McCLELLANDS
and
MAIL CREEK
Major Drainageway Plan

prepared for

CITY OF FORT COLLINS, COLORADO

and

COLORADO WATER CONSERVATION BOARD

December, 1980

prepared by

CORNELL CONSULTING COMPANY

and

JOHN S. GRIFFITH, P.E.

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MAIL CREEK AND McCLELLANDS DRAINAGE BASIN STUDY

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PREFACE

This study presents flood plain information for Mail Creek and McClellands Basins in Fort Collins and Larimer County, Colorado, and includes a preliminary design of drainage improvement facilities to eliminate or alleviate flow hazards along these channels. This is a drainageway planning study to be used by the City of Fort Collins and Larimer County to guide flood plain development and design of drainage facilities in these drainageways. All proposed drainage improvements within the basin should be checked for consistency with those facilities presented herein, and will be subject to the approval of the City or County. The hydrology used for design of all future facilities in this study reach should be obtained from this report.

This study was authorized and jointly sponsored by the City of Fort Collins and the Colorado Water Conservation Board. The study was completed by Cornell Consulting Company of Fort Collins, Colorado under an agreement with the City of Fort Collins dated June 23, 1980.

A Technical Committe was established for this project to review the progress of the study and to provide technical input from the sponsoring agencies. The Technical Committee included the following individuals:

Mr. Robert Smith, City of Fort Collins

Mr. Marc Engemoen, City of Fort Collins

Mr. D. Randolph Seaholm, Colorado Water Conservation Board

The assistance and cooperation of this committee during the course of this study is acknowledged and is greatly appreciated.

We wish to extend appreciation to all individuals, agencies, firms and organizations who provided assistance and cooperation during the course of this study. In particular, appreciation is expressed to the following irrigation companies who met with us and shared their views regarding storm water runoff conditions affecting their irrigation policies:

Pleasant Valley and Lake Canal

New Mercer Canal

Larimer County Canal No. 2

We also wish to acknowledge the assistance of the following individuals whose guidance and cooperation was particularly helpful:

Mr. Rex Burns - Larimer County;

Mr. D. Randolph Seaholm - Colorado Water Conservation Board;

Mr. Bob Smith - City of Fort Collins, Engineering; and

Mr. Marc Engemoen - City of Fort Collins, Engineering.

Through the progress of the study, previously prepared reports and documents were used to determine existing flow routing patterns and general characteristics of basins in the area. This information, highlighted below, proved very helpful due to the high degree of new development in the area:

Spring Creek Drainage Basin Study, prepared by Gingery Associates, Inc.

Foothills Basin Study, prepared by Resource Consultants Inc.

Fossil Creek Drainage Basin, prepared by the US Army Corps of Engineers.

The Landings - Master Drainage Plan, prepared by Cornell Consulting Company.

The Woodlands - Master Drainage Plan, prepared by Cornell Consulting Company.

Storm Drainage Study for Larkborough Subdivision, prepared by M & I Consulting Engineers.

Storm Drainage Study for Four Seasons PUD, prepared by M & I Consulting Engineers.

Storm Drainage Plan for Park South PUD and South Glen PUD, prepared by James H. Stewart & Associates, Inc.

Initial Drainage Study for Harmony Farms, prepared by James H. Stewart & Associates, Inc.

Drainage Report for a Portion of Imperial Estates, prepared by Professional Surveyors and Engineers, Inc.

Copies of this report are available for public distribution at the below listed offices. A Technical Addendum to this report is also available for review at the same offices; however, it has not been published in sufficient quantities for public distribution. The Technical Addendum includes all pertinent data and calculations used in the floodplain analysis.

Engineering Department
City of Fort Collins
300 LaPorte Avenue
Fort Collins, Colorado
80521

Larimer County Planning Department
Flood Management Section
200 West Oak Street
Fort Collins, Colorado
80521

Colorado Water Conservation Board
823 State Centennial Building
1313 Sherman Street
Denver, Colorado
80203

This study was prepared under the supervision and direction of the following professional engineers.

Donald M. Parsons, P.E.

Robert L. Lenz, P.E.

J.S. Griffith, P.E.

SECTION I

INTRODUCTION

Purpose

The City of Fort Collins and surrounding portions of Larimer County have experienced rapid growth in recent years resulting in increased drainage and flooding problems. Local government officials are under pressure to manage this urban development in a way which will accomodate this growth while at the same time protecting the health, safety and welfare of the area's citizens. Such a situation now exists in the McClellands and Mail Creek Drainages of Fort Collins.

The Purpose of this study is to provide a means for making decisions regarding development and floodplain regulation in McClellands and Mail Creek Drainageways. This purpose was accomplished by determining the flooded areas associated with various frequency storms. Once this was done, an economically feasible and practical plan was formulated for mitigating the drainage and flooding problems. The information in this report is intended for the use of state, county and local governments involved in planning and land use regulations. It is also intended for use by developers within the basin so that they will understand the problems and solutions and thus be able to design and construct their developments in a manner which will utilize the plan and facilities fully to the benefit of all.

Scope of Work

The scope of work defined for the study of McClellands and Mail Creek Drainageways follows the guidelines and specifications for basin studies prepared by the City of Fort Collins. In general, the study consists of the following:

1. Research and collection of base data and information pertaining to the study area. This includes contact with the local government bodies, ditch company representatives and other public and private agencies along with comments from property owners within the basin limits.
2. Define the basins' characteristics by means of available topographical mapping as well as in-field investigation.
3. Prepare a flood history for the area.
4. Conduct a hydrologic analysis for determining runoff characteristics and flow quantities associated with the 2-, 5-, 10-, 25-, 50- and 100-year storm events under both existing and fully developed conditions. Also a brief comparison to historic conditions will be made.
5. Hydraulic routing of peak flows developed in item 4 above to determine flooded areas by water surface profiles. Once determined, delineate the 100-year floodplain on available mapping.

6. Evaluate potential flooding hazard areas and associated damages within each of these floodplains.
7. Develop alternative improvement plans and preliminary designs to accomodate the 100-year storm runoff.
8. Evaluate the economic consequences of the alternatives and develop a cost-benefit analysis for use in selecting an improvement plan.
9. Prepare a final report documenting the results of the study.

Summary of Study Findings

There is no way of predicting when a flood will occur in the Mail Creek and McClellands Drainageways. Should a flood of even minor magnitude occur under existing channel conditions, considerable damage to homes, businesses, railroads and streets could result. Implementation of the recommended improvement plan would prevent potential damage caused by floods greater than a 2-year event.

In selecting the recommended plan, a systems approach was used as well as evaluating isolated improvements. We initially evaluated the cost (including maintenance and operation) of a wide variety of improvements, and combinations of these improvements, in order to find the most effective plan. We then added to this, those major drainage improvements which are likely to be built when unimproved ground is developed. Therefore, economically beneficial improvements in conjunction with improvements likely to occur as a direct result of development are part of the final plan. Continuity of the plan from reach-to-reach was a major consideration, as were the environmental and aesthetic aspects of the alternatives.

Flooding problems in Reach 1 occur only during intense storms because of the well-defined channel. With peak flow reductions affected by detention in Reach 2B, an improved spillway at Fairway Dam is all that is necessary to eliminate flood damage. Reach 2A and 2B exhibit extensive flood damage potential due to the lack of a well-defined channel for even the 2-year storm flows. Because of the limited amount of development in this area, a grass-lined channel with box culvert crossings of Harmony Road, Crest Road and Nordic access road will effectively pass the 100-year storm event. The proposed upstream detention system will allow a reduction in the size and construction costs of downstream improvements. Also, since the recommended detention is in an undeveloped area, final location and configuration can be coordinated at the time (if convenient) of development and possibly be utilized as a multi-use facility. Grass-lined channels between improvements are likely to occur at time of development with final locations established in conjunction with the developer's plan.

Reach 3, the New Mercer Canal, has the capacity to carry approximately the 25-year storm in addition to the ditch's irrigation flows. Peak flow reductions due to detention in Reach 4 enables the canal to carry the 100-year storm event within its existing banks. An improved overflow spillway section in the existing Larkborough detention pond safely passes the 100-year storm flows.

Reaches 4 and 5 are primarily agricultural land with isolated development. A multi-use detention facility with an overflow section can effectively detain and transmit flows through the Larkborough Subdivision at the lower end of these reaches. Drainage crossing at Shields Street and at Pleasant Valley and Lake Canal as well as a grass-lined channel throughout Reaches 4 and 5 will be a result of future development. Benefits of uninterrupted traffic flows, water quality and aesthetics will be realized by these improvements.

Reach 6 is at the present all agricultural except for Reach 6C which is being developed for residential and multi-family uses. The drainage improvements which are proposed as a part of this development can adequately pass the 100-year design flows. A box culvert under Timberline Road at the lower limit of Reach 6A effectively passes the 100-year storm event. A pipe culvert jacked under the Union Pacific Railroad is highly beneficial improvement because of the inadequacy of the existing pipe to pass flows equal to the 10-year storm and greater. Major interruptions to railway service could occur if the existing culvert is not enlarged. A grass-lined channel with varying capacity will be constructed from Timberline Road to Harmony Road once development occurs in this area. Floodplain management will be an effective means to control the layout and scheduling of improvements to provide continuity in this reach.

Benefit/cost calculations for the recommended plan are listed in Table I-1. In addition to reducing flood damage, benefits of the overall plan are that of providing park and recreation opportunities in the floodplain, enhanced land values and improved visual impact of the floodplain, improvement of water quality, preservation of the floodplain ecology, and reduced potential for public inconvenience. Also, several improvement schemes have a benefit/cost ratio greater than one, thus effectively utilizing public funds.

Mapping and Surveys

Topographic mapping for this study was furnished by the City of Fort Collins and Larimer County. The scale is 1" = 100', and the contour interval is 2-feet. All mapping north of Harmony Road is orthophotography of quarter sections. South of Harmony Road, the topography was taken from the manuscript prepared for the Corps of Engineers' Fossil Creek flood study, verified by field surveys.

Floodplain information prepared for this report is presented on this topographic mapping at a scale of 1" = 100', and copies of these flood plain maps are available from the City of Fort Collins or from Larimer County. The floodplain maps printed in this report are reduced to a scale of 1" = 200' for easy presentation.

Field surveys were completed by Intermill Land Surveying to supplement the topographic mapping as required. These cross-sections were taken at stream crossing structures, at locations where the channel was obscured by trees or foliage, and at other locations where elevations were critical to the hydraulic computations. In general, field information was consistent with the topographic mapping.

Interpretation and Use

The 2-, 5-, 10-, 25-, 50-, and 100-Year flood events were used as the flood frequencies for this floodplain analysis. These various flood events have an average occurrence of one in the number of years as indicated. For example, the 100-year flood occurs, on the average, once a 100- year period, and has a one (1%) percent chance of being equaled or exceeded in any given year.

The particular uses for the various flood events in addition to those stated above are as follows:

2-Year through 50-Year Flood Events -

Information regarding these lower frequency floods is especially useful for future engineering studies and land use planning purposes related to minor road systems, minor channel improvements, the location of parks and recreational facilities, agricultural lands, and appurtenant structures. For structures and use of this type of the smaller tributaries and in areas where the high risk of structural failure is economically feasible and the hazard to life and property non-existent, the use of the lower frequency floods may be considered.

100-Year Flood Event -

The 100-Year flood event may also be used for engineering design purposes where a lower risk of failure than the 10- or 50-year flood is desired. However, the most important use of the 100-year flood event lies in floodplain designation and land use regulation as set forth in the state statutes. The State of Colorado considers the 100-year frequency flood as the flood event to be used in designing and protecting structures and dwellings for human occupation. Therefore, all floodplain regulations are based upon the 100-year flood.

TABLE I-1 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON
RECOMMENDED IMPROVEMENTS
McCLELLANDS AND MAIL CREEK

Reach/ Improvement Description	1 Construction Costs: Pond Construction	2 Construction Costs: Outlet Works	3 Construction Costs: Utility Relocation	4 Contingency 50%	5 ROW Acquisition	6 Total Const. Costs	7 Annual Const. Costs	8 Annual O & M	9 Total Annual Improvements Costs	10 Residual Flood Damage	11 Annual Benefit	12 Net Annual Benefit	13 Total Annual Costs	14 B/C Ratio
REACH 6														
A Existing										35,430				
Combination Improvemt. 3	--	20,500	--	10,300	--	30,800	2,170	2,100	4,270	6,190	29,240	24,970	10,460	6.85

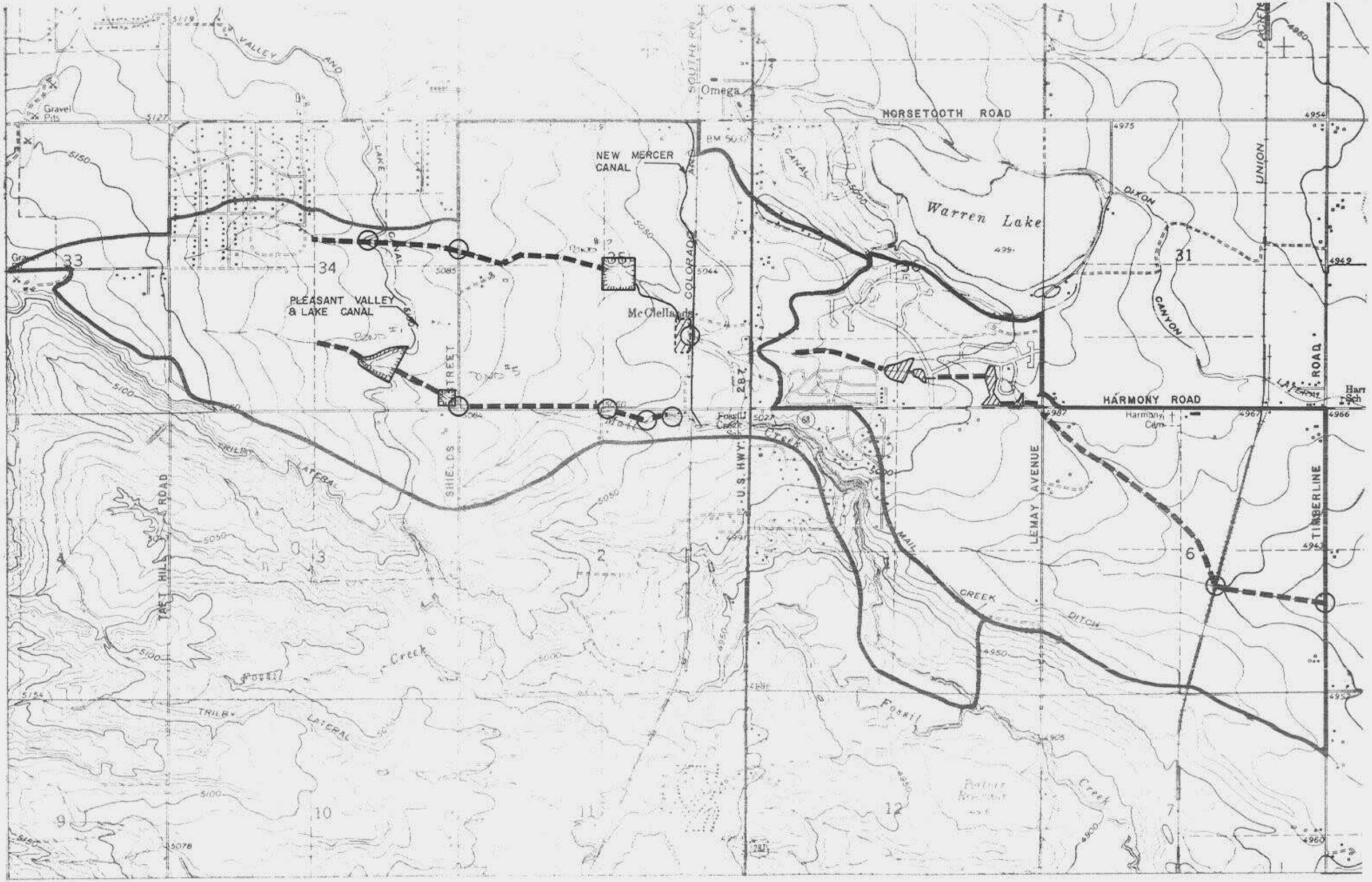
Total Acres 1,117.2 Improvement Cost/Total Acres = $30,800/1,117.2 = $29.60
Total Undeveloped Acres 860.1 (approx) Improvement Cost/Total Undeveloped Acres = $30,800/ 860.1 = $35.80

TABLE I-1 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON

RECOMMENDED IMPROVEMENTS

McCLELLANDS AND MAIL CREEK

Reach/ Improvement Description	1 Construction Costs: Pond/Ditch Construction	2 Construction Costs: Outlet Works Crossings	3 Construction Costs: Utility Relocation	4 Contingency 50%	5 ROW Acquisition	6 Total Const. Costs	7 Annual Const. Costs	8 Annual O & M	9 Total Annual Improvements Costs	10 Residual Flood Damage	11 Annual Benefit	12 Net Annual Benefit	13 Total Annual Costs	14 B/C Ratio
REACHES 1&2														
A Existing										77,250				
Combination Improvemt. 1	372,660	61,220	17,500	225,690	127,700	804,770	57,390	11,170	68,560	10,190	67,060	-1,500	78,750	0.98
Combination Improvemt. 1 w/o ROW Acquisition Pond #1	372,660	61,220	17,500	225,690	22,700	699,770	49,910	4,990	60,330	10,190	67,060	6,730	70,520	1.11
	Total Acres 906.2				Improvement Cost/Total Acres = $699,770/906.2 = $772.20/acre									
	Total Undeveloped Acres 721.4				Improvement Cost/Total Undeveloped Acres = $699,770/721.4 = $970.02/acre									
REACHES 3, 4 & 5														
A Existing										5,850				
Combination Improvemt. 2	38,760	11,000	--	24,880	102,310	176,950	12,620	1,260	13,880	1,190	4,660	-9,220	15,070	0.34
Combination Improvemt. 2 w/o ROW Acquisition	33,760	11,000	--	24,880	--	74,640	5,320	530	5,850	1,190	4,660	-1,190	7,040	0.80
	Total Acres 710.2				Improvement Cost/Total Acres = $74,640/710.2 = $105.10/acre									
	Total Undeveloped Acres 423.3				Improvement Cost/Total Undeveloped Acres = $74,640/425.3 = $176.33/acre									


Omega
NEW MERCER CANAL
PLEASANT VALLEY & LAKE CANAL
McClellands
Warren Lake
HORSETOOTH ROAD
HARMONY ROAD
DIXON CANYON
UNION PACIFIC
LATERAL ROAD
TAFT HILL ROAD
SHIELDS STREET
U.S. HWY. 287
LEMAY AVENUE
TIMBERLINE
COLORADO
SOUTHERN
Harmony Cem.
Fossil Creek
Mail Creek
Fossil Creek Ditch
TRILBY LATERAL
Gravel Pits
33
34
35
36
31
6
1
2
3
9
10
11
12

INDEX OF IMPROVEMENTS

GRASSLINED CHANNEL

RECOMMENDED DETENTION POND

STRUCTURAL IMPROVEMENTS

FIGURE I-1

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MANAGEMENT / ENGINEERING
p.o. box 646, fort collins, colorado 80522 (303)482-6650

McCLELLANDS & MAIL CREEK DRAINAGE STUDY
IMPROVEMENT SUMMARY

SHEET 1 OF 1

SECTION II

STUDY AREA DESCRIPTION

On the southern boundary of Fort Collins, Colorado, the adjacent Mail Creek and McClellands Drainage Basins originate in Section 34, 35, and 36, Township 7 North, Range 69 West, and drain to the southeast through Section 1, Township 6 North, Range 69 West and Section 6, Township 6 North, Range 68 West. Mail Creek is a tributary to Fossil Creek; McClellands is also a tributary to Fossil Creek, but this study does not include tributary areas of the McClellands Basin east of Timberline Road. Development in the uplands of the basins has changed the drainage patterns in the basins in recent years. To assess the impacts of these changes, three (3) basin conditions have been examined. These are described in the following paragraphs and illustrated on Figures II-1, II-2 and II-3 (located in the rear pocket).

MAIL CREEK BASIN

The historic Mail Creek Basin is long and narrow in shape. It is approximately 3.57 miles in length and 7,200 feet wide at its broadest point; it drains 2.47 square miles more or less. Originating at an elevation of 5,185 feet above mean sea level (MSL), Mail Creek falls 291 feet to an elevation of 4,894 feet above MSL at the confluence with Fossil Creek. The historic Mail Creek Basin and subbasins are shown on Figure II-1 (located in the rear pocket).

Mail Creek has long been used to transport irrigation waters. The Pleasant Valley and Lake Canal traverses the upper area of the Mail Creek Basin and Mail Creek receives waste irrigation water from the laterals in this area. Further downstream, the New Mercer Canal and Larimer County Canal No. 2 Waste Ditch discharge directly into Mail Creek. Irrigation water flows in Mail Creek and is either diverted out of the creek at the Mail Creek ditch headgate or continues to flow downstream to Fossil Creek and eventually to Fossil Creek reservoir.

Other manmade features directly affecting the drainage characteristics of Mail Creek are the Colorado & Southern Railroad, College Avenue, Harmony Road, and two (2) private on-stream lakes in Larimer County.

Approximately 1,195 acres of the existing Mail Creek Basin are in the City of Fort Collins, north of Harmony Road. Drainage patterns in the basin have been affected in recent years principally by development occurring in the City. Essentially, development of previously agricultural land in Section 35 has diverted runoff from the uplands of the McClellands Basin to Mail Creek via the New Mercer Canal, and new storm sewer.

The lower portions of the Mail Creek Basin in Larimer County are also being developed. Land use patterns are low density residential and agricultural. The increased area of the Mail Creek Basin and existing and future drainage patterns are shown in Figures II-2 and II-3(located in the back pocket).

McCLELLANDS BASIN

Bordering the Mail Creek Basin on the north, the McClellands Basin shares with Mail Creek similarities of land use, topography, soils and manmade features which affect drainage. Upstream of Timberline Road, the basin is long and narrow in shape. It is 2.37 miles in length and 6,400 feet wide at its broadest point. It drains 1.75 square miles more or less. The basin originates at an elevation of 5,025 feet above MSL and falls 89 feet to an elevation of 4,936 feet above MSL at Timberline Road.

The historic McClellands Basin (see Figure II-1, in back pocket) drained approximately 1,117 acres west of Timerline Road. Land uses were predominately agricultural. West of College Avenue, there are few places where there is a distinct drainage channel. The basin is intersected by the Pleasant Valley and Lake and the New Mercer Irrigation Canals, which were built in the late 1800's and carry approximately 30 cfs and 80 cfs respectively in the vicinity of Harmony Road. There are no wasteways or spill structures in McClellands, so it is highly probable that most storm runoff originating upstream of these canals was diverted to Mail Creek since the construction of the canals.

The McClellands Drainage Basin has been experiencing steady development in recent years in the subbasins north of Harmony Road in the City of Fort Collins. Most of the development has been done in accordance with the drainage criteria of Fort Collins, and considerable on-site detention is being created. Development is forthcoming in the section south of Harmony Road, portions of which have been annexed into the City, however, existing land uses in the lower reaches are still agricultural.

Manmade features affecting drainage patterns in the McClellands Basin are the Union Pacific and Colorado & Southern Railroads, College Avenue, Harmony Road and the Larimer County No. 2 and New Mercer Canals. The existing and future McClellands Basin are illustrated in Figures II-2 and II-3 (back pocket).

MAIL CREEK STUDY REACHES

Mail Creek reaches included in this study begin at the confluence with Fossil Creek and extend approximately 3.3 miles upstream to the center of Section 34. For analysis, study reaches (Figure II-4) were broken out into the following homogeneous segments:

Reach 1A - Mail Creek from confluence with Fossil Creek to Mail Creek Lane.
Reach 1B - Mail Creek Lane to Palmer Drive.
Reach 1C - Palmer Drive to U.S. 287 (College Avenue).
Reach 1D - U.S. 287 to C & S Railroad.
Reach 2A - C & S Railroad to Shields Street.
Reach 2B - Shields Street to upstream study limits.
Reach 3 - New Mercer Canal between Mail Creek and McClellands tributary.
Reach 4A - McClellands tributary from New Mercer Canal to center of Section 34.
Reach 4B - McClellands tributary from center of Section 34 to Shields Street.
Reach 5 - McClellands tributary from Shields Street to upstream study limits.

Reach 6A - McClellands from Timberline Road to Union Pacific Railroad.
Reach 6B - McClellands from Union Pacific Railroad to Harmony Road.
Reach 6C - McClellands from Harmony Road to center Section 35.
Reach 6D - McClellands from center of Section 35 to upstream study limits.

Reach 1 of Mail Creek is a well-defined channel with steep, sometimes vertical banks, and an abundance of vegetation. It is a natural section in generally good condition. The channel section in Reach 1A is 30 to 50 feet wide at the bottom with an 8-foot to 20-foot wide low flow channel which meanders across it. The channel is 10-feet deep and contains native grasses, willows, and occasional cottonwood trees. The overbanks are cultivated for alphalfa and hay. The channel section in Reach 1B is similar to that in Reach 1A except that two (2) culverts have been placed in the stream and the overbank areas are now residential rather than agricultural. Upstream from Passway Drive, the channel is steep with 15-foot banks which show evidence of sloughing in some areas.

A small dam has been placed across the Mail Creek channel at Palmer Drive, Reach 1C, and a reservoir has formed behind it for a private lake. Further upstream, another dam has been constructed forming another small lake. However, the purpose of the structure is for the inlet works for the Mail Creek irrigation ditch. At the upstream end of this second lake, the Larimer County Canal No. 2 waste ditch discharges excess irrigation flows into Mail Creek.

Likewise, in Reach 1D, irrigation water flows into Mail Creek from the New Mercer Canal at a point just downstream from the C & S Railroad. The channel section in this reach is in a natural condition with heavy growths of vegetation which are fed by the constant flow of irrigation water.

Reach 2A, for example, does carry a small trickle flow, but is more open and flatter than the lower reaches. The channel runs parallel to Harmony Road and has been obliterated to no more than swales by the shoulder of the road west of Crest Road. The small trickle flow originates from irrigation runoff and domestic sources, since many contributing subbasins have recently been developed. Culverts have been placed in the channel at several locations, but are all too small to carry significant runoff. In one location, small dams have been constructed in part of the channel on private property for landscaping purposes, and these represent a potential flood threat to that individual property.

Reach 2B upstream from Shields Street contains no well-defined drainage channel. It is more a swale which is cultivated. About 1,000-feet west of Shields the Pleasant Valley and Lake Canal intersects the drainageway and intercepts runoff originating above it.

Reach 1 and 2 constitute historic Mail Creek. Runoff in Mail Creek now includes storm flows from the McClellands Basin west of the Larimer Canal No. 2 waste ditch because manmade features including College Avenue and the New Mercer Canal, cutoff the natural drainageway and redirect storm flows to the south. Because of this, the Mail Creek Basin now envelopes all of the historic McClellands Basin west of the Larimer County Canal No. 2 and therefore three (3) additional reaches are included in the Mail Creek Basin study area.

Reach 3, the New Mercer Canal, is one link between historic McClellands and Mail Creek. The Canal has recently been relocated and the channel section enlarged. Storm flows from Reaches 4 and 5 are now discharged directly into the canal. A 54-inch diameter RCP conveys irrigation and storm flows under the C & S Railroad and Harmony Road into Mail Creek. The maximum irrigation flow possible in the ditch is 125 cfs, but the average irrigation flow is estimated to be 80 cfs. For analysis purposes, 80 cfs was assumed to be flowing in the canal during all storm events.

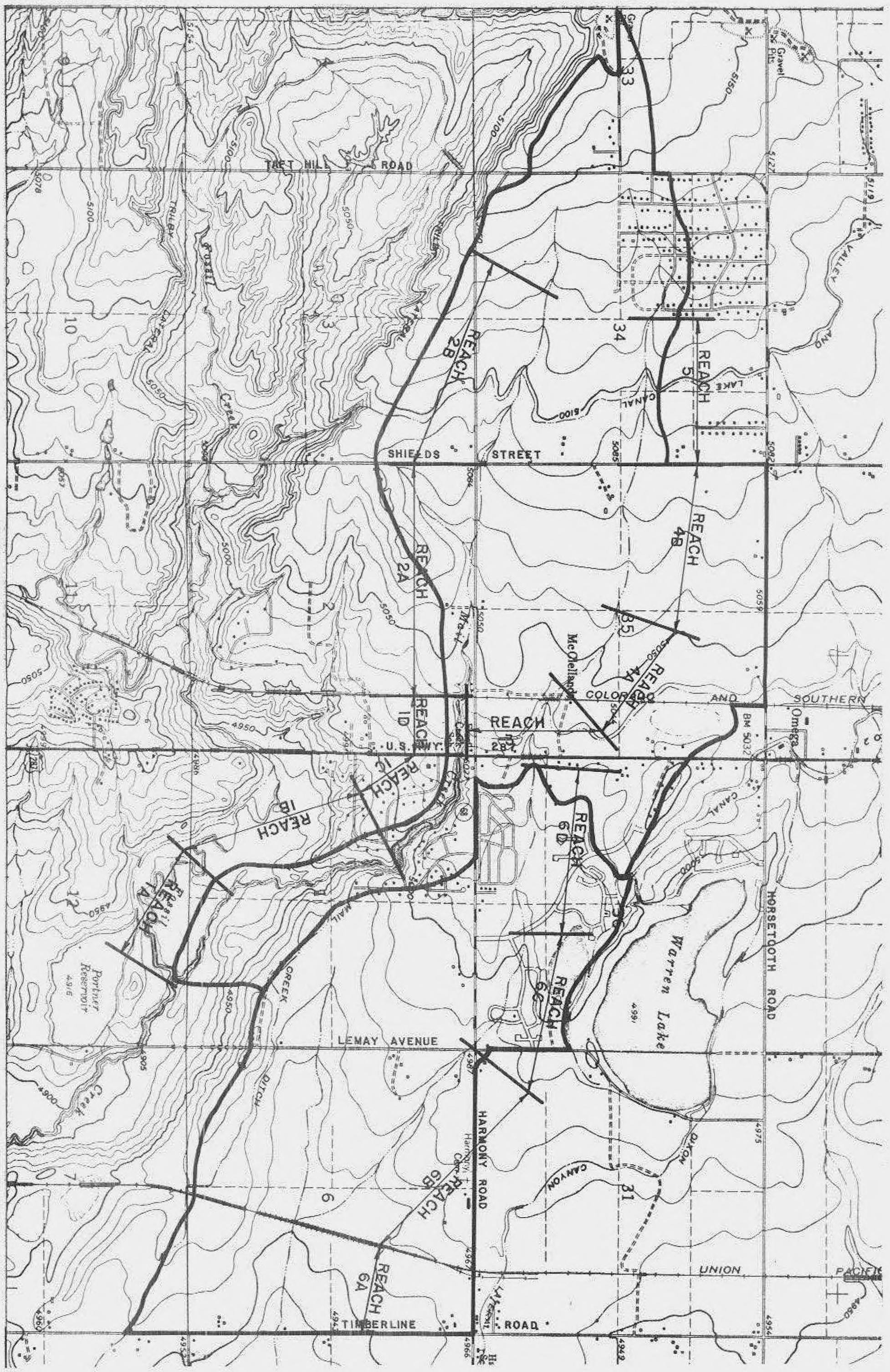
Reaches 4 and 5 extend along the historic McClellands drainageway from the New Mercer Canal to the upstream study limits west of Shields Street. The basin topography is relatively flat and historic land use is primarily agricultural. The channel is shallow and wide, and is now flanked by new residential areas in Reach 4. In Reach 4A, the channel has been replaced with a 24-inch diameter RCP storm sewer.

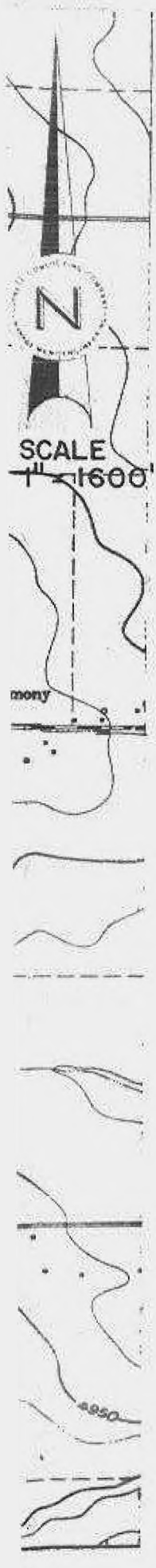
Upstream from Shields Street, Reach 5, there is no well-defined drainage channel and the floodplain area is cultivated. The Pleasant Valley and Lake Canal intersects the drainage near the upper study limit and storm runoff from areas above the canal are intercepted and transported out of the basin toward Fossil Creek.

McCLELLAND STUDY REACHES

Study Reach 6 begins at Timberline Road and extends 2.3 miles upstream to the present McClellands Basin Boundary. Reach 6A and 6B, which are south of Harmony Road, traverse agricultural lands and are fairly shallow and wide ....Because of the flatness of the terrain, a large pool can develop behind the railroad embankment and downstream areas.

Reaches 6C and 6D, which are north of Harmony Road, have been developed into a series of detention ponds interconnected with open channels and an underground storm sewer. Most of the basin within these reaches has been urbanized except for a small area just west of the center of Section 36.


TAFT HILL ROAD
SHIELDS STREET
U.S. HWY. 24
LEMAY AVENUE
HARMONY ROAD
TIMBERLINE ROAD
UNION PACIFIC
COLORADO AND SOUTHERN
REACH 1A
REACH 1B
REACH 1C
REACH 1D
REACH 2A
REACH 2B
REACH 3
REACH 4A
REACH 4B
REACH 5
REACH 6A
REACH 6B
REACH 6C
REACH 6D
Gravel Pits
Fountain Creek
Jimmy Camp Creek
Harmony Creek
Monument Creek
Ditch
Canal
Lake
Canyon
Valley
Porter Reservoir
McClellands
Omega
Warren Lake
Horsetooth Road
BM 5032
5100
5050
5000
4950
4900



MAIL CREEK

REACH	LOCATION
1 A	CONFLUENCE WITH FOSSIL CREEK TO MAIL CREEK LN.
1 B	MAIL CREEK LANE TO PALMER DRIVE
1 C	PALMER DRIVE TO U.S. HIGHWAY 287
1 D	U.S. HIGHWAY 287 TO C.&S. RAILROAD
2 A	C.&S. RAILROAD TO SHIELDS STREET
2 B	SHIELDS STREET TO UPSTREAM LIMITS
3	NEW MERCER CANAL
4 A	NEW MERCER CANAL TO MIDDLE OF SECT. 35
4 B	MIDDLE OF SECTION 35 TO SHIELDS STREET
5	SHIELDS STREET TO THE EAST BORDER OF IMPERIAL ESTATES

McCLELLANDS BASIN

REACH	LOCATION
6 A	TIMBERLINE ROAD TO U.P. RAILROAD
6 B	U.P. RAILROAD TO HARMONY ROAD
6 C	HARMONY ROAD TO BOARDWALK DRIVE
6 D	BOARDWALK DRIVE TO LARIMER CO. CANAL # 2

FIGURE II-4

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McCLELLANDS & MAIL CREEK DRAINAGE BASINS STUDY REACHS

SHEET 1 OF 1

SECTION III: SUMMARY OF HYDROLOGIC ANALYSIS

A detailed hydrologic analysis was performed to define the runoff quantities for historic, existing and future basin conditions. This analysis was done as a basis for delineating floodplains for the study reaches and for deriving and evaluating alternative solutions to flooding problems. For hydraulic design purposes, flood flows derived from future basin conditions are used because future development increases potential runoff.

Derivation of Hydrographs

There is little recorded information regarding past floods for either Mail Creek or McClellands Basins; however, reliable rainfall, soils and land use data are available for these basins, and these data have been applied to the derivation of synthetic flood hydrographs for this study area. Hydrologic analysis was performed to determine flood hydrographs based on runoff from the 2-, 5-, 10-, 25-, 50-, and 100-year storms, for historic, existing and future fully developed conditions. Because the present drainage patterns on Mail Creek and McClellands are diverse and resulting routing procedures numerous, a version of the runoff block of the Environmental Protection Agency's Stormwater Management Model, (SWMM), as modified by the Corps Missouri River Division, was selected to model the drainage basin runoff characteristics. The input data was calibrated against SWMM runs for Fossil Creek performed by the U.S. Army Corps of Engineers, for areas common to both basins.

The SWMM program is a kinematic wave hydrologic model which synthesizes flood hydrographs by routing precipitation through a system of subcatchments and stream channels. Input requirements for the SWMM model are rainfall hyetographs, watershed parameters, and channel segment characteristics. The drainage basins, sub-area and channel configurations developed in this study for application in the SWMM program are shown on Figures II-1, II-2 and II-3 of the drawings (located in back pocket). Final calibrated values for the Mail Creek and McClellands Basin parameters used in the SWMM analysis are listed in the Technical Addendum. Channel segment parameters used in the analysis have been determined to approximate the existing channel, culvert, and detention ponds which carry the flow.

Design storm hydrographs have been derived by routing runoff from design rainfall through the channel and pipe system of Mail Creek and McClellands drainageways.

Rainfall Data

Design rainfall values for the 2-, 5-, 10-, 25-, 50-, and 100-year return periods have been determined from the "Precipitation Frequency Atlas of the Western United States, Volume III-Colorado," published by the National Weather Service (Reference #1). Rainfall values are listed in Table III-1. A 2-hour design storm hyetograph developed according to Weather Bureau procedures was used for this study.

Land Use

A percent impervious area was estimated for each subbasin for use in the SWMM program by calculating a weighted average of the different types of land uses within each subbasin. Types of land use for the City of Fort Collins were taken from the aerial mapping, current City and County zoning maps and land use plans. Typical percents of impervious area for each type of land use were taken from the Fort Collins Drainage Criteria Manual (Reference #2) and verified against real measurements taken from the 100-foot scale mapping. Percents impervious for existing basin conditions includes all subdivision proposed and approved although not necessarily constructed at the time of this analysis. Future basin values are derived primarily from zoning maps and land use plans for the City and Larimer County, and assume all development in the basin is complete according to the zoning.

Subareas were determined from USGS 7-1/2 minute quadrangle maps, 100-scale orthophotographic mapping from the City of Fort Collins, the Fossil Creek Basin study, and the location of major basin features such as railroads, arterial streets and irrigation canals. Land uses and subareas are shown for historic, existing, and future basin conditions on Figures II-1, II-2 and II-3, respectively (included in the rear pocket).

Losses

Losses due to infiltration were estimated from USDA Soil Conservation Service Soils Survey. A variable infiltration rate using Horton's equation is available in the SWMM program, and this option was utilized in the derivation of hydrographs. Initial and final infiltration rates were estimated by taking weighted averages of the maximum and minimum permeabilities of the different types of soils within each subbasin. Outliners were not included. A decay rate of 0.0018/sec. was adopted from the Fossil Creek Study. Values of infiltration coefficients for the subbasins range from 0.40 to 3.00.

Maximum depression storage values were obtained from the Urban Storm Drainage Criteria Manual. Uniform depression storage coefficients of 0.3 for pervious and 0.1 for impervious areas were used in this study.

Flood Hydrographs

Selected flood hydrographs are illustrated in Figures III-2, III-3, III-4, III-5, III-6, III-7, III-8 and III-9. Peak flood flows for the various design frequencies have been plotted in Table III-2. Complete hydrologic data and computer output is contained in the Technical Addendum, available through the City of Fort Collins.

Flood History

Information concerning the historic flooding occurrences in Mail Creek and McClellands Basin is sparce. Because of the lack of development within the boundaries of the floodplain, few reports were filed that indicated (due to lack of) significant flood damage

Within a 24-hour period on September 20-21, 1902, 6.84-inches of rainfall was recorded. Flooding of streets up to one-foot deep and cellars was reported in the Fort Collins area. Also, there were reports of some agricultural crop damage in the Bellvue area. However, no particular damage was reported in McClellands and Mail Creek Basins.

The flooding on May 2, 1904 was a result of 3.0-inches of rain falling in the Fort Collins area within a 24-hour period. A 7-year-old boy drowned 6-miles east of Fort Collins as a result of a bank failure in the Larimer and Weld Canal. Also, substantial damage was caused by excessive rainfall in the upper Boxelder area. Again, no particular damage was reported in the basin study area.

On September 4, 1938, 3.5-inches of rain fell within a 24-hour period, causing flooding and damage in scattered areas around Fort Collins. An additional 1.5-inches of rain fell in the following 39-hour period. Most of the damage occurred in the Bellvue area northwest of Fort Collins. Damage to roadways and bridges was substantial in the Spring Canyon area. No noted reports of damage were found for the Mail Creek and McClellands Basins.

A total of 6.1-inches of rain fell on the Fort Collins area on August 3 and 4, 1951, causing flooding deemed responsible for the death of seven (7) people. A 24-hour precipitation of 2.95-inches followed by another 24-hour precipitation of 3.11-inches created flooding in several areas of the City. Damage to the county hospital, post office and numerous basements was reported. However, no particular damage was reported in the area of this study.

During a 4-day period from July 13-17, 1965, heavy rainfall was reported with a maximum of 2.5-inches within a 24-hour period. The great amount of rainfall coupled with high flows in the irrigation ditches which flow into Mail Creek caused extensive damage to the pond spillway and drop structure in the Fairway Estates subdivision. The spillway at that time consisted of a low water bridge and grouted rip-rap chute approximately 200 feet west of the present structures. This spillway was replaced with a double box culvert and concrete chute with energy dissipator blocks in the fall of 1965 for approximately $12,000.00. The damaged drop structure was rebuilt in the spring of 1966 for approximately $3,000.00. It was the opinion of the owner of Fairway Estates that the damage to the structures could have been minimal had it not been for the substantial contributing flows from the New Mercer Canal; all of which routed through Mail Creek instead of into Mail Creek Ditch.

On August 15, 1975, nearly 4-inches of rain fell on the central western area of Fort Collins. Minor flash flooding was reported and many basements were flooded requiring assistance from the local fire department.

The headline, "Can It Rain Here" - You Bet It Can" was seen in the Fort Collins Coloradoan on July 26, 1977, as rainfall from 2.5 to 5.1 inches fell on Fort Collins within a 24-hour period. In the area south of Horsetooth Reservoir, 5.1-inches fell, causing widespread flooding of basements and crawl spaces, requiring assistance from the Fire Department. Harmony Road between Shields Street and U.S. 287 was hard-hit by this storm and was closed due to poor conditions. As reported by the New Mercer Ditch Company, close to 4-feet of water was flowing over the drop structure at the Mail Creek ditch headgate. No significant damage was reported elsewhere in the basin study area.

TABLE III-1

PRECIPITATION INTENSITY (in/hr)

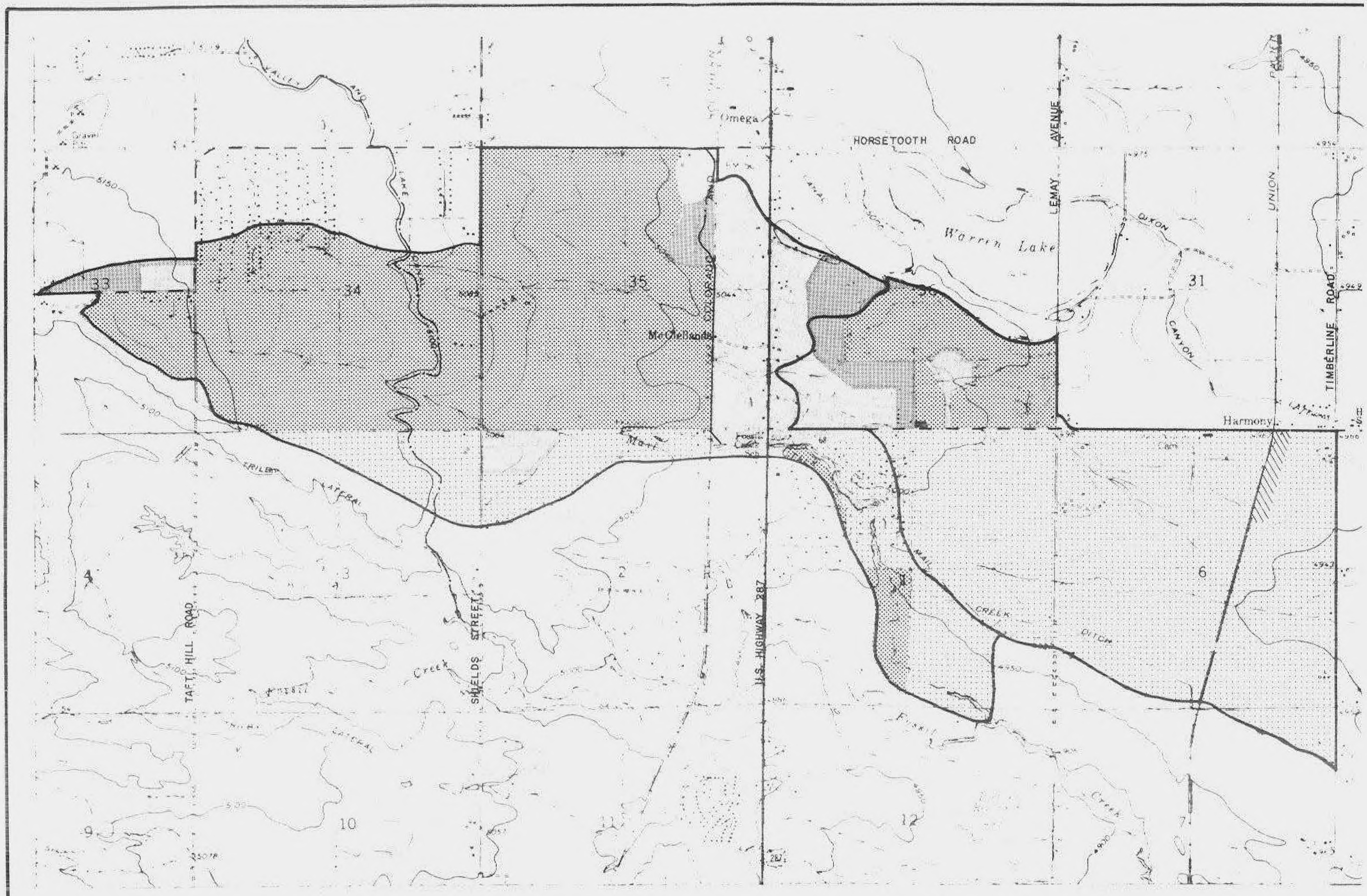
Time Interval (min)	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Percent of Total
0							
5	0.36	0.51	0.61	0.73	0.84	0.95	2.7
10	0.42	0.59	0.70	0.84	0.97	1.09	3.1
15	0.51	0.72	0.86	1.03	1.19	1.34	3.8
20	0.87	1.23	1.47	1.76	2.03	2.29	6.5
25	1.46	2.07	2.47	2.94	3.40	3.83	10.9
30	3.48	4.91	5.87	6.99	8.08	9.11	25.9
35	1.92	2.71	3.24	3.86	4.46	5.03	14.3
40	0.91	1.29	1.54	1.84	2.12	2.39	6.8
45	0.87	1.23	1.47	1.76	2.03	2.29	6.5
50	0.46	0.64	0.77	0.92	1.06	1.20	3.4
55	0.42	0.59	0.70	0.84	0.97	1.09	3.1
60	0.36	0.51	0.61	0.73	0.84	0.95	2.7
65	0.19	0.27	0.32	0.38	0.44	0.49	1.4
70	0.16	0.23	0.27	0.32	0.37	0.42	1.2
75	0.16	0.23	0.27	0.32	0.37	0.42	1.2
80	0.13	0.19	0.23	0.27	0.31	0.35	1.0
85	0.13	0.19	0.23	0.27	0.31	0.35	1.0
90	0.11	0.15	0.18	0.22	0.25	0.28	0.8
95	0.11	0.15	0.18	0.22	0.25	0.28	0.8
100	0.11	0.15	0.18	0.22	0.25	0.28	0.8
105	0.09	0.13	0.16	0.19	0.22	0.25	0.7
110	0.09	0.13	0.16	0.19	0.22	0.25	0.7
115	0.09	0.13	0.16	0.19	0.22	0.25	0.7
120	0	0	0	0	0	0	0
Total Precipitation (in)	1.12	1.58	1.89	2.25	2.60	2.93	

Notes:
1. Information was obtained from the NOAA Atlas Isopluvial Maps for precipitation values.
2. Tables 11 and 12 of the NOAA atlas were used to determine n-minute precipitation values.
3. No area adjustments were made from Figure 14 of the NOAA Atlas due to the size of basin.

TABLE III-2

PROBABLE PEAK FLOWS AT SELECTED POINTS WITHIN MAIL CREEK BASIN
(EXISTING CONDITIONS)

Location	SWMM Point	Peak Flows (cfs) 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
1. Confluence with Fossil Creek	1	63	136	218	314	409	497
2. Palmer Drive Spillway	100	61	126	204	292	375	461
3. U.S. Highway 287	13	61	130	201	280	372	473
4. C & S Railroad	15	30	68	117	192	281	375
5. New Mercer Canal	33	34	58	70	82	153	183
6. Crest Road	17	20	54	95	156	225	289
7. Shields Street at Harmony Road	21	6	20	37	63	92	121
8. Pleasant Valley & Lake Canal	22	7	16	31	52	77	104
9. Middle of Section 35	43	15	36	61	98	141	187
10. Shields Street 1/2-mile north of Harmony Road	44	28	54	79	115	157	201
11. Pleasant Valley & Lake Canal 1/2-mile north of Harmony Road	48	34	57	76	102	310	159
12. East Border of Imperial Estates	49	44	72	94	122	152	184
McCLELLANDS BASIN							
1. McClellands @ Timberline	2	35	71	87	105	127	149
2. McClellands @ U.P. Railroad	82/90/85	38	65	92	133	181	243
3. Mid-Section 6	85	26	36	44	56	69	84
4. Lemay & Harmony Road	108	30	39	42	45	47	50
5. Between Detention	88	34	51	63	77	92	106
6. Midway - Section 36	89	38	66	86	112	139	167


HORSETOOTH ROAD
LEMAY AVENUE
TIMBERLINE ROAD
UNION
Omega
Warren Lake
McClellands
Harmony
TAFT HILL ROAD
SHIELDS STREET
U.S. HIGHWAY 287
MAIL CREEK DITCH
CANYON
Creek
33
34
35
36
31
4
3
2
6
9
10
12
7

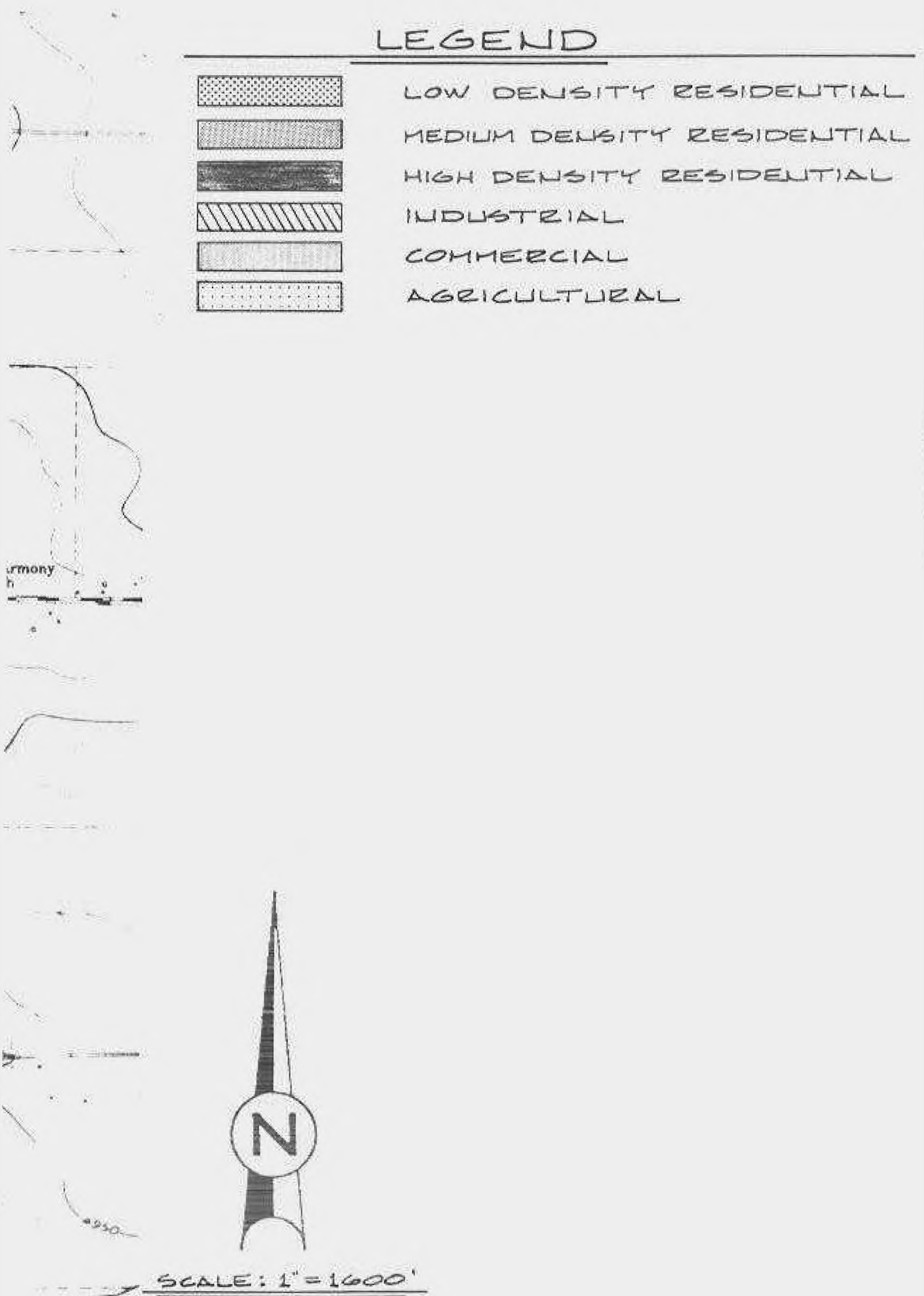


FIGURE III-1

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 fort collins, colorado 80522 (303)482-6650

McCLELLANDS & MAIL CREEK DRAINAGE STUDY
ZONING MAP

SHEET 1 OF 1

Figure III-2

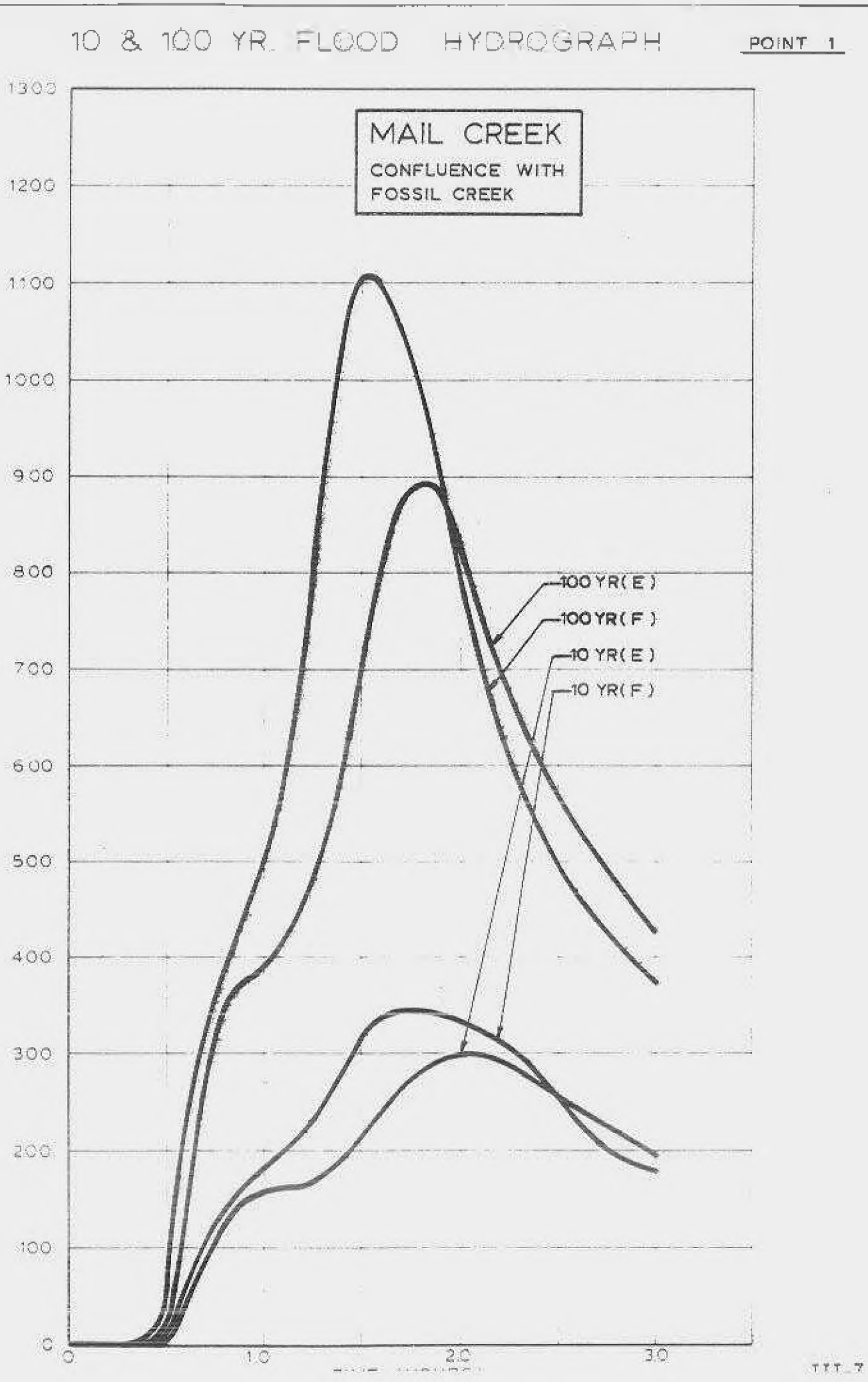

10 & 100 YR. FLOOD HYDROGRAPH
POINT 1
MAIL CREEK
CONFLUENCE WITH
FOSSIL CREEK
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
100 YR(E)
100 YR(F)
10 YR(E)
10 YR(F)
DISCHARGE (CFS)
0
1.0
2.0
3.0
TTT-7

Figure
III-3

10 & 100 YR. FLOOD HYDROGRAPH

POINT 12

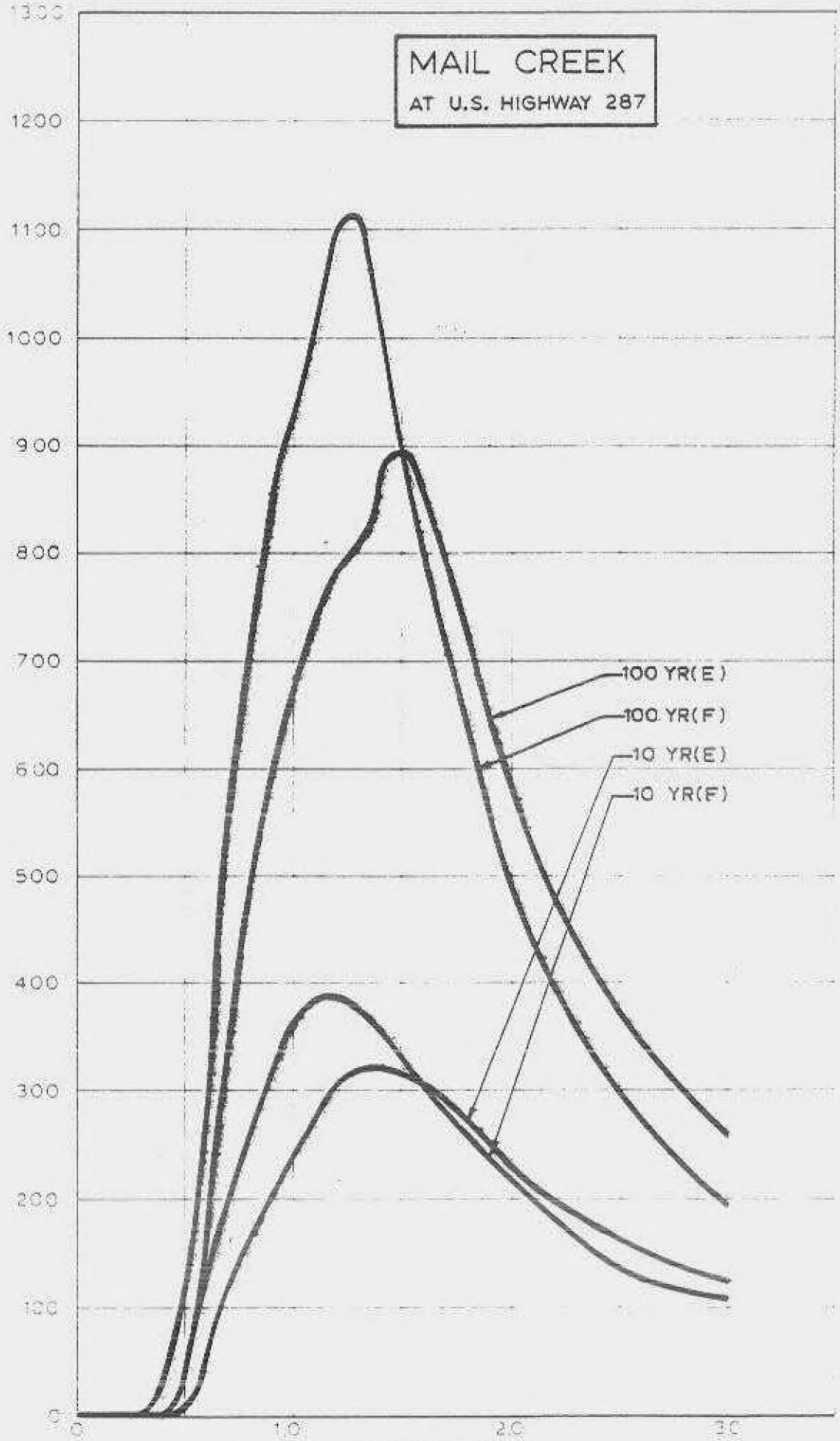


Figure III-4

10 & 100 YR. FLOOD HYDROGRAPH

POINT 14

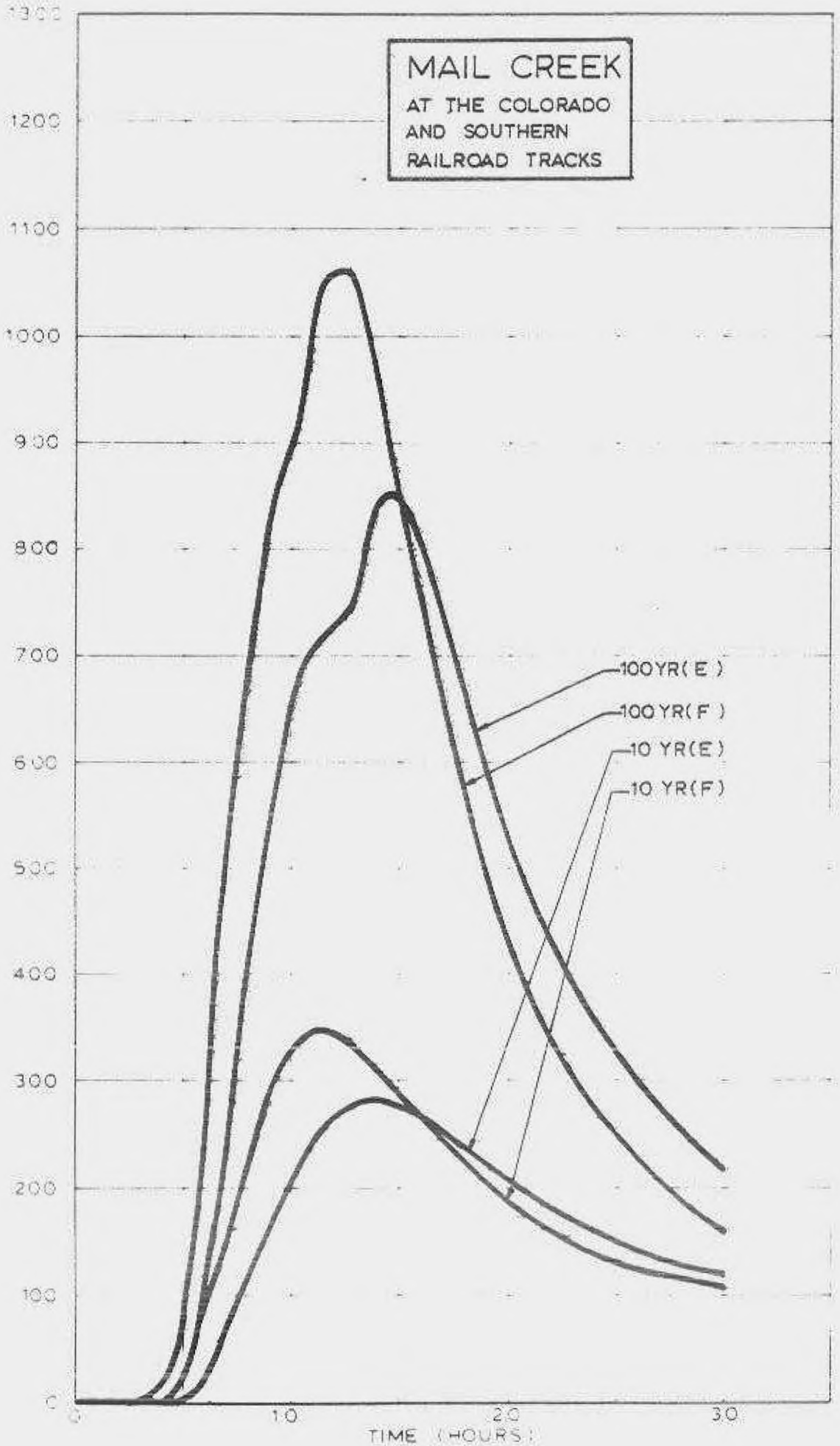


Figure
III-5

10 & 100 YR FLOOD HYDROGRAPH

POINT 20

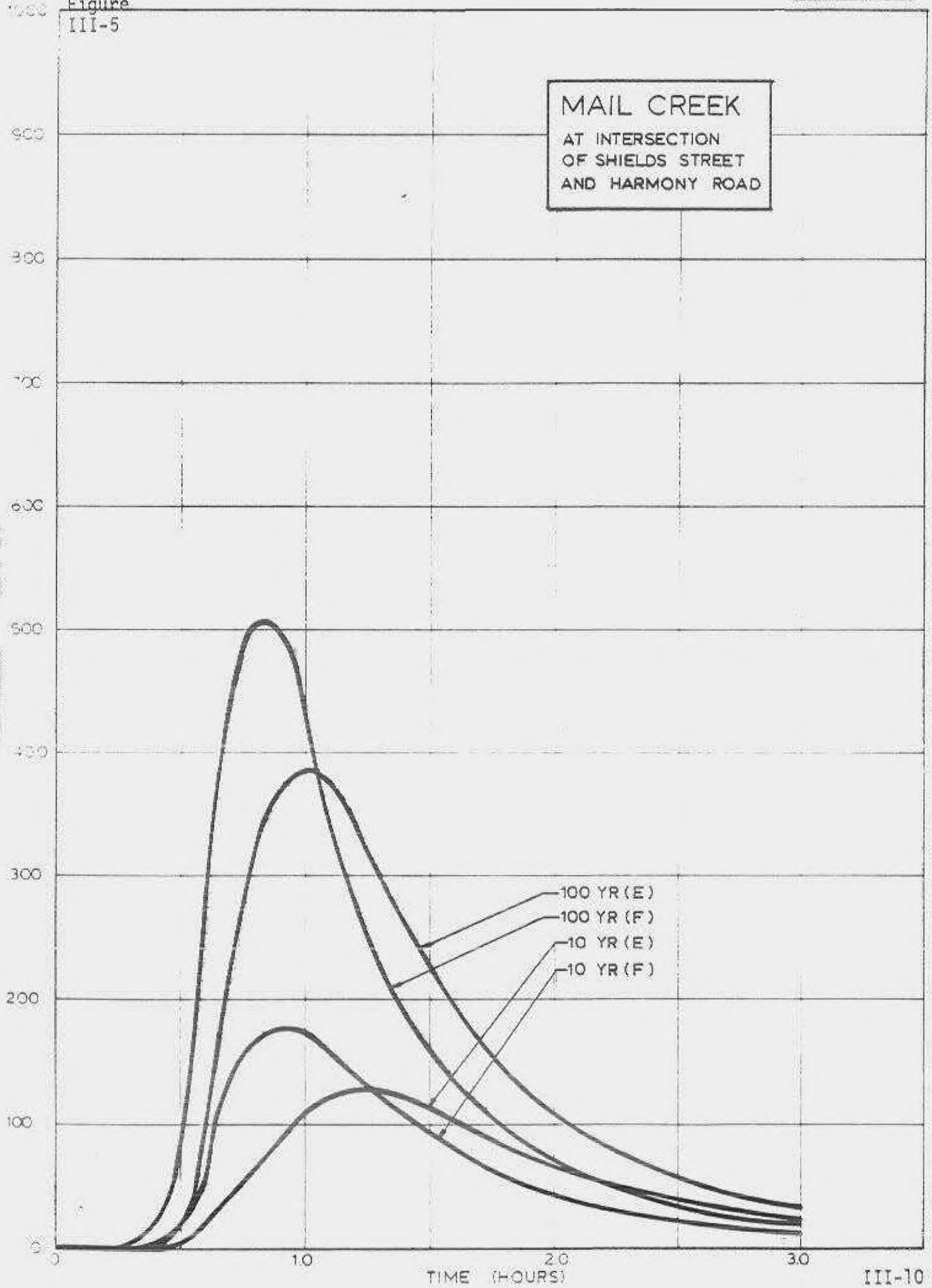
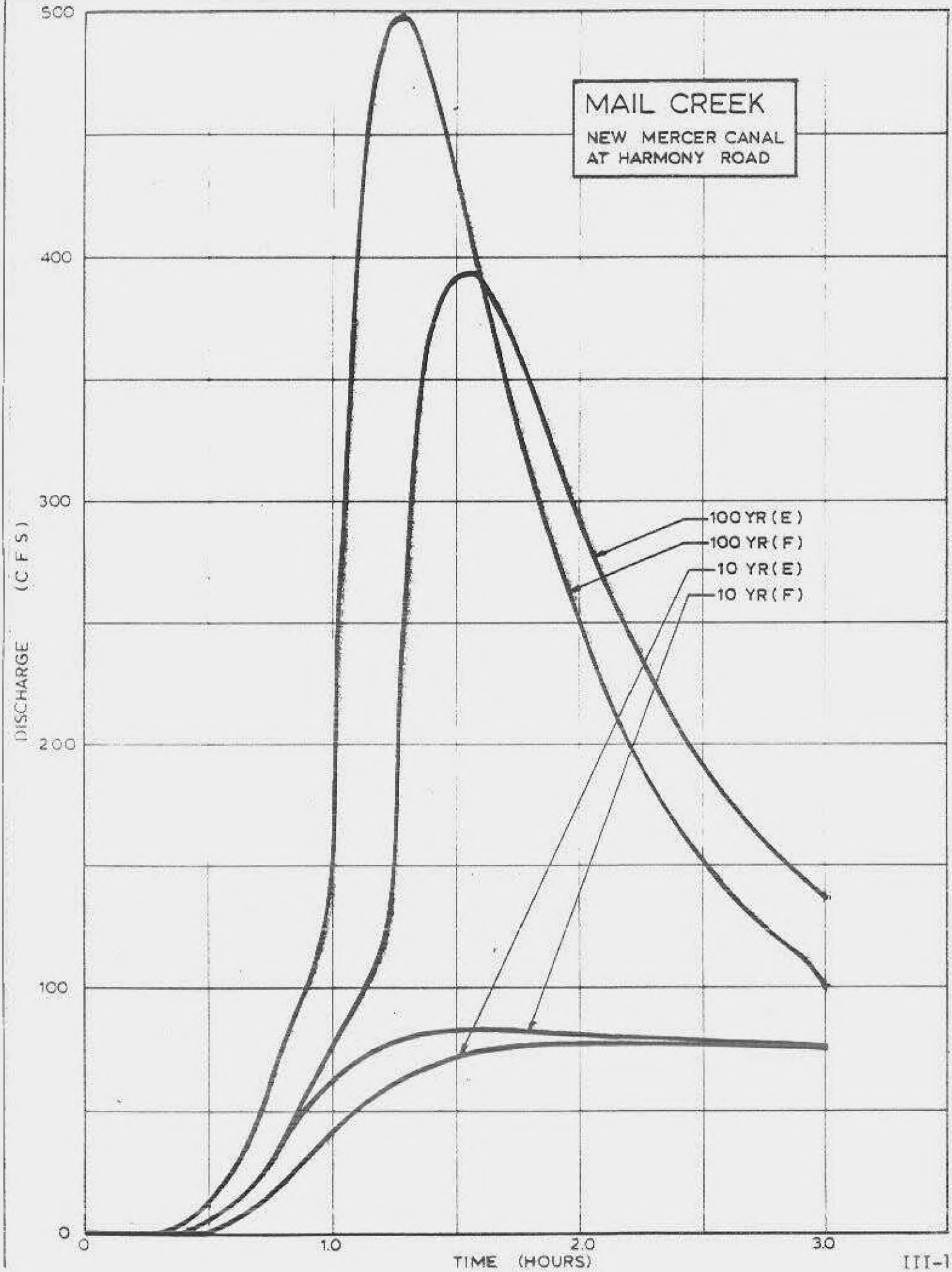


Figure III-6

10&100 YR. FLOOD HYDROGRAPH

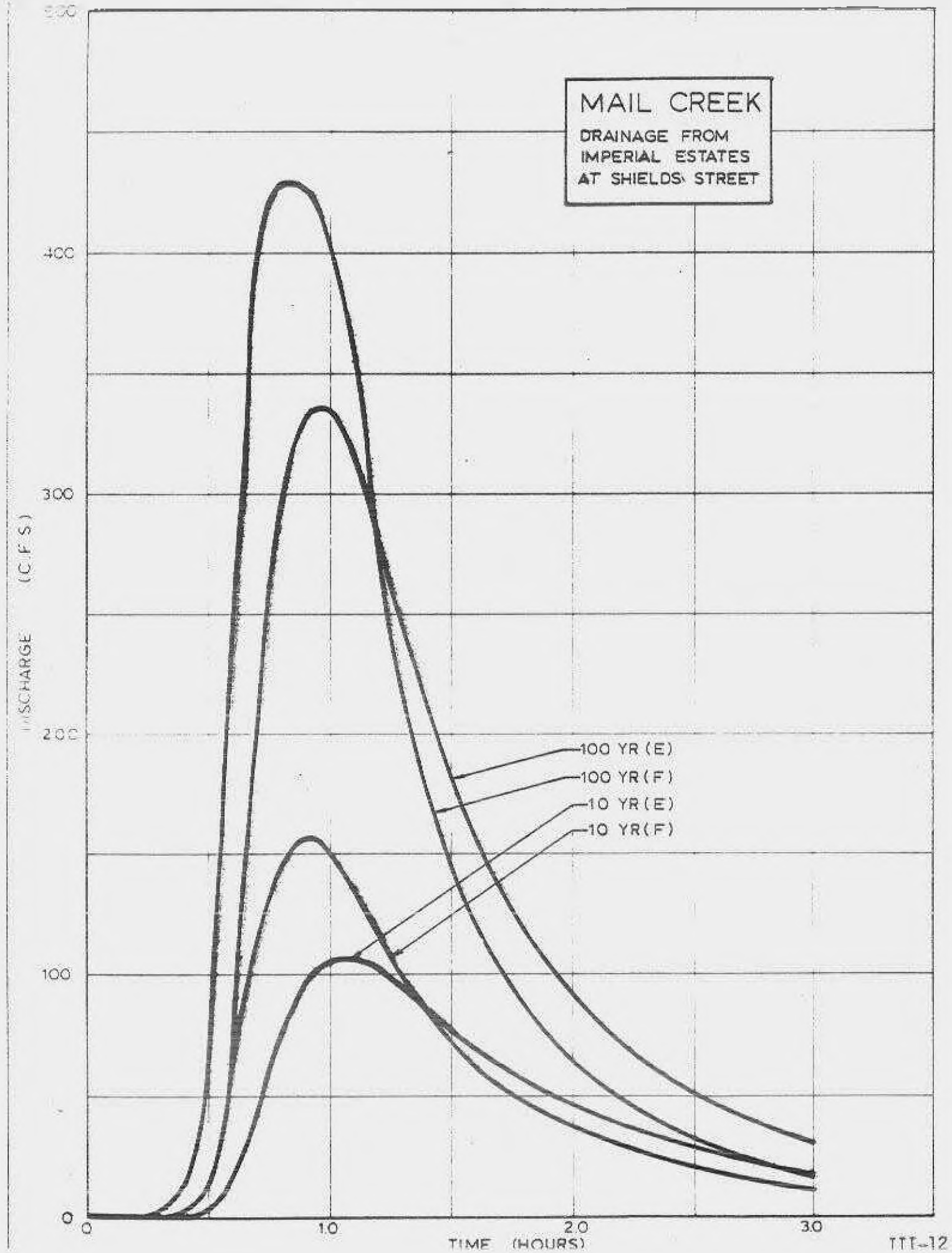
POINT 33



igure
II-7

10 & 100 YR FLOOD HYDROGRAPH

POINT 44

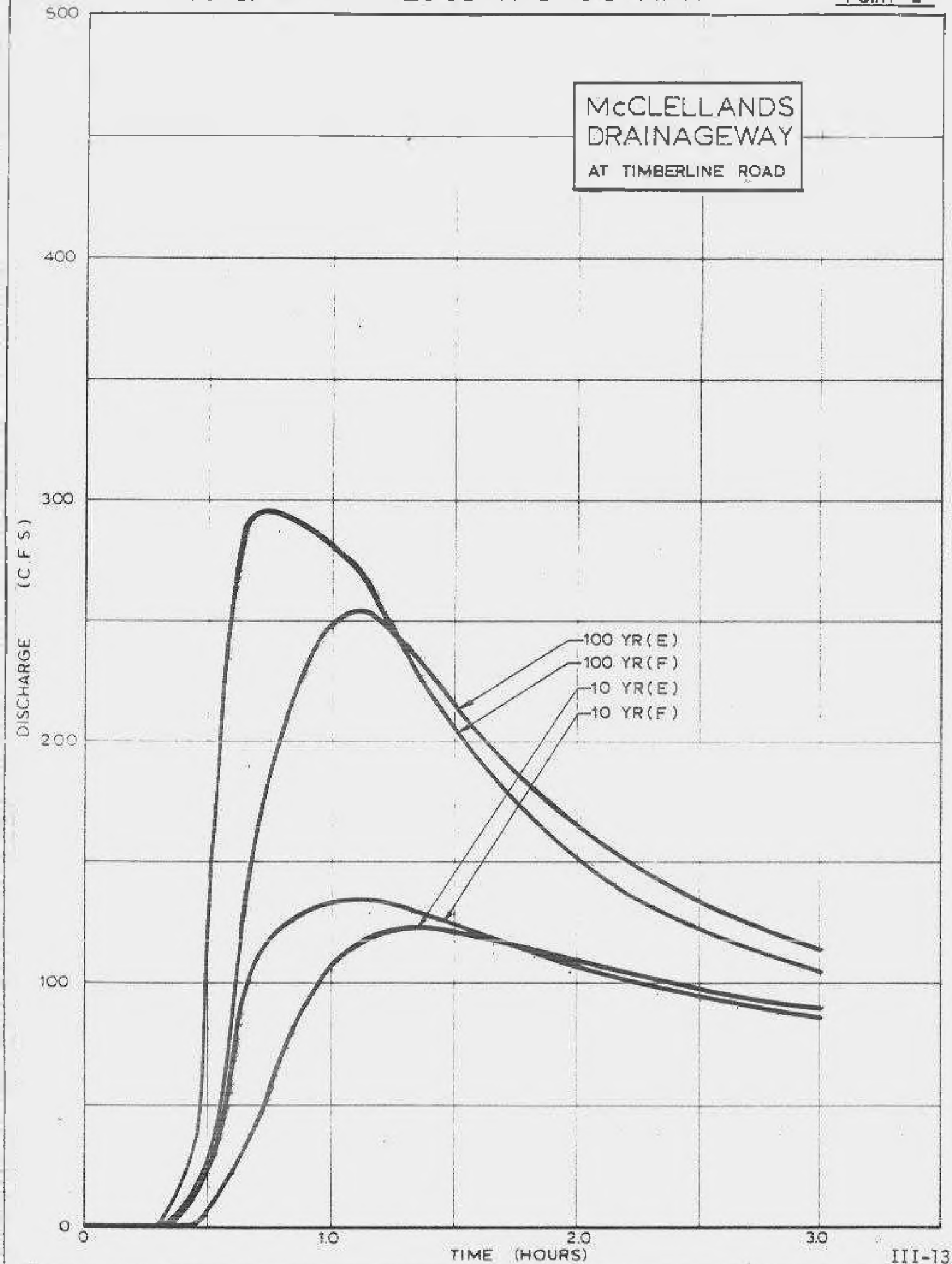


III-12

Figure
II-8

10 & 100 YR FLOOD HYDROGRAPH

POINT 2



igure
-9

10 & 100 YR FLOOD HYDROGRAPH

POINT 85

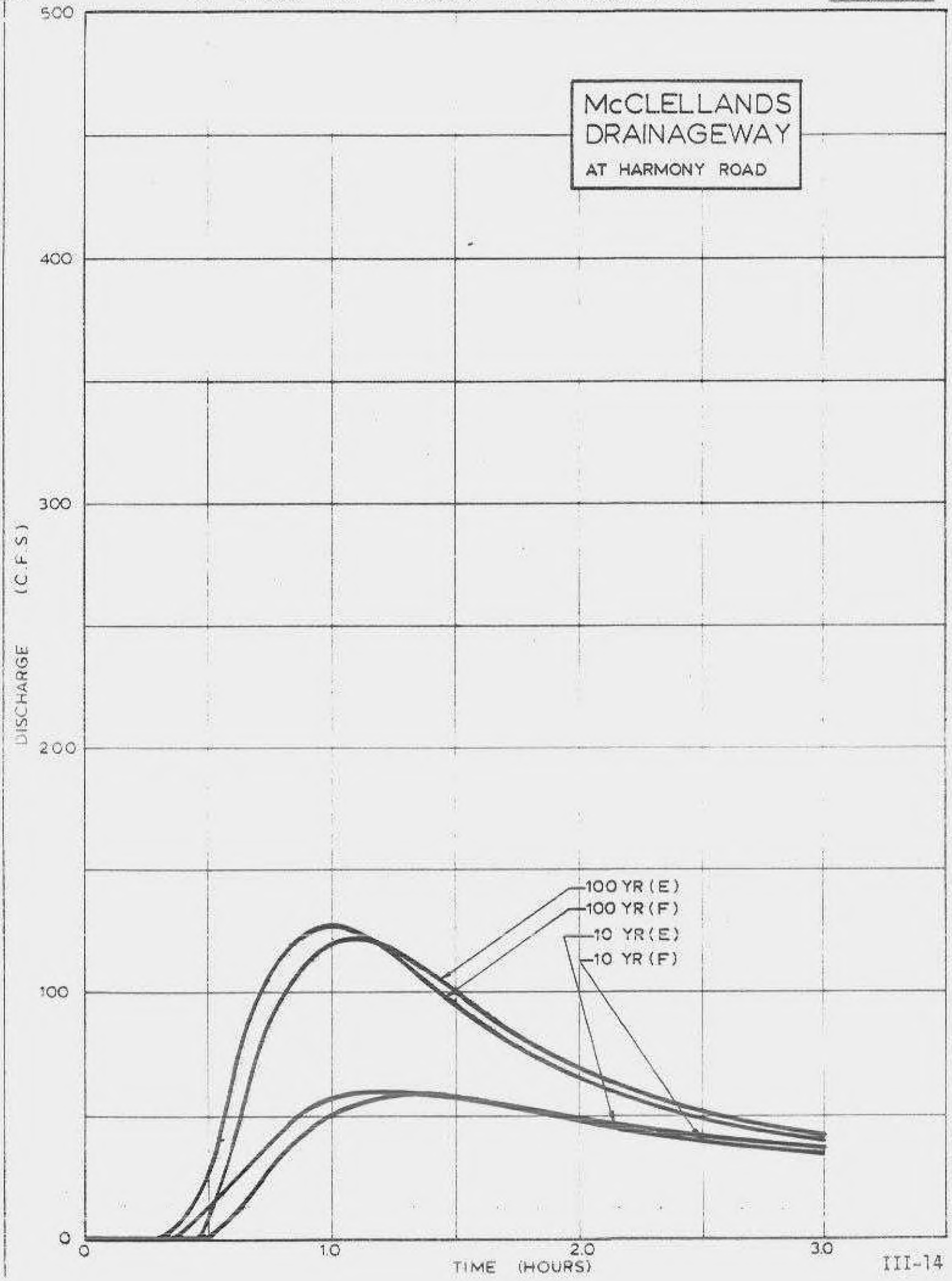


Figure
III-10

DISCHARGE PROBABILITY PROFILES

MAIL CREEK

EXISTING CONDITIONS

CITY OF FORT COLLINS
COLORADO WATER CONSERVATION BOARD

Figure
III-11

DISCHARGE PROBABILITY PROFILES

MAIL CREEK

FUTURE DEVELOPED CONDITIONS

CITY OF FORT COLLINS
COLORADO WATER CONSERVATION BOARD

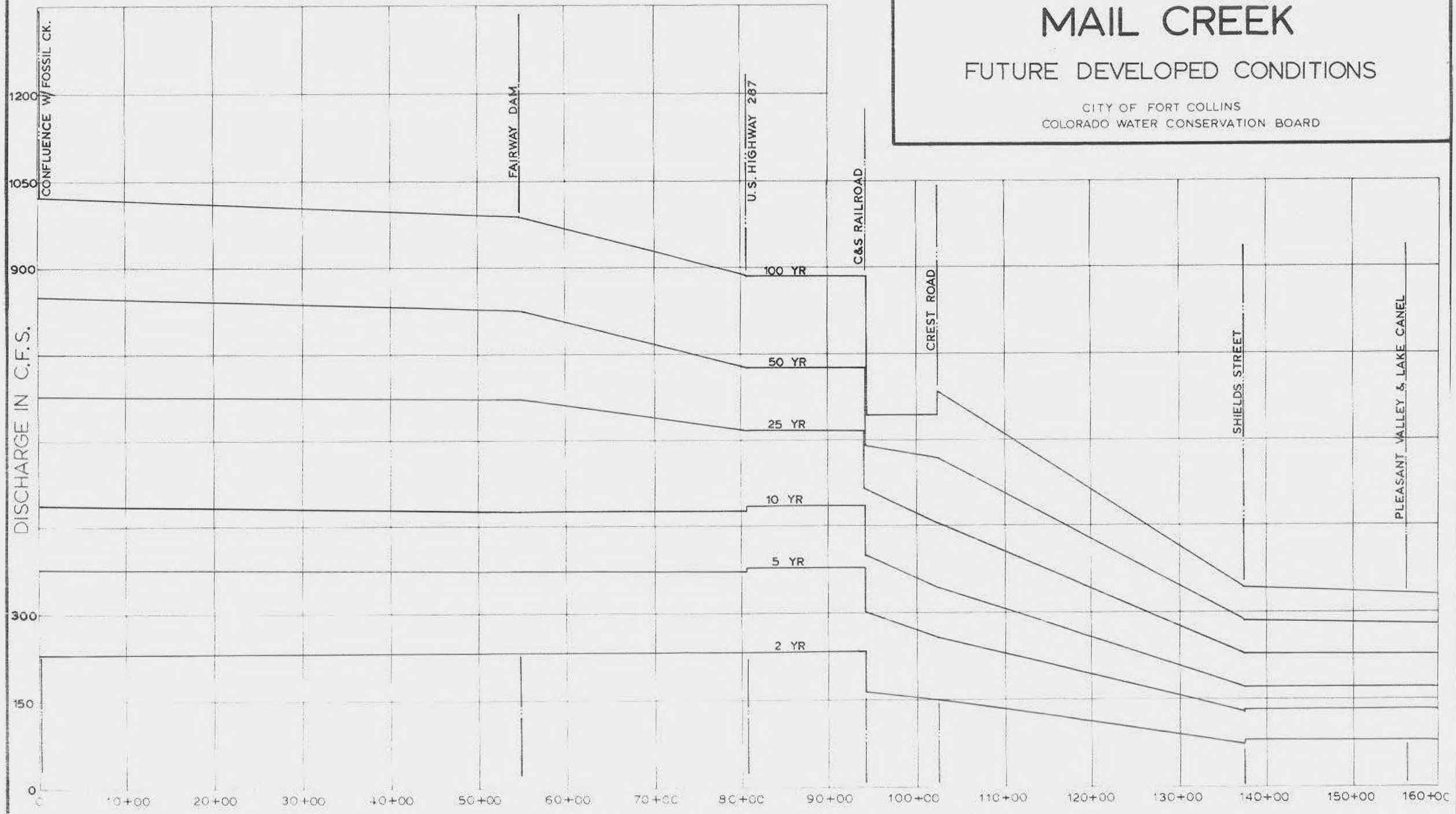


FIGURE III-12

DISCHARGE PROBABILITY PROFILES

McCLELLANDS BASIN

EXISTING CONDITIONS

CITY OF FORT COLLINS
COLORADO WATER CONSERVATION BOARD

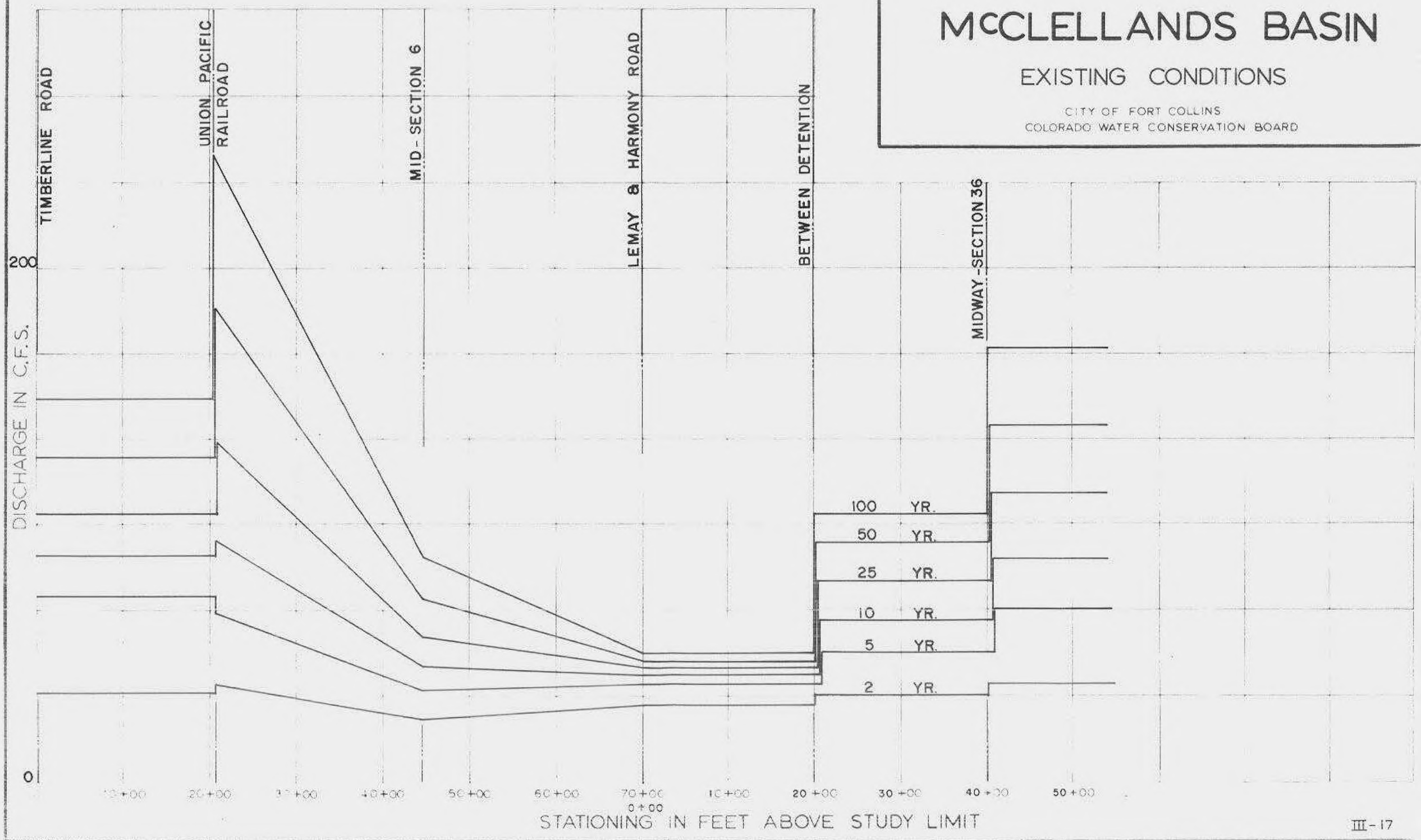


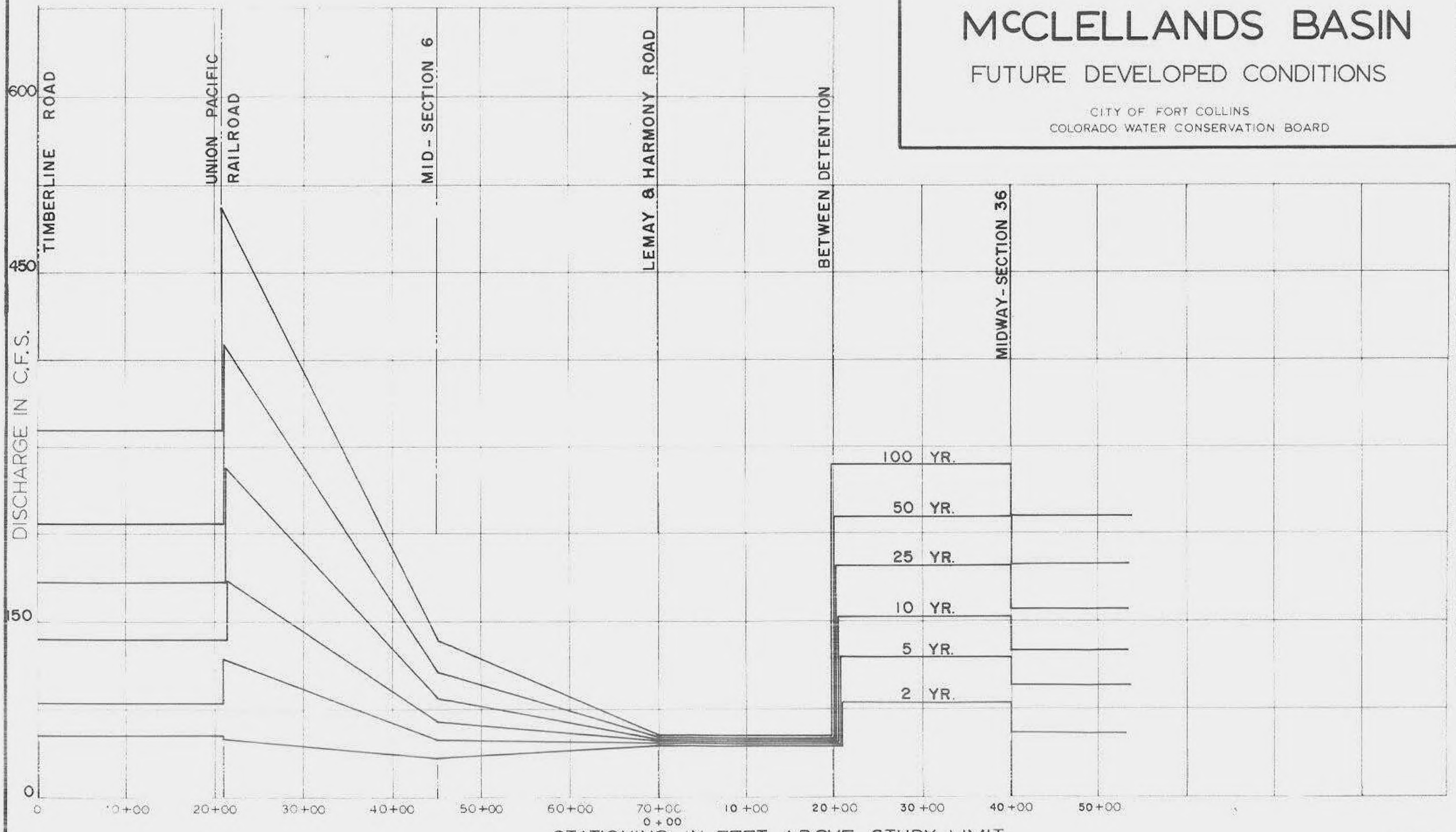
FIGURE
III-13

DISCHARGE PROBABILITY PROFILES

McCLELLANDS BASIN

FUTURE DEVELOPED CONDITIONS

CITY OF FORT COLLINS
COLORADO WATER CONSERVATION BOARD



SECTION IV

Hydraulic Determinations

Analyses of the hydraulic characteristics of Mail Creek and McClellands Basins were performed to provide estimates of the water surface elevations to each of the design floods for the existing channel conditions. A total of approximately 5.9 miles of channel was included in the analysis, with 3.6 miles in Mail Creek and 2.3 miles in McClellands Basin. All floodplains were delineated by routing the peak flood flow through the channel and calculating the depth of flow in the channel and adjacent floodplain. The depth of a flood, or water surface elevation, is directly related to the conveyance characteristics of the channel and floodplains: channel geometry, roughness, longitudinal slope, and presence of obstructions such as bridges, houses and large trees.

Water surface profiles and floodplains were computed using the most recent version of the U.S. Army Corps of Engineers HEC-2 computer program (Reference #3). Cross-sections were digitized from available topographic maps and have been augmented by field surveys at regularly spaced intervals and at channel obstructions (culverts, roads, etc.). Locations of the cross-sections are depicted on the existing floodplain plates with a more detailed description contained within the Technical Addendum. Cross-sections that were field surveyed are noted with an asterick (*) on the flooded area plates.

Channel roughness coefficients (Manning's "n" values) for these computations were assigned on the basis of field inspection of the floodplain areas (tabulated in the Technical Addendum). Hydraulic losses through culverts have been determined with the use of nomographs published by the Bureau of Reclamation and input into HEC-2 program. In developing rating curves for the culverts in the study reaches, zero blockage was assumed for culverts greater than 2-feet in diameter. The normal bridge routing of the HEC-2 program was used to calculate losses through non-standard culverts. The structural integrity of existing culverts, bridges, detention dams and other channel features has not been evaluated in this analysis, except Fairway Dam.

Fairway Dam has been re-evaluated by the State Engineer's office. The original design of Fairway Dam was based on a significantly smaller drainage area and a lower intensity of development which indicated the dam, spillway and culverts under Palmer Drive were sufficient to handle the flood flows. However, present re-evaluation indicates a need for further study and probably structural improvements to accomodate larger flood flows which have resulted from new development in the contributing drainage area. The enlarged basin is the result of the diversion of flows in the upper portion of the historic McClellands Basin at the C & S Railroad into and through the New Mercer Ditch to Mail Creek.

Computed water surface profiles and the floodplain delineation for the 100-year existing and future discharges are shown on the existing floodplain plates for designated reaches at 1" = 200' scale. These plates are at the end of this section. Floodplains for the 2-, 10-, 25-, and 50-year events have been plotted on working drawings and are included in the Technical Addendum. Water surface elevations for these storms have also been tabulated on Tables IV-1 and IV-2.

Flood Hazard Areas

The Mail Creek and McClellands Basins are presently in different stages of use and development varying from existing agricultural to fully developed conditions. With the exception of Larimer County Voc-Tech Center and portions of the basins adjacent to College Avenue, the developed reaches are in residential use. Those portions of the basins which are most subject to the hazards of flooding are:

Reach No. 1 (Plates 2, 3 and 4)

Mail Creek drainageway within Fairway Estates Subdivision, although deep and subject to some erosion, does not pose a significant flooding hazard. For the most part, the runoff from the 100-year storm is contained within the existing channel and sufficient right-of-way for flood flows was provided at the time of development. There are two (2) exceptions to the containment of the 100-year runoff in this reach. One is at the Passway Drive crossing of Mail Creek. The insufficient culvert capacity under Passway Drive causes a backwater condition which results in water overtopping the road and some flooding of adjacent residential properties. The other exception is at Palmer Drive, where the box culverts which are part of the Fairway Dam spillway do not have enough capacity for more than the 25-year storm.

Reach No. 2 (Plates 4, 5 and 6)

Both the access road to Nordic Construction Company and Crest Road in the lower end of Reach No. 2 are overtopped during even small storms causing erosion and the potential for loss of access. In addition, the existing house in between these two roads is threatened by the 100-year flood. Even though the 100-year flow is below the first flood elevation, backwater behind the Nordic Construction Company access road and the C & S Railroad may cause structural damages to the building.

Prior to the construction of the improvements for The Woodlands PUD and at the time of initiation of this study, Harmony Road from about 500-feet west of Crest Road to Shields Street was subject to inundation during the 100-year runoff. Three of Larimer County Voc-Tech Center's buildings and their contents have associated damages from this major storm as well. The drainage swale parallel to Harmony Road which has been constructed by Woodlands PUD was designed to contain the 100-year flows, but the structures for crossings over this swale and the crossing at Harmony Road were designed for the 2-year historic runoff.

All four (4) legs of the intersection of Shields Street and Harmony Road are overtopped during even the minor storm causing the potential for serious interruption to traffic in this part of Fort Collins. Upstream of Shields Street, there is a wide floodplain resulting from the damming effect of this intersection. A little further west, the Pleasant Valley and Lake Canal is overtopped causing damage to ditch banks and the potential introduction of silt and excess water into the irrigation system.

Reach No. 3 (Plate 7)

The New Mercer Canal carries the runoff from the upper portions of McClellands Basin to Mail Creek. During periods of high runoff, the depth of flow in the canal becomes greater than originally designed for. This results in the inundation of the ditch service road on the east and some associated erosion damage. At the confluence with Mail Creek, excessive discharge velocities could cause some additional erosion and/or deposition of silt. Finally, overtopping of the Larkborough Subdivision detention pond along its east bank will also contribute to the flooding and erosion problem in this reach.

Reach No. 4 (Plates 8 and 9)

There is a substantial amount of overland flow through the streets and yards in Larkborough Subdivision during the 100-year storm. Although the flows are not above the first floor elevation for any of these units, there is the potential to have structure and content damage to seventeen (17) homes. Between Larkborough and Shields Street, the floodplain consumes a considerable amount of ground which is presently in agricultural use. During floods here, there exists the potential for crop and/or flood damage.

Reach No. 5 (Plate 9)

The Shields Street crossing consists of one 15-inch corrugated metal pipe. As a result, Shields Street is overtopped during even minor storm events causing traffic interruption and some erosion problems. Upstream of Shields Street, considerable agricultural ground is consumed by floodplain. Finally, during flooding, the Pleasant Valley and Lake Canal would probably breach and thus require repairing and probable removal of some silt deposits.

Reach No. 6 (Plates 10 through 13)

The lower portions of the McClellands drainageway have extremely wide floodplains as a result of backwater behind culverts at both Timberline Road and the Union Pacific Railroad. Both of these crossings would be overtopped by 10-year storms or greater, and would be in danger of washing out. Because of the tall and steep embankment of the railroad, extensive damage to the railroad as well as adjacent property could result during a storm of 25-year frequency or greater.

Upstream from Harmony Road, the McClellands drainageway has been improved as part of the residential development which has taken place, and all improvements are adequate for the 100-year design flows. No flood hazards are apparent in either of these reaches.

TABLE IV-1

MAIL CREEK FLOODPLAIN DATA TABLE FOR FUTURE CONDITIONS

Cross-Section	Stationing Above Mouth(ft)	Description	Thalweg Elevation (ft above MSL)	2-Year Elevation (ft above MSL)	10-Year Elevation (ft above MSL)	25-Year Elevation (ft above MSL)	50-Year Elevation (ft above MSL)	100-Year Elevation (ft above MSL)
X-100	0 + 00		4,895.3	4,896.72	4,898.7	4,899.20	4,900.7	4,901.7
X-101	2 + 00		4,898.9	4,900.69	4,902.7	4,903.15	4,906.1	4,908.1
X-102	6 + 00		4,901.3	4,904.40	4,906.6	4,907.03	4,907.7	4,908.6
X-103	11 + 00		4,905.7	4,907.87	4,909.9	4,910.14	4,911.1	4,911.6
X-104	16 + 00		4,907.3	4,910.80	4,912.6	4,912.93	4,915.6	4,916.4
X-105	19 + 50		4,910.0	4,912.06	4,914.1	4,914.46	4,951.6	4,916.4
X-106	19 + 75	Mail Creek Lane	4,910.2	4,912.16	4,914.1	4,914.51	4,915.5	4,916.2
X-107	20 + 25	Mail Creek Lane	4,910.7	4,912.34	4,914.5	4,914.97	4,917.1	4,918.4
X-108	20 + 50		4,910.8	4,912.65	4,915.6	4,916.45	4,919.6	4,923.0
X-109	24 + 00		4,912.6	4,915.62	4,917.3	4,917.74	4,919.9	4,923.1
X-110	29 + 00		4,918.3	4,920.52	4,923.1	4,923.27	4,924.5	4,924.9
X-111	32 + 90		4,924.4	4,925.80	4,927.9	4,928.52	4,929.4	4,930.5
X-112	33 + 15		4,924.8	4,926.12	4,928.0	4,928.52	4,940.2	4,941.0
X-113	33 + 65		4,925.7	4,927.00	4,928.8	4,929.27	4,940.5	4,941.2
X-114	33 + 90		4,925.7	4,927.79	4,930.5	4,931.24	4,941.8	4,943.6
X-115	38 + 00		4,926.1	4,929.17	4,931.5	4,932.10	4,941.8	4,943.6
X-116	42 + 60		4,931.5	4,932.92	4,936.4	4,936.89	4,941.8	4,943.6
X-117	48 + 00		4,939.2	4,491.11	4,924.5	4,942.99	4,943.3	4,944.9
X-118	53 + 00		4,946.3	4,947.93	4,949.9	4,950.24	4,952.0	4,952.5
X-119	54 + 00		4,947.4	4,949.64	4,951.8	4,952.30	4,953.5	4,954.7
X-120	54 + 82	Palmer Drive	4,979.3	4,980.23	4,981.6	4,981.95	4,982.9	4,985.7
X-121	55 + 42	Palmer Drive	4,980.3	4,981.44	4,983.1	4,983.54	4,983.9	4,986.0
X-122	55 + 92		4,980.5	4,981.82	4,984.1	4,984.62	4,986.3	4,986.3
X-123	59 + 75		4,980.5	4,981.83	4,984.1	4,984.62	4,986.3	4,986.3

TABLE IV-I

Sheet 2 of 3

MAIL CREEK FLOODPLAIN DATA TABLE FOR FUTURE CONDITIONS

Cross-Section	Stationing Above Mouth(ft)	Description	Thalweg Elevation (ft above MSL)	2-Year Elevation (ft above MSL)	5-Year Elevation (ft above MSL)	10-Year Elevation (ft above MSL)	25-Year Elevation (ft above MSL)	100-Year Elevation (ft above MSL)
X-124	66 + 60		4,978.9	4,981.87	4,984.1	4,984.66	4,986.3	4,986.3
X-125	67 + 60		4,982.8	4,984.81	4,987.7	4,987.97	4,988.7	4,989.1
X-126	68 + 10		4,995.8	4,997.01	4,998.1	4,998.32	4,998.9	4,999.3
X-127	78 + 00		4,996.8	4,999.4	5,000.0	5,001.1	5,001.9	5,002.5
X-128	80 + 50	U.S. Highway 287	5,001.9	5,002.95	5,004.3	5,004.82	5,006.0	5,006.8
X-129	81 + 50	U.S. Highway 287	5,004.4	5,006.09	5,008.3	5,009.20	5,010.9	5,010.8
X-130	82 + 50		5,004.4	5,007.43	5,011.3	5,013.03	5,013.5	5,011.2
X-131	82 + 75		5,004.1	5,007.46	5,011.3	5,013.03	5,013.9	5,012.8
X-132	87 + 30		5,009.7	5,014.65	5,016.3	5,017.01	5,018.0	5,018.5
X-133	94 + 15	C & S Railroad	5,023.0	5,024.01	5,025.1	5,025.68	5,025.9	5,025.9
X-134	94 + 40	C & S Railroad	5,023.0	5,024.36	5,025.2	5,025.86	5,026.5	5,026.6
X-135	95 + 00		5,024.0	5,024.67	5,026.1	5,026.87	5,027.5	5,027.6
X-136	95 + 25		5,024.4	5,025.05	5,027.3	5,028.55	5,029.7	5,029.9
X-137	96 + 85	Nordic Access Rd.	5,028.7	5,029.79	5,030.6	5,031.09	5,031.5	5,031.5
X-138	97 + 10	Nordic Access Rd.	5,028.7	5,038.57	5,038.9	5,039.20	5,039.4	5,031.4
X-139	97 + 95		5,029.9	5,038.76	5,039.3	5,039.56	5,039.8	5,039.8
X-140	98 + 20		5,030.3	5,038.76	5,039.3	5,039.56	5,039.8	5,039.8
X-141	102 + 40	Crest Road	5,036.8	5,038.76	5,039.3	5,039.61	5,039.9	5,038.9
X-142	102 + 65	Crest Road	5,037.2	5,042.77	5,043.4	5,043.57	5,043.8	5,043.9
X-143	103 + 45		5,037.2	5,043.04	5,043.8	5,044.05	5,044.3	5,044.3
X-144	103 + 70		5,037.6	5,043.04	5,043.8	5,044.06	5,044.3	5,044.3
X-145	111 + 20		5,049.8	5,050.98	5,051.6	5,052.02	5,052.3	5,052.5
X-146	117 + 20		5,055.1	5,057.38	5,658.0	5,058.42	5,058.8	5,059.0
X-147	127 + 07		5,065.4	5,066.88	5,067.5	5,067.90	5,068.4	5,068.8

TABLE IV-I

Sheet 3 of 3

MAIL CREEK FLOODPLAIN DATA TABLE FOR FUTURE CONDITIONS

Cross-Section	Stationing Above Mouth (ft)	Description	Thalweg Elevation (ft Above MSL)	2-Year Elevation (ft Above MSL)	10-Year Elevation (ft Above MSL)	25-Year Elevation (ft Above MSL)	50-Year Elevation (ft Above MSL)	100-Year Elevation (ft above MSL)
X-148	133 + 77		5,074.3	5,074.91	5,075.3	5,075.45	5,075.7	5,076.0
X-149	137 + 17	Shields Street	5,081.1	5,081.35	5,081.6	5,081.78	5,081.9	5,081.7
X-150	137 + 42	Shields Street	5,079.7	5,085.07	6,085.3	5,085.32	5,085.4	5,085.4
X-151	138 + 02		5,078.5	5,085.21	5,085.4	5,085.50	5,085.6	5,085.7
X-152	138 + 27		5,078.9	5,085.21	5,085.4	5,085.50	5,085.6	5,085.7
X-153	146 + 42		5,085.5	5,085.92	5,086.2	5,086.36	5,086.5	5,086.6
X-154	154 + 62		5,093.7	5,094.18	5,094.5	5,094.72	5,049.9	5,095.0
X-155	156 + 22	Lake Canal	5,100.8	5,101.16	5,101.4	5,101.62	5,101.8	5,102.0
X-156	156 + 32	Lake Canal	5,097.0	5,101.30	5,101.7	5,102.03	5,102.2	5,102.4
X-157	160 + 82		5,103.0	5,103.49	5,103.8	5,103.99	5,104.1	5,104.2
X-158	166 + 22		5,112.0	5,112.46	5,112.7	5,112.90	5,113.0	5,113.1

TABLE IV-2

MAIL CREEK NORTHERN REACH FLOODPLAIN DATA TABLE FOR FUTURE CONDITIONS

Cross-Section	Stationing Above Mouth (ft)	Description	Thalweg Elevation (ft above MSL)	2-Year Elevation (ft above MSL)	10-Year Elevation (ft above MSL)	25-Year Elevation (ft above MSL)	50-Year Elevation (ft above MSL)	100-Year Elevation (ft above MSL)
X-200	0 + 00	Middle of Sec.35	5,085.8	5,059.17	5,059.5	5,059.64	5,059.0	5,060.0
X-201	4 + 00	Middle of Sec.35	5,063.0	5,063.52	5,063.9	6,064.09	5,064.2	5,064.2
X-202	9 + 00		5,067.3	5,067.80	5,068.3	5,068.43	5,068.6	5,068.9
X-203	14 + 00		5,071.8	5,072.29	5m072.7	5,072.90	5,073.1	5,073.1
X-204	19 + 00		5,075.8	5,076.27	5,076.7	5,076.84	5,077.0	5,077.2
X-205	24 + 30		5,078.6	5,079.71	5,080.2	5,080.39	5,080.6	5,080.6
X-206	26 + 00		5,080.0	5,080.60	5,081.2	5,081.35	5,081.5	5,081.7
X-207	26 + 50	Shields Street	5,080.0	5,085.31	5,085.6	5,085.79	5,085.8	5,085.9
X-208	27 + 00	Shields Street	5,081.0	5,085.42	5,085.8	5,085.94	5,086.1	5,086.2
X-209	27 + 50		5,084.0	5,085.42	5,085.8	5,085.94	5,086.1	5,086.2
X-210	30 + 70		5,084.7	5,085.42	5,085.1	5,085,92	5,086.0	5,086.1
X-211	35 + 70		5,089.8	5,090.16	5,090.4	5,090.90	5,091.1	5,091.3
X-212	40 + 85	Lake Canal	5,101.0	5,101.10	5,101.2	5,101.80	5,102.4	5,102.5
X-213	48 + 00	Lake Canal	5,098.0	5,101.50	5,101.0	5,102.1	5,102.8	5,102.9
X-214	50 + 50		5,101.8	5,102.37	5,102.9	5,103.23	5,103.4	5,103.5
X-215	54 + 30		5,106.8	5,107.63	5,108.6	5,108.81	5,108.9	5,109.0
X-216	55 + 50		5,108.3	5,108.83	5,109.4	5,109.63	5,109.8	5,109.8

TABLE IV-3

McCLELLAND LOWER REACH FLOODPLAIN DATA TABLE FOR FUTURE CONDITIONS

Cross-Section	Stationing Above Mouth (ft)	Description	Thalweg Elevation (ft above MSL)	2-Year Elevation (ft above MSL)	10-Year Elevation (ft above MSL)	25-Year Elevation (ft above MSL)	50-Year Elevation (ft above MSL)	100-Year Elevation (ft above MSL)
X-300	-0 + 80		4,943.2	4,935.79	4,936.1	4,936.24	4,936.4	4,936.5
X-301	-0 + 30	Timberline Road	4,934.4	4,940.17	4,940.2	4,940.24	4,940.4	4,940.4
X-302	0 + 30	Timberline Road	4,934.7	4,940.27	4,940.5	4,940.63	4,940.7	4,940.7
X-303	0 + 80		4,934.9	4,940.29	4,940.5	4,940.66	4,940.7	4,940.8
X-304	10 + 00		4,938.9	4,940.45	4,942.3	4,942.37	4,942.5	4,942.5
X-305	19 + 77		4,944.6	4,947.44	4,948.0	4,948.19	4,948.3	4,948.5
X-306	20 + 27	Union Pacific RR	4,044.8	4,947.44	4,948.4	4,948.60	4,961.2	4,961.2
X-307	20 + 87	Union Pacific RR	4,045.0	4,948.47	4,950.3	4,950.50	4,961.4	4,961.4
X-308	21 + 37		4,945.4	4,949.15	4,950.7	4,950.94	4,961.4	4,961.4
X-309	25 + 00		4,947,0	4,949.20	4,950.7	5,950.96	4,961.4	4,961.4
X-310	35 + 00		4,954.4	4,954.67	4,954.8	4,954.82	4,961.4	4,961.4
X-311	45 + 00		4,960.0	4,962.06	4,962.5	4,962.60	4,962.6	4,962.7
X-312	55 + 00		4,969.6	4,970.67	5,970.8	4,970.89	4,971.0	4,971.1
X-313	65 + 00		4,976.5	4,977.52	4,977.8	4,977.91	4,977.9	4,978.0
X-314	70 + 00	Lemay Avenue	4,982.0	4,983.12	4,983.3	4,983.29	4,983.3	4,983.2

SECTION V

Flood Damage

The proposed improvements for the McClellands and Mail Creek Basins have been evaluated by comparing amortized improvement costs with the average annual flood damage costs. The magnitude of flood damages and costs for flood control improvements are directly dependent upon estimates of flood flows and limits of the respective floodplains. Given the flood hydrographs for floods in a range of recurrence intervals, dollar amounts for flood damage and costs for implementing preventative measures are estimated based on an analysis of the existing hydraulic conditions.

The annual potential flood damage to public and private property within the floodplain is a function of the development within the floodplain. Unregulated, future development could spread to the floodplain areas and increase annual flood damage. With regulation, future flood damage potential should tend to decrease because of the limitations placed on construction in the floodplain. To analyze the effectiveness of proposed improvements, a baseline condition is used based on the existing channel conditions subject to floods generated by the estimated future drainage basin conditions. This approach is conservative, but because the drainage basin is urbanizing rapidly, it is reasonable.

Flood damage to property is estimated by catagorizing land use activities within the floodplain. For each design flood, the floodplain was delineated and damage calculated according to land use category and flow depth. Structural damage was determined by estimating replacement costs for utilities, roads, culverts, and so forth. For residential and commercial structures, flood damage was estimated using property valuations obtained from local real estate listings and from individual property owner's information and then applying a damage factor according to the difference in the flood depth and the first flood elevation of the structure. The damage factors were obtained from curves published by the Federal Insurance Administration, (reference #4). Content damage for residential structures was estimated by applying similar depth-related damage factors to forty (40%) percent of the estimated structural value. Forty (40%) percent of structure value for contents was used based on past inflation rates and appreciation rates in the housing industry. This procedure was used because updating content cost figures from the mid-1970's County tax records divided by 0.3 proved to be unrealistic in evaluating structure costs. Because of the isolated and sporadic nature of floodplain, a content data for commercial and industrial properties was obtained by interviewing individual management personnel on a casy-by-case basis.

Flood damage estimated for each category and reach are listed in Table IV-1. These figures represent direct flood damages. Other "damages" occur during a flood which are not so easily quantified. Probably the most significant hazards associated with the occurrence of a flood are the threats to the both physical and emotional health, and safety of people. Additionally, there are flood "damages" which result from inconvenience: interruption of traffic flows, obstruction of emergency vehicle movement, loss of sales by businesses dependent upon flood-damaged establishments for goods and services, and interruption of domestic services.

Further there is destruction of floodplain ecology, and a loss of recreational opportunities. A value of thirty (30%) percent of total damage was used to quantify these "intangible" damages.

The dollar amounts listed in Table V-1 have been plotted against the exceedence probability (Inverse of the return period) by reach to illustrate where the bulk of flood damages occur. Where heavy flood damages result from the more frequent floods, inadequate channel capacity is indicated. Where flood damages rise only in the less frequent floods, good channel capacity exists.

The area beneath the flood damage curves represents the average annual flood damage. This is the average yearly cost of leaving the existing conditions as they are. Listed in Table V-1 are the average annual flood damages summarized by reach. These are the "baseline" conditions against which the alternative plans are judged.

TABLE V-1

FLOOD DAMAGE BY CATEGORY

MAIL CREEK AND McCLELLANDS BASINS

Reach	Category	2-Year	10-Year	25-Year	50-Year	100-Year	Average Annual Damage Cost
1A	Total Reach 1A	0	0	0	0	0	0
1B	SFR w/b*	0	0	0	0	27,500	
	Road and Culverts	0	0	0	193,050	193,050	
	Clean-Up	0	0	0	32,790	32,790	
	Total Reach 1B	0	0	0	225,840	253,340	7,630
1C	Roads and Culverts	0	0	31,200	31,200	31,200	
	Clean-Up	0	0	14,380	14,380	14,380	
	Total Reach 1C	0	0	45,580	45,580	45,580	3,210
1D	Total Reach 1D	0	0	0	0	0	0
2A	SFR w/o b*	5,840	11,660	13,820	15,250	15,960	
	Industrial	16,150	76,370	162,010	232,760	337,710	
	Roads and Culverts	5,560	11,130	22,260	22,260	22,260	
	Clean-Up	4,520	5,160	8,780	10,820	13,650	
	Total Reach 2A	32,070	104,320	206,870	281,090	389,310	58,930
2B	Ditches	0	1,300	1,300	2,630	3,950	
	Roads and Culverts	1,160	3,690	6,470	8,890	11,560	
	Clean-Up	6,410	7,210	8,440	9,500	12,510	
	Total Reach 2B	7,570	12,200	16,210	21,020	28,020	8,270
3	Ditches	0	0	14,690	23,620	31,720	
	Clean-Up	0	0	6,370	6,370	6,370	
	Total Reach 3	0	0	21,060	29,990	38,090	2,030
4A	SFR w/ b*	0	0	39,210	46,640	48,300	
	SFR w/o b*	0	0	2,950	3,510	3,640	
	Clean-Up	0	0	4,860	5,790	7,790	
	Total Reach 4A	0	0	47,020	55,940	59,730	3,810
4B	Commercial	0	3,350	4,310	4,780	9,090	
	Clean-Up	3,350	5,310	6,400	7,380	8,890	
	Total Reach 4B	3,350	8,660	10,710	12,160	17,980	4,500

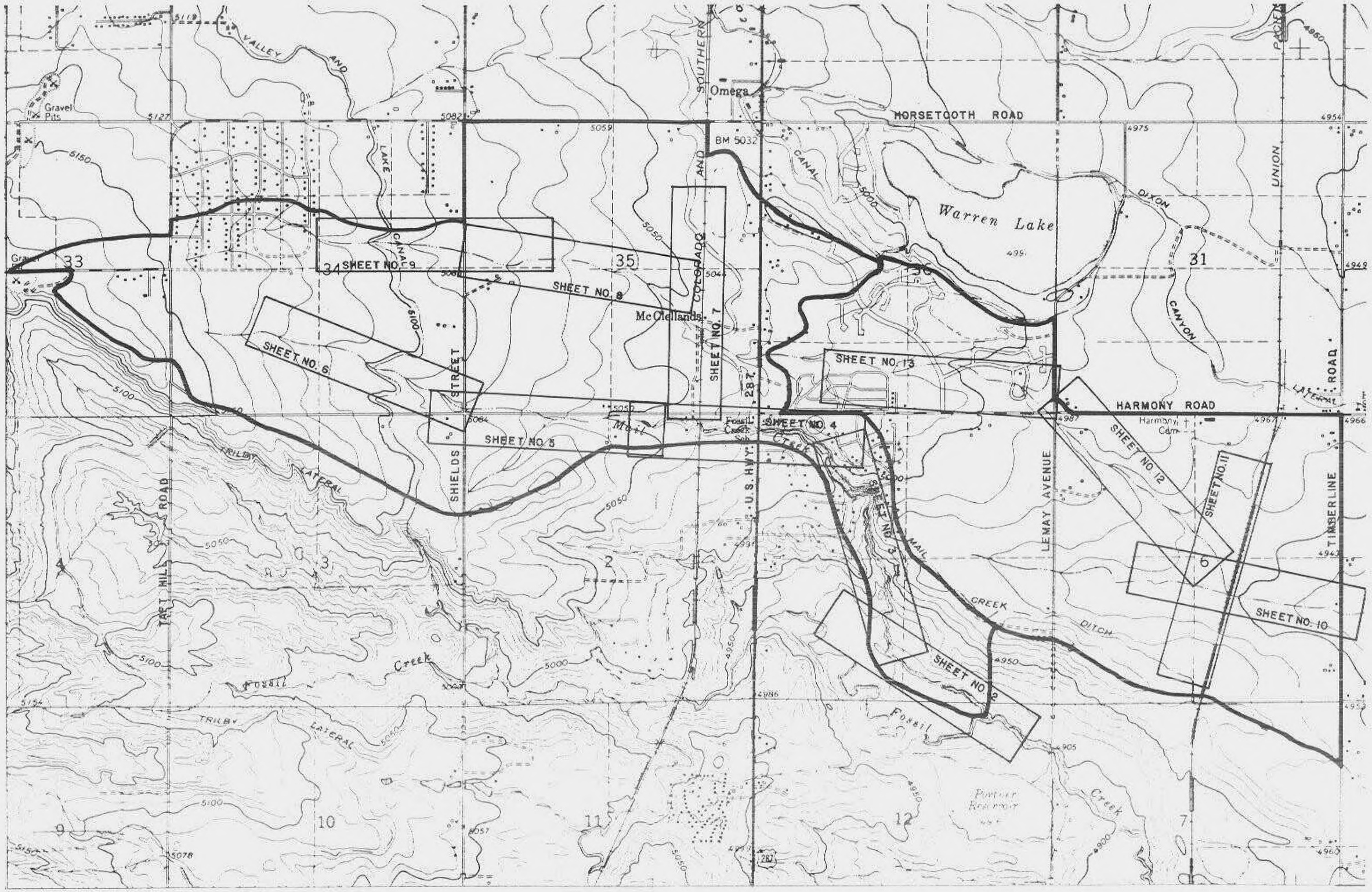
TABLE V-1

FLOOD DAMAGE BY CATEGORY

MAIL CREEK AND McCLELLANDS BASINS

Reach	Category	2-Year	10-Year	25-Year	50-Year	100-Year	Average Annual Damage Cost
5	Ditches	1,300	1,300	1,300	2,650	3,950	
	Roads and Culverts	1,160	3,690	6,470	8,890	11,560	
	Clean-Up	4,520	6,010	7,060	8,720	10,300	
	Total Reach 5	6,980	11,000	14,830	20,260	25,810	7,020
6A	Roads and Culverts	1,460	2,630	5,250	8,750	8,750	
	Clean-Up	5,730	10,020	11,100	12,530	14,600	
	Total Reach 6A	7,190	12,650	16,350	21,280	23,350	7,920
6B	Railroads	0	27,060	27,060	27,060	27,060	
	Clean-Up	5,730	39,650	40,620	41,860	44,460	
	Total Reach 6B	5,730	66,710	67,680	68,920	71,520	27,510
6C	Total Reach 6C	0	0	0	0	0	0
6D	Clean-Up	880	1,720	2,190	2,450	2,920	
	Total Reach 6D	880	1,720	2,190	2,450	2,920	970

*SFR = Single Family Residential; w/b = with basement; w/o b = without basement.


VALLEY AND
Gravel Pits
LAKE CANAL
SOUTHERN
Omega
BM 5032
HORSETOOTH ROAD
CANAL
Warren Lake
DIXON
UNION PACIFIC
CANYON
LATERAL
ROAD
SHEET NO. 9
SHEET NO. 8
McClellands
SHEET NO. 7
SHEET NO. 6
SHEET NO. 13
HARMONY ROAD
Harmony Cem.
SHEET NO. 5
SHIELDS STREET
Fossil Creek
SHEET NO. 4
U.S. HWY. 287
LEMAY AVENUE
SHEET NO. 12
SHEET NO. 11
TIMBERLINE
TAFT HILL ROAD
TRILBY LATERAL
Creek
MAIL
DITCH
SHEET NO. 3
SHEET NO. 2
SHEET NO. 10
Fossil
Creek
33
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35
36
31
1
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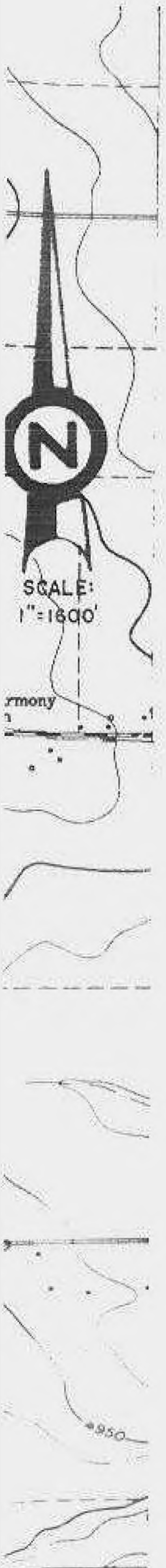

INDEX

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p.o. box 646 fort collins colorado 80522 (303) 482-1050

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

MASTER PLAN EXISTING CONDITIONS

NOTE: WATER SURF
PLAIN BOUNDARY A
FLOWS WITH EXIST

SEE SHEET 3 of 13

SCALE: 1"=200'

100 YEAR FLOODPLAIN BOUNDARY

Fossil Creek Parkway

Mail Creek Lane

100 YEAR FLOODPLAIN
EXISTING FLOWS

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS

X-110 X-109 X-108 X-107 X-106 X-105 X-104 X-103 X-102 X-101

4925
4920
4915
4910
4905
4900
4895

30+00 25+00 20+00 15+00 10+00

SEE SHEET 3 of 13

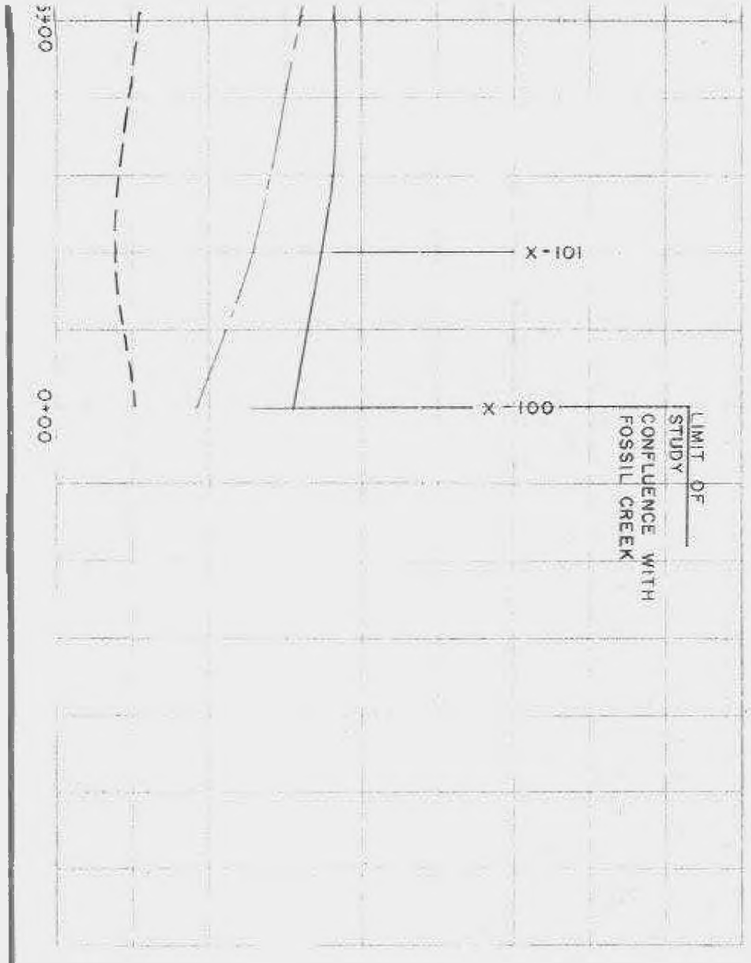
℄ MAIL CREEK LN.

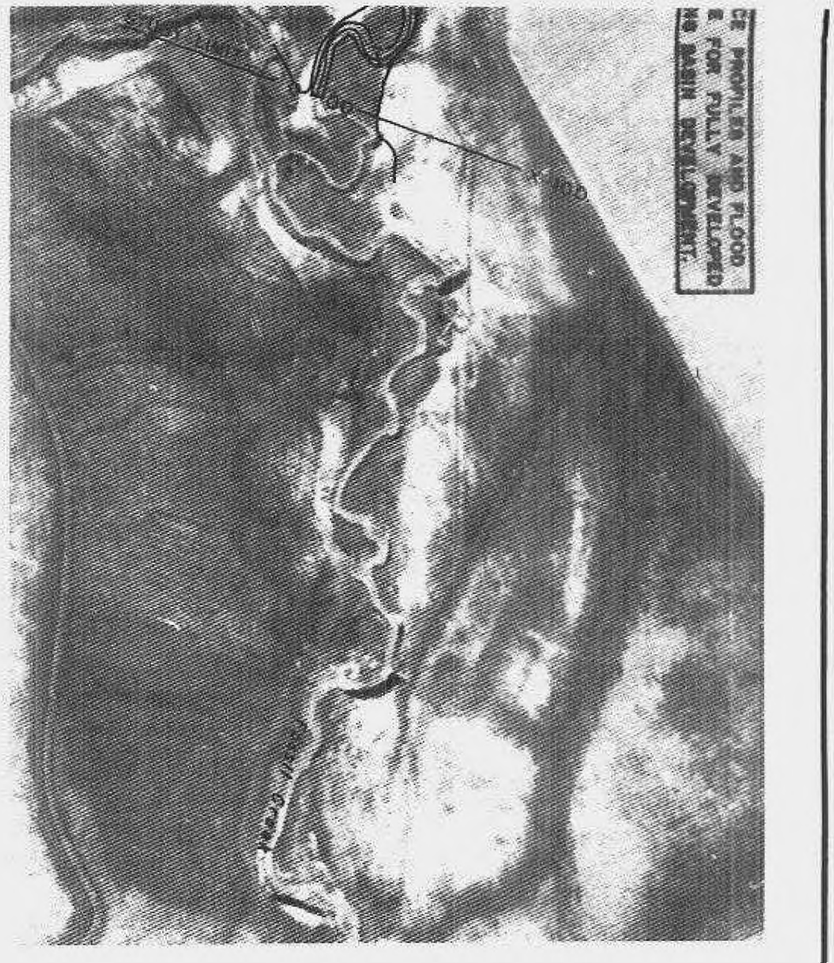
EXISTING 75'~14' DIAMETER CORREGATED METAL ARCH UNDER MAIL CREEK LANE

100 YR W.S. PROFILE EXISTING FLOWS

100 YR. W.S. PROFILE DEVELOPED FLOWS

℄ EXISTING CHANNEL





SHEET 2 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 0+00 TO 29+00

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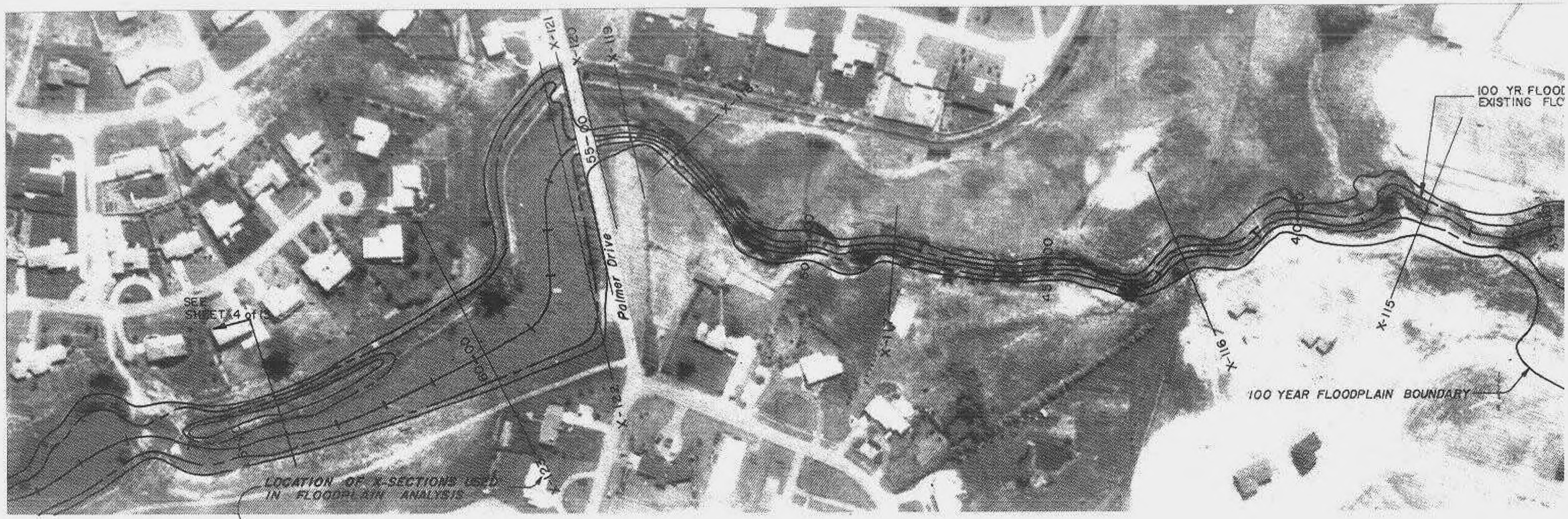
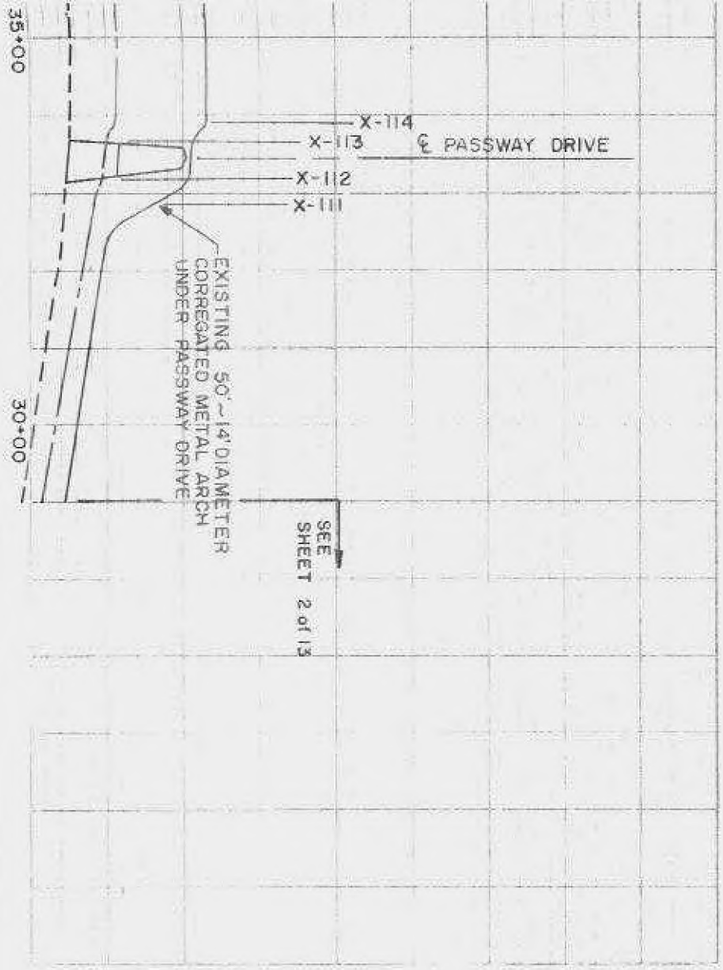
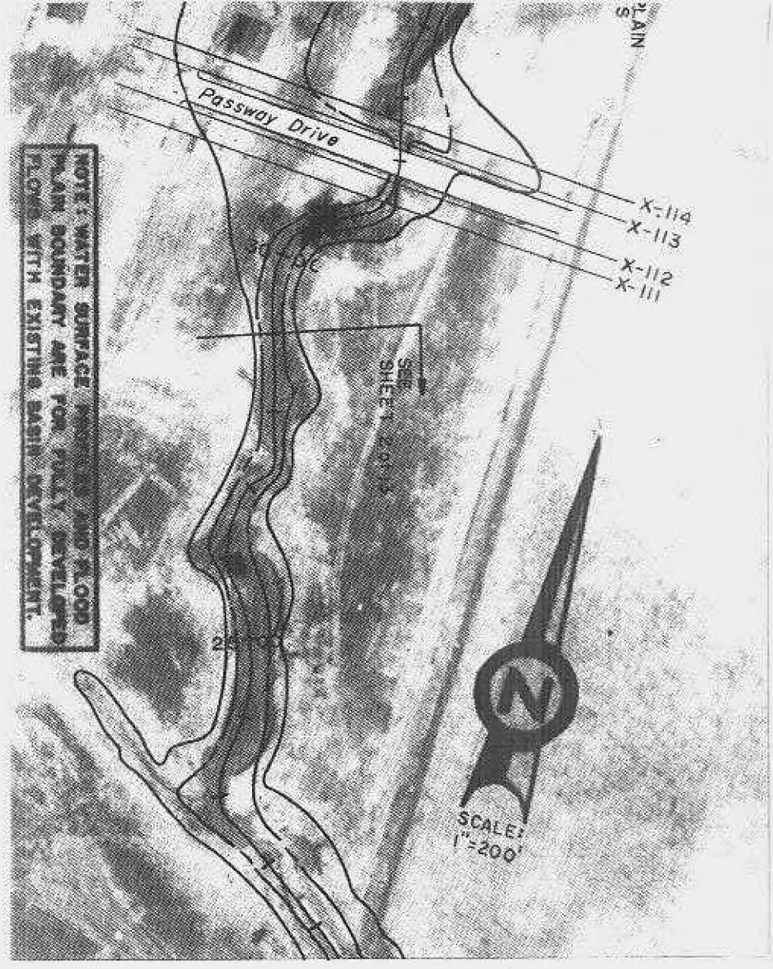

SEE SHEET 4 of 13
LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS
X-123
X-122
X-121
X-120
X-119
X-118
X-117
X-116
X-115
Palmer Drive
100 YR FLOOD
EXISTING FLO
100 YEAR FLOODPLAIN BOUNDARY
5000
4990
4980
4970
4960
4950
4940
4930
4920
℄ PALMER DR.
FAIRWAY DAM SPILLWAY
EXISTING 60'~DOUBLE 3'BY 9'-9" CONCRETE
BOX CULVERT UNDER PALMER DRIVE
SEE
SHEET 4 of 13
100 YR. W.S. PROFILE
EXISTING FLOWS
100 YR. W.S. PROFILE
DEVELOPED FLOWS
℄ EXISTING CHANNEL
60+00
55+00
50+00
45+00
40+00



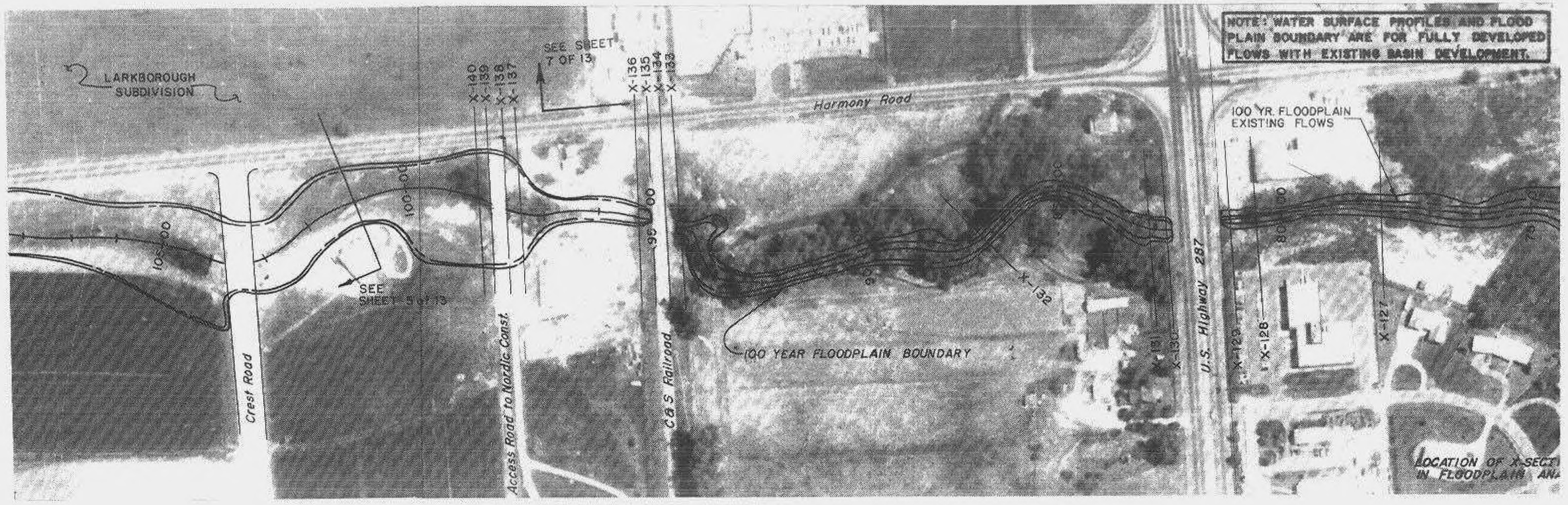


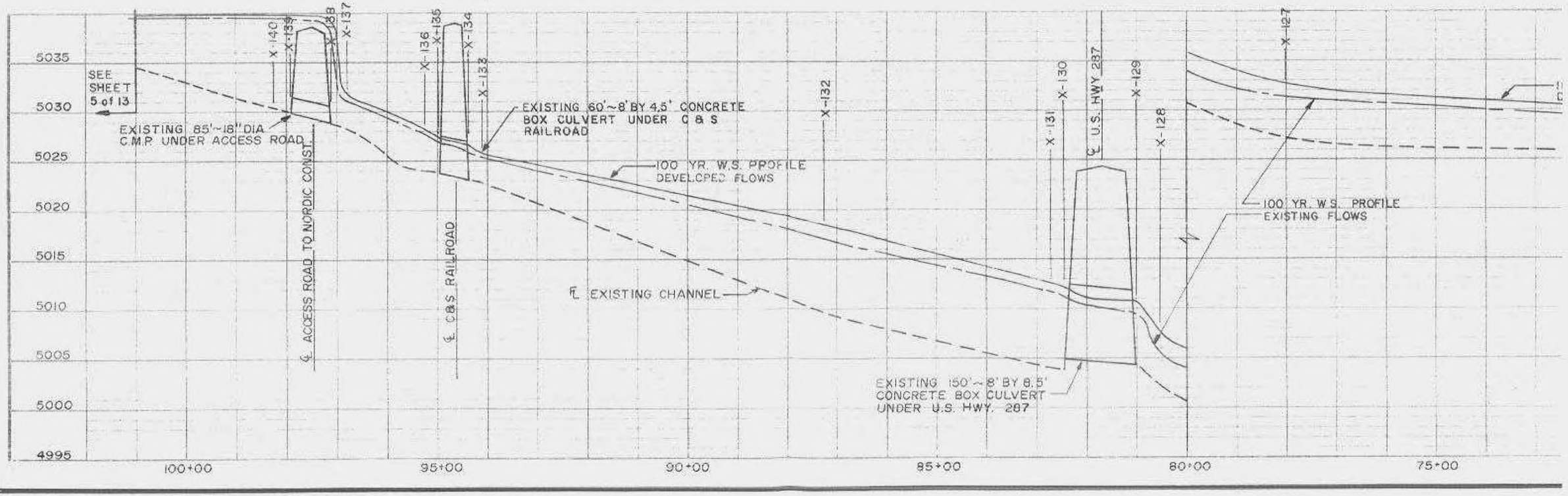
SHEET 3 of 13

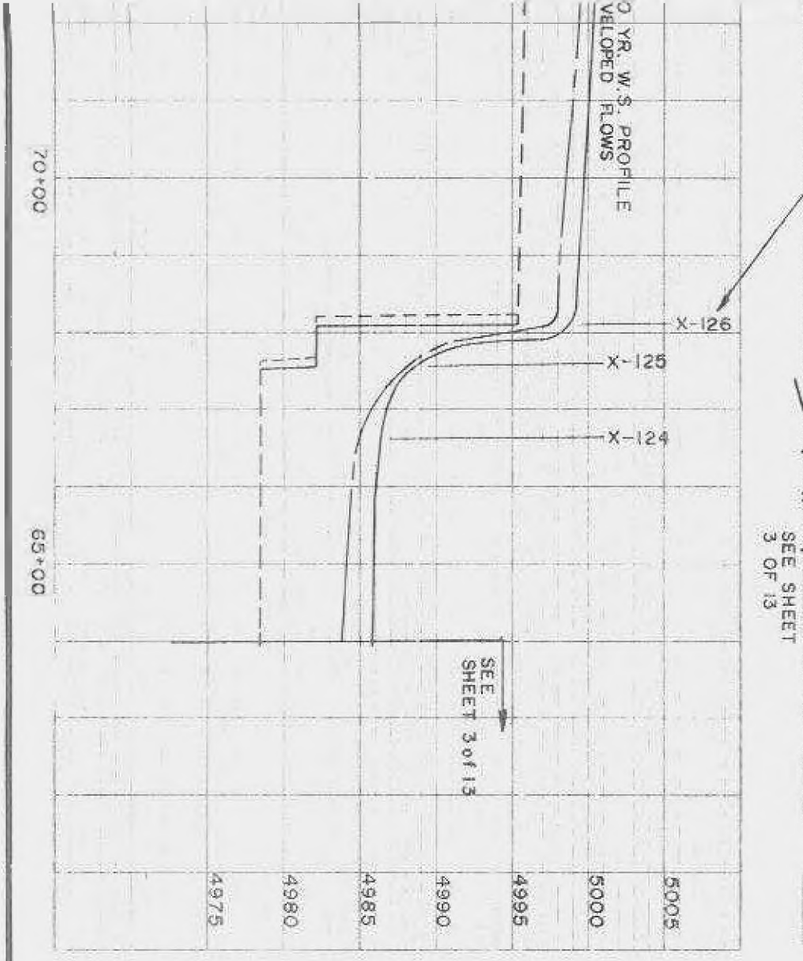
McCLELLANDS & MAIL CREEK DRAINAGE STUDY

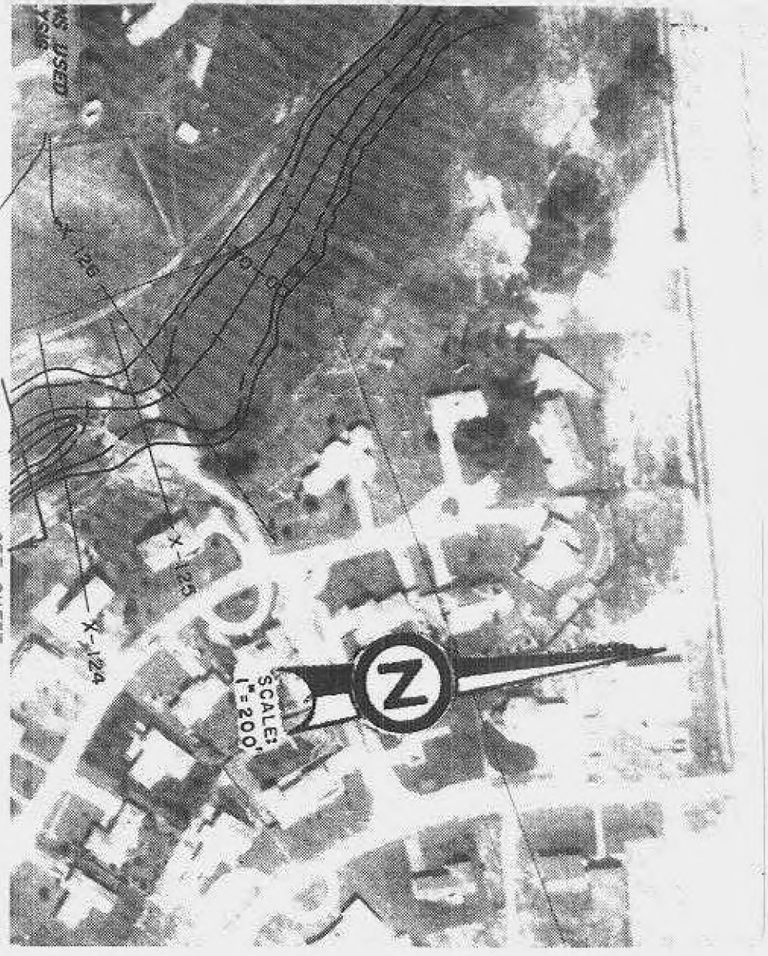
EXISTING FLOOD AREAS
STATION 29+00 TO 64+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646, fort collins, colorado 80522 (303)482-6650


NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH EXISTING BASIN DEVELOPMENT.
LARKBOROUGH SUBDIVISION
SEE SHEET 7 OF 13
SEE SHEET 5 of 13
Harmony Road
Crest Road
Access Road to Nordic Const.
C&S Railroad
U.S. Highway 287
100 YEAR FLOODPLAIN BOUNDARY
100 YR. FLOODPLAIN EXISTING FLOWS
X-140
X-139
X-138
X-137
X-136
X-135
X-134
X-133
X-132
X-131
X-130
X-129
X-128
X-127
100-00
95-00
90-00
85-00
80-00


5035
5030
5025
5020
5015
5010
5005
5000
4995
100+00
95+00
90+00
85+00
80+00
75+00
SEE SHEET 5 of 13
EXISTING 85'~18" DIA C.M.P. UNDER ACCESS ROAD
℄ ACCESS ROAD TO NORDIC CONST.
℄ C&S RAILROAD
EXISTING 60'~8' BY 4.5' CONCRETE BOX CULVERT UNDER C & S RAILROAD
100 YR. W.S. PROFILE DEVELOPED FLOWS
℄ EXISTING CHANNEL
EXISTING 150'~8' BY 8.5' CONCRETE BOX CULVERT UNDER U.S. HWY. 287
℄ U.S. HWY. 287
100 YR. W.S. PROFILE EXISTING FLOWS
X-140
X-139
X-138
X-137
X-136
X-135
X-134
X-133
X-132
X-131
X-130
X-129
X-128
X-127





SHEET 4 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 64+00 TO 101+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins , colorado 80522 (303)482-6650

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH EXISTING BASIN DEVELOPMENT.

WOODLANDS SUBDIVISION

100 YEAR FLOODPLAIN BOUNDARY

100 YEAR FLOODPLAIN EXISTING FLOWS

SEE SHEET 6 of 13

Shields Street

Harmony Road

Larimer County Voc-Tech Center

X-162 X-161 X-150 X-149 X-148 X-147 X-146 X-145

140+00 135+00 130+00 125+00 120+00 115+00

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS

5075 5070 5065 5060 5055 5050 5045 5040 5035

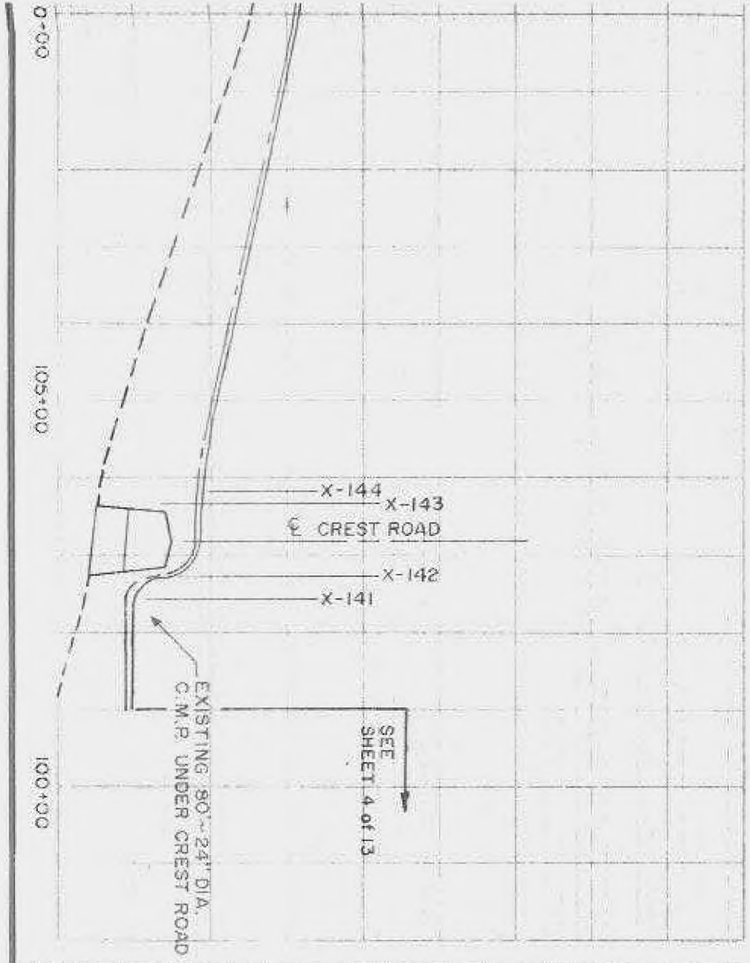
100 YR. W.S. PROFILE DEVELOPED FLOWS

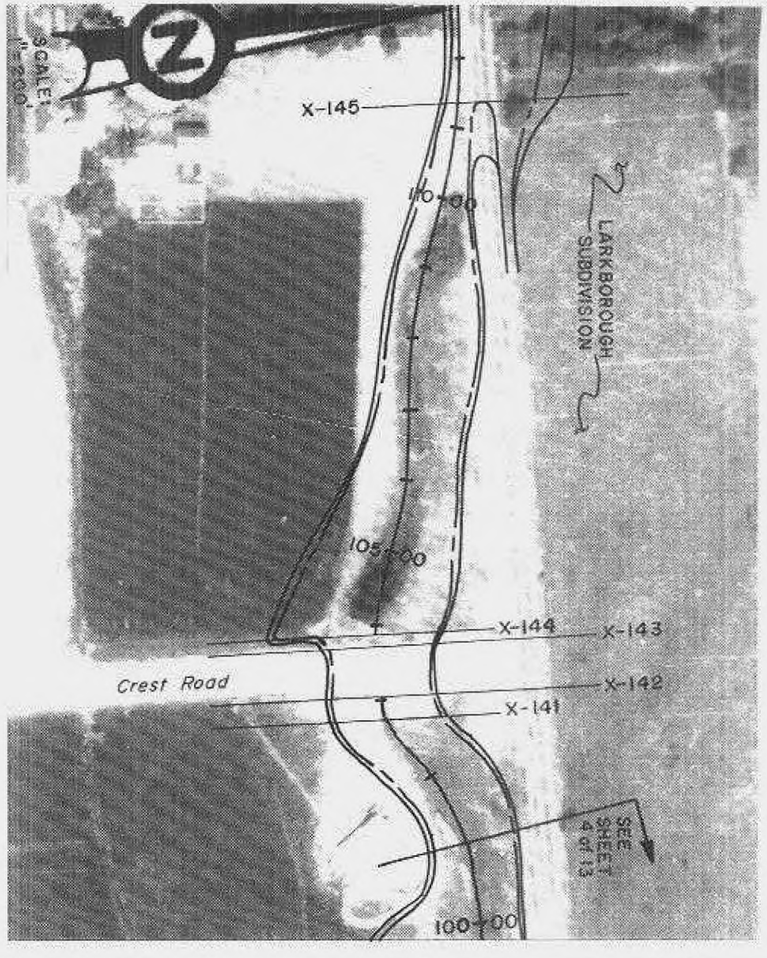
100 YR. W.S. PROFILE EXISTING FLOWS

℄ EXISTING CHANNEL

SEE SHEET 6 of 13

135+00 130+00 125+00 120+00 115+00



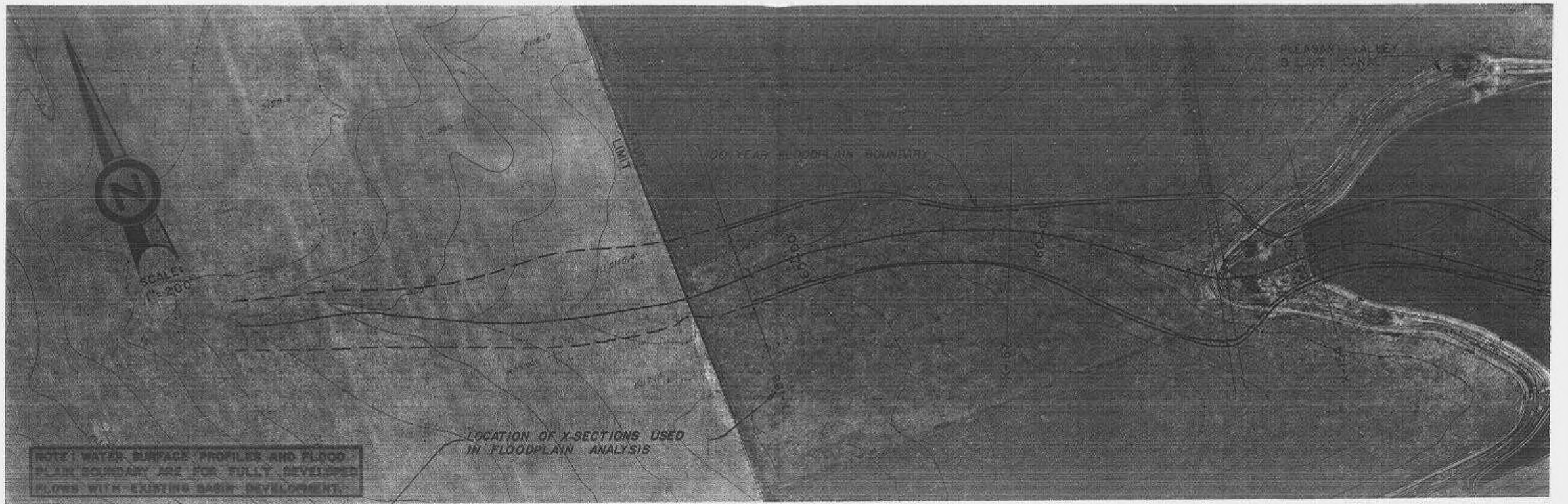


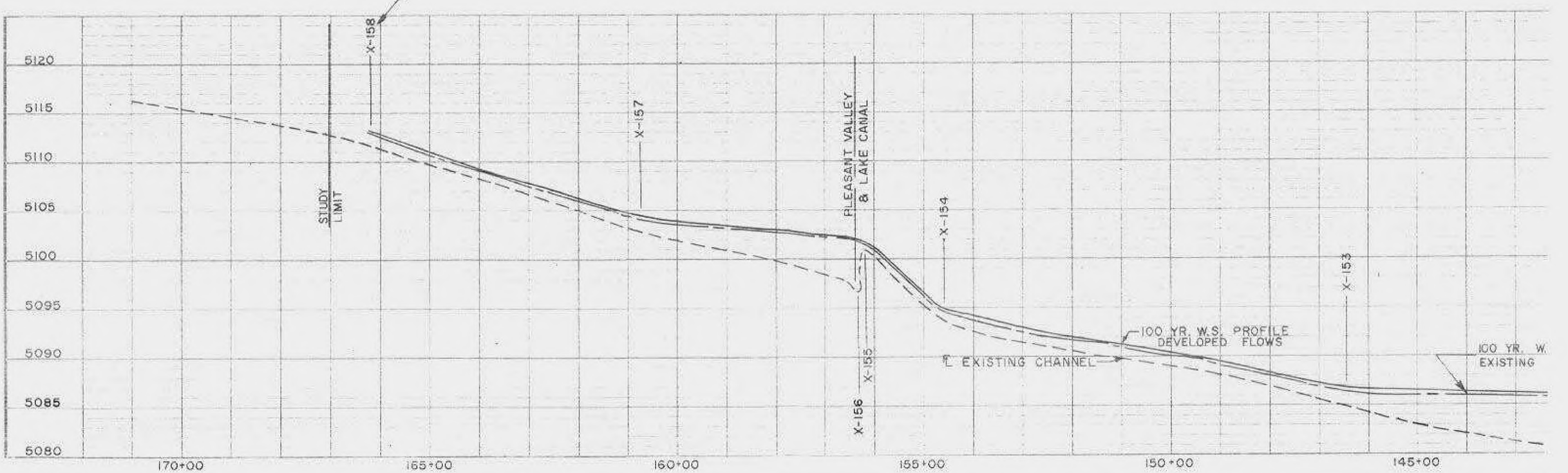
SHEET 5 of 13

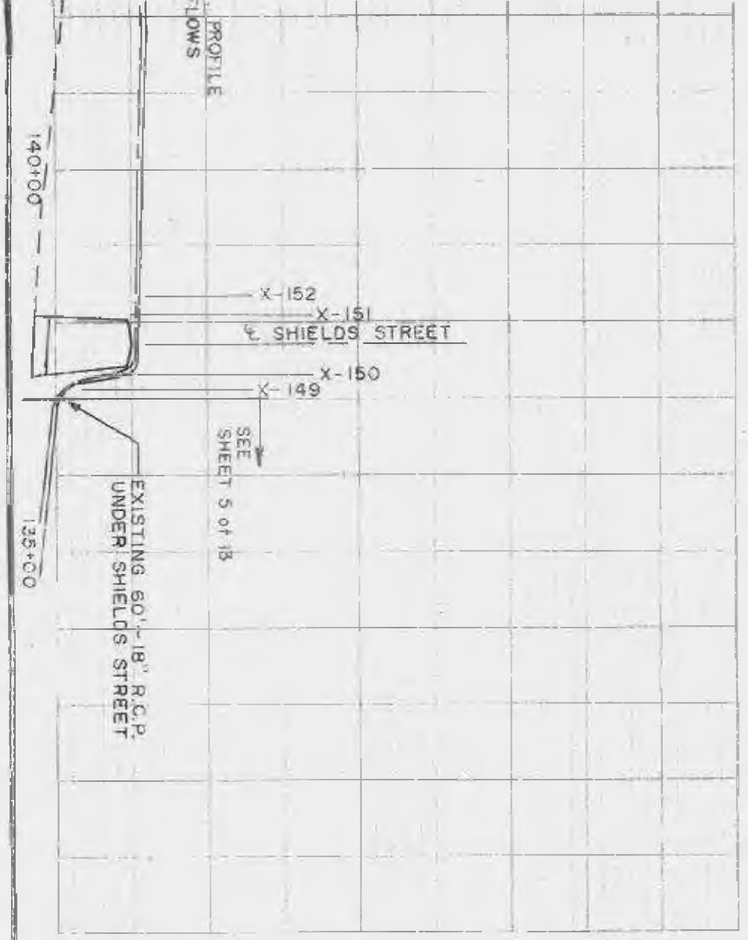
McCLELLANDS & MAIL CREEK DRAINAGE STUDY

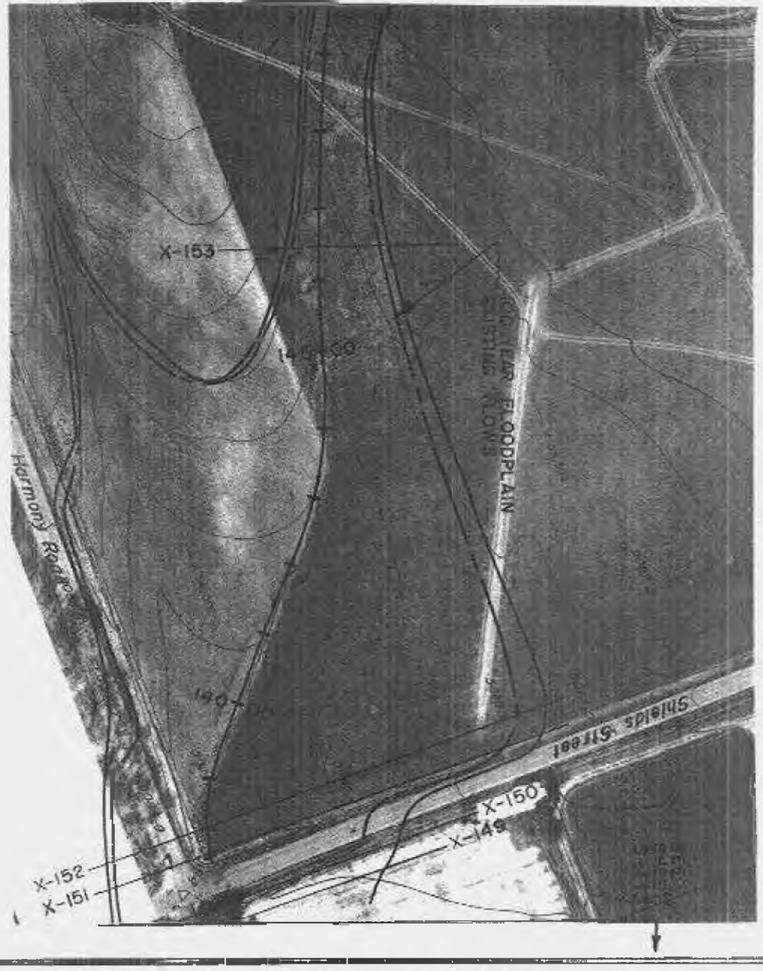
EXISTING FLOOD AREAS
STATION 101+00 TO 137+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins . colorado 80522 (303)482-6650


SCALE: 1"=200'
LIMIT
100 YEAR FLOODPLAIN BOUNDARY
PLEASANT VALLEY & LAKE CAN
LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS
NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH EXISTING BASIN DEVELOPMENT.


5120
5115
5110
5105
5100
5095
5090
5085
5080
170+00
165+00
160+00
155+00
150+00
145+00
X-158
X-157
X-156
X-155
X-154
X-153
STUDY LIMIT
PLEASANT VALLEY & LAKE CANAL
100 YR. W.S. PROFILE DEVELOPED FLOWS
℄ EXISTING CHANNEL
100 YR. W. EXISTING





SHEET 6 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 137+00 TO STUDY LIMIT

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
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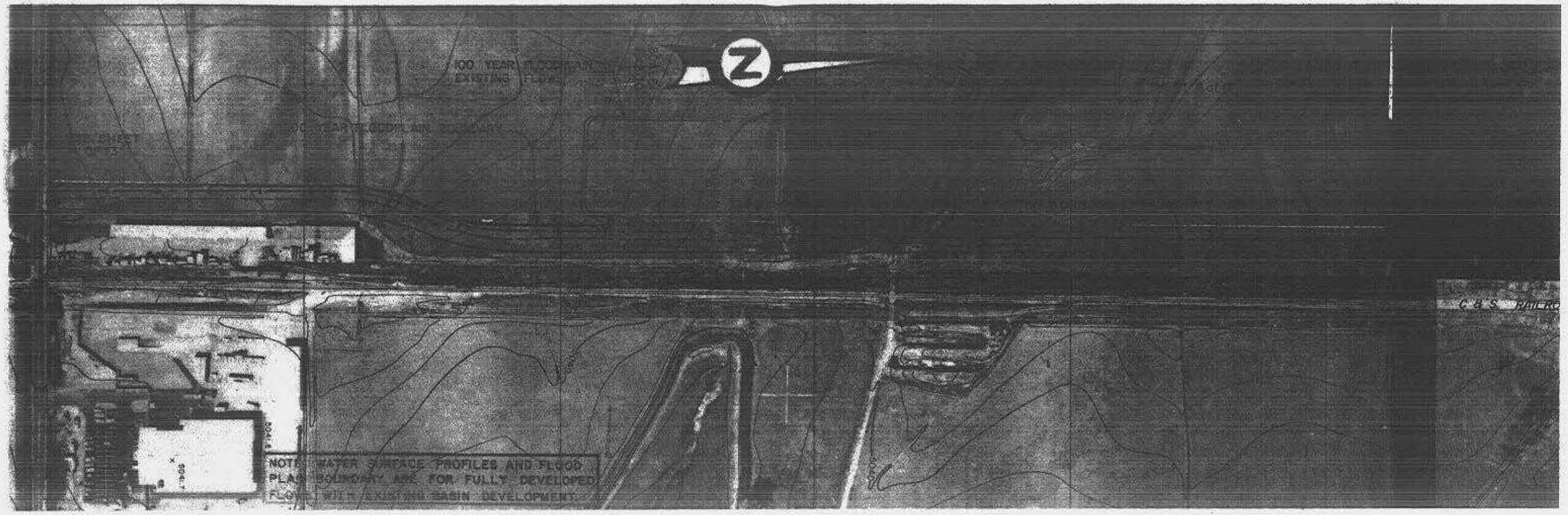
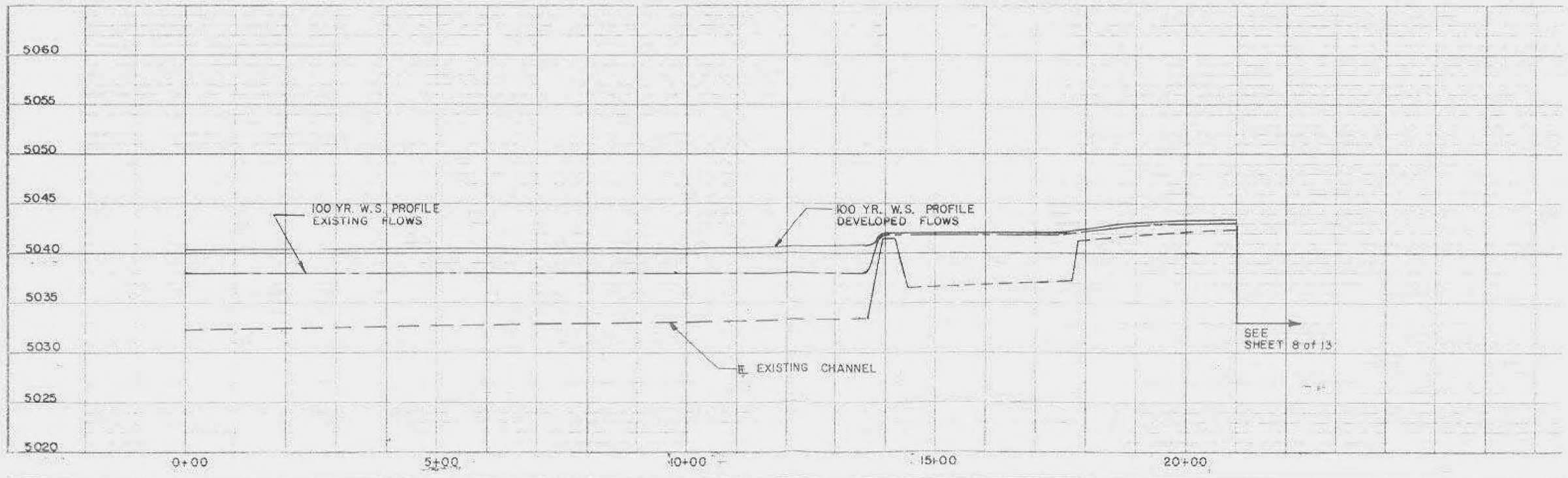
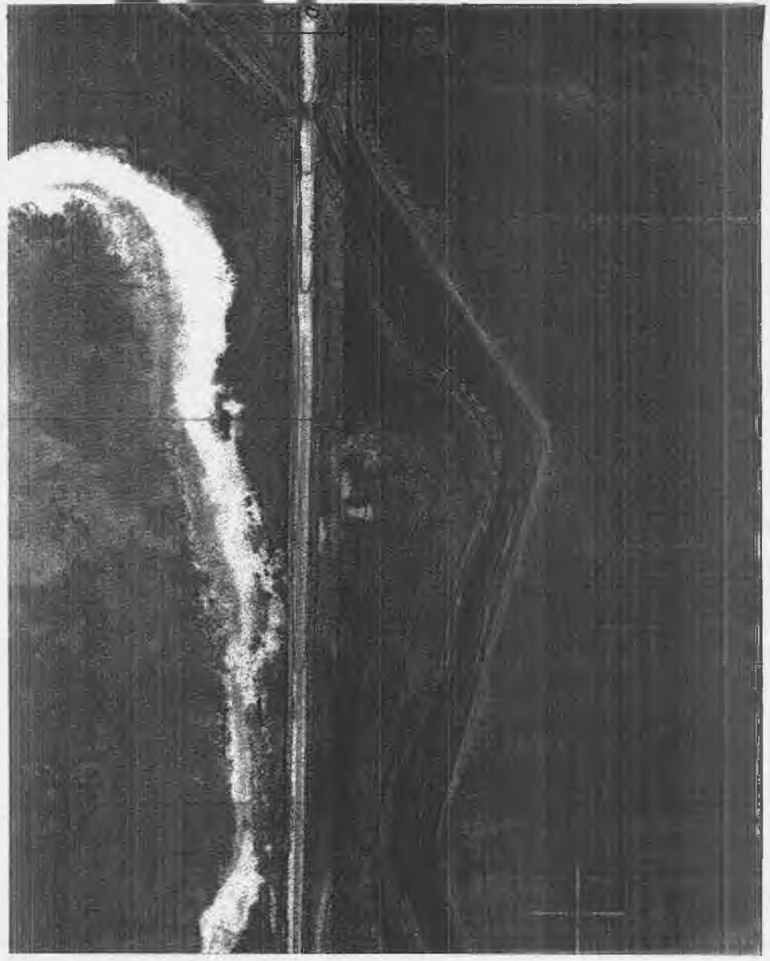

100 YEAR FLOODPLAIN
EXISTING FLOWS
NOTE: WATER SURFACE PROFILES AND FLOOD
PLAIN BOUNDARY ARE FOR FULLY DEVELOPED
FLOWS WITH MAXIMUM BASIN DEVELOPMENT


5060
5055
5050
5045
5040
5035
5030
5025
5020
0+00
5+00
10+00
15+00
20+00
100 YR. W.S. PROFILE
EXISTING FLOWS
100 YR. W.S. PROFILE
DEVELOPED FLOWS
E. EXISTING CHANNEL
SEE
SHEET 8 of 13



SHEET 7 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
NEW MERCER CANAL

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
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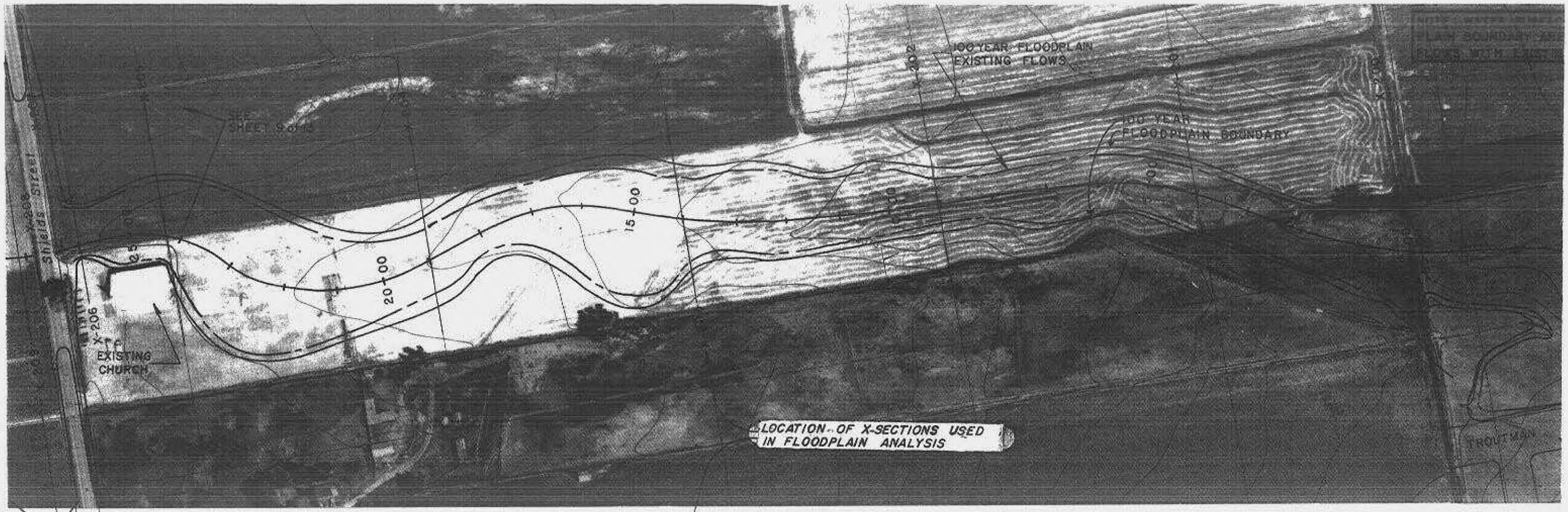
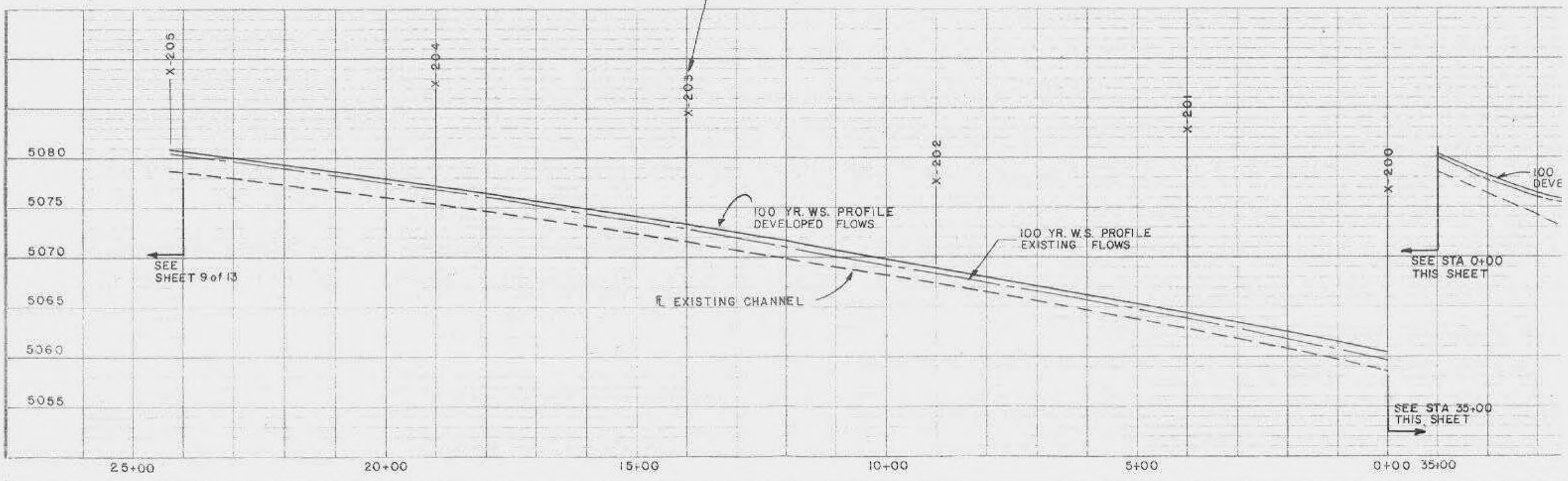
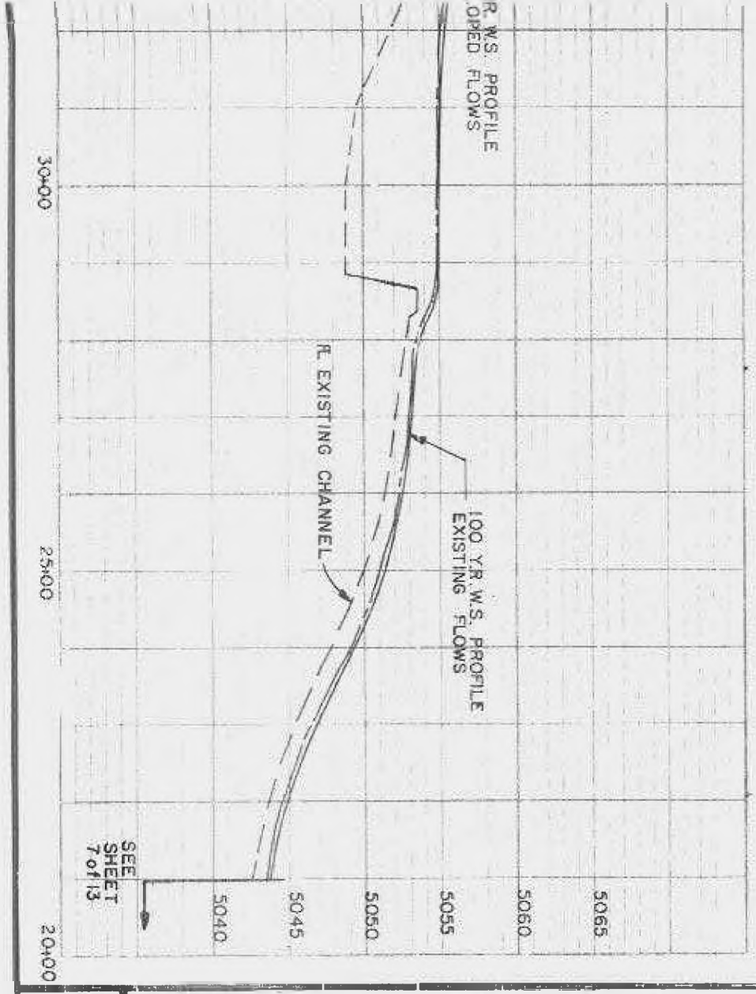
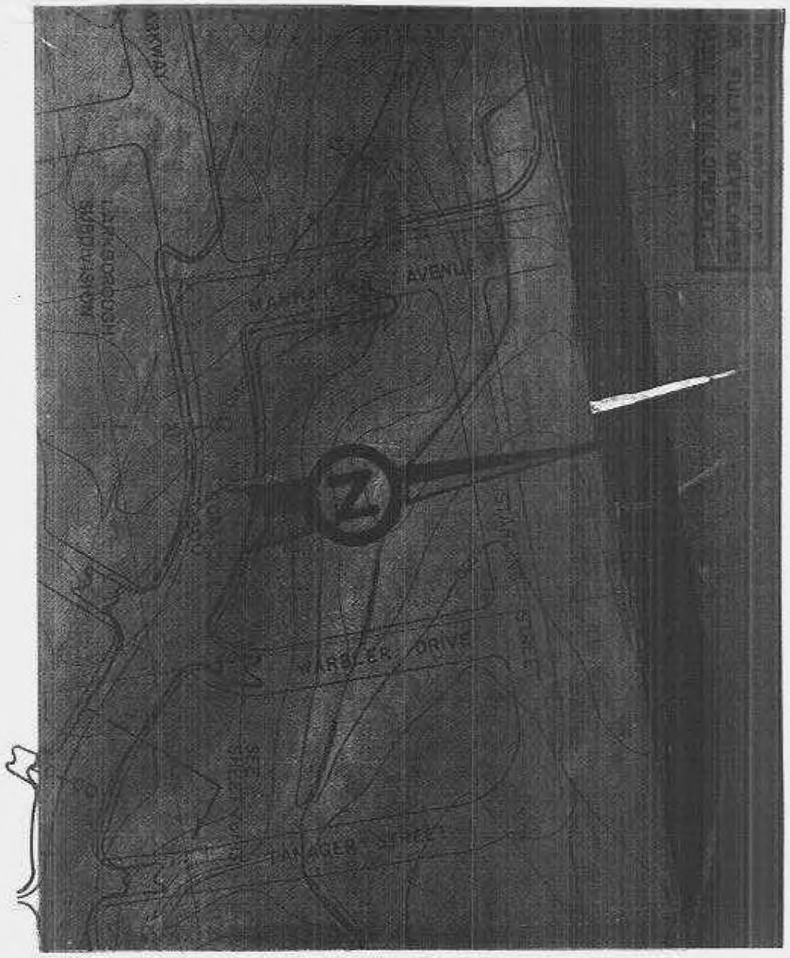

100 YEAR FLOODPLAIN
EXISTING FLOWS
100 YEAR
FLOODPLAIN BOUNDARY
SEE
SHEET 9 of 13
Shields Street
X-206
℄
EXISTING
CHURCH
20+00
15+00
LOCATION OF X-SECTIONS USED
IN FLOODPLAIN ANALYSIS
TROUTMAN


X-205
X-204
X-203
X-202
X-201
X-200
5080
5075
5070
5065
5060
5055
100 YR. W.S. PROFILE
DEVELOPED FLOWS
100 YR. W.S. PROFILE
EXISTING FLOWS
℄ EXISTING CHANNEL
SEE
SHEET 9 of 13
SEE STA 0+00
THIS SHEET
SEE STA 35+00
THIS SHEET
100
DEVE
25+00
20+00
15+00
10+00
5+00
0+00 35+00





SHEET 8 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 0+00 TO 24+00

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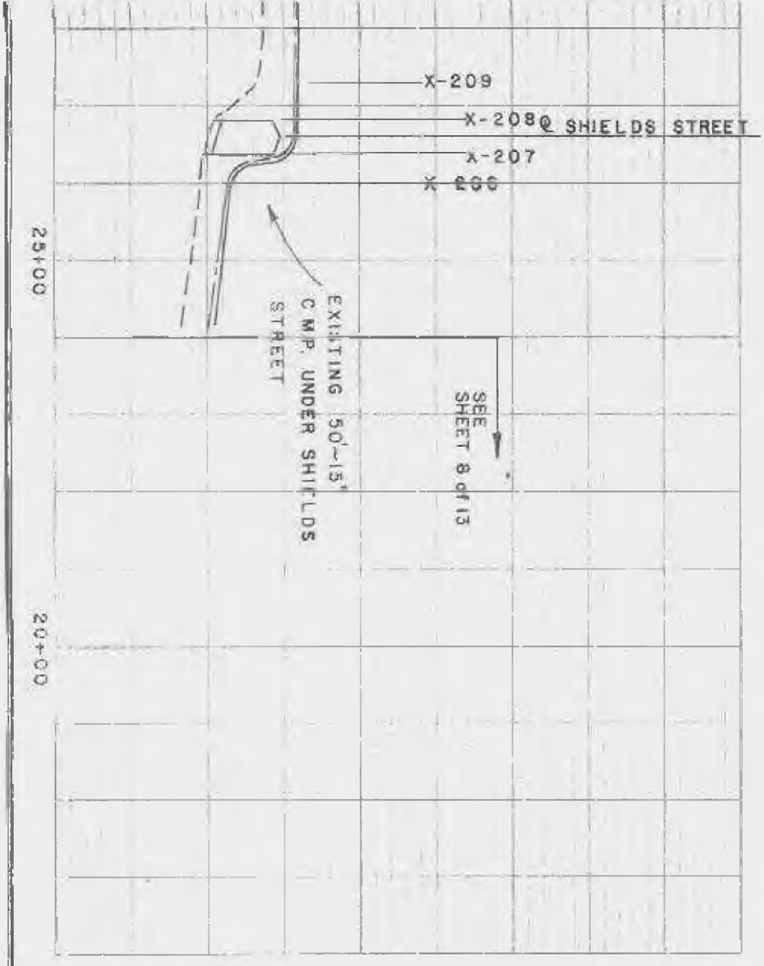
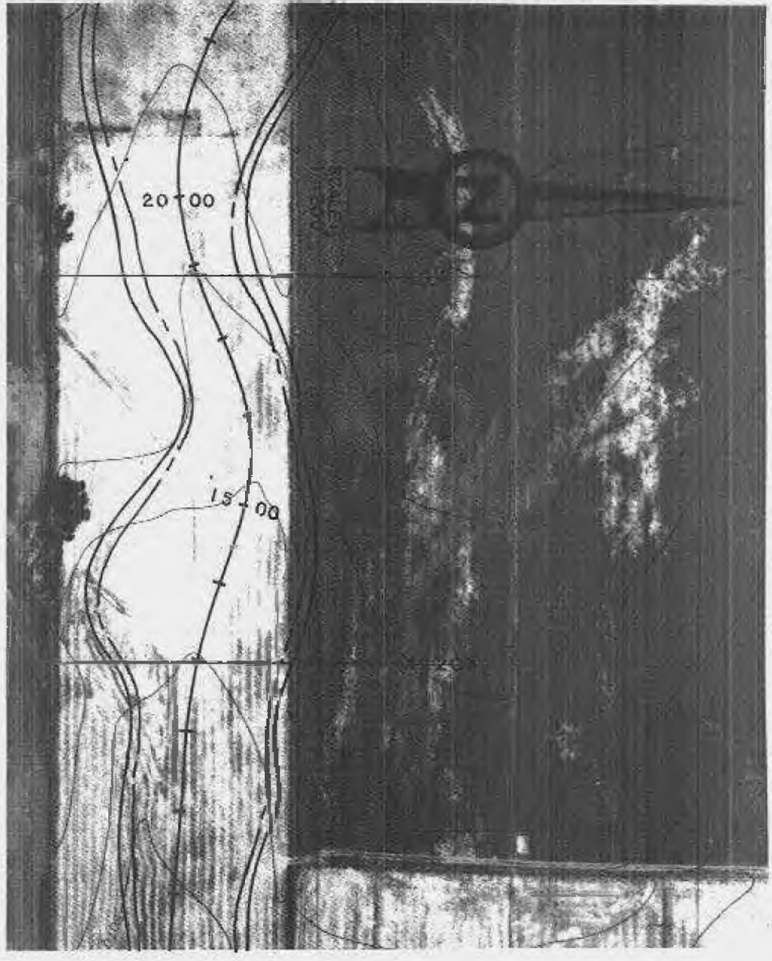
STUDY LIMIT
100 YEAR FLOODPLAIN BOUNDARY
X-214
X-213
PLEASANT VALLEY B LAKE CANAL
100 YEAR FLOODPLAIN EXISTING FLOWS
X-212
X-211
X-210
X-209
Shields Street
SEE SHEET 8 of 12
X-216
X-215
LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS
5110
5105
5100
5095
5090
5085
5080
5075
100 YR. W.S. PROFILE EXISTING FLOWS
100 YR. W.S. PROFILE DEVELOPED FLOWS
℄ EXISTING CHANNEL
55+00
50+00
45+00
40+00
35+00
30+00



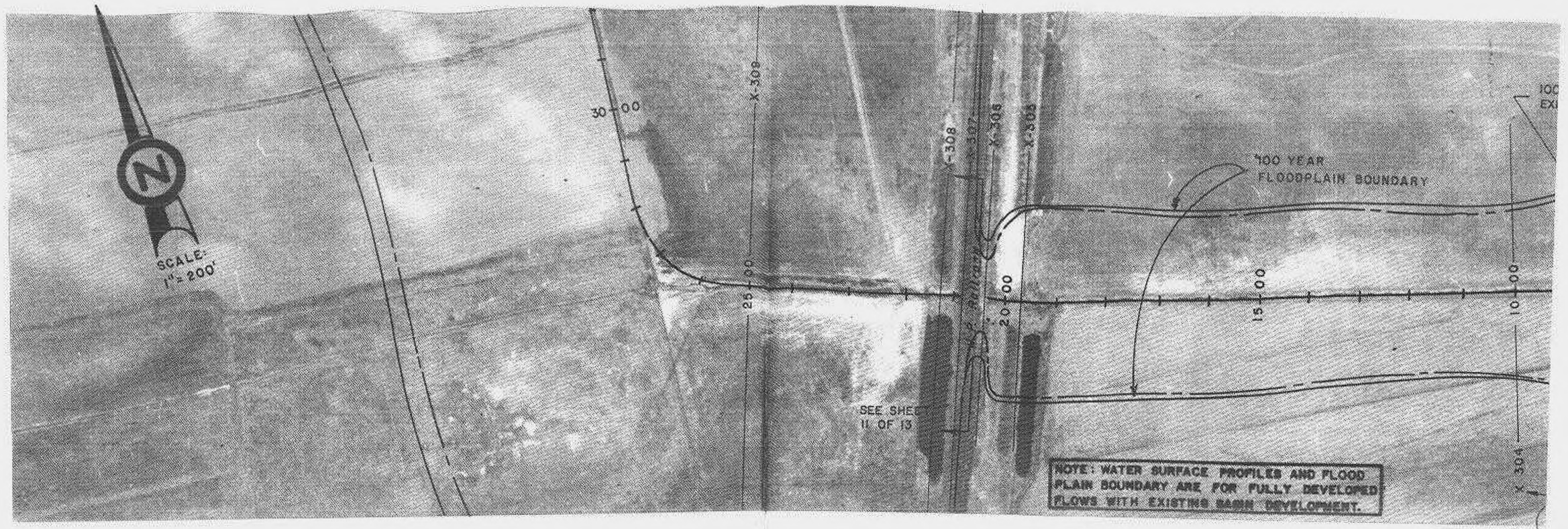


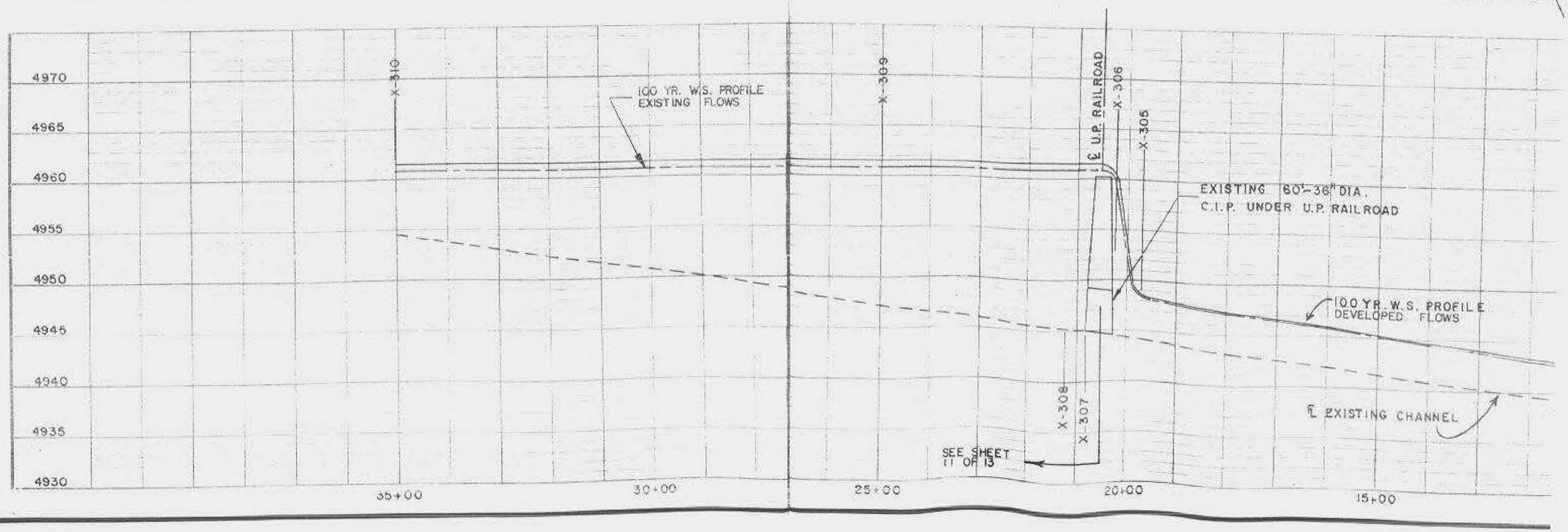
SHEET 9 of 13

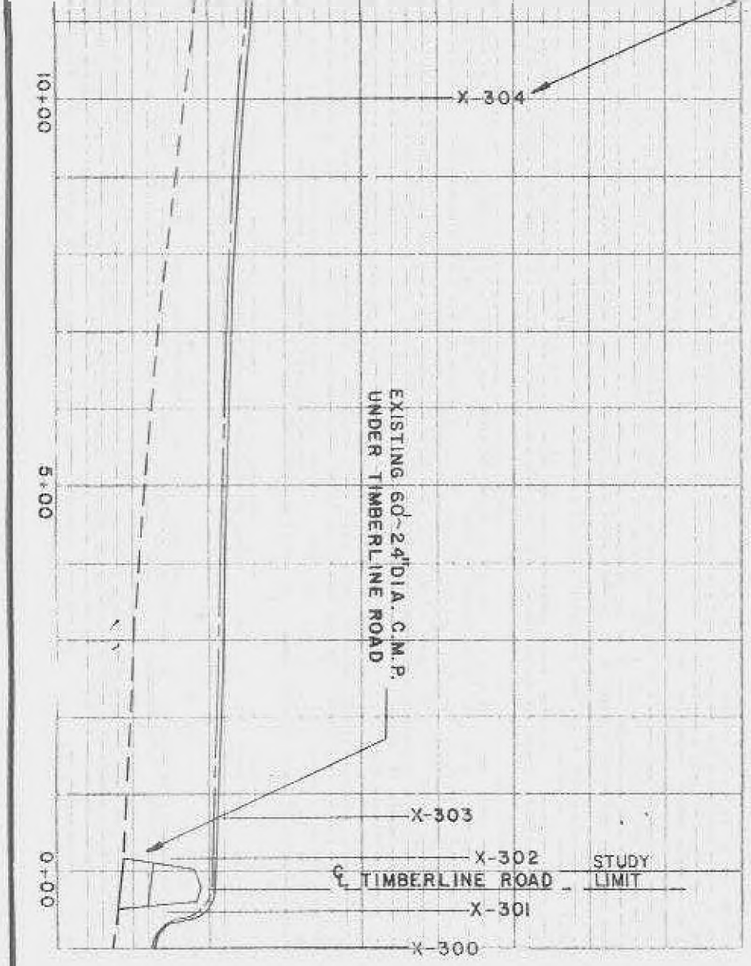
McCLELLANDS & MAIL CREEK DRAINAGE STUDY

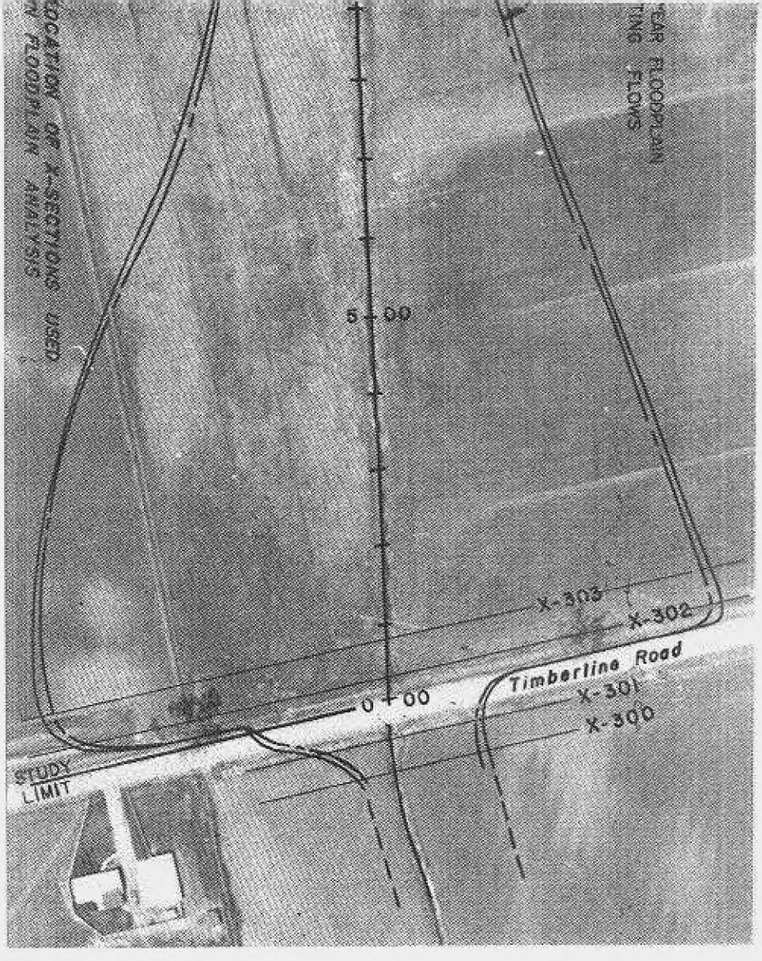
EXISTING FLOOD AREAS
STATION 24+00 TO STUDY LIMIT

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins . colorado 80522 (303)482-6650


N
SCALE:
1" = 200'
30+00
25+00
20+00
15+00
10+00
X-308
X-307
X-306
X-305
X-304
℄ RAILROAD
100 YEAR
FLOODPLAIN BOUNDARY
SEE SHEET
11 OF 13
NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH EXISTING BASIN DEVELOPMENT.


4970
4965
4960
4955
4950
4945
4940
4935
4930
X-310
X-309
X-308
X-307
X-306
X-305
℄ U.P. RAILROAD
100 YR. W.S. PROFILE
EXISTING FLOWS
EXISTING 60"-36" DIA.
C.I.P. UNDER U.P. RAILROAD
100 YR. W.S. PROFILE
DEVELOPED FLOWS
℄ EXISTING CHANNEL
SEE SHEET
11 OF 13
35+00
30+00
25+00
20+00
15+00





SHEET 10 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 0+00 TO 32+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
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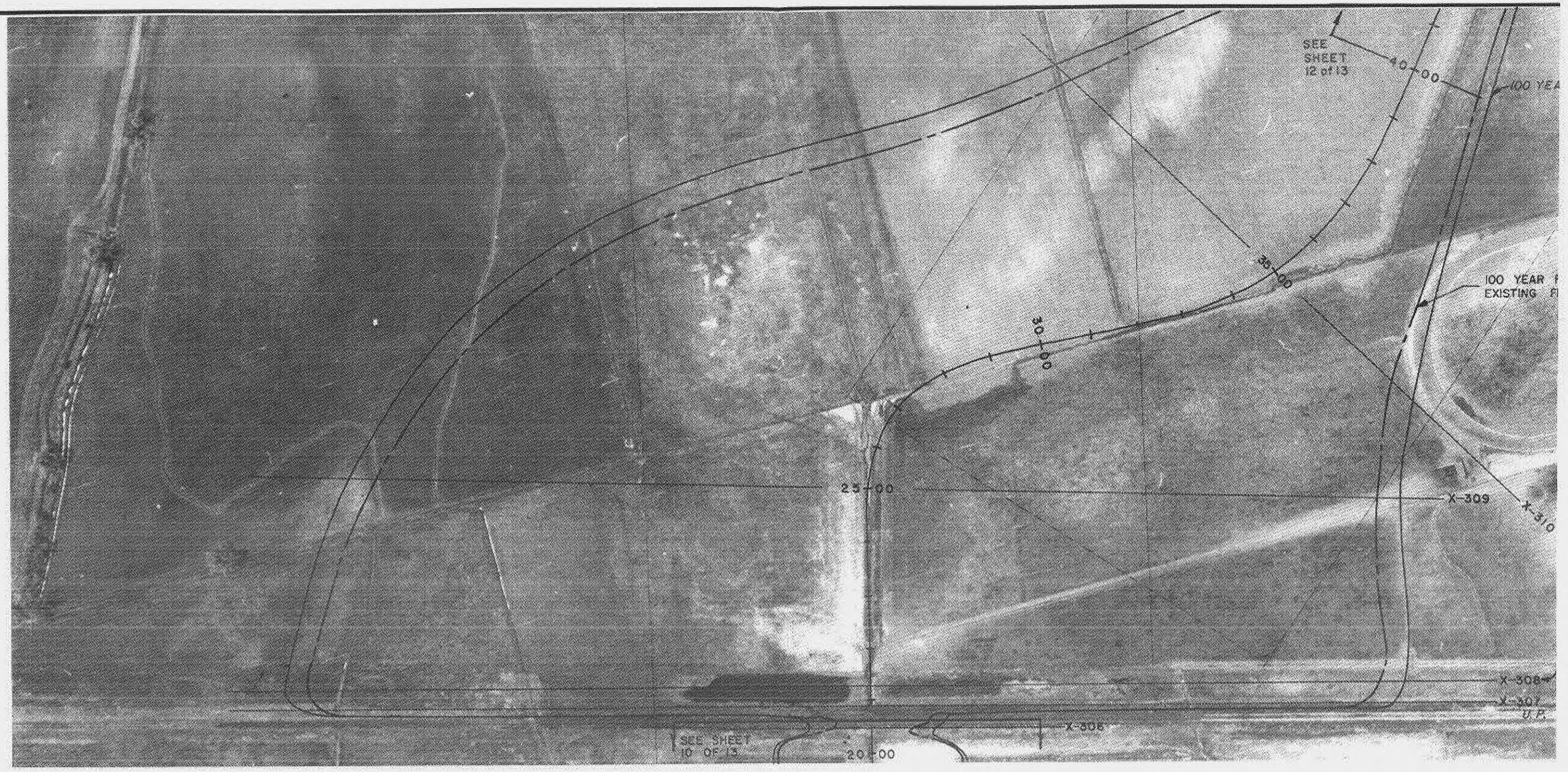
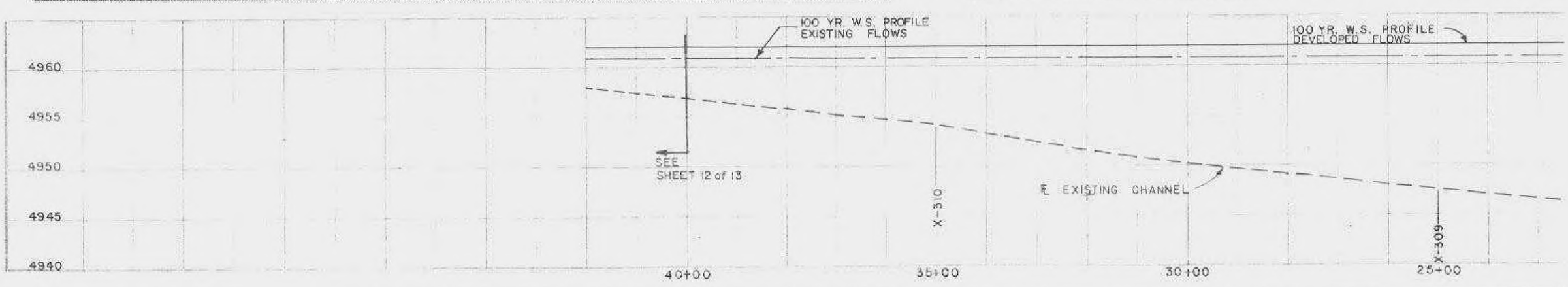
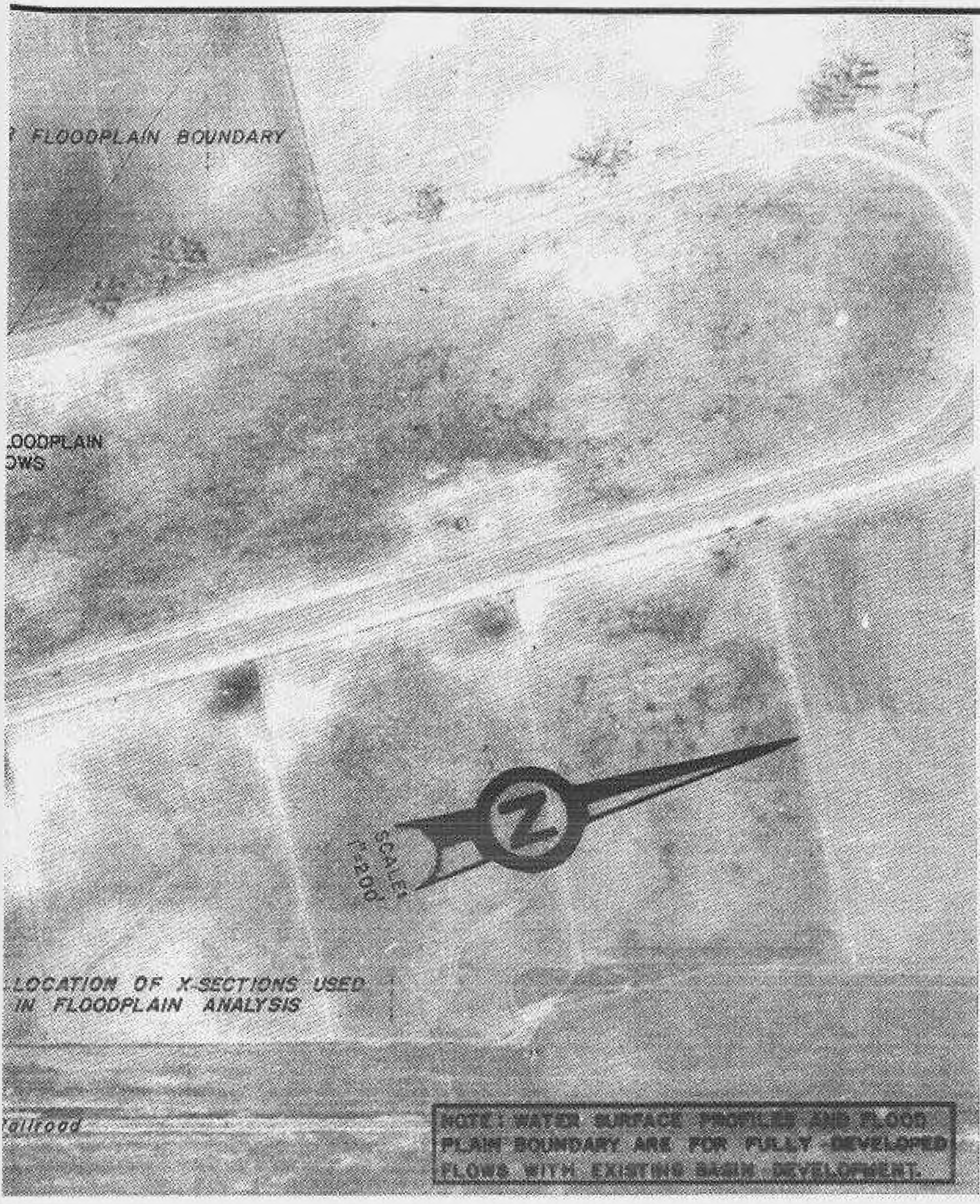
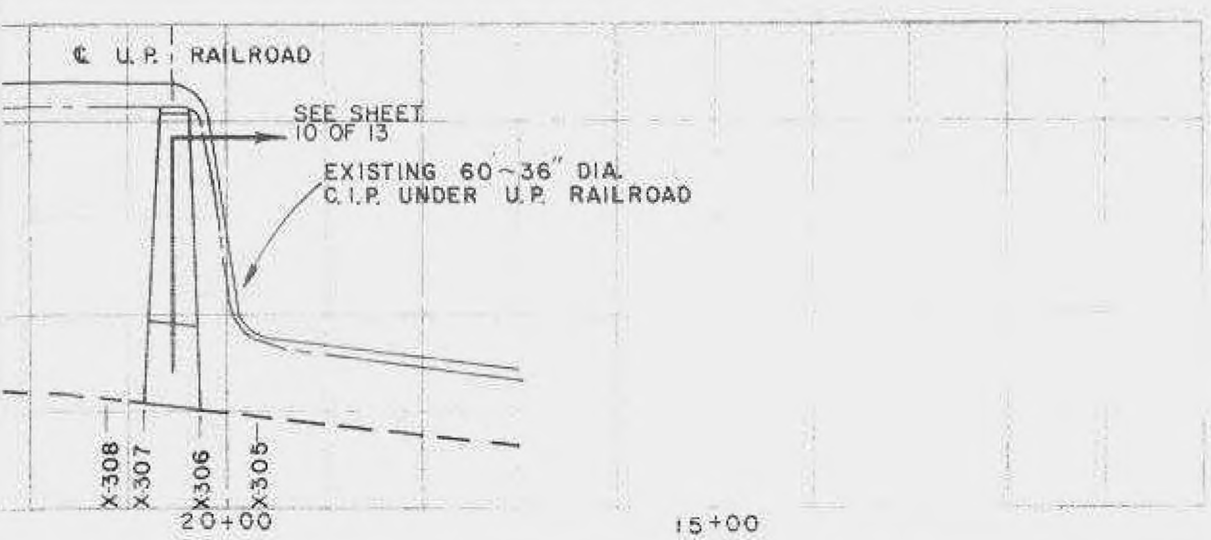

SEE
SHEET
12 of 13
40+00
100 YEA
35+00
100 YEAR F
EXISTING FL
30+00
25+00
X-309
X-310
X-308
X-307
U.P.
X-306
SEE SHEET
10 OF 13
20+00


100 YR W.S. PROFILE
EXISTING FLOWS
100 YR. W.S. PROFILE
DEVELOPED FLOWS
4960
4955
4950
4945
4940
SEE
SHEET 12 of 13
X-310
℄ EXISTING CHANNEL
X-309
40+00
35+00
30+00
25+00





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MANAGEMENT / ENGINEERING
p.o. box 646, fort collins, colorado 80522 (303) 482-6650

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 32+00 TO 40+00

SHEET
11 of 13

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH EXISTING BASIN DEVELOPMENT.

SCALE: 1"=200'

Harmony Road

Lemay Avenue

SEE SHEET 13 of 13

X-313

X-312

X-311

X-314

65+00

60+00

55+00

50+00

45+00

100 YEAR FLOODPLAIN BOUNDARY

100 YEAR FLOODPLAIN EXISTING FLOWS

LOCATION OF X-SEC IN FLOODPLAIN A

4985

4980

4975

4970

4965

4960

4955

4950

7.0+00

65+00

60+00

55+00

50+00

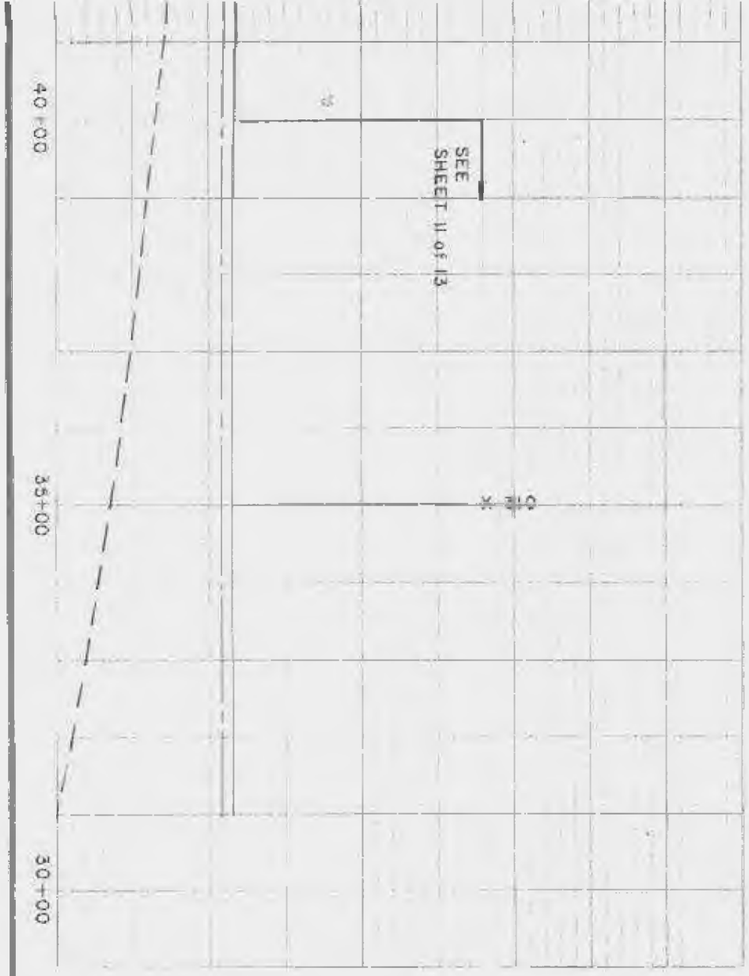
45+00

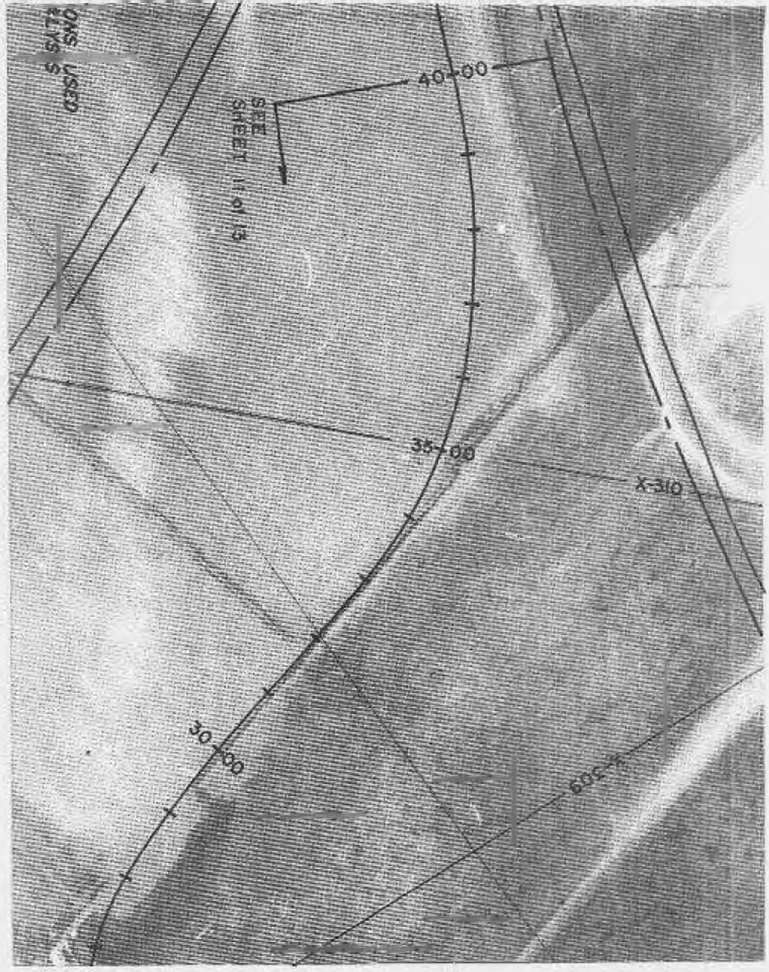
SEE SHEET 13 of 13

℄ EXISTING CHANNEL

100 YR. W.S. PROFILE EXISTING FLOWS

100 YR. W.S. PROFILE DEVELOPED FLOWS



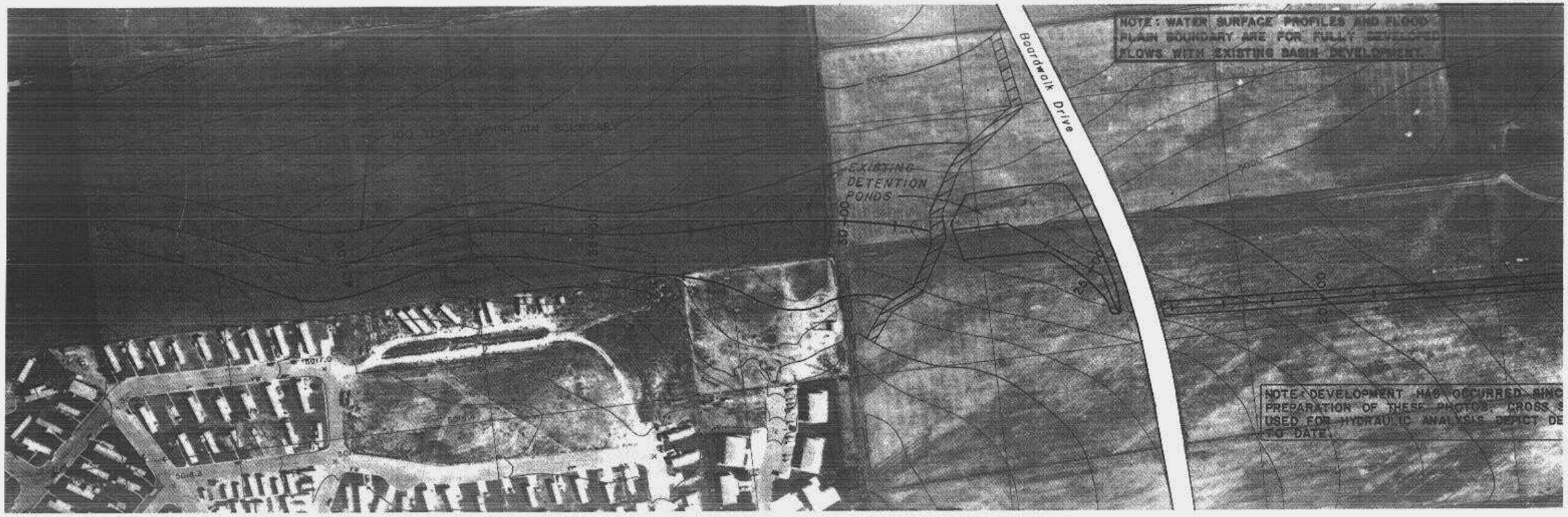


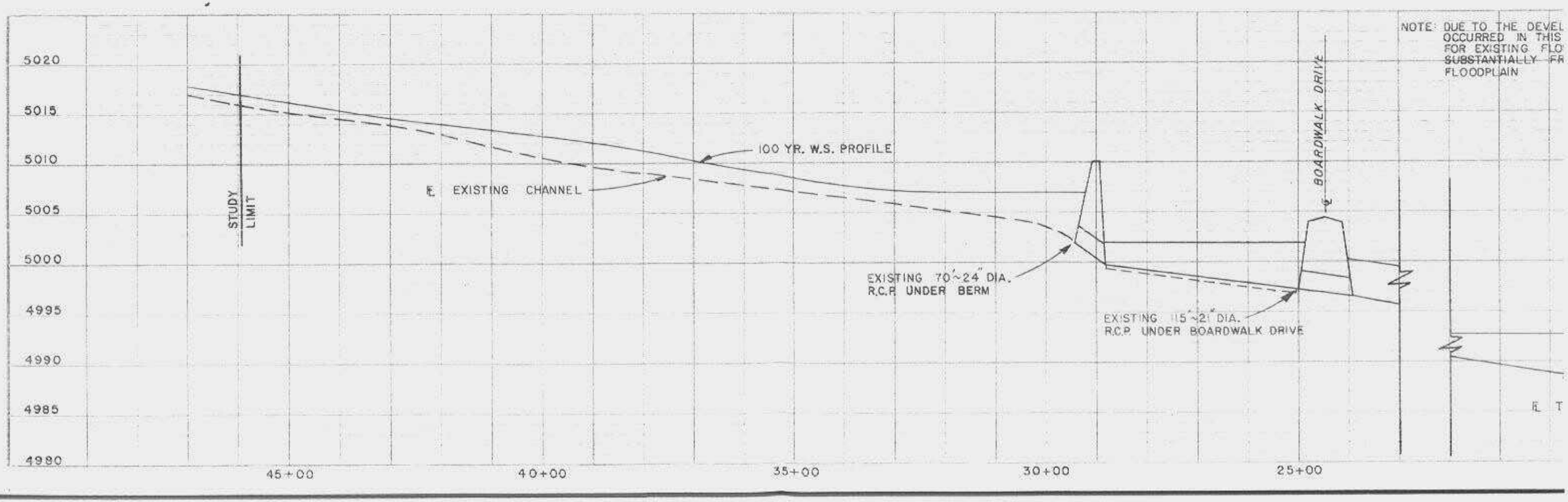
SHEET 12 of 13

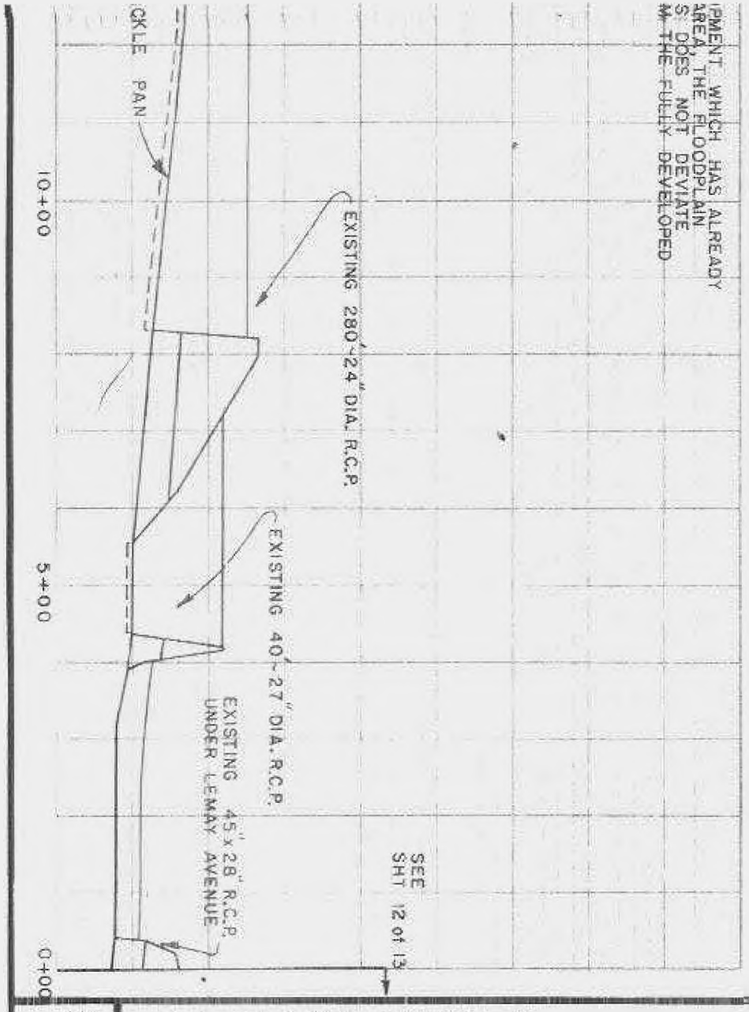
McCLELLANDS & MAIL CREEK DRAINAGE STUDY

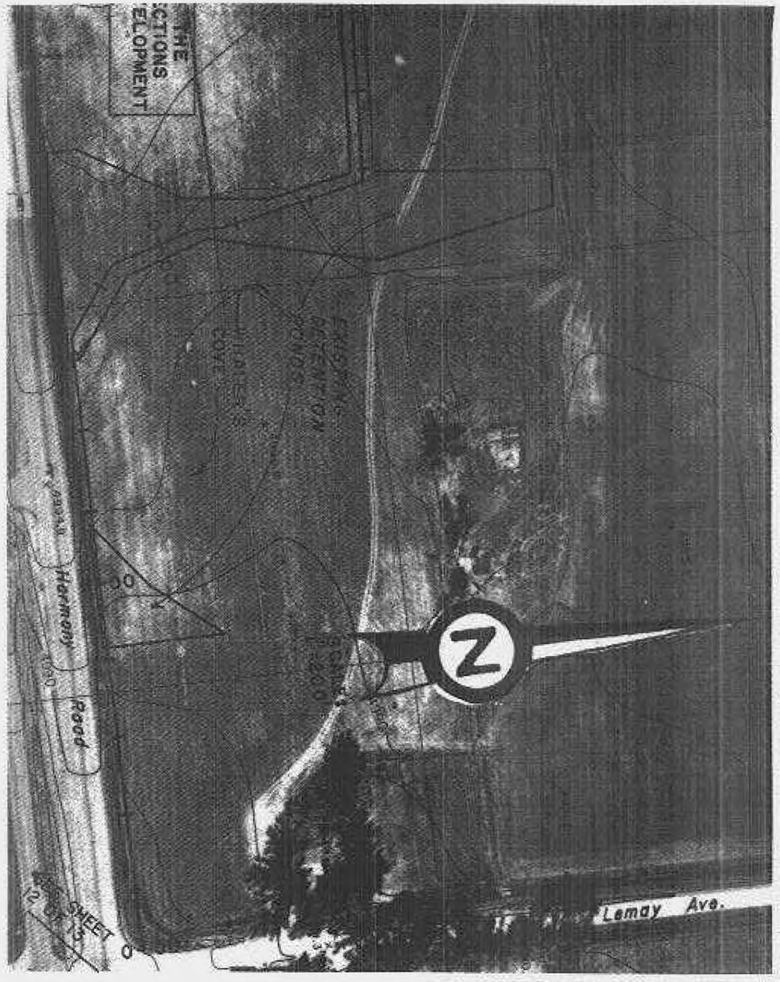
EXISTING FLOOD AREAS
STATION 40+00 TO 70+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins . colorado 80522 (303)482-6650


NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH EXISTING BASIN DEVELOPMENT.
Boardwalk Drive
EXISTING DETENTION PONDS
NOTE: DEVELOPMENT HAS OCCURRED SINC
PREPARATION OF THESE PHOTOS. CROSS S
USED FOR HYDRAULIC ANALYSIS REFLECT DE
TO DATE.


NOTE: DUE TO THE DEVEL
OCCURRED IN THIS
FOR EXISTING FLO
SUBSTANTIALLY FR
FLOODPLAIN
5020
5015
5010
5005
5000
4995
4990
4985
4980
STUDY LIMIT
℄ EXISTING CHANNEL
100 YR. W.S. PROFILE
EXISTING 70'~24" DIA. R.C.P. UNDER BERM
℄ BOARDWALK DRIVE
EXISTING 115'~21" DIA. R.C.P. UNDER BOARDWALK DRIVE
℄ T
45+00
40+00
35+00
30+00
25+00





SHEET 13 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

EXISTING FLOOD AREAS
STATION 0+00 TO 47+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
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SECTION VI

ALTERNATIVES

Expenditure of public funds by the City of Fort Collins for flood control requires that the most feasible potential flood control plans be identified and compared. Alternative flood control plans considered for implementation on McClellands and Mail Creek include:

A. Maintaining existing channel configuration.

B. Improving the drainageway in a naturally landscaped configuration following the general historic channel alignment and maintaining a minimum flow channel.

C. Installing major underground conduits along the general course of the historic stream channel, using local right-of-way wherever possible.

D. Lining channels to reduce right-of-way requirements.

E. Relocating channels to routes other than the historic channel alignment.

F. Diverting all or part of the peak flows at points upstream from potential hazard areas.

G. Construct detention and/or retention ponds.

H. Construct levees.

I. Installing, removing, or replacing structural improvements at specific problem areas.

J. Floodproofing individual structures.

K. Implementing floodplain management regulations and making flood insurance available.

L. Implementing flood warning and informational systems, and developing evacuation plans.

M. Acquiring flood prone properties and relocating residents out of floodplain.

N. Other plans.

O. Combinations of the preceeding.

Traditionally, flood control projects are undertaken with the basic objective of reducing or preventing damage to property. In screening alternative for implementation in the McClellands and Mail Creek Basins, these complementary objectives addressing the general public welfare have been considered.

- Enhancement of land and property values in areas adjacent to the floodplain.
- Improvement of the aesthetic quality of the urban landscape.
- Improvement of water quality.
- To preserve the ecological and environmental values of natural floodplain areas.
- To reduce the threat to life from floods.
- To reduce drainage and flood related health hazards.
- Enhancement or provision of recreational opportunities.
- Reduction of public inconvenience.
- To reduce potential traffic hazards due to flood water.
- Accomodation of emergency vehicle movement.
- To utilize public funds effectively.

In order to compare alternatives for The McClellands and Mail Creek Basins, the study channels have been divided into these reaches:

Reach 1A - Mail Creek from Confluence with Fossil Creek to Mail Creek Lane.

Reach 1B - Mail Creek Lane to Palmer Drive.

Reach 1C - Palmer Drive to U.S. 287 (College Avenue)

Reach 1D - U.S. 287 to C & S Railroad.

Reach 2A - C & S Railroad to Shields Street.

Reach 2B - Shields Street to Upstream Study Limits.

Reach 3 - New Mercer Canal between Mail Creek and McClellands tributary.

Reach 4A - McClellands tributary from New Mercer Canal to center of Section 34.

Reach 4B - McClellands tributary from center of Section 34 to Shields Street.

Reach 5 - McClellands tributary from Shields Street to upstream study limits.

Reach 6A - McClellands from Timberline Road to U.P. Railroad.

Reach 6B - McClellands from U.P. Railroad to Harmony Road.

Reach 6C - McClellands from Harmony Road to center Section 35.

Reach 6D - McClellands from center of Section 35 to upstream study limits.

Because each reach presents unique problems, alternative flood control plans have been considered on a reach by reach basis.

The alternative flood control plans, identified by reach in the alternative matrix, (in the Technical Addendum) can be separated into two (2) basic categories: structural and non-structural. Alternative A, J, K, L and M would fall into the non-structural category. Preliminary screening of each alternative plan-reach leads to the elimination of those shown in shaded sectors as being unfeasible for practical application for economic, technical, or political reasons. Discussion of the feasibility of each of the alternatives follows.

Non-Structural Alternatives

Alternative A: Maintain Existing Configuration

This is the simplest and most basic of all alternatives and all other alternatives are evaluated by comparison with it. By proposing to maintain the floodplain as it exists at the present, future flood damage can be reasonably predicted. Additional flood damage potential to future development would be controlled under this alternative by floodplain zoning, however, no improvement to existing structures of channel section would occur.

Although no flood damage reductions are attributable to this alternative, future flood damages would gradually decline with the enforcement of floodplain regulations. The enforcement of floodplain regulations is required for local participation in the federally subsidized flood insurance program and is considered part of this alternative. Continuing channel maintenance would be required to remove flood debris from culverts, irrigation ditches, and streets and to repair erosion damage; but because this is the baseline condition, the benefit/cost methodology assumes that there are no damage reduction benefits associated with this alternative.

Alternative J: Flood Proofing Individual Structures

Flood proofing involves additions or improvements to an existing structure which would prevent or decrease flood damage. Such improvements can be grouped in four (4) categories:

- Temporary and/or permanent closures of openings in existing structures.
- Raising existing structures.
- Constructing small walls or levees around structures.
- Rearranging or protecting damageable property witnin a structure.

Flood proofing is accomplished on a structure by structure basis since the type and extent of flood proofing required depends upon the specific circumstances. A detailed discussion of the several types of flood proofing, the advantages and disadvantages, and some approximate cost data is contained in Reference #5. In addition, both the U.S. Army Corp of Engineers and the Federal Insurance Administration have publications on flood proofing. The costs of flood proofing structures in the McClellands and Mail Creek floodplain would be the responsibility of individual property owners. This alternative was examined principally in Reaches 2 and 4, where a single residence, and a church are subjected to inundation by the 50- and 100-year floods.

Alternative K: Floodplain Management and Flood Insurance

Flood insurance is unique among the non-structural measures available to communities because it does not reduce flood damages or provide a measure of safety to residents. It is, instead, a measure an individual property owner can take to indemnify himself from losses suffered during a flood.

Flood insurance is available to all persons in all of the communities involved in this study since all are participating communities in accordance with the rules and regulations of the Federal Insurance Administration. Insurance is available for both structure and contents; however, residential property not covered by insurance includes:

> Fences, retaining walls, seawalls, outdoor swimming pools, bulkheads, wharves, piers, bridges, docks; other open structures located on or partially over water; or personal property in the open.
>
> Land values; lawns, trees, shrubs or plants, growing crops, or livestock; underground structures or underground equipment, and those portions of walks, driveways and other paved surfaces outside the foundation walls of the structure. Accounts, bills, currency, deeds, evidences of debt, money, securities, bullion, manuscripts or other valuable papers of records, numismatic or philatelic property.
>
> Animals, birds, fish, aircraft, motor vehicles (other than motorized equipment pertaining to the service of the premises and not licensed for highway use), trailers on wheels, watercraft including their furnishings and equipment.

Flood insurance is part of every alternative in that the opportunity to purchase such insurance is always available. While the capital outlay by local governments would be minimal, the disadvantages of relying solely on flood insurance are that none of the potential flood hazards would be mitigated, and none of the other objectives of the plan are addressed. This is true to some degree for nearly all the non-structural alternatives considered in this analysis as well, and should be kept in mind when considering non-structural flood control measure for implementation in the McClelland and Mail Creek Basins.

Alternative L: Flash Flood Forecast, Flood Warning and Evacuation Plans

This alternative consists of establishing a procedure and strategies to be followed in response to a flood threat. The U.S. Army Corps of Engineers recommends the following, (Reference J):

- A system for early recognition and evaluation of potential floods.
- Procedures for issuance and dissemination of a flood warning.
- Arrangement for temporary evacuation of people and property.
- Provisions for installation of temporary protective measures.
- Means to maintain vital services.
- A plan for post flood reoccupation and economic recovery of the flooded area.

The interactions between the above components is graphically represented in Figure VI-1. Flood forecast, warning and evacuation is more dependant upon hydrologic and demographic factors than other non-structural strategies which are related to the depth of flooding and the type of structure involved. This system is best applied to situations where land use patterns are well established and it is not socially or economically feasible to establish restrictive land use planning.

The disadvantages of implementing a flood warning system on Mail Creek and McClelland Basins are two (2). First, because the basins are small, the peaks of the design floods occur quickly in all reaches, leaving a short evacuation time. Secondly, it would require capital expenditures by and cooperation between local governments while giving only marginal economic return, since flood damage would not be appreciably reduced. The principal advantage of a flood warning system on Mail Creek and McClellands Basins would be in organized evacuation of people and livestock from the floodplain and in the provision for maintenance of emergency vehicle movement. If a flood forecast and evacuation system is considered for implementation on Mail Creek and McClellands Basins, it should be done in conjunction with other alternative plans which effectively reduce flood damages, and it should be set up on an area-wide or City-wide basis.

Alternative M: Acquisition of Flood Prone Properties and Relocation of Occupants

Acquisition of private property located in the floodplain by local or state governments is usually accomplished by either outright purchase of the property or acquisition of land use easements. Outright purchase of property is usually most desirable for undeveloped land or land containing few structures, residences or other facilities. Once the flood prone land has been acquired, it can become part of land use patterns compatible with the goal of reducing flood hazards to the public, such as open space, parks and public golf courses.

In most reaches of Mail Creek and McClellands Basins, acquisition of right-of-way will be part of any structural alternative. In Reaches 2A, and 2B, the purchase of the entire property inundated by the 100-year flood along with limited structural improvement may be economically desirable. These parcels could be left as open space or developed as a public park. In other, more densely developed areas, acquisition of more property than is necessary to construct flood control improvements would be too costly and is therefore, not considered further in this analysis.

Structural Alternatives

Alternative B: A Natural Type Waterway Following the General Historic Channel and Maintaining a Lowflow Channel

Alternative B is a slight variation of Alternative A. It is possible that during periods of land development change and alterations were made on the historic channel. It is further possible that these changes and alterations now are counter-productive to the goal of eliminating or reducing flood damage. Additionally, a low flow channel would be provided to control erosion and direct the nearly constant irrigation flows in Mail Creek.

Where it is feasible to allow the waterway to revert to its historic channel, it is necessary to review old aerial photographs, maps and records in order to compare the location of the historic waterway to the location of the present waterway. By so doing, it is possible to determine how much right-of-way will have to be purchased to allow this reversion to occur.

In the case of Mail Creek and McClellands Basins, this alternative will be feasible where there is sufficient open space in developed areas, and where the channel and floodplain are not presently developed, and are in a natural state. In the latter case, this alternative is the equivalent of Alternative A, except for the addition of a low flow channel. In the developed areas of Mail Creek and McClellands floodplains, there are few places where it is economically feasible to implement this plan because of the extensive right-of-way requirements. This alternative, therefore, has been eliminated from further consideration in these reaches.

Alternative C: The Installation of Major Underground Conduits along the General Course of the Historic Stream Channel, Using Local Right-of-Way Whenever Possible

Closed conduits are considered as a viable alternative under three (3) conditions:

1) When it is acceptable for an open, lined channel to be constructed, but the dangers of a large body of fast moving, relatively deep water make it necessary to enclose the channel.

2) Where closed conduits already exist that have the capacity to transport the design flood.

3) In densely developed areas where the closed conduits are used as part of a storm water collection system.

The principal disadvantages of utilizing closed conduits is that they are generally substantially more expensive to construct than equivalent open channels, which sometimes results in a box culvert or pipe being designed for a smaller design flood. Runoff interception of closed conduits is not as effective as with an open channel, and the problems are aggravated by debris that tends to collect and effectively block the entrances to closed conduits, further reducing the capacity of the structure. Since the conduit is underground, little, if any, residual flood carrying capacity above the design flood is achieved. Larger floods can and do occur. When an unusual event does occur, the lack of an adequate surface flood route can be disastrous. For these reasons, underground conduits have not been considered for implementation on Mail Creek and McClellands Basins, because there are no space or right-of-way restrictions which preclude the construction of adequate open channel facilities.

Alternative D: The Use of Lined Flood Channels in Order to Reduce Right-of-Way Requirements

The linings for channel alternative considered in this study consist of either concrete or grass. All channel sections considered are trapezoidal and have been sized according to the design flood. Cost estimates provide for a maintenance road to be constructed adjacent to the channel.

The primary reason for using lined channels is to confine the design flood in as small an area as possible. This reduces the area of the floodplain and consequently, the right-of-way requirements. Besides the obvious benefits or reduced floodplain area, there are many secondary benefits associated with the use of lined channels, such as increased property values and decreased insurance requirements for property adjacent to the floodplain.

The choice between a grass-lined and a concrete channel is a matter of aesthetics and economics. Concrete channels transport stormwater more efficiently and generally have smaller operation and maintenance requirements, but have higher initial construction costs and are less pleasing aesthetically than grass-lined channels.

Greater right-of-way areas are required by grass-lined channels due to low velocity requirements, flattened side slopes, and relatively high side and bottom friction. While concrete channels require less right-of-way than grass channels, the higher velocities associated with lower friction factors and increased gradients pose problems to public safety, and also have a tendency to increase capacity requirements of the downstream channel reaches by decreasing the time of concentration and channel storage.

Alternative E: Relocating Channel to Routes Other than Historic Channel

and

Alternative F: Diverting all or Part of Peak Flows at Point(s) Upstream from Potential Hazard Areas

These channel relocation alternatives refer to structural methods of rerouting the flood channel, possibly even out of the drainage basin, in order to reduce construction, operation and maintenance costs. It entails the use of lined flood channels and possibly the renovation or alteration of road or ditch crossings.

There are only two (2) places on Mail Creek and McClelland Basins where relocating the channel is possible. This alternative was considered in Reaches 2 and 5 for conveying storm flows in the Pleasant Valley and Lake Canal, either to Harmony Road or completely out of the basin to Fossil Creek. Because relocating drainage flow patterns in this manner may have legal pitfalls for the City, this alternative was virtually eliminated from further consideration in this study.

Alternative G: Detention and/or Retention Facilities

Reservoirs for the control of floods are a means of supplying flood protection when the natural reservoir storage potential of a watershed may not provide the storage capacity needed. The amount of storage required depends upon the degree of protection needed and the non-damaging capacity of downstream reaches. The effect of storage is to decrease the peak of the flood in the reaches of channel immediately below the dam. Stored water is then released at a rate compatible with downstream conditions.

Flood detention is already widespread in Mail Creek and McClellands Basins, both directly and indirectly. Further containment of stormwaters may be accomplished by providing additional ponds in Reaches 2B, 4, 5 and 6. The primary benefits would be realized in Reaches 1, 2, 3 and 4, in the form of reduced flow peaks, as is shown in the peak flow diagram, Figure V-3. Because some structures are greatly inadequate in the lower reaches, additional flood control measures may need to be implemented in conjunction with construction of additional detention facilities to significantly reduce flood damage.

Alternative H: Construct Levees

A levee is an embankment constructed to confine water to a defined area. They are used commonly for flood control and irrigation purposes where topography is relatively flat and natural or artificial channel sections are not adequate. Levees can be used to confine flood or irrigation water in cases where channel gradients limit the depth to which a channel can be excavated.

Use of levees in Mail Creek and McClellands Basins was not considered necessary nor desirable, because of the well defined natural channel sections in the lower reaches, and because existing channel gradients in all reaches would allow excavation of an adequate channel section. For drainage and flood control purposes, an excavated channel section is preferable to a levee because it allows runoff to enter the channel. Furthermore, should the channel experience some erosion or an embankment failure, an excavated channel would be more likely to contain floodwaters whereas failure of a levee would release floodwaters out over a much larger area of the floodplain.

Alternative I: Selected or Limited Structure and Channel Improvements

Limited structure of channel improvements are considered for those cases where flood damages are localized or where damage occurs as the result of an individual structure or segment of channel that is not capable of transporting the design flood.

Consideration to the improvement of structures will be focused on road and irrigation canal crossings. In many cases, structures under roads on Mail Creek and McClellands Basins are sized to handle only low flows. As a result of development in the drainage basins, the volume of runoff has increased beyond the capacities of many of the structures resulting in backwater flooding at most road intersections. Where the natural channel or floodplain in general is capable of transporting the design flood except for short, limited reaches, without excessive property damage, minor improvements to the deficient reaches can result in a significant reduction in damages. Improvements can be culverts or bridges, drop structures, diversion structures, etc.

Water Quality

Because of the intermingling of storm water and irrigation water in Mail Creek and McClellands Basins, water quality is a point of concern by area residents and local officials. The nationwide significance of pollution caused by storm-generated discharges was first identified in the 1964 U.S. Public Health Service's publication on the "Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems." Congress, in recognizing this problem, authorized funds under the Federal Water Pollution Control Act of 1965 and following legislation for the research, development, and demonstration of techniques for controlling this source of pollution. The 1972 Amendments place new and stronger emphasis on urban runoff as a source of pollution. "An accelerated effort ..." is stressed" ... to develop, refine, and achieve practical application of waste management methods applicable to non-point sources of pollutants to eliminate the discharge of pollutants including, but not limited to, elimination of runoff of pollutants ..."

There is no doubt that pollutants are entering Mail Creek and McClellands in stormwater, but there is presently limited data with which to assess the severity of the problem. Some stormwater pollution data has been collected as part of a study being carried out in the Denver Metropolitan Area by the U.S.G.S. under the joint sponsorship of the Urban Drainage and Flood Control District, the Denver Regional Council of Governments and the Denver Water Board. Runoff quantity and quality measurements were taken on three (3) local drainageways during 1976 and 1977. Initial sampling result indicate that the major components of local stormwater pollution are organic compounds, heavy metals, oils and greases. Concentrations of these pollutants vary, but preliminary indications are that organics are approximately equivalent to secondary sewage treatment effluent and the heavy metals, oils and greases are predominately in the form of suspended solids. It is likely that a comparable situation exists in Fort Collins.

Some removal of these pollutants will occur naturally on Mail Creek and McClellands Basins. The natural forces of purification are many and varied, but are never rapid. The presence of aquatic plants and animals (such as would be present in open grass-lined channels) and drop structures all help to aerate the water and maintain the dissolved oxygen concentrations necessary for the elimination of organic compounds, while drop structures and channel linings help to reduce erosion and consequently the suspended solids settle out of stormwater. The general effect that each of the alternative plans will have on the water quality of Mail Creek and McClellands Basins can be judged by the provisions for the natural purification processes present in each plan. These are listed in Table VI-1. In no case will constructing any of the alternatives have a detrimental impact on the water quality of Mail Creek and McClellands Basins.

Control of pollution beyond the capacity of the natural purification processes present in Mail Creek and McClellands Basins will require supplemental study and is beyond the scope of this report. The City of Fort Collins and Larimer County should be involved in setting objectives and strategies for embarking on a water quality management program. The tools for reducing stormwater pollution, from enforcement of litter laws to installation of complex water treatment facilities, do exist and are constantly being increased in number and improved upon.

Summary of Feasible Alternative Plans

Because of the number of possible alternatives for each reach, an initial screening was necessary to eliminate those which were comparatively impractical before proceeding into the benefit/cost analysis (Refer to Technical Addendum for Matrix Evaluation form used). The alternative flood control plans which appear to be most promising are listed by reach in Table VI-2. Further analysis of these alternatives for the 100-year design storm is described in the next section.

TABLE VI-1 NATURAL PURIFICATION ATTRIBUTES OF ALTERNATIVE PLANS

ALTERNATIVE/DESCRIPTION	PURIFICATION PROCESS						
	EXPOSURE TO SUNLIGHT	AERATION OF WATER	REMOVAL OF SUSPENDED SOLIDS		REMOVAL OF CHEMICAL POLLUTANTS	NO PREDICTABLE CHANGE	INSUFFICIENT DATA
			SETTLEMENT	EROSION CONTROL			
A MAINTAIN THE EXISTING CONFIGURATION (FLOOD PLAIN REGULATION)	●		● ①	● ②			
B INSTALL NATURAL TYPE WATERWAY IN HISTORIC COURSE	●	●					
INSTALL MAJOR UNDERGROUND CONDUITS				●			
J INSTALL LINED FLOOD CHANNELS — GRASS LINING	●	●		●			
— CONCRETE LINING	●	●		●			
E & F RELOCATE CHANNEL TO OTHER ROUTES							●
G. DETENTION AND/OR RETENTION FACILITIES	●		●				
H. CONSTRUCT LEVEES	●						
I. SELECTED STRUCTURAL IMPROVEMENTS				●			
J to M. NON-STRUCTURAL						●	●

① EXISTING DETENTION PONDS

② IN REACHES 2A, 3, AND 4A ONLY, WHERE GRASSLINED CHANNELS OR STORM SEWERS HAVE BEEN CONSTRUCTED.

TABLE VI-2 - SUMMARY OF FEASIBLE ALTERNATIVE PLANS

Reach	Alternatives	Remarks
1A -- Fossil Creek to Mail Creek Lane	A	Do nothing, PW = $0
	B	Low flow channel
	K	Floodplain management
1B -- Mail Creek Lane to Palmer Drive	A	Do nothing, PW = $106,990
	B	Low flow channel
	G	Upstream detention
	I	Culvert at Passway Drive and local bank stabilization
	J	Floodproof 4 units in Fossil Creek Meadows
	K	Floodplain management
	L	Flood warnings & evacuation
	O	Combination of structural & non-structural & detention
1C -- Palmer Drive to U.S. Highway 287	A	Do nothing, PW = $45,010
	B	Low flow channel
	G	Detention upstream
	I	Flow separation M.C. ditch, Palmer Drive spillway, spillways @ M.C. ditch headgate, sanitary sewer
	K	Floodplain management
	L	Flood warning & evacuation
	N	Clear Vegetation
	O	Combinations of above
1D -- U.S. Highway 287 to C&S Railroad	A	Do nothing, PW = $0
	B	Low flow channel
	G	Maintain natural detention, upstream detention

TABLE VI-2- SUMMARY OF FEASIBLE ALTERNATIVE PLANS

Reach	Alternatives	Remarks
1D -- continued	I	Irrigation flumes
	K	Floodplain management
	N	Clear vegetation
2A -- C&S Railroad to Shields Street	A	Do nothing, PW = $826,320
	B	Low flow channel
	D	Grass-lined along north side Harmony Road
	G	On-stream detention (proposed)
	I	Crossing under Harmony Road, Crest Road, Nordic Construction access road, remove or modify small dams
	J	Floodproof VocTec & Crest Road residence
	K	Floodplain management
	O	Combine above
2B -- Shields Street to Upstream Limit	A	Do nothing, PW = $115,960
	B	Low flow channel
	D	Grass-lined channel
	E	Relocate channel to Harmony Road ROW (use Pleasant Valley & Lake Canal to intercept)
	F	Divert via Pleasant Valley & Lake Canal to Fossil Creek
	G	Maintain existing volume at Shields, increase upstream detention
	I	Flow separation @ Pleasant Valley & increase culvert @ Shields
	K	Floodplain management
	O	Combine above

TABLE VI 2 - SUMMARY OF FEASIBLE ALTERNATIVE PLANS

Reach	Alternatives	Remarks
3 -- New Mercer Canal	A	Do nothing, PW = $28,460
	B	Low flow channel
	G	Upstream detention improvements
	I	Culvert @ Harmony Road, improve road; outfall of New Mercer @ Mail Creek
	K	Floodplain management
	L	Flood warning - irrigation trash rack @ Harmony
	O	Combination
4A -- New Mercer Canal to Mid-Section 35	A	Do nothing, PW = $53,420
	C	Major underground conduit
	G	Upstream detention
	J	Floodproof
	K	Floodplain management
	L	Flood warning
	O	Combination of above
4B -- Mid-Section 35 to Shields Street	A	Do nothing, PW = $63,100
	B	Low flow channel
	D	Grass-lined channel
	G	Upstream detention
	I	Short channel around church
	J	Floodproof
	K	Floodplain management
	L	Flood warning
	O	Combine above
5 -- Shields Street to Imperial Estates	A	Do nothing, PW = $98,430
	B	Low flow channel
	D	Grass-lined channel
	F	Pleasant Valley Canal flow diversion

TABLE VI 2- SUMMARY OF FEASIBLE ALTERNATIVE PLANS

Reach	Alternatives	Remarks
5 -- continued	G	Detention ponds
	I	Culvert @ Shields, flow separation @ P.V. Canal
	K	Floodplain management
	O	Combine above
6A -- Timberline Road to U.P. Railroad	A	Do nothing, PW = $111,050
	B	Low flow channel
	D	Grass-lined channel
	G	Detention pond - upstream
	I	Culvert @ Timberline
	K	Floodplain management
	O	Combine above
6B -- U.P. Railroad to Harmony Road	A	Do nothing, PW = $385,750
	B	Low flow channel
	D	Grass-lined channel
	G	Maintain U.P. - additional upstream areas
	I	Culvert under railroad
	K	Floodplain management
	L	Floodwarning - railroad & livestock
	O	Combine above
6C -- Harmony Road to Boardwalk Drive	A	Do nothing, PW = $0
	G	Increase detention for downstream
	K	Floodplain management
6D -- Boardwalk Drive to Larimer County Canal No. 2	A	Do nothing, PW = $13,590
	D	Grass-lined channel
	I	Check Larimer Canal No. 2 waste ditch
	K	Floodplain management
	O	Combine above

SECTION VII

ECONOMIC ANALYSIS

The alternative plans listed in Table VI-2 are all considered feasible for further investigation. Using 100-year design flows based on fully developed basin conditions with existing detention and channel conditions, structural improvements were sized and construction and operation and maintenance costs were estimated from the Unit Cost Data Table, Table VII-1. Since flood damage calculations were done by reaches, flood control plans were considered by reaches. Flood damages which could be expected to occur after an improvement is constructed were also estimated, and the difference between flood damage figures for a given reach before and after a specific improvement is made are the "benefits" which accrue to the reach where the improvement is made. Because Mail Creek and McClellands Basins are "major" drainageways, alternative plans should satisfy multiple objectives. Additional project benefits, considered "intangible" in this analysis, are the degree to which each of the project objectives listed in Section V are met by the alternative plans.

A detailed estimate of construction costs and flood damage estimates for each of these alternative plans is listed by reach in Tables VII-2 thru 5. Construction costs are broken down into five (5) basic components (Columns 1 through 5): channel improvements, street improvements, utility relocations, and engineering and contingency factor, and right-of-way acquisition costs. The summation of these costs (Column 6) is the total capital improvement cost of the alternative. This has been amortized over a 50-year project life at the 6-7/8% interest rate to produce the annual construction cost (Column 7). To this is added the estimated annual operation and maintenance cost (Column 8) to determine the total annual improvement cost (Column 9).

For each reach, the first alternative listed is the baseline condition. The average annual flood damage for the existing condition and the residual annual flood damage for the existing condition and the residual annual flood damage for the other alternatives appear in Column 10. The annual benefit (Column 11) is the difference between the flood damage for the baseline condition and the residual flood damage for the particular alternative. The net annual benefit (Column 12) is the annual benefit less the annual improvement costs (Column 11 - Column 9). This figure is the actual dollars in savings (or losses) which would result after implementing the alternative. The total annual cost (Column 13) is the sum of the annual improvement cost and the residual annual flood damages (Column 9 + Column 10).

The benefit/cost ratio (Column 14) is the annual benefit divided by the annual improvement cost (Column 11 + Column 9) of each alternative. It can also be viewed as the dollar return in mitigated flood damages for each improvement dollar spent. The benefit/cost ratio must be greater than one for the plan to be economically viable on the basis for flood control. The larger the ratio, the more efficiently funds are being utilized for flood control purposes.

Selection of the Recommended Plan

Examination of the floodplains and benefit/cost data while keeping in mind the goals of the study leads to the selection of one alternative plan for each reach as the overall most beneficial. A review of the flood plain conditions reveals that flood damage in both the Mail Creek and McClellands study reaches is localized, due primarily to specific structures or channel segments which are inadequate for the design flows. Several reaches are located in undeveloped areas and design flows are contained within the existing natural channel resulting in minimal flood damages. Where existing natural channels are adequate, it is because of the basin topography and the fact that upstream development has been orderly and considerate of storm drainage; detention is widespread.

Because of the nature of the flood hazards and potential damages in Mail Creek and McClellands Basins, it is not surprising the alternatives which have the highest benefit/cost ratios are those which address specific problem areas. The selected structural improvements in Reaches 1B, 1C and McClellands, which consist of improvements to culverts and street crossings are the most effective. Similarly in Reaches 2, 3, 4 and 5, those selected structural alternatives have the highest benefit/cost ratios because of the localized nature of the flood damages.

Because of the City's policy requiring detention with development and because detention enhances the B/C ratios in downstream reaches by reducing construction costs, detention alternatives were considered separately and in combination with local structural improvements. Starting with a total of 14 detention ponds in Mail Creek and 3 in McClellands, the number and size of the ponds were systematically reduced until estimated construction costs became reasonable in comparison with potential benefits. We used the SWMM program to model the downstream effects of the proposed detention ponds. After modeling several arrangements and discharges, three (3) detention ponds in Mail Creek and none in McClellands appeared cost-effective.

It is important to note that the cost effectiveness of the detention ponds used strictly for flood control is not that good. In considering implementation of detention alternatives, therefore, multiple use facilities should be envisioned. By using the sites for parks and recreation opportunities, water quality control points, and other activities, and ROW acquisition and construction costs attributable to flood control would be reduced, and "intangible" benefits would increase, raising the B/C ratios.

Consideration of these factors has lead us to recommend a combination of improvements for Mail Creek and McClellands Basins, consisting of selected structural improvements, detention, and continued floodplain management with flood insurance. The recommendation is to improve the Palmer Drive Spillway, Reach 1C, construct new street crossings and a trapezoidal channel in Reach 2A, and two (2) detention ponds in Reach 2B, possibly conbining a flow separation structure with the pond embankment at the Pleasant Valley and Lake Canal.

Because of the significant storage capacity existing in the New Mercer Canal, the improvements recommended in Reaches 3, 4 and 5 are considered separately from Mail Creek. These recommendations are to improve the spillway at the Larkborough detention pond and to provide a multi-use detention facility at the head of the 24-inch RCP storm sewer in Reach 4A. This facility is recommended despite the B/C ratio of 0.8 because of the possibility of reducing some construction costs if a multi-use facility is designed. In Reach 4B, continued floodplain management and flood insurance for the church, and continued floodplain management in Reach 5 are recommended.

In the McClellands Basin, development has taken place mostly north of Harmony Road and sound storm drainage practices have been observed. In the lower reaches, flood damages are concentrated at Timberline Road and the Union Pacific Railroad. Our recommendations for McClellands are simply to provide improved culverts at these locations and to continue the program of floodplain management. The improved culvert at the railroad is particularly important due to the high probability of an embankment failure during even a minor (10-year) event.

Finally, a summary of the benefits and costs for these recommendations are listed in Table I-1. For Mail Creek and McClellands, the combined estimated construction is $ 805,210.00. These costs have been broken down per improvement and on a per acre basis as noted in Table VII-7.

TABLE VII-1
UNIT COST DATA WITH O & M

Item	Unit		Unit Cost ($)
Excavation: Trench	C.Y.		2.30
Common	C.Y.		2.00
Fill			
Common	C.Y.		5.00
Select Structural	C.Y.		7.35
Removal of Excess Material	C.Y.		1.30
Borrow of Fill Material	C.Y.		2.90
Maintenance Road	L.F.		15.00
Utility Relocation			
Sanitary Sewer	L.F.		30.00
Water	Each		1,200.00
Land Acquisition			
Commercial	Acre		65,000.00
Residential	Acre		14,000.00
Catch Basins	Foot of opening		200.00
Concrete Pipe - In Place		W/asph.	A/O asph.
18"	L.F.	23.80	19.05
21"	L.F.	27.15	22.18
24"	L.F.	30.40	25.22
27"	L.F.	41.87	36.47
30"	L.F.	47.58	41.96
33"	L.F.	51.84	46.01
36"	L.F.	60.50	54.45
42"	L.F.	70.80	64.32
48"	L.F.	83.09	76.18
54"	L.F.	100.94	93.60
60"	L.F.	118.41	110.63
66"	L.F.	134.60	126.39
72"	L.F.	155.08	146.44
78"	L.F.	187.15	178.08
84"	L.F.	208.51	199.00
Asphalt Replacement	Ton		35.00
Seeding & Mulching	Acre		2,000.00
Riprap			
Placed	Ton		26.00
Gabion	C.Y.		90.00
Trickle Channel	L.F.		25.00
O & M - Detention Ponds & Grasslined Channels			10%
O & M - Improved Crossings			400.00
Contingency Engineering, Administrative, Legal, Construction			50%

TABLE VII-2 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON
STRUCTURAL IMPROVEMENTS - FULLY DEVELOPED FLOWS
MAIL CREEK - FOSSIL CREEK CONFLUENCE TO C&S RAILROAD

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reach/ Improvement Description	Construction Costs Channel Improvement	Street Crossings	Utility Relocation	Contingency 50%	ROW Acquisition	Total Const. Costs	Annual Const. Costs	Annual O & M	Total Annual Improvements Costs	Residual Flood Damage	Annual Benefit	Net Annual Benefit	Total Annual Costs	B/C Ratio
REACH 1A														
A Existing								800	800	0				
B Low Flow	50,000	--	--	25,000	--	75,000	5,350	1,200	6,550	0				
REACH 1B														
A Existing										7,630				
B Low Flow	85,000			42,500	--	127,500	9,090	2,000	11,090	7,630	0			
G Detention 6 ponds								2,000	2,000	1,120	6,510	4,510	3,120	N/A*
G Detention 2 ponds								2,000	2,000	1,190	6,440	4,440	3,190	N/A*
I Sel. Str.		7,750		3,880	--	11,630	830	2,000	2,830	3,300	4,330	1,500	6,130	1.53
REACH 1C														
A Existing										3,210				
B Low Flow	67,500	--	--	33,750	--	101,250	7,220	1,600	8,820	3,210	0			
G Detention 6 ponds								1,600	1,600	3,070	140	-1,460	4,670	N/A*
G Detention 2 ponds								1,600	1,600	3,200	10	-1,500	4,800	N/A*
I Sel. Str.	35,000			17,500	--	52,500	3,740	1,600	5,340	5,230	5,610	270	10,570	1.05
REACH 1D														
A Existing								200	200		0			
K F.P. Mgmt.								200	200		0			

*Construction costs included in reaches upstream from U.S. Highway 287.

TABLE VII-3 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON
STRUCTURAL IMPROVEMENTS - ACCOMMODATING FULLY DEVELOPED FLOWS
MAIL CREEK - U.S. HIGHWAY 287 TO UPSTREAM LIMITS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reach/ Improvement Description	Construction Costs: Channel Improvement	Street Crossings	Utility Relocation	Contingency 50%	ROW Acquisition	Total Const. Costs	Annual Const. Costs	Annual O & M	Total Annual Improvements Costs	Residual Flood Damage	Annual Benefit	Net Annual Benefit	Total Annual Costs	B/C Ratio
REACH 2A														
A Existing										58,930				
B,D Low Flow/ Grasslined Channel	269,570	--	--	134,790	72,830	477,190	34,030	3,400	37,430	7,030	51,900	14,470	44,460	1.39
I Sel. Str. 180' CBC	--	29,560	7,500	18,530	--	55,590	3,970	400	4,370	58,080	850	-3,520	62,450	0.19
I Sel. Str. 60' CBC	--	11,560	5,000	8,280	--	24,840	1,770	400	2,170	56,370	2,560	390	58,540	1.18
I Sel. Str. 40' CBC	--	8,560	2,500	5,530	--	16,590	1,180	400	1,580	48,910	10,020	8,440	50,490	6.34
REACH 2B														
A Existing										8,270				
B,D Low Flow/ Grasslined Channel	173,610	--	--	86,810	44,430	304,860	21,740	2,180	23,920	3,130	5,140	-18,780	27,050	0.21
I Sel. Str.	--	10,840	--	5,420	--	16,260	1,160	400	1,560	7,200	1,070	-490	8,760	0.69
I Sel. Str. 80' CBC	--	13,120	10,000	11,560	--	34,680	2,470	400	2,870	6,450	1,820	-1,050	9,320	0.63
REACH 4A														
A Existing										3,810				
C Mjr Undgr Conduit- 36" Ø	--	108,900	10,000	59,450	--	178,350	12,720	400	13,120	1,500	2,310	-10,810	14,620	0.18
C Mjr Undgr Conduit- CBC	--	29,300	5,000	17,150	--	51,450	3,670	400	4,070	3,040	770	-3,300	7,110	0.19

TABLE VII-3 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON

STRUCTURAL IMPROVEMENTS - ACCOMMODATING FULLY DEVELOPED FLOWS

MAIL CREEK - U.S. HIGHWAY 287 TO UPSTREAM LIMITS

Reach/ Improvement Description	1 Construction Costs: Channel Improvement	2 Construction Costs: Street Crossings	3 Construction Costs: Utility Relocation	4 Contingency 50%	5 ROW Acquisition	6 Total Const. Costs	7 Annual Const. Costs	8 Annual O & M	9 Total Annual Improvements Costs	10 Residual Flood Damage	11 Annual Benefit	12 Net Annual Benefit	13 Total Annual Costs	14 B/C Ratio
REACH 4B														
A Existing										4,500				
B,D Low Flow/ Grasslined Channel	168,140	--	--	84,070	38,760	290,970	20,750	2,080	22,830	90	4,410	-18,420	22,920	0.19
B,D Low Flow/ Grasslined Channel	15,690	--	--	7,850	3,620	27,160	1,940	200	2,140	3,150	1,350	-790	5,290	0.63
REACH 5A														
A Existing										7,020				
B,D Low Flow/ Grasslined Channel	162,100	--	--	81,050	37,330	280,480	20,000	2,000	22,000	3,930	3,090	-18,910	25,930	0.14
I Sel. Str.	--	10,840	--	5,420	--	16,260	1,160	400	1,560	5,950	1,070	-490	7,510	0.69
I Sel. Str. 80' CBC	--	14,560	10,000	12,280	--	36,840	2,630	400	3,030	5,200	1,820	-2,170	8,230	0.60
REACH 3														
A Existing										2,030				
B,D Low Flow/ Grasslined Channel	136,620	--	--	68,310	--	204,930	14,620	1,470	16,090	1,020	1,010	-15,080	17,110	0.06

TABLE VII-4 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON

DETENTION PONDS AND STRUCTURAL IMPROVEMENTS - DETAINED FLOWS

MAIL CREEK - U.S. HIGHWAY 287 TO UPSTREAM LIMITS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reach/ Improvement Description	Construction Costs: Channel Improvement	Street Crossings	Utility Relocation	Contingency 50%	ROW Acquisition	Total Const. Costs	Annual Const. Costs	Annual O & M	Total Annual Improvements Costs	Residual Flood Damage	Annual Benefit	Net Annual Benefit	Total Annual Costs	B/C Ratio
REACH 2A														
A Existing										58,930				
B,D Low Flow/ Grasslined Channel	224,000	26,550	7,500	129,030	45,000	432,080	30,810	3,100	33,910	15,580	38,670	4,760	49,490	1.14
I Sel. Str.	--	11,560	5,000	8,280	--	24,840	1,770	400	2,170	56,370	2,560	390	58,540	1.18
I Sel. Str.	--	8,560	2,500	5,530	--	16,590	1,180	400	1,580	48,910	10,020	8,440	50,490	6.34
REACH 2B														
A Existing										8,270				
I Sel. Str.		6,100	10,000	8,050	--	24,150	1,720	400	2,120	7,010	1,260	-860	9,130	0.59
REACH 5A														
A Existing										7,020				
I Sel. Str. 2' CBC	--	12,430	10,000	11,220	--	33,650	2,400	400	2,800	5,390	1,630	-1,170	8,190	0.58
	Pond Cost	Outlet Works												
REACHES 1-5														
G Detention #1-21.3 af	84,430	5,000	--	44,720	105,000	239,150	17,060	1,700	18,760					
G Detention #2-17.2 af	68,560	5,000	--	36,780	85,400	195,740	13,960	1,400	15,360					
G Detention #3-17.5 af	69,560	5,000	--	37,280	86,800	198,640	14,170	1,420	15,590					
G Detention #4-7.0 af	28,940	5,000	--	16,970	36,010	86,910	6,200	520	6,720					
G Detention #5-4.3 af	18,160	5,000	--	11,580	22,700	57,440	4,100	410	4,510					
G Detention #6-12.5 af	50,310	5,000	--	27,660	63,000	145,970	10,410	1,040	11,450					
COMBINATION OF 1 & 5									23,270	45,840	12,690	-10,580	73,110	0.55

TABLE VII-4 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON
DETENTION PONDS AND STRUCTURAL IMPROVEMENTS - DETAINED FLOWS
MAIL CREEK - U.S. HIGHWAY 287 TO UPSTREAM LIMITS

	Reach/ Improvement Description	1 Construction Costs: Pond Cost	2 Construction Costs: Channel Crossings	3 Construction Costs: Utility Relocation	4 Contingency 50%	5 ROW Acquisition	6 Total Const. Costs	7 Annual Const. Costs	8 Annual O & M	9 Total Annual Improvements Costs	10 Residual Flood Damage	11 Annual Benefit	12 Net Annual Benefit	13 Total Annual Costs	14 B/C Ratio
	REACH 2														
A	Existing										67,200				
	Detention Ponds 1-5 & Sel. Str.	112,590	283,790	25,000	210,690	172,700	804,770	57,390	5,740	63,130	4,330	62,870	-260	67,460	1.00
	Detention Ponds 1-5 & Sel. Str. w/o ROW Acquisitions	112,590	283,790	25,000	210,690	45,000	677,070	48,290	7,260	55,550	4,330	62,870	-7,320	59,880	1.13

TABLE VII -5 - BENEFIT/COST ANALYSIS DATA FOR ALTERNATIVE PLAN COMPARISON

McCLELLANDS BASIN - TIMBERLINE ROAD TO UPSTREAM STUDY LIMITS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reach/ Improvement Description	Construction Costs: Channel Improvement	Street Crossings	Utility Relocation	Contingency 50%	ROW Acquisition	Total Const. Costs	Annual Const. Costs	Annual O & M	Total Annual Improvements Costs	Residual Flood Damage	Annual Benefit	Net Annual Benefit	Total Annual Costs	B/C Ratio
REACH 6A														
Existing										7,920				
Low Flow	50,000	7,700	--	28,900	36,000	122,600	8,740	600	9,340	1,060	6,860	-2,480	10,400	0.73
Grass Lined Ch.	150,200	7,700	--	79,000	69,600	306,500	21,850	600	22,450	300	7,620	-14,580	22,750	0.34
Upst. Det.	98,660	3,540	--	51,100	53,240	206,540	14,730	7,605	22,335	4,355	3,565	-18,770	26,690	0.16
Sel. Str.	--	7,700	--	3,900	--	11,600	830	600	1,430	5,770	2,150	720	7,200	1.50
Flood Plain Mgmt.														
REACH 6B														
Existing										27,510				
Low Flow	125,000	12,800	--	68,900	90,000	296,700	21,160	1,500	22,660	550	26,960	4,300	23,210	1.19
Grass Lined Ch.	303,500	12,800	--	158,150	126,000	600,450	42,820	1,500	44,320	380	27,130	17,190	44,700	0.61
Detention #2	56,950	3,350	--	30,150	42,000	132,450	9,446	6,000	15,446	27,510	-0-	-15,446	27,525	-0-
Detention #3	129,070	5,840	--	67,450	72,210	274,570	19,582	10,300	29,882	420	27,090	-2,792	30,302	0.90
Select Str.	--	12,800	--	6,400	--	19,200	1,340	1,500	2,840	420	27,090	24,220	3,290	9.4
FPL Mgmt.									--	27,510	-0-			--
Flood Warn.									--	27,510	-0-			--
REACH 6C														
Existing										-0-				
F.P. Mgmt.														--
REACH 6D														
Existing										970				
Grass Lined Ch.	99,910	--	--	49,960	40,300	190,190	13,560	480	14,040	--	970	-13,070	14,040	.07
F.P. Mgmt.														

TABLE VII-6

COMPUTED PEAK FLOWS AT SELECTED POINTS WITHIN MAIL CREEK BASIN

(IMPROVED CONDITIONS)

Location	SWMM Point	Peak Flows (cfs) 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
1. Confluence with Fossil Creek	1	197	325	410	490	584	702
2. Palmer Drive Spillway	100	198	316	390	460	543	663
3. U.S. Highway 287	13	194	302	373	452	525	597
4. C&S Railroad	15	130	228	290	360	423	486
5. New Mercer Canal	33	67	78	85	95	105	114
6. Crest Road	17	108	176	220	271	322	374
7. Shields Street at Harmony Road	86	78	78	78	78	78	78
8. Pleasant Valley & Lake Canal	84	14	14	14	14	14	14
9. Middle of Section 35	43	80	143	196	266	339	415
10. Shields Street 1/2-mile north of Harmony Road	44	107	183	245	327	411	493
11. Pleasant Valley & Lake Canal 1/2-mile north of Harmony Road	48	79	134	174	232	292	351
12. East Border of Imperial Estates	49	80	145	193	255	319	383
McCLELLANDS BASIN							
1. McClellands @ Timberline	2	53	90	136	183	236	316
2. McClellands @ U.P. Railroad	82/90/85	50	117	185	283	388	504
3. Mid-Section 6	85	34	50	65	86	108	131
4. Lemay & Harmony Road	108	44	47	49	51	53	55
5. Between Detention	88	79	120	155	198	240	283
6. Midway - Section 36	89	56	96	125	162	200	240

TABLE VII-7

MAIL CREEK AND McCLELLANDS DRAINAGE BASINS

IMPROVEMENT COST SUMMARY

Reach	Improvement Description	Reason For Improvement*	Total Construction Cost
1-A	Floodplain Management	1	0
1-B	Floodplain Management	1	0
1-C	Fairway Dam Spillway	1	$52,500
1-D	Floodplain Management	1	0
2-A	Box Culvert at Nordic Access Road	1	$16,590
	Box Culvert at Crest Road	1	$24,840
	Grass-lined Channel and Box Culvert at Harmony Road	1	$442,600
	Grass-lined Channel for Continuity	2	$165,000
2-B	Pipe Crossing at Shields Street	1	$24,150
	On-line Detention	1	$134,150
	Grass-lined Channel for Continuity	2	$304,860
3	Overflow Spillway at Larkborough Detention Pond	1	$9,000
4-A	On-line Detention	1	$65,640
4-B	Grass-lined Channel	2	$290,970
5	Box Culvert at Shields Street	2	$33,650
	Grass-lined Channel	2	$280,480
	Flow Separation at Pleasant Valley & Lake Canal	2	$16,260
6-A	Box Culvert at Timberline Road	1	$11,600
	Grass-lined Channel for Continuity	2	$306,500
6-B	Pipe Crossing at Union Pacific Railroad	1	$19,200
	Grass-lined Channel for Continuity	2	$600,450

TABLE VII-7

MAIL CREEK AND McCLELLANDS DRAINAGE BASINS

IMPROVEMENT COST SUMMARY

Reach	Improvement Description	Reason for Improvement*	Total Construction Cost
6-C	Floodplain Management	1	0
6-D	Grass-lined Channel for Continuity	2	$ 190,190

TOTAL IMPROVEMENT COSTS	$ 2,988,630
Total Drainage Area .....2,733.66 acres Cost per Square Foot .....$ 0.0251/sf	
TOTAL COST OF IMPROVEMENTS RECOMMENDED AS A RESULT OF B/C ANALYSIS	$ 800,270
Total Drainage Area.....2,733.6 acres Cost per Square Foot .....$ 0.0067/sf	
COST OF ADDITIONAL IMPROVEMENTS LIKELY TO BE BUILT AT TIME OF DEVELOPMENT	$ 2,188,360
Total Undeveloped Area.....2,004.8 acres Cost per Square Foot.....$ 0.0251/sf	

* Reason 1: Recommended improvements as a result of B/C analysis.

Reason 2: Improvements likely to occur at time of development

SECTION VIII

PRELIMINARY DESIGN CONSIDERATIONS AND CRITERIA

Implementation

Because of the total cost of improvements is extensive and the coordination for implementation of such a plan is complicated and time-consuming, the recommended improvements could only be built on a phased basis over an extended period of time. We have recommended a priority order for implementation of our best alternative based upon benefit/cost ratio, jurisdictional responsibility, and availability of right-of-way. A separate listing is indicated for those improvements which are outside the city limits.

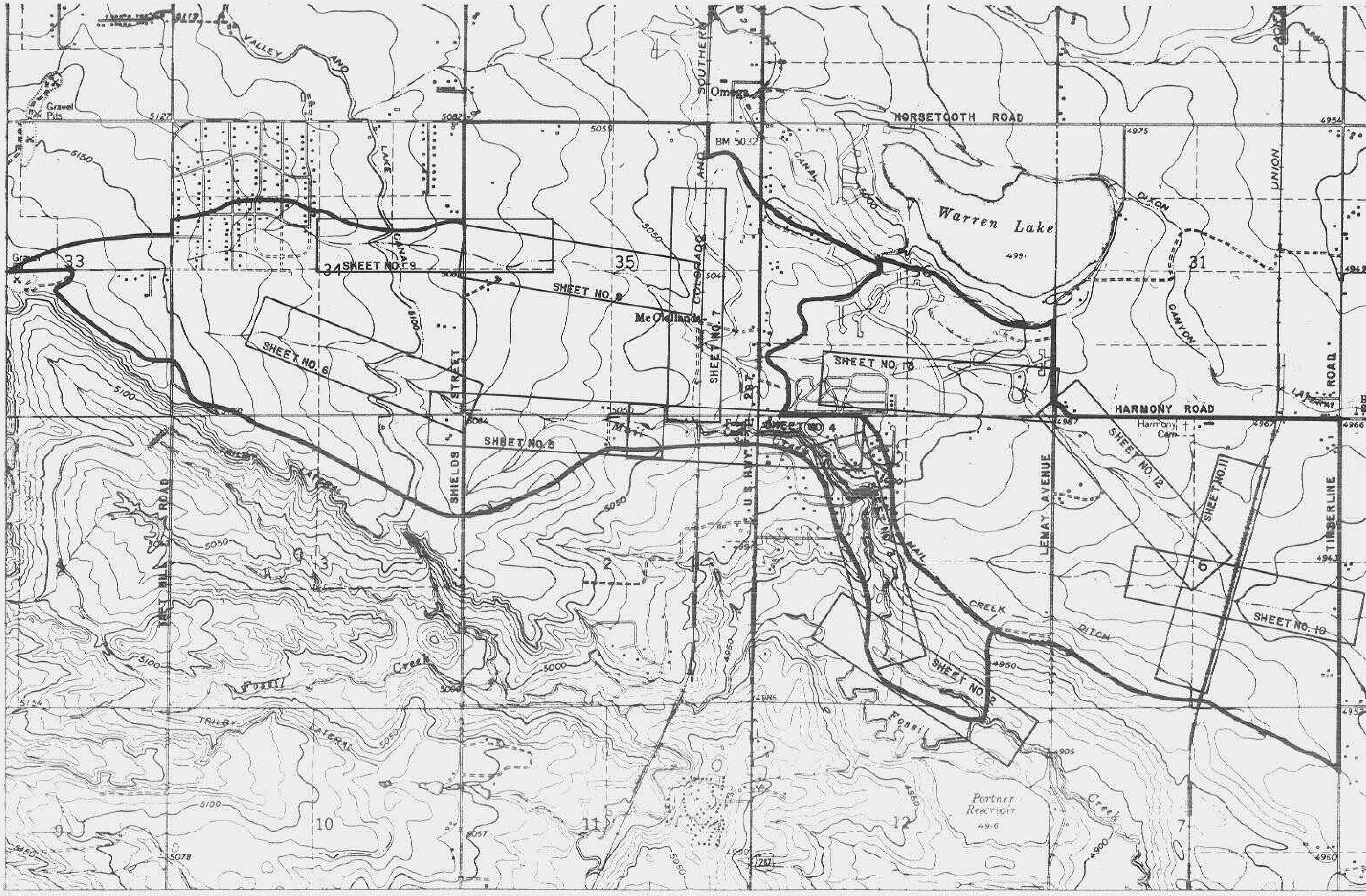
Improvements within the City are:

1. Floodplain Management: Floodplain management, through the development process, is already a part of the Citys control process for dealing with potential flood hazards. It is important that the floodplains indicated in this report, both existing and future, be utilized when considering future development within these basins. In the case of Larkborough Subdivision, the existing floodplain indicates that there is the potential for damage to future homes. The proposed detention pond upstream of Larkborough Subdivision reduces the impact of flooding through this subdivision substantially. However, if this pond is not expected to be built in the near future, it is recommended that measures be taken to control the elevations of future construction within the floodplain.

2. Get Help From Others: Explore the possibility of funding sources, such as Larimer County for improvements to be built in Larimer County or the Union Pacific Railroad for an enlarged culvert under their tracks. Try to get Nordic Construction Company to dedicate the right-of-way for enlarging the culvert under their access road. Keep in contact with the State Engineer so that no time will be lost deciding what improvements are necessary for Fairway Dam.

3. Enlarge Culvert Under Harmony Road: The existing 42-inch culvert under Harmony Road at the east boundary of the Woodlands PUD does not have sufficient capability to handle the future 100-year flows based upon our recommended plan. Enlarging this culvert would prevent the overtopping of this road and eliminate the resultant damage during a major storm.

4. Improve Spillway to Existing Larkborough Pond: This spillway presently has the potential for overtopping and failure during the 25-year storm. Enlarging this spillway to handle the design flows would reduce the possibility of extensive downstream damage. The detention pond above Larkborough should be built at approximately the same time to protect the investment in this spillway.


HORSETOOTH ROAD
HARMONY ROAD
Warren Lake
Omega
McClellands
Gravel Pits
BM 5032
VALLEY AND LAKE CANAL
COLORADO AND SOUTHERN
UNION PACIFIC
DIXON CANYON
SHIELDS STREET
LEMAY AVENUE
TIMBERLINE ROAD
U.S. HWY. 287
SHEET NO. 9
SHEET NO. 8
SHEET NO. 7
SHEET NO. 6
SHEET NO. 5
SHEET NO. 4
SHEET NO. 13
SHEET NO. 12
SHEET NO. 11
SHEET NO. 10
SHEET NO. 2
Harmony Cem
TRILBY LATERAL
Fossil Creek
CREEK DITCH
Portner Reservoir
33
34
35
36
31
2
3
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9
10
11
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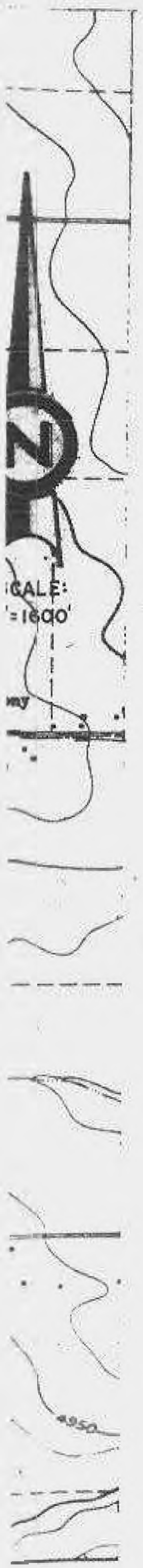

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McCLELLANDS & MAIL CREEK
DRAINAGE STUDY

MASTER PLAN IMPROVED CONDITIONS

NOTE : WATER SURFACE PROFILES AN
PLAIN BOUNDARY ARE FOR FULLY
FLOWS WITH PROPOSED BASIN IN

SCALE: 1"=200'

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS

Fossil Creek Parkway

Mail Creek Lane

SEE SHEET 4 of 13

SEE SHEET 3 of 13

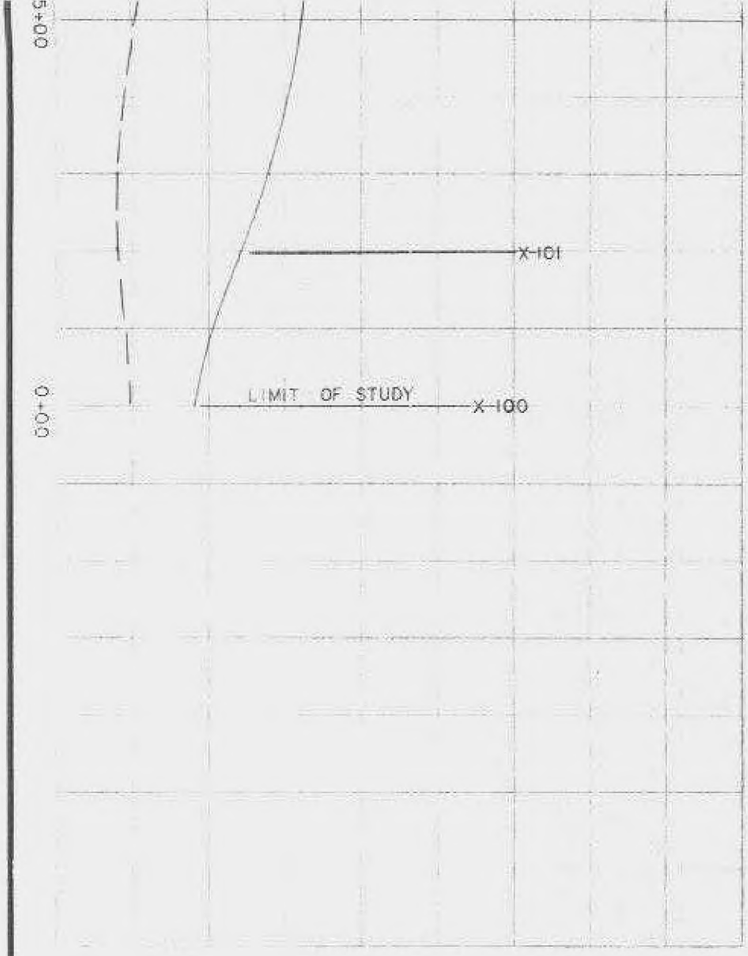
EXISTING 75'~14' DIAMETER CORREGATED METAL ARCH UNDER MAIL CREEK LANE

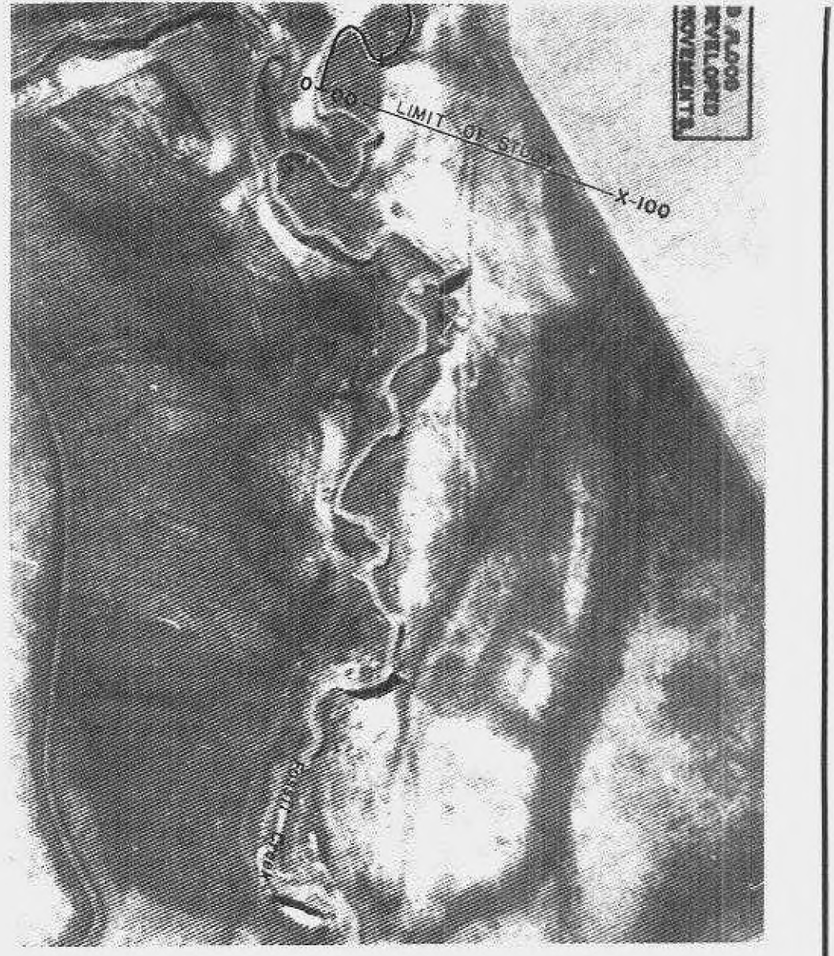
IMPROVED 100 YR. W.S. PROFILE

℄ EXISTING CHANNEL

4925
4920
4915
4910
4905
4900
4895

30+00 25+00 20+00 15+00 10+00





SHEET 2 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 0+00 TO 29+00

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MANAGEMENT / ENGINEERING
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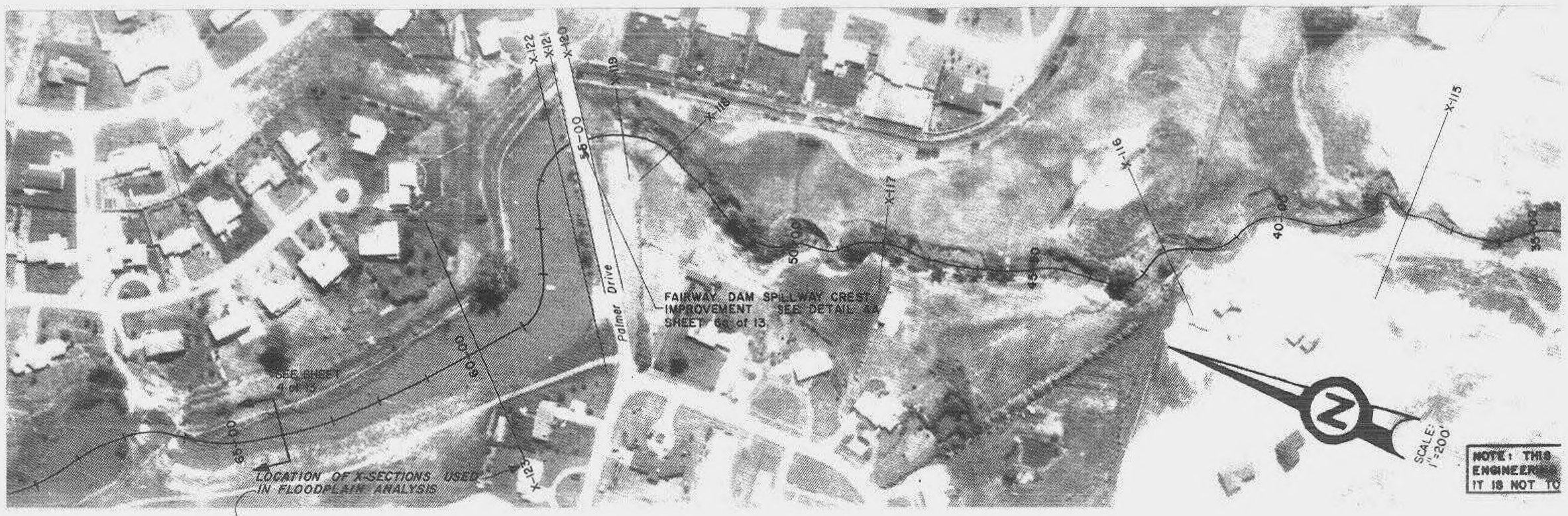
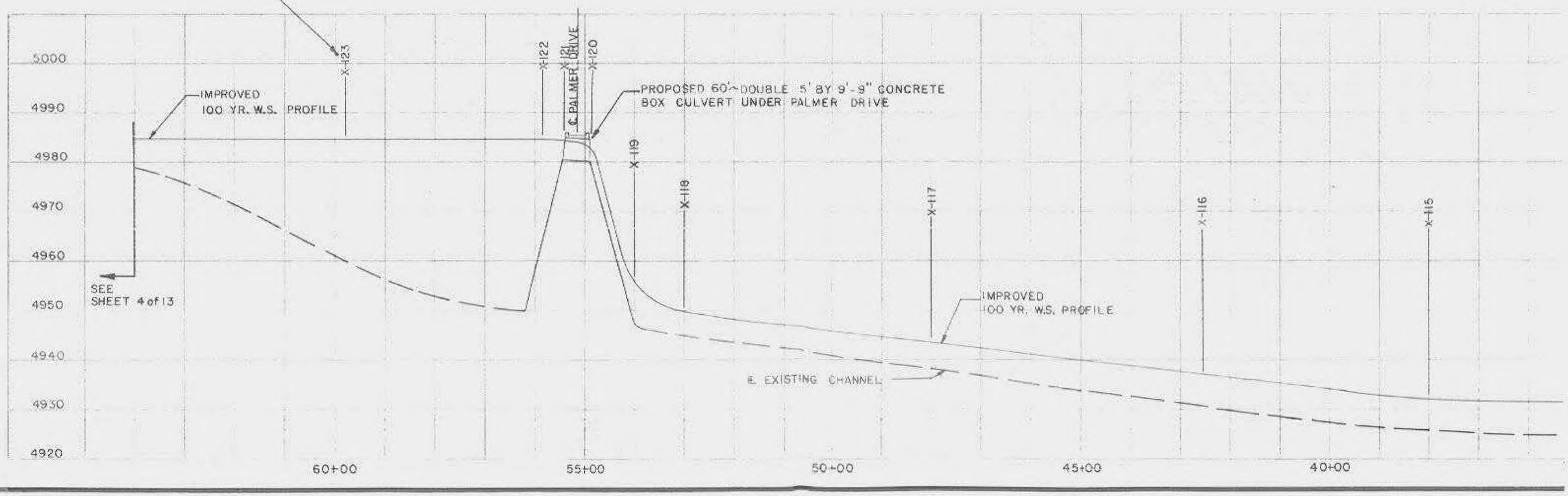
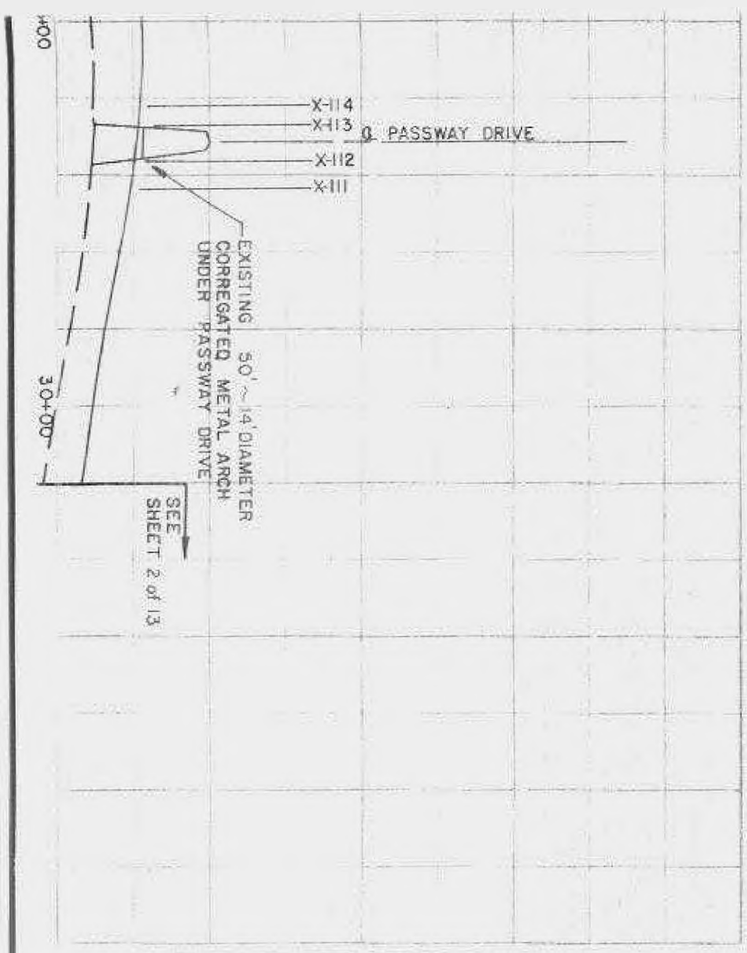
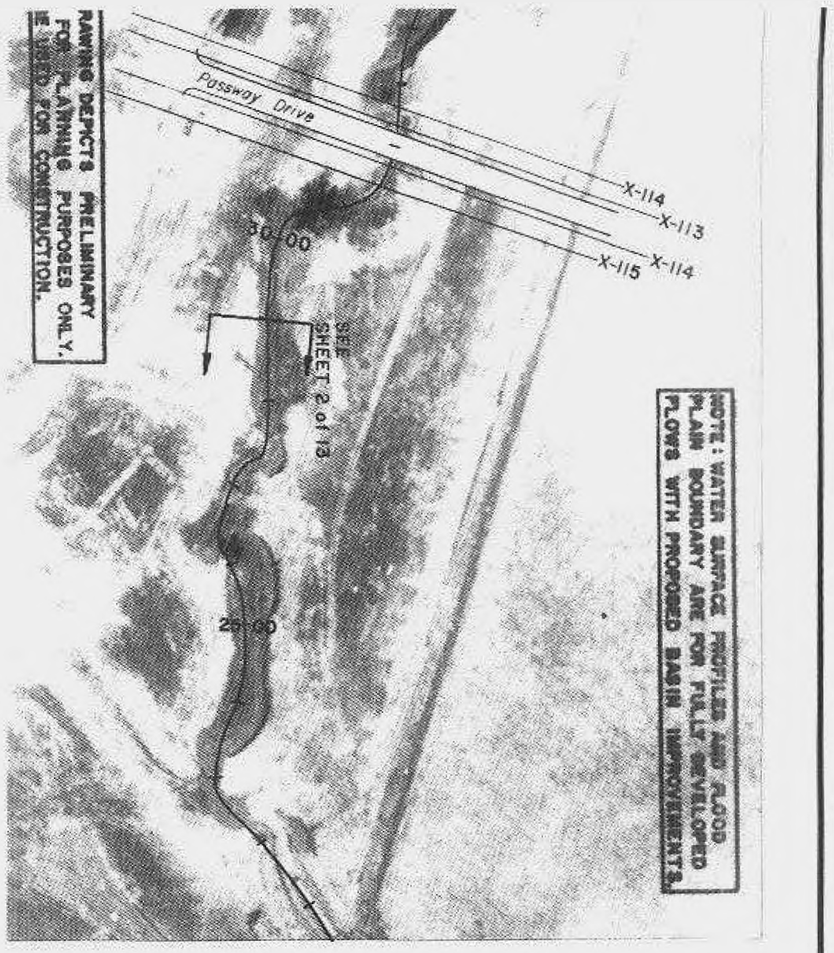

X-122
X-121
X-120
X-119
X-118
X-117
X-116
X-115
55-00
Palmer Drive
50-00
40-00
FAIRWAY DAM SPILLWAY CREST IMPROVEMENT SEE DETAIL 4A SHEET 6 of 13
SEE SHEET 4 of 13
60-00
LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS
X-123
SCALE: 1"=200'
NOTE: THIS ENGINEER
IT IS NOT TO


5000
4990
4980
4970
4960
4950
4940
4930
4920
IMPROVED 100 YR. W.S. PROFILE
X-123
X-122
X-121
X-120
℄ PALMER DRIVE
PROPOSED 60'~DOUBLE 5' BY 9'-9" CONCRETE BOX CULVERT UNDER PALMER DRIVE
X-119
X-118
X-117
X-116
X-115
SEE SHEET 4 of 13
IMPROVED 100 YR. W.S. PROFILE
E. EXISTING CHANNEL
60+00
55+00
50+00
45+00
40+00





SHEET 3 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 29+00 TO 64+00

CORNELL CONSULTING COMPANY
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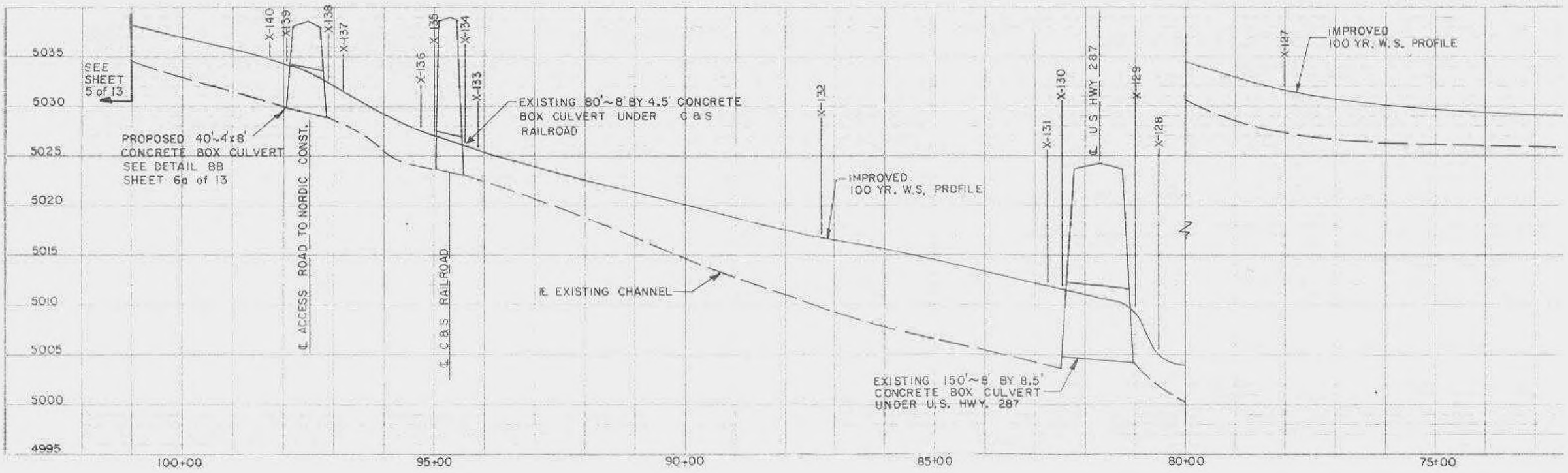
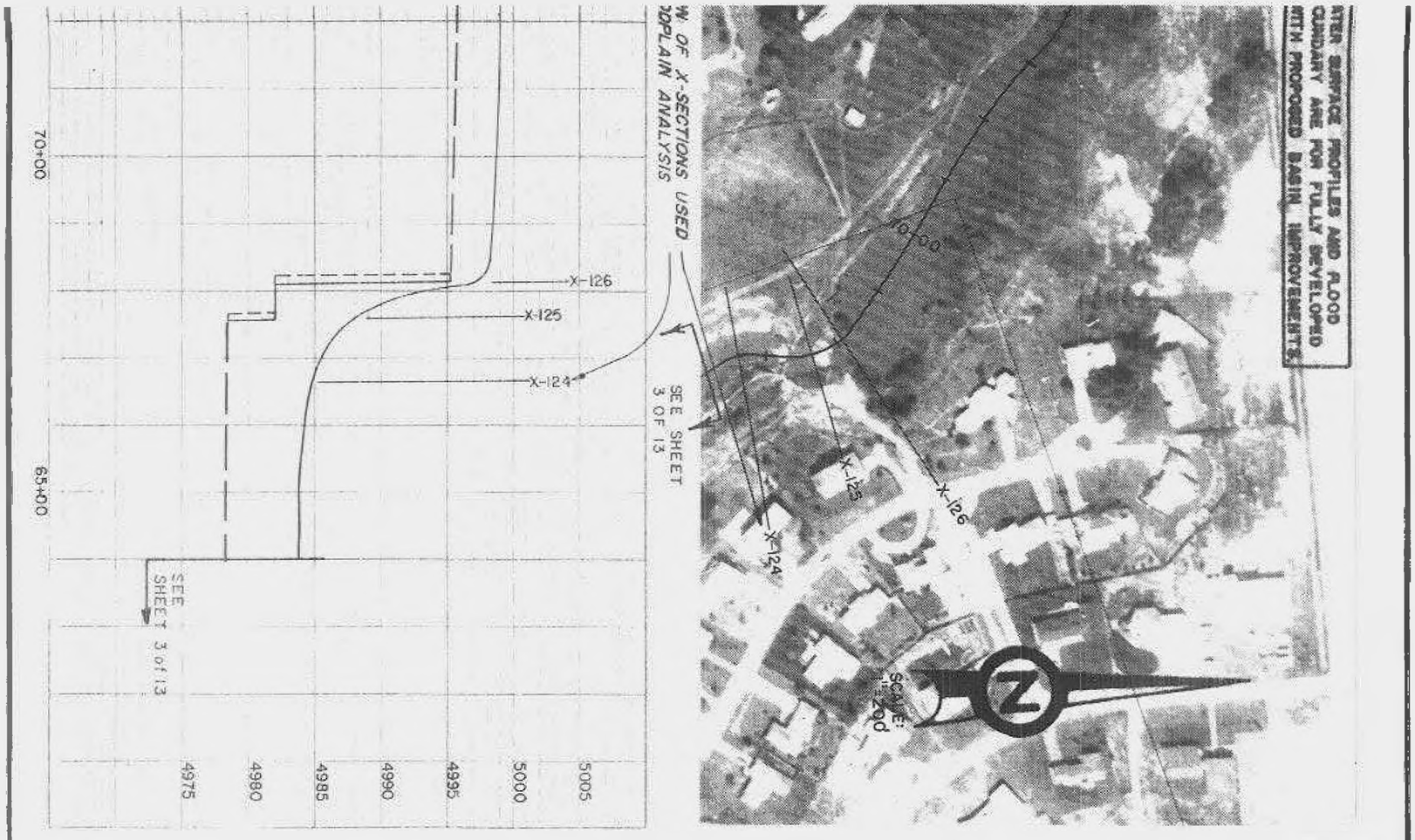
p.o. box 646 . fort collins . colorado 80522 (303)482-6650


500' GRASSLINED CHANNEL - SEE DETAIL HH SHEET 9a of 13
SEE SHEET 5 of 13
SEE SHEET 7 OF 13
PROPOSED 40 - 4 x 8 CONCRETE BOX CULVERT: SEE DETAIL BB SHEET 6a of 13
Crest Road
Access Road to Nordic Const.
C & S Railroad
Harmony Road
U.S. Highway 287
X-140
X-139
X-138
X-137
X-136
X-135
X-134
X-133
X-132
X-131
X-130
X-129
X-128
X-127
NOTE: THIS DRAWING DEPICTS PRELIMINARY ENGINEERING FOR PLANNING PURPOSES ONLY. IT IS NOT TO BE USED FOR CONSTRUCTION.


5035
5030
5025
5020
5015
5010
5005
5000
4995
SEE SHEET 5 of 13
PROPOSED 40'~4'x8' CONCRETE BOX CULVERT SEE DETAIL BB SHEET 6a of 13
℄ ACCESS ROAD TO NORDIC CONST.
℄ C & S RAILROAD
EXISTING 80'~8' BY 4.5' CONCRETE BOX CULVERT UNDER C & S RAILROAD
℄ EXISTING CHANNEL
IMPROVED 100 YR. W.S. PROFILE
℄ U.S. HWY 287
EXISTING 150'~8' BY 8.5' CONCRETE BOX CULVERT UNDER U.S. HWY. 287
IMPROVED 100 YR. W.S. PROFILE
100+00
95+00
90+00
85+00
80+00
75+00



SHEET 4 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 64+00 TO 101+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646, fort collins, colorado 80522 (303)482-6650

NOTE: THIS DRAWING DEPICTS PRELIMINARY ENGINEERING FOR PLANNING PURPOSES ONLY. IT IS NOT TO BE USED FOR CONSTRUCTION.

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.

PROPOSED 180' 4'x8' CONCRETE BOX CULVERT SEE DETAIL BB SHEET 6a of 13

2580'± GRASS LINED CHANNEL SEE DETAIL II SHEET 9a of 13

Shields Street

Harmony Road

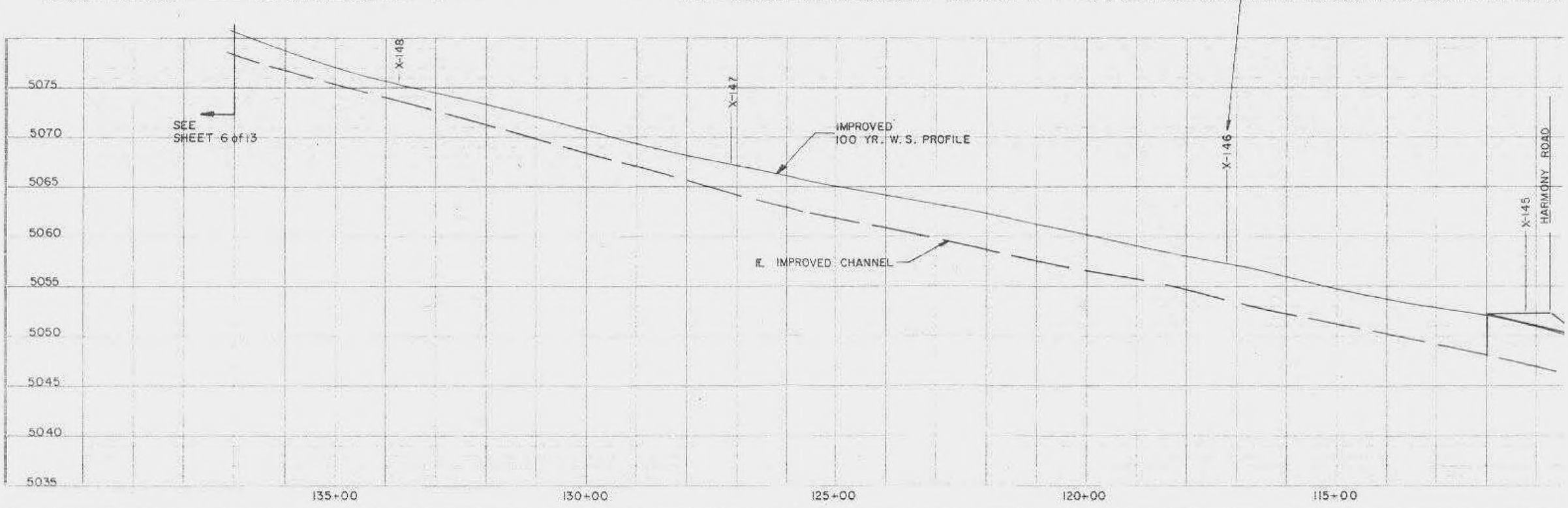
Larimer County Voc-Tech Center

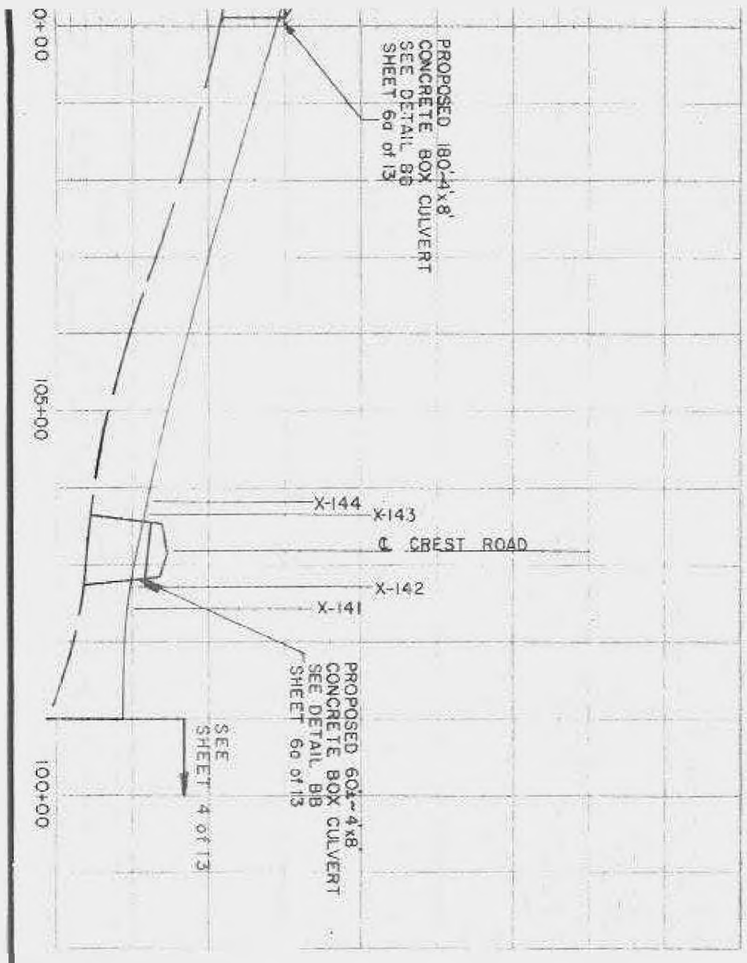
SEE SHEET 6 of 13

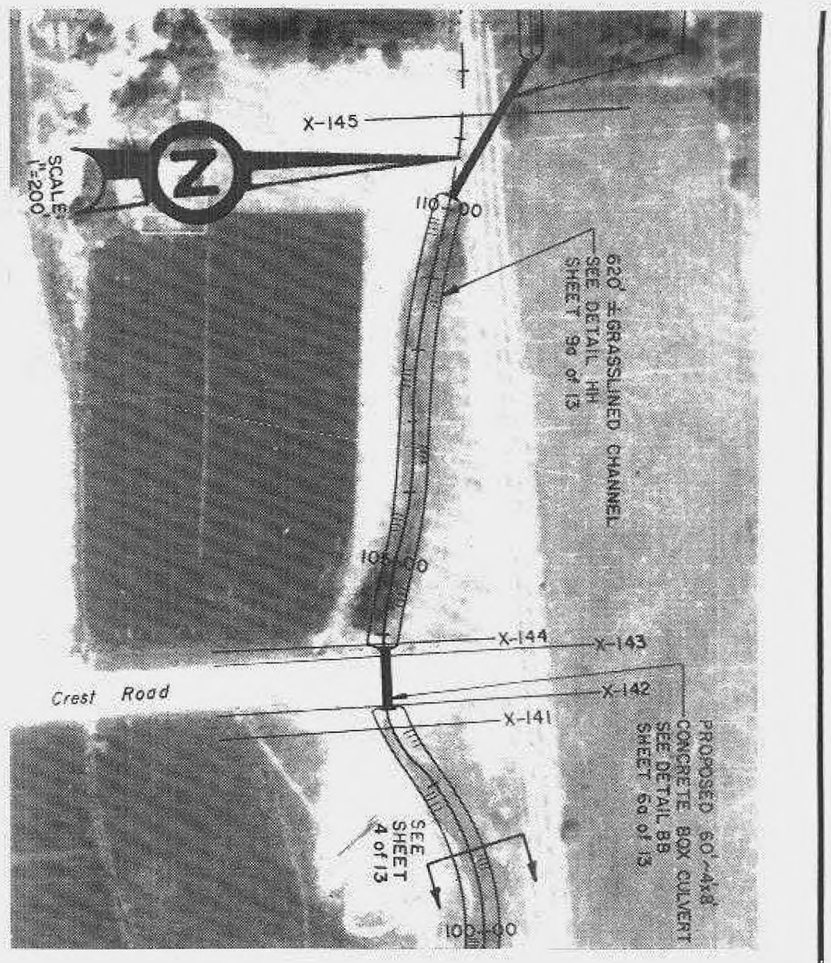
X-152 X-151 X-150 X-149 X-148 X-147 X-146 X-145

135+00 130+00 125+00 120+00 115+00

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS







SHEET 5 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 101+00 TO 137+00

CORNELL CONSULTING COMPANY
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p.o. box 646, fort collins, colorado 80522 (303)482-6650

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.

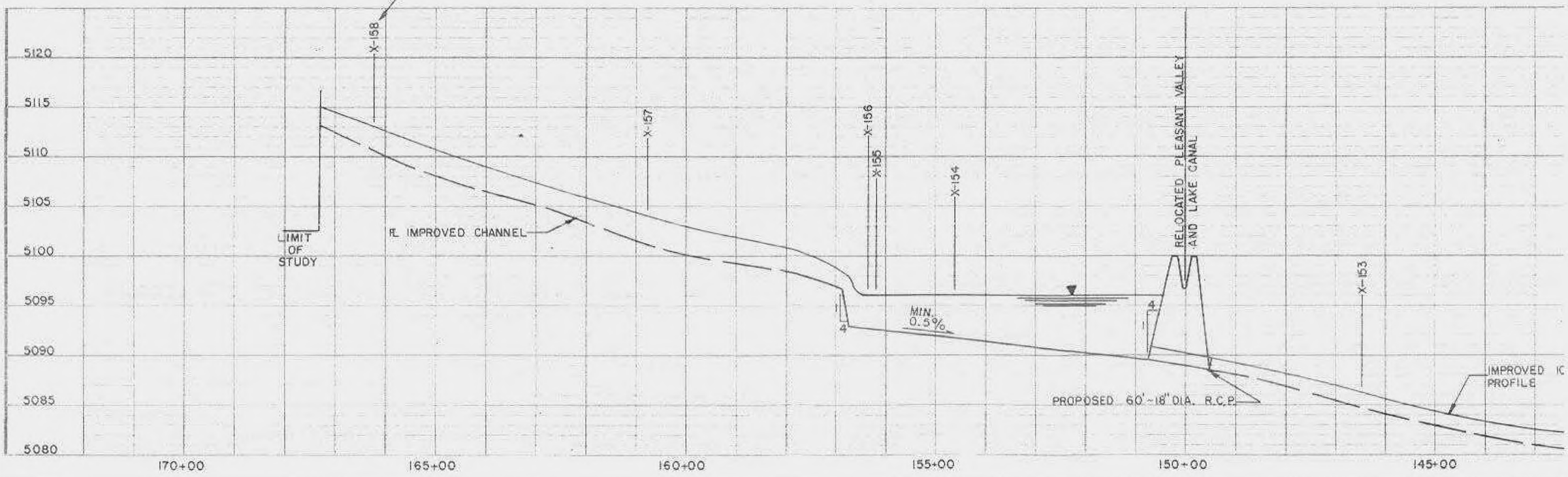
NOTE: THIS DRAWING DEPICTS PRELIMINARY ENGINEERING FOR PLANNING PURPOSES ONLY. IT IS NOT TO BE USED FOR CONSTRUCTION.

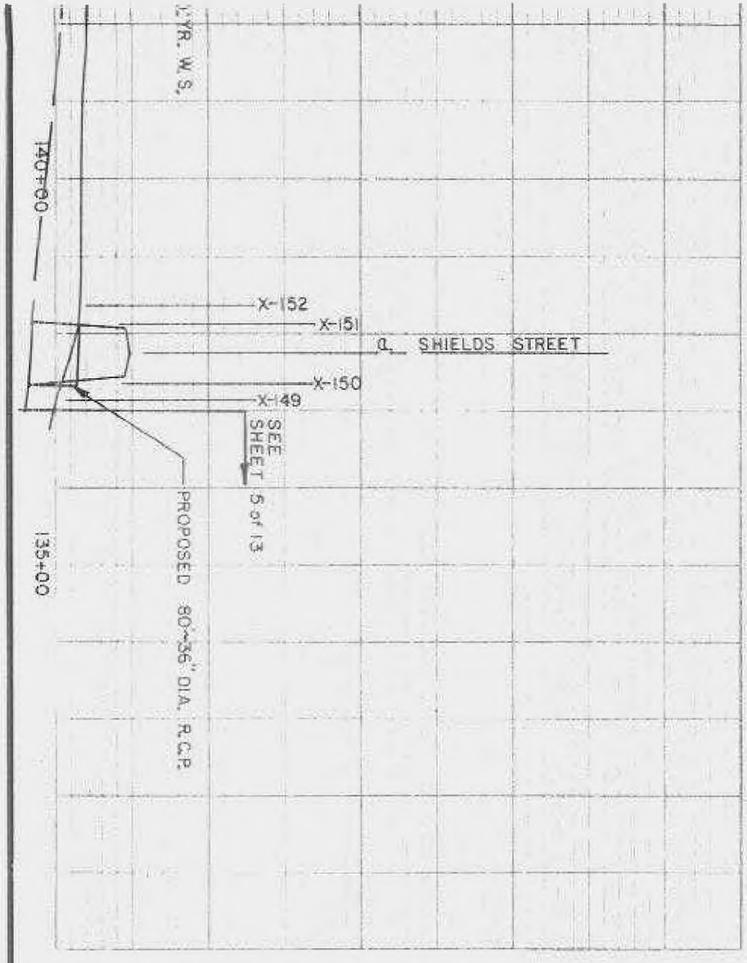
1080 ± GRASSLINED CHANNEL
SEE DETAIL HH
SHEET 9a of 13

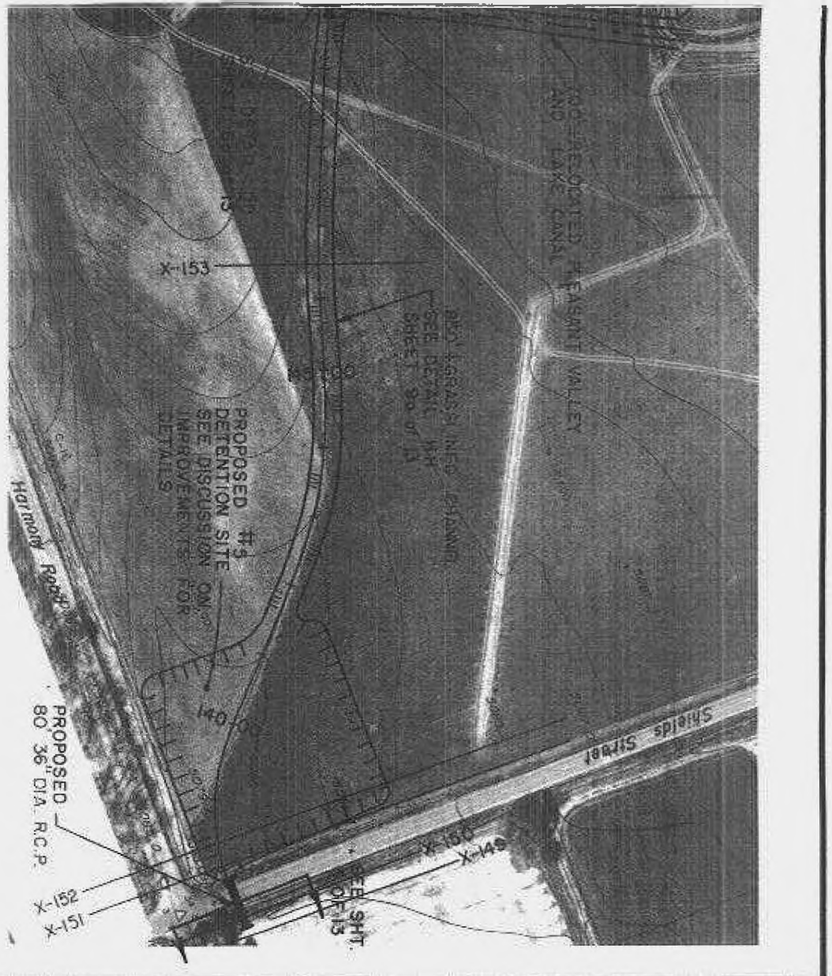
LIMIT OF STUDY

SCALE: 1"=200'

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS







SHEET 6 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS
STATION 137+00 TO STUDY LIMIT

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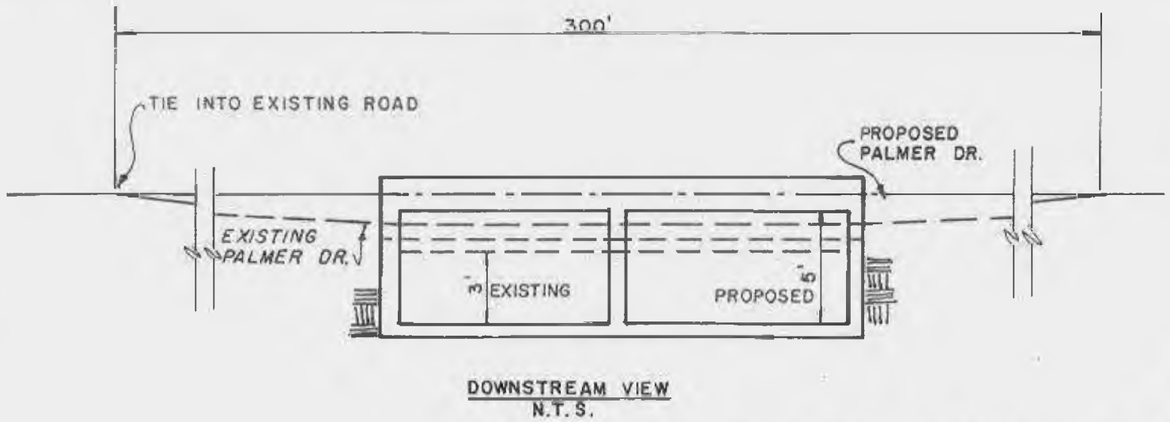
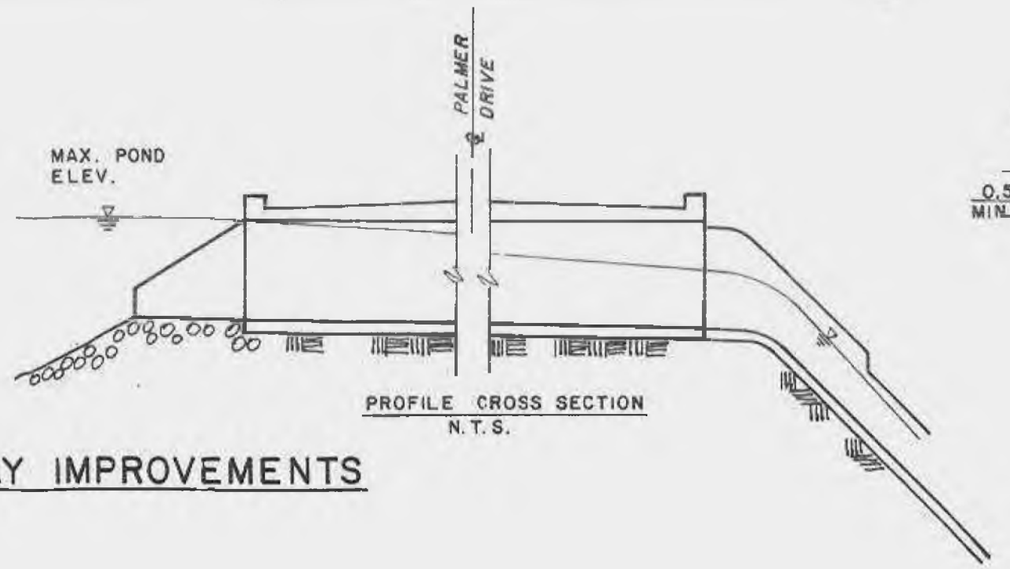
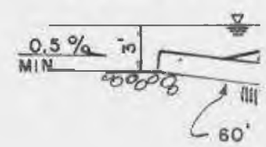


DOWNSTREAM VIEW
N.T.S.



PROFILE CROSS SECTION
N.T.S.

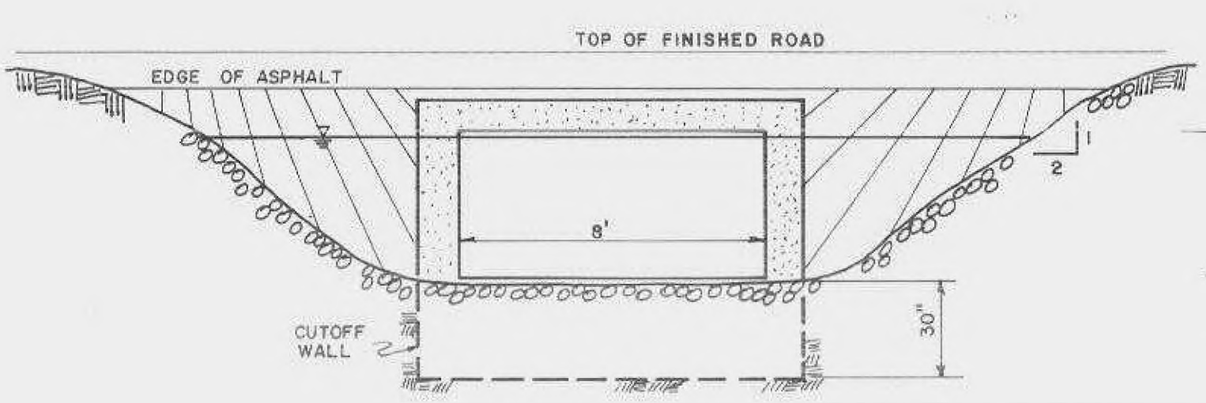
21.3 ACRE FT. S

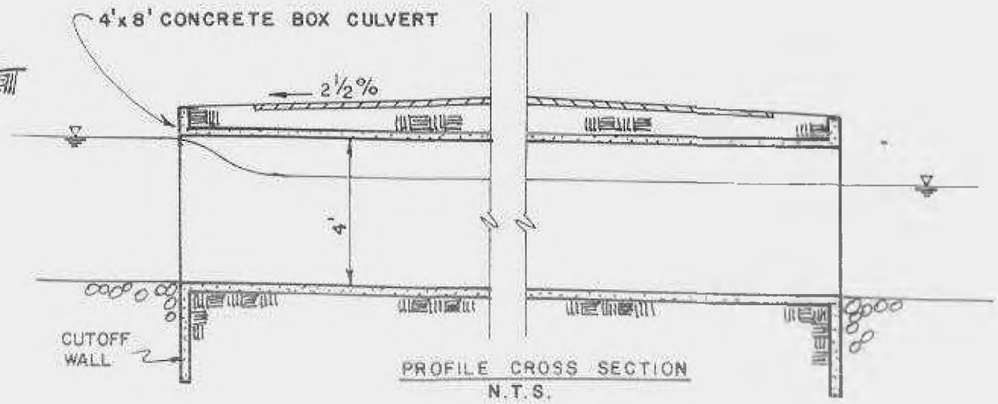


DETAI
CROS
& LA
STA. 14

DETAIL AA, FAIRWAY DAM SPILLWAY IMPROVEMENTS
STA. 55+12

ROAD	CULVERT	LOCATION
CREST RD.	4'x8' BOX	STA. 102+85 to 103+45
NORDIC ACCESS RD.	4'x8' BOX	STA. 97+45 to 97+85
HARMONY RD.	4'x8' BOX	STA. 110+30 to 112+10



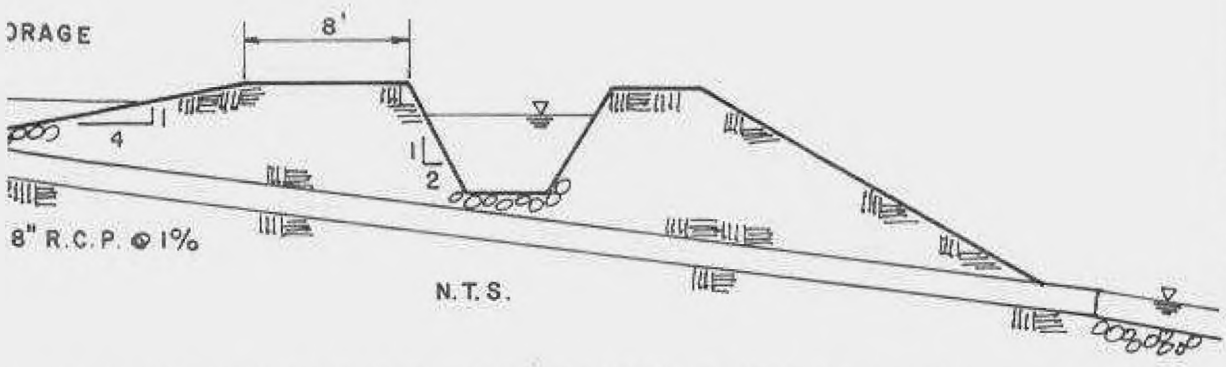


PROFILE CROSS SECTION
N.T.S.

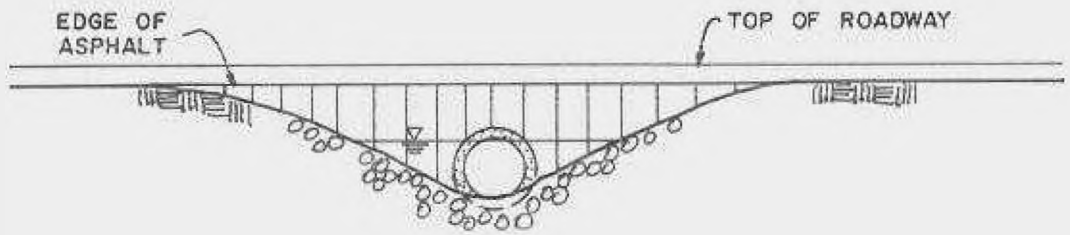
3'

DET
STA.

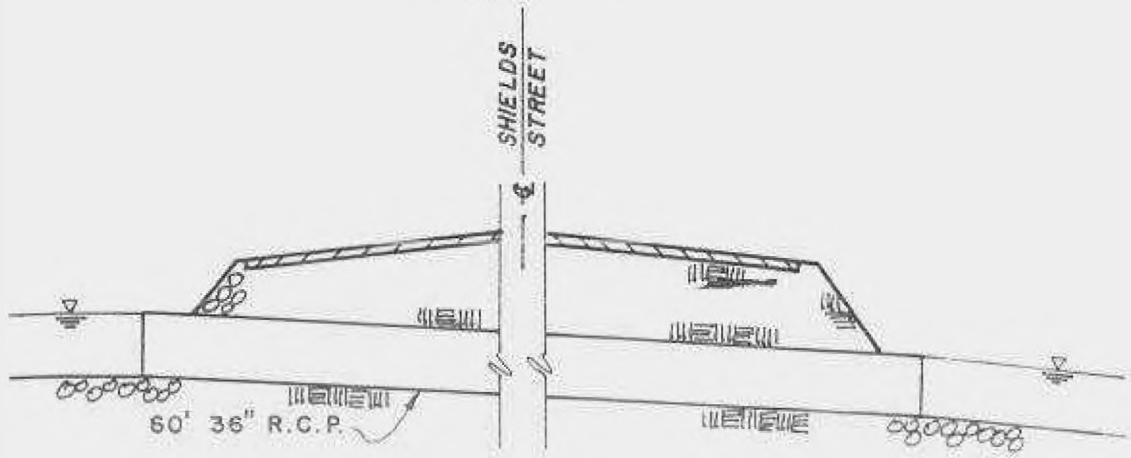
DETAIL BB, TYPICAL CROSS SECTION
CONCRETE BOX CULVERT



. DD, DETENTION POND "A" OUTLET &
SECTION OF RELOCATED PLEASANT VALLEY
KE CANAL
)+80 TO 150+40



END VIEW
N.T.S.



PROFILE CROSS SECTION
N.T.S.

AIL CC, CULVERT UNDER SHIELDS STREET
137+72

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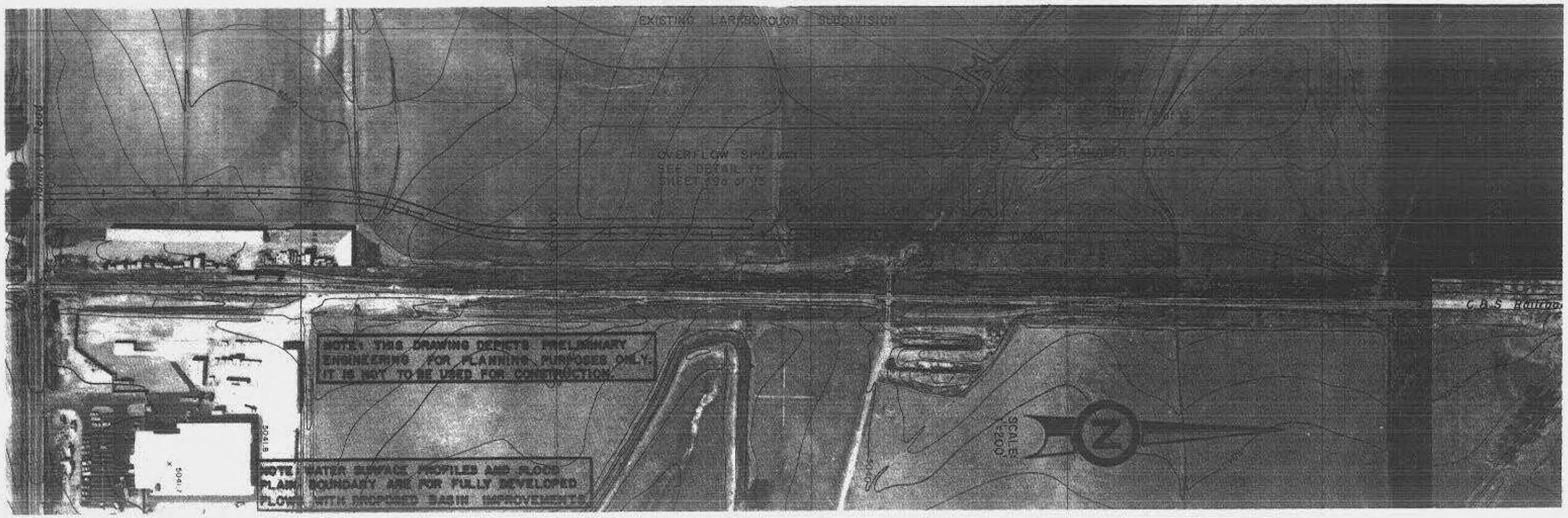
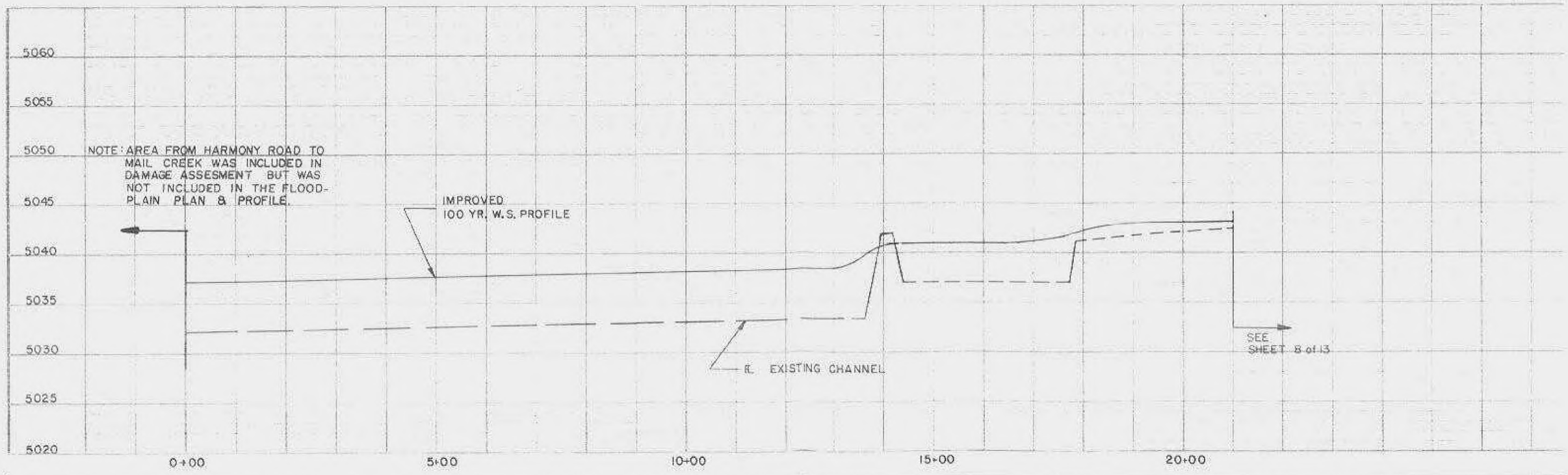
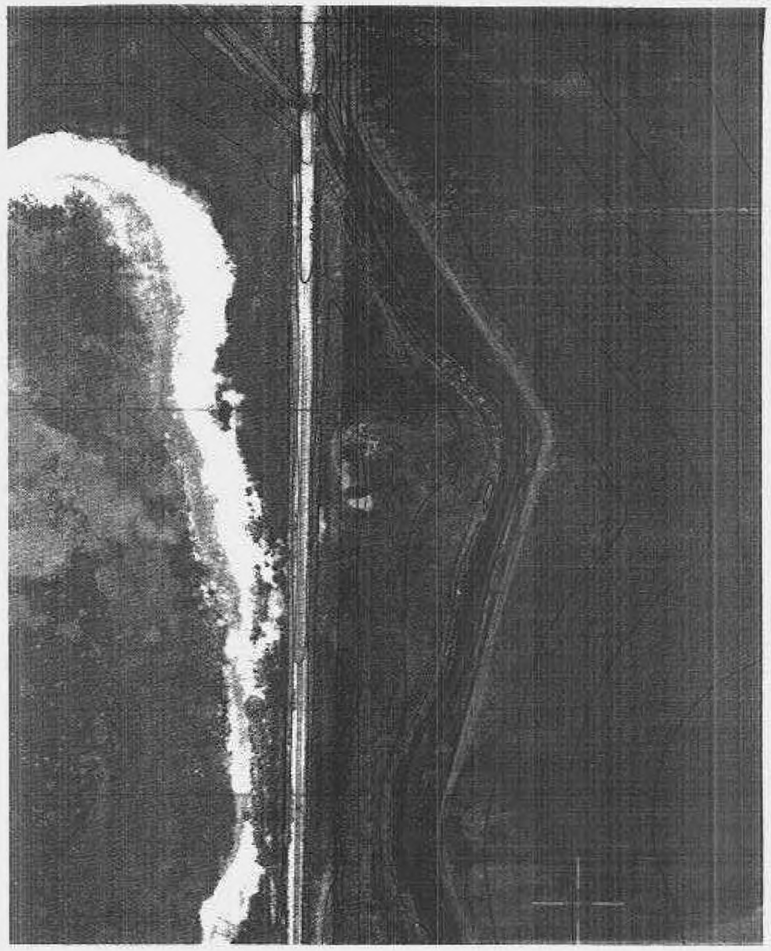
McCLELLANDS & MAIL CREEK
DRAINAGE STUDY
DETAIL SHEET


EXISTING LARKSBOROUGH SUBDIVISION
HARBERT DRIVE
OVERFLOW SPILLWAY
SEE DETAIL AT
SHEET 9 OF 13
C.B.S. Railroad
NOTE: THIS DRAWING DEPICTS PRELIMINARY ENGINEERING FOR PLANNING PURPOSES ONLY. IT IS NOT TO BE USED FOR CONSTRUCTION.
NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOW WITH PROPOSED BASIN IMPROVEMENTS
SCALE 1"=200'


5060
5055
5050
5045
5040
5035
5030
5025
5020
NOTE: AREA FROM HARMONY ROAD TO MAIL CREEK WAS INCLUDED IN DAMAGE ASSESMENT BUT WAS NOT INCLUDED IN THE FLOOD-PLAIN PLAN & PROFILE.
IMPROVED
100 YR. W.S. PROFILE
℄ EXISTING CHANNEL
SEE
SHEET 8 of 13
0+00
5+00
10+00
15+00
20+00



SHEET 7 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

NEW MERCER CANAL

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins . colorado 80522 (303)482-6660

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED RADIX IMPROVEMENTS.

NOTE: THIS DRAWING IS FOR PRELIMINARY PLANNING PURPOSES ONLY. IT IS NOT TO BE USED FOR CONSTRUCTION.

2050' ± GRASS LINED CHANNEL
SEE DETAIL 8H
SHEET 9a of 13

Shields Street

SEE SHEET 9 of 13

X-206 X-205 X-204 X-203

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS

TROUTMAN

X-205 X-204 X-203 X-202 X-201 X-200

IMPROVED 100 YR. W.S. PROFILE

R. IMPROVED CHANNEL

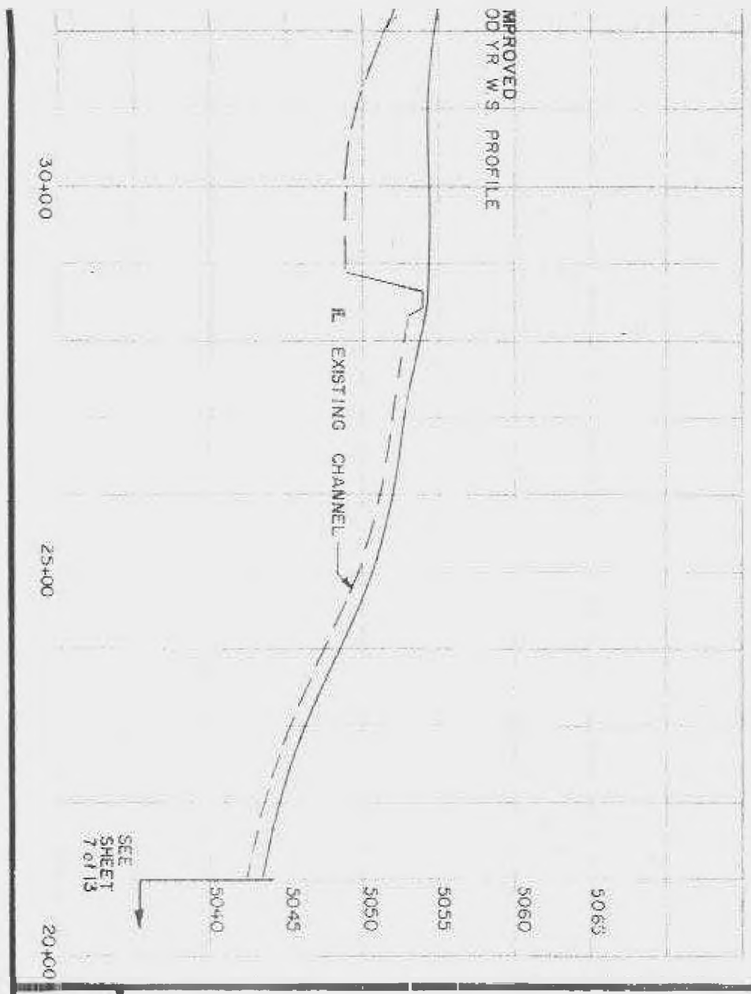
5080
5075
5070
5065
5060
5055

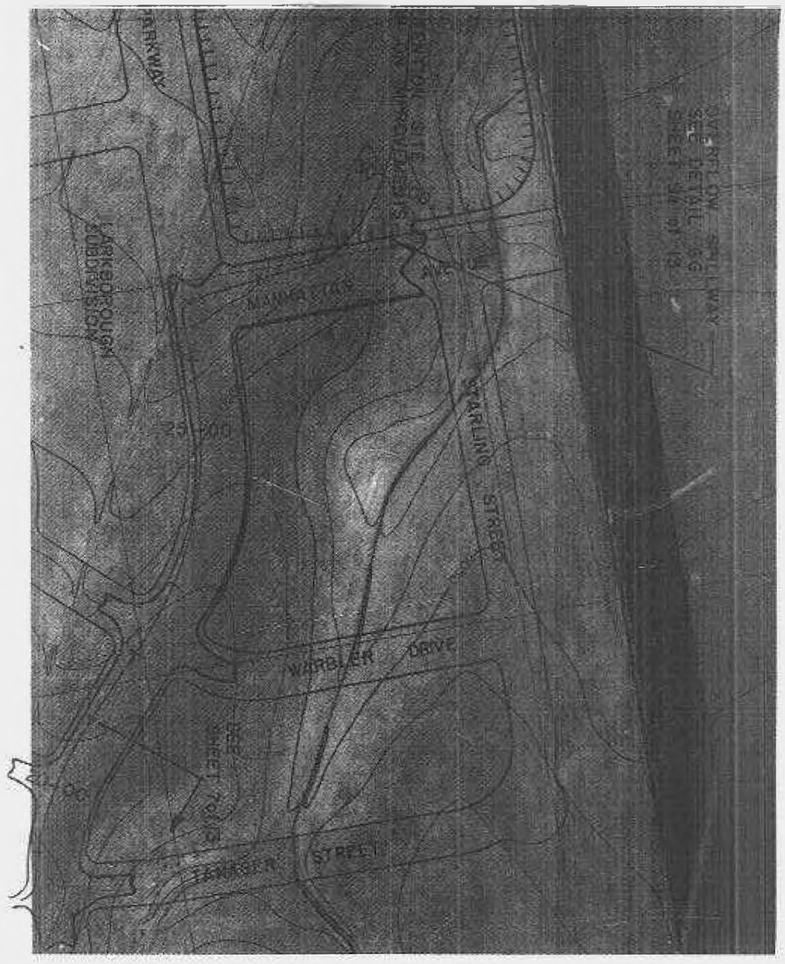
SEE SHEET 9 of 13

SEE STA 0+00 THIS SHEET

SEE STA 35+00 THIS SHEET

25+00 20+00 15+00 10+00 5+00 0+00 35+00





SHEET 8 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 0+00 TO 24+00

CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins . colorado 80522 (303)482-6650

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.

LIMIT OF STUDY

PROPOSED 10'-1.3'x8' CONCRETE BOX CULVERT SEE DETAIL KK SHEET 9a of 13

PROPOSED RELOCATION OF PLEASANT VALLEY & LAKE CANAL

262.0' ± GRASS LINED CHANNEL SEE DETAIL HH SHEET 9a of 13

℄ OF EXISTING DRAINAGE WAY

40+00

X-210

X-209

X-208

X-207

Shields Street

PROPOSED 80'-3.0
CONCRETE BOX CU
SEE DETAIL KK
SHEET 9a of 13

LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS

IMPROVED 100 YR. W. S. PROFILE

X-214

X-213

X-212

RELOCATED PLEASANT VALLEY & LAKE CANAL

X-211

X-210

LIMIT OF STUDY

X-216

X-215

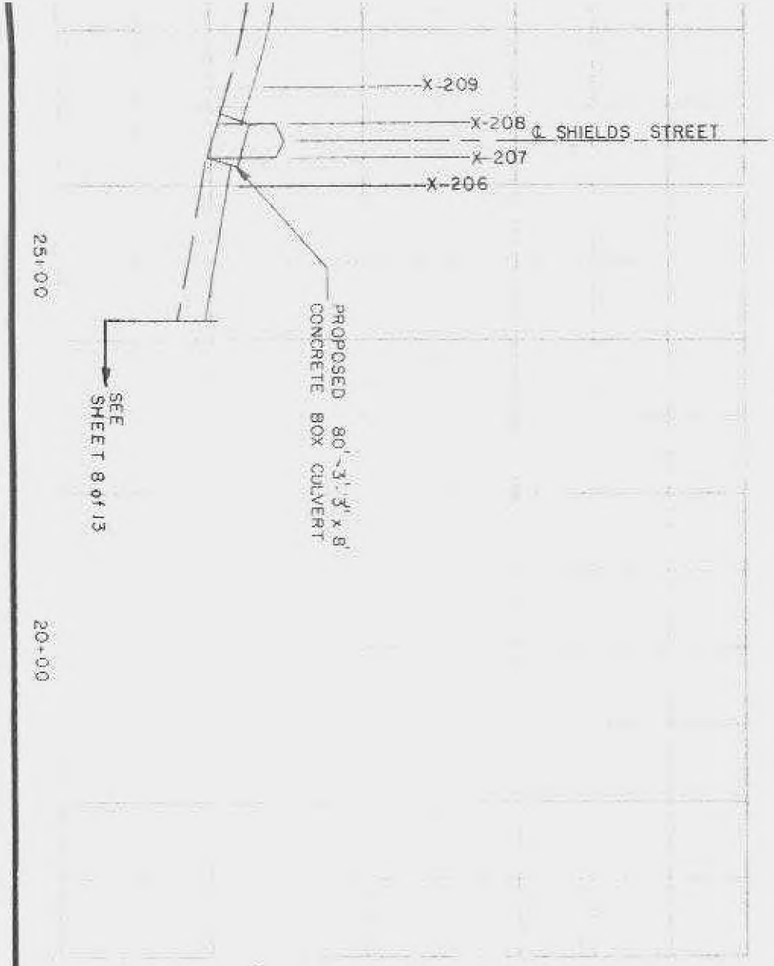
43+00± (EXISTING)
43+00± (IMPROVED)

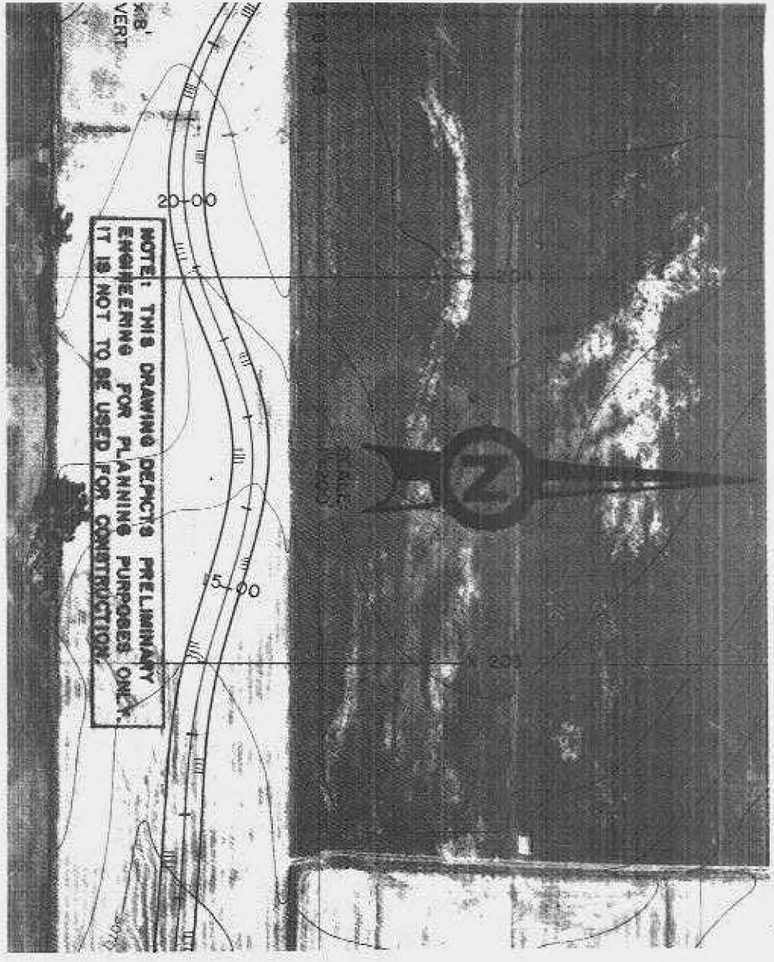
℄ IMPROVED CHANNEL

PROPOSED 100'-3.3'x8' CONCRETE BOX CULVERT

5110
5105
5100
5095
5090
5085
5080
5075

55+00
50+00
45+00
40+00
35+00
30+00



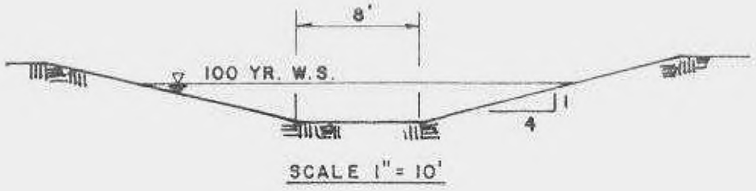


SHEET 9 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS
STATION 24+00 TO STUDY LIMIT

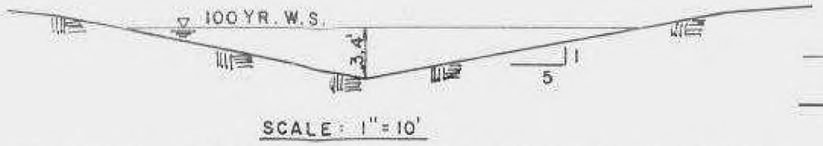
CORNELL CONSULTING COMPANY
MANAGEMENT / ENGINEERING
p.o. box 646 . fort collins . colorado 80522 (303)482-6650



SCALE 1" = 10'

DETAIL HH, TYPICAL CROSS SECTION

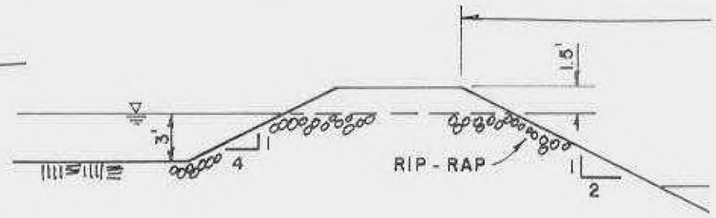
STA 0+00 TO 26+20, STA 27+00 TO 39+00,
STA 40+00 TO 55+50

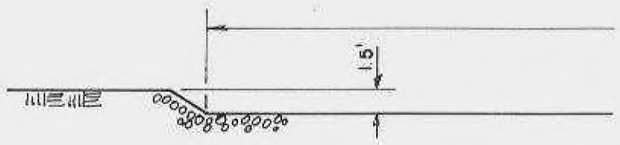


SCALE: 1" = 10'

DETAIL II, TYPICAL CROSS SECTION

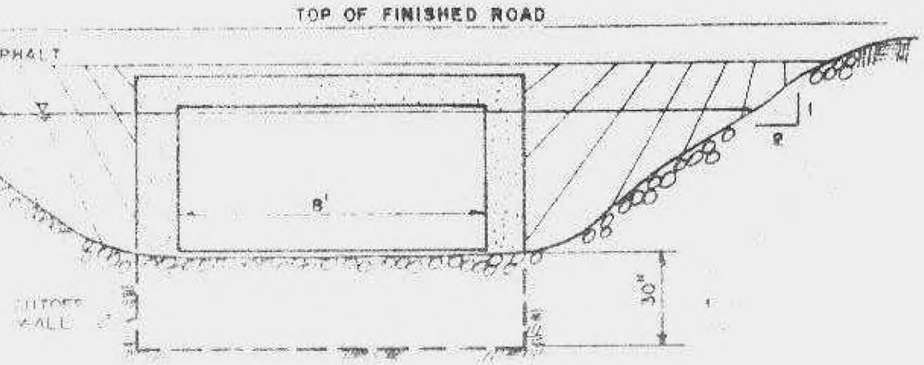
STA 112+00 TO STA 137+20 MAIL CREEK

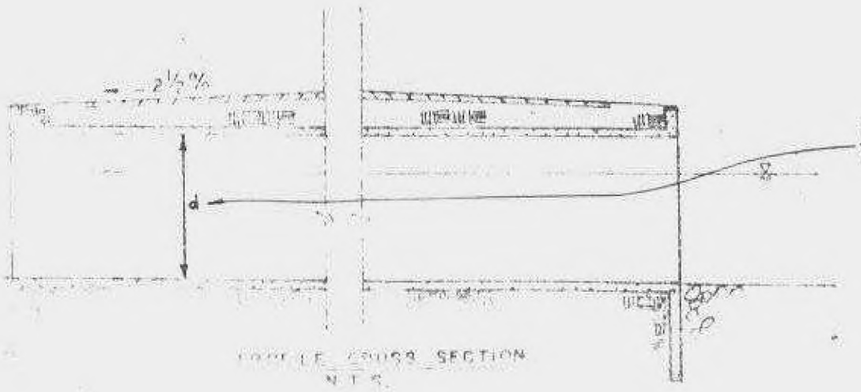




DETAIL FF, OVERFLOW SPILLW

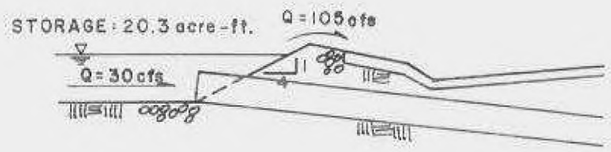
FROM EXISTING LARKBOROUGH DETE

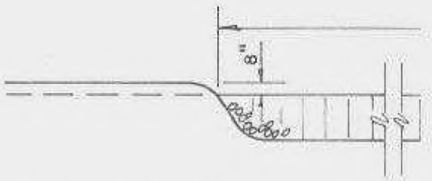




DETAIL NN, TYPICAL CROSS SECTION

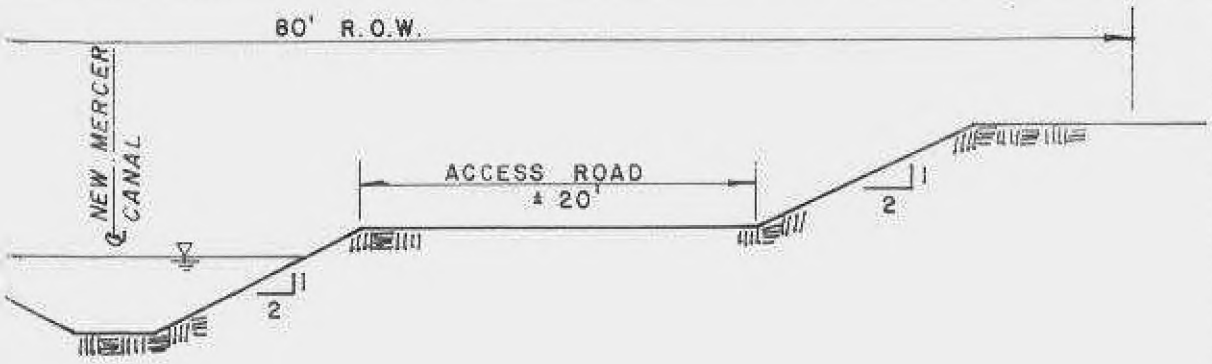
CONCRETE BOX CULVERT
UNDER SHIELDS STREET
UNDER RELOCATED PLEASANT VALLEY & LAKE CANAL

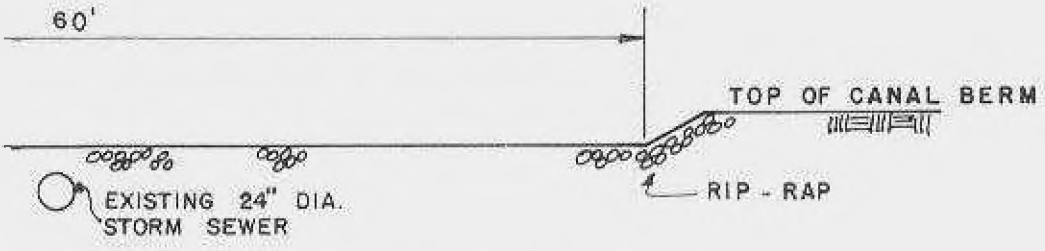




DETAIL GG, SPILLW

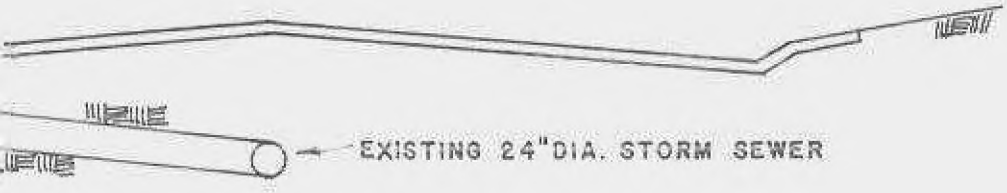
DETENTION POND NO. 3





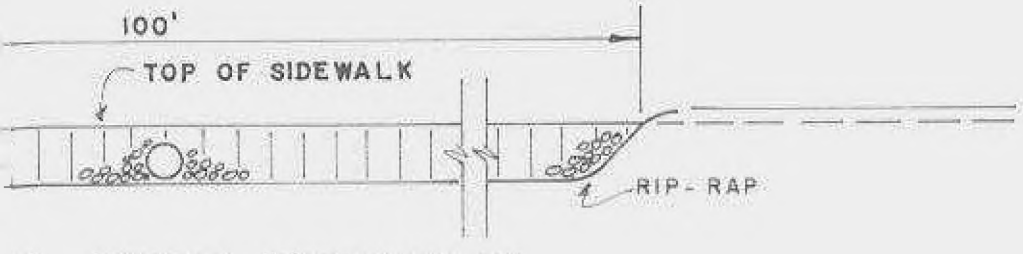
AY INTO NEW MERCER CANAL

TION POND SCALE : 1" = 10'



OUTLET CROSS SECTION

N.T.S.



AY OVER SIDEWALK

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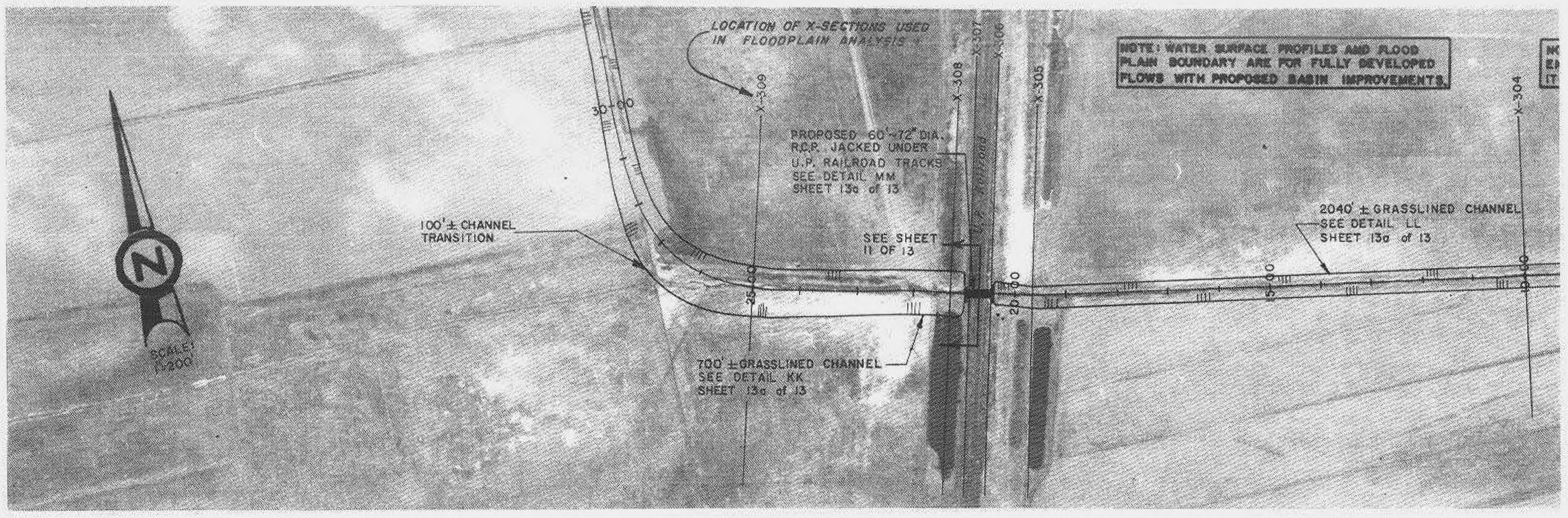
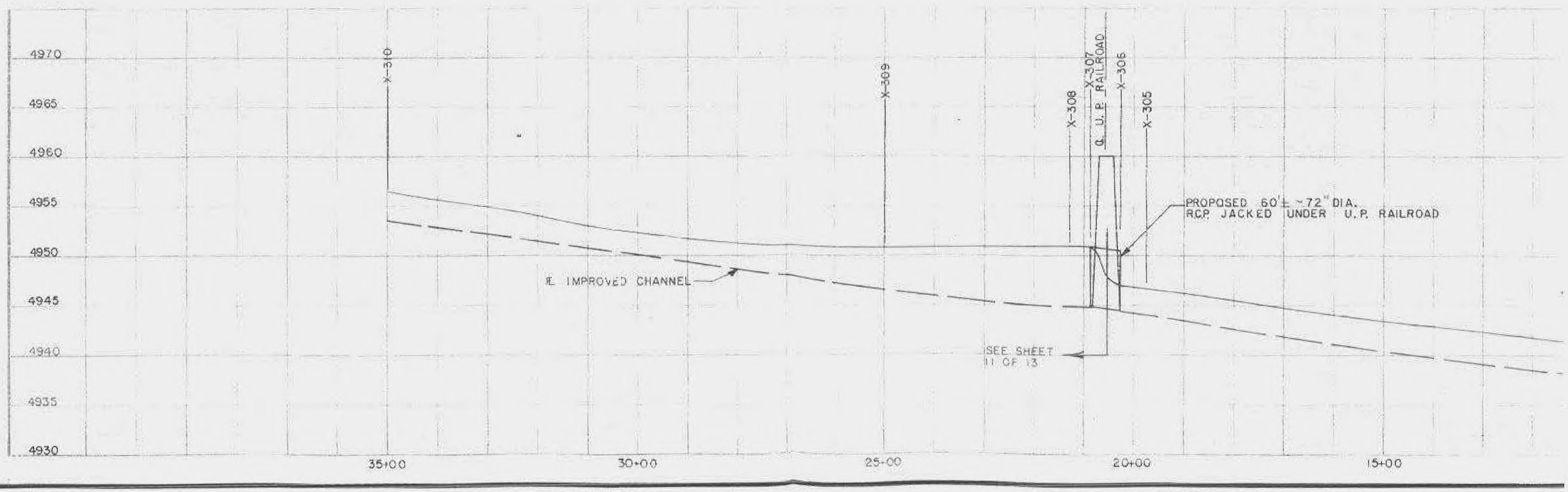
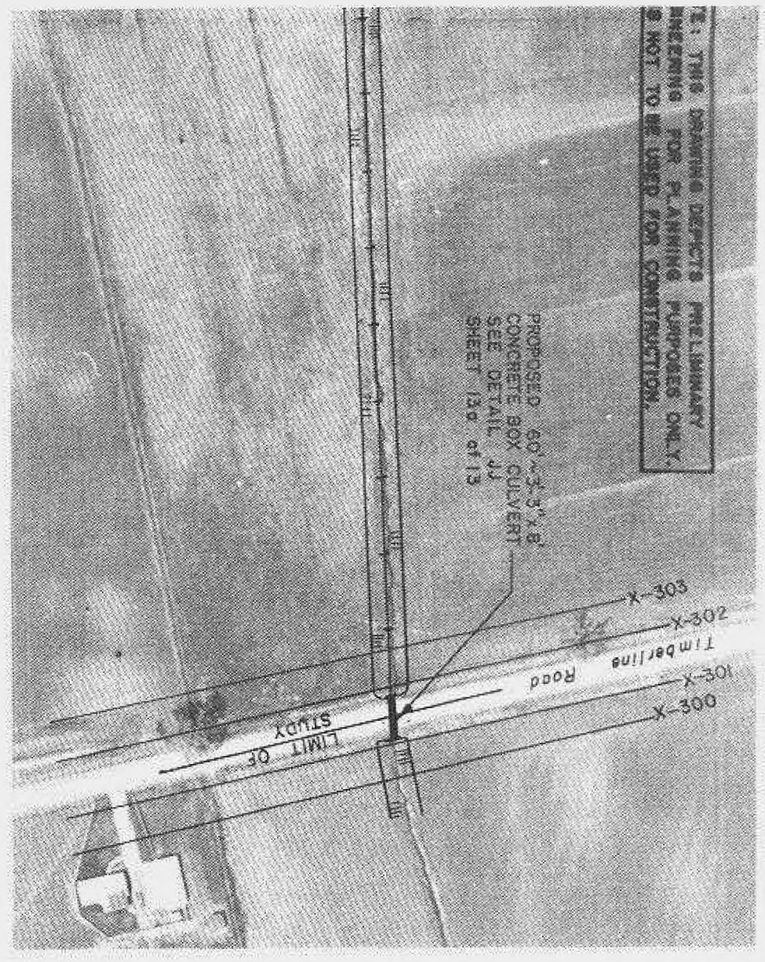
McCLELLANDS & MAIL CREEK
DRAINAGE STUDY
DETAIL SHEET


LOCATION OF X-SECTIONS USED IN FLOODPLAIN ANALYSIS
NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.
X-309
X-308
X-307
X-306
X-305
X-304
30+60
25+00
20+00
PROPOSED 60'±-72" DIA. R.C.P. JACKED UNDER U.P. RAILROAD TRACKS SEE DETAIL MM SHEET 13a of 13
100'± CHANNEL TRANSITION
SEE SHEET 11 OF 13
2040'± GRASSLINED CHANNEL SEE DETAIL LL SHEET 13a of 13
700'± GRASSLINED CHANNEL SEE DETAIL KK SHEET 13a of 13
N
SCALE: 1"=200'


4970
4965
4960
4955
4950
4945
4940
4935
4930
X-310
X-309
X-308
X-307
X-306
X-305
℄ U.P. RAILROAD
℄ IMPROVED CHANNEL
PROPOSED 60'± -72" DIA. RCP JACKED UNDER U.P. RAILROAD
SEE SHEET 11 OF 13
35+00
30+00
25+00
20+00
15+00



SHEET 10 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 0+00 TO 30+50

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4260' ± GRASSLINED CHANNEL
SEE DETAIL LL
SHEET 13a of 13

SEE
SHEET 12 of 13

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.

700' ± GRASSLINED CHANNEL
SEE DETAIL KK
SHEET 13a of 13

X-309

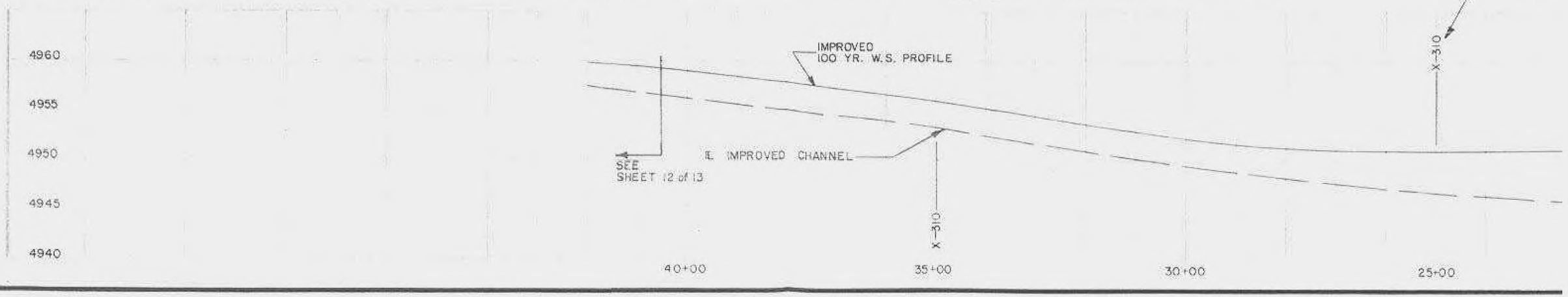
X-308

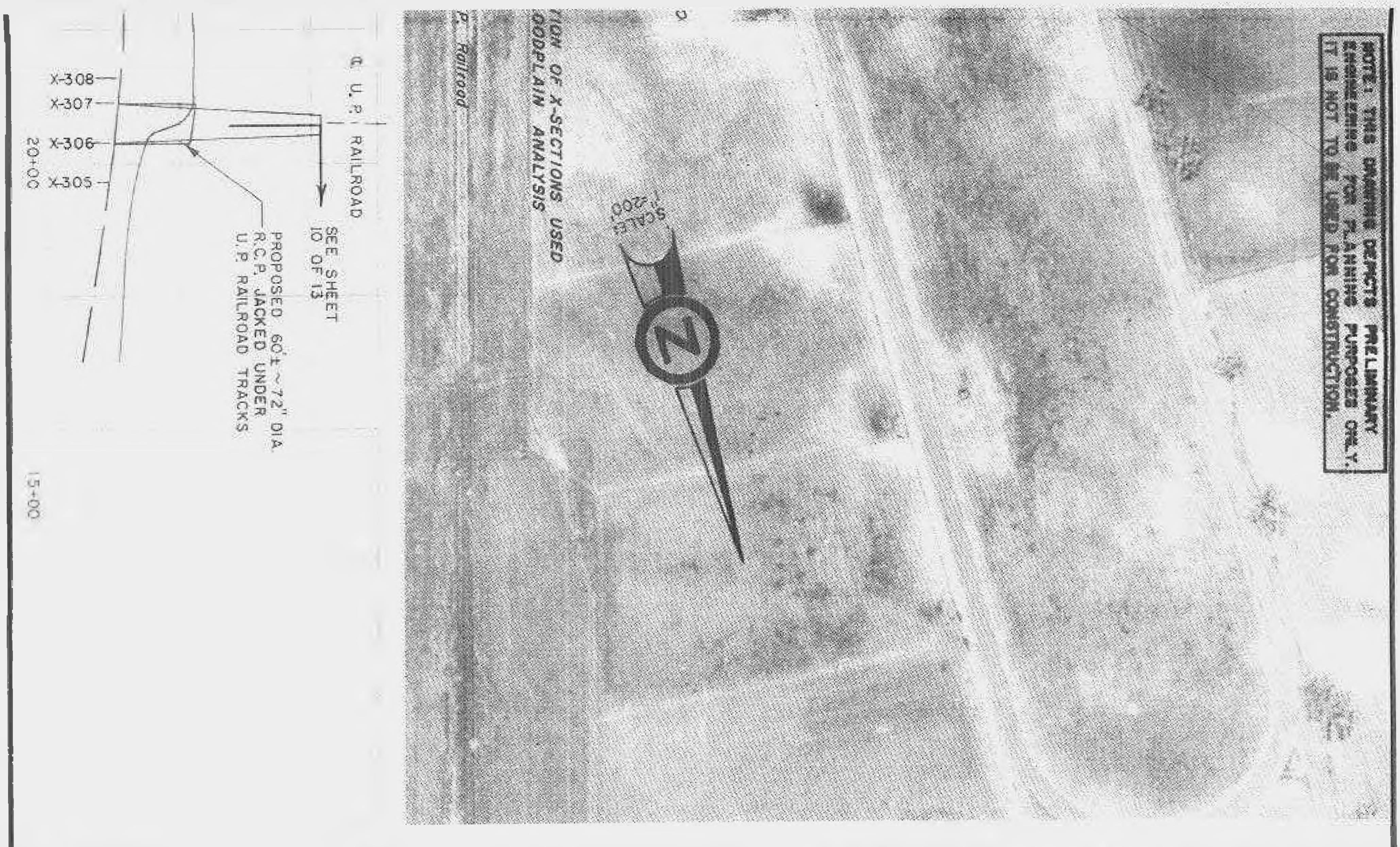
X-307

X-306

SEE SHEET
10 OF 13

LOC
IN





SHEET 11 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 30+50 TO 40+50

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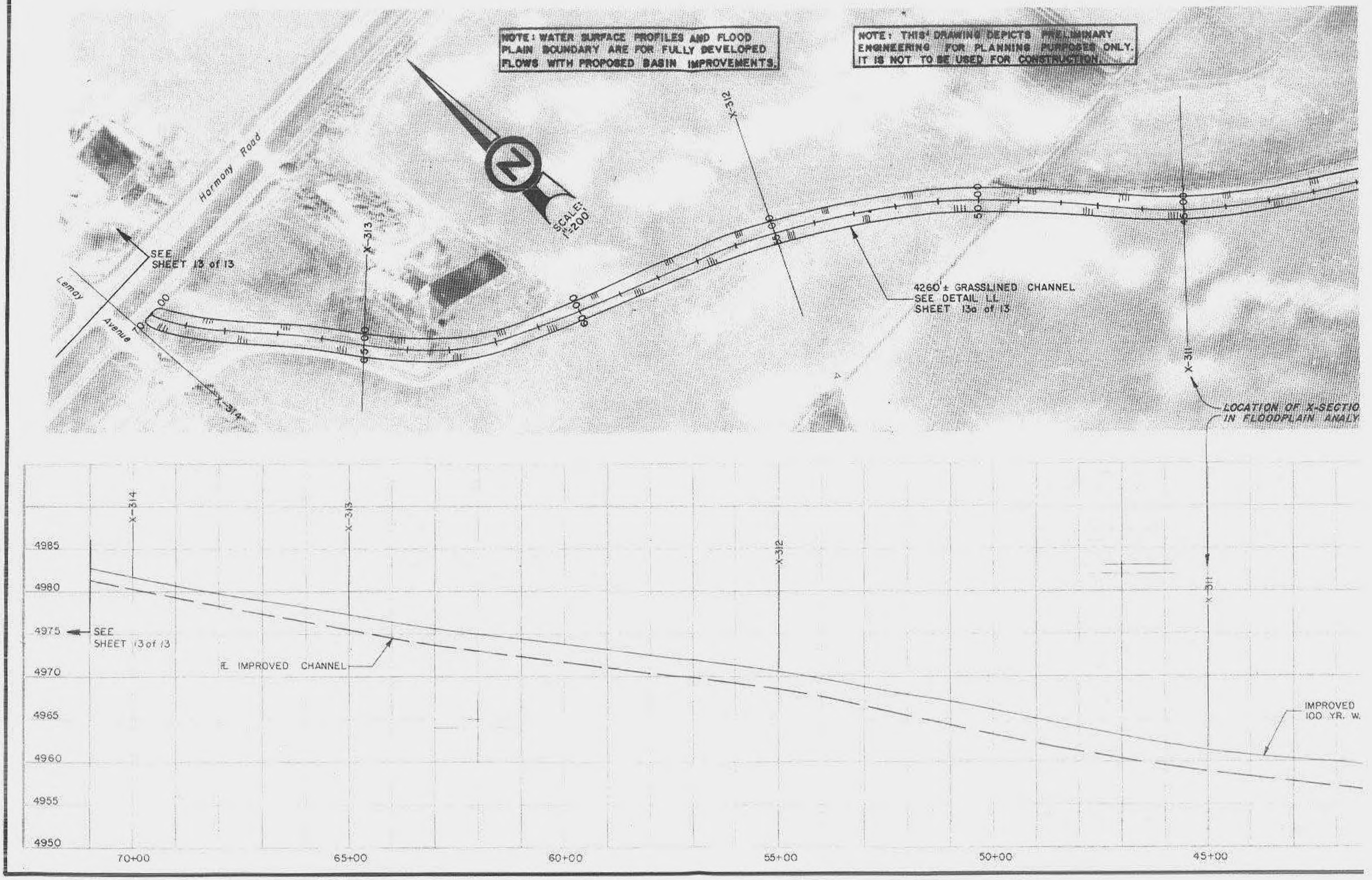
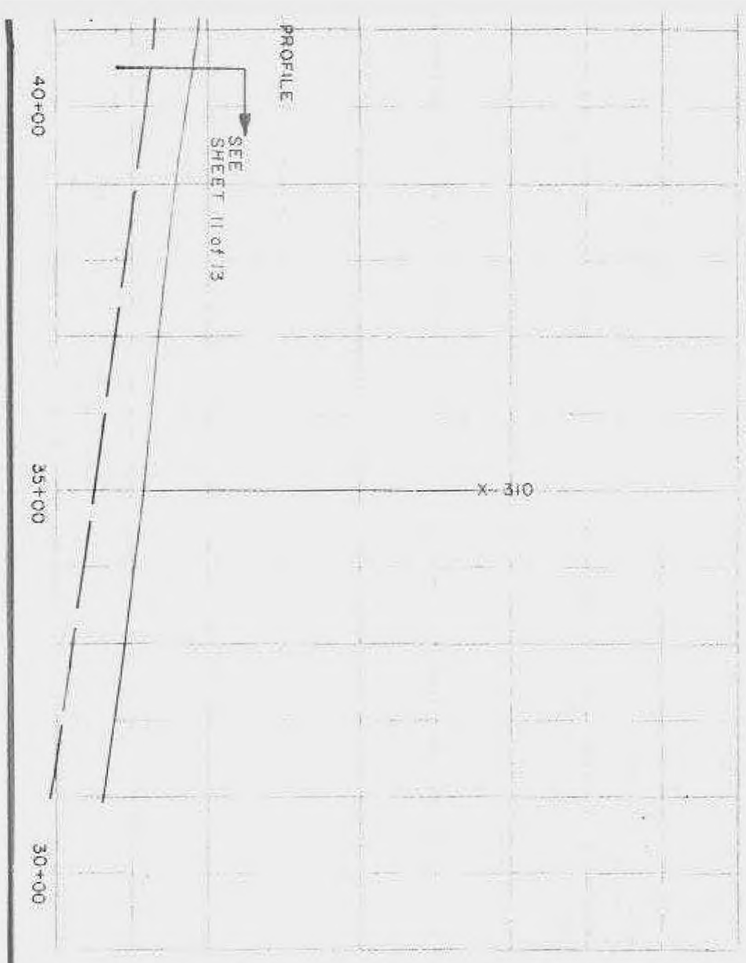
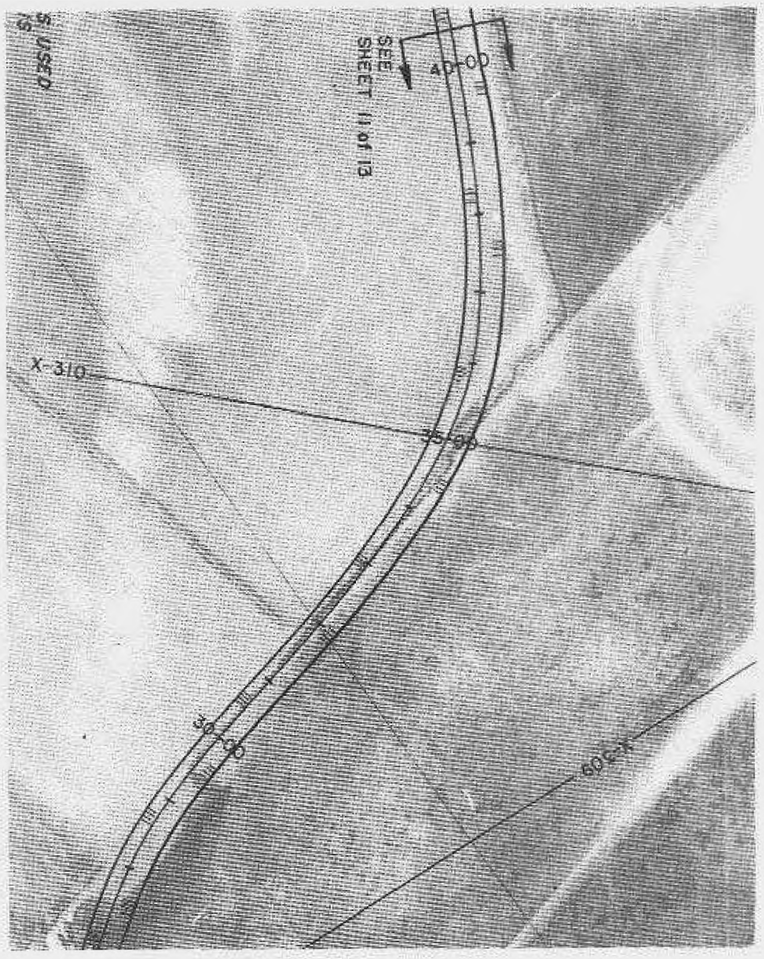

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.
NOTE: THIS DRAWING DEPICTS PRELIMINARY ENGINEERING FOR PLANNING PURPOSES ONLY. IT IS NOT TO BE USED FOR CONSTRUCTION.
SCALE: 1"=200'
Harmony Road
Lemay Avenue
SEE SHEET 13 of 13
X-313
X-312
X-311
X-314
4260'± GRASSLINED CHANNEL
SEE DETAIL LL
SHEET 13a of 13
LOCATION OF X-SECTIO
IN FLOODPLAIN ANALY
4985
4980
4975
4970
4965
4960
4955
4950
SEE SHEET 13 of 13
℄ IMPROVED CHANNEL
IMPROVED
100 YR. W.
70+00
65+00
60+00
55+00
50+00
45+00





SHEET 12 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 40+50 TO STUDY LIMIT

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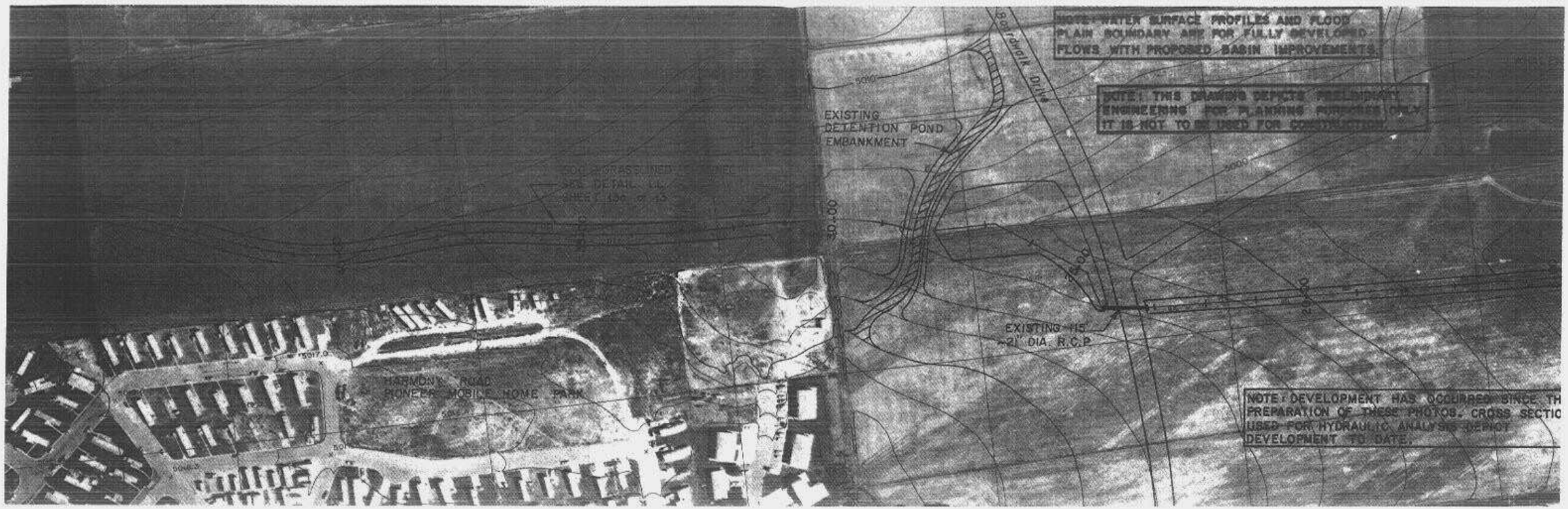
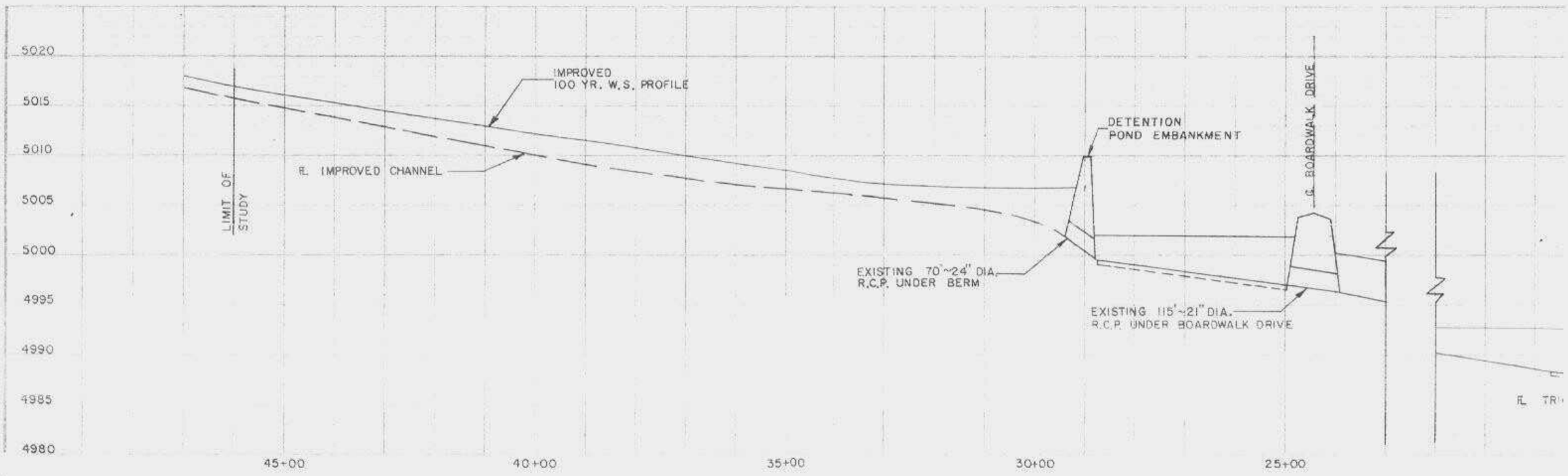
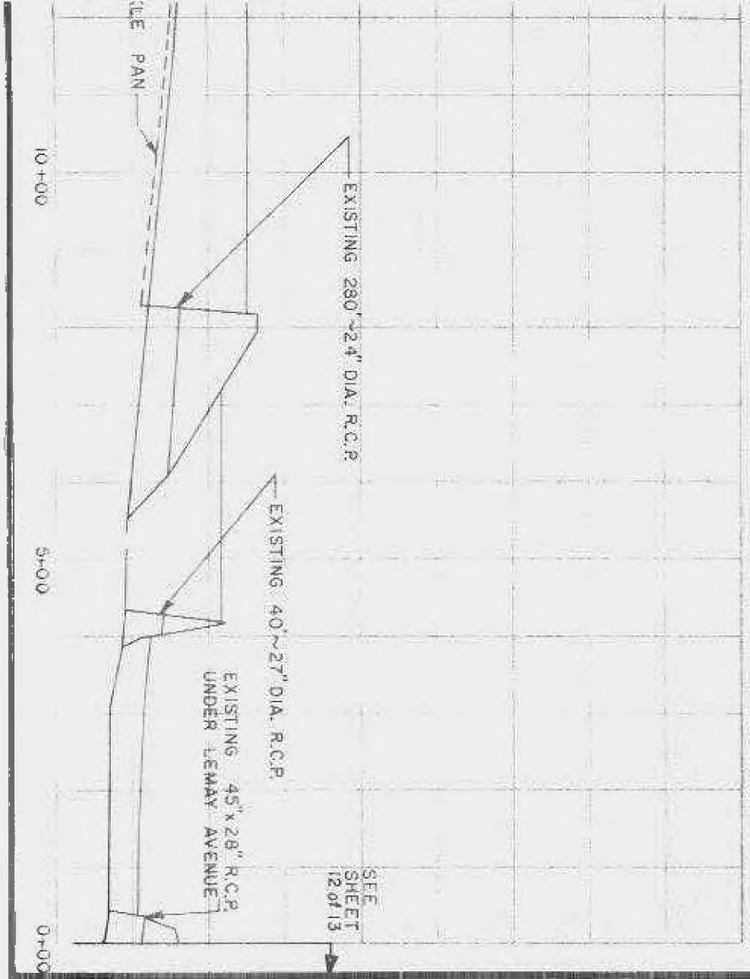

NOTE: WATER SURFACE PROFILES AND FLOOD PLAIN BOUNDARY ARE FOR FULLY DEVELOPED FLOWS WITH PROPOSED BASIN IMPROVEMENTS.
NOTE: THIS DRAWING DEPICTS PRELIMINARY ENGINEERING FOR PLANNING PURPOSES ONLY IT IS NOT TO BE USED FOR CONSTRUCTION.
EXISTING DETENTION POND EMBANKMENT
Boardwalk Drive
HARMONY ROAD
PIONEER MOBILE HOME PARK
EXISTING 115' ~21" DIA. R.C.P.
NOTE: DEVELOPMENT HAS OCCURRED SINCE TH PREPARATION OF THESE PHOTOS. CROSS SECTIO USED FOR HYDRAULIC ANALYSIS DEPICT DEVELOPMENT TO DATE.


5020
5015
5010
5005
5000
4995
4990
4985
4980
45+00
40+00
35+00
30+00
25+00
IMPROVED 100 YR. W.S. PROFILE
R. IMPROVED CHANNEL
LIMIT OF STUDY
DETENTION POND EMBANKMENT
℄ BOARDWALK DRIVE
EXISTING 70'~24" DIA. R.C.P. UNDER BERM
EXISTING 115'~21" DIA. R.C.P. UNDER BOARDWALK DRIVE



SHEET 13 of 13

McCLELLANDS & MAIL CREEK DRAINAGE STUDY

FLOOD AREAS IMPROVED CONDITIONS

STATION 0+00 TO STUDY LIMIT

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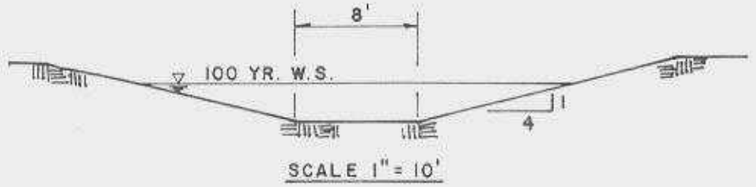


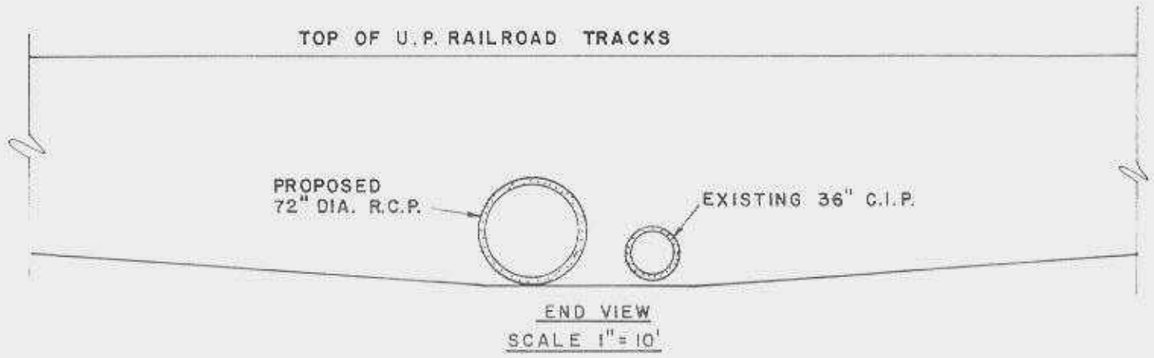
SCALE 1" = 10'

DETAIL LL, TYPICAL CROSS-SECTION

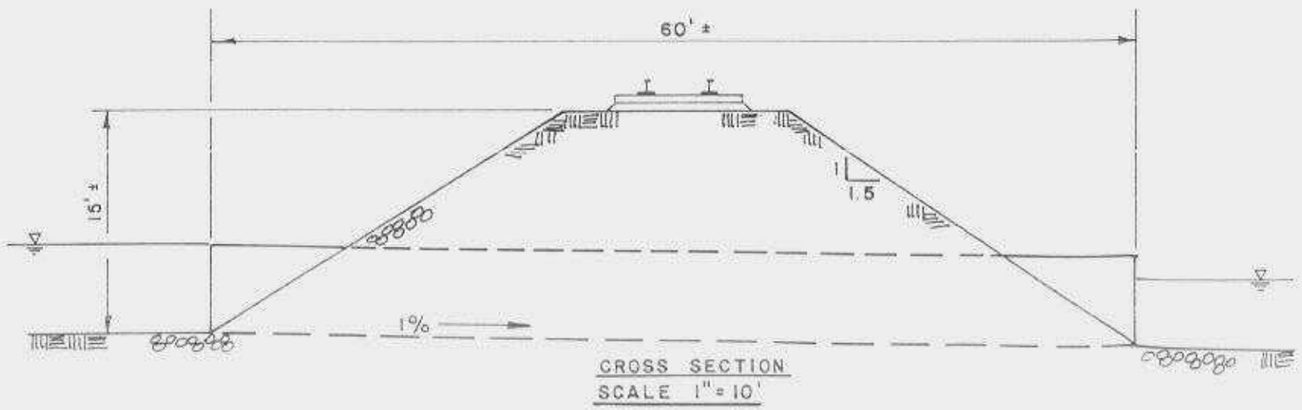
STA 0+00 TO 21+00, STA 27+00 TO 70+00

DETAIL

STA 21+0(



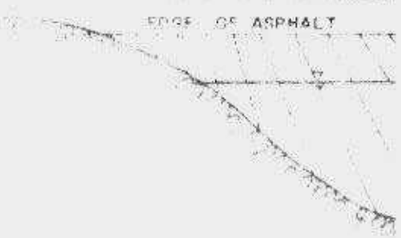
END VIEW
SCALE 1" = 10'

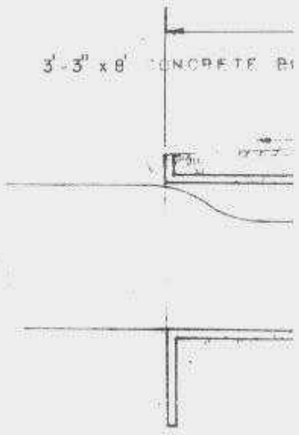


CROSS SECTION
SCALE 1" = 10'

DETAIL MM, TYPICAL CROSS-SECTION

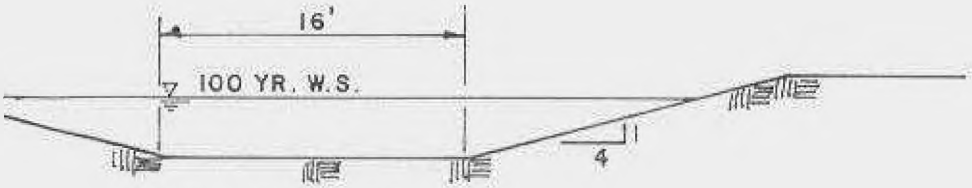
STA 20+27 TO 20+87





DETAIL J

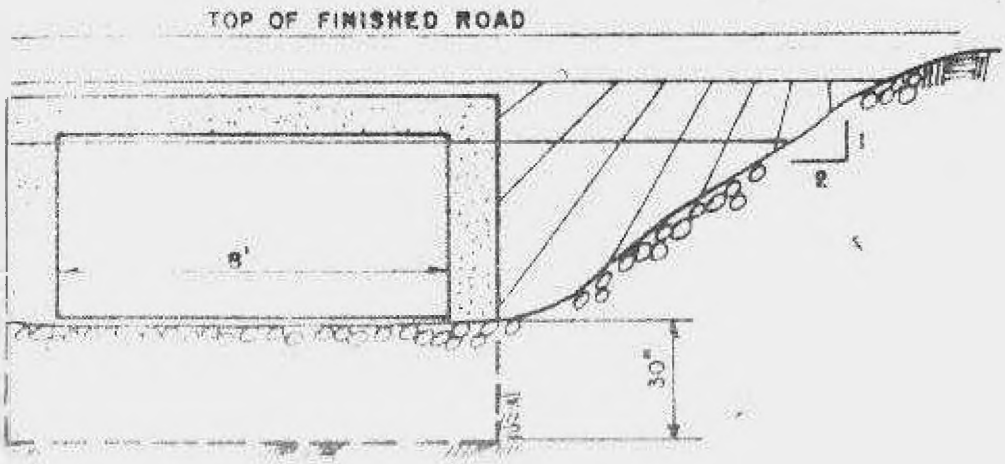
CONCRETE
UNDER TI

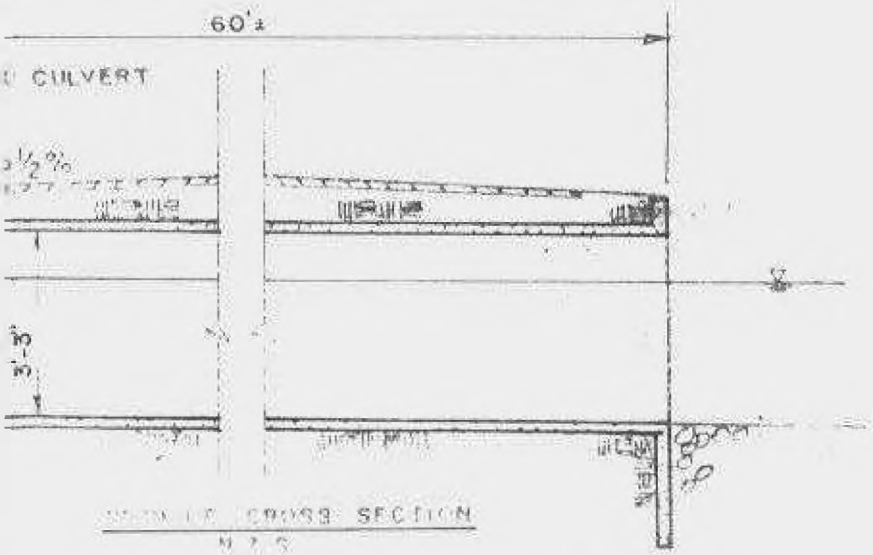


SCALE 1" = 10'

KK, TYPICAL CROSS-SECTION

TO 27+00





J, TYPICAL CROSS-SECTION

BOX CULVERT
BERLINE ROAD

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McCLELLANDS & MAIL CREEK
DRAINAGE STUDY
DETAIL SHEET