



STORMWATER MASTERPLAN 2021 UPDATE

Prepared for:
Joplin, Missouri

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1. INTRODUCTION

The City of Joplin, Missouri, is located in the southwestern corner of Missouri approximately three miles east of the Missouri-Oklahoma state line on Interstate 44. The city is split between Jasper County and Newton County with approximately three-fourths of the city limits located within Jasper County, which is loosely identified as the section of the city north of 32nd Street. The City of Joplin includes approximately 40 square miles within the city limits and has a population of 50,150, according to the 2010 census (U.S. Census Bureau 2012). The daytime population of the City of Joplin has been estimated to be as high as 240,000 because many people commute to the City of Joplin from outside of the city limits for school or work.

Figure 1 provides a map of the City of Joplin's city limits and stormwater drainage divides. Stormwater runoff from the City of Joplin naturally flows to Turkey Creek to the north, Shoal Creek to the south, and Short Creek to the west. Each of these three streams flow west into the Spring River. The majority of runoff from within the City of Joplin's city limits drains north toward Turkey Creek. The north-south drainage divide between the Turkey Creek basin and the Shoal Creek basin is generally located between 20th Street and 32nd Street, which is also near the county line. Runoff from the south side of the City of Joplin drains toward Shoal Creek while only a small portion of the city located west of Maiden Lane and between Seventh Street and 26th Street has runoff that flows west to Short Creek. A small area in the southwestern portion of the City of Joplin's city limits that is included in this study collects runoff that drains to Fivemile Creek.

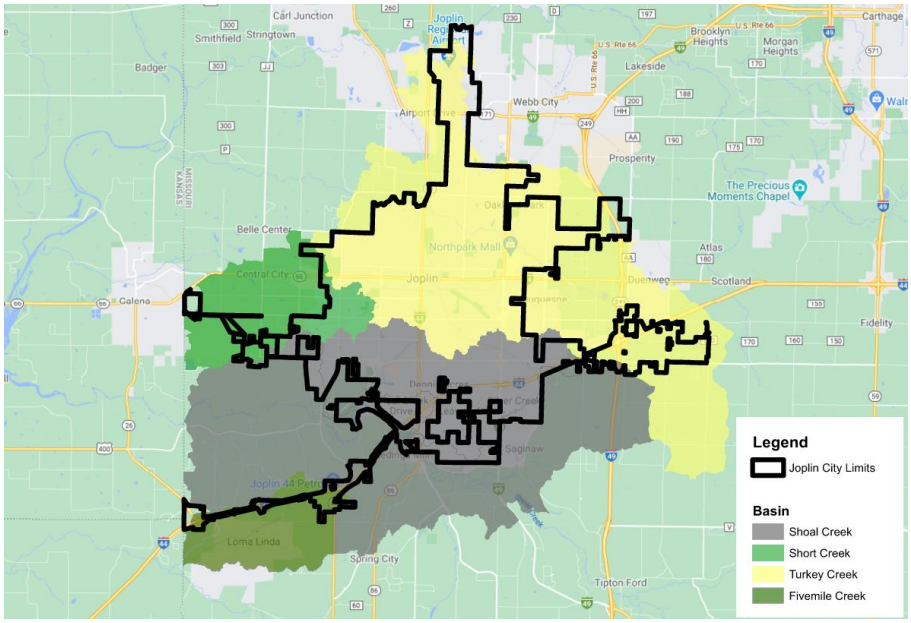


Figure 1. The City of Joplin's city limits and drainage divide.

In 1998, the City of Joplin established its first stormwater master plan (Burns & McDonnell 1998). This document was created before the city had a dedicated funding source for stormwater improvements. This master plan included an evaluation of watershed runoff potential, identification of stormwater improvement projects, recommendations for stormwater operations and maintenance, and an explanation of funding mechanisms to fund the proposed stormwater projects. A few years later in 2001, the City of Joplin passed a one-quarter-cent parks and stormwater sales tax to fund the stormwater improvements projects identified in the master plan. The sales tax would require renewal after 10 years. In 2008, an update to the stormwater master plan was completed (Allgeier, Martin, and Associates Inc. 2009), and it identified a new list of stormwater improvements, which were funded by a 10-year extension of the parks and stormwater sales tax.

In 2020, the City of Joplin hired Olsson to update its stormwater master plan (Burns & McDonnell 1998) in advance of the fall 2021 ballot proposal to renew the parks and stormwater sales tax. This master plan update that was partially funded by a stormwater grant through the Missouri Department of Natural Resources (DNR) was needed to do the following:

1. Evaluate and sort public feedback of stormwater problem areas.
2. Identify solutions to stormwater issues that are effective and well-coordinated with other upcoming projects in the city.
3. Prioritize stormwater projects based on a scoring that considers their benefit to flood reductions and water quality, total project cost, recreational benefit, and economic development opportunities.
4. Evaluate and update stormwater operations and maintenance plans.
5. Expand watershed models to better understand how runoff from the City of Joplin affects areas southwest of the city limits.
6. Evaluate principal streams for stability and identify erosion threats to existing infrastructure.
7. Expand the geospatial storm sewer inventory to better manage and more easily evaluate the city's storm sewer network.
8. Provide clear expectations to the public for what improvements will be included in the upcoming 2021 renewal for the parks and stormwater sales tax.

The stormwater complaints received through public engagement are diverse and include stream and yard erosion, street flooding, building flooding, aging infrastructure in disrepair, and safety issues. Many residential subdivisions were constructed prior to the city's current stormwater requirements and without underground storm sewer systems. Events like the abnormally high rainfall in April 2017 resulted in ponding up to several feet deep in some locations. In other cases, infrastructure that is working well to control flood events is now nearing the end of its lifespan. The Old Willow Branch box culvert system was constructed in the 1930s to address

frequent flooding to the downtown area (Caldwell 2018). Even after this culvert was constructed, downtown experienced severe flooding including the flood of record in 1943, shown in Figure 2, which took seven days to recede from city streets (Caldwell 2017). It was not until the parks and stormwater sales tax passed in 2001 that the Old Willow Branch capacity was finally improved by adding a parallel system that would provide 25-year capacity and meet city design standards. The parks and stormwater sales tax will continue to allow the City of Joplin to address flooding issues and prevent damage and economic losses. The sales tax may also be used to address aging infrastructure like the original Old Willow Branch box culvert that are now in need of repair or replacement. These examples provide a small sample of the stormwater issues that will be addressed with the projects in this master plan.



Figure 2. 1943 Flood at Main Street (Joplin Globe 1943).

2. SUMMARY OF SCOPE

2.1 Public Involvement Phase

City staff has maintained a list of stormwater concerns and problem areas across the city based on citizen complaints, operation staff feedback, and personal experience. During the public involvement phase of the project, stakeholders and citizens evaluated and prioritized this list of stormwater concerns and noted problem areas to add to the list. Public feedback was obtained through two avenues. First, questionnaires were sent to all citizens so they could provide input on the frequency, magnitude, and character of flooding issues occurring on their properties. Second, the city conducted three public meetings and invited citizens to attend and discuss their



Figure 3. City staff and Olsson staff meeting with public to discuss stormwater concerns.

stormwater concerns in person as seen in Figure 3. These two forms of public engagement allowed for all voices to be heard, even if some citizens were unable to attend the public meetings. This was especially important because the public engagement piece of this project took place during the height of the 2020 COVID-19 pandemic, when many people were less likely to attend a public gathering. All the information provided by the public was combined with the list maintained by city staff to create the definitive list of known stormwater problems.

2.2 Minor System Improvements

The complete list of stormwater problem areas identified through the public involvement phase includes projects of all sizes.

City crews can address many of the problems, such as replacing a single undersized or deteriorated pipe, adding erosion protection, grading ditches, clearing trees, and removing debris. Additionally, some projects require minimal engineering and may be assigned to a contractor; such projects may include replacing pipes or inlets in poor condition in-kind.

These projects typically only affect one or two properties and are considered minor system improvements. Minor system improvements are not disregarded in the stormwater master plan; however, because city crews and subcontractors can easily address these problems and because the city can allot resources at its discretion, no additional evaluation of these projects is currently required.

The prioritized project list for this stormwater master plan focuses on major system improvements.

2.3 Major System Improvements

One goal of the city's stormwater master plan is to identify and prioritize stormwater improvement projects for the city's Capital Improvement Plan. To achieve that goal, we evaluated the list of problems and concerns that were created in the public involvement phase. Next, we prioritized those issues and identified which were most important to complete as projects during the next 10-year funding cycle. Olsson performed a conceptual evaluation of the projects to identify likely solution concepts, probable construction costs, known utility conflicts,

right-of-way requirements, and permitting requirements. Concepts were evaluated using publicly available data for topography, utilities, and right-of-way to identify costs and major issues that might affect project schedule, feasibility, or effectiveness. Details of these projects are available for review in Appendix A.

2.4 Hydrologic and Hydraulic Evaluation of Southwest Joplin

Olsson's scope also included performing hydrologic evaluation of major and minor watersheds in an approximately 43-square-mile area to the southwest of the city limits. This evaluation will be used to identify major and minor drainage basins, peak runoff rates, and future (developed) condition peak runoff rates. It will also be used to identify the hydraulic conveyance capacity of existing culvert crossings. The previous master plan studies performed a similar evaluation within the city limits, but the city determined it would be beneficial to understand the character of drainage in this new area southwest of the city because stormwater from within the city limits drains into this new area. This evaluation will help the city understand the impacts of runoff from the city and will also help evaluate impacts from/to annexed land within this area.

2.5 Limited Geomorphic Assessment

A limited geomorphic assessment of principal streams within the city limits of the City of Joplin was performed to identify areas of stream erosion and instability that threatened infrastructure. The limited geomorphic assessment was based on review of historic and current aerial photography to identify stream movements over time. Exhibits showing the areas identified by the limited geomorphic assessment are located in Appendix B. Section 5 highlights some of the exposed utilities and threatened infrastructure that should be monitored and/or addressed.

2.6 Operations and System Maintenance Evaluation

A comprehensive stormwater master plan includes an evaluation of the city's operations and maintenance (O&M) plans for its existing stormwater infrastructure, such as open channels, detention basins, stormwater inlets, storm sewer pipes, and culverts. After that evaluation, O&M recommendations are made and are based on the amount of stormwater infrastructure that requires maintenance within the city.

2.7 Geographic Information System Storm Sewer Inventory

The city's existing geographic information system (GIS) storm sewer database is used by city staff and the public to quickly locate storm sewer information such as location, size, material, depth, and condition. The current system includes datasets from different sources, causing overlap, conflicting data, and various levels of accuracy. Additionally, some storm sewer networks are missing altogether from the current storm sewer datasets.

Where data was missing, approximately 2,200 structures were inspected in the field and added to the inventory. The existing storm sewer datasets were reviewed and combined by selecting the most accurate and complete datasets where datasets overlapped. All data is now consolidated into one dataset for storm sewer structures and one dataset for storm pipes.

3. HYDROLOGY AND HYDRAULICS

The evaluation process for stormwater projects starts with understanding the hydrology. In this case, hydrology refers to calculating the amount of stormwater that will run off into the drainage system during a storm event and the peak rate at which it runs off, measured in cubic feet of water per second (cfs). Peak runoff rates are calculated for several statistical events to quantify the likelihood that each event will occur in a given year. For example, 1 percent annual exceedance probability (AEP) has a 1 percent chance of occurring in a given year and is commonly referred to as having a 100-year return frequency. Once the relationship between peak flow rate and return frequency is understood for the project location, the evaluation process can look at the hydraulic capability of the drainage system to convey those flow rates and evaluate hydraulic improvements to meet city standards for the design capacity.

The hydrologic and hydraulic (H&H) evaluation for this master plan is divided into two parts. The first part is the evaluation of problem areas and potential major system improvements within the city limits. The second part is the watershed evaluation for the area to the southwest of the city limits.

3.1 Major System Improvements – Project Evaluation

The City of Joplin provided project summaries as the starting point for understanding each project. These summaries, based on citizen feedback, were collected and organized into projects for further evaluation. Each summary listed the location of the project, the number of affected properties, the type of flooding that was occurring, the frequency and magnitude of flooding when known, and the background information of the area. Projects were also identified from information gathered during public involvement meetings, including answers from questionnaires and conversations held with citizens. From this point, Olsson evaluated each project using aerial maps, street view images, pictures from citizens, lidar data, and GIS utility information. When more information was needed, Olsson also visited sites to walk the location, measure culvert sizes and invert depths, and build a greater breadth of understanding of the reported concern.

Focus was directed on the 26 projects that required engineering analysis and detailed cost estimates. These projects' locations are shown in Figure 4. Smaller projects that could be completed by city staff or that may be replace-in-kind projects, requiring little analysis, were

removed from further consideration. Olsson then analyzed the top 26 projects by identifying existing conditions and developing conceptual solutions. The conceptual analysis for each project looked at the most reasonable alternative based on desktop review. The ultimate solutions will change to some extent during final design after collecting boundary surveys, topographic surveys, utility locates, and completing a more detailed evaluation of solutions and conflicts.

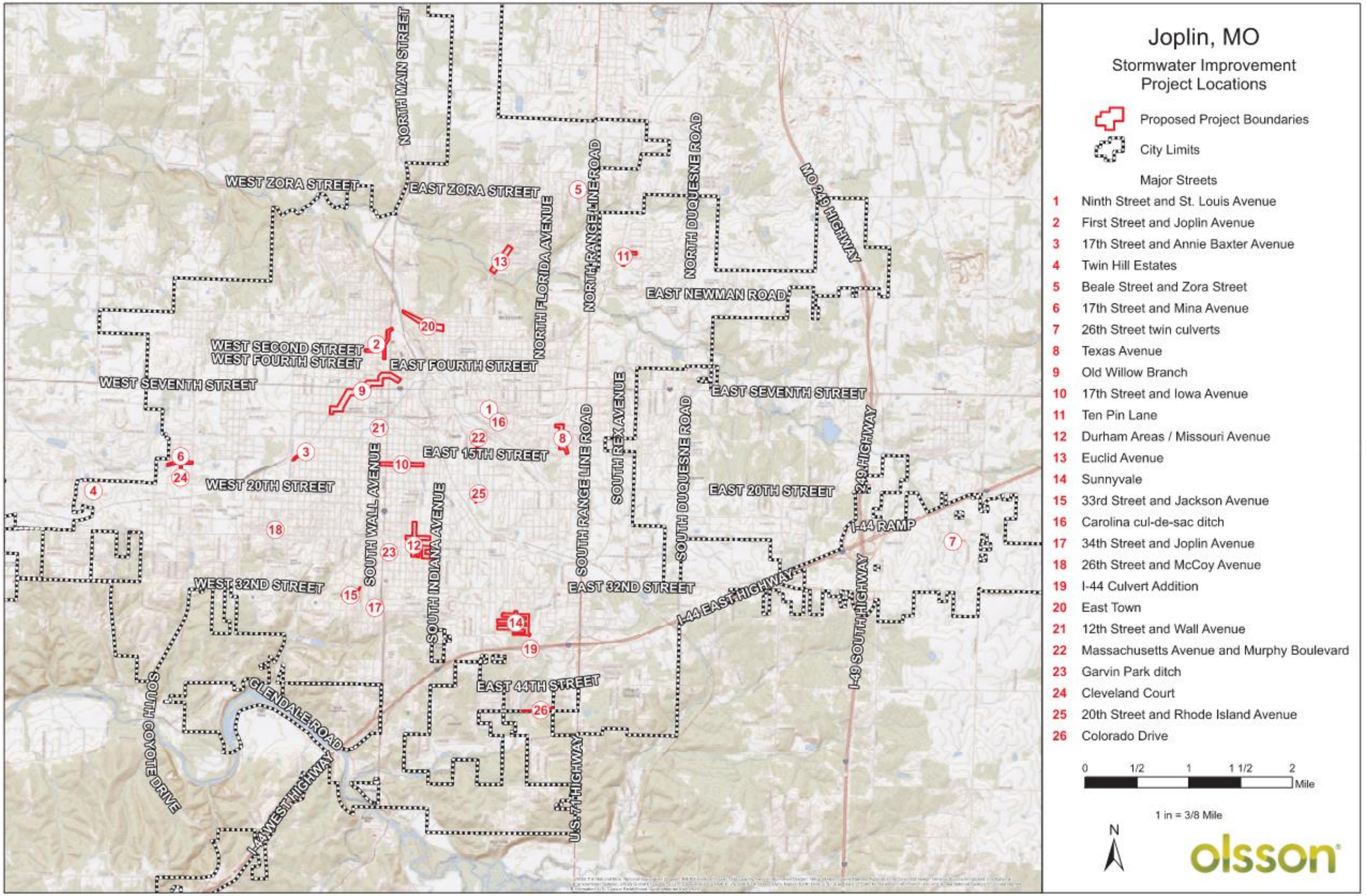


Figure 4. Major System Improvement Project locations.

The finalized list of improvement projects – such as those for storm sewers, open channels, and culvert crossings – were then designed to meet guidelines from the city's stormwater management criteria. This meant most storm sewers, open channels, and culvert crossings were designed to convey the 10-year storm event, which is the storm event that has a 10 percent chance of occurring in any single year. Overflow systems – such as street gutters and above ground swales – in combination with enclosed storm sewers and open channels, were sized to convey the 100-year storm event, which is the storm event that has a 1 percent chance of occurring in any single year. Open channels were sized so that when a 100-year flood occurs, water remains at least 1 foot below building elevations. Lidar information was used to estimate building elevations.

Multiple alternatives were considered for many of the projects. One preferred alternative was selected for each project by weighting effectiveness, estimated project cost, permitting requirements, utility relocations, aesthetics, and impacts to the surrounding properties. In a few of the projects, only one solution was evident.

Hydrology and hydraulic calculations used methods recommended by the City of Joplin's Stormwater Management Criteria (Allgeier, Martin, and Associates Inc. 2018). Additional information on technical methods used for evaluation are included in Appendix E.

3.2 Southwest Joplin – Watershed Evaluation

Understanding natural drainage patterns and the potential for stormwater runoff is helpful in quickly assessing flood risks and evaluating drainage improvements. Olsson was tasked with performing hydrologic modeling of watersheds and subwatersheds in an approximately 43-square-mile area to the southwest of the city limits and modeling culvert hydraulics for select culverts in the area. Part of this task was identifying the boundaries of the watersheds and subwatersheds, which was done by grouping hydrologically similar areas. The subwatershed sizes can be adjusted based on the amount of detail desired. The target size for the subwatersheds was 100 acres on average, with a range typically between 40 to 200 acres. This subwatershed size compares well with the previous subwatershed delineations performed within the City of Joplin's city limits. Culvert identification and evaluation focused on culverts that are 36 inches or greater in height, greater than 100 acres in drainage area, and located outside of the Federal Emergency Management Area (FEMA) floodplain. The results of the watershed hydrology modeling were delivered as a digital model, spatial GIS files of watersheds and culverts containing modeling results, and watershed maps. Stream centerlines, existing detention basins, and culvert locations were also traced manually based on 2020 aerial imagery and elevation data.

Hydrologic modeling is used to calculate peak runoff rates for each subwatershed. Modeling was completed using U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System

(HEC-HMS) version 4.6.1. A model was developed for existing conditions within the watershed and for future conditions, which accounts for an average of 50 percent impervious cover in future development. The results from this model were used in the hydraulic evaluation of culverts but may also be used by city staff and engineers to quickly identify runoff rates throughout the study area. The processes for identifying each of the model input values are discussed in detail in Appendix E.

3.2.1 Watersheds/Subwatersheds

Olsson identified 229 subwatersheds and 13 watersheds. Following the naming convention from the previous stormwater master plan (Burns & McDonnell 1998), each subwatershed was given a five-digit identification number. The first two numbers indicate which watershed it is part of, and the last three numbers indicate the location within the watershed. Generally, the final three digits increase by five, moving downstream to upstream within the watershed. Please see the watershed exhibits located in Appendix B for subwatershed and culvert locations and numbering.

There were two cases where the entire upstream contributing drainage area of a watershed was not modeled as part of this study. In the first case, the portion of the Short Creek watershed located within city limits is already delineated within the previous masterplan update (Burns & McDonnell 1998). The runoff results at the city limits were added into Olsson's hydrology model so peak flow rates are consistent with FEMA modeling (2012). The second case is Shoal Creek. The Shoal Creek watershed is approximately 400 square miles at the limits of our study area. The hydrology for Shoal Creek has been previously studied in the Newton County Flood Insurance Study (FIS) so there was no need to duplicate this analysis (FEMA 2010). However, subwatersheds within our study limits that drain to Shoal Creek are evaluated. Peak flow rates are calculated for drainage up to, but not including, Shoal Creek. For cumulative peak flow rates at Shoal Creek, the values from the Newton County FIS should be referenced. Further modeling is required for areas pertaining to Shoal Creek. Final watershed delineations are shown in Figure 5. For more detailed maps, refer to Appendix B. Hydrology results for each watershed can be found in Appendix C.

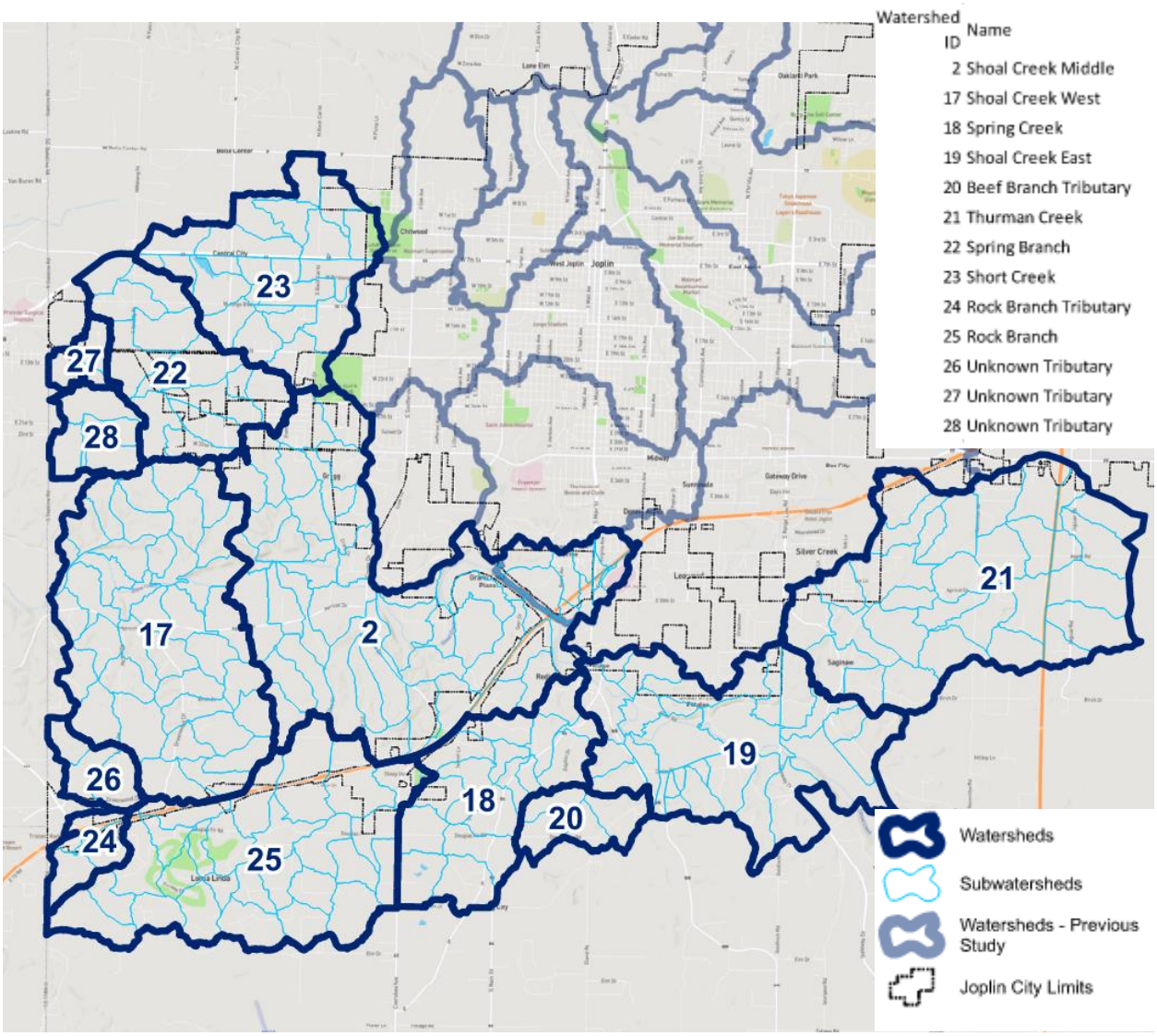


Figure 5. Major and minor watersheds for the study area southwest of the City of Joplin.

3.2.2 Culvert Analysis

The goal of culvert analysis is to provide a framework to understand whether a culvert is adequately sized to handle flood flows. Many times, the roadway profile for a stream crossing affects the design capacity of the culvert as much as the culvert size. For example, roadway geometry might require a higher embankment than the culvert design would require, resulting in additional conveyance capacity prior to water overtopping the road. Alternately, the roadway may be naturally low, and a larger culvert will not improve hydraulics because the overtopping point is too low relative to the water elevation, even without the culvert restriction. The culvert evaluation in this master plan identifies the frequency of roadway overtopping for each culvert,

which is the result of several factors including the hydrology, the culvert size, and the roadway profile.

Olsson compiled a list of culvert locations to evaluate. Culverts in the floodplain were not included because they are likely modeled in the county's FIS. Driveway culverts and culverts under 36 inches in diameter were also excluded to focus on larger drainage crossings. After culvert locations were identified, Olsson's survey group went into the field to verify and record data necessary to develop a hydraulic model for each culvert. Each culvert was numbered based on which subwatershed it was in; if there was more than one culvert in a given subwatershed, they were numbered downstream to upstream (i.e., subwatershed 24005 includes culverts 24005-01, 24005-02, and 24005-03). These results are available in tabular form in Appendix C and images of the culverts can be found in Appendix D.

3.2.3 Summary of Existing Hydrology by Major Watershed

A map of the 13 watersheds identified is shown in Figure 5. The Shoal Creek watershed within the study area is divided into three major watersheds to maintain a consistent size among major watersheds. Spring Creek, Thurman Creek, Spring Branch, Short Creek, and Rock Branch were each defined by one major watershed boundary. Five other watersheds were partially in the project area and partially out of the area and the portions of the watersheds in the project were studied but their sections located outside of the project area were not studied because they are beyond the scope of the project. Major watershed locations are shown in Figure 5.

3.2.3.1 Shoal Creek

The Shoal Creek area was divided into three watersheds (watersheds 2, 17, and 19) to keep a reasonable watershed size for study purposes. This approach is consistent with how large, major watersheds were divided within the city limits in the previous master plan update. Because approximately 400 square miles of drainage southeast of the City of Joplin contributes to Shoal Creek at the boundary of the study area and this watershed has been analyzed previously in the Newton County FIS, no additional evaluation of cumulative peak flows along Shoal Creek are included in this master plan. Shoal Creek has a wide, flat, floodplain that bounds the southern portion of the City of Joplin's city limits flowing from east to west. Bridge crossings are located at major arterial roads including Range Line Road, Main Street, Interstate 44, and Schifferdecker Road. Outside of the wide floodplain, slopes are generally steep, and the primary land use is wooded with some residential development. Future development potential and potential for increases in runoff in Shoal Creek watersheds are limited by steep slopes and floodplain.

3.2.3.2 Spring Creek

Spring Creek (Watershed 18) covers approximately 2.88 square miles and is located south of Interstate 44 and Highway C. The main tributary is Spring Creek, which flows northeast to Shoal

Creek. The land slopes in this watershed are moderately steep, ranging from 4 to 14 percent. Roughly 75 percent of the soils in the area are hydrologic soil group (HSG) B. Existing woods and type B soils result in low runoff potential across this watershed. There is minimal industrial and residential development throughout the watershed. Most of the undeveloped areas in the watershed show low potential for further development because of moderate slopes and dense forest. However, there is good development potential at the upper edge of the watershed adjacent to State Highway 43 and that development could result in future runoff increases.

3.2.3.3 Thurman Creek

Thurman Creek (Watershed 21) covers approximately 6.61 square miles and is located southeast of the City of Joplin between Interstate 44 and Interstate 49. The main tributary is Thurman Creek, which flows southwest through the watershed and discharges into Shoal Creek. The land slopes are moderately steep, ranging from 3 to 13 percent with flatter slopes occurring in the northeastern portion of the watershed. In this watershed, roughly 90 percent of the soils are in HSG D, which contributes to a high runoff potential. There is moderate development in the area, almost all of which is residential. Additional residential development is likely in the northern and eastern portions of the watershed resulting in increases in future runoff potential.

3.2.3.4 Spring Branch

Spring Branch (Watershed 22) covers approximately 2.62 square miles and is located west of the City of Joplin along the railroad tracks. The main tributary is Spring Branch, which flows northwest and releases into Short Creek. The area is very flat with land slopes ranging from 1 to 4 percent and nearly 90 percent of the soils in this watershed are in HSG A or HSG B, resulting in very low peak flow rates. Approximately 25 percent of the land is developed, and most of the development is residential. This area indicates a high potential for further development because of the flat terrain and proximity to infrastructure and because most of the land use is pasture/hay. Future development may contain residential, commercial, and industrial uses resulting in increases to future peak runoff.

3.2.3.5 Short Creek

Short Creek (Watershed 23) covers approximately 3.44 square miles and is located directly west of the City of Joplin. The main tributary is Short Creek, which flows northwest through the watershed. In this watershed, a portion of the flows come directly from the City of Joplin. Approximately 1.78 square miles of the upstream end of the watershed is located within the city limits and was previously delineated as County Club (Watershed 8) in the 2009 supplemental stormwater masterplan (Allgeier, Martin, and Associates Inc. 2009). The land in the Short Creek watershed is very flat with land slopes generally ranging from 1 to 4 percent. Half of the soils in this area are in HSG A or HSG B, and the other half are in HSG D. Peak flow rates in this watershed are low because of the significant amount of HSG A and HSG B soils. Roughly 50

percent of the land in this watershed is developed, with an equal amount of residential and industrial development. The undeveloped land in this area indicates a high potential for further development because of the low slopes, proximity to infrastructure, and undeveloped land use that is mostly pasture/hay. Future runoff potential is expected to increase with resulting development.

3.2.3.6 Rock Branch

Rock Branch (Watershed 25) covers approximately 5.56 square miles and is located southwest of the City of Joplin, directly south of Interstate 44. The main tributary in this watershed is Rock Branch, which flows southwest into Fivemile Creek. Most of the watershed's land slopes range from 4 to 16 percent. Land in the northeast is flatter than land in the southwest. Roughly 75 percent of the soils in this watershed are in HSG D, which contributes to a high runoff potential. The watershed is mostly developed; development is equally split among residential, commercial, and recreational uses. A golf course located in the middle of the watershed along Rock Branch has led to modifications to the channel. Several ponds have been created along the channel, and water has been redirected through culverts. Undeveloped areas in this watershed have limited potential for development because of woods and moderate slopes. However, there is good development potential at the upper edge of the watershed adjacent to State Highway 43 that could result in future runoff increases.

3.2.3.7 Partial Watersheds

Watersheds 20, 24, 26, 27, and 28 are considered partial watersheds because only small pieces of these watersheds are located within the study area. These watersheds are located on the outer boundary of the study area and naturally drain away from the study area. Peak flow rates are calculated at the boundary location of the study and are available in Appendix C.

4. RECOMMENDED SYSTEM IMPROVEMENTS

After completing the necessary hydrology and hydraulics work on the 26 projects that required further evaluation, Olsson ranked the projects using its project prioritization scoring, which provides a score based on the benefits provided by the project and on the benefit-to-cost ratio. The "other factors" category notes additional project benefits outside of flood control and additional funding sources. A higher score means the project will have a greater flood reduction benefit and a higher benefit-to-cost ratio. When these other factors are present, the benefit-to-cost ratio will be even higher than the stormwater benefit-to-cost ratio alone. The purpose of ranking projects is to give the City of Joplin a quantifiable and objective process in prioritizing projects based on the benefits they provide to maximize the value of the city's stormwater funds. Olsson's prioritization scoring is a tool to help the city understand a project's anticipated stormwater benefit and is not a comprehensive view of political, economic, opportunistic, and

other factors that may otherwise affect which projects are implemented first. It is important that city staff perform an independent ranking of projects that considers these factors and combine the lists to identify the most important projects based on all known factors.

4.1 Prioritization Methodology

The project prioritization scoring assigns points to seven different category factors. The points for each category factor were multiplied by frequency and severity multipliers for the total possible benefit. The total possible benefit is then multiplied by the percentage of the problem that is anticipated to be solved by the proposed conceptual solution. For example, if 50 percent of flooding homes can be protected, only 50 percent of the total possible benefit points are earned. The total points from the factors were then added up to provide the project's total benefit points. In the event of a tie, the "other factors" section was used to break the tie.

The seven category factors were (1) loss of life; (2) property flooding; (3) street flooding; (4) structure and property erosion; (5) erosion causing failure to drainage structures; (6) system condition; and (7) recreation benefit. Available rating points for each category varied to reflect the effect on the community. Loss of life received the most potential points. Flooding of habitable buildings received the same points as arterial street flooding. Street flooding was given more points compared to yard flooding to reflect the broad impact to the community. Table 1 shows Olsson's project benefit rating table that was used to score each project.

Table 1. Example project benefit rating table (Blank).

Categories	Factor #	**Description of Problems Addressed by Project**	**Eliminates Factor**	**Rating Points**	**Frequency Multiplier**	**Severity Multiplier**	**% Resolved by Project***	**Total Points**
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable buildings	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of more than 7 inches of arterial street	3b,3c,3d	30				
	3b	Flooding of more than 7 inches of collector street	3a,3c,3d	25				
	3c	Flooding of more than 7 inches of residential street	3a,3b,3d	20				

	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "poor"	6b	10				
	6b	System condition rated "fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						
* % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements								

Frequency multipliers were used to capture the significance of repetitive flooding losses. Frequency multipliers only applied to property flooding, street flooding, and system condition. To determine the frequency multiplier for flooding, it is necessary to know the return period of the storm event or the number of times it has flooded in 10 years. The more frequent or likely to flood, the higher the multiplier. The system condition frequency multiplier applies a multiplier value of one per 100 feet of storm sewer or channel replaced to account for the expanded risk associated with a large system that is in poor condition. The system condition frequency multiplier led to high system condition scores for large infrastructure replacement projects such as Old Willow Branch and First Street and Joplin Avenue. These high scores reflect the need for these projects in terms of the impact that a failure would have to storm drainage and nearby infrastructure. Table 2 shows the frequency multipliers for different category factors.

Table 2. Frequency multipliers for project prioritization scoring.

Applies to Category Factor No.	Frequency Multiplier	Multiplier Value
2-3	One time in 10 years (10- to 100-year design storm)	1
2-3	Two times in 10 years (5- to 10-year design storm)	2
2-3	Three or more times in 10 years (less than 5-year design)	3
6	One multiplier point per 100 feet of system replaced	1

Severity multipliers were used to reflect the magnitude of the flooding problems by applying a multiplier for the number of structures flooding, the depth of street flooding, and the risk associated with the system failure. The largest multiplier was applied to the loss of life category. Property flooding received a 0.5 multiplier per building flooded. Street flooding received multipliers based on either depth of street flooding or restrictions to emergency vehicles. Street flooding depths of more than 3 feet received the maximum street flooding multiplier of three. Erosion threatening habitable buildings, utilities, streets, and bridges received multipliers from one to three. Imminent failure of structures received the maximum erosion multiplier of three. Erosion causing failure to drainage structures received severity multipliers from one to four. The greater the multiplier means the more properties flood from the failure of the drainage structure. Table 3 shows the severity multiples for different category factors.

Table 3. Severity multipliers for project prioritization scoring.

Applies to Category Factor No.	Severity Description	Multiplier Value
1	Number of known deaths. 1 for each death	8
2a, 2b	Number of buildings flooded historically or by 100-year design storm	0.5/building
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Street flooding of 1-3 feet	2
3a,3b,3c,3d	Street flooding of more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

The “percentage resolved by the project” multiplier is a measure of effectiveness of the project. Some projects may help with the stormwater issue but not completely resolve the problem. The percentage of credit given was based on the percentage of flood or erosion reduction achieved based on the number of structures removed or on the percentage of necessary base flood level reduction. If all structures are protected from flooding and the storm conveyance system meets the city’s design requirements outlined in the Stormwater Management Criteria (Allgeier, Martin, and Associates Inc. 2018), 100 percent of the issues are deemed to be solved by the project.

Finally, the “other factors” category was used for tie breakers between projects. The four other factors were (1) benefits to other infrastructure; (2) outside cost support; (3) regional benefit; and (4) aesthetics. Each project received a “yes” or “no” score for these factors.

4.2 Prioritization Scoring

A project prioritization score was calculated to rank the projects based on the stormwater benefit they provide and their benefit-to-cost ratios. Smaller projects that may not provide a large benefit to the community can still be important projects and are many times easier to complete. This scoring approach provides opportunities for projects both large and small to score well.

The total prioritization score consists of up to 50 points for the benefit score and up to 50 points for the benefit-to-cost-ratio score. Projects were ranked by their benefit score and then assigned zero to 50 points, based on their ranking. For example, the highest ranked project would receive 50 points, while the 26th ranked project would receive zero points.

A benefit-to-cost ratio was calculated using the stormwater benefit score discussed above and dividing by the total project cost. This ratio was then normalized so that the highest benefit-to-cost ratio was set to 100. As with the benefit score, projects were ranked in order of the benefit-to-cost ratios and then assigned up to 50 points, based on their ranking.

Points for benefits and benefit-to-cost ratios were added to calculate a total prioritization score. Finally, projects were ranked based on their total prioritization score.

4.3 Capital Improvement Project List

The capital improvement project list was developed using Olsson’s evaluation of major system improvement projects. The project list was prioritized based on the above approach which emphasized flood control benefits and the benefit-to-cost ratio for the project. In total, 26 projects were evaluated and prioritized. Some of these projects can address several concerns at once. The 26 capital improvement projects will address stormwater issues including building flooding, street flooding, erosion issues, and damaged infrastructure by constructing improvements that include the following:

- Constructing new storm sewer systems in five neighborhoods that currently do not have storm sewer or roadside ditches.
- Rehabilitation or replacement of four storm sewer systems that are nearing the end of their service life.
- Conveyance improvements at seven culvert crossing locations.
- Extending existing storm sewer systems to address flooding at five locations.
- Channel restoration or stabilization at six locations with erosion concerns.

- Conveyance improvements at seven open channel locations to resolve adjacent flooding complaints.
- Opportunities to coordinate with parks improvements and provide recreational and aesthetic improvements at four locations.

Identifying the existing issues, the proposed solutions, the estimated costs, and the calculated benefits for each of these projects is an important piece of this stormwater master plan. Detailed descriptions for each project containing this information are included in Appendix A.

4.4 Minor System Improvements

Minor system improvements are differentiated from major system improvements by the size of the project and the level of evaluation required to determine an acceptable solution. Minor systems improvements typically include solutions such as localized grading, adding an inlet, or installing channel lining to prevent further erosion. Although these issues are small in scale, it is still important to ensure they are addressed appropriately. A section of the stormwater program budget is dedicated to minor system improvements and many of these issues may be addressed by city maintenance crews. Project sheets provided by the city for minor system improvements are included in Appendix G.

4.5 Economic Development and Emergency Funds

Economic development and emergency funds are included in the stormwater program budget to cover unforeseen issues that have a high probability to occur in the coming 10-year cycle. Economic development refers to the opportunity to perform storm sewer improvements or flood reduction that will help facilitate development within the city limits and ultimately increase city revenues and contribute to the local economy. These opportunities are unknown at this time; however, flood reduction improvements are commonly used by other communities to incentivize developers. Emergency funds are used to cover emergency repairs that exceed typical maintenance. The city's stormwater infrastructure is extensive. Though proactive maintenance and replacement is performed to prevent failures, for a variety of different reasons, unforeseen failures may still occur and require immediate attention.

5. LIMITED GEOMORPHIC ASSESSMENT

To comply with funding requirements for this master plan, a limited geomorphic assessment of the principal streams within the city limits of Joplin, Missouri, was conducted. A summary of the methodology used and the findings of the limited geomorphic assessment are located in Appendix F.

The limited geomorphic assessment identified locations of channel instability. In some locations channel instability is threatening infrastructure such as utility lines or roadway culverts. Additional erosion during a severe storm event could result in this infrastructure being damaged or washing away. The following list summarizes the most critical issues that were identified during the limited geomorphic assessment. In most locations, these issues are small in scale and can typically be addressed with city crews. For this reason, potential stabilization measures associated with these issues at the various sites identified are not included in the major system improvements that are evaluated and ranked with this master plan. These items are important and should be monitored and addressed, as needed, using the ditch and detention maintenance funds or minor system improvement funds. The following summarizes some of the themes observed during this assessment along with common approaches to stabilization.

- Channel Degradation and Widening
    - Different approaches may be required based on the evolutionary stage of the channel that follows a cycle understood as the Channel Evolution Model (CEM).
    - Degradation, which is downward erosion of stream bottoms, will migrate upstream until it encounters something resistant to erosion. Degradation can be halted using strategically placed grade controlling structures, such as rock or concrete, that establish the stream elevation and resist downward erosion.
    - Widening can be addressed with bank protection measures such as armoring, grading, and vegetation, although degradation should also be addressed.
- Bank Erosion
    - Can be addressed with bank protection measures such as armoring, grading, and vegetation.
- Channel Migration
    - Can be addressed using bank protection such as armoring, grading, and vegetation and flow training structures such as riprap spurs that redistribute high velocities farther away from the bank.

For a complete summary of the findings of the limited geomorphic assessment, please see the geomorphic assessment figures located in Appendix B and the complete summary of the geomorphic assessment located in Appendix F.

6. OPERATION AND MAINTENANCE

Part of an effective stormwater system is a strong O&M plan. Maintenance can be divided into three different categories – routine, remedial, and capital improvements. Because capital improvement measures for the City of Joplin are discussed in Section 4.3, the focus of this section will be on how to fund routine and remedial maintenance. According to the Stormwater Management Manual, routine maintenance is defined as, "…activities that happen periodically, which may be driven by the passage of time, not the specific deterioration of the system (APWA 2020)." Remedial maintenance is defined as, "…correct[ing] specific deficiencies in [an] existing system without upgrading its capacity (APWA 2020)." Though time and defects are drivers of maintenance that indicate why an activity should be done, there are also prompts that inform communities when an activity should be initiated. These prompts are known as external input and internal goals. External input often refers to complaints a community may receive regarding a system failing or other issues; this prompt will trigger reactive maintenance. Internal goals will trigger proactive maintenance, which allows a community to continuously maintain and improve its system.

Some communities have very little budget allocated for stormwater maintenance and are consequently forced to be more reactionary with their maintenance approach. Alternatively, some communities have funding sources that allow them to be more proactive in their approach to maintenance. A proactive approach may include frequent inspection of existing systems and a planned replacement program for elements that are in poor condition. Using data from communities with a population of less than 100,000, Hirschman and Kosco (2008) provide a clear breakdown of typical maintenance program costs associated with different maintenance program approaches.

The City of Joplin currently performs routine and remedial maintenance implemented and funded through a hybrid approach. The city maintains enclosed storm sewer systems within right-of-way and some enclosed storm sewer systems and detention basins within easements. Open channels are often not located within drainage easements; however, the city does perform periodic maintenance such as debris removal to ensure they function properly. The annual budget for the O&M program is currently $550,000, including $300,000 for ditch and detention pond maintenance and $250,000 for storm sewer and catch basin maintenance; the operations staff consists of eight full-time employees. Stormwater O&M budgets are funded by the Parks and Stormwater Sales Tax. Comparing the City of Joplin's O&M budget to the typical ranges referenced in Table 4, the budget is appropriate for the hybrid maintenance approach.

Table 4. Three maintenance program approaches (Hirschman and Kosco 2008).

Typical Program Characteristics	Typical Annual Maintenance Program Budget Range[a]	Typical Funding Mechanisms
1. Private Maintenance		
▶ Property owners and homeowners associations responsible for maintenance ▶ Less costly for local program, but often is a neglected program element ▶ Legal and program tools needed to establish responsibility: ordinance, maintenance agreement, easements, and compliance tools ▶ Strong outreach and education needed for an effective program	$8,000 to $161,000[b]	General fund Plan review and inspection fees Maintenance bonds or escrow accounts
2. Local Program Maintenance		
▶ Local program responsible for most maintenance functions ▶ Owners may be responsible for routine tasks (mowing, picking up trash, aesthetics) ▶ Requires highest budget and staff commitment ▶ More common in cities and towns with established public works function and jurisdiction over roads and drainage	$161,000 to $2.4M[b]	Stormwater utility Other utility (e.g., sewer) rates Transportation maintenance funds General fund
3. Hybrid Approach: Blend of Public and Private Maintenance		
▶ Local government maintains facilities on public land and/or major private facilities within easements, while private parties are responsible for facilities within easements and on most private property ▶ Most common maintenance approach ▶ Can be cost-effective, but still requires local government budget and staffing	$80,000 to $482,000[b]	Stormwater utility Capital improvement program General fund

[a]Maintenance program budget figures were derived from research on local stormwater programs, primarily Phase II Municipal Separate Storm Sewer Systems (MS4s), conducted in 2005. Because most programs are still in the early stages of program development, these figures represent nominal costs associated with a maintenance program and do not include other costs, such as the cost of stormwater capital improvement projects. Costs will increase as program responsibilities and accountability increase. Typically, larger municipalities, such as Phase I communities, have much larger maintenance budgets.
[b]Ranges have been updated to reflect inflation from 2005 to 2021. An annual inflation value of 3 percent was used based on information from the Construction Cost Index in that time period.

The data provided in Table 4 is based on a national study from 2005, which took place as many cities were developing their maintenance approaches to meet federal Municipal Separate Storm Sewer System (MS4) requirements. Maintenance programs have continued to develop since this time and regional data may also show higher maintenance requirements because Missouri has a higher average annual precipitation than many states.

To provide a more regional comparison of systems similar to the City of Joplin's, Olsson performed research on nearby communities to understand the relationship between stormwater system size, maintenance approach, and O&M budget. Each community was asked to provide feedback on the metrics in Table 5. The results of the survey are summarized in Table 6. Olsson received responses from five out of 12 communities who were sent questionnaires.

Table 5. Survey for communities.

Metric	Data Requested
1	Total length of storm sewer in city.
2	Total number of storm sewer structures (inlets, junction boxes).
3	Total best practice management structures (BMPs) that the city maintains.
4	Number of operations staff responsible for storm sewer maintenance, preferably in terms of man-hours focusing on storm or full-time equivalents.
5	Total maintenance budget for storm sewer, open channel, and BMP maintenance. - Typical maintenance items include sediment/debris removal, vegetation removal, inspection, localized pipe/structure replacement, and the equipment/labor necessary to perform these tasks. - Please list any other significant costs which you include in the provided maintenance budget, beyond this list.

Table 6. Community responses.

	Community 1	***Community 2***	***Community 3***	***Community 4***	***Community 5***
Population[a]	*20,237*	*19,055*	*116,830*	*48,190*	*159,498*
Area (square miles)[a]	*12.8*	*8.5*	*77.6*	*34.1*	*81.7*
Metrics					
1	23	60	230	174	322
2	1,448	2,750	13,800	11,294	37,280
3	n/a	246	19	205	60
4	6	4	n/a	16	32
5	$270,200	$350,000	$747,000	$1,300,000	$2,126,000

[a]U.S. Census data from 2010 was used.

The responses were kept anonymous at the request of the communities. Each community performs routine and remedial maintenance implemented and funded through a hybrid approach. Community 4 represents a city with a very proactive approach to maintenance and that has a dedicated program for pipe inspection and replacement. The other communities provide a mix of proactive and reactive approaches. Because each community that participated in Olsson's request for stormwater maintenance data is unique, a perfect relationship between cost and system size should not be expected. However, using the questions as metrics, trends can still be identified that provide more information on stormwater O&M budgets and operations staffing in this region.

Olsson's approach to identifying trends focused on metrics that logically would affect the staffing and funding requirements for maintenance. The first and most obvious metric Olsson compared is the size of the storm sewer system. Communities use their GIS storm sewer networks to inventory storm sewer pipe and storm sewer structures, although in some cases the total size must be estimated because of missing data in the GIS inventory. Olsson evaluated O&M budget and staffing levels compared to total storm sewer length and total storm sewer structures. Length of open channels and total number of best management practices (BMPs) would also affect the total maintenance effort; however the respondents had difficulty identifying these metrics, so the data Olsson received was inconsistent. Comparing the size of the storm sewer system to the total maintenance budget and staffing levels, which include maintenance of open channels and BMPs, was considered acceptable for identifying trends. The second metric, city population, was compared to O&M budget and staffing level. This metric could help show population influences of tax revenue and development growth on the maintenance program. Finally, the total area of the city was compared to O&M budget and staffing. The size of the city intuitively would increase maintenance requirements. Focusing on the size of the city rather than the size of the storm sewer network accounts for open channel conveyance systems that require maintenance and are more common in older developments and areas that have not yet developed. Looking at trends in O&M budgets and staffing levels by using all three of these metrics will provide a thorough review of regional maintenance programs that will be used to identify recommended ranges for O&M budget and operations staffing.

Figures 6 through 13 show the relationship between the metrics discussed above and the O&M budget, and figures 14 through 17 compare those metrics to operations staffing. Linear relationships were identified to show how each metric affected the maintenance programs. Upper and lower 90 percent confidence limits are also shown to help identify recommended ranges for the maintenance program, which accounts for sample size and some uncertainty in the data. Table 7 shows the recommended stormwater budget based on each of these metrics. Table 8 shows the recommended stormwater operations staffing levels based on each of these metrics. Relationships for staffing levels show less consistency than budget relationships. Respondents acknowledged it is sometimes difficult to identify what portion of maintenance staff is specifically focused on stormwater maintenance. Often, maintenance staff members are responsible for streets, parks, stormwater facilities, buildings, and any other issues that arise. This unclear divide in staffing responsibilities is likely one cause for a weaker correlation in staffing data.

Recommendations for maintenance program size are consistent based on storm sewer length, city population, and city area; the total number of storm sewer structures resulted in lower trends. It is unclear why storm sewer structures data resulted in a lower projection than total storm sewer length because these metrics should provide an equal estimate of the total system

size. Because the total storm sewer length relationships matched well with the relationships for population and city area, these three metrics were used for the final recommendations and the relationship based on total storm sewer structures was discarded. Based on the review of regional storm sewer O&M programs, the City of Joplin's O&M budget is expected to be between $716,000 and $843,000 with a median value of $779,500, while the operations staff is expected to be between 12 and 15 employees with a median staff size of 13.5. The upper and lower confidence limits provide a range of how staffing and O&M budgets are expected to vary based on differences in maintenance approach, level of service, and specific circumstances. The City of Joplin's current O&M budget and operations staffing fall within the confidence limits but below the median values.

Table 7. Budget recommendations based on metrics.

Budget based on (x variable)	**Median**	**Lower Limit**	**Upper Limit**	**Median Equation**
Storm Sewer Length (miles)	$716,000	$248,000	$1,182,000	Budget=5562.34x+58653
Number of Structures	$500,000	$114,000	$885,000	Budget=50.28x+289252
Population	$740,000	$121,000	$1,358,000	Budget=9.70x+252952
City Area (square miles)	$843,000	$169,000	$1,516,000	Budget=15715.39x+283915

Table 8. Full-time employee (FTE) recommendations based on metrics.

FTE based on (x variable)	**Median**	**Lower Limit**	**Upper Limit**	**Median Equation**
Storm Sewer Length (miles)	12	7.5	16.5	FTE=0.093x+0.98
Number of Structures	7.5	3	12.5	FTE=0.00076x+4.52
Population	12.5	7	17.5	FTE=0.00019x+2.92
City Area (square miles)	15	13	17	FTE=0.38x+1.48

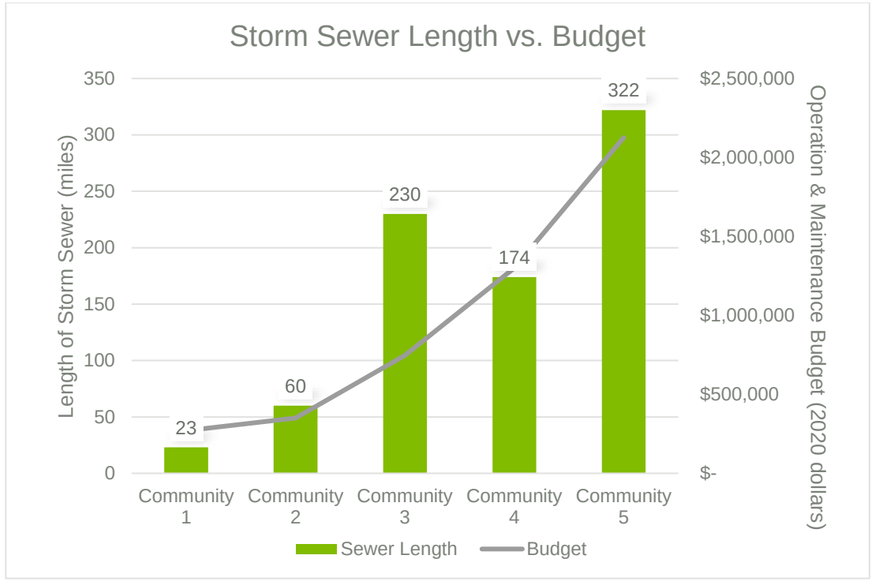


Figure 6. Relationship between storm sewer length and budget. Storm sewer length is plotted on the left axis and budget is plotted on the right axis.

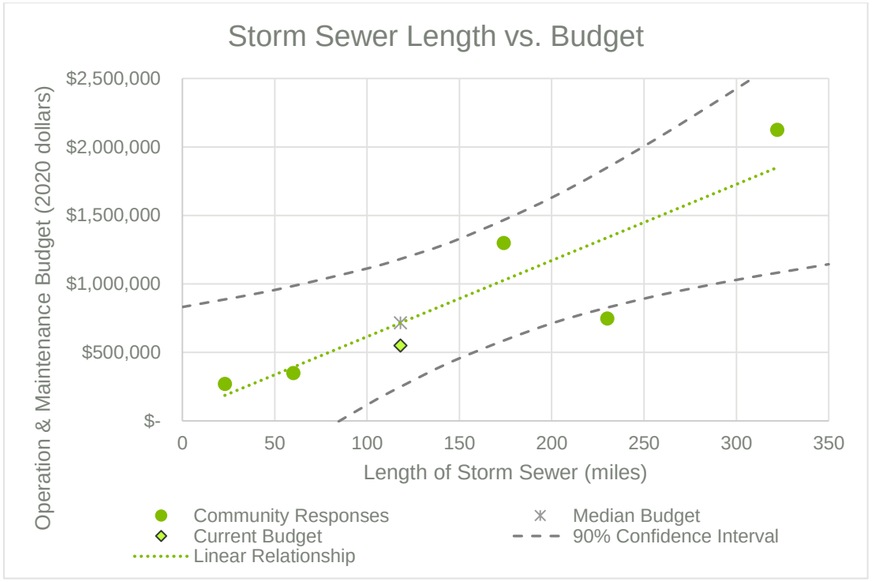


Figure 8. Median maintenance budget compared to the City of Joplin's current budget based on length of storm sewer in miles.

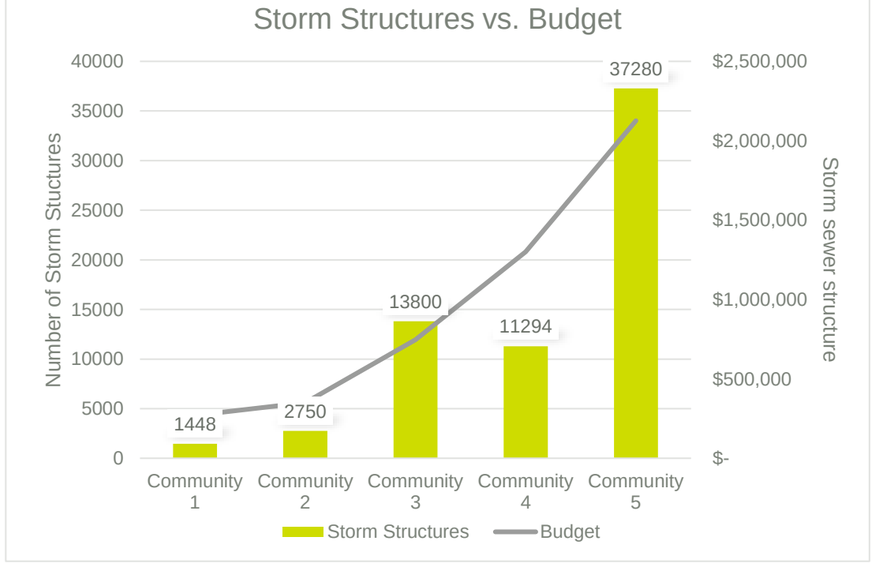


Figure 7. Relationship between number of storm sewer structures and budget. Number of storm sewer structures is plotted on the left axis and budget is plotted on the right axis.

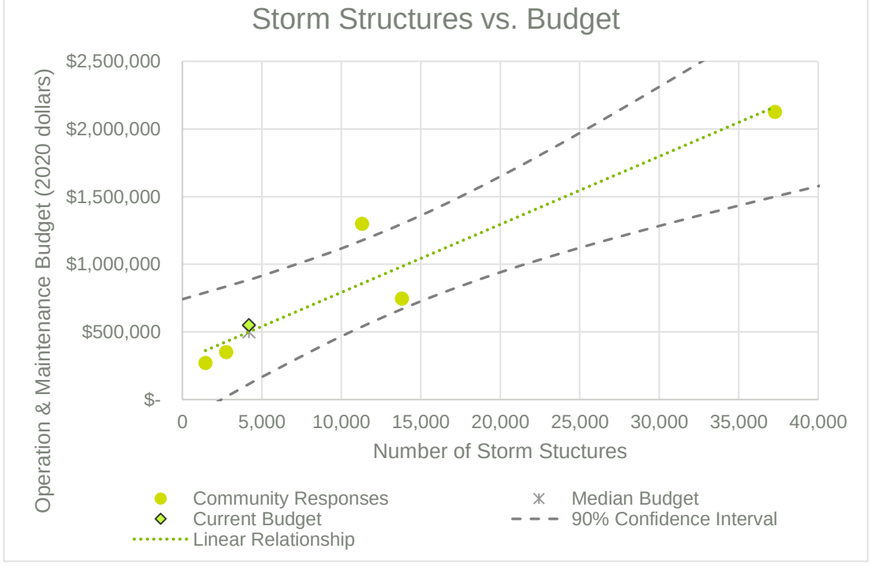


Figure 9. Median maintenance budget compared to the City of Joplin's current budget based on number of storm sewer structures.

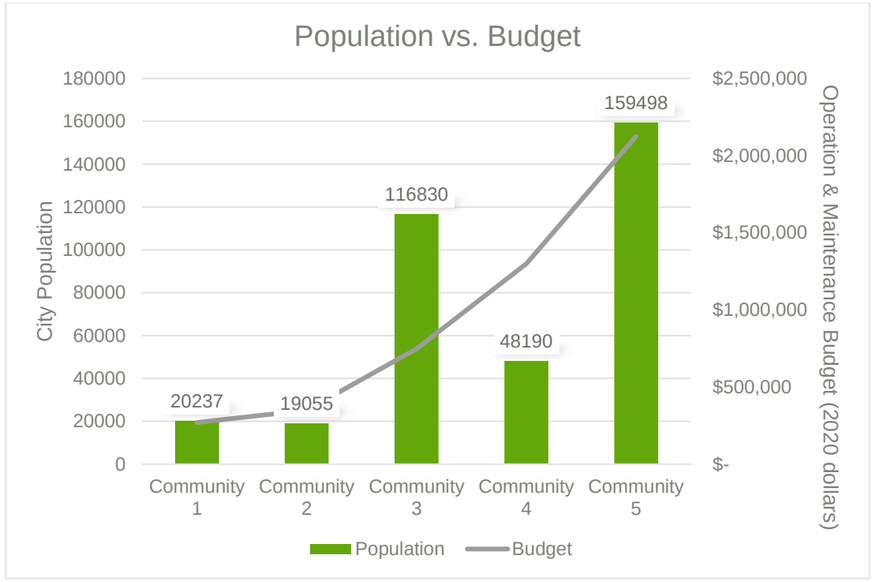


Figure 10. Relationship between population and budget. City of Joplin population is plotted on the left axis and budget is plotted on the right axis.

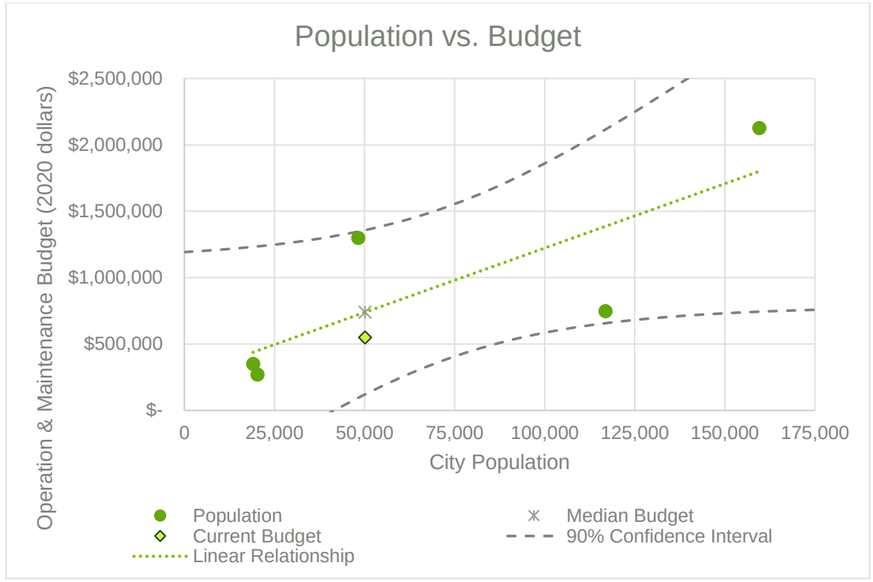


Figure 12. Median maintenance budget compared to the City of Joplin's current budget based on population.

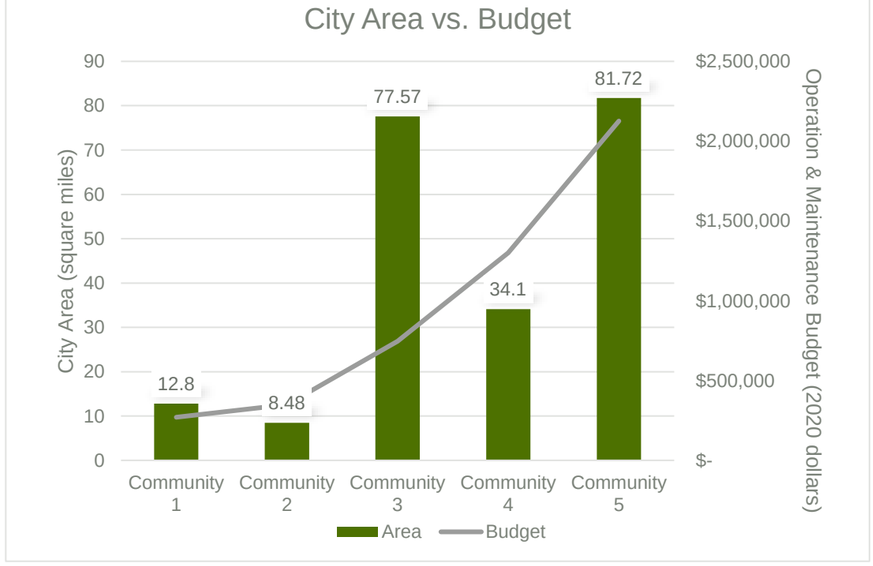


Figure 11. Relationship between area and budget. City of Joplin area is plotted on the left axis and budget is plotted on the right axis.

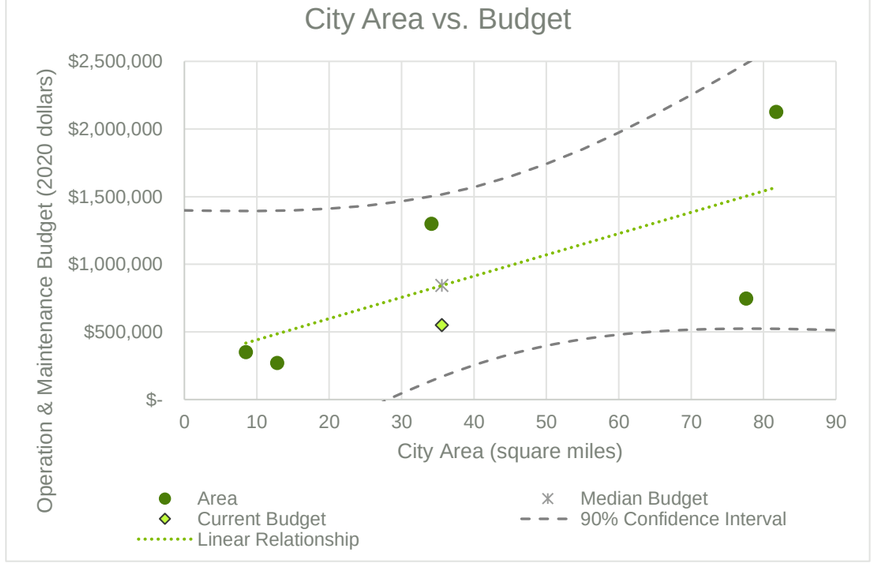


Figure 13. Median maintenance budget compared to the City of Joplin's current budget based on city area in square miles.

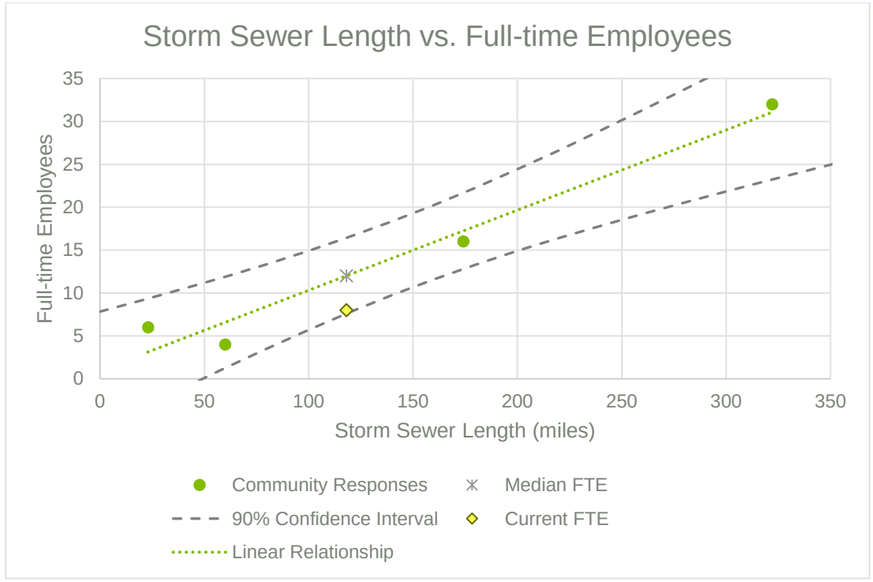


Figure 14. Median number of full-time employees (FTE) compared to the City of Joplin's current number of FTE based on storm sewer length in miles.

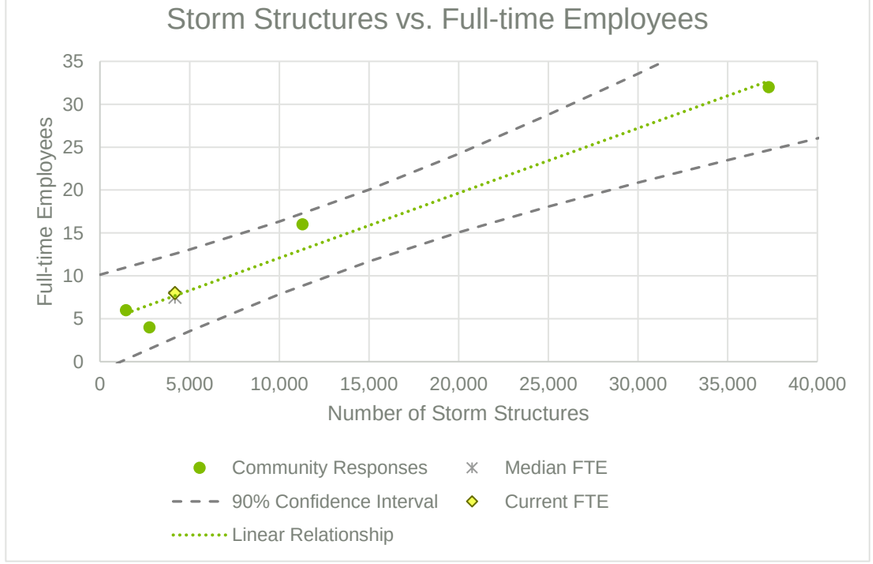


Figure 15. Median number of full-time employees (FTE) compared to the City of Joplin's current number of FTE based on number of storm sewer structures.

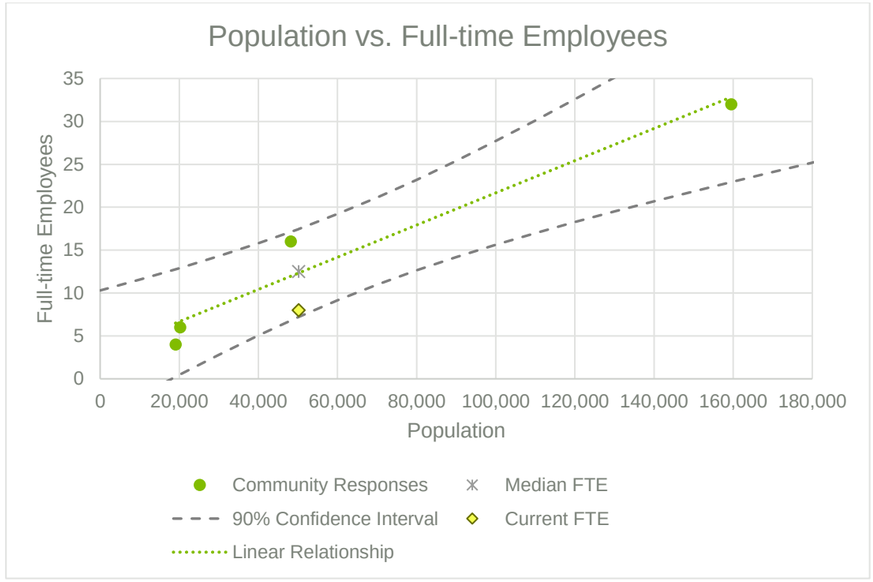


Figure 16. Median number of full-time employees (FTE) compared to the City of Joplin's current number of FTE based on population.

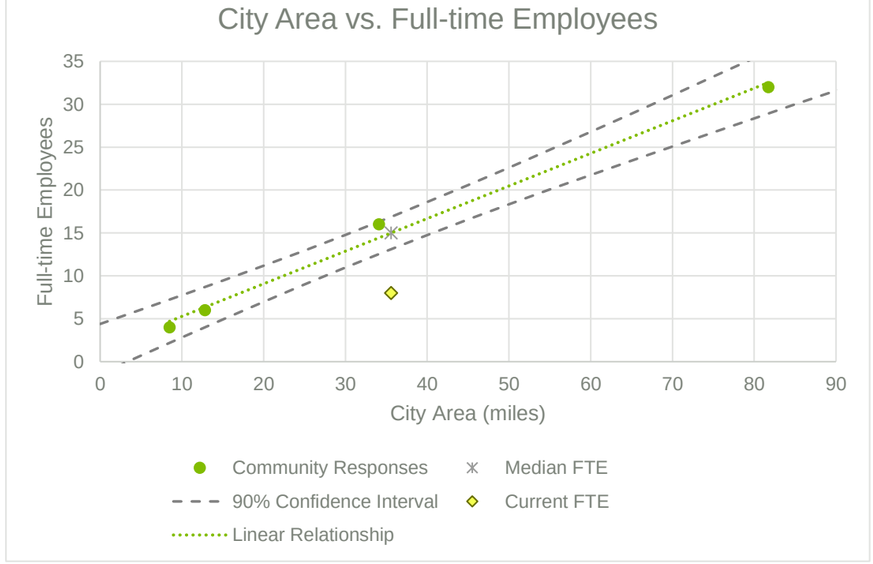


Figure 17. Median number of full-time employees (FTE) compared to the City of Joplin's current number of FTE based on city area in square miles.

7. GEOGRAPHIC INFORMATION SYSTEM STORM SEWER INVENTORY

The GIS storm sewer database is a useful tool for city staff and the community to understand what infrastructure is currently present in the city. Although a detailed survey is required to design new system improvements, availability of accurate GIS storm sewer data enables desktop concept-level evaluations of drainage system capacity without the time and expense of a field trip or survey. The city's storm sewer dataset was previously separated into three individual datasets. Olsson merged these datasets into one dataset. Areas with overlapping data were evaluated to determine the more accurate data based on aerials and attribute data. Areas with missing spatial or attribute data were identified for the field investigation portion of this scope of work.

Inlet information acquired in the field was combined with the existing, cleaned-up storm sewer database to create one dataset. Olsson added 2,203 structures to the storm sewer inventory while drawing pipe connections in the process. Though every structure in the city is still not included in the database, field investigation focused on areas with the most missing information to fill gaps in the existing inventory. Understanding the existing storm sewer infrastructure in the community is a valuable first step in identifying deficiencies, whether they are deficiencies related to system capacity or condition. The improved storm sewer inventory is a tool that will help identify needs and help evaluate stormwater-related complaints.

8. CONCLUSIONS

The City of Joplin's parks and stormwater sales tax requires renewal by city vote every 10 years. In advance of the upcoming fall 2021 election, which will ask citizens to renew the sales tax, the city hired Olsson to evaluate stormwater issues and identify a program of improvements that would be funded by the proposed tax renewal. Through a series of public meetings and community questionnaires, Olsson and city staff gathered public feedback on issues related to flooding, erosion, and storm sewer infrastructure. Once problems were identified, they were sorted into categories based on size. Projects categorized as major system improvements were evaluated in detail to define acceptable solutions, estimate total project costs, and determine benefits provided by the project. Projects were scored and ranked based on the total benefit provided and their benefit-to-cost ratios. The result of this effort is a ranked stormwater capital improvement project list.

In addition to the prioritized project list, this masterplan includes other information on the existing stormwater infrastructure, watersheds, and streams that will be useful to city staff and to

the development community when evaluating stormwater concerns. The existing storm sewer GIS database has been reviewed to reduce old or duplicate information and expanded to included 2,203 new structures and their connected pipes. The city's watershed database, which contains information on watershed runoff potential and culvert capacities, has been expanded to include an additional 43 square miles southwest of Joplin. O&M plans for stormwater infrastructure have been updated with recommendations for maintenance funding and operations staffing. Lastly, principal streams within city limits have been reviewed to identify stability issues and threats to existing infrastructure. This stormwater master plan provides a comprehensive evaluation of stormwater in the City of Joplin and provides tools that will aid city staff in managing stormwater for the next 10 years.

9. REFERENCES

Allgeier, Martin, and Associates Inc. (2009). *Supplemental Stormwater Management Master Plan,* City of Joplin, Joplin, MO.

Allgeier, Martin, and Associates Inc. (2018). *Stormwater Management Criteria,* City of Joplin, Joplin, MO.

APWA (American Public Works Association). (2020). *Stormwater Management Manual: An Overview of Programs and Practices*, APWA Press, Kansas City, MO.

Burns & McDonnell. (1998). *Stormwater Management Master Plan,* City of Joplin, Joplin, MO.

Caldwell, B. (2017). "Bill Caldwell: Torrential rains brought record flooding in 1943." *Joplin Globe*. https://www.joplinglobe.com/news/local_news/bill-caldwell-torrential-rains-brought-record-ooding-in-1943/article_0cabd74d-8a2e-525e-b2c3-1de1b5ea63a4.html (April 12, 2021)

Caldwell, B. (2018). "Bill Caldwell: The saga of Willow Branch vs. downtown Joplin." *Joplin Globe*. https://www.joplinglobe.com/news/local_news/bill-caldwell-the-saga-of-willow-branch-vs-downtown-joplin/image_38c5e28c-8104-5a78-84f6-37d5be0e7930.html (April 12, 2021).

FEMA (Federal Emergency Management Agency). (2010). "Flood Insurance Study: Newton County, Missouri and incorporated areas." *Flood Insurance Study Number 29145CV000A*, FEMA, Region 7.

FEMA (Federal Emergency Management Agency). (2012). "Flood Insurance Study: Jasper County, Missouri and incorporated areas." *Flood Insurance Study Number 29097CV000C*, FEMA, Region 7.

Hirschman, D. J., and Kosco, J. (2008). *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program*, NEPIS, United States.

Joplin Globe. (1943). "Downtown Joplin between Fifth and Sixth streets on Main were covered with up to three feet of water as the Willow branch storm sewer was overwhelmed by the torrential rainfall on May 18, 1943. This Thomas Korn Studio photo was one of several he took for the Globe." Joplin Globe.

U.S. Census Bureau. (2012). "United States Summary: 2010 Population and Housing Unit Counts." *CPH-2-1*, United States Summary U.S. Government Printing Office, Washington, DC.

Appendix A

Stormwater Capital Improvement Projects – Project Information

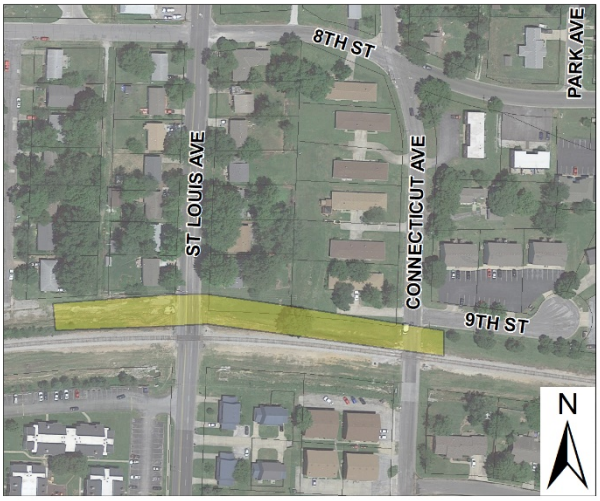
Joplin Stormwater Master Plan
Project Overview

Project Name	Type	Prioritization Rank	Total Prioritization Score	Benefit Score	Dimensionless B/C Ratio	Estimate (2021)	Estimate (2031)	Next Step	Design/ Construction Year	Anticipated Cost in Design/Construction Year	Total Money Remaining (assuming $30M budget)	Notes
Minor System Improvements	Annual Expense	N/A	N/A	N/A	N/A	$ 961,850.00	$ 1,102,653.23		N/A	N/A	$29,038,150.00	
Ditch and Detention Pond Maintenance	Annual Expense	N/A	N/A	N/A	N/A	$ 3,000,000.00	$ 3,439,163.79		N/A	N/A	$26,038,150.00	
Catch Basin and Closed System Maintenance	Annual Expense	N/A	N/A	N/A	N/A	$ 2,500,000.00	$ 2,865,969.83		N/A	N/A	$23,538,150.00	
Economic Development and Emergency Funds	Annual Expense	N/A	N/A	N/A	N/A	$ 1,500,000.00	$ 1,719,581.90		N/A	N/A	$22,038,150.00	
9th Street & St. Louis Avenue	Culvert/Ditch	1	86	153	100	$ 237,000.00	$ 319,000.00		2026	$ 274,747.96	$21,763,402.04	
1st Street & Joplin Avenue***	Rehabilitation	2	76	300	20	$ 2,295,000.00	$ 3,084,000.00	Concept Study	2027	$ 149,256.54	$21,614,145.51	Concept Study Only
17th Street & Annie Baxter Avenue	Ditch	3	72	130	32	$ 632,000.00	$ 849,000.00		2026	$ 732,661.21	$20,881,484.29	
Twin Hill Estates	Culvert/Ditch	4	68	100	40	$ 386,000.00	$ 519,000.00		2022	$ 397,580.00	$20,483,904.29	High B/C Ratio and low cost justify fitting on this cycle.
Beale Avenue & Zora Street	Ditch	5	68	60	64	$ 146,000.00	$ 196,000.00		2026	$ 169,254.01	$20,314,650.28	High B/C Ratio and low cost justify fitting on this cycle.
17th Street & Mina Avenue	Storm Sewer	6	62	220	17	$ 1,992,000.00	$ 2,677,000.00		2023	$ 2,113,312.80	$18,201,337.48	
26th Street Twin Culverts	Culvert /Ditch	7	66	113	29	$ 595,000.00	$ 800,000.00		2027	$ 710,461.12	$17,490,876.36	High B/C Ratio and low cost justify fitting on this cycle.
Texas Avenue (11th - 15th Street)	Storm Sewer	8	62	150	19	$ 1,238,000.00	$ 1,664,000.00		2026	$ 1,435,181.30	$16,055,695.06	
Old Willow Branch***	Rehabilitation	9	60	530	10	$ 8,299,000.00	$ 11,153,000.00	Concept Study	2028	$ 461,202.70	$15,594,492.36	Concept Study Only
17th Street & Iowa Avenue	Storm Sewer	10	58	210	17	$ 1,927,000.00	$ 2,590,000.00		2025	$ 2,168,855.48	$13,425,636.88	
Ten Pin Lane	Storm Sewer	11	60	100	29	$ 543,000.00	$ 730,000.00		2027	$ 648,370.40	$12,777,266.48	
Durham Acres/Missouri Avenue	Storm Sewer	12	52	180	13	$ 2,092,000.00	$ 2,811,000.00		2024	$ 2,285,984.88	$10,491,281.60	
Euclid Avenue	Ditch/Storm Sewer	13	54	120	18	$ 1,044,000.00	$ 1,403,000.00		2028	$ 1,283,988.32	$9,207,293.28	
Sunnyvale (Lloyd Addition) and I-44 Culvert Study	Storm Sewer	14	54	321	18	$ 2,712,000.00	$ 3,645,000.00		2029	$ 3,435,480.46	$5,771,812.82	Include additional 175k for concept study of I-44 culvert addition. Additional benefits from I-44 culvert additional project are included in the project scoring. May not fit on this cycle.
33rd Street & Jackson Avenue	Ditch	15	52	60	22	$ 424,000.00	$ 570,000.00		2022	$ 436,720.00	$5,335,092.82	High B/C Ratio and low cost justify fitting on this cycle.
Carolina Circle Cul-de-sac Ditch	Storm Sewer	16	52	30	51	$ 92,000.00	$ 124,000.00		2027	$ 109,852.81	$5,225,240.01	High B/C Ratio and low cost justify fitting on this cycle.
34th Street & Joplin Avenue	Storm Sewer	17	50	55	29	$ 291,000.00	$ 391,000.00		2030	$ 379,689.00	$4,845,551.02	May not fit on this cycle.
26th Street & McCoy Avenue	Storm Sewer	18	50	30	42	$ 110,000.00	$ 148,000.00		2030	$ 143,525.05	$4,702,025.97	May not fit on this cycle.
I-44 Culvert Addition***	Culvert	19	46	237	7	$ 5,108,000.00	$ 6,865,000.00		2031	$ 6,864,724.87	($2,162,698.90)	Concept Study Funds Shifted to Sunnyvale Project. This row is for design and construction. Additional Funding sources will be required.
East Town	Culvert/Storm Sewer	20	34	90	12	$ 1,216,000.00	$ 1,634,000.00		2024	$ 1,328,756.03	($3,491,454.93)	Outside funding may allow to fit on this cycle
12th Street & Wall Avenue	Rehabilitation	21	32	40	18	$ 352,000.00	$ 473,000.00		2032	$ 487,250.32	($3,978,705.25)	May not fit on this cycle.
Massachusetts Avenue & Murphy Boulevard	Ditch	22	28	60	10	$ 967,000.00	$ 1,300,000.00		2032	$ 1,338,554.15	($5,317,259.41)	May not fit on this cycle.
Garvin Park Ditch	Storm Sewer	23	24	35	14	$ 379,000.00	$ 509,000.00		2032	$ 524,624.64	($5,841,884.04)	May not fit on this cycle.
Cleveland Court	Ditch	24	16	50	7	$ 1,061,000.00	$ 1,426,000.00		2032	$ 1,468,672.14	($7,310,556.18)	May not fit on this cycle.
20th Street & Rhode Island Avenue	Culvert/Ditch	25	12	30	9	$ 527,000.00	$ 708,000.00		2032	$ 729,491.25	($8,040,047.43)	May not fit on this cycle.
Colorado Drive	Ditch	26	0	10	2	$ 998,000.00	$ 1,341,000.00		2032	$ 1,381,465.40	($9,421,512.83)	May not fit on this cycle.
Total						$ 35,663,000.00	$ 47,929,000.00					

***Total Project Cost is shown. Concept study/design is recommended in this 10-year cycle.

Project Name: Ninth Street and St. Louis Avenue

Project ID: 7-5



Pertinent Data Summary

Watershed: Joplin Creek East

Priority No.: 1

Design Capacity: N/A

Estimated Cost: $237,000

Topographic (Section): 27N 33W Section 11 and 12

Existing Problem Description

Three properties have experienced flooding from an undersized ditch and undersized culverts at Connecticut Avenue and St. Louis Avenue just north of the Missouri Pacific Railroad near Ninth Street. Both culverts are 24 inches. The capacity for these culverts is near a 2-year storm event. Both intersections have had significant flooding. The ditch just east of St. Louis Avenue is very flat and shallow. Water will pool at this area before overtopping the roadway. The ditch west of St. Louis Avenue has capacity to carry a 100-year storm event but has experienced a lot of erosion.

Recommended Improvements

Description: Install a 2-foot-by-2-foot box culvert under Connecticut Avenue. Retain the existing 24-inch culvert. The extra culvert will increase the capacity to a 25-year storm event. Excavate a ditch downstream of Connecticut Avenue to St. Louis Avenue. The channel will require a 5-foot bottom width with 4:1 side slope. Depth will be 2.5 feet with a channel slope of at least 2.0 percent. Install a 36-inch RCP under St. Louis Avenue. Retain the existing 24-inch culvert. Streambank stabilization downstream of St. Louis Avenue will be necessary.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer, channel, and culvert improvements. Appropriate material lining of the drainage ditch improvements should be evaluated during final design, taking into account all project goals including water quality.

Permitting: Permitting from the Missouri Pacific Railroad and a 404 nationwide permit is anticipated.

Utility Relocations: The culvert and drainage ditch layouts seek to avoid utilities as much as possible. The St. Louis Avenue culvert is near a sanitary sewer line. Also, both culverts are near overhead electric. Sanitary sewer depths are unknown and could reduce capacity of the proposed design or require relocation of overhead electric and sanitary sewer lines during final design.

Right-of-way Acquisition: The proposed ditch layouts were identified to stay within existing right-of-way, where possible. Additional right-of-way may be required at the northeast property at the intersection of St. Louis Avenue and the railroad. Additional right-of-way will be determined based on boundary survey and final design solutions.

Downstream Controls: The drainage ditch continues for 1,100 feet before discharging into Joplin Creek.

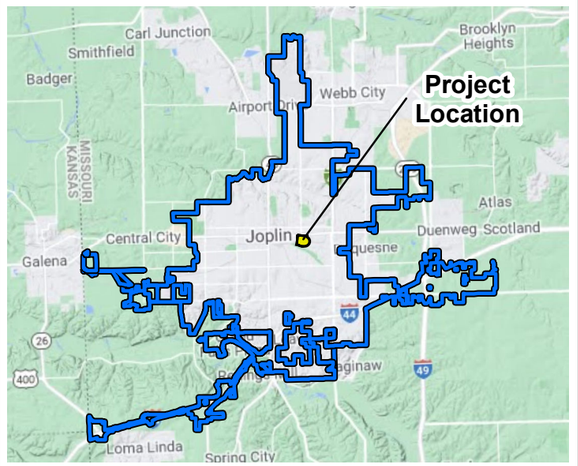


9th Street & St. Louis Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Channel Stabilization
- Proposed Storm Sewer
- Proposed Channel Improvements
- Floodplain
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
9th Street & St. Louis Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 10,000.00	$ 10,000.00
Erosion Control	LS	1	$ 3,000.00	$ 3,000.00
Demolition	LS	1	$ 4,500.00	$ 4,500.00
24" RCP	LF	60	$ 100.00	$ 6,000.00
24" FES	EA	2	$ 1,250.00	$ 2,500.00
2' x 2' RCB	LF	60	$ 200.00	$ 12,000.00
Concrete Wingwalls and Apron for 2' x 2' Box Culvert	EA	2	$ 5,000.00	$ 10,000.00
Channel Stabilization	LF	135	$ 300.00	$ 40,500.00
Excavation (Trapezoidal Channel)	LF	350	$ 150.00	$ 52,500.00
			Subtotal	$ 141,000.00
			Utility Relocation (10%)	$ 14,100.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 40,000.00
			Right of Way (5%)	$ 7,050.00
			Construction Contingency (25%)	$ 35,250.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 237,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 319,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: 9th Street & St. Louis Avenue

Description of Problem: Undersized culverts and nuisance flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25	3	1.5	100%	112.5
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**152.5**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: First Street and Joplin Avenue (Williamsburg)

Project ID: 7-2



Pertinent Data Summary

Watershed: Joplin Creek East

Priority No.: 2

Design Capacity: N/A

Estimated Cost: $125,000 (Concept Study) $2,295,000 (Total Project Cost)

Topographic (Section): 28N 33W Section 2, 3

Existing Problem Description

The First Street and Joplin Avenue box culvert is nearly a century old. It is a 4-foot-by-4-foot box culvert located at the intersection of Third Street and Joplin Avenue and travels to the north and east to the intersection of B Street and Main Street. There is a west branch that starts at the intersection of Second Street and Byers Avenue and connects to the main branch at First Street and Joplin Avenue. The box culvert has started to deteriorate. Remediation will require replacement of a portion or all of the box culvert. If the box culvert collapsed, it would cause flooding for many properties on the north side of downtown Joplin. The box culvert intersects several utility corridors for sanitary sewer, gas, water, and electric.

Recommended Improvements

Description: The first step in rehabilitating the First Street and Joplin Avenue box culvert is to conduct a study. This study should evaluate the existing system condition and feasibility of replacement along the current alignment, identify additional alignment alternatives, and develop an opinion of probable cost for each alternative. The study will determine if the project must be constructed in phases. The estimate for this project is based on prices to replace the existing box culverts with identical sizes. It is intended to only provide an order of magnitude for the total project.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements. Project is not expected to increase outlet velocity.

Permitting: To be determined in the conceptual study.

Utility Relocations: Conflicts with sanitary sewer, water, gas, and electric exist. Exact conflicts to be further identified in the conceptual study.

Right-of-way Acquisition: The proposed storm sewer layout should follow the existing layout where possible. Exact right-of-way must be further identified in the conceptual study.

Downstream Controls: The culvert joins a double box culvert and flows to the east under a twin railroad track just before discharging into Joplin Creek.

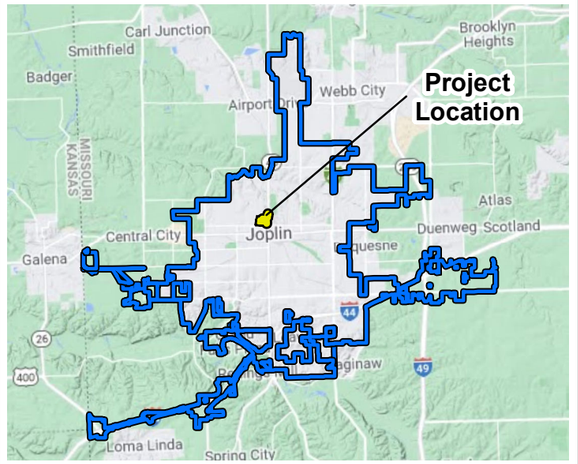
1st Street and Joplin Avenue (Williamsburg)

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- 10ft Contours
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
1st Street & Joplin Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 85,000.00	$ 85,000.00
Erosion Control	LS	1	$ 30,000.00	$ 30,000.00
Demolition	LS	1	$ 40,000.00	$ 40,000.00
18" RCP	LF	350	$ 75.00	$ 26,290.00
24" RCP	LF	381	$ 100.00	$ 38,090.00
36" RCP	LF	731	$ 135.00	$ 98,730.00
4' x 4' RCB	LF	631	$ 400.00	$ 252,490.00
5' x 6' RCB	LF	960	$ 550.00	$ 528,140.00
Type D Curb Inlet	EA	3	$ 3,300.00	$ 9,900.00
Junction Box	EA	9	$ 3,000.00	$ 27,000.00
Pavement Repair	SY	3123	$ 50.00	$ 156,150.00
Sidewalk Repair	SY	260	$ 60.00	$ 15,600.00
Driveway Repair	SY	42	$ 75.00	$ 3,150.00
Curb & Gutter	LF	1313.00	$ 30.00	$ 39,390.00
			Subtotal	$ 1,349,930.00
			Utility Relocation (10%)	$ 134,990.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 337,480.00
			Right of Way (10%)	$ 134,990.00
			Construction Contingency (25%)	$ 337,480.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 2,295,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 3,084,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: 1st Street & Joplin Avenue (Williamsburg)

Description of Problem: Failing Storm Sewer

Project Benefit Rating

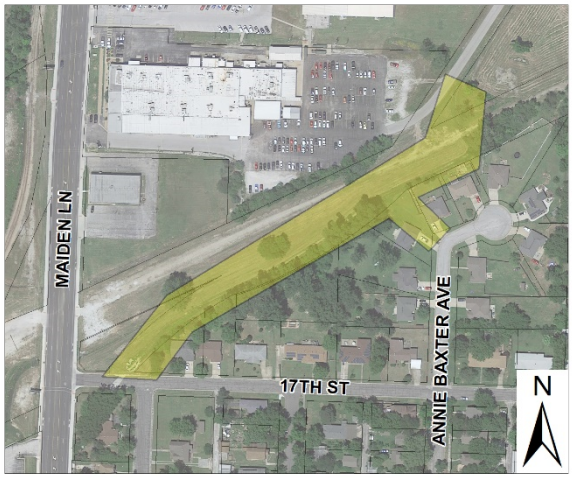
Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10	30		100%	300
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**300**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: 17th Street and Annie Baxter Avenue

Project ID: 6-3

Pertinent Data Summary

Watershed:	Joplin Creek West
Priority No.:	3
Design Capacity:	385 cfs (100-year, Main Channel) 45 cfs (100-year, Lateral Swale)
Estimated Cost:	$632,000
Topographic (Section):	27N 33W Section 10

Existing Problem Description

Three residences on the north end of the cul-de-sac of 17th Street and Annie Baxter Avenue experienced flooding in the spring of 2019 on two separate occasions. An existing open ditch located just northeast of the intersection of 17th Street and Maiden Lane conveys a significant amount of stormwater runoff from the surrounding area and an existing storm sewer system discharges into the open ditch near the Annie Baxter Avenue cul-de-sac. Recent improvements along Maiden Lane included widening and improving the stormwater system along the street. Since these improvements, the existing open ditch has not been improved to account for a possible increase in runoff. The area draining to the open ditch is around 125 acres and the ditch is severely undersized to convey even the 2-year storm. In 2019, residents on the north end of the Annie Baxter Avenue cul-de-sac reported both structural flooding from the open ditch overtopping and at least 2 inches of street flooding possibly caused by storm sewer backwater. The storm sewer inlet has the capacity to convey the 25-year storm event, but no overland swale exists to convey higher flows.

Recommended Improvements

Description: The open ditch has a very shallow slope and is constrained vertically, so it must be widened to the north to improve capacity. Install a trapezoidal channel with a 40-foot bottom width, depth of 1 foot, and 8:1 side slope. It will only convey a 2-year storm event but it's the best option considering the vertical constraints and nearby abandoned railroad tracks to the north. Install an overland lateral swale above the existing storm sewer that runs between two homes and outlets into the open ditch. The swale will have a 5-foot bottom width, depth of 2 feet, and 3:1 side slope. The swale will convey a 100-year storm event with 1 foot of freeboard per the City of Joplin's requirements.

Water Quality: Appropriate material lining of the drainage ditch should be evaluated during final design, taking into account all project goals including water quality. Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements.

Permitting: A 404 nationwide permit is anticipated.

Utility Relocations: A sanitary sewer line runs parallel to the abandoned railroad. Sanitary sewer depths are unknown and could limit the proposed design or require relocation of sanitary sewer lines during final design.

Right-of-way Acquisition: The proposed open ditch improvements should stay within existing right-of-way where possible. Additional right-of-way or a temporary construction easement may be required for the lateral swale between two homes and will be determined based on boundary survey and final design solutions.

Downstream Controls: An existing culvert just downstream of the proposed open ditch improvements may hinder the capacity of the ditch and cause backwater issues. The culvert flows to the north under an apparent abandoned railroad line. The size and capacity of this culvert is unknown.

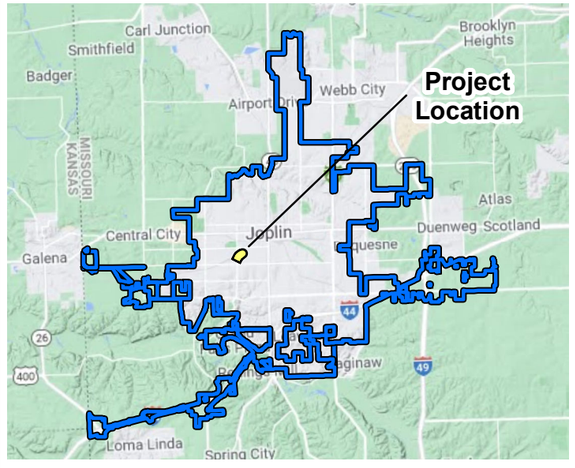
17th Street & Annie Baxter Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Channel Improvements
- Floodplain
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Culverts
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
17th Street & Annie Baxter Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 5,000.00	$ 5,000.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
Channel Restoration	LF	1139	$ 300.00	$ 341,700.00
			Subtotal	$ 371,700.00
			Utility Relocation (10%)	$ 37,170.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 92,930.00
			Right of Way (10%)	$ 37,170.00
			Construction Contingency (25%)	$ 92,930.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 632,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 849,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek West

Location: 17th Street & Annie Baxter Avenue

Description of Problem: Street and structure flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30	3	1	100%	90
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	2	1	100%	40
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**130**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Twin Hills Estates

Project ID: 18-1



Pertinent Data Summary

Watershed: Short Creek

Priority No.: 4

Design Capacity: N/A

Estimated Cost: $386,000

Topographic (Section): 27N 33W Section 18

Existing Problem Description

An existing culvert, west of the County Club golf course, spans under a bridge that provides access to residents of properties along Magnolia Lane. A large amount of the surface runoff at this crossing comes from the golf course to the east. The existing RCP culvert is undersized and causes the bridge connecting Black Cat Road and Mongolia Lane to frequently be overtopped by water during rain events. An unimproved ditch downstream of the culvert conveys the stormwater for approximately 500 feet until it reaches another undersized culvert. The sizes of both culverts are estimated to be 48-inch RCPs. The aboveground collection system continues and begins to run west along 20th Street with similarly sized culverts at each drive crossing. Upon review of aerial imagery, it appears that a scour pool has formed in the natural channel just downstream of the first crossing. Contours also suggest the channel slope between the first and second culverts is very shallow, causing backwater problems at the upstream culvert and reducing its conveyance abilities.

Recommended Improvements

Description: Remove the upstream culvert and damaged roadway and replace with a similar sized RCP culvert. It doesn't appear improvement of the culvert size would be effective because of downstream controls. Replace the natural open channel between the two culverts with a concrete channel to improve conveyance and prevent further backwater issues at the culvert crossing.

Water Quality: Appropriate material lining of drainage ditch should be evaluated during final design, taking into account all project goals including water quality. Increases of velocity should be avoided if possible. If not possible, increased velocities should be mitigated with proper energy dissipation. Also, design of erosion and sediment control will be necessary to limit water quality impacts during construction of culvert and channel improvements.

Permitting: No permitting is anticipated.

Utility Relocations: The channel layout seeks to avoid utilities as much as possible. A sanitary sewer line runs parallel for a portion of the open channel. Sanitary sewer line depths

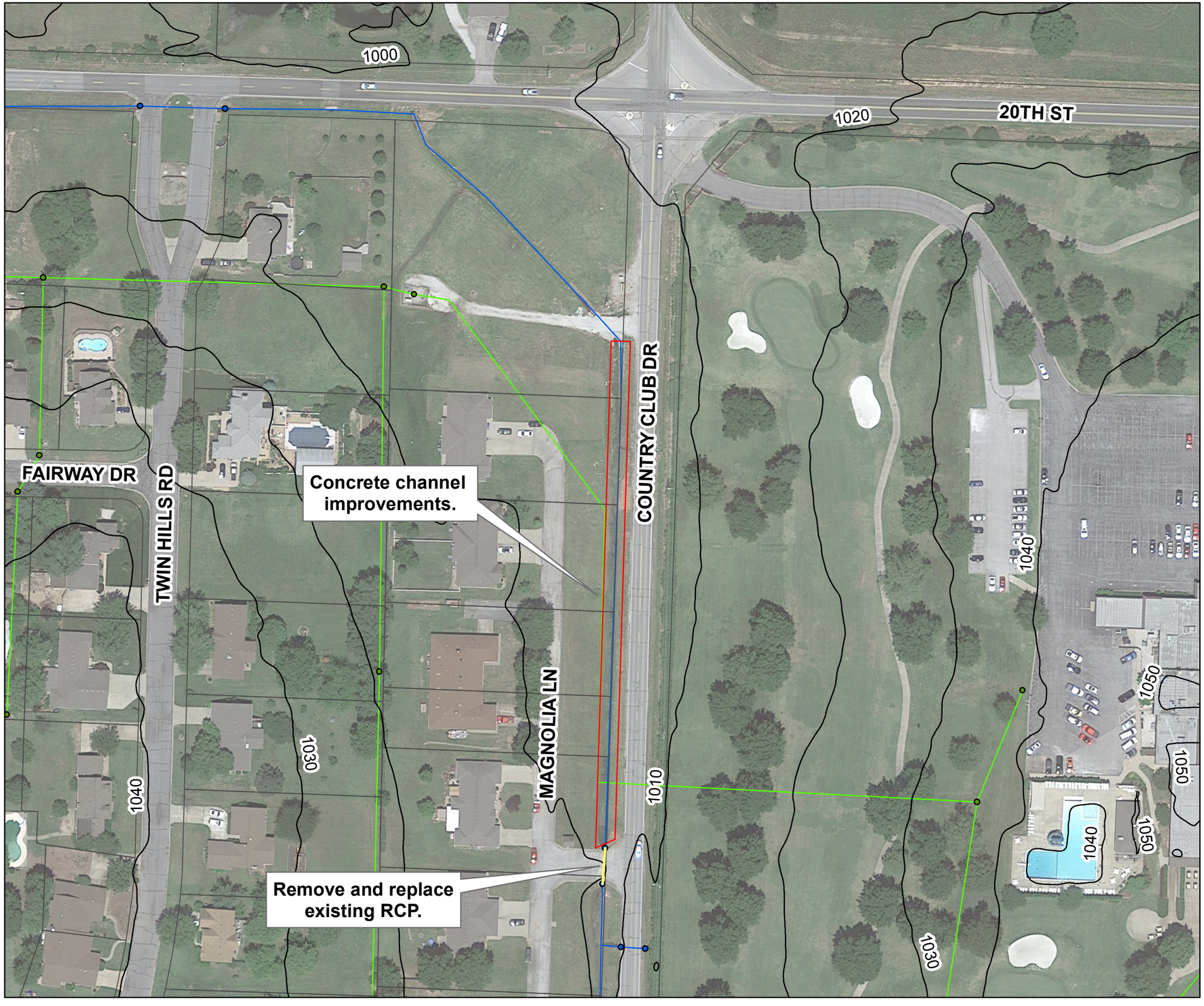
are unknown and could reduce capacity of the proposed design or require relocation.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Additional right-of-way may be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The improved channel will discharge into the downstream aboveground collection system with unimproved channels and possibly undersized culvert crossings.

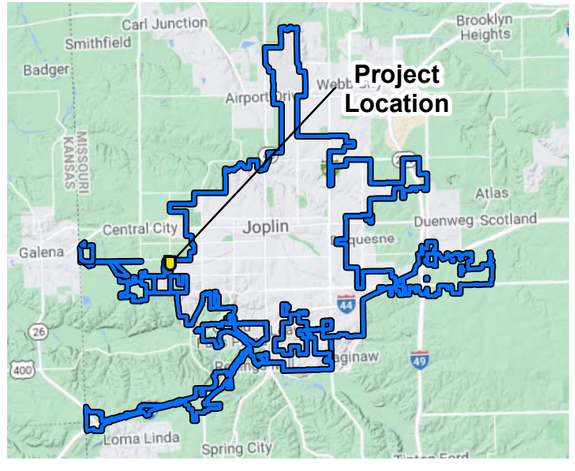
Twin Hills Estates

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Channel Improvements
- Proposed Storm Sewer
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Twin Hills Estates

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 5,000.00	$ 5,000.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
48" RCP	LF	38	$ 155.00	$ 5,890.00
Pavement Repair	SY	314	$ 55.00	$ 17,270.00
Curb & Gutter	LF	168	$ 30.00	$ 5,040.00
Concrete Channel	LF	530	$ 300.00	$ 159,000.00
			Subtotal	$ 217,200.00
			Utility Relocation (15%)	$ 32,580.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 60,000.00
			Right of Way (10%)	$ 21,720.00
			Construction Contingency (25%)	$ 54,300.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 386,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 519,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Short Creek

Location: Twin Hills Estates

Description of Problem: Undersized culvert

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	1.5	100%	90
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**100**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Beale Avenue and Zora Street

Project ID: 17-1



Pertinent Data Summary

Watershed: Baker's Branch (Oakland)

Priority No.: 5

Design Capacity: N/A

Estimated Cost: $146,000

Topographic (Section): 28N 33W Section 25

Existing Problem Description

Four residents north of Zora Street and east of Beale Avenue have reported damage to stand-alone structures such as storage sheds and privacy fences because of large volumes of surface runoff in backyards. There is no existing channel to direct the backyard runoff. The surface runoff is captured just north of Zora Street by an area inlet that discharges into the existing stormwater system.

Recommended Improvements

Description: Install a swale in the backyards of the four residents to direct the surface flow during large rain events. The swale will direct flow to the south and discharge into the existing area inlet.

Water Quality: Appropriate material lining of drainage ditch should be evaluated during final design, taking into account all project goals including water quality. Also, design of erosion and sediment control will be necessary to limit water quality impacts during construction.

Permitting: No permitting is anticipated.

Utility Relocations: No known utility conflicts in the project location. Any utilities could reduce capacity of the proposed design or require relocation.

Right-of-way Acquisition: It is unknown if right-of-way exists. If none exists, it will be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The proposed swale will discharge into the existing stormwater system along Zora Street.

Beale Avenue & Zora Street

(CONCEPTUAL NOT FOR CONSTRUCTION)

MATTHEWS DR

BEALE AVE

HIGHVIEW AVE

ZORA ST

TURK AVE

1040

1030

1020

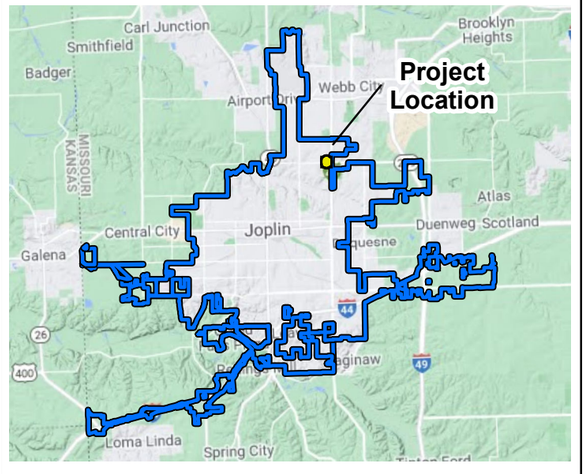
1010

Install vegetated swale.

Discharge into existing area inlet.

Legend

- Proposed Channel Improvements
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 37.5 75 150 Feet

1 inch = 75 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Beale Street & Zora Street

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 5,000.00	$ 5,000.00
Erosion Control	LS	1	$ 2,000.00	$ 2,000.00
Demolition	LS	1	$ 3,000.00	$ 3,000.00
Excavation (Trapezoidal Channel)	LF	453	$ 150.00	$ 67,950.00
			Subtotal	$ 77,950.00
			Utility Relocation (15%)	$ 11,690.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 25,000.00
			Right of Way (15%)	$ 11,690.00
			Construction Contingency (25%)	$ 19,490.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 146,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 196,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Baker's Branch (Oakland)

Location: Beale Avenue & Zora Street

Description of Problem: Nuisance backyard flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20	3	1	100%	60
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**60**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: 17th Street and Mina Avenue

Project ID: 5-1



Pertinent Data Summary

Watershed: Country Club

Priority No.: 6

Design Capacity: 70 cubic feet per second (cfs) (10-year)

Estimated Cost: $1,992,000

Topographic (Section): 27N 33W Section 08

Existing Problem Description

More than 10 properties have flooded along Mina Avenue between 17th Street and 13th Street. Vehicles have been flooded during multiple events when Mina Avenue became impassible. Mina Avenue floods during storm events that are even less significant than the 2-year return period storm. Standing water is common during more frequent rainfall events. The entire drainage area of the neighborhood is more than 30 acres. Land use is single-family residential. Stormwater naturally flows to Mina Avenue, which is the center of this neighborhood. Runoff is conveyed through curb and gutter. No enclosed storm sewer exists. Drainage discharges to a ditch located at the intersection of 17th Street and Mina Avenue. This ditch drains via two culverts into an unnamed tributary of Short Creek. This drainage ditch and the intersection of 17th Street and Mina Avenue are in the floodplain.

Recommended Improvements

Description: Storm sewer installed along Mina Avenue from 17th Street to 14th Street will have a design capacity equivalent to the 10-year storm event. The storm sewer will discharge through twin 3-foot-by-3-foot box culverts into the unnamed tributary for Short Creek just downstream of 17th Street and Mina Avenue. The two existing culverts that are downstream of 17th Street and Mina Avenue will be removed and the ditch that drains into the unnamed tributary for Short Creek will be improved. This will convey surcharge to the storm sewer for storm events greater than 10-year return periods.

Water Quality: During final design the outfall and drainage ditch into unnamed tributary for Short Creek will be evaluated to consider water quality impacts. Also, design of erosion and sediment control will be necessary to limit water quality impacts during construction.

Permitting: Floodplain development permit for grading in the floodplain and a 404 nationwide permit.

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. Conflicts with overhead electric on the western side of Mina Avenue exist. Also, the proposed storm sewer crosses sanitary sewer at several locations. Sanitary sewer and waterline depths are unknown and may require relocation during final design to achieve the storm sewer design capacity.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Additional right-of-way may be required downstream of 17th Street and Mina Avenue and where storm sewer cuts the corners at intersections. Extents of additional right-of-way will be determined based on boundary survey and final design solutions.

Downstream Controls: Without ditch improvements downstream of 17th Street and Mina Avenue, the design capacity of the system will be limited to the 10-year return period. Both 17th Street and Mina Avenue are in the floodplain from the unnamed tributary for Short Creek. Storm sewer and ditch improvements will not eliminate flooding during 100-year storms.

17th Street & Mina Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)

14TH ST

15TH ST

16TH ST

17TH ST

CLEVELAND AVE

MINA AVE

SCHIFFERDECKER AVE

1030

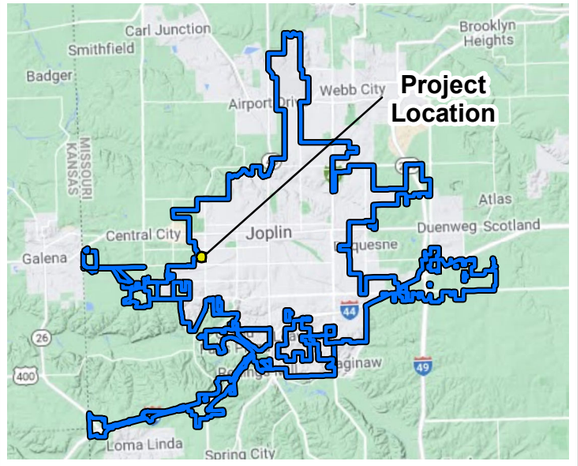
1020

1010

**Discharge to Short Creek Tributary.
Install energy dissipation.
See Cleveland Court Exhibit for ditch improvments.**

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Proposed Channel Improvements
- Floodplain
- 2ft Contours
- Streams
- Parcels
- Sanitary Sewer Manholes
- Sanitary Sewer



0 75 150 300 Feet

1 inch = 150 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
17th Street & Mina Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 70,000.00	$ 70,000.00
Erosion Control	LS	1	$ 25,000.00	$ 25,000.00
Demolition	LS	1	$ 35,000.00	$ 35,000.00
15" RCP	LF	432	$ 65.00	$ 28,080.00
18" RCP	LF	2185	$ 75.00	$ 163,875.00
24" RCP	LF	532	$ 100.00	$ 53,200.00
2' x 2' RCB	LF	313	$ 200.00	$ 62,600.00
3' x 3' RCB	LF	1216	$ 300.00	$ 364,800.00
Type D Curb Inlet	EA	40	$ 3,300.00	$ 132,000.00
Concrete Wingwalls and Apron for 3' x 3' Box Culvert	EA	1	$ 5,000.00	$ 5,000.00
Pavement Repair	SY	2215	$ 55.00	$ 121,825.00
Curb & Gutter	LF	2420	$ 30.00	$ 72,600.00
Driveway Repair	SY	480	$ 35.00	$ 16,800.00
Excavation (Trapezoidal Channel)	LF	45	$ 150.00	$ 6,750.00
Seeding	AC	0.7	$ 20,000.00	$ 14,000.00
			Subtotal	$ 1,171,530.00
			Utility Relocation (15%)	$ 175,730.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 292,880.00
			Right of Way (5%)	$ 58,580.00
			Construction Contingency (25%)	$ 292,880.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,992,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 2,677,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Country Club

Location: 17th Street & Mina Avenue

Description of Problem: Street flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	3	100%	180
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**220**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: 26th Street Twin Culverts (Industrial Park)

Project ID: 9-1

Pertinent Data Summary

Watershed: Turkey Creek East

Priority No.: 7

Design Capacity: 1055 cfs (100-year; Channel Improvements)

589 cfs (10-year; Culvert Crossing)

Estimated Cost: $595,000

Topographic (Section): 27N 32W Section 15

Existing Problem Description

Two 30-inch culverts convey water under 26th Street in the Crossroads Industrial Park, just west of County Road 190. The culverts were originally designed to convey the 10-year storm event during the early developmental stages of the industrial park. As development has continued in the area, peak flows at this crossing have increased and the capacity of the culverts has reduced to less than a 2-year storm event. The amount of drainage area that is conveyed by this crossing is approximately 310 acres. Minor storm events currently make the road impassable and negatively affect neighboring businesses.

Recommended Improvements

Description: Replace the existing double 30-inch culvert with an 8-foot-by-4-foot double box culvert. This culvert will be designed to convey the 10-year storm event. The channel upstream of the crossing will also be improved with a trapezoidal channel. The channel will have a bottom width of 20 feet with 5:1 side slope. The depth of the channel will be 2.75 feet with a channel slope of at least 0.7 percent.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of channel and culvert improvements. Appropriate material lining of the drainage ditch improvements should be evaluated during final design, taking into account all project goals including water quality.

Permitting: A 404 nationwide permit is anticipated.

Utility Relocations: The storm sewer and ditch layout seeks to avoid utilities as much as possible. A sanitary sewer line runs parallel to the ditch and crosses just upstream of the culvert. A portion of this line will likely have to be replaced. Also, a gas line crosses at the culvert. Sanitary sewer and gas line depths are unknown and

could reduce capacity of the proposed design or require relocation of sanitary sewer and gas lines during final design.

Right-of-way Acquisition: The proposed channel and culvert layout was identified to stay within existing right-of-way, where possible. It is unknown whether there are easements for the channel. If none exist, additional right-of-way will be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The proposed RCB will discharge into an existing channel of unknown capacity that may experience flooding with increased flows.

26th Street Twin Culverts

(CONCEPTUAL NOT FOR CONSTRUCTION)

Discharge to existing channel.

24TH ST

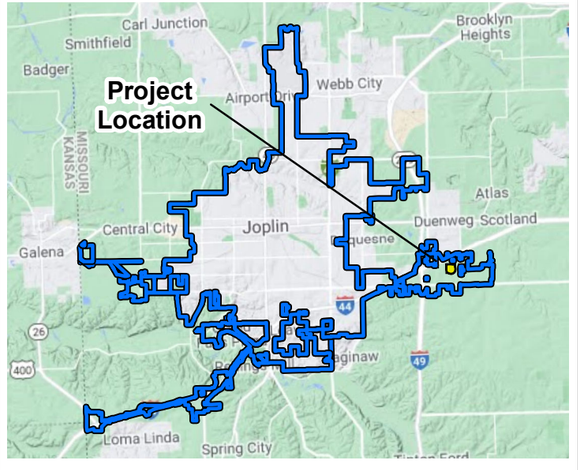
26TH ST

CL 191

PRIGMOR AVE

Legend

- Proposed Channel Improvements
- Proposed Storm Sewer
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
26th Street Twin Culverts

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 5,000.00	$ 5,000.00
Demolition	LS	1	$ 7,500.00	$ 7,500.00
8' x 4' Double RCB	LF	99	$ 1,200.00	$ 118,800.00
Concrete Wing Walls and Apron for 8' x 4' Box Culvert	EA	2	$ 7,500.00	$ 15,000.00
Pavement Repair	SY	150	$ 55.00	$ 8,250.00
Concrete Street Gutter	SY	58	$ 35.00	$ 2,030.00
Curb & Gutter	LF	246	$ 30.00	$ 7,380.00
Excavation (Trapezoidal Channel)	LF	873	$ 150.00	$ 130,950.00
Seeding	AC	2	$ 20,000.00	$ 40,000.00
			Subtotal	$ 349,910.00
			Utility Relocation (10%)	$ 34,990.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 87,480.00
			Right of Way (10%)	$ 34,990.00
			Construction Contingency (25%)	$ 87,480.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 595,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 800,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Turkey Creek East

Location: 26th Street Twin Culverts (Industrial Park)

Description of Problem: Undersized culvert and ditch

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25	3	1.5	100%	112.5
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**112.5**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

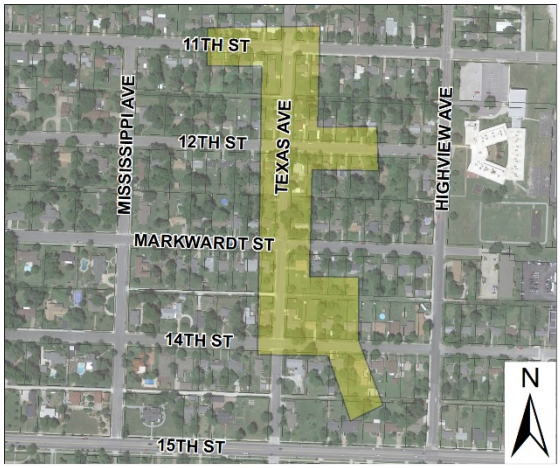
Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Texas Avenue (11th Street – 15th Street)

Project ID: 7-1



Pertinent Data Summary

Watershed:	Joplin Creek East
Priority No.:	8
Design Capacity:	170 cfs (10-year)
Estimated Cost:	$1,238,000
Topographic (Section):	27N 33W Section 12

Existing Problem Description

More than 10 properties have flooded along Texas Avenue between 11th Street and 15th Street. The intersection of Texas Avenue and 13th Street floods the most because it is located in a sump. The entire drainage area of the neighborhood is nearly 100 acres. Land use is primarily single-family residential with commercial use to the east near Ridge Line Road. The center of the watershed is oriented from the intersection of Texas Avenue and 13th Street and then to the southeast between Texas Avenue and Highview Avenue. Runoff is conveyed through curb and gutter and existing storm sewer. The enclosed system is only located at the intersection of Texas Avenue and 13th Street and runs southeast. It discharges to an open culvert north of 15th Street, which also receives runoff by an open channel from the east. The culvert flows south, discharging into an open channel south of 15th Street between Texas Avenue and Highview Avenue. Flooding is a result of limited and undersized storm sewer.

Recommended Improvements

Description: Install storm sewer from 11th to 14th streets and along Texas Avenue. Install a 6-foot-by-3-foot box culvert at the intersection of Texas Avenue and 13th Street. It will follow the path of the existing storm sewer, discharging to the open culvert north of 15th Street. The proposed storm sewer system will have a design capacity equivalent to the 10-year storm event.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements. In addition, the outfall into the existing open channel will be evaluated for water quality impacts.

Permitting: No permitting is anticipated.

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. Multiple sanitary sewer crossings exist on Texas Avenue. The proposed storm sewer has significant conflicts with sanitary sewer and overhead electric north of 14th Street and east of Texas Avenue. Sanitary sewer, water, and gas line depths are

unknown and may require relocation during final design to achieve the storm sewer design capacity.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Additional right-of-way may be required south of 13th Street. It is unknown whether easements exist for existing storm sewer or if those easements will be adequate for the proposed storm sewer. Extents of additional right-of-way will be determined based on boundary survey and final design solutions.

Downstream Controls: The capacity of the open culvert north of 15th Street is unknown. Any culvert less than 9-foot-by-3-foot would be undersized for the 10-year storm event. The open channel south of 15th Street can convey a 25-year storm event. The culvert downstream of this open channel would have to be a 12-foot-by-4-foot culvert to convey the 10-year storm event.

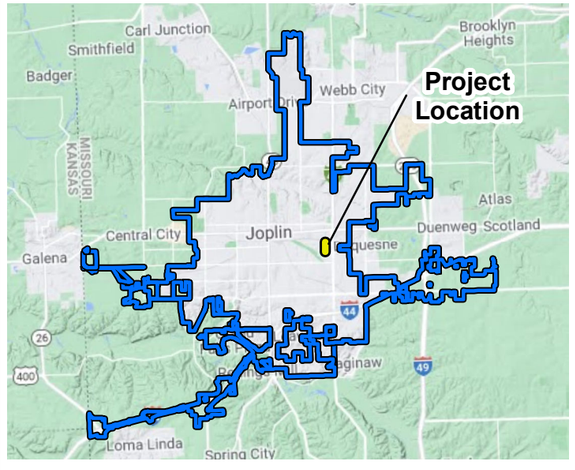
Texas Avenue (11th - 15th Street)

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Texas Avenue (11th - 15th Street)

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 45,000.00	$ 45,000.00
Erosion Control	LS	1	$ 15,000.00	$ 15,000.00
Demolition	LS	1	$ 25,000.00	$ 25,000.00
15" RCP	LF	328	$ 65.00	$ 21,290.00
18" RCP	LF	857	$ 75.00	$ 64,310.00
24" RCP	LF	171	$ 100.00	$ 17,070.00
36" RCP	LF	452	$ 135.00	$ 61,030.00
4' x 4' RCB	LF	731	$ 400.00	$ 292,520.00
6' x 4' RCB	LF	68	$ 500.00	$ 34,060.00
Type D Curb Inlet	EA	26	$ 3,300.00	$ 85,800.00
Junction Box	EA	1	$ 3,000.00	$ 3,000.00
Pavement Repair	SY	644	$ 55.00	$ 35,440.00
Sidewalk Repair	SY	42	$ 35.00	$ 1,460.00
Curb & Gutter	LF	178	$ 30.00	$ 5,340.00
Driveway Repair	SY	228	$ 35.00	$ 7,980.00
Seeding	AC	0.7	$ 20,000.00	$ 13,670.00
			Subtotal	$ 727,970.00
			Utility Relocation (10%)	$ 72,800.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 181,990.00
			Right of Way (10%)	$ 72,800.00
			Construction Contingency (25%)	$ 181,990.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,238,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,664,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: Texas Avenue (11th - 15th Street)

Description of Problem: Street flooding

Project Benefit Rating

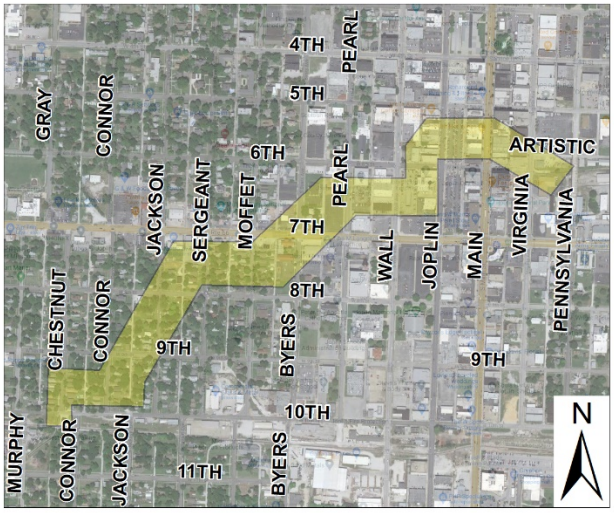
Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	2	100%	120
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**150**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: Old Willow Branch

Project ID: 6-2

Pertinent Data Summary

Watershed: Joplin Creek West

Priority No.: 9

Design Capacity: N/A

Estimated Cost: $375,000 (Concept Study) $8,299,000 (Total Project Cost)

Topographic (Section): 28N 33W Section 2, 3, 10

Existing Problem Description

Old Willow Branch is an extensive enclosed system built a century ago. It starts at the intersection of 10th Street and Chestnut Avenue and travels to the northeast through downtown Joplin before it discharges into an open channel near the intersection of Sixth Street and Pennsylvania Avenue. Pictures show the box culvert has deteriorated. Rebar is exposed with sides and bottoms eroded. Old Willow Branch and the parallel storm sewer named New Willow Branch have a combined capacity of a 25-year storm event. If Old Willow Branch were to fail, many properties would flood in and around downtown. Also, several buildings are located over the box culvert. A collapse would affect these buildings. The box culvert intersects several utility corridors for sanitary sewer, gas, water, and electric.

Recommended Improvements

Description: The first step in rehabilitating Old Willow Branch is to conduct a study. This study should evaluate the existing system condition and feasibility of rehabilitation or replacement along the current alignment, identify additional alignment alternatives, and develop an opinion of probable cost for each alternative. The box culvert under buildings may have to be abandoned and filled with slurry and replaced with a new layout. The project will have to be completed in several phases. The estimate for this project is based on prices to replace the existing box culverts downstream from Seventh Street and Byers Avenue with identical sizes and fill segments located under buildings with slurry. It is intended to only provide an order of magnitude for the total project.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements. In addition, the outfall into existing channel will be evaluated for water quality impacts. Project is not expected to increase outlet velocity.

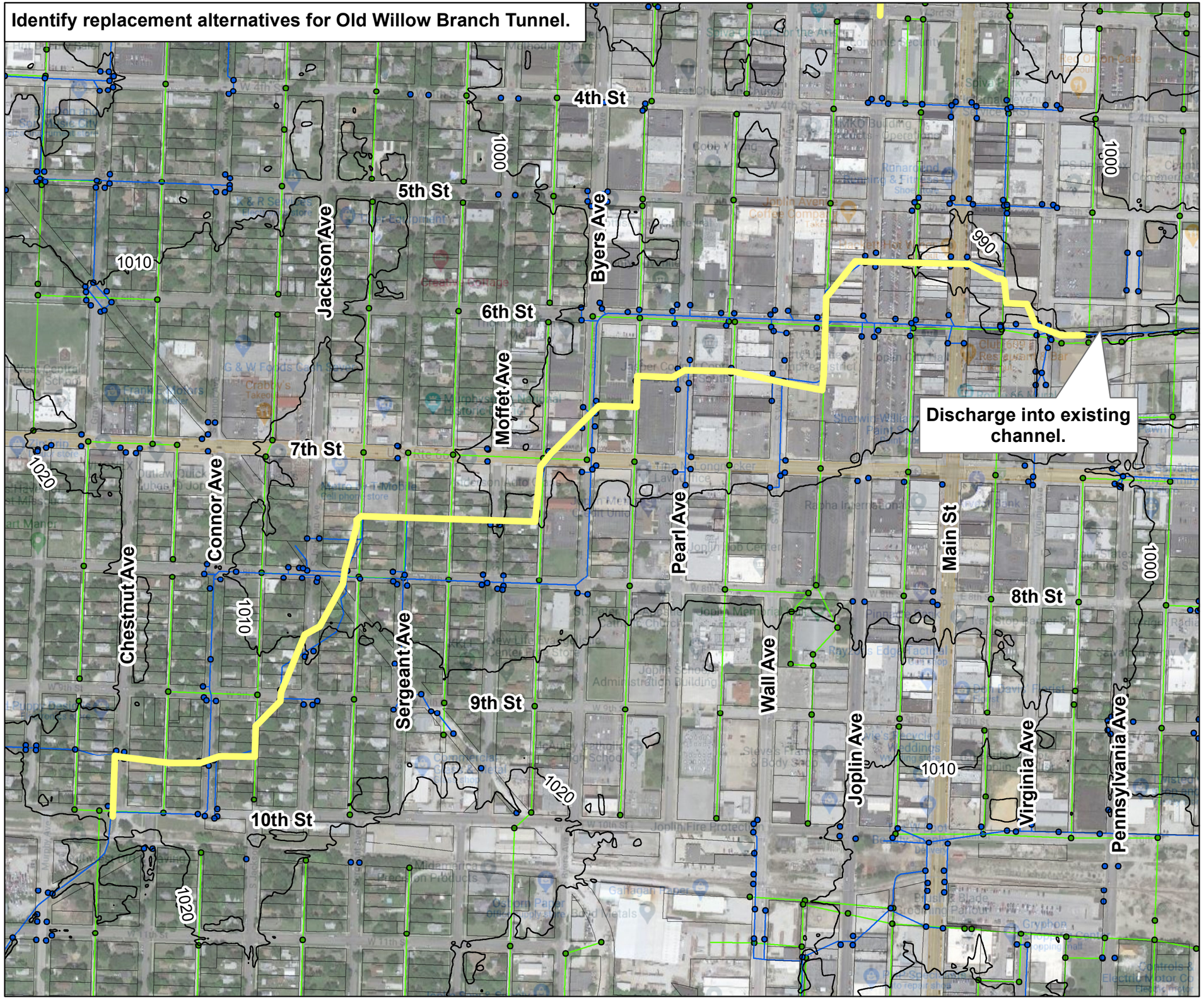
Permitting: To be determined in the conceptual study.

Utility Relocations: Utility impacts and conflicts with existing buildings are expected to be significant. Exact conflicts to be further identified in the conceptual study.

Right-of-way Acquisition: Right-of-way requirements are expected to be significant. Exact right-of-way must be further identified in the conceptual study.

Downstream Controls: The culvert discharges into an open channel. This channel flows through multiple culverts before discharging into Joplin Creek.

Identify replacement alternatives for Old Willow Branch Tunnel.

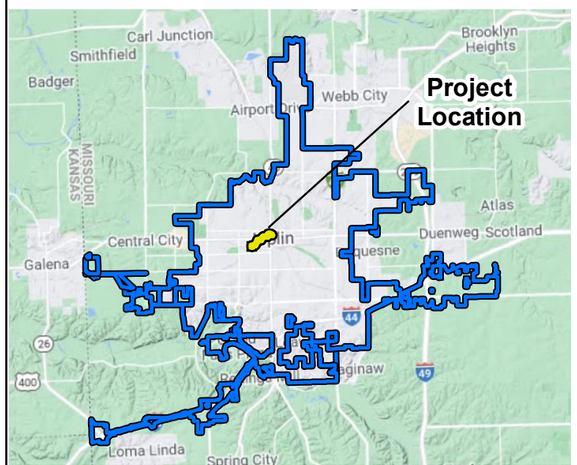


Old Willow Branch

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Existing Old Willow Branch Tunnel
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 175 350 700 Feet

1 inch = 350 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Old Willow Branch

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 450,000.00	$ 450,000.00
Erosion Control	LS	1	$ 150,000.00	$ 150,000.00
Demolition	LS	1	$ 110,000.00	$ 110,000.00
Abandonment (Flowable Fill)	CY	4873	$ 300.00	$ 1,462,000.00
12' x 4' RCB	LF	2741	$ 800.00	$ 2,193,000.00
Pavement Repair	SY	4463	$ 55.00	$ 245,470.00
			Subtotal	$ 4,610,470.00
			Utility Relocation (15%)	$ 691,570.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 1,152,620.00
			Right of Way (15%)	$ 691,570.00
			Construction Contingency (25%)	$ 1,152,620.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 8,299,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 11,153,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek West

Location: Old Willow Branch

Description of Problem: Failing Storm Sewer

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10	53		100%	530
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**530**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: 17th Street and Iowa Avenue

Project ID: 6-4



Pertinent Data Summary

Watershed: Joplin Creek West

Priority No.: 10

Design Capacity: NA

Estimated Cost: $1,927,000

Topographic (Section): 27N 33W Section 11

Existing Problem Description

A portion of the Iowa Avenue branch stormwater system along 17th Street, west of Iowa Street, has deteriorated over time and failed during a rain event in the spring of 2019. The failure was most likely caused by invert corrosion of the old, corrugated metal pipe (CMP) over time. A portion of the pipe east of Iowa Street where the system discharges into Joplin Creek was recently replaced.

Recommended Improvements

Description: Replace the existing 72-inch CMP with a 72-inch RCP. The pipe will be replaced from Iowa Street to Joplin Avenue, where the system transitions from a 72-inch CMP to a 48-inch CMP. It will follow the path of the existing storm sewer, connecting to the recently replaced pipe east of Iowa Street.

Water Quality: Design of erosion and sediment control will be necessary to limit water quality impacts during construction. Project is not expected to increase outlet velocity.

Permitting: No permitting is anticipated

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. The layout crosses sanitary sewer eight times. Also, the layout crosses water and gas lines. Sanitary sewer, gas, and waterline depths are unknown and could reduce capacity of the proposed design or require relocation of sanitary sewer, gas, and waterlines during final design.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Additional right-of-way is not anticipated but will be determined based on boundary survey and final design solutions.

Downstream Controls: The recently replaced culvert size and capacity is unknown. The downstream culvert size and tail water elevation of Joplin Creek will affect the capacity of the system.

17th Street & Iowa Avenue

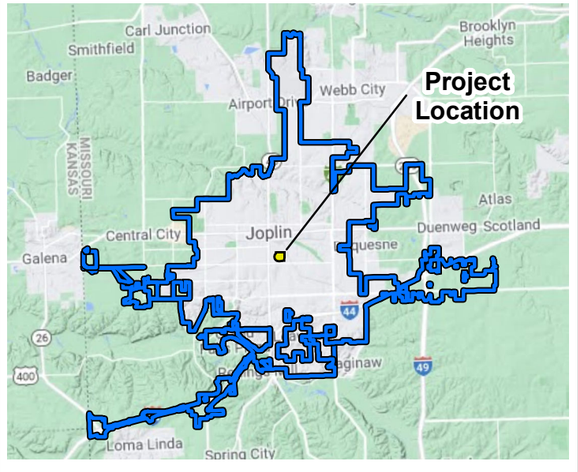
(CONCEPTUAL NOT FOR CONSTRUCTION)

14TH ST
15TH ST
16TH ST
17TH ST
18TH ST
19TH ST
JOPLIN AVE
MAIN ST
VIRGINIA AVE
PENNSYLVANIA AVE
KENTUCKY AVE
GRAND AVE
MISSOURI AVE
IOWA AVE
1020
1010
1030
1000

Tie into recent storm sewer improvements.

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 125 250 500 Feet

1 inch = 225 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
17th Street & Iowa Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 45,000.00	$ 45,000.00
Erosion Control	LS	1	$ 15,000.00	$ 15,000.00
Demolition	LS	1	$ 20,000.00	$ 20,000.00
72" RCP	LF	2223	$ 350.00	$ 778,050.00
Junction Box	EA	19	$ 3,000.00	$ 57,000.00
Pavement Repair	SY	2573	$ 55.00	$ 141,520.00
Sidewalk Repair	SY	709	$ 35.00	$ 24,820.00
Driveway Repair	SY	100	$ 35.00	$ 3,500.00
Curb & Gutter	LF	1542	$ 30.00	$ 46,260.00
Seeding	AC	0.13	$ 20,000.00	$ 2,600.00
			Subtotal	$ 1,133,750.00
			Utility Relocation (10%)	$ 113,380.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 283,440.00
			Right of Way (10%)	$ 113,380.00
			Construction Contingency (25%)	$ 283,440.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,927,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 2,590,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek West

Location: 17th Street & Iowa Avenue

Description of Problem: Failing Storm Sewer

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10	21		100%	210
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**210**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: Ten Pin Lane

Project ID: 10-2

Pertinent Data Summary

Watershed: Turkey Creek Central

Priority No.: 11

Design Capacity: 62 cfs (100-year, Storm Sewer + Ditch, Ten Pin)

49 cfs (100-year, Storm Sewer + Ditch, Willow Ct)

Estimated Cost: $543,000

Topographic (Section): 28N 32W Section 31

Existing Problem Description

Two properties on Willow Court have a history of yard flooding multiple times each year during heavy rain events. Runoff flows across the properties' driveways and front yards before draining down a concrete swale adjacent to the house. The concrete swale ends approximately 40 feet from Willow Court. Downstream of the concrete swale, there is erosion to the grass swale. Nearly 25 acres drain to this small concrete swale. About 70 percent of this drainage area comes from the intersection of Ten Pin Lane and Whispering Oak Drive. Stormwater drains along a concrete swale that extends from the intersection of Ten Pin Lane and Whispering Oak Drive to Willow Lane. Halfway between the swale connecting the intersection and Willow Lane is another concrete swale that flows to the west. Most of the runoff from Ten Pin Lane drains to Willow Lane instead of turning to the west. This extra stormwater floods the street and adjacent yards. Runoff is conveyed through curb and gutter and concrete swales. No enclosed storm sewer exists.

Recommended Improvements

Description: Install storm sewer along Ten Pin Lane and Willow Court. Build a 30-inch RCP to discharge drainage from Ten Pin Lane. A trapezoidal grass channel with a 5-foot bottom width, depth of 2 feet, and 3:1 side slope will convey a 100-year storm event with 1 foot of freeboard in combination with the storm sewer. A diversion berm will be required to ensure all runoff from Ten Pin Lane drains to the west instead of continuing to flow south to Willow Court. Install a 24-inch RCP to discharge drainage from Willow Court. A trapezoidal grass channel with a 5-foot bottom width, depth of 1.5 feet, and 3:1 side slope will convey a 100-year storm event with 1 foot of freeboard in combination with the storm sewer.

Water Quality: Appropriate material lining of drainage ditch should be evaluated during final design, taking into account all project goals including water quality. Increases of velocity should be avoided if possible. If not possible, increased velocities should be mitigated with proper energy dissipation. Also, design of erosion and

sediment control will be necessary to limit water quality impacts during construction of storm sewer and channel improvements.

Permitting: No permitting is anticipated.

Utility Relocations: The storm sewer and swale layout seek to avoid utilities as much as possible. A sanitary sewer line runs south along Whispering Oak Drive and Willow Court. This line intersects the storm sewer at two locations. No overhead electric exists. Storm sewer crosses gas and waterlines at the intersection of Whispering Oak Drive and Ten Pin Lane. Sanitary sewer, gas, and waterline depths are unknown and could reduce capacity of the proposed design or require relocation of sanitary sewer, gas, and waterlines during final design.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Additional right-of-way may be required where storms sewers discharge to the west if easements do not exist for the existing concrete swales. Additional right-of-way requirements will be determined based on boundary survey and final design solutions.

Downstream Controls: Not Applicable

Ten Pin Lane

(CONCEPTUAL NOT FOR CONSTRUCTION)

Remove concrete channel and replace with grass channel.

Remove concrete channel downstream of proposed grass channel. Divert all flow to proposed grass channel.

Remove concrete channel and replace with grass channel.

Whispering Oaks Dr

10 Pin Ln

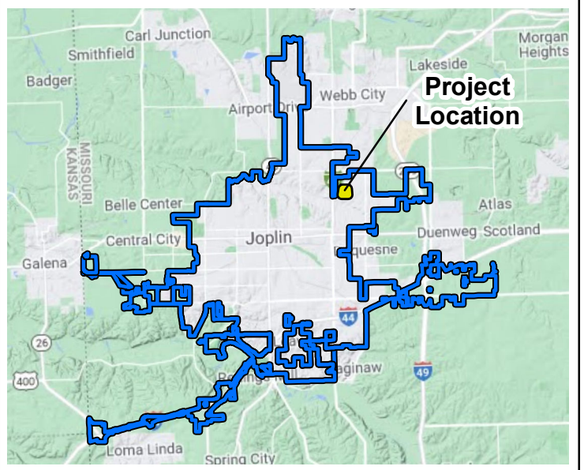
Willow Ln

Willow Ct

1025 1020 1025 1030 1025 1020 1015 1025 1010 1015 1020 1030 1035

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Proposed Channel Improvements
- 5ft Contour
- Parcels
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Ten Pin Lane

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 20,000.00	$ 20,000.00
Erosion Control	LS	1	$ 7,500.00	$ 7,500.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
15" RCP	LF	152	$ 65.00	$ 9,880.00
18" RCP	LF	547	$ 75.00	$ 41,030.00
24" RCP	LF	406	$ 100.00	$ 40,600.00
30" RCP	LF	380	$ 120.00	$ 45,600.00
24" FES	EA	1	$ 1,250.00	$ 1,250.00
30" FES	EA	1	$ 1,400.00	$ 1,400.00
Type D Curb Inlet	EA	15	$ 3,300.00	$ 49,500.00
Excavation (Trapezoidal Channel)	LF	350	$ 150.00	$ 52,500.00
Pavement Repair	SY	510	$ 55.00	$ 28,050.00
Curb & Gutter	LF	591	$ 30.00	$ 17,730.00
Driveway Repair	SY	153	$ 35.00	$ 5,360.00
Seeding	AC	0.20	$ 20,000.00	$ 4,000.00
			Subtotal	$ 334,400.00
			Utility Relocation (7.5%)	$ 25,080.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 83,600.00
			Right of Way (5%)	$ 16,720.00
			Construction Contingency (25%)	$ 83,600.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 543,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 730,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Turkey Creek Central

Location: Ten Pin Lane

Description of Problem: Street and yard flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20	3	0.5	100%	30
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	1	100%	60
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**100**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

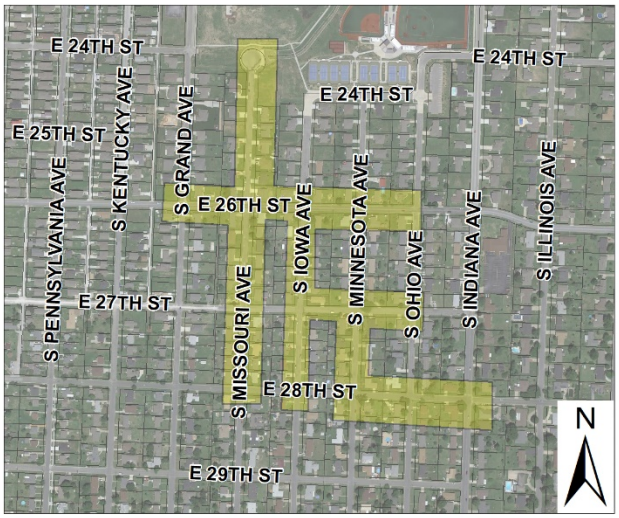
Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Durham Acres/Missouri Avenue

Project ID: 6-1



Pertinent Data Summary

Watershed:	Joplin Creek West
Priority No.:	12
Design Capacity:	210 cfs (10-year)
Estimated Cost:	$2,092,000
Topographic (Section):	27N 33W Section 14

Existing Problem Description

More than 20 properties have flooded in Durham Acres and along Missouri Avenue. Street ponding up to 12 inches has been reported during intense storms. Video from 2019 shows Missouri Avenue north of 26th Street flooding with 12 inches of swift-flowing water. The entire drainage area of the neighborhood is more than 90 acres, and it is primarily single-family residential. Runoff travels east and west to Missouri Avenue. It is then conveyed along Missouri Avenue through curb and gutter and existing storm sewer. The existing enclosed system is only located along the intersections of Iowa Avenue and Missouri Avenue and 26th Street. It then runs parallel to Missouri Avenue. The drainage ditch at the end of Missouri Avenue is the outfall. Limited and undersized storm sewer causes flooding. The current enclosed system cannot convey a 2-year storm event.

Recommended Improvements

Description: Install storm sewer throughout the drainage area. Retain the 36-inch culvert parallel to Missouri Avenue. Install an additional 4-foot-by-4-foot box culvert parallel to the 36-inch culvert. Both the 4-foot-by-4-foot box culvert and 36-inch culvert will junction with a 6-foot-by-4-foot box culvert that will discharge at the end of Missouri Avenue into the open channel. The proposed storm sewer system will have a design capacity equivalent to the 10-year storm event.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of the storm sewer improvements. In addition, the outfall into the existing open channel will be evaluated for water quality impacts.

Permitting: No permitting is anticipated.

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. Multiple sanitary sewer conflicts exist. Most of the conflicts are on 28th Street and 26th Street. A few streetlights must be relocated with the proposed layout. Also, the waterline along Missouri Avenue runs parallel to the proposed storm sewer and may require relocation. Sanitary sewer, water, and gas line depths are unknown

and may require relocation during final design to achieve the storm sewer design capacity.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Additional right-of-way at the back of existing right-of-way may be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The capacity of the drainage ditch downstream of the Missouri Avenue cul-de-sac will influence the capacity of this storm system. The open channel was recently designed and constructed with Joplin High School in 2014. Downstream tail water was assumed to be at the elevation of the crown of pipe.

Alternative Solutions: A 6-foot-by-4-foot box culvert could be used along Missouri Avenue downstream of 26th Street instead of the existing 36-inch culvert and 4-foot-by 4-foot-box culvert.

Discharge to existing channel.

Retain existing 36" RCP 26th Street North.

26th St

27th St

28th St

29th St

Pennsylvania Ave

Kentucky Ave

Grand Ave

Missouri Ave

Iowa Ave

Minnesota Ave

Ohio Ave

Indiana Ave

Illinois Ave

1020

1050

1040

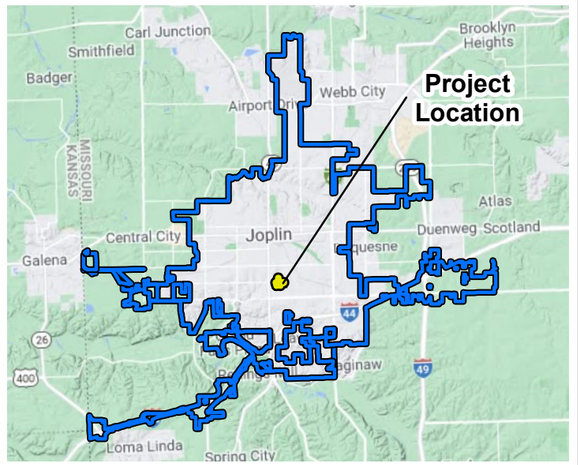
1030

1060

Durham Acres/Missouri Avenue (CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 125 250 500 Feet

1 inch = 250 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Durham Acres/Missouri Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 80,000.00	$ 80,000.00
Erosion Control	LS	1	$ 25,000.00	$ 25,000.00
Demolition	LS	1	$ 40,000.00	$ 40,000.00
15" RCP	LF	480	$ 65.00	$ 31,220.00
18" RCP	LF	2411	$ 75.00	$ 180,860.00
24" RCP	LF	1521	$ 100.00	$ 152,140.00
36" RCP	LF	739	$ 135.00	$ 99,820.00
48" RCP	LF	309	$ 155.00	$ 47,870.00
4' x 4' RCB	LF	731	$ 400.00	$ 292,520.00
6' x 4' RCB	LF	68	$ 500.00	$ 34,060.00
Type D Curb Inlet	EA	36	$ 3,300.00	$ 118,800.00
Junction Box	EA	2	$ 3,000.00	$ 6,000.00
Concrete Wingwalls and Apron for 6' x 4' Box Culvert	EA	1	$ 5,000.00	$ 5,000.00
Pavement Repair	SY	1359	$ 55.00	$ 74,750.00
Sidewalk Repair	SY	9	$ 35.00	$ 310.00
Curb & Gutter	LF	836	$ 30.00	$ 25,080.00
Driveway Repair	SY	760	$ 35.00	$ 26,590.00
Seeding	AC	1.4	$ 20,000.00	$ 27,840.00
			Subtotal	$ 1,267,860.00
			Utility Relocation (10%)	$ 126,790.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 316,970.00
			Right of Way (5%)	$ 63,390.00
			Construction Contingency (25%)	$ 316,970.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 2,092,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 2,811,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek West

Location: Durham Acres/Missouri Avenue

Description of Problem: Street flooding

Project Benefit Rating

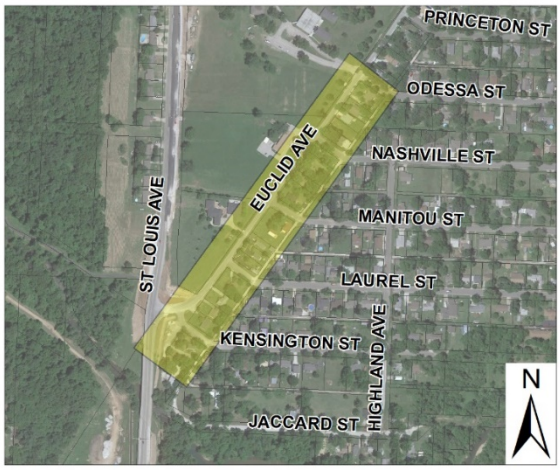
Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25	3	2	100%	150
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**180**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: Euclid Avenue

Project ID: 10-1

Pertinent Data Summary

Watershed:	Turkey Creek Central	
Priority No.:	13	
Design Capacity:	165 cfs (100-year, Ditch)	45 cfs (100-year, Storm Sewer)
Estimated Cost:	$1,044,000	
Topographic (Section):	28N 33W Section 36	

Existing Problem Description

More than 30 properties have flooded along Euclid Avenue and the parallel alley east of Euclid Avenue from Odessa Street to Kensington Street. The primary stormwater conveyance is the ditch on the west side of Euclid Avenue. Runoff from the east is directed to this ditch via pipe at the intersection of Euclid Avenue and Odessa Street. Neighbors reported the ditch west of Euclid overtopped during a 25-year storm event. The ditch has not been maintained and several driveway culverts are undersized. A small ditch that conveys runoff from the road downstream of Odessa Street is located on the east side of Euclid Avenue. Residents along the alley parallel to Euclid Avenue say the alley floods during heavy rain events. The alley is a major corridor for sanitary sewer, gas, and overhead electric.

Recommended Improvements

Description: Improve the ditch on the west side of Euclid Avenue. A trapezoidal channel with a 5-foot bottom width, depth of 3.5 feet, and 3:1 side slope will convey a 100-year storm event with 1 foot of freeboard per City of Joplin requirements. Install driveway culverts of 5-feet-by-2.5-feet. Convert the ditch on the east side of Euclid Avenue to an enclosed storm sewer with a 30-inch reinforced concrete pipe (RCP). Curb inlets will be installed on the east side of Euclid Avenue. Placement of the storm sewer and elimination of the open ditch on the east side of Euclid Avenue will allow sidewalk improvements. To avoid utility relocation costs for utilities in the alley, curb inlets will be placed on the southwest side at the intersections of Nashville Street to Kensington Street and the alley. Curb will be installed on the south side of the intersections with a roll curb at the alley entrance, creating a sump at the curb inlet. The inlets will drain into the enclosed system along Euclid Avenue.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements. In addition, the outfall into the existing channel will need to be evaluated for water quality impacts. Appropriate material lining of the west drainage ditch should be

evaluated during final design, taking into account all project goals including water quality.

Permitting: Floodplain development permit for grading in the floodplain.

Utility Relocations: The storm sewer and ditch layout seeks to avoid utilities as much as possible. The sanitary sewer at the intersection of Nashville Street and Euclid Avenue could limit the depth of the drainage ditch and/or conflict with the proposed storm sewer on the east side of Euclid Avenue. Additional conflicts with water, gas, and overhead electric exist. Sanitary sewer, water, and gas line depths are unknown and may require relocation during final design to achieve the storm sewer design capacity.

Right-of-way Acquisition: The proposed storm sewer and ditch layout was identified to stay within existing right-of-way, where possible. Minor sections of additional right-of-way may be required for the enlarged drainage channel and storm sewer along Euclid Avenue. New right-of-way extents will be determined based on boundary survey and final design solutions.

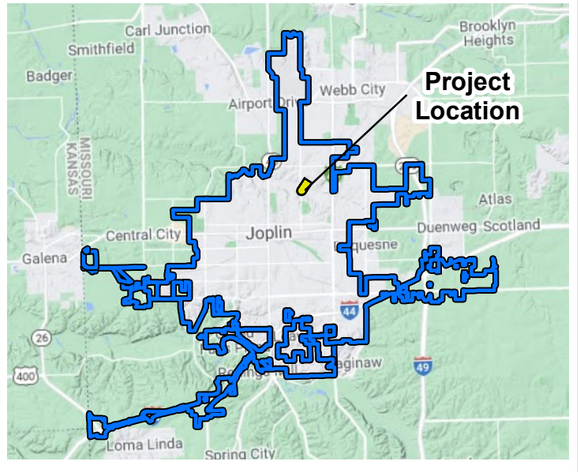
Downstream Controls: The capacity of the culvert at the intersection of St. Louis Avenue and Euclid Avenue is unknown. The size of this culvert will affect the capacity of the ditch on the west side of Euclid Avenue. Also, both the ditch and enclosed storm sewer discharge into the floodplain of Turkey Creek.

Euclid Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Proposed Channel Improvements
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

olsson

Euclid Ave

St. Louis Ave

Odessa St

Nashville St

Manitou St

Laurel St

Kensington St

Highland Ave

Patterson Ave

1020

1010

1000

990

980

970

960

950

Discharge to existing channel.

Install curb and gutter along Euclid Avenue and roll curb at each enterance along alleyway.

Discharge to existing channel.

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Euclid Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 35,000.00	$ 35,000.00
Erosion Control	LS	1	$ 15,000.00	$ 15,000.00
Demolition	LS	1	$ 20,000.00	$ 20,000.00
15" RCP	LF	637	$ 65.00	$ 41,400.00
18" RCP	LF	120	$ 75.00	$ 8,980.00
24" RCP	LF	698	$ 100.00	$ 69,790.00
30" RCP	LF	480	$ 120.00	$ 57,550.00
5' x 2.5' RCB	LF	61	$ 375.00	$ 22,770.00
Type D Curb Inlet	EA	9	$ 3,300.00	$ 29,700.00
Excavation (Trapezoidal Channel)	LF	1146	$ 150.00	$ 171,900.00
Turf Reinforcement Mat	SY	3463	$ 10.00	$ 34,630.00
Pavement Repair	SY	131	$ 55.00	$ 7,210.00
Sidewalk Improvements	SY	1820	$ 35.00	$ 63,700.00
Curb & Gutter	LF	1806	$ 30.00	$ 54,180.00
Driveway Repair	SY	255	$ 35.00	$ 8,930.00
Seeding	AC	0.10	$ 20,000.00	$ 1,920.00
			Subtotal	$ 642,660.00
			Utility Relocation (7.5%)	$ 48,200.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 160,670.00
			Right of Way (5%)	$ 32,130.00
			Construction Contingency (25%)	$ 160,670.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,044,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,403,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Turkey Creek Central

Location: Euclid Avenue

Description of Problem: Street and yard flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	1.5	100%	90
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**120**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Sunnyvale (Lloyd Addition) Storm Sewer Improvements

Project ID: 1-1



Pertinent Data Summary

Watershed:	Silver Creek
Priority No.:	14
Design Capacity:	150 cfs (10-year)
Estimated Cost:	$2,537,000
Topographic (Section):	27N 33W Section 24

Existing Problem Description

More than 20 properties have flooded in Sunnyvale (Lloyd Addition). Several feet of water have been documented along the intersections of 36th Street and Brownell Avenue and 34th Place and Brownell Avenue in 2015 and 2019. Also, nuisance flooding has been reported along many other intersections in the neighborhood. The entire drainage area of the neighborhood is 70 acres. Land use is single-family residential. Stormwater naturally flows east to Silver Creek Tributary II, which is adjacent to the properties along Brownell Avenue. Runoff is conveyed through curb and gutter. No enclosed storm sewer exists except at the intersection of 36th Street and Brownell. Flooding is a result of no underground stormwater conveyance and a floodplain issue with Silver Creek Tributary II caused by insufficient culvert capacity at Interstate 44 (I-44). Many of the properties located along Brownell Avenue are in the floodplain.

Recommended Improvements

Description:	Installing storm sewer along 34th Street to 36th Street and Brownell Avenue will ease flooding from 10-year storm events or less. The storm sewer will discharge through a 6-foot-by-4-foot box culvert into Silver Creek Tributary II just downstream of the 36th Street culvert. During 10-year storm events, street flooding along Brownell Avenue from 34th Place to 36th Street will persist but in a reduced capacity because of backwater from the I-44 culvert for Silver Creek Tributary II. A potential solution to the headwater flooding is discussed in alternative solutions.
Water Quality:	Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements. In addition, the outfall into Silver Creek Tributary II will be evaluated for water quality impacts.
Permitting:	Floodplain development permit for grading in the floodplain and a 404 nationwide permit.

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. Sanitary sewer lines along 34th Place and 35th Street travel down the middle of the street parallel to the proposed storm sewer. Relocation of these sanitary sewer lines is possible. Waterlines along 34th Street run parallel to proposed storm sewer and may require relocation. In addition, streetlight and gas conflicts exist. Relocation during final design may be necessary to achieve the storm sewer design capacity.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. Minor sections of additional right-of-way may be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The 7-foot-by-7-foot box culvert for Silver Creek Tributary II under I-44 is undersized. During a 10-year storm, ponding from the I-44 culvert floods 36th Street.

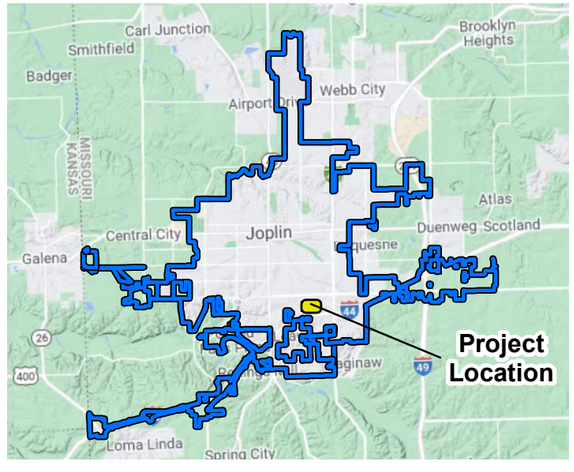
Alternative Solutions: See I-44 Culvert Addition project.

Sunnyvale (Lloyd Addition)

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Floodplain (eff. 11/01/2020)
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

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Highland Ave
Delaware Ave
McConnell Ave
Brownell Ave
Park Ave
34th St
34th Pl
35th St
36th St
1050
1040
1030
1020
1010
1000

Discharge to Silver Creek Tributary. Install energy dissipation.

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Sunnyvale (Lloyd Addition)

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 50,000.00	$ 50,000.00
Erosion Control	LS	1	$ 20,000.00	$ 20,000.00
Demolition	LS	1	$ 50,000.00	$ 50,000.00
15" RCP	LF	470	$ 65.00	$ 30,550.00
18" RCP	LF	1895	$ 75.00	$ 142,125.00
24" RCP	LF	1338	$ 100.00	$ 133,800.00
36" RCP	LF	2272	$ 135.00	$ 306,720.00
48" RCP	LF	343	$ 155.00	$ 53,165.00
4' x 4' RCB	LF	333	$ 400.00	$ 133,200.00
6' x 4' RCB	LF	65	$ 500.00	$ 32,500.00
Type D Curb Inlet	EA	47	$ 3,300.00	$ 155,100.00
Concrete Wingwalls and Apron for 6' x 4' Box Culvert	EA	1	$ 5,000.00	$ 5,000.00
Pavement Repair	SY	3950	$ 55.00	$ 217,250.00
Curb & Gutter	LF	4960	$ 30.00	$ 148,800.00
Driveway Repair	SY	1070	$ 35.00	$ 37,450.00
Seeding	AC	1.1	$ 20,000.00	$ 22,000.00
			Subtotal	$ 1,537,660.00
			Utility Relocation (10%)	$ 153,770.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 384,420.00
			Right of Way (5%)	$ 76,880.00
			Construction Contingency (25%)	$ 384,420.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 2,537,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 3,410,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Silver Creek

Location: Sunnyvale (Lloyd Addition)

Description of Problem: Street and structure flooding

Project Benefit Rating

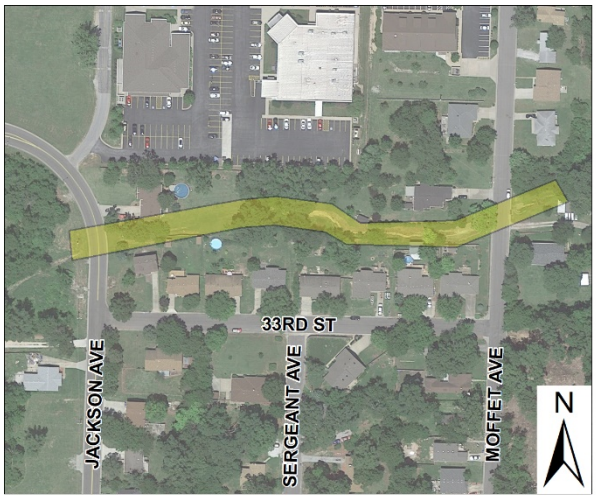
Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30	3	3	65%	175.5
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	3	75%	135
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**320.5**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: 33rd Street and Jackson Avenue

Project ID: 3-1

Pertinent Data Summary

Watershed: Water Works

Priority No.: 15

Design Capacity: 226 cfs (100-year, channel upstream Jackson Avenue)
142 cfs (100-year, channel upstream Moffet Avenue)

Estimated Cost: $424,000

Topographic (Section): 27N 33W Section 22

Existing Problem Description

Many residents have reported flooding issues caused by an unimproved open channel running between Jackson Avenue and Moffet Avenue, just North of 33rd Street. The channel runs through 10 properties where residents have reported extensive nuisance flooding of backyards and structural flooding of sheds during rainfall events at or exceeding a 10-year storm event. No residential structure flooding has been reported to date. An upstream 36-inch RCP conveys water under Moffet Avenue. A large downstream RCP culvert designed to convey most of the channel flow and a smaller overflow pipe connected to a street inlet both exist under Jackson Avenue. The size of each pipe is unknown, but the larger RCP is estimated to have a 60-inch diameter. The 60-inch RCP can convey a 25-year storm event without overtopping but is not used to its full capacity because the natural channel just before Jackson Avenue is very flat with undefined side slopes, resulting in low capacity. This inefficient drainage ditch causes backwater issues on properties upstream of the Jackson Avenue culvert. The entrance of the Moffet Avenue culvert and about 70 feet of the downstream channel is a concrete channel which transitions into a natural channel. The concrete channel is sized to convey the 100-year storm event with no freeboard, but channel erosion and overgrowth has reduced its capacity. The natural channel upstream of Moffet Avenue is undersized and only conveys the 10-year storm event with no freeboard. The 36-inch RCP under Moffet is undersized and does not have the capacity to convey a 2-year design storm.

Recommended Improvements

Description: Replace the existing 36-inch CMP under Moffet Avenue with a 48-inch RCP. The channel upstream and downstream of Moffet Avenue will be replaced with a concrete channel with a bottom width of 4 feet, height of 1.5 feet, and 4:1 side slope. The channel will convey the 100-year storm event but have no freeboard because of the proximity of several homes. The 60-inch CMP under Jackson Avenue will be replaced with a pipe of the same size, but the upstream invert of the pipe will be dropped 3 feet to allow a constant upstream concrete channel slope of around 2 percent.

Water Quality: Appropriate material lining of drainage ditch should be evaluated during final design, taking into account all project goals including water quality. Increases of velocity should be avoided if possible. If not possible, increased velocities should be mitigated with proper energy dissipation. Also, design of erosion and sediment control will be necessary to limit water quality impacts during construction.

Permitting: A 404 nationwide permit is anticipated.

Utility Relocations: Sanitary sewer and gas lines cross the channel and may limit the capacity of improvements and the ability to lower the flowline. Sanitary sewer and gas line depths are unknown and could reduce capacity of the proposed design or require relocation of sanitary sewer or gas lines during final design.

Right-of-way Acquisition: The proposed channel layout was identified to stay within existing right-of-way, where possible. It is unknown whether a drainage easement exists for the ditch between Moffet Avenue and Jackson Avenue. Additional right-of-way may be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The Jackson Avenue culvert discharges into a downstream channel that may affect the capacity of the culvert.

Alternative Solutions: The proposed concrete channel could be constructed as a natural channel. The trapezoidal channel will require a 10-foot bottom width with 3:1 side slope and a depth of 2 feet. The capacity of the proposed ditch is a 100-year storm event with no freeboard. The size of a natural channel with 1 foot of freeboard is not possible in this area without a channel with vertical walls because of the proximity of the houses.

33rd Street & Jackson Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)

32ND ST

Discharge to existing channel.

1010

1000

990

33RD ST

1030

JACKSON AVE

SERGEANT AVE

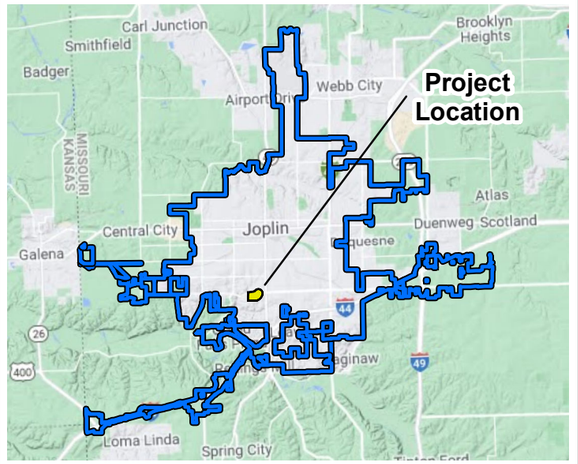
MOFFET AVE

1040

1020

Legend

- Proposed Channel Improvements
- Proposed Storm Inlets
- Proposed Storm Sewer
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
33rd Street & Jackson Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 5,000.00	$ 5,000.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
48" RCP	LF	50	$ 155.00	$ 7,750.00
48" FES	EA	2	$ 2,400.00	$ 4,800.00
60" RCP	LF	72	$ 190.00	$ 13,680.00
60" FES	EA	2	$ 3,500.00	$ 7,000.00
Pavement Repair	SY	112	$ 55.00	$ 6,160.00
Curb & Gutter	LF	112	$ 30.00	$ 3,360.00
Seeding	AC	0.50	$ 20,000.00	$ 10,000.00
Type D Curb Inlet	EA	2	$ 3,300.00	$ 6,600.00
Concrete Channel	LF	668	$ 240.00	$ 160,320.00
			Subtotal	$ 249,670.00
			Utility Relocation (10%)	$ 24,970.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 62,420.00
			Right of Way (10%)	$ 24,970.00
			Construction Contingency (25%)	$ 62,420.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 424,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 570,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Water Works

Location: 33rd Street & Jackson Avenue

Description of Problem: Ditch erosion and nuisance yard flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	1	1	100%	20
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**60**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Carolina Circle Cul-de-sac Ditch

Project ID: 7-6



Pertinent Data Summary

Watershed: Joplin Creek East

Priority No.: 16

Design Capacity: 16 cfs (10-year)

Estimated Cost: $92,000

Topographic (Section): 27N 33W Section 12

Existing Problem Description

An existing unimproved open channel runs between several houses west of Carolina Circle cul-de-sac with a capacity equal to roughly a 2-year storm event. It is estimated that up to four residential properties have experienced flooding during a 5-year storm event. The open ditch starts at the west corner of the Carolina Circle cul-de-sac and connects to a street inlet along Connecticut Avenue.

Recommended Improvements

Description: Replace the existing unimproved open channel with an enclosed storm sewer. Install a 24-inch RCP along the existing layout of the open channel. It will convey a 50-year storm event. The storm pipe will connect to the existing inlet along Connecticut Avenue. Install a double curb inlet at the sump of the Carolina Circle cul-de-sac along with an area inlet in the middle of the proposed storm sewer reach.

Water Quality: Design of erosion and sediment control will be necessary to limit water quality impacts during construction. Project is not expected to increase outlet velocity.

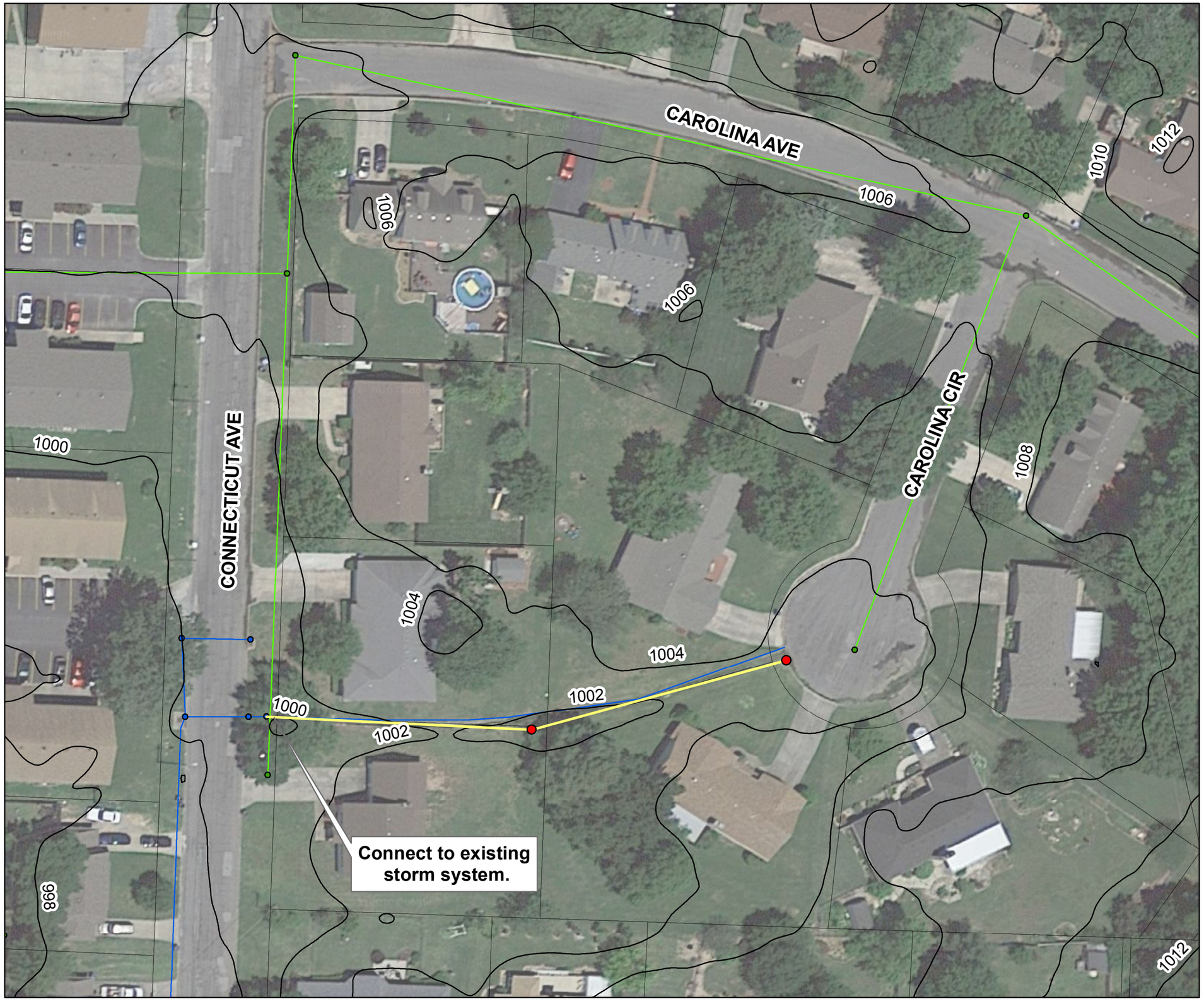
Permitting: No permitting is anticipated

Utility Relocations: The storm sewer layout follows the existing open ditch and seeks to avoid utilities as much as possible. The proposed storm sewer crosses sanitary sewer, gas, and waterlines where it connects to existing storm sewer on Connecticut Avenue. Sanitary sewer, gas, and waterline depths are unknown and could reduce capacity of the proposed design or require relocation of sanitary sewer, gas, and waterlines during final design.

Right-of-way Acquisition: It is unknown whether the City of Joplin has easements for the existing drainage ditch. If no easements exist, additional right-of-way will be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The proposed 24-inch RCP will discharge into an existing system with a smaller pipe diameter of 15 to 18 inches. This reduction in pipe size will constrict the capacity of the system but can be improved in the future.

Alternative Solutions: The proposed storm sewer pipe could be constructed as a natural channel. The trapezoidal channel will require a 2-foot bottom width with 3:1 side slope and a depth of 2.25 feet. The capacity of the proposed natural channel is a 100-year storm event with 1 foot of freeboard.

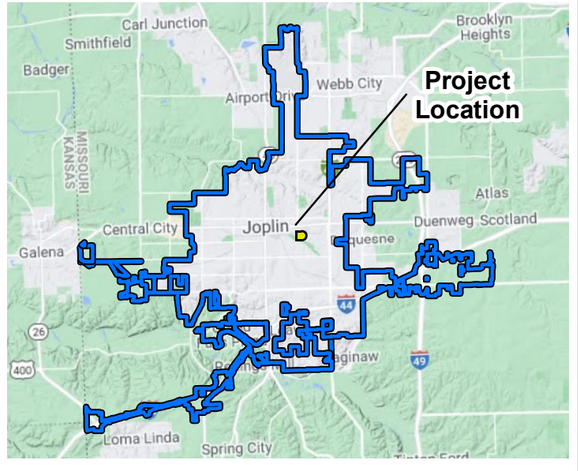


Carolina Circle Cul-de-sac Ditch

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 25 50 100 Feet

1 inch = 50 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Carolina Circle Cul-de-sac Ditch

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 2,500.00	$ 2,500.00
Erosion Control	LS	1	$ 1,000.00	$ 1,000.00
Demolition	LS	1	$ 1,500.00	$ 1,500.00
24" RCP	LF	277	$ 80.00	$ 22,160.00
Type D Curb Inlet	EA	2	$ 3,300.00	$ 6,600.00
Area Inlet	EA	1	$ 4,000.00	$ 4,000.00
Sod	AC	0.06	$ 96,800.00	$ 5,810.00
Sewer Encasement	LF	10	$ 100.00	$ 1,000.00
			Subtotal	$ 44,570.00
			Utility Relocation (10%)	$ 4,460.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 25,000.00
			Right of Way (15%)	$ 6,690.00
			Construction Contingency (25%)	$ 11,140.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 92,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 124,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: Carolina Circle Cul-de-sac Ditch

Description of Problem: Nuisance Flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**30**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

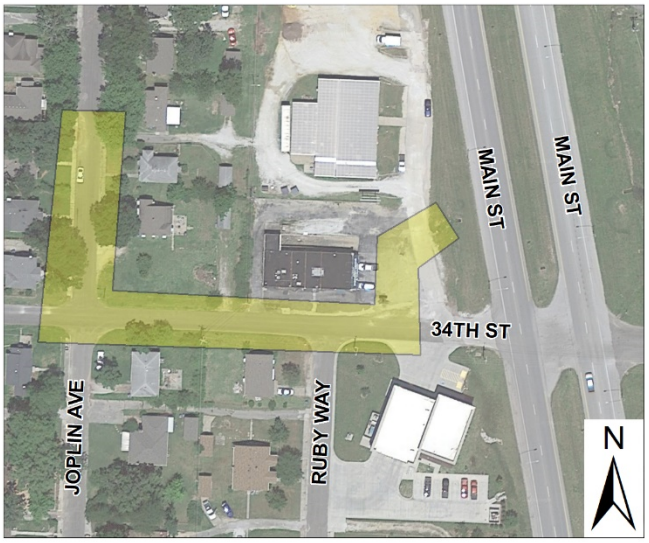
Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: 34th Street and Joplin Avenue

Project ID: 3-3



Pertinent Data Summary

Watershed:	Water Works
Priority No.:	17
Design Capacity:	27 cfs (100-year)
Estimated Cost:	$291,000
Topographic (Section):	27N 33W Section 22

Existing Problem Description

Five properties have flooded along Joplin Avenue near the sump just north of 34th Street. The four curb inlets located in this sump are undersized and in poor condition. The pipe size these inlets discharge into is unknown. During heavy rains, the sump fills up and overflows down an alleyway to the east. In 2019, the businesses downstream of the alleyway reported structural flooding from a 25-year storm event. A sanitary sewer manhole is in the middle of the four curb inlets.

Recommended Improvements

Description: Replace the four curb inlets at the sump. A 24-inch RCP would convey a 100-year storm event. The storm sewer will connect to an existing grate inlet in the parking lot of the convenience store located at the intersection of 34th Street and Main Street before discharging into the open channel along Main Street. If the existing storm sewer is adequately sized, only the curb inlets must be replaced.

Water Quality: Design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer. In addition, the outfall into the existing open channel will be evaluated for water quality impacts.

Permitting: No permitting is anticipated

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. A sanitary sewer line is located near the curb inlets. Also, the proposed storm sewer crosses sanitary sewer, water, and gas lines on 34th Street. Sanitary sewer, gas, and waterline depths are unknown and could reduce capacity of the proposed design or require relocation of sanitary sewer, gas, and waterlines during final design.

Right-of-way Acquisition: The proposed storm sewer and ditch layout was identified to stay within existing right-of-way, where possible. New right-of-way extents may be required

in the parking lot of the convenience store and will be determined based on boundary survey and final design solutions.

Downstream Controls: Not Applicable

34th Street & Joplin Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)

Discharge to open channel.

Oak Ridge Dr

Joplin Ave

Main St

12th St

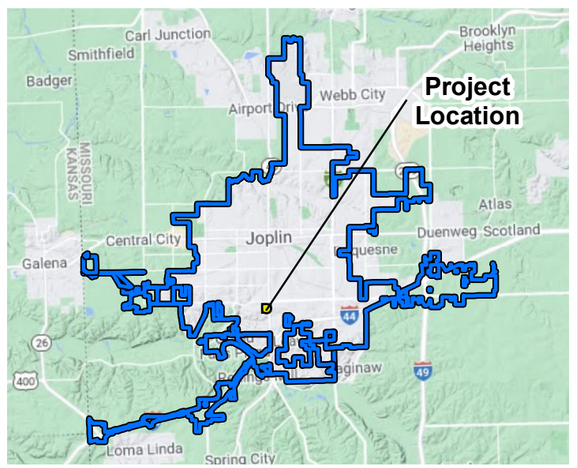
34th St

Ruby Way

1016
1050
1040
1030
1010
1020
1012
1014

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
34th Street & Joplin Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 10,000.00	$ 10,000.00
Erosion Control	LS	1	$ 4,000.00	$ 4,000.00
Demolition	LS	1	$ 5,000.00	$ 5,000.00
15" RCP	LF	50	$ 65.00	$ 3,250.00
18" RCP	LF	20	$ 75.00	$ 1,500.00
24" RCP	LF	603	$ 100.00	$ 60,300.00
24" FES	EA	1	$ 1,250.00	$ 1,250.00
Type D Inlets	EA	4	$ 3,300.00	$ 13,200.00
Grate Inlet	EA	1	$ 3,300.00	$ 3,300.00
Junction Box	EA	2	$ 3,000.00	$ 6,000.00
Pavement Repair	SY	820	$ 55.00	$ 45,100.00
Curb & Gutter	LF	410	$ 30.00	$ 12,300.00
Driveway Repair	SY	5	$ 35.00	$ 180.00
Seeding	AC	0	$ 20,000.00	$ 2,000.00
Sidewalk	SY	70	$ 35.00	$ 2,450.00
			Subtotal	$ 169,830.00
			Utility Relocation (10%)	$ 16,980.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 45,000.00
			Right of Way (10%)	$ 16,980.00
			Construction Contingency (25%)	$ 42,460.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 291,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 391,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Water Works

Location: 34th Street & Joplin Avenue

Description of Problem: Street flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30	1	0.5	100%	15
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	2	1	100%	40
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**55**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

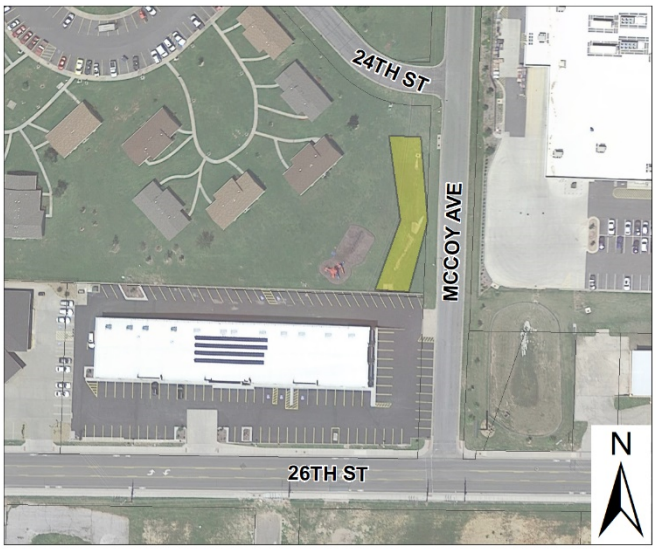
Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: 26th Street and McCoy Avenue

Project ID: 3-4



Pertinent Data Summary

Watershed: Water Works

Priority No.: 18

Design Capacity: N/A

Estimated Cost: $110,000

Topographic (Section): 27N 33W Section 16

Existing Problem Description

A 60-inch RCP running south under 1701 W. 26th Street is fed by an open channel, which is fed by a 36-inch RCP and a 48-inch CMP. The 48-inch CMP has a discharge capacity of 83 cfs and is designed to convey the 25-year storm event. The 36-inch RCP has a discharge capacity of 69 cfs and is designed to convey the 10-year storm event. The 60-inch RCP is designed to convey the 100-year storm event but is not operating at full capacity because of the open channel upstream. A difference in grade between the culvert and channel flowline combined with a metal grate at the mouth of the 60-inch RCP is limiting the discharge capacity of the pipe. The loss in discharge capacity has caused more headwater upstream of the pipe, as well as localized flooding.

Recommended Improvements

Description: Replace the existing open channel with an underground storm system. Extend the 60-inch RCP upstream and connect it with the 48-inch CMP. Extend the 36-inch RCP to the junction box for the 60-inch RCP and 48-inch CMP. Install an area inlet to drain the adjacent playground.

Water Quality: Design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer. Project is not expected to increase outlet velocity.

Permitting: No permitting is anticipated

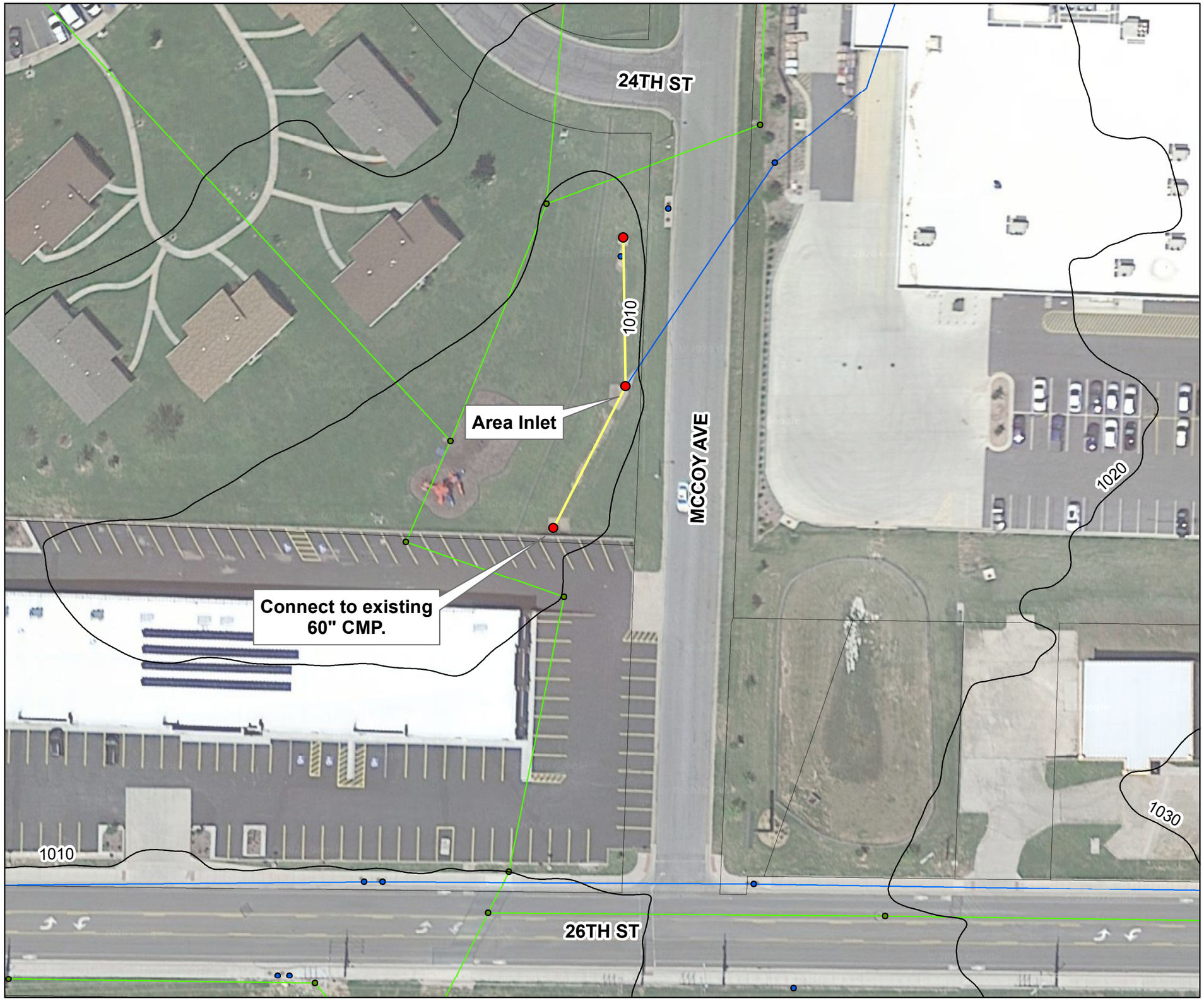
Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. No utility conflicts are anticipated for this project.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within existing right-of-way, where possible. It is unknown if there are existing easements for the open channel. If there are none, additional right-of-way will be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The proposed underground system will connect to the existing storm sewer system.

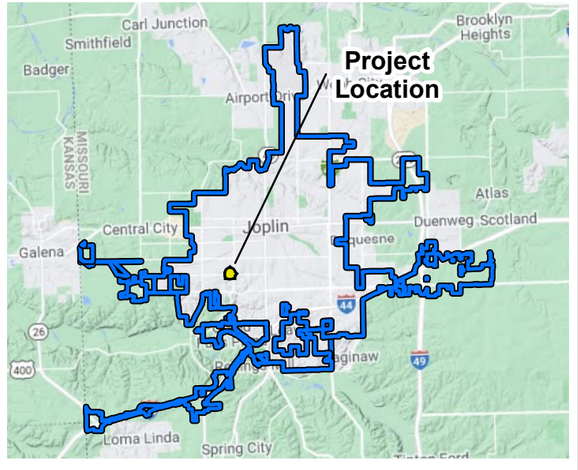
26th Street & McCoy Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 25 50 100 Feet

1 inch = 50 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
26th Street & McCoy Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 5,000.00	$ 5,000.00
Erosion Control	LS	1	$ 1,000.00	$ 1,000.00
Demolition	LS	1	$ 1,500.00	$ 1,500.00
36" RCP	LF	84	$ 135.00	$ 11,340.00
60" RCP	LF	78	$ 190.00	$ 14,820.00
Junction Box	EA	2	$ 3,000.00	$ 6,000.00
Area Inlet	EA	1	$ 4,000.00	$ 4,000.00
Seeding	AC	0.20	$ 20,000.00	$ 4,000.00
Fill	CY	1000	$ 15.00	$ 15,000.00
			Subtotal	$ 62,660.00
			Utility Relocation	$ -
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 25,000.00
			Right of Way (10%)	$ 6,270.00
			Construction Contingency (25%)	$ 15,670.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 110,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 148,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Water Works

Location: 26th Street & McCoy Avenue

Description of Problem: Storm sewer extension

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**30**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: I-44 Culvert Addition

Project ID: 1-2

Pertinent Data Summary

Watershed: Silver Creek

Priority No.: 19

Design Capacity: 1,300 cfs (100-year)

Estimated Cost: $175,000 (Conceptual Study) $5,283,000 (Total Project Cost)

Topographic (Section): 27N 33W Section 24

Existing Problem Description

Flooding problems along and near Brownell Avenue in Sunnyvale are the result of an undersized 7-foot-by-7-foot box culvert under I-44 that conveys Silver Creek Tributary II. Construction crews built the culvert in the 1950s while building I-44. Development over the past 60 years has diminished the culvert capacity to less than a 10-year storm event before flooding along Brownell Avenue occurs. The Sunnyvale neighborhood was constructed low, relative to the culvert elevation. Many of the properties located in the floodplain in Sunnyvale flood because of the undersized box culvert.

Recommended Improvements

Description: Conduct a hydraulic study to see if additional culverts under I-44 cause increases in water surface elevations beyond the confluence of Silver Creek, affecting downstream properties along Silver Creek. The study should also analyze the cost-benefit of various culvert alternatives with different trenchless installation techniques and explore the possibility of using the culvert for a trail crossing. Install the best cost-benefit culvert via trenchless techniques. Install flood control channel improvements from 36th Street to the confluence of Silver Creek. The channel improvements downstream of I-44 will be necessary to offset increase in peak flows. Install two additional 7-foot-by-6-foot box culverts and flared wingwalls under 36th Street. Necessity of further flood control improvements will be determined in the conceptual study. If feasible, install a trail from 36th Street to 44th Street along Silver Creek Tributary II and Silver Creek. The estimate is based on one 14-foot-by-10-foot box culvert alternative. This option will virtually eliminate headwater backing up to the intersection of 36th Street and Brownell Avenue except during a 500-year storm event.

Water Quality: Final design of proposed box culvert will need to evaluate impacts on water quality. Erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer improvements.

Permitting: Floodplain development permit for grading in the floodplain and a section 404 nationwide permit.

Utility Relocations: Relocation of the existing 24-inch sanitary sewer line is likely, although alternative alignments and profiles may be considered during the conceptual study. Conflicts with gas and water exist along Richard Joseph Boulevard. Relocation during final design may be necessary to achieve the storm sewer design capacity.

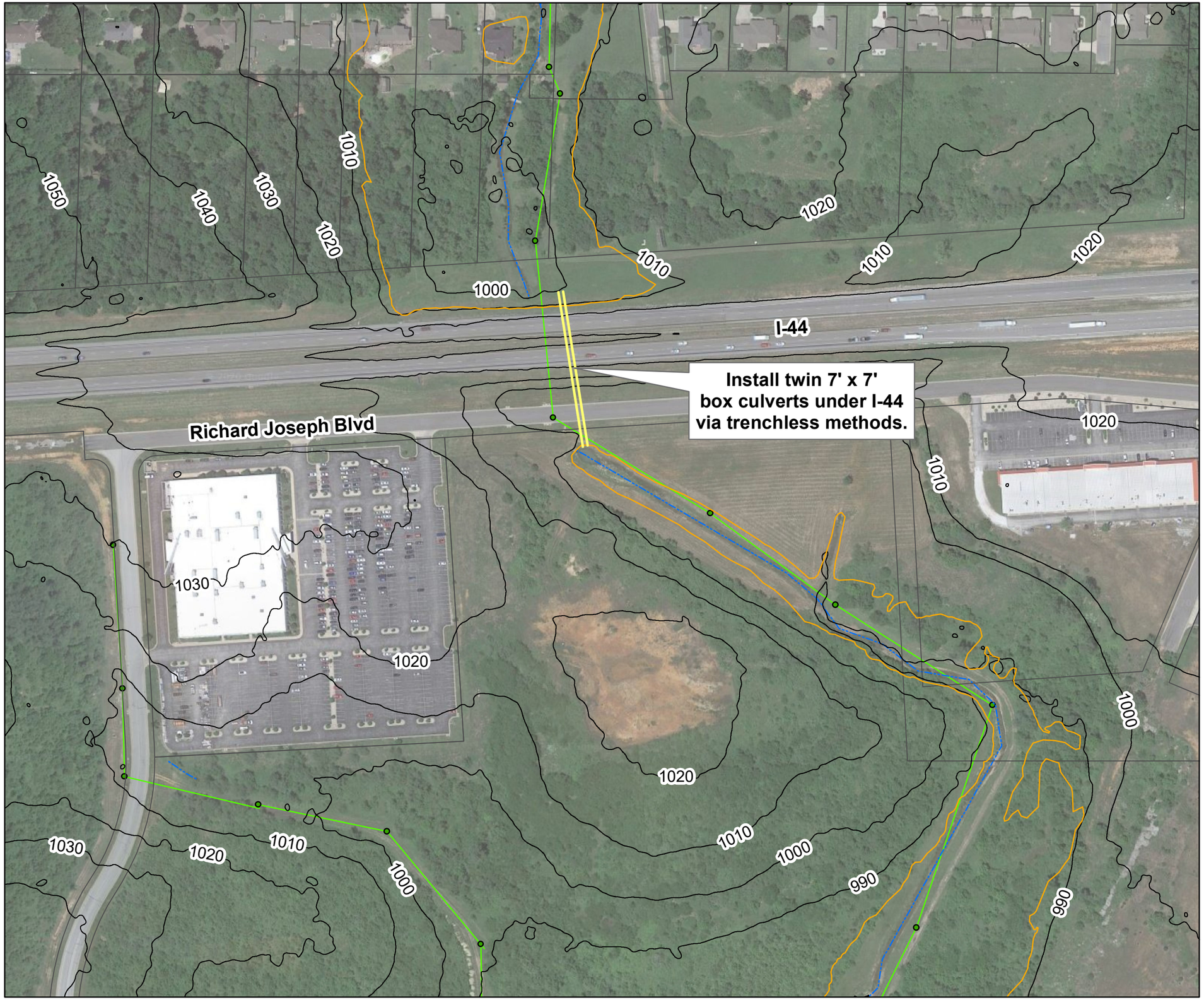
Right-of-way Acquisition: Additional right-of-way will be required downstream of I-44 along Silver Creek Tributary II to convey the increased flow. The extents of rights-of-way will be determined based on boundary survey and final design solutions.

Downstream Controls: The confluence with Silver Creek is 0.4 mile from I-44.

Alternative Solutions: The conceptual study should identify multiple alternatives. Another option is to install three 72-inch reinforced concrete pipes. Without improvements to the 36th Street bridge and downstream channel improvements to the I-44 culvert, there will still be flooding at 36th Street and Brownell Avenue. However, this option would prevent headwater from backing up to the intersection of 36th Street and Brownell Avenue during a 100-year storm event.

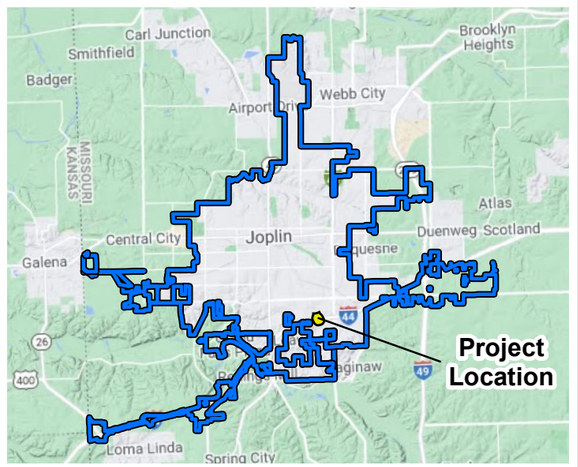
I-44 Culvert Addition

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Storm Sewer
- Floodplain (eff. 11/01/2020)
- 10ft Contours
- Parcels
- Streams
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
I-44 Culvert Addition

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 100,000.00	$ 100,000.00
Erosion Control	LS	1	$ 50,000.00	$ 50,000.00
14' x 10' RCB Trenchless Installation	LF	330	$ 5,000.00	$ 1,650,000.00
14' x 10' RCB	LF	330	$ 1,500.00	$ 495,000.00
Concrete Wingwalls and Apron for 7' x 7' Box Culvert	EA	4	$ 7,500.00	$ 30,000.00
Channel Improvements	LF	2000	$ 300.00	$ 600,000.00
Trail	SY	3945	$ 60.00	$ 236,700.00
Seeding	AC	2	$ 20,000.00	$ 40,000.00
			Subtotal	$ 3,201,700.00
			Utility Relocation (10%)	$ 320,170.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 800,430.00
			Right of Way (5%)	$ 160,090.00
			Construction Contingency (25%)	$ 800,430.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 5,283,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 7,100,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Silver Creek

Location: I-44 Culvert Addition

Description of Problem: Undersized culvert

Project Benefit Rating

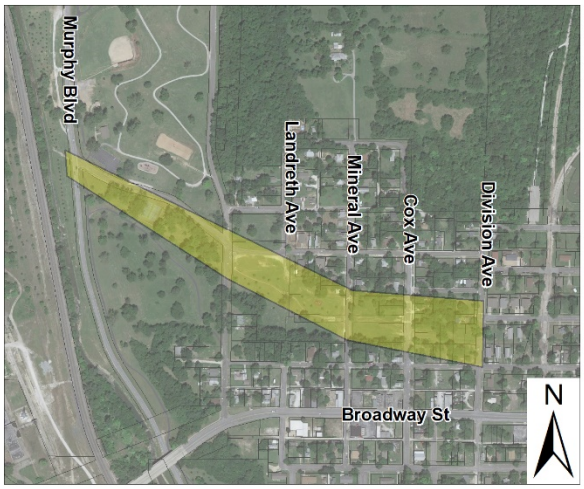
Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30	3	3	50%	135
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	3	40%	72
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				20
		Project Total Benefit Points						**237**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	Y
Aesthetics	Y

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: East Town

Project ID: 7-4

Pertinent Data Summary

Watershed:	Joplin Creek East
Priority No.:	20
Design Capacity:	365-405 cfs (25-50-year, RBC) 130 cfs (10-year, 42-inch RCP)
Estimated Cost:	$1,216,000
Topographic (Section):	27N 33W Section 2

Existing Problem Description

Two properties flood along the drainage ditch that starts at the intersection of Valley Street and Division Avenue. Extensive storm sewer conveys over 80 acres to the ditch located at the intersection of Valley Street and Division Avenue. Three culverts discharge into the ditch. The culvert coming from the northeast is undersized and can only convey a 2-year storm event. The other culverts can convey a 50-year storm event. The downstream ditch is undersized and begins to flood the structure at this intersection in less than a 2-year storm event. Nuisance flooding occurs along the ditch until it reaches Joplin Creek East. The culverts from Cox Avenue to Murphy Boulevard are undersized and can only convey a 2-year storm event before flooding the street. The undersized culvert for Mineral Avenue floods the structure on the west side of Mineral Avenue during 10-year storm events or greater. No other structure floods because several structures have been removed and park property is located along the drainage ditch from Mineral Avenue until it discharges into Joplin Creek East. The culvert at Murphy Boulevard discharges into the floodplain

Recommended Improvements

Description: Improve the ditch between Division Avenue and Cox Avenue. A trapezoidal channel with a 15-foot bottom width, depth of 4 feet, and 3:1 side slope will convey a 100-year storm event with 1 foot of freeboard per City of Joplin requirements. Install twin 9-foot-by-3-foot box culverts under Cox Avenue. Install a 10-foot-by-5-foot box culvert under Mineral Avenue. Install 12-foot-by-4-foot box culverts under Landreth Avenue and Murphy Boulevard, respectively. All of these culverts will convey a 25 - 50-year storm event.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer, channel, and culvert improvements. In addition, the outfalls into existing open channel will be evaluated for water quality impacts. Appropriate material lining of the drainage ditch improvements should be evaluated during final design, taking into account all project goals including water quality.

Permitting: A section 404 nationwide permit and floodplain development permit are anticipated.

Utility Relocations: Water and gas lines intersect Cox Avenue, Mineral Avenue, and Landreth Avenue culverts. Also, there is one sanitary sewer crossing in the ditch between Division Avenue and Cox Avenue. Sanitary sewer, water, and gas line depths are unknown and could limit the proposed design or require relocation of lines during final design.

Right-of-way Acquisition: Right-of-way acquisition of the property that floods at the intersection of Valley Street and Division Avenue will be required. No other right-of-way acquisition is anticipated.

Downstream Controls: Joplin Creek East is 120 feet downstream of the Murphy Boulevard culvert.

Alternative Solutions: Ditch improvements between Division Avenue and Cox Avenue might be more expensive than buying out the property at the intersection of Valley Street and Division Avenue.

Install 12' x4' box culvert

Install 12' x4' box culvert

Install 10' x5' box culvert

Install Twin 9'x3' box culverts

Install 42" RCP

Mineral Ave

North St

Furnace St

Valley St

Hill St

Broadway St

Central St

Landreth Ave

Murphy Blvd

Cox Ave

Division Ave

960

970

980

990

1000

1010

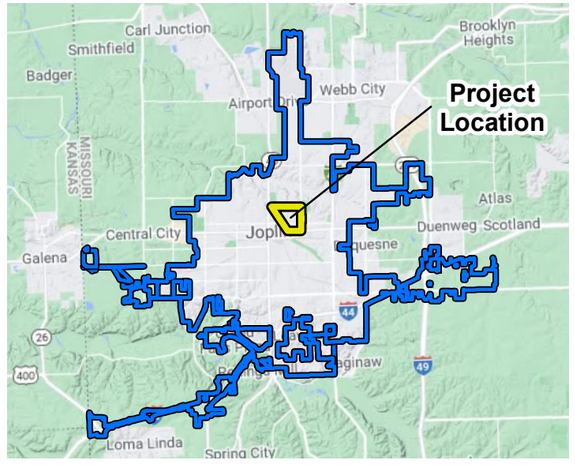
1020

East Town

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Proposed Storm Inlets
- Proposed Storm Sewer
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Streams
- Sanitary Sewer Manholes
- Sanitary Sewer



0 155 310 620 Feet

1 inch = 300 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
East Town

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 40,000.00	$ 40,000.00
Erosion Control	LS	1	$ 15,000.00	$ 15,000.00
Demolition	LS	1	$ 20,000.00	$ 20,000.00
42" RCP	LF	465	$ 145.00	$ 67,430.00
Jack & Bore 42" RCP	LF	65	$ 1,750.00	$ 113,750.00
9' x 3' RCB	LF	130	$ 600.00	$ 78,000.00
10' x 5' RCB	LF	106	$ 750.00	$ 79,500.00
12' x 4' RCB	LF	163	$ 800.00	$ 130,400.00
42" FES	EA	1	$ 2,100.00	$ 2,100.00
Concrete Wingwalls and Apron for Twin 9' x 3' Box Culvert	EA	2	$ 10,000.00	$ 20,000.00
Concrete Wingwalls and Apron for 10' x 5' Box Culvert	EA	2	$ 10,000.00	$ 20,000.00
Concrete Wingwalls and Apron for 12' x 4' Box Culvert	EA	4	$ 10,000.00	$ 40,000.00
Curb & Gutter	LF	254	$ 30.00	$ 7,620.00
Pavement Repair	SY	476	$ 55.00	$ 26,200.00
Sidewalk Repair	SY	7	$ 35.00	$ 250.00
Seeding	AC	0.27	$ 20,000.00	$ 5,330.00
Fence	LF	280.00	$ 35.00	$ 9,800.00
			Subtotal	$ 675,380.00
			Utility Relocation (10%)	$ 67,540.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 168,850.00
			Right of Way (20%)	$ 135,080.00
			Construction Contingency (25%)	$ 168,850.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,216,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,634,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: East Town

Description of Problem: Undersized culverts

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20	3	0.5	100%	30
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	3	1	100%	60
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**90**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

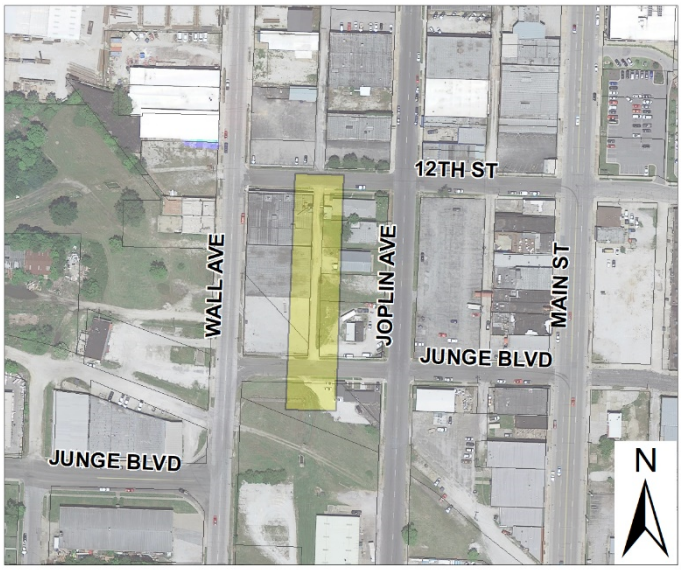
Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	Y
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: 12th Street and Wall Avenue

Project ID: 6-5



Pertinent Data Summary

Watershed: Joplin Creek West

Priority No.: 21

Design Capacity: N/A

Estimated Cost: $352,000

Topographic (Section): 28N 33W Section 10

Existing Problem Description

The 12th Street and Wall Avenue box culvert is aged and has deteriorated to the point where it requires remediation. The existing culvert is a 6-foot-by-4-foot reinforced box culvert. It is located just east of Wall Avenue in the alleyway between 12th Street and Junge Boulevard. Remediation will require either rehabilitation or replacement. If the box culvert collapsed, it could cause flooding for more than five properties and could cause potential damage and be a safety concern to adjacent buildings. The alleyway where the box culvert is located is a utility corridor for sanitary sewer and overhead electric.

Recommended Improvements

Description: The first step is to determine whether remediation or replacement is the best option. The estimate for this project is based on prices to replace the existing box culvert with another box culvert of an identical size. The proximity of existing buildings to the alleyway will be a challenge for either remediation or replacement.

Water Quality: Design of erosion and sediment control will be necessary to limit water quality impacts during construction of storm sewer. Project is not expected to increase outlet velocity.

Permitting: No permitting is anticipated

Utility Relocations: Conflicts with overhead electric exist. A sanitary sewer line runs parallel to the culvert to the east.

Right-of-way Acquisition: No right-of-way besides temporary construction easements are anticipated.

Downstream Controls: The culvert connects to an 8-foot-by-4-foot box culvert. This box culvert flows north.

12th Street & Wall Avenue

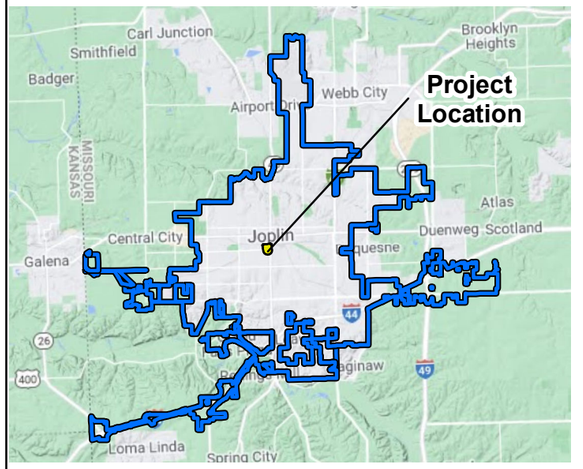
(CONCEPTUAL NOT FOR CONSTRUCTION)

Connect to Existing 8' x 4' RBC.

1016
1014
1010
1012
Wall Ave
12th St
Main St
Junge Blvd
Joplin Ave

Legend

- Proposed Storm Sewer
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 50 100 200 Feet

1 inch = 100 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
12th Street & Wall Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 5,000.00	$ 5,000.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
6' x 4' RCB	LF	326	$ 500.00	$ 163,000.00
Concrete Wingwalls and Apron for 6' x 4' Box Culvert	EA	1	$ 5,000.00	$ 5,000.00
Pavement Repair	SY	125	$ 55.00	$ 6,880.00
Curb & Gutter	LF	20	$ 30.00	$ 600.00
Gravel	SY	460	$ 15.00	$ 6,900.00
Seeding	AC	0.05	$ 20,000.00	$ 1,000.00
			Subtotal	$ 213,380.00
			Utility Relocation (10%)	$ 21,340.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 53,350.00
			Right of Way (5%)	$ 10,670.00
			Construction Contingency (25%)	$ 53,350.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 352,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 473,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek West

Location: 12th Street & Wall Avenue

Description of Problem: Failing storm sewer

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10	4		100%	40
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**40**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Massachusetts Avenue and Murphy Boulevard

Project ID: 7-3



Pertinent Data Summary

Watershed: Joplin Creek East

Priority No.: 22

Design Capacity: N/A

Estimated Cost: $967,000

Topographic (Section): 27N 33W Section 11

Existing Problem Description

Seven properties have reported nuisance groundwater along Massachusetts Avenue from Joplin Creek. The creek is located to the west behind the houses on Massachusetts Avenue. Nuisance groundwater has been limited to City of Joplin property on Parr Hill Park. No structural flooding has been reported by any residents. Heavy rain events cause nuisance flooding along Joplin Creek. The high water table exacerbates and extends the effects in the overbank flooding for extended periods of time. Also, the streambank has deteriorated and requires stabilization.

Recommended Improvements

Description: Restore the channel from 15th Street to Murphy Boulevard to provide a natural stream alignment and restore vegetation along the streambank. Install French drains and a geotextile cellular confinement in the east overbank to stabilize the soil and reduce nuisance groundwater.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of channel restoration and soil stabilization. In addition, the outfalls into Joplin Creek will be evaluated for water quality impacts. Designer will need to determine how to mitigate disturbance below the ordinary high water mark during stream restoration.

Permitting: Floodplain development permit for grading in the floodplain and a 404 nationwide permit.

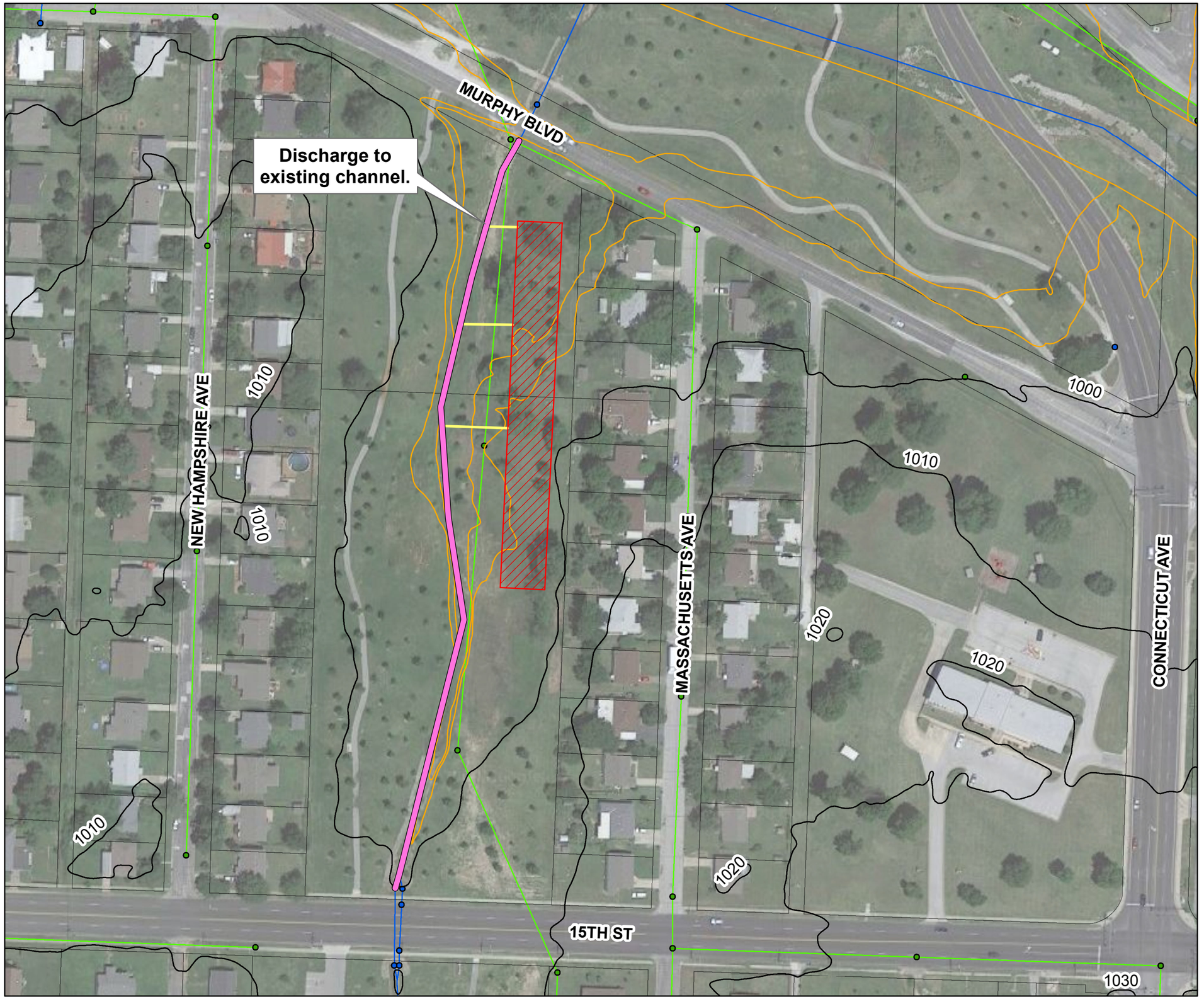
Utility Relocations: One sanitary sewer line runs parallel to Joplin Creek in the overbank. Sanitary sewer depths are unknown and could limit the proposed design or require the relocation of sanitary sewer lines during final design.

Right-of-way Acquisition: No right-of-way acquisition is anticipated. The improvements will stay within existing right-of-way with Parr Hill Park.

Downstream Controls: The project is in the floodplain. Downstream floodwater control is the Murphy Boulevard culvert.

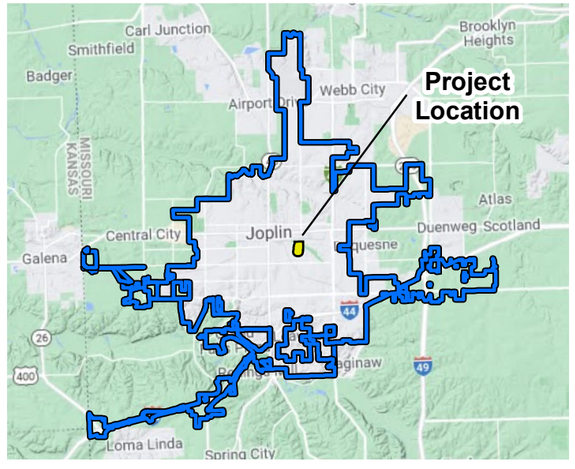
Massachusetts Avenue & Murphy Boulevard

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Channel Stabilization
- Proposed Soil Stabilization
- Proposed Storm Sewer
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 75 150 300 Feet

1 inch = 125 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Massachusetts Avenue & Murphy Boulevard

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 35,000.00	$ 35,000.00
Erosion Control	LS	1	$ 15,000.00	$ 15,000.00
Demolition	LS	1	$ 20,000.00	$ 20,000.00
Cellular Confinement Geotextile and French Drains	SY	3406	$ 65.00	$ 221,397.22
Channel Stabilization	LF	1009	$ 300.00	$ 302,700.00
Native Plants	LS	1	$ 30,000.00	$ 30,000.00
			Subtotal	$ 624,097.22
			Utility Relocation (5%)	$ 31,200.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 156,020.00
			Right of Way	$ -
			Construction Contingency (25%)	$ 156,020.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 967,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,300,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: Massachusetts Avenue & Murphy Boulevard

Description of Problem: Streambank restoration & nuisance flooding

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10			100%	
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				20
		Project Total Benefit Points						**60**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	Y

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Garvin Park Ditch

Project ID: 3-2



Pertinent Data Summary

Watershed:	Water Works
Priority No.:	23
Design Capacity:	325 cfs (50-year)
Estimated Cost:	$379,000
Topographic (Section):	27N 33W Section 14

Existing Problem Description

An existing open channel with steep side slopes and rough concrete cuts diagonally through Garvin Park, causing a hazard for citizens using the park. The open channel divides several main features of the park and causes citizens to either cross the existing bridge spanning the middle of the channel or cross the channel itself and put their safety at risk. Park staff must also regularly maintain the open channel to ensure optimal performance and safety of the channel.

Recommended Improvements

Description: Replace the existing channel with an 8-foot-by-5-foot reinforced concrete box culvert. The buried box culvert will eliminate the current risks that are present because of the open channel. A buried system will allow park features to be accessed without obstruction and provide a more enjoyable open space for citizens while also providing ease of construction for future park features. Less maintenance will also be required by park staff. Park funds may be used for this improvement.

Water Quality: Design of erosion and sediment control will be necessary to limit water quality impacts during construction.

Permitting: Jurisdictional determination is necessary to determine if a 404 permit is required.

Utility Relocations: Utility impacts should be minimal because the alignment will follow the existing open channel. The light near the middle of the ditch must be removed and replaced upon completion of the stormwater improvements.

Right-of-way Acquisition: The proposed storm sewer layout was identified to stay within the park limits, where possible. No right-of-way acquisition is anticipated for this project.

Downstream Controls: The proposed RCB will discharge into the existing storm sewer system of the same box size.

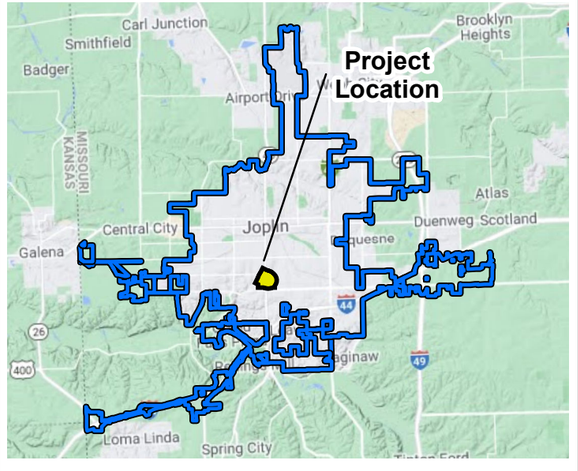
Garvin Park Ditch

(CONCEPTUAL NOT FOR CONSTRUCTION)



Legend

- Proposed Storm Sewer
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 25 50 100 Feet

1 inch = 50 feet

N

olsson

Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Garvin Park Ditch

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 5,000.00	$ 5,000.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
8' x 5' RCB	LF	326	$ 650.00	$ 211,900.00
Seeding	AC	0.18	$ 20,000.00	$ 3,600.00
			Subtotal	$ 245,500.00
			Utility Relocation (5%)	$ 12,280.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration	$ 60,000.00
			Right of Way	$ -
			Construction Contingency (25%)	$ 61,380.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 379,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 509,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Water Works

Location: Garvin Park Ditch

Description of Problem: Storm sewer extension

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5	3		100%	15
Recreation Benefit	7	Recreation benefit		20				20
		Project Total Benefit Points						**35**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

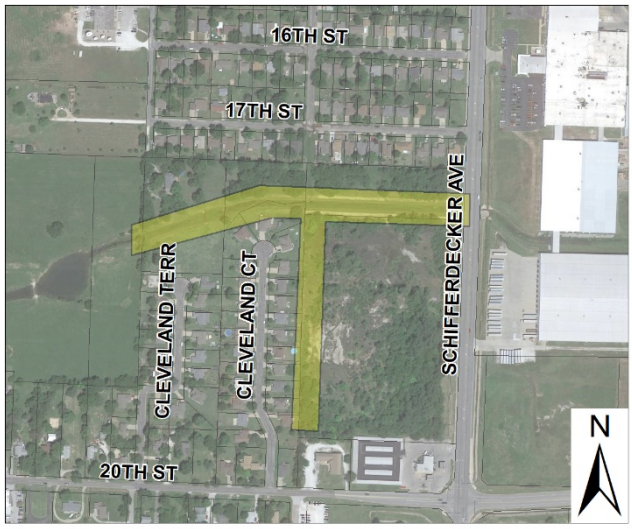
Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	Y
Aesthetics	Y

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Cleveland Court

Project ID: 5-2



Pertinent Data Summary

Watershed: Country Club

Priority No.: 24

Design Capacity: N/A

Estimated Cost: $1,061,000

Topographic (Section): 27N 33W Section 08

Existing Problem Description

More than 12 properties have experienced nuisance flooding from the ditch east of Cleveland Court north of 20th Street and from the unimproved ditch that is north of Cleveland Court and west of Schifferdecker Avenue. The unimproved ditch is an unnamed tributary for Short Creek. The flooding issues for the ditch east of Cleveland Court are the result of the ill-defined channel that meanders across properties that have fences. For this reason, the capacity of the ditch is unknown. The drainage area is nearly 9 acres. The unnamed tributary for Short Creek has a capacity of a 25-year storm event with no freeboard. The existing channel is well defined but has thick vegetation. The slope of this channel is only 0.3 percent. The drainage area is 670 acres. The section of the creek is in the floodplain.

Recommended Improvements

Description: Dig a trapezoidal drainage ditch east of Cleveland Court behind the residential properties with a 7.5-foot bottom width, depth of 2 feet, and 4:1 side slope. The capacity of the proposed ditch will be a 100-year storm event with 1 foot of freeboard. For the unnamed tributary for Short Creek, replace the existing channel with a concrete channel. This ditch will convey a 100-year storm with 1 foot of freeboard.

Water Quality: Appropriate material lining of drainage ditch and unnamed tributary of Short Creek should be evaluated during final design, taking into account all project goals including water quality. Increases of velocity should be avoided if possible. If not possible, increased velocities should be mitigated with proper energy dissipation. Also, design of erosion and sediment control will be necessary to limit water quality impacts during construction.

Permitting: Floodplain development permit for grading in the floodplain and a 404 nationwide permit.

Utility Relocations: The drainage ditch layout seeks to avoid utilities as much as possible. A sanitary sewer line crosses the unnamed tributary for Short Creek just south of Mina Avenue. Overhead electric also exists near the proposed ditch east of Cleveland

Court. Sanitary sewer depths are unknown and could reduce capacity of the proposed design or require relocation of overhead electric and sanitary sewer lines during final design.

Right-of-way Acquisition: The proposed ditch layouts were identified to stay within existing right-of-way, where possible. Additional right-of-way may be required particularly for the ditch east of Cleveland Court and will be determined based on boundary survey and final design solutions.

Downstream Controls: Downstream of the drainage ditch is Short Creek. Tail water from Short Creek will affect capacities of each proposed ditch.

Alternative Solutions: The drainage ditch for the unnamed tributary for Short Creek could be constructed as a natural channel. The trapezoidal channel would require a 60-foot bottom width with 4:1 side slope. Depth would be 5.5 feet. The capacity of the proposed ditch is a 100-year storm event with 1 foot of freeboard.

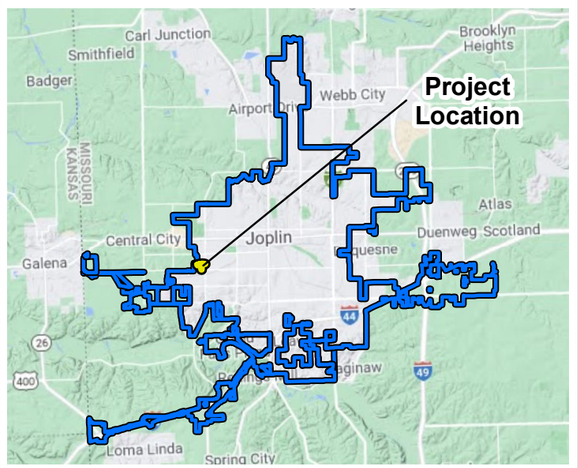
Cleveland Court

(CONCEPTUAL NOT FOR CONSTRUCTION)

Cleveland Ave
Mina Ave
16th St
17th St
1020
1030
1010
1040
Tie into existing channel.
Discharge to existing channel.
Cleveland Terrace
Cleveland Ct
Schifferdecker Ave
20th St

Legend

- Proposed Ditch
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 100 200 400 Feet

1 inch = 200 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Cleveland Court

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 25,000.00	$ 25,000.00
Erosion Control	LS	1	$ 10,000.00	$ 10,000.00
Demolition	LS	1	$ 15,000.00	$ 15,000.00
Concrete Channel	LF	1294	$ 330.00	$ 427,020.00
Excavation (Trapezoidal Channel)	LF	860	$ 150.00	$ 129,000.00
			Subtotal	$ 606,020.00
			Utility Relocation (10%)	$ 60,600.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 151,510.00
			Right of Way (15%)	$ 90,900.00
			Construction Contingency (25%)	$ 151,510.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,061,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,426,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Country Club

Location: Cleveland Court

Description of Problem: Streambank restoration & structure flooding

Project Benefit Rating

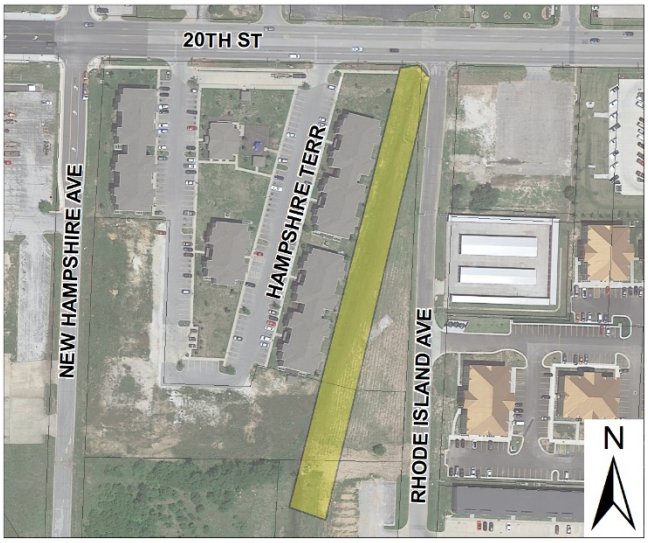
Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20	1	1	100%	20
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**50**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4



Project Name: 20th Street and Rhode Island Avenue

Project ID: 7-7

Pertinent Data Summary

Watershed: Joplin Creek East

Priority No.: 25

Design Capacity: 475 cfs (100-year)

Estimated Cost: $527,000

Topographic (Section): 27N 33W Section 11 and 14

Existing Problem Description

Two properties have flooded along the ditch west of Rhode Island Avenue south of 20th Street. Because of increased sedimentation and development in the 280-acre watershed, capacity of the ditch has decreased to a 10-year storm event. The culverts downstream of the ditch at 20th Street were recently rebuilt. Three 8-foot-by-3-foot box culverts were constructed. The third barrel (west culvert) is intentionally obstructed by concrete because right-of-way could not be acquired downstream of 20th Street. The capacity of the existing twin box culverts is a 25-year storm event.

Recommended Improvements

Description: Improve the ditch on the west side of Rhode Island Avenue by installing a concrete channel. A trapezoidal channel with a 10-foot bottom width, depth of 4 feet, and 5:1 side slope will convey a 100-year storm event with 1 foot of freeboard per City of Joplin requirements. Remove the concrete obstructions for the third box culvert and complete construction of the third culvert cell. The culvert will convey a 100-year storm event without overtopping.

Water Quality: Appropriate material lining of drainage ditch should be evaluated during final design, taking into account all project goals including water quality. Increases of velocity should be avoided if possible. If not possible, increased velocities should be mitigated with proper energy dissipation. Also, design of erosion and sediment control will be necessary to limit water quality impacts during construction of culvert and channel improvements.

Permitting: A 404 nationwide permit might be required. A jurisdictional determination will be required.

Utility Relocations: The storm sewer and ditch layout seek to avoid utilities as much as possible. The downstream culvert crosses a waterline. A sanitary line crosses near the upstream culvert but it is expected no excavation is needed to remove the blockage from the third culvert cell. Sanitary sewer and waterline depths are

unknown and could reduce capacity of the proposed design or require relocation of sanitary sewer and waterlines during final design.

Right-of-way Acquisition: Acquisition of right-of-way downstream of 20th Street will be required to use the third box culvert. Also, it is unknown if there are existing easements for the existing channel. If none exist, additional right-of-way will be required. New right-of-way extents will be determined based on boundary survey and final design solutions.

Downstream Controls: Not Applicable

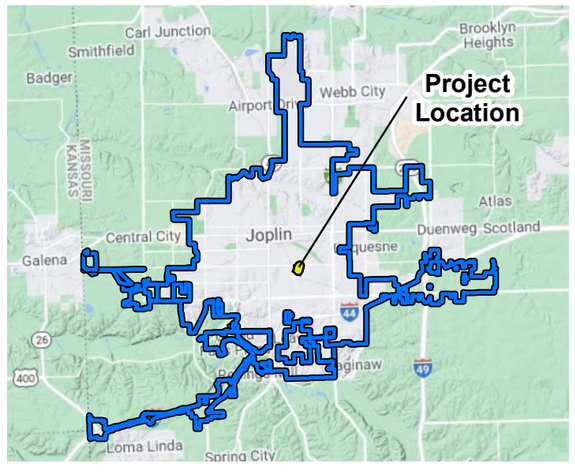


20th Street & Rhode Island Avenue

(CONCEPTUAL NOT FOR CONSTRUCTION)

Legend

- Proposed Channel Improvements
- 2ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 75 150 300 Feet

1 inch = 150 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
20th Street & Rhode Island Avenue

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 15,000.00	$ 15,000.00
Erosion Control	LS	1	$ 10,000.00	$ 10,000.00
Demolition	LS	1	$ 10,000.00	$ 10,000.00
8' x 3' RCB	LF	20	$ 550.00	$ 11,000.00
Concrete Wingwalls and Apron for 8' x 3' Box Culvert	EA	1	$ 5,000.00	$ 5,000.00
Excavation	CY	700	$ 20.00	$ 14,000.00
Concrete Channel	LF	700	$ 350.00	$ 245,000.00
			Subtotal	$ 310,000.00
			Utility Relocation (10%)	$ 31,000.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 77,500.00
			Right of Way (10%)	$ 31,000.00
			Construction Contingency (25%)	$ 77,500.00
			2021 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 527,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 708,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Joplin Creek East

Location: 20th Street & Rhode Island Avenue

Description of Problem: Undersized ditch and culvert expansion

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10	3		100%	30
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**30**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	Frequency Multiplier	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	Severity Description	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Project Name: Colorado Drive

Project ID: 1-3



Pertinent Data Summary

Watershed: Silver Creek

Priority No.: 26

Design Capacity: 235 cfs (100-year, Ditch)

Estimated Cost: $998,000

Topographic (Section): 27N 33W Section 25

Existing Problem Description

An unimproved open channel runs east to west behind 10 properties just south of Colorado Drive. The amount of area draining to this ditch is approximately 64 acres with a peak 100-year storm event of around 235 cfs. The open channel discharges into Silver Creek. No structural flooding has been reported by residents along Colorado Drive; however, scouring and erosion of property during heavy rain events has been reported. There is potential for structural damage in the future if the channel is not stabilized.

Recommended Improvements

Description: Stabilize the existing open channel that runs behind the 10 properties along Colorado Drive to mitigate further erosion and property damage. The channel will have a bottom width of 8 feet with 3:1 side slope. The depth of the channel will be 3 feet with an average channel slope of 3 percent. The capacity of the channel will be a 100-year storm event with 1 foot of freeboard.

Water Quality: Final design of erosion and sediment control will be necessary to limit water quality impacts during construction of channel and culvert improvements. Appropriate material lining of the drainage ditch improvements should be evaluated during final design, taking into account all project goals including water quality.

Permitting: Jurisdictional determination is required to determine if a 404 permit is required. Floodplain development permit for grading in the floodplain

Utility Relocations: The storm sewer layout seeks to avoid utilities as much as possible. No utility conflicts are anticipated for this project.

Right-of-way Acquisition: It is unknown if there are existing easements for the open channel. If there are none, additional right-of-way will be required and will be determined based on boundary survey and final design solutions.

Downstream Controls: The proposed improved channel will discharge into Silver Creek.

Colorado Drive

(CONCEPTUAL NOT FOR CONSTRUCTION)

JOHNSON DR

ANNIE RIDGE DR

STINNETT DR

SMITH AVE

COLORADO DR

1040

1030

1040

1030

1020

1000

1010

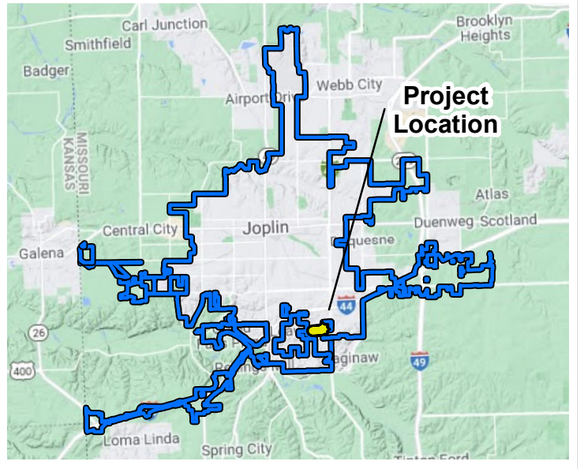
1050

Channel stabilization with trapezoidal channel.

Discharge into Silver Creek.

Legend

- Proposed Channel Improvements
- Floodplain
- 10ft Contours
- Streams
- Parcels
- Existing Storm Structures
- Existing Storm Lines
- Sanitary Sewer Manholes
- Sanitary Sewer



0 75 150 300 Feet

1 inch = 150 feet

N

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Opinion of Probable Costs
for
STORMWATER IMPROVEMENTS
for
Colorado Drive

Description	Unit	Qty	Unit Price	Extension
Mobilization and Bonds	LS	1	$ 35,000.00	$ 35,000.00
Erosion Control	LS	1	$ 15,000.00	$ 15,000.00
Demolition	LS	1	$ 20,000.00	$ 20,000.00
Channel Stabilization	LF	1723	$ 300.00	$ 516,900.00
			Subtotal	$ 586,900.00
			Utility Relocation (10%)	$ 58,690.00
			Survey, Engineering, Permitting, Construction Observation, Construction Administration (25%)	$ 146,730.00
			Right of Way (10%)	$ 58,690.00
			Construction Contingency (25%)	$ 146,730.00
			2021TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 998,000.00**
			2031 TOTAL OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,341,000.00**

Stormwater Management Plan
Project Rating Table

City of Joplin, MO Basin & Watershed: Silver Creek

Location: Colorado Drive

Description of Problem: Streambank restoration

Project Benefit Rating

Categories	Category Factor #	Description of Problems Addressed by Project	Eliminates Factor	Rating Points	Frequency Multiplier	Severity Multiplier	% Resolved by Project*	Total Points
Loss of Life	1	Loss of Life		40				
Property Flooding	2a	Flooding of habitable building	2b,2c	30				
	2b	Flooding of garages and outbuildings	2a,2c	20				
	2c	Nuisance flooding of yards	2a,2b	10				
Street Flooding	3a	Flooding of arterial street of more than 7 inches	3b,3c,3d	30				
	3b	Flooding of collector street of more than 7 inches	3a,3c,3d	25				
	3c	Flooding of residential street of more than 7 inches	3a,3b,3d	20				
	3d	Widespread or long-term ponding in streets	3a,3b,3c	20				
Structure and Property Erosion	4a	Erosion threatens habitable buildings, utilities, streets, bridges	4b	30				
	4b	Erosion to streambank/backyard	4a	10				10
Erosion to Drainage Structures	5	Erosion causes failure of drainage structure		10				
System Condition	6a	System condition rated "Poor"	6b	10				
	6b	System condition rated "Fair"	6a	5				
Recreation Benefit	7	Recreation benefit		20				
		Project Total Benefit Points						**10**

** % flood or erosion reduction achieved based on # structures removed or % of necessary base flood level reduction; 100% if meets City of Joplin design requirements*

Applies to Category Factor #	**Frequency Multiplier**	Multiplier Value
2-3	One time in ten years or by 10- to 100-year design storm	1
2-3	Two times in ten years or by 5- to 10-year design storm	2
2-3	Three or more times in 10 years or less than under 5-year design	3
6	One multiplier point per 100' of system replaced	1

Other Factors	
	Y or N?
Benefits other infr.	N
Outside cost support	N
Regional benefits	N
Aesthetics	N

Applies to Category Factor #	**Severity Description**	Multiplier Value
1	Number of known deaths *=1 for each death	8
2a, 2b	No. of buildings flooded historically or by 100-year design storm	0.5/bldg
3a,3b,3c,3d	Restricts emergency vehicles	1.5
3a,3b,3c,3d	Flooding of street between 1-3 feet	2
3a,3b,3c,3d	Flooding of street more than 3 feet	3
4a	Nuisance erosion creates maintenance problems	1
4a	Moderate erosion, failure of structure or facility within next 5 years possible	2
4a	Severe erosion, failure of structure or facility imminent	3
5	Collapse causes flooding of land by 100-year design storm	1
5	Collapse causes flooding of garages/outbuildings by 100-year design storm	1.5
5	Collapse causes 1-3 habitable buildings to be flooded	2
5	Collapse causes 4-6 habitable buildings to be flooded	3
5	Collapse causes more than 6 habitable buildings to be flooded	4

Appendix B
Figures

Joplin, MO

Stormwater Improvement Project Locations

Proposed Project Boundaries

City Limits

Major Streets

1 Ninth Street and St. Louis Avenue
2 First Street and Joplin Avenue
3 17th Street and Annie Baxter Avenue
4 Twin Hill Estates
5 Beale Street and Zora Street
6 17th Street and Mina Avenue
7 26th Street twin culverts
8 Texas Avenue
9 Old Willow Branch
10 17th Street and Iowa Avenue
11 Ten Pin Lane
12 Durham Areas / Missouri Avenue
13 Euclid Avenue
14 Sunnyvale
15 33rd Street and Jackson Avenue
16 Carolina cul-de-sac ditch
17 34th Street and Joplin Avenue
18 26th Street and McCoy Avenue
19 I-44 Culvert Addition
20 East Town
21 12th Street and Wall Avenue
22 Massachusetts Avenue and Murphy Boulevard
23 Garvin Park ditch
24 Cleveland Court
25 20th Street and Rhode Island Avenue
26 Colorado Drive

0 1/2 1 1 1/2 2 Mile

1 in = 3/8 Mile

N

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USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau, TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020

Southwest Joplin Watershed Evaluation

Short Creek
Page 1
Unknown Tributary 2
Spring Branch
Unknown Tributary 3
Shoal Creek West
Page 2
Page 3
Shoal Creek Middle
Thurman Creek
Page 4
Unknown Tributary 1
Rock Branch Tributary
Page 5
Rock Branch
Page 6
Spring Creek
Beef Branch Tributary
Shoal Creek East
Page 7

Watersheds
Watersheds - Previous Study
Joplin City Limits
Detention Areas
Stream Centerlines

N

0 1,750 3,500 Feet

1 Inch = 3,500 Feet

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Southwest Joplin Watershed Evaluation

Page 1:
Spring Branch
Short Creek
Unknown Tributary 2
Unknown Tributary 3

Short Creek

Spring Branch

Unknown Tributary 2

Unknown Tributary 3

23090 23095 23075 23080 23085 23100 23000 23005 23001 23010 23025 23015 23017 23020 22000 22005 23030 23040 23045 22010 23050 23060 23035 23065 22015 27005 23055 22020 22025 27000 23070 22030 22055 22035 22045 22060 28000 22050 28010 2165 2170 22040 28005 28015 2120 2160 2140 17045 2115 17030 17040 17150 17025 17035 17140 17145 2135 2150 2155 2110

Belle Center

Chitwood

Joplin

Duquesne

Oronogo

Webb City

Carterville

Carl Junction

Tipton Ford

Twin Hills Golf & Country Club

Schifferdecker Golf Course

Schifferdecker Park

Premier Surgical Ins

Culverts

Culverts (Not Modeled)

Watersheds

Watersheds - Previous Study

Sub-Watersheds

Joplin City Limits

Detention Areas

Stream Centerlines

N

0 1/8 1/4 Mile

1 Inch = 1/4 Mile

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Southwest Joplin Watershed Evaluation

Page 2:
Shoal Creek West

Shoal Creek West

Unknown Tributary 1

28010 28005 28015 22035 22040 22050 22060 2170 2170-01 2165 2160-01 2120 2160 2155-03 2140 2115 2155-02 2155-01 2155 17045 17040 17150 17030 17035 17140 2135 2150 2110 17025 17145 2095 17000 17055 17060 2090 2130 2145 17135 17050 2125 17175 17010 17065 2105 2200 2070 17005 17010-01 17090 17155 2100 2175 2205 17090-01 17070-01 17180 2070-01 2180-01 17155-01 2195 17015 17095-01 17070 17095 17160 17075-01 2205 2190 17020 17075 2075 17165 2080 2180 17100 17080-01 17105-01 2185 17105 17085 17170 2085 17080 17115-01 17110 26000 2225 17115 17130 26005 25080 25090 17125 26010 17120 25085 25060 25015 25065 24005 25010 25055 24005-03 24010 25005 25010 25050 25070 25095

Culverts

Culverts (Not Modeled)

Watersheds

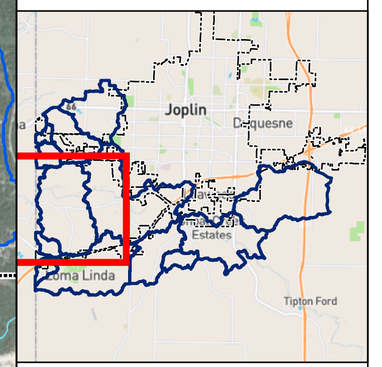
Watersheds - Previous Study

Sub-Watersheds

Joplin City Limits

Detention Areas

Stream Centerlines



N

0 1/8 1/4 Mile

1 Inch = 1/4 Mile

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Southwest Joplin Watershed Evaluation

Page 3:
Shoal Creek Middle

Shoal Creek Middle

Culverts

Culverts (Not Modeled)

Watersheds

Watersheds - Previous Study

Sub-Watersheds

Joplin City Limits

Detention Areas

Stream Centerlines

N

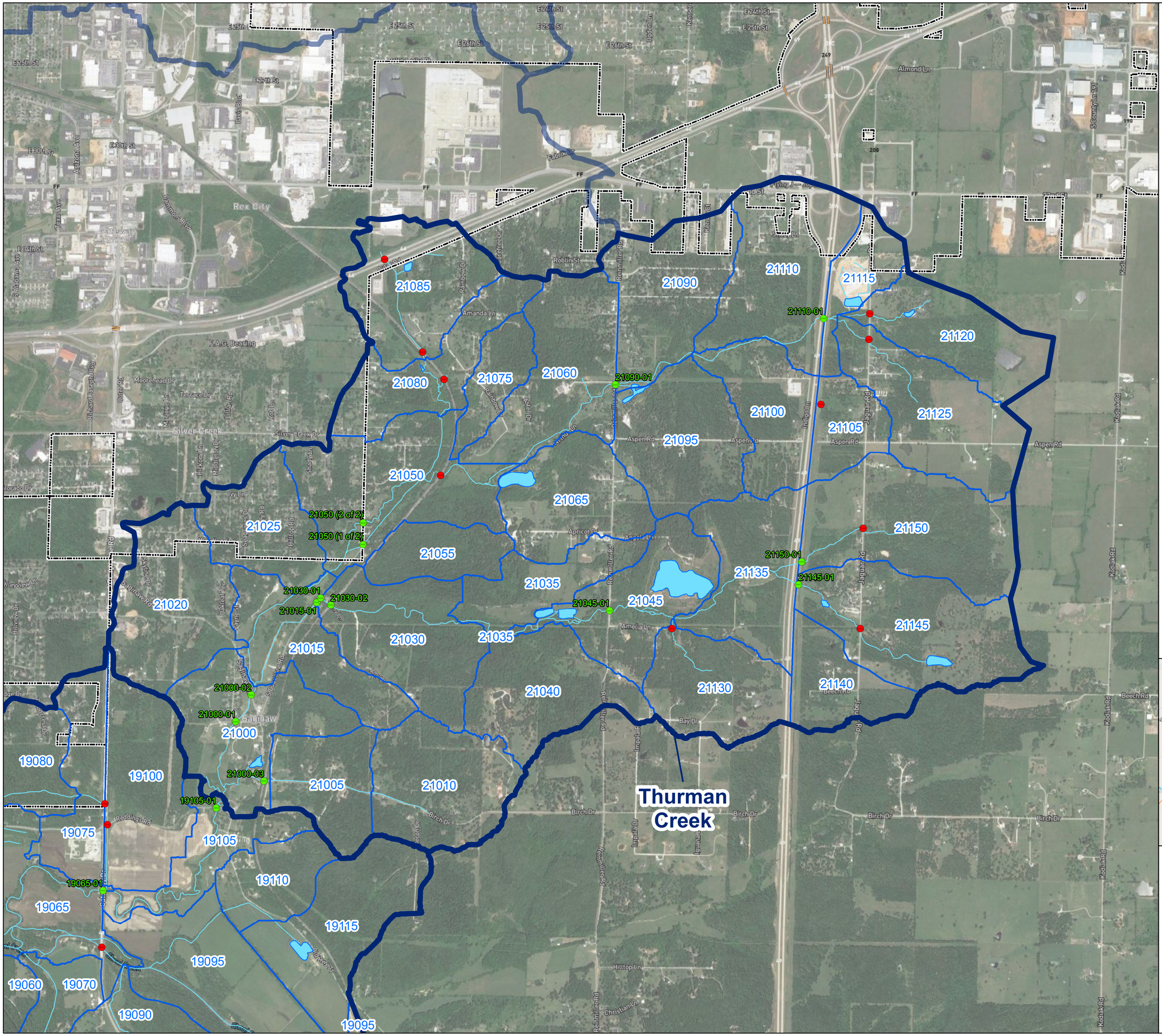
0 1/8 1/4 Mile

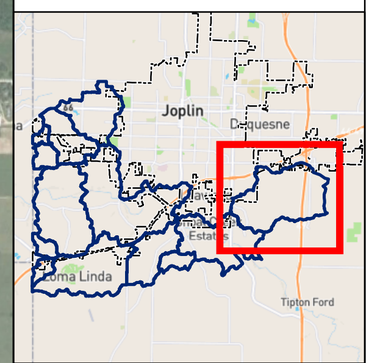
1 Inch = 1/4 Mile

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Southwest Joplin Watershed Evaluation

Page 4:
Thurman Creek





N

0 1/8 1/4 Mile

1 Inch = 1/4 Mile

- Culverts
- Culverts (Not Modeled)
- Watersheds
- Watersheds - Previous Study
- Sub-Watersheds
- Joplin City Limits
- Detention Areas
- Stream Centerlines

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Southwest Joplin Watershed Evaluation

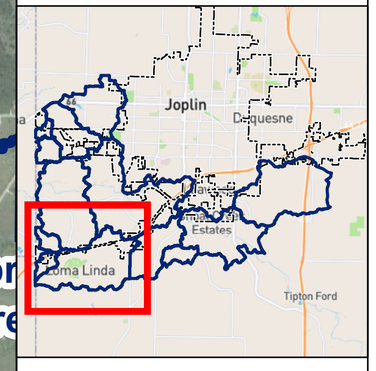
Page 5:
Rock Branch Tributary
Rock Branch
Unknown Tributary 1

Unknown Tributary 1

Rock Branch Tributary

Rock Branch

- Culverts
- Culverts (Not Modeled)
- Watersheds
- Watersheds - Previous Study
- Sub-Watersheds
- Joplin City Limits
- Detention Areas
- Stream Centerlines



N

0 1/8 1/4 Mile

1 Inch = 1/4 Mile

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Southwest Joplin Watershed Evaluation

Page 6:
Spring Creek
Beef Branch Tributary

Culverts

Culverts (Not Modeled)

Watersheds

Watersheds - Previous Study

Sub-Watersheds

Joplin City Limits

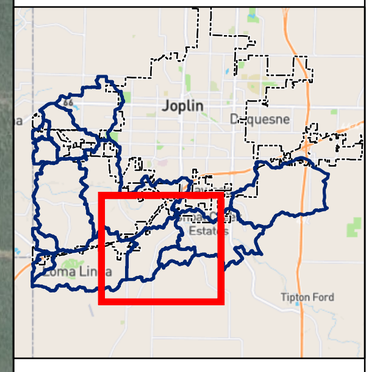
Detention Areas

Stream Centerlines

Additional Upstream Drainage

Beef Branch Tributary

Spring Creek



N

0 1/8 1/4 Mile

1 Inch = 1/4 Mile

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Southwest Joplin Watershed Evaluation

Page 7:
Shoal Creek East

Culverts

Culverts (Not Modeled)

Watersheds

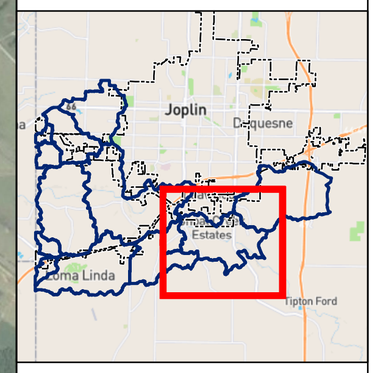
Watersheds - Previous Study

Sub-Watersheds

Joplin City Limits

Detention Areas

Stream Centerlines



N

0 1/8 1/4 Mile

1 Inch = 1/4 Mile

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Additional Upstream Drainage

Additional Upstream Drainage

Beef Branch Tributary

Shoal Creek East

Joplin Geomorphic Assessment

Tuckahoe
Page 1
Center
Royal Heights
Page 2
Baker's Branch (Oakland)
Page 3
Opossum
Leadville
Page 4
Lone Elm
Page 5
Turkey Creek Central
Page 6
Country Club
Page 7
Joplin Creek West
Page 8
Joplin Creek East
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Water Works
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Page 12
McClelland
Page 10
Silver Creek
Page 14
Shoal Creek
Page 13

Watersheds
Watersheds - 2021 Project
Stream Centerlines
Joplin City Limits

N

0 1/4 1/2 Mile

1 Inch = 1/2 Mile

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Joplin Geomorphic Assessment

Page 1: Tuckahoe Center

Tuckahoe

Center

Royal Heights

Opossum

Lone Elm

Bedrock outcrop in channel
Bank retreat
Failed riprap/concrete rubble structure
Bankline erosion
Exposed pipe crossing (abandoned?)
Bedrock outcrop
Exposed sewer line crossing
Bank erosion and channel migration
Avulsion through pond
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bank erosion and channel migration
Bank erosion/retreat?
Eroding bankline
Eroding bankline
Overbank channel
Eroding bankline
Concrete bridge floor
Concrete encased sewer line and pipe crossing
Bank erosion and migration
Erosion on outside of bend
Concrete weir for utilities crossing
Exposed pipeline?
Bankline erosion
Bankline erosion
Bankline erosion
Bank retreat
Exposed sewer line crossing
Bank erosion
Concrete being undermined by degradation and scour
Concrete lined
Exposed concrete encased utility
Concrete wall and riprap GCS?
Exposed sewer line and manhole?
Aerial sewer pipeline crossing
Overbank channel
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion

Joplin Geomorphic Assessment

Page 2:
Royal Heights
Baker's branch west

Center

Royal Heights

Baker's Branch

Not a drainage

Not a drainage

Not a channel

Not a drainage

No channel here

Split flow

No channel

Not a drainage

Not a drainage

Embankment erosion

Mass failure of embankment slope

No defined drainage

Embankment erosion?

Roadside drainage - no channel

Roadside drainage - no channel

Bank erosion threatening power pole

Exposed sewerline?

Rermnants of man-made structure

Flow split

Bank erosion

Split flow channel

Bank erosion

Bank erosion

Scour hole

Bank erosion

Exposed sewer manhole in channel

Bank erosion

Bank erosion

Recent overbank flooding and sediment deposition

Bank erosion

Scour hole

Exposed unknown concrete structure crossing

Overbank channel

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

No defined drainage

Bedrock outcrop in channel

Bank erosion

Not a drainage

Not a drainage

Sand and gravel mining turned pond

Exposed sewer line crossing

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

Bankline erosion

Exposed sewerline crossing - new riprap protection

Bankline erosion

Exposed sewerline - replaced and new riprap cover

Exposed sewerline removed - new riprap protection for US line

Exposed unknow structure

Exposed sewer line crossing

Boulder riprap?

Concrete right bank, ACBs in bed and on left bank = GCS?

Concrete or bedrock in bank

Bankline erosion

Bankline erosion

Exposed concrete encased sewer line crossing

No defined drainage or channel

No channel or drainage

Minor bank erosion

- Points of Interest
- Lines of Interest
- Areas of Interest
- Watersheds
- Watersheds - 2021 Project
- Streams
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 3:
Baker's Branch east

Baker's Branch

Split flow

Flow split

Bank erosion

Split flow channel

Bank erosion

Bank erosion

Scour hole

Boulder GCS

Bank erosion

Bank erosion

Recent overbank flooding and sediment deposition

Not a drainage

No defined drainage

Abandoned flow path

Bankline erosion

Exposed concrete encased sewer line crossing

Bankline retreat

Bankline retreat

Bankline erosion

Overbank channel

Exposed concrete encased sewer line crossing - recently removed or replaced(?)

Bank erosion

Overbank flow

Bankline erosion

Bank erosion

Bank erosion

Bank erosion

Bank erosion

Missouri Southern State University

MSSU Cross Country Course

Prosperity

- ★ Points of Interest
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1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 4:
Leadville
Opossum
Lone Elm

Opossum

Leadville

Lone Elm

Bedrock outcrop in channel
Bank retreat
Failed riprap/concrete rubble structure
Concrete wall and riprap OCS?
Bedrock outcrop
Exposed pipe crossing (abandoned?)
Bankline erosion
Exposed sewer line crossing
Bank erosion and channel migration
Avulsion through pond
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bank erosion/retreat?
Eroding bankline
Eroding bankline
Concrete encased sewer line and pipe crossing
Aerial sewer pipeline crossing
Overbank channel
Concrete bridge floor
Eroding bankline
Bank erosion and migration
Exposed pipeline?
Bankline erosion
Erosion on outside of bend
Concrete weir for utilities crossing
Bankline erosion
Bankline erosion
Bank retreat
Exposed sewer line crossing
Bank erosion
Concrete lined
Concrete being undermined by degradation and scour
Exposed concrete encased utility
Slow erosion threatening trail
Bank erosion
Flanked check structure?
Bank erosion
Flanked check structure?
Headcut
Incising channel, eroding and unstable, headcut at US end
Not a drainage
Unknown structure crossing
Bedrock outcrop in channel
Exposed sewer line crossing
Exposed pipeline crossing (gas?)
Unstable, incised, severely degraded chan
Concrete box/channel bottom
Stacked stone walls, concrete
Not a drainage
Channel goes underground
Drainage goes underground

Points of Interest
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 5:
Joplin Creek East north
Turkey Creek Central west

Bedrock outcrop in channel
Bank retreat
Failed riprap/concrete rubble structure
Bankline erosion
Exposed pipe crossing (abandoned?)
Bankline erosion
Bankline erosion
Bankline erosion
Bank erosion and channel migration
Avulsion through pond
Bankline erosion
Bankline erosion
Bankline erosion
Bank erosion and channel migration
Bank erosion/retreat?
Eroding bankline
Concrete encased sewer line and pipe crossing
Eroding bankline
Concrete bridge floor
Aerial sewer pipeline crossing
Exposed pipeline?
Bankline erosion
Concrete weir for utilities crossing
Bankline erosion
Bankline erosion
Bank retreat
Exposed sewer line crossing
Bank erosion
Concrete lined
Concrete being undermined by degradation and scour
Exposed concrete encased utility
Slow erosion threatening trail
Bank erosion
Bedrock outcrop in channel
Unknown structure crossing
Bedrock outcrop in channel
Exposed sewer line crossing
Exposed pipeline crossing (gas?)
Concrete lined channel section
Concrete bottom
Channelized
Riprap deflector/spur
Channelized
Riprap deflector/spur
Unstable, incised, severely degraded channel
Channelized
Bath St Concrete weir?
Concrete box/channel bottom
Exposed concrete encased utilities crossing?
Exposed pipeline
Concrete weir?
Unstable, severely degrading channel
Stacked stone walls, concrete bottom
Concrete wall and riprap CCS?
Exposed sewer line and manhole?
Overbank channel
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bank erosion threatening power pole
Exposed sewerline?
Rermnants of man-made structure
No defined drainage
Exposed sewer line crossing
Exposed sewerline crossing - new riprap protection
Exposed sewerline - replaced and new riprap cover
Exposed sewerline removed - new riprap protection for US line
Exposed unknown concrete structure crossing
Bedrock outcrop in channel
Bank erosion
Scour hole
Bank erosion
Not a drainage
Sand and gravel mining turned pond
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
Bankline erosion
No defined drainage or channel
No channel or drainage
Minor bank erosion
Minor bank erosion
Minor bank erosion
Minor bank erosion
Scour hole
Not a drainage
Exposed sewer line crossing
Unknown structure
Bank erosion
Bank erosion
Concrete structure across channel
Exposed utility crossing
Bank erosion
Concrete and riprap lined channel
Bank erosion
Scour hole at end of concrete channel
Bank erosion
check structure

Lone Elm
Joplin Creek West
Joplin Creek East
Turkey Creek Central

★ Points of Interest
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Joplin City Limits

N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 6:
Turkey Creek Central east

Turkey Creek Central

Joplin Creek East

Duquesne

Bank erosion
Exposed sewer manhole in channel
Scour hole
Exposed unknown concrete structure crossing
Bedrock outcrop in channel
Not a drainage
Sand and gravel mining turned pond
Bankline erosion
Exposed sewerline crossing - new riprap protection
Exposed sewerline - replaced and new riprap cover
Exposed sewerline removed - new riprap protection for US line
Exposed unknow structure
Exposed sewer line crossing
Boulder riprap?
Concrete right bank, ACBs in bed and on left bank = GCS?
Concrete or bedrock in bank
No defined drainage or channel
No channel or drainage
Minor bank erosion
Not a drainage
Scour hole
Recent overbank flooding and sediment deposition
Not a drainage
No defined drainage
Exposed concrete encased sewer line crossing
Bankline retreat
Overbank channel
Exposed concrete encased sewer line crossing - recently removed or replaced (?)
Overbank flow
Exposed sewer line crossing
Not a channel/drainage
Not a drainage
Riprap lined channel
Bank erosion

Points of Interest
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 7:
Country Club

Headcut

Incising channel, eroding and unstable, headcut at US end

Not a drainage

Not a drainage

Channel goes underground

Drainage goes underground

Underground drainage

Underground drainage

Realigned, not channel here

Not a drainage

Realigned, no channel here

Not a drainage

Rock check structure

Underground

Not a drainage

Defined, unstable channel due to uncontrolled pond overflow

Not a drainage

Not a drainage

Headcut

No defined drainage

Minor slope erosion

Toe erosion

Minor slope retreat

No defined drainage

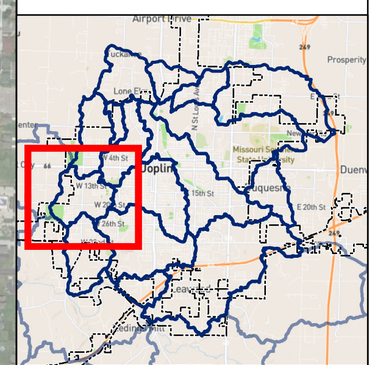
Large scour hole, undermining concrete invert

Bank erosion

Toe erosion

Country Club

- Points of Interest
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 8:
Joplin Creek West

Joplin Creek West

Exposed pipeline crossing (gas?)
Concrete lined channel section
Concrete bottom
Riprap deflector/spur
Channelized
Unstable, incised, severely degraded channel
Concrete weir?
Concrete box/channel bottom
Exposed concrete encased utilities crossing?
Exposed pipeline
Unstable, severely degrading channel
Stacked stone walls, concrete bottom
Exposed sewer line crossing
Unknown structure
Bank erosion
Concrete structure across channel
Exposed utility crossing
Concrete and riprap lined
Scour hole at end of concrete channel
Rock check structure
Underground
Not a drainage
Headcut
Headcut with incising channel DS
Aerial gas pipeline crossing
Well-defined, degrading channel, unstable
No defined drainage
Toe erosion
Minor slope erosion
Minor slope retreat
Exposed sewer line crossing
No channel or swale
Large scour hole undermining concrete invert
Bank erosion
Toe erosion
Slope failure
Beaver dam?
Temporary ponding by beaver d

Points of Interest
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 9:
Joplin Creek East south
Duquesne

Turkey Creek Central

Joplin Creek East

Duquesne

Minor bank erosion
Scour hole
Bankline retreat
Bankline erosion
Overbank channel
Exposed concrete encased sewer line crossing recently removed or replaced(?)
Bank erosion
Overbank flow
Bankline erosion
Bank erosion
Bank erosion
Bank erosion
Exposed sewer line crossing
Not a channel/drainage
No defined drainage
Not a channel/drainage
Not a drainage
Not a drainage
Exposed sewer line crossing
Bank erosion
Unknown structure
Bank erosion
Concrete structure across channel
Exposed utility crossing
Concrete and nprap lined channel
Bank erosion
Scour hole at end of concrete channel
Bank erosion
Bank erosion
Bank erosion
Scour hole
Beaver dam?
Beaver Dam?
Temporary ponding by beaver dams
Minor bank erosion
Realigned, no channel
Rock check structure

Points of Interest
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N

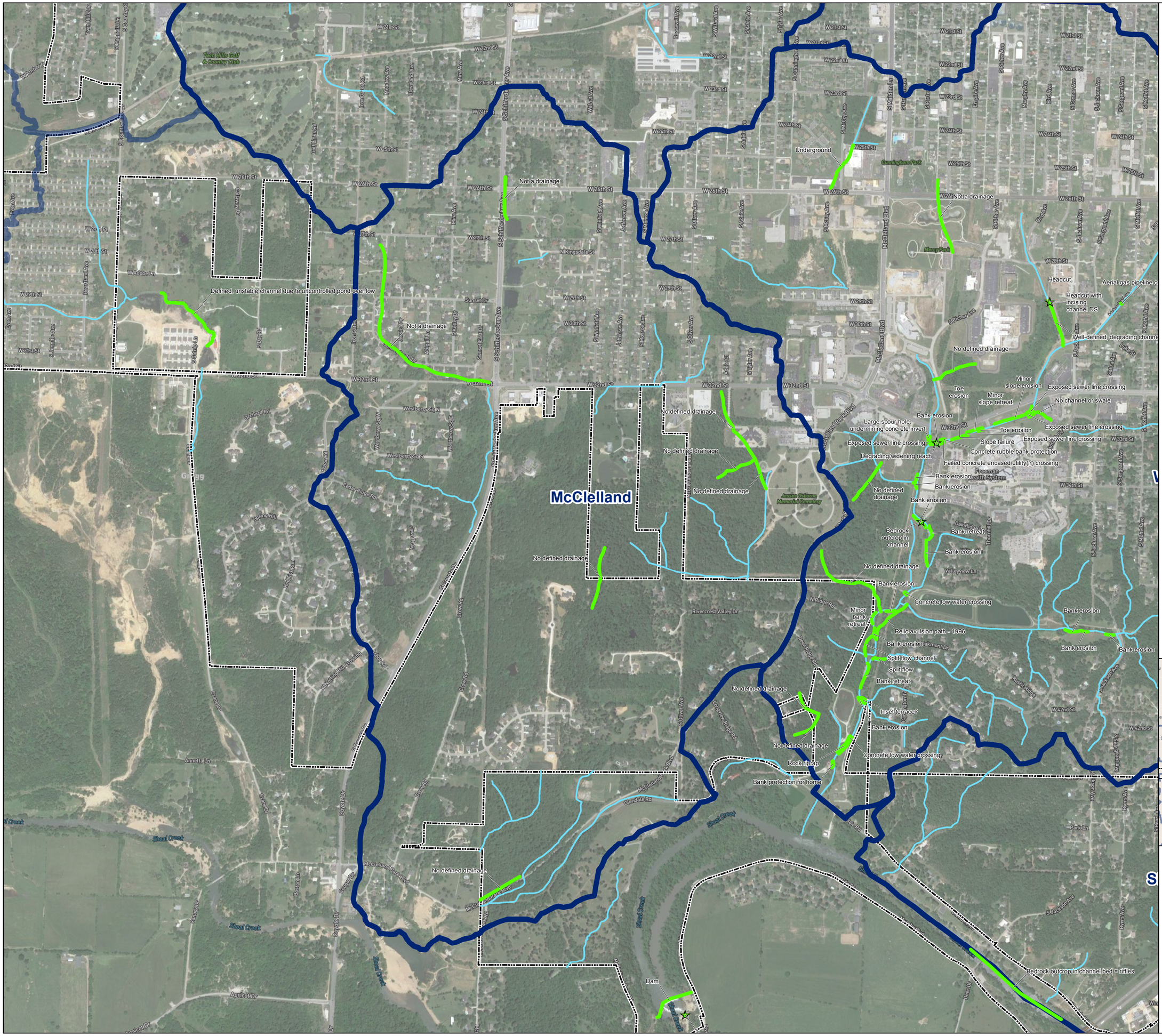
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1 Inch = 850 Feet

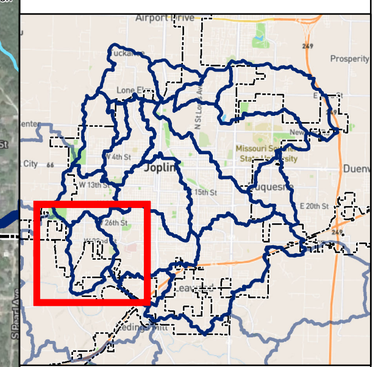
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Joplin Geomorphic Assessment

Page 10: McClelland



- Points of Interest
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 11:
Water Works

Not a drainage
Underground
Not a drainage
Headcut
Headcut with incising channel DS
Aerial gas pipeline crossing
Well-defined, degrading channel, unstable
No defined drainage
Toe erosion
Minor slope retreat
Minor slope erosion
Exposed sewer line crossing
No channel or swale
Bank erosion
Large scour hole undermining concrete invert
Exposed sewer line crossing
Toe erosion
Exposed sewer line crossing
Slope failure
Concrete rubble bank protection
Degrading widening reach
Failed concrete encased utility(?) crossing
Bank erosion
Bank erosion
No defined drainage
Bank erosion
Bedrock outcrop in channel
Bank retreat
Bank erosion
No defined drainage
Bank erosion
Concrete low water crossing
Minor bank retreat
Relic avulsion path - 1996
Bank erosion
Split flow channel
Split flow
Bank retreat
No defined drainage
Inset terrace?
Bank erosion
No defined drainage
Rock riprap
Concrete low water crossing
Bank protection for home
No defined drainage
No defined drainage
No defined drainage
No defined drainage
Bedrock outcrop control in channel
Widening, degrading channel with riprap and some grout on banks
Bedrock outcrop in channel
Old partially failed culvert
Exposed sewer line crossing?
Bank erosion
Bank erosion
Concrete weir
Concrete weir
Rock check structure
Beaver dam?
Beaver Dam?
Temporary ponding b

Water Works
Shoal Creek
Midway
Sunnyva
Silver
Denn
Acres

★ Points of Interest
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N
0 425 850
Feet
1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 12:
Silver Creek north

Duquesne

Rex City

Silver Creek

Bank erosion
Bank erosion
Bank erosion
Scour hole
Minor bank erosion
Temporary ponding by beaver dams
Realigned, no channel
Rock check structure
Flanked concrete pipe with riprap at DS end?
Riprap pipeline crossing?
1996 channel - cutoff
New bank retreat
Slowly eroding bankline
Realigned
Concrete crossing
Bank erosion and exposed pipeline
Minor toe erosion
Bank erosion
Bank and toe erosion
Minor toe erosion
Some channel degradation in this reach
Scour hole at DS end of culvert
Bank erosion
Bank erosion
Bank erosion
Bank erosion
Exposed sewer line crossing
Bank erosion
Original channel, secondary channel now
Split flow
Bank erosion
Minor bank erosion
Small, well-defined, man-made eroding channel, currently not a problem
Bank erosion
Bank erosion
Bank erosion
Bank erosion
Bank erosion

- Points of Interest
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N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 13:
Shoal Creek
Silver Creek south

Water Works

Sunnyva

Dennis Acres

Silver Creek

Shoal Creek

Shoal Creek Estates

Oak Ridge Village

Jasper Osborne Memorial Cemetery

No defined drainage

Bank erosion

Bedrock outcrop in channel

Bank retreat

Valleyview Ln

Concrete low water crossing

Minor bank retreat

Relic avulsion path - 1996

Split flow channel

Split flow

Inset terrace?

Rock riprap

Widening, degrading channel with riprap and some grout on banks

Old partially failed culvert

Exposed sewer line crossing?

Minor toe erosion

Slowly eroding bankline

New bank retreat

Bank erosion and exposed p

Original channel, secondary channel now

Minor bank erosion

Concrete weir

Rock check structure

Bedrock outcrop in channel bed = riffles

Rock check structures

Not a drainage

Split flow path (old cutoff)

New concrete bridge

Well-defined channel with extensive overbank avulsions/splays, very unstable area

Weir

Bedrock outcrop control

Unknown structure across channel?

Dam/weir

Concrete outfall

Riviera Dr

Concrete low water crossing

Split flow channel, well developed now but not in 1996, somewhat stable but could become main channel

Highly disturbed by mining, no well defined drainage, excess sediment runoff

Heavily agrraded area due to sediment input from mining, wide shallow channel, unstable

Well-defined, degrading channel, unstable

Apparent headcut

Bank erosion/retreat

Points of Interest

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Areas of Interest

Watersheds

Watersheds - 2021 Project

Streams

Joplin City Limits

N

0 425 850 Feet

1 Inch = 850 Feet

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Joplin Geomorphic Assessment

Page 14:
Silver Creek middle

Rock Check structure
Flanked concrete pipe with riprap at DS end?
Riprap pipeline crossing?
New bank retreat
Slowly eroding bankline
Bank erosion and exposed pipeline
1996 channel - cutoff
Realigned
Concrete crossing
Minor toe erosion
Bank erosion
Bank and toe erosion
Minor toe erosion
Some channel degradation in this reach
Scour hole at DS end of culvert
Bank eroison
Bank erosion
Bank erosion
Bank erosion
Bank erosion
Exposed sewer line crossing
Original channel, secondary channel now
Bank erosion
Split flow
Minor bank erosion
Small, well defined, man-made eroding channel, currently not a problem
Bank erosion
Bank erosion
Bank erosion
Bank erosion
Bank erosion
Minor bank erosion
Man-made dam
Not a drainage
Split flow path (old cutoff)
New concrete bridge
Bank erosion
No defined drainage
ed now but not in 1996, become main channel
Highly disturbed by mining, no well defined drainage, excess sediment runoff
om mining, el, unstable
Well-defined, degrading channel, unstable
Apparent headcut

Silver Creek

Rex City
Gateway Drive
Sam's Club
F.A.G. Bearing
Outer Rd
Sunnyvale
Midway
Saginaw Rd
S Range Line Rd
Woodland Dr
Martin Dr
Grandview Dr
Valleyview Dr
Southview Dr
Quail Ridge Dr
Fox Hollow Dr
Fairchild St
Arch Ln
Colorado Dr
Moorehead Dr
Terrace Dr
Keller Dr
Silver Creek Dr
Ivy Ln
Cheryl St
Tana St
Amanda Ln
Rainbow Dr
Airport Drive
Joplin
Duenweg
Prosperity

- ★ Points of Interest
- Lines of Interest
- Areas of Interest
- Watersheds
- Watersheds - 2021 Project
- Streams
- Joplin City Limits

N

0 425 850 Feet

1 Inch = 850 Feet

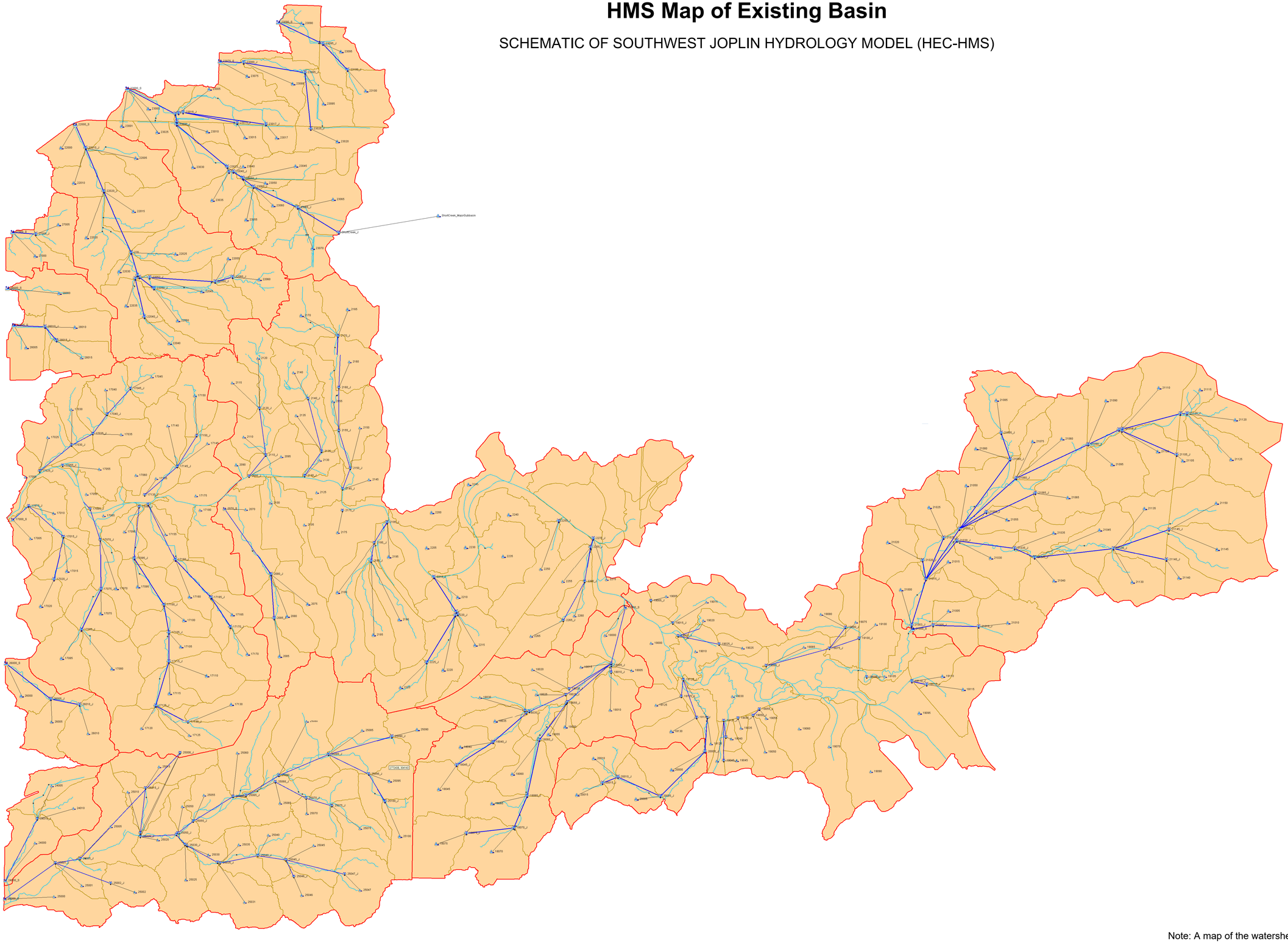
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Appendix C

Hydraulic Modeling Results

HMS Map of Existing Basin

SCHEMATIC OF SOUTHWEST JOPLIN HYDROLOGY MODEL (HEC-HMS)



Note: A map of the watersheds can be found in Appendix B

SOUTHWEST JOPLIN - HYDROLOGIC MODELING RESULTS (HEC-HMS)

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
21010	100.8	1 hr	195.6	1 hr	284.4	1 hr	365.5	1 hr	467.3	1 hr	552.9	1 hr
21010_J	100.8	1 hr	195.6	1 hr	284.4	1 hr	365.5	1 hr	467.3	1 hr	552.9	1 hr
21010_R	100.8	1 hr	195.6	1 hr	284.4	1 hr	365.5	1 hr	467.3	1 hr	552.9	1 hr
21005	42.4	1 hr	92.7	1 hr	143.5	1 hr	191.2	1 hr	251.5	1 hr	304	1 hr
21005_J	142.8	1 hr	285.8	1 hr	419.6	1 hr	543.8	1 hr	700.8	1 hr	834.6	1 hr
21020	88.7	1 hr	181.6	1 hr	271.3	1 hr	354	1 hr	458.7	1 hr	548.3	1 hr
21020_J	88.7	1 hr	181.6	1 hr	271.3	1 hr	354	1 hr	458.7	1 hr	548.3	1 hr
21150	115.9	1 hr	227.2	1 hr	328	1 hr	420.8	1 hr	538.3	1 hr	635.9	1 hr
21145	124.9	1 hr	237.3	1 hr	337.9	1 hr	430	1 hr	546	1 hr	641.6	1 hr
21145_J	240.8	1 hr	464.4	1 hr	665.8	1 hr	850.8	1 hr	1084.3	1 hr	1277.2	1 hr
21145_R	240.8	1 hr	464.4	1 hr	665.8	1 hr	850.8	1 hr	1084.3	1 hr	1277.2	1 hr
21135	53.9	3 hr	112.6	1 hr	173.2	1 hr	230.8	1 hr	306.3	1 hr	370.5	1 hr
21140	65.3	1 hr	121.3	1 hr	172.9	1 hr	219.6	1 hr	277.3	1 hr	325.9	1 hr
21140_J	65.3	1 hr	121.3	1 hr	172.9	1 hr	219.6	1 hr	277.3	1 hr	325.9	1 hr
21130	96.2	1 hr	181.8	1 hr	262	1 hr	335.2	1 hr	425.2	1 hr	501.5	1 hr
21140_R	65.3	1 hr	121.3	1 hr	172.9	1 hr	219.6	1 hr	277.3	1 hr	325.9	1 hr
21135_J	420	1 hr	819.9	1 hr	1181.3	1 hr	1514.3	1 hr	1933.5	1 hr	2281.8	1 hr
21135_R	420	1 hr	819.9	1 hr	1181.3	1 hr	1514.3	1 hr	1933.5	1 hr	2281.8	1 hr
21040	71.3	1 hr	150.6	1 hr	229.2	1 hr	302.2	1 hr	394	1 hr	473.6	1 hr
21045	48.2	3 hr	103.8	1 hr	162.6	1 hr	219.7	1 hr	294.5	1 hr	359.1	1 hr
21045_J	527.3	3 hr	1014.2	1 hr	1474.8	1 hr	1903.8	1 hr	2437.7	1 hr	2884.8	1 hr
21045_R	527.3	3 hr	1014.2	1 hr	1474.8	1 hr	1903.8	1 hr	2437.7	1 hr	2884.8	1 hr
21035	19.7	3 hr	43.2	1 hr	72.1	1 hr	100.7	1 hr	139.8	1 hr	173.8	1 hr
21035_J	546.9	3 hr	1054	1 hr	1540.1	1 hr	1995.6	1 hr	2563.4	1 hr	3036.6	1 hr
21035_R	546.9	3 hr	1054	1 hr	1540.1	1 hr	1995.6	1 hr	2563.4	1 hr	3036.6	1 hr
21030	37.3	3 hr	74.4	3 hr	120.7	1 hr	172.1	2 hr	229.6	1 hr	282.8	1 hr
21030_J	583.2	3 hr	1126.6	1 hr	1659.5	1 hr	2161.4	1 hr	2789.6	1 hr	3314.6	1 hr
21125	109.8	1 hr	204.6	1 hr	288.8	1 hr	365.7	1 hr	461.8	1 hr	540.9	1 hr
21120	81.6	1 hr	155.3	1 hr	222	1 hr	282.7	1 hr	359.2	1 hr	422.8	1 hr
21120_J	190.5	1 hr	358	1 hr	507.8	1 hr	644.4	1 hr	815.4	1 hr	957.4	1 hr
21120_R	190.5	1 hr	358	1 hr	507.8	1 hr	644.4	1 hr	815.4	1 hr	957.4	1 hr
21115	50.8	1 hr	94.6	1 hr	135.1	1 hr	172	1 hr	217.5	1 hr	255.7	1 hr
21115_J	231.1	1 hr	433.5	1 hr	613	1 hr	776.4	1 hr	981.9	1 hr	1151.1	1 hr
21115_R	231.1	1 hr	433.5	1 hr	613	1 hr	776.4	1 hr	981.9	1 hr	1151.1	1 hr
21110	93.5	1 hr	191.2	1 hr	283.6	1 hr	369.1	1 hr	478.5	1 hr	570.5	1 hr
21110_J	319.9	1 hr	613.3	1 hr	876.1	1 hr	1116.6	1 hr	1420.2	1 hr	1672.1	1 hr
21105	54.3	1 hr	99	1 hr	140.2	1 hr	177.3	1 hr	222.7	1 hr	261	1 hr
21105_J	54.3	1 hr	99	1 hr	140.2	1 hr	177.3	1 hr	222.7	1 hr	261	1 hr
21100	42.9	3 hr	85.5	1 hr	130.2	1 hr	172.5	1 hr	227	1 hr	273.1	1 hr
21105_R	54.3	1 hr	99	1 hr	140.2	1 hr	177.3	1 hr	222.7	1 hr	261	1 hr
21100_J	88.4	1 hr	177.8	1 hr	261.9	1 hr	339.6	1 hr	438.1	1 hr	521.2	1 hr
21093_J	408.1	1 hr	790.1	1 hr	1135.2	1 hr	1452.2	1 hr	1854.2	1 hr	2189.5	1 hr
21110_R	408.1	1 hr	790.1	1 hr	1135.2	1 hr	1452.2	1 hr	1854.2	1 hr	2189.5	1 hr
21090	83	1 hr	166.4	1 hr	244.1	1 hr	315.7	1 hr	407	1 hr	483.5	1 hr
21095	107.7	1 hr	219.5	1 hr	324.1	1 hr	417.9	1 hr	541.8	1 hr	639.2	1 hr
21090_J	549.3	3 hr	1048.1	1 hr	1519.7	1 hr	1961.8	1 hr	2505.5	1 hr	2956.2	1 hr
21090_R	549.3	3 hr	1048.1	1 hr	1519.7	1 hr	1961.8	1 hr	2505.5	1 hr	2956.2	1 hr
21060	83.6	1 hr	172.9	1 hr	258.2	1 hr	337.3	1 hr	438.3	1 hr	524.2	1 hr
21075	28.5	1 hr	59.2	1 hr	89.1	1 hr	116.8	1 hr	151.8	1 hr	181.8	1 hr
21060_J	654.6	3 hr	1240.1	1 hr	1800.8	1 hr	2323.1	1 hr	2969.1	1 hr	3502	1 hr
21060_R	654.6	3 hr	1240.1	1 hr	1800.8	1 hr	2323.1	1 hr	2969.1	1 hr	3502	1 hr
21085	112.1	1 hr	210.8	1 hr	301.9	1 hr	384.6	1 hr	487.3	1 hr	573.8	1 hr
21085_J	112.1	1 hr	210.8	1 hr	301.9	1 hr	384.6	1 hr	487.3	1 hr	573.8	1 hr
21085_R	112.1	1 hr	210.8	1 hr	301.9	1 hr	384.6	1 hr	487.3	1 hr	573.8	1 hr
21080	68.3	1 hr	136.5	1 hr	201.7	1 hr	261.4	1 hr	336.3	1 hr	400.3	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
21080_J	180.2	1 hr	346.6	1 hr	502.1	1 hr	643.8	1 hr	820.2	1 hr	970.5	1 hr
21080_R	180.2	1 hr	346.6	1 hr	502.1	1 hr	643.8	1 hr	820.2	1 hr	970.5	1 hr
21050	78.9	3 hr	162.2	1 hr	247.7	1 hr	328.9	1 hr	434.6	1 hr	524.1	1 hr
21055	49.6	1 hr	96.8	1 hr	141.7	1 hr	183.3	1 hr	234.8	1 hr	278.2	1 hr
21055_J	49.6	1 hr	96.8	1 hr	141.7	1 hr	183.3	1 hr	234.8	1 hr	278.2	1 hr
21065	64.7	1 hr	135.2	1 hr	203.2	1 hr	266.6	1 hr	347.8	1 hr	416.8	1 hr
21065_J	64.7	1 hr	135.2	1 hr	203.2	1 hr	266.6	1 hr	347.8	1 hr	416.8	1 hr
21065_R	64.7	1 hr	135.2	1 hr	203.2	1 hr	266.6	1 hr	347.8	1 hr	416.8	1 hr
21055_R	49.6	1 hr	96.8	1 hr	141.7	1 hr	183.3	1 hr	234.8	1 hr	278.2	1 hr
21050_J	985.2	3 hr	1873.4	1 hr	2712.7	1 hr	3486.5	1 hr	4456.6	1 hr	5263	1 hr
21050_R	985.2	3 hr	1873.4	1 hr	2712.7	1 hr	3486.5	1 hr	4456.6	1 hr	5263	1 hr
21030_R	583.2	3 hr	1126.6	1 hr	1659.5	1 hr	2161.4	1 hr	2789.6	1 hr	3314.6	1 hr
21020_R	88.7	1 hr	181.6	1 hr	271.3	1 hr	354	1 hr	458.7	1 hr	548.3	1 hr
21015	49.3	3 hr	103.4	1 hr	158.6	1 hr	211.1	1 hr	279.6	1 hr	337.7	1 hr
21025	69.6	1 hr	135	1 hr	196.2	1 hr	252	1 hr	321.8	1 hr	381.1	1 hr
21025_J	69.6	1 hr	135	1 hr	196.2	1 hr	252	1 hr	321.8	1 hr	381.1	1 hr
21025_R	69.6	1 hr	135	1 hr	196.2	1 hr	252	1 hr	321.8	1 hr	381.1	1 hr
21015_J	1741.1	3 hr	3282.8	1 hr	4787.5	1 hr	6179.8	1 hr	7928.5	1 hr	9395.6	1 hr
21015_R	1741.1	3 hr	3282.8	1 hr	4787.5	1 hr	6179.8	1 hr	7928.5	1 hr	9395.6	1 hr
21000	47.9	3 hr	101.3	1 hr	160.9	1 hr	218.7	1 hr	295.6	1 hr	361.5	1 hr
21003_J	1786.2	3 hr	3357.6	1 hr	4902	1 hr	6332.4	1 hr	8128.7	1 hr	9634.4	1 hr
21005_R	142.8	1 hr	285.8	1 hr	419.6	1 hr	543.8	1 hr	700.8	1 hr	834.6	1 hr
21000_S	1899.2	3 hr	3535.3	1 hr	5157.2	1 hr	6660.2	1 hr	8545.4	1 hr	10133.5	1 hr
18070	71.3	3 hr	152.1	1 hr	232.9	1 hr	309.4	1 hr	408.2	1 hr	492.9	1 hr
18075	120.2	1 hr	221.5	1 hr	314.9	1 hr	399.2	1 hr	502.5	1 hr	590.2	1 hr
18075_J	120.2	1 hr	221.5	1 hr	314.9	1 hr	399.2	1 hr	502.5	1 hr	590.2	1 hr
18075_R	120.2	1 hr	221.5	1 hr	314.9	1 hr	399.2	1 hr	502.5	1 hr	590.2	1 hr
18070_J	188.7	1 hr	373.4	1 hr	547.3	1 hr	707.6	1 hr	910.1	1 hr	1080.4	1 hr
18070_R	188.7	1 hr	373.4	1 hr	547.3	1 hr	707.6	1 hr	910.1	1 hr	1080.4	1 hr
18065	51.3	3 hr	106.5	1 hr	168	1 hr	227.3	1 hr	305.4	1 hr	372	1 hr
18065_J	230.5	1 hr	477.6	1 hr	713.2	1 hr	932.6	1 hr	1212.3	1 hr	1451	1 hr
18065_R	230.5	1 hr	477.6	1 hr	713.2	1 hr	932.6	1 hr	1212.3	1 hr	1451	1 hr
18060	27.4	3 hr	63.1	1 hr	108.2	1 hr	156.4	1 hr	219.1	1 hr	278.4	1 hr
18060_J	248.4	3 hr	525.4	1 hr	795.8	1 hr	1052.4	1 hr	1374.3	1 hr	1648.5	1 hr
18060_R	248.4	3 hr	525.4	1 hr	795.8	1 hr	1052.4	1 hr	1374.3	1 hr	1648.5	1 hr
18055	9.7	3 hr	21.7	1 hr	38.1	1 hr	55.1	2 hr	77.4	1 hr	97.6	1 hr
18055_J	257.8	3 hr	546.7	1 hr	832.6	1 hr	1105.3	1 hr	1448.5	1 hr	1739.6	1 hr
18050	7.9	3 hr	17.4	1 hr	29.6	1 hr	41.7	1 hr	58.2	1 hr	72.6	1 hr
18050_J	265.6	3 hr	563.7	1 hr	861.1	1 hr	1145.5	1 hr	1504.1	1 hr	1807.5	1 hr
18055_R	265.6	3 hr	563.7	1 hr	861.1	1 hr	1145.5	1 hr	1504.1	1 hr	1807.5	1 hr
18030	46.9	3 hr	93.4	1 hr	142.3	1 hr	188.7	1 hr	248.4	1 hr	299	1 hr
18045	72.7	1 hr	144.4	1 hr	210	1 hr	270.5	1 hr	347.6	1 hr	411.8	1 hr
18045_J	72.7	1 hr	144.4	1 hr	210	1 hr	270.5	1 hr	347.6	1 hr	411.8	1 hr
18045_R	72.7	1 hr	144.4	1 hr	210	1 hr	270.5	1 hr	347.6	1 hr	411.8	1 hr
18040	32.2	3 hr	70	1 hr	110.2	1 hr	149.5	1 hr	200.9	1 hr	245.8	1 hr
18040_J	104	3 hr	211.2	1 hr	313.3	1 hr	408.6	1 hr	531.5	1 hr	634.5	1 hr
18040_R	104	3 hr	211.2	1 hr	313.3	1 hr	408.6	1 hr	531.5	1 hr	634.5	1 hr
18035	34.3	3 hr	67.4	3 hr	108.2	1 hr	153.7	2 hr	203.3	1 hr	249.8	1 hr
18035_J	135.7	3 hr	273.4	1 hr	416.4	1 hr	552	1 hr	727.4	1 hr	874.4	1 hr
18030_J	46.9	3 hr	93.4	1 hr	142.3	1 hr	188.7	1 hr	248.4	1 hr	299	1 hr
18027_J	182.6	3 hr	366.5	1 hr	557.9	1 hr	739.6	1 hr	974.5	1 hr	1172.4	1 hr
18035_R	182.6	3 hr	366.5	1 hr	557.9	1 hr	739.6	1 hr	974.5	1 hr	1172.4	1 hr
18025	10.8	3 hr	24.8	1 hr	42	1 hr	59.8	1 hr	84.5	1 hr	106.5	1 hr
18025_J	193	3 hr	385	1 hr	590.4	1 hr	785.5	1 hr	1036.8	1 hr	1249.8	1 hr
18025_R	193	3 hr	385	1 hr	590.4	1 hr	785.5	1 hr	1036.8	1 hr	1249.8	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
18010	28	3 hr	63.3	1 hr	108.5	1 hr	153.6	1 hr	216.2	1 hr	271.2	1 hr
18010_J	28	3 hr	63.3	1 hr	108.5	1 hr	153.6	1 hr	216.2	1 hr	271.2	1 hr
18010_R	28	3 hr	63.3	1 hr	108.5	1 hr	153.6	1 hr	216.2	1 hr	271.2	1 hr
18005	6.4	3 hr	14.2	1 hr	26.3	1 hr	39.4	2 hr	56.2	1 hr	72.3	1 hr
18005_J	33.8	3 hr	77.4	1 hr	134.7	1 hr	192.5	2 hr	272	1 hr	342.5	1 hr
18015	19.4	3 hr	43.9	1 hr	73.5	1 hr	103.8	1 hr	145.5	1 hr	182.2	1 hr
18020	28.5	3 hr	58.5	1 hr	96.2	1 hr	133.1	1 hr	181.8	1 hr	223.8	1 hr
18020_J	28.5	3 hr	58.5	1 hr	96.2	1 hr	133.1	1 hr	181.8	1 hr	223.8	1 hr
18020_R	28.5	3 hr	58.5	1 hr	96.2	1 hr	133.1	1 hr	181.8	1 hr	223.8	1 hr
18015_J	537.4	3 hr	1099.1	1 hr	1708	1 hr	2292.8	1 hr	3036.4	1 hr	3670.2	1 hr
18015_R	537.4	3 hr	1099.1	1 hr	1708	1 hr	2292.8	1 hr	3036.4	1 hr	3670.2	1 hr
18000	32.2	3 hr	69.1	1 hr	109.6	1 hr	149.1	1 hr	201.6	1 hr	247	1 hr
25015	121.1	1 hr	212.4	1 hr	293.4	1 hr	366	1 hr	454.7	1 hr	528.5	1 hr
25015_J	121.1	1 hr	212.4	1 hr	293.4	1 hr	366	1 hr	454.7	1 hr	528.5	1 hr
25015_R	121.1	1 hr	212.4	1 hr	293.4	1 hr	366	1 hr	454.7	1 hr	528.5	1 hr
25010	72.6	1 hr	133.9	1 hr	190.3	1 hr	241.9	1 hr	305.1	1 hr	358.1	1 hr
25090	202.5	1 hr	317	1 hr	411.9	1 hr	497.3	1 hr	597.7	1 hr	678.5	1 hr
25090_J	202.5	1 hr	317	1 hr	411.9	1 hr	497.3	1 hr	597.7	1 hr	678.5	1 hr
25095	89	1 hr	161.5	1 hr	226.6	1 hr	284.9	1 hr	357.7	1 hr	417.8	1 hr
25100	95.9	1 hr	163.5	1 hr	221.9	1 hr	273.7	1 hr	337.4	1 hr	389.2	1 hr
25100_J	95.9	1 hr	163.5	1 hr	221.9	1 hr	273.7	1 hr	337.4	1 hr	389.2	1 hr
25100_R	95.9	1 hr	163.5	1 hr	221.9	1 hr	273.7	1 hr	337.4	1 hr	389.2	1 hr
25095_J	183.7	1 hr	322.3	1 hr	443.8	1 hr	552.6	1 hr	686.6	1 hr	796.9	1 hr
25085	172	1 hr	325.9	1 hr	467	1 hr	595.2	1 hr	755.7	1 hr	890.2	1 hr
25095_R	183.7	1 hr	322.3	1 hr	443.8	1 hr	552.6	1 hr	686.6	1 hr	796.9	1 hr
25090_R	202.5	1 hr	317	1 hr	411.9	1 hr	497.3	1 hr	597.7	1 hr	678.5	1 hr
25085_J	523.5	1 hr	911.5	1 hr	1256.3	1 hr	1564.6	1 hr	1940.9	1 hr	2254.7	1 hr
25085_R	523.5	1 hr	911.5	1 hr	1256.3	1 hr	1564.6	1 hr	1940.9	1 hr	2254.7	1 hr
25080	137	3 hr	256.3	1 hr	378.1	1 hr	491.7	1 hr	634.8	1 hr	754.8	1 hr
25080_J	630.7	1 hr	1141.4	1 hr	1598	1 hr	2009.2	1 hr	2522.4	1 hr	2946.2	1 hr
25080_R	630.7	1 hr	1141.4	1 hr	1598	1 hr	2009.2	1 hr	2522.4	1 hr	2946.2	1 hr
25070	61.4	1 hr	128.1	1 hr	192.3	1 hr	252	1 hr	328.6	1 hr	393.6	1 hr
25075	39.9	3 hr	78.9	1 hr	119.5	1 hr	158	1 hr	207.3	1 hr	248.9	1 hr
25075_J	39.9	3 hr	78.9	1 hr	119.5	1 hr	158	1 hr	207.3	1 hr	248.9	1 hr
25075_R	39.9	3 hr	78.9	1 hr	119.5	1 hr	158	1 hr	207.3	1 hr	248.9	1 hr
25070_J	97.9	3 hr	196.1	1 hr	292.7	1 hr	383.2	1 hr	500.4	1 hr	599	1 hr
25070_R	97.9	3 hr	196.1	1 hr	292.7	1 hr	383.2	1 hr	500.4	1 hr	599	1 hr
25065	41.3	3 hr	83.7	1 hr	132.9	1 hr	180.5	1 hr	242.7	1 hr	295.9	1 hr
25068_J	139.2	3 hr	279.7	1 hr	425.6	1 hr	563.7	1 hr	742.9	1 hr	894	1 hr
25065_J	755.4	1 hr	1421.1	1 hr	2023.6	1 hr	2572.3	1 hr	3264.4	1 hr	3837.9	1 hr
25065_R	755.4	1 hr	1421.1	1 hr	2023.6	1 hr	2572.3	1 hr	3264.4	1 hr	3837.9	1 hr
25060	57.7	3 hr	115.8	1 hr	179	1 hr	239.3	1 hr	317.5	1 hr	383.8	1 hr
25060_J	805.3	1 hr	1536.5	1 hr	2202.3	1 hr	2811.4	1 hr	3579.9	1 hr	4220.2	1 hr
25060_R	805.3	1 hr	1536.5	1 hr	2202.3	1 hr	2811.4	1 hr	3579.9	1 hr	4220.2	1 hr
25055	62.3	1 hr	133.9	1 hr	204.2	1 hr	270.1	1 hr	354.6	1 hr	426.8	1 hr
25055_J	853.8	1 hr	1636.8	1 hr	2351.8	1 hr	3010.6	1 hr	3835.8	1 hr	4523	1 hr
25055_R	853.8	1 hr	1636.8	1 hr	2351.8	1 hr	3010.6	1 hr	3835.8	1 hr	4523	1 hr
25050	13.6	3 hr	30.3	1 hr	49.2	1 hr	68.4	1 hr	94	1 hr	116.6	1 hr
25050_J	863.1	1 hr	1658.7	1 hr	2388.3	1 hr	3059.6	1 hr	3900.8	1 hr	4602.6	1 hr
25047	87.1	1 hr	175	1 hr	255.9	1 hr	330.7	1 hr	426.2	1 hr	505.5	1 hr
25047_J	87.1	1 hr	175	1 hr	255.9	1 hr	330.7	1 hr	426.2	1 hr	505.5	1 hr
25047_R	87.1	1 hr	175	1 hr	255.9	1 hr	330.7	1 hr	426.2	1 hr	505.5	1 hr
25046	77.4	1 hr	149.2	1 hr	216.9	1 hr	278.6	1 hr	354.9	1 hr	420.2	1 hr
25046_J	77.4	1 hr	149.2	1 hr	216.9	1 hr	278.6	1 hr	354.9	1 hr	420.2	1 hr
25046_R	77.4	1 hr	149.2	1 hr	216.9	1 hr	278.6	1 hr	354.9	1 hr	420.2	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
25045	34.7	3 hr	75.1	1 hr	117.9	1 hr	159.3	1 hr	213.8	1 hr	260.9	1 hr
25045_J	186.8	1 hr	380.2	1 hr	557.9	1 hr	722.9	1 hr	935.8	1 hr	1114.1	1 hr
25045_R	186.8	1 hr	380.2	1 hr	557.9	1 hr	722.9	1 hr	935.8	1 hr	1114.1	1 hr
25040	38	3 hr	78	1 hr	119	1 hr	157.9	1 hr	208.6	1 hr	251.6	1 hr
25040_J	224.1	3 hr	458.2	1 hr	676.9	1 hr	880.8	1 hr	1144.4	1 hr	1365.2	1 hr
25040_R	224.1	3 hr	458.2	1 hr	676.9	1 hr	880.8	1 hr	1144.4	1 hr	1365.2	1 hr
25035	19.9	3 hr	41.8	1 hr	68.9	1 hr	95.5	1 hr	131	1 hr	161.5	1 hr
25035_J	243.7	3 hr	499.9	1 hr	745.7	1 hr	976.3	1 hr	1275.4	1 hr	1526.7	1 hr
25031	54	3 hr	105.8	1 hr	163.5	1 hr	218.5	1 hr	289.3	1 hr	349.5	1 hr
25031_J	296.8	3 hr	603.5	1 hr	905.6	1 hr	1189.4	1 hr	1557.6	1 hr	1868.7	1 hr
25031_R	296.8	3 hr	603.5	1 hr	905.6	1 hr	1189.4	1 hr	1557.6	1 hr	1868.7	1 hr
25030	5.5	3 hr	12.6	3 hr	22.1	2 hr	35.6	2 hr	50.3	1 hr	64.9	1 hr
25030_J	300.8	3 hr	614.2	1 hr	927.1	1 hr	1222.6	1 hr	1606.4	1 hr	1931.6	1 hr
25025	50.2	3 hr	102.7	1 hr	157.7	1 hr	210.1	1 hr	278.4	1 hr	336.2	1 hr
25025_J	350.6	3 hr	714.4	1 hr	1081.3	1 hr	1428.9	1 hr	1879.5	1 hr	2259	1 hr
25025_R	350.6	3 hr	714.4	1 hr	1081.3	1 hr	1428.9	1 hr	1879.5	1 hr	2259	1 hr
25048_J	1188.4	3 hr	2363	1 hr	3452.2	1 hr	4462.7	1 hr	5740.2	1 hr	6807.6	1 hr
25050_R	1188.4	3 hr	2363	1 hr	3452.2	1 hr	4462.7	1 hr	5740.2	1 hr	6807.6	1 hr
25020	10.8	3 hr	24.4	3 hr	44.3	1 hr	68.5	2 hr	97.5	1 hr	125.8	1 hr
25020_J	1197.5	3 hr	2381.8	1 hr	3488.4	1 hr	4516.2	1 hr	5813.3	1 hr	6902.5	1 hr
25010_J	186.5	1 hr	331.5	1 hr	460.4	1 hr	577.3	1 hr	720.8	1 hr	839.9	1 hr
25008_J	1335.1	3 hr	2626.1	1 hr	3827.7	1 hr	4945.2	1 hr	6348	1 hr	7521.6	1 hr
25020_R	1335.1	3 hr	2626.1	1 hr	3827.7	1 hr	4945.2	1 hr	6348	1 hr	7521.6	1 hr
25005	55.1	3 hr	114	1 hr	180.3	1 hr	244.3	1 hr	328.6	1 hr	400.6	1 hr
25005_J	1388.5	3 hr	2720.1	1 hr	3975.4	1 hr	5141.3	1 hr	6603.2	1 hr	7835.8	1 hr
25005_R	1388.5	3 hr	2720.1	1 hr	3975.4	1 hr	5141.3	1 hr	6603.2	1 hr	7835.8	1 hr
25002	39.9	3 hr	85.9	1 hr	133.9	1 hr	179.9	1 hr	240.1	1 hr	291.8	1 hr
25002_J	39.9	3 hr	85.9	1 hr	133.9	1 hr	179.9	1 hr	240.1	1 hr	291.8	1 hr
25002_R	39.9	3 hr	85.9	1 hr	133.9	1 hr	179.9	1 hr	240.1	1 hr	291.8	1 hr
25001	19.4	3 hr	44.2	1 hr	74.6	1 hr	105.6	1 hr	148.8	1 hr	186.8	1 hr
25001_J	1443.8	3 hr	2811.8	1 hr	4117.5	1 hr	5331.4	1 hr	6850.9	1 hr	8133.6	1 hr
25001_R	1443.8	3 hr	2811.8	1 hr	4117.5	1 hr	5331.4	1 hr	6850.9	1 hr	8133.6	1 hr
25000	41.5	3 hr	88.8	1 hr	148.3	1 hr	207.1	1 hr	286	1 hr	354.3	1 hr
25000_S	1484.6	3 hr	2881.9	1 hr	4226.1	1 hr	5477.6	1 hr	7044.9	1 hr	8366.1	1 hr
23035	18.5	3 hr	39.3	3 hr	65.3	1 hr	96.8	2 hr	131.6	1 hr	164.7	1 hr
ShortCreek MajorSubbasin	212.7	3 hr	410.4	3 hr	603.1	3 hr	864.3	3 hr	1088.6	2 hr	1320.9	2 hr
ShortCreek_J	212.7	3 hr	410.4	3 hr	603.1	3 hr	864.3	3 hr	1088.6	2 hr	1320.9	2 hr
ShortCreek_R	212.7	3 hr	410.4	3 hr	603.1	3 hr	864.3	3 hr	1088.6	2 hr	1320.9	2 hr
23070	38.8	3 hr	77.7	3 hr	127.1	1 hr	180.3	2 hr	241.9	1 hr	298.1	1 hr
23065	49.6	3 hr	106.8	1 hr	166.5	1 hr	223.8	1 hr	298.9	1 hr	363.3	1 hr
23065_J	263.9	3 hr	511.4	3 hr	756.3	3 hr	1081.7	3 hr	1325.4	3 hr	1585.3	2 hr
23065_R	263.9	3 hr	511.4	3 hr	756.3	3 hr	1081.7	3 hr	1325.4	3 hr	1585.3	2 hr
23055	29.3	3 hr	60.8	1 hr	98.7	1 hr	135.7	1 hr	184.6	1 hr	226.6	1 hr
23060	25.5	3 hr	54.4	1 hr	85.3	1 hr	115.2	1 hr	154.7	1 hr	188.7	1 hr
23060_J	299.9	3 hr	580.9	3 hr	854.8	3 hr	1219	3 hr	1491.3	3 hr	1775.7	3 hr
23060_R	299.9	3 hr	580.9	3 hr	854.8	3 hr	1219	3 hr	1491.3	3 hr	1775.7	3 hr
23050	5.5	3 hr	11.8	1 hr	18.6	1 hr	25.3	1 hr	34.1	1 hr	41.7	1 hr
23050_J	303.6	3 hr	587.8	3 hr	864.5	3 hr	1232.3	3 hr	1507.3	3 hr	1794.4	3 hr
23045	41.2	3 hr	88	1 hr	135.9	1 hr	181.8	1 hr	241.3	1 hr	292.6	1 hr
23042_J	329.5	3 hr	634.4	3 hr	927.8	3 hr	1318.4	3 hr	1610.1	3 hr	1913.6	3 hr
23050_R	329.5	3 hr	634.4	3 hr	927.8	3 hr	1318.4	3 hr	1610.1	3 hr	1913.6	3 hr
23040	5.4	3 hr	11.9	1 hr	19.3	1 hr	26.5	1 hr	36	1 hr	44.4	1 hr
23040_J	332.9	3 hr	640.5	3 hr	936.5	3 hr	1330.5	3 hr	1624.4	3 hr	1930.6	3 hr
23035_J	18.5	3 hr	39.3	3 hr	65.3	1 hr	96.8	2 hr	131.6	1 hr	164.7	1 hr
23033_J	350.2	3 hr	674.7	3 hr	985.3	3 hr	1399.5	3 hr	1708.5	3 hr	2030.4	3 hr
23040_R	350.2	3 hr	674.7	3 hr	985.3	3 hr	1399.5	3 hr	1708.5	3 hr	2030.4	3 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
23030	18.9	3 hr	41.1	3 hr	69.1	2 hr	105.6	2 hr	140	2 hr	177.3	1 hr
23030_J	368.1	3 hr	712.7	3 hr	1041.8	3 hr	1481.5	3 hr	1809.4	3 hr	2151.8	3 hr
23030_R	368.1	3 hr	712.7	3 hr	1041.8	3 hr	1481.5	3 hr	1809.4	3 hr	2151.8	3 hr
23010	12.4	3 hr	27.1	1 hr	43.2	1 hr	59	1 hr	79.5	1 hr	97.4	1 hr
23010_J	375.3	3 hr	725.5	3 hr	1060.2	3 hr	1506.7	3 hr	1839.6	3 hr	2187.3	3 hr
23010_R	375.3	3 hr	725.5	3 hr	1060.2	3 hr	1506.7	3 hr	1839.6	3 hr	2187.3	3 hr
23017	51.1	1 hr	85.1	1 hr	114.8	1 hr	141.1	1 hr	172.9	1 hr	198.9	1 hr
23017_J	51.1	1 hr	85.1	1 hr	114.8	1 hr	141.1	1 hr	172.9	1 hr	198.9	1 hr
23015	54.5	1 hr	96.5	1 hr	134	1 hr	167.5	1 hr	208.5	1 hr	242.9	1 hr
23015_J	54.5	1 hr	96.5	1 hr	134	1 hr	167.5	1 hr	208.5	1 hr	242.9	1 hr
23015_R	54.5	1 hr	96.5	1 hr	134	1 hr	167.5	1 hr	208.5	1 hr	242.9	1 hr
23017_R	51.1	1 hr	85.1	1 hr	114.8	1 hr	141.1	1 hr	172.9	1 hr	198.9	1 hr
23005	79.5	3 hr	161.1	1 hr	237.3	1 hr	308	1 hr	398.5	1 hr	474.4	1 hr
23016_J	105.6	1 hr	181.6	1 hr	248.7	1 hr	308.6	1 hr	381.3	1 hr	441.8	1 hr
23003_J	184.2	1 hr	342.7	1 hr	485.5	1 hr	616	1 hr	779.1	1 hr	914.3	1 hr
23005_J	479.2	3 hr	887.3	3 hr	1271.4	1 hr	1772.5	3 hr	2267.4	1 hr	2745	1 hr
23005_R	479.2	3 hr	887.3	3 hr	1271.4	1 hr	1772.5	3 hr	2267.4	1 hr	2745	1 hr
23000	10.5	3 hr	24.9	3 hr	43.2	2 hr	67.9	2 hr	92.5	2 hr	119.1	1 hr
23025	0.9	6 hr	2.9	3 hr	5.6	3 hr	11.6	3 hr	16.6	2 hr	23.5	2 hr
23001	0.3	6 hr	1	3 hr	2.1	3 hr	4.2	3 hr	6.1	3 hr	8.6	2 hr
23000_S	489.3	3 hr	912.3	3 hr	1312	3 hr	1840.5	3 hr	2372.3	1 hr	2886.8	1 hr
18000_S	566.5	3 hr	1147.5	1 hr	1782.2	1 hr	2391.2	1 hr	3165.5	1 hr	3829.9	1 hr
22035	82.3	1 hr	159.3	1 hr	228.7	1 hr	292.4	1 hr	372.9	1 hr	439.6	1 hr
22040	58.4	1 hr	111.6	1 hr	159.4	1 hr	203.2	1 hr	258.2	1 hr	304	1 hr
22040_J	58.4	1 hr	111.6	1 hr	159.4	1 hr	203.2	1 hr	258.2	1 hr	304	1 hr
22040_R	58.4	1 hr	111.6	1 hr	159.4	1 hr	203.2	1 hr	258.2	1 hr	304	1 hr
22050	89.8	1 hr	166.8	1 hr	236.2	1 hr	298.8	1 hr	377.5	1 hr	442.6	1 hr
22050_J	89.8	1 hr	166.8	1 hr	236.2	1 hr	298.8	1 hr	377.5	1 hr	442.6	1 hr
22060	24	3 hr	54.4	1 hr	95	1 hr	136.6	2 hr	192.6	1 hr	242.9	1 hr
22060_J	24	3 hr	54.4	1 hr	95	1 hr	136.6	2 hr	192.6	1 hr	242.9	1 hr
22060_R	24	3 hr	54.4	1 hr	95	1 hr	136.6	2 hr	192.6	1 hr	242.9	1 hr
22055	11.1	3 hr	23	1 hr	37.4	1 hr	51.5	1 hr	70.1	1 hr	86	1 hr
22055_J	34.8	3 hr	77.1	1 hr	132.1	1 hr	186.9	2 hr	261.1	1 hr	326.4	1 hr
22055_R	34.8	3 hr	77.1	1 hr	132.1	1 hr	186.9	2 hr	261.1	1 hr	326.4	1 hr
22045	38.5	3 hr	75.6	1 hr	122.5	1 hr	169.9	2 hr	227.5	1 hr	278.4	1 hr
22053_J	73.3	3 hr	152.8	1 hr	254.5	1 hr	356.4	2 hr	488.4	1 hr	604	1 hr
22050_R	89.8	1 hr	166.8	1 hr	236.2	1 hr	298.8	1 hr	377.5	1 hr	442.6	1 hr
22045_J	149.1	3 hr	306.2	1 hr	474	1 hr	634.8	1 hr	845.6	1 hr	1025.3	1 hr
22035_J	140.3	1 hr	270.1	1 hr	387	1 hr	494.3	1 hr	629.3	1 hr	741.3	1 hr
22033_J	285.9	3 hr	575.7	1 hr	860.4	1 hr	1128.8	1 hr	1474.1	1 hr	1766.6	1 hr
22045_R	285.9	3 hr	575.7	1 hr	860.4	1 hr	1128.8	1 hr	1474.1	1 hr	1766.6	1 hr
22025	45.9	3 hr	94.9	1 hr	153.8	1 hr	211.2	1 hr	287	1 hr	352	1 hr
22030	17.3	3 hr	35.6	1 hr	55	1 hr	73.6	1 hr	97.9	1 hr	118.6	1 hr
22030_J	348.9	3 hr	703.7	1 hr	1065.4	1 hr	1408.7	1 hr	1851.8	1 hr	2226.2	1 hr
22030_R	348.9	3 hr	703.7	1 hr	1065.4	1 hr	1408.7	1 hr	1851.8	1 hr	2226.2	1 hr
22020	40.3	3 hr	85.8	1 hr	142.9	1 hr	199.3	1 hr	274.9	1 hr	340.3	1 hr
22015	25.4	3 hr	54.7	3 hr	91.3	1 hr	138.3	2 hr	189	1 hr	238.1	1 hr
22020_J	412.8	3 hr	829.2	1 hr	1280.7	1 hr	1713.5	1 hr	2271.5	1 hr	2747.8	1 hr
22020_R	412.8	3 hr	829.2	1 hr	1280.7	1 hr	1713.5	1 hr	2271.5	1 hr	2747.8	1 hr
22010	4.3	3 hr	12.7	6 hr	25.8	3 hr	45	2 hr	64.6	2 hr	86.9	2 hr
22005	1.9	24 hr	5.9	3 hr	11.3	3 hr	23.5	3 hr	33.7	3 hr	46.9	2 hr
22010_J	412.8	3 hr	831	1 hr	1295.3	1 hr	1750.5	1 hr	2344.9	1 hr	2857.7	1 hr
22010_R	412.8	3 hr	831	1 hr	1295.3	1 hr	1750.5	1 hr	2344.9	1 hr	2857.7	1 hr
22000	3.4	3 hr	10	3 hr	19.1	3 hr	33.8	2 hr	47.4	2 hr	64.5	2 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
22000_S	412.8	3 hr	834.3	1 hr	1308.1	1 hr	1773.9	1 hr	2383.1	1 hr	2910.7	1 hr
17120	43.8	3 hr	95.5	1 hr	153	1 hr	210.1	1 hr	286.4	1 hr	352.9	1 hr
17130	27.7	3 hr	58.5	1 hr	94.3	1 hr	129.1	1 hr	175.5	1 hr	215.4	1 hr
17130_J	27.7	3 hr	58.5	1 hr	94.3	1 hr	129.1	1 hr	175.5	1 hr	215.4	1 hr
17130_R	27.7	3 hr	58.5	1 hr	94.3	1 hr	129.1	1 hr	175.5	1 hr	215.4	1 hr
17125	25.3	3 hr	54.1	1 hr	88.2	1 hr	121.6	1 hr	166.5	1 hr	205.2	1 hr
17125_J	96.1	3 hr	205.3	1 hr	331	1 hr	453.1	1 hr	616.9	1 hr	758.2	1 hr
17125_R	96.1	3 hr	205.3	1 hr	331	1 hr	453.1	1 hr	616.9	1 hr	758.2	1 hr
17110	30	3 hr	64.3	1 hr	104.6	1 hr	144.3	1 hr	197.5	1 hr	243.4	1 hr
17115	14.2	3 hr	31.9	1 hr	56.3	1 hr	81.6	2 hr	115	1 hr	145.2	1 hr
17115_J	139.9	3 hr	299.9	1 hr	489.8	1 hr	675.9	1 hr	925.3	1 hr	1140.9	1 hr
17115_R	139.9	3 hr	299.9	1 hr	489.8	1 hr	675.9	1 hr	925.3	1 hr	1140.9	1 hr
17105	16.7	3 hr	36.5	3 hr	63.8	1 hr	93	2 hr	129.8	1 hr	163.3	1 hr
17105_J	156.2	3 hr	335.5	1 hr	552.8	1 hr	766.5	1 hr	1053.7	1 hr	1301.3	1 hr
17105_R	156.2	3 hr	335.5	1 hr	552.8	1 hr	766.5	1 hr	1053.7	1 hr	1301.3	1 hr
17100	24	3 hr	53.8	1 hr	89.5	1 hr	125.9	1 hr	175.7	1 hr	219.5	1 hr
17100_J	179.1	3 hr	381.6	1 hr	632	1 hr	879.8	1 hr	1209.4	1 hr	1495	1 hr
17100_R	179.1	3 hr	381.6	1 hr	632	1 hr	879.8	1 hr	1209.4	1 hr	1495	1 hr
17095	12.6	3 hr	28.7	3 hr	52.1	1 hr	81.2	2 hr	115.7	1 hr	149.5	1 hr
17095_J	190.3	3 hr	403.9	1 hr	676	1 hr	948.3	1 hr	1309.2	1 hr	1622.8	1 hr
17095_R	190.3	3 hr	403.9	1 hr	676	1 hr	948.3	1 hr	1309.2	1 hr	1622.8	1 hr
17090	9.9	3 hr	22.6	1 hr	38.9	1 hr	55.3	1 hr	78.2	1 hr	98.4	1 hr
17090_J	200.1	3 hr	421	1 hr	706.3	1 hr	994.1	2 hr	1368.2	1 hr	1697.5	1 hr
19125	19.9	3 hr	44.2	1 hr	72.1	1 hr	100.5	1 hr	138.7	1 hr	172.3	1 hr
19125_J	19.9	3 hr	44.2	1 hr	72.1	1 hr	100.5	1 hr	138.7	1 hr	172.3	1 hr
19130	20.4	3 hr	45.1	1 hr	75.1	1 hr	105	1 hr	146	1 hr	181.7	1 hr
19130_J	20.4	3 hr	45.1	1 hr	75.1	1 hr	105	1 hr	146	1 hr	181.7	1 hr
20010	44.8	3 hr	96.5	1 hr	149.1	1 hr	199	1 hr	263.4	1 hr	319.2	1 hr
20015	26.4	3 hr	59.2	1 hr	98.2	1 hr	138.1	1 hr	190.1	1 hr	237.1	1 hr
20015_J	26.4	3 hr	59.2	1 hr	98.2	1 hr	138.1	1 hr	190.1	1 hr	237.1	1 hr
20015_R	26.4	3 hr	59.2	1 hr	98.2	1 hr	138.1	1 hr	190.1	1 hr	237.1	1 hr
20010_J	71.2	3 hr	155.7	1 hr	245.6	1 hr	333.6	1 hr	448.7	1 hr	548.9	1 hr
20010_R	71.2	3 hr	155.7	1 hr	245.6	1 hr	333.6	1 hr	448.7	1 hr	548.9	1 hr
20005	16	3 hr	36.2	1 hr	62.5	1 hr	88.8	2 hr	125.1	1 hr	157.1	1 hr
20005_J	87	3 hr	191.7	1 hr	306.6	1 hr	421.2	1 hr	572.8	1 hr	705.2	1 hr
20005_R	87	3 hr	191.7	1 hr	306.6	1 hr	421.2	1 hr	572.8	1 hr	705.2	1 hr
20000	29.5	3 hr	63.8	1 hr	110.2	1 hr	157.9	2 hr	219.5	1 hr	274.2	1 hr
20000_J	116.3	3 hr	254.8	1 hr	416.6	1 hr	577.9	1 hr	792.3	1 hr	979.1	1 hr
20000_R	116.3	3 hr	254.8	1 hr	416.6	1 hr	577.9	1 hr	792.3	1 hr	979.1	1 hr
19120	15.9	3 hr	32.4	3 hr	53.7	1 hr	76.4	2 hr	103.4	1 hr	127.8	1 hr
19033_J	132.1	3 hr	286.5	1 hr	470.2	1 hr	653.1	1 hr	895.7	1 hr	1106.9	1 hr
19130_R	20.4	3 hr	45.1	1 hr	75.1	1 hr	105	1 hr	146	1 hr	181.7	1 hr
19125_R	19.9	3 hr	44.2	1 hr	72.1	1 hr	100.5	1 hr	138.7	1 hr	172.3	1 hr
2170	29.9	3 hr	62.5	3 hr	105.9	1 hr	151.2	2 hr	207.5	1 hr	257.8	1 hr
2165	13.1	3 hr	31.6	3 hr	55.3	2 hr	89.9	2 hr	127.3	1 hr	165.7	1 hr
2170_J	42.3	3 hr	93	3 hr	159	1 hr	241	2 hr	334.7	1 hr	423.1	1 hr
2170_R	42.3	3 hr	93	3 hr	159	1 hr	241	2 hr	334.7	1 hr	423.1	1 hr
2160	12.2	3 hr	28.1	3 hr	48.8	2 hr	76.8	2 hr	104.7	1 hr	135.2	1 hr
2160_J	54.6	3 hr	120.7	3 hr	204.8	2 hr	317.6	2 hr	439.4	1 hr	558.3	1 hr
2160_R	54.6	3 hr	120.7	3 hr	204.8	2 hr	317.6	2 hr	439.4	1 hr	558.3	1 hr
2155	22.3	3 hr	47	1 hr	77.8	1 hr	108.3	1 hr	148.9	1 hr	183.8	1 hr
2155_J	75.1	3 hr	164	3 hr	276.9	1 hr	421	2 hr	579.2	1 hr	731.4	1 hr
2155_R	75.1	3 hr	164	3 hr	276.9	1 hr	421	2 hr	579.2	1 hr	731.4	1 hr
2150	9.8	3 hr	23.1	3 hr	40.3	2 hr	64.2	2 hr	89.1	1 hr	115.7	1 hr
2150_J	84.8	3 hr	186.8	3 hr	314.9	2 hr	484.8	2 hr	663.7	1 hr	841.5	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
2150_R	84.8	3 hr	186.8	3 hr	314.9	2 hr	484.8	2 hr	663.7	1 hr	841.5	1 hr
2145	14.3	3 hr	32.2	3 hr	57	1 hr	88.4	2 hr	124.9	1 hr	160	1 hr
2145_J	98.6	3 hr	218.1	3 hr	368.6	2 hr	567.1	2 hr	768.5	1 hr	976.6	1 hr
19120_J	170.6	3 hr	363.4	1 hr	603.5	1 hr	840.5	1 hr	1152	1 hr	1422.2	1 hr
19100	55.8	3 hr	119.9	1 hr	186.5	1 hr	250.5	1 hr	334.1	1 hr	405.8	1 hr
19100_J	55.8	3 hr	119.9	1 hr	186.5	1 hr	250.5	1 hr	334.1	1 hr	405.8	1 hr
19100_R	55.8	3 hr	119.9	1 hr	186.5	1 hr	250.5	1 hr	334.1	1 hr	405.8	1 hr
19075	52.5	1 hr	105	1 hr	153.9	1 hr	199	1 hr	256.5	1 hr	304.5	1 hr
19080	68.1	1 hr	131.6	1 hr	191.7	1 hr	246.8	1 hr	314.9	1 hr	372.7	1 hr
19080_J	68.1	1 hr	131.6	1 hr	191.7	1 hr	246.8	1 hr	314.9	1 hr	372.7	1 hr
19080_R	68.1	1 hr	131.6	1 hr	191.7	1 hr	246.8	1 hr	314.9	1 hr	372.7	1 hr
19075_J	168.9	1 hr	350.6	1 hr	526.7	1 hr	690	1 hr	898.2	1 hr	1075.3	1 hr
19075_R	168.9	1 hr	350.6	1 hr	526.7	1 hr	690	1 hr	898.2	1 hr	1075.3	1 hr
19065	38.4	3 hr	81.2	3 hr	133	2 hr	199.9	2 hr	268.7	1 hr	336.8	1 hr
19065_J	195.3	3 hr	416.9	1 hr	645.1	1 hr	863	1 hr	1146.7	1 hr	1389.3	1 hr
17080	43	3 hr	90.5	1 hr	148.6	1 hr	205.7	1 hr	281.9	1 hr	347.3	1 hr
17085	30	3 hr	67.4	1 hr	114.5	1 hr	161.4	1 hr	226.6	1 hr	283.7	1 hr
17080_J	72.8	3 hr	157.1	1 hr	261.9	1 hr	365.2	1 hr	504.3	1 hr	624.7	1 hr
17080_R	72.8	3 hr	157.1	1 hr	261.9	1 hr	365.2	1 hr	504.3	1 hr	624.7	1 hr
17075	15.8	3 hr	35.4	1 hr	63.6	1 hr	93.4	2 hr	132.1	1 hr	168	1 hr
17075_J	87.8	3 hr	190.2	1 hr	322.2	1 hr	453.7	1 hr	630.4	1 hr	783.9	1 hr
17075_R	87.8	3 hr	190.2	1 hr	322.2	1 hr	453.7	1 hr	630.4	1 hr	783.9	1 hr
17070	13.4	3 hr	29.5	3 hr	51.2	1 hr	78.7	2 hr	110	1 hr	140	1 hr
17070_J	100.3	3 hr	216.2	1 hr	370.9	1 hr	530.1	2 hr	735.9	1 hr	917.6	1 hr
17070_R	100.3	3 hr	216.2	1 hr	370.9	1 hr	530.1	2 hr	735.9	1 hr	917.6	1 hr
17065_J	100.3	3 hr	216.2	1 hr	370.9	1 hr	530.1	2 hr	735.9	1 hr	917.6	1 hr
17090_R	100.3	3 hr	216.2	1 hr	370.9	1 hr	530.1	2 hr	735.9	1 hr	917.6	1 hr
17045	13.4	3 hr	30	3 hr	53.9	1 hr	82	2 hr	115.9	1 hr	148.4	1 hr
17045_J	13.4	3 hr	30	3 hr	53.9	1 hr	82	2 hr	115.9	1 hr	148.4	1 hr
17045_R	13.4	3 hr	30	3 hr	53.9	1 hr	82	2 hr	115.9	1 hr	148.4	1 hr
17040	5.1	3 hr	14.3	3 hr	25.2	2 hr	42.9	2 hr	59.8	2 hr	79.1	2 hr
17040_J	17	3 hr	42.1	3 hr	73.6	2 hr	119	2 hr	169	1 hr	220.3	1 hr
17040_R	17	3 hr	42.1	3 hr	73.6	2 hr	119	2 hr	169	1 hr	220.3	1 hr
17035	3.1	6 hr	9.6	3 hr	19.3	3 hr	34.4	3 hr	49.6	2 hr	67.2	2 hr
17035_J	18.2	3 hr	50.6	3 hr	89.2	2 hr	147.5	2 hr	207.4	2 hr	273.6	1 hr
17035_R	18.2	3 hr	50.6	3 hr	89.2	2 hr	147.5	2 hr	207.4	2 hr	273.6	1 hr
17030	7.7	3 hr	19.9	3 hr	34.8	2 hr	56	2 hr	78.4	1 hr	103	1 hr
17030_J	25.3	3 hr	70.2	3 hr	123.6	2 hr	202.1	2 hr	284.5	2 hr	375.1	1 hr
17030_R	25.3	3 hr	70.2	3 hr	123.6	2 hr	202.1	2 hr	284.5	2 hr	375.1	1 hr
17025	5.6	3 hr	15.7	3 hr	27.4	2 hr	46.3	2 hr	63.6	2 hr	83.8	2 hr
17025_J	30.8	3 hr	85.9	3 hr	150.9	2 hr	248.4	2 hr	347.9	2 hr	455.3	2 hr
2085	23.5	3 hr	50.6	1 hr	83.2	1 hr	115.2	1 hr	158.4	1 hr	195.8	1 hr
2085_J	23.5	3 hr	50.6	1 hr	83.2	1 hr	115.2	1 hr	158.4	1 hr	195.8	1 hr
2075	20.6	3 hr	44.3	3 hr	75.5	1 hr	110.7	2 hr	152.9	1 hr	191.6	1 hr
2080	13.4	3 hr	30.1	3 hr	51.9	2 hr	82.3	2 hr	114.6	1 hr	147.1	1 hr
2085_R	23.5	3 hr	50.6	1 hr	83.2	1 hr	115.2	1 hr	158.4	1 hr	195.8	1 hr
2080_J	55.5	3 hr	120.8	3 hr	209.6	1 hr	305.8	2 hr	425.3	1 hr	533.8	1 hr
2080_R	55.5	3 hr	120.8	3 hr	209.6	1 hr	305.8	2 hr	425.3	1 hr	533.8	1 hr
2070	25.9	3 hr	57	3 hr	98.5	1 hr	150.5	2 hr	209.6	1 hr	266.2	1 hr
2070_S	81.3	3 hr	177.3	3 hr	299	1 hr	450.5	2 hr	615.1	1 hr	775.6	1 hr
2190	21.5	3 hr	46.5	3 hr	79.1	1 hr	117.8	2 hr	162.6	1 hr	204.4	1 hr
2185	23	3 hr	48.1	3 hr	79.8	1 hr	115.9	2 hr	157.2	1 hr	195.5	1 hr
2185_J	44.4	3 hr	94.6	3 hr	158.6	1 hr	233.4	2 hr	319	1 hr	398.7	1 hr
2185_R	44.4	3 hr	94.6	3 hr	158.6	1 hr	233.4	2 hr	319	1 hr	398.7	1 hr
2180	38.5	3 hr	79.8	3 hr	129.2	1 hr	190.6	2 hr	254.8	1 hr	316.8	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
2180_J	82.9	3 hr	174.2	3 hr	287.1	1 hr	423	2 hr	572.5	1 hr	713.7	1 hr
2180_R	82.9	3 hr	174.2	3 hr	287.1	1 hr	423	2 hr	572.5	1 hr	713.7	1 hr
2195	11.5	3 hr	25.1	1 hr	43	1 hr	61.1	2 hr	85	1 hr	106.1	1 hr
2195_J	94.2	3 hr	198.1	3 hr	326.9	1 hr	481.1	2 hr	651	1 hr	812	1 hr
2215	31.9	3 hr	70.8	1 hr	116.3	1 hr	162.3	1 hr	224.7	1 hr	279.3	1 hr
2220	35.5	3 hr	79.3	1 hr	131.1	1 hr	183.5	1 hr	251.7	1 hr	313.4	1 hr
2225	38.7	3 hr	79.3	1 hr	120.7	1 hr	159.8	1 hr	210.7	1 hr	253.7	1 hr
2225_J	38.7	3 hr	79.3	1 hr	120.7	1 hr	159.8	1 hr	210.7	1 hr	253.7	1 hr
2225_R	38.7	3 hr	79.3	1 hr	120.7	1 hr	159.8	1 hr	210.7	1 hr	253.7	1 hr
2220_J	73.3	3 hr	153.2	1 hr	238.4	1 hr	318.8	1 hr	425.9	1 hr	516.8	1 hr
2215_J	31.9	3 hr	70.8	1 hr	116.3	1 hr	162.3	1 hr	224.7	1 hr	279.3	1 hr
2213_J	105	3 hr	224	1 hr	354.4	1 hr	479.3	1 hr	648.8	1 hr	794.3	1 hr
2220_R	105	3 hr	224	1 hr	354.4	1 hr	479.3	1 hr	648.8	1 hr	794.3	1 hr
2210	20.5	3 hr	47.5	1 hr	80.6	1 hr	115.2	1 hr	163.5	1 hr	206.4	1 hr
2210_J	125.5	3 hr	270.6	1 hr	433.4	1 hr	591.1	1 hr	806.8	1 hr	992.2	1 hr
2120	8.3	3 hr	23	3 hr	40.3	2 hr	66.2	2 hr	91.9	2 hr	120	2 hr
2115	14.2	3 hr	32.2	3 hr	55.5	2 hr	87.6	2 hr	120.5	1 hr	155	1 hr
2120_J	21.8	3 hr	54.7	3 hr	95.4	2 hr	152.1	2 hr	209.8	2 hr	273.1	1 hr
2120_R	21.8	3 hr	54.7	3 hr	95.4	2 hr	152.1	2 hr	209.8	2 hr	273.1	1 hr
2110	6.8	3 hr	18.6	3 hr	32.5	2 hr	52.5	2 hr	73	2 hr	94.9	1 hr
2110_J	28.7	3 hr	73.2	3 hr	127.9	2 hr	204.6	2 hr	282.5	2 hr	366.5	1 hr
2110_R	28.7	3 hr	73.2	3 hr	127.9	2 hr	204.6	2 hr	282.5	2 hr	366.5	1 hr
2095	15.2	3 hr	33.1	3 hr	56.7	1 hr	85.8	2 hr	119	1 hr	150.5	1 hr
2095_J	42.8	3 hr	102.9	3 hr	179	2 hr	284.4	2 hr	388	2 hr	500.8	1 hr
23085	184.9	1 hr	295	1 hr	388.2	1 hr	471.5	1 hr	570.4	1 hr	650.4	1 hr
23020	165.3	1 hr	266.7	1 hr	353.7	1 hr	431	1 hr	523.2	1 hr	598.3	1 hr
23020_J	165.3	1 hr	266.7	1 hr	353.7	1 hr	431	1 hr	523.2	1 hr	598.3	1 hr
23020_R	165.3	1 hr	266.7	1 hr	353.7	1 hr	431	1 hr	523.2	1 hr	598.3	1 hr
23085_J	340.7	1 hr	547.4	1 hr	723.3	1 hr	878.8	1 hr	1063.8	1 hr	1214.5	1 hr
23085_R	340.7	1 hr	547.4	1 hr	723.3	1 hr	878.8	1 hr	1063.8	1 hr	1214.5	1 hr
23080	66.1	1 hr	126.5	1 hr	182.8	1 hr	233.9	1 hr	298	1 hr	351.7	1 hr
23080_J	406.8	1 hr	673.4	1 hr	902.9	1 hr	1108.3	1 hr	1353.3	1 hr	1556.1	1 hr
23080_R	406.8	1 hr	673.4	1 hr	902.9	1 hr	1108.3	1 hr	1353.3	1 hr	1556.1	1 hr
23075	41.6	3 hr	86.4	1 hr	132.6	1 hr	176.6	1 hr	234	1 hr	282.8	1 hr
23075_S	442.3	1 hr	756.9	1 hr	1034.5	1 hr	1284.2	1 hr	1587.3	1 hr	1838.6	1 hr
17165	13.8	3 hr	30.9	1 hr	56.5	1 hr	84.2	2 hr	119.7	1 hr	153.5	1 hr
17170	21.8	3 hr	47.7	1 hr	79.3	1 hr	110.4	1 hr	152.9	1 hr	189.8	1 hr
17170_J	21.8	3 hr	47.7	1 hr	79.3	1 hr	110.4	1 hr	152.9	1 hr	189.8	1 hr
17170_R	0	1 hr	0	1 hr	0	1 hr	0	1 hr	0	1 hr	0	1 hr
17165_J	34.4	3 hr	78.6	1 hr	135.7	1 hr	192.7	2 hr	271.7	1 hr	341.2	1 hr
17165_R	34.4	3 hr	78.6	1 hr	135.7	1 hr	192.7	2 hr	271.7	1 hr	341.2	1 hr
17160	17.2	3 hr	38.9	1 hr	69	1 hr	100.3	2 hr	141.8	1 hr	179.8	1 hr
17160_J	51.3	3 hr	116.4	1 hr	203.1	1 hr	291.7	2 hr	411.1	1 hr	517.5	1 hr
17160_R	51.3	3 hr	116.4	1 hr	203.1	1 hr	291.7	2 hr	411.1	1 hr	517.5	1 hr
17155	22.9	3 hr	49.2	3 hr	83.2	1 hr	123.2	2 hr	169.4	1 hr	212.6	1 hr
17155_J	74	3 hr	162.7	1 hr	285.5	1 hr	414.9	2 hr	579.8	1 hr	729.3	1 hr
17145	5.9	3 hr	16.7	3 hr	29.6	2 hr	50.4	2 hr	70.6	2 hr	93.6	2 hr
17150	16.6	3 hr	35.5	3 hr	58.9	2 hr	89.3	2 hr	119.7	1 hr	150.9	1 hr
17150_J	16.6	3 hr	35.5	3 hr	58.9	2 hr	89.3	2 hr	119.7	1 hr	150.9	1 hr
17150_R	16.6	3 hr	35.5	3 hr	58.9	2 hr	89.3	2 hr	119.7	1 hr	150.9	1 hr
17140	2.7	6 hr	8.2	3 hr	16.5	3 hr	29.5	3 hr	42.6	2 hr	57.7	2 hr
17145_J	21.2	3 hr	57.9	3 hr	102	2 hr	166.7	2 hr	228.2	2 hr	296.6	2 hr
17145_R	21.2	3 hr	57.9	3 hr	102	2 hr	166.7	2 hr	228.2	2 hr	296.6	2 hr
17135	8.4	3 hr	19	3 hr	32.7	2 hr	51.3	2 hr	69.7	1 hr	89.6	1 hr
17135_J	29.2	3 hr	76.2	3 hr	133.2	2 hr	215.5	2 hr	294.1	2 hr	380.1	2 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
17015	12	3 hr	27.1	3 hr	46.9	2 hr	74.3	2 hr	103.2	1 hr	132.6	1 hr
17020	16.1	3 hr	36.1	1 hr	63.7	1 hr	92.1	2 hr	129.8	1 hr	163.9	1 hr
17020_J	16.1	3 hr	36.1	1 hr	63.7	1 hr	92.1	2 hr	129.8	1 hr	163.9	1 hr
17020_R	16.1	3 hr	36.1	1 hr	63.7	1 hr	92.1	2 hr	129.8	1 hr	163.9	1 hr
17015_J	28.1	3 hr	62.2	3 hr	109.3	1 hr	165.8	2 hr	232.4	1 hr	295.6	1 hr
17015_R	28.1	3 hr	62.2	3 hr	109.3	1 hr	165.8	2 hr	232.4	1 hr	295.6	1 hr
17010	16.9	3 hr	37.5	3 hr	67.7	1 hr	100.9	2 hr	142.5	1 hr	181.7	1 hr
17010_J	44.4	3 hr	98.9	3 hr	170.4	1 hr	261.7	2 hr	365.4	1 hr	464.4	1 hr
17010_R	44.4	3 hr	98.9	3 hr	170.4	1 hr	261.7	2 hr	365.4	1 hr	464.4	1 hr
17005	13.1	3 hr	28.4	3 hr	48.4	1 hr	72.6	2 hr	100.4	1 hr	126.5	1 hr
17000_S	57.5	3 hr	127.3	3 hr	218.7	1 hr	334.2	2 hr	465.6	1 hr	590.6	1 hr
2265	29.3	3 hr	64.3	1 hr	103.1	1 hr	141.8	1 hr	192.9	1 hr	237.8	1 hr
2265_J	29.3	3 hr	64.3	1 hr	103.1	1 hr	141.8	1 hr	192.9	1 hr	237.8	1 hr
2265_R	29.3	3 hr	64.3	1 hr	103.1	1 hr	141.8	1 hr	192.9	1 hr	237.8	1 hr
2260	21.9	3 hr	48.9	1 hr	81	1 hr	113.4	1 hr	157.8	1 hr	196.6	1 hr
2260_J	51.2	3 hr	113.2	1 hr	183.9	1 hr	255.3	1 hr	350.7	1 hr	434.4	1 hr
2260_R	51.2	3 hr	113.2	1 hr	183.9	1 hr	255.3	1 hr	350.7	1 hr	434.4	1 hr
2255	36.7	3 hr	80	1 hr	125.7	1 hr	169.7	1 hr	226.3	1 hr	276	1 hr
2255_J	86.9	3 hr	189.8	1 hr	304.6	1 hr	417.2	1 hr	566.9	1 hr	698	1 hr
2255_R	86.9	3 hr	189.8	1 hr	304.6	1 hr	417.2	1 hr	566.9	1 hr	698	1 hr
2270	27.2	3 hr	57.3	1 hr	90.6	1 hr	122.8	1 hr	165.5	1 hr	202.2	1 hr
2270_J	114	3 hr	246.9	1 hr	394.3	1 hr	539.1	1 hr	731.5	1 hr	898.3	1 hr
26010	67.7	1 hr	141.9	1 hr	212.3	1 hr	278	1 hr	362.4	1 hr	434	1 hr
26010_J	67.7	1 hr	141.9	1 hr	212.3	1 hr	278	1 hr	362.4	1 hr	434	1 hr
26010_R	67.7	1 hr	141.9	1 hr	212.3	1 hr	278	1 hr	362.4	1 hr	434	1 hr
26005	50.8	1 hr	108.4	1 hr	164.3	1 hr	216.7	1 hr	284.2	1 hr	341.7	1 hr
26005_J	118.1	3 hr	248.9	1 hr	373.5	1 hr	490.1	1 hr	640.3	1 hr	767.6	1 hr
26005_R	118.1	3 hr	248.9	1 hr	373.5	1 hr	490.1	1 hr	640.3	1 hr	767.6	1 hr
26000	19.5	3 hr	43.4	1 hr	71.7	1 hr	100.3	1 hr	139.3	1 hr	173.5	1 hr
26000_S	137.6	3 hr	291.1	1 hr	443.5	1 hr	587.3	1 hr	773.1	1 hr	931.5	1 hr
24010	46.3	3 hr	99.5	1 hr	151.9	1 hr	201.2	1 hr	264.6	1 hr	319.1	1 hr
24005	79.2	1 hr	143.4	1 hr	201.3	1 hr	253.2	1 hr	317.4	1 hr	371.1	1 hr
24010_J	124.8	1 hr	242.8	1 hr	353	1 hr	454	1 hr	581.6	1 hr	689.2	1 hr
24010_R	124.8	1 hr	242.8	1 hr	353	1 hr	454	1 hr	581.6	1 hr	689.2	1 hr
24000	19.5	3 hr	42.5	3 hr	73.5	1 hr	109.3	2 hr	152	1 hr	191.6	1 hr
24000_S	133.8	1 hr	281.9	1 hr	424.3	1 hr	558.6	1 hr	731.7	1 hr	880.1	1 hr
28015	122.8	1 hr	205.7	1 hr	278.3	1 hr	342.9	1 hr	421	1 hr	485.1	1 hr
28015_J	122.8	1 hr	205.7	1 hr	278.3	1 hr	342.9	1 hr	421	1 hr	485.1	1 hr
28010	119.6	1 hr	201.4	1 hr	272	1 hr	334.4	1 hr	410.7	1 hr	473	1 hr
28015_R	122.8	1 hr	205.7	1 hr	278.3	1 hr	342.9	1 hr	421	1 hr	485.1	1 hr
28010_J	237.2	1 hr	398.4	1 hr	539.3	1 hr	663.4	1 hr	813.4	1 hr	936.5	1 hr
28010_R	237.2	1 hr	398.4	1 hr	539.3	1 hr	663.4	1 hr	813.4	1 hr	936.5	1 hr
28005	102.2	1 hr	177	1 hr	242.8	1 hr	301.5	1 hr	373.6	1 hr	432.9	1 hr
28005_S	339	1 hr	575.1	1 hr	780.8	1 hr	963.2	1 hr	1184.4	1 hr	1367.1	1 hr
23100	121	1 hr	209.6	1 hr	288.2	1 hr	359.3	1 hr	445.1	1 hr	516.4	1 hr
23100_J	121	1 hr	209.6	1 hr	288.2	1 hr	359.3	1 hr	445.1	1 hr	516.4	1 hr
23100_R	121	1 hr	209.6	1 hr	288.2	1 hr	359.3	1 hr	445.1	1 hr	516.4	1 hr
23095	100	1 hr	175	1 hr	241.7	1 hr	301.4	1 hr	374.2	1 hr	435	1 hr
23095_J	219.3	1 hr	381.6	1 hr	526.6	1 hr	657.3	1 hr	815.1	1 hr	947	1 hr
23095_R	219.3	1 hr	381.6	1 hr	526.6	1 hr	657.3	1 hr	815.1	1 hr	947	1 hr
23090	104.9	1 hr	181	1 hr	249	1 hr	309.7	1 hr	383.2	1 hr	444.2	1 hr
23090_S	321.5	1 hr	558.1	1 hr	768.5	1 hr	957.4	1 hr	1185.8	1 hr	1376.6	1 hr
19115	81.7	1 hr	169	1 hr	251.9	1 hr	328.9	1 hr	427.7	1 hr	511.2	1 hr
19115_J	81.7	1 hr	169	1 hr	251.9	1 hr	328.9	1 hr	427.7	1 hr	511.2	1 hr
19115_R	81.7	1 hr	169	1 hr	251.9	1 hr	328.9	1 hr	427.7	1 hr	511.2	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
19110	43.4	1 hr	88.7	1 hr	132.9	1 hr	173.6	1 hr	224.2	1 hr	268.2	1 hr
19095	55	3 hr	112.8	3 hr	185.2	1 hr	267	2 hr	359.9	1 hr	445.6	1 hr
19110_J	123.6	1 hr	253.9	1 hr	378.4	1 hr	494.2	1 hr	641	1 hr	766.6	1 hr
2140	10	3 hr	23.6	3 hr	41	2 hr	64.8	2 hr	88.4	1 hr	114.7	1 hr
2140_J	10	3 hr	23.6	3 hr	41	2 hr	64.8	2 hr	88.4	1 hr	114.7	1 hr
2140_R	10	3 hr	23.6	3 hr	41	2 hr	64.8	2 hr	88.4	1 hr	114.7	1 hr
2135	41.2	1 hr	91	1 hr	141.6	1 hr	189.2	1 hr	249.2	1 hr	301.4	1 hr
2135__J	42.9	3 hr	94	1 hr	150.3	1 hr	206.5	1 hr	282.3	1 hr	348.7	1 hr
2135_R	42.9	3 hr	94	1 hr	150.3	1 hr	206.5	1 hr	282.3	1 hr	348.7	1 hr
2130	8.1	3 hr	18.7	1 hr	31.4	1 hr	45.1	1 hr	63.6	1 hr	80.4	1 hr
2130_J	50.9	3 hr	112.5	1 hr	181.5	1 hr	250.7	1 hr	343.4	1 hr	424.7	1 hr
19090	44.7	3 hr	96.1	1 hr	163.2	1 hr	230.3	2 hr	319.8	1 hr	397.9	1 hr
19030	36.3	3 hr	77.6	3 hr	129.2	1 hr	194	2 hr	264.7	1 hr	332.4	1 hr
27005	14.7	3 hr	31.8	3 hr	53.1	2 hr	81.2	2 hr	111	1 hr	140.3	1 hr
27005_J	14.7	3 hr	31.8	3 hr	53.1	2 hr	81.2	2 hr	111	1 hr	140.3	1 hr
27000	52.3	3 hr	106.1	1 hr	156.6	1 hr	203.4	1 hr	263.5	1 hr	313.8	1 hr
27005_R	14.7	3 hr	31.8	3 hr	53.1	2 hr	81.2	2 hr	111	1 hr	140.3	1 hr
27000_S	63.2	3 hr	131.1	1 hr	204.3	1 hr	274.9	1 hr	367.5	1 hr	446.2	1 hr
2245	37.7	3 hr	77.3	3 hr	124.7	2 hr	184.3	2 hr	239.6	1 hr	298.6	1 hr
2175	31.7	3 hr	74	1 hr	128.8	1 hr	185.4	2 hr	264.1	1 hr	334.8	1 hr
2175_J	31.7	3 hr	74	1 hr	128.8	1 hr	185.4	2 hr	264.1	1 hr	334.8	1 hr
19070	37.3	3 hr	77.7	3 hr	129.4	1 hr	186.6	2 hr	253.8	1 hr	315.3	1 hr
2205	56.8	3 hr	122.7	1 hr	193	1 hr	261.4	1 hr	351.3	1 hr	428.8	1 hr
19000	68.2	3 hr	143.9	1 hr	218.9	1 hr	289.6	1 hr	381	1 hr	458.9	1 hr
2235	55.3	3 hr	117.5	1 hr	183.5	1 hr	247.1	1 hr	331	1 hr	403	1 hr
28000	124.2	1 hr	222.1	1 hr	307.9	1 hr	385.4	1 hr	481.1	1 hr	560.1	1 hr
28000_S	124.2	1 hr	222.1	1 hr	307.9	1 hr	385.4	1 hr	481.1	1 hr	560.1	1 hr
19060	31.8	3 hr	66	1 hr	110.4	1 hr	154.9	2 hr	212.6	1 hr	262.8	1 hr
2250	40.9	3 hr	83.7	1 hr	133.1	1 hr	180.8	1 hr	243.4	1 hr	296.8	1 hr
2250_J	40.9	3 hr	83.7	1 hr	133.1	1 hr	180.8	1 hr	243.4	1 hr	296.8	1 hr
17180	39.9	3 hr	86.5	1 hr	138	1 hr	188.8	1 hr	256.5	1 hr	315.3	1 hr
19020	22.9	3 hr	51.3	1 hr	84.7	1 hr	118.7	1 hr	165	1 hr	205.6	1 hr
19020_R	22.9	3 hr	51.3	1 hr	84.7	1 hr	118.7	1 hr	165	1 hr	205.6	1 hr
19025	9.2	3 hr	20.4	1 hr	33.6	1 hr	46.8	1 hr	63.8	1 hr	79.3	1 hr
19025_J	9.2	3 hr	20.4	1 hr	33.6	1 hr	46.8	1 hr	63.8	1 hr	79.3	1 hr
19025_R	9.2	3 hr	20.4	1 hr	33.6	1 hr	46.8	1 hr	63.8	1 hr	79.3	1 hr
19010_J	32.1	3 hr	71.6	1 hr	117.1	1 hr	164.1	1 hr	227.2	1 hr	282.9	1 hr
17175	34.9	3 hr	72.4	1 hr	116.2	1 hr	158.9	1 hr	215.2	1 hr	263.2	1 hr
19015	44.3	3 hr	94	1 hr	144.9	1 hr	193.7	1 hr	257.3	1 hr	311.9	1 hr
19015_J	44.3	3 hr	94	1 hr	144.9	1 hr	193.7	1 hr	257.3	1 hr	311.9	1 hr
19055_J	23.6	3 hr	53.2	1 hr	88.9	1 hr	125.1	1 hr	175	1 hr	219	1 hr
19050	17.9	3 hr	40.8	1 hr	69.3	1 hr	98	1 hr	138.2	1 hr	173.6	1 hr
19050_J	17.9	3 hr	40.8	1 hr	69.3	1 hr	98	1 hr	138.2	1 hr	173.6	1 hr
19050_R	17.9	3 hr	40.8	1 hr	69.3	1 hr	98	1 hr	138.2	1 hr	173.6	1 hr
19055	6.1	3 hr	13.7	1 hr	22.5	1 hr	31.1	1 hr	42.1	1 hr	51.9	1 hr
2240	62.4	1 hr	127.1	1 hr	190.2	1 hr	248	1 hr	320.6	1 hr	382.6	1 hr
2105	20.5	3 hr	44	3 hr	75.8	1 hr	108.9	2 hr	150.9	1 hr	188.4	1 hr
2100	25.9	3 hr	57.8	1 hr	94.7	1 hr	132.5	1 hr	183.5	1 hr	228.4	1 hr
17055	28	3 hr	59.5	1 hr	95.2	1 hr	130	1 hr	176.5	1 hr	216.4	1 hr
17055_J	28	3 hr	59.5	1 hr	95.2	1 hr	130	1 hr	176.5	1 hr	216.4	1 hr
19010	13.5	3 hr	29.3	3 hr	49.3	1 hr	75.6	2 hr	103.9	1 hr	131.4	1 hr
19105	33.8	3 hr	69.2	1 hr	106	1 hr	140.8	1 hr	186.2	1 hr	224.7	1 hr
19105_J	33.8	3 hr	69.2	1 hr	106	1 hr	140.8	1 hr	186.2	1 hr	224.7	1 hr
17050	18.3	3 hr	39.8	1 hr	67.1	1 hr	94.1	1 hr	130.7	1 hr	162.5	1 hr
2125	19.8	3 hr	43.4	1 hr	70.6	1 hr	97.7	1 hr	134.4	1 hr	166.3	1 hr

Element	2-year Max Peak Discharge	2-year Critical Duration	5-year Max Peak Discharge	5-year Critical Duration	10-year Max Peak Discharge	10-year Critical Duration	25-year Max Peak Discharge	25-year Critical Duration	50-year Max Peak Discharge	50-year Critical Duration	100-year Max Peak Discharge	100-year Critical Duration
2230	30.7	3 hr	68.8	1 hr	108	1 hr	145.2	1 hr	191.9	1 hr	232.8	1 hr
19040	2.9	3 hr	7	1 hr	12.1	1 hr	17.7	1 hr	25.4	1 hr	32.5	1 hr
19040_J	2.9	3 hr	7	1 hr	12.1	1 hr	17.7	1 hr	25.4	1 hr	32.5	1 hr
19045	4.1	3 hr	9.5	1 hr	16.9	1 hr	24.7	2 hr	35.3	1 hr	45	1 hr
19045_J	4.1	3 hr	9.5	1 hr	16.9	1 hr	24.7	2 hr	35.3	1 hr	45	1 hr
19121	5.2	3 hr	11.1	3 hr	18.6	1 hr	27.6	2 hr	37.8	1 hr	47.4	1 hr
19045_R	4.1	3 hr	9.5	1 hr	16.9	1 hr	24.7	2 hr	35.3	1 hr	45	1 hr
19040_R	2.9	3 hr	7	1 hr	12.1	1 hr	17.7	1 hr	25.4	1 hr	32.5	1 hr
19121_J	12.2	3 hr	26.7	1 hr	47.2	1 hr	68.6	2 hr	96.3	1 hr	121.7	1 hr
2200	11.8	3 hr	25.8	3 hr	45.1	1 hr	66.1	2 hr	92.2	1 hr	116	1 hr
17065	14	3 hr	30.7	1 hr	51.5	1 hr	72	1 hr	100.2	1 hr	124.7	1 hr
17060	11.9	3 hr	26.3	1 hr	44.3	1 hr	62.3	1 hr	86.7	1 hr	108.1	1 hr
2090	3.5	3 hr	9.7	3 hr	16.9	2 hr	27.4	2 hr	38.4	2 hr	50.7	1 hr
19005	15.3	3 hr	34	1 hr	55.9	1 hr	77	1 hr	104.1	1 hr	128.5	1 hr
19005_J	15.3	3 hr	34	1 hr	55.9	1 hr	77	1 hr	104.1	1 hr	128.5	1 hr
17000	4.6	3 hr	10.6	3 hr	18.4	2 hr	29.4	2 hr	41.4	1 hr	53.3	1 hr
19035	3.3	3 hr	7.6	1 hr	12.7	1 hr	18.2	1 hr	25.4	1 hr	31.9	1 hr
19035_J	3.3	3 hr	7.6	1 hr	12.7	1 hr	18.2	1 hr	25.4	1 hr	31.9	1 hr

SOUTHWEST JOPLIN - CULVERT HYDRAULIC MODELING RESULTS

FID	CULVERT_ID	DESCRIPTIO	CAP_CFS	OT_Freq	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	REMARKS
0	23005-01	3 -12' x 9' RCB	3786	100YR_CFS	375	726	1061	1508	1842	2191	
1	17070-01	2 - 6.4' x 11.2' RCB	2382	100YR_CFS	97.8	211	361	515	715	891	
2	17075-01	1 - 6' x 3' RCB	138	2YR_CFS	80.3	174	292	409	567	704	
3	18000-01	2 - 48" CMP	187	Less than 2yr	566	1144	1777	2385	3157	3818	
4	18000-02	1 - 36" x 60" CMP	87.9	Less than 2yr	559	1132	1759	2360	3124	3778	
5	21000-03	1 - 16' x 16.5' Concrete Tunnel	5334	100YR_CFS	143	286	420	544	701	835	Culvet is a tunnel under railroad. Cresting Elevation was set using LiDAR as there was no survey data available.
6	17155-01	2 - 4' x 5.5' RCB	460	50YR_CFS	51.3	116	203	292	411	518	
7	2180-01	3 - RCP (varies sizes)	756	100YR_CFS	82.9	174	287	423	573	714	This culvert has 1 - 36" RCP, 1 - 42" RCP, & 1 - 48" RCP
8	22045-03	3 - 24" RCP	91.6	5YR_CFS	34.8	76.9	132	187	260	325	
9	25065-01	Bridge	0	---	0	0	0	0	0	0	Bridge. No data available for this site.
10	25050-01	2 - 36" x 24" CMP	59.3	Less than 2yr	850	1631	2346	3005	3829	4515	
11	17115-01	3 - 22" Steel Pipe	32.9	Less than 2yr	129	276	450	620	848	1045	Modeled as HDPE with a Manning's of 0.013.
12	2270-01	1 - 8' x 6' RCB	775	100YR_CFS	86.9	190	305	417	567	698	
13	21050 (1 of 2)	1 - 24" RCP	172	Less than 2yr	887	1686	2441	3138	4011	4737	Culvert has been modeled with 21050 (2 of 2).
14	22010-01	1 - 24' x 7' RCB	1880	25YR_CFS	411	826	1279	1717	2287	2775	
15	22020-02	3 - 10' x 6' RCB	1849	25YR_CFS	390	785	1205	1607	2126	2566	
16	22020-04	2 - 34" x 52" RCP	207	2YR_CFS	164	330	510	683	905	1095	
17	17010-01	2 - 10' x 5.5' RCB	1466	100YR_CFS	28.1	62.2	109	166	232	296	
18	18060-02	1 - 5' x 3' RCB	101	Less than 2yr	214	436	647	843	1091	1303	
19	18065-01	1 - 12' x 4.5' RCB	350	2YR_CFS	205	415	614	798	1031	1229	
20	18055 (1 of 2)	1 - 7.5' x 4' RCB	319	2YR_CFS	253	536	814	1079	1411	1694	Hydrology for this location is affected by flow splits between parallel streams. Peak flow rates shown reflect all flow from watershed to the culvert. Values shown are conservative and further evaluation is required to identify actual peak flow rates.
21	18065-03	1 - 8' x 5.5' RCB	269	2YR_CFS	189	373	547	708	910	1080	
22	2155-01	1 - 24" RCP	24.9	Less than 2yr	46.4	102	174	266	369	468	
23	2160-01	2 - 72" RCP	559	100YR_CFS	45.4	99.9	170	260	361	457	
24	21000-02	1 - 23.5' x 6' RCB	1090	Less than 2yr	1739	3279	4782	6173	7921	9385	
25	21000-01	1 - 22' x 5.5' RCB	872	Less than 2yr	1762	3316	4839	6249	8020	9504	
26	25010-01	2 - 36" CMP	103	Less than 2yr	143	252	349	436	543	632	
27	23060-01	4 - 4.5'x3' RCB & 2 - 18" RCP	275	Less than 2yr	288	558	822	1174	1437	1714	
28	25095-01	1 - 36" RCP	62.6	Less than 2yr	138	241	329	409	506	586	
29	17090-01	2 - 8.4' x 4.4' RCB	750	10YR_CFS	193	408	684	960	1324	1641	
30	17105-01	1 - 4.2' x 2.1' RCB	60.2	Less than 2yr	156	336	553	767	1054	1301	
31	17095-01	1 - 13.8' x 5' RCB	729	10YR_CFS	188	398	665	931	1284	1591	
32	2245-02	1 - 4' x 3' RCB	97.3	5YR_CFS	40.9	83.7	133	181	243	297	
33	2245-01	1 - 8' x 3' RCB	108	5YR_CFS	40.9	83.7	133	181	243	297	
34	19010-01	1 - 8' x 4' RCB	265	50YR_CFS	36.6	81.4	134	135	262	327	

FID	CULVERT_ID	DESCRIPTIO	CAP_CFS	OT_Freq	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	REMARKS
35	2235-01	1 - 8' x 3.5' RCB	258	25YR_CFS	55.3	118	184	247	331	403	
36	2220-01	2 - 30" RCP	352	25YR_CFS	64.7	135	209	278	371	450	
37	17080-01	1 - 4' x 2' RCB	50.5	2YR_CFS	43.0	90.5	149	206	282	347	
38	21015-01	2 - 36" RCP	130	Less than 2yr	582	1124	1656	2157	2784	3307	The two pipes are different lengthes and have been modeled as such.
39	19105-01	1 - 42' x 5' RCB	2074	2YR_CFS	1898	3532	5152	6653	8535	10120	
40	2170-02	1 - 12' x 7' RCB	755	100YR_CFS	19.9	41.7	70.6	101	138	172	Culvert has a weir structure that was not model; It was assumed in high water events to be negligible.
41	21050 (2 of 2)	4 - 36" Corrugated Plastic Pipe	172	Less than 2yr	887	1686	2441	3138	4011	4737	Culvert has been modeled with 21050 (1 of 2).
42	23050-01	3 - 12.33' x 4' RCB	1324	25YR_CFS	304	588	865	1233	1508	1795	
43	25065-03	2 - 30" CMP	61.9	Less than 2yr	92.5	175	260	340	443	529	
44	25065-02	1 - 54" RCP	195	5YR_CFS	94.6	179	267	349	455	543	
45	2070-01	1 - 8' x 6' RCB	485	25YR_CFS	64.1	140	239	354	489	614	
46	22005-01	2 - 36" RCP	146	100YR_CFS	1.71	4.95	9.7	19.7	28.7	38.9	
47	23070 (1 of 2)	1 - 24" pipe material varies	52.1	5YR_CFS	25.8	51.5	83.9	119	160	197	Transitions from PVC (Upstream) to Corrugated Plastic Pipe (Downstream). (1 of 2)
48	19065-01	Bridge	0	---	0	0	0	0	0	0	Bridge. No data available for this site.
49	19120-01	1 - 16' x 3' RCB	382	---	0	0	0	0	0	0	Hydrology could not be completed because of large area outside of our H&H scope
50	19120-02	2 - 12' x 6.5' RCB	1483	---	0	0	0	0	0	0	Hydrology could not be completed because of large area outside of our H&H scope
51	23030-01	Bridge	0	---	0	0	0	0	0	0	Bridge. No data available for this site.
52	24005-02	1 - 48" CMP	165	10YR_CFS	52.8	95.6	134	169	212	247	
53	24005-03	1 - 48" pipe material varies	131	25YR_CFS	39.6	71.7	101	127	159	186	Pipe transitions from RCP (Upstream) to CMP (Downstream).
54	21090-01	1 - 15.5' x 3.25' RCB	396	Less than 2yr	549	1048	1520	1962	2506	2956	
55	25060-01	3 - 36" RCP	227	10YR_CFS	57.7	116	179	239	318	384	
56	25030-01	3 - 36" CMP	111	Less than 2yr	296	596	899	1185	1555	1868	
57	25035-01	3 - 36" CMP	119	Less than 2yr	236	482	717	937	1221	1460	
58	25005-01	1 - 18' x 9.1' RCB	1182	Less than 2yr	1375	2673	3904	5048	6484	7689	Bridge with a flat bottom river that was model as a RCB.
59	25015-01	2 - 36" RCP	121	Less than 2yr	121	212	293	366	455	529	
60	24005-01	1 - 60" CMP	446	100YR_CFS	59.4	108	151	190	238	278	Very tall embankment
61	2155-03	1 - 16' x 4' RCB	437	25YR_CFS	54.6	121	205	317	439	558	
62	23095-01	1 - 30" pipe material varies	39.6	Less than 2yr	219	382	527	657	815	947	Pipe transitions from VCP (Upstream) to RCP (Downstream).
63	22020-03	2 - 72" RCP	655	2YR_CFS	365	736	1121	1487	1960	2361	
64	18055 (2 of 2)	2 - 8' x 4' RCB	319	2YR_CFS	251	531	805	1066	1393	1671	Hydrology for this location is affected by flow splits between parallel streams. Peak flow rates shown reflect all flow from watershed to the culvert. Values shown are conservative and further evaluation is required to identify actual peak flow rates.
65	21030-02	1 - 16' x 17' Concrete Tunnel	5080	100YR_CFS	582	1124	1656	2157	2784	3307	Culvet is a tunnel under railroad. Cresting Elevation was set using LiDAR as there was no survey data available.
66	21045-01	2 - 8' x 4' RCB	441	Less than 2yr	492	949	1377	1774	2270	2684	

FID	CULVERT_ID	DESCRIPTIO	CAP_CFS	OT_Freq	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	REMARKS
67	21110-01	1 - 10' x 8' RCB	1379	100YR_CFS	231	434	613	776	982	1151	
68	23070 (2 of 2)	1 - 24" pipe material varies	52.1	5YR_CFS	25.8	51.5	83.9	119	160	197	Transitions from RCP (Upstream) to Corrugated Plastic Pipe (Downstream). (2 of 2)
69	21145-01	1 - 6' x 6' RCB	473	25YR_CFS	125	237	338	430	546	642	Capacity likely in excess of 100-year if storage above highway embankment for accounted for
70	21150-01	1 - 6' x 6' RCB	648	100YR_CFS	116	227	328	421	538	636	
71	22035-01	1 - 5.5'x5' Arch & 1 - 6'x6' RCB	420	10YR_CFS	140	270	387	494	629	741	East culvert (RCB) has a 2.06' dam in front of the inlet and west culvert (Arch) has a 2.23' dam in front of the inlet.
72	22045-02	1 - 4' x 3.5' RCB	94.7	2YR_CFS	60.4	127	213	299	412	510	
73	22045-01	2 - 36" CMP	136	2YR_CFS	89.8	167	236	299	378	443	
74	22000-01	2 - 12' x 9' RCB	3313	100YR_CFS	411	830	1295	1751	2348	2865	
75	20005-01	1 - 6' x 5' Arch Concrete Culvert	257	5YR_CFS	83.1	183	291	399	542	666	Culvert inlet geometry is an arch and the outlet geometry is a rectangle.
76	23005-02	3 - 36" RCP	250	2YR_CFS	155	283	398	502	632	739	
77	23005-03	1 - 4' x 4' RCB	203	25YR_CFS	54.5	96.5	134	168	209	243	
78	23005-04	1 - 4' x 4' RCB	145	25YR_CFS	48.4	80.6	109	133	163	188	
79	23085-01	2 - 30" VCP	99.8	Less than 2yr	297	478	631	768	929	1061	One barrel is a VCP and the other barrel is a RCP.
80	23090-02	3 - 30" VCP	142	Less than 2yr	219	382	527	657	815	947	One barrel transitions from VCP (Upstream) to RCP (Downstream).
81	23085-02	1 - 4' x 3' RCB	126	Less than 2yr	165	267	354	431	523	598	
82	23025-01	1 - 48" RCP	139	100YR_CFS	0.90	2.90	5.60	11.6	16.6	23.5	
83	22000-02	5 – see remarks	680	2YR_CFS	411	826	1283	1728	2310	2813	Crossing contains 3 - 2'x2' RCB, 1 - 30"x19" CMP, & 1 - 12" CMP. Cresting Elevation was set using LiDAR as there was no survey data available.
84	22020-01	1 - 36" RCP	76.3	5YR_CFS	25.0	52.9	87.3	132	174	219	
85	18005-01	Private Drive	0	---	0	0	0	0	0	0	Private Drive. No data available for this site.
86	2170-01	1 - 24" RCP	36.6	5YR_CFS	13.3	27.8	47.1	67.2	92.2	115	
87	18065-02	1 - 60" Corrugated Plastic Pipe	137	Less than 2yr	199	399	589	764	986	1173	
88	19015-01	1 - 12' x 2.5' RCB	262	25YR_CFS	59.6	128	201	194	361	440	
89	18060-01	2 - 54" x 60" CMP	276	2YR_CFS	239	502	755	993	1293	1550	Hydrology for this location is affected by flow splits between parallel streams. Peak flow rates shown reflect all flow from watershed to the culvert. Values shown are conservative and further evaluation is required to identify actual peak flow rates.
90	2255-01	1 - 10' x 11.5' RCB	1202	100YR_CFS	86.9	190	305	417	567	698	
91	21030-01	1 - 24" CMP & 1 - 36"x24" Arch Pipe	49.5	Less than 2yr	582	1124	1656	2157	2784	3307	
92	2155-02	1 - 2' x 1.5' RCB	13.7	Less than 2yr	46.4	102	174	266	369	468	
93	23090-01	2 - 36" Steel Pipe	124	Less than 2yr	219	382	527	657	815	947	Modeled as HDPE with a Manning's of 0.013.
94	23000-01	1 - 48" RCP	128	100YR_CFS	0.90	2.90	5.60	11.6	16.6	23.5	
95	18070-01	1 - 4' x 4' RCB	120	Less than 2yr	137	259	373	476	604	713	

SOUTHWEST JOPLIN - SUBWATERHSHED HYDRAULIC MODELING RESULTS

FID	WTRSHD_ID	SUBWTRSHD	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	CN	CN_F	ACRES	REMARKS
0	2	2060	0	0	0	0	0	0	0	0	68.8	Only area data available. This watershed is part of the 1998 masterplan.
1	2	2033	0	0	0	0	0	0	0	0	14.2	Only area data available. This watershed is part of the 1998 masterplan.
2	2	2034	0	0	0	0	0	0	0	0	50.3	Only area data available. This watershed is part of the 1998 masterplan.
3	2	2010	0	0	0	0	0	0	0	0	90.6	Only area data available. This watershed is part of the 1998 masterplan.
4	2	2040	0	0	0	0	0	0	0	0	39.8	Only area data available. This watershed is part of the 1998 masterplan.
5	2	2020	0	0	0	0	0	0	0	0	71.6	Only area data available. This watershed is part of the 1998 masterplan.
6	2	2045	0	0	0	0	0	0	0	0	1.86	Only area data available. This watershed is part of the 1998 masterplan.
7	2	2032	0	0	0	0	0	0	0	0	7.47	Only area data available. This watershed is part of the 1998 masterplan.
8	2	2005	0	0	0	0	0	0	0	0	127	Only area data available. This watershed is part of the 1998 masterplan.
9	2	2030	0	0	0	0	0	0	0	0	18.7	Only area data available. This watershed is part of the 1998 masterplan.
10	2	2015	0	0	0	0	0	0	0	0	39.9	Only area data available. This watershed is part of the 1998 masterplan.
11	2	2000	0	0	0	0	0	0	0	0	23.2	Only area data available. This watershed is part of the 1998 masterplan.
12	21	21025	69.6	135	196	252	322	381	79	88	113	
13	21	21085	112	211	302	385	487	574	81	88	160	
14	23	23005	479	887	1271	1773	2267	2745	77	85	171	
15	23	23025	0.90	2.90	5.60	11.6	16.6	23.5	46	69	58.3	
16	23	23045	41.2	88.0	136	182	241	293	73	82	113	
17	22	22005	1.90	5.90	11.3	23.5	33.7	46.9	46	69	118	
18	23	23030	368	713	1042	1482	1809	2152	62	76	146	
19	22	22010	413	831	1295	1751	2345	2858	51	71	147	
20	23	23060	300	581	855	1219	1491	1776	71	82	80.2	
21	22	22015	25.4	54.7	91.3	138	189	238	64	77	165	
22	23	23035	18.5	39.3	65.3	96.8	132	165	65	77	109	
23	23	23065	264	511	756	1082	1325	1585	72	82	144	
24	23	23055	29.3	60.8	98.7	136	185	227	69	80	117	
25	22	22025	45.9	94.9	154	211	287	352	69	79	182	
26	23	23070	38.8	77.7	127	180	242	298	68	79	176	
27	22	22030	349	704	1065	1409	1852	2226	72	81	51.5	
28	22	22020	413	829	1281	1714	2272	2748	67	80	187	
29	22	22045	149	306	474	635	846	1025	69	79	154	
30	22	22050	89.8	167	236	299	378	443	81	87	131	
31	2	2170	29.9	62.5	106	151	208	258	66	77	153	
32	2	2165	13.1	31.6	55.3	89.9	127	166	59	77	147	
33	28	28000	124	222	308	385	481	560	83	87	164	
34	2	2120	8.30	23.0	40.3	66.2	91.9	120	56	77	136	
35	2	2115	14.2	32.2	55.5	87.6	121	155	60	79	129	
36	17	17140	2.70	8.20	16.5	29.5	42.6	57.7	50	74	106	
37	2	2090	3.50	9.70	16.9	27.4	38.4	50.7	56	77	52.8	Shoal Creek flow data was not accounted for in this watershed.
38	17	17135	29.2	76.2	133	216	294	380	60	78	76.1	Shoal Creek flow data was not accounted for in this watershed.
39	17	17055	28.0	59.5	95.2	130	177	216	69	81	102	
40	2	2125	19.8	43.4	70.6	97.7	134	166	68	81	80.9	Shoal Creek flow data was not accounted for in this watershed.
41	17	17060	11.9	26.3	44.3	62.3	86.7	108	66	79	59.8	
42	17	17000	4.60	10.6	18.4	29.4	41.4	53.3	45	57	42.7	Shoal Creek flow data was not accounted for in this watershed.
43	17	17050	18.3	39.8	67.1	94.1	131	163	64	78	90.4	Shoal Creek flow data was not accounted for in this watershed.
44	2	2245	37.7	77.3	125	184	240	299	60	73	213	Shoal Creek flow data was not accounted for in this watershed.
45	17	17175	34.9	72.4	116	159	215	263	70	82	131	Shoal Creek flow data was not accounted for in this watershed.
46	17	17065	14.0	30.7	51.5	72.0	100	125	66	80	68.8	Shoal Creek flow data was not accounted for in this watershed.

FID	WTRSHD_ID	SUBWTRSHD	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	CN	CN_F	ACRES	REMARKS
47	21	21035	547	1054	1540	1996	2563	3037	67	81	92.8	
48	2	2100	25.9	57.8	94.7	133	184	228	68	80	112	
49	2	2175	31.7	74.0	129	185	264	335	64	80	195	Shoal Creek flow data was not accounted for in this watershed.
50	21	21045	527	1014	1475	1904	2438	2885	72	84	147	
51	21	21020	88.7	182	271	354	459	548	77	87	175	
52	2	2230	30.7	68.8	108	145	192	233	73	85	77.5	Shoal Creek flow data was not accounted for in this watershed.
53	17	17180	39.9	86.5	138	189	257	315	70	82	141	
54	2	2070	81.3	177	299	451	615	776	62	78	189	
55	21	21030	583	1127	1660	2161	2790	3315	68	84	169	
56	2	2105	20.5	44.0	75.8	109	151	188	66	80	114	
57	2	2235	55.3	118	184	247	331	403	71	83	169	Shoal Creek flow data was not accounted for in this watershed.
58	21	21040	71.3	151	229	302	394	474	76	87	153	
59	2	2270	114	247	394	539	732	898	70	83	92.3	
60	2	2210	126	271	433	591	807	992	65	82	113	
61	21	21000	1899	3535	5157	6660	8545	10134	69	82	167	
62	2	2250	40.9	83.7	133	181	243	297	70	82	145	
63	2	2075	20.6	44.3	75.5	111	153	192	65	82	122	
64	18	18000	567	1148	1782	2391	3166	3830	70	84	110	
65	2	2190	21.5	46.5	79.1	118	163	204	64	81	136	
66	19	19100	55.8	120	187	251	334	406	72	83	160	
67	2	2185	23.0	48.1	79.8	116	157	196	66	82	122	
68	19	19010	32.1	71.6	117	164	227	283	41	48	93.7	Shoal Creek flow data was not accounted for in this watershed.
69	19	19105	33.8	69.2	106	141	186	225	73	82	93.6	Shoal Creek flow data was not accounted for in this watershed.
70	2	2180	82.9	174	287	423	573	714	66	82	207	
71	19	19000	68.2	144	219	290	381	459	70	80	171	Shoal Creek flow data was not accounted for in this watershed.
72	18	18020	28.5	58.5	96.2	133	182	224	68	83	122	
73	19	19065	38.4	81.2	133	200	269	337	65	75	234	Shoal Creek flow data was not accounted for in this watershed.
74	17	17085	30.0	67.4	115	161	227	284	66	82	158	
75	2	2215	31.9	70.8	116	162	225	279	68	82	138	
76	17	17110	30.0	64.3	105	144	198	243	69	84	122	
77	17	17115	140	300	490	676	925	1141	64	80	89.2	
78	17	17130	27.7	58.5	94.3	129	176	215	69	84	106	
79	17	17080	43.0	90.5	149	206	282	347	68	83	184	
80	18	18030	46.9	93.4	142	189	248	299	74	85	130	
81	18	18015	537	1099	1708	2293	3036	3670	66	82	95.6	
82	18	18025	193	385	590	786	1037	1250	65	82	57.5	
83	18	18050	266	564	861	1146	1504	1808	66	82	40.7	
84	17	17120	43.8	95.5	153	210	286	353	69	83	160	
85	19	19095	55.0	113	185	267	360	446	67	80	274	Shoal Creek flow data was not accounted for in this watershed.
86	19	19060	31.8	66.0	110	155	213	263	67	83	149	Shoal Creek flow data was not accounted for in this watershed.
87	25	25080	631	1141	1598	2009	2522	2946	76	86	323	
88	19	19090	44.7	96.1	163	230	320	398	66	82	229	Flow data is only available for the watershed, upstream flows were beyond the scope of this project.
89	20	20000	116	255	417	578	792	979	66	81	164	
90	24	24005	79.2	143	201	253	317	371	82	89	100	
91	24	24010	46.3	99.5	152	201	265	319	74	86	114	
92	19	19070	37.3	77.7	129	187	254	315	66	82	193	Shoal Creek flow data was not accounted for in this watershed.
93	25	25005	1389	2720	3975	5141	6603	7836	71	83	189	

FID	WTRSHD_ID	SUBWTRSHD	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	CN	CN_F	ACRES	REMARKS
94	25	25020	1198	2382	3488	4516	5813	6903	61	79	92.7	
95	24	24000	134	282	424	559	732	880	64	81	127	
96	23	23085	341	547	723	879	1064	1215	90	92	119	
97	23	23100	121	210	288	359	445	516	85	90	112	
98	23	23020	165	267	354	431	523	598	89	91	115	
99	27	27005	14.7	31.8	53.1	81.2	111	140	63	76	101	
100	22	22060	24.0	54.4	95.0	137	193	243	65	77	145	
101	22	22040	58.4	112	159	203	258	304	80	86	103	
102	28	28015	123	206	278	343	421	485	87	88	103	
103	2	2140	10.0	23.6	41.0	64.8	88.4	115	60	78	104	
104	17	17045	13.4	30.0	53.9	82.0	116	148	62	78	104	
105	17	17150	16.6	35.5	58.9	89.3	120	151	63	80	112	
106	21	21010	101	196	284	366	467	553	79	89	162	
107	19	19080	68.1	132	192	247	315	373	79	89	101	
108	17	17020	16.1	36.1	63.7	92.1	130	164	64	82	100	
109	19	19020	22.9	51.3	84.7	119	165	206	67	82	103	
110	17	17170	21.8	47.7	79.3	110	153	190	67	83	100	
111	2	2265	29.3	64.3	103	142	193	238	70	84	102	
112	2	2085	23.5	50.6	83.2	115	158	196	68	83	101	
113	19	19115	81.7	169	252	329	428	511	76	86	175	
114	2	2225	38.7	79.3	121	160	211	254	74	85	103	
115	18	18010	28.0	63.3	109	154	216	271	65	82	155	
116	26	26010	67.7	142	212	278	362	434	76	86	153	
117	25	25090	203	317	412	497	598	679	91	92	116	
118	19	19050	17.9	40.8	69.3	98.0	138	174	66	82	95.3	
119	25	25015	121	212	293	366	455	529	84	90	131	
120	18	18045	72.7	144	210	271	348	412	78	87	143	
121	20	20015	26.4	59.2	98.2	138	190	237	68	83	104	
122	25	25075	39.9	78.9	120	158	207	249	74	84	107	
123	18	18075	120	222	315	399	503	590	82	88	152	
124	25	25100	95.9	164	222	274	337	389	86	90	101	
125	23	23095	219	382	527	657	815	947	84	89	108	
126	23	23080	407	673	903	1108	1353	1556	80	87	101	
127	23	23000	489	912	1312	1841	2372	2887	60	75	110	
128	23	23015	54.5	96.5	134	168	209	243	84	88	62.5	
129	22	22000	413	834	1308	1774	2383	2911	52	73	98.8	
130	23	23050	304	588	865	1232	1507	1794	70	80	18.7	
131	27	27000	63.2	131	204	275	368	446	77	84	113	
132	22	22055	34.8	77.1	132	186.9	261	326	69	79	45.0	
133	22	22035	140	270	387	494	629	741	79	83	150	
134	28	28010	237	398	539	663	813	937	87	88	118	
135	2	2160	54.6	121	205	318	439	558	60	78	118	
136	17	17040	17.0	42.1	73.6	119	169	220	54	76	100	
137	2	2135	42.9	94.0	150	207	282	349	74	86	100	
138	2	2110	28.7	73.2	128	205	283	367	57	78	100	
139	21	21080	180	347	502	644	820	971	78	88	121	
140	17	17145	21.2	57.9	102	167	228	297	54	76	120	

FID	WTRSHD_ID	SUBWTRSHD	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	CN	CN_F	ACRES	REMARKS
141	21	21055	49.6	96.8	142	183	235	278	79	89	72.6	
142	2	2205	56.8	123	193	261	351	429	70	83	177	Shoal Creek flow data was not accounted for in this watershed.
143	17	17015	28.1	62.2	109	166	232	296	61	80	108	
144	19	19015	44.3	94.0	145	194	257	312	73	85	124	
145	17	17075	87.8	190	322	454	630	784	63	80	107	
146	17	17165	34.4	78.6	136	193	272	341	62	81	100	
147	2	2080	55.5	121	210	306	425	534	61	80	117	
148	2	2260	51.2	113	184	255	351	434	67	83	101	
149	21	21005	143	286	420	544	701	835	74	87	102	
150	19	19075	169	351	527	690	898	1075	77	86	101	
151	17	17105	156	336	553	767	1054	1301	64	81	103	
152	2	2220	73.3	153	238	319	426	517	68	83	135	
153	17	17125	96.1	205	331	453	617	758	69	83	103	
154	19	19110	124	254	378	494	641	767	77	87	80.0	
155	26	26005	118	249	374	490	640	768	74	85	120	
156	25	25085	524	912	1256	1565	1941	2255	80	88	265	
157	20	19130	20.4	45.1	75.1	105	146	182	67	82	95.3	
158	18	18040	104	211	313	409	532	635	71	84	100	
159	20	20010	71.2	156	246	334	449	549	73	85	119	
160	25	25010	187	332	460	577	721	840	82	89	86.9	
161	25	25095	184	322	444	553	687	797	82	89	117	
162	25	25070	97.9	196	293	383	500	599	76	85	134	
163	18	18070	189	373	547	708	910	1080	74	85	183	
164	23	23090	322	558	769	957	1186	1377	85	89	102	
165	23	23075	442	757	1035	1284	1587	1839	73	83	116	
166	23	23010	375	726	1060	1507	1840	2187	71	80	39.2	
167	28	28005	339	575	781	963	1184	1367	85	90	108	
168	2	2150	84.8	187	315	485	664	842	60	77	103	
169	2	2155	75.1	164	277	421	579	731	68	82	100	
170	17	17035	18.2	50.6	89.2	148	207	274	50	75	123	
171	2	2130	50.9	113	182	251	343	425	65	81	41.2	
172	21	21050	985	1873	2713	3487	4457	5263	73	85	216	
173	17	17010	44.4	98.9	170	261.7	365	464	60	75	120	
174	2	2195	94.2	198	327	481	651	812	65	81	62.2	
175	17	17160	51.3	116	203	292	411	518	64	80	110	
176	17	17070	100	216	371	530	736	918	62	80	101	
177	17	17100	179	382	632	880	1209	1495	67	82	113	
178	19	19005	15.3	34.0	55.9	77.0	104	129	70	83	50.1	
179	19	19030	36.3	77.6	129	194	265	332	46	54	226	Shoal Creek flow data was not accounted for in this watershed.
180	2	2255	86.9	190	305	417	567	698	72	84	105	
181	26	26000	138	291	444	587	773	932	67	83	88.3	
182	18	18035	136	273	416	552	727	874	69	83	148	
183	25	25065	755	1421	2024	2572	3264	3838	70	82	147	
184	18	18065	231	478	713	933	1212	1451	71	84	172	
185	21	21060	655	1240	1801	2323	2969	3502	77	87	177	
186	17	17030	25.3	70.2	124	202	285	375	58	78	100	
187	2	2095	42.8	103	179	284	388	501	63	80	104	Shoal Creek flow data was not accounted for in this watershed.

FID	WTRSHD_ID	SUBWTRSHD	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	CN	CN_F	ACRES	REMARKS
188	17	17155	74.0	163	286	415	580	729	65	79	119	
189	17	17095	190	404	676	948	1309	1623	60	79	112	
190	25	25060	805	1537	2202	2811	3580	4220	72	84	174	
191	18	18060	248	525	796	1052	1374	1649	66	82	130	
192	17	17025	30.8	85.9	151	248	348	455	55	76	105	
193	21	21075	28.5	59.2	89.1	117	152	182	76	87	58.4	
194	2	2145	98.6	218	369	567	769	977	61	78	118	Shoal Creek flow data was not accounted for in this watershed.
195	17	17090	200	421	706	994	1368	1698	65	79	75.7	
196	18	18005	33.8	77.4	135	193	272	343	62	80	47.8	
197	18	18055	258	547	833	1105	1449	1740	64	81	59.6	
198	25	25055	854	1637	2352	3011	3836	4523	75	86	149	
199	21	21065	64.7	135	203	267	348	417	76	86	142	
200	25	25050	1188	2363	3452	4463	5740	6808	67	81	61.9	
201	25	25035	244	500	746	976	1275	1527	68	81	87.0	
202	20	19125	19.9	44.2	72.1	101	139	172	68	81	82.7	
203	2	2200	11.8	25.8	45.1	66.1	92.2	116	65	78	73.9	
204	17	17005	57.5	127	219	334	466	591	63	80	85.6	
205	21	21015	1741	3283	4788	6180	7929	9396	73	85	134	
206	20	20005	87.0	192	307	421	573	705	65	82	91.2	
207	2	2240	62.4	127	190	248	321	383	77	84	114	Shoal Creek flow data was not accounted for in this watershed.
208	19	19040	2.90	7.00	12.1	17.7	25.4	32.5	64	81	17.8	
209	19	19055	23.6	53.2	88.9	125	175	219	70	83	20.0	
210	19	19025	9.20	20.4	33.6	46.8	63.8	79.3	69	84	33.3	
211	20	19120	15.9	32.4	53.7	76.4	103	128	67	79	75.6	Flow data is only available for the watershed, upstream flows were beyond the scope of this project.
212	19	19035	3.30	7.60	12.7	18.2	25.4	31.9	67	82	15.5	
213	19	19045	4.10	9.50	16.9	24.7	35.3	45.0	63	81	27.4	
214	23	23040	333	641	937	1331	1624	1931	70	80	18.4	
215	21	21090	549	1048	1520	1962	2506	2956	78	87	162	
216	21	21095	108	220	324	418	542	639	78	88	160	
217	21	21100	88.4	178	262	340	438	521	74	86	118	
218	21	21105	54.3	99.0	140	177	223	261	82	89	64.4	
219	21	21110	320	613	876	1117	1420	1672	77	87	192	
220	21	21115	231	434	613	776	982	1151	81	89	62.9	
221	21	21120	81.6	155	222	283	359	423	80	88	133	
222	21	21125	110	205	289	366	462	541	81	89	176	
223	21	21130	96.2	182	262	335	425	502	80	89	131	
224	21	21135	420	820	1181	1514	1934	2282	73	85	151	
225	21	21140	65.3	121	173	220	277	326	81	89	88.0	
226	21	21145	125	237	338	430	546	642	80	88	211	
227	21	21150	116	227	328	421	538	636	79	88	222	
228	25	25002	39.9	85.9	134	180	240	292	72	85	115	
229	25	25000	1485	2882	4226	5478	7045	8366	67	82	195	
230	25	25031	54.0	106	164	219	289	350	73	85	165	
231	25	25045	187	380	558	723	936	1114	72	84	106	
232	25	25001	1444	2812	4118	5331	6851	8134	66	82	101	
233	25	25025	50.2	103	158	210	278	336	73	85	144	
234	25	25030	301	614	927	1223	1606	1932	60	77	53.0	

FID	WTRSHD_ID	SUBWTRSHD	2YR_CFS	5YR_CFS	10YR_CFS	25YR_CFS	50YR_CFS	100YR_CFS	CN	CN_F	ACRES	REMARKS
235	25	25047	87.1	175	256	331	426	506	77	88	176	
236	25	25046	77.4	149	217	279	355	420	79	89	117	
237	25	25040	224	458	677	881	1144	1365	73	85	104	
238	23	23001	0.30	1.00	2.10	4.20	6.10	8.60	45	70	23.6	
239	23	23017	51.1	85.1	115	141	173	199	87	90	44.1	
240	20	19121	5.20	11.1	18.6	27.6	37.8	47.4	65	80	29.4	Flow data is only available for the watershed, upstream flows were beyond the scope of this project.

Appendix D

Culvert Photo Log

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 1. 2070-01: One 8-foot-by-6-foot reinforced concrete box, upstream view.



Photo 2. 2070-01: One 8-foot-by-6-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 3. 2155-01: One 24-inch reinforced concrete pipe, upstream view.



Photo 4. 2155-01: One 24-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 5. 2155-02: One 2-foot-by-1.5-foot reinforced concrete box, upstream view.



Photo 6. 2155-02: One 2-foot-by-1.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 7. 2155-03: One 16-foot-by-4-foot reinforced concrete box, upstream view.



Photo 8. 2155-03: One 16-foot-by-4-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 9. 2160-01: Two 72-inch reinforced concrete pipes, upstream view.



Photo 10. 2160-01: Two 72-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 11. 2170-01: One 24-inch reinforced concrete pipe, upstream view.



Photo 12. 2170-01: One 24-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 13. 2170-02: One 12-foot-by-7-foot reinforced concrete box, upstream view.



Photo 14. 2170-02: One 12-foot-by-7-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 15. 2180-01: Pipe one of three. One 36-inch reinforced concrete pipe, upstream view.



Photo 16. 2180-01: Pipe two of three. One 42-inch reinforced concrete pipe, upstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 17. 2180-01: Pipe three of three. One 48-inch reinforced concrete pipe, upstream view.



Photo 18. 2180-01: Three reinforced concrete pipes (various sizes), downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 19. 2220-01: Two 30-inch reinforced concrete pipes, upstream view.



Photo 20. 2220-01: Two 30-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 21. 2235-01: One 8-foot-by-3.5-foot reinforced concrete box, upstream view.



Photo 22. 2235-01: One 8-foot-by-3.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 23. 2245-01: One 8-foot-by-3-foot reinforced concrete box, upstream view.



Photo 24. 2245-01: One 8-foot-by-3-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 25. 2245-02: One 4-foot-by-3-foot reinforced concrete box, upstream view.



Photo 26. 2245-02: One 4-foot-by-3-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 27. 2255-01: One 10-foot-by-11.5-foot reinforced concrete box, upstream view.



Photo 28. 2255-01: One 10-foot-by-11.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 29. 2270-01: One 8-foot-by-6-foot reinforced concrete box, upstream view.



Photo 30. 2270-01: One 8-foot-by-6-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 31. 17070-01: Two 6.4-foot-by-11.2-foot reinforced concrete boxes, upstream view.



Photo 32. 17070-01: Two 6.4-foot-by-11.2-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 33. 17075-01: One 6-foot-by-3-foot reinforced concrete box, upstream view.



Photo 34. 17075-01: One 6-foot-by-3-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 35. 17080-01: One 4-foot-by-2-foot reinforced concrete box, upstream view.



Photo 36. 17080-01: One 4-foot-by-2-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 37. 17090-01: Two 8.4-foot-by-4.4-foot reinforced concrete boxes, upstream view.



Photo 38. 17090-01: Two 8.4-foot-by-4.4-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 39. 17095-01: One 13.8-foot-by-5-foot reinforced concrete box, upstream view.



Photo 40. 17095-01: One 13.8-foot-by-5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 41. 17105-01: One 4.2-foot-by-2.1-foot reinforced concrete box, upstream view.



Photo 42. 17105-01: One 4.2-foot-by-2.1-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 43. 17115-01: Three 22-inch steel pipes, upstream view.



Photo 44. 17115-01: Three 22-inch steel pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 45. 17155-01: Two 4-foot-by-5.5-foot reinforced concrete boxes, upstream view.



Photo 46. 17155-01: Two 4-foot-by-5.5-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 47. 18000-01: Two 48-inch corrugated metal pipes, upstream view.



Photo 48. 18000-01: Two 48-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 49. 18000-02: One 36-inch-by-60-inch corrugated metal pipe, upstream view.



Photo 50. 18000-02: One 36-inch-by-60-inch corrugated metal pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 51. 18055 (1 of 2): One 7.5-foot-by-4-foot reinforced concrete box, upstream view.



Photo 52. 18055 (1 of 2): One 7.5-foot-by-4-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 53. 18055 (2 of 2): Two 8-foot-by-4-foot reinforced concrete boxes, upstream view.



Photo 54. 18055 (2 of 2): Two 8-foot-by-4-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 55. 18060-01: Two 54-inch-by-60-inch corrugated metal pipes, upstream view.



Photo 56. 18060-01: Two 54-inch-by-60-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 57. 18060-02: One 5-foot-by-3-foot reinforced concrete box, upstream view.



Photo 58. 18060-02: One 5-foot-by-3-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 59. 18065-01: One 12-foot-by-4.5-foot reinforced concrete box, upstream view.



Photo 60. 18065-01: One 12-foot-by-4.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 61. 18065-02: One 60-inch corrugated plastic pipe, upstream view.



Photo 62. 18065-02: One 60-inch corrugated plastic pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 63. 18065-03: One 8-foot-by-5.5-foot reinforced concrete box, upstream view.



Photo 64. 18065-03: One 8-foot-by-5.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 65. 18070-01: One 4-foot-by-4-foot reinforced concrete box, upstream view.



Photo 66. 18070-01: One 4-foot-by-4-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 67. 19010-01: One 8-foot-by-4-foot reinforced concrete box, upstream view.



Photo 68. 19010-01: One 8-foot-by-4-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 69. 19015-01: One 12-foot-by-2.5-foot reinforced concrete box, upstream view.



Photo 70. 19015-01: One 12-foot-by-2.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 71. 19105-01: One 42-foot-by-5-foot reinforced concrete box, upstream view.



Photo 72. 19105-01: One 42-foot-by-5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 73. 19120-01: One 16-foot-by-3-foot reinforced concrete box, upstream view.



Photo 74. 19120-01: One 16-foot-by-3-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 75. 19120-02: Two 12-foot-by-6.5-foot reinforced concrete boxes, upstream view.



Photo 76. 19120-02: Two 12-foot-by-6.5-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 77. 20005-01: One 6-foot-by-5-foot concrete arch culvert, upstream view.



Photo 78. 20005-01: One 6-foot-by-5-foot concrete arch culvert, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 79. 21000-01: One 22-foot-by-5.5-foot reinforced concrete box, upstream view.



Photo 80. 21000-01: One 22-foot-by-5.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 81. 21000-02: One 23.5-foot-by-6-foot reinforced concrete box, upstream view.



Photo 82. 21000-02: One 23.5-foot-by-6-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 83. 21000-03: One 16-foot-by-16.5-foot concrete tunnel, upstream view.



Photo 84. 21000-03: One 16-foot-by-16.5-foot concrete tunnel, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 85. 21015-01: Two 36-inch reinforced concrete pipes, upstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 86. 21015-01: Pipe one of two. One 36-inch reinforced concrete pipe, downstream view.



Photo 87. 21015-01: Pipe two of two. One 36-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 88. 21030-01: Pipe one of two. One 24-inch corrugated metal pipe, upstream view.



Photo 89. 21030-01: Pipe two of two. One 36-inch-by-24-inch plastic arch pipe, upstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 90. 21030-01: Pipe one of two. One 24-inch corrugated metal pipe, downstream view.



Photo 91. 21030-01: Pipe two of two. One 36-inch-by-24-inch plastic arch pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 92. 21030-02: One 16-foot-by-17-foot concrete tunnel, upstream view.



Photo 93. 21030-02: One 16-foot-by-17-foot concrete tunnel, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 94. 21045-01: Two 8-foot-by-4-foot reinforced concrete boxes, upstream view.



Photo 95. 21045-01: Two 8-foot-by-4-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 96. 21050 (1 of 2): One 24-inch reinforced concrete pipe, upstream view.



Photo 97. 21050 (1 of 2): One 24-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 98. 21050 (2 of 2): Four 36-inch corrugated plastic pipes, upstream view.



Photo 99. 21050 (2 of 2): Four 36-inch corrugated plastic pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 100. 21090-01: One 15.5-foot-by-3.25-foot reinforced concrete box, upstream view.



Photo 101. 21090-01: One 15.5-foot-by-3.25-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 102. 21110-01: One 10-foot-by-8-foot reinforced concrete box, upstream view.



Photo 103. 21110-01: One 10-foot-by-8-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 104. 21145-01: One 6-foot-by-6-foot reinforced concrete box, upstream view.



Photo 105. 21145-01: One 6-foot-by-6-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 106. 21150-01: One 6-foot-by-6-foot reinforced concrete box, upstream view.



Photo 107. 21150-01: One 6-foot-by-6-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 108. 22000-01: Two 12-foot-by-9-foot reinforced concrete boxes, upstream view.



Photo 109. 22000-01: Two 12-foot-by-9-foot reinforced concrete boxes, downstream view.



Photo 110. 22000-02: Part one of two. Three reinforced concrete boxes and two corrugated metal pipes, upstream view.



Photo 111. 22000-02: Part two of two. Three reinforced concrete boxes and two corrugated metal pipes, upstream view.



Photo 112. 22000-02: Part one of two. Three reinforced concrete boxes and two corrugated metal pipes, downstream view.



Photo 113. 22000-02: Part two of two. Three reinforced concrete boxes and two corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 114. 22005-01: Two 36-inch reinforced concrete pipes, upstream view.



Photo 115. 22005-01: Two 36-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 116. 22010-01: One 24-foot-by-7-foot reinforced concrete box, upstream view.



Photo 117. 22010-01: One 24-foot-by-7-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 118. 22020-01: One 36-inch reinforced concrete pipe, upstream view.



Photo 119. 22020-01: One 36-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 120. 22020-02: Three 10-foot-by-6-foot reinforced concrete boxes, upstream view.



Photo 121. 22020-02: Three 10-foot-by-6-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 122. 22020-03: Two 72-inch reinforced concrete pipes, upstream view.



Photo 123. 22020-03: Two 72-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 124. 22020-04: Two 34-inch-by-52-inch reinforced concrete pipes, upstream view.



Photo 125. 22020-04: Two 34-inch-by-52-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 126. 22035-01: Structure one of two. One 6-foot-by-6-foot reinforced concrete box, upstream view.



Photo 127. 22035-01: Structure two of two. One 5.5-foot-by-5-foot concrete arch upstream view.



Photo 128. 22035-01: Structure one of two. One 6-foot-by-6-foot reinforced concrete box, downstream view.



Photo 129. 22035-01: Structure two of two. One 5.5-foot-by-5-foot concrete arch downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 130. 22045-01: Two 36-inch corrugated metal pipes, upstream view.



Photo 131. 22045-01: Two 36-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 132. 22045-02: One 4-foot-by-3.5-foot reinforced concrete box, upstream view.



Photo 133. 22045-02: One 4-foot-by-3.5-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 134. 22045-03: Three 24-inch reinforced concrete pipes, upstream view.



Photo 135. 22045-03: Three 24-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 136. 23000-01: One 48-inch reinforced concrete pipe, upstream view.



Photo 137. 23000-01: One 48-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 138. 23005-01: Three 12-foot-by-9-foot reinforced concrete boxes, upstream view.



Photo 139. 23005-01: Three 12-foot-by-9-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 140. 23005-02: Three 36-inch reinforced concrete pipes, upstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 141. 23005-02: Part one of two. Three 36-inch reinforced concrete pipes, downstream view.



Photo 142. 23005-02: Part two of two. Three 36-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 143. 23005-03: One 4-foot-by-4-foot reinforced concrete box, upstream view.



Photo 144. 23005-03: One 4-foot-by-4-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 145. 23005-04: One 4-foot-by-4-foot reinforced concrete box, upstream view.



Photo 146. 23005-04: One 4-foot-by-4-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 147. 23025-01: One 48-inch reinforced concrete pipe, upstream view.



Photo 148. 23025-01: One 48-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 149. 23050-01: Three 12.33-foot-by-4-foot reinforced concrete boxes, upstream view.



Photo 150. 23050-01: Three 12.33-foot-by-4-foot reinforced concrete boxes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 151. 23060-01: Four 4.5-foot-by-3-foot reinforced concrete boxes and two 18-inch reinforced concrete pipes, upstream view.



Photo 152. 23060-01: Four 4.5-foot-by-3-foot reinforced concrete boxes and two 18-inch reinforced concrete pipes, downstream view.



Photo 153. 23070 (1 of 2): One 24-inch polyvinyl chloride (PVC) pipe transitioning to corrugated plastic pipe, upstream view.



Photo 154. 23070 (1 of 2): One 24-inch polyvinyl chloride (PVC) pipe transitioning to corrugated plastic pipe, downstream view.



Photo 155. 23070 (2 of 2): One 24-inch reinforced concrete pipe transitioning to corrugated plastic pipe, upstream view.



Photo 156. 23070 (2 of 2): One 24-inch reinforced concrete pipe transitioning to corrugated plastic pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 157. 23085-01: Two 30-inch vitrified clay pipes, upstream view.



Photo 158. 23085-01: Two 30-inch vitrified clay pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 159. 23085-02: One 4-foot-by-3-foot reinforced concrete box, upstream view.



Photo 160. 23085-02: One 4-foot-by-3-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 161. 23090-01: Two 36-inch steel pipes, upstream view.



Photo 162. 23090-01: Two 36-inch steel pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 163. 23090-02: Three 30-inch vitrified clay pipes, upstream view.



Photo 164. 23090-02: Three 30-inch vitrified clay pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 165. 23095-01: One 30-inch vitrified clay pipe transitioning to reinforced concrete pipe, upstream view.



Photo 166. 23095-01: One 30-inch vitrified clay pipe transitioning to reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 167. 24005-01: One 60-inch corrugated metal pipe, upstream view.



Photo 168. 24005-01: One 60-inch corrugated metal pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 169. 24005-02: One 48-inch corrugated metal pipe, upstream view.



Photo 170. 24005-02: One 48-inch corrugated metal pipe, downstream view.



Photo 171. 24005-03: One 48-inch reinforced concrete pipe transitioning to corrugated metal pipe, upstream view.



Photo 172. 24005-03: One 48-inch reinforced concrete pipe transitioning to corrugated metal pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 173. 25005-01: One 18-foot-by-9.1-foot reinforced concrete box, upstream view.



Photo 174. 25005-01: One 18-foot-by-9.1-foot reinforced concrete box, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 175. 25010-01: Two 36-inch corrugated metal pipes, upstream view.



Photo 176. 25010-01: Two 36-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 177. 25015-01: Two 36-inch reinforced concrete pipes, upstream view.



Photo 178. 25015-01: Two 36-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 179. 25030-01: Three 36-inch corrugated metal pipes, upstream view.



Photo 180. 25035-01: Three 36-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 181. 25050-01: Two 36-inch-by-24-inch corrugated metal pipes, upstream view.



Photo 182. 25050-01: Two 36-inch-by-24-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 183. 25060-01: Three 36-inch reinforced concrete pipes, upstream view.



Photo 184. 25060-01: Three 36-inch reinforced concrete pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 185. 25065-02: One 54-inch reinforced concrete pipe, upstream view.



Photo 186. 25065-02: One 54-inch reinforced concrete pipe, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 187. 25065-03: Two 30-inch corrugated metal pipes, upstream view.



Photo 188. 25065-03: Two 30-inch corrugated metal pipes, downstream view.

Note: Watershed Maps showing culvert locations are in Appendix B



Photo 189. 25095-01: One 36-inch reinforced concrete pipe, upstream view.



Photo 190. 25095-01: One 36-inch reinforced concrete pipe, downstream view.

Appendix E

Technical Methods For Hydrology and Hydraulics

1. TECHNICAL METHODS FOR HYDROLOGY AND HYDRAULICS

1.1 Major System Improvement – Project Evaluation

Hydrologic and hydraulic (H&H) calculations used the Rational method and Technical Release 55 (TT-55) (NRCS 1986) method as recommended by the City of Joplin's Stormwater Management Criteria (Allgeier, Martin, and Associates Inc. 2018). Time of concentration equations, runoff coefficients, and rainfall intensity also matched Stormwater Management Criteria (Allgeier, Martin, and Associates Inc. 2018) guidance. Rainfall distribution used the appropriate Huff distribution.

Table 1: Hydrologic Method by Watershed Size

Watershed Size	Hydrologic Method Used
<40 acres	Rational
>40 acres	TR-55

Several methods were used to calculate hydraulic capacities of existing pipes and determine the appropriate size for proposed improvements. The Manning's equation was used to find conveyance capacity for simple storm sewer analysis and open channel flow. It was assumed the slope of the pipes matched the slope of the topography. HY-8 models were created to analyze roadway culverts. Olsson developed StormCAD models to evaluate extensive storm sewer systems. In these StormCAD models, only primary storm sewer lines were analyzed. This provided analysis of critical points in the storm sewer necessary to identify an opinion of probable cost for the project. Once the mainlines were sized, the small tributary sizes were estimated based on their drainage areas relative to the trunk line's drainage area. Inlets assumed full capture.

1.2 Watershed Evaluation

The focus of this study is to provide a conceptual overview of the area so the city and its stakeholders can readily access information about runoff potential and culvert capacity. The result of this conceptual evaluation provides a broad understanding of the overall watershed. Several components make up a hydrologic model as shown in Figure 1. Each component consists of a discussion detailing what information was used.

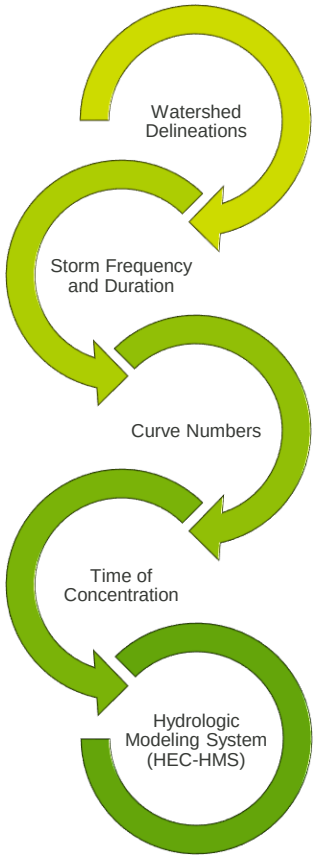


Figure 1. Components of hydrologic modeling.

1.2.1 Watersheds/Subwatersheds

The subwatershed delineations were created using ArcMap's Spatial Analyst Hydrology toolset, 2012 lidar data for Jasper County, and best available digital elevation model (DEM) data for Newton County. The delineations were used to provide area data for the watersheds. Once the delineations were set, the other components needed for HEC-HMS modeling were developed.

1.2.2 Storm Frequency and Duration

Rainfall data for the different storms evaluated were from the Joplin Stormwater Management Criteria (Allgeier, Martin, and Associates Inc. 2018). The Huff rainfall distribution was used to develop hyetographs for each storm duration and storm frequency that was being evaluated. Olsson evaluated 2-year, 5-year, 25-year, 50-year, and 100-year frequencies for 1-hour, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour durations. Critical durations, the duration rainfall that results in the highest peak flow rate, were selected based on the highest flows generated for a given storm frequency. The selected critical durations and the corresponding storm frequency for each subwatershed can be found in the Southwest Joplin – Hydrologic Modeling Results table in Appendix C.

1.2.3 Curve Numbers

Curve numbers are parameters selected from TR-55 (NRCS 1986) that are used in the hydrologic model. The values are classified by cover type and soil type. To select suitable curve numbers, the soil types were identified using the Soil Survey Geographic Database (SSURGO) and cover types were derived using the National Land Cover database (NLCD; NRCS 2020; USGS 2016). The NLCD provides land use data which requires assumptions on equivalent

cover types. Table 1 shows the assumed equivalent land use classifications and TR-55 cover types that were used.

Table 1. Assumed equivalent land use classifications and cover types.

NLCD LAND USE CLASSIFICATION	EQUIVALENT TR-55 COVER TYPE
Barren Land	Fallow – Bare Soil
Cultivated Crops	Row Crops – Straight row – Good condition
Deciduous Forest	Woods – Fair condition
Developed, High Intensity	Urban – Commercial and Business
Developed, Medium Intensity	Urban – Industrial
Developed, Low Intensity	Residential – One-quarter acre average lot size
Developed, Open Space	Open space – Good condition (grass cover >75%)
Emergent Herbaceous Wetlands	Brush – Poor condition
Evergreen Forest	Woods – Fair condition
Grassland/Herbaceous	Brush – Poor condition
Mixed Forest	Woods with grass combination – Fair condition
Open Water	Impervious area
Pasture/Hay	Pasture – Fair condition
Shrub/Scrub	Brush – Fair condition
Woody Wetlands	Woods – Fair condition

For existing conditions, curve numbers shown in Table 2 were used to calculate runoff. For the future development condition, zoning information was not available to identify future land uses in much of our study area. After discussions with the city, Olsson approximated the impact of future development and assumed an increase to 50 percent impervious area across the study area. Impervious areas are important to monitor because an increase in impervious areas can cause increases in peak runoff rates and volumes. Future development will likely be mostly low intensity such as residential uses or undeveloped areas, although small areas may contain high-intensity development such as commercial and industrial uses. Future condition curve numbers can be found in Table 3. Weighted average curve numbers for each subwatershed were developed in a geographic information system (GIS) using an overlay of hydrologic soil groups from the SSURGO and land use data from the NLCD (NRCS 2020; USGS 2016).

Table 2. Existing condition TR-55 runoff curve numbers.

	HYDROLOGIC SOIL GROUP			
	A	**B**	**C**	**D**
BARREN LAND	77	86	91	94
CULTIVATED CROPS	67	78	85	89
DECIDUOUS FOREST	36	60	73	79
DEVELOPED, HIGH INTENSITY	89	92	94	95
DEVELOPED, MEDIUM INTENSITY	81	88	91	93

DEVELOPED, LOW INTENSITY	61	75	83	87
DEVELOPED, OPEN SPACE	39	61	74	80
EMERGENT HERBACEOUS WETLANDS	48	67	77	83
EVERGREEN FOREST	36	60	73	79
GRASSLAND/HERBACEOUS	48	67	77	83
MIXED FOREST	43	65	76	82
OPEN WATER	98	98	98	98
PASTURE/HAY	49	69	79	84
SHRUB/SCRUB	35	56	70	77
WOODY WETLANDS	36	60	73	79

Table 3. Future condition TR-55 runoff curve numbers.

	HYDROLOGIC SOIL GROUP			
	A	**B**	**C**	**D**
BARREN LAND	87.5	92.0	94.5	96.0
CULTIVATED CROPS	68.5	79.5	86.0	89.0
DECIDUOUS FOREST	68.5	79.5	86.0	89.0
DEVELOPED, HIGH INTENSITY	89.0	92.0	94.0	95.0
DEVELOPED, MEDIUM INTENSITY	81.0	88.0	91.0	93.0
DEVELOPED, LOW INTENSITY	68.5	79.5	86.0	89.0
DEVELOPED, OPEN SPACE	68.5	79.5	86.0	89.0
EMERGENT HERBACEOUS WETLANDS	73.0	82.5	87.5	90.5
EVERGREEN FOREST	68.5	79.5	86.0	89.0
GRASSLAND/HERBACEOUS	68.5	79.5	86.0	89.0
MIXED FOREST	68.5	79.5	86.0	89.0
OPEN WATER	98.0	98.0	98.0	98.0
PASTURE/HAY	68.5	79.5	86.0	89.0
SHRUB/SCRUB	68.5	79.5	86.0	89.0
WOODY WETLANDS	67.0	79.0	85.5	88.5

1.2.4 Time of Concentration

Another input required for hydrologic modeling is the lag time. Lag time represents the length of time it takes water to travel through a watershed from the farthest hydrologically distant point. To determine lag time, the time of concentrations must be calculated. Time of concentration was established for each subwatershed using an abbreviated American Public Works Association (APWA) method. According to APWA 5600 (KC Chapter of APWA 2011), time of concentration is equal to inlet time plus travel time. For the inlet time calculation, the following APWA equation was used.

$$T_i = 1.8*(1.1-C) * (D^{1/2}/S^{1/3})$$

Where:

T_i = Inlet Time in minutes
C = Rational Method Runoff Coefficient as determined in accordance with paragraph 5602.3 located in APWA 5660 (KC Chapter of APWA 2011)
D = Overland flow distance parallel to slope in feet
S = Slope of tributary area surface perpendicular to contour in percent

Travel time for the channel was estimated using Table 5602-6 from APWA 5600 (KC Chapter of APWA 2011). Table 5602-6 estimates the velocities in feet per second based on an average channel slope.

Inlet time and travel time were added together to get the time of concentration. Lag time was calculated by multiplying time of concentration by 0.6.

1.2.5 Hydrologic Modeling and Results

The hydraulic model was created once the delineations, storm frequencies and durations, curve numbers, and lag times were gathered. Hydrologic modeling is used to calculate peak runoff rates for each subwatershed. Modeling was completed using U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS) version 4.6.1. A model was developed for existing conditions within the watershed and for future conditions, which accounts for an average of 50 percent impervious cover in future development. The results from this model were used in the hydraulic evaluation of culverts but may also be used by city staff and engineers to quickly identify runoff rates throughout the study area.

The results are available in two formats, through the figures and tables provided in Appendix B and Appendix C, respectively, or, through GIS. The GIS method allows for information to be presented dynamically, allowing users to view multiple results at once, and allows integration with other GIS layers the city has. Results are shown in two GIS shapefiles, one for watersheds and another for subwatersheds. Information in each file varies, Table 4 and Table 5 show what kind of data is available.

Table 4. Subwatershed shapefile field names and descriptions.

FIELD NAME	DESCRIPTION
WTRSD_ID	Watershed identification number
SUBWTRSHD	Subwatershed identification number
2YR_CFS	Peak 2-year storm cumulative flow* in cubic feet per second that travels through the subwatershed
5YR_CFS	Peak 5-year storm cumulative flow* in cubic feet per second that travels through the subwatershed
10YR_CFS	Peak 10-year storm cumulative flow* in cubic feet per second that travels through the subwatershed

25YR_CFS	Peak 25-year storm cumulative flow* in cubic feet per second that travels through the subwatershed
50YR_CFS	Peak 50-year storm cumulative flow* in cubic feet per second that travels through the subwatershed
100YR_CFS	Peak 100-year storm cumulative flow* in cubic feet per second that travels through the subwatershed
CN	Weighted curve numbers based on existing conditions
CN_F	Weighted future curve numbers based on a 50 percent increase of impervious area
ACRES	Area of the subwatershed in acres
REMARKS	Comments regarding the subwatershed

*Some flows for subwatersheds in Shoal Creek are not cumulative, because the upstream Shoal Creek flows were beyond the scope of this project. This is denoted in the REMARKS field of the shapefile.

Table 5. Watershed shapefile field names and descriptions.

FIELD NAME	DESCRIPTION
WATERSHED	Watershed identification number
ACRES	Area of the watershed in acres

1.2.6 Culvert Analysis

Culvert modeling requires a different approach and software from watershed modeling. Culvert sizes, materials, and elevations were required to complete modeling. To simplify the modeling and place the focus on the culvert size, tail water depths of 1 foot were chosen to avoid tail water effects to the culvert capacity. Higher tail water conditions may occur as the result of limited downstream channel capacity or other downstream controls such of bridges, culverts, ponds, etc. Though these conditions may limit the culvert capacity, the culvert size is not the cause. The approach isolates the culvert size to be evaluated independently of other controls. Prior to replacing or improving a culvert crossing, a complete hydrologic and hydraulic evaluation should be performed considering all controls and making a recommendation for a replacement size.

The Federal Highway Administration HY-8 program, version 7.60, was used to identify the peak flow rate at which roadway overtopping begins for each culvert. This value can be compared to the hydrology results to identify the overtopping frequency for each culvert. These results are available in tabular form in Appendix C. The HY-8 results were added to the culvert shapefile, which contains the field described in Table 6.

Table 6. Culvert shapefile field names and descriptions.

FIELD NAME	DESCRIPTION
CULVERT_ID	Culvert identification number

DESCRIPTION	Quantity, size, and material of culverts
CAP_CFS	The overtopping capacity in cubic feet per second of the culvert
OT_FREQ	Overtopping frequency of the culvert
2YR_CFS	Peak 2-year storm cumulative flow* in cubic feet per second that travels through the culvert
5YR_CFS	Peak 5-year storm cumulative flow* in cubic feet per second that travels through the culvert
10YR_CFS	Peak 10-year storm cumulative flow* in cubic feet per second that travels through the subwatershed
25YR_CFS	Peak 25-year storm cumulative flow* in cubic feet per second that travels through the culvert
50YR_CFS	Peak 50-year storm cumulative flow* in cubic feet per second that travels through the culvert
100YR_CFS	Peak 100-year storm cumulative flow* in cubic feet per second that travels through the culvert
REMARKS	Comments regarding the culvert

*Some flows for culverts in Shoal Creek are not cumulative, because the upstream Shoal Creek flows were beyond the scope of this project. This is denoted in the REMARKS field of the shapefile.

It is important to note overtopping frequency does not indicate that the culvert meets other design criteria for that storm. For example, a culvert with a 100-year overtopping frequency may be the result of a high embankment. Although the roadway may not overtop, an undersized pipe may still result in velocities that are higher than allowable through the culvert.

Though HY-8 modeling works for standard culvert scenarios, when modeling nontraditional situations, such as separated culverts that function within one, wide floodplain during flood conditions, some culverts had to be modeled in a group. There were three instances where this occurred. Culverts that were modeled together during flood conditions are identified by the same culvert number followed by text indicating the number of culverts involved. Culvert locations and numbering can be seen on the watershed maps located in Appendix B and on the culvert modeling results located in Appendix C.

2. REFERENCES

Allgeier, Martin, and Associates Inc. (2018). *Stormwater Management Criteria,* City of Joplin, Joplin, MO.

KC Chapter of APWA (Kansas City Metropolitan Chapter of the American Public Works Association). (2011). "Division V Section 5600 Storm Drainage Systems & Facilities." *APWA 5600,* Kansas City, MO.

NRCS (Natural Resources Conservation Service). (1986). "Urban Hydrology for Small Watersheds." *Technical Release 55 (TR-55),* United States Department of Agriculture, Washington, D.C.

NRCS (Natural Resources Conservation Service). (2020). "Web Soil Survey." https://websoilsurvey.nrcs.usda.gov. (March 2021).

USGS (United States Geological Survey). (2016). *National Land Cover Database 2016 – Landcover & Imperviousness*, MRLC (Multi-Resolution Land Characteristics) Consortium, United States.

Appendix F

Limited Geomorphic Assessment

1. LIMITED GEOMORPHIC ASSESSMENT

To comply with funding requirements for this master plan, a limited geomorphic assessment of the principal streams within the city limits of Joplin, Missouri, was conducted. The following is a summary of the methodology used and highlights of the findings of the limited assessment.

1.1 Methodology for Completing the Limited Geomorphic Assessment

This limited geomorphic assessment was performed by conducting a desktop analysis of available aerial imagery and of geographic information system (GIS) data. The aerial imagery that was used includes multiple years of imagery. Aerial photography between 1997 and 2017 was available via the Google Earth Pro desktop application (Google 2021), and the city provided 2020 aerial photography as MrSID image files (Joplin 2020). Available GIS data from the city included shapefiles of streamlines, major watersheds, city boundaries, 2-foot contours from 2003 lidar images, and sewer lines. Streamlines are lines delineating a channel or flow path (well defined, poorly defined, or undefined). Because this assessment did not include a field review, Google Earth Street Views (i.e., 360-degree ground photography) at roadway crossings of streams and drainageways were examined to determine drainageway type, general size, and relative stability. Google Earth Street Views are included in the Google Earth Pro desktop application. The detailed results of the assessment were provided to city personnel as KMZ/KML files. A summary of the results is provided below.

The principal drainage paths that were examined as part of the desktop analysis were taken from the city-provided streamlines data. In some cases where the streamlines did not follow the actual flow path or channel seen on the most recent aerial photography, these streamlines were adjusted to match existing conditions. In several cases, the city-provided streamlines were located where no drainage path was evident on the aerial photography and were located where full development exists; these streamlines were noted as such. In many instances, the drainages or stream segment passed underground via pipes or culverts and these areas were not evaluated. Streams or stream segments that are concrete lined or have an armored bed and banks were identified using the most current aerial photography and only evaluated where there was evident failure or degradation of the concrete and armor.

The physical form of the drainages defined by the streamlines ranged from poorly defined V- or U-shaped drainage pathways (swales) with no defined channel to large, natural streams to constructed floodways. Many of the drainage swales and channels were man-made. Many of the man-made channels consisted of formed concrete trapezoidal channels or channels with riprap-lined or concrete-grouted bed and banks.

Degradation was evident in several of the streams and man-made channels as indicated by the exposure of sanitary sewer lines and other concrete-encased utility crossings within the bottom of the channels. These crossings can provide temporary grade control but will eventually fail with additional degradation. This degradation often occurs because of increased stream flows associated with urbanization and other land use changes. In the larger streams like Center and Turkey creeks, this degradation has been accompanied by a slow widening of the stream over time as noted by a comparison of the Google Earth Pro 1996 aerial photography with the 2017 Google Earth Pro and 2020 MrSID aerial photography (Google 2021; Joplin 2020). Bedrock, bridge culverts, and other concrete structures in the channel bottom tend to halt the upstream progression of degradation, but widening, bank erosion, and channel migration can still occur.

1.2 General Findings

The types of drainages and their physical form and the general stability of the drainages are described for each of the 17 defined watersheds (see Figure 1 below) denoted in the stormwater master plan (Burns & McDonnell 1998). The watersheds are named in Table 1 below.

Table 1. Watershed names.

1 Silver Creek	7 Joplin Creek East	13 Leadville
2 Shoal Creek	8 Duquesne	14 Tuckahoe
3 Water Works	9 Turkey Creek East	15 Center
4 McClelland	10 Turkey Creek	16 Royal Heights
5 Country Club	11 Lone Elm Central	17 Baker's Branch
6 Joplin Creek West	12 Opossum	

Two additional city areas not included in these watersheds are the areas around the Joplin Airport and the area along the Interstate 44 (I-44) corridor to the southwest. Smaller areas not included in these watersheds lie on the western margin of the city.

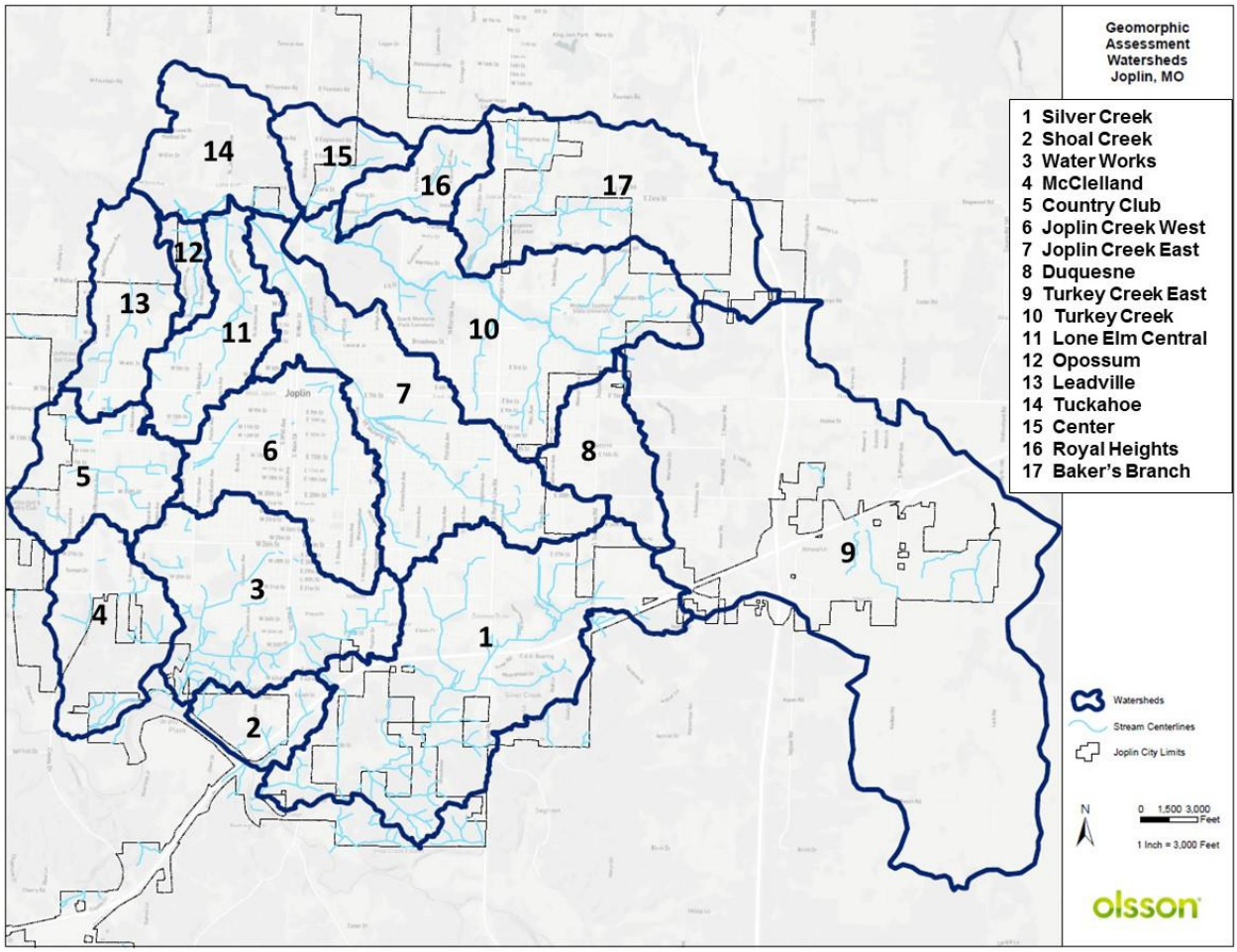


Figure 1. City of Joplin watersheds map.

1.2.1 Silver Creek

The Silver Creek Watershed lies within the southern part of the city and is 6.26 square miles (mi^2) in size. The primary stream in the watershed is Silver Creek. All other streamlines within the watershed are tributaries to Silver Creek.

Silver Creek is a generally stable, well-defined, somewhat sinuous meandering channel over most of its length. There are areas of apparent split flow along the channel. The split flow areas contain a main flow path/channel that carries all flows and a secondary flow path/channel that is activated only during higher flows. During flooding, either channel can become the main flow path, so development within the intervening areas should be avoided. Other small reaches in Shoal Creek are defined by a man-made floodway, concrete channel, and underground drainageway. Bedrock is exposed in the channel in the lower reach and there is at least one sanitary sewer line crossing exposed in the middle reach.

The tributary principal streams within the watershed are represented by poorly to well-defined drainage swales, man-made channels and ditches, or small, well-defined channels. In general,

all these streams are stable with only localized erosion. All the identified erosion sites currently do not pose a threat to any structures, roads, or facilities.

1.2.2 Shoal Creek Watershed

The Shoal Creek Watershed lies in the south-central part of the city. The area of the watershed within the city limits as defined by the previous master plan (Burns and McDonnell 1998) is 0.86 mi^2. There are only a few principal streamlines within the watershed. The smaller streamlines are represented by drainage swales that are poorly defined to somewhat defined and stable. The main streamline is located along the south side of the I-44 corridor and is represented by a drainage swale that is poorly defined to somewhat defined and stable. In the middle of the reach, the drainage goes underground. The upper end of the reach is mostly defined by a riprapped man-made floodway with riprap check structures at the downstream end and two concrete weirs at the upstream end. No significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.3 Water Works Watershed

The Water Works Watershed is located in the south-central part of the city and is 3.39 mi^2 in size. There are two main principal streams and several smaller principal streams within the watershed. One of the two main principal streams flows from north to south on the western side of the watershed and the other flows east to west along the southern part of the watershed.

The north-south stream downstream of the confluence of the east-west stream is generally stable and has a well-defined channel with some minor bank erosion. Upstream of the confluence to the McIntosh Circle Drive crossing, the channel is still well defined but shows some significant erosion in places; this erosion is not currently threatening any homes or other structures. However, degradation has exposed a sewer line crossing just downstream of the road crossing and is undermining the concrete floor under the roadway's corrugated metal pipes (CMPs [**Figure 2**]). This degradation currently threatens the unprotected roadway crossing.



Figure 2. Google Street View taken in 2018 looking downstream from the McIntosh Circle Drive crossing (Google 2021).

Upstream of the McIntosh Circle Drive crossing to the South Jackson Avenue crossing, the stream is defined by a man-made floodway and channel. Toe erosion, or erosion at the bottom of the channel's side slope, is evident in the reach below the West 32nd Street crossing, and possible degradation in the reach has exposed three concrete-encased sewer line crossings. Upstream of the South Jackson Avenue crossing, the stream is defined by a riprap and concrete grout-lined man-made channel showing signs of some degradation of the bank protection; portions of the concrete wall along Mohaska Avenue are failing in places.

The east-west main principal stream comprises a well-defined channel that has undergone some degradation over much of its length downstream of the Main Street crossing. Minor bank erosion is present along the reach and one sewer line is exposed in the upper part of the reach. Just upstream of the Main Street crossing, the channel is undergoing significant degradation and widening, but bedrock outcrops at the upstream end of this degraded segment have captured and halted the degradation from moving further upstream. This degraded section is not threatening any structures or infrastructure. The remaining upstream segment of this principal stream is generally stable and consists of a well-defined channel giving way to a well-defined drainage swale.

The secondary principal streams within this watershed consist of poorly to well-defined drainage swales and a few small, well-defined channel segments. Most are generally stable.

Except as noted above, no significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.4 McClelland Watershed

The McClelland Watershed is located in the southwest side of the city and is 1.92 mi^2 in size. There are only a few principal streams within the city limits in this watershed. Almost all the principal streams are represented by a poorly defined drainage swale. A couple of the streams have short reaches of concrete channel. All the principal streams in this watershed are stable. No significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.5 Country Club Watershed

The Country Club Watershed is located in the west-central part of the city and is 1.78 mi^2 in size. The few principal streams in the watershed are stable, poorly to well-defined drainage swales; man-made floodways and drainage swales; concrete channels; and small man-made channels. No significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.6 Joplin Creek West Watershed

The Joplin Creek West Watershed is located in the central part of the city and is 2.70 mi^2 in size. Only a few principal streams are delineated in this watershed, and most are man-made channels or drainageways, many with some form of bed and bank protection. The main area of concern is located just upstream of the intersection of East Fifth Street and Southeast Murphy Boulevard. This area is the confluence of two principal streams. Short segments of both streams just upstream of the confluence are severely degrading and widening (**Figure 3**). The banks are being undermined by degradation and pose a threat to nearby structures and upstream bridges. An exposed sewer line crossing is also located at the confluence and is currently susceptible to being damaged or ruptured. If this is an active sewer line, its stability should be addressed as soon as possible.



Figure 3. Google Street View taken in 2013 and 2019 looking upstream from the intersection of East Fifth Street and Southeast Murphy Boulevard, showing the severe channel degradation of two principal streams at their confluence (Google 2021).

Except as noted above, no other significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.7 Joplin Creek East Watershed

The Joplin Creek East Watershed is located entirely within the central part of the city and is 4.0 mi^2 in size. The main principal stream in this watershed is Joplin Creek; all other streams in the watershed are tributaries to Joplin Creek. Although Joplin Creek is a tributary to Turkey Creek, the confluence lies within the Lone Elm Watershed.

Much of Joplin Creek north of Northwest Murphy Boulevard appears to have been channelized in the past. This is evidenced by its nearly straight planform. This reach has some slow bank erosion, mainly at the downstream end. Three exposed utility line crossings within this reach indicate that the reach has degraded over time.

Upstream of Northwest Murphy Boulevard to Broadway Street, Joplin Creek is defined by a wide, man-made floodway. The four exposed concrete-encased utility crossings within the reach and the two small locations of bedrock cropping out in the creek bed suggest that degradation has also occurred in this reach. However, the reach currently appears to be stable.

From Southeast Murphy Street to East Fourth Street, Joplin Creek goes from a concrete channel to a wide, shallow floodway with sand and gravel bars in the bottom. From East Fourth Street upstream to the railroad tracks at East Fifth Street, Joplin Creek is still defined as a wide floodway with sand and gravel bars. Within this reach are three rock deflectors, a concrete weir (at grade), and an exposed concrete-encased utility crossing. These structures suggest the reach has experienced some instability in the past but has since stabilized. The reach of Joplin Creek also contains the confluence of a tributary.

From the railroad tracks upstream to the railroad tracks just north of the Campbell Parkway crossing, the creek is defined by a trapezoidal concrete grout channel/floodway. In some places, a concrete wall lines the toe of the grouted banks. Undermining or degradation of the grouted banks is apparent in some places, but the reach is generally stable. An unknown structure and a concrete-encased sewer line are located just below the railroad tracks.

Upstream of the Campbell Parkway crossing to East 20th Street, the creek is defined by a wide shallow floodway with short reaches of concrete grouted channel. Minor erosion of the unprotected banks occurs in a few places within the reach. A barely exposed concrete-encased utility crossing is present at the lower end of the reach, but in general the reach is stable.

The remainder of the creek is stable and is defined by a grouted concrete channel, to a concrete channel, to a shallow, man-made floodway, to a well-defined drainage swale.

Many of the tributary principal stream segments in Joplin Creek East are defined by man-made channels with unprotected bed and banks, concrete grouted bed and banks, or are concrete channels. Several segments, mainly in the upland areas, are composed of well-defined drainage swales. Most of these tributary streams are generally stable and pose no threat to structures or infrastructure. There are only a few locations showing signs of minor bank erosion and bed degradation, which are currently not a threat.

1.2.8 Duquesne Watershed

The Duquesne Watershed is located in the central part of the city and is 1.26 mi^2 in size. Almost all the watershed lies outside of the city limits. Only one principal stream, located at the north end of the watershed, is in the watershed, and it is a tributary to Turkey Creek. A short, eroding section of the south bank of Turkey Creek is located there as well. The principal stream is a stable, shallow, poorly defined channel and drainageway that is lined with riprap at its downstream end.

Except as noted above, no other significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.9 Turkey Creek East Watershed

The Turkey Creek East Watershed is located in the southeast side of the city and is 13.1 mi^2 in size. A small eastward extension of the city limits falls within the middle of the watershed. Only a few principal streams are located within the city limits, and almost all of them are represented by small, well-defined natural or man-made channels or well-defined drainage swales. All the principal streams in this watershed are stable. No significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.10 Turkey Creek Watershed

The Turkey Creek Watershed is located in the central part of the city and is 4.85 mi^2 in size. The main principal stream in this watershed is Turkey Creek, and all other principal streams in the watershed are tributaries to Turkey Creek.

Within the watershed, Turkey Creek is a somewhat sinuous stream with short reaches in the middle to upper part of the watershed that appear to have been straightened in the distant past. Gravel bars are well developed along the creek. When comparing the 1996 aerial photography with the 2020 aerial photography, numerous areas show slow bank retreat in most places; the bank retreat appears to be less than 1 foot per year. There are several exposed utility crossings; most of them are sewer lines. The exposure of the utility crossings also suggests slow, reach-wide degradation has occurred and may still be occurring. Leaning and fallen trees seen in Google Street Views would also support long-term degradation and channel widening is ongoing. Bank erosion close to pedestrian trails and urban development may threaten these

features in the future. However, it does not appear that erosion on Turkey Creek is currently threatening any structures or infrastructure.

The principal tributary streams to Turkey Creek in the watershed consist of well-defined to poorly defined drainage swales, poorly defined to well-defined channel segments, and riprap-lined and concrete channel segments. Although there is some minor, localized erosion, all the tributary principal streams are stable and pose no threat to structures or infrastructure.

1.2.11 Lone Elm Watershed

The Lone Elm Watershed is located in the central part of the city and is 1.61 mi^2 in size. The main principal stream in this watershed is Lone Elm Hollow, and all other principal streams in the watershed are tributaries to it. Most of Lone Elm Hollow has been channelized.

Lone Elm Hollow from just upstream of the confluence to Northridge Terrace is defined by a relatively small, straight, man-made channel/floodway. Bank erosion is occurring at the downstream end above the confluence. From Northridge Terrace to Northwest Murphy Boulevard, the stream is a grouted concrete-lined trapezoidal channel. From Northwest Murphy Boulevard to just below West C Street, the stream is a stable, well-defined channel. For the remainder of the stream length upstream, the stream is defined by a grouted concrete or riprap-lined trapezoidal channel. The upstream end consists of a well-defined to poorly defined drainage swale. Except for the very downstream end, this stream is stable.

The few tributary principal streams are either very small, well-defined drainage channels or well-defined to poorly defined drainage swales. One stream has a segment of concrete channel. All the tributary streams are stable and pose no threat to structures or infrastructure.

1.2.12 Opossum Watershed

The Opossum Watershed is located in the west-central part of the city and is 0.39 mi^2 in size. The main principal stream consists of a poorly defined to a somewhat well-defined channel. Most of the few tributary principal streams in the watershed are stable, poorly defined drainage swales. No significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.13 Leadville Watershed

The Leadville Watershed is located in the northwestern part of the city and is 1.58 mi^2 in size. Only about two-thirds of the watershed falls within the city limits. The watershed has one main principal stream and a few small tributary streams. The main principal stream from the confluence upstream to West Fourth Street consists of a relatively wide, shallow channel that appears man-made and has minor localized bank erosion. The remaining upstream end of the stream is defined by a concrete trapezoidal channel. The tributary streams are small, well-defined, man-made channels and drainage swales. The streams in this watershed are stable and pose no threat to structures or infrastructure.

1.2.14 Tuckahoe Watershed

The Tuckahoe Watershed is located in the northwest corner of the city and is 1.74 mi^2 in size. Only a small sliver along the southern boundary of the watershed lies within the city limits. The principal streams include a segment of Turkey Creek and one small tributary stream. The northern city boundary in this watershed approximately follows the centerline of Turkey Creek.

Based on a comparison of the 1996 and the Google Earth 2017 aerial photography (Google 2021), this reach of Turkey Creek is sinuous and actively meandering as noted by long-term bank erosion and bank retreat at a number of meander bends. Additional areas of instability in this reach include flow splits, overbank channels, a breach into and through a pond, and the exposure of two sewer line crossings and a failed riprap/concrete rubble structure. Although there is substantial lateral instability along this reach of Turkey Creek, there are no structures or other infrastructure that are currently threatened. **Figure 4** shows Turkey Creek downstream of the North Lone Elm Road bridge. Turkey Creek is the only principal tributary stream in this watershed and consists of a stable, poorly defined drainage swale.



Figure 4. Google Street View taken in 2019 from the North Lone Elm Road bridge looking downstream on Turkey Creek. Note exposed sewer line in foreground and eroding right bank in background (Google 2021).

1.2.15 Center Watershed

The Center Watershed is located in the northern part of the city just south of the Joplin Airport and is 0.87 mi^2 in size. Only about half of the watershed lies within the city limits. One larger and two smaller principal streams are in the watershed. The lower end of the main principal stream consists of a small, well-defined channel that turns into a riprapped, man-made channel upstream to the North Main Street and East Zora Street intersection. The remaining upstream segment consists of a poorly defined drainage swale at the upstream end and a man-made channel downstream near the development along East Andrea Street. The remaining principal streams consist of poorly defined channels to poorly defined drainage swales. All the streams in this watershed are stable and pose no threat to structures or infrastructure.

Except as noted above, no other significant stream erosion or threats to structures and infrastructure were noted in this watershed.

1.2.16 Royal Heights Watershed

The Royal Heights Watershed is located in the northern part of the city and is 0.90 mi^2 in size. There is one main principal stream and a few small tributary streams. The main principal stream from the confluence upstream to North St. Louis Avenue is a somewhat small, slightly sinuous, well-defined, shallow channel that is slightly incised at the downstream end. One exposed concrete-encased utility crossing in this reach suggests that some degradation may have occurred within the reach.

From North St Louis Avenue to East Zora Street, the stream is a man-made floodway. Upstream of East Zora Street the stream is mostly a straight, well-defined, man-made drainage swale with some erosion of the bike trail embankment. This embankment erosion currently threatens the trail, especially where mass failures of the embankment may occur.

The few tributary principal streams are small, well-defined to poorly defined drainage swales. One tributary stream is defined by a concrete channel. All the tributary streams are stable and pose no threat to structures or infrastructure.

1.2.17 Baker's Branch Watershed

The Baker's Branch Watershed is located at the northeast corner of the city and is 3.88 mi^2 in size. Only a portion of the watershed falls within the city limits. There is one main principal stream and a few small tributary streams. The downstream end of the main principal stream passes through a man-made pond, which appears to have been an old sand and gravel mine. Bank erosion on the left bank at the upstream end of the pond is close to the home at that location and may threaten it in the future.

From the pond upstream to Range Line Road, the stream is defined by a wide, shallow, well-defined gravel and cobble bed channel. There is an exposed concrete structure across the channel in the middle of the reach, but the type of structure is unknown. The segment from

Range Line Road upstream to North Goetz Boulevard is outside of the city limits. Upstream of North Goetz Boulevard to the eastern city limit, the stream is still defined by a wide, shallow, well-defined gravel and cobble bed channel with areas of bank erosion. Recent overbank flooding and sediment deposition along the left bank just downstream of North Duquesne Road could potentially threaten the home at that location. All other areas of bank erosion along this stream do not currently pose a threat to structures or infrastructure.

The remaining tributary streams consist of small, poorly defined to well-defined channels and ditches and well-defined to poorly defined drainage swales. Some of these have man-made or realigned segments. All the tributary streams are generally stable and pose no threat to structures or infrastructure.

1.2.18 Other Areas

Several areas, including the Joplin Airport, fall within the city boundaries but are not encompassed by the major watersheds. The principal streams in the Joplin Airport are generally stable and range from poorly defined drainage swales to well-defined man-made channels and ditches. The remaining outlying principal streams consist of a wide range of channel and drainage swale types that are generally stable. A few short stream segments show some instability such as localized erosion or aggradation associated with sediment input from mining. No threats to structures or infrastructure were noted along these streams.

1.3 Summary

Many of the larger streams show signs of long-term degradation, as evidenced by exposed utility crossings. Some segments of the larger streams also show signs of channel widening, as evidenced by bank erosion on both sides of the channel. However, the vast majority of the principal streams within the City of Joplin, Missouri, are stable with only localized segments of instability. In addition, most of the principal streams are either well-defined, man-made channels or well-defined to poorly defined drainage swales.

2. RESOURCES

City of Joplin GIS Home Page. (2020). “2020 Joplin Aerials 3-inch resolution. https://joplingis.org/ (March, 2021).

Burns & McDonnell. (1998). *Stormwater Management Master Plan,* City of Joplin, Joplin, MO.

Google Earth Pro 7.3.3.7786. (1997-2017). “Joplin area, Joplin, Missouri.” http://www.google.com/earth/index.html (March, 2021).

Appendix G

Minor System Improvement – Summary Sheet

Project Name: Rolla street (between Brownell & Florida)

Data Summary

Estimated Cost: $90,000

Number of affected properties: 6

Existing Problem Description:

Standing water has been observed on street several days after rain events. Currently the area has no stormwater infrastructure in place and primarily relies on surface drainage for stormwater runoff conveyance. The standing water is a result of a sump that exists on Rolla street between Brownell avenue and Florida avenue. The nuisance flooding has also extended to adjacent properties, with at least two property owners (2516 Rolla and 2522 Rolla) reporting standing water on their property as well as City Right-of-way.



Project Name: 26th street and Highland avenue

Data Summary

Estimated Cost: $30,000

Number of affected properties: 4

Existing Problem Description:

The intersection of S. Highland avenue and E. 26th street is susceptible to water ponding. Standing water will accumulate on the south east corner of Highland avenue and 26th street overtopping the existing ADA ramp.



Project Name: Geneva avenue (between 9th and 10th)

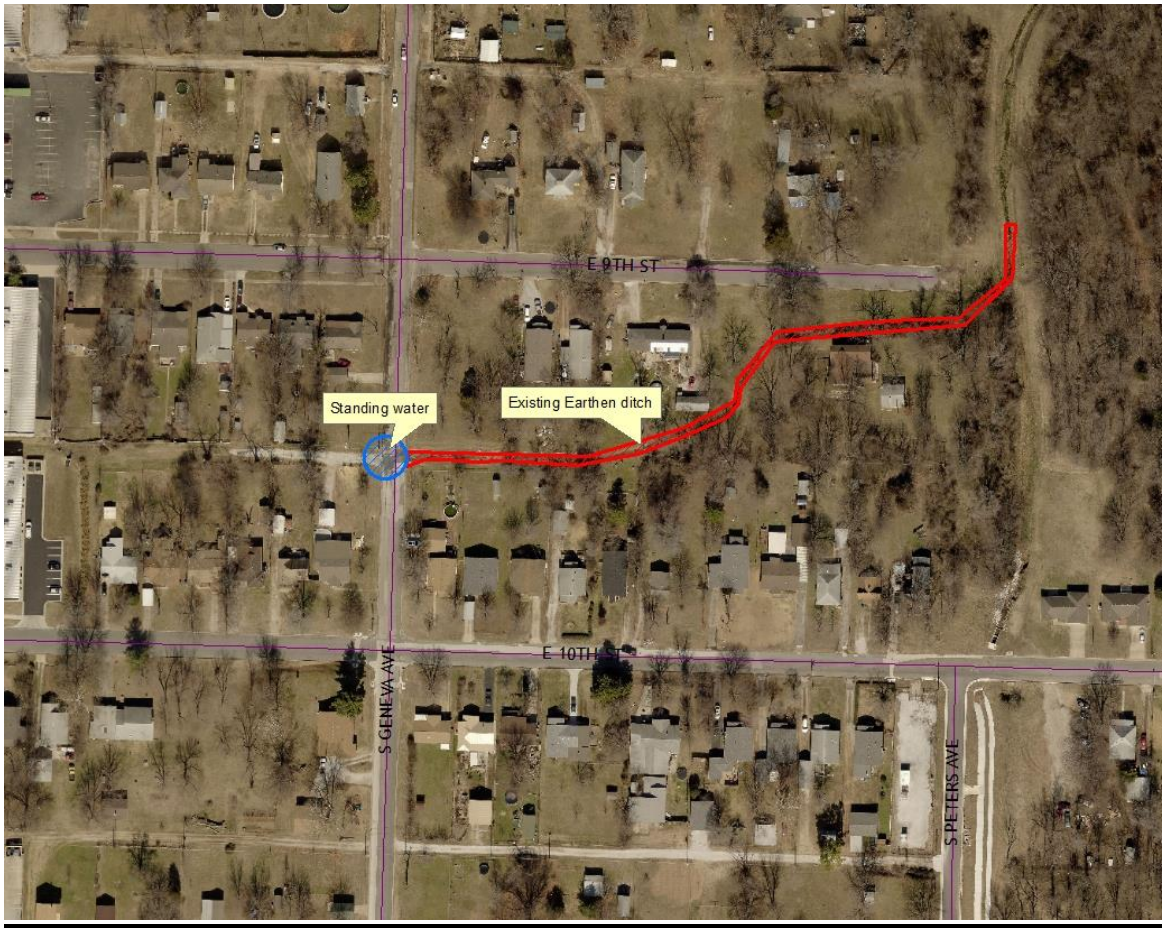
Data Summary

Estimated Cost: $100,000

Number of affected properties: 11

Existing Problem Description:

This reach consists of an unlined, unimproved open channel having a bankful capacity less than a 10-year capacity. Erosion of the channel itself is considered a problem as well as ponding on Geneva avenue for days after rain events. In addition, sediments washed downstream collect on Geneva and coupled with the standing water have impacted the integrity of the street. While no structural flooding has been reported as of yet, residents have expressed concern on numerous occasions regarding the rising water level in the ditch and its proximity to habitable structures.



Project Name: East Adrienne drive

Data Summary

Estimated Cost: $26,000

Number of affected properties: 4

Existing Problem Description:

Water ponding has been reported by a property owner at 3802 E. Adrienne drive. At the intersection of N. Ketron Dr and E. Adrienne drive minor nuisance flooding has been observed and reported due in large part to the relatively flat grade of the intersection which fails to adequately channel surface runoff to the North. The standing water, which can last days after a rain event, can negatively impact the integrity of the road.



Project Name: South Forest Avenue

Data Summary

Estimated Cost: $85,000

Number of affected properties:

Existing Problem Description:

This reach consists of an unimproved open channel. The 8th and Patterson storm water project added stormwater improvements upstream of this reach. As a result, runoff is directed more efficiently to the channel. Sedimentation and vegetative growth have inhibited the bankfull capacity of the channel. It is estimated that the bank is overtopped at a rate of roughly 5-year intervals with as many as 9 residential properties affected.



Project Name: 23rd and Adele

Data Summary:

Estimated Cost: $420,000

Number of affected properties: 2

Existing Problem Description:

At the intersection of 23rd and Adele water will pond at the South East corner of the intersection. Stormwater runoff in the area is conveyed as surface runoff utilizing the existing curb and gutter. While the ponding at the intersection can be significant after large rain events, the flooding experienced is limited to the street and can therefore be categorized as nuisance flooding.



Project Name: 34th street (between Connecticut and Finley)

Data Summary

Estimated Cost: $30,000

Number of affected properties: 1

Existing Problem Description:

Currently East 35th street between Connecticut avenue and Finley avenue has no Curb and Gutter infrastructure in place on City Right-of-Way. All stormwater runoff is conveyed through a ditch on the North and South side of Finley avenue. Due to the natural topography of the location, this area is susceptible to water ponding. The property owner at 3502 Finley avenue has reported excessive surface water in the ditch adjacent to their property with standing water lingering for days after rain events.



Project Name: East Douglas Place ditch

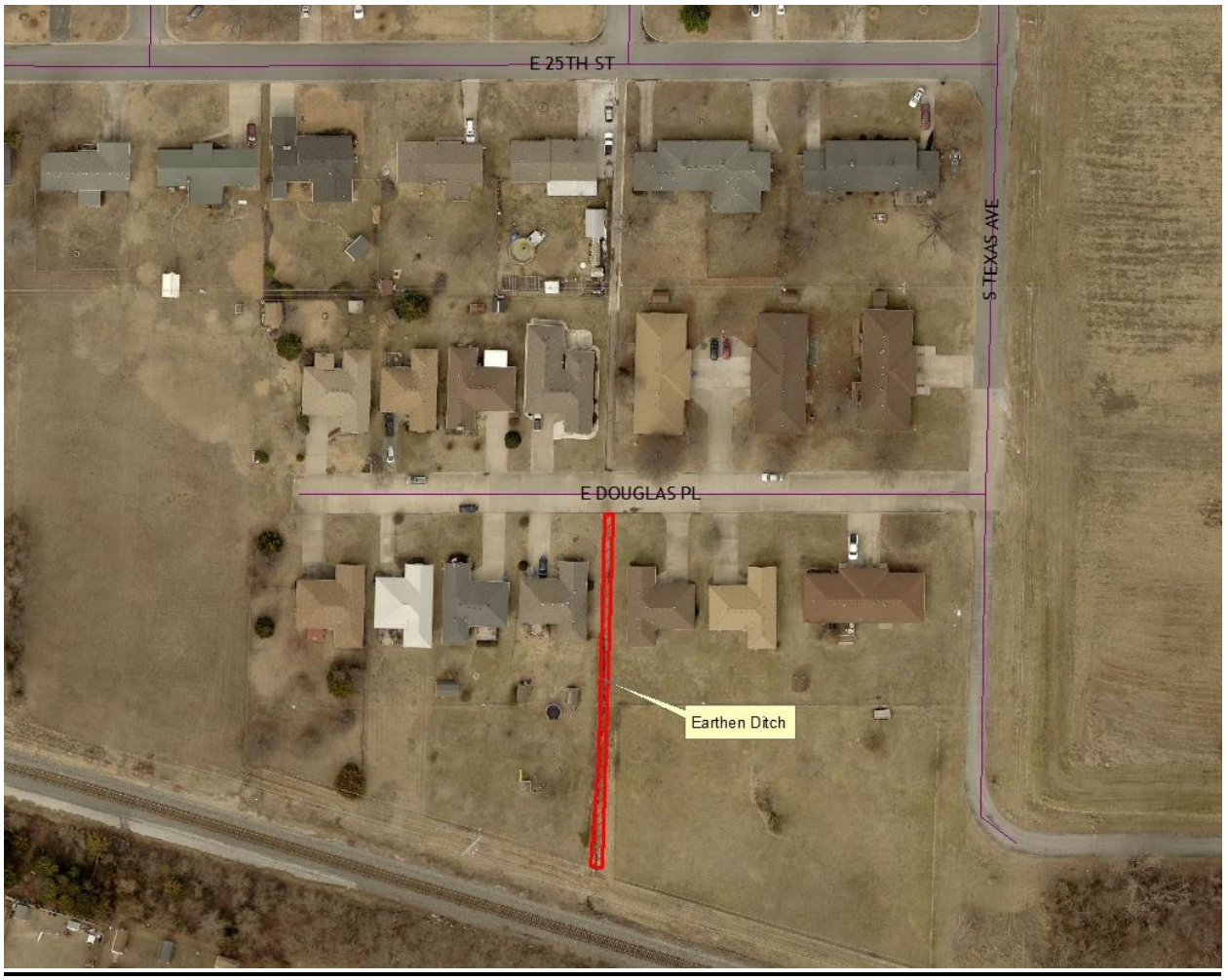
Data Summary

Estimated Cost: $30,000

Number of affected properties: 2

Existing Problem Description:

This reach consists of an unimproved open channel. Surface runoff comes off of East Douglas place and discharges into the open channel due south towards the railroad. The channel presently has lost capacity due to the accumulation of sediment and vegetative growth. The culvert by the railroad has a sub 10-year level of service capacity which acts as a choking point for stormwater runoff causing it to backflow into neighboring residential properties (affecting at least 2)



Project Name: 1502 N St. Louis Avenue

Data Summary

Estimated Cost: $20,000

Number of affected properties:1

Existing Problem Description:

An existing culvert running underneath St louis avenue discharges stormwater runoff from the East side of St Louis to the West where it ultimately sheet flows into Turkey creek. During heavy rain events, the property owner at 1502 N. St. Louis avenue, which is adjacent to the culvert, has reported stormwater build up at the point of discharge of the culvert. The build-up is a result of runoff accumulating behind energy dissipating riprap which constricts flows at an excessive scale during heavy rain events.



Project Name: 4501 E Newman

Data Summary

Estimated Cost: $38,000

Number of affected properties: 1

Existing Problem Description:

Property owner at 4501 Newman road experiencing standing water and nuisance flooding on the property, primarily on the front lawn, though no structural flooding has been reported. A watershed of approximately 111 acres drains through the property as surface runoff where it then crosses Newman Road via a 48-inch diameter Reinforced Concrete Pipe arch culvert. The culvert was sized for a 10-year design capacity.



Project Name: 20th and Patterson

Data Summary

Estimated Cost: $92,000.00

Number of affected properties: 15

Existing Problem Description:

The 7 property owners on the west side of Patterson avenue, North of 22nd street have reported standing water in their backyard. Due to the flat topography of the area there is minimal fall to the south towards 22nd street resulting in the standing water and nuisance flooding. To date no structural flooding has been reported.



Project Name: 1710 S. Maiden Lane

Data Summary

Estimated Cost: N/A

Number of affected properties: 1

Existing Problem Description:

The development at 1710 S. Maiden Lane experiences flooding of the property's parking lot. The existing earthen ditch at the West side of the parking lot has not been maintained and excessive sediment and vegetative build up have dramatically decreased the conveyance capacity of the ditch.



Project Name: 20th and Davis

Data Summary

Estimated Cost: $57,000

Number of affected properties: 1

Existing Problem Description:



The east side of Davis boulevard lacks a defined ditch as well as a whistle under the driveway of the Sunbelt rental commercial store at this location. Property owner has reported structural flooding resulting from runoff coming in from the west off of Davis Blvd.

Project Name: Blue Heron Drive (Cattails subdivision)

Data Summary

Estimated Cost: $635,000

Number of affected properties: 6

Existing Problem Description:



The Cat tails subdivision west of Duquesne road and North of Newman road primarily routes stormwater runoff in the subdivision to a pond to the north via surface drainage. Standing water has been reported on Blue Heron drive affecting 6 property owners constituting mostly as nuisance flooding.

Project Name: Cambridge Road (North Ridge Estates)

Data Summary

Estimated Cost: $205,000

Number of affected properties: 1

Existing Problem Description:



A suspected underground spring or other source of groundwater has caused noticeable deterioration of the street and curb and gutter (Roll back curb and gutter) at Cambridge road. Water has been observed to seep out of the pavement causing damage to street infrastructure. No structural flooding has been reported as of yet and the number of impacted property owners is currently limited to 2 residences.

Project Name: Katie Lane

Data Summary

Estimated Cost: N/A

Number of affected properties: 12

Existing Problem Description:



An unimproved natural drainage way runs behind 13 residences located on the east side of Katie Lane adjacent to the Frisco Greenway trail. Residents have reported nuisance flooding during frequent rain events. 5-year rain events have seen runoff overtop the ditch into neighboring yards. This general area has also been identified as having issues with groundwater, possibly an underground stream, as groundwater has been observed to percolate out of the ground, resulting in the consistent wet and mossy conditions on Katie Lane.

Project Name: 10th & Jefferson

Data Summary

Estimated Cost: N/A

Number of affected properties: 8

Existing Problem Description:



Two sumps have been identified at the intersections of 10th & Jefferson and 10th & Monroe. Significant ponding has been reported during rain events in excess of a 2-year rain event. Standing water on the street and affecting the properties at each of the 4 corners of the intersections (8 total). 10th street at this location can become impassable via vehicular traffic during 25+ year rain events.

Project Name: West 28th place (Cedar Ridge)

Data Summary

Estimated Cost: N/A

Number of affected properties: 6

Existing Problem Description:



An inlet on the north side of W 28th place discharges into an unimproved open ditch running north, between 4 residences before going under W 28th street via a culvert and continuing north along another unimproved open ditch. Residents on both 28th street and 28th place have reported backwater from runoff overtopping the ditch. Reports have also been received of runoff overtopping the road on 28th street. Culvert likely sized for a 10-year level of service which would be expected to be overwhelmed during the 25-year rain event in which the overtopping was reported at.

Project Name: 30th and Michigan

Data Summary

Estimated Cost: N/A

Number of affected properties: 4

Existing Problem Description:



Between S Michigan and S Kansas avenue standing water has been reported and observed in the unimproved dedicated right-of-way for 30th street. Water ponds on the east side of the intersection of 30th and Michigan avenue affecting 2 property owners. A small ditch has been cut by residents in an attempt to convey the runoff to the east where a curb cut dumps the runoff into Kansas avenue, however the flat topography of this location promotes standing water which also affects two property owners on the west of Kansas avenue.

Project Name: Chelsea drive

Data Summary

Estimated Cost: N/A

Number of affected properties: 2

Existing Problem Description:



Property owner at 3709 Chelsea drive has reported standing water in the ditch to the east of his home. Nuisance flooding on the banks of either side of the unimproved drainage channel has also been reported by both property owners. Issue appears to be maintenance related due to overgrowth of vegetation and the presence of obstructions.

Project Name: 26th and Grand

Data Summary

Estimated Cost: N/A

Number of properties affected: 15

Existing Problem Description:



Standing water in the backyards of residents east of grand avenue as well as west of Missouri avenue have been reported. Prior to construction of the existing high school to the north east, runoff would flow north between these residences into an open field via a small concrete swale. After the tornado and the high school was constructed, a berm to the north put in with the high school impeded discharge of the concrete swale which already held water prior to that due to the flat nature of the ditch as well as its lack of maintenance.

Project Name: 2401 Stinnett drive

Data Summary

Estimated Cost: N/A

Number of properties affected: 7

Existing Problem Description:



Stormwater runoff from east 46th street discharges to the west through the backyards of 7 properties along the north side of Stinnett drive. The property at 2401 Stinnett drive is at the lowest grade elevation of the flowline and has experienced significant scouring and erosion due to the surface runoff from upstream. A flat spot on Annie Ridge causes ponding water on the street until enough runoff accumulates to flow into the inlets to the south.

Project Name: 3302 Moorehead drive

Data Summary

Estimated Cost: N/A

Number of properties affected: 2

Existing Problem Description:



Property owner at 3302 Moorehead drive has reported significant scouring and erosion of the banks of the natural stream running along his property.

Project Name: 4511 Oaklawn

Data Summary

Estimated Cost: N/A

Number of affected properties: 2

Existing Problem Description:



North of 4511 Oaklawn there is an inlet on the east side of oaklawn drive which discharges into a culvert and open ditch to the east towards silver creek. During large rain events, the rising water table in silver creek causes water to back up into the open ditch and overtop onto the adjacent property. The ditch itself is a simple unimproved earthen ditch and suffered the effects of erosion. No structural flooding has been reported.

Project Name: 3rd and McCoy

Data Summary

Estimated Cost: N/A

Number of affected properties: 8

Existing Problem Description:



This section of 3rd street, west of S. McCoy avenue, has no curb and gutter infrastructure or roadside ditches in place. Stormwater runoff ponds both at the dead end of the west side of 3rd street as well as at the intersection of 3rd and McCoy.

Project Name: Witmer Subdivision (Irongates)

Data Summary

Estimated Cost: N/A

Number of affected properties: 13+

Existing Problem Description:



The Witmer subdivision primarily conveys stormwater runoff as a combination of surface drainage and ditches. The ditches in this neighborhood lack definition and have diminished or in some cases non-existent capacity for stormwater conveyance, resulting in standing water on City streets as well as private property.

Project Name: McCoy avenue 21st to 22nd street

Data Summary

Estimated Cost: N/A

Number of affected property owners: 11+

Existing Problem Description:



This four-block radius bounded by Cunningham avenue to the west, 21st street to the North, 22nd street to the south, and maiden lane to the east has numerous locations for ponding water. The intersection of McCoy and 22nd street suffers from heavy inundation of stormwater as runoff slowly sheet flows to the south into the parking lot of an apartment complex where it eventually flows into a flume in the parking lot. Several stormwater improvements were made downstream of this area allowing for a system for any newly constructed storm infrastructure to tie into.

Project Name: 30th and Vermont

Data Summary

Estimated Cost: N/A

Number of affected property owners: 2

Existing Problem Description:



The east side of the intersection of 30th and Vermont has standing water during, and several days after, rain events affecting at least 4 properties. Runoff from the west on 30th street ponds at the dead end and slowly sheet flows to the west towards Massachusetts avenue.

Project Name: 3013 N Brownell

Data Summary

Estimated Cost: N/A

Number of affected properties: 2

Existing Problem Description:



The unimproved ditch north of 3013 N Brownell discharges runoff to the west of Brownell via two culverts. During large rain events, stormwater runoff overtops the ditch to the north by as much as 15 feet past the northern bank of the ditch when capacity for conveyance through the culverts is exceeded resulting in stormwater backing up. No structural flooding has been reported nor has the ditch been observed to overtop Brownell avenue.

Project Name: Finley Subdivision

Data Summary

Estimated Cost: N/A

Number of affected properties: 6

Existing Problem Description:



The Finley subdivision is plagued by standing water as a result of the exceedingly flat terrain. Standing water has been observed in both the alleys and ditches of the subdivision for days after the rain event. With the Connecticut avenue widening adding stormwater improvements to Connecticut, the project offers a new system for any stormwater improvements in this neighborhood to connect to.

Project Name: Zora & Duquesne (Turkey Creek)

Data Summary

Estimated Cost: N/A

Number of affected properties: 2

Existing Problem Description:



This section of Turkey creek south of Zora lies within the mapped floodplain. Significant erosion and scouring has been observed on the banks of Turkey creek on either side of Duquesne road. While structural flooding has been confirmed at 2120 Duquesne road, this residence does lie within the mapped floodplain.

Project Name: Tall Grass Estates

Data Summary

Estimated Cost: N/A

Number of affected properties: 8+

Existing Problem Description:



The south and east side of the Tall Grass Estates subdivision is plagued year-round by standing water, the cause of which is speculated to be due in part to groundwater from the subdivision's close proximity to the mapped floodplain (the east section residing entirely within the floodplain). 8 homes on the south side of Plumthicket drive currently suffer from standing water, present even weeks after the last rain event.

Project Name: 26th and Highland

Data Summary

Estimated Cost: N/A

Number of affected properties: 9

Existing Problem Description:



Standing water has been reported by residents on the west side of S Highland avenue south of 26th street affecting at least 9 properties. Surface runoff from the south sheet flows to the north towards 26th street.

Project Name: 32nd and Oliver

Data Summary

Estimated Cost: N/A

Number of affected properties: 3

Existing Problem Description:



The unimproved open channel on the east side of Oliver, North of 32nd street discharges across Oliver avenue via surface runoff before discharging into the paved ditch on the west side of Oliver. The sheet flow of stormwater across Oliver during rain events presents a public risk to vehicle traffic, especially during larger storms, and results in the presence of frequent standing water compromising the integrity of the road. The unimproved ditch to the east has been observed to overtop during heavy rain events and cause structural flooding to the apartment residences to the north and south of it.

Project Name: 17th and Indiana

Data Summary

Estimated Cost: N/A

Number of affected properties: 3

Existing Problem Description:



The dead end on east 17th street, east of Indiana has been observed to have standing water during and after rain events. The flat terrain in this region is the main cause of the ponding as stormwater is unable to make its way east to a culvert underneath the train tracks. With no ditch or swale in the area to convey the runoff east, the primary means of conveyance for the stormwater is in the form of surface drainage by sheet flowing towards the east.

Project Name: Junge & Byers

Data Summary

Estimated Cost: N/A

Number of affected properties: 2

Existing Problem Description:



Excessive surface water at the intersection of Byers and Junge caused by insufficient inlet capacity to convey runoff from the roadway. During large rain events, structural flooding has been observed of the commercial property on the north east corner of the intersection.

Project Name: 6021 W. Highland Drive, Relief Sewer

Project Identification Number: 1-4

Data Summary

Watershed:	Silver Creek
Priority No.:	21
Design Capacity:	25 Year
Estimated Cost:	$30,000
Model ID No.:	1062
Map Sheet Reference Number:	11

Existing Problem Description

The development has a large swale that runs through the back of several properties. The property owner at 6021 W. Highland Ave. has water that backs up in the yard due to the insufficient capacity of the 21" culvert until it discharges over the road to the northwest.

Recommended Improvements

Add a parallel 24" RCP to pass the 25-year flood event.

Downstream Controls

Existing open channel immediately downstream is adequate for design discharge.

Potential Alternatives

Do nothing; allow ponding to occur on property owner.

Project Name: Grand Ave. & 34th St., Paved Ditch

Project Identification Number: 3-8

Data Summary

Watershed:	Water Works
Priority No.:	11
Estimated Cost:	$15,000
Sub-basin ID No.:	3130
Map Sheet Reference Number:	8

Existing Problem Description

The flume on the south side of the intersection of Grand Ave. and 34th St. is insufficient to convey the amount of runoff that accumulates at that point. The earthen ditch to the south of the existing flume has weeds, small trees, and large deposits of sediment accumulated in it; all of which impede the water as it flows south and contributes to the water backing up into the intersection.

Recommended Improvements

Replace existing flume with type I flume as per City of Joplin Standard Plans. Clean and re-shape approximately 200 feet of ditch south of the new flume.

Downstream Controls

None.

Potential Alternatives

Line ditch with concrete to reduce maintenance and increase capacity of ditch without increasing current size.

Project Name: Intersection of 32nd St. & Pearl Ave.

Project Number: 12

Project Identification Number: 3-9

Data Summary

Watershed:	Water Works
Priority No.:	
Design Capacity:	2-year
Estimated Cost:	$89,000
Sub-basin ID No.:	3225
Map Sheet Reference Number:	8

Existing Problem Description

Water flowing from the north down Pearl Ave. does not flow into the existing curb inlets on the north side of 32nd St. The pavement surface also does not provide positive drainage into existing inlets and causes minor ponding. This causes surface water to accumulate on 32nd St. and Pearl Ave. until it evaporates.

Recommended Improvements

Install 2-8' x4'curb inlet boxes on the north side of intersection to intercept flow along Pearl Ave. before it reaches 32nd St., add 30 feet of 30" RCP to connect new inlet boxes to the existing inlet boxes. Cold mill roadway surface to ensure proper drainage into existing inlets and overlay with I to 2 inches of asphalt.

Downstream Controls

None.

Potential Alternatives

Rework surface of intersection to force water into existing inlets, do not install new inlets or new pipes.

Project Name: Main St. from 25th St. to 27th St., New System

Project Identification Number: 3-10

Data Summary

Watershed:	Water Works
Priority No.:	5
Estimated Cost:	$537,000
Model ID No.:	3315
Map Sheet Reference Number:	8

Existing Problem Description

Water ponds along Main St. due to inadequate curb inlets. Structure No. 3300 (8' x 5' RCB) has a capacity of 240 cfs, the 5-year storm event yields 260 cfs more than the structure is capable of carrying, and the 10-year storm event yields 310 cfs, which is the desired design capacity.

Recommended Improvements

Install 7 - 8' x 4' curb inlets on the east side of Main St. from 25th St. to 27th St. connected with 24" RCP. Install 3 - 8' x 4' curb inlets on the north side of 27th St. emptying via a 24" concrete flared end section into the open channel n01ihwest of the 27th St. and Joplin Ave. intersection.

Downstream Controls

None.

Potential Alternatives

Run line into existing RCB on Main St.

Project Name: Intersection of 9th St. and Minnesota Ave., Storm Sewers

Project Number: 20

Project Identification Number: 4-15

Data Summary

Watershed:	Joplin Creek West
Priority No.:	
Design Capacity:	
Estimated Cost:	$129,000
Model ID No.:	
Map Sheet Reference Number:	

Existing Problem Description

Excessive surface water along 9th St. caused by insufficient inlet capacity to convey runoff from roadway. Area at headwall on north side of 9t' St. and entrance of pipe on south side of 9 th St. partially blocked with debris and rock. Structure No. 4220 has 1330 cfs of capacity currently. 10-yeai· sto1m discharge for this structure is 1570 cfs.

Recommended Improvements

Install two 8'x 4' curb inlets on 9th St. west of the intersection of 9 th St. & Minnesota Ave., one on the north side of the street, one on the south side. Install 30 LF 18" RCP between the two new curb inlets. Use the existing 36" RCP on north side of 9th St., build a curb inlet box and headwall structure to utilize existing pipe. Install two 8'x 4' curb inlets on 9th St. west of the railroad tracks, replacing the existing inlets. Install 50 LF of 15" RCP between the two new curb inlets. Install two 8'x 4' curb inlets on 9th St. west of the intersection of 9th St. & the small alley going north, one on the north side of the street, one on the south side. Install 30 LF 15" RCP between the two new curb inlets. Connect the east pair of inlets to the middle pair using 175 linear feet of 18" RCP on the north side of 9th St.

Downstream Controls

None.

Potential Alternatives

Replace structure No. 4220 (2-11' x 4' RCB) with 2-15' x 4' RCB, capable of discharging more than 1570 cfs.

Use a precast single span arch for structure No. 4220.

Project Name: Intersection of 14th St. and Florida Ave., Replacement

Project Identification Number: 6-11

Data Summary

Watershed:	Joplin Creek East
Priority No.:	10
Estimated Cost:	$54,000
Sub-basin ID No.:	6325
Map Sheet Reference Number:	5

Existing Problem Description

3' x 6.5' drop inlet in back yard of2625 14th St. property not allowing enough flow into it, causes yard flooding. This is because of small openings in the box and yard debris builds up around the openings. Also, the pipe from the inlet to the street is collapsed due to tree roots.

Recommended Improvements

Add inlet to reduce chances of clogging, replace existing 18" pipe with 24" RCP, this will require the removal of several large trees.

Downstream Controls

None.

Project Name: Intersection of Lone Elm Rd. and Murphy Blvd.

Project Identification Number: 7-10

Data Summary

Watershed:	Lone Elm
Priority No.:	19
Estimated Cost:	$565,000
Model ID No.:	7020, 7030
Map Sheet Reference Number:	4

Existing Problem Description

Structure No. 7020 (2 - 10' x 4' RCB) under Murphy Blvd. is undersized, with only slightly more capacity than a 2 year storm discharge. Structure No. 7030 (6' x 2' RCB) under Lone Elm Rd. has only slightly more capacity than a 5-year sto1m discharge. At the n01ih corner of the Lone Elm Rd. and Murphy Blvd. intersection, water ponds on the edge of the roadway and in the beginning of the ditch. The beginning of the ditch has silted in blocking the discharge path for surface runoff from the northeast going around the curb radius and into the ditch. On the northeast side of Lone Elm Rd. approximately 150' n01ih of the afore mentioned intersection there is a 15" corrugated plastic pipe used for egress/ingress to a property that is also installed too *high* where water cannot pass in low flow conditions. In this same location, a 24" RCP runs west under Lone Elm Rd. to a concreted ditch. The ditch is capable of carrying more flow than the pipe; the pipe entrance is also partially blocked.

Recommended Improvements

Improvements to or replacement of Structure No. 7020 to enable passage of the 10-yem storm event is recommended. When structure No. 7020 is replaced and allows more passage of water, structure No. 7030 would be capable of conveying more flow. Hence structure No. 7030 can remain in place, along with the 24" RCP flowing to it and the 6' x 3.5' curb inlet conveying water into the 24" RCP. On the n01iheast side of the intersection the ditch is to be cleaned and a type 2 flume as per City of Joplin standard plans installed to provide positive drainage from the roadway into the ditch. Re-grade approximately 120' of the earth ditch. The existing 15" CPP used for egress/ingress should be replaced with a 24" RCP. The existing 24" RCP flowing west under Lone Elm Rd. should be upgraded to a 36" RCP. Construction of a headwall at the low point of the ditch on the east side of Lone Elm Rd. will facilitate the new 24" RCP and also the new 36" RCP exit and entrance needs, respectively. Re-grade approximately 200 feet of the ditch on the east side of Lone Elm Rd. north of the new headwall structure.

Downstream Controls

The ditch north of these improvements along the west side of Lone Elm Rd. is adequate for the design discharges, however, structure No. 7010 is not. Consideration should be given to the effectiveness of these improvements given downstream restrictions.

Project Name: Cleveland Ave. Between 25th St. and 24th St.

Project Identification Number: 8-5

Data Summary

Watershed:	Country Club
Priority No.:	9
Estimated Cost:	$40,000
Model ID No.:	8024
Map Sheet Reference Number:	7

Existing Problem Description

Area flooding along Cleveland Ave. between 24th and 25th streets due to existing system being inadequate.

Recommended Improvements

Replace existing 16" CMP with45 linear feet of 24" RCP and shape the gutter leading into the new flared end section.

Downstream Controls

Project 8-4 should be done in conjunction with or prior to this project.

Potential Alternatives

Existing HDPE piping and inlet system extending south from the ditch near 24th along Cleveland Ave. is a newer system that was constructed as part of the subdivision prior to the subdivisions' incorporation into the city of Joplin. This system was not designed or constructed in a manner to prevent nuisance flooding in yards and of the roadway. This system could be completely replaced for approximately $400,000 (Project 8-5A)

Project Name: Salem St. just east of Park Ave.

Project Identification Number: 10-5

Data Summary

Watershed:	Turkey Creek Central
Priority No.:	17
Estimated Cost:	$14,000
Model ID No.:	
Map Sheet Reference Number:	2

Existing Problem Description

The ditch flowing south onto Salem St. floods across the street and continues flowing south.

Recommended Improvements

Install 24 linear feet of 24" RCP with a flared end section pointed north to intercept the southbound flow. Connect the pipe to the existing curb inlet box on the north side of Salem St.

Downstream Controls

None.

Project Name: Windsor St. from Michigan Ave. to Illinois Ave.

Project Identification Number: 12-2

Data Summary

Watershed:	Royal Heights
Priority No.:	13
Estimated Cost:	$85,000
Sub-basin ID No.:	12005
Map Sheet Reference Number:	2

Existing Problem Description

At the intersection of Michigan Ave. and Windsor St. the runoff flows south off the stub out of Michigan Ave. over riprap and into an earthen ditch. The ditch is eroding and the riprap is too small, causing it to migrate downstream. At the intersection of Illinois Ave. and Windsor St. the runoff flows to a low point in the street located in front of 1032 Windsor St. An existing curb inlet (8.5' x 3.5') is in place to remove the water from the street, which then flows into a 24" corrugated plastic pipe that discharges at the back of the property into an existing channel. Any overflow flows through the yard to the back of the prope1iy into the same channel. This area collects a significant amount of runoff from three directions, and the existing stormwater control devices are insufficient to remove the water in a timely fashion. At the east end (stub out) of Windsor St. the water flows straight off the street into a channel. There does not appear to be any prominent problem in this area.

Recommended Improvements

Add larger riprap where Michigan Ave. stubs out to the south. Clean out the ditch from there and line with riprap. Add curb inlet extensions to existing curb inlet in front of 1032 Windsor St. Run a parallel line consisting of 160 L.F of 24" CPP, discharging at the south side of the prope1iy.

Downstream Controls

Impractical to attempt downstream channel improvements in the woods. Limbs and debris will wash out during major storm events, the channel is adequate if not blocked.

Potential Alternatives

Channel flowing south from intersection Michigan Ave. and Windsor St. could be concreted if Michigan Ave. was not going to be extended.

Project Name: Industrial Park Road and Kennedy Lane, Regional Detention

Project Identification Number: 13-2

Data Summary

Watershed:	Baker's Branch (Oakland)
Priority No.:	36
Estimated Cost:	$237,000
Sub-basin ID No.:	13061
Map Sheet Reference Number:	3

Existing Problem Description

Excessive surface water coming from the existing industrial park is causing ditch to erode on private property to the South. The industrial park was constructed prior to regulations being in place to require storm water detention.

Recommended Improvements

Construct a six-acre regional detention basin within the industrial park to decrease the 2- and 5- year design storms by 40%, the 10-year by 25%, and the higher intense storms by approximately I 0%. By controlling the more frequent storms, erosion of the natural channel may subside. Following are the estimated pre- and post-developed flows immediately downstream of the proposed detention basin:

	DISCHARGE (cfs)					
	2YR	5YR	l0YR	25YR	50YR	l00YR
Pre-Developed	224	443	624	797	1026	1191
Post-Developed	138	260	468	664	915	1082
%Reduction	38%	41%	25%	16%	10%	9%

Downstream Controls

None.

Project Name: 5748 Rivercrest Valley

Data Summary

Estimated Cost:

Number of affected properties: 4

Existing Problem Description:

Within the property of 5748 Rivercrest valley, which is outside the City limits, an unimproved ditch runs North/South across the west side of the property through a culvert under Rivercrest drive. The watershed upstream of this property includes the Osbourne cemetery which is City property. This upstream watershed from the cemetery has caused erosion of the property at 5748 River crest valley. City staff have considered the possibility of building a detention basin upstream of the property, within the cemetery, to capture runoff and decrease discharge rates downstream of the cemetery.



Project Name: 5th and Porter

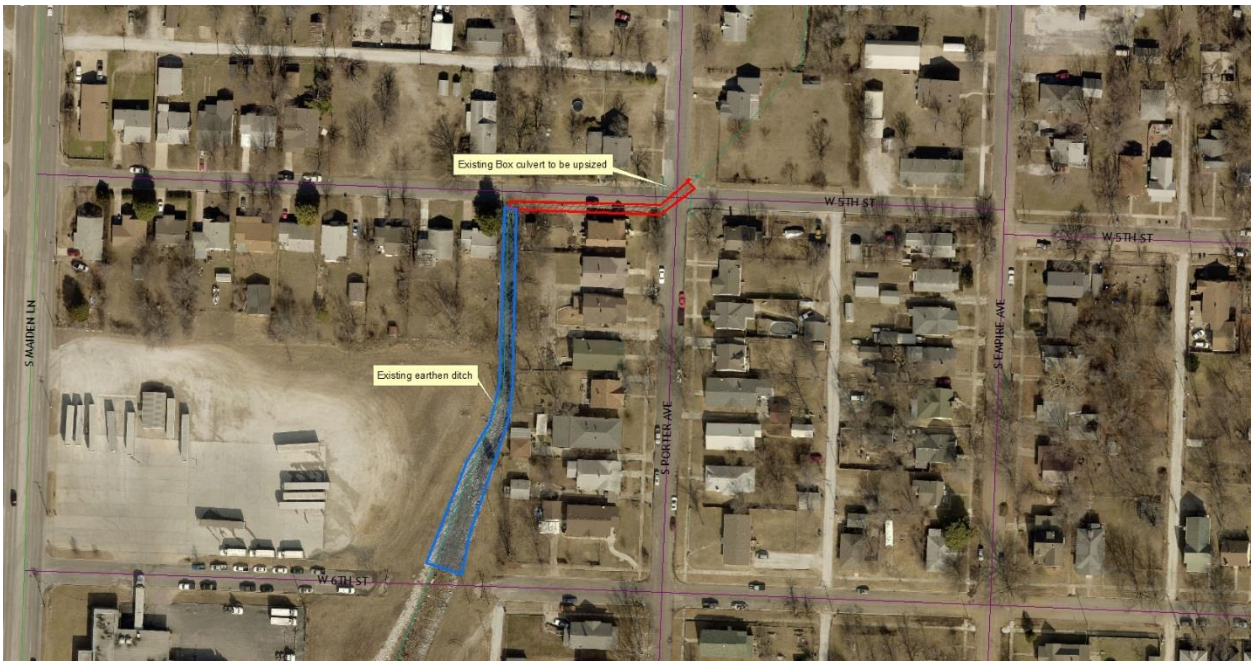
Data Summary

Estimated Cost: N/A

Number of affected properties: 9

Existing Problem Description:

The existing 5’ x 4’ box under 5th street was compromised during the 25-year rain that passed through the area in the spring of 2019. During that rain event, the hydraulic pressure buildup from the system failing downstream led to the top of the 5’ x 4’ box (which was acting as the top of the sidewalk) failing and collapsing. With the 4th and Porter stormwater project currently underway, the system downstream of the 5’ x 4’ box is being replaced starting at the junction box (which the 5’ x 4’ box ties into) on the northeast corner of 5th and porter and going downstream. Upstream of this repair, the 5’ x 4’ box will need to be upsized and improvements to the existing earthen ditch made in order to reduce frequency of flooding experienced by residential units adjacent to the ditch.



Project Name: Murphy Boulevard and Crest drive

Data Summary

Estimated Cost:

Number of affected properties: 1

Existing Problem Description:

At the intersection of Crest drive and W Murphy BLVD reports of standing water during heavy rain events have been received by residents. Runoff in this location is drained off the street by two inlets on Crest drive which may be undersized and cannot keep up with the incoming runoff flow.



Project Name: 18th and Cleveland Terrace

Data Summary

Estimated Cost: N/A

Number of affected properties: 3

Existing Problem Description:

The cul-de-sac at the end of Cleveland terrace becomes inundated during heavy rain events. The existing unimproved earthen ditch is in need to regrading and maintenance.



Project Name: 19th and Harlem

Data Summary

Estimated Cost: N/A

Number of affected properties: 20+

Existing Problem Description:

The intersection of 19th and Harlem holds water after rain events. Harlem street north of 19th street has degraded considerably due to water damage. Standing water in the gutters has been observed in several locations along Harlem avenue after rain events.



Project Name: 19th and Ohio

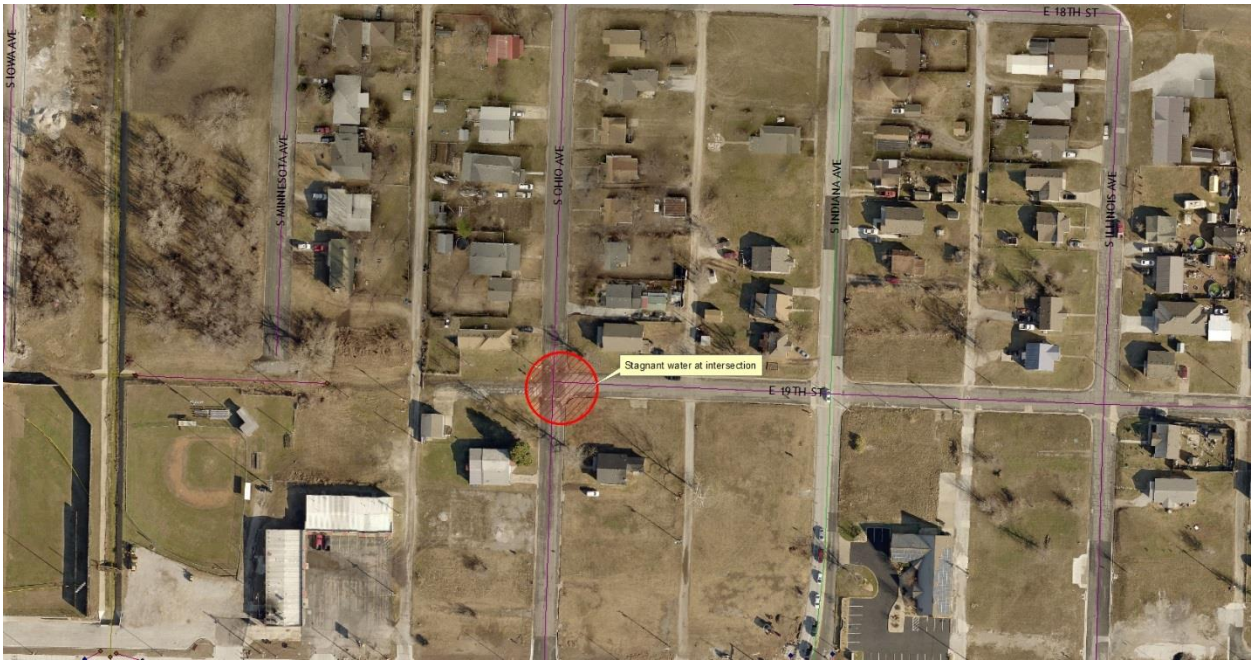
Data Summary

Estimated Cost: N/A

Number of affected properties: 2

Existing Problem Description:

Water ponds at the intersection of 19th and Ohio



Project Name: 24th and Highland

Data Summary

Estimated Cost: N/A

Number of affected properties: 3 commercial properties

Existing Problem Description:

The street (Highland avenue) and parking lot behind McAllister's (2330 South Rangeline Road) suffers from excessive surface flooding primarily due to insufficient and undersized stormsewer system in the area. Existing curb inlets are undersized.



Project Name: College Skyline Subdivision

Data Summary

Estimated Cost: N/A

Number of affected properties: 2+

Existing Problem Description:

A low spot exists near the intersection of Whispering Oaks drive and Bakers branch drive. A small concrete flume conveys stormwater off of the street and between two residential properties. The property at 1726 Whispering Oaks drive has reported structural flooding in the form of stormwater runoff entering their attached garage. The concrete flume itself can be overwhelmed during large rain events, resulting in flooding of adjacent yards. This subdivision lacks an enclosed storm sewer system, as all stormwater run off is conveyed as surface runoff, with a significant watershed draining to the concrete ditch.



Project Name: Norman Foulke Addition

Data Summary

Estimated Cost: N/A

Number of affected properties: 20+

Existing Problem Description:

The Norman Foulke addition, south of 26th street and west of Indiana avenue has several intersections on 27th and 28th street which become inundated with water during heavy rain events. The intersection of 27th and Minnesota specifically becomes a public safety hazard for vehicles during more frequent storms and impassable during heavier storms including during 10 year storms which is the standard level of service for residential subdivisions within the City of Joplin.



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Olsson Project No. 020-2337