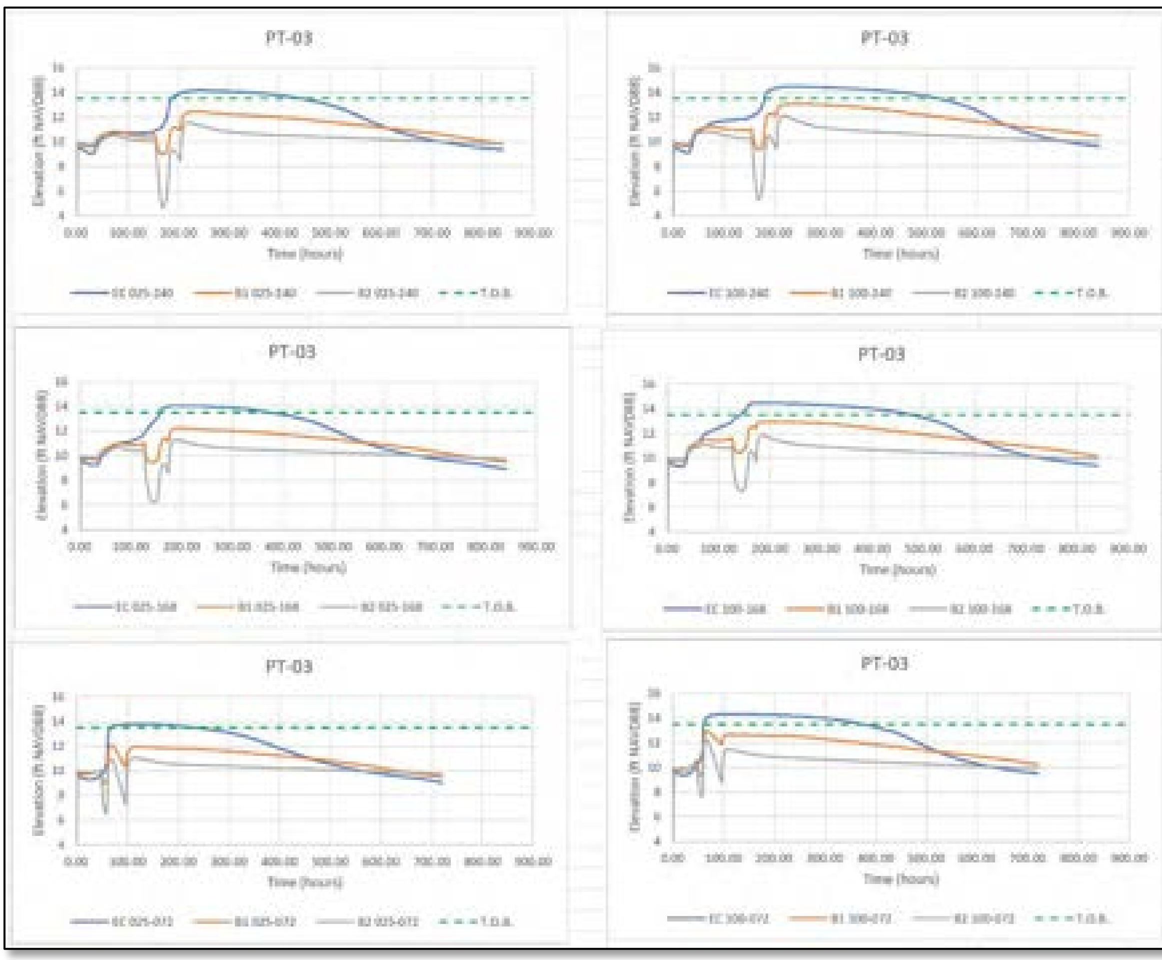


Figure 139 Comparison of Stage Hydrographs at PT-03 for Existing Conditions (EC), and Berm Alignments B1 and B2

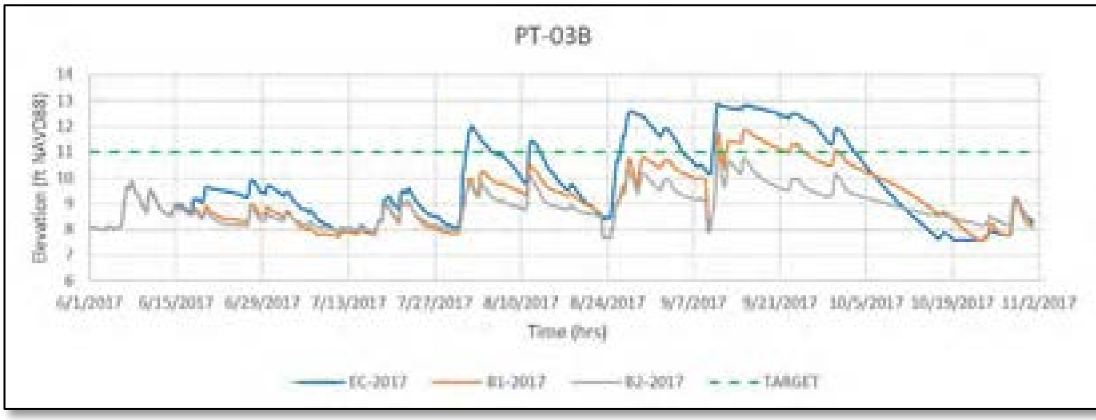
6.2.3 Bonita Beach Road South Canal: PT-03B

A summary of maximum water surface elevations for existing conditions (EC) and berm alignments B1 and B2 are included in Table 29. Berm alignment B1 lowers maximum water surface elevations between 0.18 feet (100yr-72hr) and 1.22 feet (25yr-168hr) at reference point PT-03B. Berm alignment B2 lowers the maximum stages between 0.39 feet (100yr-72hr) and 1.92 feet (25yr-168hr). Stage hydrographs are provided in Figure 140. The South Canal serves as the primary outlet for most of the developments south of Bonita Beach Road and water levels in that canal affect the hydraulics of all connection points. An arbitrary target elevation of 11 feet NAVD in that canal is shown in Figure 140. The duration above that elevation is significantly reduced for all simulations and implies that tailwater conditions are also reduced. Therefore, the hydraulic efficiency of all hydraulic connections to the canal should also be significantly increased.

Maximum Water Surface Elevations at PT-03B

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	12.93	11.88	11.17	-1.05	-1.76
025-072	13.05	12.53	12.19	-0.52	-0.86
025-168	12.83	11.61	10.91	-1.22	-1.92
025-240	12.84	11.87	11.27	-0.97	-1.57
100-072	13.56	13.38	13.17	-0.18	-0.39
100-168	13.36	12.64	11.95	-0.72	-1.41
100-240	13.22	12.48	11.92	-0.74	-1.30

Table 29 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-03B for Existing Conditions (EC), and Berm Alignments B1 and B2



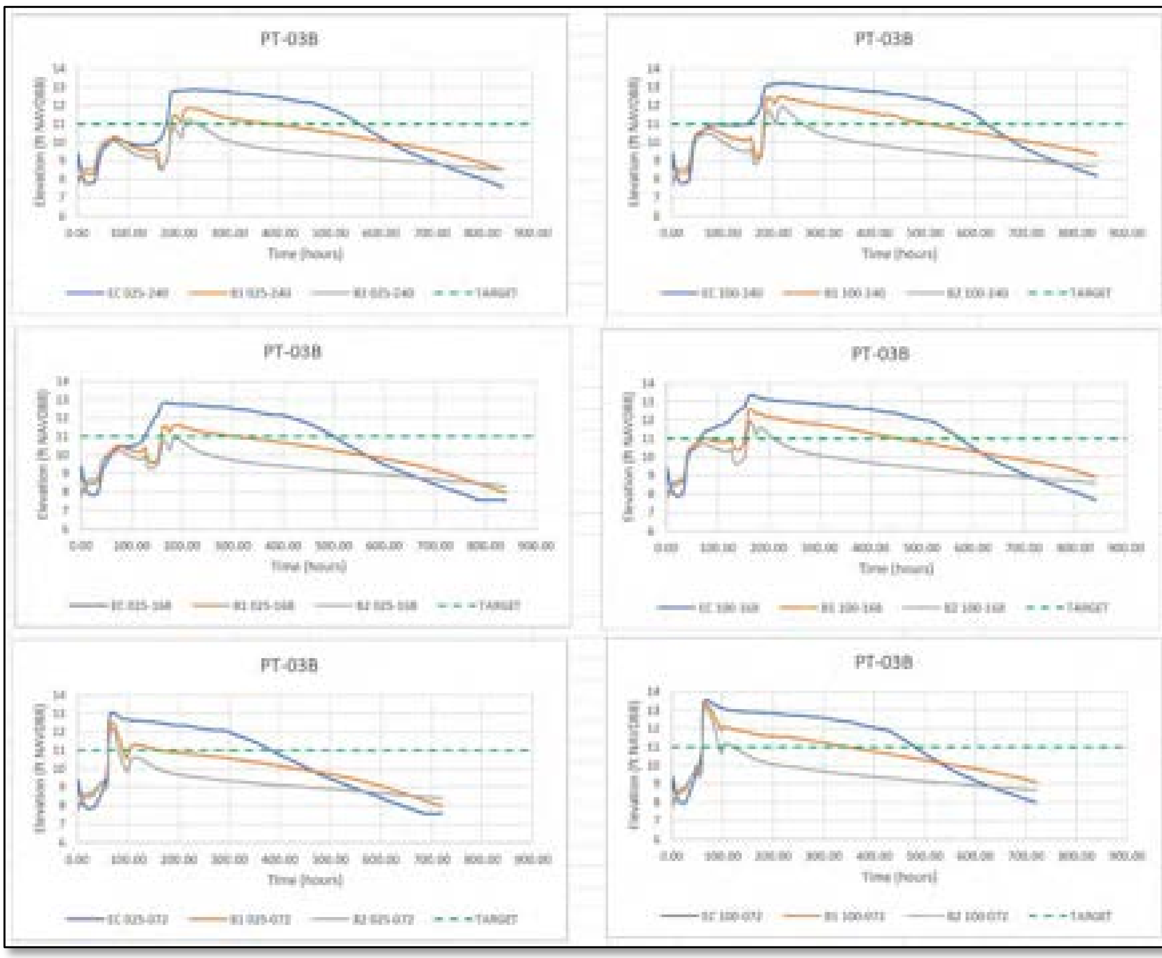


Figure 140 Comparison of Stage Hydrographs at PT-03B for Existing Conditions (EC), and Berm Alignments B1 and B2

6.2.4 Citrus Park Neighborhood: PT-04

Although some reductions in maximum water surface elevations occur for all simulations in the Citrus Park neighborhood as indicated in Table 30, flooding problems are not totally alleviated. However, the duration of flooding is significantly reduced as shown in Figure 141. A more detailed analysis of this neighborhood is warranted to determine if localized improvements could reduce or eliminate the flooding problems.

Maximum Water Surface Elevations at PT-04					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	14.46	14.35	14.36	-0.11	-0.10
025-072	14.41	14.39	14.39	-0.02	-0.02
025-168	14.30	14.16	14.17	-0.14	-0.13
025-240	14.29	14.19	14.2	-0.10	-0.09
100-072	14.71	14.62	14.62	-0.09	-0.09
100-168	14.62	14.3	14.3	-0.32	-0.32
100-240	14.67	14.33	14.33	-0.34	-0.34

Table 30 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-04 for Existing Conditions (EC), and Berm Alignments B1 and B2

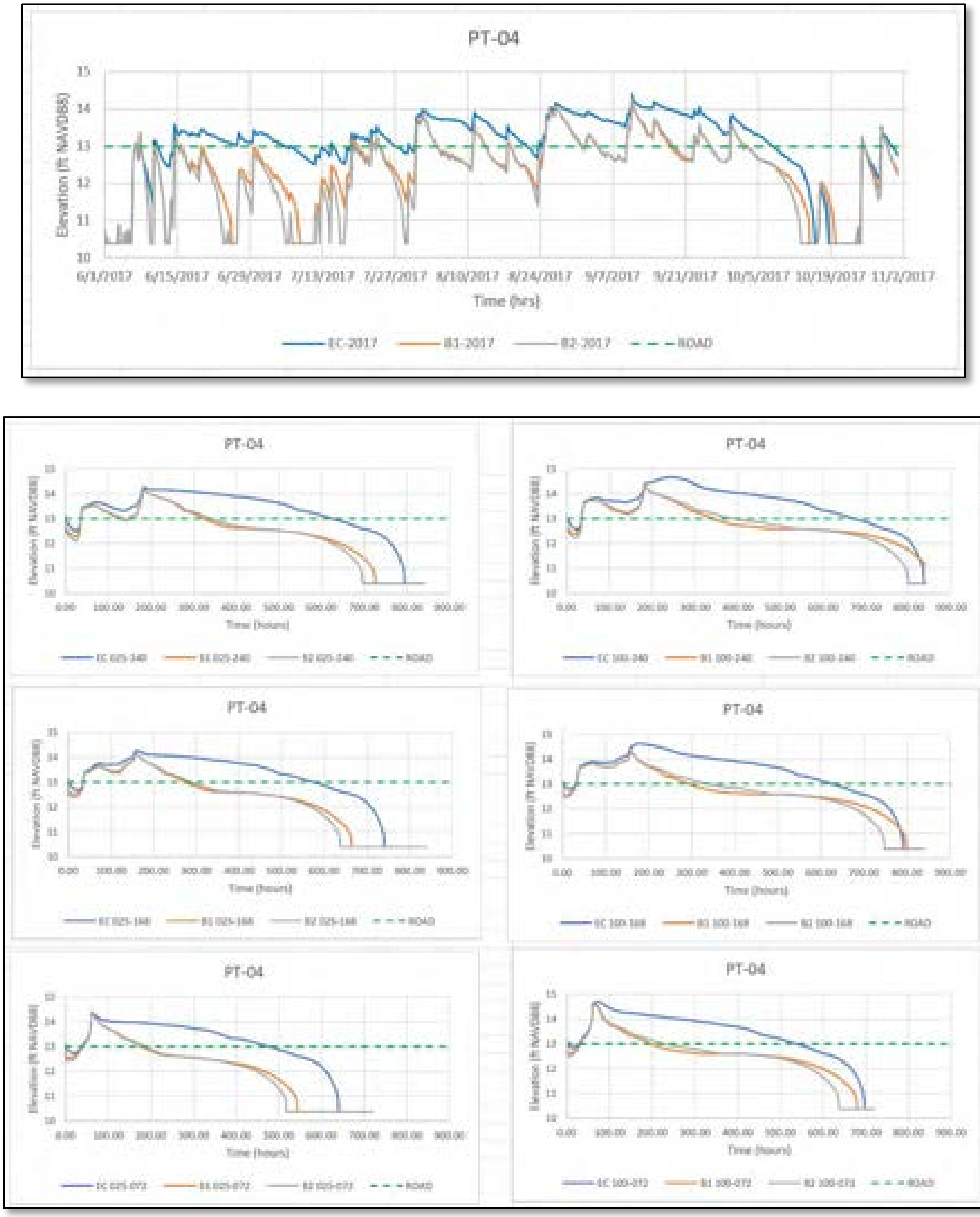


Figure 141 Comparison of Stage Hydrographs at PT-04 for Existing Conditions (EC), and Berm Alignments B1 and B2

6.2.5 Halfway Creek at Three Oaks Parkway: PT-05

As previously mentioned in this document, incorporating conceptual improvements into the SLC ICPR4 model west of I-75 was beyond the scope of this project. However, some improvements were needed to reasonably evaluate the performance of the berm and reservoir system. These were described in 6.1.3 Appurtenant Works. Multiple iterations and refinements were not evaluated.

Maximum water surface elevations at PT-05 are included in Table 31. Increased water surface elevations for the B1 alignment range from 0.50 feet (25yr-72hr) to 1.67 feet (100yr-240hr). Alignment B2 also causes increases ranging from 0.70 feet (25yr-72hr) to 1.75 feet (100yr-240hr). B2 increases are higher than the B1 increases for all simulations except the Summer 2017, which is slightly lower. The minimum road elevation in this area is approximately 15.3 feet NAVD. All 100yr maximum water surface elevations for B1 and B2 are either slightly lower or slightly higher than the approximate minimum road elevation. All other simulations are below the road elevation. Stage hydrographs are presented in Figure 142.

Maximum Water Surface Elevations at PT-05

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	13.52	14.86	14.81	1.34	1.29
025-072	13.83	14.33	14.53	0.50	0.70
025-168	13.42	14.56	14.68	1.14	1.26
025-240	13.48	14.75	14.87	1.27	1.39
100-072	14.39	15.21	15.34	0.82	0.95
100-168	13.84	15.39	15.51	1.55	1.67
100-240	13.81	15.48	15.56	1.67	1.75

Table 31 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-05 for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum discharge rates under Three Oaks Parkway are included in Table 32. Decreases occur for the 72-hour storms for the B1 and B2 alignments, but all other simulations result in increased peak flow rates. The rainfall distribution for the 72-hour storms has extremely high rainfall intensities at about hour 60. The high rates of flow at about this time for the 72-hour storms (see Figure 143) are due to local runoff and not related to the berm and reservoir system. Recall that the gates across the berm are closed at this point in the simulations.

Volumes of water passing under Three Oaks Parkway at Halfway Creek are provided in Table 33. Significant increases occur for the B1 and B2 alignments for all simulations. This is expected because water was diverted away from the Island Club at Corkscrew slough and toward Halfway Creek.

Maximum Discharge Rates (cfs) at PT-05					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	162	804	583	642	421
025-072	1,241	1,144	1,084	-97	-157
025-168	162	814	638	652	476
025-240	200	797	637	597	437
100-072	1,653	1,567	1,455	-86	-198
100-168	205	902	639	697	434
100-240	230	883	649	653	419

Table 32 Comparison of Maximum Discharge Rates (cfs) at PT-05 for Existing Conditions (EC), and Berm Alignments B1 and B2

Volumes (acft) at PT-05					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	8,132	49,215	48,379	41,083	40,247
025-072	1,820	12,106	11,896	10,286	10,076
025-168	2,270	15,276	14,881	13,006	12,611
025-240	2,425	16,515	15,736	14,090	13,311
100-072	2,387	17,896	16,396	15,509	14,009
100-168	2,954	21,735	19,678	18,781	16,724
100-240	3,074	22,541	20,252	19,467	17,178

Table 33 Comparison of Volumes (acft) at PT-05 for Existing Conditions (EC), and Berm Alignments B1 and B2

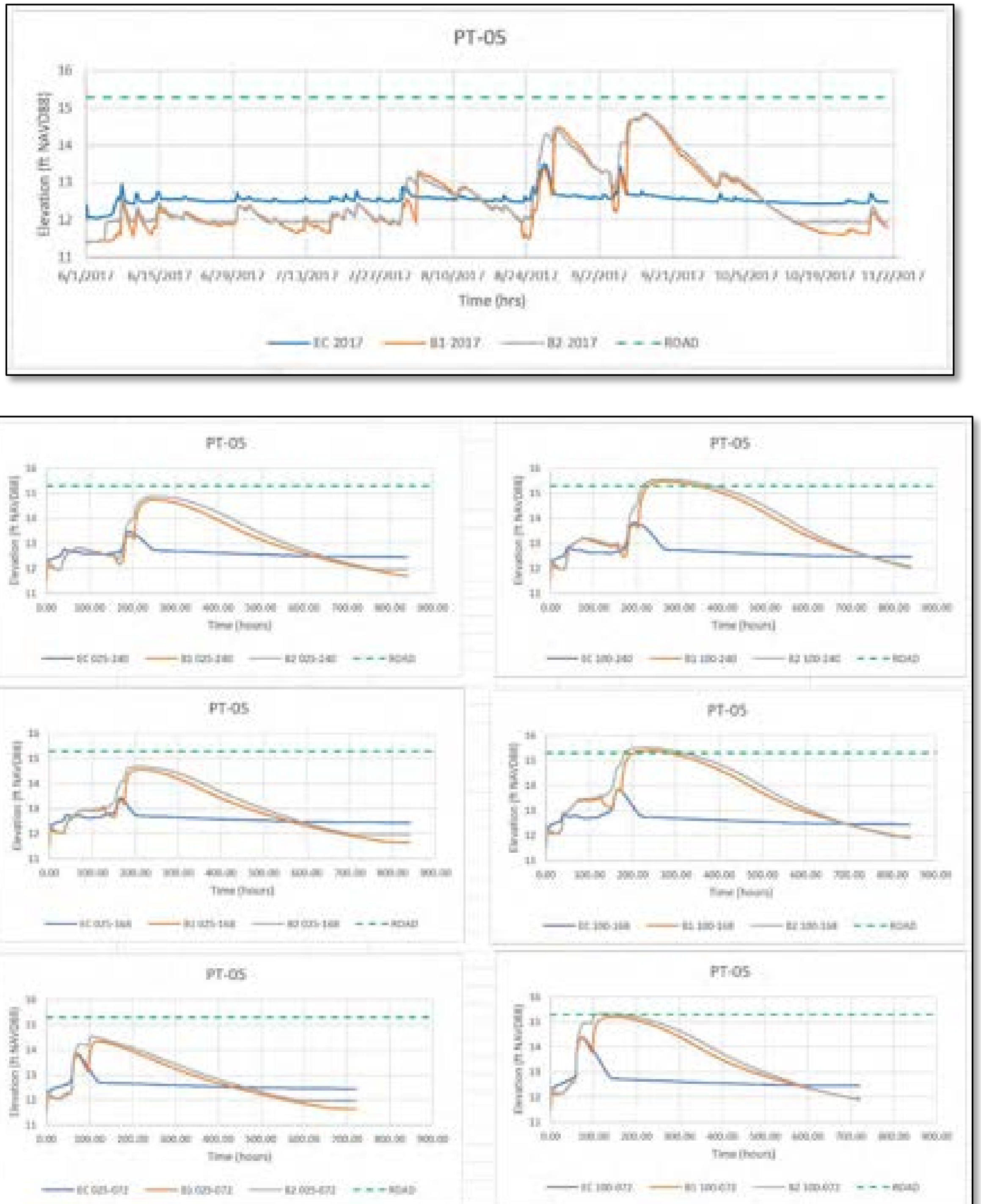
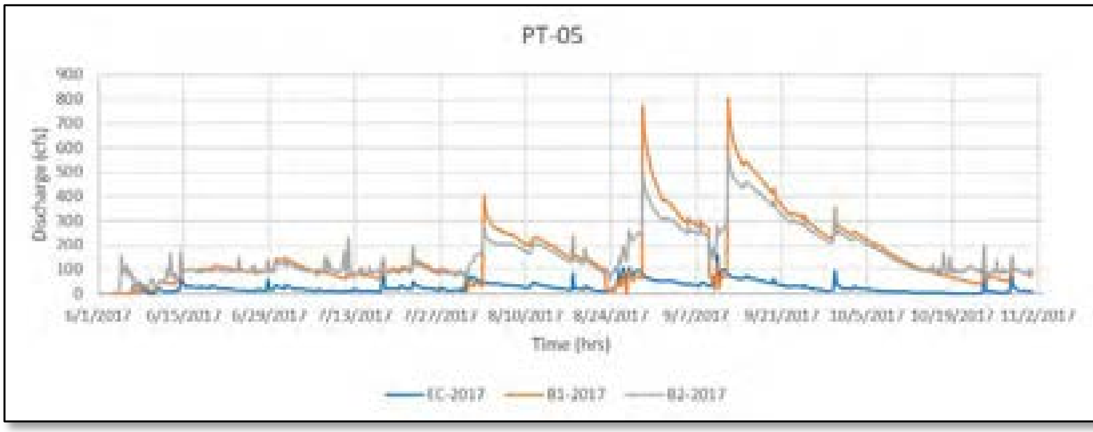


Figure 142 Comparison of Stage Hydrographs at PT-05 for Existing Conditions (EC), and Berm Alignments B1 and B2



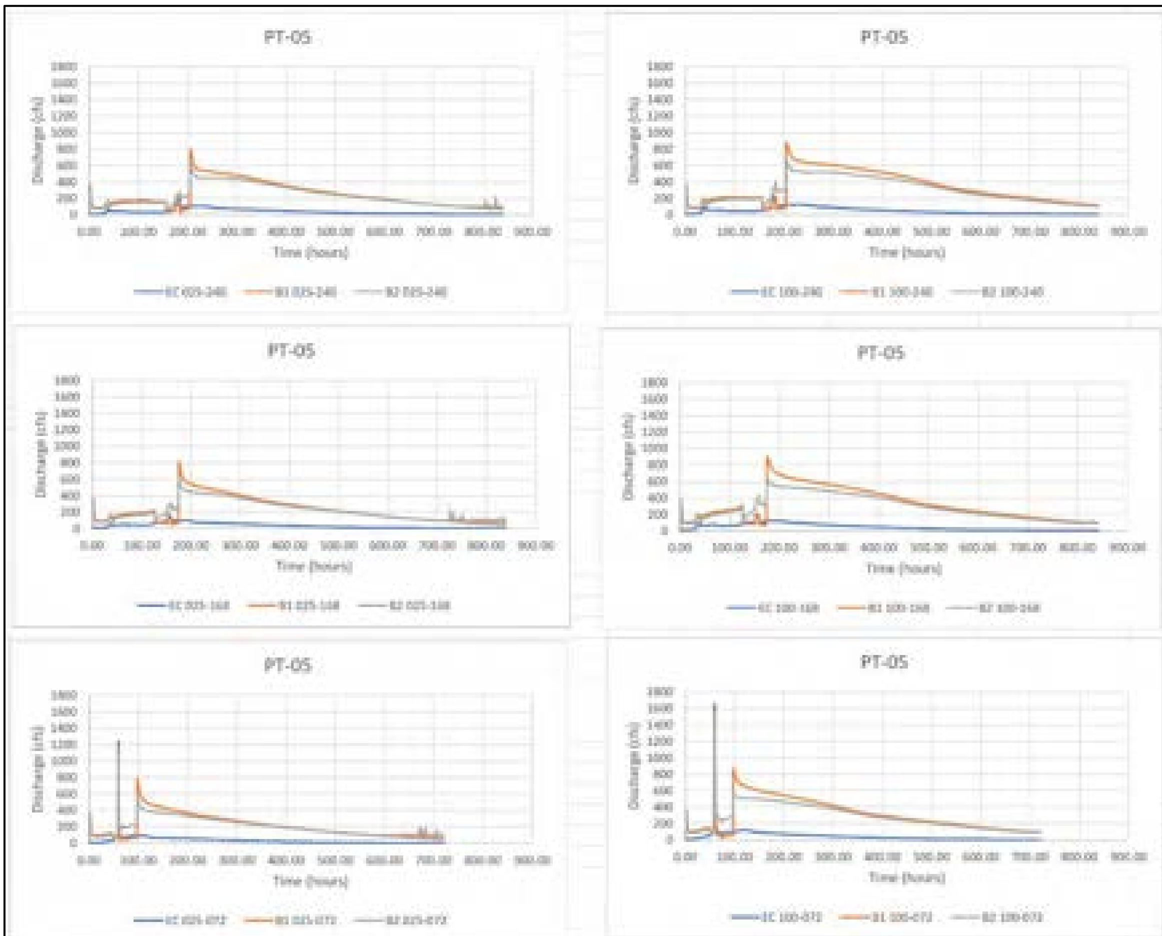


Figure 143 Comparison of Discharge Hydrographs at PT-05 for Existing Conditions (EC), and Berm Alignments B1 and B2

6.2.6 Halfway Creek at Weir Structure East of Via Coconut Point: PT-06

Maximum water surface elevations at PT-06 are included in Table 34. Increased water surface elevations for the B1 alignment range from 0.43 feet (25yr-72hr) to 1.54 feet (100yr-240hr). Alignment B2 also causes increases ranging from 0.60 feet (25yr-72hr) to 1.61 feet (100yr-240hr). The B2 increases are equal or higher than the B1 increases for all simulations except the Summer 2017, which is slightly lower. Maximum water surface elevations are below the minimum road elevation of 15.3 feet NAVD in this area for all simulations except the 100yr-240hr (B1 & B2) and the 100yr-168hr (B2) storms. These are slightly higher than the low road elevation. Stage hydrographs are presented in Figure 144.

Maximum Water Surface Elevations at PT-06					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	13.48	14.73	14.66	1.25	1.18
025-072	13.79	14.22	14.39	0.43	0.60
025-168	13.38	14.44	14.53	1.06	1.15
025-240	13.43	14.62	14.72	1.19	1.29
100-072	14.35	15.06	15.16	0.71	0.81
100-168	13.79	15.23	15.32	1.44	1.53
100-240	13.77	15.31	15.38	1.54	1.61

Table 34 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-06 for Existing Conditions (EC), and Berm Alignments B1 and B2

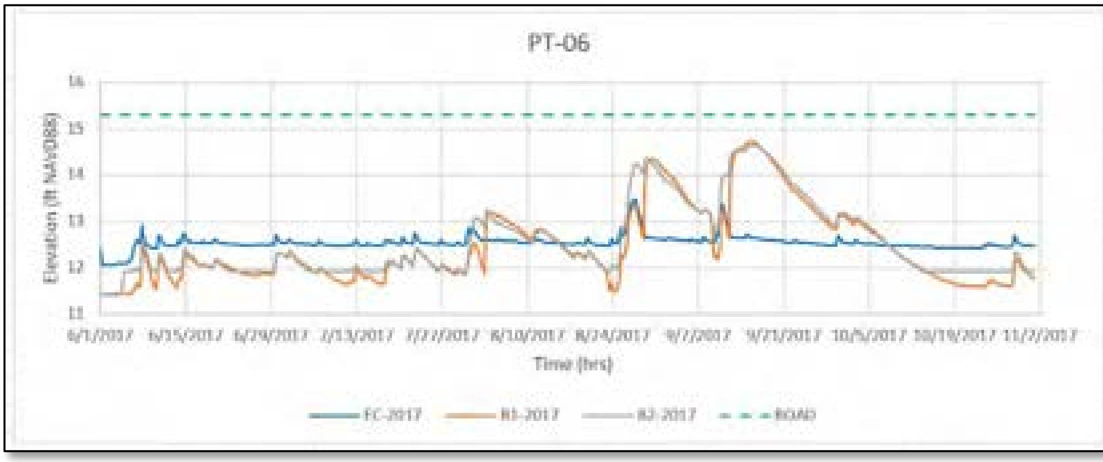
Maximum discharge rates are provided in Table 35. Increases occur for all simulations except the 25-year 72-hour storm (both berm alignments) and the 100-year 72-hour storm (B2 alignment). Volumes increase for all simulations are indicated in Table 36. Discharge hydrographs are shown in Figure 145.

Maximum Discharge Rates (cfs) at PT-06					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	234	611	497	377	263
025-072	555	536	472	-19	-83
025-168	212	528	446	316	234
025-240	311	525	450	214	139
100-072	533	634	505	101	-28
100-168	209	656	527	447	318
100-240	320	631	520	311	200

Table 35 Comparison of Maximum Discharge Rates (cfs) at PT-06 for Existing Conditions (EC), and Berm Alignments B1 and B2

Volumes (acft) at PT-06					
	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	9,899	51,186	50,331	41,287	40,432
025-072	2,123	12,434	12,235	10,310	10,112
025-168	2,674	15,698	15,311	13,024	12,637
025-240	2,861	16,973	16,188	14,112	13,327
100-072	2,832	18,354	16,859	15,523	14,027
100-168	3,510	22,318	20,250	18,808	16,740
100-240	3,656	23,135	20,844	19,479	17,188

Table 36 Comparison of Volumes (acft) at PT-06 for Existing Conditions (EC), and Berm Alignments B1 and B2



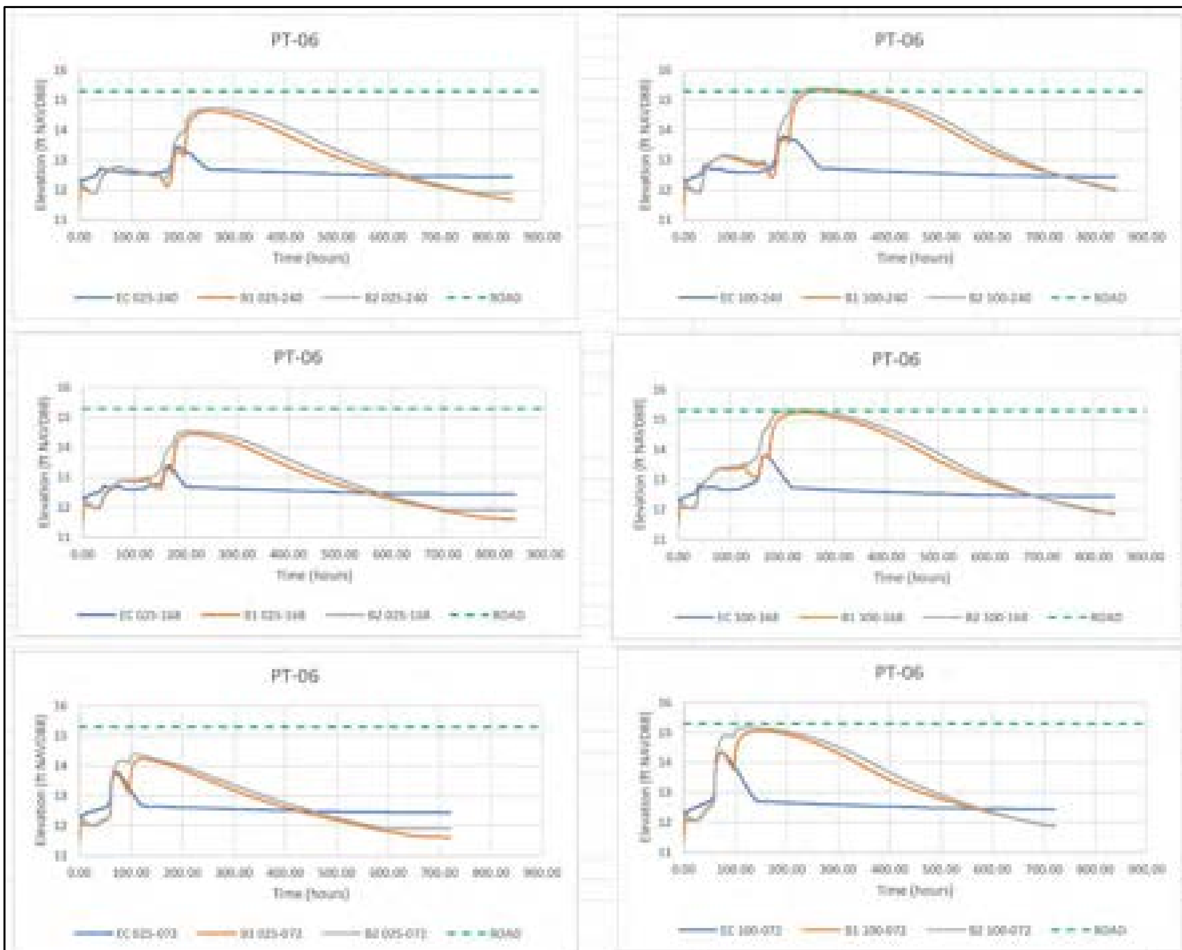


Figure 144 Comparison of Stage Hydrographs at PT-06 for Existing Conditions (EC), and Berm Alignments B1 and B2

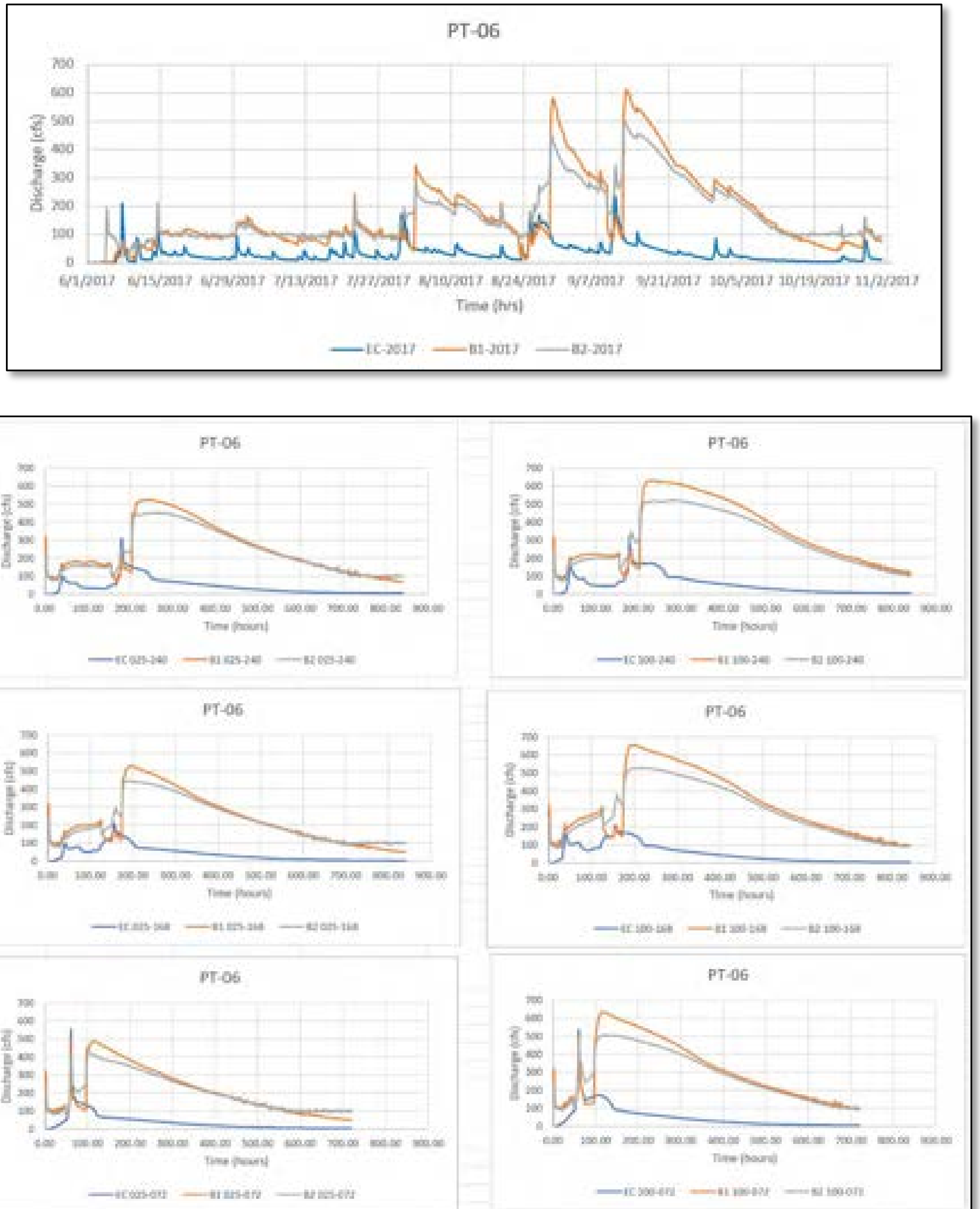


Figure 145 Comparison of Discharge Hydrographs at PT-06 for Existing Conditions (EC), and Berm Alignments B1 and B2

6.2.7 Halfway Creek at Rapallo: PT-06B

The minimum road elevation in the Rapallo neighborhood is approximately elevation 14.0 feet NAVD. As indicated in Table 37, maximum elevations for all simulations of the B1 and B2 berm alignments equal or exceed the road elevation with the single exception of the 25yr-72hr storm for B1. Extensive street flooding was identified by (Waldrop Engineering, 2018) in the Rapallo neighborhood during Hurricane Irma. The simulated maximum flood elevation for Summer 2017 (Irma) is 13.4 feet NAVD, which is below the minimum road elevation. This could be lower because of assumptions made on the gate operation of the Halfway Creek bypass structure at Three Oaks Parkway, or the flooding of Rapallo could be a localized issue. Regardless, the proposed appurtenant works associated with berm alignments B1 and B2 could exacerbate problems and additional or alternate improvements might be needed. Stage hydrographs are shown in Figure 146.

Maximum Water Surface Elevations at PT-06B

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	13.40	14.43	14.41	1.03	1.01
025-072	13.70	13.97	14.16	0.27	0.46
025-168	13.28	14.17	14.28	0.89	1.00
025-240	13.34	14.33	14.47	0.99	1.13
100-072	14.26	14.70	14.84	0.44	0.58
100-168	13.70	14.85	14.98	1.15	1.28
100-240	13.68	14.93	15.05	1.25	1.37

Table 37 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-06B for Existing Conditions (EC), and Berm Alignments B1 and B2

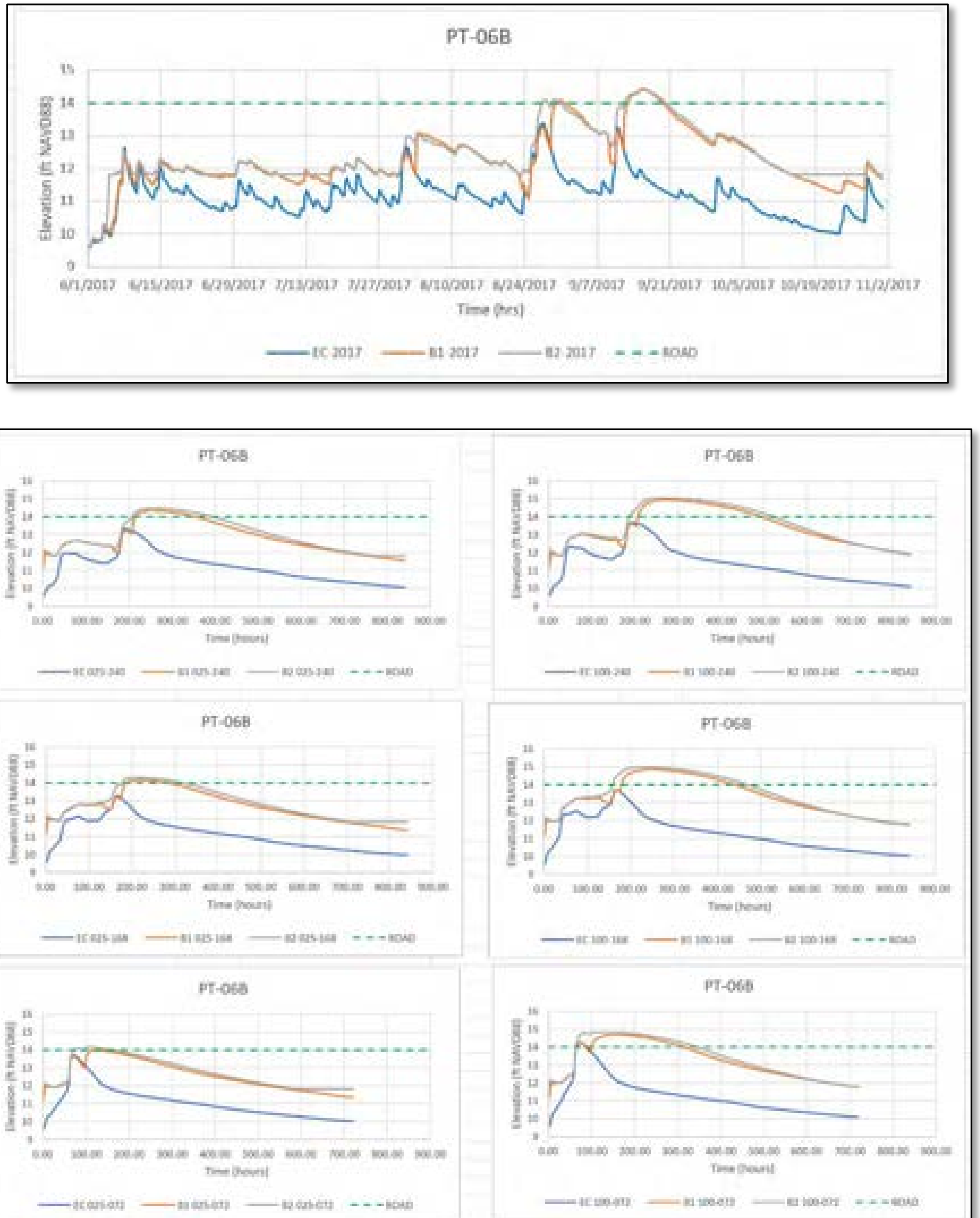


Figure 146 Comparison of Stage Hydrographs at PT-06B for Existing Conditions (EC), and Berm Alignments B1 and B2

6.2.8 Island Club at Corkscrew: PT-07

Extensive street flooding of the Island Club at Corkscrew neighborhood was reported by (Waldrop Engineering, 2018). The approximate minimum roadway elevation in this area is 14.6 feet NAVD. All simulations exceed this elevation as indicated in Table 38. Reductions in the peak stages range from 0.22 feet (25yr-72hr) to 0.44 feet (100yr-168hr) for both B1 and B2. The peak stages are almost identical for all simulations between B1 and B2. This is expected because the Island Club slough has been mostly isolated from the berm and reservoir system. The duration of flooding is greatly reduced for all simulations with the proposed berm alignments and appurtenant works as shown in Figure 147.

Maximum Water Surface Elevations at PT-07					
	EC	**B1**	**B2**	**(B1-EC)**	**(B2-EC)**
Summer 2017	15.26	14.87	14.86	-0.39	-0.40
025-072	15.22	15.00	14.99	-0.22	-0.23
025-168	15.23	14.82	14.82	-0.41	-0.41
025-240	15.18	14.83	14.83	-0.35	-0.35
100-072	15.52	15.23	15.23	-0.29	-0.29
100-168	15.43	14.99	14.99	-0.44	-0.44
100-240	15.37	14.98	14.98	-0.39	-0.39

Table 38 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-07 for Existing Conditions (EC), and Berm Alignments B1 and B2

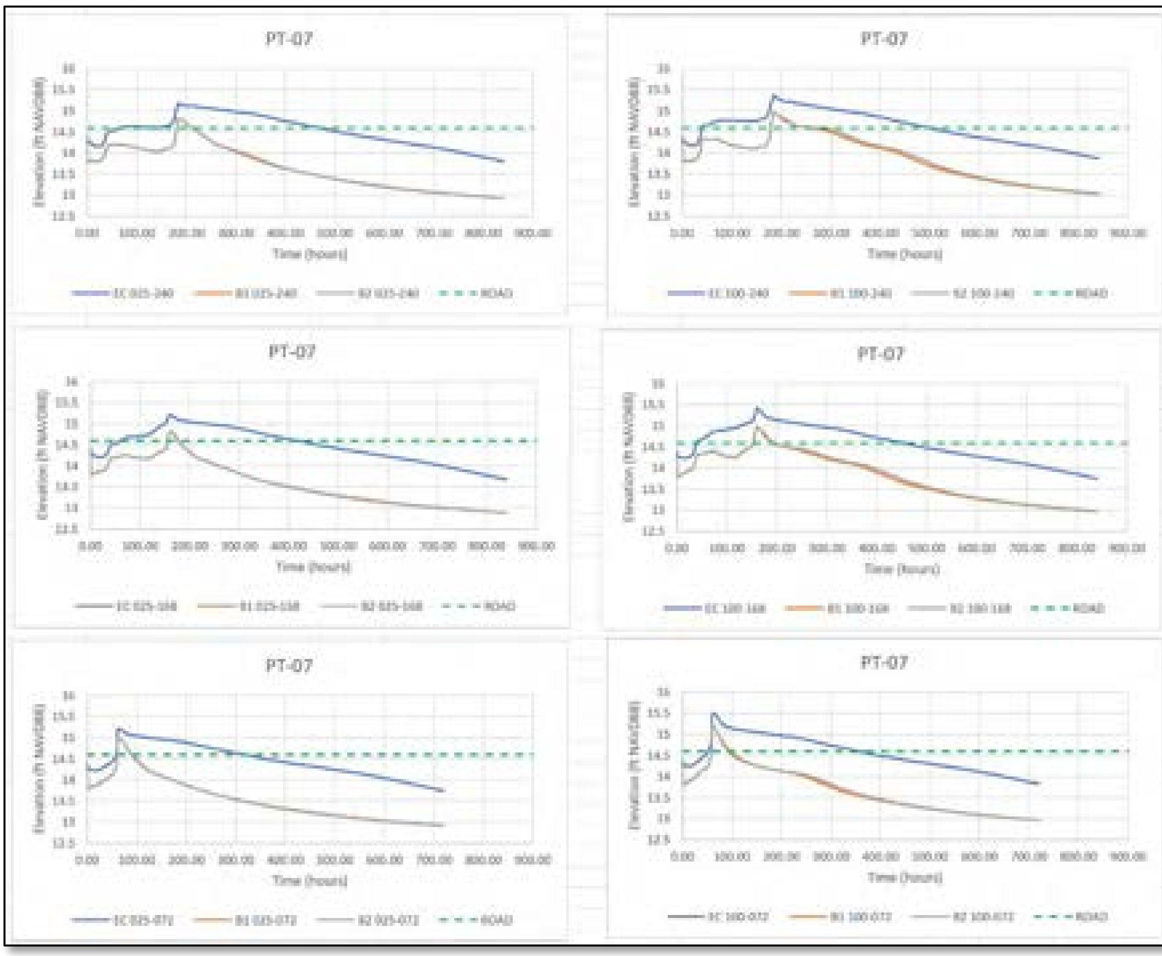


Figure 147 Comparison of Stage Hydrographs at PT-07 for Existing Conditions (EC), and Berm Alignments B1 and B2

6.2.9 Inside the Reservoir: PT-24, PT-32, and PT-33

Reference points PT-24, PT-32 and PT-33 are inside the proposed reservoir east of the berm. PT-32 and PT-33 are in the Larry Kiker Preserve at Lee County groundwater monitoring wells MW-03 and MW-12, respectively. PT-24 is about 5,000 feet north of the mid-point of the Kehl Canal. Maximum water surface elevations are provided in Table 39. Water surfaces are higher for both berm alignments for all simulations. This is expected since that is the purpose and function of the berm and reservoir system.

Stage hydrographs are provided in Figure 148, Figure 149, and Figure 150 for PT-24, PT-32, and PT-33, respectively. The water surfaces for berm alignment B1 are higher than B2 in the Larry Kiker Preserve at PT-32 and about the same at PT-33. Water surfaces are higher for B2 at PT-24.

Maximum water surface profiles for Hurricane Irma, the 25-year 240-hour storm and the 100-year 240-hour storm for flow paths A' – A and D' – D (see Figure 136 for locations of these flow paths), both in the Kiker Preserve, are shown in Figure 151 and Figure 152, respectively. The maximum water surface elevations for berm alignment B1 are higher than B2 for both flow paths.

Maximum Water Surface Elevations at PT-24

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	16.06	17.17	17.56	1.11	1.50
025-072	15.77	16.42	16.99	0.65	1.22
025-168	15.92	16.63	17.17	0.71	1.25
025-240	15.99	16.72	17.24	0.73	1.25
100-072	16.13	17.1	17.53	0.97	1.40
100-168	16.28	17.33	17.73	1.05	1.45
100-240	16.30	17.38	17.78	1.08	1.48

Maximum Water Surface Elevations at PT-32

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	15.57	16.85	16.36	1.28	0.79
025-072	15.54	16.45	16.08	0.91	0.54
025-168	15.59	16.55	16.22	0.96	0.63
025-240	15.58	16.46	16.19	0.88	0.61
100-072	15.86	16.95	16.55	1.09	0.69
100-168	15.89	17.07	16.71	1.18	0.82
100-240	15.84	16.91	16.76	1.07	0.92

Maximum Water Surface Elevations at PT-33

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	16.59	17.24	17.11	0.65	0.52
025-072	16.48	16.88	16.86	0.40	0.38
025-168	16.58	17.01	17.00	0.43	0.42
025-240	16.61	17.06	17.08	0.45	0.47
100-072	16.76	17.39	17.33	0.63	0.57
100-168	16.88	17.53	17.49	0.65	0.61
100-240	16.86	17.53	17.54	0.67	0.68

Table 39 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-24, PT-32 and PT-33 for Existing Conditions (EC), and Berm Alignments B1 and B2

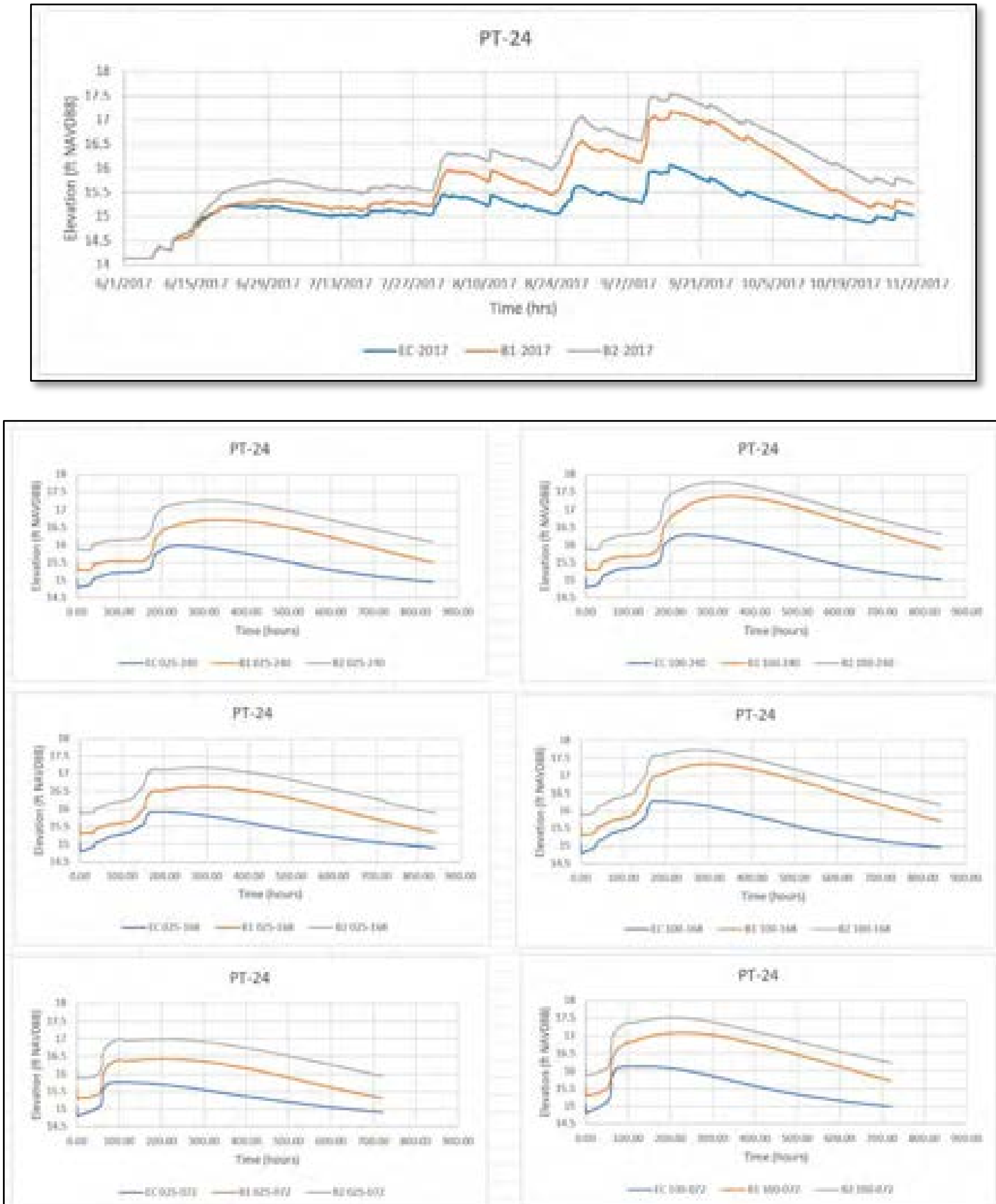


Figure 148 Comparison of Stage Hydrographs at PT-24 for Existing Conditions (EC), and Berm Alignments B1 and B2

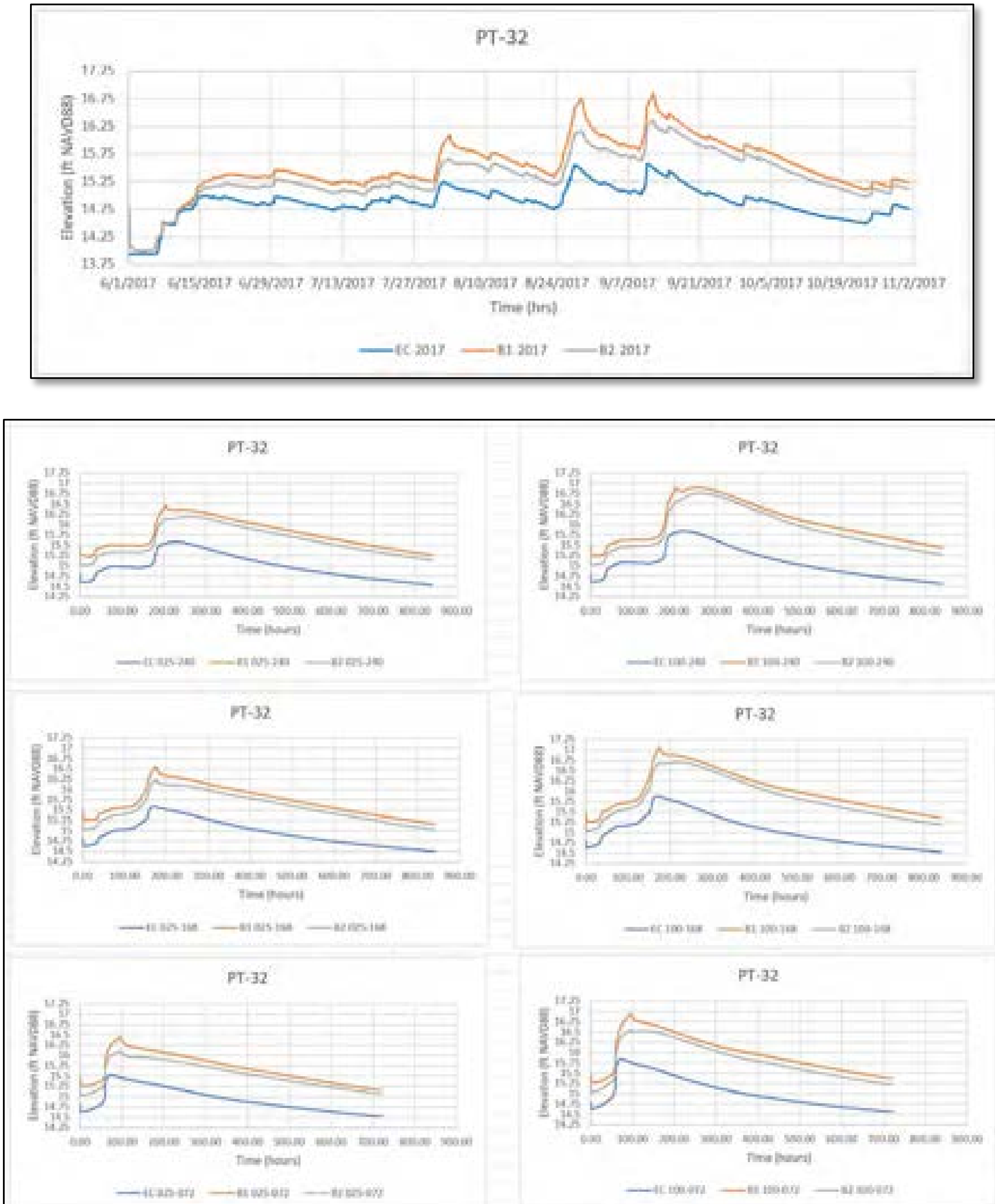
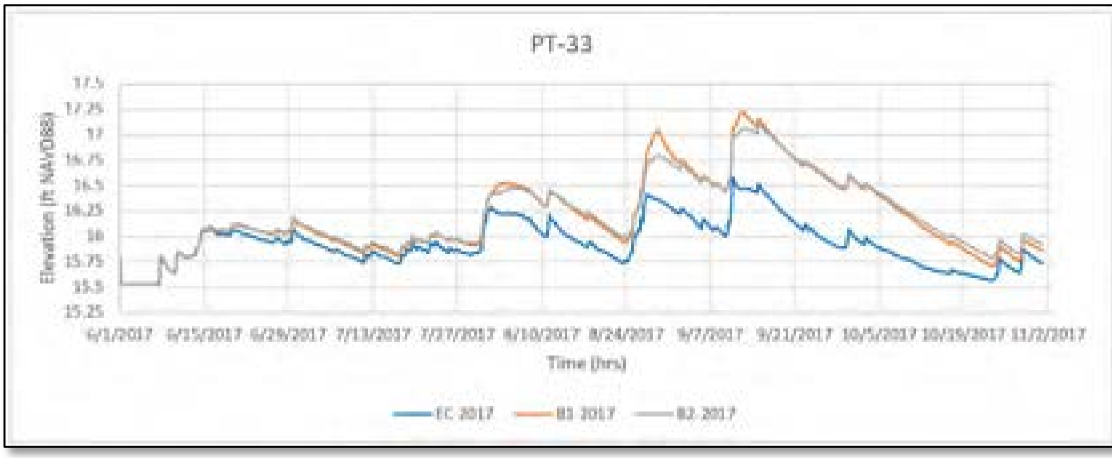


Figure 149 Comparison of Stage Hydrographs at PT-32 for Existing Conditions (EC), and Berm Alignments B1 and B2



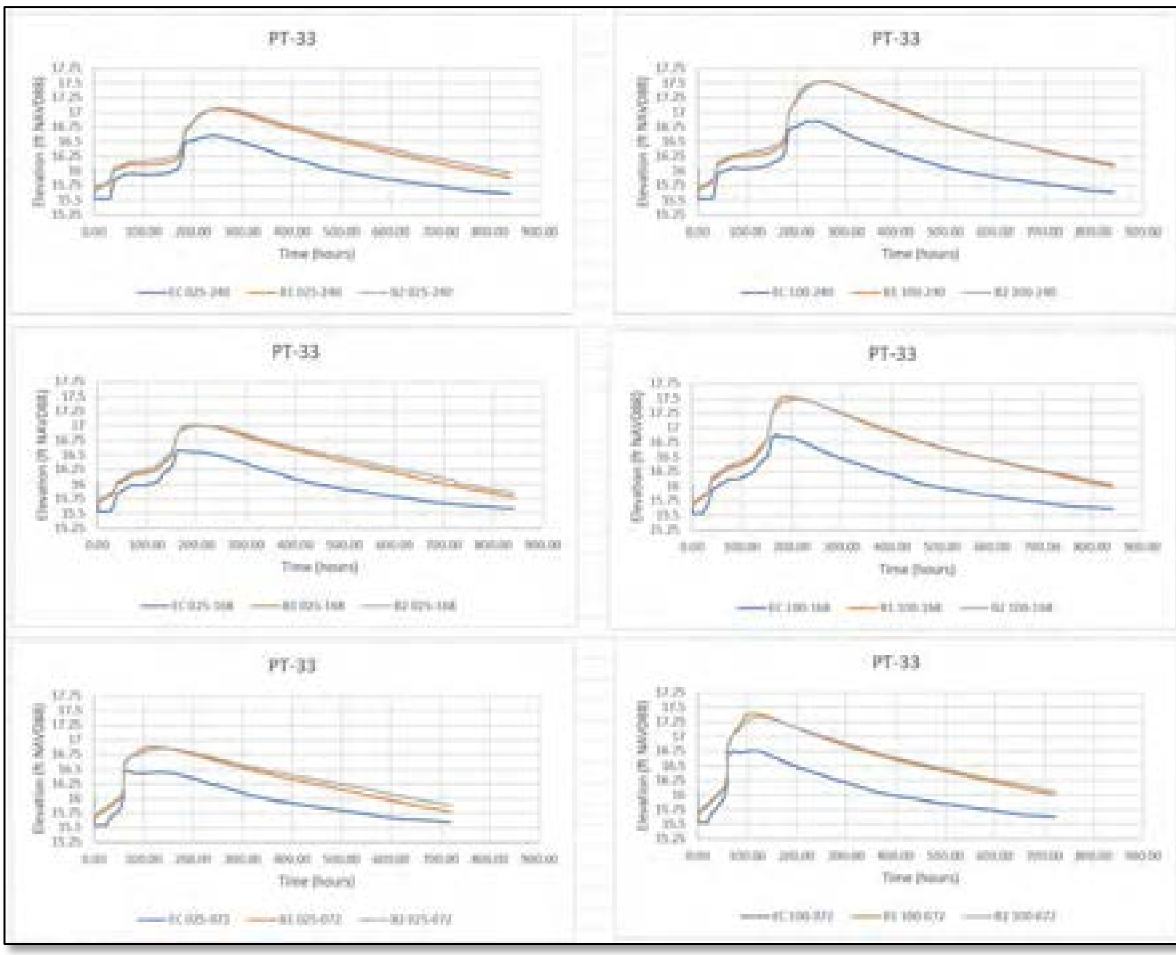
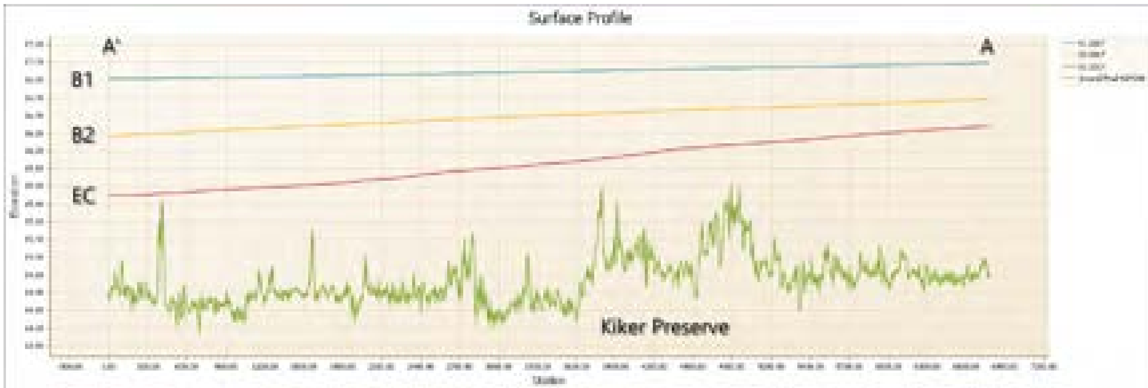


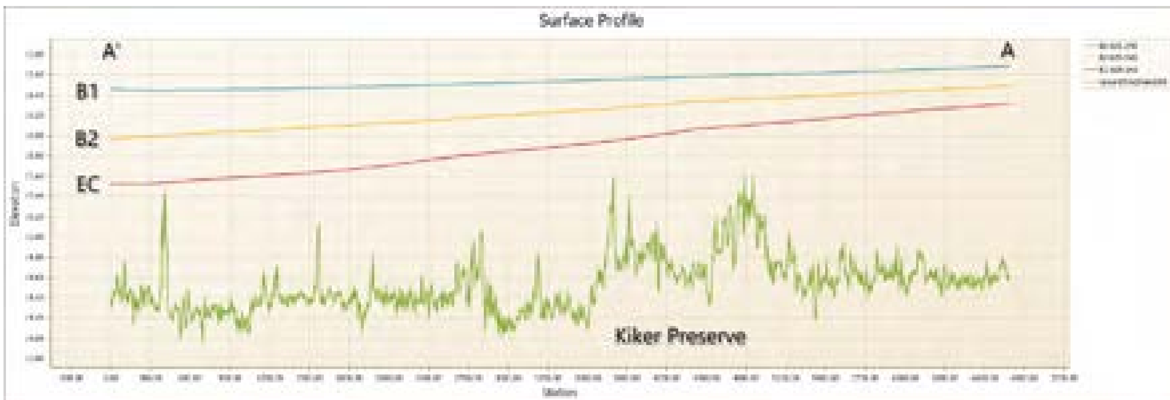
Figure 150 Comparison of Stage Hydrographs at PT-33 for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum Water Surface Profile A' – A

Hurricane Irma



25-Year 240-Hour



100-Year 240-Hour

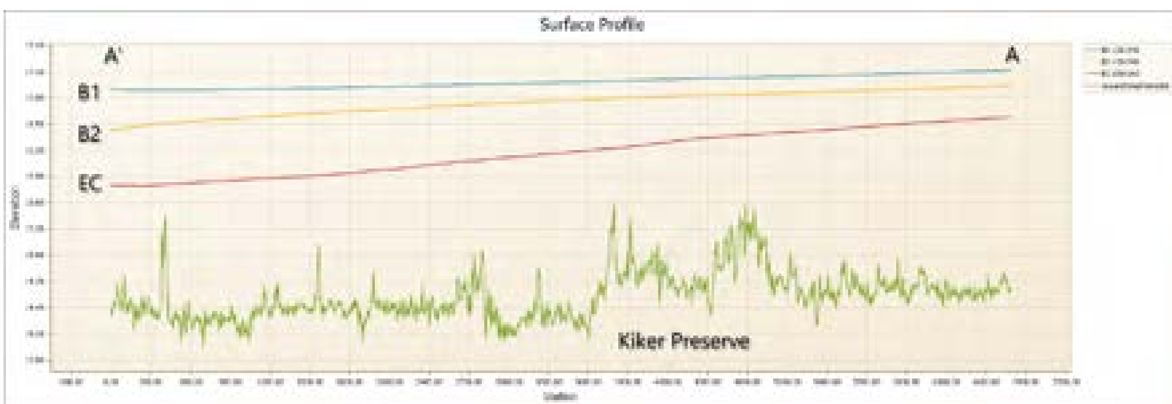
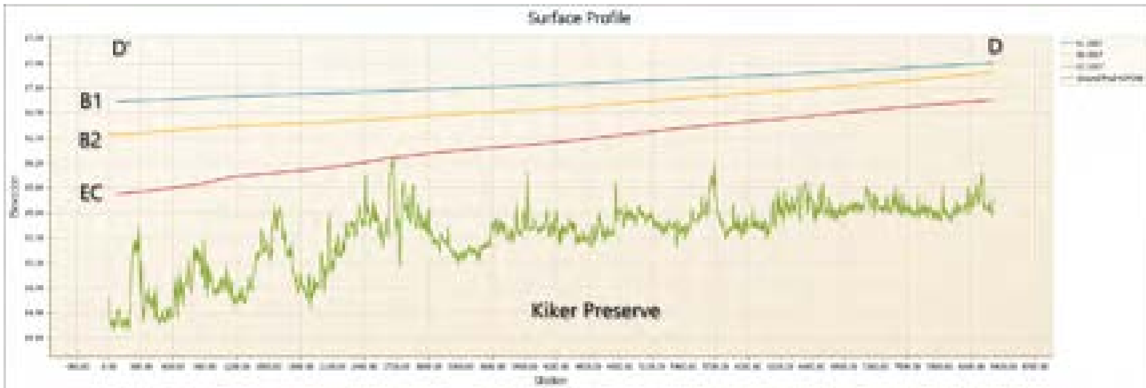
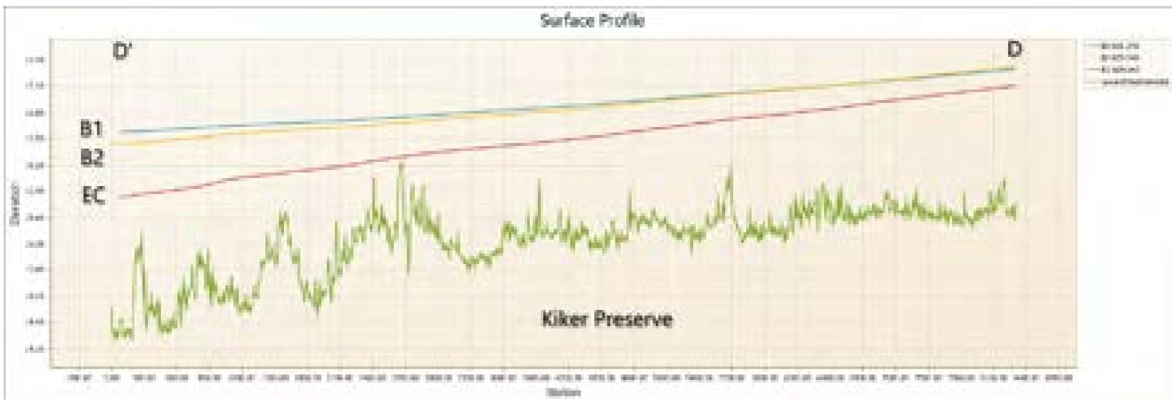


Figure 151 Comparison of Water Surface Profiles Along Flow Path A' – A for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum Water Surface Profile D' – D Hurricane Irma



25-Year 240-Hour



100-Year 240-Hour

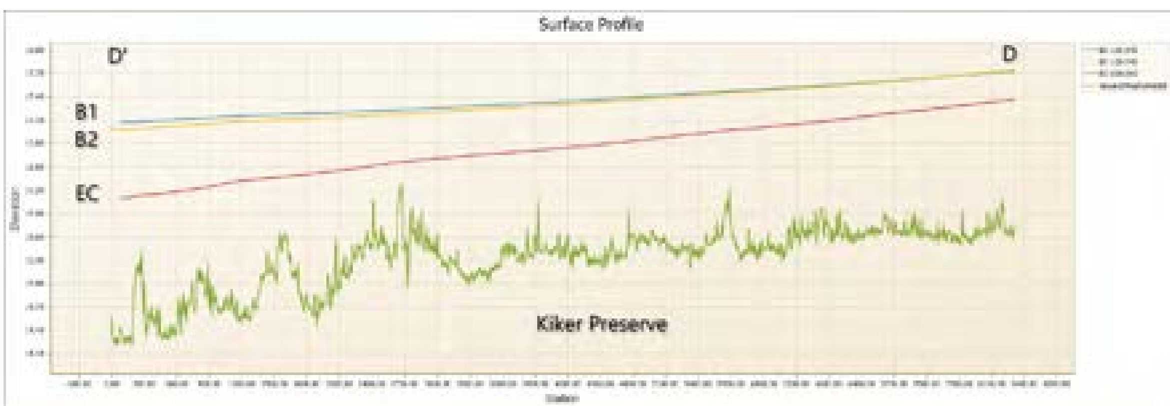


Figure 152 Comparison of Water Surface Profiles Along Flow Path D' – D for Existing Conditions (EC), and Berm Alignments B1 and B2

STREAMLINE TECHNOLOGIES

6.2.10 Lee/Collier Border: PT-09, PT-10, PT-11, and PT-12

Stage hydrographs are provided in Figure 153, Figure 154, Figure 155, and Figure 156 for PT-09, PT-10, PT-11, and PT-12, respectively. Water surface profiles for Hurricane Irma, the 25yr-240hr, and 100yr-240hr simulations for flow paths G' – G, I' – I, K' – K, and L' – L can be found on Figure 157, Figure 158, Figure 159, and Figure 160, respectively.

As indicated in the various stage hydrographs, water surface profiles, and maximum water surface elevations, increases occur above existing conditions for both berm alignments and for all simulations. A maximum overall increase of 0.49 feet occurs at PT-09 for the 100yr-168hr simulation (B2 alignment).

The various water surface profiles indicate that the magnitude of increased water levels into Collier County diminish with distance away from the proposed reservoir/berm project.

Maximum Water Surface Elevations at PT-09

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	17.25	17.51	17.73	0.26	0.48
025-072	17.14	17.33	17.32	0.19	0.18
025-168	17.14	17.39	17.46	0.25	0.32
025-240	17.10	17.41	17.52	0.31	0.42
100-072	17.41	17.60	17.76	0.19	0.35
100-168	17.41	17.70	17.90	0.29	0.49
100-240	17.40	17.73	17.93	0.33	0.53

Maximum Water Surface Elevations at PT-10

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	18.06	18.38	18.45	0.32	0.39
025-072	17.87	18.09	18.04	0.22	0.17
025-168	17.92	18.21	18.17	0.29	0.25
025-240	17.93	18.26	18.23	0.33	0.30
100-072	18.16	18.48	18.48	0.32	0.32
100-168	18.23	18.59	18.63	0.36	0.40
100-240	18.25	18.62	18.66	0.37	0.41

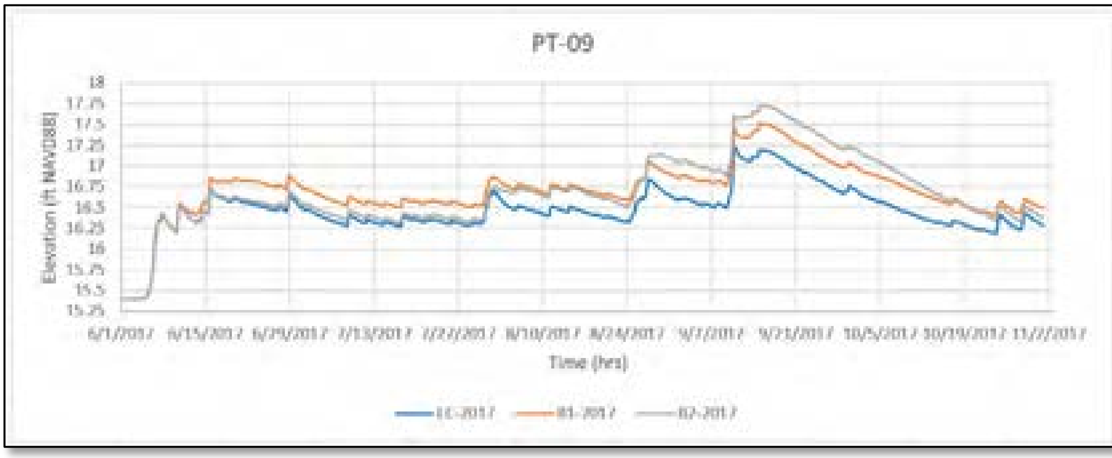
Maximum Water Surface Elevations at PT-11

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	18.49	18.71	18.75	0.22	0.26
025-072	18.27	18.42	18.36	0.15	0.09
025-168	18.33	18.55	18.49	0.22	0.16
025-240	18.35	18.59	18.55	0.24	0.20
100-072	18.59	18.82	18.81	0.23	0.22
100-168	18.68	18.93	18.94	0.25	0.26
100-240	18.7	18.96	18.98	0.26	0.28

Maximum Water Surface Elevations at PT-12

	EC	B1	B2	(B1-EC)	(B2-EC)
Summer 2017	18.86	18.95	18.98	0.09	0.12
025-072	18.58	18.66	18.64	0.08	0.06
025-168	18.66	18.79	18.76	0.13	0.10
025-240	18.7	18.84	18.82	0.14	0.12
100-072	18.94	19.09	19.08	0.15	0.14
100-168	19.05	19.20	19.19	0.15	0.14
100-240	19.07	19.23	19.23	0.16	0.16

Table 40 Comparison of Maximum Water Surface Elevations (ft NAVD) at PT-09, PT-10, PT-11, and PT-12 for Existing Conditions (EC), and Berm Alignments B1 and B2



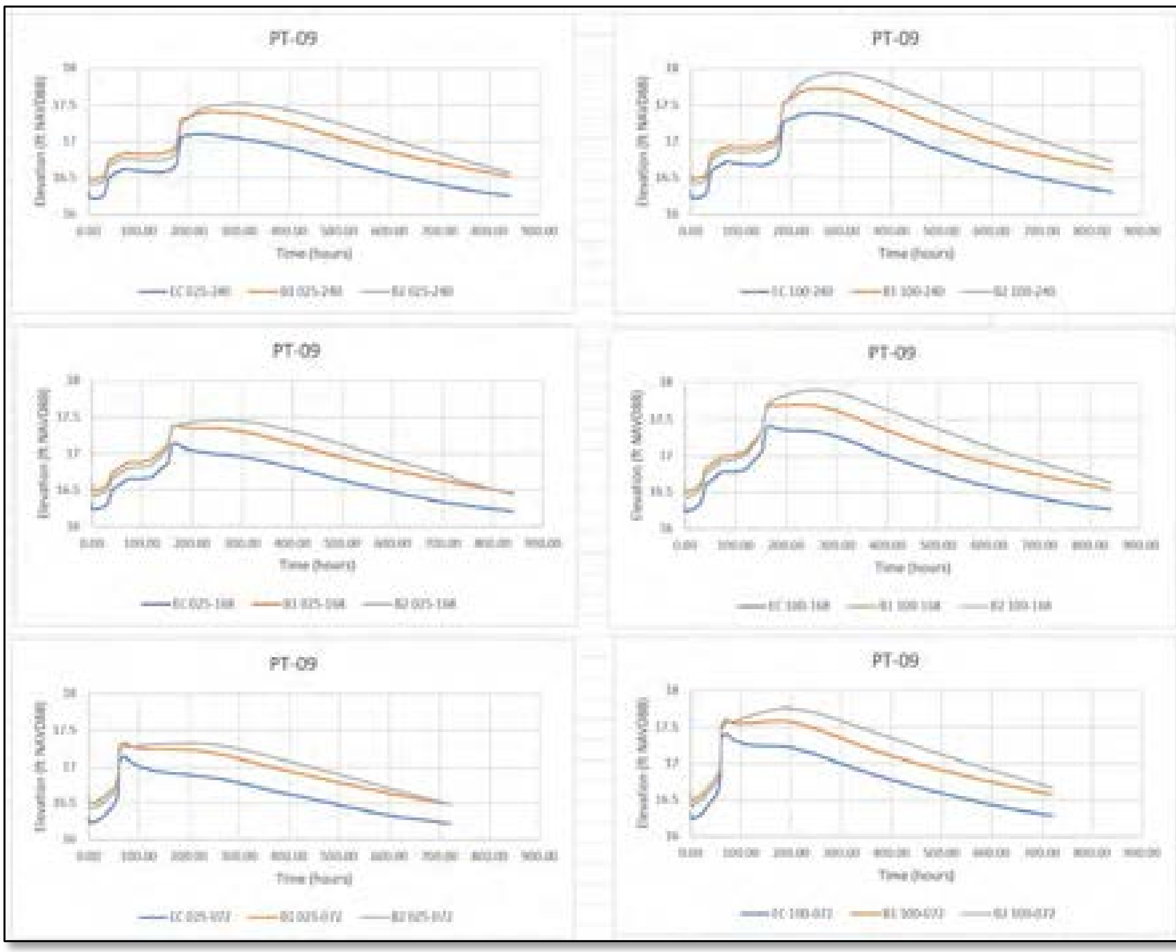


Figure 153 Comparison of Stage Hydrographs at PT-09 for Existing Conditions (EC), and Berm Alignments B1 and B2

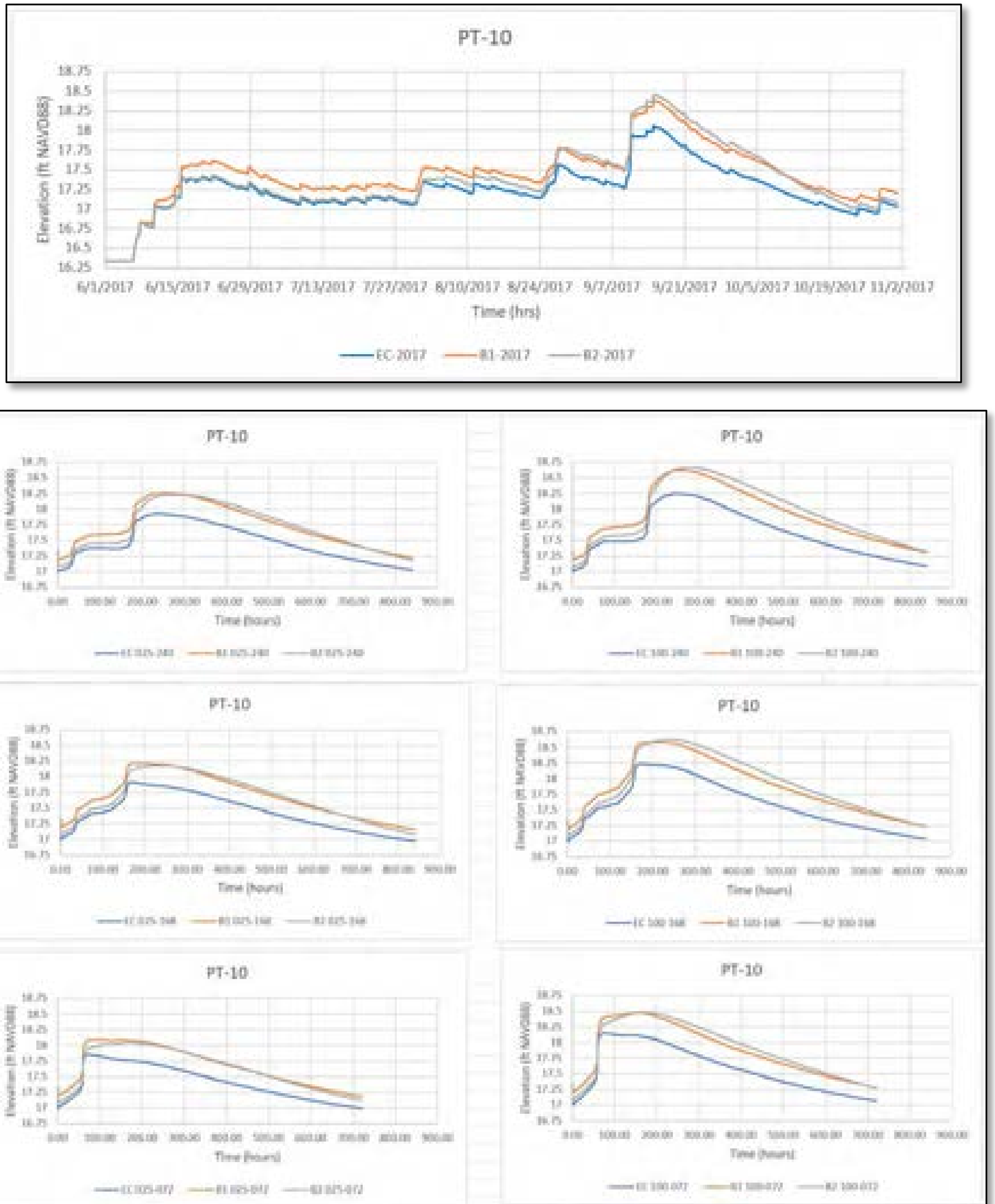


Figure 154 Comparison of Stage Hydrographs at PT-10 for Existing Conditions (EC), and Berm Alignments B1 and B2

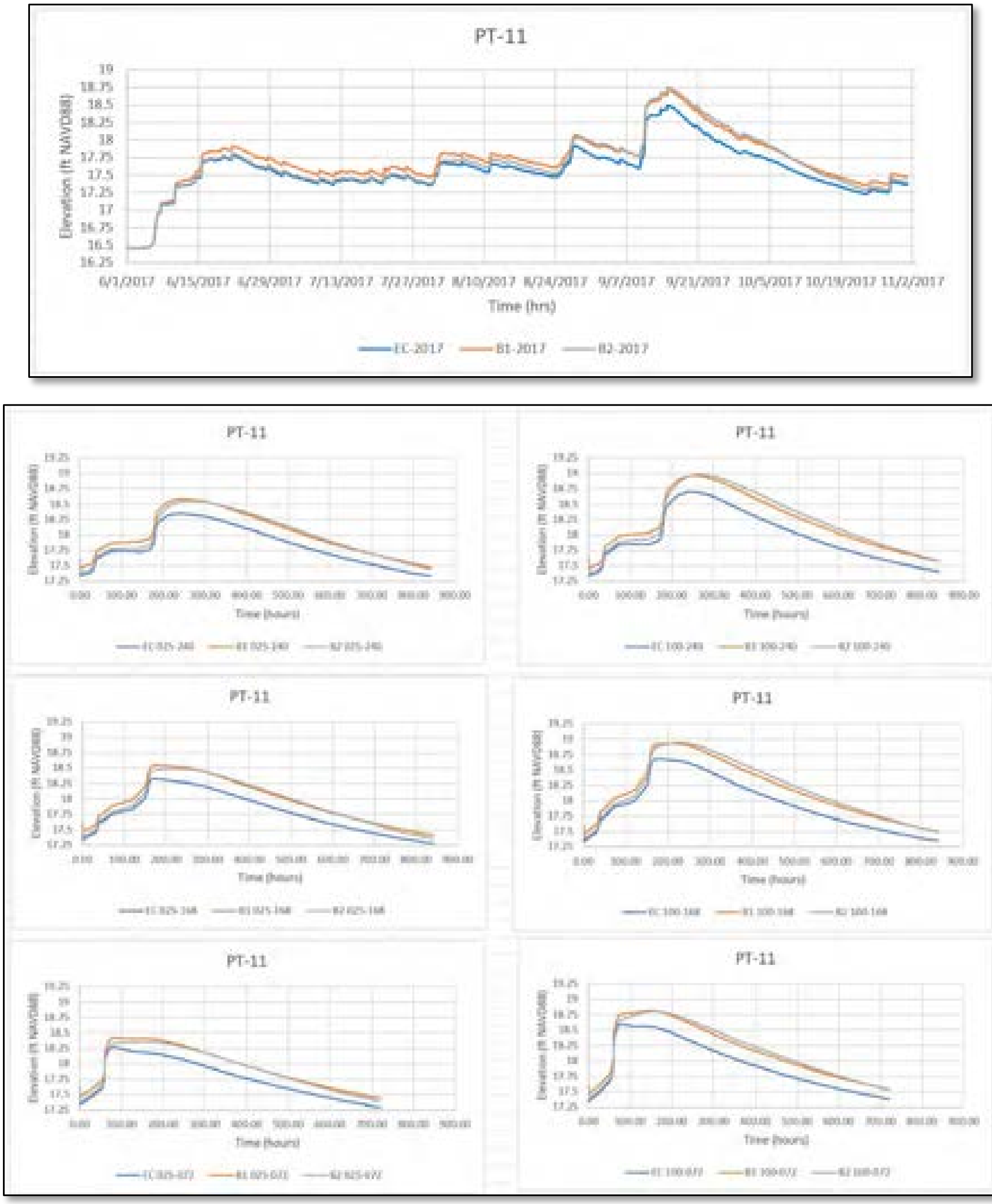
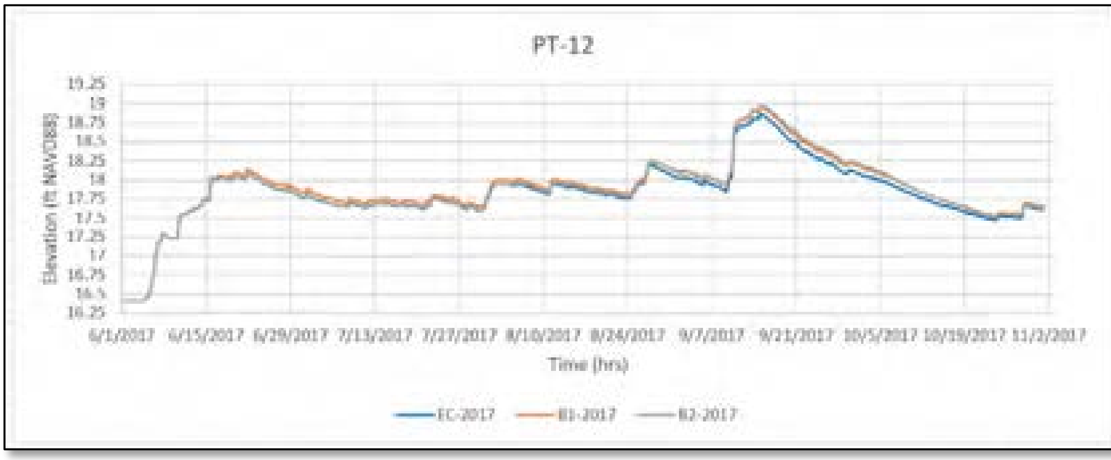


Figure 155 Comparison of Stage Hydrographs at PT-11 for Existing Conditions (EC), and Berm Alignments B1 and B2



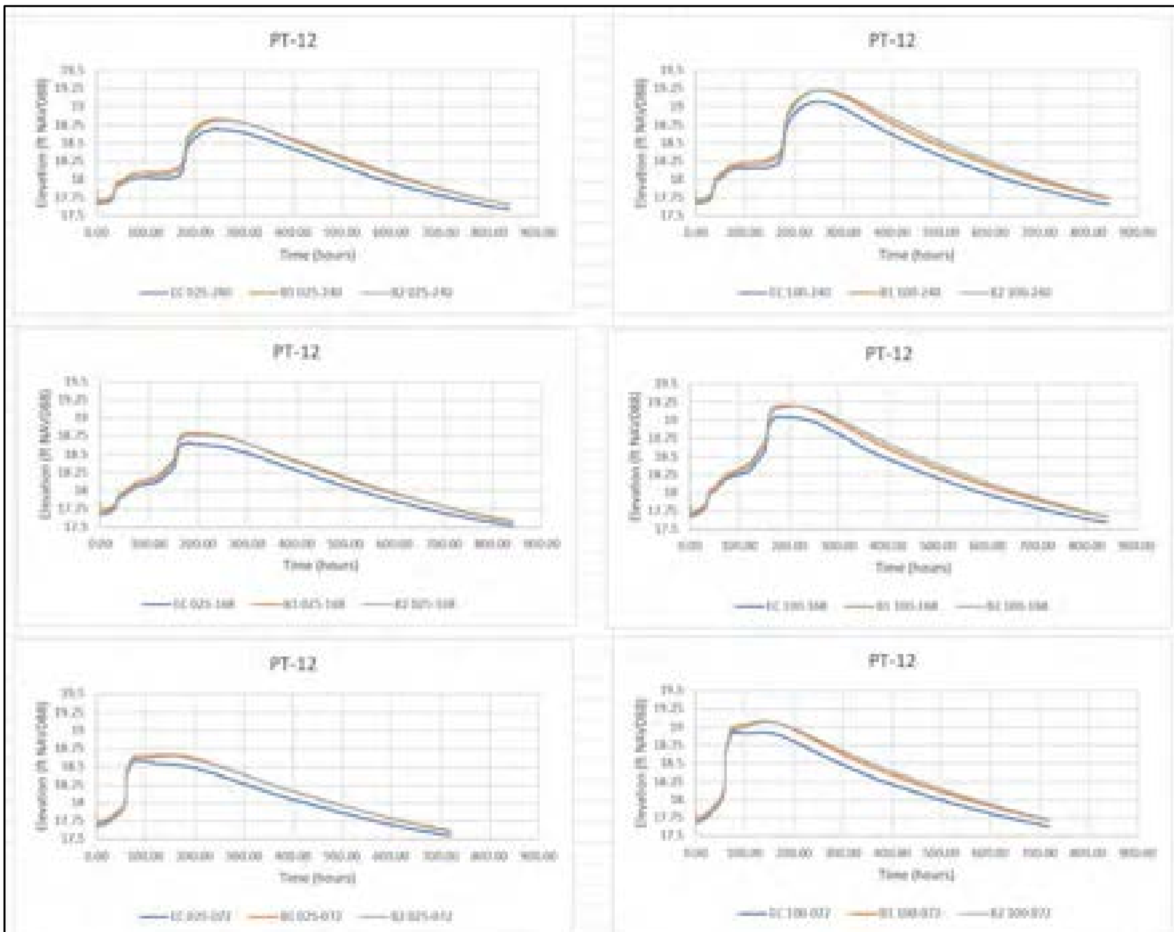
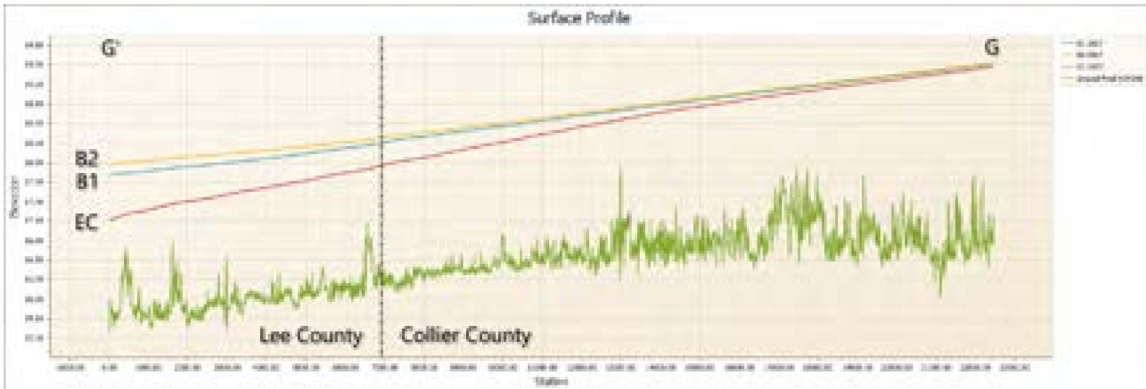
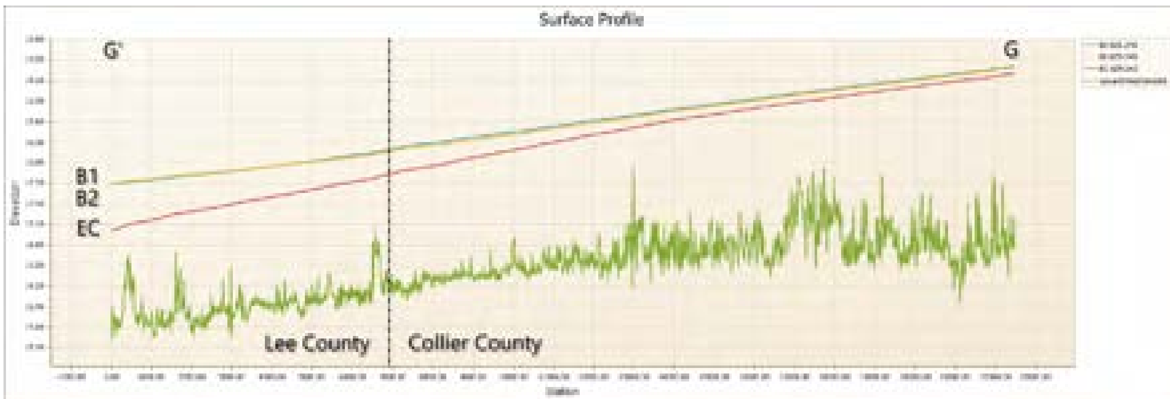


Figure 156 Comparison of Stage Hydrographs at PT-12 for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum Water Surface Profile G' – G Hurricane Irma



25-Year 240-Hour



100-Year 240-Hour

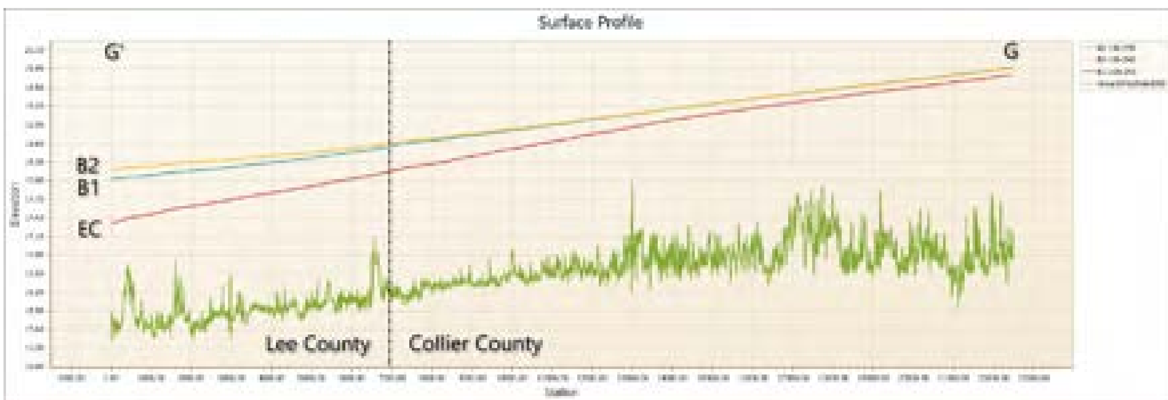


Figure 157 Comparison of Water Surface Profiles Along Flow Path G' – G for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum Water Surface Profile I’ – I Hurricane Irma

25-Year 240-Hour

100-Year 240-Hour

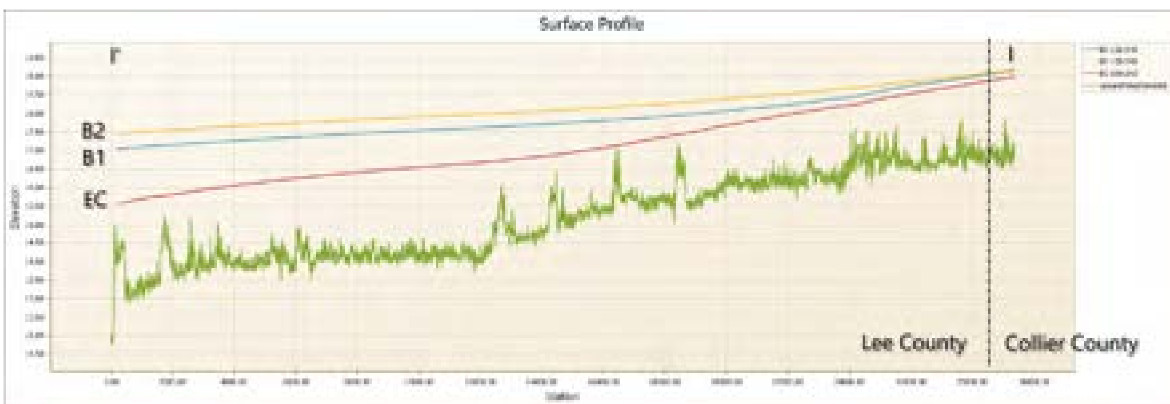
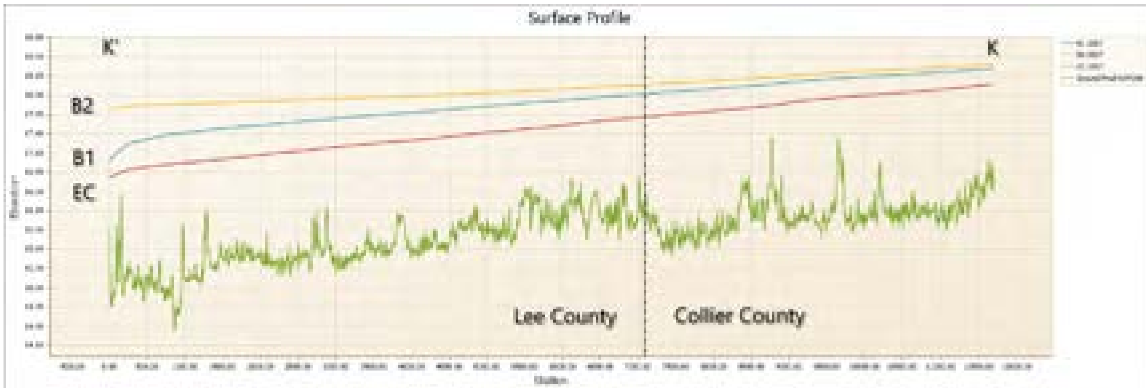
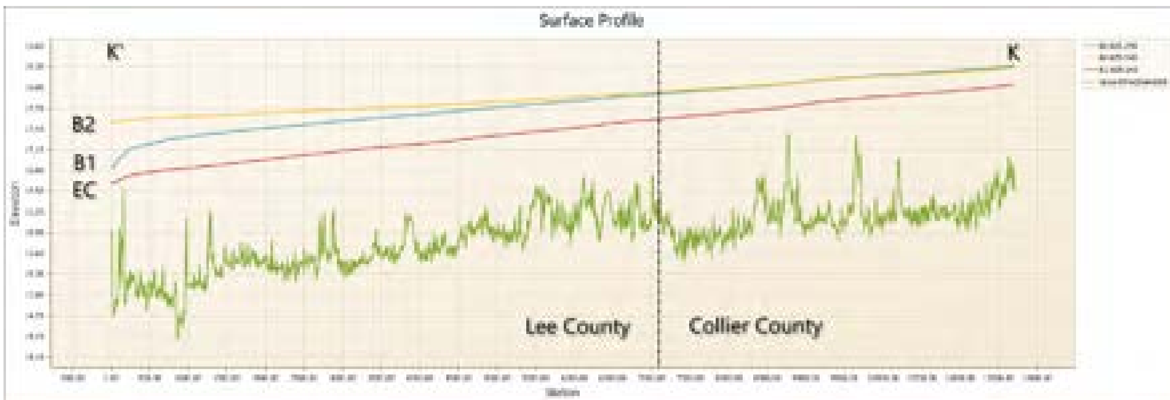


Figure 158 Comparison of Water Surface Profiles Along Flow Path I’ – I for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum Water Surface Profile K' – K Hurricane Irma



25-Year 240-Hour



100-Year 240-Hour

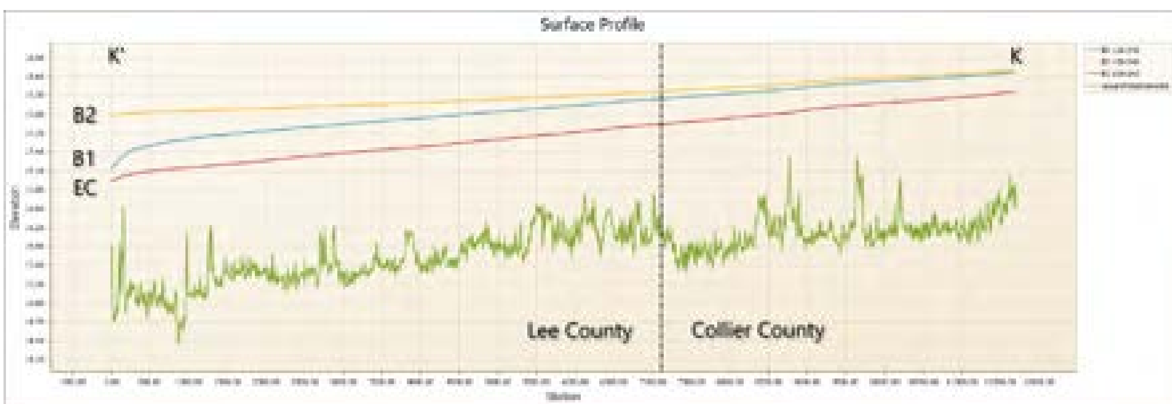
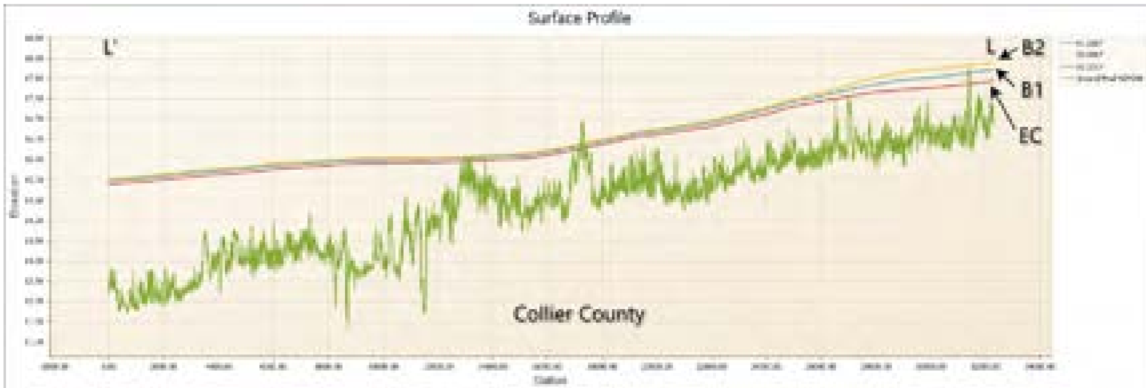


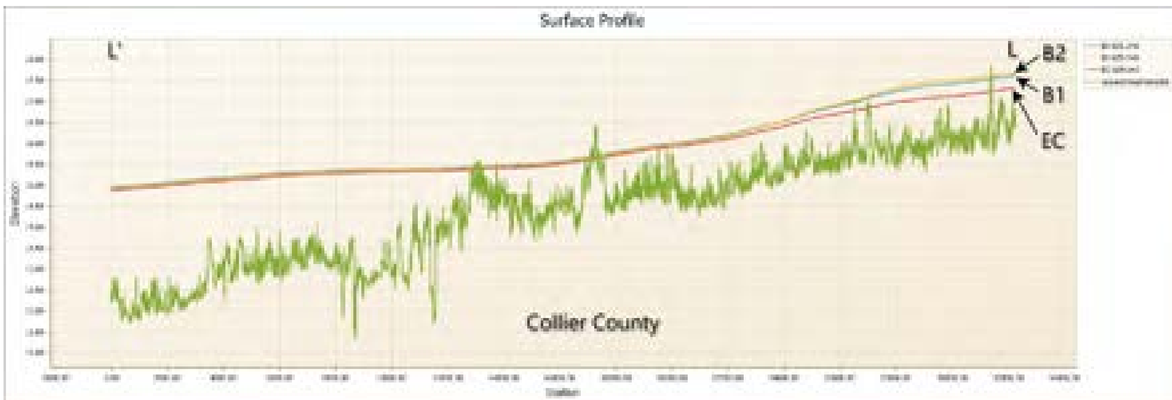
Figure 159 Comparison of Water Surface Profiles Along Flow Path K' – K for Existing Conditions (EC), and Berm Alignments B1 and B2

Maximum Water Surface Profile L’ – L

Hurricane Irma



25-Year 240-Hour



100-Year 240-Hour

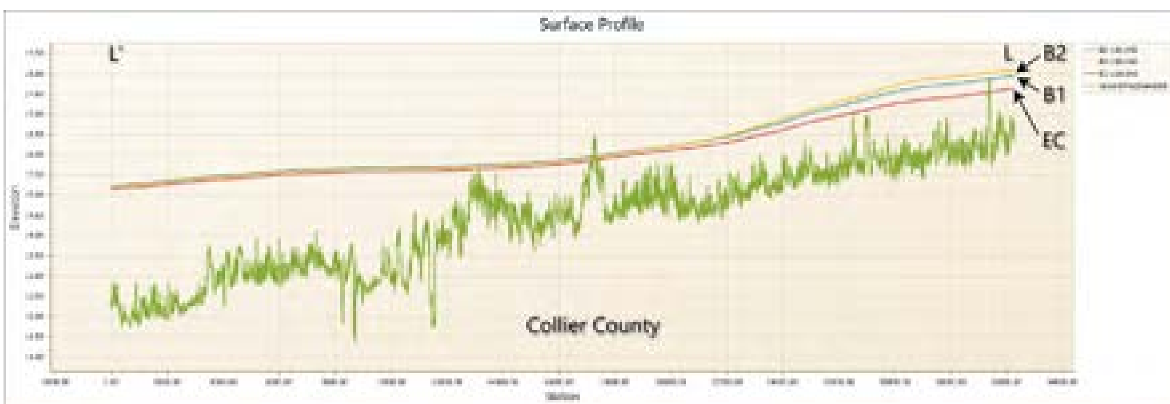


Figure 160 Comparison of Water Surface Profiles Along Flow Path L’ – L for Existing Conditions (EC), and Berm Alignments B1 and B2

6.4 Impacts of Berm/Reservoir System on Hydroperiods

There are several tools in ICPR4 to quantify hydroperiods as described in 4.3 Hydroperiod Assessment. These include: (1) long-term time series charts of stage hydrographs at specific computational points; (2) raster charts of long-term stage time series data that provide visual seasonal changes in water surface elevations; (3) stage-duration curves at specific computational points that relate water surface elevations to exceedance probability; and, (4) spatial extents of depths of inundation based on exceedance probability.

Existing conditions (EC), berm alignment 1 (B1), and berm alignment 2 (B2) were simulated for the 5-year verification period (2013 – 2017). The output interval was set at 6 hours for each of these simulations providing 7,300 data points for approximately 68,000 computational nodes. These were then evaluated in probabilistic terms – the probability that a water surface elevation will be equaled or exceeded at a specific location in the study area.

6.4.1 Hidden Cypress and Larry Kiker Preserves

The flooding extents of inundation for 1-, 2-, 3-, 6-, and 9-month periods (i.e., 8%, 17%, 25%, 50%, and 75% exceedance probabilities), on average, in the Hidden Cypress and Larry Kiker Preserves for existing conditions (EC), berm alignment 1 (B1), and berm alignment 2 (B2) are shown in Figure 161. These were generated using ICPR4's animation panel and are based on averages over the 5-year simulation period. The shaded areas in the top row depict the areas expected to be flooded for 9 months per year, on average, for existing conditions (left image), berm alignment 1 (center image), and berm alignment 2 (right image). Rows 2, 3, 4, and 5 (top to bottom) are for flooding periods of 6, 3, 2, and 1 months, respectively. As the period of time decreases, the extents of flooding increase.

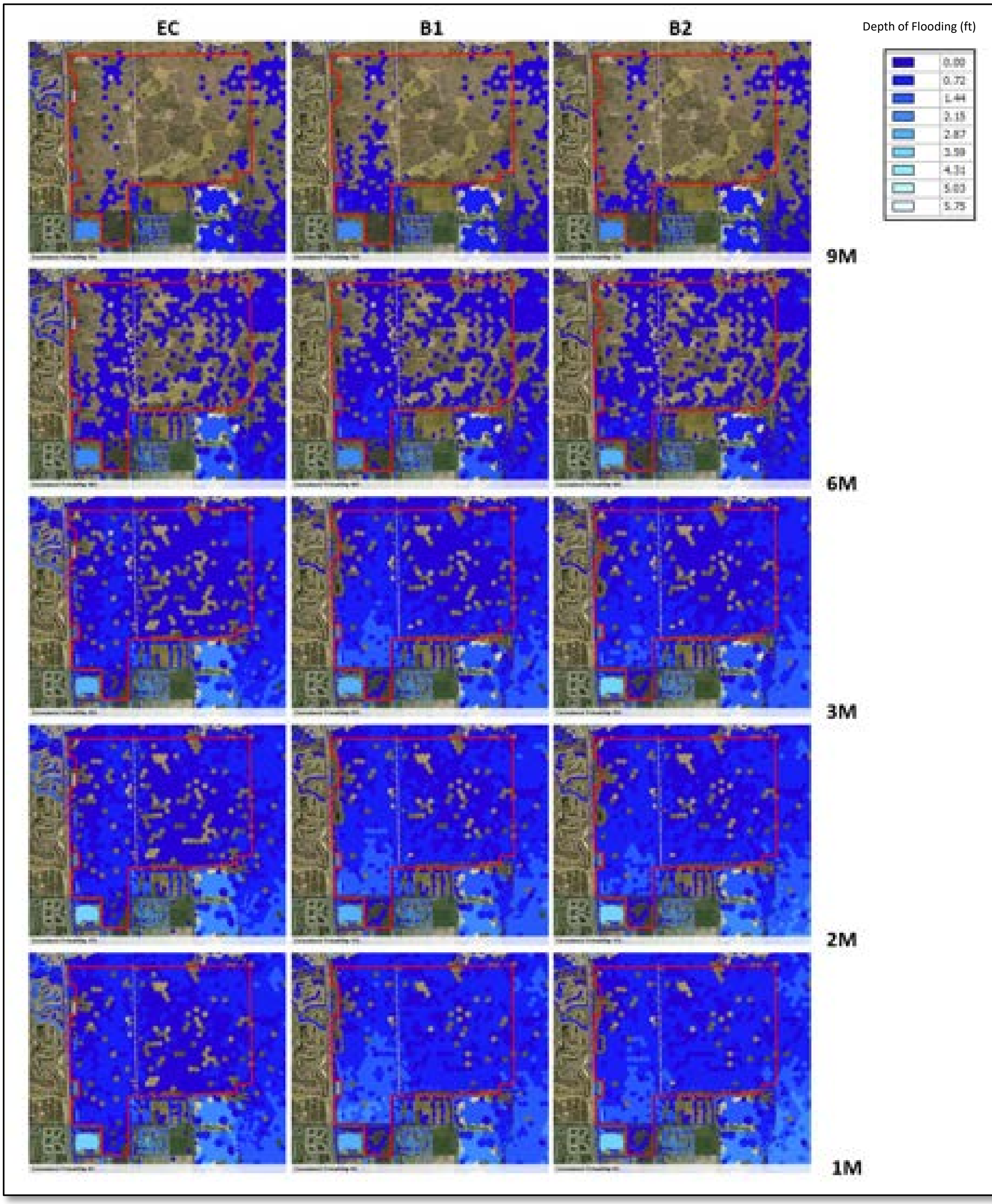


Figure 161 Flooding Extents and Depth for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 for 1-, 2-, 3-, 6-, and 9-month Periods in the Larry Kiker Preserve

Locations of the 13 monitoring wells are shown in Figure 162 with land cover by FLUCCS code. Table 41 includes descriptions of the FLUCCS codes and the area of each inside the Larry Kiker and Hidden Cypress Preserves. Stage duration curves and raster charts at each well for existing conditions (EC), berm alignment 1 (B1), and berm alignment 2 (B2) are provided in Figure 163 through Figure 175.

Based on the stage duration curves, locations MW-2, MW-8, and MW-11 are inundated 1 to 3 months per year on average. Locations MW-1, MW-9, and MW-12 are flooded about 5 months per year on average and locations MW-3, MW-4, MW-5, MW-6, MW-7, MW-10, and MW-13 are flooded about 7.5 to 10.5 months per year on average.

The hydroperiod is increased by B1 and B2 for all locations except MW-4. MW-4 is located on the south side (downstream side) of the proposed berm alignments. Consequently, less water reaches MW-4 on an annual basis. All other locations are on the north side (upstream side) of the berm alignments.

Seasonal variations in flooding, including depths of flooding, caused by the berm alignments can be determined from the raster charts.

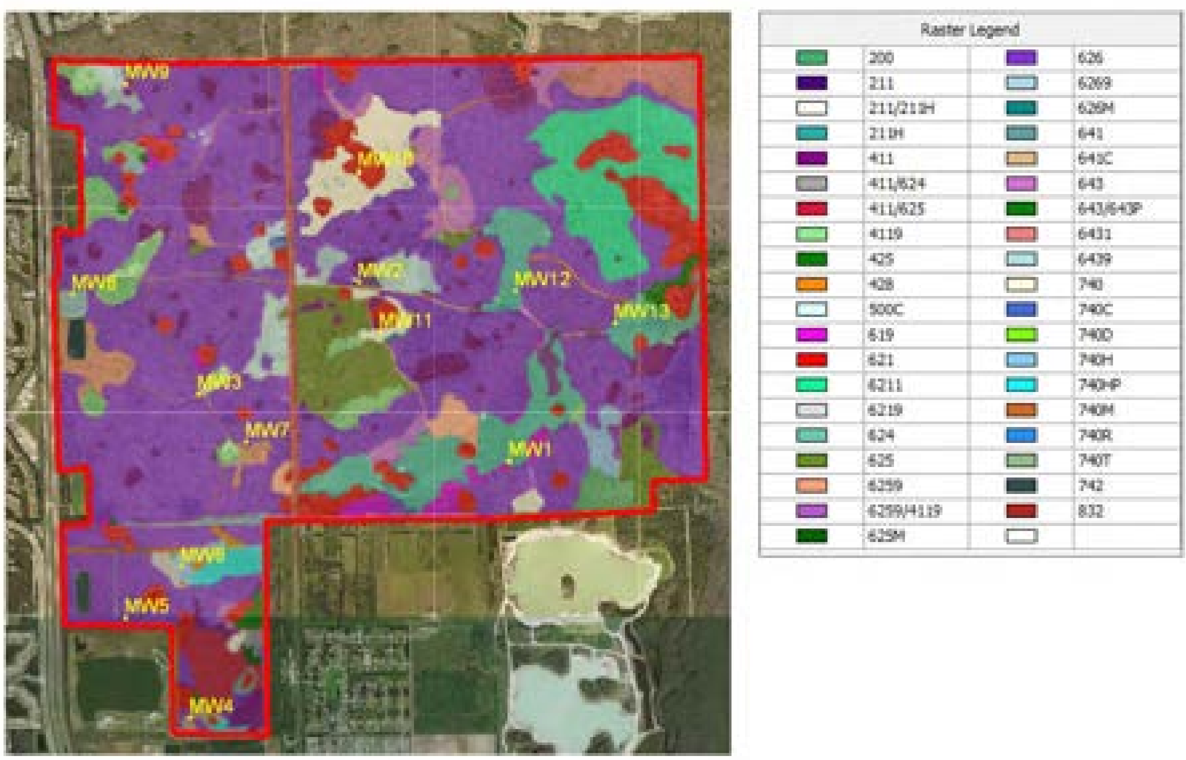


Figure 162 Land Cover Map by FLUCCS Code and Monitoring Well Locations for the Hidden Cypress and Larry Kiker Preserves (Source: Ecoplanz)

FLUCCS Code	Description	Acres	Classification
200	Upland Agriculture Field	25.94	Upland
211	Improved Pasture	18.58	Upland
211H	Improved Pasture, hydric	231.62	Wetland
211/211H	Improved Pasture/Improved Pasture, hydric	119.86	Upland & Wetland Mosaic
411	Mesic Pine Flatwoods	217.62	Upland
4119	Pine Flatwoods, logged	125.01	Upland
411/624	Pine Flatwoods with Scattered Oak	4.59	Upland
411/625	Pine Flatwoods/Hydric Flatwoods	51.38	Upland
425	Temperate Hardwood Hammock	15.70	Upland
428	Mesic Sabal Palm	5.21	Upland
500C	Cow Pond	1.63	OSW
619	Exotic Hardwood Wetland	50.77	Wetland
621	Cypress	271.85	Wetland
6211	Cypress Strand	225.28	Wetland
6219	Cypress, disturbed	7.66	Wetland
624	Pine-Cypress-Sabal Palm	24.31	Wetland
625	Hydric Flatwoods	175.59	Wetland
6259	Hydric Flatwoods, disturbed	79.62	Wetland
6259/4119	Hydric Flatwoods/Pine Flatwoods, disturbed	15.54	Wetland with Upland Interspersed
625M	Hydric Flatwoods, 50% Melaleuca	2.96	Wetland
626	Cypress-Pine Savannah, hydric	2214.19	Wetland
6269	Cypress-Pine Savannah, hydric, disturbed	4.68	Wetland
626M	Cypress-Pine Savannah, hydric, >75% Melaleuca	1.23	Wetland
641	Freshwater Herbaceous Marsh	3.94	Wetland
641C	Herbaceous Marsh with Scattered Cypress	7.32	Wetland
643	Wet Prairie	73.10	Wetland
643/643P	Wet Praire with Planted Trees	7.96	Wetland
6431	Wet Praire with limestone at surface	65.36	Wetland
6439	Wet Paririe, disturbed	109.41	Wetland
740	Disturbed Lands	4.66	Upland
740C	Disturbed Lands, Former Hunting Camp	2.95	Upland
740D	Disturbed Lands, ditch	13.11	OSW
740H	Disturbed Lands, hydric	55.31	Wetland
740HP	Disturbed Lands, hydric, planted trees	29.34	Wetland
740M	Maintenance Trail	83.45	Upland & Wetland
740R	Crushed Rock Road with Ditches	10.63	Upland & OSW
740T	Disturbed Lands, trail	1.37	Wetland
742	Borrow Lake	18.64	OSW
832	Electric Power Transmission Line & Easement	48.10	Upland & OSW
	Total Acres	**4425.47**	

Table 41 FLUCCS Code Descriptions and Areas for the Hidden Cypress and Larry Kiker Preserves (Source: Ecoplanz)

STREAMLINE TECHNOLOGIES

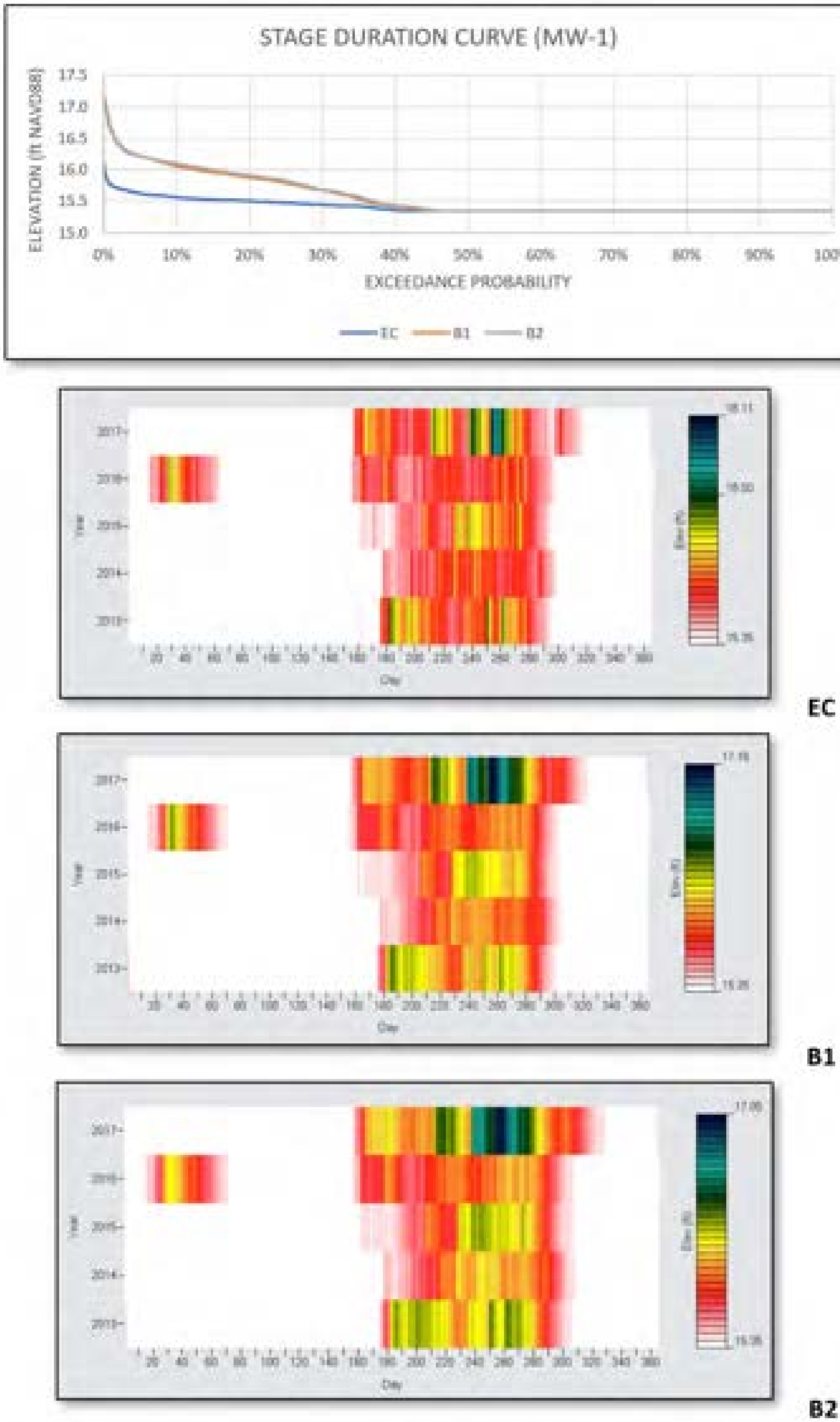


Figure 163 Stage Duration Curve and Raster Charts for MW-1

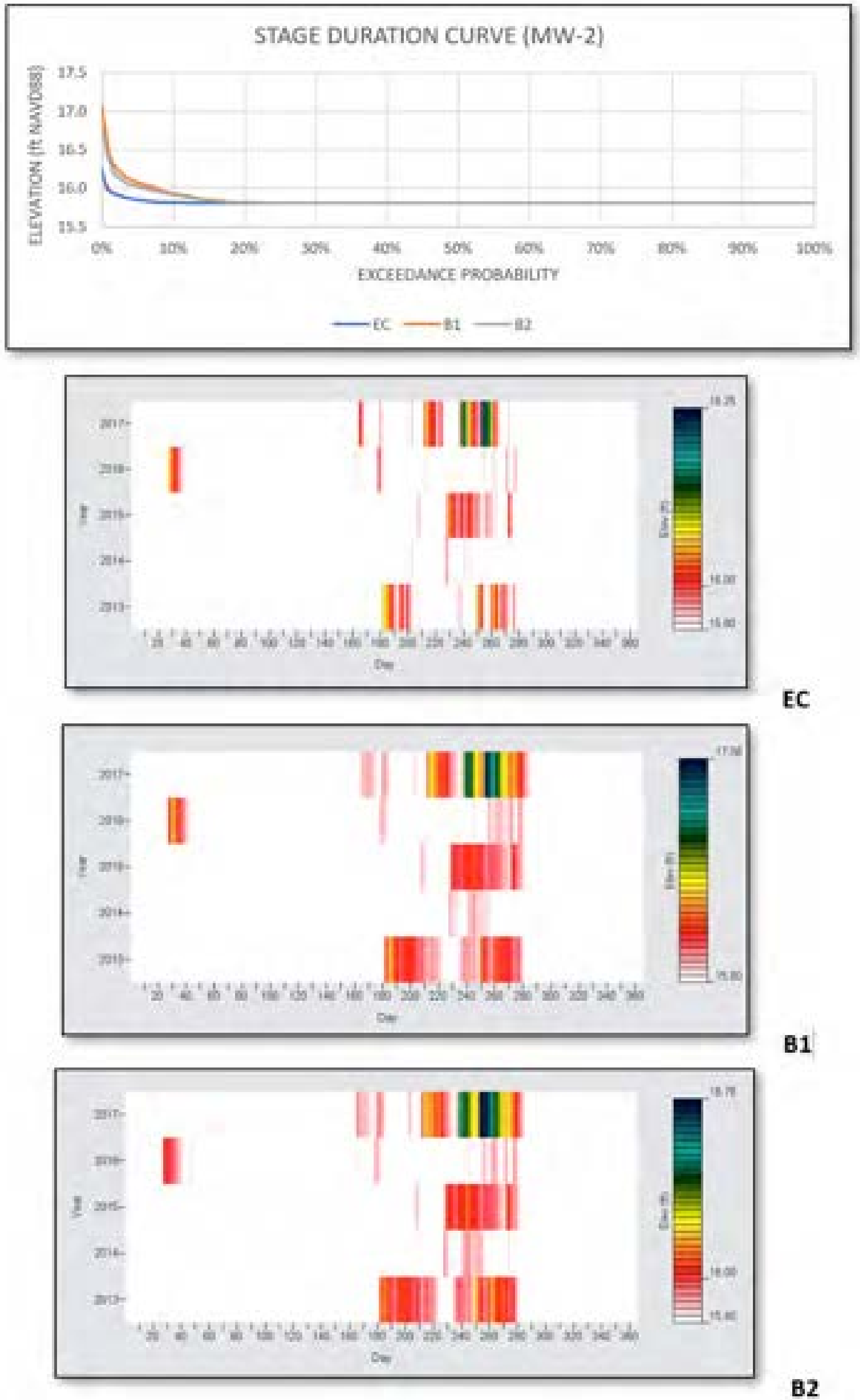
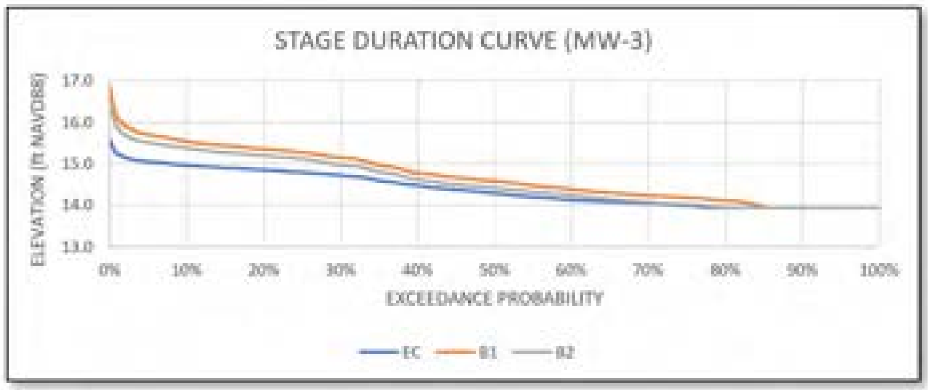
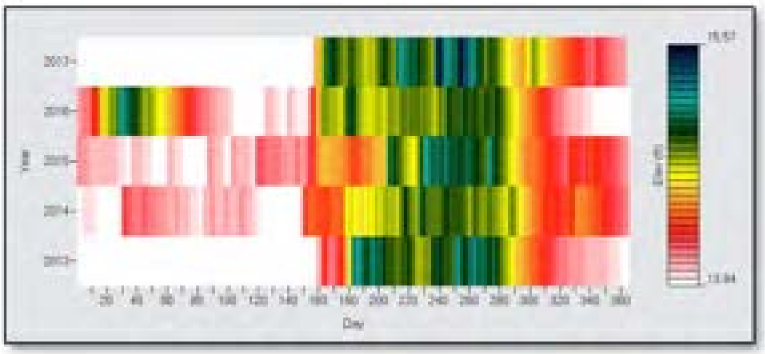
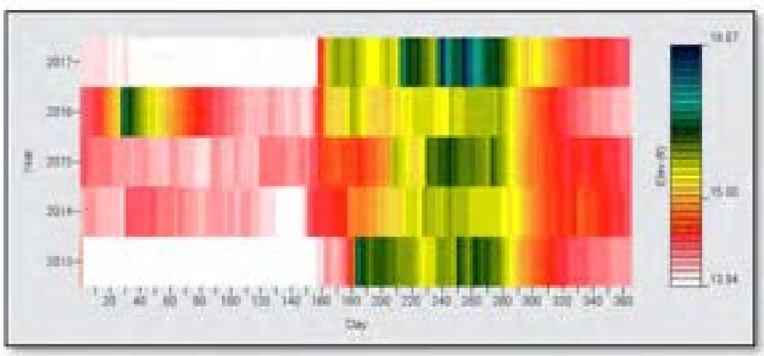


Figure 164 Stage Duration Curve and Raster Charts for MW-2

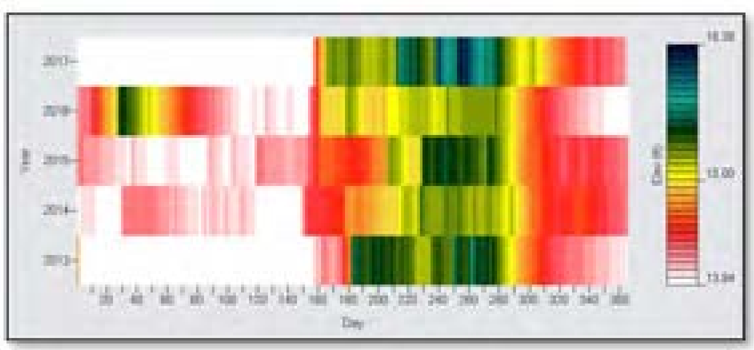




EC



B1



B2

Figure 165 Stage Duration Curve and Raster Charts for MW-3

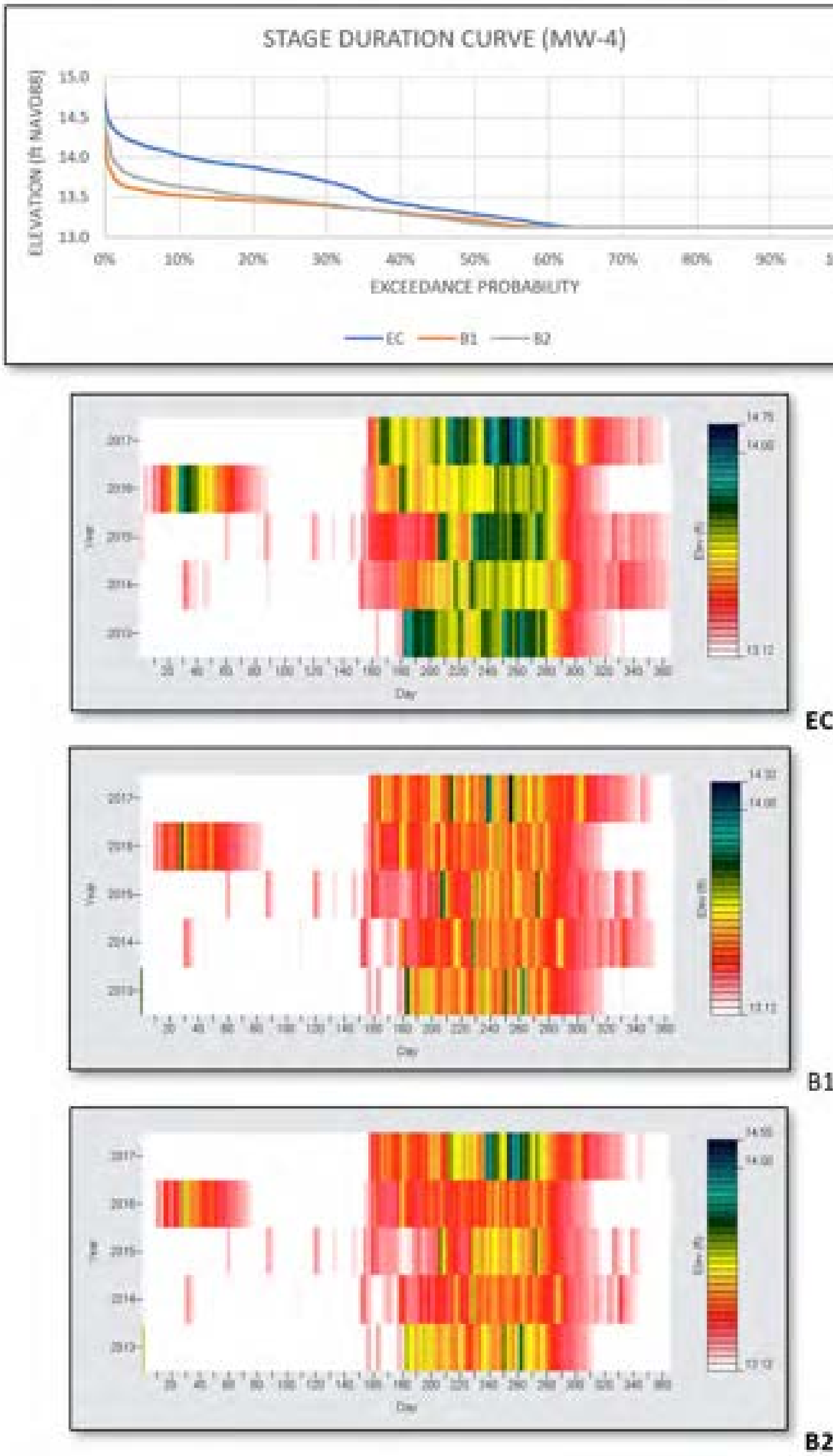


Figure 166 Stage Duration Curve and Raster Charts for MW-4

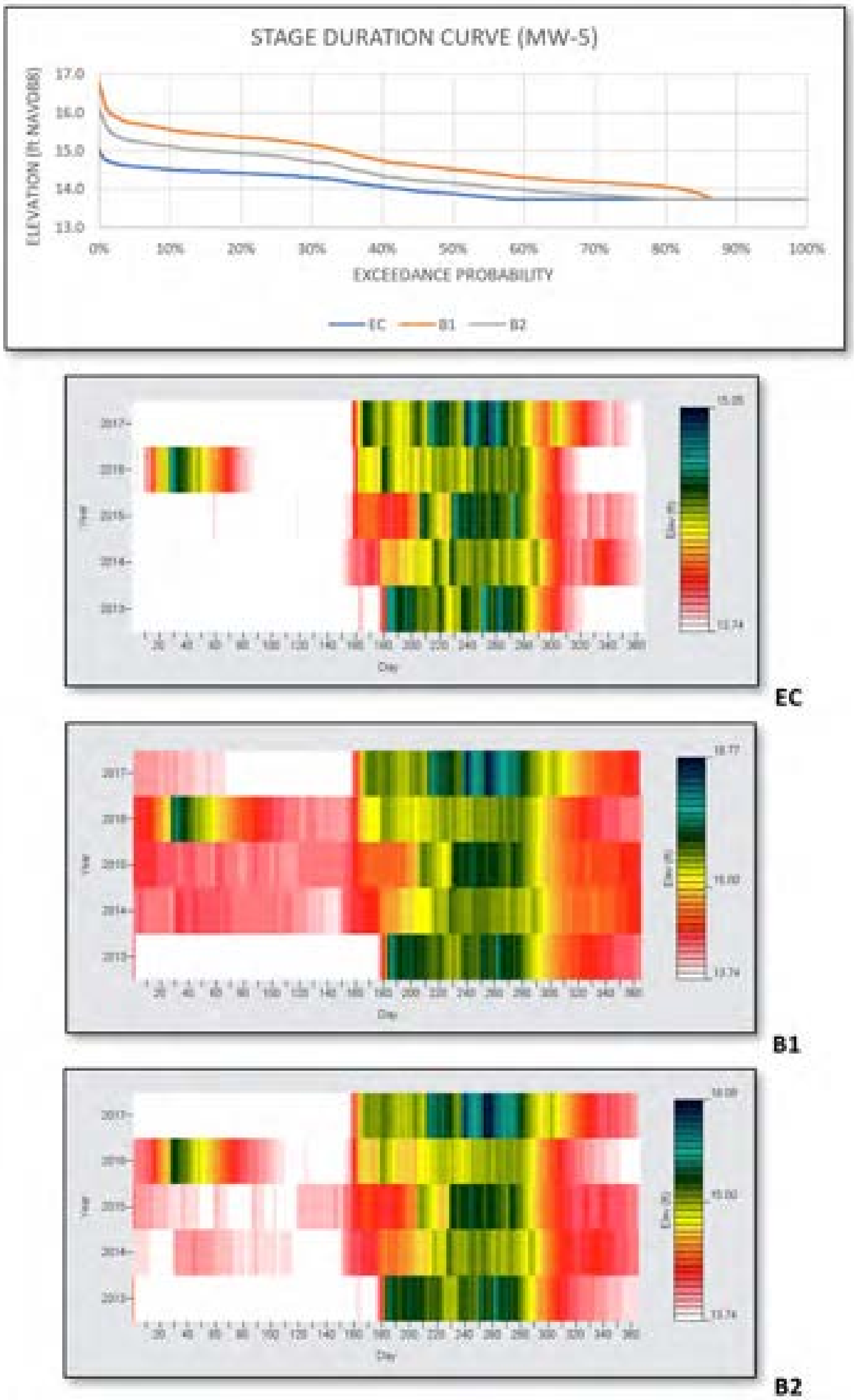


Figure 167 Stage Duration Curve and Raster Charts for MW-5

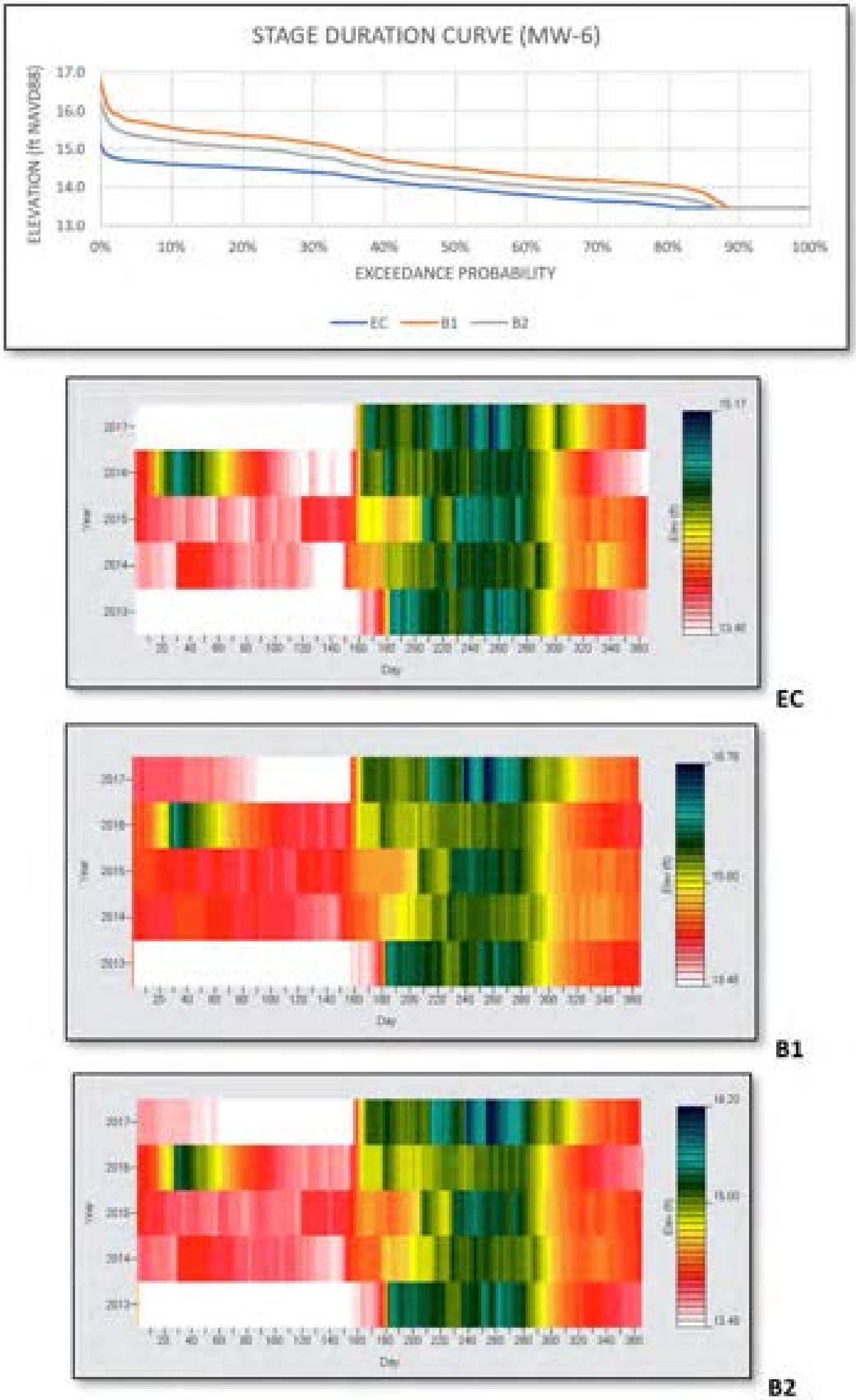


Figure 168 Stage Duration Curve and Raster Charts for MW-6

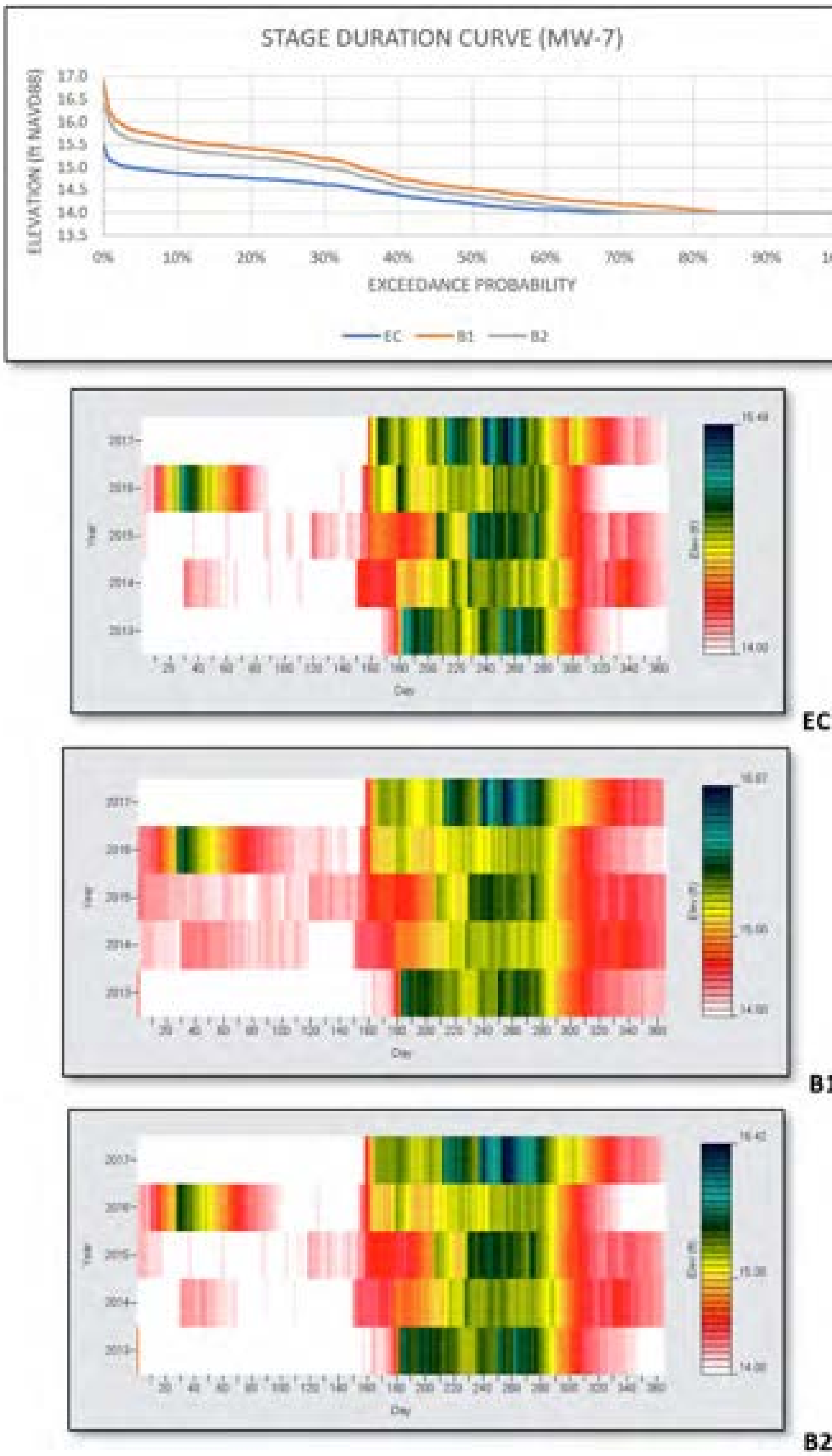
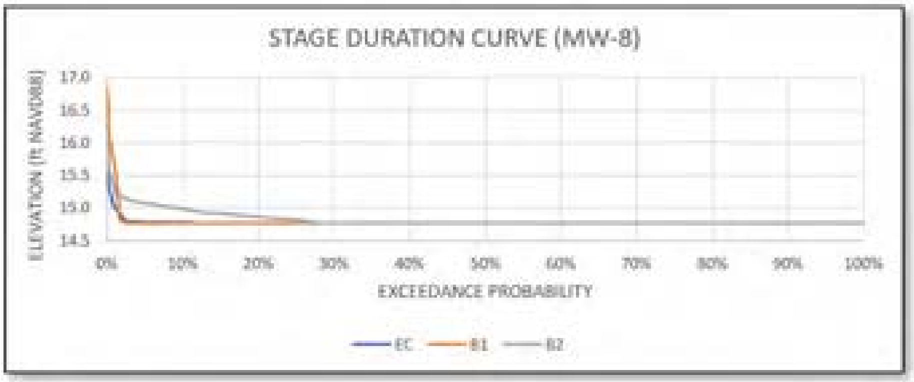
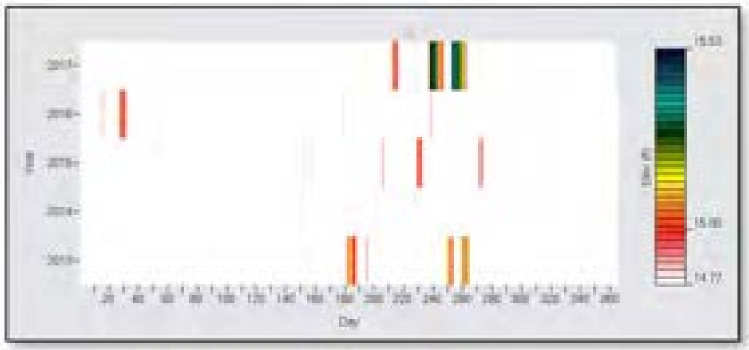
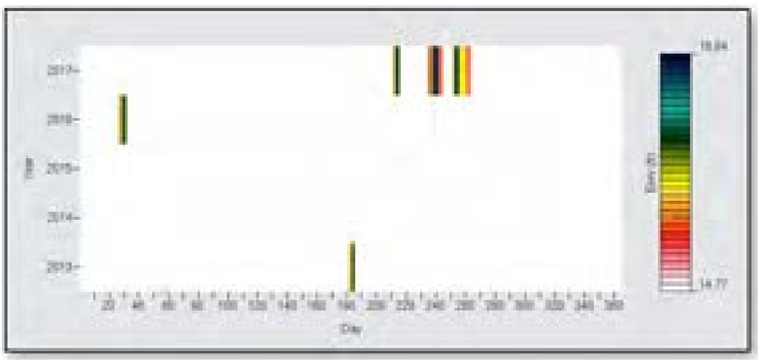


Figure 169 Stage Duration Curve and Raster Charts for MW-7

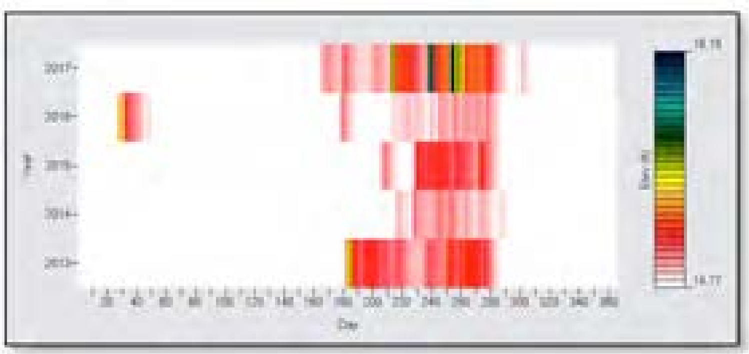




EC

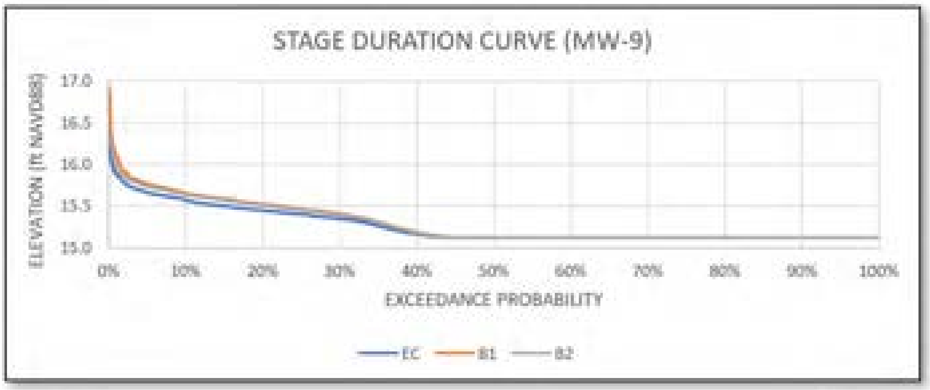


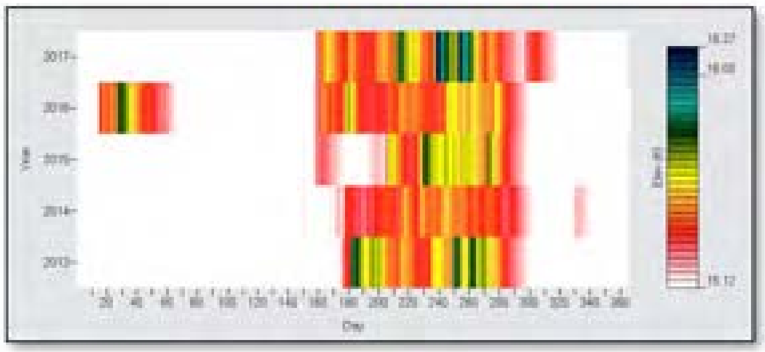
B1



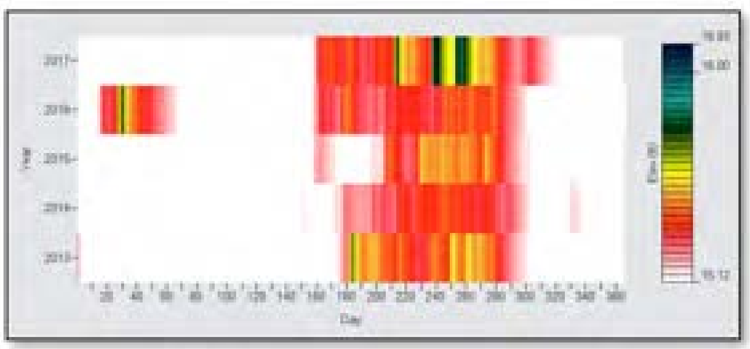
B2

Figure 170 Stage Duration Curve and Raster Charts for MW-8

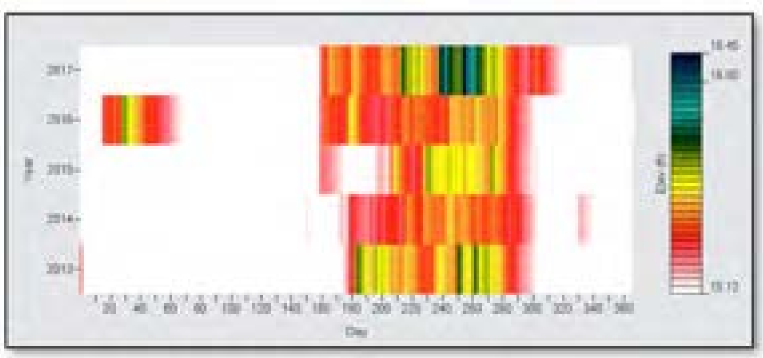




EC



B1



B2

Figure 171 Stage Duration Curve and Raster Charts for MW-9

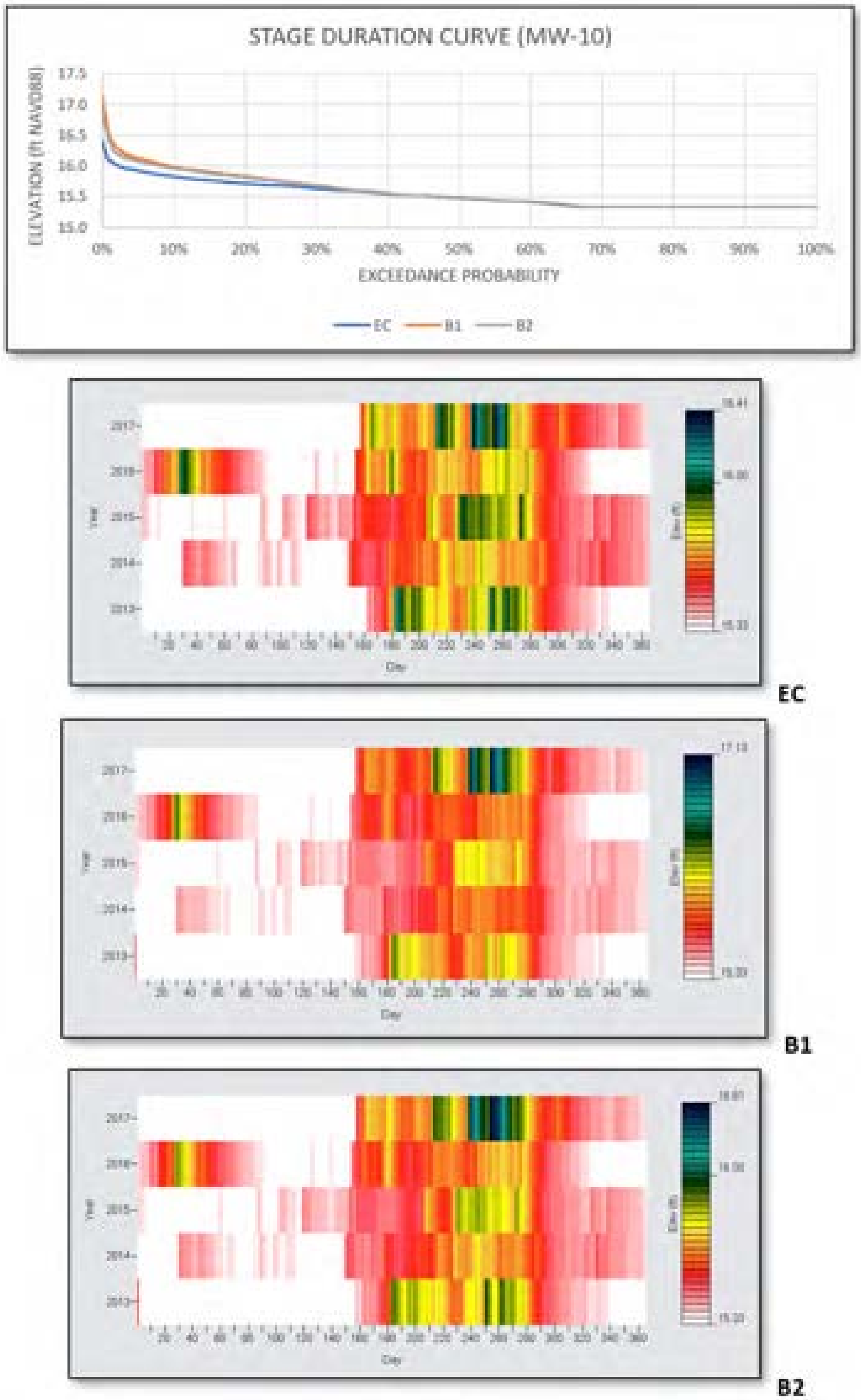
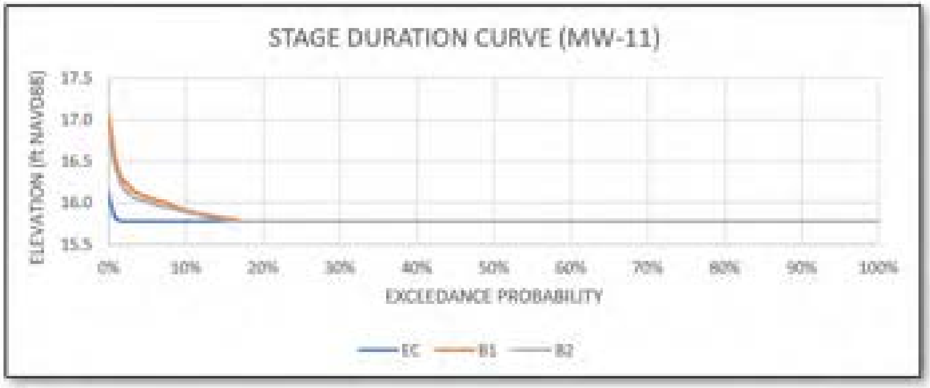
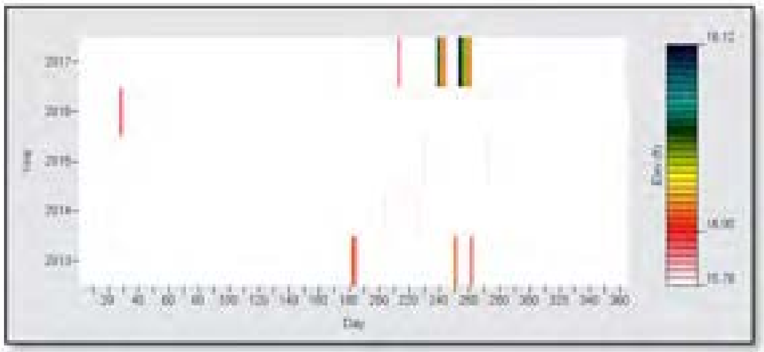
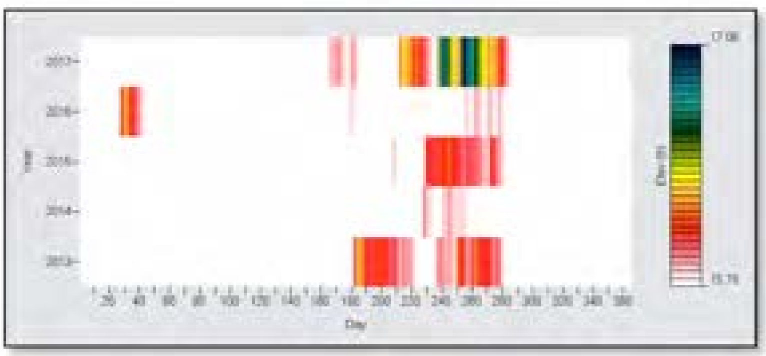


Figure 172 Stage Duration Curve and Raster Charts for MW-10

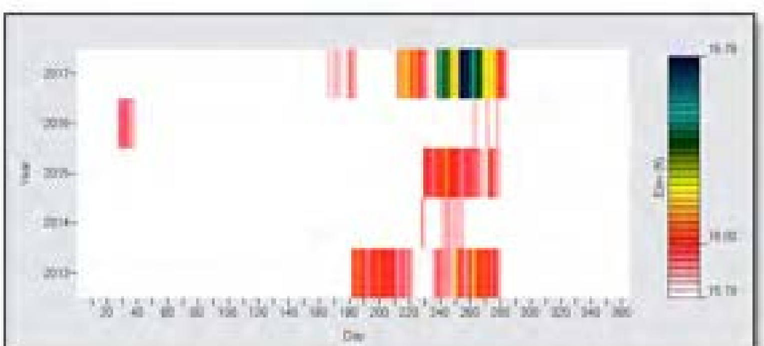




EC



B1



B2

Figure 173 Stage Duration Curve and Raster Charts for MW-11

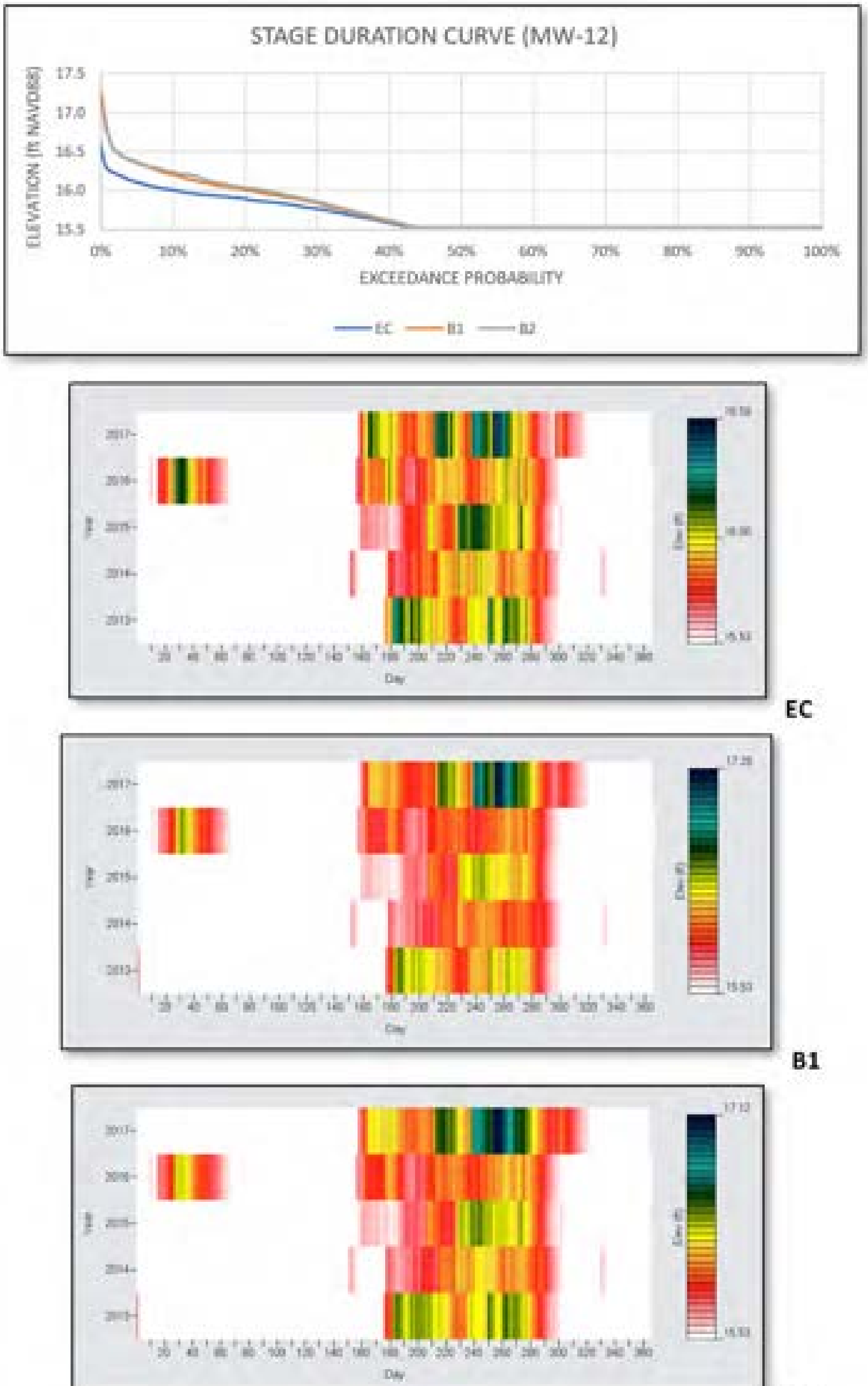


Figure 174 Stage Duration Curve and Raster Charts for MW-12

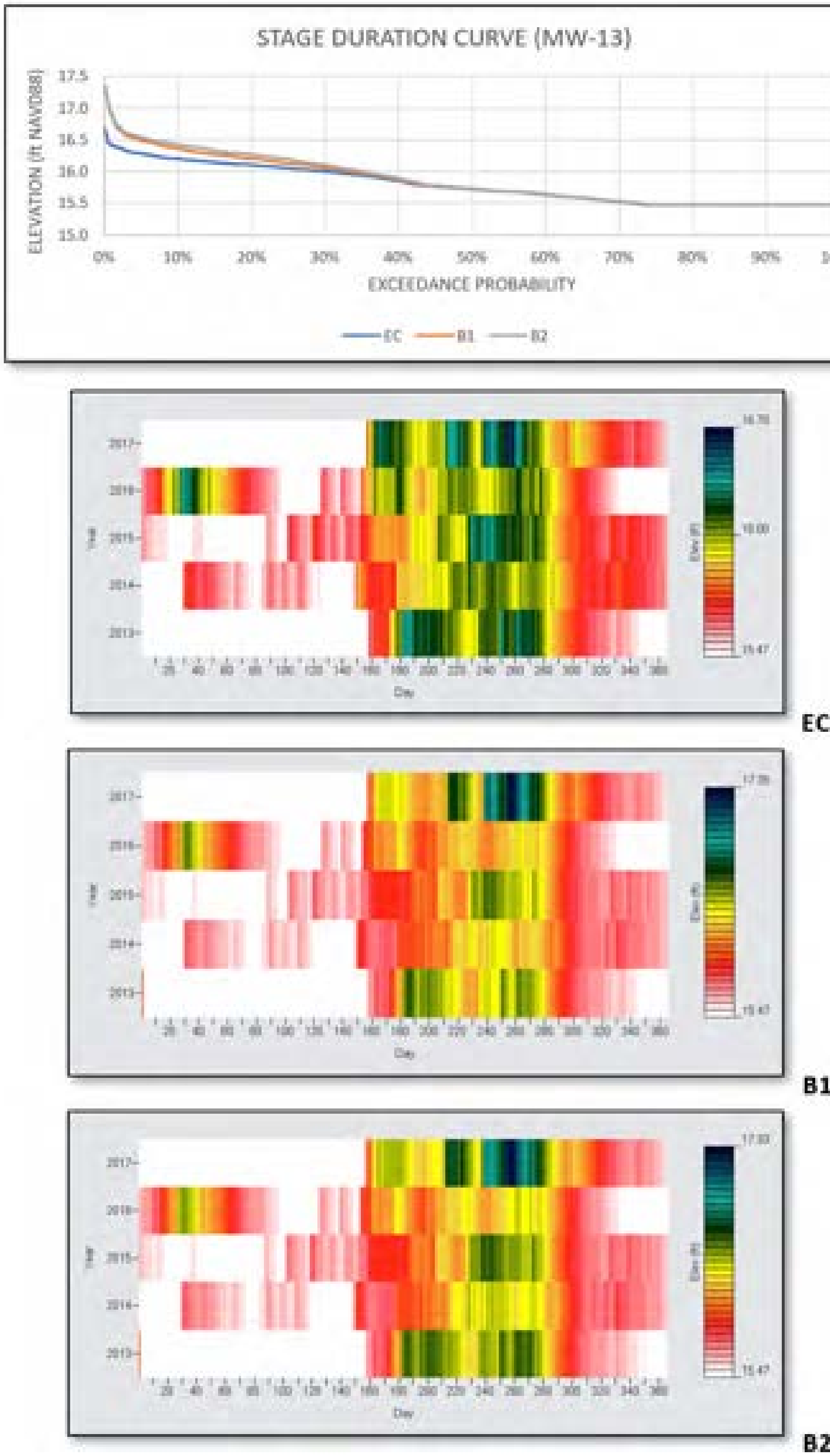


Figure 175 Stage Duration Curve and Raster Charts for MW-13

6.4.2 Regional Berm/Reservoir System and Beyond

The flooding extents for 1-, 2-, 3-, 6-, and 9-month periods (i.e., 8%, 17%, 25%, 50%, and 75% exceedance probabilities), on average, for existing conditions (EC), berm alignment 1 (B1), and berm alignment 2 (B2) are shown in Figure 176. These were generated using ICPR4's animation panel and are based on averages over the 5-year simulation period. The shaded areas in the top row depict the areas expected to be flooded for 9 months per year, on average, for existing conditions (left image), berm alignment 1 (center image), and berm alignment 2 (right image). Rows 2, 3, 4, and 5 (top to bottom) are for flooding periods of 6, 3, 2, and 1 months, respectively. As the period of time decreases, the extents of flooding increase.

Stage duration curves for the EC, B1, and B2 scenarios at the thirteen reference points depicted in Figure 177 are presented in Figure 178 through Figure 190.

6.4.2.1 PT-22 and PT-23

PT-22 is just east of the proposed north-south alignment of berm B1 and PT-23 is just west of it. Flow patterns in this area were shown previously in Figure 126. Water moves from the northeast to the southwest into the Kehl Canal. Berm alignment B1 blocks this flow pattern and shunts water to the south. Consequently, the hydroperiod is increased at PT-22 (Figure 178) for the B1 alignment whereas the hydroperiod is reduced at PT-23 (Figure 179) for that alignment. Alignment B2 allows the natural flow patterns in this area to continue. The hydroperiod at PT-22 is only slightly increased with the B2 alignment.

6.4.2.2 PT-24, PT-25, and PT-26

PT-24, PT-25, and PT-26 are in the SFWMD Southern Corkscrew Regional Ecosystem Watershed (C.R.E.W.) and inside the berm/reservoir extents. Hydroperiod increases occur at these three locations for both berm alignments. The increases at PT-25 are less than those at PT-24 and PT-26. Berm alignment B2 creates longer hydroperiods than B1 at these locations.

6.4.2.3 PT-28

PT-28 is in the berm/reservoir extents but father north in a slough. Negligible impacts occur to the hydroperiod at this location (see Figure 183).

6.4.2.4 PT-09, PT-10, and PT-11

PT-09, PT-10, and PT11 are in Collier County just east of the Lee/Collier county line. The hydroperiod is increased slightly for berm alignment B1 at these locations. The hydroperiod for berm alignment B2 matches the existing condition closer. Refer to Figure 184, Figure 185, and Figure 186.

6.4.2.5 PT-12, PT-14, PT-16, and PT-17

PT-12 and PT-14 are located farther east in Collier County. PT16 and PT-17 are also located in Collier County south of the berm/reservoir system. Although the hydroperiod is increased slightly for both B1 and B2 at these locations, the increase is relatively minor. Refer to Figure 187, Figure 188, Figure 189, and Figure 190.

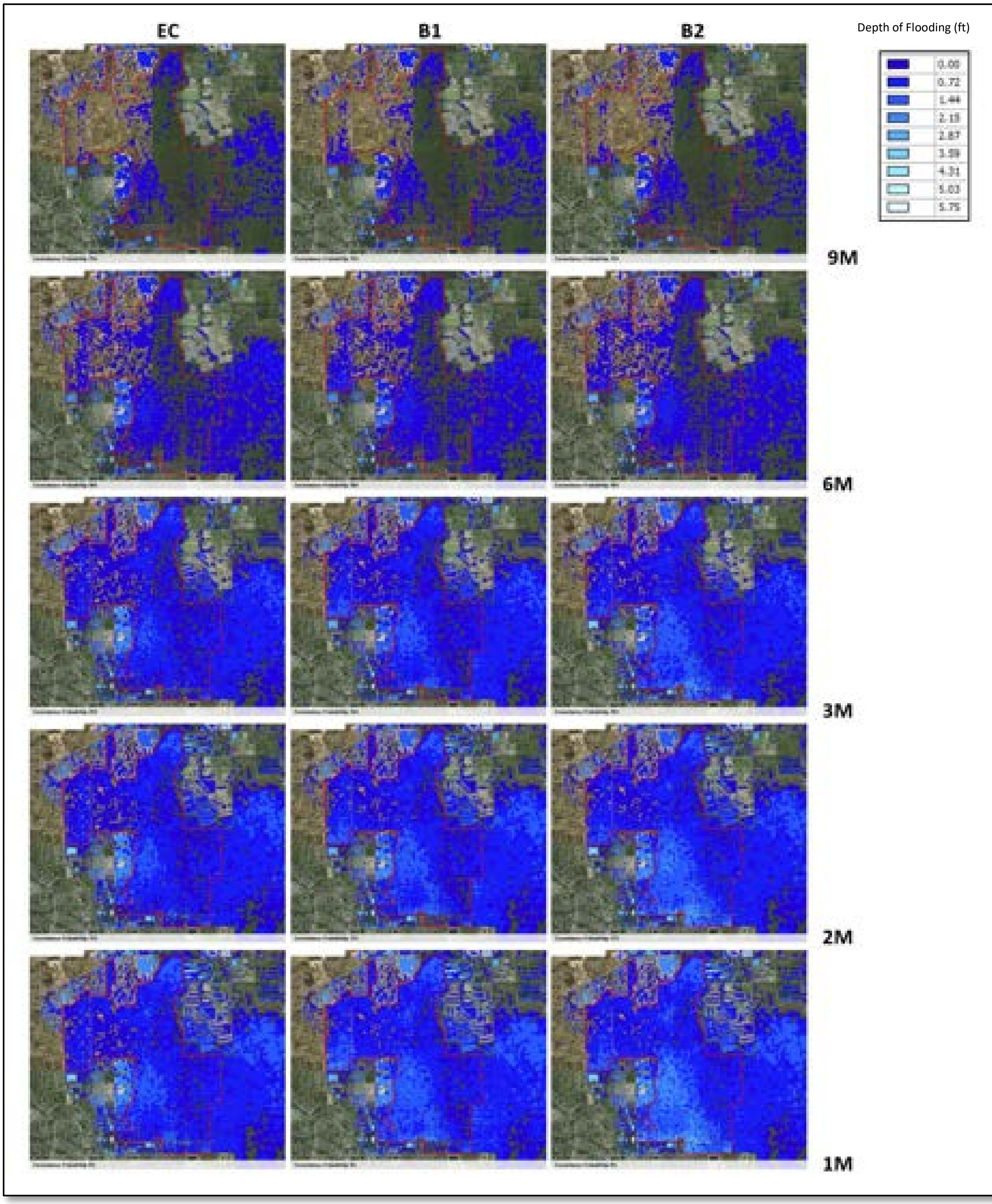


Figure 176 Flooding Extents and Depths for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 for 1-, 2-, 3-, 6-, and 9-month Periods in the Proposed Berm/Reservoir System

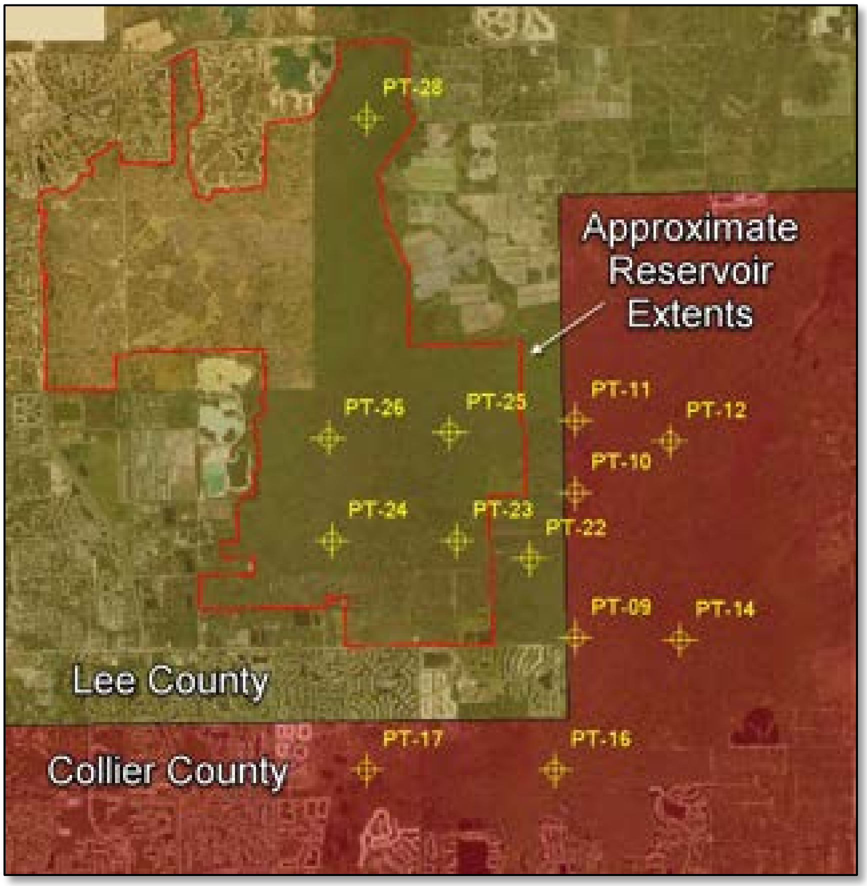


Figure 177 Reference Point Locations

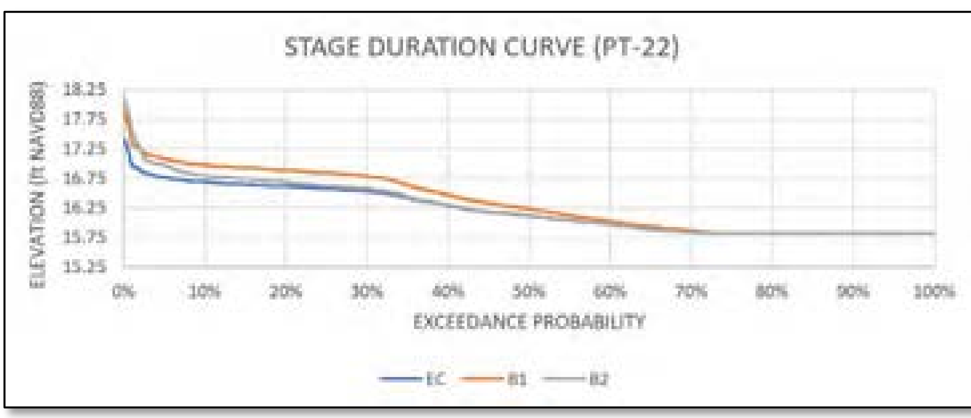


Figure 178 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-22

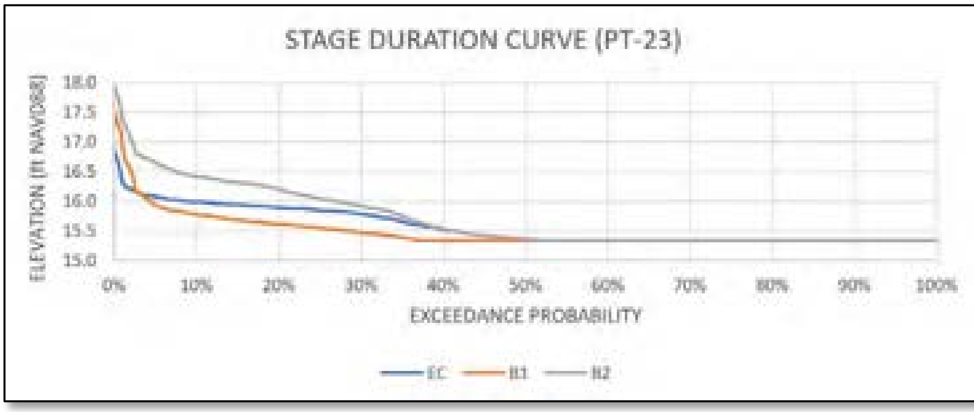


Figure 179 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-23

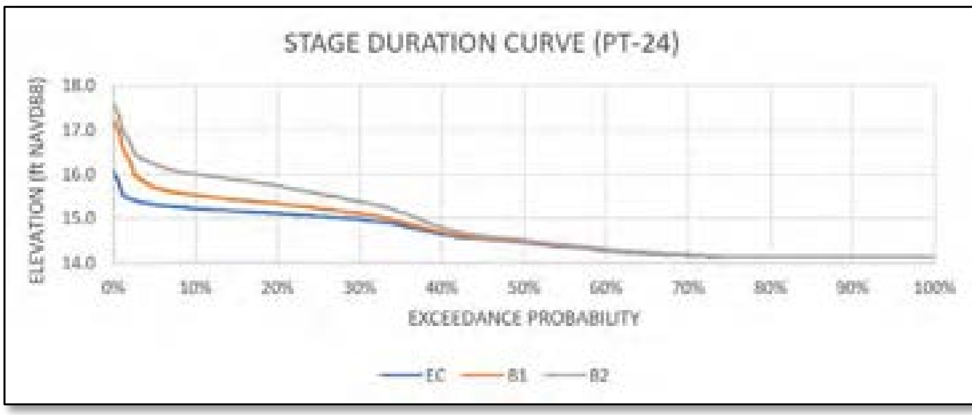


Figure 180 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-24

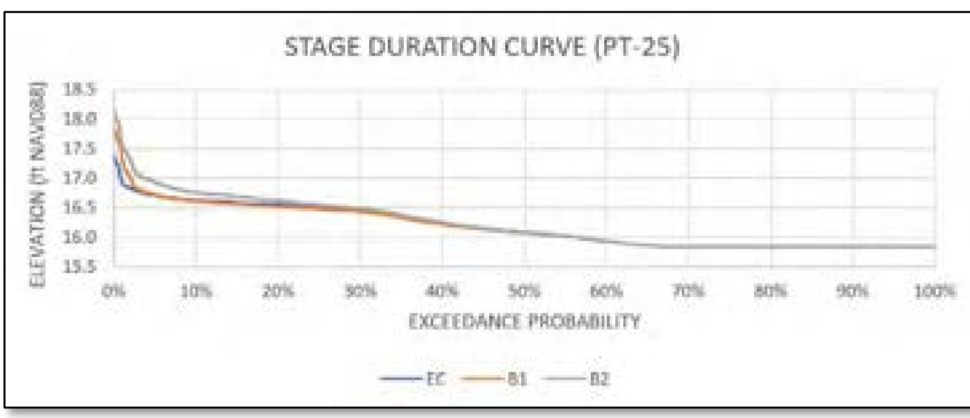


Figure 181 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-25

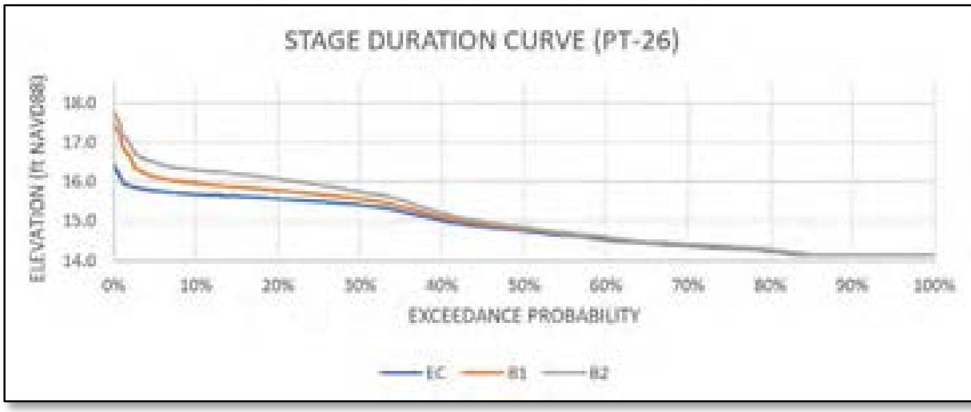


Figure 182 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-26

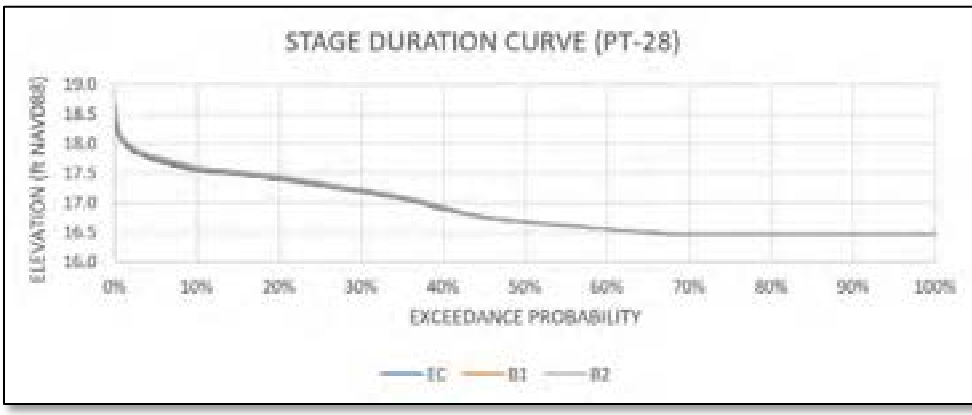


Figure 183 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-28

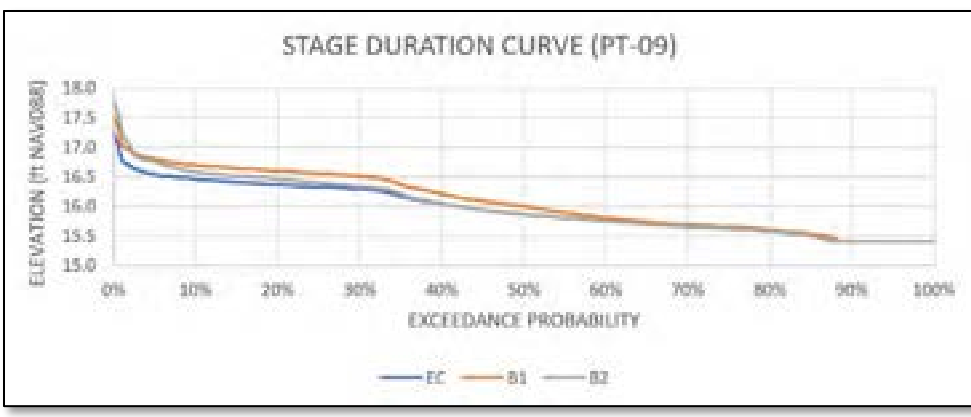


Figure 184 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-09

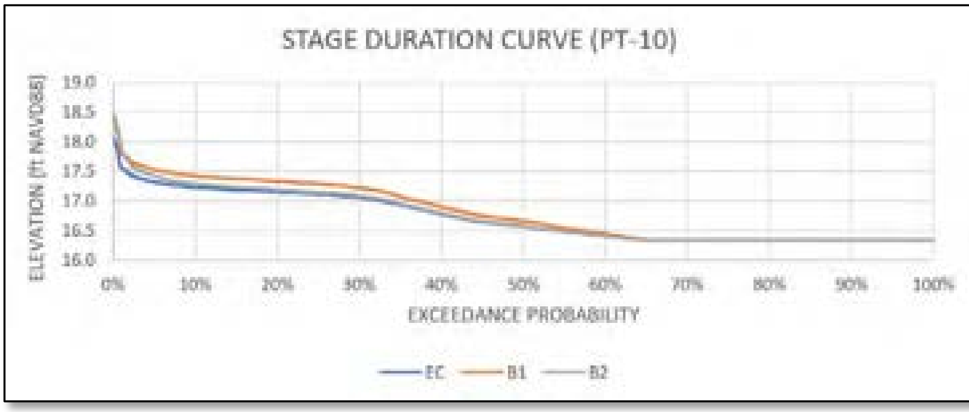


Figure 185 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-10

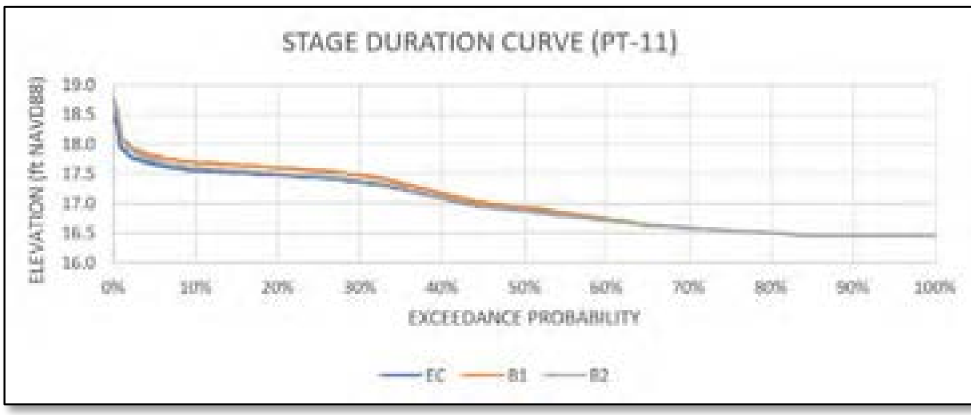


Figure 186 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-11

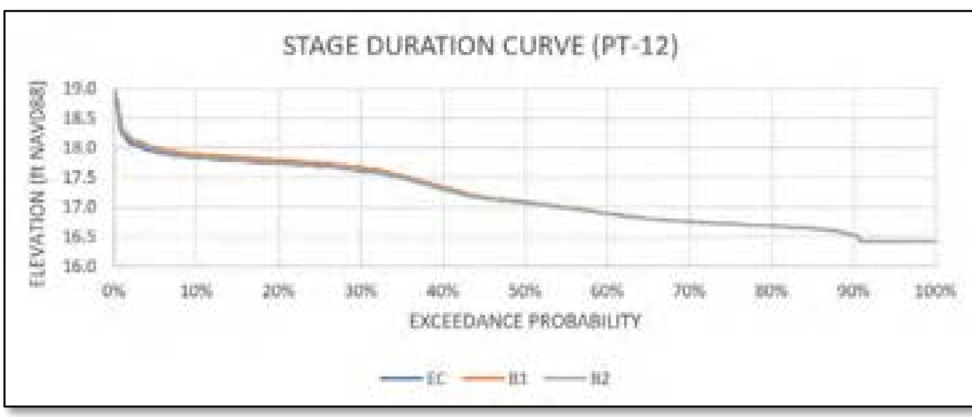


Figure 187 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-12

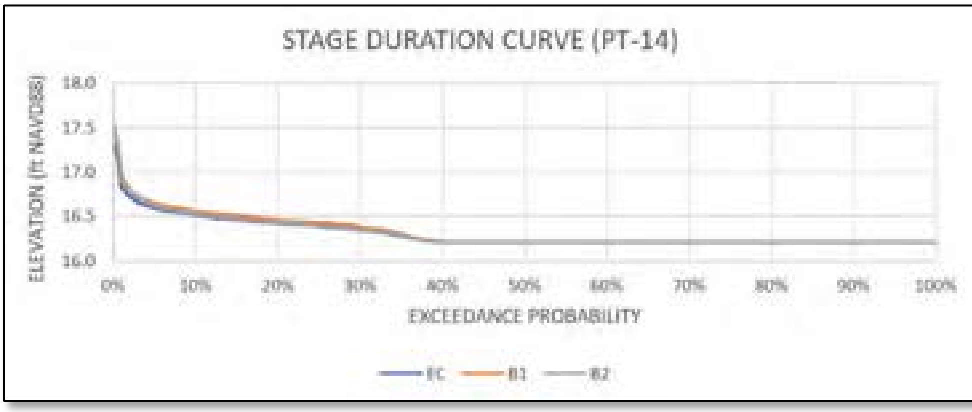


Figure 188 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-14

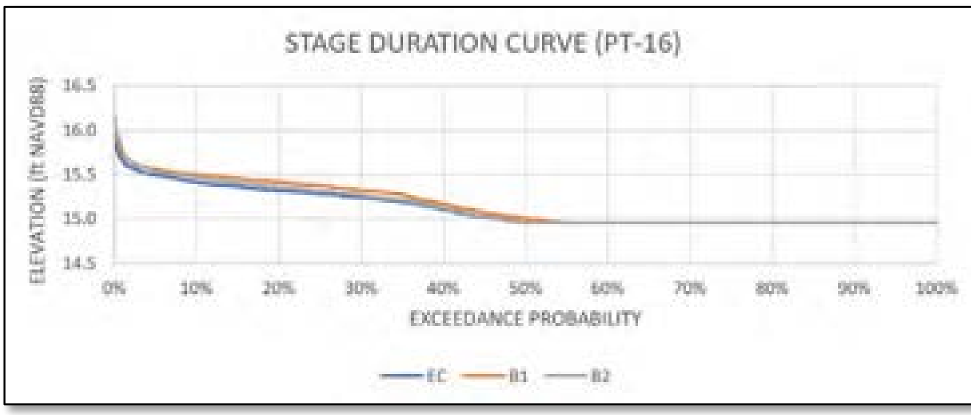


Figure 189 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-16

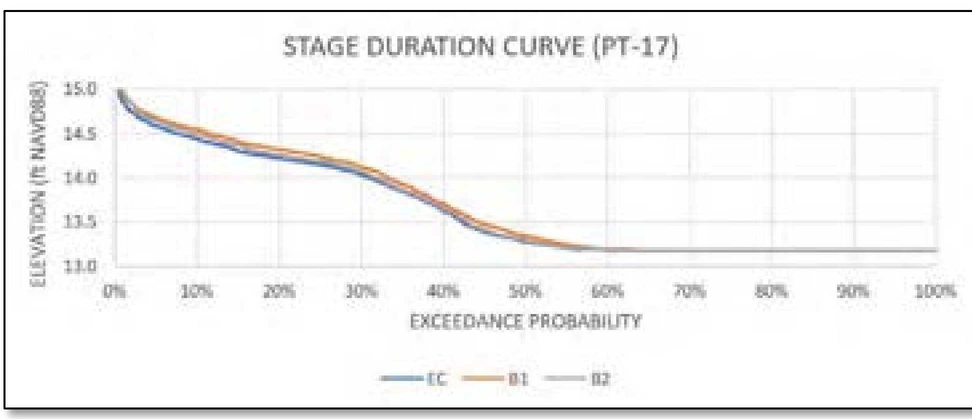


Figure 190 Stage Duration Curves for Existing Conditions (EC), Berm Alignment B1, and Berm Alignment B2 at PT-17

7. Summary & Recommendations

7.1 Summary

1. The Southern Lee County (SLC) ICPR4 model encompasses portions of Lee, Collier, and Hendry counties and the City of Bonita Springs. Approximately 250 square miles is modeled as 2D overland flow – a physics-based modeling approach that tracks the movement of surface water through the vast wetland systems east of Interstate 75. It includes evapotranspiration and soil moisture accounting and can be used to simulate long term historical periods and single discrete design storm events. See 2. Model Setup for details of the model development.
2. The SLC ICPR4 model was calibrated for a 5-month period (June 1 – November 1, 2017). Six (6) statistical metrics were used to measure success (R^2, NSE, ME, MAE, RMSE, and ½ Standard Deviation) at eight (8) locations dispersed across the study area. Three (3) locations were along the Kehl Canal and Imperial River, four (4) were in wetland systems, and one (1) was in Lake Trafford. Ratings of "Good", "Fair", and "Poor" were assigned to each metric. Of the 48 ratings, 39 were categorized as "Good" and 9 were "Fair" leaning closer to the "Good" rating than the "Poor" rating. The calibration is considered "Good" overall. See Table 12 for a summary of the ratings.
3. The SLC ICPR4 model results for the calibration period were compared with recent MIKE SHE/11 calibration results (March 2020) at the Kehl Canal Structure (upstream and downstream sides) and at the USGS 02291500 Imperial River near Bonita Springs gage. The SLC ICPR4 model was more accurate in all three cases. See Figure 23, Figure 24, Figure 25, and Figure 26 for these comparisons.
4. A 5-year simulation period (2013 – 2017) was used for verification purposes to test the ability of the model to simulate wet and dry periods. The six (6) statistical metrics described in item (2) were tested at the USGS 02291500 Imperial River gage and the SFWMD HF1 gage. Of the 12 statistical metric ratings, 10 were "Good" and 2 were "Fair". The verification is considered "Good" overall at these two (2) gages. See Table 13 and Table 14 for a summary of these metrics. Visual comparisons were made at 3 other locations: Lee County 49-GW9 (Figure 35), 49-GW10 (Figure 36), and 49-GW6 (Figure 38), all considered reasonable. And, observed ranges of water level fluctuations at 13 monitoring wells in the Larry Kiker and Hidden Cypress Preserves were compared to simulated ranges of water level fluctuations at the same locations for the 5-year verification period. Overall, 11 of the 13 wells experienced groundwater depths less than about 2.25 feet below the ground surface which supports the underlying assumption that a maximum vadose zone thickness of 2 feet used in the SLC ICPR4 model is reasonable. See Figure 40 for this comparison.
5. Six discrete storms (i.e., single event synthetic design storms) were simulated including the 25- and 00-year, 72-, 168- and 240-hr events. These include a combination of high rainfall intensity (the 72-hour storms) and high-volume events (the 168- and 240-hour storms). Rainfall totals for each storm were obtained from NOAA Atlas 14 at the Kehl Canal structure. See Table 9 for a summary of rainfall totals and rainfall distributions used for these storms.
6. Assessment of Existing Conditions
    a. **Particle Tracing Analysis:** A particle tracing analysis was performed at 17 starting locations in the watershed. Flow paths were etched from the starting points to a point of

zero velocity. This analysis provided insight on the complex flow patterns and travel times in the massive wetland system east of I-75. The weighted average velocity through the wetland system was determined to be 2,369 feet per day or 0.027 feet per second following Hurricane Irma. The general flow direction is from the northeast to the southwest with a substantial area draining from Collier County into Lee County and the Kehl Canal. This is an important consideration relative to berm alignments at the eastern end of the Kehl Canal. Water surface profiles along 6 of the flow paths were prepared comparing maximum water surface elevations for the various discrete storm events and Hurricane Irma. See 4.1 Particle Tracing Analysis for details of this analysis.

b. **Imperial River and the Kehl Canal:** Long periods of out-of-bank flooding occur along the Imperial River and the Kehl Canal for the 6 simulated discrete storm events. See Table 16 and Table 17 for a summary of maximum stages and flows, volumes, and flood durations.

c. **Citrus Park Neighborhood:** The SLC ICPR4 model flooding during Hurricane Irma in the Citrus Park neighborhood compare well with reported flood elevations there (Waldrop Engineering, 2018). The low road elevation is approximately 13 feet NAVD and extensive flooding occurs for the calibration period and all 6 discrete storm events. See 4.2.3 Citrus Park Neighborhood: PT-04 for a discussion of flooding in this neighborhood.

d. **Halfway Creek from I-75 to Via Coconut Point:** The SLC ICPR4 model indicated minimal flooding along Halfway Creek between I-75 and the large weir structure just east of Via Coconut Point. All 100yr maximum water surface elevations for B1 and B2 are either slightly lower or slightly higher than the approximate minimum road elevation of 15.3 feet NAVD88. All other simulations are below the road elevation. There appears to be excess capacity for this portion of Halfway Creek, but some improvements may be required to accommodate the additional flow from the berm/reservoir system. See 4.2.4 Halfway Creek at Three Oaks Parkway: PT-05 and 4.2.5 Halfway Creek at Weir Structure East of Via Coconut Point: PT-06 for more details.

e. **Halfway Creek at Rapallo:** Extensive street flooding in the Rapallo neighborhood from Hurricane Irma was reported by (Waldrop Engineering, 2018). It is unclear if this flooding was caused by localized drainage problems or from backwater effects of Halfway Creek or some combination of both. Regardless, taking advantage of the apparent excess capacity in Halfway Creek mentioned in item (6.d) might further impact flooding conditions in the Rapallo neighborhood. See 4.2.6 Halfway Creek at Rapallo: PT-06B for more details.

f. **Island Club at Corkscrew:** Extensive street flooding in the Island Club at Corkscrew neighborhood was reported by (Waldrop Engineering, 2018). SLC ICPR4 simulations of the calibration period compare well with the reported flooding. Also, all 6 discrete storm events cause extensive flooding in this area. Most of the water crossing I-75 from the Larry Kiker Preserve area flows through a slough located south of Island Club in a northwest direction toward the South Branch of the Estero River, exacerbating the flooding problems (see Figure 89). Impacts to this area will be important when considering the outfall system for berm and reservoir system east of I-75.

g. **Hydroperiods:** The 5-year verification period (2013-2017) was used to assess and quantify hydroperiods, which are defined by the relationship between surface inundation and time. ICPR4 includes several tools for quantifying hydroperiod. Time series charts (see Figure 93) can be used to identify wet and dry periods at specific locations. Raster charts (see Figure 94) provide a visual tool for determining seasonal variations. Stage duration curves (see Figure 95) are used to express flood elevations in terms of exceedance probabilities. ICPR4's animation tools can be used to spatially view flooded areas based on exceedance probabilities (see Figure 96).

7. There are 3 other projects of interest in the study area that were evaluated. A copy of the existing condition scenario was made in the SLC ICPR4 model and the following 3 projects of interest were added to the model. The 25- and 100-year 72-hour simulations were run to test these projects. They are summarized below. Note: these projects were not included in the 6. Assessment of Regional Berm and Reservoir System.
    a. **Corkscrew Road Culvert Upsizing and Wildlife Crossing:** Improvements to Corkscrew Road include replacing 6 existing horizontal elliptical cross drains with twin 6'x12' box culverts. A wildlife crossing is also proposed at the same location (modeled as an 8'x24' box culvert). These changes had little impact on existing conditions upstream and downstream of the proposed culvert upgrades as indicated in the water surface profiles depicted in Figure 107.
    b. **Logan Boulevard Channel:** (Lago Consulting & Services, 2019) presented several alternatives to connect the Kehl Canal at Radio Tower Road to the Logan Boulevard channel south of Bonita Beach Road and ultimately to a wetland slough and the Cocohatchee Canal farther south. Alternative L4a as described in that document was incorporated into the SLC ICPR4 model for this investigation as shown in Figure 108. The proposed improvements include a 77 cfs pump station to move water from the Bonita Beach Road canal into the Logan Boulevard channel. A 200 cfs pump station is used to move water from the Logan Boulevard channel into a wetland slough south of the channel. Although the 77 cfs pump station has some beneficial effects on the Bonita Beach Road canal, the capacity of the 200 cfs pump station is significantly diminished because of backflow from the wetland slough into the Logan Boulevard channel. This pump station might not be necessary if berm alignment B2 (see Figure 127) is adopted and constructed because higher head differentials might be adequate to force flows through the Logan Boulevard channel and into the wetland slough via gravity. However, this was not tested.
    c. **Proposed New I-75 Crossing at Bonita Springs Golf Course:** (Lago Consulting & Services, 2019) presented five (5) alternatives near the Bonita Fairways Golf Course to reduce flooding during extreme storm events like Hurricane Irma. The first, GC1, addressed local flooding issues near the Bonita Springs Golf Course. Alternatives GC2 through GC5 were mostly concerned with lowering flood elevations east of I-75 by creating a new connection across I-75. Many of the improvements west of I-75 included in these alternatives were needed to accommodate the increased and prolonged flows from east of I-75. According to (Lago Consulting & Services, 2019), alternatives G4 and G5 provide the greatest reduction in peak flood stages east of I-75, approximately 0.75 feet (at the intake structures) for Hurricane Irma conditions. Alternative GC4 was incorporated into the SLC ICPR4 model (see Figure 118). Modeling of this project produces similar

reductions in flood stages on the east side of I-75 as reported by (Lago Consulting & Services, 2019). But the radius of influence of these reductions is less than 1 mile and most of the area impacted by the reductions is inside the Larry Kiker and Hidden Cypress Preserves (see Figure 124 and Figure 125). It is unclear how these improvements might affect the hydroperiods in the preserves. This project will be an expensive undertaking and should be closely coordinated with the proposed berm and reservoir system should the City decide to move forward with it.

8. Proposed Berm Alignments (see Figure 127)
    a. Flow patterns at the southeastern corner of Lee County (see Figure 126) were examined relative to the originally proposed conceptual berm alignment. There were 2 primary concerns with that alignment:
        i. The eastern north-south leg would sever recently restored wetlands in the SFWMD Southern Corkscrew Regional Ecosystem Watershed (C.R.E.W.).
        ii. The north-south leg in item (8.a) would likely adversely change the natural flow patterns in this area and "shunt" water either into the Kehl Canal through a back door, or push more water south into Collier County than naturally occurs, or both.
    b. To mitigate the impact of item (8.a.i), the original north-south berm alignment in the Southern C.R.E.W. area was shifted to the west to mostly align with existing roadways. This is referred to as berm alignment "B1". The shifted alignment in B1 does not alleviate the concerns expressed in item (8.a.ii).
    c. To address the concerns of item (8.a.ii), a second berm alignment referred to as "B2" is proposed. This alignment follows Radio Tower Road south to Bonita Beach Road instead of paralleling the north side of the eastern half of the Kehl Canal into the SFWMD Southern C.R.E.W. Project Area. It then parallels the north side of Bonita Beach Road to the east. This alignment would involve elevating Radio Tower Road to 20 feet NAVD. Bonita Beach Road could be used as the berm if it is at or above elevation 20 feet NAVD. This captures the natural flow patterns in the southeastern corner of Lee County.
    d. The B2 alignment follows the B1 alignment between Radio Tower Road and I-75. But B2 ties into I-75 instead of paralleling it (like B1) in the Kiker Preserve area. Smaller local berms are placed at the various I-75 crossings.
    e. The B2 alignment is about 26% shorter than B1 (75,000 feet versus 101,000 feet), yet it stores about 14% more water than B1 for the 100-year 240-hour storm. Environmental impacts are significantly reduced as well.
9. Apputenant Works
    a. **Along Halfway Creek:** Project works west of I-75 were outside the scope of work for this study. However, some improvements were necessary to determine reasonable performance aspects of the proposed reservoir system. These were kept to a minimum with an emphasis on: (1) minimizing environmental impacts; (2) reducing flooding in the Island Club at Corkscrew neighborhood; and, (3) utilizing apparent excess capacity along Halfway Creek in The Brooks neighborhood. See Figure 131 for details of these improvements. Multiple iterations and optimization of these improvements were not included. The improvements west of I-75 along Halfway Creek included in the SLC ICPR4 model should be considered a starting point.

   b. **Gated Structures in Berm:** Various gated structures are proposed across both berm alignments. There are 4 gated structures proposed at the western side of the Kiker Preserve for both berm alignments (Figure 131 and Figure 132). There are also 4 gated structures for both berm alignments along the north side of the Kehl Canal (Figure 133 and Figure 134). The gates are closed during extreme events and opened only after flood levels in downstream works have subsided.

10. Assessment of Project Conditions – Project conditions for both berm alignments were compared to existing conditions for the 25- and 100-year 72-, 168-, and 240-hour storm events. Various tables of maximum stage, maximum discharge, and volumes were used for comparison purposes as well as stage and discharge hydrographs. Water surface profiles are also compared at various locations. A summary of the key points follow. Note: The 5. Other Projects of Interest were not included in the berm and reservoir system assessment.
    a. **Imperial River and the Kehl Canal:** Major reductions in flows and stages occur along the Imperial River and the Kehl Canal for both berm alignments. However, berm alignment B2 reduces flows and stages more than B1. For example, berm alignment B2 lowers the maximum stages at the upstream side of the Kehl Canal structure between 2.05 feet (100yr-72hr) and 2.75 feet (25yr-168hr) and B1 lowers them between 1.38 feet (100yr-72hr) and 1.81 feet (25yr-168hr). Both alignments result in significant reductions though. See 6.2.1 USGS Station 02291500, Imperial River: PT-02 and 6.2.2 Kehl Canal Structure (Upstream Side): PT-03 for more details.
    b. **Bonita Beach Road South Canal:** Berm alignment B1 lowers maximum water surface elevations between 0.18 feet (100yr-72hr) and 1.22 feet (25yr-168hr) in the South Canal (about 4,600 feet east of Bonita Grande Drive). Berm alignment B2 lowers the maximum stages between 0.39 feet (100yr-72hr) and 1.93 feet (25yr-168hr). The duration of elevated flood stages is also greatly reduced. *The 77 cfs pump station in the South Canal at Logan Boulevard and other improvements at Logan Boulevard being considered by the City of Bonita Springs are not included in these calculations.*

       The South Canal serves as the primary outlet for most of the developments south of Bonita Beach Road and water levels in that canal affect the hydraulics of all connection points. Therefore, the hydraulic efficiency of all hydraulic connections to the canal should also be significantly improved. See 6.2.3 Bonita Beach Road South Canal: PT-03B for further details.
    c. **Citrus Park Neighborhood:** Although some reductions in maximum water surface elevations occur for all simulations in the Citrus Park neighborhood, flooding problems are not totally alleviated. However, the duration of flooding is significantly reduced. A more detailed analysis of this neighborhood is warranted to determine if localized improvements could reduce or eliminate the flooding problems if the regional berm/reservoir system (either alignment) is adopted and constructed. See 6.2.4 Citrus Park Neighborhood: PT-04 for more details.
    d. **Halfway Creek Between I-75 and Via Coconut Point:** Increased water surface elevations for the B1 alignment range from 0.27 feet (25yr-72hr) to 1.67 feet (100yr-240hr). Alignment B2 also causes increases ranging from 0.46 feet (25yr-72hr) to 1.61 feet (100yr-240hr). B2 increases are higher than the B1 increases for all simulations except the

Summer 2017, which is slightly lower. The minimum road elevation in this area is approximately 15.3 feet NAVD. The 100yr-168hr and 100yr-240hr maximum water surface elevations for B1 and B2 are either slightly lower or slightly higher than the approximate minimum road elevation. All other simulations are below the road elevation. See 6.2.5 Halfway Creek at Three Oaks Parkway: PT-05 and 6.2.6 Halfway Creek at Weir Structure East of Via Coconut Point: PT-06 for details.

e. **Halfway Creek at Rapallo:** The minimum road elevation in the Rapllo neighborhood is approximately elevation 14.0 feet NAVD. Maximum water surface elevations for all simulations of the B1 and B2 berm alignments equal or exceed the road elevation with the single exception of the 25yr-72hr storm for B1, which is only slightly lower. Some changes/additions to the proposed works west of I-75 will be required to mitigate these impacts. See 6.2.7 Halfway Creek at Rapallo: PT-06B for more details.

f. **Island Club at Corkscrew:** The approximate minimum roadway elevation in this area is 14.6 feet NAVD. *All simulations exceed this elevation.* Reductions in the peak stages range from 0.22 feet (25yr-72hr) to 0.44 feet (100yr-168hr) for both B1 and B2. The peak stages are almost identical between B1 and B2 for all simulations. This is expected because the Island Club slough has been mostly isolated from the berm and reservoir system. The duration of flooding is greatly reduced for all simulations with the proposed berm alignments and appurtenant works. See 6.2.8 Island Club at Corkscrew: PT-07 for further details.

g. **Inside the Berm/Reservoir System:** Stage hydrographs were compared at two locations (PT-32 and PT-33) in the Kiker Preserve and one point (PT-24) about 5,000 feet north of the midpoint along the Kehl Canal. The water surfaces for berm alignment B1 are higher than B2 in the Kiker Preserve at PT-32 and about the same at PT-33. Water surfaces are higher for B2 at PT-24.

   Maximum water surface profiles for Hurricane Irma, the 25-year 240-hour storm and the 100-year 240-hour storm for flow paths A' – A and D' – D (see Figure 136 for locations of these flow paths), both in the Kiker Preserve, are shown in Figure 151 and Figure 152, respectively. The maximum water surface elevations for berm alignment B1 are higher than B2 for both flow paths. See 6.2.9 Inside the Reservoir: PT-24, PT-32, and PT-33 for details.

h. **Lee/Collier Border:** Stage hydrographs were compared at 4 locations along the Lee/Collier border: PT-09, PT-10, PT-11, and PT-12. Water surface profiles were prepared for Hurricane Irma, the 25yr-240hr, and 100yr-240hr simulations for flow paths G' – G, I' – I, K' – K, and L' – L (see Figure 136 for locations of these flow paths).

   Maximum water surface elevations increase above existing conditions for both berm alignments and for all simulations. Increases vary from 0.06 feet (25yr-72hr, B2 at PT-12) to an overall maximum of 0.49 feet (100yr-168hr, B2 at PT-09). The various water surface profiles indicate that the magnitude of increased water levels into Collier County diminish with distance away from the proposed reservoir/berm project. See 6.2.10 Lee/Collier Border: PT-09, PT-10, PT-11, and PT-12 for details.

11. Impact of Berm/Reservoir System on Hydroperiods – Existing conditions (EC), berm alignment 1 (B1), and berm alignment 2 (B2) were simulated for the 5-year verification period (2013 – 2017).

The output interval was set at 6 hours for each of these simulations providing 7,300 data points for approximately 68,000 computational nodes. These were then evaluated in probabilistic terms – the probability that a water surface elevation will be equaled or exceeded at a specific location in the study area.

a. **Larry Kiker and Hidden Cypress Preserves:** Stage Duration curves and raster charts were prepared at each of the 13 monitoring well locations (MW-01 through MW-13). Based on the stage duration curves, locations MW-2, MW-8, and MW-11 are inundated 1 to 3 months per year on average. Locations MW-1, MW-9, and MW-12 are flooded about 5 months per year on average and locations MW-3, MW-4, MW-5, MW-6, MW-7, MW-10, and MW-13 are flooded about 7.5 to 10.5 months per year on average.

   The existing condition hydroperiod is increased by B1 and B2 for all locations except MW-4. MW-4 is located on the south side (downstream side) of the proposed berm alignments. Consequently, less water reaches MW-4 on an annual basis. All other locations are on the north side (upstream side) of the berm alignments.

   Seasonal variations in flooding, including depths of flooding, caused by the berm alignments can be determined from the raster charts. See 6.4.1 Hidden Cypress and Larry Kiker Preserves for further details.

b. **Regional Berm/Reservoir System and Beyond:** Hydroperiods for the existing condition (EC), berm alignment B1, and berm alignment B2 scenarios at the thirteen reference points depicted in Figure 177 are discussed below. Further details can be found in 6.4.2 Regional Berm/Reservoir System and Beyond.

   i. **PT-22 and PT-23:** PT-22 is just east of the proposed north-south alignment of berm B1 and PT-23 is just west of it. Existing flow patterns indicate that water moves from the northeast to the southwest into the Kehl Canal. Berm alignment B1 blocks this flow pattern and shunts water to the south. Consequently, the hydroperiod is increased at PT-22 for the B1 alignment whereas the hydroperiod is reduced at PT-23 for that alignment. Berm alignment B2 allows the natural flow patterns in this area to continue. The hydroperiod at PT-22 is only slightly increased with the B2 alignment.

   ii. **PT-24, PT-25, and PT-26:** PT-24, PT-25, and PT-26 are in the SFWMD Southern Corkscrew Regional Ecosystem Watershed (C.R.E.W.) and inside the berm/reservoir extents. Hydroperiod increases occur at these three locations for both berm alignments. The increases at PT-25 are less than those at PT-24 and PT-26. Berm alignment B2 creates longer hydroperiods than B1 at these locations.

   iii. **PT-28:** PT-28 is in the berm/reservoir extents but father north in a slough. Negligible impacts occur to the hydroperiod at this location.

   iv. **PT-09, PT-10, and PT-11:** PT-09, PT-10, and PT11 are in Collier County just east of the Lee/Collier county line. The hydroperiod is increased slightly for berm alignment B1 at these locations. The hydroperiod for berm alignment B2 matches the existing condition closer.

   v. **PT-12, PT-14, PT-16, and PT-17:** PT-12 and PT-14 are located farther east in Collier County. PT16 and PT-17 are also located in Collier County south of the berm/reservoir system. PT-17 is near the proposed outfall location of the Logan

Boulevard channel. Although the hydroperiod is increased for both B1 and B2 at these locations, the increase is relatively minor.

7.2 Recommendations

1. Berm alignment B2 is 26% shorter and holds 14% more water than alignment B1. It also maintains natural flow patterns and minimizes hydroperiod impacts near the Lee/Collier county line. This is the recommended berm alignment, but it will need to be refined.
2. Berm alignments B1 and B2 split the Hidden Cypress Preserve and eliminate natural flow patterns to southern square of the preserve. These alignments follow the conceptual alignment in the Southern Lee County Flood Mitigation Plan. It is recommended that Lee County consult with an environmental scientist to determine if the berm alignment should be modified in this location to the south side of this preserve.
3. If the county decides to pursue the berm and reservoir system, it is recommended that a second phase to the work described in this report be conducted. The outfall system west of I-75 is critical to the success of the berm and reservoir system and they must be designed simultaneously.
4. It is recommended that contributions from future upstream projects, even if conceptual, be included in future SLC ICPR4 modeling efforts.
5. It is recommended that the SLC ICPR4 model be extended to Estero Bay including paths along Halfway Creek and the South Branch of the Estero River. This will expand the study area significantly, but it is important in determining far reaching downstream impacts.
6. It is recommended that an environmental scientist review the hydroperiod assessments for both berm alignments and become an integral part of any future modeling efforts with SLC ICPR4.
7. The Bonita Springs ICPR4 model west of I-75 was integrated into the SLC ICPR4 model mostly "as is". That model was developed and calibrated by others with an entirely different set of objectives and assumptions than the modeling effort for this investigation. If the SLC ICPR4 model is to be used in the future for improvements along the Imperial River west of I-75 or along Spring Creek, it is recommended that further calibration/testing be performed on that portion of the model and adjustments made as needed.
8. In addition to the conceptual projects related to the Southern Lee County Flood Mitigation Plan, other stakeholders such as the City of Bonita Springs are considering implementing water management improvements (e.g., the Logan Boulevard channel system and a new cross drain under I-75). These types of projects can have regional impacts. It is recommended that these projects be closely coordinated and incorporated into the SLC ICPR4 model.

References

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Appendix A: Land Use Names by FLUCCS Code

1100: Low Density, <2 dwelling units/acre,1100: Low Density, <2 dwelling units/acre
1110: Low Density, Fixed Single Family Units,1110: Low Density, Fixed Single Family Units
1120: Low Density, Mobile Home Units,1120: Low Density, Mobile Home Units
1130: Low Density, Mixed Units (Fixed and Mobile Home Units),1130: Low Density, Mixed Units (Fixed and Mobile Home Units)
1180: Residential, rural - one unit on 2 or more acres,1180: Residential, rural - one unit on 2 or more acres
1190: Low Density, Under Construction,1190: Low Density, Under Construction
1200: Medium Density, 2>5 dwelling units/acre,1200: Medium Density, 2>5 dwelling units/acre
1210: Medium Density, Fixed Single Family Units,1210: Medium Density, Fixed Single Family Units
1220: Medium Density, Mobile Home Units,1220: Medium Density, Mobile Home Units
1230: Medium Density, Mixed Units (Fixed and Mobile Home Units),1230: Medium Density, Mixed Units (Fixed and Mobile Home Units)
1290: Medium Density, Under Construction,1290: Medium Density, Under Construction
1300: High Density, 6 or more dwelling units/acre,1300: High Density, 6 or more dwelling units/acre
1310: High Density, Fixed Single Family Units,1310: High Density, Fixed Single Family Units
1320: High Density, Mobile Home Units,1320: High Density, Mobile Home Units
1330: High Density, Multiple Dwelling Units, Low Rise,1330: High Density, Multiple Dwelling Units, Low Rise
1340: High Density, Multiple Dwelling Units, High Rise,1340: High Density, Multiple Dwelling Units, High Rise
1350: High Density, Mixed Units (Fixed and Mobile Home Units),1350: High Density, Mixed Units (Fixed and Mobile Home Units)
1390: High Density, Under Construction,1390: High Density, Under Construction
1400: Commercial and Services,1400: Commercial and Services
1411: Shopping Centers,1411: Shopping Centers
1423: Junk Yards,1423: Junk Yards
1460: Oil and Gas Storage,1460: Oil and Gas Storage
1480: Cemeteries,1480: Cemeteries
1490: Commercial and Services Under Construction,1490: Commercial and Services Under Construction
1540: Oil and Gas Processing,1540: Oil and Gas Processing
1550: Other Light Industrial,1550: Other Light Industrial
1560: Other Heavy Industrial (Ship Repair, Ship Building, Large Lumber Mills),1560: Other Heavy Industrial (Ship Repair, Ship Building, Large Lumber Mills)
1610: Strip mines,1610: Strip mines
1620: Sand and Gravel Pits,1620: Sand and Gravel Pits
1630: Rock Quarries,1630: Rock Quarries
1640: Oil and Gas Fields,1640: Oil and Gas Fields
1650: Reclaimed Lands,1650: Reclaimed Lands
1660: Holding Ponds,1660: Holding Ponds
1670: Abandoned Mining Lands,1670: Abandoned Mining Lands
1700: Institutional,1700: Institutional
1710: Educational Facilities,1710: Educational Facilities
1760: Correctional,1760: Correctional
1800: Recreational,1800: Recreational
1810: Swimming Beach,1810: Swimming Beach

1820: Golf Courses,1820: Golf Courses
1830: Race Tracks,1830: Race Tracks
1840: Marina's and Fish Camps,1840: Marina's and Fish Camps
1850: Parks and Zoos,1850: Parks and Zoos
1870: Stadiums - facilities not associated with High Schools, Colleges, or Universities,1870: Stadiums - facilities not associated with High Schools, Colleges, or Universities
1900: Open Land (Urban),1900: Open Land (Urban)
1920: Inactive Land with Street Pattern,1920: Inactive Land with Street Pattern
2100: Cropland and Pastureland,2100: Cropland and Pastureland
2110: Improved Pastures,2110: Improved Pastures
2120: Unimproved Pastures,2120: Unimproved Pastures
2130: Woodland Pastures,2130: Woodland Pastures
2140: Row Crops,2140: Row Crops
2150: Field Crops,2150: Field Crops
2156: Sugar Cane,2156: Sugar Cane
2160: Mixed Crops,2160: Mixed Crops
2210: Citrus Groves,2210: Citrus Groves
2230: Other Groves (Pecan, Avocado, Coconut, Mango, etc),2230: Other Groves (Pecan, Avocado, Coconut, Mango, etc)
2240: Abandoned Tree Crops,2240: Abandoned Tree Crops
2320: Poultry Feeding Operations,2320: Poultry Feeding Operations
2410: Tree Nurseries,2410: Tree Nurseries
2420: Sod Farms,2420: Sod Farms
2430: Ornamentals,2430: Ornamentals
2500: Specialty Farms,2500: Specialty Farms
2510: Horse Farms,2510: Horse Farms
2520: Dairies,2520: Dairies
2540: Aquaculture,2540: Aquaculture
2600: Other Open Lands (Rural),2600: Other Open Lands (Rural)
2610: Fallow Cropland,2610: Fallow Cropland
3100: Herbaceous (Dry Prairie),3100: Herbaceous (Dry Prairie)
3200: Shrub and Brushland,3200: Shrub and Brushland
3210: Palmetto Prairies,3210: Palmetto Prairies
3220: Coastal Scrub,3220: Coastal Scrub
3300: Mixed Upland Nonforested,3300: Mixed Upland Nonforested
4110: Pine Flatwoods,4110: Pine Flatwoods
4130: Sand Pine,4130: Sand Pine
4200: Upland Hardwood Forests,4200: Upland Hardwood Forests
4220: Brazilian Pepper,4220: Brazilian Pepper
4240: Melaleuca,4240: Melaleuca
4270: Live Oak,4270: Live Oak
4271: Oak - Cabbage Palm Forests,4271: Oak - Cabbage Palm Forests
4280: Cabbage Palm,4280: Cabbage Palm
4340: Upland Mixed - Coniferous / Hardwood,4340: Upland Mixed - Coniferous / Hardwood
4370: Australian Pine,4370: Australian Pine
4410: Coniferous Plantations,4410: Coniferous Plantations
4430: Forest Regeneration Areas,4430: Forest Regeneration Areas

5110: Natural River, Stream, Waterway,5110: Natural River, Stream, Waterway
5120: Channelized Waterway,5120: Channelized Waterway
5200: Lakes,5200: Lakes
5300: Reservoirs,5300: Reservoirs
5400: Bays and Estuaries,5400: Bays and Estuaries
5410: Embayments Opening Directly to Gulf or Ocean,5410: Embayments Opening Directly to Gulf or Ocean
5420: Embayments Not Opening Directly to Gulf or Ocean,5420: Embayments Not Opening Directly to Gulf or Ocean
5430: Saltwater Ponds,5430: Saltwater Ponds
5720: Gulf of Mexico,5720: Gulf of Mexico
6100: Wetland Hardwoods Forests,6100: Wetland Hardwoods Forests
6110: Bay Swamps,6110: Bay Swamps
6111: Bayhead,6111: Bayhead
6120: Mangrove Swamps,6120: Mangrove Swamps
6150: Stream and Lake Swamps (bottomland),6150: Stream and Lake Swamps (bottomland)
6170: Mixed Wetland Hardwoods,6170: Mixed Wetland Hardwoods
6172: Mixed Shrubs,6172: Mixed Shrubs
6180: Cabbage Palms,6180: Cabbage Palms
6191: Wet Melaleuca,6191: Wet Melaleuca
6200: Wetland Coniferous Forests,6200: Wetland Coniferous Forests
6210: Cypress,6210: Cypress
6215: Cypress- Domes/Heads,6215: Cypress- Domes/Heads
6216: Cypress - Mixed Hardwoods,6216: Cypress - Mixed Hardwoods
6240: Cypress - Pine - Cabbage Palm,6240: Cypress - Pine - Cabbage Palm
6250: Hydric Pine Flatwoods,6250: Hydric Pine Flatwoods
6300: Wetland Forested Mixed,6300: Wetland Forested Mixed
6410: Freshwater Marshes,6410: Freshwater Marshes
6411: Freshwater Marshes - Sawgrass,6411: Freshwater Marshes - Sawgrass
6420: Saltwater Marshes,6420: Saltwater Marshes
6430: Wet Prairies,6430: Wet Prairies
6440: Emergent Aquatic Vegetation,6440: Emergent Aquatic Vegetation
6510: Tidal Flats,6510: Tidal Flats
6600: Salt Flats,6600: Salt Flats
7400: Disturbed Lands,7400: Disturbed Lands
7430: Spoil Areas,7430: Spoil Areas
7470: Dikes and Levees,7470: Dikes and Levees
8100: Transportation,8100: Transportation
8110: Airports,8110: Airports
8113: Private Airports,8113: Private Airports
8115: Grass Airports,8115: Grass Airports
8120: Railroads,8120: Railroads
8140: Roads and Highways,8140: Roads and Highways
8200: Communications,8200: Communications
8300: Utilities,8300: Utilities
8310: Electric Power Facilities,8310: Electric Power Facilities
8320: Electrical Power Transmission Lines,8320: Electrical Power Transmission Lines

8330: Water Supply Plants (Including pumping stations),8330: Water Supply Plants (Including pumping stations)
8340: Sewage Treatment,8340: Sewage Treatment
8350: Solid Waste Disposal,8350: Solid Waste Disposal

Appendix B: Soil Name by NRCS MUKEY Unique Soil Identifier

1151405	Boca sand
1151406	Pineda sand, limestone substratum
1151407	Oldsmar sand, 0 to 2 percent slopes
1151408	Wabasso sand, 0 to 2 percent slopes
1151409	Immokalee sand, 0 to 2 percent slopes
1151410	Malabar sand, 0 to 2 percent slopes
1151411	Riviera fine sand, 0 to 2 percent slopes
1151412	Pineda-Pineda, wet, fine sand, 0 to 2 percent slopes
1151413	Winder fine sand, 0 to 2 percent slopes
1151414	Gentry fine sand, depressional
1151415	Wabasso sand, limestone substratum, 0 to 2 percent slopes
1151416	Myakka sand, 0 to 2 percent slopes
1151417	Basinger sand, 0 to 2 percent slopes
1151418	Pompano sand, 0 to 2 percent slopes
1151419	Gator muck, frequently ponded, 0 to 1 percent slopes
1151420	Okeelanta muck
1151421	Holopaw sand, 0 to 2 percent slopes
1151422	Valkaria sand
1151423	Hallandale sand, 0 to 2 percent slopes
1151424	Pomello fine sand, 0 to 5 percent slopes
1151425	Holopaw sand, limestone substratum
1151426	Riviera sand, limestone substratum
1151427	Boca sand, depressional
1151428	Oldsmar sand, limestone substratum
1151429	Riviera sand, frequently ponded, 0 to 1 percent slopes
1151430	Holopaw sand, frequently ponded, 0 to 1 percent slopes
1151431	Chobee fine sandy loam, limestone substratum, depressional
1151432	Tuscawilla fine sand
1151434	Riviera sand, limestone substratum, depressional
1151435	Jupiter fine sand, 0 to 2 percent slopes
1151436	Pahokee muck, drained, 0 to 1 percent slopes
1151438	Aquents, organic substratum
1151439	Delray sand, depressional
1151440	Malabar fine sand, high, 0 to 2 percent slopes
1151442	Terra Ceia muck, frequently ponded, 0 to 1 percent slopes
1151443	Chobee fine sandy loam, frequently ponded, 0 to 1 percent slopes
1151444	Oldsmar sand, depressional
1151445	Winder fine sand, frequently ponded, 0 to 1 percent slopes
1151446	Myakka sand, depressional
1151447	Malabar sand, frequently ponded, 0 to 1 percent slopes
1151448	Pineda sand, depressional
1151450	Hallandale sand, depressional

1151458 Water
1413456 Malabar fine sand, 0 to 2 percent slopes
1413459 Immokalee fine sand, 0 to 2 percent slopes
1413460 Myakka fine sand, 0 to 2 percent slopes
1413462 Hallandale fine sand, 0 to 2 percent slopes
1413463 Pineda fine sand, limestone substratum, 0 to 2 percent slopes
1413464 Pomello fine sand, 0 to 2 percent slopes
1413465 Oldsmar fine sand, 0 to 2 percent slopes
1413466 Basinger fine sand, 0 to 2 percent slopes
1413469 Boca fine sand, 0 to 2 percent slopes
1413470 Chobee, Winder, and Gator soils, depressional
1413472 Boca, Riviera, limestone substratum, and Copeland fine sands, depressional
1413473 Holopaw fine sand, 0 to 2 percent slopes
1413475 Wabasso fine sand, 0 to 2 percent slopes
1413476 Hilolo, Jupiter, and Margate fine sands
1413477 Urban land, 0 to 2 percent slopes
1413478 Urban land-Holopaw-Basinger complex
1413479 Urban land-Immokalee-Oldsmar, limestone substratum, complex
1413480 Urban land-Aquents complex, organic substratum
1413481 Udorthents, shaped
1413482 Tuscawilla fine sand
1413483 Urban land-Matlacha-Boca complex
1413484 Satellite fine sand, 0 to 2 percent slopes
1413485 Durbin and Wulfert mucks, frequently flooded
1413486 Urban land-Satellite complex
1413487 Canaveral-Beaches complex
1413488 Winder, Riviera, limestone substratum, and Chobee soils, depressional
1413489 Paola fine sand, gently rolling
1413490 Pennsuco silt loam
1413492 Ochopee fine sandy loam, low
1413493 Ochopee fine sandy loam
1413494 Kesson muck, frequently flooded
1413495 Estero and Peckish soils, frequently flooded
1413496 Jupiter-Boca complex
1413497 Basinger fine sand, occasionally flooded
1413499 Waters of the Gulf of Mexico
1413500 Water
1483406 Pompano fine sand, 0 to 2 percent slopes
1483407 Waters of the Gulf of Mexico
1483408 Myakka fine sand, 0 to 2 percent slopes
1483409 Felda fine sand, 0 to 2 percent slopes
1483410 Boca fine sand, 0 to 2 percent slopes
1483411 Valkaria fine sand, 0 to 2 percent slopes
1483416 Gator muck, frequently ponded, 0 to 1 percent slopes

1483417	Canaveral fine sand, 0 to 2 percent slopes
1483419	Beaches
1483423	Pineda-Pineda, wet, fine sand, 0 to 2 percent slopes
1483424	Pompano fine sand, frequently ponded, 0 to 1 percent slopes
1483425	Immokalee sand, 0 to 2 percent slopes
1483427	Oldsmar sand, 0 to 2 percent slopes
1483428	Malabar fine sand, 0 to 2 percent slopes
1483429	Wabasso sand, 0 to 2 percent slopes
1483431	Satellite fine sand, 0 to 2 percent slopes
1483435	Anclote sand, frequently ponded, 0 to 1 percent slopes
1483437	Wabasso sand, limestone substratum, 0 to 2 percent slopes
1483438	Smyrna fine sand, 0 to 2 percent slopes
1483439	Malabar fine sand, frequently ponded, 0 to 1 percent slopes
1483442	Felda fine sand, frequently ponded, 0 to 1 percent slopes
1483445	Floridana sand, frequently ponded, 0 to 2 percent slopes
1483446	Myakka fine sand, frequently ponded, 0 to 1 percent slopes
1483450	Urban land, 0 to 2 percent slopes
1483451	Hallandale fine sand, wet, 0 to 2 percent slopes
1483454	Malabar fine sand, high, 0 to 2 percent slopes
1483458	Matlacha gravelly fine sand, 0 to 2 percent slopes
1483461	Bradenton fine sand, 0 to 2 percent slopes
1483462	Pineda fine sand, frequently ponded, 0 to 1 percent slopes
1483466	Pineda fine sand, limestone substratum, 0 to 2 percent slopes
1483469	EauGallie sand, 0 to 2 percent slopes
1483470	Water
3045908	Holopaw-Okeelanta, frequently ponded, assocaition, 0 to 1 percent slopes
3045922	Holopaw fine sand, limestone substratum, 0 to 2 percent slopes
3045923	Chobee, limestone substratum-Dania, frequently ponded, assocaition, 0 to 1 percent slopes
3045924	Riviera, limestone substratum-Copeland fine sand association, 0 to 2 percent slopes
3045925	Riviera fine sand, limestone substratum, 0 to 2 percent slopes
3045926	Ft. Drum-Malabar, high association, 0 to 2 percent slopes
3045927	Pineda-Riviera fine sands association, 0 to 2 percent slopes
3045928	Hallandale-Boca fine sands association, 0 to 2 percent slopes
3102831	Boca fine sand, tidal, 0 to 1 percent slopes
3102832	Canaveral fine sand-Urban land complex, 0 to 2 percent slopes
3102834	Captiva fine sand, frequently ponded, 0 to 1 percent slopes
3102835	Captiva fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102837	Cocoa fine sand-Urban land complex, 0 to 2 percent slopes
3102838	Cocoa fine sand, 0 to 2 percent slopes
3102839	Copeland fine sandy loam, frequently ponded, 0 to 1 percent slopes
3102841	Copeland fine sandy loam, ponded-Urban land complex, 0 to 1 percent slopes
3102843	Daytona sand-Urban land complex, 0 to 5 percent slopes
3102844	Daytona sand, 0 to 5 percent slopes

3102845	EauGallie sand-Urban land complex, 0 to 2 percent slopes
3102847	Electra fine sand-Urban land complex, 0 to 2 percent slopes
3102848	Electra fine sand, 0 to 2 percent slopes
3102850	Estero muck, tidal-Urban land complex, 0 to 1 percent slopes
3102851	Estero muck, tidal, 0 to 1 percent slopes
3102852	Felda fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102853	Felda fine sand-Urban land complex, 0 to 2 percent slopes
3102854	Floridana sand, ponded-Urban land complex, 0 to 1 percent slopes
3102857	Hallandale fine sand, wet-Urban land complex, 0 to 2 percent slopes
3102858	Hallandale fine sand, tidal, 0 to 2 percent slopes
3102861	Heights fine sand, 0 to 2 percent slopes
3102864	Isles fine sand, 0 to 1 percent slopes, frequently flooded
3102867	Isles fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102868	Isles muck, tidal-Urban land complex, 0 to 1 percent slopes
3102869	Isles muck, tidal, 0 to 1 percent slopes
3102870	Isles fine sand, frequently ponded, 0 to 1 percent slopes
3102872	Kesson fine sand, tidal-Urban land complex, 0 to 1 percent slopes
3102873	Malabar fine sand-Urban land complex, 0 to 2 percent slopes
3102874	Malabar fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102875	Malabar fine sand, high-Urban land complex, 0 to 2 percent slopes
3102876	Kesson fine sand, tidal, 0 to 1 percent slopes
3102878	Matlacha gravelly fine sand-Urban land complex, 0 to 2 percent slopes
3102879	Matlacha gravelly fine sand, limestone substratum-Urban land complex, 0 to 2 percent slopes
3102880	Myakka fine sand-Urban land complex, 0 to 2 percent slopes
3102881	Myakka fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102882	Matlacha gravelly fine sand, limestone substratum, 0 to 2 perent slopes
3102883	Oldsmar fine sand, limestone substratum, 0 to 1 percent slopes
3102885	Oldsmar fine sand, limestone substratum, 0 to 1 percent slopes
3102887	Oldsmar fine sand, limestone substratum-Urban land complex, 0 to 2 percent slopes
3102888	Oldsmar sand-Urban land, 0 to 2 percent slopes
3102889	Orsino fine sand-Urban land complex, 0 to 5 percent slopes
3102890	Orsino fine sand, 0 to 5 percent slopes
3102893	Peckish mucky fine sand, tidal-Urban land complex, 0 to 1 percent slopes
3102894	Pineda fine sand-Urban land complex, 0 to 2 percent slopes
3102895	Pineda fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102896	Peckish mucky fine sand, tidal, 0 to 1 percent slopes
3102898	Pompano fine sand-Urban land compex, 0 to 2 percent slopes
3102899	Pompano fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102902	Punta fine sand-Urban land complex, 0 to 2 percent slopes
3102903	Punta fine sand, 0 to 2 percent slopes
3102906	Satellite fine sand-Urban land complex, 0 to 2 percent slopes
3102907	Smyrna fine sand-Urban land complex, 0 to 2 percent slopes
3102908	St. Augustine sand-Urban land complex, 0 to 2 percent slopes

3102909 St. Augustine sand, 0 to 2 percent slopes
3102910 St. Augustine, organic substratum-Urban land complex, 0 to 2 percent slopes
3102912 Valkaria fine sand-Urban land complex, 0 to 2 percent slopes
3102913 Wabasso sand-Urban land complex, 0 to 2 percent slopes
3102914 Wabasso sand, limestone substratum-Urban land complex, 0 to 2 percent slopes
3102916 Wulfert muck, tidal, 0 to 1 percent slopes
3102918 Wulfert muck, tidal-Urban land complex, 0 to 1 percent slopes
3102920 Winder sand, frequently ponded, 0 to 1 percent slopes
3102923 Winder sand, ponded-Urban land complex, 0 to 1 percent slopes
3102934 Terra Ceia muck, frequently ponded, 0 to 1 percent slopes
3102935 Terra Ceia muck, ponded-Urban land complex, 0 to 1 percent sloeps
3102936 Boca fine sand, slough, 0 to 1 percent slopes
3102937 Boca fine sand, slough-Urban land complex, 0 to 1 percent slopes
3102938 Caloosa fine sand-Urban land complex, 0 to 2 percent slopes
3102940 Caloosa fine sand, 0 to 2 percent slopes
3102941 Bradenton fine sand-Urban land complex, 0 to 2 percent slopes
3102942 Gator muck, ponded-Urban land complex, 0 to 1 percent slopes
3102943 Hallandale fine sand, slough, 0 to 1 percent slopes
3102944 Hallandale fine sand, slough-Urban land complex, 0 to 1 percent slopes
3102947 Valkaria fine sand, frequently ponded, 0 to 1 percent slopes
3102948 Valkaria fine sand, ponded-Urban land complex, 0 to 1 percent slopes
3102949 Anclote sand, ponded-Urban land complex, 0 to 1 percent slopes
3102950 Boca fine sand-Urban land complex, 0 to 2 percent slopes
3102951 Boca fine sand, tidal-Urban land complex, 0 to 2 percent slopes
3102952 Immokalee sand-Urban land complex, 0 to 2 percent slopes
3102953 Pineda fine sand, limestone substratum-Urban land complex, 0 to 2 percent slopes

4.4 5-Year and 10-Year Events

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BACKGROUND

As part of Task 3.3.6 – Simulation of Design Storms and Flood Risk Areas Identification, the 10-year 24-hour and 5-year 24-hour events were to be simulated for both existing and proposed conditions. This report summarizes the results of the analysis, including the hydraulic grade line for existing maximum water elevations vs. proposed maximum water elevations in the each of the Study Areas: East Lee County (Study Area 1.1), Southeast Lee County (Study Area 1.3), and South Ft. Myers / Whiskey Creek (Study Area 1.4).

RAINFALL DISTRIBUTION

Since 5- and 10-year storms are lower intensity, they were run with a shorter 2-week simulation period of 8/24/2017 through 9/6/2017. In addition, measured daily tidal stages were used as boundary conditions at tidal boundaries and for upper saturated zone layers along the coast. Whereas the 25-year 3-day and 100-year 3-day design storms used modified tidal stages that align with the Irma storm surge event, no storm surge is assumed for the smaller design storms.

The rainfall amount for 10-year 24-hour is 6", and for the 5-year 24-hour the rainfall amount is 5". The rainfall over the 24 hours can be seen in **Figure 1**, and how it compares to the 25-year 72-hour and 100-year 72-hour events in **Figure 2**.

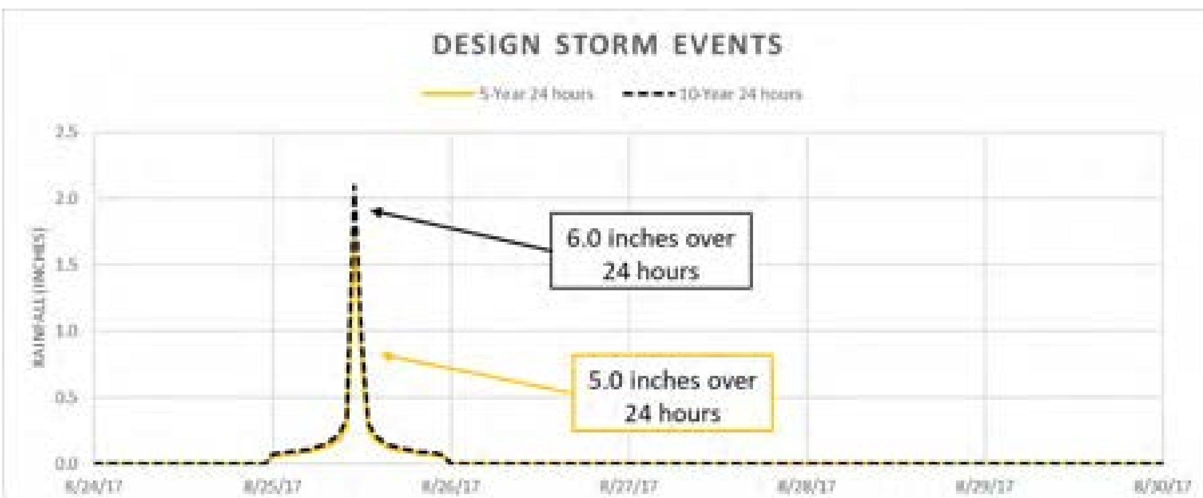

Figure 1. Rainfall Distribution for 5-year 24-hour and 10-year 24-hour events

Figure 2. Rainfall Distribution for 25-year 72-hour and 100-year 72-hour events

MODEL RESULTS

The following simulations were run:

<u>2017 Conditions</u>:

- Existing Conditions
- Proposed 1.1 Project Conditions (5-year 24-hour)
- Proposed 1.3 Project Conditions (5-year 24-hour)
- Proposed 1.4 Project Conditions (5 year 24-hour)
- Proposed 1.1 Project Conditions (10-year 24-hour)
- Proposed 1.3 Project Conditions (10-year 24-hour)
- Proposed 1.4 Project Conditions (10-year 24-hour)

EAST LEE COUNTY (STUDY AREA 1.1)

The following schematics show the results of both the 5-year 24-hour and 10-year 24-hour events for Study Area 1.1.

5-year 24-hour Design Storm Results

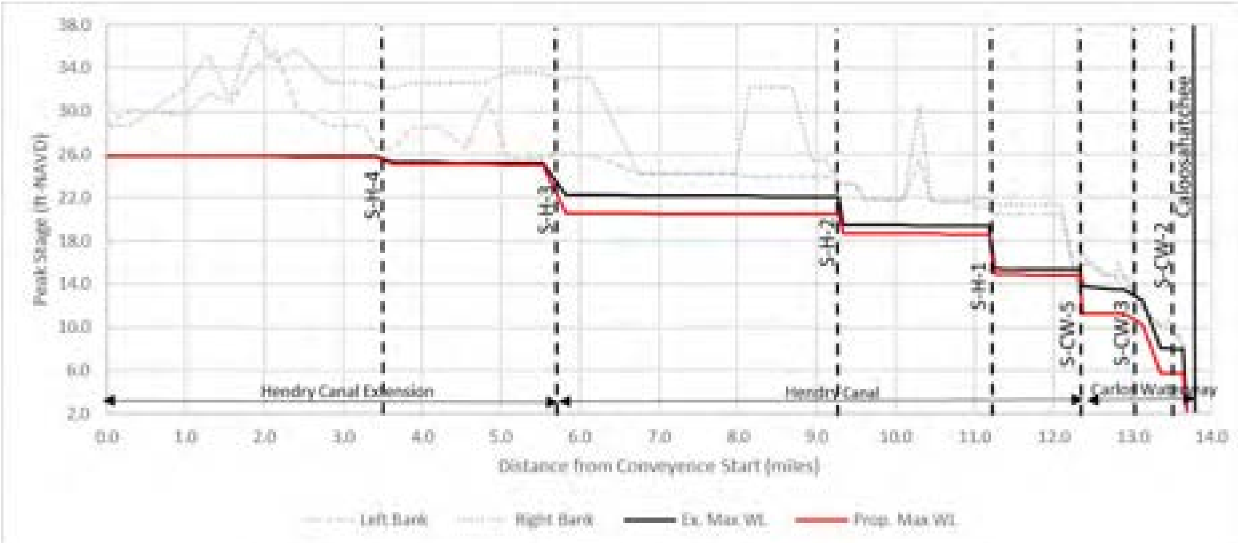

Figure 3. Peak Stages during the 5-yr Design Storm within Hendry Canal and Carlos Waterway

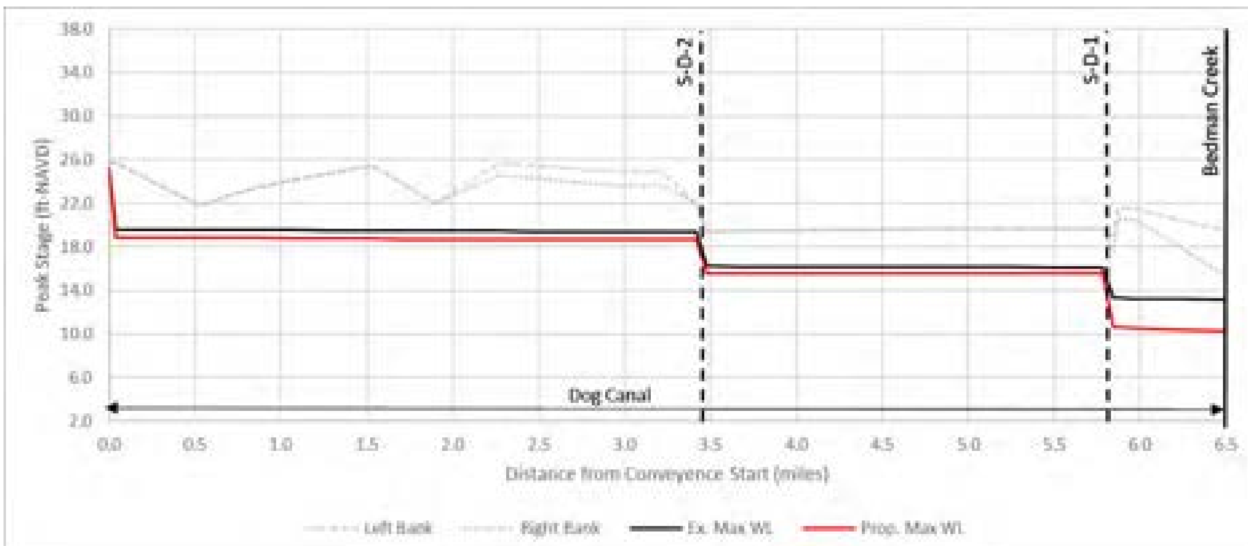

Figure 4. Peak Stages during the 5-yr Design Storm within Dog Canal

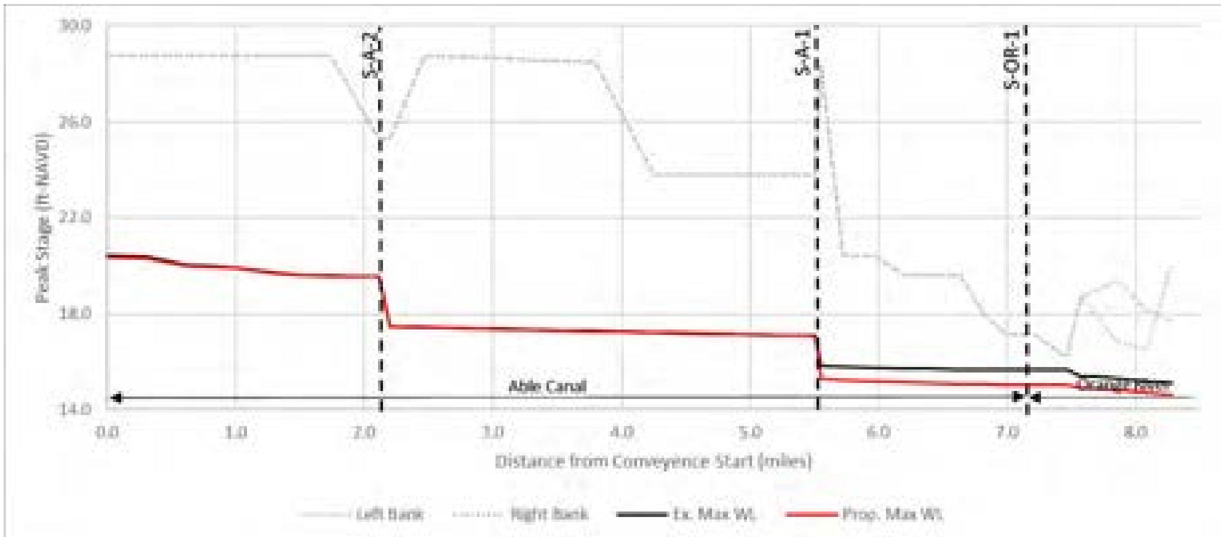

Figure 5. Peak Stages during the 5-yr Design Storm within Able Canal

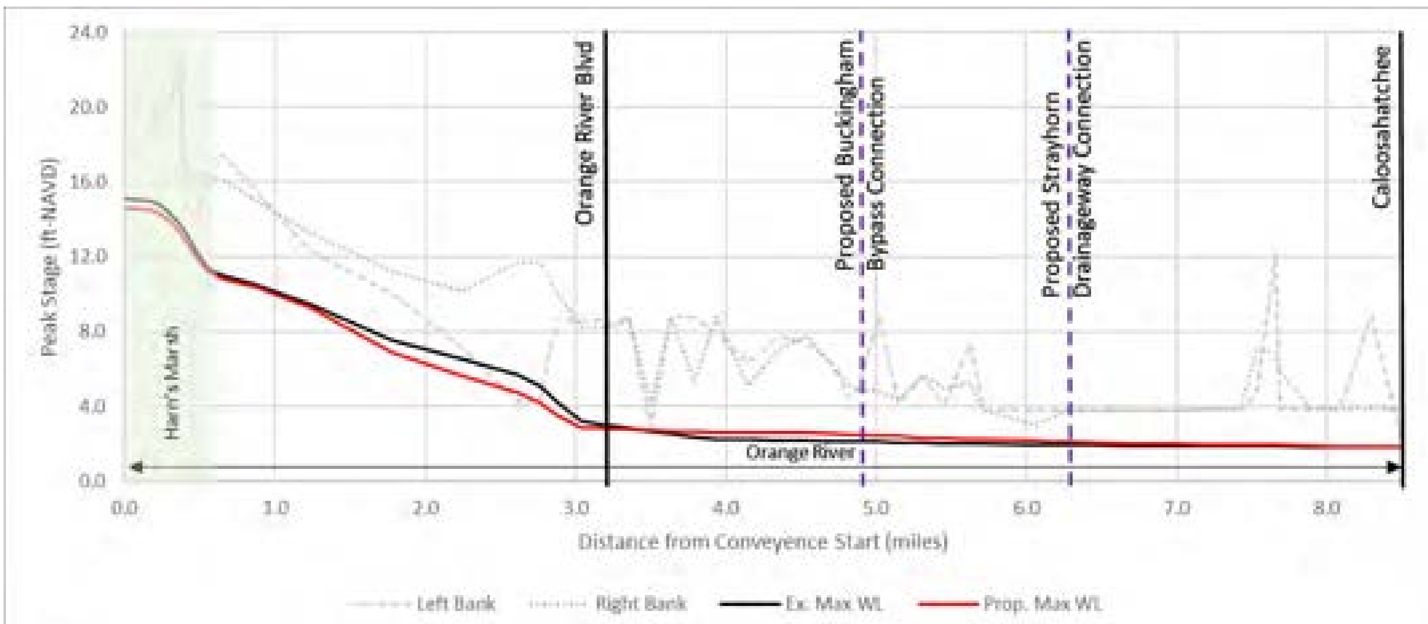

Figure 6. Peak Stages during the 5-yr Design Storm within Orange River

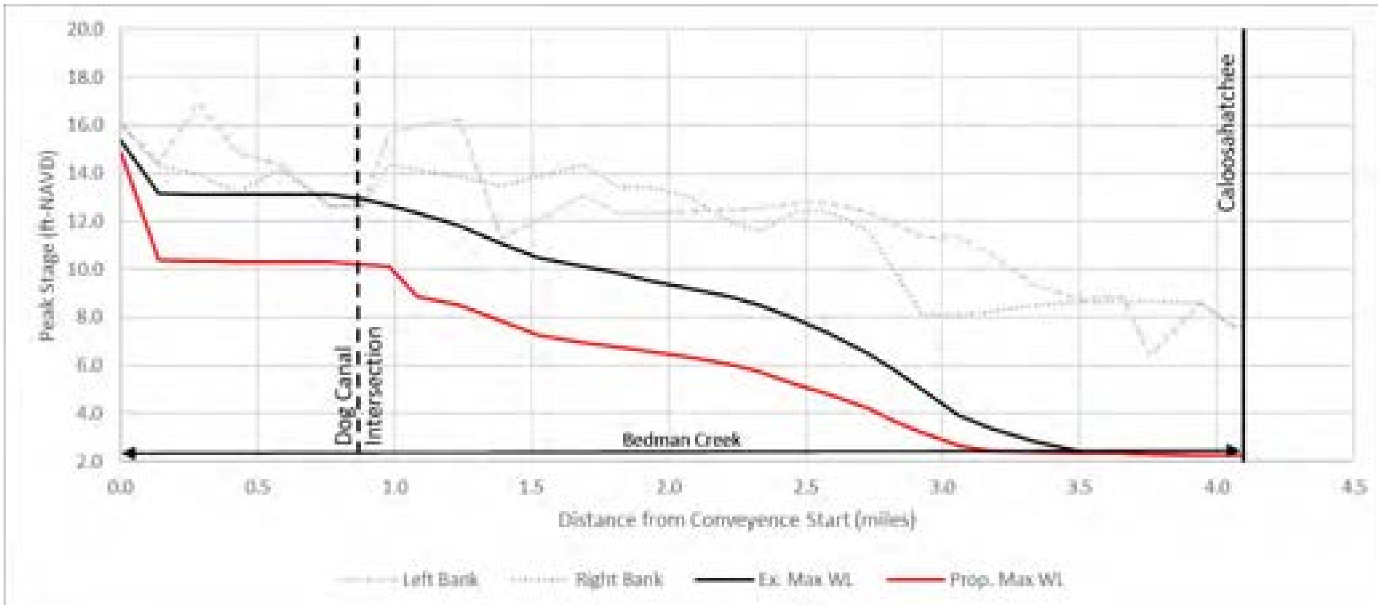

Figure 7. Peak Stages during the 5-yr Design Storm within Bedman Creek

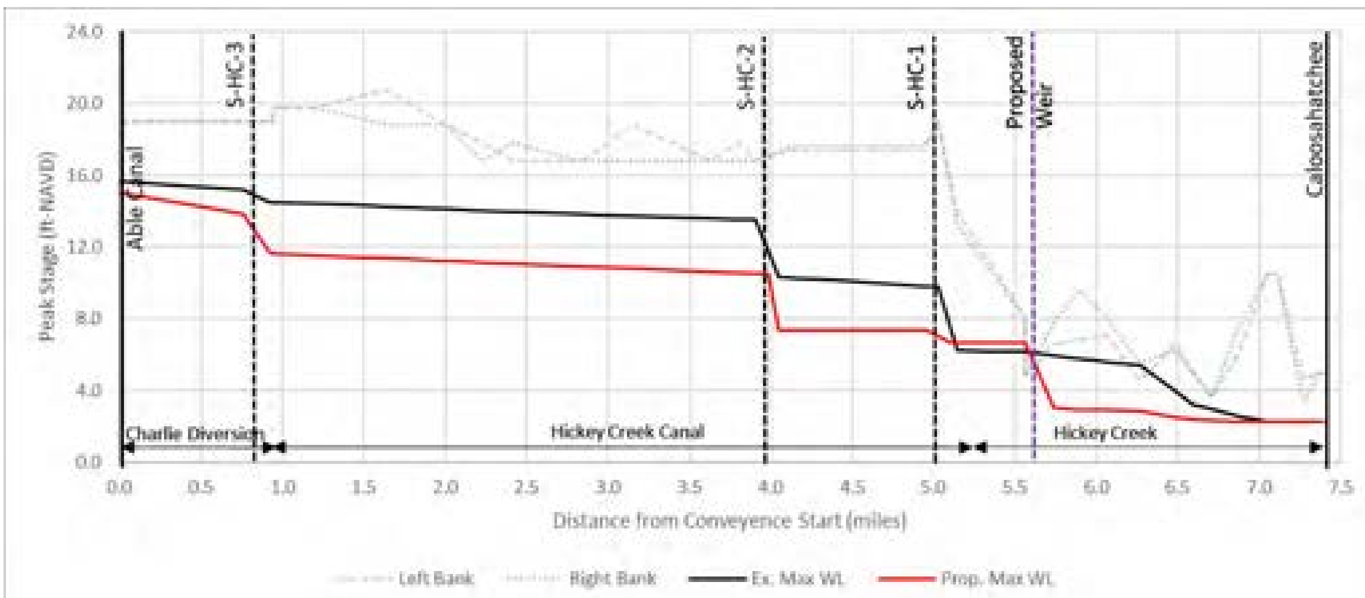

Figure 8. Peak Stages during the 5-yr Design Storm within Hickey's Creek

10-year 24-hour Design Storm Results

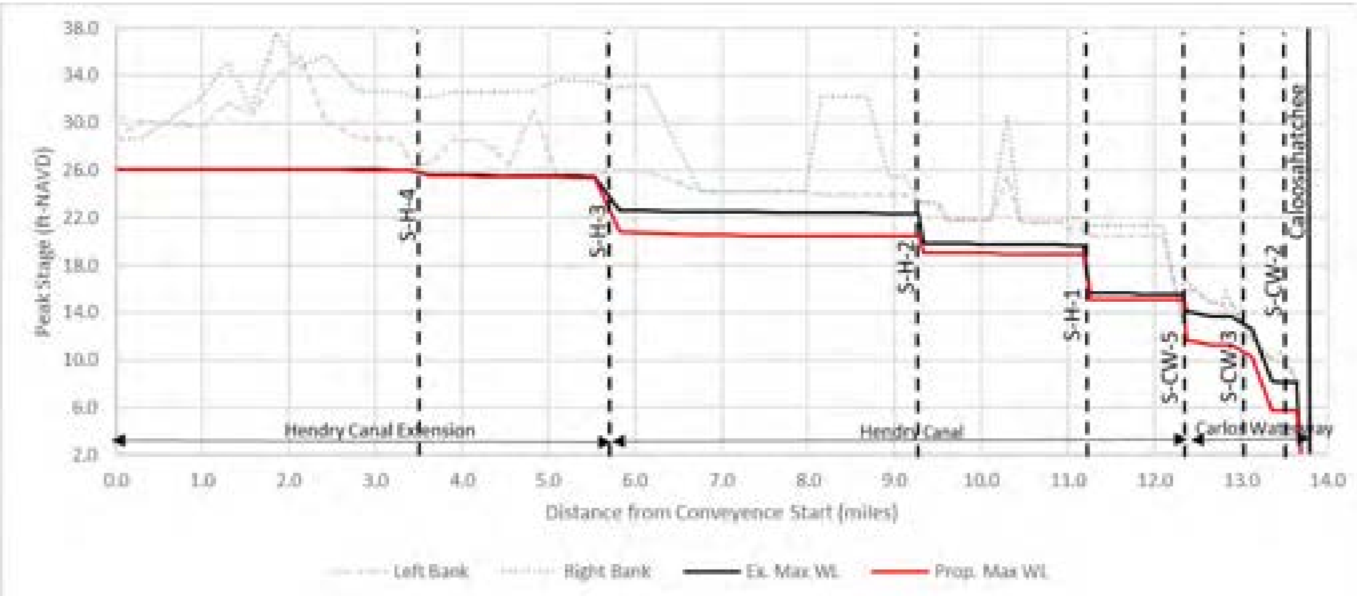

Figure 9. Peak Stages during the 10-yr Design Storm within Hendry Canal and Carlos Waterway

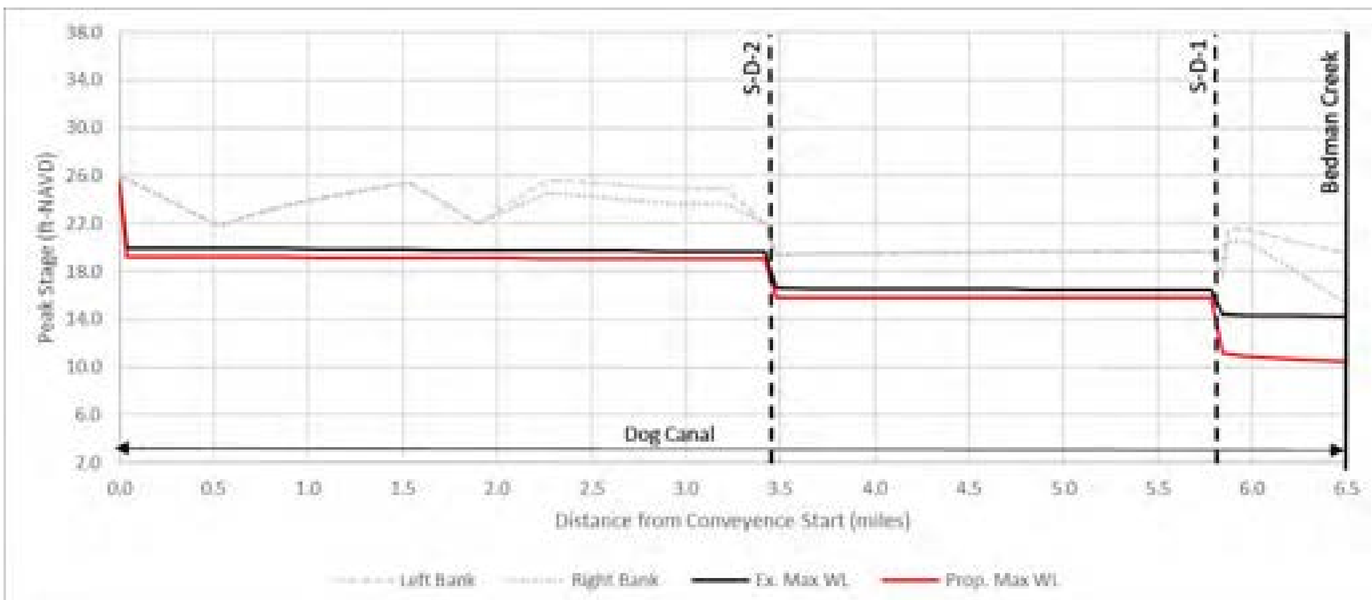

Figure 10. Peak Stages during 10-yr Design Storm within Dog Canal

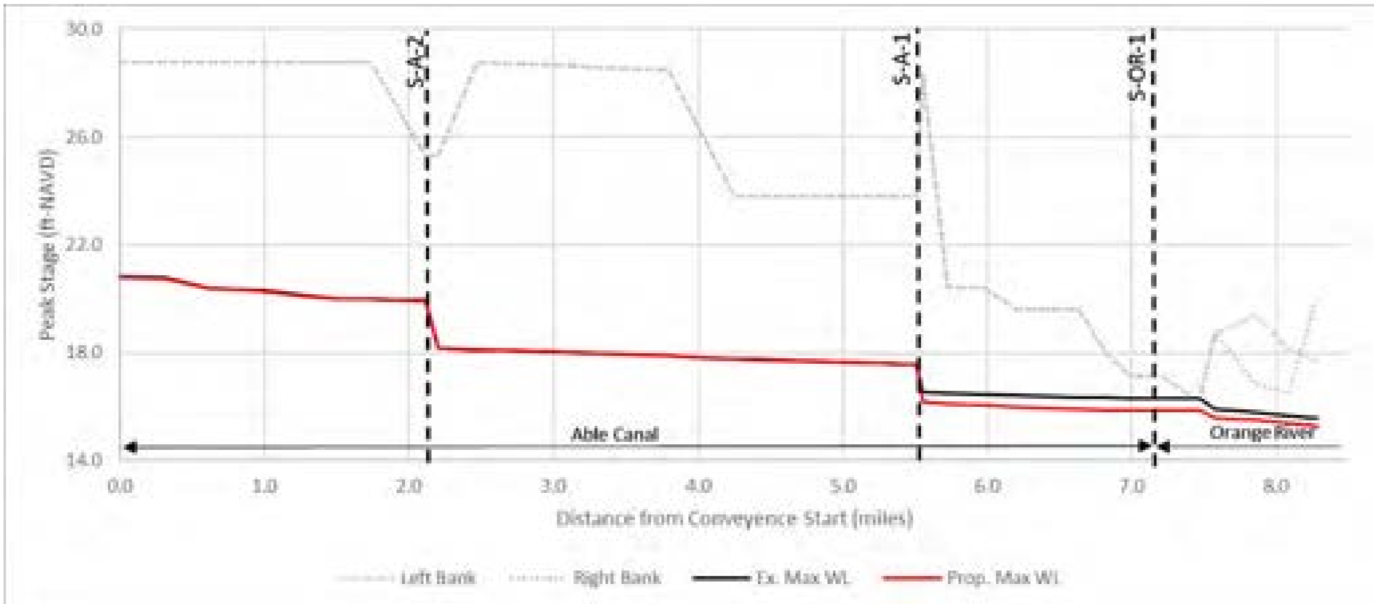

Figure 11. Peak Stages during 10-yr Design Storm within Able Canal

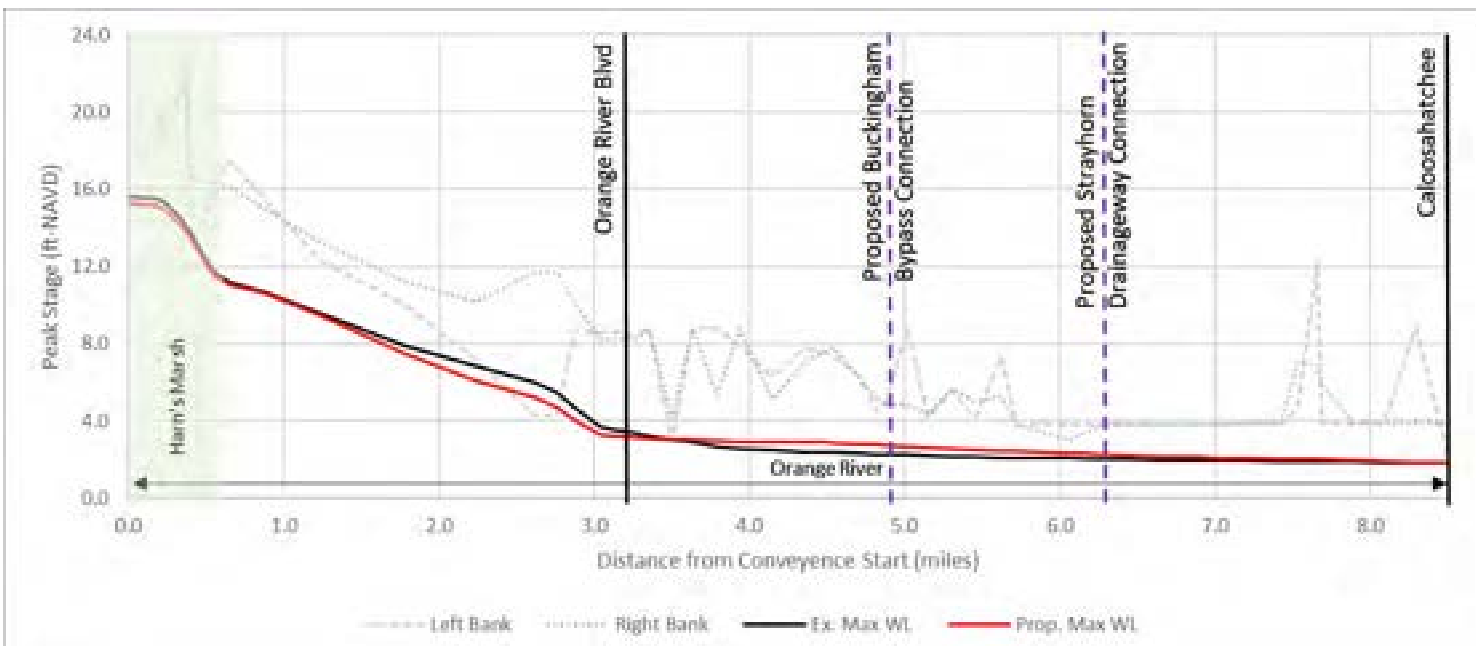

Figure 12. Peak Stages during 10-yr Design Storm within Orange River

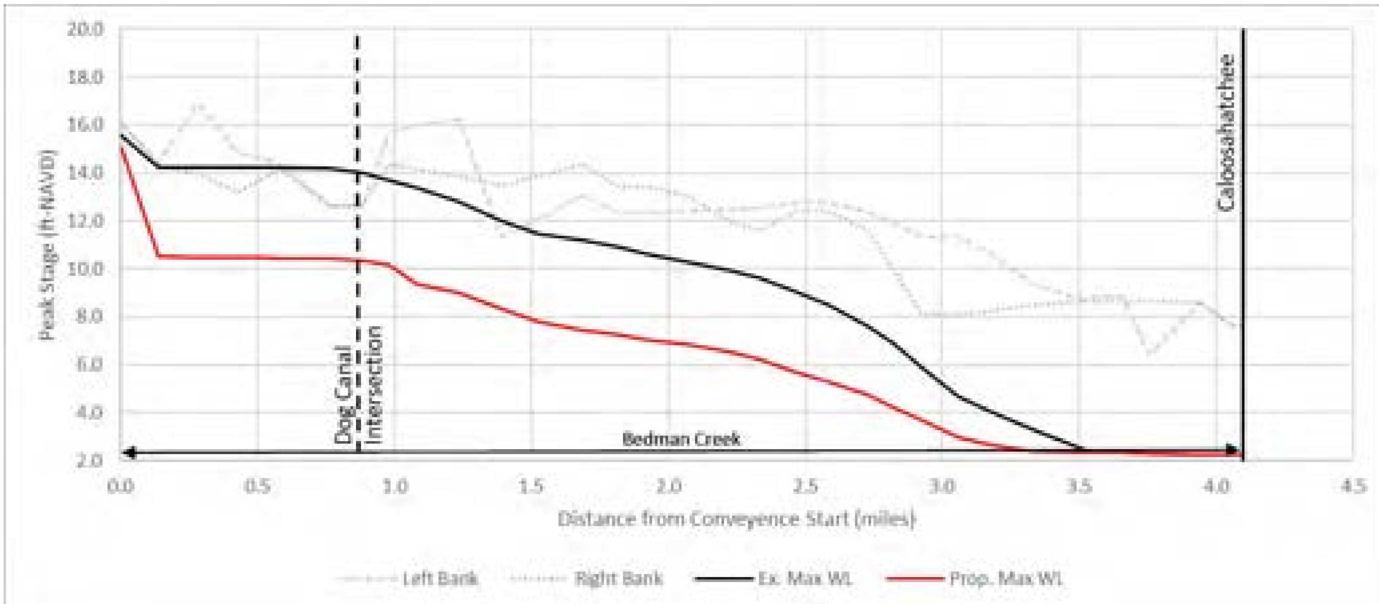

Figure 13. Peak Stages during 10-yr. Design Storm within Bedman Creek

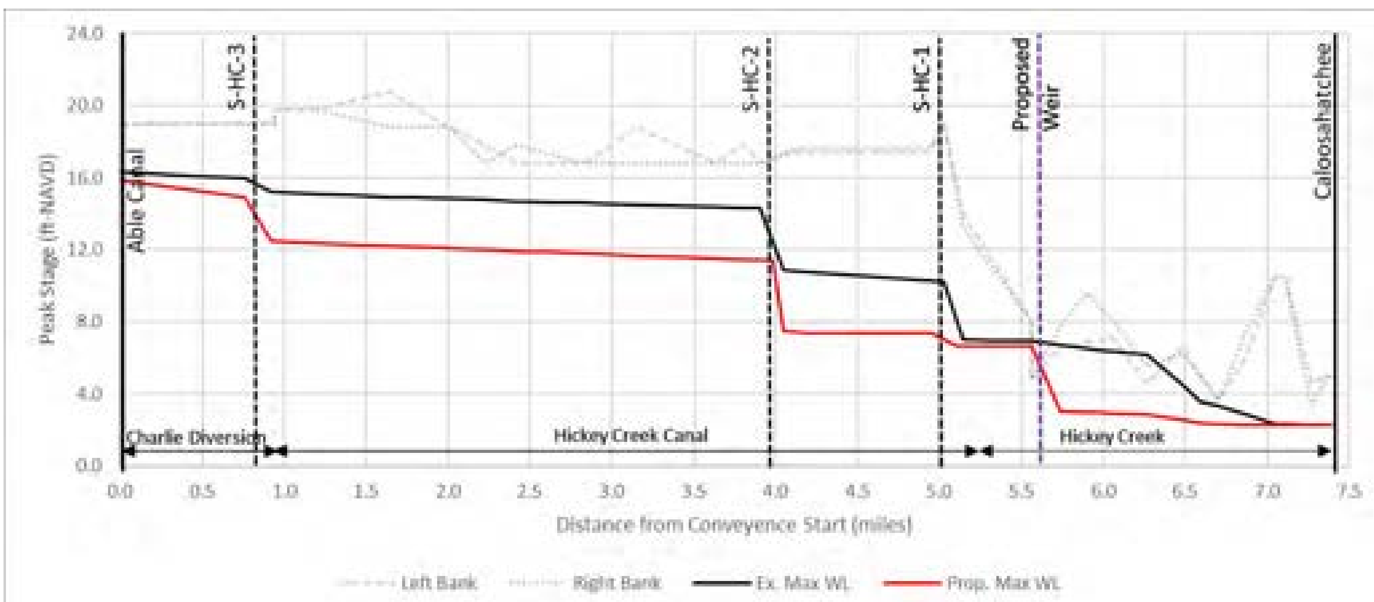

Figure 14. Peak Stages during 10-yr Design Storm within Hickey's Creek

SOUTHEAST LEE COUNTY (STUDY AREA 1.3)

The following schematics show the results of both the 5-year 24-hour and 10-year 24-hour events for Study Area 1.3.

5-year 24-hour Design Storm Results

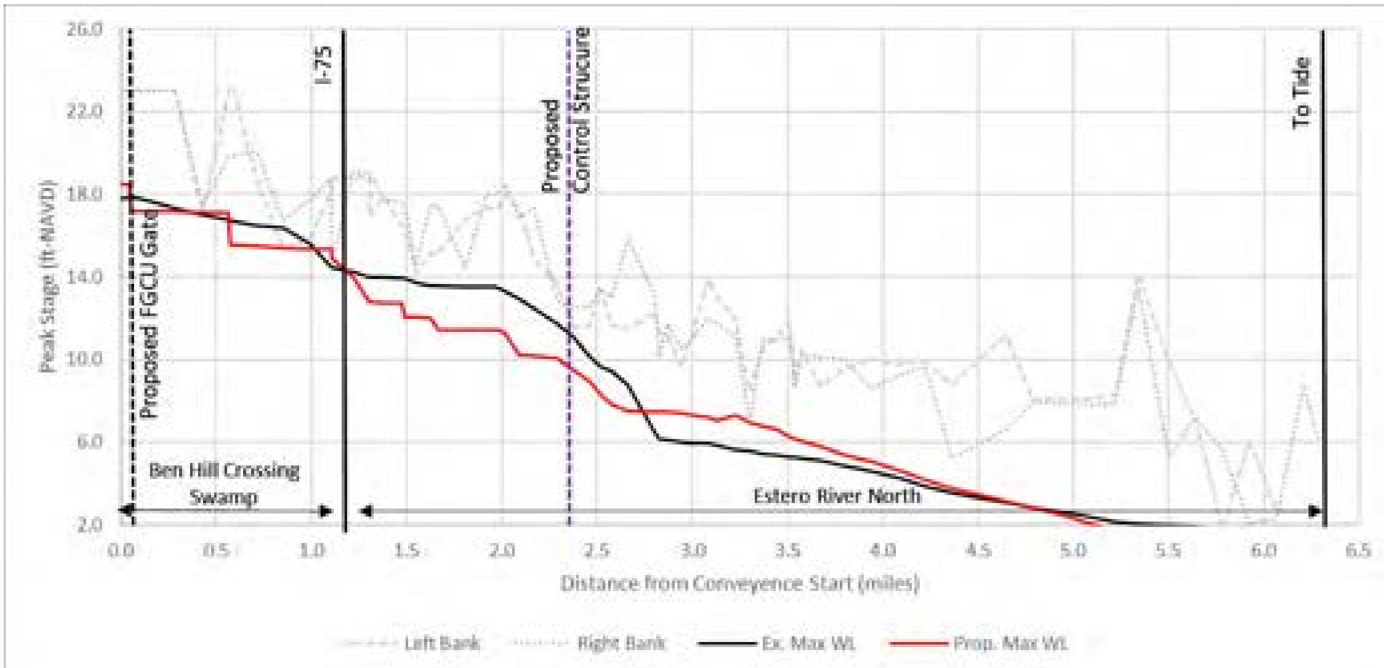

Figure 15. Peak Stages during 5-yr Design Storm within Estero River North Branch

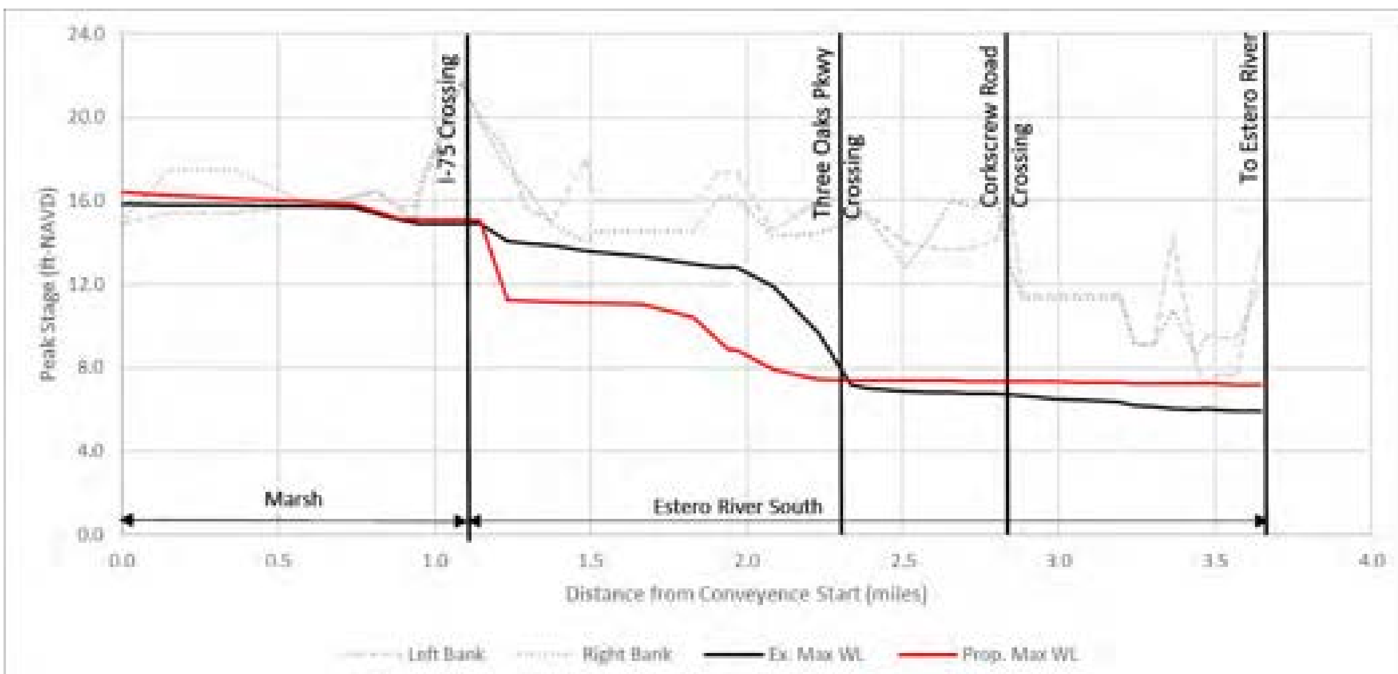

Figure 16. Peak Stages during 5-yr Design Storm within Estero River South Branch

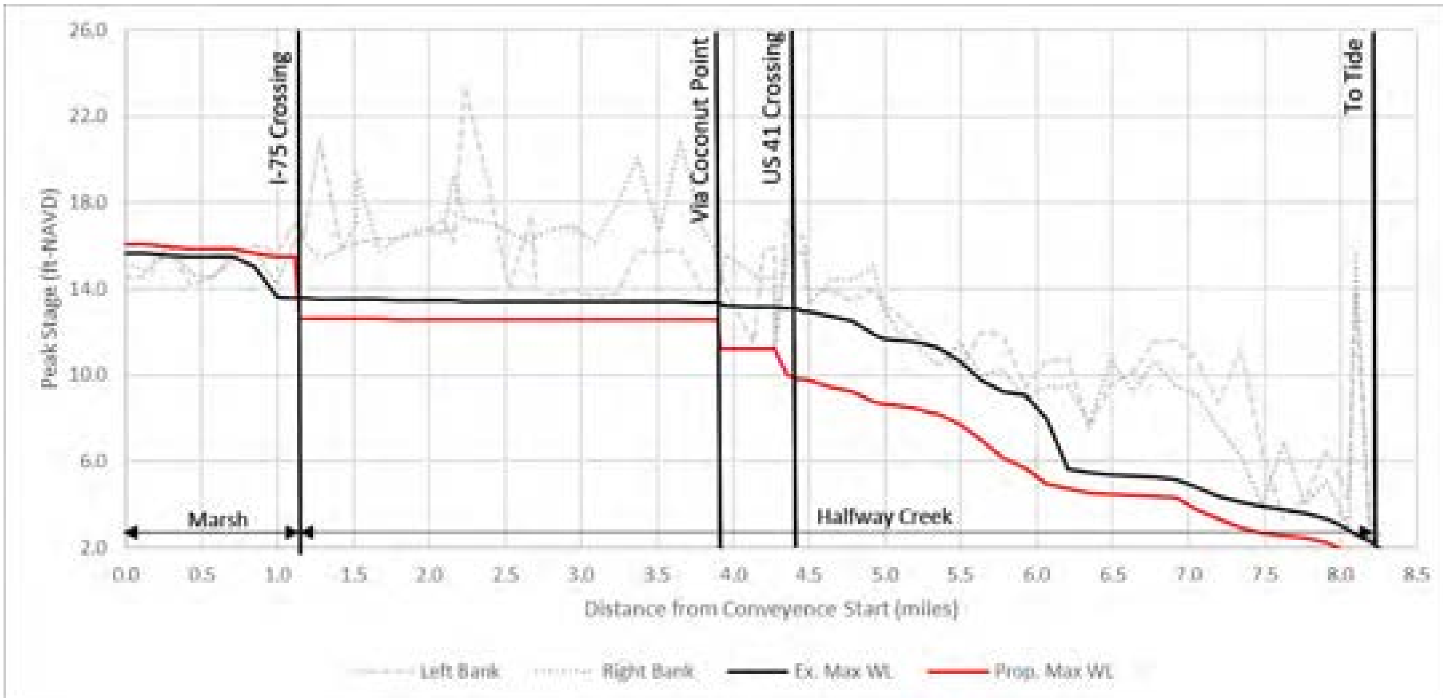

Figure 17. Peak Stages during 5-yr Design Storm within Halfway Creek

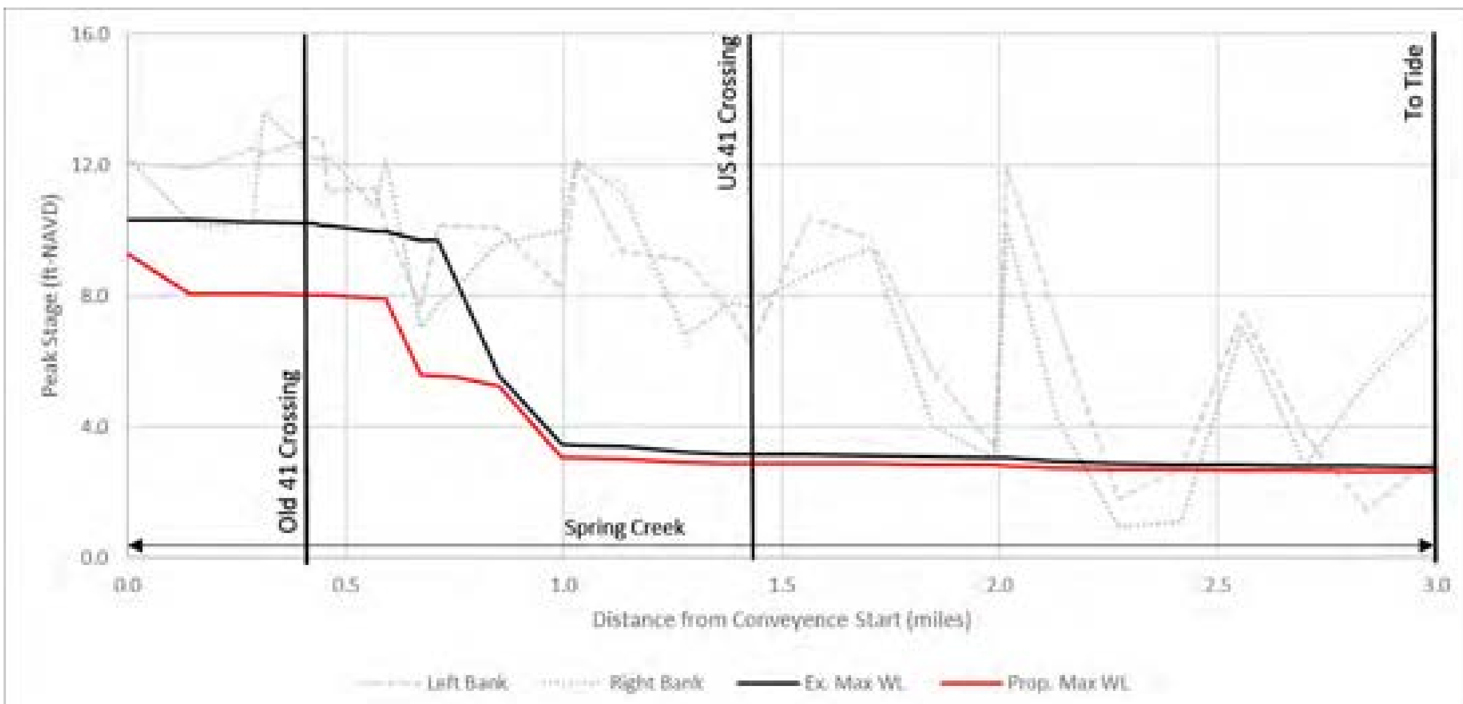

Figure 18. Peak Stages during 5-yr within Spring Creek

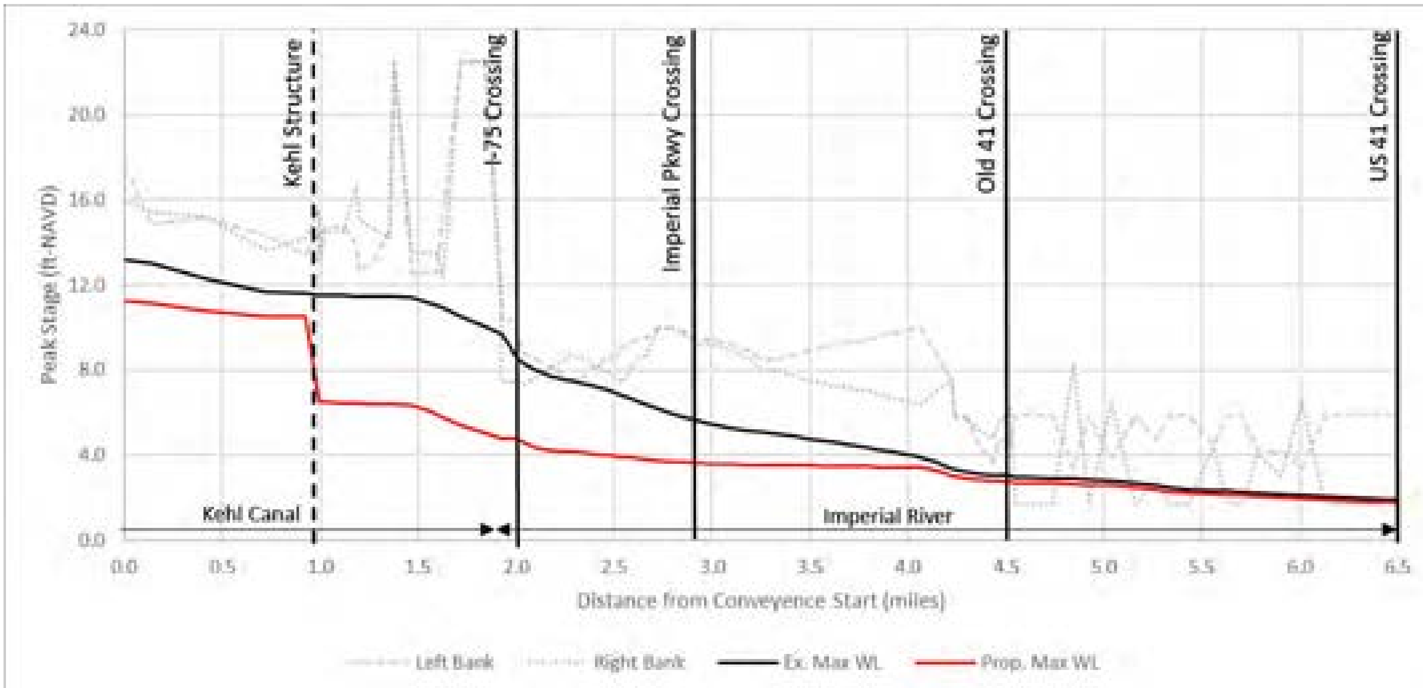

Figure 19. Peak Stages during 5-yr Design Storm within Imperial River

10-year 24-hour Design Storm Results

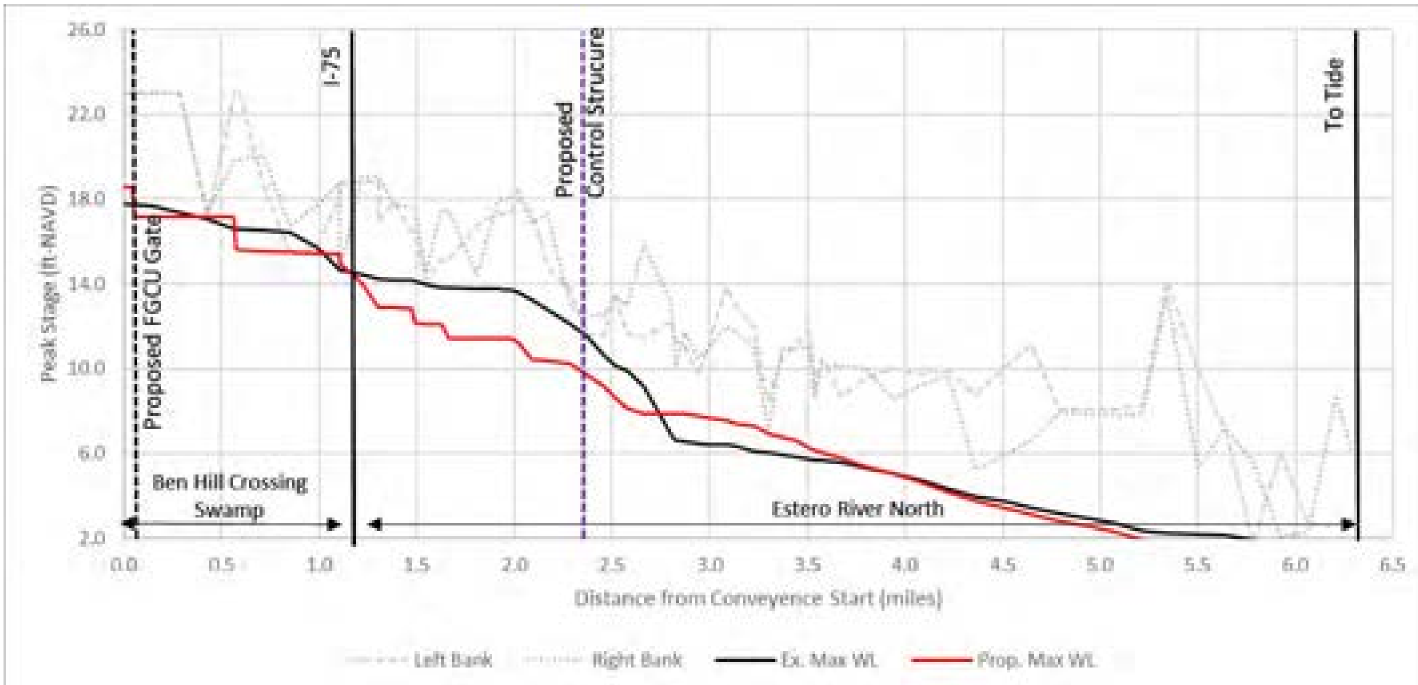

Figure 20. Peak Stages during 10-yr Design Storm within Estero River North Branch

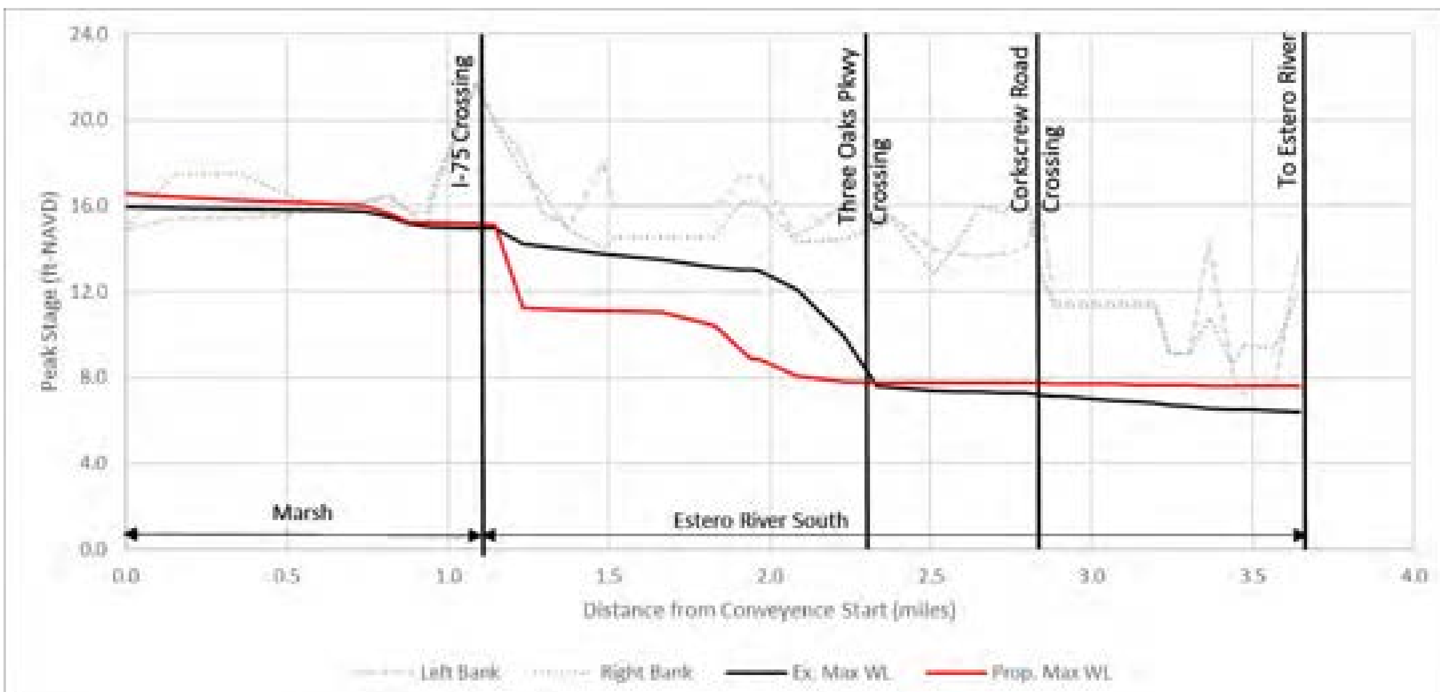

Figure 21. Peak Stages during 10-yr. Design Storm within Estero River South Branch

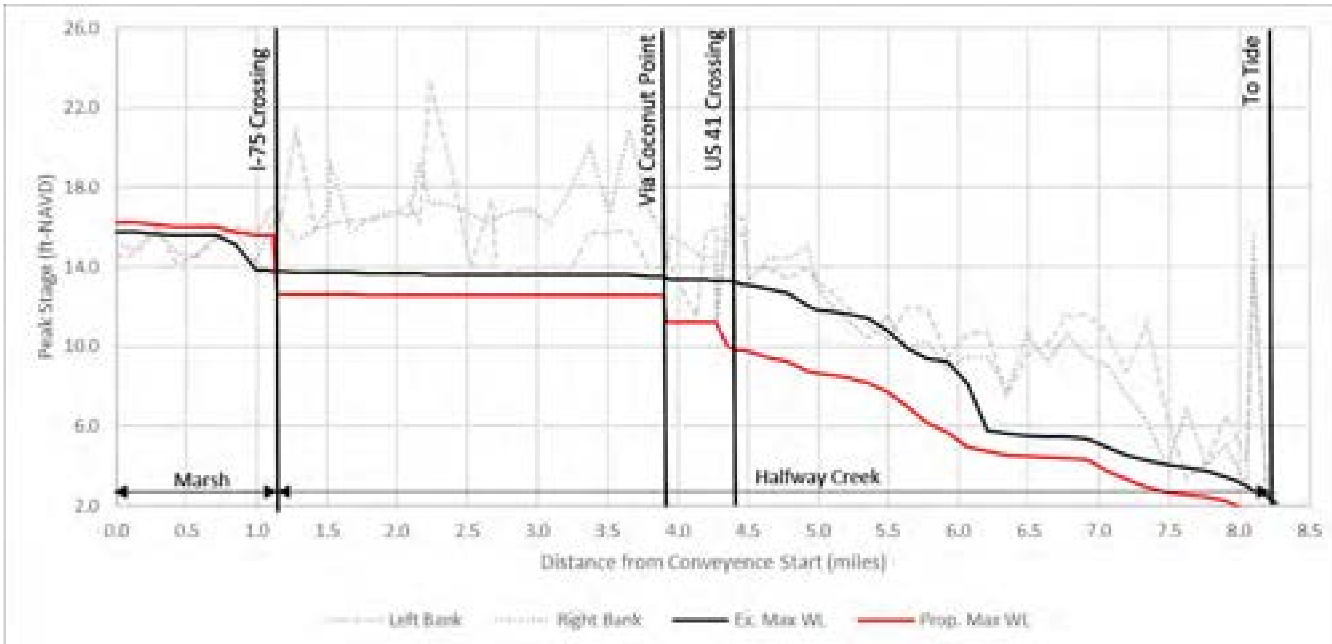

Figure 22. Peak Stages during 10-yr. Design Storm within Halfway Creek

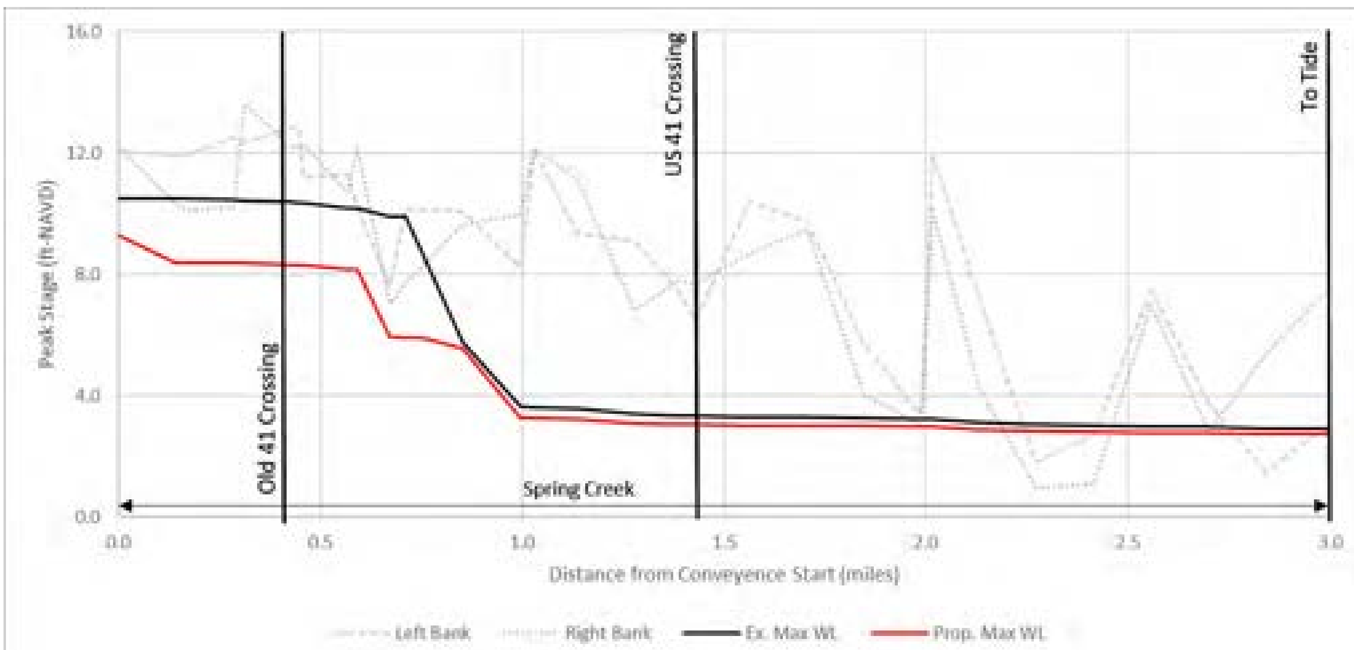

Figure 23. Peak Stages during 10-yr Design Storm within Spring Creek

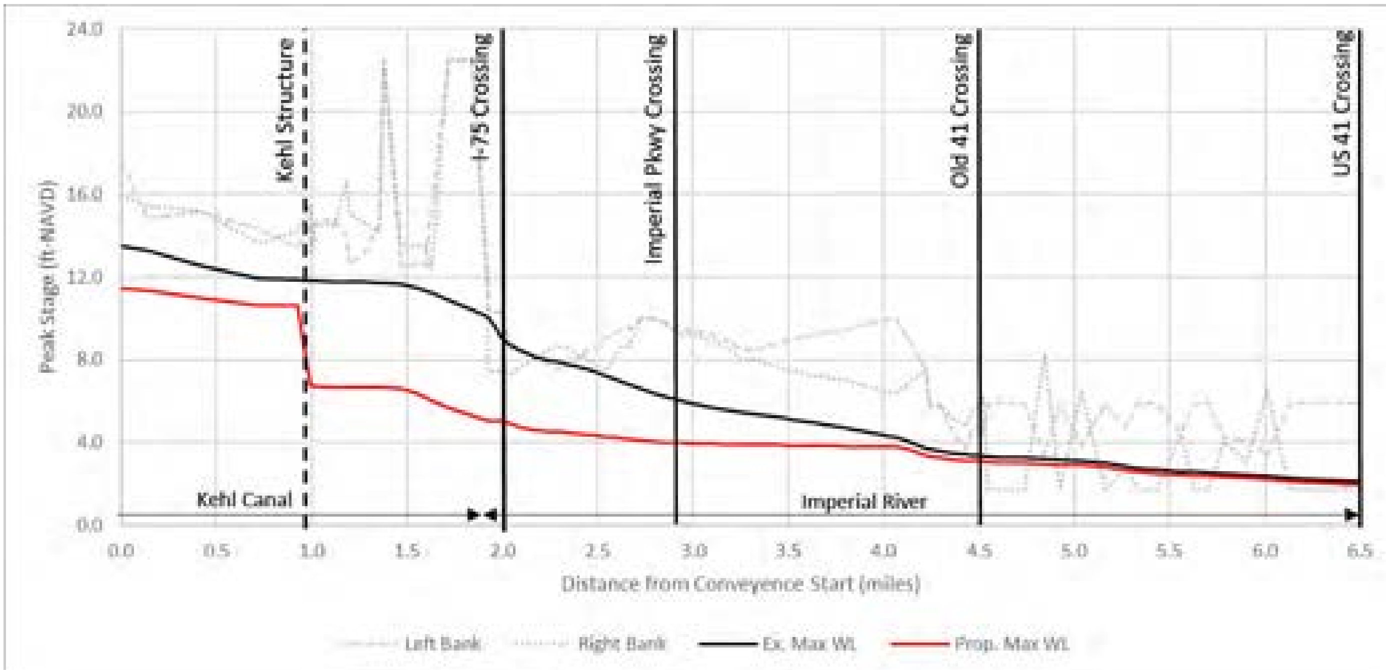

Figure 24. Peak Stages during 10-yr. Design Storm within Imperial River

SOUTH FT. MYERS / WHISKEY CREEK (STUDY AREA 1.4)

The following schematics show the results of both the 5-year 24-hour and 10-year 24-hour events for Study Area 1.4.

5-year 24-hour Design Storm Results

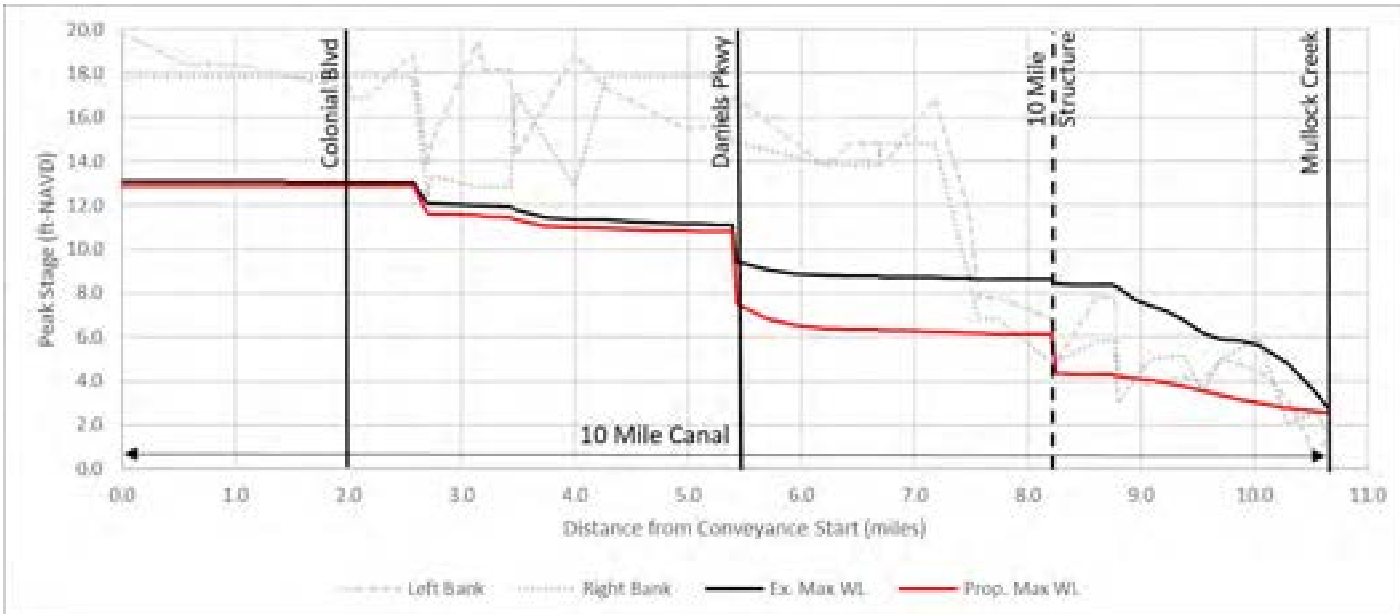

Figure 25. Peak Stages during 5-yr. Design Storm within 10 Mile Canal

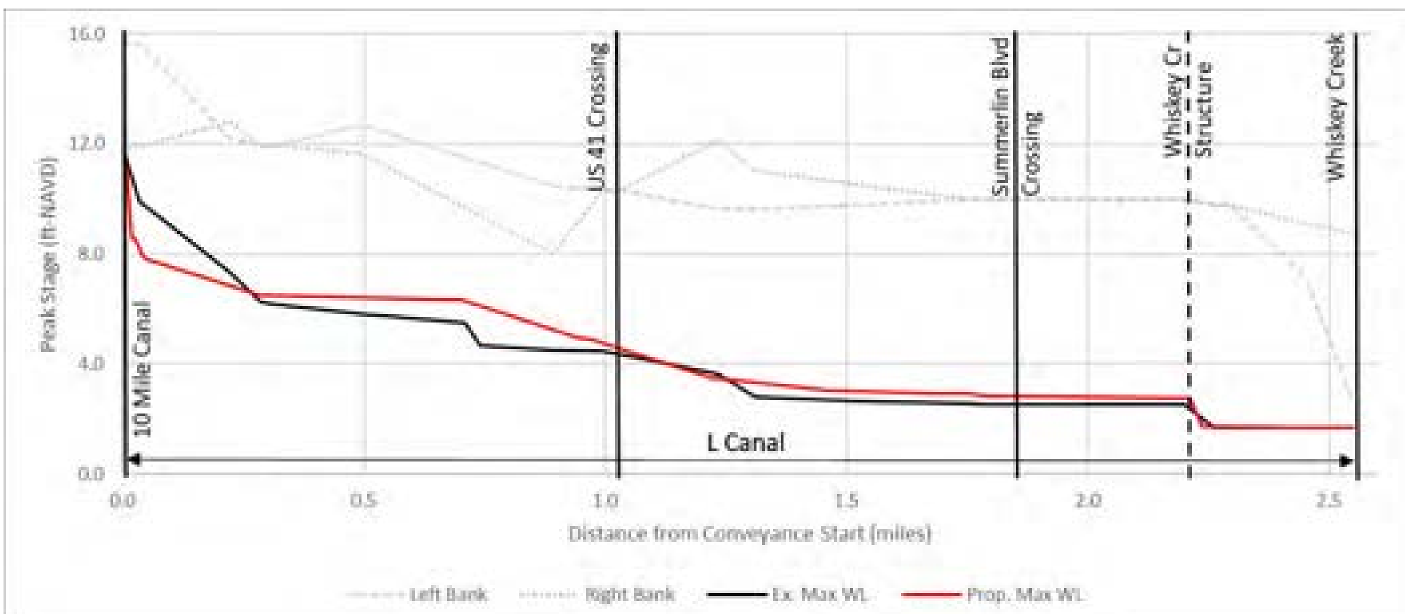

Figure 26. Peak Stages during the 5-yr. Design Storm within L Canal

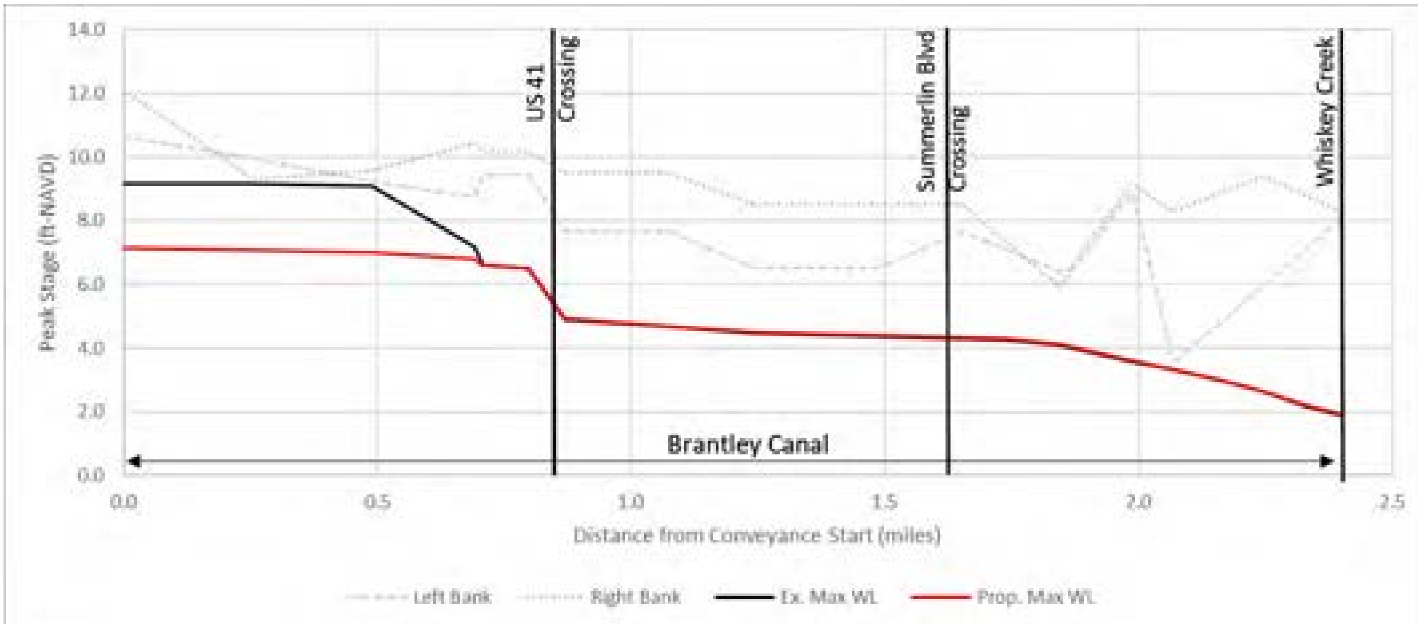

Figure 27. Peak Stages during the 5-yr. Design Storm within the Brantley Canal

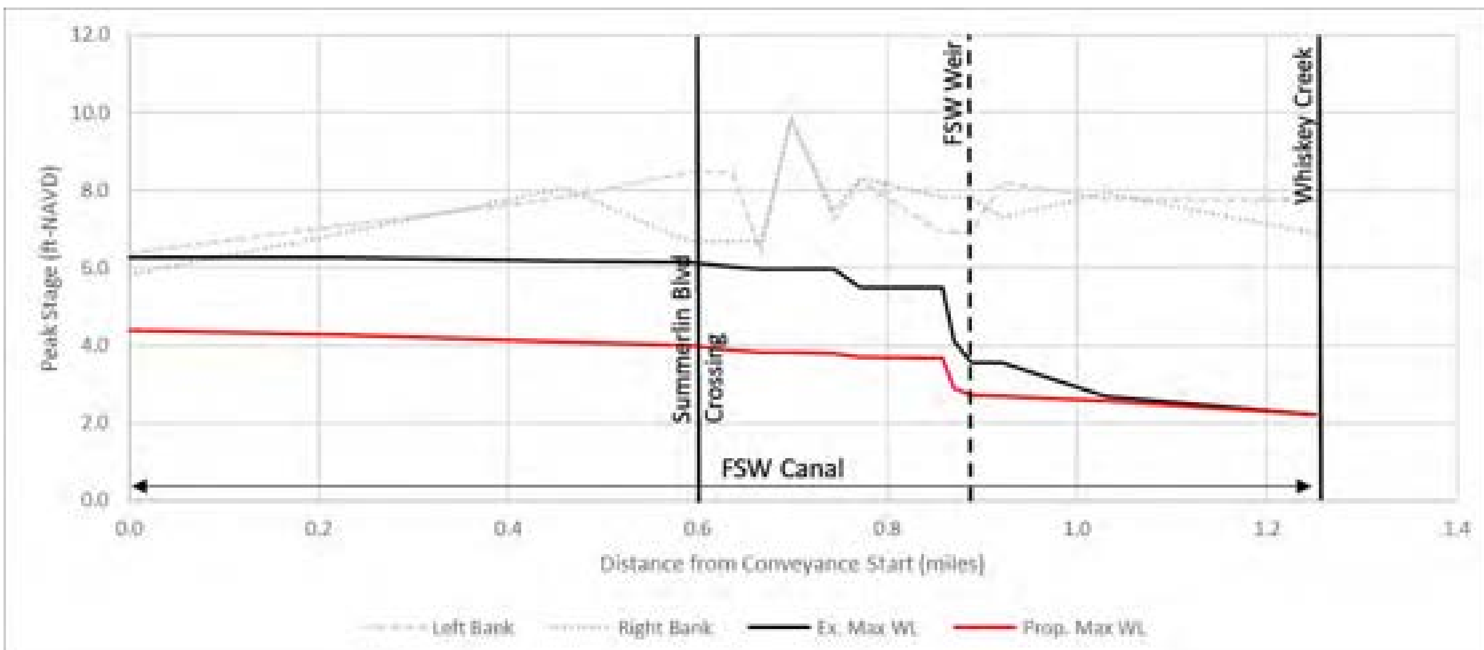

Figure 28. Peak Stages during the 5-yr. Design Storm within FSW Canal

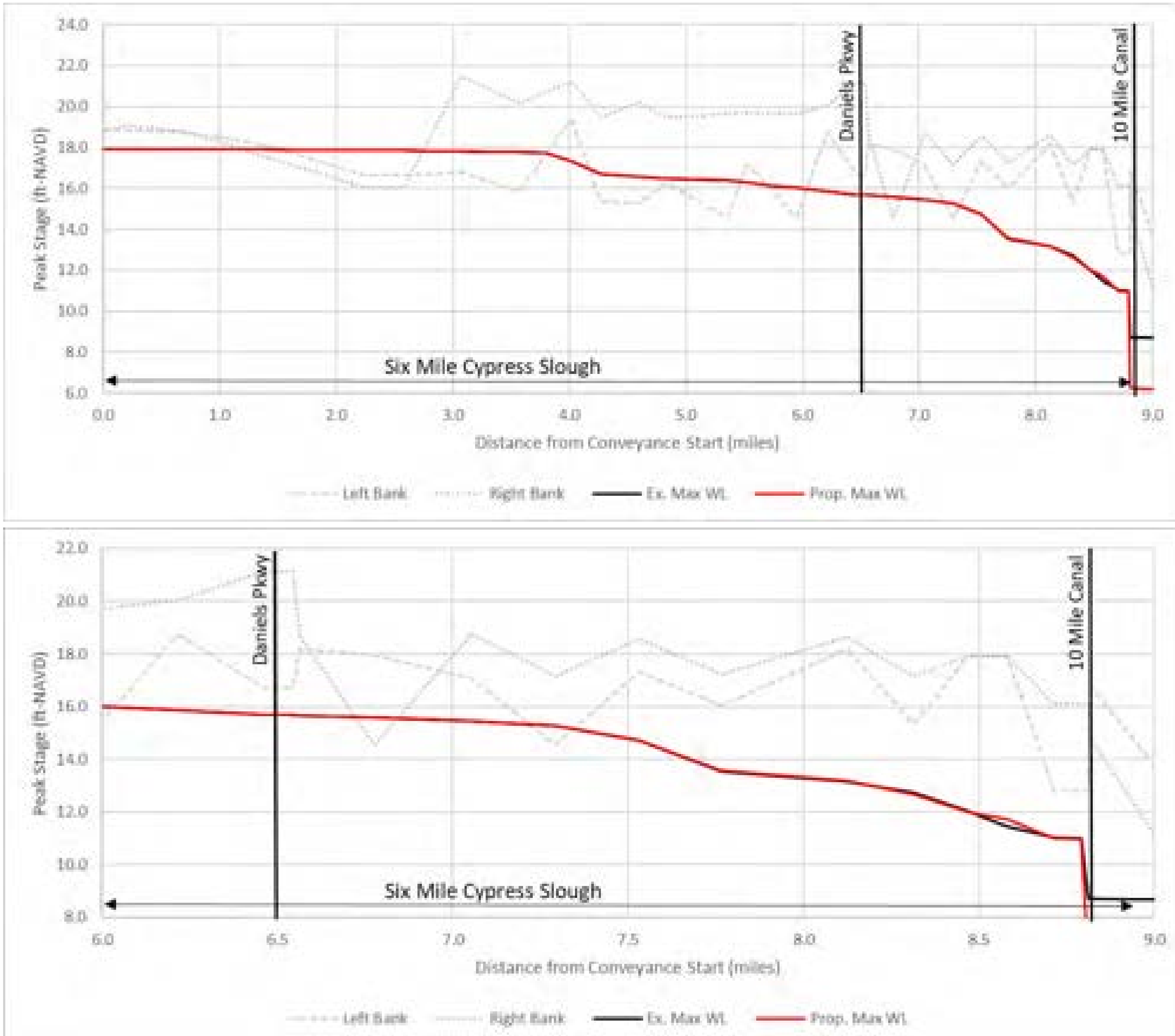

Figure 29. Peak Stages during the 5-yr. Design Storm within Six Mile Cypress Slough

10-year 24-hour Design Storm Results

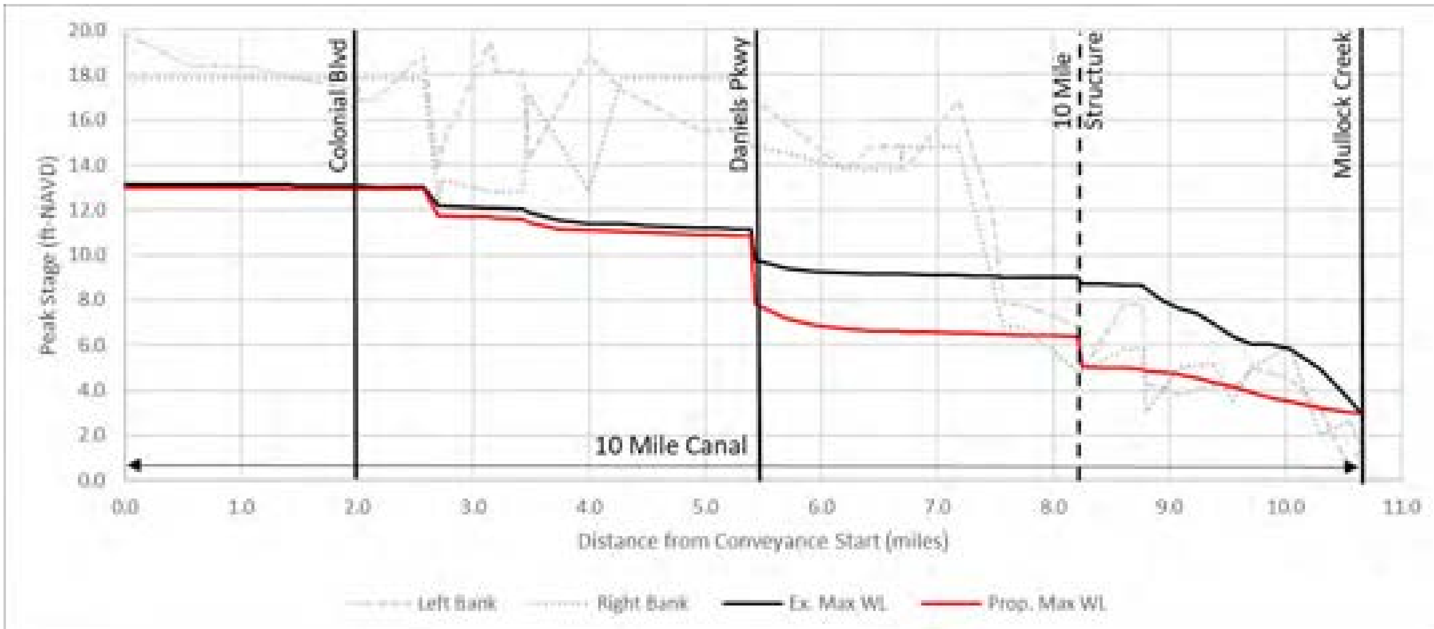

Figure 30. Peak Stages during the 10-yr. Design Storm within 10 Mile Canal

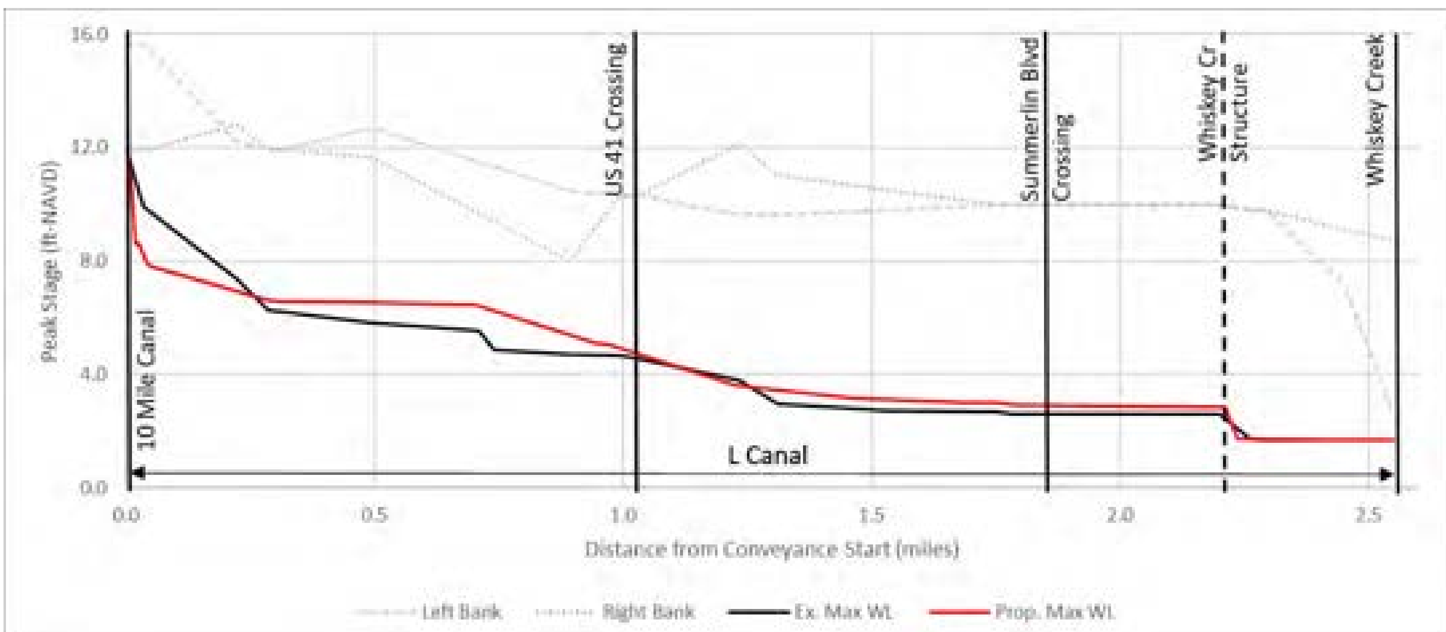

Figure 31. Peak Stages during the 10-yr. Design Storm within L Canal

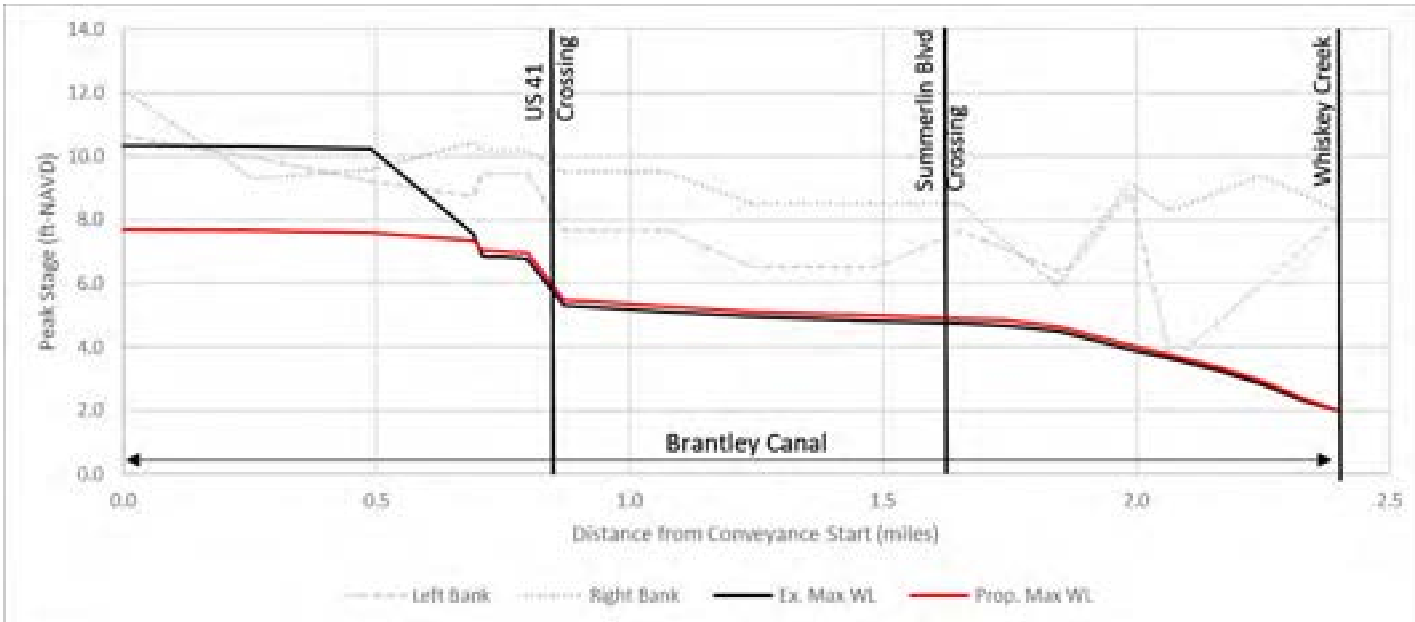

Figure 32. Peak Stages during the 10-yr. Design Storm within Brantley Canal

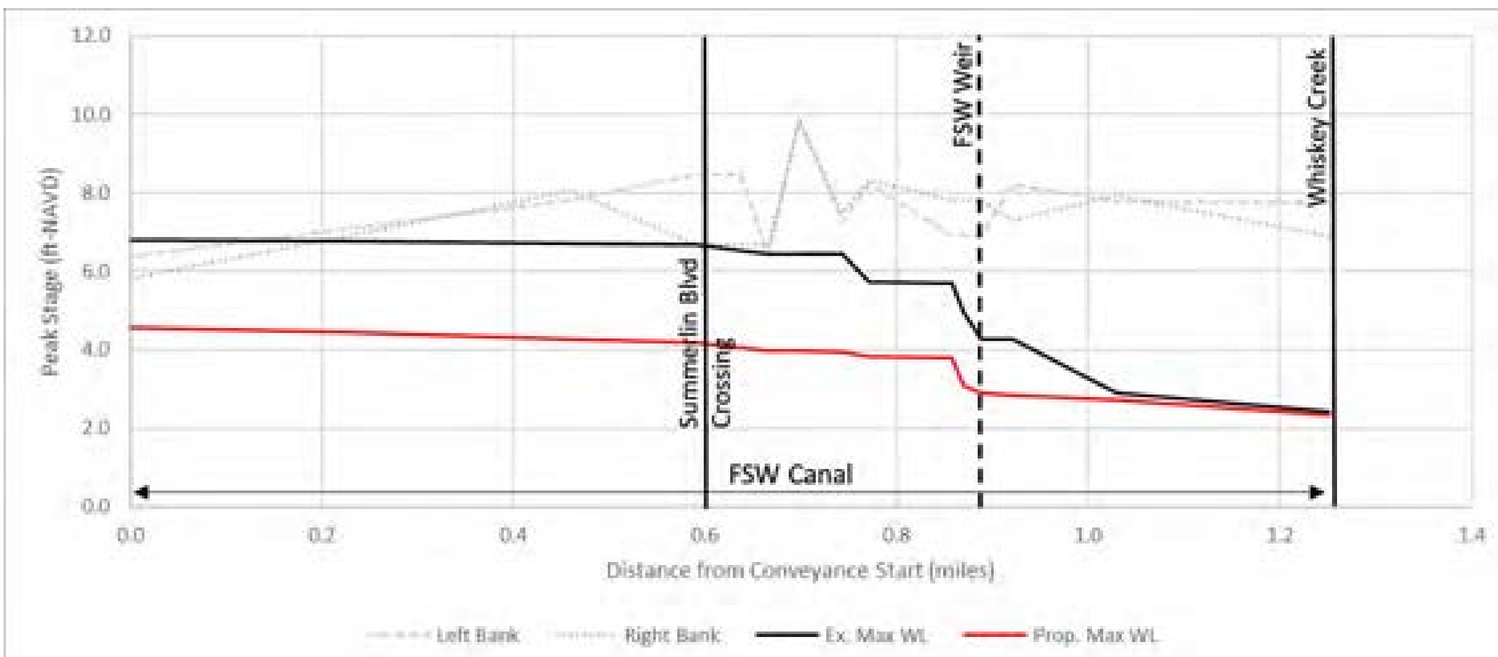

Figure 33.Peak Stages during the 10-yr. Design Storm within FSW Canal

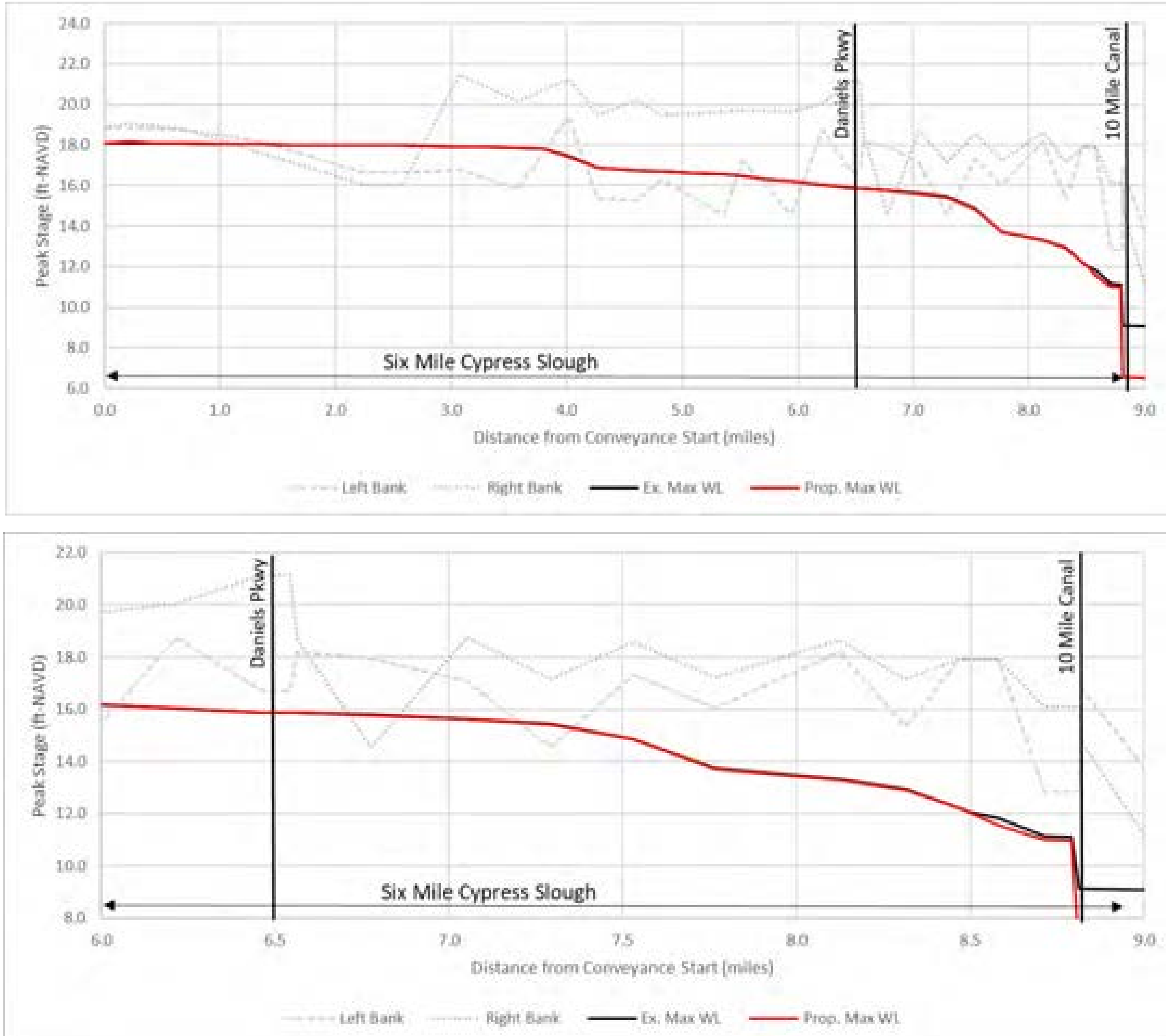

Figure 34. Peak Stages during the 10-yr. Design Storm within Six Mile Cypress Slough