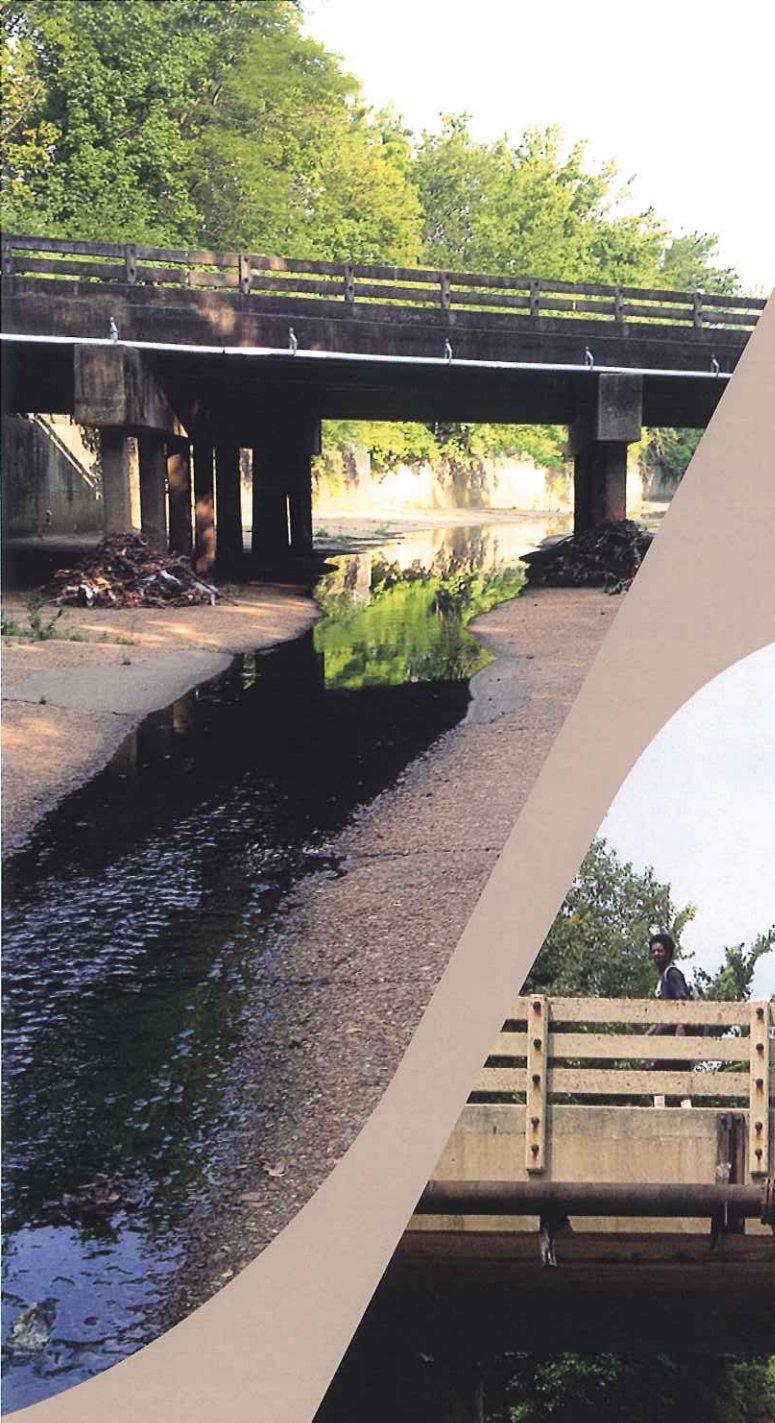
FINAL

Cypress Creek WATERSHED Drainage Master Plan

VOLUME 1



Prepared for:

The City of Memphis
Department of Engineering

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FINAL REPORT SUBMITTED
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EXECUTIVE SUMMARY

PROJECT BACKGROUND AND PURPOSE

Over the years, Memphis has expanded its boundaries further eastward from its initial riverside development and, as a result, some of the drainage infrastructure originally employed has proven inadequate to sufficiently convey stormwater runoff. In 2012, a review of the stormwater program identified 7 major study districts, which were further subdivided into numerous smaller study areas. The intent and objective was to study each basin within the city. The City of Memphis is in the initial stages of a multi-year program to develop drainage master plans for a majority of the city. The Cypress Creek basin was identified for the first round of studies.

The Cypress Creek basin is in an older, established area of Memphis. The area is comprised of a mixture of residential, commercial, and industrial areas, and includes 3 golf courses. The Cypress Creek basin is 8.36 square miles in area and contains over seven miles of concrete lined open channels. It is bounded by East Parkway along the West, Highland Street to the East, Barron Avenue along the South, and Chelsea Avenue to the North. The Project Study Area Map is shown in Figure 1.

Volume I of this report summarizes the results of the hydrologic and hydraulic (H&H) modeling and analysis to determine recommendations to improve drainage conditions throughout the study area. The results from this study will help to identify and implement potential capital improvements projects (CIPs) in efforts to mitigate the impacts of existing and future flooding.

Another component of this project was to update and develop the City's storm drainage inventory. While it was necessary to collect the data needed for the model, additional data on the storm structures was collected specifically for the inventory update. This required an extensive data collection effort. The following is a summary of the survey and data collected in the field:

- Stream Cross Sections: 189
- Road Crossings: 36
- Storm Drainage Structures: 1,000
- Ditch/Swale Typical Sections: 32

EXISTING CONDITIONS MODELING RESULTS

The Cypress Creek basin was modeled in Innovyze's software InfoSWMM. The basin was divided into 5 main systems. Figure 2 indicates these systems, which were identified as the Main Channel-North, Main Channel-South, Tributary 1, Tributary 2, and Tributary 3. The main channel begins at the southern end of the basin near Chisca Avenue and extends to the northwest corner of the basin near University Avenue. The main channel was divided into two separate sections at Sam Cooper Boulevard. Tributary 1 is located the central-west portion of the basin. It begins near Garden Lane and extends north toward Scott Street where it converges into the main channel. Tributary 2 is located on the east side of the basin. This tributary begins at Poplar Avenue and extends north to Walnut Grove Road where it converges with the main channel. Tributary 3 begins at the southwest corner of the basin area near Deadrick Avenue and extends north to Poplar Avenue where it converges with the main channel. The drainage areas for the tributaries (1, 2 and

3) are approximately 13%, 12% and 20% of the total 8.36 square mile Cypress Creek watershed area, respectively.

The evaluation of the existing conditions modeling results was focused on the Cypress Creek watershed's response to the 2- and 10-year synthetic rainfall events. As such, reporting of the analysis results is provided in terms of these events. The runoff volumes are primarily a function of the impervious cover percentage, soil characteristics, and overland flow routing. For this watershed, the most influential of these factors relative to its effect on runoff volume is the impervious cover percentage. The relative magnitudes of the calculated runoff volumes carried by Cypress Creek and its tributaries are in alignment with each stream's ranking in terms of impervious cover percentage as shown by the comparison table below. In this table, the runoff volumes per unit of catchment area for each stream were compared to the average impervious coverage percentages for the drainage area of each stream.

Table E.1: Impervious Cover and Rainfall Runoff Volumes for the Main Channel and Tributaries

Stream Name	Drainage Area (acres)	Average Impervious Cover (%)	2-yr Runoff Volume (MG)	10-yr Runoff Volume (MG)	2-yr Volume per Acre (MG/acre)	10-yr Volume per Acre (MG/acre)
Cypress Creek	5353	45	345	523	0.064	0.098
Tributary 1	716	60	55	81	0.077	0.113
Tributary 2	660	31	35	52	0.053	0.079
Tributary 3	1095	49	74	112	0.068	0.102

IDENTIFIED PROBLEM AREAS

After several iterations of modeling and consultation with the City of Memphis, the following areas of flooding concern were identified:

- Tillman Police Station – Police station parking lot and driveway entrance at Tillman Street
- Orange Mound Neighborhood - Area bounded by Southern Avenue, Semmes Street, Park Avenue and Airways Boulevard
- North Belt Line Neighborhood - Area bounded by Milton/Central Avenue, Cypress Creek Tributary 3, Midland Avenue and South Hollywood Street
- South Belt Line Neighborhood – Area bounded by Midland Avenue, Cypress Creek Tributary 3, Southern Avenue and South Hollywood Street
- Central-Poplar Neighborhood Storm System – Running from Poplar Avenue and between South Reese Street and Alexander Street to Joffre Avenue
- Joffre Neighborhood Storm System – Running from Joffre Avenue west to Cypress Creek
- South Holmes Street Storm System – Running from Central Avenue along South Holmes Street to Central-Poplar Neighborhood System
- Railroad Tracks in front of Mid-South Coliseum

- Tributary 1 between Faxon Avenue and Tutwiler Avenue
- Tributary 3 between Lundee Place and Central Avenue
- Binghampton Neighborhood Storm System – Running from Tillman Street to confluence of Cypress Creek

ALTERNATIVE ANALYSIS DESCRIPTION

Based on the scope of work for this project, ten separate improvement alternatives analyses were to be performed based on the identified flooding areas. In consideration of the number of alternative analyses performed, the scope stipulated that permutations of potential improvements are not considered as separate alternatives, however multiple improvement scenarios to address the same existing condition are considered as separate alternatives.

A meeting with City staff was held on March 4, 2015. At this meeting preliminary modeling results and improvement alternatives were discussed. Two of the problem areas identified for improvement alternatives were Orange Mound Neighborhood and Belt Line Neighborhood areas. In addition, concerns about localized flooding at the Tillman Police Station were also raised. All three of these areas were analyzed for improvements.

TILLMAN POLICE STATION

The Tillman Police Station is located at 426 Tillman Street. This site was analyzed for possible mitigation options. Frequent flooding was reported onsite and at the driveway to Tillman Street. The existing system consists of two runs of 18 inch diameter pipe that outfall to a 24 inch pipe that directly connects to Cypress Creek. Several alternatives were run, but the option that alleviated the flooding was converting the three single pipe runs with triple 30 inch barrels at each run. This effectively provides for a small amount of onsite detention that alleviates street flooding in the 2- and 10-year storm events. An exhibit showing the recommended improvements is shown on Figure 5.

ORANGE MOUND IMPROVEMENT ANALYSIS

For the purposes of this study, the Orange Mound Neighborhood was defined as the area bounded by Southern Avenue, Semmes Street, Park Avenue and Airways Boulevard. Significant flooding during the 2-year synthetic design storm was shown by the Cypress Creek watershed model within the Orange Mound area. Storm water collection within this area is facilitated by a primary storm sewer trunk line that begins at the intersection of Buntyn Street and Supreme Avenue and outfalls into Tributary 3 directly downstream of Southern Avenue. The trunk line generally follows the path of the lowest-lying topography within the Orange Mound area. The trunk line receives significant inflows of storm water runoff at generally five main collection points. These points include: the intersection of Buntyn Street and Supreme Avenue, Park Avenue, Douglass Avenue, Carnes Avenue, and Spottswood Avenue.

Two secondary stormwater lines were also analyzed in conjunction with the trunk line because flooding is shown to occur along these systems. These systems, for purposes of this study,are referred to as the Douglass Avenue system and the Carnes Avenue system, The Douglass Avenue system runs along Douglass Avenue until it outfalls to the trunk line. The Carnes Avenue system begins at Haynes Street and runs northwest to Carnes Avenue where it outfalls to the trunk line.

In addition, there are two smaller secondary systems that connect to the system from Douglass Avenue and Carnes Avenue.Seven scenarios of improvement alternatives were simulated in the model for the Orange Mound Neighborhood area. These scenarios are summarized in Volume II of this report. At the conclusion of the analyses, the most effective improvement option for this area involved increasing the capacity of the trunk line and the Douglass and Carnes Avenue systems. An exhibit of the area along with the recommended improvements is shown in Figures 6A, 6B, and 6C.

North Belt Line Improvement Analysis

There is an existing drainage system that begins just upstream of Boston Street (behind the Central States Foods parking lot) and ends at the confluence with Tributary 3 near Lundee Place. The Cypress Creek watershed model shows flooding along this system. Five improvement alternatives were simulated for this system to alleviate the flooding. Documentation of these simulations is included in Volume II of this report.

Once the analysis was complete, the most effective improvement option for this area involved increases in system capacity at Boston Street, Hodges Street, and Buntyn Street and conversion of the outfall ditch from the downstream side of Josephine Street to the confluence with Tributary 3 to a closed system. An exhibit of this improvement is shown in Figure 7.

Preliminary Planning Cost Information

Preliminary planning costs were prepared for the proposed improvement alternatives at the Tillman Police Station, Orange Mound Neighborhood and North Belt Line Neighborhood. These costs are based on planning-level design information and are not to be considered an Engineer's Estimate of Probable Construction Costs, but purely a budget estimate for planning purposes. These estimates were derived from preliminary evaluations with local contractors and comparing Tennessee Department of Transportation (TDOT) bid tab unit costs.

Table E.2 shows a breakdown of the preliminary cost information for each alternative. Worksheets showing more detailed information are located in Appendix C.

Table E.2: Preliminary Planning Cost Comparison

Alternative	Preliminary Planning Costs
Tillman Police Station	$445,556
Orange Mound Neighborhood	$7,691,774
Belt Line Neighborhood	$1,640,093

Conclusions

Overall the Cypress Creek watershed study provides a great assessment of the overall performance of the channel and infrastructure. The model is also an excellent tool for the study and evaluation of possible improvement alternatives. The existing conditions analysis of the watershed concluded that Cypress Creek and its tributaries perform reasonably well with only a

few isolated areas of overbank flooding in the 10-year storm event. Although the stormwater infrastructure is aging, the simulations performed generally showed a functioning system. Approximately 25% of the modeled storm pipes are at or over capacity in the 2-year storm event, and approximately 33% are operating at or over capacity in the 10-year storm event.

Eleven areas of significant flooding were identified during the study. Three of the areas were analyzed in detail for alternatives: Tillman Police Station, Orange Mound Neighborhood, and North Belt Line Neighborhood. Three additional areas were analyzed in limited detail, they were: Central-Poplar Neighborhood, Joffre Neighborhood, and South Belt Line Neighborhood.

The alternatives selected are all summarized in this report, and information regarding their development is included in Volume II of this report. The Tillman Police Station project is the least expensive, and since the project is entirely contained with the station's property and the street right-of-way, it could be designed and constructed the quickest. The Orange Mound alternative is the most costly and complicated of the recommendations, but it could be phased over time to increase its viability. The North Belt Line improvements will be more expensive to construct that the Tillman Police Station project, yet will provide benefit to the adjacent residents. Based on the results of this study, we recommend that the City of Memphis include the identified improvement alternatives in their plan for their Capital Improvement Projects.

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1 INTRODUCTION

1.1 PROJECT BACKGROUND AND PURPOSE

Over the years, Memphis has expanded its boundaries further eastward from its initial riverside development and, as a result, some of the drainage infrastructure originally employed has proven inadequate to sufficiently convey stormwater runoff. In 2012, a review of the stormwater program identified 7 major study districts, which were further subdivided into numerous smaller study areas. The intent and objective was to study each basin within the city. The City of Memphis is in the initial stages of a multi-year program to develop drainage master plans for a majority of the city.

This report presents the results of the hydrologic and hydraulic (H&H) modeling and analysis to determine recommendations to improve drainage conditions throughout the subject area. This report provides the results for the Cypress Creek Watershed Drainage Master Plan, one of the first basins to be studied under this program. The results from this study will help to identify and implement potential capital improvements projects (CIPs) in efforts to mitigate the impacts of existing and future flooding.

Another component of this project was to update and develop the City's storm drainage inventory. While it was necessary to collect the data needed for the model, additional data on the storm structures was collected specifically for the inventory update. This required an extensive data collection effort. The following is a summary of the survey and data collected in the field.

- Stream Cross Sections: 189
- Road Crossings: 36
- Storm Drainage Structures: 1,000
- Ditch/Swale Typical Sections: 32

Hydraulic modeling extents for the storm water systems that outfall to Cypress Creek and its tributaries were based on a minimum subbasin size of 75-acres to 100-acres, which included many of the pipes with diameters 24-inches and larger. This limit was set by the City as a part of this scope of work. Junctions and conduits were created along the modeling extents based on collected survey data. Hydraulic connectivity between the termination point of the hydrologic-based overland flow routing and the beginning of the stormwater system was established using routing conduits defined by generalized transects.

1.2 STUDY AREA

The Cypress Creek basin is in an older, established area of Memphis. The area is a mixture of residential, commercial, and industrial development, and includes 3 golf courses. The study area consisted of the 8.36 square mile Cypress Creek basin which contains over seven miles of concrete-lined open channels. It is bounded by East Parkway along the West, Highland Street to the East, Barron Avenue along the South, and Chelsea Avenue to the North. The Project Study Area Map is shown in Figure 1. To properly analyze rainfall-to-runoff response and hydrograph routing and timing, the area was divided into various smaller sub-catchment areas. The subject area was modeled in Innovyze's modeling software InfoSWMM provided by the City of Memphis.

1.3 PUBLIC INVOLVEMENT

The intended purpose of public outreach activities was to provide a forum for property owners, residents, and business owners in the study area to discuss and provide information regarding observed stormwater drainage problems witnessed throughout the basin area. These efforts focus on the following: (a) informing the public of the impending drainage study and associated field activities, (b) providing a platform for citizens to inform the City of existing drainage-related issues, and (c) aggregating any such data for use in modeling and planning purposes. Four (4) public outreach meetings were coordinated and conducted at the beginning of the project. The meetings were advertised and communicated through flyers and email correspondence. The meetings occurred on the following dates and locations:

- Wednesday, May 7, 2014 – Benjamin Hooks Central Library
- Tuesday, May 13, 2014 – Orange Mound Community Center
- Monday, May 19, 2014 – First Baptist Church Broad
- Thursday, May 22, 2014 – Hollywood Community Center

Each person in attendance was given the opportunity to complete a survey with questions determined through collaboration with the City of Memphis. See Appendix B for examples of the public involvement materials. No problem areas were identified during the public involvement meetings.

In addition, the consultant attempted to contact owners and managers of select commercial and/or industrial properties adjacent to the main Cypress Creek channel and its major tributaries directly via phone to gather drainage information. Approximately 20 property owners were contacted with no beneficial information obtained for the project.

2 HYDROLOGIC AND HYDRAULIC MODELING ANALYSIS

The Cypress Creek watershed model is a tool that can be used to simulate the watershed's response to rainfall. Through the model, a better understanding of this response can be achieved through evaluation of calculated discharges and water levels along the storm water conveyance elements within the watershed. The primary conveyance elements within the Cypress Creek watershed include swales, ditches, streams, culverts, bridges, roadways and piped storm water systems.

The Cypress Creek model was divided into 5 main systems. Figure 2 indicates these systems, which were identified as the Main Channel North, Main Channel South, Tributary 1, Tributary 2, and Tributary 3. The main channel begins at the southern end of the basin near Chisca Avenue and extends to the northwest corner of the basin near University Avenue. The main channel was divided into two separate sections at Sam Cooper Boulevard. Tributary 1 is located in the central-west portion of the basin. It begins near Garden Lane and extends north toward Scott Street where it converges into the main channel. Tributary 2 is located on the east side of the basin. This tributary begins at Poplar Avenue and extends north to Walnut Grove Road where it converges with the main channel. Tributary 3 begins at the southwest corner of the basin area near Deadrick Avenue and extends north toward Poplar Avenue where it converges with the main channel. The drainage areas for the tributaries (1, 2 and 3) are approximately 13%, 12% and 20% of the total 8.36 square mile Cypress Creek watershed area, respectively.

2.1 METHODOLOGY

The following Hydrologic and Hydraulic (H & H) analyses were performed:

- Developed a calibrated H&H model of the Cypress Creek Basin study area, approximately 8.36 square miles, using the June 28, 2014 and September 11, 2014 storms;
- Using the calibrated model, developed an H&H model of the Cypress Creek Basin study area and model the existing conditions under the 2-year, 10-year, and 100-year, 24-hour design storms; and
- Using the existing conditions model, developed drainage improvement alternatives for flood mitigation

H&H analyses for the majority of the Cypress Creek Basin study were carried out using the United States Environmental Protection Agency's (EPA) Storm Water Management Model version 5.0.022 (SWMM5) and Innovyze's InfoSWMM modeling software provided by the City of Memphis. For a more detailed explanation of the model development, see Volume II of this report.

2.2 EXISTING CONDITIONS MODELING RESULTS

The evaluation of the existing conditions modeling results was primarily focused on the Cypress Creek watershed's response to the 2-year and 10-year synthetic rainfall events. As such, reporting of the analysis results is provided in terms of these events. The model shows that during the 2-year and 10-year rainfall events, approximately 345 million gallons (MG) and 523 million gallons (MG) of runoff, respectively, exits the modeled outfall, located directly downstream of University Street. Of these totals, approximately 15% is discharged from Tributary 1, 10% from Tributary 2, 20% from Tributary 3, and the remaining 55% is discharged to Cypress Creek through the numerous storm water outfalls that tie to the main channel along its reach, for both rainfall events.

The runoff volumes are a function of the impervious cover percentage, soil characteristics and overland flow routing. For this watershed, the most influential of these factors relative to its effect

on runoff volume was the impervious cover percentage. The relative magnitudes of the calculated runoff volumes carried by Cypress Creek and its tributaries are in alignment with each stream's ranking in terms of impervious cover percentage as shown by the comparison table below. In Table 1, the runoff volumes per unit of catchment area for each stream are compared to the average impervious coverage percentages for the drainage area of each stream.

Table 1: Impervious Cover and Rainfall Runoff Volumes for the Main Channel and Tributaries

Stream Name	Drainage Area (acres)	Average Impervious Cover (%)	2-yr Runoff Volume (MG)	10-yr Runoff Volume (MG)	2-yr Volume per Acre (MG/acre)	10-yr Volume per Acre (MG/acre)
Cypress Creek	5353	45	345	523	0.064	0.098
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The rainfall runoff volumes enter the streams in varying flow patterns based primarily on the rainfall pattern and the efficiency of the storm water conveyance systems within each sub-catchment. The runoff patterns were observed through hydrograph plots along any conduit of interest within the model. The model shows that during the 2-year and 10-year rainfall events, the peak discharge at the Cypress Creek outfall is approximately 6900 cfs and 9900 cfs, respectively. The peak flows for both rainfall events for Tributary 1, 2 and 3 are approximately 20%, 10% and 30% of the Cypress Creek watershed peak flows, respectively.

Exhibit 1 shows the 2-year hydrographs at the outfalls of Cypress Creek and its tributaries. Tributaries 1 and 3 (shown in green and blue, respectively) exhibit similar shapes in their response to the 2-year rainfall. This can be attributed to the fact that both tributaries receive discharges from relatively short pipe systems at frequent intervals along the stream with the exception of the Tributary 3 storm drainage system located north of Southern Avenue. There are, however, two noticeable differences between the hydrographs for Tributaries 1 and 3. The first being the rising limb of the Tributary 1 hydrograph is much steeper than Tributary 3, and the second being the Tributary 3 hydrograph has a much sharper peak. The less steep rising limb and the less sharp or attenuated peak for Tributary 1 represents inefficiencies in the storm water systems along the stream. This includes storage areas created by railroad obstructions as well as undersized, low profile culvert crossings along the tributary itself.

The Tributary 2 hydrograph shows a pattern of lower but sustained peak flow rates released over a longer period. This is representative of the relatively longer reaches of storm water systems that discharge less frequently along the reach of Tributary 2. It also demonstrates the attenuation of flows associated with the dispersing of runoff within the Links at Galloway Golf Course.

Based upon shape alone, the Cypress Creek hydrograph appears to be specifically influenced by the Tributary 1 and 3 hydrographs during the early stages of increasing runoff. Then, as time progresses, the hydrograph appears to become more influenced by the numerous outfall pipes discharging to the creek at varying rates and times. The Cypress Creek hydrograph also reflects some lag in the flows attributed to the significant length of channel routing to the outfall.

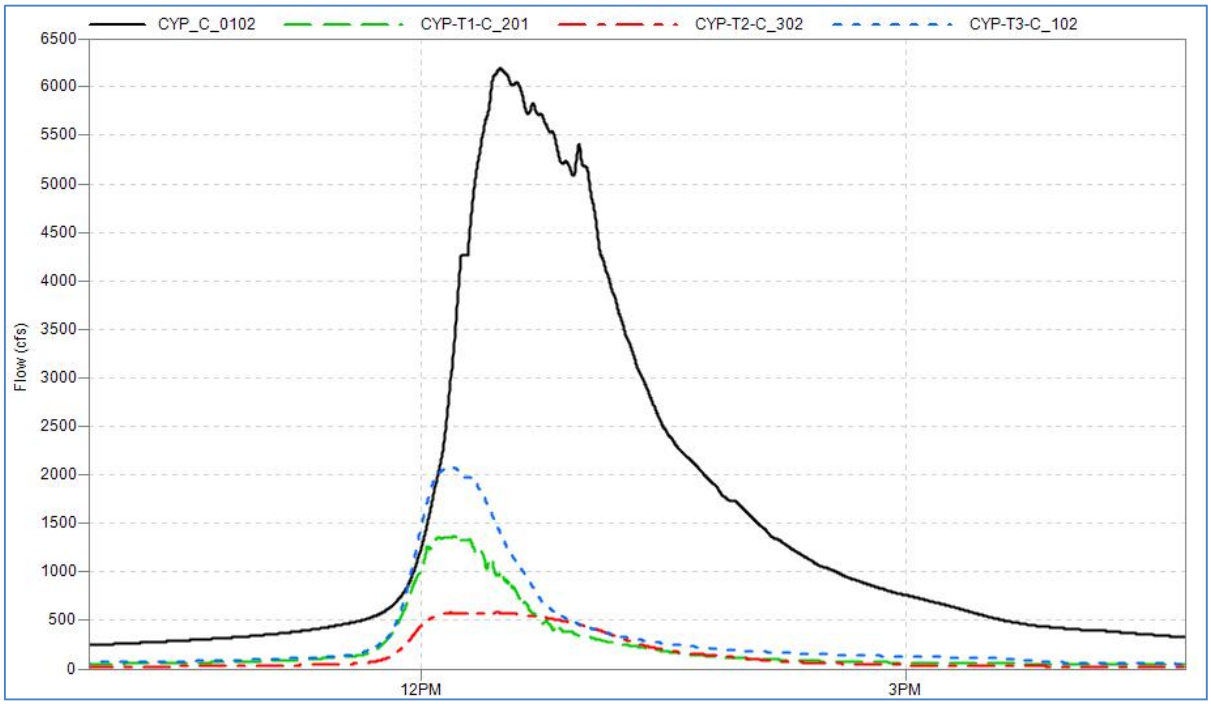


Exhibit 1: 2-Year Flow Hydrographs at the Cypress Creek and Cypress Creek Tributary Outfalls

The existing conditions analysis for the Cypress Creek watershed provides information about the overall performance of the simulated storm water systems. The watershed is comprised of approximately 462 storm system pipes that are greater than 24 inches in diameter/height/width. Of these, roughly 25% are operating at or over capacity during the 2-year rainfall event, and approximately 33% are operating at or above capacity during the 10-year rainfall event. See Figures 4A and 4B to reference the locations of these under-performing conduits. It is important to note that the modeling results calculated for system elements located at the upper end of the hydraulic modeling extents will have a lower level of accuracy and reasonability because these elements are receiving all of the limitedly routed sub-catchment runoff at one time. In reality there are smaller storm water system elements that are discharging to these locations at different rates and different times. Achieving a higher confidence level in the results at these locations would require further study based on inclusion of smaller storm system elements and further sub-catchment delineation.

2.3 IDENTIFICATION OF PROBLEM AREAS

One of the primary purposes for developing a hydrologic and hydraulic model for the Cypress Creek Watershed was for the identification and verification of flooding areas within the watershed. Part of this identification process began with the public involvement meetings, as previously

discussed. Although no problem areas were identified during these meetings, two areas of flooding concern were provided to the modeling team by the City of Memphis. These areas included:

- Joffre Neighborhood Storm System – Running from Joffre Avenue west to Cypress Creek. At this location, street and home flooding has been reported in the past.
- Railroad Tracks in front of Mid-South Coliseum - The railroad has reported that in large storm events, flooding occurs within the ditch adjacent to the tracks.
- Tillman Police Station –Frequent flooding was reported to occur within the parking lot and at the driveway entrance onto Tillman Street.

The watershed model provided verification of the City-reported flooding areas listed above, and also identified further problem areas for consideration. Flooding areas identified by the model include areas considered to be impacted by either significant or nuisance flooding. Areas of significant flooding includes those which pose a potential threat to roadways or structures. Identified areas of significant flooding include:

- Orange Mound Neighborhood - Area bounded by Southern Avenue, Semmes Street, Park Avenue and Airways Boulevard
- North Belt Line Neighborhood - Area bounded by Milton/Central Avenue, Cypress Creek Tributary 3, Midland Avenue and South Hollywood Street
- South Belt Line Neighborhood – Area bounded by Midland Avenue, Cypress Creek Tributary 3, Southern Avenue and South Hollywood Street
- Central-Poplar Neighborhood Storm System – Running from Poplar Avenue and between South Reese Street and Alexander Street to Joffre Avenue
- South Holmes Street Storm System – Running from Central Avenue along South Holmes Street to Central-Poplar Neighborhood System
- Tributary 1 between Faxon Avenue and Tutwiler Avenue
- Tributary 3 between Lundee Place and Central Avenue
- Binghampton Neighborhood Storm System – Running from Tillman Street to confluence of Cypress Creek

Areas of nuisance flooding include those which do not impact roadways or structures. Identified areas of nuisance flooding include:

- Chickasaw Country Club Golf Course
- Memphis Country Club Golf Course
- Links at Galloway Golf Course

Other areas that were identified include where the model calculated flooding, but the model results have a lower level of accuracy and reasonability. This is because the stormwater system elements are located at the upper end of the hydraulic modeling extents. These areas include:

- Poplar Avenue and Ridgefield Road Intersection
- Poplar Avenue and Windover Road Intersection
- North Highland Street near intersection with Johnwood Drive
- North Hollywood Street and Vandale Avenue Intersection

3 ALTERNATIVE ANALYSIS AND PRELIMINARY COST INFORMATION

3.1 ALTERNATIVE ANALYSIS DESCRIPTION

Based on the scope of work for this project, ten separate improvement alternatives analyses were to be performed based on the identified flooding areas. In consideration of the number of alternative analyses performed, the scope stipulated that permutations of potential improvements are not considered as separate alternatives. However, multiple improvement scenarios addressing the same existing condition are considered as separate alternatives.

On March 4, 2015 a meeting was held with the City of Memphis to discuss preliminary modeling results. At this time, two problems areas had been identified through the preliminary modeling. These areas included the Orange Mound Neighborhood and the Belt Line Neighborhood. One additional area of analysis reported by the City during this meeting, was the Tillman Police Station. At the conclusion of the meeting, these three areas were agreed upon as starting points for the improvement alternatives analysis.

As the modeling progressed through survey updates, quality control checks and calibration simulations, the Orange Mound Neighborhood, Belt Line Neighborhood and Tillman Police Station continued to show as flooding areas. However, upon reviewing the finalized Belt Line Neighborhood flooding impacts, it was observed that calculated flooding along streets and residences just north of Belt Line were more significant in terms of the number of homes that could potentially be impacted. Therefore, the initial Belt Line alternatives analysis focus shifted to the neighborhood north of Belt Line.

Additional problem areas were being identified as the modeling finalization process was occurring. The intention was to develop a complete list including additional areas supplemental to the alternatives previously identified during the preliminary modeling meeting. However, after analyzing more than ten different improvement scenarios for just the Orange Mound Neighborhood, North Belt Line Neighborhood and the Tillman Police Station, consideration of improvement analyses for any of the other locations would have been considered outside of this scope of work. Despite this fact, general analyses of the Central-Poplar and Joffre Neighborhood areas were performed in order to provide a preliminary assessment of these areas in terms of performance limitations and big picture solutions.

The final improvement alternatives selected for the Orange Mound Neighborhood, North Belt Line Neighborhood and Tillman Police Station are documented below. A detailed description of the multiple alternatives developed for these areas that were not selected is included in Volume II of the report. The preliminary assessments of the Central-Poplar and Joffre Neighborhood areas is also included below.

3.1.1 Tillman Police Station

The Tillman Police Station located at 426 Tillman Street was analyzed for possible mitigation options. An exhibit of the area and the proposed alternative is shown in Figure 5. From discussions with City staff, frequent flooding occurs within the parking lot and at the driveway entrance on Tillman Street. Based on existing conditions modeling results paired with existing topography and aerial imagery, it appears that 2 buildings could potentially be impacted by flooding during the 2-year event, and 24 buildings could potentially be impacted during the 10-year event. Because the flooding problems on the Tillman Police Station property are in part caused by pipes of size less than 24 inches, the area was outside the scope of the inventory, and additional survey

was required to incorporate it into the model. This system consists of two 18 inch diameter pipes that drain to a 24 inch pipe that directly outfalls to Cypress Creek. Because this system is a draining a large area (18 acres) from the west, which directly contributes flow to the system at the station's driveway, the model indicates that the system is undersized and the backwater from the creek is not the cause of the flooding. Once this determination was made, several alternatives were modeled. The alternative that provided the best results in the 2-year and 10-year storm events included the replacement of two runs of 18 inch pipe and one run of 24 inch pipe, with three 30 inch barrels at each pipe section. This effectively provides for a small amount of onsite detention and alleviates street flooding in the 2-year and 10-year storm events. A profile of the drainage system is show in Exhibit 2 and Figure 5 shows the proposed alternative.

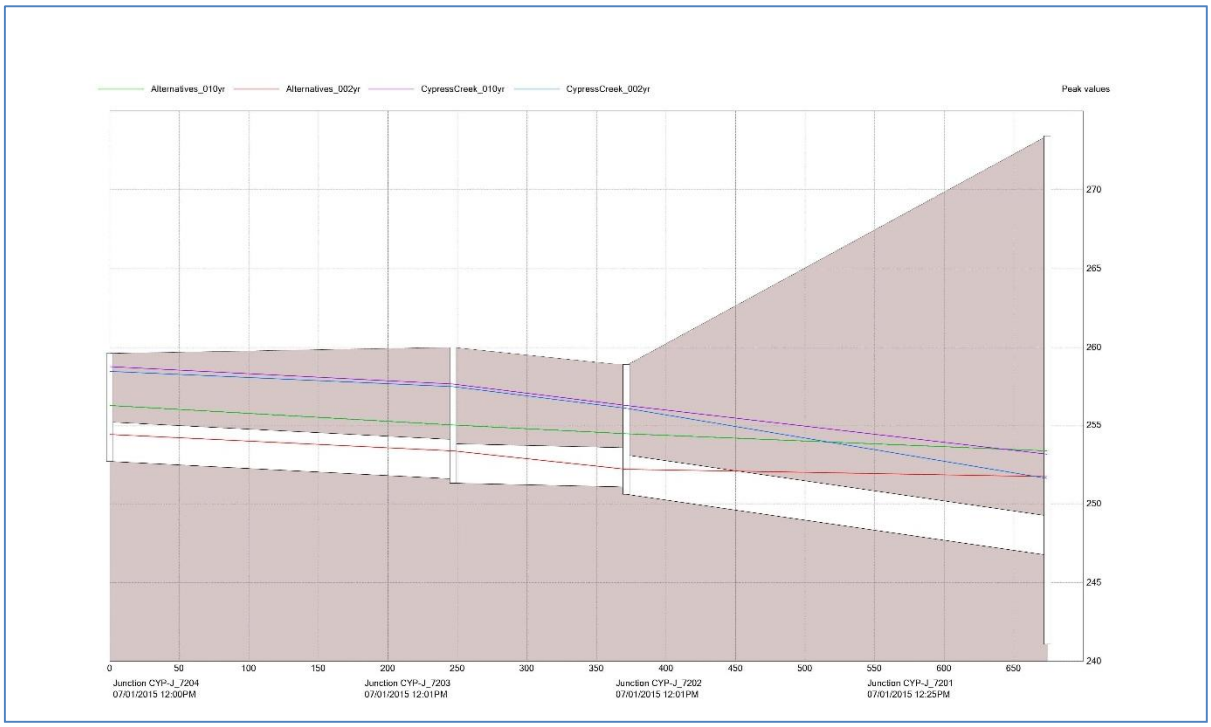


Exhibit 2: Tillman Police Station Improvements 2- and 10-Year Profiles

3.1.2 Orange Mound Neighborhood

The area within the Cypress Creek watershed located south of Park Ave and draining to Cypress Creek Tributary 3 is, for the purposes of this report, considered Orange Mound. The Cypress Creek watershed model showed significant flooding during the 2-year synthetic design storm within the Orange Mound area. More specifically, based on existing conditions modeling results paired with existing topography and aerial imagery, it appears that 23 buildings could potentially be impacted by flooding during the 2-year event, and 70 buildings could potentially be impacted during the 10-year event. Stormwater collection within this area is facilitated by a primary storm sewer trunk line beginning at the intersection of Buntyn Street and Supreme Avenue and outfalls into Tributary 3 directly downstream of Southern Avenue. The trunk line generally follows the path of the lowest-lying topography within the Orange Mound area and receives significant inflows of storm water runoff at five main collection points. These points include: the intersection of Buntyn

Street and Supreme Avenue, Park Avenue, Douglass Avenue, Carnes Avenue, and Spottswood Avenue.

Because flooding is shown to occur during the 2-year rainfall event, two secondary stormwater lines were analyzed in conjunction with the trunk line. These systems, for purposes of this study, are referred to as the Douglass Avenue system and the Carnes Avenue system. The Douglass Avenue system runs along Douglass Avenue and outfalls into the trunk line. The Carnes Avenue system begins at Haynes Street and runs northwest to Carnes Avenue where it outfalls into the trunk line. Due to the extent of flooding shown in the Orange Mound Neighborhood, numerous scenarios were simulated in order to isolate the most effective improvement option. Documentation of the seven improvement alternatives analyzed in the Orange Mound area is provided in Volume II of this report. After thorough analysis, it was concluded that the most effective improvement option for this area consisted of increasing the capacity of the trunk line and the Douglass and Carnes Avenue systems. Exhibits of the area along with the recommended improvements are shown in Figures 6A, 6B, and 6C. Profiles along the main trunk line, Douglass Avenue, and Carnes Avenue are shown in Exhibits 3-5 respectively.

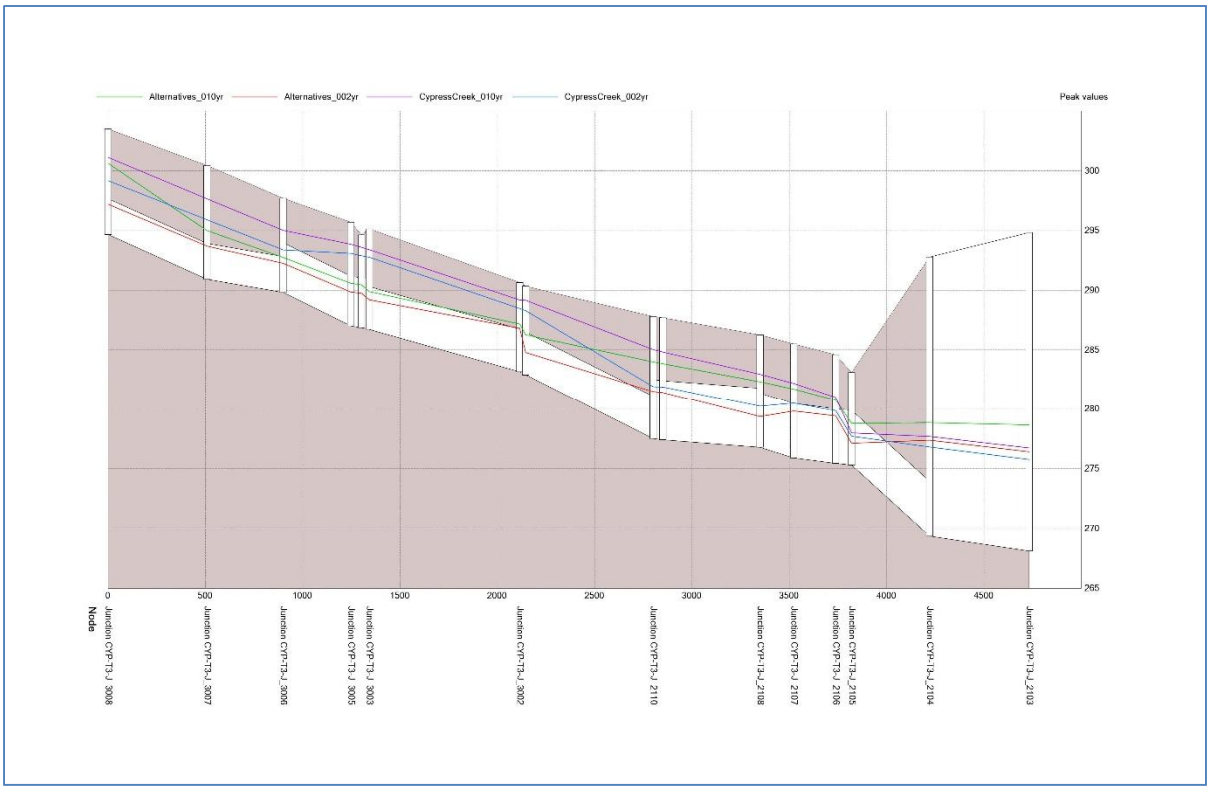


Exhibit 3: Orange Mound Trunk Line Improvements 2- and 10-Year Profiles

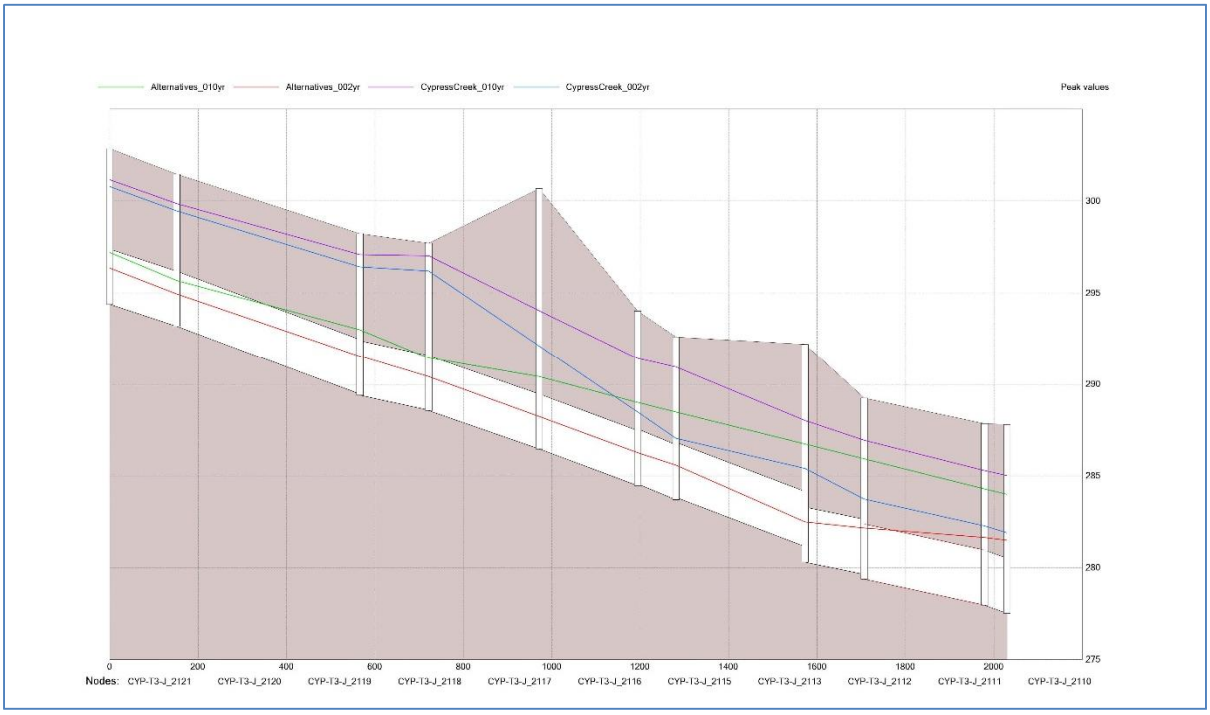


Exhibit 4: Douglass Avenue System Improvements 2- and 10-Year Profiles

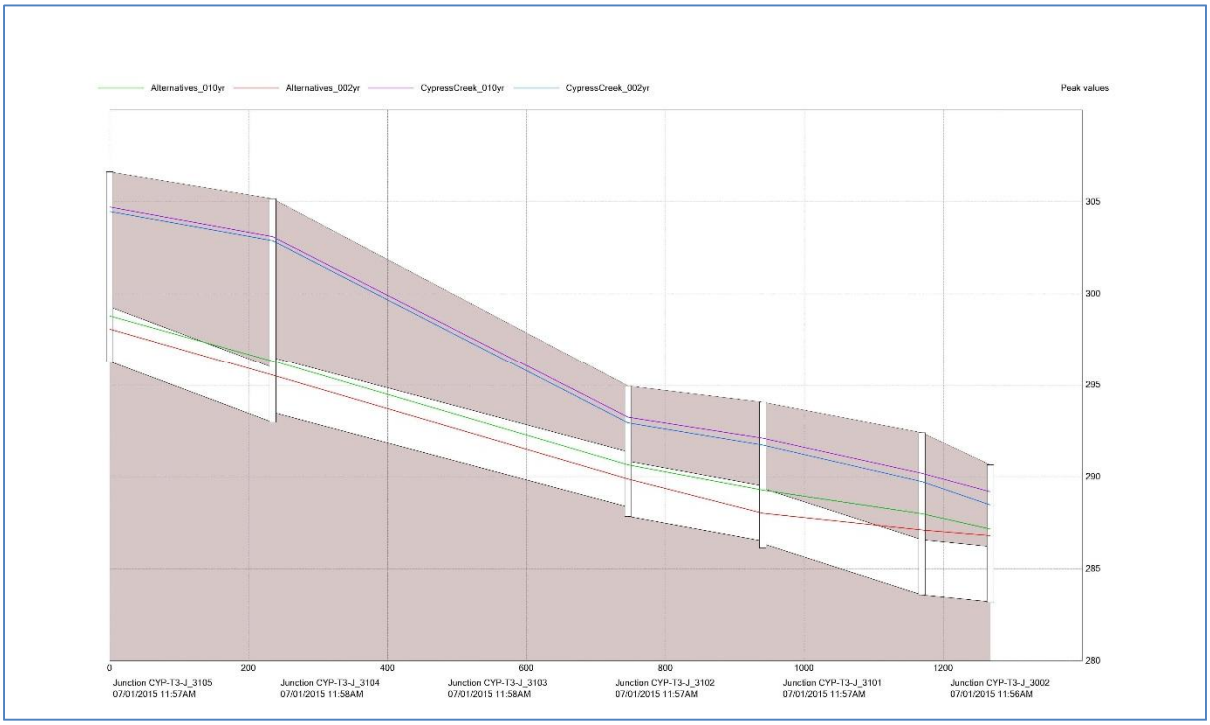


Exhibit 5: Carnes Avenue System Improvements 2- and 10-Year Profiles

3.1.3. North Belt Line Neighborhood

For this study, the North Belt Line Neighborhood system begins directly upstream of Boston Street and behind the Central States Foods parking lot and ends at the confluence with Tributary 3 near Lundee Place. Based on existing conditions modeling results paired with existing topography and aerial imagery, it appears that 6 buildings could potentially be impacted by flooding during the 2-year event, and 11 buildings could potentially be impacted by flooding during the 10-year event. These potential flooding locations were calculated based on the assumption that runoff from an approximately 1200 linear foot section of South Hollywood Street extending south of Central Avenue and adjacent areas drain to this roadway section. The runoff is collected within the City stormwater system and crosses under the railroad tracks at an unknown location and joins a 60-inch by 45-inch box culvert located under the Central State Foods rear parking lot. Due to limited access and possible existence of blind stormwater junctions, engineering judgement and field investigation were used to connect systems. In addition, deductive reasoning ensured that the runoff from the area has no other obvious alternative connection point to the box culvert east of the railroad.

Five improvement alternatives were analyzed for this system in order to develop the alternative that most effectively mitigates flooding along the system for the 2-year and 10-year events. Documentation of these improvement alternatives is provided in Volume II of this report. At the conclusion of the analysis, the most effective improvement option for this area involved increases in the system capacity at Boston Street, Hodges Street and Buntyn Street and converting the outfall ditch from the downstream side of Josephine Street to the confluence with Tributary 3 to a closed system. An exhibit of the area along with the recommended improvements is shown in Figure 7.

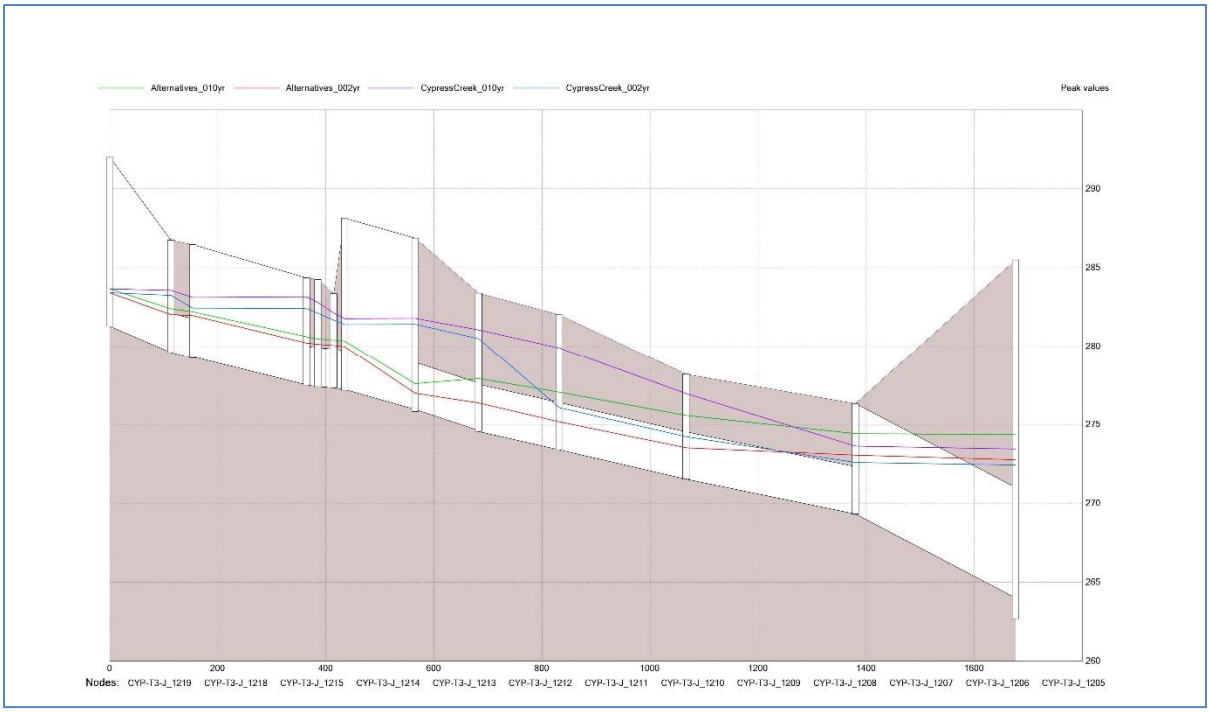


Exhibit 6: Belt Line Neighborhood Improvements 2- and 10-Year Profiles

3.1.4 Central-Poplar Neighborhood

For the purpose of the alternatives analysis, the Central-Poplar Neighborhood drainage system begins within Poplar Avenue and ends at Joffre Street. From this point, the system continues, but is referred to as the Joffre Neighborhood for the purpose of this alternatives analysis. The Joffre Neighborhood area will be discussed in the next section. Stormwater runoff from portions of Poplar Plaza and Poplar Avenue are carried through the Central-Poplar Neighborhood. These stormwater discharges combined with those associated with the neighborhood and its streets, exceed the capacity of the existing stormwater drainage system. The existing conditions model showed flooding during the 2-year rainfall event at most of the stormwater junctions along the system. More specifically, based on existing conditions modeling results paired with existing topography and aerial imagery, it appears that 23 buildings could potentially be impacted by flooding during the 2-year event, and 25 buildings could potentially be impacted during the 10-year event.

Prelminary analysis showed that a reduction in peak discharge entering the system from the Poplar Plaza and Poplar Avenue drainage systems would help alleviate flooding within a section of the system located upstream of Alexander Street. At Alexander Street, runoff from additional areas of Poplar Avenue and Alexander Street enter the system, and the effects of reduced flows from the northern commercial areas is diminished. Without a reduction in peak flows from Poplar Plaza and Poplar Avenue, the alternative would be to nearly triple the capacity of the pipes through the Central-Poplar Neighborhood system to mitigate flooding for the 2-year rainfall event. This is assuming no improvements to the system downstream of Joffre Street. Conversion of two open ditch connections to closed conduits in this system would also be necessary for flood mitigation for the 10-year event. If improvements are made within the Joffre system, as described in the following section, then the pipe capacity through the Central-Poplar system would only require a doubling of capacity to mitigate flooding for the 2- and 10-year events.

3.1.5. Joffre Neighborhood

For the purpose of the alternatives analysis, the Joffre Neighborhood drainage system begins at Joffre Street and continues west to the confluence with Cypress Creek. This system is a continuation of the Central-Poplar Neighborhood system. The existing conditions model showed flooding during the 2-year rainfall event at the two Joffre Avenue crossings and at South Holmes Street. More specifically, based on existing conditions modeling results paired with existing topography and aerial imagery, it appears that 4 buildings could potentially be impacted by flooding during the 2-year event, and 32 buildings could potentially be impacted during the 10-year event. In addition, the open ditches located west of South Greer Street are at maximum capacity during the 2-year event, with flooding at every junction and ditch occurring during the 10-year event. Based on the limited improvement alternatives analysis performed for this system, mitigation of flooding along the system during the 2-year storm event would require adding one additional duplicate barrel along every section of the closed conduit system from South Holmes Street to the outfall. In addition the conversion of the two open ditch sections located close to the outfall to closed conduit systems of similar dimension to their connecting conduits would be required. This is assuming improvements within the Central-Poplar system are in place as mentioned in the above section. Flood mitigation during the 10-year event would require adding two duplicate barrels along every section of the closed conduit system from South Holmes Street to the outfall, also assuming the Central-Poplar system improvements are in place. In addition the conversion of the two open ditch sections located close to the outfall to closed conduit systems of similar dimension to their connecting conduits would be required.

3.1.6 South Belt Line Neighborhood

For the purpose of the alternatives analysis the South Belt Line Neighborhood drainage system begins at South Hollywood Street and continues east through the Belt Line Neighborhood where it outfalls to Cypress Creek Tributary 3 at Midland Avenue. This system receives flows from the Memphis Fairgrounds, the Mid-South Coliseum and the Liberty Bowl areas. The peak runoff from the Mid-South Coliseum and fairgrounds areas is attenuated by a railroad crossing culvert and upstream storage ditch in front of the Coliseum. The City has reported flooding adjacent to the tracks at this location, which has been verified by the existing conditions model. The modeling shows water surface levels staging up within the ditch and overtopping the tracks during the 10-year rainfall event. During planning discussions related to the City's plans to redevelop the old Memphis Fairgrounds site, the possibility of adding onsite detention has been mentioned. If detention is proposed on the Fairgrounds site, then this would most likely reduce the flooding at the railroad tracks and potentially improve flooding conditions along the South Belt Line system. However this improvement could increase flooding along Tributary 3. With the viability of this alternative improvement being an unknown, the preliminary analysis for the South Belt Line system was carried out assuming conditions west of South Hollywood Street would remain as they are, and therefore only potential improvements to the east of South Hollywood Street were analyzed.

The South Belt Line system shows no flooding during the 2-year rainfall event; however, the conduits and open ditches are shown to be functioning at capacity. During the 10-year rainfall simulation, Belt Line Street, Boston Street, and the culvert at the end of Baltimore Street overtop, with water levels exceeding the ditch bank elevations upstream of these crossings. Based on existing conditions modeling results paired with existing topography and aerial imagery, it appears that 9 buildings could potentially be impacted by flooding during the 10-year event. To mitigate flooding along this system during the 10-year event, the culverts at Belt Line, Boston, and Baltimore Streets were widened from 8 feet to 12 feet. This reduced the flood levels upstream of these streets, but it caused increased levels and impacts downstream of Baltimore Street. This was caused by the increased flows being released from the upsized culverts upstream. In order to address this, the improvements would need to be carried further downstream to Buntyn Street, where the existing culvert would need to be widened by 5 feet.

3.1.7 Alternatives Property Assessments

After identifying the areas for potential improvement alternatives, a preliminary property data investigation was performed. Using the Shelby County Assessor's website and Tom Leatherwood's Shelby County Register of Deeds, parcel and owner information was obtained. However, almost all plats observed from these sites failed to illustrate drainage easements along the channel. Figures 5, 6, and 7 in Appendix A show the parcels impacted by the aforementioned improvement alternatives as well as properties owned by the government, whether it be the City of Memphis, Shelby County, or the State of Tennessee.

3.2 PRELIMINARY PLANNING COST INFORMATION

Preliminary planning costs were prepared for the proposed improvement alternatives at the Tillman Police Station, Orange Mound Neighborhood and North Belt Line Neighborhood. These costs are based on planning-level design information and are not to be considered an Engineer's Estimate of Probable Construction Costs, but purely a budget estimate for planning purposes. These estimates were derived from preliminary evaluations with local contractors and comparing Tennessee Department of Transportation (TDOT) bid tab unit costs.

Table 2 shows a breakdown of the preliminary cost information for each alternative. Worksheets showing more detailed information are located in Appendix C.

Table 2: Preliminary Planning Cost Comparison

Alternative	Preliminary Planning Costs
Tillman Police Station	$445,556
Orange Mound Neighborhood	$7,691,774
Belt Line Neighborhood	$1,640,093

4 CONCLUSIONS

The Cypress Creek Watershed study provides an assessment of the watershed response to rainfall and the level of performance at which the existing stormwater infrastructure can carry runoff from this rainfall to Cypress Creek and its tributaries. Through the model, a better understanding of this response can be achieved through evaluation of calculated discharges and water levels along the storm water conveyance elements within the watershed. The model is helpful in identifying areas of limited system capacity and flooding. The model is great tool for performing efficient analyses of improvement alternatives to determine the positive and negative aspects of the alternatives in the relation to the entire watershed.

The existing conditions analysis for the Cypress Creek Watershed demonstrated that Cypress Creek and its tributaries perform reasonably well during high flows. Only a few locations of overbank flooding was found during the 10-year rainfall event. The existing conditions analysis also showed that the simulated storm water systems within the watershed performed generally well, considering the age of the infrastructure within the watershed. Approximately 25 % of the stormwater conduits were functioning at or over flow capacity during the 2-year storm event, and approximately 33% were functioning at or over the flow capacity if the design year event (10-year event).

The existing conditions modeling results for the 2- and 10-year events revealed 11 areas where flooding was shown to potentially impact roadways, buildings, or both. Of these areas, three were analyzed in comprehensive detail for the development of improvement alternatives, and three were analyzed in reduced detail for improvement alternatives based on scope of work limitations. The areas analyzed in detail included: Tillman Police Station, Orange Mound Neighborhood and North Belt Line Neighborhood. The areas analyzed in limited detail included: Central-Poplar Neighborhood, Joffre Neighborhood, and South Belt Line Neighborhood. Based on modeling results, the recommended improvements for all six of these areas demonstrated the mitigation of flooding along the analyzed stormwater system.

Preliminary planning cost estimates were completed for the three areas studied in detail. The alternatives vary is costs and complexity. The Tillman Police Station improvement plan has the lowest cost, and will mitigate flooding within the property boundaries and at the intersection of Tillman Street and the station driveway. In addition, construction impacts would be relatively limited due to the location and extents of the improvements. This alternative could potentially be the quickest to design and construct. This would provide a viable Capital Improvement Project (CIP) that could get quickly underway, and demonstrate the results of the watershed studies.

The Orange Mound improvements are the most costly, but they could be phased over time to increase the project's feasibility. Although this is the most extensive alternative, the project would provide a great deal of relief to the residents. Several construction phasing options could be determined to help the project's viability. The North Belt Line improvements will be more expensive to construct that the Tillman Police Station project, yet will provide benefit to the adjacent residents. Based on the results of this study, we recommend that the City of Memphis include the identified improvement alternatives in their plan for their Capital Improvement Projects.

APPENDIX A:

FIGURES

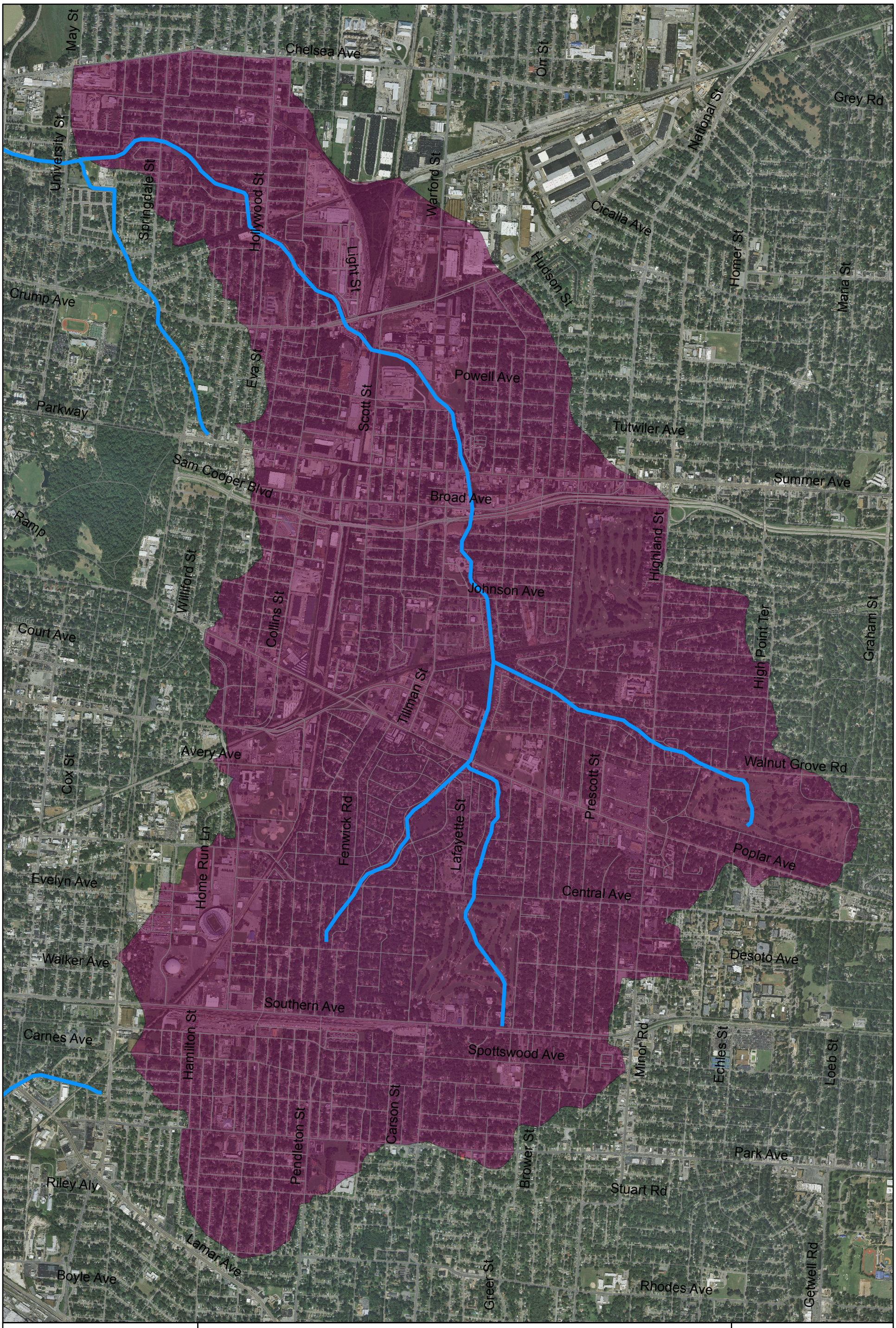


Figure 1:
Cypress Creek
Project Study Area Map
Memphis, TN
August 2015

Legend
- Cypress Creek Channel
- Cypress Creek Basin

N

1 inch = 2,000 feet

Kimley»Horn

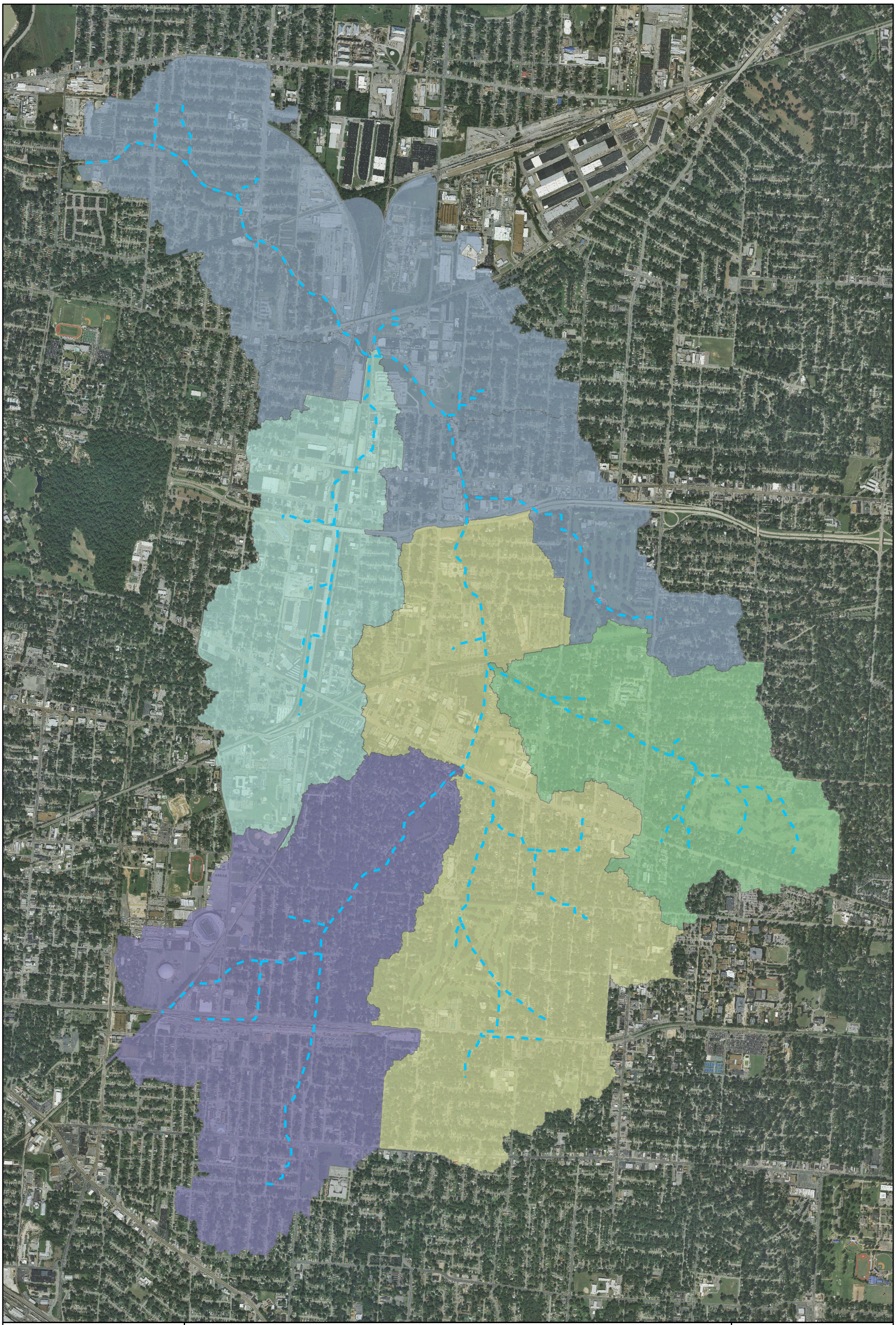


Figure 2:
Cypress Creek
Model Breakdown Map
Memphis, TN
August 2015

Legend

- Hydraulic Extents
- Main Channel - North
- Main Channel - South
- Tributary 1
- Tributary 2
- Tributary 3

N

1 inch = 2,000 feet

Kimley»Horn

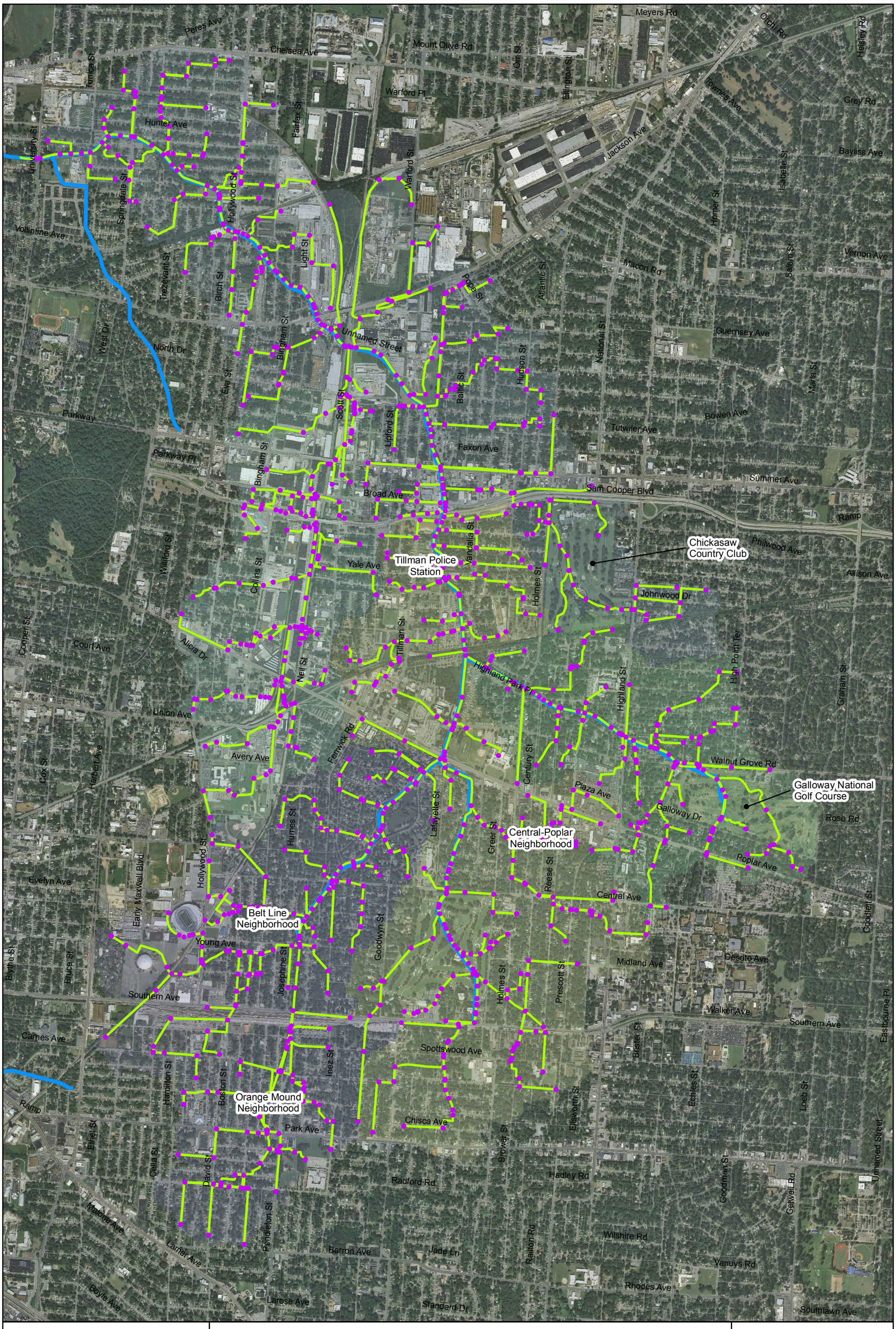


Figure 3:
Cypress Creek
Existing Conditions Map
Memphis, TN
August 2015

Legend
- Junctions
- Conduits
- Cypress Creek Channel

N

1 inch = 2,000 feet

Kimley»Horn

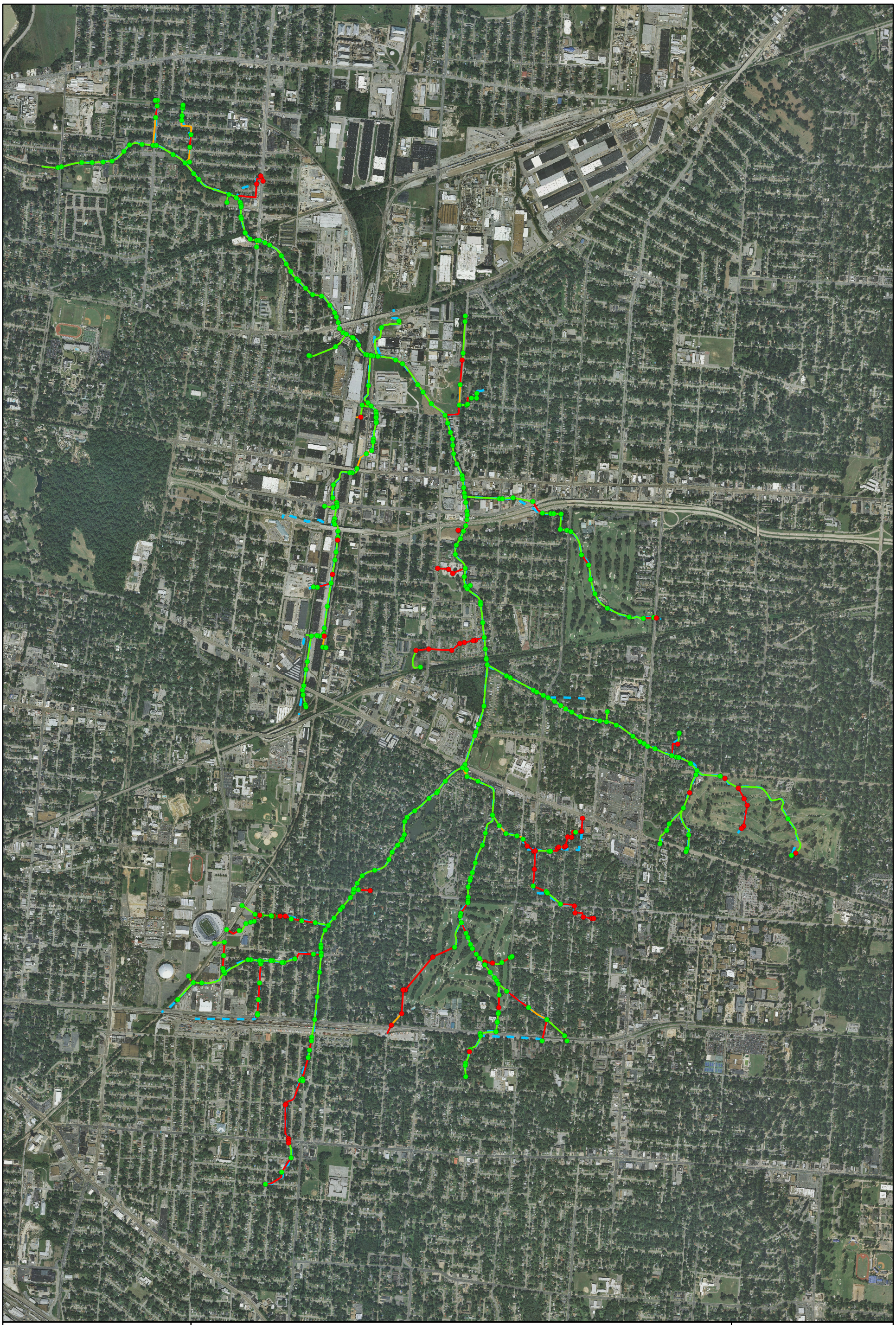


Figure 4A:
Cypress Creek
Operating Capacity Map
Memphis, TN
August 2015

Legend

Junctions: 2-Year

Surcharging
0
1

Conduits: 2-Year

CAPFLOW
0 - 0.75
0.75 - 0.92
0.92 - 5.79

N

1 inch = 2,000 feet

Kimley»Horn

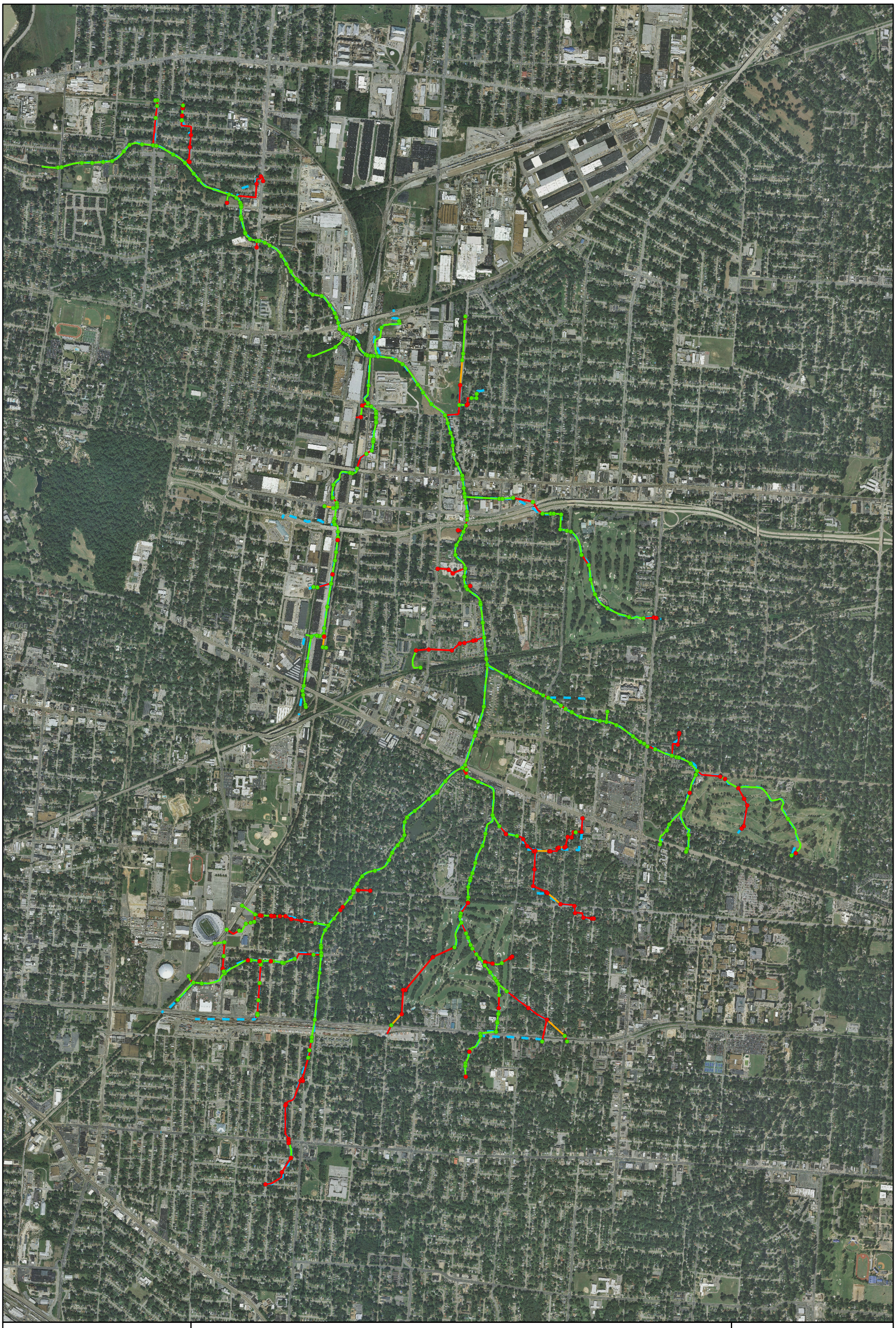


Figure 4B:
Cypress Creek
Operating Capacity Map
Memphis, TN
August 2015

Legend

Junctions: 10-Year Surcharging
- 0
- 1

Conduits: 10-Year CAPFLOW
- 0 - 0.75
- 0.75 - 0.92
- 0.92 - 5.86

N

1 inch = 2,000 feet

Kimley»Horn

Existing Drainage System:
390 LF - 18" RCP
285 LF - 24" RCP

Proposed Alternative:
675 LF - 3 Barrel 30" RCP

Inundation
2-Year
10-Year

Broad Ave
Sam Cooper Blvd
Sam Cooper Blvd
Lipford St
Tillman St
Autumn Ave
Princeton Ave
Princeton Ave
Glankler St
Allison Ave
TILLMAN POLICE STATION
285'
Nathan Ave
105'
Outfall to
Cypress Creek
Nathan Ave
Special Junction
285'
Special Junction
Gracewood St
Yale Ave
Yale Ave
Bearfield Pl
Hale Ave
Johnson Ave
Johnson Ave
Crystal Ave
Baltic St
McAdoo Ave

Inundation Shown is for Existing Conditions

Figure 5:
Tillman Police Station Improvement Alternative
Memphis, TN
August 2015

Legend
- Storm Drainage Structure (TYP.)
- Cypress Creek Channel
- Tillman Station Improvements
- Subcatchments
- Government Owned Property
- Property Boundary

N

1 inch = 200 feet

Kimley»Horn

		EXISTING			IMPROVEMENT		
FID	Length (ft.)	Barrel No.	Height/Diameter (ft.)	Width (ft.)	Barrel No.	Height/Diameter (ft.)	Width (ft.)
0	152	1	2.5	0	2	3	4.5
1	414	1	2.5	0	2	3	4.5
2	292	1	4	4	2	3	4.5
3	215	2	4.583	8.33	3	4.583	8.33
4	82	2	4.583	8.33	3	4.583	8.33
5	401	2	4.583	8.33	3	4.583	9
6	229	1	3.5	0	2	3	4
7	87	1	3	0	2	3	4.5
8	235	1	2	0	2	3	3.5
9	194	1	3	0	2	3	4
10	30	1	3.583	8	3	3.583	8
11	99	1	3.5	0	2	3	4
12	250	1	3	0	2	3	4.5
13	20	1	4.167	8	2	4.167	8
14	512	1	2.5	0	2	3	3.5
15	223	1	3	0	2	3	4.5
16	55	1	4.167	8	2	4.167	8
17	40	1	4.167	8	2	4.167	8
18	773	1	3.583	8	2	3.583	8
19	134	1	4	0	2	3	4.5
20	150	1	3	0	2	3	4.5
21	655	1	3.583	8	3	3.583	8
22	49	2	5	8	3	5	8
23	391	1	3	6	1	3	8
24	272	1	4.5	0	2	3	4.5
25	51	1	4.5	0	2	3	4.5
26	500	2	5	8	3	5	8
27	173	2	4.583	8.33	3	4.583	8.33

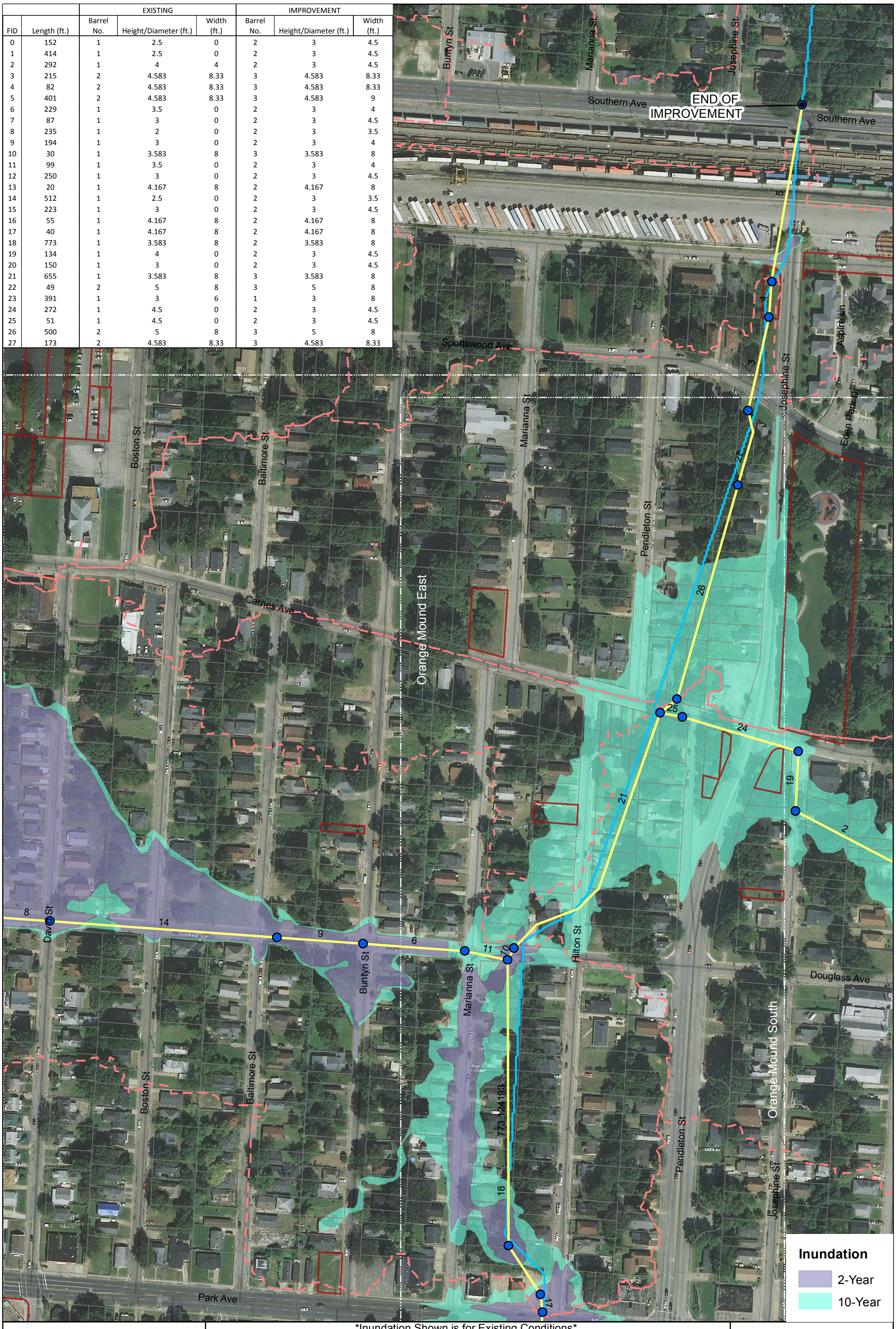


Figure 6A:
Orange Mound North Improvement Alternative

Memphis, TN
August 2015

Inundation Shown is for Existing Conditions

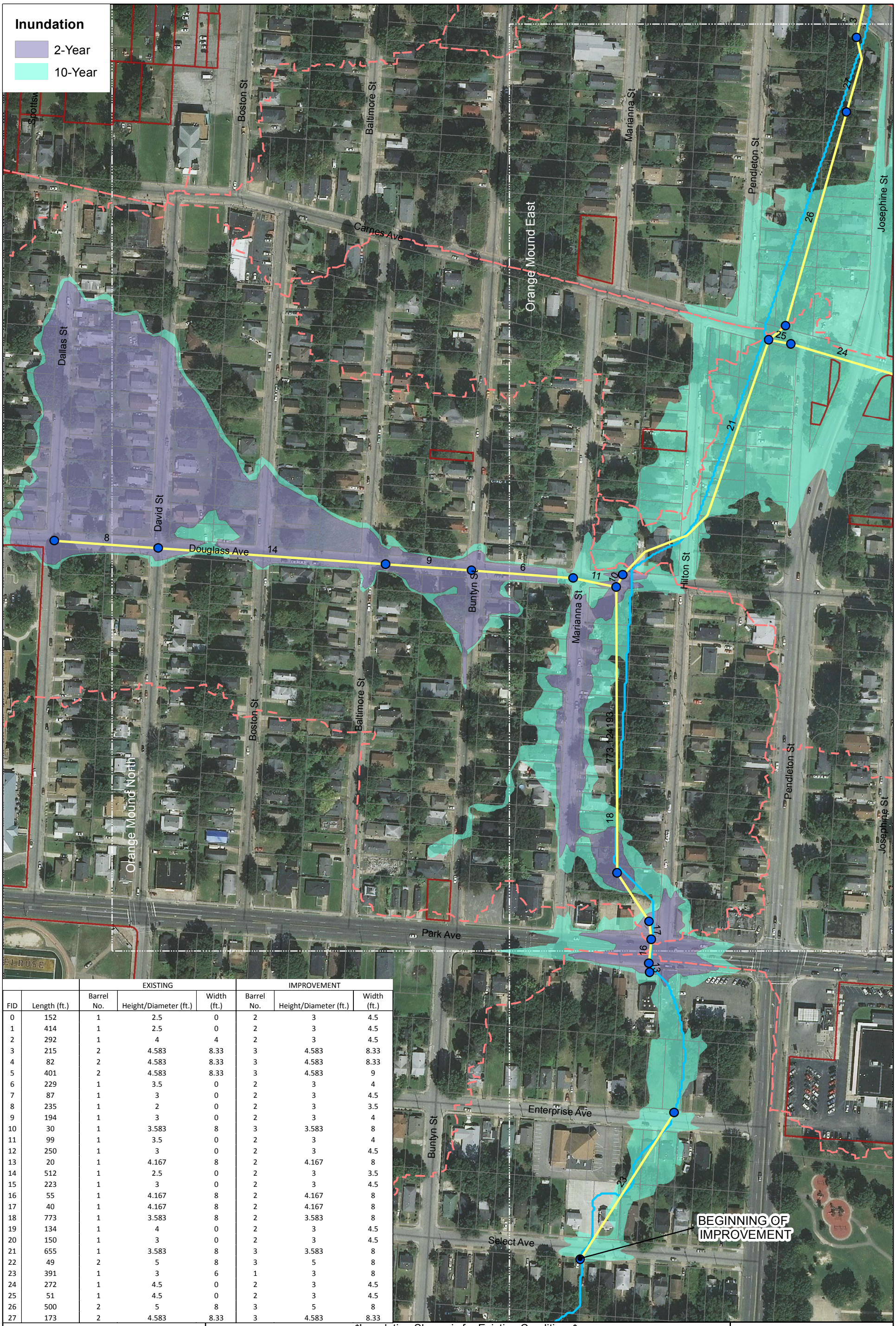
Legend

- Storm Drainage Structure (TYP.)
- Orange Mound Improvements
- Cypress Creek Channel
- Subcatchments
- Government Owned Property
- Property Boundary

N

1 inch = 200 feet

Kimley»Horn



FID	Length (ft.)	EXISTING Barrel No.	EXISTING Height/Diameter (ft.)	EXISTING Width (ft.)	IMPROVEMENT Barrel No.	IMPROVEMENT Height/Diameter (ft.)	IMPROVEMENT Width (ft.)
0	152	1	2.5	0	2	3	4.5
1	414	1	2.5	0	2	3	4.5
2	292	1	4	4	2	3	4.5
3	215	2	4.583	8.33	3	4.583	8.33
4	82	2	4.583	8.33	3	4.583	8.33
5	401	2	4.583	8.33	3	4.583	9
6	229	1	3.5	0	2	3	4
7	87	1	3	0	2	3	4.5
8	235	1	2	0	2	3	3.5
9	194	1	3	0	2	3	4
10	30	1	3.583	8	3	3.583	8
11	99	1	3.5	0	2	3	4
12	250	1	3	0	2	3	4.5
13	20	1	4.167	8	2	4.167	8
14	512	1	2.5	0	2	3	3.5
15	223	1	3	0	2	3	4.5
16	55	1	4.167	8	2	4.167	8
17	40	1	4.167	8	2	4.167	8
18	773	1	3.583	8	2	3.583	8
19	134	1	4	0	2	3	4.5
20	150	1	3	0	2	3	4.5
21	655	1	3.583	8	3	3.583	8
22	49	2	5	8	3	5	8
23	391	1	3	6	1	3	8
24	272	1	4.5	0	2	3	4.5
25	51	1	4.5	0	2	3	4.5
26	500	2	5	8	3	5	8
27	173	2	4.583	8.33	3	4.583	8.33

Inundation Shown is for Existing Conditions

Figure 6B:
Orange Mound South Improvement Alternative

Memphis, TN
August 2015

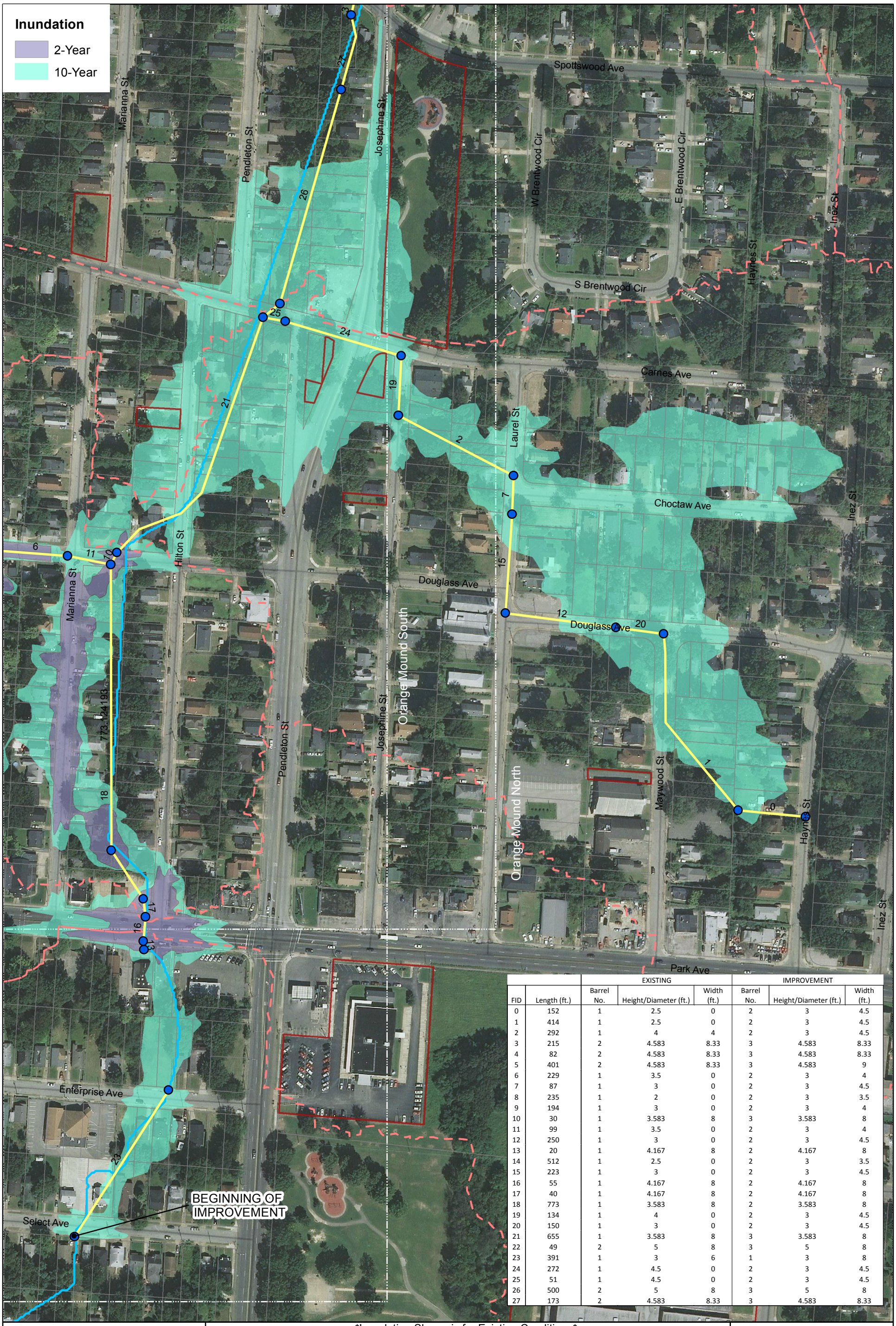
Legend

- Storm Drainage Structure (TYP.)
- Orange Mound Improvements
- Cypress Creek Channel
- Subcatchments
- Government Owned Property
- Property Boundary

N

1 inch = 200 feet

Kimley»Horn



FID	Length (ft.)	EXISTING Barrel No.	EXISTING Height/Diameter (ft.)	EXISTING Width (ft.)	IMPROVEMENT Barrel No.	IMPROVEMENT Height/Diameter (ft.)	IMPROVEMENT Width (ft.)
0	152	1	2.5	0	2	3	4.5
1	414	1	2.5	0	2	3	4.5
2	292	1	4	4	2	3	4.5
3	215	2	4.583	8.33	3	4.583	8.33
4	82	2	4.583	8.33	3	4.583	8.33
5	401	2	4.583	8.33	3	4.583	9
6	229	1	3.5	0	2	3	4
7	87	1	3	0	2	3	4.5
8	235	1	2	0	2	3	3.5
9	194	1	3	0	2	3	4
10	30	1	3.583	8	3	3.583	8
11	99	1	3.5	0	2	3	4
12	250	1	3	0	2	3	4.5
13	20	1	4.167	8	2	4.167	8
14	512	1	2.5	0	2	3	3.5
15	223	1	3	0	2	3	4.5
16	55	1	4.167	8	2	4.167	8
17	40	1	4.167	8	2	4.167	8
18	773	1	3.583	8	2	3.583	8
19	134	1	4	0	2	3	4.5
20	150	1	3	0	2	3	4.5
21	655	1	3.583	8	3	3.583	8
22	49	2	5	8	3	5	8
23	391	1	3	6	1	3	8
24	272	1	4.5	0	2	3	4.5
25	51	1	4.5	0	2	3	4.5
26	500	2	5	8	3	5	8
27	173	2	4.583	8.33	3	4.583	8.33

Figure 6C:
Orange Mound East Improvement Alternative
Memphis, TN
August 2015

Inundation Shown is for Existing Conditions

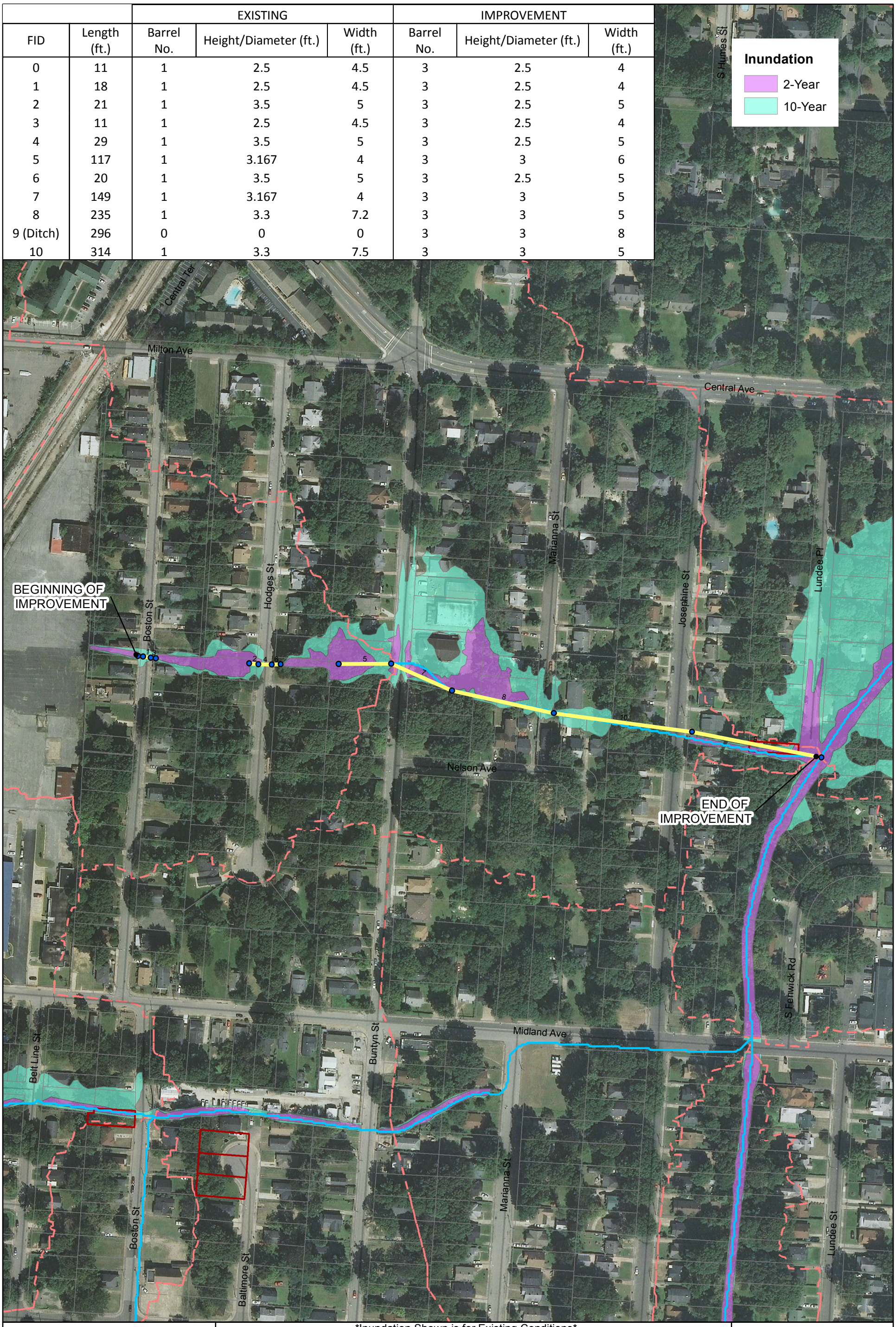
Legend
- Storm Drainage Structure (TYP.)
- Orange Mound Improvements
- Cypress Creek Channel
- Subcatchments
- Government Owned Property
- Property Boundary

N

1 inch = 200 feet

Kimley»Horn

		EXISTING			IMPROVEMENT		
FID	Length (ft.)	Barrel No.	Height/Diameter (ft.)	Width (ft.)	Barrel No.	Height/Diameter (ft.)	Width (ft.)
0	11	1	2.5	4.5	3	2.5	4
1	18	1	2.5	4.5	3	2.5	4
2	21	1	3.5	5	3	2.5	5
3	11	1	2.5	4.5	3	2.5	4
4	29	1	3.5	5	3	2.5	5
5	117	1	3.167	4	3	3	6
6	20	1	3.5	5	3	2.5	5
7	149	1	3.167	4	3	3	5
8	235	1	3.3	7.2	3	3	5
9 (Ditch)	296	0	0	0	3	3	8
10	314	1	3.3	7.5	3	3	5



Inundation Shown is for Existing Conditions

Figure 7:
Belt Line Improvement Alternative
Memphis, TN
August 2015

Legend

- Storm Drainage Structure (TYP.)
- Belt Line Improvements
- Cypress Creek Channel
- Government Owned Property
- Subcatchments
- Property Boundary

N

1 inch = 200 feet

Kimley»Horn

APPENDIX B:

PUBLIC INVOLVEMENT MATERIALS

Stormwater

CITY OF MEMPHIS STORMWATER PROJECT

COMMERCIAL FLOODING SURVEY

The Kimley-Horn & Associates, Inc. has been contracted by the City of Memphis to assist in a study of the effects of stormwater flooding in Memphis communities. The information you provide will be important in future plans to help resolve the flooding issues in your area. Thank you for your participation.

Business Name _____

Business Address _____

Contact Name_____

Contact's Email Address _____

Phone _____

1. How long has the business operated at this location? _____
2. Have you ever experienced any flooding at this location? Y N When _____

   How severe? 1"-6" deep _____ 6"-12" deep _____ More than 12" deep _____
3. How many buildings on this property have flooded? _____
4. Have yards on the property flooded? Y N

		How Deep	How Often	Date of Last Occurrence
Basement or first floor?	Y N	_____	_____	_____
Other?	Y N	_____	_____	_____

   Describe location of "other": _____
   _____
5. What was the level of water at its highest on your property? _____ When did this occur? _____
6. Has the flooding gotten worse or better over the years? WORSE BETTER
7. When the street floods, does water flow in the street or just stand? How long after a storm does the water linger? Describe location of street flooding (i.e., street address, intersection, etc.) _____
   _____
8. Have you ever had water run the first floor/basement, and if so could you tell if it was sanitary sewer or stormwater? Please provide description and how often. _____
   _____
9. Do you have any photos of flooding you would like to share with the study? Y N
10. Do you know of a high water mark we could observe? Y N
11. What is the best time to call to discuss this project with you? _____

YOUR INPUT IS GREATLY APPRECIATED AND NEEDED TO ASSIST US TO DO THE MOST GOOD WITH THIS PROJECT.

For more information about this project contact:
Harvey W. Matheny, P.E.
Kimley-Horn and Associates, Inc.
6625 Lenox Park Drive, Suite 117, Memphis, TN 38115
901.374-9109
CypressCreek@kimley-horn.com

* PLEASE MAKE SURE WE HAVE YOUR EMAIL ADDRESS IF YOU'D LIKE TO BE NOTIFIED ABOUT FUTURE MEETINGS AND PROJECT UPDATES AS THEY OCCUR.

City of Memphis

WE NEED YOUR INPUT ABOUT CYPRESS CREEK!

The City of Memphis, through its Stormwater Infrastructure Mapping & Modeling program, has selected seven teams to study, map, and improve the drainage infrastructure across the City of Memphis.

Although the drainage design standards have been continuously improved over the years, much of the infrastructure has not been improved to properly characterize the stormwater runoff and flooding potential. The result is numerous areas with repetitive flooding problems affecting roadways and structures, particularly in older areas of the City.

There will be a series of community meetings in Cypress Creek Basin area. The eventual goal is to study the drainage basin and undertake projects in the basin to mitigate the impacts of future storm events on the public infrastructure and private property. Join us Wednesday, May 7th at 6 p.m. at the Central Library as we begin this multi-year study. We need your input!

Who: **The City of Memphis**

What: **To discuss the Cypress Creek Basin**

When: **Wednesday, May 7, 2014 @ 6 p.m.**

Where: **The Benjamin Hooks Central Library**
3030 Poplar Avenue
Memphis, TN 38111

Please RSVP to rhjones@cmgpr.com .

City of Memphis

WE NEED YOUR INPUT ON THE CYPRESS CREEK BASIN DRAINAGE!

The City of Memphis, through its *Stormwater Infrastructure Mapping & Modeling* program, has selected seven teams to study, map, and improve the drainage infrastructure across the City of Memphis.

Although the drainage design standards have been continuously improved over the years, much of the infrastructure has not been improved to properly characterize the stormwater runoff and flooding potential. The result is numerous areas with repetitive flooding problems affecting roadways and structures, particularly in older areas of the City.

There will be a series of community meetings in the Cypress Creek Basin area. The eventual goal is to study the drainage basin and undertake projects in the basin to mitigate the impacts of future storm events on the public infrastructure and private property.

If stormwater runoff and flooding is a concern in your neighborhood, please attend our community meeting. We need your input!

Tuesday, May 13, 2014
Orange Mound Community Center
2572 Park, 38114
6pm – 7:30pm

Monday, May 19, 2014
First Baptist Church
2835 Broad, 38112
6pm – 7:30pm

Thursday, May 22, 2014
Hollywood Community Center
1560 N. Hollywood, 38108
5:30pm – 6:45pm

Please RSVP to rhjones@cmgpr.com

APPENDIX C:

PRELIMINARY PLANNING COST INFORMATION

Kimley»Horn
6625 Lenox Park Dr, STE 117
Memphis, TN 38115

CLIENT	City of Memphis
JOB	Cypress Creek Drainage Master Plan
Alternative Scenario	Tillman Police Station Improvement Alternative

Description	Units	Total Quantity	Unit Price	Total Cost
CONCRETE PIPE (30")	L.F.	2,025	$70.00	$141,750
SPECIAL STRUCTURE - CURB INLET	EA	1	$35,000.00	$35,000
SPECIAL STRUCTURE - INLET	EA	2	$35,000.00	$70,000
SAWCUT (CONCRETE)	L.F.	675	$2.00	$1,350
PATCHING (CONCRETE)	S.Y.	1,125	$65.00	$73,125
TIE TO EXISTING CHANNEL (CONCRETE)	EA	1	$5,000.00	$5,000
EXCAVATION AND HAUL-OFF	C.Y.	200	$40.00	$8,000
EROSION CONTROL	EA	1	$10,000.00	$10,000
TRAFFIC CONTROL	EA	1	$10,000.00	$10,000
DESIGN FEES	EA	1	$50,000.00	$50,000
		TOTAL		$404,225
		CONSTRUCTION CONTIGENCY	10%	$40,423
		GRAND TOTAL		$444,648

Kimley»Horn
6625 Lenox Park Dr, STE 117
Memphis, TN 38115

CLIENT	City of Memphis
JOB	Cypress Creek Drainage Master Plan
Alternative Scenario	Orange Mound Neighborhood Improvement Alternative

Description	Units	Total Quantity	Unit Price	Total Cost
BOX CULVERT (3' x 4')	L.F.	3,807	$256.00	$974,592
BOX CULVERT (3' x 5')	L.F.	4,050	$290.00	$1,174,500
BOX CULVERT (3' x 8')	L.F.	391	$470.00	$183,770
BOX CULVERT (4' x 8')	L.F.	3,831	$495.00	$1,896,345
BOX CULVERT (5' x 8')	L.F.	1,557	$565.00	$879,705
BOX CULVERT (5' x 9')	L.F.	1,203	$675.00	$812,025
EXCAVATION AND HAUL-OFF	S.Y.	930	$40.00	$37,200
STREET CUT (ASPHALT)	S.Y.	3,720	$1.50	$5,580
SPECIAL STRUCTURE	EA	10	$35,000.00	$350,000
DMH (4'-6')	EA	10	$3,500.00	$35,000
CURB & GUTTER REMOVE/REPLACE	L.F.	55	$23.00	$1,265
SIDEWALK REMOVE/REPLACE	L.F.	55	$28.00	$1,540
TREE REMOVAL	EA	14	$1,500.00	$21,000
EROSION CONTROL	EA	1	$10,000.00	$10,000
TRAFFIC CONTROL	EA	1	$10,000.00	$10,000
DESIGN FEES	EA	1	$600,000.00	$600,000
		TOTAL		$6,992,522
		CONSTRUCTION CONTIGENCY	10%	$699,252
		GRAND TOTAL		$7,691,774

Kimley»Horn
6625 Lenox Park Dr, STE 117
Memphis, TN 38115

CLIENT	City of Memphis
JOB	Cypress Creek Drainage Master Plan
Alternative Scenario	Belt Line Neighborhood Improvement Alternative

Description	Units	Total Quantity	Unit Price	Total Cost
BOX CULVERT (3' x 4')	L.F.	120	$256.00	$30,720
BOX CULVERT (3' x 5')	L.F.	2,244	$266.00	$596,904
BOX CULVERT (3' x 6')	L.F.	351	$304.00	$106,704
BOX CULVERT (3' x 8')	L.F.	888	$382.00	$339,216
PATCHING (ASPHALT)	S.Y.	320	$25.00	$8,000
TIE TO EXISTING CHANNEL (CONCRETE)	EA	1	$5,000.00	$5,000
EXCAVATION AND HAUL-OFF	C.Y.	80	$40.00	$3,200
STREET CUT (ASPHALT)	S.Y.	320	$1.50	$480
SPECIAL STRUCTURE - INLET	EA	1	$35,000.00	$35,000
SPECIAL STRUCTURE - CURB INLET	EA	5	$35,000.00	$175,000
CURB & GUTTER REMOVE/REPLACE	L.F.	50	$23.00	$1,150
SIDEWALK REMOVE/REPLACE	L.F.	40	$28.00	$1,120
TREE REMOVAL	EA	10	$1,500.00	$15,000
DMH (4'-6')	EA	1	$3,500.00	$3,500
EROSION CONTROL	EA	1	$10,000.00	$10,000
TRAFFIC CONTROL	EA	1	$10,000.00	$10,000
DESIGN FEES	EA	1	$150,000.00	$150,000
		TOTAL		$1,490,994
	CONSTRUCTION CONTIGENCY		10%	$149,099
		GRAND TOTAL		$1,640,093