CITY OF PADUCAH

STORM WATER DRAINAGE STUDY

Including:

- ★ Analyses of Five Flood Prone Areas
- ★ Drainage Design Criteria for Future Development
- ★ Funding Considerations

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I. INTRODUCTION

The purpose of this report is to examine persistent flooding problems within five selected areas of the City of Paducah. Inadequacies of exiting storm drainage networks in several of the areas have resulted in considerable property damage throughout the years. In addition to property damage, flooding has presented additional potential problems to the public such as stalled traffic, overflow of sanitary sewage into streets and ponding of water which could result in accidental drownings.

Current storm drainage design criteria utilized by other communities in Kentucky and other states are discussed in this report. Recommended storm drainage criteria for the City of Paducah is presented to aid city officials in the proper design of future stormwater drainage facilities. Existing storm drainage facilities will be analyzed utilizing the recommended criteria to determine deficiencies within individual areas.

A conceptual improvement plan is presented for each of the study areas and potential funding options are also discussed.

II. CURRENT STORMWATER DRAINAGE DESIGN CRITERIA

A. General

Stormwater management has become increasingly important as communities throughout the nation continue to develop. Many communities have adopted ordinances or development regulations to govern the proper design of stormwater management facilities.

Many factors must be considered in the design of stormwater management facilities. Of primary concern is the protection of the public's health and safety. Economics also plays an important role. The optimum goal is to provide a reasonable level of protection against flooding at a cost that can be realistically afforded.

The majority of community regulations and ordinances today are geared to new developments. Typically, two conditions are addressed:

1. Protect downstream areas from the additional runoff created by new developments
2. Provide an adequate stormwater drainage system within each new development.

B. Selection of Design Storm Event

The selection of a design storm event is probably the most important step in preparing a stormwater management policy. A design storm is representative of the quantity of precipitation that would fall over a given period of time. The period of time precipitation occurs during a given storm event is referred to as time of duration. Another variable associated with the definition of a design storm is the return period. The return period refers to the frequency of reoccurrence of a particular storm. As an example, a

storm with a 10 year return period would have a 10% probability of occurring in any given year.

Risk assessment has traditionally been the avenue for the selection of a design storm for various stormwater drainage facilities. Some stormwater facilities are constructed to handle larger storms than others. The consequences of a failure of a given facility is of foremost concern.

Design storm criteria from other communities as well as the Kentucky Department of Highways Drainage Manual was reviewed in order to present what typically is being done in other areas of the state and the nation.

Summaries of the various storm design criteria are shown in Tables I, II, III and IV. Included in each table is the design storm and the check storm if there is one applicable. The check storm is generally utilized to analyze performance of conveyance channels and structures under higher storm loading conditions to assure that the designed facility will be able to operate adequately without flood damage to property or potential threats to the safety of the public.

TABLE I

DESIGN STORM CRITERIA FOR STORM SEWERS

Source	Design Frequency	Check Frequency
Louisville, KY	10 year	100 year
Lexington, KY	10 year	25 year
Prince William Co., VA	10 year	N/A
KY Dept. of Highways	5 year	10 year
Charlotte, NC	5 year	10 year

TABLE II

DESIGN STORM CRITERIA FOR OPEN CHANNELS

Source	Design Frequency	Check Frequency
Louisville, KY	10 year	100 year
Lexington, KY	10 year	100 year
Prince William Co., VA*	10 yr./25 yr.	25 year
KY Dept. of Highways	10 year	N/A
Charlotte, NC	5 year	10 year

* Varies as a function of the watershed size.

TABLE III

DESIGN STORM CRITERIA FOR CULVERTS/BRIDGES

Source	Design Frequency	Check Frequency
Louisville, KY	10 year	100 year
Lexington, KY	10 year	100 year
Prince William Co., VA*	10 yr./25 yr./50 yr.	100 year
KY Dept. of Highways*	10 yr./25 yr./50 yr.	100 year
Charlotte, NC	10 year	100 year

* Varies as a function of the watershed size and/or road classification.

TABLE IV

DESIGN STORM CRITERIA FOR DETENTION BASINS

Source	Design Frequency and Duration
Louisville, KY	100 year, 1 hour
Lexington, KY*	10 yr., 1 hr.; 25 yr., 24 hr.; 100 yr., 24 hr.
Prince William Co., VA	10 yr., 6 hr.
Charlotte, NC	10 yr., 6 hr.

* Detention basins in Lexington are designed for four storm conditions.

Efforts were made to assign design storms to the City of Paducah's stormwater drainage system in the past. The City of Paducah's stormwater drainage network consists of open channels, storm sewers and combination sewers. One report on the City of Paducah storm and combined sewers focused on establishing a design storm criteria based on risk. Each zone of Paducah was considered with a different return period being established for storm sewers and combination sewers. A slightly higher return period was established for combination sewers due to the potential health threats associated with exposure to sanitary sewage. The return period varied from 2 years for residential R-1 storm sewers to 25 years for combination sewers in the downtown area. The criteria was used to design relief sewers for several areas in Paducah that experienced periodic flooding problems. Apparently the relief sewers have reduced flooding satisfactorily in these areas.

However, to insure consistent overall performance of drainage systems for future development, it is recommended the City of Paducah adopt a policy establishing a standard design storm for each type of conveyance channel or stormwater management facility. Recommended design criteria will be presented in a following section of this report.

III. METHODS FOR CALCULATING RUNOFF

There are several methods currently in use by designers nationwide for calculating runoff. Some methods are more suitable for use in a particular application than other methods.

The Kentucky Department of Highways uses the rational formula method exclusively for calculating runoff for watersheds with areas up to 200 acres.

The rational formula consists of the simple formula:

$Q = CIA$ where

C = runoff coefficient (dimensionless)

I = rainfall intensity (in./hr.)

A = watershed area (acres)

Values for the runoff coefficient C have been well documented for various surface conditions. The National Weather Bureau has developed a series of curves which relate rainfall intensity-duration and frequency for given areas within the United States. The curves are commonly termed as frequency-duration curves. The rainfall intensity can be obtained from regional rainfall intensity-duration curves. The duration is taken as equivalent to the time of concentration. The time of concentration is defined as the time required for runoff to travel from the most remote point in the watershed to the outlet point of the watershed. The rational formula is useful in sizing sewers, open channels, culverts, etc. for instantaneous flows for watersheds with areas of 200 acres or less. However, the rational method is not as appropriate as other methods for the development of runoff hydrographs for use in designing stormwater detention facilities.

The U.S. Dept. of Agriculture Soil Conservation Service has introduced two methods for calculating runoff hydrographs which are being

commonly used throughout the U.S. for urban hydrology. Technical Release No. 20 is applicable to both small and large rural and urban watersheds.

Technical Release No. 55 presents a more simplified procedure for calculating runoff hydrographs for small urban and urbanizing watersheds. Both of the SCS procedures are rather complicated, therefore the theories of each method will not be addressed by this report.

IV. RECOMMENDED STORM DRAINAGE DESIGN CRITERIA

As previously discussed, the task of establishing storm drainage design criteria for the City of Paducah, consistent with past policies, is difficult. Due to the complex nature of the existing storm sewer and combination sewer network of Paducah as a whole, it is hard to determine the exact design capacity of the entire system. Relief sewers throughout Paducah constructed in the early 1960's were reportedly designed to enable the storm sewers in flood prone areas to operate satisfactorily under five year storm loading. Documentation in earlier studies indicates a significant portion of the storm and combination sewer system, when analyzed using current criteria, was severely undersized. The majority of the deficiencies can be attributed to a lack of foresight by early designers in development planning and design assumptions which are now obsolete. Therefore, without extensive hydraulic studies correlated with field measurements, it is difficult, at best, to determine the capacity of the existing sewer network. Thus, capacity of the existing sewer network is not recommended as a basis for establishing design criteria.

Those areas of the existing system which prompt repeated flooding complaints can be addressed on a one by one basis and be upgraded to a level of suitable service comparable to other existing storm and combination sewers within the surrounding area.

It is recommended the City of Paducah adopt a mainstream policy for future design of storm drainage facilities. The recommendations presented in this report are based on policies which have been successful in other urban communities. The recommended design criteria for future design of various drainage facilities in the City of Paducah is as follows:

1. **Open Channels and Roadside Ditches**

The recommended design storm for the design of open channels and roadside ditches is a storm with a recurrence frequency of 10 years. The time of concentration for open channel and roadside ditch design should be assumed to be 20 minutes.

2. **Storm Sewers and Inlets**

The recommended design storm for the design of storm sewers and inlets is the 5 year storm. Storm sewers and inlets should be checked under 10 year storm loading conditions for ponding limits. Ponding limits for streets with curb and gutter should be limited to 8' measured from gutter to driving lane. The duration of the design storm should be assumed to be equal to the time of concentration. The minimum time of concentration should be assumed to be 8 minutes.

3. **Entrance Pipes and Cross Drains**

The recommended design storm for the design of entrance pipes and cross drains is the 10 year storm. The duration of the design storm should be assumed to be equal to the calculated time of concentration. The minimum time of concentration should be assumed to be 8 minutes. Entrance pipes and cross-drains should be checked under 25 year storm conditions to insure against overtopping of roadways and flood damage to residential areas. Situations requiring pipes larger than 36 inches should be designed using the culvert criteria in the following paragraph.

4. **Culverts**

The recommended storm for the calculation of runoff for culvert design should be the 25 year storm. The recommended check storm is the 100 year storm. The maximum headwater under 100 year storm conditions should not be allowed to overtop roads or

provoke flood damage to residential areas or other local improvements.

5. **Detention Facilities**

Detention facilities should be designed to detain the runoff addition created by the development of a subdivision, industrial development or commercial development. Detention facilities should be designed to detain a volume equal to the difference between the total 100 year - 1 hour design storm post-development discharge and the total 100 year - 1 hour design storm predevelopment discharge. The maximum discharge from the detention facility should be limited to the 25 year - 1 hour design storm predevelopment discharge.

6. **Shared Detention Facilities**

In some cases, it may be reasonable for the city to participate in the construction of basins which might serve several tracts having different ownership or, at least, to act as coordinator to encourage more efficient development of detention facilities to serve several potential development sites in a drainage area. In cases where the city might develop a basin, reimbursement should be expected from benefited properties as they develop.

7. **Waivers**

An important item in any stormwater management policy is a waiver statement. A variety of developments may not require stormwater management facilities if it can be proven that the proposed development will not result in excessive additional runoff downstream of the development. Several factors must be considered in the development of waiver criteria. Other communities usually base waivers on such factors as the size of the development, the

increased runoff impact the development will generate and the overall adequacy of the discharge channel downstream of the development. When applying for a waiver, it is usually the developer's responsibility to provide sufficient evidence that the development will have no adverse impact downstream. The actual granting of a waiver should be subject to the discretion of the stormwater management administrator in all cases.

V. RECOMMENDED METHODS FOR CALCULATING RUNOFF

The rational formula is the most universally recognized method for calculating runoff available. The rational formula is generally used by communities for calculating peak runoff for watersheds up to 200 acres. The accuracy of the rational formula tends to decrease as the size of the watershed increases. For that reason, it is recommended the use of the rational formula be limited to watersheds with an area less than 200 acres.

For watersheds with a total area greater than 200 acres, the TR-55 or TR-20 methods, released by the United States Dept. of Agriculture Soil Conservation Service, should be utilized. These methods are more accurate for larger watersheds due to the capability for routing a hydrograph through the watershed to the point of interest.

For the proper design of a detention basin, a runoff hydrograph for the proposed development must be developed. Detention facilities should be designed exclusively by using either the TR-55 or TR-20. Both of these methods are capable of directly calculating an accurate runoff hydrograph whereas the rational formula is not.

VI. ANALYSIS OF FLOOD STUDY AREAS

A). 29th and Clay Drainage Area

1. Overview:

The 29th and Clay drainage area is part of a large watershed referred to herein as the Perkins Creek watershed. The outlet point of the Perkins Creek watershed analyzed in this section of the report is near the stormwater Pump Station No. 1 adjacent to the floodwall near Noble Park. An illustration depicting the Perkins Creek Watershed and it's corresponding subwatersheds as they relate to the 29th and Clay drainage area is depicted in Figure 1 of Appendix A of this report.

The 29th and Clay Street drainage area is part of Subwatershed P-2 of the Perkins Creek watershed as shown in Figure 1 of Appendix A. The study area is bounded to the north by Ross Avenue, to the west by McGuire Avenue and 30th Street, to the south by Monroe Street and to the east by 27th Street

Current zoning for the portion of the study area between Trimble Street and Jefferson Street is low to medium residential. Zoning north of Trimble Street is primarily high density residential and general business. The topography of the area is relatively flat. The most predominant soil in the area is the Henry series according to the Soil Conservation Service Ballard and McCracken Soil Survey. The Henry series characteristically has a shallow fragipan which hinders infiltration of precipitation.

The area is drained by a combination sewer running along Clay Street, Joe Clifton Drive, Harrison Street and 27th Street

to a diversion manhole at 27th Street and Madison Street At the diversion manhole, storm runoff from the 29th and Clay Street drainage area combines with runoff from portions of watershed P-1 southwest of the area and is transported to a double 90" culvert emptying into Perkins Creek via a large relief sewer running along 27th Street.

Several residents were interviewed in the study area in an attempt to gather actual field information which would be beneficial in correlating theoretical drainage calculations. Substantial damage has occurred to personal property in the 2800 block of Clay Street through the years. One resident living at 2819 Clay Street had experienced one occasion when flood water had entered her apartment and was standing at approximately one foot in depth.

Residents report the area floods approximately three times per year. The most serious flooding appears to be isolated to a low area between Joe Clifton Drive and California Court along Clay Street. The low area typically serves as a detention basin when sewers become overloaded. When the storm dissipates, floodwater recedes gradually. The basement apartments in the Riviera Apartment Complex have suffered substantial damage throughout the years due to the surcharging effect of the combination sewers.

The flooding problems in the area seem to be one of the residents' foremost concerns. Some of the residents have learned to cope with the problem while many others have relocated from the area since the majority of the property consists of rental units.

2. Analysis:

When considering the flooding scenario described by residents, it appears the combination sewers serving the 29th and Clay drainage area become overloaded approximately two to three times per year. A hydraulic analysis was performed in an effort to determine the approximate capacity of the existing sewers. The 5 year design storm flows for the combination sewer network were calculated, assuming the total watershed area is developed fully in accordance with current City of Paducah zoning regulations. Table V summarizes the calculated flows and capacities for the combination sewer up to the 90" relief sewer at 27th and Madison.

TABLE V

SUMMARY OF ANALYSIS OF THE 29TH & CLAY ST. SEWERS

5 YEAR DESIGN STORM

In	Street Location From	To	Size In.	Design Capacity CFS	5 Yr. Design Flow CFS	Theoretical Overload CFS
Clay	29th	California Ct.	12"	1.6	12	10.4
Clay	California Ct.	28th	15"	2.9	24	21.1
Trimble	29th	California Ct.	12"	1.5	9	7.5
Trimble	California Ct.	28th	15"	2.6	13	10.4
28th	Laclede	Trimble	21"	7.2	25	17.8
28th	Trimble	Clay	24"	10.1	52	41.9
28th	Clay	Harrison	30"	20.2	91	70.8
Harrison	28th	27th	30"	12.2	118	105.8
27th	Harrison	Madison	30"	18.5	65	46.5
27th	*	*	30"	60	60	N/A

* Overflow to 90" relief sewer

Design capacities in Table V were calculated using the manning equation assuming non-surcharged full pipe flow. Actually, the sewers in the area are operating under surcharged conditions during moderate to heavy storm periods. The surcharged capacity of the 30" trunkline in Harrison Street is estimated to be 25 CFS.

The sewers are severely overloaded under 5 year storm loading conditions. A check under 2 year storm loading conditions indicates the sewers are even overloaded severely at the 2 year storm design conditions. Therefore, it is not surprising the system fails 2 to 3 times every year as observed by residents.

The obvious deficiencies in the system are the undersized sewers which convey runoff from the 29th and Clay drainage area to the 90" relief sewer along 27th Street.

Therefore, relief should be provided through the construction of new sewers or detention facilities to enable the area to drain adequately.

The existing 90" sewers along 27th Street and Ross Avenue were analyzed as possible tie-in points for new relief sewers serving the 29th and Clay drainage area. In order to perform an analysis on the large sewer, runoff from other subwatersheds in the Perkins Creek watershed was determined using the Soil Conservation Service TR-55 methods. A summary of the analysis of the sewers is included in Table VI. Only those portions of the relief sewers which are pertinent to this study are shown.

TABLE VI

SUMMARY OF THE ANALYSIS OF THE LARGE RELIEF SEWERS SERVING WATERSHEDS P-1, P-2 AND P-3 UNDER 5 YEAR DESIGN LOADING

Street Location In	From	To	Size In.	Design Capacity CFS	5 Yr. Design Flow CFS	Theoretical Overload CFS
Ross Ave.	McGuire	Joe Clifton	90"	330	656	326
Ross Ave.	Joe Clifton	27th	90"	350	745	395
27th St.	Madison	Harrison	72"	259	366	107
27th St.	Harrison	Clay	72"	200	372	172
27th St.	Clay	Trimble	84"	135(310)	393	83
27th St.	Trimble	Laclede	84"	135(310)	420	110
27th St.	Laclede	HC Mathis	90"	142(375)	443	68
27th St.	HC Mathis	Park Ave.	90"	142(375)	443	68
Noble Pk.	Park Ave.	Perkins Crk.	(2)90"	750	1099	349

( ) Capacity under surcharged conditions

The 90" relief sewers constructed in the late 1950's do not appear to have sufficient capacity to carry the 5 year design storm runoff.

A check of the large sewers under 2 year storm conditions was performed and the results are shown in Table VII.

TABLE VII

SUMMARY OF THE ANALYSIS OF THE LARGE RELIEF SEWERS SERVING WATERSHEDS P-1, P-2 AND P-3 UNDER 2 YEAR DESIGN STORM LOADING

In	Street Location From	To	Size In.	Design Capacity CFS	2 Yr. Design Flow CFS	Theoretical Overload CFS
Ross Ave.	McGuire	Joe Clifton	90"	330	437	107
Ross Ave.	Joe Clifton	27th	90"	350	506	156
27th St.	Madison	Harrison	72"	259	301	42
27th St.	Harrison	Clay	72"	200	305	105
27th St.	Clay	Trimble	84"	135(310)	317	OK
27th St.	Trimble	Laclede	84"	135(310)	339	19
27th St.	Laclede	HC Mathis	90"	142(375)	350	OK
27th St.	HC Mathis	Park Ave.	90"	142(375)	362	OK
Noble Pk.	Park Ave.	Perkins Crk.	(2)90"	750	868	118

( ) Capacity under surcharged conditions

From the results of the analysis, it appears the large relief sewer along 27th Street has sufficient capacity to handle the runoff from a 2 year design storm. Preliminary flow estimates indicate the Ross Avenue sewer may be somewhat overloaded. However, the flow estimate for the Ross Avenue sewer was developed assuming the entire contributing watershed to be fully developed as zoned, which is actually not the case. Actual 2 year design flows in the 90 inch Ross Avenue sewer are estimated to be in the range of the capacity of the sewer.

In summary, the sewers in the 29th and Clay drainage area are not sufficient in capacity to meet the proposed 5 year

storm design criteria for sewer design. Also, the large 90" relief sewers serving the surrounding area do not meet the criteria.

Detention is not recommended as a solution to this problem due to the lack of available land in the area. It is estimated that 7 acre-ft. of storage would have to be provided for sufficient retention of 5 year storm runoff. This would be the equivalent of a one-acre pond 7' deep. In addition to the pond, a high capacity pump station most likely would have to be constructed due to the lack of relief for a gravity discharge.

The most suitable solution to the problem would be the construction of a new storm sewer to relieve the area.

Engineering calculations estimate the relief sewer running along 30th Street and Ross Avenue is nearly overloaded during 2 year design storm loading. Addition of runoff from the 29th and Clay drainage area could magnify the problem.

Flow estimates for the 27th Street relief sewer included the estimated runoff from the 29th and Clay drainage area. The large sewer appears to have sufficient capacity for a 2 year storm. Therefore, the outlet for the new storm sewer serving the 29th and Clay drainage area should be the 27th Street relief sewer.

3. Recommendations:

The construction of new storm sewers and related appurtenances along Clay Street and Trimble Street from 29th Street to the relief sewer in 27th Street is recommended to relieve the flooding problem in the 29th and Clay drainage area of

Paducah. The new sewers should be designed for a 2 year design storm since the majority of the sewers surrounding the area appear to be designed to handle runoff generated by a two year storm. The proposed alignments for the sewers along with preliminary pipe sizes are shown on Figure VI in Appendix B.

Installation of the new sewers would reduce the frequency of the flooding in the area from three times per year to once every two years, based upon long term averages. The magnitude of flooding for storms up to the five year frequency storm should be reduced substantially.

4. **Cost/Benefit:**

The cost of new storm sewers in the developed area of 29th and Clay Street is estimated to be $681,600. A preliminary cost estimate for the project is included on sheet C1 of Appendix C. Traffic and utility congestion, as well as major pavement removal and replacement adds substantial cost to the project.

Of significant importance to the project is the benefit/cost ratio. Benefits can be related to losses which result from flooding. The losses can be characterized as intangible and tangible. Tangible losses are generally related to actual losses suffered to property. Things like traffic impedance, health and safety threat, and loss of potential business are intangible losses which are difficult to assess.

Initially, upon construction, approximately eight Riviera apartments suffered damage every time excessive surcharging occurred in the sanitary sewer serving the complex. The owners installed backflow prevention devices in the laterals

serving the apartments. Although this has helped relieve the problem, the backup of sewage into the apartments reportedly still occurs occasionally.

All of the properties in the 2800 and 2900 block of Clay Street have suffered some damage to their lawns. The damage ranges from accumulation of drift to erosion. Floodwaters backed up into approximately four of the California Court Apartments during the storm of September, 1985. However, direct damage to the apartments does not appear to take place at any frequency for which it is reasonable to design. There have also been reports of water backing up into cars which have been parked along Clay Street.

Construction of the proposed storm sewers is anticipated to reduce tangible losses significantly. Approximately 14 residential units would be affected directly by the project. Other residents within the area will be affected to a lesser degree.

In an effort to develop a benefit/cost ratio with respect to tangible benefits, an estimate of the flood damage over a ten year period was pro-rated to an annual cost. The estimated annual cost of flood damage in the area is $7,000/year. Assuming the sewers were designed for a useful life of 50 years, the annual cost would translate to a present worth of $86,000 at a 8% rate of return. Thus, the cost/benefit ratio, considering tangible benefits, is estimated at 0.13. Therefore, from this respect, the project does not appear to be feasible.

When adding such factors as emergency maintenance costs, police costs, inconvenience to traffic, the ratio approaches

0.25. The unknown in a benefit/cost analysis for this area is the potential liability involved with the hazard to the public generated by flooding in the area.

Hidden liabilities exist if there is a drowning or exposure to bacteria in sanitary sewage. These are difficult to establish within the scope of this study. Development of such factors would involve a detailed risk analysis.

In summary, when considering a conventional benefit/cost analysis, the proposed project does not appear to be feasible. In any case, the city should embark upon a extensive maintenance program to insure optimum operation of the existing facilities.

A sufficient maintenance program would entail a regularly scheduled cleaning of inlets, manholes and sewers. Such a schedule would insure the existing sewers would operate at maximum capacity during any given storm occurrence.

B. Cross Creek Drainage Area

1. Overview:

The area referred to as the Cross Creek Drainage Area is bounded to the South by the Paducah and Illinois Railroad; to the West by Mississippi Street and C Street; to the North by 21st Street and to the East by the Illinois Central Railroad. The study area along with the watershed influencing the drainage of the area is illustrated in Figure 2 of Appendix A.

This section of the stormwater study concentrated on two zones within the area as a whole which have exhibited persistent flooding problems throughout the years. Zone 1 of the study concentrates on the area along the Beltline and Old Mayfield Road where floodwater has been observed to overtop each of the roads on several occasions. The second zone concentrates on the area near Morgan School within the Cornell Subdivision area. Conversations with residents indicate severe ponding occurs around Morgan School during moderate to heavy rain storms. Periodic flooding has occurred in areas upstream of Morgan School. Ditches back up and runoff tends to pond in yards.

The two zones in the study area are interrelated by a common drainage channel known as Cross Creek. Upstream of the Beltline, Cross Creek drains an estimated 1,180 acres.

2. Analysis of the Beltline and Old Mayfield Road Area:

Flooding periodically occurs in this area when headwaters of Cross Creek overtop the Beltline and Old Mayfield Road. Conversations with two business owners in the area indicate serious overtopping occurs approximately one time every two

years, usually in the spring. The typical rainfall observed during periods of flooding is in the range of 2" to 3" per hour. The maximum flood level observed was approximately Elevation 58.0 city datum during the heavy storm in September of 1985. Approximately 5' of water was standing in Skin Head's Restaurant and Leneave's Garage. The typical water level during typical flooding is approximately 0.5' above the sidewalk near Skin Head's Restaurant. Observed 01/03/00

The Federal Emergency Management Agency Flood Insurance Map shows the majority of the immediate area fronting the Beltline from the intersection at 21st Street to Old Mayfield Road is within the 100 year floodplain.

Flood profile maps indicate the box culverts under Old Mayfield Road and the Beltline constrict the channel of Cross Creek resulting in approximately 4' of headwater above the Old Mayfield Road culvert during 100 year storm conditions. The excess headwater effect leads to the overtopping of Old Mayfield Road and the Beltline. One resident indicated the flooding problem seems to have worsened over the years as portions of the low area around Cross Creek near Old Mayfield Road may have been filled. Such filling would be in violation of the city's flood insurance ordinance.

An analysis was performed on the Old Mayfield Road and Beltline culverts at Cross Creek. The contributing watershed area was delineated using current City of Paducah sewer maps and U.S.G.S. topographical maps. The total watershed area contributing flow to the Old Mayfield Road is estimated to be 1,170 acres. Since each of the culverts is under state main-

tained roadways, the rational method was chosen to develop runoff estimates for the watershed in accordance with Kentucky Department of Highway Drainage Manual. The time of concentration for the watershed was estimated to be 70 minutes. The estimated peak runoffs for a 25 year storm and a 100 year storm were calculated in accordance with Kentucky Department of Highways culvert design criteria. The total estimated runoffs for the 25 year design storm and the 100 year design storm at the Old Mayfield Road culvert are 1,215 CFS and 1,490 CFS, respectively.

The culvert under Old Mayfield Road is double barrel in configuration. Each barrel was constructed during different periods of time. Initially a 10' x 8.5' brick arch culvert was constructed years ago with a 7' x 8' concrete box culvert added some time later. Immediately downstream of the double barrel culvert is a 10' x 10' concrete box culvert under the Beltline.

> 141 Ft²
↓
TO
↓
100 Ft²

The box culvert under the Beltline was analyzed using methods recommended by the Kentucky Department of Highways. The tailwater elevation for the culvert was obtained by interpolation from the FEMA Flood Profile for Cross Creek. For a 25 year storm design flow of 1,215 CFS, the calculated Hw/D ratio for the culvert is estimated to be 1.6 for the culvert operating at outlet control. Inlet control was checked and determined not to be critical. The 1.6 Hw/D actually indicates floodwater will overtop the road during a 25 year storm occurrence. The headwater from the Beltline culvert causes the Old Mayfield Road culvert to operate under pres-

sure flow, thus floodwater overtops Old Mayfield Road also. The effect of the undersized culvert causes Cross Creek to overtop out of its bank, resulting in the major flooding experienced by the area.

As drainage characteristics of the Cross Creek watershed continue to change, it is apparent that the construction of new culverts under Old Mayfield Road and the Beltline may be required to ease the periodic flooding that occurs in the vicinity. The existing culverts are estimated to have sufficient capacity for a 7 year storm, if properly maintained, without provoking overtopping the Beltline or Old Mayfield Road. However, ponding does occur in the area once every two years. A hydraulic analysis indicates the storm sewers along Beltline are undersized. Storm sewer improvements may be required to further alleviate the ponding problem.

3. Analysis of the Morgan School and Cornell Subdivision Area:

The area around Morgan School near the Cornell Subdivision is relatively flat with poorly draining soils. The residential area above Morgan School is gently rolling with an average slope of approximately 0.6%. Drainage is provided by shallow to moderate depth roadside drainage ditches. The typical roadside ditch in areas upstream of Morgan School is a 1' wide flat bottom ditch with 1:1 side slopes. The maximum depth of the typical roadside ditch is approximately 1.5'. The maximum capacity of the typical ditch above the Morgan School area is estimated at 10 CFS.

The recommended Kentucky Department of Highways design storm for open channels and roadside ditches is the 10 year,

20 minute design storm. Assuming a runoff coefficient of 0.4, the ditches should be capable of handling a drainage area of approximately 6 acres. It appears the ditches in the Cornell Subdivision area downstream of 30th Street are undersized. For example, the approximate runoff to the intersection of 29th Street and Virginia Street near Morgan School is estimated to be 22 CFS during a 10 year design storm. This design flow would require 2' flat bottom ditch with 2:1 side slopes with a 1.5' depth, which is substantially larger than the existing ditches. A flow of this magnitude would require a 30" culvert as a minimum which is far larger than existing culverts within the area.

4. Recommendations:

Beltline and Old Mayfield Road Highway Area

Analysis and experience tends to prove the culverts under Old Mayfield Road and the Beltline are undersized in relation to current design standards. Current design practice dictates the design of large box culverts for a maximum headwater depth equal to the barrel depth of the culvert. Preliminary estimates indicate an additional 12' X 10' culvert under the Beltline and an additional 12' X 8' under Old Mayfield Road are needed to meet current design criteria. These estimates were developed solely for estimating purposes and should not be used for design. An estimate for upgrading the Old Mayfield Road and Beltline culverts is included on Page C2 of Appendix C.

As discussed in the analysis section of this report, the sewers along the Beltline warrant upgrading to further relieve ponding problems. The most feasible solution appears to be

the addition of a relief sewer through private property to Cross Creek. The proposed alignment of the relief sewer is shown on Figure 7 in Appendix B of this report. The estimate for construction of the relief storm sewer is included in the estimate Page C2 of Appendix C. Sizes used for the estimate are preliminary and should be further scrutinized upon design.

The Morgan School and Cornell Subdivision Area

There are basically two alternative ways to upgrade the drainage in the Cornell Subdivision area. The first alternative would be to build large drainage ditches within the subdivision which would be capable of handling a 10 year, 20 minute duration storm. The ditches would need to be paved to reduce the roughness factors. A serious drawback to this alternative would be the depth required for the ditches. From 29th Street northward to Cross Creek the ditches would become deep due to the large culvert pipes required to prevent overtopping of roadways. Large, deep ditches present traffic hazards and other public hazards in addition to degrading the aesthetics of the neighborhood.

Therefore, it is recommended the City of Paducah consider the construction of curb and gutter and a storm sewer network in the affected areas. Figure 7 in Appendix B illustrates the areas which are recommended for curb and gutter and storm sewers. Curb and gutter, with the addition of storm sewers, would add to the aesthetics of the neighborhood as well as reduce the flooding problems. An estimate is provided in Appendix C, page C3.

Several culverts and ditches in the area were noticed to be in immediate need of maintenance. Ditches and culverts in need of repair should receive prompt maintenance which could ease the flooding problems in a portion of the affected area until the proposed improvements are implemented.

5. Benefit/Cost Discussion:

Beltline and Old Mayfield Road Highway Area

The development of an exact benefit/cost ratio for this phase of the project would be lengthy and require extensive door to door surveys of every resident and business in the area. Several assumptions were made to arrive at an approximate figure which can be used as an indicator of the feasibility of the project.

Proposed improvements would reduce the occurrence and severity of flooding in the area. The approximate 25 year flood elevation along Cross Creek is estimated to be 338.5±. Construction of the proposed culverts would reduce the maximum stage to within the banks of Cross Creek. An estimated 60 residences and 6 businesses lie within the 25 year flood plain in Cross Creek. The majority of residences have floor elevations above elevation 385. For purposes of this study, it is assumed that 20% of the residences (12) and all of the businesses suffer serious flood damages every 25 years. It was assumed that 6 residences and 6 businesses suffer minor flood damage every 10 years.

The total loss for businesses in the area was estimated at $6,000 every ten years and $100,000 every 25

years. The total loss for residences was estimated at $6,000 every ten years and $12,000 every twenty five years. The total estimated losses over a 50 year period are equivalent to a present worth value of approximately $27,000. The preliminary cost estimate for the proposed improvements to the area is $442,750.00. Therefore, the tangible benefit/cost ratio is approximately 0.06 which clearly tends to limit the feasibility of the project. It must be pointed out that intangible factors such as liability in relation to traffic accidents and possible drownings are not accounted for in the approximate benefit/cost ratio. Should such factors be taken into consideration, the project would become more economically feasible.

Cornell Drainage Area

The proposed improvements to the Cornell Area are estimated to affect approximately 120 residences by an increase in property value and approximately 30 residences by reducing flooding damage. Conversations with residents indicate major flood damage in the area has been minimal. As the major complaint in the area is erosion and water ponding in yards, the estimated pro-rated annual flood damage cost would be somewhere in the range of $8,000 annually. When adding the extra tax revenue generated by the increased property values in the project area, the net realized benefit would be roughly $10,000/year. Considering a 50 year design life and annual rate of return of 8%, this annual loss would

be equivalent to approximately $122,330. The estimated cost for the proposed improvements is $1,287,950.00. Therefore, the estimated benefit/cost ratio would be approximately 0.1 which is far below values which are considered feasible. Therefore, from a tangible point of view, the project does not appear to be feasible.

However, there are many intangible benefits that can be reaped upon completion of the project. For instance, the overall safety of school children would be improved by reducing the ponding areas around Morgan School. Movement of traffic during storm occurrences would also be improved.

C. The Littleville Drainage Area

1. Overview:

The area referred to as the Littleville drainage area in this report is bounded to the north by the Beltline, to the east by the Old Nashville and St. Louis Railroad, to the south by the city limits and to the west by the Illinois Central Gulf Railroad. The drainage area is depicted in Appendix B, Figure 3.

The area is typically flat offering minimal relief for adequate surface drainage. The soils at the surface of the drainage area are predominantly of the Henry and Okaw Series which are characterized by the Soil Conservation Service as poorly drained. Therefore, infiltration of surface water can be considered as minimal. Numerous depressed areas exist within the area which act as mini-detention basins which help attenuate peak runoff.

There have been previous projects which have dealt with the Littleville Area drainage problems as well as continuous efforts by the City of Paducah Street Department. The most recent extensive project was a ditching program in 1980. The project consisted of the excavation of large interceptor ditches to aid drainage in the Littleville Area and the area between Old Mayfield Road and the Illinois Central Gulf Railroad.

Stormwater traditionally ponded along the west side of the railroad from Division Street to the Beltline. Drainage ditches were excavated to relieve the ponding. The ditches on the west side of the tracks were excavated to divert water to a culvert under the Beltline. An existing culvert under the

I.C. Railroad was cleaned and improved to allow ponded water to drain to the Littleville side of the tracks. An interceptor ditch was cut along private property to an existing ditch near Hawaii Street to maintain flow discharged from the culvert. City forces excavated a large ditch from Hawaii Street south along Pool Road to an existing 5' X 7' box culvert under the Paducah and Illinois Railroad. The city obtained permission from the county to continue the improvement of the ditch from the railroad to it's outlet in a branch that flows to Island Creek. The project best served only the south portion of Littleville west of Pool Road from Roosevelt Street to the Railroad.

The ditch running from Paxton Street to the L & N Railroad and south along the railroad was also improved during the ditching program. This phase of the project helped relieve ponding of runoff along Paxton Street.

Conversations with residents indicate there are a couple of areas within the Littleville area which still flood on a regular basis. Water tends to pond along Little Avenue near the State Street intersection as well as along State Street. Residents also report that water tends to pond regularly in the ditches along Bloom Avenue. Water also periodically overtops Pool Road near the Paducah Lakes area.

2. Analysis:

The area of concern around Little Avenue drainage area in general, is very flat. Existing ditches are sloped at below minimum recommended grades. Sediment and drift debris accumulate on a regular basis in the ditches due to the flat

grades. According to residents, city maintenance personnel rarely maintain the ditches. Residents normally end up cleaning out existing pipes and ditches usually immediately following the passage of moderate to heavy storms to relieve ponding.

The outlet of existing ditches along State Street and Little Avenue is near the intersection of Bloom Avenue and State Street. Runoff enters a 30" pipe culvert at this location and is conveyed under the Beltline to Cross Creek. The invert of the entrance of the pipe culvert is approximately 10 feet lower than the average ground elevation of the Little Avenue area. Therefore, there is enough relief available to adequately drain the Little Avenue area to the culvert.

Approximately 17 acres is drained by the ditches running along Little Avenue and State Street. Runoff was calculated utilizing the rational formula for both a five year storm and a ten year storm. Analysis indicates the capacity of the culvert under the Beltline west of the intersection of Bloom Avenue and State Street is sufficient for carrying the 5 year design storm runoff. However, ditches within the viinity of Little Avenue and State Street appear to be too small with too little slope to adequately convey runoff to this pipe system.

3. Recommendations:

Two alternative methods of conveying the runoff were considered:

The first alternative considered was the excavation of new ditches along existing ditch alignments. A minimum grade of 0.5% is recommended for construction of ditches in order to

minimize deposition. Considering the minimum slope required, ditches running along State Street would have to be an estimated 4 feet in depth which is generally considered excessive for residential areas.

The other alternate considered is the construction of storm sewers into the area of concern. The construction of an adequate storm sewer would consist of the construction of approximately 400 L.F. of 30 inch RCP along State Street and approximately 400 L.F. of 21 inch RCP along Little Avenue. Figure 8 in Appendix B illustrates the proposed improvements.

The problem area around Bloom Avenue can be improved somewhat by initiating a new ditching program in the area fronting Bloom Avenue from Virgie Street to Hawaii Street. Ditches can be improved to discharge to the large drainage ditch in the area constructed in 1980.

City forces are capable of completing the ditching work proposed; therefore, no estimate is included for the work.

The remainder of flooding problems can be reduced by initiating a comprehensive ditch maintenance program.

As the majority of the drainage area offers minimal relief, numerous drainage ditches are constructed below minimum recommended slope. Over a period of time, these ditches will silt in and be overgrown with vegetation, reducing capacity, thus spurring localized ponding. Ditches should be maintained on an annual basis as a minimum. Failure to do so will result in an unnecessary hazard and inconvenience to the residents of the Littleville area.

4. Cost/Benefit Discussion:

The Littleville Avenue/State Street part of the proposed drainage improvements to Littleville area would benefit an estimated 10 to 15 residences. The preliminary project cost estimate is $133,410.00. Damages to private property have been relatively minimal. A tangible benefit/cost ratio for the proposed storm sewer would be somewhere in the range of 0.25 which is far below the feasible level.

However, when intangible benefits are considered, the project feasibility tends to increase. Near drowning incidents have been reported in the area. Water reportedly overtops roads within the area, frequently making travel unsafe. These factors must be taken into consideration when studying the feasibility of the proposed improvements.

The proposed ditch maintenance program is definitely justified. The feasibility of the proposed storm sewer extension appears to be questionable.

D. 36th Street at Branch Creek Drainage Area

1. Overview:

The 36th Street and Branch Creek drainage area is part of the Perkins Creek watershed. The study area is bounded to the South by Gregory Avenue and Buckner Lane; to the West by Buckner Lane; to the North by Pines Road; and to the East by 32nd Street. Current zoning for the area is R-1 low density residential. The watershed comprising the 36th and Branch Creek drainage area is shown in Appendix A, Figure 4.

The topography of the area is gently rolling, offering adequate slopes for surface drainage. A variety of soils are predominant in the watershed ranging from the Memphis silt loam along the ridge tops to the Vicksburg silt loam in the lower stream reaches. The majority of the soils have moderate permeability which generally reduces runoff through infiltration.

The area of the watershed upstream of 36th Street is drained by surface ditches that empty into Branch Creek. Several years ago Branch Creek was filled in from 36th Street to 32nd Street to enable development of the area. Branch Creek now empties into a large storm sewer which runs along Branch Street from 36th Street to 32nd Street. At 32nd Street, the sewer turns and runs along 32nd Street, emptying into an open drainage channel at the floodwall.

Two residents of 36th Street were interviewed and gave accounts of past flooding occurrences. Flooding occurs in the area according to residents about once every year. When the

large sewer flows at capacity, water tends to back up and fill the low area near the railroad at 34th and Branch Street. Once the low area has filled, severe surcharging causes floodwaters to overtop 36th Street and flow down Branch Street. During periodic heavy storms, floodwaters back up into several of the resident's basements along Branch Street resulting in extensive flood damage.

2. **Analysis:**

The watershed area contributing to the Branch Creek sewer upstream of 36th Street is estimated at approximately 165 acres. An additional estimated 95 acres is served by the sewer from 36th Street to its outlet near the floodwall. The time of concentration for the watershed upstream of 36th Street is estimated at 24 minutes. The time of concentration for the other subareas contributing to the sewer were substantially lower. Runoff was calculated by both the Soil Conservation Service TR-55 method and the rational formula. The capacity of the sewer and hydraulic grade lines were developed using the THYSS computer program. The results of the analysis are included in Table VIII. Since the analysis under 2 year storm loading shows the sewer is extremely overloaded, the summary of the 5 year analysis is not shown.

TABLE VIII

SUMMARY OF THE ANALYSIS OF THE BRANCH STREET RELIEF SEWER UNDER 2 YEAR DESIGN LOADING

Street Location In	From	To	Size In.	Design Capacity CFS	2 Yr. Design Flow CFS	Theoretical Overload CFS
Branch St.	Branch Crk.	37th	48"	220	174	---
Branch St.	36th	Jefferson	54"	126	204	78
Branch St.	Jefferson	34th	60"	162	233	71
Branch St.	34th	32nd	60"	170	265	95
32nd St.	Branch St.	Pines Rd.	60"	168	298	130
32nd St.	Pines Rd.	Outlet	60"	168	325	157

From the results of the analysis, it can be seen that the sewer is severely overloaded even under two year storm loading conditions. It appears the sewer may have been designed to handle the 2 year design storm flow upstream of 36th Street. Inlets downstream of 36th Street may not have been taken into account in the original design.

The overall capacity of the sewer appears to be about 175 CFS which correlates to a storm with an intensity of approximately 1.65 In./Hr. which is less than a one year storm.

During storm events which exceed the intensity of a 1 year design storm, the Branch Street sewer operates in a surcharged condition. Runoff from the upper portion of the watershed will typically back up out of inlets in the lower elevation portion of the sewer and flow overland to low areas where it is accumulated until it can be drained off. Runoff from the lower area of the watershed also flows overland to the low areas.

3. Recommendations:

Relief is needed for the overload on the existing Branch Creek Sewer. Two alternatives are available for providing the required relief.

Alternative No. 1 would be the construction of a new large storm sewer from 34th Street and Branch to the outlet of the existing sewer near the floodwall along 32nd Street. Selection of an alignment for the proposed sewer would be difficult due to utility congestion. A preliminary estimate indicates the cost of a new large storm relief sewer would be approximately $850,000.00.

Alternative No. 2 would consist of the construction of a detention basin utilizing the low areas of the Westwood Country Club. Preliminary analysis indicates a basin with a storage capacity of 12 Ac. Ft. would be required to adequately reduce flooding downstream along Branch Street and 32nd Street. A combination of excavation and building a berm would be required. Demolition of the existing inlet structure and approximately 200 L.F. of existing 48" RCP is also recommended. A new outlet structure for the basin would be required. The outlet structure should have the capability of variable rate discharge.

Ponded water detained in the basin would have a maximum retention time of approximately two hours which shouldn't disrupt the normal activities of the golf course. The basin would have to be maintained on a regular basis to remove drift debris, etc. A schematic drawing of the proposed improvements is included in Figure 9 of Appendix B. A cost estimate is provided in Appendix C.

4. Benefit/Cost Discussion:

Flooding affects approximately 20 residences along Branch Creek every two years to some degree. Floodwaters have reportedly filled basements on several occasions, resulting in thousands of dollars of damage. The preliminary project estimate for the proposed improvements is $99,200.00. The estimated average cost per residence for the proposed project would be approximately $410.00 annually over a 50 year design life. Actual damage in the area when pro-rated to an annual cost is probably 25% of the estimated average cost per residence figure. Therefore, from a tangible benefit point of view, the project is hard to justify. Again, however, all of the intangible variables, such as traffic hazards and public safety, must be considered.

E. 7th and Jones Street Drainage Area

1. Overview:

This section of the study is centered around a residence at southwest corner of the 7th and Jones Street intersection. The residence is constructed in a low lying lot which typically ponds with every substantial rainfall event.

There are small drainage ditches along Jones Street which run from 8th Street to 6th Street. The ditches normally convey stormwater to the storm sewer running along 6th Street. However, the ditch on the south side of Jones Street empties into the lot where the ponding has been experienced. According to records in the City Engineer's office, prior to 1956, drainage away from the lot was provided by an 18" culvert under the Illinois Central Railroad south of the area. In 1956, the property south of the railroad was developed. During the development of the property, it is theorized the pipe was filled and plugged, leaving no outlet for the runoff coming to subject residence.

Previous efforts to locate the pipe with a backhoe by City Engineering personnel have failed. Therefore, it may be difficult to prove if the pipe had been installed under the railroad as shown on railroad drawings. If by chance the pipe can be found, it may be possible to negotiate with the developer of the property south of the railroad tracks, some kind of remedial action to correct the drainage problems.

If further efforts to locate the pipe fail, the city might want to consider filling the low area of the lot to grade with the remainder of the lot. The lot would be graded to drain to

the front of the property. The ditch running along the front of the lot could be reshaped to promote positive drainage to the 6th Street storm sewer. The cost for filling and grading the lot is estimated at $6,000.00.

2. **Benefit Cost/Discussion:**

The majority of the damage to the property due to flooding is yard damage. Grass will not grow due to the length of time water remains ponded in the area. The property value of the residence could probably be increased $2,000.00 by filling the yard and establishing a stand of grass.

Though cost outweighs benefits by a factor of three and probably entities other than the city are to blame for this problem, the city might choose to contribute to the solution with city forces, such as by having some fill placed by the street department.

VII. FUNDING POLICIES FOR FINANCING DRAINAGE PROJECTS

A. Past Funding Policies

The City of Paducah has funded past storm sewer projects by a variety of methods including general obligation bonds, sewer revenue bonds and tax assessments. Individual property owners have also contributed significantly to past drainage projects.

In earlier years, sewer construction was financed by a special tax assessment against benefitting property. The collection of such tax assessments became difficult and a transition to other methods of financing gradually evolved.

Bonding has been a method of financing which has proven successful in the past. Construction of large relief sewers for the overloaded combination sewers in a large part of Paducah's west end between 21st Street and 27th Street was financed by bonds issued in the early 1960's and 1970's.

Recently, the responsibility of drainage improvements in developing neighborhoods and commercial districts has shifted towards the individual property owner or developer. Developers have been held responsible for the installation of all required drainage facilities. Individual property owners wanting to install culverts or storm sewers in ditches are required to assume the financial burden of the improvements.

B. Current Available Methods of Funding

1. General Obligation Bonds:

General Obligation Bonds are normally used to finance projects which benefit all of the citizens of a community. Bond payments for principal and interest are normally obtained from the general fund. General Obligation Bonds can be

obtained at slightly lower interests than market rate due to the lower risk. General Obligation Bond, when used to finance storm sewer construction serving confined areas, may tend to provoke public opposition by citizens who do not receive any benefit from the project.

2. Sewer Revenue Bonds

Issuance of Sewer Revenue Bonds is a method of financing which is being used by communities throughout the United States for sewer extensions. Principal and Interest payments necessary to retire the bonds are obtained from user fees. Revenue bonds generally command a higher interest rate than general obligation bonds due to the slightly higher risk involved.

The applicability of Revenue Bonds to storm sewer projects in Paducah is questionable because at the present time, the City of Paducah does not charge user fees for storm sewers. Some other communities have initiated user fees for storm sewer service. The fees are usually based on the runoff each property contributes to the drainage system. Some communities have used zoning districts as a basis for determining the required user fee.

Sewer Revenue Bonds have been used to finance past sewer projects for relief of the overloaded City of Paducah combination sewers. Future relief sewer projects should be eligible for funding using Revenue Bonds.

3. Sewer Depreciation Extension Fund

The City of Paducah has a sewer depreciation and extension fund that was established years ago to extend sanitary

sewers, improve wastewater treatment facilities and wastewater pumping stations. The extension fund is supported by sanitary sewer tap on fees and sewer service charges. It is our understanding that your legal counsel has rendered an opinion that the possibility may exist for the use of some future storm water projects.

4. Community Development Block Grant Program (CDBG)

The Community Development Block Grant Program is administered by the State to promote economic and general development in deprived areas of the state. The program helps fill the void left by declining Federal funding programs. One of the major conditions of the program is the financial condition of the community. In order to be eligible, 51% of an area to be served must have income below a regional level established by the state.

Several criteria are evaluated upon submittal of a CDBG application. These criteria include cost, household income and overall benefit of the project. A ranking system, based upon the criteria, is utilized by the state to award the grants.

5. Kentucky Infrastructure Authority

The Kentucky Infrastructure Authority is a branch of the State government which is part of the Department of Finance and Administration. The Kentucky Infrastructure Authority was created to aid in administration of state funds for the financing of sewer related projects and other infrastructure projects. Establishment of this authority was also somewhat in response to cutbacks in federal funding.

Several different financing programs are under the jurisdiction of the Kentucky Infrastructure Authority. These include the Infrastructure Revolving Fund Program, the Wastewater Revolving Fund Program, and the Governmental Agencies Market Rate Loan Program.

The Kentucky Infrastructure Authority finances projects through the issuance of loans under each program at varying interest rates. A number of factors are used to rate the applicability of an individual project to a particular funding program.

Several of the projects proposed in this report may be eligible for low interest financing under programs administered by the Kentucky Infrastructure Authority at interest rates as low as 4%. A significant advantage of using Kentucky Infrastructure Authority funding over conventional funding programs is that none of the city's bonding capacity is used.

C. Funding Recommendations

1. 29th and Clay Street Drainage Project

The proposed improvements in the 29th and Clay Street area are needed to help reduce the overflow occurrences of the combination sewers serving the area. The total estimated cost of the project is $681,600.00.

Placing a share of the cost burden on the individual adjacent property owners in this case would be difficult since the area is already served by storm sewers. Since the sewers were undersized initially, it would be difficult to place the responsibility of remediation on the individual property owner.

Therefore, it is recommended the city utilize bonding, Kentucky Infrastructure Authority Funding or the Sewer Extension Depreciation Fund, if applicable, to fund the proposed improvements if the division is made to implement this project.

2. Cornell Drainage Project

The majority of the proposed improvements for the Beltline Area relate to drainage structures which are maintained by the state. The cost for upgrading the culverts under Old Mayfield Road and the Beltline is estimated to be in the range of $375,000.00. The proposed improvements should be accomplished by means of a highway improvement project through the Kentucky Department of Transportation.

The proposed construction of the relief storm sewer in the Beltline area estimated at $68,000.00 should also be eligible for some state funding as it will help relieve the overload on the storm sewers serving the Beltline.

The proposed improvements within the Cornell Drainage Area are estimated to cost approximately $1.3 million dollars. Approximately $435,000 of this will be incurred as a result of curb, gutter and sidewalk construction. The cost of this portion of the project could be assessed directly to the adjacent property owners. The city could sell revenue bonds to finance the construction, allowing the development of an affordable debt retirement plan. The remaining $865,000 dollars associated with the project might be funded by the city utilizing bonding and/or Kentucky Infrastructure funding.

3. Littleville Drainage Project

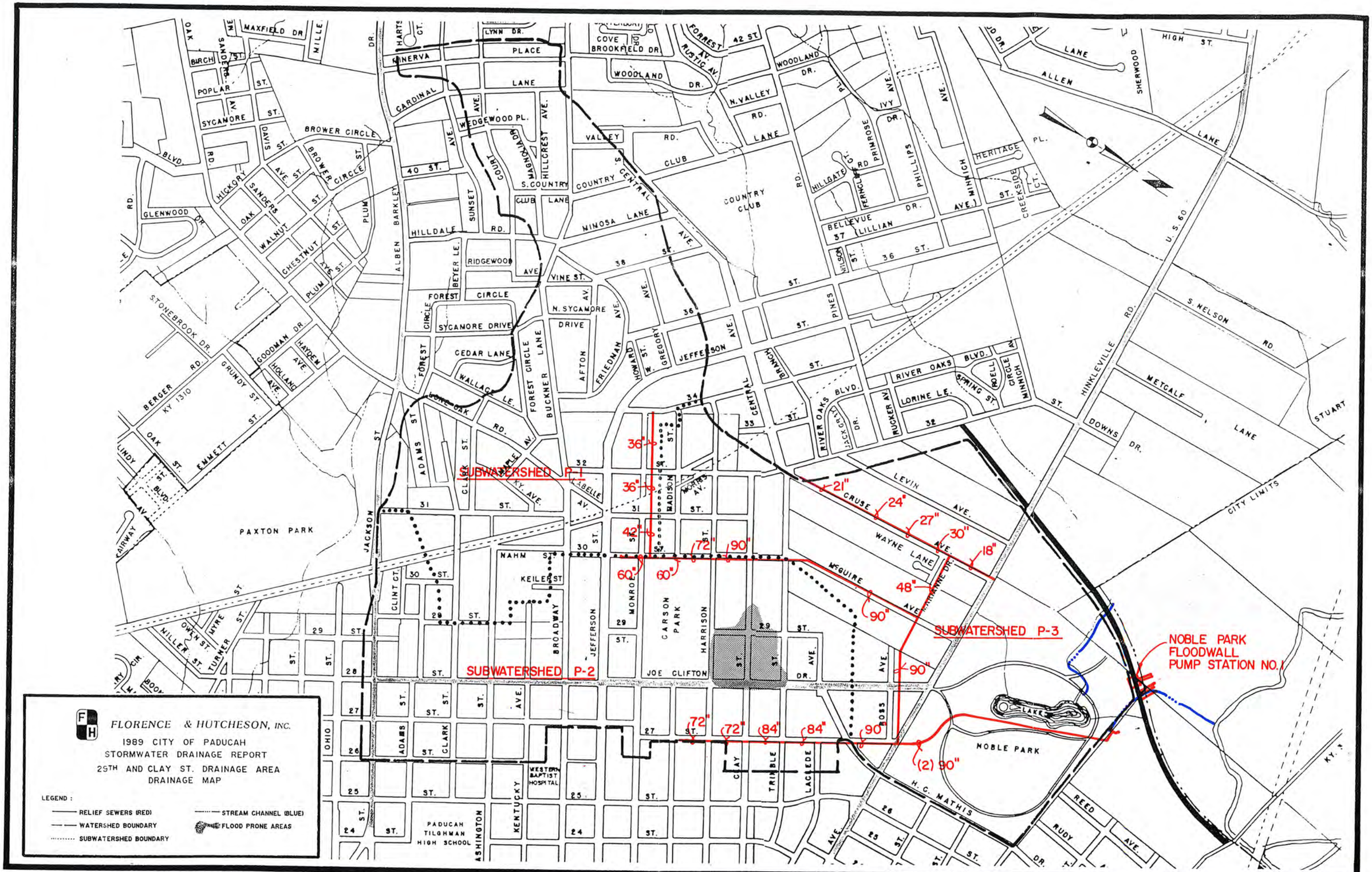
The proposed Littleville drainage improvements are estimated to cost approximately $133,410.00. The average income in the Littleville area may entitle the City of Paducah to a Community Development Block Grant which could be utilized to fund the improvements. Should a grant not be obtained, a low interest rate loan could probably be obtained from the Kentucky Infrastructure Authority to fund the improvements.

4. 36th Street and Branch Creek Drainage Project

The total estimated cost for financing the 36th and Branch Creek Drainage Project is approximately $100,000. The only viable avenues for financing the proposed improvements are bonding or a Kentucky Infrastructure Authority Loan.

APPENDIX A

DRAINAGE MAPS



F H

FLORENCE & HUTCHESON, INC.

1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
29TH AND CLAY ST. DRAINAGE AREA
DRAINAGE MAP

LEGEND :

- RELIEF SEWERS (RED)
- WATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY
- STREAM CHANNEL (BLUE)
- FLOOD PRONE AREAS

FIG. 1

FLORENCE & HUTCHESON, INC.

1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
CORNELL AREA
DRAINAGE MAP

LEGEND :

- STORM SEWER (RED)
- STREAM CHANNEL (BLUE)
- WATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY
- FLOOD PRONE AREAS

SUBWATERSHED C-11

SUBWATERSHED C-7

SUBWATERSHED C-4

SUBWATERSHED C-3

SUBWATERSHED C-6

SUBWATERSHED C-8

SUBWATERSHED C-5

SUBWATERSHED C-2

SUBWATERSHED C-10

SUBWATERSHED C-9

SUBWATERSHED C-1

EXIST. 5'x10' BOX CULVERT

EXIST. 7'x8' BOX CULVERT & 10'x8.5' ARCH CULVERT

48" RELIEF SEWER

68"x 31"

15" 18" 21" 12" 30" 24" 27" 36"

FIG. 2

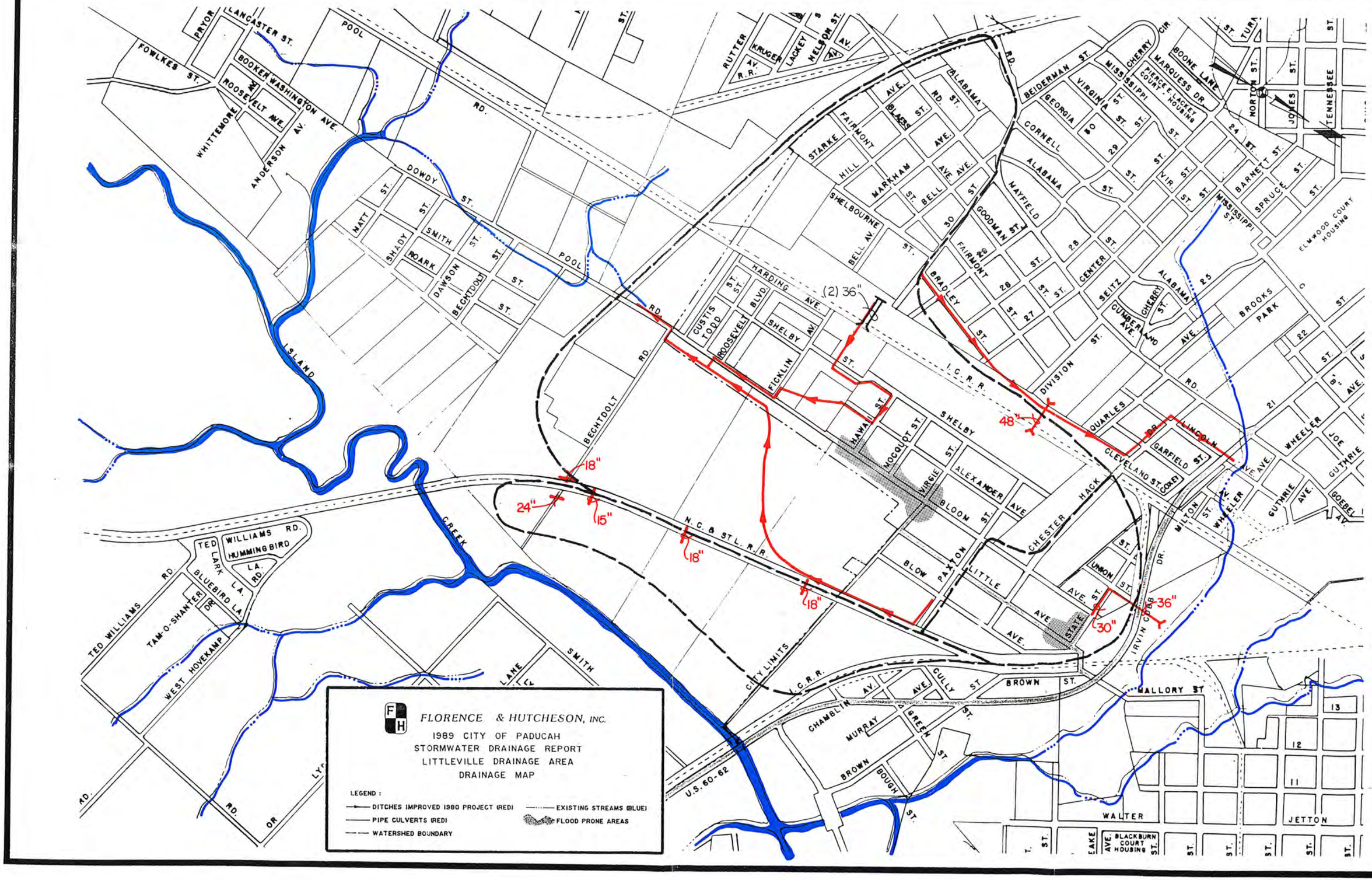

FLORENCE & HUTCHESON, INC.
1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
LITTLEVILLE DRAINAGE AREA
DRAINAGE MAP
LEGEND :
DITCHES IMPROVED 1980 PROJECT (RED)
EXISTING STREAMS (BLUE)
PIPE CULVERTS (RED)
FLOOD PRONE AREAS
WATERSHED BOUNDARY
(2) 36"
48"
18"
24"
15"
18"
18"
36"
30"
N. C. & ST. L. R.R.
I. C. R. R.
CITY LIMITS
U.S. 60-62
LANCASTER ST.
POOL RD.
FOWLKES ST.
BOOKER WASHINGTON AVE.
ROOSEVELT AVE.
WHITTEMORE
ANDERSON AV.
DOWDY ST.
SMITH ST.
ROARK ST.
SHADY ST.
MATT ST.
DAWSON ST.
BECHTDOLT ST.
BECHTDOLT RD.
RUTTER AV.
KRUGER AV.
LACKEY AV.
NELSON ST.
ALABAMA AV.
HARDING AVE.
CUSTIS BLVD.
ROOSEVELT ST.
SHELBY AV.
FICKLIN ST.
HAWAII ST.
MOCOLOT ST.
VIRGIL ST.
ALEXANDER AVE.
BLOOM ST.
BLOW ST.
PAXTON AVE.
LITTLE AVE.
CHESTER HACK
CLEVELAND ST.
DIVISION ST.
QUARLES DR.
GARFIELD ST.
LINCOLN DR.
MILTON ST.
UNION ST.
STATE AVE.
IRVIN COBB DR.
BEIDERMAN ST.
GEORGIA ST.
VIRGINIA ST.
MISSISSIPPI ST.
CHERRY CIR
MARQUESS DR.
BOONE LANE
PIERCE E. LACKEY COURT HOUSING
NORTON ST.
JONES ST.
TENNESSEE ST.
BARNETT ST.
SPRUCE ST.
VIR ST.
ELMWOOD COURT HOUSING
STARKE AVE.
FAIRMONT ST.
HILL ST.
MARKHAM AVE.
BLACK ST.
BELL ST.
SHELBOURNE BELL AV.
GOODMAN ST.
MAYFIELD ST.
CORNELL ST.
BRADLEY ST.
FAIRMONT ST.
CENTER ST.
SEITZ ST.
CUMBERLAND AVE.
ALABAMA AVE.
BROOKS PARK
WHEELER AVE.
JOE GUTHRIE AVE.
GOEBEL AV.
CHAMBLIN AV.
MURRAY ST.
GREEN ST.
BROWN ST.
BOUGH ST.
CULLY ST.
MALLORY ST
WALTER
JETTON
BLACKBURN COURT HOUSING
TED WILLIAMS RD.
TAM-O-SHANTER DR.
BLUEBIRD LA.
WILLIAMS RD.
HUMMING BIRD LA.
TED LARK LA.
WEST HOVEKAMP
SMITH LANE
ISLAND CREEK

FIG. 3

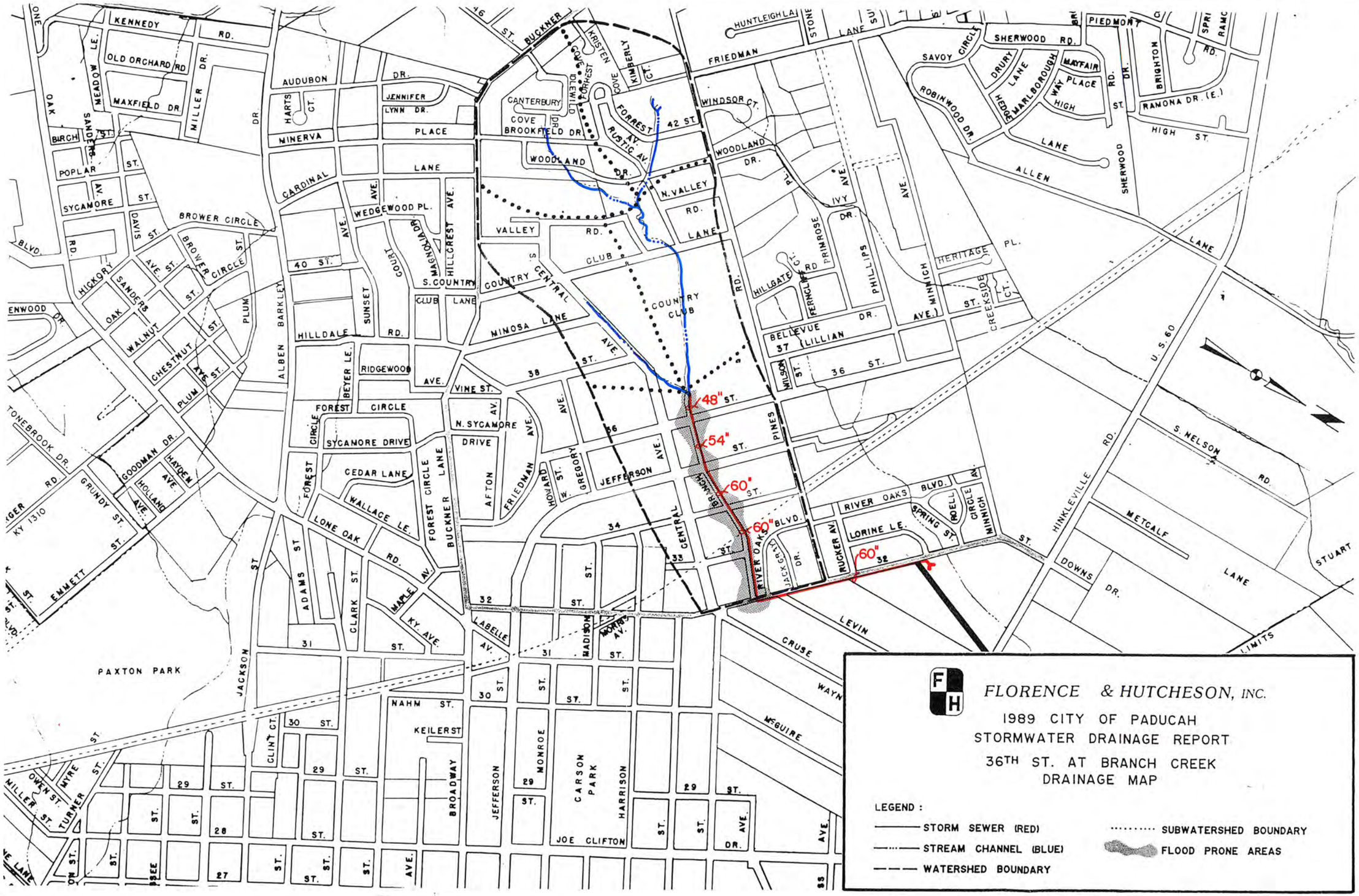

48"
54"
60"
60"
60"
FLORENCE & HUTCHESON, INC.
1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
36TH ST. AT BRANCH CREEK
DRAINAGE MAP
LEGEND :
STORM SEWER (RED)
STREAM CHANNEL (BLUE)
WATERSHED BOUNDARY
SUBWATERSHED BOUNDARY
FLOOD PRONE AREAS
PAXTON PARK
COUNTRY CLUB
CARSON PARK
JOE CLIFTON
U.S. 60

FIG. 4

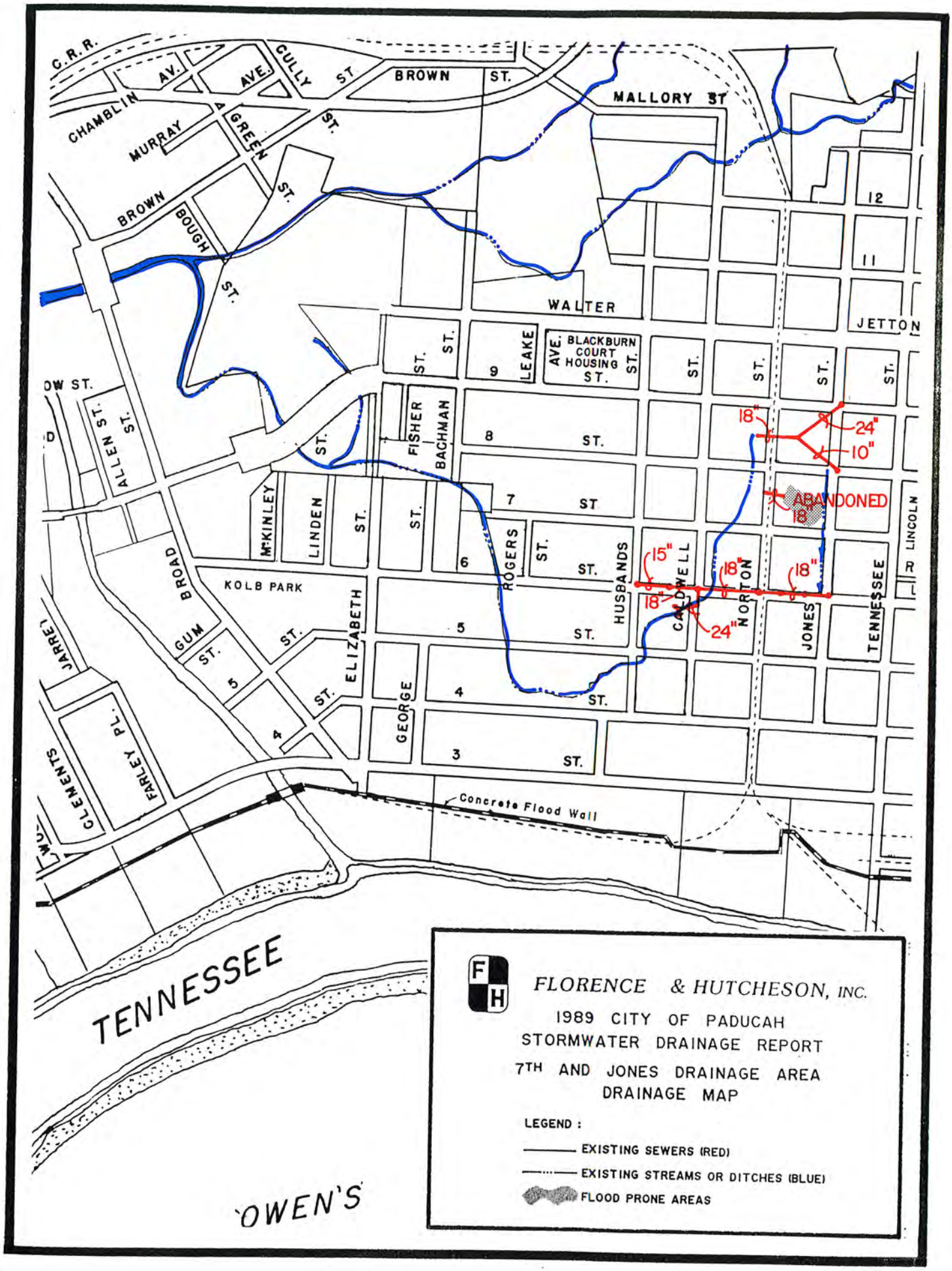

C.R.R.
CHAMBLIN AV.
MURRAY AVE.
GULLY ST
BROWN ST.
MALLORY ST
GREEN ST.
BROWN
BOUGH ST.
WALTER
JETTON
BLACKBURN COURT HOUSING
LEAKE
FISHER
BACHMAN
ALLEN ST.
McKINLEY
LINDEN
ROGERS
HUSBANDS
CALDWELL
NORTON
JONES
TENNESSEE
LINCOLN
KOLB PARK
BROAD
GUM
ELIZABETH
GEORGE
JARREL
CLEMENTS
FARLEY PL.
Concrete Flood Wall
18"
24"
10"
ABANDONED
15"
TENNESSEE
OWEN'S
FLORENCE & HUTCHESON, INC.
1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
7TH AND JONES DRAINAGE AREA
DRAINAGE MAP
LEGEND :
EXISTING SEWERS (RED)
EXISTING STREAMS OR DITCHES (BLUE)
FLOOD PRONE AREAS

FIG. 5

APPENDIX B

PROPOSED IMPROVEMENTS

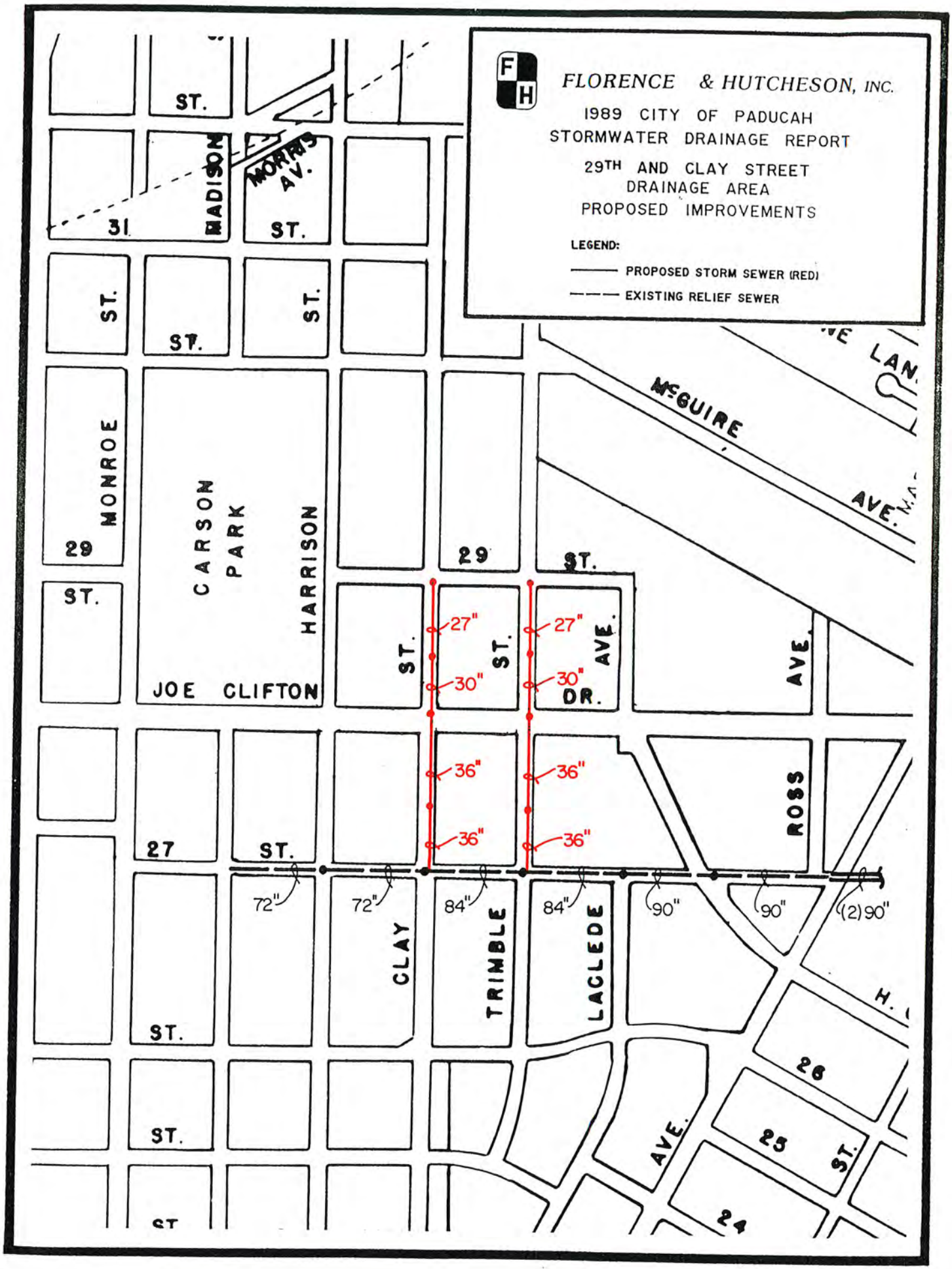
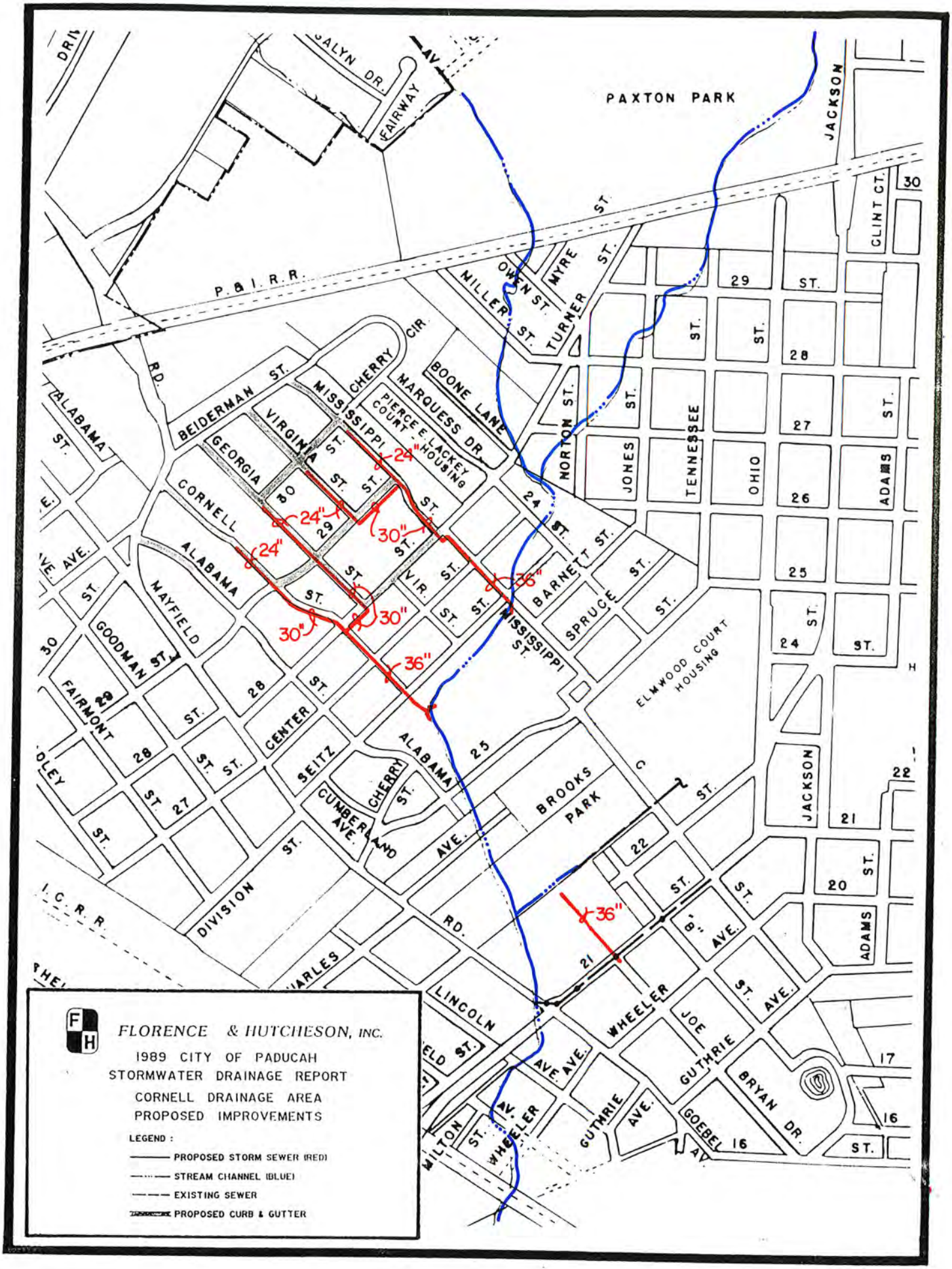

FLORENCE & HUTCHESON, INC.
1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
29TH AND CLAY STREET
DRAINAGE AREA
PROPOSED IMPROVEMENTS
LEGEND:
PROPOSED STORM SEWER (RED)
EXISTING RELIEF SEWER
MADISON
MORRIS AV.
ST.
31
29
27
MONROE
CARSON PARK
HARRISON
JOE CLIFTON
McGUIRE
AVE.
DR.
27"
30"
36"
72"
84"
90"
(2)90"
CLAY
TRIMBLE
LACLEDE
ROSS
26
25
24

FIG. 6



FLORENCE & HUTCHESON, INC.

1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
CORNELL DRAINAGE AREA
PROPOSED IMPROVEMENTS

LEGEND :

- PROPOSED STORM SEWER (RED)
- STREAM CHANNEL (BLUE)
- EXISTING SEWER
- PROPOSED CURB & GUTTER

FIG. 7

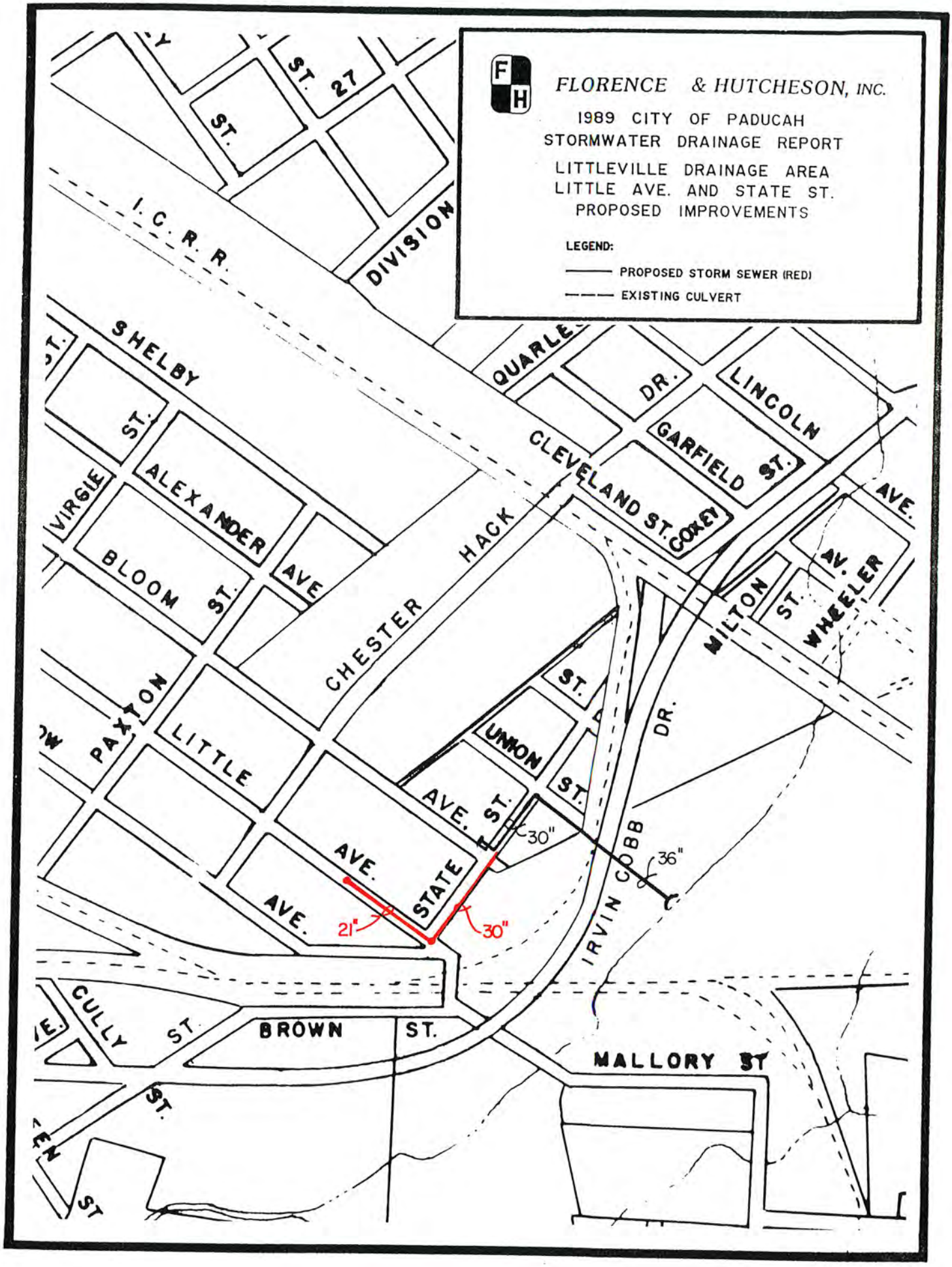

FLORENCE & HUTCHESON, INC.
1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
LITTLEVILLE DRAINAGE AREA
LITTLE AVE. AND STATE ST.
PROPOSED IMPROVEMENTS
LEGEND:
PROPOSED STORM SEWER (RED)
EXISTING CULVERT
I.C.R.R.
DIVISION
ST. 27
ST.
SHELBY
ST.
VIRGIE
ALEXANDER
BLOOM ST.
AVE
CHESTER
HACK
CLEVELAND ST. CORET
QUARLE
DR.
LINCOLN
GARFIELD ST.
AVE.
MILTON
ST.
AV.
WHEELER
PAXTON
LITTLE
AVE.
AVE.
STATE
AVE. ST.
UNION
ST.
ST.
DR.
IRVIN COBB
30"
36"
21"
30"
CULLY
ST.
BROWN
ST.
MALLORY ST
ST.
ST

FIG. 8

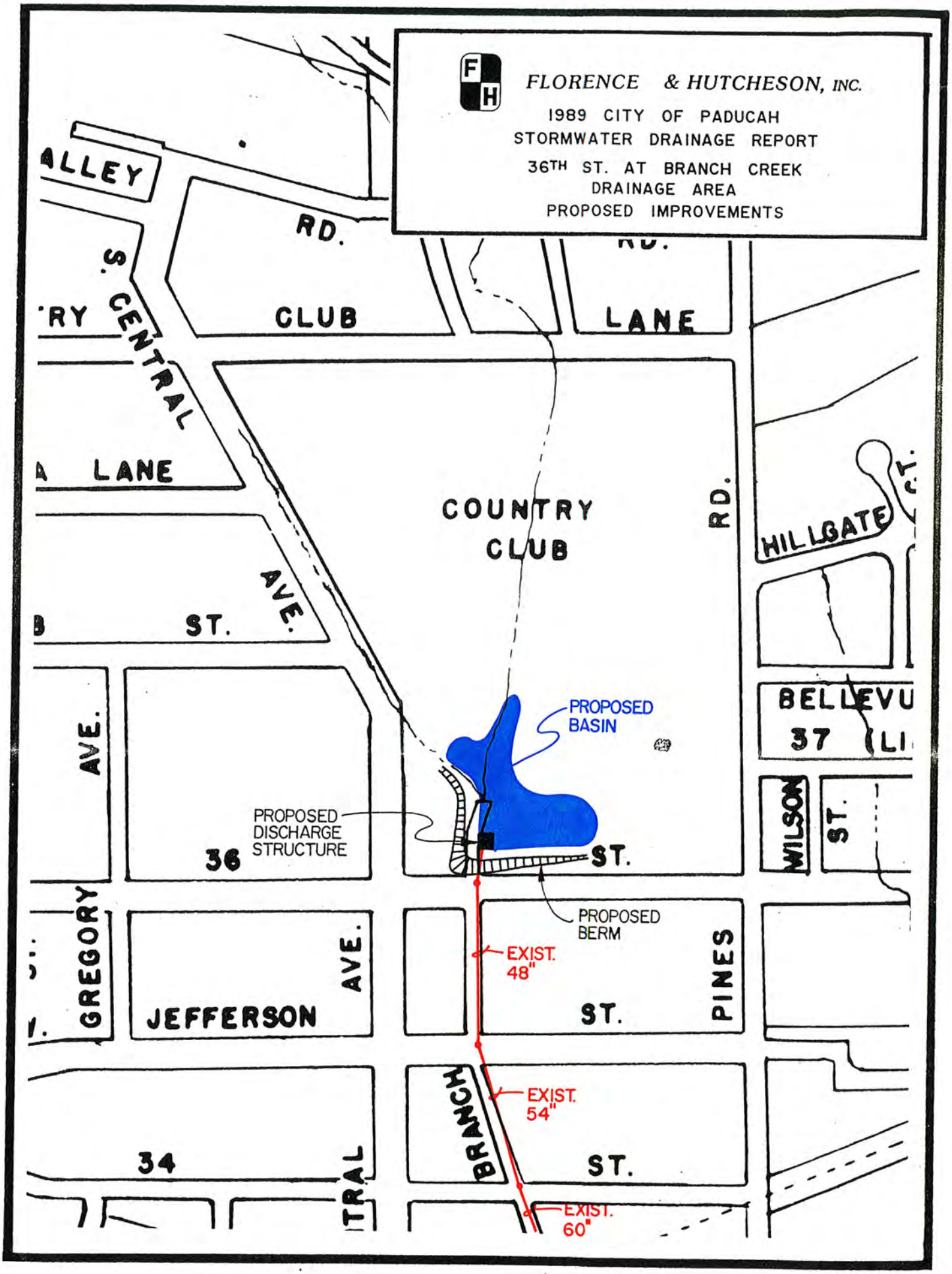
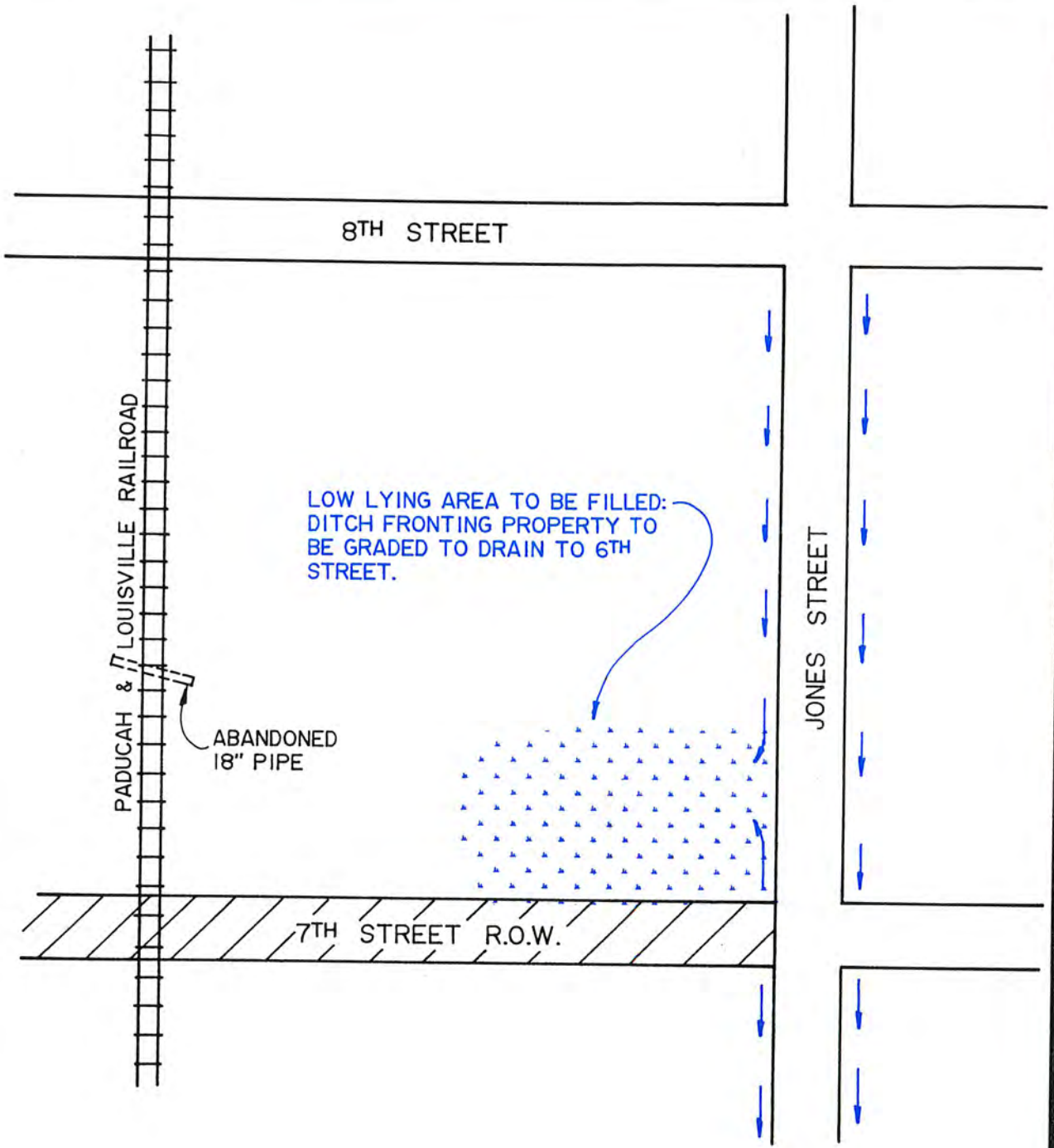

FLORENCE & HUTCHESON, INC.
1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
36TH ST. AT BRANCH CREEK
DRAINAGE AREA
PROPOSED IMPROVEMENTS
ALLEY
RD.
S. CENTRAL
CLUB
LANE
COUNTRY CLUB
RD.
HILLGATE CT.
AVE.
ST.
PROPOSED BASIN
PROPOSED DISCHARGE STRUCTURE
36
ST.
BELLEVU
37
WILSON
ST.
GREGORY
AVE.
JEFFERSON
AVE.
PROPOSED BERM
EXIST. 48"
ST.
PINES
EXIST. 54"
BRANCH
34
ST.
EXIST. 60"

FIG. 9



FLORENCE & HUTCHESON, INC.

1989 CITY OF PADUCAH
STORMWATER DRAINAGE REPORT
7TH AND JONES DRAINAGE AREA
PROPOSED IMPROVEMENTS

FIG. 10

APPENDIX C

COST ESTIMATES

CITY OF PADUCAH

29th & CLAY DRAINAGE AREA

CONCEPTUAL SEWER PROJECT

PRELIMINARY PROJECT COST ESTIMATE

Item	Description	Unit	Est. Qty.	Unit Price	Total
1.	24" RCP	L.F.	484	38.00	$ 22,230,00
2.	27" RCP	L.F.	280	44.00	12,320.00
3.	30" RCP	L.F.	280	50.00	14,000.00
4.	36" RCP	L.F.	550	62.00	34,100.00
5.	36" RCP Tunneled	L.F.	200	440.00	88,000.00
6.	Junction Box	Each	2	2000.00	4,000.00
7.	Drop Box Inlet	Each	8	2000.00	16,000.00
8.	Catch Basin Inlet	Each	18	1200.00	21,600.00
9.	Select Fill	Tons	11000	12.00	132,000.00
10.	Concrete	C.Y.	896	100.00	89,600.00
11.	Bituminous Concrete	Tons	375	50.00	18,750.00
12.	Traffic Control	L.S.	1	10,000.00	10,000.00
13.	Mobilization	L.S.	1	20,000.00	20,000.00
14.	Utility Repair	L.S.	1	10,000.00	10,000.00
15.	Utility Relocation	L.S.	1	25,000.00	25,000.00
		Subtotal			$517,600.00
		Engineering			48,000.00
		Inspection			27,000.00
		Contingencies (15%)			89,000.00
		Total Estimated Cost			**$681,600.00**

CITY OF PADUCAH

OLD MAYFIELD ROAD AND BELTLINE DRAINAGE AREA

CONCEPTUAL SEWER PROJECT

PRELIMINARY PROJECT COST ESTIMATE

Item	Description	Unit	Est. Qty.	Unit Price	Total
1.	12 X 10 Culvert under Beltline	L.S.	1	105,000	$105,000,00
2.	12 X 8 Culvert under Old Mayfield Rd.	L.S.	1	96,000	96,000.00
3.	30" RCP Storm Sewer	L.F.	600	50	3,000.00
4.	Concrete Headwall	L.S.	1	2,000	2,000.00
5.	Utility Relocation	L.S.	1	40,000	40,000.00
6.	Utility Repair	L.S.	1	10,000	10,000.00
7.	Traffic Control Beltline Highway	L.S.	1	20,000	20,000.00
8.	Traffic Control Old Mayfield Rd.	L.S.	1	30,000	30,000.00
		Subtotal			$333,000.00
		Engineering			32,000.00
		Inspection			20,000.00
		Contingencies (15%)			57,750.00
		Estimated Project Cost			**$442,750.00**

CITY OF PADUCAH

CORNELL DRAINAGE AREA

CONCEPTUAL DRAINAGE PROJECT

PRELIMINARY PROJECT COST ESTIMATE

Item	Description	Unit	Est. Qty.	Unit Price	Total
1.	Standard Curb & Gutter	L.F.	17,000	12.00	$204,000.00
2.	Concrete Entrances	Each	130	500.00	65,000.00
3.	Sidewalk	L.F.	8,500	7.50	63,750.00
4.	Inlets	Each	40	2000.00	80,000.00
5.	18" RCP	L.F.	600	32.00	88,000.00
6.	24" RCP	L.F.	1,800	38.00	22,230,00
7.	30" RCP	L.F.	1,880	50.00	14,000.00
8.	36" RCP	L.F.	1,300	62.00	80,600.00
9.	Junction Box	Each	7	2000.00	14,000.00
10.	Select Fill	Tons	10,000	12.00	120,000.00
11.	Bituminous Concrete	Tons	2900	40.00	116,000.00
12.	Utility Repair	L.S.	1	15,000.00	15,000.00
13.	Utility Relocation	L.S.	1	50,000.00	50,000.00
14.	Mobilization	L.S.	1	10,000.00	10,000.00
15.	Traffic Control	L.S.	1	10,000.00	10,000.00
		Subtotal			$1,009,950.00
		Engineering			66,000.00
		Inspection			42,000.00
		Contingencies (15%)			170,000.00
		Estimated Project Total			**$1,287,950.00**

CITY OF PADUCAH

LITTLEVILLE DRAINAGE AREA

CONCEPTUAL DRAINAGE PROJECT

PRELIMINARY PROJECT COST ESTIMATE

Item	Description	Unit	Est. Qty.	Unit Price	Total
1.	18" RCP	L.F.	120	29.00	$ 3,480.00
2.	21" RCP	L.F.	400	34.00	13,600.00
3.	30" RCP	L.F.	400	50.00	20,000.00
4.	Drop Inlets	Each	8	2000.00	16,000.00
5.	Junction Boxes	Each	2	2000.00	4,000.00
6.	Select Fill	Tons	1265	12.00	15,180.00
7.	Concrete	C.Y.	102	100.00	10,200.00
8.	Bituminous Concrete	Tons	70	50.00	3,500.00
9.	Traffic Control	L.S.	1	1000.00	1,000.00
10.	Mobilization	L.S.	1	2000.00	2,000.00
11.	Utility Repair	L.S.	1	2000.00	2,000.00
12.	Utility Relocation	L.S.	1	7000.00	7,000.00
		Subtotal			$ 97,960.00
		Engineering			10,250.00
		Inspection			7,800.00
		Contingencies (15%)			17,400.00
		Estimated Project Total			**$133,410.00**

CITY OF PADUCAH

36th STREET & BRANCH CREEK DRAINAGE AREA

CONCEPTUAL DRAINAGE PROJECT

PRELIMINARY PROJECT COST ESTIMATE

CONSTRUCTION OF DETENTION BASIN

Item	Description	Unit	Est. Qty.	Unit Price	Total
1.	Excavation	Yds.	10000	4.00	$ 40,000.00
2.	Embankment	Yds.	2000	5.00	10,000.00
3.	Easement	L.S.	1	5000.00	5,000.00
4.	Golf Course Modification	L.S.	1	12000.00	12,000.00
5.	Landscaping & Seeding	L.S.	1	5000.00	5,000.00
6.	Removal of Existing Inlet & Sewer	L.S.	1	10000.00	10,000.00
		Subtotal			$ 73,000.00
		Engineering			7,500.00
		Inspection			5,840.00
		Contingencies (15%)			12,950.00
		Estimated Project Cost			**$ 99,290.00**

CITY OF PADUCAH

7th & JONES STREET AREA

CONCEPTUAL DRAINAGE PROJECT

PRELIMINARY PROJECT COST ESTIMATE

Item	Description	Unit	Est. Qty.	Unit Price		Total
1.	Borrow Fill	Yds^3.	1210	3.50	$	4,235,00
2.	Landscaping & Seeding	L.S.	1	1000.00		1,000.00
		Subtotal			$	5,235.00
		Contingencies (15%)				785.00
		Estimated Project Total			**$**	**6,020.00**