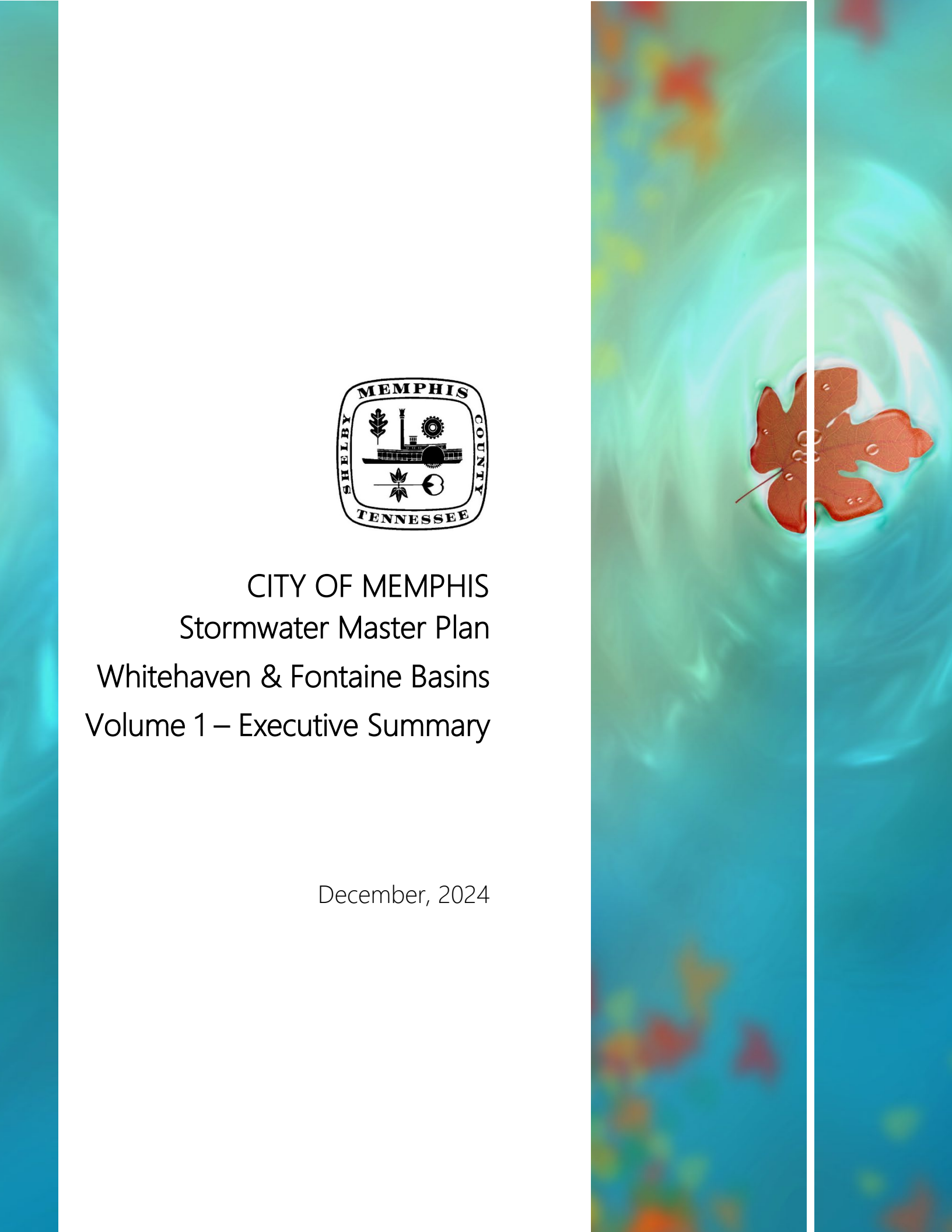

CITY OF MEMPHIS
Stormwater Master Plan
Whitehaven & Fontaine Basins
Volume 1 – Executive Summary

December, 2024

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C. Executive Summary

Our team was selected by the City of Memphis (the City) to study the Whitehaven watershed's existing conditions. This watershed, as defined for this study, includes two basins, historically identified on the City of Memphis drainage maps as Whitehaven and Fontaine. Together, these basins encompass 5.3 square miles or 3,420 acres.

The study conducted an inventory of the storm drain systems which were input into a computer model to serve as a "living" record, which can be added to and edited for future use.

A Master Plan identifying flooding problems within the basin as prepared, along with recommended solutions of proposed projects and estimated costs for those projects.

The following resources were used by our team in gathering information about flooding in the basin area:

1. Three (3) Public Meetings were conducted.
2. The complaint history provided by the City's Public Works Department was also reviewed and analyzed.
3. Drainage studies performed previously were reviewed and incorporated as appropriate.
4. FEMA studies were reviewed.
5. Climate and precipitation data was reviewed.
6. A topographic survey of existing drainage infrastructure was conducted.
7. Digital elevation model (DEM) obtained by Light Detection and Ranging (LiDAR) was used.
8. Rain gauges and stream depth gauges were installed by the City.
9. Data provided by U of M's Center for Partnerships in GIS was used to increase accuracy in establishing pervious and impervious areas.

As required by the City, InfoSWMM software was utilized to build the model, incorporating data from resources listed above. Adjustments were made to the model during the calibration phase, including rain gauge data and engineering judgement, along with parameters established in the City's Drainage Manual. More details regarding the model development and existing system analysis are included in Sec 4 of the full report.

The analysis of the final stormwater model led to the development of four (4) proposed projects to address flooding. Additionally, eight (8) more proposed projects have been identified as a response to item 2 on our list of resources – "complaint history provided by the City's Public Works Department." A summary of the twelve (12) total projects and estimated costs are provided in Table 1.

Table 1

Summary of Recommended Projects for Whitehaven Basin

Proposed Projects (based on model analysis)

	Location	Identified Problem	Recommended Projects	Est Cost
A	Commercial Parkway	Undersized 102" pipe; flow restriction	Billboard Site Drive	$ 942,000
B	Highland Creek Apts	Undersized channel and box culvert	Winchester Grove Apts Ditch Channelization	$ 9,284,000
C	Bluebird Road	Undersized channel and box culvert	Bluebird Road Ditch Channelization	$ 7,197,000
D	Millbranch Road	Undersized channel and box culvert	Millbranch to Brooks Drainage Improvements	$ 15,648,000

Proposed Projects (based on Public Works Flood Tickets)

	Location	Identified Problem	Recommended Projects	Est Cost
1	1438 & 1460 Winchester Rd	Flooding - Winchester & Graceland	Winchester & Graceland Drainage Improvements	$ 112,000
2	1324 East Raines Rd	Flooding - Raines & Faronia	Raines & Faronia Drainage Improvements	$ 397,000
3	3481 Graceland Dr	Flooding - Winchester & Graceland (left lane)	Graceland & Birch Bend Drainage Improvements	$ 26,000
4	1448 Timothy Dr	Flooding in back of property	Graceland & Timothy Drainage Improvements	$ 28,000
5	1360 Laudeen Dr	Flooding	Randall & Laudeen Drainage Improvements	$ 171,000
6	3210 Hernando Dr	Flooding in building	Hernando Road Drainage Improvements	$ 58,000
7	801 & 793 Dellrose Dr	Flooding in road	Dellrose Drive Drainage Improvements	$ 54,000
8	1070, 1097, 1120 Bluebird & 1081 Twinkletown	No stormdrain system along Bluebird and Twinkletown Roads	Twinkletown Road Drainage Improvements	$ 593,000

Table ES-1. Summary of Recommended Projects

Section 1 Background

1.1 Purpose

The purpose of developing this Master Plan is to identify flooding problems within the Whitehaven Basin and recommend solutions with estimated costs. The recommendations will be used to prioritize drainage improvement projects within the City. The plan includes the development of a hydrologic and hydraulic model of the basin based on field survey information and GIS-based topographic information. The model was used to identify problem areas and model potential solutions.

1.2 Team Members

The team selected for the Whitehaven Basin study included:

Powers Hill Design, LLC
80 Monroe Avenue, Suite 420
Memphis, TN 38103
901-543-8000
Nisha Powers, President
Steve Hill, P.E., Project Manager

Smith Seckman Reid, Inc. (SSR)
2650 Thousand Oaks Boulevard, Suite 3200
Memphis, TN 38118
901-683-3900
Ben Ledsinger, P.E., Project Manager
Justin Avent, P.E., Modelling & Analysis

Milestone Land Surveying, Inc.
10360 Highway 70, Suite 1
Lakeland, TN 38002
901-867-8671
Daryl Menard, RLS, Surveyor

1.3 Study Area Overview

The Whitehaven watershed as defined for this study includes two basins historically identified on the City of Memphis drainage maps – Whitehaven and Fontaine. Together, these basins encompass 5.3 square miles or 3,420 acres. The Whitehaven basin falls within the Lower Nonconnah Creek drainage basin. The USGS Hydrologic Unit Code (HUC) for Lower Nonconnah Creek is 0801-0211-0103. The Whitehaven basin discharges into Nonconnah Creek through nine (9) separate outfalls spanning almost 2 miles along Nonconnah Creek.

Figure ES-1 illustrates the location of the Whitehaven study area.

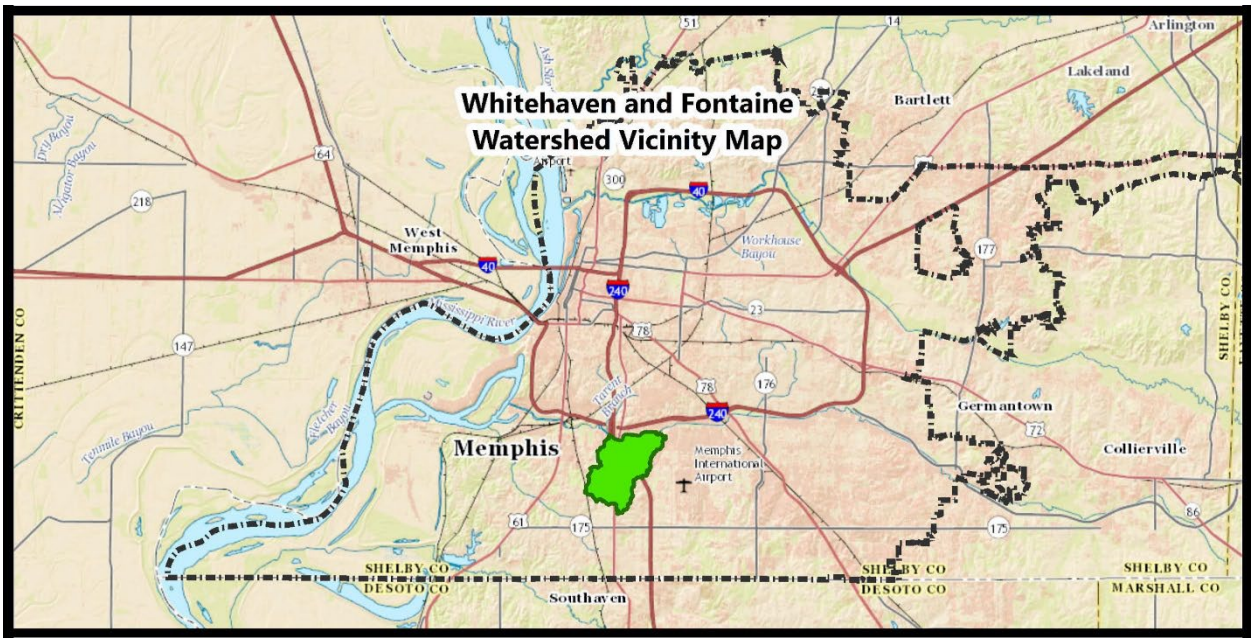

Figure ES-1. Whitehaven Vicinity Map

Study area basin boundaries were provided by the City of Memphis. While these boundaries were a good starting point, it soon became apparent that they were not 100% accurate. Through analysis using Arc Hydro Tools (detailed below), new basin boundaries were established which reflected the current topography obtained from LiDAR data. These refined basin boundaries are shown in Figure ES-2.

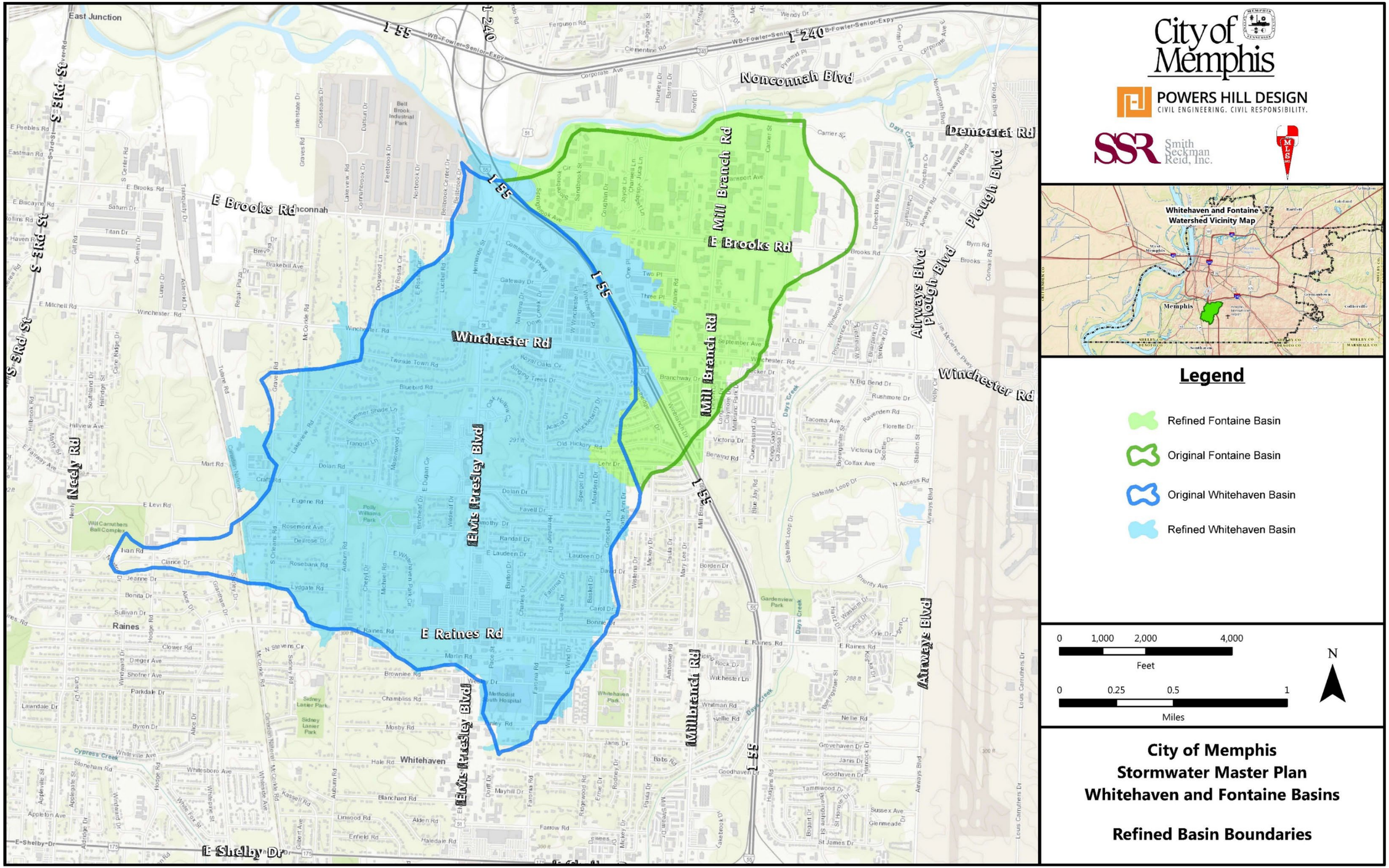

Figure ES-2. Refined Basin Boundaries

1.4 InfoSWMM Software

After extensive research and analysis of available software for the modeling of storm water systems, City staff selected InfoSWMM software for use on all Storm Water Master Plans under the City's Storm Water Program.

1.5 Public Involvement and Outreach

The public outreach effort for the Whitehaven basin focused on: (a) informing the public of the impending drainage study, and (b) providing a platform for citizens to inform the City of existing drainage-related issues. Based on discussions with City staff, it was determined that a total of three (3) public meetings would be held in the Whitehaven Basin to insure that citizens would have an opportunity to attend a meeting near them.

Section 2 Review of Previous Studies and Available Data

Drainage-related studies have been conducted in the vicinity of the Whitehaven basin in the past. Available studies were reviewed in preparation for this study, and pertinent information was incorporated as appropriate.

The Federal Emergency Management Agency (FEMA) has performed a detailed flood study of Nonconnah Creek. However, none of the tributaries of Nonconnah Creek within the Whitehaven basin have been studied. The Nonconnah Creek Flood Insurance Study provides information regarding the boundary conditions at the discharge points of the Whitehaven basin and establishes relevant tailwater elevations to be used within the InfoSWMM model.

In September 2010, Fisher Arnold (FA) conducted a study in the Fontaine of the area from Millbranch Road north across Brooks and into the flood plain of Nonconnah Creek. FA concluded that it would cost over $6,000,000 in culvert and channel improvements from Winchester to north of Brooks to prevent flooding of the two properties on Millbranch (3343 and 3368). Modeling done as a part of this study affirms FA's results for this area of the Fontaine Basin, as discussed in the Recommended Improvements section of this report.

2.1 Complaints Heat Map

As a part of the 2012 assessment of the City's Storm Water Program, City staff provided work order records from 2005 through 2011, which included over 40,000 customer calls and responses by City's Drain Maintenance Division crews. These records were used to create a GIS-based point density "heat map" of work orders to identify areas that received frequent customer complaints and/or required routine maintenance to preserve the function of the storm water drainage system. This heat map was used to determine areas of focus where close attention to ground surface and storm water system characteristics was needed. The heat map for the Whitehaven and Fontaine watersheds is shown in Figure ES-3. The highest intensity of complaints/work orders is located around the center of the Whitehaven watershed, centered near the intersection of Elvis Presley and Craft Road.

In addition to the heat map data, updated flood complaint information was provided by City staff through 4/28/22, and complaints were provided by area residents during the initial public meetings. These areas of concern were evaluated during the modeling of the basin to evaluate potential improvements to the drainage system.

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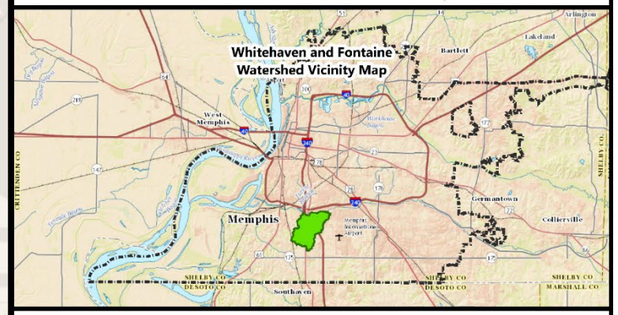

Legend

Complaints Value

- 82 - 231
- 231 - 379
- 379 - 528
- 528 - 676
- 676 - 824
- 824 - 973
- 973 - 1,121
- 1,121 - 1,270

0 950 1,900 3,800
Feet

0 0.25 0.5 1
Miles

N

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Stormwater Master Plan
Whitehaven and Fontaine Basins

Complaints Heatmap

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure ES-3. Complaints Heatmap

Section 3 Study Area Characteristics

The characteristics of the study area are discussed in the following sections.

3.1 Climate and Precipitation

The Memphis area experiences a "mid-latitude, moist continental" climate with cool but not bitterly cold winters, hot and humid summers, and a high degree of variability during spring and fall, along with a fair amount of precipitation year-round.

Memphis averages about 54" of precipitation each year. The wettest months are typically March, April and May in the spring, and November and December in the winter, averaging between 5" – 6" during those months. The driest month is August, with typically less than 3" of precipitation.

Table ES-2 shows the monthly average precipitation for the Memphis area.

Table ES-2. Average Monthly Precipitation

Month	Precipitation (inches)
January	3.98
February	4.41
March	5.16
April	5.51
May	5.24
June	3.62
July	4.61
August	2.87
September	3.07
October	3.98
November	5.47
December	5.75
Total:	**53.67**

Two rain gauges were installed within the study area. The gauges were located at Fire Stations – one located at 1025 East Raines Road, and one located at 3242 Fontaine Road. They collected field measurements from 6/24/2014 through 10/8/2014. During this monitoring period, the gauges collected 45 measurements greater than 0.1" out of the total 10,187 recorded measurements.

Two stream gauges were placed within the study area. The stream gage for Whitehaven was located in the open concrete channel in front of Heartbreak Hotel southwest of the intersection of Bluebird Road and Elvis Presley Boulevard. Hydraulically, this location was just downstream of where the upper half of the Whitehaven Basin converges to a single open concrete channel via three major conveyance systems. For the Fontaine portion of the study area, the gauge was located in the open concrete channel behind TAG Truck Center southeast of the intersection of Fontaine Road and East Brooks Road. This stream gage was hydraulically located in the lower third of the Fontaine Basin.

3.2 Topography

The Whitehaven and Fontaine basins slope generally to the north, with all of their outfalls discharging into Nonconnah Creek. Interstate 55 is the defining border between the Whitehaven and Fontaine watersheds, and almost without exception, all areas north of I-55 drain to Fontaine outfalls while areas to the south of I-55 drain to Whitehaven outfalls. There are a few small exceptions to this rule, with a few very small portions being drained under I-55. The Whitehaven portion has 2 distinct outfalls, while the Fontaine portion has 7 distinct outfalls.

3.3 Batch Subwatershed Delineation

Using Arc Hydro Tools modified to represent real-world circumstances, a satisfactory, hydrologically accurate set of catchments was achieved. These final catchments can be seen in Figure ES-4.

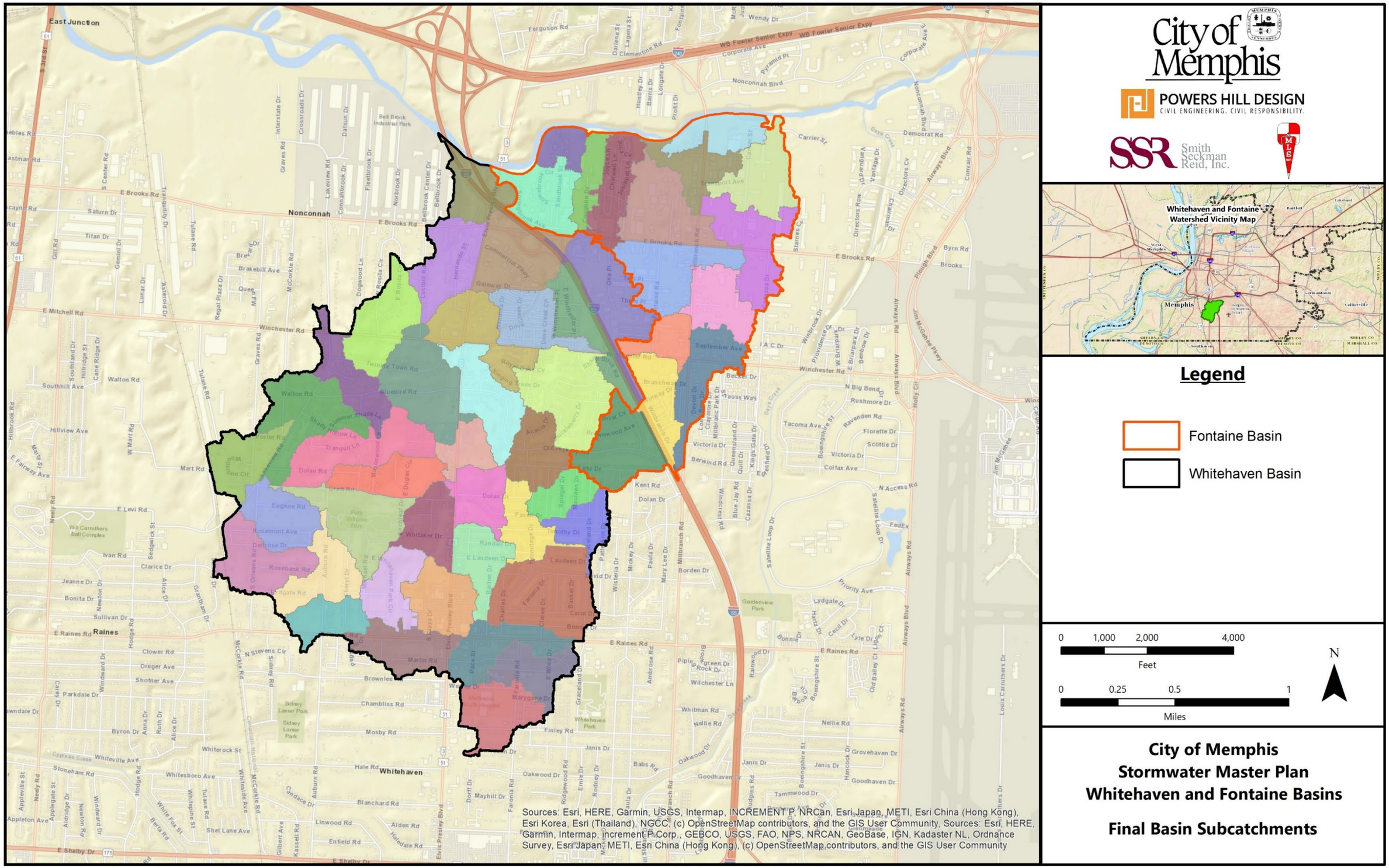

Figure ES-4. Final Basin Subcatchments

3.4 Impervious Area Calculations

Using composite land cover data, the percentage of impervious area was calculated for each subcatchment within the study area. These values are shown, symbolized by a range of percentage imperviousness, in Figure ES-5.

The modelers adjusted the impervious area values during the development and calibration of the SWMM models. The calibration process involved adjustments of various factors in the model (such as % impervious, subcatchment width, subcatchment slope, etc.). The final impervious area values in the model are shown in Figure 28 for the Whitehaven & Fontaine basins.

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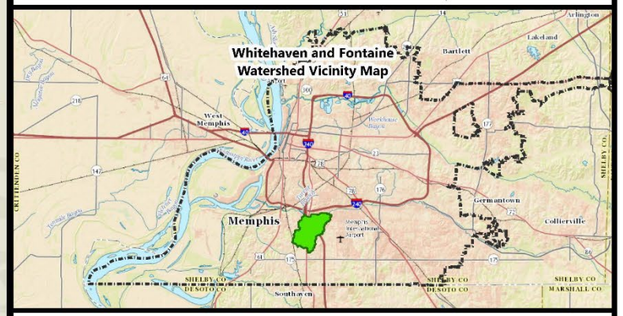


Legend

PERCENTAGE IMPERVIOUS

- <40%
- 40 - 50%
- 50 - 75%
- >75%
- **Whitehaven Basin**
- **Fontaine Basin**

0 1,000 2,000 4,000
Feet

0 0.25 0.5 1
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Catchments Percentage Impervious

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure ES-5. Catchment Percentage Impervious

Section 4 Summary of Existing System Analysis and Results

The following sections describe the model development and calibration processes, scenarios modelled, and results of those scenarios.

4.1 Model Development

The surveyed pipe and structure data were exported into a shapefile format and imported into the InfoSWMM model to construct the underground stormwater infrastructure networks within the model. The open channel conduits within the model and their cross-sections were constructed directly within the InfoSWMM model. The rain gauges, outfalls, and weirs within the model were also constructed directly within the InfoSWMM model. The Subcatchments within the model were created using the InfoSWMM watershed creation tools. These tools were used to delineate the original subcatchments based on the DEM and populate the subcatchment width and slope values. The original boundaries of the subcatchments were edited to reflect the drainage patterns of the underground storm sewer networks present throughout. The Green Ampt soil infiltration values, Manning's N values, and depression storage values within the model were populated based on the City of Memphis Storm Water Management Manual, and the "Default H&H Values from SWMM5" and "APPENDIX A - Useful Tables" sections of the InfoSWMM documentation.

4.2 Model Calibration

The City of Memphis installed rain gauges and stream depth gauges at two locations: one in the Whitehaven Basin and one in the Fontaine basin. These operated for the period from June 24, 2014 until August 29, 2014. During that period, only one rainfall event of any significance occurred on June 28th and 29th. Between June 28 at 6:30 p.m. and June 29 at noon, a total of 5.99" of rain was recorded in the Whitehaven basin, and a total of 6.34" of rain was recorded in the Fontaine basin.

Using the one significant rain event recorded during the monitoring period, the model was calibrated to more accurately reflect the performance of the drainage system during that event.

4.3 Existing Conditions Analysis and Results

Figures ES-6 through ES-12 depict the modeled conduits and nodes network for the Whitehaven Basin. Figures ES-13 through ES-16 depict the modeled conduits and nodes network for the Fontaine Basin.

Whitehaven Scenarios: For the analysis of the performance of the existing drainage system, the following scenarios were modeled (For the Whitehaven modeling, the City was working on a capital project to upgrade an undersized culvert in the Polly Williams Park area (Conduit ID: 327). Existing conditions modeling was done without this improvement included.):

BASE: This model contains the existing conditions scenario with 10 percent recurrence interval storm. Note that because of default InfoSWMM settings, when the scenario is activated, the entire network becomes the active facility, turning on all conduit, ponds, etc. Scenario EX10YEAR contains the correct facility settings to run the existing 10 percent annual recurrence interval storm scenario.

CALIBRATION: Existing conditions scenario without culvert improvements in Polly Williams Park with rain gage data applied for calibration to stream gage data.

EX2-YEAR: Existing conditions scenario without culvert improvements in Polly Williams Park with 50 percent recurrence interval storm.

EX5-YEAR: Existing conditions scenario without culvert improvements in Polly Williams Park with 20 percent recurrence interval storm.

EX10YEAR: Existing conditions scenario without culvert improvements in Polly Williams Park with 10 percent recurrence interval storm.

EX25YEAR: Existing conditions scenario without culvert improvements in Polly Williams Park with 4 percent recurrence interval storm.

EX50YEAR: Existing conditions scenario without culvert improvements in Polly Williams Park with 2 percent recurrence interval storm.

EX100YEAR: Existing conditions scenario without culvert improvements in Polly Williams Park. Subcatchment data set is 1 percent recurrence interval storm.

Fontaine Scenarios: The modeler prepared and ran the following scenarios for the Fontaine basin to assess performance of the existing drainage system:

BASE: This model contains the existing conditions scenario with 10 percent recurrence interval storm. Note that because of default InfoSWMM settings, when the scenario is activated, the entire network becomes the active facility, turning on all conduit, ponds, etc. Scenario EXISTING_10YR contains the correct facility settings to run the existing 10 percent annual recurrence interval storm scenario.

EXISTING_2YR: Existing conditions scenario with 50 percent recurrence interval storm.

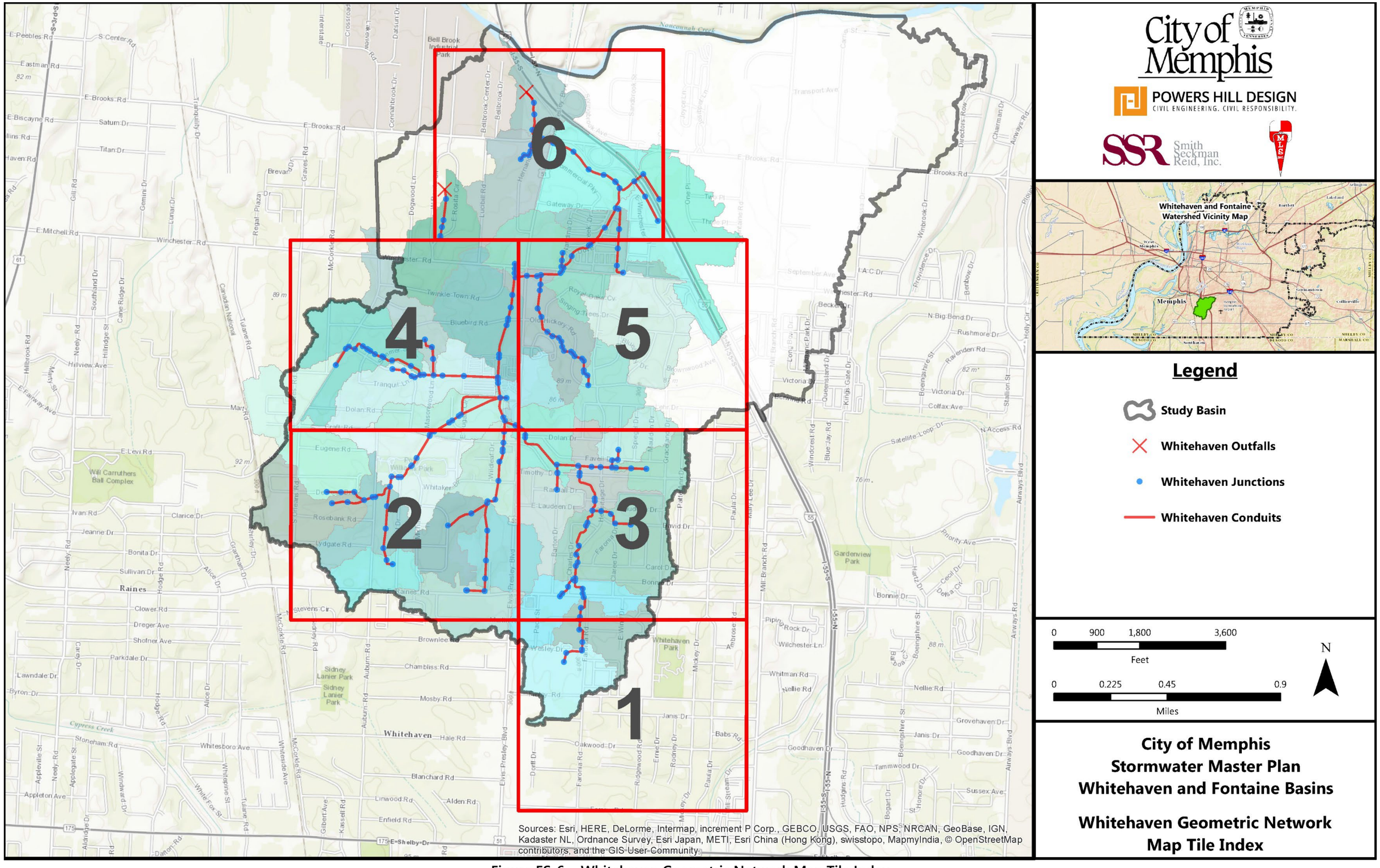
EXISTING_5YR: Existing conditions scenario with 20 percent recurrence interval storm.

EXISTING_10YR: Existing conditions scenario with 10 percent recurrence interval storm.

EXISTING_25YR: Existing conditions scenario with 4 percent recurrence interval storm.

EXISTING_50YR: Existing conditions scenario with 2 percent recurrence interval storm.

EXISTING_100YR: Existing conditions scenario with 1 percent recurrence interval storm.



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Legend

- Study Basin
- Whitehaven Outfalls
- Whitehaven Junctions
- Whitehaven Conduits

0 900 1,800 3,600
Feet

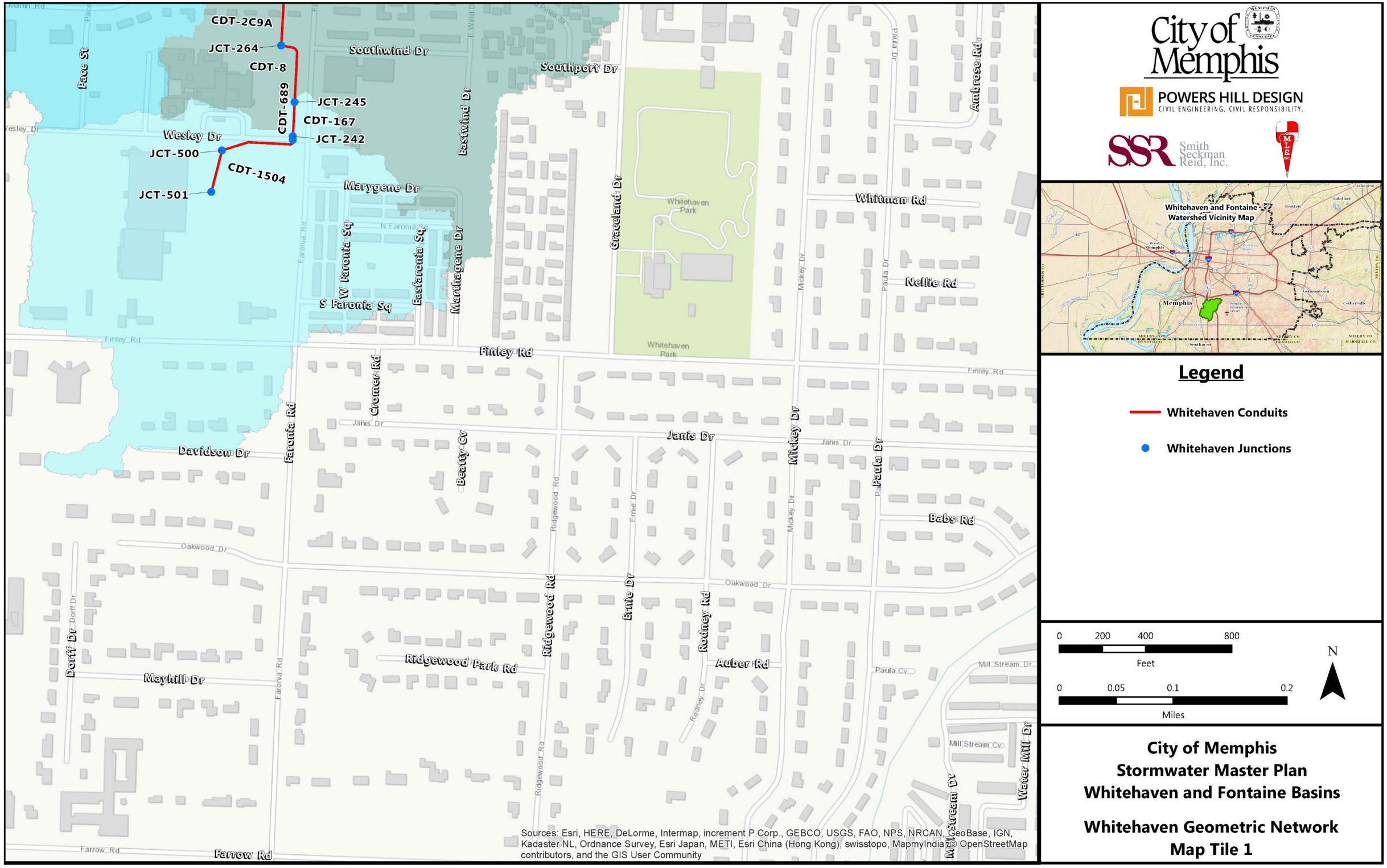
0 0.225 0.45 0.9
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile Index

Figure ES-6. Whitehaven Geometric Network Map Tile Index



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Legend

- Whitehaven Conduits
- Whitehaven Junctions

0 200 400 800
Feet

0 0.05 0.1 0.2
Miles

N

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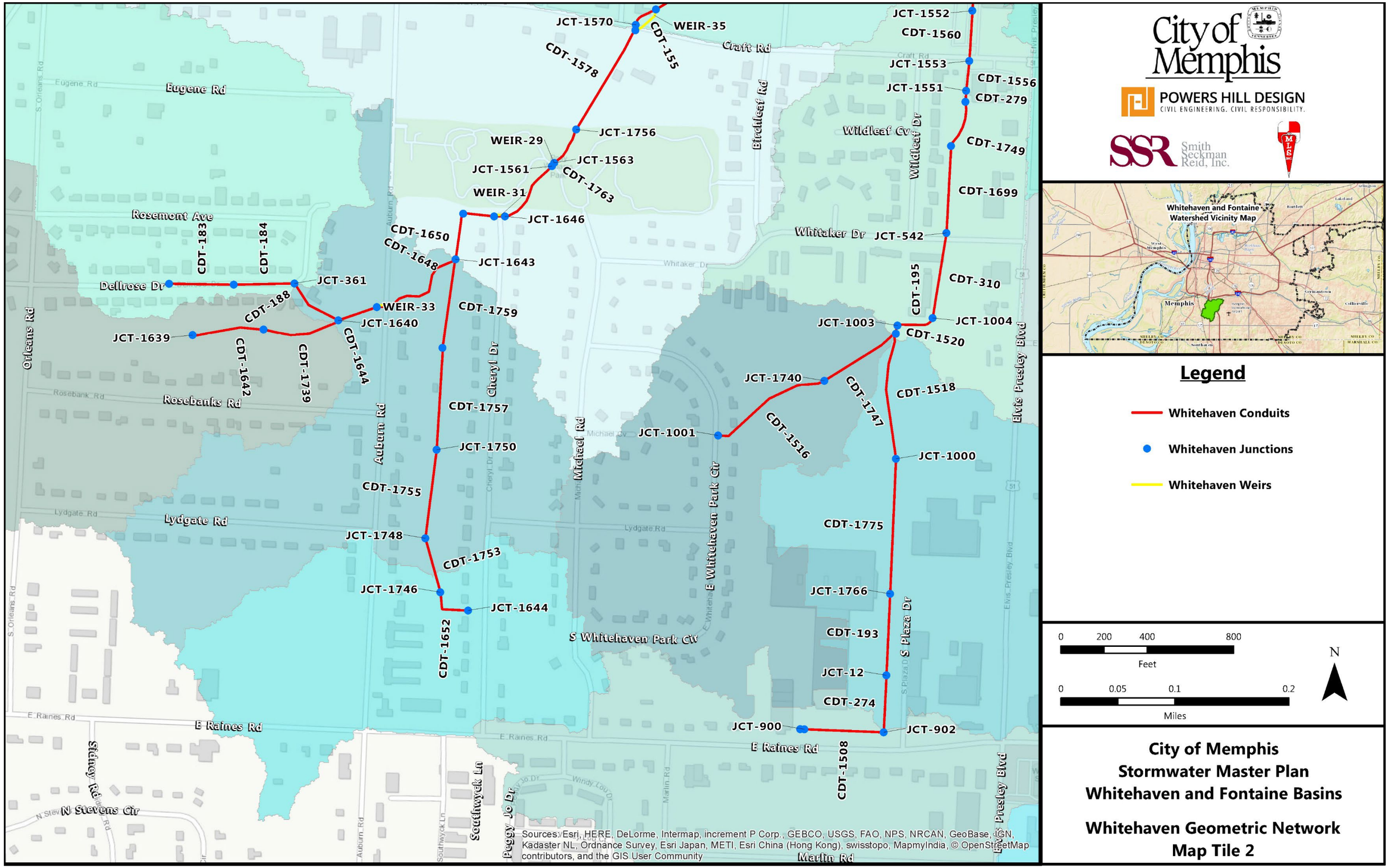
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile 1

Figure ES-7. Whitehaven Geometric Network Map Tile 1



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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Legend

- Whitehaven Conduits
- Whitehaven Junctions
- Whitehaven Weirs

0 200 400 800
Feet

0 0.05 0.1 0.2
Miles

N

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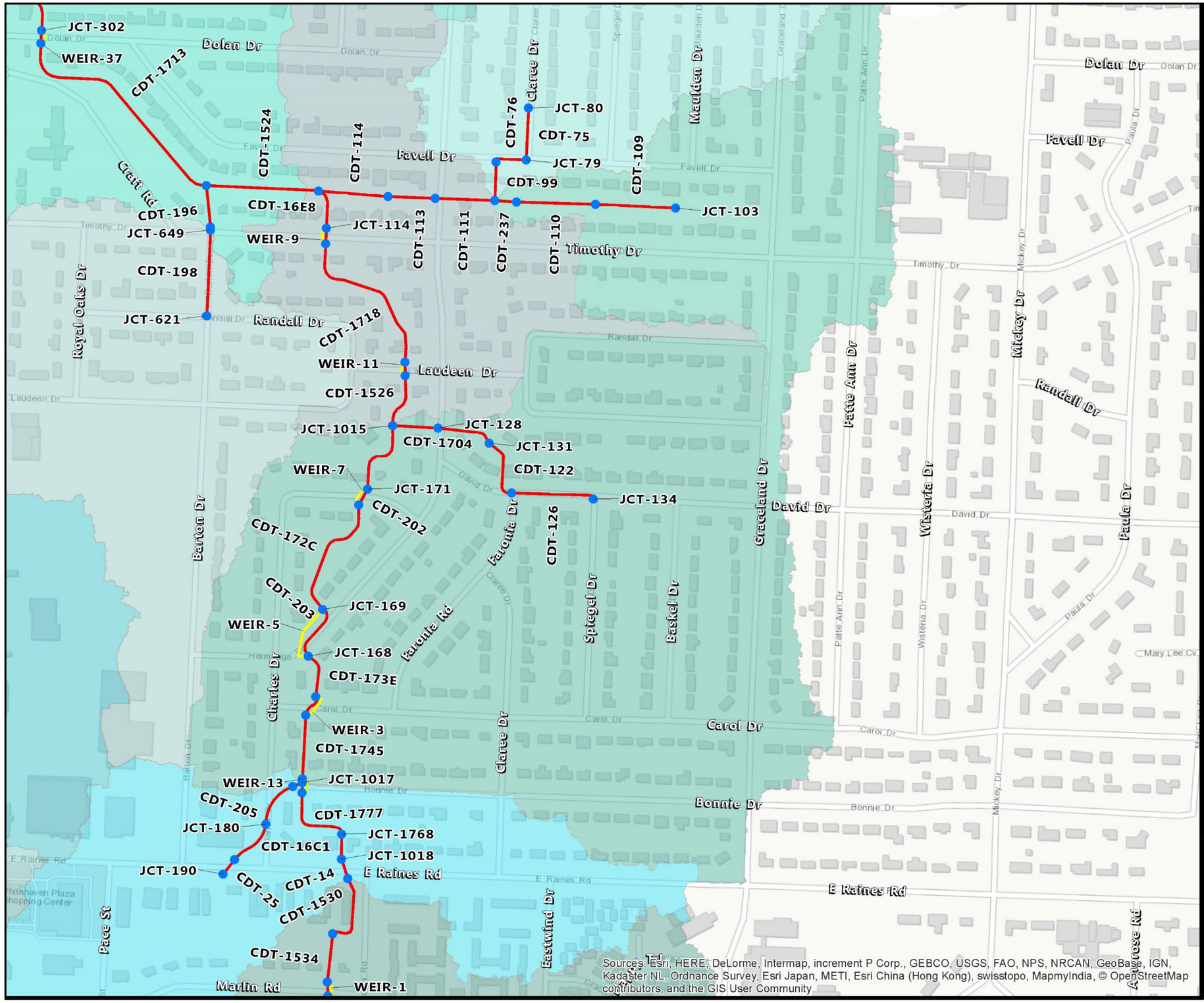
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile 2

Figure ES-8. Whitehaven Geometric Network Map Tile 2



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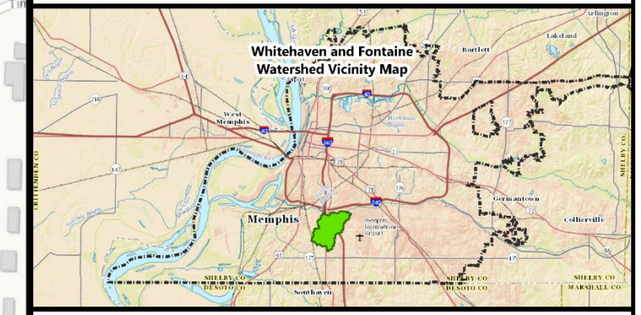

Legend

- Whitehaven Conduits
- Whitehaven Junctions
- Whitehaven Weirs

0 200 400 800
Feet

0 0.05 0.1 0.2
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile 3

Figure ES-9. Whitehaven Geometric Network Map Tile 3

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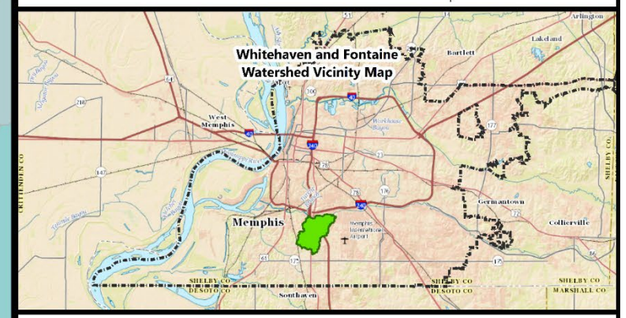


Legend

- Whitehaven Conduits
- Whitehaven Junctions
- Whitehaven Weirs
- Whitehaven Storage

0 200 400 800
Feet

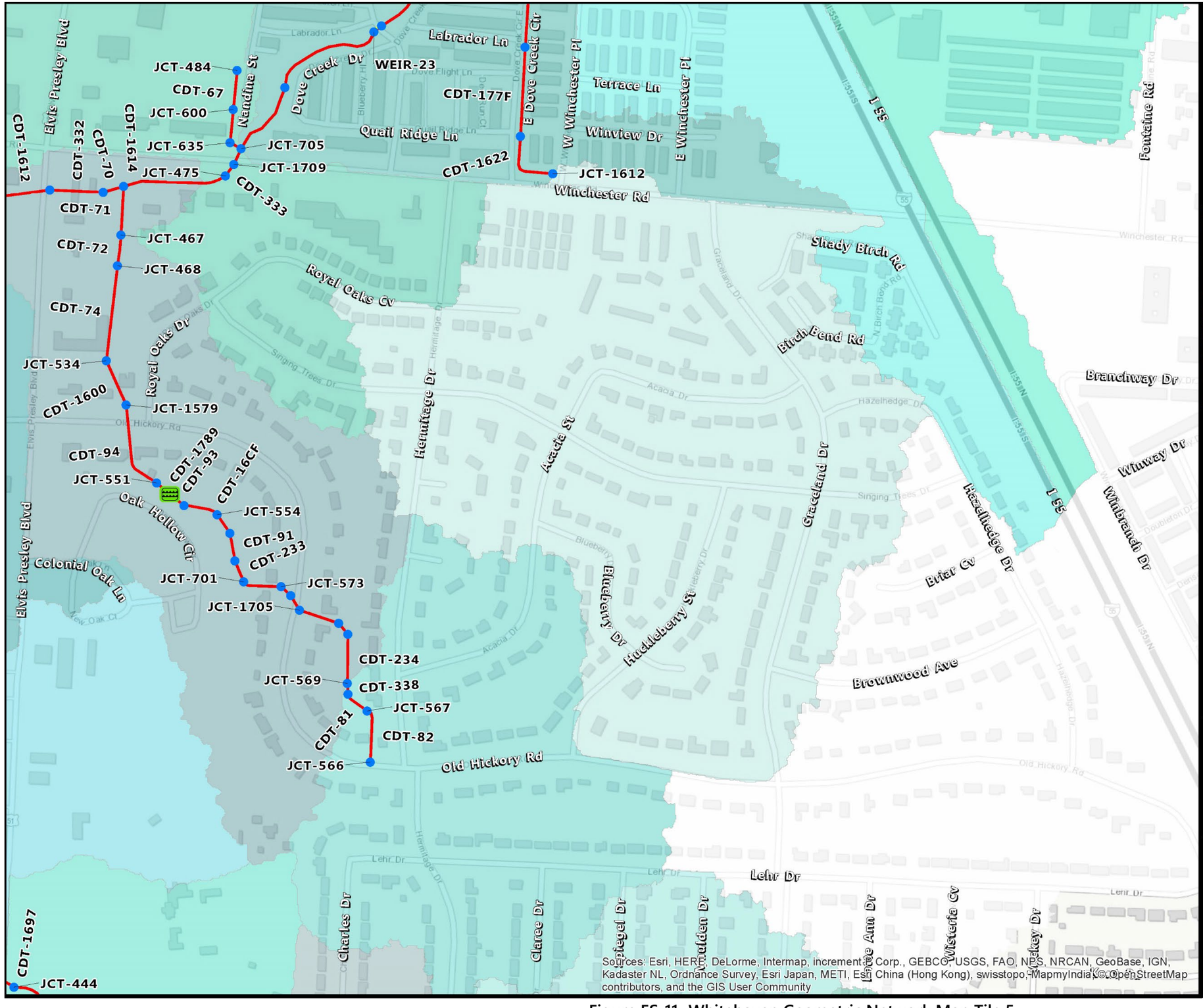
0 0.05 0.1 0.2
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile 4

Figure ES-10. Whitehaven Geometric Network Map Tile 4



City of Memphis

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Legend

- Whitehaven Conduits
- Whitehaven Junctions
- Whitehaven Weirs
- Whitehaven Storage

0 200 400 800
Feet

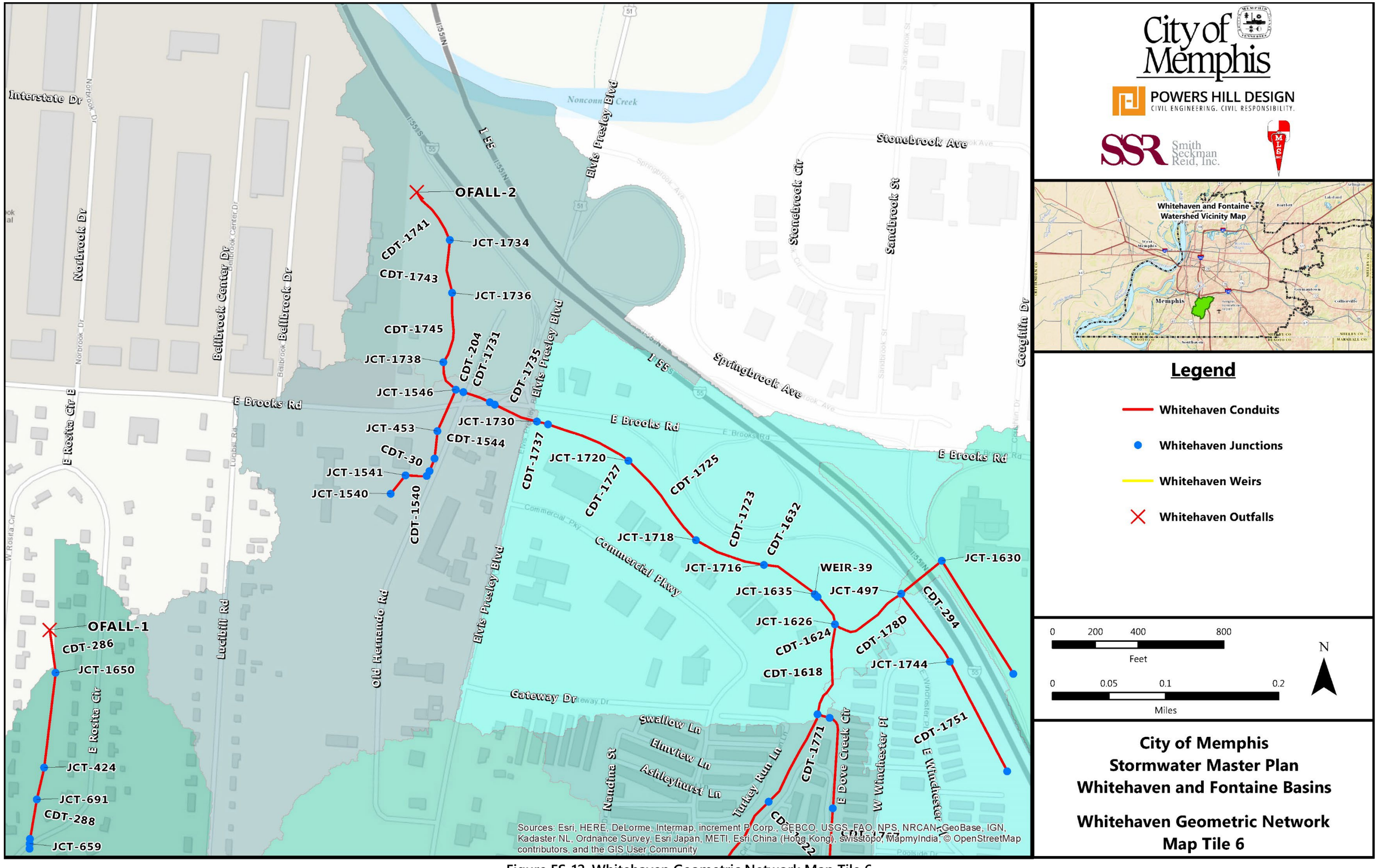
0 0.05 0.1 0.2
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile 5

Figure ES-11. Whitehaven Geometric Network Map Tile 5



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Legend

- Whitehaven Conduits
- Whitehaven Junctions
- Whitehaven Weirs
- Whitehaven Outfalls

0 200 400 800
Feet

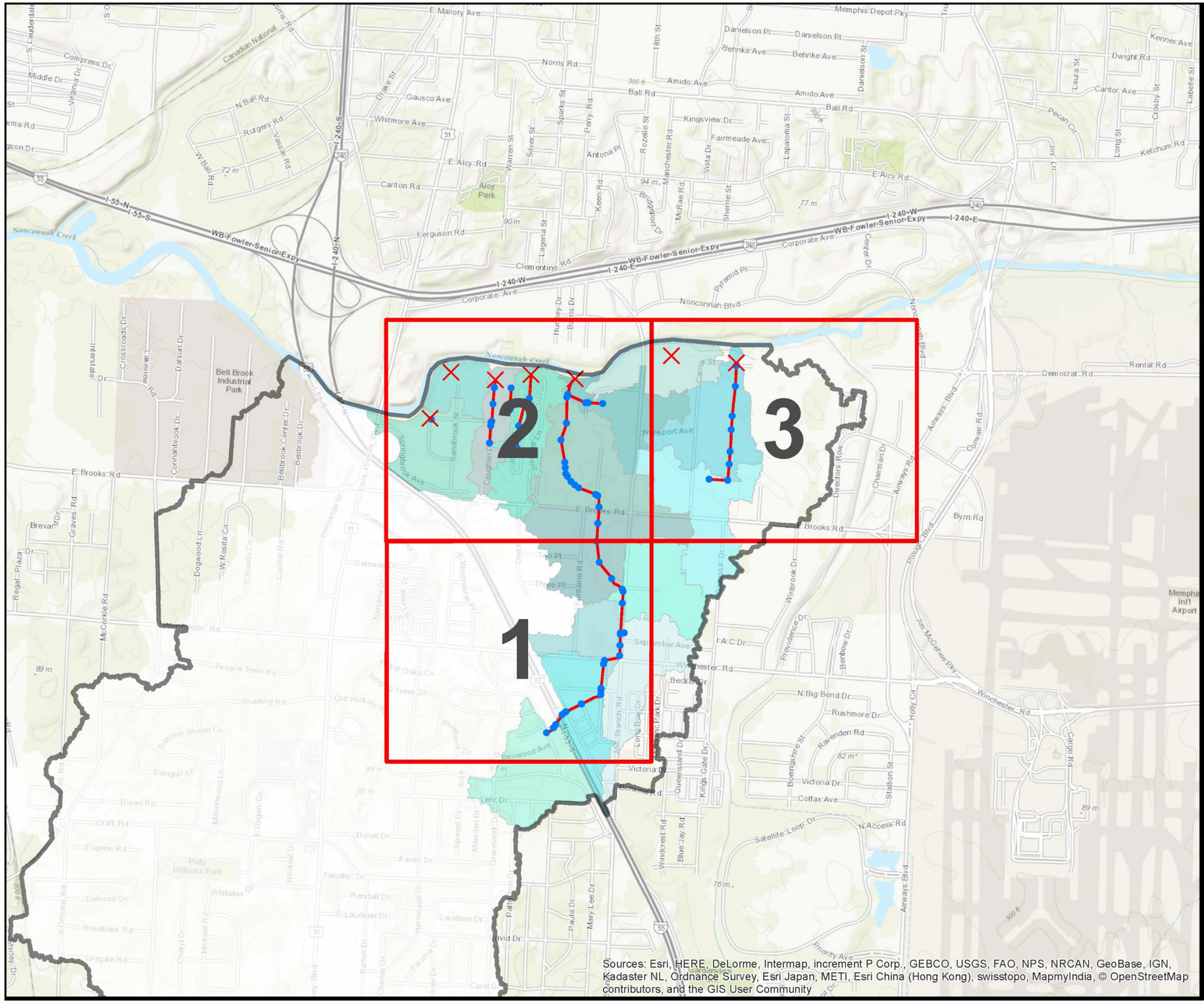
0 0.05 0.1 0.2
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Whitehaven Geometric Network
Map Tile 6

Figure ES-12. Whitehaven Geometric Network Map Tile 6



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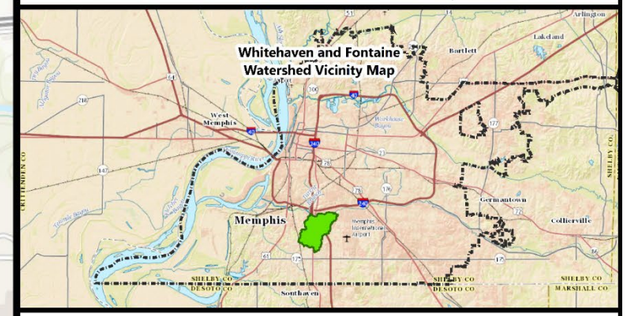


Legend

- Study Basin
- Fontaine Conduits
- Fontaine Junctions
- Fontaine Outfalls

0 900 1,800 3,600
Feet

0 0.225 0.45 0.9
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Fontaine Geometric Network
Map Tile Index

Figure ES-13. Fontaine Geometric Network Map Tile Index

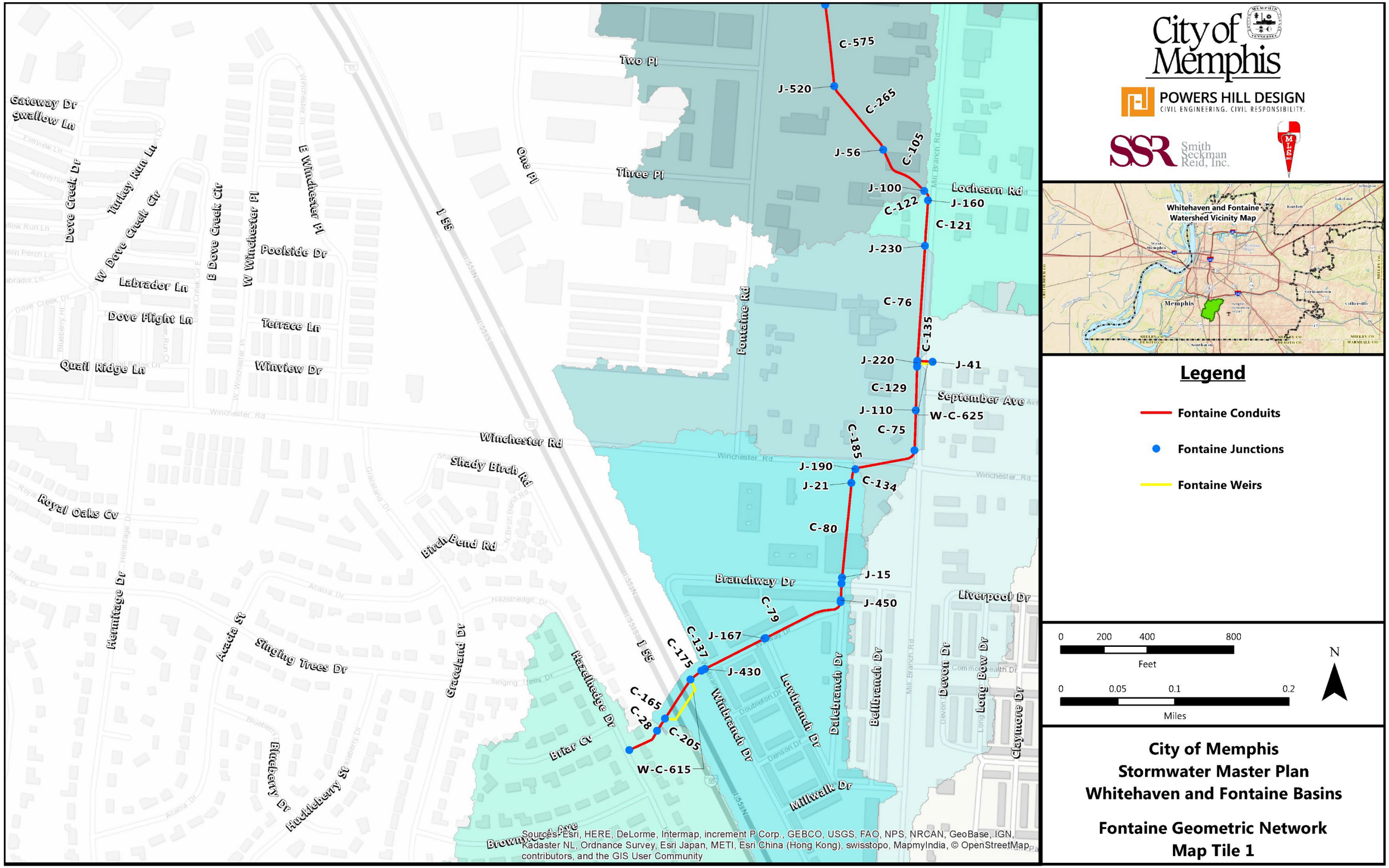
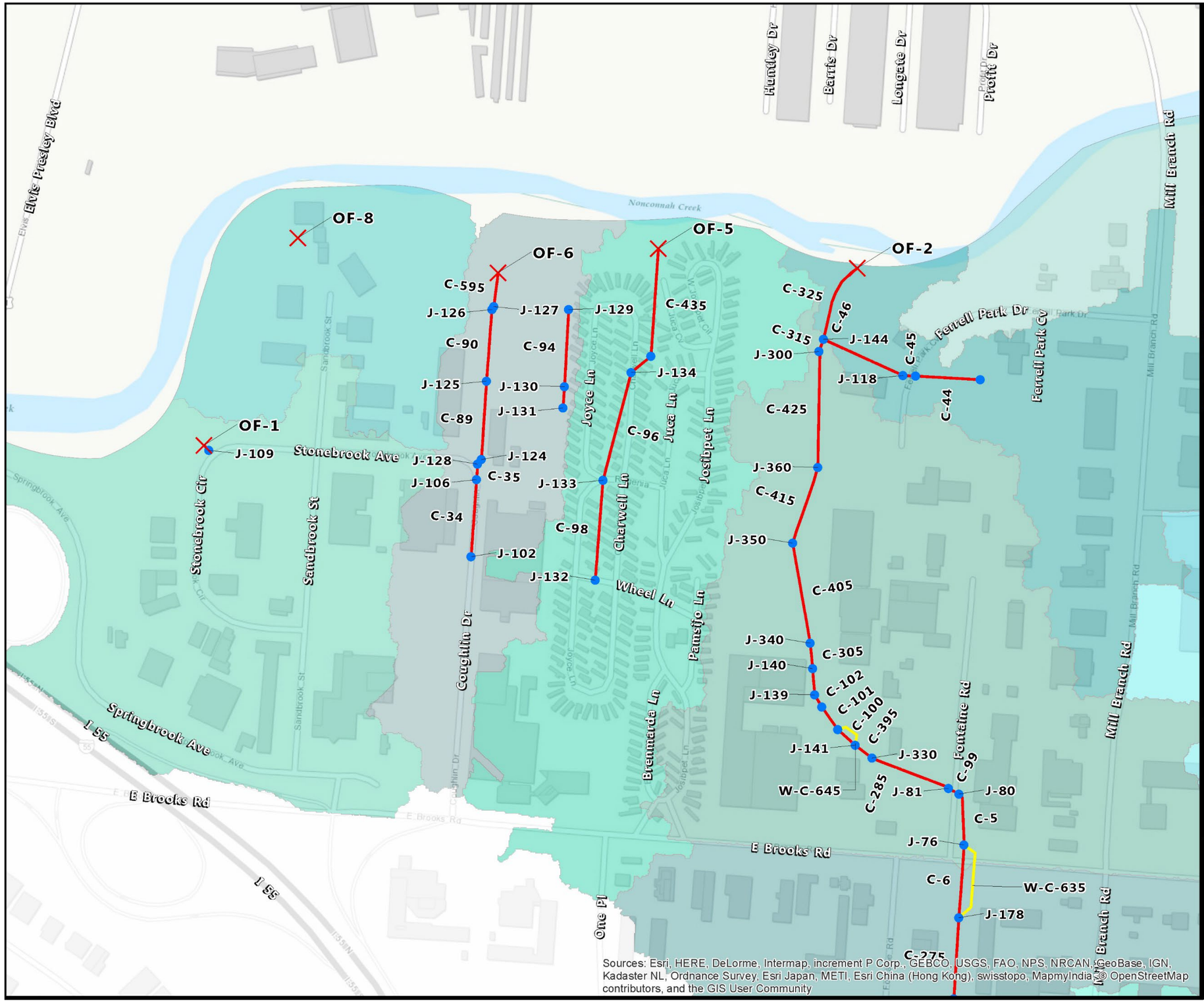


Figure ES-14. Fontaine Geometric Network Map Tile 1



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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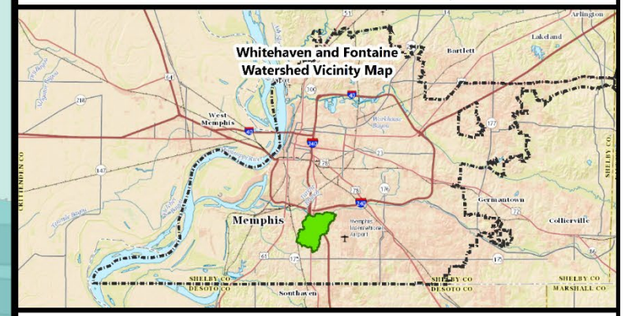


Legend

- Fontaine Conduits
- Fontaine Junctions
- Fontaine Weirs
- Fontaine Outfalls

0 200 400 800
Feet

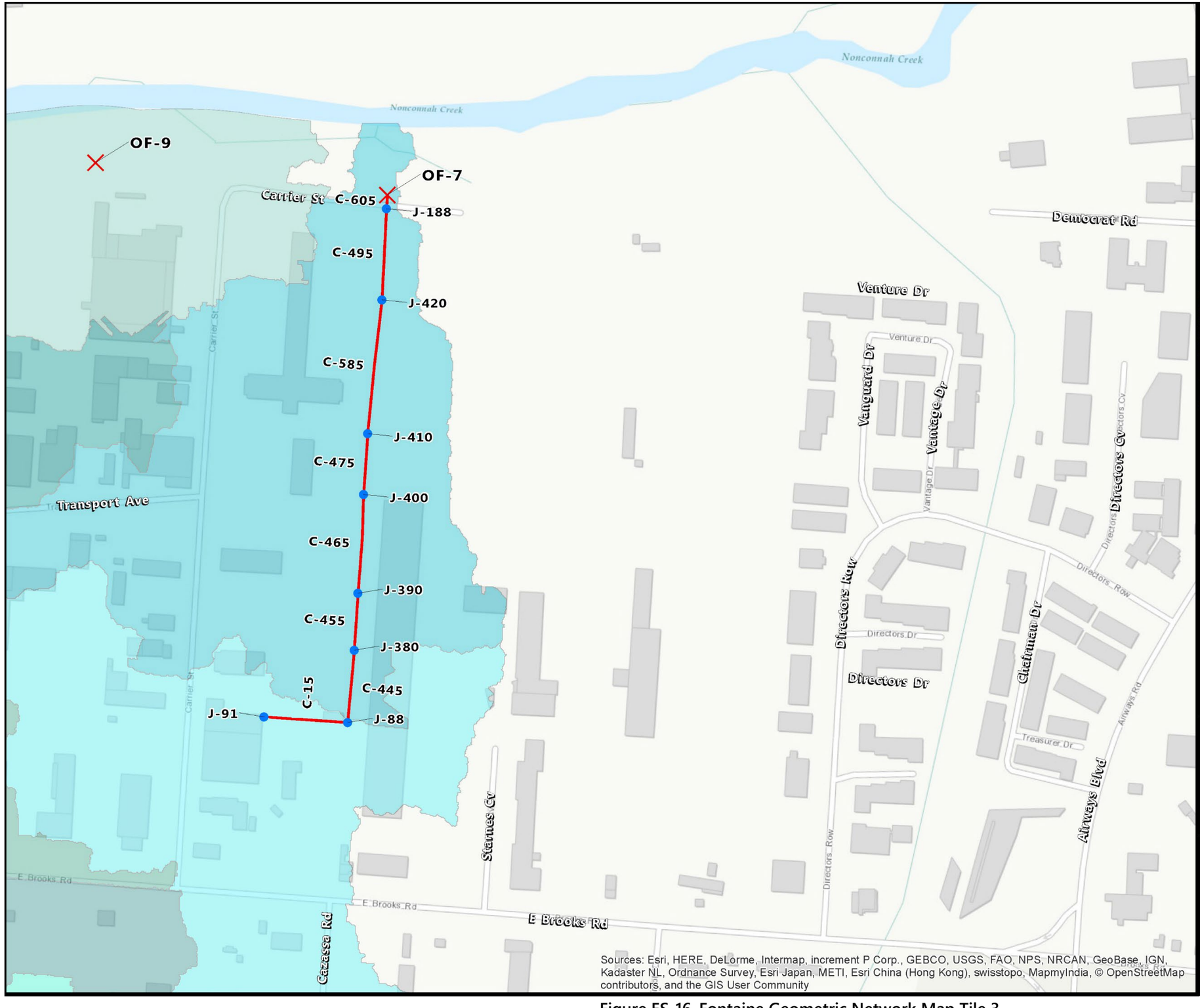
0 0.05 0.1 0.2
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Fontaine Geometric Network
Map Tile 2

Figure ES-15. Fontaine Geometric Network Map Tile 2



City of Memphis

POWERS HILL DESIGN
CIVIL ENGINEERING. CIVIL RESPONSIBILITY.

Smith Seckman Reid, Inc.

Legend

- Fontaine Conduits
- Fontaine Junctions
- Fontaine Outfalls

0 200 400 800
Feet

0 0.05 0.1 0.2
Miles

N

City of Memphis
Stormwater Master Plan
Whitehaven and Fontaine Basins

Fontaine Geometric Network
Map Tile 3

Figure ES-16. Fontaine Geometric Network Map Tile 3

4.3.1 Flood Extent Predicted by Modeling

Using the calibrated InfoSWMM model, the 2-year and 100-year storm events were run, and the predicted water levels were determined. Based on the predicted levels, flooding extents were plotted based on Lidar contours in the basins.

For the Whitehaven basin, the most significant flooding areas from the 100-year storm event were in the following locations:

- Area between Bluebird Road and Twinkletown Road west of Elvis Presley Blvd. (Figure ES-18)
- Winchester Grove Apartments located north of Winchester between Elvis Presley and I-55 (Figure ES-19 & Figure ES-20)

For the Fontaine basin, the most significant flooding area from the 100-year storm event extended from Mill Branch Road northwest to Brooks Road (Figure ES-21).

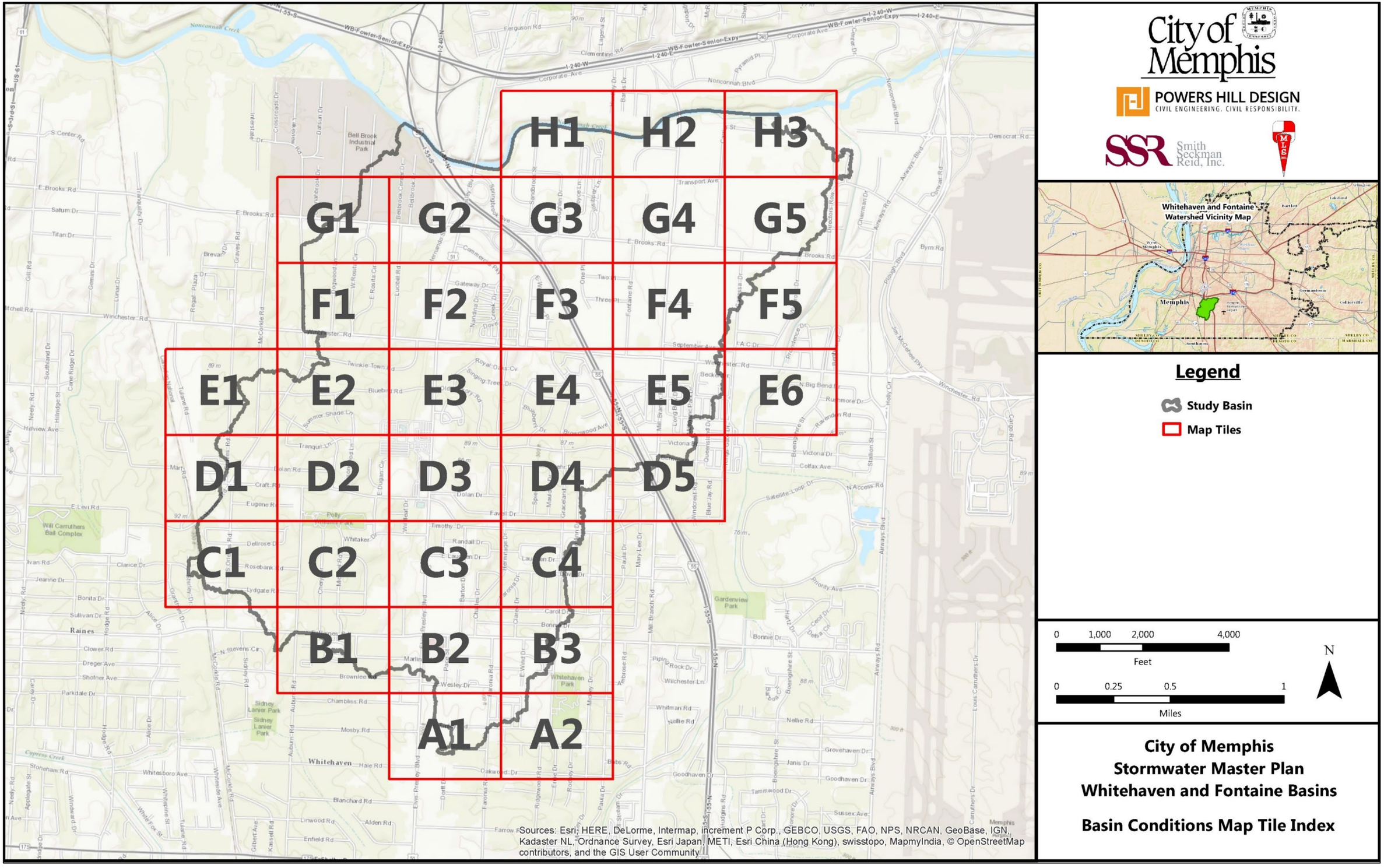
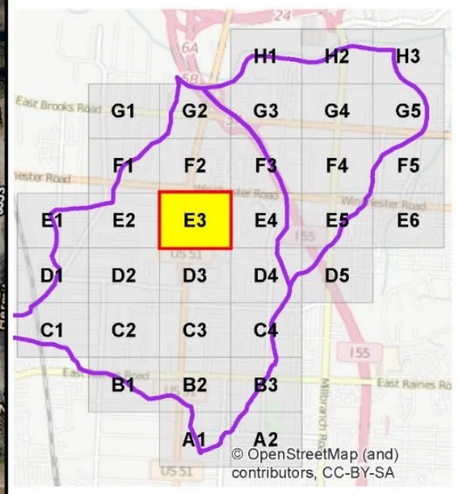


Figure ES-17. Basin Area Key Map

Existing 2-Year Flood Plain

Existing 100-Year Flood Plain



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MEMPHIS SHELBY COUNTY TENNESSEE

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NORTH

1 inch = 200 feet

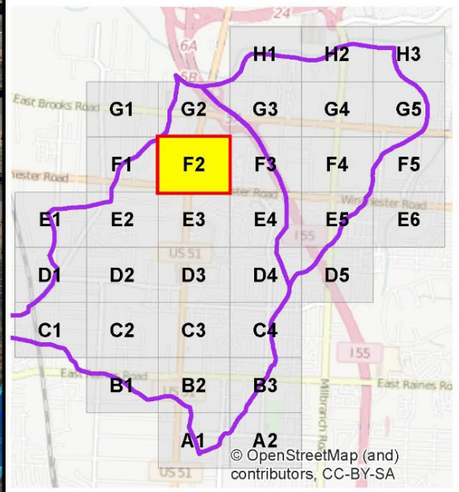
Whitehaven Basin
Existing Conditions

E3	13640360	February 2016
Exhibit	Project No.	Date

Figure ES-18. Whitehaven Existing Conditions, Tile E3

Existing 2-Year Flood Plain

Existing 100-Year Flood Plain



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SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH

1 inch = 200 feet

Whitehaven Basin
Existing Conditions

F2	13640360	February 2016
Exhibit	Project No.	Date

Figure ES-19. Whitehaven Existing Conditions, Tile F2

Figure ES-20.Whitehaven Existing Conditions, Tile F3

Figure ES-21. Fontaine Existing Conditions, Tile F4

4.4 Modeled Improvements to Address Flooding

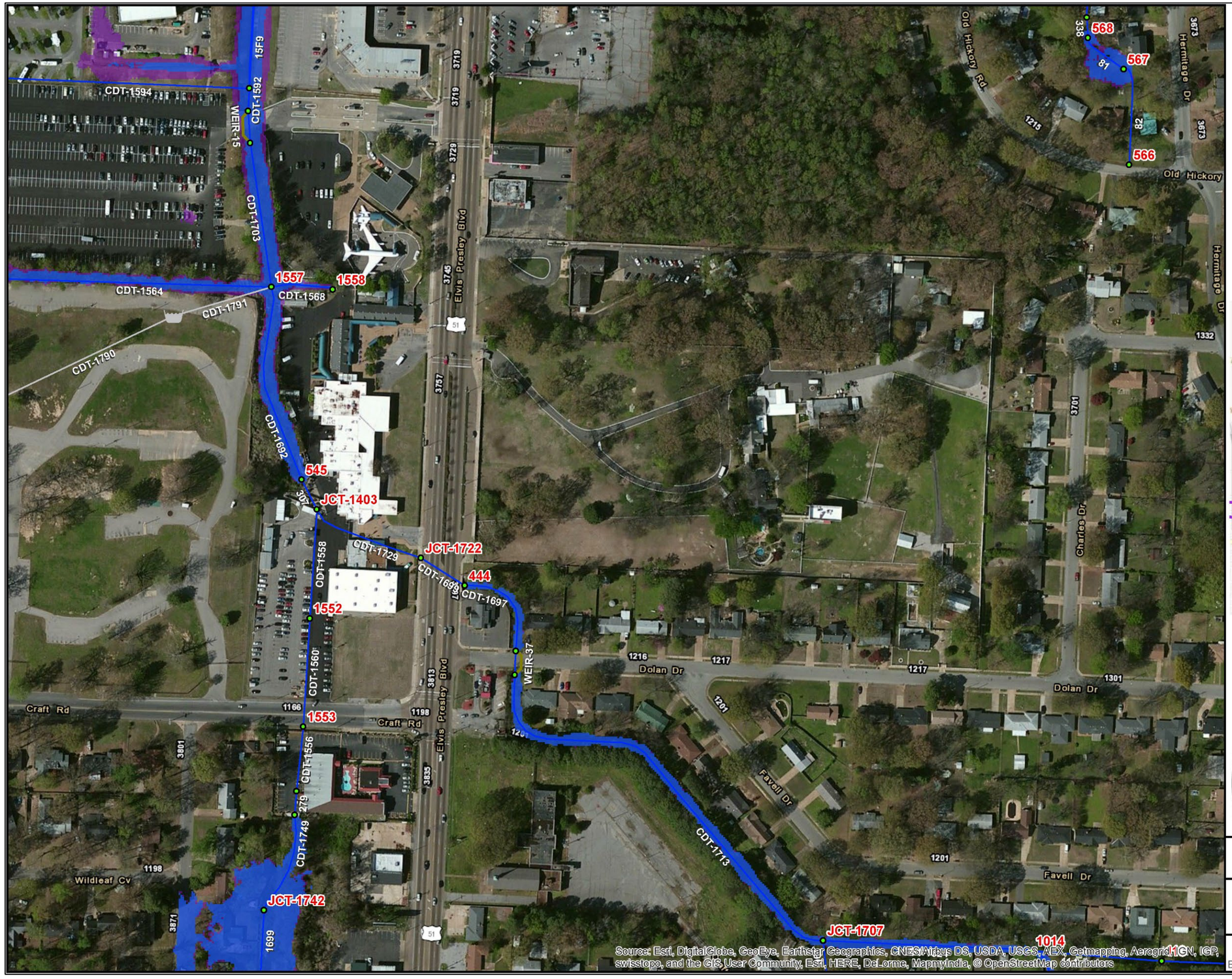
Whitehaven Scenarios: The modeler prepared and ran a total of 20 scenarios for the Whitehaven basin. Based on the City's requirements for scenario modeling, the alternatives analyzed were based on containing the 100-year storm event within existing channels. The final selected scenario for the Whitehaven basin is described below:

BLUEBIRDREDIROCK3: Proposed improvements scenario with culvert improvements in Polly Williams Park (Conduit ID: 327), the natural channels downstream of Bluebird Road improved to 27′ wide channels with MSE sidewalls and a natural channel bottom (Conduit ID's: CDT-1709, CDT-1779 & CDT-1705). The entrance and exit losses at the bridge crossing of Bluebird Road were also improved in this scenario (Junction ID's: JCT-1701 & JCT-1703). The restriction under Winchester Road upstream of the Winchester Grove Apartments (a double 14′ x 13′ box culvert flowing into a double 10.5′ x 9.5′ box culvert (Conduit ID: CDT-1715)) was changed to a continuous double 14′ x 13′ box culvert crossing. The bridge crossing inside Winchester Grove Apartments has also been improved from a double 12′ x 10′ box culvert to a double 18′ x 10′ box culvert (Conduit ID: 1625). Approximately 469′ of the channel upstream (Conduit ID: CDT-1719) and 472′ of the channel downstream (Conduit ID: CDT-1622) of this bridge crossing were modeled as a 36′ wide channel with MSE sidewalls and a natural channel bottom. The 102″ pipe restriction downstream of Winchester Grove Apartments removed (Conduit ID: CDT-1787). Subcatchment data set is 1 percent recurrence interval storm. THIS SCENARIO WAS THE FINAL RECOMMENDATION OF IMPROVEMENTS FOR WHITEHAVEN.

Fontaine Scenarios: The modeler prepared and ran a total of 9 scenarios for the Fontaine basin. This section provides descriptions of these scenarios. Based on the City's requirements for scenario modeling, the alternatives analyzed were based on containing the 100-year storm event within existing channels. The final selected scenario for the Fontaine Basin is described below:

TRANSITIONANDBOXESIMPROVED: Proposed conditions scenario with culvert improvements beginning south of Millbranch Road and Lochearn Road by increasing 542′ of concrete box culvert from 9′ x 5′ to 16′ x 5′ (Conduit ID's: 121, 122 & C-105). The entrance loss at the transition from a natural channel to a restricted 8′ x 7′ concrete channel was eliminated (Junction ID: 280). The channel downstream of this transition was increased to a 16′ x 6.5′ concrete channel (Conduit ID: C-275). The concrete channel that crosses Brooks Road was increased from 7′ x 6.5′ to 14′ x 6.5′ (Conduit ID: 6). The concrete box culvert downstream of this channel crossing Brooks Road was improved by increasing an 8′ x 5′ box to a 14′ x 6.5′ box culvert (Conduit ID's: 5 & 99). Subcatchment set is the 1 percent recurrence interval storm. THIS WAS THE FINAL RECOMMENDATION OF IMPROVEMENTS FOR FONTAINE BASIN.

Figure ES-22 through Figure ES-40 on the following pages depict the comparison between existing conditions and the recommended alternatives to accommodate the 100-year storm.

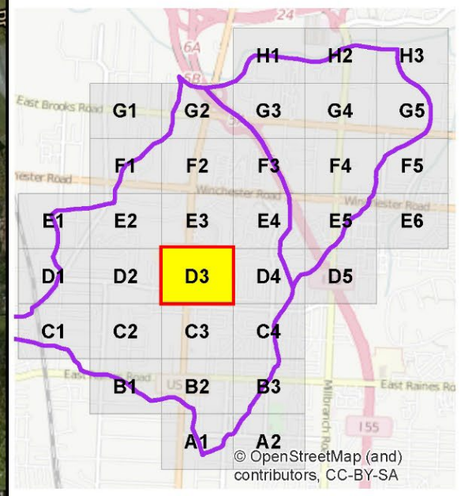


Whitehaven Scenario 1:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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MEMPHIS SHELBY COUNTY TENNESSEE

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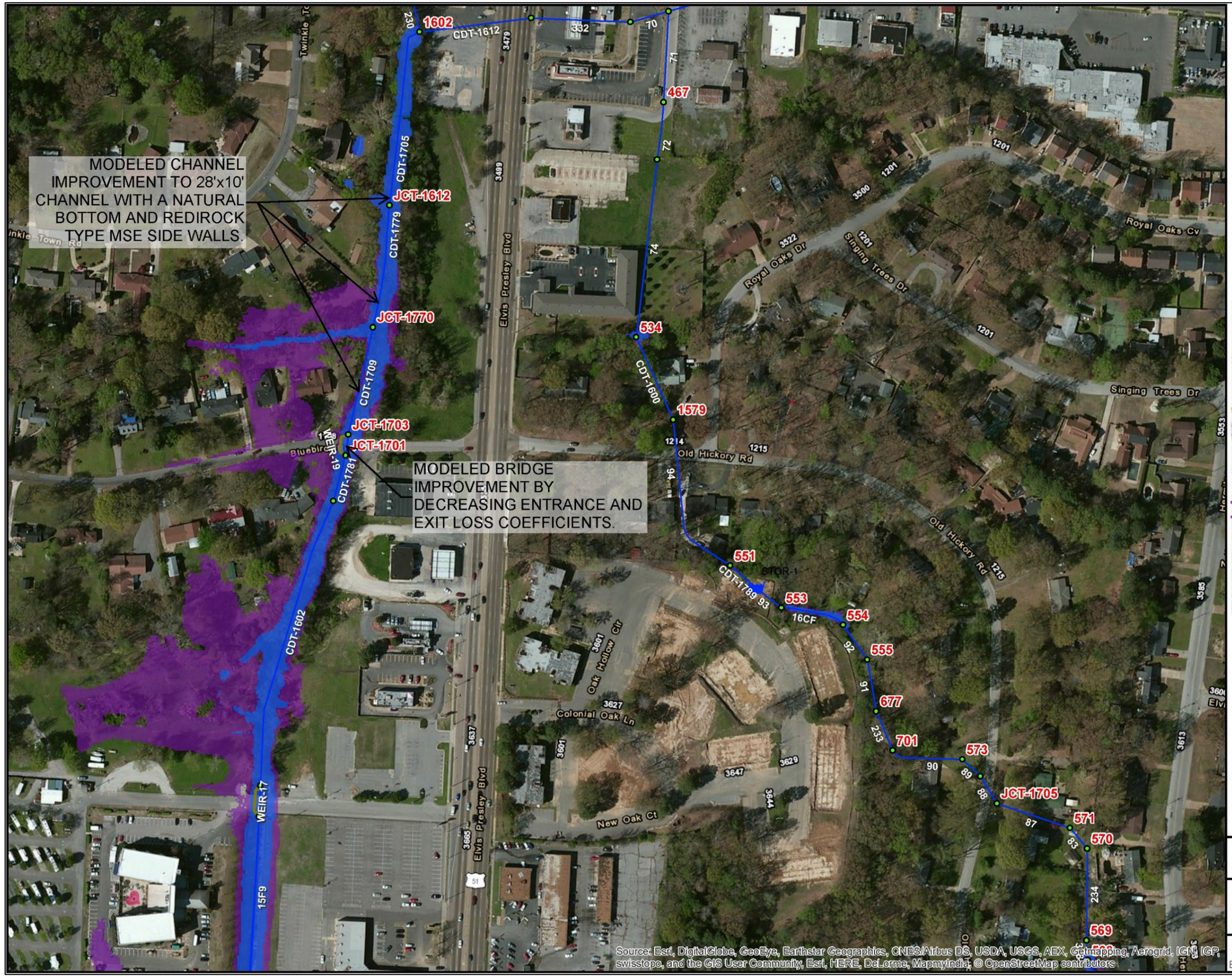
NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

D3-P	13640360	February 2016
Exhibit	Project No.	Date

Figure ES-22.Whitehaven Proposed Conditions, Scenerio 0, Tile D3

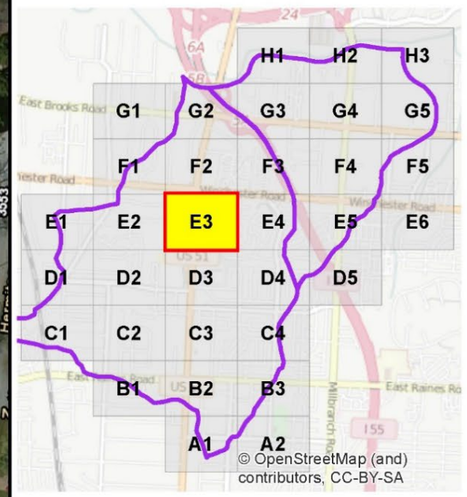


Whitehaven Scenario 1:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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NORTH	1 inch = 200 feet		
Whitehaven Basin Proposed Conditions			
E3-P Exhibit	13640360 Project No.	February 2016 Date	

Figure ES-23.Whitehaven Proposed Conditions, Scenerio 0, Tile E3

Whitehaven Scenario 1:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

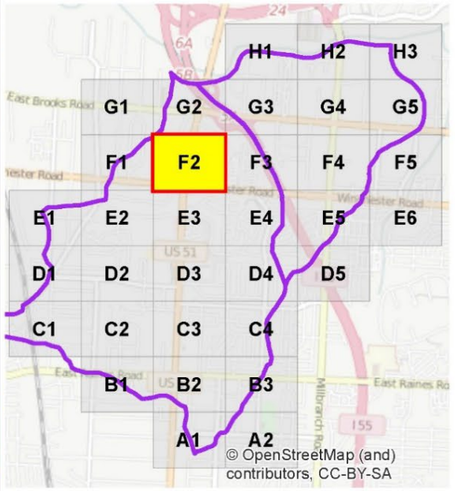
Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario

MODELED CHANNEL IMPROVEMENT FROM NATURAL CHANNEL TO 36'x11' CHANNEL WITH A NATURAL BOTTOM AND REDIROCK TYPE MSE SIDE WALLS.

BRIDGE CROSSING CHANGED FROM A DOUBLE 12'x10' CONCRETE BOX CULVERT TO A DOUBLE 11'x18' CONCRETE BOX CULVERT

MODELED CHANNEL IMPROVEMENT FROM NATURAL CHANNEL TO 36'x11' CHANNEL WITH A NATURAL BOTTOM AND REDIROCK TYPE MSE SIDE WALLS.



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SSR Smith Seckman Reid, Inc.

NORTH

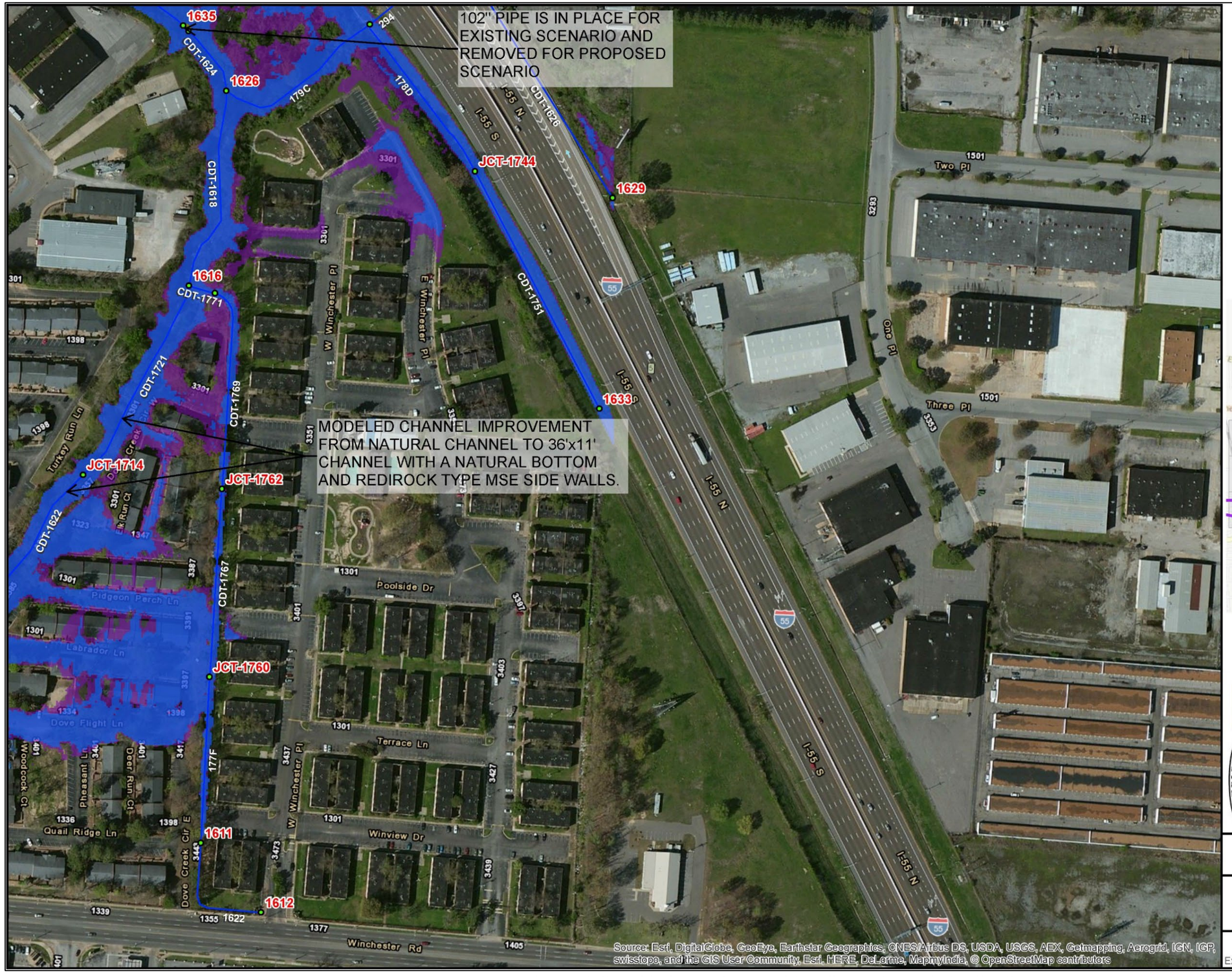
1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

F2-P	13640360	February 2016
Exhibit	Project No.	Date

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors

Figure ES-24.Whitehaven Proposed Conditions, Scenerio 0, Tile F2

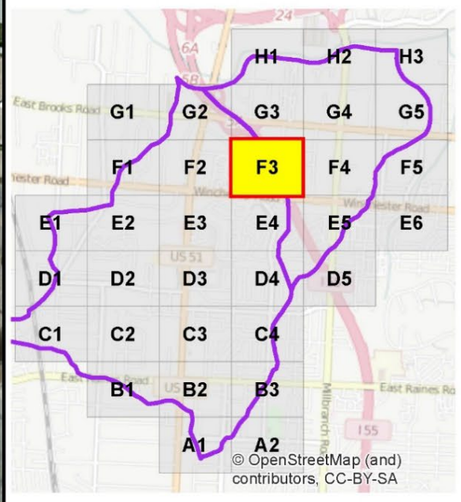


Whitehaven Scenario 1:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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SSR Smith Seckman Reid, Inc.

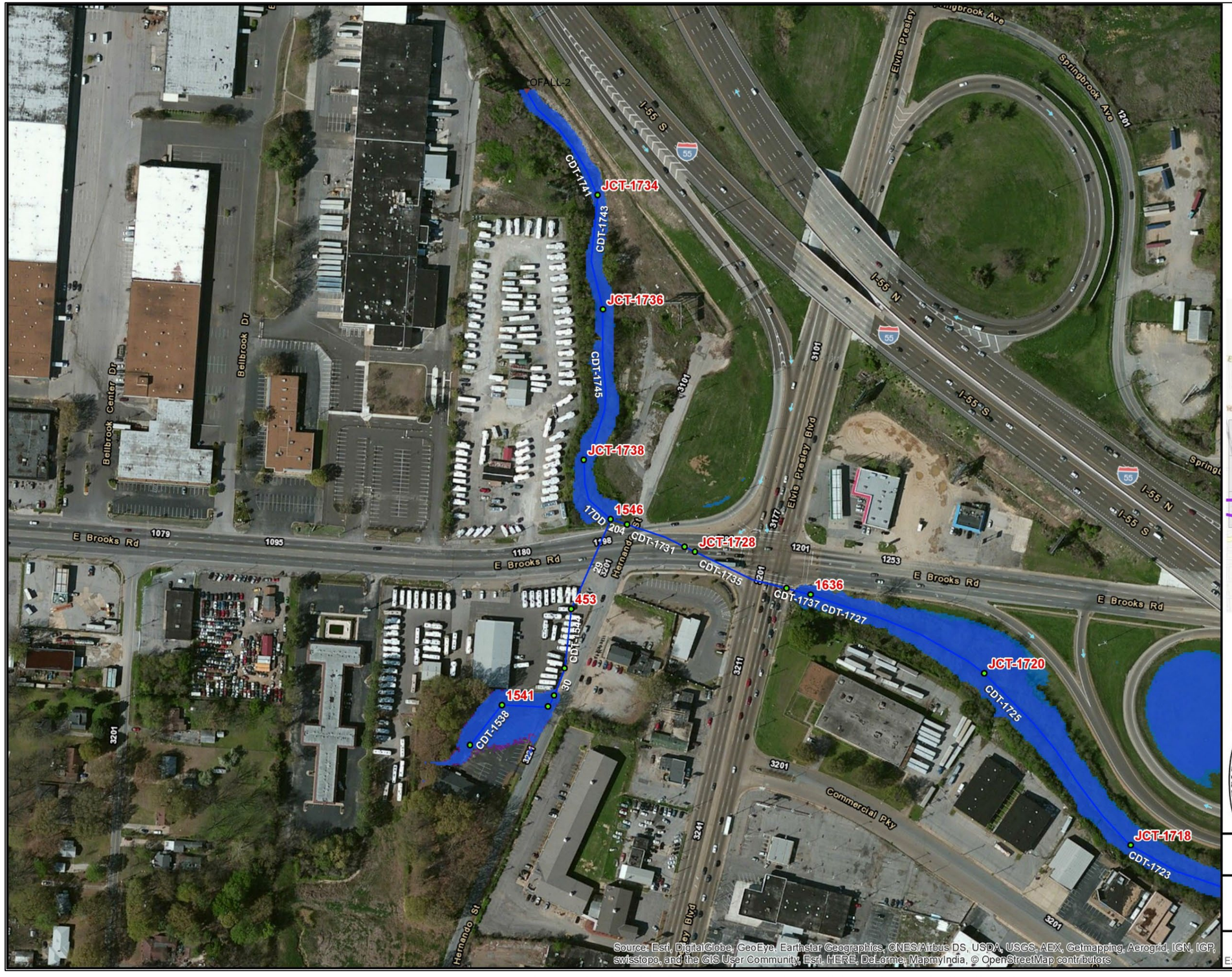
NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

F3-P	13640360	February 2016
Exhibit	Project No.	Date

Figure ES-25.Whitehaven Proposed Conditions, Scenerio 0, Tile F3

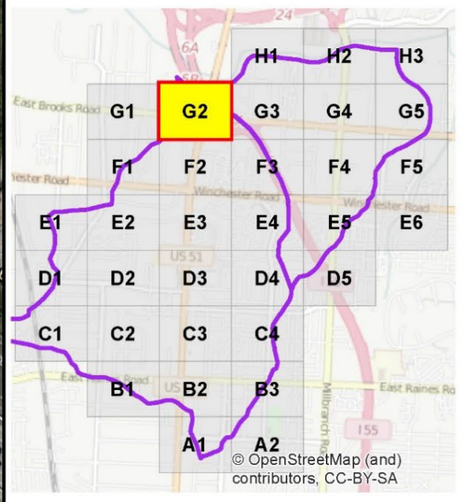


Whitehaven Scenario 1:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

G2-P	13640360	February 2016
Exhibit	Project No.	Date

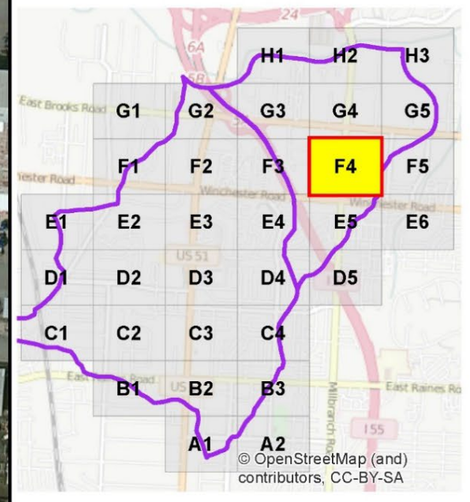
Figure ES-26.Whitehaven Proposed Conditions, Scenerio 0, Tile G2

Fontaine Scenario 1:

Improved Transition, Improved Channels and Culverts Upstream and Downstream of Junction J-280

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain



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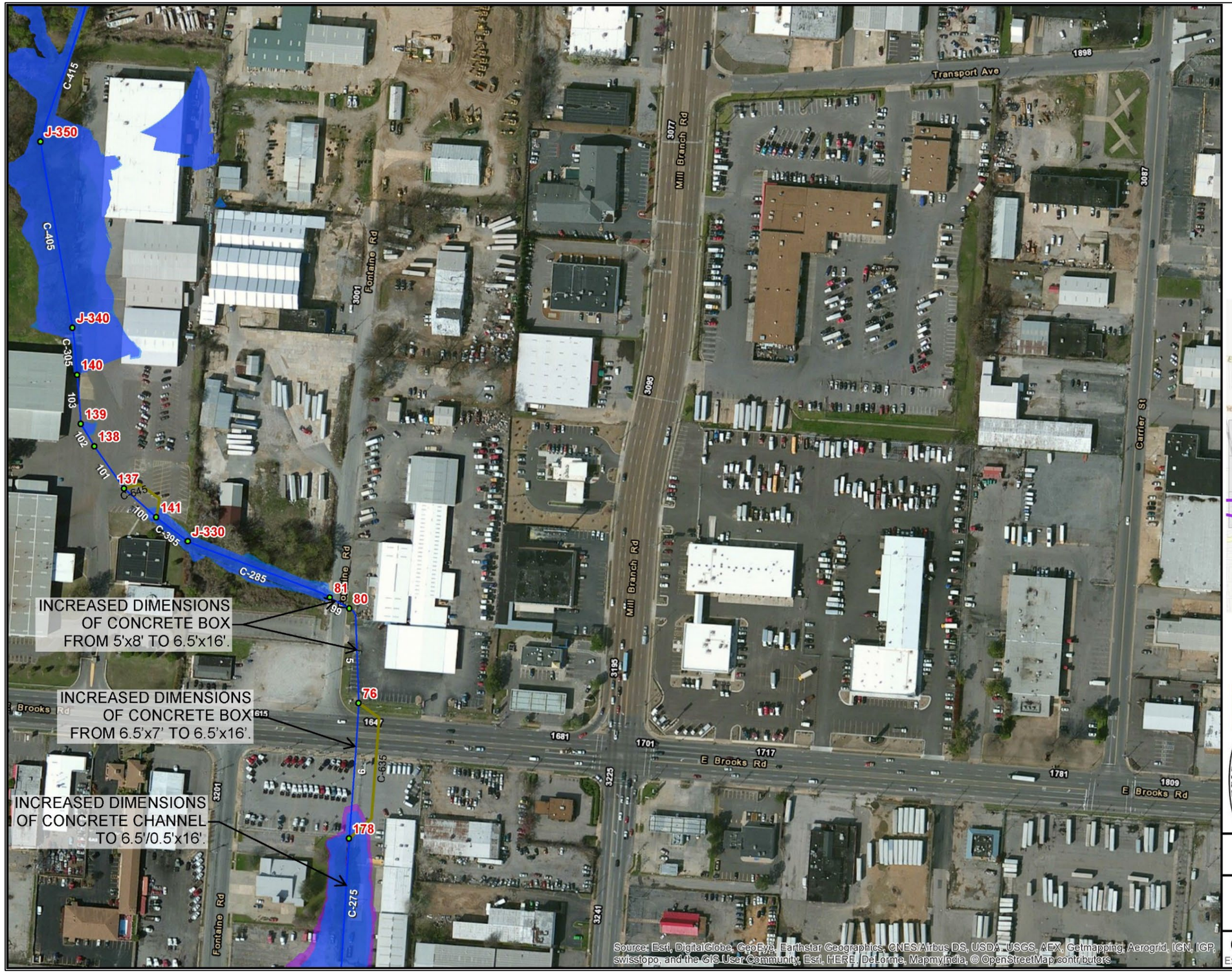
SSR Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet	
Fontaine Basin Proposed Conditions		
F4-P1 Exhibit	13640360 Project No.	February 2016 Date

Figure ES-27. Fontaine Proposed Conditions, Scenerio 1, Tile F4

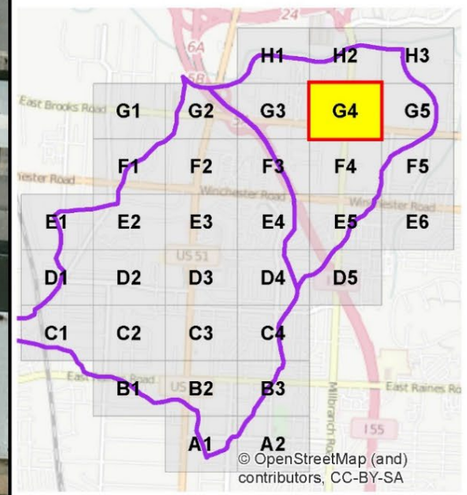


Fontaine Scenario 1:

Improved Transition, Improved Channels and Culverts Upstream and Downstream of Junction J-280

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain



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MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet	
Fontaine Basin Proposed Conditions		
G4-P1 Exhibit	13640360 Project No.	February 2016 Date

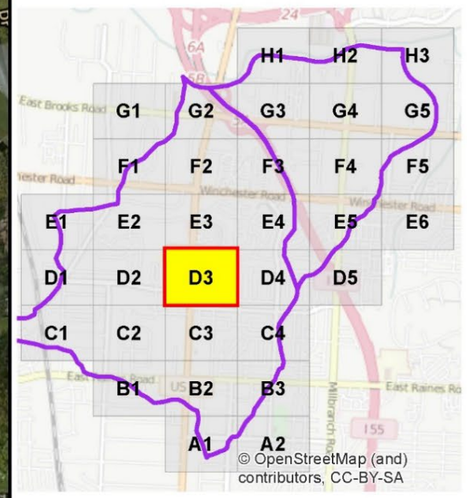
Figure ES-28.Fontaine Proposed Conditions, Scenerio 1, Tile G4

Whitehaven Scenario 2:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is removed for both Existing Scenario and Proposed Scenario



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Memphis Shelby County Tennessee

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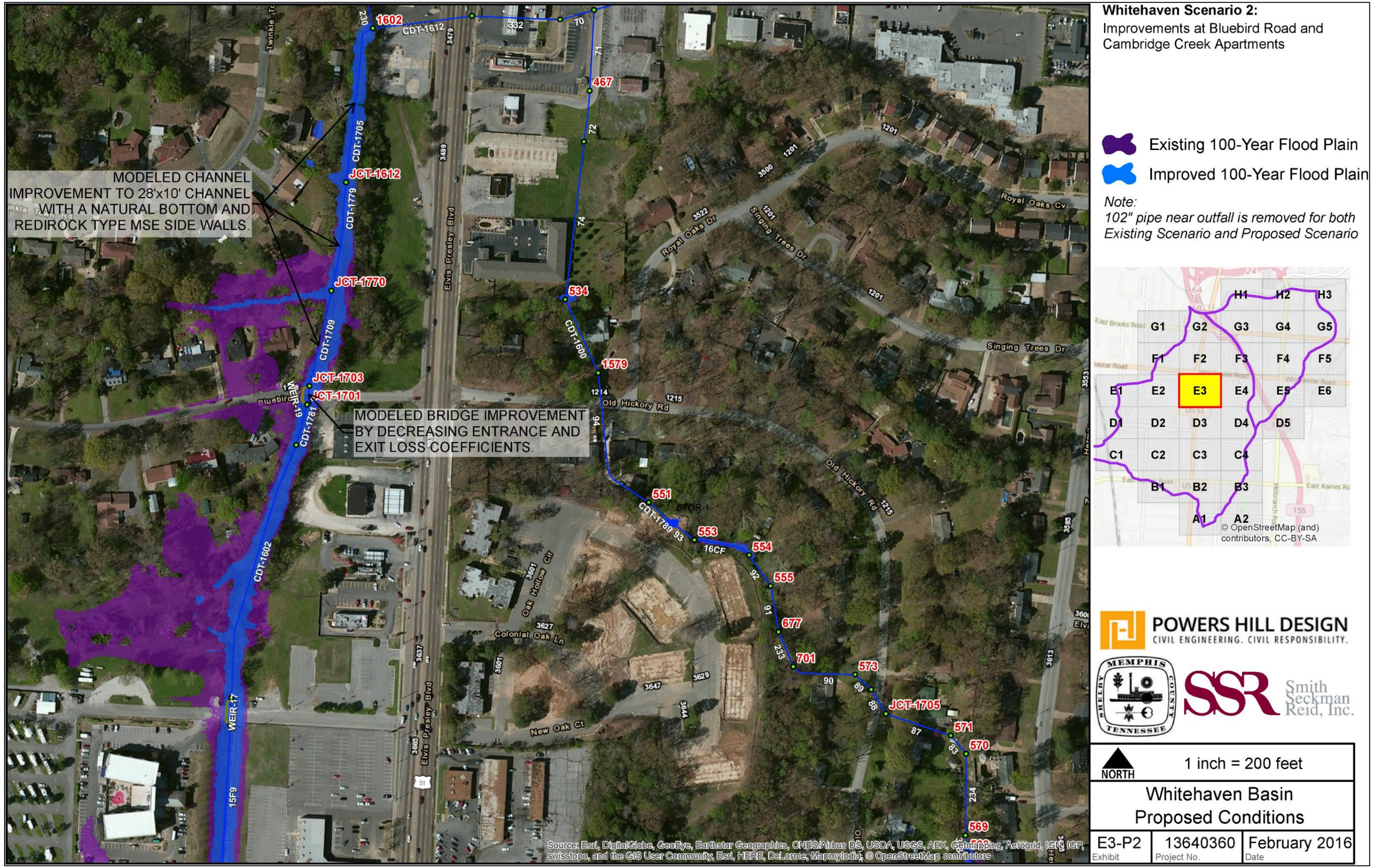
NORTH	1 inch = 200 feet	
Whitehaven Basin Proposed Conditions		
D3-P2 Exhibit	13640360 Project No.	February 2016 Date

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors

Figure ES-29.Whitehaven Proposed Conditions, Scenerio 2, Tile D3



Whitehaven Scenario 2:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is removed for both Existing Scenario and Proposed Scenario

POWERS HILL DESIGN
CIVIL ENGINEERING. CIVIL RESPONSIBILITY.

MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet	
Whitehaven Basin Proposed Conditions		
E3-P2 Exhibit	13640360 Project No.	February 2016 Date

Figure ES-30.Whitehaven Proposed Conditions, Scenerio 2, Tile E3

Whitehaven Scenario 2:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

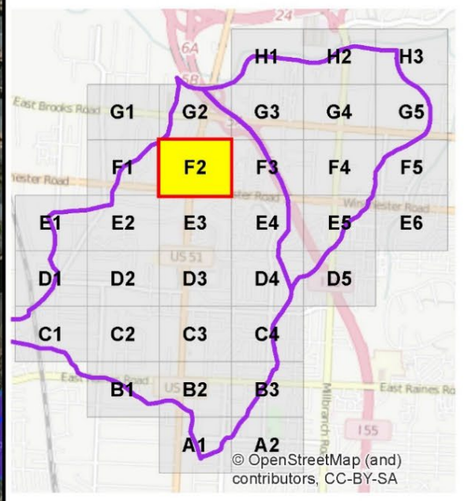
Improved 100-Year Flood Plain

Note:
102" pipe near outfall is removed for both Existing Scenario and Proposed Scenario

MODELED CHANNEL IMPROVEMENT FROM NATURAL CHANNEL TO 36'x11' CHANNEL WITH A NATURAL BOTTOM AND REDIROCK TYPE MSE SIDE WALLS.

BRIDGE CROSSING CHANGED FROM A DOUBLE 12'x10' CONCRETE BOX CULVERT TO A DOUBLE 11'x18' CONCRETE BOX CULVERT

MODELED CHANNEL IMPROVEMENT FROM NATURAL CHANNEL TO 36'x11' CHANNEL WITH A NATURAL BOTTOM AND REDIROCK TYPE MSE SIDE WALLS.



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MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH

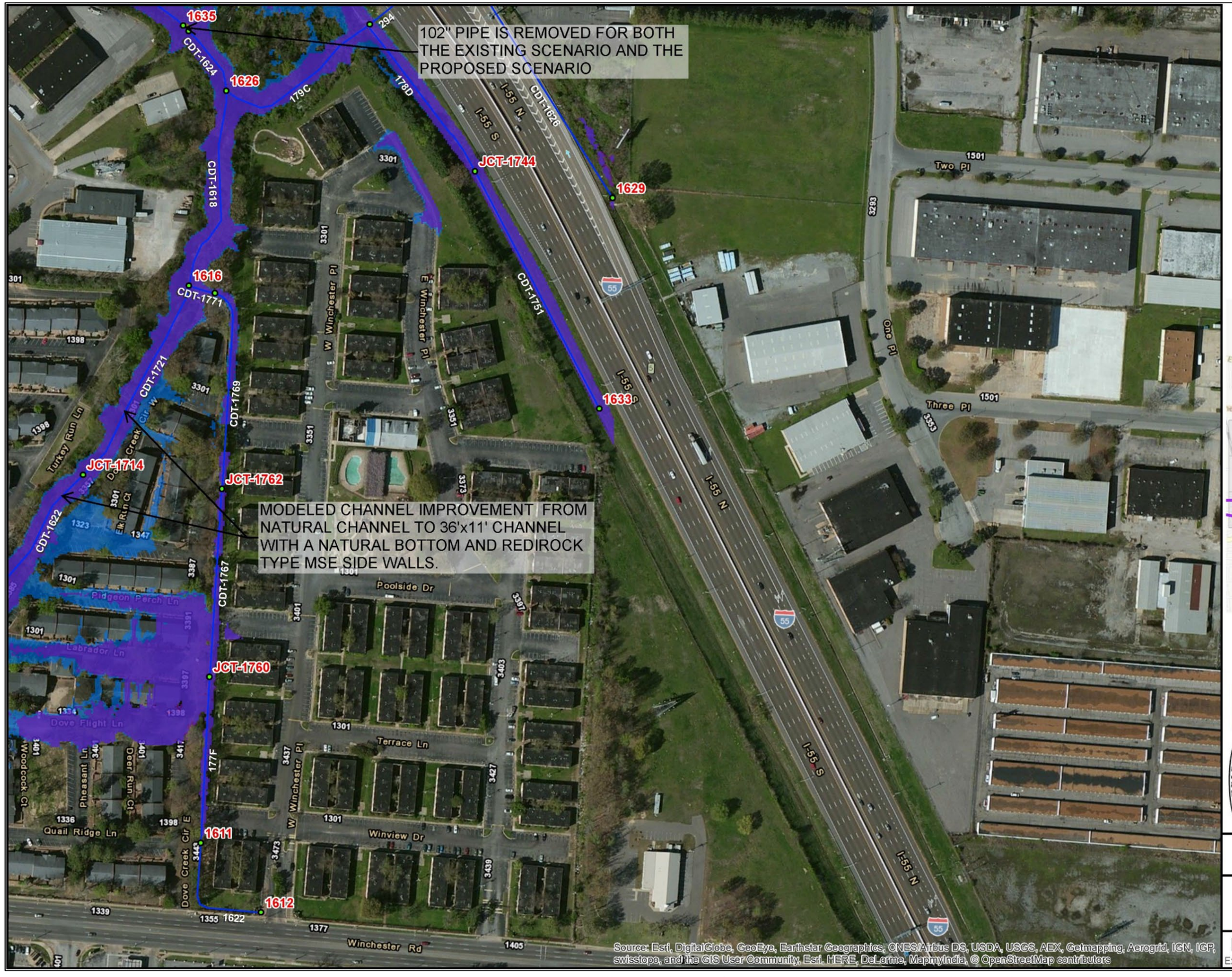
1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

F2-P2	13640360	February 2016
Exhibit	Project No.	Date

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors

Figure ES-31. Whitehaven Proposed Conditions, Scenerio 2, Tile F2

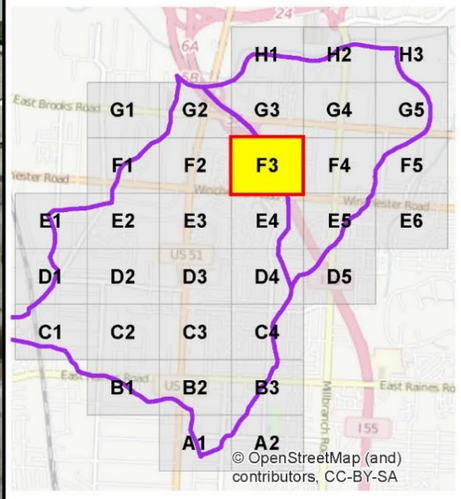


Whitehaven Scenario 2:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is removed for both Existing Scenario and Proposed Scenario



POWERS HILL DESIGN
CIVIL ENGINEERING. CIVIL RESPONSIBILITY.

MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

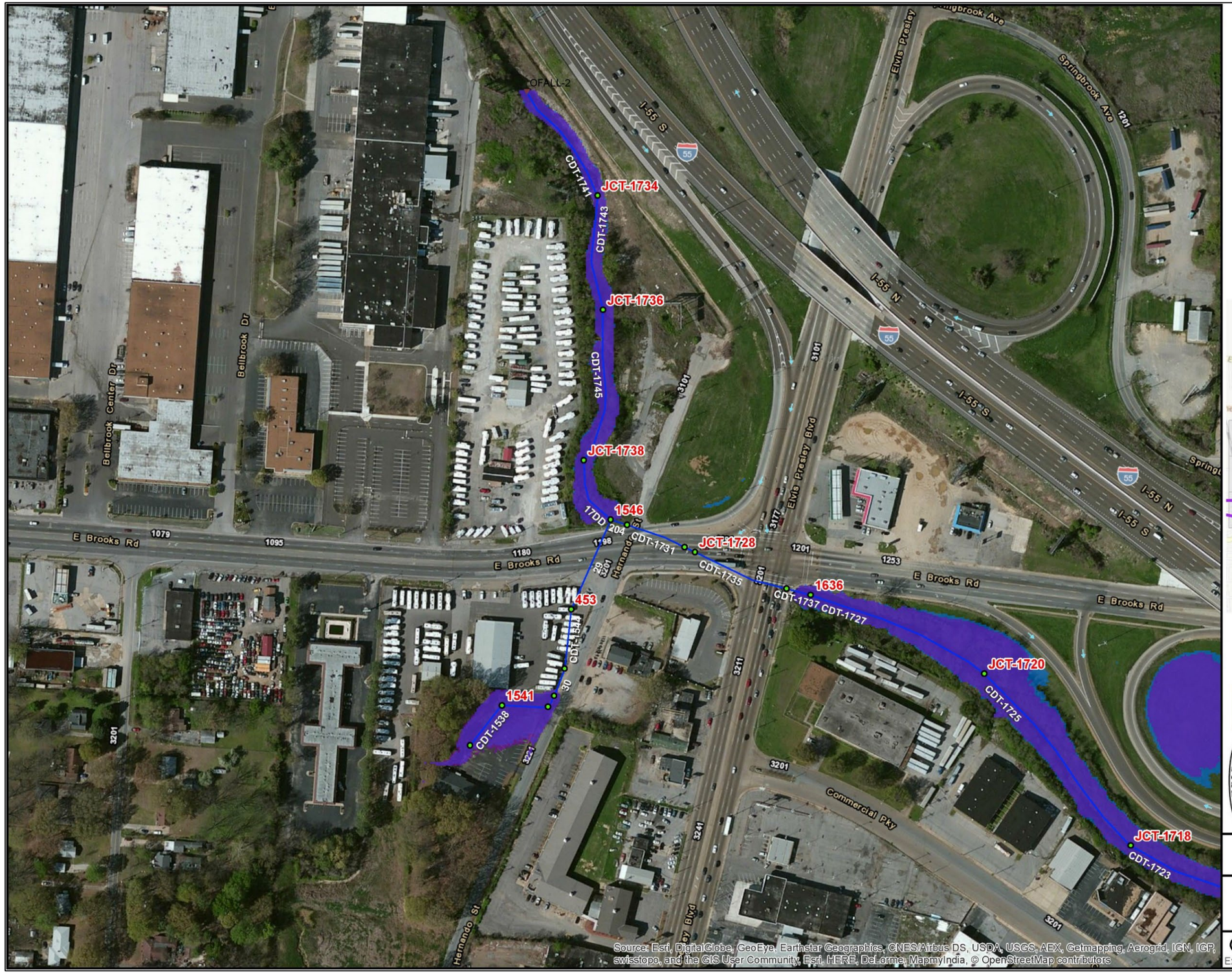
NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

F3-P2	13640360	February 2016
Exhibit	Project No.	Date

Figure ES-32.Whitehaven Proposed Conditions, Scenerio 2, Tile F3

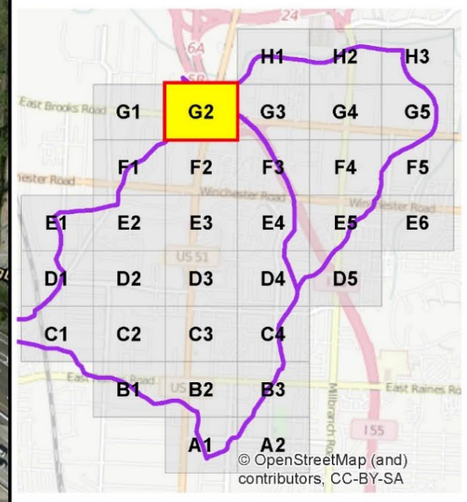


Whitehaven Scenario 2:
Improvements at Bluebird Road and Cambridge Creek Apartments

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is removed for both Existing Scenario and Proposed Scenario



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MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

G2-P2	13640360	February 2016
Exhibit	Project No.	Date

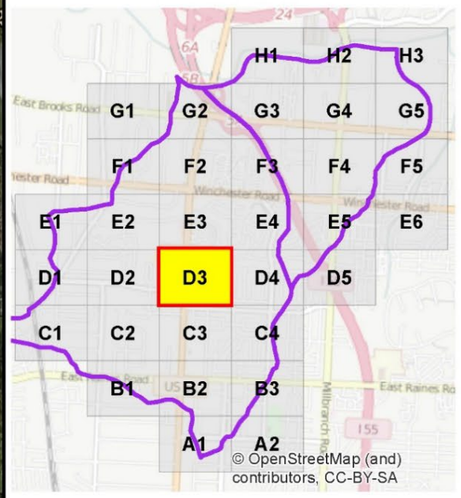
Figure ES-33.Whitehaven Proposed Conditions, Scenerio 2, Tile G2

Whitehaven Scenario 3:
Improvements at Bluebird Road Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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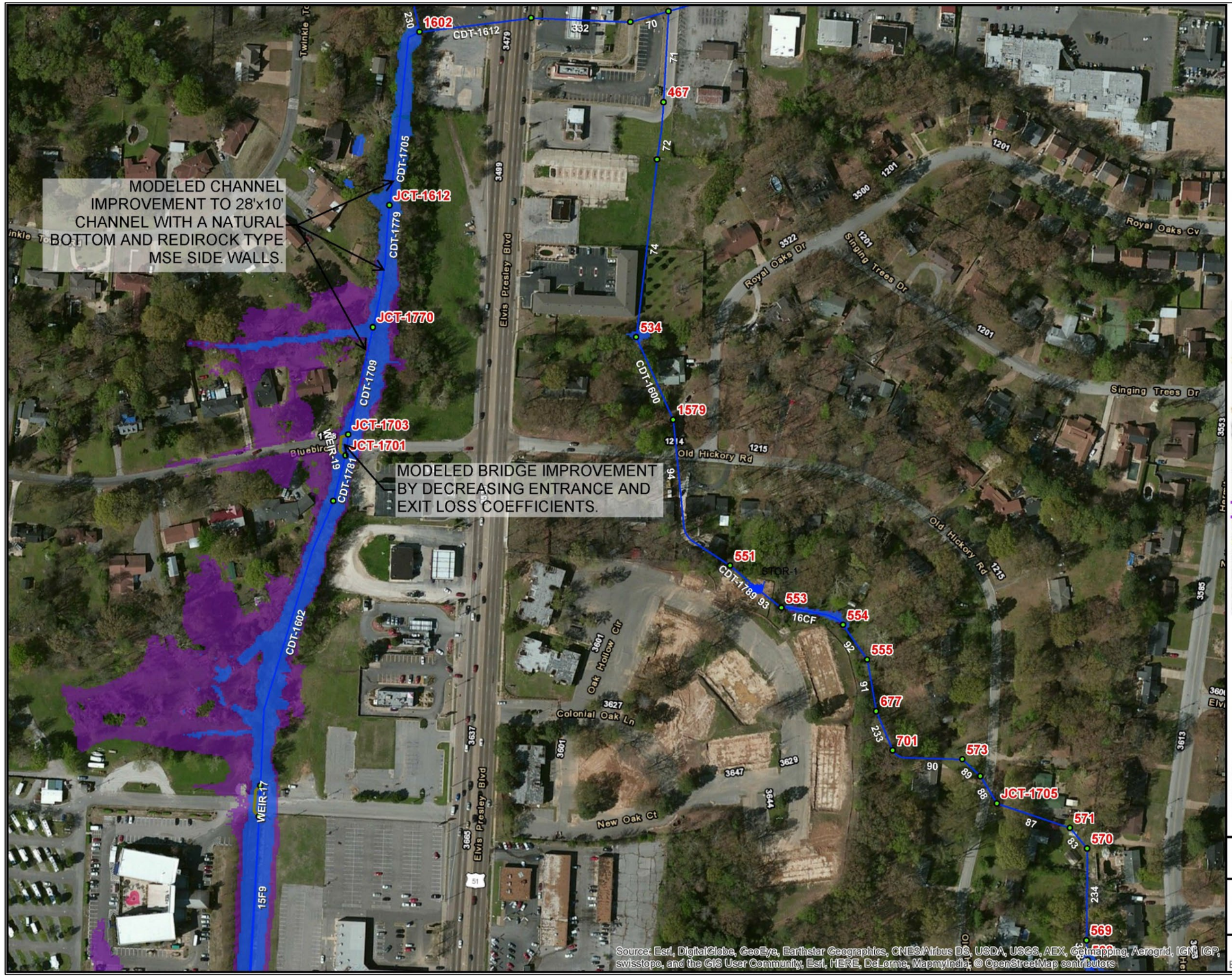
MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet	
Whitehaven Basin Proposed Conditions		
D3-P3 Exhibit	13640360 Project No.	February 2016 Date

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors

Figure ES-34.Whitehaven Proposed Conditions, Scenerio 3, Tile D3

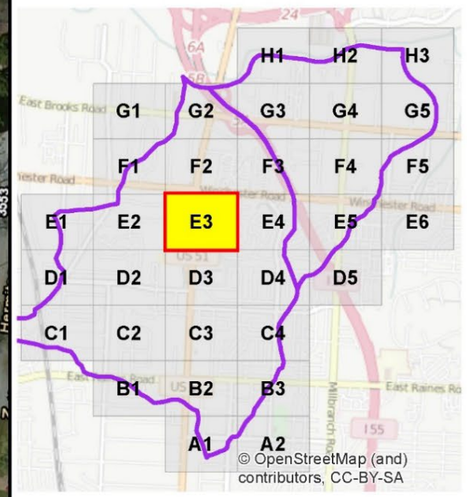


Whitehaven Scenario 3:
Improvements at Bluebird Road Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



POWERS HILL DESIGN
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MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet		
Whitehaven Basin Proposed Conditions			
E3-P3 Exhibit	13640360 Project No.	February 2016 Date	

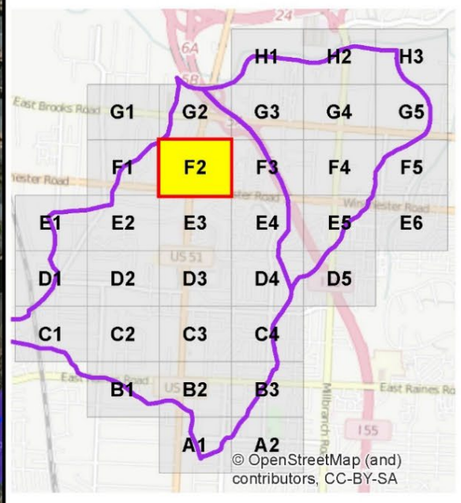
Figure ES-35.Whitehaven Proposed Conditions, Scenerio 3, Tile E3

Whitehaven Scenario 3:
Improvements at Bluebird Road Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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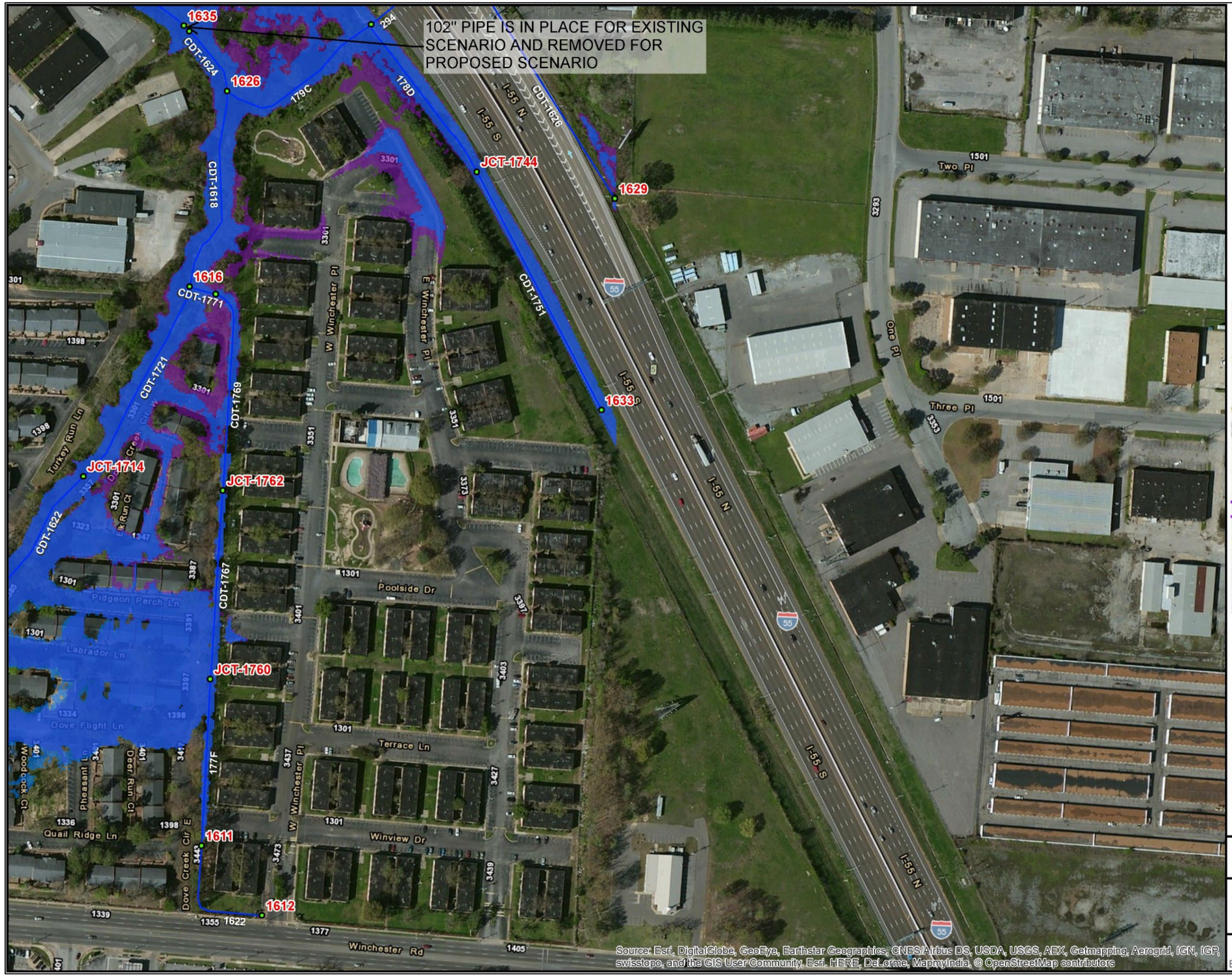
Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet	
Whitehaven Basin Proposed Conditions		
F2-P3 Exhibit	13640360 Project No.	February 2016 Date

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors

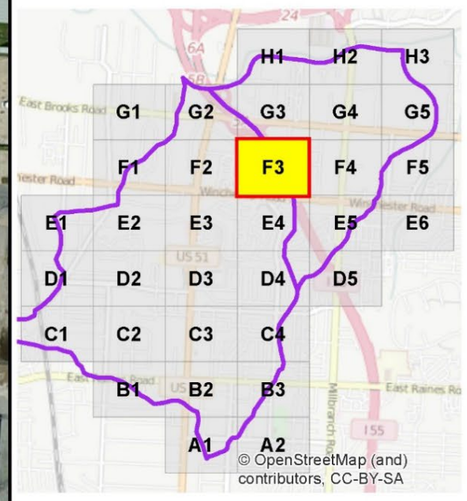
Figure ES-36.Whitehaven Proposed Conditions, Scenerio 3, Tile F2



Whitehaven Scenario 3:
Improvements at Bluebird Road Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain



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SSR Smith Seckman Reid, Inc.

NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

F3-P3	13640360	February 2016
Exhibit	Project No.	Date

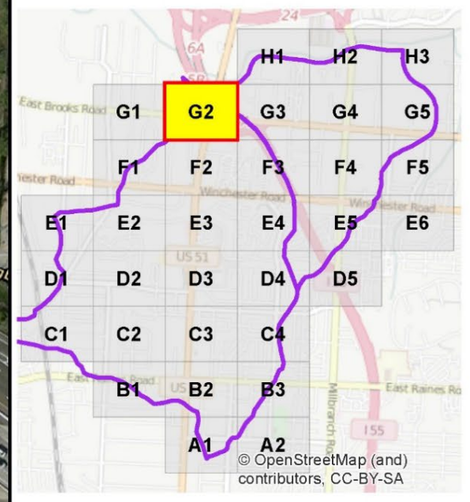
Figure ES-37.Whitehaven Proposed Conditions, Scenerio 3, Tile F3

Whitehaven Scenario 3:
Improvements at Bluebird Road Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



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MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH

1 inch = 200 feet

Whitehaven Basin
Proposed Conditions

G2-P3	13640360	February 2016
Exhibit	Project No.	Date

Figure ES-38.Whitehaven Proposed Conditions, Scenerio 3, Tile G2

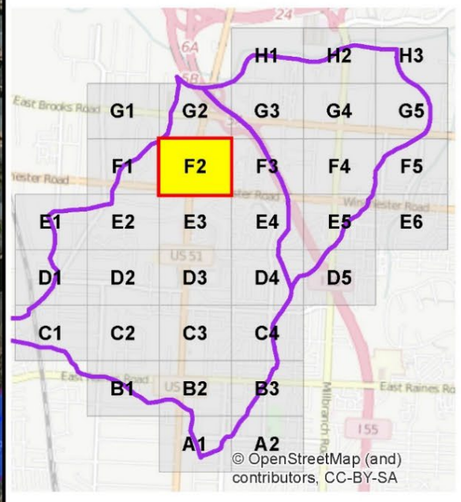
Whitehaven Scenario 4:

Removal of 102" Pipe Restriction Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain

Note:
102" pipe near outfall is in place for Existing Scenario and removed for Proposed Scenario



POWERS HILL DESIGN
CIVIL ENGINEERING. CIVIL RESPONSIBILITY.

MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

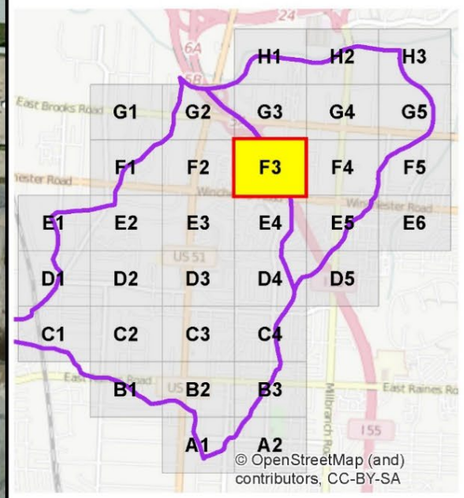
NORTH	1 inch = 200 feet	
Whitehaven Basin Proposed Conditions		
F2-P4 Exhibit	13640360 Project No.	February 2016 Date

Figure ES-39.Whitehaven Proposed Conditions, Scenerio 4, Tile F2

Whitehaven Scenario 4:
Removal of 102" Pipe Restriction Only

Existing 100-Year Flood Plain

Improved 100-Year Flood Plain



POWERS HILL DESIGN
CIVIL ENGINEERING. CIVIL RESPONSIBILITY.

MEMPHIS SHELBY COUNTY TENNESSEE

SSR Smith Seckman Reid, Inc.

NORTH	1 inch = 200 feet	
Whitehaven Basin Proposed Conditions		
F3-P4 Exhibit	13640360 Project No.	February 2016 Date

Figure ES-40.Whitehaven Proposed Conditions, Scenerio 4, Tile F3

Section 5 Summary and Final Recommendations

5.1 Summary of Recommended Improvements Based on Modeling

Figure ES-41 provides locations and brief description of recommended Projects A-D (Based on modeling) and Projects 1 – 8 (Based on Public Works Flood Tickets).

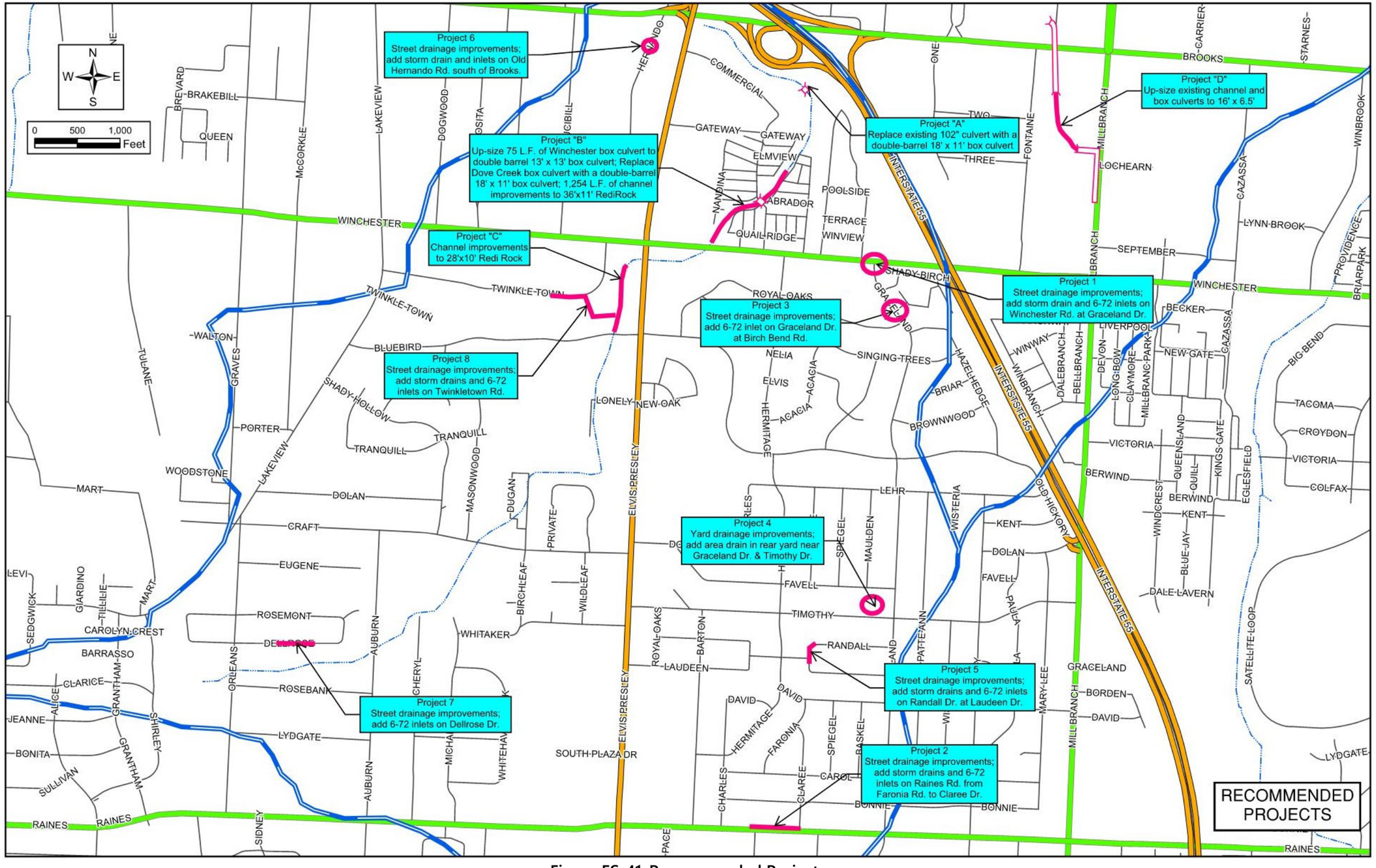


Figure ES-41. Recommended Projects

5.1.1 Project "A": Billboard Site Access Drive

One of the commercial properties on Commercial Parkway extends across the main drainage ditch for the Whitehaven Basin. An access drive was installed across this ditch using a 102" steel pipe for a culvert. Based on aerial photography of the area, it appears this work was done some time after 2010. The 102" pipe is greatly undersized, and is restricting flow, causing flooding in the Highland Creek Apartments.

It is recommended that this undersized pipe be removed from the ditch. Figure ES-40 illustrates the reduction in flooding that would result from removal of this restriction. If this pipe is removed, alternate access to the billboard site could be provided through properties east of the main drainage ditch. Alternately, if this driveway access is to be maintained, it would require the installation of a two-barrel box culvert, with each opening being 11' wide by 18' deep. Table ES-3 provides a cost estimate and Figure ES-42 shows typical details for this project.

PROJECT "A"					
BILLBOARD SITE DRIVE BOX CULVERT					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 12,000.00	$ 12,000.00
2	CLEARING AND GRUBBING	1	LS	16,000.00	16,000.00
3	EXCAVATION - GRADING	1	LS	12,000.00	12,000.00
4	BORROW MATERIAL	200	CY	50.00	10,000.00
5	COMPACTED CRUSHED STONE	300	TON	50.00	15,000.00
6	GROUTED CLASS C RIP RAP	100	TON	140.00	14,000.00
7	SODDING	500	SY	10.00	5,000.00
8	4' CHAIN LINK FENCE	100	LF	40.00	4,000.00
9	EROSION CONTROL	1	LS	12,000.00	12,000.00
10	DEWATERING	1	LS	12,000.00	12,000.00
11	UTILITY RELOCATIONS	1	LS	65,000.00	65,000.00
12	UNDERCUT	250	CY	80.00	20,000.00
13	REMOVE EXISTING CULVERT	1	LS	25,000.00	25,000.00
14	2 @ 11'x18' BOX CULVERT	1	LS	375,000.00	375,000.00
15	STREET REPAIR	200	SY	65.00	13,000.00
				Subtotal:	$ 610,000.00
				Surveying, Design & Permitting (16%):	98,000.00
				Easement Acquisitions:	20,000.00
				Bidding & CA (10%):	61,000.00
				Legal & Admin. (5%):	31,000.00
				Contingency (20%):	122,000.00
				Total Project Budget:	$ 942,000.00

Table ES-3. Project "A" Cost Estimate

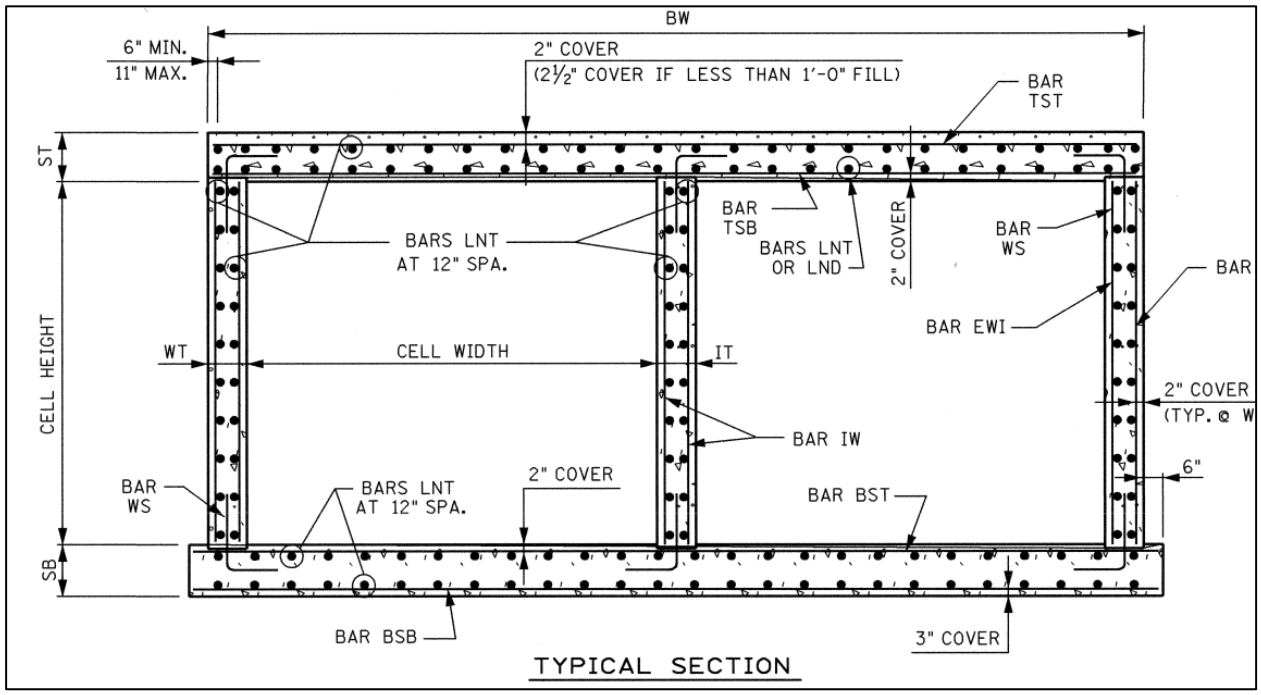


Figure ES-42.Project "A" Details

5.1.2 Project "B": Winchester Grove Apartments Channelization

The main drainage ditch for the Whitehaven Basin crosses Winchester Road and bisects the Winchester Grove Apartment site downstream of Winchester for a distance of approximately 1,250 feet. The downstream 75′ of the box culvert that crosses Winchester is a double barrel 10.5′ x 9.5′ box, while the remainder of the box culvert upstream of this location is a double barrel 14′ x 13′ box. Within the ditch section downstream of Winchester, there is one street crossing (Dove Creek Drive). The downstream end of the Winchester box culvert, the existing natural channel and the box culvert under Dove Creek Drive are all undersized and inadequate to carry the flow from the 100-year storm event. In addition, the upstream channel improvements recommended for the Bluebird Road area (Project "C") would increase the peak flows in this channel segment, further exacerbating existing flooding issues. In order to make the needed improvements upstream, this segment must be improved.

It is recommended that the undersized section of box culvert under Winchester and at Dove Creek Drive be enlarged and the existing natural channel be widened and straightened using RediRock segmented block walls to stabilize the channel walls. The existing flow channel would remain natural as required by TDEC, but a stable channel 36′ wide by 11′ deep would be created. In addition, the existing section of Winchester box culvert would be enlarged from a double barrel 10.5′ x 9.5′ to a double barrel 14′ x 13′ box culvert. Finally, the existing box culvert at Dove Creek Drive would be enlarged from a double barrel 10′x12′ box to a double barrel 11′x18′ box. Table ES-4 provides a cost estimate and Figure ES-43 shows typical details for this project.

PROJECT "B"					
WINCHESTER GROVE APARTMENTS DITCH CHANNELIZATION					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 140,000.00	$ 140,000.00
2	CLEARING AND GRUBBING	1	LS	150,000.00	150,000.00
3	EXCAVATION - GRADING	1	LS	200,000.00	200,000.00
4	BORROW MATERIAL	1,100	CY	50.00	55,000.00
5	GRAVITY RETAINING WALL	30,000	SF	75.00	2,250,000.00
6	COMPACTED CRUSHED STONE	7,000	TON	50.00	350,000.00
7	GROUTED CLASS C RIP RAP	600	TON	140.00	84,000.00
8	GROUTED CLASS A-1 RIP RAP	250	TON	150.00	37,500.00
9	SODDING	5,000	SY	10.00	50,000.00
10	4' CHAIN LINK FENCE	3,400	LF	40.00	136,000.00
11	EROSION CONTROL	1	LS	95,000.00	95,000.00
12	DEWATERING	1	LS	100,000.00	100,000.00
13	UTILITY RELOCATIONS	1	LS	625,000.00	625,000.00
14	UNDERCUT	1,500	CY	75.00	112,500.00
15	REMOVE EXISTING BOX CULVERT	1	LS	125,000.00	125,000.00
16	2 @ 13'x14' BOX CULVERT	1	LS	750,000.00	750,000.00
17	2 @ 11'x18' BOX CULVERT	1	LS	450,000.00	450,000.00
18	STREET REPAIR	1,000	SY	65.00	65,000.00
				Subtotal:	$ 5,775,000.00
				Surveying, Design & Permitting (16%):	924,000.00
				Easement Acquisitions:	349,000.00
				Bidding & CA (10%):	578,000.00
				Legal & Admin. (5%):	289,000.00
				Contingency (20%):	1,155,000.00
				Total Project Budget:	$ 9,070,000.00

Table ES-4. Project "B" Cost Estimate

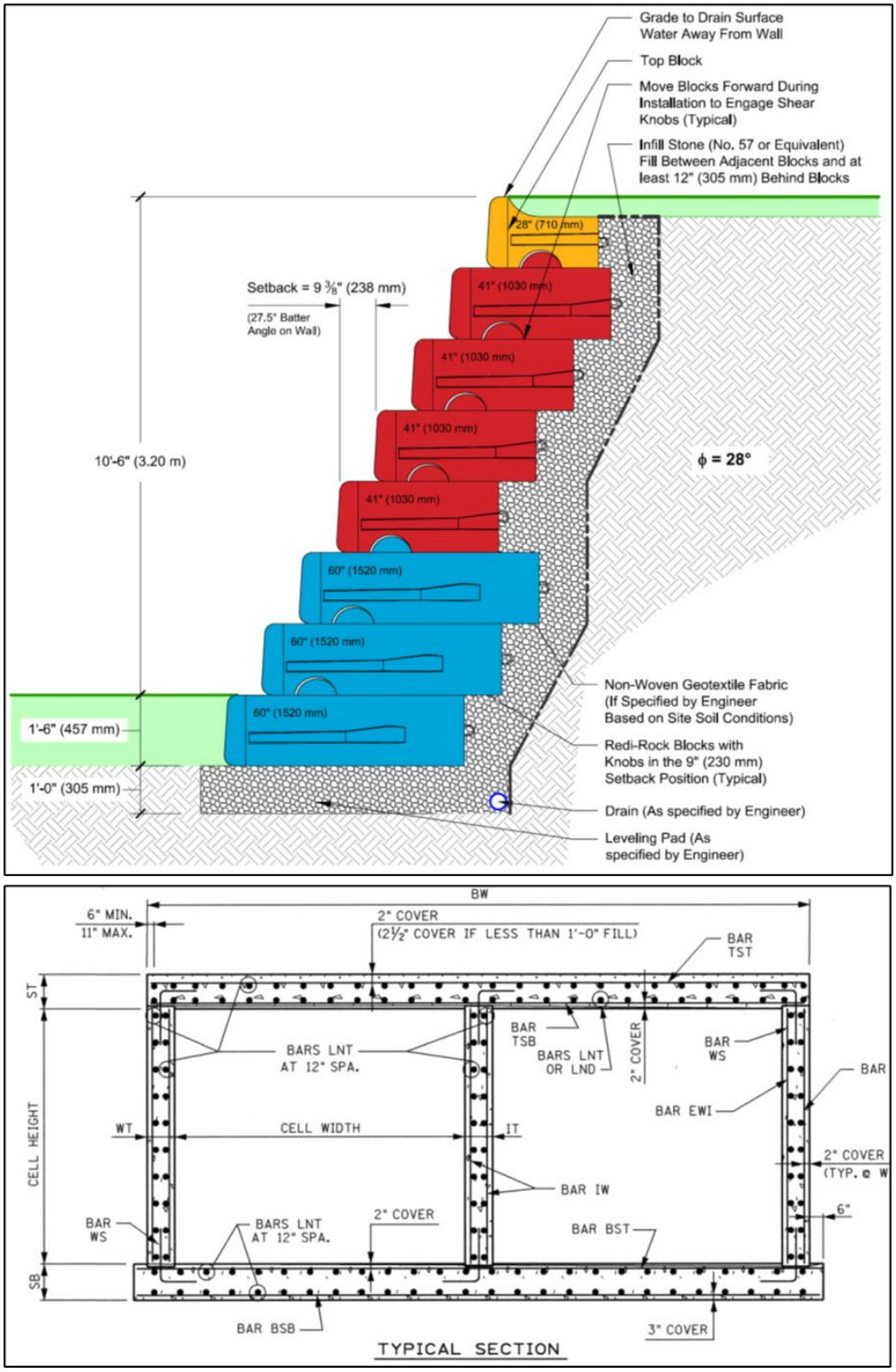


Figure ES-43.Project "B" Details

5.1.3 Project "C": Bluebird Road Channelization

Residences along Bluebird Road located southwest of the intersection of Winchester and Elvis Presley have experienced flooding for several years. Modelling indicates that the natural channel between the Heartbreak Hotel entrance drive and the box culvert just south of Winchester is inadequate to convey the flow it receives. This segment is overgrown with trees, and the channel is irregular and hydraulically inefficient.

It is recommended that this natural channel be widened and straightened using RediRock segmented block walls to stabilize the channel walls. As with the Highland Creek Apartment project, the existing flow channel would remain natural as required by TDEC, but a stable channel of adequate size would be created. For the Bluebird ditch segment, the required channel size is 28' wide by 10' deep. The existing bridge at Bluebird Road is adequate in size and will remain as-is. Table ES-5 provides a cost estimate and Figure ES-44 shows typical details for this project.

PROJECT "C"					
BLUEBIRD ROAD DITCH CHANNELIZATION					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 125,000.00	$ 125,000.00
2	CLEARING AND GRUBBING	1	LS	125,000.00	125,000.00
3	EXCAVATION - GRADING	1	LS	150,000.00	150,000.00
4	BORROW MATERIAL	1,500	CY	50.00	75,000.00
5	GRAVITY RETAINING WALL	39,000	SF	75.00	2,925,000.00
6	COMPACTED CRUSHED STONE	6,000	TON	50.00	300,000.00
7	GROUTED CLASS C RIP RAP	500	TON	140.00	70,000.00
8	GROUTED CLASS A-1 RIP RAP	250	TON	150.00	37,500.00
9	SODDING	5,000	SY	10.00	50,000.00
10	4' CHAIN LINK FENCE	3,300	LF	40.00	132,000.00
11	EROSION CONTROL	1	LS	90,000.00	90,000.00
12	DEWATERING	1	LS	65,000.00	65,000.00
13	UTILITY RELOCATIONS	1	LS	250,000.00	250,000.00
14	UNDERCUT	1,000	CY	75.00	75,000.00
15	STREET REPAIR	500	SY	65.00	32,500.00
				Subtotal:	$ 4,502,000.00
				Surveying, Design & Permitting (16%):	720,000.00
				Easement Acquisitions:	400,000.00
				Bidding & CA (10%):	450,000.00
				Legal & Admin. (5%):	225,000.00
				Contingency (20%):	900,000.00
				Total Project Budget:	$ 7,197,000.00

Table ES-5. Project "C" Cost Estimate

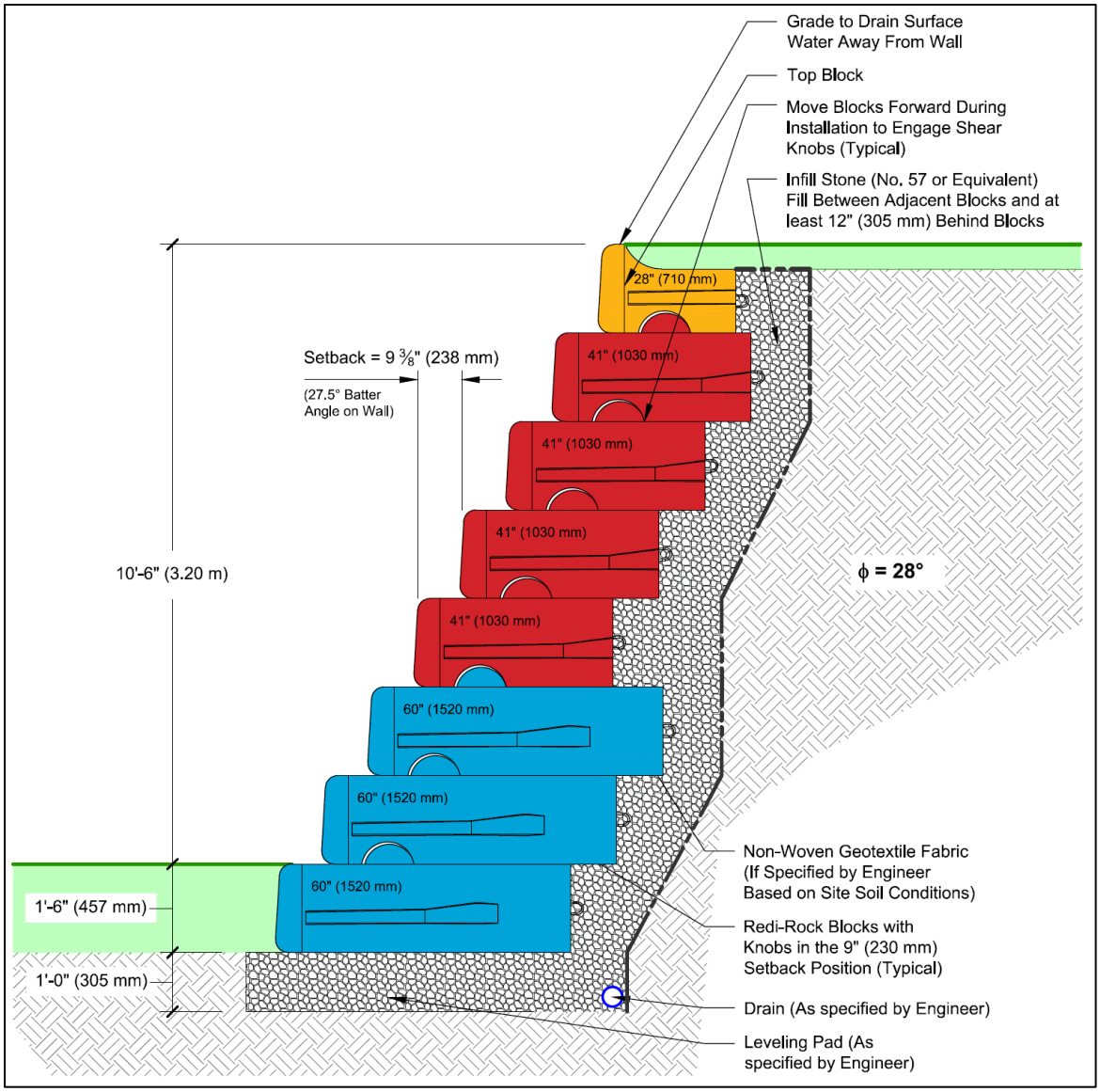


Figure ES-44. Project "C" Details

5.1.4 Project "D": Millbranch to Brooks Drainage Improvements

Project "D" is located in the Fontaine Basin, and extends from Millbranch Road just south of Lochearn, north across Brooks Road at Fontaine Road. This area includes box culverts under Millbranch and Brooks, sections of unimproved natural channel and a segment of concrete-lined channel. One segment of box culvert is located under an existing building on Millbranch and will need to be re-located around the building.

SSR's modeling recommends up-sizing the box culverts and channel segments throughout the entire 2,200' length of this area. The recommended section is 16' wide by 6' deep. Open channel sections will consist of RediRock walls with natural channel bottom. Box culvert sections will be 16' x 6' sections. Table ES-6 provides a cost estimate and Figure ES-45 shows typical details for this project.

PROJECT "D"					
MILLBRANCH TO BROOKS DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 300,000.00	$ 300,000.00
2	CLEARING AND GRUBBING	1	LS	125,000.00	125,000.00
3	EXCAVATION - GRADING	1	LS	200,000.00	200,000.00
4	BORROW MATERIAL	1,500	CY	50.00	75,000.00
5	GRAVITY RETAINING WALL	18,000	SF	75.00	1,350,000.00
6	COMPACTED CRUSHED STONE	2,000	TON	50.00	100,000.00
7	GROUTED CLASS C RIP RAP	700	TON	140.00	98,000.00
8	GROUTED CLASS A-1 RIP RAP	500	TON	150.00	75,000.00
9	SODDING	1,500	SY	10.00	15,000.00
10	4' CHAIN LINK FENCE	2,500	LF	40.00	100,000.00
11	EROSION CONTROL	1	LS	200,000.00	200,000.00
12	DEWATERING	1	LS	100,000.00	100,000.00
13	UTILITY RELOCATIONS	1	LS	1,250,000.00	1,250,000.00
14	UNDERCUT	4,000	CY	75.00	300,000.00
15	REMOVE EXISTING BOX CULVERT	1	LS	380,000.00	380,000.00
16	16' X 6' BOX CULVERT	1,160	LF	4,400.00	5,104,000.00
17	STREET REPAIR	4,000	SY	65.00	260,000.00
				Subtotal:	$ 10,032,000.00
				Surveying, Design & Permitting (16%):	1,605,000.00
				Easement Acquisitions:	500,000.00
				Bidding & CA (10%):	1,003,000.00
				Legal & Admin. (5%):	502,000.00
				Contingency (20%):	2,006,000.00
				Total Project Budget:	$ 15,648,000.00

Table ES-6. Project "D" Cost Estimate

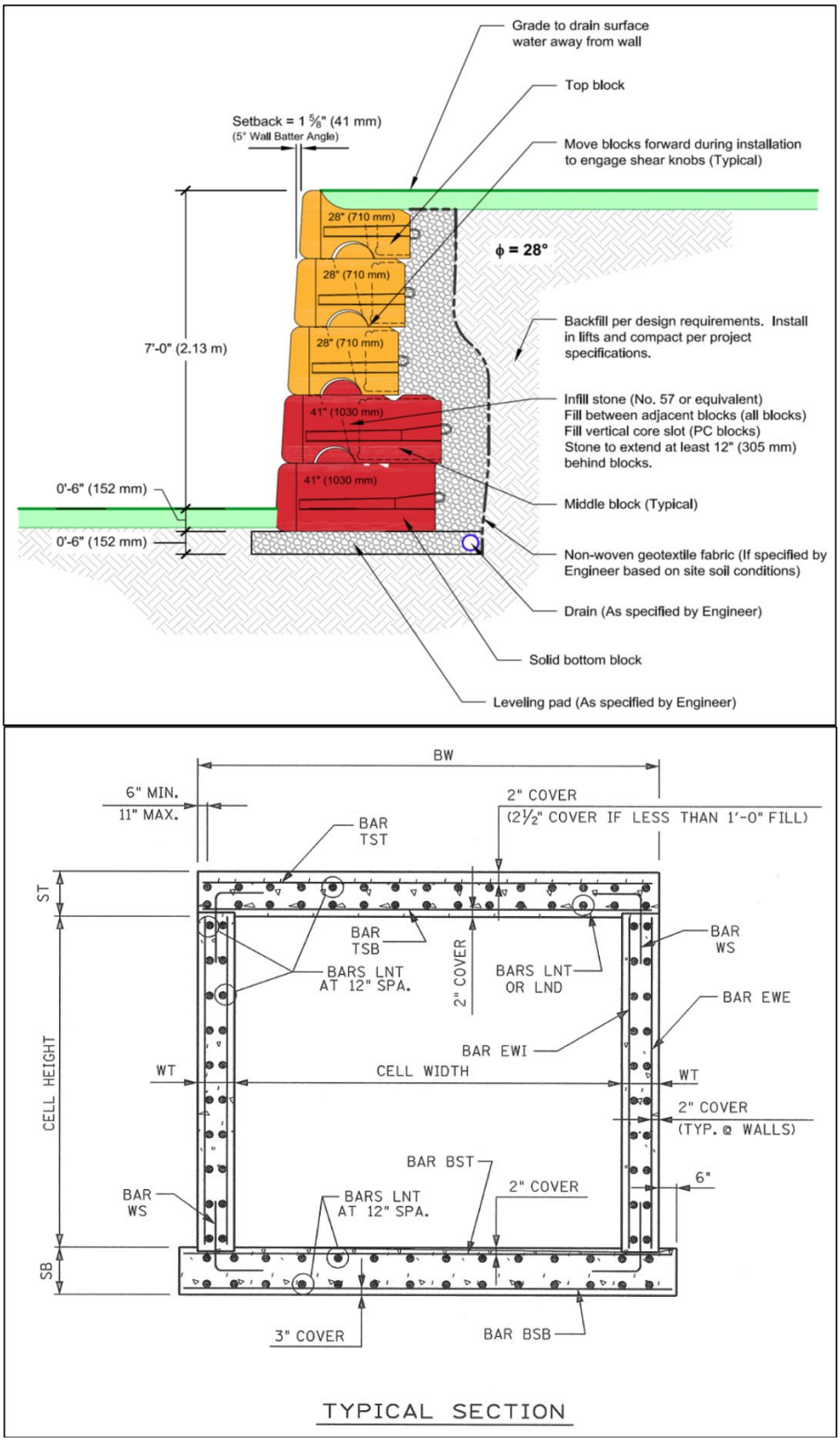


Figure ES-45.Project "D" Details

5.2 Recommended Improvements Based on Public Works Flood Tickets

The Memphis Public Works Department provided historical data on flood tickets documenting complaints received from citizens in the Whitehaven-Fontaine area. These complaints were classified and analyzed to determine if the issues raised could be addressed by drainage improvements.

For the Whitehaven basin, a total of 147 tickets were analyzed and were classified by the nature of the complaint. Many tickets were duplicates of the same issue at a given location. Based on an analysis of the issues and locations, a total of 8 projects were identified to address specific drainage issues. This information is summarized in Table ES-7.

Classification	# of Tickets	# of Locations	# of Projects
Minor St., Yard or Bldg. Flooding	69	27	8
Maintenance Issues	21	9	--
TDOT Issues	2	1	--
Outside of Basin	16	9	--
Non-Drainage Issue	15	10	--
Private Drainage Issue	11	8	--

Table ES-7. Summary of Public Works Flood Tickets

5.2.1 Project 1: Winchester & Graceland Drainage Improvements

The intersection of Winchester Road and Graceland Drive needs additional inlets on both sides of Winchester just east of Graceland Dr. to catch drainage flowing west along Winchester. Proposed improvements include the addition of an 18" storm drain along the south side of Winchester Road east across Graceland Drive, the north across Winchester, and the installation of two 6-72 drain inlets on Winchester.

PROJECT 1					
WINCHESTER & GRACELAND DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 3,000.00	$ 3,000.00
2	DEMOLITION	1	LS	2,000.00	2,000.00
3	18" RCP	250	LF	100.00	25,000.00
4	6-72 INLETS	2	EA	5,000.00	10,000.00
5	STONE BACKFILL	150	TON	50.00	7,500.00
6	CURB REPAIR	100	LF	50.00	5,000.00
7	SIDEWALK REPAIR	400	SF	20.00	8,000.00
8	ASPHALT REPAIR	60	SY	100.00	6,000.00
9	EROSION CONTROL	1	LS	2,000.00	2,000.00
10	UTILITY ADJUSTMENTS	1	LS	5,000.00	5,000.00
11	SODDING	10	SY	50.00	500.00
				Subtotal:	$ 74,000.00
			Surveying, Design & Permitting (16%):		12,000.00
			Easement Acquisitions:		-
			Bidding & CA (10%):		7,000.00
			Legal & Admin. (5%):		4,000.00
			Contingency (20%):		15,000.00
			Total Project Budget:		$ 112,000.00

Table ES-8. Project 1 Cost Estimate

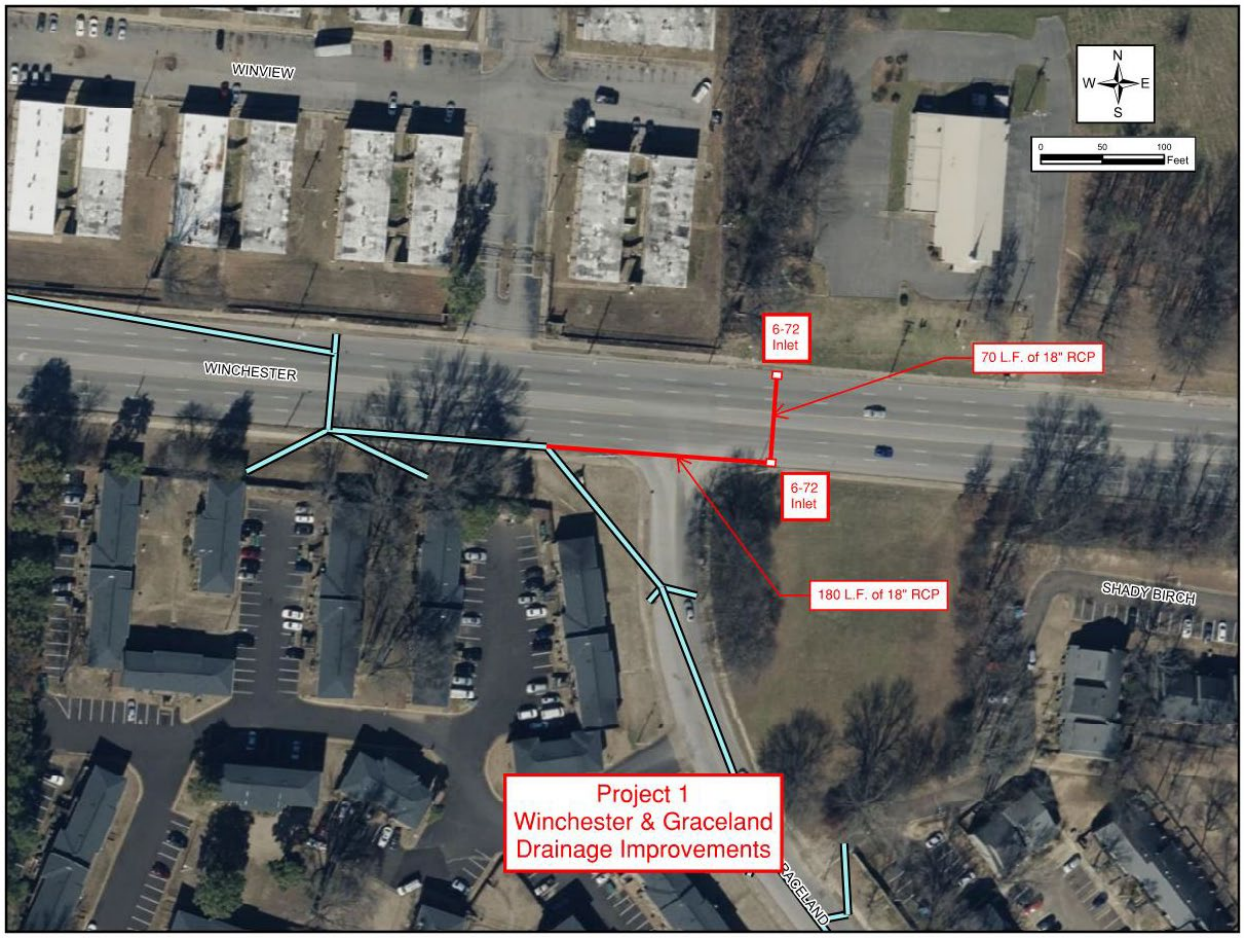


Figure ES-46.Project 1 Details

5.2.2 Project 2: Raines & Faronia Drainage Improvements

The intersection of Raines Road and Faronia Drive experiences street flooding due to the large drainage area draining west on Raines, with no drain inlets along Raines until the water reaches Faronia. Raines Road needs additional drain inlets on both sides of the road east of Faronia Drive to capture this drainage before it floods the intersection. Improvements will include the installation of 24" and 18" storm drains along the north side of Raines Road from just west of Faronia to the east side of Claree Street, and the installation of two 18" storm drains crossing Raines to the south side. A total of six 6-72 drain inlets will be installed on Raines Road (four on the north side and two on the south side).

PROJECT 2					
RAINES & FARONIA DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 5,000.00	$ 5,000.00
2	DEMOLITION	1	LS	10,000.00	10,000.00
3	18" RCP	220	LF	100.00	22,000.00
4	24" RCP	570	LF	120.00	68,400.00
5	6-72 INLETS	6	EA	5,000.00	30,000.00
6	STONE BACKFILL	660	TON	50.00	33,000.00
7	CURB REPAIR	600	LF	50.00	30,000.00
8	SIDEWALK REPAIR	300	SF	20.00	6,000.00
9	ASPHALT REPAIR	250	SY	100.00	25,000.00
10	EROSION CONTROL	1	LS	10,000.00	10,000.00
11	UTILITY ADJUSTMENTS	1	LS	10,000.00	10,000.00
12	SODDING	260	SY	50.00	13,000.00
				Subtotal:	$ 262,400.00
				Surveying, Design & Permitting (16%):	42,000.00
				Easement Acquisitions:	-
				Bidding & CA (10%):	26,000.00
				Legal & Admin. (5%):	13,000.00
				Contingency (20%):	52,000.00
				Total Project Budget:	$ 395,400.00

Table ES-9. Project 2 Cost Estimate

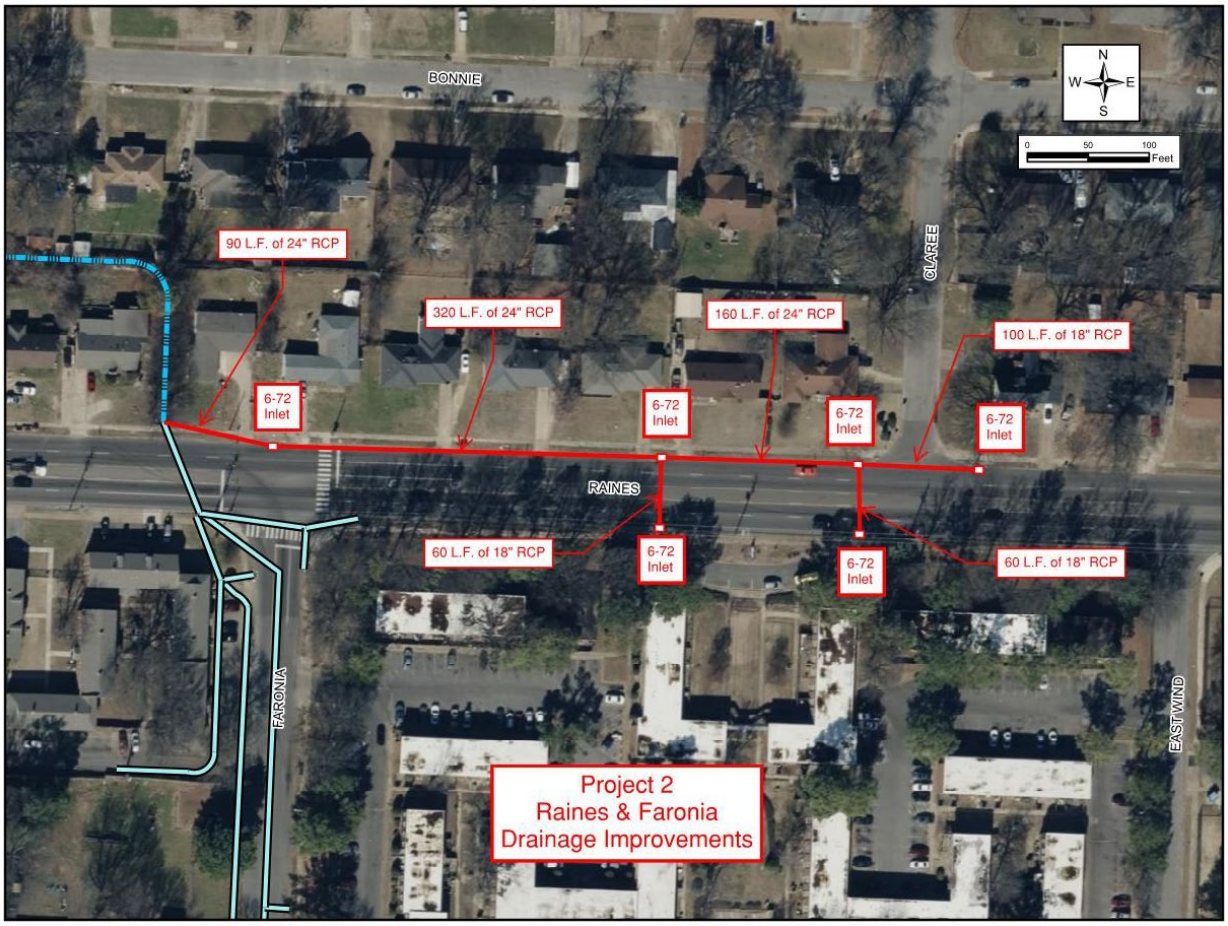


Figure ES-47.Project 2 Details

5.2.3 Project 3: Graceland & Birch Bend Drainage Improvements

There is a section of Graceland Drive between Acacia Street and Shady Birch Road with no drain inlets on the west side of the street. Citizen complaints are that the west side of Graceland Drive in this area floods. The addition of a 6-72 inlet near the intersection of Graceland Drive and Birch Bend Road is recommended. The project includes the installation of one 6-72 inlet on the west side of Graceland near Birch Bend Road and one 18" storm drain connecting to an existing drain manhole.

PROJECT 3					
GRACELAND & BIRCH BEND DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 2,000.00	$ 2,000.00
2	DEMOLITION	1	LS	1,000.00	1,000.00
3	18" RCP	20	LF	100.00	2,000.00
4	6-72 INLETS	1	EA	5,000.00	5,000.00
5	STONE BACKFILL	20	TON	50.00	1,000.00
6	CURB REPAIR	20	LF	50.00	1,000.00
7	SIDEWALK REPAIR	35	SF	20.00	700.00
8	ASPHALT REPAIR	10	SY	100.00	1,000.00
9	EROSION CONTROL	1	LS	1,000.00	1,000.00
10	UTILITY ADJUSTMENTS	1	LS	2,000.00	2,000.00
11	SODDING	6	SY	50.00	300.00
				Subtotal:	$ 17,000.00
			Surveying, Design & Permitting (16%):		3,000.00
			Easement Acquisitions:		-
			Bidding & CA (10%):		2,000.00
			Legal & Admin. (5%):		1,000.00
			Contingency (20%):		3,000.00
			Total Project Budget:		$ 26,000.00

Table ES-10. Project 3 Cost Estimate

Figure ES-48.Project 3 Details

5.2.4 Project 4: Graceland & Timothy Drainage Improvements

The property owner at 1448 Timothy Drive has repeatedly reported flooding in his rear yard. There is an existing 30" storm drain flowing west through this rear yard, but the nearest inlet is 2 lots away. The addition of a 3 x 3 inlet on this existing storm drain will alleviate this flooding problem. The improvements will include excavation to the existing 30" storm drain and construction of a new 3 x 3 drain inlet on top of the 30" storm drain.

PROJECT 4					
GRACELAND & TIMOTHY DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 2,000.00	$ 2,000.00
2	DEMOLITION	1	LS	1,000.00	1,000.00
3	3 X 3 INLET	1	EA	10,000.00	10,000.00
4	STONE BACKFILL	10	TON	50.00	500.00
5	EROSION CONTROL	1	LS	1,000.00	1,000.00
6	SODDING	50	SY	50.00	2,500.00
				Subtotal:	$ 17,000.00
				Surveying, Design & Permitting (16%):	3,000.00
				Easement Acquisitions:	2,000.00
				Bidding & CA (10%):	2,000.00
				Legal & Admin. (5%):	1,000.00
				Contingency (20%):	3,000.00
				Total Project Budget:	$ 28,000.00

Table ES-11. Project 4 Cost Estimate

Figure ES-49.Project 4 Details

5.2.5 Project 5: Randall & Laudeen Drainage Improvements

The property owner at 1360 Laudeen Drive has repeatedly reported flooding in his yard from the street just east of his property. The section of Randall Drive from Laudeen Drive to Graceland Drive (~900' of street) drains west to a corner, then south ~200' to the first available drain inlet. In a heavy rain event, this drainage runs across the street and into the property at 1360 Laudeen. This project would extend the existing storm drain system on Laudeen up to Randall Dr. to intercept this drainage. The improvements include 340 L.F. of 18" storm drain, one drain manhole and two 6-72 inlets on the north and south sides of Randall Drive.

PROJECT 5					
RANDALL & LAUDEEN DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 5,000.00	$ 5,000.00
2	DEMOLITION	1	LS	3,000.00	3,000.00
3	18" RCP	340	LF	100.00	34,000.00
4	6-72 INLETS	2	EA	5,000.00	10,000.00
5	DRAIN MANHOLE	1	EA	5,000.00	5,000.00
6	STONE BACKFILL	280	TON	50.00	14,000.00
7	CURB REPAIR	220	LF	50.00	11,000.00
8	SIDEWALK REPAIR	50	SF	20.00	1,000.00
9	ASPHALT REPAIR	150	SY	100.00	15,000.00
10	EROSION CONTROL	1	LS	5,000.00	5,000.00
11	UTILITY ADJUSTMENTS	1	LS	5,000.00	5,000.00
12	SODDING	100	SY	50.00	5,000.00
				Subtotal:	$ 113,000.00
				Surveying, Design & Permitting (16%):	18,000.00
				Easement Acquisitions:	-
				Bidding & CA (10%):	11,000.00
				Legal & Admin. (5%):	6,000.00
				Contingency (20%):	23,000.00
				Total Project Budget:	$ 171,000.00

Table ES-12. Project 5 Cost Estimate

Figure ES-50.Project 5 Details

5.2.6 Project 6: Hernando Road Drainage Improvements

The property owner at 3210 Hernando Road reports flooding of his building from the ditch south of his property. The ditch along the east side of Hernando Road intercepts drainage from ~8 acres of commercial property, with no drainage pipe to route this water into the drainage system. There is an existing 3′ x 2′ box culvert that crosses Hernando Road north of the ditch. This project would install a drainage pipe from the open ditch to the box culvert. The project would include 110 L.F. of 18″ storm drain, a new No. 11 drain inlet on top of the existing box culvert, and a new headwall at the south end of the new 18″ storm drain.

PROJECT 6					
HERNANDO ROAD DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 3,000.00	$ 3,000.00
2	DEMOLITION	1	LS	2,000.00	2,000.00
3	18" RCP	110	LF	100.00	11,000.00
4	NO. 11 INLET	1	EA	5,000.00	5,000.00
5	HEADWALL	1	EA	5,000.00	5,000.00
6	STONE BACKFILL	60	TON	50.00	3,000.00
7	ASPHALT REPAIR	30	SY	100.00	3,000.00
8	EROSION CONTROL	1	LS	2,000.00	2,000.00
9	UTILITY ADJUSTMENTS	1	LS	2,000.00	2,000.00
10	SODDING	40	SY	50.00	2,000.00
				Subtotal:	$ 38,000.00
	Surveying, Design & Permitting (16%):				6,000.00
		Easement Acquisitions:			-
			Bidding & CA (10%):		4,000.00
			Legal & Admin. (5%):		2,000.00
			Contingency (20%):		8,000.00
			Total Project Budget:		$ 58,000.00

Table ES-13. Project 6 Cost Estimate

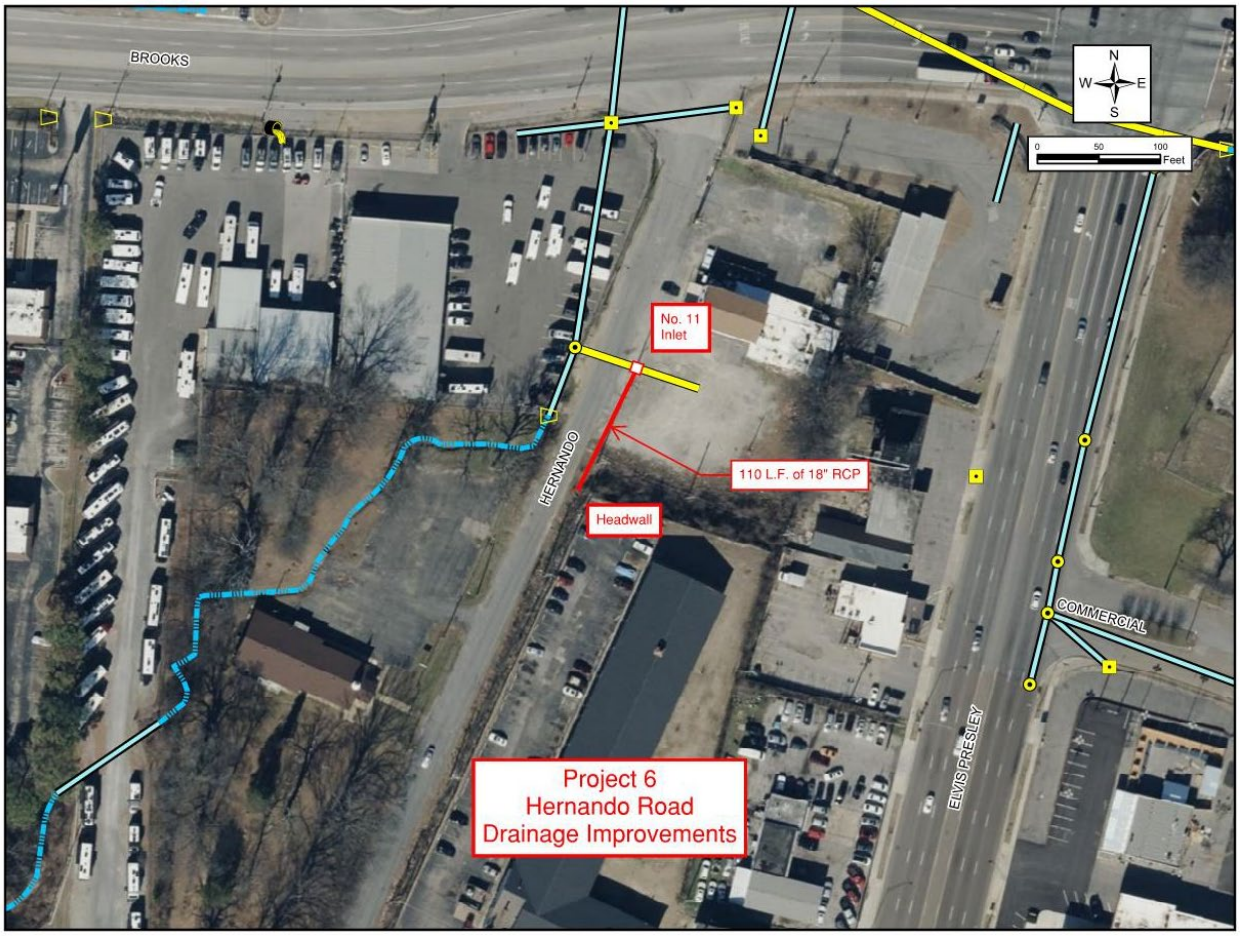


Figure ES-51. Project 6 Details

5.2.7 Project 7: Dellrose Drive Drainage Improvements

Approximately 6 acres of residential subdivision drains into Dellrose Drive, with only two drain inlets at the low end of the street to intercept this drainage. There is a 36" storm drain that runs down the center of Dellrose Drive for approximately 600', but there are no drain inlets along this section. This project would install three 6-72 drain inlets along Dellrose Drive to intercept the drainage along the street. The project would include the installation of three 6-72 drain inlets (two on the north side of Dellrose and one on the south side), and three sections of 18" storm drain to connect the three new inlets to existing storm drain manholes in Dellrose.

PROJECT 7					
DELLROSE DRIVE DRAINAGE IMPROVEMENTS					
CONSTRUCTION COST ESTIMATE					
WHITEHAVEN STORMWATER STUDY					
Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 2,000.00	$ 2,000.00
2	DEMOLITION	1	LS	2,500.00	2,500.00
3	18" RCP	45	LF	100.00	4,500.00
4	6-72 INLETS	3	EA	5,000.00	15,000.00
5	STONE BACKFILL	40	TON	50.00	2,000.00
6	CURB REPAIR	30	LF	50.00	1,500.00
7	ASPHALT REPAIR	25	SY	100.00	2,500.00
8	EROSION CONTROL	1	LS	2,000.00	2,000.00
9	UTILITY ADJUSTMENTS	1	LS	2,000.00	2,000.00
10	SODDING	20	SY	50.00	1,000.00
				Subtotal:	$ 35,000.00
	Surveying, Design & Permitting (16%):				6,000.00
		Easement Acquisitions:			-
			Bidding & CA (10%):		4,000.00
			Legal & Admin. (5%):		2,000.00
			Contingency (20%):		7,000.00
			Total Project Budget:		$ 54,000.00

Table ES-14. Project 7 Cost Estimate

Figure ES-52. Project 7 Details

5.2.8 Project 8: Twinkletown Road Drainage Improvements

Approximately 20 acres of residential subdivision along Twinkletown Road drains along the street through inadequate side ditches and undersized driveway culverts, eventually flooding the rear yards of residences fronting on Twinkletown Road and Bluebird Road. This project would install a new drainage system from the main drainage channel just west of Elvis Presley Blvd., up to and along Twinkletown Road to intercept this drainage and route it into the main drainageway. The project includes 30", 24" and 18" storm drains from the main drainage channel up to and along Twinkletown Road. Since Twinkletown Road is a rural street section, drainage will have to be intercepted using No. 11 inlets along the roadway. In addition, one 3 x 3 inlet will be installed in the rear yards, and headwalls at the upstream and downstream ends of the new drainage system.

PROJECT 8
TWINKLETOWN ROAD DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE
WHITEHAVEN STORMWATER STUDY

Item	Description	Quantity	Unit	Unit Price	Amount
1	MOBILIZATION	1	LS	$ 20,000.00	$ 20,000.00
2	DEMOLITION	1	LS	15,000.00	15,000.00
3	18" RCP	40	LF	100.00	4,000.00
4	24" RCP	300	LF	120.00	36,000.00
5	30" RCP	650	LF	160.00	104,000.00
6	NO. 11 INLET	6	EA	5,000.00	30,000.00
7	3 X 3 INLET	1	EA	10,000.00	10,000.00
8	HEADWALLS	2	EA	10,000.00	20,000.00
9	STONE BACKFILL	100	TON	50.00	5,000.00
10	DRIVEWAY REPAIR	600	SF	40.00	24,000.00
11	ASPHALT REPAIR	20	SY	100.00	2,000.00
12	EROSION CONTROL	1	LS	20,000.00	20,000.00
13	UTILITY ADJUSTMENTS	1	LS	20,000.00	20,000.00
14	SODDING	600	SY	50.00	30,000.00
				Subtotal:	$ 340,000.00
				Surveying, Design & Permitting (16%):	54,000.00
				Easement Acquisitions:	80,000.00
				Bidding & CA (10%):	34,000.00
				Legal & Admin. (5%):	17,000.00
				Contingency (20%):	68,000.00
				Total Project Budget:	$ 593,000.00

Table ES-15. Project 8 Cost Estimate

Figure ES-53.Project 8 Details