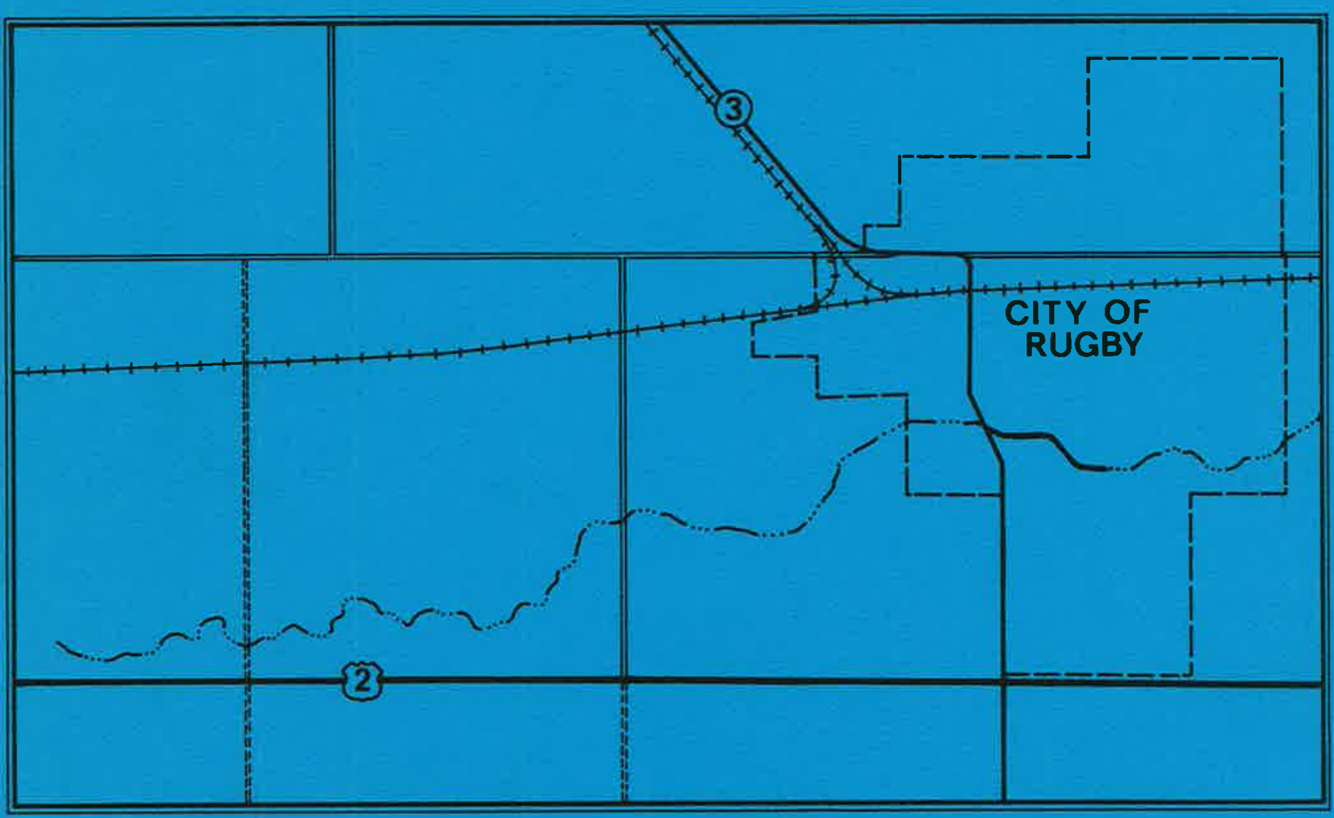
PRELIMINARY ENGINEERING REPORT

RUGBY FLOOD CONTROL

PIERCE COUNTY, NORTH DAKOTA

SWC PROJECT NO. 1566



NORTH DAKOTA
STATE WATER COMMISSION
DECEMBER, 1985

PRELIMINARY ENGINEERING REPORT

Rugby Flood Control Project
SWC Project #1566

November 1985

North Dakota State Water Commission
900 East Boulevard
Bismarck, North Dakota 58505-0187

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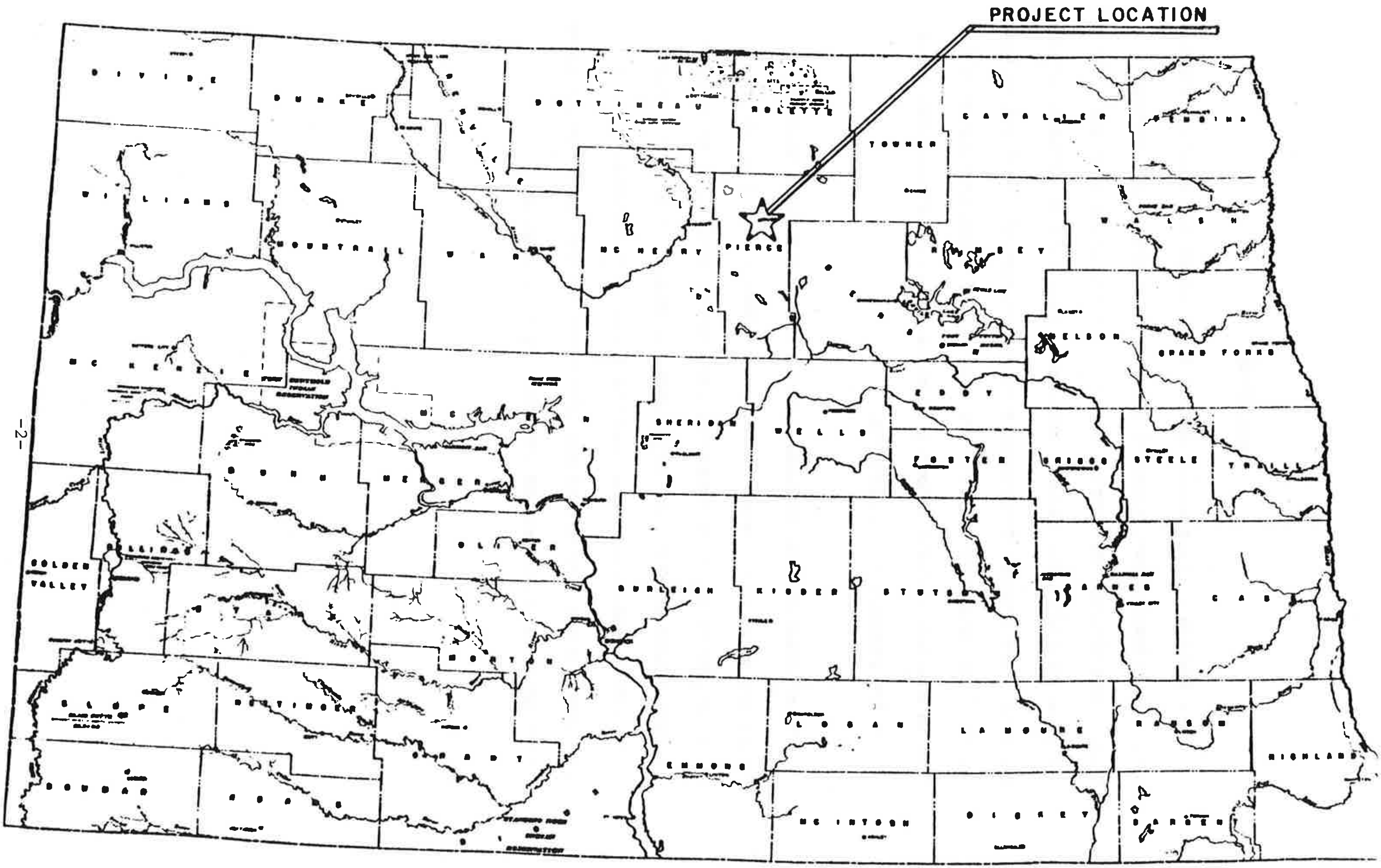
PROJECT LOCATION
DIVIDE
BURKE
BOTTINEAU
ROLETTE
CAVALIER
PEMBINA
TOWNER
WILLIAMS
MOUNTRAIL
WARD
MC HENRY
PIERCE
WALSH
NELSON
GRAND FORKS
MC KENZIE
SHERIDAN
WELLS
EDDY
FOSTER
GRIGGS
STEELE
TRAILL
DUNN
MERCER
OLIVER
GOLDEN VALLEY
BURLEIGH
KIDDER
CASS
SLOPE
HETTINGER
GRANT
EMMONS
LOGAN
LA MOURE
RANSOM
RICHLAND
BOWMAN
ADAMS
MC INTOSH
DICKEY
SARGENT

FIGURE 1

III. HYDROLOGY

A hydrologic analysis of the Rush Lake Tributary flowing through Rugby was performed using the HEC-1 computer model. This model was developed by the U.S. Army Corps of Engineers. It was used to determine the peak discharges and flow volumes of various frequency storms and watershed conditions. It formulates a mathematical hydrologic model of the watershed basin based on the following data: the amount of rainfall or snowmelt runoff, the total temporal distribution of this runoff, soil type, land use, and the hydraulic characteristics of basin channels and drainage areas. The HEC-1 model is designed to calculate the surface runoff of the watershed by representing the basin as a interconnected system of hydrologic and hydraulic components. A single component may represent a hydrograph from subbasin runoff, combined subbasins, channel routing or a reservoir routing.

The first step in the analysis was to delineate the watershed boundary on a topographic map. In this case, USGS 7.5 minute topographic maps of the area were used. Once the watershed was delineated, the watershed basin was divided into a number of subbasins. These subbasins are areas of similar hydrologic features. Their limits are most often determined by changes in hydrologic conditions or by defining areas of specific interest or function.

The total watershed above the inlet to the city storm sewer consists of 78.4 square miles. Of this, it was determined that only 6.2 square miles contribute flows directly to the 48-inch pipe. The remaining 72.2 square miles of non-contributing watershed contain many small

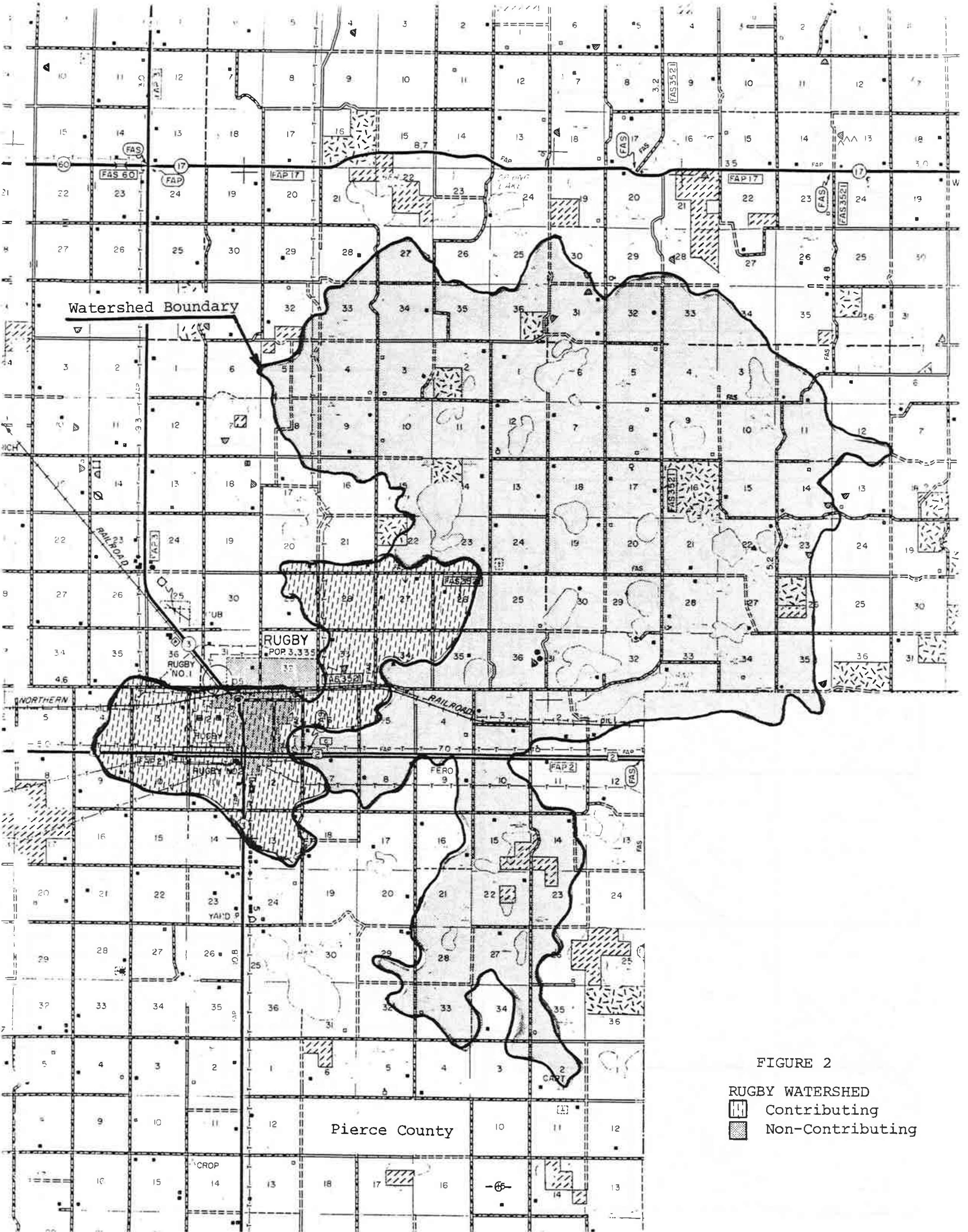

FIGURE 2

RUGBY WATERSHED

Contributing

Non-Contributing

through the railroad embankment located south of the section line road between Sections 33-157-72, and Section 6-156-72. This embankment acts as a restriction to the flow of water from the upstream watershed into the downstream basin. See Figure 3. The resulting inflows and outflows at this embankment are given in Table 1.

TABLE 1

Peak Inflows, Outflows and Maximum Elevations
At Railroad Embankment

Hydrologic Event (frequency)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum Elevation (msl)
	RAINFALL		
100-year	380	95	1539.5
50-year	295	90	1539.1
25-year	225	80	1537.8
10-year	160	65	1536.7
	SNOWMELT		
100-year	390	100	1541.2
50-year	320	90	1539.8
25-year	250	80	1538.4

Considering the location of the embankment, and its impacts on downstream flows, it would be desirable to maintain existing conditions. Figure 4 shows the inflows, outflows, and stage duration curves at the embankment. Also shown is the resulting reduction in peak flows on the 100-year snowmelt.

The second feature to be evaluated was the 48-inch CMP and its capacity to pass flows from the upstream watersheds. It is the policy of state and federal agencies to review conditions based on a 100-year design frequency. The 100-year snowmelt runoff, which has the largest peak flow and volume was used for design purposes. The peak flows for various hydrologic events at the inlet to the pipe are shown in Table 2.

TABLE 2

Peak Inflows at Pipe Inlet

Hydrological Event (frequency)	Peak Inflow (cfs) (rainfall)	Peak Inflow (cfs) (snowmelt)
100-year	190	210
50-year	145	180
25-year	110	145
10-year	85	(not calculated)

The final item of concern is the downstream channel below the outlet to the storm sewer. The HEC-1 model results given in Table 3 are for a point approximately one-half mile downstream from the outlet to the pipe. This includes drainage from the city and some additional downstream land.

TABLE 3

Peak Flows Downstream From Rugby

Hydrologic Event (frequency)	Peak Flow (cfs) (rainfall)	Peak Flow (cfs) (snowmelt)
100-year	260	280
50-year	200	240
25-year	160	190
10-year	110	(not calculated)

IV. PRELIMINARY PIPE DESIGN

A. Existing Conditions

Under present conditions, the retention of flood waters behind the railroad embankment would not eliminate flooding. The HEC-1 model indicates that the peak flow is produced by the watershed below the embankment. Current flooding problems are, however, related to discharges from the embankment. Presently, these discharges follow the downstream flows which have not been removed because of the inadequacy of the 48-inch CMP. Thus resulting in an extended duration of flooding.

It had been considered that the pipe in the railroad embankment be gated and the storage behind this embankment be used to further reduce flows into the city. It was also suggested that the county roadway to the north which was scheduled for reconstruction might also be used for this purpose.

After reviewing the hydrologic model, both of these options were dropped from consideration. The railroad embankment was not constructed to retain water for extended periods. In addition, the storage available was not adequate to contain a 100-year event without the flooding of a significant area. This included some areas that would remain flooded even after floodwaters are released. The top of the railroad embankment is at elevation 1549.5 msl and the invert of the 30-inch RCP at elevation 1532.0 msl.

There is also the possibility of flooding a nearby structure. The resulting water elevations behind the embankment under existing

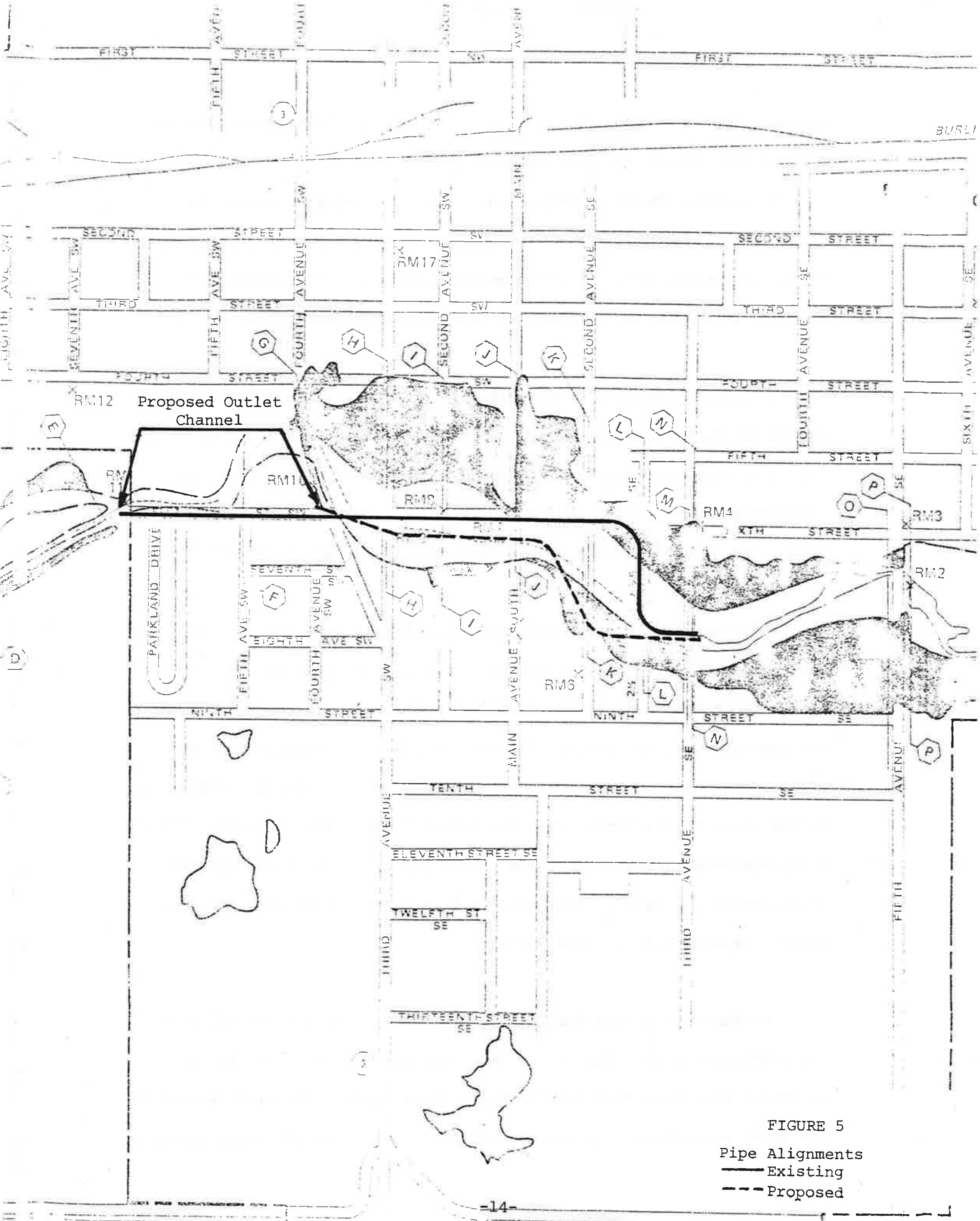

FIGURE 5

Pipe Alignments

—— Existing

– – – Proposed

for approximately another six hours. The flows then taper off to about 100 cfs lasting for another two days. This is shown in Figure 6.

The result of these flows is a condition where for a short period of time the roadway at the inlet to this pipe may be at or near overtopping. Considering the short duration of these flows, a larger pipe which would add considerable cost to the project, could not be justified. If at some time improvements are to be made to this roadway consideration should be given to raising its elevation to provide more freeboard.

V. DOWNSTREAM CHANNEL IMPROVEMENTS

A. Existing Conditions

The existing outlet and downstream channel conditions were evaluated using the HEC-2 hydraulic model developed by the Corps of Engineers. The HEC-2 model uses cross-sections, reach lengths, stream crossings and given channel conditions to determine the water surface profiles along a watercourse. That portion of the downstream area reviewed using the HEC-2 model, shown in Figure 7, extends approximately two and one-half miles from the outlet of the proposed storm sewer.

Originally constructed to carry flows from the 48-inch CMP, the existing outlet channel is not adequate to handle the design flows of the proposed project. Backwaters from existing conditions would significantly reduce the effectiveness of any pipe system. To provide the necessary flow capacity for the design event, improvements to the outlet channel and downstream areas are required.

Downstream from the outlet channel the natural streambed is restricted by both sediment and weed growth. The first portion is narrow and needs to be widened. Beginning in the SW 1/4 of Section 2, Township 156 North, Range 73 West, the channel widens and its capacity increases. The existing stream gradient, however, is flat and needs to be improved if backwaters are to be reduced.

The downstream crossings along this channel are in various conditions. The first crossings between Section 2 and 3 is a multiplate structure and is in good condition. The roadway is also high enough that it will not be overtopped during the design flood. The next two crossings are in poor conditions. The culverts at these locations are blocked with weeds and silt. During flood events these culverts become ineffective because of their size and most of the flows go over these roadways. The size of each of these crossings is given in Figure 7.

B. Design Criteria

The basic requirement for the downstream improvements is that they be designed and constructed to minimize backwater impacts on the proposed system. The selection of a 72-inch CMP set the allowable backwater conditions.

The HEC-2 hydraulic model was used to analyze several alternatives for downstream improvements. Options ranged from consideration of various channel widths and crossing improvements to combinations of both. The result was the selection of a preliminary channel design with a minimum bottom width of 20 feet and 4:1 side slopes.

The greatest improvement to the backwater conditions resulted from the widening of those areas that were narrow and the improvement to the stream gradient. Improvements beyond the selected design yielded small benefits compared to the limits of the model and the proposed design. The gradient available was determined to be the limiting factor in the design.

A review of the downstream crossings determined that in their present condition they did not have a strong effect on backwater discussed. The downstream improvements required to eliminate all backwater problems were not specifically investigated. From a review of trial options it was determined that they could not be economically justified. The project as designed does provide for the adequate control of the design flows.

With the need for channel improvements such as those described, it was necessary for the City of Rugby to obtain an application to drain. This application has been reviewed and approved by the Pierce County Water Resource District. In the review of such an application, it is necessary to consider the impacts that such a project have on downstream lands. Using the HEC-1 hydrologic model, it was determined that the increases in peak flows downstream were approximately six percent. This is within the limitations of the model and is not considered a significant change. The volume of the flows downstream from the project would remain unaffected as the project will not drain additional lands.

The improved flow conditions and increased capacity downstream will reduce some areas of local flooding. Those areas downstream from the improvements would not be significantly affected by the project.

VII. SUMMARY

The intent of this investigation was to review the flood problems associated with the City of Rugby. An analysis of existing conditions indicated that current problems could be attributed to the capacity of the 48-inch CMP, to the development of areas along the natural streambed, and to the conditions along the downstream channel. Each of these areas was considered in this investigation. The railroad embankment above the city is an important part in the design of the proposed project. After analyzing its impacts using the HEC-1 model, it is apparent that conditions at this embankment should not be changed. Consideration of its use as a storage facility determined that this was not a feasible solution, but that it was capable of controlling flows from the design flood in its present state.

The condition of the existing 48-inch CMP indicated the urgent need for its replacement. Its capacity to carry flood flows is very limited and deteriorating. After a review of alternatives, the selected option was for the complete replacement of the system.

The 72-inch RCP selected to replace the existing system meets both requirements for the system design. The first was that it have the capacity to carry the 210 cfs design flows without allowing any flows through the city. The second, that it be hydraulically efficient and have a long life expectancy. The proposed alignment of the new system was chosen for minimum cost and maximum hydraulic efficiency of the system.

During this investigation, the City of Rugby hired Wold Engineering from Bottineau to develop plans and specifications for this project. At the request of the city, they proceeded with the plans based on the preliminary information developed from this investigation. As a result, the final design was finished before the completion of this investigations report.

The downstream crossings, though not requiring specific changes as part of the design, do need to be improved. The two lower crossings shown in Figure 8, are silted in and clogged with weeds. Because of these conditions, most of the flows will overtop these roadways. It is recommended that these crossings be cleaned and upgraded.

A suggested improvement is that the 24-inch CMP at the lower crossing be moved to the crossing one mile upstream, between Sections 3 and 4. An additional 48-inch CMP should then be installed in its place at the same invert elevation as the existing 48-inch CMP. It is recommended that if these roadways are to be raised, the proposed conditions be reviewed using the HEC-2 model developed for this project. This is important because raising these roadways could have a significant effect on backwater conditions at the outlet to the storm sewer.

2. Field surveys necessary to design any channel changes that may be needed.

3. A hydrologic study of the watershed above the city to determine the flows through the city.

4. Determine the size of pipe needed to carry the expected flows.

5. Preliminary design of channel starting at Highway 3 and extending downstream for no more than three miles.

6. Evaulate the effects the proposed project would have on flooding.

7. Look at possible alternatives to carry flows through the city.

8. Preliminary cost estimates.

9. Preliminary engineering report presenting the results of the study.

IV. DEPOSIT - REFUND

The City shall deposit a total of $1,200 with the Commission to partially defray the costs of the investigation. Upon receipt of a request from the City to terminate proceeding further with the preliminary investigation or upon a breach of this agreement by any of the parties, the Commission shall provide the City with a statement of all expenses incurred in the investigation and shall refund to the City any unexpended funds.

V. RIGHTS-OF-ENTRY

The City agrees to obtain written permission from any affected landowners for field investigations by the Commission which are required for the preliminary investigation.