City of Moore

Comprehensive Stormwater Management & Master Drainage Plan

Final Report

January 2017

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MESHEK & ASSOCIATES, PLC

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SECTION 1. EXECUTIVE SUMMARY

The City of Moore Comprehensive Stormwater Management and Master Drainage Plan began in 2015 with a kickoff meeting including the City of Moore and Meshek & Associates, PLC (Meshek). Key components of the plan included the development of updated hydrologic and hydraulic models for a majority of the City; a review of the City's policies regarding drainage and floodplain management; the development of an updated Storm Water Management Plan (SWMP); the development of a Total Maximum Daily Load (TMDL) compliance and monitoring plan for discharging stormwater into Lake Thunderbird; and analyze the financial needs for stormwater infrastructure improvements and the possibilities of funding infrastructure improvements and monitoring plans. The area of study is shown in **FIGURE 1-1**.

The City of Moore Master Drainage Plan (MDP) gives the city several beneficial tools for analyzing and managing future development and existing infrastructure. Foremost, the MDP provides an updated set of hydrologic and hydraulic models for city staff, developers, and consulting engineers to utilize for analysis of development or infrastructure improvements. From these updated models, the hydrologic model provides a hydrograph and timing of peak discharge flowrates at boundaries between each of the subdivided drainage basins or sub-basins. The hydraulic models provide updated floodplains, floodway, and water surface profiles for risk assessment and future development planning including emergency management and hazard mitigation.

The resulting analysis for Little River Watershed included a combined 195 sub-basins and 11.2 square miles of drainage area; North Fork River included 204 sub-basins with a combined 15.25 square miles of drainage area; and, Canadian River Tributaries included 20 sub-basins with a combined 1.3 square miles of drainage area. The Little River Watershed is further broken down into studied tributary basins: Stream E and Northmoor Creek. The North Fork River Watershed is further broken down into studied tributary basins: Stream A and Stream D. Additional detailed information on the studied watersheds and streams can be found in **SECTIONS 3-7**.

Our first step in the process of developing the CSWMP included meeting with City staff to identify all known problem areas and coordinate a public meeting to solicit input from citizens. At a public meeting held on May 14, 2015 at the Band Senior Center in Moore, Oklahoma, over 70 people were recorded on sign-in sheets and over 120 were counted in attendance. Approximately one week prior to the public meeting, the City of Moore experienced a significant rainfall event resulting in substantial flooding across the City. Maps of the City were used to identify the locations of flooding. Meshek staff visited with citizens and recorded concerns including descriptions of the problem areas along with pictures and videos.

Figure 1-1: Flooding on Interstate-35 at Little River Crossing in May 2015

The data gathered from local citizens and City staff was used to guide the development of our detailed hydrologic and hydraulic models. The areas of study for the hydrologic and hydraulic models included the Little River and North Fork River basins in the overall Little River Watershed (LR) and the Canadian River Tributary basins. Each of these basins contain tributaries within the City of Moore of which only specific tributaries were studied in detail hydraulically. The naming conventions for these tributaries were consistent with the naming conventions used in the current FEMA databases.

We obtained rainfall data for the May 5-8, 2015 storms from two Oklahoma Climatological Survey gage stations and applied it to our updated models. We prepared floodplains and compared them to photographs, high water marks, news reports, etc. We then made small adjustments in a few areas but the models were consistent with the reported flooding in the May 5-8, 2015 storms. This calibration of our updated computational models to a known flooding storm provided additional confidence in the accuracy of the updated models. More detail of the hydrologic and hydraulic model calibration can be found in **SECTION 2**.

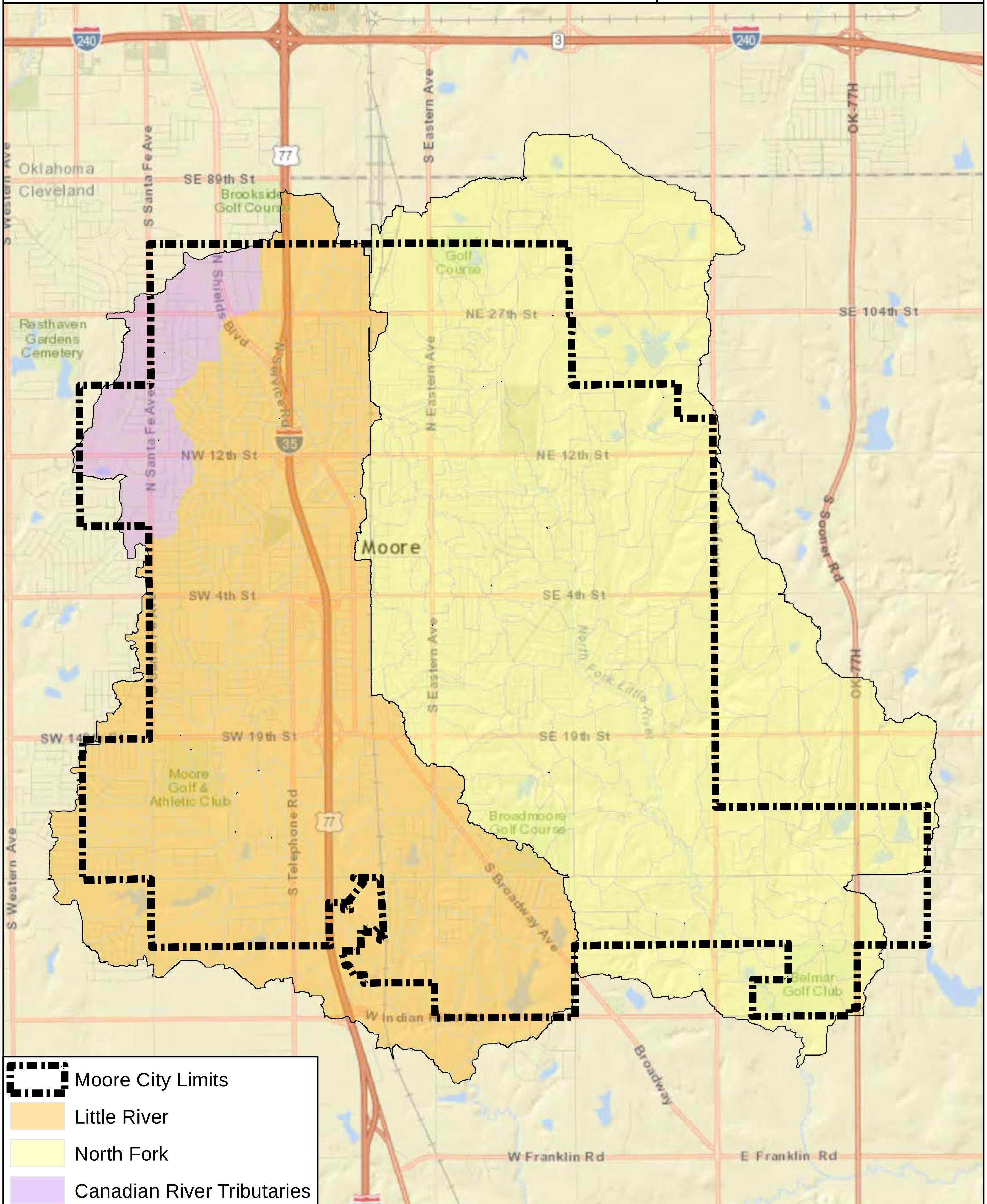
A review of Article J containing the current Drainage and Erosion Control Ordinance for the City of Moore was performed in this MDP. Based on the review of this document, we recommended the City of Moore develop a new 'Design Criteria Manual' to encompass current practices, procedures, and technologies of engineering and design for stormwater infrastructure. In addition, all commercial, residential, or public use development will cause an increase in peak discharge flow rates through increased impervious area and/or loss of floodplain storage. This increase in peak discharge flowrates also causes increases in the floodplains and floodways both upstream and downstream of the source or stream junctions. Therefore, any development should be hydrologically and hydraulically studied in detail both upstream and downstream to determine the effects of development and how the increase in peak discharge flowrates can be offset or mitigated, typically achieved through detention. Review comments and recommendations for the current Drainage and Erosion Control Ordinance is given in **SECTION 8**. Attached in **APPENDIX 8-A** is an example of a soundly written Drainage Design Criteria Manual for the City of Owasso, Oklahoma.

The development of this Comprehensive Storm Water Management Plan (CSWMP) should serve as a guide for capital improvements and in several other capacities throughout the future for the City of Moore. A total of 71 problem areas of concern were documented and based on detailed analysis, 35 recommended plans were developed. The total cost of these improvements are in excess of $27.9M. Each of these projects were prioritized based on several objective criteria described in **SECTION 9**. This plan also includes a preliminary feasibility analysis for the development of a Storm Water Utility Fee (SWUF). In addition to the capital improvements identified in this plan, there are many ongoing costs associated with implementation of the TMDL Compliance and Monitoring Plan and the updated SWMP. A SWUF is one option to assist with these funding needs.

In addition to the Prioritization Plan, the updated Storm Water Management Plan and the TMDL Compliance and Monitoring Plan serve as guides for improving water quality in the City of Moore. **SECTION 10** and **SECTION 11** of this document include a copy of the updated SWMP and the TMDL Compliance and Monitoring Plan. Future storm water improvements should both reduce the risk of flooding and protect storm water quality within the drainage basins of the City of Moore.

Safety and an emergency action plan for flooding events is crucial knowledge for the general public to understand. At an undefinable point in the future, any creek or river will generate flooding. Drowning or injury hazards arise when our man-made structures cross flood prone areas. When a creek or river is overtopping a roadway, possibly only inches in depth, the stormwater discharge may have the capacity to lift any vehicle off the roadway or ground and carry the vehicle downstream. The same stormwater discharge overtopping a roadway may also have the capacity to washout the roadway pavement, soil embankment, or the hydraulic structure, all while the damage remains hidden beneath the water surface. Meshek & Associates wants the general public to understand the risk of injury and loss of life hazards from flooding by supporting the 'Turn Around Don't Drown' initiative. In an attempt to save lives and prevent injuries, this initiative conveys the idea to stop or turn around rather than attempt to pass through a flooded area. Roadway gutters, culverts, storm sewer systems, and detention ponds are other man-made systems designed to convey stormwater. These systems pose a drowning or injury hazard to people or pets when they are discharging any amount of stormwater. Any flooding should be considered as a natural disaster event, therefore people and pets should remain indoors, proceed to high ground if necessary, or comply with emergency personnel requests.

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA

Project Location

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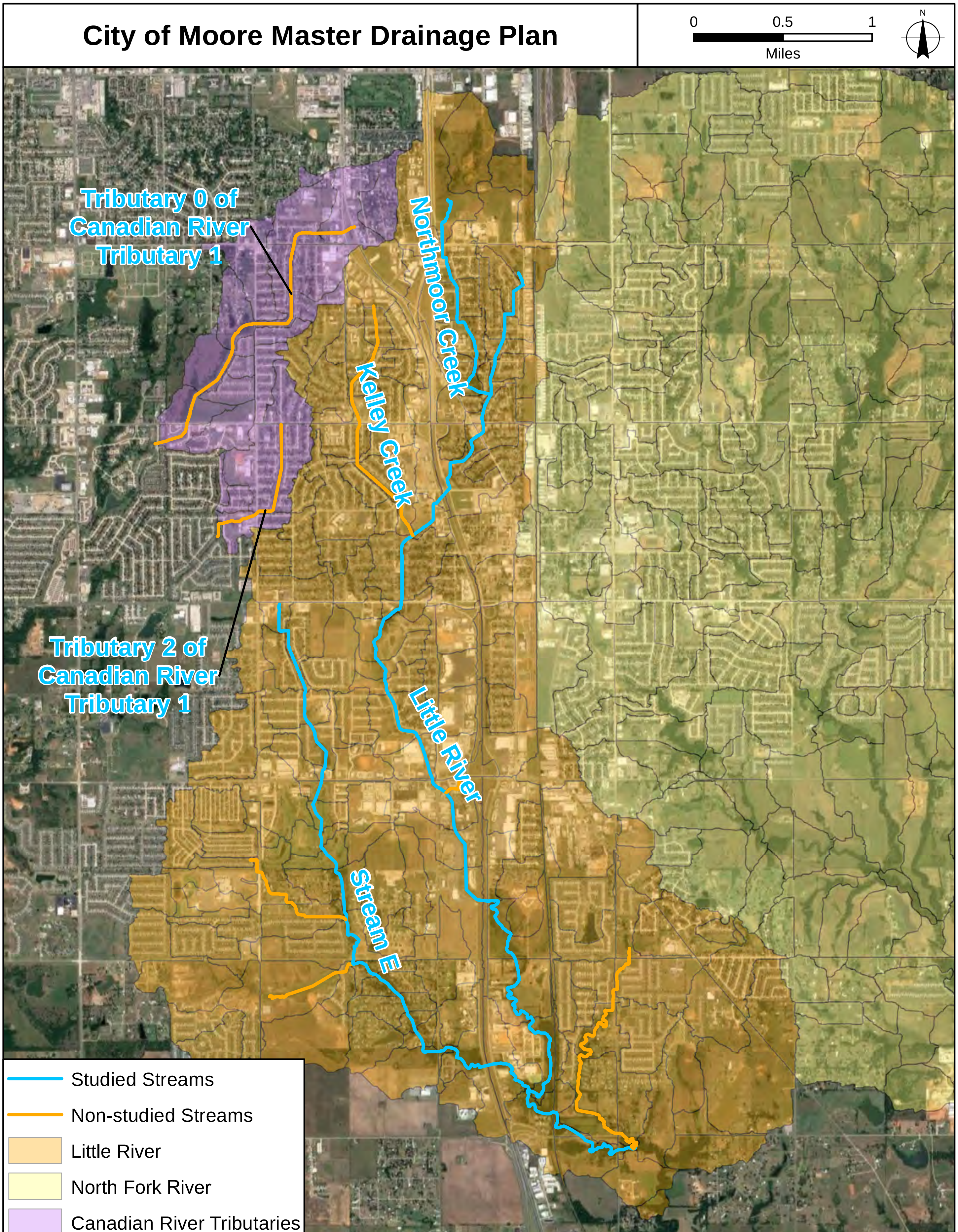
City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA 1893

Little River Studied Streams

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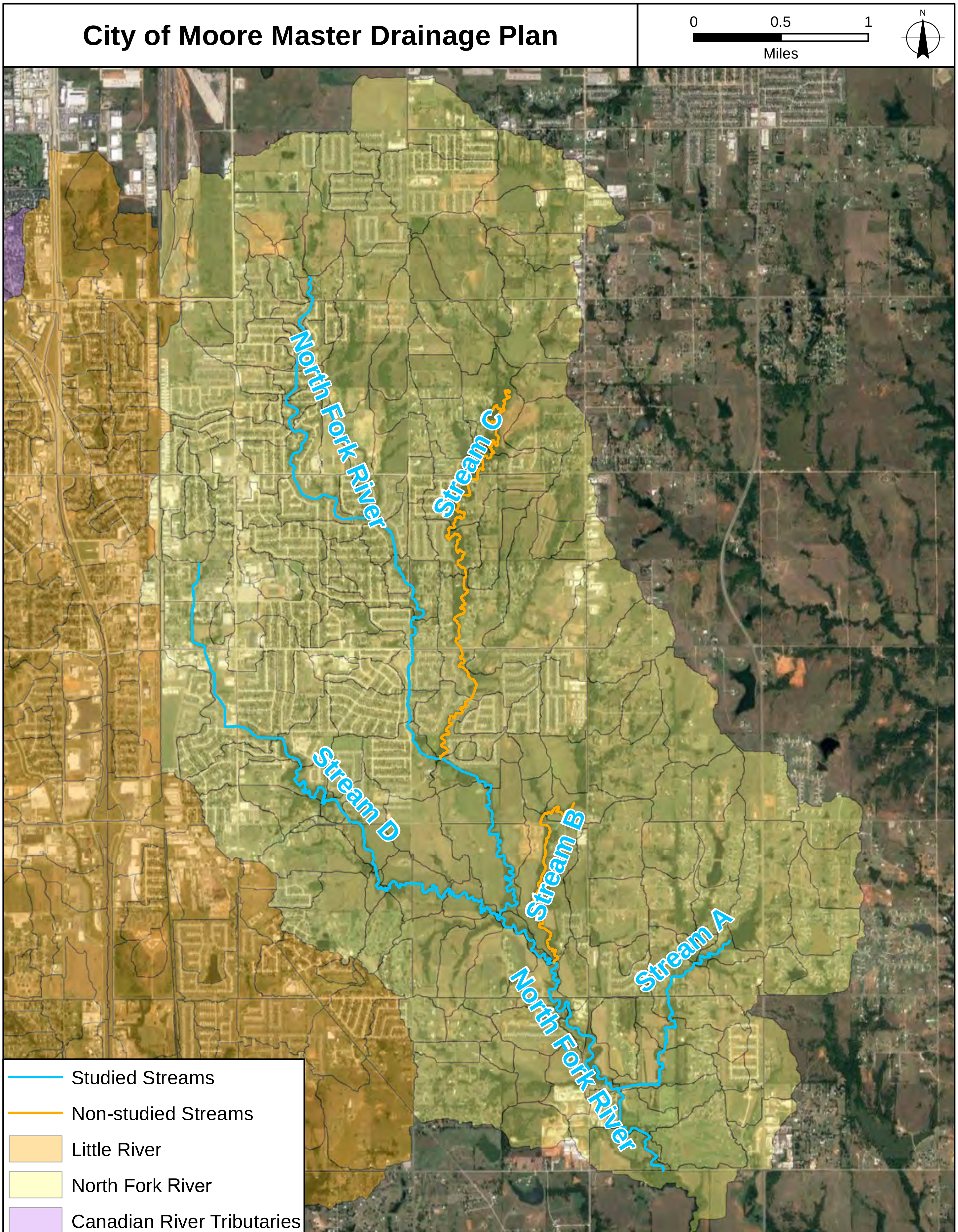
Figure 1 - 3

City of Moore Master Drainage Plan



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North Fork Studied Streams

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Section 2
Methodology

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SECTION 2. STUDY METHODOLOGY

Hydrologic and hydraulic modeling of the Little River and Canadian River Tributary watersheds was performed using HEC-HMS (version 4.0) and GeoHECRAS computer programs developed by the US Army Corps of Engineers and CivilGEO Engineering Software. The GeoHECRAS software operates on the HEC-RAS hydraulic modeling software developed by the US Army Corps of Engineers and uses additional GeoRAS graphical interfaces to edit input and output data of a hydraulic model. The final hydraulic model will be exported to standard HEC-RAS (version 5.0) files and submitted to the City of Moore. These programs are Windows-based and GIS-based versions of HEC-1 and HEC-2, long considered industry standards for hydrology and hydraulics.

For each of the stream reaches studied, the major drainage features were identified and then modeled to determine their ability to convey the peak flows for the 1-, 2-, 5-, 10-, 25-, 50-, 100- and 500-year storms.

A 2015 Digital Terrain Model provided by the City of Norman was combined with 2010 two foot topography data provided by the City of Moore to create a terrain model of the study area. The watershed delineation was performed manually using this topographic data and the stream cross sections were cut using the combined Terrain Model.

Bridge and culvert data was obtained from a survey conducted by Meshek or measured in the field.

The HEC-HMS output showing flows at all major junction locations for frequencies ranging from the 1- year to 500-year floods are also included in Appendices for each section complete with the locations of HMS junctions in the HEC-HMS schematics.

2.1. Hydrologic Analysis

The following assumptions were incorporated in the hydrologic modeling and analysis processes:

A. Subdivision of Drainage Basins: Major drainage areas were subdivided based on the homogeneity of the watershed and the need to define flowrates for hydraulic analysis at various points within the basins. The target size of the sub-basins was approximately 40 acres. Each study basin section contains a figure with sub-basin delineations.

B. Soil Types: Infiltration rates were correlated to runoff potential for the various soils types within the basins. All soils have a hydrologic soil group (HSG) classification that indicates the relative amount of runoff that can be expected from a soil type. The four hydrologic soil groups are classified by the NRCS (SCS) as follows:

- **Group A** soils have a low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr.).

- **Group B** soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr.).
- **Group C** soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately-fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr.).
- **Group D** soils have a high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious materials. These soils have a very low rate of water transmission (0-0.05 in/hr.).

Each sub-basin was assigned a Curve Number (CN), based on the HSG classification of the soil combined with the type and percent of existing land usage. These values are explained in detail and tabulated within the individual reports. Each study basin section contains a figures with HSG and existing land usage delineations.

C. Hydrograph Development: The NRCS Unit Hydrograph method was used in the analysis. Utilizing the total rainfall values and the CN value described above, the storm runoff volume is calculated from a given total rainfall. Peak flowrates and hydrograph shape are determined based on experimental data developed by the Natural Resource Conservation Service (NRCS). This method is described in Section 4, "Hydrology" of the National Engineering Handbook, USDA, SCS August 1972.

D. Rainfall: **TABLE 2-1** below gives the rainfall depths used in the hydrologic analyses. The rainfall data for the study is taken from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation Frequency Data Server for the State of Oklahoma. As an example, the Little River Watershed has a 100-year frequency or 1% annual chance storm rainfall depth of 9.25 inches based on a 24-hour duration period. The point rainfall was distributed using the NRCS Type II, 24-hour storm distribution curve within HEC-HMS.

TABLE 2-1. RAINFALL DEPTH DURATION

Duration	Rainfall Depth Duration for City of Moore, Oklahoma - Inches							
	Frequency (Return Period)							
	1-year	2-year	5-year	10-year	25-year	50-year	100-year	500-year
5-minute	0.42	0.49	0.61	0.71	0.86	0.98	1.10	1.41
10-minute	0.62	0.72	0.90	1.04	1.26	1.43	1.61	2.06
15-minute	0.76	0.88	1.09	1.27	1.54	1.75	1.97	2.51
30-minute	1.10	1.29	1.60	1.87	2.26	2.57	2.90	3.71
1-hour	1.46	1.70	2.13	2.50	3.06	3.51	3.99	5.21
2-hour	1.80	2.11	2.66	3.14	3.86	4.46	5.09	6.71
3-hour	2.02	2.36	2.98	3.54	4.38	5.08	5.84	7.82
6-hour	2.41	2.80	3.51	4.18	5.21	6.09	7.06	9.63
12-hour	2.84	3.25	4.03	4.78	5.96	6.99	8.13	11.21
24 hour	3.26	3.72	4.59	5.44	6.78	7.95	9.25	12.78
From NOAA Atlas 14 Precipitation Frequency Data Server								

E. Storage Routing: The stream reaches within each basin where floodplains were developed, were hydraulically studied in detail using GeoHEC-RAS. The studied streams are described in additional detail in the individual stream reports. Storage discharge ratings were calculated in studied stream reaches by determining storage volumes for varying discharge flowrates using a hydraulic model analysis. The storage discharge ratings were applied to the hydrology model utilizing the Modified Puls Method within HEC-HMS. Discharge hydrographs were then routed from point to point through the hydrology model for each reach to generate effective peak discharge flowrates for each reach and storm frequency. The effective peak discharge flowrates account for the effects of floodplain storage in hydraulically studied stream reaches. For those stream reaches without hydraulic models, discharge hydrographs were routed from point to point based on travel time and did not factor floodplain storage volume.

F. Existing Stormwater Detention Facilities: Throughout the watershed, several existing ponds large enough to provide significant stormwater detention, such as to reduce discharge intensity and affect peak discharge timing, were surveyed to calculate the detention pond's storage discharge rating curve. Detention pond storage discharge rating curves are the relation of the storage volume and outlet discharge flowrate at particular water surface elevations in the detention pond. Detention ponds and the associating storage discharge rating curves are added to the HEC-HMS model to account for pond storage volume and peak discharge timing.

2.2. HYDRAULIC ANALYSIS

The following assumptions were incorporated in the hydrologic modeling and analysis processes:

A. Downstream Boundary Conditions: Downstream boundary conditions for the Little River and North Fork River were calculated using the normal depth method within GeoHEC-RAS. The downstream boundary conditions determine the starting water-surface elevation of a hydraulic model. The last downstream cross section for the Little River was placed at a previously lettered cross section in a previous detailed study. The last downstream cross section for the North Fork River model was placed ambiguously at a distance far enough downstream of E. Indian Hills Road that the hydraulic effects from both the normal depth boundary conditions and the hydraulic structure crossing at E. Indian Hills Road did not interact.

B. Existing Storage Discharges: In those basins for which floodplains were developed, the storage volumes were computed for each reach within the hydraulic model to determine the storage discharge rating for each reach. These values were used in the HEC-HMS model to account for the effects of existing floodplain storage and generate effective peak discharge flowrates. Final water surface profiles were then computed for each frequency in the GeoHEC-RAS model based on effective peak discharge flowrates.

C. Bridge and Culvert Analysis: Each roadway crossing was modeled using the bridge or culvert modeling methods available within GeoHEC-RAS. Resultant storm frequency capacity of each hydraulic structure from the GeoHEC-RAS model was determined and rounded down if a storm frequency overtopped the hydraulic structure by three (3) inches or more.

D. Floodplain Mapping: As a part of this study, Floodplains were delineated with updated existing conditions for the 100-year and 500-year frequency storm events. The floodplains were mapped to an upstream boundary where the contributing drainage area is less than one square mile or to a boundary as defined at the beginning of this study, and a downstream boundary approximately 0.5 miles beyond the city limits. The City of Moore intends to utilize the updated floodplains developed in this MDP to plan future infrastructure improvements.

2.3. Model Calibration

Rainfall data from the May 5-8, 2015 storm events was obtained from the Oklahoma Climatological Survey (OCS). This rainfall data was measured from the Norman and Oklahoma City East rain gage locations, and was given in 5 minute intervals from May 5, 2015 through May 8, 2015. Based on the maximum total precipitation recorded during a 24-hour period from the OCS rainfall data, the extrapolated storm frequency from the NOAA depth duration **Table 2-1** for both stations, was approximately a 5-year to 10-year storm. The rainfall data obtained from the gages was applied to the hydrology model sub-basins utilizing a weighted ratio method. Based on the proximity of each sub-basin to each storm gage, various ratios were used to distribute the rainfall from each gage to each sub-basin in the hydrology model. The hydrology model executed a simulation based on the May 5-8, 2015 rainfall data and existing hydrologic conditions, then returned computed peak discharge flowrates in each sub-basin for this particular storm event. These peak discharge flowrates at studied stream locations were entered in an existing conditions hydraulic model. The hydraulic model executed a simulation based on the peak discharge flowrates and existing hydraulic conditions, then returned computed water surface elevations for the May 5-8, 2015 rainfall along the studied streams.

Water surface elevations produced in the hydraulic model, were then compared to flooding data; high water marks, pictures, video and news reports of flooding. Small adjustments were made to calibrate the hydrology and hydraulic models to the May 5-8, 2015 storms to provide an accurate comparison of computer based simulations to the flooding data collected in the field.

The City of Moore requested an explanation of how a 5-year to 10-year frequency storm events of May 2015 could cause widespread flooding and streams discharging at full capacity. Depending on topography, the majority of natural stream channels typically have the capacity to contain peak stormwater discharges from 2-year to 5-year frequency storm events. In several areas across the City of Moore, natural streams have been replaced with constructed channelization, and in some cases the constructed channels don't have the capacity to convey peak stormwater discharges. It is also possible that sediment deposits or other debris obstructions could have caused individual areas to experience additional flooding, though we didn't find evidence of this occurring. In larger storm events yielding peak discharges beyond the capacity of the stream channel, stormwater will spread into the floodplains or the low-lying areas adjacent to a stream that act as additional conveyance and/or storage areas. The capacity of roadway culvert or bridge crossings may also account for the level of flooding from a storm event. If the roadway crossing does not possess the same capacity as the stream it spans, then backwater flooding may occur immediately upstream or overtopping of the roadway crossing itself may occur. Based on the hydrology data collected, modeled simulations, and physical accounts, the May 5-8, 2015 storm produced an expected level of flooding for a 5-year to 10-year storm event. Stream channels and man-made stormwater infrastructure were discharging at or greater than full capacity, therefore creating flooding through utilization of the floodplains or other low-lying areas.

Section 3
Little River

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3.1. PREVIOUS STUDIES

FEMA has performed previous detailed and re-delineated studies of the Little River Watershed in 1979 and again in 2013 as documented in the Cleveland County Flood Insurance Study (FIS). Any alternatives and recommendations proposed in this section were generated as part of this detailed study. Information regarding the background for this most recent study can be found in **SECTION 1 - EXECUTIVE SUMMARY** and **SECTION 2 - METHODOLOGY**.

3.2. EXISTING CONDITIONS HYDROLOGY

The studied sections of the Little River Watershed consist of approximately 11.2 square miles of drainage area which is generally located north of W Franklin Road, south of SE 89th Street, east of S Western Avenue, and west of Bryant Avenue. Northmoor Creek generally flows north to south and west to east to discharge to the Little River. The Little River generally flows north to south and west to east and discharges into Lake Thunderbird, eventually draining to the Canadian River. The studied Little River Watershed is divided into 127 sub-basins, which are depicted in **FIGURE 3-1.**

The hydrologic soil groups are shown in **FIGURE 3-2** with the existing land use depicted in **FIGURE 3-3.** More information on the hydrologic methodology can be found in **SECTION 2.1 HYDROLOGIC ANALYSIS**.

The hydrologic coefficients used for input in the HEC-HMS model include the lag time, soil complex curve number (CN) and drainage area. The HEC-HMS schematic, showing the connectivity of the hydrologic elements, can be found in **FIGURE 3-4** with more detailed HEC-HMS schematics provided in **APPENDIX 3-A**. A summary of hydrologic coefficients is presented in **TABLE 3-1**.

The flowrates for existing conditions of the Little River Drainage Basins were developed using HEC-HMS. A list of the flowrates at major junctions for the existing conditions is presented in **Table 3-2**.

City of Moore Master Drainage Plan

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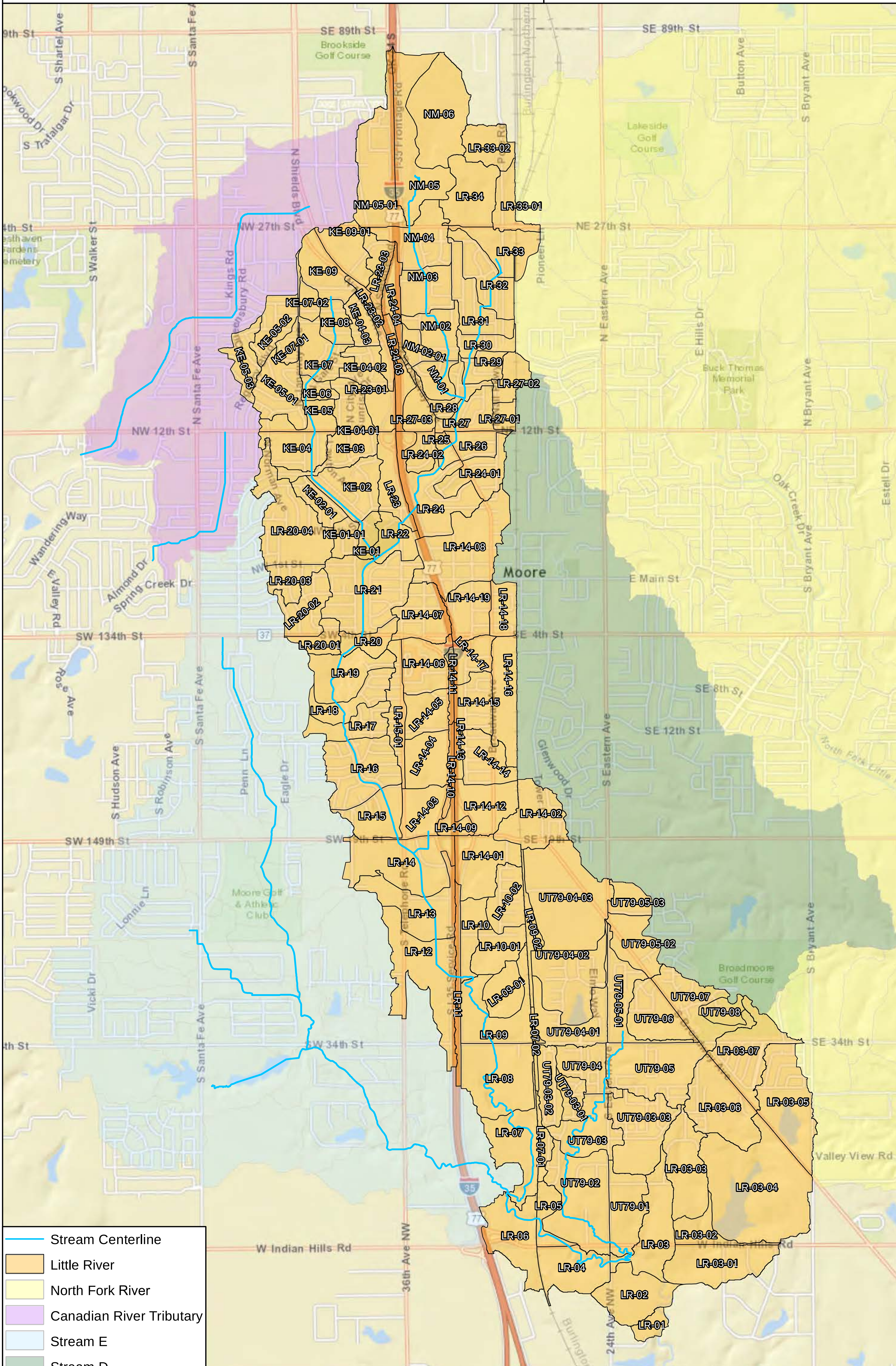

Little River Drainage Basins

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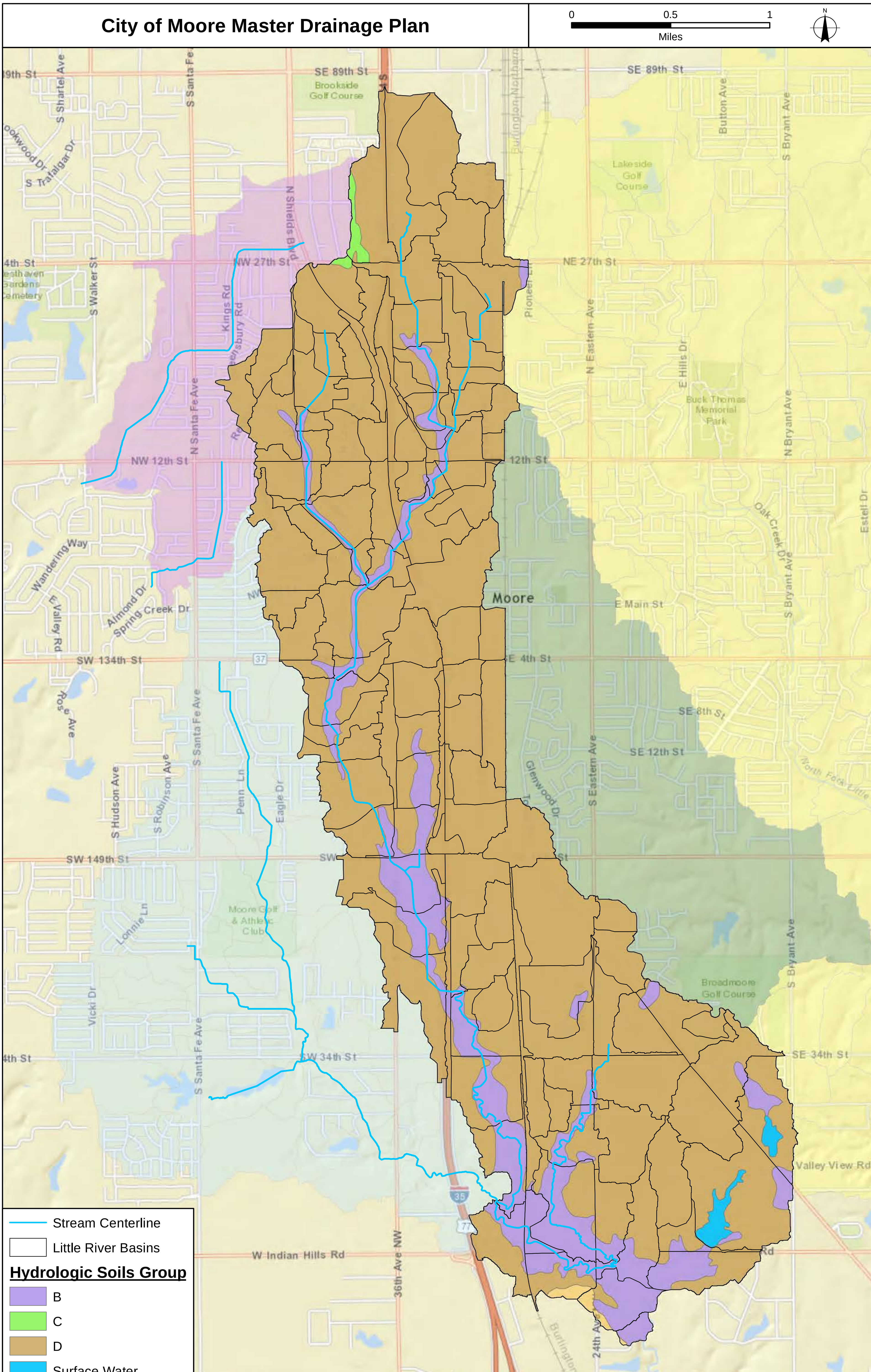
Figure 3 - 1

City of Moore Master Drainage Plan



Little River
Hydrologic Soils Group

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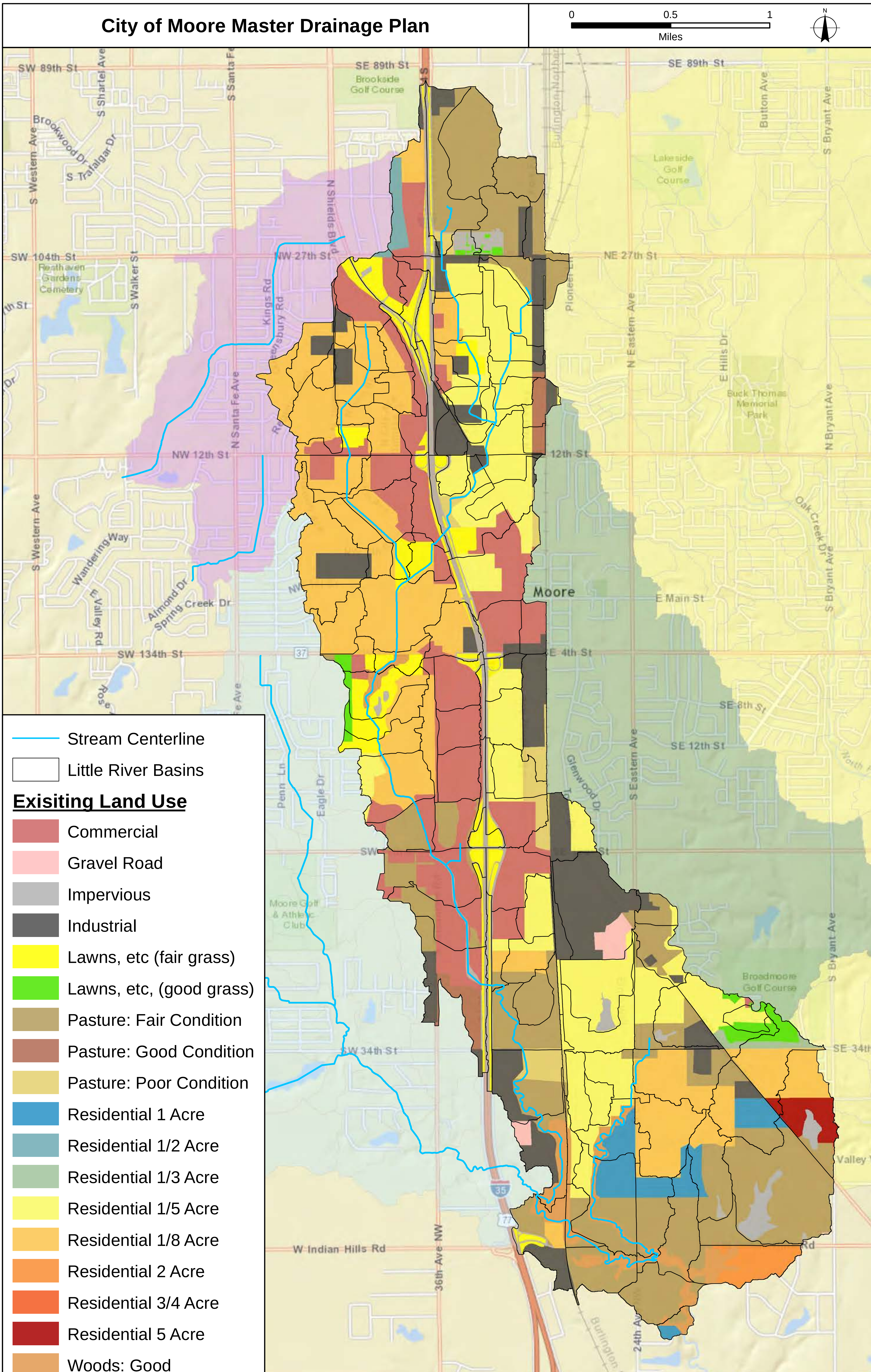
Figure 3 - 2

City of Moore Master Drainage Plan



Little River
Existing Land Use

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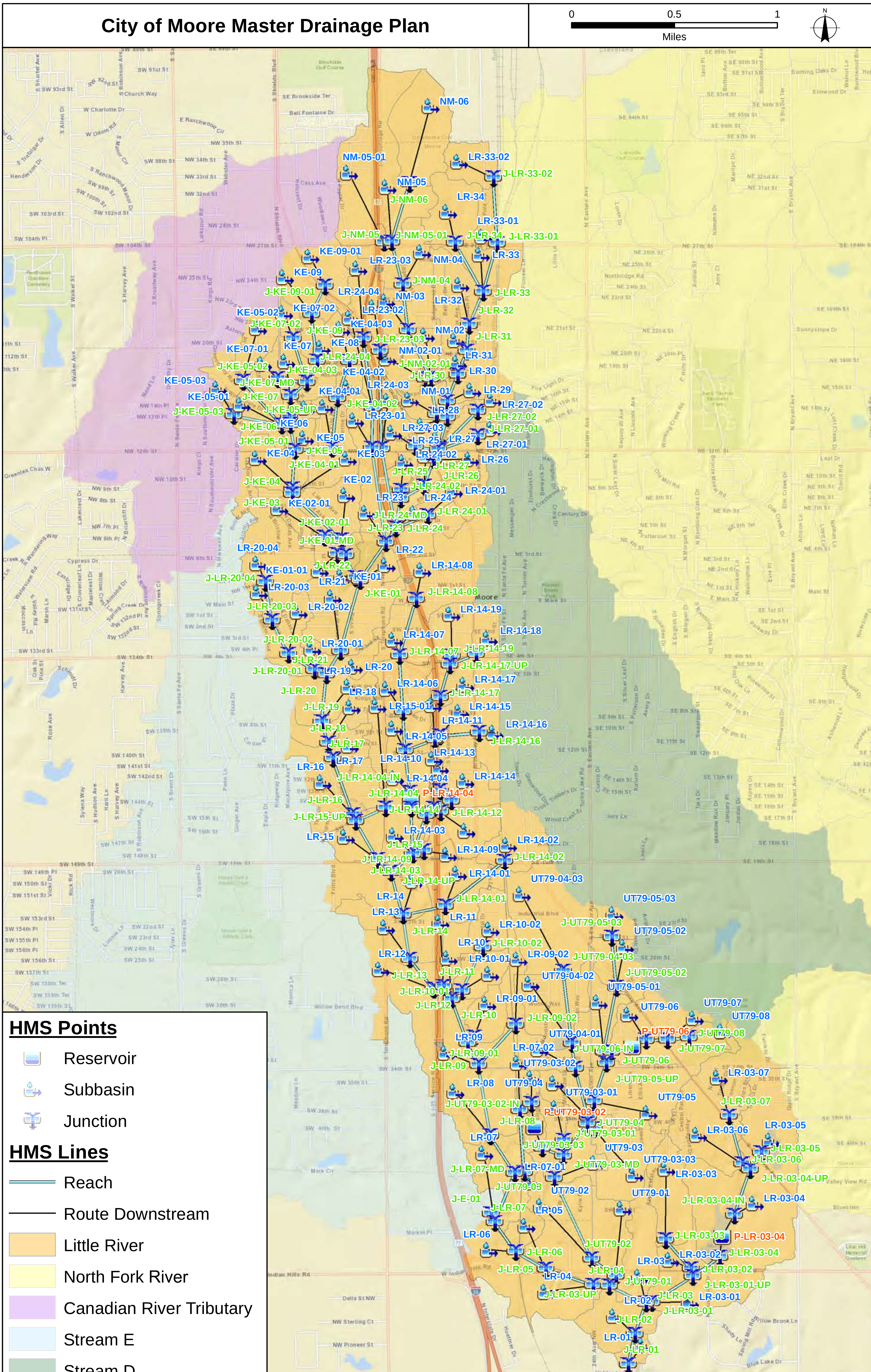
Figure 3 - 3

City of Moore Master Drainage Plan



Little River
HEC - HMS Schematic

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Figure 3 - 4

TABLE 3-1. LITTLE RIVER DRAINAGE BASINS SUMMARY OF HYDROLOGIC COEFFICIENTS FOR EXISTING CONDITIONS

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
KE-01	82.3	5.5	12.8	0.02
KE-01-01	92.0	4.7	13.7	0.02
KE-02	92.4	13.5	44.2	0.07
KE-02-01	92.0	8.7	18.9	0.03
KE-03	93.8	14.2	29.8	0.05
KE-04	92.1	16.3	34.3	0.05
KE-04-01	92.3	11.5	26.2	0.04
KE-04-02	92.5	7.1	22.0	0.03
KE-04-03	93.4	10.3	17.3	0.03
KE-05	88.5	8.8	22.1	0.03
KE-05-01	91.6	13.1	43.0	0.07
KE-05-02	92.2	11.8	28.9	0.05
KE-05-03	92.0	24.5	24.9	0.04
KE-06	90.4	4.6	10.5	0.02
KE-07	92.4	6.0	36.2	0.06
KE-07-01	92.1	4.7	10.1	0.02
KE-07-02	92.5	3.9	10.2	0.02
KE-08	92.0	3.3	18.8	0.03
KE-09	93.3	9.5	34.3	0.05
KE-09-01	88.6	6.1	31.1	0.05
LR-01	63.1	3.4	11.1	0.02
LR-02	70.0	12.6	48.0	0.08
LR-03	76.3	12.1	55.0	0.09
LR-03-01	71.4	13.3	57.7	0.09
LR-03-02	81.4	5.3	22.0	0.03
LR-03-03	86.2	10.9	54.6	0.09
LR-03-04	84.7	13.0	152.1	0.24
LR-03-05	85.9	15.3	73.5	0.11
LR-03-06	87.0	14.3	63.8	0.10
LR-03-07	87.7	21.7	56.4	0.09
LR-04	73.3	34.6	44.6	0.07
LR-05	65.2	9.5	18.1	0.03
LR-06	81.8	14.2	54.7	0.09
LR-07	75.1	12.5	51.8	0.08
LR-07-01	84.1	8.0	11.1	0.02
LR-07-02	88.3	11.4	5.2	0.01
LR-08	84.1	16.4	73.7	0.12
LR-09	78.5	8.4	53.5	0.08
LR-09-01	84.0	10.0	26.5	0.04
LR-09-02	92.1	12.9	14.0	0.02
LR-10	91.6	11.8	23.8	0.04
LR-10-01	89.3	8.4	29.8	0.05
LR-10-02	89.8	11.9	31.2	0.05
LR-11	91.8	17.7	16.3	0.03

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
LR-12	89.1	22.0	83.1	0.13
LR-13	89.8	24.9	55.0	0.09
LR-14	90.6	10.3	76.8	0.12
LR-14-01	93.7	8.4	47.4	0.07
LR-14-02	91.4	10.7	49.9	0.08
LR-14-03	93.6	7.6	31.8	0.05
LR-14-04	93.7	5.4	35.9	0.06
LR-14-05	94.7	6.8	27.8	0.04
LR-14-06	94.5	6.0	37.4	0.06
LR-14-07	93.4	10.4	59.6	0.09
LR-14-08	92.4	20.8	87.1	0.14
LR-14-09	88.6	7.7	11.2	0.02
LR-14-10	93.9	18.4	8.3	0.01
LR-14-11	95.2	8.3	6.8	0.01
LR-14-12	93.3	10.3	40.3	0.06
LR-14-13	92.2	14.9	6.5	0.01
LR-14-14	89.0	12.0	35.5	0.06
LR-14-15	89.5	11.8	31.2	0.05
LR-14-16	92.1	9.3	44.9	0.07
LR-14-17	90.1	19.5	22.7	0.04
LR-14-18	94.6	12.2	37.0	0.06
LR-15	86.5	14.8	35.6	0.06
LR-15-01	92.7	15.8	26.7	0.04
LR-16	91.7	10.1	64.7	0.10
LR-17	89.3	10.8	25.5	0.04
LR-18	87.0	11.1	24.5	0.04
LR-19	79.7	13.0	42.1	0.07
LR-20	80.3	6.5	18.5	0.03
LR-20-01	86.6	4.4	16.6	0.03
LR-20-02	92.0	9.1	33.1	0.05
LR-20-03	92.0	8.5	20.8	0.03
LR-20-04	92.3	22.0	78.4	0.12
LR-21	91.1	12.5	86.7	0.14
LR-22	85.4	4.9	24.0	0.04
LR-23	92.9	10.1	30.7	0.05
LR-23-01	93.9	10.5	17.5	0.03
LR-23-02	92.7	9.6	16.2	0.03
LR-23-03	91.7	11.8	22.4	0.03
LR-24	89.2	7.8	60.7	0.09
LR-24-01	89.2	7.0	32.5	0.05
LR-24-02	88.5	6.7	16.0	0.02
LR-24-03	93.9	8.1	19.5	0.03
LR-24-04	90.3	7.3	18.8	0.03
LR-25	87.5	3.2	8.6	0.01

TABLE 3-2. LITTLE RIVER DRAINAGE BASINS SUMMARY OF HYDROLOGIC COEFFICIENTS FOR EXISTING CONDITIONS (CONTINUED)

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
LR-26	89.1	9.6	18.8	0.03
LR-27	88.7	8.8	26.4	0.04
LR-27-01	83.5	6.4	9.6	0.02
LR-27-02	85.0	9.6	19.0	0.03
LR-27-03	92.9	7.9	18.5	0.03
LR-28	87.6	6.3	19.1	0.03
LR-29	88.8	8.9	17.5	0.03
LR-30	88.9	4.0	16.7	0.03
LR-31	89.3	8.3	37.6	0.06
LR-32	89.8	11.1	39.0	0.06
LR-33	88.3	4.9	23.7	0.04
LR-33-01	86.6	11.5	22.1	0.03
LR-33-02	84.1	9.9	28.9	0.05
LR-34	87.3	11.5	48.4	0.08
NM-01	88.2	5.7	19.1	0.03
NM-02	85.3	7.7	30.2	0.05
NM-02-01	92.2	10.9	13.0	0.02
NM-03	90.3	7.2	35.5	0.06
NM-04	91.7	9.8	48.8	0.08
NM-05	87.1	20.7	75.3	0.12
NM-05-01	91.0	12.9	74.5	0.12
NM-06	84.0	17.3	78.0	0.12
UT79-01	80.2	11.2	42.2	0.07
UT79-02	73.5	13.6	84.5	0.13
UT79-03	77.7	10.2	42.9	0.07
UT79-03-01	89.0	13.2	15.7	0.02
UT79-03-02	89.0	12.7	24.9	0.04
UT79-03-03	91.7	16.5	62.7	0.10
UT79-04	87.4	11.4	31.5	0.05
UT79-04-01	88.8	19.6	43.5	0.07
UT79-04-02	89.3	10.9	66.1	0.10
UT79-04-03	92.4	16.4	110.9	0.17
UT79-05	90.0	15.0	73.9	0.12
UT79-05-01	87.5	11.7	37.1	0.06
UT79-05-02	86.3	12.1	34.6	0.05
UT79-05-03	86.2	24.2	17.2	0.03
UT79-06	88.6	7.9	41.2	0.06
UT79-07	85.8	13.1	46.3	0.07
UT79-08	85.6	8.9	14.7	0.02

TABLE 3-3. LITTLE RIVER DRAINAGE BASINS – EXISTING FLOWRATES AT MAJOR JUNCTIONS (CFS)

Description	HMS Junction	Stream	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year	Drainage Area, mi^2
NE 27th Street	J-LR-34	Little_River	70	87	132	169	217	254	293	388	0.08
N Nail Pkwy	J-LR-33	Little_River	156	194	300	387	504	594	685	914	0.22
NE 20th Street	J-LR-31	Little River	232	287	444	580	754	879	1005	1348	0.34
NE 18th Street	J-LR-30	Little River	245	306	473	616	809	942	1073	1432	0.37
Meadowbrook Dr	J-LR-29	Little River	261	326	500	638	898	1023	1169	1545	0.40
Northmoor Creek	J-LR-28	Little River	573	713	1066	1369	1698	1952	2199	2921	1.03
NE 12th Street	J-LR-27	Little River	619	768	1154	1478	1828	2154	2499	3259	1.15
N Broadway St	J-LR-26	Little River	630	782	1176	1504	1884	2191	2513	3313	1.18
Interstate 35	J-LR-24	Little River	692	853	1225	1486	1857	2128	2489	3293	1.41
N Telephone Rd	J-LR-23	Little River	785	945	1354	1583	1920	2210	2587	3409	1.55
Kelly Creek	J-LR-22	Little River	1508	1818	2605	3163	3878	4423	4940	6248	2.37
SW 4th Street	J-LR-21	Little River	1573	1886	2669	3198	3975	4435	4889	6538	2.51
SW 17th Street	J-LR-16	Little River	1724	2076	2945	3524	4367	4969	5523	7523	3.04
S Telephone Rd	J-LR-15	Little River	1750	2105	2984	3567	4395	4966	5504	7196	3.14
SW 25th Street	J-LR-14	Little River	2231	2677	3750	4424	5378	6097	6725	9119	4.23
Interstate 35	J-LR-12	Little River	2273	2730	3794	4512	5539	6298	7024	9345	4.45
SE 34th Street	J-LR-09	Little River	2292	2749	3854	4596	5672	6502	7332	9563	4.76
Stream E	J-LR-07	Little River	2948	3572	5516	7007	9206	10879	12631	17463	8.84
W Indian Hills Rd	J-LR-05	Little River	2905	3526	5466	6982	9038	10891	12658	17512	8.96
Unnamed Trib 79	J-LR-03-UP	Little River	2963	3636	5662	7260	9416	11577	13569	18749	10.29
Limit of Study	J-LR-01	Little River	2921	3632	5782	7462	9712	12048	14130	19393	11.23
NE 27th Street	J-NM-05	Northmoor	223	273	405	506	637	758	958	1373	0.36
Highland Drive	J-NM-04	Northmoor	273	338	506	628	789	915	1025	1502	0.44
NE 21st Street	J-NM-03	Northmoor	299	372	545	671	845	977	1092	1574	0.50
NE 18th Street	J-NM-02	Northmoor	327	406	594	733	921	1065	1190	1665	0.57
Little River	J-NM-01	Northmoor	329	408	600	744	930	1074	1211	1690	0.60
NW 22nd Street	J-KE-09	Kelly Creek	123	149	217	271	342	396	451	588	0.10
NW 18th Street	J-KE-08	Kelly Creek	145	175	255	317	400	463	527	688	0.13
NW 16th Street	J-KE-07	Kelly Creek	270	324	467	579	729	841	956	1242	0.23
NW 12th Street	J-KE-05	Kelly Creek	522	628	910	1132	1427	1652	1883	2458	0.54
NW 8th Street	J-KE-04	Kelly Creek	568	683	988	1229	1549	1793	2044	2669	0.59
NW 5th Street	J-KE-02	Kelly Creek	714	858	1238	1539	1936	2239	2551	3330	0.74
Little River	J-KE-01	Kelly Creek	731	879	1270	1579	1989	2302	2624	3429	0.78

3.3. EXISTING CONDITIONS HYDRAULICS

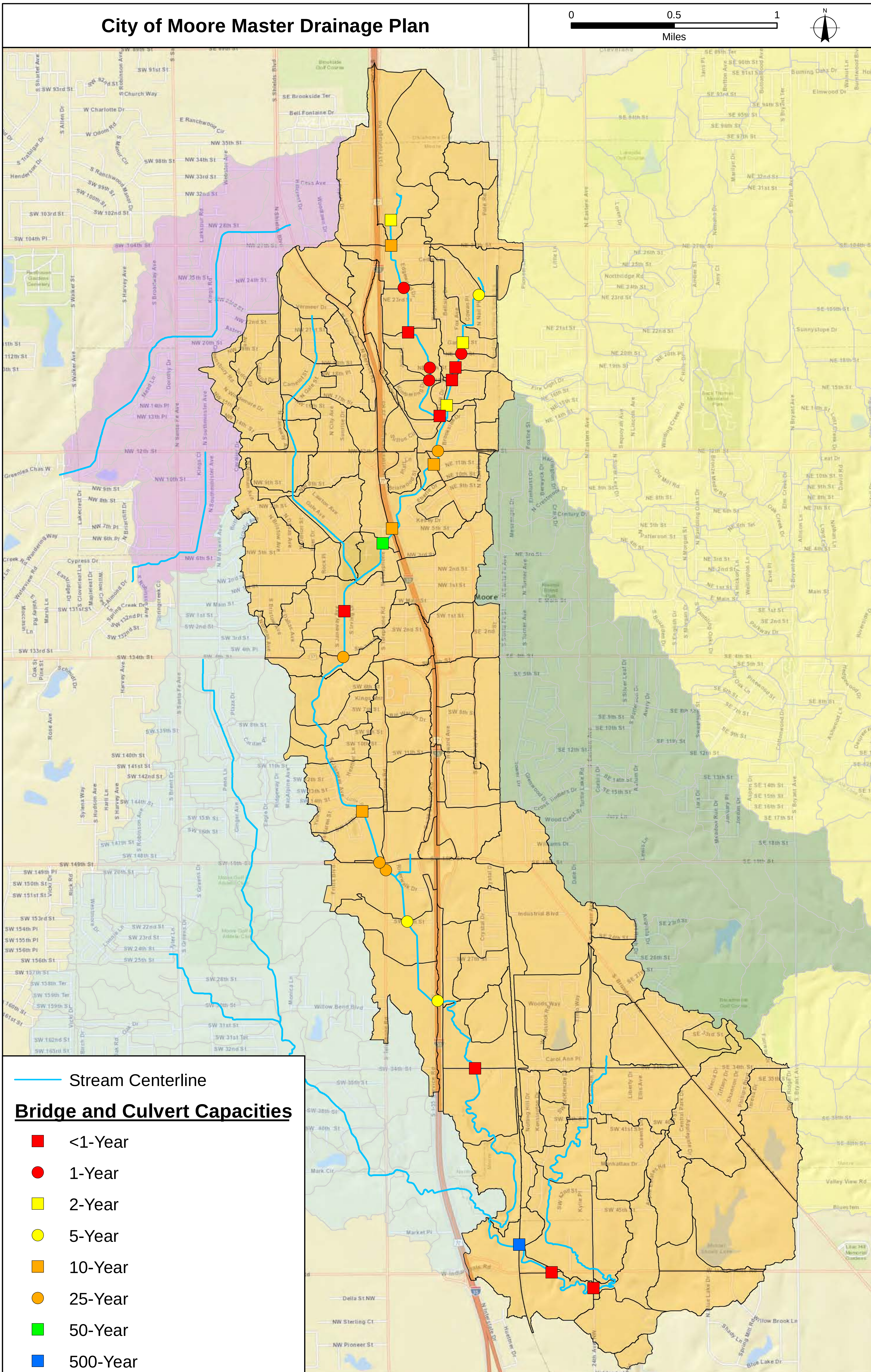
The Little River Watershed consists of 2 hydraulically studied streams, the Little River and Northmoor Creek, comprising approximately 9.4 stream miles. These streams were modeled using GeoHEC-RAS software to determine bridge/culvert capacities, water surface profiles, and floodplains. More information on the hydraulic methodology can be found in **SECTION 2.2 HYDRAULIC ANALYSIS**.

FIGURE 3-5 illustrates the location of the studied bridges and/or culverts and the capacity associated with updated existing condition flowrates.

APPENDIX 3-B shows the water surface profiles for existing conditions for the 10-year, 25-year, 50-year, 100-year, and 500-year storm events.

APPENDIX 3-C shows the updated City of Moore regulatory 100-year and 500-year floodplains and floodway which terminate at the limit of the hydraulic study, shown on the exhibit.

City of Moore Master Drainage Plan



Little River
Bridge & Culvert Capacities

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Figure 3 - 5

3.4. PROBLEM AREAS

Flooding problems areas identified in the Little River Watershed are based on flooding comments and observations received from community residents, City of Moore staff, and Meshek & Associates, PLC. The location of these problem areas are shown in **FIGURE 3-6, FIGURE 3-7** and **FIGURE 3-8**, and are labeled according to the GIS-ID problem area numbers and descriptions below. Unless noted otherwise, all problem area comments generally refer to flooding and drainage problems observed in the May 5-8, 2015 storm events.

A. Problem Area 1: Little River Culvert at SW 34th Street

The existing culvert located along the main stem of Little River under SW 34th Street consists of approximately 44 linear feet of triple 60-inch corrugated metal pipes (CMPs). The existing structure has a hydraulic capacity less than a 1-year frequency storm event. During a 10-year storm event, SW 34th Street roadway would be overtopped by 3.61 feet and during a 100-year storm event, SW 34th Street roadway would be overtopped by 4.25 feet (GIS ID-1011).

B. Problem Area 2: Little River Culvert at Interstate 35

The existing Little River culvert crossing Interstate 35 highway consists of approximately 310 linear feet of double 12 feet wide by 11 feet tall and a single 14 feet wide by 11 feet tall reinforced concrete boxes (RCBs). The existing structure has a hydraulic capacity able to convey the 5-year frequency storm event. During a 10-year storm event, Interstate 35 highway would be overtopped by 0.40 feet and during a 100-year storm event, Interstate 35 highway would be overtopped by 3.51 feet (GIS ID-1007). Significant backwater is created directly upstream of this crossing with flooding of commercial retail property, including buildings and parking lots located between the Little River and the Interstate 35 Access Road (GIS ID-132 & ID-1008).

C. Problem Area 3: S Janeway Ave. at Little River

S. Janeway Avenue on both banks of the main stem of Little River from SW 10th Street to SW 17th Street has regular roadway flooding due to storm sewer inlets and systems clogged from soil and other debris possibly from construction sites or tornado damage (GIS ID-172).

A private residential property located at 1205 S Janeway Avenue also receives flooding in the backyard of the property (GIS ID-51).

D. Problem Area 4: S Irving Dr. at Little River

A private residential property located at 319 S Irving Drive had flooding inside of the residential structure (GIS ID-154). The cause of flooding may be due to high flowrate discharges in the adjacent main stem of Little River and backwater from the 25-year storm frequency capacity of the existing SW 4th Street box culvert crossing Little River. The cause of flooding may also originate from an inadequate storm sewer capacity with inlets located on S. Irving Drive and adjacent to the address noted above.

E. Problem Area 5: SW 1st St & S Janeway Ave Intersections

Private residential properties located at and around 704 SW 1st Street have reported ponding on the west side of the residential structures (GIS ID-2). The cause of ponding water appears to be caused by ground topography providing inadequate drainage in the north and south direction between residential structures.

A private residential property owner has observed ponding water on S Janeway Avenue at the intersections with SW 1st Street adjacent to the property at 206 S Janeway Avenue (GIS ID-17). The cause of ponding water is due to ground topography and roadway geometry providing inadequate drainage east towards the Little River channel.

F. Problem Area 6: Kelly Creek between NW 8th St and NW 5th St

The concrete lining of Kelly Creek channel is fracturing and breaking apart in locations upstream of NW 5th St (GIS ID-1027).

N Janeway Avenue regularly has ponding roadway discharge and does not effectively drain. Currently, there are no existing storm sewer systems at the intersections with NW 7th Street, N Dillon Avenue, or Bear Drive (GIS ID-1003, ID-1014, ID-1026).

Flooding from Kelly Creek overtopping the NW 8th Street roadway may be caused by illegal dumping of trash and vegetation debris into the creek downstream (GIS ID-176).

G. Problem Area 7: Intersection of NW 21st St & Sunrise Dr. east of Kelly Creek

A private residential property located at 600 NW 21st Street possesses a flat in-ground tornado storm shelter. The property owner claimed roadway discharge reached an elevation above the curb and created a flooding hazard for occupants in the tornado storm shelter. High water stormwater elevations in street flow may be caused by flat terrain and additional street flow from N Moore Avenue diverted west down NW 21st Street (GIS ID-23).

H. Problem Area 8: NE 21st St just East of Northmoor Creek

A private residential property located at 209 NE 21st Street had flooding inside of the residential structure (GIS ID-157). The cause does not appear to be generated from Northmoor Creek backwater effects at NE 21st Street. Ground topography indicates stormwater runoff originating from neighboring private residences to the north and northeast drains towards the indicated property noted above.

I. Problem Area 9: Lower Unnamed Tributary 79 to Little River

A private residential property located along the west bank of Unnamed Tributary 79 to Little River at 4606 MacKenzie Drive had flooding inside of the residential structure (GIS ID-134). However, no other adjacent residential properties with similar positions and elevations to the tributary reported any flooding in residential structures.

A private residential property located along the east bank of Unnamed Tributary 79 to Little River at 821 SW 42nd Street observed floodwaters from Unnamed Tributary 79 reaching to within 20 feet of the residential structure and an estimated floodplain width of over 200 feet (GIS ID-4).

J. Problem Area 10: Unnamed Tributary 79 to Little River & S Broadway St

The existing culvert located along the Unnamed Tributary 79 of Little River under S Broadway Street consists of approximately 52 linear feet of single 5 feet wide by 2 feet tall reinforced concrete box (RCB). The existing structure has a hydraulic capacity less than the 1-year frequency storm event. During a 10-year storm event, S. Broadway Avenue roadway would be overtopped by 0.90 feet and during a 100-year storm event, S. Broadway Avenue roadway would be overtopped by 1.12 feet (GIS ID-1020).

Private residential property located at 3312 Michelle Court and 3308 Michelle Court had flooding inside of the residential structures (GIS ID-131 & ID-133). These property owners observed flooding originating from a concrete flume channel with an inadequate hydraulic capacity. A private residential property located at 3313 Carol Circle had flooding inside of the residential structure (GIS ID-129). A private residential property located at 300 SE 33rd Street had floodwaters come close to the residential structure and observed the flooding originating from the adjacent golf course (GIS ID-128).

Private residential property located at 100 Wesley Circle has had flooding in the yard and has observed a concrete flume, on the southern boundary of the property, to have inadequate capacity for discharge originating from the golf course (GIS ID-127). Private residential property located at 104 Wesley Circle has flooding in the residential structure and has observed a concrete flume, on the southern boundary of the property, to have inadequate capacity for discharge originating from the golf course (GIS ID-126).

K. Problem Area 11: SE 24th St between S Eastern Ave and Port Rush Dr

Residents of Quail Ridge North subdivision have reported the SE 24th Street roadway to have flooding and poor drainage between S Eastern Avenue and Port Rush Drive (GIS ID-11 & ID-175). SE 24th Street acts as the sole entrance roadway to the subdivision. Topography indicates the cause of flooding may be due to relatively flat ground. Residents of Quail Ridge North subdivision also reported street flooding at the intersection of S Eastern Ave and SE 24th Street (GIS ID-130). Both areas have had multiple attempts to correct the flooding issue.

L. Problem Area 12: Intersection of SW 28th St & Elmo Way

A private residential property located at 415 SW 28th Street had flooding against the exterior of the residential structure. (GIS ID-169). The property owner observed stormwater discharge originating from neighboring private property to the east and north. Flooding may be caused by drainage ditches on S. Eastern Avenue overtopping large storm events and discharging to the address noted.

M. Problem Area 13: Intersection of SW 19th St & BNSF Railroad Line

At the intersection where SW 19th Street dips under the BNSF railroad line, the SW 19th Street roadway flooded to a depth of approximately 5.5 feet in the May 5-8, 2015 storms (GIS ID-1004). This depth was approximated from high water marks in photographs.

N. Problem Area 14: S Broadway St between SW 14th St & SW 16th St

Stormwater discharge emanating from the new Central Park crosses over S Broadway Street and flows west down residential roadways SW 14th Street, SW 15th Street, and SW 16th Street (GIS ID-26).

O. Problem Area 15: Intersection of S Howard Ave & SW 10th St

Roadway discharge collects at a sump just north of the intersection of S Howard Avenue & SW 10th Street. The discharge then transfers into a storm sewer system to exit the subdivision to the west. The storm sewer system may be of inadequate hydraulic capacity to convey the peak discharge. The topography of S. Howard Avenue is relatively flat and may be inadequate to convey roadway discharge (GIS ID-20).

P. Problem Area 16: S Howard Ave between SW 5th St & SW 6th St

Private residential property owners located on S Howard Avenue have observed Interstate-35 stormwater discharge overtop the embankment of drainage channels and divert south on S Howard Avenue. A private residential property located at 609 S Howard Avenue had flooding in an automobile. (GIS ID-96). A private residential property located at 701 S Howard Avenue had flooding inside of the residential structure (GIS ID-155).

Property owners have also observed roadway discharge draining west on SW 5th Street and SW 6th Street, carrying sediment and construction debris from the new Central Park (GIS ID-49 & ID-15).

Q. Problem Area 17: SW 1st St & SW 2nd St between I-35 & S Telephone Rd

Private residential property owners located on SW 1st Street and SW 2nd Street between Interstate-35 and S. Telephone Road have observed inadequate roadway and ditch drainage. The private property topography also indicates surface discharge drains towards the residential structures. Therefore, when discharge within the right-of-way boundary of the City of Moore rises out of the roadway and ditches, residential structures receive flooding (GIS ID-45, ID-47, & ID's-52:56). Residents have also indicated W Main Street roadway floods between N. Telephone Road and N. Classen Avenue (GIS ID-48).

R. Problem Area 18: SW 2nd St & I-35 & S Telephone Rd

A private residential property located at 417 SW 2nd Street had flooding inside of the residential structure (GIS ID-46). The property owner observed flooding originating from backwater effects at an adjacent open-channel draining to a culvert crossing at SW 2nd Street.

S. Problem Area 19: Alley between SW 1st St & SW 2nd St from N Chestnut Ave to N Howard Ave

Private residential property owners have observed a residential alley, located between SW 1st Street to SW 2nd Street and N Chestnut Avenue to N Howard Avenue, with flooding issues (GIS ID-44, ID-68:70). Several private residential structures have had flooding inside of the residential structure. The owners have also noticed bar ditches filling with sediment over time, causing a loss in hydraulic capacity and flooding yards.

T. Problem Area 20: Alley between NW 1st St & W Main St from N Howard Ave to N Broadway St

A commercial property located at 129 W Main Street had flooding inside of the commercial structure (GIS ID-92). The property owner observed flooding originating from an alley with inadequate drainage, located between NW 1st Street and W Main Street from N Howard Avenue to N Broadway Street. Ground topography indicates gutter from N. Broadway Street has the ability to drain west on NW 1st Street or to the alley and flood commercial property.

U. <u>Problem Area 21: Open-Channel between Thompson Dr. & Kelly Dr. from Freeman Dr. to N Broadway St</u>

A private residential property located at 106 Thompson Drive has observed eroding banks in the open-channel behind their property. This bank erosion is leading to the erosion of the foundation of a storage unit located at the rear of the property and directly adjacent to the open-channel (GIS ID-16). The property owner also claims the flowline of the open-channel is filling with sediment and the channel slope is being reduced.

V. <u>Problem Area 22: Storm Sewer Inlets on N Nail Pkwy</u>

Storm sewer systems located on N Nail Pkwy, located between Fox Avenue and NE 12th Street, have inadequate capacity for stormwater discharge originating from a grass pasture that drains west to N Nail Parkway (GIS ID-31, ID-1005, & ID-1006). A private residential property located at 1300 N Nail Parkway frequently has water pushed into the garage when vehicles drive through roadway discharge in the N Nail Parkway gutter. (GIS ID-24).

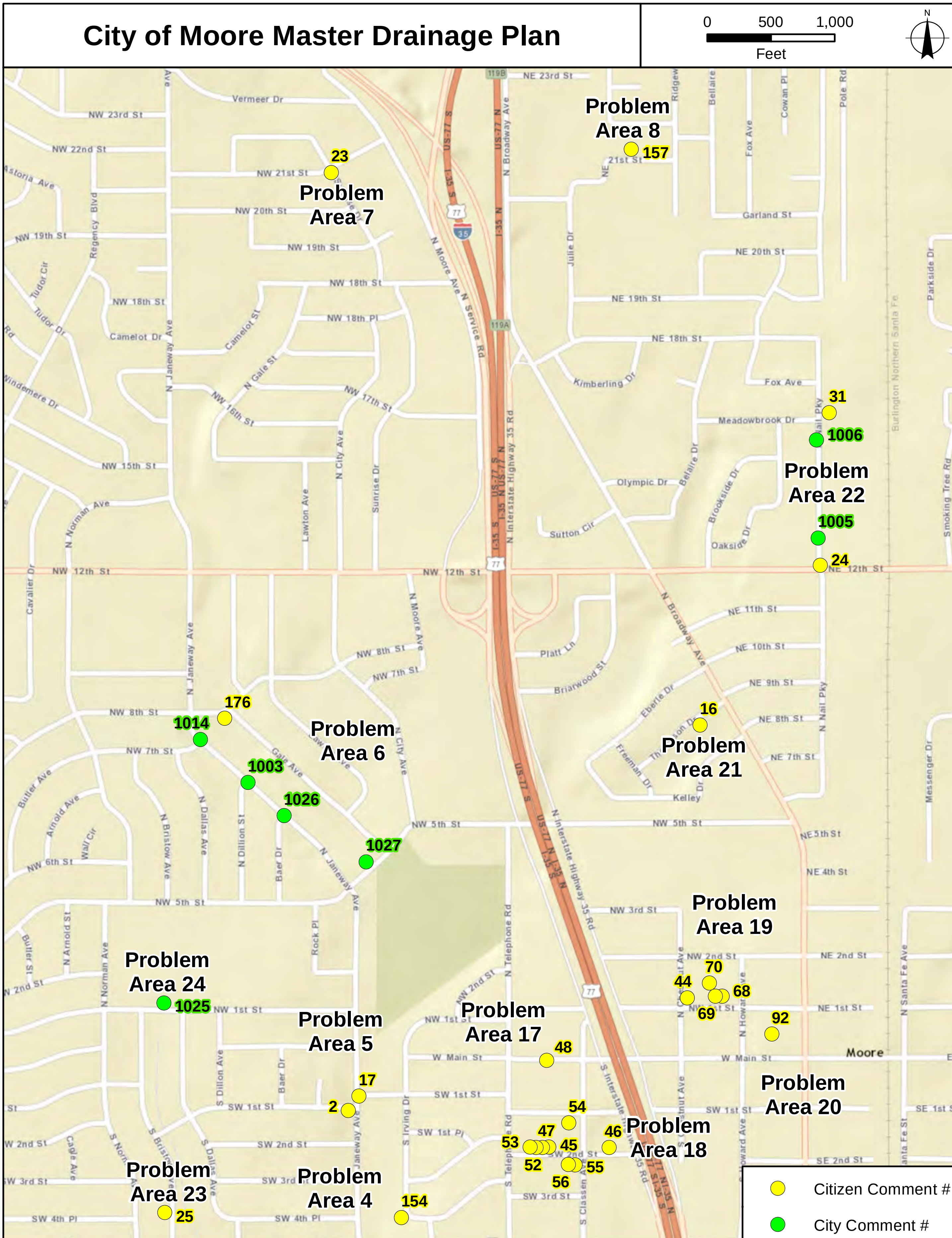
W. <u>Problem Area 23: S Bristow Ave between SW 1st St & SW 4th St</u>

A private residential property located at 315 S Bristow Avenue had flooding in the backyard (GIS ID-25). The property owners also observed the S Bristow Avenue roadway to be completely flooded. Ground topography indicates S. Bristow Avenue is relatively flat between SW 1st Street and SW 4th Street.

X. <u>Problem Area 24: Open-Channel adjacent to N Bristow Ave & NW 1st St</u>

The City of Moore reported an unnamed tributary of the Little River may be causing flooding to private residential property around the open channel on NW 1st Street between N. Dallas Avenue and N. Bristow Avenue (GIS ID-17 & ID-1025). The City of Moore has suggested the detention pond immediately upstream in the Southgate-Rippetoe Elementary School property creates a high peak discharge flowrate. The culvert crossing located at NW 1st Street may also have an inadequate hydraulic capacity for roadway drainage.

City of Moore Master Drainage Plan



Little River Problem Areas

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Figure 3 - 6

City of Moore Master Drainage Plan

0 500 1,000
Feet

Little River
Problem Areas

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Figure
3 - 7

City of Moore Master Drainage Plan

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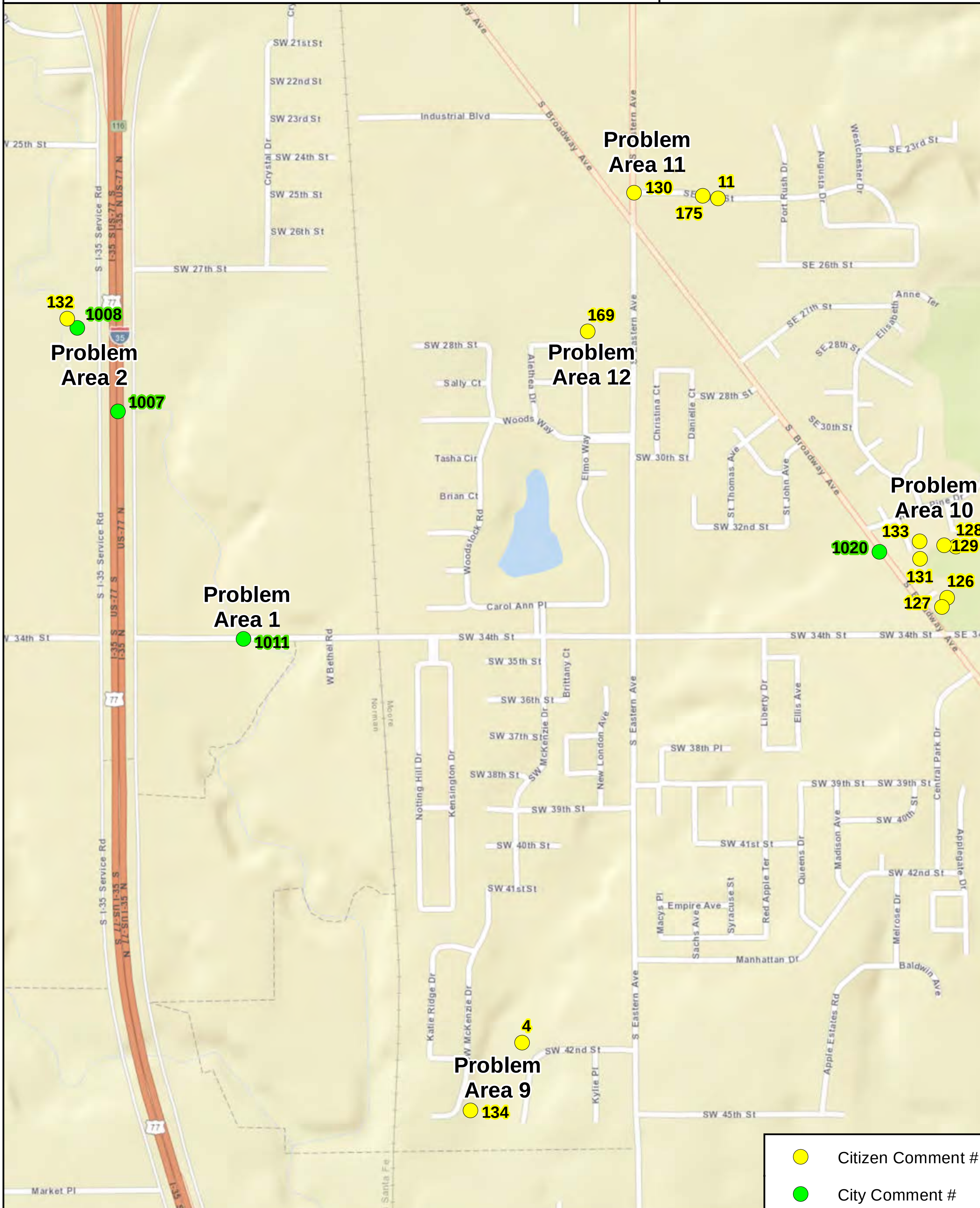

Little River Problem Areas

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Figure 3 - 8

3.5. Evaluation of Alternatives and recommendations

Alternatives and recommendations for mitigating flooding problems may consist of channelization, increasing culvert structure capacity through replacement or enlargement, creating detention pond facilities, or increasing storm sewer system capacity through replacement or new system construction. It's important to note that when alternatives and recommendations given in this master drainage plan proceed to design documents, the design should be hydrologically and hydraulically analyzed in further detail prior to constructing any improvements described in this section. The alternatives and recommendations in this master drainage plan are given as plausible concepts and an additional detailed study of the design would prevent increases in water-surface elevations and floodplains or cause flooding in other areas. The alternatives and recommendations for the problem areas are defined as follows:

A. Problem Area 1: Little River Culvert at SW 34th Street

The City of Moore currently is in the planning stage to make improvements to the SW 34th Street crossing over the Little River by constructing an Interstate 35 overpass for the SW 34th Street roadway. The overpass would be constructed with bridge spans crossing both Interstate 35 and the Little River. The plans would need to be reviewed to assure the proposed bridge spans create additional hydraulic capacity and do not cause an increase in the 100-year stormwater-surface elevation or floodplain.

B. Problem Area 2: Little River Culvert at Interstate 35

The current median concrete barrier places approximately an additional 3 feet of height needed to fully overtop Interstate 35, and therefore causes significantly higher backwater elevations upstream of the Interstate 35 crossing. In order to substantially reduce the backwater elevation caused in the 100-year storm for existing conditions, approximately 800 linear feet of median concrete barrier wall on Interstate 35 would be replaced with a cable barrier at the southern Little River and Interstate 35 crossing. Should a 100-year capacity culvert alternative be constructed beneath Interstate 35, the recommended length of cable median barrier would decrease. A cost of $18 per linear foot is estimated to remove the current concrete barrier and replace it with a cable barrier system.

Alternative 1 – Construct 100-year Capacity Bridge Culverts. This alternative would consist of constructing a new bridge structure which can convey the 100-year storm event without a detention pond facility in the Little River park. This structure would consist of approximately 308 linear feet of quadruple 16 feet wide and 12 feet tall RCBs. The 100-year discharge of the Little River at the Interstate 35 southern crossing is approximately 7,032 cfs.

The cost for Alternative 1 is estimated at $1,764,400 and is detailed in **Appendix 3-D**.

Alternative 2 (Recommended) – Construct 100-year Capacity Bridge Culverts. This alternative would consist of constructing a new bridge structure which can convey the 100-year storm event with a detention pond facility in the Little River Park. This structure would consist of approximately 308 linear feet of triple 20 feet wide and 12 feet tall RCBs. The 100-year discharge of the Little River at the Interstate 35 southern crossing is approximately 6,786 cfs.

The cost for Alternative 2 is estimated at $1,644,700 and is detailed in **Appendix 3-D**.

C. <u>Problem Area 3: Janeway Ave. at Little River</u>

The City of Moore is currently planning to make improvements to the Little River park and channel between the Little River Park and SW 19th Street. The plans will need to be reviewed to determine the net effects of floodplain storage and peak discharge flowrates. The City of Moore will need to provide adequate maintenance of storm sewer systems in order to achieve designed discharge capacity in any given storm event.

Regarding the flooding at 1205 S Janeway Avenue, ground topography indicates two parallel grass-lined channels currently exist and drain from west to east. The southern channel is located in the backyards of neighboring private property owners along SW 11th Street upstream of the private property owner located at 1205 S. Janeway Avenue. This southern grass channel discharges directly to the backyard of the affected property. The northern channel is located along the southern boundary line in Little River Park. The northern grass channel discharges directly to the Little River and does not appear to have an effect on the property noted above. Due to the southern grass channel being located on private property and not on public property, the City of Moore is not responsible for the discharge from neighboring private property.

D. <u>Problem Area 4: Irving Dr. at Little River</u>

The residential property at 319 S Irving Drive, will be located within the City of Moore's corrected effective existing 100-year floodplain for the Little River created in this master drainage plan study. We expect this property to have flooding in various storm frequency events.

<u>Alternative (Recommended) – Construct 100-year Capacity Vertical Wall Channel and Bridge Culverts</u>. This alternative would consist of constructing a new concrete vertical wall channel sections in the Little River channel between NW 1st Street and SW 4th Street. The plan would also consist of replacing the box culvert structures for the SW 1st Street and SW 4th Street crossings to be able to convey the 100-year storm event. This recommendation would consist of approximately 2,160 linear feet of concrete vertical wall channelization with dimensions of 50 feet wide and 10 feet in depth. The SW 1st Street crossing would consist of a triple 14 feet wide by 8 feet tall RCBs, approximately 37 feet in length. The SW 4th Street crossing would consist of a quadruple 12 feet wide by 11 feet tall RCBs, approximately 67 feet in length.

The locations of the proposed improvements are shown in **FIGURE 3-9.** The cost for this Recommendation is estimated at $3,998,400 and is detailed in **APPENDIX 3-D**.

E. <u>Problem Area 5: SW 1st Street adjacent to Little River</u>

Ponding on the west side of the residential property structures appears to be caused by inadequate drainage due to ground topography on private property. Due to the drainage problem being caused by topography on private property and not on public property, the City of Moore is not directly responsible for the ponding and drainage issues. The source of ponding is due to the steep topography draining directly towards the west side of the residential structures without any fall towards the front or rear of the residential structures. A solution to the ponding problem may be for the private property owner to have a residential sized drainage system installed on either or both sides of the property to discharge stormwater to the front or rear of the property.

The City of Moore, within the period of this master drainage study, completed a roadway full-depth pavement rehabilitation on S Janeway Avenue between the intersections with SW 1st Street. The locations were paved in concrete and a storm sewer system was added for roadway drainage. This recent pavement rehabilitation and storm sewer system should be observed during storm events to determine the effectiveness of the newly constructed improvements to solve the drainage problems in the area. If the new roadways do not prove effective in draining stormwater runoff, then a larger storm sewer system may be necessary to provide adequate drainage capacity to the problem areas listed. These sections of roadway are located within the 100-year floodplain, and we expect the roadways to have flooding in various storm frequency events.

City of Moore Master Drainage Plan

Little River
Problem Area 4 : Alternative 1

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Figure 3 - 9

F. Problem Area 6: Kelly Creek between NW 8th St and NW 5th St

The City of Moore would need to adequately clean any sedimentation and debris, and provide maintenance of the concrete lining in open-channel systems in order to achieve designed discharge capacity for any given storm event.

Recommendation Part 1 – Condition Assessment of Concrete Channel. This recommendation would consist of making an assessment of the existing Kelly Creek concrete channel, from NW 8th Street to NW 5th Street, to either re-condition or replace the existing concrete channel. This structure would consist of a channel base approximately 13 feet wide with a depth of 4 to 6 feet. The concrete channel lining is assumed to be 8 inches in thickness and would have an approximate replacement cost of $294.67 per linear foot of channel section. The Kelly Creek channel section from NW 12th Street to NW 8th Street should be assessed as well. However, it appears from aerial photographs that this section of the channel may need to only have sediment deposits removed.

Recommendation Part 2 – Construct 100-year Storm Sewer Systems. Additional storm sewer systems could be constructed on N. Janeway Avenue at the intersections with NW 7th Street and Bear Drive that would discharge into the adjacent Kelly Creek. The storm sewer system at intersection of N Janeway Avenue and NW 7th Street would consist of approximately 250 linear feet of 24 inch diameter RCP and the ability to convey the local 100-year storm event. The storm sewer system at the intersection of N Janeway Avenue and Baer Drive would consist of approximately 250 linear feet of 36-inch diameter RCP and the ability to convey the local 100-year storm event. The intersection of N. Janeway Avenue and N. Dillon Avenue was also analyzed for a storm sewer system; however, a minimum 72-inch diameter system would be required to achieve a 10-year discharge capacity, which was not feasible due to topography and residential structure spacing. Therefore, the drainage system at the intersection of N Janeway Avenue and N Dillon Avenue would consist of a private property acquisition, voluntarily sold, at 720 N Janeway Avenue and constructing a 10 foot wide concrete flume channel within the acquired property. The flume was designed to achieve a 100-year event capacity of approximately 45 cfs, utilizing standard curbed sides with 0.5 foot depth and a slope of 0.02 foot per foot. At the intersection of N Janeway Avenue and N Dillon Avenue, Janeway Avenue would need to be re-graded and paved to drain towards the newly constructed concrete flume channel.

The locations of the proposed improvements are shown in **FIGURE 3-10**. The cost for the recommendation part 2 is estimated at $364,500 and is detailed in **APPENDIX 3-C**.

G. Problem Area 7: Intersection of NW 21st St & Sunrise Dr east of Kelly Creek

Topography indicates that the roadway discharge at the intersection of NW 21st Street and Sunrise Drive does drains south and should not be altered to drain west towards Kelly Creek with a storm sewer system. The affected property at 600 NW 21st Street also appears to be elevated above the adjacent roadways and risk of flooding should be minimal. Further study may be necessary to determine whether roadway discharge from the N. Moore Avenue roadway, east of the problem area, diverts west down NW 21st Street to discharge at the intersection with Sunrise Drive. If this scenario does occur, then additional grading of the NW 21st Street apron to N. Moore Avenue or additional storm sewer inlets at the intersection may be necessary.

City of Moore Master Drainage Plan

Little River
Problem Area 6 : Recommendation
Part 1 & Part 2

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Figure 3 - 10

H. Problem Area 8: NE 21st St just East of Northmoor Creek

Ground topography and hydraulic modeling indicate that flooding in the private residence of 209 NE 21st Street was caused by stormwater runoff from neighboring private residences to the north and northeast and not caused by backwater in Northmoor Creek at the NE 21st Street crossing. Since the flooding problem caused by stormwater runoff from private property and not by Northmoor Creek, the City of Moore is not directly responsible for the flooding problem. A solution to the ponding problem may be for the private property owner to have a residential sized drainage system installed on either or both sides of the property to discharge stormwater to the front of the property.

I. Problem Area 9: Lower Unnamed Tributary 79 to Little River

An assessment was made to determine the feasibility of constructing a regional detention facility for flooding mitigation purposes on Unnamed Tributary 79 (UT 79), located at the northeast corner of SW 34th Street and S. Eastern Avenue, in order to reduce the peak discharge at the problem area. A disadvantage to constructing a regional detention pond on UT 79, is that the hydrologic peak discharge timing between UT 79 and the Little River is different. In current existing conditions, the peak discharge in UT 79 flows into the Little River approximately 52 minutes ahead of the upstream peak discharge in the Little River. Since the peak discharge in UT 79 has the lead in timing over the peak discharge in the Little River, a detention pond would slow down the peak discharge of UT 79 and cause higher peak discharge flowrates into the Little River when the peak discharge of the Little River arrives. This would cause the peak discharge flowrate of the Little River downstream of UT 79 to increase and therefore creating higher water-surface elevations and larger floodplains. Therefore, we do not recommend constructing a regional detention facility for mitigation purposes at the location listed above. Significant detention pond facilities would need to be constructed upstream of this problem area on the Little River and Stream E in order to effectively reduce the peak discharge flowrates and floodplains in the problem area. Any future development would still require detention to offset increased peak discharges from development only. The properties at 4606 MacKenzie Drive and 821 SW 42nd Street, are located directly adjacent to the 100-year floodplain, and we expect the backyards of these properties to have flooding in various storm frequency events.

The locations of the condemned improvements are shown in **FIGURE 3-12**. Due to the variability of the scope, a cost estimate was not prepared at this time.

J. Problem Area 10: Unnamed Tributary 79 to Little River & S Broadway St

Recommendation Part 1 – Construct Embankment Berm. This recommendation would consist of constructing a new embankment berm along the property line of the Broadmoore Golf Course and private residential properties at 304 SE 33rd Street, 300 SE 33rd Street and 3313 Carol Circle to prevent stormwater discharge from draining towards the SE 33rd Street and Carol Circle intersection.

The locations of the proposed improvements are shown in **FIGURE 3-13**. The cost for the recommendation part 1 is estimated at $22,200 and is detailed in **APPENDIX 3-D.**

Recommendation Part 2– Construct 10-Year Storm Sewer System. This recommendation would consist of constructing a storm sewer system which can convey the 10-year storm event. The storm sewer would extend from the SE 33rd Street and Carol Circle intersection and discharging on the north side of the Broadmoore Elementary School. The new storm sewer system would consist of approximately 850 linear feet of 30 inch diameter RCP. The 10-year discharge to the location of the storm sewer system inlets on SE 33rd Street is approximately 31.7 cfs. The 100-year discharge to the location of the storm sewer system inlets on SE 33rd Street is approximately 56 cfs.

The locations of the proposed improvements are shown in **FIGURE 3-13**. The cost for the recommendation part 2 is estimated at $232,200 and is detailed in **APPENDIX 3-D.**

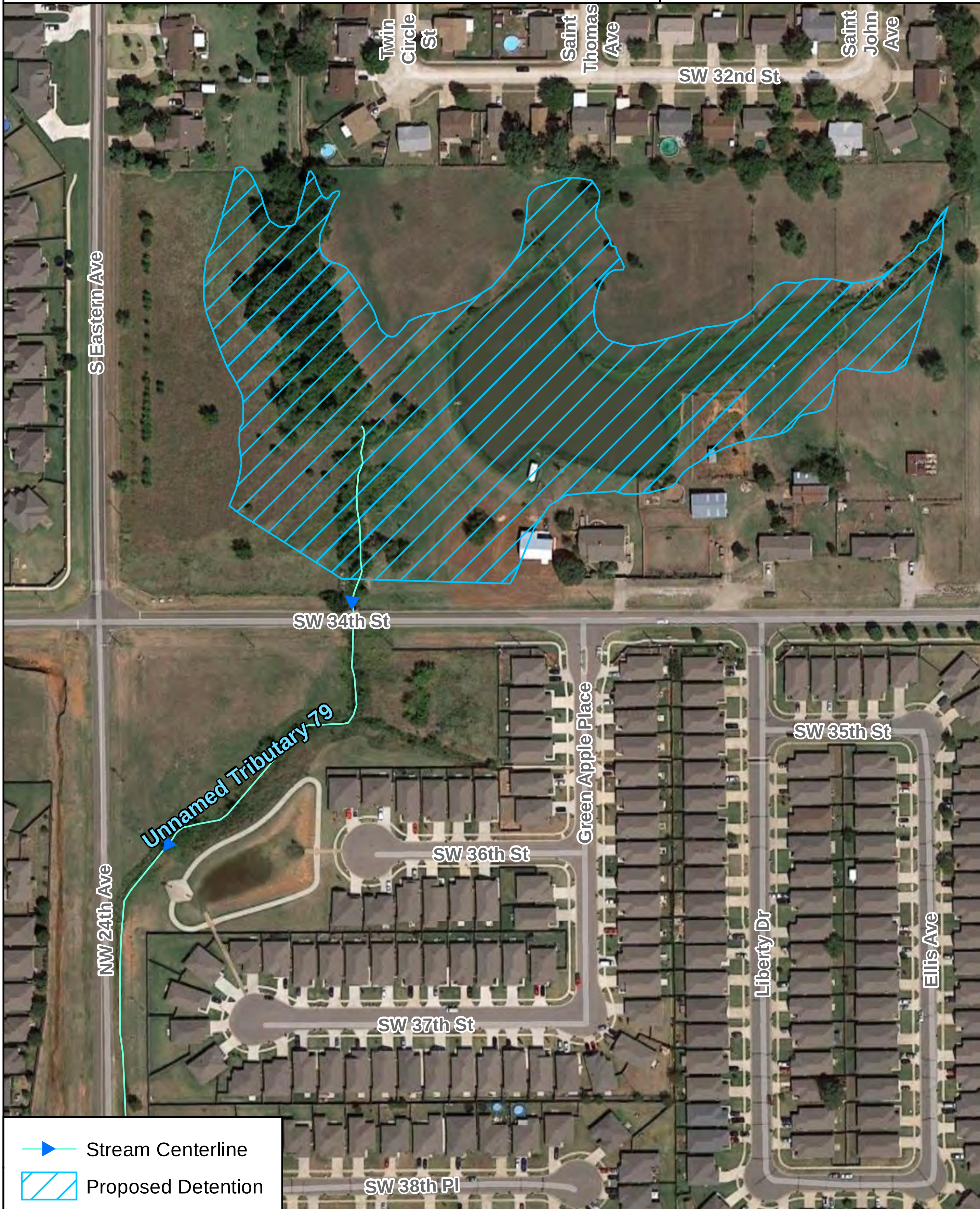
Recommendation Part 3– Construct 100-Year Capacity Storm Sewer System. This recommendation would consist of constructing a storm sewer system which can convey the 100-year storm event. The storm sewer would extend from the Broadmoore Golf Course between 104 Wesley Circle and 101 SE 34th Street, then discharging to a proposed grass open-channel on the southeast corner of the Broadmoore Elementary School. The new storm sewer system would consist of approximately 330 linear feet of 30 inch diameter RCP. The 100-year discharge to the location of the storm sewer system inlets on the edge of the Broadmoore Golf Course is approximately 29.5 cfs.

The locations of the proposed improvements are shown in **FIGURE 3-13**. The cost for the recommendation part 3 is estimated at $142,900 and is detailed in **APPENDIX 3-D.**

Recommendation Part 4– Construct 100-Year Capacity Open-Channel. This recommendation would consist of constructing a new grass lined open-channel for the recommended part 3 storm sewer to discharge. The open channel would connect and discharge to the existing open-channel located on the southwest side of the Broadmoore Elementary School. The dimensions of the channel should have an approximate 990 foot length, 2 foot minimum depth, 1 foot minimum bottom width, and minimum 2.5:1 (H:V) side slopes. A Manning's 'n' value of 0.035 and a slope of 0.008 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the location of the open-channel on the southwestern side of the Broadmoore Elementary School is approximately 47.3 cfs.

The locations of the proposed improvements are shown in **FIGURE 3-13**. The cost for the recommendation part 4 is estimated at $24,300 and is detailed in **APPENDIX 3-D.**

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA

Little River
Problem Area 9 : Recommendation

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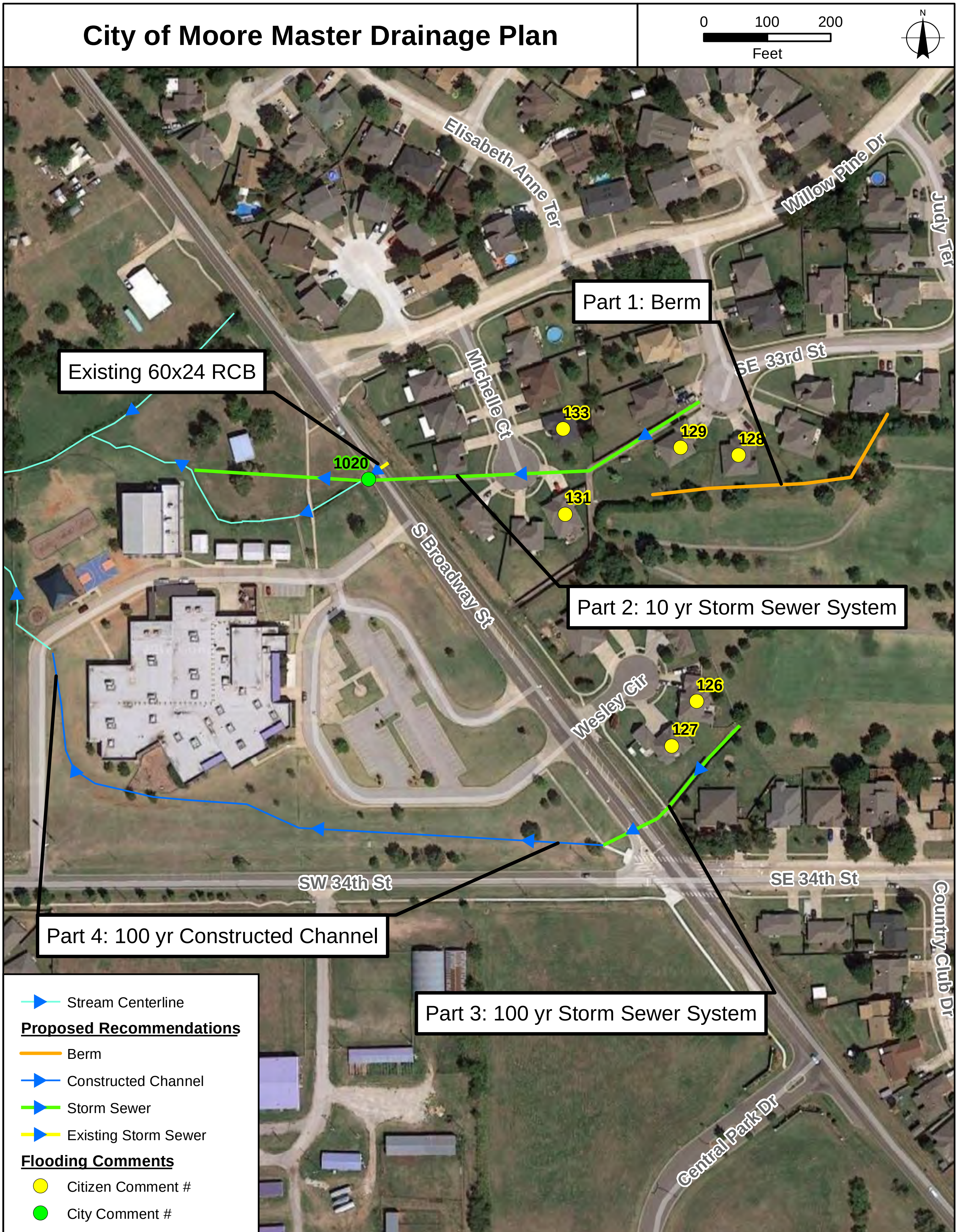
Figure 3 - 11

City of Moore Master Drainage Plan



Little River
Problem Area 10: Recommendation
Parts 1, 2, 3, & 4

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Figure 3 - 12

K. Problem Area 11: SE 24th St between S Eastern Ave and Port Rush Dr

Recommendation – Construct Concrete Paved Ditch. This recommendation would consist of constructing an 8 foot wide concrete paved ditch from SE 24th Street to S Broadway Street, turning southeast and ending at the culvert inlet adjacent to S Broadway Street approximately 725 feet southeast of the intersection with S Eastern Avenue. The culvert inlet on Broadway Street should also have a headwall installed in order to lower the flowline of the concrete flume channel. The drainage ditches at the north corner of S Eastern Avenue and S Broadway Street should also have a 4 foot wide concrete paved ditch constructed. The newly constructed concrete paved ditches should have periodic maintenance to clean out debris and sediment.

The locations of the proposed improvements are shown in **FIGURE 3-14**. The cost for the recommendation is estimated at $68,800 and is detailed in **APPENDIX 3-D.**

L. Problem Area 12: Intersection of SW 28th St & Elmo Way

Alternative 1 – Increase Drainage Ditch Capacity. This alternative would consist of re-grading and increasing the capacity of the western stormwater drainage ditches along S. Eastern Avenue. The locations of the proposed improvements are shown in **FIGURE 3-15**. Due to the variability of the scope, a cost estimate was not prepared at this time.

Alternative 2 (Recommended) – Construct 100-Year Capacity Concrete Flume Channel. This alternative would consist of constructing a concrete flume channel between 415 SW 28th Street and 2900 Elmo Way. This system would consist of approximately 200 linear feet of concrete flume channel. The dimensions of the channel should have an approximate 6 inch minimum depth, 5 foot minimum bottom width, and 1:0 (H:V) minimum side slopes. A Manning's 'n' value of 0.013 and a slope of 0.0247 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the proposed concrete flume channel is approximately 20.4 cfs.

The locations of the proposed improvements are shown in **FIGURE 3-15**. The cost for alternate 2 is estimated at $14,800 and is detailed in **APPENDIX 3-D.**

M. Problem Area 13: Intersection of SW 19th St & BNSF Railroad Line

The existing storm sewer system drains southwest to an adjacent commercial retail storm sewer system and has an outlet to an open-channel on the east side of the S I-35 Service Road. A storm sewer model of the existing system was analyzed capacity of the existing storm sewer system is approximately less than a 1-year storm event. Additional detailed on-site investigation and analysis of the existing storm sewer system would be necessary in order to determine a final design. A complete survey of the existing storm sewer system could not be determined from a typical discovery survey and the system was modeled based on conduit sizes given by the City of Moore and invert elevations were estimated.

Recommendation – Increase Storm Sewer Capacity. This recommendation would consist of constructing a new storm sewer system which can convey the 100-year storm event for a sump location. The new storm sewer structure would consist of approximately 1,910 linear feet of 42-inch diameter reinforced concrete pipe. The 100-year discharge to the SW 19th Street underpass is approximately 62.8 cfs.

The locations of the proposed improvements are shown in **FIGURE 3-16**. The cost for the recommendation is estimated at $1,763,295 and is detailed in **APPENDIX 3-D.**

City of Moore Master Drainage Plan

Little River
Problem Area: 11 Recommendation

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Figure 3 - 13

City of Moore Master Drainage Plan

Little River
Problem Area: 12
Alternatives 1 & 2

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Figure 3 - 14

City of Moore Master Drainage Plan

Little River
Problem Area 13: Recommendation

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Figure 3 - 15

N. Problem Area 14: S Broadway St between SW 14th St & SW 16th St

Based on knowledge from The City of Moore, the open grass field across S Broadway Street from SW 11th Street to SW 16th Street does not currently have any plans for development. Once construction of the new Central Park is completed, exposed soil areas should be recovered in grass to slow down surface discharge. If the open grass field were to be developed in the future, then proper stormwater drainage and detention systems should be integrated into the design. The subdivision roadways, located between S Broadway Street to Interstate 35 and SW 5th Street to SW 16th Street, are designed to discharge stormwater through the gutters and roadways that ordinate from S Broadway Street and the existing grass field to the east.

O. Problem Area 15: Intersection of S Howard Ave & SW 10th St

Recommendation - Property Acquisition and Construct 50-Year Capacity Culvert. This recommendation would consist of purchasing the voluntarily sold private property located at 1009 S Howard Avenue, and constructing a channelized culvert crossing for S Howard Avenue which can convey the 50-year storm event. This structure would consist of approximately 60 linear feet of triple 5 feet wide by 3 feet tall RCB's. Sanitary sewer and water utilities adjacent to S. Howard Avenue will need to be accommodated with a new culvert crossing.

The locations of the proposed improvements are shown in **FIGURE 3-17**. The cost for the recommendation is estimated at $363,900 and is detailed in **APPENDIX 3-D.**

P. Problem Area 16: S Howard Ave between SW 5th St & SW 6th St

The City of Moore intends to expand its criteria for drainage design and water quality in new construction projects in an effort to prevent sedimentation deposition from construction sites onto roadways or into storm sewer systems.

Recommendation – Construct 100-year Capacity Open-Channel. This recommendation would consist of expanding the existing Interstate 35 drainage channel to be able to convey the 100-year storm. The southern embankment of the channel should be constructed high enough to prevent overflow onto S. Howard Avenue. The drainage area to the channel is approximately 43.6 acres and in a 100-year storm the channel would have a peak discharge approximately 260 cfs. The recommended open-channel shape is a naturally vegetated trapezoidal channel. The existing channel has a measured slope of approximately 0.009 ft/ft, a measured bottom width of approximately 3 to 4 feet, and a measured depth of approximately 1.5 to 2 feet. The peak discharge for a 100-year storm event is approximately 260 cfs. In order for the channel to have a 100-year hydraulic capacity, the channel depth would need to be increased to a minimum of 3.5 feet. Therefore, the embankment berm on south side of the channel would need to be raised in order to achieve a minimum channel depth of 3.5 feet. A Manning's 'n' value of 0.035 and side slopes of 3:1 (H:V) were assumed in hydraulic calculations of the open-channel.

The locations of the proposed improvements are shown in **FIGURE 3-18**. The cost for the recommendation is estimated at $45,200 and is detailed in **APPENDIX 3-D.**

City of Moore Master Drainage Plan

Little River
Problem Area 15: Recommendation

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Figure 3 - 16

City of Moore Master Drainage Plan

CITY of MOORE OKLAHOMA

Little River
Problem Area 16: Recommendation

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Figure 3 - 17

Q. Problem Area 17: SW 1st St & SW 2nd St between I-35 & S Telephone Rd

The City of Moore, within the period of this master drainage study, completed a roadway full-depth pavement rehabilitation, in which sections of S. Classen Avenue, W. Main Street, SW 1st Street, and SW 2nd Street between S. Telephone Road and I-35 Frontage Road were paved in concrete with curb and gutter added for roadway drainage. This recent pavement rehabilitation should be observed during storm events to determine the effectiveness of the newly constructed roadway to solve the drainage and flooding problems in the area. If the new roadways do not prove effective in draining stormwater runoff, then a storm sewer system may be necessary to provide adequate drainage capacity to the problem areas listed.

R. Problem Area 18: SW 2nd St & I-35 & S Telephone Rd

In the period of this master drainage study, a newly constructed OnCue gasoline station was constructed at the corner of SW 4th Street and I-35 Frontage Road. In the process of construction, the drainage culvert for the open channel crossing on SW 2nd Street was replaced with a new storm sewer system that discharges into the OnCue detention pond located northeast of the SW 4th Street and S Classen Avenue intersection. The recently constructed storm sewer system crossing on SW 2nd Street should be observed during storm events to determine its hydraulic capacity and effectiveness to reduce flooding. If the new storm sewer system does not prove effective in reducing flooding, then the flooded property located at 417 SW 2nd Street, may be voluntarily sold to the City of Moore.

S. Problem Area 19: Alley between SW 1st St & SW 2nd St from N Chestnut Ave to N Howard Ave

The City of Moore, within the period of this master drainage study, completed an alleyway full-depth pavement rehabilitation, located between N Howard Avenue to N Chestnut Avenue and NW 1st Street to NW 2nd Street. The alleyway was paved in concrete with a trickle channel in the center added for drainage. Also, a wide and shallow concrete trickle channel was also constructed over the drainage ditch on the east side of N Howard Avenue between NW 1st Street to NW 2nd Street. This trickle channel should allow for stormwater discharge heading west towards the problem area to be diverted south on N Howard Avenue to a storm sewer system. This recent pavement rehabilitation should be observed during storm events to determine the effectiveness of the newly constructed alleyway and channel to solve the drainage and flooding problems in the area. If the new improvements do not prove effective in draining stormwater discharge, then curb and gutter roadways or a storm sewer system may be necessary to provide adequate drainage capacity to the problem areas listed.

T. Problem Area 20: Alley between NW 1st St & W Main St from N Howard Ave to N Broadway St

The City of Moore, within the period of this master drainage study, completed an alleyway full-depth pavement rehabilitation, located between N Howard Avenue to N Broadway Street and NW 1st Street to W Main Street. The alleyway was paved in concrete with a trickle channel in the center added for drainage. This recent pavement rehabilitation should be observed during storm events to determine the effectiveness of the newly constructed alleyway to solve the drainage and flooding problems in the area. If the new improvements do not prove effective in draining stormwater discharge, then curb along the alleyway or a storm sewer system may be necessary to provide adequate drainage capacity to the problem areas listed.

U. Problem Area 21: Open-Channel between Thompson Dr & Kelly Dr from Freeman Dr to N Broadway St

The open channel discharging behind the residential property at 106 Thompson Drive can be armored with vegetation or alternative means to prevent erosion. The private residential property at the address listed above had also been without any grass cover in the backyard for a period of time in the past two years. No vegetation or grass cover would expose soil to erosion from any level of stormwater runoff. The open channel directly behind the property address listed above has an adequate slope of approximately 0.009 foot per foot and therefore should not cause considerable erosion behind the property listed. Just downstream, the slope increases to approximately 0.028 foot per foot. The City of Moore has recently cleaned this channel to address this problem. Regular maintenance to clean debris and protection of embankments against any observed erosion should address the problem.

V. Problem Area 22: Storm Sewer Inlets on N Nail Pkwy

The N. Nail Parkway apron connecting to NE 12th Street should be raised in order to prevent roadway discharge along NE 12th Street from diverting north onto N. Nail Parkway. The gutters on N. Nail Parkway should also be cleaned and maintained to allow for designed roadway discharge. The private property owner at 1300 N. Nail Parkway should consider raising the height of the driveway apron to N. Nail Parkway to prevent roadway discharge from draining to the residential structure.

The City of Moore currently has preliminary concept plans from a designer to develop the grass pasture between NE 12th Street to NE 19th Street and N Nail Parkway to the BNSF railroad line. The development would include additional impervious areas, such as buildings, parking lots, and roadways. However, a local detention pond should be constructed onsite to account for the increased peak discharge flowrates due to additional impervious area. The City of Moore also has a preliminary concept design to perform a roadway pavement full-depth rehabilitation on Meadowbrook Drive. As part of the paving project, a storm sewer system would be installed beneath the Meadowbrook Drive roadway, leading from the detention pond described above, west to discharge into the Little River. Considering the proposed storm sewer system captures discharge from the proposed development and N Nail Parkway, or existing drainage basins LR-27-01 and LR-27-02, a pipe size for the 10-year storm would require approximately a 54 inch diameter RCP with a peak discharge of 114 cfs, and a pipe size for the 100-year storm would require approximately a 72 inch diameter RCP for a peak discharge of 205 cfs.

Alternative 1 – Construct Detention Facilities. This recommendation consists of constructing two detention pond facilities on an undeveloped section of property, located between N Nail Parkway to the BNSF railroad tracks and NE 19th Street and NE 12th Street. The locations of the proposed detention pond sites are directly upstream of the affected areas and should reduce the peak discharge flowrates draining west to the sub-division and storm sewer systems. The recommended detention ponds would have approximately 4.0 acre-feet and 5.5 acre-feet of storage and should reduce the 100-year storm peak discharge by approximately 82 percent and 70 percent respectively.

The locations of the proposed improvements are shown in **Figure 3-19**. The cost for Alternative 1 is estimated at $1,770,400 and is detailed in **Appendix 3-D**.

Alternative 2 – Property Acquisition and Construct Drainage System. This alternate would consist of acquiring voluntarily sold private residential properties located at 1308 N Nail Parkway, 1309 N Nail Parkway, 122 Oakside Drive, 1332 N Nail Parkway, 1333 N Nail Parkway, and 140 Oakside Drive and constructing new concrete flume channels across the lots. The proposed southern concrete flume channel would consist of approximately 570 linear feet of concrete channel. The dimensions of the channel should have an approximate 9 inch minimum depth, 10 foot minimum bottom width, and 1:0 (H:V) side slopes. A Manning's 'n' value of 0.013 and a slope of 0.024 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the proposed southern concrete flume channel is approximately 89 cfs. The proposed northern concrete flume channel would consist of approximately 435 linear feet of concrete channel. The dimensions of the channel should have an approximate 8 inch minimum depth, 16 foot minimum bottom width, and 1:0 (H:V) side slopes. A Manning's 'n' value of 0.013 and a slope of 0.035 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the proposed northern concrete flume channel is approximately 154 cfs.

The locations of the proposed improvements are shown in **Figure 3-20**. The cost for alternative 2 is estimated at $1,322,600 and is detailed in **Appendix 3-C.**

City of Moore Master Drainage Plan

CITY of MOORE OKLAHOMA

Little River
Problem Area 22: Alternative 1

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Figure 3 - 18

City of Moore Master Drainage Plan

Proposed Flume

Proposed Property Acquisition

Flooding Comments

Citizen Comment #

City Comment #

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Little River
Problem Area 22: Alternative 2

Figure 3 - 19

W. Problem Area 23: S Bristow Ave between SW 1st St & SW 4th St

Ground topography indicates that flooding in the backyard of the private residential property located at 315 S Bristow Avenue was caused by stormwater runoff from neighboring private residential properties to the west. Due to the flooding problem being caused by topography on private property and not on public property, the City of Moore is not responsible for the flooding problem. A solution to the flooding problem may be for the private property owner to have a residential sized drainage system installed on either or both sides of the property to discharge stormwater to the front of the property.

Recommendation – Construct 100-year Storm Sewer System. This recommendation would consist of constructing an extended storm sewer system on S Bristow Avenue from SW 4th Street which can convey the 100-year storm. This storm sewer structure would consist of approximately 450 linear feet of 5 foot wide by 3 foot tall RCB culvert and 2 concrete recessed curb inlets. The 100-year discharge to the proposed storm sewer system is approximately 81.5 cfs.

The locations of the proposed improvements are shown in **FIGURE 3-21**. The cost for the recommendation is estimated at $389,500 and is detailed in **APPENDIX 3-D.**

X. Problem Area 24: Open-Channel adjacent to N Bristow Ave & NW 1st St

A typical detention pond facility should reduce the peak discharge flowrates in an area. The open-channel system running between residential private property lots may cause flooding in yards. If any residential structures have flooding, the private residential property may be voluntarily sold to the City of Moore, or the detention pond in the Southgate-Rippetoe Elementary School property may be expanded. The outlet structure leading from the detention pond travels west beneath a grass-lined open-channel and turns south to discharge into the open-channel. The outlet structure does not need to cross under the open-channel before discharging. Therefore, the pipe can be cut to have and overall length of approximately 180 feet downstream of the detention pond.

The NW 1st Street roadway crossing over the unnamed tributary should have better drainage if the concrete curb was cut or removed to allow free drainage into the open-channel.

The locations of the proposed improvements are shown in **FIGURE 3-22**. Due to the variability of the scope, a cost estimate was not prepared at this time.

City of Moore Master Drainage Plan

CITY of MOORE OKLAHOMA

Little River
Problem Area 23: Recommendation

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Figure 3 - 20

City of Moore Master Drainage Plan

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CITY of MOORE OKLAHOMA 1893

Little River
Problem Area 24: Recommendation

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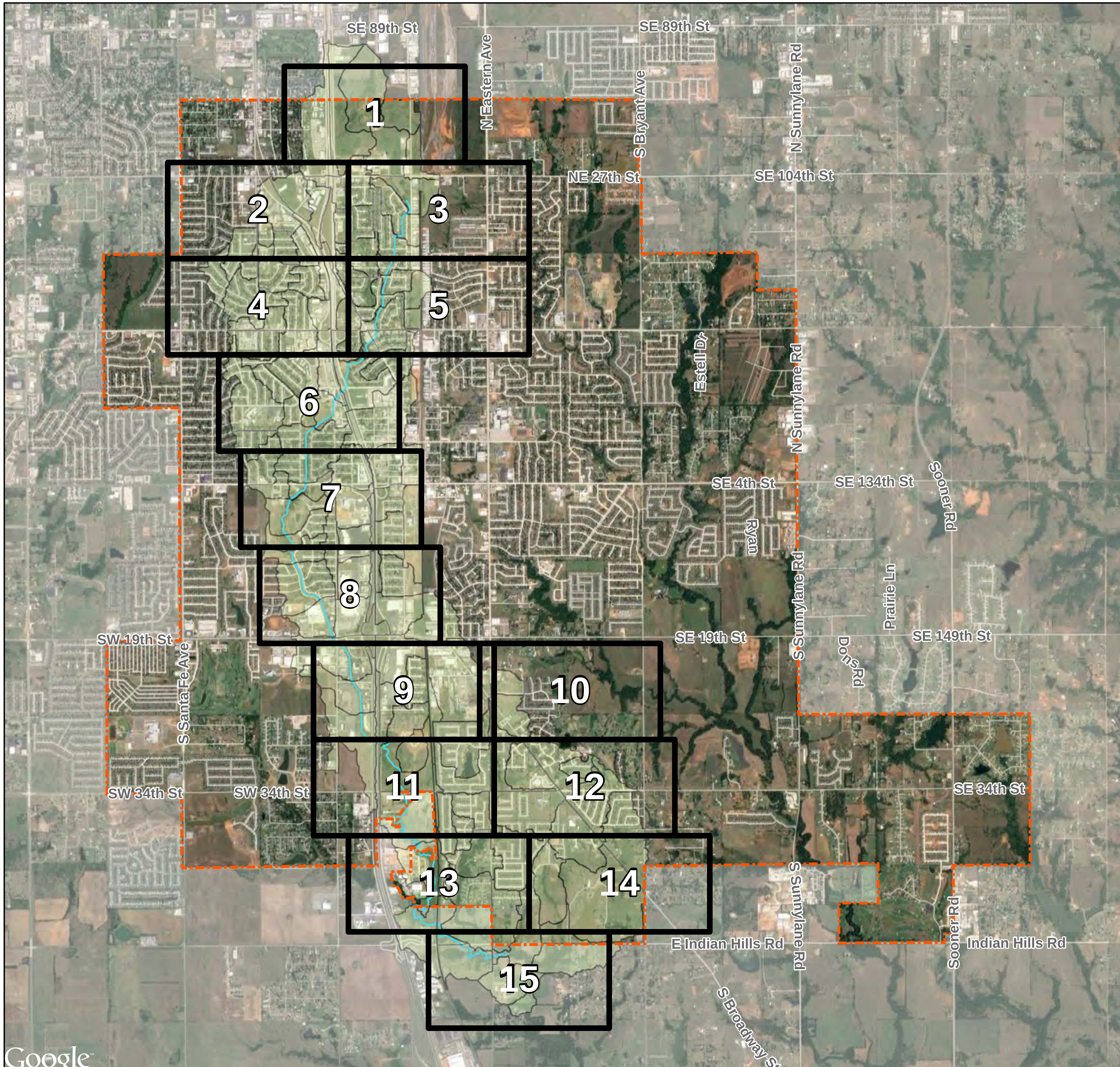
Figure 3 - 21



City of Moore
Master Drainage Plan

Little River
Detailed HEC-HMS Schematics
Section 3 - Appendix A

Atlas Pages
Moore City Limits
Little River Basin
Little River

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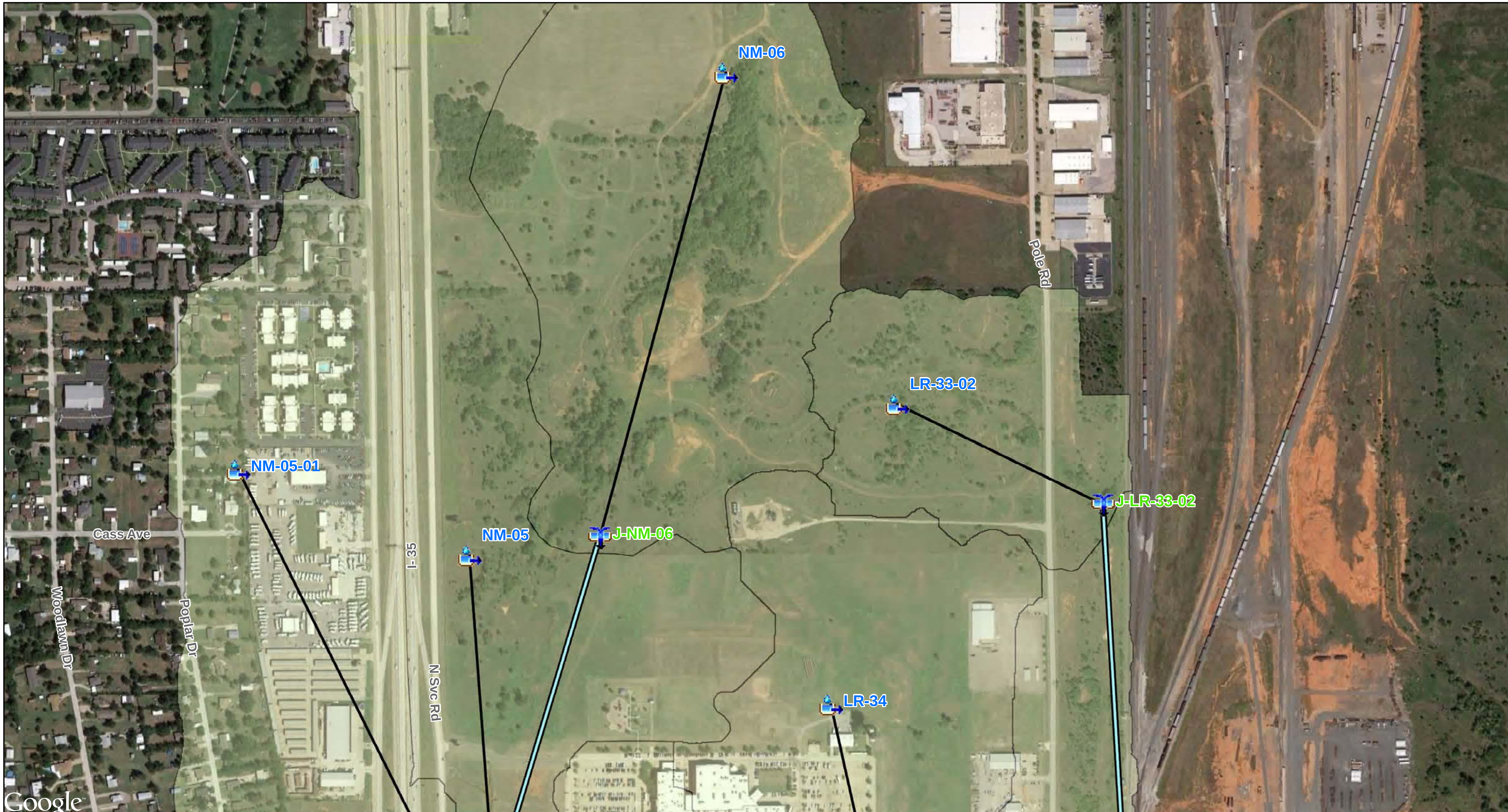

City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

Section 3 - Appendix A

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Feet

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HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
- Reach
- Route Downstream
- Little River Basin

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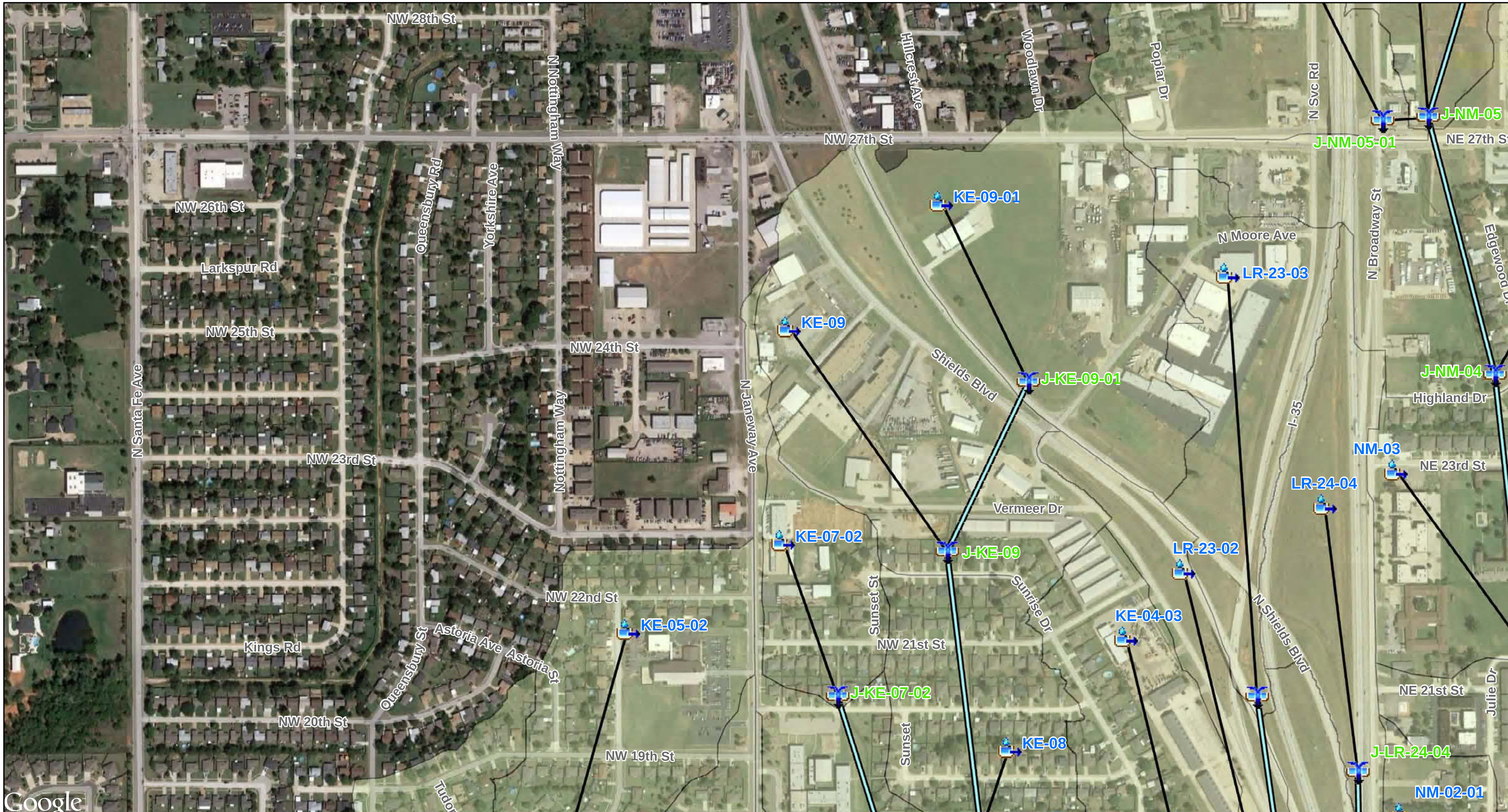
CITY of MOORE OKLAHOMA



City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

Section 3 - Appendix A

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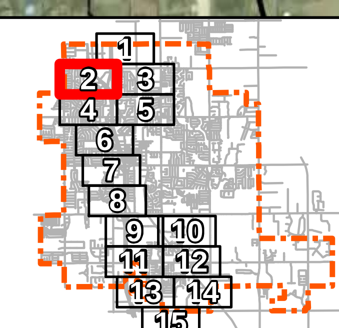
MESHEK & ASSOCIATES, PLC

HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
- Reach
- Route Downstream
- Little River Basin



CITY OF MOORE OKLAHOMA

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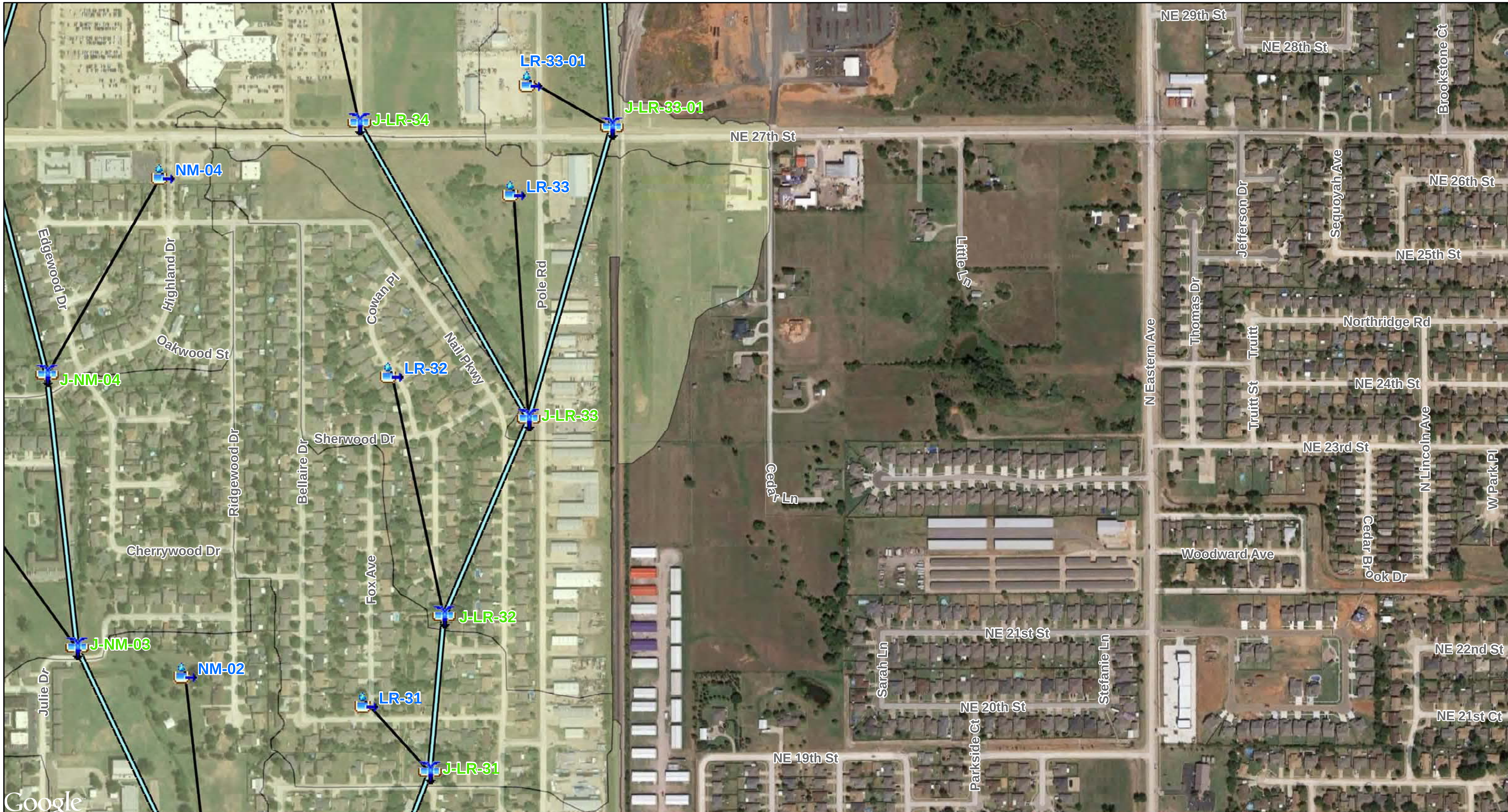

City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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MESHEK & ASSOCIATES, PLC

HMS Points

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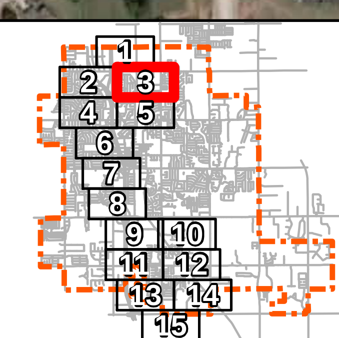

CITY OF MOORE OKLAHOMA

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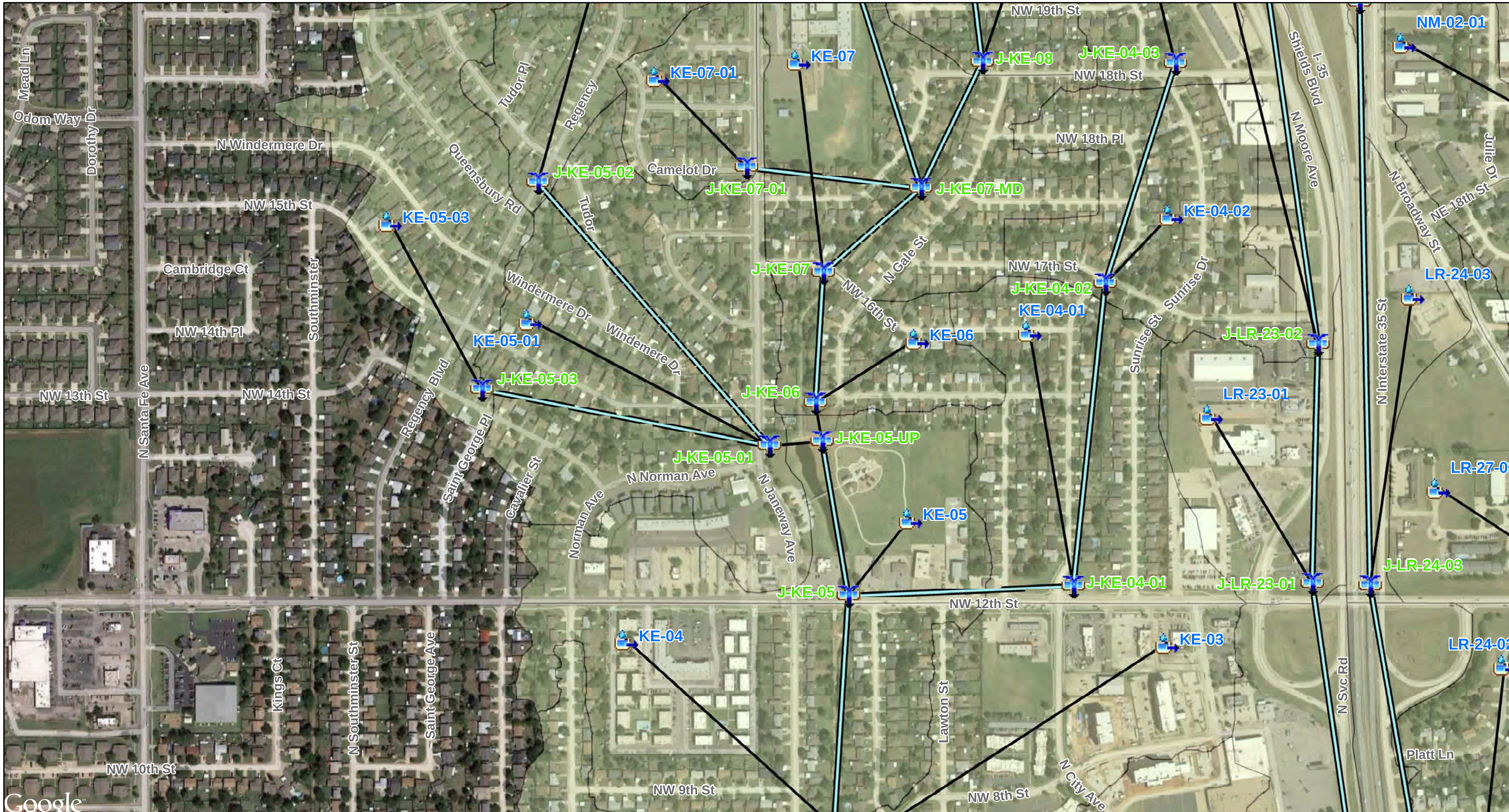
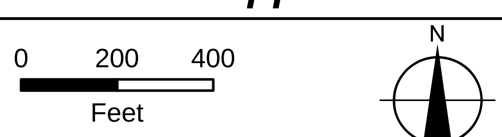


City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

Section 3 - Appendix A



MESHEK & ASSOCIATES, PLC

HMS Points
- Reservoir
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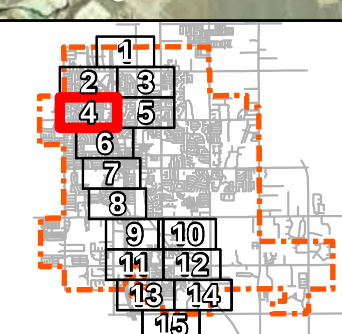
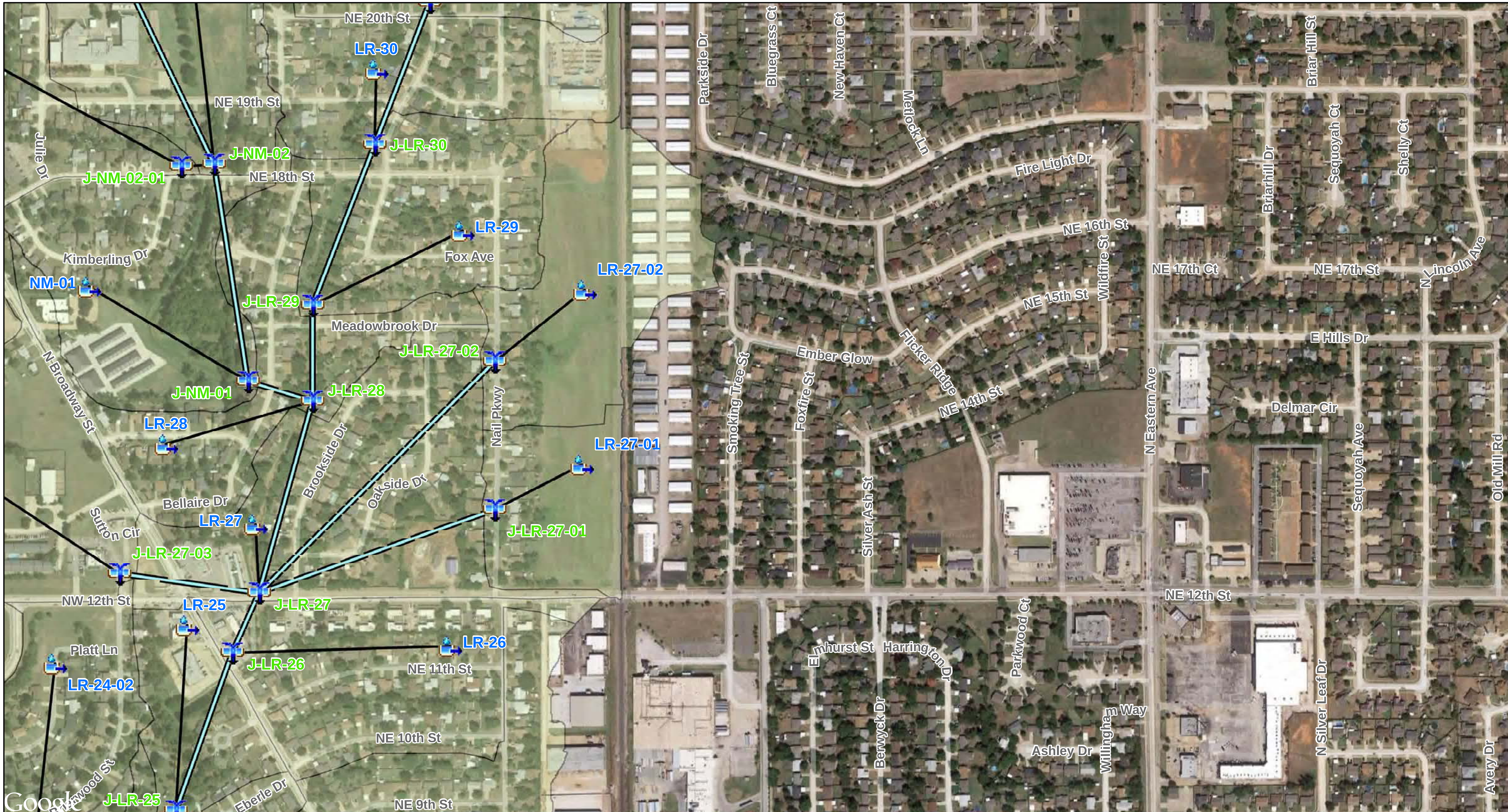
- Junction

HMS Lines
- Reach
- Route Downstream
- Little River Basin



CITY OF MOORE OKLAHOMA



City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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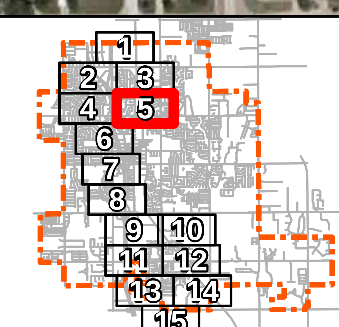
HMS Points

- Reservoir
- Subbasin
- Junction

HMS Lines

- Reach
- Route Downstream
- Little River Basin



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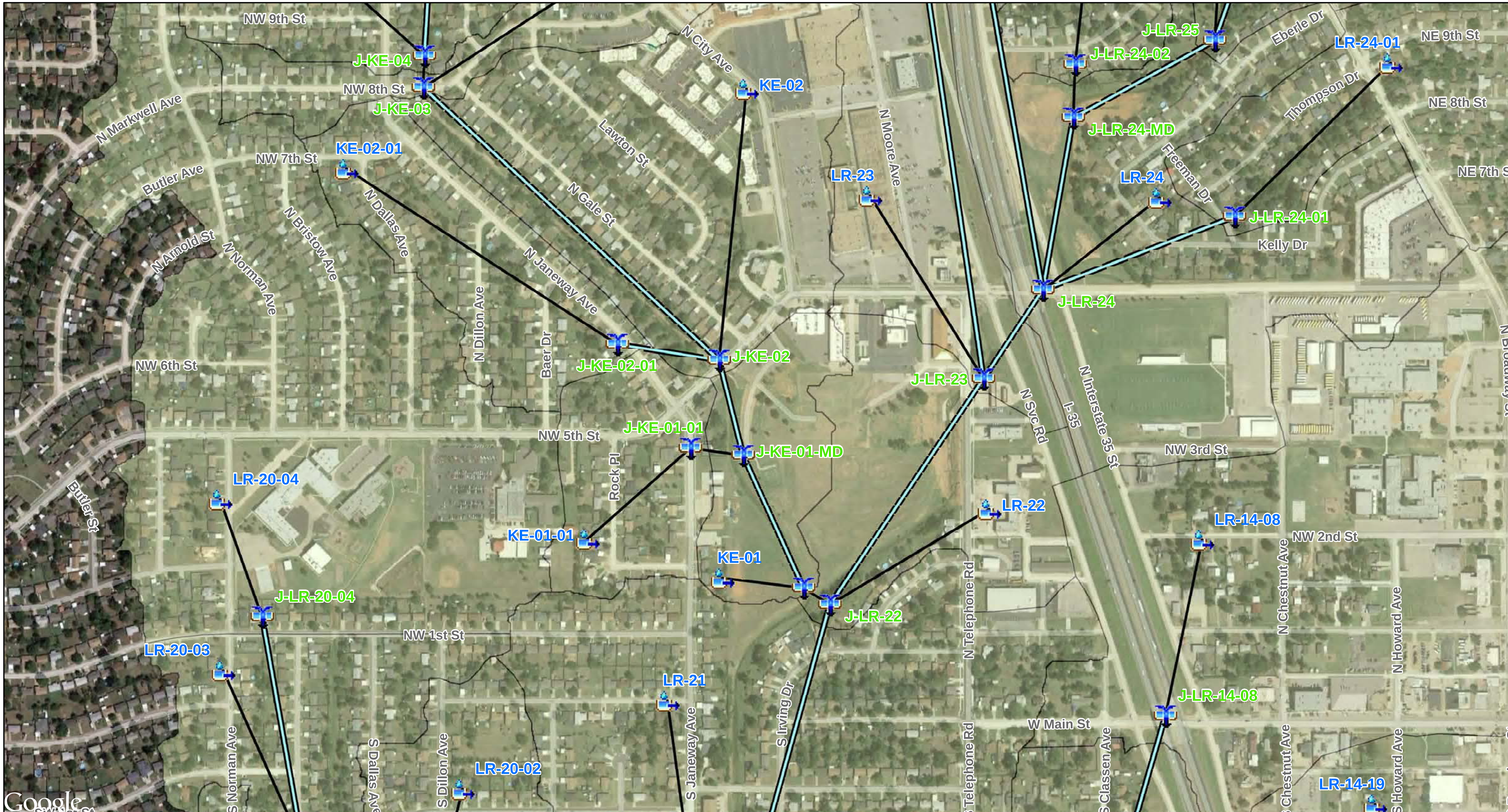

City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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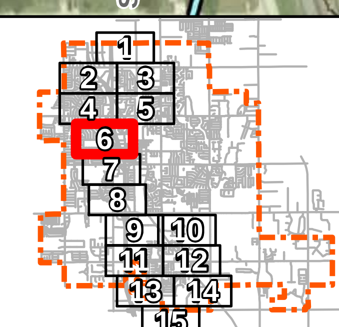
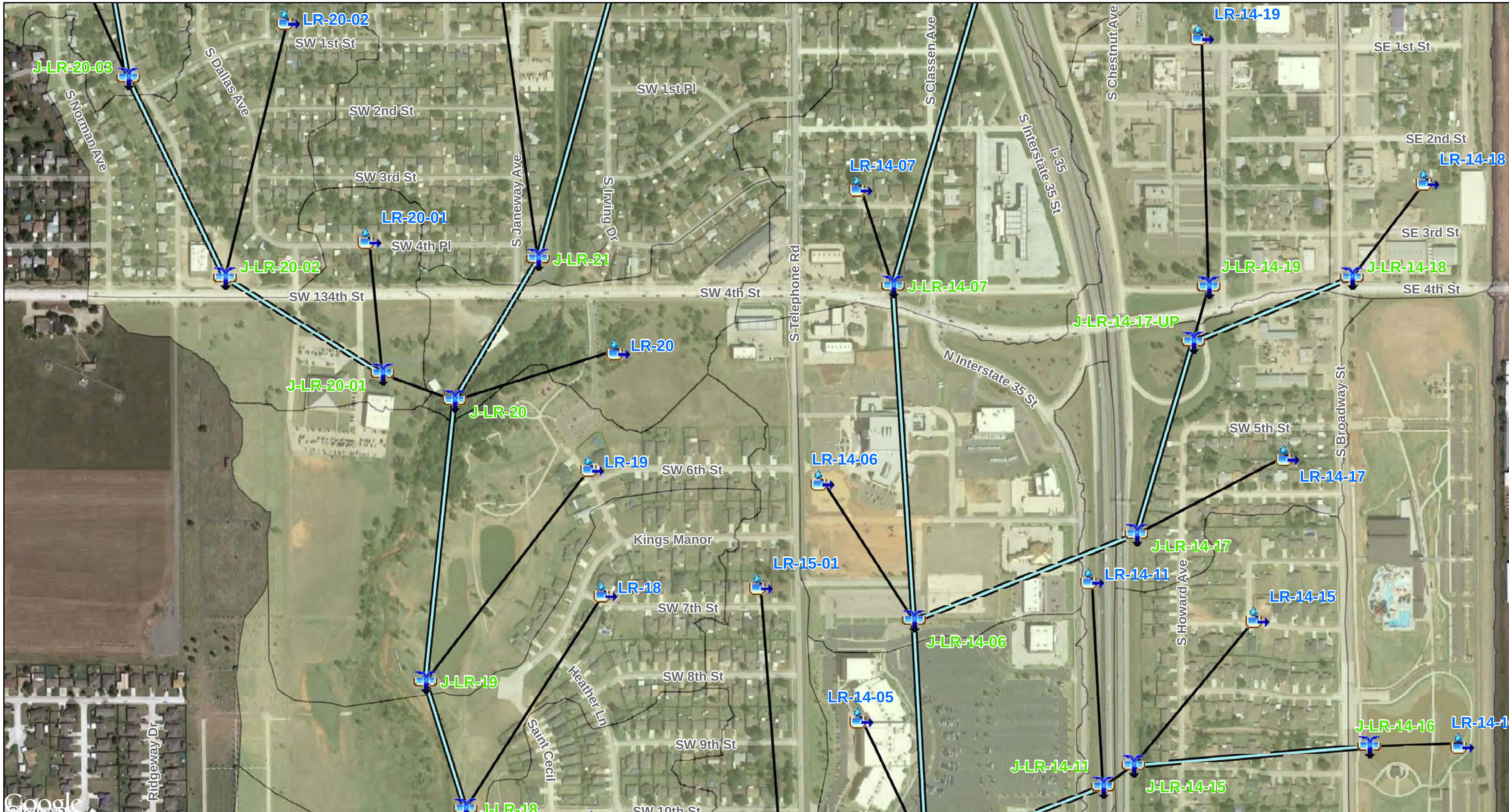
MESHEK & ASSOCIATES, PLC

HMS Points		HMS Lines	
	Reservoir		Reach
	Subbasin		Route Downstream
	Junction		Little River Basin



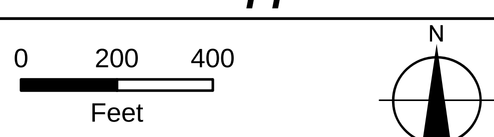
CITY OF MOORE OKLAHOMA



City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

Section 3 - Appendix A

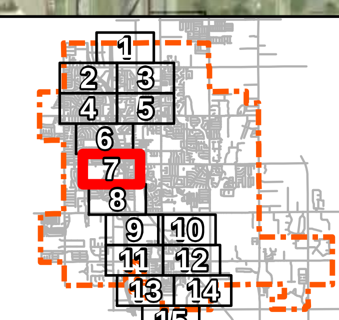


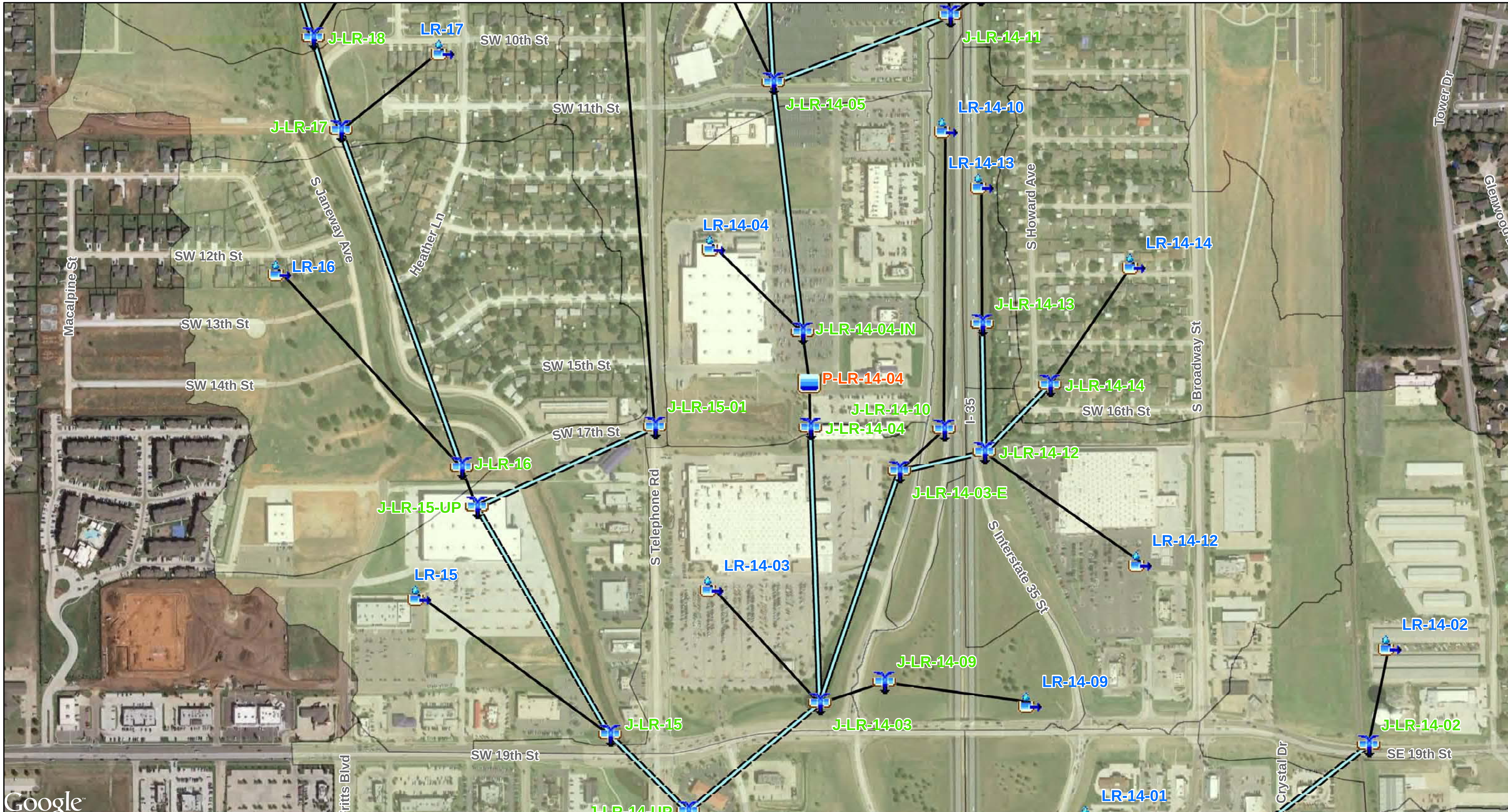
HMS Points

- Reservoir
- Subbasin
- Junction

HMS Lines

- Reach
- Route Downstream
- Little River Basin





City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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MESHEK & ASSOCIATES, PLC

HMS Points
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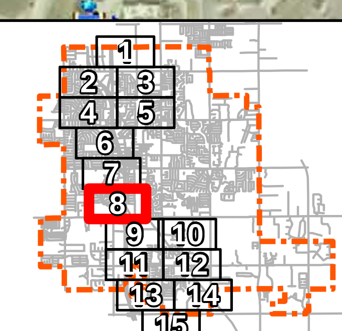
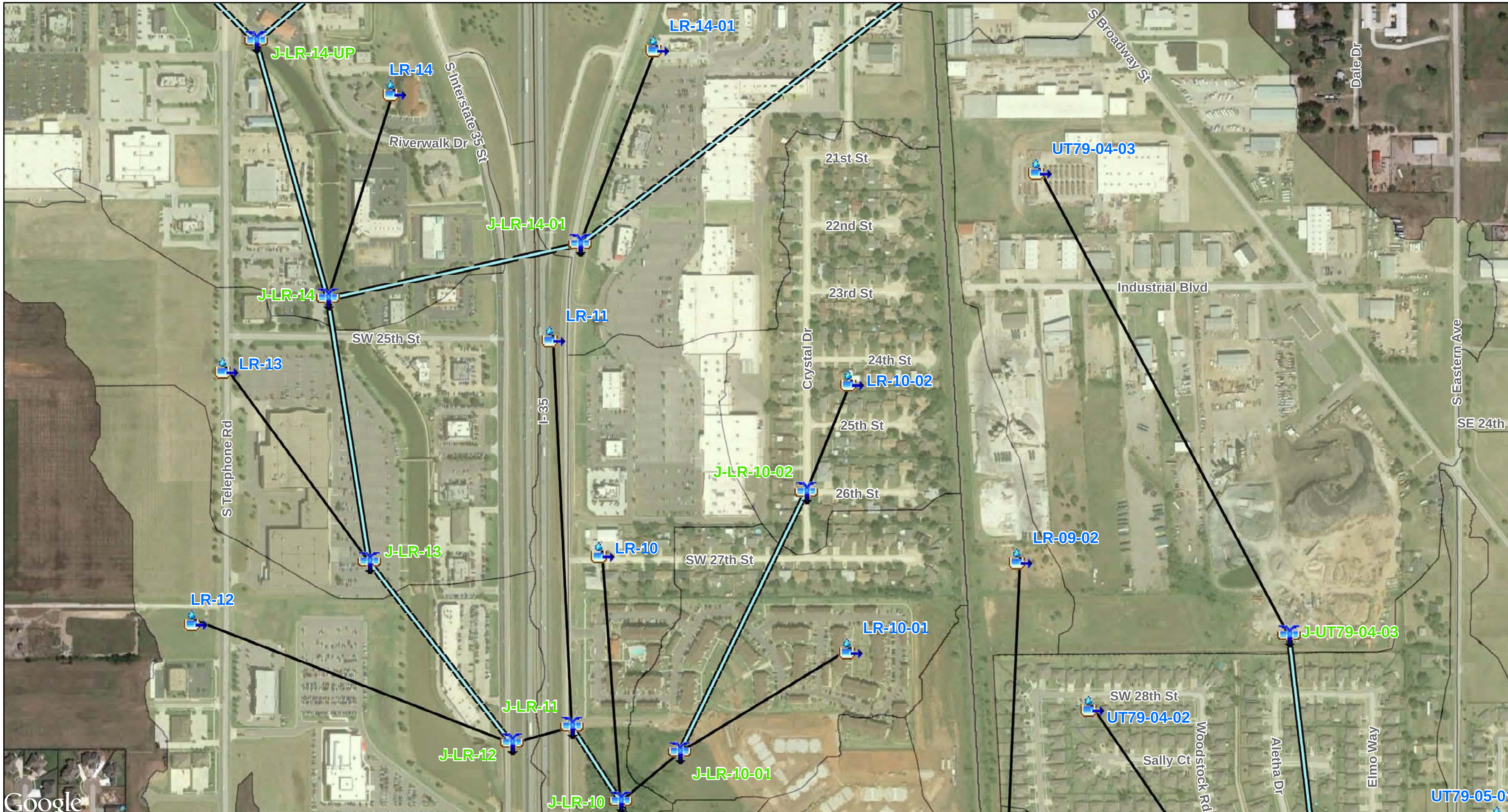


CITY of MOORE OKLAHOMA



City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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MESHEK & ASSOCIATES, PLC

HMS Points
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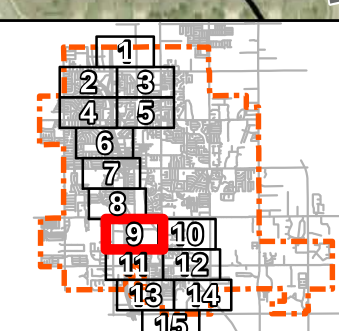
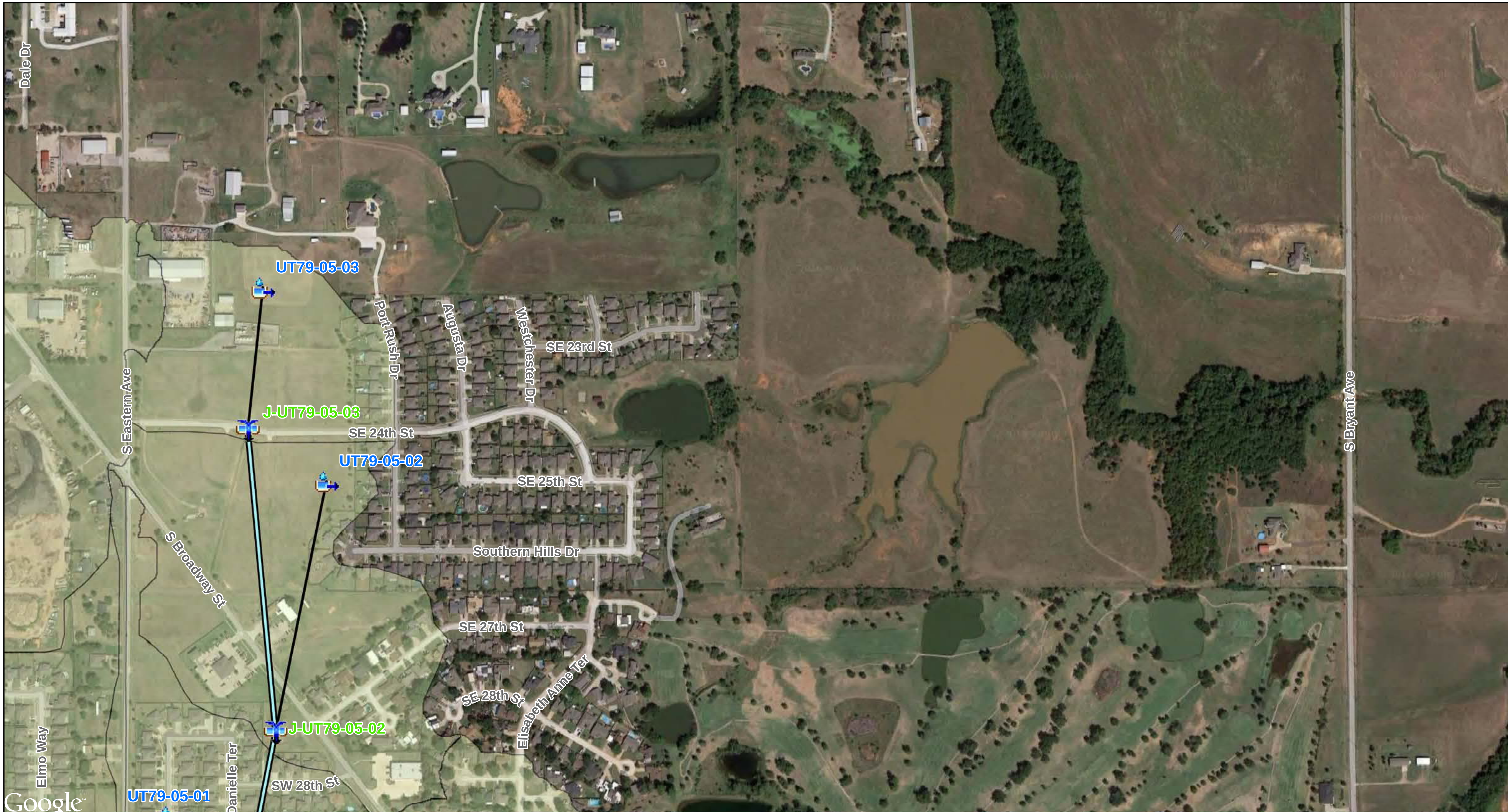


CITY of MOORE OKLAHOMA



City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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Feet

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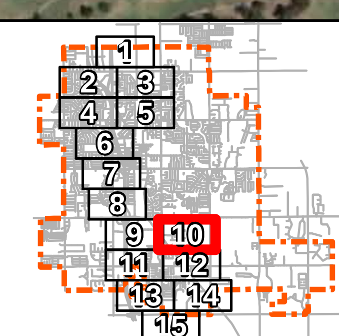
MESHEK & ASSOCIATES, PLC

HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
- Reach
- Route Downstream
- Little River Basin



CITY of MOORE OKLAHOMA

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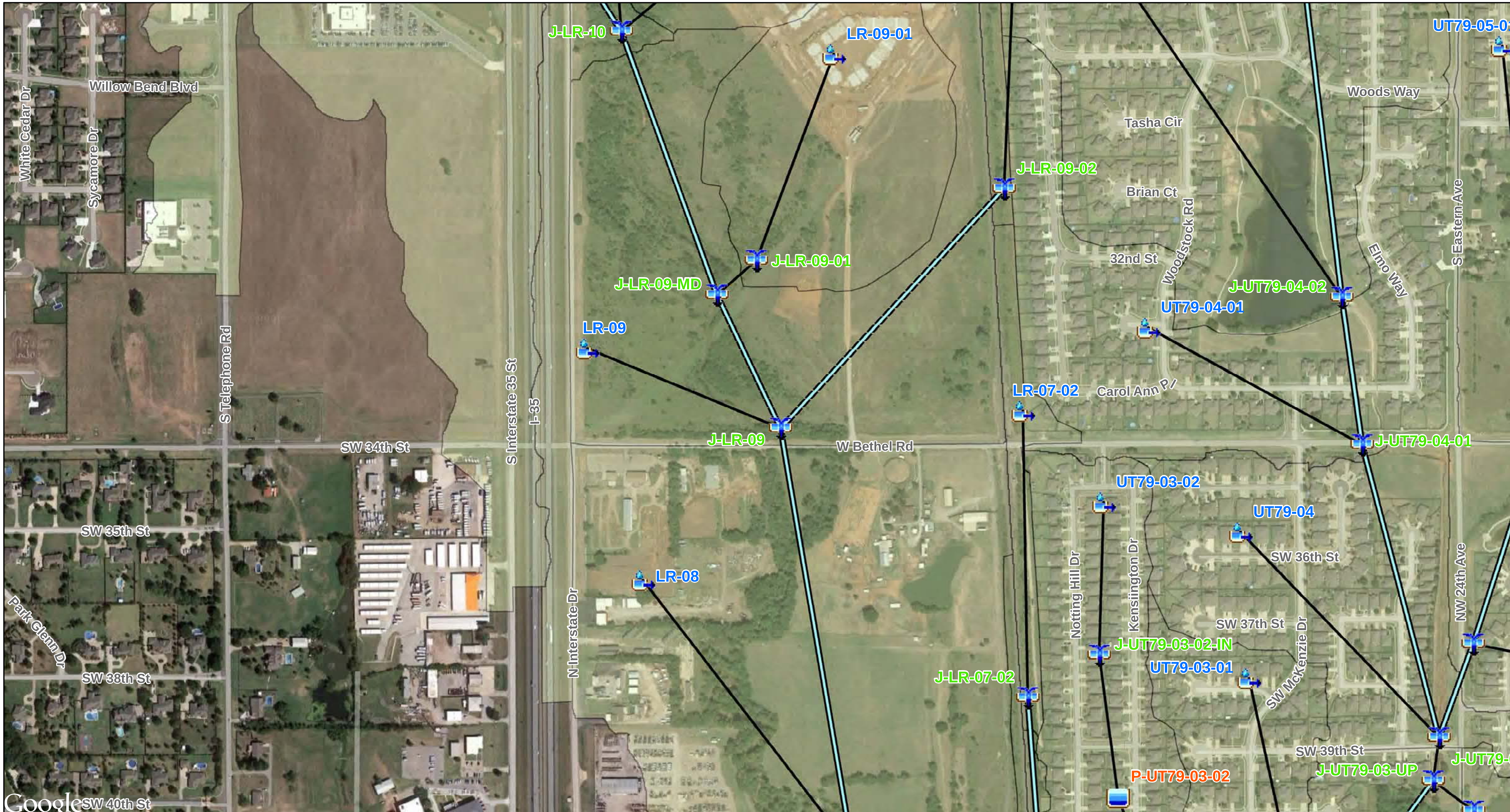

City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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MESHEK & ASSOCIATES, PLC

HMS Points

Reservoir

Subbasin

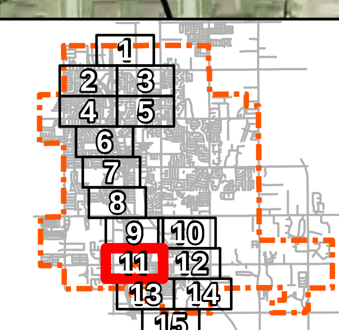
Junction

HMS Lines

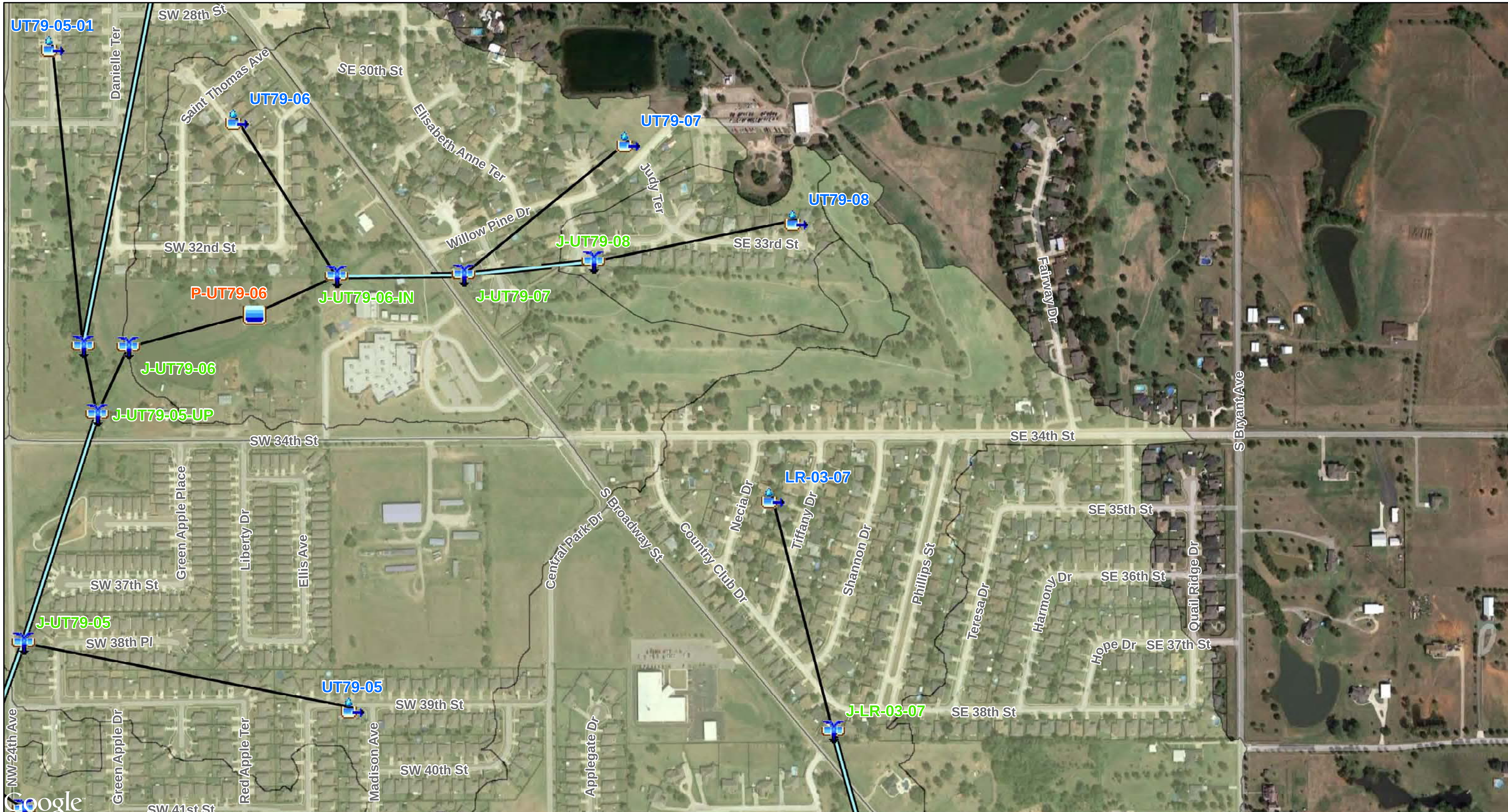
Reach

Route Downstream

Little River Basin



CITY OF MOORE OKLAHOMA



City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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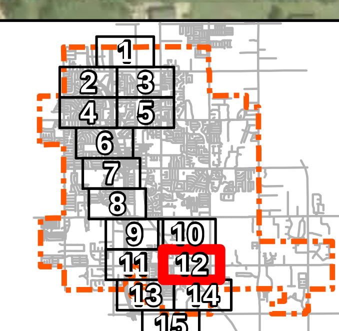
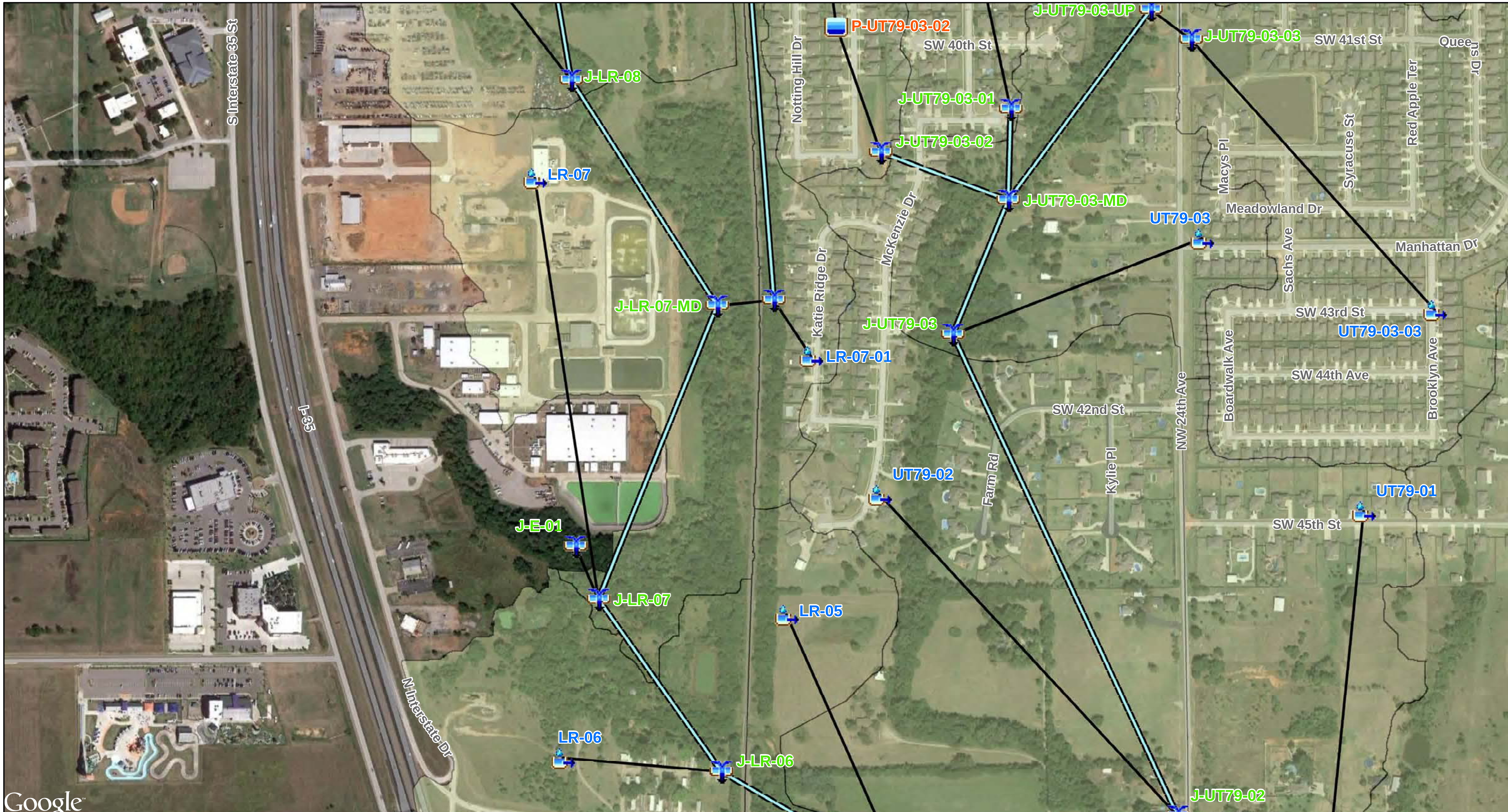
MESHEK & ASSOCIATES, PLC

HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Little River Basin





City of Moore - Master Drainage Plan

Little River Detailed HEC-HMS Schematics

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MESHEK & ASSOCIATES, PLC

HMS Points
- Reservoir
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Feet

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MESHEK & ASSOCIATES, PLC

HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
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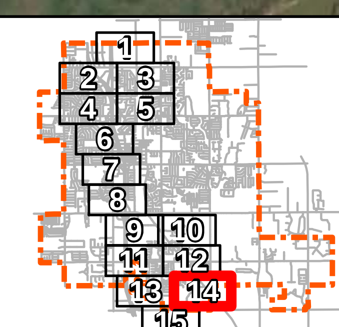
- Route Downstream
- Little River Basin



CITY of MOORE OKLAHOMA

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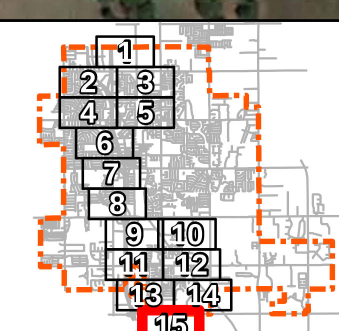
MESHEK & ASSOCIATES, PLC

HMS Points	**HMS Lines**
Reservoir	Reach
Subbasin	Route Downstream
Junction	Little River Basin



CITY of MOORE OKLAHOMA

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #02 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	12000	$ 12.00	$ 144,000.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	1100	$ 3.00	$ 3,300.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 100,000.00	$ 100,000.00
4	**10" PCC PAVEMENT**	**SY**	630	$ 94.00	$ 59,220.00
5	**12" PCC PAVEMENT**	**SY**	1060	$ 113.00	$ 119,780.00
6	**STANDARD BEDDING MATERIAL - (4) 16' x 12' RCB**	**CY**	1940	$ 20.00	$ 38,800.00
7	**Quadruple 16' x 12' RCB**	**LS**	1	$ 762,300.00	$ 762,300.00
				Subtotal	**$ 1,227,400.00**
				15% Contingency	**$ 184,110.00**
				Subtotal	**$ 1,411,510.00**
				25% Utility Relocation Contingency	**$ 352,877.50**
				Total	***$ 1,764,387.50***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #02 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	UNCLASSIFIED EXCAVATION	CY	13200	$ 12.00	$ 158,400.00
2	SOLID SLAB BERMUDA SODDING	SY	600	$ 3.00	$ 1,800.00
3	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 100,000.00	$ 100,000.00
4	10" PCC PAVEMENT	SY	630	$ 94.00	$ 59,220.00
5	12" PCC PAVEMENT	SY	990	$ 113.00	$ 111,870.00
6	STANDARD BEDDING MATERIAL - (3) 20' x 12' RCB	CY	1740	$ 20.00	$ 34,800.00
7	Triple 20' x 12' RCB	LS	1	$ 678,000.00	$ 678,000.00
				Subtotal	**$ 1,144,090.00**
				15% Contingency	**$ 171,613.50**
				Subtotal	**$ 1,315,703.50**
				25% Utility Relocation Contingency	**$ 328,925.88**
				Total	***$ 1,644,629.38***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #04 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	30000	$ 12.00	$ 360,000.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	11200	$ 3.00	$ 33,600.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 50,000.00	$ 50,000.00
4	**STANDARD BEDDING MATERIAL - Channel**	**CY**	5760	$ 20.00	$ 115,200.00
5	**12" PCC VERTICAL WALL CHANNEL**	**LS**	1	$ 1,944,000.00	$ 1,944,000.00
6	**8" PCC PAVEMENT**	**SY**	650	$ 75.00	$ 48,750.00
7	**STANDARD BEDDING MATERIAL - (3) 14' x 8' RCB**	**CY**	160	$ 20.00	$ 3,200.00
8	**Triple 14' x 8' RCB**	**LF**	37	$ 2,300.00	$ 85,100.00
9	**STANDARD BEDDING MATERIAL - (4) 12' x 11' RCB**	**CY**	330	$ 20.00	$ 6,600.00
10	**Quadruple 12' x 11' RCB**	**LS**	1	$ 135,000.00	$ 135,000.00
				Subtotal	**$ 2,781,450.00**
				15% Contingency	**$ 417,217.50**
				Subtotal	**$ 3,198,667.50**
				25% Utility Relocation Contingency	**$ 799,666.88**
				Total	***$ 3,998,334.38***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #06 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
INTERSECTION OF NW 7TH ST & N JANEWAY AVE					
1	**UNCLASSIFIED EXCAVATION**	**CY**	50	$ 12.00	$ 600.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	100	$ 3.00	$ 300.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	75	$ 40.00	$ 3,000.00
4	**PAVEMENT REMOVAL**	**SY**	67	$ 10.00	$ 670.00
5	**8" PCC PAVEMENT**	**SY**	67	$ 75.00	$ 5,025.00
6	**STANDARD BEDDING MATERIAL - 24" RCP**	**CY**	97	$ 20.00	$ 1,930.00
7	**24" RCP**	**LF**	250	$ 80.00	$ 20,000.00
				Subtotal	$ 31,525.00
INTERSECTION OF N DILLON AVE & N JANEWAY AVE					
8	**PROPERTY ACQUISITION - 720 N. Janeway Ave.**	**LS**	1	$ 106,600.00	$ 106,600.00
9	**UNCLASSIFIED EXCAVATION**	**CY**	970	$ 12.00	$ 11,640.00
10	**SOLID SLAB BERMUDA SODDING**	**SY**	575	$ 3.00	$ 1,725.00
11	**PAVEMENT REMOVAL**	**SY**	448	$ 10.00	$ 4,480.00
12	**8" PCC PAVEMENT & CHANNEL**	**SY**	564	$ 75.00	$ 42,300.00
13	**STANDARD BEDDING MATERIAL - Concrete Channel**	**CY**	31	$ 20.00	$ 620.00
				Subtotal	$ 167,365.00
INTERSECTION OF BAER DR & N JANEWAY AVE					
14	**UNCLASSIFIED EXCAVATION**	**CY**	290	$ 12.00	$ 3,480.00
15	**SOLID SLAB BERMUDA SODDING**	**SY**	160	$ 3.00	$ 480.00
16	**PAVEMENT REMOVAL**	**SY**	140	$ 10.00	$ 1,400.00
17	**8" PCC PAVEMENT**	**SY**	140	$ 75.00	$ 10,500.00
18	**STANDARD BEDDING MATERIAL - 36" RCP**	**CY**	188	$ 20.00	$ 3,760.00
19	**36" RCP**	**LF**	250	$ 140.00	$ 35,000.00
				Subtotal	$ 54,620.00
				Subtotal	**$ 253,510.00**
				15% Contingency	**$ 38,026.50**
				Subtotal	**$ 291,536.50**
				25% Utility Relocation Contingency	**$ 72,884.13**
				Total	***$ 364,420.63***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #10 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
PART 1 - EMBANKMENT BERM					
1	**UNCLASSIFIED EXCAVATION**	**CY**	250	$ 12.00	$ 3,000.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	800	$ 3.00	$ 2,400.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
				Subtotal	**$ 15,400.00**
PART 2 - CAROL CIRCLE STORM SEWER					
1	**UNCLASSIFIED EXCAVATION**	**CY**	910	$ 12.00	$ 10,920.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	750	$ 3.00	$ 2,250.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	200	$ 40.00	$ 8,000.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
5	**8" PCC PAVEMENT**	**SY**	260	$ 75.00	$ 19,500.00
6	**STANDARD BEDDING MATERIAL - 30" RCP**	**CY**	440	$ 20.00	$ 8,800.00
7	**30" RCP**	**LF**	850	$ 120.00	$ 102,000.00
				Subtotal	**$ 161,470.00**
PART 3 - WESLEY CIRCLE STORM SEWER					
1	**UNCLASSIFIED EXCAVATION**	**CY**	1600	$ 12.00	$ 19,200.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	350	$ 3.00	$ 1,050.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	400	$ 40.00	$ 16,000.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
5	**8" PCC PAVEMENT**	**SY**	135	$ 75.00	$ 10,125.00
6	**STANDARD BEDDING MATERIAL - 30" RCP**	**CY**	170	$ 20.00	$ 3,400.00
7	**30" RCP**	**LF**	330	$ 120.00	$ 39,600.00
				Subtotal	**$ 99,375.00**
PART 4 - ELEMENTARY SCHOOL OPEN-CHANNEL					
1	**UNCLASSIFIED EXCAVATION**	**CY**	440	$ 12.00	$ 5,280.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	2200	$ 3.00	$ 6,600.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
				Subtotal	**$ 16,880.00**
				Subtotal	**$ 293,125.00**
				15% Contingency	**$ 43,968.75**
				Subtotal	**$ 337,093.75**
				25% Utility Relocation Contingency	**$ 84,273.44**
				Total	***$ 421,367.19***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #11 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	600	$ 12.00	$ 7,200.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	1000	$ 3.00	$ 3,000.00
3	**8' PCC PAVED DITCH - 820' LENGTH**	**CY**	84	$ 338.00	$ 28,493.40
4	**4' PCC PAVED DITCH - 500' LENGTH**	**CY**	27	$ 338.00	$ 9,126.00
				Subtotal	**$ 47,819.40**
				15% Contingency	**$ 7,172.91**
				Subtotal	**$ 54,992.31**
				25% Utility Relocation Contingency	**$ 13,748.08**
				Total	***$ 68,740.39***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #12 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	40	$ 12.00	$ 480.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	300	$ 3.00	$ 900.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	120	$ 40.00	$ 4,800.00
4	**5' PCC PAVED DITCH - 200' LENGTH**	**CY**	12	$ 338.00	$ 4,056.00
				Subtotal	**$ 10,236.00**
				15% Contingency	**$ 1,535.40**
				Subtotal	**$ 11,771.40**
				25% Utility Relocation Contingency	**$ 2,942.85**
				Total	***$ 14,714.25***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #13 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	67650	$ 12.00	$ 811,800.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	1400	$ 3.00	$ 4,200.00
3	**STANDARD BEDDING MATERIAL - 42" RCP**	**CY**	1758	$ 20.00	$ 35,160.00
4	**42" RCP**	**LF**	1910	$ 190.00	$ 362,900.00
5	**PAVEMENT REMOVAL**	**SY**	148	$ 10.00	$ 1,480.00
6	**8" PCC PAVEMENT**	**SY**	148	$ 75.00	$ 11,100.00
				Subtotal	**$ 1,226,640.00**
				15% Contingency	**$ 183,996.00**
				Subtotal	**$ 1,410,636.00**
				25% Utility Relocation Contingency	**$ 352,659.00**
				Total	***$ 1,763,295.00***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #15 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**PROPERTY ACQUISITION - 1009 S Howard Ave**	**LS**	1	$ 145,000.00	$ 145,000.00
2	**UNCLASSIFIED EXCAVATION**	**CY**	1000	$ 12.00	$ 12,000.00
3	**SOLID SLAB BERMUDA SODDING**	**SY**	1210	$ 3.00	$ 3,630.00
4	**PAVEMENT REMOVAL**	**SY**	81	$ 10.00	$ 810.00
5	**8" PCC PAVEMENT**	**SY**	81	$ 75.00	$ 6,075.00
6	**STANDARD BEDDING MATERIAL - (3) 5' x 3' RCB**	**CY**	320	$ 20.00	$ 6,400.00
7	**Triple 5' x 3' RCB**	**LF**	180	$ 440.00	$ 79,200.00
				Subtotal	**$ 253,115.00**
				15% Contingency	**$ 37,967.25**
				Subtotal	**$ 291,082.25**
				25% Utility Relocation Contingency	**$ 72,770.56**
				Total	***$ 363,852.81***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #16 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	1400	$ 12.00	$ 16,800.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	2200	$ 3.00	$ 6,600.00
3	**6' Tall Wooden Privacy Fence**	**LF**	200	$ 40.00	$ 8,000.00
				Subtotal	**$ 31,400.00**
				15% Contingency	**$ 4,710.00**
				Subtotal	**$ 36,110.00**
				25% Utility Relocation Contingency	**$ 9,027.50**
				Total	***$ 45,137.50***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #22 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	PROPERTY ACQUISITION	LS	1	$ 1,130,000.00	$ 1,130,000.00
2	SELECT BORROW & EXCAVATION	CY	5300	$ 15.00	$ 79,500.00
3	SOLID SLAB BERMUDA SODDING	SY	3000	$ 3.00	$ 9,000.00
4	24" RCP - Northern Detention Pond	LF	46	$ 80.00	$ 3,680.00
5	DOUBLE 18" RCP - Southern Detention Pond	LF	84	$ 52.00	$ 4,368.00
6	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 5,000.00	$ 5,000.00
				Subtotal	**$ 1,231,548.00**
				15% Contingency	**$ 184,732.20**
				Subtotal	**$ 1,416,280.20**
				25% Utility Relocation Contingency	**$ 354,070.05**
				Total	***$ 1,770,350.25***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #22 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
SOUTHERN CONCRETE FLUME CHANNEL					
1	**PROPERTY ACQUISITION**	**LS**	1	$ 363,000.00	$ 363,000.00
2	**UNCLASSIFIED EXCAVATION**	**CY**	350	$ 12.00	$ 4,200.00
3	**SOLID SLAB BERMUDA SODDING**	**SY**	3420	$ 3.00	$ 10,260.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 50,000.00	$ 50,000.00
5	**4" PCC CHANNEL**	**LF**	570	$ 54.00	$ 30,780.00
6	**STANDARD BEDDING MATERIAL**	**CY**	130	$ 20.00	$ 2,600.00
7		**LF**		$ 80.00	$ -
				Subtotal	**$ 460,840.00**
NORTHERN CONCRETE FLUME CHANNEL					
8	**PROPERTY ACQUISITION**	**LS**	1	$ 363,000.00	$ 363,000.00
9	**UNCLASSIFIED EXCAVATION**	**CY**	350	$ 12.00	$ 4,200.00
10	**SOLID SLAB BERMUDA SODDING**	**SY**	2200	$ 3.00	$ 6,600.00
11	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 50,000.00	$ 50,000.00
12	**4" PCC CHANNEL**	**LF**	435	$ 75.00	$ 32,625.00
13	**STANDARD BEDDING MATERIAL**	**CY**	140	$ 20.00	$ 2,800.00
				Subtotal	**$ 459,225.00**
				Subtotal	**$ 920,065.00**
				15% Contingency	**$ 138,009.75**
				Subtotal	**$ 1,058,074.75**
				25% Utility Relocation Contingency	**$ 264,518.69**
				Total	***$ 1,322,593.44***

City of Moore					
Appendix 3-B Moore Master Drainage Plan Alternatives - Little River - Problem Area #23 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	72	$ 12.00	$ 864.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	100	$ 3.00	$ 300.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**CONCRETE RECESSED INLET**	**LS**	2	$ 5,000.00	$ 10,000.00
5	**STANDARD BEDDING MATERIAL - 5'x3' RCB**	**CY**	400	$ 20.00	$ 8,000.00
6	**5'x3' RCB**	**LF**	450	$ 440.00	$ 198,000.00
7	**8" PCC PAVEMENT**	**SY**	650	$ 75.00	$ 48,750.00
				Subtotal	**$ 270,914.00**
				15% Contingency	**$ 40,637.10**
				Subtotal	**$ 311,551.10**
				25% Utility Relocation Contingency	**$ 77,887.78**
				Total	***$ 389,438.88***

Section 4
Stream E

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SECTION 4. STREAM E WATERSHED

4.1. PREVIOUS STUDIES

FEMA has performed previous detailed and re-delineated studies of Stream E, most recently in the 2013 update to the Cleveland County Flood Insurance Study (FIS). Any alternatives proposed in this section were generated as part of this detailed study. Information regarding the background for this most recent study can be found in **SECTION 1 - EXECUTIVE SUMMARY** and **SECTION 2 - METHODOLOGY**.

4.2. EXISTING CONDITIONS HYDROLOGY

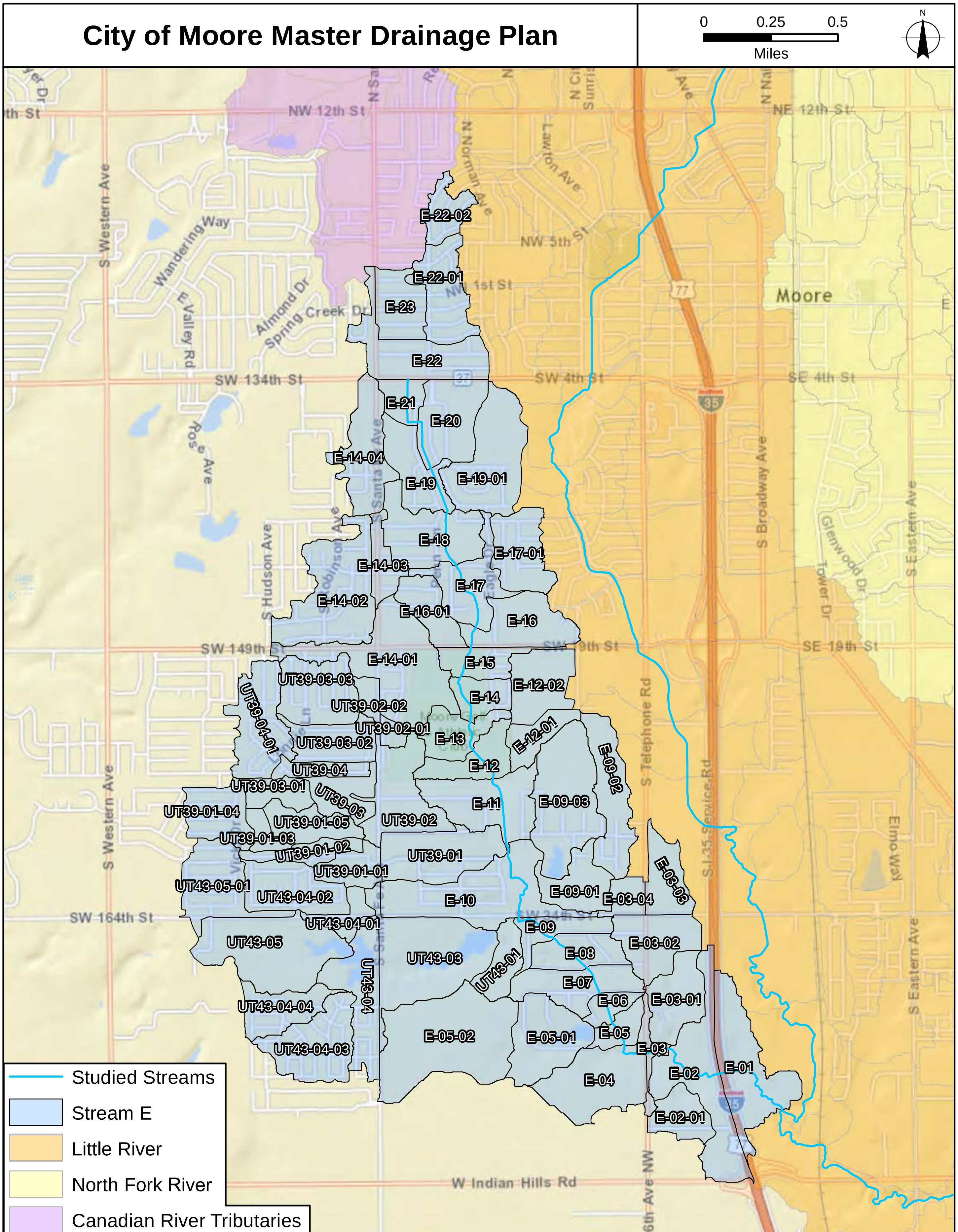
The Stream E Watershed is a tributary of the Little River, and consists of approximately 2.66 square miles of drainage area which is generally located between Western Avenue and Interstate 35, north of Indian Hills Road and south of Northwest 10th Street. Stream E generally flows north to south and west to east to discharge into the Little River. The Stream E Watershed is divided into 68 sub-basins which are depicted in **FIGURE 4-1.**

The hydrologic soil groups are shown in **FIGURE 4-2** with the existing land use depicted in **FIGURE 4-3.** More information on the hydrologic methodology can be found in **SECTION 2.1 HYDROLOGIC ANALYSIS**.

The hydrologic coefficients used for input in the HEC-HMS model include the lag time, soil complex curve number (CN) and drainage area. The HEC-HMS schematic, showing the connectivity of the hydrologic elements, can be found in **FIGURE 4-4** with more detailed HEC-HMS schematics provided in **APPENDIX 4-A**. A summary of hydrologic coefficients is presented in **TABLE 4-1**.

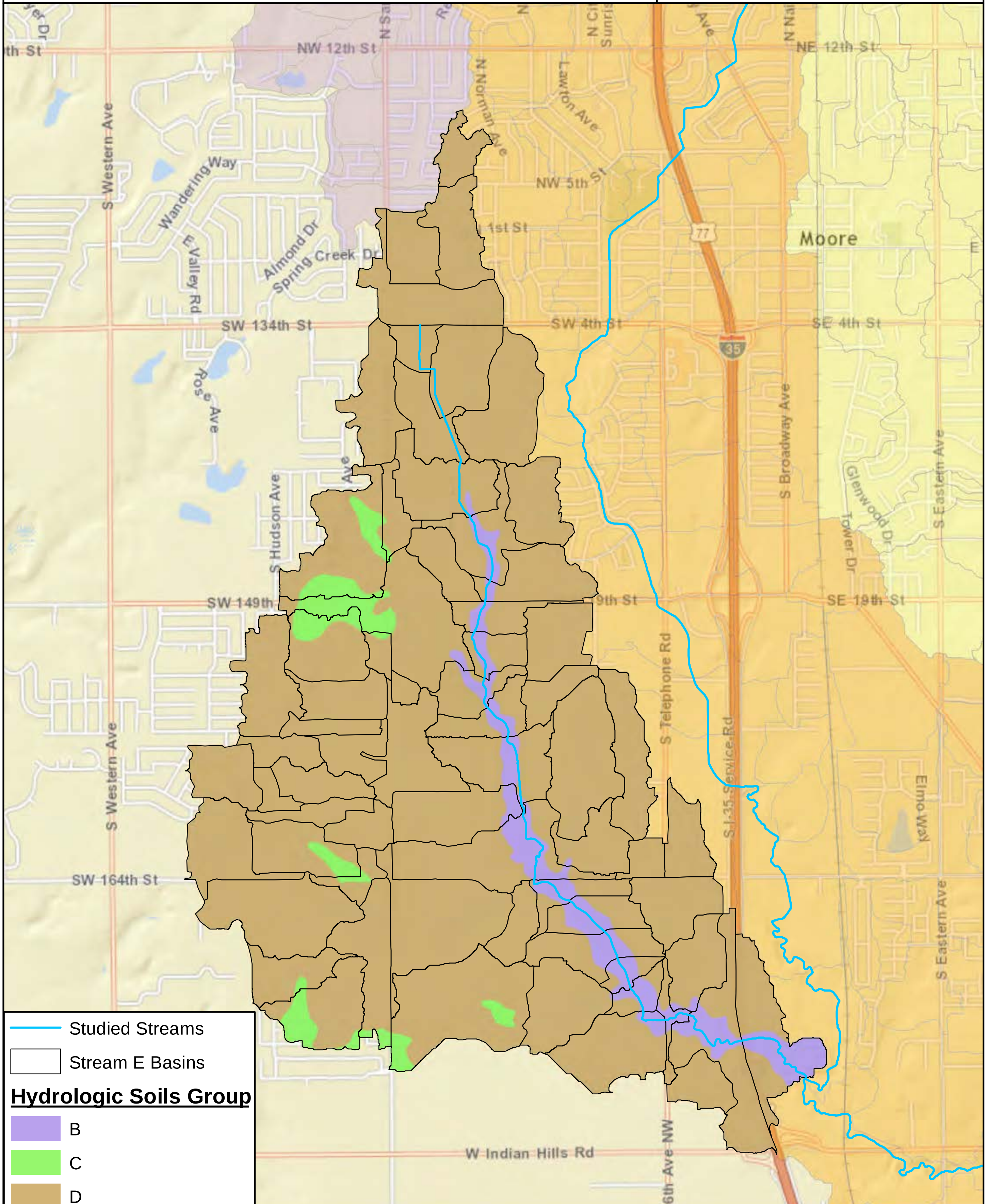
The flowrates for existing conditions for Stream E Drainage Basins were developed using HEC-HMS. A list of the flowrates at major junctions for the existing conditions is presented in **Table 4-2**.

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA 1893	**Stream E Drainage Basins**	MESHEK & ASSOCIATES, PLC 1437 S Boulder Ave, Suite 1550 Tulsa, OK 74119 Ph:(918) 392-5620 www.meshekengr.com	**Figure 4 - 1**

City of Moore Master Drainage Plan



Stream E
Hydrologic Soils Group

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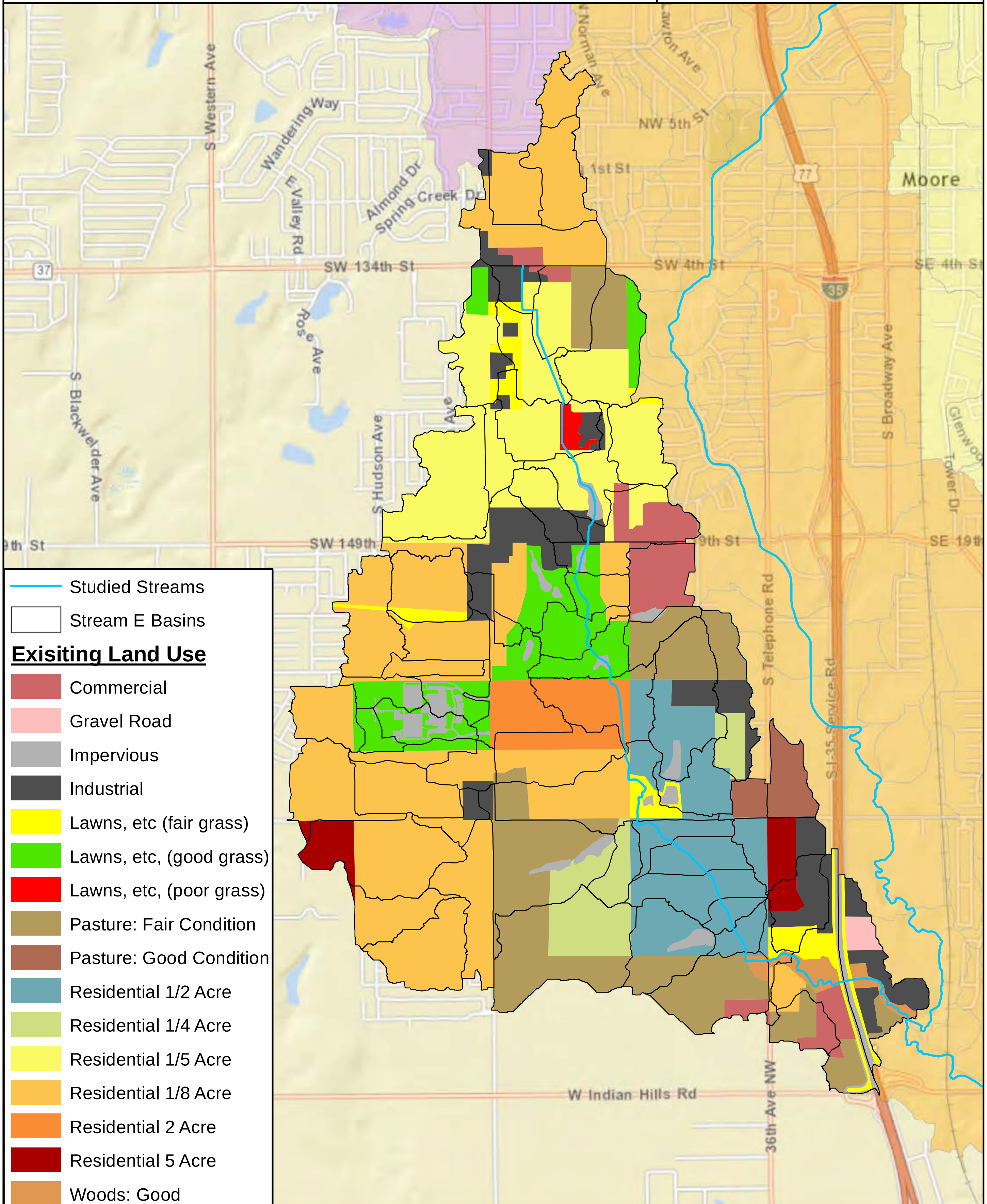
Figure 4 - 2

City of Moore Master Drainage Plan

0 0.25 0.5
Miles



CITY of MOORE OKLAHOMA

Stream E
Existing Land Use

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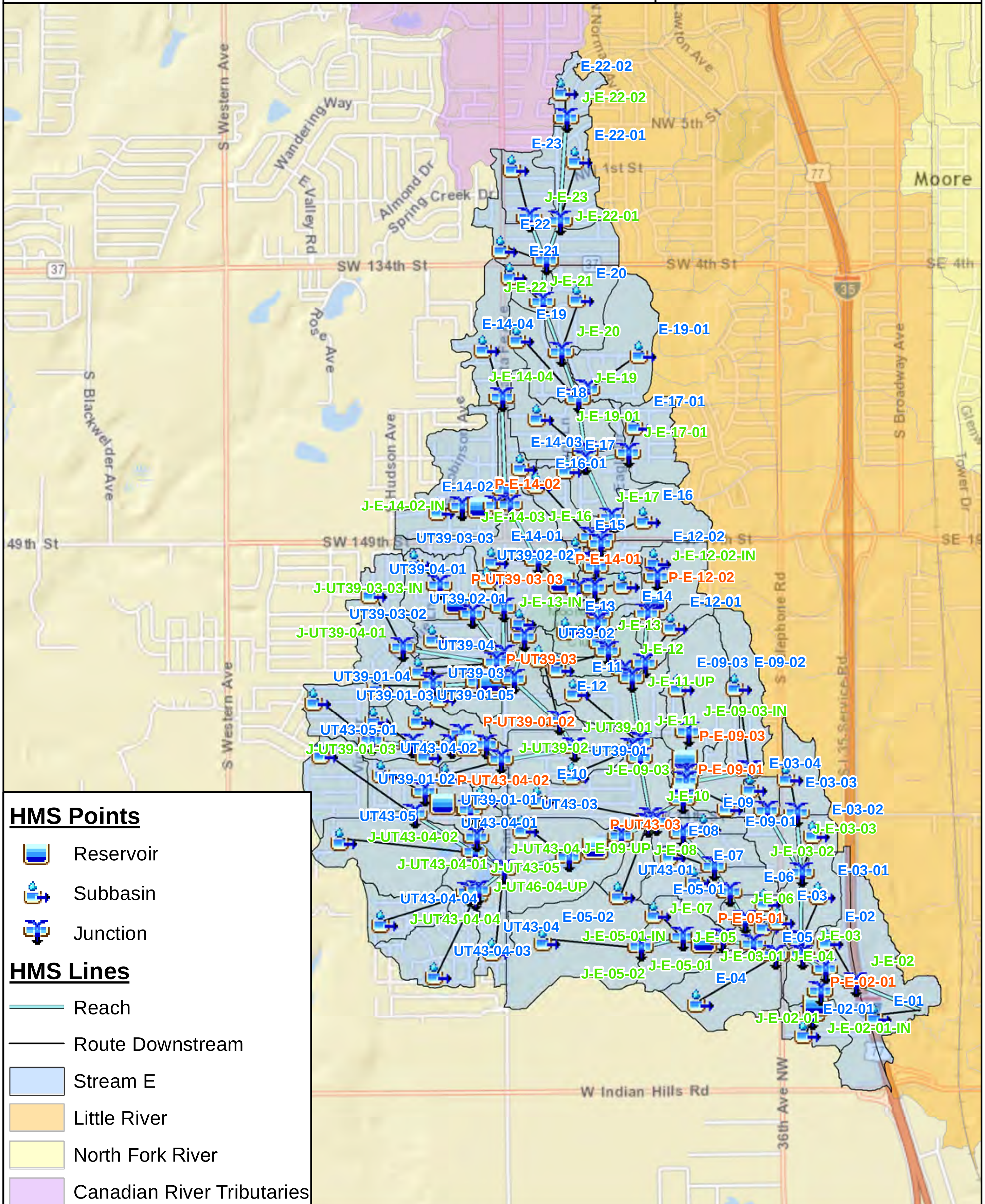
Figure 4 - 3

City of Moore Master Drainage Plan



City of Moore, Oklahoma	**Stream E** **HEC-HMS Schematic**	MESHEK & ASSOCIATES, PLC 1437 S Boulder Ave, Suite 1550 Tulsa, OK 74119 Ph:(918) 392-5620 www.meshekengr.com	**Figure 4 - 4**

TABLE 4-1. STREAM E DRAINAGE BASINS SUMMARY OF HYDROLOGIC COEFFICIENTS FOR EXISTING CONDITIONS

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
E-01	85.9	13.9	62.4	0.10
E-02	83.9	15.3	68.1	0.11
E-02-01	88.6	6.6	22.2	0.03
E-03	78.4	5.4	9.5	0.01
E-03-01	88.3	10.1	34.0	0.05
E-03-02	85.7	14.3	38.0	0.06
E-03-03	80.1	12.2	26.7	0.04
E-03-04	80.5	5.7	12.2	0.02
E-04	83.2	27.9	53.7	0.08
E-05	77.4	4.2	13.6	0.02
E-05-01	85.9	9.0	46.8	0.07
E-05-02	84.7	28.0	98.9	0.15
E-06	76.2	5.9	10.9	0.02
E-07	81.3	13.5	35.3	0.06
E-08	79.3	7.6	26.2	0.04
E-09	79.8	10.1	18.9	0.03
E-09-01	85.9	16.7	29.2	0.05
E-09-02	88.9	35.0	43.7	0.07
E-09-03	86.8	23.5	70.5	0.11
E-10	85.6	19.2	76.4	0.12
E-11	80.1	13.5	51.1	0.08
E-12	78.2	3.6	26.0	0.04
E-12-01	84.2	16.1	18.9	0.03
E-12-02	95.0	6.6	35.9	0.06
E-13	77.0	7.3	24.5	0.04
E-14	80.0	6.1	18.4	0.03
E-14-01	88.9	10.1	84.0	0.13
E-14-02	88.2	17.8	73.6	0.12
E-14-03	89.0	8.1	16.2	0.03
E-14-04	87.7	13.4	44.3	0.07
E-15	88.1	22.0	20.7	0.03
E-16	92.9	16.1	40.0	0.06
E-16-01	90.7	18.7	24.0	0.04
E-17	89.4	10.5	37.7	0.06
E-17-01	88.8	15.2	36.2	0.06
E-18	88.9	19.5	50.8	0.08
E-19	88.0	24.5	32.9	0.05
E-19-01	85.1	25.6	73.5	0.11
E-20	87.6	14.7	43.4	0.07
E-21	91.5	6.9	14.9	0.02
E-22	92.5	18.6	51.0	0.08
E-22-01	92.0	17.0	39.6	0.06
E-22-02	92.0	12.7	18.3	0.03
E-23	92.0	30.4	28.9	0.05

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
UT39-01	86.3	13.5	50.0	0.08
UT39-01-01	91.4	11.7	19.0	0.03
UT39-01-02	87.8	14.7	16.1	0.03
UT39-01-03	81.1	29.9	9.5	0.01
UT39-01-04	90.8	18.0	30.9	0.05
UT39-01-05	88.0	17.1	24.2	0.04
UT39-02	83.0	8.9	47.9	0.07
UT39-02-01	87.4	2.4	6.1	0.01
UT39-02-02	92.7	14.5	8.3	0.01
UT39-03	87.6	13.5	22.7	0.04
UT39-03-01	86.3	15.7	17.4	0.03
UT39-03-02	91.8	20.3	30.1	0.05
UT39-03-03	90.3	14.7	43.1	0.07
UT39-04	92.0	6.4	13.3	0.02
UT39-04-01	91.7	19.8	47.2	0.07
UT43-01	86.6	13.3	20.1	0.03
UT43-03	85.9	4.8	61.6	0.10
UT43-04	91.8	12.6	45.4	0.07
UT43-04-01	92.1	8.0	12.9	0.02
UT43-04-02	91.7	11.6	40.6	0.06
UT43-04-03	91.5	14.2	48.8	0.08
UT43-04-04	91.7	12.9	28.9	0.05
UT43-05	89.4	28.0	76.0	0.12
UT43-05-01	91.7	19.6	44.1	0.07

TABLE 4-2. STREAM E DRAINAGE BASINS – EXISTING FLOWRATES AT MAJOR JUNCTIONS (CFS)

Description	HMS Junction	Stream	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year	Drainage Area, mi^2
SW 4th Street	J-E-22	Stream E	181	218	314	391	492	570	650	853	0.22
SW 5th Street	J-E-21	Stream E	169	185	307	400	510	578	661	886	0.24
SW 8th Street	J-E-20	Stream E	197	214	289	409	568	653	728	992	0.31
SW 14th Street	J-E-18	Stream E	321	377	528	647	852	1048	1200	1658	0.54
SW 19th Street	J-E-16	Stream E	400	479	689	848	1054	1255	1516	2209	0.76
Unnamed Trib 39	J-E-10-UP	Stream E	617	773	1136	1484	2102	2578	3099	4945	2.04
SW 34th Street	J-E-10	Stream E	655	814	1222	1610	2317	2825	3404	5750	2.39
Unnamed Trib 43	J-E-09-UP	Stream E	743	946	1516	2138	3140	3815	4546	7449	2.97
SW 38th Street	J-E-08	Stream E	744	940	1514	2145	3153	3840	4572	7443	3.04
SW 40th Street	J-E-07	Stream E	746	944	1521	2157	3175	3868	4606	7503	3.09
S Telephone Rd	J-E-04	Stream E	769	975	1610	2314	3411	4276	5046	8065	3.43
Interstate 35	J-E-02	Stream E	817	1016	1672	2403	3480	4390	5226	8120	3.75
Little River	J-E-01	Stream E	825	1029	1690	2416	3486	4324	5256	7896	3.85

4.3. Existing Conditions Hydraulics

The Stream E Watershed consists of 3.8 stream miles of hydraulic study. Stream E was modeled using GeoHEC-RAS software to develop bridge\culvert capacities, water surface profiles, and floodplains. More information on the hydraulic methodology can be found in **Section 2.2 Hydraulic Analysis**.

Figure 4-5 illustrates the location of the studied bridges and/or culverts and the capacity associated with updated existing condition flowrates.

Appendix 4-B shows the water surface profiles for existing conditions for the 10-year, 25-year, 50-year, 100-year, and 500-year storm events.

Appendix 4-C shows the updated City of Moore regulatory 100-year and 500-year floodplains and floodway which terminate at the limit of the hydraulic study, shown on the exhibit.

City of Moore Master Drainage Plan

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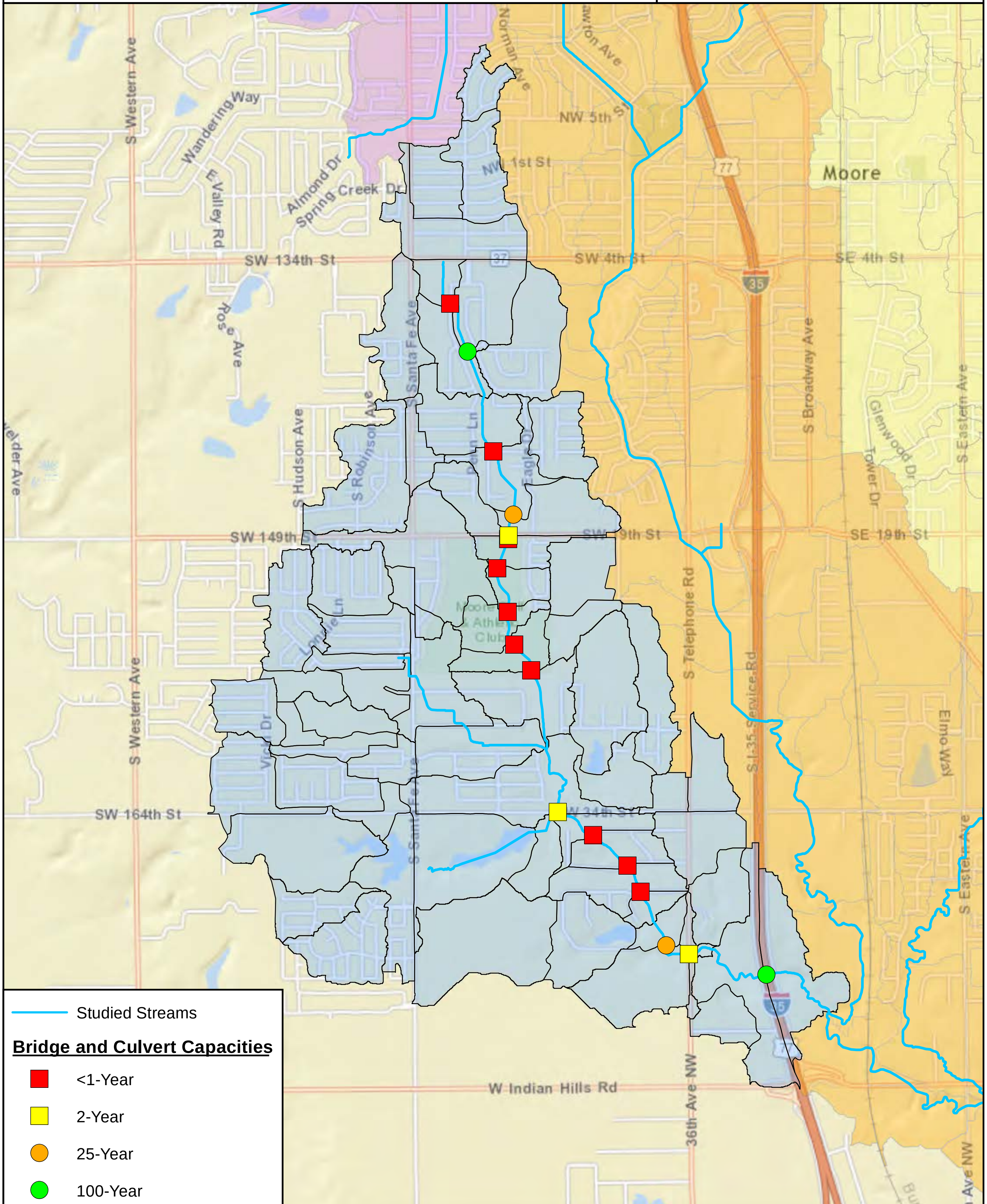

CITY of MOORE OKLAHOMA

Stream E
Bridge & Culvert Capacities

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Figure 4 - 5

4.4. Problem Areas

The flooding problems areas identified in the Stream E Drainage Basins are based on flooding comments and observations received from community residents, City of Moore staff, and Meshek & Associates. The location of these problem areas are shown in **Figure 4-6, Figure 4-7** and **Figure 4-8**, and are labeled according to the GIS-ID problem area numbers and descriptions below. Unless noted otherwise, all problem area comments generally refer to flooding and drainage problems observed in the May 5-8, 2015 storm events.

A. Problem Area 1: S Telephone Rd Crossing Stream E

Private property residents adjacent to Stream E, located immediately upstream of the S. Telephone Road crossing, observed piles of soil and/or gravel placed in the Stream E floodplain on the north side of Stream E directly east of S. Telephone road. Based on historic aerial photography, the piles began to appear around 2007 to 2008 (GIS ID-124).

The City of Moore suggested Stream E should be channelized and cleared of tree/bush vegetation from a section immediately upstream of S Telephone Road crossing to the Interstate 35 crossing (GIS ID-1021).

A private residential property located at 4209 S Telephone Road had flooding in the yard. The property owner sites the cause of flooding originates from soil piles (noted above), increase in run-off from a new apartment complex, located at the southeast corner of the S. Telephone Road and Stream E crossing, and the inadequate capacity of the natural open-channel geometry and vegetation (GIS ID-120).

A private residential property located at 4201 S. Telephone Road had flooding in the backyard. The flooding also carried an outbuilding or shed downstream (GIS ID-153).

B. Problem Area 2: Stream E at SW 38th St Crossing

The existing SW 38th Street culvert crossing Stream E under consists of approximately 45 linear feet of triple 10 feet wide by 6 feet tall reinforced concrete box (RCB). The existing structure has a hydraulic capacity less than the 1-year frequency storm event. During a 10-year storm event, SW 38th Street roadway would be overtopped by 2.48 feet and during a 100-year storm event, SW 38th Street roadway would be overtopped by 4.76 feet (GIS ID-1022).

C. Problem Area 3: Stream E & SW 34th Street & Private Driveway Bridge

A private residential property located at 1604 SW 35th Street had flooding in yard (GIS ID-121). The property owner has observed high discharge flows through Stream E that are eroding banks and threatening trees and driveway bridges (GIS ID-121 & ID-5).

A private residential property located at 1621 SW 35th Street had flooding inside of the residential structure (GIS ID-122).

A private residential property owner observed an approximate water depth of 4 feet near mailboxes at the end of the SW 35th Street cul-de-sac during the May 2015 storms and flooding (GIS ID-123).

The existing SW 34th Street culvert crossing Stream E consists of approximately 69 linear feet of triple 12 feet wide by 7 feet tall reinforced concrete box (RCB). The existing structure has a hydraulic capacity of a 2-year frequency storm event. During a 10-year storm event, SW 34th Street roadway would be overtopped by 1.65 feet and during a 100-year storm event, SW 34th Street roadway would be overtopped by 2.95 feet (GIS ID-1009).

D. Problem Area 4: Stream E & Eagle Dr

A private residential property located at 1005 Eagle Drive had flooding inside of the residential structure (GIS ID-160).

E. Problem Area 5: Stream E Channel & Storm Sewer from W Main St to SW 4th St

The City of Moore and private residential property owners located around the Stream E concrete channel and storm sewer from W Main St to SW 4th St have reported flooding in yards and roadways (GIS ID-12, ID-1010, & ID-1012). A private residential property owner located at 1029 SW 2nd St has also observed the concrete channel to have an inadequate slope as there is typically ponded water in the base. The property owner has also had flooding in an automotive vehicle parked next to a flooding concrete channel (GIS ID-12).

F. Problem Area 6: N Santa Fe Ave & N Markwell Ave

The City of Moore and local private residential property owners have observed roadway flooding on N Santa Fe Avenue from NW 12th Street to SW 4th Street and on N Markwell Avenue from NW 5th Street to SW 4th Street (GIS ID-9, ID-17, ID-18, ID-1001, ID-1023).

G. Problem Area 7: Intersection of SW 31st St and S Santa Fe Ave to Oak Dr

The City of Moore and several private residential property owners, located on Oak Drive, Maple Lane, and SW 31st to the intersection with S Santa Fe Avenue, have reported severe flooding in roadways, yards, and residential structures (GIS ID-102:119). A detention pond, located on the southeast corner of the Southmoore High School property and adjacent to residential structures on Oak Drive overtopped and discharged through the southern spillway. Additionally, storm sewer systems may have surcharged into roadways due to the high water surface elevation in the detention pond. It appears spillway discharge and a storm sewer system with an inadequate hydraulic capacity were the causes of flooding in the area.

H. Problem Area 8: Oak Drive & Pin Oak Road

A private residential property located at 2125 Oak Drive had flooding in the backyard (GIS ID-151). The owner noted an installed private drainage system barely possessed the hydraulic capacity for surface runoff from the storms in May of 2015. Ground topography indicates the area has a relatively flat slope for drainage.

I. Problem Area 9: Detention Pond at Pin Oak Rd & SW 34th St

A private residential property owner observed a residential detention pond overtopping SW 34th Street roadway approximately 800 feet east of the intersection of Pin Oak Road and SW 34th Street (GIS ID-152). The hydrology model indicates the detention pond does not overtop until a 500-year frequency storm event.

J. Problem Area 10: SW 19^{th} St & S Santa Fe Ave Commercial Complex

A private residential property owner observed a low point or sump on a commercial access roadway where storm water ponds, located behind 2017 SW 19^{th} Street on the southwest corner of the SW 19^{th} Street and S Santa Fe Avenue intersection (GIS ID-10).

K. Problem Area 11: Ridgeway Drive & Moore Cemetery

A private residential property owner, located at 1000 Ridgeway Drive, had observed backyard flooding and surface runoff originating from Moore Cemetery discharging in a grass lined channel behind the residential properties on the west side of Moore Cemetery. Ground topography indicates the grass lined open-channel along the western property line of Moore Cemetery has a relatively flat slope (GIS ID-50).

L. Problem Area 12: Intersection of Plaza Dr and SW 5^{th} St

A private residential property owner, located at 604 Plaza Drive, observed roadway flooding near the intersection of Plaza Drive and SW 5^{th} Street (GIS ID-170).

City of Moore Master Drainage Plan

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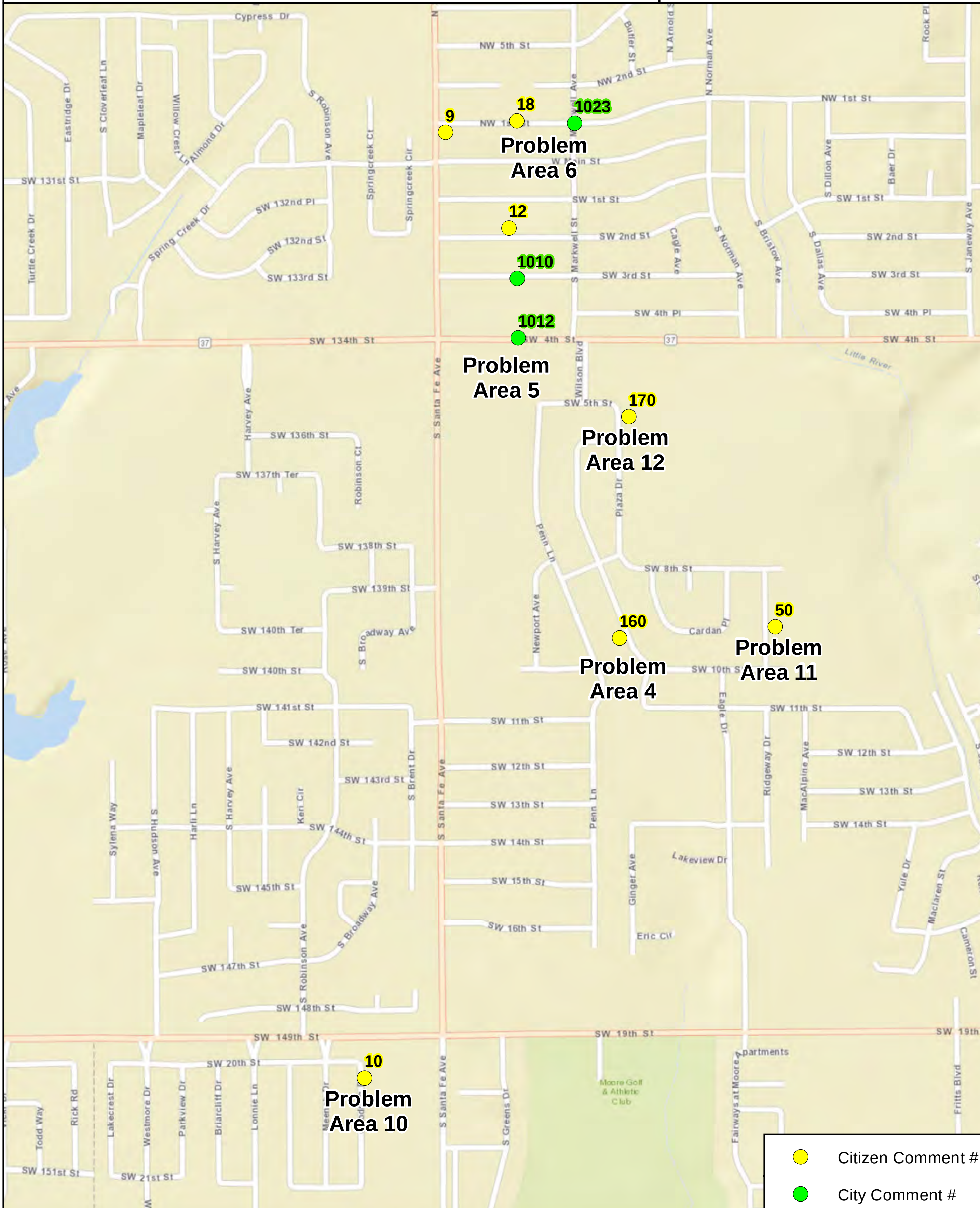
Feet



Stream E Problem Areas

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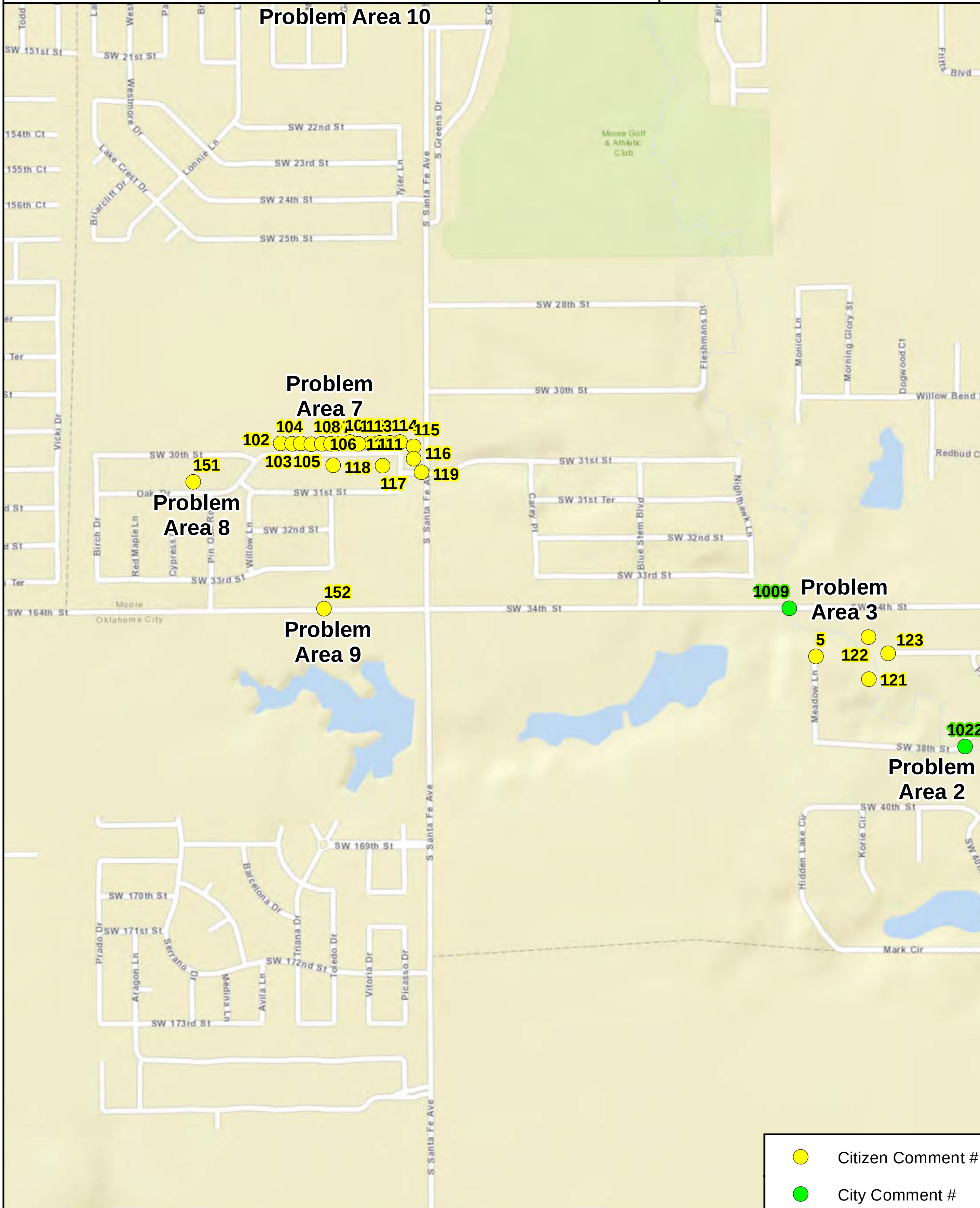
Figure 4 - 6

City of Moore Master Drainage Plan

0 500 1,000
Feet



Stream E
Problem Areas

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Figure 4 - 7

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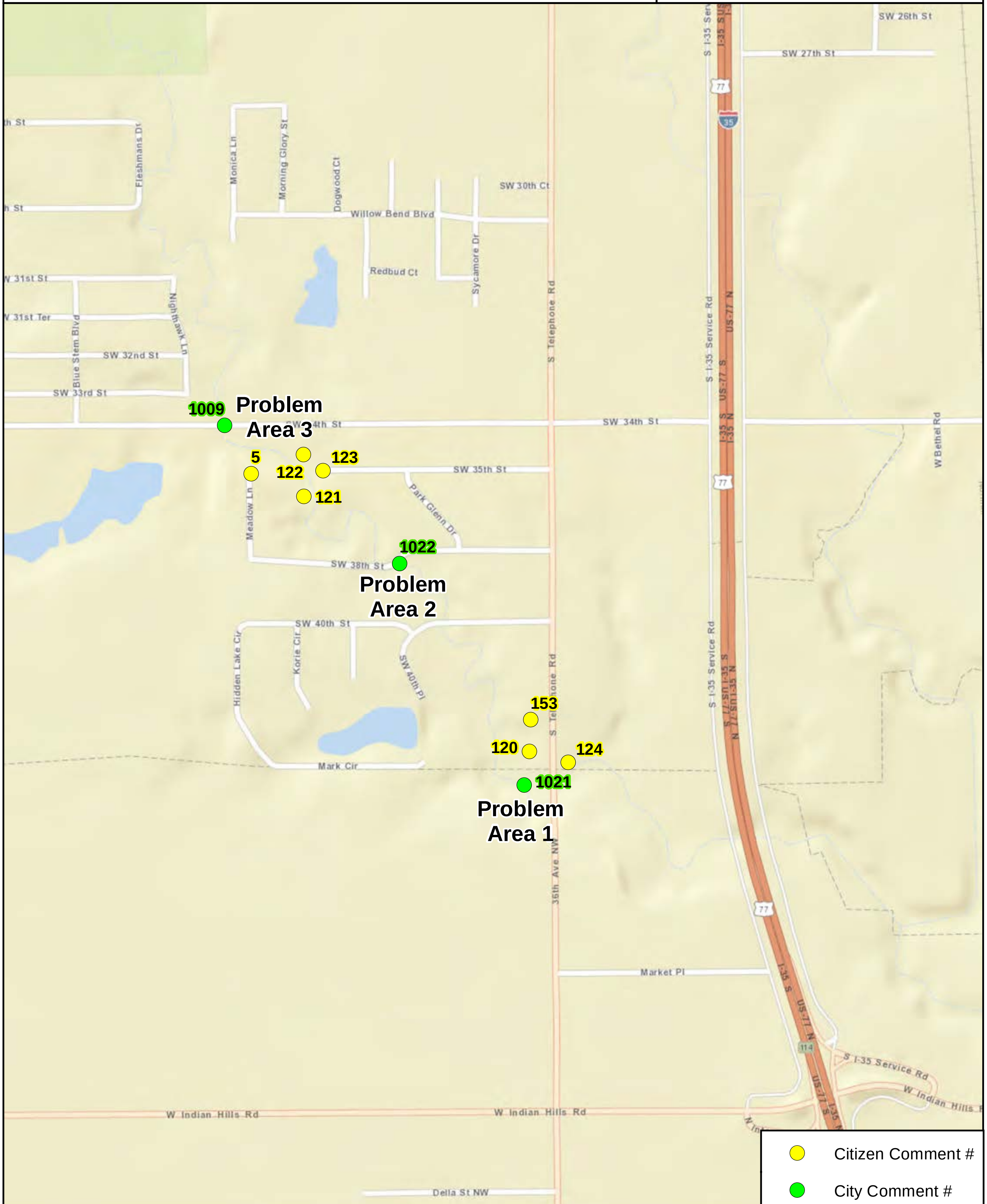

Stream E Problem Areas

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Figure 4 - 8

4.5. EVALUATION OF ALTERNATIVE AND RECOMMENDATIONS

Alternatives and recommendations for mitigating flooding problems may consist of channelization, increasing culvert structure capacity through replacement or enlargement, creating detention pond facilities, or increasing storm sewer system capacity through replacement or new system construction. It's important to note that when alternatives and recommendations given in this master drainage plan proceed to design documents, the design should be hydrologically and hydraulically analyzed in further detail prior to constructing any improvements described in this section. The alternatives and recommendations in this master drainage plan are given as plausible concepts and an additional detailed study of the design would prevent increases in water-surface elevations and floodplains or cause flooding in other areas. The alternatives and recommendations for the problem areas are defined as follows:

A. Problem Area 1: S Telephone Rd Crossing Stream E

The apartment complex, located at southeast corner of the S Telephone Road and Stream E crossing, does have some free release of storm-water runoff to Stream E downstream of S Telephone Road. However, the majority of the apartment complex does appear to drain to a detention pond, located at the southeast corner of the property. The detention of the storm-water runoff from the apartment complex should account and offset for the impervious development.

The private residential properties located at 4201 and 4209 S Telephone Road, are currently located within the 100-year floodplain. We expect these properties to have flooding in various storm frequency events.

Alternative – Construct Channelized Stream Segment. The Stream E channel between S Telephone Road and Interstate 35 could remain in a natural state with existing channel meanders and vegetation. This will give the stream additional storage capacity, erosion protection, and prevent possible downstream flooding. The City of Moore requested a design for trapezoidal channel dimensions should the city choose to channelize the stream segment. The existing Stream E channel segment between S Telephone Road and Interstate 35 approximately contains the 5-year storm event with a peak discharge of 1672 cubic feet per second. In order to achieve a similar hydraulic capacity, the dimensions of the channel should have an approximate 8.5 foot minimum depth, 17 foot minimum bottom width, and minimum 3:1 (H:V) side slopes. A Manning's 'n' value of 0.04 and a slope of 0.0018 foot per foot were assumed in hydraulic calculations.

Recommendation – Remove Piles of Fill in Floodplain. This alternative would consist of removing piles of unknown soil/gravel fill material placed within the floodplain of Stream E, located on the north side of Stream E just east of S Telephone Road.

The locations of the proposed improvements are shown in **FIGURE 4-9**. Due to the variability of the scope, a cost estimate was not prepared at this time.

B. Problem Area 2: Stream E & SW 38th St Crossing

In an attempt to size a larger SW 38th Street culvert crossing over Stream E, Meshek has determined the necessary size of a culvert required to pass a given storm event while not causing a rise in the 100-year water-surface elevation is impractical. Out of several sizes hydraulically modeled, the largest was a quadruple 20 foot wide by 15 foot tall RCB structure which would require raising the roadway profile by 9 feet, and would still cause a significant upstream increase in the 100-year storm water-surface elevation and floodplain.

An alternative to increasing the structure size would be to create additional upstream detention pond facilities to reduce the peak discharge to SW 38th Street. However, nearly all land upstream of the SW 38th Street that contributes a significant impact to the peak discharge at SW 38th Street is already developed and would require significant private or commercial property acquisition.

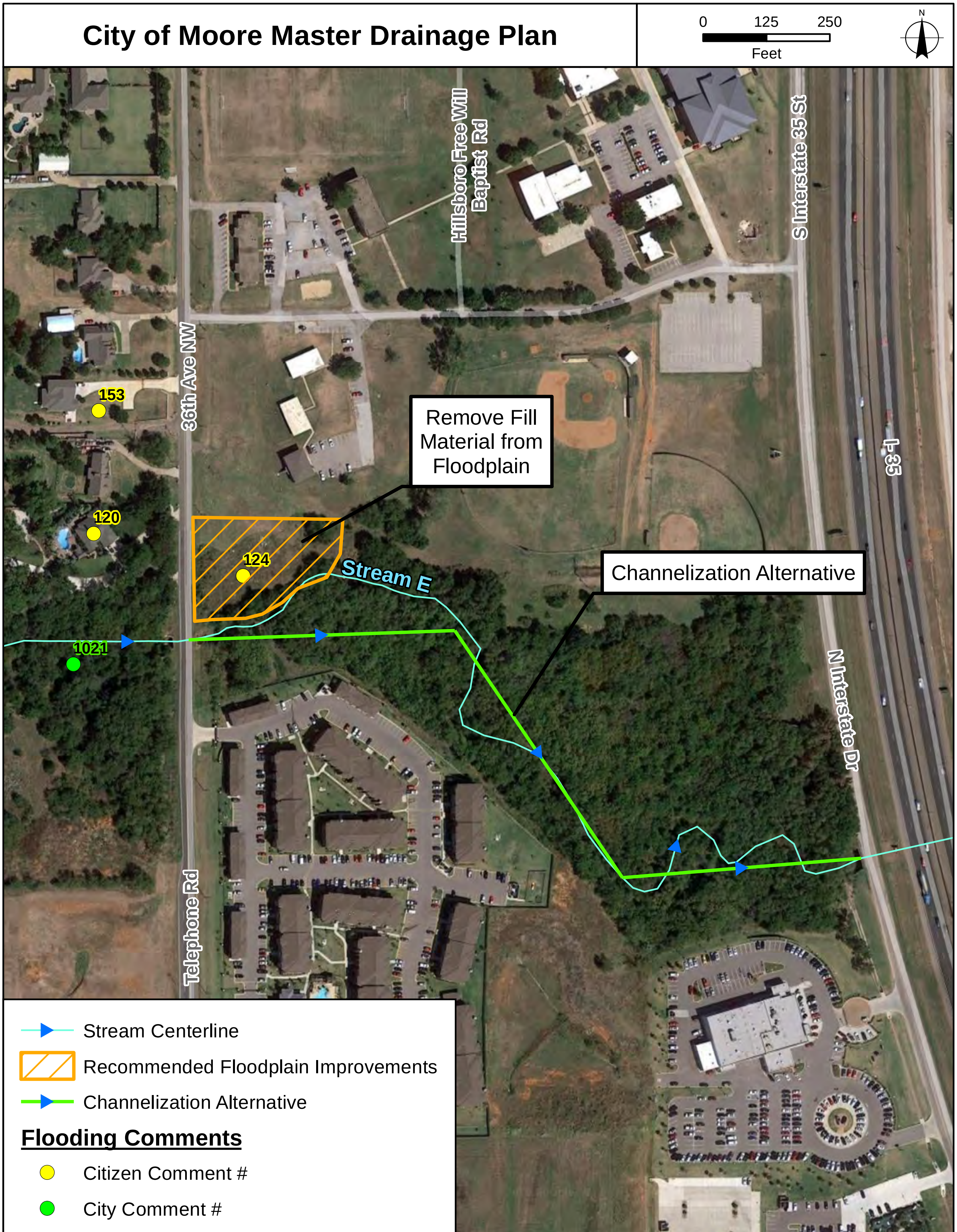
C. <u>Problem Area 3: Stream E & SW 34th Street & Private Driveway Bridge</u>

In an attempt to size a larger SW 34th Street culvert or bridge crossing over Stream E, Meshek has determined the necessary size of a culvert or bridge required to pass a given storm event while not causing a rise in the 100-year water-surface elevation is impractical. Out of several sizes hydraulically modeled, the largest was a 150 foot length slab span bridge structure which would require raising the roadway profile by 5 feet, and would still cause a significant upstream increase in the 100-year storm water-surface elevation and floodplain.

An alternative to increasing the structure size would be to create additional upstream detention pond facilities to reduce the peak discharge to SW 34th Street. However, nearly all land upstream of the SW 34th Street that contributes a significant impact to the peak discharge at SW 34th Street is already developed and would require significant private or commercial property acquisition.

The yard of the private residential property located at 1604 SW 35th Street, currently located within the 100-year floodplain. We expect the yard of this property to have flooding in various storm frequency events. The private residential property located at 1621 SW 35th Street, currently located within the 100-year floodplain. We expect the property to have flooding in various storm frequency events.

City of Moore Master Drainage Plan



Stream E
Problem Area 1: Recommendation

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Figure 4 - 9

D. Problem Area 4: Stream E & Eagle Dr

The private residential property, located at 1005 Eagle Drive, is currently located within the 100-year floodplain of Stream E. However, the residential structure will be removed from the corrected effective existing 100-year floodplain of the Stream E created in this master drainage plan study. We expect the backyard of this property to have flooding in various storm frequency events.

E. Problem Area 5: Stream E Channel & Storm Sewer from W Main St to SW 4th St

City of Moore officials expressed they possessed a preliminary design to replace the Stream E concrete open-channel and storm sewer system between NW 1st Street and SW 4th Street. The complete details of the preliminary design were not disclosed, however in light of this master drainage plan having a detailed hydrology model, Meshek has provided an approximated design for replacement of the concrete channel or alternate storm sewer system pipe size. A 1:0 (H:V) side slopes, a Manning's 'n' value of 0.013, and a flowline slope of 0.0058 foot per foot were assumed in hydraulic design calculations of the concrete open-channel. A velocity of 6 feet per second was assumed in hydraulic design calculations of the storm sewer.

Roadway Crossing	Storm Frequency	Discharge (cfs)	Design Concrete Open-Channel Size	Design Street Culvert Size	Design Storm Sewer Size
NW 1st Street	100-Year	23.1	4' Width x 1' Depth		30" RCP
W Main Street	100-Year	46.7	5' Width x 1.5' Depth	5' x 1.5' RCB	42" RCP
SW 1st Street	100-Year	93.4	5.5' Width x 2' Depth	5.5' x 2' RCB	54" RCP
SW 2nd Street	100-Year	122.6	6.5' Width x 2' Depth	6.5' x 2' RCB	60" RCP
SW 3rd Street	100-Year	169.7	5.5' Width x 3' Depth	5.5' x 3' RCB	72" RCP
SW 4th Street	10-Year	391		14' x 5' RCB	14' x 5' RCB

The locations of the proposed improvements are shown in **FIGURE 4-10**. Due to the variability of the scope, a cost estimate was not prepared at this time.

F. Problem Area 6: N Santa Fe Ave & N Markwell Ave

The City of Moore, within the period of this master drainage study, completed a roadway full-depth pavement rehabilitation, in which sections of N Markwell Avenue between NW 5th Street and SW 4th Street were paved in concrete. This recent pavement rehabilitation should be observed during storm events to gage the effectiveness of the newly constructed roadway to solve the drainage and flooding problems in the area. If the new roadways do not prove effective in draining surface runoff, then additional storm sewer system may be necessary to provide adequate drainage capacity to the problem areas listed.

S. Santa Fe Avenue between NW 12th Street and SW 4th Street has an acceptable slope for capacity of the roadway discharge. It is unclear from the flooding comment as to the exact locations of and extent of flooding. The roadway gutters are designed to carry roadway discharge in the right-hand lane of each direction of travel. There are some storm sewer systems on S. Santa Fe Avenue, however the system size and hydraulic capacity may need to be increased.

G. Problem Area 7: Intersection of SW 31st St and S Santa Fe Ave to Oak Dr

Pryor to performing final study and planning of a storm sewer solution, a complete storm sewer system observation and assessment should be performed on the existing network from the Oak Ridge subdivision through the Bluestem Ridge subdivision.

Recommendation – Construct Berm & Parallel Storm Sewer System & Increase Storage Volume. This recommendation would consist of constructing a berm adjacent to private residential properties on the north side of Oak Drive and the east side Maple Lane, increasing the storage volume of the detention pond, creating a spillway towards S Santa Fe Avenue, and adding a parallel storm sewer system. The existing storm sewer system leading from the detention pond has an approximate 1-year storm capacity, however the remaining storm sewer system downstream has an approximate 25-year storm capacity. The re-designed pond should have a 100-year water-surface elevation of 1206.0 feet, a new spillway discharging east towards S Santa Fe Avenue at an elevation of 1206.0 feet, a 500-year water-surface elevation of 1207.0 feet, and a top of pond elevation of 1208.0 feet. The berm should be constructed adjacent to the private property fence line from 2021 Oak Drive east and turning south along S Santa Fe Avenue to 3104 Maple Lane, approximately 1,300 linear feet. The berm should be constructed to adequately act as a pond's embankment to contain storm water while having 3:1 (H:V) side slopes. The top of berm should be constructed to match the top of pond elevation, 1208.0 feet. Since the 500-year water-surface should be designed to not be higher than elevation 1207.0 feet, this will give the pond a 1 foot of vertical freeboard safety factor. The parallel storm sewer system would consist of approximately 360 linear feet, or less if the pond was extended east, of a 36 inch diameter RCP. The new parallel storm sewer line would match existing invert elevations and extend from the detention pond and tie into the existing storm sewer line on the east side of S Santa Fe Avenue. When the proposed parallel storm sewer system is combined with the existing storm sewer system, the total system should have the ability to convey the 100-year storm event from the detention pond. The existing detention pond should be expanded, primarily towards the east, to increase the total storage volume in the pond approximately from 21.5 acre-feet to 34 acre-feet at elevation 1208.0 feet. The pond should have a new spillway at elevation 1206.0 feet, discharging east into S Santa Fe Avenue. The spillway should only be utilized by the 500-year storm event and this new spillway and berm should prevent flooding into private residential properties located in the Oak Ridge subdivision on the south side of the detention pond. Also, the existing storm sewer line on Oak Drive with a trench inlet, located directly south of the detention pond, should also be redesigned to prevent static flow or backflow from the detention pond when the detention pond has a significant water surface elevation. A backflow prevention valve or gate should be installed on the storm sewer system. This will cause roadway discharge on Oak Drive to continue east towards Maple Lane and Santa Fe Avenue when the water surface of the pond becomes higher than the water-surface of roadway discharge on Oak Drive.

The locations of the proposed improvements are shown in **FIGURE 4-11**. The cost for the Recommendation is estimated at $650,200 and is detailed in **APPENDIX 4-D**.

City of Moore Master Drainage Plan

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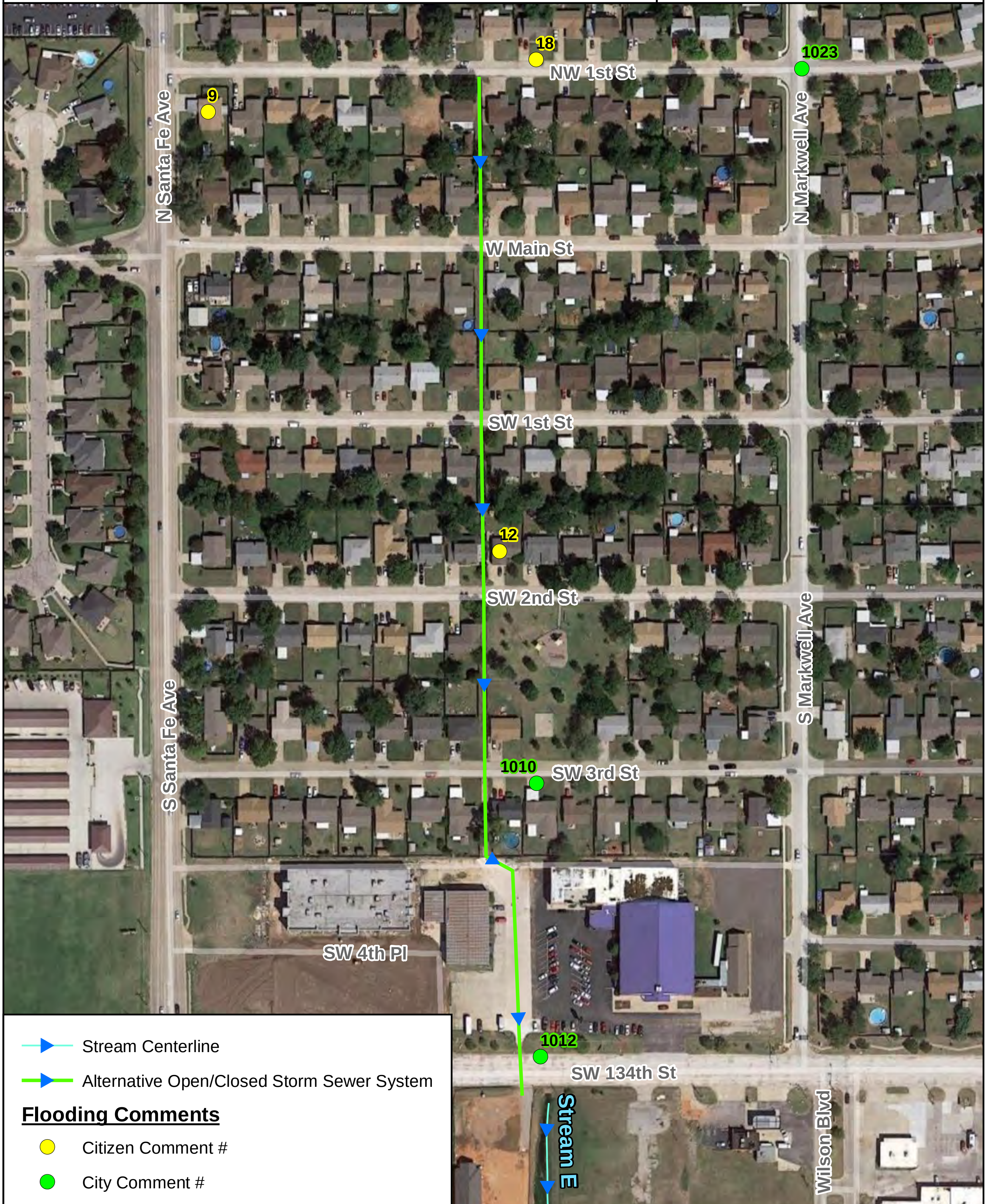

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Stream E
Problem Area 5: Alternative

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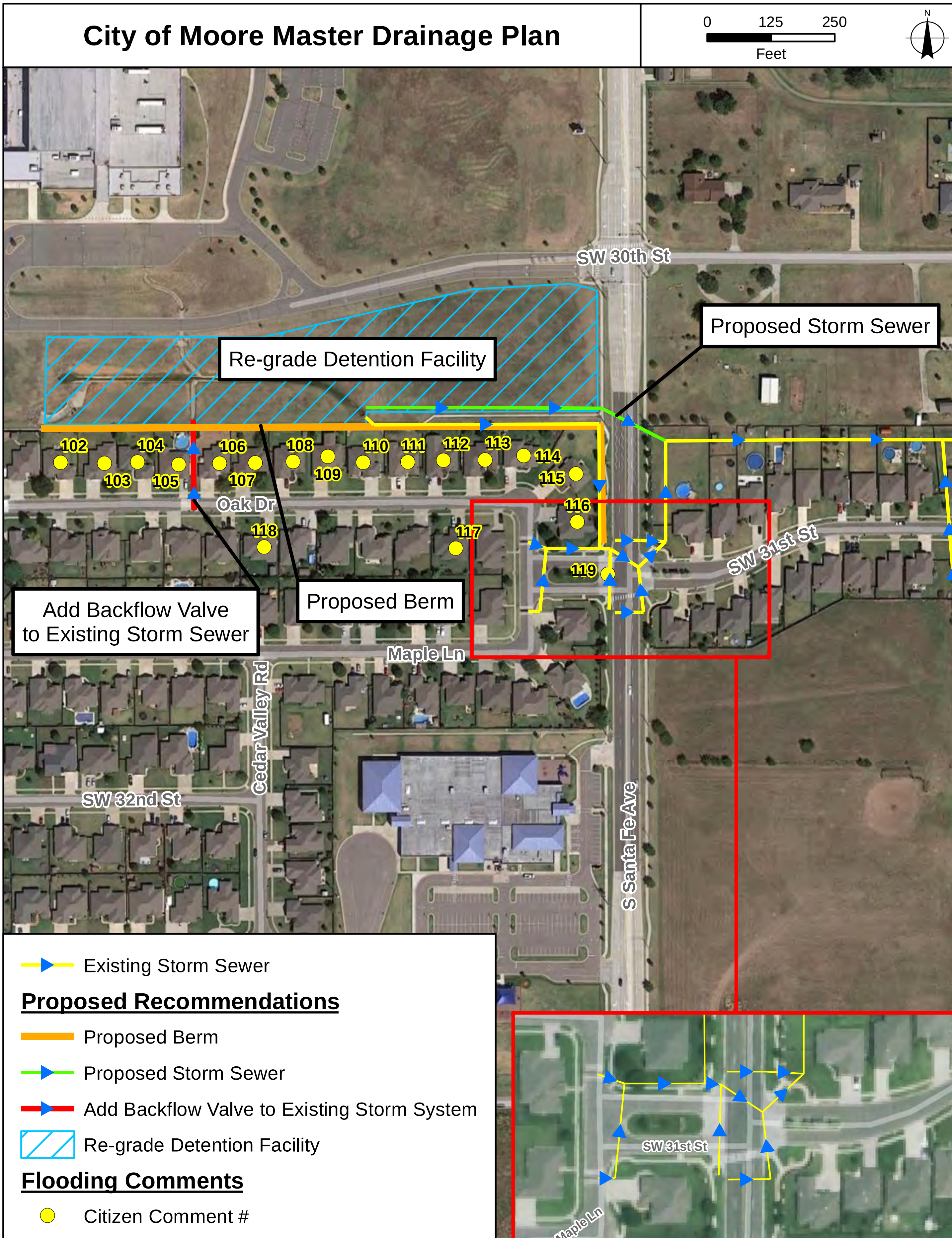
Figure 4 - 10

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA

Stream E
Problem Area 7: Recommendation

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Figure 4 - 11

H. Problem Area 8: Oak Drive & Pin Oak Road

The residential property with flooding in backyard, located at 2125 Oak Drive, appears to be caused by flat ground topography on private property. Due to the flooding problem being caused by topography on private property and not on public property, the City of Moore is not responsible for the flooding issues. The residential property owner should keep the private drainage system clean of debris and sediment, and in good working order throughout the year. An alternative option may be to construct paved ditch or swale channels across the property to assist in discharging storm water.

I. Problem Area 9: Detention Pond at Pin Oak Rd & SW 34th St

Based upon the hydrologic study performed, the detention pond facility, located approximately 800 feet east of the northeast corner of the intersection of Pin Oak Road and SW 34th Street, should not overtop the embankment spillway or SW 34th Street roadway until a 500-year storm event. The 500-year storm is an appropriate design storm for a detention pond to utilize a spillway. However, after an observation of the culvert discharging from the pond to the south side of SW 34th Street, the culvert has an open grate on the north side of SW 34th Street which appears to be designed to drain storm water discharge from the roadway ditch. Since the pipe size of the culvert does not increase as it crosses SW 34th Street, the additional storm water discharge from the ditch may exceed the capacity of the existing culvert and cause the ditch or pond to backup and eventually overtop the SW 34th Street roadway. The recommendation below notes the culvert size required, as it crosses SW 34th Street, to possess enough hydraulic capacity for the discharge from both the detention pond and drainage ditch for the 100-year storm event.

Recommendation – Construct 100-year Capacity Culvert. This recommendation would consist of constructing a new culvert which can convey the 100-year storm event as it crosses SW 34th Street. This structure would consist of approximately 40 linear feet of a 60 inch diameter RCP. The combined 100-year discharge from the detention pond and roadway drainage ditch to the location of the pipe as it crosses SW 34th Street is approximately 135.1 cfs. The 100-year discharge from the detention pond is approximately 91.6 cfs.

The locations of the proposed improvements are shown in **Figure 4-12**. The cost for the recommendation is estimated at $27,000 and is detailed in **Appendix 4-D**.

J. Problem Area 10: SW 19th St & S Santa Fe Ave Commercial Complex

The access road behind 2017 SW 19th Street with ponding appears to be caused by flat ground topography on commercial property. Due to the ponding problem being caused by topography on commercial property and not on public property, the City of Moore is not responsible for the ponding issues. A solution to the ponding problem may be for the commercial property owner to construct a drainage channel from the access roadway east towards S Santa Fe Avenue.

K. Problem Area 11: Ridgeway Drive & Moore Cemetery

Backyard flooding at the residential property 1000 Ridgeway Drive, appears to be caused by a flat slopped grass lined open-channel along the boundary between private residential properties and Moore cemetery. Due to the flooding problem being caused by topography on private property and not on public property, the City of Moore is not responsible for the flooding issues. A solution to the flooding problem may be for the residential property owners to construct a berm along the property line to prevent discharge in the open-channel from diverting west until it reaches SW 10th Street. As an alternative option, Moore Cemetery could construct a curb along the western edge of the western driveway to create a gutter for surface discharge to drain south to SW 10th Street.

L. Problem Area 12: Intersection of Plaza Dr and SW 5th St

A private residential property owner, located at 604 Plaza Drive, observed full width roadway flooding near the top of curb at the intersection of Plaza Drive and SW 5th Street. Flooding only has occurred in the roadway and did not enter any structures. The SW 5th Street and Plaza drive roadways have adequate slope to discharge the storm water. Further investigation and 2D hydraulic modeling of this area would be necessary to determine the root cause of the roadway flooding. In order to solve the roadway flooding problem, a significant storm sewer system would need to be constructed beneath Plaza Drive and either tie into and replace existing storm sewer system to the south or the proposed storm sewer would need to turn west and cut through several backyards to reach Stream E. One possible cause for the additional roadway discharge may be from an inadequately sized storm sewer system and culvert crossing for Stream E at SW 4th Street. Storm water might be backing up and diverting south on Wilson Boulevard. If this is the cause, a larger culvert system as described in problem area 5 above may help to alleviate the roadway discharge on SW 5th Street and Plaza drive. The Wilson Boulevard entrance aprons at SW 4th Street may also be raised and re-paved to help prevent SW 4th Street storm water from diverting down Wilson Boulevard.

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Stream E
Problem Area 9: Recommendation

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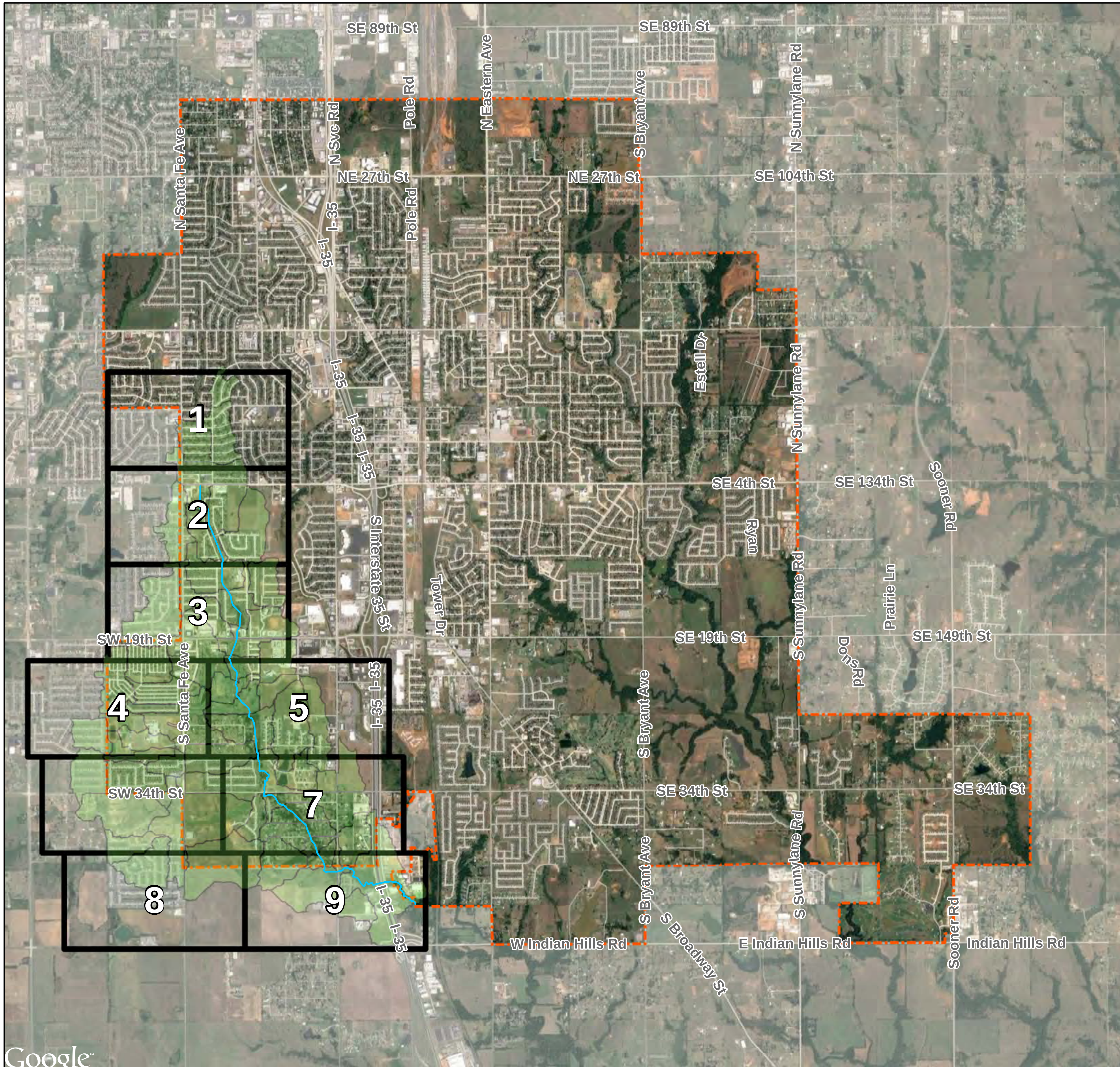

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City of Moore
Master Drainage Plan

Stream E
Detailed HEC-HMS Schematics
Section 4 - Appendix A

- Atlas Pages
- Moore City Limits
- Stream E Basin
- Stream E

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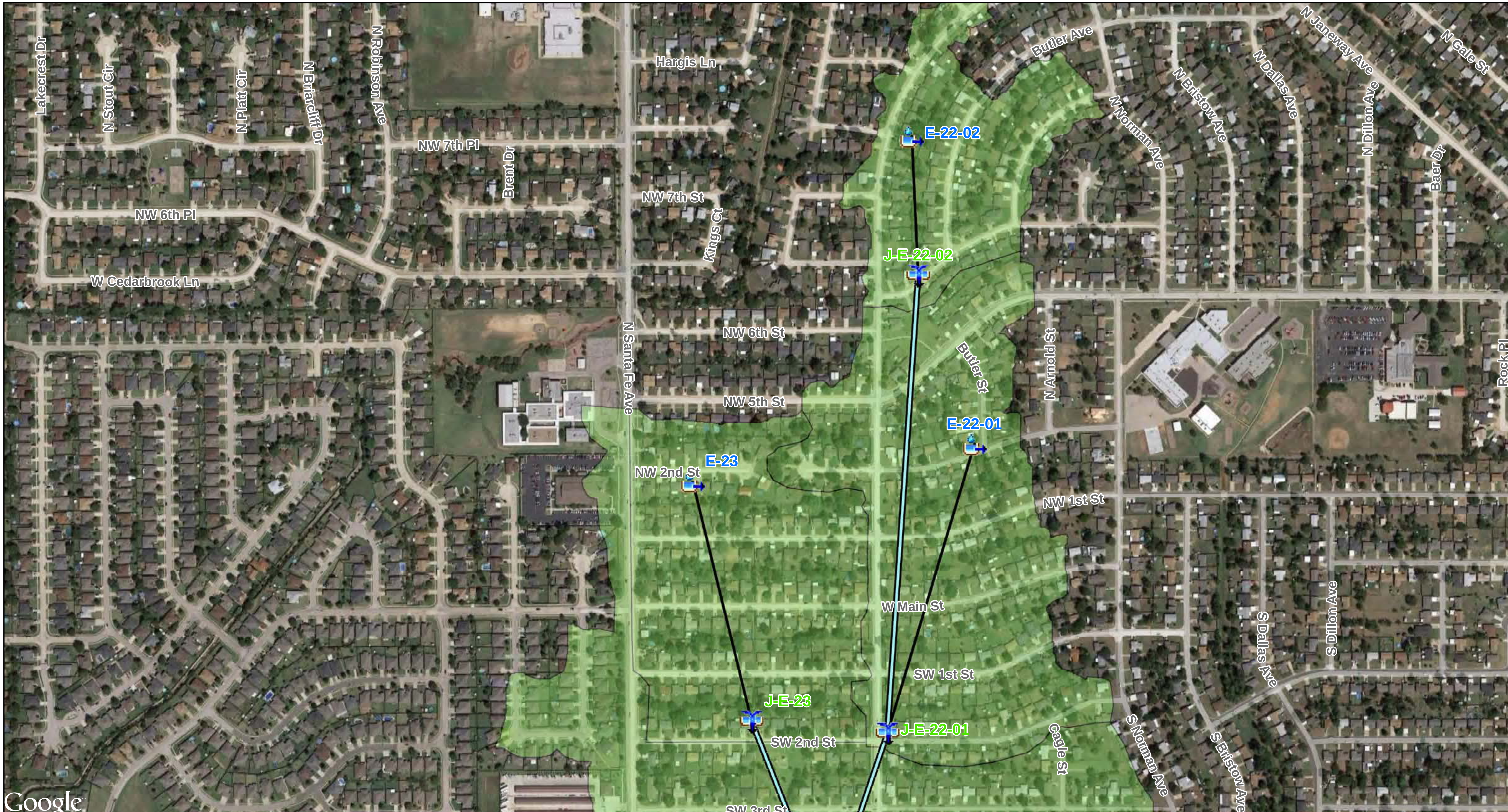

City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

Section 4 - Appendix A

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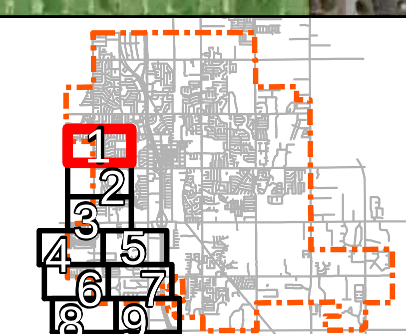
HMS Points

- Reservoir
- Subbasin
- Junction

HMS Lines

- Reach
- Route Downstream
- Stream E Basin



CITY of MOORE OKLAHOMA

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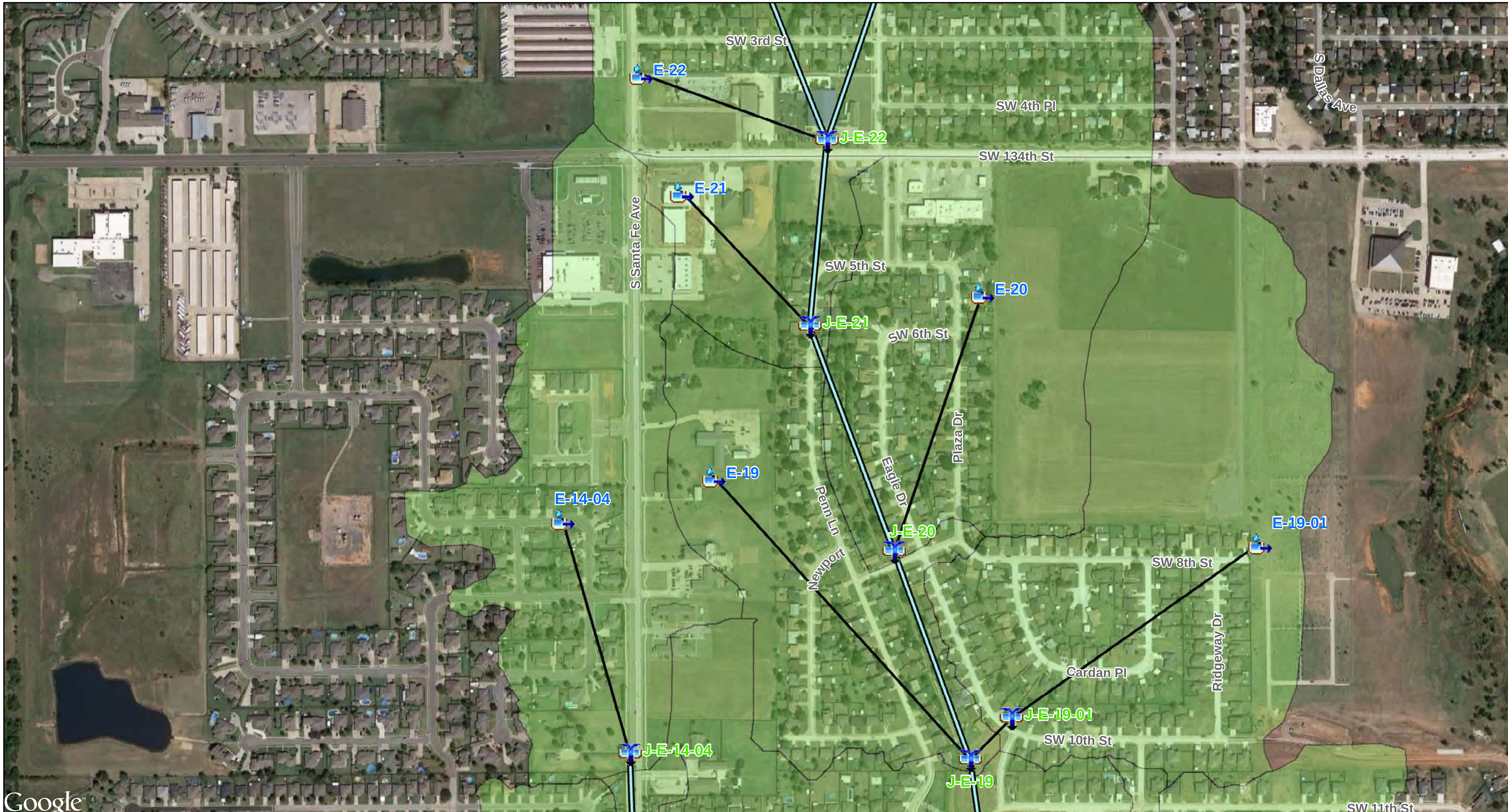

City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

Section 4 - Appendix A

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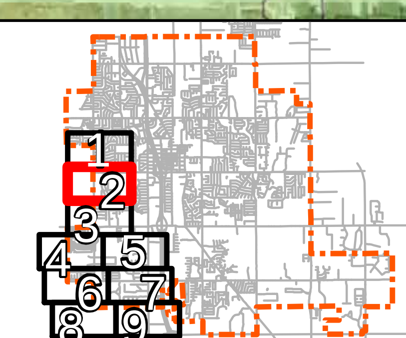
HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Stream E Basin



CITY of MOORE OKLAHOMA

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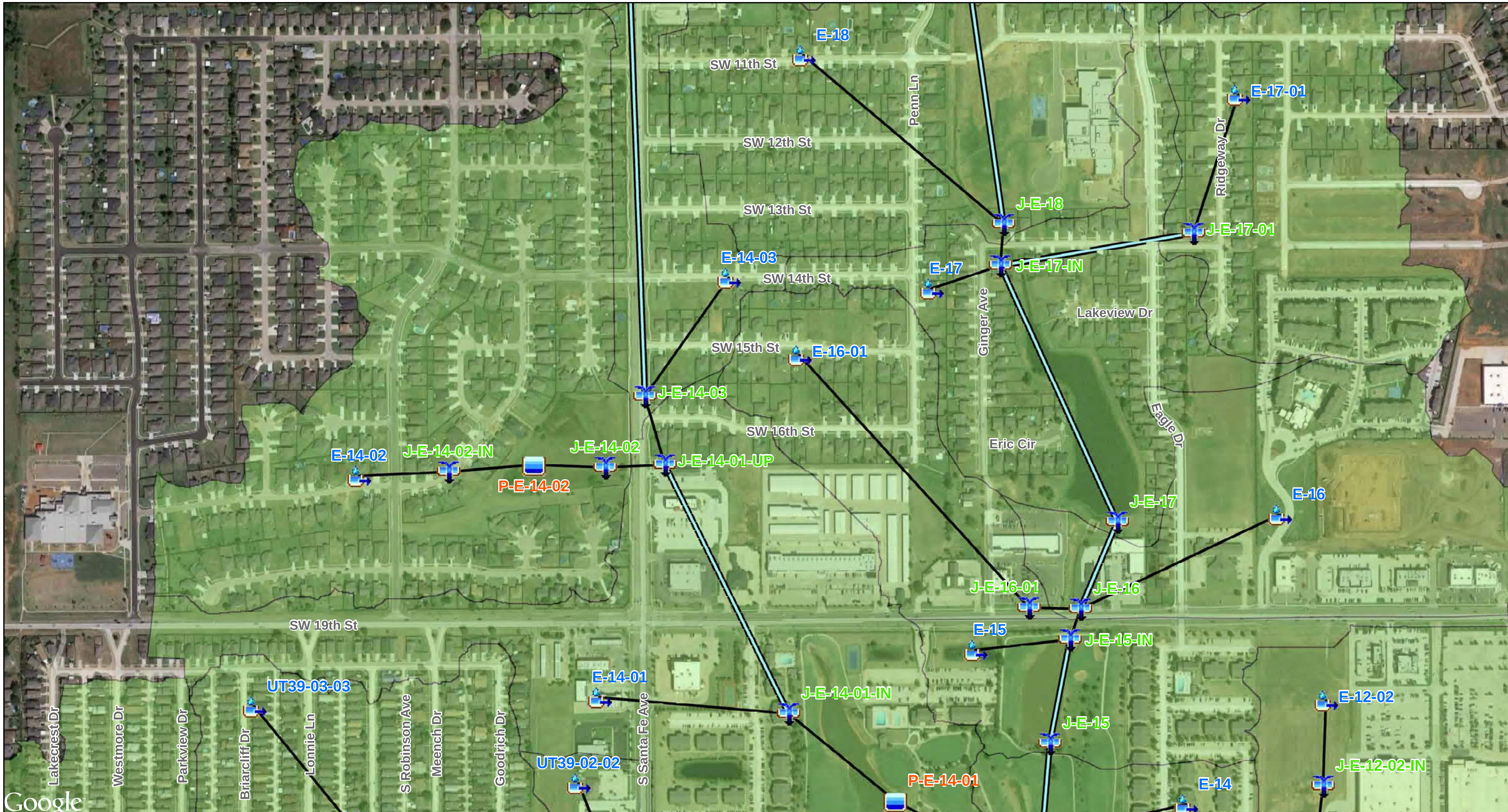
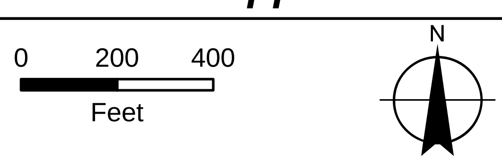


City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

Section 4 - Appendix A



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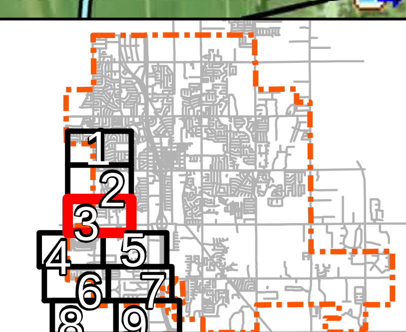
HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Stream E Basin



CITY OF MOORE OKLAHOMA

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City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

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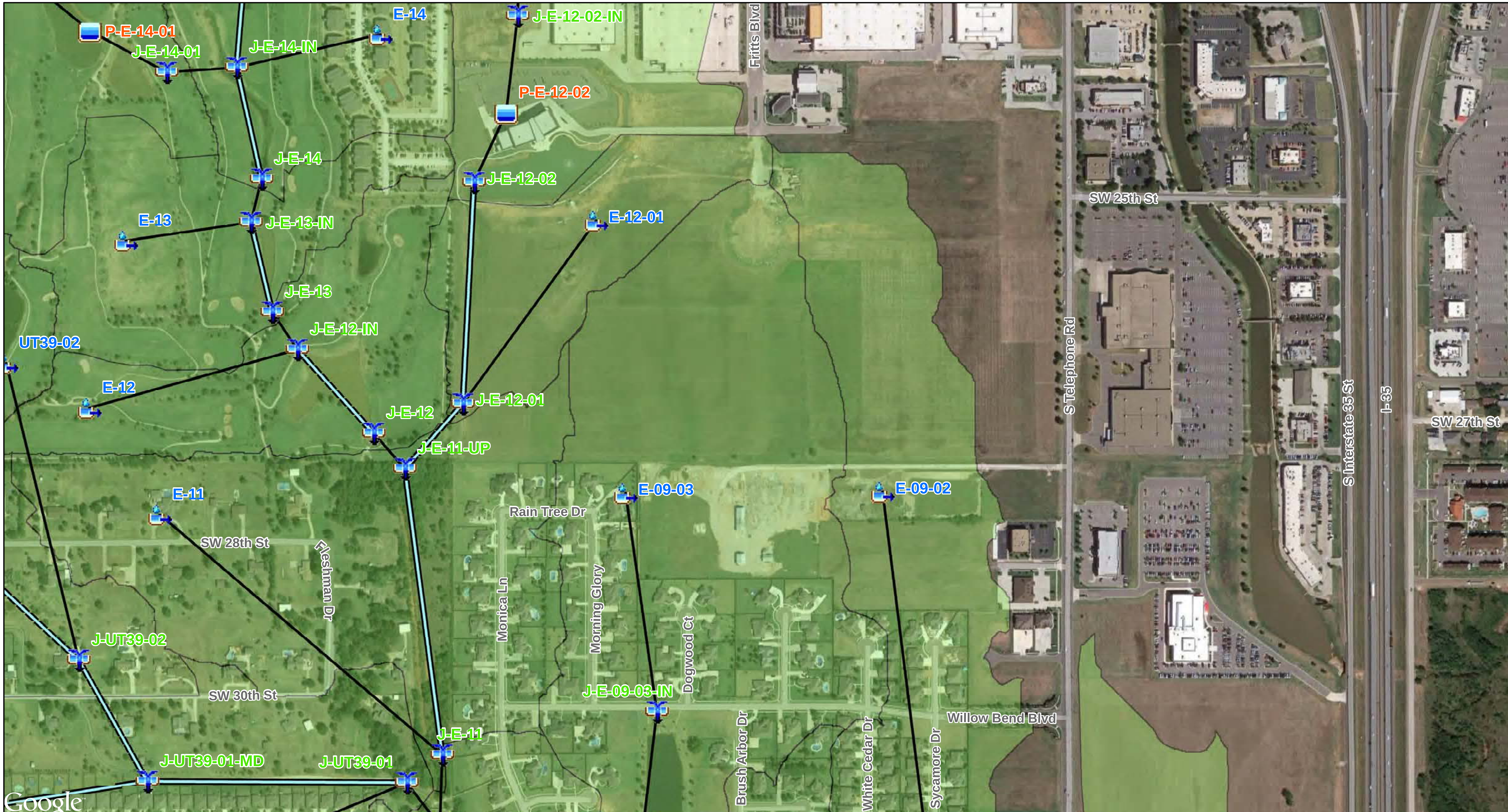

City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

Section 4 - Appendix A

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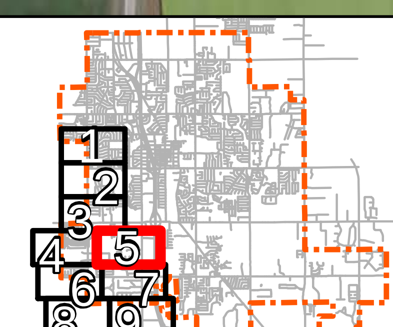
HMS Points	**HMS Lines**
Reservoir	Reach
Subbasin	Route Downstream
Junction	Stream E Basin



CITY of MOORE OKLAHOMA

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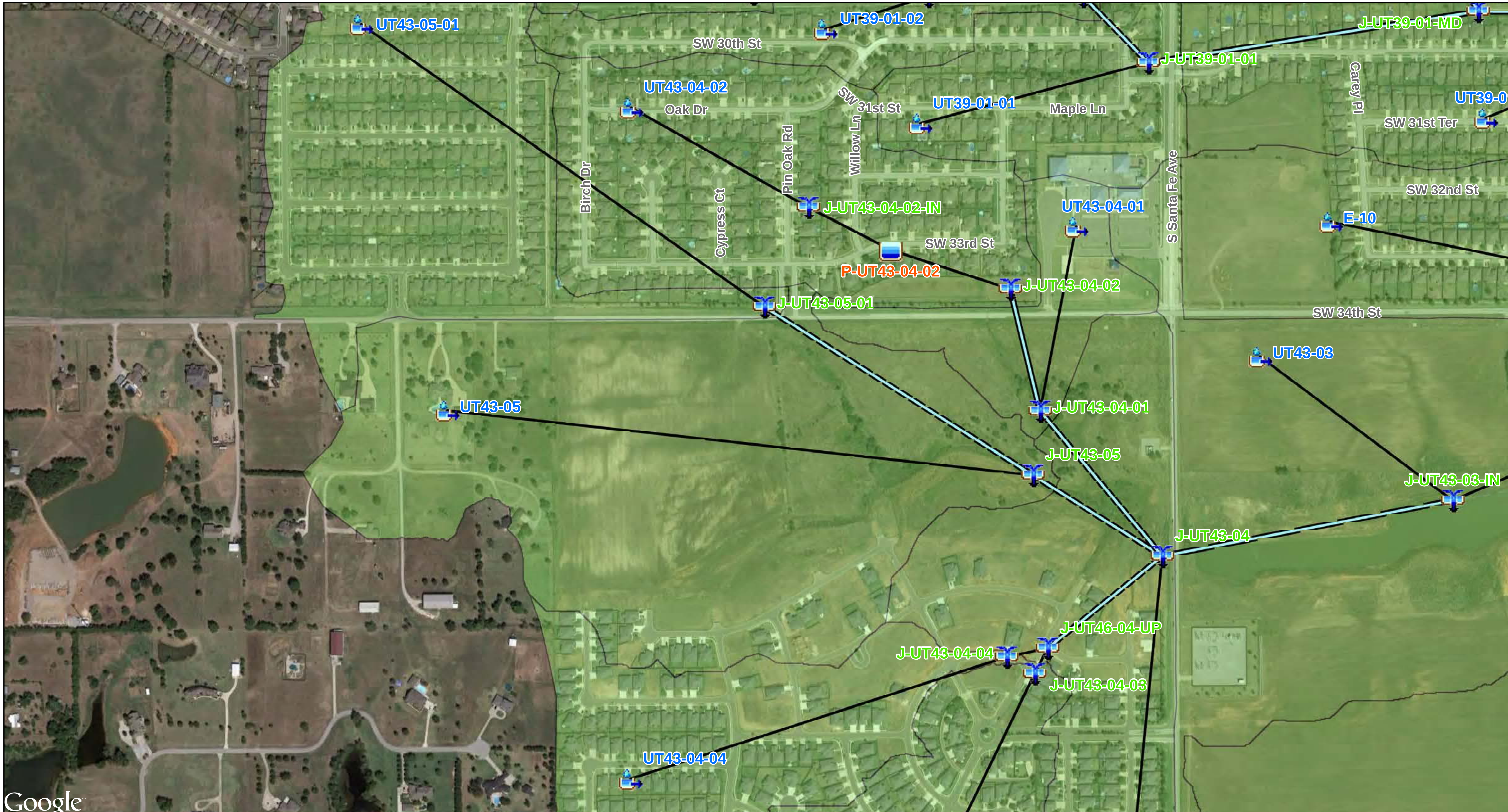

City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

Section 4 - Appendix A

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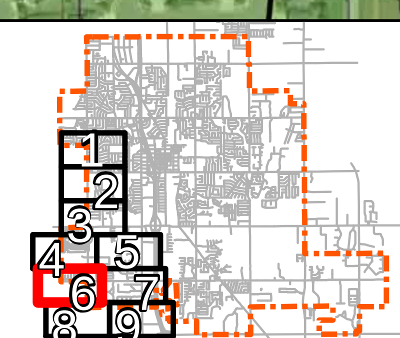
HMS Points

- Reservoir
- Subbasin
- Junction

HMS Lines

- Reach
- Route Downstream
- Stream E Basin



CITY of MOORE OKLAHOMA

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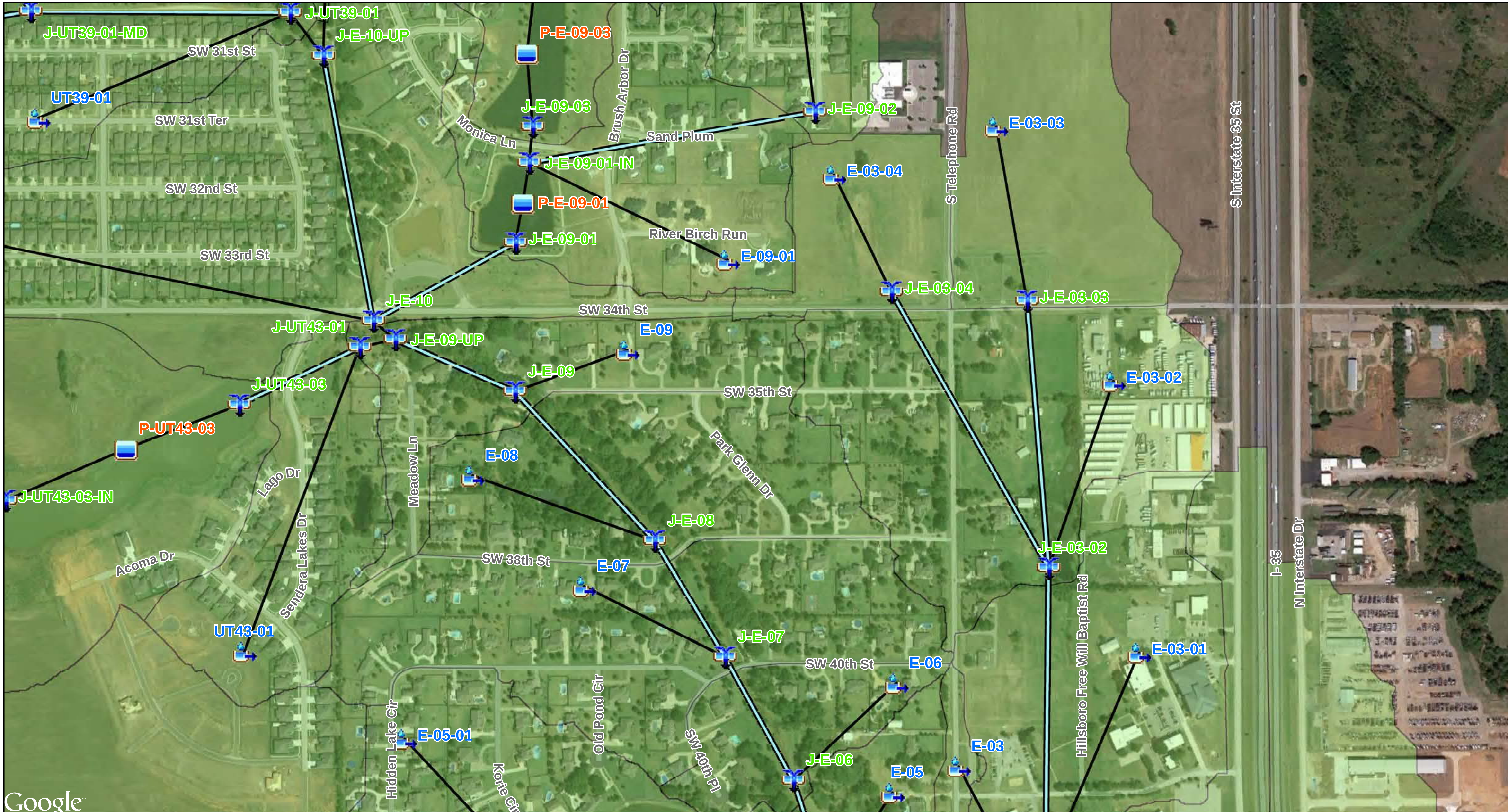

City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics

Section 4 - Appendix A

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HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
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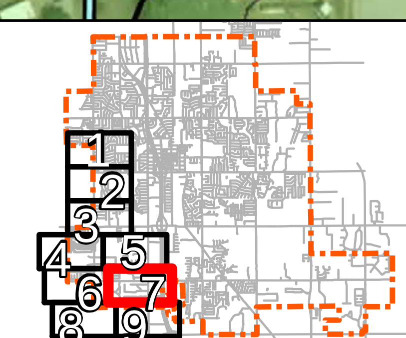
- Route Downstream
- Stream E Basin



CITY OF MOORE OKLAHOMA

City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics
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HMS Points
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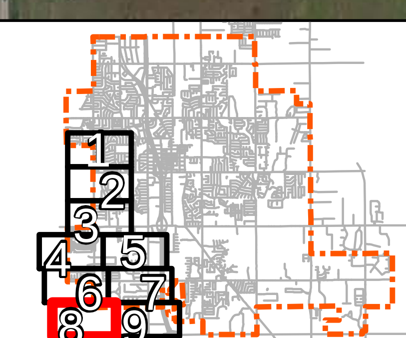

CITY of MOORE OKLAHOMA

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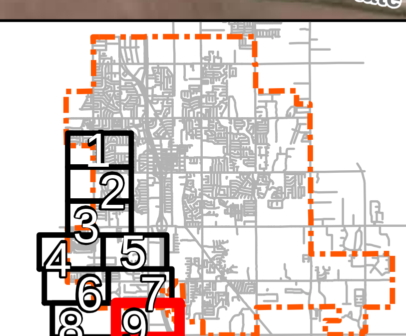
City of Moore - Master Drainage Plan

Stream E Detailed HEC-HMS Schematics
Section 4 - Appendix A

HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Stream E Basin



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City of Moore					
Appendix 4-B Moore Master Drainage Plan Alternatives - Stream E - Problem Area #07 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	20600	$ 12.00	$ 247,200.00
2	**SELECT BORROW**	**CY**	630	$ 15.00	$ 9,450.00
3	**SOLID SLAB BERMUDA SODDING**	**SY**	31000	$ 3.00	$ 93,000.00
4	**4" PCC SIDEWALK**	**SY**	750	$ 40.00	$ 30,000.00
5	**8" PCC PAVEMENT**	**SY**	35	$ 75.00	$ 2,625.00
6	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 15,000.00	$ 15,000.00
7	**STANDARD BEDDING MATERIAL - 36" RCP**	**CY**	230	$ 20.00	$ 4,600.00
8	**36" RCP**	**LF**	360	$ 140.00	$ 50,400.00
				Subtotal	**$ 452,275.00**
				15% Contingency	**$ 67,841.25**
				Subtotal	**$ 520,116.25**
				25% Utility Relocation Contingency	**$ 130,029.06**
				Total	***$ 650,145.31***

City of Moore					
Appendix 4-B Moore Master Drainage Plan Alternatives - Stream E - Problem Area #09 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	100	$ 12.00	$ 1,200.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	120	$ 3.00	$ 360.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**8" PCC PAVEMENT**	**SY**	26	$ 75.00	$ 1,950.00
5	**STANDARD BEDDING MATERIAL - 60" RCP**	**CY**	65	$ 20.00	$ 1,300.00
6	**60" RCP**	**LF**	40	$ 223.00	$ 8,920.00
				Subtotal	**$ 18,730.00**
				15% Contingency	**$ 2,809.50**
				Subtotal	**$ 21,539.50**
				25% Utility Relocation Contingency	**$ 5,384.88**
				Total	***$ 26,924.38***

Section 5
Canadian River Tributaries

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SECTION 5. CANADIAN RIVER TRIBUTARIES WATERSHED

5.1. PREVIOUS STUDIES

FEMA has performed previous detailed and re-delineated studies of streams in the Canadian River Tributary Watershed as documented in the Cleveland County Flood Insurance Study (FIS). Any recommendations and alternatives proposed in this section were generated as part of this detailed study. Information regarding the background for this most recent study can be found in **SECTION 1 - EXECUTIVE SUMMARY** and **SECTION 2 - METHODOLOGY**.

5.2. EXISTING CONDITIONS HYDROLOGY

The studied sections of the Canadian River Tributary 1 Watershed consist mainly of two tributaries. The largest tributary is identified as Tributary 0 of Canadian River Tributary 1, with approximately 1.0 square miles of drainage area. The smaller tributary is named Tributary 2 of Canadian River Tributary 1, with approximately 0.3 square miles of drainage area. This study area is generally south of SW 89th Street, north of Main Street, west of Interstate 35, and east of S Western Avenue. These tributaries flow south and west to the Canadian River. The studied Canadian River Tributaries Watershed is divided into 20 sub-basins, which are depicted in **FIGURE 5-1.**

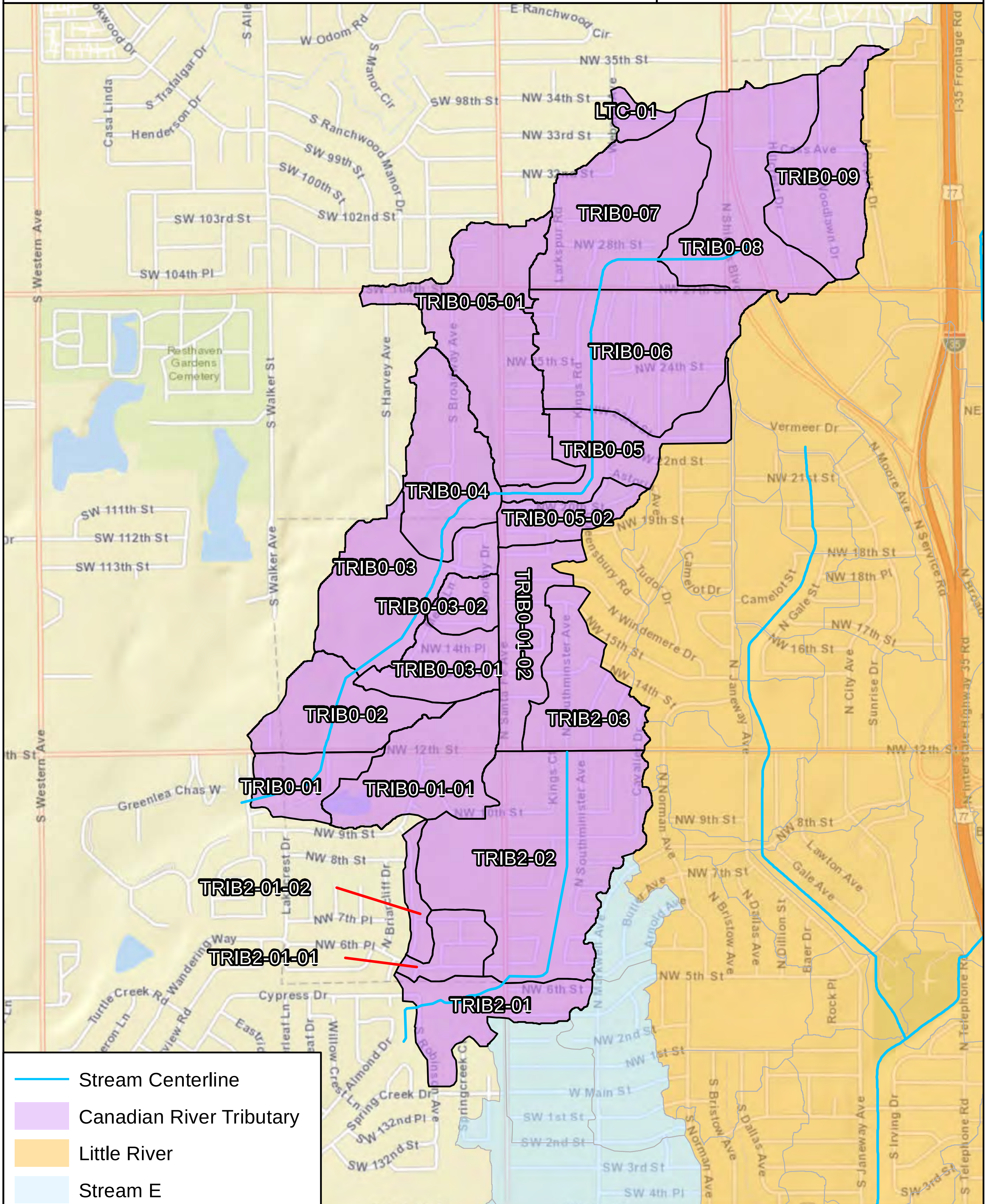
The hydrologic soil groups are shown in **FIGURE 5-2** with the existing land use depicted in **FIGURE 5-3.** More information on the hydrologic methodology can be found in **SECTION 2.1 HYDROLOGIC ANALYSIS**.

The hydrologic coefficients used for input in the HEC-HMS model include the lag time, soil complex curve number (CN) and drainage area. The HEC-HMS schematic, showing the connectivity of the hydrologic elements, can be found in **FIGURE 5-4** with more detailed HEC-HMS schematics provided in **APPENDIX 5-A**. A summary of hydrologic coefficients is presented in **TABLE 5-1**.

The flowrates for existing conditions of the Canadian River Tributaries Drainage Basins were developed using HEC-HMS. A list of the flowrates at major junctions for the existing conditions is presented in **Table 5-2**.

City of Moore Master Drainage Plan

0 0.25 0.5
Miles
N



Canadian River Tributary Drainage Basins

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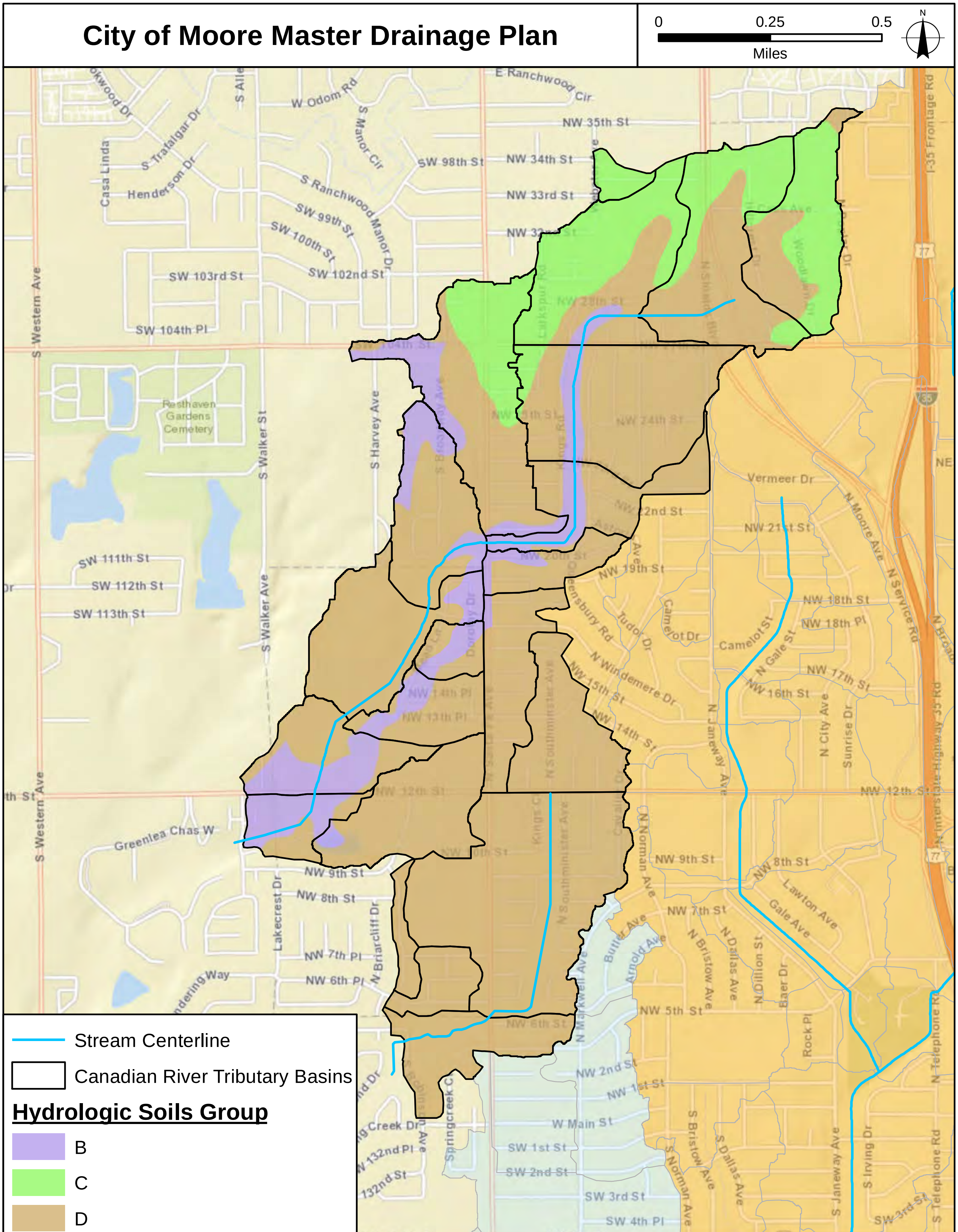
Figure 5 - 1

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA

Canadian River Tributary Hydrologic Soils Group

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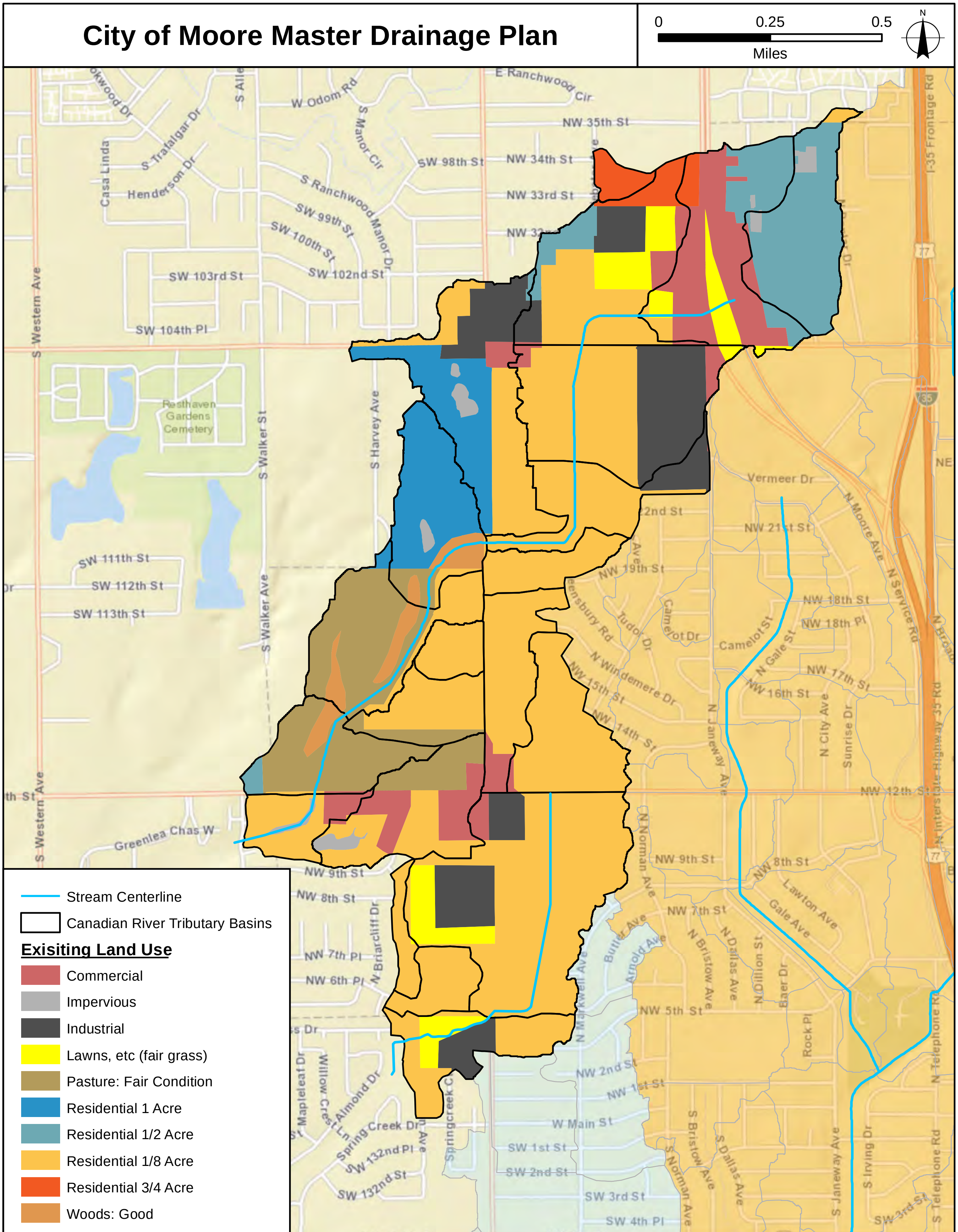
Figure 5 - 2

City of Moore Master Drainage Plan



Canadian River Tributary Existing Land Use

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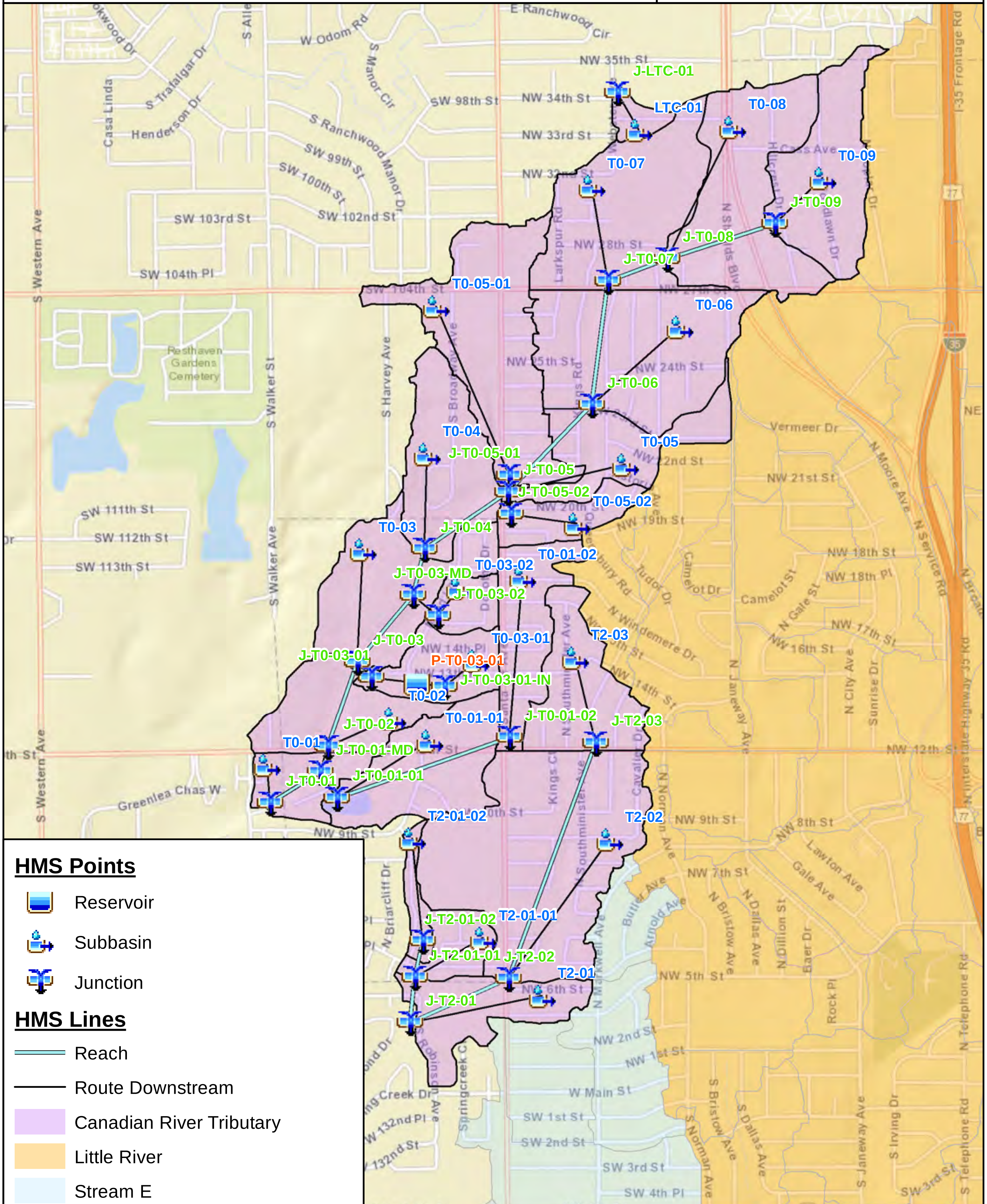
Figure 5 - 3

City of Moore Master Drainage Plan

0 0.25 0.5
Miles
N



Canadian River Tributary
HEC - HMS Schematic

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Figure
5 - 4

TABLE 5-1. CANADIAN RIVER TRIBUTARIES DRAINAGE BASINS SUMMARY OF HYDROLOGIC COEFFICIENTS FOR EXISTING CONDITIONS

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
LTC-01	80.0	11.6	5.9	0.01
TRIB0-01	89.1	5.5	18.2	0.03
TRIB0-01-01	91.1	13.7	43.3	0.07
TRIB0-01-02	92.1	19.1	30.8	0.05
TRIB0-02	77.0	9.6	33.6	0.05
TRIB0-03	84.0	14.4	49.2	0.08
TRIB0-03-01	88.3	7.6	22.5	0.04
TRIB0-03-02	89.1	6.6	10.7	0.02
TRIB0-04	78.9	9.2	41.9	0.07
TRIB0-05	90.3	12.4	32.7	0.05
TRIB0-05-01	86.2	20.7	72.0	0.11
TRIB0-05-02	90.6	7.7	16.3	0.03
TRIB0-06	91.7	9.2	74.5	0.12
TRIB0-07	87.3	15.0	64.4	0.10
TRIB0-08	89.1	18.5	63.8	0.10
TRIB0-09	83.1	24.4	45.7	0.07
TRIB2-01	90.8	6.4	31.1	0.05
TRIB2-01-01	92.0	10.8	13.7	0.02
TRIB2-01-02	91.9	14.2	7.1	0.01
TRIB2-02	91.5	17.2	110.7	0.17
TRIB2-03	92.1	12.7	36.1	0.06

TABLE 5-2. CANADIAN RIVER TRIBUTARIES DRAINAGE BASINS – EXISTING FLOWRATES AT MAJOR JUNCTIONS (CFS)

Description	HMS Junction	Stream	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year	Drainage Area, mi^2
Hillcrest Avenue	J-T0-09	Tributary 0 of Canadian River Tributary 1	34	44	71	93	124	148	173	237	0.07
Nottingham Way	J-T0-08		104	129	198	254	330	389	450	605	0.17
NW 27th Street	J-T0-07		174	216	330	423	548	646	746	999	0.27
NW 23rd Street	J-T0-06		268	328	493	626	804	942	1084	1442	0.39
Santa Fe Avenue	J-T0-05		400	490	737	937	1205	1413	1627	2165	0.58
Odom Way	J-T0-04		427	526	795	1016	1311	1541	1777	2374	0.65
NW 12th Street	J-T0-02		502	619	961	1233	1597	1881	2174	2916	0.84
Crystal Gardens	J-T0-01		596	732	1128	1445	1864	2194	2532	3391	0.99
NW 12th Street	J-T2-03	Tributary 2 of Canadian River Tributary 1	62	75	107	133	167	193	220	286	0.06
N Santa Fe Ave	J-T2-02		211	254	367	457	577	668	761	996	0.23
S Robinson Ave	J-T2-01		258	310	450	561	707	820	936	1229	0.31

5.3. Existing Conditions Hydraulics

Updated detailed hydraulic models were not prepared for streams of the Canadian River Tributary 1 Watershed in this MDP. The detailed studies of the open-channel areas currently mapped by FEMA were not a high enough priority to restudy at this time. The hydrology models were used to identify flowrates for frequency storm events at strategic locations. These flowrates were used to prepare conceptual design improvements where flooding problem areas were identified. These areas are discussed in detail in **Section 5.4**.

5.4. PROBLEM AREAS

Flooding problems areas identified in the Canadian River Tributaries Drainage Basins are based on flooding comments and observations received from community residents, City of Moore staff, and Meshek & Associates, PLC. The location of these problem areas are shown in **FIGURE 5-5** and **FIGURE 5-6**, and are labeled according to the GIS-ID problem area numbers and descriptions below. Unless noted otherwise, all problem area comments generally refer to flooding and drainage problems observed in the May 5-8, 2015 storm events.

A. Problem Area 1: Intersection of N Santa Fe Ave and NW 6th Pl

The City of Moore reported roadway flooding on N. Santa Fe Ave, possibly due to backwater effects from a culvert crossing for Tributary 2 of Canadian River Tributary 1, located on N. Santa Fe Avenue between NW 6th Place and NW 6th Street (GIS ID-1001).

B. Problem Area 2: NW 6th Pl near Intersection with N Robinson Ave

A private residential property located at 1205 NW 6th Place had flooding in the residential structure on several occasions (GIS ID-29). The ground topography indicates a majority of neighboring residential property to the north and west drains directly towards the address listed above.

C. Problem Area 3: N Robinson Ave near Intersection with NW 7th Pl

A private residential property located at 820 N. Robinson Avenue had flooding in residential structure and backyard (GIS ID-150). The property owner has observed flooding originating from the southeast corner of the Highland West Junior High School. The ground topography indicates the ground has a relatively flat slope may pond at the southwest corner of the Junior High School adjacent to the address listed above.

A private residential property owner has observed ponding water and inadequate drainage in the eastern visitor parking lot and southern entrance driveway of the Highland West Junior High School (GIS ID-173).

D. Problem Area 4: Hillcrest Ave between Cass Ave to NW 27th St

The City of Moore has observed and inlet and storm sewer system that has an inadequate hydraulic capacity, located on Hillcrest Avenue between Cass Avenue and NW 27th Street (GIS ID-1002).

E. Problem Area 5: Intersection of NW 34th St & Webster St

A private residential property located at 3510 Webster Street, has observed flooding in yard getting near to the residential structure (GIS ID-174).

The private property owner, noted above, has also expressed concern regarding 1 to 2 feet depth of flooding at the nearby Houchin Elementary School (GIS ID-174). The ground topography indicates the elementary school is positioned on high ground near the ridge of the sub-basin for the Tributary 0 of Canadian River Tributary 1. This positon indicates there is very little drainage area above the elementary school, and flooding should not be an issue unless there is a local property drainage problem.

City of Moore Master Drainage Plan

0 500 1,000
Feet
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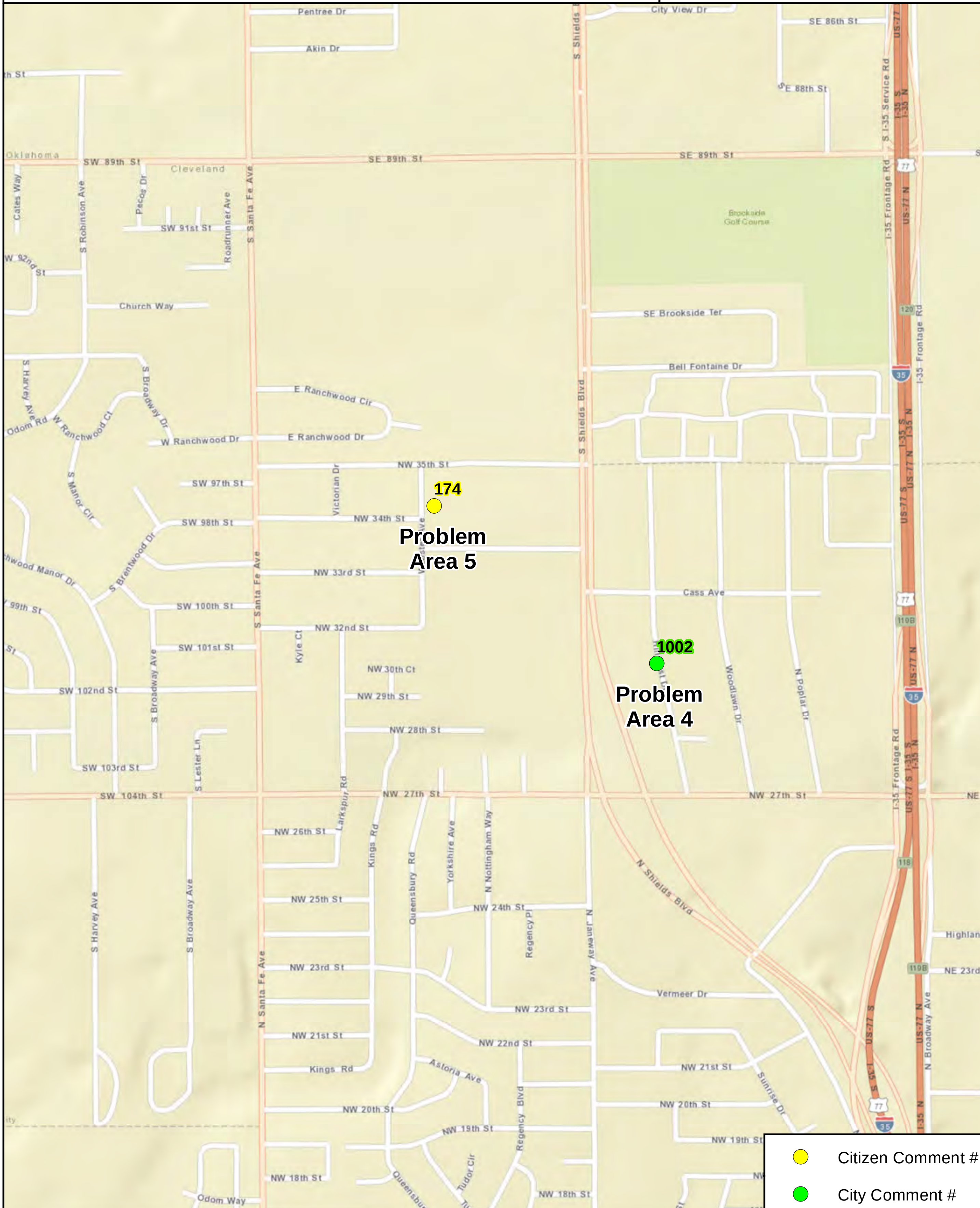

CITY of MOORE OKLAHOMA

Canadian River Tributary Problem Areas

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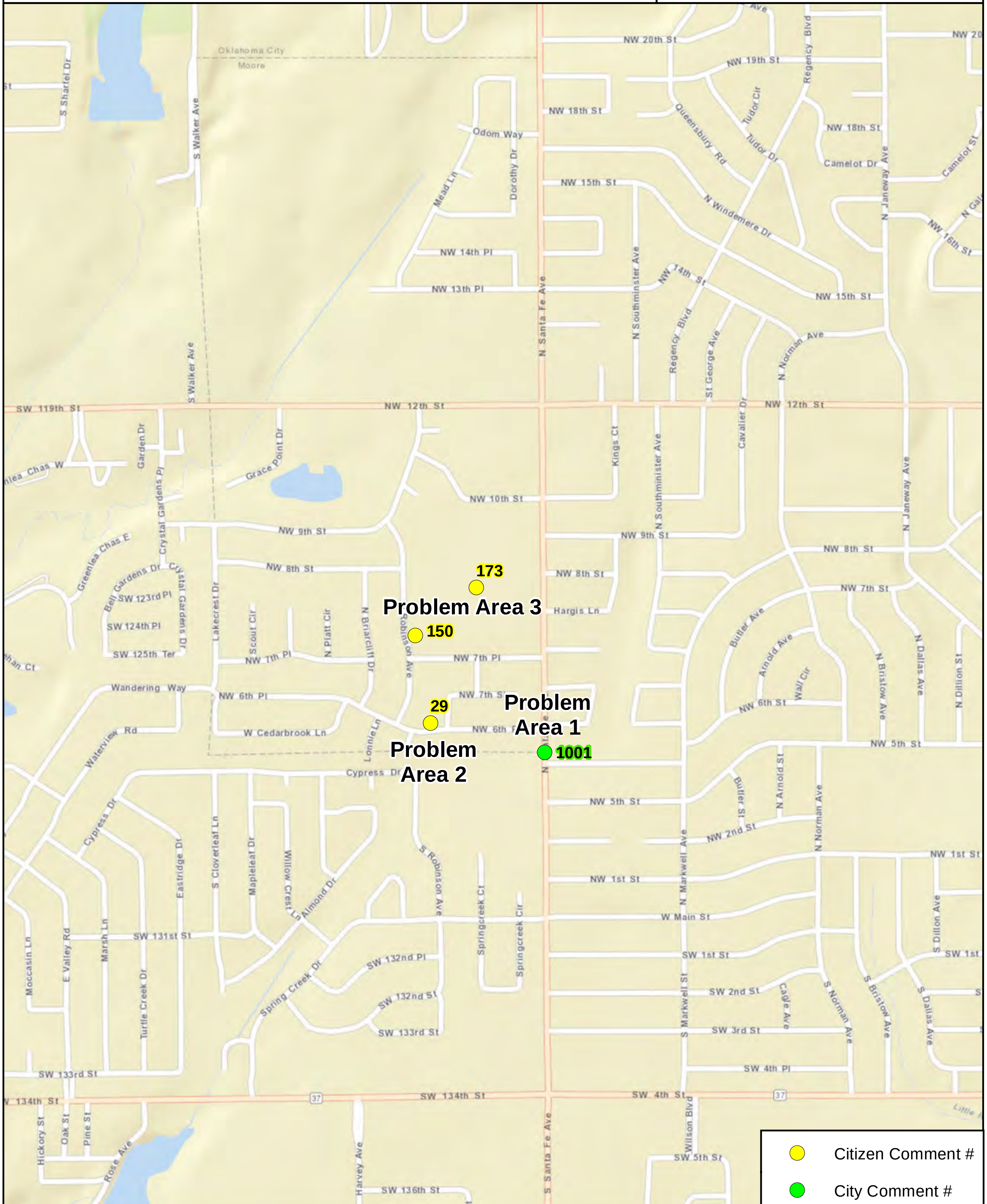
Figure 5 - 5

City of Moore Master Drainage Plan

0 500 1,000
Feet
N



Canadian River Tributary Problem Areas

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CITY of MOORE OKLAHOMA

Figure 5 - 6

5.5. EVALUATION OF ALTERNATIVE AND RECOMMENDATIONS

Alternatives and recommendations for mitigating flooding problems may consist of channelization, increasing culvert structure capacity through replacement or enlargement, creating detention pond facilities, or increasing storm sewer system capacity through replacement or new system construction. It's important to note that when alternatives and recommendations given in this master drainage plan proceed to design documents, the design should be hydrologically and hydraulically analyzed in further detail prior to constructing any improvements described in this section. The alternatives and recommendations in this master drainage plan are given as plausible concepts and an additional detailed study of the design would prevent increases in water-surface elevations and floodplains or cause flooding in other areas. The alternatives and recommendations for the problem areas are defined as follows:

A. Problem Area 1: Intersection of N Santa Fe Ave and NW 6th Pl

Alternative 1 – Construct Overflow Concrete Flume. Due to N Santa Fe Avenue having a sump as it crosses Tributary 2 of Canadian River Tributary 1, ponding in the roadway will occur with the existing drainage inlets. Stormwater should not be expected to get significantly deeper than the curb. If the City of Moore finds the level of ponding on N Santa Fe Avenue to be a significant problem, a concrete flume may be constructed thru the curb on the downstream side of the culvert under the N Santa Fe Avenue sidewalk in order to reduce roadway ponding.

B. Problem Area 2: NW 6th Pl near Intersection with N Robinson Ave

The flooding at the residential property 1205 NW 6th Place, appears to occur due to a significant amount of drainage area from neighboring private properties to the north and west. Due to the flooding problem being caused on private property and not on public property, the City of Moore is not responsible for the flooding issues. The garage entrance on the west side is at grade and may have been the source of flooding. A solution may be for the property owner to construct and grade either a swale or berm along the west side of the house from the back yard to the curb. The swale or berm should allow the water to discharge to NW 6th Place without entering the garage.

C. Problem Area 3: N Robinson Ave near Intersection with NW 7th Pl

Alternative 1 (Recommendation)– Construct a Berm & Extend Concrete Paved Ditch. This alternative would consist of constructing a soil berm against the fence line at the southwest corner of the Highland West Junior High School and extending the concrete paved ditch further west to the same southwest corner. The berm would consist of approximately 300 linear feet of soil built up approximately 2 foot in height. The existing concrete paved ditch, should be extended approximately 110 feet west to southwest corner of the Junior High School property.

The locations of the proposed improvements are shown in **FIGURE 5-7**. The cost for Alternative 1 is estimated at $17,600 and is detailed in **APPENDIX 5-B**.

Alternative 2 – Construct a Concrete Flume Channel & Berm. This alternative would consist of constructing a concrete flume channel from the southwest corner of the Highland West Junior High School southwest to N Robinson Avenue. The concrete flume dimensions would consist of approximately 100 linear feet of six feet wide and one foot depth, extending from the corner of the Junior High School to N Robinson Avenue. A similar berm as in alternative 1 should be constructed against the fence line at the southwest corner of the junior high school to assist in directing stormwater to the concrete flume channel.

The locations of the proposed improvements are shown in **FIGURE 5-7**. The cost for Alternative 2 is estimated at $19,700 and is detailed in **APPENDIX 5-B**.

City of Moore Master Drainage Plan

Canadian River Tributary
Problem Area 3 : Alternative 1 & 2

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Figure 5 - 7

D. Problem Area 4: Hillcrest Ave between Cass Ave to NW 27th St

Alternative– Construct Recessed Concrete Curb Inlets. This alternative would consist of replacing the existing grate inlets with a recessed concrete curb inlet. The 10-year peak discharge to the location of the storm sewer inlets is approximately 93 cfs. The inlet design assumptions consist of a 24 foot long orifice opening, 10’’ height of curb opening orifice, a 1 foot effective head on the center of the orifice throat, and an 80% theoretical capacity to allow for partial obstruction and clogging. The 100-year peak discharge to the location of the storm sewer inlets is approximately 173 cfs. A 3 foot wide trench grate inlet spanning the width of Hillcrest Avenue would be required to capture the 100-year peak discharge. The capacity of the existing storm sewer system leading from these inlets was not evaluated as part of this problem area. We would expect a 48 inch diameter RCP storm sewer system would convey the 10-year peak discharge and a 72 inch diameter RCP system would convey the 100-year peak discharge. Additional analysis would be required to determine the necessary storm sewer system size for a particular storm frequency event. Historical street views of the inlets on Hillcrest Avenue, indicate these inlets are frequently clogged with trash and vegetation debris. In order to maintain design hydraulic capacity of a storm sewer system, the storm sewer system must remain clean and free of debris at all times.

The locations of the proposed improvements are shown in **FIGURE 5-8**. The cost for Alternative 1, a 10-year storm inlet, is estimated at $29,400 and is detailed in **APPENDIX 5-B**.

E. Problem Area 5: Intersection of NW 34th St & Webster St

Alternative – Improve Ditch Capacity. The roadway drainage ditches in this area are filling with silt and several driveway culverts are not functioning properly. This alternative requires cleaning the ditches so that positive drainage is conveyed through the driveway culverts. There are several blocks in this area of town with similar issues. A prioritized plan of the areas with the most problems could be developed with a multi-year plan to improve the drainage system.

The locations of the proposed improvements are shown in **FIGURE 5-9**. Due to the variability of the scope, a cost estimate was not prepared at this time.

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Canadian River Tributary
Problem Area 4: Alternative

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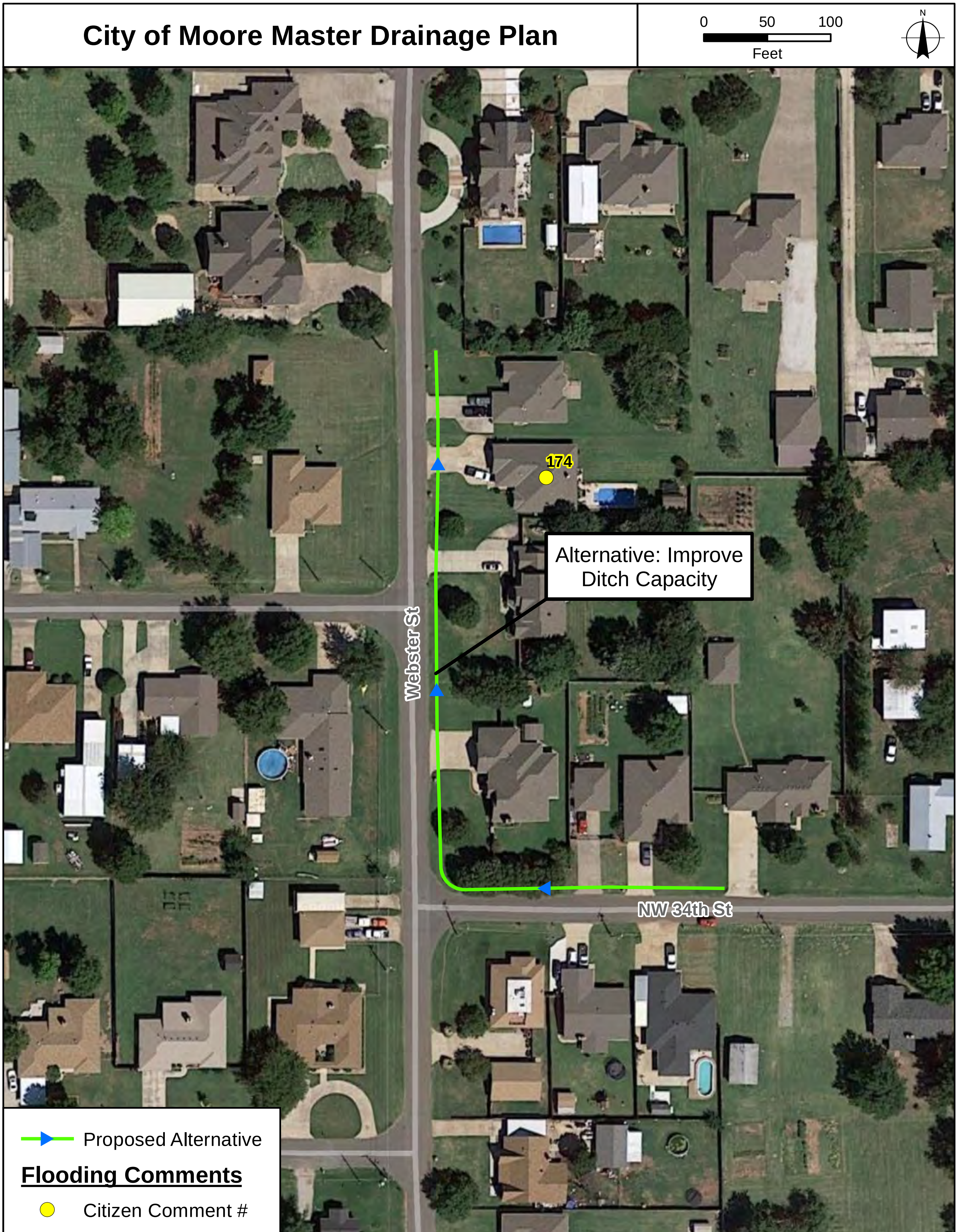
Figure 5 - 8

City of Moore Master Drainage Plan



CITY OF MOORE OKLAHOMA

Canadian River Tributary
Problem Area 5: Alternative

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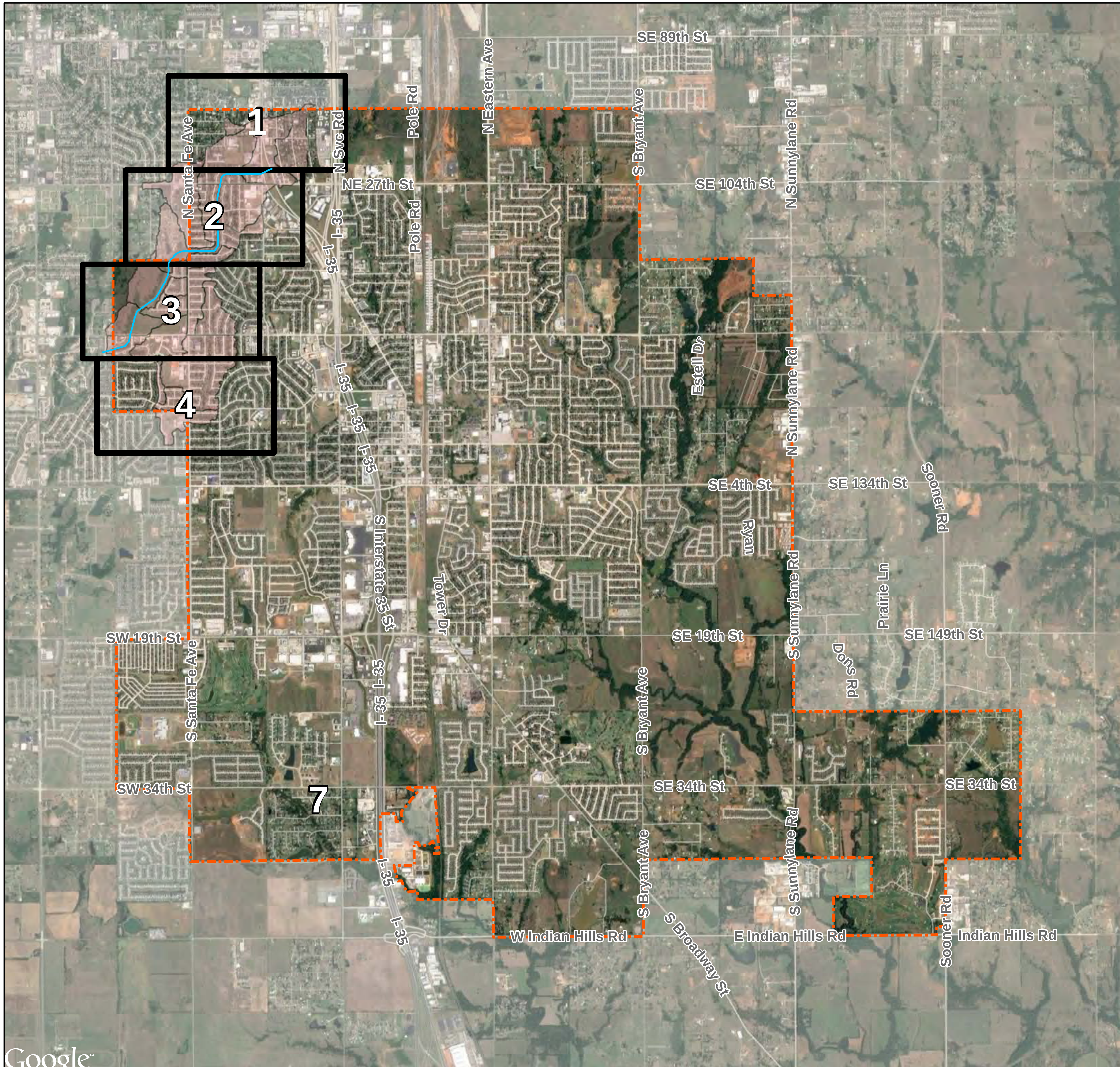
Figure 5 - 9



City of Moore
Master Drainage Plan

Canadian River Tributaries
Detailed HEC-HMS Schematics
Section 5 - Appendix A

- Atlas Pages
- Moore City Limits
- Canadian River Tributary Basins
- Canadian River Tributary

N

0 0.5 1
Miles

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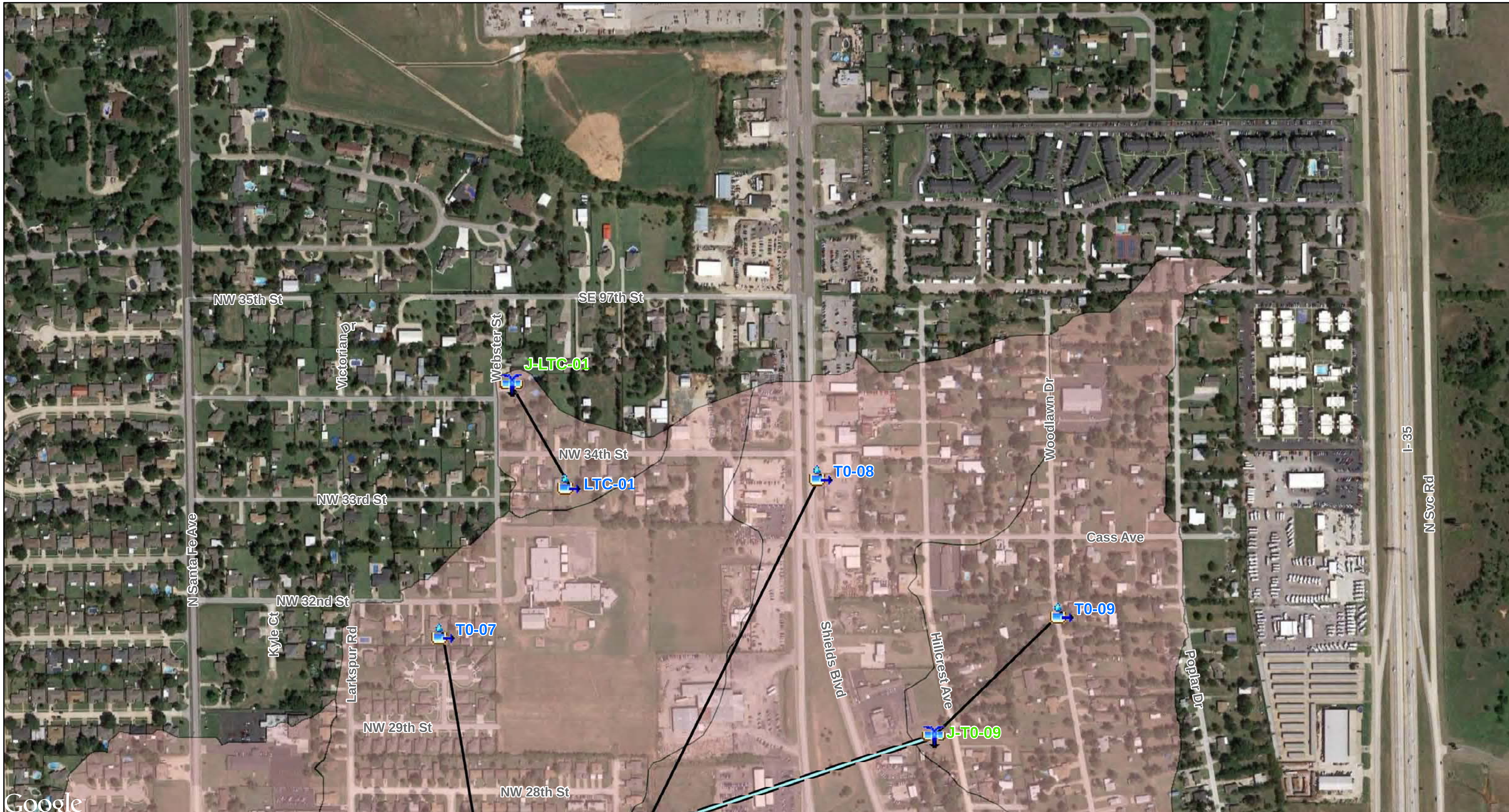
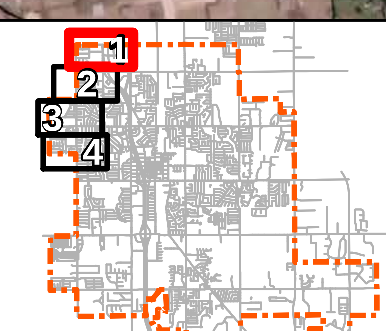


City of Moore - Master Drainage Plan

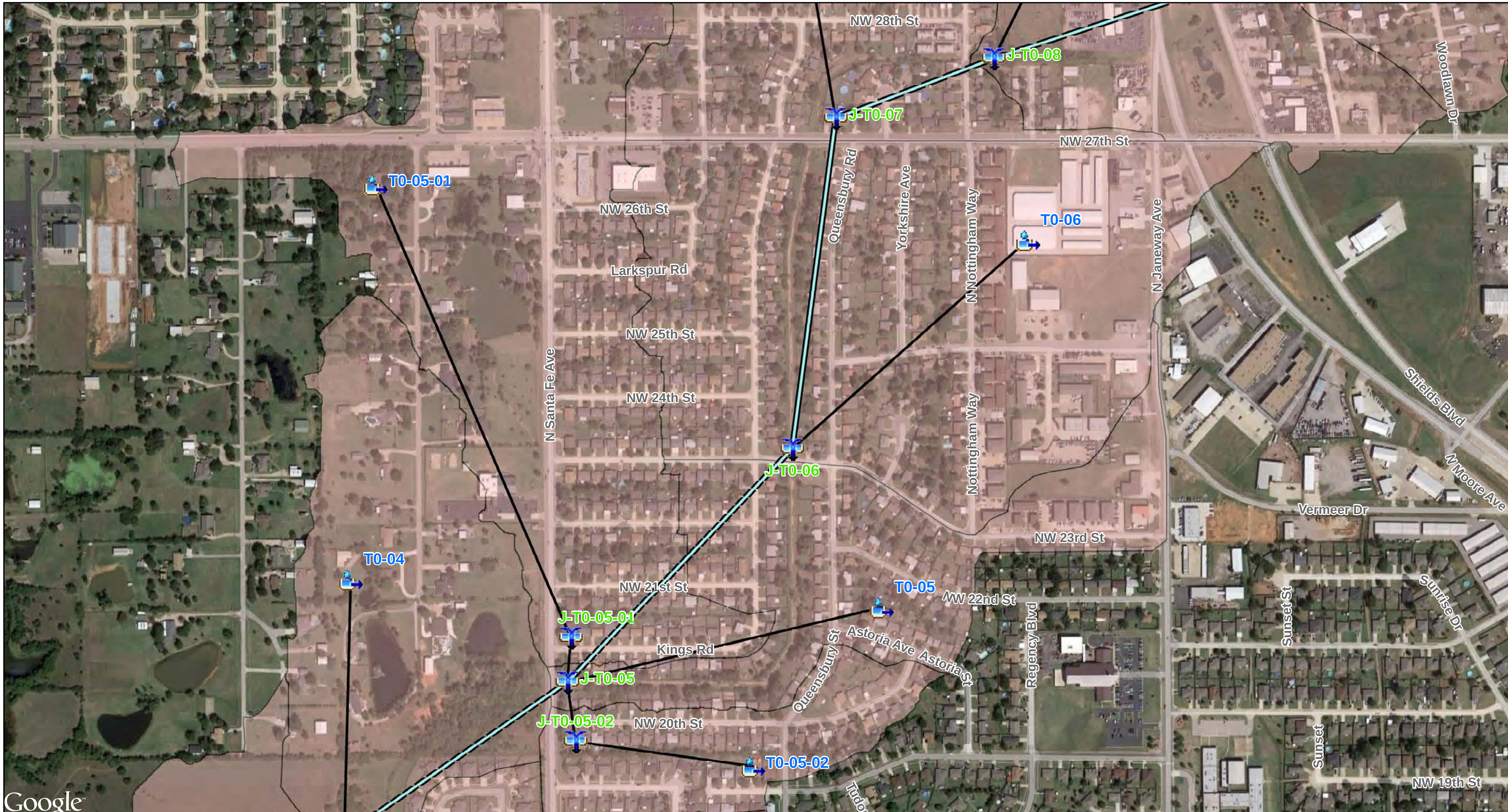
Canadian River Tributaries
Detailed HEC-HMS Schematic Atlas
Section 5 - Appendix A

0 200 400
Feet

HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Canadian River Tributaries



Map Page 1 of 4



City of Moore - Master Drainage Plan

Canadian River Tributaries

Detailed HEC-HMS Schematic Atlas

Section 5 - Appendix A

0 200 400

Feet

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HMS Points

Reservoir

Subbasin

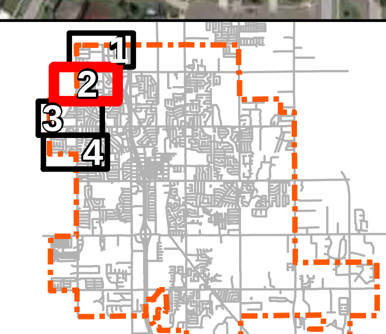
Junction

HMS Lines

Reach

Route Downstream

Canadian River Tributaries



CITY OF MOORE OKLAHOMA

Map Page 2 of 4

City of Moore - Master Drainage Plan

Canadian River Tributaries

Detailed HEC-HMS Schematic Atlas

Section 5 - Appendix A

0 200 400

Feet

N

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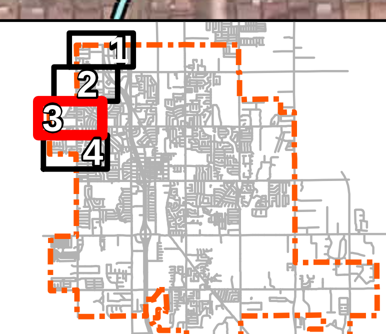
HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Canadian River Tributaries



CITY OF MOORE OKLAHOMA 1893

Map Page 3 of 4

City of Moore - Master Drainage Plan

Canadian River Tributaries

Detailed HEC-HMS Schematic Atlas

Section 5 - Appendix A

0 200 400
Feet

N

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HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	Canadian River Tributaries

1
2
3
4

CITY OF MOORE OKLAHOMA 1893

City of Moore					
Appendix 5-B Moore Master Drainage Plan Alternatives - Tribs of Canadian River - Problem Area #03 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	200	$ 12.00	$ 2,400.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	1100	$ 3.00	$ 3,300.00
3	**CLASS C CONCRETE**	**CY**	10	$ 338.00	$ 3,380.00
4	**DITCH LINER PROTECTION**	**LF**	110	$ 10.00	$ 1,100.00
5	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 2,000.00	$ 2,000.00
				Subtotal	**$ 12,180.00**
				15% Contingency	**$ 1,827.00**
				Subtotal	**$ 14,007.00**
				25% Utility Relocation Contingency	**$ 3,501.75**
				Total	***$ 17,508.75***

City of Moore					
Appendix 5-B Moore Master Drainage Plan Alternatives - Tribs of Canadian River - Problem Area #03 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	250	$ 12.00	$ 3,000.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	750	$ 3.00	$ 2,250.00
3	**CLASS C CONCRETE**	**CY**	16	$ 338.00	$ 5,408.00
4	**DITCH LINER PROTECTION**	**LF**	100	$ 10.00	$ 1,000.00
5	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 2,000.00	$ 2,000.00
				Subtotal	**$ 13,658.00**
				15% Contingency	**$ 2,048.70**
				Subtotal	**$ 15,706.70**
				25% Utility Relocation Contingency	**$ 3,926.68**
				Total	***$ 19,633.38***

City of Moore					
Appendix 5-B Moore Master Drainage Plan Alternatives - Tribs of Canadian River - Problem Area #04 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	20	$ 12.00	$ 240.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	60	$ 3.00	$ 180.00
3	**10" TALL RECESSED CURB INLET - 8' LENGTH**	**LS**	3	$ 5,000.00	$ 15,000.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
				Subtotal	**$ 20,420.00**
				15% Contingency	**$ 3,063.00**
				Subtotal	**$ 23,483.00**
				25% Utility Relocation Contingency	**$ 5,870.75**
				Total	***$ 29,353.75***

Section 6
North Fork River

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918.392.5620 fax: 918.392.5621

MESHEK & ASSOCIATES, PLC

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SECTION 6. NORTH FORK RIVER WATERSHED

6.1. PREVIOUS STUDIES

FEMA has performed previous detailed and re-delineated studies of streams in the North Fork River Watershed. Any alternatives and recommendations proposed in this section were generated as part of this detailed study. Information regarding the background for this most recent study can be found in **SECTION 1 - EXECUTIVE SUMMARY** and **SECTION 2 - METHODOLOGY**.

6.2. EXISTING CONDITIONS HYDROLOGY

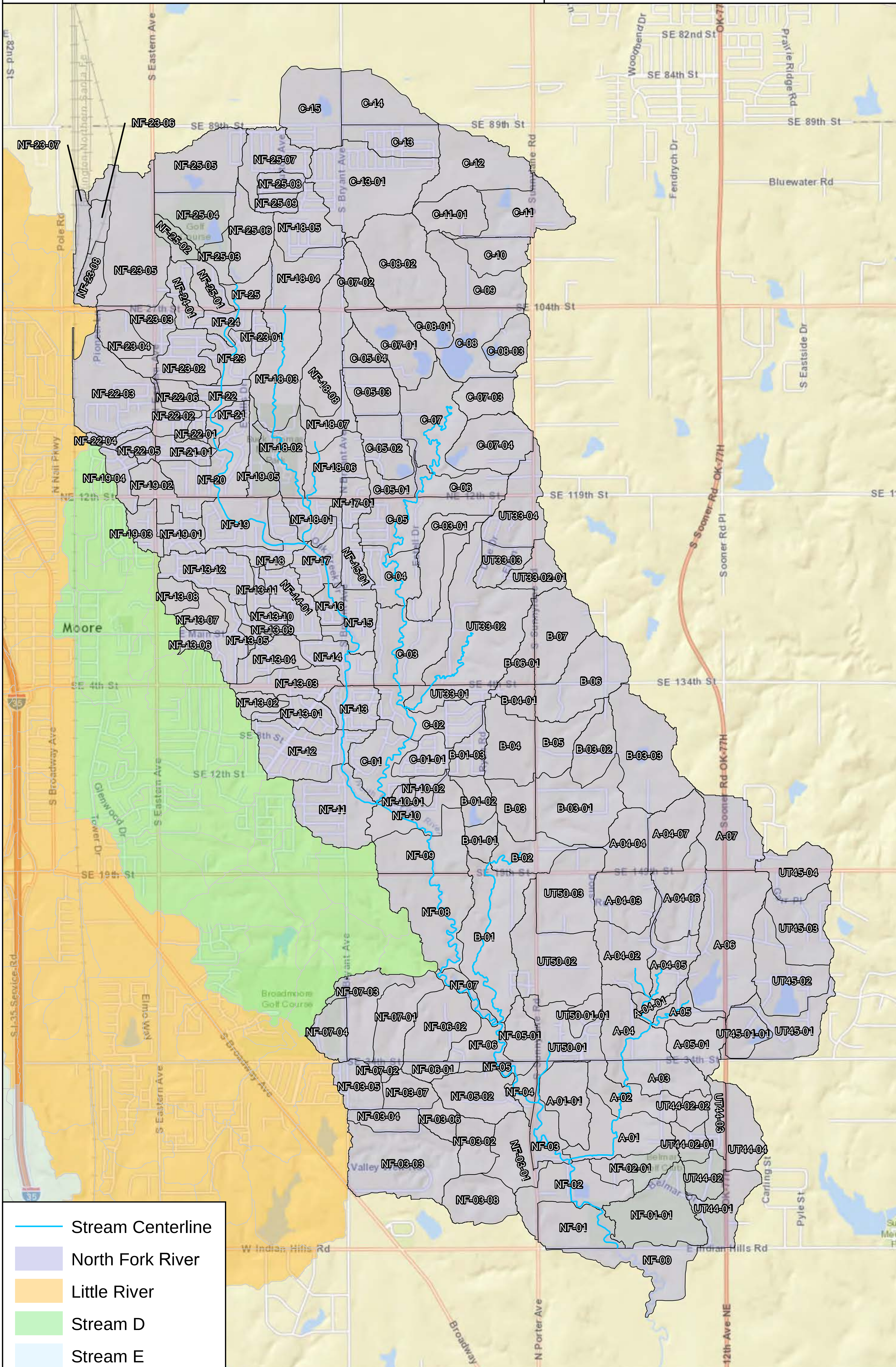
The studied North Fork River Watershed consists of approximately 12.8 square miles of drainage area. The study area is generally located north of E. Franklin Road, south of Interstate 240, east of the BNSF Railroad Line, and west of S Air Depot Boulevard. Stream A generally flows north to south and east to west to discharge into the North Fork River. North Fork River generally flows north to south and west to east to discharge into the Little River, which eventually drains to the Canadian River. The studied North Fork River Watershed is divided into 169 sub-basins which are depicted in **FIGURE 6-1.**

The hydrologic soil groups are shown in **FIGURE 6-2** with the existing land use depicted in **FIGURE 6-3.** More information on the hydrologic methodology can be found in **SECTION 2.1 HYDROLOGIC ANALYSIS**.

The hydrologic coefficients used for input in the HEC-HMS model include the lag time, soil complex curve number (CN) and drainage area. The HEC-HMS schematic, showing the connectivity of the hydrologic elements, can be found in **FIGURE 6-4** with more detailed HEC-HMS schematics provided in **APPENDIX 6-A**. A summary of hydrologic coefficients is presented in **TABLE 6-1**.

The flowrates for existing conditions of the North Fork River Drainage Basins were developed using HEC-HMS. A list of the flowrates at major junctions for the existing conditions is presented in **Table 6-2**.

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA

North Fork River
Drainage Basins

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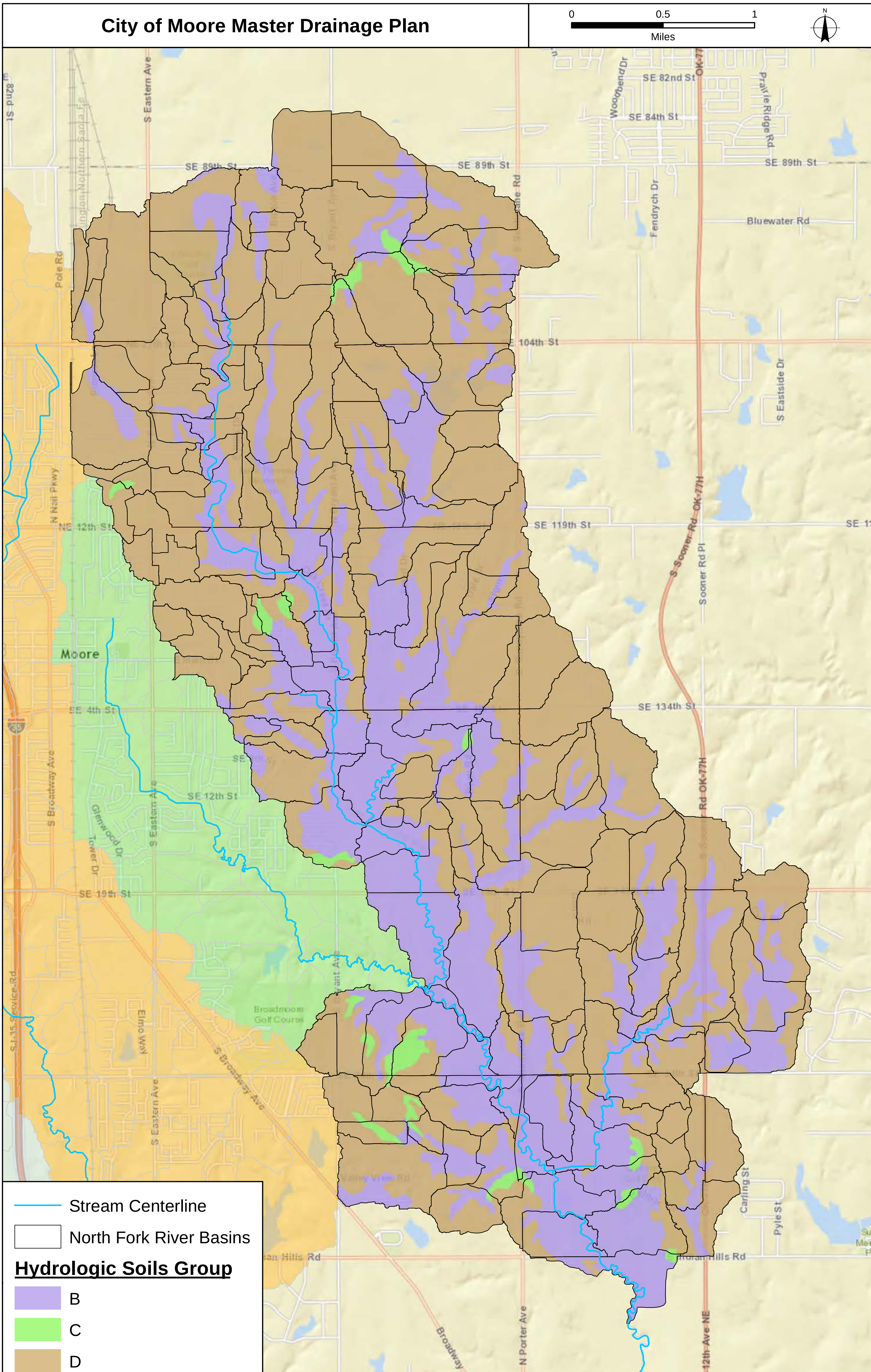
Figure 6 - 1

City of Moore Master Drainage Plan



North Fork River
Hydrologic Soils Group

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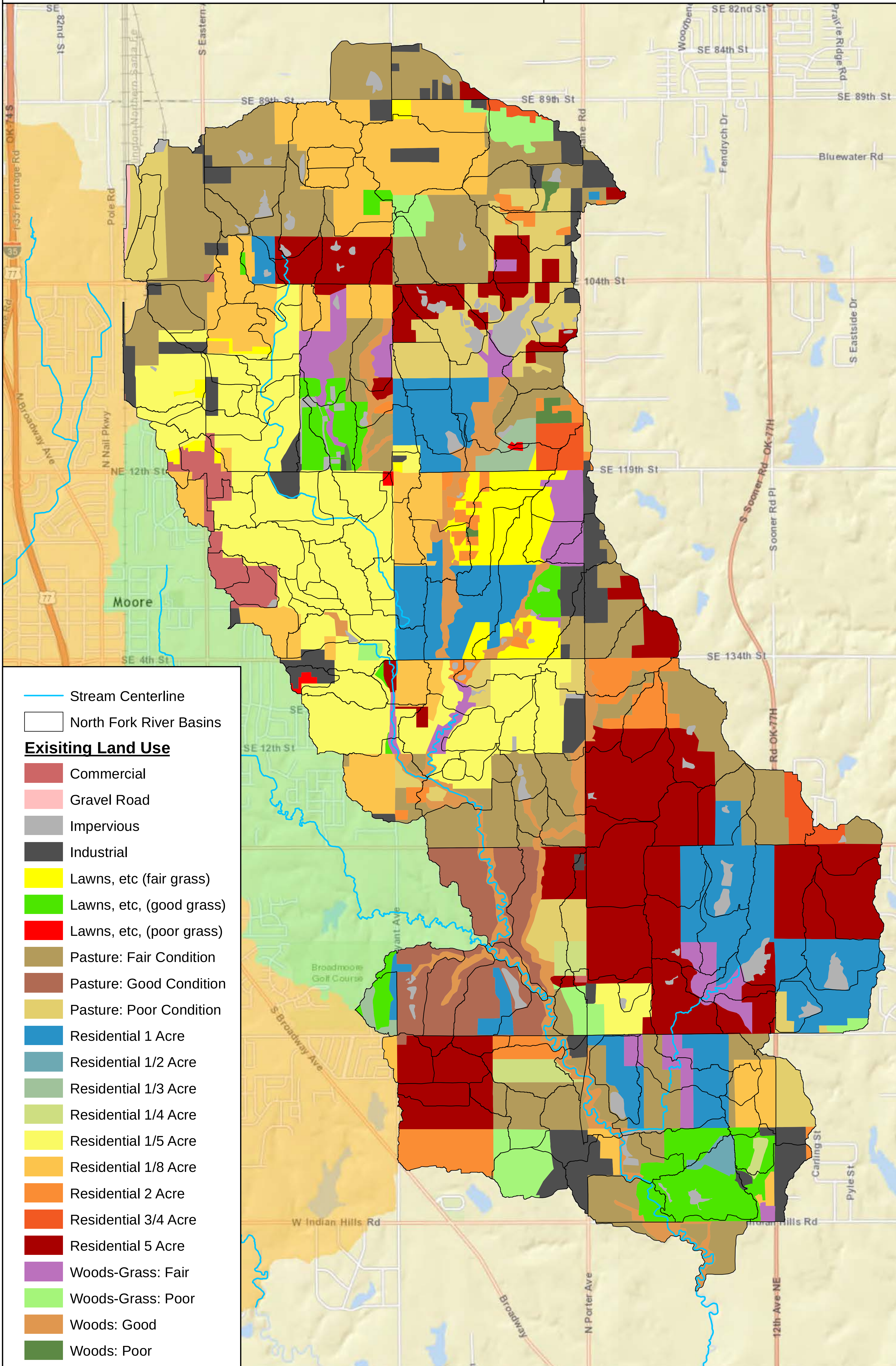
Figure 6 - 2

City of Moore Master Drainage Plan



North Fork River
Existing Land Use

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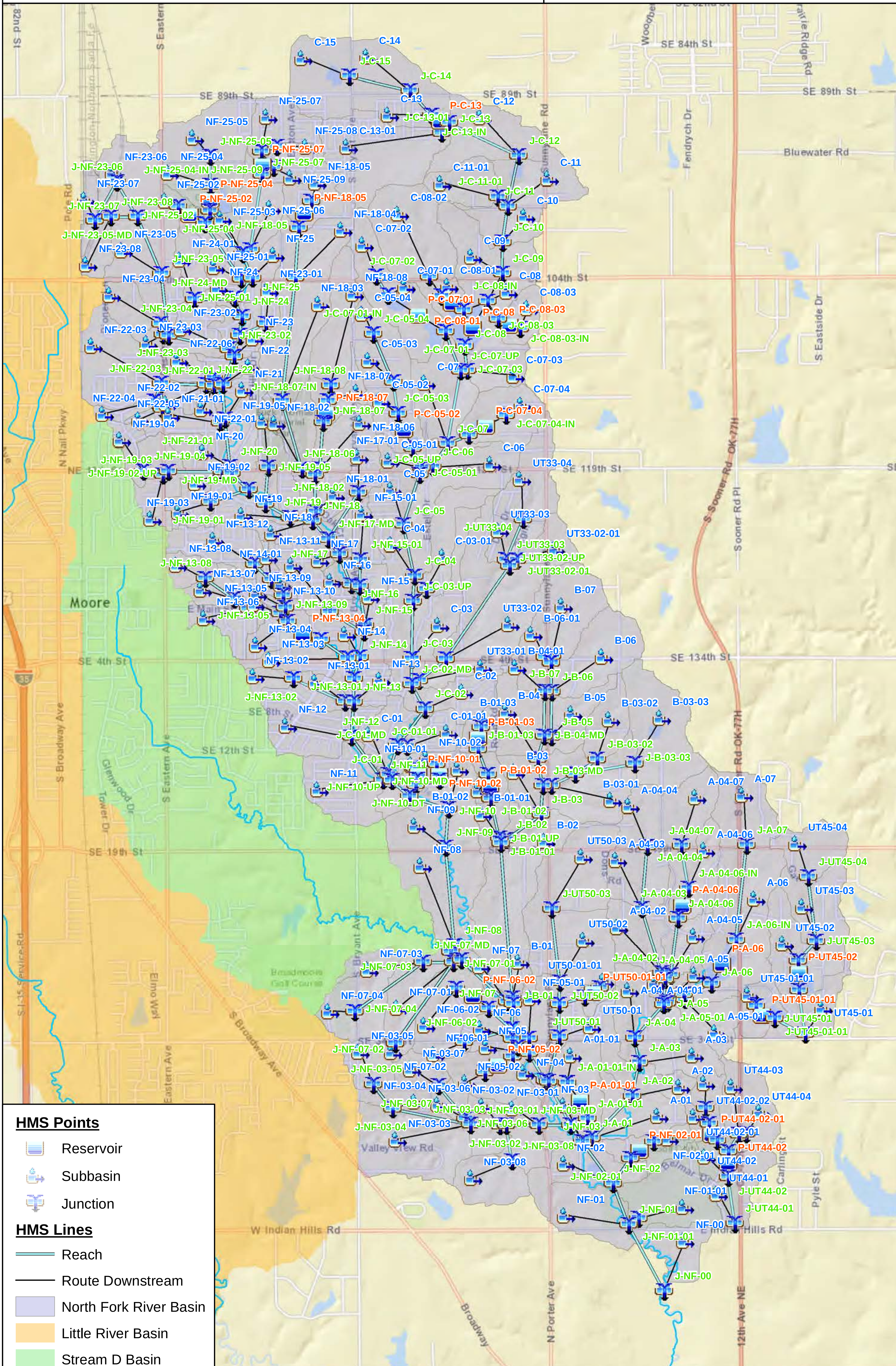
Figure 6 - 3

City of Moore Master Drainage Plan



North Fork River HEC - HMS Schematic

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Figure 6 - 4

TABLE 6-1. NORTH FORK RIVER DRAINAGE BASINS SUMMARY OF HYDROLOGIC COEFFICIENTS FOR EXISTING CONDITIONS

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
A-01	69.2	15.6	69.2	0.11
A-01-01	72.6	10.4	58.0	0.09
A-02	75.3	10.2	47.8	0.07
A-03	79.4	10.8	52.4	0.08
A-04	77.3	10.4	64.3	0.10
A-04-01	72.2	9.7	12.9	0.02
A-04-02	78.2	10.5	61.5	0.10
A-04-03	82.8	6.3	58.8	0.09
A-04-04	82.0	12.8	44.3	0.07
A-04-05	73.2	10.7	41.5	0.06
A-04-06	78.4	7.8	66.2	0.10
A-04-07	81.3	14.3	58.3	0.09
A-05	71.5	8.7	24.7	0.04
A-05-01	79.8	7.7	44.1	0.07
A-06	78.2	9.9	149.8	0.23
A-07	83.1	13.1	70.6	0.11
B-01	70.2	19.4	135.1	0.21
B-01-01	79.4	5.1	20.1	0.03
B-01-02	86.2	1.8	25.9	0.04
B-01-03	83.7	9.2	26.4	0.04
B-02	75.0	12.8	44.2	0.07
B-03	75.6	10.0	40.9	0.06
B-03-01	78.9	14.3	99.9	0.16
B-03-02	78.3	15.2	44.4	0.07
B-03-03	81.5	18.5	115.1	0.18
B-04	85.1	12.0	64.4	0.10
B-04-01	85.6	10.1	20.3	0.03
B-05	78.4	9.5	45.7	0.07
B-06	82.2	16.3	88.9	0.14
B-06-01	87.0	16.1	25.2	0.04
B-07	86.1	16.5	73.9	0.12
C-01	74.7	10.8	57.9	0.09
C-01-01	86.8	6.4	31.6	0.05
C-02	80.5	14.2	65.6	0.10
C-03	70.4	20.7	106.0	0.17
C-03-01	77.8	24.1	56.7	0.09
C-04	71.0	10.2	48.7	0.08
C-05	79.7	20.9	81.6	0.13
C-05-01	75.5	8.6	22.5	0.04
C-05-02	77.6	6.1	48.1	0.08
C-05-03	86.1	14.7	43.5	0.07
C-05-04	84.6	8.0	22.6	0.04
C-06	78.5	13.6	40.3	0.06
C-07	71.9	19.1	88.4	0.14

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
C-07-01	84.7	5.0	69.1	0.11
C-07-02	83.0	9.8	32.1	0.05
C-07-03	84.7	7.3	37.2	0.06
C-07-04	84.4	7.0	70.3	0.11
C-08	88.1	3.9	65.8	0.10
C-08-01	86.6	4.4	25.4	0.04
C-08-02	84.0	15.0	113.7	0.18
C-08-03	87.2	4.9	33.7	0.05
C-09	82.2	9.5	74.1	0.12
C-10	82.1	6.5	39.5	0.06
C-11	86.2	10.7	71.5	0.11
C-11-01	83.6	5.5	47.7	0.07
C-12	85.0	12.5	89.7	0.14
C-13	87.3	21.2	48.3	0.08
C-13-01	89.9	22.1	138.8	0.22
C-14	84.7	21.9	62.8	0.10
C-15	86.6	12.0	83.0	0.13
NF-00	65.1	15.4	64.7	0.10
NF-01	68.7	12.9	58.9	0.09
NF-01-01	69.2	7.1	92.3	0.14
NF-02	78.6	10.8	71.7	0.11
NF-02-01	67.3	10.1	41.1	0.06
NF-03	65.3	13.2	37.4	0.06
NF-03-01	82.4	8.6	51.4	0.08
NF-03-02	77.7	10.8	35.0	0.05
NF-03-03	77.9	18.0	124.1	0.19
NF-03-04	79.3	7.0	25.9	0.04
NF-03-05	83.9	5.6	36.4	0.06
NF-03-06	78.3	3.1	18.6	0.03
NF-03-07	81.0	8.0	29.1	0.05
NF-03-08	84.8	8.4	54.2	0.08
NF-04	71.2	10.4	16.8	0.03
NF-05	67.0	7.6	14.9	0.02
NF-05-01	74.9	11.1	29.4	0.05
NF-05-02	76.6	7.1	59.2	0.09
NF-06	61.9	7.4	31.2	0.05
NF-06-01	80.4	6.6	15.5	0.02
NF-06-02	73.9	10.2	70.4	0.11
NF-07	56.4	8.8	16.0	0.02
NF-07-01	66.0	10.1	57.1	0.09
NF-07-02	80.4	4.4	8.1	0.01
NF-07-03	75.2	8.2	60.0	0.09
NF-07-04	82.7	12.1	32.5	0.05
NF-08	60.1	20.5	103.7	0.16

Table 6-1. North Fork River Drainage Basins Summary of Hydrologic Coefficients for Existing Conditions (continued)

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
NF-09	71.9	10.6	75.4	0.12
NF-10	72.0	11.5	54.0	0.08
NF-10-01	83.6	5.1	7.6	0.01
NF-10-02	87.4	4.7	11.2	0.02
NF-11	80.8	12.5	87.5	0.14
NF-12	84.9	10.2	84.1	0.13
NF-13	81.2	5.9	37.8	0.06
NF-13-01	85.6	9.8	32.9	0.05
NF-13-02	87.4	6.3	16.1	0.03
NF-13-03	85.5	10.4	43.2	0.07
NF-13-04	83.9	6.2	37.9	0.06
NF-13-05	89.3	3.5	7.1	0.01
NF-13-06	91.5	10.2	45.7	0.07
NF-13-07	94.8	7.7	25.6	0.04
NF-13-08	94.7	9.9	20.2	0.03
NF-13-09	87.2	6.4	11.8	0.02
NF-13-10	85.9	5.4	8.0	0.01
NF-13-11	88.4	7.0	12.2	0.02
NF-13-12	89.5	15.1	60.3	0.09
NF-14	78.1	7.6	40.2	0.06
NF-14-01	84.0	14.5	46.4	0.07
NF-15	76.9	9.0	40.6	0.06
NF-15-01	89.6	7.5	25.7	0.04
NF-16	79.2	3.5	18.8	0.03
NF-17	82.7	9.1	43.8	0.07
NF-17-01	86.1	8.1	22.3	0.03
NF-18	86.4	11.1	39.1	0.06
NF-18-01	81.8	6.2	33.9	0.05
NF-18-02	79.1	11.2	48.8	0.08
NF-18-03	81.9	14.6	102.4	0.16
NF-18-04	83.8	8.0	65.0	0.10
NF-18-05	89.6	7.7	55.8	0.09
NF-18-06	78.4	12.4	52.9	0.08
NF-18-07	78.3	8.1	34.4	0.05
NF-18-08	80.9	14.9	74.0	0.12
NF-19	84.3	9.6	61.0	0.10
NF-19-01	90.0	7.2	27.6	0.04
NF-19-02	92.0	11.0	42.9	0.07
NF-19-03	92.7	10.8	23.1	0.04
NF-19-04	89.3	10.8	22.7	0.04
NF-19-05	83.8	20.9	28.4	0.04
NF-20	86.2	11.6	72.6	0.11
NF-21	82.7	6.1	17.6	0.03
NF-21-01	89.3	9.8	23.5	0.04

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
NF-22	84.0	6.0	21.6	0.03
NF-22-01	88.0	5.7	7.9	0.01
NF-22-02	90.2	7.9	22.6	0.04
NF-22-03	86.1	14.8	110.1	0.17
NF-22-04	89.0	10.6	11.8	0.02
NF-22-05	88.7	5.5	13.2	0.02
NF-22-06	85.3	10.8	20.3	0.03
NF-23	87.8	9.8	37.4	0.06
NF-23-01	92.0	9.0	12.5	0.02
NF-23-02	89.0	11.4	46.9	0.07
NF-23-03	88.1	7.4	43.5	0.07
NF-23-04	84.1	7.8	33.2	0.05
NF-23-05	85.8	18.7	142.0	0.22
NF-23-06	89.0	14.7	15.0	0.02
NF-23-07	89.5	27.1	19.8	0.03
NF-23-08	86.0	11.6	24.7	0.04
NF-24	88.1	5.0	21.6	0.03
NF-24-01	91.3	10.5	29.5	0.05
NF-25	79.8	7.9	25.8	0.04
NF-25-01	82.1	5.7	26.5	0.04
NF-25-02	85.0	7.6	18.9	0.03
NF-25-03	75.6	8.3	17.6	0.03
NF-25-04	84.3	4.1	57.9	0.09
NF-25-05	81.9	19.1	82.4	0.13
NF-25-06	82.0	10.8	54.5	0.09
NF-25-07	89.5	9.3	56.3	0.09
NF-25-08	89.7	8.5	16.9	0.03
NF-25-09	89.7	5.4	14.0	0.02
UT33-01	78.2	9.9	30.1	0.05
UT33-02	79.9	19.9	155.4	0.24
UT33-02-01	87.7	14.5	34.6	0.05
UT33-03	80.2	9.8	29.8	0.05
UT33-04	84.0	18.1	69.9	0.11
UT44-01	86.2	11.5	50.5	0.08
UT44-02	78.2	7.6	28.0	0.04
UT44-02-01	87.3	8.2	20.4	0.03
UT44-02-02	90.6	7.8	18.0	0.03
UT44-03	91.1	9.1	23.3	0.04
UT44-04	89.5	18.7	46.6	0.07
UT45-01	76.1	13.1	59.4	0.09
UT45-01-01	79.5	9.4	31.1	0.05
UT45-02	78.5	19.1	81.2	0.13
UT45-03	76.7	17.0	66.9	0.10
UT45-04	81.9	11.9	53.4	0.08

TABLE 6-1. NORTH FORK RIVER DRAINAGE BASINS SUMMARY OF HYDROLOGIC COEFFICIENTS FOR EXISTING CONDITIONS (CONTINUED)

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
UT50-01	81.9	7.2	59.1	0.09
UT50-01-01	85.8	4.9	15.6	0.02
UT50-02	78.6	20.5	115.4	0.18
UT50-03	81.4	23.3	84.4	0.13

TABLE 6-2. NORTH FORK RIVER DRAINAGE BASINS – EXISTING FLOWRATES AT MAJOR JUNCTIONS (CFS)

Description	HMS Junction	Stream	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year	Drainage Area, mi^2
NE 27th Street	J-NF-25	North Fork River	273	352	562	768	1000	1187	1399	2073	0.59
NE 23rd Street	J-NF-24	North Fork River	316	403	636	859	1150	1362	1608	2260	0.67
NE 22nd Street	J-NF-23	North Fork River	516	630	989	1252	1955	2274	2538	3765	1.25
E Hills Drive	J-NF-21	North Fork River	700	858	1297	1667	2295	2751	3188	4320	1.64
NE 12th Street	J-NF-20	North Fork River	736	899	1345	1752	2325	2800	3324	4542	1.75
Bronze Medal Rd	J-NF-19	North Fork River	882	1081	1559	2037	2700	3197	3850	5192	2.08
N Bryant Avenue	J-NF-16	North Fork River	1261	1566	2358	3116	4168	4965	5921	7999	3.00
SE 4th Street	J-NF-14	North Fork River	1292	1608	2431	3193	4280	5111	6094	8276	3.23
SE 7th Street	J-NF-13	North Fork River	1393	1759	2794	3630	4803	5766	6828	9305	3.79
Stream C	J-NF-10-UP	North Fork River	1892	2438	3897	5228	7019	8465	10162	14566	7.43
SE 19th Street	J-NF-09	North Fork River	1888	2425	3889	5145	7054	8514	10250	14670	7.66
Stream D	J-NF-07-UP	North Fork River	2418	3021	4996	6365	9340	11155	13437	18903	10.26
Stream B	J-NF-06-UP	North Fork River	2504	3107	4961	6832	10201	12102	15011	21824	11.88
SE 34th Street	J-NF-06	North Fork River	2502	3107	4958	6833	10139	11975	15056	21954	12.06
S Sunnylane Rd	J-NF-04	North Fork River	2507	3113	4935	6791	9994	11851	15130	22089	12.25
Stream A	J-NF-03	North Fork River	2626	3256	5147	7131	10793	12972	16864	25619	14.74
E Indian Hills Rd	J-NF-01	North Fork River	2604	3225	5115	7149	10789	13025	17117	25840	15.14
Limit of Study	J-NF-00	North Fork River	2590	3209	5075	7137	10754	13039	16898	25854	15.24
Sooner Lake Dr	J-A-06	Stream A	29	46	282	460	668	813	959	1326	0.34
SE 34th Street	J-A-04	Stream A	249	329	612	1013	1603	2029	2521	3731	1.08
North Fork River	J-A-01	Stream A	277	369	627	1019	1713	2197	2748	4159	1.43
S Sunnylane Rd	J-B-05	Stream B	216	273	434	569	750	893	1040	1411	0.37
SE 19th Street	J-B-02	Stream B	496	635	1037	1378	1843	2212	2594	3562	1.04
North Fork River	J-B-01	Stream B	538	691	1135	1512	2063	2481	2917	4027	1.36
E Horseshoe Ln	J-C-11	Stream C	445	549	836	1070	1366	1606	1856	2489	0.85
SE 104th Street	J-C-09	Stream C	472	583	890	1139	1457	1715	1985	2670	1.03
NE 12th Street	J-C-06	Stream C	479	687	1143	1547	2140	2600	3065	4409	1.93
SE 4th Street	J-C-03	Stream C	537	768	1307	1840	2540	3070	3603	5124	2.63
Unnamed Trib 33	J-C-02-MD	Stream C	584	814	1413	1996	2763	3346	3939	5600	3.13
Wimberley Crk Dr	J-C-02	Stream C	593	821	1428	2017	2793	3384	3986	5706	3.23
North Fork River	J-C-01	Stream C	599	820	1431	2016	2795	3393	4004	5734	3.37

6.3. Existing Conditions Hydraulics

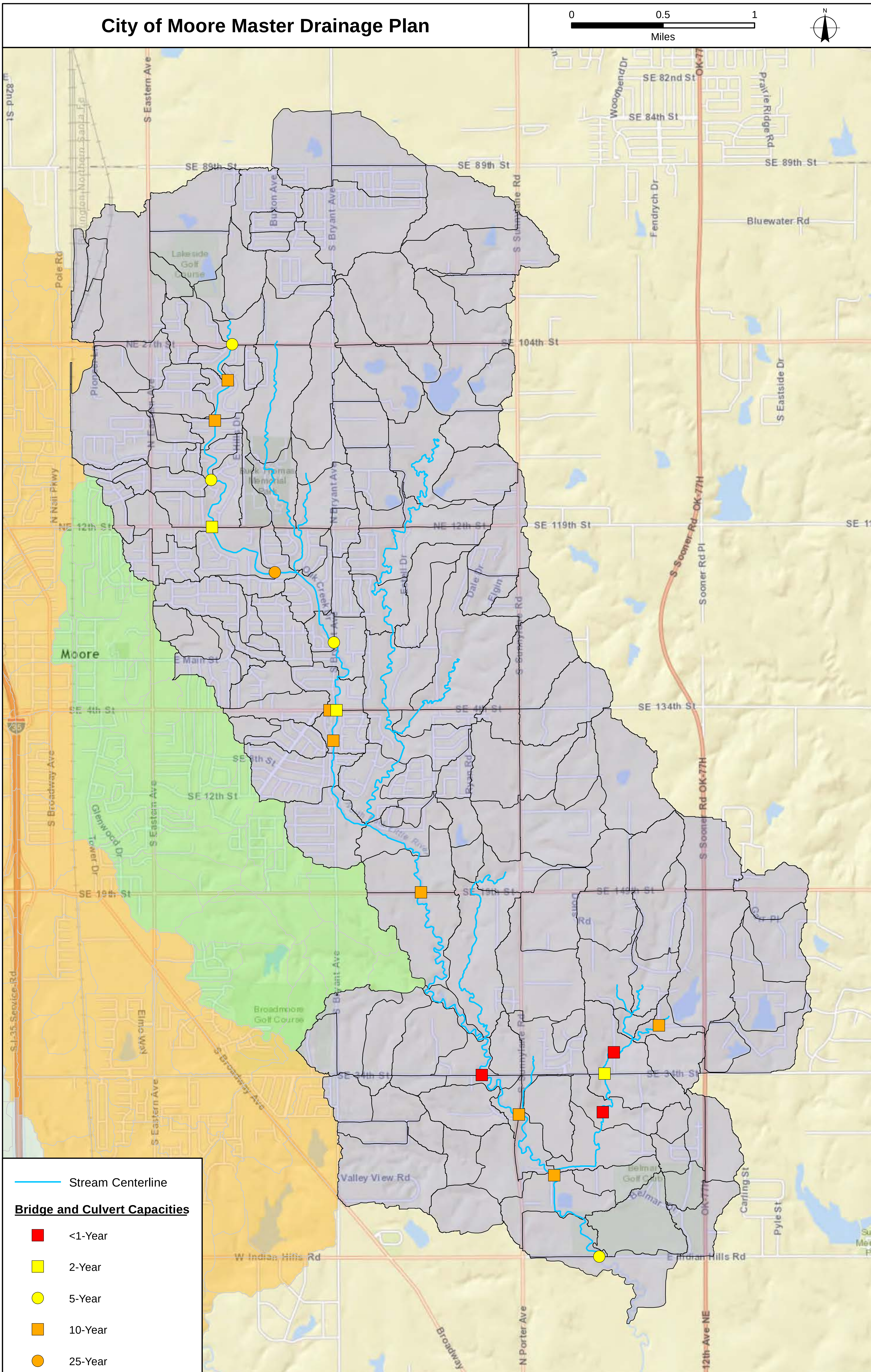
The North Fork River Watershed consists of 2 hydraulically studied streams, the North Fork River and Stream A, consisting of approximately 11.0 total stream miles. These streams were modeled using a GeoHEC-RAS software to determine bridge/culvert capacities, water surface profiles, and floodplains. More information on the hydraulic methodology can be found in **Section 2.2 Hydraulic Analysis**.

Figure 6-5 illustrates the location of the studied bridges and/or culverts and the associated existing condition storm frequency capacity.

Appendix 6-B shows the existing condition water surface profiles for the 10-year, 25-year, 50-year, 100-year, and 500-year storm events.

Appendix 6-C shows the updated City of Moore regulatory 100-year and 500-year floodplains and floodway which terminate at the limit of the hydraulic study, shown on the exhibit.

City of Moore Master Drainage Plan



North Fork River
Bridge & Culvert Capacities

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Figure 6 - 5

6.4. PROBLEM AREAS

The flooding problems areas identified in the North Fork River Drainage Basins are based on flooding comments and observations received from community residents, City of Moore staff, and Meshek & Associates, PLC. The location of these problem areas are shown in **FIGURE 6-6, FIGURE 6-7, FIGURE 6-8 AND FIGURE 6-9**, and are labeled according to the GIS-ID problem area numbers and descriptions below. Unless noted otherwise, all problem area comments generally refer to flooding and drainage problems observed in the May 5-8, 2015 storm events.

A. Problem Area 1: North Fork River near Intersection of S Sunnylane Rd & SE 34th St

A private residential property located at 3575 Joshua Lane had flooding inside of the residential structure (GIS ID-30). The property owner described the water surface elevation rising quickly from a sudden surge.

A private residential property located at 2813 SE 38th Street had flooding in the backyard with an approximate depth of 7 feet (GIS ID-144).

A private residential property located at 2800 Shady Creek Lane had flooding in a shop structure and in the backyard with an approximate depth of 2 feet (GIS ID-143). The property owner also observed flooding in the shop structure in a May 2013 storm.

B. Problem Area 2: Confluence of North Fork River and Stream C

A private residential property located at 1324 Ann's Place had flooding inside of the garage and garage storm cellar (GIS ID-97).

A private residential property located at 1329 Ann's Place had flooding inside of the residential structure (GIS ID-98).

A private residential property located at 1333 Ann's Place had flooding inside of the residential structure (GIS ID-99).

A private residential property located at 1301 Ann's Place had flooding in the backyard and within 1.5 feet of the residential structure (GIS ID-100).

Private residential property owners observed discharge flooding depths of 1 to 1.5 feet on SE 12th St roadway draining west and turning south onto Ann's Place roadway (GIS ID-101).

C. Problem Area 3: Intersection of SE 9th St & Renita Way

A private residential property located at 1001 Renita Way had flooding in the backyard (GIS ID-27).

A private residential property located on Renita Way expressed concern to attempt to keep a natural geometry and material in the North Fork River and correct erosion problems and flooding problems (GIS ID-19).

D. Problem Area 4: North Fork River near Intersection of S Bryant Ave & Parkway Dr.

A private residential property located at 309 S Wyndemere Springs had flooding in the backyard (GIS ID-167). The property owner described the discharge velocity as moderate to high.

A private residential property located at 313 S Wyndemere Springs had flooding in the backyard (GIS ID-171). The owner observed also bank erosion and deposited debris.

E. Problem Area 5: North Fork River Culvert at N Bryant Ave

A private residential property owner has observed the existing culvert located along the main stem of North Fork River under N Bryant Avenue to have an inadequate hydraulic capacity and the culvert becomes clogged with debris (GIS ID-168). The existing culvert consists of approximately 6 linear feet of triple 10 feet wide by 10 feet tall reinforced concrete box (RCBs). The existing structure has a hydraulic capacity of a 5-year frequency storm event. During a 10-year storm event, N Bryant Avenue roadway would be overtopped by 0.79 feet and during a 100-year storm event, N Bryant Avenue roadway would be overtopped by 1.9 feet.

F. Problem Area 6: North Fork River Culvert at NE 12th St

The existing culvert located along the main stem of North Fork River under NE 12th Street roadway consists of approximately 86 linear feet of double 10 feet wide by 7 feet tall reinforced concrete boxes (RCBs). The existing structure has a hydraulic capacity able to convey the 5-year frequency storm event. During a 10-year storm event, NE 12th Street roadway would be overtopped by 1.06 feet and during a 100-year storm event, NE 12th Street roadway would be overtopped by 2.62 feet.

A private residential property owner observed the existing culvert structure, described above, has an inadequate hydraulic capacity causing significant backwater upstream of the culvert. The owner also observed roadway discharge on NE 12th Street flooding the entire width of the roadway from N Eastern Avenue to the North Fork River (GIS ID-43).

A private residential property located at geographic coordinates 35.349390 by -97.471665 had flooding inside of the residential structure (GIS ID-42). The owner also observed roadway discharge from NE 12th Street divert north on Old Mill Road, and overland discharge from the west possibly emanating from N Lincoln Avenue.

A private residential property located at 1401 NE 12th Street had flooding in the backyard from a storm sewer system with an inadequate hydraulic capacity, located at the southwest corner of the Winding Creek Elementary School (GIS ID-161).

G. Problem Area 7: Lower Stream A near Sooner Drive

A private residential property owner located at 3800 Sooner Drive had flooding in the yard near the residential structure (GIS ID-139).

A private residential property owner located at 3700 Sooner Drive had flooding in the residential structure (GIS ID-138).

H. Problem Area 8: Stream A Culvert at SE 34th St

The existing culvert located along the main stem of Stream A under SE 34th Street roadway consists of approximately 40 linear feet of double 7 feet diameter corrugated metal pipe (CMPs). The existing structure has a hydraulic capacity able to convey the 2-year frequency storm event. During a 10-year storm event, SE 34th Street roadway would be overtopped by 0.53 feet and during a 100-year storm event, SE 34th Street roadway would be overtopped by 1.87 feet (GIS ID-135 & ID-137).

A private residential property owner located at 3107 Sooner Drive had flooding in the residential structure (GIS ID-135).

A private residential property owner located at 3102 Sooner Drive had flooding in the residential structure and secondary structure. The owner also had roadway access problems from roadway flooding in driveway and SE 34th Street (GIS ID-136).

A private residential property owner located at 3709 SE 34th Street had flooding in the residential structure and in multiple storm events (GIS ID-137).

I. Problem Area 9: SE 34th St near Shady Creek Ln

A private residential property located at 2500 SE 34th Street has observed poor drainage in the roadway ditch causing erosion of the property where the driveway and SE 34th Street intersected (GIS ID-140).

J. Problem Area 10: Red Rock Dr & SE 29th St Intersection

A private residential property located at 3008 Red Rock Drive has had flooding in the residential structure (GIS ID-22). The property owner has observed and video recorded surface discharge eroding and overtopping an open-channel embankment and diverting west into residential property backyards and structures.

K. Problem Area 11: Post Oak Ln & SE 5th St Intersection

A private residential property located at 524 Post Oak Lane has had flooding in the residential structure (GIS ID-67). The property owner has observed roadway discharge originating from the Highland East Junior High School and Moore Public Schools Administration Building. Topography indicated the Post Oak Lane and SE 5th Street roadways and intersection have relatively flat slopes.

L. Problem Area 12: N Morgan Drive to E Main St Storm Sewer Systems

A private residential property located at 1500 E Main Street had flooding in the residential structure (GIS ID-57). The property owner observed roadway flooding on E Main Street.

A private residential property located at 1501 E Main Street had flooding in the residential structure (GIS ID-59). The property owner observed roadway flooding on NE 1st Street overtop the curb and discharged across property to a flooded E Main Street roadway. The owner also indicates sink holes have formed in the ground of the front and back yards.

A private residential property located at 1425 E Main Street had flooding in the residential structure (GIS ID-60).

A private residential property located at 1424 E Main Street had flooding in the residential structure (GIS ID-61).

A private residential property located at 1420 E Main Street had flooding in the residential structure (GIS ID-62).

A private residential property located at 405 N Ramblin Oaks Drive had flooding in the residential structure (GIS ID-94).

A private residential property located at 408 N Ramblin Oaks Drive and 408 N Morgan Drive had flooding in yards (GIS ID-93 & ID-95).

The City of Moore observed roadway gutter inlets on N Morgan Drive are hydraulically inadequate (GIS ID-1017).

M. Problem Area 13: S Morgan Dr to S Ramblin Oaks Dr Storm Sewer System

Private residential properties located at 1400 E Main Street, 104 S Ramblin Oaks Drive, 117 S Ramblin Oaks Drive, 109 S Ramblin Oaks Drive, 105 S Ramblin Oaks Drive, and 112 S Morgan Drive had flooding in the residential structures and storm cellars (GIS ID-58, ID-64, ID-65, ID-63, ID-66, & ID-156). The property owners observed surface discharge originating from neighboring private property to east and north. There is a possibility of discharge from S Eastern Avenue flooding this property owner.

N. Problem Area 14: Intersection of SE 2nd St & S Ramblin Oaks Dr

The City of Moore has observed one or more storm sewer systems has a downstream outlet issue, located at the east end of the cul-de-sac of SE 2nd Street (GIS ID-1013).

O. Problem Area 15: Stream C & S Wyndemere Lakes Dr

A private residential property located at 216 S Wyndemere Lakes Drive had flooding in yard from storm sewer culvert with inadequate hydraulic capacity between neighbor to the north and from Stream C on the east property line (GIS ID-125).

P. Problem Area 16: Intersection of NE 20th St & N Lincoln Ave

Private residential properties located at 1209 NE 20th Street, 2009 N Lincoln Avenue, 1201 NE 20th Street, 1205 NE 20th Street, 1204 NE 20th Street, 2008 N Lincoln Avenue, 2004 N Lincoln Avenue, and 2000 N Lincoln Avenue had flooding in the residential structures (GIS ID's-32:39). The property owners observed flooding originating from roadway discharge flooding on NE 20th Street and N Lincoln Avenue. Flooding may have also originated from an open channel located between NE 20th Street and NE 19th Street due to backwater effects from North Fork River located behind several flooded residential structures.

A private property owner observed the discharge in the open channel located between NE 20th Street and NE 19th Street overtopping the Briar Hill Street culvert and roadway (GIS ID-41).

A private property owner located at 901 NE 20th Street had flooding in the backyard from developing neighboring property directly to the north (GIS ID-40).

Q. Problem Area 17: Intersection of Cedar Brook Dr & N Lincoln Ave

Private residential property owner has observed trash dumping in the open-channel near the intersection of Cedar Brook Drive and N Lincoln Avenue (GIS ID-14).

R. Problem Area 18: E Park Pl near Intersection with NE 23rd St

A private residential proper owner located at 2401 E Park Place has observed the inlets and/or storm sewer system located in the cul-de-sac of E Park Place to be hydraulically inadequate (GIS ID-28). The property owner also observed the flowline of an open-channel draining to the North

Fork River directly to the south, contains several ponding areas and may contribute to flooding in the backyard of the property address listed above.

S. Problem Area 19: N Bryant Ave near NE 15th St

A private residential property owner located at 1701 N Bryant Avenue has observed ditches with standing water and inadequate capacity for discharge along N Bryant Avenue between NE 15th Street and NE 18th Street (GIS ID-13). The property owner also observed culverts crossing N Bryant Avenue having inadequate hydraulic capacity, specifically referencing a culvert immediately to the north of 1705 N Bryant Avenue.

T. Problem Area 20: Foxfire Subdivision: Intersection of Flicker Ridge & NE 14th St

A private residential property owner has observed repetitive roadway flooding and standing water at the intersection of Flicker Ridge and NE 14th Street along with a deteriorating concrete roadway at this intersection likely caused by standing water (GIS ID-7). Topography indicates Flicker Ridge roadway is relatively flat between NE 14th Street and NE 12th Street.

U. Problem Area 21: Slater Dr & SE 41st St Roadways

Private property owners near the intersection of Slater Drive and SE 41st Street have observed significant roadway flooding and sediment transport on Slater Drive to SE 41st Street (GIS ID-148 & ID-149). The property owners observed trash and sediment clogging storm sewer inlets.

V. Problem Area 22: Intersection of Murray Ct & SE 28th St

Private residential property owners located at 4805 SE 28th Street and 2900 Murray Court reported flooding in backyards nearing the residential structures (GIS ID-145 & ID-146). Ground topography and historic aerial photographs indicate residential structures listed at the addresses above and at 2904 Murray Court were constructed adjacent to the natural grass-lined open-channel which drained surface discharge prior to development.

W. Problem Area 23: Detention Pond & SE 31st Circle

A private residential property located at 4801 SE 31st Circle had flooding in the residential structure due to failure of a detention pond dam immediately upstream (GIS ID-147).

X. Problem Area 24: SE 7th Street near Intersection with Whispering Oaks Blvd

A private residential property located at 1516 SE 7th Street had flooding in the residential structure (GIS ID-159). Ground topography indicates flooding originated from neighboring residential property to the northwest.

City of Moore Master Drainage Plan

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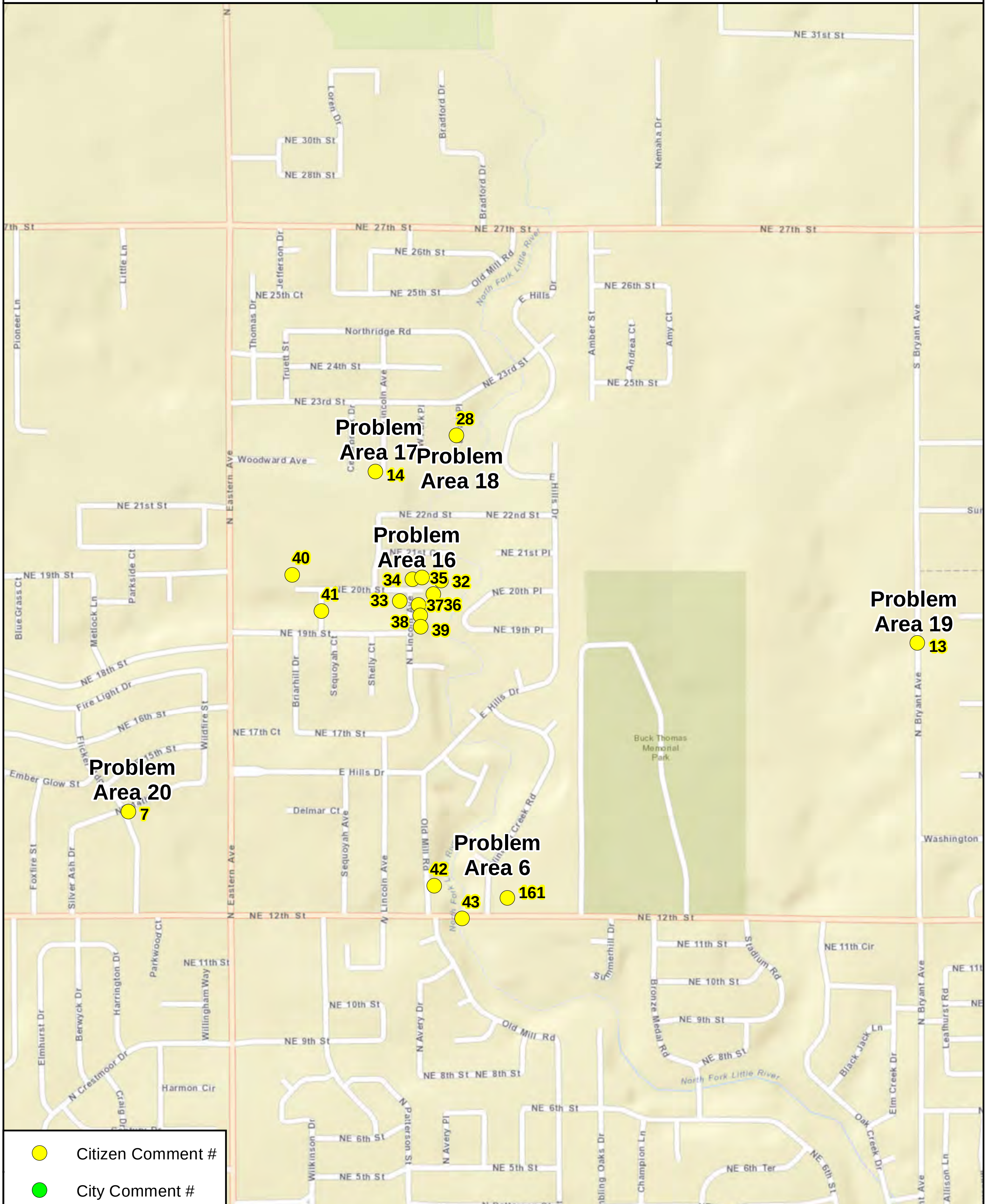

North Fork River Problem Areas

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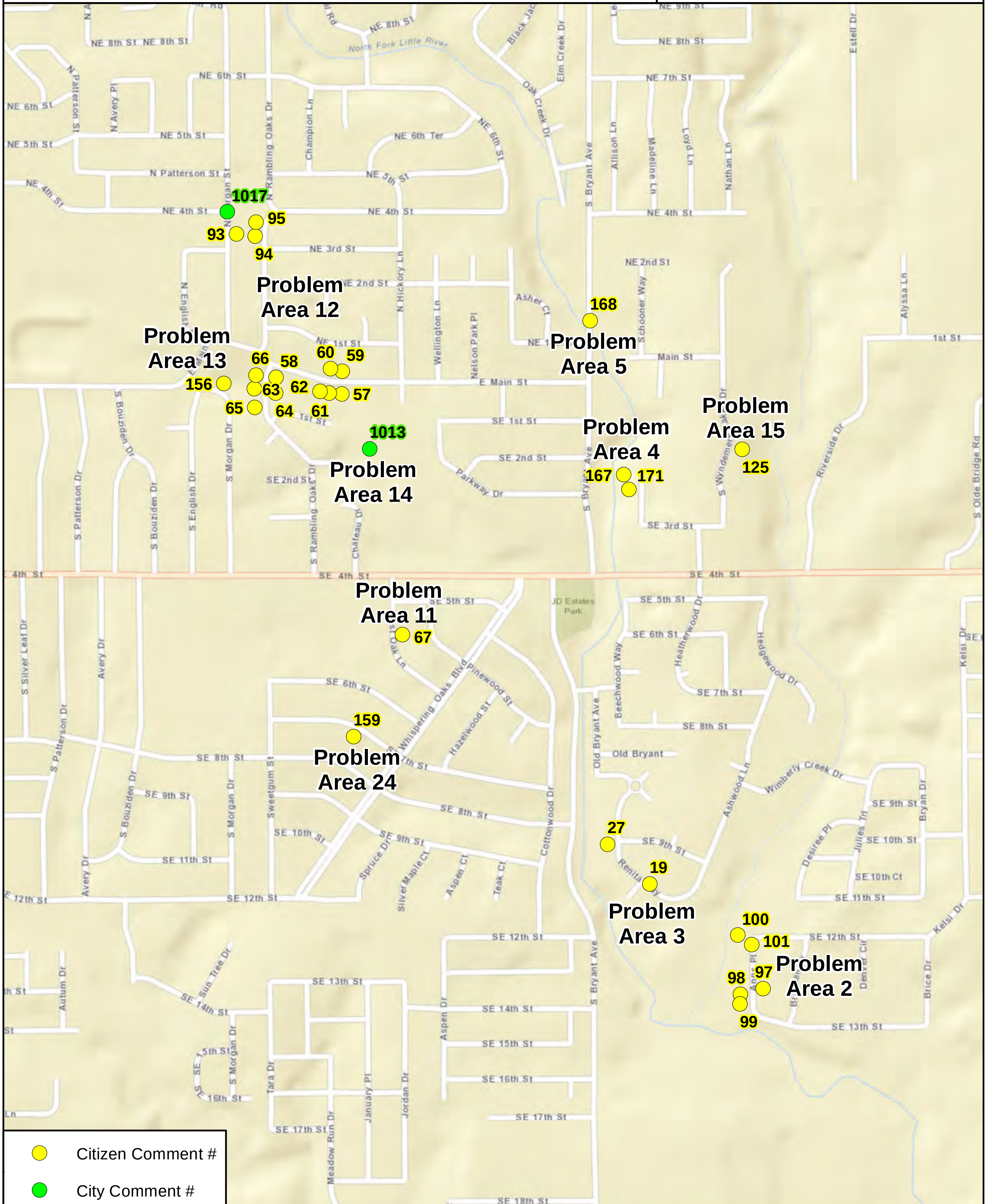
Figure 6 - 6

City of Moore Master Drainage Plan



North Fork River Problem Areas

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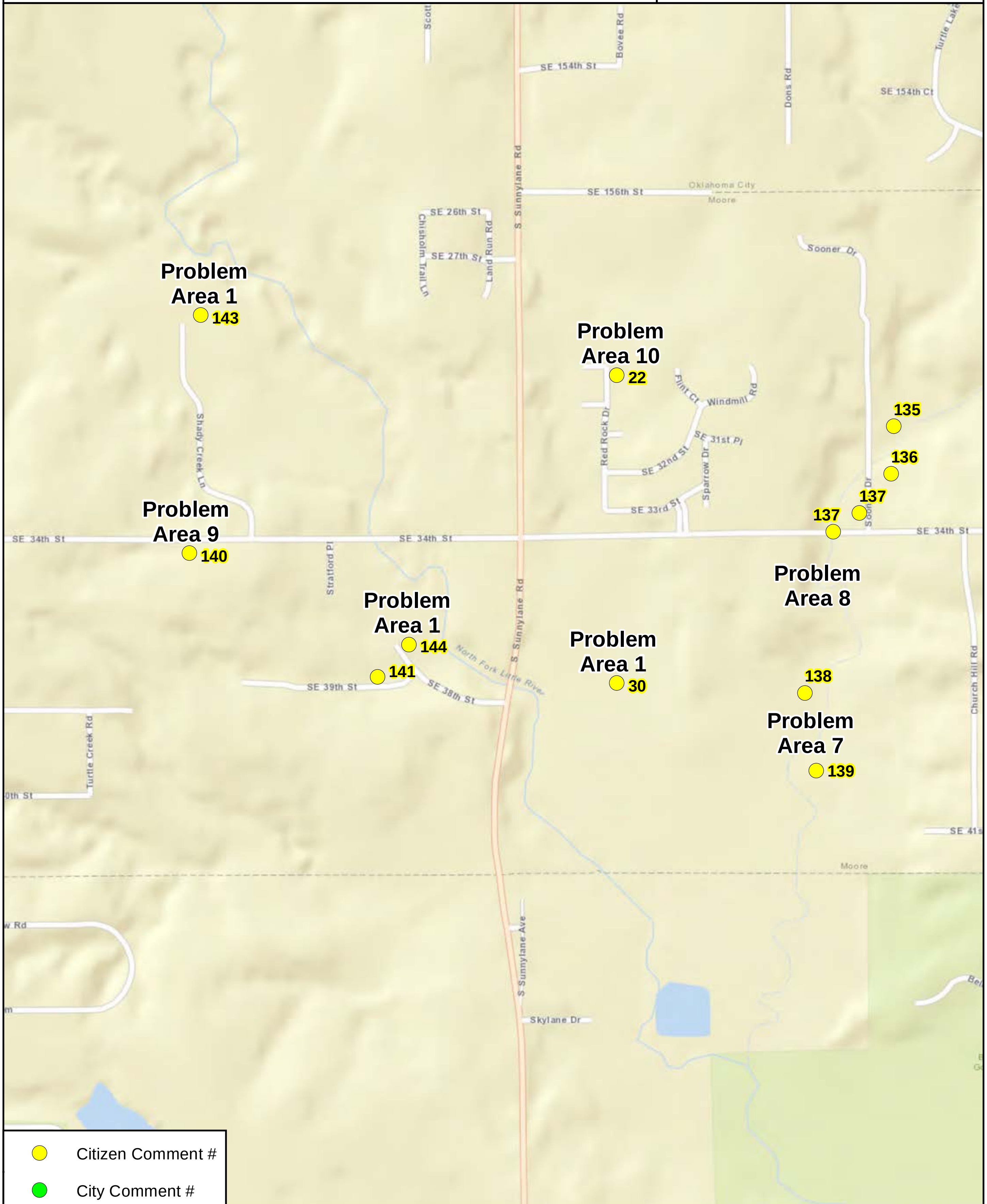
Figure 6 - 7

City of Moore Master Drainage Plan



North Fork River Problem Areas

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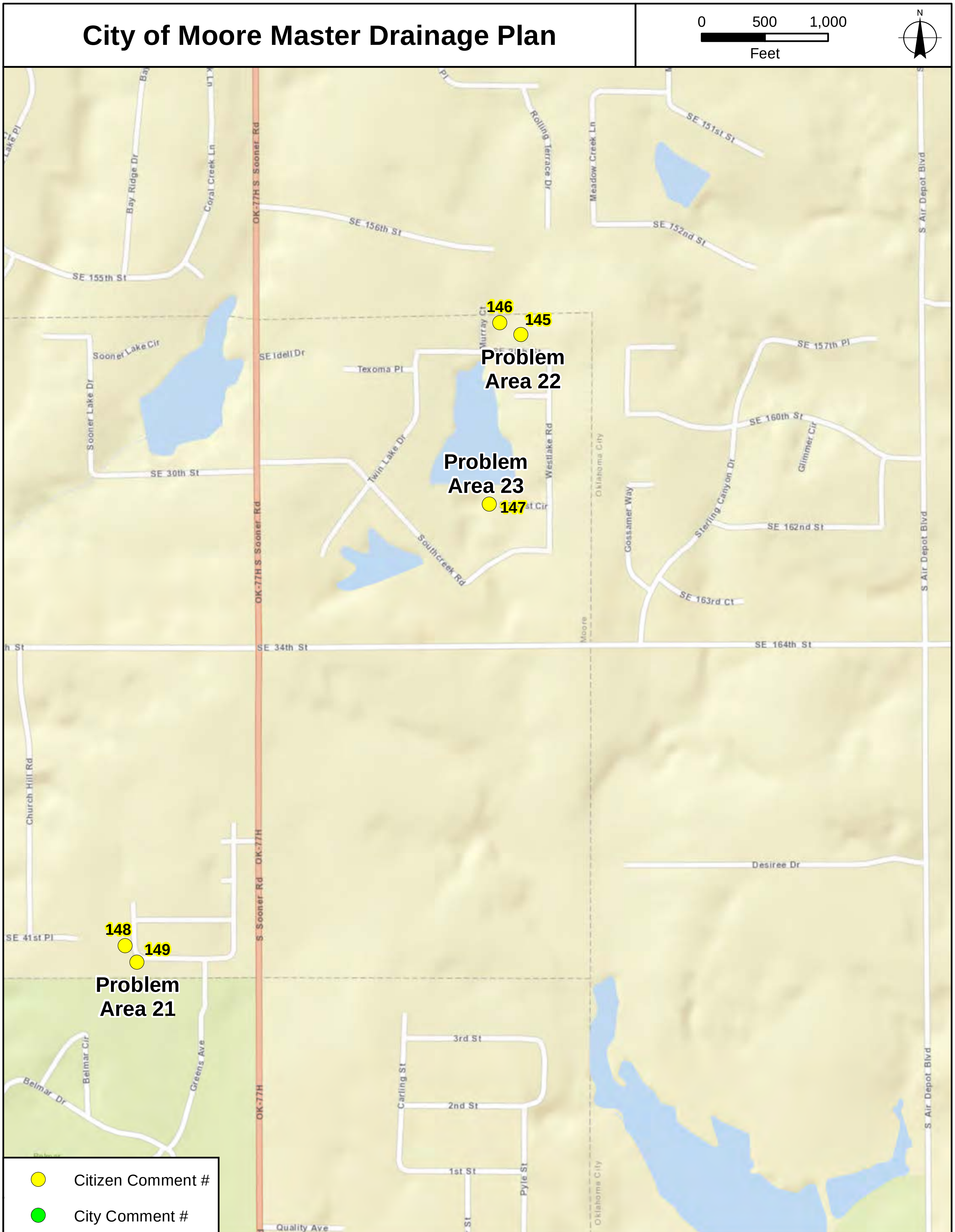
Figure 6 - 8

City of Moore Master Drainage Plan



North Fork River Problem Areas

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Figure 6 - 9

6.5. Evaluation of Alternatives and recommendations

Alternatives and recommendations for mitigating flooding problems may consist of channelization, increasing culvert structure capacity through replacement or enlargement, creating detention pond facilities, or increasing storm sewer system capacity through replacement or new system construction. It's important to note that when alternatives and recommendations given in this master drainage plan proceed to design documents, the design should be hydrologically and hydraulically analyzed in further detail prior to constructing any improvements described in this section. The alternatives and recommendations in this master drainage plan are given as plausible concepts and an additional detailed study of the design would prevent increases in water-surface elevations and floodplains or cause flooding in other areas. The alternatives and recommendations for the problem areas are defined as follows:

A. Problem Area 1: North Fork River near Intersection of S Sunnylane Rd & SE 34th St

The private residential property, located at 3575 Joshua Lane, is currently not located within the 100-year floodplain of the North Fork River. However, the residential property will be located within the City of Moore's corrected effective existing 100-year floodplain of the North Fork River created in this master drainage plan study. We expect this property to have flooding in various storm frequency events.

The backyard of a private residential property, located at 2813 SE 38th Street, is located within the 100-year floodplain of the North Fork River. However, it appears the residential structure itself is removed from the 100-year floodplain. We expect the backyard of this property to have flooding in various storm frequency events.

The private residential property, located at 2700 & 2800 Shady Creek Lane, is located completely within the 100-year floodplain. We expect these properties to have flooding in various storm frequency events.

Recommendation – Construct Upstream Detention Facilities. This alternative would consist of constructing several significant upstream detention facilities on Stream C and the North Fork River in order to reduce peak discharge flowrates throughout the North Fork River drainage basin. Stream C, and the North Fork River are the most optimal streams to construct detention pond facilities based on their slower hydrologic peak discharge timing.

The City of Moore requested Meshek & Associates to determine the feasibility of constructing an inline regional detention pond facility on the North Fork River, near the confluence with Stream D, for the purpose to either mitigate downstream flooding or to offset future development. The hydrologic model indicates the peak discharge flowrates on North Fork River, at the confluence with Stream D, for the 10-year storm to be approximately 6,380 cubic feet per second and for the 100-year to be approximately 13,190 cubic feet per second. The amount of storage required to effectively mitigate the 100-year storm peak discharge on the North Fork River to reach a 10-year peak discharge quantity is approximately 700 acre-feet. Additional storage would also be necessary for the 500-year peak discharge and to provide a factor of safety incorporated into the detention pond design. The dam and outlet structure would be substantial in size and also be classified as high hazard dam with several residential properties and an elementary school in the direct inundation path of a dam breach scenario. Should the pond be utilized for offsetting future development, the amount of storage required would be approximately 200 acre-feet, and could vary based on the size and type of developed area the pond would be designed for. The pond would still require a significant dam and outlet structure size based upon the width of the floodplain and significantly large peak discharge flowrates. Therefore, based on the physical scale required for a detention pond to be effective and the potential for a dam breach to cause loss of life due to existing development downstream, Meshek & Associates does not recommend constructing an inline regional detention pond on the North Fork River near the confluence with Stream D.

As a second alternative, Meshek & Associates also determined the feasibility of constructing an inline regional detention pond facility on Stream D, just upstream or downstream of S Bryant Avenue, for the purpose to either mitigate downstream flooding or to offset future development. Similar to constructing an inline regional detention pond on the North Fork River, an inline regional detention pond on Stream D would require a substantially sized dam and outlet structure based on the width of the floodplain and large peak discharge flowrates. The hydrologic model indicates the peak discharge flowrates at the bottom of Stream D for the 10-year storm to be approximately 2500 cubic feet per second, and for the 100-year storm to be approximately 4720 cubic feet per second. The amount of storage required to effectively mitigate the 100-year storm peak discharge on Stream D to reach a 10-year peak discharge quantity is approximately 250 acre-feet and the downstream impact of reducing 2220 cubic feet per second is minimal. Additional storage would also be necessary for the 500-year peak discharge and to provide a factor of safety incorporated into the detention pond design. Should the pond be utilized for offsetting future development, the amount of storage required would be approximately 80 acre-feet, and could vary based on the size and type of developed area the pond would be designed for. Another major disadvantage to constructing an inline detention pond on Stream D, is that the hydrologic peak discharge timing between Stream D and the North Fork River is different. In current existing conditions, the peak discharge in Stream D flows into the North Fork River approximately 42 minutes ahead of the peak discharge in the Nork Fork River. Since the peak discharge in Stream D has the lead in timing over the peak discharge in the North Fork River, a detention pond would slow down the peak discharge of Stream D and cause a higher discharge into the North Fork River when the peak discharge of the North Fork River arrives. This would cause the peak discharge flowrate of the North Fork River downstream of Stream D to increase and create higher water-surface elevations and larger floodplains. Therefore, based on the physical scale required for a detention pond to be effective and the increase in peak discharge flowrates a detention pond would cause downstream on the North Fork River, Meshek & Associates does not recommend constructing an inline regional detention pond on Stream D upstream or downstream of S Bryant Avenue.

Alternative – Remove Champion Drive Bridge. This alternative would consist of removing the bridge structure on Champion Drive, which leads to an abandoned ball field complex. In removing this structure and roadway from the hydraulic model, we've determined the effects are very insignificant and only slightly lower water-surface elevations on the North Fork River within a few hundred feet upstream or downstream of Champion Drive.

The location of the proposed improvements are shown in **FIGURE 6-10**. Due to the variability of the scope, a cost estimate was not prepared at this time.

City of Moore Master Drainage Plan

North Fork River
Problem Area 1: Alternative

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Figure 6 - 10

B. Problem Area 2: Confluence of North Fork River and Stream C

In order to effectively mitigate and reduce peak discharge flowrates and flooding from Stream C and the North Fork River, several major detention facilities would need to be constructed upstream of the affected flooding problem locations in problem area 2.

Recommendation Part 1 – Construct 100-year Capacity Storm Sewer System. This part of the recommendation would consist of constructing a new storm sewer system which can convey the 100-year storm event at the intersection of Anns Place and SE 12th Street. This structure would consist of approximately 175 linear feet of 18 inch diameter RCP and approximately 7 total standard cast iron curb inlets and grates with an 80% theoretical capacity to allow for partial obstruction and clogging. The 100-year discharge to the location of the storm sewer system inlets at the intersection of Anns Place and SE 12th Street is approximately 11.1 cfs.

The locations of the proposed improvements are shown in **FIGURE 6-11**. The cost for the Recommendation part 1 is estimated at $60,900 and is detailed in **APPENDIX 6-D**.

Recommendation Part 2 – Construct 100-year Capacity Storm Sewer System. This part of the recommendation would consist of constructing a new storm sewer system which can convey the 100-year storm event on Anns Place roadway adjacent to the community parking lot. This structure would consist of approximately 160 linear feet of 15 inch diameter RCP. The 100-year discharge to the location of the storm sewer system inlets on Anns Place roadway adjacent to the community parking lot is approximately 7.6 cfs.

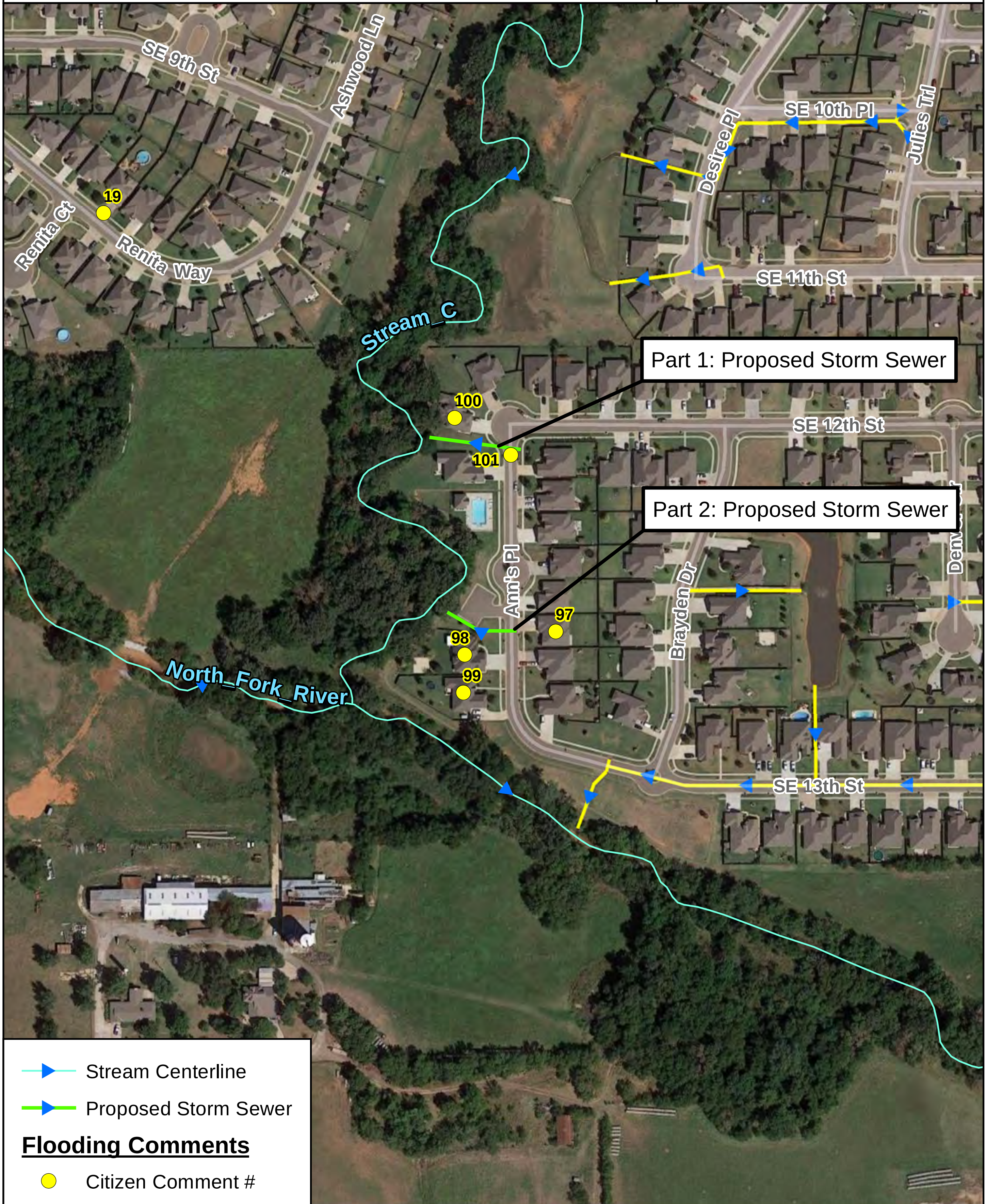
The locations of the proposed improvements are shown in **FIGURE 6-11**. The cost for the Recommendation part 2 is estimated at $47,700 and is detailed in **APPENDIX 6-D**.

C. Problem Area 3: Intersection of SE 9th St & Renita Way

The private residential property, located at 1001 Renita Way, is currently located completely within the 100-year floodplain. However, the residential structure itself will be removed from the corrected effective existing 100-year floodplain of the North Fork River created in this master drainage plan study. We expect the backyard of this property to have flooding in various storm frequency events.

In the practice of water resource engineering, we typically attempt to keep natural shapes and meanders of creeks and rivers in order to maximize storage volume and maintain channel velocities. It is the intent of this master drainage plan to reduce flooding of developed areas through proposed construction of new detention facilities and new hydraulic structures, while educating the city and public on stormwater risks and best practices. Banks of the channel should be covered in vegetation or other armoring materials to prevent sediment erosion.

City of Moore Master Drainage Plan



North Fork River
Problem Area 2: Recommendation
Part 1 & 2

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Figure 6 - 11

D. Problem Area 4: North Fork River near Intersection of S Bryant Ave & Parkway Dr

The backyards of private residential properties, located at 309 and 313 S Wyndemere Springs adjacent to the North Fork River, are contained within the 100-year floodplain of the North Fork River. We expect the backyards of these properties to have flooding in various storm frequency events. When flooding does occur in the North Fork River, stay clear of floodwaters as they are very dangerous. If necessary, retreat to higher ground and stay off of roadways as much as possible during flooding events. It appears the City of Moore has cut a straight 250 foot channel section just downstream of the properties listed above. The straight channel along with the adjacent natural meander section should aid to increase the channel storage volume. The North Fork River channel should be kept cleaned of debris and maintained in order to achieve full hydraulic capacity. Banks of the channel should be covered in vegetation or armoring materials to prevent sediment erosion.

E. Problem Area 5: North Fork River Culvert at N Bryant Ave

The City of Moore, in the period of study for this master drainage plan, has approved the design of a pavement and utilities rehabilitation and improvements project for N Bryant Avenue between SE 4th Street and NE 12th Street. Included within this project, the city will also replace the N Bryant Avenue box culvert crossing over the North Fork River with a Conspan arch structure. This proposed arch structure will increase the hydraulic capacity discharging beneath the roadway and reduce the discharge over the roadway. The arch structure, with a larger single opening, should also allow debris to pass through the structure and reduce clogging. Hydrologic and hydraulic models of the proposed N Bryant Avenue structure crossing over North Fork River have been created with updated existing hydrologic and hydraulic data from this master drainage plan. Our models have indicated the proposed arch structure should have an increased hydraulic capacity over the existing box culvert structure, while not causing a rise in 100-year water-surface elevations upstream or downstream of the N Bryant Avenue crossing. The water-surface elevations were able to stay constant or slightly decrease due to the incorporated design of an existing head-cut in the North Fork River channel, located just downstream of the N Bryant Avenue crossing.

F. Problem Area 6: North Fork River Culvert at NE 12th St

Recommendation Part 1 – Construct 50-year Capacity Culvert & Grade Roadway Apron. This recommendation consists of constructing a new culvert structure which can convey the 50-year storm event. This structure would consist of approximately 86 linear feet of triple 16 foot wide by 8 foot tall RCBs. Also, an alternative structure consisting of approximately 86 linear feet of 55 foot wide by 8.93 foot tall Conspan arch should achieve a comparable hydraulic capacity. The 50-year discharge to the NE 12th Street crossing is approximately 2,819 cfs. In addition to the culvert replacement, the vacant property adjacent to the NE 12th Street crossing and the North Fork River, should also be acquired and excavated to compensate for loss of floodplain storage volume on the upstream side of the NE 12th Street crossing. The compensatory floodplain storage should help prevent increased peak discharge flowrates and flooding downstream. The last part of the recommendation is to grade and raise the Old Mill Road entrance apron approximately 1 foot along the northern edge of NE 12th Street. This should prevent any NE 12th Street roadway or ditch discharge from diverting north onto Old Mill Road.

The locations of the proposed improvements are shown in **FIGURE 6-12**. The cost for the Recommendation part 1 is estimated at $813,600 and is detailed in **APPENDIX 6-D**.

Recommendation Part 2 – Grade Open-Channel. This recommendation would consist of grading the grass channel in the Winding Creek Elementary School yard to drain more effectively to the storm sewer inlet, located at the southwest corner in the school property, and ensure any excess surface discharge drains directly to NE 12th Street.

The locations of the proposed improvements are shown in **FIGURE 6-12**. Due to the variability of the scope, a cost estimate was not prepared at this time.

Recommendation Part 3 – Construct Replacement 100-year Capacity Storm Sewer System. This recommendation consists of replacing an existing storm sewer system with a new storm sewer system which could convey the 100-year storm event. This recommendation would consist of replacing the existing Sequoyah Avenue and N Lincoln Avenue to the North Fork River storm sewer system with approximately 294 linear feet of 36 inch diameter RCPs, 550 linear feet of 42 inch diameter RCPs, 15 cast iron curb inlets on Sequoyah Avenue, and 11 cast iron curb inlets along N Lincoln Avenue. The number of inlets above provide an 80% theoretical capacity to allow for partial obstruction and clogging. The 100-year discharge to the location of t he inlets on Sequoyah Avenue is approximately 43.7 cfs. The 100-year discharge to the location of the inlets on N Lincoln Avenue is approximately 21.9 cfs. Pryor to design, the existing storm sewer system should be surveyed for condition assessment and existing capacity.

The locations of the proposed improvements are shown in **FIGURE 6-12**. The cost for the Recommendation part 3 is estimated at $466,900 and is detailed in **APPENDIX 6-D**.

Recommendation Part 4 – Construct Replacement 100-year Capacity Storm Sewer System. This recommendation consists of replacing an existing storm sewer system with a new storm sewer system which could convey the 100-year storm event. This recommendation would consist of replacing the existing Old Mill Road to the North Fork River storm sewer system with approximately 225 linear feet of 30 inch diameter RCPs. Old Mill Road currently has enough inlets for a 100-year capacity, however 2 additional cast iron curb inlets would be necessary to provide an 80% theoretical capacity to allow for partial obstruction and clogging. The 100-year discharge to the location of the inlets is approximately 27.7 cfs. Pryor to design, the existing storm sewer system should be surveyed for condition assessment and existing capacity.

The locations of the proposed improvements are shown in **FIGURE 6-12**. The cost for the Recommendation part 4 is estimated at $71,300 and is detailed in **APPENDIX 6-D**.

G. Problem Area 7: Lower Stream A near Sooner Drive

Recommendation – Construct Upstream Detention Facility. This alternative consists of constructing a detention pond facility on an Unnamed Tributary to Stream A, located between Sooner Drive and Sooner Lake Drive approximately in line with SE 30th Street. The alternative detention pond would have approximately 65 acre-feet of storage and should reduce the 100-year storm peak discharging south towards Stream A by approximately 54 percent.

The locations of the proposed improvements are shown in **FIGURE 6-13**. The cost for the Recommendation is estimated at $414,900 and is detailed in **APPENDIX 6-D**.

City of Moore Master Drainage Plan

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North Fork River
Problem Area 6: Recommendation
Part 1, 2, 3, & 4

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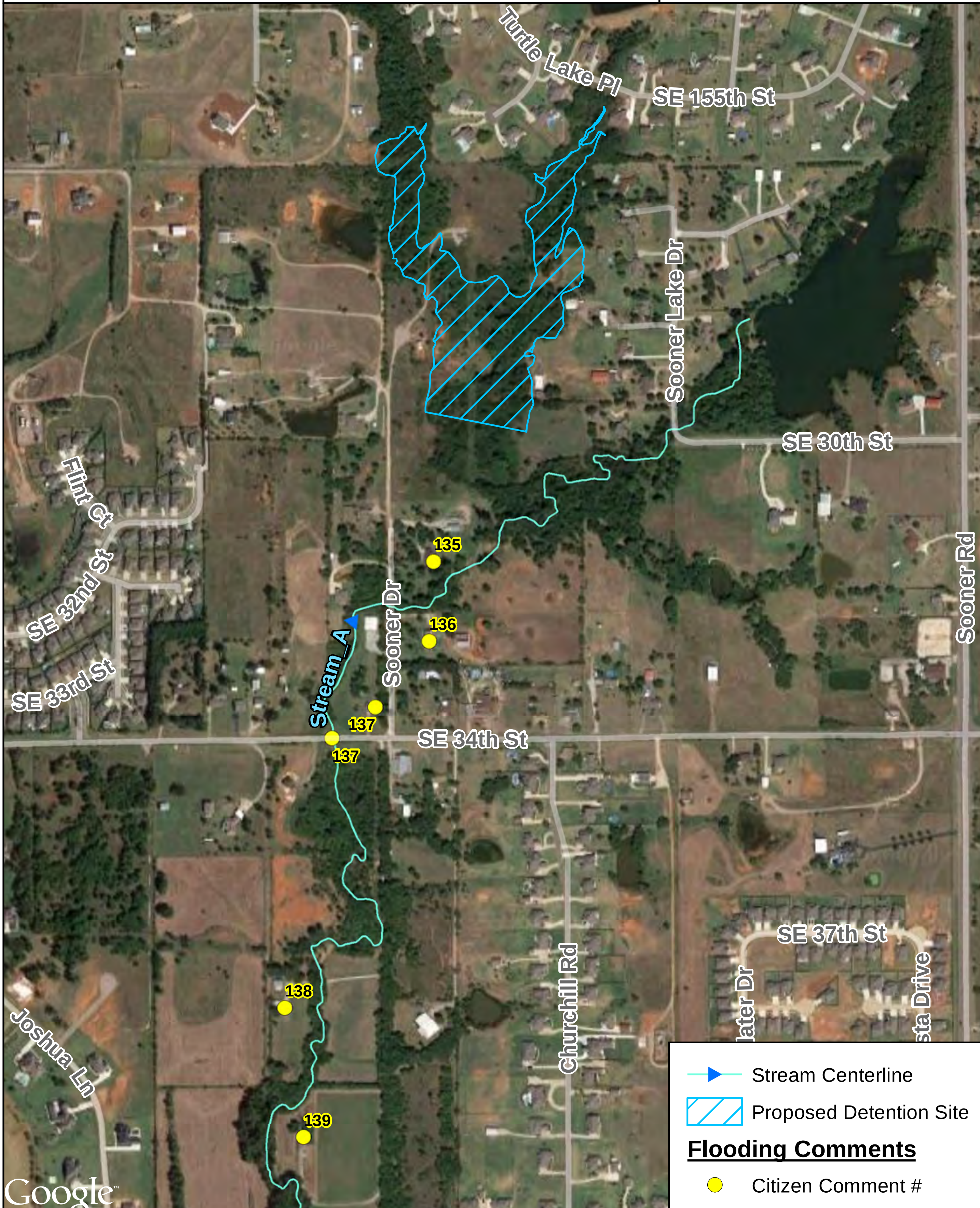
Figure 6 - 12

City of Moore Master Drainage Plan



North Fork River
Problem Area 7: Recommendation

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Figure 6 - 13

H. Problem Area 8: Stream A Culvert at SE 34th St & Sooner Dr

Alternative 1 – Construct 10-year Capacity Culvert. This alternative would consist of constructing a new culvert structure which can convey the 10-year storm event. This structure would consist of approximately 40 linear feet of double 10 foot wide by 7 foot tall RCBs. The 10-year discharge to the SE 34th Street crossing is approximately 1,013 cfs.

The cost for Alternative 1 is estimated at $205,300 and is detailed in **APPENDIX 6-D**.

Alternative 2 (Recommended) – Construct 100-year Capacity Culvert. This alternative would consist of constructing a new culvert structure which can convey the 100-year storm event. This structure would consist of approximately 40 linear feet of triple 14 foot wide by 7 foot tall RCBs. The 100-year discharge to the SE 34th Street crossing is approximately 2,521 cfs.

The cost for Alternative 2 is estimated at $468,200 and is detailed in **APPENDIX 6-D**.

I. Problem Area 9: SE 34th St near Shady Creek Ln

Recommendation – Grade Drainage Ditch. This recommendation consists of re-grading the drainage ditches along SE 34th Street, near 2500 SE 34th Street, to achieve greater storage and discharge capacity.

The location of the proposed improvements are shown in **FIGURE 6-14**. Due to the variability of the scope, a cost estimate was not prepared at this time.

J. Problem Area 10: The Falls Subdivision off SE 34th Street

Recommendation – Construct 100-year Open-Channel. This recommendation consists of re-grading the open-channel leading to the detention pond at the center of The Falls subdivision. The open-channel should be shaped with a built up embankment adjacent to the fence line of private property on the west side to ensure the channel does not overtop into private property. The embankment would consist of approximately 260 linear feet in length with the top of the embankment being a minimum of 2 feet above the toe of the embankment. The dimensions of the open-channel should have an approximate minimum base width of 3 feet, minimum depth of 3 feet, and minimum side slopes of 3:1 (H:V). A Manning's 'n' value of 0.035 and a slope of 0.015 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year storm peak discharge to the channel is approximately 101 cfs. The open-channel should then be covered in grass vegetation in order to prevent erosion of sediment and scour channels. If necessary, additional grading could be performed to divert stormwater discharge north to an Unnamed Stream instead of allowing stormwater to drain south to The Falls subdivision detention pond.

These improvements are shown in **FIGURE 6-15**. The cost for the Recommendation is estimated at $21,100 and is detailed in **APPENDIX 6-D**.

K. Problem Area 11: Post Oak Ln & SE 5th St Intersection

Recommendation – Construct Detention Facility. This recommendation consists of constructing a detention pond facility on the Moore Public School property to reduce the peak discharge created by the increase in impervious areas at the Administration Building and Highland East Junior High School. The recommended detention pond would have approximately 3.0 acre-feet of storage and should reduce the 100-year storm peak discharging east towards SE 5th Street by approximately 50 percent.

The locations of the proposed improvements are shown in **Figure 6-16**. The cost for the Recommendation is estimated at $246,400 and is detailed in **Appendix 6-D**.

L. Problem Area 12: N Morgan Drive to E Main St Storm Sewer Systems

Subsurface investigations should also be performed at 1501 E. Main Street to determine whether or not sink holes are present and are caused by an existing City of Moore utility system.

Pryor to performing final study and planning of a storm sewer solution, a complete storm sewer system observation and assessment should be performed on the existing storm sewer system from N Morgan Drive to E Main Street network.

Alternate 1 – Construct Replacement 100-year Capacity Storm Sewer System. This alternative consists of replacing the existing storm sewer system which could convey the 100-year storm event. The existing storm sewer system has an approximate 5-year storm capacity. The N. Morgan Drive to E. Main Street system would consist of replacing the existing system with approximately 1,690 linear feet of 6 foot diameter RCPs, 2 trench grate inlets on N Morgan Drive, 20 cast iron curb and grate inlets along N Ramblin Oaks Drive just north of NE 3rd Street, 22 cast iron curb and grate inlets along NE 2nd Street at N Ramblin Oaks Drive, 18 cast iron curb and grate inlets along NE 1st Street just west of Pinewood Circle, and 2 recessed concrete curb inlets on E Main Street east of S Ramblin Oaks Drive.

The locations of the proposed improvements are shown in **Figure 6-17**. The cost for Alternative 1 is estimated at $2,427,700 and is detailed in **Appendix 6-D**.

Alternate 2 (Recommended) – Construct New 100-year Capacity Storm Sewer System. This recommendation consists of constructing a new storm sewer system which could convey the 100-year storm event. The N Morgan Drive to E Main Street system would consist of replacing the existing system from N Morgan Drive to N Ramblin Oaks Drive, then constructing a new system south adjacent to N Ramblin Oaks Drive roadway and east adjacent to the E Main Street roadway. The storm sewer system would consist of approximately 1,300 linear feet of 6 foot diameter RCP, 2 trench grate inlets on N Morgan Drive, 20 cast iron curb and grate inlets along N Ramblin Oaks Drive just north of NE 3rd Street, 22 cast iron curb and grate inlets along N Ramblin Oaks Drive at NE 2nd Street, 2 recessed concrete curb inlets along E Main Street just west of S Ramblin Oaks Drive, and 2 recessed concrete curb inlets on E Main Street east of S Ramblin Oaks Drive.

This recommendation would also incorporate constructing a new storm sewer system which can convey the 100-year storm event from S Morgan Drive to connect to the E Main Street line proposed above. The S Morgan Drive to E Main Street system would consist of replacing the existing system from S Morgan Drive to S Ramblin Oaks Drive, then constructing a new system north adjacent to S Ramblin Oaks Drive roadway. The storm sewer system would consist of approximately 520 linear feet of 8 foot wide by 5 foot tall RCB, 2 trench grate inlets on S Morgan Drive, a 4 foot by 4 foot cast iron grate inlet between S Morgan Drive and S Ramblin Oaks Drive, and 20 cast iron curb and grate inlets along S Ramblin Oaks Drive just south of E Main Street.

The locations of the proposed improvements are shown in **FIGURE 6-17**. The cost for Alternative 2 is estimated at $4,702,000 and is detailed in **APPENDIX 6-D**.

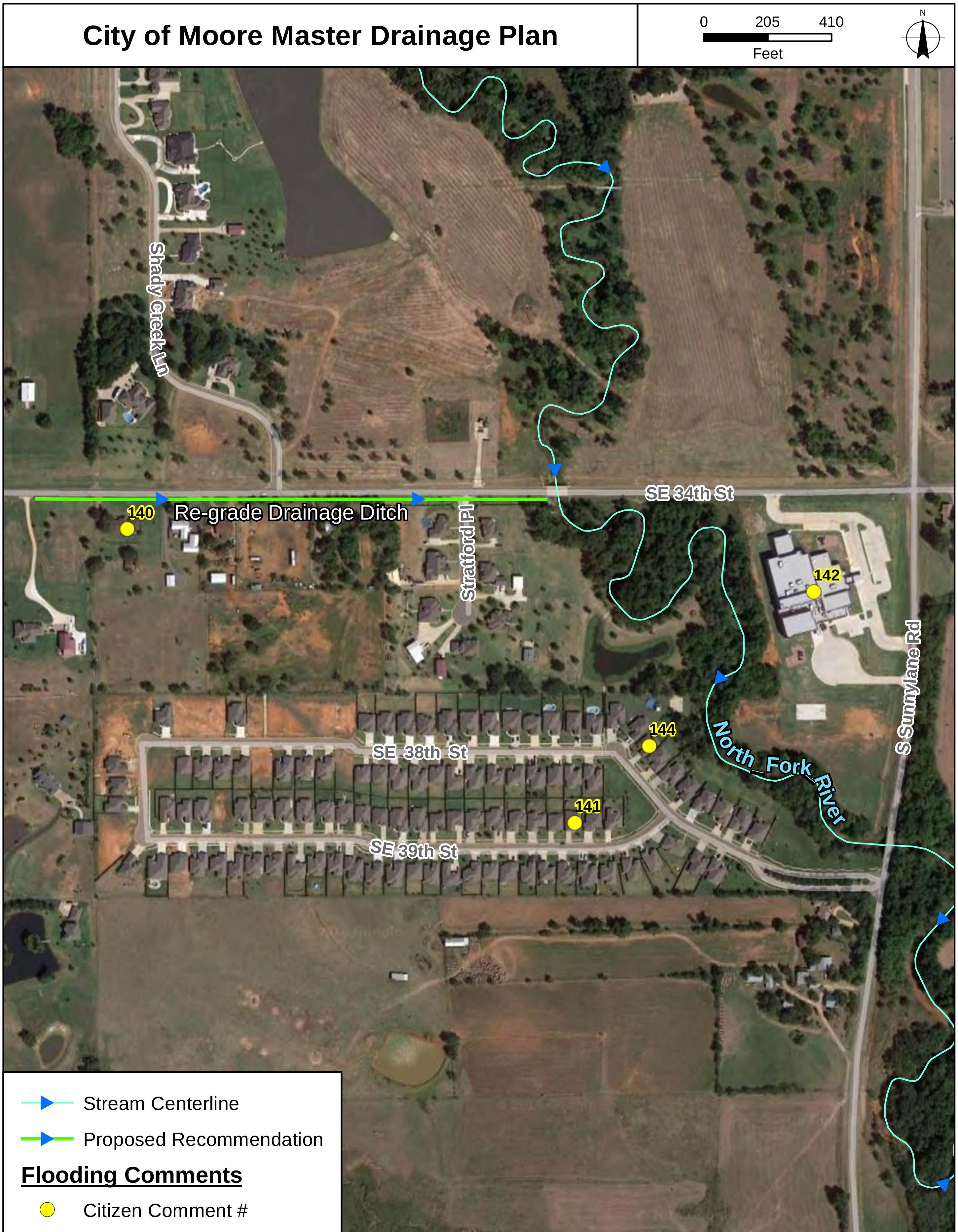
M. Problem Area 13: S Morgan Dr to S Ramblin Oaks Dr Storm Sewer System

Pryor to performing final study and planning of a storm sewer solution, a complete storm sewer system observation and assessment should be performed on the existing storm sewer system from S Morgan Drive to S Ramblin Oaks Drive network. The alternative described below fully replaces the existing storm sewer system on its current alignment. The recommended alternate 2 of problem area 12 includes the design parameters and estimated costs to construct a new storm sewer system alignment for the S Morgan Drive to S Ramblin Oaks Drive storm sewer system.

Alternative – Construct 100-year Capacity Storm Sewer System. This alternative consists of constructing a storm sewer system which can convey the 100-year storm event. The existing storm sewer system has a hydraulic capacity approximately less than a 1-year storm. The S Morgan Drive to S Ramblin Oaks Drive system would consist of replacing the existing system with approximately 910 linear feet of 10 foot wide by 5 foot tall RCBs, a trench grate inlet system across S Morgan Drive, a 4 foot by 4 foot cast iron grate inlet between S Morgan Drive and S Ramblin Oaks Drive, and approximately 12 cast iron curb inlets and grates on S Ramblin Oaks Drive. This alternative was design to be constructed in conjunction with the problem area 12 alternative. The problem area 12 recommendation incorporates design and cost estimation for a new storm sewer system from S Morgan Drive to S Ramblin Oaks Drive.

The locations of the proposed improvements are shown in **FIGURE 6-18.** The cost for the Recommendation is estimated at $2,002,300 and is detailed in **APPENDIX 6-D**.

City of Moore Master Drainage Plan



North Fork River
Problem Area 9: Recommendation

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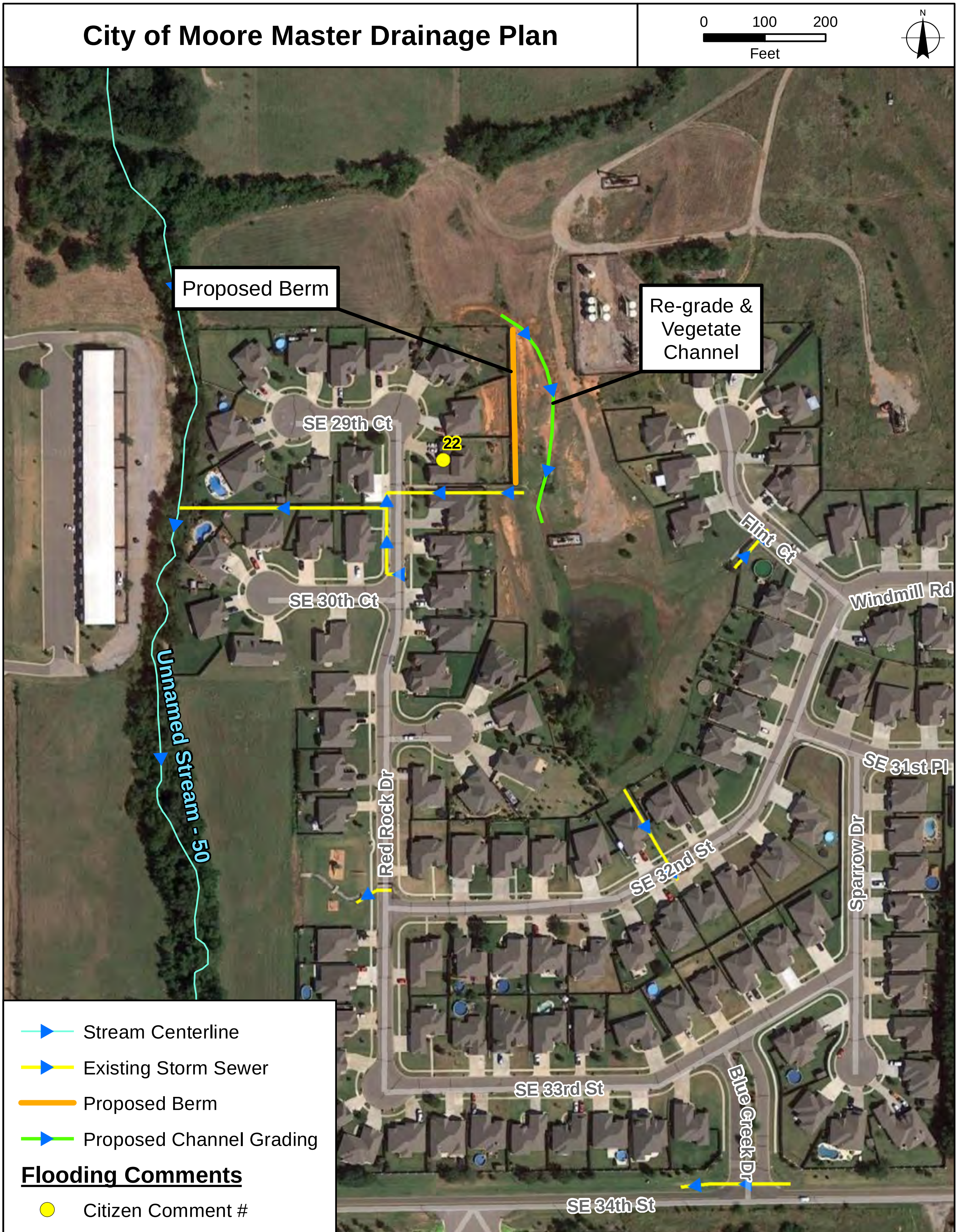
Figure 6 - 14

City of Moore Master Drainage Plan



North Fork River
Problem Area 10: Recommendation

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Figure 6 - 15

City of Moore Master Drainage Plan

0 125 250
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North Fork River
Problem Area 11: Recommendation

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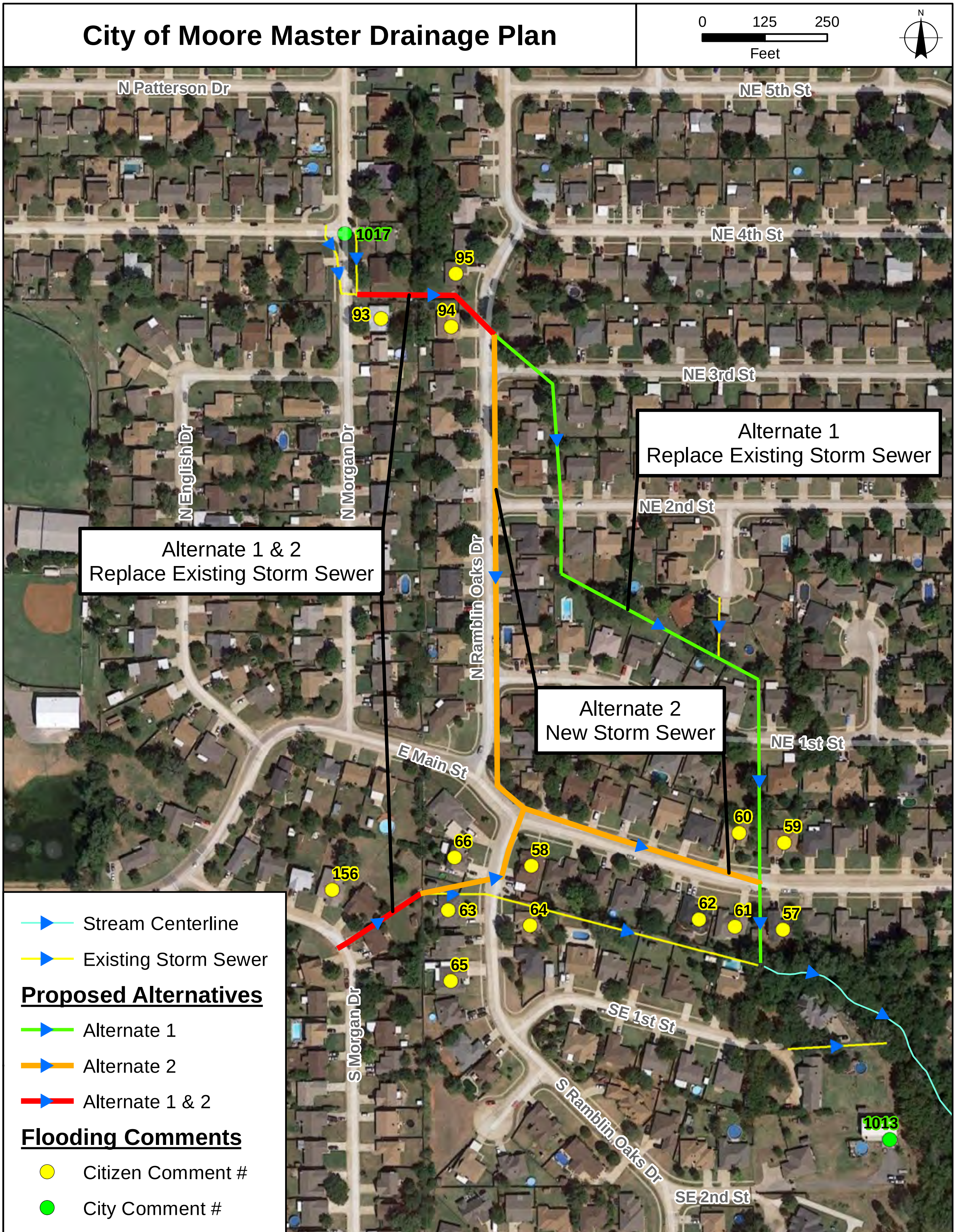
Figure 6 - 16

City of Moore Master Drainage Plan



North Fork River
Problem Area 12: Alternative 1 & 2

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Figure 6 - 17

City of Moore Master Drainage Plan

Stream Centerline

Existing Storm Sewer

Replace Existing Storm Sewer

Flooding Comments

Citizen Comment #

City Comment #

North Fork River
Problem Area 13: Alternative

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Figure 6 - 18

N. Problem Area 14: Intersection of SE 2nd St & S Ramblin Oaks Dr

The City of Moore made the basic observation of the storm sewer system outlet having hydraulic inadequacy. We recommend the system be inspected and any sediment or debris be cleaned from the system. The downstream flowline from the outlet should also be assured to have a positive outfall. If the storm sewer system outlet continues to hydraulically inadequacy, then we can provide a design for a new storm sewer system.

O. Problem Area 15: Stream C & S Wyndemere Lakes Dr

Recommendation – Construct 100-year Capacity Storm Sewer System. This recommendation consists of constructing a storm sewer system which can convey the 100-year storm event. The new storm sewer system would consist of replacing the existing system with approximately 280 linear feet of 18 inch diameter RCP. The 100-year discharge to the location of the pipe inlet is approximately 12.6 cfs. Remaining overland flow from the east side of S Wyndemere Lakes Drive roadway and across the front yard of 216 S Wyndemere Lakes Drive may also be increased by constructing a concrete paved ditch and/or by opening up the privacy fence to allow surface discharge through.

The locations of the proposed improvements are shown in **FIGURE 6-19**. The cost for the Recommendation is estimated at $48,000 and is detailed in **APPENDIX 6-D**.

P. Problem Area 16: Intersection of NE 20th St & N Lincoln Ave

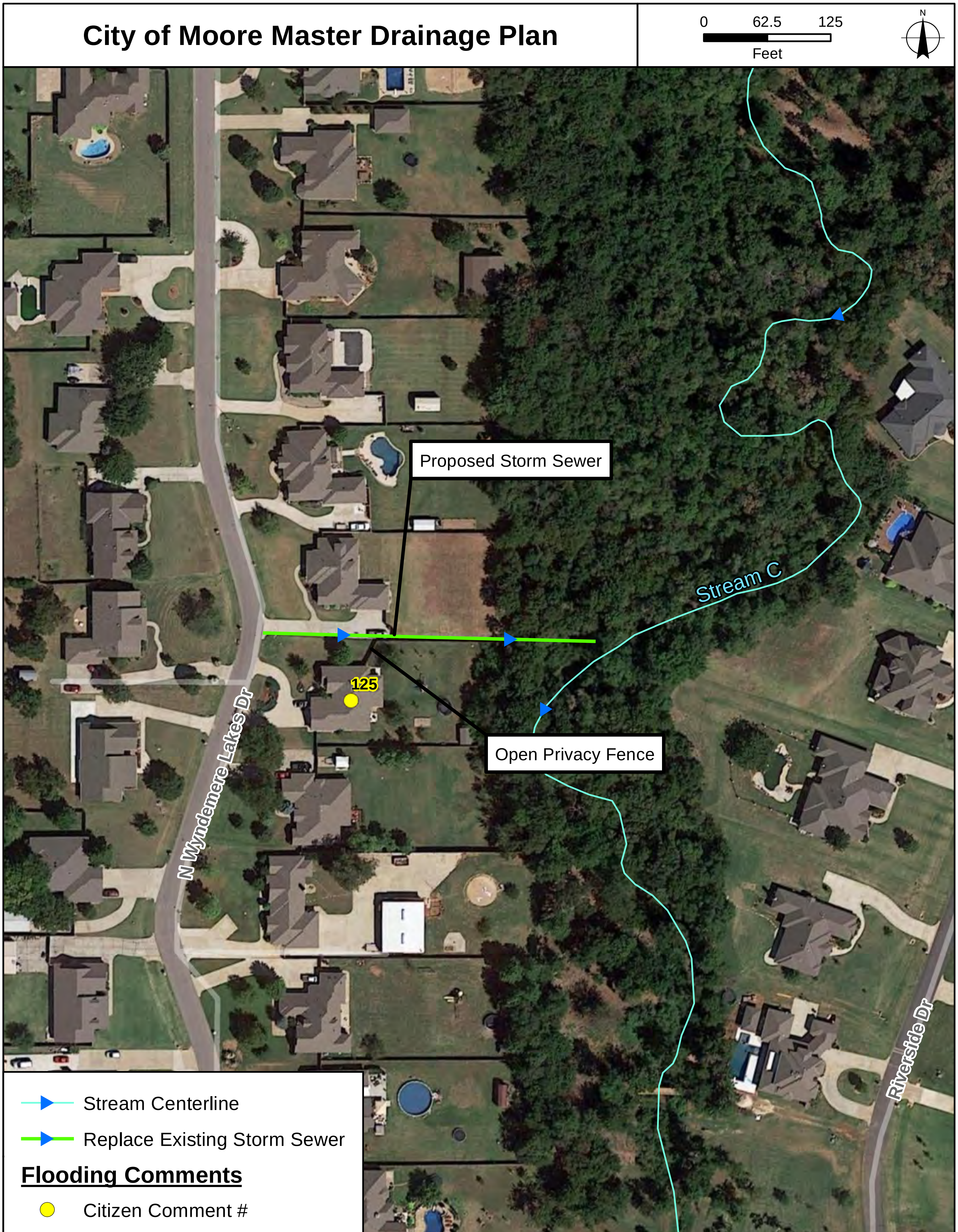
Recommendation Part 1– Construct Detention Facility. This recommendation consists of constructing a detention pond facility on an undeveloped section of property, located adjacent to N. Eastern Avenue between NE 18th Street and NE 19th Street, directly upstream of the affected areas to reduce the peak discharge created by the increase in impervious areas in upstream sub-divisions. The recommended detention pond would have approximately 21.5 acre-feet of storage and should reduce the 100-year storm peak discharge by approximately 28 percent.

The locations of the proposed improvements are shown in **FIGURE 6-20**. The cost for the Recommendation part 1 is estimated at $1,514,900 and is detailed in **APPENDIX 6-D**.

Recommendation Part 2 – Construct 100-year Capacity Storm Sewer System. This alternative would consist of constructing a storm sewer system N Lincoln Avenue, which can convey the 100-year storm event. This system would consist of approximately 287 linear feet of 10 foot wide by 6 foot tall RCB. The 100-year discharge to the location of the storm sewer under N Lincoln Avenue with the recommended detention pond in place is approximately 614 cfs. The 100-year discharge to the location of the storm sewer under N Lincoln Avenue without the recommended detention pond in place is approximately 911 cfs. The 100-year storm roadway discharge draining to N Lincoln Avenue, between NE 19th Street and NE 20th Street, is approximately 57.9 cfs.

The locations of the proposed improvements are shown in **FIGURE 6-20**. The cost for Recommendation part 2 is estimated at $693,000 and is detailed in **APPENDIX 6-D**.

City of Moore Master Drainage Plan



North Fork River
Problem Area 15: Recommendation

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Figure 6 - 19

City of Moore Master Drainage Plan

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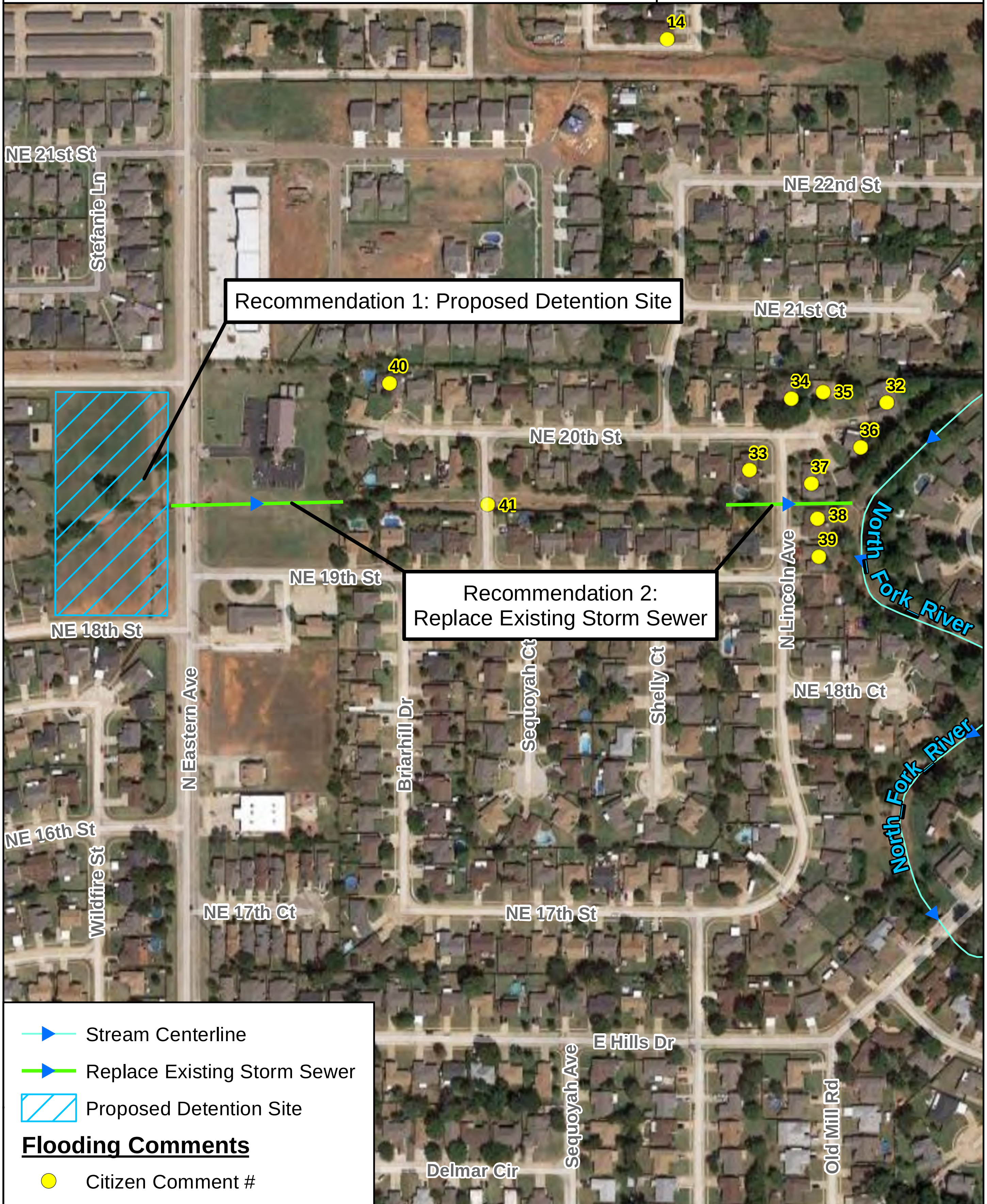

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North Fork River
Problem Area 16:
Recommendation 1 & 2

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Figure 6 - 20

Q. Problem Area 17: Intersection of Cedar Brook Dr & N Lincoln Ave

Regular maintenance should be kept for cleaning debris and trash out of open-channels, ditches, storm sewers systems, or culverts. When hydraulic systems are filled with vegetation debris, trash, or sediment, the hydraulic capacity of these systems can become significantly reduced.

R. Problem Area 18: E Park Pl near Intersection with NE 23rd St

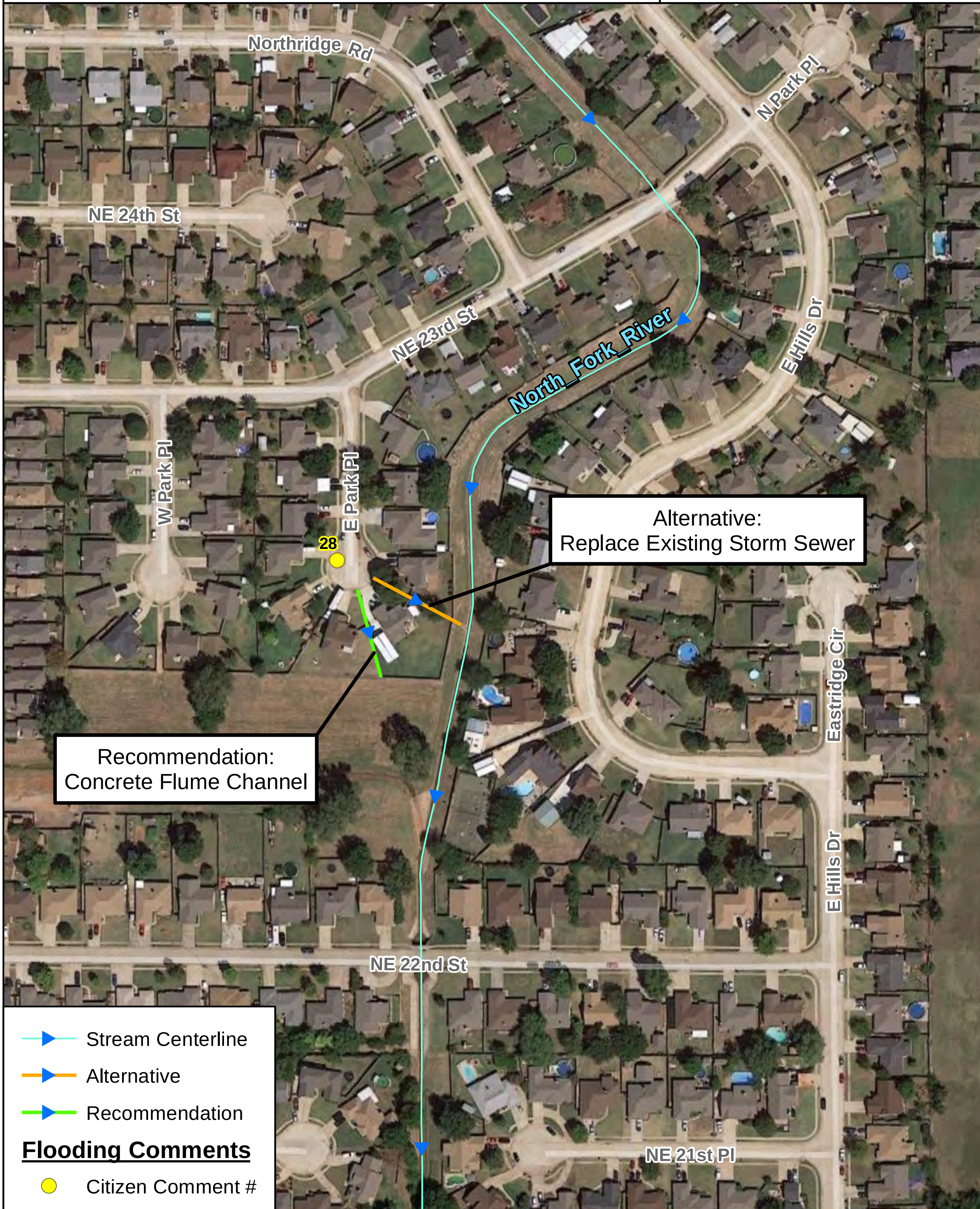
Alternative 1 – Construct 100-year Capacity Storm Sewer System. This recommendation consists of constructing a storm sewer system which can convey the 100-year storm event. The new storm sewer system would consist of replacing the existing system with approximately 150 linear feet of 42 inch diameter RCP. The new storm sewer system would also replace the existing roadway inlets with a 10 inch tall by 20 foot long recessed curb inlet. The inlet design has a 9 inch effective head on the center of the orifice throat, and an 80% theoretical capacity to allow for partial obstruction and clogging. The 100-year discharge to the location of the storm sewer system inlets on E Park Place is approximately 60 cfs.

The locations of the proposed improvements are shown in **Figure 6-23**. The cost for Alternative 1 is estimated at $79,300 and is detailed in **Appendix 6-D**.

Alternative 2 (Recommendation)– Construct 100-year Capacity Concrete Flume Channel. This alternative would consist of constructing a concrete flume channel which can convey the 100-year storm event. This system would consist of approximately 140 linear feet of concrete channel. The dimensions of the channel should have an approximate 9 inch depth, 5 foot bottom width, and 1:0 (H:V) side slopes. A Manning's 'n' value of 0.013 and a slope of 0.025 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the proposed concrete flume channel in the cul-de-sac on E Park Place, minus the capacity of the existing storm sewer system, is approximately 45 cfs.

The locations of the proposed improvements are shown in **Figure 6-21**. The cost for Alternative 2 is estimated at $29,400 and is detailed in **Appendix 6-D**.

City of Moore Master Drainage Plan



North Fork River
Problem Area 18: Recommendation & Alternative

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Figure 6 - 21

S. Problem Area 19: N Bryant Ave near NE 15th St

Roadway ditches adjacent to N Bryant Avenue are designed to convey and store stormwater runoff until stormwater can drain to a stream or another storm sewer system. All culverts in the roadway ditches should be maintained and clean of debris to prevent loss of capacity. Below is a recommendation and alternative to increase the size of the culvert crossing N Bryant Avenue.

Alternative 1 – Construct 10-year Capacity Culvert. This recommendation would consist of constructing a new culvert which can convey the 10-year storm event. This structure would consist of approximately 50 linear feet of a 24 inch diameter RCP. The 10-year discharge to the location of the pipe is approximately 15.4 cfs.

The locations of the proposed improvements are shown in **FIGURE 6-22**. The cost for Alternative 1 is estimated at $22,700 and is detailed in **APPENDIX 6-D**.

Alternative 2 (Recommendation)– Construct 100-year Capacity Culvert. This alternative would consist of constructing a new culvert which can convey the 100-year storm event. This structure would consist of approximately 50 linear feet of a 30 inch diameter RCP. The 100-year discharge to the location of the pipe is approximately 30.2 cfs.

The locations of the proposed improvements are shown in **FIGURE 6-22**. The cost for Alternative 2 is estimated at $26,000 and is detailed in **APPENDIX 6-D**.

T. Problem Area 20: Foxfire Subdivision: Intersection of Flicker Ridge & NE 14th St

Recommendation – Construct 10-year Capacity Storm Sewer System & Open-Channel. This recommendation would consist constructing a new storm sewer system and an open-channel which can convey the 10-year storm event. This structure would consist of approximately 530 linear feet of 42 inch RCP. The 10-year discharge to the location of the inlets at Flicker Ridge and NE 14th Street is approximately 51.2 cfs. This recommendation would also consist of building a grass lined open-channel for the storm sewer to discharge. The open channel would connect and discharge to existing storm sewer system located on the west side of N Eastern Avenue. The new open-channel would consist of approximately 450 linear feet in length. The dimensions of the channel should have an approximate 3 foot minimum depth, 1 foot minimum bottom width, and minimum 3:1 (H:V) side slopes. A Manning's 'n' value of 0.035 and a slope of 0.0182 foot per foot were assumed in calculations.

The locations of the proposed improvements are shown in **FIGURE 6-23**. The cost for the Recommendation is estimated at $348,400 and is detailed in **APPENDIX 6-D**.

U. Problem Area 21: Slater Dr & SE 41st St Roadways

The Belmar North Sub-division, within the period of this master drainage study, has developed several additional lots and has completed construction of all roadways and storm sewer systems. This recent sub-division development should be observed during storm events to gage the effectiveness of the newly constructed roadways and storm sewers to solve the drainage and flooding problems in the area. If the new roadways and storm sewer systems do not prove effective in draining surface runoff to prevent flooding of residential structures, then additional storm sewer system may be necessary to provide adequate drainage capacity to the problem areas listed. Aerial photography reveals the subdivision was designed to mainly use roadway discharge as the primary system conveyance for stormwater. Storm sewer systems are at the southern edge and downstream end of the subdivision. It is recommended that all existing storm sewer systems and the detention pond, located on the south edge of the Belmar North subdivision, be cleaned of any sediment deposits from construction of the subdivision in order to achieve designed hydraulic capacity. Storm sewer systems and detention ponds should always be maintained and clean of debris.

V. Problem Area 22: Intersection of Murray Ct & SE 28th St

The residential properties at 4805 SE 28th Street, 2900 Murray Court, and 2904 Murray Court with flooding in the yards appears to be caused by ground topography on private property. Due to the flooding problem being caused by topography on private property and not on public property, the City of Moore is not responsible for the flooding issues. The flooding problem is due to the properties listed above being constructed adjacent to the natural grass-lined open-channel which, prior to development drained surface discharge from the north to the retention pond now located at the center of the subdivision. A solution to the flooding problem may be for the residential property owners to either construct a concrete lined drainage ditch or storm sewer system to assist stormwater discharging across the properties.

W. Problem Area 23: Detention Pond & SE 31st Circle

The residential property at 4801 SE 31st Circle with flooding in the residential structure appears to be caused by a detention pond dam failure on private property. Due to the flooding problem being caused by topography on private property and not on public property, the City of Moore is not responsible for the flooding issues. The homeowner’s association should have the dam of the detention pond rebuilt based on the recommendations from a competent geotechnical engineering firm and an onsite subsurface investigation. The newly reconstructed dam should also be inspected for structural functionality and safety on an annual basis and after major storm events which fill the pond.

X. Problem Area 24: SE 7th Street near Intersection with Whispering Oaks Blvd

The residential property at 1516 SE 7th Street with flooding in the residential structure appears to be caused by ground topography on private property. Due to the flooding problem being caused by topography on private property and not on public property, the City of Moore is not responsible for the flooding issues. The source of flooding is due to the steep topography draining directly towards the northwest side of the residential structure without any fall towards the front or rear of the residential structure. A solution to the flooding problem may be for the private property owner to have a residential sized drainage system installed on either or both sides of the property to discharge stormwater to the front or rear of the property.

City of Moore Master Drainage Plan

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North Fork River
Problem Area 19:
Recommendation & Alternative

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Figure 6 - 22

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0 100 200
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North Fork River
Problem Area 20: Recommendation

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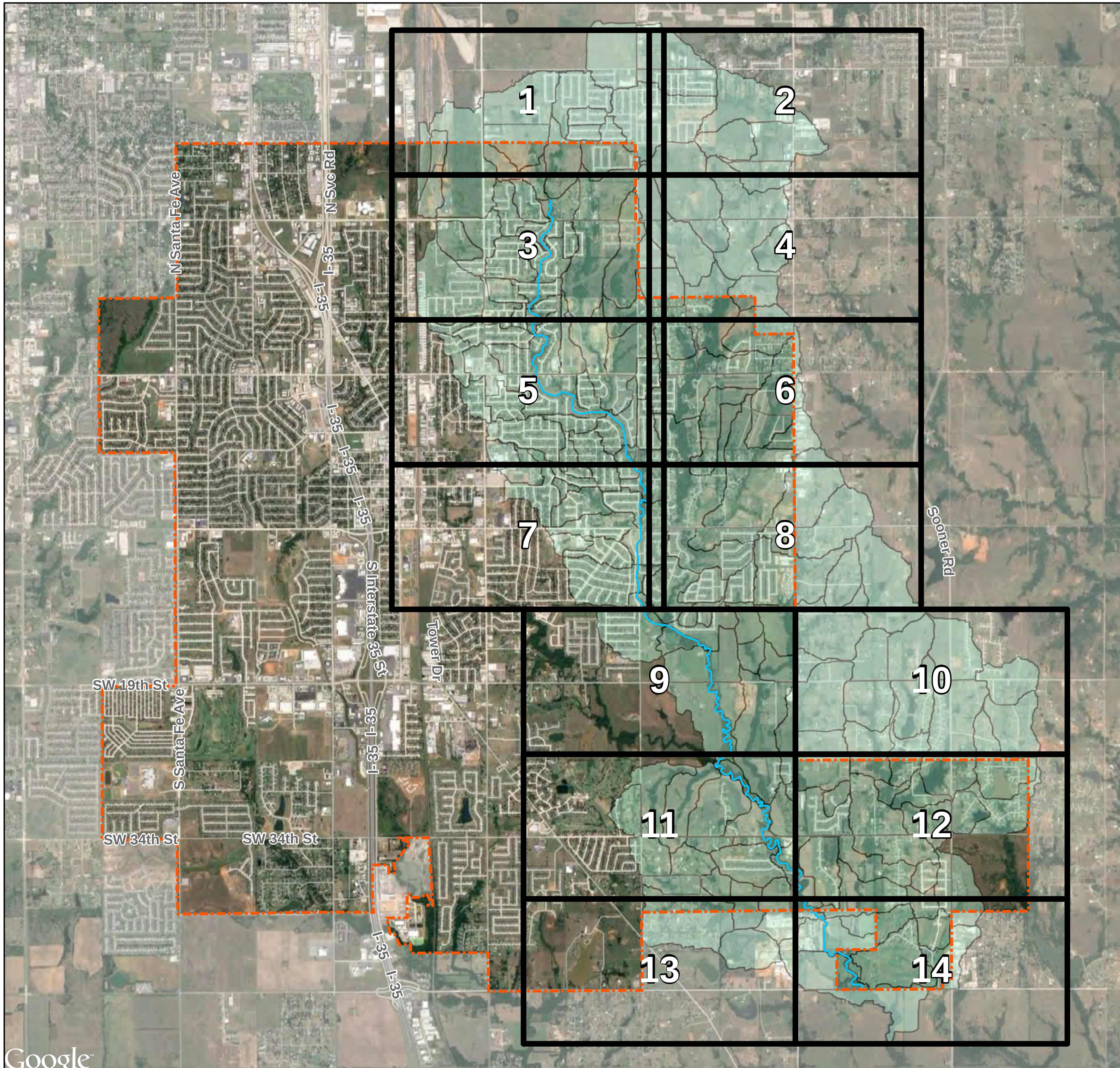
Figure
6 - 23



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City of Moore Master Drainage Plan

North Fork River
Detailed HEC-HMS Schematics
Section 6 - Appendix A

Atlas Pages
Moore City Limits
North Fork River Basin
North Fork River

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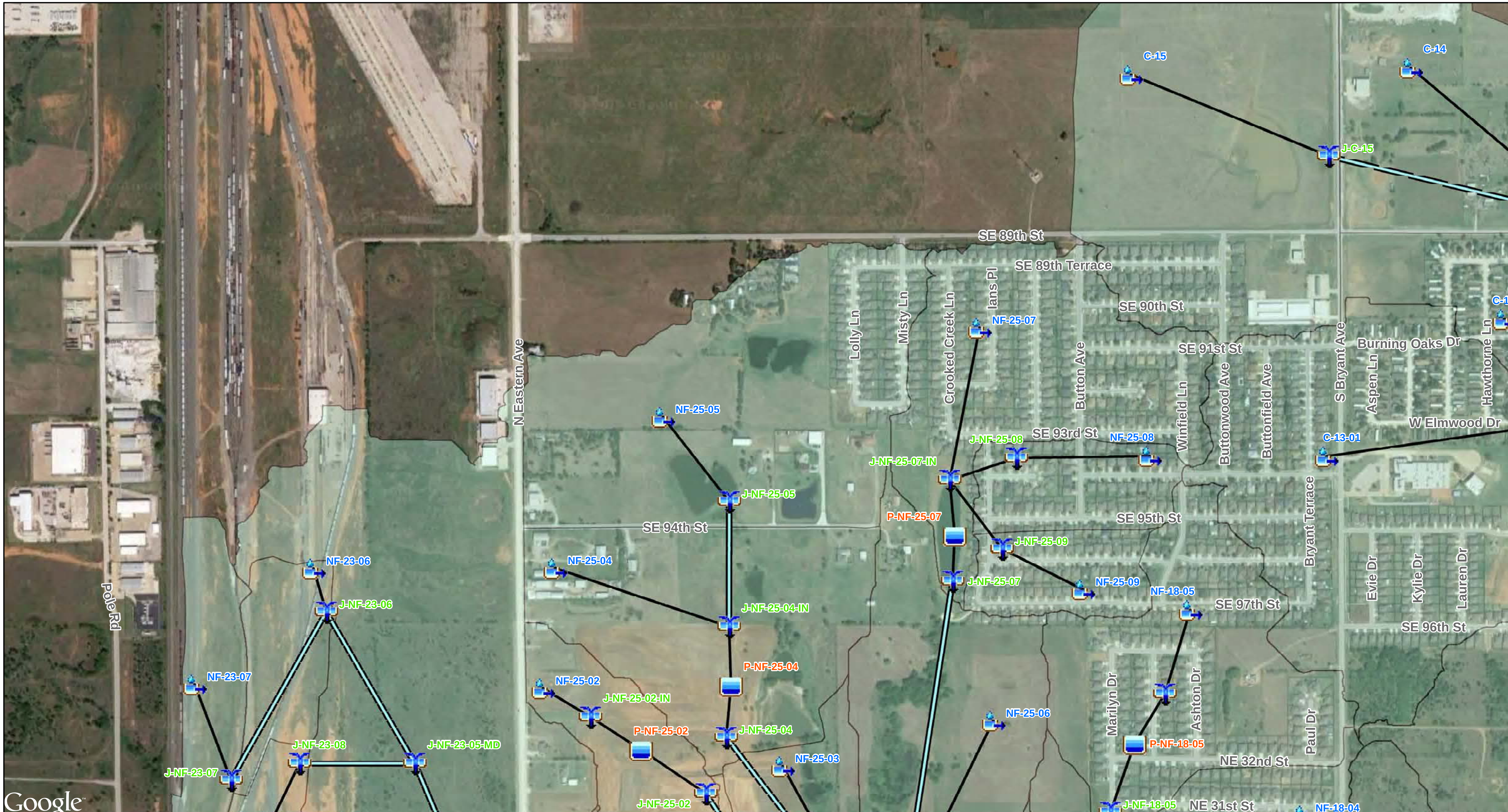

City of Moore - Master Drainage Plan

North Fork River Detailed HEC-HMS Schematics

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HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
- Reach
- Route Downstream
- North Fork River Basin

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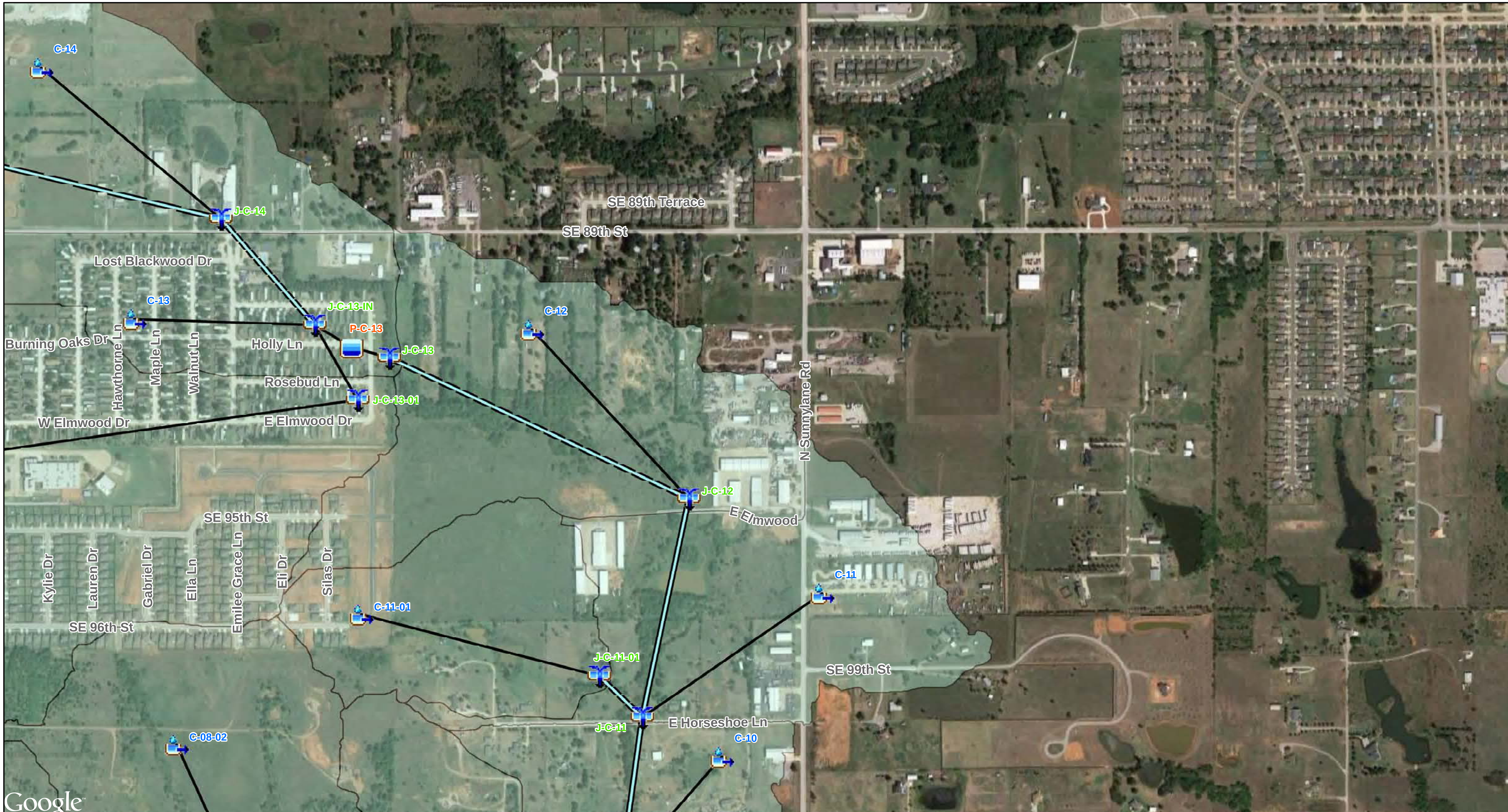

City of Moore - Master Drainage Plan

North Fork River Detailed HEC-HMS Schematics

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HMS Points

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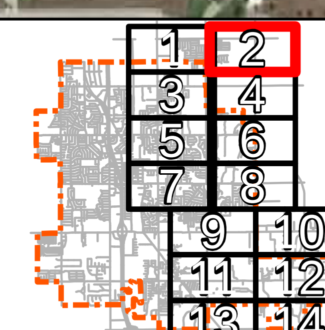

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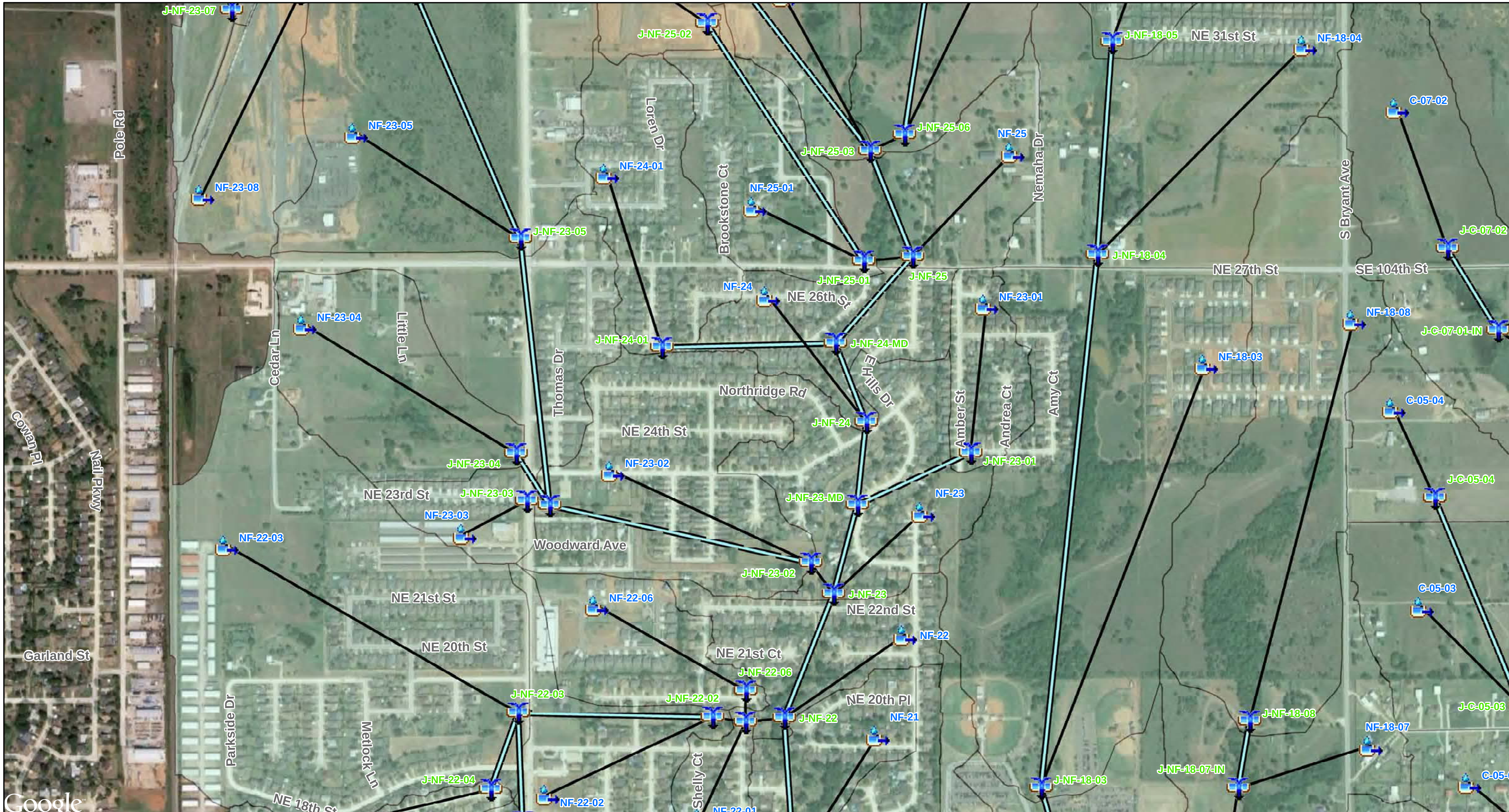

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North Fork River Detailed HEC-HMS Schematics

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HMS Points

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Route Downstream

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CITY OF MOORE OKLAHOMA

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City of Moore - Master Drainage Plan

North Fork River Detailed HEC-HMS Schematics

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HMS Points
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- Subbasin
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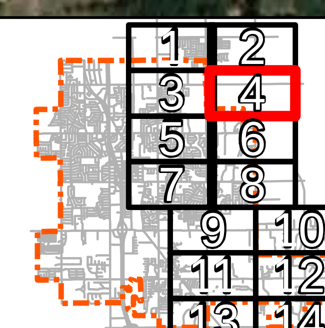
- Reach
- Route Downstream
- North Fork River Basin



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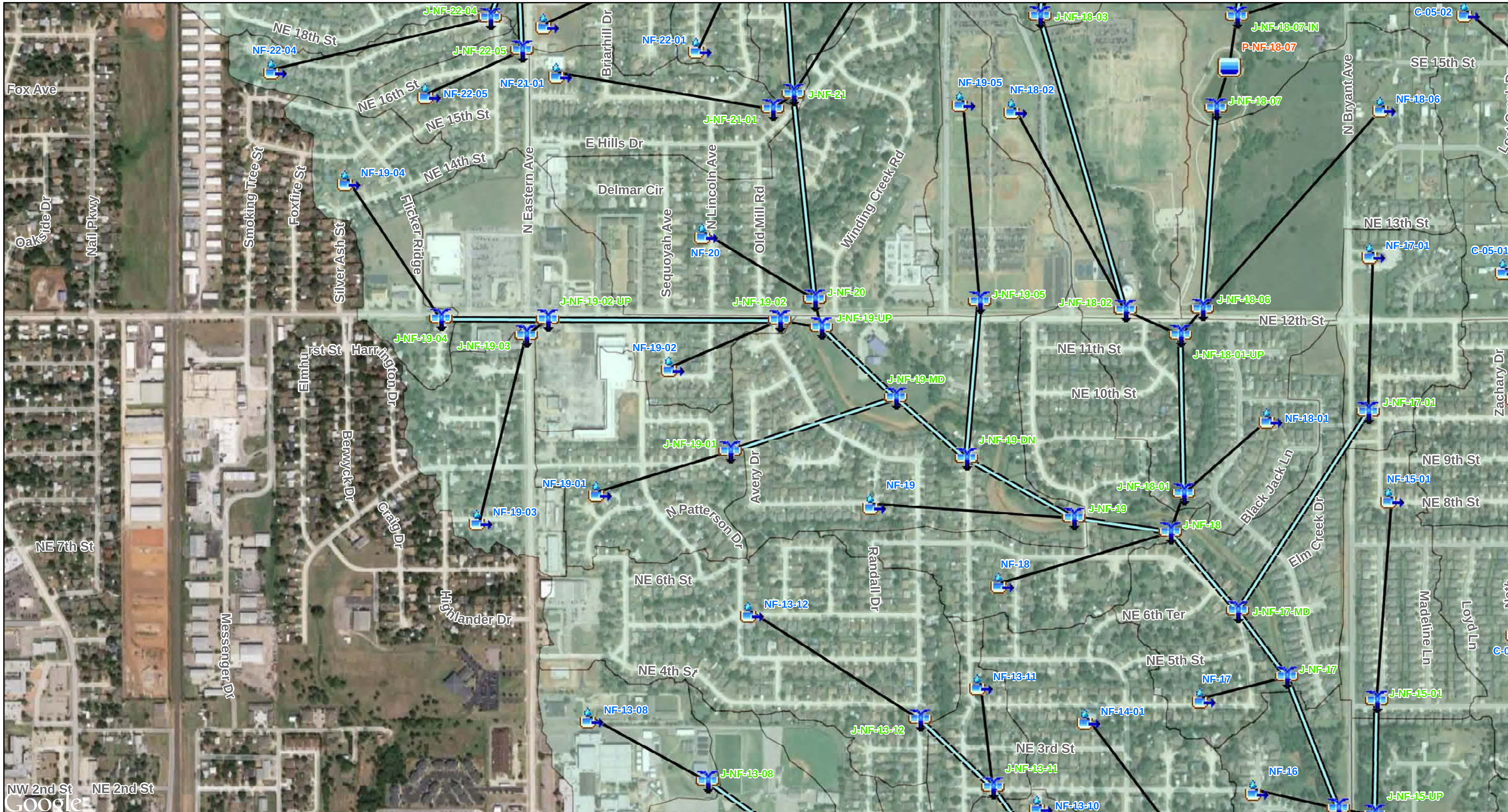

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North Fork River Detailed HEC-HMS Schematics

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HMS Points

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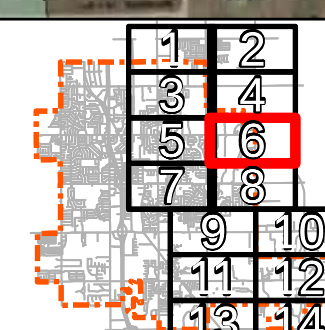

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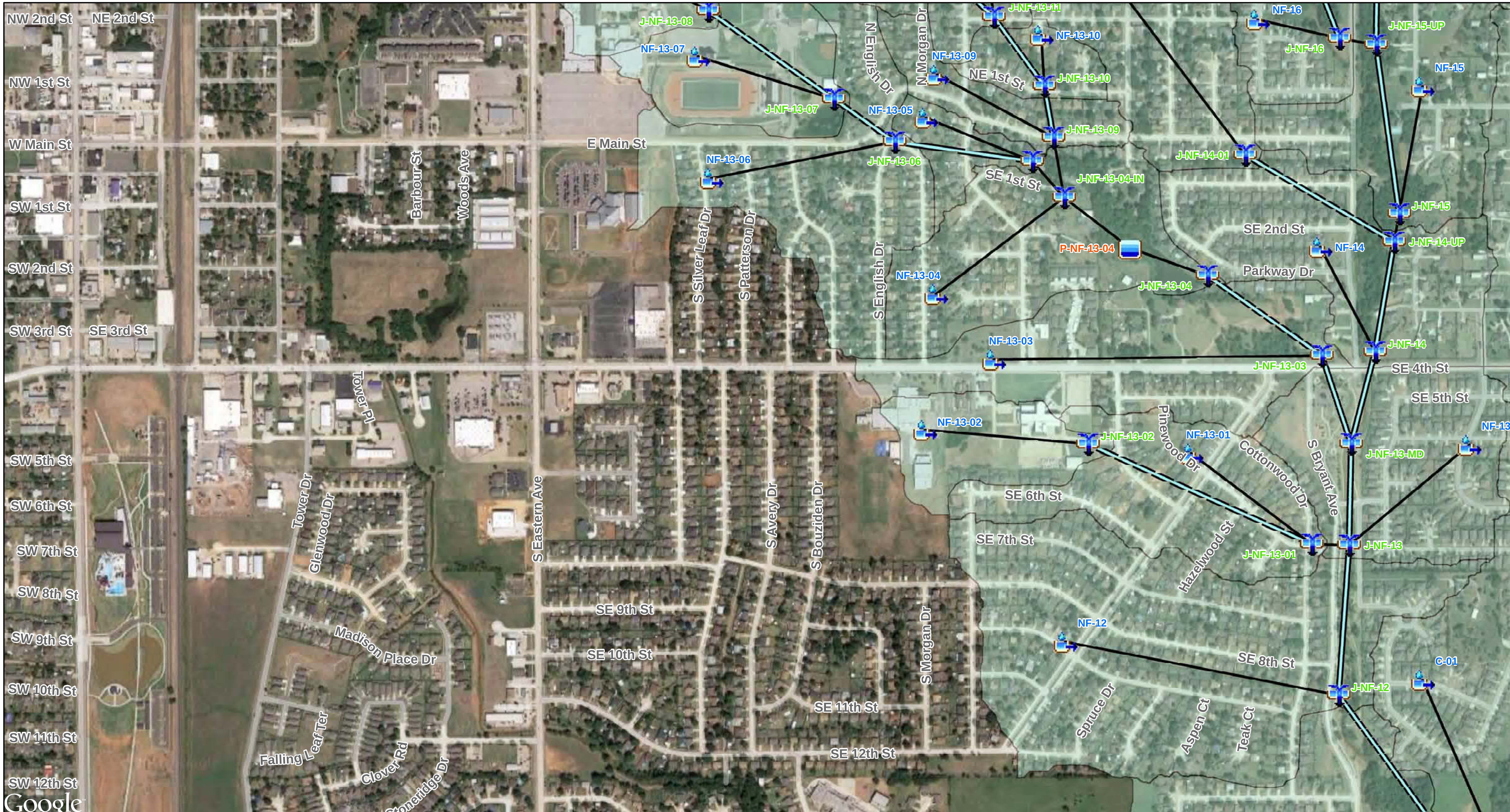

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North Fork River Detailed HEC-HMS Schematics

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HMS Points
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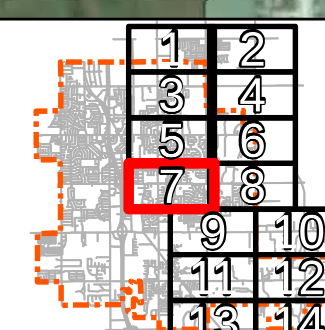

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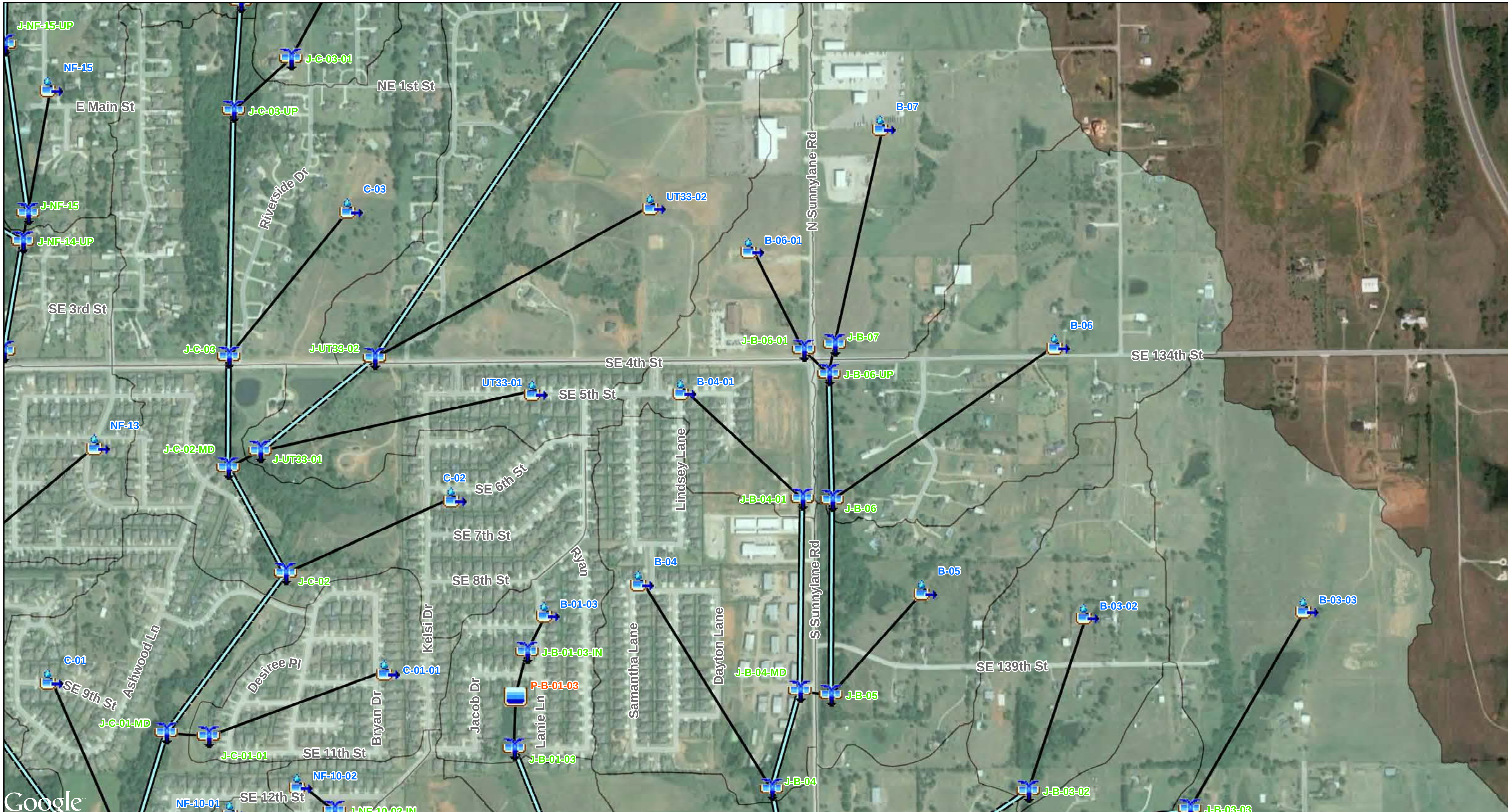

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North Fork River Detailed HEC-HMS Schematics

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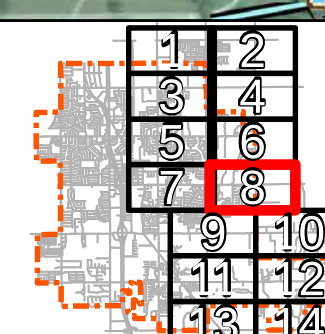

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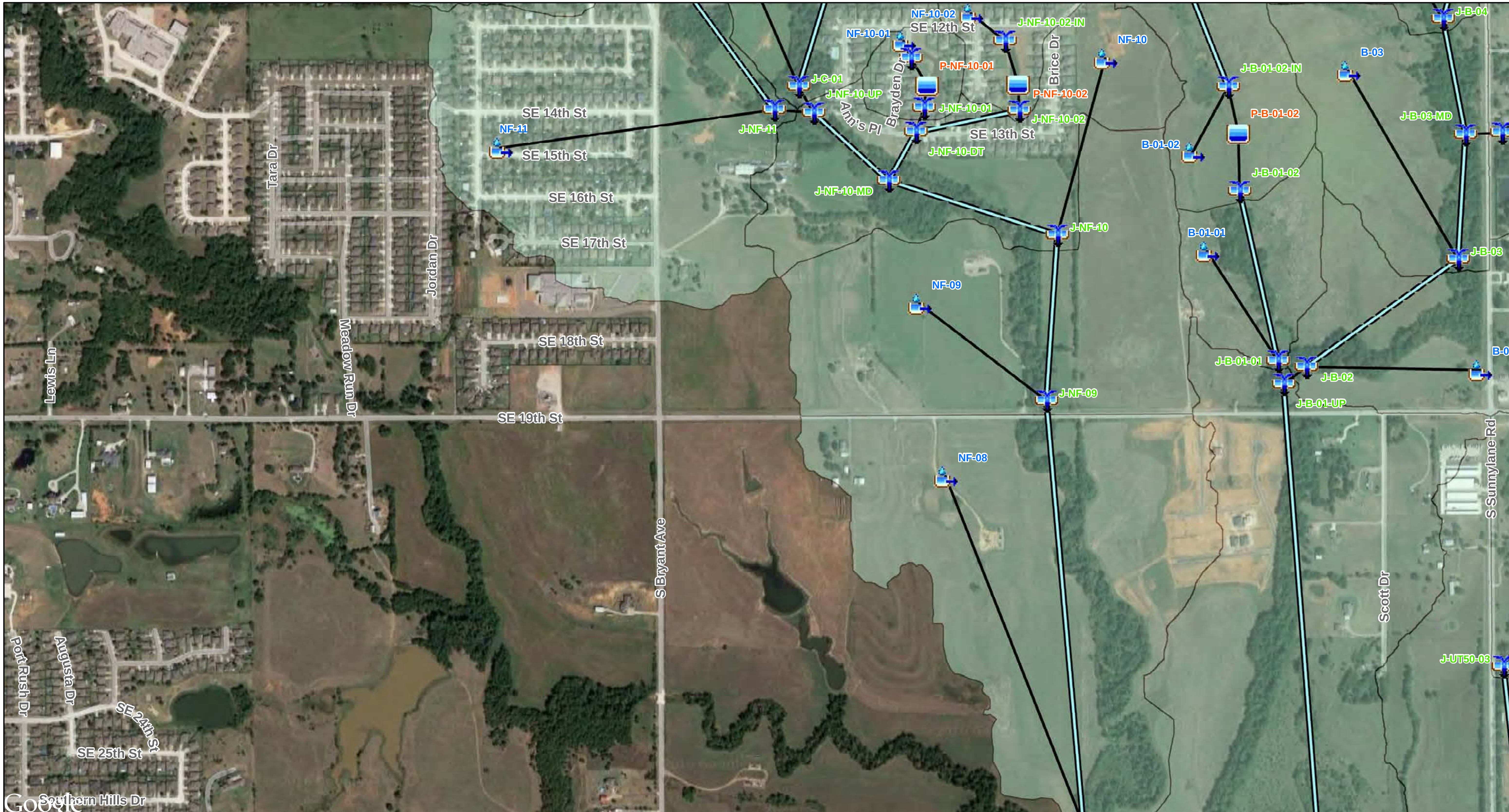

City of Moore - Master Drainage Plan

North Fork River Detailed HEC-HMS Schematics

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HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	North Fork River Basin

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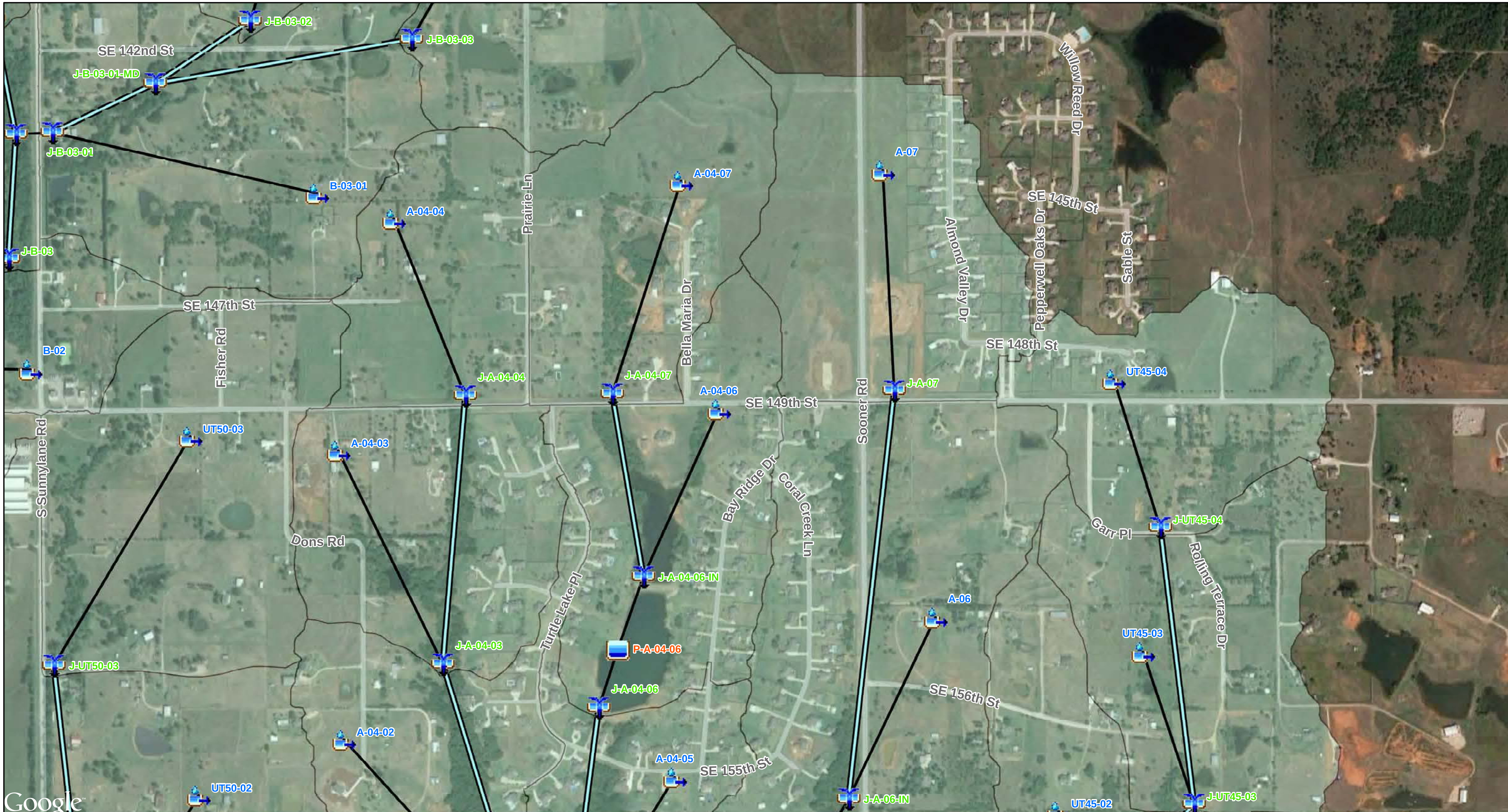

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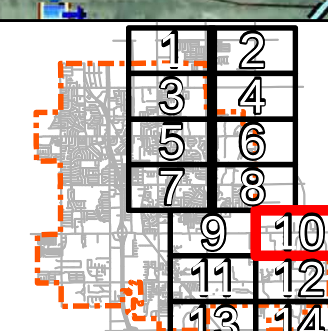

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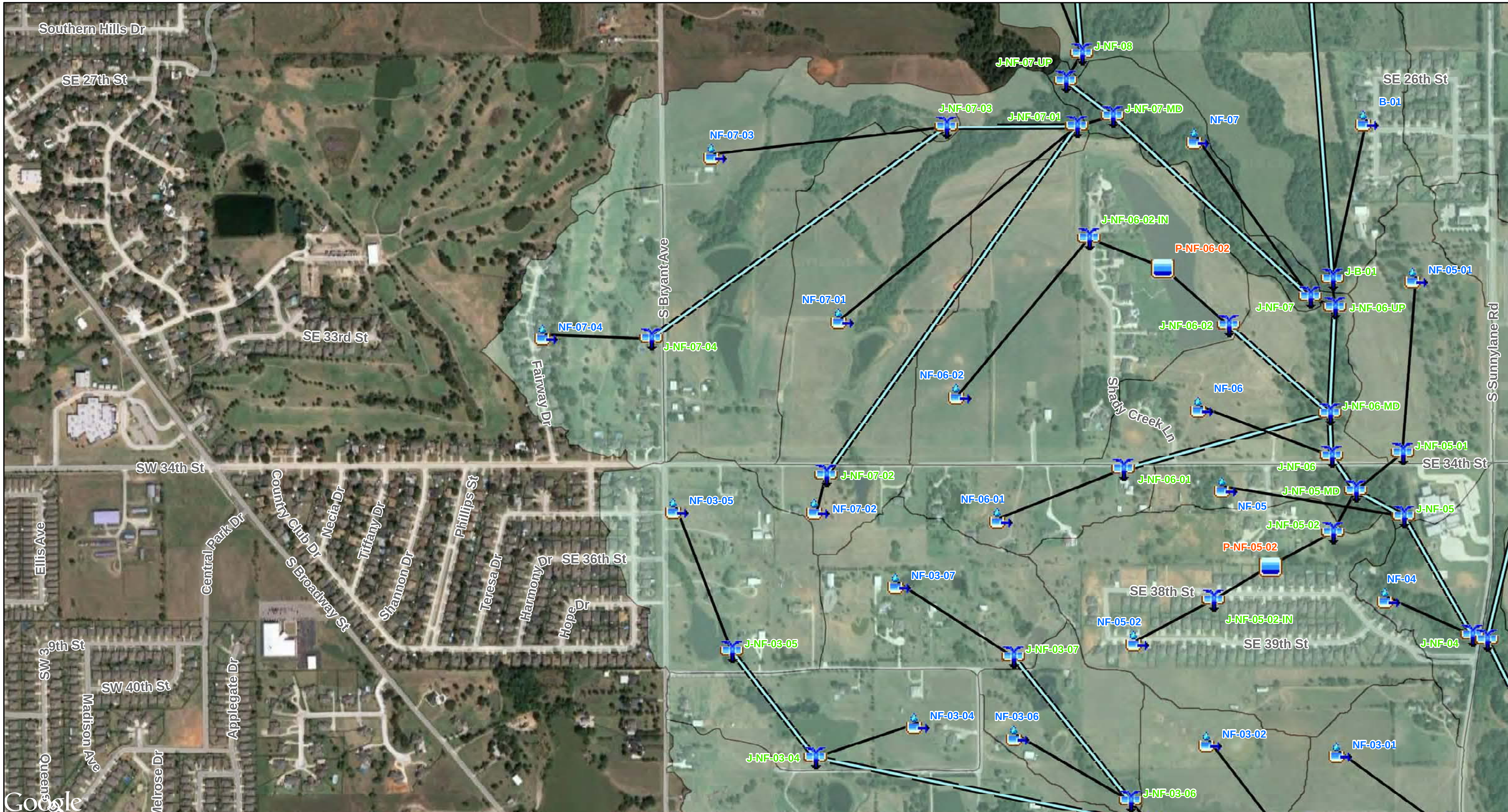

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North Fork River Detailed HEC-HMS Schematics

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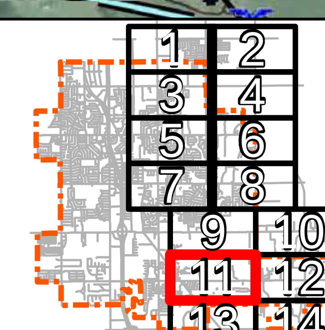

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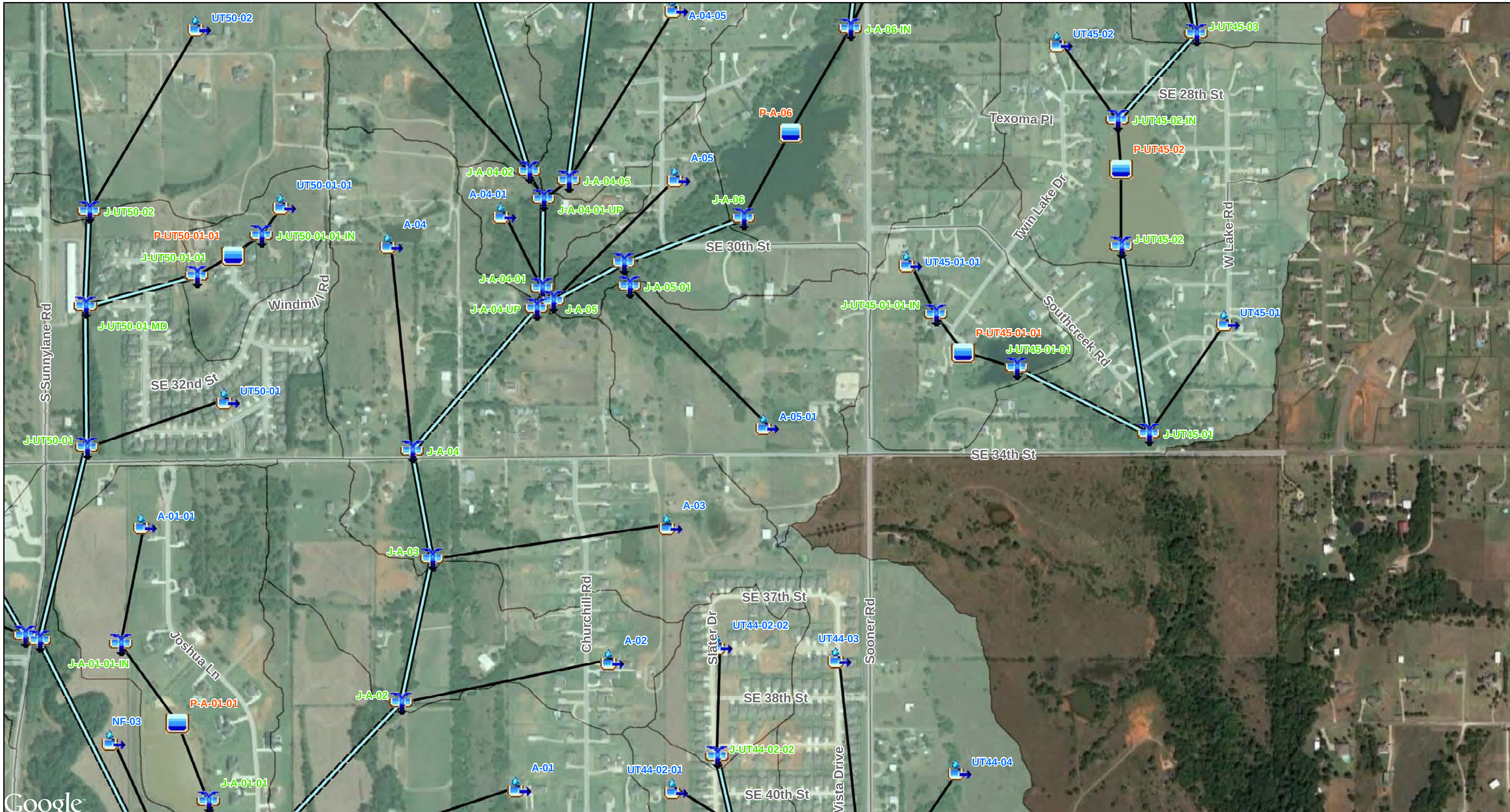

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HMS Points
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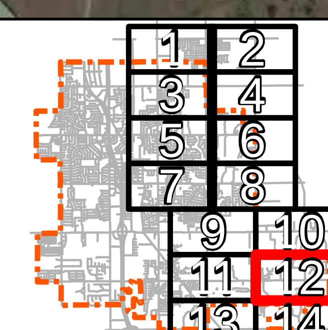

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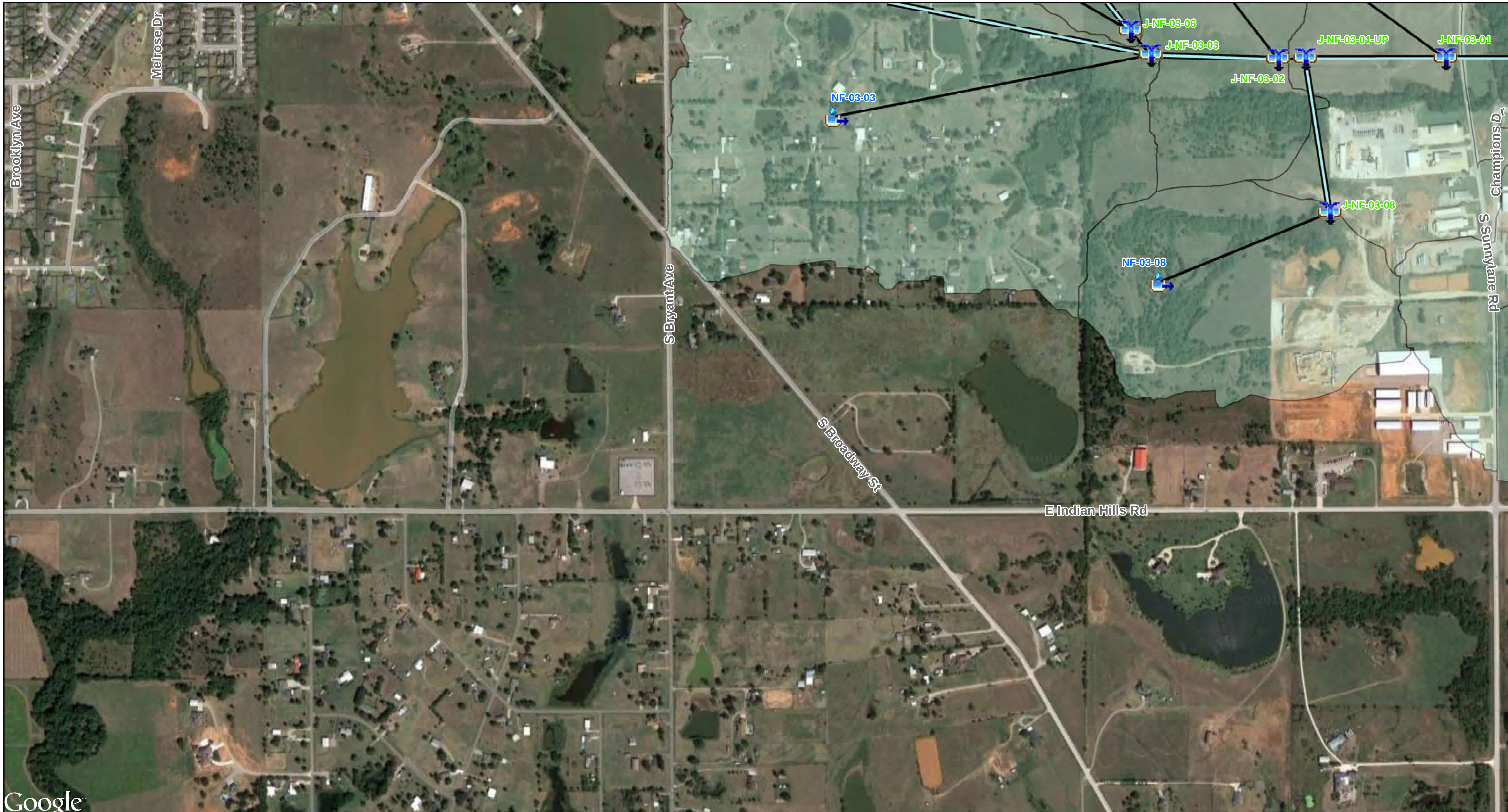

City of Moore - Master Drainage Plan

North Fork River Detailed HEC-HMS Schematics

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HMS Points	HMS Lines
Reservoir	Reach
Subbasin	Route Downstream
Junction	North Fork River Basin

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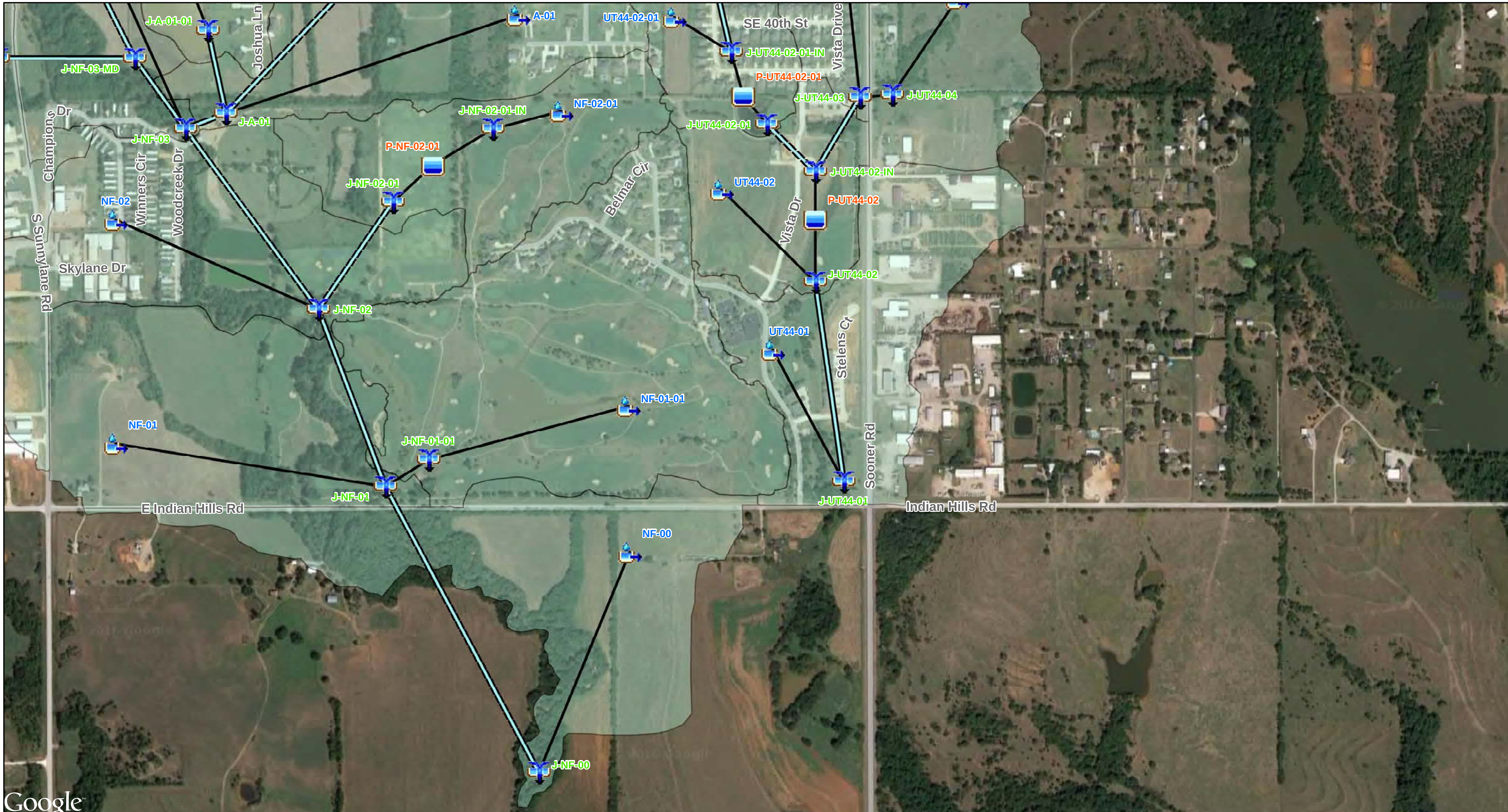

City of Moore - Master Drainage Plan

North Fork River Detailed HEC-HMS Schematics

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HMS Points

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CITY of MOORE OKLAHOMA

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #02 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
PART 1 - 12TH STREET STORM SEWER TO STREAM C					
1	**UNCLASSIFIED EXCAVATION**	**CY**	75	$ 12.00	$ 900.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	210	$ 3.00	$ 630.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**8" PCC PAVEMENT**	**SY**	16	$ 75.00	$ 1,200.00
5	**CAST IRON CURB INLETS AND GRATES**	**LS**	7	$ 3,500.00	$ 24,500.00
6	**STANDARD BEDDING MATERIAL - 18" RCP**	**CY**	50	$ 20.00	$ 1,000.00
7	**18" RCP**	**LF**	175	$ 52.00	$ 9,100.00
				Subtotal	**$ 42,330.00**
PART 2 - PARKING LOT STORM SEWER TO STREAM C					
1	**UNCLASSIFIED EXCAVATION**	**CY**	70	$ 12.00	$ 840.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	150	$ 3.00	$ 450.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**8" PCC PAVEMENT**	**SY**	10	$ 75.00	$ 750.00
5	**CAST IRON CURB INLETS AND GRATES**	**LS**	5	$ 3,500.00	$ 17,500.00
6	**STANDARD BEDDING MATERIAL - 15" RCP**	**CY**	45	$ 20.00	$ 900.00
7	**15" RCP**	**LF**	160	$ 48.00	$ 7,680.00
				Subtotal	**$ 33,120.00**
				Subtotal	**$ 75,450.00**
				15% Contingency	**$ 11,317.50**
				Subtotal	**$ 86,767.50**
				25% Utility Relocation Contingency	**$ 21,691.88**
				Total	***$ 108,459.38***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #06 - Recommendation Part 1,3&4					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
Part 1 - NE 12th Street Culvert and Roadway Apron					
1	PROPERTY ACQUISITION - Storage Compensation	LS	1	$ 55,000.00	$ 55,000.00
2	UNCLASSIFIED EXCAVATION - Storage Compensation	CY	14400	$ 11.00	$ 158,400.00
3	UNCLASSIFIED EXCAVATION - NE 12th Street RCB	CY	2110	$ 12.00	$ 25,320.00
4	SOLID SLAB BERMUDA SODDING	SY	450	$ 3.00	$ 1,350.00
5	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 25,000.00	$ 25,000.00
6	8" PCC PAVEMENT - NE 12th Street RCB	SY	310	$ 75.00	$ 23,250.00
7	8" PCC PAVEMENT - Old Mill Rd Apron	SY	280	$ 75.00	$ 21,000.00
8	STANDARD BEDDING MATERIAL - (3) 16' x 8' RCB	CY	330	$ 20.00	$ 6,600.00
9	Triple 16' x 8' RCB	LS	1	$ 250,000.00	$ 250,000.00
				Subtotal	**$ 565,920.00**
PART 3 - SEQUOYAH & LINCOLN STORM SEWER TO NORTH FORK RIVER					
1	UNCLASSIFIED EXCAVATION	CY	1100	$ 12.00	$ 13,200.00
2	SOLID SLAB BERMUDA SODDING	SY	700	$ 3.00	$ 2,100.00
3	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 30,000.00	$ 30,000.00
4	8" PCC PAVEMENT	SY	61	$ 75.00	$ 4,575.00
5	CAST IRON CURB INLETS AND GRATES	LS	26	$ 3,500.00	$ 91,000.00
6	STANDARD BEDDING MATERIAL - 36" RCP	CY	185	$ 20.00	$ 3,700.00
7	STANDARD BEDDING MATERIAL - 42" RCP	CY	506	$ 20.00	$ 10,120.00
8	36" RCP	LF	294	$ 140.00	$ 41,160.00
9	42" RCP	LF	550	$ 190.00	$ 104,500.00
10	6' WOODEN PRIVACY FENCE	LF	610	$ 40.00	$ 24,400.00
				Subtotal	**$ 324,755.00**

Continued

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #06 - Recommendation Part 1,3&4					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
PART 4 - OLD MILL ROAD STORM SEWER TO NORTH FORK RIVER					
1	**UNCLASSIFIED EXCAVATION**	**CY**	190	$ 12.00	$ 2,280.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	180	$ 3.00	$ 540.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**8" PCC PAVEMENT**	**SY**	15	$ 75.00	$ 1,125.00
5	**CAST IRON CURB INLETS AND GRATES**	**LS**	2	$ 3,500.00	$ 7,000.00
6	**STANDARD BEDDING MATERIAL - 30" RCP**	**CY**	120	$ 20.00	$ 2,400.00
7	**30" RCP**	**LF**	225	$ 120.00	$ 27,000.00
8	**6' WOODEN PRIVACY FENCE**	**LF**	105	$ 40.00	$ 4,200.00
				Subtotal	**$ 49,545.00**
				Subtotal	**$ 940,220.00**
				15% Contingency	**$ 141,033.00**
				Subtotal	**$ 1,081,253.00**
				25% Utility Relocation Contingency	**$ 270,313.25**
				Total	***$ 1,351,566.25***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #07 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	1630	$ 12.00	$ 19,560.00
2	**SELECT BORROW**	**CY**	6575	$ 15.00	$ 98,625.00
3	**SOLID SLAB BERMUDA SODDING**	**SY**	3333	$ 3.00	$ 10,000.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 50,000.00	$ 50,000.00
5	**STANDARD BEDDING MATERIAL - 10' x 4' RCB**	**CY**	120	$ 20.00	$ 2,400.00
6	**10' x 4' RCB**	**LF**	90	$ 1,200.00	$ 108,000.00
				Subtotal	**$ 288,585.00**
				15% Contingency	**$ 43,287.75**
				Subtotal	**$ 331,872.75**
				25% Utility Relocation Contingency	**$ 82,968.19**
				Total	***$ 414,840.94***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #08 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	430	$ 12.00	$ 5,160.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	340	$ 3.00	$ 1,020.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 25,000.00	$ 25,000.00
4	**8" PCC PAVEMENT**	**SY**	75	$ 75.00	$ 5,625.00
5	**STANDARD BEDDING MATERIAL - (2) 10' x 7' RCB**	**CY**	100	$ 20.00	$ 2,000.00
6	**Double 10' x 7' RCB**	**LF**	80	$ 1,300.00	$ 104,000.00
				Subtotal	**$ 142,805.00**
				15% Contingency	**$ 21,420.75**
				Subtotal	**$ 164,225.75**
				25% Utility Relocation Contingency	**$ 41,056.44**
				Total	***$ 205,282.19***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #08 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	1000	$ 12.00	$ 12,000.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	340	$ 3.00	$ 1,020.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 25,000.00	$ 25,000.00
4	**8" PCC PAVEMENT**	**SY**	110	$ 75.00	$ 8,250.00
5	**STANDARD BEDDING MATERIAL - (3) 14' x 7' RCB**	**CY**	170	$ 20.00	$ 3,400.00
6	**Triple 14' x 7' RCB**	**LF**	120	$ 2,300.00	$ 276,000.00
				Subtotal	**$ 325,670.00**
				15% Contingency	**$ 48,850.50**
				Subtotal	**$ 374,520.50**
				25% Utility Relocation Contingency	**$ 93,630.13**
				Total	***$ 468,150.63***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #10 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	560	$ 12.00	$ 6,720.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	2640	$ 3.00	$ 7,920.00
				Subtotal	**$ 14,640.00**
				15% Contingency	**$ 2,196.00**
				Subtotal	**$ 16,836.00**
				25% Utility Relocation Contingency	**$ 4,209.00**
				Total	***$ 21,045.00***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #11 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**SELECT BORROW & EXCAVATION - Detention Dam**	**CY**	4400	$ 15.00	$ 66,000.00
2	**UNCLASSIFIED EXCAVATION - Detention Area**	**CY**	5000	$ 12.00	$ 60,000.00
3	**SOLID SLAB BERMUDA SODDING**	**SY**	9000	$ 3.00	$ 27,000.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 15,000.00	$ 15,000.00
5	**STANDARD BEDDING MATERIAL - 12" RCP**	**CY**	18	$ 20.00	$ 360.00
6	**12" RCP**	**LF**	70	$ 43.00	$ 3,010.00
				Subtotal	**$ 171,370.00**
				15% Contingency	**$ 25,705.50**
				Subtotal	**$ 197,075.50**
				25% Utility Relocation Contingency	**$ 49,268.88**
				Total	***$ 246,344.38***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #12 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	UNCLASSIFIED EXCAVATION	CY	13700	$ 12.00	$ 164,400.00
2	SOLID SLAB BERMUDA SODDING	SY	3000	$ 3.00	$ 9,000.00
3	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 140,000.00	$ 140,000.00
4	CAST IRON TRENCH GRATE	LS	6	$ 10,000.00	$ 60,000.00
5	CAST IRON CURB & GRATE INLETS	LS	54	$ 3,500.00	$ 189,000.00
6	CAST IRON GRATE INLET	LS	1	$ 5,000.00	$ 5,000.00
7	CONCRETE RECESSED INLET	LS	4	$ 5,000.00	$ 20,000.00
5	4" PCC SIDEWALK	SY	560	$ 40.00	$ 22,400.00
6	6" PCC DRIVEWAY	SY	370	$ 60.00	$ 22,200.00
7	8" PCC PAVEMENT	SY	530	$ 75.00	$ 39,750.00
8	STANDARD BEDDING MATERIAL - 72" RCP	CY	2600	$ 20.00	$ 52,000.00
9	72" RCP	LF	1300	$ 522.00	$ 678,600.00
10	STANDARD BEDDING MATERIAL - 14' x 6' RCB	CY	1140	$ 20.00	$ 22,800.00
11	14' x 6' RCB	LF	640	$ 2,100.00	$ 1,344,000.00
12	STANDARD BEDDING MATERIAL - 8' x 5' RCB	CY	660	$ 20.00	$ 13,200.00
13	8' x 5' RCB	LF	522	$ 890.00	$ 464,580.00
12	6' WOODEN PRIVACY FENCE	LF	600	$ 40.00	$ 24,000.00
				Subtotal	**$ 3,270,930.00**
				15% Contingency	**$ 490,639.50**
				Subtotal	**$ 3,761,569.50**
				25% Utility Relocation Contingency	**$ 940,392.38**
				Total	***$ 4,701,961.88***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #12 - Alternate					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	6480	$ 12.00	$ 77,760.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	2770	$ 3.00	$ 8,310.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 140,000.00	$ 140,000.00
4	**CAST IRON TRENCH GRATE**	**LS**	2	$ 10,000.00	$ 20,000.00
5	**CAST IRON CURB & GRATE INLETS**	**LS**	60	$ 3,500.00	$ 210,000.00
6	**CONCRETE RECESSED INLET**	**LS**	2	$ 5,000.00	$ 10,000.00
7	**4" PCC SIDEWALK**	**SY**	60	$ 40.00	$ 2,400.00
8	**6" PCC DRIVEWAY**	**SY**	350	$ 60.00	$ 21,000.00
9	**8" PCC PAVEMENT**	**SY**	240	$ 75.00	$ 18,000.00
10	**STANDARD BEDDING MATERIAL - 72" RCP**	**CY**	3380	$ 20.00	$ 67,600.00
11	**72" RCP**	**LF**	1690	$ 522.00	$ 882,180.00
12	**STANDARD BEDDING MATERIAL - 8' x 6' RCB**	**CY**	240	$ 20.00	$ 4,800.00
13	**8' x 6' RCB**	**LF**	175	$ 930.00	$ 162,750.00
14	**6' WOODEN PRIVACY FENCE**	**LF**	1600	$ 40.00	$ 64,000.00
				Subtotal	**$ 1,688,800.00**
				15% Contingency	**$ 253,320.00**
				Subtotal	**$ 1,942,120.00**
				25% Utility Relocation Contingency	**$ 485,530.00**
				Total	***$ 2,427,650.00***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #13 - Alternative					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	5200	$ 12.00	$ 62,400.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	1900	$ 3.00	$ 5,700.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 75,000.00	$ 75,000.00
4	**CAST IRON TRENCH GRATE**	**LS**	1	$ 30,000.00	$ 30,000.00
5	**CAST IRON CURB & GRATE INLETS**	**LS**	12	$ 3,500.00	$ 42,000.00
6	**CAST IRON GRATE INLET**	**LS**	1	$ 5,000.00	$ 5,000.00
7	**8" PCC PAVEMENT**	**SY**	200	$ 75.00	$ 15,000.00
8	**STANDARD BEDDING MATERIAL - 10' x 5' RCB**	**CY**	1290	$ 20.00	$ 25,800.00
9	**10' x 5' RCB**	**LF**	910	$ 1,200.00	$ 1,092,000.00
10	**6' WOODEN PRIVACY FENCE**	**LF**	1000	$ 40.00	$ 40,000.00
				Subtotal	**$ 1,392,900.00**
				15% Contingency	**$ 208,935.00**
				Subtotal	**$ 1,601,835.00**
				25% Utility Relocation Contingency	**$ 400,458.75**
				Total	***$ 2,002,293.75***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #15 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	UNCLASSIFIED EXCAVATION	CY	120	$ 12.00	$ 1,440.00
2	SOLID SLAB BERMUDA SODDING	SY	92	$ 3.00	$ 276.00
3	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 15,000.00	$ 15,000.00
4	8" PCC PAVEMENT	SY	7	$ 75.00	$ 555.00
5	STANDARD BEDDING MATERIAL - 18" RCP	CY	77	$ 20.00	$ 1,540.00
6	18" RCP	LF	280	$ 52.00	$ 14,560.00
				Subtotal	**$ 33,371.00**
				15% Contingency	**$ 5,005.65**
				Subtotal	**$ 38,376.65**
				25% Utility Relocation Contingency	**$ 9,594.16**
				Total	***$ 47,970.81***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #16 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
PART 1 - DETENTION FACILITY & OUTLET STRUCTURE					
1	**PROPERTY ACQUISITION**	**LS**	1	$ 235,000.00	$ 235,000.00
2	**SELECT BORROW & EXCAVATION - Detention Pond**	**CY**	34690	$ 15.00	$ 520,350.00
3	**UNCLASSIFIED EXCAVATION - Outlet Structure**	**CY**	1255	$ 12.00	$ 15,060.00
4	**SOLID SLAB BERMUDA SODDING**	**SY**	474	$ 3.00	$ 1,422.00
5	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 35,000.00	$ 35,000.00
6	**8" PCC PAVEMENT**	**SY**	81	$ 75.00	$ 6,075.00
7	**STANDARD BEDDING MATERIAL - 6'x5' RCB**	**CY**	420	$ 20.00	$ 8,400.00
8	**6'x5' RCB**	**LF**	372	$ 625.00	$ 232,500.00
				Subtotal	**$ 1,053,807.00**
PART 2 - STORM SEWER TO NORTH FORK RIVER					
1	**UNCLASSIFIED EXCAVATION**	**CY**	1245	$ 12.00	$ 14,940.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	480	$ 3.00	$ 1,440.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 30,000.00	$ 30,000.00
4	**8" PCC PAVEMENT**	**SY**	72	$ 75.00	$ 5,400.00
5	**CAST IRON CURB INLETS AND GRATES**	**LS**	19	$ 3,500.00	$ 66,500.00
6	**STANDARD BEDDING MATERIAL - 10'x5' RCB**	**CY**	410	$ 20.00	$ 8,200.00
7	**10'x5' RCB**	**LF**	287	$ 1,200.00	$ 344,400.00
8	**6' WOODEN PRIVACY FENCE**	**LF**	280	$ 40.00	$ 11,200.00
				Subtotal	**$ 482,080.00**
				Subtotal	**$ 1,535,887.00**
				15% Contingency	**$ 230,383.05**
				Subtotal	**$ 1,766,270.05**
				25% Utility Relocation Contingency	**$ 441,567.51**
				Total	***$ 2,207,837.56***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #18 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	215	$ 12.00	$ 2,580.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	170	$ 3.00	$ 510.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 15,000.00	$ 15,000.00
4	**RECESSED CURB INLET**	**LS**	1	$ 5,000.00	$ 5,000.00
5	**8" PCC PAVEMENT**	**SY**	10	$ 75.00	$ 750.00
6	**STANDARD BEDDING MATERIAL - 42" RCP**	**CY**	140	$ 20.00	$ 2,800.00
7	**42" RCP**	**LF**	150	$ 190.00	$ 28,500.00
				Subtotal	**$ 55,140.00**
				15% Contingency	**$ 8,271.00**
				Subtotal	**$ 63,411.00**
				25% Utility Relocation Contingency	**$ 15,852.75**
				Total	***$ 79,263.75***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #18 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	570	$ 12.00	$ 6,840.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	300	$ 3.00	$ 900.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 2,500.00	$ 2,500.00
4	**STANDARD BEDDING MATERIAL - 4"**	**CY**	50	$ 20.00	$ 1,000.00
5	**CONCRETE FLUME CHANNEL**	**CY**	16	$ 75.00	$ 1,200.00
6	**6' WOOD PRIVACY FENCE**	**LF**	200	$ 40.00	$ 8,000.00
				Subtotal	**$ 20,440.00**
				15% Contingency	**$ 3,066.00**
				Subtotal	**$ 23,506.00**
				25% Utility Relocation Contingency	**$ 5,876.50**
				Total	***$ 29,382.50***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #19 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	35	$ 12.00	$ 420.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	40	$ 3.00	$ 120.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
4	**8" PCC PAVEMENT**	**SY**	11	$ 75.00	$ 825.00
5	**STANDARD BEDDING MATERIAL - 24" RCP**	**CY**	20	$ 20.00	$ 400.00
6	**24" RCP**	**LF**	50	$ 80.00	$ 4,000.00
				Subtotal	**$ 15,765.00**
				15% Contingency	**$ 2,364.75**
				Subtotal	**$ 18,129.75**
				25% Utility Relocation Contingency	**$ 4,532.44**
				Total	***$ 22,662.19***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #19 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	UNCLASSIFIED EXCAVATION	CY	45	$ 12.00	$ 540.00
2	SOLID SLAB BERMUDA SODDING	SY	40	$ 3.00	$ 120.00
3	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	1	$ 10,000.00	$ 10,000.00
4	8" PCC PAVEMENT	SY	12	$ 75.00	$ 900.00
5	STANDARD BEDDING MATERIAL - 30" RCP	CY	24	$ 20.00	$ 480.00
6	30" RCP	LF	50	$ 120.00	$ 6,000.00
				Subtotal	**$ 18,040.00**
				15% Contingency	**$ 2,706.00**
				Subtotal	**$ 20,746.00**
				25% Utility Relocation Contingency	**$ 5,186.50**
				Total	***$ 25,932.50***

City of Moore					
Appendix 6-B Moore Master Drainage Plan Alternatives - North Fork River - Problem Area #20 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	920	$ 12.00	$ 11,040.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	965	$ 3.00	$ 2,895.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
4	**CAST IRON CURB INLETS AND GRATES**	**LS**	25	$ 3,500.00	$ 87,500.00
5	**8" PCC PAVEMENT**	**SY**	279	$ 75.00	$ 20,925.00
6	**STANDARD BEDDING MATERIAL - 42" RCP**	**CY**	462	$ 20.00	$ 9,240.00
7	**42" RCP**	**LF**	530	$ 190.00	$ 100,700.00
				Subtotal	**$ 242,300.00**
				15% Contingency	**$ 36,345.00**
				Subtotal	**$ 278,645.00**
				25% Utility Relocation Contingency	**$ 69,661.25**
				Total	***$ 348,306.25***

Section 7
Stream D

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MESHEK & ASSOCIATES, PLC

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SECTION 7. STREAM D WATERSHED

7.1. PREVIOUS STUDIES

FEMA has performed previous detailed and re-delineated studies of the Stream D Watershed in 1987 as documented in the Cleveland County Flood Insurance Study (FIS). All alternatives proposed in this section were generated as part of this detailed study. Information regarding the background for this most recent study can be found in **SECTION 1 - EXECUTIVE SUMMARY** and **SECTION 2 - METHODOLOGY**.

7.2. EXISTING CONDITIONS HYDROLOGY

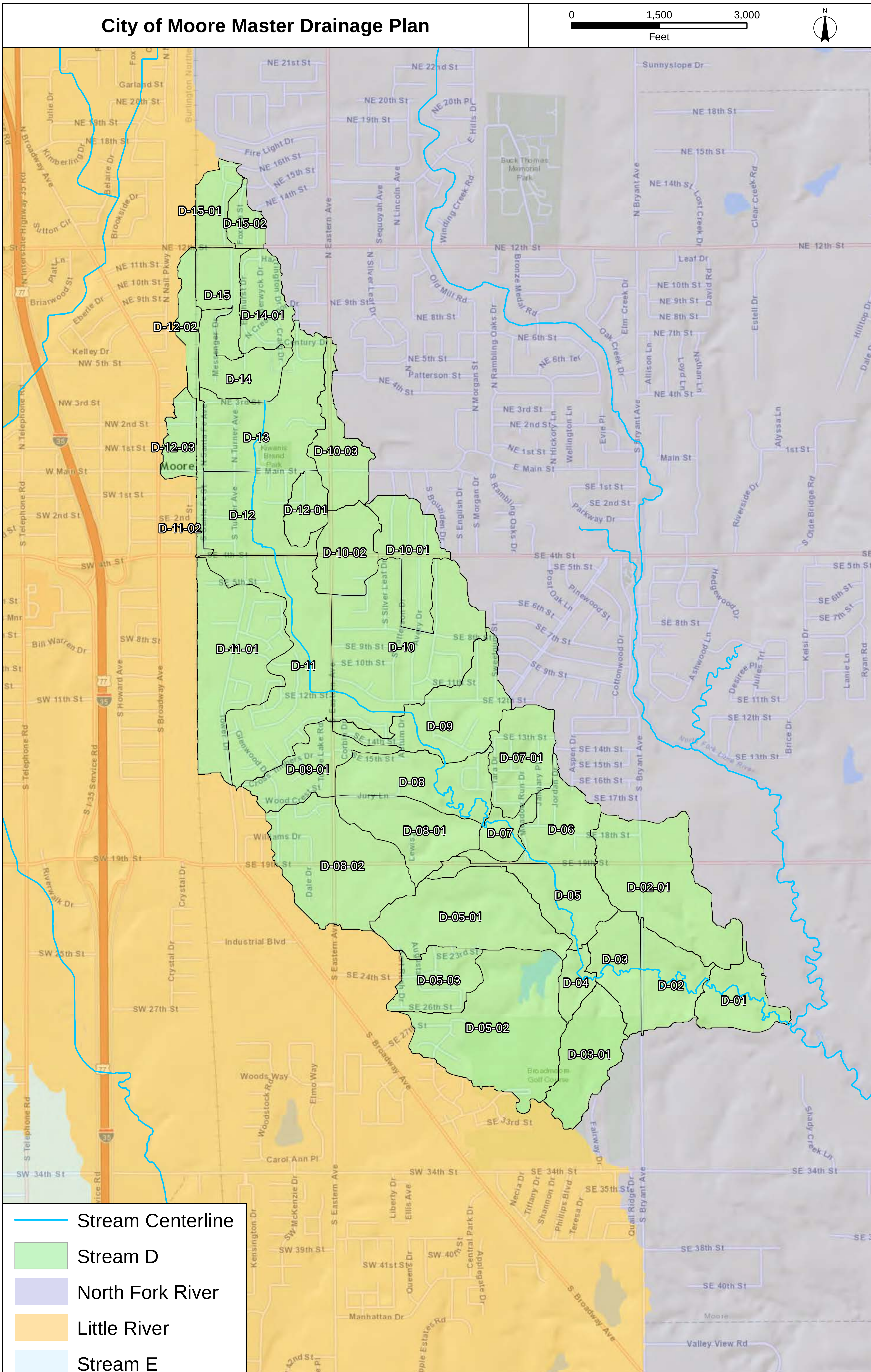
The Stream D Watershed consists of approximately 2.45 square miles of drainage area. The Stream D Watershed is generally located east of S Broadway Avenue, west of S Sunnylane Road, north of SE 34th Street, and south of NE 12th St. Stream D generally flows north to south and west to east to discharge into the North Fork River, which eventually drains to the Little River and Lake Thunderbird. The Stream D Watershed is divided into 35 sub-basins, which are depicted in **FIGURE 7-1.**

The hydrologic soil groups are shown in **FIGURE 7-2** with the existing land use depicted in **FIGURE 7-3.** More information on the hydrologic methodology can be found in **SECTION 2.1 HYDROLOGIC ANALYSIS**.

The hydrologic coefficients used for input in the HEC-HMS model include the lag time, soil complex curve number (CN) and drainage area. The HEC-HMS schematic, showing the connectivity of the hydrologic elements, can be found in **FIGURE 7-4** with more detailed HEC-HMS schematics provided in **APPENDIX 7-A**. A summary of hydrologic coefficients is presented in **TABLE 7-1**.

The flowrates for existing conditions for Stream D Drainage Basins were developed using HEC-HMS. A list of the flowrates at major junctions for the existing conditions is presented in **Table 7-2**.

City of Moore Master Drainage Plan



Stream D
Drainage Basins

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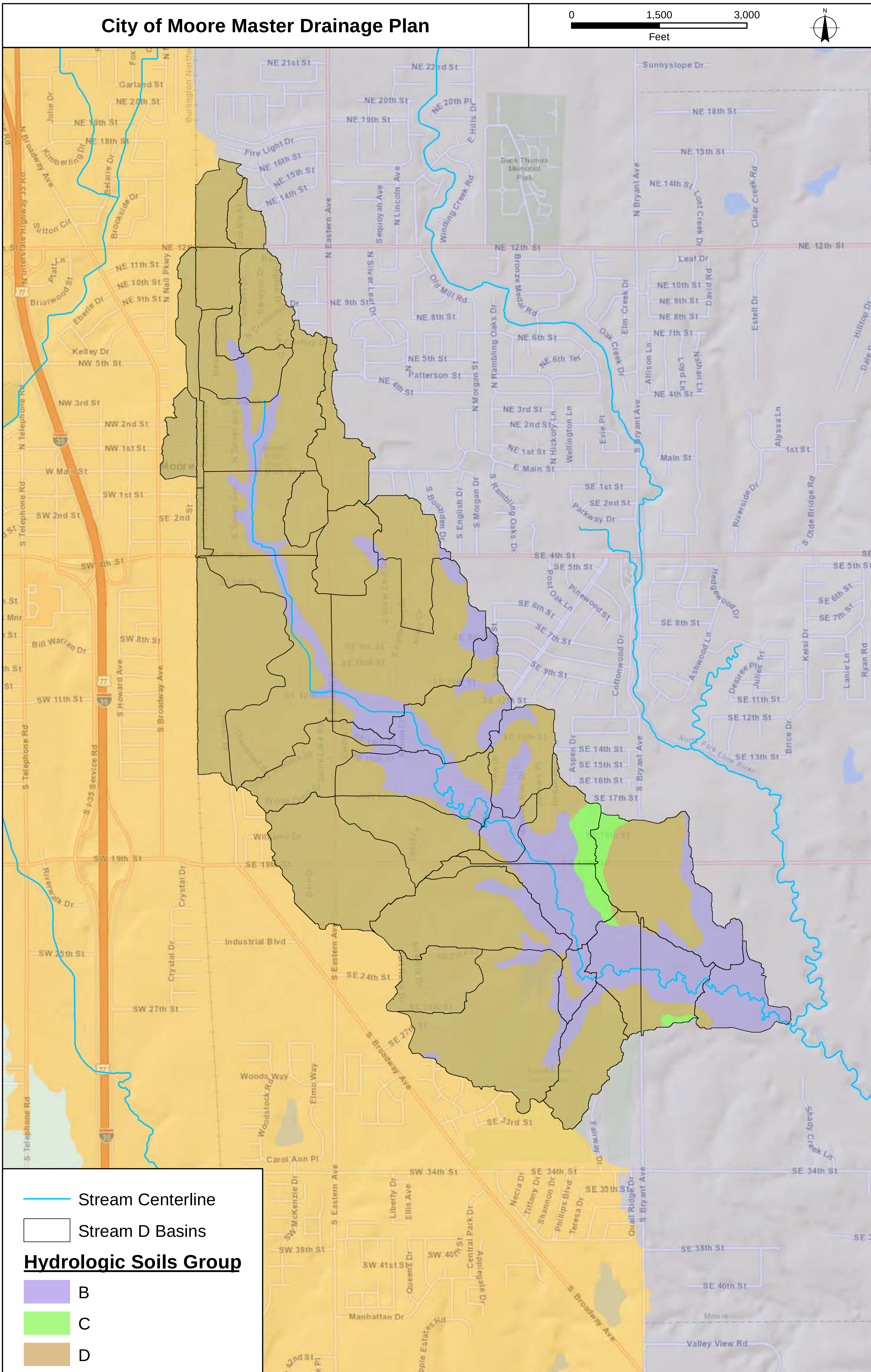
Figure 7 - 1

City of Moore Master Drainage Plan



Stream D
Hydrologic Soils Group

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Figure 7 - 2

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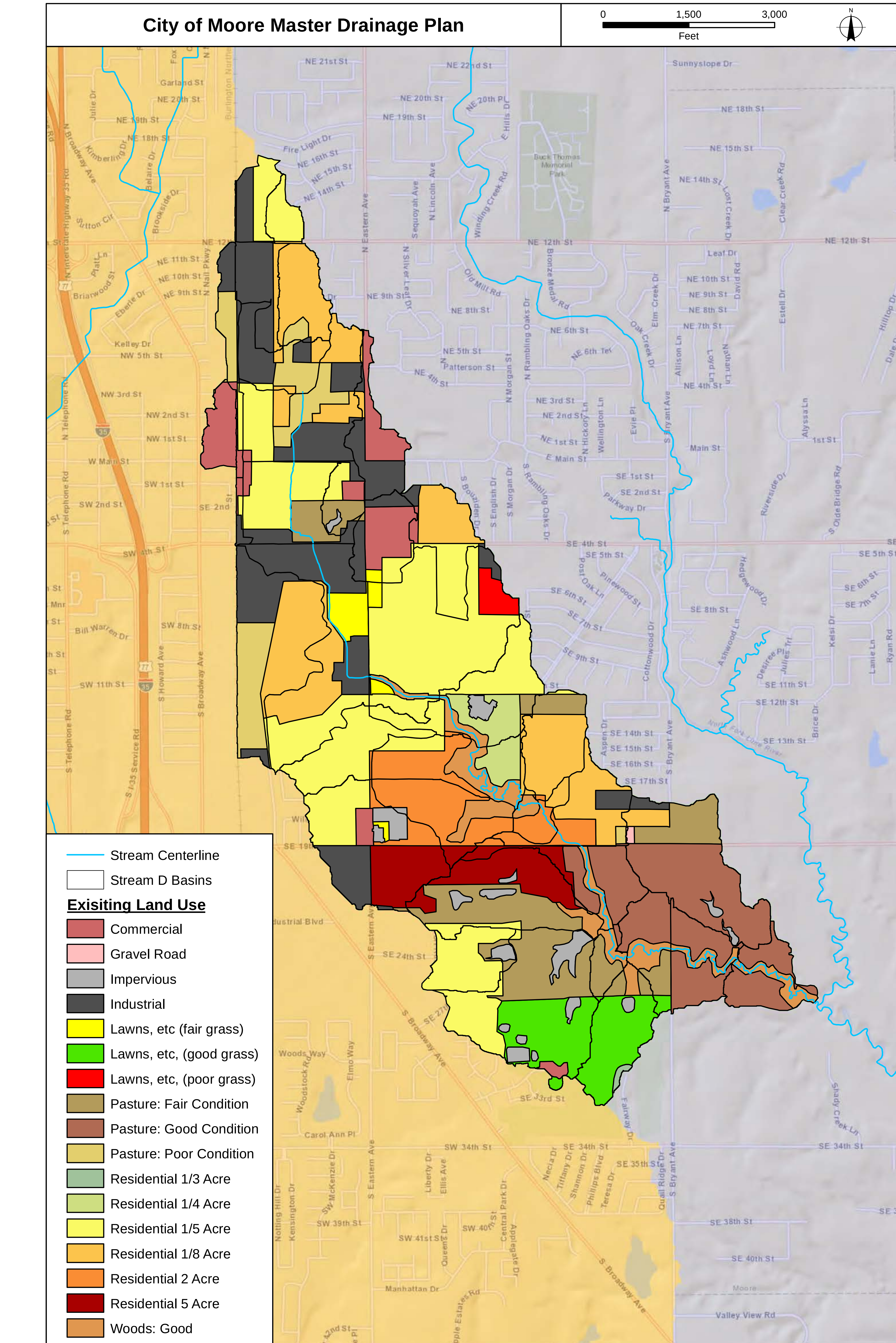

Stream D
Existing Land Use

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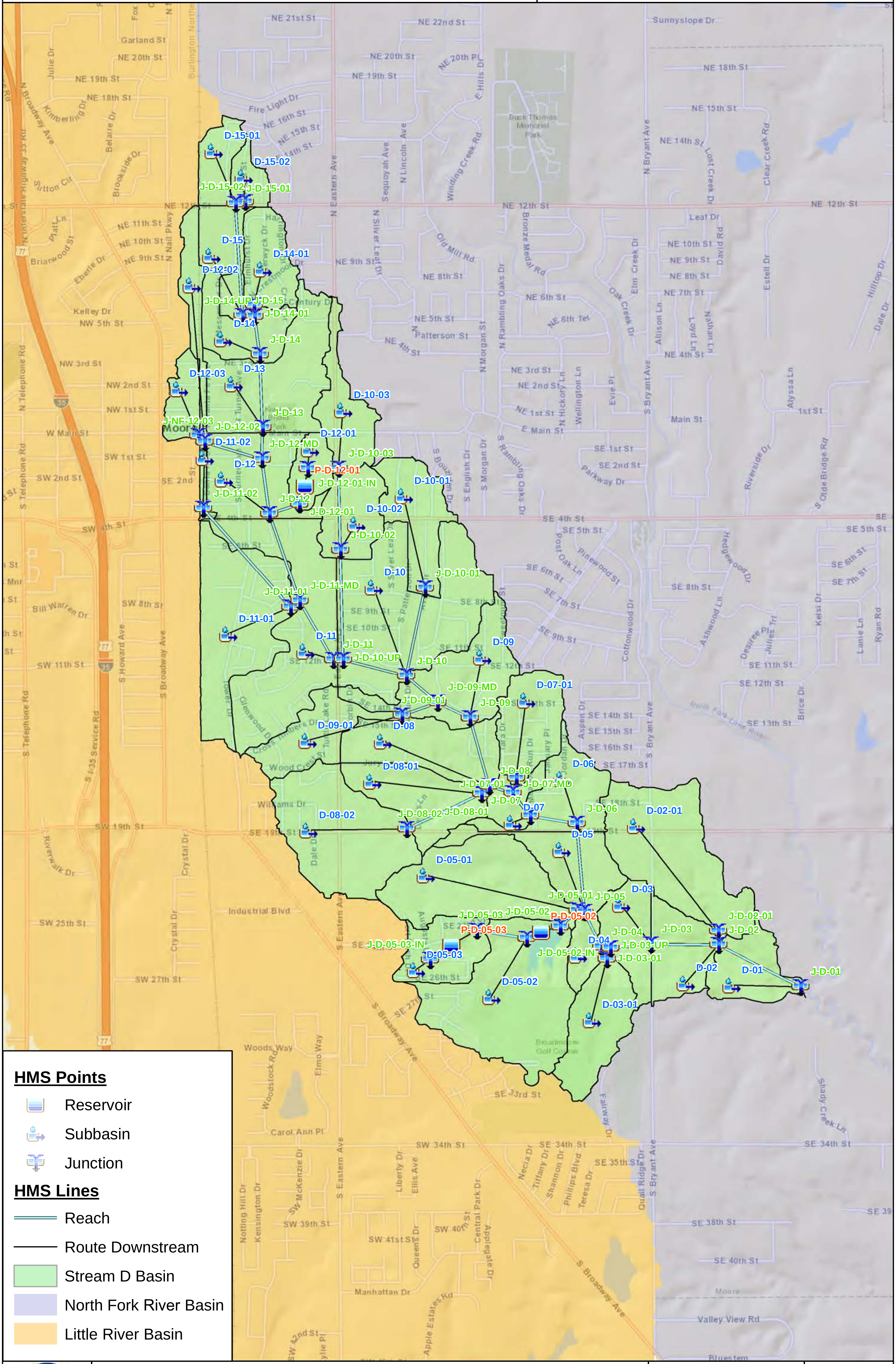
Figure 7 - 3

City of Moore Master Drainage Plan

0 1,500 3,000
Feet



Stream D
HEC - HMS Schematic

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Figure 7 - 4

Table 7-1. Stream D Drainage Basins Summary of Hydrologic Coefficients for Existing Conditions

Drainage Area	CN	Lag (min)	Area (Acres)	Area (Sq Miles)
D-01	60.6	12.5	31.4	0.05
D-02	65.2	7.0	34.2	0.05
D-02-01	77.2	13.6	86.0	0.13
D-03	66.6	6.8	29.9	0.05
D-03-01	78.3	9.3	43.6	0.07
D-04	67.4	3.7	12.8	0.02
D-05	65.5	7.4	39.9	0.06
D-05-01	80.9	14.1	78.5	0.12
D-05-02	83.9	11.8	106.5	0.17
D-05-03	89.1	12.5	32.3	0.05
D-06	84.1	12.0	38.2	0.06
D-07	70.7	3.9	14.5	0.02
D-07-01	87.2	8.9	38.6	0.06
D-08	72.3	16.6	51.5	0.08
D-08-01	80.8	12.4	44.8	0.07
D-08-02	87.9	9.5	85.3	0.13
D-09	82.0	7.5	58.7	0.09
D-09-01	88.5	9.3	36.3	0.06
D-10	86.4	11.3	117.5	0.18
D-10-01	90.7	12.1	39.5	0.06
D-10-02	92.8	6.4	32.5	0.05
D-10-03	93.9	12.7	31.7	0.05
D-11	89.6	12.1	98.0	0.15
D-11-01	91.3	20.8	84.1	0.13
D-11-02	92.7	11.2	3.5	0.01
D-12	86.7	7.3	50.9	0.08
D-12-01	89.0	5.6	16.5	0.03
D-12-02	90.9	13.0	20.2	0.03
D-12-03	95.0	14.4	16.8	0.03
D-13	90.1	14.8	73.2	0.11
D-14	90.4	14.2	31.2	0.05
D-14-01	91.7	11.0	30.4	0.05
D-15	92.5	11.5	25.8	0.04
D-15-01	90.5	11.3	19.5	0.03
D-15-02	89.1	5.1	11.9	0.02

TABLE 7-2. STREAM D DRAINAGE BASINS – EXISTING FLOWRATES AT MAJOR JUNCTIONS (CFS)

Description	HMS Junction	Stream	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year	Drainage Area, mi^2
NE 3rd Street	J-D-14	Stream D	195	236	344	429	541	627	715	934	0.19
E Main Street	J-D-13	Stream D	161	233	432	547	697	838	959	1308	0.30
SE 4th Street	J-D-12	Stream D	237	288	490	681	912	1092	1257	1725	0.47
S Eastern Avenue	J-D-11	Stream D	414	506	739	922	1206	1456	1711	2386	0.76
SE 19th Street	J-D-06	Stream D	842	1064	1614	2071	2660	3100	3644	5067	1.67
S Bryant Avenue	J-D-03	Stream D	957	1216	1895	2445	3231	3815	4489	6257	2.21
North Fork River	J-D-01	Stream D	947	1223	1941	2500	3353	3981	4713	6587	2.44

7.3. Existing Conditions Hydraulics

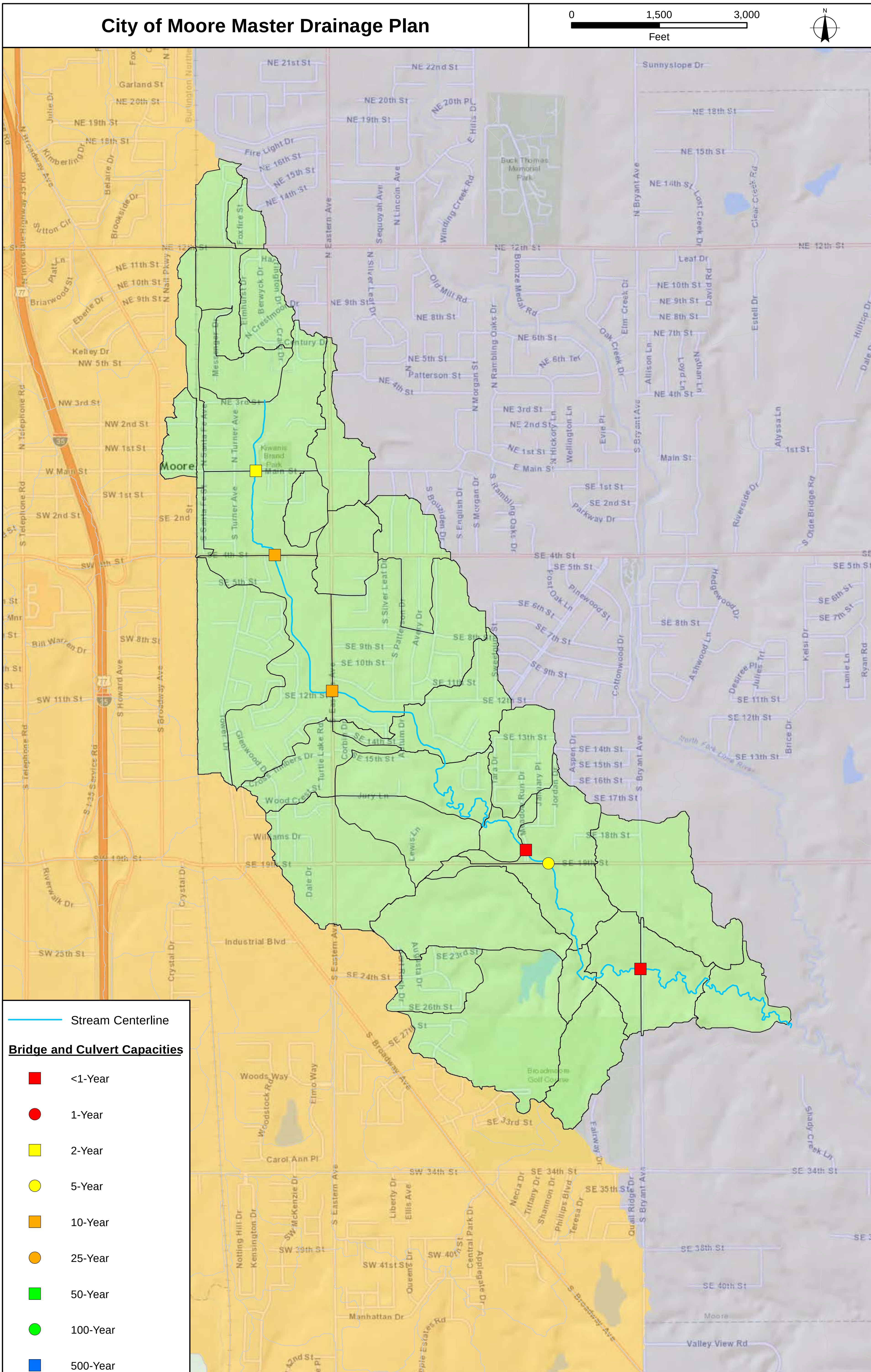
The Stream D Watershed consists of approximately 4.3 studied stream miles. The stream was modeled using GeoHEC-RAS software to determine bridge\culvert capacities, water surface profiles, and floodplains. More information on the hydraulic methodology can be found in **Section 2.2 Hydraulic Analysis**.

Figure 7-6 illustrates the location of the studied bridges and/or culverts and the capacity associated with updated existing condition flowrates.

Appendix 3-B shows the water surface profiles for existing conditions for the 10-year, 25-year, 50-year, 100-year, and 500-year storm events.

Appendix 3-C shows the updated City of Moore regulatory 100-year and 500-year floodplains and floodway which terminate at the limit of the hydraulic study, shown on the exhibit.

City of Moore Master Drainage Plan



CITY of MOORE OKLAHOMA

Stream D
Bridge & Culvert Capacities

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Figure 7 - 5

7.4. PROBLEM AREAS

The flooding problems areas identified in the Stream D Drainage Basins are based on flooding comments and observations received from community residents, City of Moore staff, and Meshek & Associates, PLC. The location of these problem areas are shown in **FIGURE 7-6** and **FIGURE 7-7**, and are labeled according to the GIS-ID problem area numbers and descriptions below. Unless noted otherwise, all problem area comments generally refer to flooding and drainage problems observed in the May 5-8, 2015 storm events.

A. Problem Area 1: Stream D & Autumn Dr Cul-de-sac

Private residential properties located at 1413 Autumn Drive, 1409 Autumn Drive, 1405 Autumn Drive, 1401 Autumn Drive, 1400 Autumn Drive, 1404 Autumn Drive, and 1408 Autumn Drive had flooding in the residential structures (GIS ID-84:90). A property owner had observed the storm sewer inlets no longer draining roadway discharge, located at the end of Autumn Drive in the cul-de-sac (GIS ID-91).

The existing elliptical 42''X24''-123' storm sewer has an adverse slope and consists of approximately four 5 foot by 1 foot cast iron rectangular drainage grate inlets. Rectangular grate inlets are more prone to clogging from debris and has a lower inflow capacity than other inlet options.

B. Problem Area 2: Stream D & SE 12th St from S Eastern Ave to S Patterson Dr

Private residential property located along the southern side of SE 12th Street from S Eastern Avenue to S Patterson Drive had flooding in backyards from Stream D and roadway discharge from SE 12th Street overtopped curb to enter garages and storm cellars (GIS ID-71, ID-73:83 & ID-162:166).

A private residential property owner located at 1108 S Easter Avenue observed roadway discharge and backwater building north and south from Stream D on S Eastern Avenue to turn and discharge east down SE 12th Street and SE 13th Street (GIS ID-72).

The City of Moore has observed inadequate hydraulic capacity in the existing culvert located along Stream D under S Eastern Avenue (GIS ID-1018). The existing culvert consists of approximately 73 linear feet of double 8 feet wide by 5 feet tall reinforced concrete box (RCB). The apron upstream of the RCB culvert has a 2.4 foot vertical drop. The existing structure has a hydraulic capacity of a 10-year frequency storm event. During a 25-year storm event, S Eastern Avenue roadway would be overtopped by 0.37 feet and during a 100-year storm event, S Eastern Avenue roadway would be overtopped by 0.87 feet. The City of Moore also observed the Stream D channel immediately downstream of S Eastern Avenue requires maintenance for issues (GIS ID-1024).

C. Problem Area 3: Cindy Brook Lane Cul-de-sac

The existing storm sewer inlets, located at the end of the Cindy Brook Lane cul-de-sac on the western edge of the Broadmoore Golf Course, are reported by the City of Moore to have an inadequate capacity (GIS ID-1019).

D. Problem Area 4: SE 19th St between Lewis Ln & Meadow Run Dr

A private property owner located at 1301 SE 19th Street has observed erosion on the property (GIS ID-8). The owner has also observed surface discharge originating from SE 19th Street crossing the property at the address listed above.

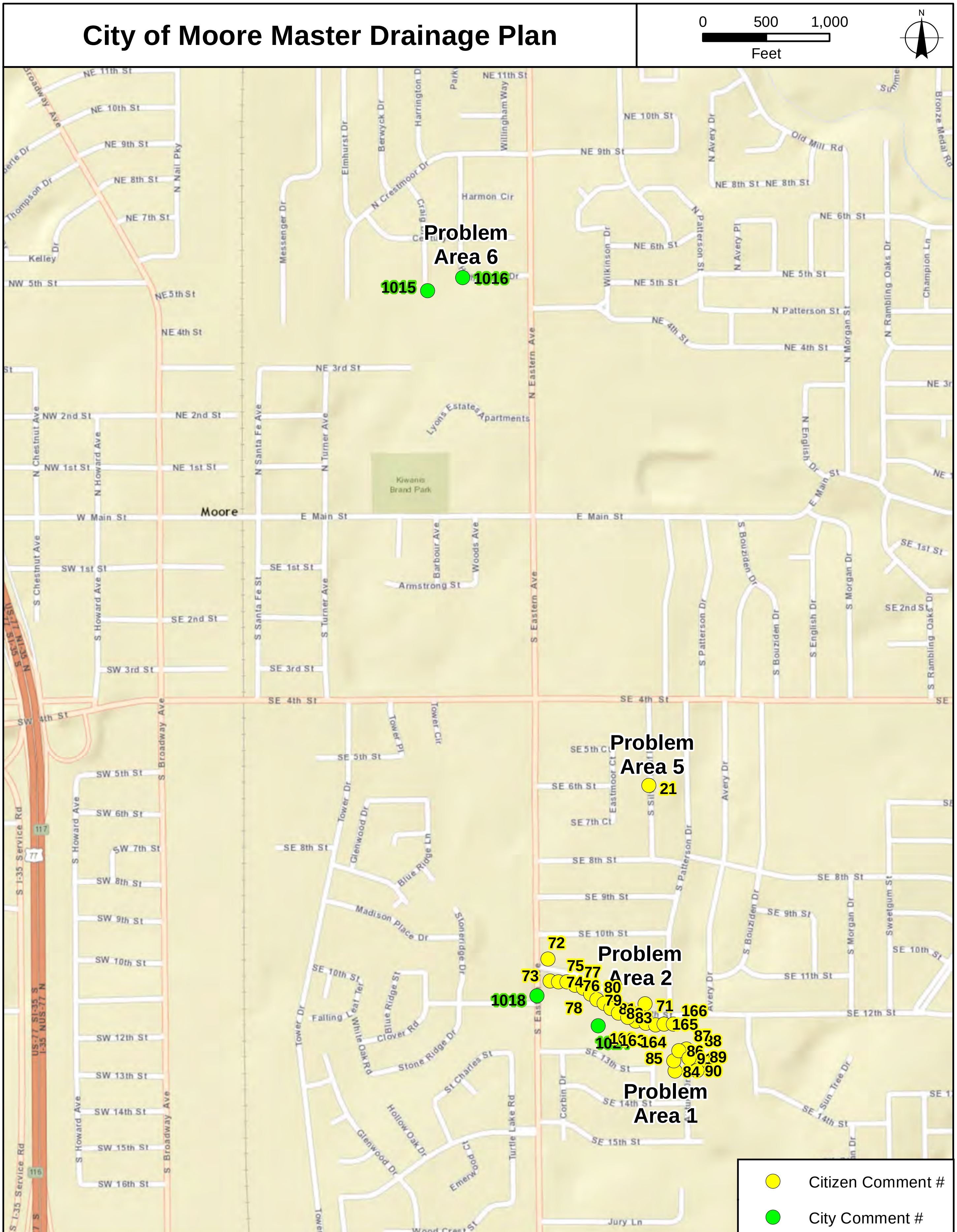
E. Problem Area 5: S Silver Leaf Dr between SE 4th St & SE 8th St

A private residential property located at 617 S Silver Leaf Drive has observed sediment filling the roadway gutters of S Silver Leaf Drive and SE 8th Street (GIS ID-21). The owner observed the sediment originating from tornado damaged properties.

F. Problem Area 6: Drainage Flumes at Craig Dr & Highlander Dr

The City of Moore has observed concrete flume channels with inadequate hydraulic capacity located at the southern end of the Craig Drive cul-de-sac and along a corner of the Highland Drive roadway (GIS ID-1015 & ID-1016).

City of Moore Master Drainage Plan



Stream D Problem Areas

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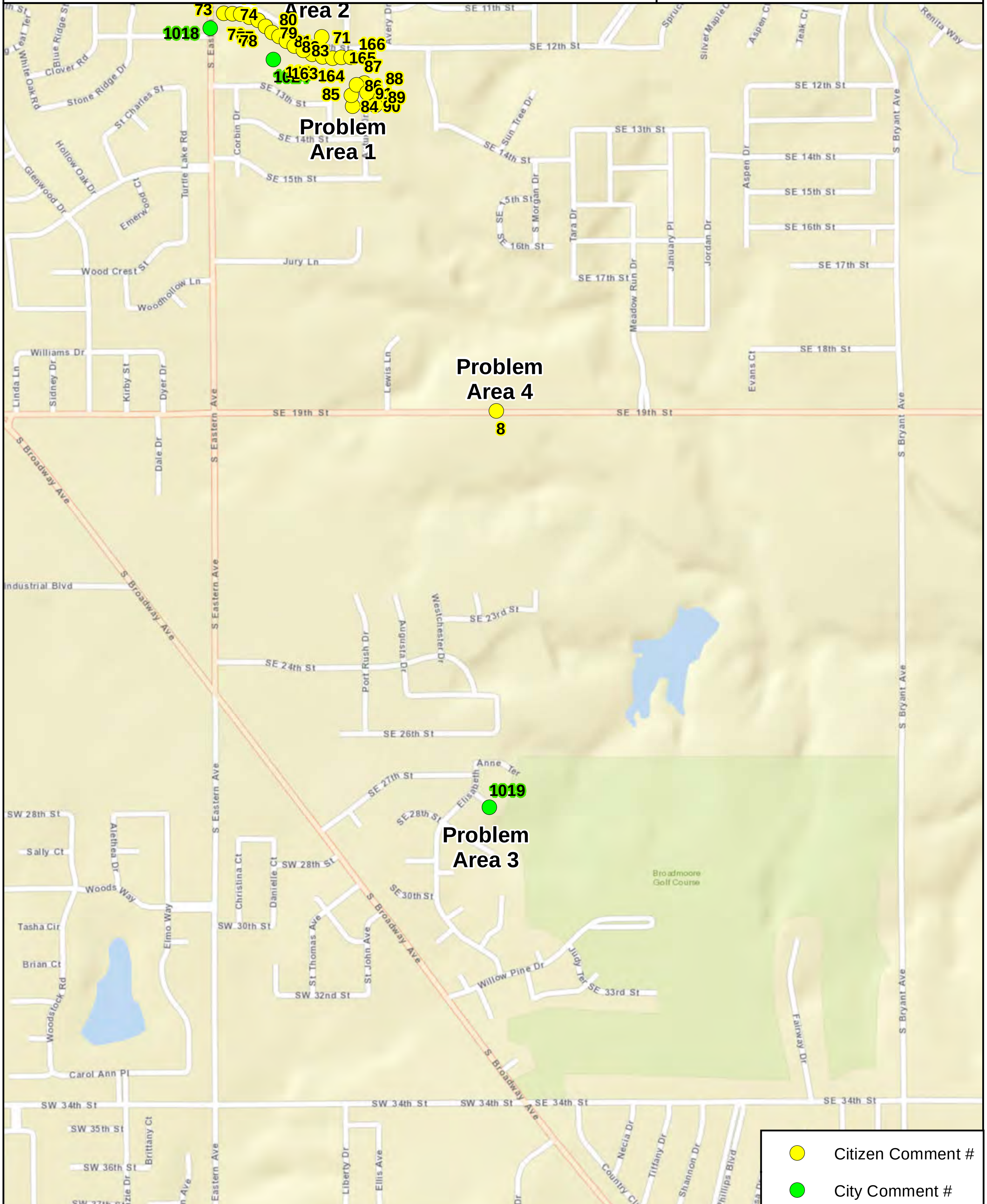
Figure 7 - 6

City of Moore Master Drainage Plan



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Stream D Problem Areas

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Figure 7 - 7

7.5. EVALUATION OF ALTERNATIVE AND RECOMMENDATIONS

Alternatives and recommendations for mitigating flooding problems may consist of channelization, increasing culvert structure capacity through replacement or enlargement, creating detention pond facilities, or increasing storm sewer system capacity through replacement or new system construction. It's important to note that when alternatives and recommendations given in this master drainage plan proceed to design documents, the design should be hydrologically and hydraulically analyzed in further detail prior to constructing any improvements described in this section. The alternatives and recommendations in this master drainage plan are given as plausible concepts and an additional detailed study of the design would prevent increases in water-surface elevations and floodplains or cause flooding in other areas. The alternatives and recommendations for the problem areas are defined as follows:

A. Problem Area 1: Stream D & Autumn Dr. Cul-de-sac

Several private residential properties around the Autumn Drive cul-de-sac will be located within the City of Moore's corrected effective existing 100-year floodplain of the North Fork River created in this master drainage plan study. We expect these properties to have flooding in various storm frequency events.

Alternative 1 (Recommended) – Construct 25-year Capacity Recessed Inlet. This alternative would consist of constructing a new recessed curb inlet which can convey the 25-year storm event. The existing storm sewer pipe from Autumn Drive to Stream D has a capacity for approximately a 25-year storm event. The existing cast iron rectangular grate inlets should be replaced with a recessed concrete curb inlet to allow for additional inlet capacity to the existing storm sewer. The inlet design assumptions consist of a 11 foot long orifice opening, 10'' height of curb opening orifice, a 1-foot effective head on the center of the orifice throat, and an 80% theoretical capacity to allow for partial obstruction and clogging. The 25-year peak discharge to the storm sewer inlet is approximately 35.3 cfs.

The locations of the proposed improvements are shown in **FIGURE 7-8**. The cost for Alternative 1 is estimated at $15,700 and is detailed in **APPENDIX 7-D**.

Alternative 2 – Construct 100-year Capacity Storm Sewer System. This alternative would consist of constructing an additional storm sewer system, which when combined with the existing system, can convey the 100-year storm event. The new storm sewer system would consist of approximately 190 linear feet of 27 inch tall by 42 inch wide concrete horizontal ellipse pipe and a recessed concrete curb inlet. The inlet design assumptions consist of a 12 foot long orifice opening, 10'' height of curb opening orifice, a 1-foot effective head on the center of the orifice throat, and an 80% theoretical capacity to allow for partial obstruction and clogging. The 100-year peak discharge to the storm sewer inlet is approximately 49 cfs.

The locations of the proposed improvements are shown in **FIGURE 7-8**. The cost for Alternative 2 is estimated at $88,000 and is detailed in **APPENDIX 7-D**.

B. Problem Area 2: Stream D & SE 12th St from S Eastern Ave to S Patterson Dr

Several private residential properties around the S Patterson Drive cul-de-sac, SE 13th Street, and SE 12th Street will be located within the City of Moore's corrected effective existing 100-year floodplain of the North Fork River created in this master drainage plan study. We expect these properties to have flooding in various storm frequency events.

As S Eastern Avenue crosses Stream D, the curb on either side of the roadway is continuous and will drain any roadway discharge from the south or overtopping from Stream D north towards the intersection with SE 12th Street. This causes additional and unnecessary roadway discharge to travel to SE 12th Street, which then turns east and discharges down SE 12th Street. In order to prevent additional roadway discharge from draining to SE 12th Street, the curb along S Eastern Ave as it crosses Stream D should be cut out and to allow roadway and overtopping to enter Stream D. Additional concrete trickle paths can be constructed from the roadway gutter to Stream D to assist the discharge from S Eastern Avenue. The intersection apron of SE 12th Street with S Eastern Avenue can also be re-paved to prevent roadway discharge from draining east down SE 12th Street.

Recommendation Part 1 – Construct 50-year Capacity Culvert. This alternative would consist of constructing an additional box culvert next to the existing structure which can convey the 50-year storm event. This structure would consist of adding approximately 74 linear feet of a 12 foot wide by 5 foot tall RCB on the south side of the existing RCB and moving the existing 2.4 foot drop approximately 5 feet upstream.

The locations of the proposed improvements are shown in **FIGURE 7-9**. The cost for Recommendation Part 1 is estimated at $199,700 and is detailed in **APPENDIX 7-D.**

Recommendation Part 2 – Construct 100-year Stream Channelization. This alternative would consist of channelizing Stream D downstream of the S Eastern Avenue crossing in order to prevent private residential structure flooding in the 100-year storm caused by Stream D. The stream channelization would consist of increasing the cross-sectional area of the channel for approximately 1500 linear feet, starting from the downstream side of the S Eastern Avenue and terminating behind the private residential property located at 1309 S Avery Drive. The dimensions for the initial 730 linear feet of channel downstream of S Eastern Avenue, should be expanded to have an approximate 20 foot minimum bottom width and 3:1 (H:V) side slopes. The dimensions for the channel from 730 linear feet to 1500 linear feet downstream of S Eastern Avenue, should be expanded to have an approximate 35 foot minimum bottom width and 1:1 (H:V) side slopes utilizing retaining block or concrete linings. The flowline in this segment of channel should also be dropped approximately 1 to 2 feet as necessary in order to maintain a minimum flowline slope of approximately 0.0045 foot per foot.

The locations of the proposed improvements are shown in **FIGURE 7-9**. The cost for the Recommendation Part 2 is difficult to accurately estimate and a preliminary design would be necessary. The conceptual estimated cost is approximately $400,000, utilizing a general cost per linear foot.

Alternative – Property Acquisition. This alternative would consist of private residential properties voluntarily selling to the City of Moore between SW 34th Street and Telephone Road and located within the corrected effective 100-year floodplain generated by this master drainage plan. The private residential properties are located at 1413 Autumn Drive, 1409 Autumn Drive, 1405 Autumn Drive, 1401 Autumn Drive, 1400 Autumn Drive, 1404 Autumn Drive, 1408 Autumn Drive, 909 SE 13th Street, 913 SE 13th Street, 1400 S Patterson Drive, 1404 S Patterson Drive, 816 SE 12th Street, 820 SE

12th Street, and 824 SE 12th Street. The properties may then be utilized to increase channel capacity or floodplain storage. Property acquisitions containing residential and commercial structures has been expressed by the City of Moore to be highly unlikely, and the alternative should be viewed as a last option for comparing alternative costs.

The cost for the Alternative is estimated at $1,776,800 and is detailed in **APPENDIX 7-D.**

C. Problem Area 3: Cindy Brook Lane Cul-de-sac

Recommendation – Construct 100-year Capacity Storm Sewer System. This alternative would consist of replacing the existing storm sewer with one which can convey the 100-year storm event. The new storm sewer system would consist of approximately 230 linear feet of 42 inch diameter RCP. The 100-year peak discharge to the location of the storm sewer inlet on Cindy Brook Lane is approximately 59 cfs. The existing storm sewer pipe from Autumn Drive to Stream D has a capacity for approximately a 100-year storm event. The existing cast iron curb and grate inlets should be replaced with a recessed curb inlet to allow for additional inlet capacity to the existing storm sewer. The inlet design assumptions consist of a 19 foot long orifice opening, 10'' height of curb opening orifice, a 1-foot effective head on the center of the orifice throat, and an 80% theoretical capacity to allow for partial obstruction and clogging.

Locations of the proposed improvements are shown in **FIGURE 7-10**. The cost for Alternative 1 is estimated at $95,000 and is detailed in **APPENDIX 7-D**.

D. Problem Area 4: SE 19th St between Lewis Ln & Meadow Run Dr

No structures are located within the 100-year floodplain on Stream D between SE 15th Street and S Bryant Avenue, therefore no course of action is recommended. Peak discharges in streams are not permanent and will subside in a finite amount of time. We do not recommend diverting additional storm water to discharge along 19th Street that would naturally discharge either north or south in existing conditions. Diverting additional storm water without significant hydrologic and hydraulic analysis could cause flooding in structures that do not currently flood.

E. Problem Area 5: S Silver Leaf Dr. between SE 4th St & SE 8th St

The City of Moore intends to expand its criteria for drainage design and water quality in new construction projects in an effort to prevent sedimentation deposition from construction sites onto roadways or into storm sewer systems.

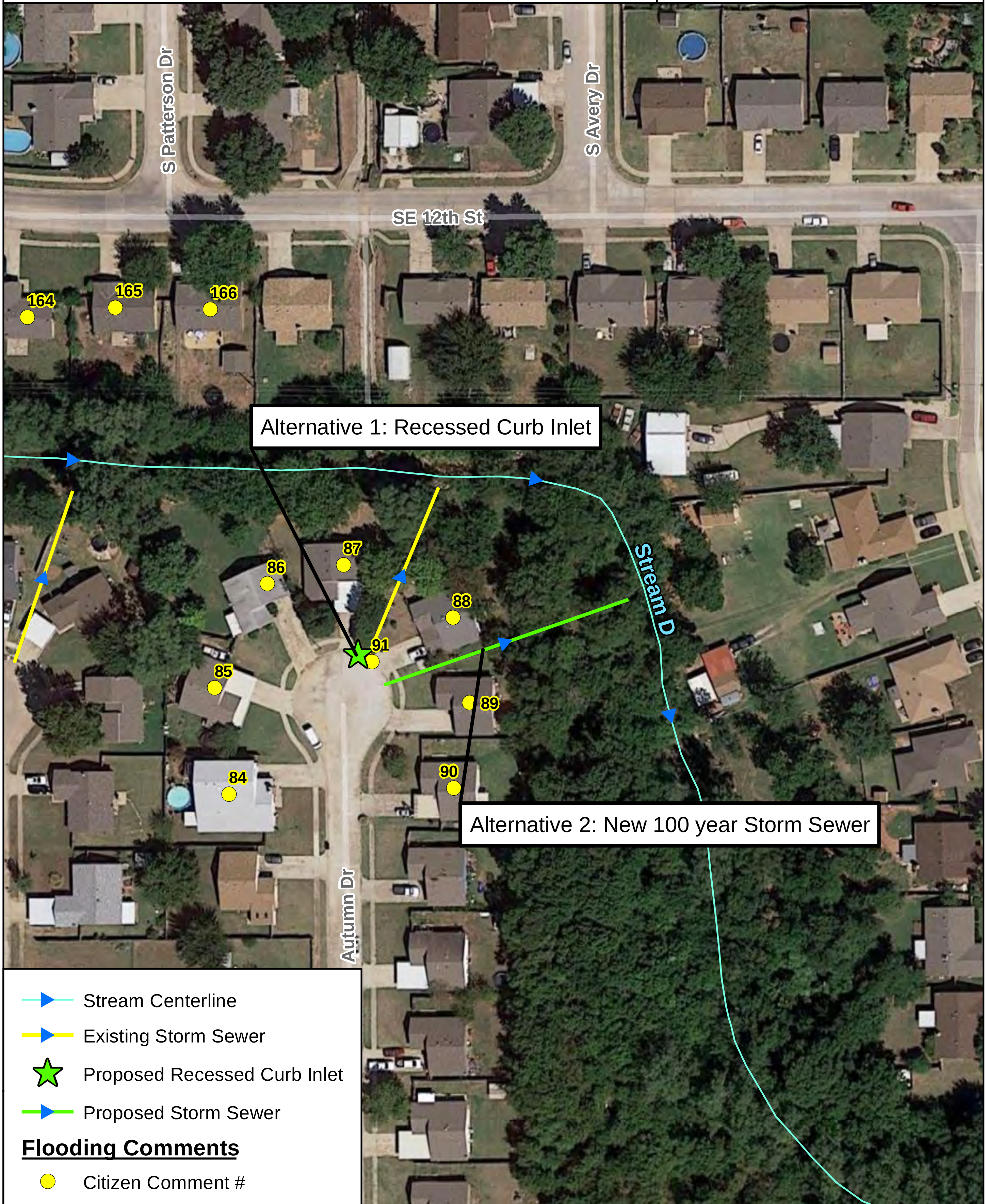
F. Problem Area 6: Drainage Flumes at Craig Dr & Highlander Dr

Recommendation – Construct 100-year Capacity Concrete Flume Channels. This alternative consists of reconstructing the existing concrete flume channels at Craig Drive cul-de-sac and Highlander Drive. The western Craig Drive concrete flume would consist of approximately 200 linear feet of channel. The dimensions of the western channel should have an approximate 8 inch minimum depth, 6 foot minimum bottom width, and 1:0 (H:V) side slopes. A Manning's 'n' value of 0.013 and a slope of 0.003 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the proposed concrete flume channel is approximately 12 cfs. The eastern Highlander Drive concrete flume would consist of approximately 300 linear feet of channel. The dimensions of the eastern channel should have an approximate 8 inch minimum depth, 6 foot minimum bottom width, and 1:0 (H:V) side slopes. A Manning's 'n' value of 0.013 and a slope of

0.017 foot per foot were assumed in hydraulic calculations of the open-channel. The 100-year discharge to the proposed concrete flume channel is approximately 38 cfs. It is recommended that the eastern concrete flume channel be reconstructed with only one smooth radius curve to increase hydraulic efficiency. The two concrete flumes channels noted above were designed to be continued approximately 50 feet beyond the southern edge of the access roadway of the Fresh Start Community Church in order to achieve a positive flowline slope.

The locations of the proposed improvements are shown in **FIGURE 7-11**. The cost for the Recommendation is estimated at $88,200 and is detailed in **APPENDIX 7-D**.

City of Moore Master Drainage Plan



Stream D
Problem Area 1: Alternative 1 & 2

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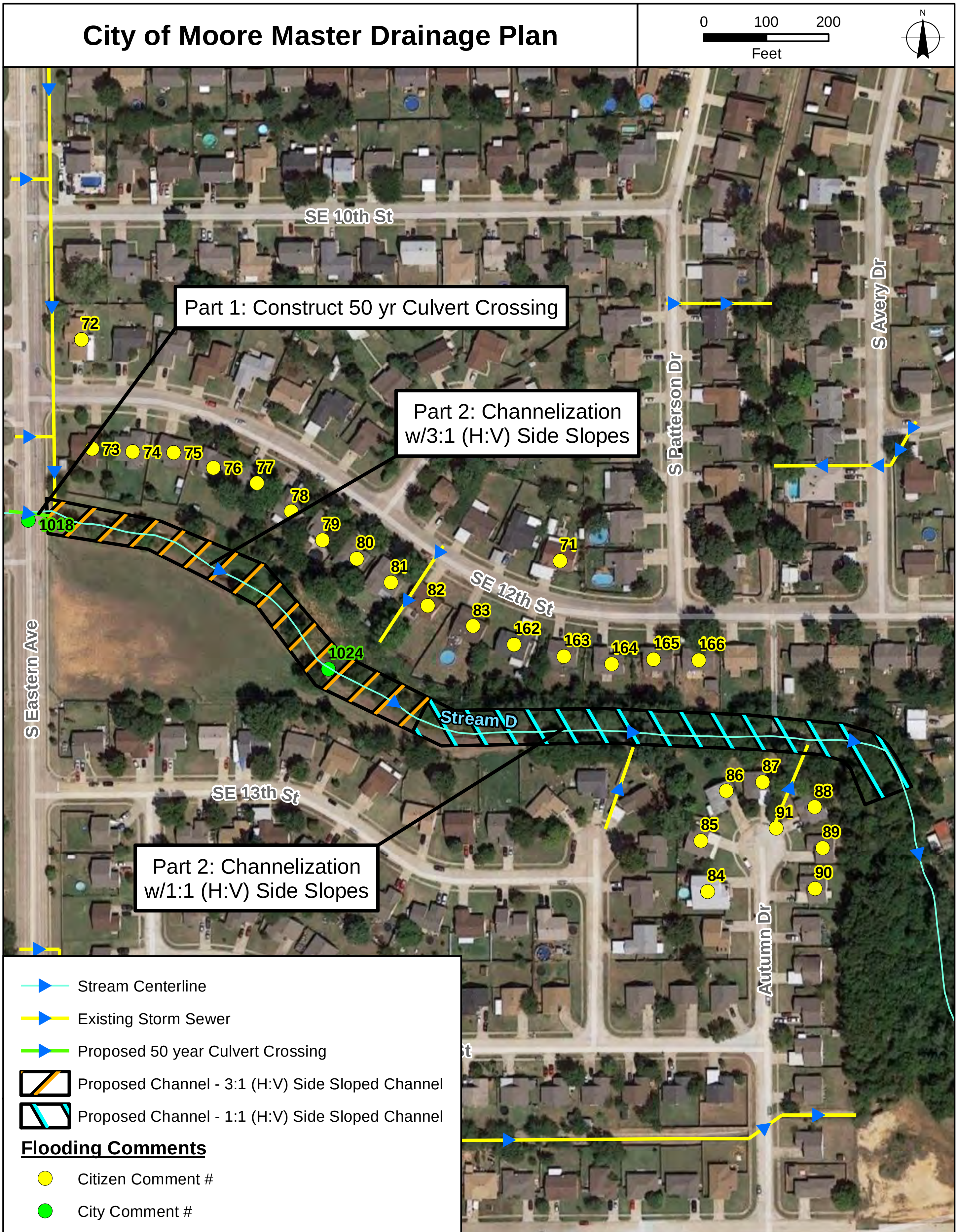
Figure 7 - 8

City of Moore Master Drainage Plan



Stream D
Problem Area 2: Recommendation
Part 1 & 2

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Figure 7 - 9

City of Moore Master Drainage Plan

Stream D
Problem Area 3: Alternative 1

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Figure 7 - 10

City of Moore Master Drainage Plan

Stream D
Problem Area 6: Recommendation

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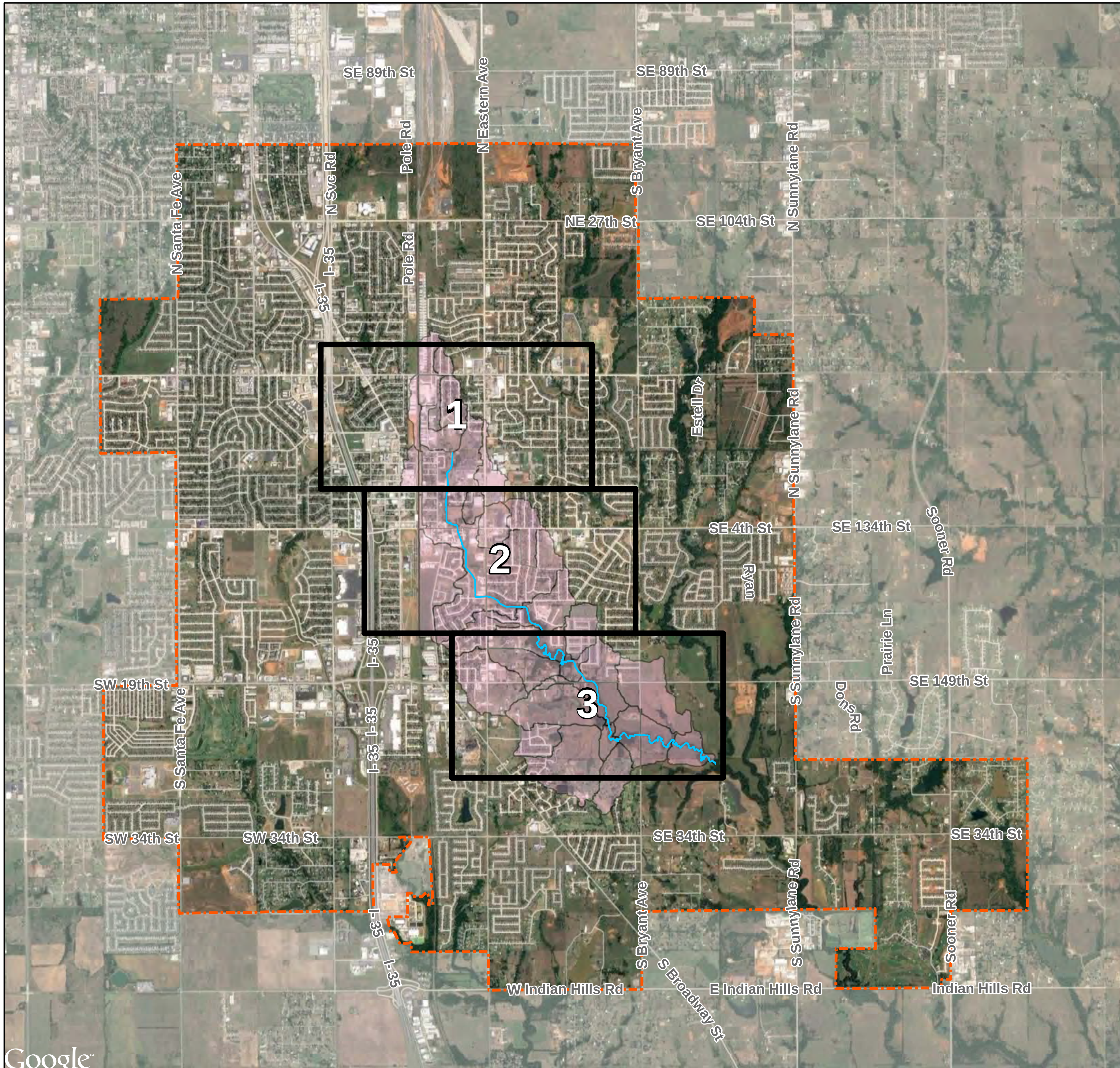
Figure 7 - 11



City of Moore Master Drainage Plan

Stream D
Detailed HEC-HMS Schematics
Section 7 - Appendix A

Atlas Pages
Moore City Limits
Stream D Basin
Stream D

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Miles

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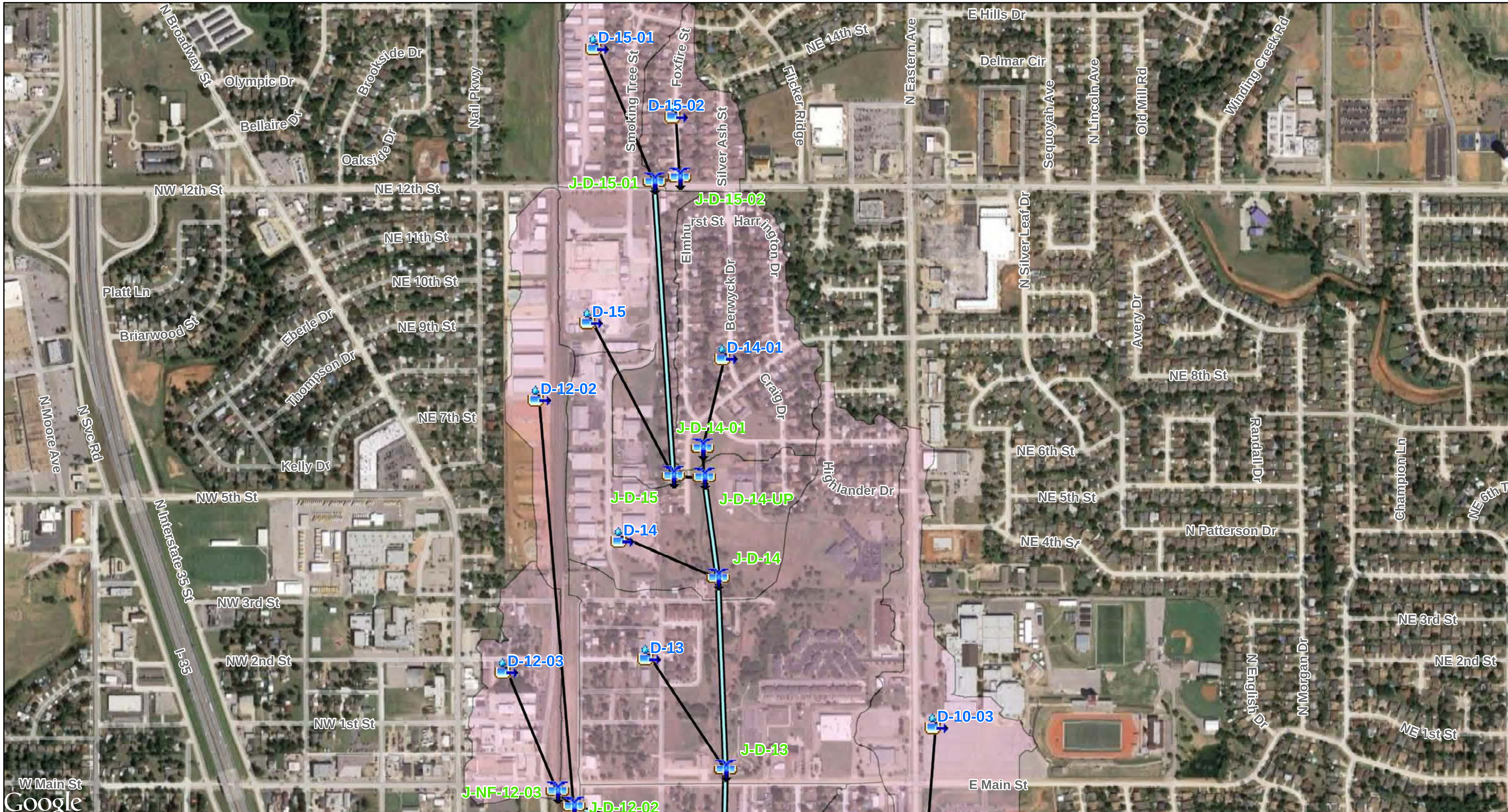

City of Moore - Master Drainage Plan

Stream D Detailed HEC-HMS Schematics

Section 7 - Appendix A

0 300 600
Feet

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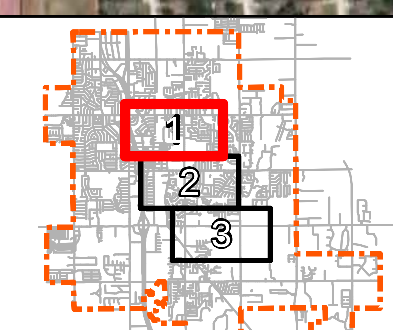
HMS Points

- Reservoir
- Subbasin
- Junction

HMS Lines

- Reach
- Route Downstream
- Stream D Basin



CITY OF MOORE OKLAHOMA

Map Page 1 of 3

City of Moore - Master Drainage Plan

Stream D Detailed HEC-HMS Schematics

Section 7 - Appendix A

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Feet

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HMS Points
- Reservoir
- Subbasin
- Junction

HMS Lines
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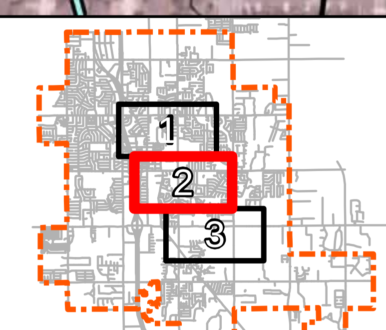
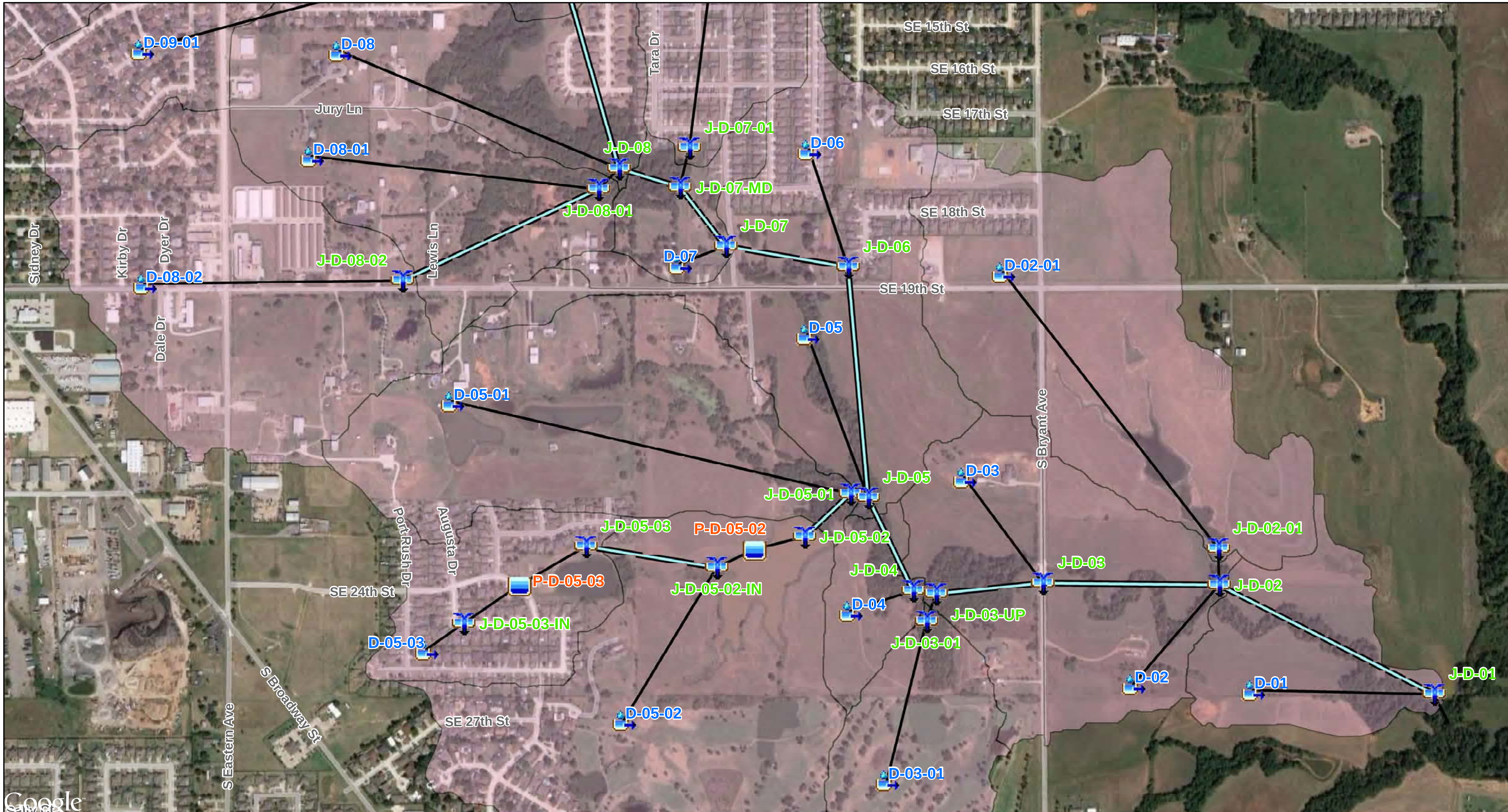
- Route Downstream
- Stream D Basin



CITY of MOORE OKLAHOMA 1893

Map Page 2 of 3



City of Moore - Master Drainage Plan

Stream D Detailed HEC-HMS Schematics

Section 7 - Appendix A

0 300 600
Feet

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HMS Points

- Reservoir
- Subbasin
- Junction

HMS Lines

- Reach
- Route Downstream
- Stream D Basin

1
2
3

CITY OF MOORE OKLAHOMA 1893

Map Page 3 of 3

City of Moore					
Appendix 7-B Moore Master Drainage Plan Alternatives - Stream D - Problem Area #01 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	10	$ 12.00	$ 120.00
2	**8" PCC PAVEMENT**	**SY**	10	$ 75.00	$ 750.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**CONCRETE RECESSED INLET**	**LS**	1	$ 5,000.00	$ 5,000.00
				Subtotal	**$ 10,870.00**
				15% Contingency	**$ 1,630.50**
				Subtotal	**$ 12,500.50**
				25% Utility Relocation Contingency	**$ 3,125.13**
				Total	***$ 15,625.63***

City of Moore					
Appendix 7-B Moore Master Drainage Plan Alternatives - Stream D - Problem Area #01 - Alternative 2					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	220	$ 12.00	$ 2,640.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	320	$ 3.00	$ 960.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	80	$ 40.00	$ 3,200.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
5	**CONCRETE RECESSED INLET**	**LS**	1	$ 5,000.00	$ 5,000.00
6	**STANDARD BEDDING MATERIAL - 27" x 42" PIPE**	**CY**	100	$ 20.00	$ 2,000.00
7	**27" x 42" HORIZONTAL ELLIPTICAL PIPE**	**LF**	190	$ 223.00	$ 42,370.00
				Subtotal	**$ 61,170.00**
				15% Contingency	**$ 9,175.50**
				Subtotal	**$ 70,345.50**
				25% Utility Relocation Contingency	**$ 17,586.38**
				Total	***$ 87,931.88***

City of Moore					
Appendix 7-B Moore Master Drainage Plan Alternatives - Stream D - Problem Area #02 - Recommendation Part 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	500	$ 12.00	$ 6,000.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	400	$ 3.00	$ 1,200.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 5,000.00	$ 5,000.00
4	**8" PCC PAVEMENT**	**SY**	110	$ 75.00	$ 8,250.00
5	**STANDARD BEDDING MATERIAL - 12' x 5' RCB**	**CY**	150	$ 20.00	$ 3,000.00
6	**12' x 5' RCB**	**LS**	74	$ 1,560.00	$ 115,440.00
				Subtotal	**$ 138,890.00**
				15% Contingency	**$ 20,833.50**
				Subtotal	**$ 159,723.50**
				25% Utility Relocation Contingency	**$ 39,930.88**
				Total	***$ 199,654.38***

City of Moore					
Appendix 7-B Moore Master Drainage Plan Alternatives - Stream D - Problem Area #02 - Alternative					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
PROPERTY ACQUISITION					
1	**1413 AUTUMN DRIVE**	**LS**	1	$ 160,000.00	$ 160,000.00
2	**1409 AUTUMN DRIVE**	**LS**	1	$ 90,000.00	$ 90,000.00
3	**1405 AUTUMN DRIVE**	**LS**	1	$ 95,000.00	$ 95,000.00
4	**1401 AUTUMN DRIVE**	**LS**	1	$ 90,000.00	$ 90,000.00
5	**1400 AUTUMN DRIVE**	**LS**	1	$ 95,000.00	$ 95,000.00
6	**1404 AUTUMN DRIVE**	**LS**	1	$ 90,000.00	$ 90,000.00
7	**1408 AUTUMN DRIVE**	**LS**	1	$ 95,000.00	$ 95,000.00
8	**909 SE 13TH STREET**	**LS**	1	$ 105,000.00	$ 105,000.00
9	**913 SE 13TH STREET**	**LS**	1	$ 110,000.00	$ 110,000.00
10	**1400 S PATTERSON DRIVE**	**LS**	1	$ 105,000.00	$ 105,000.00
11	**1404 S PATTERSON DRIVE**	**LS**	1	$ 105,000.00	$ 105,000.00
12	**816 SE 12TH STREET**	**LS**	1	$ 110,000.00	$ 110,000.00
13	**820 SE 12TH STREET**	**LS**	1	$ 150,000.00	$ 150,000.00
14	**824 SE 12TH STREET**	**LS**	1	$ 145,000.00	$ 145,000.00
				Subtotal	**$ 1,545,000.00**
				15% Contingency	**$ 231,750.00**
				Total	**$ 1,776,750.00**

City of Moore					
Appendix 7-B Moore Master Drainage Plan Alternatives - Stream D - Problem Area #03 - Alternative 1					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
1	**UNCLASSIFIED EXCAVATION**	**CY**	360	$ 12.00	$ 4,320.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	390	$ 3.00	$ 1,170.00
3	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 7,500.00	$ 7,500.00
4	**CONCRETE RECESSED INLET**	**LS**	1	$ 5,000.00	$ 5,000.00
5	**STANDARD BEDDING MATERIAL - 42" RCP**	**CY**	220	$ 20.00	$ 4,400.00
6	**42" RCP**	**LF**	230	$ 190.00	$ 43,700.00
				Subtotal	**$ 66,090.00**
				15% Contingency	**$ 9,913.50**
				Subtotal	**$ 76,003.50**
				25% Utility Relocation Contingency	**$ 19,000.88**
				Total	***$ 95,004.38***

City of Moore					
Appendix 7-B Moore Master Drainage Plan Alternatives - Stream D - Problem Area #06 - Recommendation					
ITEM	**DESCRIPTION**	**UNIT**	**TOTAL**	**UNIT PRICE**	**TOTAL COST**
PART 1 - WESTERN CRAIG DRIVE FLUME CHANNEL					
1	**UNCLASSIFIED EXCAVATION**	**CY**	50	$ 12.00	$ 600.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	200	$ 3.00	$ 600.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	170	$ 40.00	$ 6,800.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
5	**4" PCC CHANNEL**	**LF**	200	$ 33.00	$ 6,600.00
6	**STANDARD BEDDING MATERIAL**	**CY**	20	$ 20.00	$ 400.00
				Subtotal	**$ 25,000.00**
PART 2 - EASTERN HIGHLANDER DRIVE FLUME CHANNEL					
1	**UNCLASSIFIED EXCAVATION**	**CY**	80	$ 12.00	$ 960.00
2	**SOLID SLAB BERMUDA SODDING**	**SY**	300	$ 3.00	$ 900.00
3	**6' WOODEN PRIVACY FENCE**	**LF**	350	$ 40.00	$ 14,000.00
4	**REMOVAL OF STRUCTURES AND OBSTRUCTIONS**	**LS**	1	$ 10,000.00	$ 10,000.00
5	**4" PCC CHANNEL**	**LF**	300	$ 33.00	$ 9,900.00
6	**STANDARD BEDDING MATERIAL**	**CY**	30	$ 20.00	$ 600.00
				Subtotal	**$ 36,360.00**
				Subtotal	**$ 61,360.00**
				15% Contingency	**$ 9,204.00**
				Subtotal	**$ 70,564.00**
				25% Utility Relocation Contingency	**$ 17,641.00**
				Total	***$ 88,205.00***

Section 8
Drainage Criteria Review

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MESHEK & ASSOCIATES, PLC

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SECTION 8. DRAINAGE CRITERIA REVIEW

8.1. Background

As part of the Comprehensive Stormwater Management and Drainage Plan, Meshek performed a review of the City of Moore's **Article J – Drainage and Erosion Control Ordinance**. Included with this review are comments and/or suggestions of ways to improve the current criteria to help prevent unnecessary future problems with stream flooding and erosion, water quality, and localized flooding. The comments are displayed in red font and can be found within the actual text of the Article in the following pages of this document. Many municipalities have developed very strong drainage criteria that could be used as a guide should the City of Moore decided to make changes. The City of Tulsa, City of Owasso provided in **Appendix 8-A**, and City of Stillwater are examples of Drainage Criteria which could be used to help strengthen particular areas of criteria for the City of Moore.

8.2. Additional Recommendations

The City of Moore should consider developing a "Design Criteria Manual" and referencing it by ordinance. This manual should contain minimum design standards consistent with current practices, procedures and technologies for design and construction of stormwater infrastructure.

Major areas of concern in the City of Moore, are defining when a hydrograph method is required for drainage analysis, utilization of detention facilities to offset development or mitigate flooding, and type of materials used for storm sewers or culverts. During our review of several recent developments, we noticed several of the detention ponds and storm sewer systems were significantly under designed, which generally indicates a hydrograph method was not utilized. Detention facilities should always be constructed to offset development and assist in flooding mitigation. However, in order for detention facilities to have a positive impact in a watershed, updated engineering design standards and practices should be incorporated into a criteria manual. We also noticed an extensive use of corrugated metal pipe for culverts and storm sewer systems across the city. Apart from cost, corrugated metal pipe has no hydraulic engineering benefit compared to reinforced concrete or smooth interior HDPE pipes.

This manual should also include any best management practices identified in your SWMP or TMDL Compliance and Monitory Plan. In addition to drainage, this manual should contain minimum construction requirements for streets, water distribution and sanitary sewer systems.

8.3. Article J With Comments

ARTICLE J - DRAINAGE AND EROSION CONTROL ORDINANCE

SECTION 12-581 - GENERAL.

A. It is the goal of this policy to limit storm water runoff rates after development to their historic rates or less, as an aid in erosion control and to decrease the probability of downstream flooding.

B. The purpose of this drainage policy is to establish standard principles and practices for the design and construction of drainage systems within the City of Moore. The design factors, formulae, graphs and procedures are intended for use as an Engineering guide in the solution of drainage problems involving determination of the quantity, rate of flow, method of collection, storage, conveyance and discharge of storm water.

C. Methods of design other than those indicated herein may be considered where experience clearly indicates they are preferable and they exceed the minimum requirements as listed herein. However, there should be no extensive variations from the practices established herein without the express approval of the city engineer and/or the community development director. Post development runoff calculations must meet or be less than the maximum flow rates using the methods and procedures presented in this ordinance.

(Ord. No. 393(02), 12/2/02)

SECTION 12-582 - MINIMUM DRAINAGE REQUIREMENTS FOR THE CITY OF MOORE.

A. General design criteria. Drainage facilities shall be designed to convey runoff for the following frequency storms:

1. Inlets on Grade - 10 year storm event. (Bypass or Flow Spread Requirements should be added)
2. Inlets in a sump and all storm sewer downstream from that point - 50-year storm event with provisions for 100-year storm event overflow.
3. Curbed streets in a residential district - 25-year storm event.
4. Bridges and bridge boxes - 50-year storm event with provisions for 100-year storm event overflow.
5. Open channels - 50-year storm event and concrete lined to contain the 25-year storm event for channels with a drainage area greater than ten (10) acres. (What if it is less than 10 acres?)
6. Detention facilities - Multiple storm events including the 2, 5, 10, 25, 50 and 100-year storm events.
7. Culverts under any street - 50-year storm event.
8. Driveway culverts - 25-year storm event.
9. Side ditches in rural estates type subdivisions - 25-year storm event.
10. Any other facilities in commercial, institutional and other high value districts - 10-year storm event.

B. Dedicated drainage easements shall encompass all land lying below the water surface elevation of the 100-year flood.

C. Private streets shall include a drainage easement which includes the street and any side ditches so that access can be maintained to the drainage ways.

D. Detention facilities. Storm water detention shall be required for all developments at the time of their construction. This shall include all subdivisions of land and any new construction of a commercial or industrial nature. Exclusions shall be considered for individual residential construction on a lot of two (2) acres or more, however in basins where the community development director determines that there has been historical flooding, detention will be required. Residential construction in an approved addition prior to this ordinance shall not require detention. New developments shall employ the use of a regional detention pond and shall not use multiple individual ponds unless approved by the city engineer or the community development director. All detention facilities shall remain in the care of the private sector and shall be the responsibility of the property owner's association. All maintenance shall be the responsibility of the property owner's association. Exclusions for fee-in-lieu-of detention could also occur with a development located at the bottom of a watershed discharging directly into the river/creek. Detention in this scenario could actually reduce the local peak so that it increases the overall peak in the river/creek. These cases may warrant development of regional detention facilities or payment of fee-in-lieu-of detention.

(Ord. No. 393(02), 12/2/02)

SECTION 12-582.1 - DRAINAGE AND DETENTION FEE-IN-LIEU-OF. (DETENTION FACILITES AND FEE-IN-LIEU-OF DETENTION)

A. All development except for the following specific exclusions shall be subject to the requirements of this section:

   1. Single-family residential homes being constructed on unplatted properties;

   2. Agricultural facilities being constructed in A-1 or A-2 zoning;

   3. Additions or alterations to single-family residential homes.

B. In drainage areas with known downstream flooding of structures, or if it is determined that development of subject property will cause or contribute to flooding or sedimentation of existing structures downstream, the developer shall install detention facilities meeting all requirements of the Detention Ordinance.

   1. Detention shall be required for any multi-family development within zoning districts R-3 and R-4.

   2. Detention shall be required for any development exceeding 20 acres, or as determined by the community development director. If on-site detention is not required, a fee-in-lieu of detention shall be required. (Any development should provide for a local or regional detention facility to account for increased peak discharge flowrates, or may pay fee-in-lieu-of detention as an exception at the discretion of a city engineer.)

C. Detention shall not be required in drainage areas where the city has no record of downstream flooding of structures and drainage calculations provided by the developer or the city indicate projected flooding of existing downstream structures would not occur assuming the drainage basin were totally developed utilizing maximum projected land use as indicted in the long range City of Moore plan. (Development will always cause an increase in discharge flowrates and development may occur downstream in the future. Local or regional detention, or fee-in-lieu-of detention exceptions should always be constructed or collected.)

D. When it has been determined on-site detention is required, engineering plans and drainage calculations shall be provided to the community development director or his designee for review and approval when filing a final plat or applying for a building permit.

E. When it has been determined by the community development director that alternative methods of protecting downstream properties can be accomplished without causing substantial detriment to the public good, safety or welfare or without being contrary to the spirit, purpose and intent of this chapter, the community development director may accept a fee in lieu of requiring on-site detention facilities. The fees shall be determined by the average impervious surface per lot of each zoning district. (Fees-in-lieu-of detention should be considered, at the discretion of a city engineer, as an exception based on proximity to a creek or river or potential for adverse impacts downstream. A detailed hydrologic and hydraulic analysis of altered hydrologic timing downstream and change in floodplain storage should be performed.)

1. Fees to be accepted shall be tendered prior to the filing of the plat for residential subdivisions or the issuance of the building permit for commercial projects according to the amount of impervious surface to be constructed.

2. Impervious surface shall mean any hard-surfaced areas which prevent or retard the entry of water into the soil in the manner and to the extent that such water entered the soil under natural conditions, or where water is caused to run off the surface in greater quantities or at an increased rate of flow than was present under natural conditions. Impervious surfaces shall include, but are not limited to, rooftops; sidewalks; paving; driveways; parking lots; walkways; patio areas; storage areas; and asphalt, concrete, gravel, oiled macadam or other surfaces which similarly affect the natural infiltration or runoff patterns or real property in its natural state.

3. Impervious surface installed or constructed as a part or portion of a public street or a private or public sidewalk in a street right-of-way shall not be calculated as a part of the fee collected in lieu of on-site detention.

4. Fees accepted shall be deposited in a separate account; fees shall be utilized for the costs and expenses incurred or to be incurred in evaluating, preventing, reducing, eliminating, or attempting to eliminate, prevent, or reduce the known or projected flooding problems in the city; and shall be utilized to maintain such facilities and stormwater control system.

5. The fees in lieu of on-site detention shall be in the following amounts:

Zoning District	Impervious Area*	Fee per Sq. Ft.	Fee Assessed per Lot
RE	3,500	$0.075	$262.50
R-1	2,500	$0.075	$187.50
R-2	4,500	$0.075	$337.50
Commercial/Institutional	Actual Impervious Area	$0.075	Due at Building Permit

Industrial	Actual Impervious Area	$0.075	Due at Building Permit

6. As used in this section, the fees tendered hereunder shall be deemed accepted when the funds required are received by the city treasurer.

7. It is unlawful for any person to erect, construct, install, enlarge, alter, repair, move, improve, make, put together, or convert any building, structure, improvement, facility, or impervious surface within the city, or cause the same to be done, without first paying any fee in lieu of detention as required by this section.

(Ord. No. 483(04), 10/18/04)

SECTION 12-583 - FLOODPLAIN DESIGNATIONS.

A. Any reference to official flood plain maps shall mean the highest order of flood plain designation recognized by the City of Moore. The city's community development director will maintain a file of such designations. unless otherwise declared in writing by the city engineer, the descending order of flood plain studies shall be as follows:

1. An officially ordered study such as those watershed studies completed as a part of a master drainage study.

2. Individual basin studies approved and accepted by the city engineer.

3. Maps of the flood insurance administration of the department of housing and urban development on which flood prone areas are delineated.

B. The highest available order of study shall be the basis of design unless it can be clearly shown that the subject study is in error. Contested studies shall be brought to the attention of the city engineer who will submit the claim of error along with supporting data to the study author for consideration. Final decision as to the credibility of the study will be rendered in writing by the city engineer or the community development director.

C. Drainage plan preparation. Drainage Plans shall be submitted as follows:

1. Plan and profile shall be drawn on sheets 24″ × 36″ to a horizontal scale of 1″ = 20′ or 1″ = 40′ and vertical scale of 1″ = 2′ or 1″ = 4′ (except that scales may vary on special projects, such as culverts and channel cross sections). All plans shall be prepared by a registered professional engineer licensed to practice in the State of Oklahoma and shall bear the engineer's seal.

2. Plans for the proposed drainage system shall include, as a minimum:

   a. Property lines, lot and block numbers, dimensions, right-of-way and easement lines, flood plains, street names, paved surfaces (existing or proposed), contract limits, location, size and type of inlets, manholes, culverts, pipes, channels and related structures, outfall details, miscellaneous riprap placement, two (2) feet contour lines (minimum) and title block. Stationing shall be provided along the construction centerline. The north arrow shall remain pointing to the top of the sheet, or to the left.

3. Profiles shall indicate the proposed system (size and material) with elevations, flow-lines, gradients, left and right bank channel profiles, station numbers, maximum water elevations of any standing body of water, inlets, manholes, ground line and curb line elevations, typical sections, riprap construction, filling details, minimum permissible slab elevations adjacent to 100-year flood plains, open drainage features, pipe crossings, design flow capacities, title block and any other necessary information.

4. When official flood plain designations and delineations of floodways denoting limits of permissible flood flow restricting developments exist, then they shall be shown on all preliminary plats and final plans submitted for approval wherever such plans and plats contain flood plains and/or floodway segments. In any case in which official flood plains are not delineated they shall be determined on the basis of standard Corp of Engineers HEC I and HEC II or other methods approved by the city engineer, and shall be shown on all preliminary plats and final plans submitted for approval.

D. Submittals.

1. Computations and plans to support all drainage designs shall be submitted to the city engineer for review. The computations and plans shall be in such form as to provide the basis for timely and consistent review and will be made a part of the permanent record for future evaluation. The computations and plans shall be accompanied by the certification of a registered professional engineer licensed to practice in the State of Oklahoma. Before final approval, the submitting engineer shall provide an "as built" plan accompanied with a letter of certification stating that the submitted plan complies with all governing ordinances and adopted drainage standards of the City of Moore.

2. Specified minimum drainage parameters for historic, developed or proposed conditions that must be shown prior to approval are as follows:

   a. Drainage area.
   b. Length and slope of drainage basin.
   c. Time of concentration (in minutes).
   d. Intensity (in inches/hr) (for specified storm).
   e. Runoff coefficients (c values for rational method if used).
   f. Q (flow rate in cfs).
   g. Design slope and length for all culverts.
   h. Roughness coefficient for all channels and culverts.
   i. Q flow rate (in cfs) for all channels and culverts.
   j. Velocity (in ft/s) corresponding with each calculated q.
   k. Designation of material types for all channel and culverts.
   l. Specific materials and/or methods for erosion and sedimentation control.
   m. Detention pond volume calculations

n. Detention pond depth vs storage curve

o. Detention pond depth vs discharge curve.

p. Detention pond location, elevations and dimensions.

q. Detention storage calculations with inflow and outflow hydrographs.

(Ord. No. 393(02), 12/2/02)

Add a SECTION 12-XXX for RAINFALL and include a rainfall table (Depth/Duration/Storm Event) using the latest NOAA Atlas 14 Data which is specific for Moore, Oklahoma.

SECTION 12-584 - DETERMINATION OF STORMWATER RUNOFF. Add a Section for use of NRCS Curve Number Method (Formerly the SCS Method). Provide a Table with CN Values.

A. *General.* The rational method will be accepted as adequate for drainage areas up to 640 acres. For larger areas, other methods may be used. The methodology developed by the U.S. Geological Survey titled "Techniques for estimating flood discharges for Oklahoma streams" will be acceptable as adequate for drainage basins in excess of six hundred forty (640) acres. Other hydrographic models or methods may be approved by the city engineer.

The rational method is based on the following assumptions:

(1) The peak rate of runoff at any point is a direct function of the average rainfall intensity during the time of concentration to that point.

(2) The frequency of the peak discharge is the same as the frequency of the average rainfall intensity.

(3) The time of concentration is the time required for the runoff to become established and flow from the most remote part of the drainage area to the point under design.

The latter assumption applies to the part most remote in time, not necessarily in distance. In the rational method, average intensities have no time sequence relation to the actual rainfall pattern during the storm. The intensity-duration curve is not a time sequence.

B. *Rational method of runoff computation.* The rational formula is defined as follows:

Q = CIA, where:

Q = Runoff volume in cubic feet per-second (cfs)

A = Area to be drained in acres (ac.)

C = Runoff coefficient

I = Rate of rainfall over the entire drainage area in inches per hour, based on the time of concentration

1. Runoff coefficient "c": It should be noted that the runoff coefficient "c" is the variable of the rational method which-is least susceptible to precise determination. Its use in the formula implies a fixed relation for any given drainage area, which in reality is not the case. A reasonable coefficient must be chosen to represent the integrated effects of

infiltration, detention storage, evaporation, retention, flow routing, and interception. All of these affect the time distribution and peak rate of runoff.

Ranges for "c" values are as follows:	
Single family residence	0.70
Multi family	0.75
Apartments	0.80
Commercial/industrial	0.90
Parks-golf courses	0.40
Undeveloped, pasture and cultivated	0.40
Acreage development less than two (2) acres per lot	0.60
Two (2) acres per lot or more development	0.50

2. Rainfall intensity (I): Rainfall intensity (I) is the average rainfall rate in inches per hour which is considered for a particular drainage basin or sub-basin and is selected on the basis of design rainfall duration and design frequency of occurrence. The design duration is equal to the time of concentration for the drainage area under consideration. Intensity duration curves for this region are included herein. Provide the Intensity Equation $I = a/(Tc+b)^c$ and provide Table of Parameters

    a. The time of concentration used in the rational equation is the critical time of concentration for the point of interest. The critical time of concentration is the time associated with the peak runoff from the watershed to the point of interest. The time of concentration to any point in a storm drainage system is a combination of the "inlet time" and the "time of flow in the conduit". Street flow shall be considered as being in an open paved channel. Manning's equation is acceptable for determining open channel and free water surface flows.

    b. An acceptable formula for use in determining overland time of concentration is: (TR-55 also acceptable)

    $$T_c = k\,(L^{.375}/S^{.2})$$

    L = length of flow in feet (Overland values should not exceed 300 feet in length)

    S = average slope in feet/foot

    K = constant for character of surface

    Values of k:

    Pavement 0.372

    Bare soil 0.604

Poor grass 0.942

Average grass 1.04

Dense grass 1.13

c. An acceptable formula for determining channel flow time is:

$T_c = k\ (L^2/S^{.385})$

Values of k:

Curbed street 0.0035

Concrete lined channel 0.006

Sodded swale 0.008

Bar ditch 0.012

d. The time of flow in a closed conduit is the quotient of the length of the conduit and velocity of flow as computed using the hydraulic characteristics of the conduit. The time required to fill the conduit shall be neglected even though it may represent an appreciable percentage of total time of concentration.

3. Drainage area (A): The size, shape and characteristics of the watershed must be determined. Drainage areas shall be determined through the use of planimetric topographic maps, supplemented by field surveys where topographic data has changed or where the map relief makes it difficult to distinguish the direction of flows. A drainage area map shall be provided for each project. The drainage area contributing to the system being designed and drainage sub-area contributing to each inlet point shall be identified. The outlines of the drainage divides must follow actual lines rather than artificial land divisions.

(Ord. No. 393(02), 12/2/02)

SECTION 12-585 - FLOW IN STREETS.

A. *General.* The location of inlets and permissible flow of water in the streets shall be related to the extent and frequency of interference to traffic and the probability of flood damage to surrounding property. interference to traffic is regulated by design limits of the spread of water into traffic lanes, especially in regard to collector streets and arterials.

B. *Design criteria.*

1. Flow in gutters on straight or parabolic crown paved streets or roads may be determined by using Manning's formula for channel flow. (Use modified Manning’s formula specific to curb & gutter flow)

2. Minimum gutter slope on residential streets shall not be less than 0.004 ft/ft (0.4%).

3. Maximum gutter slope shall not be more than .08 ft/ft (8.0%).

4. Lowering of the standard height of street crown or splitting of curb heights shall not be allowed for the purpose of hydraulic design unless approved by the city engineer. In no case will it be allowed on collector or arterial streets.

5. All street sections shall have a positive crown.

6. Street capacity: the flow depth at the gutters shall not exceed six (6) inches for a 50-year storm. (Top of curb should not be exceeded in 100-year storm) A concrete overflow flume shall be provided at all sump locations to provide for the 100-year overflow. (100-Year storm sewer systems may be necessary in sumps where overland must convey through private residential property or in close proximity to other structures.)

7. The use of a cul-de-sac or dead end street as the terminal point of residential street flow shall not be allowed for drainage areas exceeding five (5) acres. A minimum of seventy (70) percent of the flow in a residential street shall be removed to a storm sewer or drainage system prior to reaching the point of curvature of a cul-de-sac or the end of the street for drainage areas exceeding five (5) acres in size but in no case shall the sum of the bypassed flow equivalent drainage area and the drainage area to the end of the cul-de-sac exceed 5 acres.

8. The maximum drainage area that may be conveyed on a curbed street is twenty (20) acres. (This area may need to be reduced or eliminate this criteria. If this criteria line is removed, the amount of discharge in gutter should be limited to keep an open driving lane on collectors and 2 open driving lanes on arterials.)

(Ord. No. 393(02), 12/2/02)

SECTION 12-586 - ENCLOSED STORM SEWERS.

A. *General.* All storm sewers shall be designed by the application of the Manning's or Kutter's equations either directly or through appropriate charts or nomographs. In the preparation of hydraulic designs, investigations shall be made of all existing structures and their performance on the waterway in question. Sewer sizing based on storm frequency shall be as set forth in Section 12-611 "Minimum drainage requirements for the City of Moore". Verify this section is in agreement with Section 12-611 “Minimum drainage requirement for the City of Moore”

In addition, runoff from storms exceeding the design storm up to the 100-year storm should be anticipated and disposed of with minimum damage to surrounding property and the sewer must be accessible for maintenance. Drainage between lots will be conveyed in an enclosed storm sewer with a concrete flume for overflow conditions.

B. *Materials of construction.*

1. Reinforced concrete pipe shall conform to the requirements of ASTM C76. Unless otherwise specified, all pipe shall be class III for twenty-four (24) inch and smaller and Class II for twenty-seven (27) inch and larger in accordance with ASTM C76, wall b. If a closed Box design is used in lieu of pipe, the design shall conform to Oklahoma Department of Transportation RCB Standards or structural design calculations shall be provided.

2. Corrugated metal pipe wall thickness shall meet ODOT fill height table for metal pipe (FHTMP-4-00E). (Corrugated metal pipe (CMP) should not be permitted. The flowline of CMP typically rusts out prior to designed lifespan and may cause further erosion and sinkholes adjacent to the pipe. Corrugated plastic pipe and CMP, with interior corrugations, should not be permitted as it reduces discharge capacity and causes aggradation of sediment in pipe. Storm sewer and culvert pipe materials should consist of either reinforced concrete or high density polyethylene (HDPE). HDPE pipe should have a smooth interior; we recommend ADS – HP Storm Pipe (High Density Polypropylene).)

3. Corrugated metal pipe shall not be place under paved public streets unless approved by The City Engineer.

C. *Design criteria.*

1. Pipes which are a part of the storm sewer system shall have a minimum diameter of eighteen (18) inches.

2. Enclosed storm sewers shall be designed for open-channel flow to satisfy, as well as possible, the requirements for unsteady and non-uniform flow. Sealed joints are required for any pipe that can operate under head. Any pipe under any paving shall be "O" ring type pipe and wrapped to prevent infiltration of the fill material into the pipe.

3. Grades: the minimum slope shall be such to maintain a minimum velocity of 2.5 fps flowing full. The maximum slope shall be such that the velocity does not exceed twenty (20) feet per second.

4. Flows may be computed by either the kutters or manning equation. The kutter and the manning equations are used for pipes and conduits of all shapes flowing either full or partially full.

5. Roughness coefficient "n" for storm sewers:

Materials of construction	Design coefficient Manning's
Box Culverts	.013
Concrete pipe	.013
Annular plain corrugated metal pipe	.024 .027
Smoothflow helical plain corrugated metal pipe	.018 .024
Special cases: "n" as approved by City Engineer	

6. General rules to be observed:

a. Pipe size and slope selected so that flow will not decrease at inlet, manholes or other changes in geometry.

b. Do not discharge a larger pipe into a smaller one.

c. At change in pipe size, match top of pipes.

d. Design capacity of the conduit shall not exceed the conduit capacity at critical slope.

An acceptable critical slope formula is:

S = 111 N 2/D 1/3

S_c = critical slope

N = mannings "n"

D = circular pipe diameter feet

e. A one-foot free-board shall be maintained below the proposed finish grade through the storm sewer system. The submittal of energy calculations shall be required on any reach of a system which exceeds five hundred (500) lineal feet; on the total system that exceeds one thousand five hundred (1,500) lineal feet; on a reach of a system which has an elevation change exceeding ten (10) feet. This is confusing and needs to be reworded so that it's clear. "The Hydraulic Grade Line (HGL) shall be shown on all profiles of storm sewers including more than one pipe section. The Energy Grade Line (EGL) for the design flow shall be no more than one foot above the final grade at manholes, inlets, or other junctions."

7. Manhole locations: Manholes shall be located at intervals not to exceed three hundred fifty (350) feet for pipe sizes forty-two (42) inches or less. For pipe sizes larger than forty-two (42) inches, manholes shall be located as determined by the city engineer. Manholes shall be located at conduit junctions, changes of grade, and changes of alignment for all pipe sizes. (Perhaps a maximum spacing table which compares Pipe Size vs Spacing)

8. Pipe connections: Manholes, junction boxes or inlets shall be used at all pipe connections and/or changes in pipe size.

9. Head losses at structures: Minor energy head losses at structures shall be disregarded. Major losses shall be taken into account if they significantly affect the sewer performance.

10. Pipe extensions: The use of one material to extend a sewer constructed of a different material shall not be allowed except at manholes, junction boxes or inlets.

11. Pipe laid on curves: Degree of curvature shall be as per manufacturer's recommendations.

12. Outlet erosion protection: All storm sewer outlets shall have erosion protection provided by headwalls, flared end sections, curtain walls, energy dissipators, rip rap, etc. As required by accepted engineering practices and approved by the city engineer.

D. *Inlet system.*

1. Inlet design and location in street sections must be compatible with the allowable spread of water on the street section as established in Section III "Flow in Streets". Verify this section is in agreement with Section III "Flow in Streets"
2. Inlet location shall not interfere with vehicular or pedestrian traffic.
3. Whenever possible, inlets will intercept water before it reaches a pedestrian crosswalk.
4. Inlets shall not be located in a curb radius. Where existing conditions exist that require an inlet in the radius, the radius shall not be less than 38 feet.
5. Inlets shall be sized to prevent water from minor streets spilling over and flooding major streets.
6. Where a curbed street crosses a bridge, gutter flow shall be intercepted and not allowed to flow onto the bridge.
7. Inlets shall be installed at a low point or on the minimum slope of 0.4% and shall have the following accepted capacities:

Std. Inlet Designation	Grate (cfs)	Hood (cfs)	Total (cfs)
1 - 0	1.6	2.5	4.1
2 - 0	3.2	5.0	8.2
2 - 1	3.2	10.1	13.2
2 - 2	3.2	15.0	18.2
2 - 3	3.2	20.0	23.2
2 - 4	3.2	25.0	28.2
2 - 5	3.2	30.0	33.2

This table doesn't differentiate between on-grade inlets and sump inlets. A specific series of equations is typically used for On-Grade Inlets to determine capacity, bypass, and is accompanied by clogging factors. Another set of criteria is utilized for Sump Inlets.

The above inlet designation is as follows: The first number represents the number of grates with matching hoods. The second number represents the number of additional pairs of hoods.

8. The storm sewer system at a low point (sump) must provide a concrete overflow channel capable of carrying the 100-year frequency storm in a designated drainage easement.
9. Any inlet grates over which a bicyclist can ride shall be of a design considered bicycle safe.

(Ord. No. 393(02), 12/2/02)

SECTION 12-587 - OPEN DRAINAGE CHANNELS.

A. *Natural drainage flow.* Increases in runoff which change the equilibrium of natural areas in the system mandate specific engineering solutions to conserve these natural systems and the pre-development characteristics of the area.

B. *Open storm drainage requirements.*

1. All land adjoining open natural or improved storm drainage channels having an elevation below the 100-year flood elevation of the channel shall be dedicated for the purpose of providing drainage, public park and/or utility easement.

2. All channel improvements shall be approved by the city engineer prior to the commencement of any work thereon.

3. Whenever channel improvements are carried out, sodding, back-sloping, cribbing and other bank protection shall be designed and constructed to control siltation and erosion (gradation and aggradation) for the anticipated conditions and flow resulting from a one hundred (100) year frequency rainfall.

4. Any channel grading shall be such that water will not gather in pools.

5. Drainage easements of satisfactory width to provide working room for construction and access for channel maintenance shall be provided. An open drainage channel shall not be located in a street easement except where a paved street surface is at least two lanes wide and is provided on both sides of a channel so as to provide access.

C. *Design considerations.*

1. Channels should be as wide and shallow, and on as flat a grade as hydraulics and topography will allow.

2. Hydraulic characteristics of channels shall be determined by mannings open-channel equation. The "n" value used for channels shall be based on the design engineer's experience and judgement in regard to the individual channel characteristics and approved by the city engineer. When submitting calculations, include the source.

3. Constructed channel geometry: Whenever a trapezoidal channel is constructed, the minimum bottom width shall be four (4) feet with side slopes of not steeper than four (4) to one (1) for sodded sections and a minimum bottom width of three (3) feet with side slopes of not steeper than one (1) to one (1) for paved or rock lined sections.

   If the radius of the centerline of the channel is less than 3 x b, additional outside bank height is required and may be determined by the following:

   $$H = \frac{v^2(t + b)}{2gr}$$

   H = additional height on outside edge of channel (ft.)

   v = velocity of flow in channel (fps)

t = width of flow at water surface (ft.)

b = bottom width of channel (ft.)

r = centerline radius of turn (ft.)

g = acceleration of gravity (32.3 ft/sec2)

4. Flow velocities in channels: Velocities shall not exceed six (6) fps for sections sodded in bermuda grass. Velocities in concrete lined or paved sections shall not exceed fifteen (15) fps. Whenever improved conduits carrying water discharge into channels either natural or manmade scour protection shall be installed.

5. Trickle channels: All channels altered or improved from the natural state will require a minimum three-foot wide paved trickle channel. The paved trickle channel shall be designed in a manner that will minimize erosion or undermining of the Improvement. Sodding, soil stabilization, or other methods of erosion control shall be required adjacent to the paved channel.

6. Concrete flumes. Concrete flumes in lieu of enclosed pipe shall not be allowed except under the following conditions:

   a. Drainage area shall not exceed five (5) acres.

   b. The structure shall extend to the rear of the adjacent lots and shall lie within an easement, or common area and discharge into a drainage easement, park or common area maintained by the city or property owners association.

   c. A curtain wall shall be provided at the discharge end.

   d. The entrance to the flume shall be sized based on the following weir equation:

      $Q = C L h^{3/2}$

   Q = Runoff volume in cubic feet per section

   L = Weir opening

   h = Height of weir opening

   C = 3.0

   Where h does not exceed the height of the curb at the entrance.

   e. The water surface in the flume shall never be higher than the top of the curb at the entrance during any flow condition.

7. Exit provisions: Any paved channel more than three (3) feet deep with slopes steeper than 2:1 shall have recessed hand/toe pockets in the channel wall spaced vertically on fifteen (15) inch centers alternating on a twelve (12) inch width. The pockets (steps) shall be located a maximum of two hundred (200) feet apart along the channel and alternate from side to side.

8. Rip rap outlet stabilization shall be constructed at the discharge end of the open drainage channel when the new channel discharges into a undeveloped channel or when the discharge velocities are erosive.
9. Fences shall not be erected below the shoulder of the sodded section or below limits of 100-year flood line, and in no case shall fences be closer than six feet measured horizontally to the edge of the paved section, unless paved section is sized for 100-year flood then the fence may be set next to paved channel. In all other situations, fence shall be a minimum of six (6) feet away from channel.

(Ord. No. 393(02), 12/2/02)

SECTION 12-588 - BRIDGES AND CULVERTS.

A. *Materials and size.*

1. Culverts under private drive approaches may be reinforced concrete pipe or corrugated metal pipe. Size shall be not less than eighteen (18) inches or twenty-one (21) inches in length times fifteen (15) inches in width corrugated metal pipe arch. (CMP should not be permitted within City of Moore right-of-way, see comments for section 12-586 B-2)

2. Culverts under public streets shall be reinforced concrete conforming to Oklahoma Department of Transportation standards.

B. *General design requirements.*

1. Bridges and culverts shall be designed to pass the 50-year storm (100-year storm) unless used as an outlet for a detention pond. Structures under residential streets shall be designed so that water overtopping the structure from a 100-year frequency storm shall not flood the street to a depth greater than six (6) inches above the street crown. Structures crossing under arterial or collector streets shall be designed so that waters overtopping the structure from a 100-year frequency storm shall not flood the street to a depth greater than six (6) inches above the street crown. Allowable spread of waters shall not exceed the adjacent floodway.

2. Scour protection shall be provided to control erosion.

3. Flared end sections with curtain walls may be used in lieu of headwalls on culverts of forty-eight (48) inches or less. Concrete flared end sections discharging water shall be tied back a minimum of three (3) pipe lengths.

(Ord. No. 393(02), 12/2/02)

SECTION 12-589 - STORM WATER STORAGE.

A. *General.* Storm water detention shall be required for all developments at the time of their construction. This shall include all subdivisions of land and any new construction of a commercial or industrial nature. Exclusions may be considered for individual residential construction not associated with a multi-lot development. Exclusions may also be considered for residential construction on a lot of five (5) acres or more. Residential construction in an approved addition prior to this ordinance shall not require detention. New developments shall employ the use of a regional detention pond and shall not use multiple individual ponds unless approved by the city. All detention facilities shall remain in the care of the private sector and shall be the responsibility of the property owner's association. All maintenance shall be the responsibility of the property owner's association.

B. *Rainfall storage.*

1. Rooftop storage or underground storage shall not be permitted.

2. Parking lot storage, if used, may employ ponding areas with a controlled outlet structure to control the discharge. Special attention shall be given to the potential flooding of parked cars. Parking lot detention depths cannot exceed 9 inches.

3. Property line swale ponding and small on-site ponds, if used, shall be examined for possible adverse effects on building foundations due to saturation of the subsoil.

C. *Design considerations for rainfall and runoff storage.*

1. Sizing of detention facilities shall be by approved methods such as APWA unit hydrograph, scs method, etc. which is further outlined in Section 12-584. (Unit-hydrograph method should be required.)

2. The storage facility shall be designed to pass, as a maximum, the historic runoff rate and shall control the increased runoff due to the development under consideration. (Detention facilities should be designed at a minimum to provide enough storage to not exceed pre-development runoff conditions for the design storm events based on peak discharge flowrates given in the MDP or updated NRCS hydrologic drainage basin studies.)

3. Release rates shall be based on head over the outlet and shall not exceed the historic flow for the 2, 5, 10, 25, 50 and 100-year design frequency storm discharges.

4. When a combination of storage facilities are used to control runoff, the system as a whole shall be designed with the capacity to detain the design storms with discharge rates in accordance with b and c above.

5. All facilities shall be provided with an emergency spillway with scour protection. Earth embankments shall have side slopes not steeper than 3:1. Proper materials shall be used to provide stability and minimum seepage.

6. The storage volume of a detention facility shall be oversized by 10% to allow for sedimentation. Exception - concrete with sedimentation control or written maintenance program to allow for sediment control.

7. All detention ponds shall be provided with a paved trickle channel from the main inlet point to the outlet structure to transmit low flows. Except where it is not required by the design as approved by the city engineer.

8. Erosion control for storage and/or detention facilities shall be in accordance with EPA requirements.

9. A paved access road shall be provided to all-detention areas for maintenance purposes. The paved access road shall be dedicated as part of the detention area.

10. Earth dams and other earth embankments shall be designed by a licensed professional Engineer in accordance with accepted engineering practices to assure that dam failures will not occur. Design criteria used by the soil conservation service in the selection of materials and construction procedures will be accepted.

11. Energy dissipaters shall be installed downstream of the outlet structure to return flow to channel design velocity.

12. Table XXXX outlines the various freeboard requirements for storm water storage facilities.

PROVIDE FREEBOARD TABLE HERE

(Ord. No. 393(02), 12/2/02)

SECTION 12-590 - EROSION AND SEDIMENTATION.

A. *General.* The purpose of this section is to provide effective management for the control of erosion and sedimentation and to protect water quality and the general health, safety and welfare of the residents of the City of Moore. The items detailed herein are to be considered as a minimum. EPA and ODEQ guidelines shall be followed where more restrictive.

1. Appropriate erosion and sedimentation facilities shall be installed and maintained throughout the construction period for any construction activity on individual tracts or lots.

2. All erosion and sediment control methods necessary for land treatment measures which will effectively minimize and control erosion and sedimentation during and following any proposed construction activity shall be indicated on the final construction and/or building permit plans.

3. All earth slopes and earth areas new or existing subject to erosion, such as, adjacent to trickle channels, inlet structures, and outlet structures, within any area designated for detention or drainage shall be slab sodded with bermuda sod or have permanent established growth of vegetation. All vegetation areas shall be fertilized, watered, and in an established growing condition prior to completion or acceptance of any drainage facility. Drainage channels shall be slab sodded to the limits of the 100-year design storm.

4. Erosion and sediment control on urban areas established by the Cleveland County Conservation District shall be used to determine best practices, define terms and provide basic methodology.

B. *Design considerations.*

1. General design principles. Practical combinations of the following principles shall be utilized, as a minimum, in planning measures to be installed for any land disturbing activity.

a. The land disturbing activity shall conform to existing topography and soil type so as to create the lowest practicable erosion potential.

b. The disturbed area and the duration of exposure to erosive elements shall be kept to a practicable minimum through construction scheduling and management.

c. Cut and fill operations should be kept to a minimum.

d. Disturbed soil shall be stabilized as quickly as practicable.

f. Natural vegetation shall be retained, protected, and supplemented whenever feasible.

g. Temporary vegetation or mulching shall be employed to protect exposed critical areas during development.

h. Permanent vegetation and structural erosion control measures shall be installed as soon as practicable.

C. *General practice:* Soil and water conservation measures include but are not necessarily restricted to vegetation, sediment basins, dikes, grade stabilization structures, sediment traps, land grading, diversions, waterways or outlets, and riprap. Vegetative practices shall be applied to control erosion. The practice can be either temporary and/or permanent depending on the site specific needs.

D. *Erosion and sediment control criteria.*

1. Long term permanent seeding, sprigging, or planting producing vegetative cover. Bermuda grass, kentucky 31 tall fescue and weeping lovegrass are some of the types of permanent vegetation that shall be used to control erosion.

2. Short term seeding, producing temporary vegetative cover. Small grains like oats, rye and wheat, and sudans and sorghums are the most feasible temporary vegetation and shall be used to control erosion. This practice is effective for areas where soil is left exposed for a period of six (6) to twelve (12) months. The time may be shorter during periods of erosive rainfall.

3. Sodding: covering areas with a turf of perennial sod forming grass.

4. Dikes and swales: the design drainage areas for dikes and swales shall not exceed five acres. The minimum dimensions shall be in accordance with EPA guidelines.

   a. Diversion dike.

   b. Interceptor dike or swale.

   c. Perimeter dike or swale.

   d. Straw bale dike: where no other practice is feasible, a temporary barrier with a life expectancy of three months or less can be installed across or at the toe of a slope for the contributing drainage areas, in accordance with the EPA standards.

5. A stabilized construction entrance shall be built in accordance with the EPA standards to reduce or eliminate the tracking or flowing of sediment onto public right-of-way.

6. A concrete or stone outlet structure shall be constructed in areas where the entire drainage area to the structure is not stabilized or where there is a need to dispose runoff at a protected outlet or where concentrated flow for the duration of the period of construction needs to be diffused.

7. A grade stabilization structure in the form of a paved chute or flume shall be constructed to prevent erosion, where concentrated flow of surface runoff is to be conveyed down a slope, in accordance with EPA standards. The maximum allowable drainage area upstream of such a structure shall not exceed thirty-six (36) acres.

8. A grade stabilization structure in the form of a pipe slope drain shall be constructed to prevent erosion, where concentrated flow of surface runoff is to be conveyed down a slope, in accordance with EPA standards. The maximum allowable drainage area upstream of such a structure shall not exceed five acres.

9. Storm water detention facilities may be used temporarily as sediment basins. A temporary outlet structure for the storm water detention facility to work as a sediment pond shall be constructed. At the end of the construction activity, the developer shall make sure that the outlet structure shall meet the design requirements of a storm water detention facility. The EPA General Permit requires that, where it is attainable, a temporary or permanent sediment basin be installed in any drainage location where more than ten (10) acres in the upstream drainage area are disturbed at one time. The sediment basin must provide at least three thousand six hundred (3,600) cubic feet of storage for every acre of land which it drains (flows from upland areas that are undisturbed may be diverted around the basin). For drainage locations with ten (10) or fewer disturbed acres, sediment traps, filter fences, or equivalent measures must be installed along the downhill boundary of the construction site.
10. Hay and sod mulching, as a temporary measure, may be used for embankment stabilization in areas where surface runoff is to be directed down a slope.
11. Erosion matting may be used for embankment and slope stabilization where appropriate. The specified use must be recommended by the manufacturer for the proposed material.
12. Silt fencing may be used for slope stabilization where appropriate. The specified use must be recommended by the manufacturer for the proposed material.

(Ord. No. 393(02), 12/2/02)

SECTION 12-590.1 - RESERVED

Editor's note—

Ord. No. 602(07), adopted November 5, 2007, repealed § 12-590.1, which pertained to land disturbing activity and derived from Ord. No. 533(06), 2/21

Section 8 - Appendix A
City of Owasso
Example Drainage Design Criteria

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918.392.5620 fax: 918.392.5621

MESHEK & ASSOCIATES, PLC

SECTION 0500 **STORMWATER SYSTEMS**

SECTION 0500 **STORMWATER SYSTEMS**

0501 GENERAL REQUIREMENTS

0501.1 Stormwater Master Plan

The stormwater drainage systems shall comply with the provisions of the Stormwater Master Drainage Plan.

0501.2 ODEQ Permitting

All ODEQ standards and permits shall be followed.

0501.3 Alignment Surveys

Alignment surveys for street projects shall be performed as specified in Section 0110, General; Paragraph 0116.3, Alignment Surveys.

0501.4 Maintenance Bond

The construction contractor shall post a maintenance bond or Irrevocable Letter of Credit in an amount equal to 100 percent of the determined amount of construction costs for a two-year period after completion and acceptance of all improvements. The bond shall be written wherein the City is the grantee.

0501.5 City of Owasso Review

The City of Owasso reserves the right to direct changes in stormwater alignment, grade, and appurtenance placements. Design calculations shall be presented within an Engineering Report for review by the Engineer.

0501.6 Plan Requirements

A. Construction plans shall comply with Subsection 0117, Engineering Design Criteria.

B. Plans shall include the following:

   1. Profiles with elevations for all storm sewer lines, culverts, swales and any other means of conveying storm water.

   2. Direction of flow both pre- and post-development.

   3. Building pad elevations

0501.7 Property Owner/Developer Responsibilities

It shall be the responsibility of all owners of property within the City, whether undeveloped, developed, or undergoing development to maintain any and all stormwater facilities. The following requirements apply to all owners throughout the transfers/sales of property and particularly to the Developer and his contractor during construction of his/her development.

A. Mow and provide minor maintenance of drainage channels and their slopes for that portion of the channel lying within their property line.

B. Keep clear all drainage channels within the boundaries of their properties in accordance with the requirements of this article.

C. Control all storm water runoff and drainage from points and surfaces on the property.

D. Prevent any and all drainage interferences, obstructions, blockages, or other adverse effects upon drainage, into, through, or out of the property.

E. Take no action which will alter or otherwise change designed and installed storm water management control systems and take no action on existing property that shall adversely affect stormwater runoff in any manner contrary to the provisions of this Section, whether temporary, permanent, or a combination thereof.

F. The City may require improvements and/or drainage easements beyond subdivision boundaries, development, or property improvement for the following reasons:

    1. Facilitate flow of stormwater from or through the property,

    2. Avoid damage from changed runoff conditions,

    3. Provide continuous improvement of the overall storm drainage system, and

    4. Accommodate all drainage conditions or requirements.

G. Where stormwater runoff flows require the logical extension of any street or its associated drainage in order to prevent flooding, ponding, or uncontrolled runoff, the extension shall be provided by the Developer.

H. During construction: Developers, property owners, builders, and Contractors shall be required to keep streets, gutters, inlets, drainage pipes, swales, ditches, drainage channels, emergency drainage swales and all drainage devices and structures clean and free from debris, sedimentation, soil, and any deleterious materials. Any failure to meet this requirement shall, upon sufficient notice and failure to immediately correct the notified condition, constitute grounds for initiation of enforcement action, including, but not limited to, stopping all work until correction is completed.

I. Developers, builders, property owners, or their legal agents, upon receipt of notice by the City of Owasso that repair or maintenance is required within a channel lying within their property, shall be responsible for effecting such repair or maintenance within the time specified, or the City shall have repair and maintenance performed at the expense of the property owner unless it can be proven that the damage was caused by another entity.

0501.8 City of Owasso Responsibilities

It shall be the responsibility of the City of Owasso to:

A. Following acceptance of infrastructure and expiration of maintenance bonds, repair and maintain drainage channels and their slopes when located within or upon easements or rights-of-way dedicated to the City of Owasso.

B. Develop and implement standards and specifications required to clearly and accurately interpret the physical requirements of this section.

C. Make such necessary improvements of primary and secondary drainage channels that cannot or will not be improved through private development.

D. Improve and maintain floodway areas and areas between the floodway and limits of the 100-year floodplain (flood fringe) that are dedicated public areas, rights-of-way, parklands, or public-owned buildings or developments.

E. Improve and maintain all public-owned drainage channels or systems outside the flood fringe area.

0501.9 Homeowners Association

Covenants (or Deed of Dedication Restrictions) developed during the subdivision platting process must provide for the formation of a homeowners (or commercial owners) association. The responsibilities for stormwater management attached to the Developer during construction of infrastructure must transfer to the association. These responsibilities pertain to maintenance of stormwater features within commons areas and those not located within a dedicated utility or drainage easement.

0502 EASEMENTS

0502.1 Overland Flows

A. All restricted drainage easements will be shown detailed on the construction plans and final plat, as well as described in the conditions and restrictions of the plat.

B. No structures or obstructions of any form shall be allowed on drainage easements.

C. The conditions and restrictions of the plat shall designate the responsible party for maintenance of the area within the drainage easement.

D. Adequate right-of-way must be provided for access and maintenance to the drainage easement.

0502.2 Floodplain

The City may accept dedication of the entire floodway and/or floodplain area for an unimproved channel. Floodway development must be in accordance with a Conditional Letter of Map Revision (CLOMR) from FEMA. Floodplain development must be in accordance with a Flood Development Permit issued by the floodplain manager.

0502.3 Storm Sewer

The minimum easement width shall be 15 feet or the outside diameter of pipe plus 10 feet, whichever is greater, and the pipe shall be laid in the center of easement.

0503 DRAINAGE SYSTEM REQUIREMENTS

0503.1 Review by the City of Owasso

All stormwater designs and construction plans shall be approved by the Engineer.

0503.2 Classifications

Stormwater drainage systems, both public and private, may consist of storm sewers (closed conduits); improved channels constructed in conformity with adopted City standards; unimproved drainageways left in their natural condition; the areas covered by restricted drainage easements for the purpose of providing overland flow; and appurtenances to the above including the street system, curbs and gutters, detention/retention ponds and lakes, underground detention structures, inlets, manholes, junction boxes, headwalls, dissipaters, and culverts.

0503.3 System Design

A. The stormwater drainage system shall be designed to receive and pass the runoff from a 100-year frequency rainstorm within dedicated easements or public rights-of-way under full urbanization. Full urbanization is defined as the total development in an area that is anticipated. The entire flow shall be confined within the said stormwater drainage system.

B. Drainage areas in acres, runoff coefficients, peak flows from 5-year, 10-year and 100-year frequency rainstorms, time of concentration, and capacity of each inlet and pipe shall be summarized and tabulated on the plans. This summary table shall also be a part of the drainage calculations.

C. The stormwater collection system shall be designed to either:

   a. As a minimum, pass the 5-year frequency runoff in a pipe network with overland flow capacities (within dedicated easements or rights-of-way) so that the combination of the two will pass the 100-year runoff under fully urbanized condition OR

   b. Pass the entire 100-year runoff in the pipe network. The network inlets must be designed to convey the runoff even in the event of blockage or bypass.

0503.4 Overland Flow

The overland flow portion of the collector system shall be confined to dedicated rights-of-way or restricted drainage easements to assure that stormwater can pass through the development without inundating the lowest level of any building, dwelling, or structure. Restricted drainage easements shall be shown on the plat.

0504 RAINFALL

0504.1 Introduction

Presented in this section are the design rainfall data which shall be used for runoff hydrograph calculations. All hydrological analyses for the City of Owasso shall utilize the rainfall data presented herein for calculation of storm runoff.

0504.2 Total Rainfall

Rainfall data to be used for projects in the City of Owasso are contained below. US Weather Bureau Technical Paper No. 40, Rainfall Frequency Atlas of the United States is the basis for cumulative rainfall data of storm durations greater than one hour. The National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35 is the basis for cumulative rainfall data of storm durations from 5 to 60 minutes.

Total Rainfall Depth – Inches
Frequency (Return Period)

Duration	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
5-minute	0.40	0.48	0.56	0.62	0.72	0.79	0.86	1.01
10-minute	0.71	0.84	0.99	1.11	1.27	1.41	1.54	1.83
15-minute	0.84	1.01	1.20	1.34	1.54	1.70	1.86	2.23
30-minute	1.14	1.40	1.73	1.96	2.29	2.55	2.81	3.39
1-hour	1.44	1.81	2.28	2.60	3.07	3.44	3.80	4.58
2-hour	1.70	2.13	2.80	3.30	3.85	4.44	5.00	6.12
3-hour	1.87	2.28	3.13	3.63	4.25	4.83	5.43	6.60
6-hour	2.19	2.71	3.64	4.30	5.08	5.71	6.40	7.80
12-hour	2.63	3.23	4.31	5.10	6.00	6.71	7.55	9.20
24-hour	3.00	3.75	5.15	5.88	7.00	7.78	8.75	10.68

Source: U.S. Weather Bureau Technical Paper No. 40 and HYDRO-35

0505 RUNOFF

0505.1 Approved Methods

A. The following table contains methods of runoff analysis that may be used for the design of components of the storm drainage system as applicable:

Runoff Methods

	Peak Q	Volume Calc	Maximum Drainage Area, AC
SCS Method	Yes	Yes	2,000
Rational Method	Yes	No	60

B. The SCS method of runoff analysis is preferable for use in the City of Owasso.

0505.2 Rational Method

A. Formula: The Rational Method is based on the formula: Q=CIA

"Q" the maximum rate of runoff in cubic feet per second.
"C" runoff coefficient of the area.
"I" the average intensity of rainfall in inches per hour for a duration equal to the time of concentration (T_c).
"T_c" the time of concentration is the time required for water to flow from the most remote point of the basin to the point being investigated and to reach a steady state condition.
"A" The contributing watershed area in acres.

B. Time of concentration: In lieu of the foregoing, formulas may be used as contained in the ODOT Roadway Design Manual, Section 15.3.2.1.

1. One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the most remote part of the drainage area to the point under consideration.

2. The time of concentration consists of overland flow time, T_o plus the time of travel, T_f, in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time, T_o, plus the time of travel in a combined form, such as a small swale, channel, or drainage. The latter portion, T_f, of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainage. Overland flow time, on the other hand, will vary with surface slope, surface cover, and distance of surface flow. The infiltration rate of the soil, the presence of depression storage areas, and the amount of antecedent rainfall will also affect the overland flow time, since the rainfall must first overcome these losses before a steady state runoff condition will be achieved. Thus, the time of concentration can be calculated using the following equation:

   $T_c = T_o + T_f$ In which:

   T_c = time of concentration (minutes)
   T_o = initial, or overland flow time (minutes)
   T_f = travel time in the ditch, channel, gutter, storm sewer, etc. (minutes)
   Minimum time of concentration, T_c, shall be 5 minutes.

3. The overland flow time, T_o, in non-urbanized watersheds may be calculated as follows: $T_o = 1.8\ (1.1\text{-}C)(L_o^{0.5})/(S_o^{0.333})$

Where: C = runoff coefficient L_o = length of overland flow, (feet, 500-foot max)

S_o = average basin slope (percent)

4. The equation for overland flow time, T_o, is generally adequate for distances up to 500 feet. For longer basin lengths, the runoff will combine and the sheet flow

assumption is no longer valid. The time of concentration would then be overland flow in combination with the travel time, T_f, which is calculated using the hydraulic properties of the swale, ditch, or channel. The time of concentration is the sum of the overland flow time, T_o, and the travel time, T_f.

C. Runoff Coefficient: The runoff coefficient, C, represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception, all of which affect the time distribution and peak rate of runoff. Determination of the runoff coefficient requires judgment and understanding on the part of the design engineer. The recommended range of C values for different surface characteristics as well as for different aggregate land uses are shown below. Coefficient values selected from the range available shall be consistent with the urbanized percent imperviousness (i.e. minimum percent imperviousness requires minimum runoff coefficient value). Also, for flat slopes and permeable soils, use the lower values. For steep slopes and impermeable soils use the higher values.

Runoff Coefficients/Percent Imperviousness for Rational Method

Land Use or Surface Characteristic	Percent Imperviousness	Runoff Coefficients
BUSINESS:		
Commercial Areas	70 to 95	0.70 to 0.95*
Neighborhood Areas	60 to 80	*
RESIDENTIAL:		
Single Family	35 to 50	0.47 to 0.64*
Multi-unit (detached)	45 to 55	*
Multi-unit (attached)	65 to 75	*
½ acre lot or larger	30 to 45	*
Apartments	65 to 75	*
INDUSTRIAL		
Light uses	70 to 80	*
Heavy uses	80 to 90	
PARKS, CEMETERIES	4 to 8	*
PLAYGROUNDS	40 to 60	*
RAILROAD YARDS	35 to 45	*
STREETS		
Paved	90 to 100	0.95
Gravel	50 to 70	0.65
DRIVES AND WALKS	90 to 100	0.95
ROOFS	85 to 95	0.95
LAWNS		
Sandy Soils	5 to 10	0.10 to 0.20
Clayey soils	10 to 30	0.13 to 0.35

* Runoff coefficient to be calculated using actual impervious area and soil groups. Use values in the following table.

Runoff Coefficients – SCS Hydrologic Soil Groups

Land Use or Surface Characteristic		A	B	C	D
LAWNS AND PASTURES					
Flat	0-2% slope	0.08	0.15	0.22	0.30
Average	2-6% slope	0.13	0.20	0.27	0.35
Steep	greater than 6% slope	0.18	0.25	0.32	0.40
WOODLAND					
Flat	0-2% slope	0.06	0.13	0.20	0.26
Average	2-6% slope	0.11	0.18	0.25	0.31
Steep	greater than 6% slope	0.17	0.23	0.29	0.36
MEADOW					
Flat	0-2% slope	0.05	0.12	0.19	0.25
Average	2-6% slope	0.10	0.17	0.24	0.30
Steep	greater than 6% slope	0.15	0.22	0.29	0.35
CULTIVATED					
Flat		0.20	0.27	0.34	0.40

D. Intensity: The intensity, I, is the average rainfall rate in inches per hour for the period of maximum rainfall of a given frequency having a duration equal to the time of concentration. For a given time of concentration, T_c, and a given design storm frequency, the rainfall intensity, I, can be obtained using the following equation:

$$I = d/(T_c + e)^f$$

Where

I = Rainfall Intensity, inches per hour
T_c = Time of Concentration, minutes
d, e, f = Parameters defined in below

Rainfall Intensity Parameters

Design Storm	Parameter d	e	f
2 Year	56.43	11.5	0.81
5 Year	72	15	0.80
10 Year	82	15	0.80
25 Year	95	15	0.80
50 Year	108	15	0.80
100 Year	120	15	0.80

Source: Drainage Design Manual, ODOT, February, 1988

0505.3 SCS Unit Hydrograph Method

A. Introduction: A hydrograph method shall be used to determine peak runoff rates from watersheds larger than 60 acres, (which is the upper limit of the Rational Method), and for all detention pond analyses. Paragraph 0505.1 indicates methods applicable to various size watersheds. This section contains brief explanations of the various hydrograph methods; however, the design engineer is assumed to be familiar with the basic assumptions and limitations regarding the applicability of the method used.

B. Design storm precipitation:

1. The design storm for the Owasso area shall have a minimum duration of twice the time of concentration for peak flow calculations. For design of detention storage basins, a 24-hour storm shall be used.

2. A precipitation hyetograph shall be used as the input for all runoff calculations. The specified precipitation is assumed to be uniformly distributed over the watershed. The hyetograph represents average precipitation depths over a computation interval.

3. The unit duration incremented shall be in multiples of one, two or five minutes (e.g., 1, 2, 5, 10, or 15-minutes) with the maximum unit duration to be 15 minutes under most circumstances. An acceptable unit storm duration should not exceed one-fifth of the time to peak of the watershed, t_p. As an example, if the watershed has a t_p of 35 minutes, then an appropriate unit storm duration would be five minutes.

C. SCS unit hydrograph method: The Soil Conservation Service (SCS) method is presented in detail in Section 4 of the U.S. Department of Agriculture *Soil Conservation Service Engineering Handbook and Model Drainage Manual*, American Association of State Highway and Transportation Officials, 1991. The SCS computer program TR20 or the U.S. Army Corps of Engineers computer program HEC-1 or HEC-RAS are acceptable ways of utilizing the SCS methodology. The SCS publication TR55 may be used for areas up to 2,000 acres.

0506 STREET DRAINAGE

0506.1 Criteria for Street Drainage

A. Depth in streets: Use of streets for conveyance of stormwater runoff shall be within the following limitations:

1. For the 10-year frequency rainstorm, two driving lanes of arterial streets and one driving lane for collector streets shall remain open. Depth of flow shall not exceed curb height for residential streets. Where no curb exists, stormwater encroachment shall not extend past the street right-of-way.

2. At sump locations, the water depth shall not exceed 12 inches above the top of the grate for the 100-year frequency rainstorm. But in no case, shall the 100-year flow extend beyond the right-of-way.

3. Where sump collection systems are used, a permanent overflow route shall be contained in a dedicated drainage easement providing an emergency bypass in the event of complete blockage of the sump inlets. Where feasible, concrete flumes are the preferred emergency overflow structure.

4. Where driveways are downgrade from the street section, the drive to street transition shall be designed to prevent water from flowing down the driveway.

B. Location of storm sewers: Storm sewer shall not be placed within the wheel path of any driving lane of the pavement. The traffic lane is defined as the normal width provided for each lane and delineated by pavement stripes. The preferred location of the storm sewer is according to the following order of priority listed.

1. Behind the curb

2. Down the center of the traffic lane

3. On centerline

0506.2 Drainage Impact on Streets

A. Sheet flow: To minimize the effects of hydroplaning and splashing of sheet flow, the streets of Owasso shall be designed with a 2% (1/4" per foot) cross slope. In addition, for arterial streets, the amount of flow permitted in the street is limited to the outside lane before a storm sewer inlet is required (Refer to Paragraph 506.1.A).

B. Cross flow: Cross flow over tops of streets is not preferred but, if necessary, shall be accounted for in the drainage calculations and shall be limited to intersections. The depth of flow for the 10-year event shall not exceed 3 inches.

C. Concrete valley gutters: Concrete valley gutters shall be used as necessary to transport flow across the crown of a street, particularly at intersections. Valley gutters should be minimized at locations other than intersections. When a valley gutter is designed for locations other than intersections, a drop inlet shall transport the flow to the stormwater conveyance system. The width of the valley gutter will be determined by the depth required with a side slope of no more than 5% but shall be no less than three feet. Valley gutters shall be constructed with Portland cement concrete and in accordance with Standard Detail STRT-07A.

0506.3 Hydraulic Evaluation

A. Curb and gutter capacity:

1. The allowable storm capacity of each street section with curb and gutter shall be calculated using the modified Manning's formula:

$$Q = 0.56(Z/N)S^{1/2}Y_T^{8/3}$$

Where: Q = discharge is cfs
Z = reciprocal of the street cross slopes (S_x,ft/ft)
Y_T= depth of flow at the gutter (feet)
S = longitudinal grade of street (ft/ft)
N = Manning's roughness coefficient

2. Manning's roughness coefficient, N, shall be used according to the applicable construction condition as shown below.

Manning's N-values for Street Gutters

Construction Type		N
Concrete gutter troweled finish		0.012
Asphalt Pavement		
	Smooth texture	0.013
	Rough texture	0.015
Concrete gutter with asphalt pavement		
	Smooth	0.013
	Rough	0.015
Concrete pavement		
	Float finish	0.014
	Broom finish	0.016
Brick		0.016

Note: For gutters on flat grade where sediment may accumulate, increase all above values of N by 0.002.
Source: Drainage Design Manual, ODOT, February, 1988

3. When the street cross section has different cross slopes, capacity computation shall take into account the various cross slopes.

4. Calculations for inlets, pipes, and gutter flow shall be summarized and tabulated on the plans.

B. Roadside ditch capacity: The capacity of a roadside ditch shall be computed using Manning's equation. The allowable flow over the paved portion of the street is computed according to Paragraph 0506.3.A. This capacity of the roadside ditch and street capacity are combined to determine the entire street section capacity. The paved street portion contributes to the total capacity only when the depth of flow in the roadside ditch is exceeded for the design storm. As in streets with curb and gutter, the maximum allowable depth at the pavement edge shall not exceed the limits set in Paragraph 0506.1.A. Borrow ditches shall not exceed three (3) feet deep with maximum side slopes of 3:1 H:V (4:1 H:V preferable).

0507 STORM SEWER INLETS

0507.1 Design Criteria

A. Inlet types:

1. Four types of inlets are used in the City of Owasso: curb opening inlets, combination grated with curb opening inlets, median inlets, and area inlets. Multiple inlets occur when more than one inlet (of the same type) are used in a continuous series, resulting in greater flow interception capacity.

2. Inlet types shall be in accordance with the City's Standard Details.

3. On arterial streets offset type inlets, ODOT Standard SSCD-1-15, shall be used.

B. Location of inlets:

1. Inlets shall be located at all low points in the gutter grade, on side streets at intersections where runoff would flow onto an arterial street or highway and upgrade of bridges to prevent runoff from flowing onto the bridge deck. Inlets are also required when the allowable depth of flow in the gutter is exceeded. Inlets shall not exceed 600-foot spacing unless special conditions prevent such spacing and shall be approved by the Engineer.

2. Inlets at intersections shall be located in such a manner that no part of the inlet will encroach upon the curb return. No drainage structure shall be permitted at a wheelchair ramp. Inlets on a continuous grade in the interior of a block should be placed upstream of a nearby driveway, if possible. The flowline and top of curb elevations shall be shown on all inlets.

3. Runoff from areas greater than one half (½) acre outside the roadway shall be collected before it reaches an arterial or collector street. Parking lots shall have internal drainage systems so as to reduce concentrated flows into streets. This item does not apply to single-family residential lots on local streets.

C. Time of concentration: A maximum T_c of 5 minutes to the first inlet shall be used for commercial and industrial areas.

D. Spacing between inlets: Spacing between inlets shall be such that depths of flow and widths of spread requirements are not violated. <u>Maximum spacing shall be 600 feet.</u>

E. Interception and bypass:

1. No more than 25% of the street runoff shall be allowed to bypass an inlet and the remaining flow shall be intercepted at the next inlet. As many of the inlets as possible shall be sump inlets.

2. The design engineer will determine the type of inlet to be used and the percent of flow to be intercepted at a particular location.

3. Hydraulic design of inlets shall be in accordance with Paragraph 0507.2.

F. Inlets in sump conditions:

1. When inlets are placed in a sump, emergency overflow shall be provided as described in Paragraph 0506.1. The drainage easement for this overflow must be shown on the plat for the development.

G. Clogging Factors

1. Hydraulic design charts presented in the document were developed with the assumption that all openings are clear, i.e., no portion of the curb or grate opening is clogged with any sort of debris. Clogging is a function of the frequency of the street sweeping and maintenance activities.

2. The following clogging factors are required to deduce the theoretical interception given by the hydraulic design charts. A clogging factor of 0/8 is interpreted to mean that the intercepted discharge obtained from the charts is multiplied by 0.8 to obtain the allowable capacity, i.e., the allowable capacity of the inlet is 80% of the theoretical capacity. The method by which these clogging factors are incorporated with the hydraulic design charts is detailed in Paragraph 0507.2.

INLET TYPE	INLET LOCATION	CLOGGING FACTOR
Curb opening only	**Continuous grade**	**0.8**
Curb opening only	**Sump**	**0.8**
Combination curb and grate	**Continuous grade**	**1.0**
Combination curb and grate	**Sump**	**0.7**
Median	**Sump(1)**	**0.8**
Grate only(2)	**Continuous grade**	**0.6**
Grate only(2)	**Sump**	**0.5**

Notes: (1) Because of the grading required around a median inlet, the inlet only operates in a sump condition during design flows.

(2) Inlets with grates only are not permitted but are included in the table for evaluation of existing conditions.

3. The curb inlets shall be located such that, on four-lane streets, at least one driving lane (each way) has no water and, on two-lane streets, the width of one traffic lane is open.

0507.2 Hydraulic Evaluation

A. Methodology: Curb/grate inlet capacities shall follow industry specified methods.

B. Grated inlets:

1. Grated inlets (at curb) without curb opening are not permitted.

2. Bicycle safe grates (in combination with curb openings) are the only grates approved by the City of Owasso within the street right-of-way.

3. When a grate is used in conjunction with a curb opening directly behind the grate, only the hydraulic capacity of the grate shall be utilized to estimate the flow that is intercepted, since the curb inlet portion is reserved to serve as overflow when the grate is blocked by debris.

4. Grate interception capacities shall be determined for the specific grate to be used in the project. For example, if the grate inlet is manufactured by Neenah Foundry, use Neenah's method of computing the capacity.

C. Curb opening inlets: Curb opening inlets shall be manufactured cast iron inlets.

D. Tabulations: Drainage areas, 10-year and 100-year flows shall be summarized and tabulated on the plans. The table shall also be a part of the Engineering Report.

0508 STORM SEWER PIPE SYSTEM

0508.1 Introduction

A "storm sewer system" refers to a system of inlets, pipes, manholes, junctions, outlets; and other appurtenant structures designed to collect and convey storm runoff to a defined drainageway. A "drainage system" also includes curbs and gutters, roadside ditches, swales, channels, and detention systems for the control of overland runoff. A storm sewer system is required when other parts of the drainage system no longer have the capacity for additional runoff without exceeding the design criteria.

0508.2 Design Criteria

A. Design storm frequency:

1. The storm sewer system, beginning at the upstream end with inlets, is required when the allowable street capacity or overflow capacity is exceeded for the design storm. The storm sewer system should be designed for the larger of the following two events to prevent violation of the criteria in Subsection 0506:

   a. The flow equal to the difference between the 10-year storm and the allowable street capacity (as stated in Paragraph 0506.1.A.1) OR

   b. The flow equal to the difference between 100-year storm and the capacity within the street right-of-way.

2. The intent is to intercept the 10-year flood and convey the flow in a storm sewer. However, it is impractical to intercept all the runoff in the street at the inlet and some "carry-over" flow will occur. The procedure simply puts a limit on the amount of carry-over flow that can occur in the street.

B. Construction materials: Storm sewers within the City of Owasso shall be constructed using reinforced concrete, high-density polyethylene (HDPE) or coated metal alloy. The materials, pipes, and appurtenances shall meet the requirements of the City's Standard Details

C. Vertical alignment:

1. Minimum cover: For pipe under paved areas, the sewer grade shall be such that a minimum cover is maintained to withstand AASHTO HS-20 loading on the pipe. The minimum cover depends upon the pipe size, type and class, and soil bedding conditions, but shall not be less than one foot from the top of pipe to the finished grade at any point along the pipe. If the pipe encroaches into the street sub-grade, a variance must be granted by the Engineer.

2. Manholes: Manholes will be required whenever there is a change in size, alignment, elevation grade and slope, or where there is a junction of two or more

sewers. For sewers equal to or larger than 60 inches in diameter, pre-formed smooth transitions shall be approved by the Engineer. The maximum spacing between manholes for various pipe sizes shall be as shown below.

Storm Sewer Alignment and Size Criteria

Manhole Spacing

Pipe Size	Maximum Spacing-Manholes	Minimum Manhole Size
15 to 24 Inches	300 Feet	4 Feet
27 to 42 Inches	400 Feet	5 Feet
48 Inches	500 Feet	6 Feet
54 to 66 Inches	500 Feet	8 Feet
>66 Inches	500 Feet	Junction Structure

Minimum Radius For Radius Pipe:

Short radius bends shall not be used on 36-inch diameter or less for public systems.

Minimum Pipe Diameter:

Type	Minimum Equiv. Pipe Dia.	Minimum Cross-Section
Main trunk	15 Inches	1.23 Sf
Lateral from Inlet	15 Inches	1.23 SF

Source: *Stormwater Criteria Manual*, City of Tulsa

3. Water main separation: The minimum vertical clearance between storm sewer and water main (for new construction), either above or below shall be 24 inches. Ductile iron pipe (with proper bedding) or concrete encasement of the water line will be required for clearances of 24 inches or less when the clearance between existing water mains cannot be maintained.

4. Sanitary sewer separation: The minimum vertical clearance between storm sewer and sanitary sewer (for new construction), either above or below, shall be 24 inches. In addition, when an existing sanitary sewer main lies above a storm sewer, or within 24 inches below, the sanitary sewer shall have impervious encasement or be constructed of ductile iron or PVC water pipe for a minimum of 10 feet on each side of the storm sewer crossing.

5. Siphons: Siphons or inverted siphons are not allowed in the storm sewer system.

6. The hydraulic grade line (HGL) and energy grade line (EGL) shall be shown on stromwater profile sheets (see Paragraph 0508.2 F.2). The HGL shall be at or above the level of normal pool elevations for permanent pool (wet) detention ponds. No outlets shall be designed to discharge below the normal pool.

D. Horizontal alignment:

1. Storm sewer alignment between manholes shall be straight except when accepted in writing by the Engineer. Approved curvilinear storm sewers may be constructed using pipe bends or radius pipes.

2. A minimum horizontal clearance of ten feet is required between sanitary and water utilities and the storm sewer. When it is not possible to obtain the required clearance, pipe shall be constructed per Subchapter 9 of the ODEQ Administrative Code, Chapter 655.

3. The storm sewer shall be behind the curb within the street right-of-way.

4. Manholes and catch basins shall be stationed on the plan sheets using centerline stationing with left or right offset dimensions. Inlets with grates shall be stationed at the centerline of the grated section.

E. Pipe size: The minimum allowable pipe size for storm sewers shall be 15 inches. Storm sewer shall be closed conduit up to 60-inch diameter pipe or its hydraulic equivalent. Stormwater drainageway systems that must carry a flow greater than the capabilities of a 60-inch conduit system may be a closed system, an improved channel constructed in accordance with the Standard Details and floodplain policies, or an unimproved channel in accordance with floodplain zoning ordinances.

F. Storm sewer capacity and velocity:

1. The capacity and velocity shall be based on the Manning's n-values presented in Subsection 0506. The maximum full flow velocity shall be less than 20 feet/sec. Higher velocities may be accepted by the Engineer if the design includes adequate provisions for uplift forces, dynamic impact forces and abrasion. The minimum velocity in a pipe based on full flow shall be 2.5 feet/sec to avoid excessive accumulations of sediment.

2. The hydraulic grade line (HGL) shall be shown on all profiles of storm sewers including more than one pipe section. The energy grade line (EGL) for the design flow shall be no more than one foot above the final grade at manholes, inlets, or other junctions. To insure that this objective is achieved, the HGL and the EGL shall be calculated by accounting for pipe friction losses and pipe form losses. Total hydraulic losses will include friction, expansion, contraction, bend, manhole, and junction losses.

3. Box culverts and bridges shall have adequate capacity to pass 100-year fully urbanized flows with a minimum of 12 inches freeboard to the crown of the roadway. Backwater analysis shall be provided by the consulting engineer to illustrate compliance with this requirement.

G. Miscellaneous criteria:

1. No pipe shall be installed downstream having a smaller capacity than the upstream pipe or combination of upstream pipes.

2. Concrete pipe shall not be less than C-76, Class III.

3. HDPE pipe shall be AASHTO M-294 corrugated outside with a smooth core.

4. Circular Pipe – All joints shall be a confined O-ring gasket meeting ASTM C443. All pipe 36 inches in diameter and smaller shall have bell and spigot joints. Pipe larger than 36 inches in diameter may have tongue and groove joints. If the hydraulic grade line is less than 6 inches above the top of the pipe during the 100-year event, the O-ring gaskets may be omitted, provided each joint is wrapped with 24 inches of approved filter fabric.

5. Junctions between different pipe sizes shall be made with the top inside of the downstream pipe no higher than the top inside of the upstream pipe.

6. Manholes or junction boxes shall be required at all changes in grade, alignment and junctions between two or more different pipe sizes.

7. The horizontal clear distance between pipes being placed in the same trench shall be a minimum of 24 inches or one-third the diameter of the largest pipe, whichever is greater. This application includes multiple pipes for culverts.

8. The largest diameter storm sewer entering or exiting a 4-foot diameter manhole shall be 24 inches. Junction boxes shall be installed when 4-foot diameter manholes cannot be used.

9. Drainage pipes shall not enter manholes within the Corbel (neck down) section.

10. All headwalls and slopewalls shall be concrete.

11. Pipes discharging at a steep gradient into drainageways and detention facilities shall be provided with a slope wall.

12. Preformed end sections are not allowed. Concrete wingwalls with aprons or concrete slope walls shall be installed.

13. Discharge points with 18-inch pipe or larger shall be fitted with a protective grate to prevent access into the pipe.

H. Storm sewer inlets and outlets:

All storm sewer outlets into open channels shall be constructed with a concrete slopewall or headwall with wingwalls. Erosion control measures shall be taken on all headwall and slopewall applications. When the outlet velocity exceeds six feet per second (6 fps), energy dissipaters shall be provided for energy dissipation.

0509 OPEN CHANNELS

0509.1 Channel Design

A. Design: Channels shall be designed in accordance with sound engineering principles.

B. Channel geometry:

1. Trapezoidal channels: Trapezoidal channels shall have a minimum bottom width of 4 feet with side slopes of not steeper than 3.5 to 1 for sodded sections and a minimum bottom width of 4 feet with side slopes of not steeper than 1:1 for paved or rock lined sections. Where the public may be exposed to hazards and nuisances of open channels, appropriate measures shall be taken to exclude the public from the perilous area.

2. Rectangular channels: Rectangular channels shall be approved by the Engineer before design is begun. All rectangular channels are to be concrete on all sides.

C. Manning's N-value: Manning's equation in the calculations of hydraulic characteristics of channels will be acceptable. The "N" value used for channels shall be based on the individual channel characteristics, as shown below. Designers should anticipate growth of future vegetation as a natural maturation process of the channel. Values less than 0.05 shall be justified by the design engineer.

Manning's N-Value for Open Channels

Channel Type	N-Value Range	Recommended Value
Grass-lined, maintained	.029 to .100	
Grass-lined, not maintained	.045 to .10	.035
Natural Streams	.025 to .100	Note (1)
Riprap Lined		
1. Ordinary riprap	.025 to .050	.035
2. Gabions	.025 to .050	.035
3. Grouted riprap	.023 to .030	.027
4. Slope mattress	.025 to .033	.028
Concrete Lined		
1. Float finish	.013 to .016	Note (2)
2. Slip formed	.013 to .016	Note (2)
3. Gunite	.016 to .023	Note (2)

Notes:
1. Source: Chow, V.T., Open Channel Hydraulics, McGraw-Hill Book Company, 1959, and pictures
2. High value used for capacity determination and low value used for velocity consideration

D. Minimum slope: Channels shall have minimum slopes of 0.1% for concrete-lined channels and 0.2% for grass lined channels. Variations must be approved.

E. Minimum velocity: Minimum velocity in a drainageway system, having a roughness coefficient less than or equal to 0.015, shall be 2.5 feet/sec to avoid sedimentation.

F. Maximum velocities: Velocities shall not exceed 6 feet/sec for sections sodded in grass. Velocities in concrete lined or paved sections shall not exceed 15 feet/sec. The dissipation of energy shall be required at the confluence of improved channels with natural channels through the use of dissipaters, stilling basins and etc. which shall be designed in accordance with FHWA HEC #14 *Hydraulic Design of Energy Dissipaters for Culverts and Channels Drainage Manual*.

G. Freeboard: The design water surface elevation should be kept within the channel banks. Any deviation from this requirement requires approval of the Engineer. A 1-foot freeboard above the energy grade line should be added to calculated flow depths to determine minimum channel depths.

H. Alignment: The centerline radius of a curve on an improved channel shall be a minimum of three (3) times the maximum top width at the design flow depth.

0509.2 Channel Types

A. Trickle channels: All channels altered or improved from the natural state will require a paved trickle channel unless a variance is granted by the Engineer. Sodding, or other methods of erosion control shall be required adjacent to the paved channel.

B. Concrete flumes: Concrete flumes in lieu of enclosed pipe shall be allowed as overflow protection for storm sewer systems, and to drain areas not exceeding five (5) acres in size. All concrete flumes shall extend to the rear of adjacent lots and shall discharge into a dedicated drainage facility or channel. There will be no special freeboard requirement for concrete flumes.

C. Rectangular concrete channels: Concrete channels shall be designed to withstand the earth loads while the channel is not in use. The thickness of the vertical concrete walls shall be a minimum of 12 inches. Weep holes and under drains shall be installed to prevent floatation.

D. Fill areas: When storm sewers are placed in fill areas, all materials in the fill area shall be constructed to a 95% standard proctor density prior to the laying of the pipe.

E. Roadside ditches: Roadside ditches shall conform to requirements of this section.

0509.3 Floodplain Data

Base Flood Elevation (BFE) or floodplain boundary changes shall be approved by FEMA via the development and approval of a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR).

0510 HYDRAULIC STRUCTURES

0510.1 Definitions

A. Culverts: A culvert is defined as a closed conduit for the passage of water under an embankment, such as a road, railroad, or driveway. The distinction between a culvert and a sewer is the means by which flow enters the conduit. Flow normally enters a culvert by an open channel, generally at a similar elevation and a culvert usually crosses a street.

B. Bridge: A bridge is constructed with abutments and superstructures, which are typically concrete, steel, or other materials. Since the superstructures are generally not an integral structural part of the abutments, and are therefore free to move, the hydraulic criteria for bridges is different than for culverts. Bridges are also usually constructed with earth or rock inverts, whereas culverts are typically the same material throughout the waterway opening.

0510.2 Culverts

A. Construction materials: Culverts shall be constructed of reinforced concrete. Other materials may be used on a case-by-case basis on acceptance by the Engineer.

Culvert Materials

Pipe Material	**Standard**
Reinforced Concrete Pipe	
Round	ASTM C-76 or AASHTO M-170
Elliptical	ASTM C-507 or AASHTO M-207
Arch	ASTM C-506 or AASHTO M-206
HDPE Pipe	AASHTO M-294
Pre-cast Concrete Manholes	ASTM C-478 or AASHTO M-199
Pre-cast Concrete Box	ASTM C-789/C-500,AASHTO M-259/273 or ODOT
Concrete Cast-in-Place Box	ODOT Standard

B. Sizing method: Culvert design shall follow the methodology presented in *Hydraulic Design of Highway Culverts*, Hydraulic Design Series HDS No. 5, FHWA, U.S. Department of Transportation and *Drainage Manual*, Oklahoma Department of Transportation, 1992.

C. Design frequency: Minimum design frequency for culverts shall be 100-year.

D. Minimum size:

1. Pipe Culverts: 18-inch diameter equivalent.

2. Box Culverts: 3 feet wide, 3 feet in height.

E. Velocity limitations:

1. In design of culverts both the minimum and maximum velocities must be considered. A minimum velocity of 2.5 feet/sec at the outlet is required to assure a self-cleaning condition of the culvert.

2. The outlet area shall include a headwall with wingwalls or an end-section in addition to the riprap protection if required. Where outlet velocities exceed six feet per second, erosion control measures shall be taken. Energy dissipaters shall be provided as required.

F. Structural design: Culverts shall be designed to withstand an HS-20 loading in accordance with the design procedures of AASHTO *Standard Specifications for Highway Bridges* and with the pipe manufacturers' recommendations. The minimum cover over top of the pipe shall be 12 inches unless otherwise accepted by the Engineer.

G. Driveway crossings: Driveway culverts shall be sized to pass the 10-year ditch flow capacity without overtopping the driveway. The minimum size culvert shall be a 15-

inch round pipe, or equivalent, for all streets. Sloped headwalls required per the City's Standard Details.

0510.3 Bridges

A. Bridge sizing criteria: The sizing criteria set forth in Paragraph 0510.2 for culverts shall apply as follows:

1. Freeboard: Freeboard is defined as the vertical clearance of the lowest structural member of the bridge superstructure above the water surface elevation of the design frequency flood. The minimum freeboard shall be 1 foot for the 100-year frequency flood, unless accepted by the Engineer.

2. Backwater: Backwater is defined as the rise in the flood water surface due to the restrictions created by the construction of the bridge. The maximum backwater shall be 1 foot.

B. Velocity limitations: The velocity limitations through the bridge opening are controlled by the potential abutment scour and subsequent erosion protection provided. When using riprap for the channel lining and/or protection of the abutments and wingwalls, the maximum channel velocity is limited to 15 feet/ sec.

C. Hydraulic analysis: The hydraulic design of bridge crossings shall be in accordance with *Drainage Manual*, Oklahoma Department of Transportation, most current version.

D. Inlet and outlet configuration: The design of bridges shall include adequate wingwalls of sufficient length to prevent abutment erosion and to provide slope stabilization from the embankment to the channel. Concrete aprons on the inlet and outlet transition slopes shall be provided to protect from the erosive forces of eddy current.

E. ODOT standards: Bridges shall be designed in accordance with AASHTO/ODOT criteria. Rails shall comply with ODOT Standard Details.

0511 STORAGE AND INFILTRATION

0511.1 General

A. Generally, urbanization results in more impervious area and a reduction in floodplain storage, both of which contribute to increased flow rates. The development plan and/or Engineering Report shall incorporate permanent, post-construction means (such as basins, ponds, infiltration trenches, dry wells and porous pavement) to provide for storm water infiltration, and reduce erosion and sediment transport.

B. If improvements are made to any natural channel downstream from an area which requires a minimum pipe diameter of 48 inches to discharge a 10-year frequency storm, current floodplain storage must be maintained.

C. The detention storage shall accommodate the excess runoff from a 100-year frequency storm. The excess runoff is that runoff generated due to urbanization which is greater than the runoff historically generated under existing conditions, for a given frequency storm. Detention facilities shall be designed so that the peak rate of discharge does not exceed that of the pre-development conditions for all storm events up to and including the 100-year event. Furthermore, facilities shall be designed to minimize increase in runoff volume and avoid detrimental effect to adjacent and downstream properties. Detention shall be provided for all storms.

D. Outlets for the stormwater collection system discharging into a detention area with a permanent pool shall be designed such that no outlet discharges below the normal pool.

E. Final as-built topography shall be provided to the Engineer to assure the detention area was constructed as designed.

F. Maintenance of the basin shall be the Developer's responsibility during and following infrastructure installation until such time as the homeowner's association assumes the responsibility.

G. Parking surfaces shall not be used for storm water detention unless allowed by special approval in infill areas only.

0511.2 Design Criteria

A. Flow determination methods: For determining the design flow to storage facilities, the methods contained in Paragraph 0505.1 are approved. For detention design, SCS or Snyders hydrograph methods shall be used.

B. Existing ponds and channel storage shall be used in flood routing under pre-existing conditions.

C. Design storm: The design storms for detention shall have a duration of 24 hours. Rainfall depths shall be in accordance with Subsection 0504.

D. Engineering report: All calculations for detention facilities shall be submitted for review by the Engineer. The submittal shall include hydrographs for both existing and developed conditions, detention facility stage-area-discharge relationships, outlet structure details, and a stage versus time analysis through the facility.

E. Time increment: The time increment used in developing the rainfall distribution and in reading off the ordinates of the unit hydrograph may be rounded off to the nearest whole time interval or to the nearest time increment.

F. Rainfall patterns: Rainfall patterns shall be consistent with the modeling technique used. An SCS Type II synthetic storm distribution is preferred.

G. Planning: Floodplain areas and detention facility locations shall be identified at the preliminary plat stage to illustrate how these areas will be managed during and after construction.

H. Backwater analysis: If a tract of land under development has a floodplain area within its boundary, the information that must be furnished either with the preliminary plat or before the final plat is submitted, shall include:

1. A backwater analysis on the existing drainage system.

2. A backwater analysis on the proposed drainage system.

I. Location:

1. Detention facilities shall be located in areas acceptable to the City. Each facility shall incorporate methods to minimize erosion and other maintenance reducing designs.

2. Detention facilities are not to be located in non-accessible areas which may demand continued high maintenance costs.

J. Additional storage:

1. If the detention facility is approved by the City to serve areas outside the subdivision in which it is located, such additional areas shall be specifically identified in the provision for detention.

2. Additional detention storage, in excess of the required storage for a drainage area, can be provided to satisfy the detention requirements for a tract of land downstream of the detention facility, providing the detention facility is constructed prior to the development of the downstream tract.

K. Detention consolidation: A minimal number of detention facilities is encouraged for each development. Regional detention facilities are encouraged for phased or cooperative development in a drainage basin. For phased developments, detention facilities shall be constructed in the first phase.

L. Multiple drainage areas: If runoff has a natural tendency to drain in several directions for a given development tract of land where detention is required, then detention storage shall be provided for the largest drainage area. Additionally, detention storage may be provided at the same facility in order to satisfy detention requirements for a separate drainage area on the same development, provided that;

1. The whole development tract of land is in the same local watershed.

2. The smaller drainage area(s) that, has/have been compensated for does/do not, either singly or in combination, adversely impact the health, welfare and safety of the general public downstream.

M. Diverting drainage courses: If a tract of land being developed is located in more than one watershed, grading work to divert flows from one watershed to another will not be permitted without proper detention facilities for all watersheds.

N. Platting: The detention area shall be identified as a separate platted area. As appropriate, it may consist of one or more platted lots, a separate block, or it may be identified as a reserve area.

O. Restrictive covenants: Provision for the detention facility shall appear among the plat's restrictive covenants.

P. Future improvements: In the event the detention facility as (a result of drainage improvements) becomes unnecessary by action of the City Council, the facility may be vacated as provided for in the covenants or applicable law.

Q. Ingress/Egress: An access way at least 20 feet wide shall be provided to any required detention area. Access may be provided by frontage on a dedicated public street or by an access easement from a dedicated public street to the detention area.

R. Embankment: Any dam or berm shall be designed in accordance with the dam safety criteria of the Oklahoma Water Resources Board. The core of the dam shall be impermeable clay.

S. Maintenance: The maintenance responsibility for on site detention facilities shall remain with the private sector and appropriate covenants shall be obtained to secure such maintenance.

T. Permanent pool (wet) detention ponds: Wet ponds shall be reviewed on a case-by-case basis. Ponds shall be designed to discharge as described above. The post-development discharge rate shall not exceed the pre-development discharge conditions for all storm events up to and including the 100-year event.

0511.3 Physical Features

A. General: Detention dams or dikes shall be constructed as earth filled and non-overflow type dams.

B. Top of berm: Spillways shall be constructed to pass the 500-year flood event with a minimum of 12 inches of freeboard on the earth dam structure unless the structure falls into a category requiring more stringent criteria. Cross sections shall be provided indicating the 5-, 100- and 500-year pool elevations.

C. Side slopes: Side slopes on detention facilities shall not be steeper than 4 horizontal to 1 vertical.

D. Access road: Access road, with grade of 10% or less, shall be provided to the detention areas for maintenance purposes.

E. Low flow trickle channel: Detention facilities shall be provided with a low flow concrete trickle channels from the inlet(s) to the outlet structure to transmit low flows.

F. Outlet structures: Storm sewer outlets into detention pondd shall consist of pipes and/or concrete structures and shall be protected by a reinforced concrete headwall or slope walls (for 24-inch or less diameter pipe) with energy dissipaters as a minimum control measure. The hydraulic grade line (HGL) at discharge shall be above the normal pool elevation.

G. Erosion control: All earth slopes and earth areas subject to erosion, such as, adjacent to low flow channels, inlet structures, and outlet structures shall be slab sodded with bermuda sod or protected with other approved erosion control measures. All other earth surfaces, within the area designated for detention facility site, shall have an established growth of bermuda grass. All covered areas shall be fertilized, watered and in an established growing condition prior to completion and acceptance of the detention facility. Requirements of Section 0600, Stormwater Pollution Prevention shall apply.

0511.4 Fee-in-Lieu of Regional On-Site Detention

A. Requirement: Detention facilities shall be designed using the City's hydrologic model and the hydraulic model for the watershed (if available). A Developer shall satisfy his requirement to provide for detention by contributing to the construction of a planned regional detention facility unless it is determined by the Engineer that on-site detention is required because of downstream capacity problems. If a hydrological model is not available for the watershed basin, the Developer must furnish a complete hydrological model at the Developer’s expense before fee-in-lieu-of detention can be considered.

B. Contribution amount: The contribution shall be the maximum of either the appropriate percentage of the actual flow contributed or the amount determined as an appropriate portion of the cost of a regional detention facility.

C. Financing: The City shall administer financing with all funds paid before construction.

D. Regional detention: The boundaries of watersheds and priority of acquisition of regional and sub-regional detention sites and construction of detention facilities and location thereof shall be established by the Engineer and approved by City Council. The City will determine if fee-in-lieu of on-site detention is applicable to a specified site.

0512 EROSION AND SEDIMENTATION CONTROL

Criteria for erosion and sediment control is included in Section 0600, Stormwater Pollution Prevention.

0513 APPLICABLE STANDARD DETAILS

STRM-01	Storm Sewer Pipe Installation
STRM-02	Storm Sewer Joint Wrapping Detail
STRM-03	Configuration of Cast Iron Curb Inlets
STRM-04	Storm Sewer Inlet Frame-Type A
STRM-05	Storm Sewer Inlet Frame-Type B
STRM-06	Storm Sewer Inlet Frame-Type C
STRM-07	Curb Inlet-Sheet I
STRM-08	Curb Inlet-Sheet II

STRM-09	Area Inlet
STRM-10	Storm Sewer Box Grate
STRM-11	Storm Sewer Box Culvert
STRM-12	Storm Sewer Headwall-Sheet I
STRM-13	Storm Sewer Headwall-Sheet II
STRM-14	Concrete Slopewall Channel with Underdraw
STRM-15	Concrete "U" Channel
STRM-16	Grass-Lined Channel-Type A
STRM-17	Grass-Lined Channel-Type B
STRT-07A	Valley Gutter

END OF SECTION

Section 9
Financial Analysis

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MESHEK & ASSOCIATES, PLC

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SECTION 9. FINANCIAL ANALYSIS

9.1. Background

One of the most significant benefits of the Comprehensive Storm Water Master Plan developed for the City of Moore is a prioritized list of recommended projects. Meshek performed a financial analysis to evaluate potential funding options for implementation of the capital improvement recommendations. Additionally, the City of Moore has ongoing expenses related to the TMDL requirements of Lake Thunderbird and the annual costs of implementing the Municipal Separate Storm Sewer Program.

9.2. Prioritization

A total of 35 improvement projects were recommended to address drainage issues throughout the City of Moore based on the hydrologic and hydraulic analyses conducted during the CSWMP. The total estimated cost of the implementation of these projects is in excess of $27.9M. From this list of improvement projects, 10 have been identified as short-term priority due to their score ranking in the prioritization process. The total estimated cost of these projects is approximately $17M. The priority assessment for each of the flooding problem areas and associated improvement projects was determined through several objective scoring criteria. The detailed prioritization of project criteria for recommended alternatives in the City of Moore MDP can be found in **Appendix 9-A**. The listed criteria below, describes a high scoring and significant flooding problem or associated improvement.

- Flooding Problem has a Documented Death or Serious Injury
- Improvement Increases Bridge/Culvert Capacity from 1-Year to 100-Year
- Improvement Removes Residential Structures from 10-Year Flood
- Improvement Aids Emergency Route Access
- Improvement Directly Affects 100+ Acres
- Frequency of Flooding Problem is Constant or occurs Every Rain Storm
- Flooding Problem has Existed Greater than 40 Years
- Improvement would Provide Positive Environmental Impact
- Improvement would Aid to Protect Public Infrastructure
- Existing Stormwater System's Physical Condition is Degraded or Nonexistent
- Majority of Funding for Improvement is from Outside Sources
- Improvement Aids Private Investment
- Short Range Project Outlook Time Frame

Currently, the City of Moore does not have the capacity to immediately fund each of the recommended improvement projects. The city will initially plan to spread the projects out over several years in order to attain the required funding through various grants, bonds, or allocations for the application to stormwater infrastructure. As funding sources are identified or become available, the City of Moore will implement specific improvement projects determined by either priority, funding constraints, or to coincide with other infrastructure construction projects. This prioritized list of improvements should be regularly updated and serve as a capital improvements program. A list of these projects is shown in Table 9-1.

Table 9-1. Prioritized List of Improvements

Proirity	Basin	Problem Area	Project Description	Cost	Score
Short-Term	Section 3 - Little River	Problem Area 3	Janeway Ave. at Little River	$ 5,500,000	100.9
Short-Term	Section 6 - North Fork River	Problem Area 5	N. Bryant & North Fork River	$ 1,000,000	78.8
Short-Term	Section 3 - Little River	Problem Area 6	Acquisition, Channel and Storm Sewer Improvements	$ 364,500	76.6
Short-Term	Section 6 - North Fork River	Problem Area 12	Ramblin Oaks Storm Sewer	$ 4,702,000	74.9
Short-Term	Section 3 - Little River	Problem Area 13	19th & BNSF Storm Sewer Improvements	$ 1,763,300	61.9
Short-Term	Section 3 - Little River	Problem Area 23	S. Bristow Storm Sewer	$ 389,500	61.9
Short-Term	Section 3 - Little River	Problem Area 10	Broadmoore Drainage Improvements	$ 421,400	60.8
Short-Term	Section 4 - Stream E	Problem Area 7	31st & Santa Fe (Oak Ridge) - Storm Sewer & Grading	$ 650,200	57.9
Short-Term	Section 6 - North Fork River	Problem Area 16	20th & Lincoln Storm Sewer Improvements	$ 2,207,900	57.0
Short-Term	Section 6 - North Fork River	Problem Area 11	5th & Post Oak Detention	$ 246,400	56.5
Mid-Term	Section 3 - Little River	Problem Area 4	Irving Dr. at Little River	$ 3,998,400	54.1
Mid-Term	Section 6 - North Fork River	Problem Area 20	Foxfire Subdivision Storm Sewer & Channel	$ 348,400	54.0
Mid-Term	Section 3 - Little River	Problem Area 11	24th & Eastern Drainage Improvements	$ 68,800	53.5
Mid-Term	Section 6 - North Fork River	Problem Area 8	Stream A 34th & Sooner Culvert	$ 468,200	52.9
Mid-Term	Section 6 - North Fork River	Problem Area 6	NE 12th St	$ 1,351,600	51.8
Mid-Term	Section 3 - Little River	Problem Area 2	Alternative 2: Detention and I-35 Culvert	$ 1,644,700	50.9
Mid-Term	Section 6 - North Fork River	Problem Area 19	Bryant & NE 15th Culvert	$ 26,000	46.9
Mid-Term	Section 6 - North Fork River	Problem Area 2	Anns Pl Flooding	$ 108,500	46.9
Mid-Term	Section 3 - Little River	Problem Area 22	North Nail Parkway Improvements	$ 1,322,600	46.8
Mid-Term	Section 6 - North Fork River	Problem Area 10	The Falls Drainage Improvements	$ 21,100	44.9
Mid-Term	Section 3 - Little River	Problem Area 16	5th & Howard Channel Improvements	$ 45,200	43.9
Long-Term	Section 6 - North Fork River	Problem Area 7	Stream A and Sooner Dr Detention	$ 414,900	43.0
Long-Term	Section 7 - Stream D	Problem Area 2	SE 12th & Eastern Culvert	$ 199,700	42.9
Long-Term	Section 7 - Stream D	Problem Area 1	Autum Dr Cul-de-sac	$ 15,700	42.6
Long-Term	Section 5 - Canadian River Tribs	Problem Area 4	Hillcrest Ave between Cass Ave & NW 27th	$ 29,400	37.0
Long-Term	Section 4 - Stream E	Problem Area 9	34th & Pin Oak Culvert	$ 27,000	35.9
Long-Term	Section 7 - Stream D	Problem Area 6	Craig Dr & Highlander Dr	$ 88,200	33.9
Long-Term	Section 5 - Canadian River Tribs	Problem Area 3	Robinson & 7th Pl	$ 17,600	30.9
Long-Term	Section 6 - North Fork River	Problem Area 18	Park Pl & 23rd St Channel	$ 29,400	29.9
Long-Term	Section 7 - Stream D	Problem Area 3	Cindy Brook Lane Cul-de-sac	$ 95,000	29.9
Long-Term	Section 3 - Little River	Problem Area 15	South Howard Drainage Imrpovements	$ 363,900	29.8
Long-Term	Section 6 - North Fork River	Problem Area 15	Wyndemere Lakes Dr Storm Sewer	$ 48,000	26.9
Long-Term	Section 3 - Little River	Problem Area 12	28th & Elmo Drainage Improvements	$ 14,800	25.8
Long-Term	Section 3 - Little River	Problem Area 24	1st & Bristow Channel Improvement	$ -	19.8
Long-Term	Section 3 - Little River	Problem Area 9	Detention for Westermeir Subdivision Flooding	$ -	19.0
			Total	**$ 27,992,300**	

9.3. Funding Needs

In the past, the City of Moore has not tracked the implementation costs of the MS4 program. The most recent SWMP developed with the 2016 permit application encourages the City to track all costs associated with the program. It is estimated that the implementation costs of the program will be $65,000 to $85,000 annually for the foreseeable future.

In the spring of 2016, the City submitted a TMDL Compliance and Monitoring Plan to the Oklahoma Department of Environmental Quality (ODEQ). The most significant future cost will be setting up the monitoring program and defining the sampling locations. This is estimated at $55,000 to $90,000 in the first year and ongoing costs are estimated at $25,000 to $50,000 in subsequent years.

9.4. Storm Water Utility Fee

There are many different methods for implementing a storm water utility fee (SWUF). In the past, many different types of methods were successfully implemented. However, legal challenges to the implementation of a fee have become more common and many municipalities have lost these challenges. The main challenge relates to whether a storm water utility fee should be considered a fee or a tax, and whether it is fairly and consistently applied. We'll forgo the legal intricacies and simply state that the most successful strategies involve developing an equivalent service unit (ESU, the typical or average impervious area for a residential parcel of land) for all residential properties. Once the ESU has been determined, it is then used as the unit basis for storm water utility charges to all customers.

We digitized 22 randomly selected residential properties and found they contained an average of 3338 square feet of impervious area; for this reason, we would propose the ESU for the City of Moore to be 3338 square feet, and that all residential accounts be assumed to contain one ESU. According to City Staff, there are 21,787 residential utility accounts. The residential storm water fee collections can be estimated by multiplying 21,787 by the unit cost of a single ESU. For an ESU of $2.50 per residential utility customer per month, $833,610 per year would be the anticipated revenue.

Non-residential parcels vary significantly in their impervious area. For this reason, the impervious area in the final implementation of the storm water utility fee would be calculated for each parcel. Once the total square footage of impervious area for a parcel is known, it would be divided by the square footage of a typical ESU (3338 square feet) to determine the number of ESU's for that customer. The calculated number of ESU's should then be multiplied by the same rate per ESU paid by residential customers.

Estimating the non-residential parcel revenue in a preliminary analysis such as this is less certain than estimating the residential collections. However, taking results from a cross tabulation of the National Land Cover dataset and the City of Moore's land use dataset as a guide, we would estimate a total 13,900 ESU's for non-residential customers. At $2.50 per ESU per month, this would generate $417,000 per year from non-residential accounts (13,900 ESUs). Based on our past experience, this finding is likely an underestimate compared to what would be found by digitizing impervious areas directly using aerial photography, which is our recommended method for determining the storm water utility fee for non-residential customers.

Based on our experience and our analysis of the City of Moore, we would anticipate an annual revenue of $1.2M to $1.5M from a Storm Water Utility Fee based on $2.50 per ESU. It is important to note that $2.50 per ESU is lower than most of the municipalities in Oklahoma who have a SWUF.

Based on our preliminary analysis, a Storm Water Utility Fee could be a significant source of funding for capital improvements and ongoing storm water related expenses. It is important to note that funding needs should be evaluated every 5-10 years to identify new concerns.

9.5. Other Financial Revenue Options

It is not uncommon for municipalities in Oklahoma to pass a special sales tax to fund specific improvements. Street and drainage improvements are common targets for this revenue as are water and wastewater projects. This approach could be used by the City of Moore as an alternative to a SWUF or to compliment it.

The City of Moore has been successful in the past when applying for grants to improve infrastructure. The two highest priority projects are currently under design and plan to be constructed with federal grants. Additionally, the data from the updated hydrology and hydraulic models can be used to assist with the development of grant applications for other federal and state programs.

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	**Section 3 - Little River**		**Section 3 - Little River**		**Section 3 - Little River**		**Section 3 - Little River**		**Section 3 - Little River**	
Problem Area	**Problem Area 2**		**Problem Area 3**		**Problem Area 4**		**Problem Area 6**		**Problem Area 9**	
Project Name	**Alternative 2: Detention and I-35 Culvert**		**Janeway Ave. at Little River**		**Irving Dr. at Little River**		**Acquisition, Channel and Storm Sewer Improvements**		**Detention for Westermeir Subdivision Flooding**	
Costs	**$ 1,644,700**		**$ -**		**$ 3,998,400.00**		**$ 364,500.00**		**$ -**	
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	10.0		10.0		10.0		10.0		2.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10	10	10	10	10	10	10	10	10	
Improves residential access to neighborhoods for 31-40 people	8		8		8		8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	
Improves residential access to neighborhoods for 11-20 people	4		4		4		4		4	
Improves residential access to neighborhoods for 0-10 people	2		2		2		2		2	2
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	1.9		1.9		9.0		0.6		0.0	
100% (1-year) value = 10		1.9				9.0				0.0
50% (2-year) value = 5										
20% (5-year) value = 2				1.9						
10% (10-year) value = 1								0.6		
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	8.0		8.0		8.0		6.0		2.0	
Remove houses that flood in the 10 year:	10.0		10.0		10.0		10.0		10.0	
Remove houses that flood in the 100 year:	8.0	8.0	8.0	8.0	8.0	8.0	8.0		8.0	
Remove loss of use or garage flooding	6.0		6.0		6.0		6.0	6.0	6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0		4.0		4.0		4.0		4.0	
Land/yard flooding or surface erosion	2.0		2.0		2.0		2.0		2.0	2.0
Improves Access	10.0		7.0		5.0		5.0		2.0	
Emergency Route	10.0	10.0	10.0		10.0		10.0		10.0	
Arterial	7.0		7.0	7.0	7.0		7.0		7.0	
Collectors	5.0		5.0		5.0	5.0	5.0	5.0	5.0	
Residential streets and alleys	2.0		2.0		2.0		2.0		2.0	2.0
Size of Area Directly Affected	3.0		10.0		5.0		5.0		3.0	
>100 acres	10.0		10.0	10.0	10.0		10.0		10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0		5.0		5.0	5.0	5.0	5.0	5.0	
1-5 acres	3.0	3.0	3.0		3.0		3.0		3.0	3.0
<1 acre	0		0		0		0		0	
Frequency of Problem	0.0		4.0		4.0		6.0		2.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	
Heavy rains (1-2 times per year)	6.0		6.0		6.0		6.0	6.0	6.0	
Once every 1-5 years	4.0		4.0	4.0	4.0	4.0	4.0		4.0	
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	2.0
Rarely occurs	0	0.0	0		0		0		0	
Years Problem Existed	5.0		7.0		7.1		7.0		3.0	
>40	10.0		10.0		10.0		10.0		10.0	
20-40	7.0		7.0	7.0	7.0	7.1	7.0	7.0	7.0	
10-19	5.0	5.0	5.0		5.0		5.0		5.0	
1-9	3.0		3.0		3.0		3.0		3.0	3.0
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		10.0		0.0		10.0		0.0	
Positive impact on water quality and ecology	10.0		10.0	10.0	10.0		10.0	10.0	10.0	
Impacts less than 0.1 acres	0	0.0	0		0	0.0	0		0	0.0
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	0.0		10.0		0.0		10.0		10.0	
Yes	10		10	10.0	10		10	10.0	10	10.0
No	0	0.0	0		0	0.0	0	0.0	0	
Physical Condition of Stormwater System	0.0		8.0		3.0		8.0		0.0	
No system or system failed	10.0		10.0		10.0		10.0		10.0	
Poor	8.0		8.0	8.0	8.0		8.0	8.0	8.0	
Average	3.0		3.0		3.0	3.0	3.0		3.0	
Good	0	0.0	0		0		0		0	0.0
Funding Sources	10.0		10.0		0.0		4.0		0.0	
Can be funded by other sources (> 50%)	10.0	10.0	10.0	10.0	10.0		10.0		10.0	
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0		7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0		4.0		4.0		4.0	4.0	4.0	
Requires bonding or other revenue	0.0		0.0		0.0	0.0	0.0		0.0	0.0
Is private investment in the system available soon (rapidly growing area)?	0.0		10.0		0.0		0.0		0.0	
Yes	10		10	10.0	10		10		10	
No	0	0.0	0		0	0.0	0	0.0	0	0.0
Project Outlook Time	3.0		5.0		3.0		5.0		-5.0	
Short Range	5.0		5.0	5.0	5.0		5.0	5.0	5.0	
Middle Range	3.0	3.0	3.0		3.0	3.0	3.0		3.0	
Long Range	-5.0		-5.0		-5.0		-5.0		-5.0	-5.0
Totals	**Total**	**50.9**	**Total**	**100.9**	**Total**	**54.1**	**Total**	**76.6**	**Total**	**19.0**

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	Section 3 - Little River		Section 3 - Little River		Section 3 - Little River		Section 3 - Little River		Section 3 - Little River	
Problem Area	**Problem Area 10**		**Problem Area 11**		**Problem Area 12**		**Problem Area 13**		**Problem Area 15**	
Project Name	**Broadmoore Drainage Improvements**		**24th & Eastern Drainage Improvements**		**28th & Elmo Drainage Improvements**		**19th & BNSF Storm Sewer Improvements**		**South Howard Drainage Imrpovements**	
Costs	**$ 421,400.00**		**$ 68,800.00**		**$ 14,800.00**		**$ 1,763,300.00**		**$ 363,900.00**	
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	10.0		10.0		2.0		10.0		4.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10	10	10	10	10		10	10	10	
Improves residential access to neighborhoods for 31-40 people	8		8		8		8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	
Improves residential access to neighborhoods for 11-20 people	4		4		4		4		4	4
Improves residential access to neighborhoods for 0-10 people	2		2		2	2	2		2	
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	4.8		9.0		1.8		1.9		1.8	
100% (1-year) value = 10				9.0						
50% (2-year) value = 5		4.8								1.8
20% (5-year) value = 2						1.8		1.9		
10% (10-year) value = 1										
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	10.0		3.5		2.0		4.0		8.0	
Remove houses that flood in the 10 year:	10.0	10.0	10.0		10.0		10.0		10.0	
Remove houses that flood in the 100 year:	8.0		8.0		8.0		8.0		8.0	8.0
Remove loss of use or garage flooding	6.0		6.0		6.0		6.0		6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0		4.0	3.5	4.0		4.0	4.0	4.0	
Land/yard flooding or surface erosion	2.0		2.0		2.0	2.0	2.0		2.0	
Improves Access	7.0		7.0		2.0		10.0		2.0	
Emergency Route	10.0		10.0		10.0		10.0	10.0	10.0	
Arterial	7.0	7.0	7.0	7.0	7.0		7.0		7.0	
Collectors	5.0		5.0		5.0		5.0		5.0	
Residential streets and alleys	2.0		2.0		2.0	2.0	2.0		2.0	2.0
Size of Area Directly Affected	5.0		3.0		0.0		10.0		3.0	
>100 acres	10.0		10.0		10.0		10.0	10.0	10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0	5.0	5.0		5.0		5.0		5.0	
1-5 acres	3.0		3.0	3.0	3.0		3.0		3.0	3.0
<1 acre	0		0		0	0.0	0		0	
Frequency of Problem	4.0		6.0		4.0		4.0		4.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	
Heavy rains (1-2 times per year)	6.0		6.0	6.0	6.0		6.0		6.0	
Once every 1-5 years	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	
Rarely occurs	0		0		0		0		0	
Years Problem Existed	3.0		5.0		5.0		7.0		5.0	
>40	10.0		10.0		10.0		10.0		10.0	
20-40	7.0		7.0		7.0		7.0	7.0	7.0	
10-19	5.0		5.0	5.0	5.0	5.0	5.0		5.0	5.0
1-9	3.0	3.0	3.0		3.0		3.0		3.0	
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		0.0		0.0		0.0		0.0	
Positive impact on water quality and ecology	10.0		10.0		10.0		10.0		10.0	
Impacts less than 0.1 acres	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Physical Condition of Stormwater System	8.0		3.0		10.0		0.0		3.0	
No system or system failed	10.0		10.0		10.0	10.0	10.0		10.0	
Poor	8.0	8.0	8.0		8.0		8.0		8.0	
Average	3.0		3.0	3.0	3.0		3.0		3.0	3.0
Good	0		0		0		0	0.0	0	
Funding Sources	4.0		4.0		4.0		0.0		4.0	
Can be funded by other sources (> 50%)	10.0		10.0		10.0		10.0		10.0	
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0		7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0
Requires bonding or other revenue	0.0		0.0		0.0		0.0	0.0	0.0	
Is private investment in the system available soon (rapidly growing area)?	0.0		0.0		0.0		10.0		0.0	
Yes	10		10		10		10	10.0	10	
No	0	0.0	0	0.0	0		0		0	0.0
Project Outlook Time	5.0		3.0		-5.0		5.0		-5.0	
Short Range	5.0	5.0	5.0		5.0		5.0	5.0	5.0	
Middle Range	3.0		3.0	3.0	3.0		3.0		3.0	
Long Range	-5.0		-5.0		-5.0	-5.0	-5.0		-5.0	-5.0
Totals	**Total**	**60.8**	**Total**	**53.5**	**Total**	**25.8**	**Total**	**61.9**	**Total**	**29.8**

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	Section 3 - Little River		Section 3 - Little River		Section 3 - Little River		Section 3 - Little River		Section 4 - Stream E	
Problem Area	**Problem Area 16**		**Problem Area 22**		**Problem Area 23**		**Problem Area 24**		**Problem Area 7**	
Project Name	**5th & Howard Channel Improvements**		**North Nail Parkway Improvements**		**S. Bristow Storm Sewer**		**1st & Bristow Channel Improvement**		**31st & Santa Fe (Oak Ridge) - Storm Sewer & Grading**	
Costs	**$**	**45,200.00**	**$**	**1,322,600.00**	**$**	**389,500.00**	**$**	**-**	**$**	**650,200.00**
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	4.0		8.0		8.0		2.0		10.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10		10		10		10		10	10
Improves residential access to neighborhoods for 31-40 people	8		8	8	8	8	8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	
Improves residential access to neighborhoods for 11-20 people	4	4	4		4		4		4	
Improves residential access to neighborhoods for 0-10 people	2		2		2		2	2	2	
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	1.9		4.8		9.9		1.8		1.9	
100% (1-year) value = 10						9.9				
50% (2-year) value = 5				4.8						
20% (5-year) value = 2		1.9						1.8		1.9
10% (10-year) value = 1										
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	4.0		8.0		4.0		2.0		10.0	
Remove houses that flood in the 10 year:	10.0		10.0		10.0		10.0		10.0	10.0
Remove houses that flood in the 100 year:	8.0		8.0	8.0	8.0		8.0		8.0	
Remove loss of use or garage flooding	6.0		6.0		6.0		6.0		6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0	4.0	4.0		4.0	4.0	4.0		4.0	
Land/yard flooding or surface erosion	2.0		2.0		2.0		2.0	2.0	2.0	
Improves Access	2.0		2.0		5.0		5.0		10.0	
Emergency Route	10.0		10.0		10.0		10.0		10.0	10.0
Arterial	7.0		7.0		7.0		7.0		7.0	
Collectors	5.0		5.0		5.0	5.0	5.0	5.0	5.0	
Residential streets and alleys	2.0	2.0	2.0	2.0	2.0		2.0		2.0	
Size of Area Directly Affected	3.0		3.0		5.0		0.0		5.0	
>100 acres	10.0		10.0		10.0		10.0		10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0		5.0		5.0	5.0	5.0		5.0	5.0
1-5 acres	3.0	3.0	3.0	3.0	3.0		3.0		3.0	
<1 acre	0		0		0		0	0.0	0	
Frequency of Problem	6.0		4.0		6.0		4.0		4.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	
Heavy rains (1-2 times per year)	6.0	6.0	6.0		6.0	6.0	6.0		6.0	
Once every 1-5 years	4.0		4.0	4.0	4.0		4.0	4.0	4.0	4.0
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	
Rarely occurs	0		0		0		0		0	
Years Problem Existed	5.0		7.0		5.0		3.0		5.0	
>40	10.0		10.0		10.0		10.0		10.0	
20-40	7.0		7.0	7.0	7.0		7.0		7.0	
10-19	5.0	5.0	5.0		5.0	5.0	5.0		5.0	5.0
1-9	3.0		3.0		3.0		3.0	3.0	3.0	
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		0.0		0.0		0.0		0.0	
Positive impact on water quality and ecology	10.0		10.0		10.0		10.0		10.0	
Impacts less than 0.1 acres	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Physical Condition of Stormwater System	8.0		3.0		10.0		3.0		3.0	
No system or system failed	10.0		10.0		10.0	10.0	10.0		10.0	
Poor	8.0	8.0	8.0		8.0		8.0		8.0	
Average	3.0		3.0	3.0	3.0		3.0	3.0	3.0	3.0
Good	0		0		0		0		0	
Funding Sources	7.0		4.0		4.0		4.0		4.0	
Can be funded by other sources (> 50%)	10.0		10.0		10.0		10.0		10.0	
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0	7.0	7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Requires bonding or other revenue	0.0		0.0		0.0		0.0		0.0	
Is private investment in the system available soon (rapidly growing area)?	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Project Outlook Time	3.0		3.0		5.0		-5.0		5.0	
Short Range	5.0		5.0		5.0	5.0	5.0		5.0	5.0
Middle Range	3.0	3.0	3.0	3.0	3.0		3.0		3.0	
Long Range	-5.0		-5.0		-5.0		-5.0	-5.0	-5.0	
Totals	**Total**	**43.9**	**Total**	**46.8**	**Total**	**61.9**	**Total**	**19.8**	**Total**	**57.9**

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	Section 4 - Stream E		Section 5 - Canadian River Tribs		Section 5 - Canadian River Tribs		Section 6 - North Fork River		Section 6 - North Fork River	
Problem Area	Problem Area 9		Problem Area 3		Problem Area 4		Problem Area 2		Problem Area 5	
Project Name	34th & Pin Oak Culvert		Robinson & 7th Pl		Hillcrest Ave between Cass Ave & NW 27th		Anns Pl Flooding		N. Bryant & North Fork River	
Costs	$ 27,000.00		$ 17,600.00		$ 29,400.00		$ 108,500.00		$ 1,000,000.00	
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	2.0		2.0		4.0		4.0		10.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10		10		10		10		10	10
Improves residential access to neighborhoods for 31-40 people	8		8		8		8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	
Improves residential access to neighborhoods for 11-20 people	4		4		4	4	4	4	4	
Improves residential access to neighborhoods for 0-10 people	2	2	2	2	2		2		2	
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	1.9		4.9		4.0		9.9		4.8	
100% (1-year) value = 10								9.9		
50% (2-year) value = 5		1.9				4.0				4.8
20% (5-year) value = 2				4.9						
10% (10-year) value = 1										
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	4.0		6.0		4.0		4.0		4.0	
Remove houses that flood in the 10 year:	10.0		10.0		10.0		10.0		10.0	
Remove houses that flood in the 100 year:	8.0		8.0		8.0		8.0		8.0	
Remove loss of use or garage flooding	6.0		6.0	6.0	6.0		6.0		6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Land/yard flooding or surface erosion	2.0		2.0		2.0		2.0		2.0	
Improves Access	7.0		2.0		2.0		2.0		10.0	
Emergency Route	10.0		10.0		10.0		10.0		10.0	10.0
Arterial	7.0	7.0	7.0		7.0		7.0		7.0	
Collectors	5.0		5.0		5.0		5.0		5.0	
Residential streets and alleys	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Size of Area Directly Affected	0.0		0.0		3.0		3.0		3.0	
>100 acres	10.0		10.0		10.0		10.0		10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0		5.0		5.0		5.0		5.0	
1-5 acres	3.0		3.0		3.0	3.0	3.0	3.0	3.0	3.0
<1 acre	0	0.0	0	0.0	0		0		0	
Frequency of Problem	4.0		4.0		6.0		4.0		2.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	
Heavy rains (1-2 times per year)	6.0		6.0		6.0	6.0	6.0		6.0	
Once every 1-5 years	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	2.0
Rarely occurs	0		0		0		0		0	
Years Problem Existed	5.0		5.0		7.0		3.0		7.0	
>40	10.0		10.0		10.0		10.0		10.0	
20-40	7.0		7.0		7.0	7.0	7.0		7.0	7.0
10-19	5.0	5.0	5.0	5.0	5.0		5.0		5.0	
1-9	3.0		3.0		3.0		3.0	3.0	3.0	
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		0.0		0.0		0.0		10.0	
Positive impact on water quality and ecology	10.0		10.0		10.0		10.0		10.0	10.0
Impacts less than 0.1 acres	0	0.0	0	0.0	0	0.0	0	0.0	0	
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	0.0		0.0		0.0		0.0		10.0	
Yes	10		10		10		10		10	10.0
No	0	0.0	0	0.0	0	0.0	0	0.0	0	
Physical Condition of Stormwater System	3.0		8.0		8.0		10.0		3.0	
No system or system failed	10.0		10.0		10.0		10.0	10.0	10.0	
Poor	8.0		8.0	8.0	8.0	8.0	8.0		8.0	
Average	3.0	3.0	3.0		3.0		3.0		3.0	3.0
Good	0		0		0		0		0	
Funding Sources	4.0		4.0		4.0		4.0		10.0	
Can be funded by other sources (> 50%)	10.0		10.0		10.0		10.0		10.0	10.0
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0		7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Requires bonding or other revenue	0.0		0.0		0.0		0.0		0.0	
Is private investment in the system available soon (rapidly growing area)?	10.0		0.0		0.0		0.0		0.0	
Yes	10	10.0	10		10		10		10	
No	0		0	0.0	0	0.0	0	0.0	0	0.0
Project Outlook Time	-5.0		-5.0		-5.0		3.0		5.0	
Short Range	5.0		5.0		5.0		5.0		5.0	5.0
Middle Range	3.0		3.0		3.0		3.0	3.0	3.0	
Long Range	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0		-5.0	
Totals	**Total**	**35.9**	**Total**	**30.9**	**Total**	**37.0**	**Total**	**46.9**	**Total**	**78.8**

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	Section 6 - North Fork River		Section 6 - North Fork River		Section 6 - North Fork River		Section 6 - North Fork River		Section 6 - North Fork River	
Problem Area	Problem Area 6		Problem Area 7		Problem Area 8		Problem Area 10		Problem Area 11	
Project Name	NE 12th St		Stream A and Sooner Dr Detention		Stream A 34th & Sooner Culvert		The Falls Drainage Improvements		5th & Post Oak Detention	
Costs	$ 1,351,600.00		$ 414,900.00		$ 468,200.00		$ 21,100.00		$ 246,400.00	
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	10.0		8.0		10.0		4.0		6.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10	10	10		10	10	10		10	
Improves residential access to neighborhoods for 31-40 people	8		8	8	8		8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	6
Improves residential access to neighborhoods for 11-20 people	4		4		4		4	4	4	
Improves residential access to neighborhoods for 0-10 people	2		2		2		2		2	
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	4.8		5.0		4.9		4.9		4.5	
100% (1-year) value = 10										
50% (2-year) value = 5		4.8		5.0		4.9		4.9		4.5
20% (5-year) value = 2										
10% (10-year) value = 1										
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	8.0		10.0		10.0		10.0		8.0	
Remove houses that flood in the 10 year:	10.0		10.0	10.0	10.0	10.0	10.0	10.0	10.0	
Remove houses that flood in the 100 year:	8.0	8.0	8.0		8.0		8.0		8.0	8.0
Remove loss of use or garage flooding	6.0		6.0		6.0		6.0		6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0		4.0		4.0		4.0		4.0	
Land/yard flooding or surface erosion	2.0		2.0		2.0		2.0		2.0	
Improves Access	7.0		7.0		7.0		2.0		2.0	
Emergency Route	10.0		10.0		10.0		10.0		10.0	
Arterial	7.0	7.0	7.0	7.0	7.0	7.0	7.0		7.0	
Collectors	5.0		5.0		5.0		5.0		5.0	
Residential streets and alleys	2.0		2.0		2.0		2.0	2.0	2.0	2.0
Size of Area Directly Affected	5.0		3.0		3.0		3.0		4.0	
>100 acres	10.0		10.0		10.0		10.0		10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0	5.0	5.0		5.0		5.0		5.0	4.0
1-5 acres	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	
<1 acre	0		0		0		0		0	
Frequency of Problem	4.0		4.0		4.0		6.0		8.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	8.0
Heavy rains (1-2 times per year)	6.0		6.0		6.0		6.0	6.0	6.0	
Once every 1-5 years	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	
Rarely occurs	0		0		0		0		0	
Years Problem Existed	3.0		7.0		7.0		5.0		5.0	
>40	10.0		10.0		10.0		10.0		10.0	
20-40	7.0		7.0	7.0	7.0	7.0	7.0		7.0	
10-19	5.0		5.0		5.0		5.0	5.0	5.0	5.0
1-9	3.0	3.0	3.0		3.0		3.0		3.0	
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		0.0		0.0		0.0		0.0	
Positive impact on water quality and ecology	10.0		10.0		10.0		10.0		10.0	
Impacts less than 0.1 acres	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Physical Condition of Stormwater System	3.0		0.0		0.0		3.0		10.0	
No system or system failed	10.0		10.0	0.0	10.0		10.0		10.0	10.0
Poor	8.0		8.0		8.0		8.0		8.0	
Average	3.0	3.0	3.0		3.0		3.0	3.0	3.0	
Good	0		0		0	0.0	0		0	
Funding Sources	4.0		4.0		4.0		4.0		4.0	
Can be funded by other sources (> 50%)	10.0		10.0		10.0		10.0		10.0	
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0		7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Requires bonding or other revenue	0.0		0.0		0.0		0.0		0.0	
Is private investment in the system available soon (rapidly growing area)?	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0		0	0.0	0	0.0	0	0.0	0	0.0
Project Outlook Time	3.0		-5.0		3.0		3.0		5.0	
Short Range	5.0		5.0		5.0		5.0		5.0	5.0
Middle Range	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Long Range	-5.0		-5.0	-5.0	-5.0		-5.0		-5.0	
Totals	**Total**	**51.8**	**Total**	**43.0**	**Total**	**52.9**	**Total**	**44.9**	**Total**	**56.5**

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	Section 6 - North Fork River		Section 6 - North Fork River		Section 6 - North Fork River		Section 6 - North Fork River		Section 6 - North Fork River	
Problem Area	Problem Area 12		Problem Area 15		Problem Area 16		Problem Area 18		Problem Area 19	
Project Name	Ramblin Oaks Storm Sewer		Wyndemere Lakes Dr Storm Sewer		20th & Lincoln Storm Sewer Improvements		Park Pl & 23rd St Channel		Bryant & NE 15th Culvert	
Costs	$	4,702,000.00	$	48,000.00	$	2,207,900.00	$	29,400.00	$	26,000.00
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	10.0		2.0		10.0		4.0		2.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10	10	10		10	10	10		10	
Improves residential access to neighborhoods for 31-40 people	8		8		8		8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	
Improves residential access to neighborhoods for 11-20 people	4		4		4		4	4	4	
Improves residential access to neighborhoods for 0-10 people	2		2	2	2		2		2	2
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	9.9		4.9		5.0		4.9		9.9	
100% (1-year) value = 10		9.9								9.9
50% (2-year) value = 5				4.9		5.0		4.9		
20% (5-year) value = 2										
10% (10-year) value = 1										
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	10.0		2.0		10.0		6.0		4.0	
Remove houses that flood in the 10 year:	10.0	10.0	10.0		10.0	10.0	10.0		10.0	
Remove houses that flood in the 100 year:	8.0		8.0		8.0		8.0		8.0	
Remove loss of use or garage flooding	6.0		6.0		6.0		6.0	6.0	6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0		4.0		4.0		4.0		4.0	4.0
Land/yard flooding or surface erosion	2.0		2.0	2.0	2.0		2.0		2.0	
Improves Access	5.0		10.0		4.0		2.0		7.0	
Emergency Route	10.0		10.0	10.0	10.0		10.0		10.0	
Arterial	7.0		7.0		7.0		7.0		7.0	7.0
Collectors	5.0	5.0	5.0		5.0	4.0	5.0		5.0	
Residential streets and alleys	2.0		2.0		2.0		2.0	2.0	2.0	
Size of Area Directly Affected	5.0		0.0		3.0		0.0		0.0	
>100 acres	10.0		10.0		10.0		10.0		10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0	5.0	5.0		5.0		5.0		5.0	
1-5 acres	3.0		3.0		3.0	3.0	3.0		3.0	
<1 acre	0		0	0.0	0		0	0.0	0	0.0
Frequency of Problem	6.0		6.0		6.0		4.0		4.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	
Heavy rains (1-2 times per year)	6.0	6.0	6.0	6.0	6.0	6.0	6.0		6.0	
Once every 1-5 years	4.0		4.0		4.0		4.0	4.0	4.0	4.0
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	
Rarely occurs	0		0		0		0		0	
Years Problem Existed	7.0		3.0		7.0		7.0		10.0	
>40	10.0		10.0		10.0		10.0		10.0	10.0
20-40	7.0	7.0	7.0		7.0	7.0	7.0	7.0	7.0	
10-19	5.0		5.0		5.0		5.0		5.0	
1-9	3.0		3.0	3.0	3.0		3.0		3.0	
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		0.0		0.0		0.0		0.0	
Positive impact on water quality and ecology	10.0		10.0		10.0		10.0		10.0	
Impacts less than 0.1 acres	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	10.0		0.0		0.0		0.0		0.0	
Yes	10	10.0	10		10		10		10	
No	0		0	0.0	0	0.0	0	0.0	0	0.0
Physical Condition of Stormwater System	3.0		0.0		3.0		3.0		3.0	
No system or system failed	10.0		10.0		10.0		10.0		10.0	
Poor	8.0		8.0		8.0		8.0		8.0	
Average	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Good	0		0	0.0	0		0		0	
Funding Sources	4.0		4.0		4.0		4.0		4.0	
Can be funded by other sources (> 50%)	10.0		10.0		10.0		10.0		10.0	
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0		7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Requires bonding or other revenue	0.0		0.0		0.0		0.0		0.0	
Is private investment in the system available soon (rapidly growing area)?	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Project Outlook Time	5.0		-5.0		5.0		-5.0		3.0	
Short Range	5.0	5.0	5.0		5.0	5.0	5.0		5.0	
Middle Range	3.0		3.0		3.0		3.0		3.0	3.0
Long Range	-5.0		-5.0	-5.0	-5.0		-5.0	-5.0	-5.0	
Totals	**Total**	**74.9**	**Total**	**26.9**	**Total**	**57.0**	**Total**	**29.9**	**Total**	**46.9**

APPENDIX 9-A
PRIORITIZATION OF PROJECT CRITERIA
FOR RECOMMENDED ALTERNATIVES

Report Section/Basin	Section 6 - North Fork River		Section 7 - Stream D		Section 7 - Stream D		Section 7 - Stream D		Section 7 - Stream D	
Problem Area	Problem Area 20		Problem Area 1		Problem Area 2		Problem Area 3		Problem Area 6	
Project Name	Foxfire Subdivision Storm Sewer & Channel		Autum Dr Cul-de-sac		SE 12th & Eastern Culvert		Cindy Brook Lane Cul-de-sac		Craig Dr & Highlander Dr	
Costs	$ 348,400.00		$ 15,700.00		$ 199,700.00		$ 95,000.00		$ 88,200.00	
Prioritization Category	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking	Point Values	Ranking
Project has a positive effect on Health and Safety	10.0		4.0		10.0		2.0		2.0	
Documented death or serious injury	10		10		10		10		10	
Improves residential/commerical access for > 40 people	10	10	10		10	10	10		10	
Improves residential access to neighborhoods for 31-40 people	8		8		8		8		8	
Improves residential access to neighborhoods for 21-30 people	6		6		6		6		6	
Improves residential access to neighborhoods for 11-20 people	4		4	4	4		4		4	
Improves residential access to neighborhoods for 0-10 people	2		2		2		2	2	2	2
Increases Bridge/Culvert Level of Service in areas of threat to life. For example, increasing a 100% (1-year) bridge/culvert to a 10% (10-year) = 10 - 1 or 9 points.	9.0		9.6		1.9		4.9		4.9	
100% (1-year) value = 10		9.0		9.6						
50% (2-year) value = 5								4.9		4.9
20% (5-year) value = 2						1.9				
10% (10-year) value = 1										
4% (25-year) value = 0.4										
2% (50-year) value = 0.2										
1% (100-year) value = 0.1										
Type and Extent of Damage	4.0		4.0		8.0		6.0		2.0	
Remove houses that flood in the 10 year:	10.0		10.0		10.0		10.0		10.0	
Remove houses that flood in the 100 year:	8.0		8.0		8.0	8.0	8.0		8.0	
Remove loss of use or garage flooding	6.0		6.0		6.0		6.0	6.0	6.0	
Removes street (nuisance) flooding or land loss (in channel) due to erosion	4.0	4.0	4.0	4.0	4.0		4.0		4.0	
Land/yard flooding or surface erosion	2.0		2.0		2.0		2.0		2.0	2.0
Improves Access	5.0		2.0		5.0		2.0		2.0	
Emergency Route	10.0		10.0		10.0		10.0		10.0	
Arterial	7.0		7.0		7.0		7.0		7.0	
Collectors	5.0	5.0	5.0		5.0	5.0	5.0		5.0	
Residential streets and alleys	2.0		2.0	2.0	2.0		2.0	2.0	2.0	2.0
Size of Area Directly Affected	3.0		3.0		3.0		0.0		3.0	
>100 acres	10.0		10.0		10.0		10.0		10.0	
40-100 acres	7.0		7.0		7.0		7.0		7.0	
6-39 acres	5.0		5.0		5.0		5.0		5.0	
1-5 acres	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0
<1 acre	0		0		0		0	0.0	0	
Frequency of Problem	6.0		6.0		4.0		6.0		6.0	
Constant or erosion with health/safety hazard	10.0		10.0		10.0		10.0		10.0	
Every rain (>5 times per year)	10.0		10.0		10.0		10.0		10.0	
Moderate rains (3-5 times per year)	8.0		8.0		8.0		8.0		8.0	
Heavy rains (1-2 times per year)	6.0	6.0	6.0	6.0	6.0		6.0	6.0	6.0	6.0
Once every 1-5 years	4.0		4.0		4.0	4.0	4.0		4.0	
Once every 6 or more years	2.0		2.0		2.0		2.0		2.0	
Rarely occurs	0		0		0		0		0	
Years Problem Existed	7.0		7.0		7.0		7.0		7.0	
>40	10.0		10.0		10.0		10.0		10.0	
20-40	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
10-19	5.0		5.0		5.0		5.0		5.0	
1-9	3.0		3.0		3.0		3.0		3.0	
<1	1.0		1.0		1.0		1.0		1.0	
Environmental Impact	0.0		0.0		0.0		0.0		0.0	
Positive impact on water quality and ecology	10.0		10.0		10.0		10.0		10.0	
Impacts less than 0.1 acres	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Impact between 0.1 - 0.5 acres	-5.0		-5.0		-5.0		-5.0		-5.0	
Impacts 0.5 or more acres	-10.0		-10.0		-10.0		-10.0		-10.0	
Investment Protection of Public Infrasture	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Physical Condition of Stormwater System	3.0		8.0		5.0		3.0		8.0	
No system or system failed	10.0		10.0		10.0		10.0		10.0	
Poor	8.0		8.0	8.0	8.0		8.0		8.0	8.0
Average	3.0	3.0	3.0		3.0	5.0	3.0	3.0	3.0	
Good	0		0		0		0		0	
Funding Sources	4.0		4.0		4.0		4.0		4.0	
Can be funded by other sources (> 50%)	10.0		10.0		10.0		10.0		10.0	
Can be funded by a combination of City funds and other funds or grants (<50%)	7.0		7.0		7.0		7.0		7.0	
Can be funded by capital funds alone	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Requires bonding or other revenue	0.0		0.0		0.0		0.0		0.0	
Is private investment in the system available soon (rapidly growing area)?	0.0		0.0		0.0		0.0		0.0	
Yes	10		10		10		10		10	
No	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Project Outlook Time	3.0		-5.0		-5.0		-5.0		-5.0	
Short Range	5.0		5.0		5.0		5.0		5.0	
Middle Range	3.0	3.0	3.0		3.0		3.0		3.0	
Long Range	-5.0		-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0
Totals	**Total**	**54.0**	**Total**	**42.6**	**Total**	**42.9**	**Total**	**29.9**	**Total**	**33.9**