PART IV-EXISTING SYSTEM PERFORMANCE

PART IV
EXISTING SYSTEM PERFORMANCE

A. GENERAL

This section presents the results of the hydrologic and hydraulic analysis of Manhattan's major drainage system using the HEC-1, HEC-2 and URBMOD computer models as described in Part III of this report. The analysis was based on the storm drainage system and land use as they existed in the fall of 1993. The performance of the existing system was reviewed based on both the current municipal drainage design criteria and the proposed "Stormwater Management Criteria" document, a copy of which is included as Appendix I to this report.

The City's current design criteria require varying design storm frequencies depending on the type of development and the location within the larger watershed. Generally, design of drainage facilities in residential areas is based on a five-year return period storm and on a ten-year return period storm in commercial/industrial areas. The proposed criteria require that all enclosed pipe systems and improved open channels, regardless of location, be capable of conveying a ten-year return period peak discharge with overflow capacity allowing the combined system (conveyance element plus overflow channel) to carry the 100-year discharge without flooding adjacent structures.

However, identifying an existing system element as failing to meet either current or proposed criteria, according to the model, does not indicate deficiencies in design or construction at the time the element was originally constructed. The principal determinants of hydraulic demand on the drainage system are land use and rainfall. Neither has remained static during the period of time over which Manhattan's drainage system has developed. Major impacts on the capacity rating of the system include updated information on the predicted intensity of rainfall based on ongoing Weather Bureau statistical analysis of precipitation records; changes in land use not anticipated at the time of the original design and construction; and development of computer modeling techniques and other

analytical methods that permit a more refined analysis of system performance than was previously practical.

B. BASIN MODEL DEVELOPMENT

1. MODEL ARRANGEMENT

Computer models were developed for 13 principal watersheds including the City of Manhattan and immediately adjacent areas. Each of the watersheds has its own unique drainage system tributary to one of the main waterways in the area. The models for the watersheds within the study include:

- 365 pipe, culvert and open channel reaches
- Five existing detention facilities
- 290,935 lineal feet (55.1 miles) of drainage system components.

Basin area incorporated into the models totals 28.3 square miles, or 18,115 acres. System maps indicating watershed limits and individual model reaches are included at the end of this section for reference. Larger scale maps with additional information for use in reviewing and using the more specific technical data developed as part of this study have been separately furnished to city staff members. A summary description of the model content is indicated by Table IV-1.

Table IV-2 summarizes the lengths of each specific type of conveyance elements in the existing major system in each watershed.

TABLE IV-1

EXISTING SYSTEM MODEL DESCRIPTION

WATERSHED NAME	AREA ACRES	NUMBER OF DRAINAGE ELEMENTS	SYSTEM HYDRAULIC LENGTH (ft)
Downtown East	1,997	53	41,820
Downtown West	993	40	26,975
Northview	279	16	7,470
Blue Hills	525	21	9,215
Virginia-Nevada	546	33	12,905
CICO Park	558	29	13,965
Little Kitten Creek	1,908	26	28,450
Rolling Hills	246	7	3,800
Wildcat Southeast	1,294	35	19,300
Wildcat Southwest	1,539	5	3,350
North	1,965	42	47,135
Stadium	614	9	9,635
Eureka Valley	5,651	49	66,915
	18,115	365	290,935

TABLE IV-2

EXISTING MAJOR SYSTEM COMPONENTS

WATERSHED NAME	LINEAL FEET HYDRAULIC LENGTH			
	OPEN CHANNEL	PIPE	BOX/BRIDGE	TOTAL
Downtown East	18,350	20,300	3,170	41,820
Downtown West	2,750	23,275	950	26,975
Northview	1,000	3,200	3,270	7,470
Blue Hills	5,700	2,600	815	9,215
Virginia-Nevada	5,950	5,300	1,655	12,905
CICO Park	9,265	3,645	1,055	13,965
Little Kitten Creek	27,230	300	920	28,450
Rolling Hills	3,400	400	0	3,800
Wildcat Southeast	15,900	550	2,850	19,300
Wildcat Southwest	3,100	-	250	3,350
North	44,600	-	2,535	47,135
Stadium	8,400	750	485	9,635
Eureka Valley	64,600	-	2,315	66,915
Total	210,245	59,820	20,370	290,935
% of System	72	21	7	100

2. HYDRAULIC CAPACITY RATING

The HEC-1 model was used to determine the demand discharge, or peak flow, to each system element and both the HEC-2 and URBMOD models were used to rate the hydraulic capacity of the element. Although the models' calculations are precise with respect to the rainfall, land use, and system data, they are predicting system performance that is naturally variable. Infinitely changing rainfall rates, seasonal and other changes in day-to-day conditions of the land surface and vegetation, and the changing maintenance condition of the system itself will all influence the actual performance of the system at any given time.

Due to these natural variations, it is not realistic to conclude that a system element is not capable of supplying a given level of hydraulic service (i.e. 5-year, 10-year, etc.) simply because the model indicates a small capacity deficiency during the modeled storm. Therefore, deficiencies were not interpreted as being significant if the magnitude of the deficiency was relatively small or if it was determined that the deficiency was of a short duration (10 to 20 minutes).

3. LEVEL OF SERVICE

The level of service was determined for the elements of the existing improved system which excludes natural open channels. (In several areas, some minor improved channels which are included in the model only for continuity, and which are not located in areas where problems exist, are not addressed under the level of service summaries.) Of the 365 conveyance elements in the watershed models, 286 are part of the improved system. Table IV-3 summarizes the overall hydraulic performance capability of the improved system throughout all of the watersheds.

TABLE IV-3

IMPROVED SYSTEM LEVEL OF SERVICE

Return Period Capacity	No. of Reaches	Percent of Improved System by Length
<2 Years	46	30
≥2 Years <5 Years	36	12
≥5 Years <10 Years	39	20
≥10 Years <25 Years	38	13
≥25 Years <100 Years	40	11
≥100 Years	87	14
Total	286	100

C. EXISTING SYSTEM PERFORMANCE

During the early phases of this project information on known drainage problems was gathered from various sources. The primary sources, other than City records, were the residents of Manhattan. Information was obtained through a questionnaire distributed to participants at a public meeting held in May, 1993 and through a phone "hotline" for reporting drainage problems over a period of several months. A total of 28 questionnaires were completed and 72 reports were filed for hotline calls.

A majority of the calls to the hotline were generated by a single, very intense storm on June 30, 1993. (Reported rainfall varied from 3.5 inches to 6 inches in approximately three hours.) While this storm certainly caused a number of problems for residents across the area, an event of this nature is not appropriate for identifying system deficiencies since drainage facilities cannot reasonably be designed to handle such "catastrophic" events; therefore, many of the reported problem areas reported as a result of this storm were not directly investigated as part of this study. In addition, a number of other calls and problems reported on the questionnaires were classified as minor system or private issues and were not included in the analysis. However, from the reports and calls received over the life of the hotline, including several after the June 30 storm, seven major problem areas have been identified where reports tend to cluster. They are 1) CICO Tributary, primarily between Dickens and Claflin where erosion along the natural channel is affecting residents' yards; 2) poor drainage and open channel capacity problems in the Snowbird subdivision in the North watershed; 3) apparent lack of

system capacity in several areas of the Virginia-Nevada watershed; 4) apparent lack of system capacity in the area southwest of Memorial Hospital in the Downtown West watershed; 5) apparent lack of system capacity along and adjacent to Allen Road east of Tuttle Creek Boulevard in the Northview watershed; 6) poor drainage and standing water in open channels between Tuttle Creek Blvd. and Butterfield in the Blue Hills watershed; and 7) severe erosion along Wildcat Creek near Georgetown Place in the Wildcat Southeast watershed. More information about each area is presented in the following specific watershed system performance sections.

1. DOWNTOWN EAST WATERSHED

a. Location

The Downtown East watershed covers 1,997 acres (3.12 square miles) along the city's east side. It headwaters near the intersection of Kimball and Denison Avenues, north of the KSU campus, and slopes generally to the southeast. As part of the natural floodplain for the Kansas and Blue Rivers, slopes are very flat, generally less than 0.5 percent. The area drains to the Kansas River at four main outlets and to the Blue River at one outlet through the city's flood protection levee which runs along the south and east sides of this watershed. Highway 24, Tuttle Creek Boulevard (US 24) and Ft. Riley Boulevard (K18) are the major thoroughfares through the area.

b. Land Use

This watershed is nearing complete development. The central business district is located in a corridor generally centered along Poyntz from approximately City Hall at 11th, east to the Kansas River and includes the Town Center Mall at Third and Poyntz. Other commercial areas are also located generally along Tuttle Creek Boulevard, Bluemont Avenue and Ft. Riley Boulevard. A large industrial park development is located to the east of Tuttle Creek Boulevard. Additional commercial and light industrial development is located in the southeast quadrant. The majority of the KSU main campus occupies the

northwest portion of the watershed and older residential neighborhoods generally occupy the central portion. Approximately half of the Manhattan Country Club and golf course is located at the north end of the watershed. The only remaining undeveloped land is generally located on the university property and in the industrial park.

c. Existing Drainage System

The existing major drainage system in this watershed is primarily an enclosed system west of Tuttle Creek Boulevard and a series of open channels and culverts east of the highway. The southern end of the basin drains to 36-inch and 48-inch pipes south of Ft. Riley Boulevard and along 4th Street to a 48-inch culvert through the levee at the south end of Temple Lane. The area generally located between Houston and Yuma drains to the east to the enclosed system around the mall. From the southwest corner of the mall 36, 48 and 54-inch pipes carry stormwater to a 72-inch CMP through the levee just north of the K177 bridge across the Kansas River. The area between Humboldt and Houston drains to the north half of the enclosed system around the mall where 54, 60 and 66-inch pipes route the water across Tuttle Creek Boulevard. From Humboldt north to Thurston, drainage is collected in a 48-inch pipe along Manhattan Ave. and in 54 and 66-inch pipes along Bluemont and across Tuttle Creek Blvd. The majority of the university campus and the residential area north of Thurston drain to a double 5'x 4' reinforced concrete box (RCB) along Bertrand east to 5th St. and then through a double 7'x 5' RCB across the water treatment plant site and Tuttle Creek Blvd. A diversion structure is located near the outlet of this RCB at the upstream end of the Riverside Drain. Other smaller areas drain to a number of culverts across Tuttle Creek Blvd.

The Riverside Drain is a relatively large open channel which is the major component of the system east of Tuttle Creek

Blvd. The channel collects flow from the culverts crossing the road from the west and from approximately one-half of the eastern portion of the watershed. Under normal conditions, the large slide gate on the diversion structure at the upstream end of the channel is open allowing drainage from the double 7'x 5' RCB to flow south along the east side of the highway. The channel runs between the highway and frontage road to Bluemont Ave., where it crosses the road through a double 9'x 6' RCB, and then further south to another frontage road crossing just north of Highway 24 where flow enters a 12'x 10' RCB. A 10'x 10' RCB, with a flood gate at the downstream end, gravity flows beneath the Union Pacific Railroad and through the levee to the Kansas River. Two 10-cfs pump stations are located adjacent to the culvert on the city-side of the levee and are activated whenever the river stage reaches a specific elevation. At this point, when the downstream flood gate is closed, the gate on the upstream diversion structure is also closed and all flow through the double 7'x 5' RCB across Tuttle Creek Blvd. is diverted northward to 72-inch pipes under Hayes Dr. and through the levee to the Blue River. Additional information on the pump station operation is contained in a separate section of this report.

Most of the remainder of the eastern watershed drains through a series of channels and pipe culverts to two box culverts across Highway 24, one 6'x 4'RCB to the southwest of the intersection with McCall Road and one 3'x 2' RCB between the McCall Rd. and Levee Dr. intersections with the highway. A relatively small area, generally north of McCall Road and east of Hayes Drive, drains north to a 24-inch pipe through the levee.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-4 which also includes

reference to the map sheet where the reach is indicated. Copies of the watershed maps are included at the end of this report section.

TABLE IV-4

EXISTING SYSTEM DESCRIPTION - DOWNTOWN EAST WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
1000	10	72" CMP through levee near K-177 Bridge
1005	10	54" RCP across Ft. Riley Blvd.
1010	10	48" RCP along Pierre, south side of Town Center Mall
1015	10	36" RCP along 3rd Street west side of mall
1020	10	10' x 10' RCB to pump station
1025	10	12' x 10' RCB across US24
1030	10	36"/54" RCP across Tuttle Creek Blvd.
1031	10	2-48" RCPs across Tuttle Creek Blvd.
1035	10	66" RCP across mall parking & along Leavenworth St.
1039	10	60" RCP on 3rd St., west side of mall
1040	10	2-36" RCPs at 3rd & Poyntz
1045	10	42" RCP across Tuttle Creek Blvd.
1050	10	66" RCP along Bluemont Avenue
1055	9/10	54" RCP along Bluemont Avenue
1060	5/9	48" RCP along Manhattan Avenue
1062	10	36" CMP across Tuttle Creek Boulevard
1065	6	36" pipe along 3rd Street
1070	6	48" pipe across Tuttle Creek Boulevard
1075	6	2-7'x 5' RCB across water plant & Tuttle Creek Blvd.
1080	6	2-5'x 4' RCB along Bertrand - 5th to 7th
1081	5/6	2-5'x 4' RCB along Bertrand - 7th to Manhattan
1085	5	Natural channel through KSU campus
1090	5	42" CMP across Kimball
1092	5	Roadside ditch, north side of Kimball
1095	5	5'x 7' RCB across Kimball
1100	5	4'x 4' RCB along N. 12th Street to Ratone
1105	5	42" CMP between Claflin & Ratone
1110	5	36" CMP along Legore Lane
1112	6	72" CMP through levee southeast of Casement & Hayes
1113	6	72" CMP across Hayes Dr., south of Casement
1114	6	Channel from diversion struc., north to Hayes Dr.
1115	6	54" RCP across Tuttle Creek Blvd.
1120	6	48" RCP along Holiday Drive
1125	6	4'x 4' RCB across Tuttle Creek Boulevard
1127	6	Roadside ditch, east side of Tuttle Creek Blvd.
1130	6	84" CMP across Casement Road
1135	6	30" RCP across Casement Road

TABLE IV-4 (cont'd)

EXISTING SYSTEM DESCRIPTION - DOWNTOWN EAST WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
1140	10	Riverside Drain - South of Sarber Lane
1141	10	Riverside Drain - Bluemont to Sarber Lane
1142	10	2-9'x 6' RCB at Bluemont, east of Tuttle Creek Blvd.
1145	6/10	Riverside Drain - Diversion struc. to Bluemont
1150	6	42" CMP across Hayes Dr.
1155	10	68"x 43" RCPHE along Sarber Lane
1160	6	6'x 4' RCB across US24
1167	6	Channel and private drive culverts from McCall to US24
1170	6	42" CMP across McCall
1172	6	Channel from Kretschmer to McCall
1174	6	24" RCP thru levee, north of Levee Dr. and Kretschmer
1175	6	36"x 22" CMPA across Kretschmer
1177	10	3'x 2' RCB across US24
1180	10	48" RCP through levee at Temple Lane
1185	10	48" RCP along south 4th Street
1190	10	36" RCP in alley south of Ft. Riley Blvd - 4th to 6th.

d. System Performance

No major drainage problem areas were identified by residents or City records in this watershed. Two reports were received concerning flows from the rather steep slopes along the south edge of the golf course causing localized problems in the vicinity of Ratone and 10th Street. This issue is not specifically addressed in the system analysis since it is not related to the major drainage system in the basin but deficiencies in the system are noted in the general vicinity.

Overall, 20 of the 49 improved system reaches have less than the recommended 10-year capacity and nine have less than a 2-year capacity. However, as previously noted, identifying a reach as having inadequate capacity according to the model does not indicate the original design was incorrect or that a problem actually exists with that element. Examples of this situation occur in several areas of this watershed including Bluemont and Bertrand Streets east of the university, and in the area of S. 4th St. and Ft. Riley Blvd. In each of these cases, modeling indicates current peak flows to the system greater than the flows used for the original design which

results in the lines being identified as inadequate. However, in reviewing the methods and information from the original design there appear to be several possible reasons for the differences.

The most influential factor appears to be the calculation of the time of concentration, or the time required for all portions of the drainage area to contribute to the flow at the point of interest. The time of concentration directly determines the intensity of rainfall used to compute peak flows in the technical method used for this design. The longer the time of concentration, the lower the intensity and thus the lower the peak flow. Methods in use for determining this time when the original design was performed result in a much longer time than current, recommended methods do; therefore, current practices will result in higher peak flows.

Other factors which can influence the results are the assumptions on land use and the amount of impervious area, which most likely has changed over time, and the specific technical methods used to calculate the flows, results of which can vary from each other by 10 to 15 percent. Again, this does not mean the original methods were incorrect, only that considerably more knowledge concerning the behavior of urban drainage areas has become available since then.

Improved major system performance for the Downtown East watershed is summarized in Table IV-5.

TABLE IV-5

EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN EAST WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
1000	120	126	178	216	270	313	356	2
1005	98	56	72	84	100	112	125	25
1010	72	42	55	64	76	85	94	25
1015	33	12	16	18	22	25	27	100

TABLE IV - 5 (cont'd.)

EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN EAST WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
1020	1850	926	1312	1591	2006	2407	2825	>10
1025	1580*	926	1312	1591	2006	2407	2825	10
1030/1031	108/204	51	66	76	90	102	113	>100
1035	167	73	106	131	166	195	223	25
1039	130	76	112	140	179	210	242	10
1040	130	60	88	110	141	166	191	>10
1045	71	40	51	59	70	79	88	25
1050	184	340	508	632	813	961	1105	<2
1055	108	142	206	253	320	373	427	<2
1060	79	49	77	99	130	156	182	5
1062	47	17	25	31	41	48	56	50
1065	65	35	50	61	77	89	102	10
1070	102	8	12	16	21	26	30	>100
1075	780	561	861	1091	1421	1683	1949	<5
1080	400	523	802	1012	1312	1552	1795	<2
1081	289	529	805	1014	1316	1561	1810	<2
1090	80	21	35	47	65	79	95	50
1095	417	8	14	18	25	31	38	>100
1100	174	159	230	283	357	415	474	<5
1105	110	146	211	260	328	381	434	<2
1110	63	88	125	152	190	220	250	<2
1112	383	271	413	479	583	670	753	5
1113	383	261	399	461	560	643	722	5
1114	62	54	90	117	169	211	253	<5
1115	238	42	72	97	134	163	194	>100
1120	116	42	73	97	134	164	195	>10
1125	240	11	19	26	35	44	52	>100
1127	163	11	19	26	35	44	52	>100
1130	361	12	21	28	39	49	58	>100
1135	41	18	29	38	50	60	71	10
1140	1250	817	1155	1401	1766	2125	2502	>5
1141	1130	751	1081	1351	1726	2079	2462	>5
1142	1182	451	685	816	1033	1268	1508	>25
1145	600±	341	523	612	787	973	1168	10
1150	40	50	76	96	125	148	172	<2
1155	98	38	58	72	93	110	128	25
1160	268	45	68	85	111	131	152	>100
1167	33	25	35	43	54	62	71	5
1170	57	25	35	43	54	62	71	>25
1174	45	37	57	73	95	113	132	<5
1175	23	2	3	4	5	6	8	>100
1177	42	14	22	28	37	44	52	>25
1180	200	63	94	118	152	179	207	100
1185	45	37	55	68	87	102	117	<5
1190	24	29	43	54	69	81	93	2

* Controlled by frontage road elevation (headwater limit).

2. DOWNTOWN WEST WATERSHED

a. Location

The Downtown West watershed is located immediately west of the Downtown East basin and covers 993 acres (1.55 square miles). Extending from the south edge of KSU stadium on the north to the levee on the south, the area slopes to the south and slightly east. Slopes tend to be very flat in the area east of 17th St. (< 0.5 %) and steeper in the western half of the watershed. The basin drains to Wildcat Creek through the levee at three locations - 14th Street, Manhattan Ave. and 10th Street - and across Ft. Riley Blvd. at Westwood Road.

b. Land Use

The Downtown West watershed is considered completely developed for the purposes of this study. The land use is primarily residential, both single and multi-family, with commercial development concentrated mainly along Ft. Riley Boulevard, Poyntz and Anderson Avenue. The north end of the watershed is university property including Bramlage Coliseum, athletic fields, the indoor practice facility and portions of married student housing. The southwest corner of the main campus lies along part of the eastern border of the drainage basin. Memorial Hospital, the Riley Co. Health Department offices and Wharton Manor are also located in the upper portion of the watershed. Manhattan High School and approximately half of Sunset Cemetery are located near the southwest corner of the area.

c. Existing Drainage System

The existing major system in this watershed is primarily an enclosed system separated into two main branches. The eastern branch begins in the upper half of the basin as two sub-branches starting around Claflin on the north end. The first begins as a 36-inch pipe along Hartford running south across Claflin into an unimproved open channel through the open area between Wharton Manor and the Riley Co. Health Department facilities. At the southeast corner of this area the enclosed

system begins again as a 4'x 2.5' RCB along the north side of Tecumseh. The system continues across Tecumseh and south along Quivera in corrugated metal pipe-arches (CMPAs) to College Heights Rd. Between College Heights and Hunting the drainage is carried in an open channel along side and back lot lines and is picked up again in a double 6'x 2.5' RCB at the northwest corner of Hunting and Sunset. This box continues along Hunting to McCollum where it joins the second sub-branch which begins at Claflin and Sunset as a 36-inch pipe and continues along McCollum as 36 and 48-inch pipes to the junction point. From the junction, a 12'x 4' RCB carries the flow along Hunting and across Denison onto the university campus where it changes to a 7'x 4' RCB under the old stadium. This box angles across the southwest corner of the campus to Anderson where it becomes a 5'X 4' RCB just west of 16th Street. The box continues east along Anderson to 14th Street where it turns south and changes to a 60-inch diameter pipe. The pipe system runs along 14th and angles across the southwest corner of the city park to Poyntz and Manhattan Ave. where a 6'x 3.3' RCB from the west becomes tributary. The system then continues south along Manhattan as 66 and 72-inch pipes to the levee. From Houston St. to the levee a 36-inch pipe also runs south along Manhattan parallel to the larger lines.

The other main branch originates just north of the cemetery near Grandview Dr. and Wickam, beginning at a box culvert across Grandview Dr. The culvert outlets into an open channel flowing north to a 2.25'x 2.25' RCB across Anderson, just west of Sunset. A very short section of channel connects this culvert to the enclosed system beginning as a 48-inch pipe across Sunset, just north of Anderson. This system continues to the east as a 4'x 4' RCB and then a 6'x 3' RCB beneath university parking lots on the west side of Denison. From the east side of Denison a 42-inch pipe angles southeast and continues east along Anderson to 16th St. where the system turns south in a 6'x 4' RCB. At approximately Laramie it

changes to a 6'X 5' box which continues south to Leavenworth and east to 14th St. South of Leavenworth the enclosed system becomes an 84-inch pipe, continuing to the levee. A 42-inch pipe connected to a 6'x 3.3' RCB coming from the west joins the system at Poyntz.

The 36, 72 and 84-inch pipes along Manhattan and 14th St. each penetrate the levee and have a flap gate installed at the outlet which allows gravity flow through the system until the Kansas River reaches a specific stage. Four detention storage ponds, located just south of Ft. Riley Blvd. and on each side of 14th St., and a 10-cfs pump station, located at the intersection of South Manhattan Ave. and the levee, are fed from the north by the three lines. More information on this pumping system is contained in a separate section of this report.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-6 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-6

EXISTING SYSTEM DESCRIPTION - DOWNTOWN WEST WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
2000	9	84" RCP along 14th, south of UPRR
2005	9	84" RCP along 14th - Poyntz to UPRR
2010	9	6'x 3.3' RCB along Poyntz
2015	9	42" RCP along Poyntz
2020	9	84" RCP along 14th - Leavenworth to Poyntz
2022	9	6'x 5' RCB along Leavenworth
2025	9	6'x 5' RCB along 16th
2027	9	6'x 4' RCB along 16th
2030	9	42" RCP along Anderson
2035	9	42" RCP across Denison
2037	9	6'x 3' RCB, west of Denison
2040	9	4'x 4' RCB across Sunset (with 48" RCP inlet)
2045	9	2.25'x 2.25' RCB across Anderson
2050	9	36" RCP across Wickam
2052	9	Channel from Grandview Dr. to Anderson
2055	9	1.5'x 2.5'/1.75'x 3.25' RCB across Grandview Dr.
2060	9	72" RCP along Manhattan - Levee to Pierre

TABLE IV- 6 (cont'd.)

EXISTING SYSTEM DESCRIPTION - DOWNTOWN WEST WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
2065	9	66" RCP along Manhattan - Poyntz to Pierre
2070	9	6'x 3.3' RCB along Poyntz
2075	9	60" RCP along 14th & through city park
2079/2080	9	5'x 4' RCB along Anderson
2085	5	7'x 4' RCB through campus
2090	5	12 x 4' RCB along Hunting
2095	5	48" RCP along McCollum
2100	5	36" RCP along McCollum
2105	5	36" RCP - Tecumseh to Claflin
2110	5	2-6'x 2.5' RCB along Hunting
2112	5	Backyard channel - College Hts. to Hunting
2115	5	2-50"x 31" CMPA along Quivera
2120	5	65"x 44" CMPA across Tecumseh
2122	5	College View (street as channel)
2125	5	42" RCP - College Hts to College View
2130	5	4'x 2.5' RCB along Tecumseh near Memorial Hospital
2132	5	Unimproved channel - Claflin to Tecumseh
2135	5	36" RCP across Claflin
2138	5	KSU detention pond, north of Jardine & Hartford
2139	5	Private detention pond, west of University & Todd
2140	9	36" RCP along Manhattan
2145	9	24" RCP through levee at 10th St.
2150	9	6'x 3' RCB at Ft. Riley Blvd & Westwood
2152	9	Channel along east side of Westwood Rd.
2155	9	42" RCP at Arthur Drive.

d. System Performance

The major problem area reported within this watershed is located to the southwest of Memorial Hospital. Essentially all of the runoff from the north end of the watershed (north of College View Rd. and west of the hospital/Harry Rd.) drains to the low point on Tecumseh at the southwest corner of the hospital property. When the capacity of the small RCB on the north side of Tecumseh is exceeded, water backs up into the open area at the upstream end then overflows and ponds in the street. On occasion the houses on the south side of Tecumseh and Platt are flooded as the water builds up. At depths exceeding approximately two feet, water overtops a low ridge between the houses at 2005 Platt and 2011 Tecumseh and flows between two houses on College View, south of Tecumseh. As the depth in this overflow channel increases, these homes are vulnerable to water

entering through basement windows. Water reportedly has been as deep as six feet in the street and has flooded cars parked in the area a number of times. Eventually the excess water flows south, roughly along Quivera, until flows have subsided enough for it to reenter the enclosed system.

Of the 39 reaches in this watershed, 26 provide less than a 10-year level of service and 17 of those provide less than a 2-year level. However, it is important to stress again that a reach identified as deficient by the model analysis does not mean that the original design was incorrect or that the element should necessarily be recommended for replacement.

Improved major system performance for the Downtown West watershed is summarized in Table IV-7.

TABLE IV-7

EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN WEST WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
2000	247	426	645	815	1063	1255	1454	<2
2005	247	306	469	595	775	915	1066	2
2010	170	50	78	99	130	154	179	100
2015	83	38	59	76	101	121	141	10
2020	319	219	338	428	563	668	777	5
2022	258	168	258	328	429	508	590	5
2025	258	168	258	328	429	508	590	5
2027	206	148	227	288	374	444	518	<5
2030	83	148	227	288	374	444	518	<2
2035	95	105	163	208	275	328	383	<2
2037	179	83	134	173	230	277	325	10
2040	159	84	135	173	232	279	338	<10
2045	28	81	129	167	224	269	315	<2
2050	47	16	25	33	43	52	60	25
2052	209	38	63	81	109	130	154	>100
2055	52	39	63	82	110	132	155	<5
2060	212	438	661	835	1079	1289	1499	<2
2064	212	401	604	767	997	1186	1383	<2
2065	130	413	625	800	1049	1255	1461	<2
2070	140	<1	1	1	2	2	2	>100
2075	116	410	622	795	1043	1254	1468	<2
2079/2080	110/199	387	592	758	1011	1219	1435	<2
2085	278	317	493	641	867	1045	1235	<2
2090	412	294	457	598	813	982	1159	<5

TABLE IV-7 (cont'd)

EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN WEST WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
2095	125	82	118	146	185	215	247	<10
2100	61	69	99	122	154	180	206	2
2105	67	33	50	62	80	95	109	10
2110	284	223	352	469	647	789	929	5
2112	39	223	352	469	549	790	931	<2
2115	20	196	315	421	585	709	844	<2
2120	39	130	217	299	417	511	604	<2
2122	131	46	71	91	120	143	166	>25
2125	144	46	71	91	120	143	166	50
2130	43	127	214	296	417	510	605	<2
2135	61	115	203	285	396	485	573	<2
2138	*	20	55	82	124	155	189	100
2139	*	12	14	15	17	18	19	100
2140	33	13	20	26	34	41	48	25
2145	48	24	36	45	59	70	80	10
2150	230	91	140	178	232	275	319	25
2155	95	42	64	81	105	125	145	>10

* Detention facility is adequate to handle the 100-year storm without overtopping the dike. Peak flows indicated are outflows at the various return periods.

3. NORTHVIEW WATERSHED

a. Location

The Northview watershed covers 279 acres (0.44 square mile) located in the northeast corner of the city. The major portion of the basin is located east of Tuttle Creek Boulevard bounded roughly by the highway on the west, Tuttle Street on the north, Gross Street on the south, and Casement Road on the east. A relatively small part of the area is located west of the highway. From the highest point in the watershed, located west of the highway, the area slopes easterly across Tuttle Creek Blvd. and then south and east toward the confluence of the Big Blue and Kansas Rivers. Located in the natural floodplain, slopes are very flat, generally less than 0.5 percent.

b. Land Use

Development within the watershed boundaries is substantially complete. Land use is primarily residential, both single and

multi-family, with some commercial development along the Tuttle Creek Blvd. frontage. The area also includes Northview and Strong Schools, and Northview Park. The portion of the basin on the west side of the highway is occupied primarily by a portion of the Manhattan Country Club golf course.

c. Existing Drainage System

The major drainage system in the Northview watershed is basically an enclosed system. One branch begins at Frey and Sloan as a 58"x 36" CMPA running east along Frey, then angling southeast across the corner of Northview Park as a 4'x 3' RCB, and continuing east along Griffith Dr. as a 3.5'x 3.5' RCB. At Casement Rd. the system turns south and runs along the road as a 72"x 44" CMPA. The second branch begins at Allen Road and Sloan and runs east along Allen Rd. as a series of 65"x 40" and 72"x 44" CMPAs, and a 6'x 5' RCB. This section of the system joins the branch from the north at Casement Rd. and the combined branches continue south as an 8'x 5' RCB which outlets to an open channel tributary to the Blue River. The runoff from the area west of Tuttle Creek Blvd. crosses the highway at two locations - a 3'x 2' RCB at Allen Road and a 4'x 4' RCB between the two ends of Lincoln Dr. - both of which discharge to the Allen Rd. system. A fairly extensive minor drainage system is tributary to both the main branches of the enclosed system in this area.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-8 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-8

EXISTING SYSTEM DESCRIPTION - NORTHVIEW WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
3000	6	8'x 5' RCB along Casement - South of Dix
3002	6	8'x 5' RCB along Casement - Allen to Dix
3005	6	48" RCP, along north end of Gladiola Ct.
3010	6	6'x 5' RCB along Allen Road
3015	6	6'x 5' RCB along Allen Road.

TABLE IV-8 (cont'd)

EXISTING SYSTEM DESCRIPTION - NORTHVIEW WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
3020	6	72"x 44" CMPA along Allen Road
3025	6	65"x 40" CMPA along Allen Road
3027	6	Paved channel at RCB outlet to Allen Rd. system
3030	6	3'x 2'/2'x 2' RCB at Tuttle Creek Blvd.
3035	6	72"x 44" CMPA along Casement-Allen to Griffith Terr.
3040	6	72"x 44" CMPA along Casement-Griffith Terr to Griffith Dr.
3045	6	3.5'x 3.5' RCB along Griffith Dr.
3050	6	4'x 3' RCB through Northview Park
3055	6	58" x 36" CMPA along Frey Dr.
3057	6	Channel from outlet of Line 3060
3060	6	4'x 4' RCB across Tuttle Creek Blvd.

d. System Performance

The major problem reported in this watershed is flooding of streets and yards due to the apparent lack of capacity in the system along Allen Road. Overflow from the system runs in Allen Rd. making it impassable at times. Water also backs up on some of the side streets off of Allen and has at times been deep enough to enter cars parked in the area according to residents of the area. However, there have been no reports of homes in the vicinity flooded by storm water.

The capacity problem along Allen Rd. is at the upper end of the system (Reaches 3020 and 3025) where the level of service is less than 2 years. A lack of inlet capacity along the entire system compounds the problem by not allowing the overflow to enter the downstream reaches of the system that do have adequate capacity. Because of the restricted capacity on the upper sections, flow from the minor system tributary to the deficient reaches is also unable to enter the major system causing that water to back up in the smaller lines and then overflow onto the side streets.

Overall, seven of the 14 improved system reaches have less than the recommended 10-year storm capacity and four lines have capacities of 2 years or less. Improved major system

performance for the Northview watershed is summarized in Table IV-9.

TABLE IV-9

EXISTING IMPROVED SYSTEM PERFORMANCE - NORTHVIEW WATERSHED

REACH No.	CAPACITY (C.F.S.)	PEAK FLOWS 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	EXISTING LEVEL OF SERVICE
3000	311	201	307	387	504	598	693	5
3002	311	168	256	324	420	499	579	10
3005	91	14	22	28	38	45	53	>100
3010	246	119	178	223	288	340	392	10
3015	246	107	160	202	261	308	356	>10
3020	86	94	140	175	225	266	307	2
3025	65	88	131	163	209	245	282	<2
3030	112	20	29	35	44	52	60	>100
3035	66	53	83	106	139	166	194	<5
3040	66	51	60	102	134	160	187	<10
3045	57	50	79	101	132	158	184	<5
3050	82	40	63	82	108	129	151	10
3055	36	39	62	79	105	125	146	2
3060	240	46	66	82	104	121	138	>100

4. BLUE HILLS WATERSHED

a. Location

The Blue Hills watershed covers 525 acres (0.82 square mile) located near the northeast corner of the city, mostly to the west of Tuttle Creek Blvd. It extends approximately to the middle of the Manhattan Country Club golf course on the south end, to just west of Manhattan Ave. on the west, to Northfield Rd. on the north, and to Casement Road on the east. From its high point at the south end, it slopes generally to the north and east at an average slope of approximately three percent.

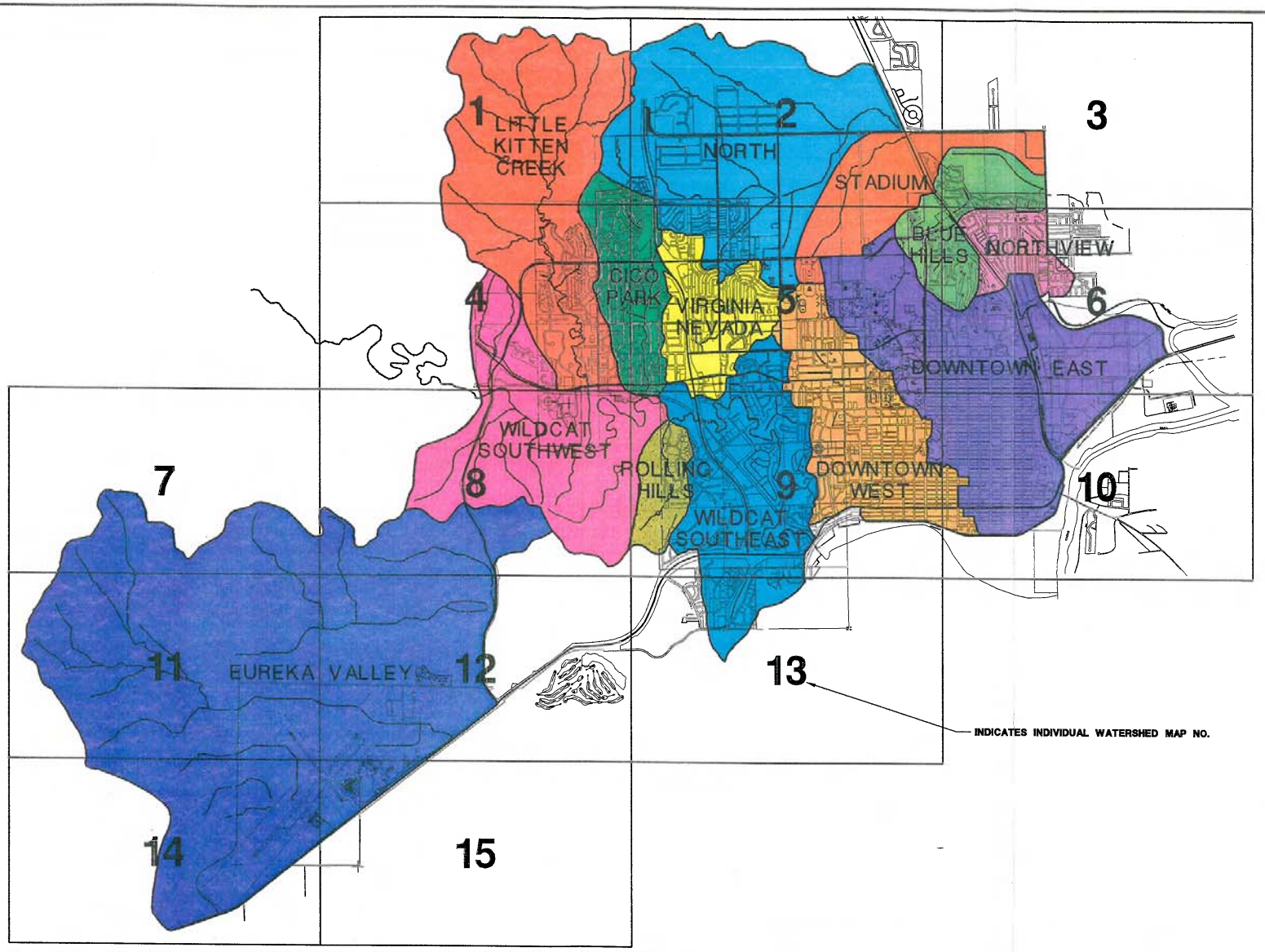
b. Land Use

The portion of the watershed currently within the corporate limits is substantially developed. The primary land uses are single-family residential and the golf course. Some commercial development, including the Blue Hills shopping center, is located along the highway and Kimball Ave. The Meadowlark Hills complex is located north of Kimball near the western edge of the basin. The area along the west edge,

south of Kimball is part of the university campus although it is not intensely developed at this time. The remaining area between Meadowlark Hills, the shopping center and the north edge of the watershed, which is outside the corporate limits, is open, undeveloped land at this time. The Comprehensive land Use Plan indicates future development in this area as high-density residential with open space left between the residential and commercial land use areas.

c. Existing Drainage System

The existing major drainage system in this watershed is primarily a series of culverts and open channels with two areas of enclosed system. The south end of the basin, which is mostly golf course, drains to open channels which cross Fairway Dr. and Ivy Circle in 42 and 48-inch pipes, respectively. Runoff from the east is collected at Manhattan Ave. in a 36-inch pipe and routed east, across Blue Hills Rd., in a 42-inch pipe which outlets to an open channel running north and east between Blue Hills and Bluestem Terr. This channel and the discharge from the Ivy Cir. culvert join in a 3'x 5' RCB running north along Ivy Dr. to just west of Tuttle Creek Blvd. and south of Kimball. At this point the box changes to a 7'x 4' RCB which crosses Kimball and discharges into the roadside ditch along the west side of the highway. Drainage from the northeast corner of the campus crosses Kimball through a 4'x 4' RCB and discharges into an unimproved open channel flowing east toward the shopping center. A 36-inch pipe culvert carries the drainage from a relatively small area east of Manhattan Ave. across Kimball. The discharge from this culvert and the channel from the upstream RCB enter a 36-inch pipe running under the shopping center which outlets into the ditch along the highway. Flow in the ditch crosses Tuttle Creek Blvd. through an 8'x 6' RCB. From this culvert the flow is carried east in an open channel to a triple 6'x 4' RCB across Brockman then through another open channel to the triple 10'x 3' RCB across Butterfield. Flows from this culvert, along with those from a paved ditch draining from the



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CITY OF
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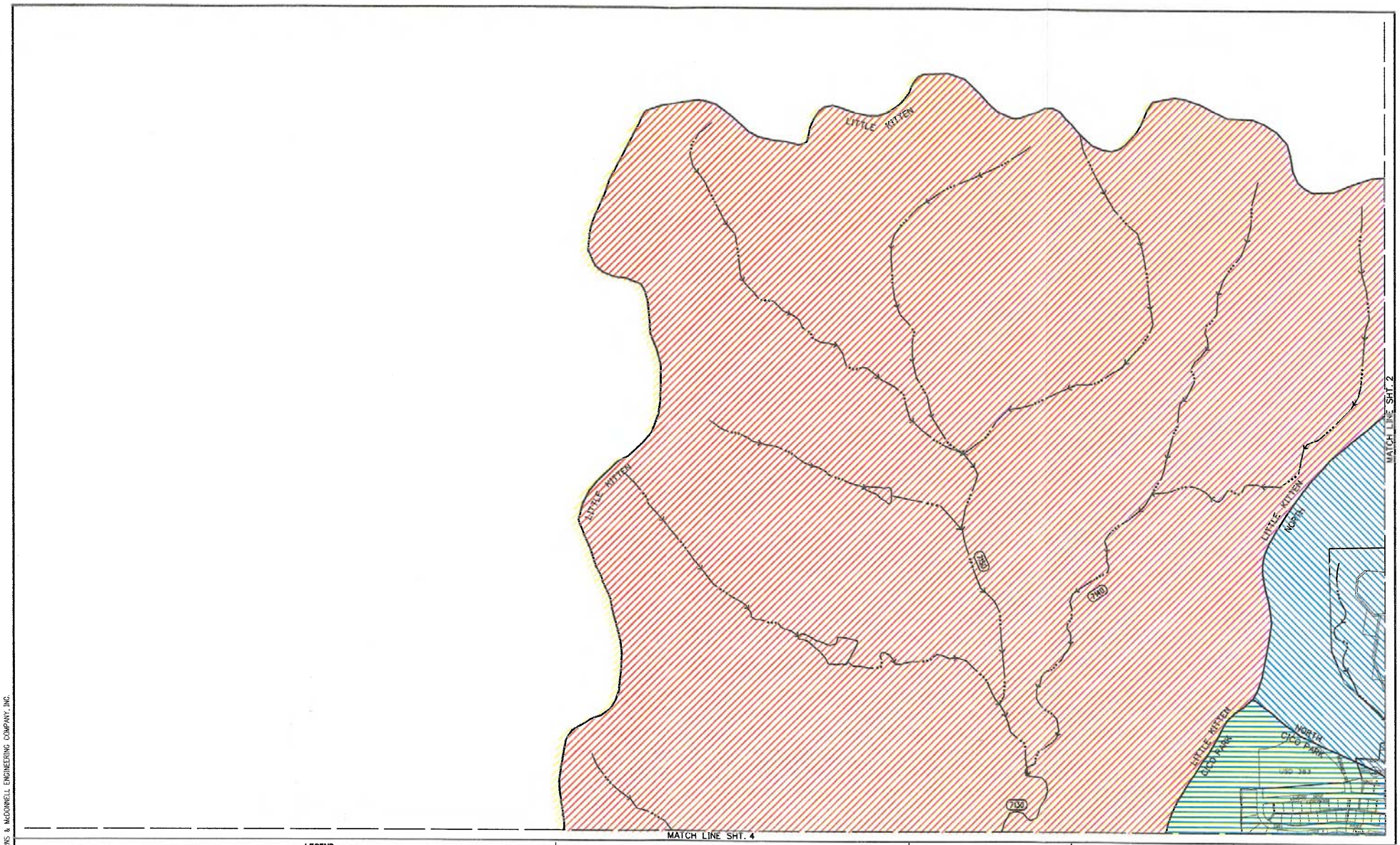
STORMWATER MANAGEMENT PLAN
FIGURE IV - 1
WATERSHED KEY MAP



LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

KEY PLAN

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FIGURE IV - 2
WATERSHED MAP NO. 1

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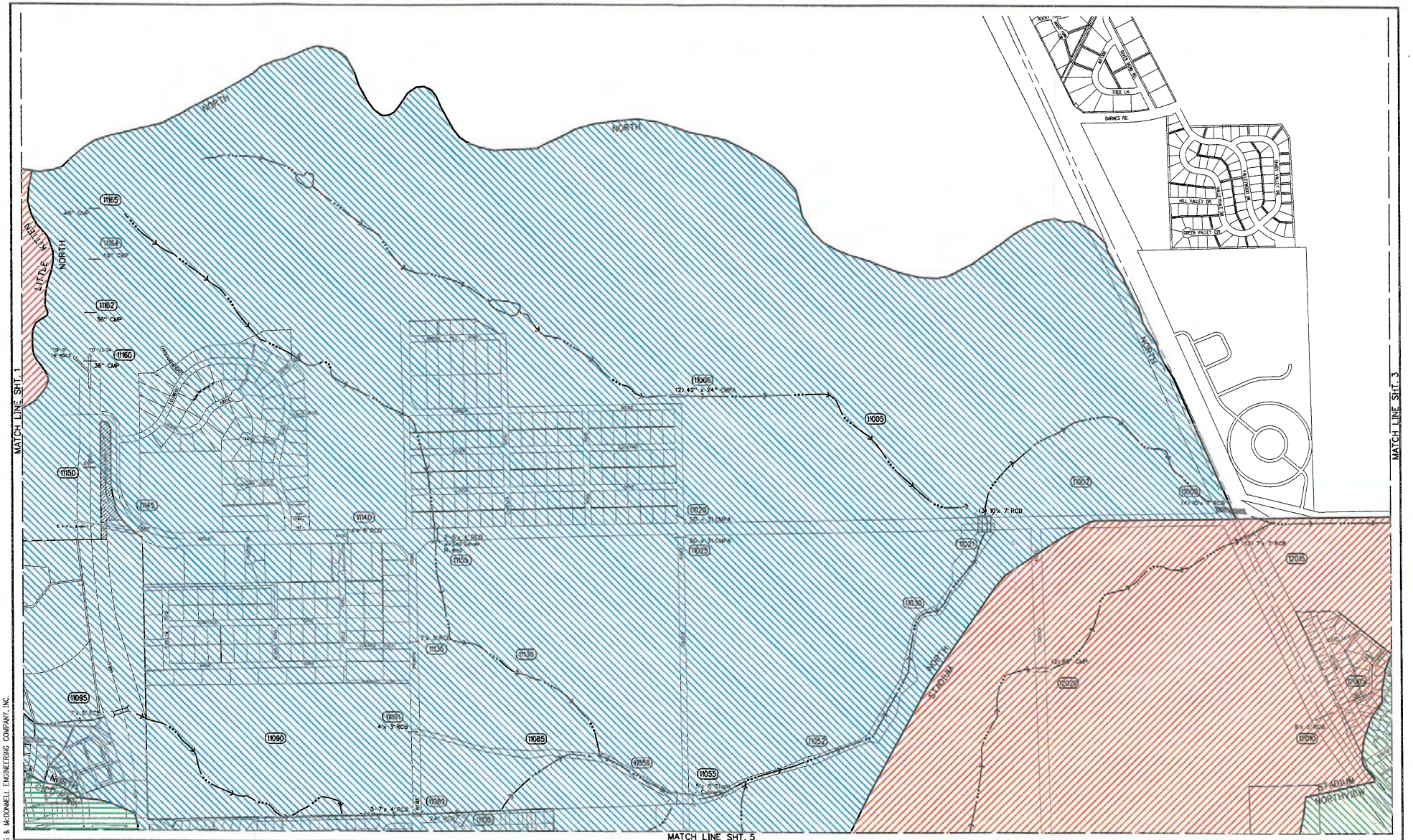

LEGEND

- MAJOR WATERSHED BOUNDARIES
- 11123 LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

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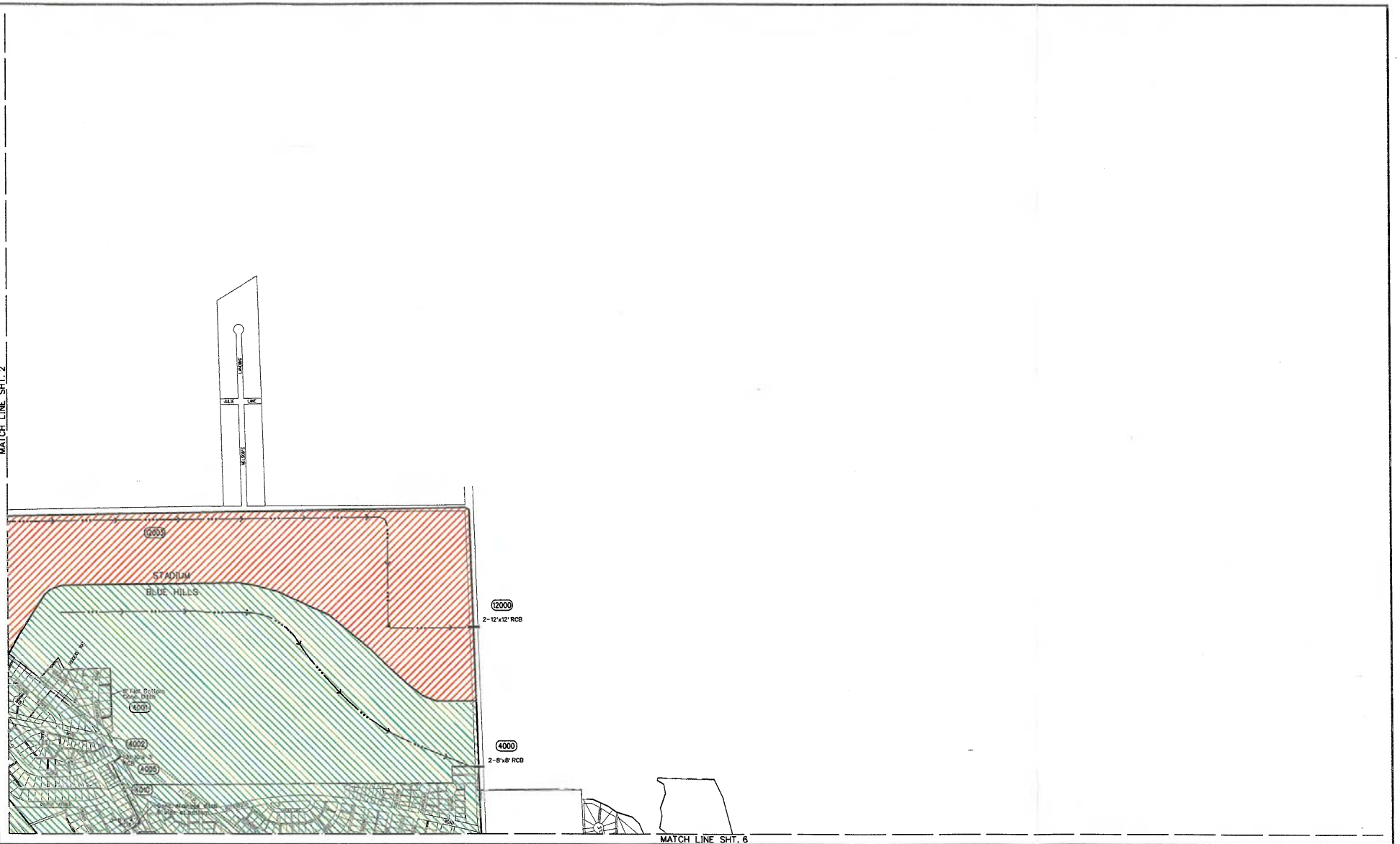
STORMWATER MANAGEMENT PLAN

FIGURE IV - 3

WATERSHED MAP NO. 2



LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

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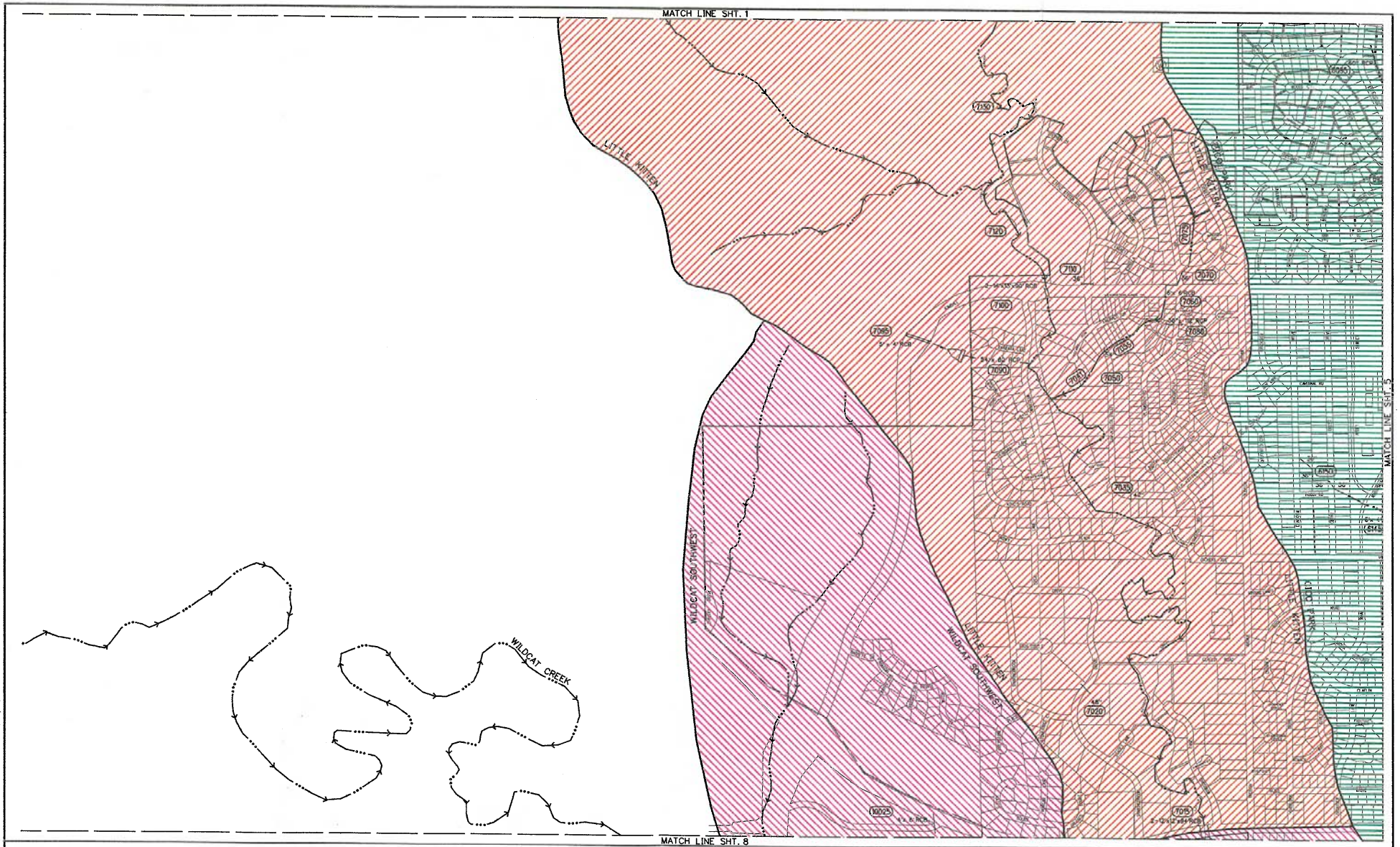
FIGURE IV - 4
WATERSHED MAP NO. 3



LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

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FIGURE IV - 5
WATERSHED MAP NO. 4

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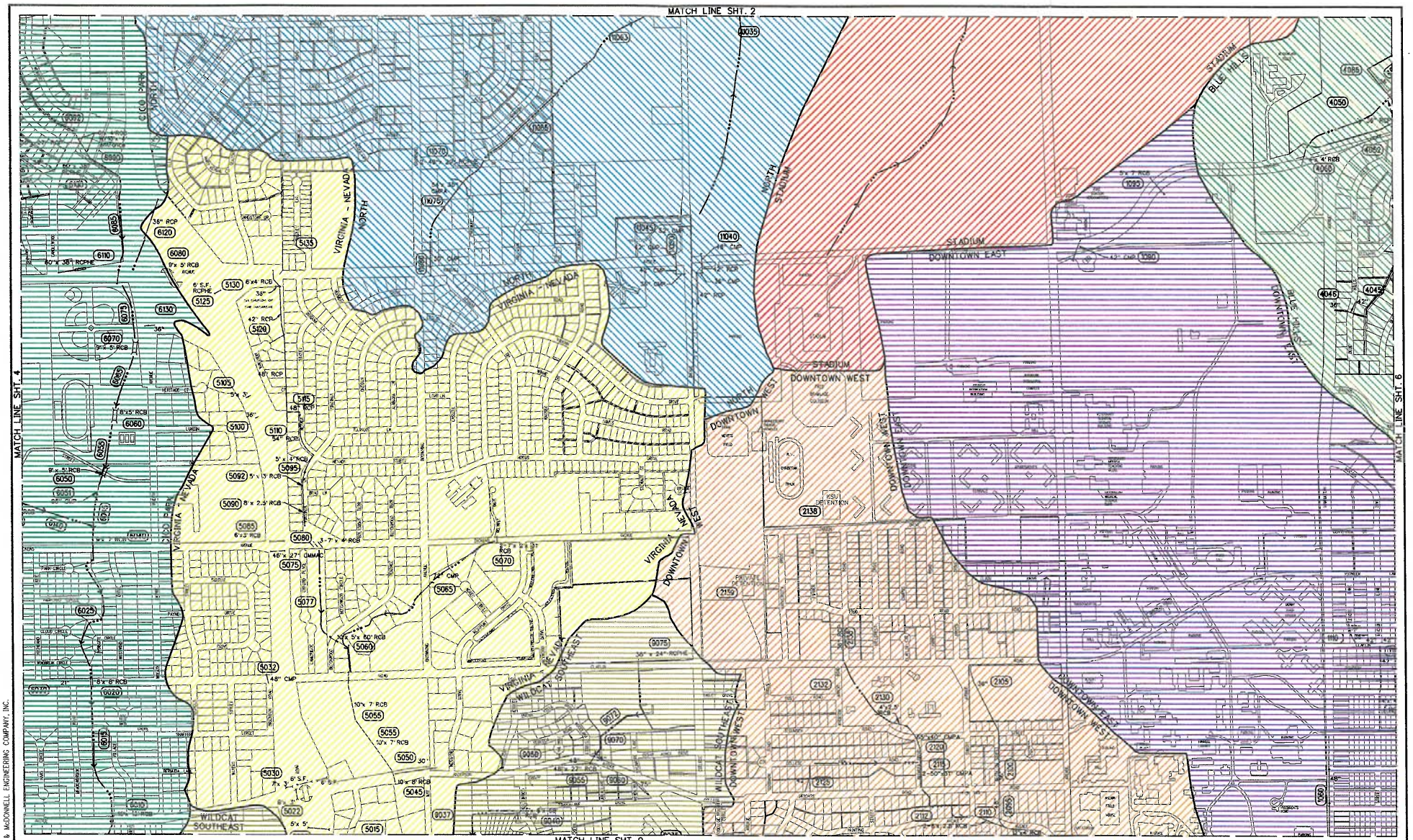

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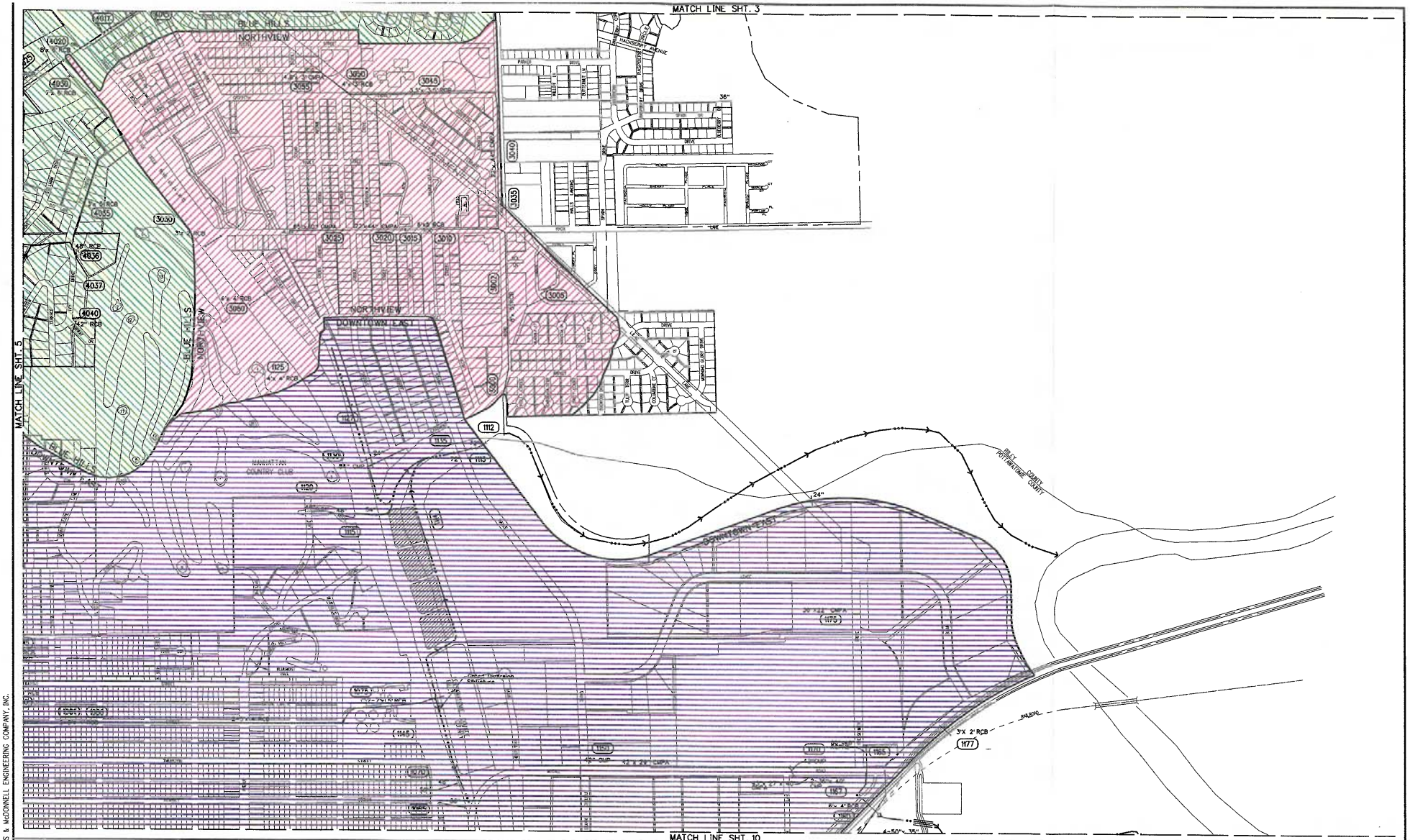
FIGURE IV - 6

WATERSHED MAP NO. 5



LEGEND

- MAJOR WATERSHED BOUNDARIES
- (1123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

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FIGURE IV - 7
WATERSHED MAP NO. 6

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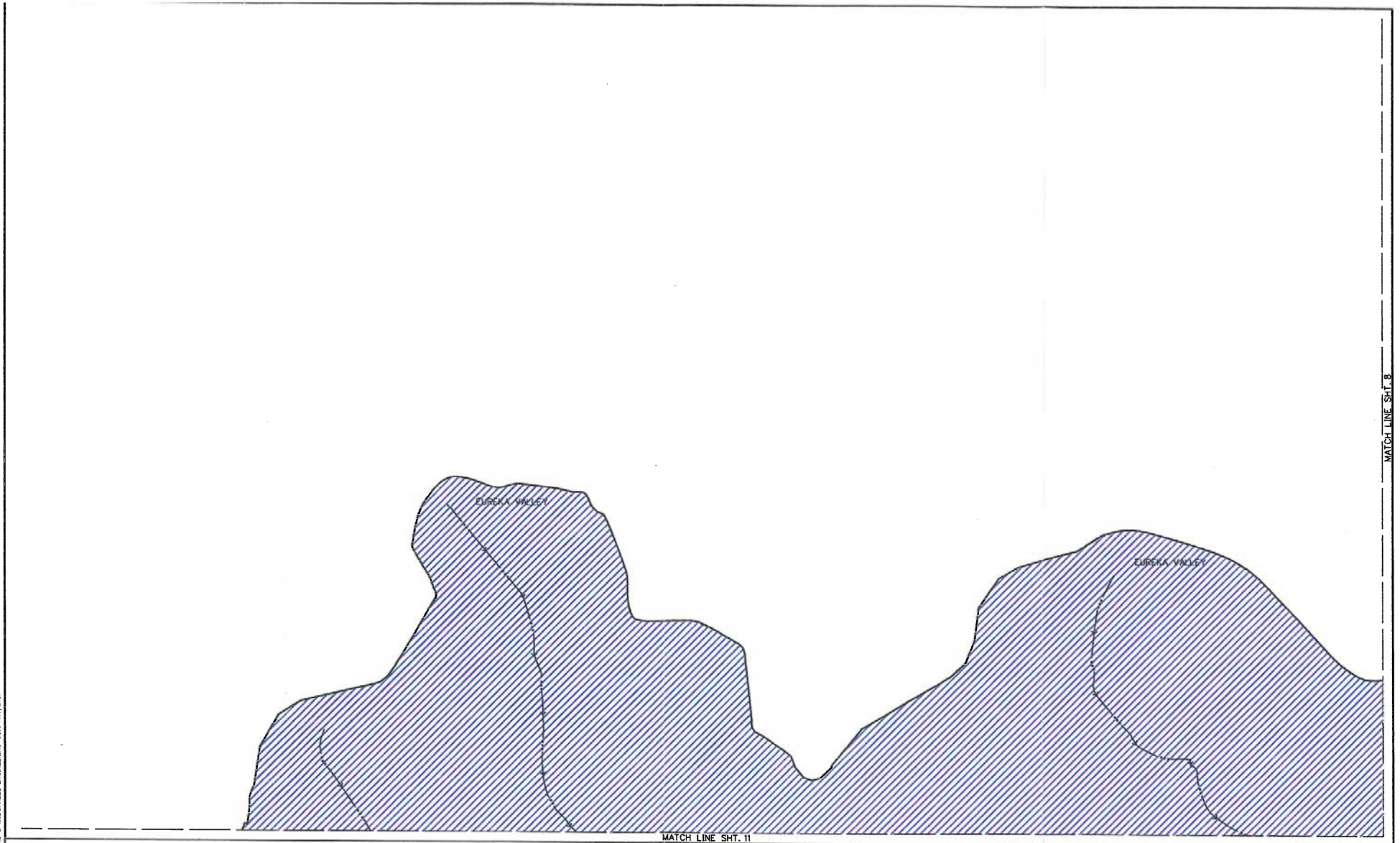

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

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FIGURE IV - 8

WATERSHED MAP NO. 7

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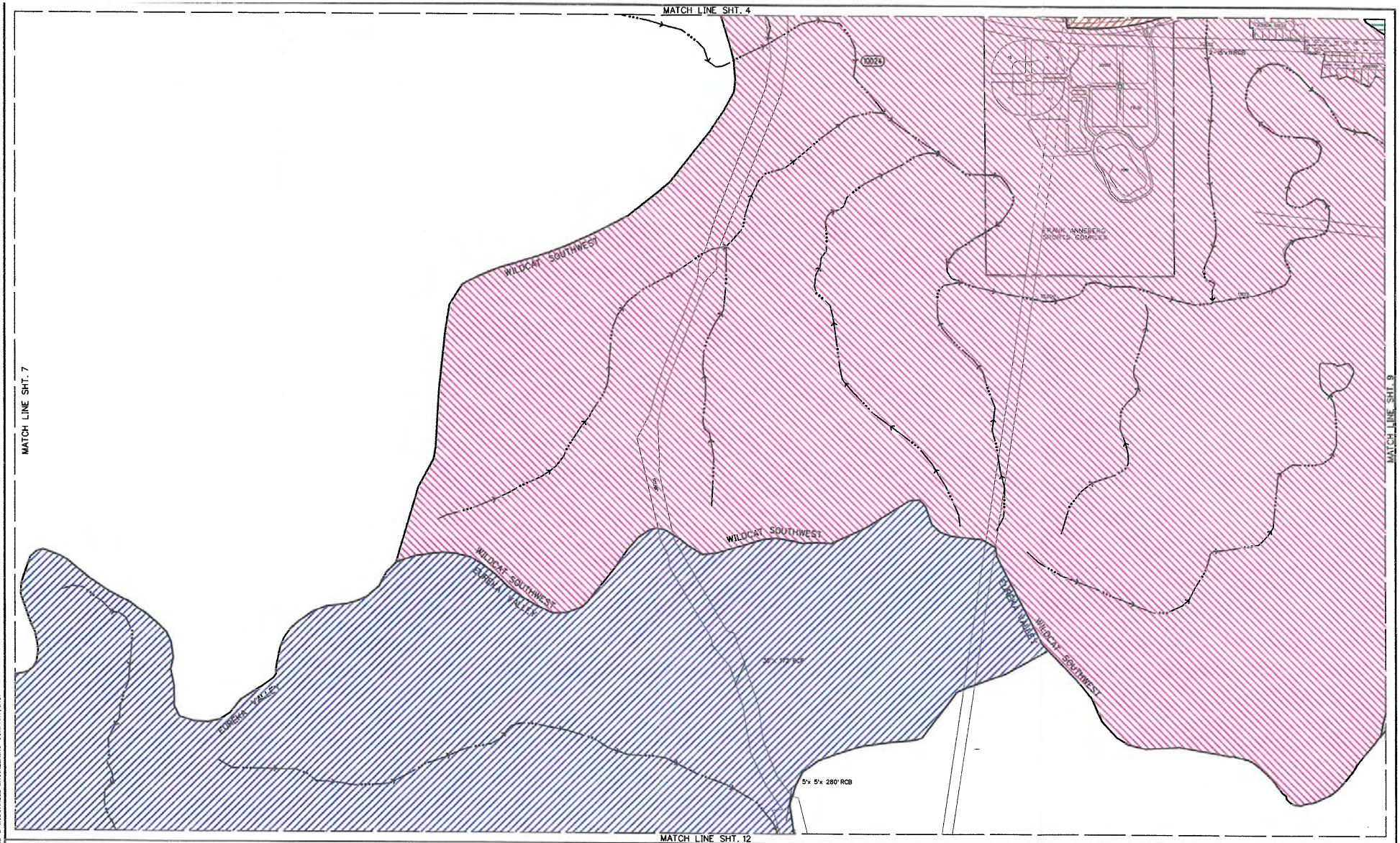

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

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STORMWATER MANAGEMENT PLAN

FIGURE IV - 9

WATERSHED MAP NO. 8

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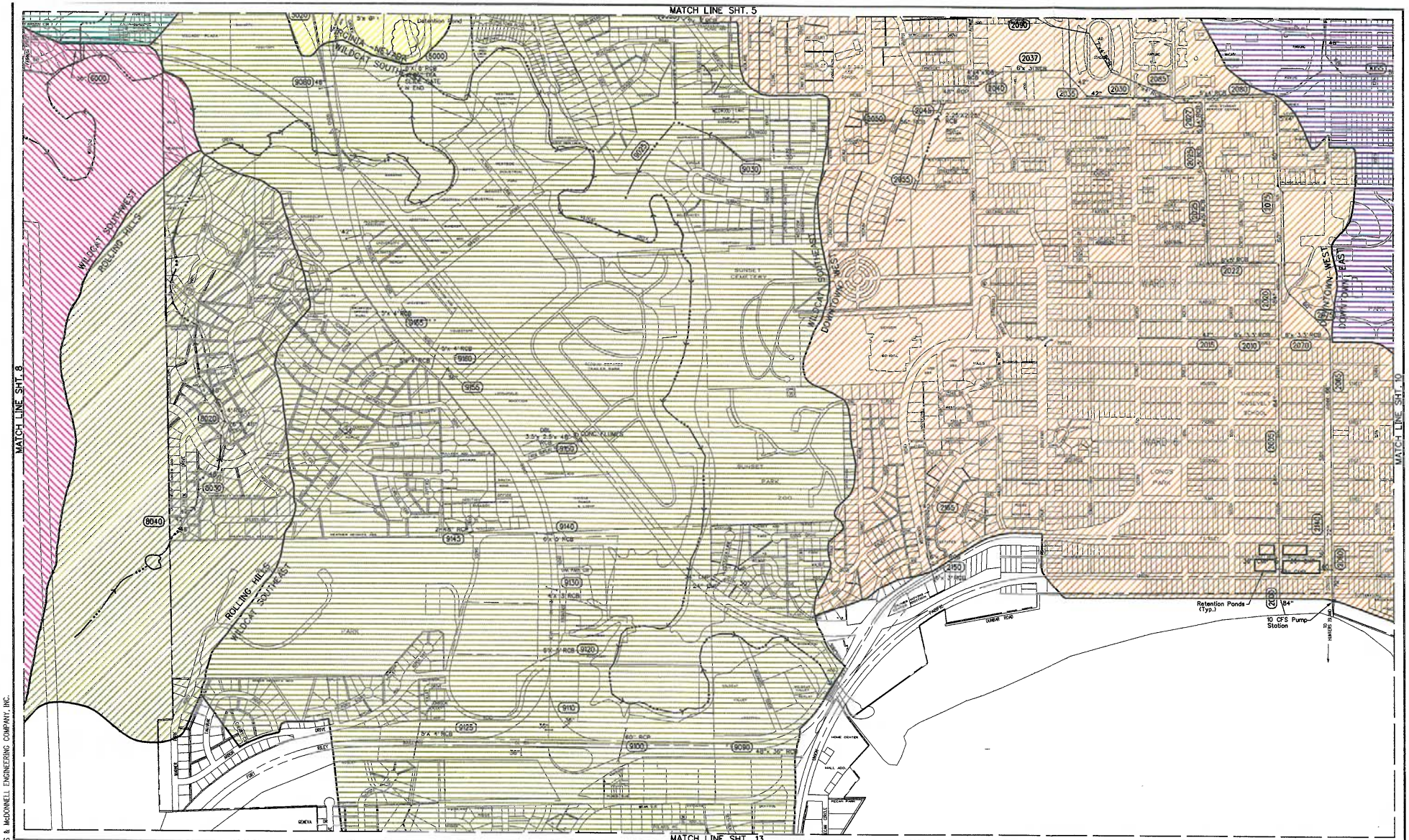

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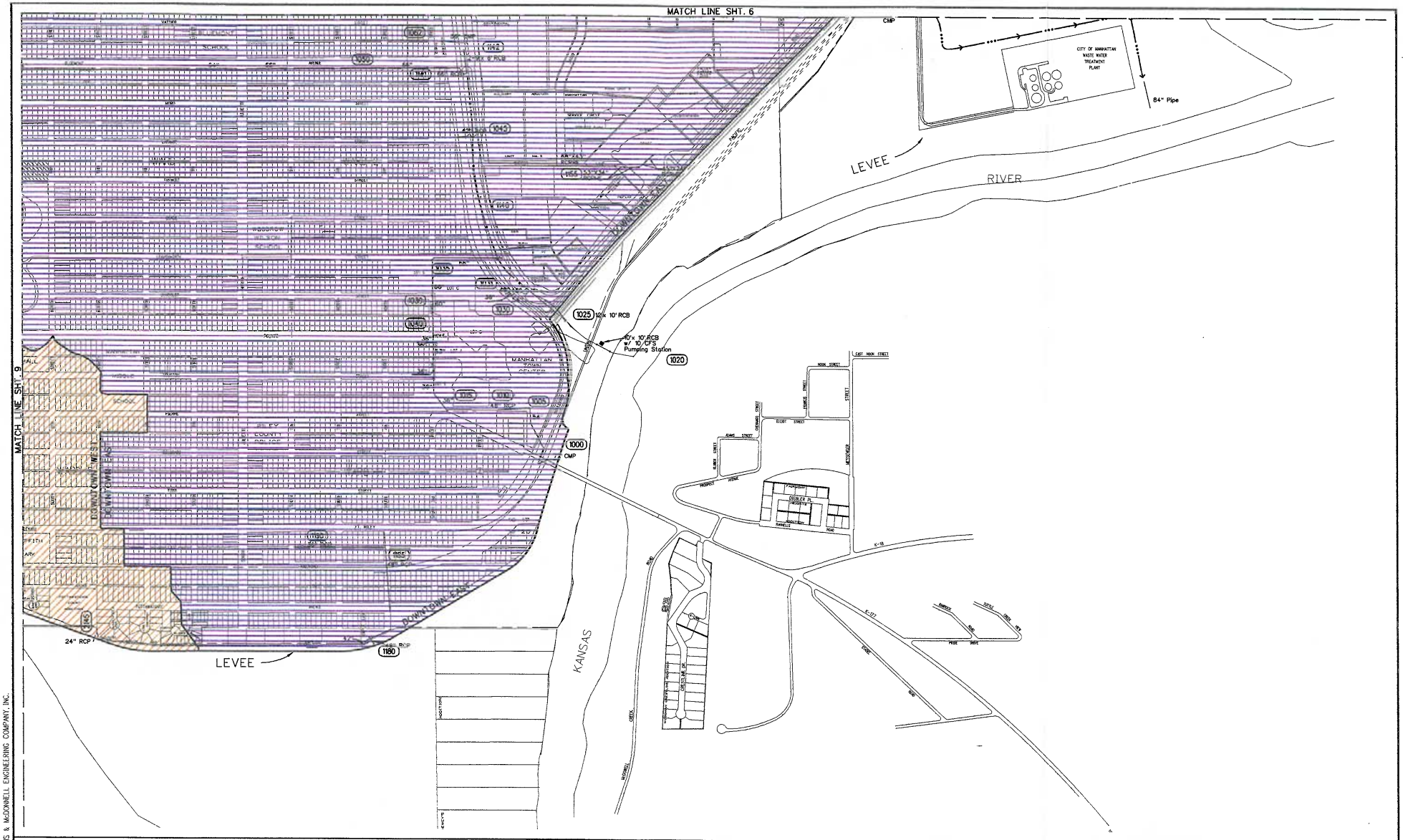
FIGURE IV - 10

WATERSHED MAP NO. 9



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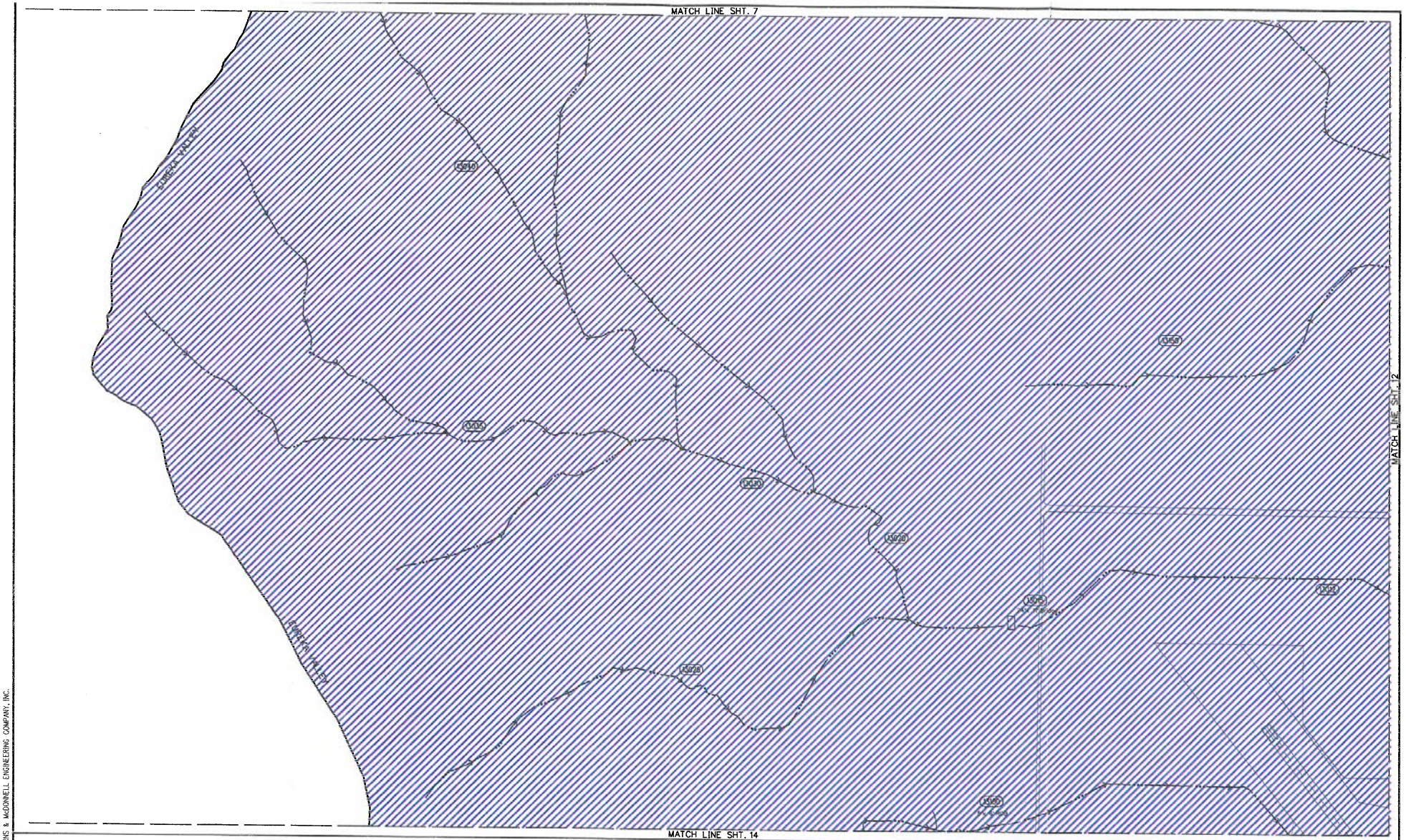

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (1123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

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STORMWATER MANAGEMENT PLAN

FIGURE IV - 12

WATERSHED MAP NO. 11

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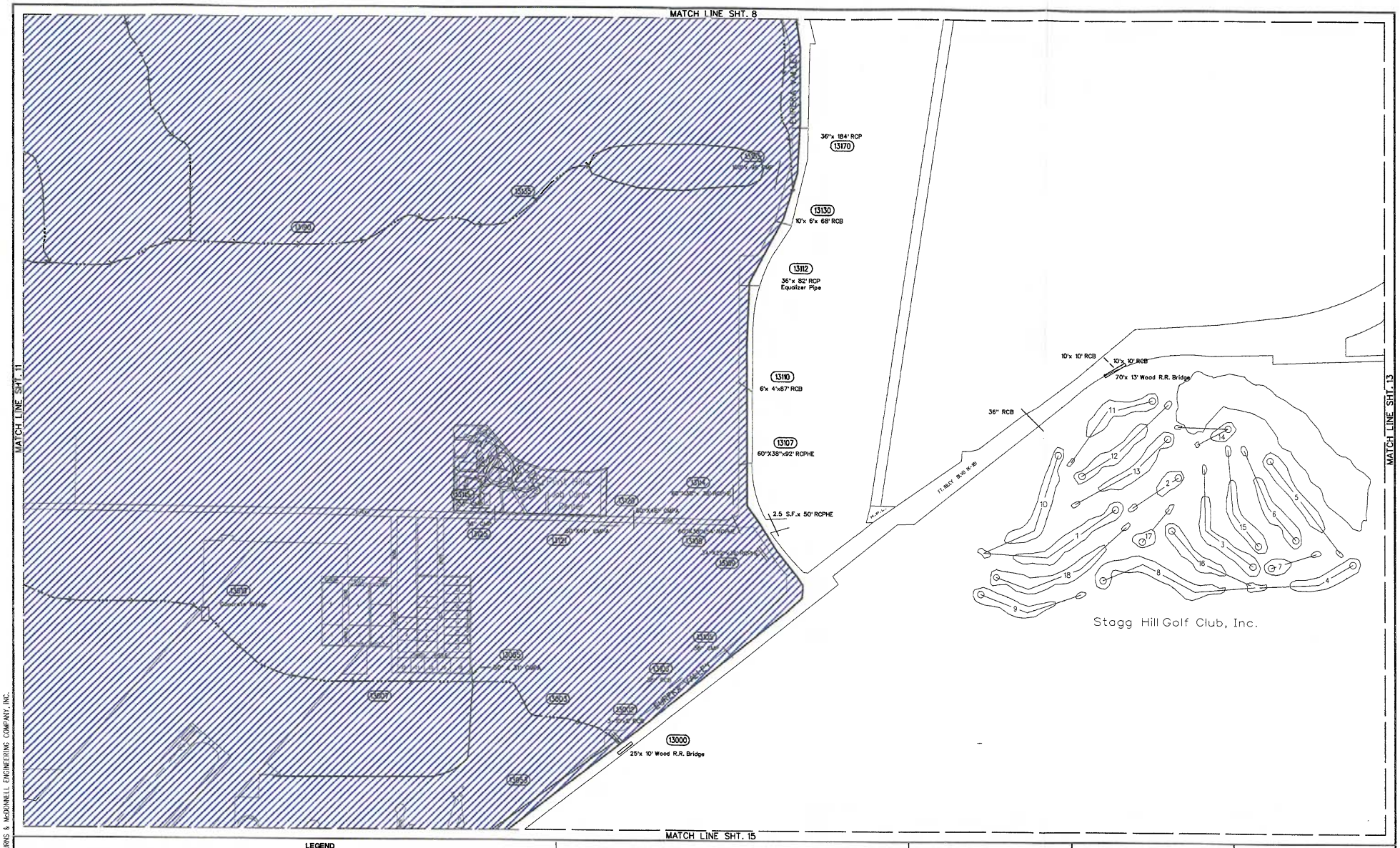

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

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STORMWATER MANAGEMENT PLAN

FIGURE IV - 13

WATERSHED MAP NO. 12

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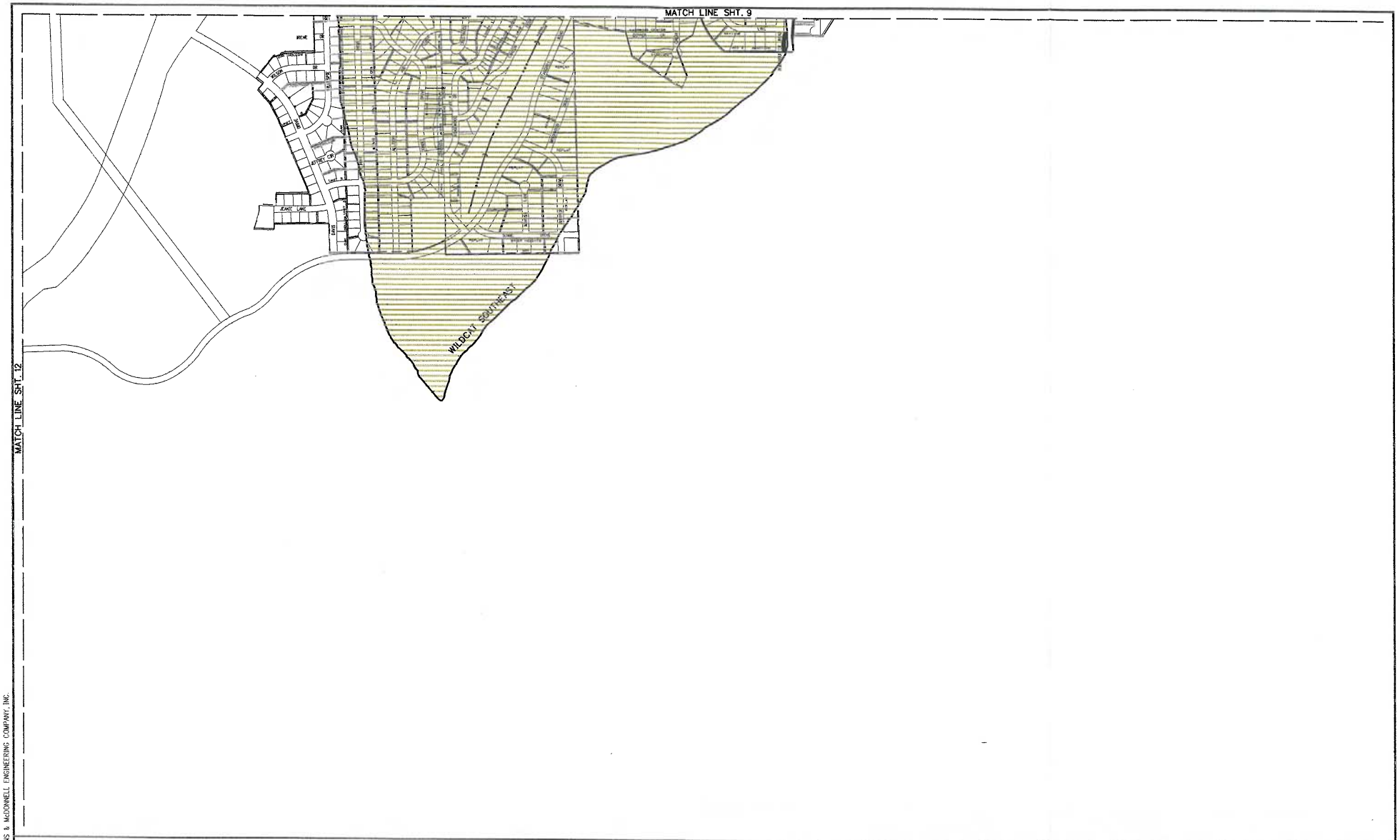

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

KEY PLAN

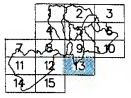

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FIGURE IV - 14
WATERSHED MAP NO. 13

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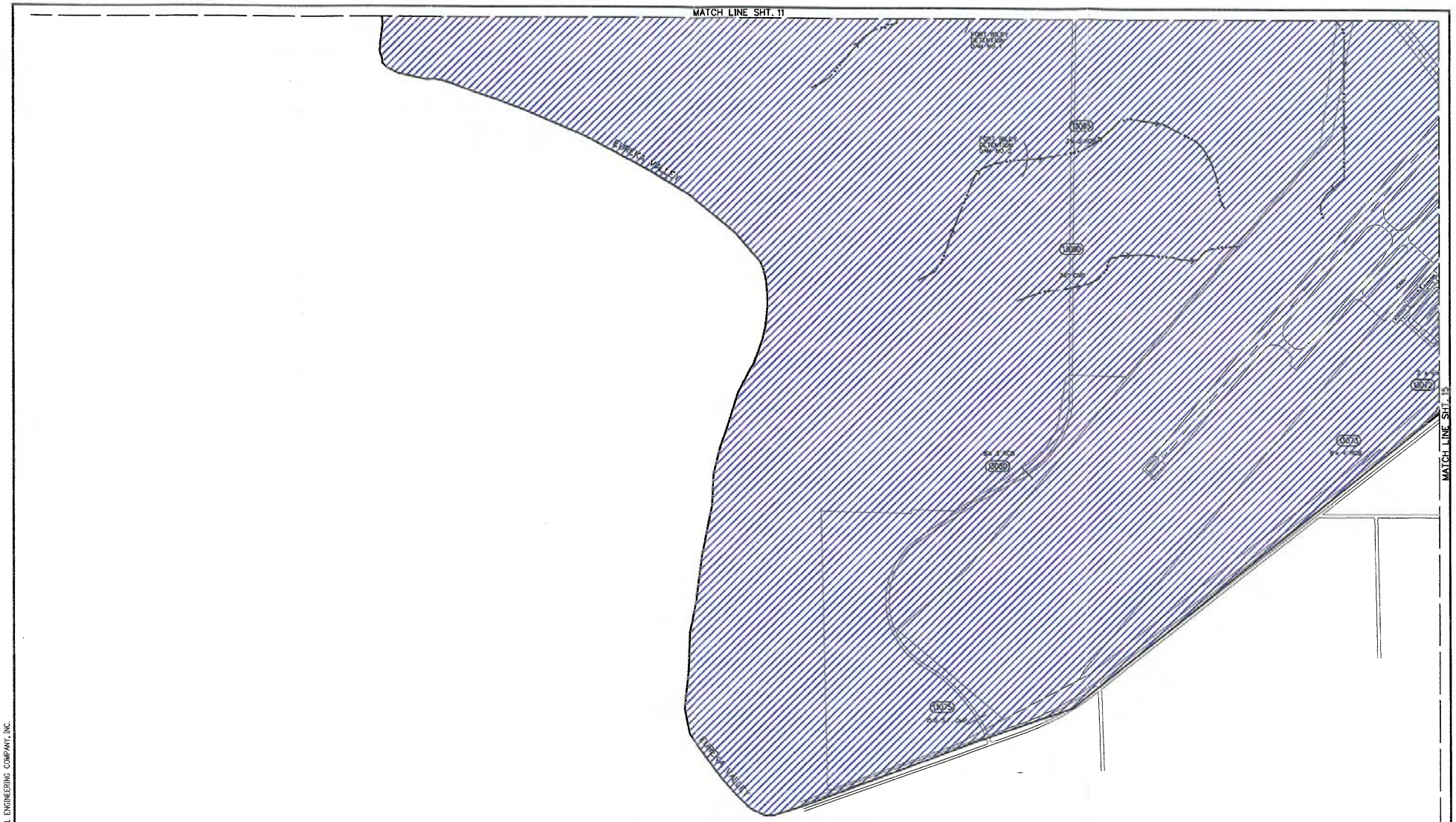

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

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STORMWATER MANAGEMENT PLAN

FIGURE IV - 15

WATERSHED MAP NO. 14

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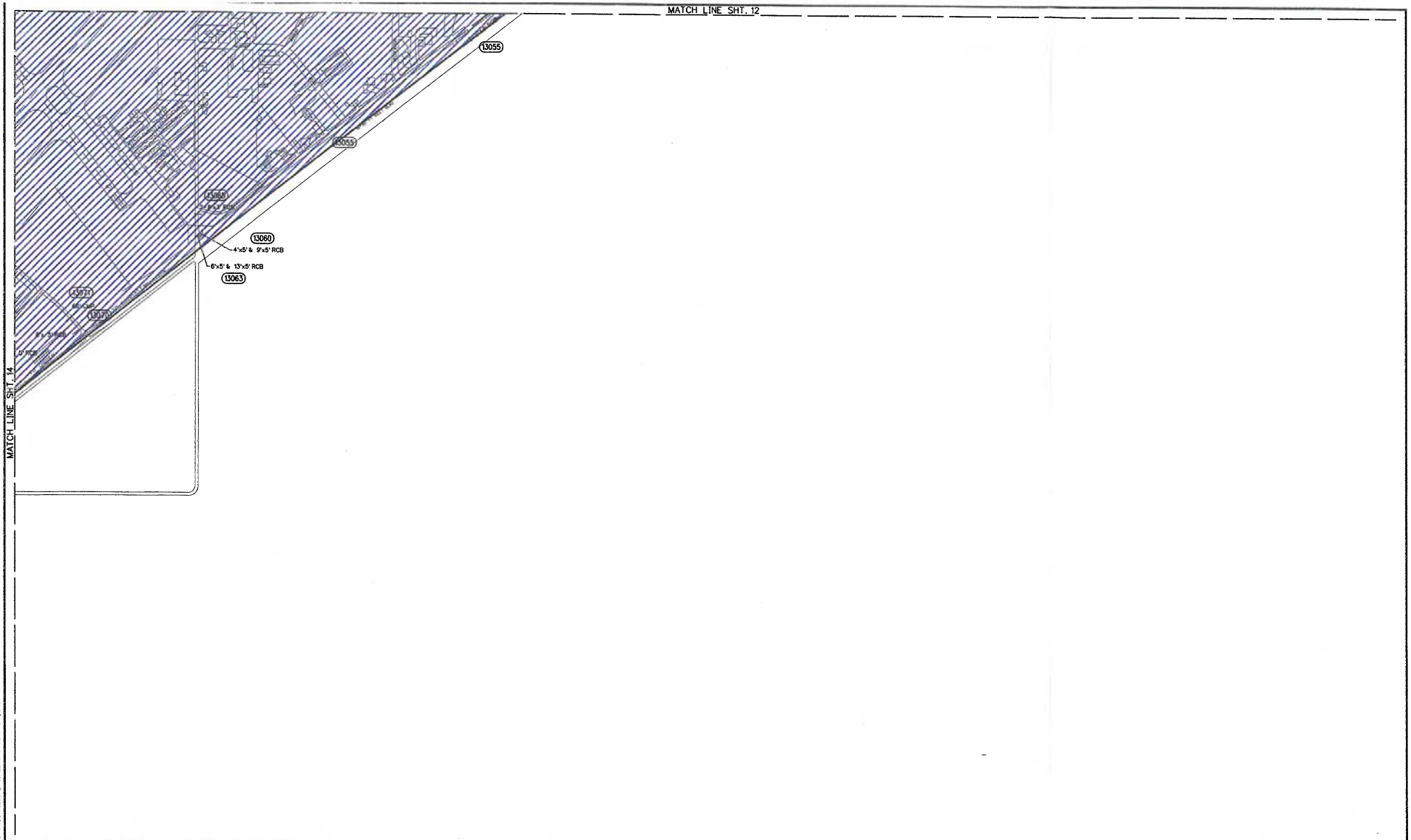

LEGEND

- MAJOR WATERSHED BOUNDARIES
- (11123) LINE NUMBERS
- OPEN CHANNEL
- EXISTING RCB OR PIPE

NORTH

KEY PLAN

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STORMWATER MANAGEMENT PLAN
FIGURE IV - 16
WATERSHED MAP NO. 15

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north along the back of the residential lots along Butterfield, drain to an extremely flat, poorly defined channel which flows across an agricultural field east of the subdivision to a double 8'x 8' RCB across Casement Road, north of Butterfield.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-10 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-10

EXISTING SYSTEM DESCRIPTION - BLUE HILLS WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
4000	3	2-8'x 8' RCB across Casement Rd., north of Butterfield
4001	3	8-ft. conc. channel east of Butterfield
4002	3	Channel from outlet of RCB across Butterfield
4005	3	3-10'x 3' RCB across Butterfield
4010	3	Channel from Brockman to Butterfield
4015	3	3-6'x 4' RCB across Brockman
4017	6	Channel from Tuttle Creek Blvd. to Brockman
4020	6	8'x 6' RCB across Tuttle Creek Blvd.
4022	6	Highway channel, west side of Tuttle Creek Blvd.
4025	6	36" CMP under Blue Hills shopping center
4030	5/6	7'x 6' RCB across Kimball
4035	6	3'x 5' RCB along east side Ivy Dr.
4036	6	48" RCP at Ivy Circle
4037	6	Channel from Fairway Drive to Ivy Cir.
4040	6	42" RCP across Fairway
4042	5/6	Channel between Blue Hills Road & Bluestem Terr.
4045/4046	5	36"/42" RCPs across Blue Hills Road
4050	5	Channel from RCB (4060) to shopping center
4052	5	Channel from pipe culvert (4055) to shopping center
4055	6	36" RCP across Kimball
4060	5	4'x 4' RCB across Kimball

d. System Performance

The problems reported in this watershed concern the open channel sections between Tuttle Creek Blvd. and the system outlet east of Butterfield. The slopes through this area are extremely flat and standing water has become a common problem. Sedimentation

in the channels and at the road culverts, also due to the flat slopes, has created maintenance needs in several areas.

Overall, four of the 18 major system improved reaches have less than the recommended 10-year capacity, three of which have less than a 2-year capacity. Improved system performance for the Blue Hills watershed is summarized in Table IV-11

TABLE IV-11

EXISTING IMPROVED SYSTEM PERFORMANCE - BLUE HILLS WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
4000	1440	326	524	684	916	1103	1298	>100
4001	54	19	32	42	58	71	84	25
4002	426	278	439	563	749	902	1052	5
4005	727	282	441	572	758	910	1058	25
4010	33	282	442	572	758	910	1058	<2
4015	657	267	419	538	709	849	994	>10
4017	41	267	419	538	709	849	994	<2
4020	720	265	418	538	709	848	989	25
4022	629	139	225	294	390	472	556	>100
4025	60	110	165	208	269	318	367	<2
4030	417	128	207	269	362	438	515	50
4035	188	78	129	169	225	274	323	>10
4036	188	15	26	35	49	60	72	>100
4040	101	15	26	35	49	60	72	>100
4045	144	37	54	67	86	99	114	>100
4046	106	37	54	67	86	99	114	>50
4055	94	8	13	17	22	26	31	>100
4060	240	71	101	123	154	178	202	>100

5. VIRGINIA-NEVADA WATERSHED

a. Location

The Virginia-Nevada watershed is located in the west central section of the city. It covers 546 acres (0.85 square mile) and is generally bounded by Wreath Ave. and Seth Child Rd. on the west, Kimball on the north, Garden Way on the south, and College in the northeast corner with the eastern boundary angling southwest to approximately Browning near Anderson. The area slopes from the east and west edges to the middle and then south at an average slope of approximately 2.5 percent. The basin is tributary to Wildcat Creek at the southern end.

b. Land Use

For purposes of this study, this watershed is considered to be fully developed. Land use is primarily single-family residential north of Dickens with some institutional (Marlatt School, the vocational technical school and a church) and multi-family residential areas mixed in. South of Dickens and east of Seth Child Rd. land use is generally commercial and multi-family residential. The commercial development includes Westloop Plaza shopping center and the University Gardens office park addition. West of Seth Child is another area of single-family residential with a commercial area along Anderson.

c. Existing Drainage System

The existing major drainage system in the Virginia-Nevada watershed is enclosed for the most part beginning at a 6'x 4' RCB across Kimball between Shirley Lane and Seaton Ave. The system continues south from Kimball in 42 and 48-inch pipes along back lot lines between Montana Ct. and Nevada Street. South of Montana Ct., the pipe turns to the east and then south again following Nevada and Virginia to Dickens. The enclosed system progresses from the 48-inch pipe to a 54-inch pipe on Nevada and then a series of 5'x 4', 5'x 3' and 8'x 2.5' RCBs along Virginia. The enclosed system outlets at the south end of Virginia into a short section of concrete-paved channel which flows to a triple 7'x 4' RCB across Dickens. Drainage from the west side of Seth Child Rd., north of Dickens, crosses the highway through several culverts of various sizes and drains east to the main stem.

From Dickens the main channel continues south as a paved open channel along the east side of an apartment complex to a 10'x 5' RCB across Beechwood Terr. Runoff from the northeast corner of the watershed drains to a double 7'x 2' RCB across Dickens, just east of Delaney Dr., which is partially silted in. From the culvert an unimproved open channel angles southwest to a 72-inch pipe across Browning and then further southwest to join the main channel at the outlet of the Beechwood Terr. culvert. Another

short section of open channel carries the flow to the 10'x 7' RCB under Westloop Plaza. This box becomes a 10'x 8' as it crosses Anderson and discharges into another open channel section which is tributary to a detention pond inside the loop of Garden Way. Drainage from west of Seth Child Rd. below Dickens runs south in a series of culverts and roadside ditches and eventually turns east, crossing Seth Child south of Anderson. A 5'x 3' RCB carries the flow across Garden Way toward the detention pond.

The private detention pond covers roughly one acre at normal water level and can hold approximately 9 acre-feet of flood storage at a maximum water elevation of 1040. The outlet of the pond is an 8'x 8' RCB with a 36-inch diameter slide gate at one end which discharges to Wildcat Creek. Based on the system analysis, the maximum stage in the pond reached during the 100-year storm is approximately 1039.3, less than maximum allowable elevation.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-12 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-12

EXISTING SYSTEM DESCRIPTION - VIRGINIA-NEVADA WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5000	9	1-acre detention pond with 8'x8' RCB outlet
5010	5	Channel from Anderson to detention pond
5015	9	5'x 3' RCB across Garden Way
5020	9	5'x 5' RCB across Seth Child
5025	5	8'x 3' RCB across Anderson
5030	5	7'x 3' RCB across Seth Child ramp
5032	5	48" CMP across Claflin
5035	5	42"x 27" RCPHE across Seth Child
5040	5	42"x 27" RCPHE across Seth Child ramp
5045	5	10'x 8' RCB across Anderson
5050	5	30" RCP along Anderson
5055	5	10'x 7' RCB under shopping center
5057	5	Channel-Beechwood Terr. to Claflin
5060	5	10'x 5' RCB across Beechwood Terr.
5062	5	Unimproved channel-Browning to Beechwood Terr.

TABLE IV-12 (cont'd)

EXISTING SYSTEM DESCRIPTION - VIRGINIA-NEVADA WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5065	5	72" CMP across Browning
5067	5	Unimproved channel-Dickens to Browning
5070	5	2-7'x 2' RCB across Dickens @ Delaney Dr.
5075	5	43"x 27" CMPA across Seth Child
5077	5	Concrete-lined channel - Dickens to Beechwood Terr.
5080	5	3-7'x 4' RCB across Dickens
5085	5	6'x 3' RCB across Seth Child
5087	5	Concrete-lined channel-Virginia outlet to Dickens
5090	5	8'x 2.5' RCB along Virginia
5092	5	5'x 3' RCB along Virginia
5095	5	5'x 4' RCB along Virginia
5100	5	36" RCP along Virginia
5105	5	5'x 3' RCB along Virginia
5110	5	54" RCP along Nevada
5115	5	48" RCP along Nevada
5120	5	42" RCP along lot lines between Nevada & Montana Ct.
5125	5	42"x 27" RCPHE across Seth Child ramp
5130	5	6'x 4' RCB across Kimball
5135	5	24" RCP from Shirley Lane inlets to Kimball

d. System Performance

Reported problems in the Virginia-Nevada watershed are primarily concentrated in two areas. The first area includes the portion of the system between Kimball and Dickens along Nevada and Virginia Streets. In this vicinity, discharge from the upstream system as well as additional local runoff, unable to enter the system, flows through yards behind the homes on Nevada and Montana Ct. and into the street near the intersection of the two streets. This water has reportedly reached depths of two to four feet at various times. Flows reached sufficient levels during the June 30 storm to wash cars down Nevada.

The other primary concern is along Shirley Lane, north of Kimball. Residents report that water frequently ponds around the single pair of curb inlets, located at the low point in the street, reaching depths of two to three feet at times and making the street impassable. As the depth increases, the water also overtops the curb and floods yards on the downstream side.

Several garages and houses adjacent to the low point were reported to have been flooded during the June 30 storm.

Of the 31 reaches analyzed in the watershed's improved system, nine have less than the recommended 10-year capacity but only two of those have less than a 2-year capacity. Improved system performance for the Virginia-Nevada watershed is summarized in Table IV-13.

TABLE IV-13

EXISTING IMPROVED SYSTEM PERFORMANCE - VIRGINIA-NEVADA WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
5010	3305	560	828	1030	1326	1560	1799	>100
5015	175	129	181	221	277	319	363	5
5020	332	113	160	195	245	283	322	100
5025	291	3	5	6	7	8	9	>100
5030	248	91	130	159	200	231	265	>50
5032	81	40	57	71	89	104	118	>10
5035	53	3	5	6	7	8	9	>100
5040	53	10	14	17	21	24	27	>100
5045	1200	522	771	959	1233	1452	1675	25
5050	75	48	72	89	114	133	153	5
5055	1050	491	732	914	1175	1378	1592	>10
5057	900	494	734	915	1175	1385	1599	10
5060	750	192	291	368	477	565	656	>100
5065	239	248	361	451	582	682	781	2
5070	112	206	298	365	461	535	610	<2
5075	38	9	15	19	25	30	36	100
5077	900	192	291	368	477	565	656	>100
5080	780	160	245	312	407	484	562	>100
5085	206	55	75	91	112	128	145	>100
5087	558	116	180	230	303	362	422	>100
5090	156	116	180	230	303	362	422	<5
5092	159	107	166	212	279	333	388	5
5095	279	107	166	212	279	333	388	25
5100	67	13	17	20	25	28	32	>100
5105	164	21	29	34	41	47	53	>100
5110	183	86	133	169	221	263	306	10
5115	144	79	122	154	202	240	279	<10
5120	101	59	93	119	157	188	220	5
5125	53	2	3	4	6	7	9	>100
5130	292	31	50	65	86	103	121	>100
5135	28	23	35	43	56	65	75	<5

6. CICO PARK WATERSHED

a. Location

The CICO Park watershed covers 558 acres (0.87 square mile) in the western half of the city. It is bounded generally by Wreath Ave. and Seth Child Rd. on the east, Hudson on the west, Lombard Dr. on the north, and the Union Pacific railroad on the south. From the east and west edges the area slopes at approximately 6.5 percent toward the main channel roughly in the center of the basin. The channel, the CICO Tributary, drains south and discharges into Wildcat Creek south of the railroad.

b. Land Use

Development within this watershed is substantially complete with the vast majority of the land developed as single-family residential. Relatively small areas of commercial development are located along Candlewood, north of Kimball. The only other large land use in the basin is CICO Park which covers the area between Wreath, Avery, Kimball and Dickens. The park contains the high school stadium, baseball fields, a municipal swimming pool, tennis courts and the county fairground buildings.

c. Existing Drainage System

The existing major drainage system in the CICO Park watershed is composed of the main channel with box culverts crossing major streets from Kimball south to the basin outlet. North of Kimball are relatively short sections of an enclosed pipe system including a 36-inch pipe running along Woods Dr. and a 60"x 38" elliptical pipe along Candlewood. A 6'x 4' RCB (with a 10'x 4' entrance) picks up the pipe system discharge, along with the flow from an improved channel running along back lot lines between Effingham and Newberry. The box crosses Candlewood, goes through the commercial area on the east side of the street, and discharges into the roadside channel along the west side of Seth Child Rd. From the outlet the channel flows south to a 9'x 5' RCB across Kimball and into CICO Park. In the park the channel has been regraded to route it generally along the east side of the park, around the various recreational facilities and

improvements. A series of box culverts carry the flow across drives and roads within the park. At the south end of the park, the channel crosses Dickens in a 9'x 7' "broken back" RCB. South of Dickens the main stem is a natural channel meandering through a residential area with an 8'x 8' RCB across Claflin and a 16'x 10' RCB across Anderson.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-14 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-14

EXISTING SYSTEM DESCRIPTION - CICO PARK WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
6005	9	Natural channel - south of Anderson
6010	5	16'x 10' RCB across Anderson
6015	5	Natural channel - Anderson to Claflin
6020	5	8'x 8' RCB across Claflin
6025	5	Natural channel - Claflin to Dickens
6030	5	21" RCP along Claflin
6040	5	9'x 7' RCB across Dickens
6045	5	Natural channel - north of Dickens
6050	5	9'x 5' RCB across Robinson Dr. in CICO Park
6051	5	96" CMP - extension of 9'x 5' RCB
6055	5	Natural channel - in CICO Park
6060	5	8'x 5' RCB across drive in CICO Park
6065	5	Natural channel - in CICO Park
6070	5	9'x 5' RCB across drive in CICO Park
6075	5	Natural channel - in CICO Park
6080	5	9'x 5' RCB across Kimball
6085	5	Paved - west side Seth Child, north of Kimball
6090	5	6'x 4' RCB (w/ 10'x 4' entrance) across Candlewood
6092	5	Improved channel along back lot lines between Effingham & Newberry
6095	4	60" RCP across Effingham
6100	5	60"x 38" RCPHE along Candlewood
6105	5	36" RCP along Woods Drive
6108	5	Paved channel, north side of Kimball
6110	5	60" x 38" RCPHE at Candlewood & Kimball
6120	5	36" RCP across Seth Child, north of Kimball
6130	5	36" RCP across Seth Child, south of Kimball
6140	5	Natural channel - in CICO Park
6145	4	5'x 4' RCB across Robinson Dr., west side of park
6150	4	36" RCP from Denholm to east of Cedar Crest Dr.

d. System Performance

The major problem reported in the CICO Park watershed is severe erosion along the natural channel, primarily between Dickens and Claflin, which is reducing backyard area on several properties and threatening to damage decks and patios in some cases. Erosion at the downstream end of the box culvert crossing Dickens is also a problem for the adjacent property. The homeowner on the east side of the channel has constructed a retaining wall along the back of the lot to protect it from further erosion. The large scour hole at the culvert outlet also poses a potential safety hazard due to water ponded approximately six feet deep.

An apparent capacity problem with the box culvert at Claflin has also been reported. Water backs up into adjacent yards at the upstream end, nearly reaching the houses at times, and overflows the street.

Overall, eight of the 21 major system reaches have less than the recommended 10-year capacity but only one has less than a 2-year capacity. Improved system performance for the CICO Park watershed is summarized in Table IV-15.

TABLE IV-15

EXISTING IMPROVED SYSTEM PERFORMANCE - CICO PARK WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
6010	2400	509	811	1043	1370	1647	1944	>100
6020	747	451	714	920	1226	1474	1726	5
6030	16	30	48	62	83	99	116	<2
6040	945	395	629	809	1067	1280	1507	>10
6050	467	328	519	666	880	1052	1232	5
6051	494*	328	516	664	877	1049	1229	5
6060	403	302	471	600	793	950	1109	<5
6070	467	271	418	533	701	836	947	<10
6080	450	241	377	481	631	750	873	<10
6085	280**	206	322	408	534	633	736	<5
6090	350	128	210	275	371	446	526	>10
6092	321	67	111	147	200	242	286	>100
6095	195	67	112	148	202	245	289	25

TABLE IV-15 (cont'd.)

EXISTING IMPROVED SYSTEM PERFORMANCE - CICO PARK WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
6100	108	36	57	74	98	118	138	>25
6105	61	30	47	61	81	97	114	10
6108	107	32	50	65	87	104	122	50
6110	125	32	50	65	87	104	122	100
6120	33	5	9	11	15	18	21	>100
6130	67	25	36	45	56	65	74	50
6145	198	49	79	102	135	163	191	100
6150	70	14	22	29	39	46	54	>100

* Full capacity, undamaged. Existing culvert has collapsed at one point reducing flow area by approximately half.

** Paved, low-flow channel only. Excess capacity with overbank areas.

7. LITTLE KITTEN CREEK WATERSHED

a. Location

The Little Kitten Creek watershed covers 1,908 acres (2.98 square miles) in the northwest corner of the study area. Most of the area lies outside of the current corporate limits, north of Kimball. It headwaters approximately two miles north of Kimball and one mile west of Hudson Ave. The eastern edge of the basin runs roughly along Hudson and the south edge, for the purposes of this analysis, is located at Anderson. The area slopes at an average of approximately 10 percent toward the main channel which drains south to Wildcat Creek.

b. Land Use

Over half of this watershed is currently undeveloped. Large-lot single-family residential development dominates the area along the creek itself for much of the length from Anderson to Kimball. Typical single-family residential lots make up the majority of the remaining developed land north of Dickens. Institutional and recreational tracts occupy small areas within the watershed. The open land in the north half of the basin is presently intended for single-family residential use in the future according to the city's Comprehensive Land Use Plan with a small area planned for neighborhood commercial zoning.

c. Existing Drainage System

The existing major drainage system in the Little Kitten Creek watershed is a series of natural, open channel sections with box culverts or bridges at major road crossings. The improved system begins basically at Kimball where the main stem of the creek and two tributaries cross the street. The eastern tributary crosses Kimball in a 6'x 6' RCB near Plymouth Rd. and continues to the southwest as an open channel with a 54-inch pipe crossing at Little Kitten Ave. This tributary joins the main channel to the east of Westbank Way and Julia Circle. The western tributary crosses Kimball at the curve where the street turns south through a 5'x 4' RCB. This channel continues to a 54-inch pipe crossing at Westbank Way, north of King's Rd., where it joins the main channel. Little Kitten Creek itself crosses Kimball through a double 14'x 13' RCB just east of Westbank Way. It continues south through the developed area as a natural open channel to Anderson where it crosses in a double 12'x 12' RCB. A double 15'x 11' box culvert carries the flow across the Union Pacific line south of Anderson. The creek joins Wildcat Creek approximately one-half mile south of the railroad.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-16 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-16

EXISTING SYSTEM DESCRIPTION - LITTLE KITTEN CREEK WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
7000	8	2-15'x 11' RCB across UPRR
7010	8	Natural channel-Anderson to UPRR
7015	4	2-12'x 12' RCB across Anderson
7020	4	48" RCP across Sharingbrook
7021	4	36" RCP across Windsong Lane
7025	4	Natural channel-Claflin to Anderson
7030	4	Natural channel-Snowy Reach to Claflin
7035	4	42" RCP across Little Kitten Avenue
7040	4	Natural channel-Wizard Cir. to Snowy Reach
7041	4	Natural channel-Little Kitten Avenue to main channel
7050	4	54" RCP across Little Kitten Ave.

TABLE IV-16 (cont'd.)

EXISTING SYSTEM DESCRIPTION - LITTLE KITTEN CREEK WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
7055	4	Channel/swale - Plymouth Road to Little Kitten Avenue
7060	4	6'x 6' RCB across Kimball
7070	4	36" RCP across Plymouth (north of Kimball)
7075	4	Swale along lot lines between Plymouth & Everett
7080	4	36" RCP across Plymouth (south of Kimball)
7090	4	54" RCP across Westbank Way
7092	4	Channel from Kimball to Westbank Way
7095	4	5'x 4' RCB across Kimball, west of main channel
7097	4	Natural channel - Kimball to Wizard Cir.
7100	4	2-14'x 13' RCB across Kimball
7110	4	36" RCP across Little Kitten Avenue, north of Kimball
7120	4	Natural channel - north of Kimball
7130	1	Natural channel - undeveloped area
7140	1	Natural channel - undeveloped area
7150	1	Natural channel - undeveloped area

d. System Performance

No major recurring drainage problems involving the improved drainage system have been reported in this watershed. Three reports concerning erosion in the open channel south of Kimball between Plymouth and Lexington Lane, and two hotline calls concerning high water levels in the main channel during the June 30 storm were received.

Concerns raised by the analysis, however, center around the impact development along the creek has had on the main channel's performance as a major part of the system. In analyzing the existing system, cross sections of Little Kitten Creek from the original FEMA Flood Insurance Study (FIS), surveyed in the mid-1970's, were compared to current cross sections. In a number of areas that have been developed since that time it was noted that the channel and overbank areas have apparently been modified during construction. In addition, the peak flows for various return period storms determined in the analysis are greater than the original values used in the FIS, due to the different technical methods used and to the different degree of development in the watershed.

One location of particular concern is behind the houses along Windsong Lane, north of Anderson. In this section of the main channel it appears that the creek bank was cut approximately three to four feet below the original elevation resulting in a greatly reduced capacity in the channel itself. The overbank area on the east side of the channel was also apparently lowered from two to five feet, depending on the particular location, and left with an extremely flat slope between the channel and some of the houses.

Although the floor elevations of the houses along this section may be above the official 100-year flood elevation shown on the FEMA maps, the channel will overflow much more frequently and to a much greater extent than reflected by the maps because of the modifications to the natural channel and overbank area coupled with the higher peak flows. The channel itself in this area has only a 5-year storm capacity. At this flow, water will reach the house at 1205 Windsong, which has a walkout basement door located only five feet above the channel invert. At a 10-year return period peak flow, water will reach the house at 1209 Windsong and apparently flood the basement of the other house.

In other areas farther north along the creek, it appears that portions of the channel and overbank areas have been filled in for development, effectively restricting the channel and overbank areas. The restriction in the flow area, along with higher peak discharges, forces water elevations to rise higher than the elevations indicated in the FIS for any particular return period storm. Areas where these modifications appear to have been the most drastic include the north end of Windsong Lane; the area east of Sharingbrook Dr. between Dickens and Claflin; the area between the east end of Snowy Reach and Little Kitten Ave.; and at the west end of Wizard Cir.

All but one of the 16 improved system enclosed reaches have capacities equal to or greater than a 10-year peak discharge. Improved system performance for the Little Kitten Creek watershed is summarized in Table IV-17.

TABLE IV-17

EXISTING IMPROVED SYSTEM PERFORMANCE - LITTLE KITTEN CREEK WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
7000	3275	749	1415	1964	2734	3403	4104	>25
7015	4320	749	1413	1962	2730	3404	4104	>100
7020	134	42	66	85	113	136	159	50
7021	70	35	55	71	94	113	132	10
7035	95	29	46	59	77	92	107	50
7050	184	80	127	164	219	264	309	>10
7055	25**	63	101	131	173	208	244	<2
7060	381	47	76	99	133	161	189	>100
7070	33	37	61	80	107	130	152	2
7075	164	28	47	61	81	99	116	>100
7080	67	18	29	37	49	58	68	100
7090	197	43	75	102	141	174	206	>50
7092	1104	43	75	102	141	174	206	>100
7095	245	17	30	41	57	70	84	>100
7100	5460	684	1275	1758	2507	3121	3750	>100
7110	67	19	29	37	49	59	68	100

** Low-flow channel only. Additional capacity in adjacent overbank areas.

8. ROLLING HILLS WATERSHED

a. Location

The Rolling Hills watershed is located south of Wildcat Creek, west of Seth Child Rd., and north of Ft. Riley Blvd. Approximately half of its 246 acres (0.38 square mile) currently lies outside of the corporate limits. The area headwaters near Warner Park Rd. and Arbor Dr. and slopes at an average of approximately 7 percent to the north, draining to Wildcat Creek, just north of Bethany Dr.

b. Land Use

The portion of the watershed located within the city is developed primarily as large-lot single-family residential. One end of Warner Park occupies the south end of the basin. The undeveloped area occupies the west half of the watershed. The Comprehensive Land Use Plan indicates this open area will be developed for residential purposes in the future.

c. Existing Drainage System

The existing major drainage system in the Rolling Hills watershed is an open natural channel, tributary to Wildcat Creek, with culverts at street crossings. A 42-inch pipe with a 48-inch inlet crosses E.J. Frick Dr. near the south end of the developed area. At Chic Cir. a 48-inch pipe, with a 76"x 46" elliptical pipe inlet, runs along the north-south section of the street and cul-de-sac. The open channel continues from Chic Cir. to Wildcat Creek.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-18 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-18

EXISTING SYSTEM DESCRIPTION - ROLLING HILLS WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
8000	9	Natural channel-Bethany Cir. to Wildcat Creek
8010	9	Natural channel-Chic Cir. to Bethany Cir.
8020	9	48" RCP w/76"x 48" RCPHE inlet at Chic Cir.
8025	9	Natural channel-Amherst to Chic Circ.
8030	9	24" RCP w/48" RCP inlet on Notre Dame Cir.
8035	9	Natural channel- E.J. Frick Dr. to Amherst
8040	9	42" RCP w/48" RCP inlet across E.J. Frick Dr.

d. System Performance

Three reports of drainage problems in this watershed were received from area residents. Two concerned erosion in a private open channel and at a culvert on Bethany Dr. The third reported high water in the open channel and flooding at three houses along Chic Cir. during the storm of June 30. This report also indicated that water overtops the culvert at Chic Cir. approximately once each year. Upon investigation, it appears that the overtopping occurs at a 15-inch inlet into the system on the west side of the street.

Of the three major system reaches, all have capacities between 5 and 10-years which conforms with the criteria in use at the time the

system was designed and constructed. Improved system performance for the Rolling Hills watershed is summarized in Table IV-19.

TABLE IV-19

EXISTING IMPROVED SYSTEM PERFORMANCE - ROLLING HILLS WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
8020	170	80	135	179	249	309	372	10
8030	134	69	118	157	219	273	328	<10
8040	71	43	76	102	420	175	209	5

9. WILDCAT SOUTHEAST WATERSHED

a. Location

The Wildcat Southeast watershed covers 1,294 acres (2.02 square miles) in the south-central part of the city. The basin straddles Wildcat Creek with most of the area located to the south and west of the creek. The southern portion of the watershed headwaters near the southeast corner of Sunrise Cemetery and slopes north and east to the creek. Across the creek, the area slopes back to the south and west. Slopes generally range between 10 and 15 percent in the area west of Seth Child Rd. and flatten to 3 to 5 percent adjacent to the creek. A steep bluff runs along the east side of the creek with slopes in the range of 5 to 10 percent in the area on the top. Seth Child Road (K113) and Ft. Riley Boulevard (K18) are the major thoroughfares in the area.

b. Land Use

This watershed is a mixture of land uses without one dominant type across the area. Residential areas include the Redbud Estates Mobile Home Park, the Washington Square townhouse development, and typical single-family areas in the south end and along the east edge. Commercial and industrial areas are located generally between Seth Child Rd. and Wildcat Creek, and along Ft. Riley Blvd. Small office areas are located toward the north end. The basin also includes the majority of Warner Park and part of Sunrise Cemetery.

For the most part, open space has been left along Wildcat Creek through the watershed. Undeveloped land remains to the west of Seth Child Rd. north of Ft. Riley Blvd., along the south side of Ft. Riley Blvd., and in smaller tracts scattered throughout the watershed. The Comprehensive Land Use Plan indicates the future land use in the area west of Seth Child Rd., which is currently in agricultural use, as commercial while the area south of Ft. Riley Blvd. is to be medium-high density residential development.

c. Existing Drainage System

The existing major drainage system in the Wildcat Southeast watershed is composed of open channels and street culverts. The area drains into Wildcat Creek at multiple points along its length. Many of the road culverts in the watershed are located on state highway right-of-way on either Seth Child Rd. or Ft. Riley Blvd. The southern end of the basin drains primarily to an open channel between Canyon Dr. and Stagg Hill Rd. which crosses the highway through a 60-inch pipe just east of the K113/K18 interchange and discharges to the creek. The west side of this area drains to a 5'x 4' RCB under K18 near the north end of Dehoff Dr. Drainage from the west side of Seth Child crosses the road in 6'x 5' RCBs at each end of Shuss Rd.; a 4'x 3' RCB near Oak Park Cir.; a 5'x 4' RCB and a 36-inch pipe at the Homestore tract; a 42-inch pipe at the north end of the frontage road; and a 48-inch pipe on the north side of the creek, just south of the K113/Anderson interchange. Drainage from the north and east crosses Anderson in 30 and 36-inch pipes near Woodland and a 3'x 3' RCB near Bellehaven. A 6'X 6' RCB crosses Connecticut south of Anderson and discharges into an open channel which runs along the north and west edges of lots along Georgetown Place before emptying into Wildcat Creek. Multiple smaller diameter pipes cross Oakdale Dr. near Grandview, and Poliska Lane at Justin Dr. to carry drainage from the east edge of the basin toward Wildcat Creek.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-20 which also includes reference to the map sheet where each reach is indicated.

TABLE IV-20

EXISTING SYSTEM DESCRIPTION - WILDCAT SOUTHEAST WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
9025	9	Channel between Wildcat Ridge & Grandview Terr.
9027	9	Channel from outlet of Oakdale culverts
9030	9	1-21" & 1-30" RCP across Oakdale Dr. @ Grandview
9032	9	Channel from outlet of Anderson RCB
9035	9	3'x 3' RCB across Anderson
9037	5	Channel around west end of Georgetown Pl.
9040	5	6'x 6' RCB across Connecticut
9050	5	30" RCP across Anderson
9055	5	48" RCP along Anderson
9060	5	4'x 2.25' RCB along Anderson
9070	5	36" RCP across Anderson
9072	5	Channel from Claflin to Anderson
9075	5	24"x 38" RCPHE across Claflin
9080	9	48" RCP across Seth Child
9090	9	4'x 3' RCB across Rosencutter Road.
9100	9	60" RCP across Ft. Riley Blvd.
9110	9	36" RCP across ramp to Seth Child
9118	9	Channel from 6'x 5' RCB outlet to creek
9120	9	6'x 5' RCB across Seth Child
9122	9	Channel from 5'x 4' RCB outlet to Seth Child Rd.
9125	9	5'x 4' RCB across Ft. Riley Blvd.
9127	9	Channel from 4'x 3' RCB outlet
9130	9	4'x 3' RCB across Seth Child
9137	9	Channel from Farm Bureau Rd. to creek
9138	9	Channel from 6'x 5' RCB outlet
9140	9	6'x 5' RCB across Seth Child
9142	9	Channel from Brush Creek Ln. culverts
9145	9	2-48" RCP across Brush Creek Ln.
9150	9	2-3.5' x 2.5' RCB across Farm Bureau Rd.
9152	9	Channel from highway culverts outlets
9155	9	36" RCP across Seth Child
9160	9	5'x 4' across Seth Child
9162	9	Channel from 5'x 4' RCB outlet
9165	9	5'x 4' RCB across Seth Child
9170	9	42" RCP across Seth Child

d. System Performance

The major drainage-related problem reported in this watershed is the severe erosion along Wildcat Creek in the vicinity of the Washington Square development. Sloughing banks have destroyed parts of several

backyards that border the creek and created large vertical drops. In some cases continuing erosion is threatening patios, decks and possibly even homes.

Since analysis of Wildcat Creek itself is not included in the scope of this study, this problem has not been addressed in terms of possible reasons or recommended repairs. However, the City has already taken action, making repairs and improvements in the area.

Overall, only five of 22 improved system reaches have less than the recommended 10-year capacity and none have a 2-year capacity or lower. Improved system performance for the Wildcat Southeast watershed is summarized in Table IV-21.

TABLE IV-21

EXISTING IMPROVED SYSTEM PERFORMANCE - WILDCAT SOUTHEAST WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
9030	71	18	28	37	49	59	69	100
9035	109	4	7	9	11	13	16	>100
9040	540	141	213	269	346	408	470	>100
9050	58	17	26	33	43	51	59	100
9055	184	108	160	200	255	299	345	<10
9060	135	32	49	62	80	95	109	>100
9070	86	75	111	138	175	206	237	<5
9075	41	27	37	45	56	64	72	<10
9080	165	70	93	110	133	151	169	100
9090	119	91	144	184	244	293	342	<5
9100	294	130	217	287	389	473	558	10
9110	94	10	16	21	28	34	39	>100
9120	450	81	134	177	240	290	342	>100
9125	300	49	78	101	134	161	188	>100
9130	180	5	10	14	20	25	30	>100
9140	330	96	161	212	289	350	414	>25
9145	250	72	121	161	220	269	319	>25
9150	164	111	168	210	271	321	371	5
9155	67	1	3	3	5	6	7	>100
9160	245	62	97	125	165	197	230	>100
9165	198	35	57	73	96	115	134	>100
9170	135	10	17	21	28	33	38	>100

10. WILDCAT SOUTHWEST WATERSHED

a. Location

The Wildcat Southwest watershed covers 1,539 acres (2.40 square miles) at the southwest corner of the city. Most of the basin, which is essentially bisected by Wildcat Creek running east-west through it, lies outside of the current corporate limits. It is bordered primarily by the Rolling Hills, Little Kitten Creek, and Eureka Valley watersheds on the east, north and southwest, respectively. The area slopes generally north and south draining to the creek either directly or through tributary channels. Slopes generally range between 10 and 15 percent except in the floodplain. Anderson Ave. and Kimball/Scenic Drive are the major streets near the area.

b. Land Use

The basin is undeveloped for the most part. North of Anderson, in the northwest corner of the watershed, is a small area of residential development, an area for an office park, and a rock quarry near Kimball. South of Anderson the Frank Anneberg Sports Complex is basically the only development. The remainder of the watershed is either agricultural or open land. The Comprehensive Land Use Plan indicates much of the area between Anderson and just south of Wildcat Creek will remain as open space in the future while the higher areas along the south edge of the basin will be developed as low-medium density residential areas. The open land north of Anderson is also to be developed primarily as residential areas.

c. Existing Drainage System

The major drainage system in the Wildcat Southwest watershed is almost completely natural open channels, including Wildcat Creek, at this time. Only two improved system components were identified: a 4'x 6' RCB across Anderson and a 72-inch pipe across a private drive, immediately downstream from the box culvert.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-22 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-22

EXISTING SYSTEM DESCRIPTION - WILDCAT SOUTHWEST WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
10024	8	72" CMP across private drive
10025	4	4'x 6' RCB across Anderson
10030	4	Natural Channel - undeveloped area, southwest of Anderson & Scenic Drive
10035	4	Natural Channel - undeveloped area, northwest of Anderson & Scenic Drive
10040	8	Natural Channel - undeveloped area, north of Anderson

d. System Performance

Since almost no development exists in this watershed, no drainage problems have been reported. The performance of the two improved system reaches in the Wildcat Southwest watershed is summarized in Table IV-23.

TABLE IV-23

EXISTING IMPROVED SYSTEM PERFORMANCE - WILDCAT SOUTHWEST WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
10024	198	100	156	200	262	311	362	10
10025	266	100	156	200	262	311	362	25

11. NORTH WATERSHED

a. Location

The North watershed includes 1,965 acres (3.07 square miles) across the northern edge of the city. The majority of the area lies outside the current corporate limits. The watershed lies roughly between Tuttle Creek Blvd. and Seth Child Rd., north of Kimball, and is bounded by the Stadium watershed to the east, the Virginia-Nevada watershed to the south, and the CICO Park and Little Kitten Creek watersheds to the west. It headwaters

just west of Seth Child Rd. approximately one-half mile north of Marlatt Ave. and drains generally to the east at an average slope of approximately 4 percent. The main channel crosses Tuttle Creek Blvd. at Marlatt Ave. and eventually drains to the Blue River.

b. Land Use

Approximately one-third of the watershed is currently developed, primarily as residential property south of Kimball with some commercial areas along Seth Child Road. The Comprehensive Land Use Plan indicates future residential development in the areas north of Marlatt and west of Browning, and in several currently undeveloped "pockets" south of Kimball. A new public school is planned on the west side of Browning, north of Gary Ave., and some additional office development is indicated in the vicinity of Marlatt and Seth Child Rd.

Almost half of the land within the basin is owned by Kansas State University which is primarily used for agricultural research. The Comprehensive Land Use Plan indicates that this property will generally remain in agricultural use in the future.

c. Existing Drainage System

The existing major drainage system in the North watershed is composed almost exclusively of open channels and road culverts. The channels have been somewhat improved by grading in developed areas such as the Snowbird subdivision, but generally follow the natural drainage paths.

The drainage system has several main branches which ultimately are all joined north of Marlatt Ave., just west of Denison. The first branch begins as a natural channel approximately 1/4-mile east of Seth Child Rd. and 2/3-mile north of Marlatt. It flows southeast through undeveloped land to Browning Ave. where it crosses the road through two 42"x 24" pipe-arches, just north of Marion Ave. The channel then continues to the east and south,

nearing Marlatt at the downstream end of a triple 10'x 7' RCB across the road. From the culvert, the channel flows to the east and slightly north through KSU's property to Tuttle Creek Blvd. where it crosses the highway through a quadruple 10'x 7' RCB. From the highway, open channels carry the flow east to the Blue River.

The second branch also begins as a natural channel near Seth Child Rd. approximately 1/2-mile north of Marlatt and flows southeast to Marion and Browning. At this point, the channel turns south crossing Marlatt through a 2-6'x 4' RCB just east of Browning and continues southeast through university property to a 5'x 8' stone culvert across College Ave. From College, the channel turns back to the northeast and flows to the triple 10'x 7' RCB across Marlatt where it joins the first branch at the downstream end.

A third branch begins west of Seth Child Rd. along the west side of the Kansas Farm Bureau Plaza, crossing Seth Child in a 7'x 6' RCB. From the highway, a natural channel runs slightly south and east, along the north edge of a residential area, to a triple 7'x 4' RCB across Browning, just north of Lawrence. From Browning, a graded channel continues to the east along the north edge of the Snowbird subdivision for approximately half the width of the developed area then turns northeast to join the second main branch approximately 1000 feet west of College.

Another branch begins in the developed area south of Kimball on each side of Browning. Runoff collected from the residential area crosses Kimball through a 30-inch pipe which outlets to a small open channel. This channel flows to the north and east crossing a driveway at the end of Parkway Dr. through a 54"x 34" pipe-arch and Snowbird Dr. through two 48"x 29" horizontal elliptical pipes. From the culverts, the flow continues in a shallow graded channel, or swale, through the back yards of the houses along Tamarron Terr. and Hillview Dr. At the edge of the development, the existing natural channel picks up the flow

continuing northeast to the 5'x 8' stone culvert at College where it joins the second branch.

The last branch begins near the intersection of Kimball and Denison. Drainage from the St. Mary Hospital site, on the southwest corner, and the KSU stadium parking lot, on the southeast corner, is collected by 36 and 42-inch pipes and routed across the streets to the northeast corner. From the outlet of the enclosed system an open channel flows north, joining the second branch slightly downstream from the stone culvert at College.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-24 which also includes reference to the map sheet where each reach is indicated.

TABLE IV-24

EXISTING SYSTEM DESCRIPTION - NORTH WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
11000	2	4-10'x 7' RCB across Tuttle Creek Blvd.
11002	2	Natural channel-Marlatt RCB outlet to Tuttle Creek Blvd
11005	2	Natural channel - College to Marlatt RCB outlet
11006	2	2-42"x 24" CMPA across College @ Marion Avenue
11007	2	Natural channel-north end Cindella Dr. to College
11010	2	Natural channel-north of Marque Hill Rd.
11019	2	Roadside ditch - north side of Marlatt
11020	2	50"x 31" CMPA across College, north side of Marlatt
11021	2	3-10'x 7' RCB across Marlatt
11022	2	Roadside ditch - south side of Marlatt
11025	2	50"x 31" CMPA across College, south side of Marlatt
11030	2	Natural channel-College to Marlatt
11035	5	Natural channel-northeast of Kimball & College
11040	5	48" CMP across Kimball, east of College
11045	5	54" CMP across College, north of Kimball
11050	5	42" CMP across Kimball, west of College
11052	2	Natural channel-east of stone culvert at College
11055	2	5'x 8' stone culvert across College
11056	2	Natural channel - to stone culvert from northeast
11063	5	Natural channel-edge of Snowbird subdivision to College
11065	5	Improved channel-back of lots on Tamarron Terr.
11070	5	2-45"x 29" RCPHE across Snowbird
11075	5	54"x 34" CMPA across drive at end of Parkway
11080	5	30" CMP across Kimball
11085	2	Natural channel-Browning (4'x 3' RCB) to confluence
11087	2	Natural Channel-Browning (3-7'x 4' RCB) to confluence

TABLE IV-24 (cont'd.)

EXISTING SYSTEM DESCRIPTION - NORTH WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
11089	2	3-7'x4' RCB across Browning at Lawrence
11090	2	Natural channel-Seth Child to Browning
11091	2	4'x 3' RCB across Browning between Lawrence and Edwards
11095	2	7'x 6' RCB across Seth Child
11100	2	2-24" RCPs across Snowbird Dr. near Tiana Terr.
11130	2	Natural channel - Marlatt & Browning to confluence
11135	2	7'x 3' RCB across Browning @ Edwards
11140	2	4'x 5' RCB across Marlatt @ Circle Rd.
11145	2	36" RCP across ramp to Seth Child
11150	2	42" CMP across Seth Child
11155	2	2 - 6'x 4' RCB across Marlatt, east of Browning
11157	2	Natural channel-Seth Child to Marlatt & Browning
11160	2	36" CMP across Seth Child
11162	2	36" CMP across Seth Child
11164	2	48" CMP across Seth Child
11165	2	48" CMP across Seth Child

d. System Performance

The problems reported in this watershed involve two areas in the Snowbird subdivision. Most of the reports concern the open channel that runs between Tamarron and Hillview and the culverts under Snowbird Dr. at the upstream end. The culverts reportedly do not drain the upstream area completely and, during fairly heavy rains, flows overtop Snowbird Dr. It has also been reported that water in the downstream channel frequently spreads over yards in a wider area than the 40-ft. easement at depths of one to two feet. During the June 30 storm, water reported as three to four feet deep, spreading over an area approximately 100 feet wide in some sections, entered several houses along the channel.

The second area involves the existing minor drainage system along the west side of Snowbird Dr. near its intersection with Tiana Terr. An open channel runs north through two empty lots owned by the City to two 24-inch culverts which are supposed to drain across the street to the open channel running along the edge of KSU's property. However, the downstream end of the west culvert is at least half obstructed by silt and weeds as is the downstream channel. The obstructed channel prevents flow from exiting the culverts and causes drainage to back up

on the south side of Snowbird, occasionally overtopping the road. At times, water reportedly flows from the north side of the street to the south through the culvert. Standing water in the channel and surrounding area is also a concern.

Overall 12 of the 28 improved reaches have less than the recommended 10-year capacity. Eleven of those have capacities of 2 years or less. Improved system performance for the North watershed is summarized in Table IV-25.

TABLE IV-25

EXISTING IMPROVED SYSTEM PERFORMANCE - NORTH WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
11000	3206	1105	1820	2437	3389	4136	4906	>10
11006	84	173	322	451	648	806	965	<2
11019	19	18	29	37	50	60	70	2
11020	64	18	29	38	51	61	71	50
11021	2330	846	1390	1817	2449	2965	3495	>10
11022	19	24	42	57	77	94	112	<2
11025	75	10	18	24	33	41	49	>100
11040	115	74	96	112	134	151	168	10
11045	157	65	94	115	145	169	192	>25
11050	80	47	65	79	98	113	128	10
11055	255	677	1118	1464	1973	2394	2831	<2
11065	11	114	181	232	306	365	425	<2
11070	61	86	134	170	225	268	312	<2
11075	99	65	101	128	166	198	231	5
11080	33	36	53	65	82	96	110	2
11089	200*/695**	286	454	583	769	916	1060	2
11091	119	24	41	55	76	93	111	100
11095	630	171	258	324	418	495	573	>100
11100	10±*/32**	13	21	28	37	44	51	<2
11135	147	135	217	281	375	453	533	2
11140	64*/200**	74	122	160	215	260	305	<2
11145	86	21	33	43	56	67	79	>100
11150	135	9	16	21	29	36	43	>100
11155	505	103	184	263	381	479	572	>50
11160	160	7	12	16	23	29	34	>100
11162	160	4	6	8	12	15	17	>100
11164	200	4	7	9	13	16	19	>100
11165	200	6	11	15	21	26	31	>100

* Capacity with barrel(s) partially silted in.
** Capacity with barrel(s) cleaned and unobstructed.

12. STADIUM WATERSHED

a. Location

The Stadium watershed covers 614 acres (0.96 square mile) located north of the Kansas State University main campus. It headwaters at the KSU Stadium on the south side of Kimball and extends north and east to Marlatt and Casement Road. Average slopes are approximately 5 percent. With only minor exceptions, all of the watershed lies outside of the corporate limits.

b. Land Use

Except for the area occupied by the stadium and a small portion of a residential area on the east side of Tuttle Creek Blvd., the watershed is basically undeveloped. Nearly all of the land is owned by the university and is used for agricultural research. The Comprehensive Land Use Plan indicates that the land will most likely continue to be used for this purpose in the future.

c. Existing Drainage System

The major drainage system in the Stadium watershed is divided into two branches. The first is a natural open channel that begins on the north side of Kimball, across from the stadium and runs northeast to two 60-inch pipes across Denison. From Denison, the channel continues to the northeast to Tuttle Creek Blvd. where it crosses the highway through a double 7'x 7' RCB which empties into an open channel along the south side of Marlatt Avenue, the Marlatt Ditch. At this location the main channel from the North watershed crosses Marlatt and also emties into the Marlatt Ditch.

The other branch drains a relatively small area north of the Meadowlark Hills complex and crosses Tuttle Creek Blvd. through a 6'x 5' RCB. From the highway the system continues through a residential area in a 36-inch pipe along Goodrich Dr. which discharges to an agricultural area at the east end of the street and then to the Marlatt Ditch. The ditch carries the combined flows east to Casement Road where it crosses through a double 12'x 12' RCB and eventually drains to the Blue River.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-26 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-26

EXISTING SYSTEM DESCRIPTION - STADIUM WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
12000	3	2-12'X 12' RCB across Casement Rd., south of Marlatt
12003	2/3	Marlatt Ditch, south side of Marlatt
12004	2	Channel from highway RCB to Goodrich
12005	2	36" RCP along Goodrich
12010	2	6'x 5' RCB across Tuttle Creek Blvd.
12015	2	2-7'x 7' RCB across Tuttle Creek Blvd., south of Marlatt
12017	2	Natural channel - Denison to Tuttle Creek Blvd.
12020	2	2-60" CMP across Denison south of Marlatt
12025	2/5	Natural channel to Denison

d. System Performance

The improved major system in this basin basically has more than adequate capacity for the existing peak flows. There were no reports of drainage problems in the Stadium watershed received from area residents and with little development in the basin, inadequacies in the system generally would affect few, if any, homes or businesses.

Three of the six improved reaches have capacities less than the recommended 10-year level. Improved system performance for the Stadium watershed is summarized in Table IV-27.

TABLE IV-27

EXISTING IMPROVED SYSTEM PERFORMANCE - STADIUM WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
12000	3600	1257	2080	2780	3886	4508	5259	<10
12003	2324	1250	2067	2761	3862	4484	5229	<10
12005	61	25	44	59	82	101	120	10
12010	450	21	38	52	72	89	106	>100
12015	1191	161	281	380	532	659	792	>100
12020	132	110	184	244	333	406	482	<5

13. EUREKA VALLEY WATERSHED

a. Location

The Eureka Valley watershed covers 5,651 acres (8.83 square miles) located outside of the city to the southwest. The watershed headwaters on the Ft. Riley military base, northwest of the Manhattan Municipal Airport, and is divided into two main subwatersheds, one draining to the east and one to the southeast via the Eureka Valley Tributary and highway drainage channels along K18. The watershed is generally bounded by natural ridge lines on the north and west, Highway K18 on the south, and Scenic Dr. on the east. The portion of the watershed on Ft. Riley and along the northern edge includes rolling to steep terrain with slopes ranging from approximately 5 to 30 percent. The remainder of the basin, located within the Kansas River floodplain, is extremely flat.

b. Land Use

Most of the Eureka Valley area is currently undeveloped. The largest developed land use is the municipal airport property. A small commercial-industrial development, the Murray Addition, is located along K18, just to the east of the airport. A small residential area and the Flint Hills Jobs Corps Center is located off of Eureka Valley Dr., northeast of the airport. The western one-third of the basin is part of the military base. The remainder of the area is primarily in agricultural use.

The Comprehensive Land Use Plan indicates future land use in Eureka Valley will be a combination of open space, agricultural, and industrial areas in addition to the municipal airport. Currently developed commercial and industrial areas will continue to be used for those purposes while the existing residential area and some of the adjacent agricultural land will be converted to industrial use.

c. Existing Drainage System

The existing major drainage system in the Eureka Valley watershed is essentially all open channel and cross-road culverts. The main branch of the northern subwatershed system begins in the area northwest of the intersection of the Ft. Riley perimeter road and Eureka Dr. This channel flows to the east and north, and joins a channel draining an area from the north at a local road. The combined channel continues to the northeast to the Eureka Lake area and then across Scenic Dr. through a 10'x 6' RCB. Two 36-inch pipes and a 5'x 5' box culvert route drainage across Scenic Dr. from smaller tributary areas to the north of Eureka Lake.

Drainage from the agricultural area immediately north of Eureka Dr. and east of the fort perimeter road drains to the east in roadside channels to an entrance drive culvert at the Job Corps Center. Approximately half of the residential area south of Eureka Dr. and the agricultural area east of it drain across the road in a 36-inch pipe and a 60"x 46" pipe-arch. Flows from these areas are routed to a pond behind the Job Corps Center and eventually to a 6'x 4' RCB across Scenic Dr. The remainder of the agricultural land on the south side of Eureka Dr. drains across the road and then east across Scenic Dr. through 60"x 38" elliptical pipes.

The southern subwatershed system begins on Ft. Riley property. Natural open channels carry runoff from the undeveloped areas to the west and northwest of the airport to a number of culverts across the fort perimeter road which also runs along the west edge of the airport property. In two of the smaller drainage areas immediately west of the runways, detention ponds have been constructed.

Drainage from the southwest part of the watershed flows through the airport property and northeast along K18 in a series of open channels and large culverts at the runways and terminal access roads. The various streams combine to form one main channel at

Airport Drive. The flows cross the road through a double 8'x 3' RCB, a two-cell RCB with cells of 4'x 5' and 9'x 5', and another two-cell RCB with 6'x 5' and 13'x 5' cells just north of the turnoff from K18. The combined channel runs northeast, between the highway and the frontage road adjacent to the Murray Addition, to a triple 6'x 3' RCB across the frontage road turnoff from K18. From this culvert, the open channel continues to a triple 10'x 8' RCB across K18.

Drainage from most of the area on Ft. Riley's property crosses the perimeter road at a 24'x 11' bridge and continues to the east in the Eureka Valley Tributary channel. This channel runs east and south through undeveloped and agricultural areas north of the airport to the triple box culvert under K18. Levees have been constructed along most of its length in an attempt to contain flows within the channel. A small portion of the residential area on the south side of Eureka Dr. drains into the channel through a 50"x 31" pipe-arch through the north levee. Part of the airport property and the agricultural area south of the channel drains to a small tributary which joins the main channel through a breach in the south levee at this same location. A narrow concrete bridge at the runway access road, and the girders and abutments of an old bridge near the southeast corner of the residential area are the only "structures" along this section of the channel.

A brief description of each reach in the watershed's major drainage system is presented in Table IV-28 which also includes reference to the map sheet where the reach is indicated.

TABLE IV-28

EXISTING SYSTEM DESCRIPTION - EUREKA VALLEY WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
13000	12	25'x 10' wooden bridge across UPRR
13002	12	3-10'x 8' RCB across K18
13003	12	Eureka Valley Tributary to K18 RCB
13005	12	50"x 31" CMPA, southeast of Daniel Ave & Ady Dr.
13007	12	Eureka Valley Tributary (EVT) - south of subdivision

TABLE IV-28 (cont'd)

EXISTING SYSTEM DESCRIPTION - EUREKA VALLEY WATERSHED

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
13010	12	Concrete bridge across runway access road
13012	11	EVT - runway access rd. to Ft. Riley
13015	11	24'x 11' bridge on EVT at Ft. Riley perimeter road
13020	11	Natural channel - Ft. Riley
13030	11	Natural channel - Ft. Riley
13035	11	Natural channel - Ft. Riley
13040	11	Natural channel - Ft. Riley
13053	12	Highway channel - north side of K18
13055	15	3-6'x 3' RCB across frontage rd., east end of Murray
13057	15	Highway channel - north side of K18
13060	15	4'x 5'/9'x 5' RCB across northbound Airport Drive
13063	15	6'x 5'/13'x 5' RCB, across southbound Airport Drive
13065	15	2-8'x 3' RCB across Airport Drive at frontage road
13070	15	8'x 5' RCB across terminal access road
13071	15	66" CMP across terminal access road
13072	14	2- 6'x 5' RCB @ ditch crossing
13073	14	8'x 4' RCB @ ditch crossing
13074	14	Highway channel - north side of K18
13075	14	60"x 46" CMPA across Ft. Riley east boundary road
13080	14	8'x 3' RCB across Ft. Riley east boundary road
13085	14	Channel through airport to terminal access rd. culvert
13090	14	36" CMP across Ft. Riley perimeter road
13095	14	3'x 3' RCB across Ft. Riley perimeter road
13100	11	5'x 6' RCB across Ft. Riley perimeter road
13105	12	36" CMP across K18
13106	12	36" RCP across business access drive
13107	12	60"x 38" RCPHE across Scenic Dr., north of Eureka Dr.
13108	12	60"x 38" RCPHE at Eureka Dr. & Scenic Dr.
13109	12	2-34"x 22" RCPHE across ditch crossing
13110	12	6'x 4' RCB across Scenic Dr., east of Jobs Corps lake
13112	12	36" RCP - equalizer pipe across Scenic Dr.
13115	12	36" CMP across Job Corps Center drive
13120	12	60"X 46" CMPA across Eureka Dr.
13121	12	60"X 46" CMPA @ ditch crossing
13125	12	36" CMP across Eureka Dr.
13130	12	10'x 6' at Scenic Dr.
13135	12	Natural channel to Eureka Lake
13140	12	Natural channel
13145	11	Natural channel
13150	11	Natural channel
13155	12	108" CMP across private access drive
13160	8	36" RCP across Scenic Dr.
13165	8	5'x 5' RCB across Scenic Dr.
13170	12	36" RCP across Scenic Dr.

d. System Performance

The Eureka Valley watershed has been subject to flooding and frequent drainage problems for a number of years. The Murray Addition was the subject of a drainage study completed in 1984 focusing on the minor drainage system within the development; however, apparently no improvements were made to the system as a result of the study. The extremely flat slopes in most of the area, coupled with the steep slopes of tributary areas along the west side of the watershed, create problems in construction of drainage facilities with sufficient slopes and headwater depths to handle the peak flows encountered.

The open channels in the floodplain areas generally provide a very low level of service (less than 2 years). The levees along the Eureka Valley Tributary have negligible effect on the capacity of the channel. However, the impact of the lack of capacity in much of the watershed is relatively minor due to the relatively low level of development. Water overtopping the levees along the tributary, or flowing out of the banks of the other open channels, spreads over very large, flat areas in adjacent agricultural areas to a relatively shallow depth. Much of the water also tends to pond in low areas of the fields and in locations such as Eureka Lake and the Job Corps "lake." With this unplanned detention in the system, many of the small channels and road culverts apparently function adequately.

The two detention ponds on Ft. Riley function as intended but have little impact on the downstream system because of the relatively small areas controlled by the facilities. A third detention facility planned for the area draining to the Eureka Valley Tributary would greatly reduce the peak flows in the channel.

Overall, 18 of the 38 improved reaches have less than the recommended 10-year capacity. Ten of those have capacities of 2 years or less. Improved system performance for the Eureka Valley watershed is summarized in Table IV-29.

TABLE IV-29

EXISTING IMPROVED SYSTEM PERFORMANCE - EUREKA VALLEY WATERSHED

REACH NO.	CAPACITY (C.F.S.)	PEAK FLOWS 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	EXISTING LEVEL OF SERVICE
13002	2146	1074	1981	2642	3626	4458	5337	<10
13003	260	730	1308	1798	2541	3166	3855	<2
13005	48	10	15	19	25	30	35	>100
13007	260	654	1173	1605	2258	2801	3382	<2
13010	270	678	1211	1666	2337	2899	3497	<2
13012	1100	641	1147	1573	2205	2729	3286	5
13015	1400	710	1256	1700	2355	2905	3493	<10
13053	260	411	642	820	1110	1353	1610	<2
13055	325	415	656	845	1150	1402	1672	<2
13057	260	380	624	811	1107	1353	1612	<2
13060	715	321	569	768	1064	1307	1557	10
13063	893	321	569	768	1064	1307	1557	>10
13065	393	80	115	141	177	206	235	>100
13070	397	148	260	350	486	604	722	>10
13071	236	245	399	520	700	845	1016	2
13072	595	148	260	350	486	604	722	50
13073	255	148	260	350	486	604	722	50
13074	245	73	128	172	240	301	367	25
13075	79	94	160	213	293	357	424	<2
13080	272	13	22	30	41	50	59	>100
13090	27	37	62	83	114	139	165	<2
13095	89	6	6	6	7	8	20	>100
13100	395	5	5	5	22	40	68	>100
13105	27	21	32	40	52	61	71	<5
13106	47	17	26	33	43	50	58	>25
13107	134	14	26	35	49	61	73	>100
13108	134	10	17	24	33	41	49	>100
13109	44	2	4	5	7	8	10	>100
13110	219	111	196	271	382	477	581	<10
13112	21	15	25	33	45	55	65	<5
13115	27	85	150	203	283	350	419	<2
13120	157	19	33	46	64	79	95	>100
13121	79	19	33	46	64	79	95	50
13125	53	28	44	58	77	92	108	10
13130	900	608	1076	1464	2062	2566	3093	<5
13155	467	304	519	688	943	1152	1367	<5
13160	70	16	27	36	49	60	71	100
13165	310	90	153	203	279	341	404	>25

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