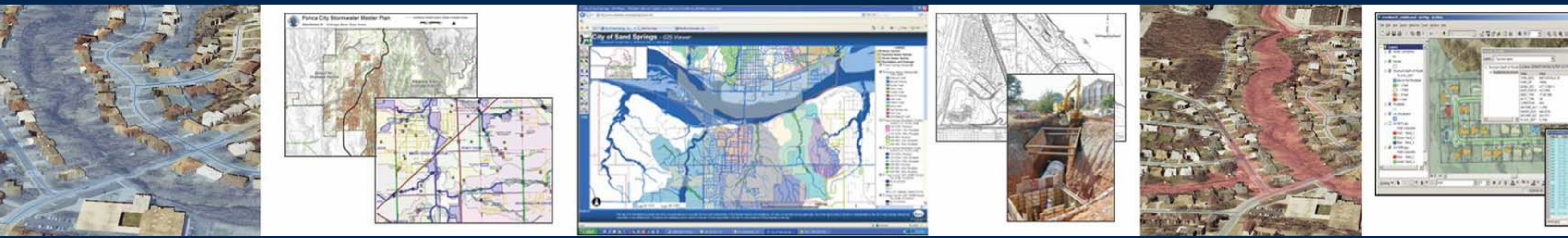

Executive Summary

Sapulpa Citywide Master Drainage Plan

June 2010

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phone: 918-392-5620 • fax: 918-392-5621
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MESHEK & ASSOCIATES, PLC

Civil & Water Resource Engineering
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EXECUTIVE SUMMARY

On March 17, 2008, the City of Sapulpa commissioned Phase I of the Sapulpa Master Drainage Plan with the remainder of the work, Phase II, commissioned on July 7, 2008. In total, 20 drainage basins were identified for study within the City of Sapulpa. The locations of the drainage basins and/or drainage systems are illustrated in **FIGURE 1-1**, **SECTION 1**, of this Report.

These drainage studies, prepared by Meshek & Associates, PLC, provide a long-term plan to: (1) improve the existing stormwater system, (2) construct new stormwater infrastructure, (3) mitigate existing drainage problems, (4) prevent future flooding issues, and (5) support future development within the City limits.

The four-step approach used in the studies included: (1) the assessment of existing drainage conditions, (2) the identification of existing Problem Areas, (3) the analyses of alternative solutions, and (4) recommendations, with estimated costs, to address existing drainage problems and prevent future drainage issues within the City of Sapulpa.

Historical flooding information was collected from City staff as well as information gathered from citizens at public meetings. This information was then reviewed in conjunction with the 10-year and 100-year floodplains to identify Problem Areas, flooded buildings, and overtopped culverts and bridges for additional study.

Alternative solutions were developed for each of the Problem Areas and Prioritization Criteria were used to rank solutions based on 13 objective, measurable factors developed with City staff.

Based on the ranking of the alternatives, a Recommended Plan was developed for each of the basins or drainage systems. These recommendations, along with the estimated costs, are presented in detail in each section of the report.

The total cost for the Recommended Plans for all studied basins within the City of Sapulpa is estimated to cost $30.34 million. This cost has been divided the drainage basins and is shown in **TABLE 1.1**, **SECTION 1**, of this report.

Following the review of all Recommended Plans, the following steps were suggested to the City for implementation of its long-term plan to reduce flooding and prevent future flooding, to improve and expand the existing drainage system, and to support responsible growth within the City:

STEP 1: Formally adopt the Master Drainage Plan with its recommendations.

STEP 2: Formally adopt newly-mapped floodplains as the City's regulatory floodplain to promote responsible development without adverse downstream impact.

STEP 3: Continue to update, annually or routinely, previous recommendations to increase funding through its Stormwater Utility Fee.

STEP 4: Maintain the hydrologic and hydraulic models, for each of the drainage basins studied, to account for improvements and changes due to development.

STEP 5: Use the current hydrologic and hydraulic models to evaluate the effects of individual developments on flow rates and velocities, as well as flood heights, both with and without onsite stormwater detention.

STEP 6: Adopt a Fee-in-Lieu of Onsite Stormwater Detention to be applied toward funding future stormwater improvements outlined in the Master Drainage Plan. This fee would be based on the amount of additional impervious area that a development would add to the watershed. Fees should be re-evaluated on an annual basis.

STEP 7: Adopt the recommended Storm Drainage Criteria to ensure orderly development without adverse downstream impacts.

STEP 8: Consider requesting the Oklahoma Water Resources Board (OWRB) to include the updated studies in this report as a part of its Risk MAP initiative.

Introduction

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SECTION 1. INTRODUCTION

The Sapulpa Master Drainage Plan studies were prepared by Meshek & Associates, PLC, under an Agreement with the City of Sapulpa, Oklahoma. The work was completed in three phases. Phase I consisted of an Impervious Area Study, including the development of a Stormwater Utility Fee to fund future stormwater quality issues, capital improvements, and ongoing maintenance to the drainage system. Phases II and III focused on the study of the numerous drainage basins within the City.

In total, 20 drainage basins were identified for study within the City of Sapulpa. In order to study the large number of drainage basins, the basins were aggregated into six major drainage systems which are listed **TABLE 1-1** in the order of presentation in the report and by contractual phase. Individual drainage basins are also listed in **TABLE 1-1** by drainage system and study phase. The locations of these major systems are illustrated in **FIGURE 1-1**. Individual drainage basin maps were also prepared and are located within each section of the report.

TABLE 1-1. SAPULPA MASTER DRAINAGE PLAN - STUDIED DRAINAGE BASINS BY PHASE

PHASE II	PHASE III
Downtown Systems	**Rock Creek Systems**
– Independence Drainage System	– Bivens Creek Drainage Basin
– Downtown System Drainage Basin	– Pleasant View, South Heights and Tanglewood Drainage System
– High School System Drainage Basin	– Old Sand Springs Road, North Heights and Hollier Park Drainage System
	South Polecat Systems
	– Hickory South Drainage Basin
	– Luker and Valley Ridge Drainage System
	East Polecat Systems
	– Hudgins Drainage Basin
	– Polecat Tributary 2 System
	North Polecat Systems
	– Quail Run and Liberty Glass Drainage System
	– Frankoma Creek and Industrial Tributary Drainage System
	– Timber Ridge Drainage Basin

STORMWATER
UTILITIES & MASTER DRAINAGE PLAN

City of Sapulpa Master Drainage Plan

Miles
0 0.5 1 2
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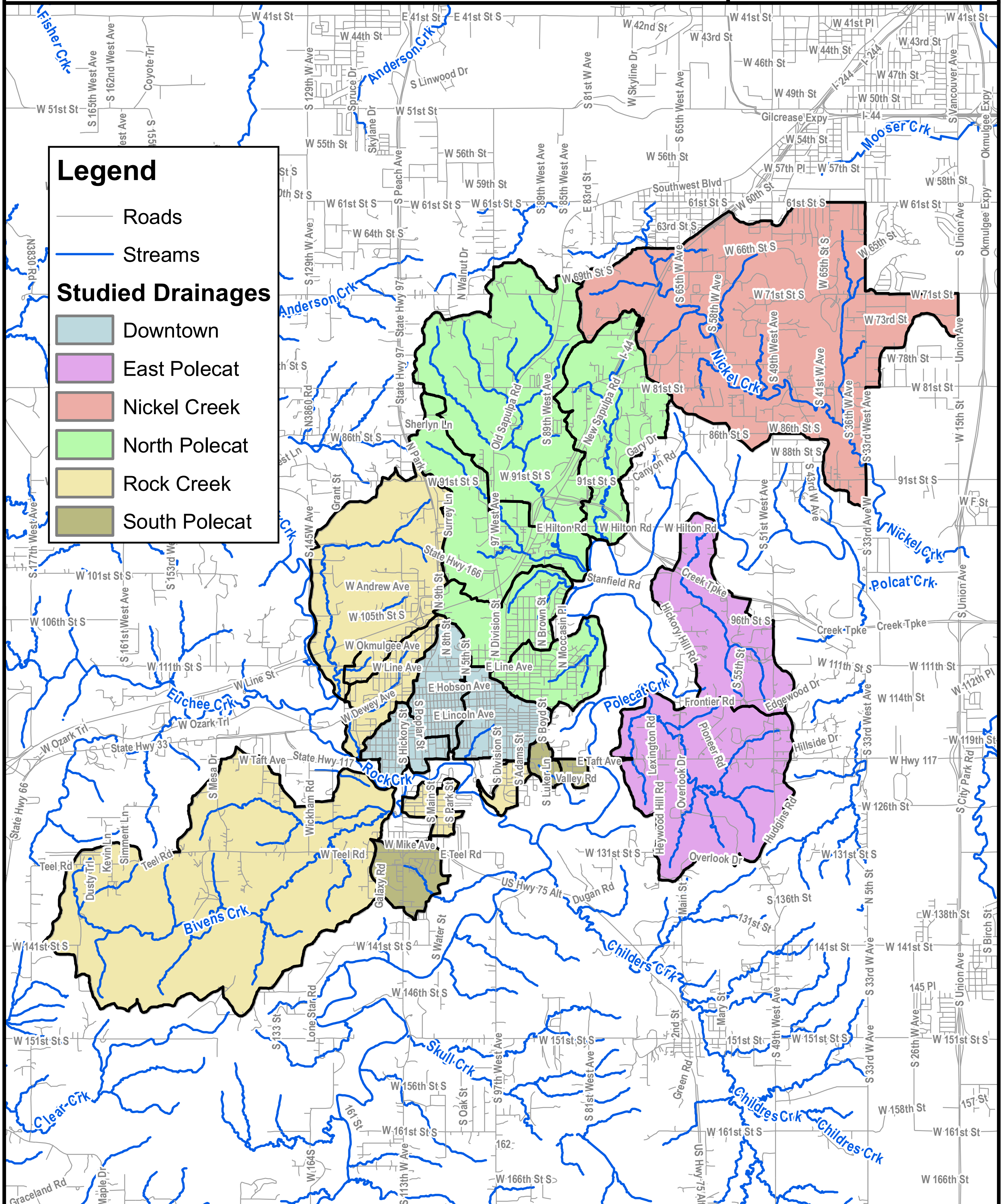

The City of Sapulpa
Oklahoma's Most Connected City

Studied Drainage Systems

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Figure: 1-1

Prioritization criteria to rank alterative solutions using objective and measurable factors were developed, in conjunction with City staff. Criteria selected by the City of Sapulpa considers and ranks 13 variables varying in weight as follows:

1. The extent of the hazard to the public health and safety;
2. The increased level of service for bridges and culverts;
3. The potential for flooding to structures, appurtenant buildings and yards;
4. Improved access by type of street, i.e. emergency route, arterial street, collector streets, or residential streets and alleys;
5. The physical size of the area impacted by the problem;
6. The frequency of the problem;
7. The period of time that the problem has existed;
8. The positive environmental impact and the size of the physical area impacted;
9. The investment protection for the stormwater system;
10. The existing physical condition of the stormwater system;
11. The availability of funding and from what sources;
12. The availability of private investment in the area, i.e. is this an area that is rapidly developing with a potential for private funding; and
13. The potential for City liability.

For the selected projects, the project ranking, using the above Prioritization Criteria, is presented in **TABLE 1-2**. The total cost for the recommended improvements for all studied basins is estimated to cost $30.34 million. The cost by drainage basin is shown in **TABLE 1-3** with more detailed information available in each individual basin section.

1.1. FIRM STUDIES

These studies, conducted as part of the Master Drainage Plan, were preceded by the Flood Insurance Study (FIS) prepared in December 1, 1977, following the City's entry into the National Flood Insurance Program. Additional studies and updates subsequently occurred as of April 26, 1983, August 3, 2009, and May 21, 2001. The most recent FIS update became effective as of August 3, 2009, as a part of FEMA's Map Modernization (Map Mod) process for Creek County. Current floodplain map panels also went into effect on August 3, 2009.

As a result of the current Master Drainage Plan, it is anticipated that modifications to the effective FIRM would only be required in those areas that have already been mapped on the effective FIRM and were also studied in detail as a part of this Master Drainage Plan. This may necessitate the submission of the current study data to FEMA for its review and update to the

TABLE 1-2. SAPULPA MASTER DRAINAGE PLAN - PROJECT PRIORITIZATION

Project	Basin	Project Costs	Prioritization 1: Project has a positive effect on Health and Safety	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.	3: Type and Extent of Damage	4: Improves Access	5: Size of Area Directly Affected	6: Frequency of Problem	7: Years Problem Existed	8: Environmental Impact	9: Investment Protection of Stormwater System (weight = 2)	10: Physical Condition of Stormwater System	11: Funding Sources	12: Is private investment in the system available soon (rapidly growing area)?	15: Liability	Score
			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
PA-2 520 N. 8th Street - Alternative 2	Downtown	$ 756,300	4	10	10	2	5	10	10	10	10	10	7	10	10	108.00
PA-1 Countrywood Way - Alternative 1	Hudgins Creek	$ 209,000	10	9.9	10	10	7	8	7	10	10	8	4	0	10	103.90
PA-9 Johnson and Hickory - identified by resident at 235 N. Main - Alternative 2	Old Sand Springs	$ 670,000	10	9	8	10	10	6	10	10	10	8	0	0	10	101.00
PA 1,3 Bryan/Independence/ Hickory - Alternative 2	Independence	$ 2,684,000	10	8	10	10	7	10	10	0	10	8	7	0	10	100.00
PA-4 120 W. Bryan - Alternative 1	Independence	$ 617,300	10	9	8	10	5	8	10	0	10	10	7	0	10	97.00
PA-3 17 S. Park Street - Alternative 1	Downtown	$ 2,347,000	10	9	8	10	7	6	10	0	10	10	7	0	10	97.00
PA-2 1119 E. Cleveland Ave. - Alternative 1	High School	$ 784,000	10	9.9	2	5	10	10	10	0	10	10	7	0	10	93.90
PA-19 - Perkins Ave. Ditch north between Brown and Hodge - Alternative 2	Liberty Glass	$ 618,700	4	9	4	2	7	10	10	10	10	8	7	0	10	91.00
PA-7 121 E. Ross Ave. Alternative 1	South Heights	$ 436,500	10	9	8	5	5	6	10	0	10	10	7	0	10	90.00
PA-5 2312 and 2322 S. Cedar St. - Alternative 2	Hickory South/S. Polecat	$ 1,584,500	10	9.9	10	10	7	6	7	0	10	10	0	0	10	89.90
PA-4&5 - 437 and 517 N. Moccasin Place - Alternative 2	Quail Run	$ 260,000	10	9.9	0	5	5	8	7	10	10	8	7	0	10	89.90
PA-5 707 & 711 S. Cedar - Alternative 1	Independence	$ 264,700	10	9	6	5	7	8	10	0	10	10	4	0	10	89.00
PA-1 Mary Lynn & Mockingbird Lane - Alternative 3	Rock Creek/Bivens Creek	$ 315,800	10	9.9	4	2	5	10	10	10	0	10	7	0	10	87.90
PA-2 1715 S. Oklahoma St. - Alternative 2	Rock Creek/Bivens Creek	$ 118,200	10	9.9	4	2	5	10	10	10	0	10	7	0	10	87.90
PA-1 Storm Sewer Trunk - Alternative 4	Downtown	$ 4,273,000	10	8	8	10	10	8	10	0	10	3	0	0	10	87.00
PA-6 1512 S. Park St. Alternative 2	South Heights	$ 462,000	10	9	4	2	7	6	10	0	10	10	7	0	10	85.00
PA-2 2600 S. Hickory St. - Alternative 2	Hickory South/S. Polecat	$ 121,900	10	9.9	4	10	7	6	5	0	10	8	4	0	10	83.90
PA-3 - 1809 E. Denton - Alternative 2	Quail Run	$ 346,531	10	9.9	10	5	0	6	7	0	10	8	7	0	10	82.90
PA-7 Taft and Mounds - Alternative 1	Independence	$ 212,300	10	9	8	5	5	6	10	0	10	3	4	0	10	80.00
PA-6 302 E. McKinley Ave. - Alternative 1	Downtown	$ 323,000	10	9	10	5	3	6	10	0	0	10	7	0	10	80.00
PA-1,5 Adams and Lincoln - Alternative 2	High School	$ 2,120,000	10	9	6	10	7	6	10	0	0	8	4	0	10	80.00
PA-4 412 S. Maple Street - Alternative 3	High School	$ 743,000	10	9	4	5	7	8	10	0	0	10	7	0	10	80.00
PA-2 - 51st and Edgewood - Alternative 1	PoleCat Trib. 2	$ 55,400	8	9	4	7	7	6	7	0	10	8	4	0	10	80.00
PA-6 - 201, 205 and 217 N. Moccasin Place - Alternative 1	Quail Run	$ 266,000	4	9	6	5	3	6	10	0	10	10	7	0	10	80.00
PA-18 - 620 N. 2nd Street - Alternative 1	Liberty Glass	$ 101,000	2	9	10	2	5	8	10	10	0	10	4	0	10	80.00
PA-2 417 W. Lee Ave. - Alternative 2	Old Sand Springs	$ 264,850	6	9	4	7	5	8	10	0	0	10	7	0	10	76.00
PA-8 800 S. Hickory St. - Alternative 2 (phased)	Independence	$ 289,000	10	10	4	10	7	10	10	0	0	0	4	0	10	75.00
PA-2 Independence & Thompson - Alternative 1	Independence	$ 387,000	8	8	4	5	3	10	10	0	0	10	4	0	10	72.00
PA-4 1928 Valley Road and 1934 Valley Road - Alternative 4	Valley Ridge	$ 500,000	8	9	6	2	0	8	7	0	10	8	4	0	10	72.00
PA-12 1014 S. Adams St. and 1138 Coutney Circle - Alternative 1	Tanglewood	$ 184,300	2	9	10	2	3	6	7	0	10	8	4	0	10	71.00
PA-3,4 65 Fairlane Court and 2406 S. Main Street - Alternative 1	Hickory South/S. Polecat	$ 342,800	10	9	6	2	7	6	7	0	0	10	4	0	10	71.00
PA-7&8 - 6, 10 and 15 N. Boyd - Alternative 2	Quail Run	$ 121,749	2	9.9	6	0	3	6	10	0	10	10	4	0	10	70.90
PA-5 301 S. Oak Street - Alternative 1	Downtown	$ 385,000	10	8	6	5	3	6	10	0	0	8	4	0	10	70.00
PA-6 820 S. Oklahoma - Alternative 4	Independence	$ 320,000	4	5	6	2	3	6	10	0	10	8	4	0	10	68.00
PA-10,11 1031 E. Courtney Ave. and 1028 E. Hastain Avenue - Alternative 1	Tanglewood	$ 286,300	4	9	10	2	3	8	0	0	10	8	4	0	10	68.00
PA-6 705 S. Mission Street - Alternative 1	High School	$ 208,500	10	5	4	2	3	6	10	0	10	3	4	0	10	67.00
PA-3 1924 Timberton Road - Alternative 2	Valley Ridge	$ 321,800	8	1	6	2	5	6	7	0	10	8	4	0	10	67.00
PA-3 700 S. Maple Street - Alternative 1	High School	$ 145,200	2	6	8	5	5	6	10	0	0	8	4	0	10	64.00
PA-10 129 N. Jennetta St. - Alternative 1	Hollier Park	$ 32,300	2	5	6	2	0	8	7	0	10	8	4	0	10	62.00
PA-1 310 W. Laura St. - Alternative 2	Hickory South/S. Polecat	$ 187,600	4	9	6	2	5	6	7	0	0	8	4	0	10	61.00
PA-11 - 1212 N. 12th St. - Alternative 1	North Heights	$ 46,700	2	9	8	2	3	8	5	0	0	8	4	0	10	59.00
PA-9 - 1338 E. McLeod Ave. - Alternative 1	Quail Run	$ 92,800	2	0	4	0	3	6	10	0	10	10	4	0	10	59.00
PA-1,2,3,4 Burnham and Goodykoontz - Alternative 1	Pleasant View	$ 1,081,000	0	0	0	0	7	6	10	0	10	8	7	0	10	58.00
PA-8 1108 E. Davis Ave. Alternative 1	Tanglewood	$ 49,500	4	9.6	6	2	3	6	10	0	0	3	4	0	10	57.60
PA-1 816 W. Springdale Alternative 3	Old Sand Springs	$ 417,000	2	2	8	4	5	6	3	0	0	10	7	0	10	57.00
PA-7 721 N. 12th St. & PA-8 640 N. 12th St. - Alternative 1	Old Sand Springs	$ 53,400	2	9	2	2	0	10	7	0	0	8	7	0	10	57.00
PA-1 - 7919 New Sapulpa Road - Alternative 1	Timber Ridge	$ 720,000	2	9	8	2	0	8	7	0	0	8	4	0	8	56.00
PA-6 702 N. Main St. - Alternative 1	Old Sand Springs	$ 56,400	2	9	6	2	3	6	3	0	0	10	4	0	10	55.00
PA-17 - 1132 E. Arch Ave. - Alternative 1	Liberty Glass	$ 39,200	2	5	4	2	3	6	10	0	0	8	4	0	10	54.00
PA-5 1203 S. Poplar St. Alternative 1	Pleasant View	$ 11,600	2	0	4	0	3	10	10	0	0	10	4	0	10	53.00
PA-2 - 550 Quail Run Lane - Alternative 2	Quail Run	$ -	2	9	10	2	3	6	7	0	0	10	4	0	0	53.00
PA-9 1100 S. Quenath Street - Alternative 1	Tanglewood	$ 3,500	2	5	6	0	0	6	7	0	0	8	4	0	10	48.00
PA-4 215 E. Dewey Ave. - Alternative 1	Downtown	$ 24,700	2	0	4	2	0	4	10	0	0	10	4	0	10	46.00
PA-7 614 E. Thompson Ave. - No Action	High School	$ -	0	0	4	0	0	0	2	10	0	8	10	0	0	34.00
PA-3 226 W. Hobson Ave. - No Action	Old Sand Springs	No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-4 125 N. Gray St. - No Action	Old Sand Springs	No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-5 329 N. Johannes St. - No Action	Old Sand Springs	No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-12 1499 N. 9th St. - No Action	North Heights	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-6 2830 S. Poplar - No Action (Does not flood houses or impact access, no available easement downstream)	Hickory South/S. Polecat	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-1 1013 S. Moccasin Place - No Action - (City has addressed the problem)	Luker Basin	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-2 1410 E. Edgewood - No Action (City has addressed the problem)	Luker Basin	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-10 - 1411 E. Pfendler Ave. - No Action (grading on private property required)	Quail Run	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-16 903 N. Ross - Alternative 1 No Action (no easements to take water between houses)	Liberty Glass	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Regional Stormwater Detention Facility No Action To be constructed with future development	Frankoma Creek Industrial Tributary	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-1 - 9700 New Sapulpa Road - No Action Private property owner responsibility	Frankoma Creek Industrial Tributary	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
PA-2 - 8025 Liberty Bell Lane No Action Private property owner's responsibility	Timber Ridge	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

TABLE 1-3. SAPULPA MASTER DRAINAGE PLAN
TOTAL RECOMMENDED PLAN COSTS BY WATERSHED

WATERSHED	ESTIMATED COST
Downtown Systems	
Independence Drainage System	$4,777,300
Downtown System Drainage Basin	$11,108,700
High School System Drainage Basin	$4,000,700
Rock Creek Systems	
Bivens Creek Drainage Basin	$434,000
Pleasant View, South Heights and Tanglewood Drainage System	$2,514,900
Old Sand Springs Road, North Heights and Hollier Park Drainage System	$1,556,150
South Polecat Systems	
Hickory South Drainage Basin	$2,237,300
Luker and Valley Ridge Drainage System	$821,900
East Polecat Systems	
Hudgins Drainage Basin	$209,000
Polecat Tributary 2 System	$55,400
North Polecat Systems	
Quail Run and Liberty Glass Drainage System	$1,909,250
Frankoma Creek and Industrial Tributary Drainage System	-0-
Timber Ridge Drainage Basin	$720,000
GRAND TOTAL	**$30,344,600**

FIRM, as needed. Drainage basins falling into this category would be:

- Bivens Creek Drainage Basin
- Liberty Glass Drainage Basin and its tributaries
- Polecat Tributary 2 System

- Frankoma Creek and Industrial Tributary Drainage System
- Timber Ridge Drainage Basin.

1.2. SUMMARY OF CONCEPTS

The following definitions and abbreviations are provided to facilitate the understanding of this document.

CCP: Corrugated Plastic Pipe.

CMP: Corrugated Metal Pipe.

FEMA: Federal Emergency Management Agency.

FIRM: Flood Insurance Rate Maps.

GPI: Grated Pipe Drop Inlet.

HYDRAULIC: Topic of science and engineering dealing with the mechanical properties of liquids. Typically, in open section, the hydraulic analysis determines the depth of flow and water surface elevation along a stream. In storm sewer systems, the hydraulic analysis determines the depth of water in a pipe of the elevation to which water would rise in a standpipe if it were flowing under pressure.

HYDROGRAPH: Measurement of the flow rate versus time, or a time record, of the discharge of a stream, river or watershed outlet following a rain event. Typically, the hydrologic analysis determines the water flow rates stated as volume/time (e.g. cubic feet per second or cfs in this report).

HYDROLOGY: Study of the movement, distribution, and quality of water throughout the Earth, and addresses both the hydrologic cycle and water resources.

LOMR: Letter of Map Revision, or documentation necessary for the revision of the floodplain delineation shown on a FIRM by FEMA.

MDP: Master Drainage Plan.

RCP: Reinforced Concrete Pipe.

RCB: Reinforced Concrete Box.

TIME OF CONCENTRATION: Time for runoff to travel from the hydraulically most distant part of the subbasin to the point of reference.

SMD: Standard Median Drain.

SECTION 2 of this report presents a description of the hydrologic and hydraulic methodology used in the preparation of the study of each drainage basin. **SECTIONS 3 THROUGH 15** present details related to individual drainage basins, their problem areas, alternative evaluations for flood mitigation projects or future preventative projects, and recommendations for each basin.

Methodology

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June 2010

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SECTION 2. STUDY METHODOLOGY

Hydrologic and hydraulic modeling of the basins in Sapulpa was performed using HEC-HMS, HEC-GeoRAS and HEC-RAS, computer programs developed by the US Army Corps of Engineers. These programs are Windows-based and GIS-based versions of HEC-1 and HEC-2, long considered industry standards for hydrology and hydraulics. Storm sewer modeling was performed using StormCAD.

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 creek channels and those flow rates in excess of the storm sewer system capacities were input into the channel and overland flow models for each stream reach, where appropriate. Cross-sections were obtained from new topographic data in the form of digital terrain models based upon the 2001 Aerial Photography flown for the Polecat Creek Drainage Study as part of the All-Hazard Mitigation Plans for the Cities of Sapulpa, Jenks and Glenpool, and Creek and Tulsa Counties. Bridge and culvert data, as well as storm sewers, were measured in the field for all streams. In many cases, the storm sewers were also videotaped for condition mapping.

Base data were prepared using HEC-GeoRAS; HEC-GeoRAS is a program developed by the US Army Corps of Engineers and is equipped with a set of procedures, tools, and utilities for processing geospatial data in ArcView using a Graphical User Interface (GUI). This interface enables the preparation of geometric data for import into HEC-RAS, for modeling purposes, and processes simulation results exported from HEC-RAS, for floodplain mapping purposes. The GIS data supplied to the HEC-RAS models included stream centerlines, flow path centerlines, main channel bank stations and reach lengths, and cross section geometric data. Additionally, Manning's "n" values were also exported from HEC-GeoRAS to HEC-RAS based on a GIS representation of land use.

At selected locations from the hydrologic analysis, 100-year peak flows for the existing conditions were tabulated and are found in each basin's appendices. The HMS output, which shows flows at all locations for frequencies ranging from the 1- to 500-year floods, were also included in the individual appendices with the locations of the 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 flow rates for hydraulic analysis at various points within the basins. Because of differing conditions in each of the boundaries, there are larger subbasins in the undeveloped areas and smaller subbasins in the developed and commercial areas. Each study basin section contains a figure with subbasin 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. Each subbasin was assigned a Curve Number (CN), based on the HSG classification of the open soil. The impervious areas were identified and used to weight the CN value assigned to each subbasin. These values are explained in detail and tabulated within the individual reports. Each basin section contains a figure showing its HSG delineations.

C. Hydrograph Development: The SCS 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 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.

D. Rainfall: **TABLE 2-1** 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).

TABLE 2-1. TOTAL RAINFALL DEPTHS FOR SAPULPA, OKLAHOMA, IN INCHES

Duration	Frequency (Return Period)							
	1-year	2-year	5-year	10-year	25-year	50-year	100-year	500-year
5-minute	0.27	0.48	0.56	0.62	0.72	0.79	0.86	1.00
10-minute	0.63	0.78	0.93	1.04	1.20	1.32	1.44	1.74
15-minute	0.81	0.99	1.18	1.32	1.53	1.69	1.85	2.19
30-minute	1.10	1.38	1.75	2.00	2.37	2.65	2.93	3.56
1-hour	1.39	1.79	2.33	2.71	3.23	3.64	4.05	4.99
2-hour	1.68	2.10	2.70	3.22	3.76	4.26	4.76	5.72
3-hour	1.83	2.19	3.06	3.54	4.20	4.68	5.73	6.69
6-hour	2.10	2.64	3.18	4.20	4.86	5.40	6.18	7.44
12-hour	2.52	3.24	4.20	4.92	5.76	6.36	7.32	8.76
24 hour	2.88		4.80	5.52	6.48	7.44	8.40	10.08

Source: U.S. Bureau Technical Paper No. 40 and Hydro 35

E. Storage Routing: The stream reaches, within each basin where floodplains were developed, were studied in detail hydraulically using HEC-RAS. The storage volumes for different flow rates were calculated during the hydraulic analysis for these reaches. These data were 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. This enabled the effects of existing floodplain storage to be easily demonstrated. For those streams without hydraulic models, hydrographs were routed from point to point based on travel time.

F. Existing Stormwater Detention Facilities: Several major ponds exist in the basins among others constructed to offset development. These ponds have an effect on the hydraulics and hydrology and were considered as a part of the modeling.

2.2. HYDRAULIC ANALYSIS

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

A. Starting Water Surface Elevations: Normal depth was used as the downstream condition at the confluence of tributaries. The water elevations in the larger stream at each confluence, such as Polecat Creek and Rock Creek water surface elevations from the new DFIRM FIS study, were used as a backwater condition for mapping. It is worth noting that while the two streams would probably not peak at coincident times, this approach shows the enveloping condition from either stream.

B. Existing Storage Volumes: In those basins for which floodplains were developed, 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.

C. Bridge and Culvert Analysis: Roadway crossings were modeled using the bridge or culvert modeling methods available within HEC-RAS. Studied streams, within the individual watersheds depict the level of overtopping of the bridges and culverts using the frequency of storm that they would pass. This information can be found in the individual basin appendices.

D. Flooded Buildings and Floodplain Mapping: Building finished floor elevations were surveyed to estimate damages during specific flooding events. The buildings that appear to be flooded at various storm levels and the existing 100-year floodplains can be viewed on the floodplain figures in the individual basin appendices for the individual watersheds.