

Dec-29-2023

# Boomer Creek Master Drainage Plan

The City of Stillwater

December 2023

Prepared by Meshek & Associates, LLC

**MESHEK**  
& ASSOCIATES, LLC

CA 1487 – June 30<sup>th</sup>, 2025

The City of  
*Stillwater*  
OKLAHOMA

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## SECTION 1. EXECUTIVE SUMMARY

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### 1.1 INTRODUCTION

In March of 2021, The City of Stillwater (City) requested that Meshek & Associates, LLC (Meshek) conduct a master drainage plan (MDP) of the Boomer Creek watershed to identify and catalog potential solutions to re-occurring flooding problems that plague this watershed. The primary study area is from W. Burris Road to E. 19<sup>th</sup> Avenue and between S. Jardot Road and S. Washington Street. The City and County jurisdictional border runs through the area. The project location can be seen in **Figure 1-1**.

Flow rates are generated for the 99.9% (1-year), 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), and 0.2% (500-year) annual chance storms under existing land use conditions. This study establishes existing conditions of 1% and 0.2% annual chance floodplains for the Boomer Creek watershed. Eighteen problem areas were identified based on the City's comments and modeling results. Multiple alternatives were considered for each problem area. Alternative descriptions, layout figures, and cost estimates are provided in **SECTION 4**, **SECTION 5**, and **SECTION 6** for Lower Boomer Creek, East Boomer Creek, and West Boomer Creek respectively.

### 1.2 PURPOSE

The Boomer Creek watershed MDP gives the City of Stillwater several beneficial tools for managing existing infrastructure and planning for future improvements. Foremost, the master plan provides unique conceptual solutions to the flooding problems identified in the Boomer Creek watershed. The components of the conceptual solutions could be applied as written, or several individual components of separate solutions could be combined depending on future requirements. Second, the study provides a set of hydraulic models on West Boomer Creek, East Boomer Creek, and Boomer Creek for the FEMA model and mapping updates upon submittal and approval. The hydraulic model includes additional streams for City regulatory mapping. The hydraulic model of the streams can be used by City staff, developers, and consulting engineers in the analysis of flood risk, development, or infrastructure improvements.

The public needs to understand the negative impacts a flooding event has on safety and emergency response. All streams, creeks, or rivers, at an indefinite point in the future, will flood due to flows greater than the capacity of the channel or a storm sewer system. Large flows are a result of a combination of storm rainfall intensity and depth, or a sudden dam breach. Drowning or injury hazards arise when development is located within flood-prone areas. When a flood overtops a roadway, even when only inches in depth, the flow may have the capacity to lift and wash any vehicle off the roadway or carry it downstream. The same flood overtopping a roadway may also have the capacity to cut out the roadway pavement, soil

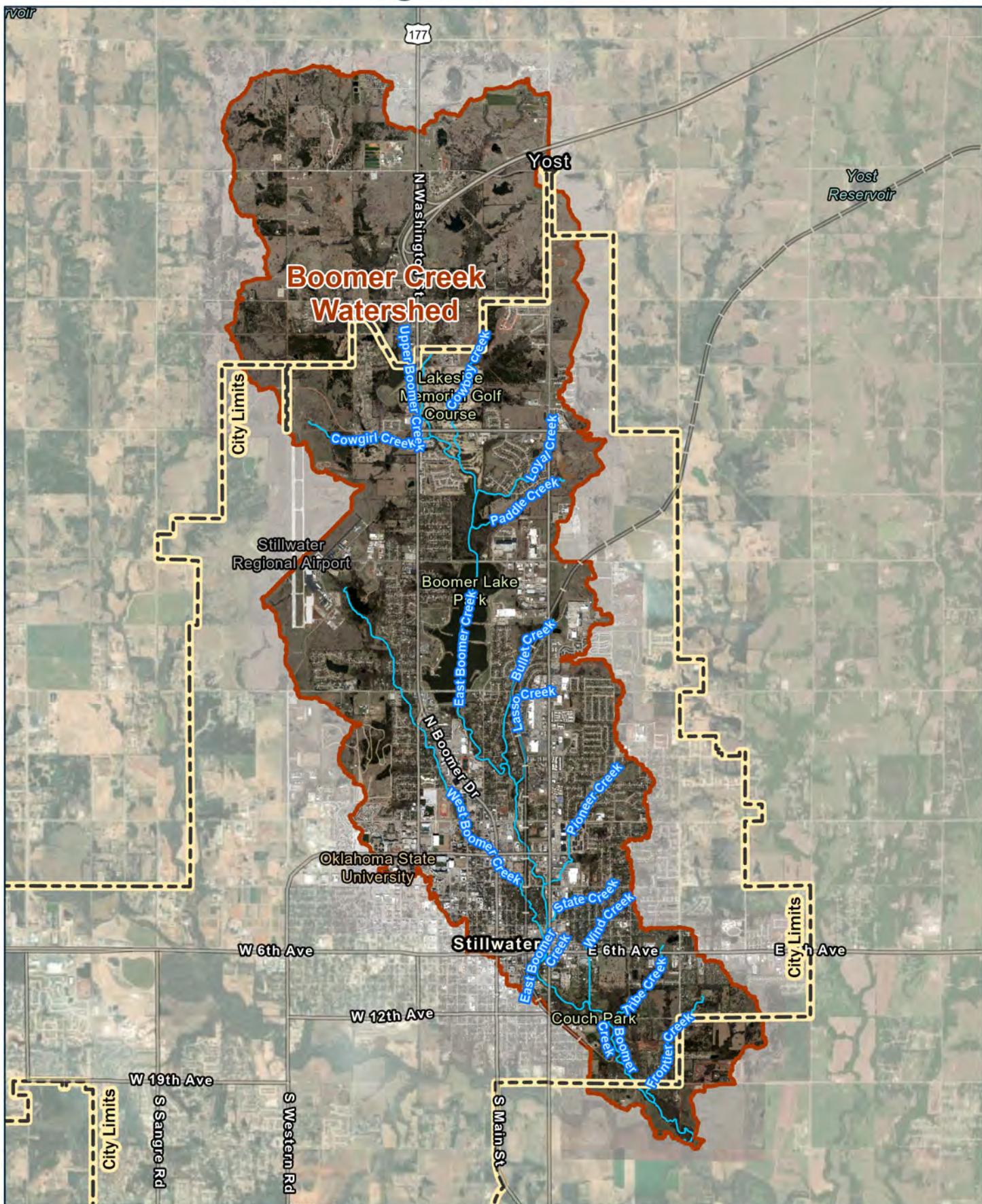
## **Boomer Creek Master Drainage Plan**

**City of Stillwater**

embankment, or the hydraulic structure; all while the damage remains hidden beneath the water surface. Meshek & Associates wants the public to understand the risk of injury and loss of life hazards from flooding through supporting the ‘Turn Around Don’t Drown’ initiative. This conveys the idea of seeking an alternate route or staying on high ground, rather than attempting to pass through a flooded area. Roadway gutters, ditches, culverts, storm sewer systems, and detention ponds are other man-made systems designed to convey stormwater. These systems pose a risk of drowning or injury to people or animals when they are discharging any amount of stormwater.

# Boomer Creek Master Drainage Plan

0 0.5 1 Miles



**Location Map**

### 1.3 SUMMARY OF RECOMMENDATIONS

This section summarizes the recommendations for all problem areas. **Figure 1-3: Problem Areas Map** shows the location of each problem area. A detailed map of the problem area alternatives for Lower Boomer Creek, East Boomer Creek, and West Boomer Creek can be found in **SECTION 4**, **SECTION 5**, and **SECTION 6** respectively. **Table 1-1** summarizes the cost estimates for the recommendations. Detailed cost estimates for all alternatives are in **Appendix G**.

A total of 18 improvement projects were recommended to address flooding problems throughout the Boomer Creek watershed within the City of Stillwater based on the hydrologic and hydraulic analyses conducted during the MDP. The overall cost of implementing all recommendations outlined in this report is approximately \$56,373,000. The priority assessment for each of the flooding problem areas and associated improvement projects was determined through several objective scoring criteria. Examples of the criteria for scoring and ranking; does the flooding problem have documented death, or serious injury; and does the improvement aid emergency route access. The prioritization table is located after the **Boomer Creek Watershed General Solutions**.

State or Federal grant programs provide funding opportunities to assist the City in implementing one or more of the recommended solutions. However, these grant programs are highly competitive in nature and require certain qualifiers, such as a Benefit-Cost Analysis (BCA) finding of 1.0 or greater. Additional research will be required to make a BCA determination for grant application purposes.

The City of Stillwater participates in two of the Federal Emergency Management Agency's (FEMA) most notable Floodplain Management programs; the National Flood Insurance Program (NFIP) and the Community Rating System (CRS). As an NFIP participating community, residents and business owners in the City can purchase affordable flood insurance policies, and the City is eligible for flood-related disaster assistance if needed. NFIP participation also enables the City to compete for state and federal grant funding as programs become available. Being recognized as a CRS community means the City of Stillwater is engaging in floodplain management practices that exceed the minimum requirements to participate in the NFIP which further reduces the premium cost of flood insurance premiums for residents and business owners. The City currently has a CRS rating of 7 which allows for an additional 15% reduction in the cost of flood insurance premiums.

## BOOMER CREEK WATERSHED GENERAL SOLUTIONS

To assist the City of Stillwater with resolving flooding issues in the Boomer Creek watershed, this MDP has developed various solutions for specific flood problems. Many of the flood problems and solutions have a repetitious or general theme. The following is a list of general watershed-wide flooding solutions that repeatedly arose:

**Solution - Provide Detention & Floodplain Storage:** Additional detention or floodplain storage volume has a significant effect on mitigating the impacts of flooding. Within the City limits, much of the Boomer Creek watershed is already developed, limiting the amount of land available for constructing new detention or floodplain storage facilities. Therefore, it is important to make use of any available space for new flood mitigation facilities.

**Solution - Encourage Low-Impact Development:** Encourage or incentivize property owners and developers to install low-impact development (LID) based on the City of Stillwater Engineering Design Guidelines for Stormwater Management manual. If enough properties use rain barrels, rain gardens, or other features to detain or infiltrate stormwater, peak levels of stormwater runoff for the more frequent events could be reduced.

**Solution - Acquire Flood Prone Properties & Restore Streams:** Acquisition of flood prone structures immediately eliminates those structures from flooding risk. Once a structure is removed, the property could also be modified to provide additional floodplain volume storage through excavation. If an acquired property had encroached on the stream channel or overbank, stream restoration could be implemented to restore the natural stream, resulting in reduced pollutant/sediment loading and improved riparian habitat.

**Solution - Improve Stormwater Infrastructure:** Many bridges, culverts, and storm sewer systems have inadequate capacity to convey stormwater runoff and create flooding on roadways beyond the City's design standards. Improving the stormwater infrastructure systems will reduce the amount of roadway flooding and improve roadway safety in the community. When roads are impassable, it not only impacts the citizens that live in the area, but also any emergency vehicles that may need access to the area.

**Solution - Recommended Master Plan Solutions:** It is recommended that the City of Stillwater address the stormwater flooding problem areas, described in this [\*\*2023 Master Plan\*\*](#), through the execution of recommended solutions described within the Master Drainage Planning section of the report, **SECTION 4**, **SECTION 5**, and **SECTION 6** for Lower Boomer Creek, East Boomer Creek, and West Boomer Creek respectively.

**PRIORITIZATION OF RECOMMENDED IMPROVEMENT PROJECTS**

**City of Stillwater  
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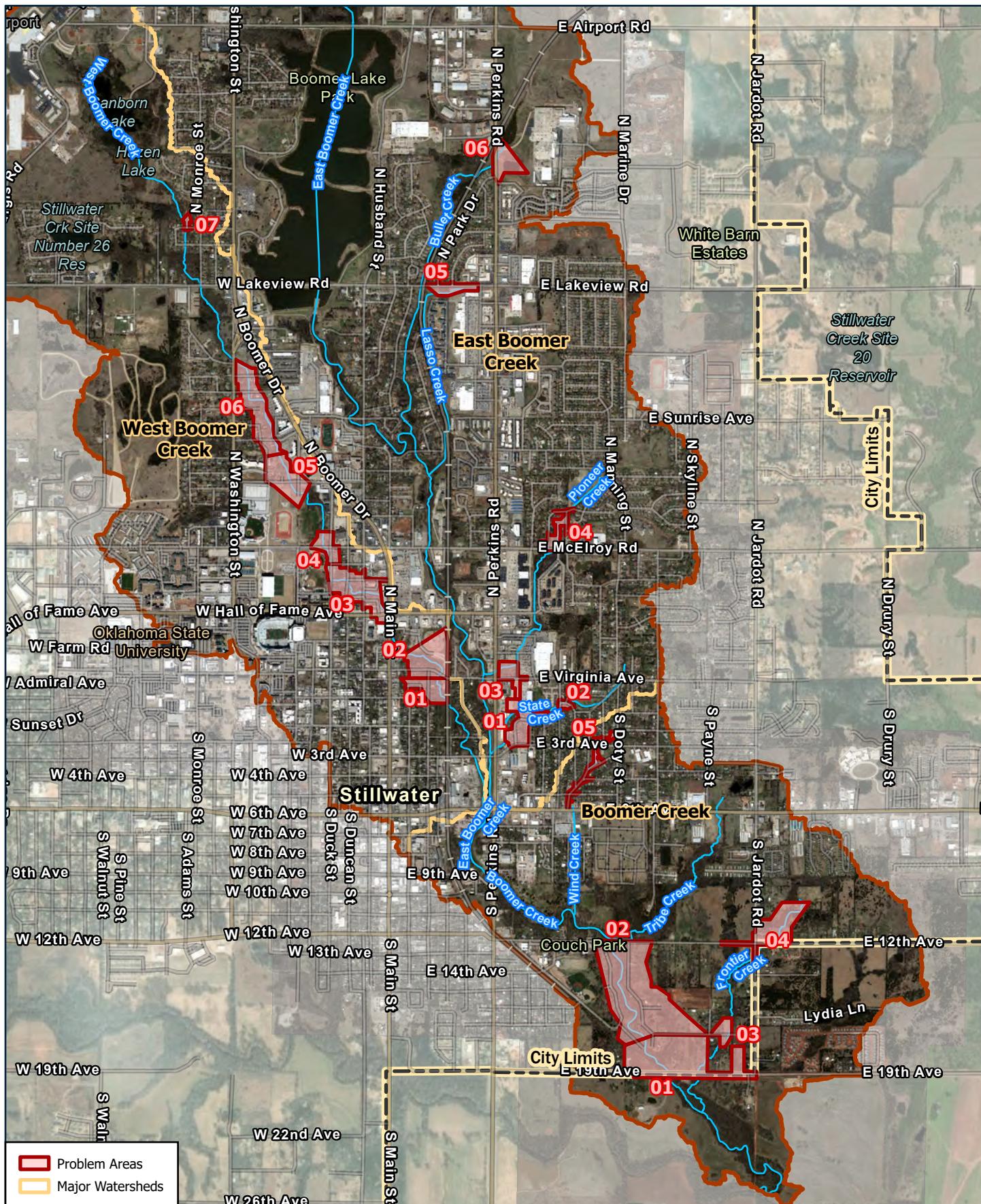
Priority	MDP Section & Basin	Problem Area	Project Description	Cost	Score
1	Section 5 - East Boomer Creek	Problem Area 06	Culvert Crossing and Drainage Ditch Improvements for Bullet Creek on the upstream side of N. Perkins Road	\$ 77,000	78.8
2	Section 6 - West Boomer Creek	Problem Area 01	Increase Floodplain Storage for West Boomer Creek south of E. Virginia Avenue and east of S. Lowry Street	\$ 1,877,000	70.0
3	Section 6 - West Boomer Creek	Problem Area 06	Property Acquisition and Relocation downstream of N. Washington Street and along W. Bennett Drive	\$ 4,812,000	68.9
4	Section 6 - West Boomer Creek	Problem Area 07	Property Acquisition and Relocation along W. Liberty Avenue	\$ 205,000	68.6
5	Section 6 - West Boomer Creek	Problem Area 03	Increase Floodplain Storage between N. Duck Street and N. Main Street	\$ 5,768,000	67.9
6	Section 5 - East Boomer Creek	Problem Area 05	Elevate an existing Berm, Increase Floodplain Storage, and add underground storage along Lasso Creek	\$ 3,322,000	66.9
7	Section 4 - Lower Boomer Creek	Problem Area 05	Detention Pond within Arrington Park and New Storm Sewer along S. Doty Street	\$ 1,699,000	65.3
8	Section 5 - East Boomer Creek	Problem Area 01	Detention Pond Expansion along State Creek just north of intersection with E. Maple Avenue and S. Dryden Street	\$ 2,265,000	63.0
9	Section 6 - West Boomer Creek	Problem Area 04	Culvert Crossing under W. McElroy Road and N. Duck Street with Roadway Improvements	\$ 4,131,000	61.9
10	Section 4 - Lower Boomer Creek	Problem Area 04	Detention Pond upstream of E. 12th Avenue and east of S. Jardot Road	\$ 4,965,000	58.9
11	Section 4 - Lower Boomer Creek	Problem Area 03	Culvert Crossing for Frontier Creek at E. 17th Avenue	\$ 674,000	58.4
12	Section 5 - East Boomer Creek	Problem Area 02	Detention Pond within Berry Park and New Storm Sewer along S. Berry Street	\$ 1,331,000	55.9
13	Section 5 - East Boomer Creek	Problem Area 04	(2) New Detention Facilities and Storm Sewer Improvements on E. McElroy Road and N. Burdick Street	\$ 5,785,000	54.9
14	Section 6 - West Boomer Creek	Problem Area 02	E. Virginia Avenue Roadway Improvement and Increase Floodplain Storage	\$ 6,972,000	52.9
15	Section 3 - West Boomer Creek	Problem Area 05	Property Acquisition and Relocation along W. Eskridge Avenue	\$ 1,442,000	48.9
16	Section 4 - Lower Boomer Creek	Problem Area 01	Property Acquisition and Relocation downstream of E. 12th Avenue and along E. 19th Avenue	\$ 2,394,000	48.9
17	Section 4 - Lower Boomer Creek	Problem Area 02	Property Acquisition and Relocation downstream of E. 12th Avenue and along S. Ransom Drive	\$ 1,082,000	43.0
18	Section 5 - East Boomer Creek	Problem Area 03	Increase Floodplain Storage for Pioneer Creek north of E. Virginia Avenue and east of N. Perkins Road	\$ 7,572,000	41.9

Total \$ 56,373,000



# Boomer Creek Master Drainage Plan

0 0.25 0.5 Miles



## Problem Areas

# Boomer Creek Master Drainage Plan

City of Stillwater

**Table 1-1: Cost Estimate Summary**

Problem Area #	Problem Description	Recommendation	Total Cost (\$)
<b>Lower Boomer Creek Watershed</b>			
Problem Area 01: Boomer Creek (01)	Residential and Roadway Flooding along E. 19 <sup>th</sup> Avenue	Property Acquisition & Relocation	\$2,394,000
Problem Area 02: Boomer Creek (02)	Residential and Roadway Flooding along E. 12 <sup>th</sup> Avenue	Property Acquisition & Relocation	\$1,082,000
Problem Area 03: Frontier Creek (01)	Roadway Flooding along E. 17 <sup>th</sup> Avenue	1% AEP Design of Roadway & Culvert Improvements	\$674,000
Problem Area 04: Frontier Creek (02)	Roadway Flooding along E. 12 <sup>th</sup> Avenue and S. Jardot Road	1% AEP Dam Design & Increase Floodplain Storage	\$4,965,000
Problem Area 05: Wind Creek (01)	Residential and Roadway Flooding along E. 3 <sup>rd</sup> Avenue and S. Doty Street	1% AEP Detention Pond with a New Storm Sewer System	\$1,699,000
		<b>Total Cost Boomer Creek Watershed</b>	<b>\$10,814,000</b>
<b>East Boomer Creek Watershed</b>			
Problem Area 01: State Creek (01)	Residential and Roadway Flooding along E. Maple Avenue	Increase Floodplain Storage	\$2,265,000
Problem Area 02: State Creek (02)	Residential and Roadway Flooding along S. Burdick Street and S. Berry Street	1% AEP Detention Pond Design & Storm Sewer System	\$1,331,000
Problem Area 03: Pioneer Creek (01)	Roadway Flooding along E. Virginia Avenue	Increase Floodplain Storage	\$7,572,000

## Boomer Creek Master Drainage Plan

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Problem Area #	Problem Description	Recommendation	Total Cost (\$)
Problem Area 04: Pioneer Creek (02)	Residential and Roadway Flooding along E. McElroy Road and N. Burdick Street	Construct a 1% AEP Design Detention Pond & Inline Structure, replaced Storm Sewer System	\$5,785,000
Problem Area 05: Lasso Creek (1)	Roadway Flooding along E. Lakeview Road	Improve Berm & add Floodplain Storage	\$3,322,000
Problem Area 06: Bullet Creek (1)	Roadway Flooding along N. Perkins Road	Improve Drainage Ditch Capacity with Trickle Channel to a 2% AEP Design	\$77,000
		Total Cost East Boomer Creek Watershed	\$20,352,000

### West Boomer Creek Watershed

Problem Area 01: West Boomer Creek	Residential and Roadway Flooding along E. Virginia Avenue and S. Lowry Street	1% Annual Chance Design Floodplain Storage & Property Acquisition	\$1,877,000
Problem Area 02: West Boomer Creek	Roadway Flooding along E. Virginia Avenue	1% Annual Chance Roadway Design & Floodplain Storage with Property Acquisition	\$6,972,000
Problem Area 03: West Boomer Creek	Residential and Roadway Flooding between N. Duck Street and N. Main Street	1% Annual Chance Design Floodplain Storage & Property Acquisition	\$5,768,000
Problem Area 04: West Boomer Creek	Roadway Flooding along W. McElroy Road	1% Annual Chance Design of Roadway & Culvert Improvements	\$4,131,000
Problem Area 05: West Boomer Creek	Residential and Roadway Flooding along W. Eskridge Avenue	Property Acquisition & Relocation	\$1,442,000

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Problem Area #	Problem Description	Recommendation	Total Cost (\$)
<b>West Boomer Creek Watershed</b>			
Problem Area 06: West Boomer Creek	Residential and Roadway Flooding between N. Washington Street and W. Bennett Drive	Property Acquisition & Relocation	\$4,812,000
Problem Area 07: West Boomer Creek	Residential and Roadway Flooding along W. Liberty Avenue	Property Acquisition & Relocation	\$205,000
		Total Cost West Boomer Creek Watershed	\$25,207,000
		<i>Grand Total</i>	<b>\$56,373,000</b>

## SECTION 2. METHODOLOGY

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### 2.1 HYDROLOGIC METHODOLOGY

Hydrologic infiltration and runoff modeling of the watershed was performed using the Natural Resource Conservation Service (NRCS-formerly Soil Conservation Service) Unit Curve Number method within HEC-HMS, v4.5, to transform excess rainfall runoff into unit hydrographs with various hydrologic coefficients. HEC-HMS was used to generate runoff hydrographs at each sub-basin outlet. The peak flow rates at basin downstream boundaries or stream confluence junctions in the HEC-HMS model were used at flow change locations within HEC-RAS. 1-Dimensional (1-D) & 2-Dimensional (2-D) HEC-RAS hydraulic models were used to route the runoff from each sub-basin throughout the watershed. The HEC-HMS and HEC-RAS program files were submitted to The City of Stillwater as part of the overall deliverable.

The HEC-HMS model calculated hydrographs that indicate peak discharge flow rates for probability profiles ranging from 99.9% annual chance (1-year) to 0.2% annual chance (500-year) floods for existing and urbanized conditions. A schematic of the HEC-HMS elements can be found in **Appendix C**.

The following assumptions were incorporated into the hydrologic modeling process:

- ❖ Subdivision of Drainage Basins: Major drainage areas were subdivided based on the homogeneity of the watershed and the need to define flow rates for hydraulic analysis at various points within the basins. The sub-basin boundaries for each watershed were determined using the available Digital Elevation Models (DEM). The sub-basins range from approximately 3 to 413 acres. A total of 276 sub-basins were delineated. The sub-basins all flow to one offsite location; the confluence with the main stem of Stillwater Creek located roughly 2,330 feet south of S. Jardot Rd and E. 19<sup>th</sup> Ave. The confluence is approximately 4,700 stream-feet downstream of E. 19<sup>th</sup> Ave. The sub-basins can be seen in **Figure 2-1**
- ❖ Time of Concentration (TOC): For the HEC-HMS model, a lag time for peak runoff to concentrate was developed for each sub-basin based on the longest flow path of the sub-basin. The sub-basin lag time parameter is calculated as 60% of the total runoff travel time of concentration. The travel time of concentration for each basin is computed in three parts. First, overland (sheet) flow travels across upland areas before concentrated shallow or channel flows are formed. Second, concentrated shallow flow travels down swales, ditches, and gutters with shallow depths before the formation of channel flow. Overland and concentrated shallow flows, natural or paved, are calculated using the equations from the NRCS National Engineering Handbook (Chapter 15). The final segments of the sub-basin travel time calculation are singular or combination of storm sewer, channel flow, or wave celerity. The travel time for storm

sewer and channel flow is calculated based on the length of the reach and an assumed average velocity, a range between 6 and 8 feet per second (FPS) for storm sewer lines, and a range between 4 and 8 FPS for channel flow, respectively. The assumed value may be altered based on the slope or varied surface roughness. Travel time for wave celerity is calculated across bodies of water typically greater than  $\frac{1}{4}$  mile in travel length. The wave velocity assumes a depth of a water body  $C_w = \sqrt{gd_{Avg}}$ . Each flow path was drawn using the available topographic DEM. Flow path lengths did not continue through areas where smaller water bodies were visible, such as small ponds; instantaneous routing was assumed. All the flow lengths were calculated from the top of a sub-basin boundary to a sole sub-basin outlet, or the edge of a small pond if the sub-basin outlet was the dam of a pond.

- ❖ **Soil Type:** Infiltration rates were correlated to runoff potential based on the various soil types within the sub-basins. All soils have a hydrologic soil group (HSG) classification that indicates the relative amount of runoff that can be expected from a soil type. The four hydrologic soil groups are classified by the NRCS as follows:
  - **Group A** soils have a low runoff potential and high infiltration rate even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr.).
  - **Group B** soils have a moderate infiltration rate when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr.).
  - **Group C** soils have a low infiltration rate when thoroughly wetted and consist chiefly of soils with a layer that impedes the downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr.).
  - **Group D** soils have a high runoff potential. They have a very low infiltration rate when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious materials. These soils have a very low rate of water transmission (0-0.05 in/hr.).

**Curve Number:** The NRCS unit hydrograph method requires each modeled drainage area to have a unitless Curve Number (CN) to compute the amount of infiltration and runoff for a given depth of rainfall. Within each project sub-basin, homogeneous areas of HSG soils intersected with land use were assigned an individual unitless CN value referenced from the NRCS National Engineering Handbook (Chapter 9). A final composite CN for each project sub-basin was then generated by summarizing each of

the individual CN's within the basin's area. Two conditions were modeled. The first condition is existing land use, and the second condition is future urbanization land use. The existing land use was determined using aerial imagery flown by Aerial Data Service (ADS) in 2021. The urbanized condition considers urbanization development in the watershed based on the City's future development projection for 2030.

**Appendix A** contains a detailed table for existing and urbanized conditions with the weighted land use, the TOC lag calculations, and a summary of the hydrologic coefficients for each sub-basin. **Figure 2-2** shows the map of the hydrologic soil groups for the studied basin. **Figure 2-3** depicts existing land use delineations. Urbanized land use is shown in **Figure 2-4**.

- ❖ **Rainfall:** **Table 2-1:** Total Rainfall Depths for the City of Stillwater (Inches) shows the Annual rainfall depths for different time durations used in the hydrologic analyses. The rainfall data for the study is taken from NOAA Atlas 14 for the City of Stillwater. Design storms for the different frequencies were developed by entering the Intensity-Duration-Frequency (IDF) information from the following table.

**Table 2-1: Total Rainfall Depths for the City of Stillwater (Inches)**

Duration	Total Rainfall Depths for the City of Stillwater, Oklahoma - Inches							
	Frequency (Return Period)							
	1-year	2-year	5-year	10-year	25-year	50-year	100-year	500-year
5-minute	0.43	0.46	0.60	0.70	0.84	0.94	1.05	1.29
15-minute	0.76	0.83	1.07	1.25	1.50	1.68	1.87	2.30
1-hour	1.51	1.63	2.12	2.49	2.97	3.33	3.70	4.53
2-hour	1.88	2.04	2.64	3.10	3.71	4.17	4.62	5.68
3-hour	2.09	2.27	2.94	3.46	4.15	4.67	5.2	6.43
6-hour	2.45	2.65	3.43	4.05	4.89	5.55	6.23	7.87
12-hour	2.81	3.03	3.90	4.62	5.63	6.45	7.31	9.49
24-hour	3.20	3.44	4.42	5.24	6.43	7.41	8.47	11.2

From NOAA Atlas 14 Precipitation Frequency Estimates Website Stillwater station visited 2021

- ❖ **Hydrograph Development:** The NRCS Unit Hydrograph method was used to generate flow hydrographs at sub-basin outlets across each watershed. The storm runoff volume is calculated from a given total rainfall using the total rainfall values and the CN value described above. A storm duration of 48 hours was used for all hydrology models. Peak flow rates and hydrograph shape are determined based on experimental data developed by the NRCS. This method is described in Chapter 16, "Hydrographs" of the National Engineering Handbook, USDA, NRCS March 2007.

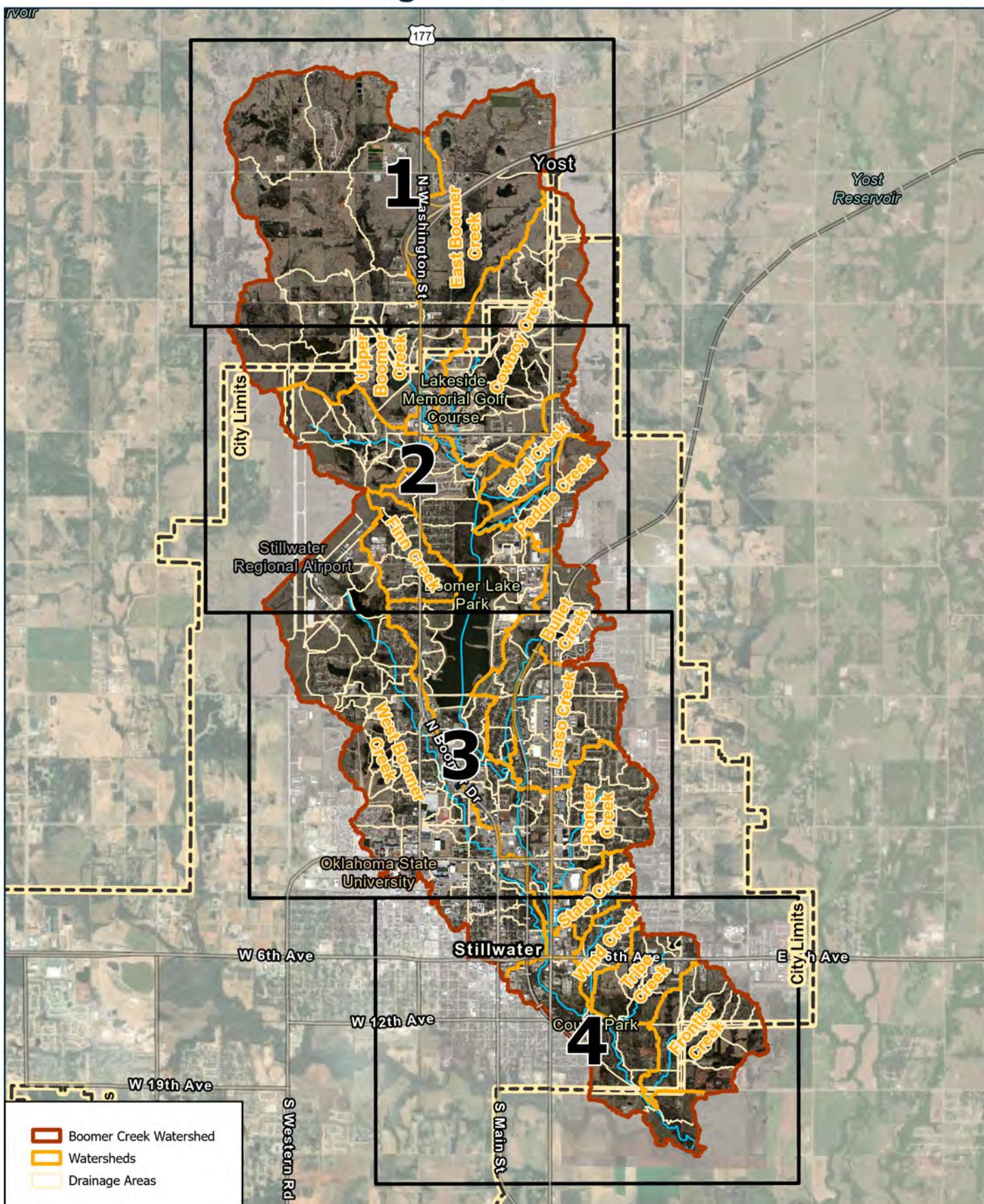
- ❖ Flow Diversion: During the analysis, there were two streams that overflowed the adjacent high ground which transferred water to an adjacent stream. A 2-D model was utilized for Lasso Creek to determine how much water was diverted into Bullet Creek. For frequencies greater than the 10% AEP (10-Year) a lateral weir was used to determine how much flow was diverted. For Loyal Creek, it was determined that flows greater than 150 cfs would be diverted into Paddle Creek. A diversion rating curve was utilized in the HMS model to reflect this condition.
- ❖ Storage Routing: Storage routing through the stream reaches was determined using the Modified Puls method within HEC-HMS. This method uses flow-storage curves based on HEC-RAS modeling for any reaches with hydraulic modeling. Discharge hydrographs were then routed from point to point through the hydrologic model for each reach to generate effective peak discharge flow rates for each reach and storm frequency. For this watershed, stream storage routing was done for the main stems of the studied streams. Lag times were used for all other reaches to account for timing.
- ❖ Existing Stormwater Detention Facilities: Storage discharge rating curves are the relation of the storage volumes and outlet discharge flow rates at various water surface elevations for a detention pond. Detention ponds and the associated storage discharge rating curves are added to the HEC-HMS model to account for pond storage volume and peak discharge timing. Forty-eight detention ponds were identified in the basin that have an impact on the flow results. These ponds had drainage areas greater than 20 acres or had an outlet structure that would significantly control the pond outflow. Five of these ponds are Natural Resources Conservation Service (NRCS) reservoirs. The NRCS reservoirs are Site 23 (Boomer Lake), Site 24, Site 26 (Whittenberg Lake), Site 28 (Hazen Lake), and Site 29 (University Estates Lake). The elevation-storage data was determined using the 2021 LiDAR DEM from ADS. See **Appendix B** for the studied pond results.

**Appendix A** shows the location of the modeled ponds, site photos of the NRCS dams and ponds with outlet control structures, and storage-elevation-discharge curves used for the detention facilities.

- ❖ Alternative Analyses: For the alternative analyses, drainage basin area ratios were used to divide peak flows at various locations necessary for sizing pipes and detention facilities. To do this, sub-basins were further subdivided based on an intermediate drainage point and the resultant area ratio was applied to the original peak basin flow.

# Boomer Creek Master Drainage Plan

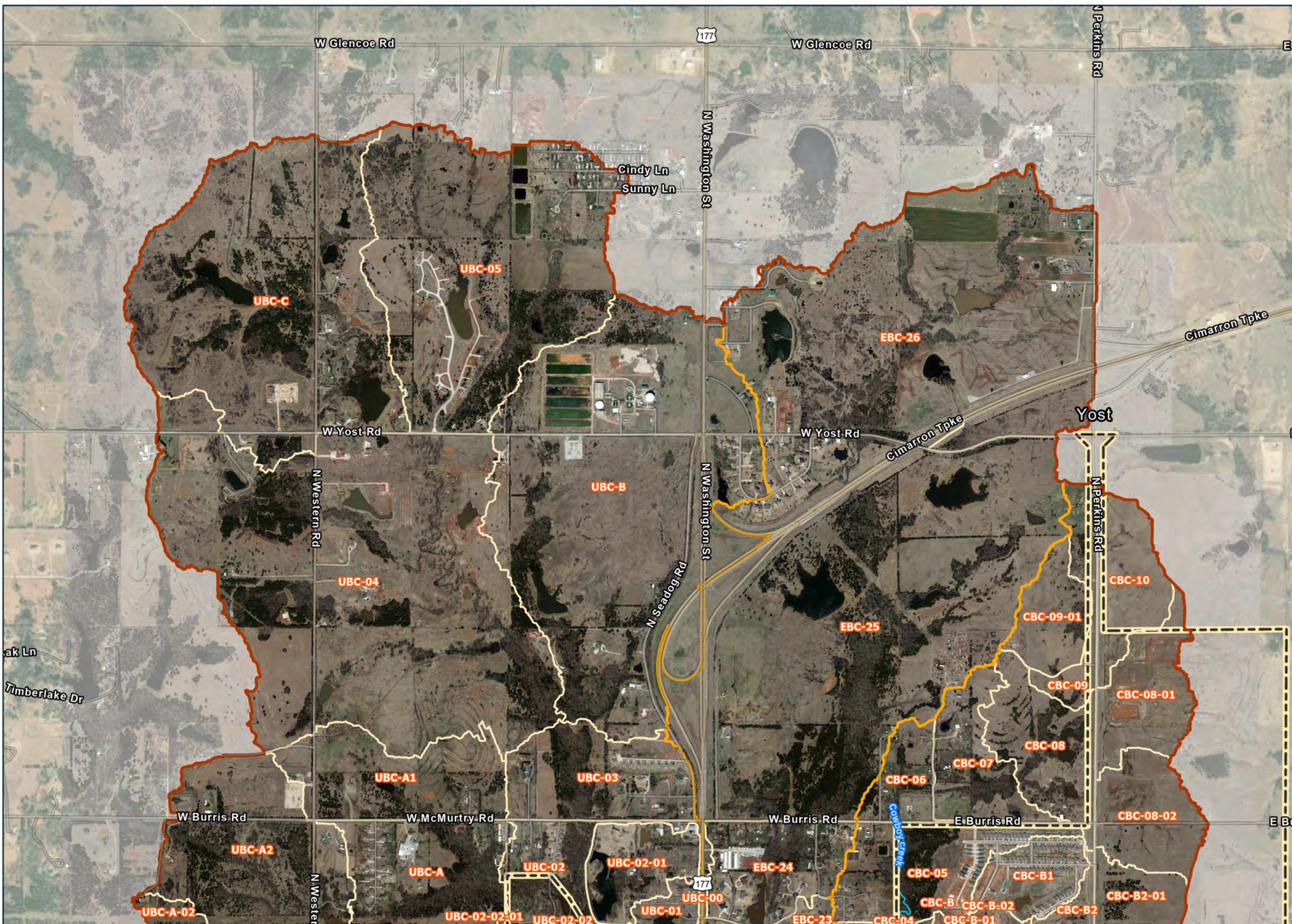
0 0.5 1  
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**Drainage Area Map**

## Boomer Creek Master Drainage Plan

### Drainage Area Map



**MESHEK**  
& ASSOCIATES, LLC

1437 S Boulder Ave - Suite 1550  
Tulsa, OK 74119 - (918) 392-5620



**Figure  
2-1  
Map 1**

Date: 3/23/2023

## Boomer Creek Master Drainage Plan

### Drainage Area Map

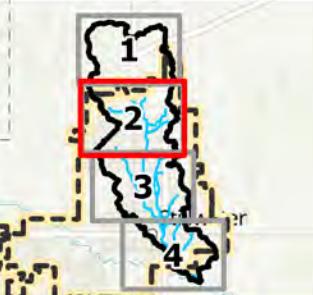
- City Limits
- Boomer Creek Watershed
- Watersheds
- Drainage Areas



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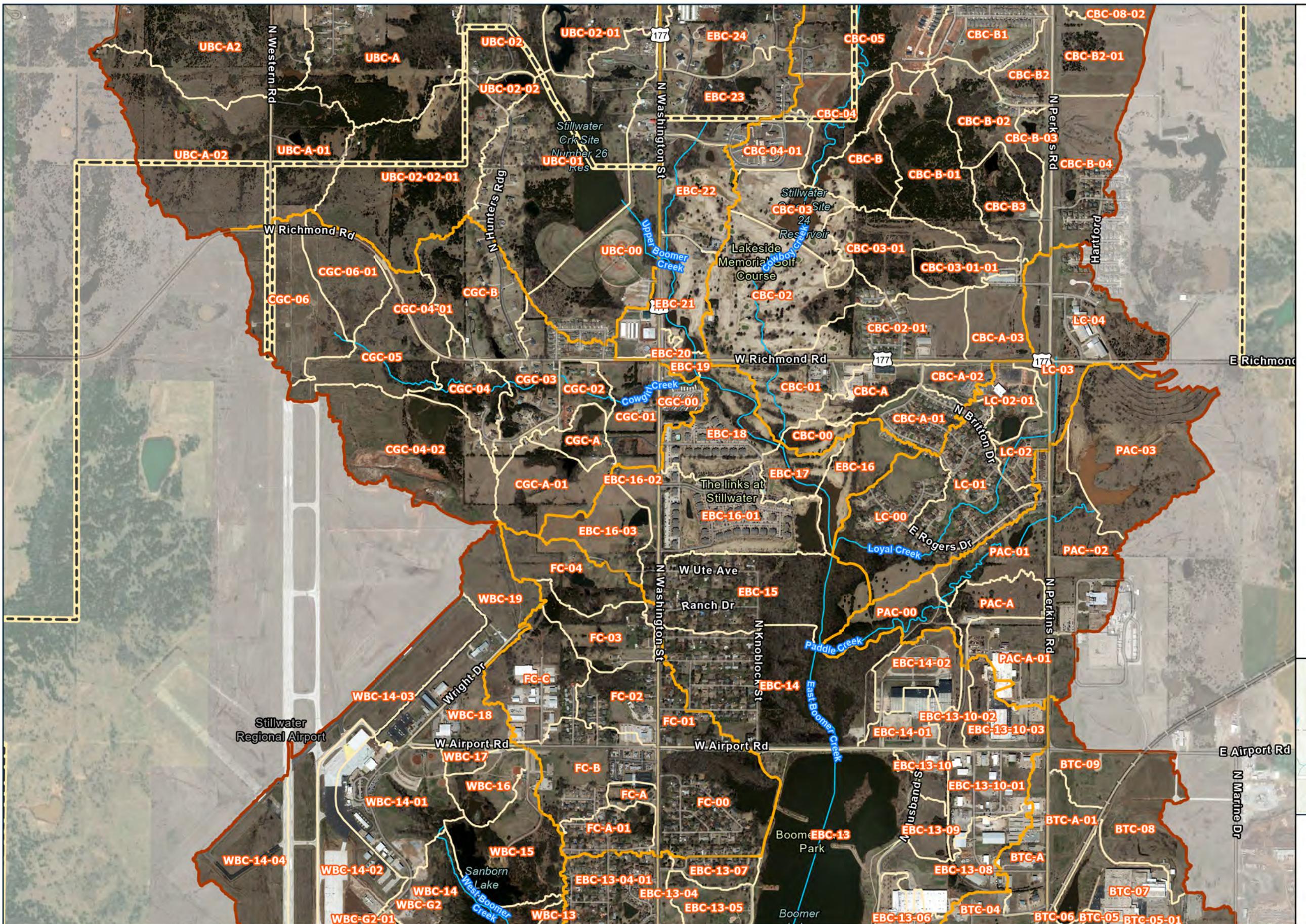
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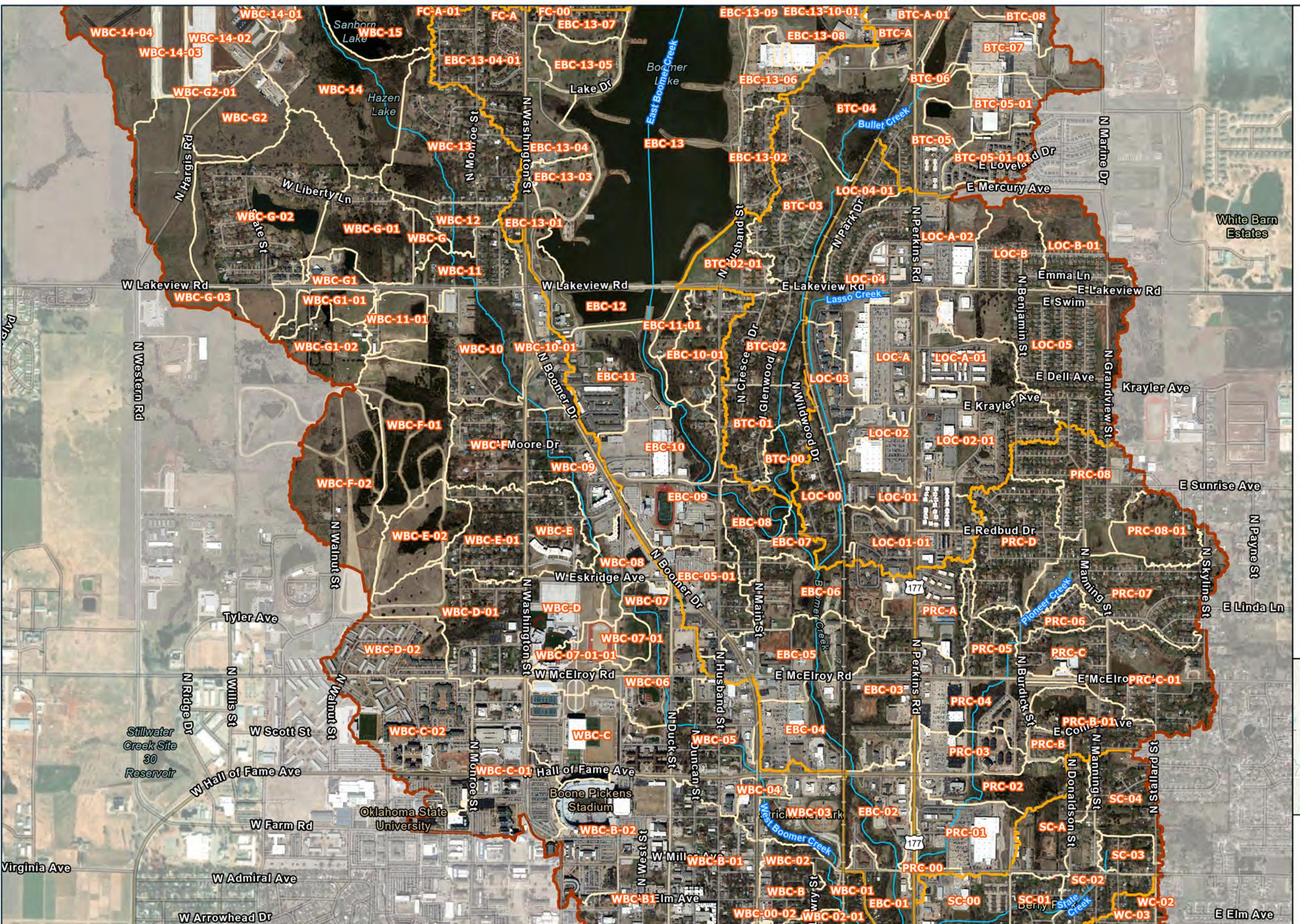
**Figure  
2-1  
Map 2**

Date: 3/23/2023



## Boomer Creek Master Drainage Plan

### Drainage Area Map



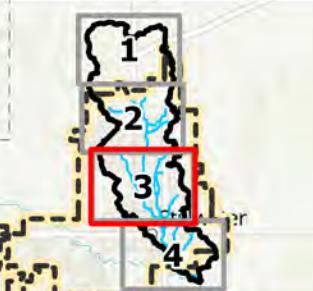
- City Limits
- Boomer Creek Watershed
- Watersheds
- Drainage Areas



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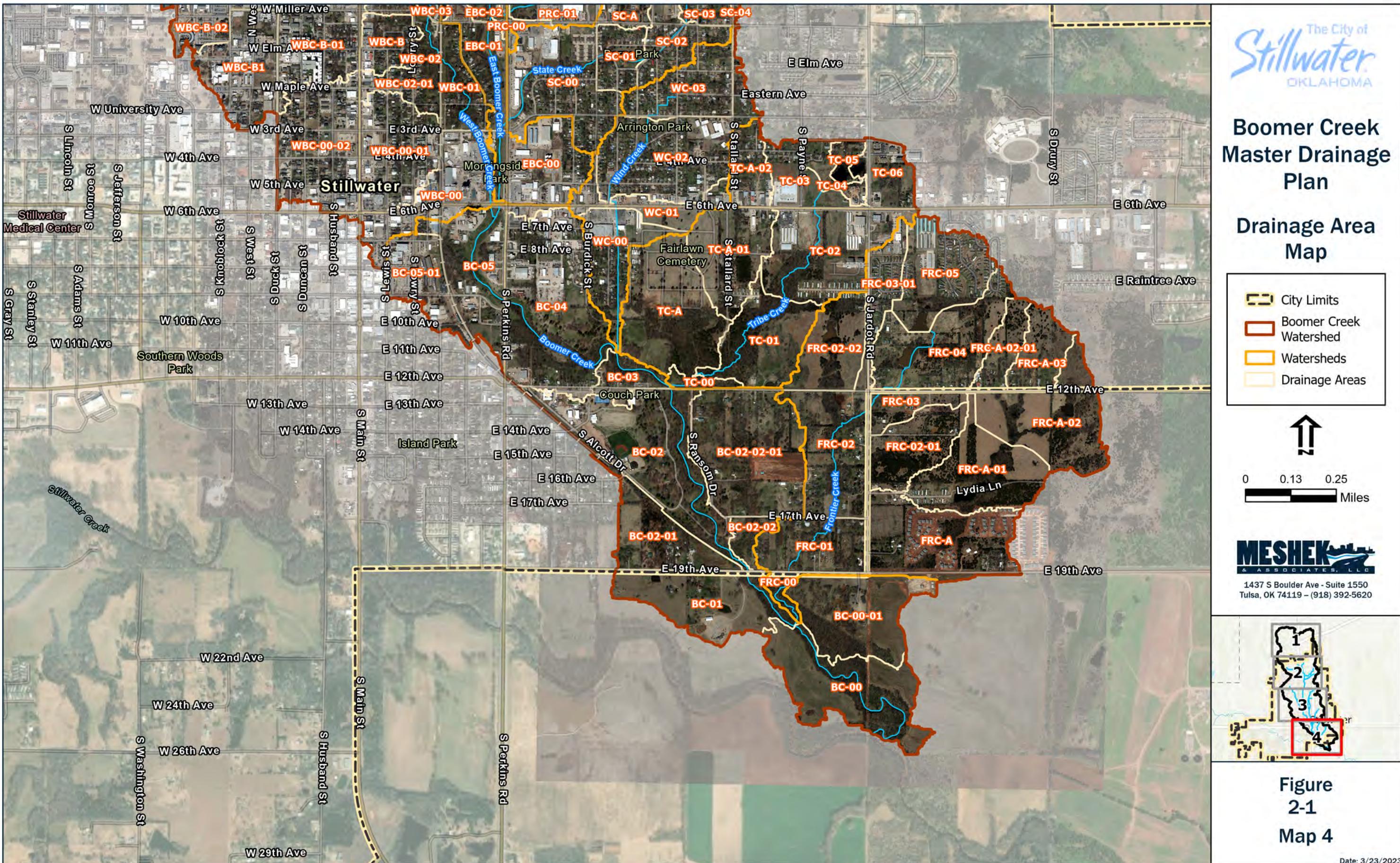
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**Figure  
2-1  
Map 3**

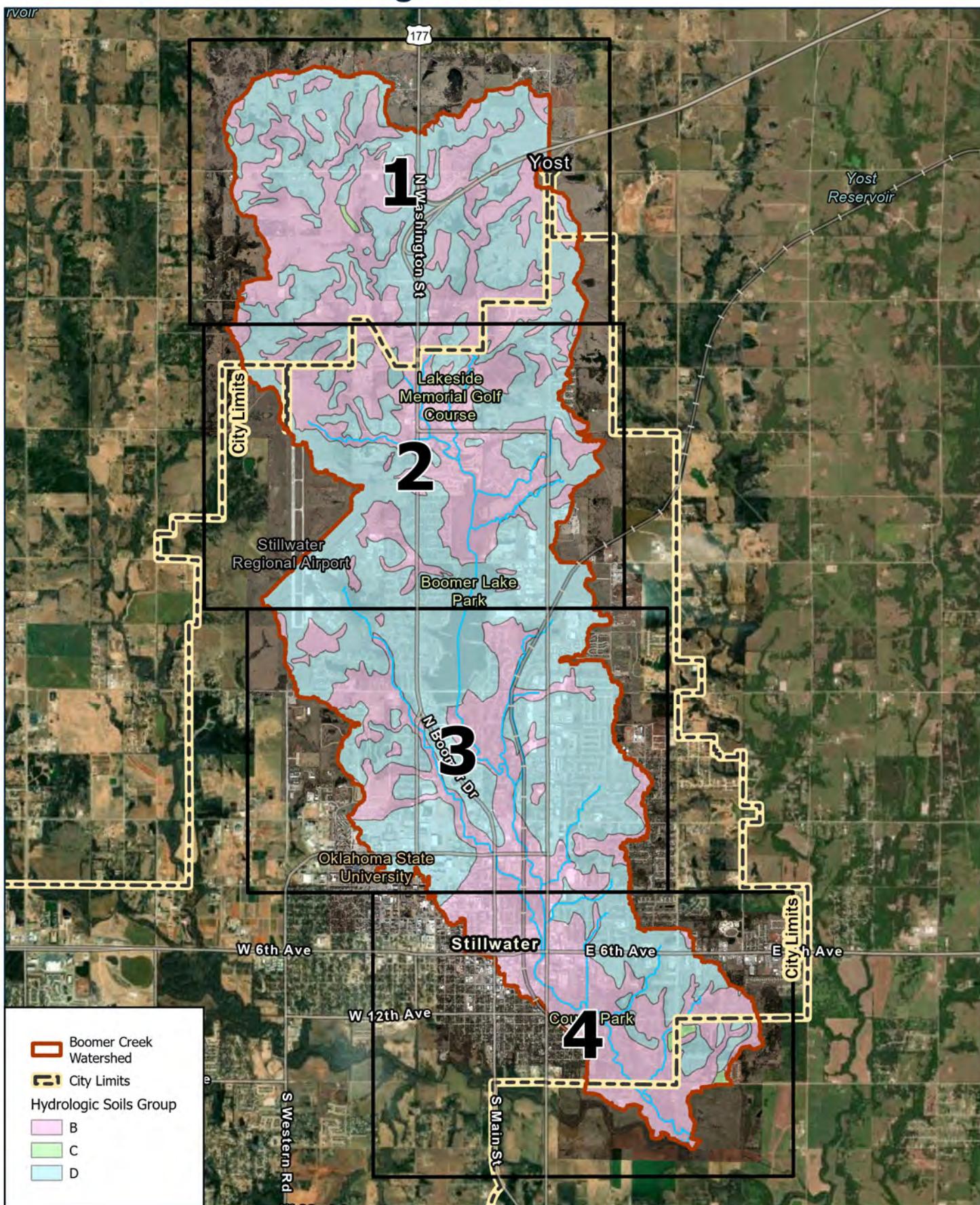
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# Boomer Creek Master Drainage Plan

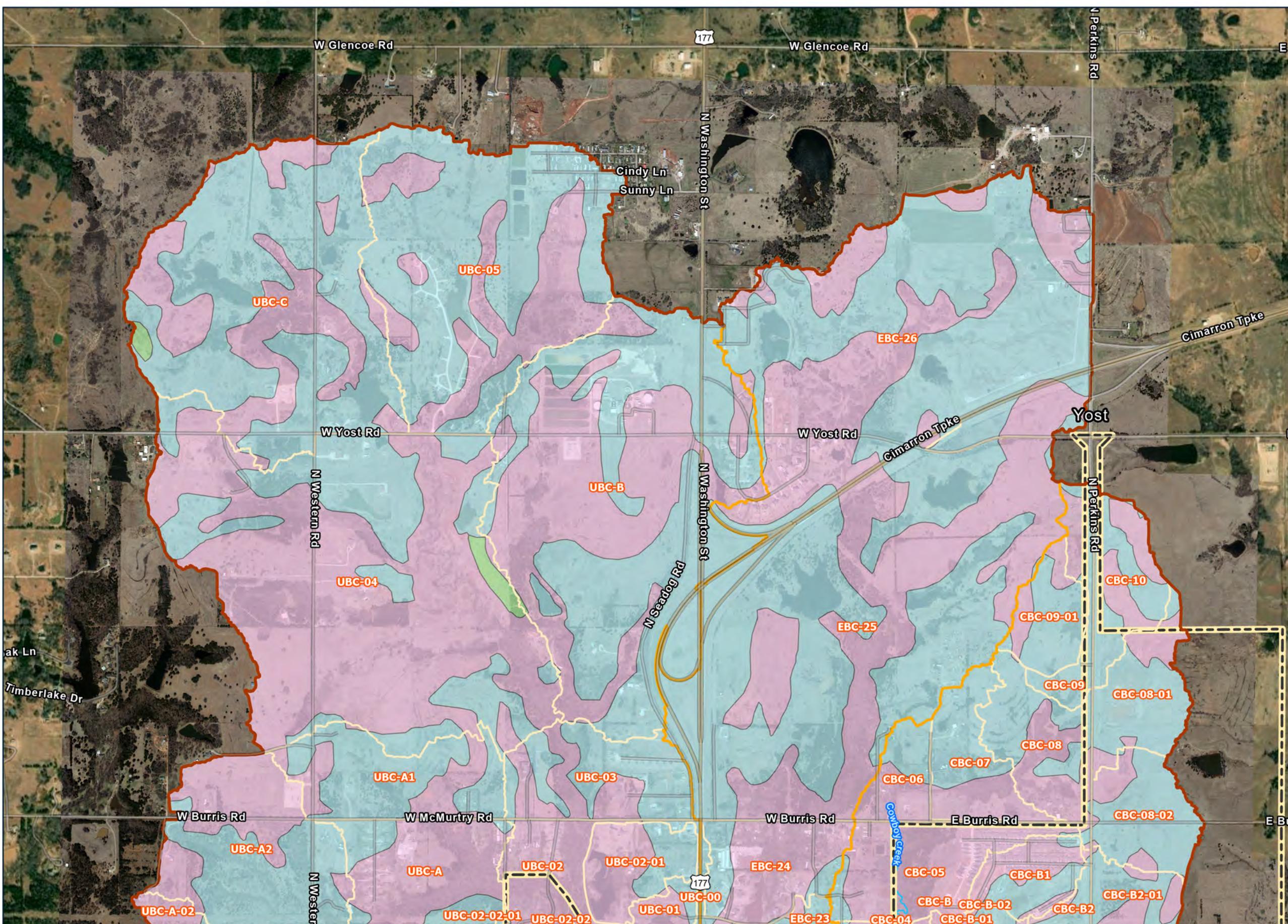
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**Hydrologic Soils Group**

## Boomer Creek Master Drainage Plan

### Hydrologic Soils Map



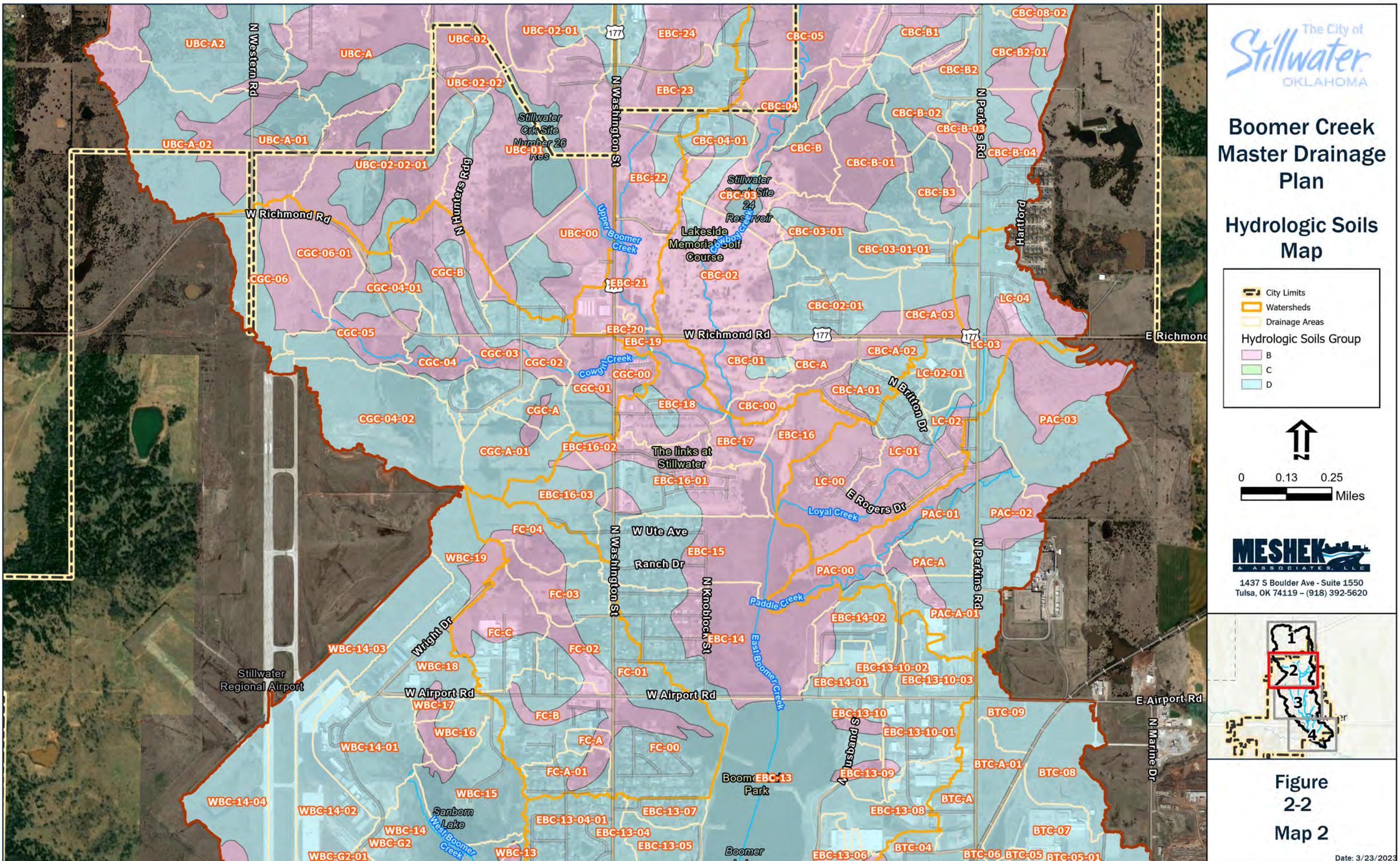
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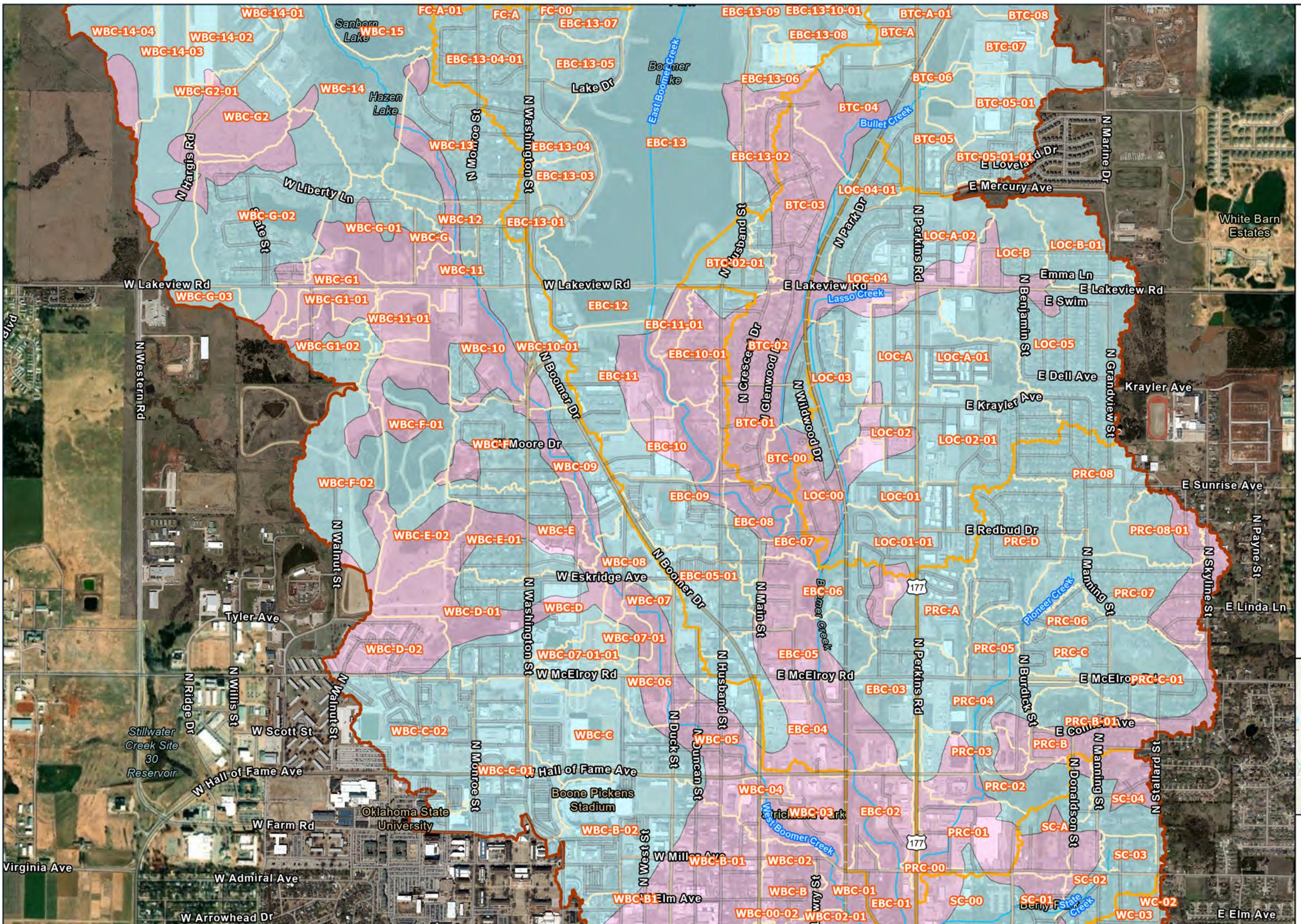


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Map 1

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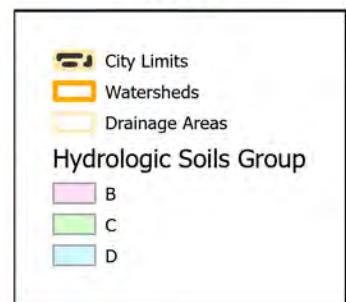
Date: 3/23/2023



# The City of *Stillwater* OKLAHOMA

# Boomer Creek Master Drainage Plan

## Hydrologic Soils Map



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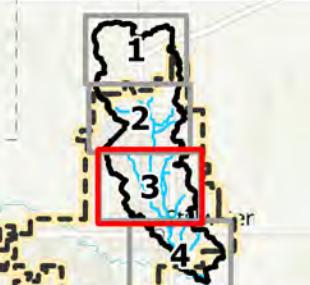
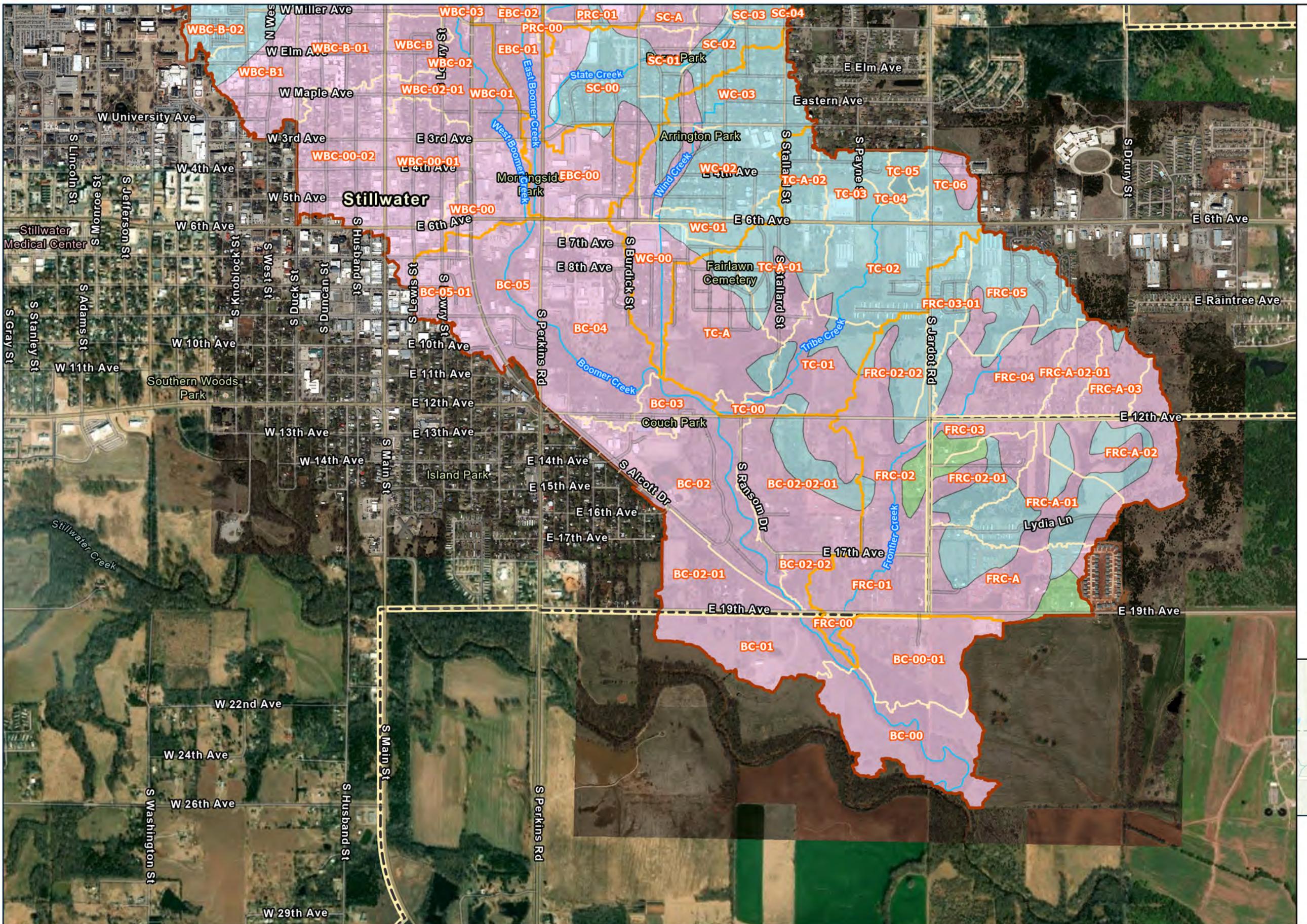


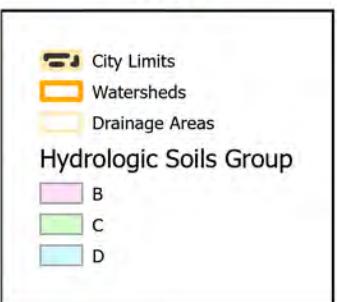
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Map 3



The City of  
**Stillwater**  
OKLAHOMA

# Boomer Creek Master Drainage Plan

## Hydrologic Soils Map

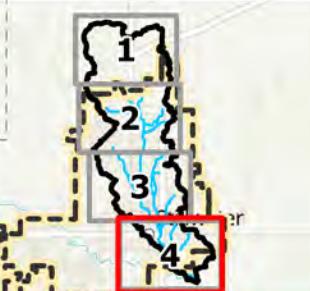


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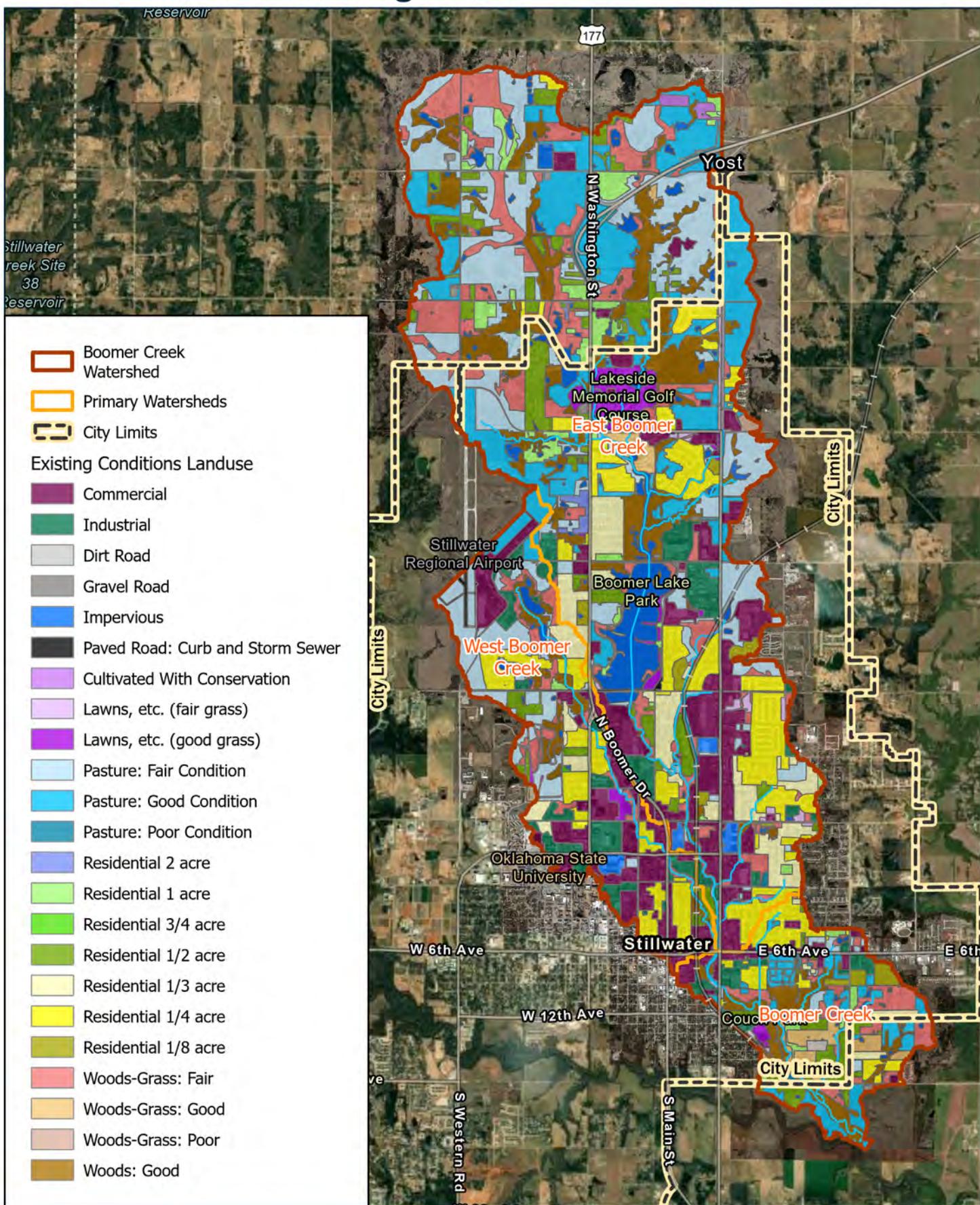
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**Figure  
2-2  
Map 4**

# Boomer Creek Master Drainage Plan

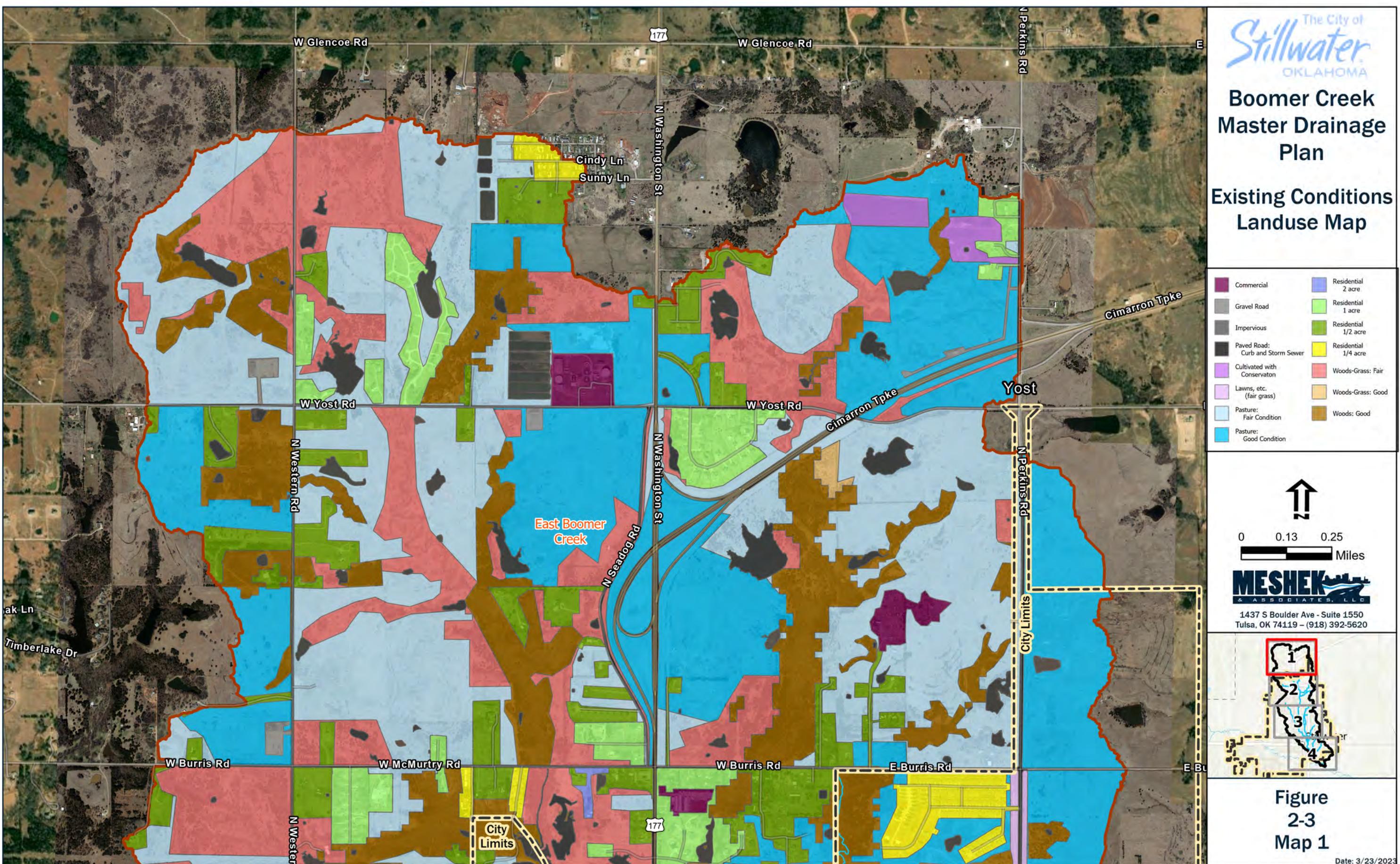
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Existing Conditions Landuse

## Boomer Creek Master Drainage Plan

### Existing Conditions Landuse Map



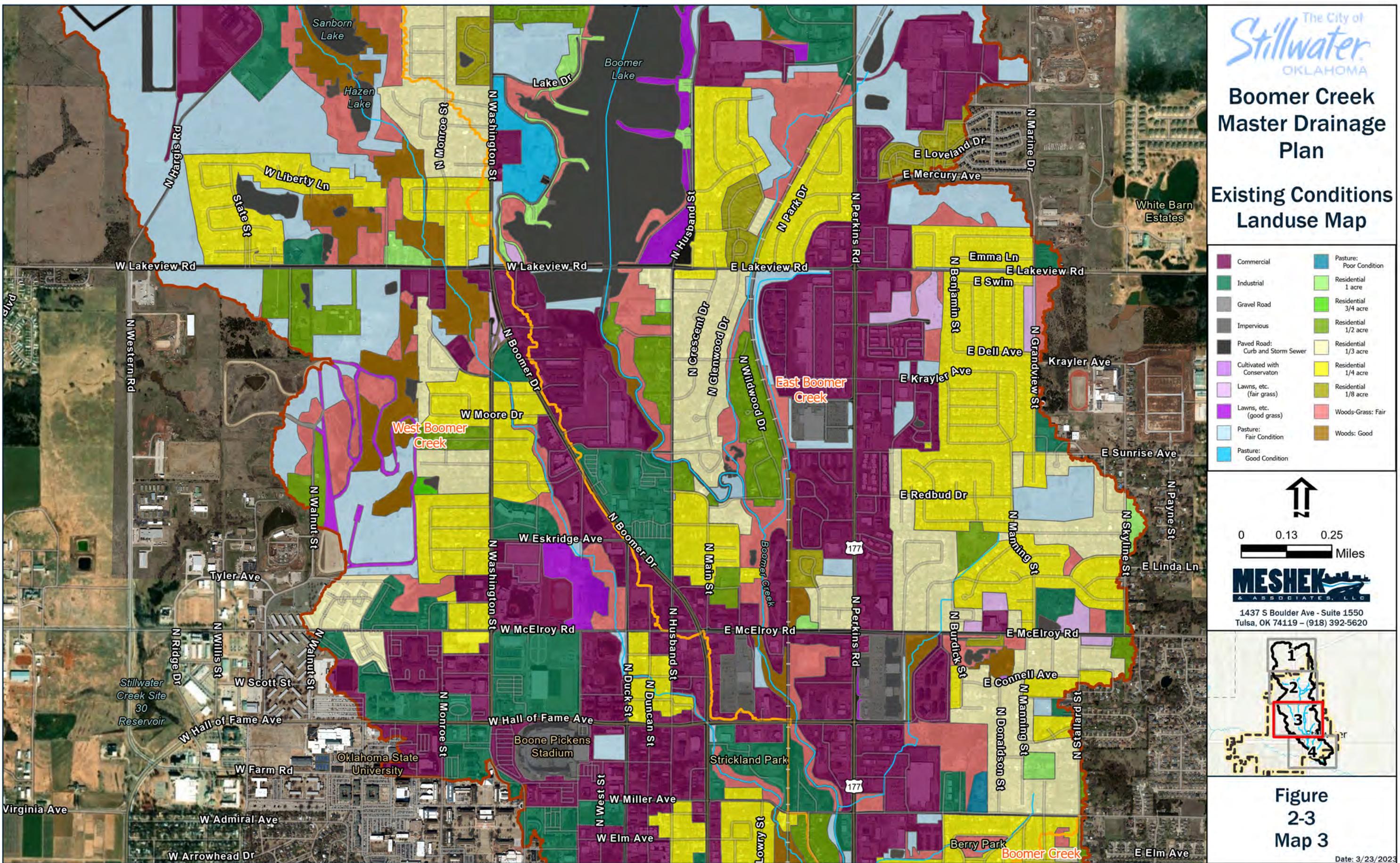
## Boomer Creek Master Drainage Plan

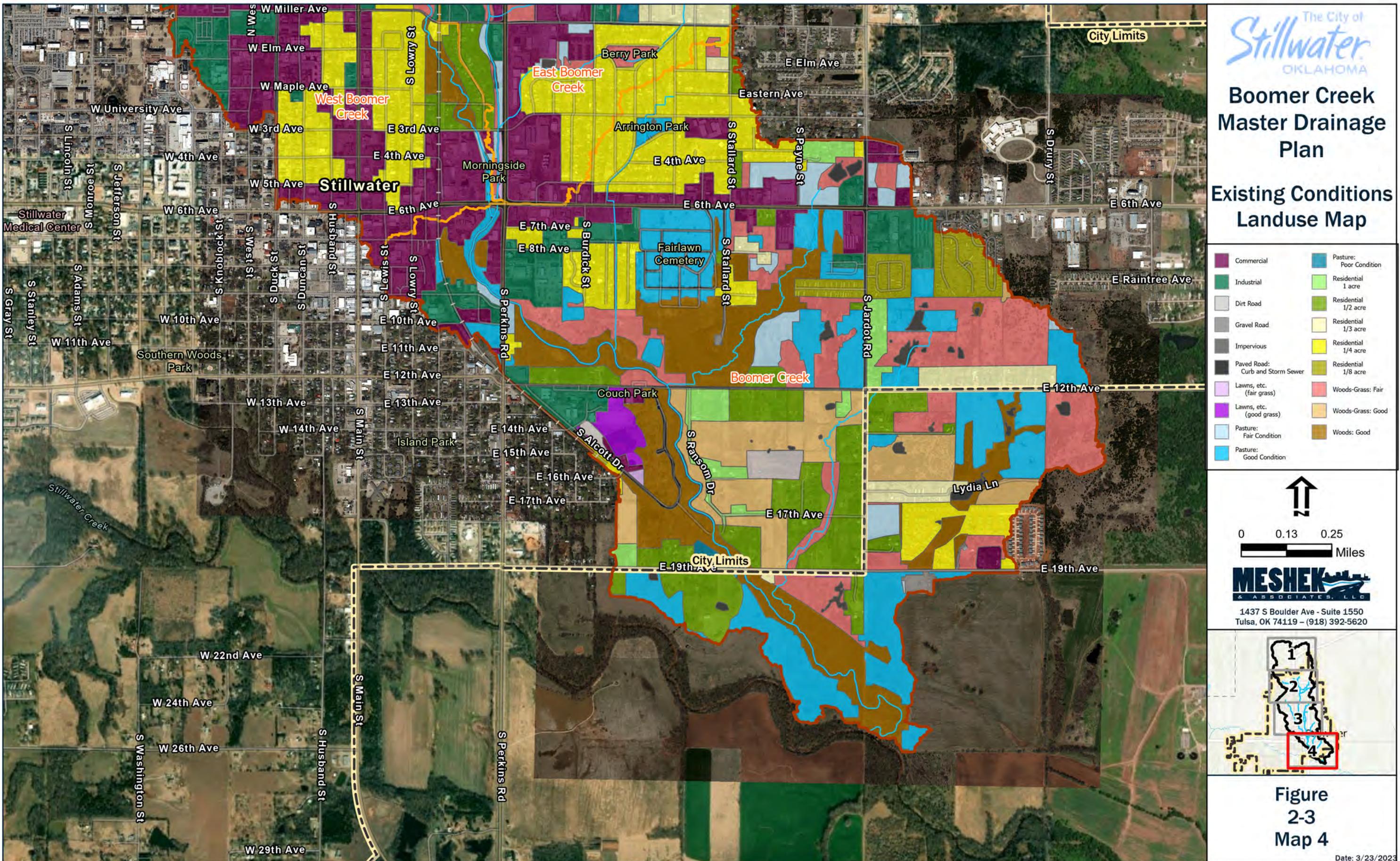
### Existing Conditions Landuse Map



## Boomer Creek Master Drainage Plan

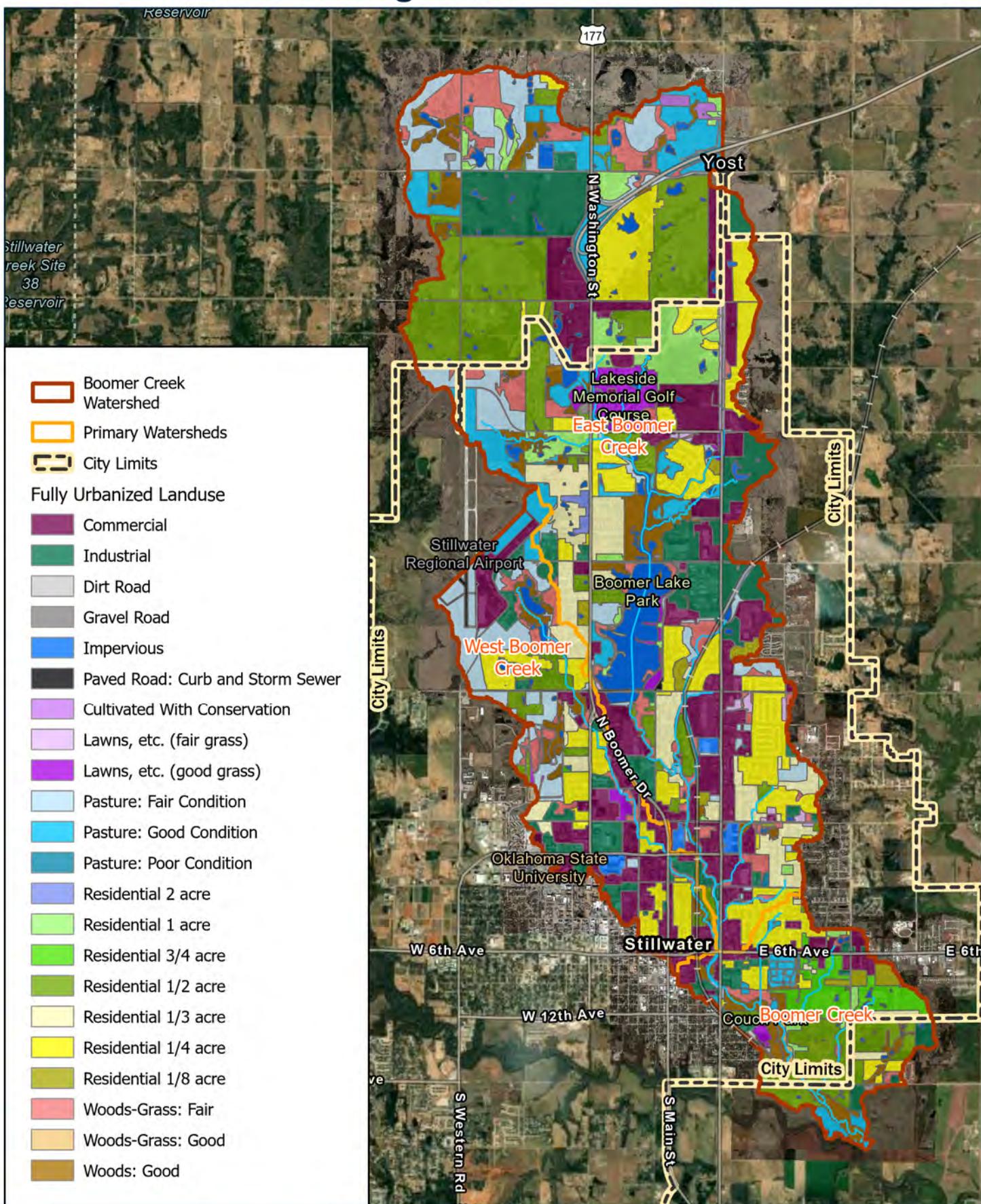
### Existing Conditions Landuse Map





# Boomer Creek Master Drainage Plan

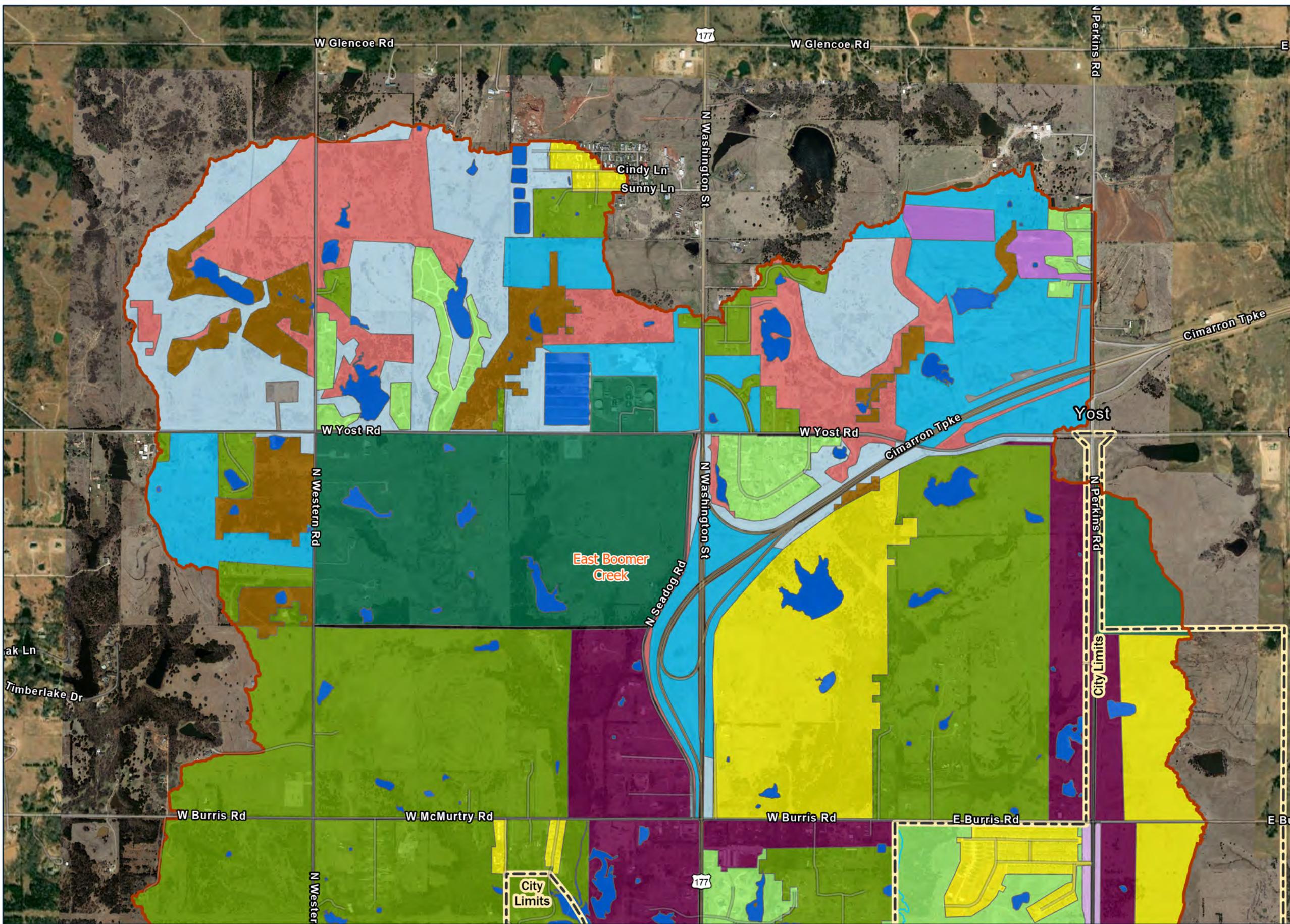
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**Urbanized Conditions Landuse**

## Boomer Creek Master Drainage Plan

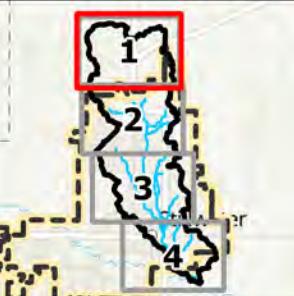
### Urbanized Conditions Landuse Map



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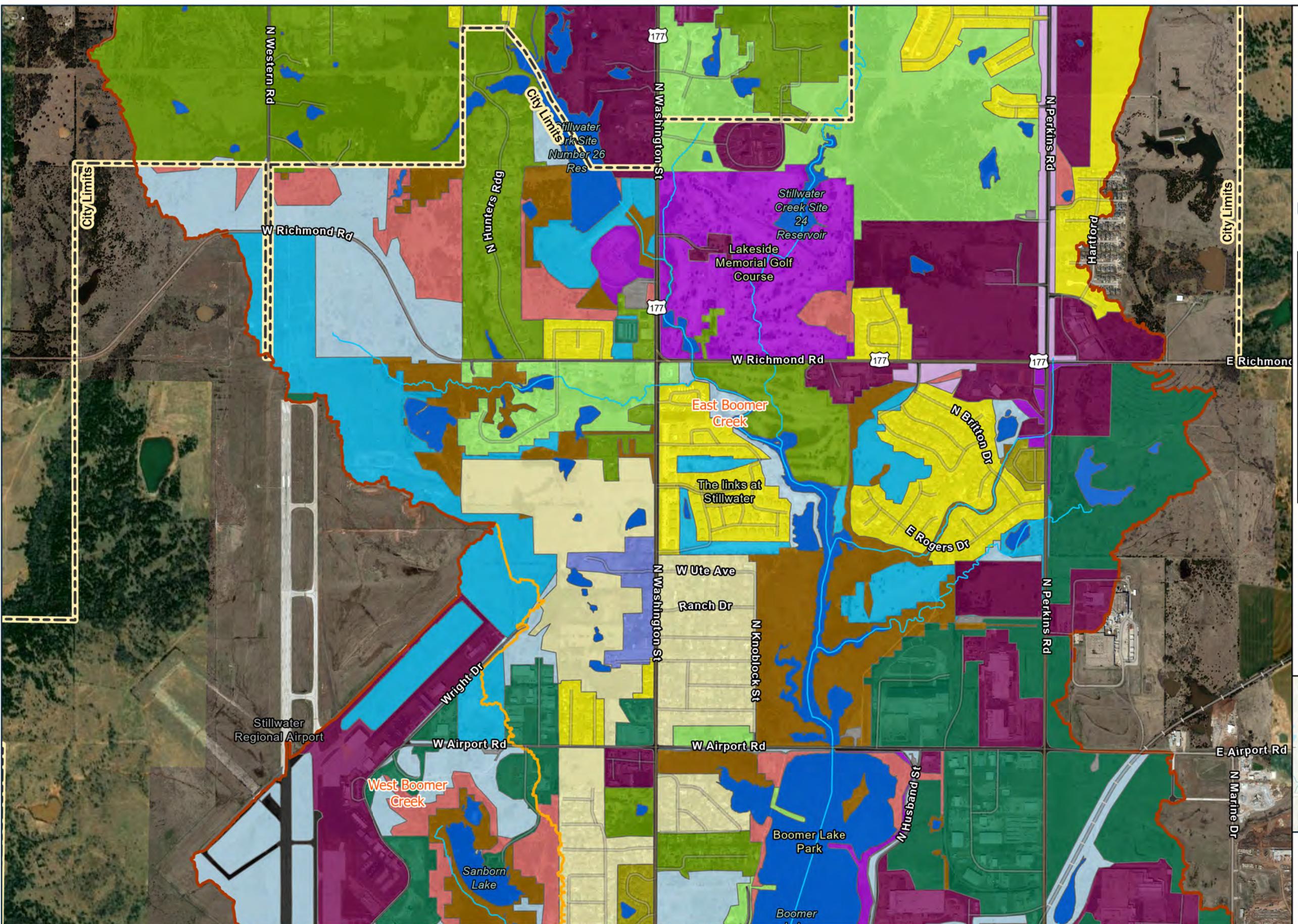


**Figure  
2-4  
Map 1**

Date: 3/23/2023

## Boomer Creek Master Drainage Plan

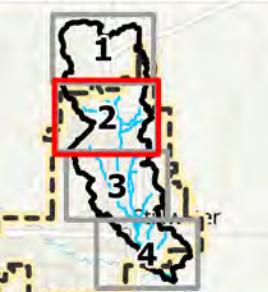
### Urbanized Conditions Landuse Map



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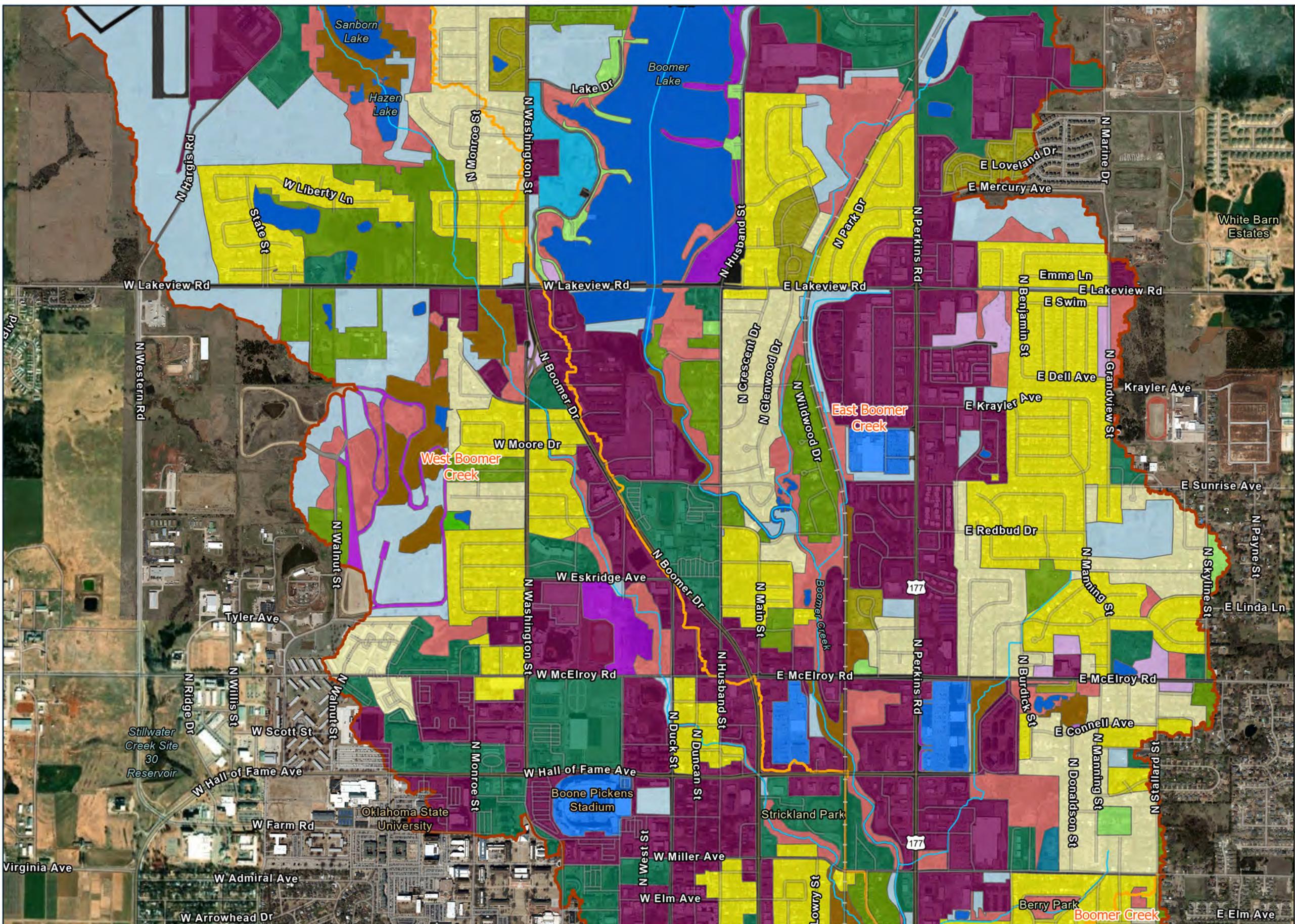


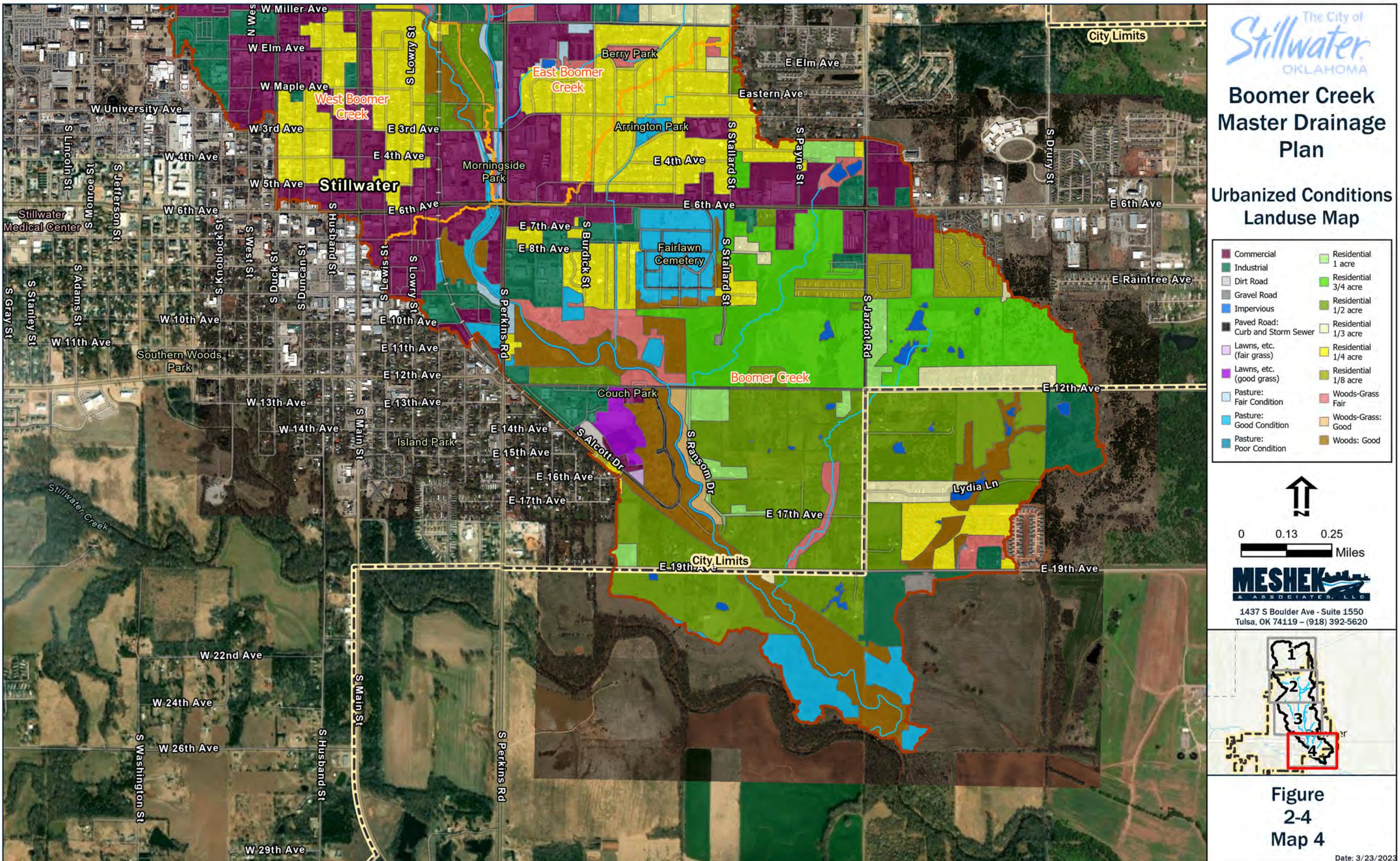
**Figure  
2-4  
Map 2**

Date: 3/23/2023

## Boomer Creek Master Drainage Plan

### Urbanized Conditions Landuse Map





## 2.2 HYDRAULIC METHODOLOGY

Riverine hydraulic modeling of the 1-D study regions was performed using the HEC-RAS computer program developed by the US Army Corps of Engineers (USACE). The hydraulic models were created and analyzed in HEC-RAS version 6.1, with program files submitted to the City of Stillwater as part of the overall MDP deliverable.

Bridge, culvert, and storm sewer data was obtained from as-built plans or surveys conducted by Meshek in 2019 and 2021. General topography elevations were taken from 2-meter LiDAR terrain data collected in 2021 by ADS.

The following assumptions were incorporated into the 1-D hydraulic modeling and analysis processes:

- ❖ Downstream Boundary Conditions: Downstream boundary conditions were set to the Known Water Surface method within HEC-RAS. The downstream boundary conditions determine the starting water-surface elevation of a hydraulic model based on Known Water Surface tailwater conditions. The Known Water Surface data was pulled from the FEMA Flood Insurance Study (FIS) Number 40119CV000A for Payne County, Oklahoma, and incorporated areas conducted on May 16, 2007. The 10%, 2%, 1%, and 0.2% annual exceedance probability flood frequencies Known Water Surface were directly taken from the study. The 4% AEP Known W.S. was interpolated between the 10% and 2% AEP Known W.S., while the 20% and 50% AEP Known W.S. were extrapolated. The Known W.S. data was extracted from Stillwater Creek approximately 770 feet downstream of FEMA-lettered cross-section O.
- ❖ Floodplain Storage Discharge Rating Curves: In the basins for which floodplains were developed, the storage volumes were computed for each reach within the hydraulic model to determine the storage discharge rating curve for each reach. The storage discharge ratings curves were used in the HEC-HMS model to account for the effects of existing floodplain storage and to generate final peak discharge flow rates. Final water surface profiles were then computed for each frequency profile in the HEC-RAS model using the final peak discharge flow rates from HEC-HMS.
- ❖ Bridge and Culvert Analysis: Each roadway crossing on a studied stream was modeled using the bridge or culvert modeling methods available within HEC-RAS. All input data was collected from as-built drawings or field surveys performed by Meshek.

### 2.2.1 Hydraulic Methodology – City of Stillwater Regulatory

An HEC-RAS 2-D hydraulic model was developed to simulate overland flooding for the 10% AEP (10-Year), 1% AEP (100-Year), and 0.2% AEP (500-Year) flood on State Creek, and a portion of Pioneer Creek. The resulting model and floodplains will be used as a City of Stillwater regulatory floodplain only.

Internal boundary conditions were used to apply the overland runoff hydrographs for local sub-basins and storm sewer intake/discharge locations.

The outflow boundary condition was set to Normal Depth as the downstream tailwater condition which roughly matched the receiving 1-D elevations.

The 2-D modeling was performed using the HEC-RAS computer program developed by the US Army Corps of Engineers (USACE). The hydraulic models were created and analyzed in HEC-RAS version 6.1, with program files submitted to The City of Stillwater as part of the overall MDP deliverable.

Bridge, culvert, and storm sewer data was obtained from a survey conducted by Meshek in 2019 and 2021, also from as-built plans, and 1-foot LiDAR terrain data collected in 2021 by ADS. The terrain data was used for ground elevations where a recent BFE survey was not available.

A 2-D model requires unsteady flow data, a digital terrain model, and appropriate computation parameters. For this project, the unsteady flow data was generated from the rainfall runoff hydrographs described in **SECTION 2.1**. Below is a list of geospatial and hydraulic inputs used in the HEC-RAS 2-D model.

The following assumptions were incorporated into the 2-D hydraulic modeling and analysis processes:

- ❖ **2-D Mesh:** The 2-D mesh is comprised of grid cells which include center points and cell faces. The cells are used to calculate overland flow, direction, velocity, depth, water surface elevation (WSE), and other parameters over the course of the simulation. Each cell face acts as a cross-section to determine these parameters.
- ❖ **Manning's N Values:** Manning's N values are a unitless roughness coefficient needed for the model computations at each 2-D cell. These roughness values, listed in the HEC-RAS Hydraulic Reference Manual, were determined based on the land cover type using aerial imagery and assigned to the 2-D mesh using a polygon layer. Each cell applies Manning's N values that fall directly under its center point.
- ❖ **Computation:** The computation timestep chosen for this model was set at 5 seconds for a simulation duration of 24 hours, which allowed for the peak results to be computed throughout the entire model area. The output results are saved every 1 minute.

### 2.2.2 Alternative Analysis Hydraulics

Several solutions in the alternative analysis of problem areas required terrain grading and roadway crossing modifications, some of these solution alternatives were modeled in HEC-RAS. Existing peak hydrograph flows and computation timestep were kept the same as existing conditions. Floodplain conveyance or storage volume was added to mitigate or resolve the 1% AEP flood risk problem areas.

## SECTION 3. MASTER DRAINAGE PLANNING

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### 3.1 MASTER PLANNING

Flooding problem areas were generally identified at locations where multiple residential or commercial structures were impacted by the 1% AEP (100-Year) floodplain or where roadways were overtopped. A minimum of two alternatives were analyzed for each problem area. Problem areas may share one or two alternative solutions, while some evaluated alternatives were determined not to be practical solutions based on effectiveness and were not listed as an alternative solution.

Cost estimates were developed for each of the alternatives. The alternative analyses are very conceptual and therefore the cost estimates only include the major line items and include a significant contingency.

The central objective of the solutions provided was to improve or mitigate flooding problems upstream or downstream of a given problem area for the 1% annual chance flood. Several solutions provide additional floodplain storage for stormwater to utilize during a flood event. In some instances, the flood waters could be pulled away from structures and roadways, and in others, structures could be demolished from the flood extent. In a few special cases, stormwater conveyance could be increased to remove a local flood risk where watershed timing appeared beneficial and downstream impacts were negligible.

In the development of the problem area alternatives, hydrologic and hydraulic models were created for conceptual purposes. Practical solutions were developed based on current flood risk, available land area, elevation constraints, and effective modeling. Required stormwater storage volume for mitigation was determined either by a hydrograph volume calculation or effective HEC-RAS floodplain volume results. Available volume for alternative detention facilities or floodplain storage systems were measured from HEC-RAS terrains. Storm sewer system capacity and velocity values were calculated using Manning's equation for pipe flow. Peak flow rate and watershed timing values were sourced from the HEC-HMS model.

### 3.2 EXISTING CONDITIONS

#### 3.2.1 Hydrologic Results – Existing Conditions

See **Table 3-1** for the peak flow results for the 50%, 10%, 4%, 2%, 1%, and 0.2% annual chance floods. The peak flow rates at basin downstream boundaries or stream confluence junctions in the HEC-HMS model were used at flow change locations within HEC-RAS. The peak flow of the sub-basins modeled in HEC-HMS with all modeled storm annual exceedance probabilities can be found in **Section 1 of Appendix B**.

# Boomer Creek Master Drainage Plan

City of Stillwater

**Table 3-1: Flow Summary Table**

<b>Peak Flow Summary</b>							
Boomer Creek	HEC-RAS Station	MDP HMS Element	Percent Annual Chance Peak Discharge (CFS)				
			50%	10%	4%	2%	1%
At Mouth	-	J-BC-00	2124	4070	5289	6366	7526
Confluence with Frontier Creek	3598	J-BC-01	2118	4058	5302	6386	7545
Downstream side of 19th Ave.	4682	J-BC-02	2028	3894	5077	6109	7197
Downstream side of 12th Ave.	8081	J-BC-03	2001	3863	5042	6135	7173
Confluence with Tribe Creek	8157	R-BC-03	1939	3692	4843	5880	6830
Confluence with Wind Creek	9209	J-BC-04	1939	3703	4843	5880	6830
Downstream side of HWY 177	11490	J-BC-05-DN	1904	3591	4617	5463	6343
Downstream side of HWY 51	13165	J-BC-05-UP	1894	3552	4557	5388	6257
East Boomer Creek	HEC-RAS Station	MDP HMS Element	Percent Annual Chance Peak Discharge (CFS)				
			50%	10%	4%	2%	1%
At Mouth	14229	R-EBC-00	1143	2247	2971	3584	4235
Downstream side of 3rd Ave	14322	J-EBC-01	1143	2271	2971	3584	4235
Downstream side of Virginia Ave.	15928	R-EBC-01	1039	2064	2705	3242	3820
Confluence with Pioneer Creek	16055	J-EBC-02	1039	2076	2705	3242	3820
Approx. 675' upstream of Virginia Ave.	16656	R-EBC-02	760	1416	1896	2290	2724
Downstream side of Hall of Fame	17698	J-EBC-03	760	1424	1896	2290	2724
Downstream side of E. McElroy Rd.	19237	J-EBC-05	742	1386	1837	2214	2622
Confluence with Lasso Creek	20838	J-EBC-06-UP	714	1327	1739	2092	2460
Downstream side of Redbud Dr.	21402	R-EBC-07	349	639	846	1003	1296
Confluence with Bullet Creek	21801	J-EBC-08	349	641	846	1003	1296
Downstream side of Husband Street	23595	J-EBC-09	195	414	606	956	1257
Downstream side of W. Franklin Ln.	23947	J-EBC-10	194	413	604	953	1254

# Boomer Creek Master Drainage Plan

## City of Stillwater

Boomer Lake Spillway	26726	J-EBC-12	192	408	597	946	1248	2206
Approx. 100' Upstream of Airport Rd.	32706	J-EBC-14	563	1045	1328	1492	1666	2146
Confluence with Paddle Creek	34154	J-EBC-15-DN	564	1033	1303	1486	1629	4408
Confluence with Loyal Creek	35439	J-EBC-16	543	990	1197	1312	2242	3152
Confluence with Cowboy Creek	37216	J-EBC-18	521	959	1150	1721	2224	2948
Confluence with Cowgirl Creek	39239	J-EBC-19	499	921	1042	1503	2147	2719
Downstream side of Richmond Dr.	39426	J-EBC-20	419	773	924	1281	1588	2164
Confluence with Upper Boomer Creek	39239	J-EBC-21-UP	417	811	937	1248	1553	2145
Downstream side of Golf Course Rd.	41446	J-EBC-22	363	770	1063	1289	1523	2069
Downstream side of Peaceable Acres Rd.	42893	J-EBC-23	361	726	1060	1283	1515	2057
West Boomer Creek	HEC-RAS Station	MDP HMS Element	Percent Annual Chance Peak Discharge (CFS)					
			50%	10%	4%	2%	1%	0.2%
At Mouth	1162	R-WBC-00-UP	736	1273	1643	1886	2124	2706
Downstream side of 3rd Ave	1292	J-WBC-01	736	1293	1643	1886	2124	2706
Downstream side of Maple Ave.	1907	R-WBC-01	734	1280	1650	1889	2152	2980
Downstream side of Railroad bridge	2803	J-WBC-02-DN	734	1286	1650	1889	2152	2980
Downstream side of Virginia Ave.	3534	J-WBC-03	645	1160	1499	1738	2014	2700
Downstream side of Hall of Fame	5405	J-WBC-05	628	1150	1482	1707	1994	2622
Downstream side of Duck St.	7121	J-WBC-06	615	1126	1447	1681	1921	2504
Downstream side of E. McElroy Rd.	7851	J-WBC-07	370	699	948	1133	1368	1882
Downstream side of N. Knoblock St.	9442	J-WBC-08	354	680	924	1105	1342	1846
Downstream side of W. Eskridge Ave.	9442	J-WBC-08-UP	345	674	916	1095	1330	1829
Approx. 360' Upstream of W. Eskridge Ave.	12491	J-WBC-09	302	619	830	998	1174	1570
Approx. 360' Upstream of W. Brooke Ln.	10136	J-WBC-10	277	556	732	873	1016	1336
Downstream side of Washington Ave.	12765	R-WBC-10	171	345	417	475	531	641

Downstream side of W. Lakeview Ave.	14524	J-WBC-11	174	353	418	476	532	645
Downstream side of W. Liberty Ave.	15969	J-WBC-13	102	197	255	293	332	422

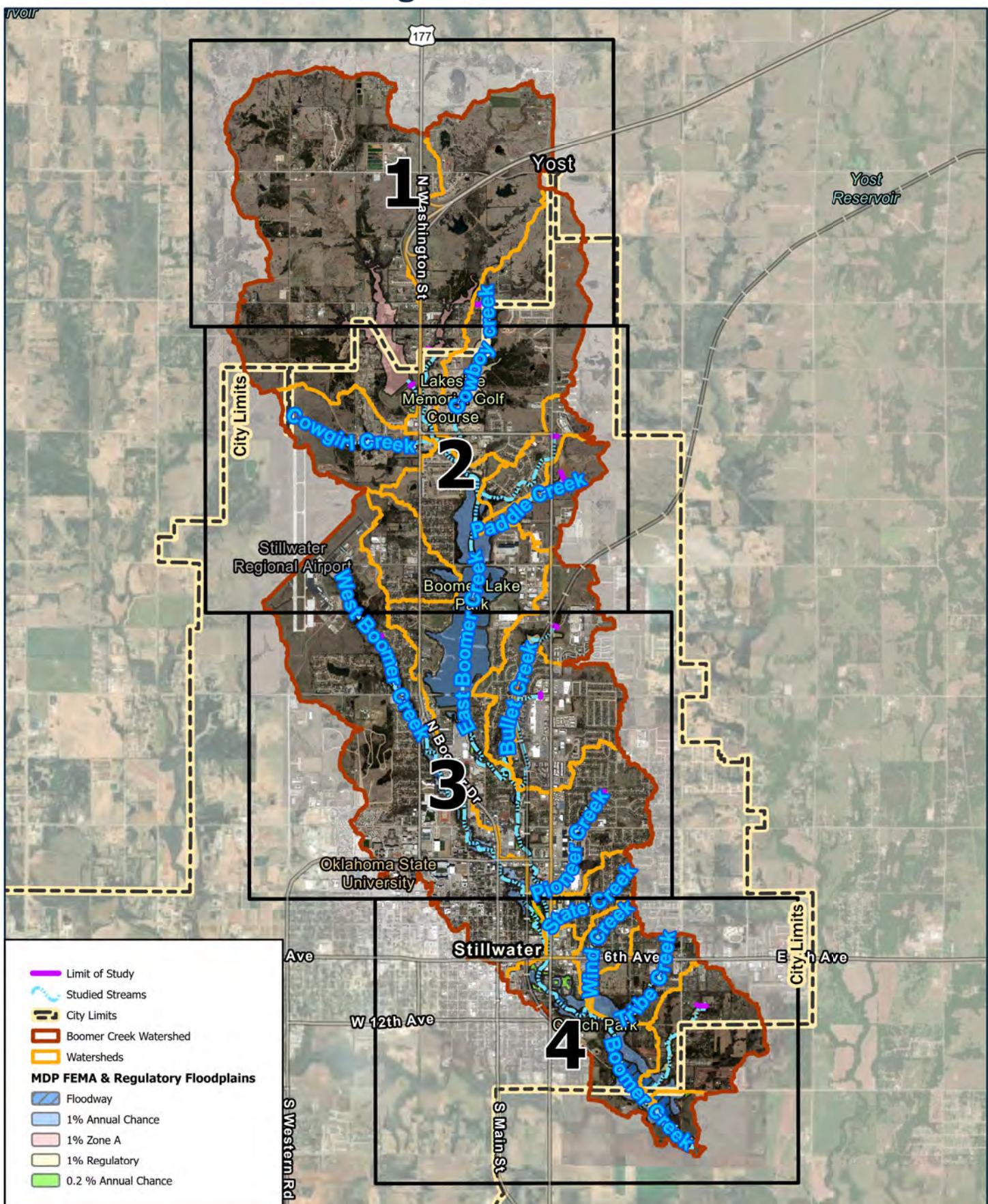
### 3.2.2 Hydraulic Results

The streams that were studied during the MDP not only include streams that are currently mapped by FEMA, but the studies were also extended further into the watershed. The City can choose to submit the updated modeling and mapping to FEMA for an update to the effective data. The portions of the stream above the FEMA mapping limits can be used internally by the City of Stillwater as "regulatory" floodplain. **Figure 3-1** shows the updated 1% and 0.2% annual chance floodplains for both the FEMA mapped and regulatory mapped areas. These maps were generated using RAS Mapper, the GIS platform within the HEC-RAS program, and edited using ArcMap v10.8. A floodplain comparison atlas for these 1% and 0.2% AEP floods can be found in **Appendix E**. The 1% annual chance water-surface elevation atlas with Base Flood Elevation (BFE) lines can be found in **Appendix F**. Water-surface flood profiles for all the studied streams are in **Appendix D: Water Surface Profiles**.

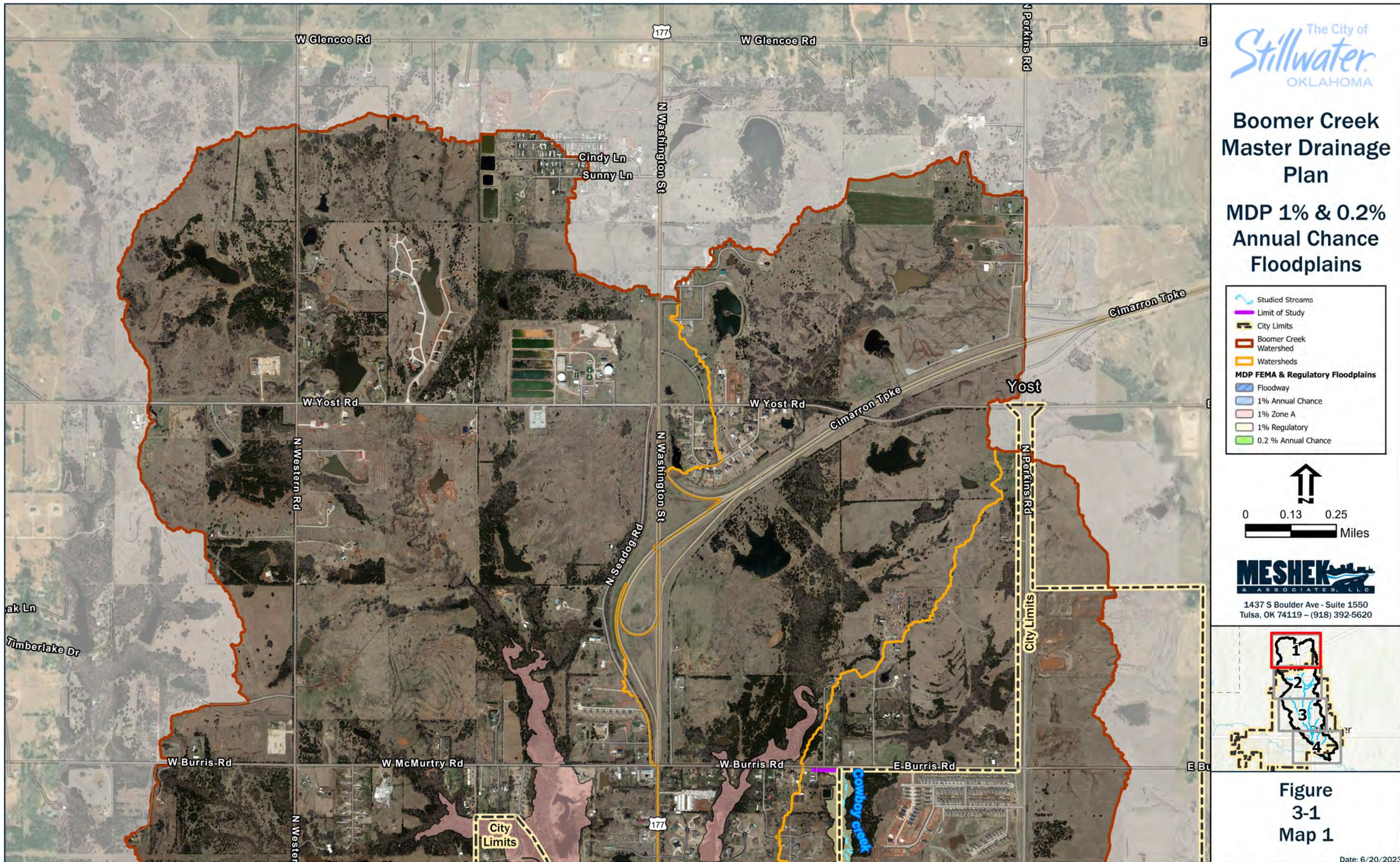
The capacities of the roadway culverts and bridges were determined during the modeling process. **Figure 3-2** shows the locations of the structures and their corresponding capacity prior to overtopping.

# Boomer Creek Master Drainage Plan

0 0.5 1 Miles



**MDP 1% & 0.2% Annual Chance Floodplains**



Date: 6/20/2023

## Boomer Creek Master Drainage Plan

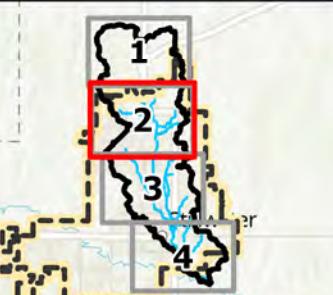
MDP 1% & 0.2%  
Annual Chance  
Floodplains



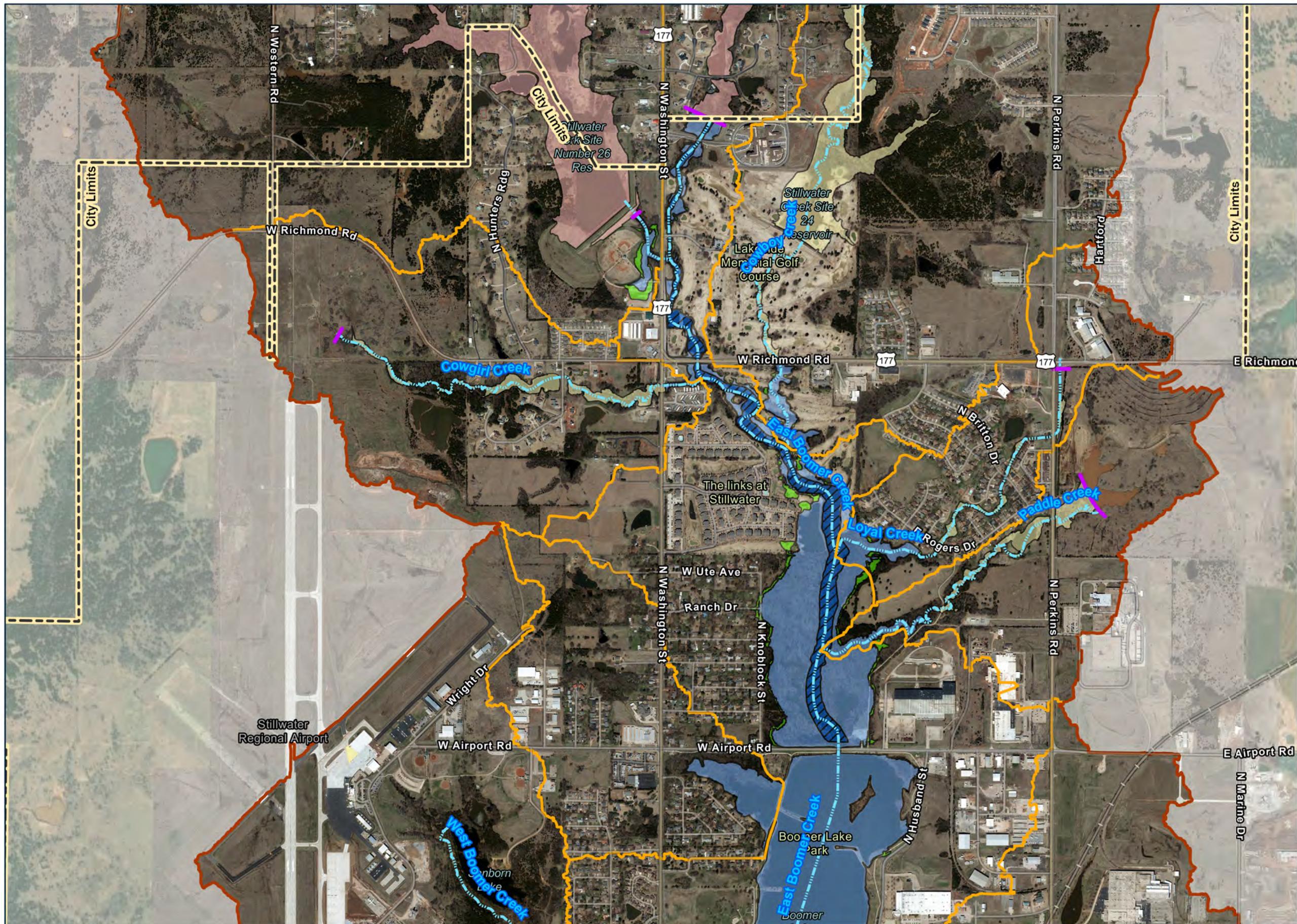
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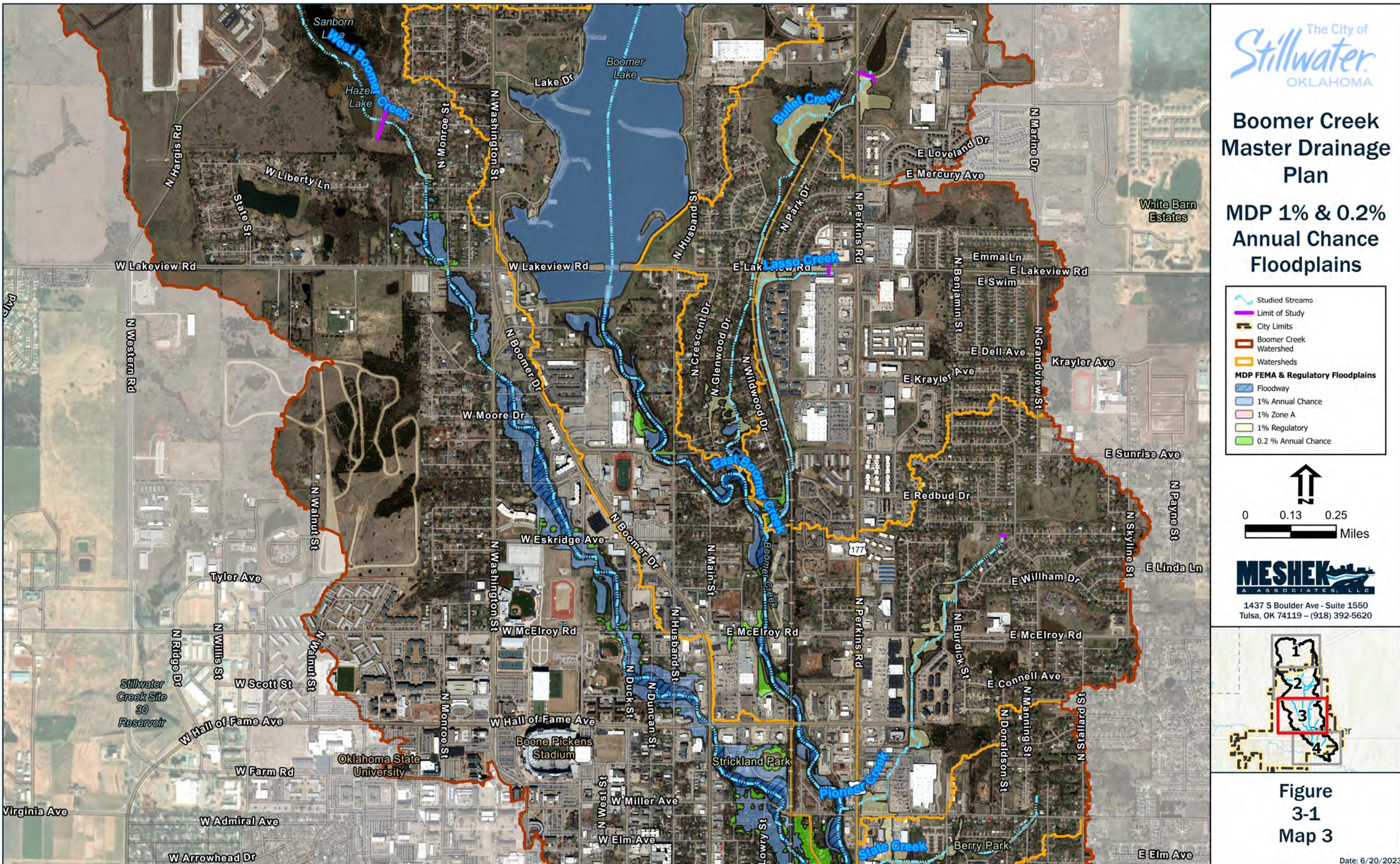
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**Figure  
3-1  
Map 2**

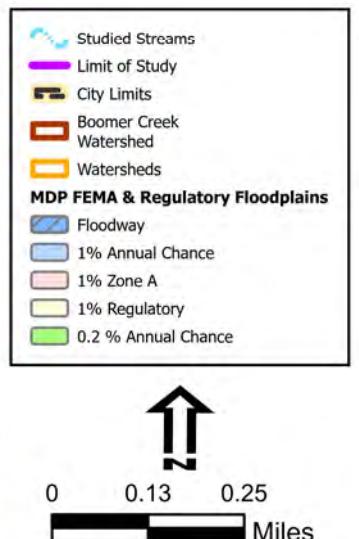




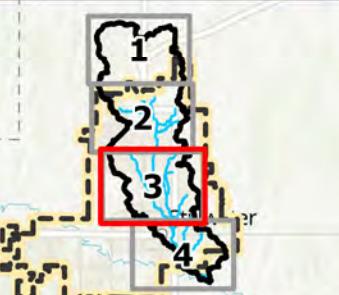
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# Boomer Creek Master Drainage Plan

## MDP 1% & 0.2% Annual Chance Floodplains



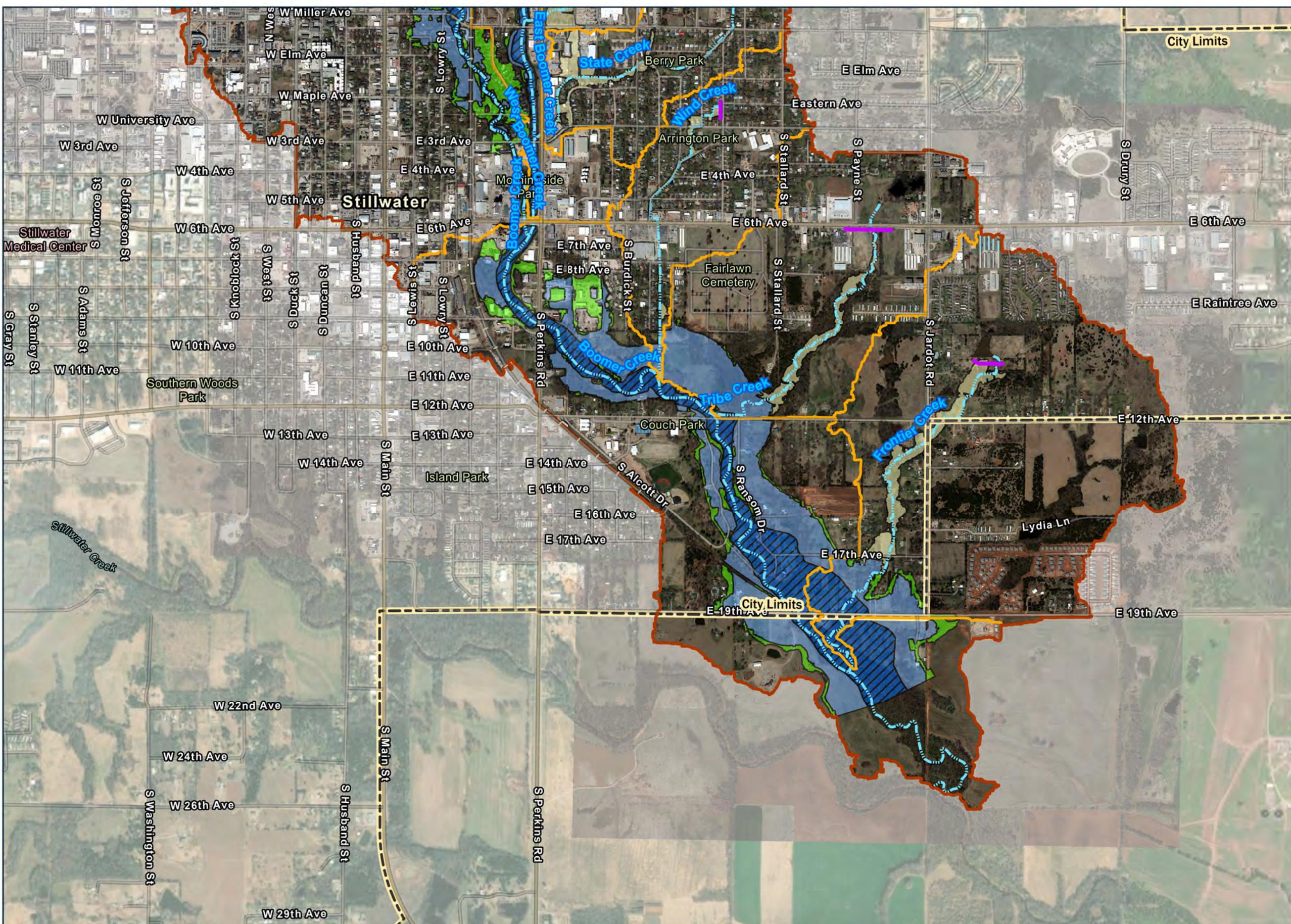
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**Figure  
3-1  
Map 3**

## Boomer Creek Master Drainage Plan

MDP 1% & 0.2%  
Annual Chance  
Floodplains



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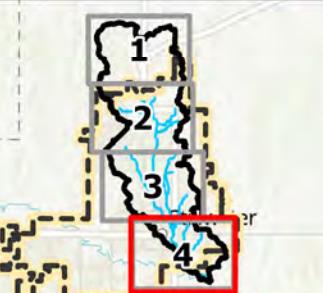
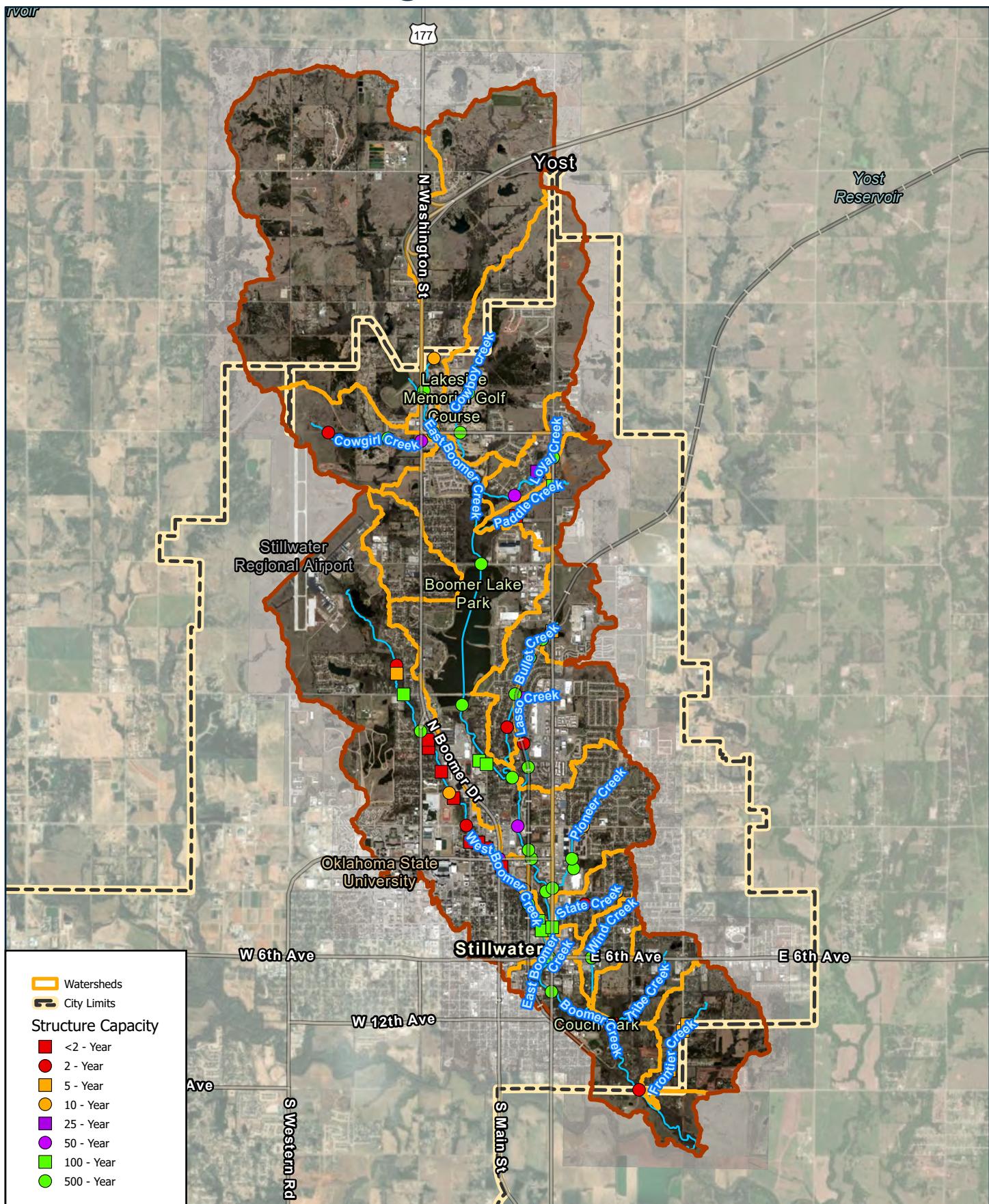


Figure  
3-1  
Map 4

Date: 6/20/2023

# Boomer Creek Master Drainage Plan

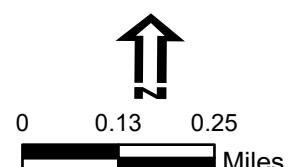
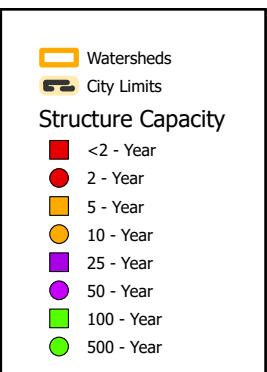
0 0.5 1 Miles



**Hydraulic Structures**



## Boomer Creek Master Drainage Plan Hydraulic Structures Map



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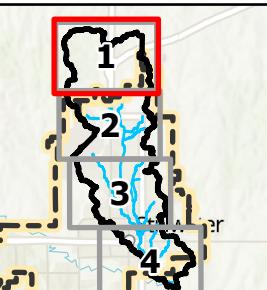
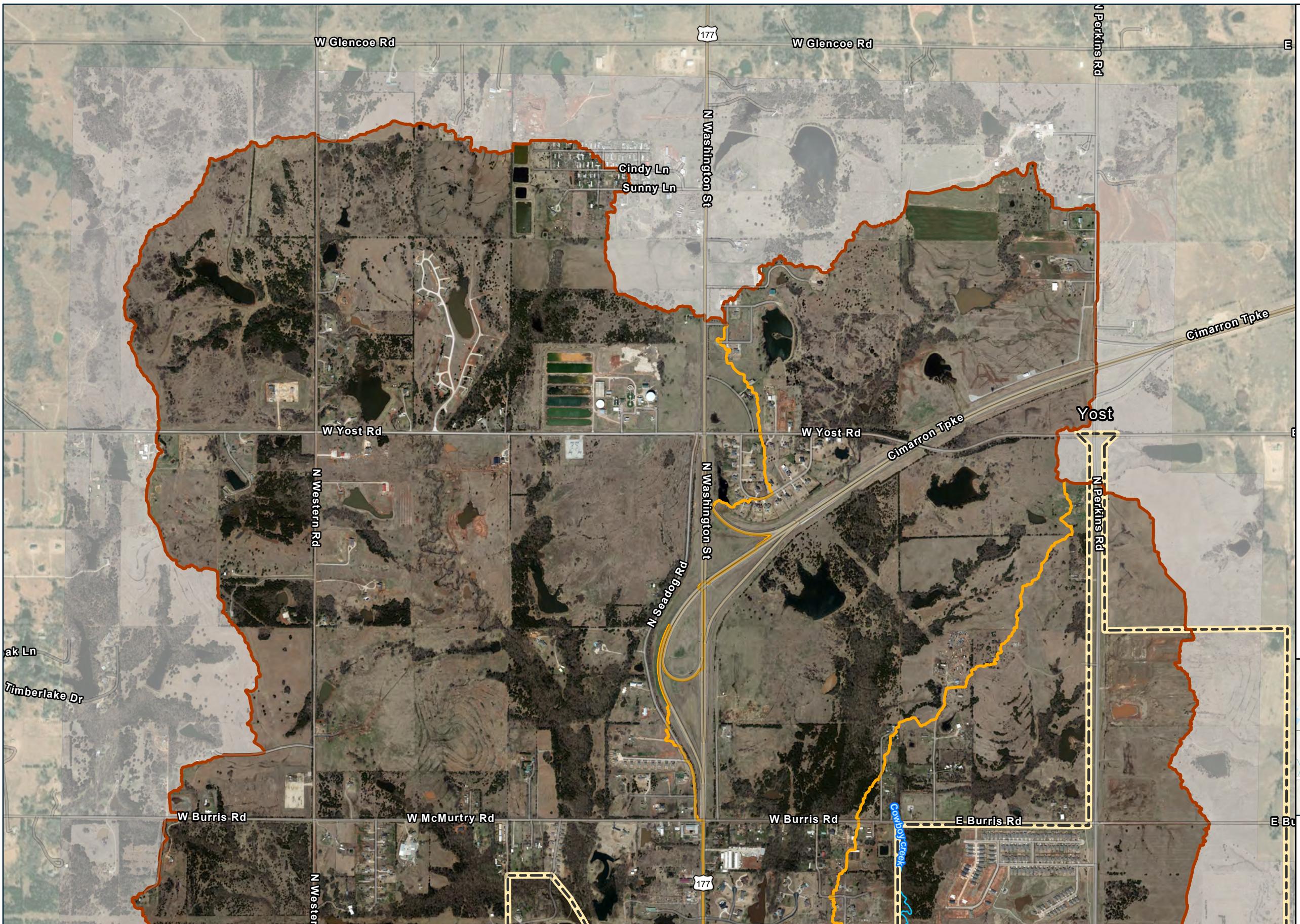


Figure  
3-2  
Map 1

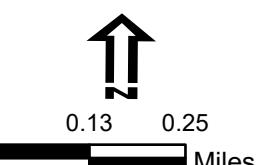
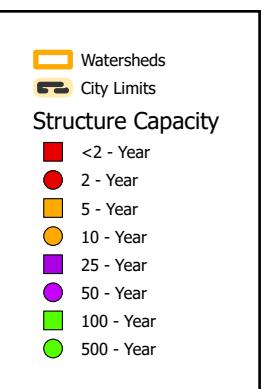
Date: 6/14/2023





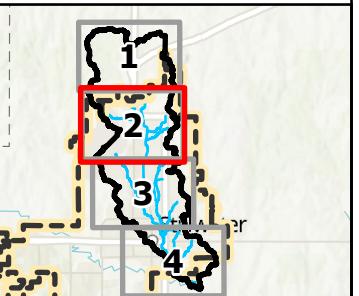
## Boomer Creek Master Drainage Plan

### Hydraulic Structures Map



**MESHEK**  
& ASSOCIATES, LLC

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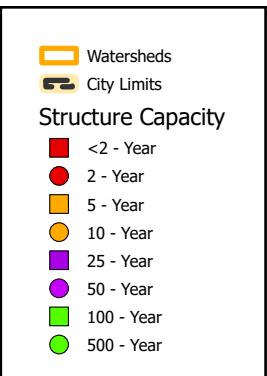
**Figure  
3-2  
Map 2**

Date: 6/14/2023



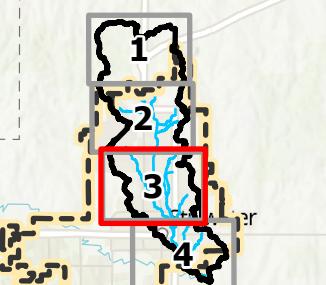


## Boomer Creek Master Drainage Plan Hydraulic Structures Map

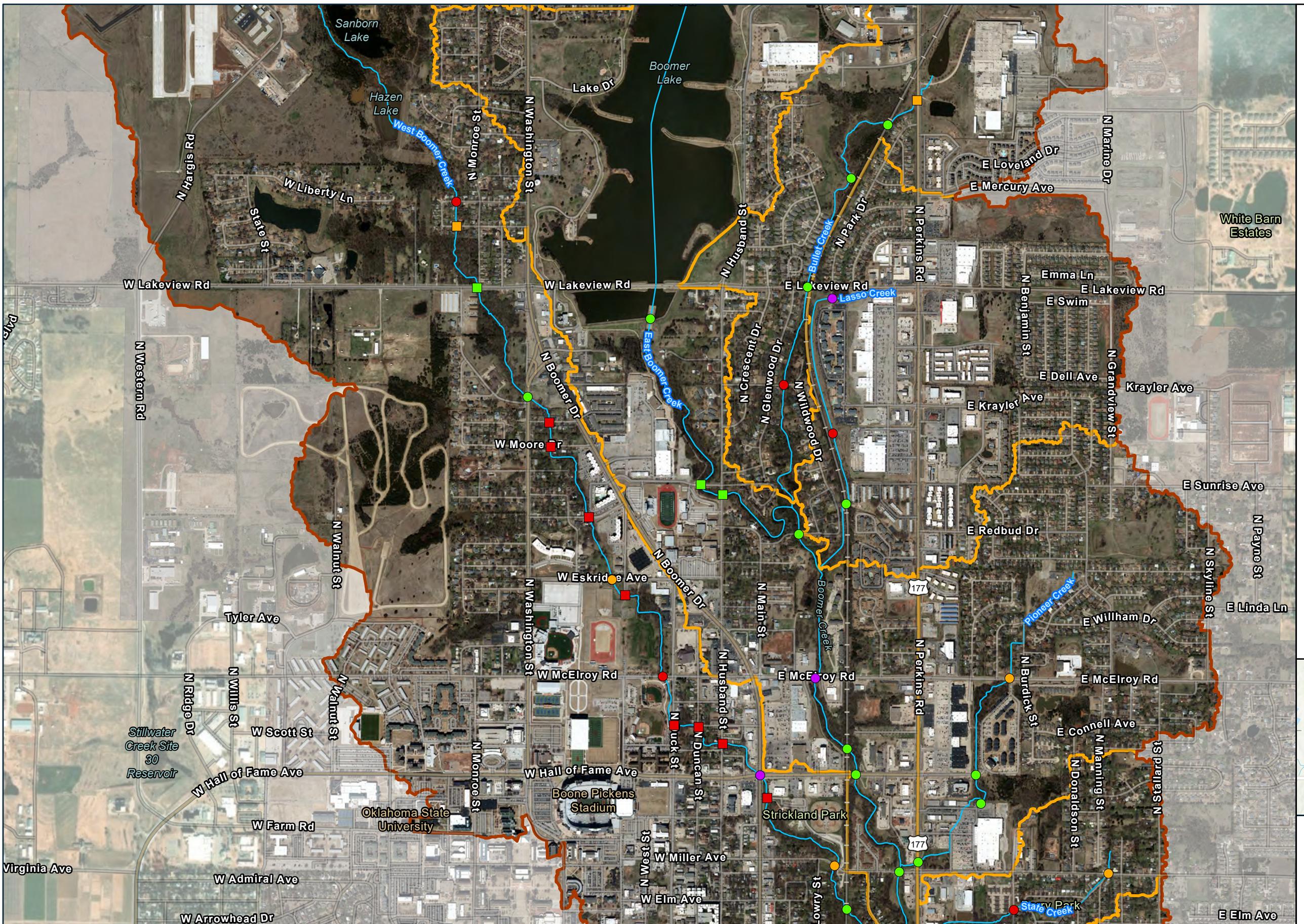


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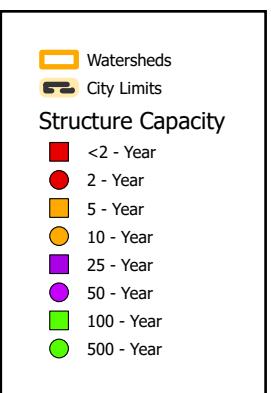
**Figure  
3-2  
Map 3**



Date: 6/14/2023

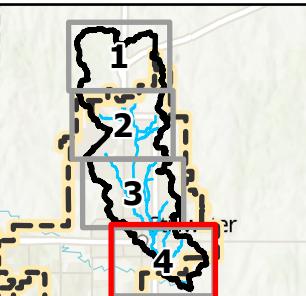


## Boomer Creek Master Drainage Plan Hydraulic Structures Map



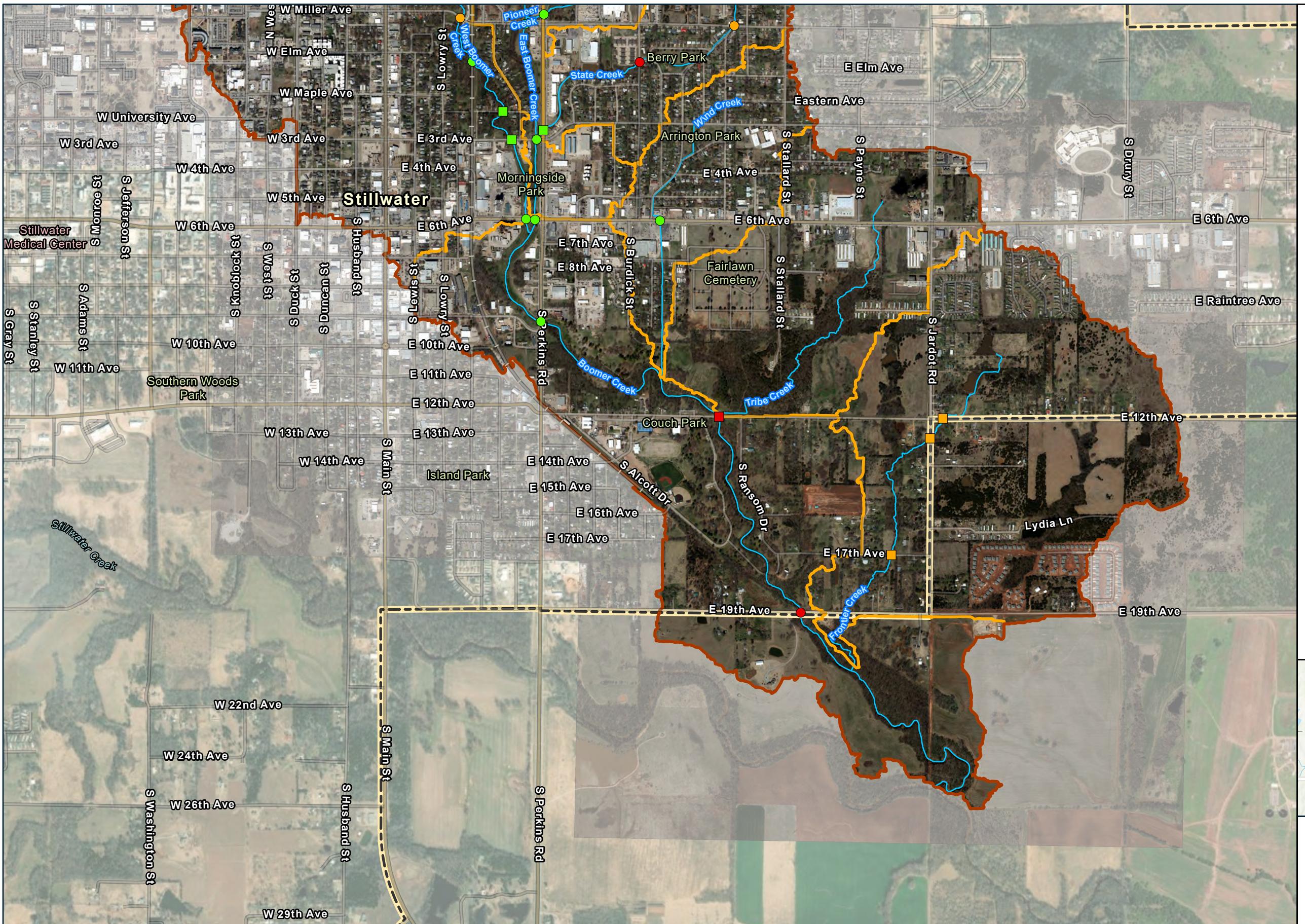
**MESHEK**  
& ASSOCIATES, LLC

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**Figure  
3-2  
Map 4**

Date: 6/14/2023



### 3.3 CITY & PUBLIC INPUT

A public meeting was held on January 18<sup>th</sup>, 2022, at the Stillwater Community Center. Comments received at that meeting, via email prior to and after the meeting, as well as comments received from City staff facilitated the problem area identification.

### 3.4 PROBLEM AREA ANALYSIS

Recommendations are provided for each problem area and are summarized in **Section 1.3**. Cost estimates are provided for each suggested alternative. **Figure 1-3** shows the location of each problem area.

A figure of problem area alternatives and their location in the Lower Boomer Creek, East Boomer Creek, and West Boomer Creek watersheds are included in **SECTION 4**, **SECTION 5**, and **SECTION 6** respectively. Flooding problem areas were identified by reviewing flooding comments and observations received from City staff and residents as well as reviewing the results of the updated modeling and mapping.

Alternatives were analyzed for each of the problem areas and one of them was selected as the recommended plan. All the alternatives were analyzed at a conceptual level. When the City decides to move forward with one of the recommendations, additional design and/or modeling will be needed to finalize the details of the project. This will ensure no adverse impact to adjacent properties and provide greater detail to refine the project cost estimate.

## SECTION 4. LOWER BOOMER CREEK PROBLEM AREA ANALYSIS

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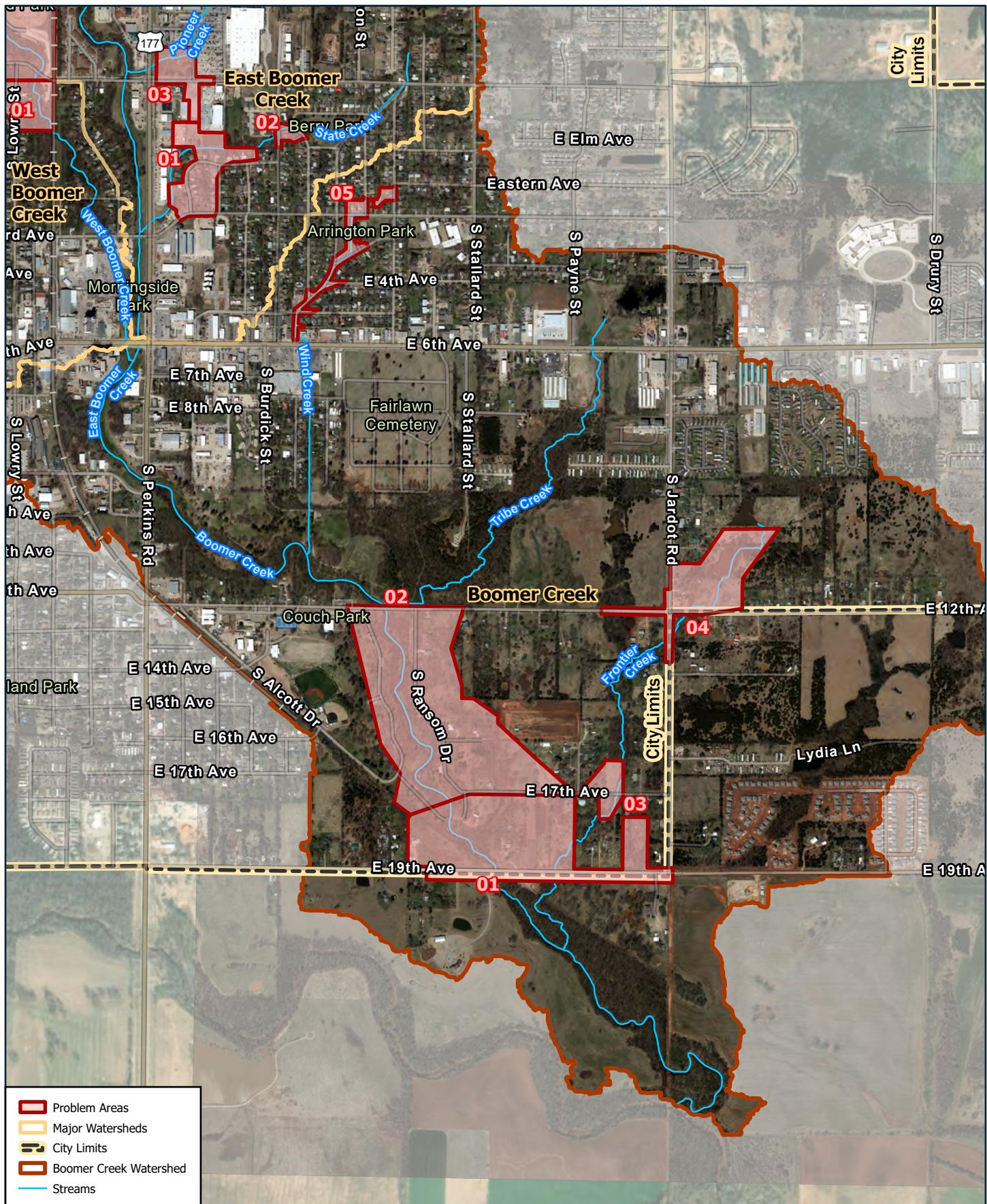
This section describes the five problem areas within the lower reach of the Boomer Creek watershed and the alternatives that were considered for mitigation. Cost estimates are provided for each alternative. Recommendations are provided for each problem area and are summarized in **Section 1.3. Figure 4-1: Lower Boomer Creek Problem Areas** shows the location of each problem area.

A detailed map of problem area alternatives and their location in the Lower Boomer Creek watershed is illustrated after each problem area description and all alternatives in **SECTION 4**. Flooding problem areas were identified by reviewing flooding comments and observations received from City staff and residents as well as reviewing the results of the updated modeling and mapping.

Alternatives were analyzed for each of the problems areas and one of them was selected as the recommended plan. All the alternatives were analyzed at a conceptual level. When the City decides to move forward with one of the recommendations, additional design and/or modeling will be needed to finalize the details of the project. This will ensure no adverse impact to adjacent properties or loss of floodplain storage and provide greater detail to refine the project cost estimate.

# Boomer Creek Master Drainage Plan

0 0.13 0.25 Miles



**Lower Boomer Creek Problem Areas**

### ***Problem Area #01: Residential and Roadway Flooding along E. 19<sup>th</sup> Avenue***

The problem area consists of residential flooding on the upstream side of E. 19<sup>th</sup> Avenue between HWY 177 and S. Jardot Road. The City of Stillwater's jurisdictional area at this location is on the north side of E. 19<sup>th</sup> Avenue and the west side of S. Jardot Road. The Payne County jurisdictional area is on the south side of E. 19<sup>th</sup> Avenue and the east side of S. Jardot Road. Approximately 26 properties experience yard flooding during the 1% annual chance flood. Of those 26 properties, there are 11 homes at risk of flooding. Roads that experience flooding during the 1% AEP flood include Alcott Drive, S. Ransom Drive, E. 16<sup>th</sup> Avenue, E. 17<sup>th</sup> Avenue, and E. 19<sup>th</sup> Avenue. During the 1% annual chance event, E. 19<sup>th</sup> Avenue overtops by roughly 5 feet deep at the roadway's lowest point.

The cause of the flooding appears to be tailwater conditions from Stillwater Creek controlling the WSE for this area and the receiving headwater just adds to the impact. Public comments indicate this problem area experiences frequent flooding in the yards and streets.

The local Frontier Creek flows without tailwater impacts, overtops E. 19<sup>th</sup> Avenue in events larger than a 50% annual chance flood. The undersized culvert, small channel capacity, and low-lying overbanks all contribute to this problem.

#### **Problem Area 01 Recommendation – Relocation and Acquisition**

Acquisition and relocation is the recommendation due to the cost of the other alternatives. Eleven properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood.

The cost of acquisition and relocation is roughly \$2,394,000. See **Figure 4-2** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

#### **Problem Area 01 Alternative 1 – Bridge Design**

This is a bridge design that should allow the roadway to pass a 1% annual chance event. The bridge would span 2,291 feet. The roadway would be raised and repaved to a minimum elevation of 859.9'. There is a maximum elevation change of 16.8 feet from the proposed bridge crest to the existing roadway lowest sag point. Due to tailwater conditions from Stillwater Creek, this alternative will not lower the water surface elevation and therefore will not remove any properties from the floodplain. This alternative requires the acquisition of properties for construction because of property location, inability to provide adequate access to properties, elevation change and roadway design constraints, and the bridge design overall.

Since Boomer Creek is a FEMA-studied stream and has an existing mapped floodway the bridge crossing and mapping changes associated will need to be submitted to FEMA as well as a Letter of Map Change (LOMC). The cost estimate does not include the FEMA LOMC submittal.

The cost of this bridge with property acquisition would roughly be \$25,990,000. See **Figure 4-3** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

**Problem Area 01 Alternative 2 – Bridge Design**

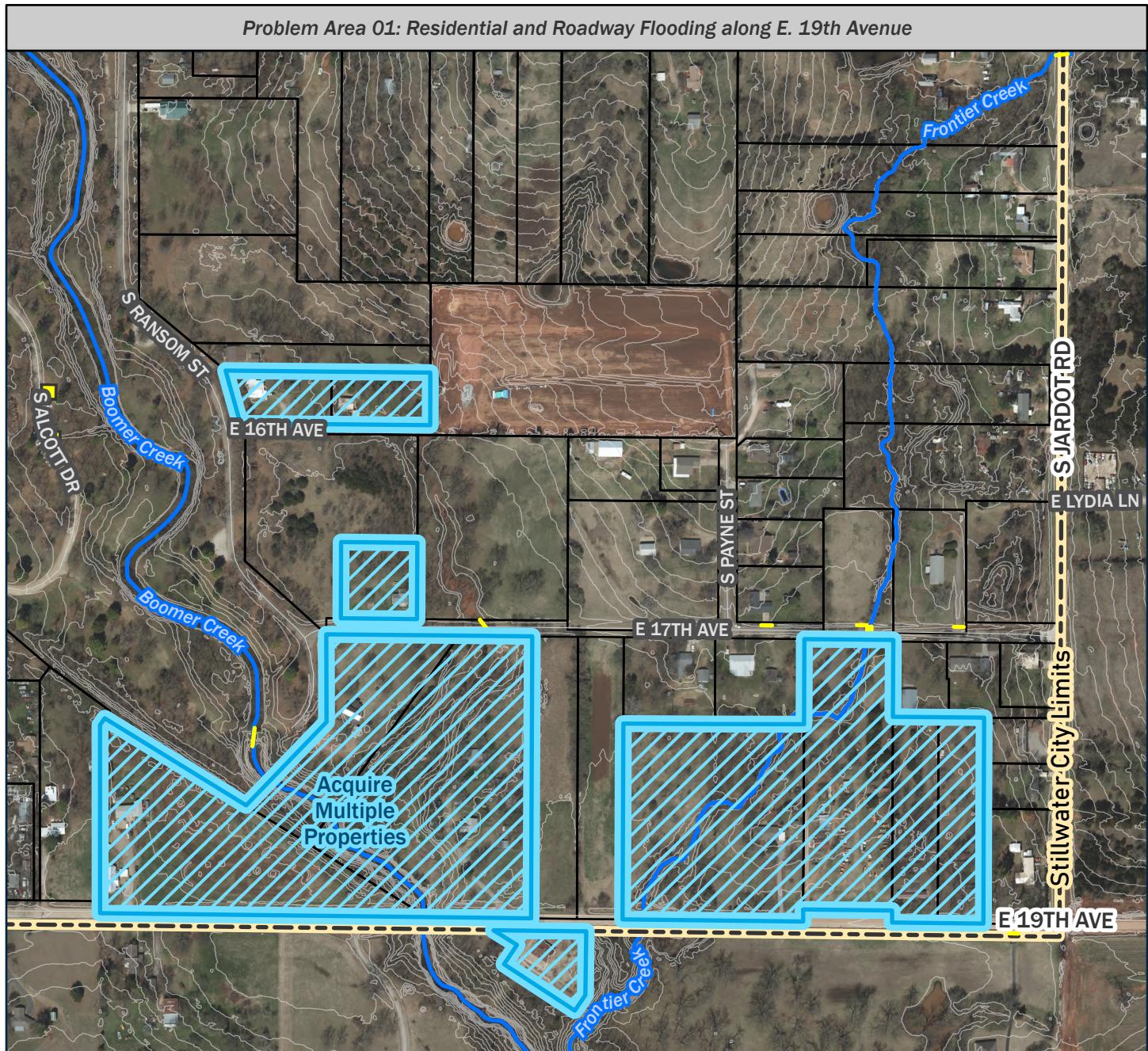
This is a bridge design that should allow the roadway to pass a 10% annual chance event. The bridge would span 440 feet. The roadway would be raised and repaved to a minimum elevation of 857.25'. There is a maximum roadway elevation change of 1.25 feet from the existing sag elevation of 857.25'. Due to tailwater conditions from Stillwater Creek, this alternative will not lower the water surface elevation and therefore will not remove any properties with yard flooding or roadways being inundated from the 10% annual chance flood. City criteria requires two feet of freeboard from the low cord of the bridge during the 1% annual chance event therefore this design does not meet the City regulations.

Since Boomer Creek is a FEMA-studied stream and has an existing mapped floodway the bridge crossing and mapping changes associated will need to be submitted to FEMA as well as a Letter of Map Change (LOMC). The cost estimate does not include the FEMA LOMC submittal.

The cost of this bridge would be roughly \$6,426,000. See **Figure 4-4** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

# Lower Boomer Creek Problem Area Alternatives

0 200 400 US Feet



## Problem Area 01 Recommendation – Relocation and Acquisition

### Property Acquisition

Cost: \$2,394,000

#### Proposed Project Locations

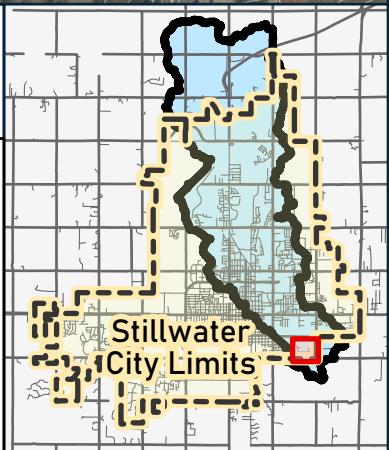
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

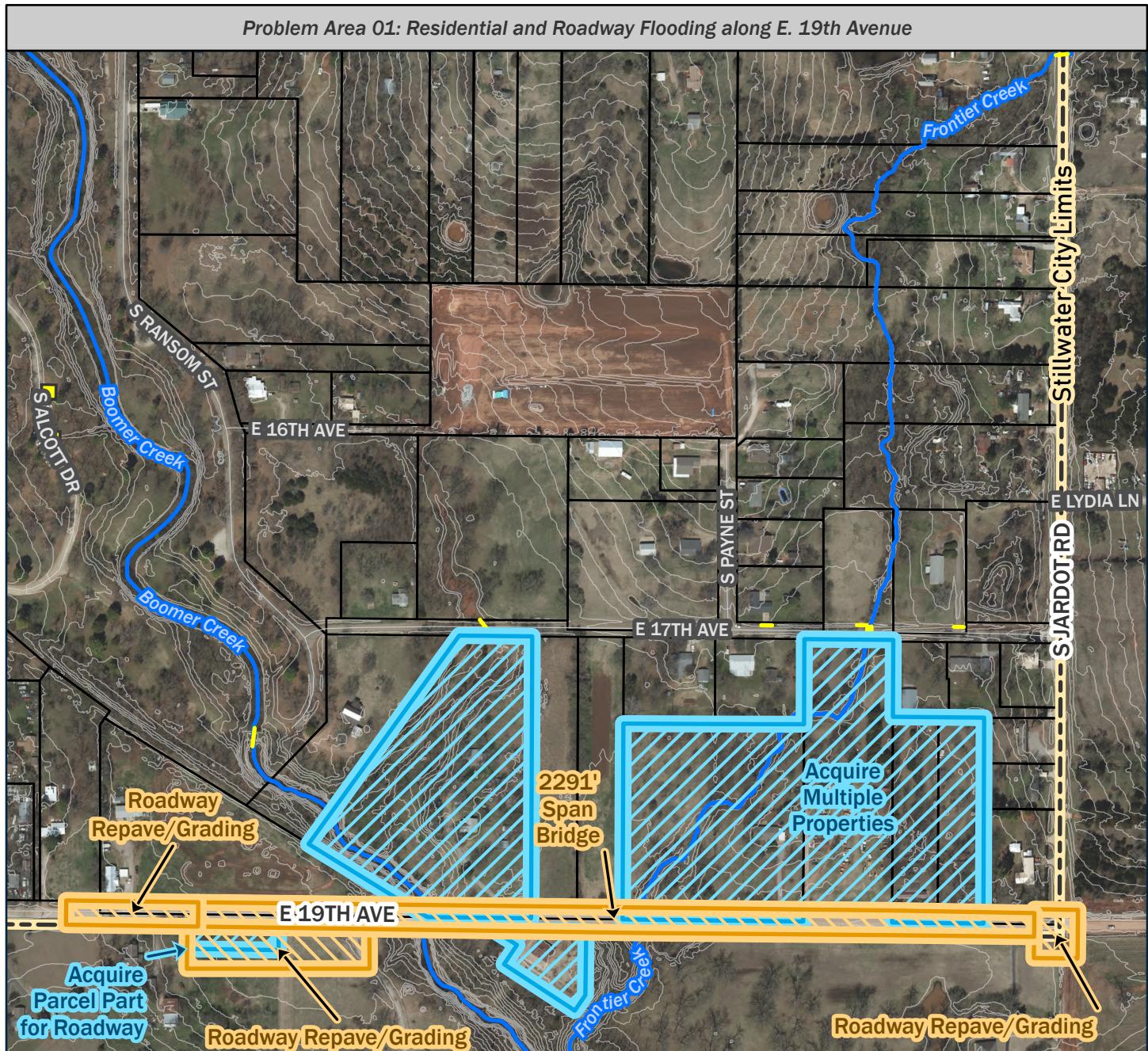
#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 200 400 US Feet



## Problem Area 01 Alternative 1 – Bridge Design

### Bridge + Property Acquisition

Cost: \$25,990,000

#### Proposed Project Locations

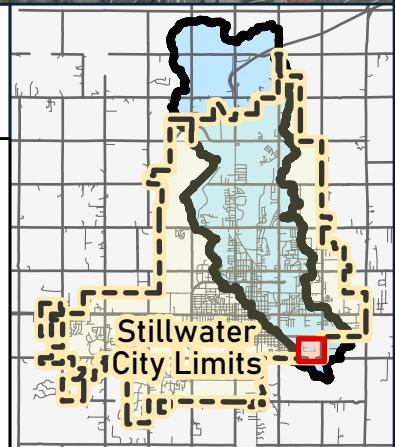
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

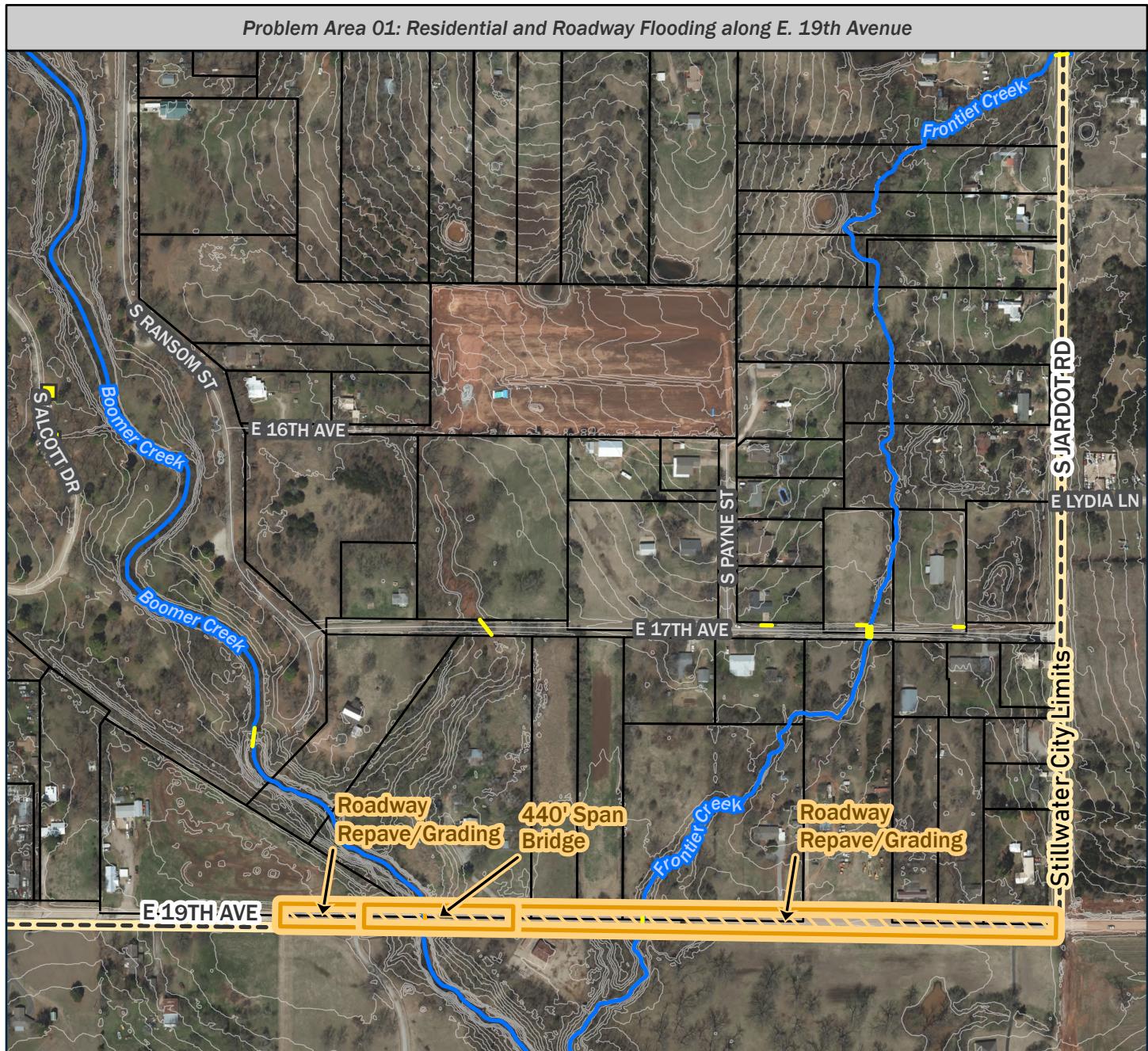
#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 200 400 US Feet

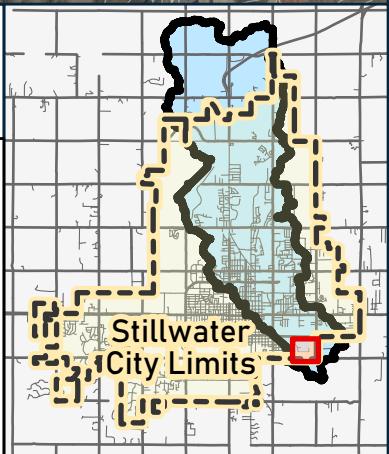


## Problem Area 01 Alternative 2 – Bridge Design

### Bridge + Road Improvements

Cost: \$6,426,000

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



***Problem Area #02: Residential and Roadway Flooding along E. 12<sup>th</sup> Avenue***

The problem area consists of residential flooding on the downstream side of E. 12<sup>th</sup> Avenue between HWY 177 and S. Jardot Road. Several properties experience yard flooding during the 1% annual chance flood. Of those properties there are three homes at risk of flooding. Roads that experience flooding during the 1% AEP flood include Alcott Drive, S. Ransom Drive, and E. 12<sup>th</sup> Avenue. During the 1% annual chance event, E. 12<sup>th</sup> Avenue is overtopped by approximately 40 inches at the roadway's lowest point.

The current bridge is undersized and causes a large head loss through the structure which causes upstream flooding and overtopping of the roadway. E. 12<sup>th</sup> Avenue has less than a 50% annual chance capacity before overtopping.

**Problem Area 02 Recommendation – Relocation and Acquisition**

Acquisition and relocation is the recommendation due to the cost of the other alternatives. Three properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood.

The cost of relocation and acquisition would be approximately \$1,082,000. See **Figure 4-5** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

**Problem Area 02 Alternative 1 – Bridge Design**

To pass the 1% annual chance event, a 950-foot bridge would be needed. The bridge would tie-in to existing grade on the east at an approximate elevation of 863.6' and on the west side at roughly 862.6'. This alternative requires acquisition of a single property due to impacts after the bridge is in place. A new roadway alignment for Alcott Dr. and S. Ramson Dr. is required due to the span of the bridge impacting the intersection.

Since Boomer Creek is a FEMA studied stream and has existing mapped floodway the bridge crossing and mapping changes associated will need to be submitted to FEMA with a Letter of Map Change (LOMC) for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this bridge would be roughly \$10,402,000. See **Figure 4-6** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

**Problem Area 02 Alternative 2 – Bridge Design**

For a 10% annual chance alternative, a 625-foot bridge is needed. The bridge would tie-in to existing grade on the east side at an approximate elevation of 862.25' and on the west side at roughly 861.25'. This alternative requires acquisition of a single property due to the impacts of the bridge post construction. A new roadway alignment for S. Ramson Dr. is also required. City criteria requires two feet of freeboard from the low cord of the bridge during the 1% annual chance event therefore this design will not meet that criteria.

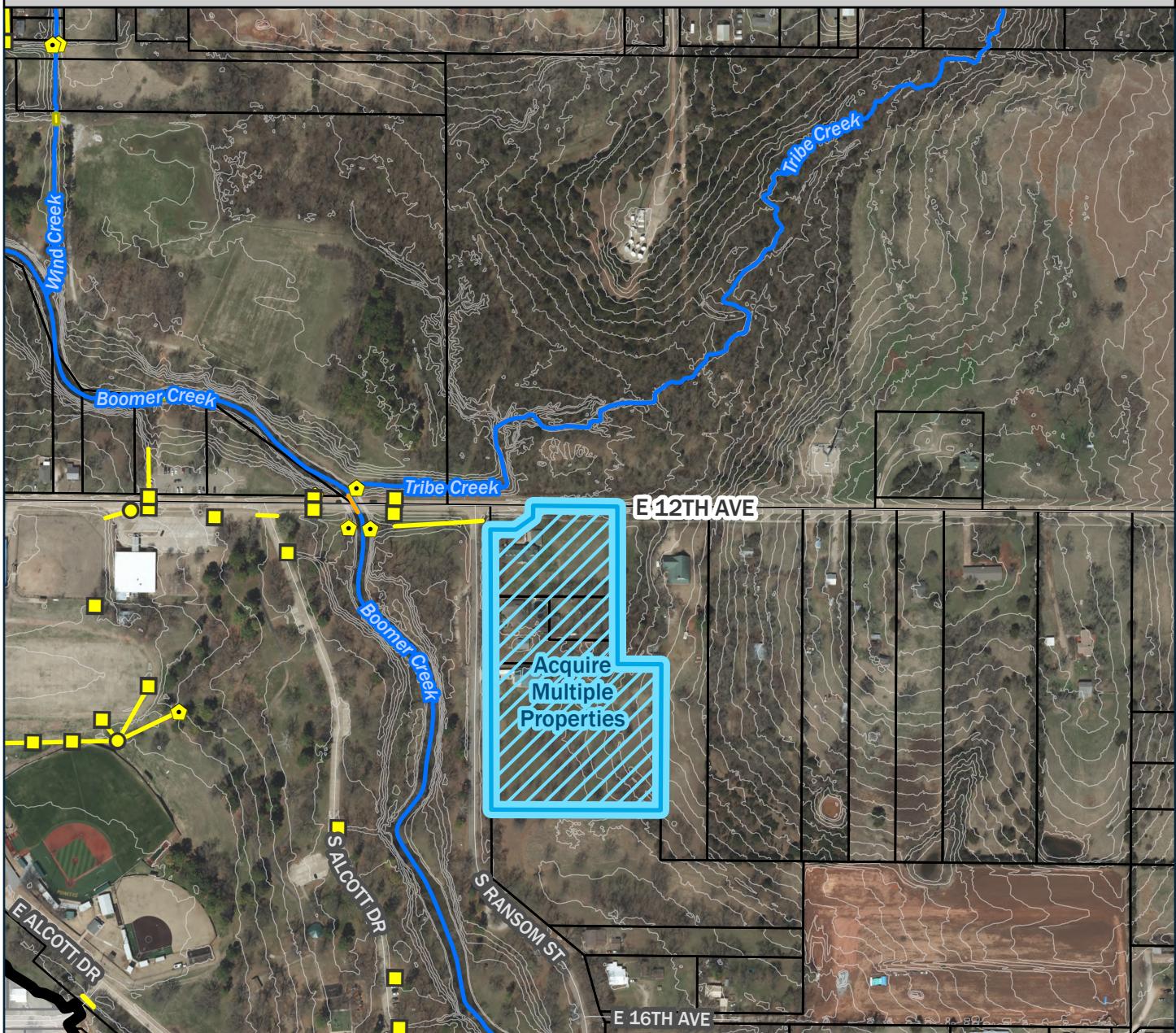
Since Boomer Creek is a FEMA studied stream and has existing mapped floodway the bridge crossing and mapping changes associated will need to be submitted to FEMA as well as a Letter of Map Change (LOMC). The cost estimate does not include the FEMA LOMC submittal.

The cost of this bridge would be roughly \$7,709,000. See **Figure 4-7** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

# Lower Boomer Creek Problem Area Alternatives

0 200 400 US Feet

## Problem Area 02: Residential and Roadway Flooding along E. 12th Avenue

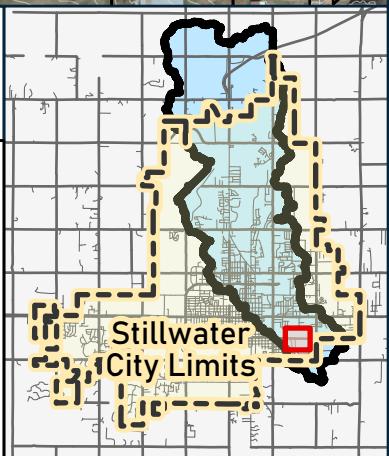


## Problem Area 02 Recommendation – Relocation and Acquisition

### Property Acquisition

Cost: \$1,082,000

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other

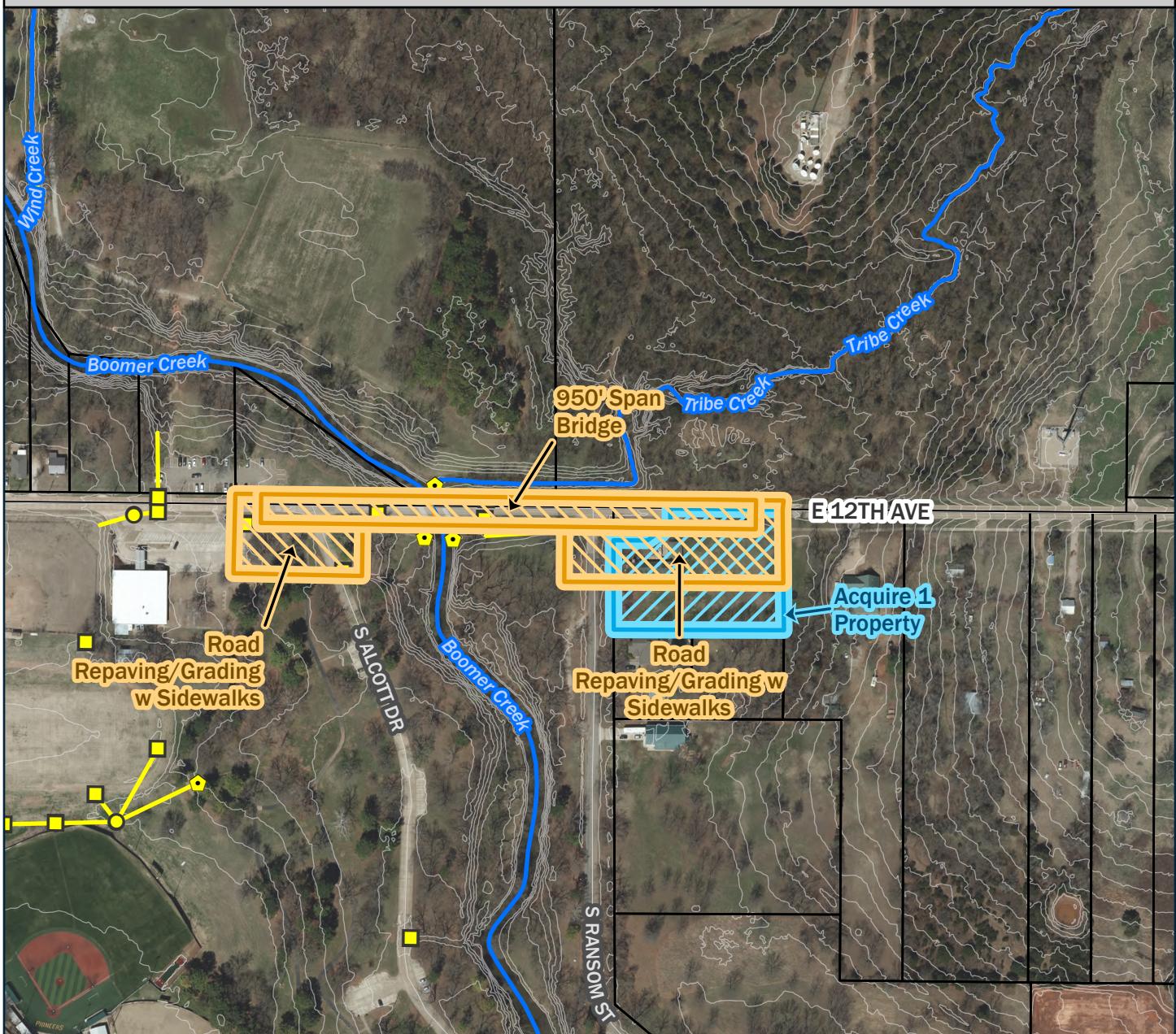


## Boomer Creek Master Drainage Plan

# Lower Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area 02: Residential and Roadway Flooding along E. 12th Avenue



### Problem Area 02 Alternative 1 – Bridge Design

**Bridge + Property Acquisition + Road Improvements** Cost: \$10,402,000

#### Proposed Project Locations

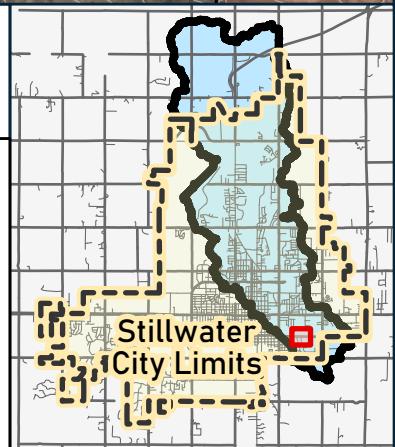
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 200 400 US Feet

## Problem Area 02: Residential and Roadway Flooding along E. 12th Avenue

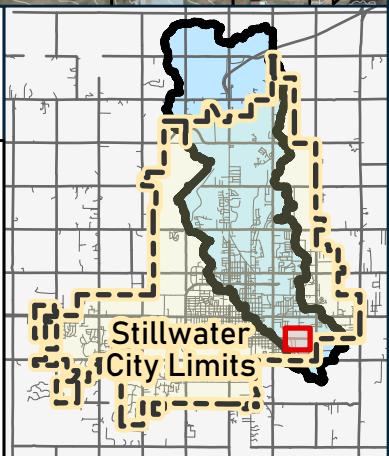


### Problem Area 02 Alternative 2 – Bridge Design

**Bridge + Property Acquisition + Road Improvements**

**Cost: \$7,709,000**

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



***Problem Area #03: Roadway Flooding along E. 17<sup>th</sup> Avenue***

The problem area consists of street flooding on E. 17<sup>th</sup> Avenue between S. Payne Street and S. Jardot Road along Frontier Creek. Several properties experience yard flooding during the 1% annual chance flood. During the 1% annual chance event, E. 17<sup>th</sup> Avenue overtops by nearly a foot deep at the roadway's lowest point.

The E. 17th Avenue roadway has a low water crossing point and an undersized culvert. The culvert is not fully utilized before the roadway is overtopped. This roadway has only a 20% annual chance hydraulic capacity before overtopping.

**Problem Area 03 Recommendation – Roadway Design**

This alternative provides the crossing to pass a 1% annual chance event. The roadway would be raised and repaved to a minimum elevation of 863'. There would be an increase of approximately 0.5 feet at the low point of the roadway. The existing culvert structure is to be replaced with a triple barrel 8' x 4' RCB structure. An estimated 1.0 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

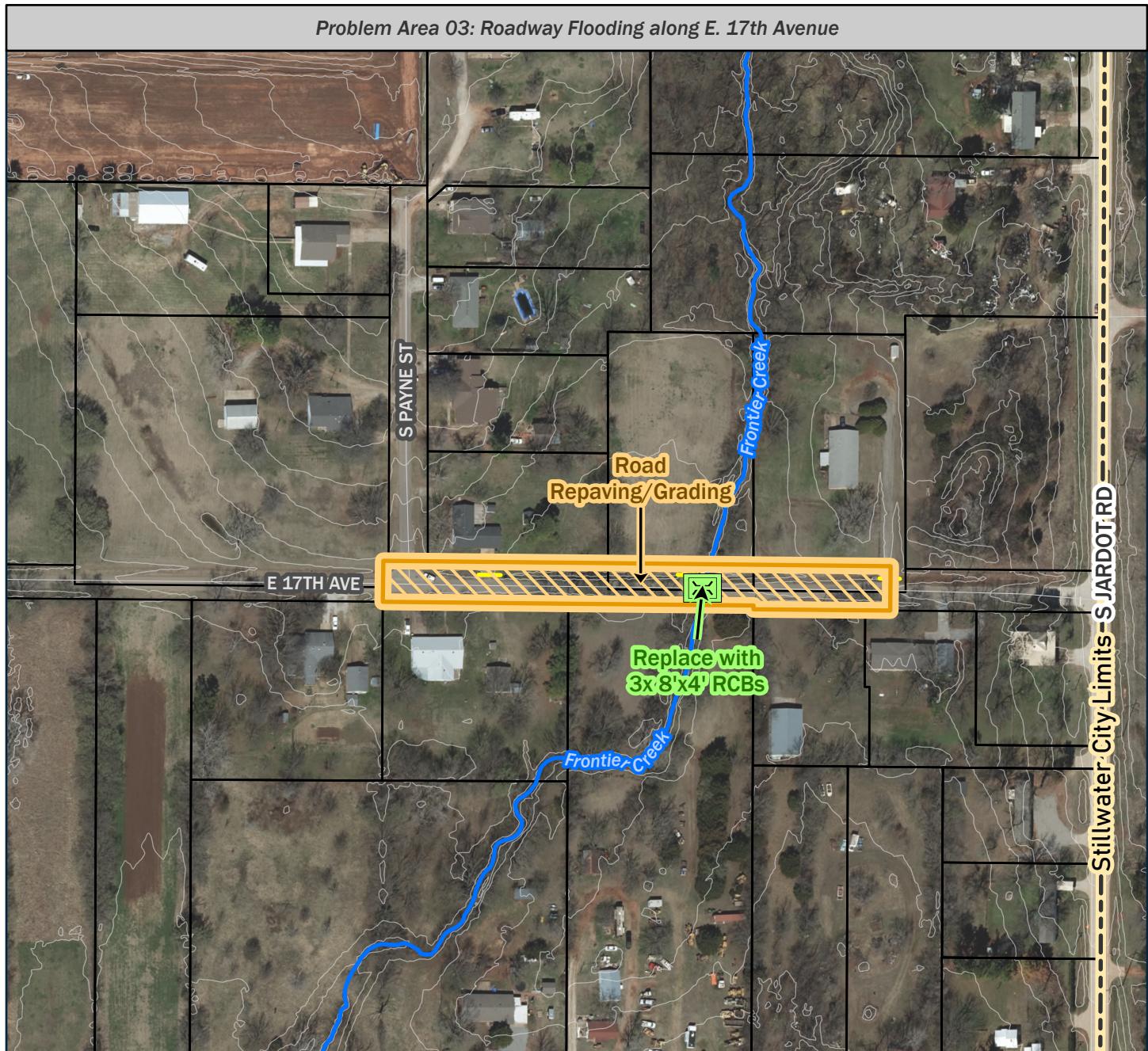
The cost of this recommendation would be roughly \$674,000. See **Figure 4-8** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

**Problem Area 03 Evaluated Alternative- Floodplain Storage**

The calculated floodplain storage required to reduce the 1% annual chance flows to a 10% annual chance is approximately 10.7 acre-feet based off the HEC-RAS 1-D hydraulic model. The grading extents shown should obtain the additional volume necessary. However, the roadway would still overtop. Due to the existing terrain and the proximity of existing development, a pond would not be feasible. Therefore, grading within the floodplain would be required to increase the floodplain storage. This would require a significant amount of property because additional depth will be limited. The excavation costs along with the property cost would make this alternative infeasible. Therefore, additional details were not developed for this evaluated alternative. See **Figure 4-9** for a layout of this alternative.

# Lower Boomer Creek Problem Area Alternatives

0 100 200 US Feet



## Problem Area 03 Recommendation – Roadway Design

Replace Culvert and Update Roadway

Cost: \$674,000

### Proposed Project Locations

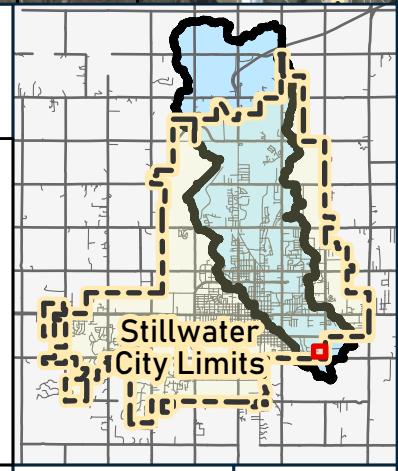
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



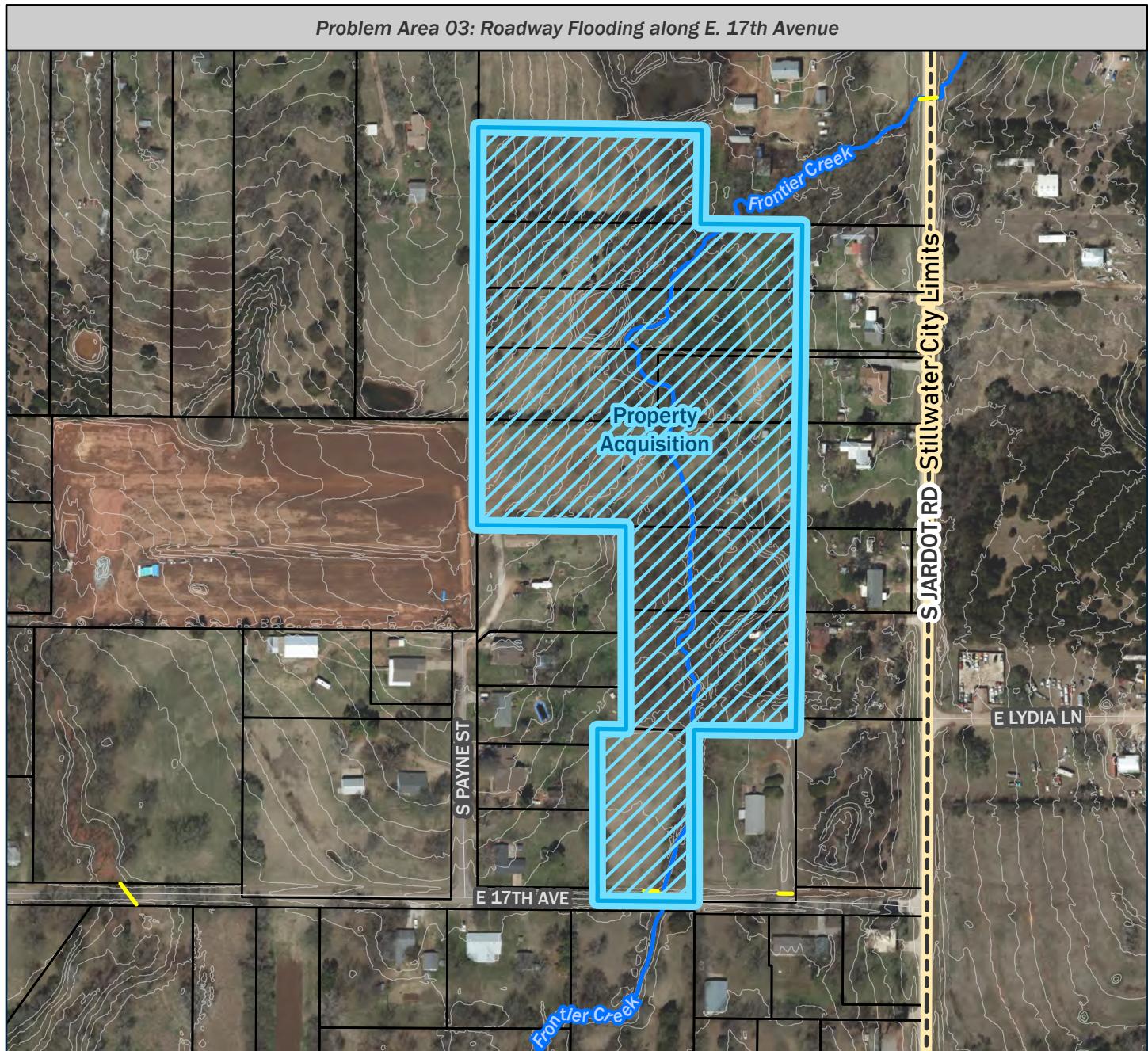
## Boomer Creek Master Drainage Plan

**MESHEK**  
Associates, LLC  
Tulsa, Oklahoma City, OK - Fayetteville, AR  
Date: 6/16/2023

Figure  
4-8

# Lower Boomer Creek Problem Area Alternatives

0 150 300 US Feet



## Problem Area 03 Evaluated Alternative – Floodplain Storage

### Evaluated FP Storage & Acquisition

Cost: \$ N/A

#### Proposed Project Locations

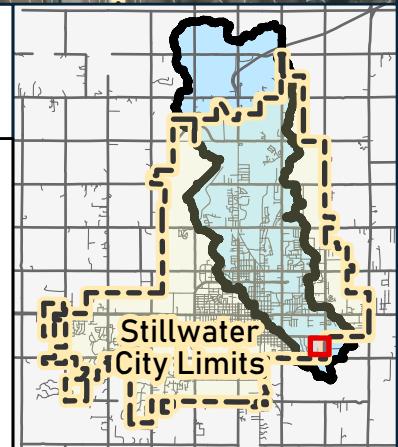
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



***Problem Area #04: Roadway Flooding along E. 12<sup>th</sup> Avenue and S. Jardot Road***

The problem area consists of street flooding on E. 12<sup>th</sup> Avenue east of S. Jardot Road and flooding along S. Jardot Road south of E. 12<sup>th</sup> Avenue intersection along Frontier Creek. The City of Stillwater jurisdictional area at this location is on the north side of E. 12<sup>th</sup> Avenue and the west side of S. Jardot Road. The Payne County jurisdictional area is on the south side of E. 12<sup>th</sup> Avenue and the east side of S. Jardot Road. Several properties experience yard flooding during the 1% annual chance flood. During the 1% annual chance event, E. 12<sup>th</sup> Avenue overtops by approximately 0.75 feet at the roadway's lowest point, while S. Jardot Road overtops by nearly a foot deep at its lowest point.

Both roadways only have a 20% annual chance capacity before overtopping at this location.

**Problem Area 04 Recommendation – Detention Design**

The floodplain storage required to reduce the 1% annual chance flows to 66 cfs (which is between a 50% and 20% annual chance event) is approximately 22.7 acre-feet based off the HEC-HMS inflow hydrograph. The recommended detention pond should allow the remaining unrestricted flow from the drainage basin and the proposed detention pond outflow to pass through the existing culvert structures crossing E. 12<sup>th</sup> Avenue and S. Jardot Road without any modification to the roadways. Both roadway culvert crossings have approximately 100 cfs capacity before being overtopped. The drainage ditch west of the pond and on the east side of S. Jardot Road would be rerouted and directed towards the detention pond. This should prevent the intersection of both roads from being overtopped in major flood events and allow the culvert crossing on S. Jardot Road to pass the proposed flow.

The cost of this recommendation would be roughly \$4,965,000. See **Figure 4-10** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

#### Problem Area 04 Alternative – Roadway Design

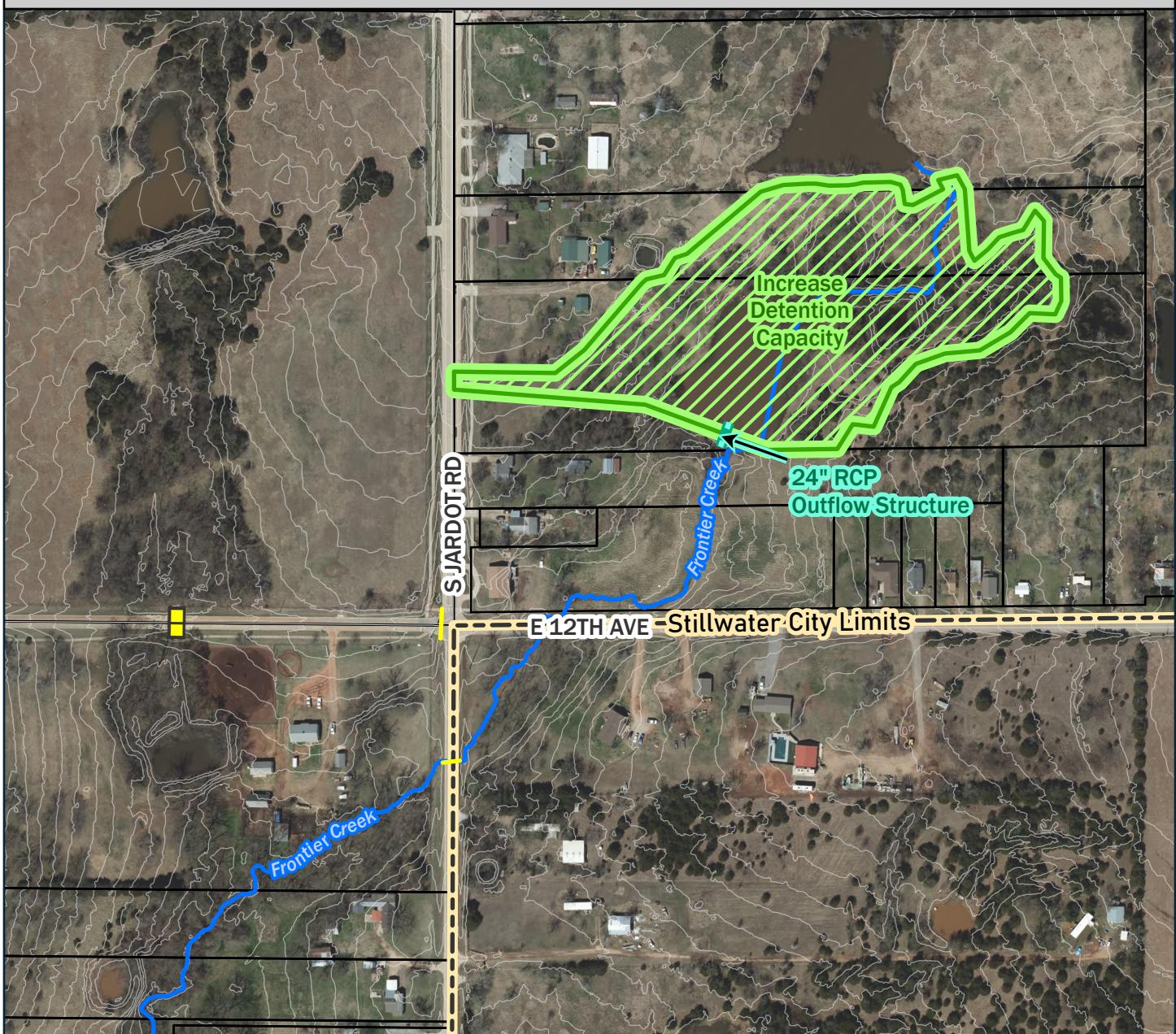
This alternative will provide roadway and culvert improvements that will increase the capacity of E. 12th Avenue and S. Jardot Road to the 1% annual chance event. Both roadways will need to be raised by approximately one foot. This will require road reconstruction for approximately 400 feet east and south of the intersection. The E. 12th Avenue culvert should be replaced with three 6'x3' RCBs. The S. Jardot Road culvert should be replaced with two 10'x3' RCBs. A new 36" RCP should be constructed under E. 12th Avenue to handle all the ditch flow along the east side of Jardot Road. Just west of the intersection, there is another low point that will experience frequent overtopping. New double 36" RCPs are needed to increase the capacity at that location. An estimated 0.9 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

The estimated cost of these roadway and culvert improvements is roughly \$1,723,000. See **Figure 4-11** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

# Lower Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area 04: Roadway Flooding along E. 12th Avenue and S. Jardot Road



### Problem Area 04 Recommendation – Detention Design

**Increase FP Storage + Control Outflow**

**Cost: \$4,957,000**

#### Proposed Project Locations

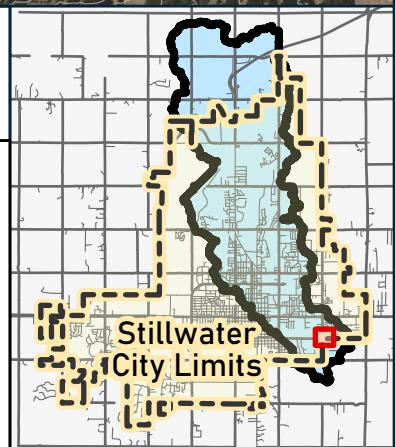
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

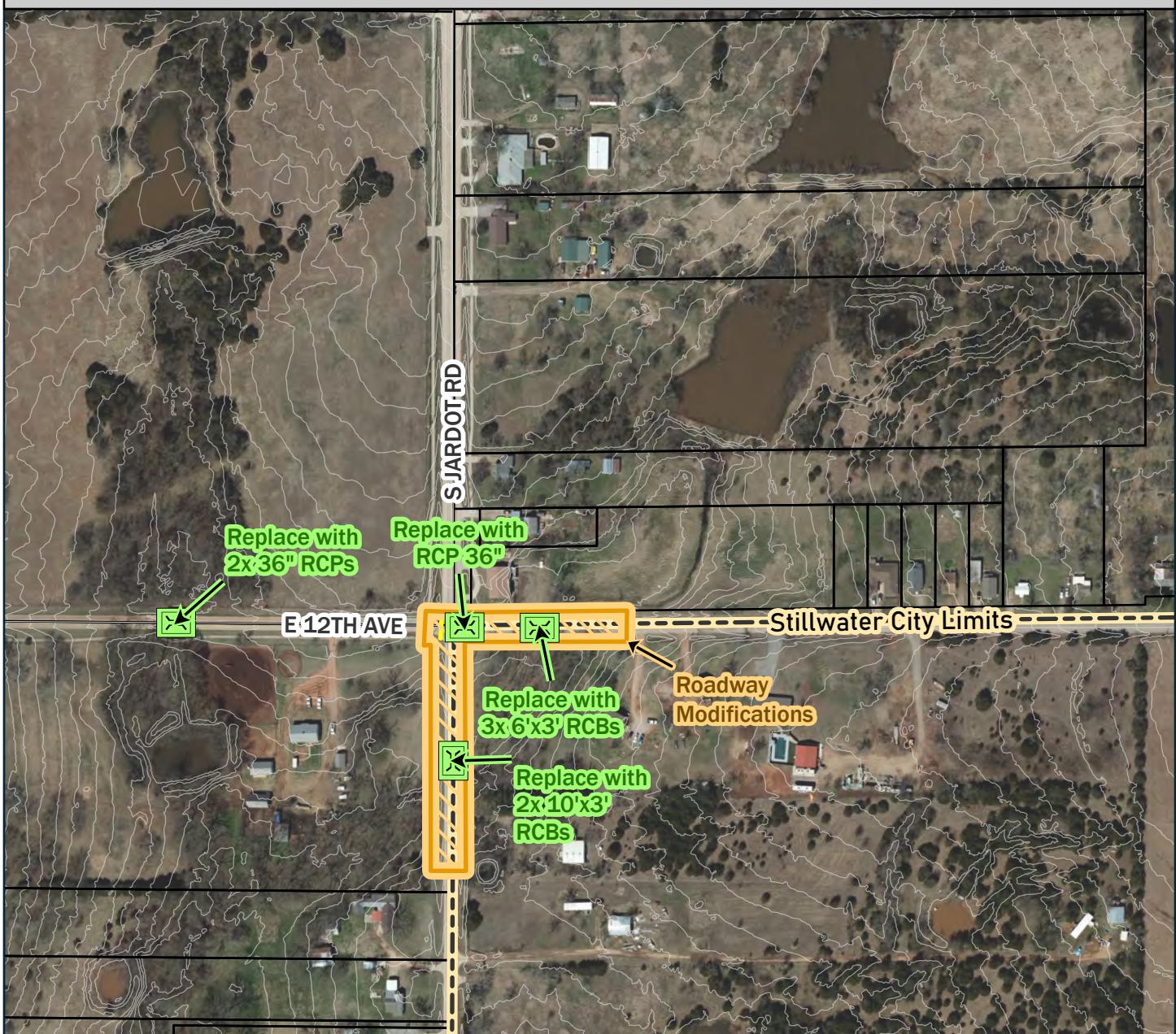
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area 04: Roadway Flooding along E. 12th Avenue and S. Jardot Road



### Problem Area 04 Alternative – Roadway Design

#### Culvert and Roadway Improvements

Cost: \$1,723,000

#### Proposed Project Locations

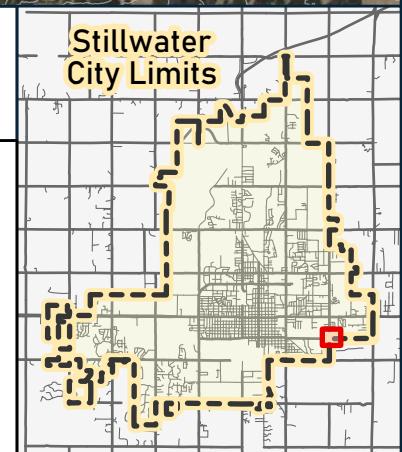
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



## Boomer Creek Master Drainage Plan

**MESHEK**  
ASSOCIATES, LLC  
Tulsa, Oklahoma City, OK - Fayetteville, AR  
Date: 6/29/2023

Figure  
**4-11**

***Problem Area #05: Residential and Roadway Flooding along E. 3<sup>rd</sup> Ave. and S. Doty Street***

The problem area consists of residential flooding on the downstream side of S. Doty Street between S. Marshall Street and S. Stallard Street and on the upstream side of E. 3<sup>rd</sup> Avenue. Approximately a dozen properties experience yard flooding during the 1% annual chance flood. Of those properties there are four homes at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance event include S. Doty Street, S. Marshall Street, Arrington Place, S. Arrington Drive, E. 4<sup>th</sup> Avenue, S. Berry Street, E. 5<sup>th</sup> Avenue and E. 3<sup>rd</sup> Avenue. During the 1% annual chance flood, E. 3rd Avenue is overtopped by roughly 2-feet deep at the roadway's lowest point.

Most of the flow in this area is overland flow. Once the flow leaves Arrington Park, the local streets must convey all the runoff. The existing culvert structure just east of S. Arrington Drive and on the north side of E. 6<sup>th</sup> Avenue has a capacity greater than the 0.2% annual chance event.

**Problem Area 05 Recommendation – Detention and Storm Sewer Design**

The floodplain storage required to reduce the 1% annual chance flows to a 2% annual chance event is approximately 3.6 acre-feet based off the HEC-HMS inflow hydrograph. An excavated pond is to be constructed within Arrington Park which should reduce the overall flow along the streets on the downstream side of the pond. An embankment is to be constructed to an elevation of 888'. The park amenities near and along Arrington Place would be protected and bordered by the dam without the need to be relocated. However, the basketball court would be removed and relocated. The 1% annual chance WSE must be no greater than elevation 887' so not to cause backwater onto E. 3<sup>rd</sup>. Avenue and to maintain the City design criteria of 1-foot freeboard. The suggested 4' x 2' RCB outlet could possibly be reduced in size or replaced if a multi-step weir and orifice opening feature is added.

A new single barrel 36" RCP storm sewer system for approximately 396 feet is to be added near E. Maple Avenue and S. Doty Street which then transitions near E. Eastern Avenue into a single 5'x3' RCB for roughly 335 feet until its outfall in Arrington Park. The storm sewer system should collect the 1% annual chance flow with minimal to no bypass and convey it to the proposed pond in Arrington Park. The mitigated flow by the storm sewer system should prevent the homes along this stream reach portion from being inundated by the 1% AEP flood.

The cost of this recommendation is approximately \$1,699,000. See **Figure 4-12** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

**Problem Area 05 Alternative 1 – Storm Sewer and Drainage Design**

A drainage ditch with capacity to handle the 1% annual chance flow is to be constructed through Arrington Park so that a storm sewer system can reroute flow and convey most of the runoff away from homes.

A new single barrel 36" RCP storm sewer system for approximately 396 feet is to be added near E. Maple Avenue and S. Doty Street which then transitions near E. Eastern Avenue into a single 5'x3' RCB for roughly 335 feet until its outfall in Arrington Park. The storm sewer system should collect the 1% annual chance flow with minimal to no bypass and convey it to the proposed drainage ditch through Arrington Park. The flow collected by the storm sewer system should prevent the homes along this stream reach portion from being inundated by the 1% AEP flood.

There is no gained floodplain storage for flood flows to be attenuated by the drainage ditch to reduce flows. A net zero change for floodplain storage should be achieved between the volume in the storm sewer and the ditch. Street flooding along S. Arrington Drive is not expected to improve or change from existing conditions. Additional floodplain storage within the park would be necessary to attenuate flood flows and reduce street flooding downstream before being collected by the existing storm sewer system at E. 6<sup>th</sup> Avenue. The detention pond in the recommendation is required to reduce flows along S. Arrington Drive.

The cost of this alternative is approximately \$1,488,000. See **Figure 4-13** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

#### Problem Area 05 Alternative 2 – Storm Sewer Design

A new storm sewer system is to be added near E. Maple Avenue and S. Doty Street. The storm sewer system should collect the 1% annual chance flow with minimal to no bypass and convey it to the existing single barrel 14.33'x3.5' RCB underneath E. 6<sup>th</sup> Avenue. The storm sewer system will start with a single barrel 36" RCP for roughly 396 feet, then switches into a single 5'x3' RCB for roughly 296 feet, which then transitions into a single 6'x3' RCB for approximately 230 feet, then changes to a single 8'x3' RCB for nearly 459 feet, which then turns into a single 10'x3' RCB for roughly 642 feet, lastly transitioning into a double barrel 6'x3' RCB for nearly 879 feet until connecting into the existing single barrel 14.33'x3.5' RCB at the intersection of S. Arrington Dr. and E. 6<sup>th</sup> Ave. The flow collected by the storm sewer system should prevent the homes along this stream reach portion from being inundated by the 1% AEP flood. Street and yard flooding along S. Arrington Drive and connected roadways is expected to significantly be reduced and flows potentially to be contained within the street curb & gutter.

The cost of this alternative is approximately \$9,500,000. See **Figure 4-14** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

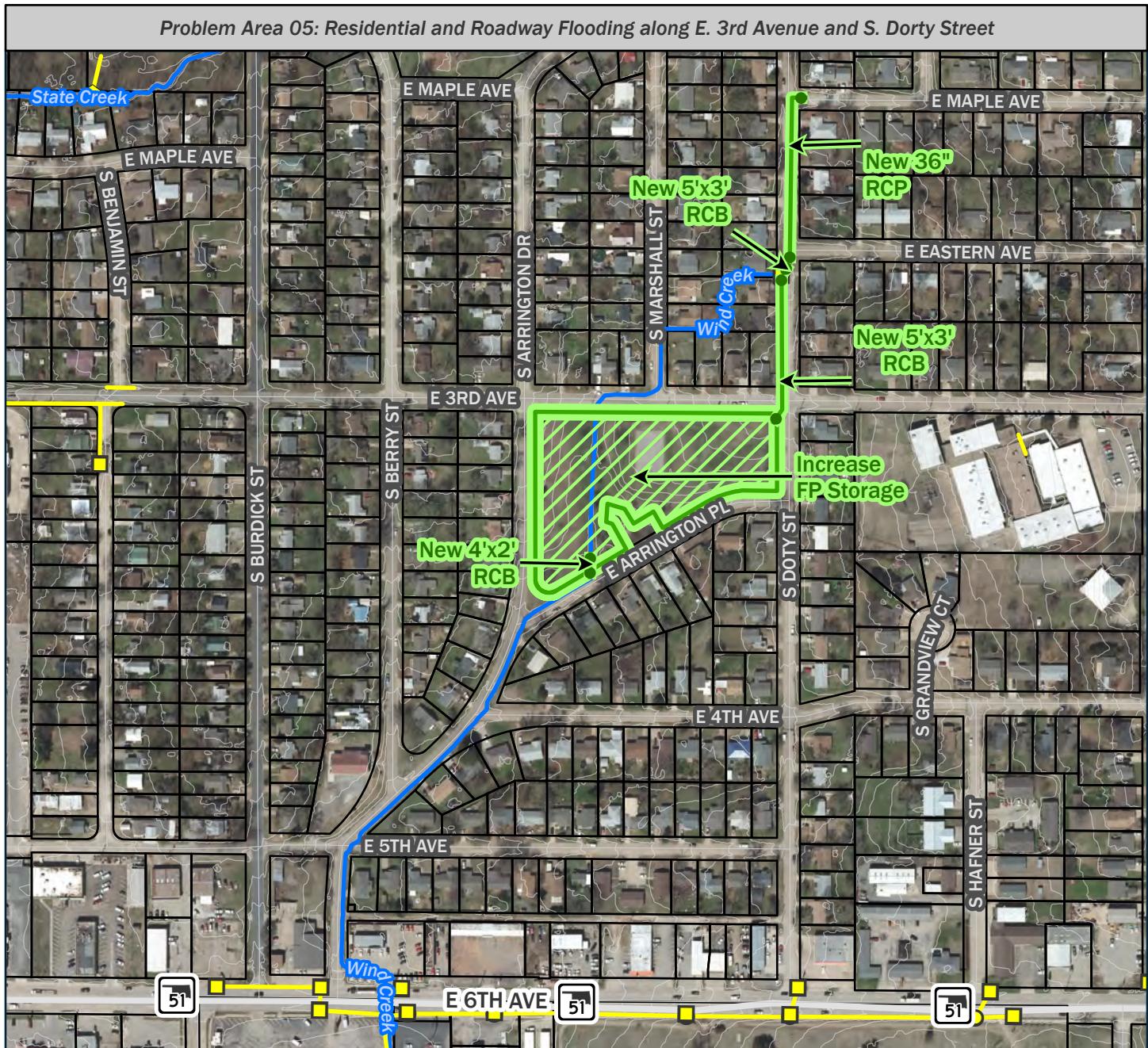
#### Problem Area 05 Alternative 3 – Relocation and Acquisition

Four properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be roughly \$592,000. See **Figure 4-15** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 1**.

# Lower Boomer Creek Problem Area Alternatives

0 160 320 US Feet



## Problem Area 05 Recommendation – Detention and Storm Sewer Design

**Detention + Storm Sewer Improvements**

**Cost: \$1,699,000**

### Proposed Project Locations

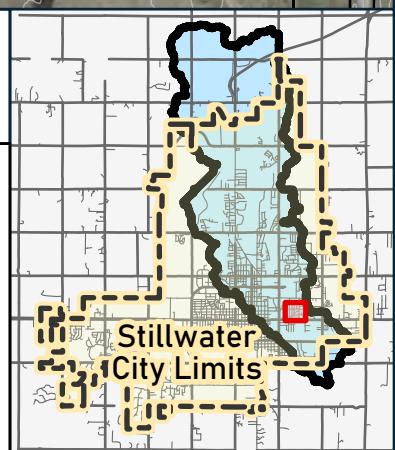
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

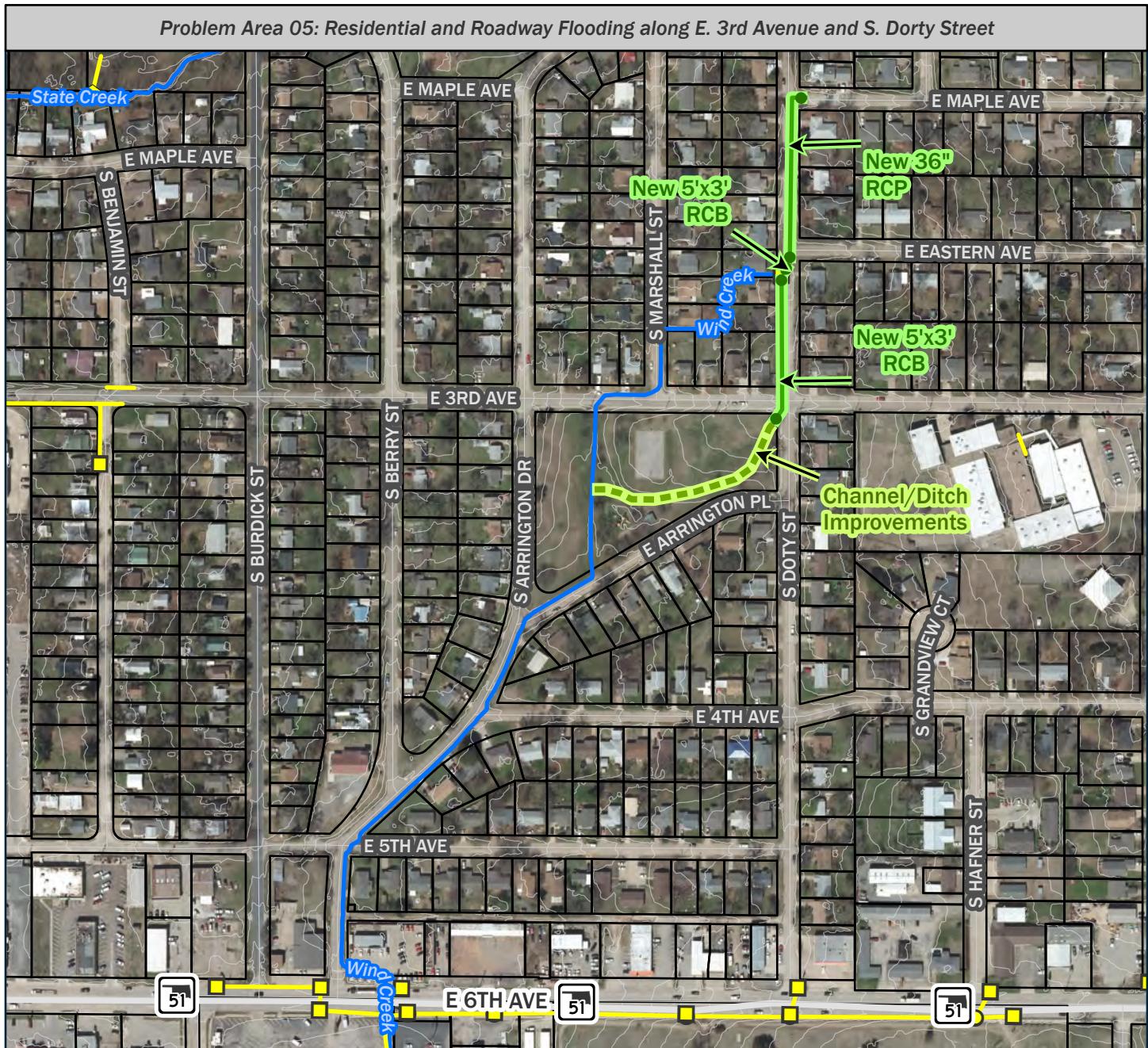
### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 160 320 US Feet



## Problem Area 05 Alternative 1 – Storm Sewer and Drainage Design

Storm Sewer + Channel Improvements

Cost: \$1,488,000

### Proposed Project Locations

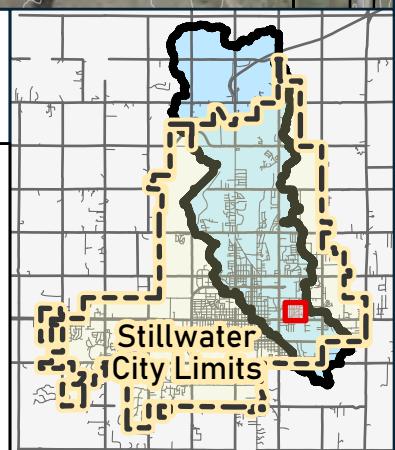
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

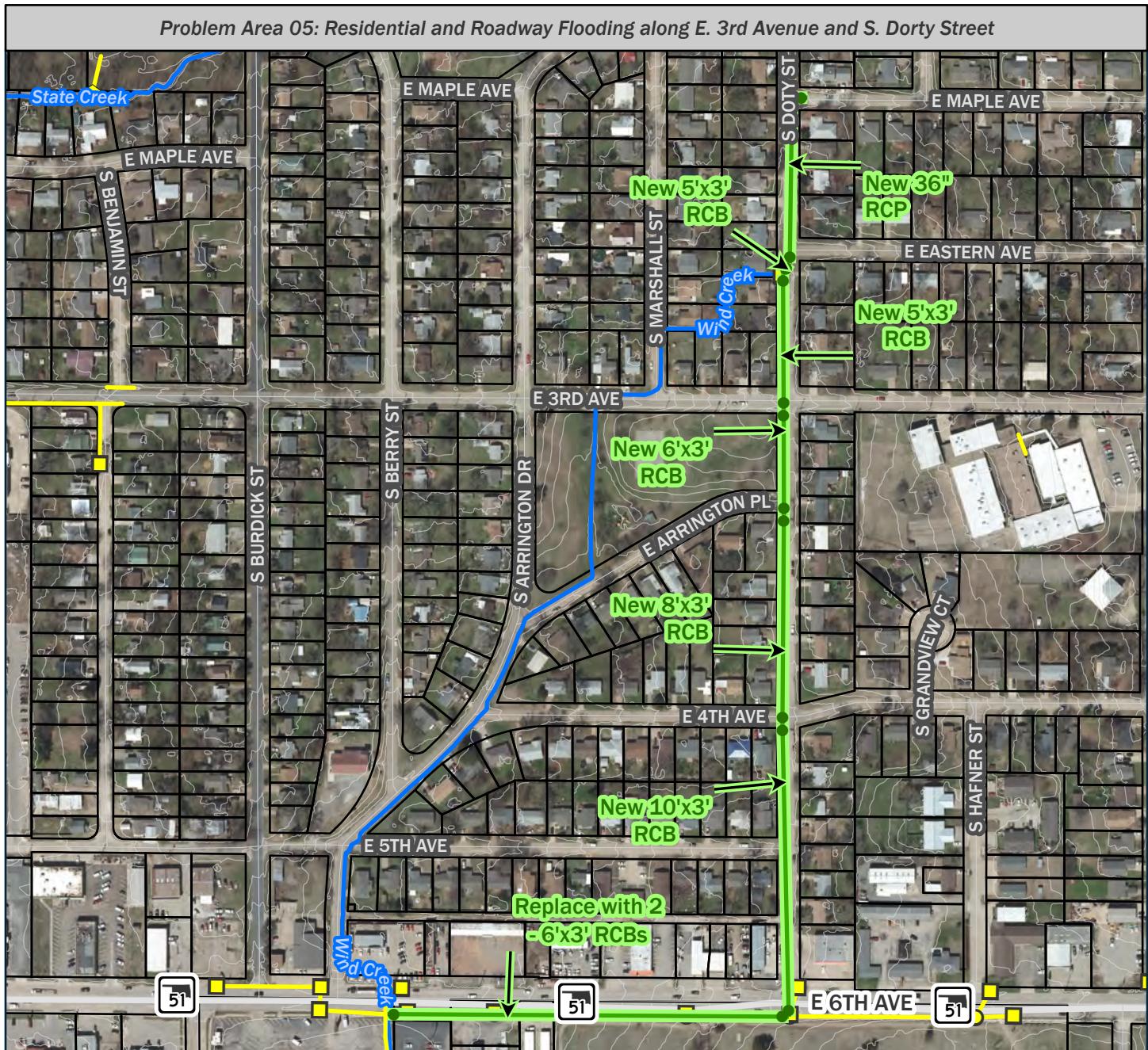
### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 160 320 US Feet

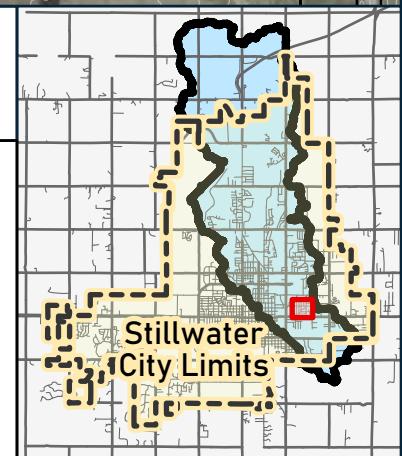


## Problem Area 05 Alternative 2 – Storm Sewer Design

### Storm Sewer Improvements

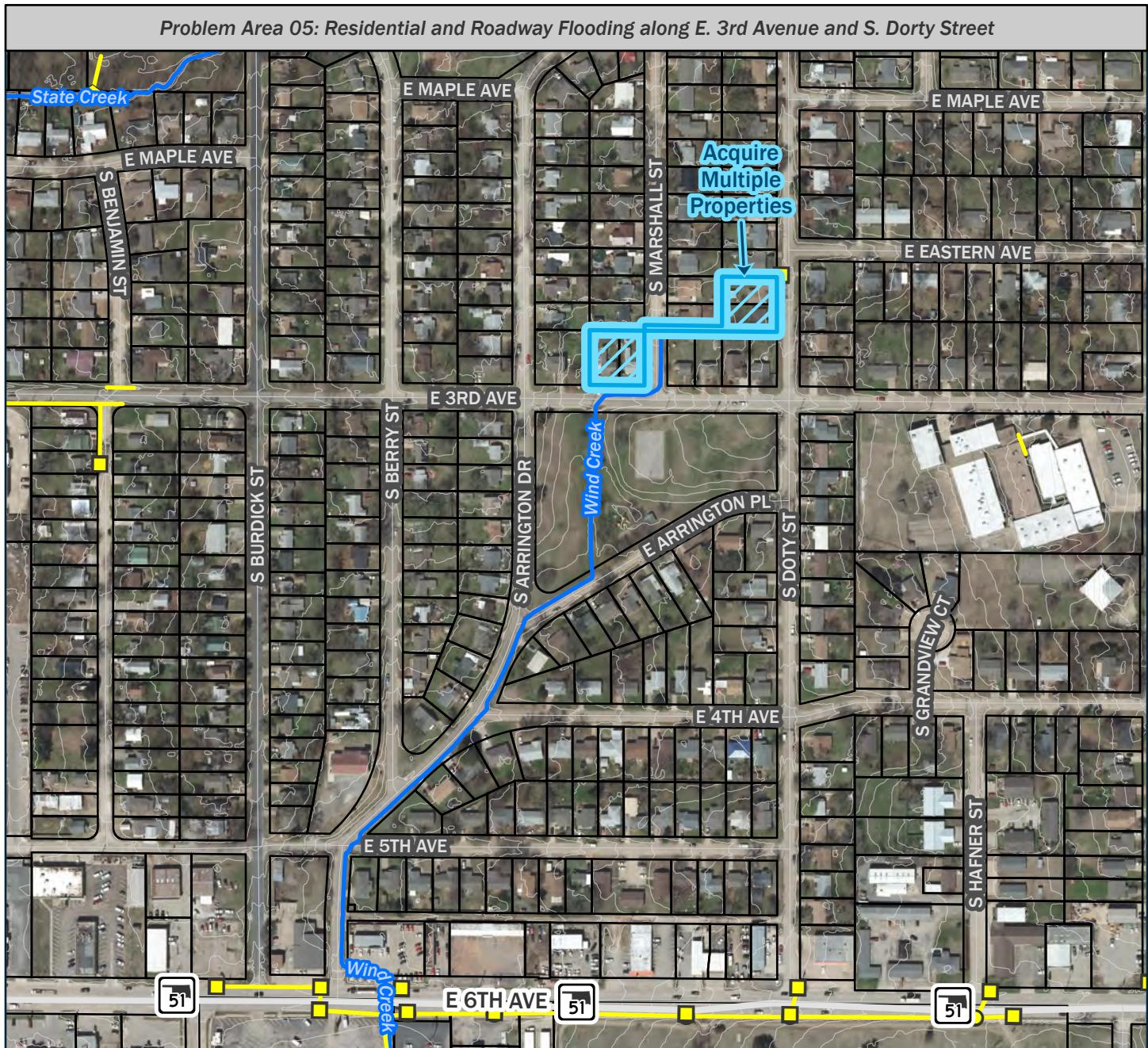
Cost: \$9,500,000

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# Lower Boomer Creek Problem Area Alternatives

0 160 320 US Feet



## Problem Area 05 Alternative 3 – Relocation and Acquisition

### Relocation and Acquisition

Cost: \$592,000

#### Proposed Project Locations

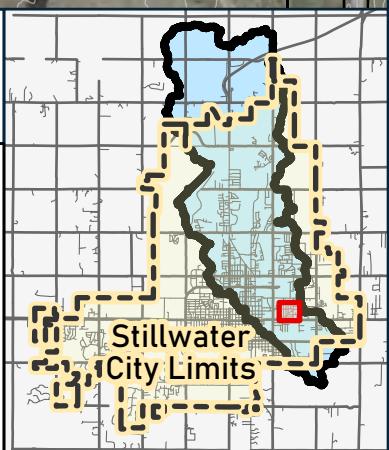
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



## SECTION 5. EAST BOOMER CREEK PROBLEM AREA ANALYSIS

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This section describes the six problem areas within the East Boomer Creek watershed and the alternatives that were considered for mitigation. Cost estimates are provided for each alternative. Recommendations are provided for each problem area and are summarized in **Section 1.3. Figure 5-1**: East Boomer Creek Problem Areas shows the location of each problem area.

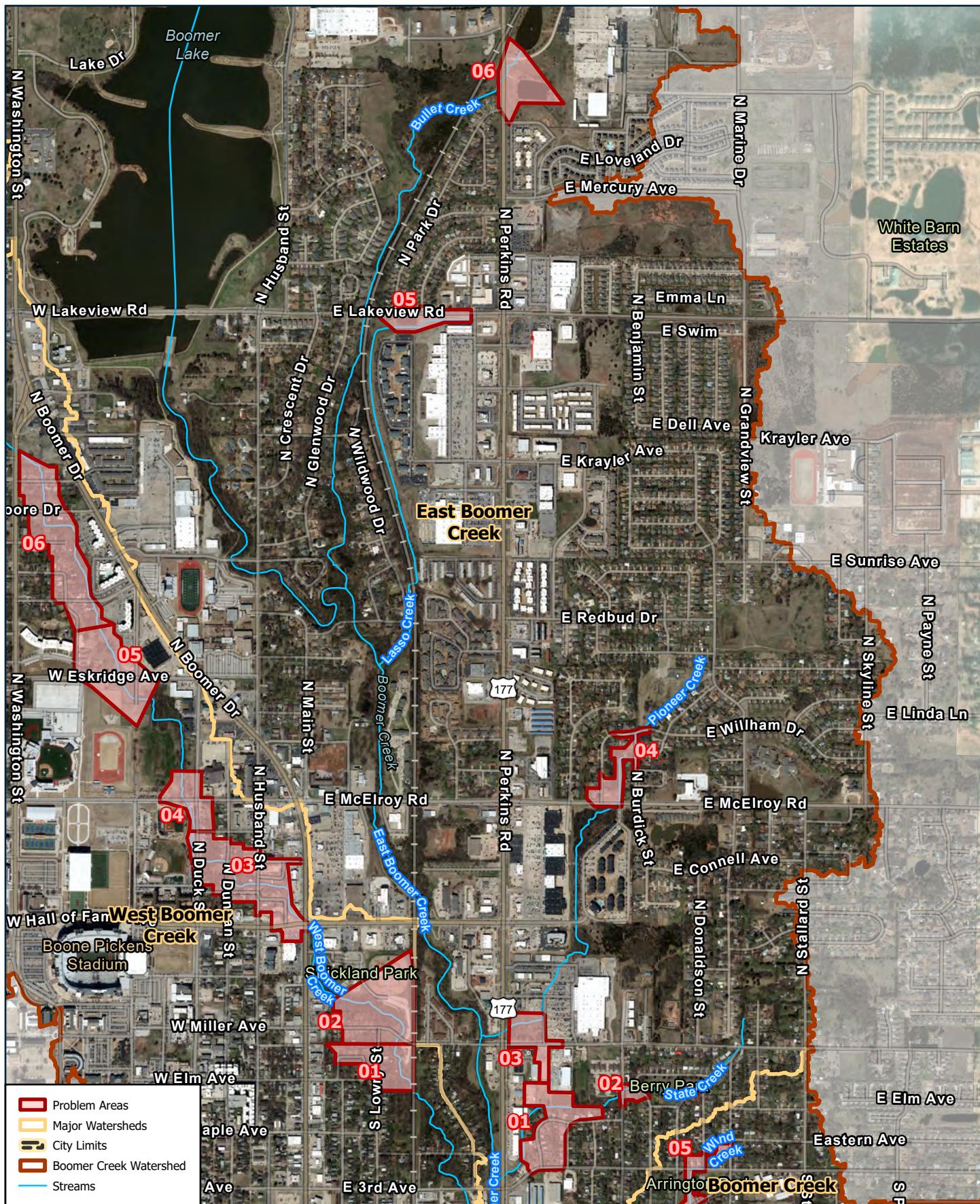
A detailed map of problem area alternatives and their location in the East Boomer Creek watershed is illustrated in **SECTION 5**. Flooding problem areas were identified by reviewing flooding comments and observations received from City staff and residents as well as reviewing the results of the updated modeling and mapping.

Alternatives were analyzed for each of the problems areas and one of them was selected as the recommended plan. All the alternatives were analyzed at a conceptual level. When the City decides to move forward with one of the recommendations, additional design and/or modeling will be needed to finalize the details of the project. This will ensure no adverse impact to adjacent properties or loss of floodplain storage and provide greater detail to refine the project cost estimate.



# Boomer Creek Master Drainage Plan

0 0.13 0.25 Miles



## East Boomer Creek Problem Areas

***Problem Area 01: Residential and Roadway Flooding along E. Maple Avenue***

The problem area consists of residential and commercial property being flooded in addition to roadway flooding on the downstream side of S. Burdick Street and along E. Maple Avenue. Roughly 39 properties experience yard flooding during the 1% annual chance flood. Of those properties there are 10 homes at risk of being inundated by the 1% AEP flood. This creek overflows its banks in rainfall events greater than the 50% annual chance. This makes the residential and commercial properties along State Creek susceptible to frequent inundation. Roads that experience flooding during the 1% annual chance event include E. Maple Avenue, S. Dryden Street, S. Hartford Street and E. 3rd Avenue.

Overland runoff from East Boomer Creek Problem Area #03 on Pioneer Creek causes additional inundation to this problem area during flood frequencies greater than a 10% annual chance event.

**Problem Area 01 Recommendation – Floodplain Storage**

An existing detention pond would be modified to provide additional floodplain storage while maintaining the existing outlet structure. An approximately 105-foot lateral weir is to be constructed on the southeast side of the proposed floodplain storage facility. The lateral weir on the upstream side would have a cross slope of 4:1 (25%) starting at existing ground until reaching an elevation of 875', then would extend for 50 feet at a constant slope of 2% until reaching an elevation of 874', then for 20 feet the weir would continue at that same elevation of 874', then the weir would have a cross slope of 4:1 (25%) until tying back into natural ground. The weir would be grass-lined at 10 feet wide and have side slopes of 4:1 until tying into the excavated grading inside the storage facility and the natural ground of the stream. The floodplain storage achievable using City design criteria is roughly 3.0 ac-ft, however more floodplain storage can be constructed if a larger wet pond is made. This alternative utilizing the 3.0 ac-ft added floodplain storage showed to be plausible at mitigating all the homes except one along this stream reach portion from being inundated by the 1% AEP flood. One property along Maple Ave would still be impacted, therefore the recommendation is to acquire that property to remove it from the flood risk. This will also allow for access to the floodplain storage facility. Several properties will still have yard flooding, but inundation will be reduced. Residential and collector street roadways would have reduced flooding as well.

The cost of this recommendation is approximately \$2,265,000. See **Figure 5-2** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

Problem Area 01 Alternative – Relocation and Acquisition

Ten properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$1,890,000. See **Figure 5-3** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

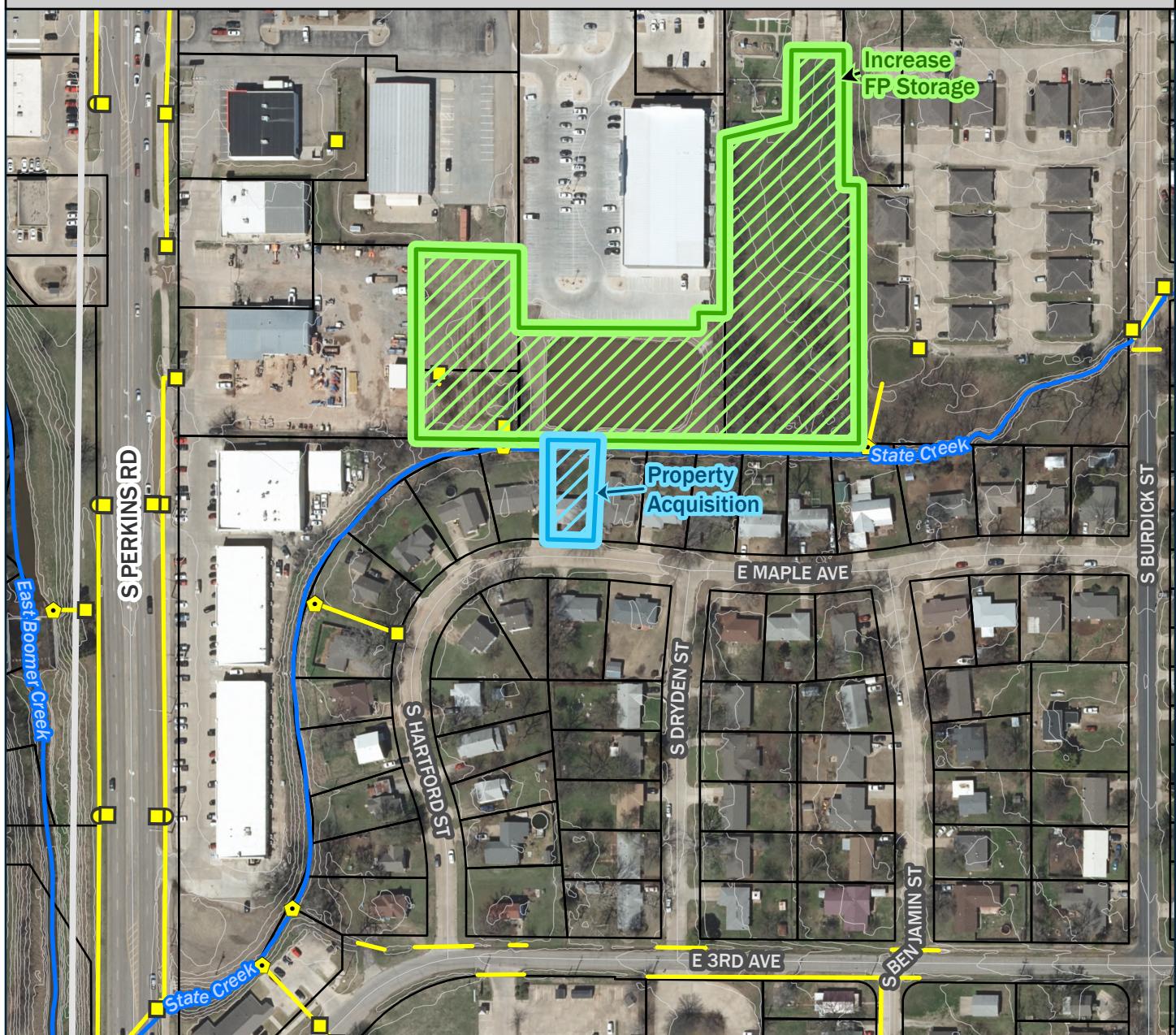
Problem Area 01 Evaluated Alternative – Stream Modification Design

This was an evaluated alternative that is not recommended. The option was to channelize the stream to maintain flow within the channel. The stream portion would be concrete lined at various widths and side slopes. The average channel width was 8 feet, and the average side slope was 3:1. This alternative provided minimal reduction in the 1% annual chance floodplain. Several properties would still have to be acquired and residential roadways would remain inundated. If this option was combined with the recommended floodplain storage facility, then it could be plausible at mitigating all homes from being inundated. Additionally, due to construction cost for the stream channel modifications it was deemed infeasible. See **Figure 5-4** for a layout of this evaluated alternative.

# East Boomer Creek Problem Area Alternatives

0 100 200 US Feet

## Problem Area 01: Residential and Roadway Flooding along E. Maple Avenue



## Problem Area 01 Recommendation – Floodplain Storage

### Floodplain Storage

Cost: \$2,265,000

#### Proposed Project Locations

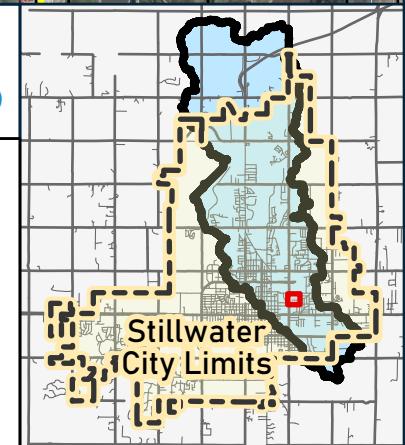
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 100 200 US Feet

## Problem Area 01: Residential and Roadway Flooding along E. Maple Avenue



### Problem Area 01 Alternative – Relocation and Acquisition

#### Property Acquisition

Cost: \$1,890,000

#### Proposed Project Locations

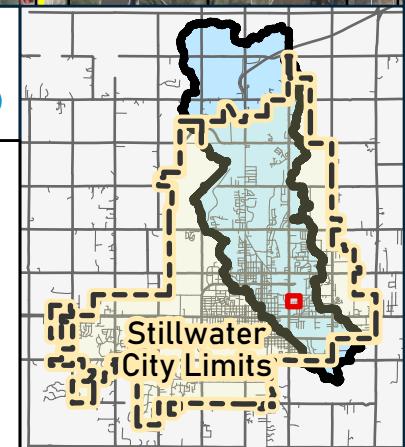
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 100 200 US Feet

## Problem Area 01: Residential and Roadway Flooding along E. Maple Avenue

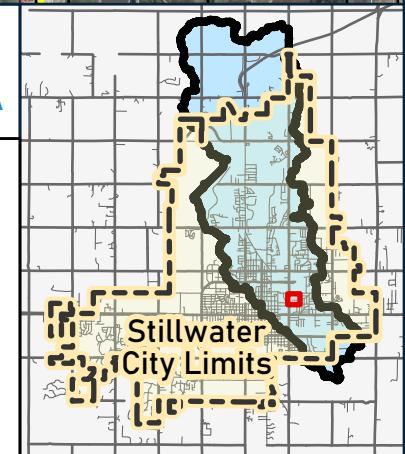


### Problem Area 01 Evaluated Alternative – Stream Modification Design

#### Channel Improvements

Cost: \$ N/A

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



***Problem Area #02: Residential and Roadway Flooding along S. Burdick St and S. Berry St***

The problem area consists of residential and roadway flooding on E. Virginia Avenue to the downstream side of S. Burdick Street and along S. Arrington Drive. Roughly 23 properties experience yard flooding during the 1% annual chance flood. Of those properties, there are 5 homes at risk of being inundated by the 1% AEP flood. The residential properties surrounding this creek reside in a low-lying area of the stream overbank and therefore are susceptible to frequent inundation. Roads that experience flooding during the 1% annual chance event include E. Virginia Avenue, S. Arrington Drive, S. Doty Street, S. Marshall Street, E. Elm Avenue, S. Berry Street and S. Burdick Street.

E. Virginia Avenue has an undersized culvert. During the 1% annual chance event, E. Virginia Avenue is overtopped by approximately one foot and has only a 10% annual chance capacity before overtopping.

S. Burdick Street has an undersized culvert. During the 1% annual chance event, S. Burdick Street is overtopped by nearly 20-inches deep at the roadway's lowest point and has less than a 50% annual chance capacity before overtopping.

Most of the flow in this area is overland flow. Once the flow leaves the channel, the local streets must convey all the runoff.

**Problem Area 02 Recommendation – Detention and Storm Sewer Design**

The floodplain storage required to reduce the 1% annual chance flows to a 10% annual chance event is approximately 9.5 acre-feet based off the HEC-HMS inflow hydrograph. Approximately 10 acre-feet of additional storage can be obtained within the park without impacting existing park structures. Excavation and a dam embankment are necessary to obtain that additional volume. An embankment having a maximum height of 8.2 feet, top of dam elevation at 891.75', and an outlet structure utilizing a 24" RCP at the dry pond invert would control flood flows. The proposed WSE of the pond for the 1% annual chance is approximately 890.7' which is nearly one foot below Arrington Drive, therefore backwater should not impact the roadway. The 0.2% annual chance WSE in the proposed pond needs to be below 891.6' so not to cause an impact onto Arrington Drive. The proposed pond would reduce the overall flow on the downstream side of the detention pond along S. Burdick Street and S. Berry Street.

A double barrel 4' x 2' RCB storm sewer system is to be added as a main trunk line extension to S. Berry Street to collect runoff that flows onto the road inundating the roadway near E. Elm Avenue and S. Berry Street. The storm sewer system is to collect the 1% annual chance flow with minimal to no bypass and convey it to a junction box where the pond outlet 24" RCP ties into on the upstream side of S. Burdick Street. The junction box will outflow with a 6' x 3' RCB, replacing the existing single barrel 5' x 2' RCB. The current culvert system transitions from a 5' x 2' RCB to an 8' x 3' RCB underneath S. Burdick Street which is calculated to have enough capacity for the 0.2% annual chance flows. The mitigated flow by the detention pond should prevent the homes along this stream reach portion from being inundated by the 1% AEP flood.

The existing 1% annual chance flow of 382 cfs should be reduced to approximately 207 cfs on the downstream side of S. Burdick St. because of the controlled outflow from the proposed pond. Residential and collector roadways on the downstream side of the detention pond will have significantly reduced flooding as well.

The cost of this recommendation is approximately \$1,331,000. See **Figure 5-5** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

#### [Problem Area 02 Alternative 1 – Detention and Storm Sewer Design](#)

This alternative is the same as the recommendation with additional storm sewer on the upstream side of the proposed detention pond.

The existing storm sewer system upstream of the detention pond is to be modified to mitigate the 1% annual chance flooding across E. Virginia Avenue and along S. Arrington Drive. The existing 30" RCP crossing E. Virginia Avenue would be replaced with a 48" RCP. An additional single barrel 36" RCP is to be utilized alongside the existing 30" RCP on the south side of E. Virginia Avenue. At the intersection of E. Elm Avenue and S. Arrington Drive the two storm sewer pipes will merge into a junction box with an outflow pipe of a single barrel 4' x 3' RCB that eventually outfalls into the detention pond. Residential and collector roadways will be mitigated or have significantly reduced flooding because of the improved storm sewer system.

The cost of this alternative is approximately \$1,955,000. See **Figure 5-6** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

#### [Problem Area 02 Alternative 2 – Relocation and Acquisition](#)

Five properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of a relocation and acquisition would be \$843,000. See **Figure 5-7** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

# East Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area 02: Residential and Roadway Flooding along S. Burdick Street and S. Berry Street



## Problem Area 02 recommendation – Detention and Storm Sewer Design

Floodplain Storage + Storm Sewer Improvements

Cost: \$1,331,000

### Proposed Project Locations

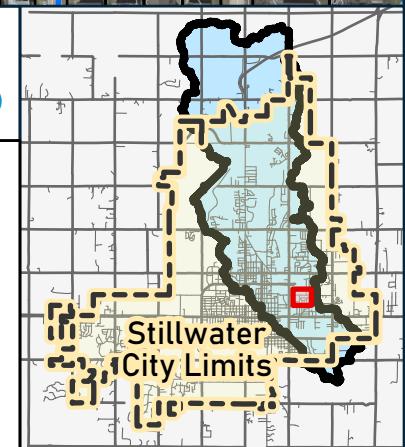
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area 02: Residential and Roadway Flooding along S. Burdick Street and S. Berry Street



### Problem Area 02 Alternative 1 – Detention and Storm Sewer Design

Floodplain Storage + Storm Sewer Improvements

Cost: \$1,955,000

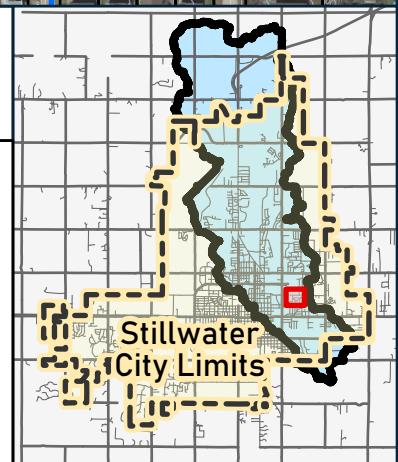
Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



## Boomer Creek Master Drainage Plan

MESHEK & ASSOCIATES, LLC  
Tulsa, Oklahoma City, OK - Fayetteville, AR  
Date: 6/16/2023

Figure  
5-6



# East Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area 02: Residential and Roadway Flooding along S. Burdick Street and S. Berry Street



### Problem Area 02 Alternative 2 – Relocation and Acquisition

#### Property Acquisition

Cost: \$843,000

#### Proposed Project Locations

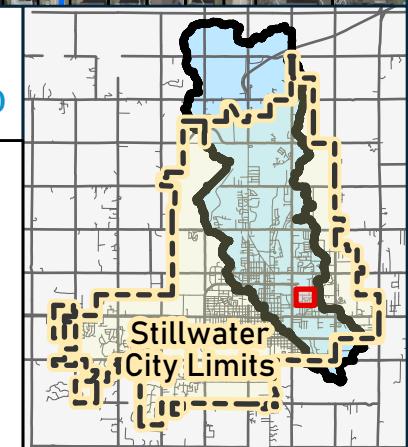
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



***Problem Area #03: Roadway Flooding along E. Virginia Avenue***

The problem area consists of street flooding on E. Virginia Avenue and along commercial parking lot drives. Approximately four properties experience overland flooding during the 1% annual chance event. During the 1% annual chance flood E. Virginia Avenue is overtopped by over 30-inches at the roadway's lowest point.

E. Virginia Avenue is inundated when the detention facility overtops. The lowest overtopping point of the pond is adjacent to the roadway. The pond does overtop to the south prior to utilizing the full capacity of the outlet culvert under N. Perkins Road. The outlet culvert can handle up to the 2% AEP flow, but the pond overtops at the 10% AEP flow. Once Virginia Avenue overtops, the flow will continue south to the East Boomer Creek Problem Area #01. This increases the flooding risk of that area.

**Problem Area 03 Recommendation – Detention Design**

The floodplain storage required to contain the 1% annual chance flood that overtops E. Virginia Avenue and flows south is approximately 6.2 acre-feet based off a hydrograph profile from a 2-D hydraulic model and storage volume analysis. Three proposed detention solutions were needed to obtain the additional floodplain storage.

The first is to excavate additional floodplain storage to an existing detention area on the north side of the Walmart shopping center. This detention pond will also have an orifice plate placed onto the existing outlet structure which is a double barrel 13' x 6' RCB. The orifice plate to be constructed should make the outlet structure to the size of a double barrel 13' x 5.5' RCB. The top 6 inches is to be blocked which will reduce the pond outflows during major flood frequencies. Roughly 2.5 ac-ft of floodplain storage is gained at this location. Potentially more storage is achievable, especially if walls are used or additional property was acquired and excavated. To follow City design criteria, ensure that the 0.2% annual chance event does not exceed a WSE greater than 882.25' to maintain a 1-foot freeboard. The floodplain storage should be maximized here to have optimized results. If East Boomer Creek Problem Area #04 recommendation was constructed in series to this detention facility, then the outlet structure could have an orifice plate where the opening is a double 12' x 5' RCB. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

Near the outfall and along the southeast side of the existing double barrel 13' x 6' RCB from the upper detention area, a second floodplain storage facility is to be constructed using underground concrete storage areas. This floodplain storage is beneath the Walmart shopping center parking lot and should not be connected to the double barrel 13' x6' RCB or allow flow from it to directly go into this detention facility. The underground storage will utilize a single barrel 10' x 4' RCB as an inflow and equalizer pipe. The calculated underground floodplain storage is approximately 2.25 ac-ft. The floodplain storage should be maximized here to have optimized results. Tailwater conditions from the third detention facility will back fill into this underground structure as part of its retention storage capacity. If East Boomer Creek Problem Area #04 recommendation was constructed, then this underground floodplain storage facility would not be required.

The final detention facility is the existing floodplain storage area along N. Perkins and E. Virginia Avenue being modified to contain the 1% annual chance flood. A berm at elevation 877.1' should outline the perimeter of the detention area to give the 1% annual chance WSE a 1-foot freeboard as required by City design criteria. Excavated soils from the first floodplain storage area can be reclaimed to construct the berm. The Walmart private drive that intersects with Virginia Avenue will act as a spillway weir and should have a minimum elevation of 876.1', which is approximately 0.5 feet higher than its existing elevation. During flooding events greater than the 10% annual chance, the existing WSE exceeds the spillway elevation of the existing Walmart detention pond and at this point the Walmart detention pond is utilized as floodplain storage. The existing dam to the Walmart detention pond will be excavated to provide additional floodplain storage. A new underground detention facility will be constructed for Walmart to compensate. Approximately 1.25 ac-ft of floodplain storage is gained at this location. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

The recommended floodplain storage area should allow the flow to pass through the existing outlet structure consisting of a double barrel 8' x 6' RCB culvert crossing N. Perkins Road without any modification to the roadway. Ponding on E. Virginia Avenue is potentially to still occur if local drainage is not adequately directed to the pond. The flow going south through commercial parking lots in existing conditions should be mitigated for the 1% annual chance and not have an impact on State Creek or East Boomer Creek Problem Area #01. It is anticipated that the 0.2% annual chance would still flood Virginia Avenue and there should be reduced flows going south through commercial parking lots to have less impact on State Creek or East Boomer Creek Problem Area #01.

To compensate for the removal of the existing Walmart detention pond, roughly a 2.2 ac-ft underground storage area is to be constructed beneath the Walmart shopping center parking lot. Existing local storm sewer will be directed to this storage facility. A single 42" RCP at the storage facility's lowest invert elevation will control minor flood flow, and a secondary 42" RCP with its crown at top of the storage facility will control major flood flows. A flap gate is to be placed at the outfall of both pipes. This underground storage area outfalls into the third storage facility similarly to the existing Walmart detention pond.

The cost of this recommendation would be roughly \$7,572,000. See **Figure 5-8** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

### Problem Area 03 Alternative – Roadway and Detention Design

This alternative will be the same as the recommendation except Virginia Avenue will be raised instead of constructing the berm for the third storage area.

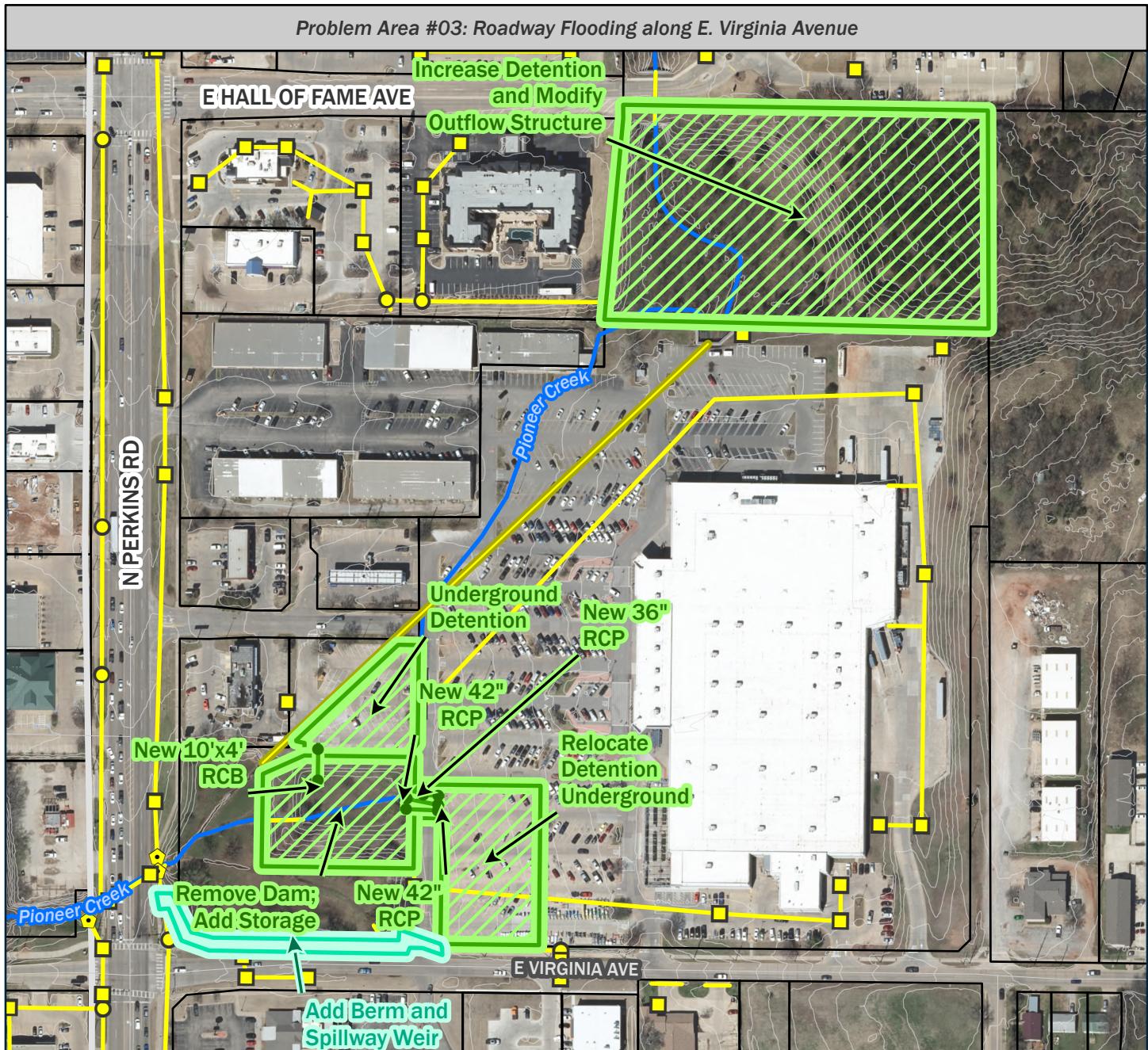
The third detention area is the existing floodplain storage area along N. Perkins and E. Virginia Avenue. Virginia Avenue is to be raised to an elevation of 877.0'. This elevation can be the curb edge or roadway crest such that flood frequencies would have to reach the 877.0' elevation before E. Virginia Avenue would be inundated. The roadway being raised will act as the berm for this detention area. This elevation should give at least a foot of freeboard for the proposed 1% annual chance WSE of the floodplain storage area as required by City criteria. Having the roadway as the floodplain storage boundary allows the runoff from the Walmart parking lot to be able to flow into the detention pond without additional drainage amenities and provides a small increase in storage capacity. Approximately 1.5 ac-ft of floodplain storage is gained at this detention facility. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

The biggest benefit to this alternative is an improved roadway that should not be inundated during the 1% annual chance flood. The proposed detention area should allow the flow to pass through the existing outflow structure consisting of a double barrel 8' x 6' RCB culvert crossing N. Perkins Road without any modification to this roadway. The flow going south through commercial parking lots in existing conditions should be mitigated for the 1% annual chance and not have an impact on State Creek or East Boomer Creek Problem Area #01. It is anticipated that the 0.2% annual chance would still flood Virginia Avenue by approximately 0.6 feet, but could be possible by emergency vehicles, and there should be reduced flows going south through commercial parking lots to have less impact on State Creek or East Boomer Creek Problem Area #01.

The cost of this alternative would be roughly \$8,291,000. See **Figure 5-9** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

# East Boomer Creek Problem Area Alternatives

0 110 220 US Feet



## Problem Area 03 Recommendation – Detention Design

### Detention

Cost: \$7,572,000

#### Proposed Project Locations

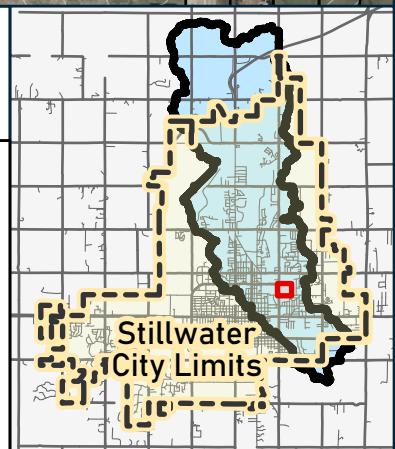
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

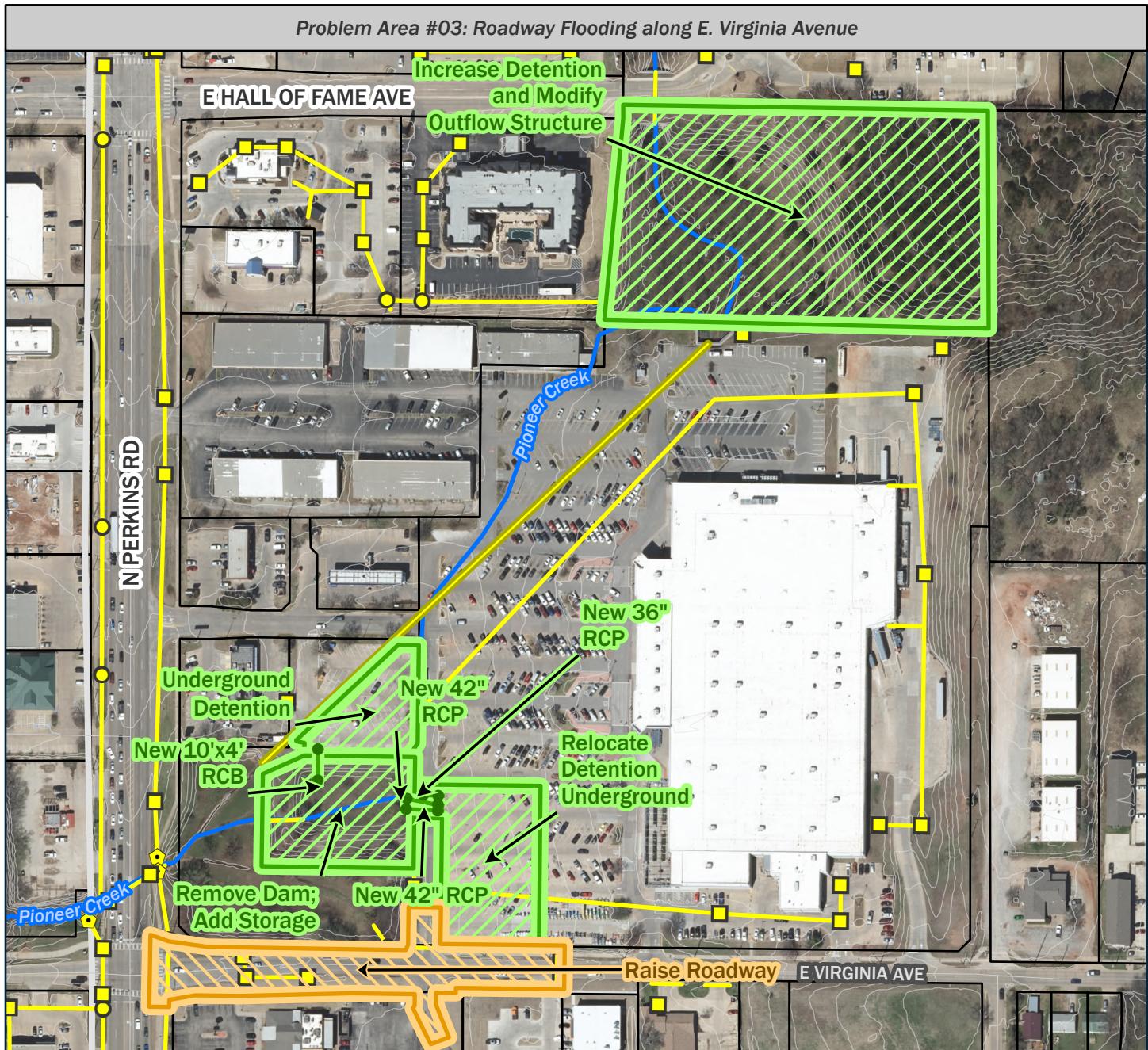
#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 110 220 US Feet



## Problem Area 03 Alternative – Roadway and Detention Design

### Detention and Roadway Improvements

Cost: \$8,291,000

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other

***Problem Area #04: Residential and Roadway Flooding along E. McElroy Road and N. Burdick Street***

This problem area consists of residential and roadway flooding. Approximately 26 properties experience yard flooding during the 1% annual chance event. Of those properties there are three homes at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance flood include E. McElroy Road, S. Burdick Street, N. Benjamin Street, E. Tyler Avenue, and E. Willham Drive.

The storm sewer system underneath E. Willham Drive, and S. Burdick Street has less than a 50% annual chance flow capacity. When this storm sewer system reaches capacity, the surrounding roadways begin to act as the main conveying path for flood flows until it reconvenes with the channel on the upstream side of E. McElroy Road. During the 1% annual chance event S. Burdick Street is overtapped by nearly 30-inches before accumulating back into the main channel.

The E. McElroy Road roadway has an undersized culvert structure. During the 1% annual chance event, E. McElroy Road is overtapped by over a foot. This roadway has only a 10% annual chance capacity before overtapping.

**Problem Area 04 Recommendation – Detention and Storm Sewer Design**

There are two detention areas for this recommendation as well as storm sewer improvements.

The first detention area is on the north side of E. Willham Drive in the greenspace of a private property. The calculated floodplain storage required to reduce the 1% annual chance flows to a 2% annual chance event is approximately 9.3 acre-feet based off the HEC-HMS inflow hydrograph. Approximately 9.5 ac-ft is available within this open space from excavation and adding a berm. None of the buildings would be affected but some of the outdoor playground equipment would have to be relocated. A berm with top of dam elevation at 903' and an outlet structure utilizing a single barrel 6' x 3" RCB at the dry pond invert would control flood flows. The outlet structure will tie into the proposed storm sewer system. This pond should reduce flows enough to minimize or eliminate any overflow from the pond into Willham Drive and Burdick Street. This design assumes the limits of excavation are not outside of the regulatory ordinary high-water mark and an individual 404 permit will likely be needed.

Downstream of the detention facility, a new 8x3 RCB is required from the junction point at the intersection of Willham Drive and Burdick Street. This will continue south for approximately 299 feet where it daylights to the open channel of Pioneer Creek. Inlets will be placed to collect the local flow into the new RCB.

The second detention area is in the greenspace of a private property on the north side of E. McElroy Road between N. Burdick Street and N. Manning Street. This detention facility not only reduces flows, but it will also change the timing of the flow downstream which will reduce the overall downstream peak flow. An inline structure with berm elevation at 909' and an outlet structure utilizing a triple barrel 4' x 4' RCB at the channel flow line invert would control

flood flows. No excavation is anticipated for this detention area. This detention area should reduce the flooding along N. Burdick Street.

A single barrel 12' x 4' RCB should replace an existing 48" RCP that crosses N. Burdick Street and outfalls into the open channel of Pioneer Creek. This culvert should minimize or eliminate any overflow into Burdick Street. The existing 1% annual chance flow to N. Burdick Street is 327 cfs and the proposed flow should roughly be 291 cfs. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

Lastly, a single barrel 4' x 3' RCB should replace a 24" RCP that crosses E. McElroy Road near the intersection with N. Benjamin Street. Inlets will be needed to collect the local flow and convey that flow to the new RCB.

The cost of this recommendation would be roughly \$5,785,000. See **Figure 5-10** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

#### Problem Area 04 Alternative 1 – Detention and Storm Sewer Design

This alternative is the same as the recommendation except for a different culvert size at N. Burdick Street and the addition of excavation within the second detention area.

The second detention area is in the greenspace of a private property on the north side of E. McElroy Road between N. Burdick Street and N. Manning Street. This detention facility not only reduces flows, but it will also change the timing of the flow downstream which will reduce the overall downstream peak flow. An inline structure with berm elevation at 909' and an outlet structure utilizing a double barrel 6' x 3' RCB at the channel flow line invert would control flood flows. The excavation would gain roughly an additional 1.5 acre-feet of storage for this detention facility. This detention area should reduce the flooding along N. Burdick Street.

A single barrel 10' x 4' RCB should replace an existing 48" RCP that crosses N. Burdick Street and outfalls into the open channel of Pioneer Creek. This culvert should minimize or eliminate any overflow into Burdick Street. The existing 1% annual chance flow to N. Burdick Street is 327 cfs and the proposed flow should be approximately 271 cfs. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

The cost of this alternative would be roughly \$5,810,000. See **Figure 5-11** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

**Problem Area 04 Alternative 2 – Relocation and Acquisition**

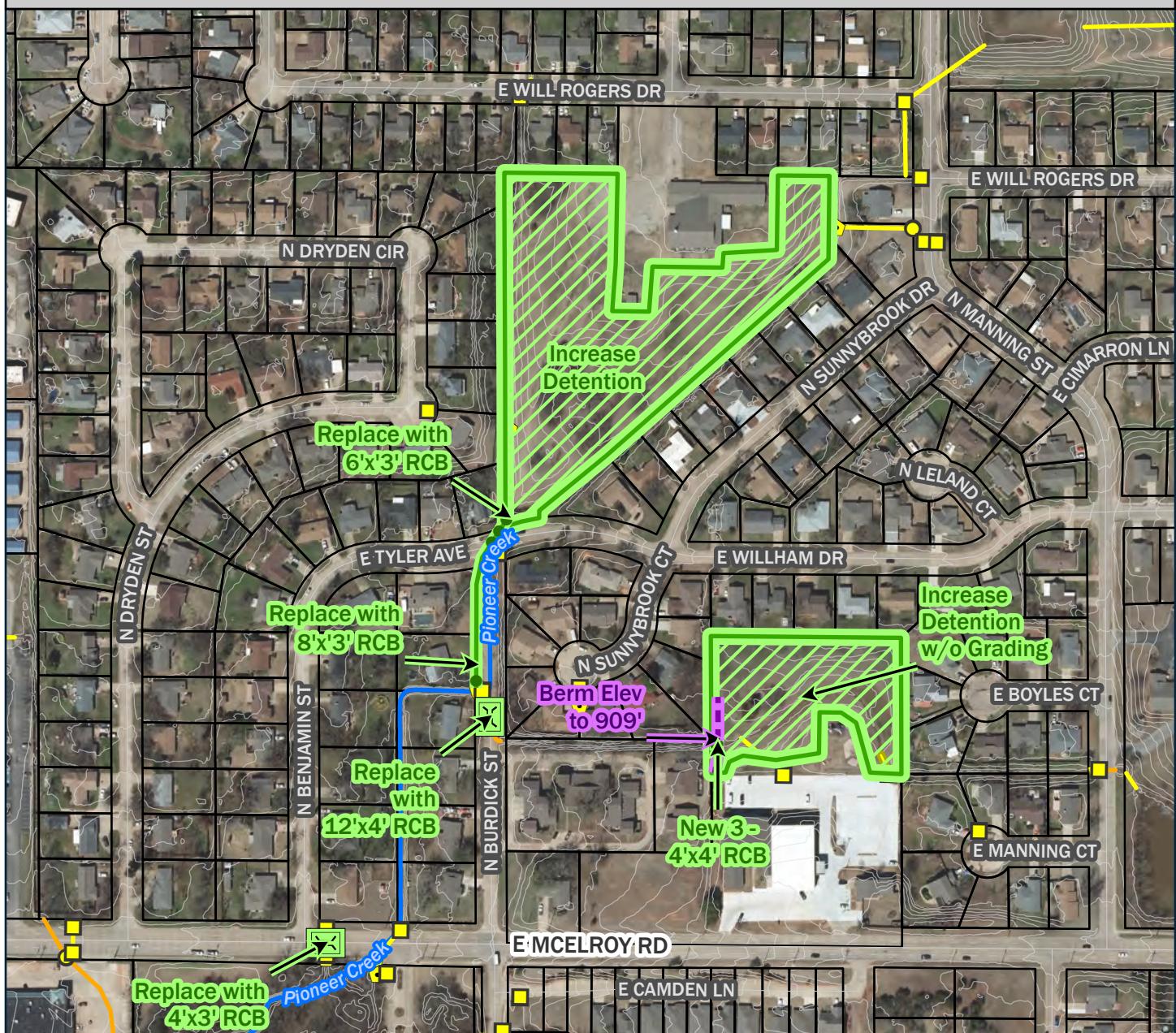
Three properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Minimal additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$789,000. See **Figure 5-12** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

# East Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #04: Residential and Roadway Flooding along E. McElroy Road and N. Burdick Street



## Problem Area 04 Recommendation – Detention and Storm Sewer Design

**Increase Detention and Storm Sewer Improvements**      **Cost: \$5,785,000**

### Proposed Project Locations

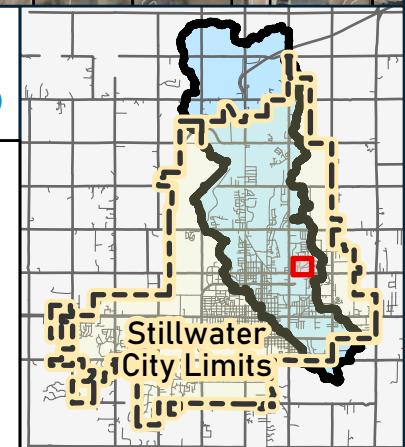
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

### Existing Storm Sewer

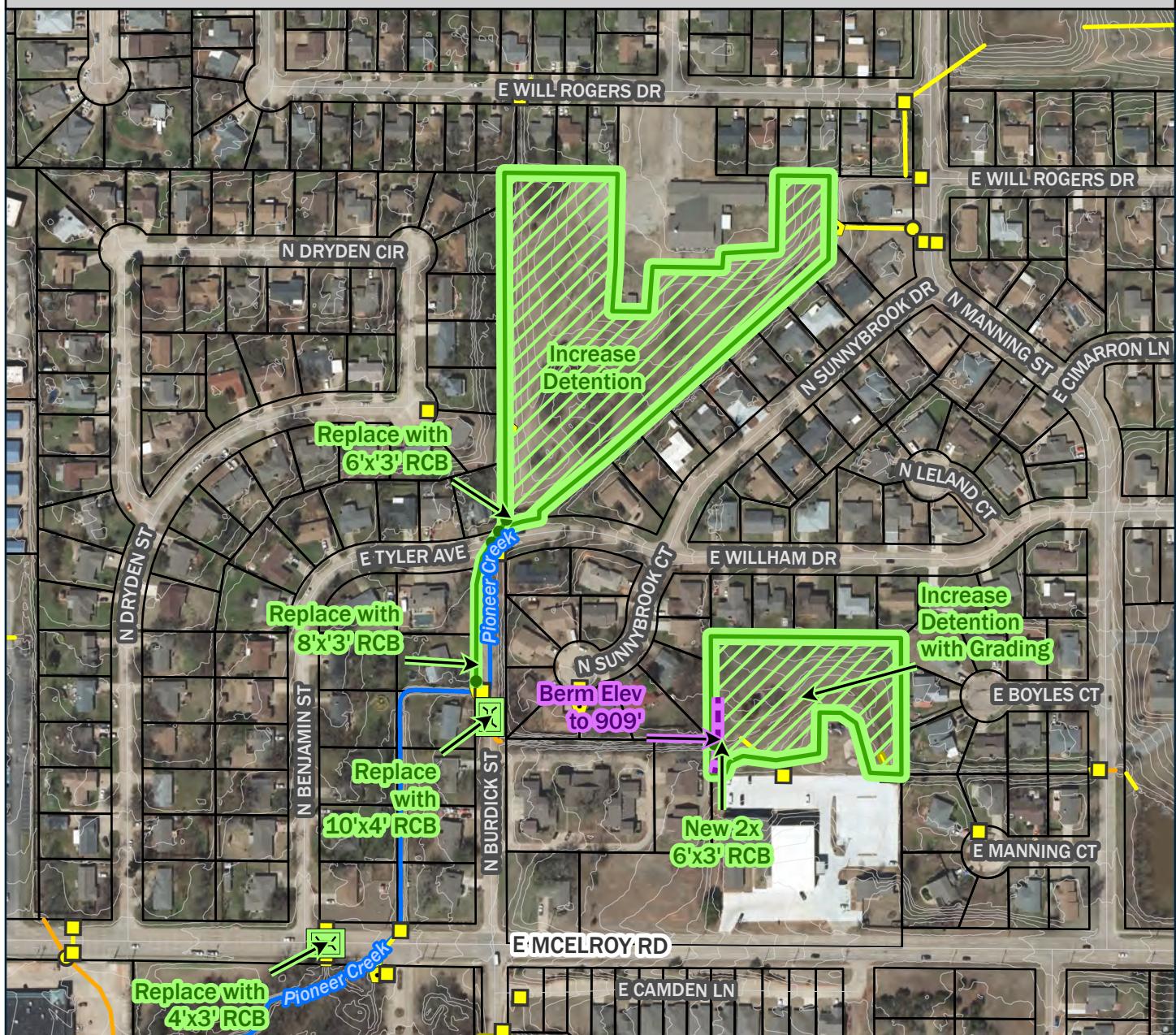
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #04: Residential and Roadway Flooding along E. McElroy Road and N. Burdick Street



### Problem Area 04 Alternative 1 – Detention and Storm Sewer Design

**Increase Detention and Storm Sewer Improvements**      **Cost: \$5,810,000**

#### Proposed Project Locations

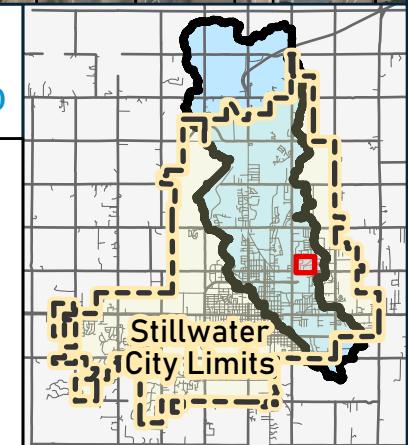
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

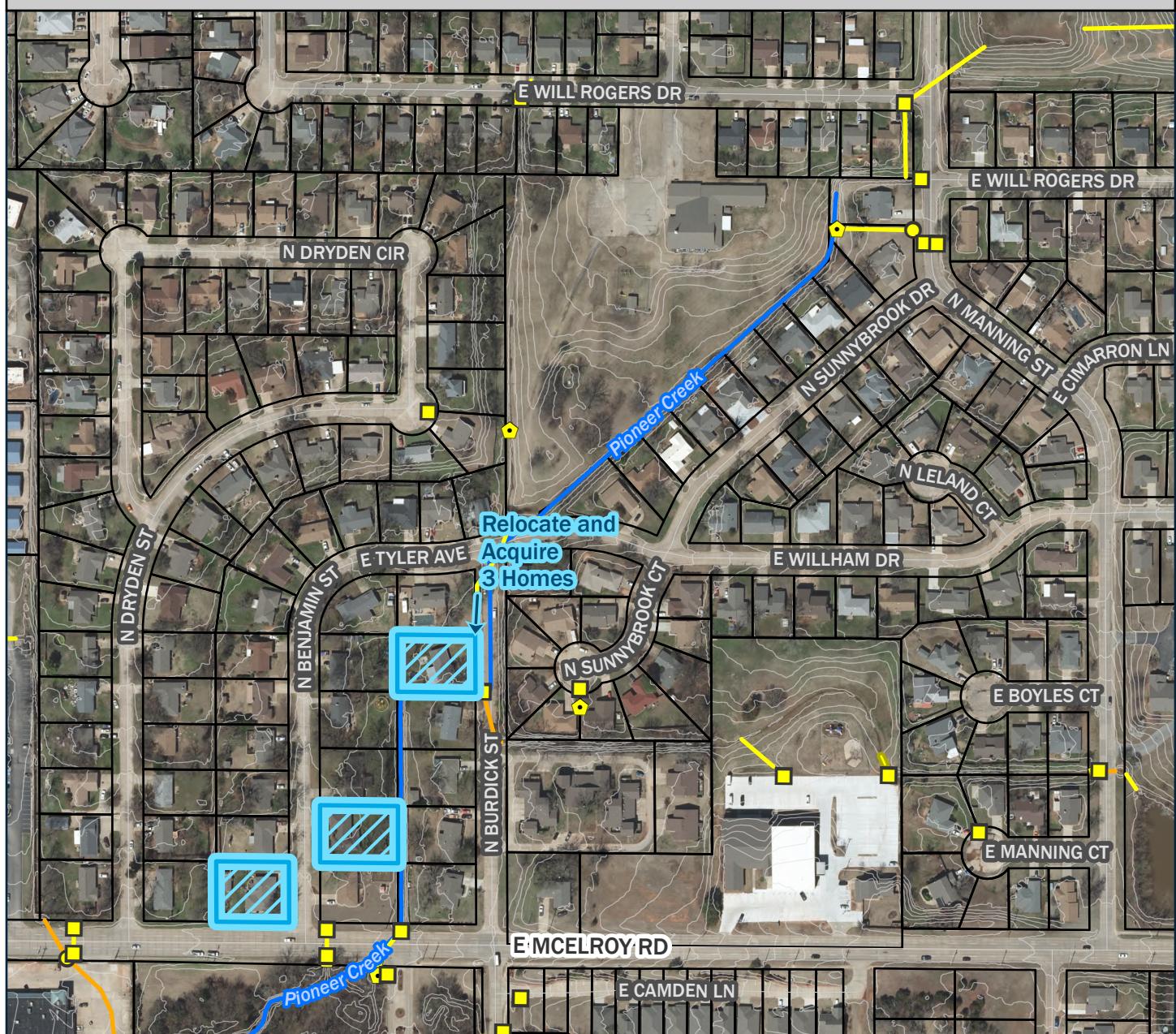
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #04: Residential and Roadway Flooding along E. McElroy Road and N. Burdick Street



### Problem Area 04 Alternative 2 – Relocation and Acquisition

#### Relocation and Acquisition

Cost: \$789,000

#### Proposed Project Locations

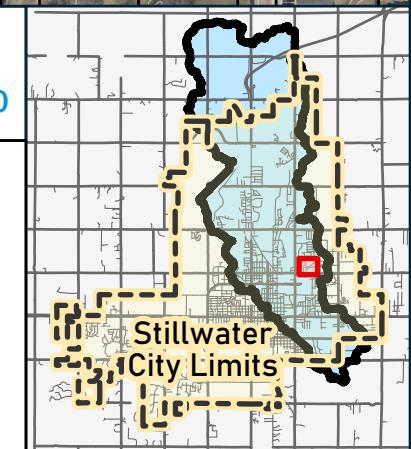
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



***Problem Area #05: Roadway Flooding along E. Lakeview Road***

This problem area consists of street flooding that is impacting an urban collector roadway, E. Lakeview Road between the railroad and N. Perkins Road. Downstream of the problem area there is an inline structure which controls the water elevation for approximately 2000 feet upstream to a pedestrian bridge crossing over the stream. The 1% annual chance event WSE resulting from this tailwater condition overtops Lakeview Road by approximately 1 foot.

Upstream of the pedestrian bridge, the main channel is too small and overtops into Lakeview Road as well. This causes additional inundation of Lakeview Road.

A lateral weir structure under a railroad between the downstream inline structure and the pedestrian bridge allows flood flows to divert from Lasso Creek into Bullet Creek during frequencies greater than a 10% annual chance flood.

**Problem Area 05 Recommendation – Berm and Floodplain Storage Design**

The floodplain storage necessary to contain the 1% annual chance flows in the channel that are currently on E. Lakeview Road upstream of the pedestrian bridge from the overbank overtopping is approximately 1.7 acre-feet based off a hydrograph profile from a 2-D hydraulic model. An existing berm on the south side of E. Lakeview Road is to be modified, starting at the existing ground elevation of 904.0'. The berm will have a continuous slope of 0.5% towards the West for roughly 250 feet until it ties into existing ground at elevation 902.5'. The 0.2% annual chance flood should then be contained within the channel for this portion of the stream. Excavated soils from the proposed floodplain storage can be reclaimed to construct the berm.

To compensate for floodplain storage loss from the berm improvement, floodplain storage will be added on the south side of the channel. The excavated floodplain storage should provide roughly 0.25 ac-ft of compensatory storage. Additional floodplain storage is necessary to offset the flow volume currently going on to Lakeview Road. This added storage will be underground, beneath the Jefferson Commons parking lot on the left overbank of the stream. The underground floodplain storage should provide the remaining required floodplain storage. Inflow and equalizer pipes will be added to the underground storage so that flow can fill the available space and then drain as flood flows subside. The berm, underground storage, and floodplain storage should reduce and possibly mitigate the street flooding on E. Lakeview Road from the intersection with N. North Star Drive to HWY-177 for all flood frequencies. This alternative does not change the water surface elevations around Lakeview Road from the backwater caused by the downstream inline structure; therefore, the roadway will continue to be inundated as in existing conditions by roughly 1 foot. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

Backwater due to the downstream inline structure causes the storm sewer system along E. Lakeview Road to surcharge and inundate the roadway during events greater than the 10% annual chance flood. A flap gate at the storm sewer system outfall is recommended to prevent this surcharge. Local drainage may still inundate the roadway, but it should remain passable.

The railroad lateral weir structure is not suggested to be modified since it would cause an adverse impact onto Bullet Creek by increasing flows and raising the WSE.

The cost of this recommendation would be roughly \$3,322,000. See **Figure 5-13** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

#### Problem Area 05 Alternative – Berm and Floodplain Storage Design

The floodplain storage necessary to contain the 1% annual chance flows in the channel that are currently on E. Lakeview Road is approximately 2.5 acre-feet based off a hydrograph profile from a 2-D hydraulic model. An existing berm on the south side of E. Lakeview Road is to be modified, starting at the existing ground elevation of 904.0'. The berm will have a continuous slope of 0.5% to the West for roughly 250 feet until it ties into existing ground at elevation 902.5'. The 0.2% annual chance flood should then be contained within the channel for this portion of the stream. Two additional berm modifications are to be constructed near and along the pedestrian walkway. The existing berm is to be raised to a minimum elevation of 901.0'. The modified berm should contain the 1% annual chance event within the channel. Excavated soils from the proposed floodplain storage can be reclaimed to construct the berms.

To compensate for floodplain storage loss from the berm improvements floodplain storage will be added on the south side of the channel. The floodplain storage should provide roughly 0.25 ac-ft of compensatory storage. Additional floodplain storage is necessary to fully off-set the flow volume currently going to Lakeview Road. This added storage will be underground, beneath the Jefferson Commons parking lot on the left overbank of the stream. The underground floodplain storage should provide the remaining required floodplain storage. Inflow and equalizer pipes will be added to the underground storage so that flow can fill the available space and then drain as flood flows subside.

Due to the tailwater conditions of the downstream inline structure the backwater causes the storm sewer system along E. Lakeview Road to surcharge and inundate the roadway during events greater than the 10% annual chance flood. A flap gate at the storm sewer system outfall is recommended to prevent this surcharge. Local drainage may still inundate the roadway, but it should remain passable.

The implementation of these floodplain mitigation actions collectively should mitigate the flooding along E. Lakeview Road.

The railroad lateral weir structure is not suggested to be modified since it would cause an adverse impact onto Bullet Creek by increasing flows and raising the WSE.

The cost of this alternative would be roughly \$4,648,000. See **Figure 5-14** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

#### Problem Area 05 Evaluated Alternative – Inline Structure Design

This was an evaluated alternative that is not recommended. The inline structure controls flow and causes tailwater conditions to overtop E. Lakeview Road. The analyzed option was to modify the existing inline structure to pass flows sooner to provide backwater relief on E. Lakeview Road. Enlarging the existing culvert to have a greater capacity or changing the weir flow design had an adverse impact of increasing peak flows downstream. The larger flows will cause enhanced nuisance flooding on properties downstream. If the structure was removed, it would cause properties to be inundated in the 1% AEP flood.

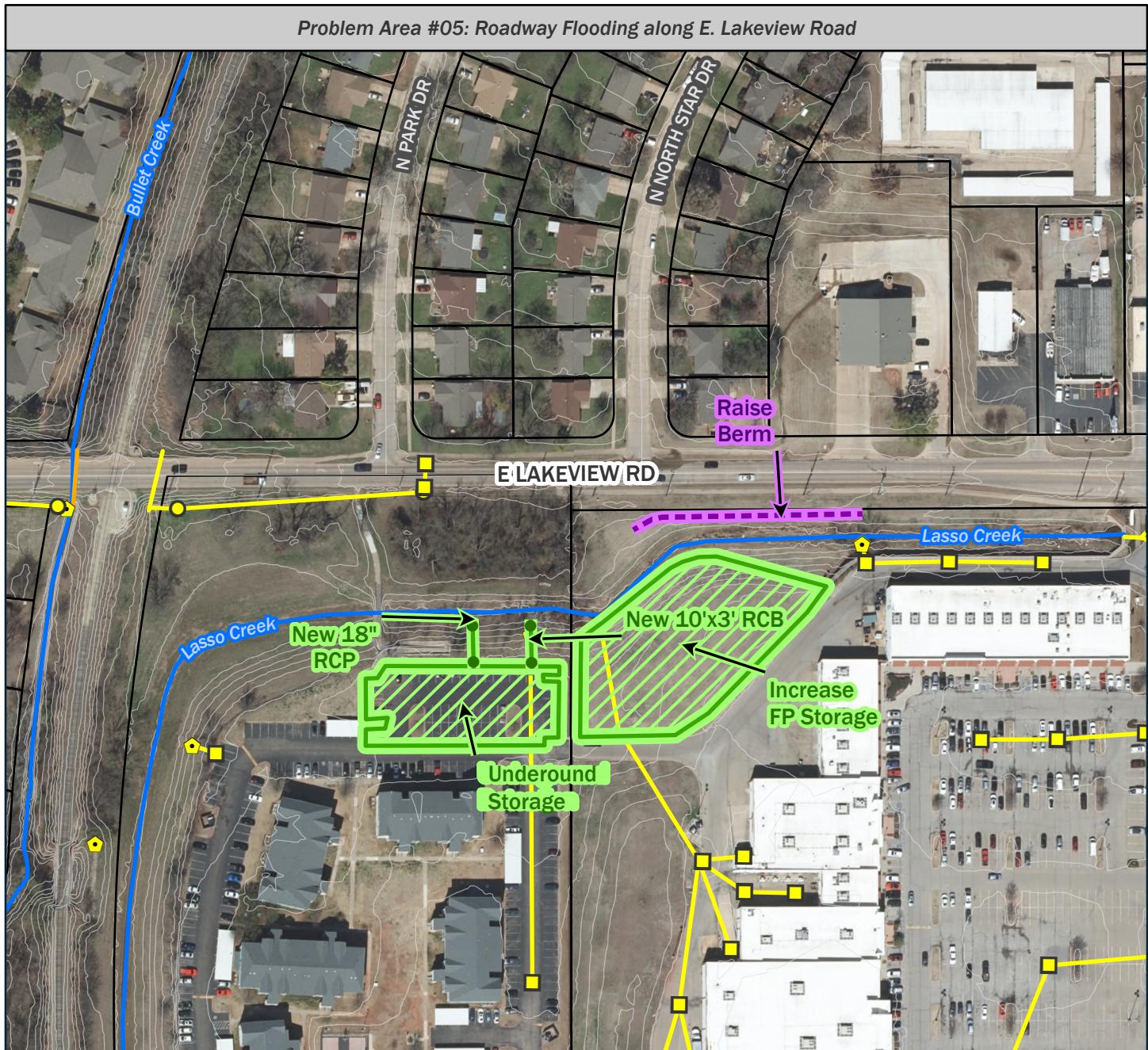
The railroad lateral weir structure is not suggested to be modified since it would cause an adverse impact onto Bullet Creek by increasing flows and raising the WSE. Since the downstream adverse impacts could not be mitigated, a detailed layout and cost estimate was not produced.

#### Problem Area 05 Evaluated Alternative – Underground Detention Design

This was an evaluated alternative that is not recommended. Based off the HEC-HMS inflow hydrograph roughly 60.6 ac-ft of floodplain storage is necessary to reduce the 1% AEP flood flows to a 10% annual chance flow. Due to existing structures and limited available space underground detention would be utilized to obtain the storage volume. The concrete underground storage area would be under the commercial parking lots east of HWY 177 and south of the main channel. The cost is approximately \$42,762,000 for this evaluated alternative. The excavation and materials cost for the underground concrete storage area would make this alternative infeasible. Therefore, additional details were not developed for this evaluated alternative. See **Appendix G** under **SECTION 2** for a detailed cost estimate.

# East Boomer Creek Problem Area Alternatives

0 80 160 US Feet

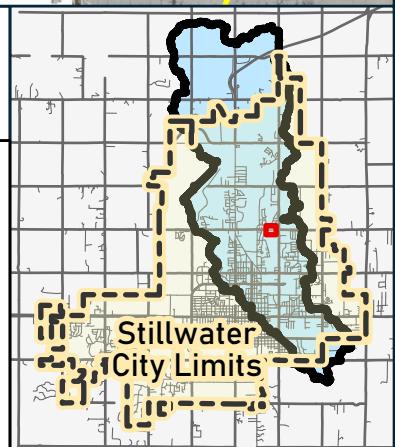


## Problem Area 05 Recommendation – Berm and Floodplain Storage Design

**Increase FP Storage + Berm**

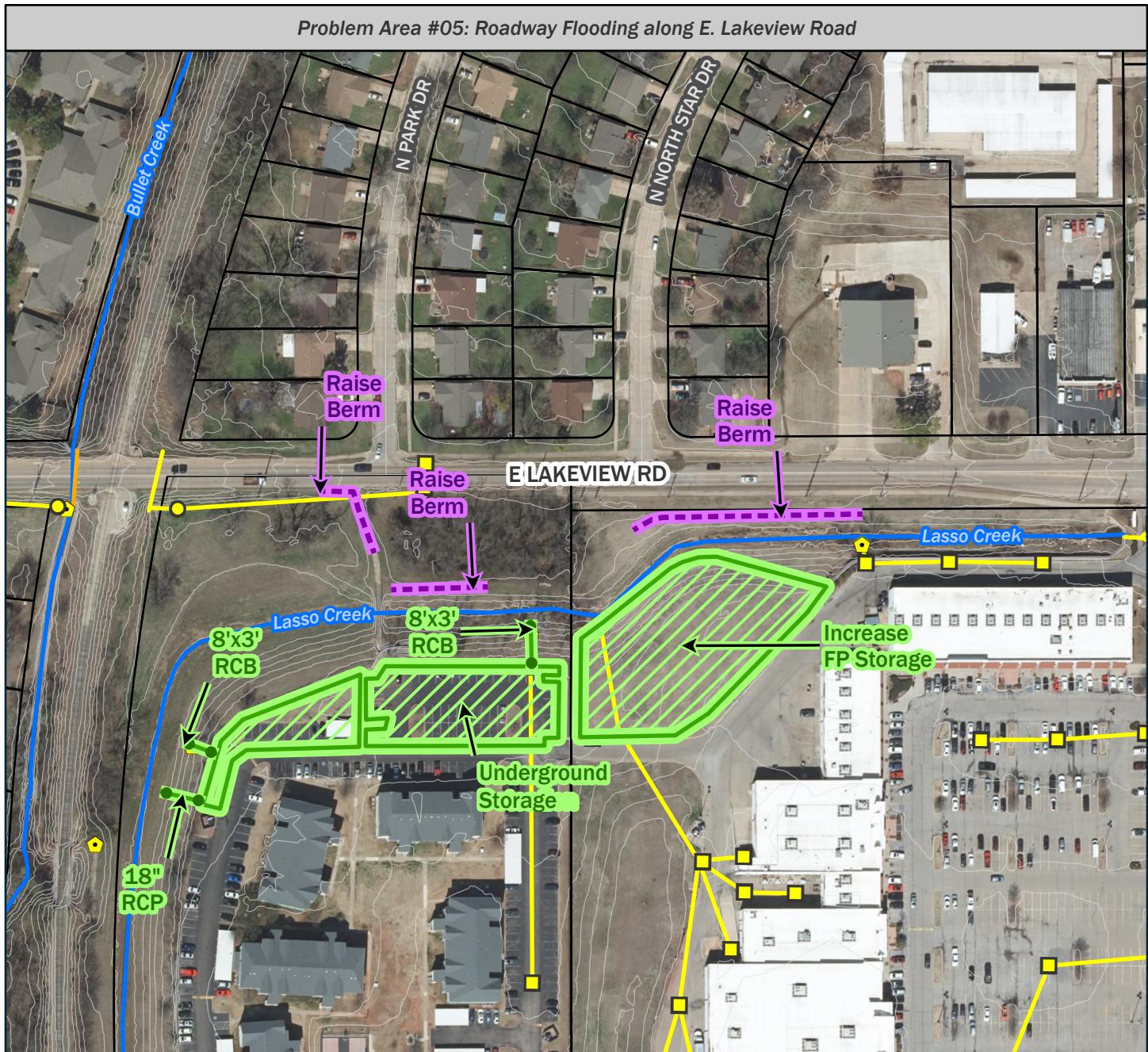
**Cost: \$3,322,000**

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 80 160 US Feet



## Problem Area 05 Alternative – Berm and Floodplain Storage Design

*Underground Detention with Berm Improvements*

**Cost: \$4,648,000**

### Proposed Project Locations

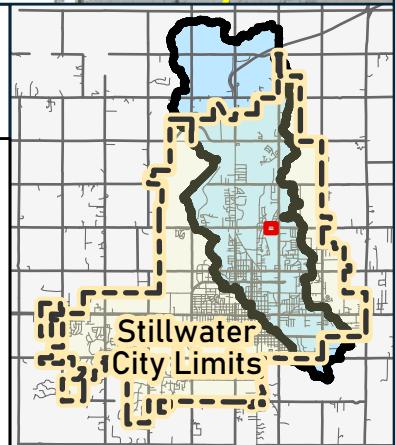
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



### ***Problem Area #06: Roadway Flooding along N. Perkins Road***

This problem area is along N. Perkins Road or Hwy 177. Bullet Creek overtops the highway by approximately 0.5 feet in the 1% AEP event.

The primary cause of this flooding is the control structure upstream of the culvert running under N. Perkins Road. The existing culvert structure underneath N. Perkins Road is a single barrel 10' x 4' RCB. The culvert has an upstream control structure that limits the culvert's capacity to less than half. The resulting culvert entrance is two trapezoidal shapes that at their peak are 2-feet tall, with a minimum height of 0.8 feet. The total width across these two openings is approximately 8.44 feet. This structure has a current capacity roughly equivalent to the 20% AEP flood. Due to the inability of this upstream control structure to allow flow to pass through the existing culvert structure it causes a ponding effect on the east side of N. Perkins Road. The resulting ponded flow eventually exceeds an elevation greater than N. Perkins Road allowing flood frequencies greater than a 10% annual chance event to overtop N. Perkins Road.

#### **Problem Area 06 Recommendation – Roadway Design**

The drainage ditch on the east side of HWY-177 is to be graded down to the upstream invert of the culvert crossing the highway. The existing control structure should be removed and a new headwall is to be constructed. This will allow the existing 10' x 4' RCB culvert to be fully utilized and should prevent HWY-177 from being overtopped in a 2% annual chance event. Armoring and erosion protection on the downstream side of the culvert is recommended. The proposed ditch grading should be enough compensated floodplain storage for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

The cost of this recommendation would be roughly \$77,000. See **Figure 5-15** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

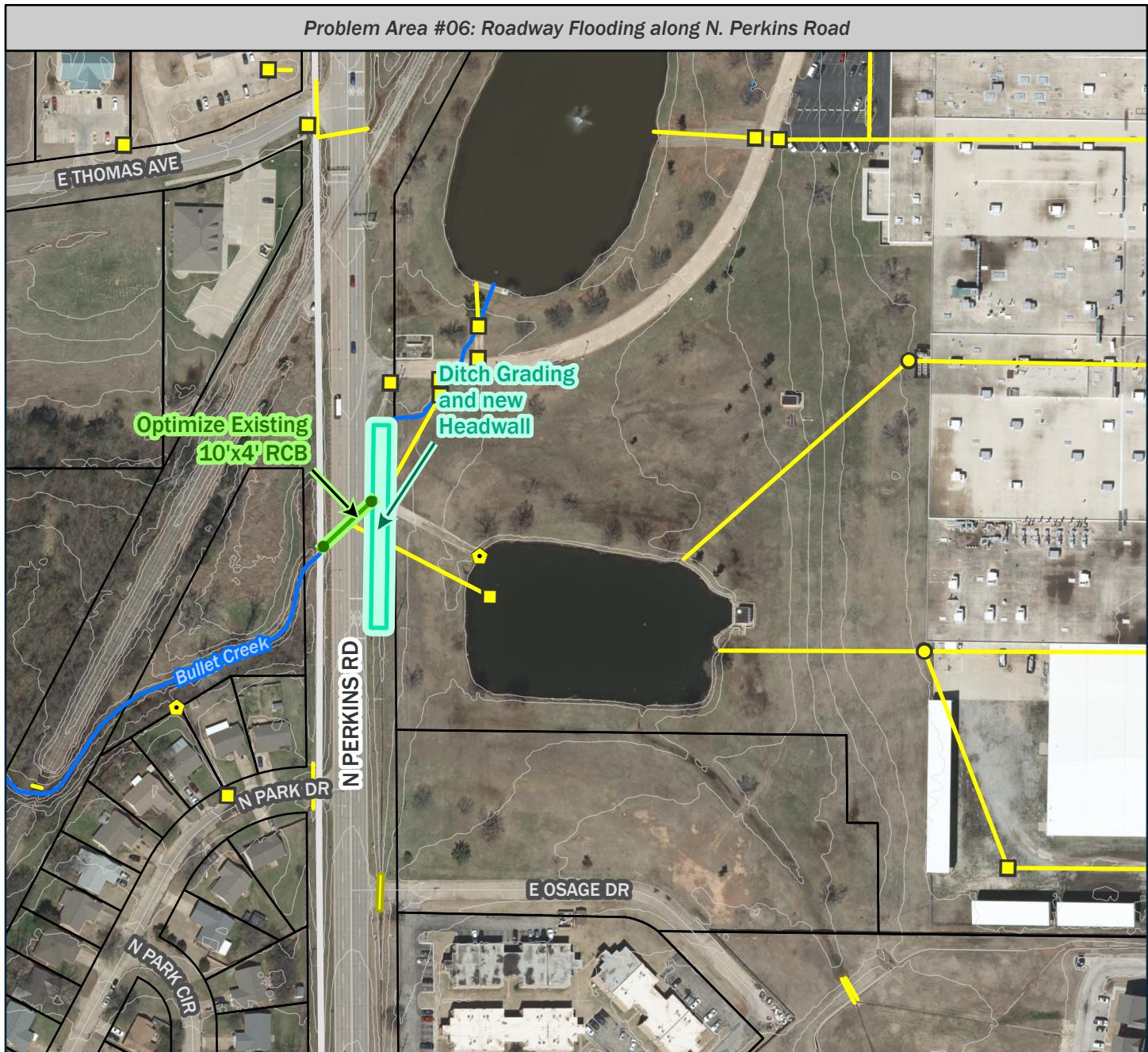
#### **Problem Area 06 Alternative – Roadway Design**

The existing 10' x 4' RCB culvert crossing HWY-177 is to be replaced with a 10' x 5' RCB that is to have the same flow line as the existing structure. The drainage ditch on the east side of HWY-177 is to be graded down to match the current upstream invert of the culvert crossing the highway. This proposed culvert should prevent HWY-177 from being overtopped in a 1% annual chance event. Armoring and erosion protection on the downstream side of the culvert is recommended. An estimated 0.5 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

The cost of this alternative would be roughly \$542,000. See **Figure 5-16** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 2**.

# East Boomer Creek Problem Area Alternatives

0 100 200 US Feet



## Problem Area 06 Recommendation – Roadway Design

**Ditch Grading + New Headwall**

**Cost: \$77,000**

### Proposed Project Locations

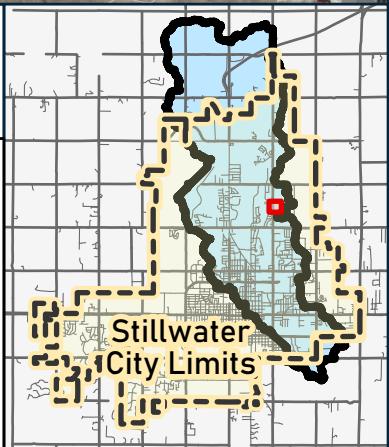
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

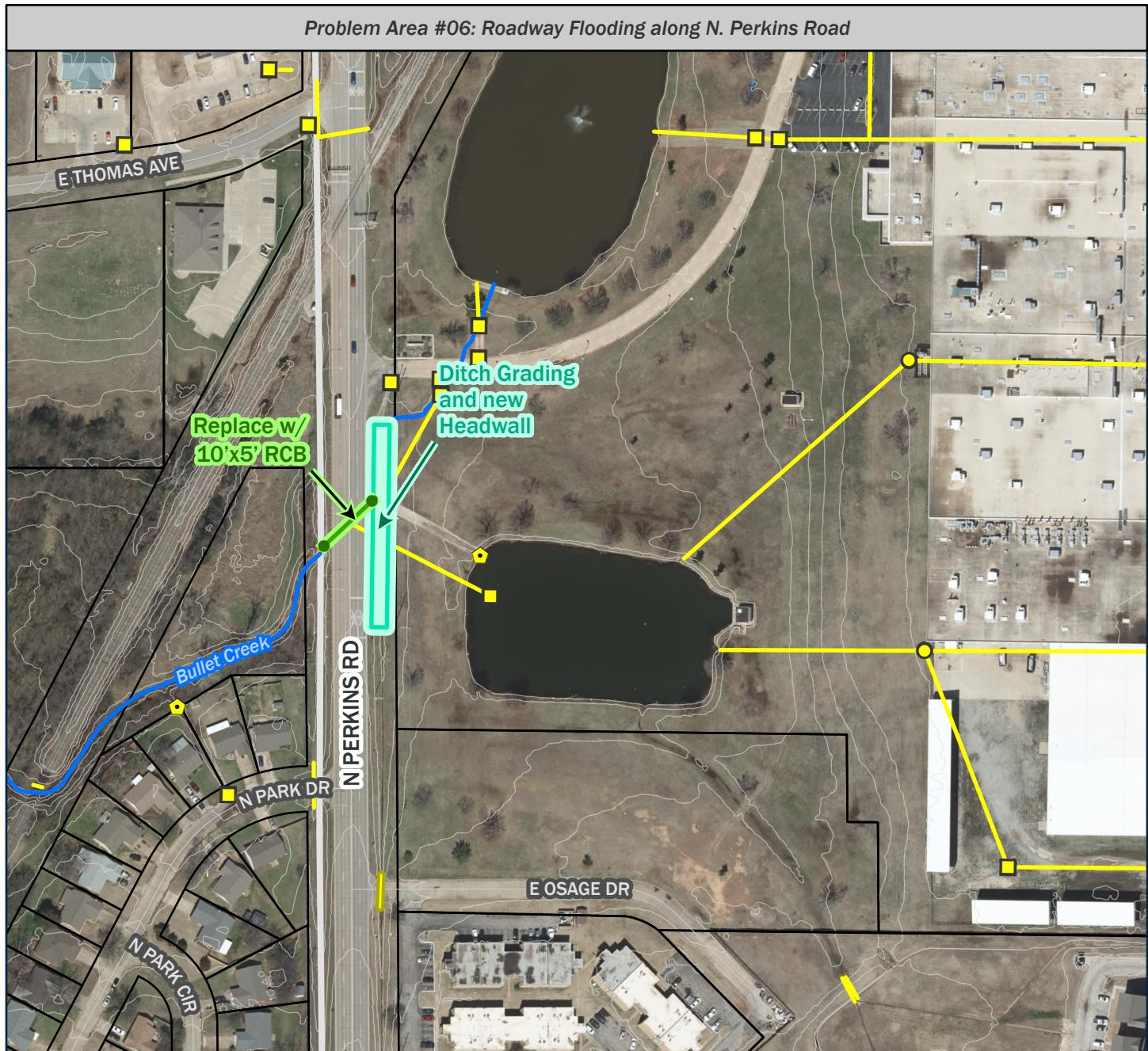
### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# East Boomer Creek Problem Area Alternatives

0 100 200 US Feet



## Problem Area 06 Alternative – Roadway Design

### Roadway and Culvert Improvements

Cost: \$542,000

#### Proposed Project Locations

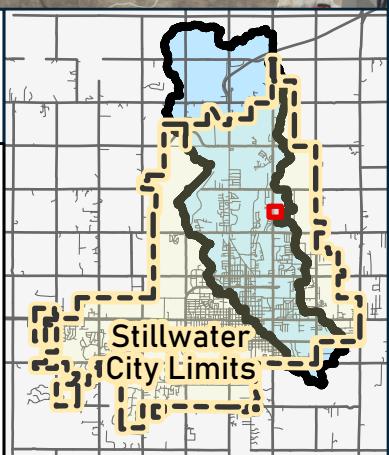
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



## SECTION 6. WEST BOOMER CREEK PROBLEM AREA ANALYSIS

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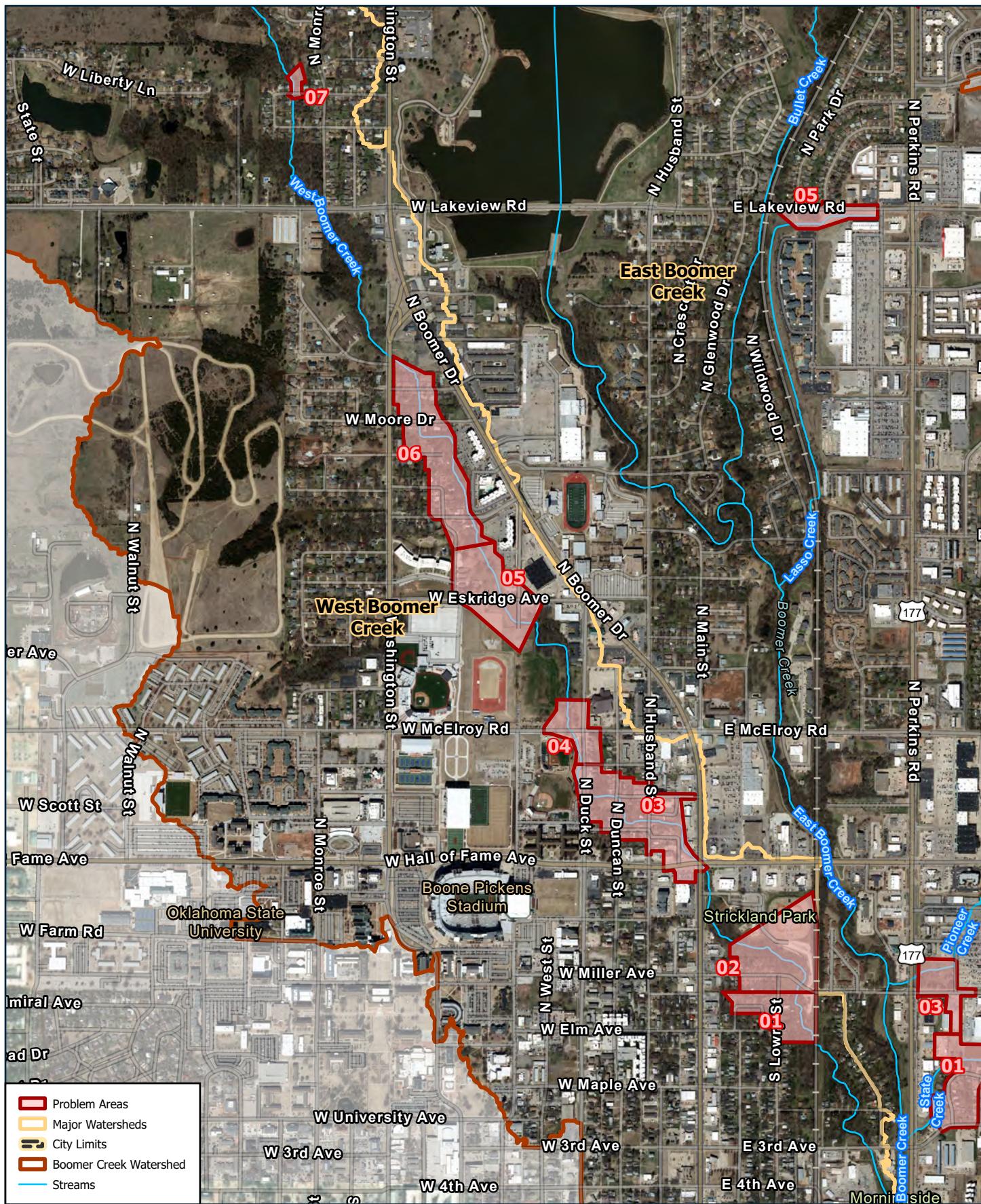
This section describes the seven problem areas within the West Boomer Creek watershed and the alternatives that were considered for mitigation. Cost estimates are provided for each alternative. Recommendations are provided for each problem area and are summarized in **Section 1.3. Figure 6-1: West Boomer Creek Problem Areas** shows the location of each problem area.

A detailed map of problem area alternatives and their location in the West Boomer Creek watershed is illustrated in **SECTION 6**. Flooding problem areas were identified by reviewing flooding comments and observations received from City staff and residents as well as reviewing the results of the updated modeling and mapping.

Alternatives were analyzed for each of the problems areas and one of them was selected as the recommended plan. All the alternatives were analyzed at a conceptual level. When the City decides to move forward with one of the recommendations, additional design and/or modeling will be needed to finalize the details of the project. This will ensure no adverse impact to adjacent properties or loss of floodplain storage and provide greater detail to refine the project cost estimate.

# Boomer Creek Master Drainage Plan

0 0.13 0.25 Miles



**West Boomer Creek Problem Areas**

***Problem Area 01: Residential and Roadway Flooding along E. Virginia Avenue and S. Lowry Street***

The problem area consists of residential flooding on the downstream side of E. Virginia Avenue between N. Main Street and HWY-177. Approximately 38 properties experience yard flooding during the 1% annual chance flood. Of those properties there are 11 homes at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance event include E. Virginia Avenue, S. Lowry Street, and Elmwood Circle. During the 1% annual chance event, S. Lowry Street overtops by over 2-feet at the roadways lowest point.

Once West Boomer Creek overtops its banks, water spreads out into the overbanks where existing structures and roadways are located.

**Problem Area 01 Recommendation – Floodplain Storage**

Additional floodplain storage and conveying area in the channel is to be created to contain the 1% AEP flood flows. Nine properties adjacent to the stream are to be acquired and converted to an improved stream channel and overbank area. The total excavation is approximately 7.3 ac-ft while gaining roughly 5.5 ac-ft of floodplain storage. Floodplain storage should be maximized for optimal improvement. The added floodplain storage from excavation will reduce the 1% annual chance flood WSE because of this there should be significantly reduced flooding on roadways, but they will remain inundated. Yard flooding should be mitigated or reduced for many properties. The two homes not acquired that were impacted by the 1% AEP flood should be removed from the floodplain due to the lowered WSE. The existing 1% annual chance flow on the upstream side of the railroad bridge is 2159 cfs and the proposed flow should be approximately 2152 cfs. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the mapping changes associated will need to be submitted to FEMA as well as a LOMC. The cost estimate does not include the FEMA LOMC submittal.

The cost of this recommendation is approximately \$1,877,000. See **Figure 6-2** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

**Problem Area 01 Alternative – Relocation and Acquisition**

Eleven properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$1,516,000. See **Figure 6-3** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

# West Boomer Creek Problem Area Alternatives

0 100 200 US Feet

## Problem Area 01: Residential and Roadway Flooding along E. Virginia Avenue and S. Lowry Street



## Problem Area 01 Recommendation – Floodplain Storage

**Acquisition + Increase Stream Capacity**

**Cost: \$1,877,000**

### Proposed Project Locations

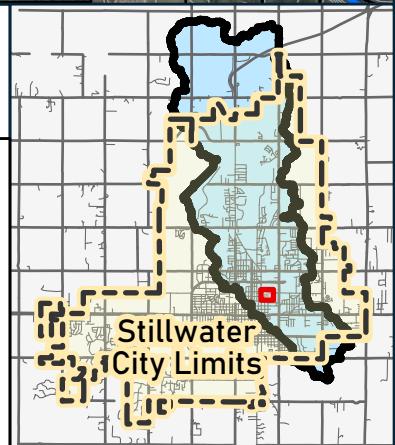
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

### Existing Storm Sewer

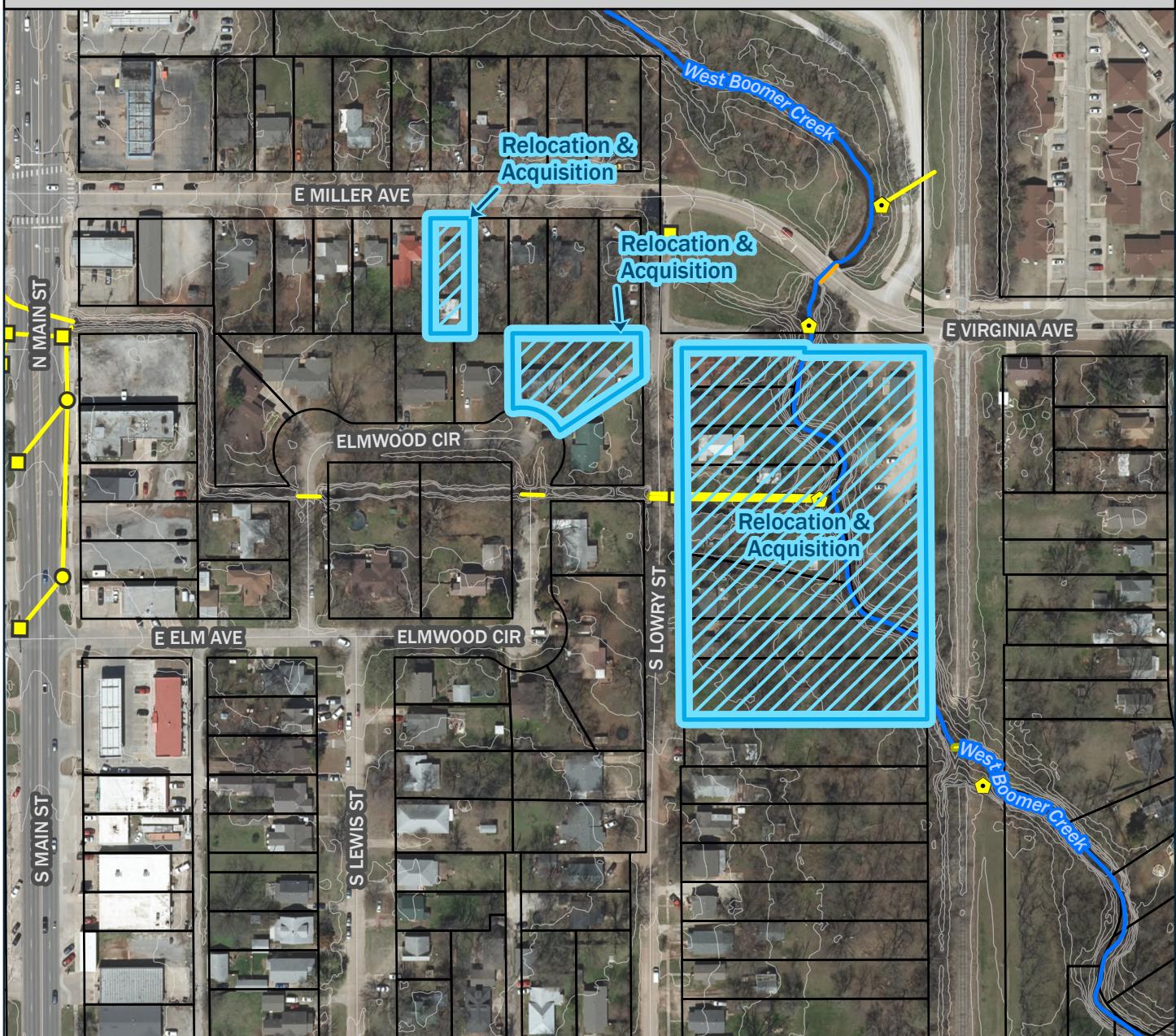
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 100 200 US Feet

## Problem Area 01: Residential and Roadway Flooding along E. Virginia Avenue and S. Lowry Street



### Problem Area 01 Alternative – Relocation and Acquisition

#### Property Relocation and Acquisition

Cost: \$1,516,000

#### Proposed Project Locations

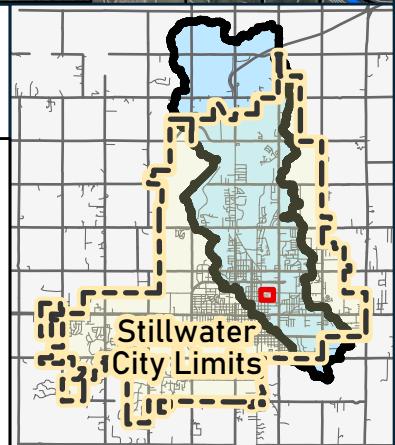
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



***Problem Area #02: Roadway Flooding along E. Virginia Avenue***

The problem area consists of street flooding on E. Virginia Avenue between N. Main Street and HWY-177. Approximately 15 properties experience yard flooding during the 1% annual chance flood. Roads that experience flooding during the 1% annual chance event include E. Virginia Avenue and S. Lowry Street. During the 1% annual chance event, E. Virginia Avenue is overtopped by nearly 30-inches at the roadway's lowest point.

The existing culvert is undersized which causes E. Virginia Avenue to overtop which then causes yard flooding in several properties before getting back into the channel on the downstream side. The downstream tailwater is very high and completely submerges the culvert. Due to the undersized culvert and the downstream tailwater, this roadway has a 10% annual chance capacity before overtopping.

**Problem Area 02 Recommendation – Floodplain Storage and Roadway Design**

The recommendation for West Boomer Problem Area #03 of increasing floodplain storage reduces flows downstream that impact this problem area. That alternative requires 20 properties to be acquired and approximately 15 ac-ft of added floodplain storage.

Additionally, a berm is to be constructed on City property, along the north property line of several properties that are on the north side of E. Virginia Ave. This berm is to start at existing ground elevation 878' from the west and tie-in to existing ground towards the east at elevation 877'. The length of the berm is roughly 350 feet and should have an approximate slope of 0.25% from the initial starting point to the tie-in location.

E. Virginia Avenue is to be raised to have an elevation of 875.0' as its lowest point near the intersection of S. Lowry Street. The roadway changes should start at existing grade elevation 877.5' along E. Miller Avenue and then tie-in to existing grade near the stream culvert crossing at elevation 875.75'. The roadway will have varying slopes for the crest alignment. Raising the roadway should mitigate E. Virginia Avenue from being inundated during the 1% annual chance flood.

An additional 12' x 10' RCB should be added to the existing culvert structure crossing Virginia Avenue. The added RCB should keep flood flows within the channel and reduce nuisance yard flooding. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the culvert crossing and mapping changes associated will need to be submitted to FEMA as well as a LOMC. The cost estimate does not include the FEMA LOMC submittal.

The cost of this recommendation including the recommendation for West Boomer Problem Area #03 is estimated to be \$6,972,000. See **Figure 6-4** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

### Problem Area 02 Alternative 1 – Floodplain Storage and Roadway Design

The recommendation for West Boomer Problem Area #03 of increasing floodplain storage reduces flows downstream that impact this problem area. That alternative requires 20 properties to be acquired and approximately 15 ac-ft of added floodplain storage.

The recommendation for West Boomer Problem Area #01 of increasing floodplain storage lowers tailwater conditions that impact this area and allows the existing culvert structure crossing E. Virginia Avenue to potentially contain the 1% annual chance flood flows. That alternative requires nine properties to be acquired and approximately 5.5 ac-ft of added floodplain storage.

Additionally, E. Virginia Avenue is to be raised to have an elevation of 875.0' as its lowest point near the intersection of S. Lowry Street. The roadway changes should start at existing grade elevation 877.5' along E. Miller Avenue and then tie-in to existing grade near the stream crossing at elevation 875.75'. The roadway will have varying slopes for the crest alignment. Raising the roadway should mitigate E. Virginia Avenue from being inundated during the 1% annual chance flood. The existing culvert crossing Virginia Avenue will be utilized.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the roadway crossing and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this recommendation is estimated to be \$8,512,000 which includes the recommendation for West Boomer Problem Area #03 and recommendation for West Boomer Problem Area #01. See **Figure 6-5** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

### Problem Area 02 Evaluated Alternative – Levee Design

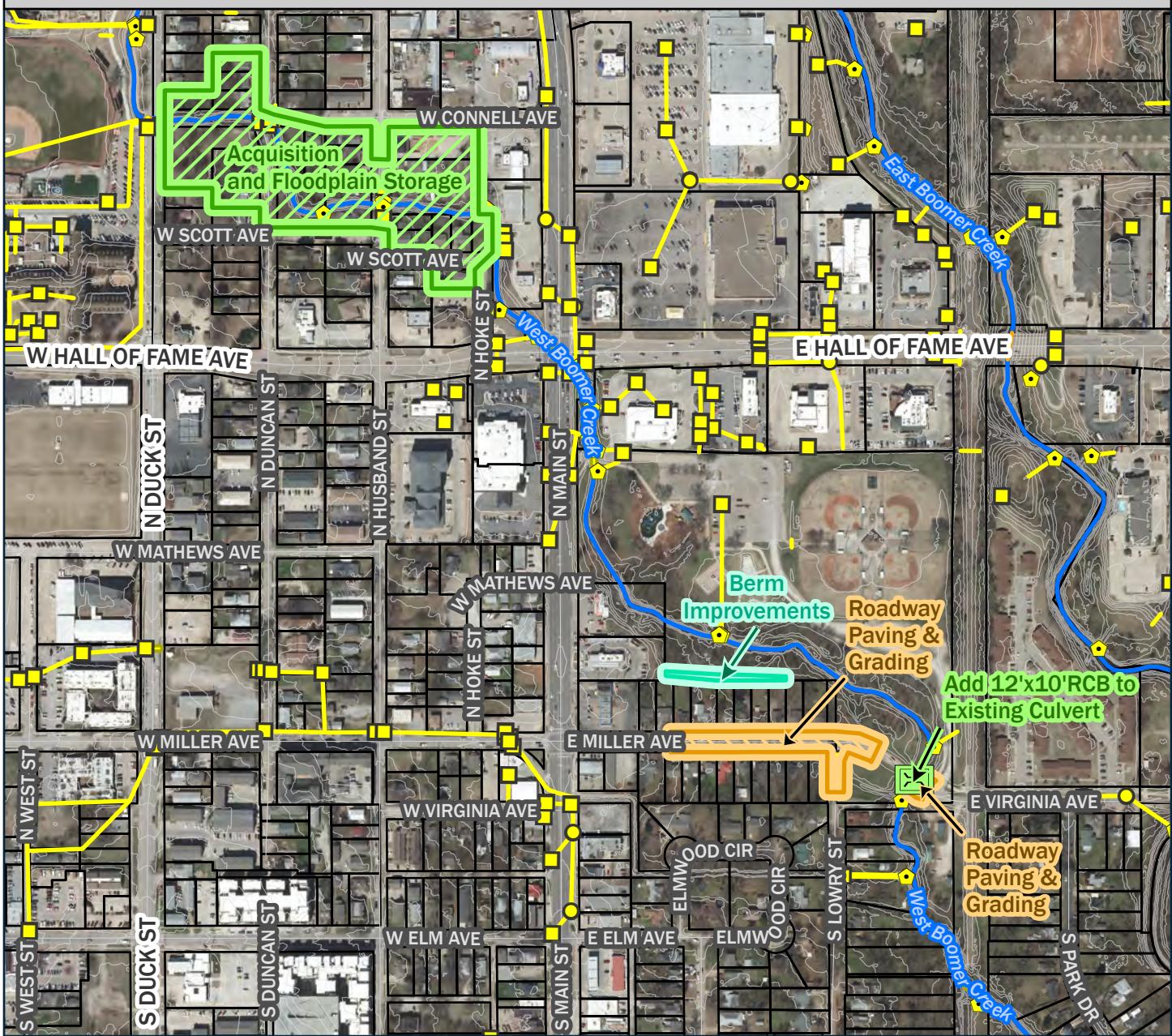
A levee and berm design were analyzed to retain water and reduce flooding on the roadway while mitigating the nuisance yard flooding for properties on the north side of E. Virginia Avenue.

Due to limited grade elevations and design criteria for a levee this option is not feasible. Additionally, the tailwater conditions will keep Virginia Avenue inundated during the 1% annual chance event. Therefore, additional details were not developed for this evaluated alternative. See **Figure 6-6** for a layout of this alternative.

# West Boomer Creek Problem Area Alternatives

0 225 450 US Feet

## Problem Area #02: Roadway Flooding along E. Virginia Avenue



### Problem Area 02 Recommendation – Floodplain Storage and Roadway

#### Floodplain Storage and Roadway Design

Cost: \$6,972,000

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other

# West Boomer Creek Problem Area Alternatives

0 225 450 US Feet

## Problem Area #02: Roadway Flooding along E. Virginia Avenue



### Problem Area 02 Alternative 1 – Floodplain Storage and Roadway Design

#### Floodplain Storage and Roadway Design

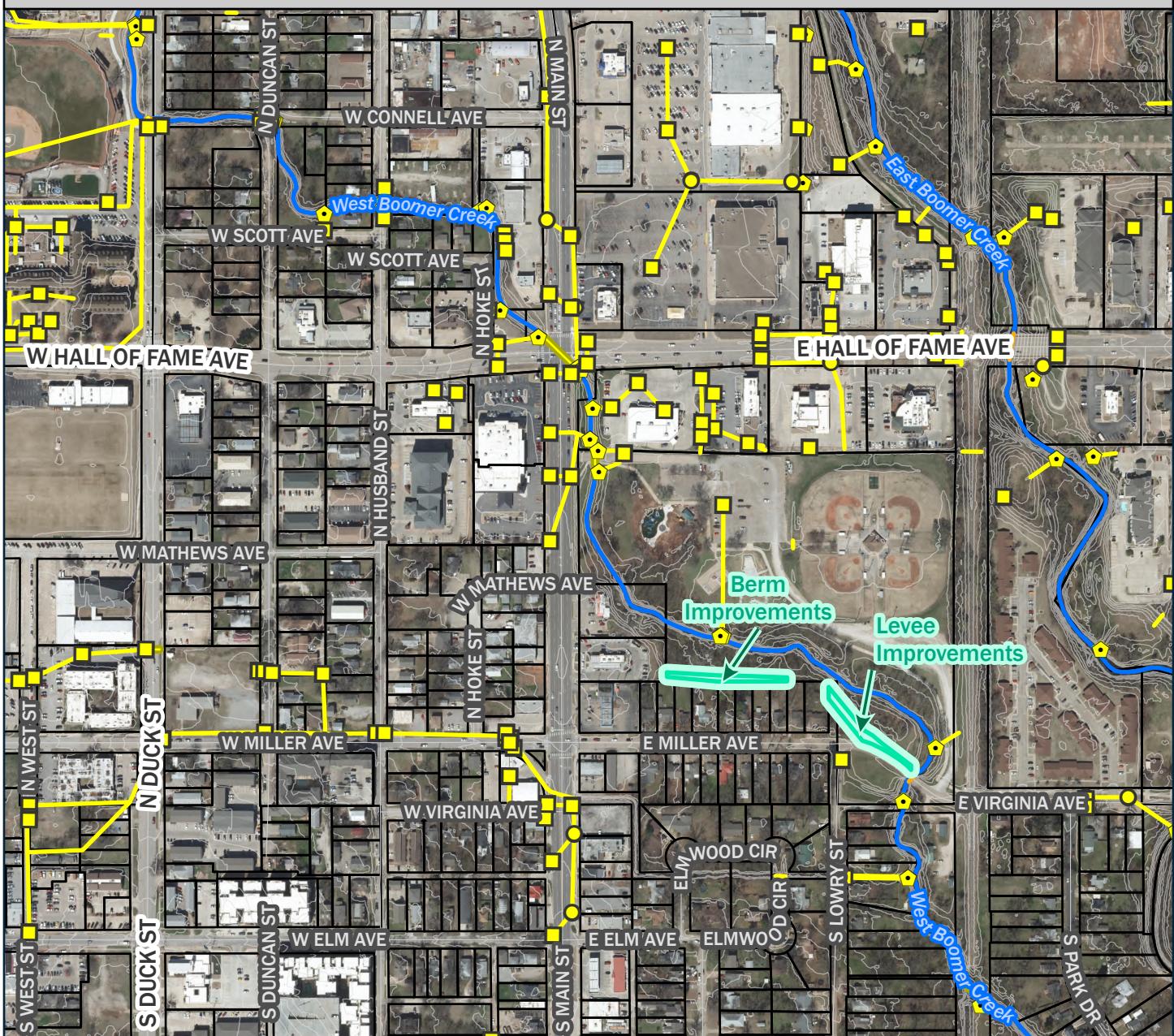
Cost: \$8,512,000

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other

# West Boomer Creek Problem Area Alternatives

0 225 450 US Feet

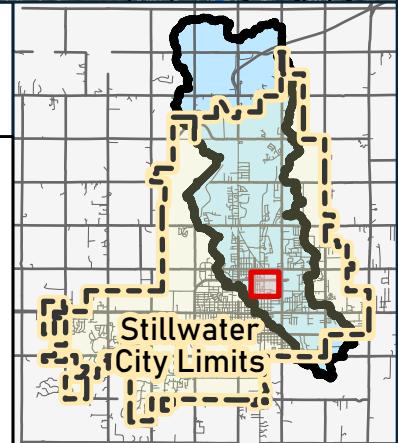
## Problem Area #02: Roadway Flooding along E. Virginia Avenue



## Problem Area 02 Evaluation – Levee Design

### Levee Design

Cost: \$ N/A



#### Proposed Project Locations

- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other

***Problem Area #03: Residential and Roadway Flooding between N. Duck Street and N. Main Street***

The problem area consists of residential flooding upstream of W. Hall of Fame Avenue between N. Duck Street and N. Main Street. Approximately 45 properties experience yard flooding during the 1% annual chance flood. Of those properties there are 24 homes at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance event include N. Duck Street, W. Scott Avenue, N. Duncan Street, N. Husband Street, Hoke Street, and W. Hall of Fame Avenue. During the 1% annual chance event, N. Duck Street and N. Husband Street are overtopped by over 2 feet at the roadways' lowest point. During the 1% annual chance flood, N. Duncan Street is overtopped by nearly 4 feet.

The existing channel begins to overtop its banks in a 50% annual chance event. Due to the limited channel capacity much of the flood flow is in the overbanks causing houses to be inundated and roadways to be flooded. All three primary roadways (N. Duck Street, N. Duncan Street, and N. Husband Street) impacted by this problem area have less than a 50% annual chance flood capacity before overtopping.

**Problem Area 03 Recommendation – Floodplain Storage**

Additional floodplain storage and conveying area is to be created to contain the 1% AEP flood flows within the channel. 19 properties and one vacant parcel are to be acquired and converted to an improved channel area and stream overbank. The total excavation is approximately 17 ac-ft while gaining roughly 15 ac-ft of floodplain storage. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark. Yard flooding should be mitigated or reduced for many properties. Four homes should be removed from the 1% AEP. There is significantly reduced flooding on roadways during the 1% annual chance event. The WSE should be lowered by roughly 0.5 feet at N. Husband Street, approximately 1.5 feet lower at N. Duncan Street, and roughly 1 foot lower at N. Duck Street. The existing 1% annual chance flows on the upstream side of the intersection of W. Hall of Fame Avenue and N. Main Street is 1994 cfs and with proposed grading for floodplain storage the flow should be reduced to roughly 1965 cfs.

Culvert crossings for N. Duck Street, N. Duncan Street, and N. Husband Street were not able to be changed due to span and depth of the floodplain in the residential area, as well as limits of City roadway design criteria.

If West Boomer Problem Area #04 floodplain storage alternative is constructed in series to this recommendation, then the resulting reduced flows should allow the culvert structure at the intersection of W. Hall of Fame Avenue and N. Main Street to contain the 1% annual chance flood and mitigate N. Main Street from being inundated in a 1% annual chance event. Also, if West Boomer Problem Area #04 floodplain storage alternative is constructed in series to this recommendation, then N. Duck Street could have a four barrel 12' x 6' RCB and N. Duncan Street have a triple barrel 14' x 8' RCB crossing which should pass the 1% annual chance flows if both roadways are elevated for about 500 feet. However, the roadway sump at the intersection of N. Duck Street and W. Cantwell Avenue would still be inundated by nearly

a foot. Additionally, Husband Street would still be incapable of being improved and would remain inundated from headwater at Hall of Fame Avenue and N. Main Street.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the roadway crossings and mapping changes associated will need to be submitted to FEMA as well as a LOMC. The cost estimate does not include the FEMA LOMC submittal or roadway improvements.

The cost of this recommendation does not include any roadway improvement and is approximately \$5,768,000. See **Figure 6-7** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

#### Problem Area 03 Alternative – Relocation and Acquisition

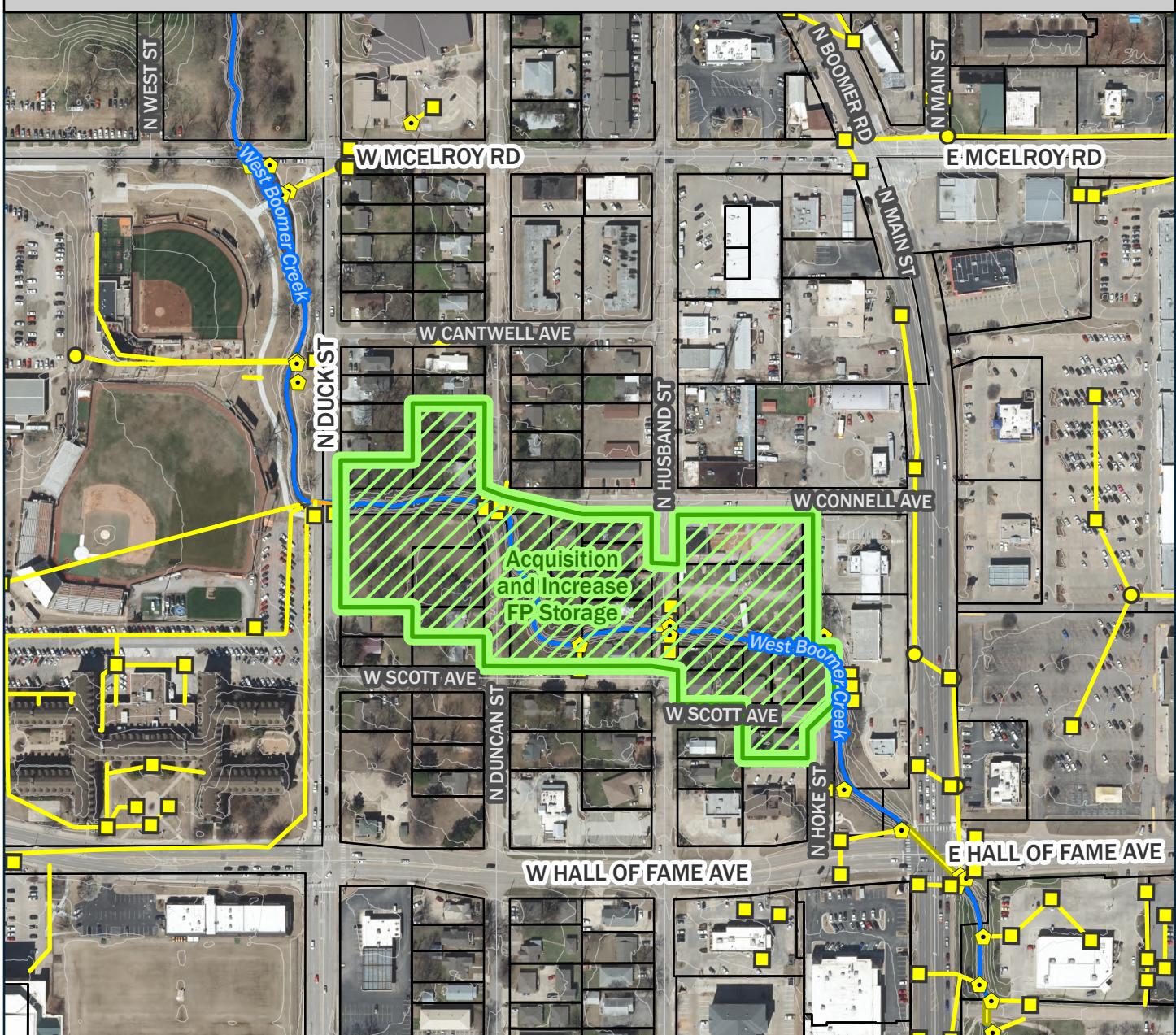
Twenty-four properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$4,673,000. See **Figure 6-8** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

# West Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #03: Residential and Roadway Flooding between N. Duck Street and N. Main Street



### Problem Area 03 Recommendation – Floodplain Storage

#### Property Acquisition and Increase FP Storage

Cost: \$5,768,000

#### Proposed Project Locations

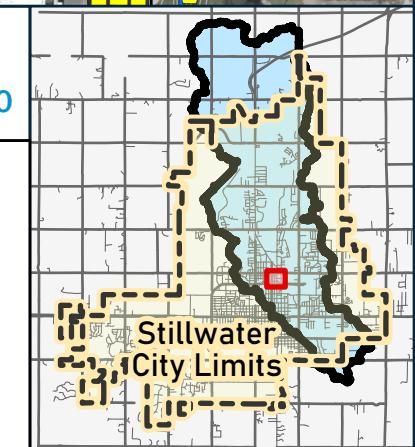
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

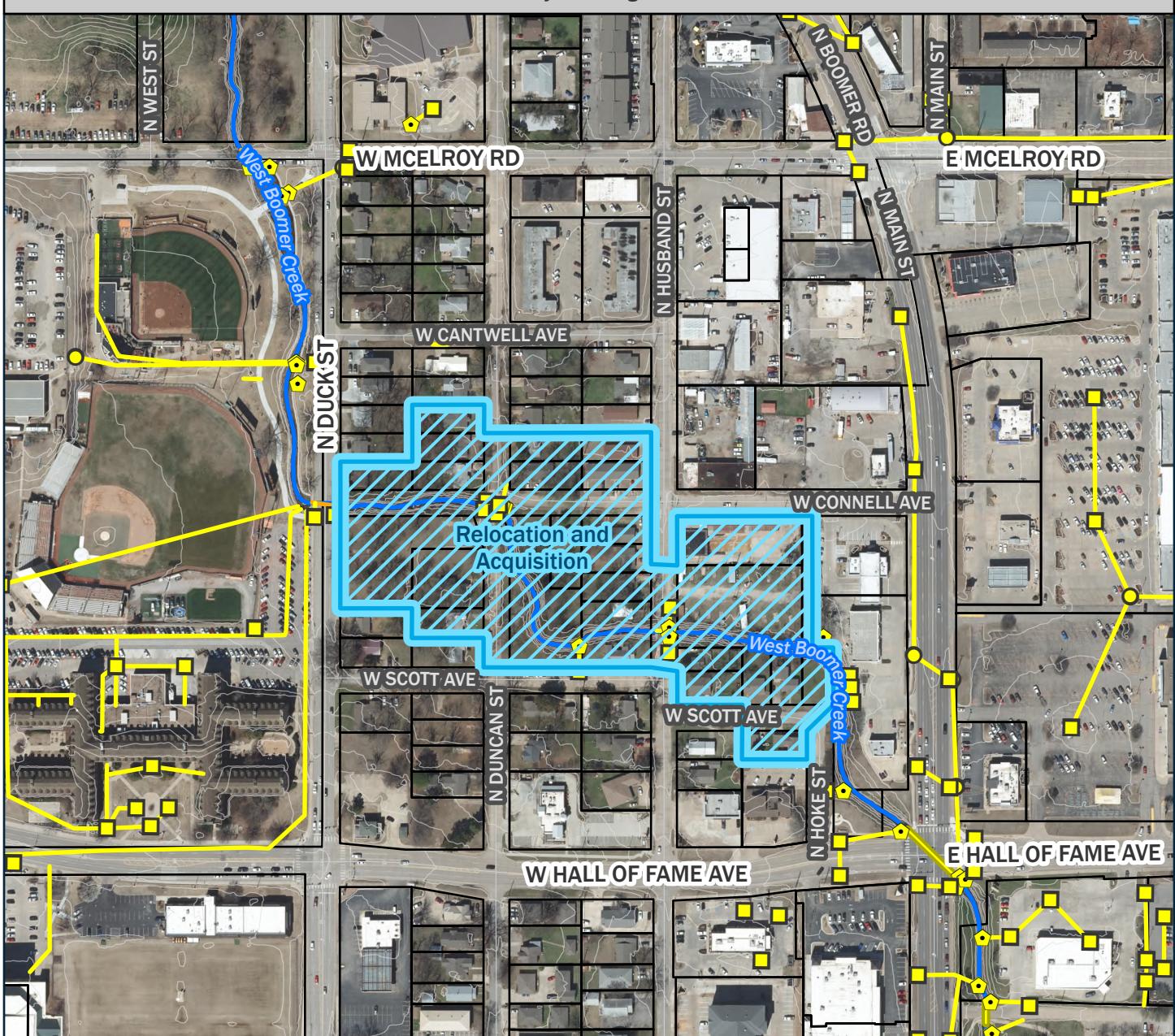
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #03: Residential and Roadway Flooding between N. Duck Street and N. Main Street



### Problem Area 03 Alternative – Relocation and Acquisition

#### Relocation and Acquisition

Cost: \$4,673,000

#### Proposed Project Locations

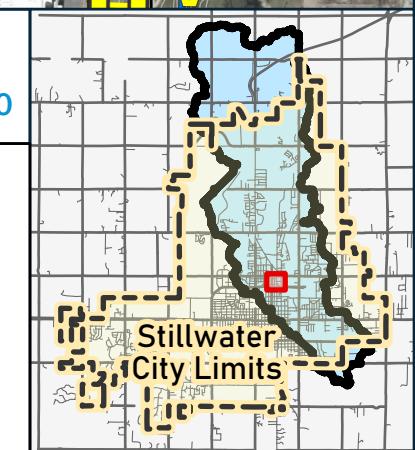
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



***Problem Area #04: Roadway Flooding along W. McElroy Road and N. Duck Street***

The problem area consists of street flooding on W. McElroy Road and along N. Duck Street. Approximately six properties experience yard flooding during the 1% annual chance flood. Roadways that experience flooding during the 1% annual chance event include W. McElroy Road, N. Duck Street, and W. Cantwell Avenue. During the 1% annual chance event, W. McElroy Road is overtopped by over 20-inches.

The current culvert structure does not have enough conveying area to allow flood flows to pass through causing headwater to build up and overtop McElroy Road which then causes yard flooding on several properties before getting back into the channel on the downstream side. Tailwater conditions on the downstream side keeps McElroy Road inundated during a 1% AEP flood. Due to the culvert crossing being unable to pass flows at a higher volume and tailwater conditions controlling the downstream WSE this roadway has a 50% annual chance hydraulic capacity before overtopping.

Due to the stream not having enough conveying area it allows flood flows to expand out into the left overbank and on to N. Duck Street. Due to tailwater conditions from the culvert crossing at N. Duck Street being undersized for the receiving flood flows this roadway remains inundated during a 1% AEP flood up to and through West Boomer Creek Problem Area #03.

**Problem Area 04 Recommendation – Roadway Design**

This is a roadway design that should allow both W. McElroy Road and N. Duck Street to pass a 1% annual chance event.

McElroy Road is to be raised and repaved for roughly 330 feet. McElroy Road would have the lowest crest point near its intersection with N. Duck Street at elevation of 886.1' and have varying slopes until the roadway ties into existing grade around 887'. The existing culvert is to be replaced with a four barrel 12'x6' RCB structure. On the north side of McElroy Road there will be a headwall for approximately 250' with minimum elevation of 888.5'. Along McElroy Road on the north side a berm with elevation of 888.5' will extend to the northwest for roughly 150 feet until tying into existing ground at the same elevation. On the west side of N. Duck Street and on the north side of McElroy Road there will be a berm with elevation 888.5' that will extend from the headwall towards the north for roughly 200 feet until tying into existing ground at elevation 888.5'. An estimated 0.2 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

N. Duck Street is to be raised and repaved for approximately 720 feet. The roadway would have its lowest crest near its intersection with W. Cantwell Avenue at an elevation of 885.33' and have varying slopes until the roadway ties into existing grade around 886'. The existing culvert is to be replaced with a five barrel 10'x7' RCB structure. Two properties are to be acquired for the roadway improvement. An estimated 0.9 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the culvert crossing and mapping changes associated will need to be submitted to FEMA as well as a LOMC. The cost estimate does not include the FEMA LOMC submittal.

The cost of this recommendation is roughly \$4,131,000. See **Figure 6-9** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

#### Problem Area 04 Alternative – Detention and Roadway Design

This design should allow both W. McElroy Road and N. Duck Street to pass a 1% annual chance event.

Floodplain storage is to be provided by excavation to create a detention facility on the upstream side of W. McElroy Road. The total excavation is approximately 27.7 ac-ft while gaining roughly 15.9 ac-ft of floodplain storage. The floodplain storage area incorporates an existing detention pond and removes its embankment. A berm at elevation 892' is to line the northern side of E. McElroy Road and the western edge of N. Duck Street until tying into existing ground at the same elevation of 892'. A spillway weir should be constructed near the existing culvert crossing with an elevation of 889'. At this elevation flood frequencies greater than the 1% annual chance flood will utilize the spillway. The spillway should be 75 feet wide at the base then slope up at a 15% slope until elevation 892' and be concrete lined with an apron for erosion protection. The 0.2% annual chance event should not exceed a WSE greater than 891' to maintain a 1-foot freeboard. The existing culvert structure crossing E. McElroy Road is to be utilized. However, the flood flows will likely pressurize the culvert system so armoring on the downstream stream side may be needed. Several properties downstream of E. McElroy Road will still have yard flooding, but inundation will be reduced. Residential and collector roadways should have reduced flooding as well. The existing 1% annual chance flow at McElroy Road is 1368 cfs and the proposed flow should be roughly 1173 cfs. The controlled flow at McElroy Road by utilizing the existing culvert reduces flows downstream to West Boomer Creek Problem Areas #03, #02, and #01 for flood frequencies greater than the 50% annual chance. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

N. Duck Street is to be raised and repaved for approximately 720 feet. The roadway would have its lowest crest near its intersection with W. Cantwell Avenue at an elevation of 885.33' and have varying slopes until the roadway ties into existing grade around 886'. The existing culvert structure is to be replaced with a four barrel 12'x6' RCB. Two properties are to be acquired for the roadway improvements. N. Duck Street will still be partly flooded, but by 0.5 feet or less at the crown of the road near the intersection with W. Cantell Avenue. Channel widening between McElroy Road and the Duck Street culvert crossing could reduce or mitigate Duck Street from being inundated if both roadway improvements are constructed but is not a part of the estimated cost. Approximately 0.9 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

## Boomer Creek Master Drainage Plan

### City of Stillwater

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the culvert crossing and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this alternative is roughly \$12,979,000. See **Figure 6-10** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

# West Boomer Creek Problem Area Alternatives

0 160 320 US Feet

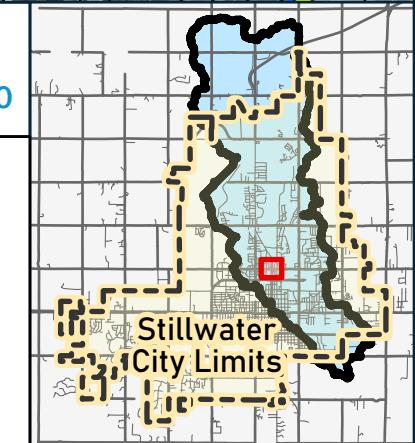


## Problem Area 04 Recommendation – Roadway Design

**Roadway Improvements with Berm & Acquisition**

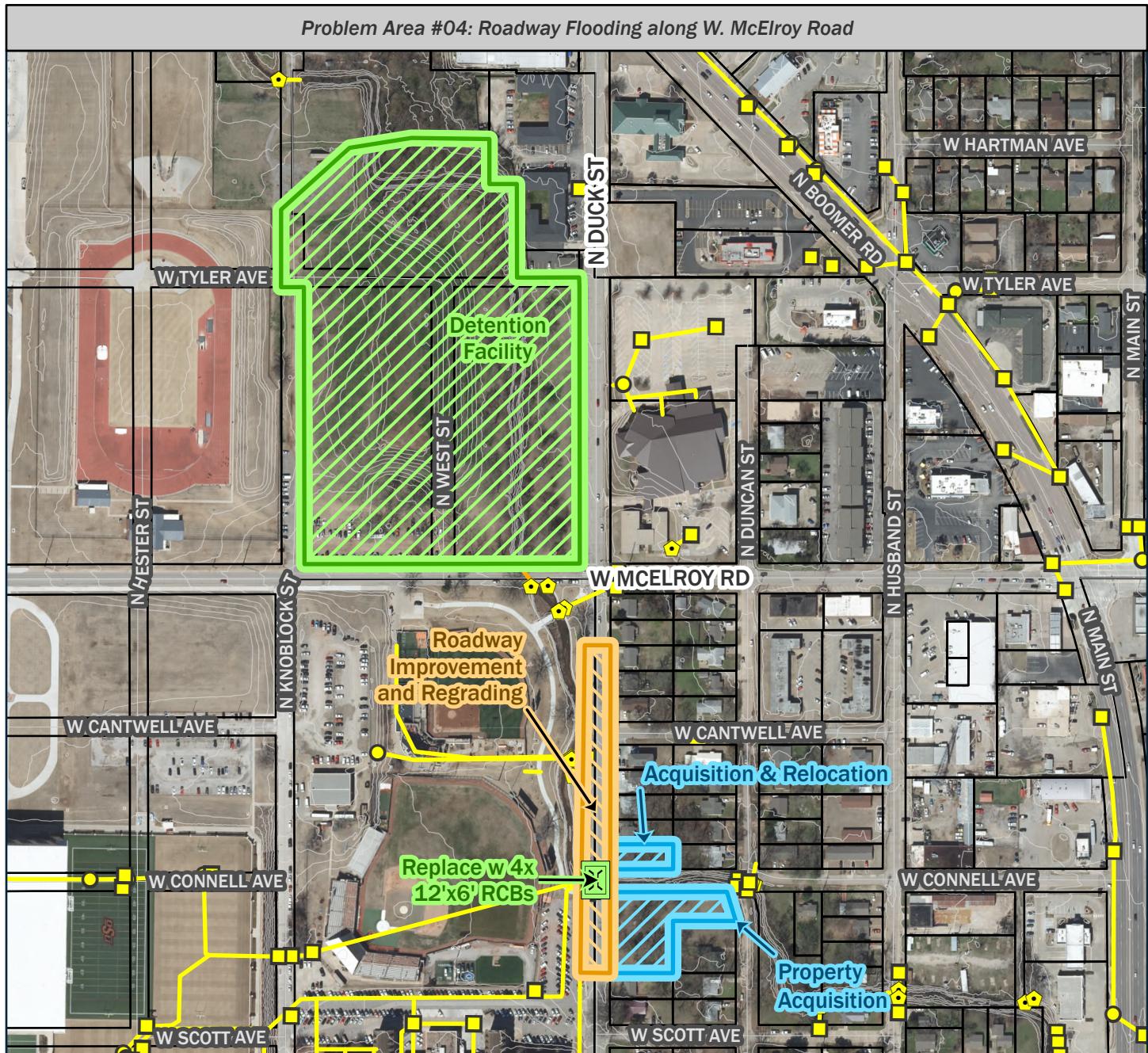
**Cost: \$4,131,000**

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 160 320 US Feet



## Problem Area 04 Alternative – Detention and Roadway Improvements

### Detention and Roadway Design

Cost: \$12,979,000

#### Proposed Project Locations

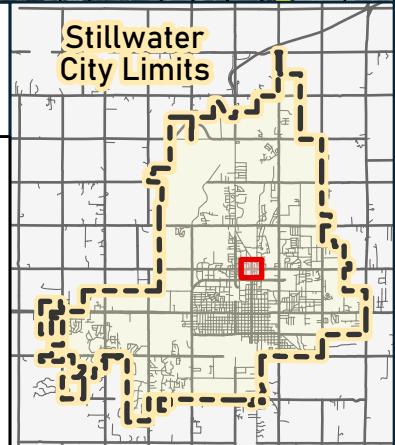
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



***Problem Area #05: Residential and Roadway Flooding along W. Eskridge Avenue***

The problem area consists of residential flooding on the upstream side of W. Eskridge Avenue between N. Ramsey Street and N. Knoblock Street. Approximately 12 properties experience yard flooding during the 1% annual chance flood. Of those properties there are 2 homes at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance event include W. Eskridge Avenue and N. Knoblock Street. During the 1% annual chance event, W. Eskridge Avenue is overtapped by roughly 3-feet deep at the roadway's lowest point.

The current culvert structure does not have enough conveying area to allow flood flows to pass through causing headwater to build up and overtop W. Eskridge Avenue which then causes two homes to be inundated before the flow gets back into the channel on the downstream side of the roadway. Tailwater conditions on the downstream side keeps Eskridge Avenue inundated during a 1% AEP flood. Due to the culvert crossing being unable to pass flows at a higher volume and tailwater conditions controlling the downstream WSE this roadway has a 10% annual chance hydraulic capacity before overtopping. However, due to a sump on W. Eskridge Avenue and an existing storm sewer system the roadway will be inundated during flood frequencies greater than a 50% annual chance event.

**Problem Area 05 Recommendation – Relocation and Acquisition**

Two properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$1,442,000. See **Figure 6-11** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 3.**

**Problem Area 05 Alternative 1 – Floodplain Storage**

Excavated floodplain storage in the channel and overbanks is to be created to contain the 1% AEP flood flows. Two properties, two vacant parcels, and two partial parcels adjacent to the stream are to be acquired and converted to an improved stream channel and overbank area. The total excavation is approximately 9.1 ac-ft while gaining roughly 6.9 ac-ft of floodplain storage. The existing W. Eskridge Avenue culvert should be able to contain the 1% annual chance flood flows due to the reduced tailwater conditions. The proposed WSE for the 1% annual chance event is roughly 893.33' at W. Eskridge Avenue, nearly a 0.6-foot reduction from the existing WSE. The proposed WSE changes upstream of Eskridge Avenue should tie-in at W. Bennett Drive.

Additional earthwork and grading are needed to raise an existing high ground area to construct a berm at an elevation of 894.33' on the north side of Eskridge Avenue starting at the upstream headwall and continuing in the northwest direction for approximately 310 feet until tying into existing ground at 895'. The berm should mitigate the 1% annual chance flood

from overtopping the roadway with a 1-foot freeboard. However, ponding water will still occur on W. Eskridge Avenue due to a storm sewer system surcharging because of the tailwater WSE during flood frequencies greater than a 20% annual chance event. The culverts crossing Knoblock Street are not to change. There will be reduced flooding on roadways during the 1% annual chance event. Yard flooding should be mitigated or reduced for many properties. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the culvert crossing and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this alternative is roughly \$5,118,000. See [Figure 6-12](#) for a layout of this alternative. The detailed cost estimate is included in [Appendix G](#) under **SECTION 3**.

#### **Problem Area 05 Alternative 2 – Floodplain Storage and Roadway Design**

This alternative is the same as alternative 1 recommendation with the addition of elevating and repaving W. Eskridge Avenue.

Eskridge Avenue is to be raised to where the roadway crest will have a minimum elevation of 893.0'. This should keep the roadway from being inundated during the 1% annual chance event. The existing culvert crossing will remain and should pass the 1% AEP flow.

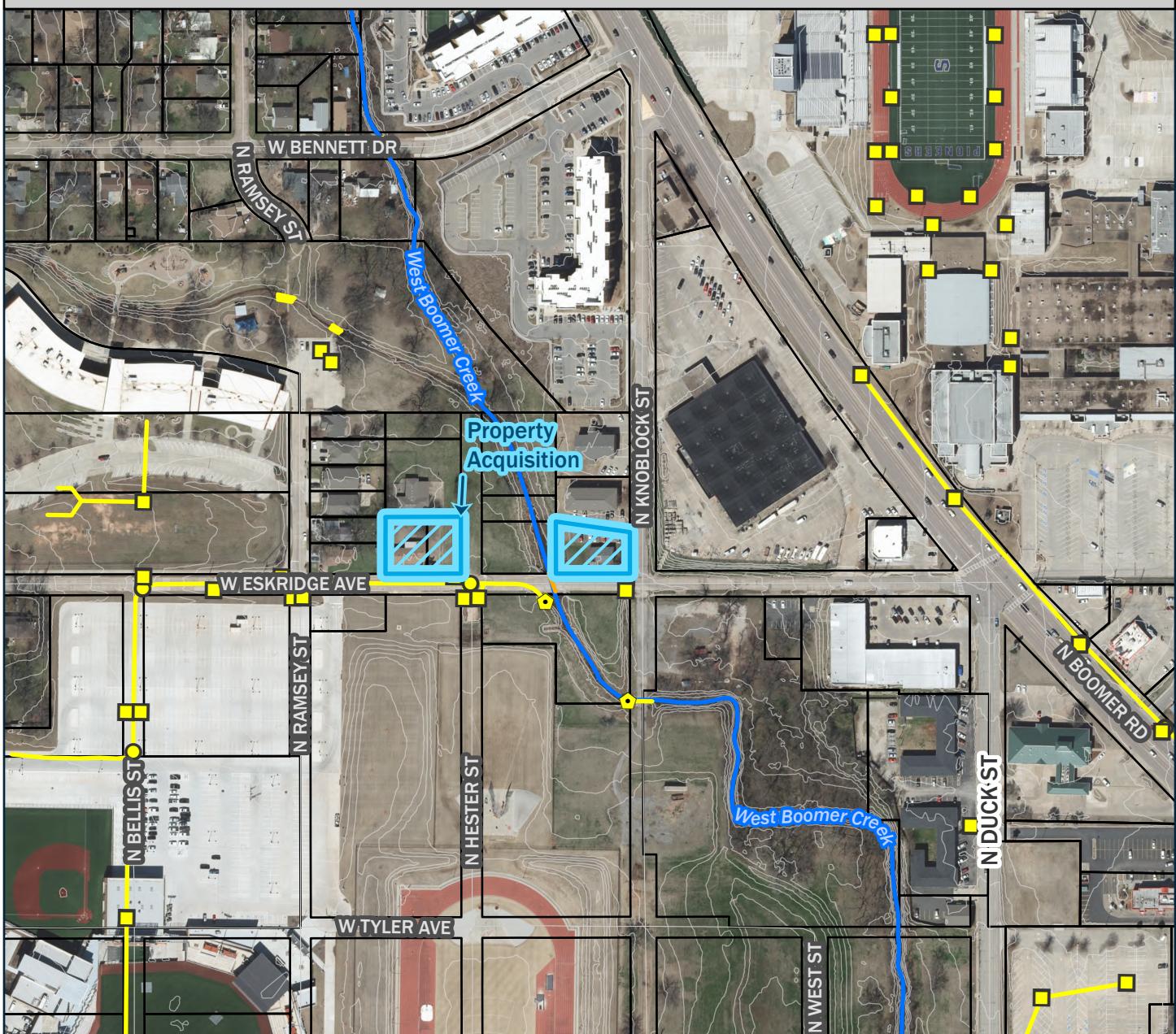
Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the culvert crossing and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this alternative is roughly \$6,338,000. See [Figure 6-13](#) for a layout of this alternative. The detailed cost estimate is included in [Appendix G](#) under **SECTION 3**.

# West Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #05: Residential and Roadway Flooding along W. Eskridge Avenue



### Problem Area 05 Recommendation – Relocation and Acquisition

#### Property Acquisition

Cost: \$1,442,000

#### Proposed Project Locations

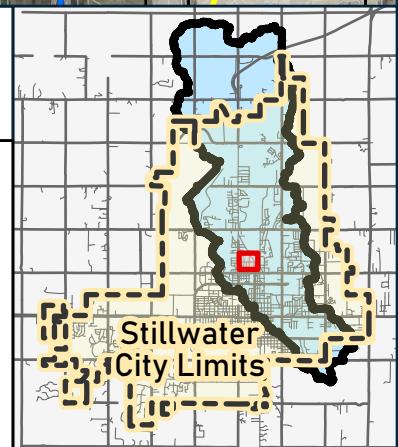
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

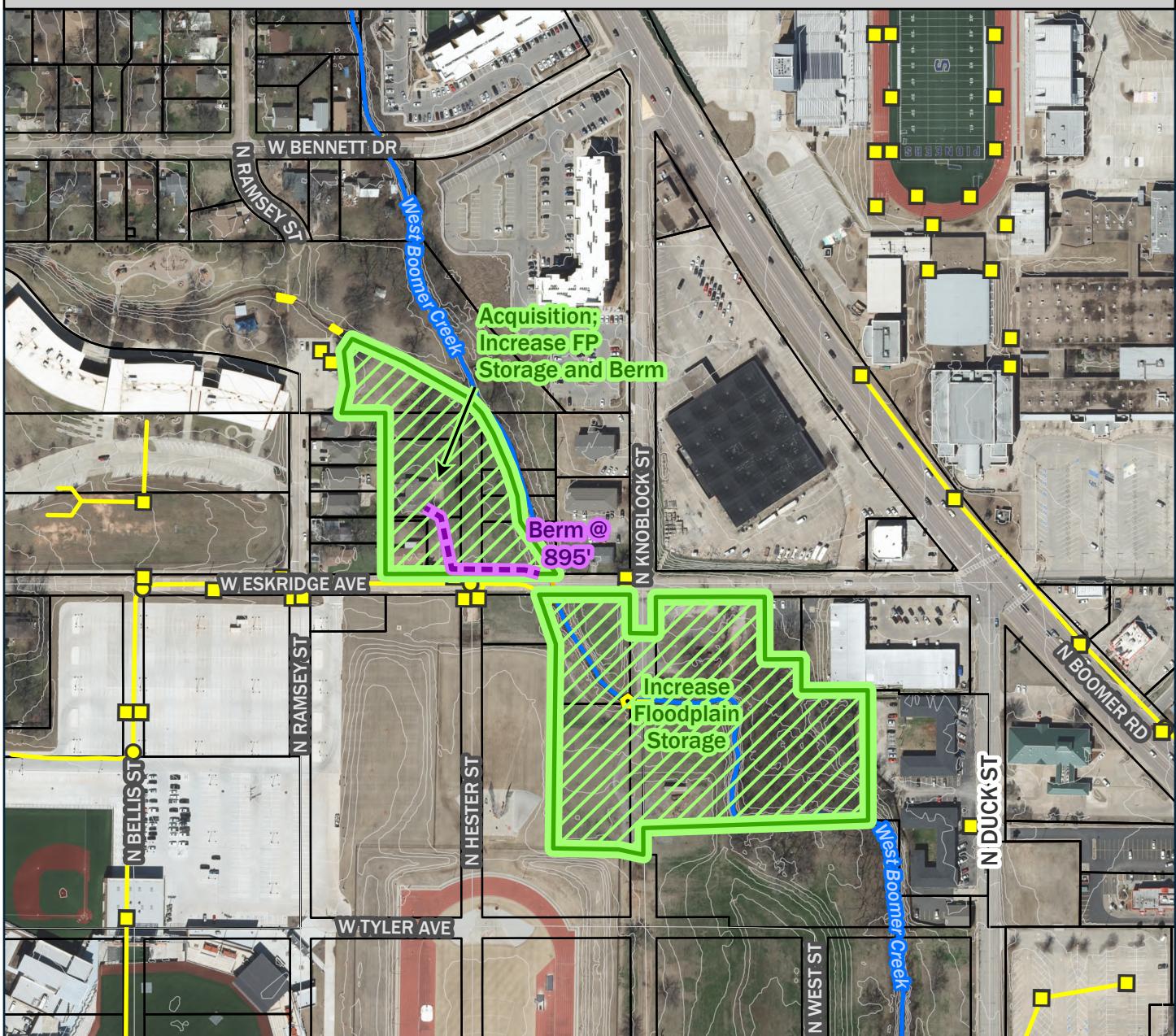
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #05: Residential and Roadway Flooding along W. Eskridge Avenue

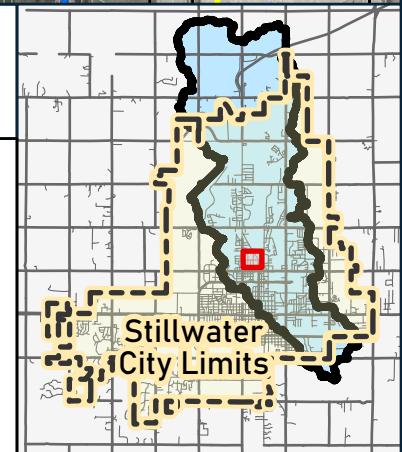


### Problem Area 05 Alternative 1 – Floodplain Storage

**Property Acquisition and increase FP Storage**

**Cost: \$5,118,000**

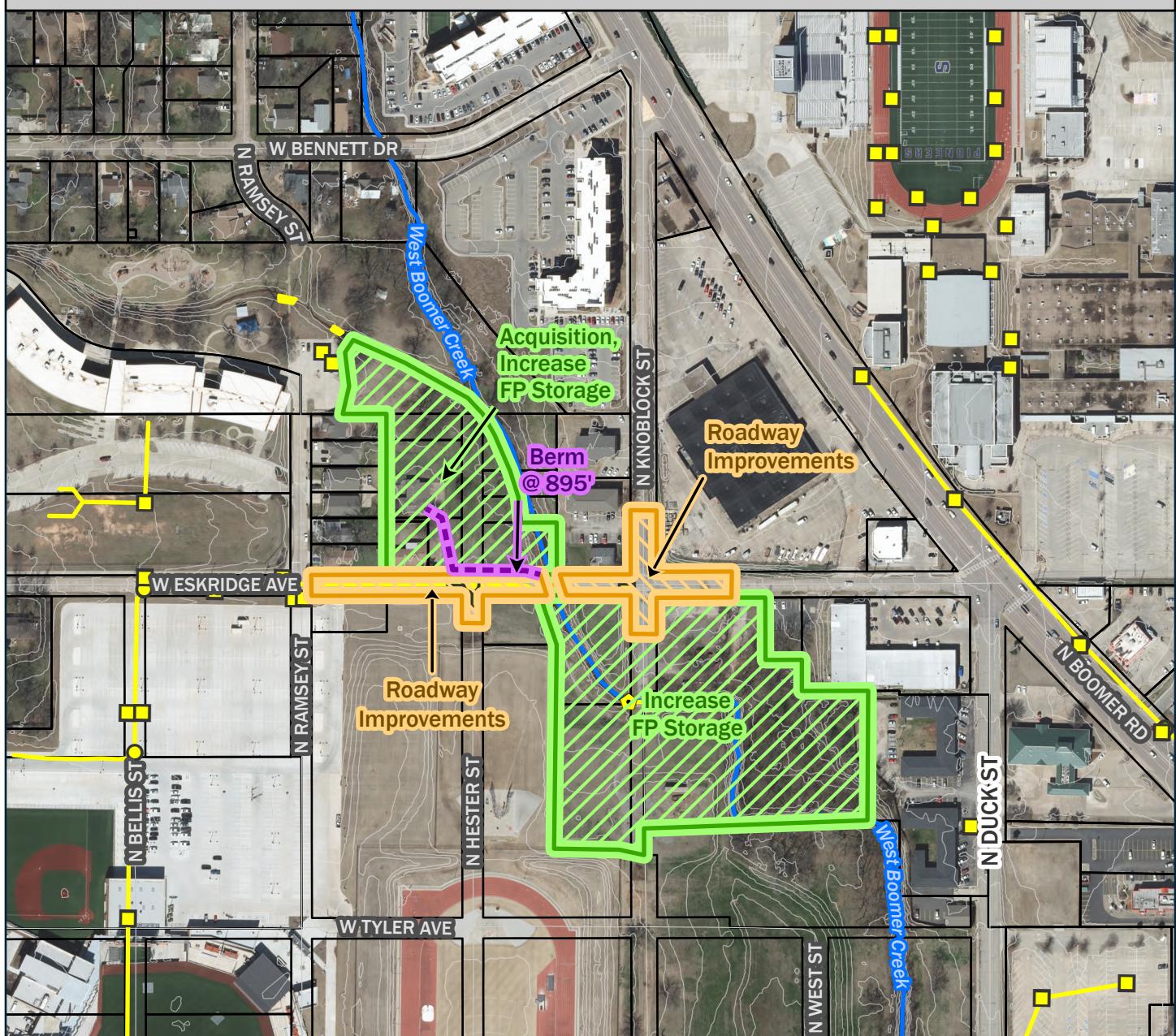
Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 150 300 US Feet

## Problem Area #05: Residential and Roadway Flooding along W. Eskridge Avenue



### Problem Area 05 Alternative 2 – Floodplain Storage and Roadway Design

**Acquisition, Floodplain Storage and Roadway Design**      **Cost: \$6,338,000**

#### Proposed Project Locations

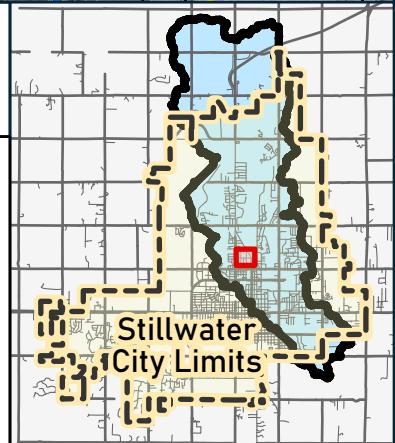
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



**Problem Area #06: Residential and Roadway Flooding between N. Washington Street and W. Bennett Drive**

The problem area consists of residential flooding between N. Washington Street and W. Bennett Drive. Approximately 55 properties experience yard flooding during the 1% annual chance flood. Of those properties there are 27 homes at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance event include W. Brooke Lane, W. Moore Avenue, W. Franklin Lane, W. Knapp Avenue, N. Ramsey Street, and W. Bennett Drive. During the 1% annual chance event, W. Bennett Drive is overtopped by over 30-inches at the roadways lowest crest point. During the 1% annual chance flood W. Moore Avenue is overtopped by over 30-inches. During the 1% AEP flood, W. Brooke Lane is overtopped by nearly 40-inches.

The existing channel begins to overtop its banks in less than a 50% annual chance event. Due to the limited channel capacity much of the flood flow is in the overbanks causing houses to be inundated and roadways to be flooded. All three primary roadways (W. Brooke Lane, W. Moore Avenue, and W. Bennett Drive) impacted by this problem area have less than a 50% annual chance flood capacity before overtopping.

**Problem Area 06 Recommendation – Relocation and Acquisition**

Twenty-seven properties are inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$4,812,000. See **Figure 6-14** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

**Problem Area 06 Alternative – Relocation and Acquisition**

Nine properties are inundated in the 4% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the properties is available after acquisition.

The cost of relocation and acquisition would be \$1,570,000. See **Figure 6-15** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

**Problem Area 06 Evaluated Alternative – Floodplain Storage**

Only 7.2 ac-ft of additional floodplain storage could be obtained within the project area. Twenty-one properties and three vacant parcels are to be acquired and converted to improved channel area and stream overbank. There should be significantly reduced flooding on roadways during the 1% annual chance event. Yard flooding should be mitigated or reduced for many properties. However, due to the added conveyance area, proposed terrain surface cover, and the inadequate compensatory storage provided for the proposed lowered water

surface elevation the flows are increased through this reach portion. Roadways could not be improved due to City design criteria and inability to provide adequate access to the impacted properties. Even if roadways were elevated to pass higher flows additional compensatory storage would be necessary. Since the required floodplain storage was not achievable to maintain or reduce flows this option is not feasible. This design assumes the limits of excavation are outside of the regulatory ordinary high-water mark. If the channel was widened, the resulting WSE decrease would require additional compensatory storage.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the roadway crossings and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of acquisition and the 8.3 ac-ft excavation to provide the 7.2 ac-ft of floodplain storage is approximately \$5,300,000. See **Figure 6-16** for a layout of this evaluated alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

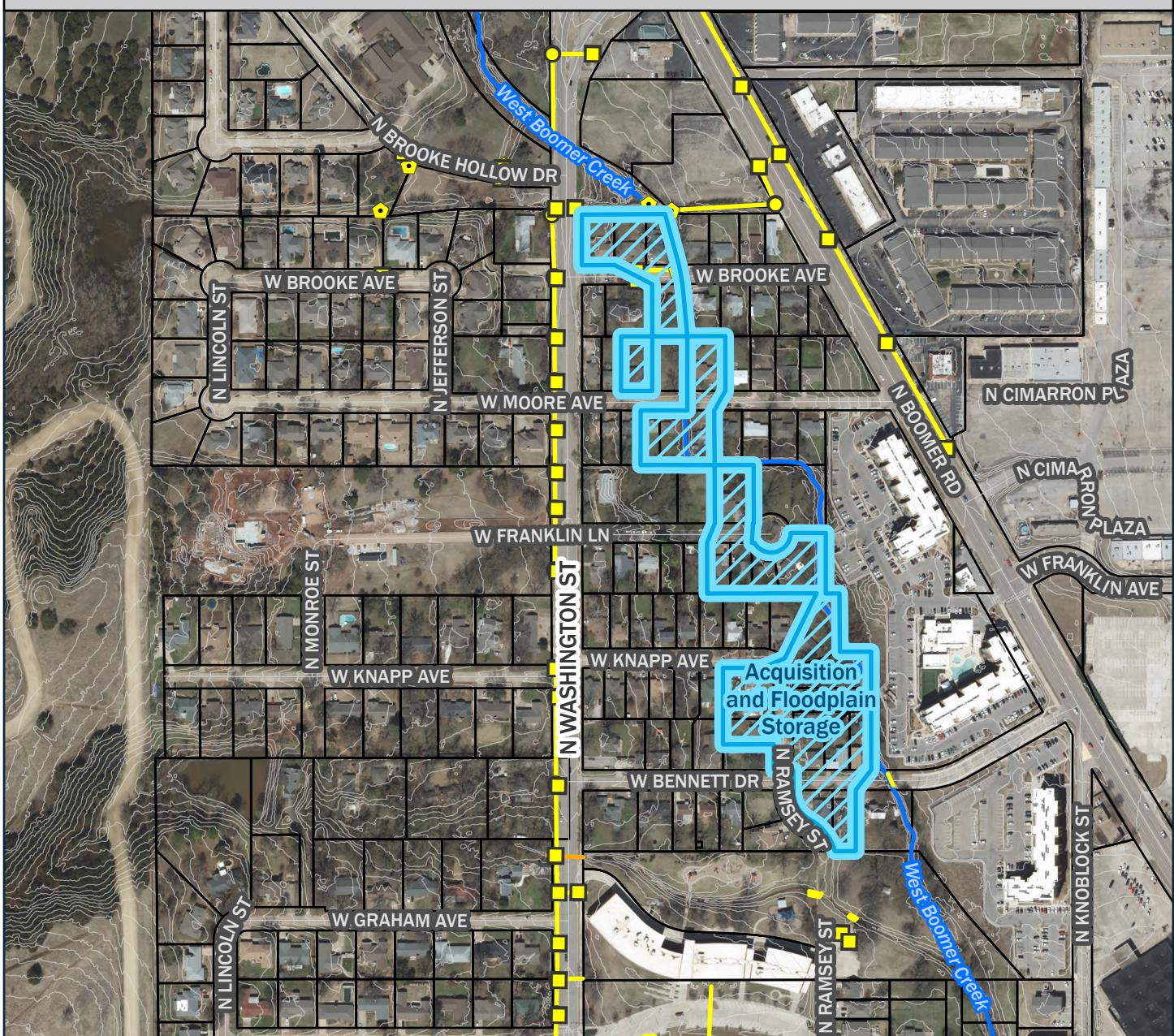
#### [Problem Area 06 Evaluated Alternative – Inline Structure Design](#)

A detention pond with berm elevation at 921.5' and an outlet structure at the channel flow line invert would control flood flows. The gained floodplain storage from the restricted flow should compensate for the fill. This detention area is primarily to control release flow timing to reduce peak flows downstream. The 1% annual chance flood had reduced flows downstream roughly equivalent to the 2% annual chance event which is not enough to mitigate properties or roadways from being inundated during the proposed 1% AEP flood. The flow to the problem area is controlled by two NRCS reservoirs upstream which limits the ability to reduce flows enough to have a beneficial impact. Since reasonable flow reduction could not be achieved this option is not feasible and additional details were not developed for this evaluated alternative. See **Figure 6-17** for a layout of this evaluated alternative.

# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

Problem Area #06: Residential and Roadway Flooding between N. Washington Street and W. Bennett Dr



## Problem Area 06 Recommendation – Relocation and Acquisition

### Relocation and Acquisition

Cost: \$4,812,000

#### Proposed Project Locations

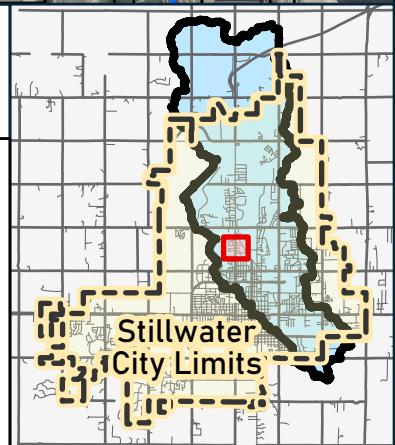
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

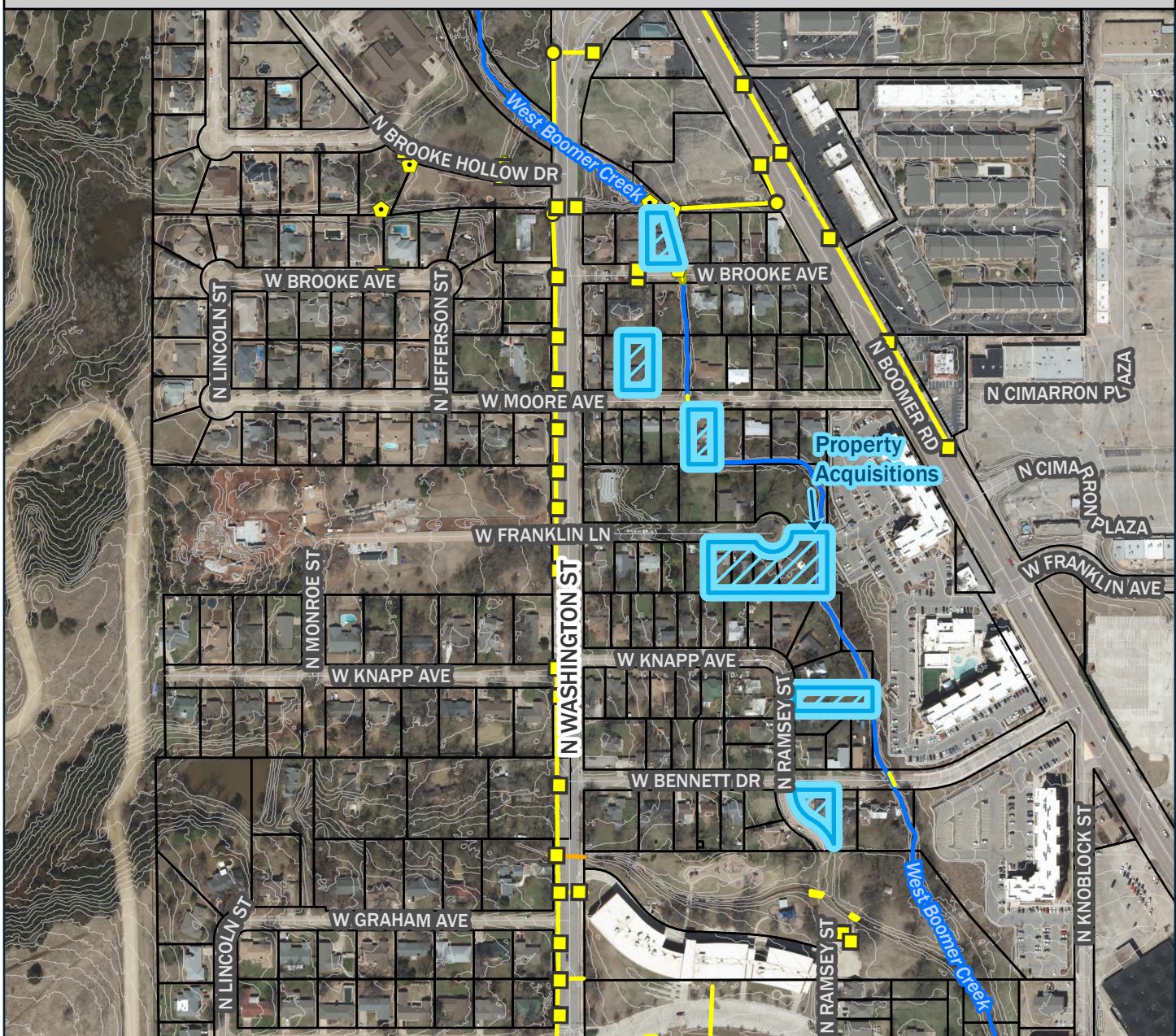
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

Problem Area #06: Residential and Roadway Flooding between N. Washington Street and W. Bennett Dr

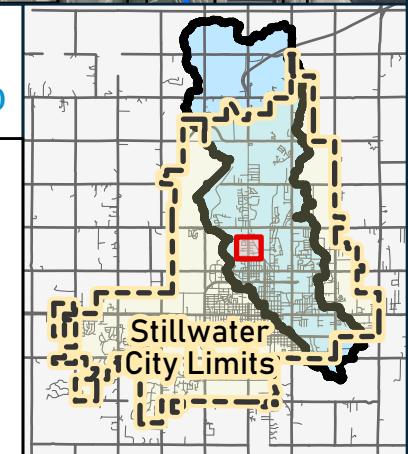


## Problem Area 06 Alternative 1 – Relocation and Acquisition

### Property Acquisition

Cost: \$1,570,000

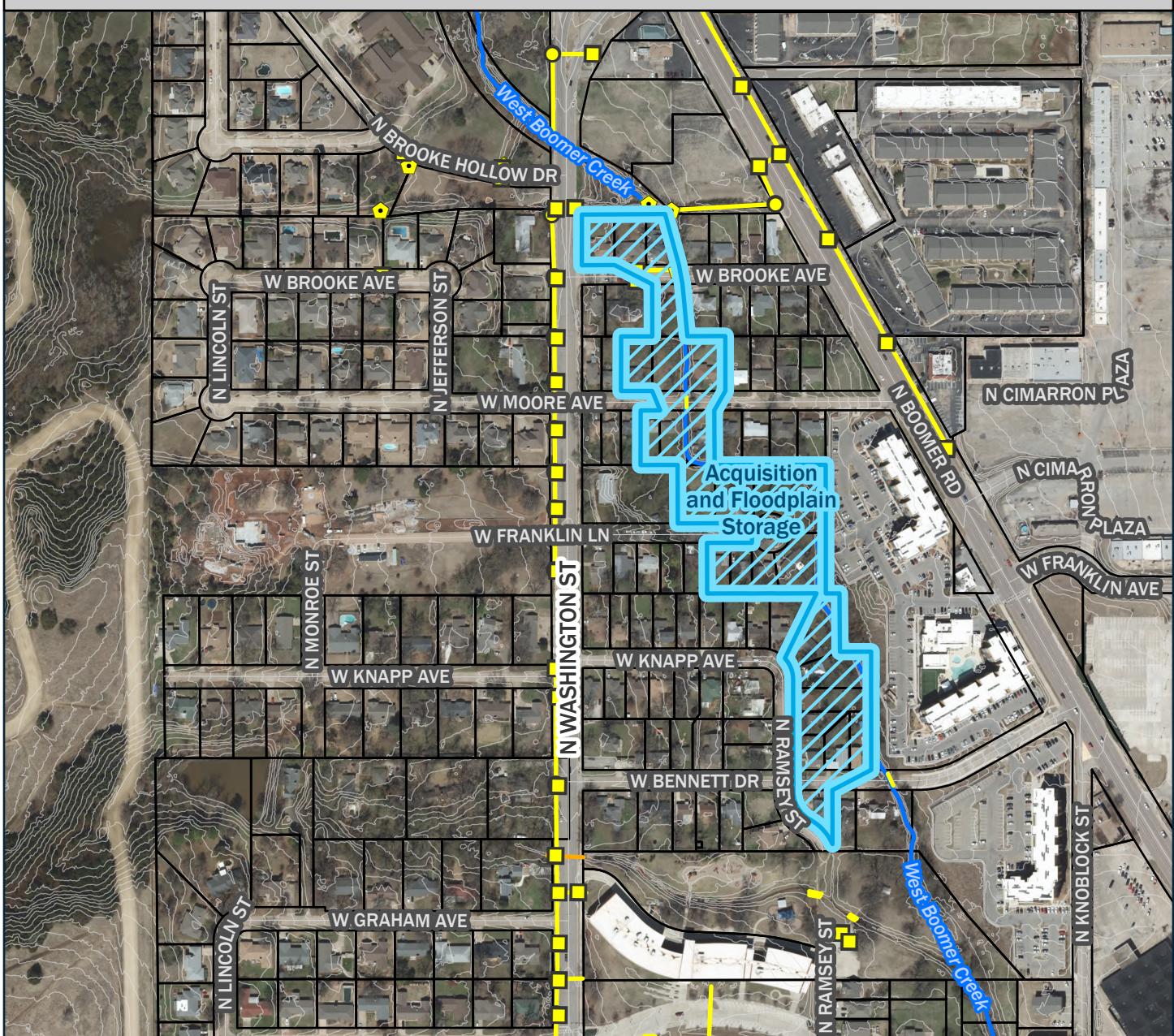
Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

Problem Area #06: Residential and Roadway Flooding between N. Washington Street and W. Bennett Dr



## Problem Area 06 Evaluated Alternative – Floodplain Storage

**Relocation and Acquisition + Increase Stream Capacity Cost: \$5,300,000**

### Proposed Project Locations

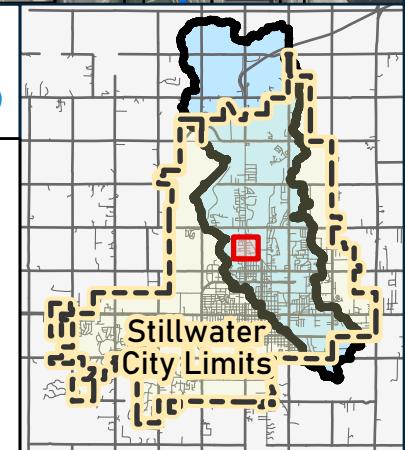
- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

### Existing Storm Sewer

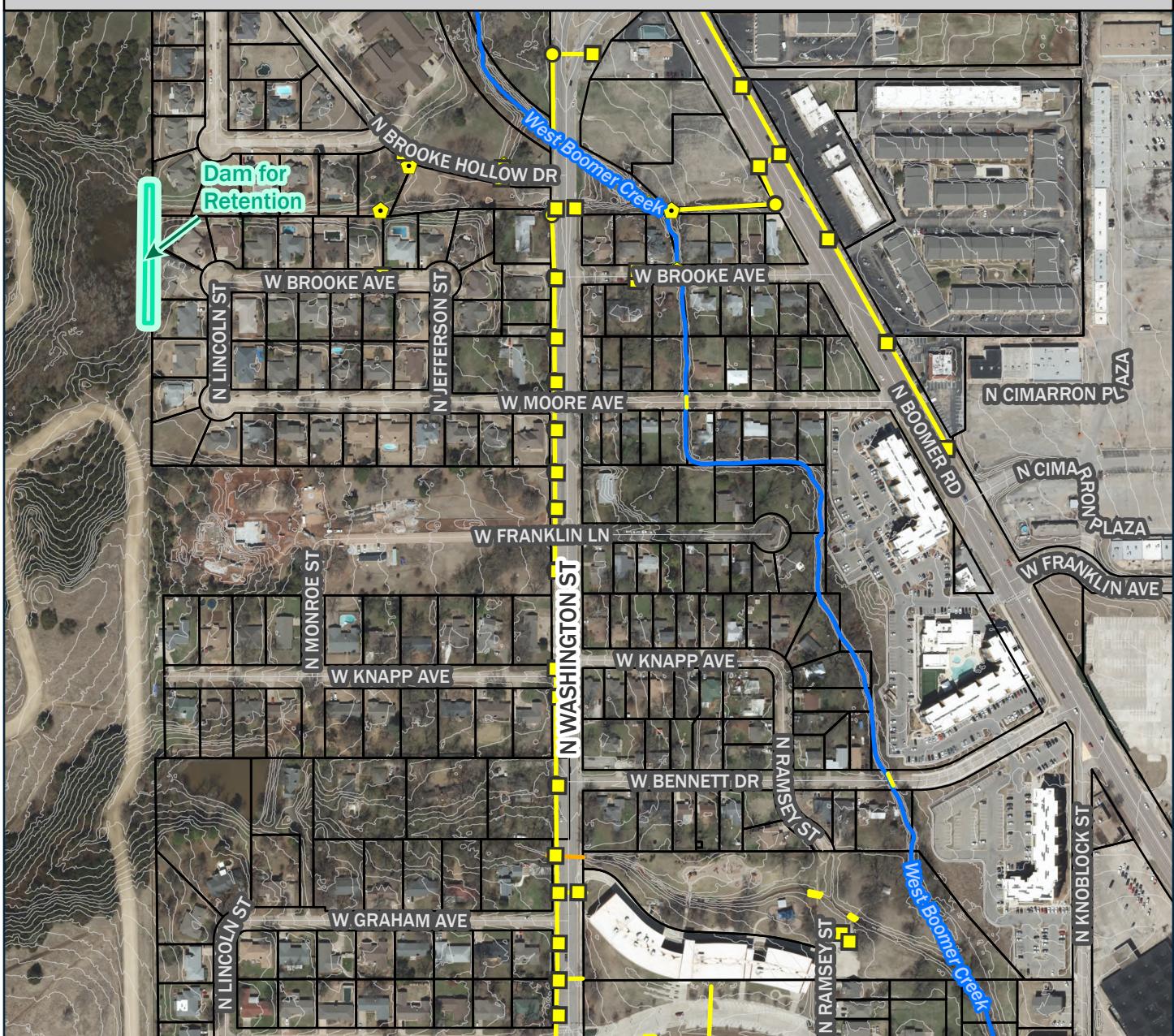
- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

Problem Area #06: Residential and Roadway Flooding between N. Washington Street and W. Bennett Dr

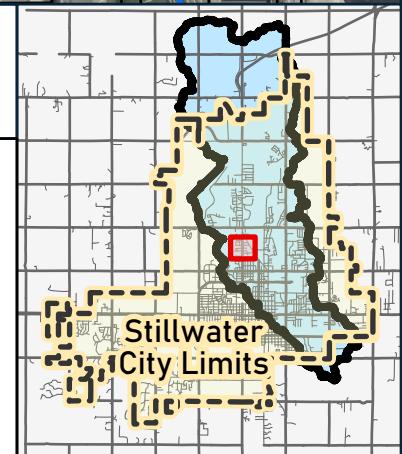


## Problem Area 06 Evaluated Alternative – Inline Structure Design

### Dam for Retention

Cost: \$ N/A

Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



***Problem Area #07: Residential and Roadway Flooding along W. Liberty Avenue***

The problem area consists of residential flooding along and downstream of W. Liberty Avenue. Approximately 15 properties experience yard flooding during the 1% annual chance flood. Of those properties there is 1 home at risk of being inundated by the 1% AEP flood. Roads that experience flooding during the 1% annual chance event include W. Liberty Avenue and W. Preston Avenue. During the 1% annual chance event, W. Liberty Avenue is overtopped by over 15-inches and Preston Avenue over one foot.

W. Liberty Avenue and W. Preston Avenue have a low water crossing point and an undersized culvert. Due to the undersized culverts, Libery Avenue has a 50% annual chance capacity and Preston Avenue has a 20% annual chance capacity before overtopping.

**Problem Area 07 Recommendation – Relocation and Acquisition**

One property is inundated in the 1% annual chance event and will be acquired. Property acquisition will not address the roadways being inundated during the 1% annual chance flood. Additional floodplain storage on the property is available after acquisition.

The cost of relocation and acquisition would be \$205,000. See **Figure 6-18** for a layout of this recommendation. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

**Problem Area 07 Alternative – Roadway Design**

Raising Liberty Avenue to have a minimum crest elevation of 916.25' and Preston Avenue to 915.25' and replacing the existing culverts with a double barrel 10' x 5' RCB culvert structure at both roadway crossings would allow the 1% AEP flows to pass but would not meet the design criteria of having a 1-foot freeboard. The flooding along W. Liberty Avenue and W. Preston Avenue should be mitigated and the one property no longer be inundated in the 1% AEP flood. An estimated 0.2 ac-ft should be compensated for during final design to eliminate the downstream impacts. For any floodplain storage loss by enlarging the culvert crossing potential compensatory storage may be required.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the roadway crossings and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this alternative is roughly \$981,000. See **Figure 6-19** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

**Problem Area 07 Alternative – Inline Structure Design**

An inline structure with berm elevation at 920' and a double barrel 48" RCP outlet structure at the channel flow line invert is to be constructed and would control flood flows.

One vacant parcel and a single partial parcel are to be acquired and excavated for detention storage. The total excavation for this detention facility is approximately 4.8 ac-ft while gaining

roughly 4.7 ac-ft of storage with an overall floodplain storage use of an estimated 7.7 ac-ft in the detention area at elevation 918.1'. This detention facility is primarily to reduce peak flows downstream. The existing 1% AEP flow on the upstream side of Liberty Avenue is 332 cfs and the proposed flow is roughly 220 cfs. The existing culvert crossing Liberty Avenue should then be able to pass the proposed 10% annual chance flood flow and Preston Avenue could possibly pass the proposed 4% AEP flow before overtopping. However, overtopping should be less than 0.5 feet for both roadways during the proposed 1% AEP flood which would allow emergency vehicles to utilize the roadway.

If the City can come to an agreement with NRCS to be able to have a higher 1% annual chance WSE than the approximate 918.1' elevation of the toe edge of the emergency spillway for Hazen Lake (Site 28), then the detention area could potentially utilize a double barrel 36" RCP outlet structure with an overall floodplain storage of approximately 9.6 ac-ft at elevation 918.8'. The berm would need to be raised to an elevation of 920.5' to maintain a 1-foot freeboard from the 0.2% annual chance WSE. This detention area should significantly reduce the flooding along W. Liberty Avenue and W. Preston Avenue and mitigate the property from being inundated in the 1% AEP flood. Both roadways could possibly pass the proposed 2% annual chance flows.

Since West Boomer Creek is a FEMA studied stream and has existing mapped floodway the roadway crossings and mapping changes associated will need to be submitted to FEMA with a LOMC for approval. The cost estimate does not include the FEMA LOMC submittal.

The cost of this alternative is roughly \$1,416,000. See **Figure 6-20** for a layout of this alternative. The detailed cost estimate is included in **Appendix G** under **SECTION 3**.

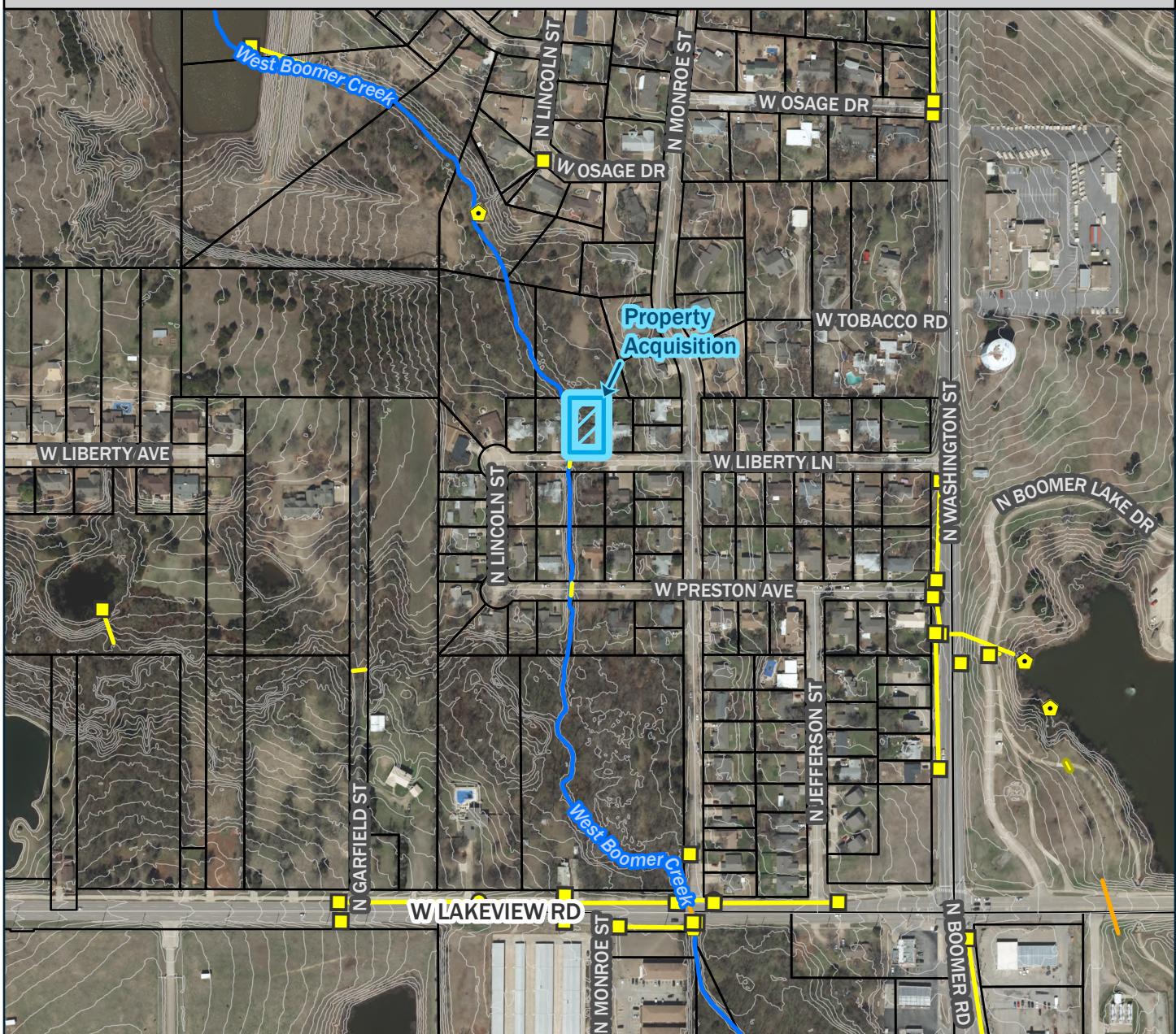
#### Problem Area 07 Evaluated Alternative – Pond Outlet Structure Design

Hazen Lake (Site 28) NRCS reservoir outlet structure is to be modified to reduce outflow to the downstream problem area. This option was analyzed due to the significant amount of floodplain storage available in Hazen Lake before the spillway would be utilized in the existing conditions 0.2% annual chance flood. However, after considerable analysis and hydrologic calculations the reduced flow would only amount to approximately 22 cfs which is not enough to reduce the impact on the inundated roadways and properties. The local drainage area is the primary contributor to the flows impacting the problem area. Since adequate flow reduction could not be achieved this option is not feasible and additional details were not developed for this evaluated alternative.

# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

## Problem Area #07: Residential and Roadway Flooding along W. Liberty Avenue

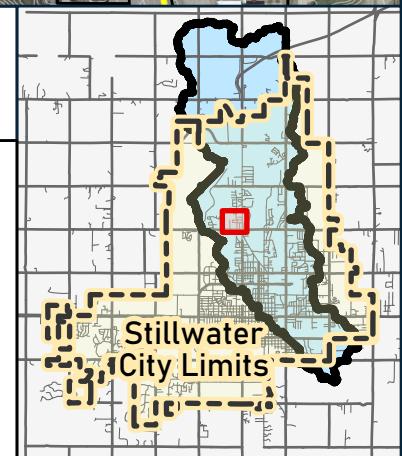


## Problem Area 07 Recommendation – Relocation and Acquisition

### Property Acquisition

Cost: \$205,000

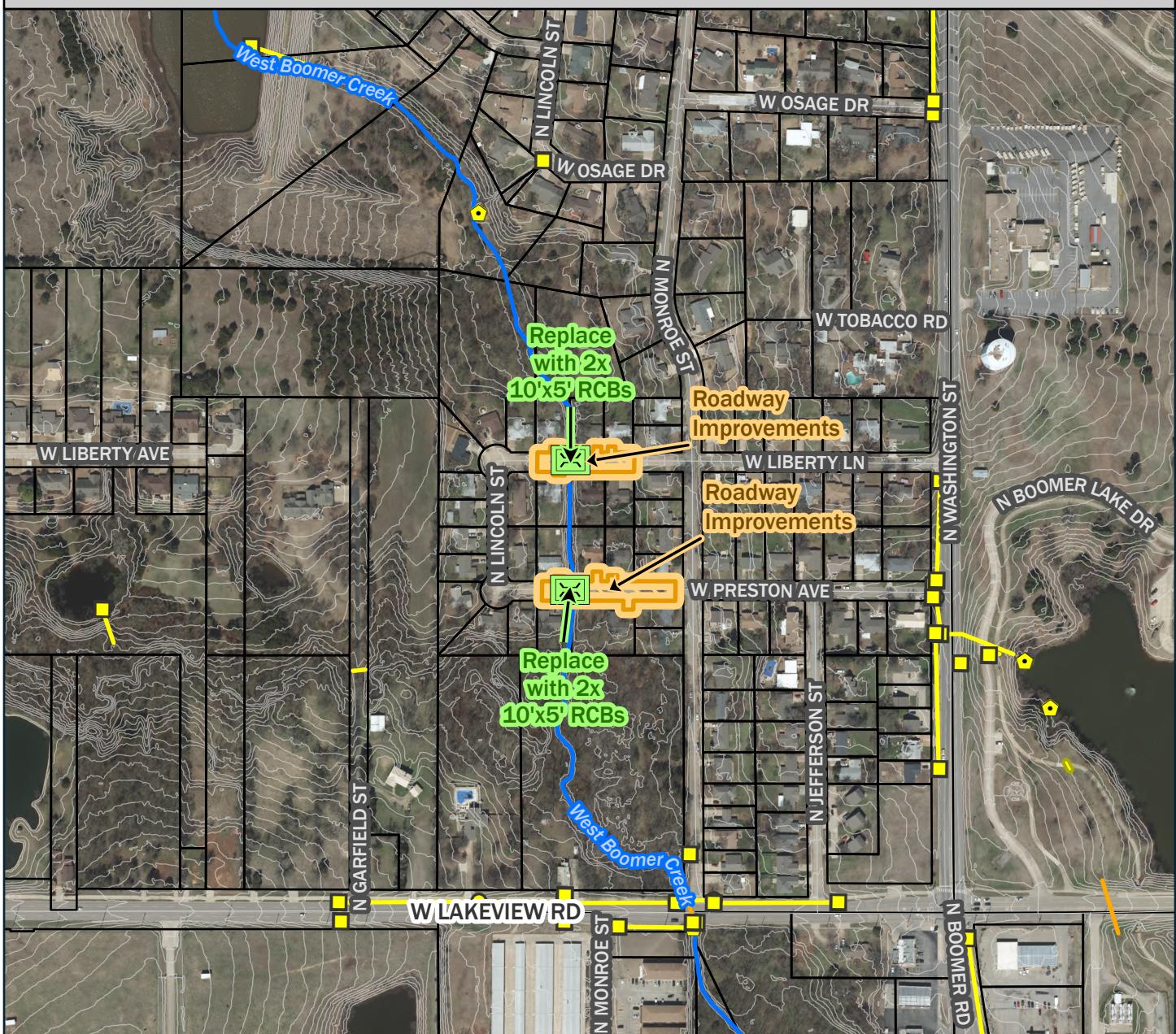
Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

## Problem Area #07: Residential and Roadway Flooding along W. Liberty Avenue

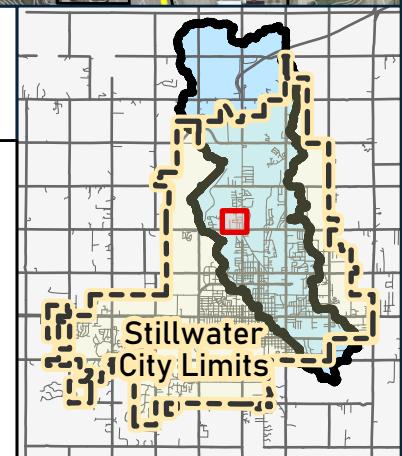


### Problem Area 07 Alternative 1 – Roadway Design

#### Roadway Design and Replace Culverts

Cost: \$981,000

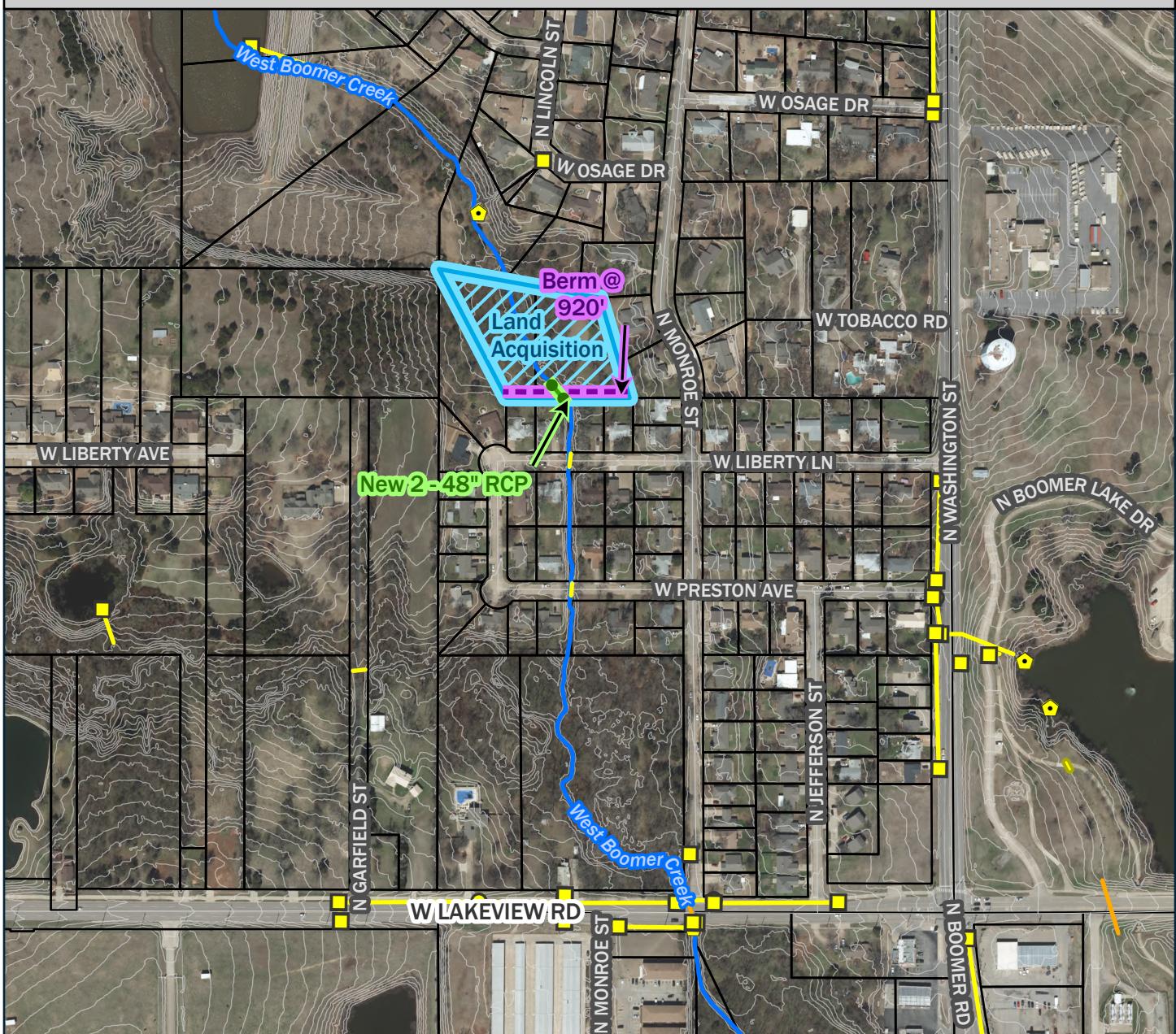
Proposed Project Locations	Proposed Project Locations	Existing Storm Sewer
Culvert Improvements	Detention	Storm Inlet
Storm Sewer Improvement	Acquisition/Relocation	Storm Manhole
Channel Improvements	Floodproofing	Storm Outlet
Berm/Dam Improvements	Roadway Improvements	Storm Sewer RCP
Other Improvement	Other Improvement	Storm Sewer RCB
		Storm Sewer Other



# West Boomer Creek Problem Area Alternatives

0 200 400 US Feet

## Problem Area #07: Residential and Roadway Flooding along W. Liberty Avenue



### Problem Area 07 Alternative – Pond Outlet Structure Design

#### Modify Outflow Structure

Cost: \$1,416,000

#### Proposed Project Locations

- Culvert Improvements
- Storm Sewer Improvement
- Channel Improvements
- Berm/Dam Improvements
- Other Improvement

#### Proposed Project Locations

- Detention
- Acquisition/Relocation
- Floodproofing
- Roadway Improvements
- Other Improvement

#### Existing Storm Sewer

- Storm Inlet
- Storm Manhole
- Storm Outlet
- Storm Sewer RCP
- Storm Sewer RCB
- Storm Sewer Other

