I. Executive Summary

A. Introduction

The City of Leavenworth has periodically experienced significant flooding. The City's current drainage systems were constructed using considerably less stringent design standards than those used today. Major flooding was experienced in 1993 and 1995. Largely as a result of the flooding in 1993 and prior years, and because the existing Storm Drainage Plan, which was prepared in 1967, is becoming outdated, the Leavenworth Department of Public Works presented a program for addressing storm drainage and flooding problems to the City Council. On October 11, 1994 the City Manager adopted Policy Report PWD 71-94 and the City engaged the services of Black & Veatch for the Stormwater Master Plan Project #1994-162. The project was steered by the Citizen's Stormwater Committee, a volunteer organization.

The short-range goals of the master plan are to evaluate improvements to existing drainage facilities to prevent street flooding during a 10-year storm, overtopping of major arterials and collector streets during a 50-year storm, and flooding of structures in the two major creeks--Three Mile and Five Mile--during a 100-year storm. The long-range goals are to develop stand-alone documents to aid the City and its engineers design and construct improvements and new facilities in the future.

B. Purpose

The primary objectives of this study were to evaluate the City's stormwater conveyance system and to prepare a master plan report; to develop financing alternatives and recommend a capital improvements implementation plan; and to evaluate the City's existing policies regarding drainage issues and to prepare a Storm Drainage Design Manual and a Subdivision Planning Manual.

The general project goals were to accomplish the following:

1. Involve the public in the development of the Stormwater Master Plan.
2. Develop a Geographic Information System (GIS) and computational model of the storm drainage system based on aerial mapping, storm sewer maps, and field measurements and observations.
3. Evaluate existing drainage system for capability to handle selected design storms under existing and future conditions.

4. Develop improvements or additions, including detention, to the existing drainage system to prevent flooding.
5. Develop cost estimates and priorities for the improvements.
6. Prepare a prioritized capital improvements program with financing plan.
7. Evaluate future NPDES requirements and the existing FEMA flood plain mapping and studies.
8. Prepare a written report giving results and backup information used in the planning.
9. Prepare Design and Planning manuals based on input from the public involvement program and a review of other cities' and agencies' manuals.

C. Findings and Results

The Leavenworth Public Works Department has taken a positive and important step in the development of one of the City's essential, yet often neglected, utilities--the stormwater conveyance system. The system incorporates more than 60 miles of channels, underground pipes, and appurtenant structures and serves a population of more than 30,000. Public involvement programs were implemented, including establishment of the Citizen's Stormwater Committee, distribution of a questionnaire to determine public opinion on several topics, and establishment of a telephone hotline for residents with flooding problems.

Responses noted on the questionnaires indicate that the most extensive storm drainage problems occur in areas with roadside ditches. Many of these ditches have been filled in by property owners. Grass clippings and other yard waste are also frequently dumped in the roadside ditches. Because of this, the City cannot provide adequate maintenance. This causes frequent localized ponding throughout the City.

Many data sources were used in developing this Stormwater Master Plan and associated documents, including the City's files and maps, engineering studies and design drawings, and studies performed by the Federal Emergency Management Agency (FEMA), among others. There were some discrepancies between the ground elevations recorded during the aerial mapping and the invert elevations in Three Mile Creek from the FIA study. The more recently recorded values were assumed to be correct and were used in the analyses. The aerial map and FEMA elevations in Five Mile Creek all agreed within one foot.

A Geographic Information System (GIS) of the subsurface stormwater conveyance system elements was developed by a joint effort of M.J. Harden Associates and Black & Veatch. M.J. Harden was hired by the City to update aerial photography and create the

digital base maps for the GIS. The GIS also includes topographic features such as ground contours, streets, and physical structures. Black & Veatch performed quality control on the x-y coordinates and elevation data for the subsurface system, and worked with M.J. Harden to finalize the GIS information. Black & Veatch also added open channel conveyance elements between closed conduits.

Several hydraulic computer models were developed to analyze the response of the City's bridges, culverts, pipes, and open channels to various hydrologic scenarios. Significant effort was expended to delineate subwatersheds, collect and input the many parameters representing the physical storm conveyance elements to the models, trouble-shoot computational instabilities, and verify the accuracy of the input parameters.

Although the capacity and capabilities of the system vary throughout the City, most of the time, it collects and conveys flows with minimal problems. The criteria for determining this, as well as other policy issues, was adopted by the Citizen's Stormwater Committee working with the City and with Black & Veatch.

When larger, less frequent storms occur, flooding results, and the duration, extent, and damage caused by the flooding vary depending on the location. Analyses for the 10-year design storm confirm that severe and repetitive flooding occurs in the Three Mile and Five Mile Creek watersheds while the outlying, or "external," watersheds appear to have fewer problems. The Three Mile and Five Mile Creek watersheds represent extreme conditions. Some of the oldest parts of the City developed along Three Mile Creek, while large agricultural areas and undeveloped plots still exist in much of the Five Mile Creek watershed. Where flooding problems were identified, preliminary improvements, consisting primarily of parallel or replacement conduits, detention facilities, and flood walls, were sized and evaluated.

The preliminary cost projections for the capital improvements projects (CIPs) range from $3,500 to $6,379,000. A priority ranking system based on benefits and costs was adopted. The priority ranking system is based on a system used in Columbus, Ohio, and adapted for Leavenworth based on the staff and Citizen's Advisory Committee input. This system ranks each project on its relative flood severity divided by its relative cost. Thus, the projects with the most severe flood problems and lowest costs are ranked highest. A total of 56 CIPs were ranked according to their prioritization index. Timing of CIP construction is also dependent on the financing plan selected. The priority list is an element of the master plan that must be updated as development proceeds, depending on the extent and the locations of development.

Although the City of Leavenworth is currently exempt from the National Pollutant Discharge Elimination System (NPDES) permit process because its population is less than 100,000, it is anticipated that the U.S. EPA will eventually adopt environmental regulations that will affect smaller communities such as Leavenworth. A long-term rainfall and stream flow monitoring program is recommended.

D. Recommendations

A summary of the recommendations and costs for each of the CIPs is presented in Table I-1.

Table I-1
Stormwater Capital Improvements Projects (CIPs)
Summary of Projects, Prioritization Index Number (PIN), and Cost Estimates

Rank	CIP ID	Project Description	PIN	Cost* $
1	3MC-Main-Broadway	Install new open channel to divert Subsystem 2R flows from Cherokee Street to Broadway bridge (Larkin project)	391	120,000
2	3MC-8L	Metropolitan & 16th to 14th & Kiowa Subsystem 8L with proposed detention pond north of Metropolitan	322	134,404
3	5MC-7L	17th Street & Vilas Street Subsystem 7L	296	358,803
4	3MC-S1L	13th & 14th & Shawnee & Delaware; 3 Mile Creek South Branch Subsystem S1L	265	64,181
5	5MC-5L	10th Avenue & Limit Street Subsystem 5L	261	541,090
6	5MC-Main-10th	Install parallel 8' x 7' RCB at 10th Avenue on 5 Mile Creek	253	40,500
7	5MC-5R	Hughes Road & McDonald Road Subsystem 5R	248	120,285
8	5MC-2L	Santa Fe & 2nd Street Subsystem 2L	242	623,252
9	3MC-5L	Broadway & 3mc Subsystem 5L	231	46,580
10	5MC-4L	West of Shrine Park Road to Goddard Circle Subsystem 4L	228	798,996
11	5MC-Main-Limit	Elevate bridge and road at junction of Limit Street and 2nd Ave. on 5 Mile Creek; install berm around low-lying structure	226	504,200
12	3MC-2R	Ohio to Spruce & 10th Street Subsystem 2R	224	1,208,717

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Rank	CIP ID	Project Description	PIN	Cost* $
12	3MCSB-Cherokee	Replace existing Cherokee Street arch on 3 Mile Creek South Branch with 2 - 10' x 10' RCBs	224	267,000
12	3MC-Main-6th St.	Remove 6th Street bridge and replace with 4 - 16' x 16' RCBs	224	274,000
15	3MC-7R	Ottawa & 20th Street Subsystem 7R	223	205,469
15	3MC-6R	Shawnee & 20th to 18th & Osage Subsystem 6R	223	1,096,353
17	3MC-Main-13th St.	Replace 13th Street bridge on 3 Mile Creek with 3 - 12' x 12' RCBs and increase deck top elevation	222	216,000
17	5MC-3R	4th Street Subsystem 3R	222	175,801
19	3MC-1R	Ohio to Spruce & Broadway Subsystem 1R	219	885,011
20	3MC-4L	Metropolitan & Broadway Subsystem 4L	214	940,640
21	3MCSB-18th St.	Replace 18th Street arch on 3 Mile Creek South Branch with 10' x 10' RCB	213	65,300
22	5MC-Main-N. Lawrence	Install parallel 8' x 8' RCB at New Lawrence Road on 5 Mile Creek	210	47,000
22	3MC-9L	Metropolitan & 18th Street Subsystem 9L	210	8,612

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Rank	CIP ID	Project Description	PIN	Cost* $
24	3MC-5R	15th & Osage Street Subsystem 5R	207	18,920
24	5MC-8R	East of 10th Avenue to Parkway Drive Subsystem 8R	207	437,457
26	5MC-4R	Hughes Road & Limit Street Subsystem 4R	203	384,948
27	3MC-S3L	18th & Sherman; 3 Mile Creek South Branch Subsystem S3L	200	26,362
28	5MC-9L	Limit Street to County Hwy. 5 Subsystem 9L	199	13,968
29	3MC-6L	Metropolitan & 9th Street Subsystem 6L	198	221,150
29	3MC-S6R	West Leavenworth Tfwy. to 20th & Spruce; 3 Mile Creek South Branch Subsystem S6R	198	22,246
29	5MC-2R	4th Street to V.A. Entrance Drive Subsystem 2R	198	1,225,170
32	3MCSB-19th St.	Parallel conduits from 19th to 20th Street with new RCBs	197	372,000
32	5MC-10R	West Leavenworth Tfwy. & 5mc Subsystem 10R	197	38,455
32	5MC-6L	14th & Limit Street Subsystem 6L	197	482,553
35	5MC-9R	West of 10th Avenue to 13th Street Subsystem 9R	195	368,846
36	3MC-7L	Metropolitan & 11th Street to 12th Street Subsystem 7L	191	75,568
37	5MC-1L	Marion, Evergreen, Pennsylvania & 4th Street Subsystem 1L	188	522,986

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Rank	CIP ID	Project Description	PIN	Cost* $
38	3MC-S8R	22nd & Spruce; 3 Mile Creek South Branch Subsystem S8R	185	56,111
39	3MC-Main-Ottawa	Replace Ottawa Street bridge with 4 - 11' x 11' RCBs and increase bridge top elevation	180	455,000
40	5MC-Main-2nd St.	Replace bridge at 2nd Street and elevate top deck of bridge and approach; install new flood wall at WWTP	176	2,137,000
40	3MC-S5R	18th, 19th & Spruce; 3 Mile Creek South Branch Subsystem S5R	176	13,208
42	5MC-1R	Marion Street Subsystem 1R	172	214,078
43	5MC-6R	East of Shrine Park Rd. to Lakeview Drive Subsystem 6R	170	28,200
44	5MC-7R	Deerfield Street & Garland Avenue Subsystem 7R	168	54,870
45	3MC-S1R	10th & Cherokee; 3 Mile Creek South Branch Subsystem S1R	165	17,412
46	5MC-10L	22nd St., Limit Street & Vilas Street Subsystem 10L	162	33,384
47	3MC-S7R	21st & Kenton; 3 Mile Creek South Branch Subsystem S7R	161	42,723
48	3MC-1L	4th Street Subsystem 1L	159	1,278,437
49	5MC-3L	10th Avenue & Thornton Subsystem 3L	158	2,275,594
50	3MC-Main-Osage	Install flood levee for two structures east of 3 Mile Creek	151	5,200

Table I-1
Stormwater Capital Improvements Projects (CIPs)
Summary of Projects, Prioritization Index Number (PIN), and Cost Estimates

Rank	CIP ID	Project Description	PIN	Cost* $
50	3MC-Main-10th	Install flood levee for two structures south of 3 Mile Creek	151	3,500
52	5MC-8L	Candlewood & Tudor Drive Subsystem 8L	136	43,646
53	3MC-8R	20th & Dakota & Ottawa Subsystem 8R	134	9,016
54	5MC-11L	Hebbelin Dr. & 23rd Street Subsystem 11L	115	47,090
55	3MC-S4L	21st & Choctaw; 3 Mile Creek South Branch Subsystem S4L	99	19,385
56	3MC-Main-Outfall	Line 3 Mile Creek from Shawnee St. to mouth of Missouri River with concrete trapezoidal channel	79	6,379,000

*Does not include land acquisition or easement costs.

The following additional recommendations are also presented for the City's consideration.

1. The problems identified, and improvements where given, in the external water-shed subsystems should be evaluated. Cost opinions should be prepared for these improvements. Site visits will probably be necessary where no recommendations were made regarding potential solutions to drainage problems.
2. More stringent zoning and flood plain restrictions should be considered. The City currently prevents construction within the FEMA-designated floodway and should consider extending this policy into tributaries not delineated in FEMA mapping. This can be based on the results of the modeling completed for this study. In the long-term, prevention of construction in the 100-year floodway will eliminate the need for costly improvements to lower water levels after development takes place.
3. The analyses for the Three Mile and Five Mile Creek watersheds should be carried forward to preliminary design and design level analyses. Many improvement configurations are possible, and the cost of additional analyses now will be more than offset by the savings derived from selecting the most cost-effective solution.
4. The Public Works Department should increase the amount and frequency of maintenance of the stormwater conveyance system. Questionnaires indicated flooding occurs throughout the City, not just along major drainageways. This is due primarily to non-functional roadside ditches and driveway culverts that have been filled in by property owners through the years. Present staff do a good job of maintaining the major drainage system and addressing the most critical problem areas. However, resources are not adequate to maintain all of the roadside ditches. Increased maintenance of these systems will allow them to function properly and eliminate many of the perceived flooding problems in the City.
5. The City should finalize and begin using the Drainage Criteria Manual and New Development Planning Manual, both of which were prepared for this project.
6. To properly plan and develop the conveyance system and timing of improvements, the City should consider increasing its technical staff. Present staff appear to lack sufficient time to devote to future needs of the system. Additional personnel should be employed to meet both engineering and GIS needs.
7. Zoning and more restrictive flood plain management are the most cost-effective means of developing the City's watersheds. Preventing development from occurring in flood prone areas will eliminate the need for costly flood control projects in the

future. Although the improvements presented in this report do not reflect these types of measures, it is crucial that the City move forward and study these options now, before the watersheds develop additional problems.

8. A rainfall and streamflow monitoring system to establish peak runoff rates and flood elevations should be installed as time allows. This will allow calibration of the models developed as part of this study.
9. The master plan should be updated on a periodic basis. Depending on the rate of development and timing of improvements, the updates should occur every 5 to 10 years.
10. The City should consider implementation of a stormwater utility to fund capital improvements projects and operation and maintenance of the drainage system.
11. Adopt the policies listed below recommended by the Citizen's Advisory Committee.

- The City of Leavenworth shall maintain roadside ditches and driveway tubes in a more consistent manner as part of an overall plan for stormwater management.
- Curb and gutter streets shall be required in all new developments.
- Property owners with property along open channels and creeks must leave natural drainageways undeveloped to allow for storm runoff from future development upstream.
- The City shall not pursue acquisition of easements or ownerships along open channels unless necessary for a specific project or as part of a new development.
- The City shall not assume maintenance of open channels. The City should consider using the existing "nuisance" ordinances to enforce maintenance needs on open channels.
- The City shall follow federal guidelines for stormwater quality issues without additional City requirements.
- To complete the stormwater model, it is necessary to select a design storm for the sizing of improvements. After discussing the current practice, the extent of known problems areas, and the design standards of surrounding area, the Committee recommends the criteria in Table I-2:

Table I-2 Recommended Design Storm	
Residential Street Systems:	10-Year Storm
Arterial/Collector Systems:	50-Year Storm
Arterial/Collector Creek Crossings:	50-Year Storm
Flood Plain/High Value Commercial Property:	100-Year Storm

E. Acknowledgments

The success of the Stormwater Master Plan depends on the direction and input of City staff, the Citizen's Stormwater Committee, and the general public. City staff who assisted with this project included Michael G. McDonald, Director of Public Works and City Engineer; Robert Patzwald, Deputy Director of Public Works; Jerry Geise, City Planner; Dan Williamson, Finance Director; Gary Ortiz, Assistant City Manager; and Mark Pentz, City Manager.

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