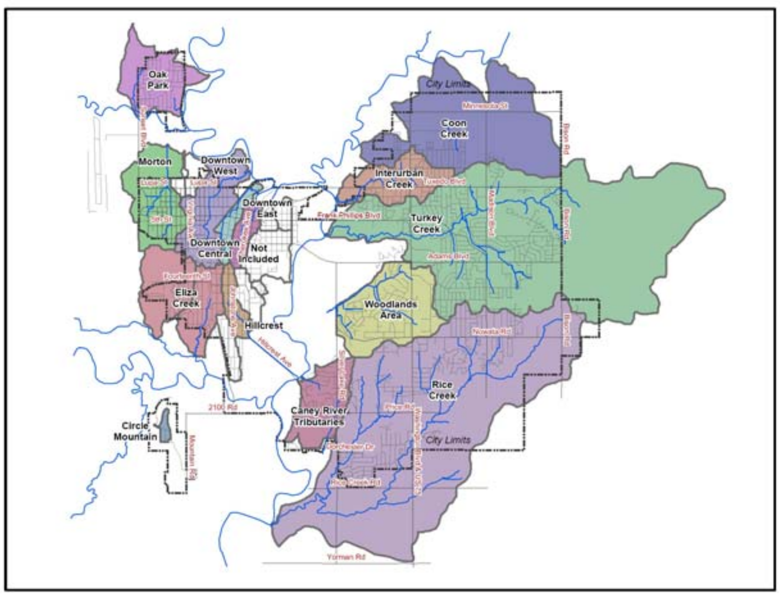
City of Bartlesville, Oklahoma

Executive Summary
Bartlesville Master Drainage Plan



Revised October 2004

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CITY OF BARTLESVILLE, OKLAHOMA
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SECTION 1 - GENERAL

This Bartlesville Master Drainage Plan was prepared by Meshek & Associates, Inc., under contract with the City of Bartlesville, Oklahoma. The Master Drainage Plan fulfills the requirements of the Hazard Mitigation Grant that partially funded this project. This summary document presents the findings of the individual reports.

As shown on Figure 1-1, the Master Drainage Plan covers the following drainage basins:

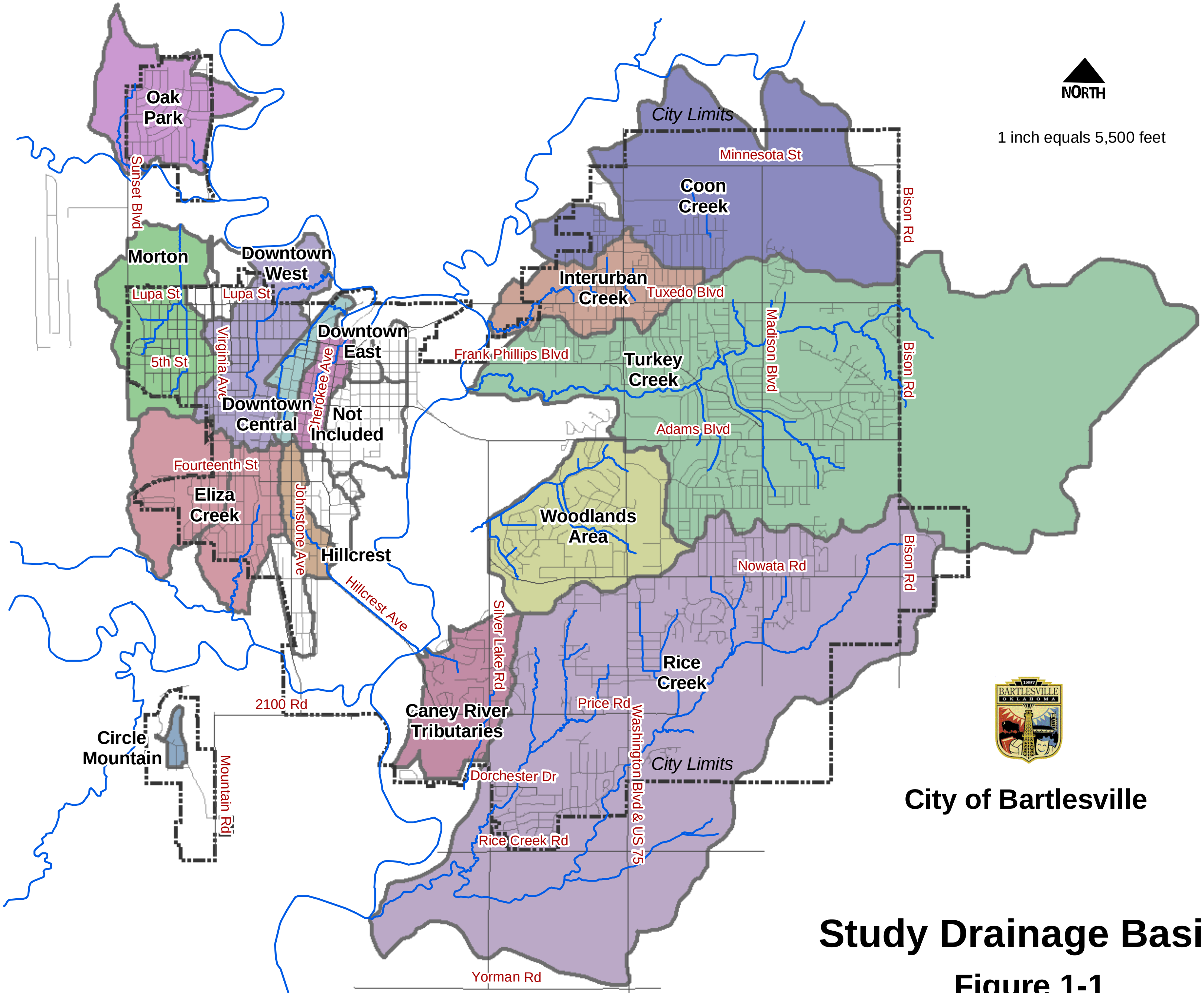
- Turkey Creek
- Rice Creek
- Interurban Creek
- Caney River Local Areas, Woodlands Area and Coon Creek Tributaries
- West Bartlesville, including Morton West, Downtown West, Downtown Central and Downtown East Areas, as well as Oak Park.

Within the West Bartlesville Master Drainage Plan, Circle Mountain was studied with hydrologic methods only. Floodplains were developed for the Eliza Creek and Hillcrest areas, however no alternative evaluations or recommended plans were prepared due to the limited nature of any flooding.

Recommended plans were developed for all other areas. The total cost of recommended improvements is $23,168,500, apportioned between the drainage basins in the following manner:

Table 1-1	
Bartlesville Master Drainage Plan	
Recommended Plan Costs	
Turkey Creek	$5,474,800
Rice Creek	$5,781,000
Interurban Creek	$2,615,700
Caney River Tributaries	$188,200
Woodlands	$1,997,500
Morton West Area	$1,662,600
Downtown West	$2,534,100
Downtown East	$2,862,700
Oak Park.	$51,900
Total	**$23,168,500**

Of these Recommended Plans, several projects were identified as High Priority Projects, totaling $11,480,800. Those projects are described in Table 1-2.



City of Bartlesville

Study Drainage Basins

Figure 1-1

High Priority Projects

Turkey Creek

Phase 1 - Sooner Park Improvements		
Sooner Park Detention Pond		$877,200
2 - 10'x8' RCB's Under Madison Blvd		$347,500
	Total	**$1,224,700**
Phase 2 - Frank Phillips to Eastland Mall		
4 - 10'x10' RCB's Under Frank Phillips Blvd		$476,400
30' Sodded Channel Downstream of Frank Phillips Blvd		$590,400
2 - 8'x5' RCB's Under Brookline Drive		$154,400
	Total	**$1,221,200**
Phase 3 - Madison Tributary Stormwater Detention		
Grand Prairie Detention Pond Modification		$1,260,100
Willow Hill Detention Pond Modification		$222,900
	Total	**$1,483,000**
	Total Turkey Creek High Priority Projects	***$3,928,900***

Rice Creek

Phase 1 - Dorchester Area		
2 - 8'x5' RCB Under Dorchester Dr.		$94,400
Channel Dorchester to Silver Lake Road		$233,600
Jo Allyn Detention Pond		$62,500
	Total	**$390,500**
Phase 2 - Fox Hollow Mitigation Project		
Freiling Detention Pond		$386,200
Fox Hollow Improvements		$411,300
Upstream Wayside Improvements		$13,800
	Total	**$811,300**
Phase 3 - Madison Tributary Detention Improvements		
RC 02-92 Detention Pond		$337,600
RC 02-911 Detention Pond		$473,900
	Total	**$811,500**
	Total Rice Creek High Priority Projects	***$2,013,300***

Interurban Creek

Phase 1 - Howard through Roselawn

20' Concrete Channel Bottom w/5' Vertical Wall Downstream of Roselawn Ave.	$111,300
20' Concrete Channel Bottom w/5' Vertical Wall Downstream of Howard Ave.	$81,300
Total	**$192,600**

Phase 2 - Northern Channel Debell through Howard

10' Concrete Channel Bottom w/5' Vertical Wall Downstream of Howard Ave. (North Channel Alignment)	$73,900
1 - 10'x5' RCB Under N.E. Howard (North Channel Alignment)	$85,500
10' Concrete Channel Bottom w/5' Vertical Wall Downstream of Katherine Ave. (North Channel Alignment)	$58,400
1 - 10'x5' RCB Under N.E. Katherine (North Channel Alignment)	$87,100
10' Concrete Channel Bottom w/5' Vertical Wall Downstream of DeBell Ave. (North Channel Alignment)	$87,700
1 - 10'x5' RCB Under N.E. DeBell (North Channel Alignment)	$87,100
10' Concrete Channel Bottom w/5' Vertical Wall Upstream of DeBell Ave. (North Channel Alignment)	$82,400
Total	**$562,100**
Total Interurban Creek High Priority Projects	***$754,700***

Caney River Tributaries

Phase 1 - Silver Lake Road and Price Road, Moonlight Drive

Sod Channel w/ 8' Concrete Liner Along Silver Lake Rd. South of Price Rd. (Area 1)	$29,000
6' Concrete Flume At Moonlight Dr. (Area 3)	$41,700
Total	**$70,700**
Total Caney Creek High Priority Projects	***$70,700***

Woodlands Creek

Phase 1 - Cedar Street to Nowata Tributary		
6'x5' RCB Under Evergreen Drive		$48,700
8' Concrete Channel Between Evergreen and Cherokee Hills		$208,700
8' Concrete Channel Downstream of Oakdale		$76,800
	Total	**$334,200**
Phase 2 - Cedar Street to Evergreen		
48" RCP Storm Sewer Between Evergreen and Cedar		$174,200
	Total	**$174,200**
	Total Woodlands Creek High Priority Projects	***$508,400***

West Bartlesville - Downtown

Phase 1 - Morton West Detention Ponds		
Construct Morton basin detention structures		$1,662,700
	Total	**$1,662,700**
Phase 2 - Downtown West Storm Sewer Improvements		
Construct Phase I Downtown East storm sewer improvements		$742,600
	Total	**$742,600**
Phase 3 - Downtown West Lupa to Hensley		
Construct Downtown West channel and structure improvements from Lupa Street to Hensley Boulevard		$1,747,600
	Total	**$1,747,600**
	Total West Bartlesville Downtown High Priority Projects	***$4,152,900***

West Bartlesville - Oak Park

Phase 1 - Oak Park		
Oak Park Drainage Improvements at Larchmont Road		$51,900
	Total	**$51,900**
	Total West Bartlesville Oak Park High Priority Projects	***$51,900***

Grand Total High Priority Projects $11,480,800

SECTION 2 - HYDROLOGIC ANALYSES

General

Current Flood Insurance Study

The Corps of Engineers completed a Flood Insurance Study in August 1978, under an agreement with the Flood Insurance Administration. Streams studied in detail included the Caney River and its tributaries, Rice, Sand, Eliza, Turkey, Coon, and Butler Creeks. Also studied in detail were one unnamed tributary each for Rice Creek and Turkey Creek. The study was revised in 1988 and again in 1992. These provide the current limits for the regulatory floodplain boundaries for the City, except where specifically modified by Letters of Map Revision (LOMR's).

The hydraulic analysis was based on cross-section data within the City. This data was obtained from photogrammetric surveys from aerial photographs flown in 1970. The 100-year and 500-year floodplains were delineated. Floodways were also developed in locations that had at least one square mile of drainage area.

Hydrologic Modeling Strategy

Hydrologic and hydraulic modeling of the basins was performed using HEC-HMS, HEC-GeoRAS and HEC-RAS, computer programs developed by the U.S. Army Corps of Engineers. These programs are Windows-based and GIS-based versions of HEC1 and HEC2, long considered industry standards for hydrology and hydraulics.

Subdivision of Major Drainage Basins

Drainage areas were sub-divided based on the homogeneity of the watershed and the need to define flow rates for hydraulic analysis at various points within the basins. The average sub-basin size is approximately 30 acres. There are larger sub-basins in the undeveloped areas and smaller sub-basins in the developed and commercial areas.

Appendix A includes sub-basin delineations for each of the studied watersheds.

Soils

The infiltration rates were taken into account by identifying the runoff potential of the various soils 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. Each sub-basin was assigned a Curve Number (CN), based on the HSG classification of the open soil. The impervious areas were identified and used to the weight the CN value assigned to each sub-basin. Theses values are explained in detail and tabulated within the individual reports.

Hydrograph Development

The synthetic unit hydrograph method used in the analysis is the SCS Unit Hydrograph method. Utilizing the total rainfall values and the CN value described above, the storm runoff volume is calculated from a given total rainfall.

Peak flow rates and hydrograph shape are determined based on experimental data developed by the Soil Conservation Service (NRCS). This method is described in Section 4, “Hydrology” of the National Engineering Handbook, USDA, SCS August 1972. A hydrograph is a measurement of the flow rate versus time from the beginning of the storm.

A measurement is made of the time of concentration of each sub-basin. This is the time for runoff to travel from the hydraulically most distant part of the sub-basin to the point of reference. The time is usually computed by determining the water travel time through each sub-basin. The lag of the unit hydrograph is the time from the center of mass of excess rainfall to the peak rate of runoff and is computed as 60% of the time of concentration. The lag is used to determine the shape of the unit hydrograph for each sub-basin.

The CN values and lag values were determined for both the existing and fully urbanized conditions.

Rainfall

The table below gives the rainfall depths used in the hydrologic analyses. The depths were obtained from Technical Paper No. 40 (TP-40) for the 2- through 24-hour storms. Rainfall depths for the 5-, 15- and 60-minute storms were obtained from Hydrometeorological Report No. 35 (HYDRO-35).

These rainfall depths were used to develop a synthetic, bell-shaped 24-hour storm, constructed so that the depth specified for any duration occurs at the center of the storm. This is referred to as a “balanced storm”.

In general, the rainfall durations shown on the left side of the table also describe the time for runoff to travel from the hydraulically most distant part of the watershed to the point of reference. In other words, the total travel time for water to a particular point within the watershed must be at least equal to the rainfall duration in order to achieve the flow rate that corresponds to its frequency.

Table 2-1

Total Rainfall Depths for Bartlesville Oklahoma – Inches

Rainfall Duration	Frequency (Return Period)							
	1-year	2-year	5-year	10-year	25-year	50-year	100-year	500-year
5-minute	0.30	0.48	0.56	0.63	0.72	0.73	0.87	1.04
10-minute	0.65	0.78	0.93	1.03	1.19	1.22	1.44	1.72
15-minute	0.89	0.99	1.18	1.32	1.52	1.55	1.84	2.20
30-minute	1.15	1.46	1.86	2.17	2.50	2.84	3.14	3.40
1-hour	1.50	1.81	2.34	2.72	3.16	3.55	4.03	4.75
2-hour	1.76	2.19	2.79	3.26	3.82	4.29	4.78	6.00
3-hour	1.91	2.26	3.12	3.60	4.18	4.69	5.30	6.80
6-hour	2.20	2.75	3.65	4.27	5.00	5.56	6.30	8.25
12-hour	2.69	3.35	4.38	5.12	5.94	6.65	7.40	9.85
24-hour	3.13	3.88	5.05	5.88	6.86	7.64	8.60	11.50

Source: U.S. Weather Bureau Technical Paper No. 40 and HYDRO-35

Storage Routing

The stream reaches within the basin where floodplains were developed were studied in detail hydraulically using HEC-RAS. These streams are described in detail in the individual reports.

The storage volumes for different flow rates were calculated during the hydraulic analysis for these reaches. This data was then applied to the HEC-HMS model and runoff hydrographs were routed from point to point through the storage volumes calculated for each of these reaches. In this manner, the effects of existing floodplain storage can be easily demonstrated. For those streams without hydraulic models, hydrographs were routed from point to point based on travel time.

Existing Stormwater Detention Facilities

There are many existing ponds in the basins studied. Besides the large pond on the Turkey Creek mainstem east of Bison Road, most of these ponds were constructed to offset development. These ponds have an effect on the hydraulics and hydrology. They are described in detail in the individual reports.

The embankments, outlet structures and spillways, as well as storage volumes, were included in the hydrologic and hydraulic analyses, based on data obtained from existing construction plans or field measurements.

Summary of Results

Resulting 100-year peak flows at selected locations from the hydrologic analysis are tabulated in the individual reports. Included are flows for both existing and future development conditions. The HMS output showing flows at all locations for frequencies ranging from the 1- to 500-year floods is included with the appendices of the individual reports. The locations of HMS junctions are also shown in the HEC-HMS schematics in the appendices of the various reports.

SECTION 3 - HYDRAULIC ANALYSES

General

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 at each rainfall recurrence interval. Predicted areas of flooding were then mapped for the peak flows for the 1-, 2-, 5-, 10-, 25-, 50-, 100- and 500-year storms.

Computed flow rates for the creek channels and those flow rates in excess of the storm sewer system capacities were input into the channel and overland flow (where appropriate) models for each stream reach. Cross-section data was prepared from digital terrain models prepared in 2002. Bridge and culvert data was measured in the field for all streams. The base data was prepared using HEC-GeoRAS. This program, developed by the US Army Corps of Engineers, is a set of procedures, tools, and utilities for processing geospatial data in ArcView using a graphical user interface (GUI). The interface allows the preparation of geometric data for import into HEC-RAS and processes simulation results exported from HEC-RAS. Water surface profile data was exported from the HEC-RAS simulations along the various streams studied, and was processed by HEC-GeoRAS using a GIS analysis for floodplain mapping.

The GIS data supplied to the HEC-RAS models includes the stream centerlines, flow path centerlines, main channel bank stations and reach lengths, and cross section geometric data. Additionally, Manning's "n" values were exported from HEC-GeoRAS based on a GIS representation of land use.

The storage volumes were computed reach by reach within the hydraulic model for various flow rates. These values were used in the final HEC-HMS model to determine the effect of existing floodplain storage on peak flow rates. Final water surface profiles were then computed for each frequency. The resulting water surface profiles for each hydraulic study reach are presented in the appendices of the various individual reports.

Starting Water Surface Elevations

The Caney River water surface elevations from the FEMA FIS study were used as the downstream condition for hydraulic studies of all studied streams in order to tie the upstream floodplains into the Caney River floodplains. The FIS included water surface elevations for the 10-, 50-, 100- and 500-year return periods. A regression analysis of this data, adjusted for current datum, was used to estimate the water surface elevations for the return periods studied at the locations of all confluences with the Caney River.

While the two streams would probably not peak at coincident times, this approach shows the enveloping condition from either stream. Starting water surface elevations for tributaries of each of the main streams were obtained from the tailwater elevations from the main stem or from the tributary with which each is confluent.

Bridge and Culvert Analysis

Each roadway crossing was modeled using the bridge or culvert modeling methods available within HEC-RAS. Appendix B contains maps for each studied stream within the individual watersheds depicting the level of overtopping of each of the bridges and culverts studied in detail, based on the frequency of storm that it will pass.

Flooded Buildings

For Turkey Creek, Rice Creek and Interurban Creek, building finished floor elevations were estimated based on field measurements compared to the digital terrain model supplied by the City. The buildings that appear to be flooded at various storm levels are shown on Figures in Appendix C.

Floodplain Mapping

Appendix D contains the resultant existing 10-year floodplain mapping for each of the individual watersheds studied. Appendix E contains the resultant existing 100-year floodplain mapping for each of the individual watersheds studied.

SECTION 4 - PROBLEM AREAS

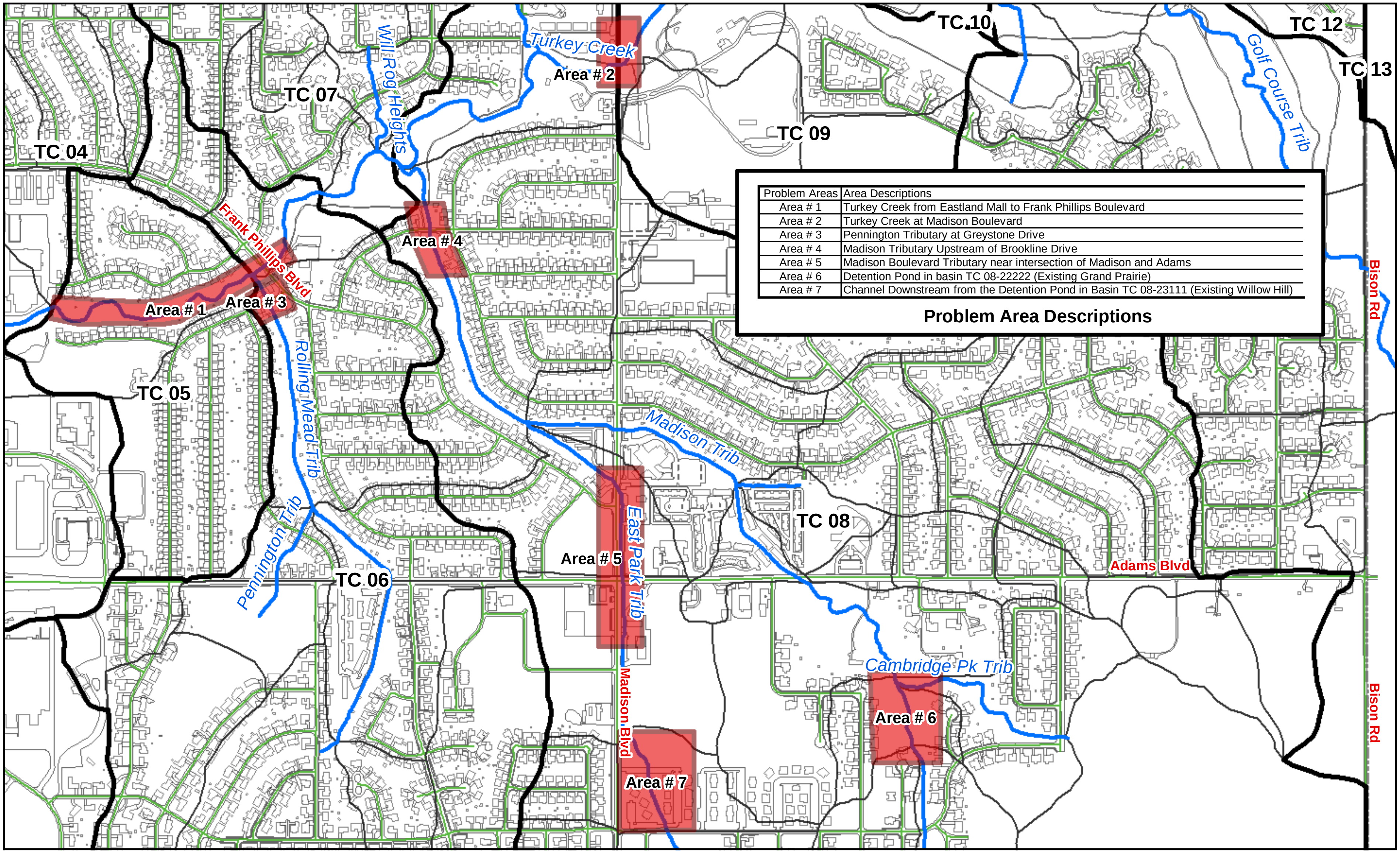
In all of the studied areas, the 10-year and 100-year floodplains were used to identify flooding problem areas. City staff also provided historical problem areas. The individual reports also provide information on bridge and culvert overtopping, as will as the depth of flooding to be expected in buildings.

All of the individual reports identify problems areas within the drainage basin. Those are summarized below, and shown on Figures 4-1 through 4-6.

Table 4-1 – Problem Areas

Turkey Creek Problem Areas (Figure 4-1)	Type of Problem	Capacity of Existing System
Area No. 1 - Turkey Creek at Frank Phillips Boulevard	Overtopped Bridge/Culvert, Inadequate Channel, Flooded Buildings	2-year
Area No. 2 - Turkey Creek at Madison Boulevard	Overtopped Bridge/Culvert	1-year
Area No. 3 - Rolling Meadows Tributary at Brookline Drive	Inadequate Storm Sewer, House Flooding	1-year
Area No. 4 - Madison Tributary Upstream of Brookline Drive	Inadequate Storm Sewer, House Flooding	5-year
Area No. 5 - Madison Boulevard Tributary near intersection of Madison and Adams	Inadequate Storm Sewer, Street Flooding	2-year
Area No. 6 - Existing Grand Prairie Detention Pond	Undersized Stormwater Detention Facility	2-year
Area No. 7 – Channel Downstream from the Existing Willow Hill Detention Pond	Inadequate Downstream Channel and Culverts	2-year

Rice Creek Problem Areas (Figure 4-2)	Type of Problem	Capacity of Existing System
Area No. 1 – Rice Creek Tributary at Dorchester Drive	Inadequate Bridge/Culvert	5-year
Area No. 2 – Rice Creek Tributary at Fox Hollow Court	Inadequate Storm Sewer	Less than 1-year
Area No. 3 – Wayside Tributary from Harvey Drive to Wayside Drive	Inadequate Culvert and Channel	2-year
Area No. 4 – Rice Creek Tributary Near Wayside School	Inadequate Culverts	Less than 1-year to 2-year
Area No. 5 – US75 at Rice Creek	Inadequate Bridge/Culvert	25-year
Area No. 6 – West Mall Tributary from Wayside Drive to Limestone Road	Inadequate Culverts	1-year to 10-year
Area No. 7 – Rolling Hills Tributary at Lewis Road	Inadequate Culvert	2-year



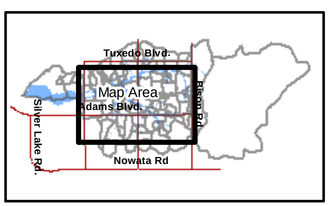
Problem Areas	Area Descriptions
Area # 1	Turkey Creek from Eastland Mall to Frank Phillips Boulevard
Area # 2	Turkey Creek at Madison Boulevard
Area # 3	Pennington Tributary at Greystone Drive
Area # 4	Madison Tributary Upstream of Brookline Drive
Area # 5	Madison Boulevard Tributary near intersection of Madison and Adams
Area # 6	Detention Pond in basin TC 08-22222 (Existing Grand Prairie)
Area # 7	Channel Downstream from the Detention Pond in Basin TC 08-23111 (Existing Willow Hill)

Problem Area Descriptions

Bartlesville Master Drainage Plan

Problem Areas Location Map - Turkey Creek

Figure 4-1



Legend

- Transportation Layer
- Turkey Creek Centerline
- Street Centerlines
- Flood Problem Areas
- City Limits
- Buildings

1 in equals 1,000 ft

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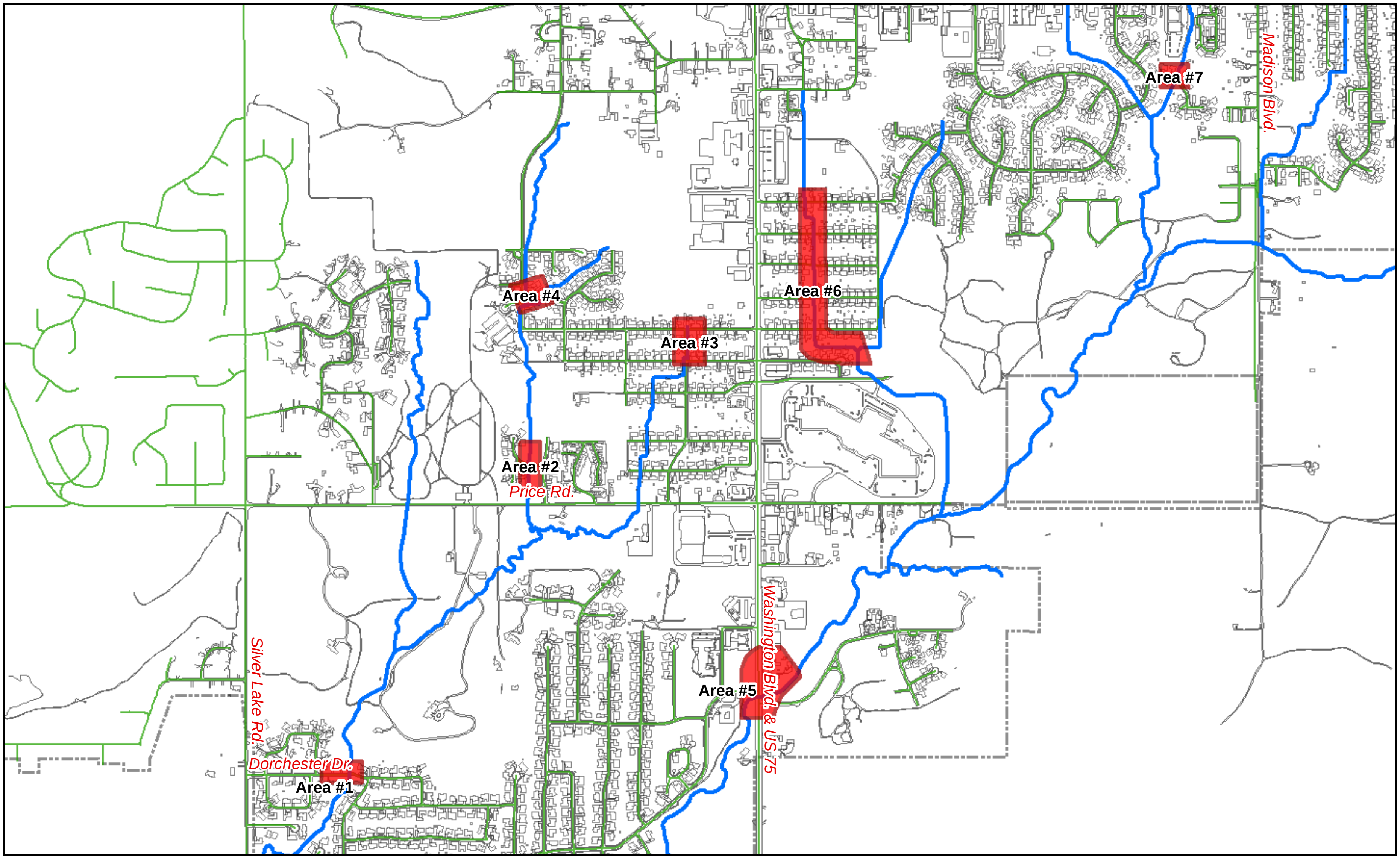
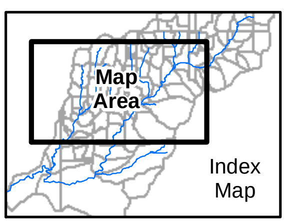


Bartlesville
Master Drainage Plan

Problem Area Locations - Rice Creek

Figure 4-2



Legend

- Transportation Layer
- Street Centerlines
- Rice Creek Centerline
- Problem Areas
- City Limits
- Buildings

1 in equals 1,500 ft

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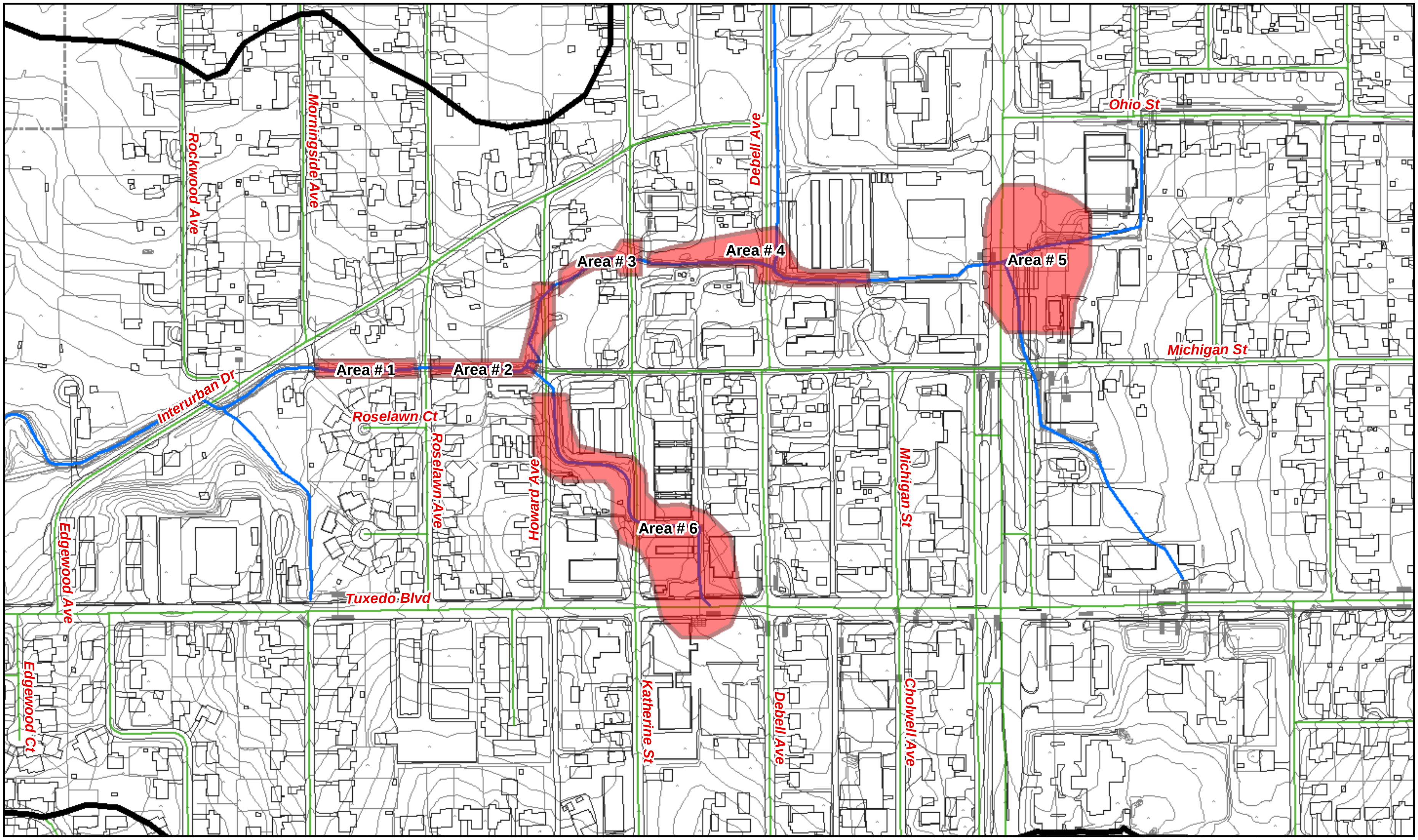
Table 4-1 – Problem Areas

Interurban Creek Problem Areas (Figure 4-3)	***Type of Problem***	***Capacity of Existing System***
Area No. 1 – Interurban Creek Channel below Roselawn Avenue	Inadequate Bridge/Culvert/Channel	2-year
Area No. 2 – Interurban Creek at Howard Avenue and Channel downstream to Roselawn	Inadequate Bridge/Culvert/Channel	Less than 1-year
Area No. 3 – Interurban Creek at Katherine Avenue and Channel downstream to confluence	Inadequate Bridge/Culvert/Channel	Less than 1-year
Area No. 4 – Interurban Creek at DeBell and Channel downstream to Katherine	Inadequate Bridge/Culvert/Channel	Less than 1-year
Area No. 5 - Interurban Creek east of US Highway 75	Inadequate Bridge/Culvert/Channel	2-year
Area No. 6 – Howard Tributary below Tuxedo Boulevard	Inadequate Storm Sewer System	5-year

Caney River Tributaries (Figure 4-4)	***Type of Problem***	***Capacity of Existing System***
Area No. 1 – Price Road and Silver Lake Road Intersection	Inadequate Bridge/Culvert	2-year
Area No. 2 - Upper Burlingame Hills	Inadequate Culverts	Less than 1-year
Area No. 3 - Hillcrest Heights Storm Sewer	Inadequate Storm Sewer	Less than 1-year

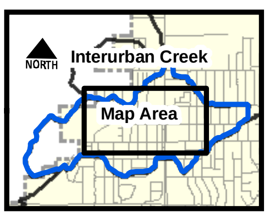
Woodlands Area (Figure 4-5)	***Type of Problem***	***Capacity of Existing System***
Area No. 1 – Woodlands Creek at Oakdale Drive	Inadequate Bridge/Culvert	1-year
Area No. 2 - Oakdale Tributary at Upper Evergreen Drive	Overflow from Pond and Inadequate Storm Sewer	1-year
Area No. 3 – Oakdale Tributary at Lower Evergreen Drive to Cherokee Hills Drive	Inadequate Culverts	2-year
Area No. 4 – Quail Place Tributary	Inadequate Ditches and Culverts	Less than 1-year
Area No. 5 – Green Country Tributary	Inadequate Culverts	1-year
Area No. 6 - Brookside Tributary	Inadequate Culverts	2-year



Bartlesville Master Drainage Plan

Problem Area Locations - Interurban

Figure 4-3



Index Map

Legend

- InterUrban Streamline
- Tranportation Layer
- Street Centerlines
- City Limits
- Problem Areas
- Buildings
- InterUrban Drainage Extents

NORTH 1 inch equals 401 feet

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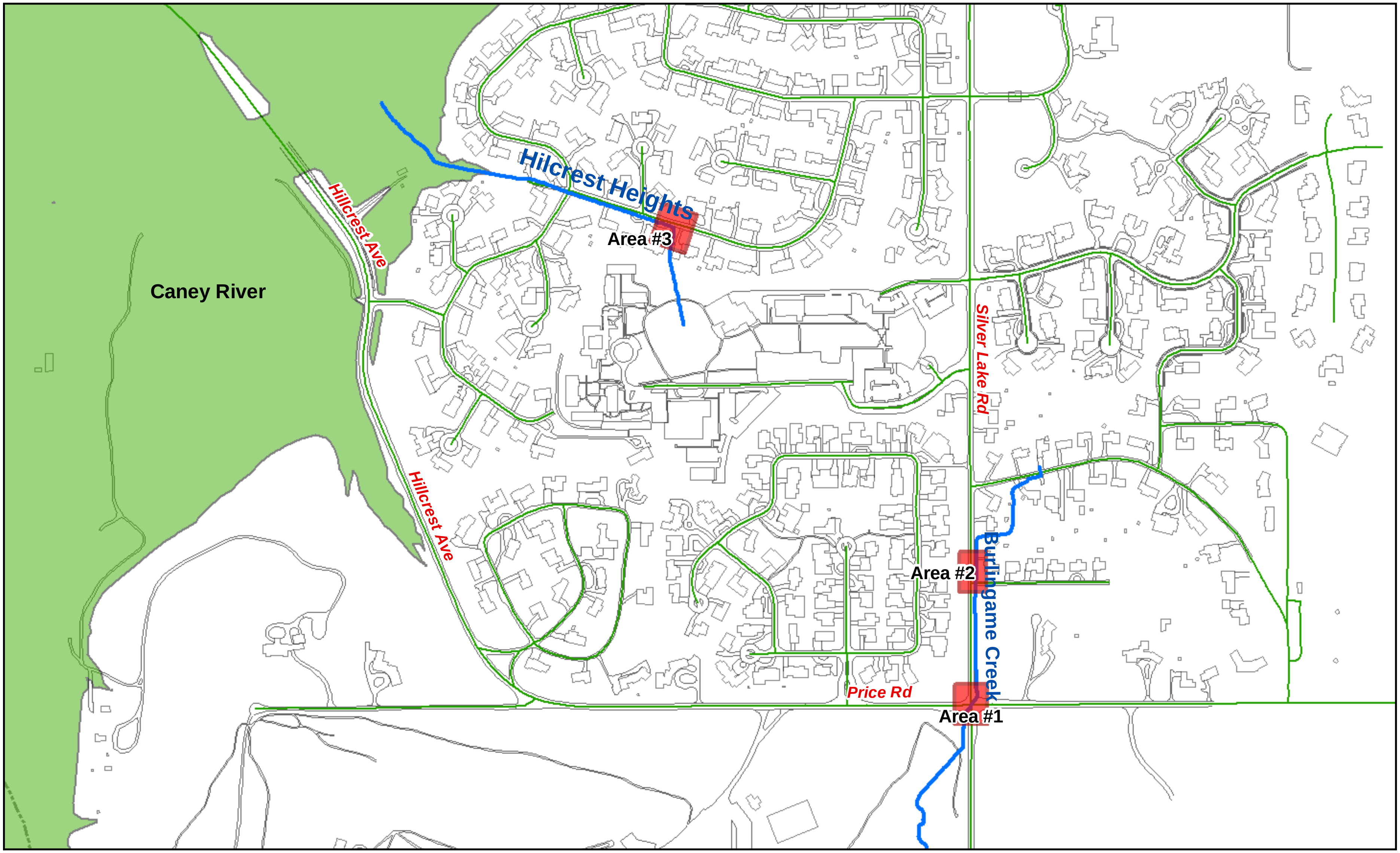
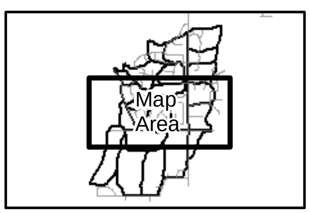


Bartlesville Master Drainage Plan

Problem Area Locations - Caney Tribs.

Figure 4-4



Index Map

Legend

- Burlingame Hills Centerline
- Transportation Layer
- Street Centerlines
- Problem Areas
- Buildings/Structures
- City Limits

1 in equals 600 ft

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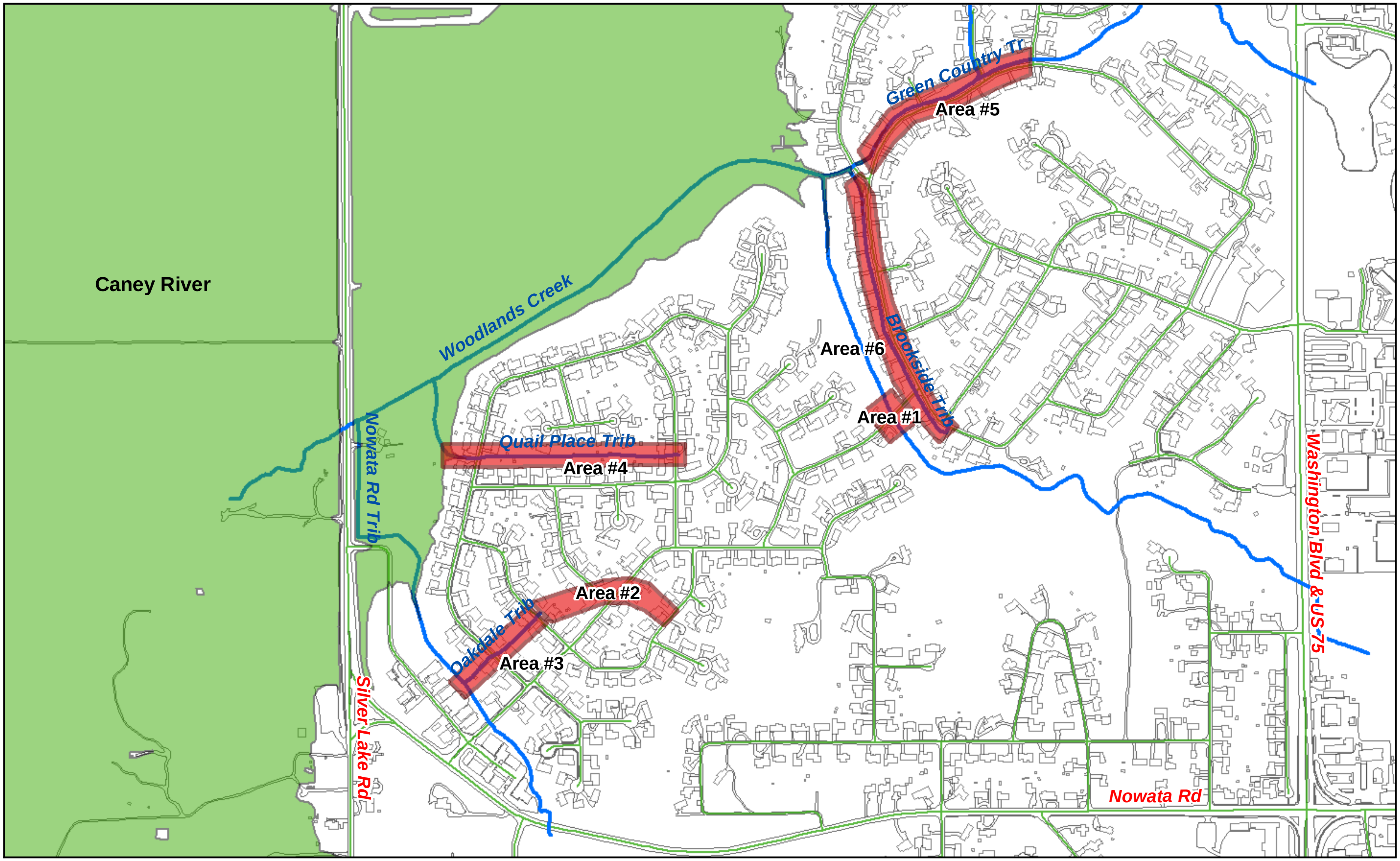
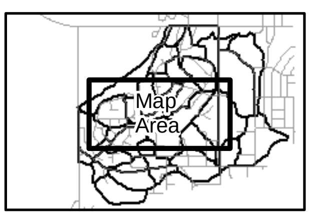


Bartlesville Master Drainage Plan

Problem Area Locations - Woodlands Area

Figure 4-5



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Legend

- Woodland Centerline
- Transportation Layer
- Street Centerlines
- Problem Areas
- City Limits
- Buildings/Structures

1 in equals 800 ft

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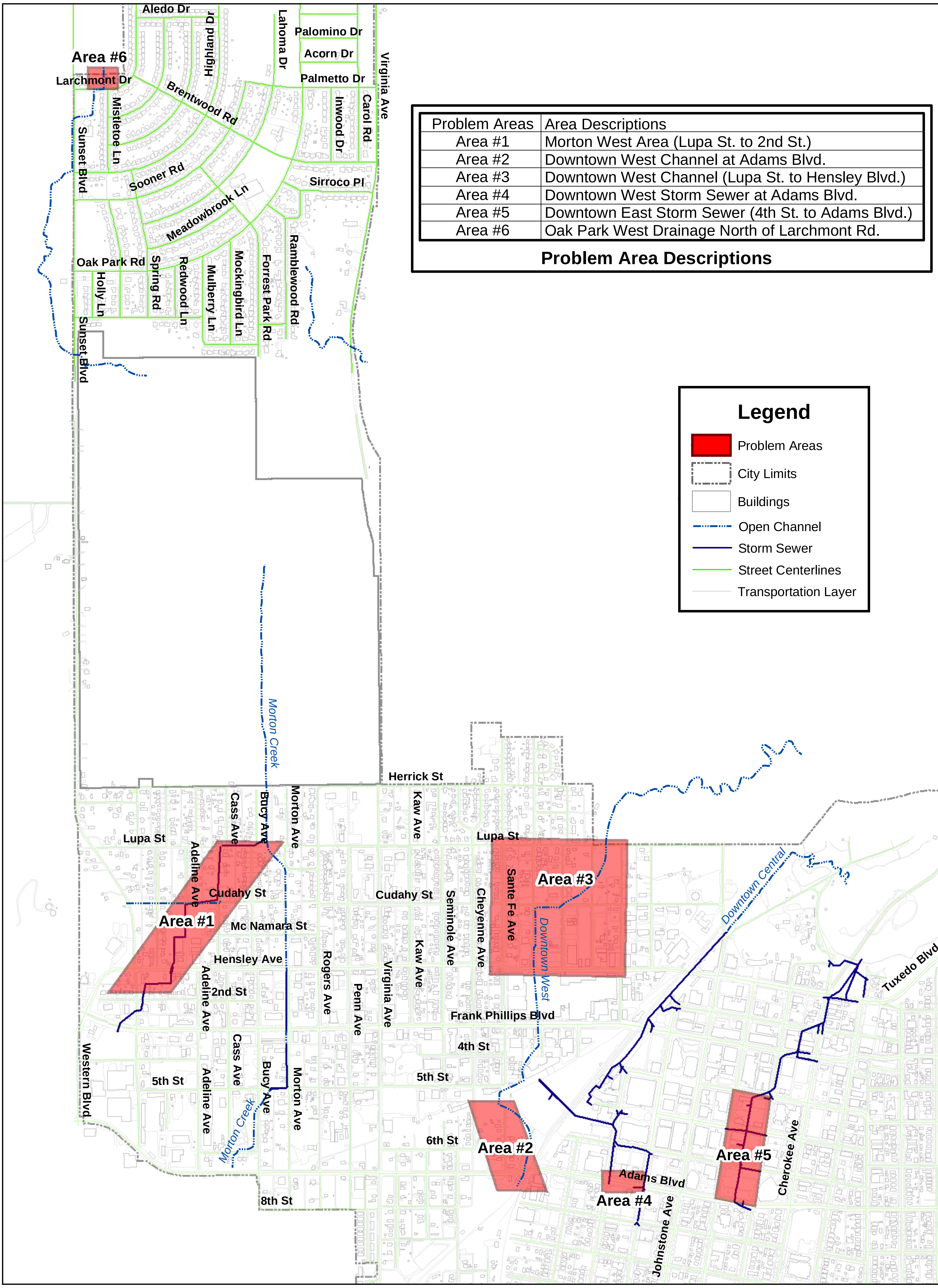
Table 4-1 – Problem Areas		
West Bartlesville Problem Area (Figure 4-6)	**Type of Problem**	**Capacity of Existing System**
Area No. 1 – Morton West Area	Street Flooding, Potential Building Flooding	Less than 1-year
Area No. 2 - Downtown West Channel at Adams Boulevard	Debris Blockage, Inadequate Culvert and Channel	Less than 1-year
Area No. 3 – Downtown West Channel Improvements	Inadequate Channel	Less than 1-year
Area No. 4 – Downtown West Storm Sewer	Inadequate Storm Sewer System	Less than 1-year
Area No. 5 – Downtown East Storm Sewer	Inadequate Storm Sewer System	Less than 1-year
Area No. 6 - Oak Park West	Inadequate Culverts	2-year



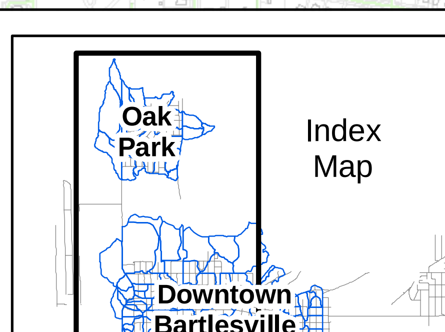
Problem Area Descriptions

Problem Areas	Area Descriptions
Area #1	Morton West Area (Lupa St. to 2nd St.)
Area #2	Downtown West Channel at Adams Blvd.
Area #3	Downtown West Channel (Lupa St. to Hensley Blvd.)
Area #4	Downtown West Storm Sewer at Adams Blvd.
Area #5	Downtown East Storm Sewer (4th St. to Adams Blvd.)
Area #6	Oak Park West Drainage North of Larchmont Rd.

Bartlesville Master Drainage Plan

Problem Area Locations - West Bartlesville

Figure 4-6



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1 in equals 1400ft

NORTH

SECTION 5 - ALTERNATIVE EVALUATIONS

General

Alternative evaluation for Turkey Creek, Rice Creek, Interurban Creek, Woodlands Creek and the Morton West Area in the West Bartlesville study, included a determination of the potential depth of flooding in buildings. Because of this, an evaluation of the effect of allowing the problems to continue and worsen could be made. Additionally, the potential of 100-year flooding above the finished floor could be evaluated in order to recommend floodplain acquisition. Therefore Alternative 1 and 2 for these three watersheds could be evaluated as described below.

Alternative 1 - No Action

Without improvements to the drainage basin, current flooding problems will continue to worsen. The table below lists the damages in the drainage basins for which building flooding were determined.

Table 5-1 Flooding Damages

Drainage Basin	Average Annual Damages	Present Worth Damages at 6-5/8% Interest for 50 Years
Turkey Creek	$ 382,374	$ 5,538,154
Rice Creek	$ 77,893	$ 1,128,169
Interurban Creek	$ 97,864	$ 1,417,128
Woodlands Creek	$ 157,659	$ 2,283,471
Morton West	$ 40,405	$ 585,202

There are a number of intangible costs, however, that must be identified as a part of this approach. The actual cost of a "No Action" approach to the master plan is the decreased quality of life brought about by the following:

- Increasing risk of loss of life
- Increasing flood damages:
    - Flooded buildings and contents
    - Roadway pavements
    - Bridge and culvert damage
    - Utilities and other public facilities
    - Emergency aid during flood events
- Increasing inconvenience due to road closings
- Loss of emergency vehicle access during flooding
- Decreased property values and development potential

The individual reports have figures that show overtopped bridges and culverts in all of the studied drainage basins, based on depth of overtopping. This condition will worsen as urbanization continues making certain streets difficult to access for both residents and for emergency vehicles when the need arises.

The floodplain maps, also included in the individual reports, show those areas where floodwaters exceed the capacities of stream and storm sewer systems. These maps illustrate the areas where flood hazards currently exist.

Alternative 2 - Acquisition
Purchase of the flooding buildings in Turkey, Rice and Interurban Creeks was also considered. The following table lists the probable cost of acquisition of all buildings, both residential and non-residential, that flood during the 100-year flood.

Table 5-2 Floodplain Acquisition		
Drainage Basin	No. of Buildings	Cost
Turkey Creek	105	$ 16,730,000
Rice Creek	22	$ 2,823,000
Interurban Creek	17	$2,425,000
Woodlands Creek	18	$2,204,317
Morton West	6	$2,076,825

Alternative 3 – Structural Alternatives
In all of the watersheds studied for which recommendations were made, structure alternatives were evaluated. In general, stormwater detention facilities were used to decrease peak discharges to levels that can be better accommodated by existing drainage structures, or that require smaller replaced structures.

In the areas where stormwater detention did not provide adequate reductions in flow rates, replacement or enlargement of existing bridges, culverts, storm sewers and creek channels were recommended.

The City's goal is to provide a 100-year level of protection for all areas for which that is possible. The most cost-effective approach however, has generally been determined to be providing a solution to the flooding that occurs during the 10-year storm. Approximately 90% of all flood events are at or below the 10-year frequency.

Therefore goal of the various alternatives in the problem areas described in the individual reports, has been to eliminate flooded buildings and overtopped structures for the 10-year storm, using regional detention to the maximum extent possible. The challenge is two-fold; first, to allow future development to occur with no increase in peak runoff rates, and secondly, to provide flood mitigation in the areas where problems currently exist.

SECTION 6 - RECOMMENDED PLANS

Turkey Creek
Alternatives 3a, 3b and 3c, described in the Turkey Creek Master Drainage Plan, were evaluated in order to minimize downstream channel and storm sewer improvements. Alternatives 3a and 3b considered various combinations of stormwater detention to meet the needs within the drainage basin. Alternative 3b provided the most upstream stormwater detention, but failed to completely eliminate the need for 10-year channel and storm sewer improvements. The decreases in discharge were not significant enough at Frank Phillips Boulevard to decrease the cost of those improvements. Additionally, the improvement to Sooner Park alone provides enough of a decrease at Madison Boulevard to eliminate the overtopping for the 100-year storm. Eliminating the two upstream stormwater detention ponds described in Alternative 3b will save approximately $1,000,000 without loss of significant benefits downstream.

The implementation of Alternative 3c in its entirety reduces the number of buildings flooded in the 10-year storm from 41 to zero. It also reduces the number of flooded buildings in the 100-year storm from 106 to 32.

The existing average annual flood damages have a present worth of $5,538,154. From a damage comparison of building flooding only, the present worth of the flood damage reduction benefit alone is approximately $3,500,000. Other flood damages that will occur during a flood event presently include pavement and bridge damage from overtopped roadways and debris, and damages to utilities. The public cost includes emergency services during floods and revised traffic for closed roadways. Additionally, increased safety during floods is an invaluable benefit. These additional benefits have not been included in the $3,500,000 estimate of benefits.

The recommended improvements include construction of improvements that will allow development to occur without increases in downstream flow rates. The cost of these improvements attributable to prevention of increased flow rates due to development is the responsibility of the private sector. It is anticipated that the improvements will be at least partially constructed by property developers. Of the 113 acre-feet of stormwater detention included in Alternative 3C, the stormwater detention requirements for the remaining anticipated development in the Turkey Creek basin are approximately 38 acre-feet, or one-third.

The cost of Alternative 3c is estimated to be $5,474,800. Of that cost, $3,442,800 is the cost of the recommended stormwater detention improvements. One-third of the cost of the stormwater detention improvements is a private cost that will be borne by the developers, reducing the total effective public cost of the stormwater detention improvements to $2,295,200.

The cost of the improvements from Frank Phillips Boulevard and Brookline Drive, downstream through the proposed channel section, is $1,221,200. This cost, added to the cost of the stormwater detention improvements, is the total cost required to provide the

$3,500,000 in flood damage reduction benefits. The benefit to cost ratio for this work is 0.73 using the total cost of $4,664,000, and is 1.00 if the private cost borne by the developers is subtracted from the total.

The cost of the Madison & Adams Intersection improvements is $810,000. This cost is for safety considerations only. No building flooding will be eliminated by this improvement. If however, that cost is added to the totals described above, the benefit to cost ratio is 0.64 for the total cost, or 0.81 if the costs borne by the developers is subtracted from the total.

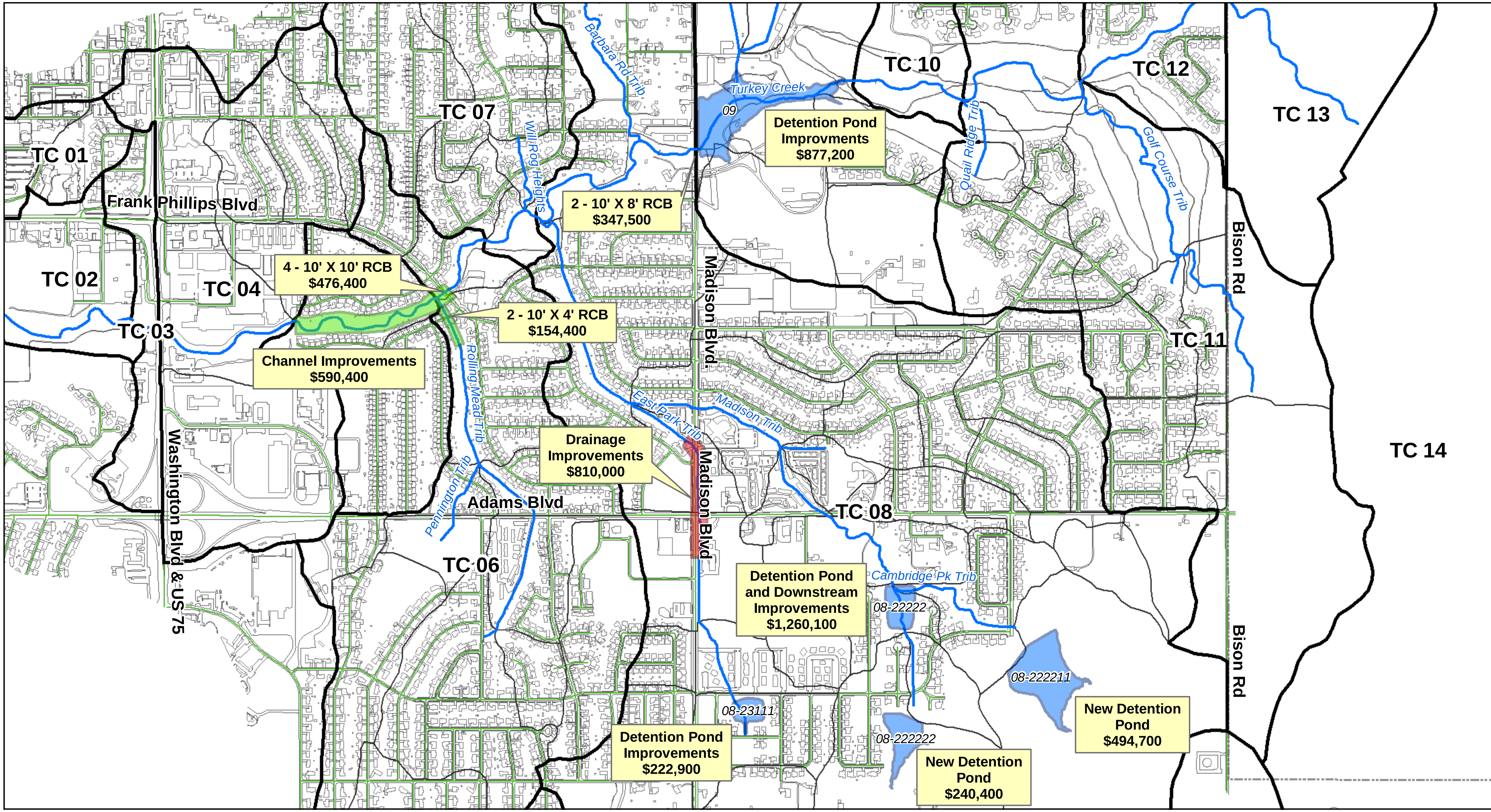
Table 6-1 summarizes the benefit to cost analysis.

Table 6-1 Turkey Creek Recommended Plan B/C Analysis

	Total Cost	***Public Cost***	***Private Cost***
Stormwater Detention Costs	$ 3,442,800.00	$ 2,295,200.00	$ 1,147,600.00
Frank Phillips, Downstream Channel, Brookline Drive	$ 1,221,200.00	$ 1,221,200.00	$ -
Subtotal	**$ 4,664,000.00**	**$ 3,516,400.00**	**$ 1,147,600.00**
Flood Damage Reduction	$ 3,500,000.00	$ 3,500,000.00	
B/C Ratio	0.75	1.00	
Adams & Madison Drainage Improvements	$ 810,800.00	$ 810,800.00	$ -
Total	**$ 5,474,800.00**	**$ 4,327,200.00**	
Flood Damage Reduction	$ 3,500,000.00	$ 3,500,000.00	
B/C Ratio	0.64	0.81	

Implementation of Alternative 3c is recommended in its entirety as shown on Figure 6-1. Within the Turkey Creek drainage basin, the following prioritization applies:

- The improvement to the Frank Phillips Boulevard roadway and downstream channel should occur simultaneously, or the channel improvements should occur first.
- The improvements near the Madison and Adams Boulevards should follow the upstream stormwater detention.
- The Pennington Tributary improvements should follow the downstream channel improvements.
- The Sooner Park stormwater detention facility is independent. However, if the downstream improvements are completed first, they will not pass the 10-year flow rates until the Sooner Park facility is completed.



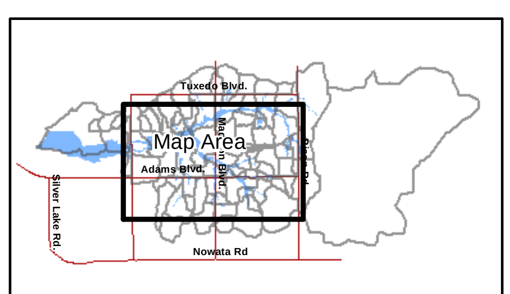
Turkey Creek Master Drainage Plan

Final Recommended Plan

Figure 6-1

Map # 1 of 1

Map Date: Mar 28, 2004



Legend

- Transportation Layer
- Turkey Creek Centerline
- Street Centerlines
- City Limits
- Recommended Detention Ponds
- Recommended Channelization
- Recommended Storm Sewer Improvements
- Buildings

1 in equals 1,000 ft

NORTH

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Turkey Creek Master Drainage Plan

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Rice Creek

Figure 6-2 shows the final recommended plan for the Rice Creek watershed. Alternatives 3A-1, 3A-2 and 3A-3, described in detail in the Rice Master Drainage Plan, were evaluated in order to maximize the areas for which regional stormwater detention can be made available while providing mitigation for existing flooding problems. Alternative 3A-2 provides the most upstream stormwater detention, but did not provide all of the mitigation required to remove the houses upstream from US75 from the floodplain. The decreases in discharge by adding the Madison detention pond were not significant enough to justify the large cost of the facility. And finally, the diversion of the Mall Tributary into the Price Road detention pond was not feasible because it would cause additional flooding upstream due to backwater. The recommendation is therefore to construct the improvements outlined in Alternative 3A-1 at a cost of $3,060,100. These include the following:

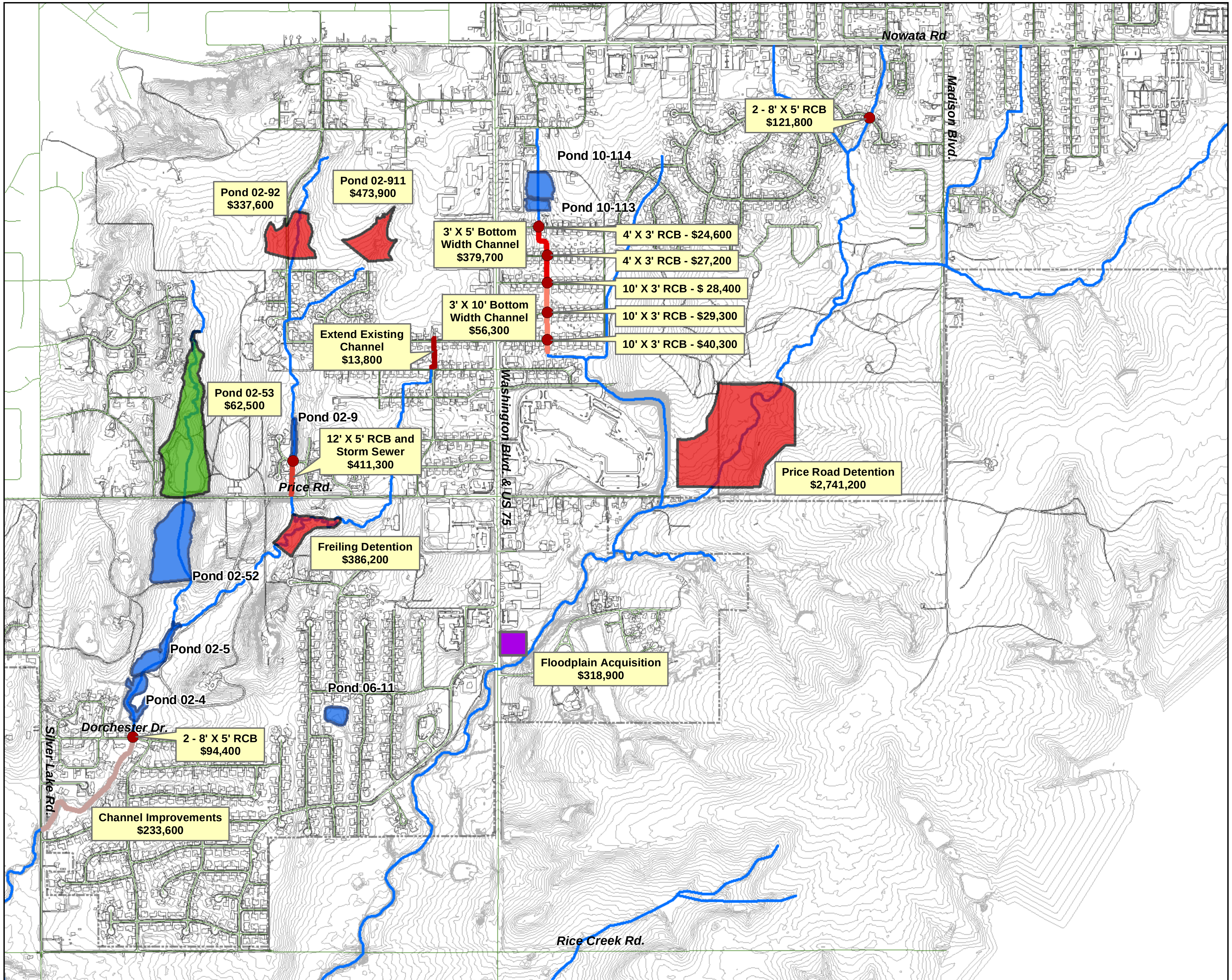
- Price Road Detention Pond
- Acquisition of Flooded Properties upstream from US 75

The recommendation for the Rice Creek Tributary is to construct the improvements recommended in Alternative 3B-1, at a total cost of $2,013,300. These include the following:

- The Jo Allyn Park Detention Improvements will provide stormwater detention to offset future development in this watershed, although is does not significantly add any mitigation benefits to the current flooding that occurs at Dorchester Road.
- The Fox Hollow Improvements will eliminate the continual roadway flooding problem in that subdivision and the potential to flood houses.
- The Freiling Detention Pond will offset both upstream development and the loss of storage from the Fox Hollow Improvements.
- Stormwater Detention in Sub-basins 02-911 and 02-92 above Fox Hollow again serve dual purposes, to offset future development and to solve downstream flooding problems.
- Extension of the Wayside Improvements will completely eliminate the potential flooding problems in this neighborhood. The downstream system, recently completed by the City, will carry the 100-year flow rates.

Finally, we recommend that the City construct the drainage improvements described in Alternative 3C-1. While limited flooding of building occurs in this neighborhood, all of the drainage structures are undersized, causing frequent overtopping during frequent floods. The total cost of Alternative 3C-1 is $707,600, which also includes replacement of the Lewis Drive culvert on the Rolling Meadows Tributary.

The cost of the Rice Creek Recommended Plan is estimated to be $5,781,000. Of that cost, $4,001,400 is the cost of the recommended stormwater detention improvements. Forty-two percent of the cost of the stormwater detention improvements is a private cost that will be borne by the developers, reducing the total effective public cost of the stormwater detention improvements to $2,896,500.



Bartlesville Master Drainage Plan

Final Recommended Plan - Rice Creek

Figure 6-2

Map Date:
Mar 25, 2004

Legend

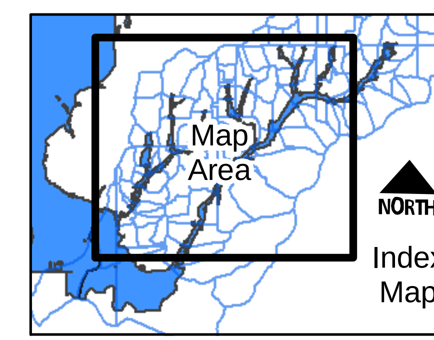
- Replace Structure
- Existing Detention Facilities
- Proposed Detention Facilities
- Modified Detention Facilities

Channel Descriptions

- Extend Existing Channel
- 12' X 5' RCB Storm Sewer
- 3' X 5' Bottom Width Channel
- 3' X 10' Bottom Width Channel
- Channel Improvements

Base Data

- Transportation Layer
- Street Centerlines
- Rice Creek Centerline
- City Limits
- Buildings



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0 500 1,000 2,000

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The cost of the improvements related to flood mitigation in Rice Creek and the Rice Creek Tributary, is $1,072,00. This cost, added to the cost of the stormwater detention improvements, is the total cost required to provide the $1,128,200 in flood damage reduction benefits. The benefit to cost ratio for this work is 0.22 using the total cost of $5,073,400, and is 0.52 if the private cost borne by the developers is subtracted from the total.

The cost of the Mall Tributary and Rolling Meadows Tributary improvements is $707,600. This cost is for safety considerations only. No building flooding will be eliminated by this improvement. If however, that cost is added to the totals described above, the benefit to cost ratio is 0.20 for the total cost, or 0.41 if the costs borne by the developers is subtracted from the total.

Table 6-2 summarizes the benefit to cost analysis.

Table 6-2 Rice Creek Recommended Plan B/C Analysis

	Total Cost	***Public Cost***	***Private Cost***
Stormwater Detention Costs	$ 4,001,400.00	$ 1,104,900.00	$ 2,896,500.00
Acquisition at US 75	$ 318,900.00	$ 318,900.00	$ -
Flood Mitigation Projects-Rice Tributary	$ 753,100.00	$ 739,400.00	$ -
Subtotal	$ 5,073,400.00	$ 2,163,200.00	$ 2,896,500.00
Flood Damage Reduction	$ 1,128,200.00	$ 1,128,200.00	
B/C Ratio	0.22	0.52	
Mall Tributary Improvements	$ 585,800.00	$ 585,800.00	$ -
Lewis Drive Replacement	$ 121,800.00	$ -	
Total	$ 5,781,000.00	$ 2,749,000.00	$ 2,896,500.00
Flood Damage Reduction	$ 1,128,200.00	$ 1,128,200.00	
B/C Ratio	0.20	0.41	

Implementation of Alternatives 3A-1, 3B-1 and 3C-1 for Rice Creek is recommended in its entirety as shown on Figure 6-2. Within the Rice Creek drainage basin, the following prioritization applies:

- The Freiling Detention Pond and the Follow Hollow Improvements should be constructed first. The loss of storage at Fox Hollow will be compensated downstream.
- Replace Dorchester Drive culvert. The upstream detention will make up for the minimal loss of floodplain storage.
- The Jo Allyn Park Detention Improvements should precede any development between Price Road and Dorchester Drive.
- Ponds 02-55, 02-92 and 02-911 should precede any develop in their upstream basins.

- The Wayside Improvements can be constructed at any time. The downstream portions of that system are in place.
- The improvements shown for the Mall Tributary should be preceded by the construction of the Price Road Detention Pond. Those improvements should be completed from downstream to upstream.

Interurban Creek

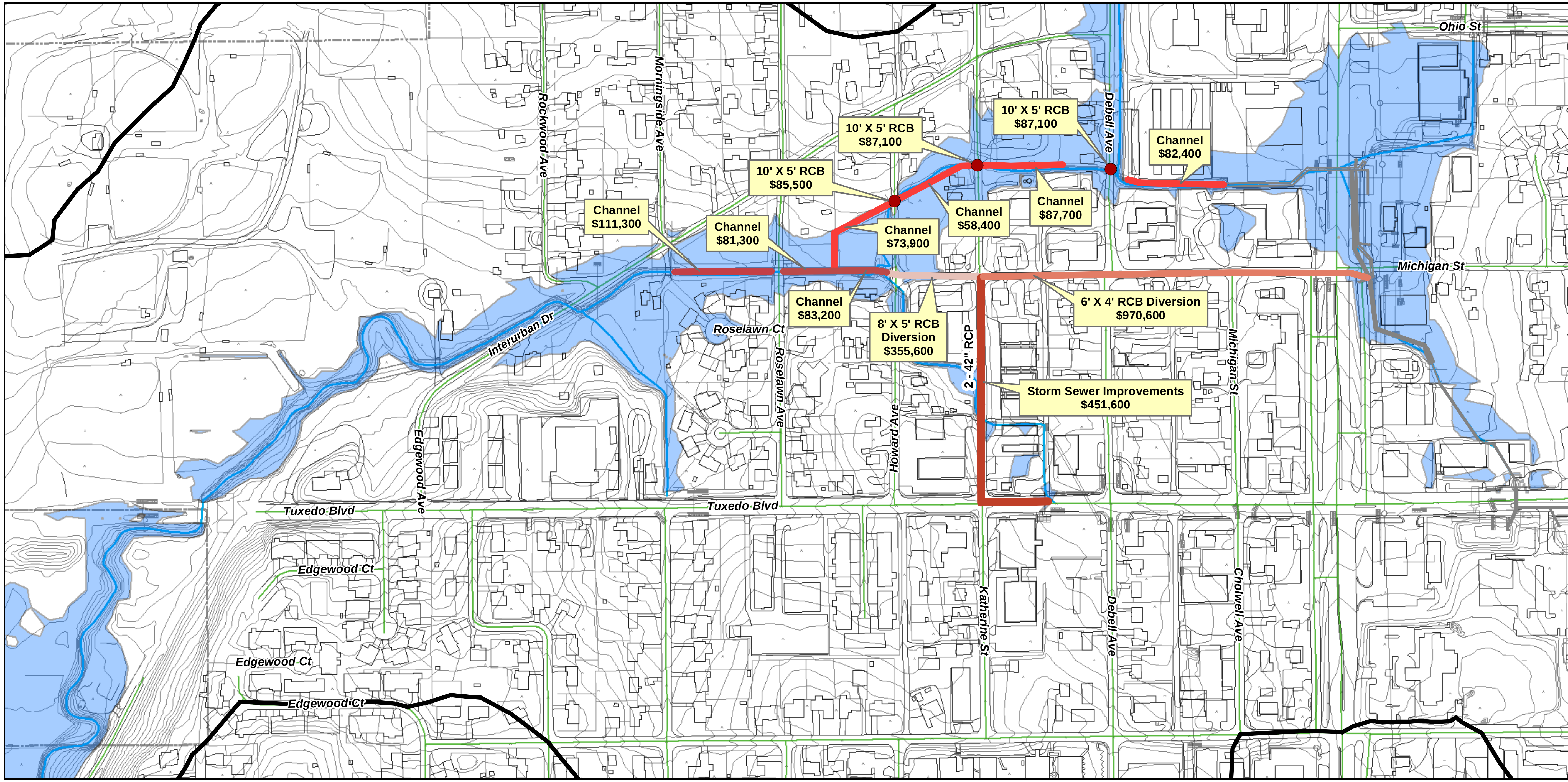
The recommended plan described in the Interurban Creek Master Drainage Plan, the 10-Year System Improvements proposes a 10-year system, with a diversion of all of the drainage sub-basin described as IU-08 into a separate storm sewer system from a collection point on Michigan east of US Highway 75, to the west, ending at the intersection of Michigan Street and Howard Avenue. This will alleviate the ponding areas in the 5-year storm, and reduce those for the larger storms, east of US Highway 75.

The improvements are shown on Figure 6-3. At the upstream end, the diversion of all of the IU-08 subarea at Michigan requires a 6-foot x 4-foot RCB from the diversion point east of US Highway 75 to Katherine Street. At that point, the flow from IU-06-11, described in Section 4 as Problem Area No. 6 – Howard Tributary below Tuxedo Boulevard, enters the system. The recommended improvement at Problem Area No. 6 is construction of a double 42-inch RCP from Tuxedo Boulevard between Katherine Street and DeBell Avenue, west along Tuxedo Boulevard and north to Michigan Street. At the intersection of Michigan Street and Katherine Street, the Michigan diversion structure enlarges to an 8-foot x 5-foot RCB to the confluence with Interurban Creek.

The concrete channel from the downstream side of the existing 8-foot x 4-foot RCB at US Highway 75 is adequate to carry the 10-year storm. Downstream from the existing concrete channel, a 10-foot bottom width, 5-foot deep, vertical wall channel will be constructed to Michigan Avenue. The structures at DeBell Avenue, Katherine Street and Howard Avenue will each be replaced with an 8-foot x 5-foot RCB.

Downstream from the confluence of Interurban Creek with the Michigan Diversion, a 20-foot bottom width, 5-foot deep, vertical wall channel will be constructed to the Interurban Drive culvert at approximately Station 54+00. From this point downstream, the channel has been improved by the City using the 10-year flow rates described in the Interurban Creek Master Drainage Plan.

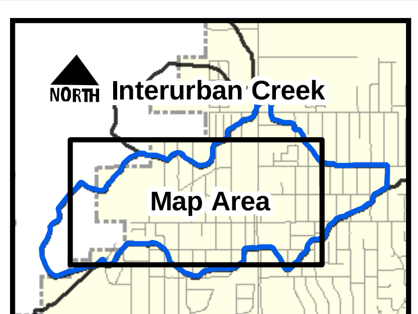
Because of the fully developed nature of this watershed and the close proximity to the flat Caney River floodplain, channelization and culvert replacement make up the recommended plan for this watershed. Figure 10 shows the individual elements of the recommended plan. The total cost of Alternative 3 is $2,615,700, considered a public cost for flood mitigation. Total flood damages on Interurban Creek above the recently completed City drainage projects are $1,417,128. The benefit-cost ratio considering reduction in building flooding damage only for this Recommended Plan is 0.54.



Bartlesville Master Drainage Plan

Final Plan - Interurban Creek

Figure 6-3 Map Date: Oct 11, 2004



Index Map

Legend

- Interurban Streamline
- Transportation Layer
- Street Centerlines
- Current City Project
- 100 Year Floodplain
- City Limits
- Buildings
- Interurban Drainage Extents

NORTH 1 inch equals 300 feet

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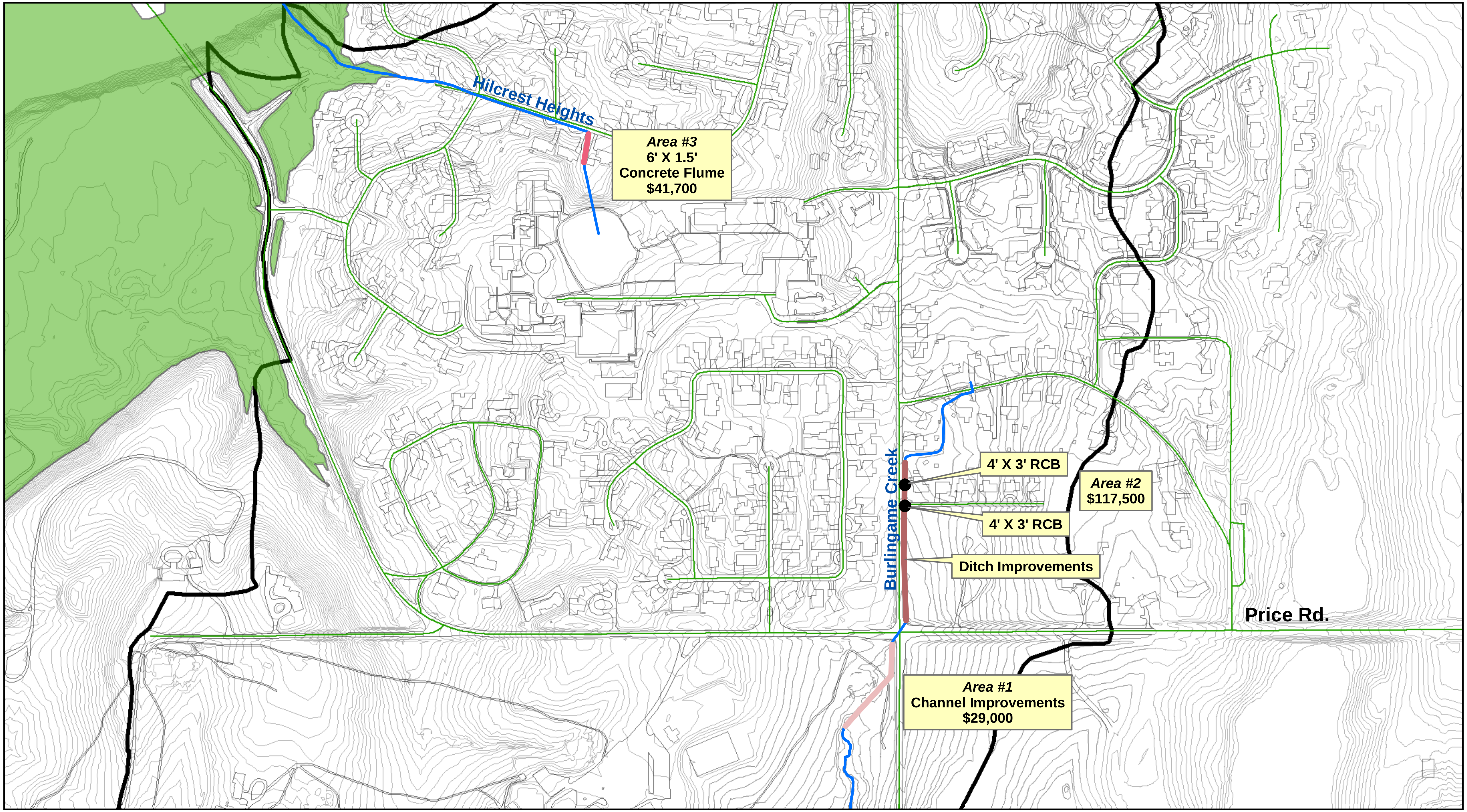
Caney River Tributaries
Figure 6-4 shows the Recommended Plan for the Caney River Tributaries. Flooding of buildings in these areas as a result of large flow rates on the tributary is minimal. Because of this, the plan for the Caney River Tributaries includes several small mitigation projects listed below. No sites were available for significant upstream detention, so developers in these watersheds will be required to provide onsite stormwater detention to offset increases in flow rates due to future development.

<u>Burlingame Hills Creek – Price Road and Silver Lake Road Intersection (Area No. 1)</u>
Approximately 140 feet downstream of this intersection, flow is restricted to a 12-inch RCP. Backwater effects from the water over the fairway of the golf course restrict the amount of flow conveyed by the 5-foot x 3-foot RCB. An 8-foot channel with 3:1 side slopes would be required to lower the tailwater and provide a 10-year level of protection at the intersection, at a cost of $29,000.

The underground structure that would be required to keep the water from flowing over the fairway in a 10-year storm event would be approximately 285 feet of 6-foot x 4-foot RCB at a much greater cost of over$200,000. The recommendation is to construct channel improvements would be made from the intersection through the fairway.

<u>Burlingame Hills Creek – Parkway Street (Area No. 2)</u>
There is a 15-inch RCP under Parkway Street and the private drive upstream of Parkway Street. To improve the system to a 10-year level of protection, a 4-foot x 3-foot RCB would be required at each crossing. Between the crossings and downstream to the intersection of Silver Lake Road and Price Road roadway ditch improvements with a 3-foot concrete ditch liner is recommended. When combined with the intersection improvements listed above, this area would be protected to the 10-year storm level. The total cost for this improvement would be $117,500. It should be constructed following the completion of the improvements described for Area No. 1.

<u>Hillcrest Heights – Moonlight Drive (Area No. 3)</u>
Water discharging from the pond on the campus of Oklahoma Wesleyan University discharges at a rate that exceeds the capacity of the 18-inch RCP drainage system and causes localized flooding. A concrete flume constructed above would allow overflow water to continue directly to the street. This would reduce the potential for flooding in the houses on either side of the system. The proposed flume would have a bottom width of 6 feet and a depth of 1.5 feet. The total cost for this improvement would be $41,700. This improvement may be completed at any time.



Bartlesville
Master Drainage Plan

*Final Plan - **Caney Tributaries***

Figure 6-4 Map Date: Oct 11, 2004

NORTH

1 in equals 400 ft

Legend

- Burlingame Hills Centerline
- Transportation Layer
- Street Centerlines
- Caney 10yr Floodplain
- Buildings/Structures
- City Limits

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Woodlands Area

Flooding of buildings in these areas as a result of large flow rates on this creek is highly localized. Because of this, the plan for the Woodlands Creek area includes several small mitigation projects listed below. No sites were available for significant upstream detention, so developers in these watersheds will be required to provide onsite stormwater detention to offset increases in flow rates due to future development. Figure 6-5 shows the improvements considered for the Woodlands Area.

Woodlands Creek – Oakdale Drive (Area No. 1)

To provide a 10-year capacity at Oakdale Drive, the existing 14-foot x 4-foot RCB would be replaced with a double 10-foot x 5-foot RCB. There is a low area along the east bank of the channel upstream of Oakdale Drive. When the depth of water is higher than Oakdale Drive it flows east into the Brookside Tributary. The roadway should be raised to an elevation of 682.5 with the culvert replacements. A berm along the east bank of the channel should be constructed to prevent water from flowing through backyards and between houses along Brookside Drive. The total cost for this improvement is $157,900. It may be constructed at any time.

Oakdale Tributary – Upper Evergreen Drive (Area No. 2)

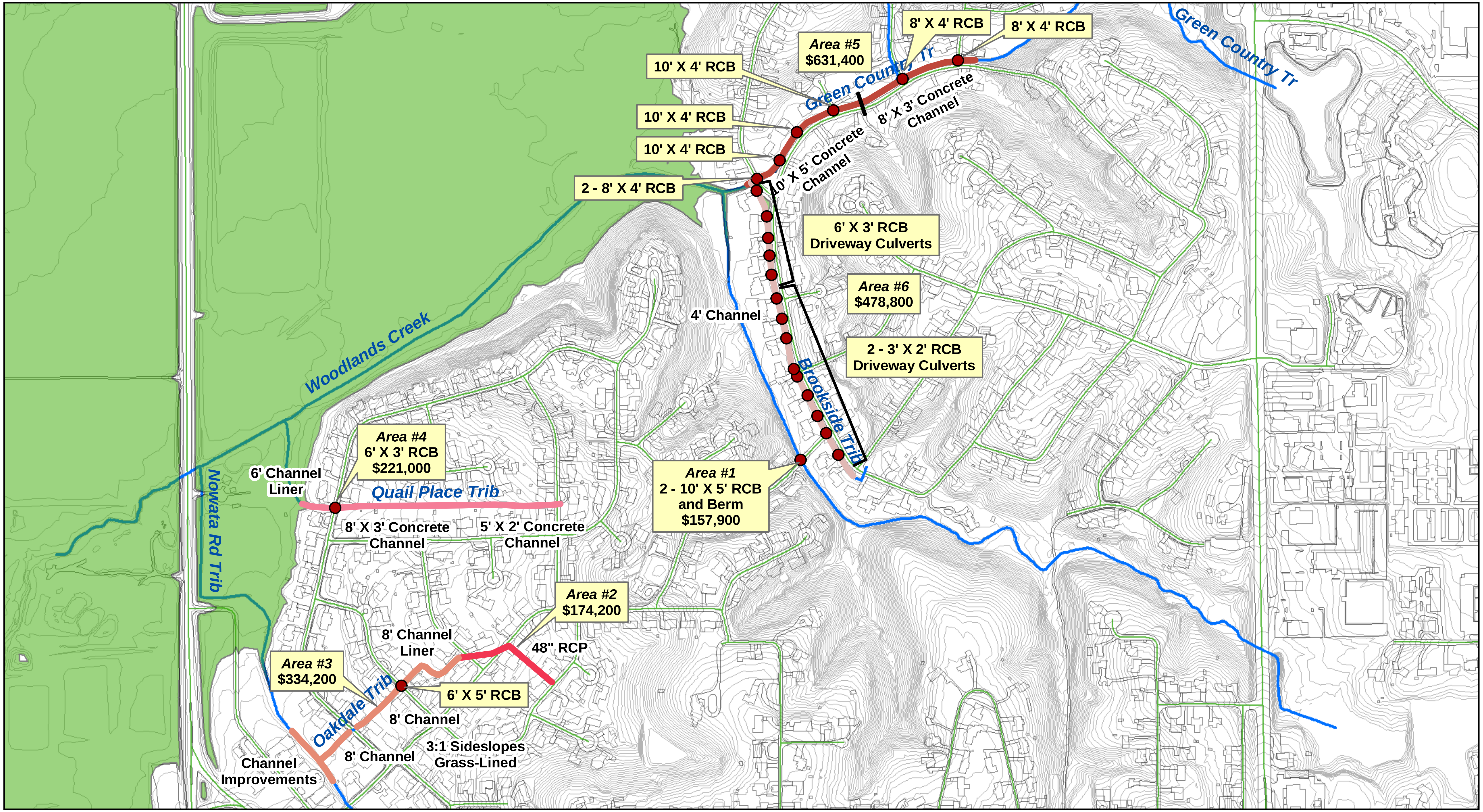
The storm sewer system that begins near 2720 Evergreen Drive has a 1-year capacity. Homes are flooded when overflow water is routed between the houses. The existing 28-inch x 20-inch CMP should be replaced with a 48-inch RCP to provide a 10-year capacity. This would require 570 feet of pipe and would discharge downstream of Cedar Street. The total cost for this improvement is $174,200. It may be constructed following completion of the improvements listed for Area No. 3.

Oakdale Tributary – Lower Evergreen Drive to Cherokee Hills Drive (Area No. 3)

The 6-foot x 2.5-foot RCB at Evergreen Drive has a 2-year capacity. A 6-foot x 5-foot RCB would be required to provide a 10-year capacity. The 6-foot x 5-foot RCB at Cherokee Hills Drive also has a 2-year capacity. The capacity of this structure is limited by the downstream water surface of the Nowata Road Tributary.

Channel improvements to Nowata Road Tributary would require approximately 300 feet of grading to lower the elevation of the channel by two feet at the confluence with the Oakdale Tributary. This reduction in tailwater would increase the level of protection against overtopping at Cherokee Hills Drive to a 10-year frequency. The Nowata Road Tributary has less than a 10-year capacity within the channel, however, now buildings appear to flood during a 10-year storm.

The channel of Oakdale Tributary from Cedar Street to the confluence with the Nowata Road Tributary has a 2-year capacity as well. A concrete channel liner with an eight-foot bottom width and 3:1 side slopes would increase the capacity to that of the culverts. The total cost for this improvement is $334,200. It may be constructed at any time, but must be constructed prior to the improvements listed for Area No. 2.



Bartlesville Master Drainage Plan

*Final Plan - **Woodlands Area***

Figure 6-5 Map Date: Oct 11, 2004

NORTH

1 in equals 500 ft

Legend

- Woodland Centerline
- Transportation Layer
- Street Centerlines
- Caney 10yr Floodplain
- City Limits
- Buildings/Structures

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Quail Place Tributary (Area No. 4)

The existing channel between Evergreen Drive and Cherokee Hills Drive has a 2-year capacity. A 5-foot x 2-foot vertical wall concrete channel would be required downstream of Evergreen Drive to carry the 10-year flow without flooding adjacent property. This channel would transition to an 8-foot x 3-foot vertical wall channel at Cherokee Hills Drive. The existing 3-foot x 2-foot RCB at Cherokee Hills Drive would need to be replaced with a 6-foot x 3-foot RCB. Approximately 100 feet of the channel downstream of Cherokee Hills Drive would need to be improved with a 6 foot concrete channel liner and 3:1 side slopes. The total cost for this improvement is $221,000. It may be constructed at any time.

Green Country Tributary (Area No. 5)

There are several structures that have less than a 2-year capacity on the Green Country Tributary. At Winding Way, the existing 10-foot x 2-foot RCB should be replaced with two 8-foot x 4-foot RCB's. The two private driveways between Winding Way and Audubon Court would also require two 8-foot x 4-foot RCB's. The existing 10-foot x 2-foot RCB at Audubon Court should be replaced with two 8-foot x 4-foot RCB's. A 10-foot x 5-foot concrete channel with vertical walls would be required in this area. The two 6-foot x 2-foot RCB's at Whippoorwill Court and the 10-foot x 2-foot RCB at Kenwood Road should be replaced with an 8-foot x 4-foot RCB. The channel section in this area should be improved with an 8-foot x 3-foot concrete channel with vertical walls. The total cost for this improvement is $631,400. It may be constructed at any time, but must be constructed from downstream to upstream. The culvert under Winding Way must be built before the improvements listed for Area No. 6.

Brookside Drive Tributary (Area No. 6)

There are several driveway structures on the Brookside Tributary. From the confluence with the Green Country Tributary, the first driveway has two 36-inch RCP's and two 30-inch RCP's with less than a 1-year capacity. An 8-foot x 4-foot RCB would convey the 10-year flow rate. The next four driveway structures have either a slab bridge or three 24-inch RCP's. They would be replaced with a 6-foot x 3-foot RCB. The remaining nine driveway culverts and Oakdale drive culverts would need to be replaced with two 3-foot x 2-foot RCB's to improve the capacity of the system from a 2-year to a 10-year frequency. Approximately 1100 linear feet of concrete channel liner with a bottom width of four feet would provide easier maintenance of the channel between these structures. The total cost for this improvement is $478,800. These improvements may be constructed following the replacement of the drainage structure under Winding Way in Problem Area No. 5.

Benefit-Cost Analysis – Woodlands Drainage Basin

Existing flood damages in the Woodlands drainage basins are approximately $2,283,471, and are shown on the table below:

Woodlands Area Flood Damages - Existing Conditions		
Frequency	**Probability**	**Damages**
500-year	0.002	$1,286,535
100-year	0.01	$769,581
50-year	0.02	$556,632
25-year	0.04	$499,901
10-year	0.1	$313,417
5-year	0.2	$218,715
2-year	0.5	$95,041
1-year	1	$41,634
	Average Annual Damages	**$157,659**
	Interest Rate	**0.06625**
	Time period	**50**
	Present Worth Damages	**$2,283,471**

The recommended plan for the Woodland Drainage Basin will remove all damages from the 10-year storm. Eliminating these damages without consideration of the improved condition during the 25-year and larger storms reduces the present worth damages in this drainage basin to $585,396 as shown below.

Woodlands Area Flood Damages - Existing Conditions		
Frequency	**Probability**	**Damages**
500-year	0.002	$1,286,535
100-year	0.01	$769,581
50-year	0.02	$556,632
25-year	0.04	$499,901
10-year	0.1	$0
5-year	0.2	$0
2-year	0.5	$0
1-year	1	$0
	Average Annual Damages	**$40,418**
	Interest Rate	**0.06625**
	Time period	**50**
	Present Worth Damages	**$585,396**

The flood damage reduction benefit for the projects in the Woodland Creek drainage basin is $1,698,075. This produces a benefit to cost ratio of 0.85.

West Bartlesville Master Drainage Plan

The West Bartlesville drainage basins were analyzed to develop floodplains for regulatory purposes and to recommend drainage projects to improve the drainage systems in accordance with the work that has already been performed by the City. In general, the drainage improvements strive to provide for 10-year protection. The West Bartlesville Recommended Plan is shown on Figure 6-6.

<u>Area No. 1 - Morton West Area</u>

The recommended plan for the Morton West area includes two proposed detention sites described in detail in the West Bartlesville Master Drainage Plan document. Site 'A' is located on approximately 2 acres of largely undeveloped land at the Southwest corner of Cudahy and Cass Avenues. One existing home at the corner of Cass and Cudahy would have to be purchased. The pond would contain 16 acre-feet.

Site 'B' is located on a 3.4-acre tract of undeveloped land south of Frank Phillips Boulevard, between Sunset and Western Avenues, and has a capacity of approximately 20 acre-feet.

A 10-year storm drainage system can be created in the basin by constructing both Sites 'A' and 'B'. Site 'B' would discharge into the existing storm sewer system to Hensley Avenue. Downstream of Hensley, the existing 48" CMP would be removed and replaced with a trapezoidal concrete channel section, with a 20-foot bottom width and 2 to 1 side slopes. This section would continue 300 feet to the North and drain into Site 'A'. Site 'A' would then discharge into the existing storm sewer downstream of Cudahy Avenue.

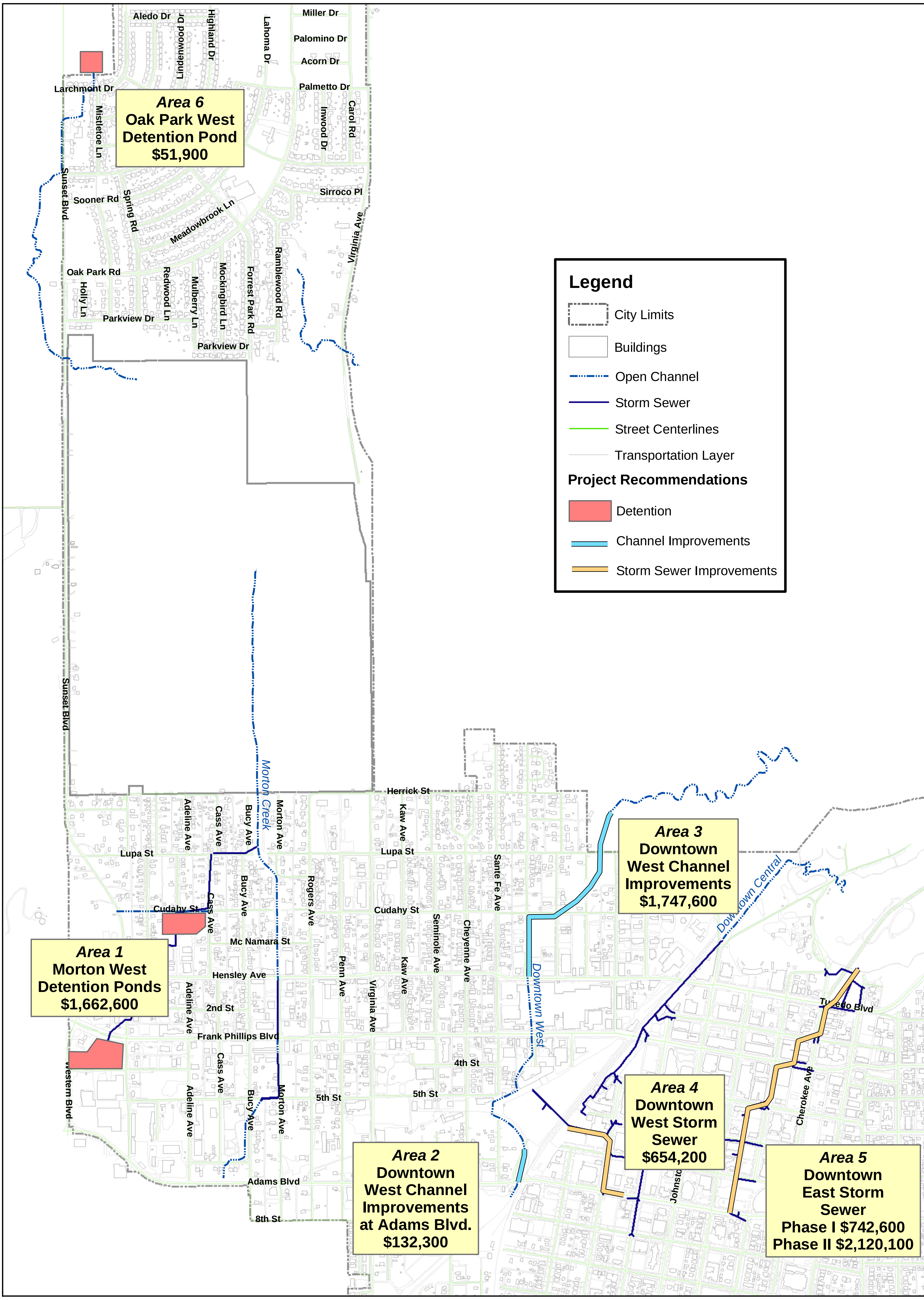
<u>Area No. 2 - Downtown West Channel at Adams Boulevard</u>

The recommended plan for this area includes cleaning and lining the channel downstream of Adams Boulevard, as well as removing silt from the structure, and removing debris upstream of the structure. In addition, the flow line of the channel just downstream of, and under Adams Boulevard, was lowered by 6 inches to simulate the removal of sediment, restoring the channel to a constant slope.

This will allow the channel convey the 10-year peak discharge without overtopping the road. The hydraulics of the small storm sewer system under the building to the East, that has its outfall in the channel under Adams Boulevard, were not studied. Headwater behind the Adams Boulevard structure may still cause this storm sewer to surcharge during intense rainfalls, but the affect will be less than at present.

<u>Area No. 3 – Downtown West Channel Improvements</u>

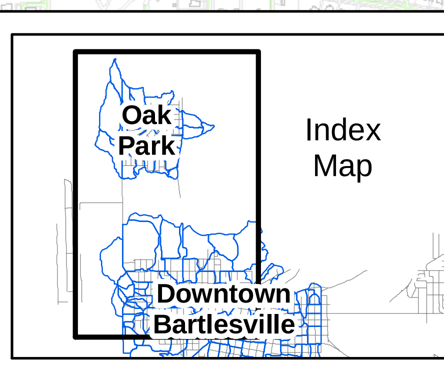
Channel widening and improvement was considered for the existing channel from Lupa Street to Hensley Boulevard, in order to prevent frequent overtopping of the existing channel banks, and to reduce the water surface elevation, thereby improving the capacity of the series of culverts under Hensley Boulevard, the Schlumberger facility, and Frank Phillips Boulevard. The Recommended Plan includes a trapezoidal concrete section with a 30-foot bottom width and 2 to 1 side slopes to convey the 10-year peak discharge from



Bartlesville
Master Drainage Plan

Final Plan - West Bartlesville Areas

Figure 6-6



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1 in equals 1,000 ft

NORTH

Hensley to Lupa Street. In addition, the existing structures at Lupa Street, the intersection of Cudahy & Theodore Avenues, and Hensley Boulevard would be replaced with a triple 8'x5' box culvert structure at each location.

The existing 10'x8' RCB under the Schlumberger facility, and the existing culvert at Frank Phillips Boulevard do not have the capacity to convey the 10-year storm. By lowering the downstream tail water, however, the proposed channel improvements would improve the capacity of these structures to at, or near, the 5-year level of protection.

Area No. 4 - Downtown West Storm Sewer

Improvements to the Downtown West storm sewer system were evaluated in order to prevent recurring flooding along Adams Boulevard, between Keeler and Jennings Avenue, and in order to prevent bypass flows from continuing overland to the north and causing surcharging of the Downtown Central storm sewer system.

For the Recommended Plan, the existing storm sewer on Keeler was left in place, and the existing 18" RCP on Jennings was replaced with a new 4'x3' RCB. This 4'x3' RCB was then extended east to the drainage sump west of Keeler Avenue. Additional inlets would be constructed on both sides of Adams Boulevard, both in the center of, and on the edges of the drainage sump. An additional 36" RCP would be added east of the Phillips parking lot, so that the system has a double 36" RCP from the outfall upstream to the intersection of 6th and Jennings Avenue.

The Downtown West storm sewer system would have a 5-year capacity. This would prevent water from ponding in the sump on Adams Boulevard during most rainfall events. It is also equal to the capacity of the existing Downtown Central storm sewer system, and would prevent bypass flows from escaping north and causing surcharging of that system.

Area No. 5 - Downtown East Storm Sewer

Two alternatives were prepared to examine the storm sewer improvements that would be needed to carry the 5-, and 10-year peak discharges in the Downtown East basin. The Recommended Plan is Alternative 1, the 5-year improvement, due to the lower cost. However the City may elect to construct Alternative 2 and provide a 10-year level of improvement in this area. Due to the relatively steep slope in the basin and the high likelihood of conflict with other utilities, alternate alignments for the main storm sewer were not considered to be practical in this basin.

Hydraulic evaluations of both the 5-, and 10-year storms showed that increased pipe size would be required along the entire length of the existing storm sewer. In order to better manage the cost of the project, a phased approach was prepared for the necessary improvements. In both alternatives, improvements to the upstream portion of the storm sewer, south of 4th Street, would be constructed in Phase I, with the remainder of the storm sewer replaced in Phase II.

In order to correct the existing flooding problems at 5th and 6th Street, it will be necessary to replace the existing 36" RCP with a higher capacity pipe. For Alternative 1, it is recommended that the existing 36" RCP from 4th Street to Adams Boulevard be replaced with a 4'x4' RCB. This will match the existing 4'x4' structure downstream, and give the overall system a 2-year capacity. It is likely that additional inlets will also be needed in the low ground along Adams Boulevard, 5th, and 6th Streets, between Osage and Dewey Avenues.

For Alternative 2, the existing 36" RCP south of 4th Street would be replaced with a 6'x4' RCB. This proposed RCB would have the capacity to carry the expected 10-year peak runoff south of 4th Street, but it would be larger than the existing downstream 4'x4' RCB. The proposed 6'x4' RCB would be designed to carry the expected 10-year peak runoff from the entire drainage area south of 5th Street, 288 cfs. The capacity of the existing downstream storm sewer is 155 cfs. Relief for the excess flow carried in the upstream box, 133 cfs, would be provided by constructing approximately 60 curb inlets along Osage and Dewey Avenues between 4th Street and Frank Phillips Boulevard, along with inlet box structures, and large lateral lines to allow the overflow rate to equalize across all 60 inlet openings. In addition to the construction of the relief curb openings, the intersections of Frank Phillips Boulevard at Osage and Dewey Avenues would be modified to flatten the crown, allowing flows to pass more easily across Frank Phillips Boulevard.

The Phase II improvements would replace the existing storm sewer from 4th Street, north to the outfall, with higher capacity pipe. For Alternative 1, the existing 4'x4' storm sewer from 4th Street, north to Frank Phillips Boulevard, would be replaced with a new 6'x4' RCB. In addition, the existing 4'x4' and 6'x4' structures from Frank Phillips Boulevard, north to the outfall, would need to be replaced with a 7'x4' RCB. With these improvements, the overall Downtown East storm sewer system would have the capacity to convey peak discharges from the 5-year storm.

For Alternative 2, the existing RCB storm sewer north of 4th Street would be replaced with a 7'x4' RCB to Frank Phillips Boulevard, and 8'x4' RCB from there to the outfall. Upon completion of the Phase II, Alternative 2 improvements, the Downtown East storm sewer system would have a 10-year capacity.

Area No. 6 - Oak Park West
Improvements to the drainage system at Larchmont Road were considered in order to improve the capacity and reliability of the existing system. Two alternative approaches were examined. Alternative 1 considered enlarging and improving the existing drainage system in order to convey higher flow rates between the existing homes along Larchmont Road. Alternative 2 considered the construction of a detention facility in the existing pasture just north of the affected homes.

Alternative 1 is the lower cost alternative and is the Recommended Plan. It would enlarge the existing drainage system to reliably convey the expected 10-year peak runoff from the drainage area north of Larchmont Road. The existing backyard curb inlet is unreliable.

The swale north of the properties on Larchmont would be graded to drain to the end of the existing concrete flume, making it the primary stormwater conveyance. The existing 3'x1' concrete flume would be replaced with a 3'x3' rectangular concrete channel section for additional capacity.

The downstream end of this channel would drain into a new 24" RCP that would carry runoff under Larchmont Road to a manhole on the south curb, and then west, into the existing inlet box. The capacity of the proposed 3'x3' rectangular channel would be greater than the 24" RCP. The excess flow would be allowed to spill over onto Larchmont Road where it would flow across the street and into the downstream channel. The existing storm sewer and area inlet to the north could be left in place. The existing 18" RCP running south from the inlet box to the downstream channel outfall, however, would be replaced with a 30" RCP to accommodate higher flows in the system.

With these improvements, the 10-year peak discharge from the drainage area north of Larchmont Road could be reliably conveyed between the existing homes with no hazard of flooding.

West Bartlesville Summary

The following table summarizes the costs within the West Bartlesville Master Drainage Plan.

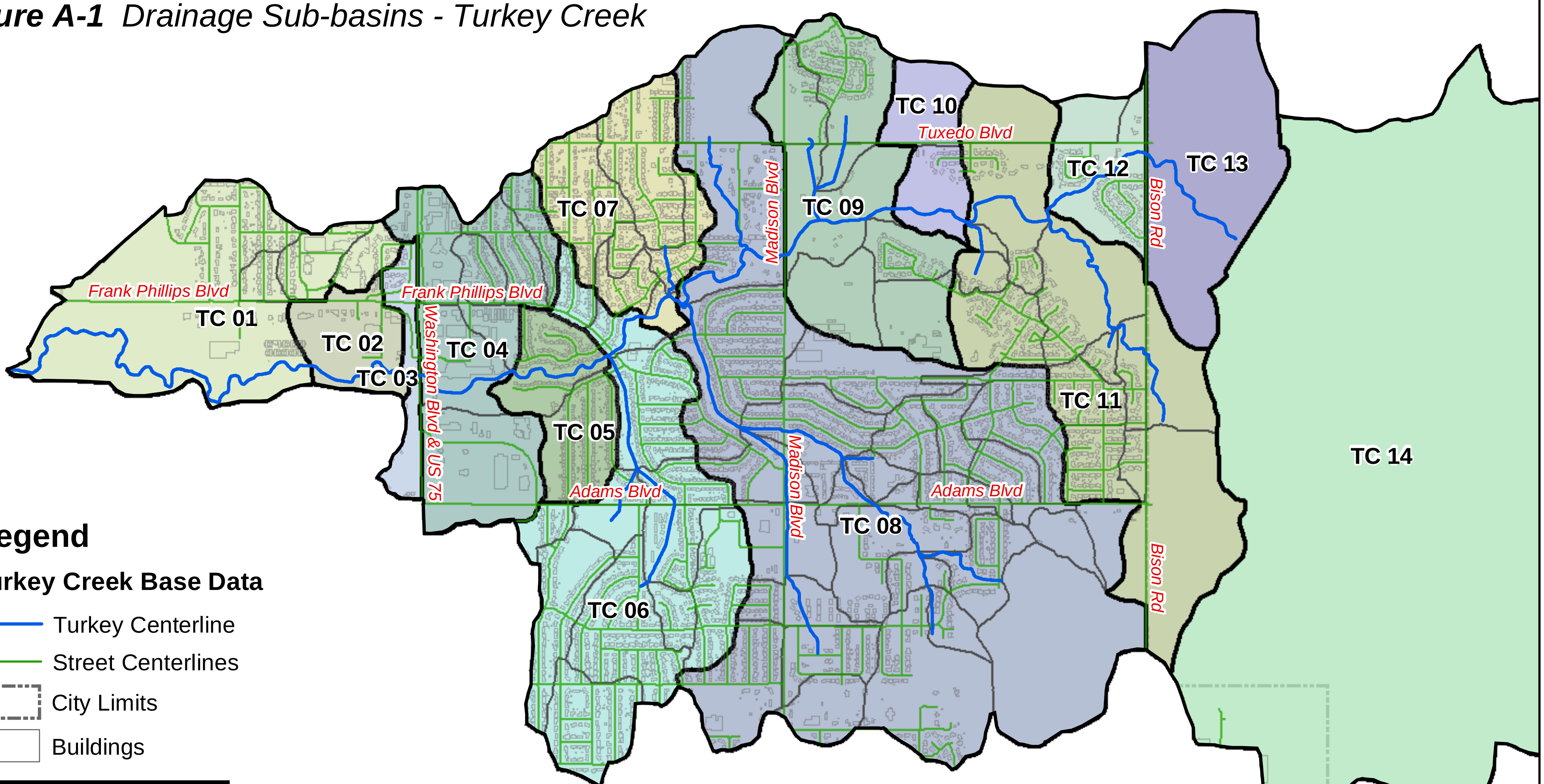
Table 6-3
Summary of Recommended Drainage Improvements
West Bartlesville Master Drainage Plan

Area No.	Project	Capital Cost
1	Morton basin detention structures	$1,662,700
3	Downtown West channel and structure improvements from Lupa Street to Hensley Boulevard	$1,747,600
4	Downtown West storm sewer improvements	$654,200
2	Downtown West channel and structure improvements at Adams Boulevard	$132,300
5	Phase 1 Downtown East storm sewer improvements	$742,600
5	Phase II Downtown East storm sewer improvements	$2,120,100
6	Oak Park drainage improvements at Larchmont Road	$51,900
	Estimated Total Capital Cost of West Bartlesville Drainage Improvements:	**$7,111,400**

APPENDIX A – Sub-Basin Delineations Of Studied Watersheds

Bartlesville Master Drainage Plan

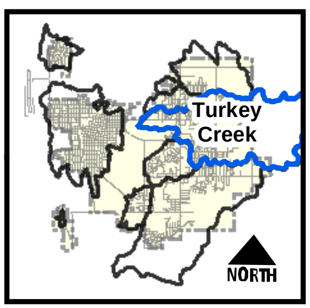
Figure A-1 *Drainage Sub-basins - Turkey Creek*



Legend

Turkey Creek Base Data

- Turkey Centerline
- Street Centerlines
- City Limits
- Buildings



Index Map

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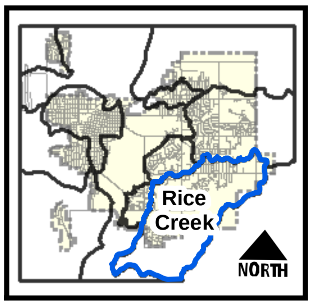
Bartlesville Master Drainage Plan

Figure A-2 *Drainage Sub-Basins - Rice Creek*

Legend

Rice Creek Base Data

- Rice Creek Centerline
- Street Centerlines
- City Limits
- Buildings



Index Map

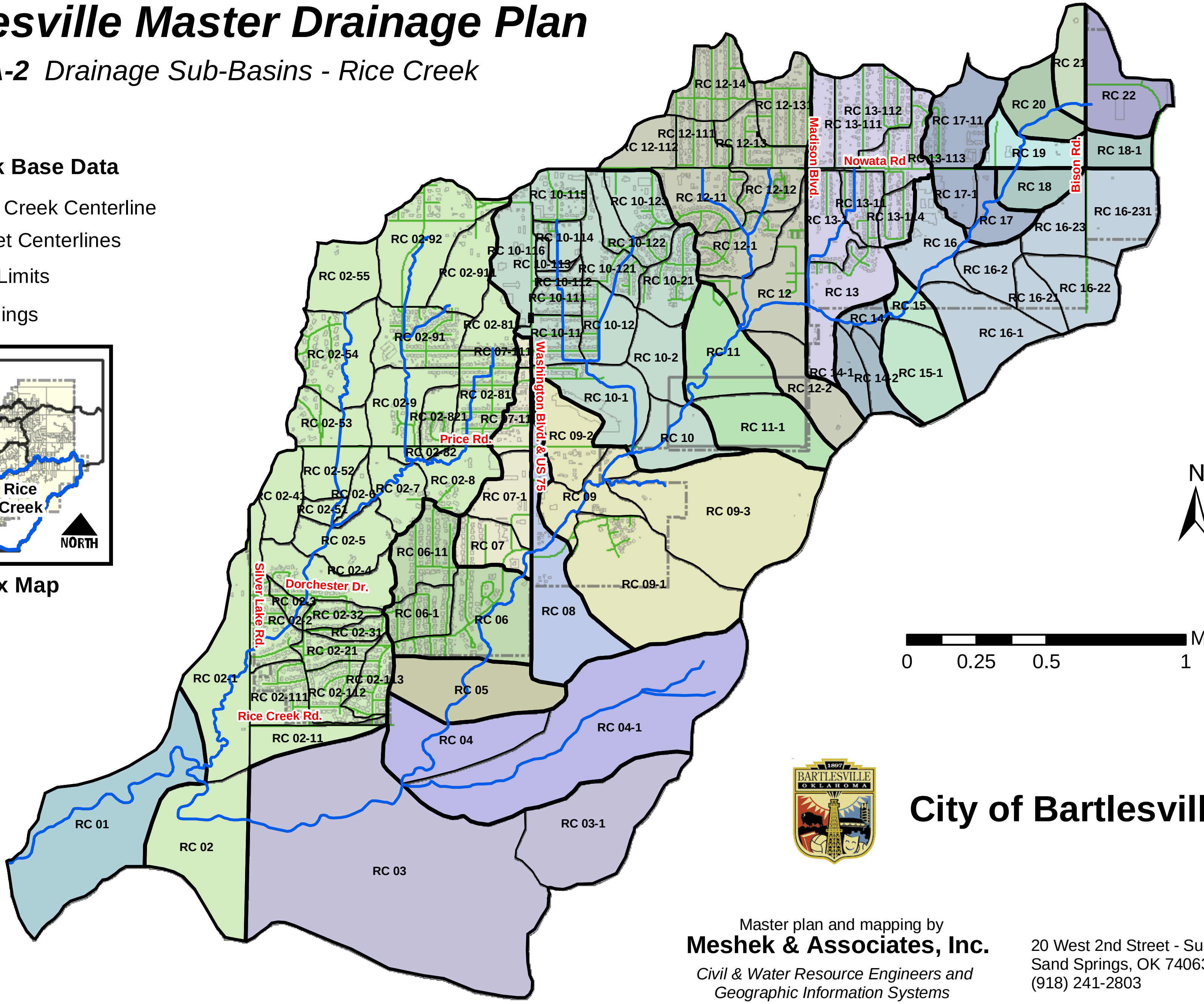


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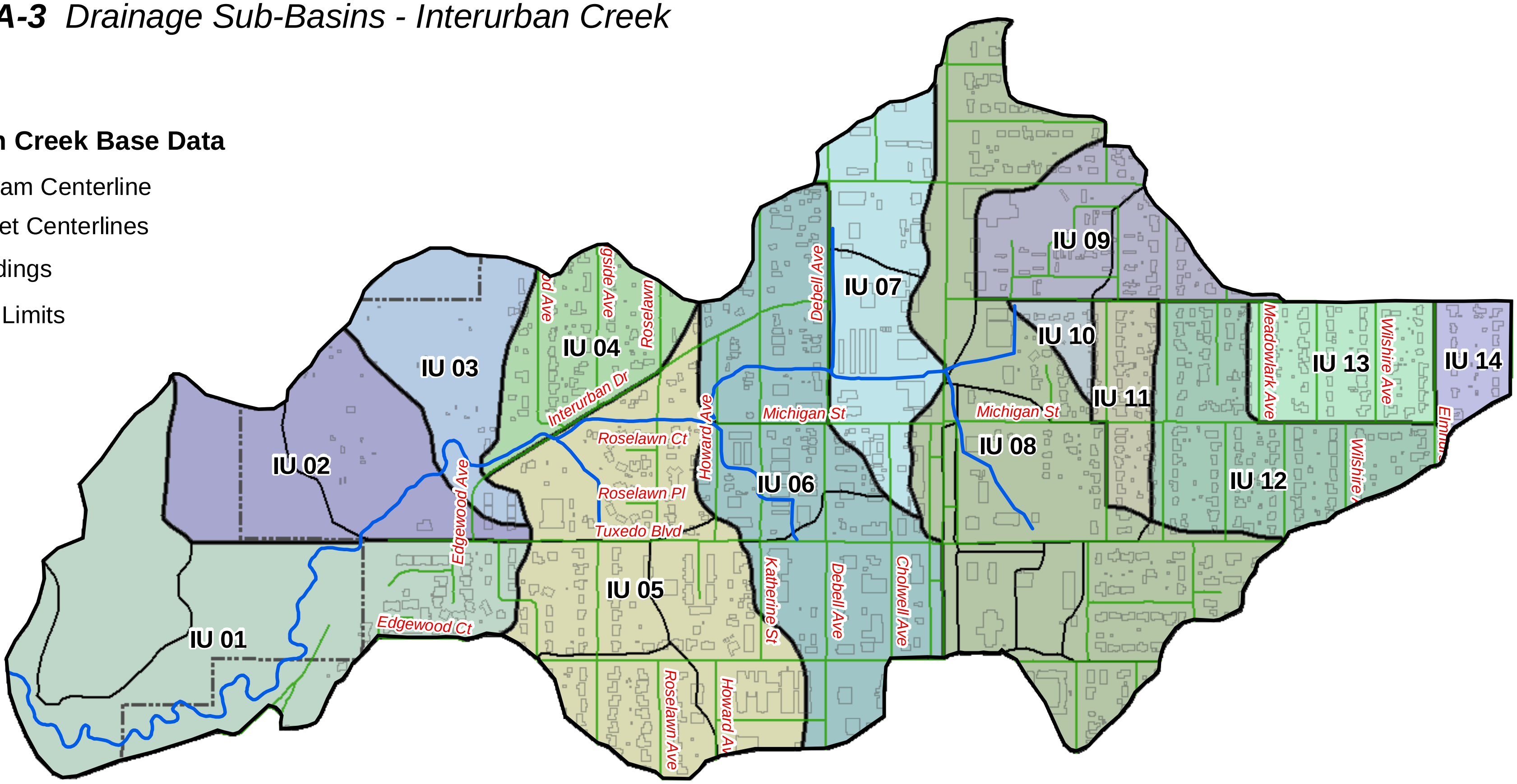
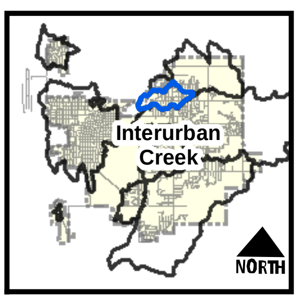
Figure A-3 *Drainage Sub-Basins - Interurban Creek*

Legend

Interurban Creek Base Data

- Stream Centerline
- Street Centerlines
- Buildings
- City Limits





Index Map

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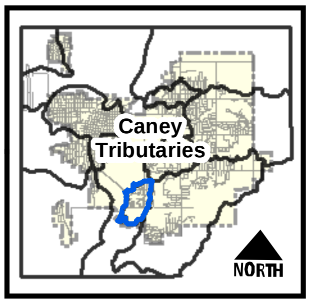
Bartlesville Master Drainage Plan

Figure A-4 *Drainage Sub-basins - Caney River Tributaries*

Legend

Rice Creek Base Data

- Caney Trib Stream Centerline
- Street Centerlines
- Buildings
- City Limits



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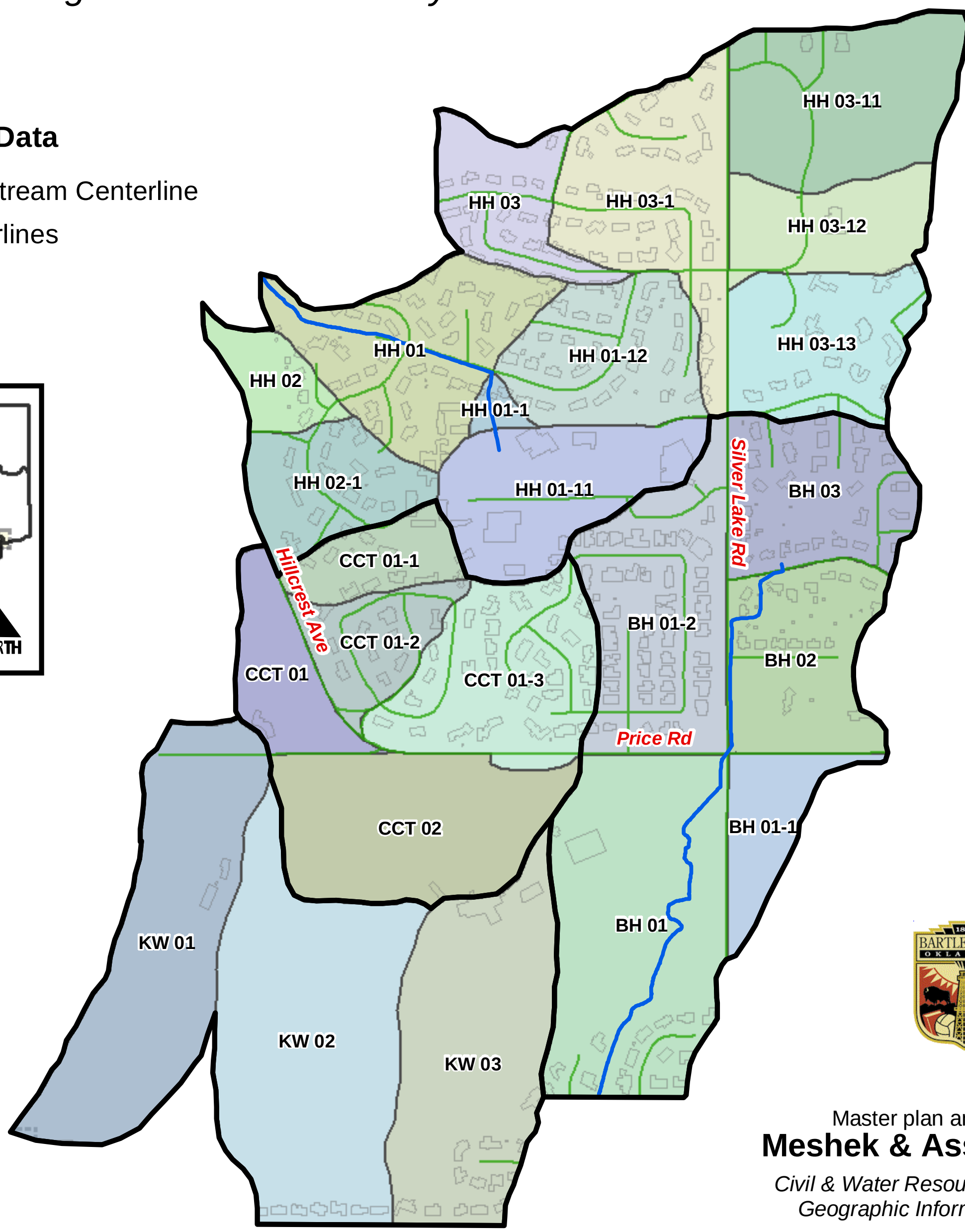

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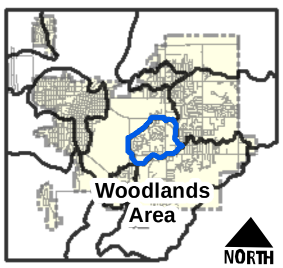
Bartlesville Master Drainage Plan

Figure A-5 *Drainage Sub-basins - Woodlands Area*

Legend

Rice Creek Base Data

- Woodlands Centerline
- Street Centerlines
- City Limits
- Buildings



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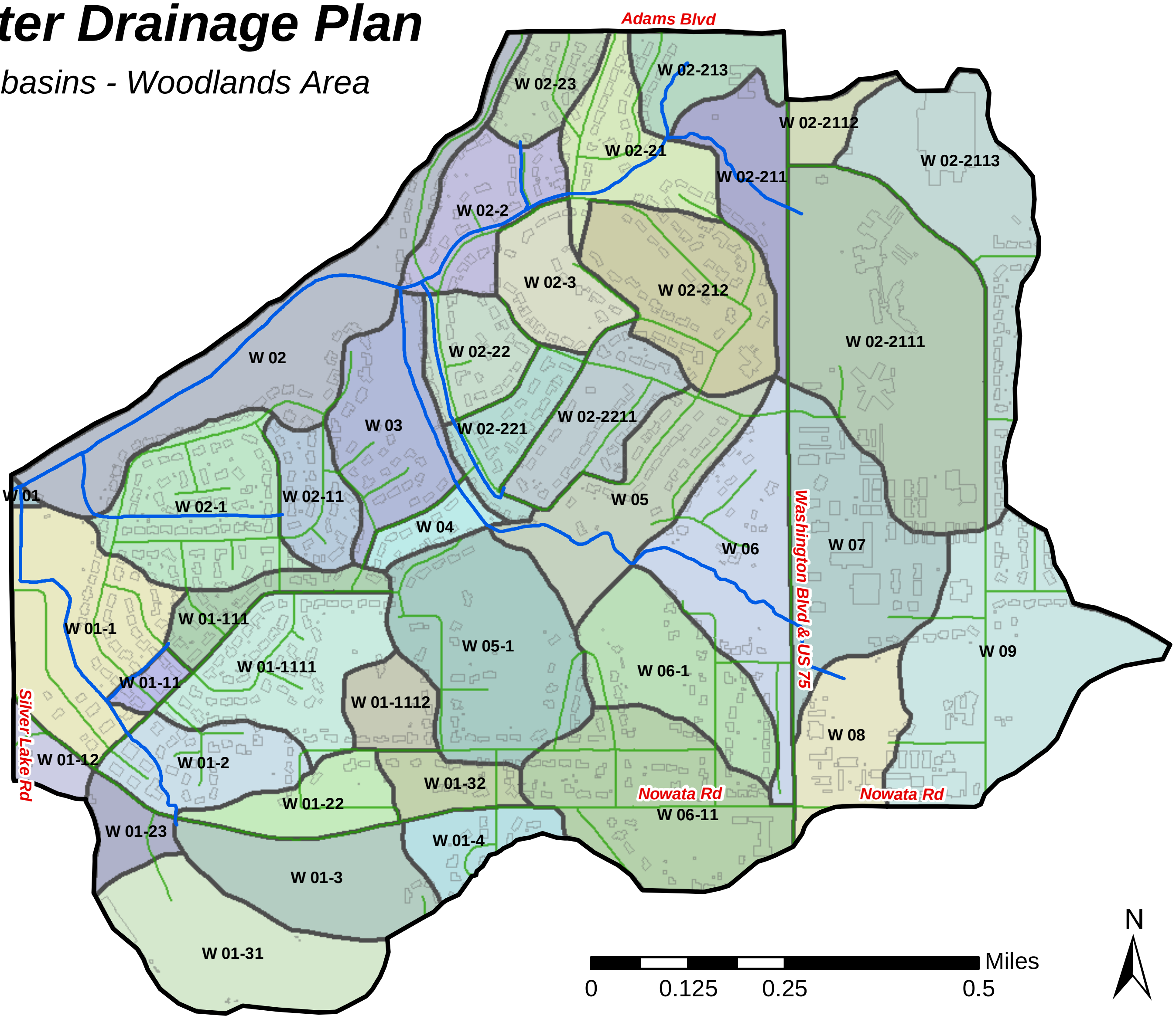

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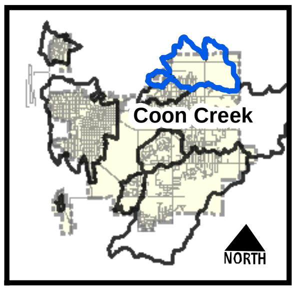
Bartlesville Master Drainage Plan

Figure A-6 *Drainage Sub-Basins - Coon Creek*

Legend

Coon Creek Base Data

- Coon Centerline
- Street Centerlines
- City Limits
- Buildings



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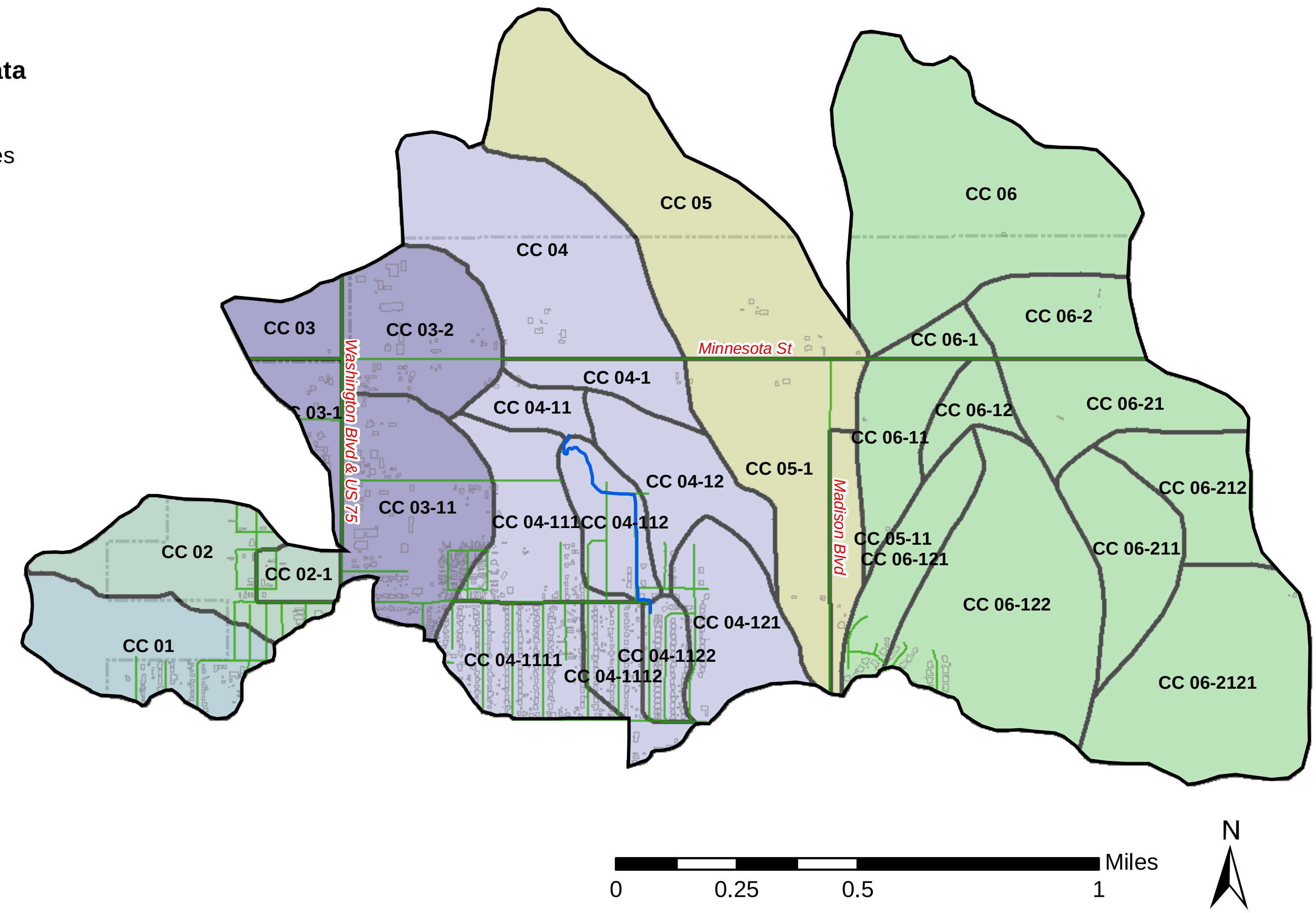

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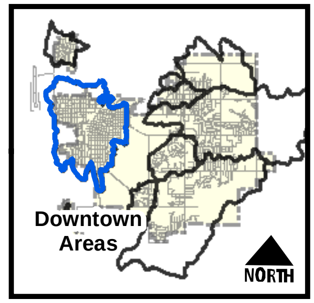
Bartlesville Master Drainage Plan

Figure A-7 *Drainage Sub-basins - Downtown Areas*



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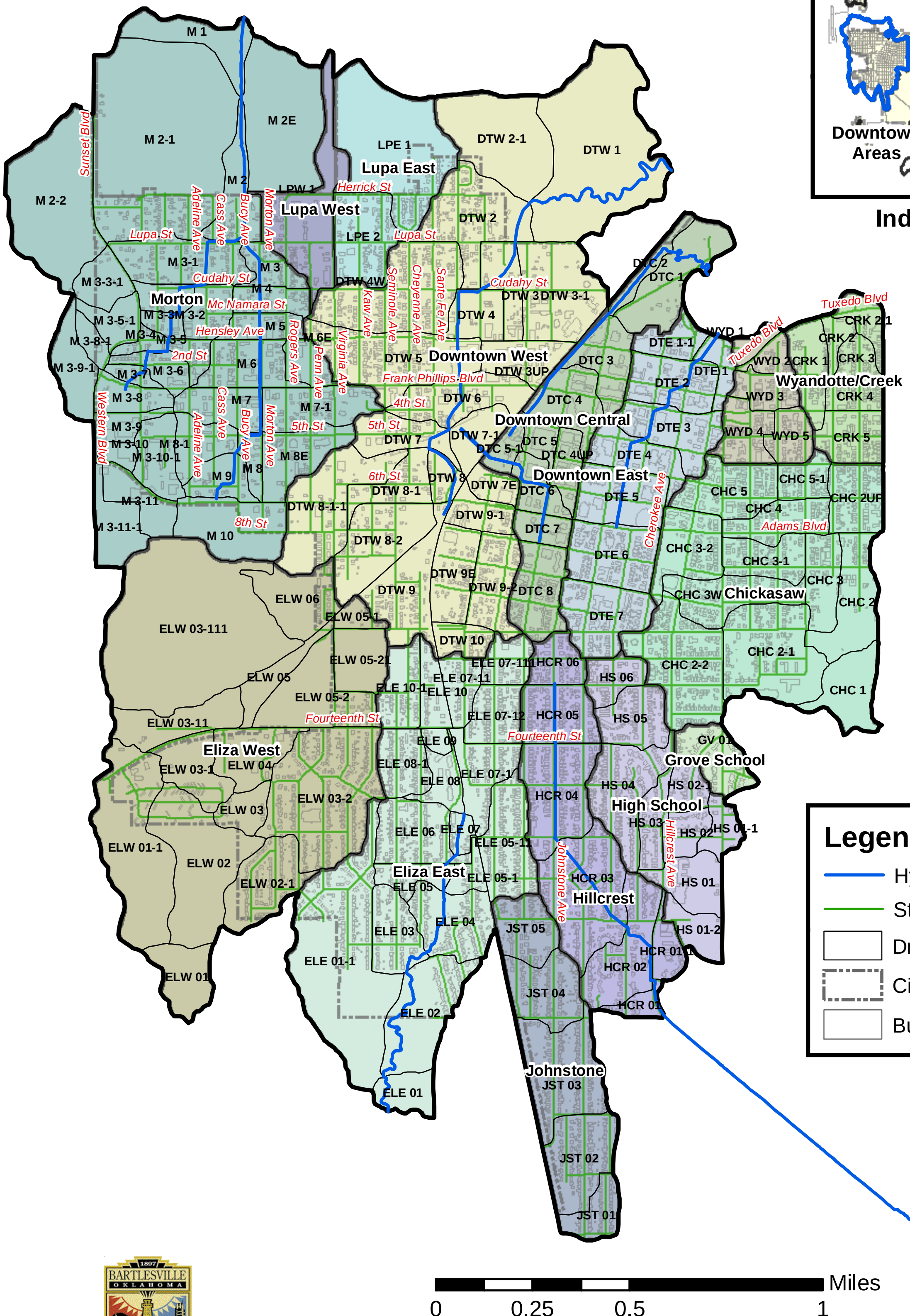

Legend

- Hydraulic Studies
- Street Centerlines
- Drainage Basins
- City Limits
- Buildings

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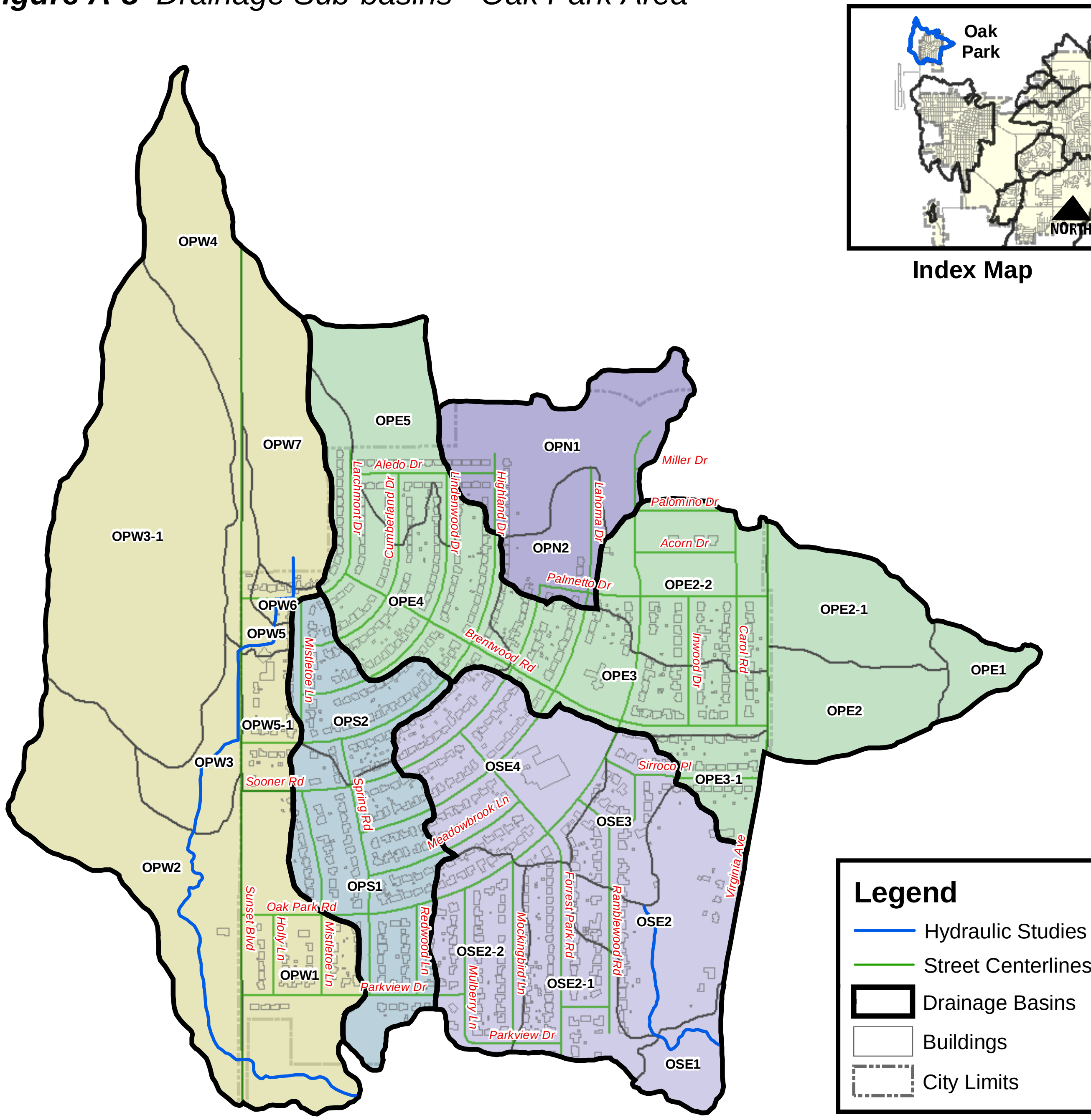
Bartlesville Master Drainage Plan

Figure A-8 *Drainage Sub-basins - Oak Park Area*



Index Map

Legend

- Hydraulic Studies
- Street Centerlines
- Drainage Basins
- Buildings
- City Limits

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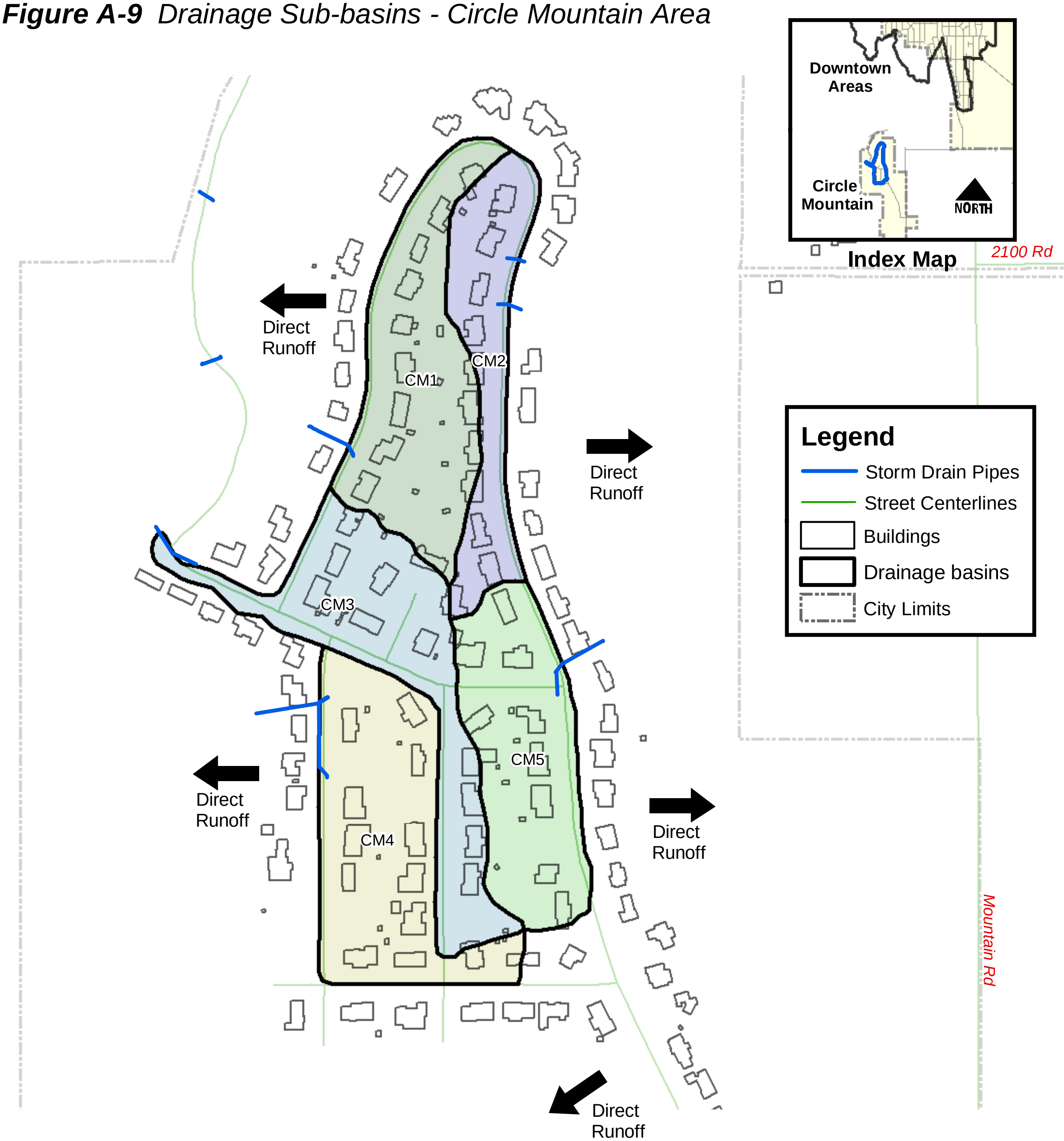
Figure A-9 *Drainage Sub-basins - Circle Mountain Area*



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