SMALL COMMUNITY WATER SUPPLY AND SEWERAGE IMPROVEMENTS

by 613-8302

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INTRODUCTION

Statement of the Problem

Many small communities throughout the United States are without municipal water and sewerage facilities. Without these facilities a small town will surely die.

The country is presently experiencing a migration from urban to rural and small town living. A rural community which offers the conveniences of good water and adequate sewage disposal could profit from this trend. The lack of these services in a potential growth community is usually the result of non-communication. Numerous financial aid programs and new construction techniques and materials make it presently possible for a community to finance and construct these improvements.

Purpose of the Study

The purpose of this study was to review all existing water and sewerage facilities in the small, incorporated communities of Riley and Pottawatomie Counties in Kansas, to produce a plan for future development of these facilities and a guide for their construction. The cities of Manhattan and Wamego were excluded from this study since engineering reports on their systems are available.

Scope of the Study

A review of existing municipal water and sewerage facilities and their treatment was made. The improvements suggested were based on future population trends (1) and past experience records.

A thorough study of the soil structure within the two counties was made to determine possible construction problems. The entire study was supplemented by a review of the existing literature as a guide for properly designing the proposed systems.

MUNICIPAL WATER FACILITIES

Raw Water Availability and Quality

Five major streams, all of which are tributaries of the Kansas River, provide the natural drainage in Riley and Pottawatomie Counties. The Republican River drains the southwest corner of Riley County, and Wildcat Creek accommodates the drainage in the southeast section. The north half and entire east limits of Riley County and the west one-third of Pottawatomie County are drained by the Big Blue River. The Vermillion River collects the run-off that occurs within the central two-thirds and northeast sections of Pottawatomie County. The remainder of Pottawatomie County drains southeasterly to Cross Creek. Wildcat Creek, Big Blue River, Vermillion River and the Kansas River all lie within the two counties and normally carry adequate surface water to provide a potential source of usable water.

Tuttle Creek Lake, which is on the Big Blue River five miles north of Manhattan, forms most of the east-west boundary between Riley and Pottawatomie Counties. This lake was designed for flood control and recreational purposes, but has been considered a source of water supply (2). Other lakes in the area that could double as water supply facilities include State Lakes No. 1 and No. 2 and the proposed Onaga Reservoir. All of these are found in Pottawatomie County.

Ground water is available throughout the two-county area, as shown on the Ground Water Availability Map, Figure 1. Nearly

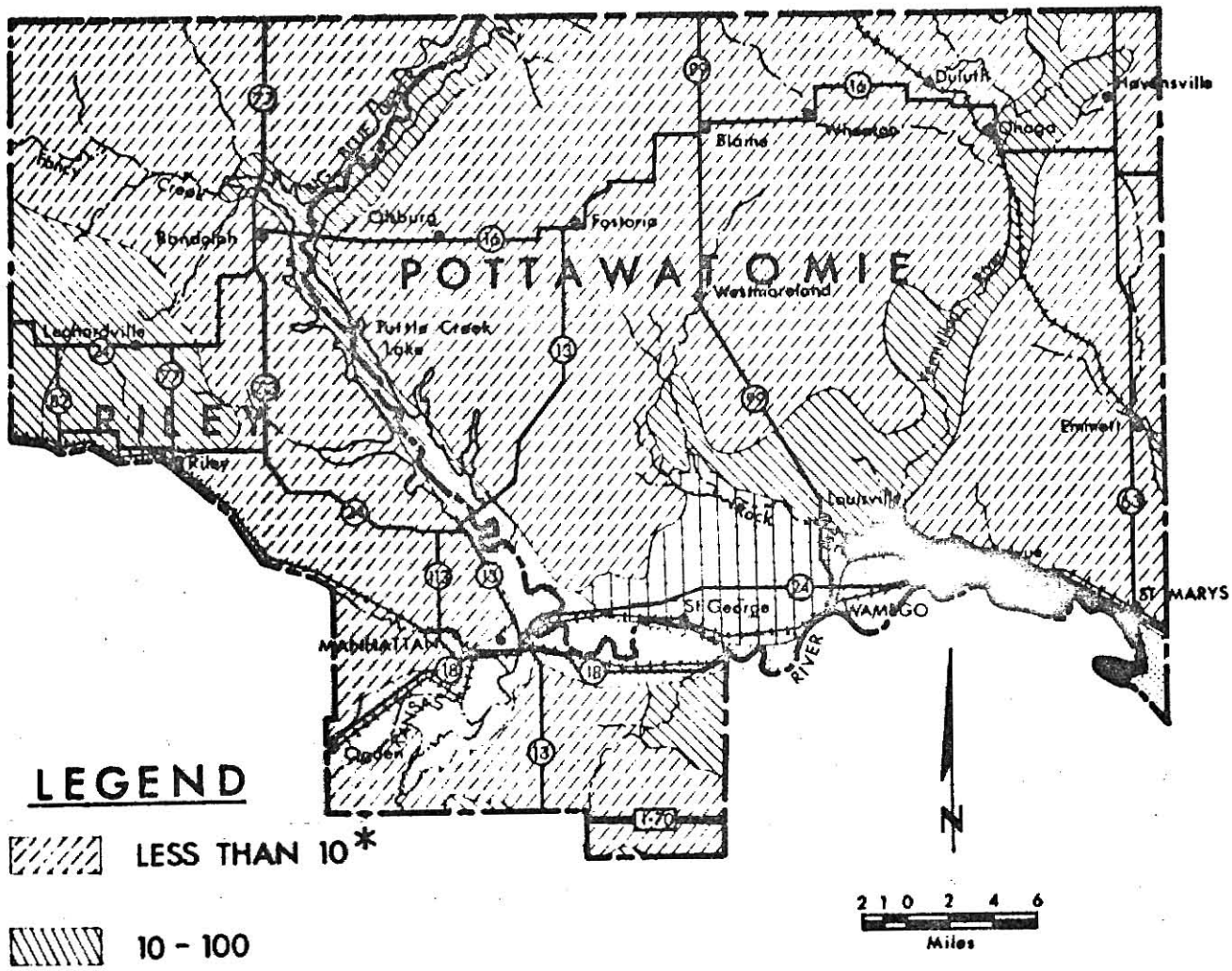
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LEGEND

- LESS THAN 10*
- 10 - 100
- 100 - 500
- 500 - 1000
- GREATER THAN 1000

* QUANTITIES OF GROUND WATER GENERALLY AVAILABLE PER WELL, IN GALLONS PER MINUTE.

Figure 1 - GROUND WATER AVAILABILITY MAP

all appreciable quantities of ground water are found in the alluvial deposits of the major streams. The Ground Water Availability Map shows the limits of the aquifers and their potential yields to properly located, drilled and equipped wells. Local variations in the geologic and hydrologic conditions may result in yields other than those indicated. It is generally 20 feet or less to water in the major stream valleys. The depth will range from 20 to 50 feet in the upland region, except in local areas where it may exceed 100 feet.

A chemical analysis of three different surface waters (3) is shown in Table 1. The data shown indicate average figures for the water year from October, 1967, to September, 1968. Surface waters are subject to wide variations in quality, depending on the season of the year. However, all surface waters in the two-county area are of a quality, such that with standard treatment methods, they could be a source of municipal water. Surface water treatment is usually very expensive, and therefore, ground water is a preferred source of domestic supply. The locations of the three ground water sampling sites are shown on Figure 2.

Ground water from ten different test wells in Riley and Pottawatomie Counties was analyzed for chemical quality (3). The results of the analyses are listed in Table 2 and the locations of the wells are shown on Figure 2. Almost all ground water found in the area contains a moderate degree of hardness and a high iron and manganese content. These are not desirable in public water supplies and can be removed by standard treatment

Stream	CFS	SiO_2	Ca	Fe	Mn	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	PO_4	B	DS	Ca Mg	NH	SAR	SC	pH	°C	SS
[1] Big Blue	2381	11	53	0	0	10	17	7.1	191	-1	36	17	.4	2.8	.40	.13	256	176	19	.6	413	7.9	--	--
[2] Vermillion	32	9	92	-.01	-.08	21	17	3.2	333	0	60	12	.4	3.7	.41	.16	390	315	48	.4	673	7.7	--	--
[3] Kansas	4050	--	66	--	--	14	66	--	207	0	78	82	--	--	--	--	423	223	53	1.8	694	--	15	236

[1] Test Location - Outlet to Tuttle Creek Lake
Drainage Area - Approximately 9,560 sq. miles

[2] Test Location - One mile upstream from Indian Creek
Drainage Area - Approximately 243 sq. miles

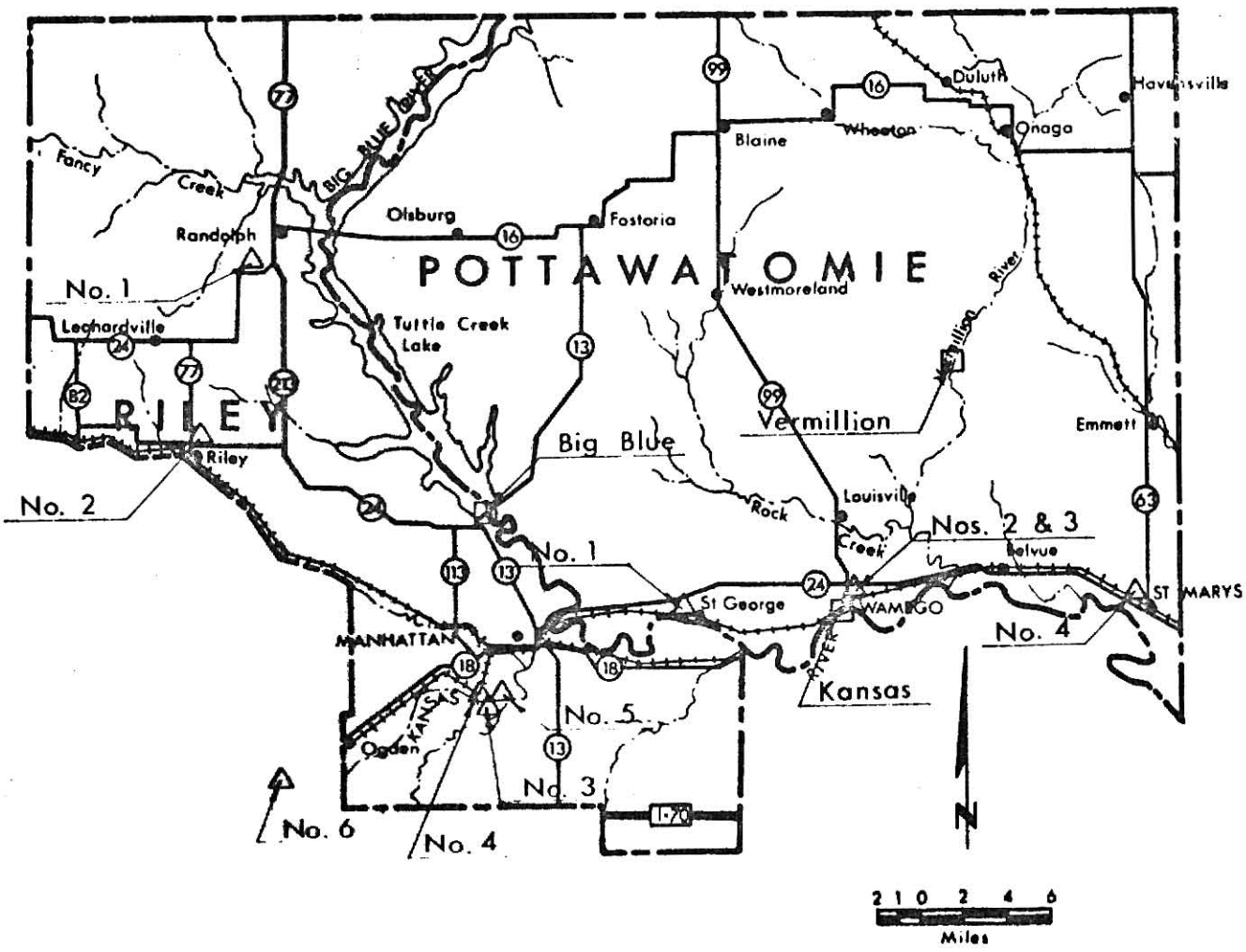
[3] Test Location - Bridge on Highway 99 at Wamego
Drainage Area - Approximately 55,240 sq. miles, of which a large area is probably non-contributing

Records Available - Chemical analyses: August 1956 to September 1958, October 1961 to September 1968
Water temperatures: August 1956 to September 1968
Sediment records: October 1957 to September 1968

Extremes - 1967-68 - Dissolved solids: Maximum, 892 mg/l Mar. 9-23; Minimum, 220 mg/l Aug. 20-22
Hardness: Maximum, 318 mg/l Jan. 1-31; Minimum, 144 mg/l Oct. 7-10, Aug. 20-22
Specific conductance: Maximum daily, 1,620 micromhos Mar. 18; Minimum daily, 123 micromhos Nov. 20
Water temperatures: Maximum, 33°C. Aug. 7; Minimum, freezing point on several days during Jan.
Sediment concentrations: Maximum daily, 5,300 mg/l Oct. 8; Minimum daily, 28 mg/l Dec. 11
Sediment loads: Maximum daily, 480,000 tons Oct. 8; Minimum daily, 68 tons Mar. 16

CFS - Discharge (cubic feet per second)
SiO_2 - Silica
Ca - Calcium
Fe - Dissolved Iron
Mn - Manganese
Mg - Magnesium
Na - Sodium
K - Potassium
HCO_3 - Bicarbonate
CO_3 - Carbonate
SO_4 - Sulfate
Cl - Chloride
F - Fluoride
NO_3 - Nitrate
PO_4 - Phosphate
B - Boron
DS - Dissolved Solids
Ca,Mg - Hardness
NH - Noncarbonate Hardness
SAR - Sodium Adsorption Ratio
SC - Specific Conductance
pH - pH
°C - Temperature
SS - Suspended Sediment

Table 1 - CHEMICAL ANALYSIS OF SURFACE WATERS



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△ GROUND WATER TEST WELLS

□ SURFACE WATER TEST SITES

Figure 2 - WATER RESOURCES TESTING LOCATIONS

Well No.	Well Depth (Ft.)	Geologic Source	Date of Collection	°C	SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	DS	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ NH	SAR	SC	pH
RILEY COUNTY[1]																						
1	85		4-22-68	--	15	1.60	.05	573	79.0	93	4.0	327	1500	100	1.1	.9	2530	1750	1490	1.0	2780	7.1
2	100		4-23-68	--	16	.01	.00	78	32.0	33	1.9	429	17	14	.1	22.0	425	326	0	.8	680	7.4
3	33	Alluvium Pleistocene Series	7-15-68	--	24	3.70	.35	96	6.9	11	8.0	283	34	15	.2	16.0	360	268	36	.3	560	7.9
4	31	Alluvium Pleistocene Series	7-15-68	--	28	1.40	.26	117	27.0	60	15.0	351	106	107	.4	4.9	658	403	115	1.3	1050	8.1
5	34	Alluvium Pleistocene Series	7-15-68	--	28	.99	1.20	120	18.0	57	10.0	349	95	85	.2	1.5	604	374	88	1.3	950	8.0
6	61	Alluvium	1- 9-68	14.4	29	4.90	--	102	20.0	76	--	350	99	78	.4	.3	606	336	49	1.8	945	7.2
POTTAWATOMIE COUNTY[2]																						
1	69	Kansan Stage	4- 9-68	--	30	.28	.00	53	4.9	16	2.8	166	12	12	.1	29.0	241	152	16	.6	370	7.4
2	78	Newman Terrace Deposit	10- 2-67	--	25	.60	.00	131	19.0	51	9.3	249	165	99	.2	1.3	624	405	201	1.1	980	7.0
3	78	Newman Terrace Deposit	3-21-68	--	30	.28	.00	115	22.0	47	9.5	224	165	88	.2	7.1	594	378	194	1.1	930	6.6
4	68	Newman Terrace Deposit	4- 8-68	--	23	.00	.00	144	24.0	39	5.9	405	88	79	.3	8.4	611	458	126	.8	1020	7.3

[1]Well No. and Location:
1. NE¼, NW¼, Sec. 28, T 7 S, R 6 E
2. NE¼, NW¼, Sec. 1, T 9 S, R 5 E
3. SE¼, SE¼, NE¼, Sec. 36, T 10 S, R 7 E
4. NW¼, NE¼, NW¼, Sec. 36, T 10 S, R 7 E
5. SE¼, SW¼, SW¼, Sec. 30, T 10 S, R 8 E
6. SW¼, SW¼, SW¼, Sec. 14, T 11 S, R 6 E

[2]Well No. and Location:
1. NE¼, SE¼, SW¼, Sec. 9, T 10 S, R 9 E
2. NW¼, SW¼, SW¼, Sec. 3, T 10 S, R 10 E
3. NW¼, SW¼, SW¼, Sec. 1, T 10 S, R 10 E
4. NW¼, SE¼, NE¼, Sec. 9, T 10 S, R 12 E

°C - Temperature
SiO_2 - Silica
Fe - Total Iron
Mn - Manganese
Ca - Calcium
Mg - Magnesium
Na - Sodium
K - Potassium
HCO_3 - Bicarbonate
SO_4 - Sulfate
Cl - Chloride
F - Fluoride
NO_3 - Nitrate
DS - Dissolved Solids (Evaporated at 180°C)
NH - Noncarbonate Hardness
SAR - Sodium Adsorption Ratio
SC - Specific Conductance (Micromhos at 25°C)
pH - pH

Table 2 - CHEMICAL ANALYSIS OF GROUNDWATER

methods. The different chemical constituents and their effects on the water are more fully explained later in the report.

Water Demand

The demand for water will vary widely, depending upon a number of factors, including city size, presence of industries, quality of water, its cost and pressure, the climate, characteristics of the population and the overall efficiency of the water distribution system. A 1965 survey (4) showed that water withdrawn for public supplies in Kansas averaged 173 gallons per capita per day (GCD). This figure included all demands such as domestic, public, commercial, industrial and system losses.

The importance of maintaining complete records of water pumpage of a city for each day cannot be overemphasized. This is the basic data required for the planning of water works improvements. The data obtained for the various cities within the planning area fluctuated greatly between the cities and also among the various data sources. However, most available statistics indicated that the usage of water within the area was below the Kansas average. This is probably due to the fact that these communities lack industries and that their economic level is low, which results in less lawn watering, car washing, etc.

Since no specific water consumption data were available and demand has been steadily increasing, all analyses and designs for water systems in the communities included in this report were based on an average annual demand of 150 GCD. The maximum

daily demand, which is the highest amount of water used per capita on the day of the year when the most water is used, was based on 200 percent of maximum daily water demands or 300 GCD. Table 3 shows the projected average and maximum daily demands for the communities within the area, based on previous population forecasts (1) for the years 1980 and 1990.

Storage of Treated Water

It is almost essential to provide for the storage of water in any type of community water system. This water is used to equalize pressure during the day and to combat any emergencies which may arise, such as a pump breakdown or power outage or to help fight fires. Unfortunately, very little in the way of criteria has been established regarding water storage requirements.

Most incorporated communities wish to protect themselves against fires. This protection, in turn, results in low fire insurance rates. The National Board of Fire Underwriters' fire demand formula (5) sets a demand rate which must be met for minimum insurance rates. Storage facilities are many times used to meet this demand.

Pumping facilities are often times not able to handle maximum hourly demands of a community. Storage facilities equalize these large demands and thus save on the design of large pumping systems otherwise used only a few hours of each day.

Storage facilities are quite often designed by some rule of thumb which may or may not reflect what a community needs.

City	1980 Pop.	1980 Average Demand	1980 Maximum Demand	1990 Pop.	1990 Average Demand	1990 Maximum Demand
Pottawatomie County						
Belvue	160	24,000	48,000	160	24,000	48,000
Emmett	170	25,500	51,000	185	27,750	55,500
Havensville	155	23,250	46,500	150	22,500	45,000
Louisville	210	31,500	63,000	220	33,000	66,000
Olsburg	160	24,000	48,000	175	26,250	52,500
Onaga	800	120,000	240,000	850	127,500	255,000
St. George	250	37,500	75,000	260	39,000	78,000
St. Marys	1,600	240,000	480,000	1,780	267,000	534,000
Wamego	2,790	418,500	837,000	3,080	462,000	924,000
Westmoreland	510	76,500	153,000	550	82,500	165,000
Wheaton	110	16,500	33,000	120	18,000	36,000
Riley County						
Leonardville	520	78,000	156,000	620	93,000	186,000
Ogden	2,600	390,000	780,000	3,000	450,000	900,000
Randolph	150	22,500	45,000	200	30,000	60,000
Riley	770	115,500	231,000	890	133,500	267,000

Table 3 - MUNICIPAL WATER DEMANDS

Storage requirements in this study were based on existing, proven facilities located in communities of the same size and having similar characteristics as those included in this study. However, it is intended that the recommended capacities be used as a general guideline rather than a firm figure.

Raw Water Treatment Requirements

All municipalities within the two-county area that have public water facilities depend on ground water for their supply. The town of Onaga is the only one which has a surface water supply, and it is used only to supplement their well sources.

Ground water is preferred over surface water due to the fact that less treatment is usually needed. With the addition of chlorine, most ground waters are made safe for human consumption. Besides disinfection, chlorination can serve other useful treatment objectives (6) as shown in Table 4.

A high degree of hardness is common in all ground water in the region. Hardness can be removed economically; however, due to the size of the towns under study, it is best accomplished by individual softening units.

Other dissolved substances found in ground water, such as iron and manganese, can be removed, but the process is more expensive. Water with high nitrate or sulfate levels are best abandoned and other sources investigated. Chlorine can remove a portion of these substances; however, sedimentation and/or filtration is also required.

Treatment Objective	Chlorine Dosage *ppm*	Contact Time *min*	ph Range	Chlorine Residual Recommended		Alkalinity Consumed as $CaCO_3$
				Type	*ppm*	
Disinfection						
Combined available chlorine residual	1.0–5.0	*		*	*	1.22 per ppm Cl_2
Free available chlorine residual	1.0–10.0				*	1.22 per ppm Cl_2
Breakpoint reaction	10 x NH_3 (as N) content	30+	6.5–8.5 (7.5 optimum)	*	*	1.22 per ppm Cl_2
Ammonia Removal						
Monochloramine formation	5 x NH_3 (as N) content	20+	>8.5	free	0.1	1.22 per ppm Cl_2
Dichloramine formation	10 x NH_3 (as N) content	20+	4.4–5.0	free	0.1	
Taste and Odor Control	10 x NH_3 (as N) content plus 1–5 ppm	20+		free	1.0	1.22 per ppm Cl_2
Phenol destruction (up to 200 ppm)	6–20 x phenol content	1.5–5 hr (stepwise)	7.0	free	variable	
Hydrogen Sulfide Removal						
Oxidation to sulfur	2.2 x H_2S content	instantaneous	5.0–9.0 (5 optimum)	free or combined	0.1	2.6 per ppm H_2S
Oxidation to sulfate	8.5 x H_2S content	instantaneous	6.5–9.0 (9 optimum)	free or combined		10 per ppm H_2S
Manganese Removal						
Oxidation to *ic* form	1.3 x Mn content	up to 3 hr (variable)	7.0–10.0 (10 optimum)	free	0.5	3.4 per ppm Mn oxidized
Iron Removal						
Oxidation to *ic* form	0.64 x Fe content	instantaneous	4.0–10.0 (>7.7 optimum)	free or combined	0.1	0.9 per ppm Fe oxidized
Red Water Prevention	maintain free residual in dead ends	variable		free	0.1	
Color Removal	1.0–10.0	15		free or combined	0.1	
Algae Control	1.0–10.0	variable		free	0.5+	
Slime Control	1.0–10.0	maintain residual throughout distribution system		free	0.5+	
Fe & S Bacteria Control	1.0–10.0	maintain residual throughout distribution system		free	1.0+	
Aid to Coagulation						
Chlorination of Copperas	1 part per 7.8 parts $FeSO_4 \cdot 7\ H_2O$					
Activated silica	1.42 lb/gal 41° Baumé sodium silicate					
Chlorine Dioxide Preparation						
Chlorination of sodium chlorite	equal parts (in practice), at pH 4 or less					

* As needed, or required by local authority.

Table 4 - CHLORINE TREATMENT DOSAGE REQUIREMENTS

Surface waters in the region are variable in quality and highly turbid. All waters would require screening, coagulation, sedimentation, filtration and chlorination. Most waters would also require presedimentation and sometimes softening, depending on the final quality desired.

Table 5 shows the various effects of conventional treatment plant operations on common attributes of raw water (6).

Wells were recommended for communities that need new or additional water supplies. Wells designed for public water supplies must comply with regulations set forth by the Kansas State Department of Health (7). Chlorination is the minimum treatment allowable for wells possessing good quality water.

Due to relatively small well yields required by the communities, only basic chlorination equipment was needed. The equipment consisted of a diaphragm pump and chlorine solution tank placed in a building set over the well discharge line. The pump is installed to operate only when the wells are operating.

Tne selection of the proper chlorination unit is based on raw water discharge pressure and amount of flow. The units have adjustable flow rates, which allow the operator to maintain a chlorine residual, usually between 0.3 and 1.0 ppm. This adjustment is desirable since various substances found in ground water, such as iron and manganese, will vary in concentration, making exact chlorine requirements difficult to determine.

* The relative degree of effectiveness of each unit operation or process is indicated by the number of plus signs (+) up to a limit of four; adverse effects are shown by minus signs (—) also to degree; and indirect effects are recorded by parentheses placed around the signs. Limitations and other factors are explained in the number references below.

Attribute	Aeration	(a) Coagulation and Sedimentation	Lime-Soda Softening and Sedimentation	Slow Sand Filtration Without (a)	Rapid Sand Filtration Preceded by (a)	Disinfection (Chlorination)
Bacteria	0	++	(+++)[1,2]	++++	++++	++++
Color	0	+++	0	++	++++	0
Turbidity	0	+++	(++)[2]	++++[3]	++++	0
Odor and taste	++[4]	(+)	(++)[2]	++	(++)	++++[5] —[6]
Hardness	+	(—)[7]	++++	0	(—)[7]	0
Corrosiveness	+++[8] —[9]	(—)[10]	[11]	0	(—)[10]	0
Iron and manganese	+++	+[12]	(++)	++++[12]	++++[12]	0

1. When very high pH values are produced by excess lime treatment
2. By inclusion in precipitates
3. But filters clog too rapidly at high turbidities
4. Not including chlorophenol tastes
5. When break-point chlorination is employed or superchlorination is followed by dechlorination
6. When (5) is not employed in the presence of intense odors and tastes
7. Some coagulants convert carbonates into sulfates
8. By removal of carbon dioxide
9. By addition of oxygen when it is low
10. Some coagulants release carbon dioxide
11. Variable, some metals are attacked at high pH values
12. After aeration.

Table 5 - TREATMENT EFFECTS ON RAW WATER ATTRIBUTES

Quality of Existing Municipal Water Supplies

To assist in making an analysis of the quality of public water available, water standards of the Kansas State Department of Health (8) were compared to the existing public supplies. These are shown in Table 6. The desirable range of impurities is, in general, that quantity of solids, chemicals or conditions which is less than the maximum number shown. The undesirable range is not necessarily harmful; however, it does not provide a desirable quality water. The significance of these chemicals, solids and conditions are listed below.

Specific Conductance: The specific conductance is a measure of the water's ability to conduct an electric current and is, therefore, an indication of the ionic strength, or mineralization of the solution. Specific conductance multiplied by a factor which varies from about 0.55 to 0.75 will give an estimate of total dissolved mineral matter. The magnitude of the factor depends on the type of minerals in the water.

Turbidity: Turbidity is a measure of the cloudiness of water and is expressed in standard units of turbidity based on the Jackson instrument. It is caused by suspended matter such as silt, organic matter, precipitated iron, etc. The drinking water standards recommend that turbidity be less than five units.

Total Dissolved Solids: The total dissolved solids is a measure in weight (mg/l) of the mineral content dissolved in the water. This figure multiplied by 8.34 gives pounds of mineral matter per million gallons of water. The United States Public

	Date	SC	Tu	TS	SiO_2	Fe	Mn	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	NO_3	F	Hardness Total	Hardness NH	TA	Total PO_4	B
Standards																							
Desirable			-5	-500		-0.3	-0.05			-125					-250	-250	-90	-1.0	-400				-1.0
Undesirable			5+	1000+		0.3+	0.05+			125+					250+	250+	90+	1.5+	400+				1.0+
Riley Co.																							
Leonardville	7-70	940	-1	624	16	0.02	0.00	7.2	112	49	36	1.8	0.0	422	157	20	24.0	0.4	481	135	346	0.12	---
Ogden	8-70	1070	+1	716	22	0.03	0.00	7.1	173	71	32	4.4	0.0	481	184	29	2.9	0.2	559	169	394	0.48	---
Randolph	2-68	1180	+1	778	13	0.18	0.00	7.7	178	84	56	1.5	0.0	405	240	56	8.0	0.3	551	219	332	0.15	---
Riley	2-69	690	-1	407	16	0.02	0.00	7.5	77	32	10	1.2	0.0	434	7	10	20.0	0.1	324	0	356	0.20	---
Pottawatomie Co.																							
Belvue	5-70	760	-1	480	23	0.13	0.00	7.6	123	17	28	4.1	0.0	429	55	20	0.4	0.1	377	25	352	0.24	---
Emmett	2-70	1030	-1	648	13	0.07	0.02	7.3	138	41	36	1.3	0.0	468	97	62	29.0	0.1	513	129	384	0.09	---
Havensville	4-70	760	-1	486	12	0.05	0.03	7.3	110	32	16	1.7	0.0	351	116	19	8.0	0.2	406	118	288	0.10	---
Olsburg	8-70	760	-1	445	14	0.03	0.00	7.2	104	25	29	1.8	0.0	449	16	18	16.0	0.1	362	0	368	0.16	---
Onaga	1-70	790	-1	492	7	0.02	0.00	8.0	115	34	20	3.3	0.0	429	76	22	3.3	0.2	426	74	352	0.04	---
St. George	3-70	390	-1	251	34	0.08	0.00	7.2	56	5	16	2.0	0.0	168	12	11	32.0	0.1	160	22	138	0.30	---
St. Marys	3-70	1010	-1	624	28	0.04	0.00	7.2	139	29	39	5.0	0.0	417	77	77	24.0	0.2	466	124	342	0.54	---
Wamego	2-69	860	-1	562	32	0.15	0.00	6.9	115	14	46	8.2	0.0	224	156	77	3.5	0.2	344	160	184	0.34	---
Westmoreland	2-69	640	-1	406	6	0.11	0.00	7.5	101	21	18	2.2	0.0	337	62	18	9.7	0.1	338	62	276	0.30	---

Date - Date of Collection
SC - Specific Conductance
Tu - Turbidity
TS - Total Solids
SiO_2 - Silica
Fe - Iron
Mn - Manganese
pH - pH
Ca - Calcium
Mg - Magnesium
Na - Sodium
K - Potassium
CO_3 - Carbonate
HCO_3 - Bicarbonate
SO_4 - Sulfate
Cl - Chloride
NO_3 - Nitrate
F - Fluoride
Hardness - Expressed as Calcium Carbonate
NH - Noncarbonate Hardness
TA - Total Alkalinity
PO_4 - Phosphate
B - Boron

Table 6 - CHEMICAL ANALYSIS OF PUBLIC WATER SUPPLIES

Health Service Drinking Water Standards recommend less than 500 mg/l total solids for drinking or culinary uses. If such water is not available, 1,000 mg/l will be considered satisfactory.

Silica: Silica is not physiologically significant to humans, livestock or in irrigation waters. However, it forms a hard scale at high temperatures and is undesirable in boiler feed water.

Iron and Manganese: Iron and manganese have little significance physiologically, but they are undesirable in a public water supply because both will produce staining of laundered fabrics and porcelain plumbing fixtures and create consumer complaint. If present in an appreciable amount, iron gives the water a rusty appearance and an unpleasant taste. Both substances create problems in the chlorination of water. The United States Public Health Service drinking water standards recommend that iron be less than 0.3 mg/l and manganese less than 0.05 mg/l. Iron and manganese can be readily removed by treatment, particularly if lime-soda softening is also being practiced.

pH: pH is a measure of the effective hydrogen ion concentration. Technically, it is defined as the logarithm of the reciprocal of the hydrogen ion concentration. A pH of 7 is considered neutral and values less than 7 are acidic and greater than 7 basic. Most natural untreated waters are slightly basic and pH values less than about 8.2 usually indicate the presence of free carbon dioxide.

Calcium: Calcium is present in water as the Ca^{++} ion and is a hardness constituent. When the water is heated, calcium may precipitate as calcium carbonate or calcium sulface and produce scaling in hot water heaters and boilers. It is derived principally from the dissolving action of water on limestone, $CaCO_3$, and gypsum, $CaSO_4$. It can be removed in the softening process.

Magnesium: Magnesium is present in water as the Mg^{++} ion and is a hardness constituent. When present in large amounts (greater than 125 mg/l), magnesium may exert a cathartic effect on people not accustomed to it, particularly if sulfate is also present in large amounts.

Sodium: Sodium is present in water as the Na^{+} ion but it is not a hardness constituent. In fact, the base exchange or zeolite process of softening increases the sodium content of the water. It is not particularly significant physiologically except to those persons having an abnormal sodium metabolism and who are thus on a sodium restricted diet. It is important in irrigation waters because a high sodium to calcium-magnesium ratio tends to decrease the permeability of the soil and thus will have a harmful effect on soil structure.

Potassium: Potassium is present in water as the K^{++} ion. In the amount normally found in natural waters, this substance is not considered to be of significance to humans. It is important to fish and other aquatic life.

Carbonate and Bicarbonate: Carbonate and bicarbonate are present in water as the ions CO_3^{--} and HCO_3^{-} and are the alkaline

substances or alkalinity of the water. When expressed as $CaCO_3$, they are termed alkalinity. Bicarbonate usually constitutes the entire alkalinity of natural waters although carbonate at times may be present in a significant amount, particularly in treated waters. Alkalinity may add some taste to water but otherwise it has little significance to humans. It is removed or altered in the lime-soda ash softening process.

Sulfate: Sulfate is present in water as the SO_4^{--} ion and is of considerable importance to users. It is one of the principal mineralizing characteristics of water in Kansas, and if present in a large amount, it will impart a bitter taste to the water and it may act as a laxative to people who are not accustomed to drinking the water. Sulfate is derived principally from the dissolving action of water on gypsum. Thus, when sulfate is high, calcium is usually high also. The drinking water standards recommend that sulfate be less than 250 mg/l. Sulfate cannot be removed economically.

Chloride: Chloride is present in water as the Cl^- ion and is also one of the principal mineralizing substances present in water in Kansas. It is derived principally by the dissolving action of water on beds of sodium chloride. Occasionally, pollution of fresh water may occur from high chloride waters such as oil field brines. When present in a sufficient amount, chloride imparts a salty taste to the water but otherwise has little or no physiological significance when present in concentrations not offensive to taste. The drinking water standards

recommend that chloride be less than 250 mg/l. Chloride cannot be removed economically.

Nitrate: Nitrate is present in water as the NO_3^- ion. It is probably derived principally by pollution of the aquifer (in well water) with water which has leached decomposed organic matter in the soil. The concentration of nitrate varies widely in Kansas well waters. Only small amounts are present in Kansas surface waters. Nitrate is important in drinking water because high concentrations may produce cyanosis or methemoglobinemia in infants. Adults and older children are not affected. A recommended limit for infant feeding of 90 mg/l as NO_3 is used for public water supplies in Kansas. Nitrate is also important in water to be used for livestock because excessive amounts may be harmful, particularly to young animals. Nitrate cannot be removed economically.

Flouride: Flouride is present in water as the F^- ion. It is derived naturally by the dissolving action of water on fluoride-bearing minerals in the earth. It is added to many public water supplies to provide an optimum concentration of fluoride. It is important in drinking water because in high concentration it may produce a mottling or discoloration of the tooth enamel of children and in low concentration it does not afford sufficient protection for the prevention of dental caries in children. A concentration of 1.0 mg/l F^- is considered optimum for public water supplies in Kansas and a concentration of 1.5 mg/l F^- is the recommended limit. While there are no fluoride removal facilities in Kansas, this substance can be removed on plant scale.

Hardness and Alkalinity: Hardness in water is caused by the Ca^{++} ion and the Mg^{++} ion. The sum of the two, both expressed as $CaCO_3$, is termed the total hardness. The types of hardness are dependent on the alkalinity. If the total hardness is greater than the total alkalinity (both expressed as $CaCO_3$), the amount of hardness equivalent to the alkalinity is termed carbonate hardness and the amount of hardness in excess is termed non-carbonate hardness. If the total hardness is less than the total alkalinity, all of the hardness is carbonate hardness and there is an excess alkalinity. Hardness can be removed by the base-exchange method of softening and both hardness and alkalinity can be reduced to desirable levels by the lime-soda ash method of softening. A total hardness above 400 mg/l as $CaCO_3$ is considered excessive for public water supplies in Kansas.

Phosphate: In the analysis, all forms of phosphate are converted to the ortho form and are determined and expressed as PO_4^{---}. Included would be the polyphosphates used in treatment of water. In the concentrations normally found in water, phosphate has little physiological significance but it does stimulate the growth of algae and thus may cause water treatment problems.

Boron: Boron is reported as the element B because the form or forms in which it exists in water are not known with certainty. In the concentrations normally found, boron is not considered to be of significance to humans. It is important in irrigation waters, however, because at concentrations above 1 mg/l it may have a harmful effect on certain plants.

Municipal Water Facilities Improvements

Twelve of the fourteen communities maintained municipal water supplies. In these cities the existing system, future population and previously predicted growth areas (1) were studied in order to obtain a possible solution to any water supply problems that may be encountered through the year 1990. An attempt was also made to estimate the cost of financing immediate needs, which were those projected to occur prior to 1981.

Louisville and Wheaton were the only cities which did not have a municipal water system. In these two cities, a water supply system was designed to serve the existing residences and any anticipated growth through the planning period. The recommendations contained herein are not to be construed as the only possible solutions, but are intended only as general guides. Detailed engineering studies must be conducted when any improvement is being considered. The cost analyses were based on average current construction costs and will vary depending on the contractor and the size and location of the work. The overhead costs included expenditures for engineering, legal fees, abstract fees, land purchases and contingencies.

Following is a detailed discussion of existing and proposed water systems and financial conditions of the various communities.

Leonardville

Existing

The water supply of Leonardville was installed in 1969 and presently serves a population of 412 through 170 meters. The

minimum monthly water rate is $1.50 for 2,000 gallons. The system is supplied with water from four deep wells located southwest of town. The wells are currently producing an average of 20,000 gallons per day, and have the capability of delivering up to 250,000 gallons per day. A 50,000 gallon elevated storage tank is located on the system.

The water is chlorinated at the well heads. It is fairly hard and has a total dissolved solids count which is moderately high but overall, it is typical of the ground water found within the region.

Future

The rated well capacities are far above that needed for future supply within the planning period. The city could possibly consider providing water to rural areas, which would also bring in additional revenues.

The only need for the system was the addition of the proposed lines serving the projected developments. Care must be taken in sizing these lines so as not to impede any future development. The quality of the water is adequate and needs no further treatment.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	4" C.I.P.	2,250	L.F.	$ 5.00	$11,250.00
2.	2" C.I.P.	1,080	L.F.	4.00	4,320.00
3.	Valves	5	Each	225.00	1,125.00

	Description	Quantity	Unit	Unit Price	Total
4.	Fittings			Lump Sum	1,500.00
5.	Fire Hydrants	5	Each	350.00	1,750.00
	Total Estimated Construction Cost				$19,945.00
	Overhead Costs				5,055.00
Total Costs					$25,000.00

City Financial Condition

1970 Population	412
1970 Assessed Valuation	$615,660.00
General Obligation Bond Capacity	$153,915.00
General Obligation Bonds Outstanding	$ 59,000.00
Available General Obligation Bond Capacity for Improvements	$121,915.00
Revenue Bonds Outstanding	$ 2,000.00
No Fund Warrants	$ 5,400.00

Ogden

Existing

The water supply system of Ogden was installed in 1949 and is presently serving an estimated population of 2,311. The system is supplied with water from three shallow wells located in the central section of the city. The last well was placed in operation in 1968 and is capable of producing 700 GPM. The other two wells have a combined rating of 275 GPM. A 100,000 gallon elevated storage tank is located on the system in the north part of town.

The water is chlorinated at the well heads. The quality of the water is typical of that found in the region, being hard and having a high total dissolved solids content.

Future

The city has sufficient water to meet all demands forecasted within the planning period and the quality is such that no additional treatment was needed.

It is recommended that the city take care in sizing the proposed lines serving the projected growth areas. This will prevent parallel lines from occurring, which is now the case. With very little added cost, much reserve capacity can be built into the lines.

Looping of existing lines should also be done when possible. This will eliminate points of stagnation, equalize pressure and eliminate sedimentation on dead ends.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	6" C.I.P.	3,330	L.F.	$ 6.00	$19,980.00
2.	4" C.I.P.	6,820	L.F.	5.00	34,100.00
3.	2" C.I.P.	1,600	L.F.	4.00	6,400.00
4.	Valves	20	Each	250.00	5,000.00
5.	Fire Hydrants	15	Each	350.00	5,250.00
6.	Highway Crossing	1	Each	400.00	400.00
7.	Railroad Crossings	2	Each	400.00	800.00

Total Estimated Construction Cost	$71,930.00
Overhead Costs	19,070.00
Total Costs	$91,000.00

City Financial Condition

1970 Population	2,311
1970 Assessed Valuation	$991,436.00
General Obligation Bond Capacity	$247,859.00
General Obligation Bonds Outstanding	$ 91,000.00
Available General Obligation Bond Capacity for Improvements	$192,859.00

Randolph

Existing

The water supply of Randolph is presently serving a population of 106 through over 40 meters. The minimum monthly water rate is $2.00 for 2,000 gallons. The system is supplied with water from two wells located southwest of town. The first, which is rated at 40 GPM, was placed in service in 1961. The second well was drilled in 1967, serves only as a standby, and is rated at 15 GPM. A 50,000 gallon standpipe is located on the system.

The water is chlorinated at the well heads before being pumped to the system. The water from both wells is very undesirable because of a high content of total dissolved solids, sulfur and hardness. The second well also contains an excess amount of iron and manganese.

Future

The quantity of water available at this time should be sufficient to supply all needs during the planning period. Since water is not readily available in the area, it was felt that the existing water supply should be treated to provide a quality of water superior to that which is presently used. It was, therefore, recommended that the city retain an engineer to study the water quality and make recommendations regarding the best treatment method available.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	4" C.I.P.	850	L.F.	$ 5.00	$4,250.00
2.	Valves	3	Each	225.00	675.00
3.	Fittings			Lump Sum	200.00
4.	Fire Hydrants	4	Each	350.00	1,400.00
	Total Estimated Construction Cost				$6,525.00
	Overhead Costs				1,475.00
Total Costs					$8,000.00*

*Does not include treatment costs.

City Financial Condition

1970 Population	106
1970 Assessed Valuation	$132,183.00
General Obligation Bond Capacity	$ 33,045.00
Available General Obligation Bond Capacity for Improvements	$ 33,045.00

Riley

Existing

The water supply system of Riley was installed in 1956 and is presently serving a population of 668 people through 293 meters. The minimum monthly water rate is $2.50 for 2,000 gallons. The system was originally supplied with water from four deep wells, each rated at 35 GPM. One well is located in the northwest corner of town, another in the north central section, and the last two are north of town. A new well, capable of producing 70 GPM, is located near the existing well in the northwest corner of town. The five wells are currently producing an average of 50,000 gallons per day but have the capability of delivering over 300,000 gallons per day. A 50,000 gallon elevated storage tank is located on the system.

The water is chlorinated at the well heads and is above average in quality as compared to most ground water found in the region.

Future

The existing wells will serve the projected demands within the planning period. The only need for the system was the addition of the proposed lines serving the projected developments. The quality of the water is good and needs no further treatment.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	6" C.I.P.	850	L.F.	$ 6.00	$ 5,100.00

	Description	Quantity	Unit	Unit Price	Total
2.	4" C.I.P.	6,900	L.F.	5.00	34,500.00
3.	Valves	8	Each	250.00	2,000.00
4.	Fittings			Lump Sum	2,500.00
5.	Fire Hydrants	20	Each	350.00	7,000.00
6.	Highway Crossing	1	Each	400.00	400.00
	Total Estimated Construction Cost				$51,500.00
	Overhead Costs				12,500.00
Total Costs					$64,000.00

City Financial Condition

1970 Population	668
1970 Assessed Valuation	$908,589.00
General Obligation Bond Capacity	$227,147.00
Temporary Notes Outstanding	$ 42,500.00
Available General Obligation Bond Capacity for Improvements	$184,647.00
Revenue Bonds Outstanding	$130,000.00

Belvue

Existing

The water supply of Belvue was installed in 1962 and is presently serving a population of 161. The system is supplied with water from one shallow well located in the north part of town. The treatment plant and well are both rated at 30,000 gallons per day and are currently producing an average of 10,000 gallons. Storage consists of a four foot diameter by

80 foot standpipe with a capacity of 7,500 gallons and a clear well located adjacent to the treatment plant with a 19,000 gallon capacity.

The water is chlorinated and treated for iron and manganese. Iron and manganese removal is accomplished with contact beds, sedimentation and sand filters. A relatively high iron and manganese content still remains after the removal process, but otherwise the supply is acceptable.

Future

The present system is adequately serving the city; however, should something happen to the present well pump, the city could be without water for an extended period. It was therefore recommended that a second well pump be purchased and used for emergencies.

Cost Estimate for Immediate Needs

One Well Pump	$ 700.00

City Financial Condition

1970 Population	161
1970 Assessed Valuation	$175,611.00
General Obligation Bond Capacity	$ 43,903.00
Available General Obligation Bond Capacity for Improvements	$ 43,903.00

Emmett

Existing

The water supply system in Emmett was installed in 1957 and is presently serving a population of 156. The minimum monthly water rate is $3.00 for 2,000 gallons. The system was originally supplied with water from one shallow, 20 GPM well; however, in 1968 an additional 20 GPM well was installed. These wells are currently producing an average of 10,000 gallons per day. A 40,000 gallon elevated storage tank is located on the system in the northwest part of town.

The water is chlorinated at the well heads and a high hardness and total dissolved solids content exist in the present supply.

Future

The existing system should be adequate to serve all needs during the planning period, with the exception of additional lines to serve the projected growth.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	4" C.I.P.	2,300	L.F.	$ 5.00	$11,500.00
2.	Valves	3	Each	225.00	675.00
3.	Fittings			Lump Sum	500.00
4.	Fire Hydrants	3	Each	350.00	1,050.00
5.	Railroad Crossing	1	Each	400.00	400.00
	Total Estimated Construction Cost				$14,125.00

Overhead Costs	$ 3,875.00
Total Costs	$18,000.00

City Financial Condition

1970 Population	156
1970 Assessed Valuation	$147,038.00
General Obligation Bond Capacity	$ 36,759.00
Available General Obligation Bond Capacity for Improvements	$ 36,759.00
Revenue Bonds Outstanding	$104,000.00

Havensville

Existing

The water supply of Havensville was installed in 1938 and is presently serving an estimated population of 163. The system is supplied with water from one shallow well located south of town. The well is rated at over 75 gallons per minute, and is currently producing 20,000 gallons per day. A second pump is stored at the well site for use during emergencies. A 20,000 gallon elevated storage tank is located on the system in the north part of town.

The water is chlorinated at the well head. The quality of the water is generally good and is typical of the ground water found within the region.

Future

The rated well capacity is far above that needed for future supply within the planning period. Since the population was

expected to stabilize or slightly decline in Havensville, the city should consider the possibility of selling water to individuals located outside the town or to a rural water district.

Cost Estimate for Immediate Needs

None.

City Financial Condition

1970 Population	163
1970 Assessed Valuation	$151,443.00
General Obligation Bond Capacity	$ 37,860.00
Available General Obligation Bond Capacity for Improvements	$ 37,860.00

Louisville

Existing

Louisville does not have an existing public water supply system. Most residences in the town maintain individual well supplies.

Future

Louisville is located in an area which has an abundance of ground water. The aquifers in the area are capable of supplying a well with as much as 500 gallons per minute. It was recommended that two wells be installed, either of which would be capable of pumping the water required for the maximum day. A 60,000 gallon standpipe, located in the central section of town, should provide adequate storage. All water lines should be four inch or larger in order to provide a system which will allow for future

expansion and one which provides adequate fire protection. The quality of the water in the immediate area has a high iron and manganese content; however, it is possible that a sufficient supply of good quality water could be found.

A more economical solution to an expensive well exploration program would be for the City to obtain water from a rural water district. The connection costs would probably not exceed the well cost included in the estimate below.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	6" C.I.P.	1,950	L.F.	$ 6.00	$ 11,700.00
2.	4" C.I.P.	12,700	L.F.	5.00	63,500.00
3.	Valves	26	Each	225.00	5,850.00
4.	Fittings			Lump Sum	5,000.00
5.	Fire Hydrants	25	Each	350.00	8,750.00
6.	Wells	2	Each	6,000.00	12,000.00
7.	Storage Facilities			Lump Sum	17,000.00
8.	Highway Crossings	2	Each	400.00	800.00
	Total Estimated Construction Cost				$124,600.00
	Overhead Costs				30,400.00
Total Costs					$155,000.00

City Financial Condition

1970 Population	204
1970 Assessed Valuation	$105,120.00

General Obligation Bond Capacity . . . . . $ 26,280.00

Available General Obligation Bond Capacity for Improvements . . . . . $ 26,280.00

Olsburg

Existing

The water supply system of Olsburg was installed in 1957 and is presently serving 151 people. Water is supplied to the system from two shallow wells. One well is located in the central part of town, and the other is located about one-half mile south of town. The two wells have a combined rating of 40,000 gallons per day. A third well, located about one-quarter mile northwest of town, is currently under construction. The well is designed to yield 40 GPM. An existing standpipe, located in the central part of town, provides a storage capacity of approximately 40,000 gallons.

The quality of the water is generally good, and it receives no treatment other than chlorination.

Future

The existing water lines in Olsburg are small as compared to most lines found in other cities. It was not recommended that this practice continue, since it will impede future growth or cause parallel lines to be constructed. The major cost in installing a water line is not the cost of the pipe but rather the cost of laying the pipe. Therefore, with very little added cost, much reserve capacity may be obtained. It was also suggested that the new line from the future well be located in such

a manner that it can be utilized by lines serving projected growth areas.

If at all possible, dead end lines should be prevented and existing ones extended and looped.

With the addition of the third well, the city should have an abundance of water and could possibly consider selling some to rural users. No additional sources of water should be required within the planning period and the quality of the water is adequate without further treatment.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	4" C.I.P.	2,650	L.F.	$ 5.00	$13,325.00
2.	Valves	5	Each	250.00	1,250.00
3.	Fittings			Lump Sum	1,000.00
4.	Fire Hydrants	4	Each	350.00	1,400.00
	Total Estimated Construction Cost				$16,975.00
	Overhead Costs				4,025.00
Total Costs					$21,000.00

City Financial Condition

1970 Population	151
1970 Assessed Valuation	$168,249.00
General Obligation Bond Capacity	$ 42,062.00
General Obligation Bonds Outstanding	$ 6,000.00
Available General Obligation Bond Capacity for Improvements	$ 36,062.00

Onaga

Existing

The water supply system of Onaga was installed in 1935 and the treatment plant in 1955. It is presently serving 761 people through 350 meters. The plant has a capacity of 140,000 gallons per day and is currently producing 72,000 gallons. The system is supplied with water from three shallow wells and one river source. Two wells are located north of Highway 16, and the other is south. All are rated at 60 GPM. The river source is the Vermillion River which can supply the system with 100 GPM. A 90,000 gallon storage tank is located in the north part of town.

All water supplied to the system first undergoes a purification and iron removal process. The process steps include contact bed aeration, calcium and lime addition, chlorination, mixing, sedimentation, sand filtration and final chlorination. The overall quality of the treated water is good.

Future

The various water supply sources are capable of producing ample water for the city during the planning period. The water treatment plant, however, does not have the capacity to meet the forecasted minimum daily demands in 1980. It was, therefore, recommended that the city select an engineer to study the possibility of expanding the treatment plant facilities in the early 1980's. The only other need of the system was the addition of new lines to serve the projected growth areas.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	4" C.I.P.	2,550	L.F.	$ 5.00	$12,750.00
2.	Valves	4	Each	250.00	1,000.00
3.	Fittings			Lump Sum	1,000.00
4.	Fire Hydrants	7	Each	350.00	2,450.00
	Total Estimated Construction Cost				$17,200.00
	Overhead Costs				4,300.00
Total Costs					$21,500.00

City Financial Condition

1970 Population	761
1970 Assessed Valuation	$975,695.00
General Obligation Bond Capacity	$243,923.00
General Obligation Bonds Outstanding	$ 84,000.00
Available General Obligation Bond Capacity for Improvements	$193,923.00

St. George

Existing

Very little is on record concerning the water supply system at St. George. The system is relatively new and consists of a cast iron distribution system with a well and standpipe located in the north central section of town.

Water from the well receives only chlorine treatment, and the quality is very good as compared to most ground water found in the region.

Future

St. George was expected to have only slight growth within the planning period. Such growth was expected to be a fill-in process which will require no additional lines. The present supply and storage should be adequate to serve the future needs. It was recommended, however, that if the existing well has only one pump, that a second pump be purchased in case the first pump fails.

Cost Estimate for Immediate Needs

None.

City Financial Condition

1970 Population	241
1970 Assessed Valuation	$163,282.00
General Obligation Bond Capacity	$ 40,820.00
General Obligation Bonds Outstanding	$ 26,000.00
Available General Obligation Bond Capacity for Improvements	$ 14,820.00

St. Marys

Existing

The original water supply system in St. Marys was installed around 1910. The source of water supply then was three wells located in the southwest section of town. These three wells are still in use, in addition to another well which was drilled nearby in 1954. These four wells are each rated at 200 GPM. A fifth well was installed in the south central part of town in

1965. This well is rated at 350 GPM. Storage consists of a 72,000 gallon elevated storage tank located in the north part of town. Additional storage of 72,000 gallons can be provided with the use of an existing storage tank located on the old St. Marys' seminary campus.

The system presently serves a population of 1,434 through 500 meters. The minimum monthly water rate is $2.00 for 3,000 gallons.

The water from all five wells is chlorinated at the well heads. The quality of the water is fair and is typical of the ground water found in the Kansas River Valley.

Future

The capacity of the wells is more than adequate to handle the future water needs of the city. Additional lines to serve the projected growth areas appeared to be the only need of the system.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	6" C.I.P.	1,550	L.F.	$ 6.00	$ 9,300.00
2.	4" C.I.P.	7,800	L.F.	5.00	39,000.00
3.	Valves	15	Each	250.00	3,750.00
4.	Fittings			Lump Sum	3,000.00
5.	Fire Hydrants	16	Each	350.00	5,600.00
	Total Estimated Construction Cost				$60,650.00
	Overhead Costs				14,350.00
Total Costs					$75,000.00

City Financial Condition

1970 Population	1,434
1970 Assessed Valuation	$1,795,908.00
General Obligation Bond Capacity	$ 448,977.00
General Obligation Bonds Outstanding	$ 306,000.00
Available General Obligation Bond Capacity for Improvements	$ 207,977.00

Westmoreland

Existing

The water supply system of Westmoreland was installed in 1914 and is presently serving a population of 485. The system is supplied with water from two shallow wells located southeast of town. These wells are rated at 40 GPM each. Another existing well is located just east of them; however, it has an extremely high iron content and is for use only during an emergency. A fourth well, rated at 50 GPM, has been drilled around the existing ones and is now operational. A 50,000 gallon elevated storage tank is located on the system in the west part of town.

The water is chlorinated in a chlorine house located in the well field. The water is generally good; however, a relatively high iron and manganese content still exists.

Future

The city presently has sufficient water to meet all demands forecasted within the planning period. In addition to the water lines needed for projected growth, the City should also consider the addition of an iron and manganese removal process to their

water supply system. The quality of the water is adequate; however, it is typical for iron and manganese concentrations to increase with continued well use.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	4" C.I.P.	3,900	L.F.	$ 5.00	$19,500.00
2.	Valves	5	Each	225.00	1,125.00
3.	Fittings			Lump Sum	1,500.00
4.	Fire Hydrants	7	Each	350.00	2,450.00
	Total Estimated Construction Cost				$24,575.00
	Overhead Costs				5,425.00
Total Costs					$30,000.00

City Financial Condition

1970 Population	485
1970 Assessed Valuation	$511,868.00
General Obligation Bond Capacity	$127,967.00
Available General Obligation Bond Capacity for Improvements	$127,967.00
Revenue Bonds Outstanding	$ 90,000.00

Wheaton

Existing

Wheaton does not have an existing public water supply system. Most residences in the town have individual well supplies.

Future

Wheaton is located in a region that does not have an abundance of ground water. However, it was believed that enough water could be found in the area to supply the City's needs. Based on this assumption, it was recommended that two wells, each capable of producing 25 gallons per minute, be located and drilled. If the 25 GPM capacity cannot be found, the City should investigate the possibility of forming or joining a rural water district.

A 30,000 gallon standpipe, located in the central portion of town, should provide adequate storage. Nearly all water lines should be 4-inch or larger in order to provide a system which will allow for future expansion and one which provides adequate fire protection. It was assumed, based on water quality from existing wells in the area, that the future water supply would need only chlorination and no other forms of treatment.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	6" C.I.P.	3,000	L.F.	$ 6.00	$ 18,000.00
2.	4" C.I.P.	8,100	L.F.	5.00	40,500.00
3.	2" C.I.P.	1,000	L.F.	4.00	4,000.00
4.	Valves	14	Each	250.00	3,500.00
5.	Fittings			Lump Sum	4,500.00
6.	Fire Hydrants	16	Each	350.00	5,600.00
7.	Wells	2	Each	6,000.00	12,000.00

	Description	Quantity	Unit	Unit Price	Total
8.	Storage Facilities			Lump Sum	$ 12,000.00
9.	Highway Crossing	1	Each	400.00	400.00
	Total Estimated Construction Cost				$100,500.00
	Overhead Costs				24,500.00
Total Costs					$125,000.00

City Financial Condition

1970 Population	106
1970 Assessed Valuation	$134,193.00
General Obligation Bond Capacity	$ 33,548.00
General Obligation Bonds Outstanding	$ 5,000.00
Available General Obligation Bond Capacity for Improvements	$ 28,548.00

MUNICIPAL SEWERAGE FACILITIES

Wastewater Flows

Sewage is defined as a combination of (a) liquid wastes conducted away from residences, business buildings, and institutions; and (b) the liquid wastes from industrial establishments; with (c) such ground, surface, and storm water as may be admitted to or find its way into sewers. The first type of sewage defined (a) is frequently known as sanitary or domestic sewage. The second type (b) is known as industrial waste and the third (c) is usually referred to as infiltration.

Sanitary sewage flows are usually based on water consumption records and have been found to be 60 to 70 percent of the water used. The remainder of the water is used for lawn watering, automobile washing and similar purposes from which water does not find its way into the sanitary sewers. Based on an average per capita water consumption of 150 gallons per day (GPD), the normal per capita sewage flow should be between 90 and 105 GPD.

Industrial waste and infiltration flows are very difficult to determine. All municipal systems should be reviewed individually to determine the extent each is affected by these flows. Unless these flows were found to contribute substantially, all municipal sewage systems were designed on an average per capita flow of 100 GPD and a maximum flow of 200 GPD.

Wastewater Characteristics

When designing sewage facilities, the characteristics of the wastes are as important as the quantity of wastes. Although normal domestic sewage is more than 99.9 percent water, the small portion of solids in suspension and solution is highly important in its effects. Where only population data are available, acceptable equivalents for design of treatment works is 0.20 pounds of suspended solids per capita per day.

Another very significant characteristic of sanitary sewage is the biochemical oxygen demand (BOD) concentration. BOD is a measure of the organic pollutants in the sewage, and together with flow and suspended solids, dictates the size of the treatment units. Normal domestic sewage is considered to yield 0.17 pounds of BOD per capita per day.

The use of home garbage grinders is increasing, which substantially affects the characteristics of domestic sewage. Full use of garbage grinders in a community increases the suspended solids up to 100 percent with an average of 60 percent and increases the BOD up to 65 percent with an average of 30 percent. The effect on the volume of the sewage is negligible.

Industrial wastes often form a very important component of sewage flows. However, as was previously stated, all municipal systems should be reviewed individually to determine what, if any, effects industry has on sewage characteristics in the communities included in this study. Unless it was found that industrial wastes did make up a portion of the sewage, all municipal

sewage treatment facilities were designed on the basis of an average per capita suspended solids of 0.24 pounds per day and an average per capita BOD of 0.20 pounds per day.

Treatment Requirements

A demand for higher standards in the treatment of sewage has recently been created, due to the population increase accompanied by a rise in per capita consumption of water. The Kansas State Board of Health is presently revising their existing policies regarding water quality; however, at this time these revised policies are in the tentative stage.

The new policies for sewage treatment design have been delayed because of the complex nature of the water quality regulations. No doubt the new regulations will require, in addition to primary treatment, the need for secondary treatment. This requirement will correspond with the regulations now in existence for all federally supported projects. Besides primary and secondary treatment, chlorination of the treatment plant effluents will also be required before 1975, or at about the same time the state requirements for secondary treatment become effective.

In conclusion, the improvements should include three types of treatment: primary, secondary and chlorination.

Treatment Methods

Sewage treatment processes may be generally classified as "primary" and "secondary." All communities that now have public sewerage systems are required to have at least primary treatment.

Primary treatment is usually accomplished by screening and sedimentation, which can be expected to remove 50 to 60 percent of the suspended solids and 25 to 35 percent of the BOD.

Secondary treatment involves biological oxidation of the organic matter to stable forms. This process may remove up to 90 percent of the suspended solids and 75 to 90 percent of the BOD. The effluent from either of the two processes may be chlorinated, which reduces the bacterial count and further lowers the BOD.

Factory built or "packaged" treatment plants and waste stabilization ponds are used extensively in the Midwest to stabilize the sanitary sewage of many small communities. Either of these is capable of carrying out both primary and secondary treatment and both were recommended for communities lacking sewage treatment facilities.

The packaged treatment plants recommended were those employing the contact stabilization process. These plants are a compact unit which carry out individual functions such as screening, sedimentation, aeration, sludge disposal and chlorination.

The raw sewage first enters the plant through a bar screen which collects all large sticks, rags and other foreign debris. After screening, the raw sewage is mixed with a biologically active material, termed activated sludge. The activated sludge is derived from the sewage itself and is produced and maintained by constant aeration. Aeration of the sewage is accomplished by

means of compressed air diffused into the sewage flow. Aeration encourages coalescence of the colloidal impurities in the sewage into activated sludge. These materials then absorb other material, and with continued air mixing, gradually increase in size. The particles contain many organisms which attack the impurities absorbed from the sewage and gradually convert them into stable compounds.

While these reactions are in progress, the activated sludge-raw sewage mixture must be continuously supplied with air. After thorough agitation and aeration, the mixture is discharged to a clarifier where the sludge settles to the bottom, leaving the treated liquid on top. The treated liquid leaves the clarifier by flowing over a wier and into a chlorine contact basin. After chlorination the liquid is discharged to a nearby stream. A portion of the activated sludge which had settled in the clarifier is returned to the start of the treatment process and reaerated. The remainder is discharged to a digester compartment where it is continuously aerated until such time that it can be applied to the land or dried on sand beds.

All contact stabilization plants installed in the State of Kansas must comply with the following design standards established by the Kansas State Board of Health:

Mixing Zone - 1:1 sludge return
Detention Time . . . . . 1½ to 2 hours

Clarifier
Detention Time . . . . . 2 to 3 hours

Chlorine Contact Basin
Detention Time . . . . . 15 minutes

Reaeration Zone
Detention Time . . . . . 7 to 8 hours

5-day BOD Loading/1000 c.f. of mixing zone and reaeration zone volume . . . . . 30 pounds

Air requirements/pound of 5-day BOD . . . . . 1500 cubic feet

Aerobic Digester
Capacity per capita served . . . . . 3.0 cubic feet

All of the above criteria are based on average day design flow.

The waste stabilization ponds are usually two or three cell shallow basins built by excavation of the ground and diking. The purpose of the ponds is to treat raw sewage by storage under conditions that favor natural biological treatment with accompanying bacterial reduction. The mechanism of treatment depends largely on the interaction of bacteria, algae and sunlight. The bacteria convert the decomposable organic matter to more stable products and, in doing so, liberate nutrient elements necessary for algal growth. The algae, utilizing these nutrients, produce a surplus of oxygen through photosynthesis and thus create and maintain aerobic conditions for the bacteria. These natural processes reduce the BOD and lower the coliform bacterial content, thus producing a relatively stabilized effluent normally free from odor.

The design of waste stabilization ponds is governed by the following criteria established by the Kansas State Board of Health:

Minimum Number of Cells 2

Pond Depth . . . . . 3 to 5 feet

Dikes
- Freeboard height . . . . . 3 feet
- Berm width . . . . . 8 feet
- Side Slope 3.5:1

Detention Time . . . . . 90 days

BOD Loading per Surface Area . . . . . 34 pounds

Chlorination of sewage effluent is accomplished by the addition of liquid chlorine or chlorine compounds to the final effluent of the treatment process prior to discharge into a water course. When chlorine is added to the plant effluent, it is necessary to provide a means of mixing the chlorine with the effluent and also to provide a contact tank large enough to permit a retention of fifteen minutes.

From the operational and maintenance standpoint, waste stabilization ponds are the most economical form of sewage treatment. Mowing the grassed dikes and weed control are the major maintenance problems associated with the ponds. A recent study (9) of three ponds in northeast Kansas showed an average 85 percent BOD removal. This compares favorably with other forms of secondary treatment.

Initial costs of "packaged" plants and stabilization ponds are about the same; however, maintenance costs differ widely, resulting in a higher long-range cost for the "packaged" plant. Also, a problem with the "packaged" plant is the finding of a competent operator living within the small community. Advantages occur when adequate land is not available for waste stabilization ponds or the treatment site is susceptible to flooding. Extended

aeration "packaged" treatment plants are reported (10) to remove from 75 to 90 percent of the BOD.

Waste stabilization ponds were recommended for all communities included in this study which did not have existing treatment facilities, with the exception of two. For these it was recommended that "packaged" treatment plants be installed since the towns are susceptible to flooding and the costs of dikes needed to protect a waste stabilization pond would be prohibitive.

Municipal Sewerage Facilities Improvements

Eight of the fourteen incorporated communities in the two-county area have public sewage systems. In these cities the existing system and the future population were studied in order to obtain a possible solution to any sewage problems that may be encountered through the year 1990. The disposal methods were also reviewed and recommendations made to update present practices to comply with foreseen regulations. An attempt was made to estimate the cost of financing immediate needs, which are those that are projected to occur prior to 1981.

Belvue, Havensville, Louisville, Olsburg, St. George and Wheaton do not have public sewage systems. In these cities a sewage system and disposal method were designed to serve the existing residences and any anticipated growth through the planning period.

The recommendations contained herein were not to be construed as the only possible solutions, but are intended only as general

guides. Detailed engineering studies must be conducted when any improvement is being considered. The cost analyses were based on average current construction costs and will vary depending on the contractor and the size and location of the work. The overhead costs included expenditures for engineering, legal fees, abstract fees, land purchase and contingencies. The financial condition of each community can be found in the Municipal Water Facilities section.

Following is a detailed discussion of existing and proposed sewage systems for the incorporated communities included in this study.

Leonardville

Existing

An 8-inch gravity sewer collection system and three-cell waste stabilization pond were installed in Leonardville in 1963. The sewer system drains south through town to the pond which is located within the city limits.

The present town population is 412; however, the pond is designed to handle the domestic sewage from a population of 570. The operating procedure is adequate and the effluent is discharged to Wildcat Creek without chlorination.

Future

Eight-inch gravity sewers, in addition to a lift station located northeast of the present city limits, would have to be added to the system to serve the projected growth areas.

Chlorination of the sewage effluent would probably be required prior to 1980, and therefore, was included in the immediate needs. A fourth pond will also be required between 1985 and 1990 if the city experiences the growth which has been projected.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	2,600	L.F.	$ 4.50	$11,700.00
2.	Manholes	7	Each	275.00	1,925.00
3.	Cleanouts	2	Each	75.00	150.00
4.	4" C.I.P. Force Main	1,050	L.F.	4.50	4,725.00
5.	Lift Station	1	Each	Lump Sum	15,000.00
6.	Chlorination Facilities			Lump Sum	3,000.00
	Total Estimated Construction Cost				$36,500.00
	Overhead Costs				9,000.00
Total Costs					$45,500.00

Ogden

Existing

The original gravity sewer system was installed in Ogden in 1918. Since that time, additional sewers have been added, along with a "conventional" primary treatment plant in 1955. The sewer system drains south through town to the treatment plant located within the city limits.

In 1960 the treatment plant was enlarged to its present capacity of 300,000 gallons per day. The treatment process

includes sedimentation, two-stage sludge digestion, and open air sludge drying. The plant is operating at near capacity on average days; however, the efficiency of the plant under existing conditions is very good. All effluent from the primary process is discharged directly to an ox bow of the Kansas River.

Future

Additional 8-inch gravity sewers should be added to the system to serve the proposed development. Engineers were recently retained by the City to study the present sewage treatment plant and make recommendations for enlarging the present plant, adding secondary treatment and changing the point of effluent discharge.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	7,950	L.F.	$ 4.50	$35,775.00
2.	Manholes	23	Each	275.00	6,325.00
3.	Treatment Facilities			Lump Sum	*
4.	Railroad Crossing	1	Each	Lump Sum	2,000.00
	Total Estimated Construction Cost				*$44,100.00
	Overhead Costs				* 10,900.00
Total Costs					*$55,000.00

*Cost Estimate for treatment facilities unknown at this time.

Randolph

Existing

An 8-inch gravity sewer system and "packaged" extended aeration treatment plant were installed in 1965. The sewer system drains west and north through town to the treatment plant located in the northwest corner of the City.

The treatment plant is designed to handle a flow of 30,000 gallons. It is presently serving a population of 106, and the operating procedure is excellent. The effluent is discharged to a tributary of Tuttle Creek Reservoir without chlorination.

Future

Additional 8-inch gravity sewers will have to be added to the system to serve the proposed development. Chlorination of the sewage effluent will probably be required prior to 1980, and therefore, was included in the immediate needs. The capacity of the treatment plant was adequate to serve the projected 1990 population of 200.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	620	L.F.	$ 4.50	$2,790.00
2.	Manholes	3	Each	275.00	825.00
3.	Chlorination Facilities			Lump Sum	2,000.00
	Total Estimated Construction Cost				$5,615.00
	Overhead Costs				1,285.00
Total Costs					$6,900.00

Riley

Existing

An 8-inch gravity sewer collection system and two-cell waste stabilization pond were installed in 1965. The sewage flows south through town by gravity, except for the extreme eastern section, which requires a lift station to transfer the sewage to the main system.

The pond, which is located south of town, is designed to handle a domestic sewage flow of 80,000 gallons per day. It is presently serving a population of 668, and the operating procedure is excellent. The effluent is discharged to Wildcat Creek without chlorination.

Future

A second pumping station and additional 8-inch gravity sewers will have to be added to the system to serve the proposed development. The pumping station would not be needed if future development extended north of the present city limits; however, new building is occurring west of the city, and it would be senseless to impede this development due to the fact that the area could not be served entirely by gravity sewers.

Chlorination of the sewage effluent will probably be required prior to 1980, and an additional pond should be constructed before 1990 if the city experiences the growth which has been projected.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	5,750	L.F.	$ 4.50	$25,875.00
2.	Manholes	17	Each	275.00	4,675.00
3.	4" C.I.P. Force Main	600	L.F.	4.50	2,700.00
4.	Lift Station	1	Each	Lump Sum	15,000.00
5.	Chlorination Facilities			Lump Sum	3,000.00
6.	Highway Crossing	1	Each	Lump Sum	2,000.00
	Total Estimated Construction Cost				$53,250.00
	Overhead Costs				13,250.00
Total Costs					$66,500.00

Belvue

Public sewerage facilities are presently under construction. The system, which serves the entire town, will consist of 8-inch gravity sewers. The sewage will be pumped from the south side of town to the northeast outskirts where it will discharge into a two-cell waste stabilization pond.

Emmett

Existing

An 8-inch gravity sewer collection system and two-cell waste stabilization pond were installed in 1967. The sewer system drains east through town to a lift station located adjacent to the pond. The lift station then transfers the sewage to the pond.

The pond is designed to handle the domestic sewage from a population of 375. It is presently serving a population of 156, and the operating procedure is excellent. The effluent is discharged into Cross Creek without chlorination.

Future

Additional 8-inch gravity sewers will have to be added to the system as it becomes necessary. Since Emmett was anticipated to have only slight growth during the planning period, chlorination of the pond effluent was the only additional treatment process required.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	1,670	L.F.	$ 4.50	$ 7,515.00
2.	Manholes	4	Each	275.00	1,100.00
3.	Chlorination Facilities			Lump Sum	2,000.00
	Total Estimated Construction Cost				$10,615.00
	Overhead Costs				2,385.00
Total Costs					$13,000.00

Havensville

Existing

Havensville does not have an existing public sewer system. Instead, most residences have individual septic tanks.

Future

An 8-inch vitrified clay pipe collection system was proposed for the City of Havensville. The system would be entirely gravity flow to the southwest outskirts of town where it would empty into a two-cell waste stabilization pond. The effluent from the pond would be chlorinated before discharge.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	10,950	L.F.	$ 4.50	$49,275.00
2.	Manholes	33	Each	275.00	9,075.00
3.	8" V.C.P. Outfall Sewer	1,100	L.F.	4.50	4,950.00
4.	Outfall Sewer Manholes	2	Each	275.00	550.00
5.	Treatment Facilities			Lump Sum	16,000.00
	Total Estimated Construction Cost				$79,850.00
	Overhead Costs				19,150.00
Total Costs					$99,000.00

Louisville

Existing

Louisville does not have an existing public sewer system. Instead, most residences have individual septic tanks.

Future

An 8-inch vitrified clay pipe collection system was proposed for the City of Louisville. The system would be entirely gravity flow to the southeast corner of town where the sewage would then

enter a lift station and be elevated to a "packaged" treatment plant.

Due to the fact that Louisville is within a region that is susceptible to flooding, an earth fill would be required to elevate the treatment plant above the maximum recorded flood elevation. The chlorinated effluent would then be discharged to Rock Creek.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	10,870	L.F.	$ 4.50	$ 48,915.00
2.	Manholes	26	Each	275.00	7,150.00
3.	Cleanouts	3	Each	75.00	225.00
4.	Lift Station	1	Each	Lump Sum	15,000.00
5.	Treatment Facilities			Lump Sum	18,000.00
6.	Highway Crossing	1	Each	Lump Sum	2,000.00
	Total Estimated Construction Cost				$ 91,290.00
	Overhead Costs				22,710.00
Total Costs					$114,000.00

Olsburg

Existing

Olsburg does not have an existing public sewer system. Instead, most residences have individual septic tanks.

Future

An 8-inch vitrified clay pipe collection system was proposed for the City of Olsburg. There would be a north and a south

gravity collection system. A lift station located in the northeast corner of town would transfer all sewage from the north system to the south system. The south system would then transfer all sewage by gravity to a two-cell waste stabilization pond located south of town. The effluent from the pond would be chlorinated before being discharged to Booth Creek.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	10,580	L.F.	$ 4.50	$ 47,610.00
2.	Manholes	30	Each	275.00	8,250.00
3.	8" V.C.P. Outfall Sewer	750	L.F.	4.50	3,375.00
4.	Outfall Sewer Manhole	1	Each	275.00	275.00
5.	4" C.I.P. Force Main	1,300	L.F.	4.50	5,850.00
6.	Lift Station	1	Each	Lump Sum	15,000.00
7.	Treatment Facilities			Lump Sum	16,000.00
8.	Highway Crossing	1	Each	Lump Sum	2,000.00
	Total Estimated Construction Cost				$ 98,360.00
	Overhead Costs				24,640.00
Total Costs					$123,000.00

Onaga

Existing

The original gravity sewer system was installed in 1926. Since that time, additional sewers have been added, along with a secondary "conventional" treatment plant in 1958. The sewer

system drains south through town to the treatment plant located southeast of the city limits.

The treatment plant is designed to serve a population of 2,000. The treatment steps include screening, grit removal, sedimentation, a trickling filter and final sedimentation. The sludge which is removed in the process undergoes two-stage digestion and is dried on open air sand beds. The effluent is discharged into Hise Creek without further treatment. The overall plant efficiency is adequate.

Future

Additional 8-inch gravity sewers should be added to the system to serve the proposed development. The treatment facilities were adequate to handle all projected growth within the planning period; however, chlorination of the sewage effluent will probably be required prior to 1980 and therefore, was included in the immediate needs.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	3,750	L.F.	$ 4.50	$16,875.00
2.	Manholes	13	Each	275.00	3,575.00
3.	Chlorination Facilities			Lump Sum	3,000.00
4.	Railroad Crossing	1	Each	Lump Sum	2,000.00
	Total Estimated Construction Cost				$25,450.00
	Overhead Costs				6,550.00
Total Costs					$32,000.00

St. George

Existing

St. George does not have an existing public sewer system. Instead, most residences have individual septic tanks.

Future

An 8-inch vitrified clay pipe collection system was proposed for the City of St. George. The system would be entirely gravity flow to the southeast corner of town. At this point, a lift station was required to elevate the sewage to the proposed "packaged" treatment plant. After treatment the effluent would be chlorinated and discharged to Blood Creek.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	10,900	L.F.	$ 4.50	$ 49,050.00
2.	Manholes	32	Each	275.00	8,800.00
3.	Cleanouts	2	Each	75.00	150.00
4.	Lift Station	1	Each	Lump Sum	15,000.00
5.	Treatment Facilities			Lump Sum	18,000.00
6.	Highway Crossings	3	Each	1,500.00	4,500.00
	Total Estimated Construction Cost				$ 95,500.00
	Overhead Costs				23,500.00
Total Costs					$119,000.00

St. Marys

Existing

The original gravity sewer collection system was installed in 1926. Since that time many additional lines have been added. The sewer system drains south through town to the treatment plant located south of the city limits. It was found that there are many flush tanks on the lines; however, the water supply lines to these tanks have been removed for some time.

Besides domestic wastes, St. Marys has a slaughter house which discharges its wastes into the public sewers. This type of waste contains a large amount of BOD; however, the amounts of settleable solids are not significant. Tests conducted on the waste indicate that the sewage discharged from the slaughter house per day is equivalent to that of 300 people.

The present sewage treatment plant at St. Marys was placed into operation in July of 1970. The new plant employs the contact stabilization process and has a design population capacity of 5,000. The effluent is discharged to an old river channel which eventually empties into the Kansas River.

Future

The new treatment plant has sufficient capacity to handle the growth which had been projected for the city within the planning period. However, since chlorination of the plant effluent will probably be required prior to 1980, it was recommended that chlorine facilities be installed in addition to 8-inch gravity sewers serving projected growth areas.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	7,400	L.F.	$ 4.50	$33,300.00
2.	Manholes	20	Each	275.00	5,500.00
3.	Cleanout	1	Each	75.00	75.00
4.	Chlorination Facilities			Lump Sum	4,000.00
	Total Estimated Construction Cost				$42,875.00
	Overhead Costs				10,125.00
Total Costs					$53,000.00

Westmoreland

Existing

An 8-inch gravity sewer collection system and two-cell waste stabilization pond were installed in 1963. The sewers drain south and east through town to the pond located south of town.

The pond is designed to handle the domestic sewage from a population of 1,020. The operating procedure is excellent, and the ponds also have an abundant reserve capacity. The effluent is discharged to Rock Creek without chlorination.

Future

Additional 8-inch gravity sewers will have to be added to the system to serve the proposed development. Chlorination of the sewage effluent was the only foreseen treatment requirement within the planning period.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	1,580	L.F.	$ 4.50	$ 7,110.00
2.	Manholes	4	Each	275.00	1,100.00
3.	Chlorination Facilities			Lump Sum	3,000.00
	Total Estimated Construction Cost				$11,210.00
	Overhead Costs				2,790.00
Total Costs					$14,000.00

Wheaton

Existing

Wheaton does not have an existing public sewer system. Instead, most residences have individual septic tanks.

Future

An 8-inch vitrified clay pipe collection system was proposed for the City of Wheaton. There would be an east and a west gravity collection system. A lift station located in the southeast part of town would transfer all sewage from the east system to the west system. The west system would carry all sewage by gravity to a two-cell waste stabilization pond located northwest of town. The effluent from the pond would be chlorinated before discharge.

Cost Estimate for Immediate Needs

	Description	Quantity	Unit	Unit Price	Total
1.	8" V.C.P.	10,200	L.F.	$ 4.50	$ 45,900.00
2.	Manholes	35	Each	275.00	9,625.00

	Description	Quantity	Unit	Unit Price	Total
3.	Cleanouts	2	Each	$ 75.00	$ 150.00
4.	8" V.C.P. Outfall Sewer	400	L.F.	4.50	1,800.00
5.	4" C.I.P. Force Main	1000	L.F.	4.50	4,500.00
6.	Lift Station	1	Each	Lump Sum	15,000.00
7.	Treatment Facilities			Lump Sum	16,000.00
	Total Estimated Construction Cost				$ 92,975.00
	Overhead Costs				23,025.00
Total Costs					$116,000.00

SUBSURFACE CONDITIONS AND RELATED CONSTRUCTION

General

Project costs related to water line and sanitary sewer construction are primarily dependent on the subsurface conditions encountered. Since this is the major item affecting costs, a thorough knowledge of the soil conditions within the area would prevent improper design and construction of water distribution and sewer collection systems.

The United States is divided into a number of physically distinguishable divisions, called physiographic provinces. The northeastern section of Kansas, which includes Riley and Pottawatomie Counties, is included in the Central Lowlands Province.

The Central Lowland can best be described as an area of deposition over most of the history of the continent. The area has, for the most part, been an ocean basin, receiving sediments for a very long time from the Appalachians to the east and more recently from the Rocky Mountains to the west. Over local areas the sedimentary rock appears to lie flat like the pages of a book, but regionally they are a saucer type of deposit with the older formations uplifted to an almost vertical position near the Rocky Mountains. Glaciation occurred from the north to approximately the Missouri and Ohio Rivers. In general, the glacial ice eroded the land to a point near the Canadian border and deposited a layer of till to the south of this area, with the thickest deposit near the center of this band. Streams

leading from the margin of the ice are over cut and refilled with some 50 to 60 feet of alluvium. Streams are yet working headward into the till plain, and wide flat divides separate the streams, becoming wider to the north, and the land gives an appearance of extreme flatness. Most of the major streams have a thick deposit of wind blown silt, called loess, to the east of the stream. These deposits of loess thin rapidly and become finer from the streams eastward, but mantle much of the land in the northern sections of this province.

Kansas is subdivided into its own physiographic provinces. Of the nine physiographic areas in the State, three appear within the two-county region.

All of Riley County and the western two-thirds of Pottawatomie County are included in the Flint Hills Upland Province. This Province is characterized by a series of cuesta ridges trending north-south running across eastern Kansas. The dip slope follows the natural dip of the rock to the west, while the escarpment slope is steeply inclined to the east. The bedrock is the cherty limestones of early Permian Age. Vegetation consists of the hardwoods in the valleys and tall grasses on the upland. Drainage is very well established and is controlled by the cuesta ridges. The soil is residual and has a very thin A horizon over a 3 to 6 foot B horizon of clay containing chert fragments.

Northeastern Pottawatomie County is included in the Dissected Till Plains Province. This is an area of well-rounded rolling hills underlain by glacial till of Kansan and Nebraskan Age

mantled by loess. The area is dissected by a well-established dendritic stream pattern. Bedrock of Pennsylvanian and Permian Age is exposed in the deeper valleys. The stream valleys are over cut by some 50 feet and are filled with alluvium. The vegetation consists of hardwood forests along the eastern portion and tall grass to the west. The soil horizons are quite thick on the loess and a very thick paleosol may be encountered on top of the till.

The third Province appearing in the two counties is the Osage Cuesta Plains. A small portion of southeastern Pottawatomie County is included in this Province. The Province is an area of cuesta ridges trending north-south, similar to the Flint Hills to the west, but developed on the less resistant rock of Pennsylvanian and lowermost Permian Age. In the area of thick sandstone of the Douglas Group, rounded hills without a cuesta appearance are found and have been named the Chautauqua Hills. Stream valleys leading from the Dissected Till Plains are overcut more than those originating in the Cuesta area. The vegetation consists of sparse hardwoods along streams and tall grass on the upland. The soils are residual and relatively thin.

Three distinct features are present throughout the two counties. These features include the uplands, valley slopes and valleys. All three exhibit distinguishable characteristics.

The uplands are those areas which contain the highest relief. In these areas the soil is approximately 20 feet in depth and underlain by alternating layers of limestone and shale. The soil,

which is derived from its underlain parent material, is commonly found to be a cohesive mixture of silt and clay.

The valley slopes are characterized by outcropping layers of limestone and shale. Thin layers of soil cover areas where the slope has allowed deposition and derivation of soils from underlain parent material.

Valley floors consist of approximately 40 feet of sand and gravel alluvial deposits overlain by 10 feet of silt and clay.

Water Main Construction

Two problems associated with the construction of nearly all waterlines are rock removal and anchorage of pipes against thrust forces. Rock removal can be very expensive if a sufficient quantity is found, since a contractor will usually bid it separately. Rock within the communities of the two counties, however, consists mainly of scattered ledges. A minimum soil cover of three feet, which is necessary to protect water lines from freezing, was found to cover all major rock formations, with the exception of a few steep valley slopes. Rock, therefore, within the communities would not be a major factor in raising water line construction costs.

Anchorage of water lines against thrust forces is a common construction procedure and is therefore accounted for in the overall bid price. However, if unusually large amounts of blocking is required due to poor soil conditions the added expense will be reflected in higher project costs.

Water pipelines are subject to thrust wherever the pipeline changes direction or diameters, or is dead ended and wherever a branch outlet exists. Thrust forces caused by hydrostatic pressures can be very large and must be properly resisted to insure the safety and dependability of the water line. Some thrust forces associated with municipal water distribution systems are small and may not require blocking.

The magnitude of the hydrostatic thrust may be determined by the following formulas:

Thrust at bends: $T = 2\pi r^2 p \sin \Delta/2$

Thrust at dead ends or branches: $T = \pi r^2 p$

Where T = thrust in pounds
r = radius of pipe joint in inches
p = water pressure in psi
Δ = bend deflection angle

Horizontal thrusts may be, and in most cases are, most economically resisted by concrete thrust blocks or collars attached to the pipe. Other alternatives may be the use of tension joints, such as welded joints for steel pipe and lugged joints for concrete and cast iron pipes. Tying sufficient lengths of pipe together longitudinally so that the frictional resistance due to the weight of the tied pipe will exceed the thrust force may also be used. Another solution, where space and topography permit, would be to replace bends with large diameter curves formed by small deflections at several joints, with each deflection limited to a value which would not require anchorage.

Concrete blocks, which were found to be the most economical solution to the resistance of thrust forces, depend mainly upon the passive pressure which can be developed by the soil against which they are poured. Frictional resistance of the block against sliding accounts for only a small portion of the total resistance in a shallow setting. The passive pressure which can be developed by a soil against a thrust block increases greatly as the depth of the base of the block below the ground surface increases. This is shown in the following formula used for determining thrust block capacities (11).

$$H = \frac{K_p w h^2 b}{2} + \frac{h^3 w \tan (45 + \phi/2) (\tan \phi)}{6} + 2bch + ch^2$$

Where H = thrust capacity in pounds
b = length of thrust block in feet
$h/2$ = height of thrust block in feet
h = depth below ground to base of block in feet
w = unit weight of the soil in pounds per cubic foot
ϕ = angle of internal friction of soil in degrees
c = cohesion of soil in pounds per square foot

$$K_p = \tan^2 (45 + \phi/2) = \frac{1 + \sin \phi}{1 - \sin \phi}$$

Soils in the region vary from clays found in the upland and valley slope areas to silt, sand and gravel combinations in the valley floors. The range in soils also brings about a wide difference in soil constants. The unit cohesion of the clay is approximately 1500 psf, whereas the valley floor soils may exhibit a cohesion of as little as 100 psf. The soils angle of internal friction also varys from 15 degrees in the uplands to 35 degrees in the valley. Using the above values, including a

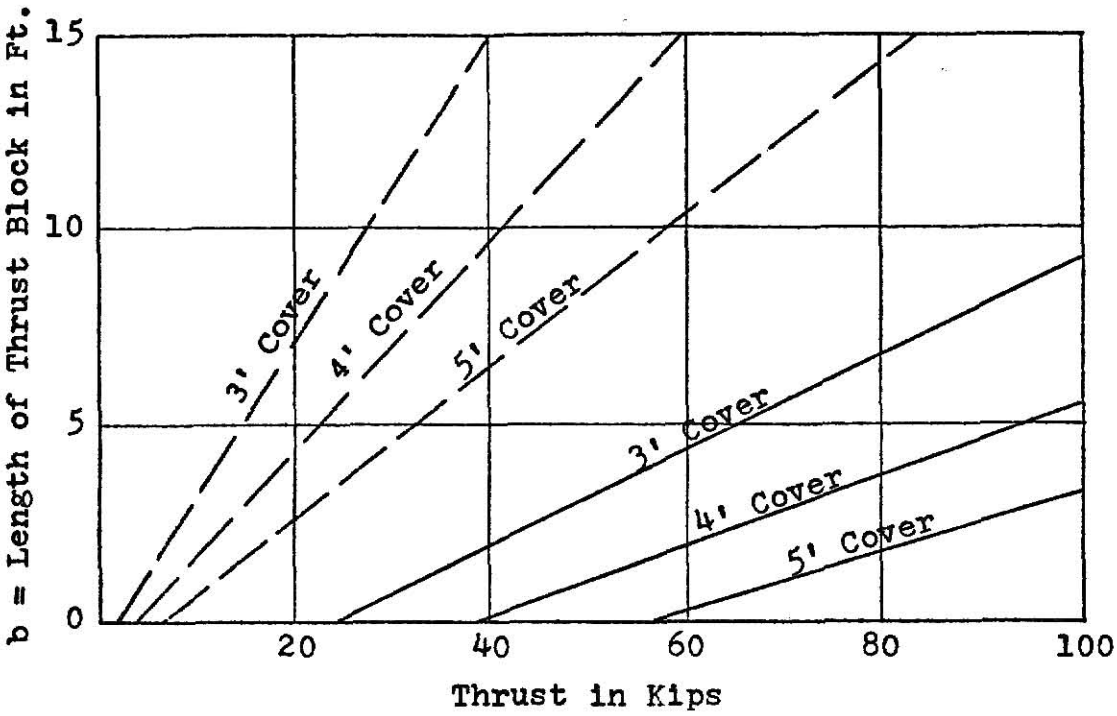
unit weight of 100 pcf and a safety factor of 1.5, a graph may be constructed showing the range of thrust block sizes required for the various thrust forces. A graph of this type and a typical thrust block detail are shown in Figure 3.

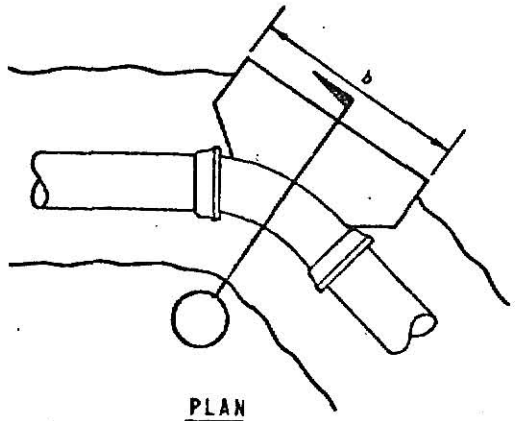
Sanitary Sewer Construction

Sewer lines, unlike water lines, the alignment of which may be altered to avoid an obstacle, must follow a straight alignment and have a constant slope between manholes. This requirement makes it difficult to avoid rock where it is present and deep cuts at the head of the lines. Rock removal and excavation depth are the major factors contributing to excessive construction costs.

Rock removal in this area, according to recent bid tabulations, usually costs between $10 and $15 a cubic yard, depending on the total volume. Rock is considered only that part of the total excavation which cannot be removed by conventional trenching or earth moving equipment. Thin ledges and weathered portions of rock are therefore usually not considered rock excavation. Rock formations, such as the Cottonwood Limestone prevalent in the Manhattan area, are very hard and will raise project costs when encountered. These limestone formations are common throughout the region and are usually unavoidable in the valley slope and upland areas, due to the required depth and alignment of the sanitary sewers.

Trenching costs in this area range between $0.30 and $0.35 per foot of depth per lineal foot of pipe installed. These





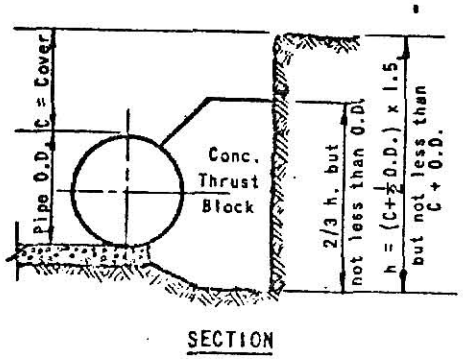


Figure 3 - THRUST BLOCK

figures are good only for average trenching conditions with no rock or other obstacles involved. Manhole costs will also rise approximately $35 per extra foot of depth encountered below the standard six foot depth. Factors contributing to the extra trenching costs include additional earth removal and recent Federal construction safety requirements.

The most recent Occupational Safety and Health Act (OSHA) requirements for excavation, trenching and shoring (12) has caused sanitary sewer project costs to rise. It is not so much the fact that these requirements are new or more stringent, but because the Federal Government is now enforcing them. Penalties for failure to adhere to the Act will now result in fines and possible project shut-downs.

OSHA requires that all trenches more than five feet in depth be shored or laid back to a stable slope. In areas where the trench width is restricted, such as in existing residential areas, the contractor has no choice but to shore the trench. Shoring is a very expensive operation since it almost always involves an extra crew to construct, dismantle and move the shoring as construction progresses.

Where area permits, the sides of the excavation may be sloped to prevent slides. Permissible slopes range from $\frac{1}{2}$:1 to 2:1 with a slope of 1:1 used for average soil conditions. Although this results in more excavation, it is usually the least expensive alternative since the number of man hours involved is reduced.

Pipe class and bedding conditions, which are controlled by the burial depth and trench width, will also affect construction costs. Vitrified clay pipe (V.C.P.) recommended for the sanitary sewers in the communities is available in standard and extra strengths. The choice of the pipe strength used and soil and trenching conditions will determine the type of bedding. Likewise, choice of bedding would determine the pipe strength required. Extensive research (13) has resulted in three standard bedding classes. These are shown in Figure 4.

Much study has also been given to relationships regarding the various combinations of soil and trenching conditions, strengths of various pipe and class of bedding. The American Society of Civil Engineers has combined the various research and findings into standards for the design of sanitary sewers (14).

Standard strength pipe in conjunction with Class B bedding would be sufficient for all sewers in the communities except where the depth is less than three feet. When shallow depth is encountered, cast iron pipe should be used to prevent damage from surface live loads. Pipe strength and bedding was not expected to raise projects costs in this area; however, the importance of them should not be overlooked.

The presence of groundwater will substantially increase construction costs; however, it was not expected to be a major problem in the communities. Many contractors will not bid projects where groundwater is expected to be a problem.

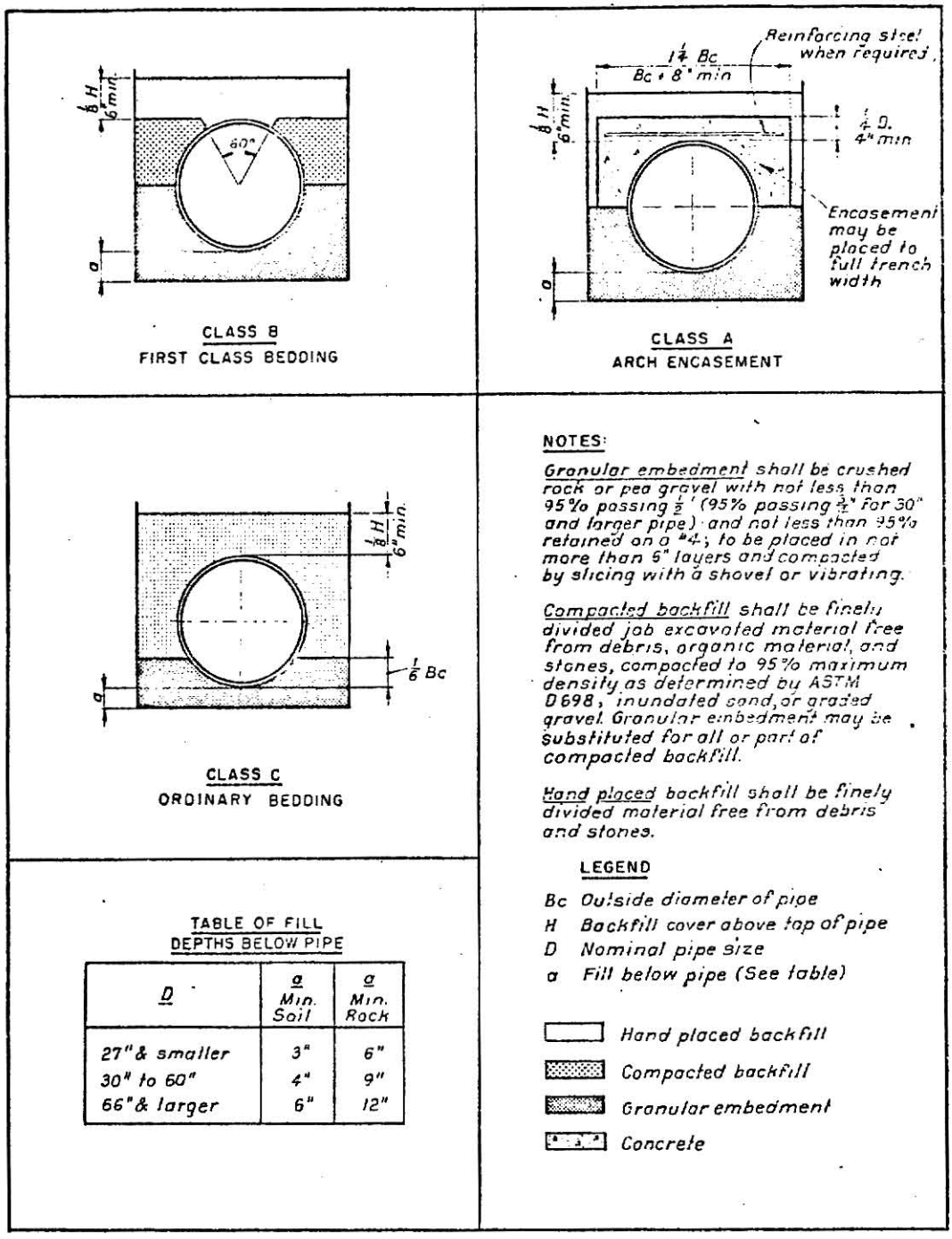


TABLE OF FILL
DEPTHS BELOW PIPE

D	a Min. Soil	a Min. Rock
27" & smaller	3"	6"
30" to 60"	4"	9"
66" & larger	6"	12"

Figure 4 - BEDDING CLASSES

Equipment needed for dewatering trenches is expensive and would not be used often enough to warrant its cost. Other costs involved in constructing a sewer below groundwater level include special water tight joints to prevent infiltration and special construction procedures or anchorage to prevent flotation of the lines due to hydrostatic forces.

CONCLUSION

Over the past 50 years, improved transportation and communication systems have developed ghost towns out of many of the small communities. Some communities have managed to survive; however, they are presently only a skeleton of their former size. These same factors of transportation and communication are now reversing the trend. Many communities, especially those adjacent to larger towns, are experiencing rapid growth. To profit from this trend, a small community must offer many of the public services found in the larger town. A high quality public water supply and reliable distribution system and community sewerage facilities are essential.

The results of this study show the need for immediate and long-range improvements, based on existing conditions and forecasted growth. There are several ways in which the proposed water and sewer improvements may be financed. Several of these methods are discussed below, any one of which, or combination thereof, should provide a sound financial solution to the needed improvements.

Revenue bonds may be issued and sold and then retired by sewer or water use charges. Rates for usage of the facility must be established prior to issuance and sale in order to provide that adequate collateral is available.

General obligation bonds may be issued and sold and then retired by imposing a mill levy upon the property within the area. Sufficient assessed valuations must be in existence to avoid exceeding mill levy limitations set by law.

Special assessments may be levied against property benefited by an improvement in proportion to the benefit derived. Bonds may then be sold using the special assessment levy as collateral.

There are many different loans and grants available from Federal, State and Local Governments. These are varied in nature and may apply to communities, rural areas or individuals. Since funding and assistance by the governmental agencies can change rapidly, it is suggested that communities interested in obtaining further information contact the Kansas State Department of Health or the Department of Federal Housing and Urban Development.

ACKNOWLEDGMENTS

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Also, in a special manner, I would like to thank the entire Civil Engineering Department at Kansas State University, which always managed to find time to make itself available whenever help was needed.

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SMALL COMMUNITY WATER SUPPLY AND SEWERAGE IMPROVEMENTS

by

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ABSTRACT

A study of establishing and/or upgrading small community water and sewerage facilities is presented. The purpose of the study was to investigate the feasibility of such improvements and to produce a plan and guide for their development and construction.

All communities were visited and researched and various city and health department officials interviewed to determine existing conditions. Projected growth forecasts were then used to study and investigate future problem areas. Recommendations regarding the establishment of the proposed improvements were made and their cost and related construction analyzed.

Results of the study showed a need for some form of improvement in nearly every community. It was concluded that if a small community expects to continue to exist and grow, it must provide adequate public services. Existing problem areas must be corrected immediately and plans initiated for the solution of forecasted improvements.