MASTER PLAN
REPORT

SANITARY, STORM & COMBINED SEWERS

PADUCAH, KENTUCKY

1961

BURNS & McDONNELL ENGINEERING COMPANY
ENGINEERS · ARCHITECTS · CONSULTANTS
Kansas City, Missouri

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TABLE OF CONTENTS

Table of Contents, Continued: Page

LIST OF FIGURES

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January 27, 1961

Honorable Mayor and City Commissioners
Paducah, Kentucky

Attention: Mr. R L. Brockman
City Manager

Gentlemen:

In accordance with our contract with the City of Paducah, we submit herewith a Master Plan report summarizing our findings and recommendations relative to the sewer system of Paducah.

A major part of our study has been devoted to the means of alleviating flood conditions caused by inadequacies of the existing storm and combined sewers. Studies also include projections into the future for both storm and sanitary sewer facilities. A summary of the findings is included as a "Synopsis" at the beginning of the report.

We wish to acknowledge the help of the City Engineer, Mr. T. A. Bradley, and his staff. His suggestions have been valuable, and his recommendations for extension of the system of separate sanitary sewers have been used in the report with very little change.

Respectfully submitted

BURNS & McDONNELL
Engineering Company

By H. J. Rosson
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- SYNOPSIS -

SYNOPSIS

The primary purpose of this report is to make a detailed study of the problem of flood damage caused by inadequacies in the existing storm and combined sewer systems and to recommend a system of relief sewers and drainage ditches which will effectively prevent such flooding.

The study reveals that the existing sewers are designed for a capacity of one-third to one-sixth that which is required by modern design standards. The existing sewers were actually designed to take advantage of some flooding of streets and low areas. Filling and development of many of these areas have compounded the problem. Water accumulates at certain low (but developed) locations during heavy storms and is drained off after the peak of the storm has passed. The time required for the water to drain away varies from one to three hours.

This situation occurs several times a year, whereas storm sewers should be designed so that streets would be flooded only once in several years, the frequency being dependent upon the dollar valuation of the damage which might be sustained.

In order to obtain a system which meets present design standards, nearly every storm sewer and combined sewer in the City would need to be replaced. A system of relief sewers has been devised, however, which will carry away the excess storm water in such a manner that there will be little resultant property damage. The improvements are described in detail, and are arranged in groups in the relative order of their importance. The improvements grouped as Step I are those considered to be of the first order of importance. Those in Step II are also important in bringing about the elimination of flood damage, but not of the same order as those in Step I. The improvements described as Step III will become necessary as land values increase and as more land area is made impervious resulting in a greater storm water runoff.

The estimates of cost for storm water relief improvements are as follows:

Step I	$ 842,400
Step II	1,203,800
Subtotal I and II	$2,046,200
Step III	6,063,900
Total	$8,110,100

Sanitary sewer improvements indicated in the report are basically those proposed by the City Engineer, plus those recommended in the "Report on Sewers for Annexed Areas," dated November 23, 1959. No major extensions of the sanitary sewers are planned, the extensions recommended being in the nature of lateral systems and extensions in relatively small areas or real estate developments.

Several methods of financing the proposed improvements are suggested, as follows:

1. Issue revenue bonds supported by the revenue from existing sewer service charges, which will provide enough capital to construct Step I of the storm water relief improvements and the necessary sanitary sewer extensions. No increase in taxes or service charges would be necessary.

2. Double the existing sewer service charges (which are very low) and issue revenue bonds which will provide enough capital to construct both Steps I and II of the storm water relief improvements and the necessary sanitary sewer extensions. No increase in taxes would be necessary.

3. Operate and extend sanitary sewerage system and sewage treatment plant out of revenues from the sewer service charge and issue general obligation bonds for the capital required to finance Steps I and II of the storm water relief improvements.

It is apparent that the net revenues of the City are adequate to support the bond issue recommended without an increase in taxes. The bond issue would be $2,100,000 and the equal annual payments including principal payments and interest would be approximately $137,000. It also appears that sufficient net revenues are available to partially finance the sewer extension program and Step III of the storm sewer program.

It is recommended that (1) Steps I and II of the storm relief program be constructed immediately before further damage, distress, and inconvenience are suffered by the people of Paducah; (2) a sound sewer extension policy and program be adopted for both sanitary and storm sewers; (3) Step III storm relief program be reappraised upon completion of Steps I and II, and if feasible, financed out of the net revenues available.

- SECTION I - GENERAL -

SECTION I - GENERAL

PURPOSE AND SCOPE:

The primary purpose of this study is to provide a solution to the persistent and troublesome problem of frequent flooding of streets, sidewalks, basements, and floors in the built-up areas of the City of Paducah. Considerable property damage results from the flooding and a potential hazard to the health and safety of the people of Paducah develops with each flood. Many of the sewers flooding are combined sewers, carrying both sanitary sewage and storm water, threatening to spread disease. The passage of traffic on important highways and trafficways within the City is hampered by the flooding, endangering lives and property in the event of simultaneous fire or other emergencies. Drownings, particularly of children who are tempted to wade and play in the flood water, form a potential hazard.

In this report the deficiencies of the existing system are reviewed and methods of relieving these deficiencies are recommended. The proposed improvements are arranged in order of priority, placing first those projects which will relieve the most serious areas of damage within the City. The recommended program will provide the City with a storm sewer system designed to modern standards and will provide for future requirements within the areas where expansion is anticipated.

Design criteria are established forming the basis for the design and construction of new sewers in the new areas where design cannot be completed at this time.

This report reviews the features of the existing sanitary sewer system and provides for methods of improving and extending that system.

A construction program is outlined and the cost thereof is indicated together with the financing necessary for its completion.

DESCRIPTION OF THE CITY OF PADUCAH:

The City of Paducah is located on the Ohio River in McCracken County, Kentucky, at the mouth of the Tennessee River and approximately thirty miles upstream from the mouth of the Ohio River. The essential commercial and industrial area of Paducah, as well as the older residential area, is located in the flood plain of the Ohio River, protected by a flood wall constructed in 1939, after the most severe flood of history in 1937. At that time, the river reached a stage of 60.6, or approximately 10 feet above the street grade at the City Hall. The City of Paducah is an old city. The first recorded population, dated 1830, was 105. By the year 1900, the population had increased to 19,446, due primarily to the advent of railroad transportation. Between 1920 and 1930, the City enjoyed its greatest rate of growth, increasing almost 9,000 persons to a population of 33,541 in 1930. Since that date, the population has remained almost constant within the city limits. However, growth has occurred in suburban areas surrounding the City. The official 1960 population of Paducah is 34,065. If the suburban areas of Lone Oak, Tyler, Woodlawn, and Reidland surrounding Paducah were included, at least 6,000 would be added to this figure. (See Figures No. 1 and No. 2).

According to data furnished by the Paducah Association of Commerce, the largest industry in Paducah is the Illinois Central Railroad employing approximately 1,500 people. The second largest industry is the Claussner Hosiery Company employing 635 people. The following industries located within the city limits are listed in the order of the number of employees:

International Shoe Company	612 employees
Magnavox Company	505 employees
Paducah Marine Ways	376 employees
Southern Bell Telephone and Telegraph Company	265 employees
Modine Manufacturing Company	207 employees
Southern Textile Machinery Co.	136 employees

Other large industries have located within a 15-mile radius of Paducah as follows:

Union Carbide Nuclear Co.-AEC 7 miles west of Paducah	1,750 employees
Shawnee Steam Power Plant-TVA 6 miles NW of Paducah	610 employees
National Carbide Company - Calvert City, Kentucky	444 employees
Pittsburgh Metallurgical Company- Calvert City, Kentucky	483 employees

B. F. Goodrich Chemical Company	
Calvert City, Kentucky	177 employees
General Aniline and Film Corp.	
Calvert City, Kentucky	164 employees
Penn Salt Chemicals Corporation	
Calvert City, Kentucky	290 employees

Calvert City is located near Kentucky Dam approximately 15 miles east of Paducah.

The latter group of industries have contributed to the economy of Paducah, but have had very little affect upon its population. The need for a greater attracting force to industry was recognized by the people of Paducah when they voted on November 8, 1960 to purchase the local power facilities and obtain electric power from TVA. With the completion of this transaction combined with a modern and progressive city government and an active campaign to attract industry to the area, a very optimistic estimate of growth of the City would be indicated.

The past growth of the City of Paducah since 1900 and estimated future growth are shown graphically in Figure No. 1. Two curves for future growth are shown; one considered optimistic and the other conservative. The conservative estimate is merely an extension of the past general growth rate pattern. It indicates a population of 39,500 in 1980 and 45,000 in year 2000. Actual growth will depend upon the success in attracting new industry to the immediate area of Paducah, as well as the extension of city limit lines to encompass the suburban developments around the City. In addition, it would be expected that industry would require assurances that the property on which it builds will not become flooded either from the river or from local storms and runoff. National and international affairs will have their effect upon the growth of Paducah, but assuming a general climate favorable to industrial development, Paducah can very well attain the growth rate indicated on the optimistic curve. This curve indicates a population of 45,000 in 1980 and 56,000 in year 2000.

DESCRIPTION OF EXISTING SEWER SYSTEMS:

The City of Paducah is served by three types of sewer systems, namely, separate sanitary sewer systems, separate storm sewer systems, and combined storm and sanitary sewer systems.

Separate Sanitary Sewer Systems:

In the oldest part of the City from the Ohio and Tennessee rivers to Ninth Street and from Park Avenue to Island Creek, the sanitary sewer system is separate from the storm sewers. In most of the newly developed areas, sanitary sewage is conveyed in a separate sewer system. Many of the sanitary sewers empty into combined sewers.

The disposal of sanitary sewage is discussed in Section III of this report.

Separate Storm Sewer Systems:

Most of the separate storm sewers are located where separate sanitary sewers have been installed. In the old part of the City, they are located in an area from the Ohio River to Ninth Street and from Park Avenue to Island Creek. Several separate storm sewers have been installed for discharge into Island Creek and its branches. One large storm sewer was constructed in Branch Road and Thirty-Second Street. In other isolated locations separate storm sewers have been installed.

Combined Sewer System:

The major portion of the City of Paducah is served by combined sewers. They predominate in the area from Ninth Street to Thirtieth Street and from Ohio to the northwesterly levee. The combined sewer system drains in a general northeasterly direction to the flood wall near Terrell and Sixth streets where the sanitary sewage is intercepted and pumped to the sewage treatment plant. The storm water is allowed to pass through the flood wall in a 102-inch pipe which can be valved off in the event of high river stages. The storm water runoff is then pumped through Lift Station No. 2 into the Ohio River. Two large relief sewers to the combined system were constructed in 1954; one in Thirtieth Street and the other in Twenty-seventh Street, providing for discharge of storm water in a northwesterly direction through Noble Park and through the flood wall at Lift Station No. 1.

Many of the storm and combined sewers were constructed before the construction of the flood wall, their outfalls discharging directly to the river. When the flood walls were constructed, it was necessary to provide gate valves and flap gates on the outfalls of the existing sewers extending through the flood wall,to construct diversion sewers which would reduce the number of outlets through the flood walls, and to construct lift stations for pumping storm water and sanitary sewage over the flood wall during periods of high river stages. A diversion sewer was installed in Second Street from Jefferson to Clark and is served by Lift Station No. 6.

The watersheds served by the combined and storm sewer systems are indicated in Figure No. 3. The watershed area designations conform insofar as possible to those designations assigned by the Corps of Engineers, U. S. Engineer Office, Louisville, Kentucky, in "Supplemental Report on Local Flood Protection Project, Paducah, Kentucky,"without a date but presumed to be approximately 1937 or 1938.

All watershed areas designated with the letter "A" discharge the greater part of their storm water through two relief lines into Noble Park and Lift Station No. 1. Their sanitary sewage is discharged through the combined system into watershed "B".

Watershed "B" is composed of combined sewers discharging into the Ohio River at Lift Station No. 2. The sanitary sewage is intercepted at this point and pumped to a sewage treatment plant. The storm water is pumped over the levee during periods of high flood stage.

Watershed "C" discharges storm water directly to the Ohio River at Pump Station No. 3.

Watersheds "D" and "E" discharge storm water to the Ohio River at Pump Station No. 5.

Watersheds "F" through "I" discharge storm water through the levee at the end of each of the streets; or when the river is high, this water is diverted to Pump Station No. 6 where it is pumped.

In Watershed "J" all of the water is diverted to Pump Station No. 6 where it is discharged into the Ohio River, or during high river stages is pumped.

Watershed "K" discharges storm water through the flood wall at Tennessee Street, or when the river is high through Pump Station No. 7.

Watershed "L" includes the entire Island Creek watershed. Only storm water or highly diluted combined sewage is discharged into this area. Storage is provided in the low areas of a "conservancy" district where it may be pumped out at a low rate during high river stages through Lift Station No. 11.

The storm water of Watershed "M" is collected and discharged at the location of Lift Station No. 12.

Watershed "O" is now drained through the flood wall at two points, but no pumping stations are provided at these locations. If this area is redeveloped, lift stations will be necessary.

Watershed "P" is located above the flood plain of the river and therefore can be drained to the river side of the levee, alleviating any necessity for pumping at high river stages.

Watersheds "Q", "R", and "S" are watersheds where future development is expected, discharging into the Perkins Creek watershed.

Watershed "T" is expected to develop soon, discharging into Crooked Creek. None of these areas will require pumping of drainage at high river stages.

The storm and combined sewer systems are discussed more fully in Section II.

- SECTION II - STORM DRAINAGE -

SECTION II - STORM DRAINAGE

STATEMENT OF THE PROBLEM:

This section of the report covers the problem of storm drainage in areas served by both combined and separate storm sewers as well as areas served by surface drainage through open channels and ditches.

It is reported that almost every combined sewer in the City would cause flooding of basements during local storms were it not for the installation of backwater valves in basement floor drains. Use of basement areas must be limited for this reason. Storage in basement areas is hazardous even when backwater valves are installed. Foreign objects in the valve frequently prevent its proper functioning. The use of sanitary facilities, laundries, or other facilities must be discontinued during periods of storm flow. Almost every home and business establishment below Thirtieth Street, with a basement, is probably affected by backwater from the combined system, but the residents have learned to "live with" the problem in spite of recurring failures of local devices.

Locations of reported local area floodings are shown in Figure 3 and are described as follows:

Flood Area No. 1 - 10th to 12th Street, Kentucky to Broadway:- It is reported that this area floods much more frequently than once a year. Water rises over the curbs, sidewalks, and into the stores, flooding the floors from one to four inches in depth. Most of the store floors are six or more inches above the sidewalk level. Damage to the floor, merchandise resting on the floor, furniture and equipment has been reported. Traffic is stopped in the streets. Frequently automobiles are flooded out and damaged. Merchants are equipped with sand bags or other devices to keep most of the water out of their stores. They have learned to "live with" the problem, but not without justifiable complaints because of the damage to property and to business. Water is frequently high for one to two hours. Several additional hours are required to clean up and restore business.

Flood Area No. 2 - Madison to Park, 21st to 25th Streets:- This area floods four or five times a year. The most serious floods occur in the summer. (July, 1959 is frequently mentioned). But flooding also occurs in the fall and spring. November 28, 1960, the area flooded over one foot deep. Most of the houses in this area do not have basements, but flooding has occurred to within two or three inches of the floors of many homes. Water has been observed backing up through manholes and street inlets. One observer reported seeing a manhole lid blown off and water spouting a foot or two into the air. Streets and yards have been flooded to a depth of two or three feet. Water frequently remains high for two to three hours. Some near tragedies with children and pets are reported.

Flood Area No. 3 - Kentucky Avenue, 17th to 24th Street:- This area floods three or four times a year to a depth of over 12 inches in the street, stopping and stalling all traffic. Several stores are flooded to a depth of three to five inches. Manhole covers were observed being blown off with water rushing out into the street. Water frequently remains high for two to three hours, cutting off all traffic on this busy state highway.

Flood Area No. 4 - Howard, Friedman, and Jefferson at 36th Street:- Water is reported to rush over the ground during heavy rainfall. Some homes have been flooded and Jefferson (35th Street) has been reported as a torrent of flowing water. Water remains high for approximately one hour.

Flood Area No. 5 - 26th Street and Kruger:- In this area water has risen to within four to six inches of the floors of several homes. Cars have been flooded and stalled. Yards, yard furniture and, shrubbery have been covered with silt and debris. Water usually remains high for one to two hours.

Flood Area No. 6 - 32nd Street and Lorine Lane:- The open creek along the back of these homes has exceeded its banks, flooding out yards and cars, and damaging homes. Water stays up over an hour.

Flood Area No. 7 - In vicinity of Union Station:- This area floods over one foot deep in a major storm, and slowly seeps away, obstructing traffic in this important area.

MODERN DESIGN CRITERIA FOR STORM SEWERS:

The amount of storm water that gutters, inlets, and sewers must be designed to receive and handle is subject to many variables which must be evaluated for a clear conception of the problem. Although it is not within the scope of this report to discuss in full the significance of all of the variables involved, it is important that their effect upon the Paducah problem be discussed.

Engineers have used since 1898 a formula for determining the flow required in storm sewers called the "Rational Formula." This formula may be expressed as follows:

$$Q = C\,i\,A$$

Where Q = Flow in cubic feet per second

C = Coefficient of runoff or ratio of runoff to rainfall

i = Average rainfall intensity in inches per hour prevailing during the period of concentration

A = Area of watershed under consideration in acres.

While this formula appears to be quite simple, the factors which make up this formula must be used with the greatest of care. The simplest and most direct factor is that of area of watershed. This obviously includes all land which is sloped in such a way that it drains to the point where the flow is to be picked up by the gutter, the inlet, or the sewer under consideration.

The value of the coefficient of runoff, "C", to be used on a given watershed is dependent upon many factors such as (1) terrain, (2) type of soil, (3) vegetation, (4) extent of development, and (5) the amount and relative locations of impervious areas. The engineer must select the value of this factor, usually between 0.10 and 0.95 that best represents the actual ratio of runoff to rainfall, not only for present conditions but also for future conditions when the area may be more fully developed.

The intensity of rainfall, "i", to be used by the engineer is dependent upon such factors as time of concentration and storm frequency. Time of concentration is usually defined as the time it takes for a drop of water to travel from the furthermost point on the watershed to the point at which flow is to be determined. This water must travel overland to a gutter or stream, down the stream to an inlet, through the inlet and into the sewer, and down the sewer to the point under consideration. The reason this time of concentration is so important, is because the intensity of the rain varies inversely as a function of the time of concentration. The shorter the period of concentration, the greater the intensity of rainfall. In this factor, the time of concentration depends upon the terrain, the soil, the development of the area, as well as the shape of the area of water-shed. Storms vary in intensity. The less intense storms occur more frequently than the very severe storms. Storms have been analyzed by the U. S. Weather Bureau so that it is possible to determine the frequency or "return period of storms" of various intensities. They are referred to as two-year storms, five-year storms, hundred-year storms. The designer must decide upon the return period of the storm for which he desires to design his facilities. In general, he would design for storms of the highest intensity, for facilities the failure of which would cause loss of life and extensive property damage, such as dams on major streams, or flood walls around cities. The flood wall of Paducah is designed for a storm of more than one hundred year return period. It would not be feasible to design storm sewers to similar standards because storm sewers will not fail if overloaded. Ponding will occur as has occurred in Paducah, but such ponding need not be as frequent as is now occurring. Practice varies throughout the country in the design of storm sewers. In general, residential areas are designed for storms of two to five year return periods where sewage is of the storm water type only and for five year return periods where the combined sewers are used. Commercial and industrial areas are designed for return periods of from five to ten years. Occasionally designers may use fifteen to twenty-five year return period storms for design in high valued commercial areas.

There are many inadequacies in the rational method for determining runoff that have stimulated engineers and researchers to attempt other procedures for determining the amount of runoff. Proper use of rational method for example, depends largely upon the judgment and experience of the engineer in selecting the proper coefficients. It does not take into account in the best manner, the amount of infiltration that occurs during a storm. Antecedent rainfall is frequently overlooked. Storage in depressions is not considered. The shape of the watershed and the storage of water in the sewer system itself, are not taken to account adequately.

Recognizing these deficiencies, R. L. Gregory and C. E. Arnold developed in 1932 a modification to the rational formula which recognized to a certain degree, such factors as watershed shape and slope, the stream pattern, and elements of channel flow. Later Horton, Horner and Jenns suggested a method of applying infiltration data to storm rainfall patterns to obtain net rainfall. Later, Hicks developed a method of determining urban runoffs for Los Angeles, California.

At Chicago, Illinois, some very extensive studies have been made of the Hydrograph Method for determining runoff and were reported by Tholin and Keifer in 1959. The Chicago method uses a design storm pattern called the "Hyetograph." On this graph rainfall intensity is plotted in inches per hour against time in minutes from the start of rainfall. Many storms were studied and an average or typical hyetograph was developed for storms of various return periods from two years to fifty years. The hyetograph was then modified, subtracting first the infiltration of ground water into the ground, subtracting next the filling of depressions in the surface of the ground, and subtracting finally the surface detention or water storage on ground to form a "hydrograph" of overland flow. This hydrograph was further modified to account for gutter storage, for storage in the lateral sewer system, and for storage along the trunk sewers to the point under analysis. Such hydrographs were developed for various types of land used from suburban residential to built up metropolitan centers. In several typical areas of Paducah, the Chicago method of design was used and checked against the rational method of design. For preliminary design, however, pipe sizes shown on Figures No. 9 and No. 10 and in Appendices A, B, and C were computed by the rational method.

RAINFALL:

Rainfall intensity-duration-frequency curves have been developed from the U. S. Department of Commerce Weather Bureau, Technical Paper No. 25 by interpolating the values given for Cairo, Illinois, and Evansville, Indiana. Paducah, Kentucky, lies between these two cities, being closer to Cairo, Illinois, than Evansville, Indiana. Therefore, by the weighted average method, the rainfall intensity-duration-frequency curves were developed for Paducah. These values were checked against the Rainfall Intensity Frequency Regime, Part I, the Ohio Valley, Technical Paper No. 29 of the U. S. Department of Commerce Weather Bureau. The isopluvials of a two-year, one-hour rainfall checked very closely the values determined, as described above by interpolation. Also, the isopleths of one-hundred-year, one-hour storms to two-year, one-hour storms were checked. The results of these values are shown in Figure No. 4.

Of considerable concern in this study on the subject of rainfall is the seasonal probability of intense rainfall. If such heavy storms should occur simultaneously with high river stages, pumping capacities would have to be designed accordingly when the gates through the flood wall are closed. Figure No. 5 is a probability curve in per cent, of obtaining a rainfall in any month of a particular year equal to or exceeding the yearly return period values taken from the isopluvial maps and diagrams. It may be noted from this curve that the greatest probability of storms of one hour duration or less occurs in July and August. On Figure No. 5 is a similar curve of seasonal probability of intense rainfall of 24-hour duration. This curve indicates three peaks--one in March, one in July, and one in September. Thus the short storms which would create high storm water runoff within the City occur in July and August, whereas the storms of long duration (24 hours or longer) occur in March, July, and September.

RIVER STAGES:

River stages are important to the design of storm sewers for two reasons. One, as the river stages rise and cover the discharge ends of the sewers, their capacities are accordingly reduced. Two, as the river rises further, the gravity flows of sewers must be cut off and all sewage must be pumped. The records of river stages at Paducah, Kentucky, for a 29-year period, from 1929 to 1957, inclusive, were analyzed. One curve was developed, Figure No. 6, indicating the average number of days various stages of the river were exceeded per year. For example, Stage 20 was exceeded on the average of 120 days per year. Stage 24.0, the elevation at which the Island Creek gates are closed, is exceeded approximately 95 days per year. Stage 36.0, the invert elevation of the Noble Park relief sewers is exceeded an average of 40 days per year. Also, shown on this chart is a band which includes 50 per cent of the total years analyzed. The probability is 50 per cent that each stage-day relationship will fall within this band. Thus, the probability is 50 per cent that stage 36 will be exceeded from 15 to 56 days per year averaging 42 days.

The chart of Figure No. 7 indicates the months of the year and the average number of days per month that the stages indicated are exceeded. Thus Stage 20 is exceeded on the average 16 days each January, 23 days each March and April, and only one day in August, September, and October. Stage 40 is exceeded on the average only three days each January, six days each February, four days each April, and none in July through October. It is important to note by comparing Figure 5 with Figure 7 that the river stages are always very low during July and August which is the season of heavy, short duration storms that create the maximum flow in storm sewers. The longer, less intense, storms occur in March simultaneously with high river stages.

STORM SEWER DESIGN:

The capacities of the existing sewers were determined by using Manning's Formula and using a coefficient of roughness of 0.013. The slopes of the sewers as indicated on existing drawings were used in determining the capacity.

The required flow of the existing storm sewers was determined from the rational method of determining quantity of storm water flow, using the criteria given in the following table.

TABLE NO. 1

Storm Flow Criteria

Type of Area	Return Period, Years: Separate Sewers	Return Period, Years: Combined Sewers	Overland Flow Time Minutes	Coef. of Run-off, C
Residential R-1 (Suburban-flat terrain)	2	5	20	0.3
Residential R-1 (Suburban-hilly terrain)	2	5	10	0.3
Residential R-2 (City)	2	5	15	0.4
Residential R-3 (two-family)	2	5	15	0.5
Residential R-4 (multiple units)	5	10	10	0.6
Business B-1 (Neighborhood)	5	10	5	0.9
Business B-2 (Downtown)	10	25	5	0.9
Business B-3 (General)	10	25	5	0.9
Industrial M-1 (General)	5	10	10	0.7
Industrial M-2 (Heavy-solid)	5	10	5	0.8
Railroad Yards M-3	5	10	20	0.3
Conservancy, Parks, Cemeteries	2	2	20	0.2

The types of areas referred to in the above reference table are areas indicated on the latest zoning map for Paducah. Longer return periods are provided for combined sewers than for separate storm sewers because of the greater health hazard. The time of flow and the coefficient of runoff indicated in the table have been adjusted to provide equivalent flows as determined by the Chicago Method in areas that were checked for Paducah. The very short overland flow time of five minutes indicated for the business areas assumes direct connection to the sewers for storm water and roof drainage.

The Chicago method of design brought out very vividly the importance of the shorter time of concentration in business area for determining the quantity of flow. The greater percentage of impervious area increases flow into the sewers but also the shorter time of concentration brings the peak rainfall more quickly to the sewer, tending to overload it. Obviously, this is why many have observed a worsening of the flooding situation.

DEFICIENCIES OF EXISTING STORM SEWER SYSTEM:

An early report on the design of a major part of the Paducah storm and combined sewer system reveals the reasons for the inadequacies of the system. This report, dated July 8, 1924 states that the sewers were designed by the "rational method" according to the following standards:

1. Average storm return period - 15 years,

2. One-hour rainfall intensity for 15-year storm - 2.0" per hour,

3. Inlet time - 15 minutes,

4. Runoff coefficient, "C" - Varied from 0.11 to 0.22, depending upon time of concentration. The lower coefficients used for the shorter time were based upon the assumption that time is measured from the beginning of the storm.

A comparison of these standards to those recommended in Table 1 indicates the following:

1. The average storm return period of 15-years used in the design of existing sewers is better than those recommended in this report.

2. The storm data of 1924 for a 15-year period storm return compare more nearly to a 7-year return period, according to the latest data on rainfall shown in Figure No. 4.

3. The inlet time (or overland flow time) compares favorably for residential areas, but is too long for business areas, or other fully developed and paved areas.

4. The runoff coefficients are from one-third to one-ninth the values recommended in Table 1. The low values used for short periods of time are in the greatest error, because of the assumption that more of the early or short time rainfall will be retained in filling depressions and in percolation into the ground. It overlooks the fact now recognized that rainfall antecedent to the maximum rate may saturate the soil and fill the depressions.

The net result of these now obsolete design criteria is that almost the entire storm sewer system of Paducah is underdesigned, providing capacities of one-third to one-sixth those required for reasonable protection against flooding. In other words, the storm sewers may be expected to be overloaded two to five times per year instead of once in 15 years as assumed in the original design.

A check upon the design of the storm and combined sewers of Paducah verified this observation. The drainage system is underdesigned from the street inlets to the river outlets. The design is reasonably well balanced, that is, the inlet capacity is approximately equal to the sewer capacity. If more inlets were added, more sewers would be overloaded, resulting in more backflow at low points.

Now, when inlet capacities are exceeded, water flows past each successive inlet down stream accumulating in quantity until streets are flooded and depressions are reached where the water can be stored. After the peak of the storm passes the water flows out of the reservoir through the limited capacity inlets and sewers until the streets are drained again. The reported ponding of one to three or four hours is not surprising.

Deficiencies of the separate watershed areas described below are based upon the standard criteria of Table 1. The information contained in the following paragraphs is shown in tabular form in Appendices A, B, and C, following Section IV of the report.

Watershed A-1:

The trunk sewer in Friedman Avenue, Howard Street, and Jefferson Avenue becomes increasingly overloaded 17, 34, and 60 cfs (cubic feet per second) respectively, as shown in Appendix A. Also, the trunk sewer in Adams Street and across Thirty-first Street is overloaded from 30 to 50 cfs. At Thirtieth and Jefferson, the outlet from Watershed A-1, the sewer relieving excessive storm flows to the Noble Park outlet facilities is so designed that the 48-inch line discharging into Watershed A-2 will be overloaded before the capacity of the 60-inch relief line is reached. The relief sewer on Thirtieth Street originates at Jefferson as a 48-inch. Although it quickly enlarges to a 60-inch size an excessive loss of head is created, tending to limit the flow into the relief sewer and thereby diverting excessive flow into the Jefferson Street sewer. Where the relief sewer size increases to 60 and 72 inches respectively, ample capacity is available to carry the entire storm flow of Watershed A-1, estimated at 300 cfs. However, it is estimated that the relief sewer is carrying only 1/2 to 2/3 the total flow to this point.

Watershed A-2:

The trunk sewer in Jackson, Twenty-sixth, and Twenty-seventh streets flowing toward Jefferson Street is overloaded its entire length as shown in Appendix A. For example, the 54-inch having a capacity of 70 cfs should have been designed for a flow of 228 cfs, which would have required an 84-inch sewer. The storm flow leaves Watershed A-2 through a 72-inch line in Madison Street at Twenty-seventh Street, which is relieved by a 72-inch line in Twenty-seventh Street. However, this relief device is so constructed that the Madison Street line must carry the greater part of the discharge. Assuming 100 cfs is received from Watershed A-1 through the 48-inch line at Thirtieth and Jefferson, the total discharge from Watershed A-2 would be 410 cfs. The capacity of the Madison Street sewer leaving the area is 145 cfs and the capacity of the 72-inch relief sewer is approximately 170 cfs. Thus, if both sewers are flowing full, the combined capacity is 315 cfs which is less than the design flow by 95 cfs. An analysis of the structure relieving the flow into the Madison Street sewer indicates that it will not permit full utilization of the relief sewer. In addition, discharge at capacity of the Madison Street sewer at Twenty-seventh Street allows for no additional inflow from the area served immediately downstream and leads to overloading of that sewer. This fact accounts for the flooding as noted in the description of flood location No. 2.

Watershed A-3:

This area is served primarily by two relief sewers, one in Thirtieth Street and the other in Twenty-seventh Street. Flow through the Thirtieth Street line is estimated at 200 cfs as it comes from Watershed A-1. Flow through the Twenty-seventh Street line is estimated at 170 cfs as it comes from Watershed A-2. Including the areas drained in Watershed A-3 the total flow is estimated at 550 cfs. The capacity of the double 90-inch line is 475 cfs, which indicates that this sewer is overloaded by 75 cfs. This is only a 16 per cent overload which would not be serious, except that it has failed to adequately relieve older sewers.

Watershed B-1:

Accumulative quantities of water flow overland into and through Watershed B-1 to low points where it is stored for gradual removal through the sewers according to their capacity. Several such low areas occur in Watershed B-1 as shown in Figure No. 3. The 72-inch sewer in Madison Street is overloaded as described in the previous sections at its point of entry into Watershed B-1. Its overloading increases through the area, except that as the sewer passes through an area of low ground elevation between Twenty-first and Twenty-fourth on Madison. At this point it actually relieves some of its overload by a reversal of flow out of inlets and up through manholes in the sewer, as described by witnesses at flooded location No. 2. At flooded location No. 3, property owners have witnessed the reversal of flow out of inlets and manholes in the sewer in Kentucky Avenue. Flooding at location No. 5 is due to the combination of low land where surface water runs past overloaded inlets into this area, and the inadequate capacity of the sewers in that area to carry away the successive load. The 48-inch, 54-inch, and 60-inch trunk sewer along Nineteenth Street from Jackson to Madison is grossly overloaded, as shown in Appendix B, the design flow being three to four times the capacity of this large sewer. Obviously, the sewer would relieve this excess capacity at low points in the terrain such as at Nineteenth and Kentucky. Also the grossly overloaded sewer causes the flow in the Madison Street sewer to be throttled and contributes further to the flooding occurring in Location No. 2. The combined flow of the Madison Street and the Nineteenth Street sewers continues in Nineteenth Street to Clay Street where it converges with the flow from another grossly overloaded sewer in Clay Street and Park Street. If the storm water were not relieved at the points of flooding, the flow in the 96-inch sewer in Clay Street between Seventeenth and Nineteenth would be 900 cfs. The capacity of this sewer is 320 cfs. The design flow for the sewer leaving Watershed B-1 is 950 cfs whereas the capacity of this sewer is only 400 cfs.

Watershed B-2:

Assuming all of the water in the streets reached the sewers and that their capacities were adequate, the trunk sewer leaving Watershed B-2 would be required to carry a flow of 210 cfs and the size required would be 66 inches. Actually, this sewer is 54 inches in diameter and has a capacity of only 40 cfs.

Watershed B-3:

No complaints of flooding have been reported in this area in spite of the fact that the trunk sewer through the area would be grossly overloaded if all of the storm water flow were conveyed to this area. According to design calculations as shown in Appendix B over 1,030 cfs of flow would be entering the 96-inch sewer at Fifteenth and Clay Avenue. Obviously, with a capacity of only 400 cfs, the sewer has relieved its overload in low areas along its route before arriving at this point. The watershed through which this sewer passes would not add much to the total load of the sewer because the local runoff peak would have passed before the flow through the 96-inch sewer from other areas would have arrived. The total flow leaving the area to the river is estimated at 1,200 cfs. The capacity of the 102-inch line is only 500 cfs. Evidently, low land provides storage for some of the excess flow.

Watershed B-4:

Although this area is relatively undeveloped at this time, it is zoned to become primarily an industrial center. It now contains several lakes or ponds which serve as reservoirs for the storage of rainwater and when these ponds are filled to overflowing the water spills into Watershed B-3. This area will probably be served in the future by a separate outfall line to the Ohio River with its own pump station for use in times of storm when the gates are closed.

Watersheds C to K Inclusive:

The sewers in these areas are overloaded by approximately the magnitude indicated for other sewers in the City as shown in Appendix C. However, the flow of storm water that is not received by the sewers flows in the streets which slope toward the river and at many of the ends of the streets the flood wall is provided with openings through which the storm water flows into the river. No complaints of flooding in this area have been reported. These sewers appear to be adequate for the type of storms that occur simultaneously with high river stages. However, one factor is noted in this area that contributes to the problem at Flooded Location No. 1. A ridge occurs at approximately Seventh Street diverting all surface flow from that point away from the river toward Tenth Street. Inasmuch as the overloaded sewers cannot receive this flow it passes on to the low area near Tenth and Kentucky.

Watershed L:

This includes all of the watershed of Island Creek and its branches. In general, it is undeveloped and thereby offers an opportunity for modern design of storm water drainage, as the drainage areas develop. However, Watersheds L-6 and L-7 are highly developed including much of the commercial center of the City. Some of the most damaging floods in the City have been reported in Watershed L-6. The inadequate capacity of sewers in this area as well as in adjacent areas causes overland flow to the low areas of this watershed. One of the lowest areas in the City is located in Watershed L-6 and therefore much of the water accumulates at this point. The drainage from this area is through a 48- and 54-inch storm sewer discharging into an arm of the conservancy area and has a capacity of 100 cfs. It is estimated that a sewer of 530 cfs is required.

Watershed L-7 is drained by a box culvert having a capacity of 283 cfs. Emptying into this culvert is a 36-inch sewer in Kentucky Avenue, the upstream end of which is at Nineteenth Street. In spite of this large sewer, flooding occurs between Seventeenth and Nineteenth on Kentucky. Also located in Kentucky Avenue between Seventeenth and Nineteenth is a 21-inch sewer draining into Watershed B-1. It appears that the 21-inch sewer is carrying the storm water drainage in Kentucky and the 36-inch sewer in Watershed L-7 is not in use to its capacity. It requires the capacity of both the 21-inch and the 36-inch to properly drain Kentucky Street only. The box culvert, owned by the Illinois Central Railroad, has ample capacity to receive all drainage of Kentucky Avenue from Nineteenth Street to Fifteenth Street.

The "Conservancy Area" is low land set aside for periodic flooding and storage of water and for gradual removal through the flood wall.

Water passes by gravity to the river at low river stages. At stages above 24.2 the gates are closed and all water is pumped. Were it not for the large storage capacity of this reservoir, pumps of much larger capacity would have been required. The Corps of Engineers designed Pump Station No. 11, to take advantage of the storage reservoir. It was designed to pump the runoff of a storm which occurred on January 20 to 24 inclusive, 1937, which occurred simultaneously with the high river stages of that year. The reservoir was designed to fill to stage 44. Subsequent records have indicated that the storm of 1937 has a return period of over 100 years. (See Figure 8, Pump Station No. 11 - Capacity Curve) Ample capacity is available for the design storage providing the area is not filled in and further restricted. The present zoning ordinance should be strengthened to prevent extensive filling of the reservoir area. Eventually this area may be converted into a city park, beautified and improved with facilities compatible to its primary purpose of storm water storage.

Watershed O:

Some drain lines installed in this area have been directed into the Island Creek watershed. The terrain of the area indicates that drainage should be toward the outlets which have been installed through the flood wall directly into the river. These outlets are equipped with flap valves and provide logical locations for future pumping stations. These outlets are of adequate capacity.

Watershed M:

No storm sewers have been installed in this area, all drainage being handled by overland flow to Pump Station No. 12, which is adequate.

Watershed P-1:

This area is served by the Branch Street Sewer which has been designed of adequate capacity for two-year return period storms. Storms of greater magnitude will, of course, overload the sewer and cause overland flow. However, since this is a separate storm sewer carrying no sanitary sewage, this design appears to be reasonable and adequate. The inlet structure does tend to clog with debris.

Watershed P-2:

Flooding at Area No. 6 is caused by inadequate ditch capacity. The ditch has been reduced in capacity by the improvements around it. Also, it is poorly maintained. The bridge of adequate capacity before development occurred now requires enlargement of waterway.

Watersheds R and S:

These areas are relatively undeveloped at present but plans for storm sewers should start early enough to assure economic and efficient development.

Watershed T:

This area is relatively undeveloped. No storm sewers have been installed. It drains into Crooked Creek. Developers should be controlled to assure adequate drainage facilities.

PROPOSED IMPROVEMENTS:

Several plans for improvements to the existing system were considered. One would be to replace the existing sewers with drain lines of adequate capacity as indicated in Appendices A to C inclusive. Obviously this is not a feasible plan. Another plan would be to provide auxiliary sewers paralleling all of the existing sewers and providing the additional capacity required in the parallel sewers. In some areas, this plan may be feasible, but in general where sewers are already of large capacity, this plan would lead to congestion in the underground facilities of existing streets. A third plan and the one generally used in the proposed improvements is to provide relief sewers designed to remove the excess flow in a direction at right angles to the existing sewers and to the points of shortest lengths for relief.

Obviously the combined system is adequate for the sanitary flow it carries. Where relief is provided for the storm flow, the proposed improvements must provide for the normal passage of sanitary sewage through the present system. Where relief is provided to combined sewers, the relief is so designed that the flow of sanitary and storm water must reach twice the maximum sanitary flow before the relief is placed in operation.

In new watersheds it is proposed that no combined sewers be installed. Also it is proposed that where flows exceed the capacity of 84-inch sewers, the drainage be provided in open ditches and creeks with adequate rights-of-way secured to construct these facilities. Developers should be required to provide for drainage of storm water through their areas, with adequate capacity to pass the drainage of areas upstream from their development.

The proposed improvements are shown in Figures No. 9 and No. 10. The watersheds are divided essentially as indicated in Figure No. 3. However, their boundaries are modified substantially by the improvements proposed. Watershed A is enlarged by the addition of new relief sewers through Noble Park and by the construction of new storm sewers discharging at the same point. This will help relieve the overloaded sewers in Watershed B. As much storm water as possible is diverted into Watershed L to reduce the overload in all of the other watersheds A to K inclusive.

Where storm sewers are proposed for construction they are sized for the ultimate development of the area according to the zoning map of the City. Sizes are tentative and would be subject to more vigorous analysis in final design.

The construction program is arranged in three steps. Step I is for immediate construction and is designed to relieve the more serious areas of flooding and damage. Step II construction is to follow as soon as plans for financing can be arranged and will provide relief for other areas of flooding and damage. Step III construction or future construction is to be done if and when funds are available and in new areas as they are developed.

The following is a detailed description of the proposed improvements:

Step I of the Construction Program (Immediate):

Project I-A: (Figure 10, Watershed A-1.4)

To eliminate the flooding in Friedman Avenue, Howard Street, and West Jefferson, it is proposed to install a 36-inch and 48-inch relief sewer down Howard Street to Monroe Street and down Monroe Street from Thirty-fourth to Thirtieth as shown in Figure No. 10. This relief sewer will also eliminate the bottleneck that now exists at Thirtieth and Jefferson in the 48-inch section of the Thirtieth Street relief sewer.

It is also proposed to install an automatic float operated gate valve in the 48-inch line in Jefferson Street downstream from the relief sewer in Thirtieth Street to shut off the flow of this line when the storm water has diluted the sanitary sewage to 50 per cent of the sanitary sewage strength. When this valve is closed all of the storm and sanitary drainage from Watershed A-1 will be diverted into the relief sewer in Thirtieth Street. This sewer has adequate capacity (300 cfs) for the entire flow from Watershed A-1. The 48-inch sewer in Jefferson Street below this point will be fully relieved and available to receive the flow from areas downstream.

It is proposed to install a similar shutoff valve in the 72-inch sewer immediately downstream from the relief sewer located in Twenty-seventh Street at Madison. This will further relieve the Madison Street sewer of the flow from areas upstream for the use of carrying flow from areas further downstream.

It is expected that the improvement described above will reduce the amount of flooding that will occur in flooded location No. 2, but will not completely alleviate the problem, according to the standards set forth in the design criteria. The overloaded sewer in Nineteenth Street will continue to cause water to back up and out of the manholes in this area. Also, the inadequate capacity of inlets in the entire drainage area in this vicinity will cause overland flow into this low area.

<u>Project I-B</u>: (Figure 9, Watershed L-6)

It is proposed that relief sewers be constructed in Watershed L-6 as shown in Figure No. 9, relieving flooded area No. 1 at Tenth and Kentucky. These relief sewers are designed in so far as possible to carry only storm water inasmuch as they are emptying into the conservancy area. One 66-inch sewer originates for this stage of construction at Eleventh and Broadway and extends between Broadway and Kentucky on private right-of-way. It is designed for a capacity of approximately 190 cfs for future extension up Eleventh Street to Clay Street. In Kentucky Avenue a 60-inch branch is extended from Eleventh Street to Tenth Street and another branch extends from Eleventh Street to the 24-inch drain line from the Illinois Central Railroad property at Thirteenth Street. Another 48-inch branch extends from Kentucky to Broadway in Twelfth Street to relieve the overloaded 42-inch line now located in that street. A float operated valve is proposed in the 36-inch line in Monroe at Twelfth Street to relieve the overloaded 54-inch line in Harahan Boulevard. The Eleventh Street relief sewer extends from Kentucky Street to Adams Street on private property where necessary and has a capacity of 400 cfs. The proposed 108-inch sewer extends down Adams Street from Eleventh to Twelfth paralleling the existing 54-inch sewer to an outfall structure. This line is designed for a capacity of 600 cubic feet per second to provide for a future connection of Watershed L-6.4. This sewer will relieve the property damage in flooded area No. 1. However, the streets will continue to be flooded and traffic will be interrupted until the sewers indicated for future construction in Watersheds L-6.2 and L-6.4 are completed.

In final design, consideration should be given to the possibility of constructing an open paved channel from Eleventh and Kentucky to the conservancy reservoir in lieu of the proposed 90- and 108-inch enclosed conduits. The route would be more direct and will cost less if right-of-way can be obtained economically.

In order to assure proper drainage of Flood Area No. 1, and maintain economical sewer design, it is necessary to have an ample slope of the sewers from Eleventh and Kentucky to the outlet in the conservancy area. This can be accomplished by maintaining a flood level in the conservancy four feet lower than now provided. As indicated in Figure No. 8, this can be done without adding pumps to Station No. 11, for storms of 25-year return period (frequency), provided the reservoir volume is not further restricted by land fill. The design of all relief sewers discharging into the conservancy area assumes, therefore, that the conservancy level will be maintained at 40.0, instead of the existing 44.0 level. This should not be construed to permit construction at lower elevations. Obviously any basement lower than the level of the hydraulic gradient of the sewer (usually designed for the top of the sewer pipe) would be flooded. It has been necessary to design to very close tolerances the drainage of existing streets to prevent flooding of buildings in the low areas of the City. Future construction in low areas should be carefully checked as to grade and elevations for drainage before being approved.

Project I-C: (Figure 9, Watershed L-7.1)

The existing 36-inch sewer in Watershed L-7.1 in Kentucky Avenue from Nineteenth to the box culvert should be reconditioned and improved with inlets added where necessary to drain Kentucky Avenue. This sewer probably will require thorough cleaning and reconstruction in sections where construction is poor and deteriorating. The 18-inch sewer on private right-of-way entering this sewer should be plugged off and abandoned. In order to determine the exact requirements of renovating this sewer, a thorough inspection of the sewer would be the first order of business in final design. The reconditioning and improving of this sewer should do much to relieve the flooding in Kentucky Avenue. However, the standards provided for in the design criteria will not be reached until additional relief sewers are constructed in Watershed L-7.2.

Project I-D: (Figure 9, Watershed L-8.5)

This project is proposed for immediate construction because it will do much to relieve flooding in Areas 2 and 3, inasmuch as it helps to relieve the overloaded sewer in Nineteenth Street. It transfers a large area from Watershed B to Watershed L.

A float operated valve is proposed in the existing 48-inch sewer at Nineteenth and Jackson. This valve will close when storm flow reaches twice the maximum sanitary flow, diverting all flow to Island Creek.

Step II of the Construction Program:

Projects in Step II of the construction program continue to relieve the more serious areas of flooding. The projects for Step II construction are listed as follows:

Project II-A: (Figure 10, Watershed A-1.2)

Labelle Avenue Relief Sewer, 33 inches in diameter from Buckner to Jefferson will relieve the overloaded sewer in Buckner and divert it to a 42-inch sewer in Jefferson that has been relieved by the first stage of construction.

Project II-B: (Figure 10, Watershed L-10.6)

Forest Circle Diversion Sewer to branch of Island Creek 42 inches in diameter will relieve the sewer in Adams Street below this point.

Project II-C: (Figure 10, Watershed P-2.2)

New storm sewer in area P-2.2 to relieve flooding of ditch now occurring. This will be a separate storm sewer designed for storms of two-year frequency.

Project II-D: (Figure 10, Watersheds A-3 and A-4.3)

Twenty-fourth Street relief sewer discharging in Noble Park originates at Madison Street 78 inches in diameter and terminates as a 90-inch square culvert. It provides direct relief for flooded area No. 2. However, street flooding and some yard flooding will not be eliminated until the proposed future sewers on Watersheds A-2.4, A-2.5, A-4.1, and A-4.2 are constructed.

Project II-E: (Figure 10, Watersheds A-5.1 and A-3)

Kruger Street relief sewer originates at Twenty-fifth and Kruger and terminates in Noble Park. This will relieve the flooding at Twenty-sixth and Kruger.

Project II-F: (Figure 9, Watershed L-8.3)

Little Street relief sewer originates at Park Avenue and terminates at the bank of Cross Creek.

Project II-G: (Figure 9, Watershed L-7.3)

Fifteenth and Kentucky storm sewer originates at Fifteenth and Broadway and terminates at box culvert in Kentucky Avenue. Relieves the overload of sewers in this area.

Project II-H: (Figure 9, Watershed L-6.1)

Broadway storm sewer, 30 inches in diameter, from Thirteenth to Twelfth Street, will relieve local flooding in that area.

Project II-I: (Figure 9, Watershed L-7.2)

Seventeenth Street relief sewer originates at Clark Street and terminates in 3-foot by 3-foot box culvert that enters the Illinois Central Railroad property. This will relieve partially the overloaded sewer in Nineteenth Street. It will require the construction of a float operated valve to shut off flow to Nineteenth Street at a predetermined flow level.

Step III - Future Construction:

The remainder of the proposed sewers shown in Figures No. 9 and No. 10 should be constructed when required, due to developments in the area or as funds are available for relief of area flooding. Their construction should be evaluated on a basis of the economic benefits derived, particularly in those areas where construction of streets and roads and improvements have already been made. It is quite conceivable that a certain amount of street and gutter flooding can be tolerated when compared to the cost of the project necessary to relieve such flooding.

Developers should be required to furnish adequate and permanent storm drain facilities for their developments and to carry the flows from all runoff areas upstream. The City may assist in providing extra capacity for the future development of upstream areas.

ESTIMATES OF CONSTRUCTION COST:

The following estimates of construction cost are based upon 1961 dollars and include all engineering, legal, interest during construction, and other overhead expenses. They do not include the cost of purchased private right-of-way if and when required.

TABLE NO. 2

Step I (Immediate) Of The Proposed Construction Program

Storm Relief Sewers

Project Number	Location Watershed Area No.	Total Project Cost
I-A	A-1.4	$173,300
I-B	L-6.1, L-6.2, L-6.4, L-6.5	453,100
I-C	L-7.1	61,500
I-D	L-8.5	154,500
	Total	$842,400

TABLE NO. 3

Step II Of The Proposed Construction Program

Storm Relief Sewers

Project Number	Location Watershed Area No.	Total Project Cost
II-A	A-1.2	$ 17,200
II-B	L-10.6	25,400
II-C	P-2.2	63,700
II-D	A-3 and A-4.3	755,900
II-E	A-5.1 and A-3	209,200
II-F	L-8.3	30,800
II-G	L-7.3	29,600
II-H	L-6.1	18,200
II-1	L-7.2	53,800
	Total	$1,203,800

TABLE NO. 4

Step III Of The Proposed Construction Program

Storm Relief Sewers
Shown on Figure No. 9

Project Number	Location Watershed Area No.	Total Project Cost
III-A	L-11.1 and L-11.5	$191,700
III-B	0-2	378,800
III-C	0-1	690,600
III-D	L-15.2	22,800
III-E	L-15.1	8,600
III-F	L-3.1	22,100
III-G	L-5	35,200
III-H	L-4.1	95,400
III-J	L-6.8	29,300
III-K	L-6.3 and L-6.5	235,200
III-L	L-6.2	104,700
III-M	B-3.1	340,600
III-N	B-4.1 to 4.4 incl.	898,000
III-O	A-5.2	(See Table No. 5)
III-P	A-5.1	30,900
III-Q	L-8.2	32,900
III-R	L-8.3	100,600
III-S	L-8.4	127,500
III-T	L-9.7	(See Table No. 5)
III-U	L-9.6	(See Table No. 5)
III-V	L-9.5	111,800
III-PP	L-8.1	92,600
	Total Figure 9	$3,549,300

TABLE NO. 5

Step III Of The Proposed Construction Program

Storm Relief Sewers
Shown on Figure No. 10

Project Number	Location Watershed Area No.	Total Project Cost
III-O	A-5.2	$167,100
III-T	L-9.7	662,000
III-U	L-9.6	94,800
III-W	A-4.1 and A-4.2	188,700
III-X	L-9.4	61,400
III-Y	A-2.1	79,100
III-Z	A-2.4	162,700
III-AA	L-9.3	29,700
III-BB	L-10.7	7,800
III-CC	L-10.2	68,000
III-DD	L-10.3	77,800
III-EE	L-10.4	57,000
III-FF	L-10.5	169,000
III-GG	L-10.6	95,300
III-HH	P-2.1	136,800
III-JJ	P-1.1	165,400
III-KK	T	115,900
III-LL	R	85,100
III-OO	L-9.1	91,000
	Total Figure No. 10	$2,514,600

Total Figure No. 9	$3,549,300
Total Figure No. 10	2,514,600
Total Step III	$6,063,900

The total cost of projects proposed herein is summarized as follows:

TABLE NO. 6

Step I Construction	$ 842,400
Step II Construction	1,203,800
Step III Construction	6,063,900
Total Project Cost	$8,110,100

ECONOMIC JUSTIFICATION:

The normal procedure in determining the economic justification for proposed flood control and alleviation projects, is to ascertain the damage derived from such floods. If the damage on an annual basis justifies the capital expenditure, the project is considered feasible. Property damage has been experienced in Paducah in connection with storm water flooding. Some merchants interviewed indicated that each storm cost them $5,000, others placed the price of $3,000 to $1,000 on the amount of damage done. Others indicated the first storm they experienced cost them heavily but since that time they have devised means of protecting themselves against serious damage. Several homes have been damaged by flood waters rising to the floors of the homes and some near tragedies have been reported in connection with children wading and playing in the water. Floods that interrupt traffic on streets cause loss of time to people. The loss of business in flooded areas due to the reluctance and/or inability of customers to trade with concerns at such locations during stormy weather is an intangible loss. The hazard to health and safety is another intangible loss. Various estimates of the annual loss due to storm water floods range from $30,000 to $50,000. Intangible damages such as loss of time and loss of business may add another $20,000 to this, making a total annual loss between $50,000 and $70,000. Theoretically, this would justify a capital expenditure between one and one-half million dollars in storm water alleviation projects. This includes no dollar value for health and safety.

Damages due to storm water flooding will increase with time as improvements in the City are made converting pervious areas to paved and roofed areas causing greater runoff. The hazards to health and safety and to the protection of property from fire and other types of damage other than flooding, can and will increase in magnitude as time passes. It would be reasonable to expect a five to ten per cent per annum increase in damages, unless something is done to alleviate the situation. Development of the City may be impeded by the reluctance of business and industry to locate in areas subject to periodic flooding. Considering the intangible benefits of an adequate storm system and the anticipated increase in damages, the estimated cost of the first two steps of construction as recommended herein appears to be amply justified. Additional construction may require reappraisal upon completion of Steps I and II.

Storm sewers located in new areas should be designed to modern standards and of adequate capacity. They can be so designed at a very nominal additional cost, because the cost of extra capacity required is not proportional to the extra capacity provided. For example a sewer of five times the capacity of another sewer, can be constructed for less than double the cost. A sewer of three times the capacity can be built for only forty per cent additional cost. The future construction would be justified on the basis of damages that would otherwise occur if the system were not constructed as indicated.

The City of Paducah must determine and limit its responsibility in connection with flood and storm water protection. The question may be asked, "Why should all have to pay for improvements to protect the few who are located in low areas?" The answer usually presented is, "The low areas become flooded because of runoff from all of the areas, high or low." And the runoff increases because of the added roof and pavement areas that City development has brought. Therefore those located in low areas are not entirely responsible for their problem. On the other hand, there is a minimum level for which reasonable protection can be provided. The conservancy area is an example of a location on which <u>no</u> construction should be permitted. The minimum elevation for which drainage should be provided at any location is dependent upon the hydraulic gradient of the system for designed flows. It should be pointed out that if the system is designed for storms that occur at a return period of once every two years, this system will become overloaded for storms having a longer return period. For example, a storm of one hundred year period would produce flows of more than double the amount for a two-year storm. With the improved system, a storm of this magnitude would cause some ponding but not as much as is now being experienced with the inadequate sewers. Therefore, not all damage will be eliminated. However, instead of three or four storms per year causing damage and flooding, the frequency will be reduced to one storm every five or ten years.

The cost of providing relief for underdesigned sewers in a built up city is, indeed, very high. The congestion of traffic and utilities as well as the expenses of removing and replacing pavement and other obstructions add substantially to the cost. Ordinances should be passed and control and cooperation should be provided to protect the City against additional and repeated violations of flood flow requirements that eventually lead to costly relief facilities, such as required now in Steps I and II of the proposed construction program.

- SECTION III - SANITARY SEWERS -

SECTION III - SANITARY SEWERS

CRITERIA FOR DESIGN:

The areas served by separate sanitary sewers are indicated on Figures No. 12 and No. 13. Also on these maps are indicated the locations of existing and proposed sewer mains and laterals.

Early sewer systems were constructed for the purpose of carrying away storm water. Later, the practice of disposing of sanitary wastes in the same sewers became an accepted practice. As this practice was continued, sewers were designed to carry both wastes, until the rivers became overloaded with filth. When, in order to relieve the pollutional load on the rivers, it was necessary to construct sewage treatment plants, it was found that the cost of treating the combined wastes was prohibitive. Later designs, therefore are planned to keep sanitary wastes and storm water separate. In cities where there are combined systems, sewage treatment is designed for a capacity somewhat above the normal sanitary flow. At times of rainfall, all flow above the designed capacity of the plant is bypassed to the receiving stream without treatment.

It is recommended that future planning of sewers for Paducah make provision for collecting storm water and sanitary sewage in separate pipe systems.

All sanitary sewers should be so designed that the minimum velocity flowing full will be not less than two feet per second. Where there is insufficient carrying velocity in the sewer, there will be deposition and decomposition of the organic matter with attendant unpleasant odors. Gases generated in the decomposition process attack concrete, metals, paint, and other materials. It is sometimes necessary to repump the sewage several times along the course of the sewer if there is insufficient fall in the topography to provide gravity flow at an adequate velocity.

For the purpose of computing sewer sizes and capacities, both of existing mains and of proposed sewers, it was necessary to make certain assumptions. One of these assumptions concerned the number of persons contributing to any given sewer. In congested areas a figure of 25 persons per acre was used. There are probably some very small areas where this number is exceeded, but they are not numerous enough to affect the design materially. In outlying areas a figure of 12 persons per acre was used. The figure 12 represents about 3.2 families per acre, with an average of 3.75 persons per family. In intermediate areas a figure somewhere between 12 and 25 persons per acre was assumed. Of course, in some of the higher value areas, with homes on large lots, a figure lower than 12 might have been used.

In computing the quantity of sanitary sewage flow, designs are based upon an average contribution of 100 gallons per capita per day. The flow varies from the average during the day, reaching a peak during the morning, and a minimum sometime after midnight. The larger the number of services connected to a specific sewer, the more the ratio of the peak to the average flow will be reduced. The design of this report is based upon an assumption that the magnitude of the peak flow in the sewer varies from 400 per cent for a small area with a connected population of 500 persons or less, to 260 per cent for an area with a connected population of 20,000. This assumption is shown graphically in Figure No. 11.

SEWERS WITHIN PRESENT CITY LIMITS:

Description of the Sewer System:

In general the areas east of Ninth Street and south of Ohio Street have separate sanitary sewers. The flow from these districts is conducted to one of two sanitary sewage pumping stations, from where it is eventually delivered to the treatment plant.

Flow from the district east of Ohio or Jones Street is delivered by gravity to the lift station at Fourth and Husbands streets. A 12-inch cast iron force main extends from this station to Third and Norton streets. A 24-inch gravity sewer extends from that point to the lift station at Third and Harrison streets. All flow from sanitary sewers from Jones Street to Park Avenue is delivered to this 24-inch main or direct to the station at Third and Harrison streets.

Sanitary sewage is pumped from the station at Third and Harrison through a 16-inch cast iron force main to a 27-inch gravity sewer originating near Sixth and Campbell streets. The 27-inch gravity main delivers the sanitary sewage to a lift station adjacent to the treatment plant at Sixth and Terrell streets.

The central part of the City is served by combined sewers. These have storm water relief at various locations, but the "dry weather" or sanitary sewage flow is normally conducted to the treatment plant by way of the 102-inch sewer to the lift station adjacent to the treatment plant.

A small portion of the area on the west side is served by separate sewers, but the major portion is served by the combined system.

Combined Sewers:

Study of the combined sewer system has been limited, largely, to storm water problems. The capacity required to carry storm water is sometimes as much as one hundred times that required to carry the sanitary sewage flow. The capacity required for sanitary flow is not usually significant compared to the storm water requirement.

Sanitary Sewers for the East Side of Paducah:

Computations of theoretical capacities of the main sewers on the East Side indicate that they are adequate for the tributary area within the present city limits. Typical computations are summarized in Table No. 7.

It will be noted by examination of the two columns on the right of Table No. 7 that the main sewers on Sixth Street and Third Street are sized for an overall population density of 10 to 15 persons per acre. The sanitary sewer system on the East Side should be adequate except for pumping capacity until the "equivalent" population contributing to this part of the system exceeds 33,000. All of the main sanitary sewers above the present lift stations have capacities in excess of the requirements for the areas within the present city limits. The effects of annexing new areas on the East Side are discussed elsewhere in this section.

The term "equivalent" population is used in order to take into account industrial flows. Hydraulically, the quantity of 100 gallons per day is used to represent the equivalent of one person. In terms of organic load, the quantity of 0.17 pounds of B.O.D. per day is used as the equivalent of one person. These are annual average values, subject to variations from day to day, and from hour to hour within the day.

TABLE NO. 7

Capacities of Sanitary Sewers

Location	Size	Capacity in gpm	Capacity as Population	Tributary Area, Acres
West 6th Street	27"	5,460	33,000	2,274
3rd St. at Madison	24"	4,060	22,500	2,205
3rd St. at Jones	24"	4,060	22,500	1,815
4th St. E. of Husbands	18"	2,030	10,000	625
4th St. at Farley	18"	2,100	10,000	502
4th St. at Woodward	15"	2,450	12,200	261
Clements at 4th Street	15"	1,330	6,000	241
Husbands at 5th Street	30"	6,510	40,000	1,190
Caldwell at Caldwell	18"	1,820	8,600	335
Caldwell at Caldwell	24"	3,150	16,500	675
Caldwell at Park	18"	1,820	8,600	271
Wheeler at Mayfield Road	24"	3,150	16,500	598
Mayfield Road at 22nd	21"	2,450	12,000	504

Figures No. 12 and No. 13 show existing sanitary sewers and also proposed extensions. In general, the routes of both the sewers and proposed extensions are taken from maps prepared by the City Engineer.

Sanitary Sewers for the West Side of Paducah:

All separate sanitary sewers on the West Side are discharged into existing combined sewers.

Many of the problems relating to sanitary sewers on the West Side were discussed in the report on "Sewers for Annexed Areas" dated November 23, 1959. The sewers shown on Figures No. 12 and No. 13 have been revised from those recommended in the previous report as required by changed conditions. For example, sewers in the Country Club Terrace Addition have now been constructed so as to discharge into an existing sewer on Pines Road, rather than as recommended previously.

Sewers are now under construction on Kennedy Road in the Bellemeade Addition, and are shown as if completed. It was previously recommended that a new gravity sewer be constructed in Blandville Road to a point near Forty-third Street. Sanitary wastes from the Bellemeade Addition and from other areas west of the "Divide" were to be pumped from a new lift station on Blandville Road near Kennedy Road to the last manhole on the new gravity sewer. However, the property on Kennedy Road has been developed before the construction of the Blandville Road sewer. Sewage from Kennedy Road will therefore need to be pumped to an existing sewer manhole located at about Fortieth Street. It is expected that in the future the arrangement will be changed to approximately that which was recommended.

It is, of course, recommended that all new sewers on the West Side be separate, with sanitary sewage being conducted to existing conduits in the City system, and storm water being conducted outside the levee to Perkins Creek.

There is one situation with respect to the sanitary sewers on the West Side to which attention should be called. The sewer on Park Avenue is adequate for the present and for some indefinite period in the future. Eventually, however, this 15-inch sewer must be relieved with another sewer of larger capacity. As indicated on Figure No. 13, this sewer serves an area of approximately 740 acres lying south of Park Avenue and Hinkleville Road between Thompson Avenue and Allen Lane. This sewer will need to be increased to at least 18-inch size from Thompson Avenue to Minnich Avenue as the area is developed and as homes and business establishments are constructed.

SANITARY SEWERS FOR FUTURE ANNEXED AREAS:

General Plan:

Discussion of sewers for future annexed areas must treat separately those areas in the Island Creek and Tennessee River watershed and those in the Perkins Creek watershed. The limits of these watersheds are indicated on Figure No. 2.

The Paducah General Plan prepared for the Paducah Planning and Zoning Commission in 1954 by Metropolitan Planners, Inc., of Indianapolis, has been used as a reference to indicate the general boundaries which might be considered for future annexations by the

City of Paducah. The limits of the areas under consideration are shown on Figure No. 2.

The Paducah General Plan included studies of alternate methods for providing sanitary sewer service for the external areas.

Estimates of cost for sewers in the external areas have not been prepared for this report for the reason that no actual survey has been made.

Sanitary Sewers for Future Annexed Areas in the Island Creek Watershed:

The Paducah General Plan provided for the entire area from Mayfield Road to the Clarks River Ferry Road to be served by a single system draining to a sewage lift station located on the west side of Island Creek at the present city limits line. The discharge from this pump station would be conducted to the existing 30-inch sanitary sewer at Caldwell Avenue.

The 30-inch sewer has ample capacity for this addition. The pump stations and main sewers from Fourth and Husbands streets to the treatment plant would have to be increased in capacity if the area is ever developed to its potential. The area between Mayfield Road and the Clarks River Ferry Road is approximately 3,000 acres, not including that which is submerged during periods of heavy rainfall.

The topography is quite flat, particularly that portion east of Island Creek. In order to provide adequate service a number of small lift stations will be required. It will not be possible to collect the sewage by gravity as indicated in the 1954 Plan. It is approximately 18,000 feet from the proposed lift station to the farthest point to be served. Gravity sewers of the sizes contemplated should have slopes from two feet to three feet per thousand, so that a total fall of nearly 50 feet would be required for gravity sewers.

There are a number of existing gravity sewers ending near the present city limits which have reserve capacity and to which wastes from small sections of the external area could be discharged. Whether these sewers, having been paid for by the present residents of Paducah, are available for use by others now outside the City, is a question for consideration by the City Administration. Some of these sewers and their reserve capacities in terms of population equivalent are:

15" Sewer at Bethel and Lowell Streets	1,000 Population Equivalent
15" Bridge Street sewer at Reeder Street	2,600 Population Equivalent
18" Caldwell Avenue sewer at Park Street	4,600 Population Equivalent
12" Schneidman Road at Starke Avenue	1,800 Population Equivalent

Use of the above sewers would permit a piecemeal annexation and development of the area to only about thirty per cent of its potential. It would be much better, therefore, to plan ahead for the full development and to provide sewerage facilities in accord with an overall plan. The overall plan could, of course, take advantage of the reserve capacity in the above sewers if that is desired.

It is suggested that sewers in the Lone Oak area which would drain naturally into the Island Creek watershed be designed so that the wastes can be pumped over the divide into sewers to be constructed in the Perkins Creek watershed. This plan would be more economical than to extend sewers from the Island Creek system to that area.

Sanitary Sewers for Future Annexed Areas in the Perkins Creek Watershed:

The Paducah General Plan of 1954 proposed three alternate methods of providing sanitary sewers for the external areas in the Perkins Creek Watershed. These plans originated in the Lone Oak area and served other areas along the way. They are briefly described as follows:

Alternate No. 1 would provide a new sewage treatment plant at the confluence of Crooked Creek with Perkins Creek to serve the area between that location and Lone Oak. No provision is made for sanitary sewer service below the proposed treatment plant. An outfall sewer to carry treated sewage is proposed to be constructed from the treatment plant to the Ohio River.

Alternate No. 2 would provide a long outfall sewer around the City from Lone Oak along Crooked Creek and Perkins Creek, and eventually to the present sewage treatment plant at Sixth and Terrill streets. This is, of course, the most expensive plan, but it does serve the largest area of potential development, and centralizes all treatment in the one plant.

Alternate No. 3 is called a "temporary expedient." Sewage would be collected from Lone Oak and from the area tributary to Crooked Creek above Pecan Avenue. It would be pumped through the City into an existing sanitary sewer at the Country Club.

This report concurs with the conclusion of the General Plan of 1954 in that Alternate No. 2 is the most comprehensive plan, providing the facility for sanitary service for all of the external area west of Paducah. Alternates No. 1 and No. 3 leave large areas for which no provision is made. Any temporary facilities required to handle isolated development areas should not be permitted to affect adversely the General Plan of Alternate No. 2. Simple treatment facilities, such as sewage lagoons, may be constructed along the route of the outfall sewer and then abandoned as the outfall is extended, or completed.

SEWAGE TREATMENT:

The existing primary sewage treatment plant includes grit removal, screening, primary sedimentation, and separate digestion of sludge solids. The plant is designed for a capacity of five million gallons per day (average flow). Reference to Figure No. 1 indicates that the existing plant is expected to be adequate in capacity for approximately 25 years. This conclusion may need to be modified because of one or more of the following circumstances: (1) The population may increase at a rate more or less than that indicated in Figure No. 1; (2) The capacity of the plant is not determined entirely by the average sanitary sewage contribution of the population--some account must be taken of the extra flow caused by collecting both sanitary sewage and storm flow in the same pipes; (3) Health authorities may be expected to require partial secondary treatment of the sewage before the expiration of 25 years. Primary treatment removes only about 30 per cent of the objectionable organic matter (as measured by B.O.D.). Approximately 70 per cent of the organic matter is discharged to the stream untreated.

For the purpose of this report, it may be said that the present sewage treatment plant is adequate for the foreseeable future.

ESTIMATES OF CONSTRUCTION COST:

The improvements and extensions indicated on Figures No. 12 and No. 13 involve construction of minor extensions to existing lines and future extensions of outfalls, trunk sewers, and lift stations.

The extensions to the existing system should be made out of a revolving fund replenished from the sewer connection fees. Each project should be evaluated for economic feasibility before construction. Estimates of the cost for such sewers have not been prepared for this report for the reason that each is a separate problem involving details not now available, and not involving the major problem of master planning. A revolving fund for the construction of these extensions is all that is required for their financing.

The future outfall relief, trunk sewer, and lift station construction proposed herein is not estimated because none are required in the immediate future, and estimates based upon today's dollar would be of little use when construction is required.

- SECTION IV - FINANCING THE PROPOSED IMPROVEMENTS -

SECTION IV - FINANCING THE PROPOSED IMPROVEMENTS

DISCUSSION OF VARIOUS METHODS OF FINANCING:

Four methods are in general use for financing sewer improvements. They are:

(1) Assessment by benefit districts;
(2) General obligation bonds;
(3) Sewer revenue bonds;
(4) "Pay as you go."

The present practice of building sewers from revenues and collecting a connection charge is a variation of (4).

For many years the most common plan for financing the construction of sewers was by special tax assessment against the property owner. Tax bills were usually negotiable and became a lien against the property. Sometimes the contractor retained the tax bills and made collections thereon. More often the contractor found it expedient to sell the tax bills, usually to a bank or other financial institution. Usually it was necessary to sell the tax bills at a discount. Through the years this method of financing has become progressively more unsatisfactory. It is still used to some extent but has largely been supplanted by other methods.

General obligation bonds are supported by the tax base of the community. Bonds are issued for long periods of time, and payments of principal and interest are made from general tax revenues. Quite often a lower interest rate can be obtained for general obligation bonds than for revenue bonds because of the smaller risk to the investor. General obligation bonds are used to finance projects which benefit the entire community. If there is not a benefit to the entire community, some other financing method should be used, in order to avoid the risk of having the project stopped by a court action instituted by a citizen who receives no benefit.

Revenue bonds are now a very popular method of financing improvements. In the case of sewer improvements, service charges are collected from all users of the sewer system. These revenues are then used to pay interest charges and payments of principal on the bonds. Revenue bonds usually command a somewhat higher interest rate than general obligation bonds. Their principal advantage is this-- the maximum bonded indebtedness of any city is limited by law. The statutes apply, however, only to general obligation bonds. A city may issue revenue bonds for any project for which revenue is received, keeping its capacity for issuing general obligation bonds available for nonrevenue producing projects such as parks and streets. Usually the only limitations imposed on the issuance of revenue bonds are those of the bond buyers, the financial institutions. These institutions study issues of revenue bonds very carefully before investing. The city's financial adviser will usually consult with financial institutions very early in the proceedings of setting up a revenue bond issue. In many localities it is not necessary to ask the citizens to approve a revenue bond issue, whereas this is always necessary for general obligation bonds.

PADUCAH'S PRESENT METHODS OF FINANCING IMPROVEMENTS:

The City has recently established a sewer service charge, collected monthly. The charge, based upon the amount of water used, is for residential customers in the amount of one dollar per month. The revenue from this charge, according to the Ordinance, is "to maintain and operate said (sewage treatment) plant and to maintain sewers, intercepting sewers leading thereto and therefrom and the construction and maintenance of other sewers necessary for use in connection with said plant."

In addition, the City collects a sewer connection charge in areas such as Minerva Place annexed October 14, 1958, as follows:

Connection to sanitary sewer	$550.00
Connection to combined sewer	$750.00

The City also enters into special contracts with developers agreeing to advance a certain proportion of the sewer construction cost. The developer designs and constructs the sewers. However all plans for and construction of the sewers must be approved by the City's consulting engineers, the Kentucky Water Pollution Control Commission, and the City Engineer. The City is reimbursed out of tap-on fees (in the amount of $600 per residence in one case). The developer will receive all fees after the city is repaid.

The revenue collected from sewerage service charges and from sewer connection fees becomes a part of the total revenues of the City and are dispersed according to the budget approved by the Mayor and Commissioners.

Collections from these sources are reported as follows:

	1958	1959	1960 (Est.)
Sewerage Service Charge	$44,579	$116,913	$116,000
Sewer Connection Charge	-	21,370	20,000
Totals	$44,579	$138,283	$136,000

Maintenance and operation of the sewage treatment plant is reported as follows:

	1958	1959	1960 (Est.)
Total Expenditures	$30,643	$ 36,800	$ 33,635

Maintenance and operation expenses of the sewers and pumping stations are included in the Public Works Department, and are not readily separable. Also, power, clerical and supervision expenses are in other accounts not readily separable In the 1955 report by Black and Veatch the total annual operating and maintenance expenses of the entire sewerage system were estimated as follows:

Treatment Plant	$35,000
Sewers and Pump Stations	42,000
Commercial Expense	11,000
Supervision	3,000
Total	$91,000

40.000

This appears to be a reasonable estimate for 1961, and indicates that the present sewerage service charge is ample for maintenance and operation of the sewerage system.

The net revenues of the City after all expenses and bond obligations are paid vary from $200,000 to $400,000 per year. This revenue has been used in 1960 for a new city hall, fire station, and other needed improvements. Thus, the City is now using the pay-as-you-go method of financing many improvements.

The major programs of improvements, such as the sewage treatment plant and the relief sewers through Noble Park, have been financed through the sale of general obligation bonds. The outstanding bonds as of December 31, 1959 are listed as follows:

Voted Bonds:	Totals	Outstanding Bonds	Coupons Not Matured
	$	$	$
Third district sewer 5 %,1922	643,500.00	572,000.00	71,500.00
Gen. Oblg. Sewer Bonds, 4 %, 1955	32,640.00	32,000.00	640.00
Gen. Oblg. Sewer Bonds, 2-3/4%, 1955	372,800.00	320,000.00	52,800.00
Gen. Oblg Sewer Bonds, 3 %, 1955	803,840.00	512,000.00	291,840.00
Gen. Oblg. Sewer Bonds, 3-1/8%, 1955	571,502.88	288,000.00	283,502.88
Totals	$2,424,282.88	$1,724,000.00	$700,282.88

A sinking fund is provided to pay principal and interest maturities. In 1959 over $205,000 were added to this fund. Disbursements were $95,680. The total assets of the fund as of December 31, 1959 were $920,641.

In 1962 the Third District bond issue will mature requiring disbursements of $650,140 from the sinking fund. In 1963 disbursements will be $62,960 and will reduce slightly each year thereafter to $32,503 in 1995.

Therefore it is apparent that the City of Paducah is operating on a sound financial basis with surpluses available that will permit the issuance of additional general obligation bonds without an increase in the tax rate or the service charges.

SEWER EXTENSION POLICY:

It is suggested that the City of Paducah adopt a policy for extending sanitary and storm sewers into new areas that will be generally applicable to both new subdivisions and existing developed area now without sewers. Such a policy would then be available to any developer or any group of owners for determining the cost of obtaining sewerage service.

The present contracts with developers have set a pattern that is, in general, quite sound. The following factors should be given consideration in further contracts:

1. Many cities are requiring the developer to provide all sewers within the developed area at no direct expense to the city.

2. Many cities require the developer to advance the funds for or to construct the necessary trunk sewers and lift stations to transport the sewage of his development to an approved point of discharge, say to an existing sewer.

3. Many cities require the developer to provide extra pipe capacities in sewers within the development area to carry flows from areas upstream from his development. The extra cost is usually paid by the city.

4. Likewise, the city may require the developer to provide extra capacity in trunk sewers, lift stations, and force main required to dispose of the sewage from areas adjacent to the trunk sewer. The extra cost is usually paid by the city.

5. The developer is frequently required to provide for storm drainage within his development area at no expense to the city and subject to no reimbursement by the city. If, however, extra capacity is required for areas upstream to the development, the city usually pays the additional cost.

6. If development is remote to existing sewers requiring temporary treatment facilities, the developer usually provides the treatment facilities at no cost to the city and subject to no reimbursement by the city.

7. Developers are required to construct to standards provided by the city, to provide all right-of-way and easements needed, and are subject to inspection and approval before acceptance.

8. Developers are usually reimbursed out of the service connection charges collected only to the extent of their investment, without interest. Frequently the reim-

bursement period is made over a ten-year period. Any balance due thereafter is cancelled. Some cities reimburse the developer only a percentage of the connection charge (say 75%), the remainder to be used for administration, engineering, inspection, and trunk sewer construction.

9. Some cities do not reimburse the developer for lateral sewers constructed within the development area. The developer merely adds this to the cost of the lot when sold. In that case the city would have a much lower connection charge than the charges now being made in Paducah.

Sewer extensions in developed areas present a special problem. The property owners are usually already served by septic tanks and irrigation fields representing a substantial investment in sewage disposal. They may be reluctant to invest in sewers unless forced by the public health agency. The financing procedure should be as liberal as possible to encourage the elimination of these health hazards. The following factors should be considered:

1. City will construct sewers upon petition by 51 per cent of front footage to be served by sewer.

2. Cost will be proportioned over 80 per cent of total front footage, unless a greater percentage petitions for service.

3. Payments may be by cash or in ten equal annual payments which will include interest on balance due, or in 120 monthly payments which will include interest and handling expenses.

4. Vacant property owners connecting at a later date would pay the same rate as those who connected immediately plus interest and handling expenses for the money advanced by the city to improve their property.

5. In some cases the city may find it expedient to advance the cost of trunk sewers through presently undeveloped areas in order to serve a developed area. The financing of such projects should be carefully analyzed to

assure eventual recovery of the city's investment and to assure proper and adequate payment by property owners benefited by the sewer.

In order to finance the program suggested herein for the extension of sanitary and storm sewers, a revolving fund is required out of which payments can be made for improvements as required, and into which service connection charge revenues are deposited as collected. It is suggested that $500,000 be placed in this fund. Assuming the conservative population growth estimate of Figure No. 1, by 1980 seventeen hundred new connections will have been made. If $600 is collected per connection, the total deposited to the account would be $1,020,000. If 75 per cent is reimbursed to the developers, the account will have gained $250,000 for partial reimbursement of the advanced funds. If the optimistic estimate of growth is realized, almost the entire amount ($480,000) will be restored to the fund.

PLAN A - REVENUE BONDS FOR FINANCING CONSTRUCTION:

The City obtains a regular and dependable revenue from its sewer service charge and sewer connection charges. This revenue will grow as the City grows. At present it enters the general funds of the City, and ostensibly pays the cost of the sewage system maintenance and operation.

According to Plan A these revenues would be placed into a separate fund subject to the requirements of the bonding companies for development of a sound revenue bond program. Present ordinances would have to be revised accordingly.

Based upon the earning power of the present sewer service charge, Step I of the Storm Sewer Relief Program and the revolving fund for sewer extensions could be financed as follows:

Step I of the storm sewer relief program (see Table 2, page 27) will cost $842,400. If the improvements of Step I are to be constructed at this time, it will be necessary to issue revenue bonds as follows:

Step I - Storm Sewer Relief	$ 842,400
Sewer Extension Fund Sewers	500,000
Total	$1,342,400

* This amount is now going into the Gen. Fund. Gen Fund pays for operation of sewage disposal plant and maintenance of entire sewer system which will amount to, or exceed $116.000. If this amount is taken from Gen Fund, where in hell is $116000. coming from to replace this amount taken from Gen. Fund.

Following this line of reasoning — why not take PR taxes from Gen Fund + pay as we go, on sewers — ??

* Assuming 25-year revenue bonds bearing interest at 4-1/2 per cent, the above amount will require annual payments of principal and interest of $90,500. Collections of sewer service revenues under the present ordinance are approximately $116,000 per year. This amount will pay the principal and interest charges with a "coverage" of 28 per cent.

Thus, the sanitary sewer improvements and Step I of the storm sewer relief improvements can be constructed within the present revenues without changing rates.

It may be assumed that sewer service revenues will increase approximately as the population of the City increases. Thus, with no increase in rates, revenues twenty years hence, in 1980, would be between $135,000 and $155,000 per year.

In the event the City elects to do both Step I and Step II immediately, and to issue revenue bonds to cover the entire cost, the amounts required will be as follows:

Sewer Extension Fund	$ 500,000
Step I - Storm Sewer Relief	842,400
Step II - Storm Sewer Relief	1,203,800
Total	$2,546,200
Proposed Bond Issue -	$2,600,000

Again, assuming 25-year revenue bonds bearing interest at 4-1/2 per cent, the requirement for annual payments of principal and interest will be $175,300. Assuming a "coverage" requirement of 25 per cent, the revenues required are $220,000 per year. This amount would necessitate increasing the rates for sewer service approximately 90 per cent.

The present sewer service charge for residences is only $1.00 per month. If this were doubled to $2.00 per month, the amount of the charge would not be unreasonable.

The surpluses accumulated in this fund would average almost $100,000 per year and could be used together with funds supplied by local developers to finance Step III of the storm sewer program, or as much of it as is desired.

The main objection to this plan of financing a program primarily for storm sewer relief is in the inequitable assessment on the basis of water used (or sanitary contribution). Some will contend that assessments should be made on the basis of evaluation.

To summarize, the sanitary sewer improvements and Step I of the storm water relief improvements can be constructed without any increase in taxes or sewer service revenue rates. By doubling the sewer service revenue rates, Steps II of the storm water relief improvements can be included in the immediate program, and a surplus can be provided to partially finance on a pay-as-you-go basis Step III.

PLAN B - GENERAL OBLIGATION BONDS FOR FINANCING CONSTRUCTION:

The financial statements and auditor's reports indicate annual net revenues over all operating and debt service expenses for the City varying from $200,000 to $400,000. Therefore, without increasing taxes it may be feasible to issue general obligation bonds for the construction of Steps I and II of the storm water relief program.

Step I - Storm Water Relief	$ 842,400
Step II - Storm Water Relief	1,203,800
Total	$2,046,200
Proposed Bond Issue -	$2,100,000

Assuming 25-year bonds, bearing 4-1/4 per cent interest, the annual payments of principal and interest will be $137,100. It is apparent that the surpluses are adequate for this additional bonding program. In addition, the surplus may be used to finance the sewer extension program. It may be necessary to increase taxes or the sewer service charge to provide adequate funds for Step III of the construction program. However, this problem may be reappraised upon completion of Steps I and II, because property valuations and other revenues will have increased with the growth of the City.

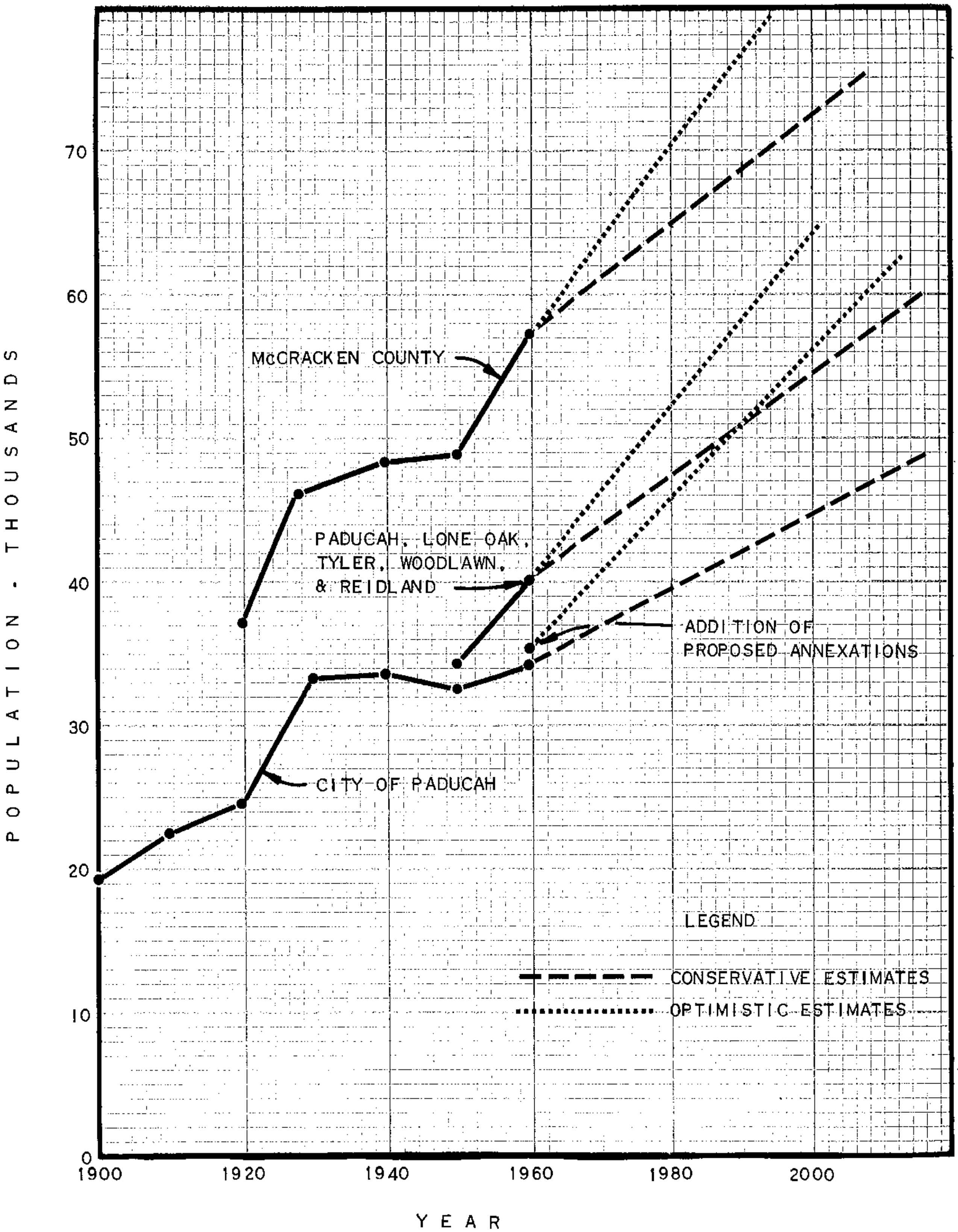
RECOMMENDATION:

It is recommended that the City adopt one of the two following plans:

1. Issue revenue bonds in the amount of $2,600,000 to finance sanitary sewer construction and Steps I and II of the storm water relief improvements. This involves raising the sewer service monthly charge to about double the present rate.

2. Finance all sanitary sewer construction from sewer service revenues, and issue general obligation bonds in the amount of $2,100,000 for construction of storm water relief improvements, Steps I and II.

Consultation with a financial consultant is recommended before adoption of a plan for financing the proposed program for construction.

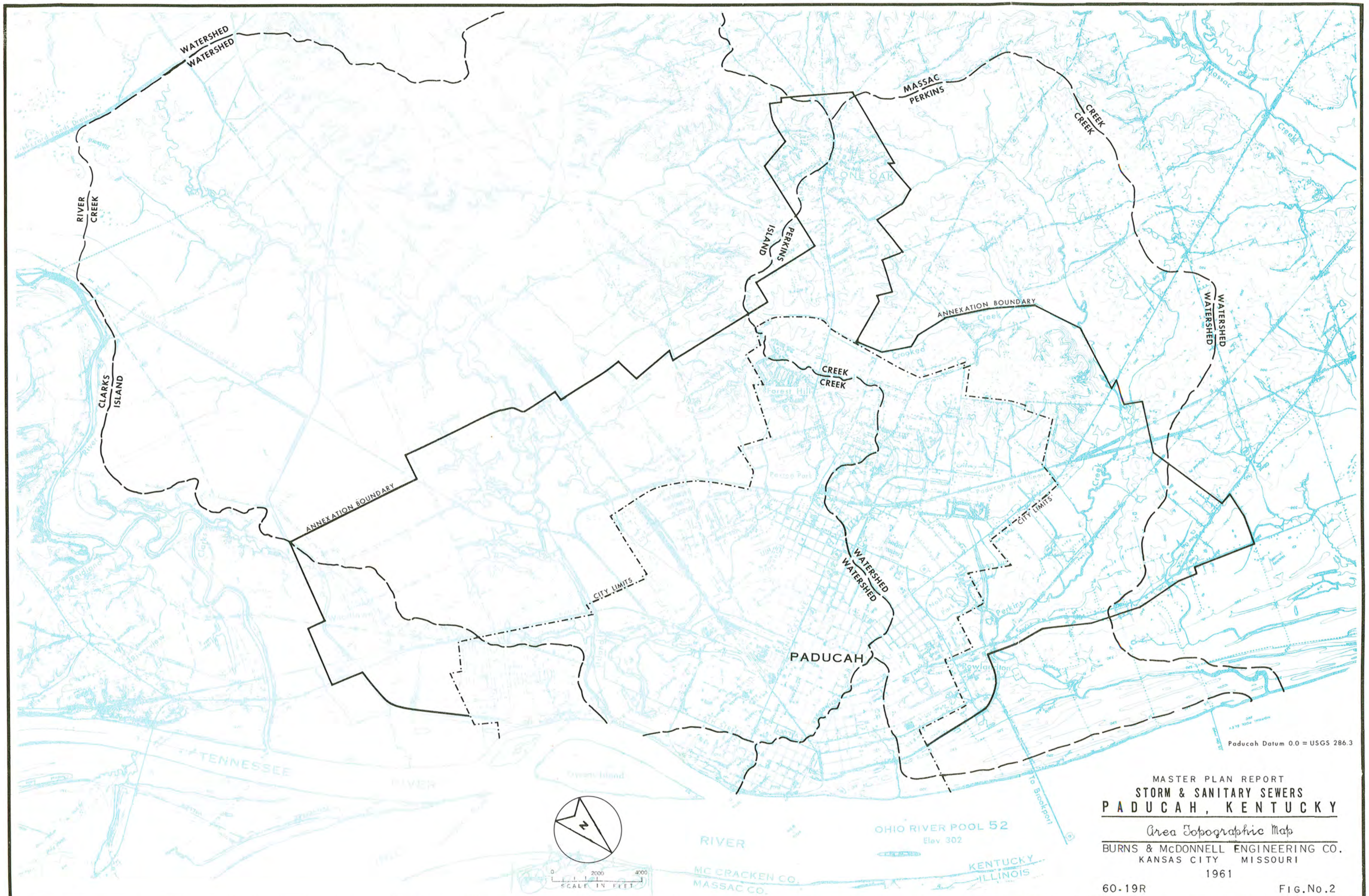


MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

Population Predictions

BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY MISSOURI
1961

60-19R FIG. No. 1



MASTER PLAN REPORT

STORM & SANITARY SEWERS

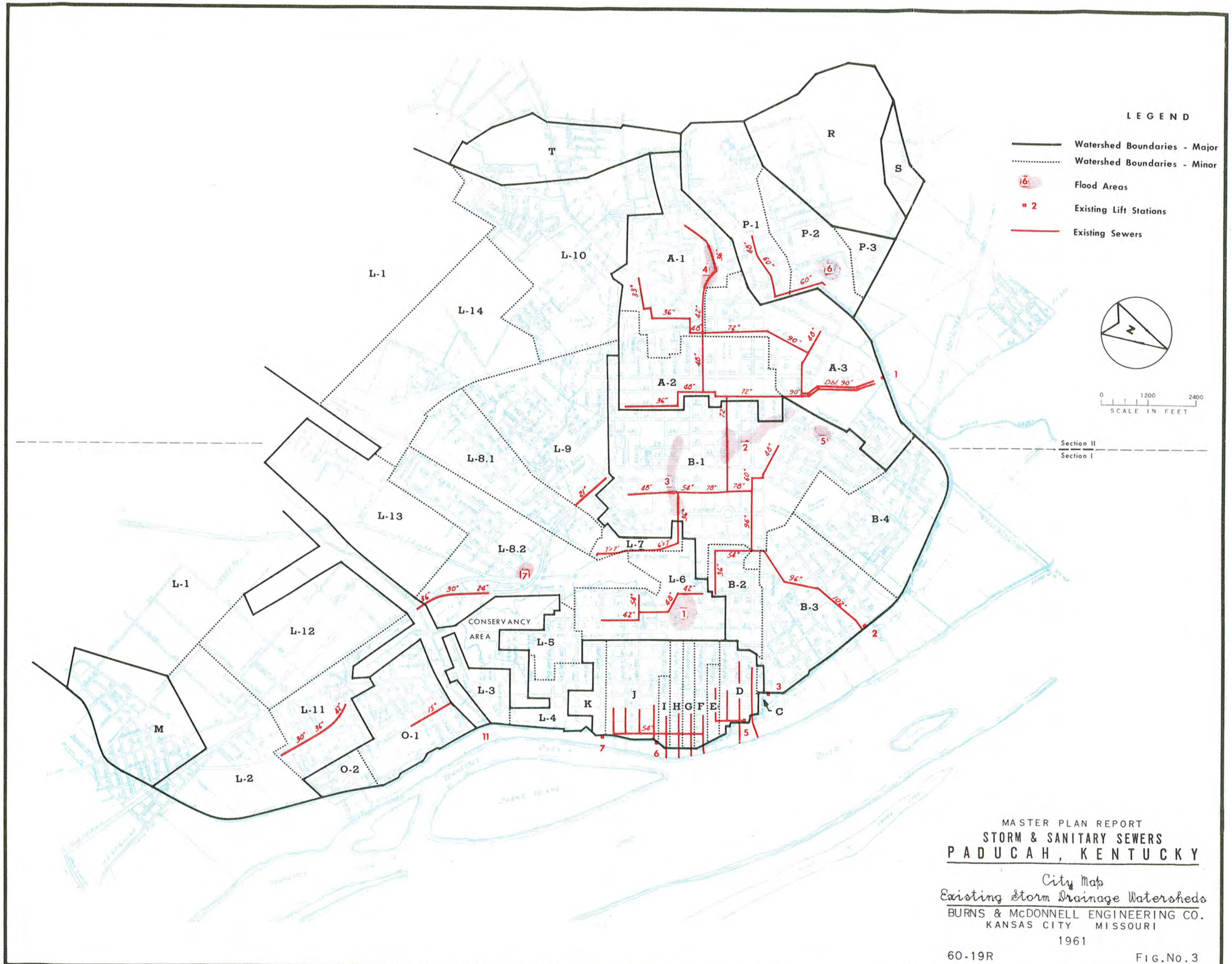
PADUCAH, KENTUCKY

Area Topographic Map

BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY MISSOURI
1961

60-19R

FIG. No. 2



MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

City Map
Existing Storm Drainage Watersheds

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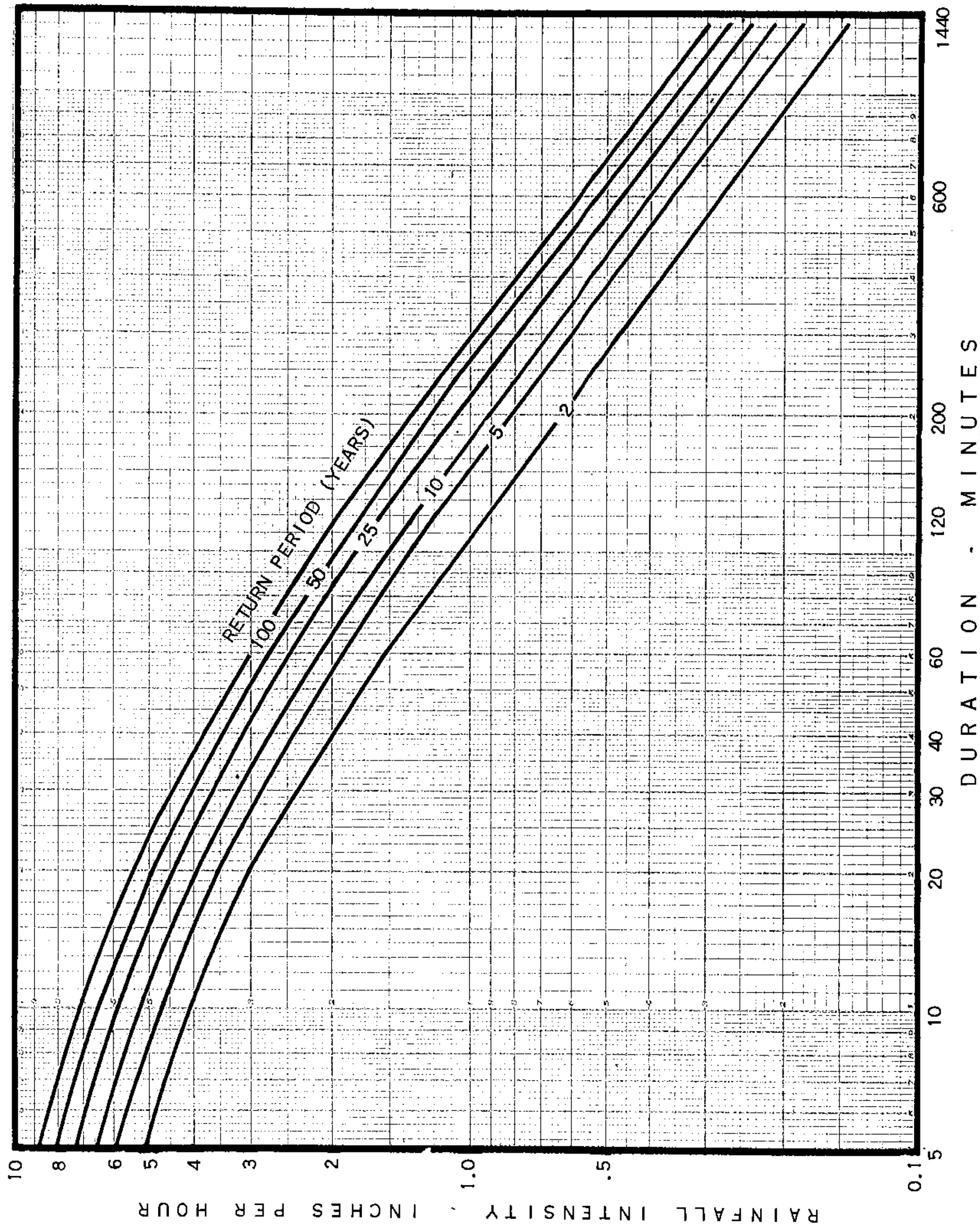
1961

60-19R FIG. No. 3



MASTER PLAN REPORT

STORM & SANITARY SEWERS

PADUCAH, KENTUCKY

Rainfall Duration-Frequency Curves

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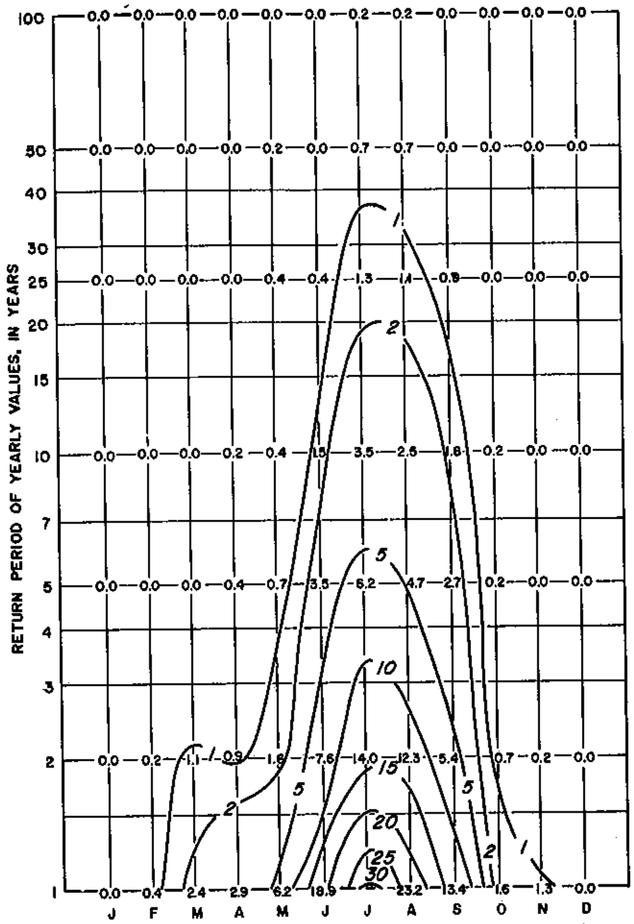
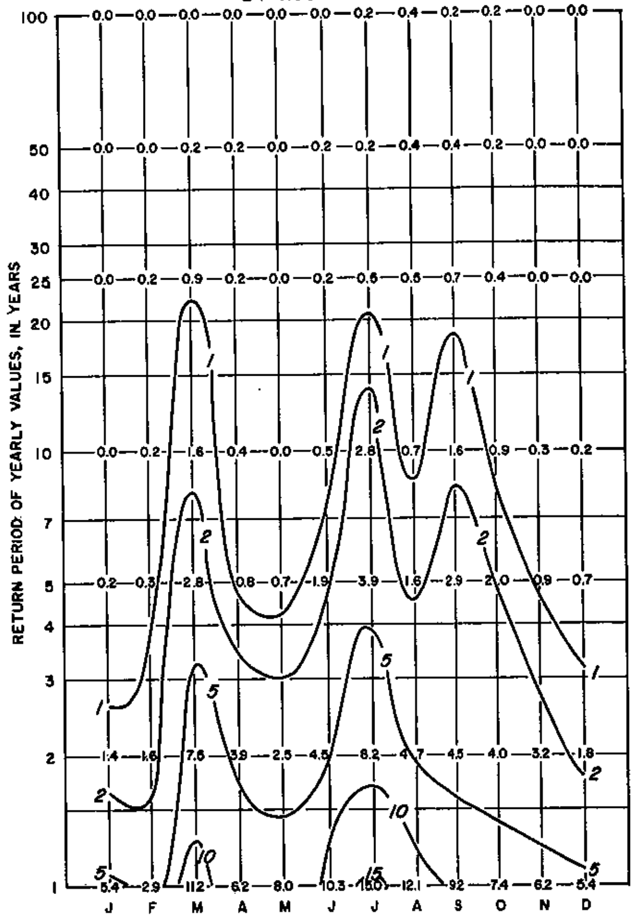
FIG. No. 4



Probability in percent of obtaining a rainfall in any month of a particular year equal to or exceeding the yearly return period values taken from the isopluvial maps and diagrams.



Probability in percent of obtaining a precipitation in any month of a particular year equal to or exceeding the yearly return period values taken from the isopluvial maps and diagrams.

From Technical Paper No. 29 - U.S. Department of Commerce

MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

Monthly Rainfall Probability Durves

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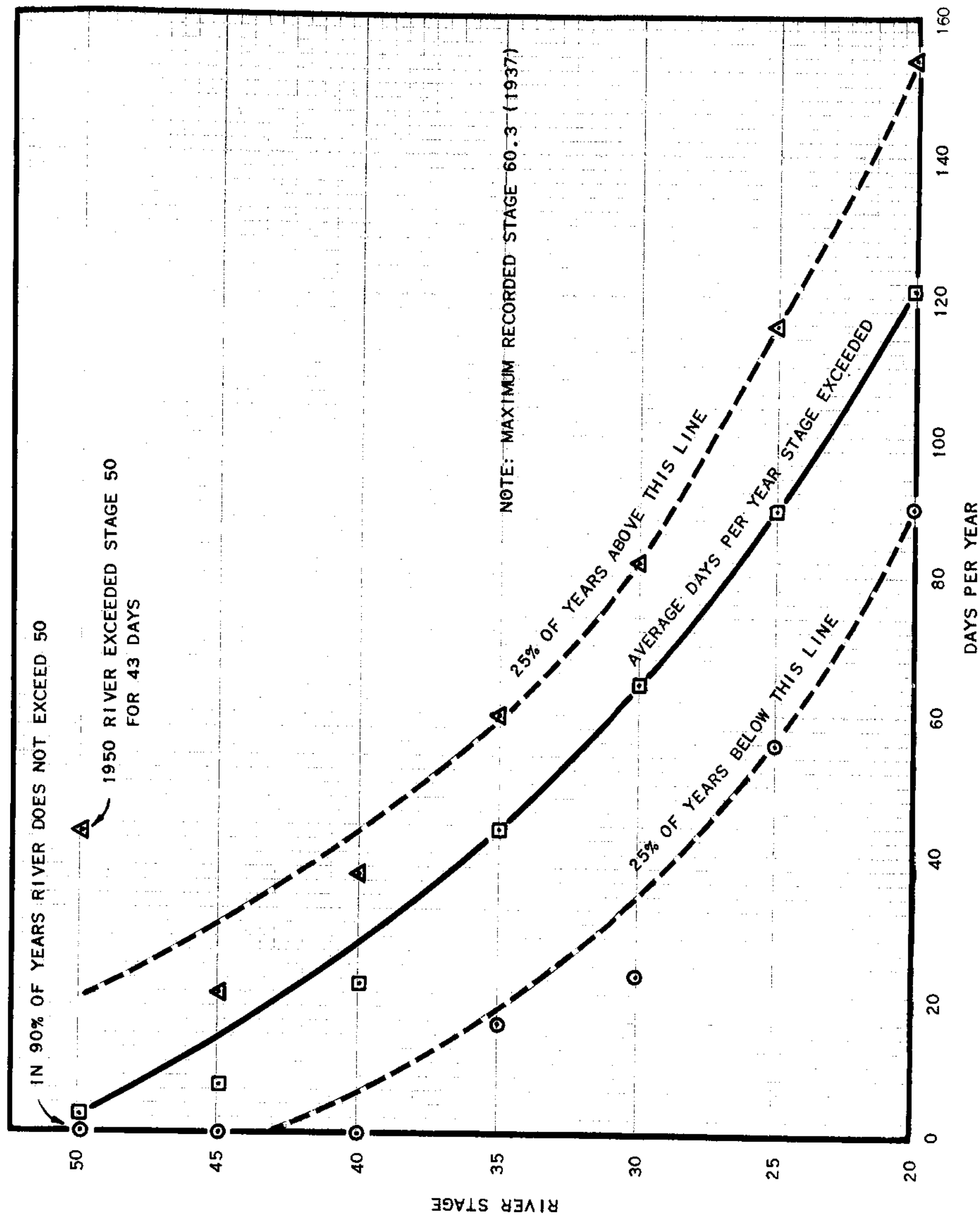
FIG. No. 5



MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

Days Per Year
River Stages Exceeded

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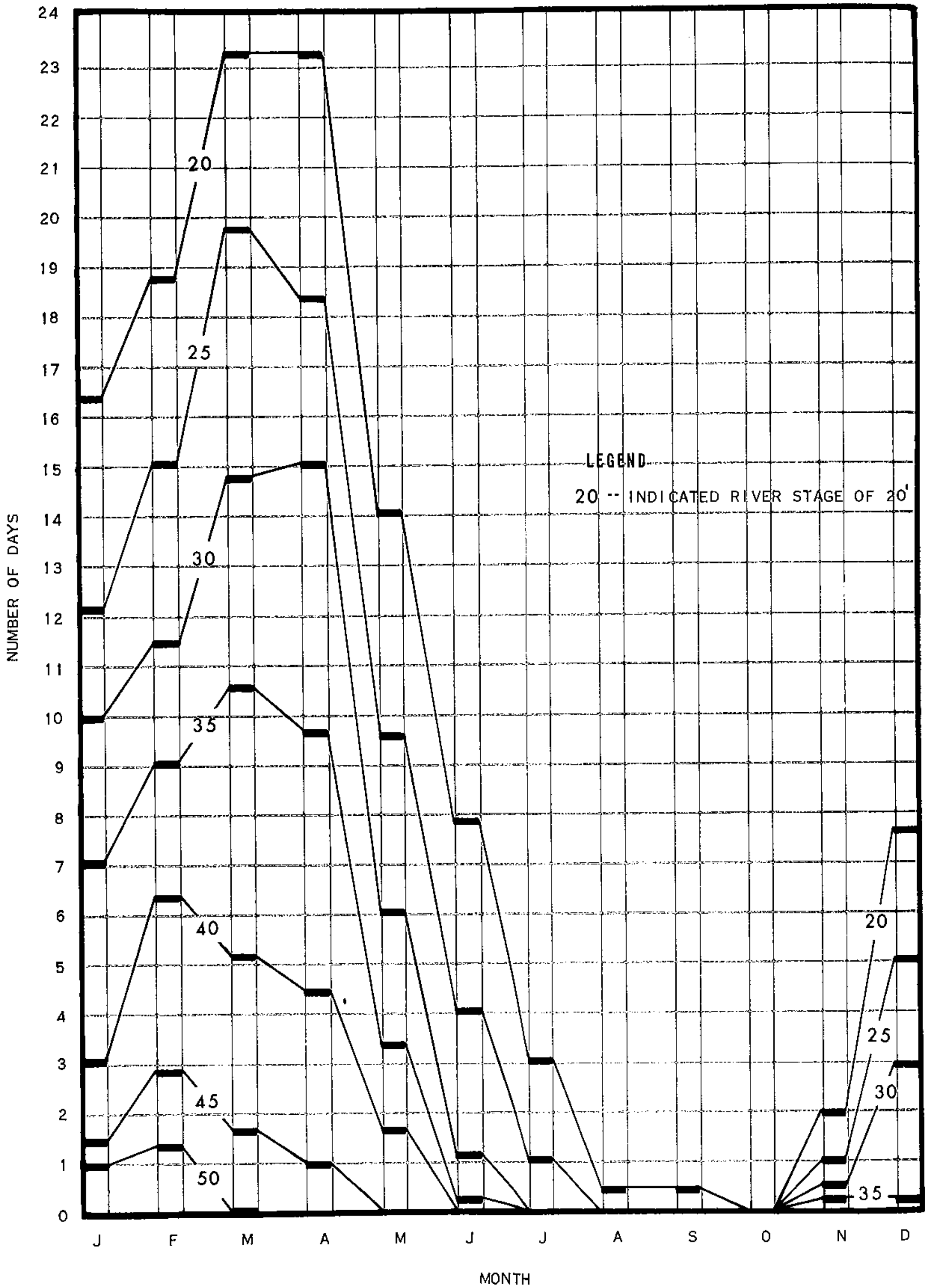
FIG. No. 6



MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

Days Per Month
River Stages Exceeded

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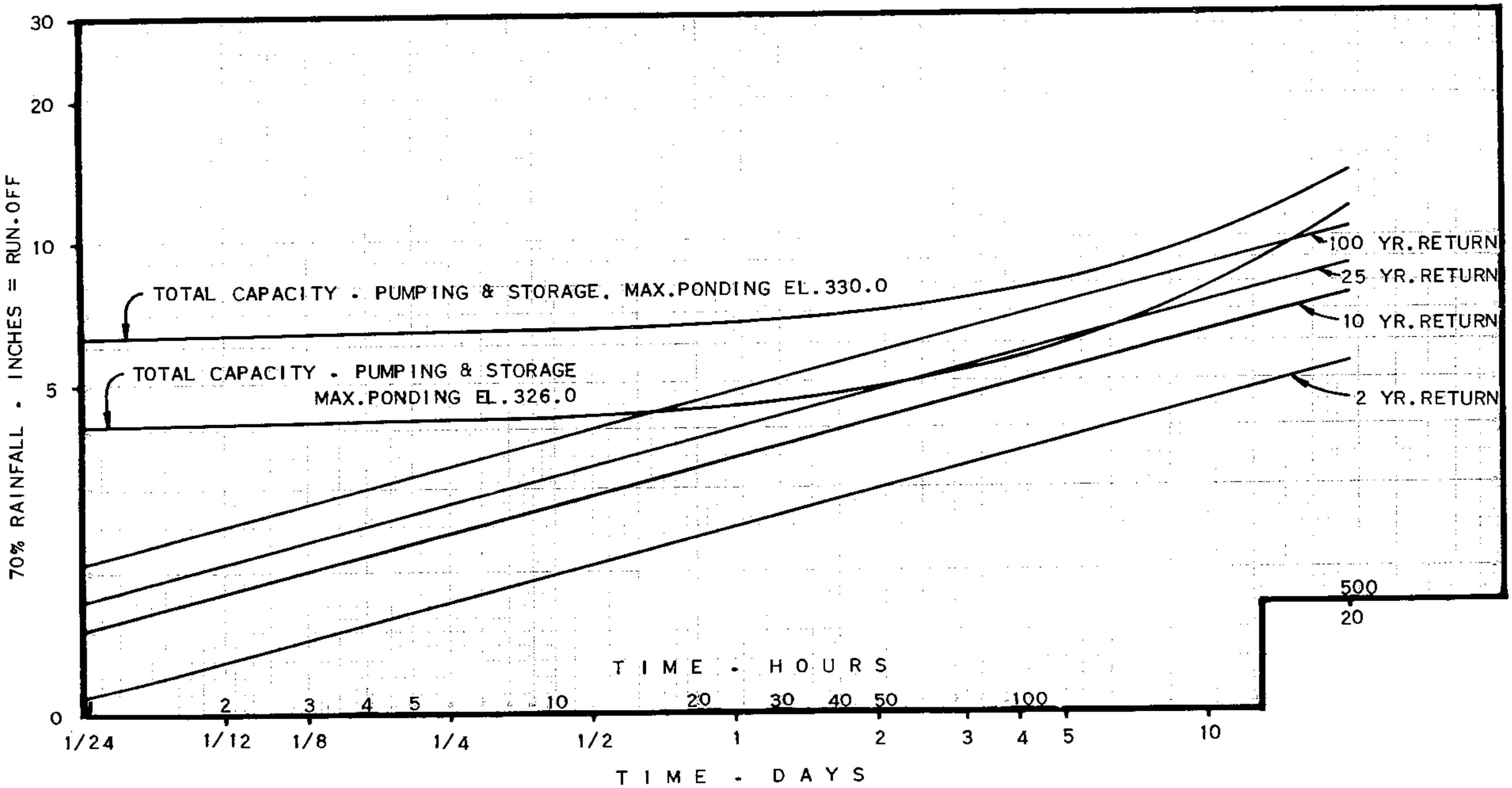
60-19R FIG. No. 7



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STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

Pump Station No. 11 Capacity Curve

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FIG.No.8

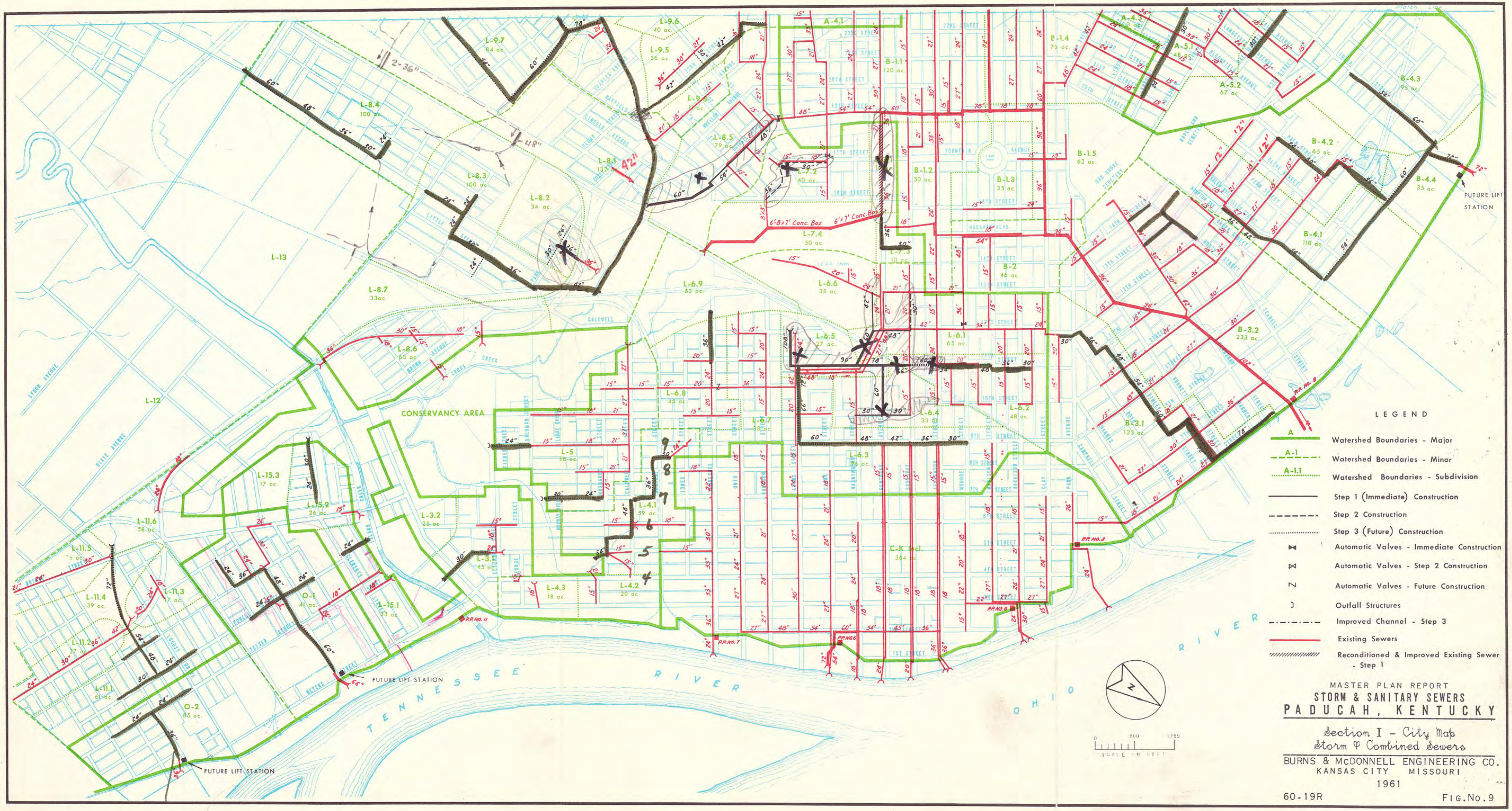
LEGEND
Watershed Boundaries - Major
Watershed Boundaries - Minor
Watershed Boundaries - Subdivision
Step 1 (Immediate) Construction
Step 2 Construction
Step 3 (Future) Construction
Automatic Valves - Immediate Construction
Automatic Valves - Step 2 Construction
Automatic Valves - Future Construction
Outfall Structures
Improved Channel - Step 3
Existing Sewers
Reconditioned & Improved Existing Sewer - Step 1
MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY
Section I - City Map
Storm & Combined Sewers
BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY MISSOURI
1961
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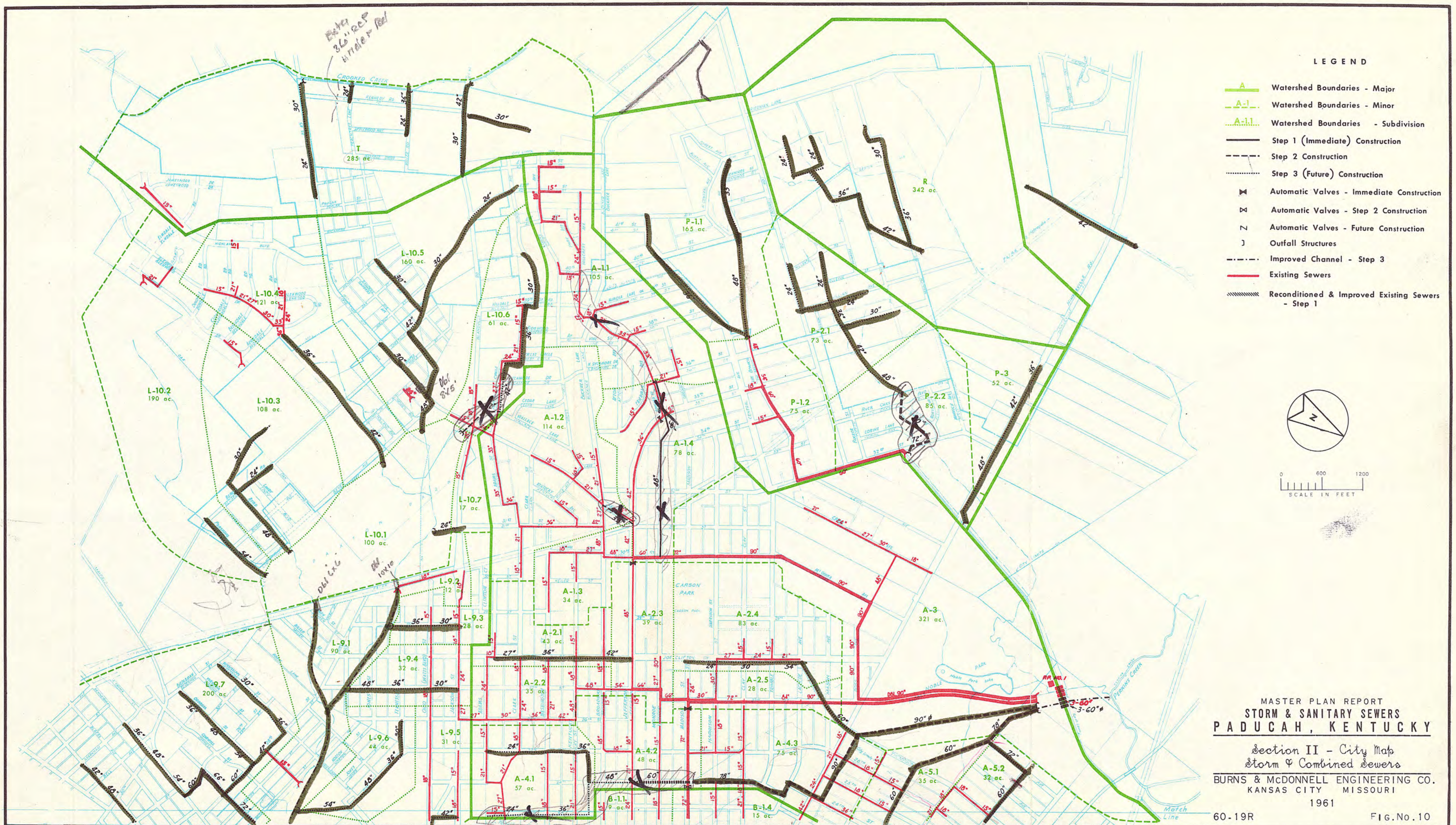
FIG. No. 9
SCALE IN FEET
TENNESSEE RIVER
OHIO RIVER
CONSERVANCY AREA
FUTURE LIFT STATION



LEGEND
Watershed Boundaries - Major
Watershed Boundaries - Minor
Watershed Boundaries - Subdivision
Step 1 (Immediate) Construction
Step 2 Construction
Step 3 (Future) Construction
Automatic Valves - Immediate Construction
Automatic Valves - Step 2 Construction
Automatic Valves - Future Construction
Outfall Structures
Improved Channel - Step 3
Existing Sewers
Reconditioned & Improved Existing Sewers - Step 1
SCALE IN FEET
0 600 1200
MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY
Section II - City Map
Storm & Combined Sewers
BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY MISSOURI
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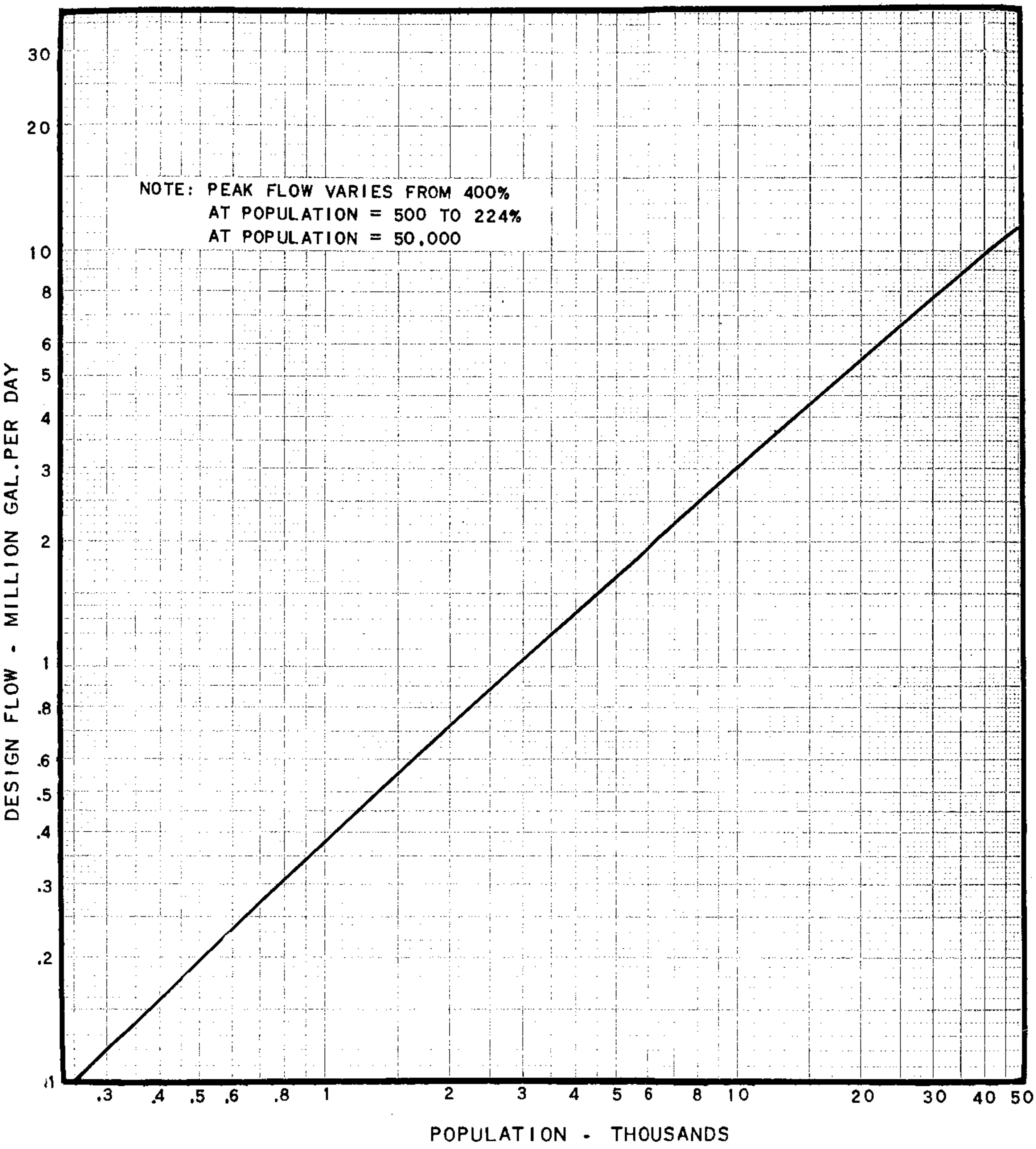
FIG. No. 10



MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY

Peak Design Flow for Sanitary Sewers

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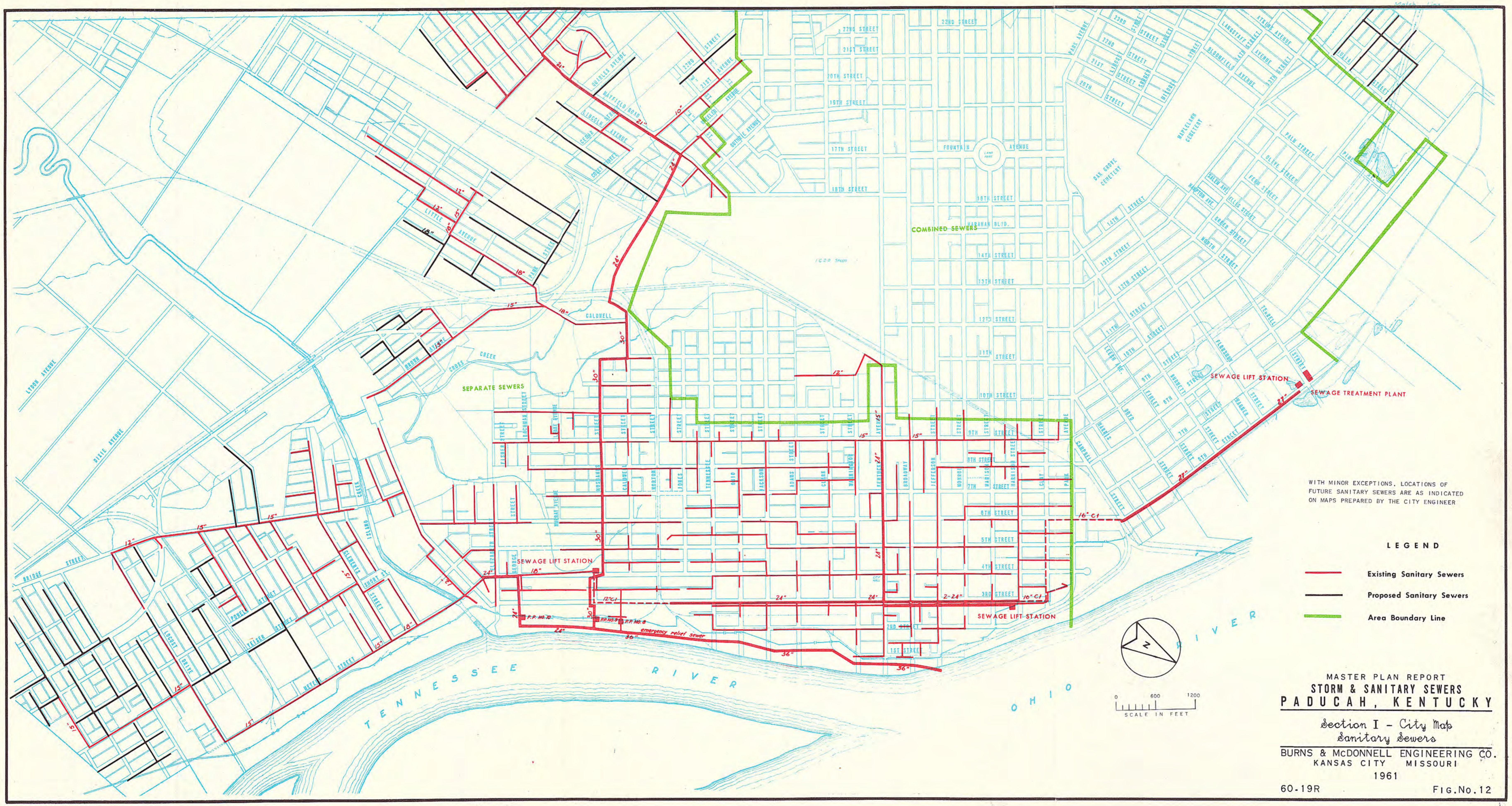
1961

60-19R FIG. No. 11



MASTER PLAN REPORT

STORM & SANITARY SEWERS

PADUCAH, KENTUCKY

Section I - City Map
Sanitary Sewers

BURNS & McDONNELL ENGINEERING CO.
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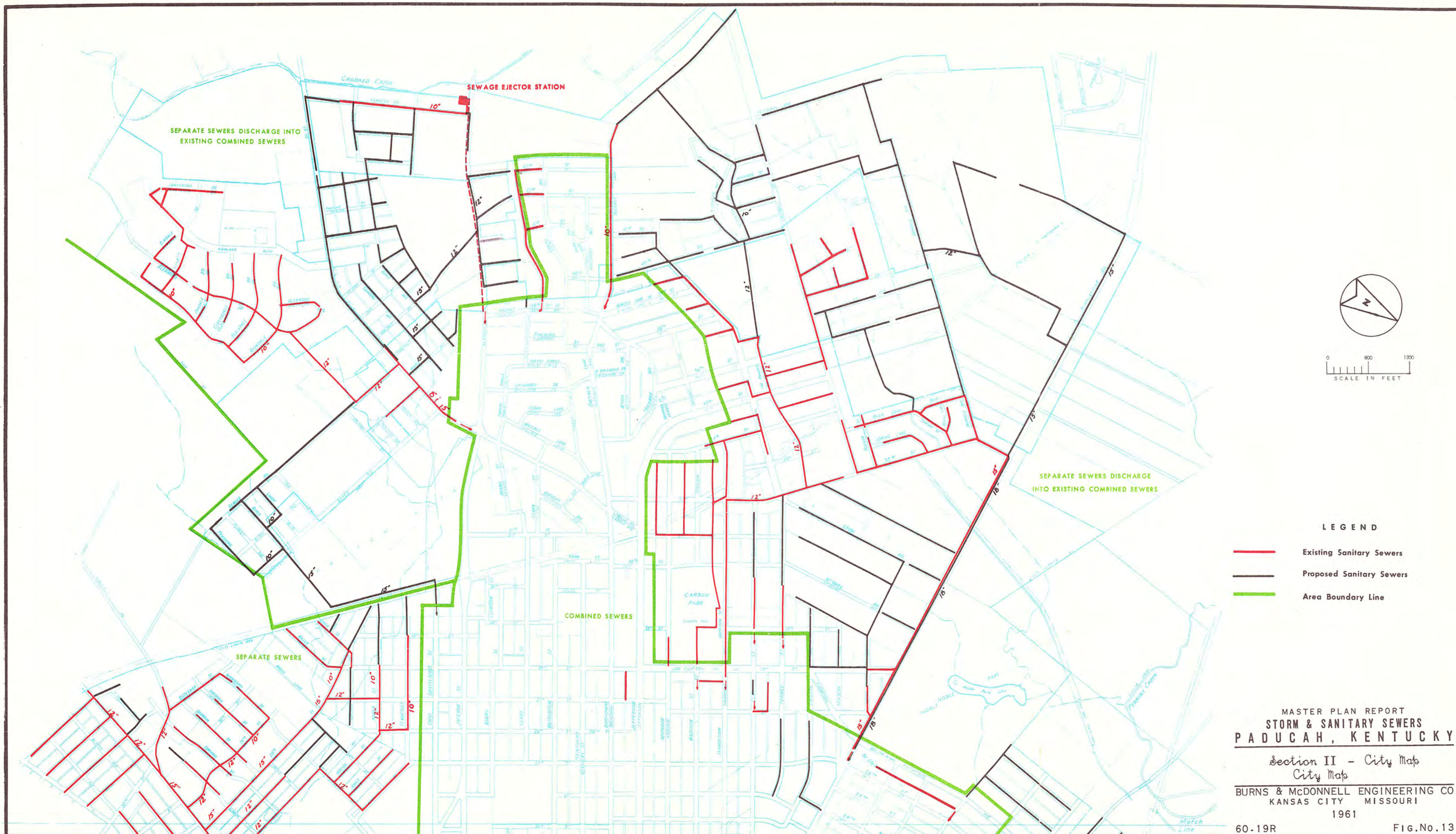
1961

60-19R

FIG. No. 12


CROOKED CREEK
SEWAGE EJECTOR STATION
SEPARATE SEWERS DISCHARGE INTO EXISTING COMBINED SEWERS
COMBINED SEWERS
CARSON PARK
SEPARATE SEWERS
SEPARATE SEWERS DISCHARGE INTO EXISTING COMBINED SEWERS
0 600 1200
SCALE IN FEET
LEGEND
Existing Sanitary Sewers
Proposed Sanitary Sewers
Area Boundary Line
Match Line
MASTER PLAN REPORT
STORM & SANITARY SEWERS
PADUCAH, KENTUCKY
Section II - City Map
City Map
BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY MISSOURI
1961
60-19R
FIG. No. 13

APPENDIX A

STORM AND COMBINED SEWERS CAPACITY DEFICIENCIES

WATERSHED A

WATER-SHED DESIG.	STREET LOCATION			EXIST. SEWER		REQ'D SEWER		
	IN	FROM	TO	SIZE IN.	CAP. CFS	CAP. CFS	SIZE IN	
A-1	Freidman	38th	37th	33	60	77	36	
	Howard	36th	35th	36	70	104	42	
	Jefferson	34th	33rd	42	100	116	45	
	Jefferson	31st	30th	42	90	151	54	
	Forest Circle	Sycamore	Wallace	27	29	47	33	
	Adams	Lone Oak	31st	33	50	92	42	
	31st	Adams	Buckner	36	68	113	45	
	Buckner	31st	30th	48	100	125	54	
	30th	Buckner	Jefferson	48	120	158	54	
	30th	Jefferson	Monroe	60	300	200	OK	1
	30th	Monroe	Madison	72	300	200	OK	
	Jefferson	30th	29th	48	125	100	54	2
A-2	Jackson	27th	26th	27	18	95	48	
	26th	Washington	Kentucky	42	50	183	72	
	27th	Broadway	Jefferson	54	70	228	84	
	Jefferson	26th	27th	48	105	118	60	3
	27th	Jefferson	Monroe	66	140	244	78	
	27th	Monroe	Madison	66	140	258	84	
	27th	Madison	Clay	72	172	170	OK	4
	27th	Clay	LaClede	84	160	180	OK	4
	27th	LaClede	Park	90	220	200	OK	4
	Madison	27th	26th	72	145	240	90	
A-3	30th	Madison	Harrison	72	300	200	OK	
	30th	Harrison	Trimble	90	350	250	OK	
	McGuire	Trimble	Ross	90	350	275	OK	
	Ross & Park	-	27th	90	400	350	OK	
	Noble Park	Park	Outlet	2-90	475	550	2-96	
	Park Ave.	Levin	McGuire	46	80	70	OK	

1 Relief sewer has a short section of 48" pipe in it. At the required 300 cfs flow this causes a head loss of over 4 feet. This would cause a back-up and flooding at 30th & Jefferson.

2 This combined sewer in Jefferson Street will be flowing at capacity (125 cfs) while relief sewer is flowing at 2/3 capacity.

3 This assumes 100 cfs discharges from watershed A-1.

4 Relief sewer built in 1954 is assumed to discharge its full capacity.

APPENDIX B

STORM AND COMBINED SEWER CAPACITY DEFICIENCIES
WATERSHED B

WATER-SHED DESIG.	STREET LOCATION IN	FROM	TO	EXIST. SEWER IN.	EXIST. SEWER CFS	REQ'D SEWER CFS	REQ'D SEWER IN.
B-1	Madison	26th	22nd	72	145	240	90 [5]
	Madison	22nd	19th	72	180	250	90
	19th Street	Jackson	Adams	48	70	182	72
	19th Street	Adams	Clark	48	70	207	70
	19th Street	Clark	Washington	54	90	350	90
	19th Street	Washington	Kentucky	54	90	380	96 [6]
	19th Street	Jefferson	Madison	78	210	610	114
	19th Street	Madison	Clay	78	210	700	120
	Park Avenue	21st	Clay	48	70	106	60
	Clay Avenue	20th	19th	60	130	400	90
	Clay Avenue	19th	17th	96	320	900	2-108
	Clay Avenue	17th	15th	96	390	950	2-108
	15th Street	Clay	Park	96	400	1030	2-108
B-2	12th Street	Madison	Monroe	36	40	210	66
	15th Street	Harrison	Clay	54	50	240	90
B-3	9th Street	Burnell	Flournoy	27	21	52	36
	Flournoy	8th	Levee	102	500	1200	2-108

[5] The Madison Street trunk sewer is overloaded in this area enough to cause sewage to boil out in low flooded Area No.2.

[6] This sewer is overloaded enough to cause extreme street flooding in low areas.

APPENDIX C

STORM AND COMBINED SEWER CAPACITY DEFICIENCIES WATERSHEDS D-L INCLUSIVE

WATER-SHED DESIG.	STREET LOCATION			EXIST. SEWER		REQ'D SEWER	
	IN	FROM	TO	IN.	CFS	CFS	IN.
D	Clay Street	4th	3rd	27	17	51	39 [7]
D	Harrison	4th	3rd	27	17	51	39 [7]
E	Monroe	4th	3rd	22	10	33	33 [7]
F	Jefferson	3rd	2nd	2-18	12	65	36 [7]
G	Broadway	3rd	2nd	2-18	10	60	36 [7]
H	Kentucky	3rd	2nd	2-18	12	65	36 [7]
I	Washington	3rd	2nd	2-18	20	45	30 [7]
J	Adams	3rd	2nd	30	18	65	48 [7]
	2nd	Adams	Clark	54	70	230	84
K	Tennessee	3rd	2nd	36	34	89	54 [7]
L-6	12th	Broadway	Kentucky	42	60	280	72
	Kentucky	12th	11th	48	80	310	78 [8]
	11th	Washington	Adams	48	80	390	84
	Adams	12th	13th	54	100	530	102
L-7	Kentucky	16th	15th	36	20	47	48 [9]
	I.C.R.R.	Kentucky	Jackson	6x7	246	120	OK
	I.C.R.R.	Jackson	Outlet	7x7	283	176	OK

[7] These sewers are overloaded, but flow down street runs directly to Ohio River through openings in flood walls. No flooding has been reported.

[8] There is no outlet from this area except through sewers. Therefore the flooding reported is to be expected.

[9] The box culvert is not being used to capacity. The 36" sewer in Kentucky may not be provided with enough inlets.