



Southland Drainage Study Volume II of II

Drainage Basins Included in Study:

**Rochester
Johnson Yards
Red Budd
Southland
Rosita**

**Prepared For:
City of Memphis
Division of Engineering**

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LIST OF ABBREVIATIONS

Abbreviation:

Meaning:

(CEASER)	Center for Applied Earth Science and Engineering Research
(CIP)	Capital Improvement Project
(CMP)	Corrugated Metal Pipe
(DEM)	Digital Elevation Model
(DTV)	Difference in Total Volume
(FHWA)	Federal Highway Administration
(GIS)	Geographic Information System
(GPS)	Global Positioning System
(HDS-5)	Hydraulic Design Series Number 5
(HERCP)	Horizontal Elliptical Reinforced Concrete Pipe
(HGL)	Hydraulic Grade Line
(H&H)	Hydrologic and Hydraulic
(LiDAR)	Light Detection and Ranging
(MLSE)	Mean Least Square Error
(NRCS)	National Resource Conservation Service
(RCAP)	Reinforced Concrete Arch Pipe
(RCP)	Reinforced Concrete Pipe
(ROW)	Right-of-Way
(R-Square)	R ²
(SCS)	Soil Conservation Service
(SSURGO)	Soil Survey Geographic Database
(SWM)	Storm Water Management
(UMRF)	University of Memphis Research Foundation
(US-EPA)	U.S. Environmental Protection Agency

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VOLUME II:

1.0 PROJECT INTRODUCTION

1.1 Project Background and Purpose

Over the last 200 years the City of Memphis has grown in both size and population. This growth has resulted in an increased rate of development and a higher percentage of pavement and rooftop impervious area within the City. As the impervious area increases so does the stormwater runoff during rainfall events. That said, much of the City stormwater infrastructure has not been improved to match the increased rate of stormwater runoff. As a result, numerous portions of the City stormwater infrastructure have inadequate conveyance capacity and repetitive flooding problems occur. This is particularly true for older areas of the City. These flooding concerns have been brought to the attention of the City of Memphis through flooding and drainage-related maintenance reports submitted by local residents.

In fiscal year 2014, the Division of Engineering began utilizing accumulated stormwater utility fees to fund a series of master plan drainage studies throughout 7 identified major drainage areas corresponding to City council districts. These 7 major drainage areas have been subdivided into 37 smaller study areas. The original plan was to systematically analyze these 37 smaller study areas at a rate of one small study area per year in each of the 7 major drainage areas. The overall goal is to analyze each study area in the City based on priority and undertake specific projects to mitigate the impacts of future storm events on the public infrastructure and private property throughout the City.

The City of Memphis hired the SSR team to perform a drainage analysis on the study area by developing a hydrologic and hydraulic (H&H) model of the stormwater infrastructure throughout the drainage basins included in the Southland Drainage Study. The model was constructed based on the combination of Geographic Information System (GIS) data and field survey data and was utilized to identify areas with flooding problems and recommend infrastructure improvements that reduce or eliminate the amount of flooding in the selected improvement areas. The estimated cost of each improvement was also quantified along with the impacts of each improvement solution. This data will be utilized by the Division of Engineering to prioritize Capital Improvement Projects (CIPs) throughout the study area and throughout the City. The field surveyed stormwater infrastructure data collected throughout the duration of the study will also be utilized to update the City's stormwater asset inventory database.

1.2 Study Area Description

The Southland Drainage Study is located south of Downtown Memphis and consists of 5 adjacent drainage basins spanning west to east from Riverport Harbor to the Dr. M.L.K. Jr. Expressway bridge and north to south from Nonconnah Creek to Ford Road Elementary School, Will Carruthers Softball Complex, and the Bluebird Estates. All but one of the drainage basins has at least one outfall that discharges directly into Nonconnah Creek. The only exception is the westernmost drainage basin, which has a single outfall that discharges directly into Riverport Harbor. From west to east the basins included in the Southland Drainage Study are as follows: Rochester Basin, Johnson Yards Basin, Red Budd Basin, Southland Basin, and Rosita Basin. The total drainage area of the Southland Drainage Study is approximately 3,341 acres and the individual basin areas are as follows: Rochester Basin (538 acres), Johnson Yards Basin (417 acres), Red Budd Basin (503 acres), Southland Basin (1,222 acres), and Rosita Basin (661 acres). Exhibit 1 in Appendix A shows the location of the five drainage basins and the City's preliminary stormwater infrastructure and watershed GIS data.

The Johnson Yards Basin was removed from the study based on limited access and collection of stormwater infrastructure data within the private Illinois Central Gulf Railroad property (Parcel ID: 075001 00087). That said, the remaining 2,924 acres in the other four basins were included in the study. The study area consists of a mixture of land use classifications including but not limited to the following: single unit and multi-family residential, low and high intensity commercial, parks and recreational facilities, open natural areas, industrial/industrial flex, roadways, and water bodies. The stormwater infrastructure throughout the basins consists of pipe networks of a variety of shapes and sizes, pipe and box culvert roadway crossings, concrete line channels, and natural channels. Nonconnah Creek is the outfall of all of the tributaries in the study with the exception of the Rochester Basin tributary, which outfalls to Riverport Harbor.

1.3 Public Involvement

The project included a public outreach component that focused on informing the public of the impending drainage project, providing a platform for citizens to inform the City of existing drainage-related issues, and aggregation of such data for use in modeling and planning purposes. Flyers were made and posted to advertise the public meeting and inform the public of the drainage study. A public meeting took place on April 28, 2016, at the Riverside M. B. Church located at 3560 S. Third Street. During the meeting details of the study were presented to local residents who attended the meeting. Those who attended were asked to provide their name and email address, complete a questionnaire, and note problem areas on map stations placed around the meeting room. Six individuals attended the meeting and provided the information requested above. The flyer, questionnaire, map, and presentation documents utilized during the public outreach component of this project are located in Appendix B of the Volume I report document.

The City of Memphis Public Works Drain Maintenance Department also collected flooding and drainage-related maintenance reports and compiled a running list of the reports in the form a GIS point file. The collected reports within the Southland study area were utilized to check the model flooding results and aid in the identification of areas with repetitive flooding problems for proposed infrastructure improvements.

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2.0 DATA COLLECTION

In an effort to better understand the unique characteristics and rainfall-runoff response of the drainage basins included in the Southland Drainage Study, a variety of data was collected and analyzed for use in the model development process. This data included a combination of the City's storm water infrastructure GIS data, digital Light Detection and Ranging (LiDAR)-derived topographic data, land use and soil GIS data, field survey data, and field collected precipitation and flow depth data. The sections below describe each of the data sets collected for incorporation into the drainage study Hydrologic and Hydraulic model.

2.1 City Stormwater Infrastructure GIS Data

The City of Memphis partnered with the University of Memphis Center for Applied Earth Science and Engineering Research (CEASER) to develop a geodatabase of the City's stormwater infrastructure. This data included the preliminary watershed boundaries and all current geospatial and descriptive information for the stormwater and drainage elements in the basins within the study area. This data was digitized utilizing record drawings and aerial photography and had not been field verified for completeness or accuracy. It was utilized as a guide for the planning and implementation of both the field survey effort and H&H model development process. The dataset included drainage elements that were outside of the scope of the field survey and therefore aided in the comprehensive understanding of the drainage systems throughout the study area and the extent of the contributing urban drainage basins. Exhibit 1 in Appendix A shows the City's preliminary stormwater infrastructure and watershed GIS data.

2.1.1 Flooding Reports

The City of Memphis Public Works Drain Maintenance Department collected flooding and drainage-related maintenance reports and compiled a running list of the reports in the form a GIS database. These georeferenced reports were analyzed and utilized during the study to check the model flooding results and aid in the identification of areas with repetitive flooding problems for proposed infrastructure improvements. Section 6 of this report includes descriptions of the flooding and drainage-related maintenance reports in the vicinity of each identified improvement area. All of the reports utilized during the study are included in the model for reference.

2.2 Topography

GIS-based digital LiDAR-derived topographic data was used as the main source of elevation data for the study. A GIS Raster Digital Elevation Model (DEM) was created from 2-foot contour elevation data and was used to analyze the areas located beyond the top of bank of the open-channel conveyances within the study area. The DEM was updated throughout the data collection and model development efforts by incorporating the field survey data into the DEM. The DEM played a key role in the hydrologic analysis of the study as it aided in the delineation of subcatchments throughout the study area and was used to quantify model subcatchment parameters. It also served as the base layer for the flood-mapping efforts while analyzing the inundation extent of the simulated model results.

Exhibit 2 through Exhibit 7 in Appendix A display the 2-foot contour elevation data for the overall study area (Exhibit 2) and each of the individual basins (Exhibits 3-7). The individual basins are presented west to east in the following order: Rochester Basin (Exhibit 3), Johnson Yards Basin (Exhibit 4), Red Budd Basin (Exhibit 5), Southland Basin (Exhibit 6), and Rosita Basin (Exhibit 7).

2.3 Land Use and Parcel Data

GIS-based parcel and land-use data was used as the main data source for surface cover classification of the basins in the drainage study. Future land use classifications established in the 2019 Memphis 3.0 Comprehensive Plan were obtained from the Shelby County Zoning database and utilized as the base data set for the hydrologic analysis conducted during the study. Each of the future land use classifications were assigned a variety of base modeling parameters corresponding to the quantity of development and impervious area within each classification type. Table 1 summarizes the various land use classifications utilized in the study.

Table 1: Land Use Classification Summary

Landuse ID	Description
A-NC	Anchor – Neighborhood Crossing
A-NMS	Anchor – Neighborhood Main Street
AN-S	Anchor Neighborhood – Primarily Single-Unit
CSH	High Intensity Commercial & Services
I	Industrial
IF	Industrial Flex
CSL	Low Intensity Commercial & Services
OSN	Open Spaces & Natural Features
PR	Parks & Recreational Facilities
NM	Primarily Multifamily Neighborhood
NS	Primarily Single-Unit Neighborhood
PQP	Public & Quasi-Public Buildings & Uses
R-W	Roadway and Waterway
M-AN-S-CSL	Modified-Anchor Single Unit-Low Intensity Commercial
M-AN-S-PR	Modified-Anchor Single Unit-Parks & Recreation
M-CSH-OSN	Modified-High Intensity Commercial-Open & Natural
M-CSH-PR	Modified-High Intensity Commercial-Parks & Recreation
M-CSH-NS	Modified-High Intensity Commercial-Single Unit
M-I-OSN	Modified-Industrial-Open Spaces & Natural
M-IF-OSN	Modified-Industrial Flex-Open Spaces & Natural
M-IF-PR	Modified-Industrial Flex-Parks & Recreation
M-CSL-PR	Modified-Low Intensity Commercial-Parks & Recreation
M-CSL-NS	Modified-Low Intensity Commercial-Single Unit
M-NM-PR	Modified-Multifamily-Parks & Recreation
M-NM-NS	Modified-Multifamily-Single Unit
M-NS-CSL	Modified-Single Unit-Low Intensity Commercial
M-NS-OSN	Modified-Single Unit-Open & Natural

Exhibit 8 through Exhibit 13 in Appendix A display the land use data for the overall study area (Exhibit 8) and each of the individual basins (Exhibits 9-13). The individual basins are presented west to east in the following order: Rochester Basin (Exhibit 9), Johnson Yards Basin (Exhibit 10), Red Budd Basin (Exhibit 11), Southland Basin (Exhibit 12), and Rosita Basin (Exhibit 13). Figure 1 in Appendix B summarizes, in table format, the percentage of each land use classification within each model subcatchment. Section 3.1 of this report includes more information about how the land use GIS data was utilized during the model development process.

2.4 Soils Data

GIS-based soils data was used as the main data source for soil infiltration classification of the basins in the drainage study. National Resource Conservation Service (NRCS) soil classification data was obtained from the Soil Survey Geographic Database (SSURGO) for the Shelby County area and trimmed to the study area. The soils data was analyzed and grouped according to the respective soil texture attribute. Each of the soil texture classifications were assigned a variety of base modeling parameters corresponding to their respective infiltration properties. Table 2 summarizes the various soil texture classifications utilized in the study.

Table 2: Soil Texture Classification Summary

Soil Texture ID
CLAY
SILT LOAM
SILTY CLAY
WATER

Exhibit 14 through Exhibit 19 in Appendix A display the soil texture data for the overall study area (Exhibit 14) and each of the individual basins (Exhibits 15-19). The individual basins are presented west to east in the following order: Rochester Basin (Exhibit 15), Johnson Yards Basin (Exhibit 16), Red Budd Basin (Exhibit 17), Southland Basin (Exhibit 18), and Rosita Basin (Exhibit 19). Figure 2 in Appendix B summarizes, in table format, the percentage of each soil texture classification within each model subcatchment. Section 3.1 of this report includes more information about how the soil texture GIS data was utilized during the model development process.

2.5 Field Survey

In an effort to field verify the provided GIS stormwater infrastructure data and develop a model that included accurate existing surface and underground infrastructure elements a field survey was conducted in the study area. The field survey was completed by Geodesy Professional Services, LLC in 2016. Control points were established throughout the study area using Global Positioning System (GPS) technology, and traditional total station field survey efforts were conducted. The geospatial location and vertical elevation of the stormwater infrastructure in the study area were collected along with georeferenced photos of the structures. The surveyed infrastructure included open drainage channels, roadway culvert crossings, bridge crossings, storm sewer pipe networks, and catch basin/ manhole/ headwall structures. Exhibit 20 in Appendix A displays the collected survey data for the overall study area. The collected survey data and photos are included in the final set of electronic deliverables.

2.5.1 Open-Channel Cross-Sections and Road Crossings

Surveyed cross-sections for open-channels located in the study area were conducted from top of bank to top of bank and included a minimum of five elevation points. Each cross-section included two top of bank elevation points, two toe of slope elevation points, and a single flow line elevation point. These cross-sections were required at each significant change in channel geometry, material, or direction, at all points of concentrated stormwater discharge, and immediately upstream and downstream of structure crossings. Generally, the required spacing between cross-sections was 500 feet or less. At the location of roadway and/or bridge crossings additional elevation data was collected at the roadway/bridge deck surface.

2.5.2 Stormwater Structures and Pipes

All storm sewer pipes greater than or equal to 24 inches were surveyed along with all connected drainage structures (catch basins, manholes, headwalls, etc.). Information was collected regarding the size, shape, and material of the surveyed storm sewer pipes. Each surveyed structure included elevation points at the flow line invert elevation, the surface opening rim elevation, and the top of structure elevation. Descriptive information was collected for each surveyed structure identifying what type of drainage structure was encountered (headwall, manhole, area inlet, 6-72 combination inlet, etc.).

2.5.3 Field Infrastructure Photos

All surveyed road crossings and outfalls were photographed and georeferenced. Structures crossing an open channel were photographed from both the upstream and downstream vantage points, and structures discharging into channels were photographed from the channel. Underground storm sewer drainage structures were photographed from the ground surface facing the front of the structure rim. The georeferenced location of the photographs was relatively close and did not have survey-grade accuracy. The collected photos were incorporated into a GIS data set.

3.0 MODEL DEVELOPMENT

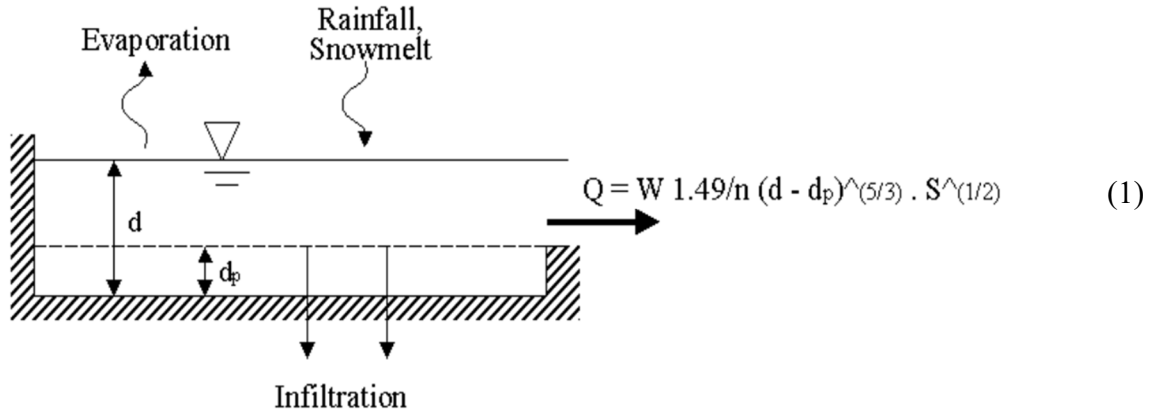
The hydrologic and hydraulic model developed during this study was created in the Innovyze modeling software package InfoSWMM Suite 15.0. The InfoSWMM software utilized an enhanced version of the US-EPA Storm Water Management Model (SWMM) analysis engine as developed and distributed by the Water Supply and Water Resources Division of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory (SWMM Version EPA SWMM 5.1.015). The project was modeled using a combination 1D/1D hydrologic and hydraulic model: which relied on traditional model mechanics to characterize flow throughout the underground drainage network, channels, and overland flow areas. The model relied on the surveyed stormwater infrastructure data and a variety of hydrologic and hydraulic input parameters to perform the rainfall-runoff simulations. The parameter values input into the model were primarily based on engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, and Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual.

Existing City stormwater infrastructure, topographic, and land use/ soil classification GIS data were utilized in conjunction with field survey data and measured rainfall/flow depth data gathered during the project to construct a representative stormwater model of the basins included in the study. A single existing conditions model was developed for the project that included the Rochester Basin, Red Budd Basin, Southland Basin, and Rosita Basin. The model was then calibrated to the measured rainfall and flow depth data gathered during the survey phase of the project and the rainfall for various NRCS Type II 24-hour storm events were simulated in the model. The model flooding results were then mapped and compared to City flooding complaints and target areas were identified for infrastructure improvements. The sections below summarize the hydrologic and hydraulic components of the model and their respective parameters.

3.1 Hydrologic Modeling Methodology

The surface runoff calculation methodology used in the model was the EPA SWMM Non-linear Reservoir method. This calculation method was established by coupling the continuity equation with Manning's equation. Each subcatchment is treated as a "reservoir" with a storage capacity equal to the maximum depression storage (d_p), which is the maximum surface storage provided by ponding, surface wetting, and rainfall interception. Inflow enters the "reservoir" from precipitation and the upstream subcatchments, and it exits the "reservoir" through infiltration, evaporation, and surface runoff (Q). Evaporation wasn't accounted for in our model, and soil infiltration was estimated using the Green-Ampt method. Surface runoff (Q) only occurs when the depth of water (d) in the subcatchment "reservoir" exceeds the maximum depression storage (d_p), in which case the outflow is given by Manning's Equation. The depth of water over the subcatchment "reservoir" (d) was continuously updated at each modeled time step through numerically solving a water balance equation over the subcatchment.

Equation (1) and the schematic diagram and below display how the EPA SWMM Non-linear Reservoir Runoff Model functions:



where:

- Q is surface runoff flow rate
- W is the subbasin width
- n is Manning's roughness coefficient
- d is the depth of water
- d_p is the maximum depression storage depth, and
- S is slope

The parameters accounted for in the hydrologic model include but are not limited to the following: sub-basin area, width, impervious area, slope, pervious and impervious overland flow Manning's n value, pervious and impervious depression storage, soil suction head, hydraulic conductivity, and initial moisture deficit. These parameters were utilized within subcatchment, soil, and rain gage model elements to calculate the amount of soil infiltration, surface storage, and surface runoff resulting from a single or series of rainfall events. The parameter values for each of these components were based on engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, and Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual. The hydrologic parameters were incorporated into the model using the topographic DEM, land use, and soil GIS data sets assembled during the data collection phase of the project. Figure 3 in Appendix B summarizes, in table format, the base hydrologic model parameters assigned to each land use and soil texture classification. The sections below summarize each of the parameters utilized in the hydrologic modeling efforts.

3.1.1 Subbasin Delineation

The preliminary watersheds provided by CEASER were analyzed and fine-tuned to represent more accurately each of the basin's watershed boundary. The topographic DEM was utilized in conjunction with the GIS and field survey stormwater infrastructure data to refine the overall watershed boundaries of each basin and subdivide them into urban subcatchments. The InfoSWMM Subcatchment Manager add-on software was used to perform the initial watershed refinement and subcatchment delineation efforts. The software could not be relied upon completely without consideration of the existing subsurface features within the basins, so the software ArcGIS Pro was used to fine-tune the subcatchment boundaries to the area contributing runoff to the entire pipe network within each subsurface storm sewer system.

The preliminary target subcatchment size range was 50-100 acres, but this range was altered based on the unique characteristics of the basins in the study. Smaller subcatchments were incorporated into the model where necessary to ensure that all upstream pipe networks included in the model had contributing runoff into the analyzed system. Larger subcatchments were incorporated where necessary to reflect undeveloped areas where no underground storm sewer systems were present or where the size of the underground pipe networks were less than 24 inches and therefore fell outside of the scope of the modeling efforts. A total of 125 subcatchments were delineated for the four basins in the H&H model. The size range of these subcatchments varied from 2.6 acres to 157.5 acres with an average subcatchment size of 23.4 acres.

Exhibit 21 in Appendix A displays the refined overall watershed boundaries of the five drainage basins included in the study. Exhibit 22 in Appendix A displays the delineated sub-basins within each of the four modeled drainage basins. Figure 4 in Appendix B summarizes, in table format, the base pre-calibration subcatchment parameters for all model subcatchments.

3.1.2 Subbasin Width

The subcatchment width parameter is used along with the depth of flow to estimate the theoretical cross-sectional area applied to the Manning's equation while calculating the surface runoff from each subcatchment. It has a storage effect and shape effect on the routing hydrograph and is often used as a calibration parameter. The InfoSWMM Subcatchment Manager add-on software was used to calculate the base width values for the subcatchments in the model. A series of surface analysis raster files were created from the topographic DEM and used for the calculation procedures. These analysis raster files included the following: flow direction raster, flow accumulation raster, flow length raster, and slope raster. The flow direction raster was used to create the flow length raster, and the initial base width values for all subcatchments were calculated by dividing the subcatchment area by the longest flow length calculated from the flow length raster file. Figure 4 in Appendix B summarizes, in table format, the base pre-calibration subcatchment parameters for all model subcatchments.

3.1.3 Subbasin Slope

The subcatchment slope parameter is used in the Manning's equation to estimate the rate of flow leaving each subcatchment. The InfoSWMM Subcatchment Manager add-on software was used to calculate the base slope values for the subcatchments in the model. A series of surface analysis raster files were created from the topographic DEM and used for the calculation procedures. These analysis raster files included the following: flow direction raster, flow accumulation raster, flow length raster, and slope raster. The flow direction raster, flow accumulation raster, and slope raster were used to calculate the initial base slope values for all subcatchments by averaging the slope along the longest flow length. Figure 4 in Appendix B summarizes, in table format, the base pre-calibration subcatchment parameters for all model subcatchments.

3.1.4 Impervious Area and Sub-Area Routing

Each subcatchment modeled utilizing the EPA SWMM methodology is composed of two sub-areas, an impervious sub-area, and a pervious sub-area. These sub-areas differ in that almost all of the rainfall that falls on the impervious sub-area is converted into runoff while the rainfall that falls on the pervious sub-area has an opportunity to infiltrate prior to producing surface runoff. The EPA SWMM methodology also allows sub-area routing to occur within each subcatchment prior to runoff exiting through the outlet of the subcatchment. This capability allows the resulting runoff from either the impervious sub-area or pervious sub-area to be routed through the opposite sub-area prior to exiting the subcatchment. This concept enables Low Impact Development (LID) entities and connected/disconnected impervious areas to be modeled if desired or needed during the model calibration efforts. The subcatchments in this H&H model did not utilize the sub-area routing option and the resulting surface runoff for both the impervious and pervious sub-areas were routed directly to the outlet of each respective subcatchment.

Impervious area percentage values were assigned to each land use classification based on the estimated quantity of anticipated development for each classification. The assigned percentages were based on aerial imagery, future land use, engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, and Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual. The GIS land use data was then overlaid on the GIS subcatchment data and area-weighted impervious area percentages were calculated for each respective subcatchment. These area-weighted calculations were performed using the InfoSWMM Subcatchment Manager add-on software. Exhibit 23 in Appendix A displays the impervious area percentages applied throughout the five drainage basins in the study area based on the land use GIS data. Figure 4 in Appendix B summarizes, in table format, the base pre-calibration subcatchment parameters for all model subcatchments.

3.1.5 Depression Storage

Depression storage is the maximum surface storage provided by ponding, surface wetting, and rainfall interception in each subcatchment. The EPA SWMM methodology treats depression storage as a “reservoir” that must be filled and exceeded prior to surface runoff occurring. Separate depression storage values are utilized for the impervious and pervious sub-areas in each subcatchment. Impervious and pervious depression storage values were assigned to each land use classification based on engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, and Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual. The GIS land use data was then overlaid on the GIS subcatchment data and area-weighted impervious and pervious depression storage values were calculated for each respective subcatchment. These area-weighted calculations were performed using the InfoSWMM Subcatchment Manager add-on software. Figure 4 in Appendix B summarizes, in table format, the base pre-calibration subcatchment parameters for all model subcatchments.

3.1.6 Sheet Flow Manning’s n

Sheet flow (overland flow) is shallow runoff, typically 1.2 inches or less in depth, flowing uniformly over a theoretical plane surface prior to reaching a concentrated flow state. Manning’s n coefficient for sheet flow represents the surface roughness and friction forces acting on the plane that the runoff is flowing across. It describes surface obstacles such as debris, vegetation, sediment, pavement, and rocks. The roughness coefficient is used in the Manning’s equation while calculating the resulting surface runoff from each subcatchment. Separate sheet flow Manning’s n values are utilized for the impervious and pervious sub-areas in each subcatchment.

Impervious and pervious sheet flow Manning’s n values were assigned to each land use classification based on engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, and Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual. The GIS land use data was then overlaid on the GIS subcatchment data and area-weighted impervious and pervious sheet flow Manning’s n values were calculated for each respective subcatchment. These area-weighted calculations were performed using the InfoSWMM Subcatchment Manager add-on software. Figure 4 in Appendix B summarizes, in table format, the base pre-calibration subcatchment parameters for all model subcatchments.

3.1.7 Soil Infiltration

Soil infiltration is the process of rainfall penetrating the ground surface into the unsaturated soil zone of the pervious sub-area in each subcatchment. The rate of soil infiltration increases or decreases the depth of water over each subcatchment “reservoir” at each calculation time step and therefore directly impacts the quantity of surface runoff resulting from a given rainfall event. The five available calculation methods for modeling soil infiltration were the Horton Method, the Modified Horton Method, the Green-Ampt Method, the Modified Green-Ampt Method, and the NRCS (SCS) Curve Number Method.

The Green-Ampt Method was used to model soil infiltration in our H&H model. This method for modeling infiltration assumes that a sharp wetting front exists in the soil column, separating soil with some initial moisture content below from saturated soil above. The input parameters required are the initial moisture deficit of the soil, the soil's hydraulic conductivity, and the suction head at the wetting front. The recovery rate of moisture deficit during dry periods is empirically related to the hydraulic conductivity.

Initial moisture deficit, hydraulic conductivity, and suction head values were assigned to each soil texture classification based on engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, and Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual. The GIS soil data was then overlaid on the GIS subcatchment data and the area percentage of each soil texture classification within each respective subcatchment was calculated. These calculations were performed using the InfoSWMM Subcatchment Manager add-on software. When performing the soil infiltration calculations, the model utilized the Green-Ampt parameter values assigned to each soil texture classification in conjunction with the calculated area percentage values of each classification within each subcatchment. Figure 3 in Appendix B summarizes, in table format, the base Green-Ampt soil infiltration parameters assigned to each soil texture classification.

3.2 Hydraulic Modeling Methodology

The hydraulic modeling efforts in the study area span west to east from Riverport Harbor to the Dr. M.L.K. Jr. Expressway bridge and north to south from Nonconnah Creek to Ford Road Elementary School, Will Carruthers Softball Complex, and the Bluebird Estates. From west to east the basins included in the study area were the Rochester Basin, the Johnson Yards Basin, the Red Budd Basin, the Southland Basin, and the Rosita Basin. The Johnson Yards Basin was removed from the study based on limited access and collection of stormwater infrastructure data within the private Illinois Central Gulf Railroad property. Hydraulic modeling efforts were performed on the stormwater infrastructure throughout the remaining four basins. These stormwater infrastructure components consisted of underground pipe networks, culvert roadway crossings, open channel bridge crossings, man-made open channels, and natural open channels. Nonconnah Creek is the outfall of all of the tributaries in the study with the exception of the Rochester Basin tributary, which outfalls to Riverport Harbor. Exhibit 24 through Exhibit 27 in Appendix A display the hydrologic and hydraulic model elements within each of the four modeled drainage basins. The individual basins are presented west to east in the following order: Rochester Basin (Exhibit 24), Red Budd Basin (Exhibit 25), Southland Basin (Exhibit 26), and Rosita Basin (Exhibit 27).

The primary hydraulic components modeled in the Rochester Basin were one main open channel tributary (Outfall 1) with five main pipe network systems intersecting the main tributary. The primary hydraulic components modeled in the Red Budd Basin were one main open channel tributary (Outfall 2) with seven main pipe network systems intersecting the main tributary. The primary hydraulic components modeled in the Southland Basin were two main open channel tributaries with three main pipe network systems intersecting the western tributary (Outfall 3) and ten main pipe network systems intersecting the eastern tributary (Outfall 4). The primary hydraulic components modeled in the Rosita Basin were six main open channel tributaries numbered as Outfall 5 through Outfall 10 from west to east. Tributary (Outfall) five had two main intersecting pipe networks. Tributary (Outfall) six had three main intersecting pipe networks. Tributaries (Outfalls) seven, nine and ten each had one main intersecting pipe network. Tributary (Outfall) eight had four main intersecting pipe networks. Exhibit 28 in Appendix A displays the open channel and closed conduits throughout the modeled drainage basins.

The hydraulic parameters accounted for in the model include but are not limited to the following: conveyance geometry, pipe/channel/overbank Manning's n value, length, slope, entry/exit losses, open/closed flow type, available surface ponding area, detention pond storage and outlet structures, and Federal Highway Administration (FHWA) inlet/outlet control culvert codes and roadway overflow weir coefficients. These parameters are utilized in the flow routing portion of the simulation as the calculated surface runoff travels through the conveyance infrastructure. The surveyed stormwater infrastructure data was converted to a GIS format and merged with the appropriate hydraulic parameters to create conveyance elements in the model. These model conveyance elements consist of junctions, conduits, storage ponds, weirs, orifices, and outfalls that mimic real world stormwater infrastructure such as headwalls, manholes, catch basin inlets, pipe networks, pipe or box culvert crossing, roadway overflow weirs, man-made ditches and armored channels, natural creeks and streams, and detention ponds.

3.2.1 Open Channels

Open channel conveyances were modeled using the combination of conduit and junction model elements. Open channel junctions were located where one of the following conditions were present: change in invert elevation, change in direction, change in channel or overbank geometry, change in channel material, intersection with concentrated pipe network discharge, confluence of tributaries, and/or intersection with roadway or bridge crossings. These open channel junction elements relied on the following data inputs: invert elevation, rim elevation, ponded surface area, and external inflow data. The collected survey data and field photos were used along with engineering judgement to populate these open channel junction parameters. The rim elevations for the open channel junctions equal the top elevation of the defined cross-section transect data, and the ponded surface area values represent additional storage above the defined rim elevation.

Open channel conduits are the elements that connect the junction elements to one another and ultimately define model conveyance properties. These elements use the Manning equation to express the relationship between flow rate (Q), cross-sectional area (A), hydraulic radius (R), slope (S), and Manning's roughness coefficient (n). Equation (2) displays the Manning's equation in standard U.S. units.

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2} \quad (2)$$

where:

Q is open channel flow rate
n is Manning's roughness coefficient
A is the cross-sectional area
R is the hydraulic radius, and
S is slope

These open channel conduit elements relied on the following data inputs: length, Manning's n coefficient, upstream invert elevation, downstream invert elevation, entry loss coefficient, exit loss coefficient, and geometric shape definition. The collected survey data and field photos were used along with engineering judgement to populate these open-channel conduit parameters. Entry and exit losses were added to the open channel conduits on a case-by-case basis but were typically only added where a change in channel cross-section geometry or material occurred, at bridge crossings, or at the confluence of tributaries.

The field survey channel cross-section data was combined with the DEM elevation data to create representative transects for the open-channel conduits in the model. These transects refer to the geometric data that describe how the bottom elevation varies with horizontal distance over the cross-section of an irregular-shaped open channel. These transects utilized the survey data for the main channel geometry and elevation values and the DEM data for the overbank floodplain geometry and elevation values. Where applicable, different Manning's roughness coefficient values were utilized for the left overbank, right overbank, and main channel sections to reflect varying surface cover conditions throughout each cross-section. Exhibit 29 in Appendix A displays two typical open channel transects (cross-sections) utilized in the model and the location of their corresponding conduits.

This provided a more realistic estimate of channel conveyance under high flow conditions. Note that once the capacity of a conduit in the model is exceeded, the upstream junction surcharges and the excess water is allowed to pond atop the junction in the defined ponded surface area and subsequently drains back into the junction as capacity becomes available. The Manning's roughness coefficients and entry/exit losses (where applicable) assigned to the open channel elements of the model were based on the following: engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual, Minor Loss Coefficients for Storm Drain Modeling with SWMM (William H. Frost), and Chapter 3 of the HEC-RAS River Analysis System Hydraulic Reference Manual (Version 5).

3.2.2 Underground Pipe Networks

Closed system pipe networks and encapsulated channel conveyances were modeled using the combination of conduit and junction model elements. Closed system junctions were located at all connected drainage structures (catch basins, manholes, headwalls, etc.) and the intersection of pipe networks (blind connections), open channel conveyances, and roadway crossings. These closed system junction elements relied on the following data inputs: invert elevation, rim elevation, ponded surface area, and external inflow data. The collected survey data and field photos were used along with engineering judgement to populate these closed system junction parameters. The rim elevations for the closed system junctions equal the surface elevation of the drainage structures, and the ponded surface area values represent additional storage above the defined rim elevation. Just like open channel junctions, once the capacity of a closed conduit is exceeded, the upstream junction surcharges and the excess water is allowed to pond atop the junction in the defined ponded surface area and subsequently drains back into the junction as capacity becomes available.

Closed conduits are the elements that connect the junction elements to one another and ultimately define model conveyance properties. These closed conduit elements were modeled as gravity flow conveyances and therefore utilized the Manning's equation defined in Section 3.2.1 for their respective flow rate calculations. These closed conduit elements relied on the following data inputs: length, Manning's n coefficient, upstream invert elevation, downstream invert elevation, entry loss coefficient, exit loss coefficient, and geometric shape definition. The collected survey data and field photos were used along with engineering judgement to populate these closed system conduit parameters. Entry and exit losses were added to the closed system conduits on a case-by-case basis but were typically only added where a pipe network intersected an open channel conveyance or at roadway culvert crossings.

Closed conduits are typically pipes that utilize standardized shapes (circular, horizontal elliptical, arch, rectangular, etc.), sizes, and materials (reinforced concrete, corrugated metal, high-density polyethylene, ductile iron, vitrified clay, etc.). Exhibit 30 in Appendix A displays a typical closed pipe network in the model. Unlike open channel conduits, closed conduits use a single representative Manning's roughness coefficient value for their respective flow rate calculations. This roughness coefficient corresponds to the material that lines the inside diameter of the pipe. The Manning's roughness coefficients and entry/exit losses (where applicable) assigned to the closed conduit elements of the model were based on the following: engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual, and Minor Loss Coefficients for Storm Drain Modeling with SWMM (William H. Frost).

3.2.3 Roadway Culvert Crossings and Bridge Crossings

Roadway culvert crossings and bridge crossings were modeled utilizing closed conduit elements in parallel with overflow weir elements. These closed conduits used the same model parameters as defined in Section 3.2.2 with the exception that they all utilized entry and exit loss coefficients, and additional Federal Highway Administration (FHWA) flow control culvert codes. The culvert codes utilized in the model are based on Charts 1-59 of the FHWA Hydraulic Design Series Number 5 (HDS-5) publication and are used to model inlet control conditions for a variety of inlet configurations (projecting pipe, headwall, mitered to slope, grooved or square edge, etc.). Roadway culvert crossings were modeled utilizing standard pipe configurations (circular, elliptical, arch, etc.), or encapsulated channel configurations (rectangular, rectangular with triangular bottom, etc.). Open channel bridge crossings were modeled utilizing custom geometric shapes defined by shape curves input into the model similar to cross-section transects. These custom shape curves were used to define the cross-section of an open channel conveyance beneath a bridge with a capped top elevation representing the bottom of the bridge deck.

Weir elements were utilized to model potential roadway or bridge deck overtopping at the locations of roadway and bridge crossings. These weirs were defined as “Roadways” and additional inputs were provided to model the overtopping of the roadway/ bridge deck in accordance with the Chart 60 of the FHWA (HDS-5) publication. These additional inputs were the roadway surface material (paved, gravel), the roadway width, and the overtopping discharge coefficient. Modeling these overflow weirs were an important component of modeling the roadway and bridge crossings because they enabled the model to quantify the height of surface flooding above the roadway/ bridge deck. The parameter assigned to these model elements were based on engineering judgement, EPA SWMM and InfoSWMM software user manual guidance, Volume 2 of the City of Memphis/ Shelby County Stormwater Management Manual, and the FHWA (HDS-5) publication.

3.2.4 Boundary and Tailwater Conditions

The City’s drainage basins discharge into downstream stormwater systems, local rivers and streams, or directly into the Mississippi River. Nonconnah Creek is the outfall of all of the tributaries in this study with the exception of the Rochester Basin tributary, which outfalls to Riverport Harbor. Boundary conditions in the model are the water surface elevations of the bodies of water downstream of the study area. This water surface elevation is effectively the tailwater elevation applied to the outfalls of the basin tributaries in the model during simulations. The most commonly used boundary conditions are the following types: free, normal, fixed, and time series. Under free outfall conditions, the tailwater elevation is determined by the minimum of the critical flow depth and normal flow depth. Under normal outfall conditions, the tailwater elevation is based on the normal flow depth of the receiving body of water. Under fixed outfall conditions, the tailwater elevation is determined by a fixed elevation input by the modeler. Under time series outfall conditions, the tailwater elevation is determined by a time series of elevations input by the modeler. All of the outfalls in this study utilized free outfall conditions.

3.3 Inundation Mapping

Inundation mapping consisted of comparing the resulting maximum hydraulic grade line (HGL) elevations simulated in the model to the surface elevations of the DEM and creating graphic representations of the results. This process was performed after the model was calibrated to the measured rainfall and flow depth data and standard design storms were simulated in the model. GIS inundation raster files that displayed the depth of surface flooding across the DEM were created for various selected design storm events. These inundation mapping procedures were performed in the InfoSWMM Risk Assessment Manager add-on software. These inundation raster files were used as the primary method of quantifying and visualizing the model results.

4.0 MODEL CALIBRATION

In order to develop a representative H&H model that accurately simulates the rainfall-runoff response of the specific basins in the study, the model had to be calibrated to the field measured rainfall and flow depth data obtained during the data collection process. Model calibration consists of fine tuning of the model parameters until the model simulates field measured conditions to an established degree of accuracy. Fine-tuning of the model entails making adjustments to the model parameters to obtain the desired output data. The degree of accuracy refers to the difference between simulated and actual values and is used to establish a level of confidence in the model. Calibration is important to establish model credibility and to increase knowledge and understanding of the system and how it responds to rainfall events. Successful model calibration is dependent upon the field measured rain gage and stage gage data and the storm events that occurred throughout the duration that the gages were installed and monitored.

4.1 Collected Rainfall and Stream Gage Data

The University of Memphis Research Foundation (UMRF) was contracted by the City of Memphis to install and collect data from three rain gages and two stage gages (pressure transducers) placed throughout the basins in study area. These gages were monitored for a time span of approximately six and a half months and the data was furnished in two-week intervals. The data for all gages were taken in 5-minute intervals and all anomalies were purged prior to use in the calibration efforts. Table 3 and Table 4 summarize the locations of the gages and the duration they were installed. Exhibit 31 in Appendix A displays the location of the gages in relation to the modeled drainage basins.

Table 3: Rain Gage Summary

Rain Gage ID	Location	Duration of Gage Data Collection
EM28453	Fire Station No. 36	5/19/2015 – 12/08/2015
EM28454	Alonzo Weaver Park	
EM28455	Will Carruthers Softball Complex	

Table 4: Stage Gage Summary

Stage Gage Serial No.	Stage Gage ID	Location	Duration of Gage Data Collection
2033851	Rochester - RSG01	The pressure transducer was installed in the rectangular concrete open channel between parcels 075012 00027 and 075012 00026 north of Dixie Road, South of Flynn Road, and west of Rochester Road.	5/21/2015 – 12/08/2015
2039706	Southland - SSG02	The pressure transducer was installed in the open channel southeast of the intersection of Saturn Drive, Gill Road, and E. Biscayne Road.	

Prior to utilizing the collected data in the model calibration efforts, the field measured rainfall and conduit stage data had to be analyzed and a series of calibration-worthy storm events selected. The analysis included reviewing the collected precipitation depth and flow depth data for various 24-hour periods and quantifying the following parameters: cumulative precipitation depth, maximum incremental precipitation depth, date and time of precipitation peak, maximum incremental depth of flow, and date and time of flow depth peak. In order to qualify as a calibration-worthy storm event the precipitation and corresponding flow depth data needed measurable quantities and alignment from a time to peak perspective. Ideally, we were looking for storm events that had a cumulative precipitation depth greater than the 1-year recurrence interval NRCS Type II 24-hour storm event precipitation depth (3.35 inches) and maximum incremental flow depth values that peaked at or after the maximum incremental precipitation peak time. Not all of the selected storm events had a cumulative precipitation depth greater than or equal to the target of 3.35 inches, but three of the five storm events did. The remaining two storm events each had a cumulative precipitation depth greater than 1.25 inches.

Based on the location of the gages, the measured quantities, and time to peak of the collected data, Rain Gage EM28453 was linked with Stage Gage RSG01 and Rain Gage EM28454 was linked to Stage Gage SSG02 for the calibration process. No rainfall data from Rain Gage EM28455 was utilized in the calibration process. Five storm events were selected for the model calibration and verification efforts. Table 5 through Table 9 summarize the quantified parameters of the five selected calibration and verification storm events.

Table 5: May 24 - 25, 2015 Verification Storm Event Summary

05/24/2015 12:00 PM to 05/25/2015 12:00 PM		
Rain Gage: EM 28453 (Weaver Park)	Cumulative Precipitation (in)	1.83
	Max Incremental Precipitation (in)	*0.291
	Date and Time of Precipitation Peak	5/24/15 11:20 PM
Flow Gage: RSG01 (Rochester Basin)	Max Incremental Depth of Flow (ft)	*1.08
	Date and Time of Flow Depth Peak	5/24/15 11:20 PM
Rain Gage: EM 28454 (Fire Station No. 36)	Cumulative Precipitation (in)	1.71
	Max Incremental Precipitation (in)	0.315
	Date and Time of Precipitation Peak	5/24/15 6:00 PM
Flow Gage: SSG02 (Southland Basin)	Max Incremental Depth of Flow (ft)	0.90
	Date and Time of Flow Depth Peak	5/24/15 6:05 PM

* Second peak during storm event.

Table 6: July 3 - 4, 2015 Verification Storm Event Summary

07/03/2015 12:00 AM to 07/04/2015 12:00 AM		
Rain Gage: EM 28454 (Fire Station No. 36)	Cumulative Precipitation (in)	3.41
	Max Incremental Precipitation (in)	0.402
	Date and Time of Precipitation Peak	7/3/15 8:30 AM
Flow Gage: SSG02 (Southland Basin)	Max Incremental Depth of Flow (ft)	1.13
	Date and Time of Flow Depth Peak	7/3/15 8:35 AM

Table 7: August 5 - 6, 2015 Verification Storm Event Summary

08/05/2015 12:00:00 PM to 08/06/2015 12:00:00 PM		
Rain Gage: EM 28454 (Fire Station No. 36)	Cumulative Precipitation (in)	4.00
	Max Incremental Precipitation (in)	0.488
	Date and Time of Precipitation Peak	8/5/15 4:40 PM
Flow Gage: SSG02 (Southland Basin)	Max Incremental Depth of Flow (ft)	1.496
	Date and Time of Flow Depth Peak	8/5/15 4:50 PM

Table 8: September 2 - 3, 2015 Verification Storm Event Summary

09/02/2015 12:00:00 PM to 09/03/2015 12:00:00 PM		
Rain Gage: EM 28453 (Weaver Park)	Cumulative Precipitation (in)	1.27
	Max Incremental Precipitation (in)	0.291
	Date and Time of Precipitation Peak	9/2/2015 4:35 PM & 4:40 PM
Flow Gage: RSG01 (Rochester Basin)	Max Incremental Depth of Flow (ft)	1.35
	Date and Time of Flow Depth Peak	9/2/15 4:45 PM

Table 9: November 17 - 18, 2015 Calibration Storm Event Summary

11/17/2015 12:00:00 PM to 11/18/2015 12:00:00 PM		
Rain Gage: EM 28453 (Weaver Park)	Cumulative Precipitation (in)	4.12
	Max Incremental Precipitation (in)	0.197
	Date and Time of Precipitation Peak	11/17/15 7:50 PM
Flow Gage: RSG01 (Rochester Basin)	Max Incremental Depth of Flow (ft)	1.94
	Date and Time of Flow Depth Peak	11/17/15 8:40 PM - 8:50 PM
Rain Gage: EM 28454 (Fire Station No. 36)	Cumulative Precipitation (in)	3.75
	Max Incremental Precipitation (in)	0.134
	Date and Time of Precipitation Peak	11/17/15 8:30 PM - 8:40 PM
Flow Gage: SSG02 (Southland Basin)	Max Incremental Depth of Flow (ft)	1.09
	Date and Time of Flow Depth Peak	11/17/15 9:45 PM

In addition to the tables above, refer to Graph 1 through Graph 7 in Appendix C for graphical representations of the field measured incremental flow depth data overlaid with the field measured incremental precipitation depth data for each of the selected storm events. These graphs aid in the visualization of the quantity and time to peak of the collected precipitation and flow depth data. The graphs are presented in the following order: 05/24/2015 – 05/25/2015 storm event (Graphs 1-2), 07/03/2015 – 07/04/2015 storm event (Graph 3), 08/05/2015 – 08/06/2015 storm event (Graph 4), 09/02/2015 – 09/03/2015 storm event (Graph 5), 11/17/2015 – 11/18/2015 storm event (Graphs 6-7).

The field measured rainfall data for the selected storm events was utilized as hydrologic time series data and assigned to the model subcatchments for the calibration process. The collected rainfall data for Rain Gage EM28453 was assigned to all of the subcatchments in the Rochester and Red Budd Drainage Basins, and the collected rainfall data for Rain Gage EM28454 was assigned to all of the subcatchments in the Southland and Rosita Drainage Basins. This separation allowed the Rochester and Red Budd calibration parameters to be modified independently from the Southland and Rosita calibration parameters. Exhibit 32 in Appendix A highlights (in yellow) the model subcatchments that were calibrated utilizing the field measured EM28453 rainfall data and RSG01 flow depth data. Exhibit 33 in Appendix A highlights (in yellow) the model subcatchments that were calibrated utilizing the field measured EM28454 rainfall data and SSG02 flow depth data.

4.2 Model Calibration and Verification Process

In an effort to accurately simulate the rainfall-runoff response of the specific basins in the study, the initial parameters input into the model had to be altered through a series of calibration iterations. These calibration iterations were performed utilizing the InfoSWMM SA Calibrator add-on software. Key calibration parameters were identified and grouped for adjustment during the calibration process and minimum and maximum adjustment ranges were established for each individual parameter based on published typical data ranges and the model’s sensitivity to each parameter. Three soil infiltration parameters and five subcatchment parameters were selected for modification during calibration. Table 10 below summarizes the selected model parameters that were modified during the calibration process.

Table 10: Calibrated Model Parameters

Green-Ampt Soil Infiltration Parameters	Suction Head (in)
	Hydraulic Conductivity (in/hr)
	Initial Moisture Deficit
Subcatchment Parameters	Imperviousness (%)
	Width (ft)
	Slope (%)
	Depression Storage for Impervious Portion (in)
	Depression Storage for Pervious Portion (in)

The three soil infiltration parameters were calibrated globally for the entire model and the five subcatchment parameters were calibrated within their respective Rain Gage groups discussed in Section 4.1. The Rochester and Red Budd subcatchment parameters were calibrated together and the Southland and Rosita subcatchment parameters were calibrated together.

The field measured rainfall obtained during the data collection phase of the project was used as the simulation input data for the calibration efforts and the field measured conduit flow depth data was used as the target output data. The Calibrator tool utilized genetic algorithms to optimally adjust all the specified parameters simultaneously to values that resulted in a simulation conduit flow depth curve that most closely matched the specified field measured flow depth curve. Initially, over 30 calibration iterations were performed within the Calibrator tool utilizing three different mathematical convergence methods and a variety of evaluation trials. The three convergence methods utilized during the initial calibration process were the Difference in Total Volume (DTV) Method, the Mean Least Square Error (MLSE) Method, and the R² (R-Square) Method, and each of the convergence calibration iterations were ran for 10-200 evaluation trials. Table 11 below summarizes the equation and goal of each mathematical convergence method utilized in the initial calibration process.

Table 11: Calibration Mathematical Convergence Methods

Difference in Total Volume (DTV)	$\text{Minimize } \left(\sum_{i=1}^N Pobs_i - \sum_{i=1}^N Psim_i \right)$
	Can range from $-\infty$ (poor performance) to ∞ (poor performance) with the ideal value being zero.
Mean Least Square Error (MLSE)	$\text{Minimize } \frac{\sum_{i=1}^N (Pobs_i - Psim_i)^2}{N}$
	Can range from zero (best fit) to ∞ (poor fit).
R ² (R-Square)	$\text{Maximize } \left(\frac{\sum_{i=1}^N (Pobs_i - \bar{Pobs})(Psim_i - \bar{Psim})}{\left[\sum_{i=1}^N (Pobs_i - \bar{Pobs})^2 \right]^{-0.5} \left[\sum_{i=1}^N (Psim_i - \bar{Psim})^2 \right]^{-0.5}} \right)^2$
	Can range from zero (poor fit) to one (best fit).

In the equations above, N designates the total number of measurements available, Pobs_i represents the observed measurement values at time i; Psim_i is the model simulated values at time i; \bar{Pobs} is mean of the measured values; \bar{Psim} is mean of the simulated values.

The Difference in Total Volume convergence method provided the best initial results, and the simulated conduit flow depth curve for the November 17 - 18, 2015 storm event most closely matched the field measured flow depth curve for both the Rochester (RSG01) and Southland (SSG02) stage gage data. Due to this outcome, the November 17 - 18, 2015 storm event was selected as the primary calibration event for the fine-tuning process, and the other four storm events were utilized as verification storm events. After the initial calibration efforts through the Calibrator tool were completed, specific parameters were selected and fine-tuned via manual adjustment to finalize the model calibration process. Table 12 summarizes the net change between the base parameter values and final calibrated parameter values.

Table 12: Net Change Between Base Parameters and Final Calibrated Parameters

Green-Ampt Suction Head (in)	Base values reduced 32.3%
Green-Ampt Hydraulic Conductivity (in/hr)	Base values increased 190%
Green-Ampt Initial Moisture Deficit	Base values increased 179%
Subcatchment Imperviousness (%)	EM28453 Subcatchments: Base values reduced 62.4% EM28454 Subcatchments: Base values reduced 75.4%
Subcatchment Width (ft)	EM28453 Subcatchments: Base values reduced 32.8% EM28454 Subcatchments: Base values increased 15.5%
Subcatchment Slope (%)	EM28453 Subcatchments: Base values reduced 28.8% EM28454 Subcatchments: Base values reduced 73.7%
Subcatchment Depression Storage for Impervious Portion (in)	EM28453 Subcatchments: Base values reduced 3.3% EM28454 Subcatchments: Base values increased 998.3%
Subcatchment Depression Storage for Pervious Portion (in)	EM28453 Subcatchments: Base values increased 1336.4% EM28454 Subcatchments: Base values increased 1155.3%

In addition to the table above, refer to Figures 5-7 in Appendix B. Figure 5 summarizes, in table format, the final calibrated model subcatchment parameters. Figure 6 compares, in table format, the base vs. final calibrated subcatchment parameters. Figure 7 compares, in table format, the base vs. final calibrated soil infiltration parameters. Referencing Figure 6, the subcatchment width for subcatchment SUB-101 is 70.49 feet in the final calibrated dataset and 104.91 feet in the base pre-calibrated dataset. This results in a calibrated over base parameter multiplier of $(70.49 \text{ feet} / 104.91 \text{ feet}) = 0.672$, i.e., 67.2%. This implies that the base pre-calibrated parameter is reduced by $100\% - 67.2\% = 32.8\%$ of the base value to equal the final calibrated subcatchment width parameter. This methodology was utilized to calculate the percentages listed in Table 12.

The final simulated conduit flow depth curve for the November 17 - 18, 2015 storm event closely matches the relative shape, peak timing, peak quantity, and fluctuations of the field measured flow depth curve for both the Rochester (RSG01) and Southland (SSG02) stage gage data. The simulated results for the Rochester stage gage rise a little earlier than the measured data at the beginning of the storm, fall at a slightly slower rate than the measured data at the end of the storm, and reach a peak depth of approximately 0.5 inches greater than the field measured flow depth data. The simulated results for the Southland stage gage rise a little later than the measured data at the beginning of the storm, fall at a slightly slower rate than the measured data at the end of the storm, and reach a peak depth of approximately 1 inch less than the field measured flow depth data.

Refer to Graph 8 through Graph 14 in Appendix C for graphical representations of the field measured flow depth data overlaid with the simulated flow depth data for the calibration and verification storm events. The graphs are presented in the following order: 11/17/2015 – 11/18/2015 calibration storm event (Graphs 8-9), 05/24/2015 – 05/25/2015 verification storm event (Graphs 10-11), 07/03/2015 – 07/04/2015 verification storm event (Graph 12), 08/05/2015 – 08/06/2015 verification storm event (Graph 13), 09/02/2015 – 09/03/2015 verification storm event (Graph 14). The simulated results for the verification storm events matched the relative shape of the measured flow depth data for each storm event, but they did not align as closely with the measured peak values as the November calibration storm event.

5.0 EXISTING CONDITIONS MODEL RESULTS

Once the model parameters were calibrated so that the model simulation results fit the shape, timing, and peak of the observed data to the maximum extent practicable, frequency rainfall data was entered into the model. The NRCS (SCS) Type II 24-hour storm precipitation distribution was utilized to develop frequency rainfall data for use in the InfoSWMM model. The rainfall depths used in the model for the 2-year through 100-year return period storm events were taken directly from Table 2-2 of Volume 2 of the City of Memphis/ Shelby County Stormwater Management (SWM) Manual and are summarized in Table 13 below:

Table 13: NRCS (SCS) 24-Hour Rainfall Depths

Annual Recurrence Interval (ARI)	Duration	Rainfall Depth (in)
2-year	24-hours	4.01
5-year	24-hours	4.89
10-year	24-hours	5.58
25-year	24-hours	6.52
50-year	24-hours	7.27
100-year	24-hours	8.02

Hydrologic time series data was created from the NRCS Type II 24-hour storm precipitation distribution data for the storm events list above. The created time series data was assigned to model rain gage elements, which were then assigned to model subcatchments as rainfall input when simulating specific design storm events. Even though the 2-year through 100-year return period storm events were simulated in the calibrated model, the analysis of the existing conditions model focused primarily on the 10-year return period storm event and secondarily on the 100-year return period storm event.

One of the primary purposes for developing the H&H model for the basins included in the Southland Drainage Study was for the identification and verification of areas experiencing repetitive flooding problems. This process included mapping the maximum hydraulic grade line (HGL) elevations simulated in the model across the DEM for various storm events and analyzing the quantity and severity of the mapped flooding throughout the basins in the study area. Though this process provides an estimate of the quantity of surface flooding, it also should be noted that unrealistic flooding can occur in specific circumstances. One example of this is where the capacity of a conduit is exceeded and the excess water ponds atop the upstream junction rim elevation within the defined surface area. This defined surface area is a vertical cylinder of water, so the maximum HGL value simulated in areas where this occurs is dependent upon the ponded surface area defined by the modeler. Another example of this is where conduits and junctions are located adjacent to hillsides that extend to surface elevations lower than the elevations of the modeled conduit and junction elements. In these situations, unrealistic inundation can potentially occur in the areas lower than the elevations of the adjacent modeled conduits and junctions.

The mapped inundation was compared to any reports of known flooding collected during the public meeting in addition to flooding reports provided by the City of Memphis. The City of Memphis Public Works Drain Maintenance Department aided our efforts by collecting flooding and drainage-related maintenance reports and compiling a running list of the reports in the form of a GIS point file. Areas where observed flooding reports and modeled inundation overlapped were identified for further evaluation. Exhibit 34 through Exhibit 41 in Appendix A display the mapped inundation results for the 10-year and 100-year storm simulations, the City of Memphis flooding and drainage-related maintenance reports, and the location of the identified improvement alternative areas in each of the individual basins. The individual basins are presented west to east in the following order: Rochester Basin (Exhibits 34-35), Red Budd Basin (Exhibits 36-37), Southland Basin (Exhibits 38-39), and Rosita Basin (Exhibits 40-41).

6.0 IMPROVEMENT ALTERNATIVES ANALYSIS & COST ESTIMATE

During the process of cross-referencing the known flooding reports and modeled inundation results eight areas were identified for proposed improvements. These identified areas were presented to the City of Memphis on 06/17/2022 and the decision was made to move forward with modeling improvement alternatives for five of the eight identified areas. Improvement alternatives were not modeled for alternatives five, six, and seven, but explanations for all eight of the identified areas are included in the sections below. Exhibit 42 in Appendix A displays the locations of the identified improvement alternative areas and the City of Memphis flooding and drainage-related maintenance reports throughout the four modeled drainage basins.

6.1 Improvement Alternative 1: IA1

Improvement alternative one was located in the Rochester basin at and northwest of the intersection of West Peebles Road and Travis Road. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout two private property parcels. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 43 in Appendix A outlines the proposed improvements within the identified area. Exhibit 44 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 45 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.1.1 Parcels Experiencing Flooding: IA1

- 075001 00065
 - The existing conditions 10-year inundation covers approximately 12% of the parcel at an inundation depth of 0.01'-1.0' and 1% of the parcel at an inundation depth of 1.0'-2.0'.
 - There are no buildings or other infrastructure features located on this property.
 - In the post-improvement conditions, the 10-year inundation within the property is reduced to a footprint of approximately 1% of the parcel at an inundation depth of 0.01' – 0.5'.

- 075001 00064
 - The existing conditions 10-year inundation covers approximately 5% of the parcel at an inundation depth of 0.01'-1.0' and 7% of the parcel at an inundation depth of 1.0'-3.0'.
 - There are no buildings located on this property.
 - Hardaway's Body Shop has a grassed fenced in area on this property.
 - In the post-improvement conditions, the 10-year inundation within the property is reduced to a footprint of approximately 5% of the parcel at an inundation depth of 0.01' – 1.0' and 1% of the parcel at an inundation depth of 1.0'-2.0'. This inundation is isolated to the open channel in the northwest corner of the parcel.

6.1.2 Proposed Improvements and Cost Estimate: IA1

The proposed improvements for this area included a series of channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available subsurface pipe storage volume.

- Closed Conduit 435-434: Remove existing 217 LF 36" reinforced concrete pipe (RCP) pipe at 0.45% and connected drainage structures and replace with 217 LF of 48" RCP pipe at 0.63% with larger drainage structures. This improvement results in a conduit capacity increase from 45 cfs to 123 cfs.

- Closed Conduit 433-434: Remove existing 30 LF 24” RCP pipe at 4.88% and connected drainage structures and replace with 30 LF of 36” RCP pipe at 1.01% with larger drainage structures. This improvement results in a conduit capacity increase from 50 cfs to 73 cfs.
- Closed Conduit 434-432: Remove 178 LF 48” RCP pipe at 0.31% and connected drainage structures and replace with 178LF of 48” RCP pipe at 0.62% with larger drainage structures. This improvement results in a conduit capacity increase from 79 cfs to 123 cfs.
- Open Channel Conduit 432-11790: Regrade 59 LF 1.59’ depth triangular grass-lined open channel at 2.90% with a new grass-lined trapezoidal channel at 0.62%. Lower the upstream elevation by 0.95’ and tie into the existing downstream elevation. The new grass-lined channel dimensions are as follows: 5.33’ bottom width, 3.4’ depth, 2.5:1 side slopes. This improvement results in a conduit capacity increase from 55 cfs to 290 cfs.

Additional improvements outside of the project modeling scope were recommended for this area. These additional improvements include the following:

- Remove existing 34 LF 15” RCP pipe and replace with 34 LF of 24” RCP pipe.

The preliminary anticipated cost for these improvements is estimated to be approximately \$492,038. Figure 8 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative one.

6.1.3 GIS Flooding and Drainage-Related Maintenance Reports: IA1

Six flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 14 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative one.

Table 14: Flooding and Drainage-Related Maintenance Reports Surrounding IA1

Street	Date Notified	Report Detail	Action Detail	Service Request Number
PEEBLES & PARKER	2/20/2014	INLET		2347313
PEEBLES & TRAVIS	10/21/2015	62-E. Drain at Peebles and Travis clogged with mud	No water standing. Cleaned 2 inlets and hauled debris. All open and flowing	2355329
583 PEEBLES	4/10/2019	Drain clogged with debris request to clear	Removed debris from 1 inlet and hauled to DM Yard. All pipes open and flowing and all maintenance complete.	4176812

3018 PARKER Rd	2/5/2020	Inspect all inlets on Map Pg 62E. Record all inlets inspected, and service any inlets as needed.	Removed debris from 8 of 14 inlets on this GRID and hauled to DM Yard. All pipes open and flowing and all maintenance complete.	4531846
583 PEBBLES	4/15/2011	DRAINS NEED CLEANING STREET FLOODED.		2334215
3037 Travis Rd	3/3/2016	Cavity & drain is leaking close to 3037 Travis Rd	No cavity in street. Cavity is in yard on top of sewer line. NOT A DM ISSUE, this is private property. owner notified.	2357272

6.2 Improvement Alternative 2: IA2

Improvement alternative two was located in the Rochester basin and was split into two sub-areas, 2A and 2B.

6.2.1 Improvement Alternative IA2A

Improvement alternative 2A was located along an existing property easement spanning from Dixie Road to Flynn Road west of Alta Road. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding along public right-of-way (ROW) and three private property parcels. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 46 in Appendix A outlines the proposed improvements within the identified area. Exhibit 47 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 48 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.2.1.1 ROW Experiencing Flooding: IA2A

- Along Dixie Road at the roadway sag between Alta Road and Ford Road.
 - The existing conditions 10-year inundation spans the width of the roadway and right-of-way and extends into an easement on the northern side of Dixie Road at an inundation depth of 0.01’ -1.0’. The total area coverage of this inundation is approximately 3,550 square feet.
 - In the post-improvement conditions, the 10-year inundation within the roadway, right-of-way, and easements is eliminated completely.

6.2.1.2 Parcels Experiencing Flooding: IA2A

- 075016 00006
 - The existing conditions 10-year inundation covers approximately 2% of the parcel’s northeast corner at an inundation depth of 0.01’ -1.0’.
 - There are no buildings or other infrastructure features located on this property.

- In the post-improvement conditions, the 10-year inundation within the property is eliminated completely.
- 075016 00007
 - The existing conditions 10-year inundation covers approximately 3% of the parcel's northwest corner at an inundation depth of 0.01'-0.5'.
 - There is a home with a concrete driveway located on this property.
 - The existing conditions 10-year inundation extends into the footprint of the driveway.
 - In the post-improvement conditions, the 10-year inundation within the property is eliminated completely.
- 075015 00013
 - The existing conditions 10-year inundation covers approximately 20% of the parcel's southern side at an inundation depth of 0.01'-1.0'.
 - There is a concrete driveway and concrete pad located on this property.
 - The existing conditions 10-year inundation extends into the footprint of the concrete driveway and concrete pad.
 - In the post-improvement conditions, the 10-year inundation within the property is eliminated completely.

6.2.1.3 Proposed Improvements and Cost Estimate: IA2A

The proposed improvements for this area included a series of channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available subsurface pipe storage volume.

- Closed Conduit 465-464: Remove existing 10 LF (42" RCP equivalent) 53" x 34" horizontal elliptical reinforced concrete pipe (HERCP) at -4.52% and connected drainage structures and replace with 10 LF of (48" RCP equivalent) 60" x 38" HERCP pipe at 0.88% with larger drainage structures. This improvement results in a conduit capacity increase from adverse slope to 133 cfs.
- Closed Conduit 464-463: Remove existing 32 LF (42" RCP equivalent) 53" x 34" HERCP pipe at 0.74% and connected drainage structures and replace with 32 LF of (48" RCP equivalent) 60" x 38" HERCP pipe at 0.88% with larger drainage structures. This improvement results in a conduit capacity increase from 91 cfs to 133 cfs.
- Closed Conduit 463-462: Remove existing 18 LF (42" RCP equivalent) 53" x 34" HERCP pipe at 5.86% and connected drainage structures and replace with 18 LF of (54" RCP equivalent) 68" x 43" HERCP pipe at 0.88% with larger drainage structures. This improvement results in a conduit capacity decrease from 256 cfs to 186 cfs, but the maximum flow rate through this conduit simulated during the existing and post-improvement conditions was 144 cfs. Therefore, the decrease in capacity in this segment is justifiable considering the overall capacity increase throughout the connected network.

- Closed Conduit 470-469: Remove existing 38 LF 24” RCP pipe at 2.33% and connected drainage structures and replace with 38 LF of (36” RCP equivalent) 45” x 29” HERCP pipe at 0.75% with larger drainage structures. This improvement results in a conduit capacity increase from 35 cfs to 60 cfs.
- Closed Conduit 469-463: Remove existing 115 LF 24” RCP pipe at 2.01% and connected drainage structures and replace with 115 LF of (36” RCP equivalent) 45” x 29” HERCP pipe at 0.75% with larger drainage structures. This improvement results in a conduit capacity increase from 32 cfs to 60 cfs.
- Closed Conduit 462-467: Remove existing 105 LF 48” RCP pipe at -2.22% and connected drainage structures and replace with 105 LF of (54” RCP equivalent) 68” x 43” HERCP pipe at 0.88% with larger drainage structures. This improvement results in a conduit capacity increase from adverse slope to 185 cfs.
- Closed Conduit 467-468: Remove existing 148 LF 48” RCP pipe at 2.83% and connected drainage structures and replace with 148 LF of (54” RCP equivalent) 68” x 43” HERCP pipe at 0.88% with larger drainage structures. This improvement results in a conduit capacity decrease from 242 cfs to 185 cfs., but the maximum flow rate through this conduit simulated during the existing and post-improvement conditions was 143 cfs. Therefore, the decrease in capacity in this segment is justifiable considering the overall capacity increase throughout the connected network.
- Closed Conduit 468-461: Remove existing 126 LF 48” RCP pipe at 0.83% and connected drainage structures and replace with 126 LF of (54” RCP equivalent) 68” x 43” HERCP pipe at 0.88% with larger drainage structures. This improvement results in a conduit capacity increase from 131 cfs to 185 cfs.
- Closed Conduit 461-460: Remove existing 10 LF 48” RCP pipe at 3.34% and connected drainage structures and replace with 10 LF of (60” RCP equivalent) 73” x 45” reinforced concrete arch pipe (RCAP) at 0.88% with larger drainage structures. This improvement results in a conduit capacity decrease from 263 cfs to 208 cfs, but the maximum flow rate through this conduit simulated during the existing and post-improvement conditions was 143 cfs. Therefore, the decrease in capacity in this segment is justifiable considering the overall capacity increase throughout the connected network.
- Closed Conduit 460-459: Reset or Remove (based on field conditions) existing 31 LF (60” RCP equivalent) 73” x 45” RCAP pipe at 0.50% and connected drainage structures and replace with 31 LF of (60” RCP equivalent) 73” x 45” RCAP pipe at 0.87% with larger drainage structures. This improvement results in a conduit capacity increase from 156 cfs to 207 cfs.

The preliminary anticipated cost for these improvements is estimated to be approximately \$881,175. Figure 9 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative 2A.

6.2.1.4 GIS Flooding and Drainage-Related Maintenance Reports: IA2A

Eight flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 15 below summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative 2A.

Table 15: Flooding and Drainage-Related Maintenance Reports Surrounding IA2A

Street	Date Notified	Report Detail	Action Detail	Service Request Number
451 FLYNN	5/1/2010	FLOODED STREET	Clean	2329290
477 DIXIE RD	5/2/2019	Clean Inlet	Cleaned inlets inspected	4216856
3099 FORD RD	1/16/2019	Inspect all inlets on Map Pg 62J.Record all inlets inspected, and service any inlets as needed.	Cleaned 45 inlets and hauled debris. Inspected 91 Pipes and inlets clear, water can flow.	4081474
3099 Ford Rd	1/31/2020	Inspect all inlets on Map Pg 62J.Record all inlets inspected, and service any inlets as needed.	Cleaned INLET	4526748
477 Dixie Rd	5/3/2019	After heavy rains back yard floods check inlets	Duplicate of 4216856	4216872
3099 FORD	5/17/2002	Drain stopped up street flooded.		227800
451 Flynn Rd	8/7/2018	Replace inlet grate close to 451 Flynn Rd	Replaced missing grate	3888862
433 Dixie Rd	4/13/2020	Sinkholes in yard/yard is sinking - 433 Dixie Rd	Cut out street 9X6. Loaded debris on DM3194 and hauled 1 load. Stabilized cavity with 3 yards of AR-1 and packed. Repaired 1st joint in 2 pipes as well as the inlet walls. No other leaks detected.	4608334

6.2.2 Improvement Alternative IA2B

Improvement alternative 2B was located east of the intersection of West Peebles Road and Alta Road at a roadway sag on West Peebles Road. Based on the mapped inundation results for the 10-year storm simulation the area didn't experience surface flooding, but it did experience surface flooding along public right-of-way (ROW) during the 100-year storm simulation. Therefore, we don't recommend this as a primary improvement, but we do recommend it as a secondary improvement. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 49 in Appendix A outlines the proposed secondary improvements within the identified area. Exhibit 50 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 51 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.2.2.1 ROW Experiencing Flooding: IA2B

- Along West Peebles Road at the roadway sag between Alta Road and Rochester Road.
 - This area didn't experience surface flooding during the existing conditions 10-year storm simulation.
 - The existing conditions 100-year inundation covers an isolated area of the roadway at an inundation depth of 0.01' - 0.5'. The total area coverage of this inundation is approximately 650 square feet.
 - In the post-improvement conditions, the 100-year inundation within the roadway is eliminated completely.

6.2.2.2 Proposed Improvements and Cost Estimate: IA2B

The proposed improvements for this area included channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available subsurface pipe storage volume.

- Closed Conduit 387A-387: Remove existing 60 LF 24" RCP pipe at 0.50% and connected drainage structures and replace with 60 LF of (36" RCP equivalent) 45" x 29" HERCP pipe at 0.90% with larger drainage structures. This improvement results in a conduit capacity increase from 16 cfs to 66 cfs.

Additional improvements outside of the project modeling scope were recommended for this area. These additional improvements include the following:

- Remove existing 25 LF assumed 15" RCP pipe and replace with 25 LF of (24" RCP Eq.) 30" x 19" HERCP pipe.
- Remove existing 25 LF assumed 15" RCP pipe and replace with 25 LF of (24" RCP Eq.) 30" x 19" HERCP pipe.

The preliminary anticipated cost for these improvements is estimated to be approximately \$175,560. Figure 10 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative 2B.

6.2.2.3 GIS Flooding and Drainage-Related Maintenance Reports: IA2B

Six flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 16 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative 2B.

Table 16: Flooding and Drainage-Related Maintenance Reports Surrounding IA2B

Street	Date Notified	Report Detail	Action Detail	Service Request Number
345 W. Peebles Rd	7/6/2016	Metal plate has shifted in front of 345 W. Peebles (Emanuel Temple COGIC) & Rochester	Used Cat 336 to rotate plate and make sure cavity in the street was properly secured. Cavity secured; street is safe.	2359328
363 PEEBLES	12/7/1998	Drain stopped up street flooded.	Clean	212116
392 W PEEBLES RD	6/7/2016	Rev. Walter White who lives at 392 W Peebles Rd. contacted us about this ditch that's on the east side of his home. Please see if city drain maintenance can spray/cut this overgrowth. W067062-060316	Cleaned concrete ditch and hauled debris.	2358965
335 PEEBLES	5/17/2002	Drain stopped up street flooded.	Clean	227801
392 PEEBLES RD	8/14/2019	See 4344884 Drainage ditch on the side of the home has overgrowth and needs to be cut and cleaned	Cleaned concrete ditch, cut overhang as far as needed using trimmer, polesaw, weed eaters.	4351676
392 PEEBLES RD	8/8/2019	Drainage ditch on the side of the home has overgrowth and needs to be cut and cleaned	cleaned ditch cut overhanging ghoul debris	4344884

6.3 Improvement Alternative 3: IA3

Improvement alternative three was located in the Rochester basin at the intersection of Jensen Road and Rochester Road. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding along public right-of-way (ROW) exclusively. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 52 in Appendix A outlines the proposed improvements within the identified area. Exhibit 53 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 54 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.3.1 ROW Experiencing Flooding: IA3

- At the intersection of Rochester Road and Jensen Road.
 - The existing conditions 10-year inundation covers an isolated area of the roadway at an inundation depth of 0.01' - 0.5'. The total area coverage of this inundation is approximately 50 square feet.
 - In the post-improvement conditions, the 10-year inundation within the roadway is eliminated completely.

6.3.2 Proposed Improvements and Cost Estimate: IA3

The proposed improvements for this area included a series of channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available subsurface pipe storage volume.

- Closed Conduit 521A-16769: Remove existing 480 LF 30" RCP pipe at 0.73% and connected drainage structures and replace with 480 LF of 36" RCP pipe at 0.66% with larger drainage structures. This improvement results in a conduit capacity increase from 35 cfs to 54 cfs.
- Closed Conduit 16769-341: Remove existing 160 LF 24" RCP pipe at 1.70% and connected drainage structures and replace with 160 LF of 42" RCP pipe at 0.71% with larger drainage structures. This improvement results in a conduit capacity increase from 29 cfs to 85 cfs.

Additional improvements outside of the project modeling scope were recommended for this area. These additional improvements include the following:

- Remove existing 31 LF 15" RCP pipe and replace with 31 LF of 24" RCP pipe.
- Remove existing 48 LF 24" RCP pipe and replace with 48 LF of 36" RCP pipe.

The preliminary anticipated cost for these improvements is estimated to be approximately \$557,273. Figure 11 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative three.

6.3.3 GIS Flooding and Drainage-Related Maintenance Reports: IA3

Nine flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 17 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative three.

Table 17: Flooding and Drainage-Related Maintenance Reports Surrounding IA3

Street	Date Notified	Report Detail	Action Detail	Service Request Number
3381 ROCHESTER	10/25/2002	Backyard floods when it rains.		230784
3343 ROCHESTER RD	8/23/2019	Request to clean drains in area full of debris	Cleaned inlets haul debris	4366058
3342 ROCHESTER RD	8/8/2019	DRAIN INLETS NEEDS TO BE CEANED OUT ON ROCHESTER RD	Removed debris from 3 inlets an hauled to DM Yard. All pipes open an flowing and all maintenance complete.	4344714
3316 ROCHESTER	7/11/2006	OPEN DRAIN IN BACKYARD NEED TO BE CLOSED OPEN THROAT DRAIN CAN NOT BE CLOSED-- WILL FLOOD PROPERTY	Site check	248017
3343 ROCHESTER RD	1/13/2021	Request for both sides of the entire street sweeping and cleaning on 3343 Rochester Rd	Preventative Manintenance	5037160
3381 ROCHESTER	9/23/2002	Water from Alta Rd. Floods the back of properties on Rochester every time it rains.	Property	229885
3343 ROCHESTER RD	4/7/2021	Asphalt around metal grate is missing and needs to be replaced	Repaired inlet at this location. No other drainage problems found.	5167022
3343 ROCHESTER RD	3/19/2019	2 Drains on the corner of 3343 Rochester Rd., needs cleaning out (full of debris)	Cleaned 3 inlets and hauled debris. Pipes and inlets clear, water can flow.	4142714
3381 ROCHESTER	10/28/1996	HOUSE FLOODED		200623

6.4 Improvement Alternative 4: IA4

Improvement alternative four was located in the Red Budd basin at the intersection of West Brooks Road and New Horn Lake Road. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout two private property parcels. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 55 in Appendix A outlines the proposed improvements within the identified area. Exhibit 56 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 57 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.4.1 Parcels Experiencing Flooding: IA4

- 075007 00025C
 - The existing conditions 10-year inundation covers approximately 2% of the parcel's eastern side at an inundation depth of 0.01'-0.5'.
 - There is a home, a concrete driveway, and a concrete pad located on this property.
 - The existing conditions 10-year inundation extends into the footprint of the concrete pad.
 - In the post-improvement conditions, the 10-year inundation within the property is eliminated completely.

- 075007 00049
 - The existing conditions 10-year inundation covers approximately 24% of the parcel at an inundation depth of 0.01'-2.0'.
 - There is a home, an asphalt access driveway running the length of the property, and a concrete pad located on this property.
 - The existing conditions 10-year inundation covers approximately 50 feet of the asphalt access driveway, half of the footprint of the concrete pad, and 80% of the footprint of the home.
 - In the post-improvement conditions, the 10-year inundation within the property is eliminated completely.

6.4.2 Proposed Improvements and Cost Estimate: IA4

The proposed improvements for this area included a series of channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available subsurface pipe storage volume.

- Closed Conduit 258-261: Remove existing 51 LF 24" RCP pipe at 3.34% and connected drainage structures and replace with 51 LF of (36" RCP equivalent) 45" x 29" HERCP pipe at 3.34% with larger drainage structures. This improvement results in a conduit capacity increase from 41 cfs to 127 cfs.

- Closed Conduit 261-262: Remove existing 207 LF 24” RCP pipe at 3.44% and connected drainage structures and replace with 207 LF of (36” RCP equivalent) 45” x 29” HERCP pipe at 3.44% with larger drainage structures. This improvement results in a conduit capacity increase from 42 cfs to 128 cfs.
- Closed Conduit 262-115: Remove existing 110 LF 24” RCP pipe at 5.85% and connected drainage structures and replace with 110 LF of (36” RCP equivalent) 45” x 29” HERCP pipe at 5.85% with larger drainage structures. This improvement results in a conduit capacity increase from 55 cfs to 167 cfs.

Additional improvements outside of the project modeling scope were recommended for this area. These additional improvements include the following:

- Remove existing 47 LF 18” RCP pipe and replace with 47 LF of (24” RCP Eq.) 30” x 19” HERCP pipe.
- Remove existing 72 LF 18” RCP pipe and replace with 72 LF of (24” RCP Eq.) 30” x 19” HERCP pipe.
- Remove existing 64 LF 18” RCP pipe and replace with 64 LF of (24” RCP Eq.) 30” x 19” HERCP pipe.

The preliminary anticipated cost for these improvements is estimated to be approximately \$594,488. Figure 12 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative four.

6.4.3 GIS Flooding and Drainage-Related Maintenance Reports: IA4

Seven flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 18 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative four.

Table 18: Flooding and Drainage-Related Maintenance Reports Surrounding IA4

Street	Date Notified	Report Detail	Action Detail	Service Request Number
BROOKS	5/31/2015	Street flooding -- W Brooks Rd & Horn Lake Rd from MPD	Cleaned 7 inlets and hauled debris	2353353
NEW HORN LAKE RD	8/30/2018	Inspect all inlets on Map Pg 62K. Record all inlets inspected, and service any inlets as needed. Record any needed maintenance on back of ticket.	Cleaned 26 inlets inspected 58. Hauled debris, Drains open and flowing. All maintenance performed	3923432
BROOKS RD	5/4/2021		Cleaned inlet	5251206
NEW HORN LAKE RD	1/14/2020	Inspect all inlets on Map Pg 62K. Record all inlets inspected, and service any inlets as needed on back.	Removed debris from 23 of 46 inlets on this GRID and hauled to DM Yard. All pipes open and flowing and all maintenance complete.	4511844
W BROOKS RD	2/11/2020	Inspect all inlets on Map Pg 62K. Record any needed maintenance on back of ticket.	Cleaned inlets on this grid and hauled away the debris to the dm dump yard pipes are open and flowing	4536406
REDBUD	5/28/2015	Redbud Rd & W Brooks Rd - clean concrete channel lining &	REFERRED TO OWNER, NOT A DM ISSUE	2353321
BROOKS	6/2/2015	Repair 672	Replaced new long 672 -- 2 anchors welded on site & relayed back inlet wall.	2353561

6.5 Improvement Alternative 5: IA5

Improvement alternative five was located in the Red Budd basin northwest of the East Peebles Road and Blues Highway (US-61) intersection. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout 7 private property parcels. During the 06/17/2022 meeting with the City of Memphis it was mentioned that there was an active design project currently underway in the area. The 284 LF 36” HDPE pipe from 16782 to 677 (beneath Hall Feed & Supply) collapsed and was causing drainage and flooding issues in the area. The ongoing design project will correct the flooding in this area by upsizing the collapsed 36” HDPE pipe and adding additional pipes and inlets connected to the western leg of the pipe network extending to E. Peebles Road. We were directed to leave the area as-is in the model and no improvements were modeled. The existing conditions flooding details are summarized below followed by a summary of the surrounding maintenance reports. Exhibit 58 in Appendix A displays the extent of the existing inundation results for the 10-year recurrence interval storm event. Exhibit 59 in Appendix A displays the extent of the existing inundation results for the 100-year recurrence interval storm event.

6.5.1 Parcels Experiencing Flooding: IA5

- 075002 00008C
 - Hall Feed & Supply is located on this property. This business has the following infrastructure features located on the property: concrete parking area, two buildings, numerous vehicles and tractor trailers, and a fence surrounding the property.
 - The existing conditions 10-year inundation extends through a portion of the footprint of one of the buildings, through the area where the tractor trailers are located, and through a portion of the fence.

- 050125 00005C
 - Rest Inn is located on this property. This business has the following infrastructure features located on the property: concrete parking area, two buildings, and a fence surrounding the property.
 - The existing conditions 10-year inundation extends through a portion of the footprint of the concrete parking area, and through a portion of the fence.

- 075002 00007
 - There is a home with an asphalt driveway located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.

- 075002 00006
 - There is a home, gravel driveway, fenced in area, and metal cargo container located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.

- 050125 00004
 - Smith Imports is located on this property. This business has the following infrastructure features located on the property: concrete parking area, asphalt parking area, one building, and a fence.
 - The existing conditions 10-year inundation extends through a portion of the footprint of the concrete parking area.

- 050125 00003
 - Smith Imports is located on this property. This business has the following infrastructure features located on the property: concrete parking area, asphalt parking area, two buildings, and a fence surrounding the property.
 - The existing conditions 10-year inundation extends through a portion of the footprint of the concrete parking area.

- 050125 00002
 - Subway is located on this property. This business has the following infrastructure features located on the property: gravel parking area, asphalt parking area, one building, and a fence surrounding a portion of the property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property

6.5.2 GIS Flooding and Drainage-Related Maintenance Reports: IA5

Thirty-eight flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 19 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative five.

Table 19: Flooding and Drainage-Related Maintenance Reports Surrounding IA5

Street	Date Notified	Report Detail	Action Detail	Service Request Number
	4/29/2014	FLOODING-STREET	Clean	0
E PEEBLES RD	5/12/2021	Stormwater Flooding	No drain problem private 48" pipelines ADS was installed by property owner on private property.	5252878
HIGHWAY 61	10/11/2019	Clean Inlet	Flooding concern is private and the responsibility of the property owner.	4424118
HIGHWAY 61	3/29/2018	Flooding -- 124 E Peebles Rd,	Refer to Construction inspection** Televised 48" before it changes size and material to A 36" ADS. 48" ADS @8ft there a 18" ADS tapped on side of ADS were drain have collapsed. 774 HE cleaned 15" RCP, televised 31 ft before running into standing water.	3671988
S THIRD ST	4/28/2017	Clean inlets close to Eastman Rd & S 3rd St of debris, etc.	Check 6 inlets cleared 2 and hauled the debris. Other 2 inlets were covered due to construction Pipe and inlets clear water can flow.	3221596

E PEBBLES RD	4/3/2019	Inspect all inlets on Map Pg 62G. Record all inlets inspected, and service any inlets as needed.	Cleaned inlets and hauled away the debris pipes are open and flowing and we also recorded the ones there where serviced and the ones that we inspected	4167052
PEEBLES	5/12/2021	Storm drain needs interior cleaning in front of feed store	No drain problem, private pipelines on private property is property owner responsibility to maintain.	5252894
	3/15/2016	Drains on eastman at gas station holding water probable blockage in pipe	cleaned 2 inlets and hauled debris, all are open and flowing	2357680
S THIRD ST	10/9/2018	CAVITY IN STREET IN FRONT OF ADDRESS, LEAKING WATER	SR on State route	3981104
THIRD	4/1/2008	FLOODED BUILDING		254353
Peebles	8/5/2015	Street Flooding -- E Peebles Rd & S 3rd St	water standing on arrival. cleaned 10 inlets and checked 10 inlets. all debris hauled to yard. open and flowing on departure. Used vac truck	2354427
MEADOWBROOK	1/8/2003	Flooding at the end of her street in wooded area where the culverts are overflowing.	Clean	231661
PEEBLES	3/27/2009	FLOODS UNDER HOUSE, YARD FOR 3 YEARS	Clean	2322793
PEEBLES	5/6/2009	FLOODED STREET AND SINK HOLES	Clean	2323450
PEEBLES	5/6/2009	FLOODED-STREET/SR#294314	Clean	2323470
PEEBLES	6/26/2014	DRAINAGE NEED CLEANING OUT -	Clean	2349137
HIGHWAY 61	9/6/2017	Clean all inlets in the intersection of E Peebles Rd btwn S 3rd St & Meadowbrook (especially @ 124 E. Peebles/water standing) of debris, etc.	Cleaned 4 inlets and hauled debris from location, drains open and running, no water standing.	3428106
EASTMAN	4/29/2014	clean drain		2348257
E PEBBLES RD	8/9/2019	Wash the line @ 137 E. Peebles	Cleaned 1 inlet and hauled debris. Pipes and inlets clear, water can flow.	4346352

S US HIGHWAY 61	1/29/2018	A cavity at 3070 S. Third has been dye tested and is getting into the drain per Env. Maintenance	Refer to 3564546	3592840
PEEBLES	6/5/2014	62-G, L- Metal grate is missing at Meadowbrook Rd at the intersection of East Peebles alongside St. Cecilia Catholic Church (28 E. Peebles, 38109).	Replace	2348788
HIGHWAY 61	10/5/2016	STREET FLOODING	cleaned 4 inlets and hauled debris to yard. open and flowing on departure	2980460
HIGHWAY 61	10/11/2019	There is flooding in this area due to clogged inlet.	Site checked flooded street. Flooded caused at location is the responsibility of property owner.	4424136
	12/29/2015	rim needs to be reset. barricade on site	chipped away old concrete, reset anchors, replaced 672, rim + grates, and sealed with cement.	2356396
PEEBLES	4/3/2008	YARD FLOODED		254450
THIRD	8/27/2014	Grate	Removed broken rim and rebuilt inlet wall assist by Lonnie Smith.	2350175
S US HIGHWAY 61	5/3/2021	Water Standing in Road	SITE CHECKED NO ACTION REQUIRED	5236528
EASTMAN	12/19/2002	Drain stopped up. Flooded.		231436
E PEEBLES RD	2/28/2018	Clean all inlets - 137 E Peebles Rd	Cleaned 2 inlets and hauled debris. Pipes and inlets clear, water can flow.	3629784
	3/14/2016	Clean inlets on Eastman Rd & S 3rd St (east side)	cleaned 1 inlets and hauled debris, all are open and flowing	2357655
S US HIGHWAY 61	12/23/2017	cave in **F/W TO DRAIN MAINT - Dye test positive for drain**	Repaired large cavity under sidewalk with Flow or Fill and stabilized and dirt on top over culvert .	3564546
PEEBLES	3/6/2018	Drain Flooding--This is more than a stopped drain. It floods w even slightest rain and stays	Cleaned 2 inlets and hauled debris. Pipes are open water can flow no blockage.	3637374

		flooded for days afterword.		
S US HIGHWAY 61	3/23/2018	Sidewalk has fallen in again.	Repaired large cavity at culvert and driveway apron , Repair sidewalk.	3663714
PEEBLES	6/19/2017	Clogged inlets near 124 Peebles causing standing water	Private pipeline is the property owner responsibility to maintain on private property. Cleaned one inlet on street and hauled debris.	3303780
PEEBLES	2/8/2018	CLOGG DRAIN IN FRONT OF THE FEED STORE	Cleaned (4) inlets and hauled debris. Pipes are open water can flow.	3605124
	3/17/2016	Rim needs to be reset @ Eastman Rd & S 3rd St	Reset original rim - sealed cement around #12 rim. R	2357781
	4/21/2016	J& M PROCLEAN REPORTED A DISLODGE INLET GRATE IS AFFECTING TRAFFIC	repoured slab. reset 672 and grate. sealed with cement	2358196
S US HIGHWAY 61	1/9/2018	672 needs to be rest on the south west corner of Eastman and s. third	Reset long 672, shipped out concrete for anchor setting. Rebuilt walls to hold 672 up.	3577000

6.6 Improvement Alternative 6: IA6

Improvement alternative six was located in the Southland basin east of the East Bell Haven Road and Blues Highway (US-61) intersection. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout 3 private property parcels. During the 06/17/2022 meeting with the City of Memphis it was mentioned that the area is on private property and is, therefore, a private issue. We were directed to leave the area as-is in the model and no improvements were modeled. The existing conditions flooding details are summarized below followed by a summary of the surrounding maintenance reports. Exhibit 60 in Appendix A displays the extent of the existing inundation results for the 10-year recurrence interval storm event. Exhibit 61 in Appendix A displays the extent of the existing inundation results for the 100-year recurrence interval storm event.

6.6.1 Parcels Experiencing Flooding: IA6

- 050124 00029C
 - There are no buildings or other infrastructure features located on this property.
 - The existing conditions 10-year inundation extends through a portion of the property, but no infrastructure features are impacted by the flooding.

- 050124 00031
 - There are no buildings or other infrastructure features located on this property.
 - The existing conditions 10-year inundation extends through the majority of the property, but no infrastructure features are impacted by the flooding.

- 050124 00012C
 - Motel 61 is located on this property. This business has the following infrastructure features located on the property: asphalt parking area, three buildings, and a fence surrounding the property.
 - The existing conditions 10-year inundation extends through a small portion of the footprint of the asphalt parking area, and through a small portion of the fence.

6.6.2 GIS Flooding and Drainage-Related Maintenance Reports: IA6

One flooding and drainage-related maintenance report was present in this area that supports the existence of flooding issues. Table 20 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative six.

Table 20: Flooding and Drainage-Related Maintenance Reports Surrounding IA6

Street	Date Notified	Report Detail	Action Detail	Service Request Number
THIRD	10/6/2014	FLOODING IN THE BACK OF THE MOTEL 61. MR SHAH THINKS IT IS COMING FROM GILL STREET	Check inlets in area no blockage and no water standing.	2350803

6.7 Improvement Alternative 7: IA7

Improvement alternative seven was located in the Rosita basin northeast of the East Brooks Road and McCorkle Road intersection. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout 3 private property parcels. During the 06/17/2022 meeting with the City of Memphis it was mentioned that the area is on private property and is, therefore, a private issue. We were directed to leave the area as-is in the model and no improvements were modeled. The existing conditions flooding details are summarized below followed by a summary of the surrounding maintenance reports. Exhibit 62 in Appendix A displays the extent of the existing inundation results for the 10-year recurrence interval storm event. Exhibit 63 in Appendix A displays the extent of the existing inundation results for the 100-year recurrence interval storm event.

6.7.1 Parcels Experiencing Flooding: IA7

- 060229 00007C
 - United Diesel Power is located on this property. This business has the following infrastructure features located on the property: asphalt parking area, two buildings, numerous vehicles, tractor trailers, and metal cargo containers, and a fence surrounding the property.
 - The existing conditions 10-year inundation extends through a portion of the footprint of the asphalt parking area where vehicles and metal cargo containers are located, and through a portion of the fence.
- 060229 00006
 - Teamsters Local 667 is located on this property. This business has the following infrastructure features located on the property: asphalt parking area, one building, and a fence surrounding the property.
 - The existing conditions 10-year inundation extends through a portion of the footprint of the asphalt parking area and through a portion of the fence.
- 060230 00044
 - A number of businesses occupy a single shared building on the property. In addition to the building there is an asphalt parking area located on the property.
 - The existing conditions 10-year inundation extends through a portion of the footprint of the asphalt parking area and through a portion of the building footprint.

6.7.2 GIS Flooding and Drainage-Related Maintenance Reports: IA7

Six flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 21 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative seven.

Table 21: Flooding and Drainage-Related Maintenance Reports Surrounding IA7

Street	Date Notified	Report Detail	Action Detail	Service Request Number
E BROOKS RD	1/23/2020	Inspect all inlets on Map Page 63 K. Record any needed maintenance on back of ticket.	Removed debris from 7 of 13 inlets on this GRID and hauled to DM Yard. All pipes open and flowing and all maintenance complete.	4520056
E BROOKS RD	8/11/2020	Clogged Culvert	Please refer to 4825062	4792444
E BROOKS RD	2/17/2017	Cleaning Inlets	Cleaned 80 and inspected 51	3302682
LAKEVIEW	4/20/2006	STREET FLOODED		247029
S Main Street	2/28/2018	Clean all inlets close to Lakeview Rd & Interstate Drive of debris, etc.	Used forks and shovels to clean 5 inlets and dug out 2 more. 776 used wash truck too clear debris from pipelines. Pipes and inlets clear, water can flow.	3629770
LAKEVIEW RD	8/28/2020	Clogged culvert on west side of Lakeview Rd., in front of unit #3132 Lakeview. Per maintenance technician, culvert 'looks completely clogged down below the grates'.	Cleaned inlets and hauled debris	4825062

6.8 Improvement Alternative 8: IA8

Improvement alternative eight was located in the Rosita basin and was split into three sub-areas, 8A, 8B, and 8C.

6.8.1 Improvement Alternative IA8A

Improvement alternative 8A was located through nine properties located along the western side Lakeview Road between Winchester Road and East Brooks Road. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout 11 private property parcels. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 64 in Appendix A outlines the proposed improvements within the identified area. Exhibit 65 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 66 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.8.1.1 *Parcels Experiencing Flooding: IA&A*

- 077005 00052
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 17 feet.
 - There is a home, a concrete driveway, and a concrete parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 12 feet.

- 077005 00022
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 32 feet.
 - There is a home, a concrete driveway, and a concrete parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 13 feet.

- 077005 00021
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 29 feet.
 - There is a home, a concrete driveway, and two concrete parking areas located on this property.
 - The existing conditions 10-year inundation covers a portion of the footprint of the concrete parking area located behind the house and comes within approximately 17 feet of the footprint of the home.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 18 feet, and the inundation is no longer within the footprint of the concrete parking area behind the house and is approximately 23 feet from the footprint of the home.

- 077005 00020
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 15 feet.
 - There is a home, a concrete driveway, and a covered concrete parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 13 feet.

- 077005 00019
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 14 feet.
 - There is a home, two asphalt driveways, and an asphalt parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 13 feet.

- 077005 00018
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 12 feet.
 - There is a home, an asphalt driveway, and an asphalt parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 10 feet.

- 077005 00017
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 11 feet.
 - There is a home, an asphalt driveway, and an asphalt parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 9 feet.

- 077005 00016
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 10 feet.
 - There is a metal cargo container, and an asphalt driveway located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 8 feet.

- 077005 00015
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 12 feet.
 - There is a home, an asphalt driveway, and an asphalt parking area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance has a maximum top water surface width of 6 feet.

- 077005 00014
 - The existing conditions 10-year inundation in the open channel conveyance running south to north through the property has a maximum top water surface width of 13 feet.
 - The existing conditions 10-year inundation in the open channel conveyance running west to east along the northern property line has a maximum top water surface width of 22 feet.
 - There is a home, a gravel driveway, and a gravel parking area located on this property.
 - The existing conditions 10-year inundation comes out of the banks of the channel, but dense tree cover on the property makes it difficult to estimate how close the inundation is to the footprint of the home and gravel driveway/parking area.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running south to north has a maximum top water surface width of 7 feet.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running west to east has a maximum top water surface width of 5 feet.

- 077005 00013
 - The existing conditions 10-year inundation in the open channel conveyance running west to east along the northern property line has a maximum top water surface width of 22 feet.
 - There is a home, a gravel driveway, and a gravel parking area located on this property.
 - The existing conditions 10-year inundation comes within approximately 7 feet of the footprint of the home.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running west to east has a maximum top water surface width of 5 feet and comes within approximately 10 feet of the footprint of the home.

6.8.1.2 Proposed Improvements and Cost Estimate: IA8A

The proposed improvements for this area included a series of channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available surface and subsurface storage volume.

- Closed Conduit 14766-14763: Remove existing 14 LF 36” corrugated metal pipe (CMP) culvert at -3.27 % and connected drainage structures and replace with 14 LF of (54” RCP equivalent) 68” x 43” RCEP pipe at 0.66% with larger drainage structures. This improvement results in a conduit capacity increase from adverse slope to 161 cfs.
- Open Channel Conduit 14763-629: Regrade 883 LF 2.59’ depth irregular-shaped grass-lined open channel with a new grass-lined trapezoidal channel. The existing open channel slope and conveyance capacity ranges are summarized in Table 22 below.

Table 22: Existing Conduit (14763-629) Slope and Capacity Summary

Percent of Total Channel Length (%)	Slope Range (%)	Conveyance Capacity Range (cfs)
2	-0.24 (adverse)	-
46	0.04 – 0.07	30 – 40
43	0.22 – 0.42	70 – 100
6	2.52 – 3.71	240 - 300
3	4.87	341

The proposed grass-lined trapezoidal channel consists of two segments. The first segment is 820 LF (14763-14428) and includes lowering the upstream invert elevation by 0.54' and the downstream invert elevation by 1.58'. The dimensions of this segment are as follows: 5' bottom width, 3.6' depth, 2.5:1 side slopes. This improvement results in a channel segment with a uniform slope of 0.57% and a conduit capacity of 305 cfs. The second segment is 63 LF (14428-629) and includes lowering the upstream invert elevation by 1.58' and the downstream invert elevation by 2.08'. The dimensions of this segment are as follows: 5' bottom width, 5' depth, 2.5:1 side slopes. This improvement results in a channel segment with a uniform slope of 0.58% and a conduit capacity of 643 cfs.

- Closed Conduits 629-14434: Remove two existing parallel 42 LF (each) 42" RCP culverts at 2.72% and 6.05% and connected drainage structures and replace with a single 42 LF 60" RCP pipe at 3.00% with new drainage structures. This improvement results in a conduit capacity increase from 166 cfs and 248 cfs (414 cfs total) to 451 cfs. It also reduces the likelihood of debris get caught on and blocking the opening of the pipes by replacing two parallel pipes with a single pipe.

The preliminary anticipated cost for these improvements is estimated to be approximately \$555,150. Figure 13 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative 8A.

6.8.1.3 GIS Flooding and Drainage-Related Maintenance Reports: IA8A

Forty-two flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 23 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative 8A.

Table 23: Flooding and Drainage-Related Maintenance Reports Surrounding IA8A

Street	Date Notified	Report Detail	Action Detail	Service Request Number
LAKEVIEW RD	3/13/2013	FLOODING-HOUSE	Site Check	0
LAKEVIEW RD	5/14/2014	FLOODING-LAND	Site Check	0
LAKEVIEW	5/14/2014	FLOODING OF PROPERTY IN FRONT & BACK YARD	Clean	2348434
Lakeview	2/21/2015	CLEAN INLET -- RISING WATER APPROACHING HOME	Private Culvert built across the natural ditch is the property owner responsibly to maintain in rear of property. Did Plan Reseacher no drainage easement>	2351920

LAKEVIEW RD	5/28/2020	STANDING WATER IN FRONT AND BACK YARD OF 3349 LAKEVIEW	No flooding present and there's no drain infrastructure near this address. No maintenance performed at this time.	4666624
LAKEVIEW	6/9/2014	DRAIN	Clean	2348889
Lakeview	7/27/2015	Drain under driveway at 3330 Lakeview overflow when it rains causing standing water in driveways	Graded roadside ditch as far as needed. hauled debris to yard.	2355608
LAKEVIEW	6/10/2014	CULVERT	Culvert built across the natural ditch is private	2348898
LAKEVIEW	9/16/2010	DITCH CREATED IN BACKYARD. WHEN RAINS EVERYTIME FLOODS PIPES RUSTED OUT.	DITCH ON PRIVATE PROPERTY. REMOVED BLOCKAGE AT LARGE 42" CROSSOVER PIPES IN UNIMPROVED DITCH IN REAR OF PROPERTY.	2331960
LAKEVIEW	6/9/2014	DRAIN	closed w/2348730 Ditch is private and belongs to property owner.	2348839
LAKEVIEW BLVD	9/19/2019	Tree across the drainage way(Email from Torian)	Used Bobcat E-85 to remove drift from crossover pipes. Loaded debris on DM3197 and hauled 1 load. Ditch and pipes clear, water can flow.	4399844
LAKEVIEW RD	4/9/2019	Clogged drain across from 3349 Lakeview	No Inlet,REOCCURED PROBLEM ON PRIVATE PROPERTY.	4176284
Lakeview	3/10/2015	63-O. Sewage in ditch rear of address at 3373 Lakeview. Neighbor behind has put a dam in ditch. Morris Malone, 398-0807	(CALLER NOTIFIED) and Left FAQ Paper. We did Plan reaseach on natural ditch no drainage easement on ditch. It is the property owener reponsibility to maintain. Emailed stormwater pictures of natural ditch blockage with trees cut by property owner at 3	2352206
LAKEVIEW	6/3/2014		Referred to Engineering Dept.	2348730
Lakeview	4/20/2015	Site Check	Attached E-Mail thread the City is not responsible for maintaining Ms Scott private improvement.	2352780
LAKEVIEW BLVD	5/4/2020	drain inlet in font of 3289 Lakeview clogged	need sewer cleaned out. gave sew er# to homeowner.	4634074
LAKEVIEW RD	4/23/2020	Clogged drain across from 3349 Lakeview Rd and the yard has overgrown the drain	left door hanger, stating that the homeowner needs to call in the work for across the street.	4621034

LAKEVIEW	7/7/2014	EARTHEN DITCH AT REAR OF THIS LOCATION IS BLOCKED WITH LG DEBRIS, WHICH IS LEADING TO MOSQUITO BREEDING	Clean	2349462
Lakeview	2/25/2015	Drift need to be removed at 42" Double Crossover Pipes	Removed Debris from 42 inch crossover pipe and hauled debris	2352003
LAKEVIEW RD	1/9/2020	DRAINS NEEDS TO BE CLEANED OUT	Drain has responded to this area several times. This residents neighbor doesn't want their yard graded. That makes this a civil matter between property owners.	4508196
LAKEVIEW RD	7/11/2018	Refer to Drain Maintenance - cave in over drain pipe at road side ditch...low place 6x3 need crew sewer- Cave in across from address @ roadside ditch** LARGE SINKHOLE IN THE STREET	Used Compressor to cut out street 7X16 hauled 1 load. Stabilized street with 16 yards of AR1. Set AR1 and 2 bags of cement around pipes on roadside to prevent wash out.	3845780
	5/12/2016	Remov debris from 42 inch crossover pipe @ 3269 Lakeview Rd	Cleaned drift at crossover pipes and natual ditch and hauled debris.	2358583
LAKEVIEW RD	6/18/2018	**F/W TO DRAIN MAINT - Cave in across from address @ roadside ditch** LARGE SINKHOLE IN THE STREET	no cavity located. spoke with property owner. cleaned roadside ditch. mario flushed pipe	3809834
LAKEVIEW RD	7/3/2019	Clogged drain across from 3349 Lakeview Rd and the yard has overgrown the drain	Residents at both outfall ends of roadside ditch declined to have their roadsides graded. That makes this a Civil matter between property owners.	4298164
LAKEVIEW	2/17/1998	Ditch stopped up. Needs cleaning. Causing flooding on this property.	Clean	207932
LAKEVIEW RD	9/22/2020	Site Check -- drainage issues -- 3370 Lakeview	Site check no action required by Drain Maintenance	4857750
LAKEVIEW BLVD	10/24/2016	Drain Flooding-After a heavy rain the ditch in our front yard at the street overflows onto the street and flows into the yard across from us	Left FAQ Paper and Door Hanger also called answering machine and left message. It is not a function of the City Drain Dept. to put in infrastrction on	3003682

			private property at private driveway apron.f.d	
Lakeview	7/21/2015	Inlets are clogged in front of address.	Graded roadside ditch as far as needed. hauled debris to yard.	2355604
LAKEVIEW RD	6/18/2020	Clean the raw sewer in the ditch -- 3373 Lakeview Rd and CALL RESIDENT OF RESULTS	No drainage problems found. Homeowner's concern is sewage getting into the unimproved ditch in rear of the property. Referred to Environmental Maintenance.	4703746
LAKEVIEW RD	3/18/2019	Drain ditch in the back yard running over flooding the front yard	Cleaned ditch, and hauled debris use Bobcat E60	4140786
LAKEVIEW RD	8/18/2017	Clean cross-over pipes & driveway pipes @ the following address: 3360, 3350 & 3370 Lakeview of mud, debris, etc.	Wash Truck cleaned pipelines, pipes are open water can flow.	3401350
LAKEVIEW BLVD	2/20/2019	Flooding from 3340 through 3360 Lakeview Blvd---stree not passanle	Ditch has already been graded. no further action required.	4115938
LAKEVIEW	5/23/2006	BACKYARD FLOODS WHENEVER IT RAINS	Job Complete	247516
LAKEVIEW RD	4/17/2019	Drainage ditch between 3269 & 3279 LAKEVIEW RD needs to be cleaned	REOCURRED PROBLEM ON PRIVATE PROPERTY.	4189570
LAKEVIEW RD	5/18/2020	DRAINS IN FRONT OF 3360 LAKEVIEW RD GLOGGED WITH DEBRIS-CAUSING FLOODS	Homeowner has previously stated that he doesn't want his front yard graded. Crossover pipe and open throat inlet are clear, water can flow.	4654648
LAKEVIEW	9/26/2014	Drain inlets clogged in front of 3340, 3330, 3350 Lakeview	Cleaned all inlets at location and hauled debris.	2350706
LAKEVIEW RD	8/31/2017	Drain Inlet Clogged please check the entire street	Wash - Truck cleaned crossover pipelines in area , pipes are open water can flow. It a Civil Matter between property owner.	3421716
LAKEVIEW	3/13/2013	DITCH BEHIND HOUSE FLOODS YARD. WASHING GROUND.	unimproved ditch - not city resp.	2343224
LAKEVIEW RD	7/14/2017	Ditch needs grading.	Used bobcat to grade the roadside ditch across from the given address.	3347712
LAKEVIEW	3/13/2013	YARD/HOUSE FLOODS DURING RAIND EVENTS	SEE TICKET 2343224- uninproved ditch,not city resp	2343225

LAKEVIEW RD	10/15/2019	Repair the damaged inlet close to 3373 Lakeview Rd	Framed up number 6 slab. Poured slab and replaced top and rim.	4426294
LAKEVIEW	7/23/1997	Flooded Ditch.	Clean	204590

6.8.2 Improvement Alternative IA8B

Improvement alternative 8B was located through thirteen properties spanning from the eastern side of Dogwood Lane to the eastern side of East Rosita Circle. Based on the mapped inundation results for the 10-year storm simulation, the area experienced surface flooding throughout 4 private property parcels. During the 06/17/2022 meeting with the City of Memphis it was mentioned that channel improvements were constructed in the area within the last 20 years. These improvements included the addition of concrete lined channels spanning from junction 14012 to 13654. The existing conditions and post-improvement flooding details are summarized below followed by an explanation of the proposed improvements and a summary of the surrounding maintenance reports. Exhibit 67 in Appendix A outlines the proposed improvements within the identified area. Exhibit 68 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 10-year recurrence interval storm event. Exhibit 69 in Appendix A compares the extent of the existing vs. post-improvement inundation results for the 100-year recurrence interval storm event.

6.8.2.1 *Parcels Experiencing Flooding: IA8B*

- 077009 00054
 - The existing conditions 10-year inundation in the open channel conveyance running east to west along the southern property line has a maximum top water surface width of 26 feet.
 - There is a home, an asphalt driveway, an asphalt parking area, and a concrete porch area located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running east to west has a maximum top water surface width of 6 feet.

- 077008 00003
 - The existing conditions 10-year inundation in the open channel conveyance running east to west along the northern property line has a maximum top water surface width of 55 feet.
 - There is a home and a concrete driveway located on this property.
 - The existing conditions 10-year inundation comes within approximately 16 feet of the footprint of the home.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running east to west has a maximum top water surface width of 5 feet and comes within approximately 35 feet of the footprint of the home.

- 077008 00002
 - The existing conditions 10-year inundation in the open channel conveyance running east to west along the northern property line has a maximum top water surface width of 55 feet.
 - There is a home and a concrete driveway located on this property.
 - The existing conditions 10-year inundation does not impact any buildings or other infrastructure features on the property.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running east to west has a maximum top water surface width of 5 feet.

- 077008 00001
 - The existing conditions 10-year inundation in the open channel conveyance running east to west along the southern property line has a maximum top water surface width of 11 feet.
 - There is a home, a garage, a concrete driveway, and a concrete parking area located on this property.
 - The existing conditions 10-year inundation comes within approximately 6 feet of the footprint of the garage.
 - In the post-improvement conditions, the 10-year inundation in the open channel conveyance running east to west has a maximum top water surface width of 9 feet and comes within approximately 7 feet of the footprint of the garage.

6.8.2.2 Proposed Improvements and Cost Estimate: IA8B

The proposed improvements for this area included a series of channel improvements summarized below. These improvements increase the overall conveyance capacity of the network in addition to providing a minor increase in available surface and subsurface storage volume.

- Open Channel Conduit 587-13654: Extend top of 4' x 7' x 0.5' (total height x width x triangular bottom depth) concrete rectangular-triangular channel walls to elevation 235. Approximate additional channel height varies from 0' to 0.97' (upstream to downstream) across 270 LF. The existing open channel depth and conveyance capacity values compared to the proposed values are summarized in Table 24 below.

- Open Channel Conduit 13654 - 13622: Extend top of 4.5' x 7.25' x 0.5' (total height x width x triangular bottom depth) concrete rectangular-triangular channel walls to elevation 235. Approximate additional channel height varies from 0.46' to 0.71' (upstream to downstream) across 37 LF. The existing open channel depth and conveyance capacity values compared to the proposed values are summarized in Table 24 below.

- Open Channel Conduit 13622-13514: Extend top of 5.33' x 7.5' x 0.5' (total height x width x triangular bottom depth) concrete rectangular-triangular channel walls to elevation 235. Approximate additional channel height varies from 0' to 1.61' (upstream to downstream) across 321 LF. The existing open channel depth and conveyance capacity values compared to the proposed values are summarized in Table 24 below.
- Open Channel Conduit 589-13654: Extend top of 4.3' x 6.5' x 0.5' (total height x width x triangular bottom depth) concrete rectangular-triangular channel walls to elevation 235. Approximate additional channel height varies from 0' to 0.66' (upstream to downstream) across 211 LF. The existing open channel depth and conveyance capacity values compared to the proposed values are summarized in Table 24 below.
- Open Channel Conduit 13988-590: Extend top of 3.3' x 6.5' x 0.5' (total height x width x triangular bottom depth) concrete rectangular-triangular channel walls to elevation 236.5. Approximate additional channel height varies from 0' to 2.13' (upstream to downstream) across 295 LF. The existing open channel depth and conveyance capacity values compared to the proposed values are summarized in Table 24 below.
- Open Channel & Closed Conduit 618-13942: Replace 15 LF 24" RCP at 2.26% and 209 LF 1.4' grass triangular ditch with 2.75:1 side slopes and a slope range of 0.78% to 1.35% with a 236 LF 2.5'(min) x 6.5' (height x width) rectangular concrete channel. The channel depth transitions from 2.5' to approximately 4.1' (upstream to downstream) with a minimum top of wall elevation of 236.5 and a uniform proposed slope of 1.06%. Lower upstream invert elevation by approximately 0.9' and connect downstream end to existing channel. The capacity of the existing 24" RCP at 2.26% was 34 cfs. The existing open channel depth and conveyance capacity values compared to the proposed values are summarized in Table 24 below.

Table 24: IA8B Existing and Proposed Open Channel Depth and Capacity Summary

Open Channel Conduit Junction Range	Existing Maximum Depth (ft)	Existing Minimum Capacity (cfs)	Existing Maximum Capacity (cfs)	Proposed Maximum Depth (ft)	Proposed Maximum Capacity (ft)
587 - 13654	4.00	56	165	4.97	192
13654 - 13622	4.45	413	430	5.16	524
13622-13514	5.33	157	413	6.94	579
589-13654	4.3	58	257	4.96	646
13988-590	3.36	77	203	5.49	403
618-13942	1.91	32	42	4.10	308

- Closed Conduit 619-618: Remove existing 37 LF 24" RCP culvert at 0.19% and connected drainage structures and replace with 37 LF of (36" RCP equivalent) 44" x 27" RCAP pipe at 2.00% with larger drainage structures. This improvement results in a conduit capacity increase from 10 cfs to 81 cfs.

- Open Channel Conduit 14319-618: Construct new 10 LF 2.5' x 4.5' (height x width) rectangular concrete channel at 2% slope from junction 14319 to 619 in existing ditch. Lower downstream invert elevation by approximately 0.23'.

The preliminary anticipated cost for these improvements is estimated to be approximately \$855,038. Figure 14 in Appendix D summarizes, in table format, an itemized planning level cost estimate for improvement alternative 8B.

6.8.2.3 GIS Flooding and Drainage-Related Maintenance Reports: IA8B

Seventeen flooding and drainage-related maintenance reports were present in this area that support the existence of flooding issues. Table 25 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative 8B.

Table 25: Flooding and Drainage-Related Maintenance Reports Surrounding IA8B

Street	Date Notified	Report Detail	Action Detail	Service Request Number
	9/18/2009	FLOODING-STREET	Clean	0
ROSITA	8/7/2008	FLOODING STREET	Wash	256355
ROSITA	12/7/2009	LEAVES IN DITCH CAUSING YARD FLOODING.	Clean	2327650
Rosita	5/12/2015	yard floods- wants to speak with someone what can be done about yard flooding.	It is not a function of the City Drain Dept. to maintain natural ditch with no blockage or debris.	2353123
W ROSITA CIR	4/16/2018	FENCING AROUND DRAINAGE DITCH NEEDS REPLACED	Repaired 4' fence wires at the headwall.	3699416
Rosita	6/2/2015	clean concrete channel lining of debris, etc. why does it floods all the time -- please call homeowner	graded roadside ditch as far as needed and hauled debris to dm yard (1 load) - M. Mathis arrived and washed driveway pipe, no blockage, open and flowing on departure and 905 am	2353441
ROSITA	9/18/2009	STREET FLOODED	Clean	2325553
ROSITA	4/26/1999	Drainage ditch side overflowed. Property flooded.	Property	213830
Rosita	5/12/2015	Drainage ditch need cleaning, called last year and still need cleaning	It is not a function of the City Drain Dept. to maintain natural ditch with no blockage or debris.	2353130
DOGWOOD LN	9/8/2020	ditch on side of the house has lot of trees and need to be cut/3264 Dogwood	Completed 2 PW (DM)-CLEANED CONCRETE DITCH	4840424

ROSITA	7/18/2014	Drain needs cleaning and yard floods when it rains.		2349691
Rosita	4/20/2015	Ditch Need Cleaning and Cutting	Cleaned concrete ditch and hauled debris as far as needed.	2352768
DOGWOOD	5/5/2015	Ditch need to be clear so the water can flow through more they did the work but did not dig futher enough to connect to the ditch from the drain MRS RATCHFORD 901-628-7780 Ticket Notes - (What is the exact location of where the drain that needs work? =	graded ditch as far as needed. hauled debris to yard. open and flowing	2352993
ROSITA	6/10/2015	Drain inlet is clogged	on private property, this belongs to the property owner. owner has been notified it is a natural ditch on private property	2353569
E ROSITA CIR	5/30/2017	Toilets stopping up and water not flowing through sinks	REFER TO SEWER, this is not a DM Issue	3270064
Dogwood	3/11/2015	CAVITY IN YARD -- WHEN IT RAINS WATER HOLDS IN HIS YARD FROM CONCRETE CHANNEL LINING. WHEN IN ROUTE PLEASE CALL FIRST.	ditch on both sides of road from brooks to winchester complete except between 3243 and 3231 dogwood. it needs to be ditched at 3243. the resident at 3231 was ADAMANT WE DONT DIG IN HIS YARD. 5/4 washed driveway pipes	2352240
DOGWOOD LN	9/8/2020	culvert in front of 3264 Dogwood clogged wih debris	Completed 2 PW (DM)-CLEANED CONCRETE DITCH	4840428

6.8.3 Improvement Alternative IA8C

Improvement alternative 8C was located at and northeast of the intersection of East Rosita Circle and West Rosita Circle. This area was specifically identified for analysis during the 06/17/2022 meeting with the City of Memphis due to the number of complaints reported in the area. Based on the mapped inundation results for the 10-year and 100-year storm simulations, the area did not experience surface flooding in the model. As a result of this, no improvements were modeled in this area. A summary of the surrounding maintenance reports is included below. Exhibit 70 in Appendix A displays the extent of the existing inundation results for the 10-year recurrence interval storm event. Exhibit 71 in Appendix A displays the extent of the existing inundation results for the 100-year recurrence interval storm event.

6.8.3.1 GIS Flooding and Drainage-Related Maintenance Reports: IA8C

Twenty-two flooding and drainage-related maintenance reports were present in this area. Table 26 summarizes the GIS flooding and drainage-related maintenance reports surrounding improvement alternative 8C.

Table 26: Flooding and Drainage-Related Maintenance Reports Surrounding IA8C

Street	Date Notified	Report Detail	Action Detail	Service Request Number
3397 E ROSITA CIR	11/7/2019	Sinkholes in the backyard and his garage floods when it rains -- 3405 E. Rosita Circle. Also, he has a drain that needs to be cleaned out also.	-	4447588
3397 W ROSITA CIR	10/21/2020	ditch north of this address full of debris, clogged needs to be cut	-	4892032
3415 W ROSITA CIR	4/8/2021	missing grate east of this address causing traffic hazard	replaced missing grates	5180688
3405 E ROSITA CIR	1/8/2021	Pipe in backyard causing flooding every time it rains and that has caused a sink hole in backyard as well.	-	5029710
3405 E ROSITA CIR	1/8/2021	Pipe in backyard causing flooding every time it rains and that has caused a sink hole in backyard as well.	-	5029734
994 WINCHESTER RD	2/10/2021	damaged manhole cover @ 994 Winchester (westbound left lane) - attached	-	5063954
1014 WINCHESTER RD	2/8/2021	Replace the manhole cover close to 1014 Winchester Rd btwn Elvis Presley & Graves	-	5062192
3392 E ROSITA CIR	8/31/2021	Cave in over drain pipe & collapsed drain inlet at 3402 E Rosita Cir.	Cut street 7x5. Dug out cavities and loaded debris on DM2331. Stabilized cavity with 3 yards of AR-1 and packed. Repaired 2 joints from inside, water can flow.	5414776

969 WINCHESTER RD	8/31/2017	Drain Inlet Clogged	CLEANED 4 INLETS & HAULED DEBRIS	3422414
969 WINCHESTER RD	8/31/2017	Flooding 969 WINCHESTER RD	duplicate of 3422414	3422416
3357 E ROSITA CIR	3/12/2019	(Looks like a grass channel), a pipe running from underneath by the driveway and the street at 3357 E Rosita Cir.	Used BobCat E-60 to grade roadside ditch in front of address. Loaded debris on DM3197 and hauled 1 load. 776 used wash truck to clear debris from pipeline. Pipes and inlets clear, water can flow.	4135508
3392 E ROSITA CIR	9/4/2019	**F/W TO DRAIN: Cave in over drain pipe @ 3402 Rosita Cir** sink hole around the manhole cover in the street and a sink hole in front of the house also	Cave in at drain. No sinkhole nothing to dye test at this time visual inspected job site	4381930
3405 East Rosita CI	11/7/2019	Sinkholes in the backyard and his garage floods when it rains -- 3405 E. Rosita Circle. Also, he has a drain that needs to be cleaned out also.	Removed debris from 1 open throat inlet an hauled to DM Yard. Flooding in garage and sinkholes are from surface wash. Pipes open an flowing and all maintenance complete.	4447588
3410 E. Rosita	11/7/2019	Cavity and flooding issues @ 3410 E. Rosita Circle	duplicate	4447590
3379 LUCIBILL RD	2/24/2020	Several drain pipe under driveway are clogged near 3379 Lucibill	Used Bobcat E-60 to grade roadside ditches. Loaded debris on DM3197 and hauled 1 load. Referred to 776 to remove debris from driveway pipes. No other drainage problems found.	4546686
3397 W ROSITA CIR	10/21/2020	ditch north of this address full of debris, clogged needs to be cut	PW (DM)-CLEANED CONCRETE DITCH hauled debris to yard	4892032
3405 E ROSITA CIR	1/8/2021	Pipe in backyard causing flooding every time it rains and that has caused a sink hole in backyard as well.	SITE CHECKED NO ACTION REQUIRED BY DRAIN MAINTENANCE	5029710
3405 E Rosita Cir.	1/8/2021	Pipe in backyard causing flooding every time it rains and that has caused	SITE CHECKED NO ACTION REQUIRED BY DRAIN MAINTENANCE	5029734

		a sink hole in backyard as well.		
1014 Winchester Rd	2/8/2021	Replace the manhole cover close to 1014 Winchester Rd btwn Elvis Presley & Graves	-	5062192
994 Winchester Rd	2/10/2021	damaged manhole cover @ 994 Winchester (westbound left lane) - attached	-	5063954
3405 E ROSITA CIR	4/29/2022	F/W to Drain: This is a Drain dept. street cut that needs to be rolled in.	Potholes	5677206
E. Rosita Cir.	9/2/2014	FLOODING-LAND	SITE CHECK	