VILLAGE CREEK WATERSHED IMPROVEMENT PLAN

STREAM AND CHANNEL IMPROVEMENTS

City of Birmingham

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1. Overview

The City of Birmingham is developing a Watershed Management Plan for Village Creek. As part of this plan, projects will be identified for future implementation to address water quality and flooding issues. Based on public feedback, review of prior watershed plans, and City priorities, several improvements along Village Creek were identified for inclusion in the Watershed Implementation Plan. Schoel Engineering incorporated several of the plan improvements into a recently completed HEC-RAS model to develop an estimate of the potential benefits each of the improvements would provide. The methodology and results of the analysis are included in this report.

2. Existing Flood Conditions within the Village Creek Watershed

Village Creek has experienced many flooding events in the past that has resulted in flood losses and damages. The National Weather Service has assigned flood categories based on the stage at the USGS site at Avenue W in Ensley. Table 1 below lists the flood categories for the USGS Avenue W site and the associated stage. Table 2 below summarizes the flood events that have occurred on Village Creek in recent history. This information was compiled from information obtained from the City of Birmingham, USGS, and NOAA rainfall records.

Table 1 Flood Categories (in feet), USGS Site at Avenue W in Ensley

Category	Stage
Major Flood Stage	16
Moderate Flood Stage	13
Flood Stage	10
Action Stage	10

Table 2 Summary of Village Creek Flood Events, 1995-2015

October 3-5, 1995 - *Hurricane Opal* The Birmingham Airport observed 10.73” of rainfall. The event resulted in damages approximating $571,000 to 200 homes and 25 businesses; 100 families and 2 shelters activated across the City. The USGS site at Avenue W at Ensley reported a stage of 11.98 ft (Flood Stage) on October 5.
January 26, 1996 The event resulted in damages city-wide approximating $39,000 to 97 homes and some evacuations. The USGS site at Avenue W at Ensley reported a stage of 13.72 ft (Moderate Flood Stage).
March 5-8, 1996 The Birmingham Airport observed 6.75” of rainfall. The event resulted in damages city-wide approximating $65,000 to 111 homes and 9 businesses including some evacuation. The USGS site at Avenue W at Ensley reported a stage of 12.84 ft (Flood Stage) on March 7.
January 6-8, 1998 The Birmingham Airport observed 4.86” of rainfall. The event resulted in damages city-wide approximating $67,000 to 208 homes, families evacuated, and 2 shelters activated. The USGS site at Avenue W at Ensley reported a stage of 13.54 ft (Moderate Flood Stage) on January 7.
June 27-28, 1999 The Birmingham Airport observed 4.68” of rainfall. The event resulted in damages approximating $250,000 to 100+ homes; evacuation and emergency services provided. The USGS site at Avenue W at Ensley reported a stage of 12.84 ft (Flood Stage) on June 28.
March 10-11, 2000 The Birmingham Airport observed 5.21” of rainfall. The event resulted in damages city-wide to 50+ homes, evacuation, & water rescues provided. The USGS site at Avenue W at Ensley reported a stage of 13.96 ft (Moderate Flood Stage) on March 11.
April 3-4, 2001 The Birmingham Airport observed 5.26” of rainfall. The USGS site at Avenue W at Ensley reported a stage of 12.93 ft (Flood Stage) on April 3.
September 21-22, 2002 The Birmingham Airport observed 3.91” of rainfall. The event resulted in damage city-wide to 50+ properties as well as emergency services and temporary relocation provided. The USGS site at Avenue W at Ensley reported a stage of 12.41 ft (Flood Stage) on September 22.
May 7, 2003 The Birmingham Airport observed 5.71” of rainfall. The event caused damages city-wide to over 1,000 properties; entailing emergency services, and water rescues. FEMA Disaster Assistance both Individual and Public Assistance was provided to the City; Damages were estimated at over $1 million. The USGS site at Avenue W at Ensley

reported a stage of 13.68 ft (Moderate Flood Stage).
February 5-6, 2004 The Birmingham Airport observed 3.32” of rainfall. The event resulted in damages to 123 structures; required water rescues and door to door warnings; This event caused approximately $75,000 in damages city-wide. The USGS site at Avenue W at Ensley reported a stage of 14.28 ft (Moderate Flood Stage) on February 6.
September 16, 2004 - *Hurricane Ivan* The Birmingham Airport observed 9.80” of rainfall. The event resulted in damages to over 400 properties; required emergency services, water rescues, evacuation of families and 4 shelters were activated. FEMA Disaster Assistance both Individual and Public Assistance was provided to the City. This event caused over $1.5 million in damages city-wide. The USGS site at Avenue W at Ensley reported a stage of 13.58 ft (Moderate Flood Stage).
September 4-5, 2011 The Birmingham Airport observed 7.97” of rainfall. The USGS site at Avenue W at Ensley reported a stage of 14.57 ft (Moderate Flood Stage).
April 6-7, 2014 – Birmingham Airport Rain Gage – 4.38” The Birmingham Airport observed 4.38” of rainfall. The event caused damages to approximately 100+ properties and required water rescues, emergency services, door to door warnings, evacuations. This event caused over $100,000 in damages city-wide. The USGS site at Avenue W at Ensley reported a stage of 13.01 ft (Moderate Flood Stage) on April 7.
July 4, 2015 The USGS site at 24th Street observed 4.19“ of rainfall. The USGS site at Avenue W at Ensley reported a stage of 11.11 ft (Flood Stage).
December 25, 2015 – 24th Street Rain Gage 4.74 “ The USGS site at 24th Street observed 4.74“ of rainfall. The USGS site at Avenue W at Ensley reported a stage of 12.65 ft (Flood Stage).

3. Effective FEMA Flood Insurance Study for Village Creek

The Village Creek Flood Insurance Study (FIS) is based on a revised hydrologic and hydraulic analysis performed by the U.S. Army Corps of Engineers (USACE) and completed in October 1991. The hydraulic analysis within the City of Birmingham was later revised by Schoel Engineering in March of 1995. These studies were eventually incorporated into the Jefferson County FIS and published January 20, 1999. Volkert, Inc performed revisions to the hydraulic model after the 1999 FIS publication to incorporate changes within the Birmingham-Shuttlesworth airport. This revision was included in a later Jefferson County FIS update.

The hydrologic model that is the basis for the flows found in effective FEMA FIS for Village Creek has not changed since the original study was published in 1981. Flows used in the FIS are from a HEC-1 hydrologic model developed by the Corps of Engineers. A detailed discussion of the methodology and development of model parameters can be found in the published USACE report dated February 1986 titled *Design Memorandum No. 1, General Design*.

Several HEC-2 models comprise the hydraulic modeling for Village Creek in the effective FEMA FIS. The USACE revised the effective hydraulic model for Village Creek in 1991. The USACE HEC-2 models were updated in the early 1990s by Schoel for the City of Birmingham. This update focused on the section of Village Creek from immediately below the airport to the area around Wade Sand and Gravel. Later revisions to the Schoel HEC-2 models were made by Volkert, Inc. to reflect modifications within the Birmingham-Shuttlesworth Airport. The combination of these HEC-2 models make up the hydraulic component of the effective FIS.

4. Methodology

The USACE recently developed a new HEC-RAS model for Village Creek as part of a Silver Jackets Flood Inundation Mapping Project. This model was used to assess the potential reduction in flood elevations due to each of the proposed improvements.

4.1 Development of Existing Conditions Hydraulic Model

The HEC-RAS model developed by the USACE and used for this study is a new hydraulic model extending from the headwaters in Roebuck through the Village Creek Wastewater Treatment Plant. A three-dimensional terrain was developed for the watershed using LiDAR data collected in 2014 and provided by the State Office of Water Resources. New cross sections were draped on the terrain and extracted for input into the model. Bridge and culvert structures were added to the model using information from a prior HEC-RAS model developed by the USACE for the Feasibility Phase Study of Village Creek in 2006. The 2006 HEC-RAS model used a combination of field survey data and data from the effective FEMA HEC-2 models to develop the structure geometry. Bridge deck, opening, and pier shape and dimensions from the 2006 HEC-RAS model were incorporated into the new HEC-RAS model for each of the structure locations. Schoel obtained the final model from the USACE once the model development was complete for the Silver Jackets Flood Inundation Mapping project.

4.2 Hydraulic Model Geometry Revisions

Following review of the model provided by the USACE to Schoel, several errors were identified that needed to be addressed to improve model accuracy. The model corrections fell into three major categories: 1) Bridge and culvert geometry revisions; 2) cross section geometry modifications; and 3) ineffective flow areas.

Several bridge structures did not have the embankment fully modeled. Only the deck immediately above the channel was included in the model for several locations. In many cases this did not reflect the true blockage due to the embankment and would result in minimal change in water surface elevation through the structure. Most of the effort to correct the model focused revisions to the bridge structures to extend the modeled embankment as appropriate. This work also included modifications to the bridge openings to better reflect the surveyed openings as shown in the 2006 HEC-RAS model.

Other revisions to the USACE model included modifications to several cross sections. This included changes to alignment, location, Manning's n-values, adjustments to bank stations. Changes to the location or alignment occurred primarily in the vicinity of bridge/culvert structures and in the Collegeville area. A few cross sections were modified to remove the area associated with lateral channels. Since these channels do not contribute conveyance in the one-dimensional direction their original inclusion was erroneous. Exhibits 1-5 located in Appendix A show the locations of each of the cross sections in the model for this assessment.

One additional change to the model was the evaluation and addition of additional ineffective flow areas. Ineffective flow areas allow for portions of a cross section to be used for flood storage but not the conveyance or flow of water. This may be due to a constriction such as those that occur at bridges due to a small bridge opening and blocked overbanks due to the elevated road embankment. For this project, ineffective flow areas were added in the Collegeville area where the floodplain expands considerably to the north. One other significant area where additional ineffective flow areas were added to cross sections in the model is the reach below the airport where Interstate 59/20 bisects the floodplain. Certain portions of the divided floodplain south of the interstate operate as floodplain storage only and have no outlet to flow downstream. With the additional ineffective flow areas in place, the model more accurately represents existing conditions along Village Creek.

4.3 Hydraulic Model Flows

The effective FEMA flows were used in this study. This provides four return periods for evaluation, the 10-year, 50-year, 100-year, and 500-year events. Flows were obtained from the effective FEMA HEC-2 models and applied at the same locations within the new HEC-RAS model. Application of flows was most important at locations of significant inflows such as tributaries or areas where significant routing occurs.

The benefit of using the effective FEMA flows is the quick integration into the model. Changes to the flows as a result of added storage were not evaluated in this study and will be discussed further in later sections. Only the hydraulic impact of each of the improvements was evaluated.

4.4 Boundary Conditions

In order to initiate the water surface elevation calculations, HEC-RAS must be provided boundary conditions. Normal depth was selected as the steady flow boundary condition used in the study HEC-RAS model. A value of 0.0006 ft/ft was entered as the downstream slope for normal depth computation for the model reach. This value was based upon the average energy grade slope from the effective FEMA HEC-2 model for the cross sections similarly located as the downstream cross section in the study HEC-RAS model.

5. Improvements

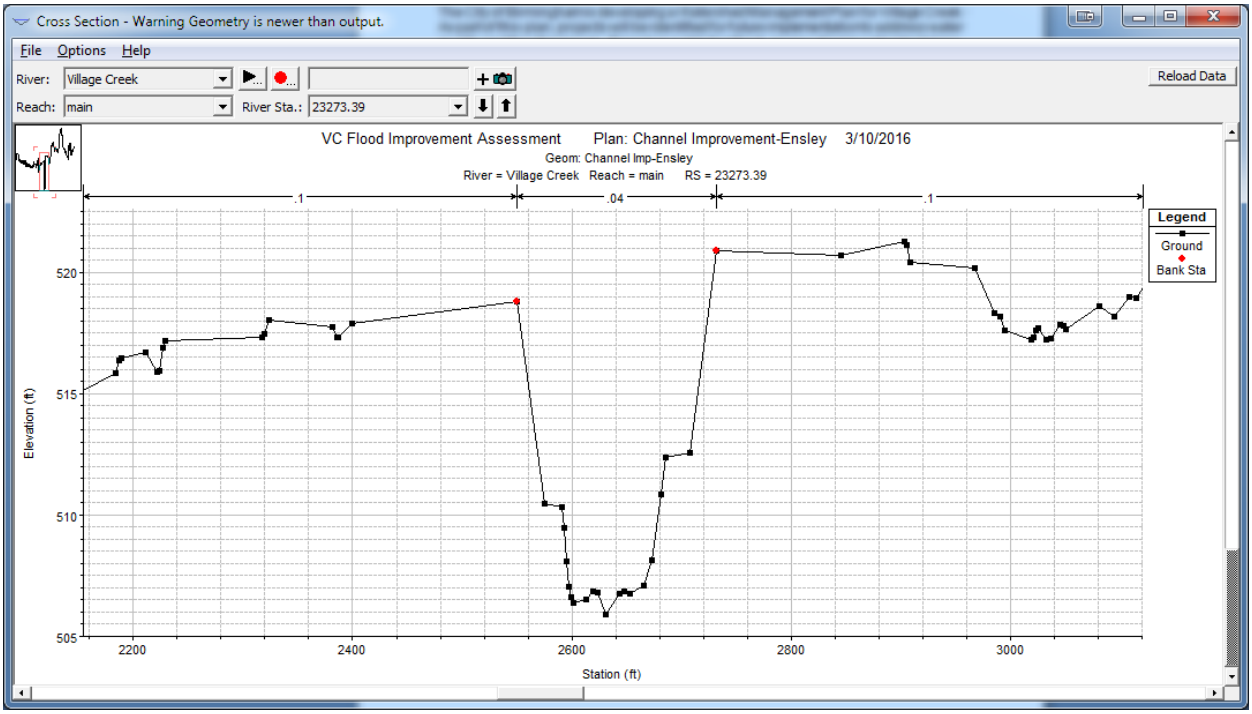
Once the revision to the existing conditions model was complete, this was used as the basis for modeling each of the proposed improvements. The improvements modeled focused on proposed improvements to the stream and structures. Several locations were analyzed for stream channel improvements including off channel storage. The locations selected for this type of improvement were 1) Ensley, 2) East Thomas, and 3) East Lake. A fourth improvement was evaluated that involved replacing the existing structure along West Blvd.

New model geometry was created to correspond with each improvement scenario in the model. The model results were compiled for comparison with the existing conditions model. Each scenario was also mapped to provide a visual comparison of the changes to the floodplain for each scenario.

5.1 Ensley

The proposed improvement studied for the Ensley area involved creating a channel or floodplain bench on both sides of the creek from Avenue W downstream to the Village Creek WWTP. This project extends nearly one mile along Village Creek. The benches were offset from the existing top of bank 25 feet and cut at a 3:1 sideslope until approximately 4 feet from the lowest channel elevation. Figure 1 below shows an example of the channel bench used in the model. The channel improvements were carried through each of the stream crossings within the study reach and included in the analysis.

Figure 1 Proposed Channel Bench at XS 23273.39 in Ensley



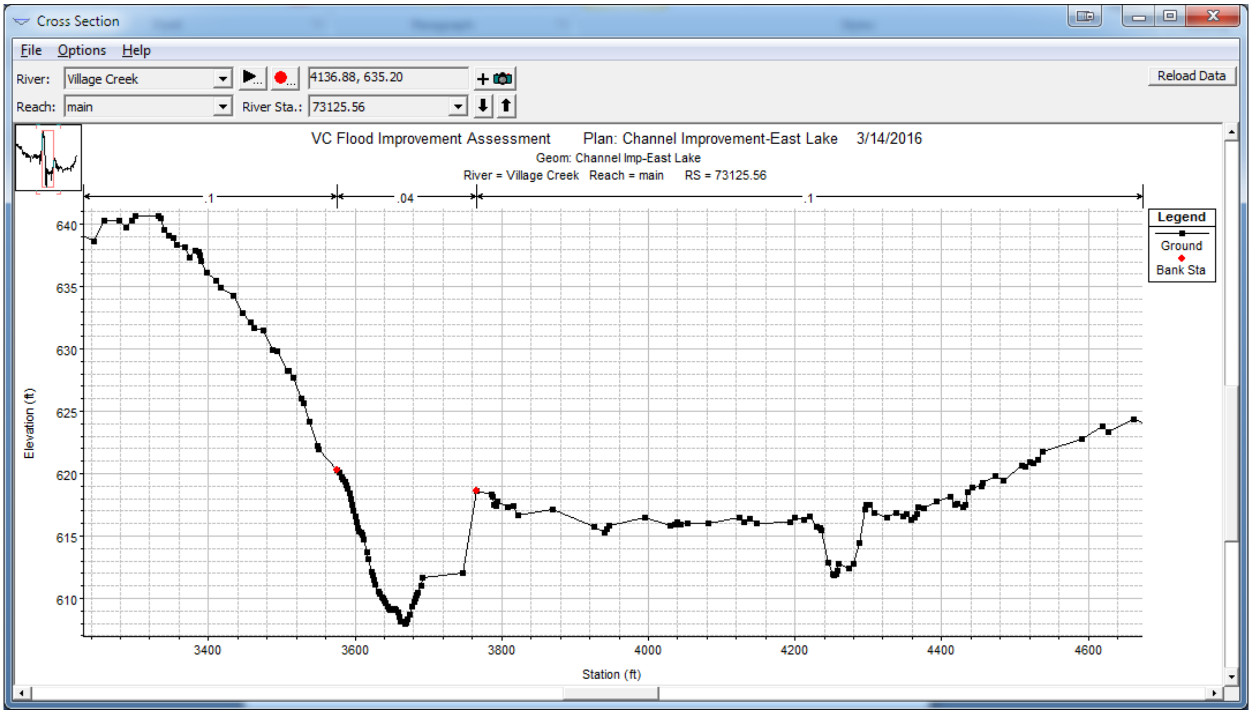
5.2 East Thomas

Two areas within the East Thomas community were identified for use as off channel storage and channel improvements. Both areas are located immediately to the south of Village Creek near the East Thomas railyard. These areas were modeled as benches approximately 4 feet above the channel thalweg. The width of each bench varied from approximately 400 feet for the downstream storage area to about 250 feet for the upstream storage area.

5.3 East Lake

Proposed improvements for the segment of Village Creek downstream of East Lake to the Airport include creating a bench 50 feet from the bank opposite of I-59/20. The bench provides additional conveyance and channel storage. This improvement was limited to one side of the creek only due the proximity of the interstate to Village Creek. Figure 2 is an example of the channel bench used in the model.

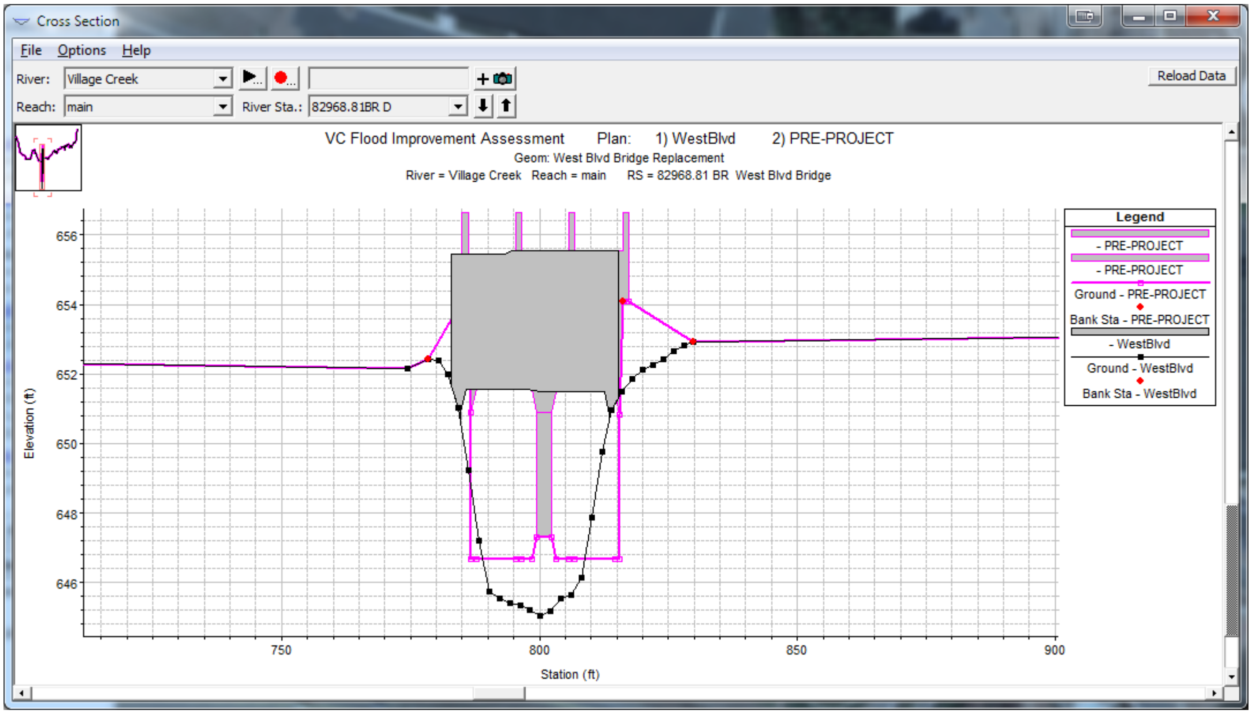
Figure 2 Example of Proposed Channel Bench in East Lake



5.4 West Blvd Bridge Replacement

The final improvement evaluated in this study was the replacement of the existing structure at West Blvd. A new single span structure was proposed to replace the existing double 12’x5’ openings. No expansion of the bridge opening was considered due to the existing downstream channel configuration. A comparison of the existing and proposed bridge modifications are shown in Figure 3 below.

Figure 3 West Blvd Bridge Modification



6. Results of Analysis

The proposed projects were shown to provide a small reduction in the water surface elevation for the series of storms modeled. The stream improvements in Ensley resulted in an approximately 0.5 foot decrease in the 10-year through the 100-year return periods. Similar decreases are shown due to the channel storage and improvements in the East Thomas area but are limited to the immediate area at each of those locations. The channel improvements in the East Lake area show up to a 1.7 foot decrease in the water surface elevations for the 10-year event; however, these are not consistent along the entire project reach.

Exhibits 6 through 9 found in Appendix B include the modeled water surface profiles for each of the proposed improvements. The profile exhibits provide a comparison of the pre- versus post-project water surface elevations. In addition, Exhibits 10 through 12 located in Appendix C show the modeled flood inundation mapping for the each of the modeled channel improvement scenarios.

If each of the scenarios were modeled using more advanced methods that analyzes the changes to the flow due to the additional storage created, we would expect the decreases to be more that those stated above.

The West Blvd improvement showed a negligible change in the modeled water surface elevations. This demonstrates that additional capacity beyond simply spanning the existing channel is needed in order to achieve a significant benefit.

APPENDIX

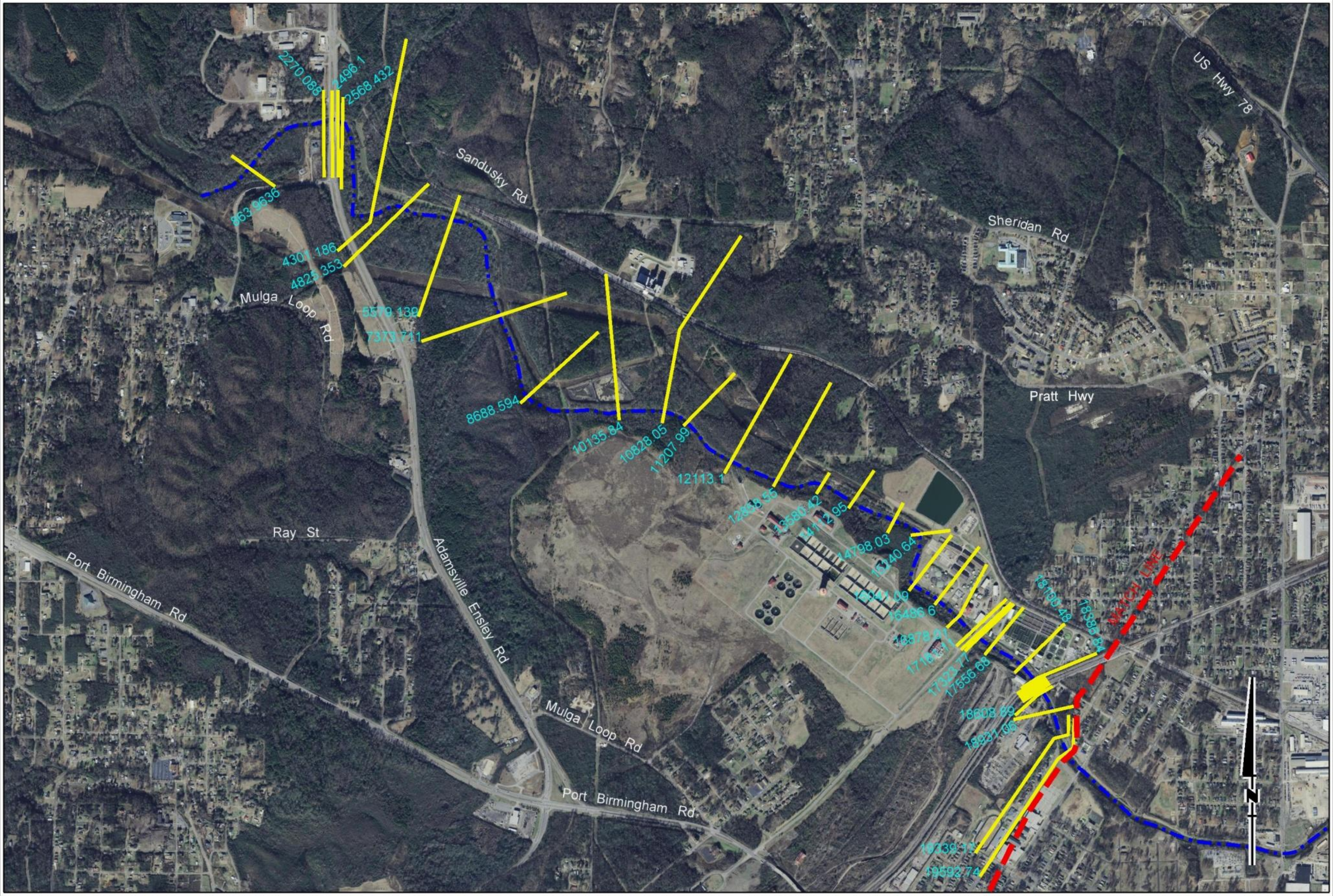
ATTACHMENT A – CROSS SECTION EXHIBITS

ATTACHMENT B – FLOOD PROFILES

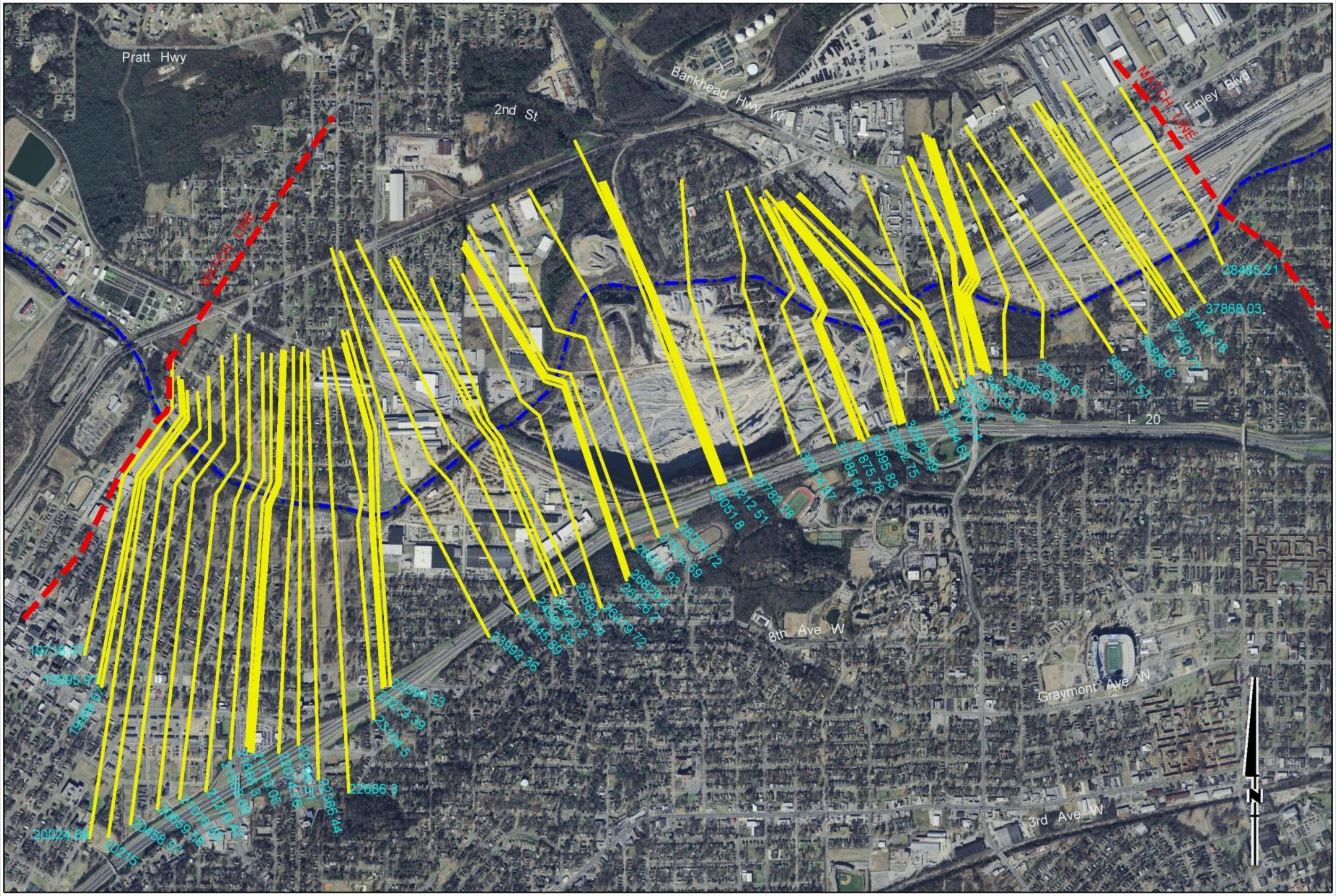
ATTACHMENT C – FLOODPLAIN INNUDATION EXHIBITS

ATTACHMENT A

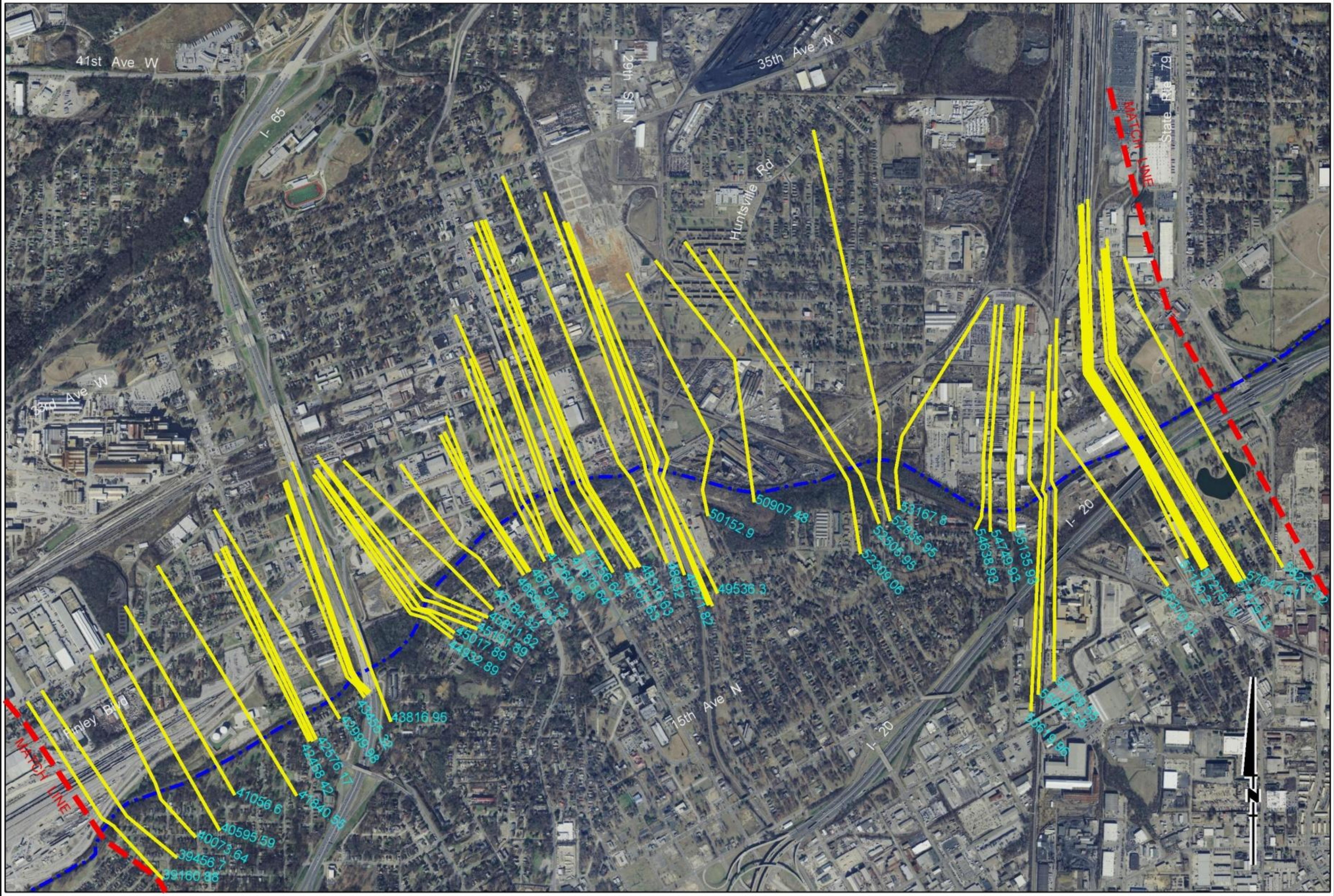
CROSS SECTION EXHIBITS



SCHOEL Consulting Engineers	VILLAGE CREEK WATERSHED MANAGEMENT PLAN PROJECT IMPROVEMENTS ASSESSMENT JEFFERSON COUNTY, ALABAMA	LEGEND CROSS SECTIONS 16041.09 CROSS SECTION LABELS	0 1000 2000 3000 GRAPHIC SCALE	EXHIBIT 1 - CROSS SECTIONS APRIL 5, 2016



SCHOEL Consulting Engineers	VILLAGE CREEK WATERSHED MANAGEMENT PLAN PROJECT IMPROVEMENTS ASSESSMENT JEFFERSON COUNTY, ALABAMA	LEGEND CROSS SECTIONS 16041.09 CROSS SECTION LABELS	0 1000 2000 3000 GRAPHIC SCALE	EXHIBIT 2 - CROSS SECTIONS APRIL 5, 2016



VILLAGE CREEK WATERSHED MANAGEMENT PLAN

PROJECT IMPROVEMENTS ASSESSMENT
JEFFERSON COUNTY, ALABAMA

SCHOEL Consulting Engineers

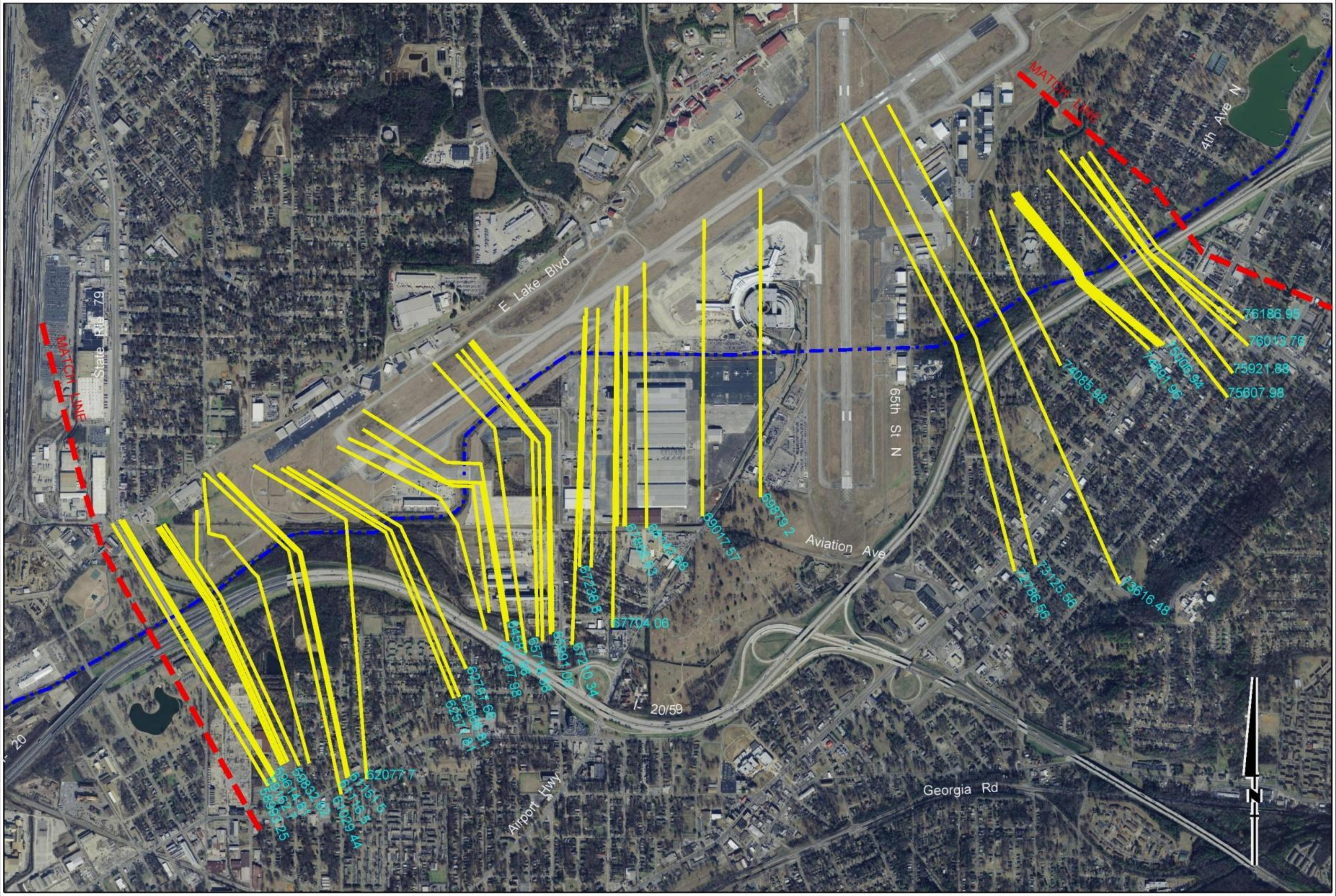
LEGEND

CROSS SECTIONS
16041.09 CROSS SECTION LABELS

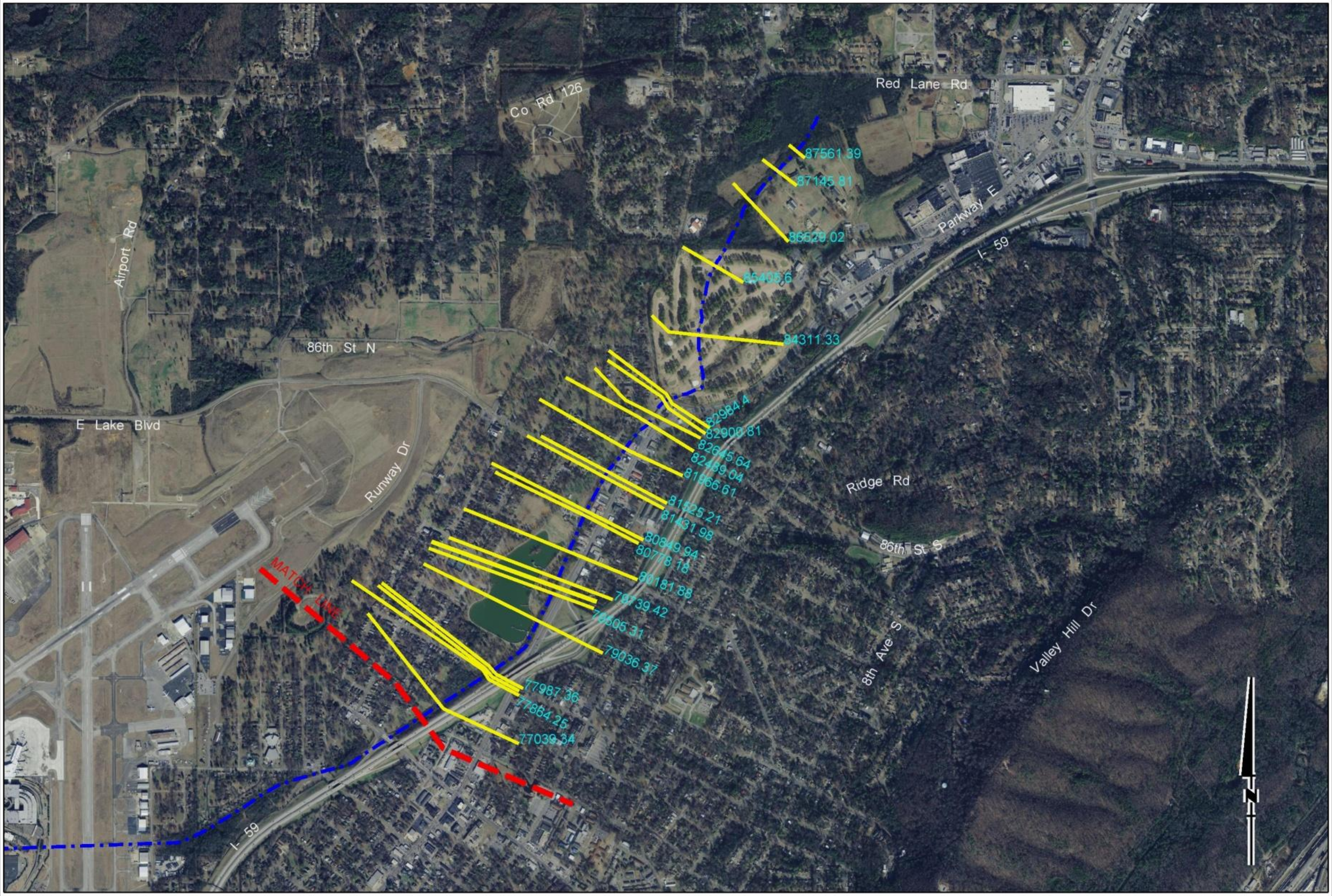
0 1000 2000 3000
GRAPHIC SCALE

EXHIBIT 3 - CROSS SECTIONS

APRIL 5, 2016



SCHOEL Consulting Engineers	VILLAGE CREEK WATERSHED MANAGEMENT PLAN PROJECT IMPROVEMENTS ASSESSMENT JEFFERSON COUNTY, ALABAMA	LEGEND CROSS SECTIONS 16041.09 CROSS SECTION LABELS	0 1000 2000 3000 GRAPHIC SCALE	EXHIBIT 4 - CROSS SECTIONS APRIL 5, 2016



VILLAGE CREEK WATERSHED
MANAGEMENT PLAN
PROJECT IMPROVEMENTS ASSESSMENT
JEFFERSON COUNTY, ALABAMA

LEGEND

CROSS SECTIONS
16041.09 CROSS SECTION LABELS

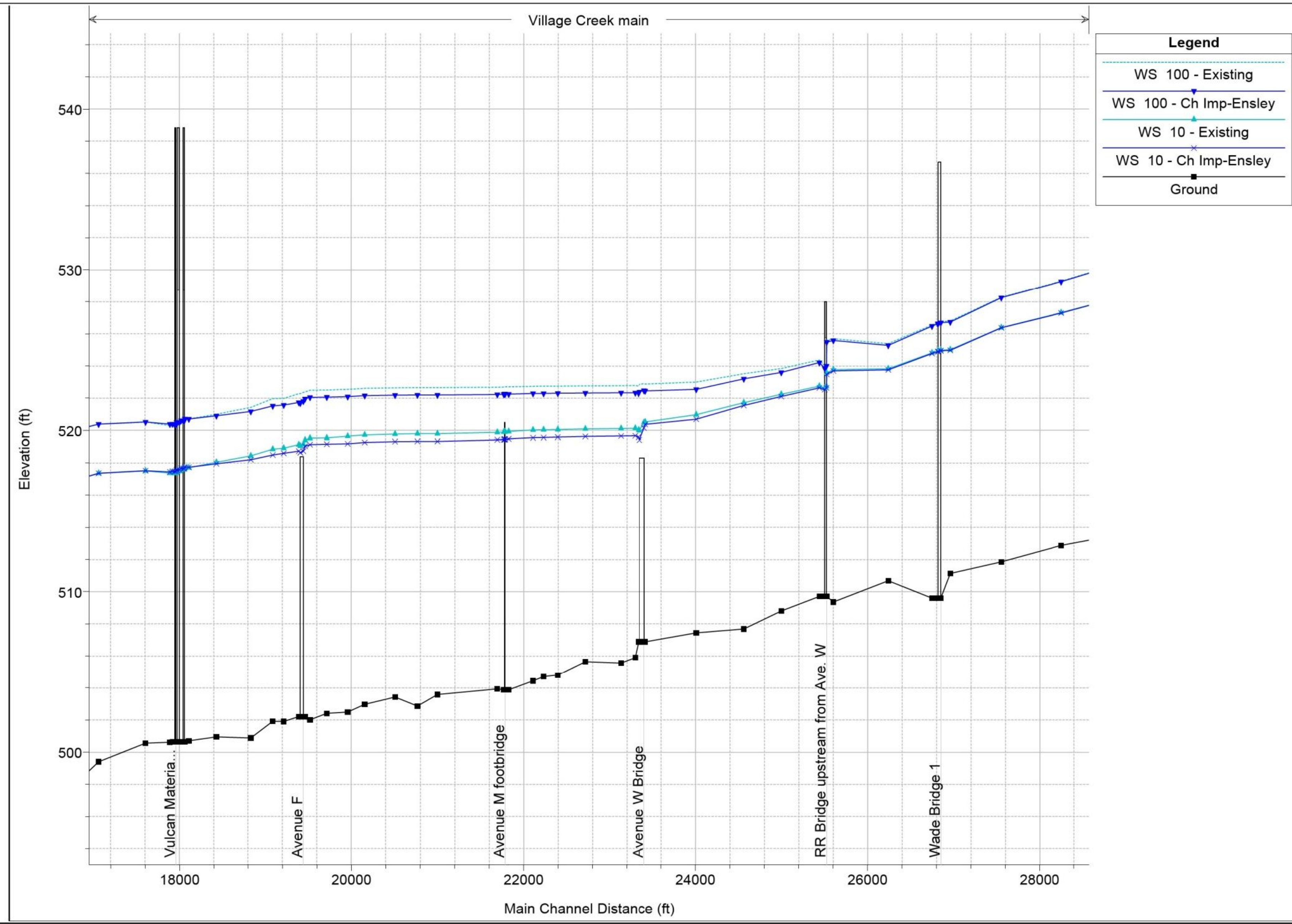
0 1000 2000 3000
GRAPHIC SCALE

EXHIBIT 5 -
CROSS SECTIONS

APRIL 5, 2016

ATTACHMENT B

FLOOD PROFILES



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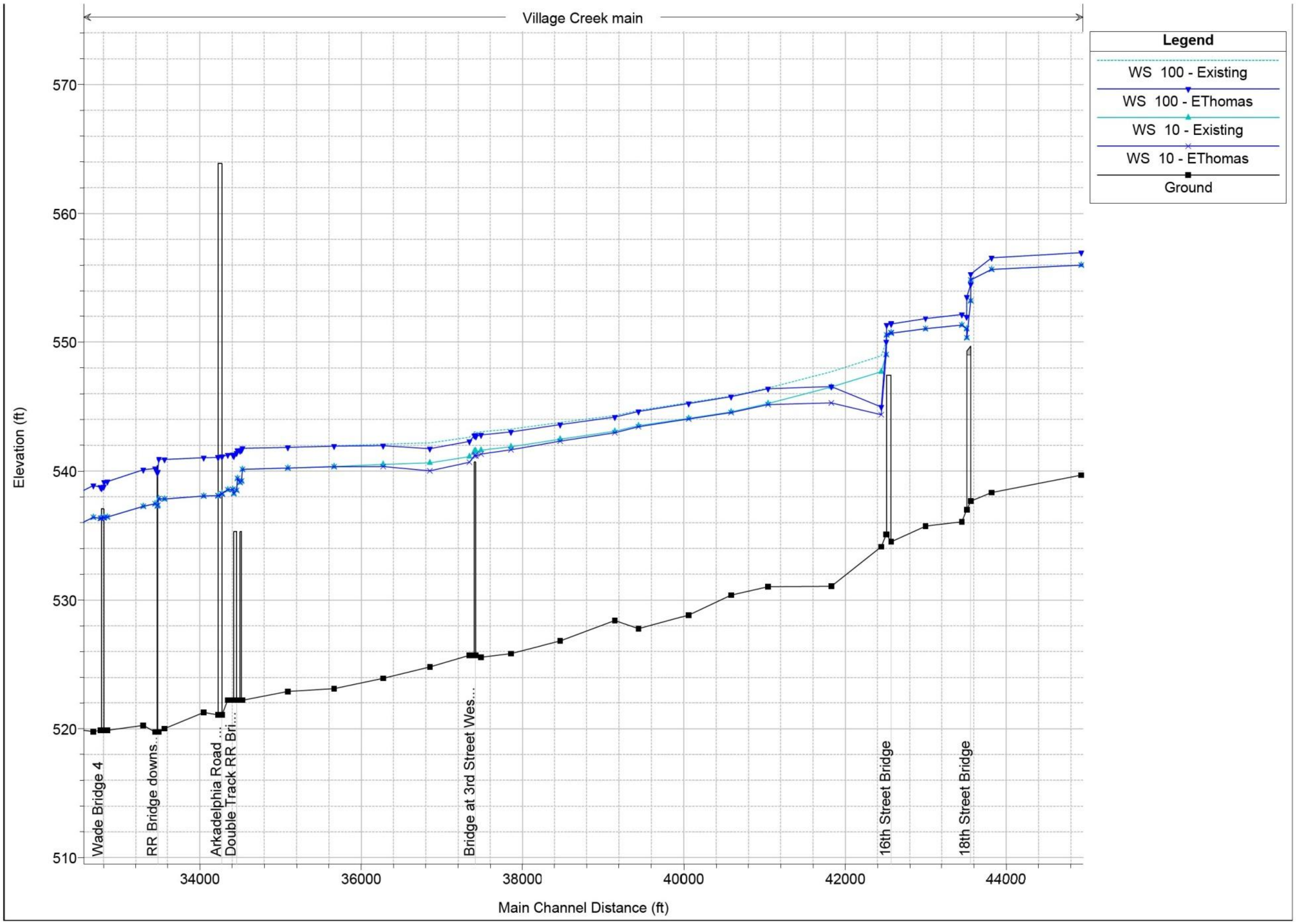
VILLAGE CREEK WATERSHED MANAGEMENT PLAN
PROJECT IMPROVEMENTS ASSESSMENT
JEFFERSON COUNTY, ALABAMA

ENSLEY CHANNEL IMPROVEMENT PROFILE COMPARISON

0 800 1600 2400
GRAPHIC SCALE

EXHIBIT 6 - PROFILES

APRIL 5, 2016



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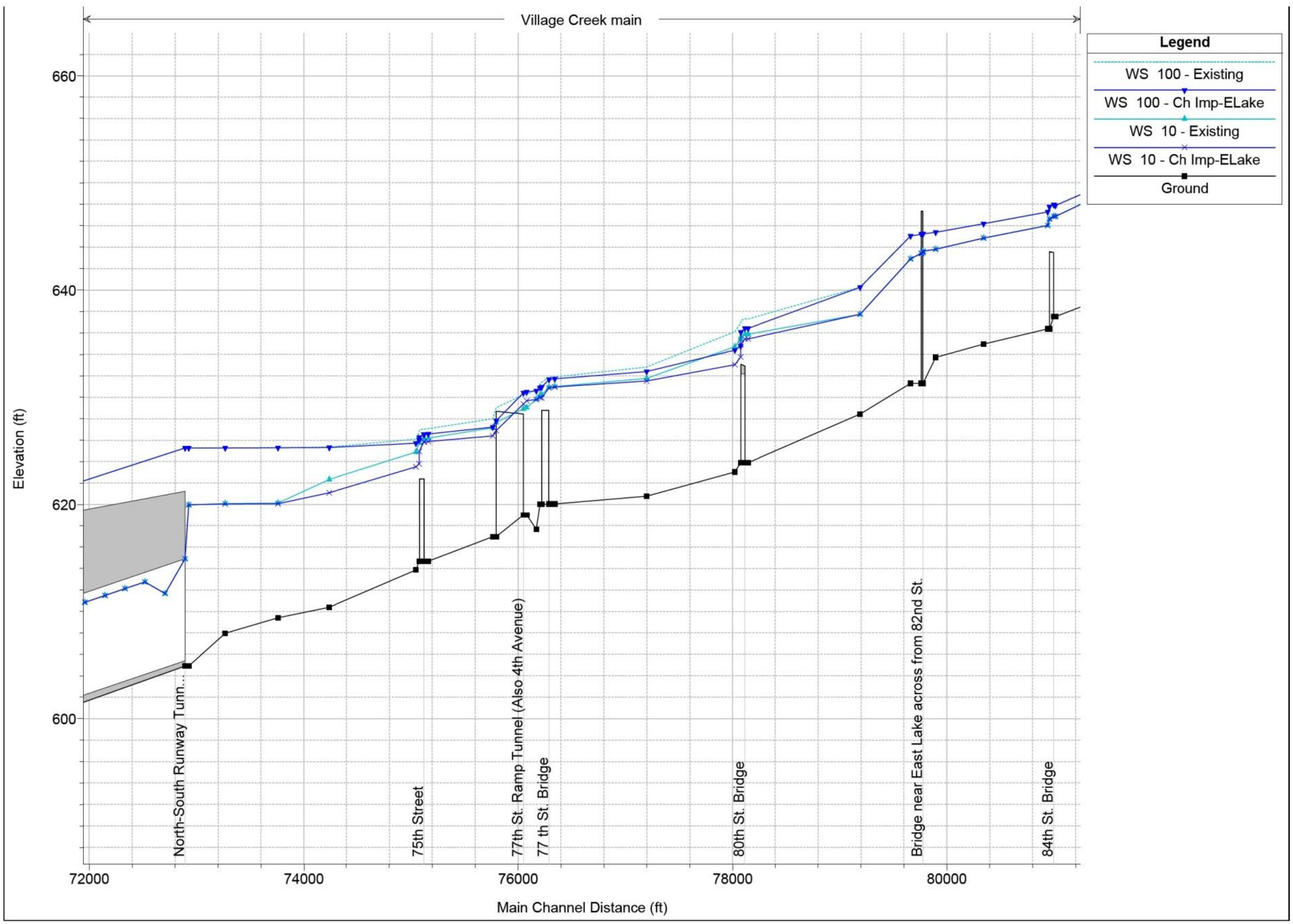
VILLAGE CREEK WATERSHED MANAGEMENT PLAN
PROJECT IMPROVEMENTS ASSESSMENT
JEFFERSON COUNTY, ALABAMA

EAST THOMAS CHANNEL IMPROVEMENT PROFILE COMPARISON

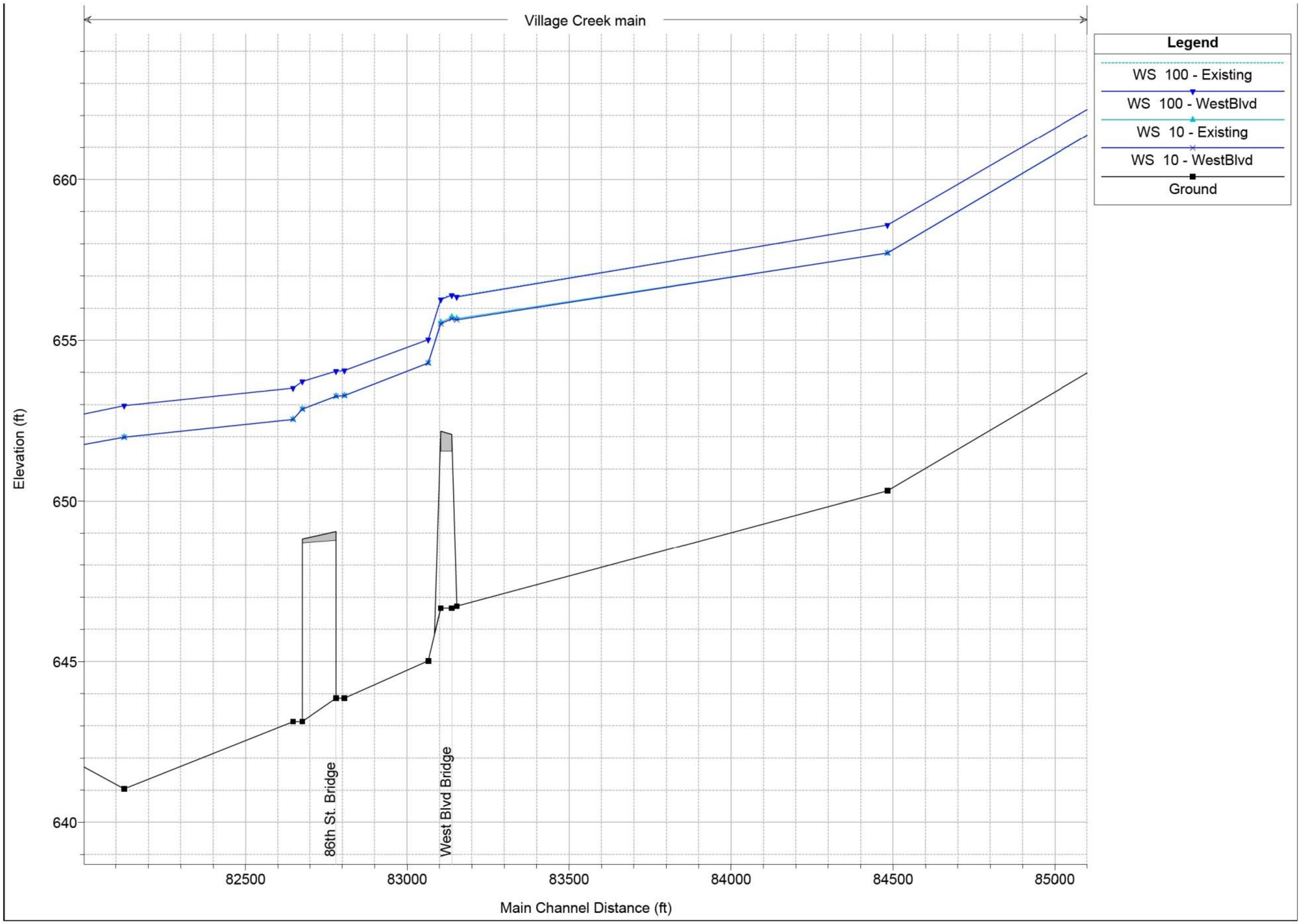
0 900 1800 2700
GRAPHIC SCALE

EXHIBIT 7 - PROFILES

APRIL 5, 2016



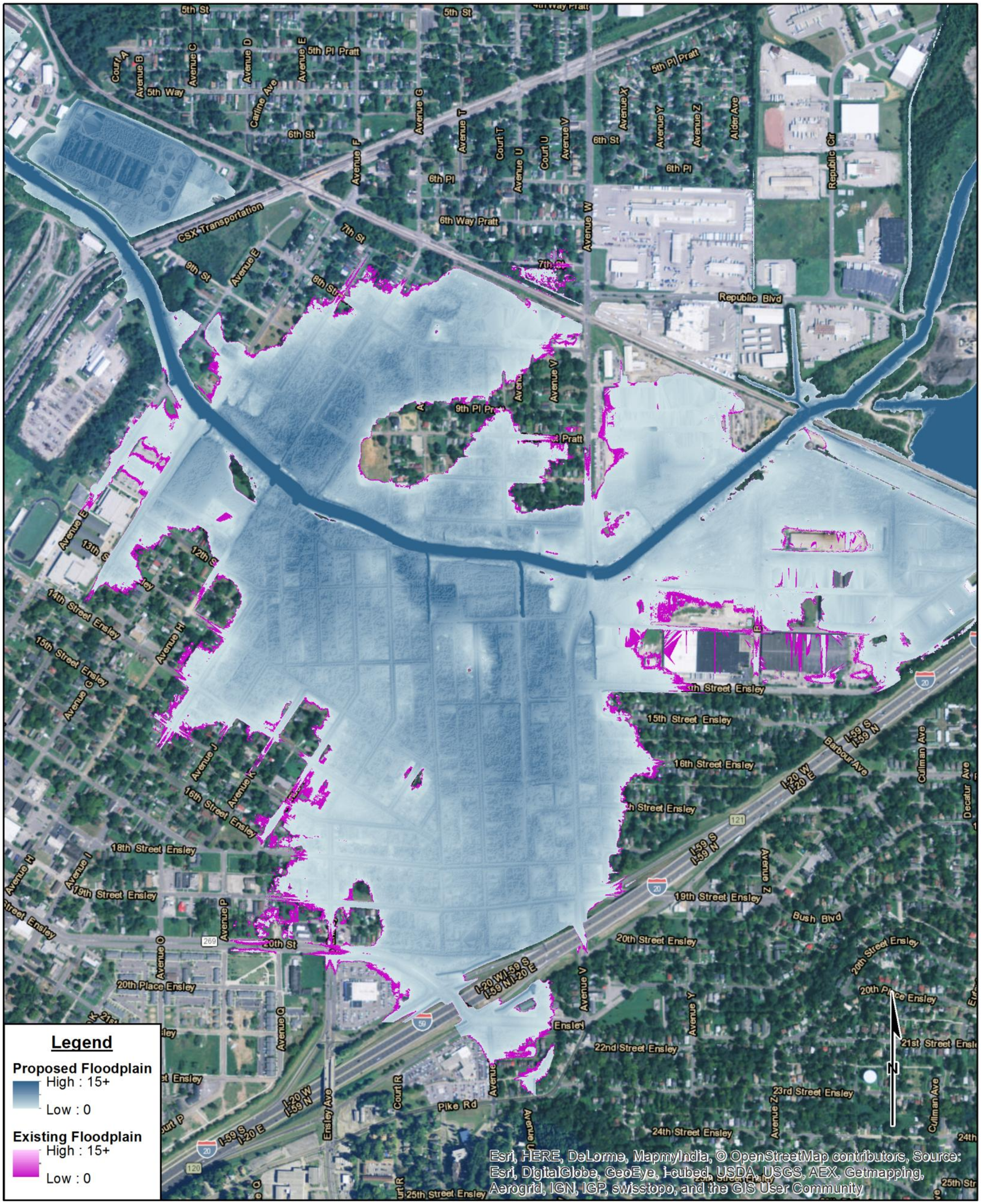
SCHOEL Consulting Engineers	VILLAGE CREEK WATERSHED MANAGEMENT PLAN PROJECT IMPROVEMENTS ASSESSMENT JEFFERSON COUNTY, ALABAMA	EAST LAKE CHANNEL IMPROVEMENT PROFILE COMPARISON	0 700 1400 2100 GRAPHIC SCALE	EXHIBIT 8 - PROFILES APRIL 5, 2016



SCHOEL Consulting Engineers	VILLAGE CREEK WATERSHED MANAGEMENT PLAN PROJECT IMPROVEMENTS ASSESSMENT JEFFERSON COUNTY, ALABAMA	WEST BLVD CHANNEL IMPROVEMENT PROFILE COMPARISON	0 225 450 675 GRAPHIC SCALE	EXHIBIT 9 - PROFILES APRIL 5, 2016

ATTACHMENT C

FLOOD INNUNDATION EXHIBITS



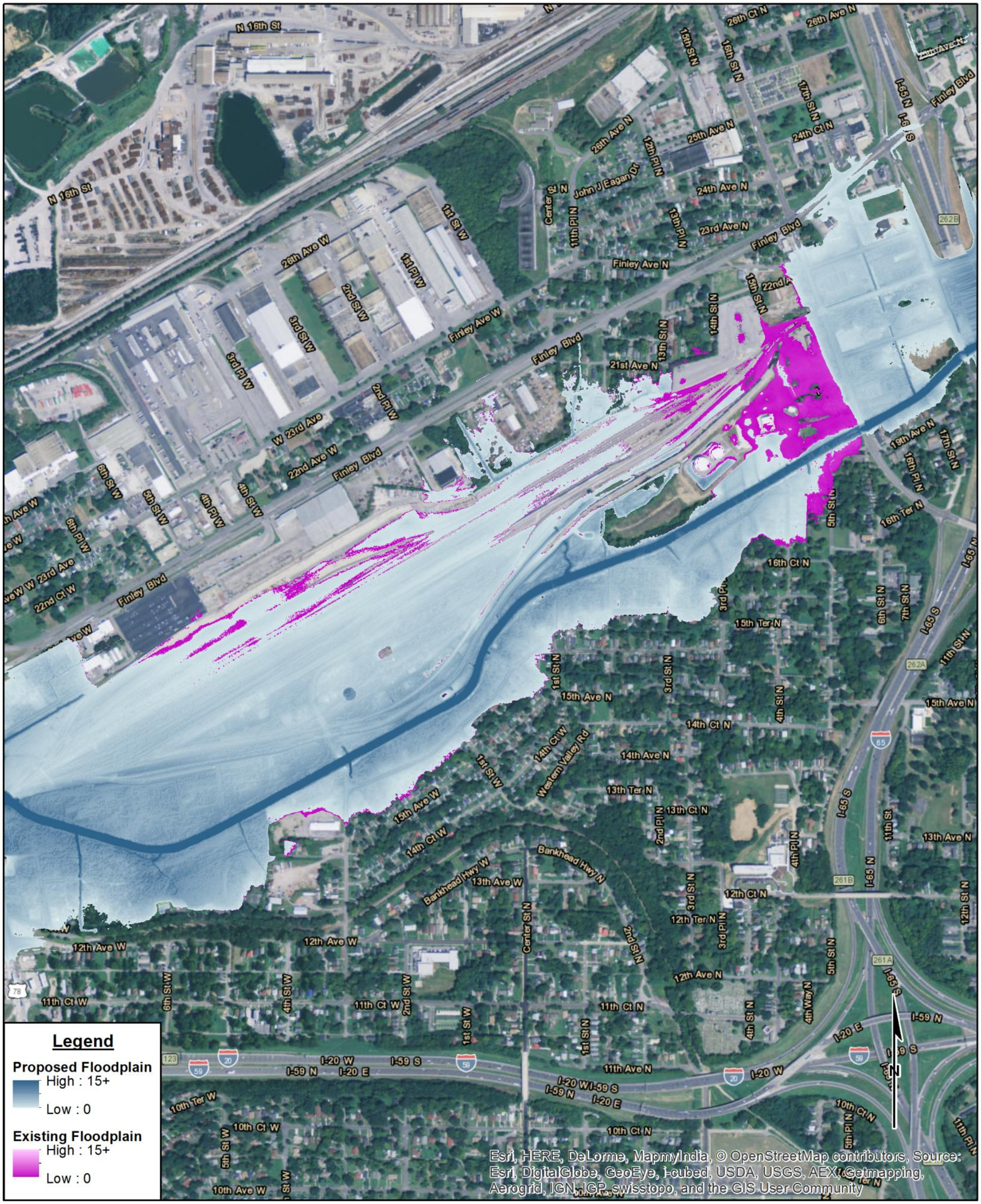
SCHOEL Consulting Engineers

VILLAGE CREEK WATERSHED MANAGEMENT PLAN
PROJECT IMPROVEMENTS ASSESSMENT

EXHIBIT 10 - ENSLEY CHANNEL IMPROVEMENT FLOODPLAIN COMPARISON

0 250 500 750 1,000 Feet

APRIL 27, 2016



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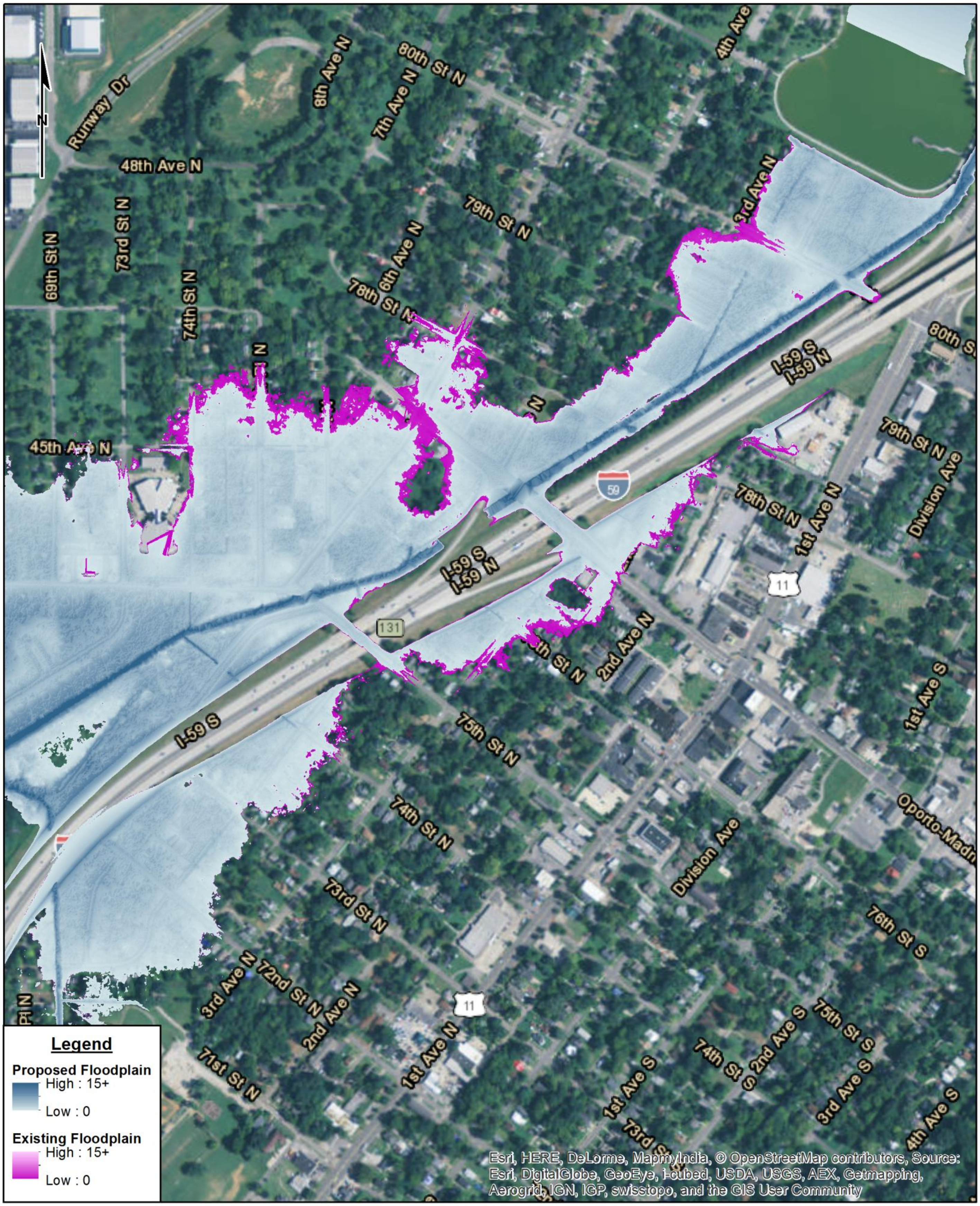
VILLAGE CREEK WATERSHED MANAGEMENT PLAN
PROJECT IMPROVEMENTS ASSESSMENT

EXHIBIT 11 - EAST THOMAS CHANNEL IMPROVEMENT FLOODPLAIN COMPARISON

0 250 500 750 1,000 Feet

APRIL 27, 2016



VILLAGE CREEK WATERSHED MANAGEMENT PLAN
PROJECT IMPROVEMENTS ASSESSMENT

EXHIBIT 12 - EAST LAKE CHANNEL IMPROVEMENT FLOODPLAIN COMPARISON

0 200 400 600 Feet

APRIL 27, 2016