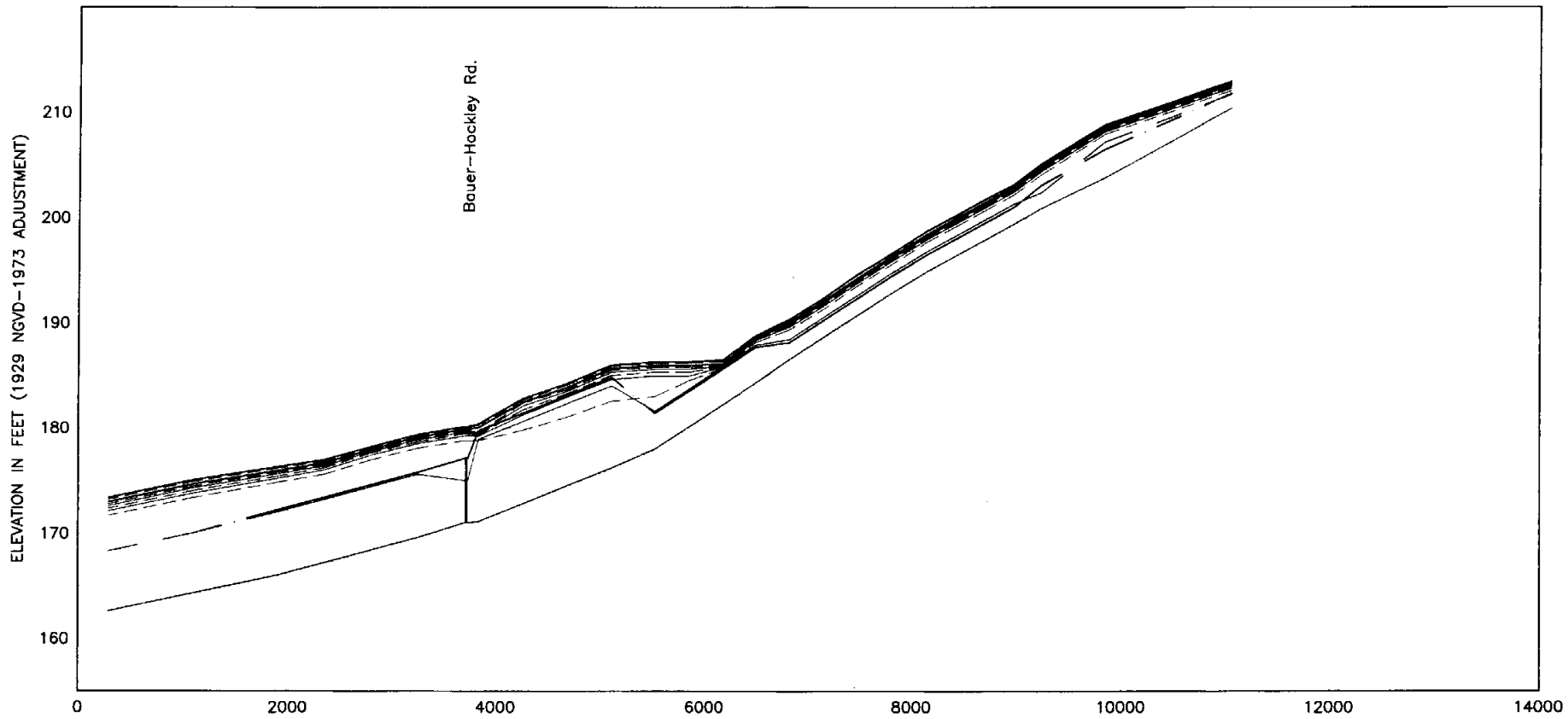


LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

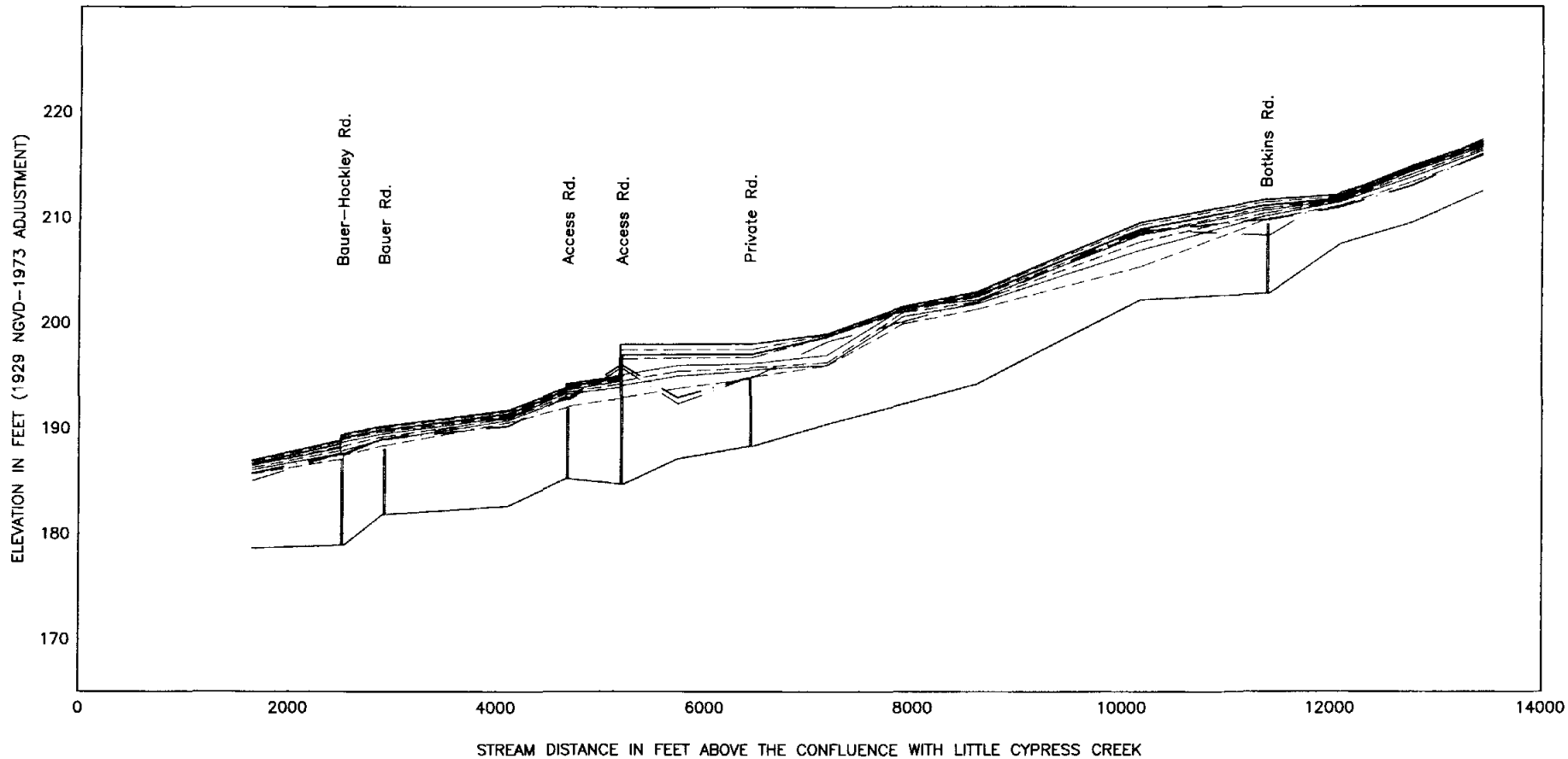
- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003	L112-00-00	EXHIBIT: A10-10



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

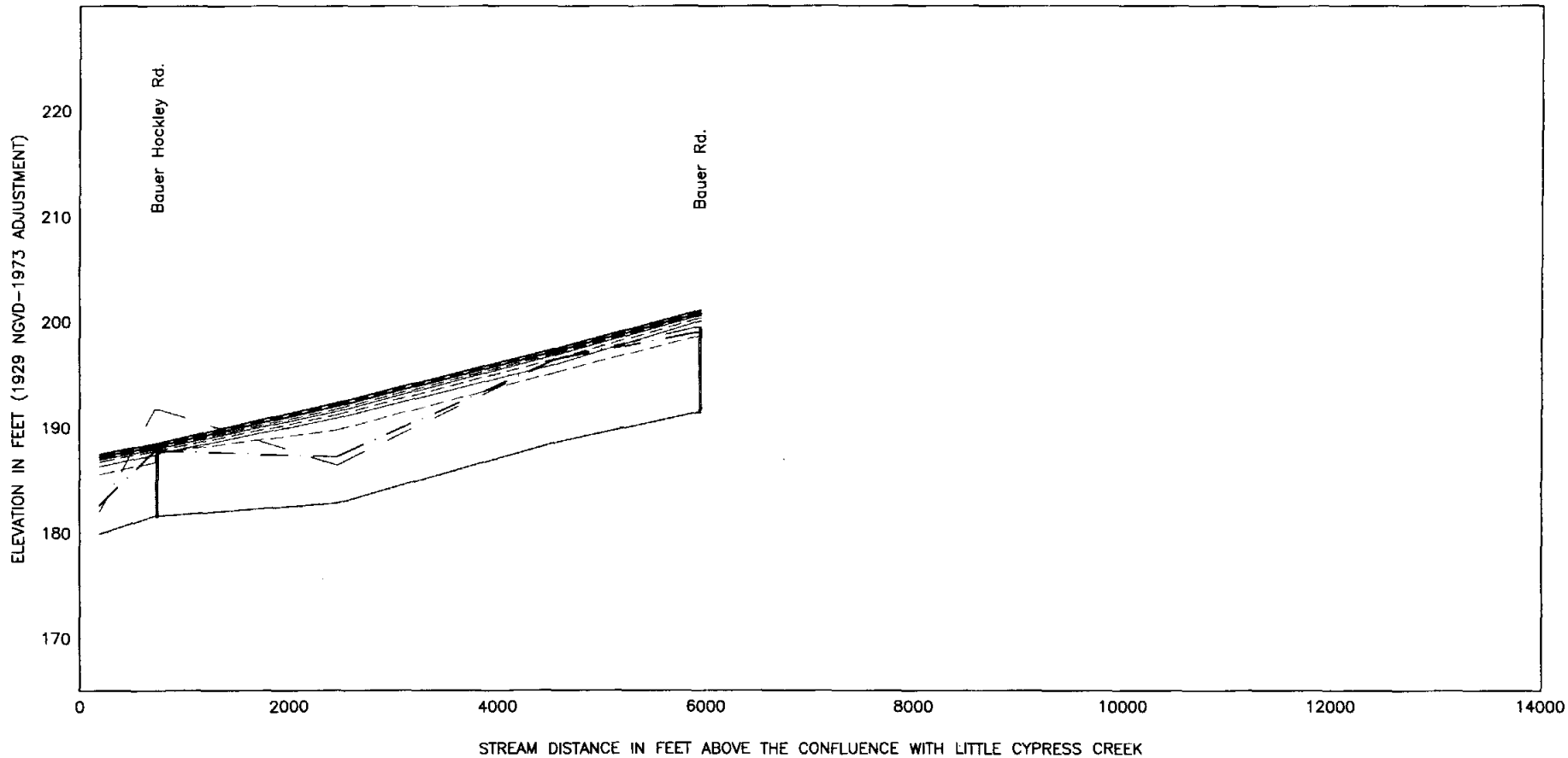
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003 | L114-00-00 | EXHIBIT: A10-11



LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

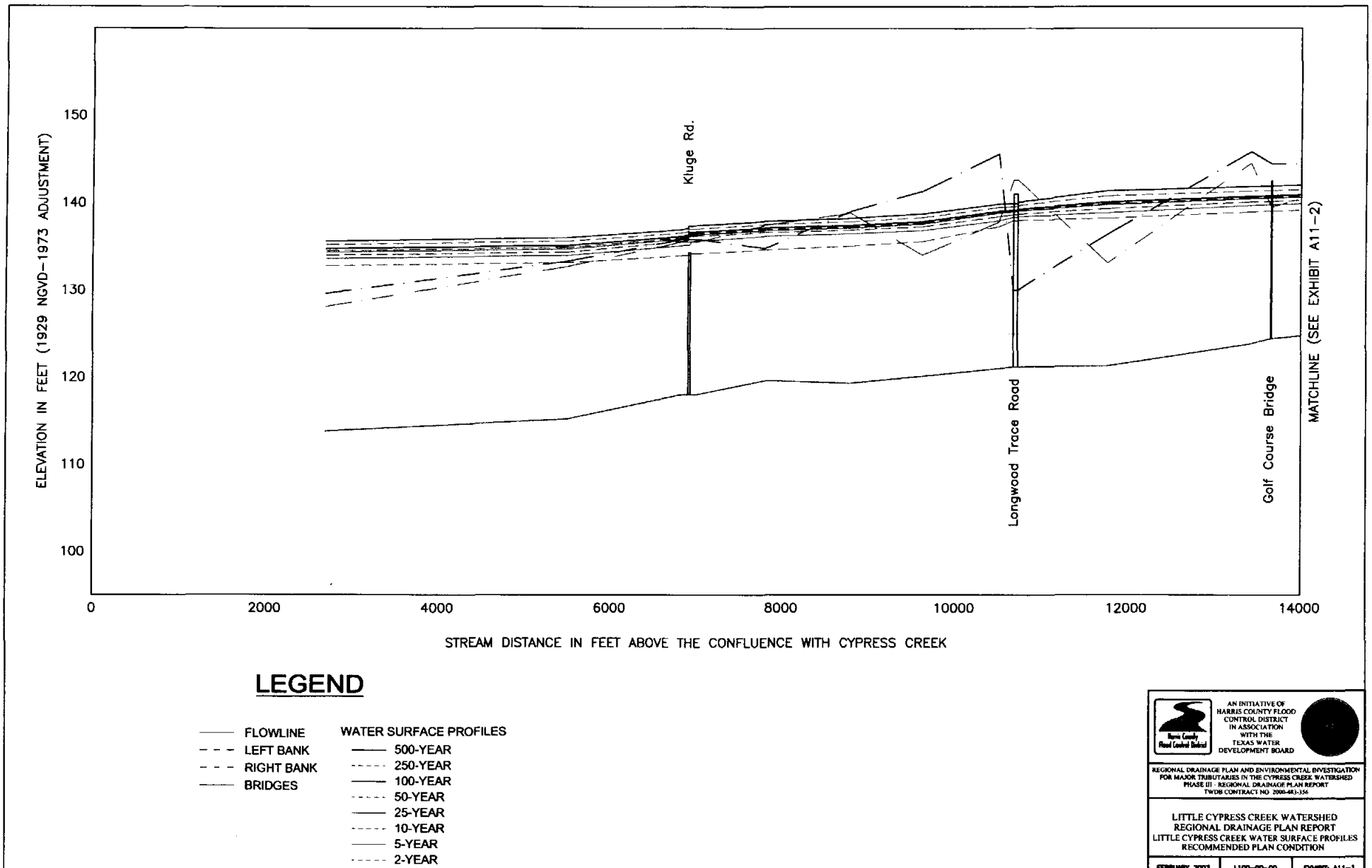
Harris County Flood Control District

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003	L114-01-00	EXHIBIT: A10-12



LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

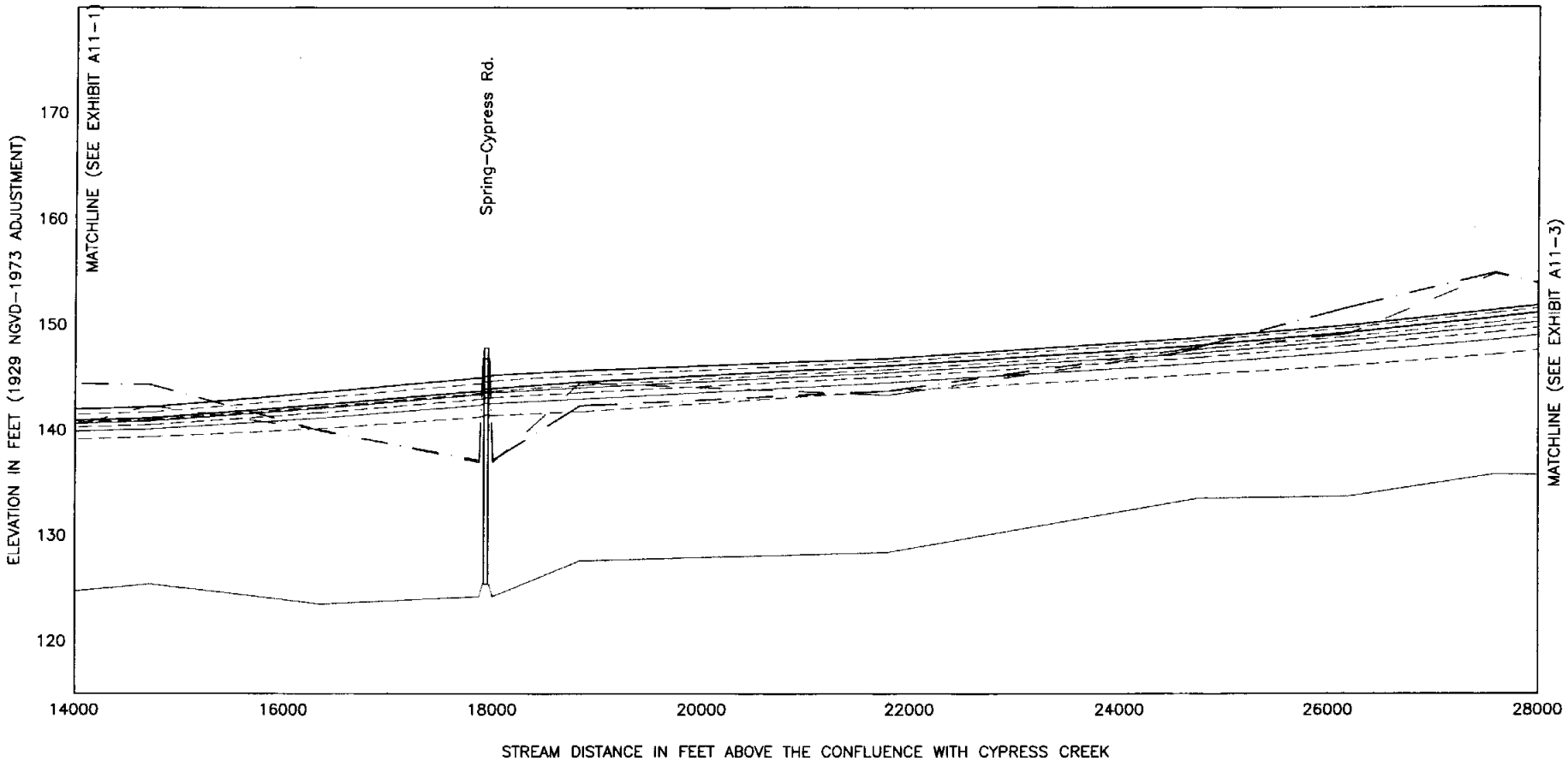
- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A11-1



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

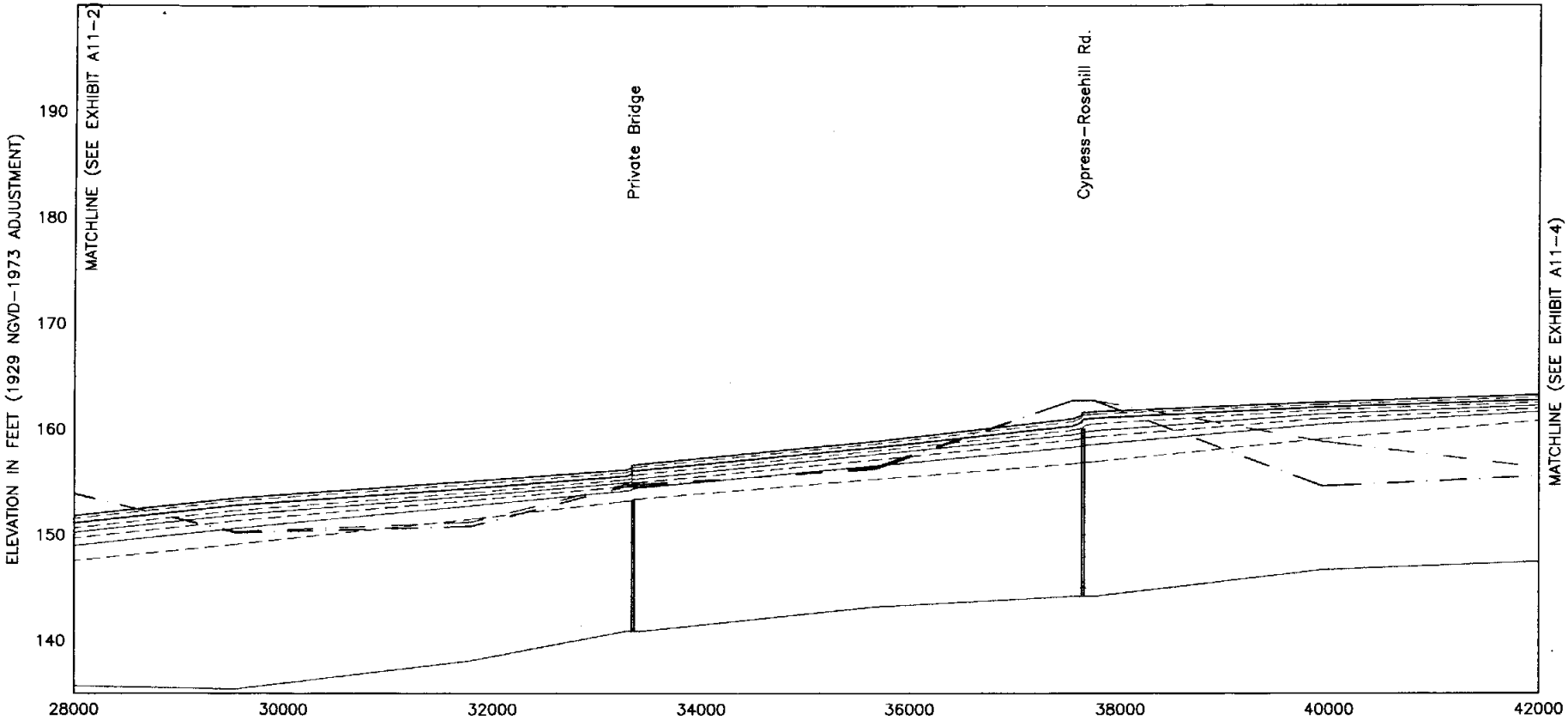
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003 | L100-00-00 | EXHIBIT: A11-2



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

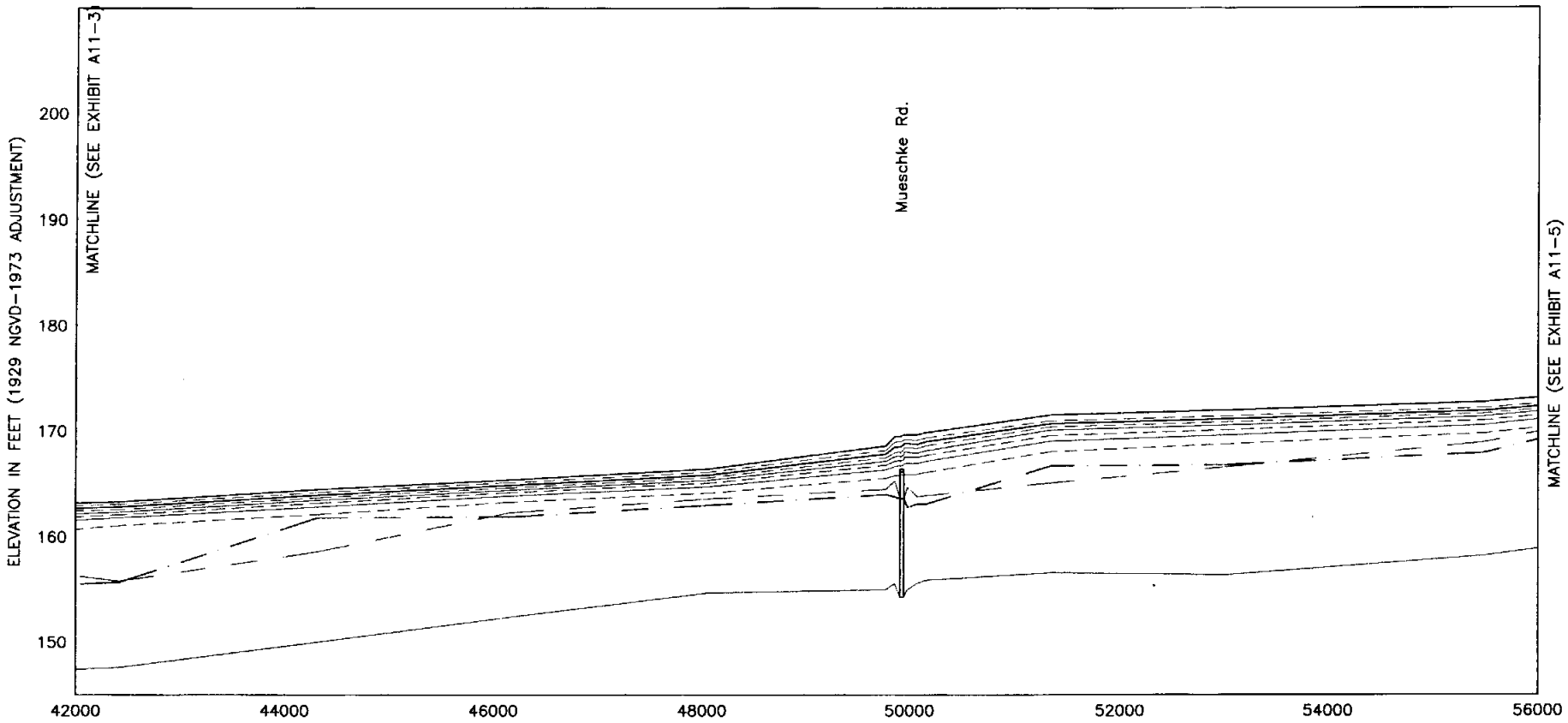
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A11-3



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

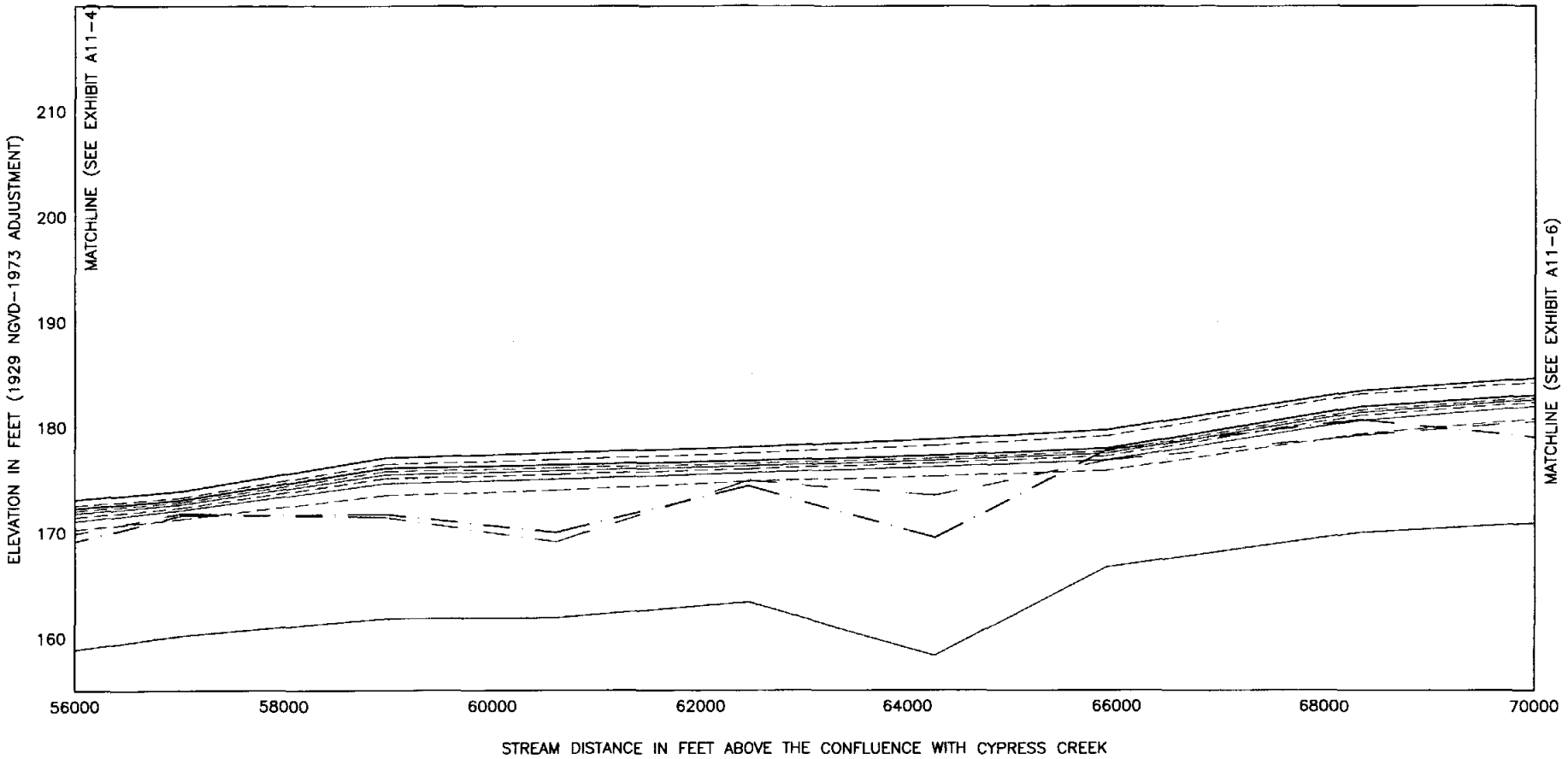
Harris County Flood Control District

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003 | L100-00-00 | EXHIBIT: A11-4



LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

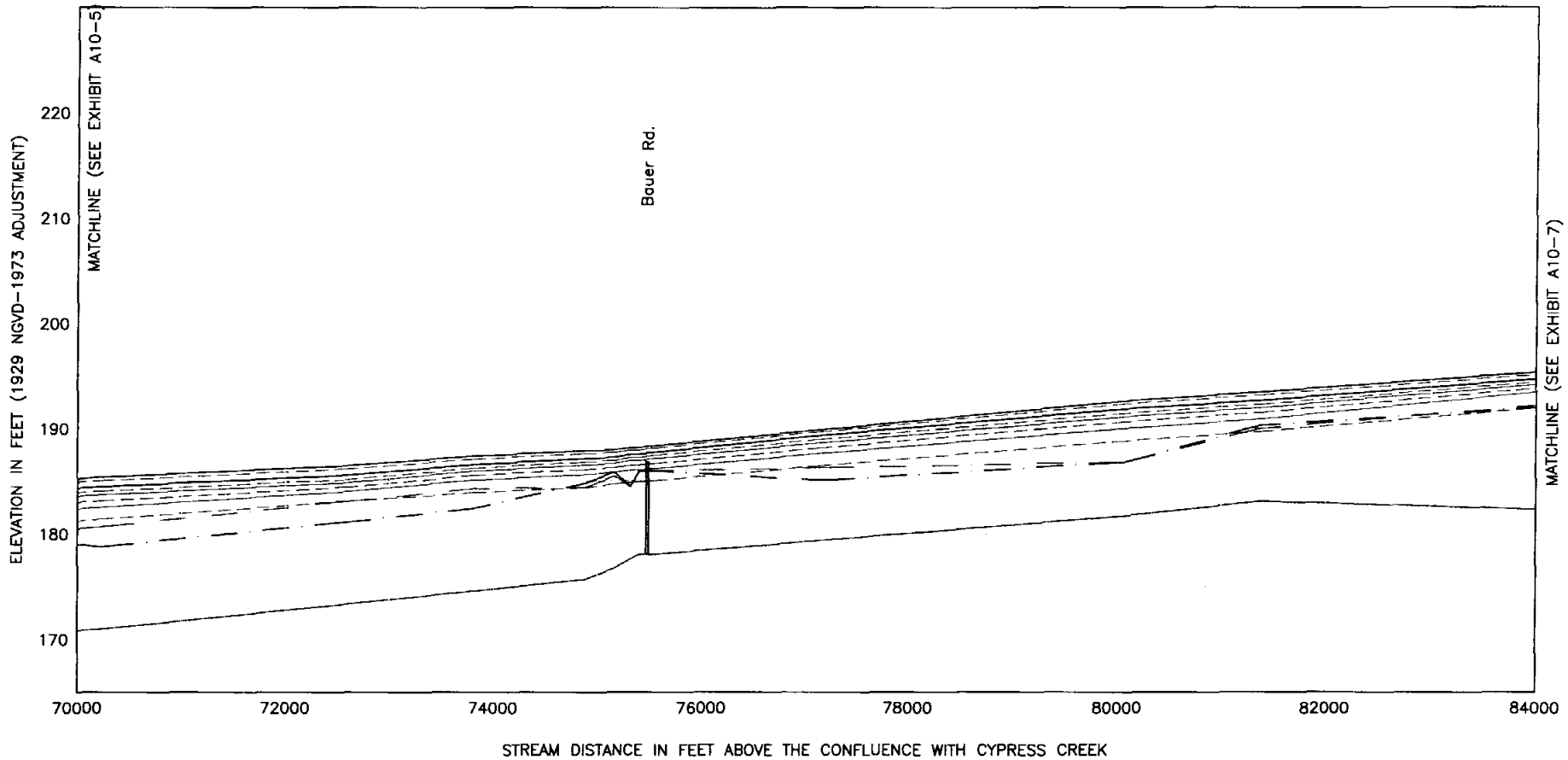
- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A11-5



LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

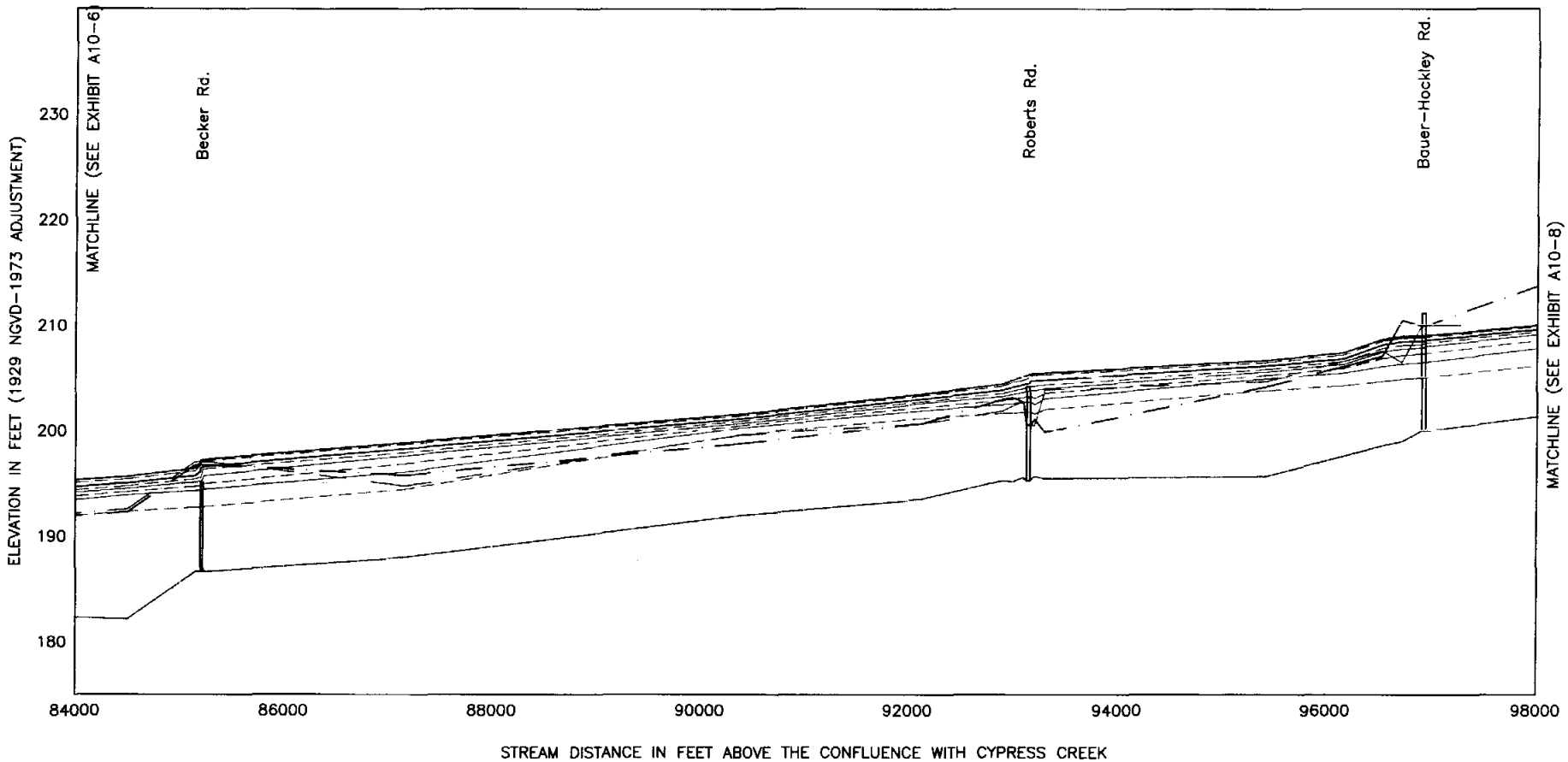
- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A10-6



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

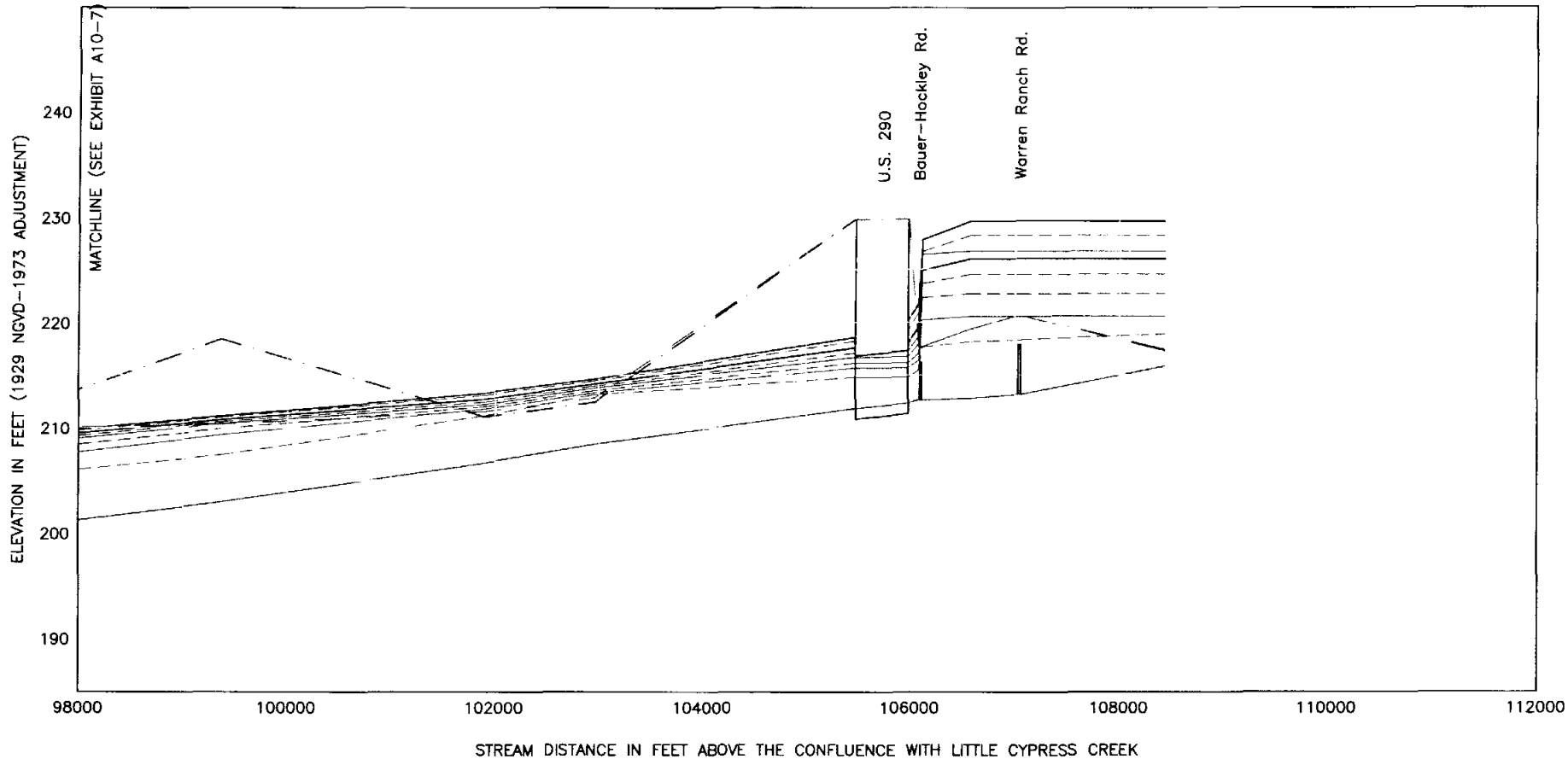
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003 | L100-00-00 | EXHIBIT: A10-7



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

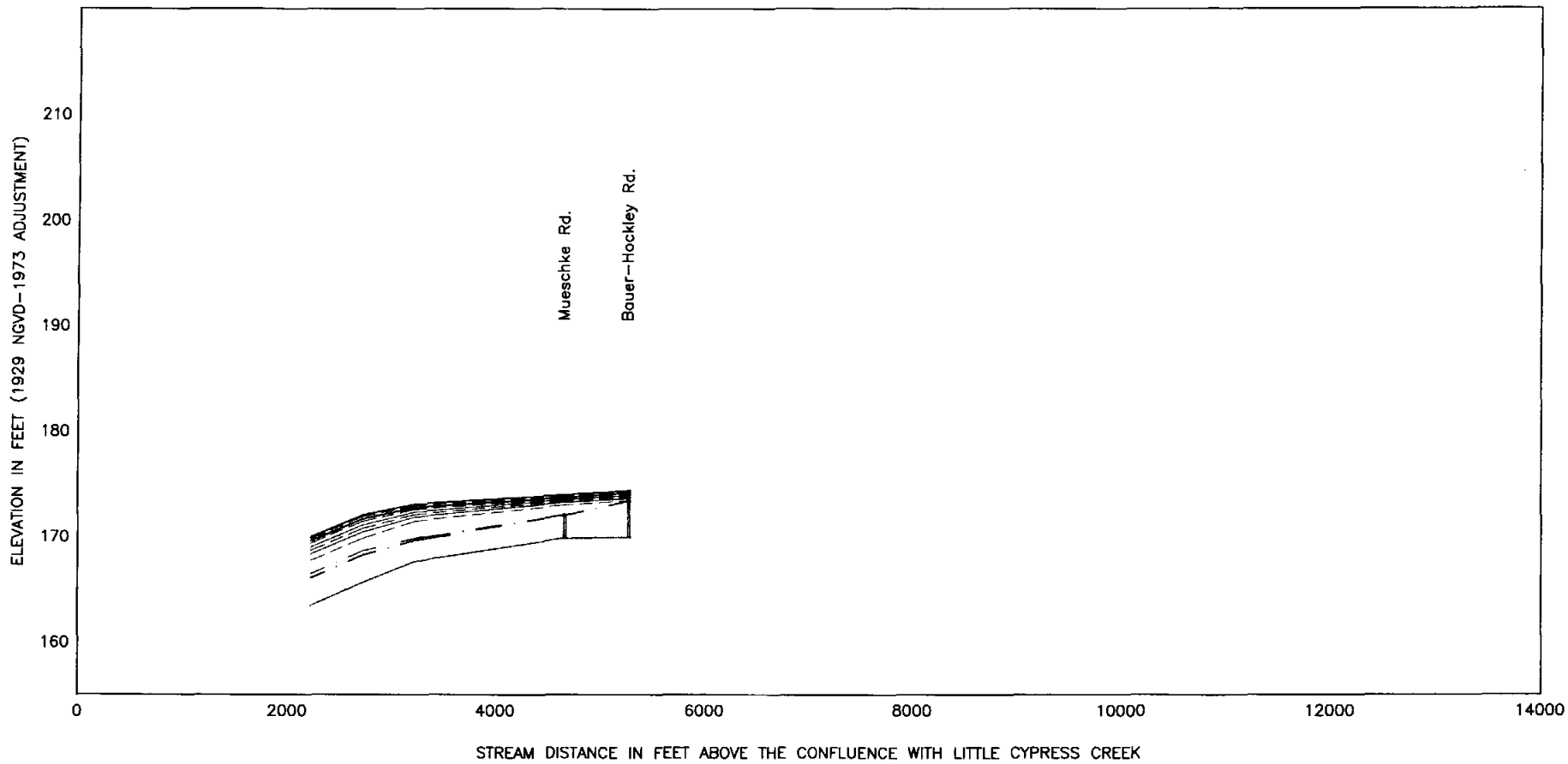
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A10-6



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

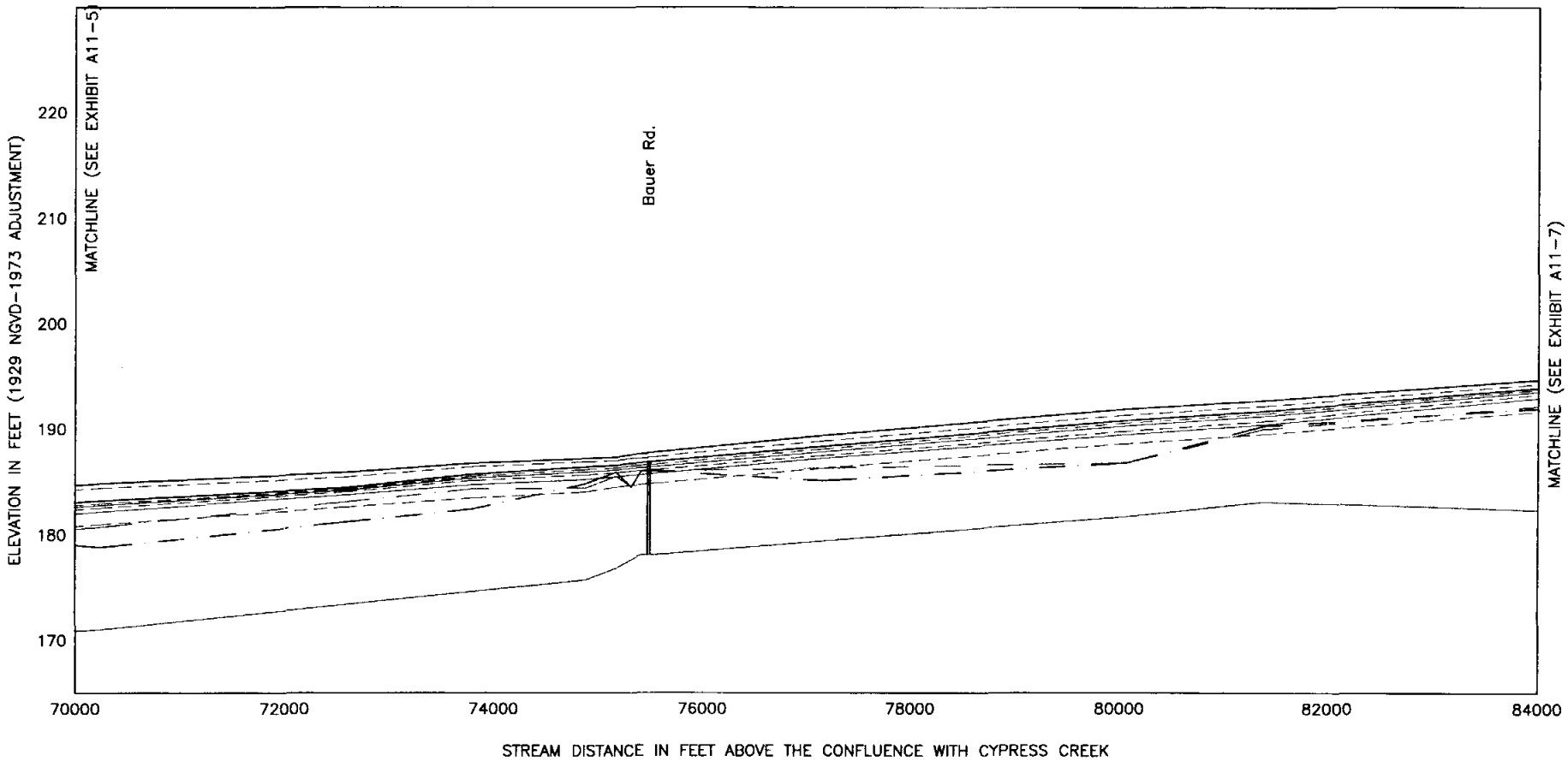
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-354

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
BASELINE CONDITION

FEBRUARY 2003 | L109-00-00 | EXHIBIT: A10-8



LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

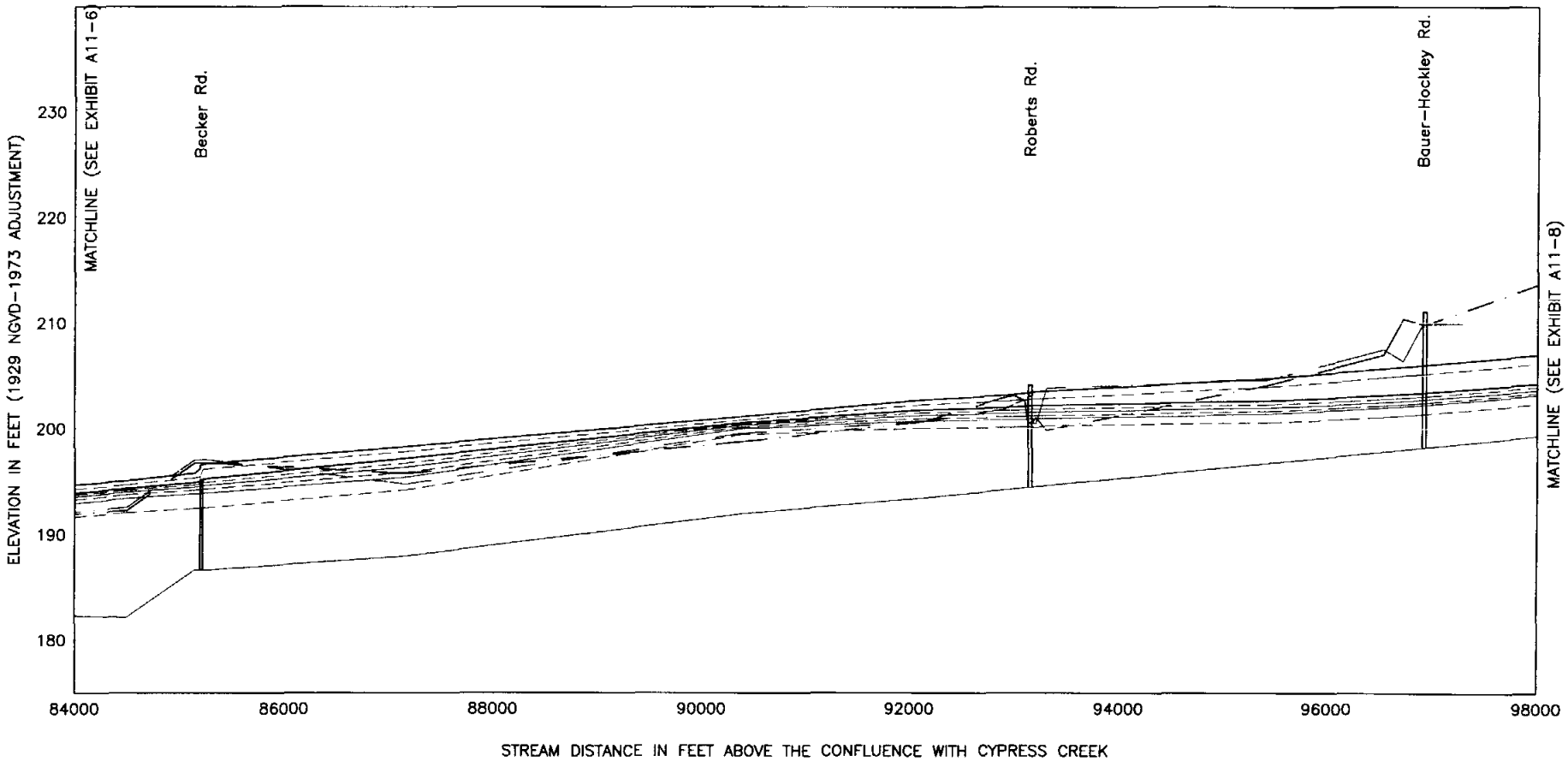
- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A11-6



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

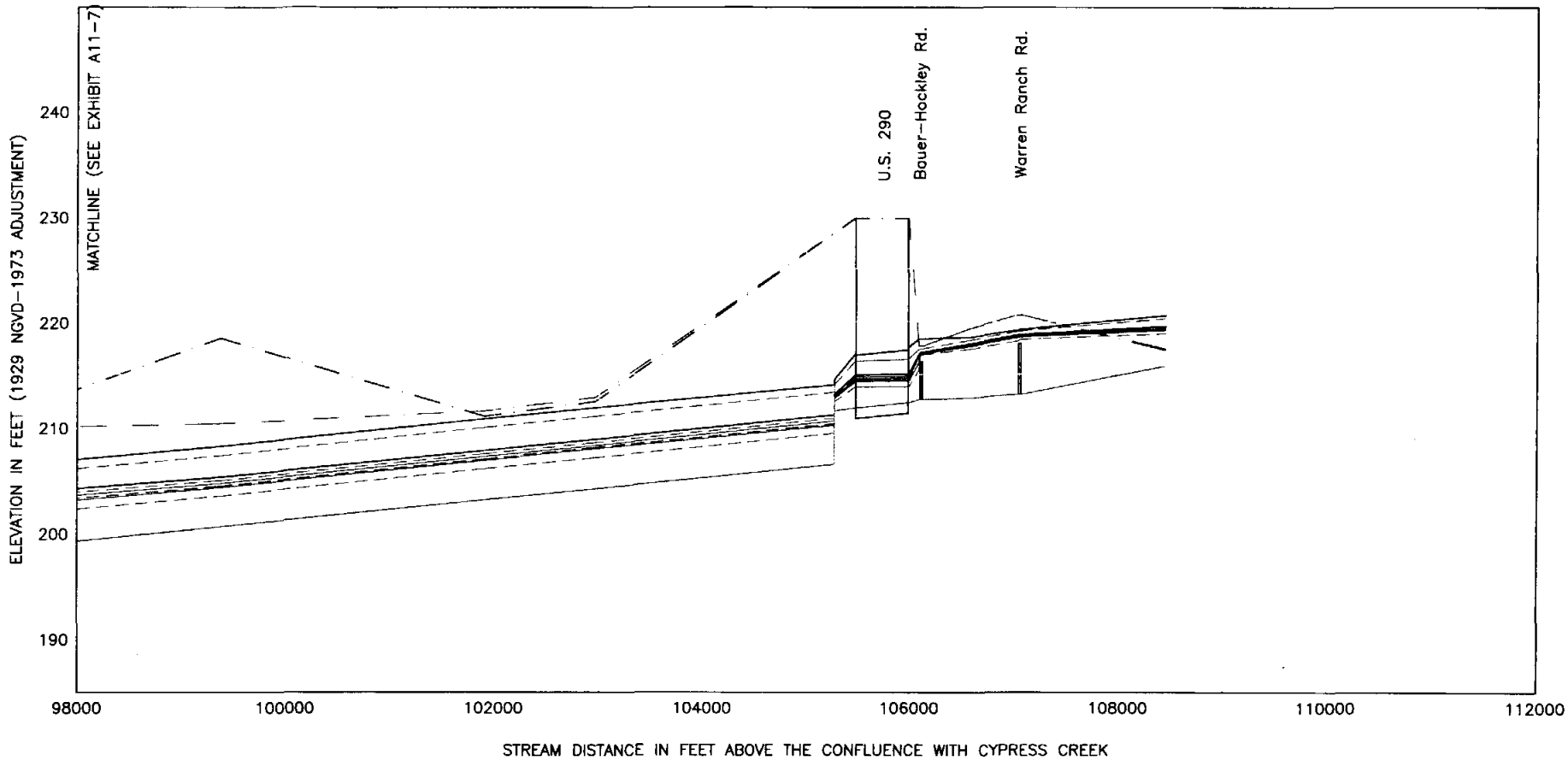
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-336

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A11-7



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

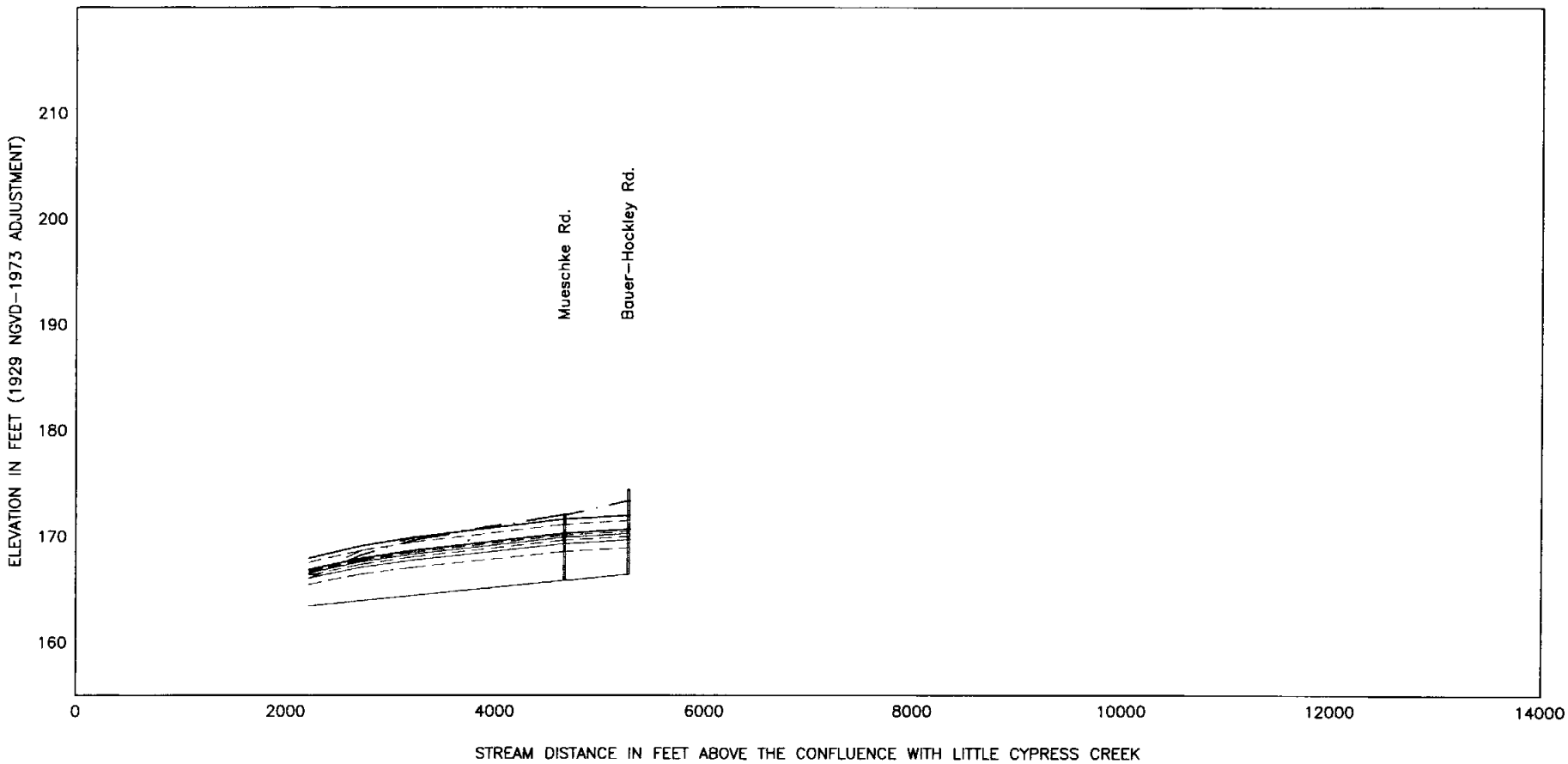
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L100-00-00	EXHIBIT: A11-8



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

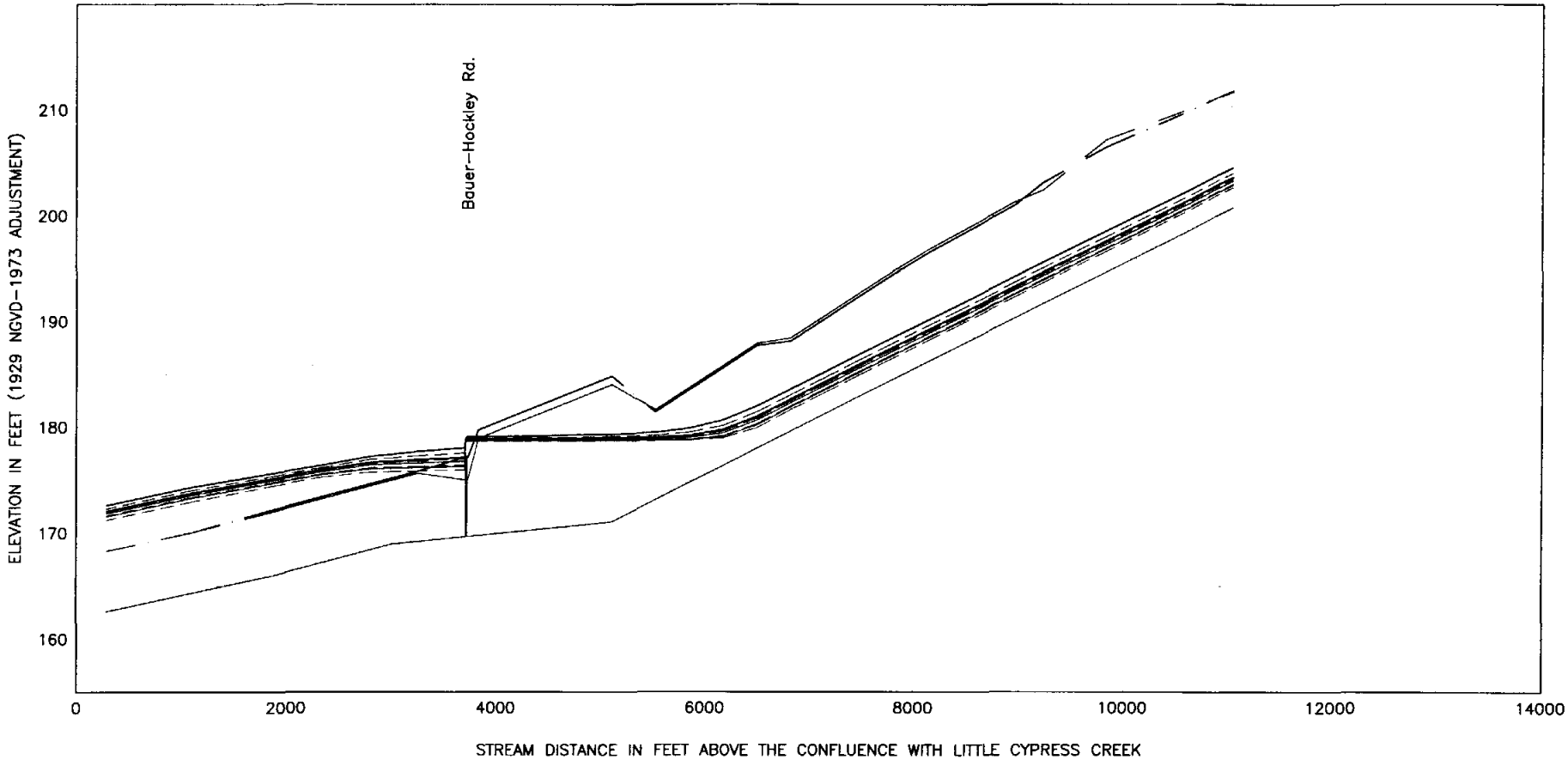
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-346

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L108-00-00	EXHIBIT: A11-9



LEGEND

- FLOWLINE
- LEFT BANK
- RIGHT BANK
- BRIDGES

WATER SURFACE PROFILES

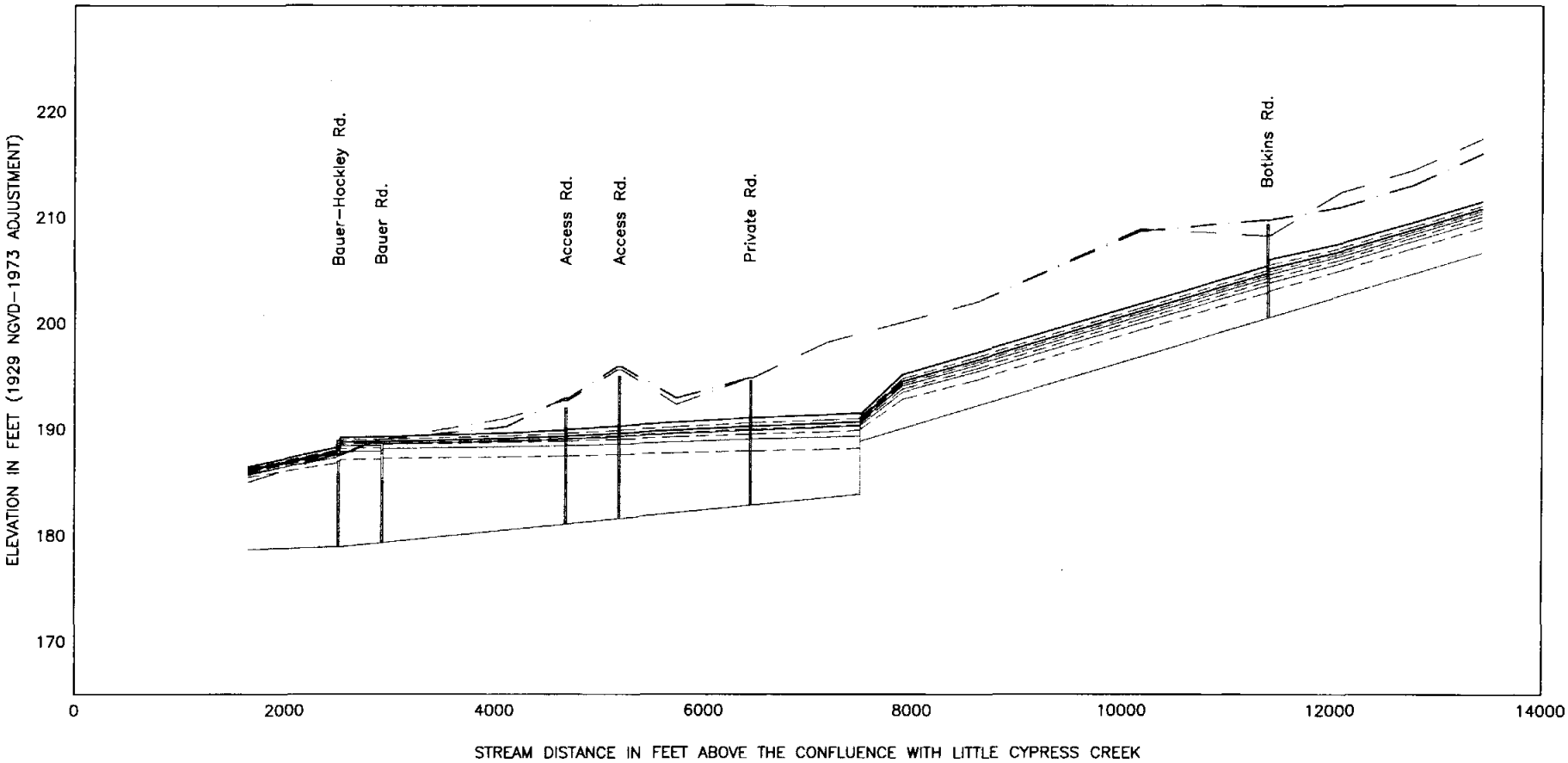
- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L112-00-00	EXHIBIT: A11-10



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

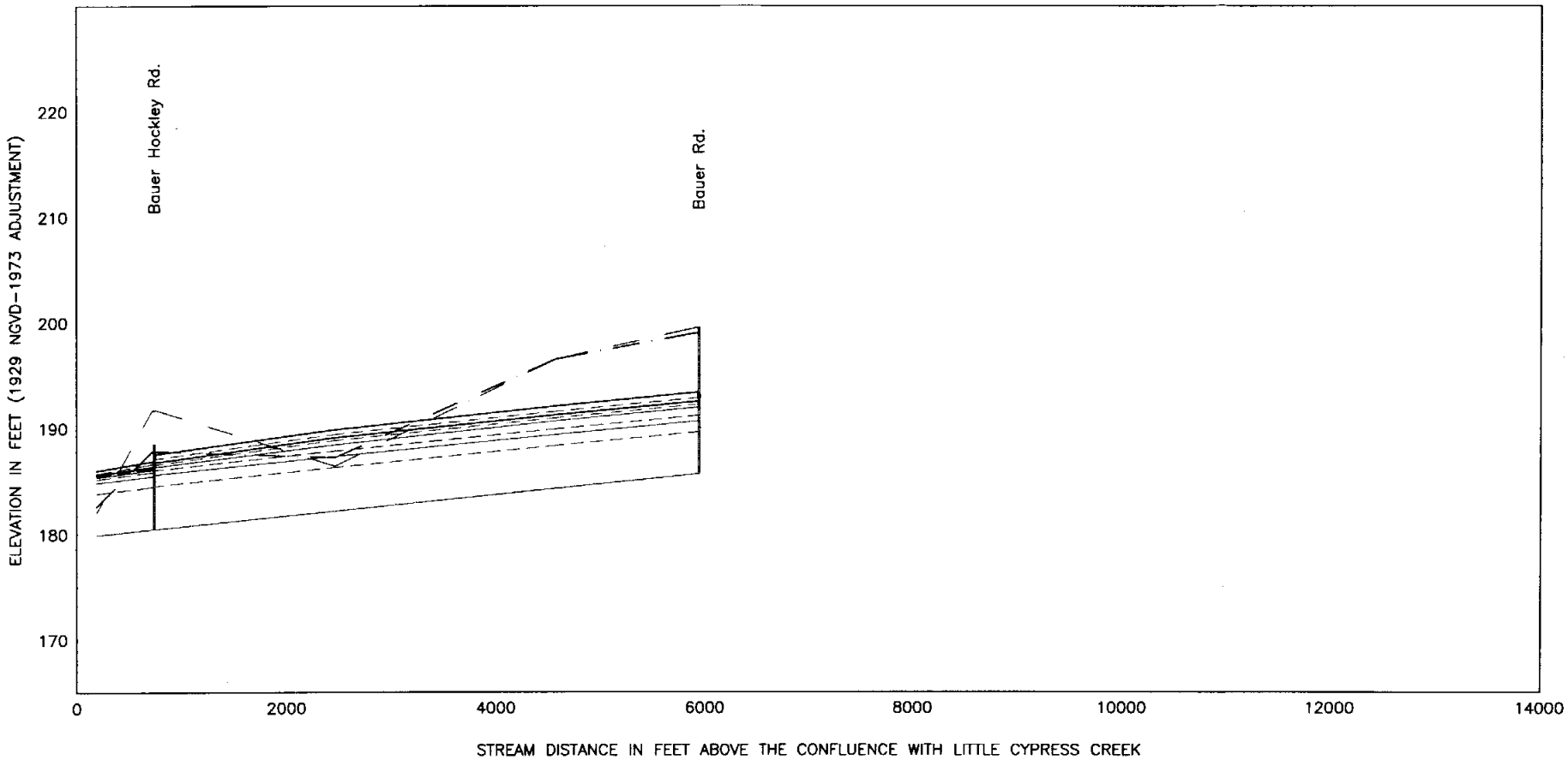
WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003	L114-00-00	EXHIBIT: A11-11



LEGEND

FLOWLINE
LEFT BANK
RIGHT BANK
BRIDGES

WATER SURFACE PROFILES
500-YEAR
250-YEAR
100-YEAR
50-YEAR
25-YEAR
10-YEAR
5-YEAR
2-YEAR

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-376

LITTLE CYPRESS CREEK WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LITTLE CYPRESS CREEK WATER SURFACE PROFILES
RECOMMENDED PLAN CONDITION

FEBRUARY 2003 | L114-01-00 | EXHIBIT: A11-12

TABLE OF CONTENTS

EXHIBITS

TABLES

DEFINITIONS

Baseline Conditions or Baseline Model - Conditions identified for the watershed from which future planning efforts and the recommended plan will be compared to determine if the study goals and objectives will be met. This condition considers the watershed 100% developed, with new development after 1984 consistent with current HCFCD criteria for on-site storm water detention in the determination of the appropriate baseline hydrologic processes. Further, this condition considers the information identified in the environmental baseline report.

Plan Conditions or Plan Model - The baseline conditions model modified to reflect the land-use conditions and recommended plan elements identified for the recommended regional drainage plan for the watershed.

ELECTRONIC FILES

File Name:	Description
HEC-1 Models:	
K120B02.ih1	Baseline Conditions 2-year Flows
K120B05.ih1	Baseline Conditions 5-year Flows
K120B10.ih1	Baseline Conditions 10-year Flows
K120B25.ih1	Baseline Conditions 25-year Flows
K120B50.ih1	Baseline Conditions 50-year Flows
K120B100.ih1	Baseline Conditions 100-year Flows
K120B250.ih1	Baseline Conditions 250-year Flows
K120B500.ih1	Baseline Conditions 500-year Flows
K120R2.ih1	Recommended Plan 2-year Flows

ELECTRONIC FILES *(continued)*

File Name:	Description
HEC-1 Models:	
K120R5.ih1	Recommended Plan 5-year Flows
K120R10.ih1	Recommended Plan 10-year Flows
K120R25.ih1	Recommended Plan 25-year Flows
K120R50.ih1	Recommended Plan 50-year Flows
K120R100.ih1	Recommended Plan 100-year Flows
K120R250.ih1	Recommended Plan 250-year Flows
K120R500.ih1	Recommended Plan 500-year Flows
HEC-RAS Models:	
K12000.prj	Project File—Lemm Gully
K12000.p03	Baseline Multiprofile Plan – Lemm Gully
K12000.p05	Recommended Multiprofile Plan – Lemm Gully
K12001.prj	Project File—Senger Gully
K12001.p03	Baseline Multiprofile Plan – Senger Gully
K12001.p07	Recommended Multiprofile Plan – Senger Gully
K12003.prj	Project File—Wunsche Gully
K12003.p03	Baseline Multiprofile Plan – Wunsche Gully
K12003.p07	Recommended Multiprofile Plan – Wunsche Gully

1.0 INTRODUCTION

The information presented in this appendix report intends to document the process of developing the recommended regional drainage plan for the Lemm Gully watershed. The plan elements identified for the recommended plan are presented, along with the recommended funding and implementation strategies identified for the plan. All supporting regional-plan modeling information for the Lemm Gully watershed is included in this report.

1.1 Project Location

The Lemm Gully watershed is located in northwest Harris County and is a subwatershed of the Cypress Creek watershed. A vicinity map of the watershed is provided in **Exhibit 1** of the main text report. The 7.7 square mile watershed drains in a southerly direction from IG&N Railroad north of Spring-Stuebner Road to Cypress Creek. As seen in **Exhibit B1** and **Exhibit B2**, the watershed is bounded by the IG&N Railroad and Spring-Stuebner Road on the north, Seals Gully watershed on the west, Hardy Road on the east, and Cypress Creek on the south. The mainstem of Lemm Gully crosses Spring-Stuebner Road, FM 2920, Spring-Cypress Road, Louetta Road, and Cypresswood Drive and has a studied length of approximately 3.1 miles to the mouth at Cypress Creek at Cypress Creek Node #18.

1.2 Background Information

HCFCD intends to prepare a storm water management and flood protection plan for nine tributary watersheds located within the Cypress Creek watershed. The Lemm Gully watershed is one of the nine watersheds. Several studies have been conducted within the Lemm Gully watershed at varying levels and are identified in Appendix B of the February 2002 *Regional Drainage Plan and Environmental Investigation for Major Tributaries in the Cypress Creek Watershed, Phase I – Hydrologic and Hydraulic Baseline Report.*

The baseline watershed boundary is shown on **Exhibit B1,** with the existing development conditions shown on **Exhibit B2**. The information identified on these exhibits was generated as part of the Phase I study efforts, and was used to assist in the identification of the appropriate regional drainage plan for the Lemm Gully watershed.

An assessment of the environmental baseline conditions of the Lemm Gully watershed was prepared as part of the Phase II – Environmental Baseline Report study efforts. The information presented in this report was used to help identify the recommended regional drainage plan and appropriate plan elements for the watershed. Environmental considerations for the Lemm Gully watershed are shown on **Exhibit B3**.

1.3 Flood Hazard

Flood hazards along Lemm Gully for which existing model information was available were identified for the baseline conditions. These flood hazards were identified by modifying the current effective hydrologic models for the watershed to reflect appropriate baseline land-use conditions, with the resulting storm flows incorporated into the appropriate hydraulic model reflecting the current conditions of the channel system. The one-percent storm flood profile information resulting from the hydraulic model was used in conjunction with existing digital terrain model produced from LIDAR-obtained ground elevation information to produce a flood-hazard boundary map.

1.4 Summary of Baseline Conditions

The results of the study efforts for identifying the baseline conditions indicate that the 1% storm flood boundary is different from the current effective Federal Emergency Management Agency regulatory flood boundary. This is predictable since updated information about the watershed and its studied streams has been used in the identification of the baseline conditions. The information prepared in the identification of the baseline conditions flood hazards and environmental baseline conditions is suitable for use in identifying the appropriate regional drainage plans.

2.0 REGIONAL DRAINAGE PLAN FORMULATION

The objectives of this Phase III study are to develop Regional Drainage Plans to guide future development of the watershed and to address existing flooding issues. The sections below detail the methodology of the plan formulation steps, the watershed resources and alternate plans developed for the Lemm Gully watershed.

2.1 Methodology

The formulation of a regional drainage plan utilized an approach that considered the information prepared as part of the Phase I and Phase II study efforts. Further, information concerning the proposed major roadway thoroughfare alignments was also used to guide the location of proposed lateral channels that could serve as outfall drainage for these roadways. A series of public meetings and coordination through advisory committee meetings helped in providing direction for identifying a recommended plan.

Hydrologic and hydraulic models prepared as part of the baseline study effort were modified appropriately to reflect alternative plans for the watershed. Alternative plans were identified and the results measured against each other to determine which project configuration represented the best plan for the watershed.

2.2 Watershed Description

The study area of Lemm Gully is part of the Cypress Creek drainage basin. The Lemm Gully watershed drains an area of approximately 7.7 square miles in northwest Harris County in a southerly direction from Stuebner-Airline Road to Cypress Creek with a total drainage length of 3.1 miles. The entire watershed is in the unincorporated areas of Harris County.

The watershed generally has a southern overland slope averaging over 20 feet per mile. The natural ground in the watershed is highest in the vicinity of Stuebner-Airline Road and Wunsche Gully in the northern portion of the watershed at approximately 136 feet above mean sea level. The lowest point in the watershed can be found at the area by the confluence of Lemm Gully and Cypress Creek with an elevation of approximately 85 feet above mean sea level.

Due to the influence of the freeway dividing the watershed, development within the watershed tends to be scattered and mixed in classification. The development in the middle part of the watershed, along I-45, is mostly commercial and industrial. The residential development tends to be in the western and eastern portions of the watershed. The mid-region of the watershed provides the areas for future development. The watershed development patterns can be seen in **Exhibit B2**.

This analysis used the baseline conditions model and modified, accordingly, the hydrologic parameters of each subarea to reflect alternative plan conditions. Where necessary, a baseline condition subarea was further subdivided in order to more accurately model particular plan elements. The Lemm Gully watershed subareas can be described as follows:

- K120A – Upstream subarea of the Lemm Gully (725 acres)
  Includes areas upstream of Wunsche Gully along Lemm Gully.
- K120B – Downstream subarea of Lemm Gully (986 acres)
  Includes areas downstream of Wunsche Gully along Lemm Gully to the Cypress Creek confluence.
- K12003A – Upstream subarea of Wunsche Gully (597 acres)
  Includes areas upstream of I-45 along Wunsche Gully.
- K12003B – Downstream subarea of Wunsche Gully (546 acres)
  Includes areas along Wunsche Gully between I-45 and its confluence with Lemm Gully
- K12001A – Upstream subarea of Senger Gully (1503 acres)
  Includes areas along Senger Gully upstream of Louetta Road.
- K12001B – Downstream subarea of the Senger Gully watershed (611 acres)
  Includes areas along Senger Gully between Louetta Road and its confluence with Lemm Gully near the watersheds outfall to Cypress Creek.

The confluence of Lemm Gully and Cypress Creek (HCFCD Unit K100-00-00) is located between Interstate 45 and Hardy Road. The Lemm Gully subareas, routing node location and station, and sub-basin names are shown on **Exhibit B2.**

2.2.1 Stream Identification

The main stem of the watershed is Lemm Gully (K120-00-00). The main tributaries to Lemm Gully are Senger Gully (K120-01-00) and Wunsche Gully (K120-03-00). Senger Gully drains the western portion of the watershed. It crosses FM 2920, Spring-Cypress Road, Louetta Road, Cypresswood Drive, and Interstate 45 before its confluence with Lemm Gully just upstream of Cypress Creek. Wunsche Gully drains the northern portion of the watershed. It crosses Spring-Stuebner Road, Interstate 45, Spring-Cypress Road, and Louetta Road before its confluence with Lemm Gully upstream of Cypresswood Drive. The main stem, Lemm Gully, drains the eastern portion of the watershed. It crosses Spring-Stuebner Road, Spring-Cypress Road, Louetta Road, and Cypresswood Drive before its confluence with Cypress Creek just downstream of Senger Gully.

2.3 Basin Resource Inventory

Information was obtained for the watershed concerning existing and planned land use, transportation facilities, structure values and economic investment, floodplains, environmental

resources, geology and soils, etc. This information was used to develop a general understanding of the natural resources, area development, and economic investment necessary to identify the problems and needs of the watershed and how best they should be considered in the overall planning efforts.

2.3.1 Stream Habitat Quality

The Environmental Baseline Report (EBR) qualitatively established stream habitat quality rankings based upon characteristics of the stream channel such as channelization, vegetation, and urban density. The ranking system is shown in the EBR and was based solely on color infrared aerial photos and local knowledge of the streams. The stream quality designations are shown on **Exhibit B3**. The goal of the regional drainage planning effort was to attempt to preserve areas of high stream quality in order to enhance the environmental benefits of the plan.

Areas of high-quality stream habitat were identified within the Lemm Gully watershed, in the downstream reach of Lemm Gully south of Louetta Road near the confluence with Cypress Creek. Short stretches of medium-quality habitat areas were identified in the upper middle reaches of Senger Gully, mid-reach of Wunsche, and in the upstream areas of Lemm Gully. Several other reaches have been identified as medium and high-quality habitat areas; however, these areas have since been rectified. The watershed streams are mostly low-quality habitat due to rectification.

2.3.2 Land Uses in the Watershed

A land use inventory of the watershed was performed using the Harris County Appraisal District (HCAD) real property database. Aerial mapping and field investigations were used to confirm land uses in the area. The watershed is primarily residential with some commercial/industrial, and public (schools, churches, open spaces) land uses. It shows that existing development in the watershed is approximately 37 percent.

Approximately 26 percent of the land use in the watershed is residential. This is largely single family. Less than 20 acres of land is used for multi-family residences. Commercial land use includes businesses and some industries although industries constitute less than 13 percent of the commercial/industrial category. Commercial land use in the watershed is currently limited to approximately 6 percent. Public land uses include schools, churches, fire and police, stations, utilities, golf courses, and recreational open space. This constitutes approximately 6 percent of the land use in the watershed with most public property (1 in 3) being places of worship. A map of land uses in the watershed can be seen in **Exhibit B3**.

2.3.3 Structure Inventory

An inventory of structures that might be affected by flooding along the main stem was performed. The purpose of the inventory was to identify and estimate the economic value or benefit if the structures were either removed or protected from flooding by the regional plans. In the Lemm Gully watershed, approximately 169 structures were identified that might be affected by flooding from the main stem and tributaries. The general location of these structures is shown on **Exhibit B4**. In order to estimate the value of these structures, a search of the Harris County Appraisal District (HCAD) records was performed using a GIS file supplied by HCFCD. The total structure (improvements) value of these structures was estimated by HCAD to be approximately $23,000,000.

2.3.4 Economic Factors for the Watershed

The Lemm Gully watershed is typical of the tributary watersheds in the lower portions of the Cypress Creek watershed. The development within the watershed is mostly residential. The remaining undeveloped areas will lend to more residential development. The pressure for development will require the extension and development of the tributary network within the watershed. Although current development regulations are written to ensure that new structures are not place in areas without adequate flood protection, there are numerous structures currently located in flood-prone areas. There are also several documented flood damaged structures. Therefore, structural damage prevention is an economic factor within the Lemm Gully watershed.

2.4 Problems and Opportunities Identification

The flood hazard information identified in the Phase I study efforts was used to determine the areas within the watershed most susceptible to out-of-bank flooding. Additionally, opportunities for enhancement of the watershed through the reduction of existing flooding and preservation of environmental features in the design of the regional plans were identified.

2.4.1 Economic Flood Damage Analysis

In the Lemm Gully watershed, 169 structures were identified as structures likely to suffer economic damage to structure and content during a 100-year event at a cost of approximately $6.4 million. The general location of these structures is shown on **Exhibit B4**. The specified dollar amount will be the likely benefit of any plan implemented that eliminates the out-of-bank 100-year floodplain.

An economic analysis was carried out for a 50-year period with a probable start date of 2010. Using the federal interest rate for fiscal year 2002 of 6.125 percent, it is expected that average annual equivalent damages to structure and content in the watershed will be approximately

$1.9 million if the current (baseline) drainage conditions remain unchanged. $525,000 of the annual damages is attributed to Lemm Gully flooding while Senger Gully flooding is expected to produce $268,000 annual economic damage. Flooding from Wunsche Gully is expected to result in up to $1.1 million in economic damage.

2.4.2 Identification of Flood-Prone Areas

As shown on **Exhibit B4**, flood prone areas can be seen to occur mostly in the lower downstream reaches of the watershed. Several areas were identified along Lemm Gully downstream of Cypresswood Drive, along Senger Gully upstream of Interstate 45, along Senger Gully upstream of Cypresswood Drive, and along Wunsche Gully downstream of Interstate 45.

2.4.3 Summary of Public Comments Received

Three public meetings have been held to discuss this project, and public comment on existing drainage problems, plan alternates, and the recommended plan have been solicited. A summary of public comments received regarding the Lemm Gully watershed is shown below.

First Public Meeting (August 2001)
No comments were received for Lemm Gully watershed during this first public meeting.

Second Public Meeting (October 2002)
Three (3) comments were received for Lemm Gully watershed during this second public meeting. These comments were in reference to the plan alternatives related to the voluntary acquisition of homes within the floodplains.

Third Public Meeting (April 2003)
One comment was received indicating a general acceptance of the plan as identified for the watershed.

2.4.4 Summary of Repetitive Flood Loss Data

Databases containing records of flooded structures and flood insurance claims were obtained from FEMA. They contained records obtained for events up to and including Tropical Storm Allison in 2001. Historically flooded properties on record were geo-coded and their approximate locations are shown in **Exhibit B4**. Several structures were identified within the subdivision North Hill Estates subdivision along Lemm Gully, Enchanted Oaks and Devonshire Woods subdivisions along Senger Gully, and other scattered locations along Senger and Wunsche Gullies.

2.4.5 Opportunities for Watershed Enhancement

This drainage study presents an opportunity to provide for future dual-use facilities such as parks and sports fields that also serve as detention facilities and preserve any areas for environmental conservation. The downstream end of Lemm Gully near its confluence with Senger Gully and Cypress Creek is a prime example of environmental preservation to maintain the high-quality stream habitat. The location of outfall channels and detention ponds to serve future development provide opportunities for multiple uses such as parks. The hike-and-bike trail system can be a potential multiple-use aspect of new or improved channels.

There are not many areas remaining within the watershed that may be beneficial to preserve and enhance in order to benefit the community. However, at the confluence of Senger Gully and Lemm Gully near Cypress Creek, there is a prime example of a high-quality stream habitat that could be designated as an environmental preservation area.

2.4.6 Identification of Major Thoroughfare Outfalls

The major roads through the watershed are shown in **Exhibit B5**. A future project, the proposed Sawmill Road, will provide an additional north-south corridor in the western section of the watershed from Holsworth Road north to The Woodlands. Many of the roadways within the watershed have recently been expanded or extended including Lexington Road, Cypresswood Drive, and Louetta Road.

2.4.7 Storm Water Quality Issues

As part of new regulations enacted by Harris County in October 2001, all new development that outfalls into Lemm Gully will be required to provide storm water quality protection for the outfall drainage. This includes roadway projects, subdivisions and other development of five acres or more. The regional plans evaluated as part of this project are planned to provide general water quality benefits, as will be discussed later, but do not specifically address individual developments or roadway projects. Additional storm water quality features will have to be designed for these projects in order to comply with the new effective regulations.

2.5 Alternate Drainage Plan Formulation

A series of alternative drainage plans were formulated for the Lemm Gully watershed. The formulation of the alternative plans was performed towards the achievement of stated goals and objectives identified for the study effort. The general objectives include the alleviation of existing drainage problems and the construction of a plan to provide the necessary drainage infrastructure for future roadways and development that the watershed may incur. Also within the objectives is applied a consideration of the environmental concerns as well as provisions for

multi-use facilities that could, in addition to flood control, provide other benefits such as recreation and aesthetics.

Generally, plan formulation alternatives for the watershed were developed by considering elements that include channel modifications alternatives, detention alternatives, and non-structural and "no-action" alternatives. The principal components of each alternative scenario included a single opportunity for each reach or a combination of these opportunities, especially in the consideration of multi-use facilities. The following section presents a description of each alternative investigated and its benefits to the Lemm Gully watershed.

2.5.1 Common Features to Alternate Plans

As mentioned many of the plan elements may provide a multi-use. Emphasis was placed on preserving areas of high-quality stream habitat as well as to provide a flood control facility. Where new channels (or channel extensions) have been recommended, the channel design is based on a wider, more aesthetic multiple-use section. This section has flat side slopes and large benches for vegetation and recreational usages. This section also tends to ensure less maintenance and results in less erosion potential. A typical cross-section of this channel is shown in **Figure 1** of the main text report. Where a detention basin has been recommended, the basin will be based on a multiple-use design. A typical layout of a detention basin is shown in **Figure 2** of the main text report.

For the analyses, a standard design for the multiple-use channel section will consist of conveyance and storage element sections. The conveyance element will consist of a meandering vegetated channel section. The channel will be approximately four feet deep with a 6-foot bottom width. The storage element will consist of a 100-foot side bench section, within which the channel shall meander. The bench section will be approximately 6 feet deep and have a minimum of 8:1 side slopes. The bench section will also have a multiple usage emphasis. A 30-foot wide maintenance berm is reserved on either side of the banks. This typical multiple-use channel design calls for a 300-foot wide waterway corridor.

For all the proposed alternatives, Wunsche Gully is proposed as a waterway corridor upstream of Interstate 45 and a floodplain and stream habitat preservation area is proposed at the confluence of Senger and Lemm Gullies. Upstream of Interstate 45, Wunsche Gully is proposed as 300-foot wide waterway corridor. The channel will run from upstream of Interstate 45 to Spring-Stuebner Road, an approximate length of 5700 feet. This component is designed to provide outfall depth for potential new development and roadways within the subarea and to remove the large out-of-bank floodplain that currently exist along the channel. The channel corridor will also provide storage to mitigate any impacts due to the removal of the floodplain. The channel will require the construction of a culvert control structure at its downstream end.

A stream corridor for floodplain/ stream habitat preservation area has been proposed at the confluence of Senger Gully and Lemm Gully for each of the alternatives. This area has been identified as having high-quality stream habitat along Senger and Lemm Gullies.

The current regulations requiring storm water detention to serve new development are assumed to remain in place for this analysis, unless otherwise noted. The plans described below provide benefits in addition to the on-site requirements. Each alternative plan elements are shown on **Exhibit B6.**

2.5.2 Alternate 1 Features and Benefits

Alternate 1 features are shown on **Exhibit B6.** Alternative 1 consists of the Wunsche Gully channel corridor and the floodplain/ stream habitat preservation area to fulfill the analysis goals. This plan provides benefits in reducing peak flows along Wunsche Gully and Lemm Gully within the watershed. The table below shows the peak flows at each hydrologic computational node in the baseline and alternate condition.

Alternative 1 Benefits (100-Year Flows)

Node	Location	Baseline Flow (cfs)	Alt 1 Flow (cfs)	Benefit (cfs)
K12003#1	Wunsche Gully at Interstate 45	1144	1055	-89
K12003#2	Wunsche Gully Confluence with Lemm Gully	1555	1484	-71
K12001#1	Senger Gully at Cypresswood Drive	1559	1559	0
K12001#2	Senger Gully Confluence with Lemm Gully	2428	2428	0
K120A	Lemm Gully Upstream of Wunsche Gully	1225	1225	0
K120#1	Lemm Gully Downstream of Wunsche Gully	2577	2385	-192
K120#2	Lemm Gully Downstream of Senger Gully	4882	4651	-231
K120#3	Lemm Gully Confluence with Cypress Creek	5959	5726	-233

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

The alternative as noted has the effect of lowering flows at the mouth by approximately 4 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 1 is $2,775,000; this includes an estimated $894,000 for the floodplain/ stream habitat corridor.

2.5.3 Alternate 2 Features and Benefits

Alternative 2 features are shown on **Exhibit B6.** Alternative 2 consists of the Wunsche Gully channel corridor, a detention basin along Senger Gully (K120#B1), and the floodplain/ stream habitat preservation area to fulfill the analysis goals. This plan provides benefits in reducing peak flows along Wunsche Gully, Senger Gully, and Lemm Gully within the watershed. The

following table shows the peak flows at each hydrologic computational node in the baseline and alternate condition.

Alternative 2 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 2 Flow (cfs)**	**Benefit (cfs)**
K12003#1	Wunsche Gully at Interstate 45	1144	1055	-89
K12003#2	Wunsche Gully Confluence with Lemm Gully	1555	1484	-71
K12001#1	Senger Gully at Cypresswood Drive	1559	1559	0
K12001#2	Senger Gully Confluence with Lemm Gully	2428	2266	-162
K120A	Lemm Gully Upstream of Wunsche Gully	1225	1225	0
K120#1	Lemm Gully Downstream of Wunsche Gully	2577	2385	-192
K120#2	Lemm Gully Downstream of Senger Gully	4882	4385	-497
K120#3	Lemm Gully Confluence with Cypress Creek	5959	5482	-477

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

The alternative as noted has the effect of lowering flows at the mouth by approximately 8 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduce peak flows entering Cypress Creek. The estimated cost for implementing Alternative 2 is $4,579,000.

2.5.4 Alternate 3 Features and Benefit

Alternate 3 features are shown on **Exhibit B6.** Alternative 3 consists of the Wunsche Gully channel corridor, the floodplain/ stream habitat preservation area, and a voluntary structural buyout to fulfill the analysis goals. This plan provides benefits in reducing peak flows along Wunsche Gully and Lemm Gully within the watershed and removes historic flooded structures for the watershed. The table below shows the peak flows at each hydrologic computational node in the baseline and alternate condition.

Alternative 3 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 3 Flow (cfs)**	**Benefit (cfs)**
K12003#1	Wunsche Gully at Interstate 45	1144	1055	-89
K12003#2	Wunsche Gully Confluence with Lemm Gully	1555	1484	-71
K12001#1	Senger Gully at Cypresswood Drive	1559	1559	0
K12001#2	Senger Gully Confluence with Lemm Gully	2428	2428	0
K120A	Lemm Gully Upstream of Wunsche Gully	1225	1225	0
K120#1	Lemm Gully Downstream of Wunsche Gully	2577	2385	-192
K120#2	Lemm Gully Downstream of Senger Gully	4882	4651	-231
K120#3	Lemm Gully Confluence with Cypress Creek	5959	5726	-233

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

The alternative as noted has the effect of lowering flows at the mouth by approximately 4 percent. This alternative will offset the effects of full development with onsite detention in

the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 3 is $2,775,000 plus $8,440,000 for voluntary structure buyout.

2.5.5 Alternative 4 Features and Benefits

Alternative 4 features are shown on **Exhibit B6.** Alternative 4 implements the elements previous presented. Alternative 4 consists of the Wunsche Gully channel corridor, the detention basin along Senger Gully (K120#B1), the floodplain/ stream habitat preservation area, and a voluntary structural buyout to fulfill the analysis goals. This plan provides benefits in reducing peak flows along Wunsche Gully and Lemm Gully within the watershed and removes historic flooded structures for the watershed. The table below shows the peak flows at each hydrologic computational node in the baseline and alternate condition.

Alternative 4 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 4 Flow (cfs)**	**Benefit (cfs)**
K12003#1	Wunsche Gully at Interstate 45	1144	1055	-89
K12003#2	Wunsche Gully Confluence with Lemm Gully	1555	1484	-71
K12001#1	Senger Gully at Cypresswood Drive	1559	1559	0
K12001#2	Senger Gully Confluence with Lemm Gully	2428	2266	-162
K120A	Lemm Gully Upstream of Wunsche Gully	1225	1225	0
K120#1	Lemm Gully Downstream of Wunsche Gully	2577	2385	-192
K120#2	Lemm Gully Downstream of Senger Gully	4882	4385	-497
K120#3	Lemm Gully Confluence with Cypress Creek	5959	5482	-477

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

The alternative as noted has the effect of lowering flows at the mouth by approximately 8 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 4 is $4,579,000 plus $8,440,000 for voluntary structure buyout.

2.5.6 Public Input on Alternate Plans

On October 8, 2002, a public meeting was held to describe the progress of the project and to inform the public regarding the alternative plans being proposed for the watershed. Comments regarding alternatives for Lemm Gully watershed were received during the public meeting. The comments were from residents of North Hill Estates along Lemm Gully. The residents were concerned that another alternative element besides voluntary buyout was not proposed for flooding relief within their subdivision.

Generally the public in response to questionnaires showed they were not averse to channel improvement projects. Multi-use facilities incorporating recreation was popular with the

respondents. Respondents were evenly split on whether they favored the use of voluntary buyouts as a flood-control measure.

2.5.7 Screening of Alternates

In order to determine the recommended plan for the Lemm Gully watershed, a number of criteria were screened to determine which of the alternatives best met the goals of the watershed and the HCFCD. This screening was performed on a relative basis. The following criteria matrix was used when evaluating the alternative plans identified for this watershed. The ability of the plan alternative to meet each criteria was ranked from 0 to 10, with 0 indicating that the criteria is not met, and 10 indicating that the criteria is met to the best of its ability. Relative weights were then set for each of the criteria as shown below based on the stated goals of the study.

Table B1 – Screening Matrix for Lemm Gully Watershed

Criteria	Weight	Plan			
		ALT 1	ALT 2	ALT 3	ALT 4
Minimal Construction Cost	0.2	7	6	4	4
Provides Aesthetics	0.5	6	7	6	8
Ease of Implementation	0.8	8	7	5	5
Flood Protection within Tributary Watershed	1	5	6	7	8
Ability to Accommodate Multiple Uses	0.5	6	7	6	8
Preserves/Enhances Water Quality	0.8	7	9	7	9
Preserves/Enhances Stream Habitat Quality	0.5	9	9	9	9
Ease of Maintenance	0.8	8	6	7	5
Reduction of Peak Flows into Cypress Creek	1	5	8	5	8
Outfalls for Future Roadways/Development	0.8	10	10	10	10
Acceptable to the Public	0.8	6	7	6	8
TOTAL	-----	**77**	**82**	**72**	**82**
WEIGHTED TOTAL	**77(max)**	**53**	**58**	**51**	**59**

2.6 Recommended Plan and Identification of Elements

Based on the criteria noted above, a plan was recommended that will meet the needs of the watershed as noted in this report. The recommended plan is described in detail in the following sub-sections.

2.6.1 Determination of Recommended Plan

Alternative 4 was chosen as the recommended plan, primarily due to the fact that it met all the criteria of the study: provided outfall for future development and roadways, provided a reduction of flows to Cypress Creek, provided flow reduction for existing flooding problems, and provides a potential for removed repetitive flooded structures from the watershed. Also,

the floodplain preservation area at the confluence of Lemm Gully, Senger Gully, and Cypress Creek will provide environmental benefit and protect the floodplain areas of Lemm Gully and Senger Gully.

Alternatives 1 and 3 does not provide the level of flow reduction into Cypress Creek or the along Senger Gully. Alternative 2 provides a similar level of protection; however, it, as with Alternative 1, does not provide a mechanism to remove repetitive flooded structures from the watershed.

2.6.2 Recommended Plan Features

The recommended plan consists of features that preserve areas of high-quality stream habitat, provide outfall drainage for future development, address existing flooding in the watershed, and provide flow reduction to Cypress Creek. The features of the plan, beginning at the mouth, consist of the elements outlined in Section 2.5.3 (Alternative 4 Features and Benefits) and further described below.

The stream corridor designated for floodplain/ stream habitat preservation consists of approximately 63 acres at the downstream end of the watershed. The corridor will run along Lemm Gully from its confluence with Cypress Creek upstream to North Hill Estates subdivision, an approximate length of 2100 feet. The corridor will run along Senger Gully from its confluence with Lemm Gully upstream to downstream of North Hill Road, an approximate length of 4000 feet. Currently the HCFCD has about 16 acres of right-of-way along this corridor.

The existing Wunsche Gully channel is shallow and has a very large floodplain. To provide outfall for future development and to remove the existing floodplain, a channel corridor is proposed along the stream. The corridor will extend from upstream of Interstate 45 to Spring-Stuebner Road, a length of approximately 5700 feet. This section is a 300-foot wide channel corridor, providing 10 feet of outfall depth. These improvements will combine conveyance and linear storage in a multiple-use channel section. These corridors also provide a potential multi-use element to the watershed as well as environmental benefit. A typical channel section is shown as **Figure 1** on the main report.

A 22-acre sideweir detention basin is proposed along Senger Gully downstream of Cypresswood Drive. The proposed detention basin has a 19-acre top area with 30-foot wide maintenance berms. The average usable depth of the basin is 8 feet. The basin weir is a 100-foot long sideweir set to an elevation two feet below natural ground. The basin provides 137 acre-feet of storage. The implementation of the basin on its own is expected to reduce peak flows to Senger Gully by as much as 260 cfs for the 100-year flood. This basin can be utilized as a multi-use facility. A typical basin layout is shown as **Figure 2** of the main report.

The voluntary buyout areas are located within the Devonshire Woods and Enchanted Oaks subdivisions along Senger Gully and the North Hill Estates subdivision along Lemm Gully. There are 61 homes that have documented flooding within these subdivisions. Although several structural floodings were caused by the receiving stream, many of the structures are suspected to have been inundated by Cypress Creek floodwaters.

2.6.3 Recommended Plan Benefits

Taken together, these elements make up the recommended plan for the Lemm Gully watershed and satisfy the criteria for this study while providing quantifiable benefits to the watershed. Some recreational elements will be necessary to add to the plan features to fully meet the desired goal for dual-use facilities. The somewhat fragmented nature of the plan elements will make a recreational feature such as a continuous trail system infeasible. However, trails in the lower reaches of Lemm Gully and Senger Gully are feasible within the stream corridor preservation area; trails are also feasible within the channel corridor along the upstream portion of Wunsche Gully. Also the detention basin proposed at the southeast corner of Cypresswood Drive and Senger Gully will be encouraged for use as a park or for soccer fields.

Hydrologic benefits due to the plan elements were summarized earlier in the alternate plan formulation section of this report. In order to maintain consistency with the Phase I report, the flows calculated as a result of the more detailed modeling were compared with the revised baseline flows, then the prorated decrease (or increase) resulting from the modeling of the recommended plan was applied to the original baseline flows to create an adjusted plan flow. The adjusted plan flows were used as the basis for the HEC-RAS modeling and floodplain mapping for the recommended plan. The revised Tc and R parameters for the recommended plan compared to the baseline are shown in **Table B2**. The resulting 100-year flows comparing the baseline conditions to the recommended plan conditions are presented in **Table B3** of this report. **Table B4** of this report presents the HEC-1 peak flows resulting from the recommended plan for various storm frequencies. The 100-year recommended plan and baseline condition floodplains are shown on **Exhibit B8**. A comparison between the recommended plan and baseline condition 100-year storm event flood profiles for Lemm Gully, Senger Gully, and Wunsche Gully are presented in **Exhibits B9-1** to **B9-4**. The Lemm Gully, Senger Gully, and Wunsche Gully eight frequencies storm event profiles for the recommended plan are presented in **Exhibits B11-1** to **B11-4**.

The plan reduces peak flows downstream along Lemm Gully, Senger Gully, and Wunsche Gully, and reduces flows entering into Cypress Creek. Additionally, water surface elevations are lowered in conjunction with the lower flows along the watersheds streams. As shown in **Table B5,** water surface elevations decrease along Lemm Gully by as much as 0.6 foot, along

Senger Gully by 0.4 foot, and along Wunsche Gully by 1.5 feet. As noted earlier, the goal of this plan was not to bring all areas of out-of-bank flooding to within the banks. The goal was to preserve some areas of out-of-bank flooding that occurs in areas that are beneficial to the watershed and to address out-of-bank flooding in areas where it causes existing or projected flooding problems outside of the stream corridor areas. Finally, the plan provides environmental benefits by preserving identified areas of high-quality stream habitat as well as preserving some naturally flood-prone areas, as noted above.

Table B2: Watershed Physical Characteristics (Baseline & Recommended Plan Conditions)

Subarea Name	Drainage Area		Watershed Length	Length to Centroid	Channel Slope	Overland Slope	Urban Dev. *	Watershed Dev. *	Channel Imp.	Channel Conv.	Ponding
	(Acre)	(Sq.Mi)	(mi)	(mi)	(ft/mi)	(ft/mi)	(%)	(%)	(%)	(%)	(%)
LEMM GULLY											
K120A	725	1.13	1.98	0.89	10.1	20	22.58	67.8	87	50	0
K120B	986	1.54	2.70	1.21	13.3	16	23.37	54.5	68	100	0
SENGER GULLY											
K12001A	1503	2.35	2.69	1.24	8.9	39	23.13	47.9	59	100	0
K12001B	611	0.95	2.32	1.40	14.4	47	38.01	38.8	39	100	0
WUNSCHE GULLY											
K12003A	597	0.93	1.52	0.68	8.7	15	13.08	50.0	66	100	0
K12003B	546	0.85	2.00	0.93	3.3	27	33.67	75.1	93	100	0

* % based on development in place prior to implementation of HCFCD on-site detention policy (1984)

Table B2 (continued)
Tc & R Values

Subarea Name	TC	R	RTIMP
	(hrs)	(hrs)	(%)
K120A	0.49	2.59	35.0
K120B	1.08	4.73	35.0
K12001A	0.75	5.43	35.0
K12001B	0.70	1.99	35.0
K12003A	0.34	2.09	35.0
K12003B	0.42	4.70	35.0

Table B3: 100-Year Flow Comparison Table (Baseline vs. Recommended Plan)

HEC-1 Analysis Point	Baseline Condition (cfs)	Recommended Condition (cfs)*	Baseline vs. Recommended Plan	
			Difference (cfs)	% Change
K12003#1	1144	1055	-89	-8
K12003#2	1555	1484	-71	-5
K12001#1	1559	1559	0	0
K12001#2	2428	2266	-162	-7
K120A	1225	1225	0	0
K120#1	2577	2385	-192	-7
K120#2	4882	4385	-497	-10
K120#3	5959	5482	-477	-8

Table B4: HEC-1 Peak Flow Rates for Recommended Plan Conditions*

HEC-1 Analysis Point	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	250-Year	500-Year
K12003#1	357	560	699	834	941	1055	1176	1271
K12003#2	516	753	928	1147	1314	1484	1687	1838
K12001#1	514	804	995	1200	1369	1559	1798	1978
K12001#2	855	1344	1620	1873	2078	2266	2493	2673
K120A	830	1249	1515	1824	2104	2385	2711	2953
K120#1	431	656	805	956	1087	1225	1407	1541
K120#2	1628	2508	3045	3547	3950	4385	4960	5380
K120#3	1991	3074	3747	4393	4916	5482	6203	6748

Table B5: Comparison of Water Surface Elevations (100-Year)
Lemm Gully (K120-00-00)

Station	Location	Baseline Condition		Recommended Plan		Difference
		Flow	WSEL	Flow	WSEL	(ft)
2480	2480	5959	87.99	5482	73.8	-0.31
3954	3955	5959	91.50	5482	79.5	-0.35
3968	LOCKRIDGE DRIVE					
3981	3980	4882	91.77	4385	79.5	-0.44
7095	7095	4882	98.57	4385	83.1	-0.66
9365	9365	3461	103.18	3160	88.8	-0.44
11055	11055	2923	105.04	2689	91.5	-0.17
13167	13167	2577	108.89	2385	97.8	-0.16
16117	16117	1225	115.50	1225	107	-0.07

Table B5 *(continued)*: **Comparison of Water Surface Elevations (100-Year)**
Senger Gully (K120-01-00)

Station	Location	Baseline Condition		Recommended Plan		Difference
		Flow	WSEL	Flow	WSEL	(ft)
300		2428	80.63	2266	80.17	-0.46
1200		2428	82.73	2266	82.28	-0.45
2200		2428	86.21	2266	85.80	-0.41
3200		2187	90.02	2075	89.71	-0.31
3607		2187	90.70	2075	90.47	-0.23
3657		2046	90.87	1961	90.62	-0.24
3706		2046	90.83	1961	90.59	-0.24
3707		2046	90.81	1961	90.57	-0.24
3777		2046	90.81	1961	90.57	-0.25
3877		2046	90.82	1961	90.59	-0.24
3917		2046	90.83	1961	90.59	-0.24
3937		2046	90.83	1961	90.59	-0.24
3977		2046	90.84	1961	90.60	-0.24
4022		2046	90.86	1961	90.63	-0.24
4063		2046	90.97	1961	90.73	-0.24
4080	NORTH HILL DRIVE					
4097		2002	90.99	1925	90.75	-0.25
4177		2002	90.94	1925	90.70	-0.24
4207		2002	90.94	1925	90.70	-0.24
4242		2002	90.94	1925	90.70	-0.25
4277		2002	90.95	1925	90.71	-0.24
4335		2002	90.95	1925	90.71	-0.25
4385		2002	90.96	1925	90.72	-0.24
4396		2002	90.96	1925	90.72	-0.24
4397		2002	90.64	1925	90.41	-0.24
4398		2002	90.64	1925	90.41	-0.24
4985		2002	92.53	1925	92.30	-0.23
6135		2002	94.97	1925	94.77	-0.20
6228		1814	95.41	1772	95.21	-0.20
6234		1814	95.42	1772	95.21	-0.21
6235		1814	95.23	1772	95.05	-0.18
6378		1814	96.41	1772	96.19	-0.22
6472		1814	96.65	1772	96.42	-0.24
6522		1814	96.76	1772	96.52	-0.24
6606		1814	96.78	1772	96.54	-0.25
6607		1814	96.88	1772	96.64	-0.25
6615		1814	96.35	1772	96.11	-0.25
6616		1814	96.09	1772	95.85	-0.25
6617		1814	96.09	1772	95.85	-0.25
6646		1814	98.36	1772	98.12	-0.25
6666		1814	98.31	1772	98.04	-0.27
6700		1814	98.36	1772	98.11	-0.25
6800		1814	98.53	1772	98.33	-0.20
8000		1814	100.39	1772	100.35	-0.04

Table B5 *(continued)*: **Comparison of Water Surface Elevations (100-Year)**
Senger Gully (K120-01-00)

Station	Location	Baseline Condition		Baseline Condition		Difference
		Flow	WSEL	Flow	WSEL	(ft)
9010		1660	101.95	1644	101.90	-0.05
9115		1660	102.34	1644	102.30	-0.04
9169		1575	102.55	1572	102.51	-0.04
9223	Cypresswood Drive					
9277		1575	103.00	1572	102.98	-0.02
9327		1575	103.00	1572	102.98	-0.02
10595		1559	104.35	1559	104.34	-0.01
12125		1559	107.78	1559	107.78	0.00
14025		1365	111.83	1365	111.83	0.00
14074		1247	111.90	1247	111.90	0.00
14090	Silverleaf Drive					
14106		1247	111.92	1247	111.91	0.01
14115		1247	111.93	1247	111.92	0.01
14615		1247	112.40	1247	112.40	0.01
15810		1247	114.39	1247	114.40	0.00
15864		1146	115.22	1146	115.23	0.00
15880	Louetta Road					
15896		1146	116.55	1146	116.57	0.00
15905		1146	116.56	1146	116.57	-0.01

Table B5 *(continued)*: **Comparison of Water Surface Elevations (100-Year)**
Wunsche Gully (K120-03-00)

Station	Location	Baseline Condition		Recommended Plan		Difference
		Flow	WSEL	Flow	WSEL	(ft)
30		1555	104.82	1484	104.69	-0.13
1000		1555	106.95	1484	106.83	-0.12
2000		1555	109.65	1484	109.52	-0.13
3000		1447	113.43	1370	113.24	-0.19
3100		1447	114.18	1370	113.98	-0.20
3200		1447	114.64	1370	114.45	-0.19
3300		1447	114.81	1370	114.62	-0.19
3353		1447	114.88	1370	114.67	-0.21
3400	LOUETTA ROAD					
3447		1447	116.22	1370	115.86	-0.36
3500		1447	116.39	1370	115.97	-0.42
3600		1447	116.50	1370	116.13	-0.37
4000		1447	117.02	1370	116.77	-0.24
5000		1347	119.93	1265	119.78	-0.15
6000		1347	122.32	1265	122.23	-0.09
6250		1347	123.39	1265	123.28	-0.11
6450		1347	124.61	1265	124.51	-0.10
6505		1233	124.72	1147	124.63	-0.09
6560		1233	124.86	1147	124.77	-0.09
6570		1233	125.00	1147	124.94	-0.06
6580		1233	125.08	1147	125.01	-0.07
6590		1233	125.14	1147	125.06	-0.07
6599		1233	125.19	1147	125.11	-0.07
6615	SPRING-CYPRESS ROAD					
6631		1233	125.38	1147	125.31	-0.06
6670		1233	125.45	1147	125.39	-0.06
7685		1233	126.37	1147	126.28	-0.09
8340		1233	126.74	1147	126.64	-0.10
8349		1152	126.74	1063	126.65	-0.09
8365	NORTH FREEWAY NORTHBOUND FRONTAGE					
8381		1152	126.76	1063	126.69	-0.09
8440		1152	126.76	1063	126.69	-0.10
8449		1152	126.77	1063	126.70	-0.10
8465	NORTH FREEWAY NORTHBOUND FRONTAGE					
8481		1152	126.84	1063	126.78	-0.09
8540		1152	126.89	1063	126.82	-0.09
8725	CHANNEL CORRIDOR CULVERT					
8750				991	127.27	
9117				991	128.85	
10117		1081	127.20	991	129.30	2.08
11000				834	129.72	
12000				834	130.27	
13000				834	131.01	
14150				834	132.03	

3.0 PLAN IMPLEMENTATION AND MANAGEMENT STRATEGIES

Since the remaining undeveloped portions of the Lemm Gully watershed are quickly developing, the right-of-way for the features identified, as part of the recommended plan, should be obtained ahead of the development, while the acreage is available. Several of the elements identified within the recommended plan are to relieve existing flooding, while the channel elements through these undeveloped areas have been identified as a guide for new development.

This information identifies ultimate drainage corridor right-of-way needed to implement the recommended plan features. Further, this identification of right-of-way will help local agencies in their coordination with new development to ensure that the appropriate considerations for drainage are being implemented. The following sections outline a suggested approach for implementing the recommended plan and identify recommended management strategies for the watershed.

3.1 Preservation of Stream Habitat Corridors

The recommended plan identifies one area of high-quality stream habitat that is to be managed without any structural flood reduction project. The area is from the mouth at the confluence of Cypress Creek to downstream of North Hill Estates along Lemm and Senger Gullies. These channel reaches have high natural stream habitat corridor that is beneficial to maintain in its existing condition.

The area contained within this stream corridor consists of approximately 16 acres of existing HCFCD right-of-way. Additional right-of-way is required for the floodplain/stream habitat preservation. The right-of-way width was determined based on the extents of mature tree cover as well as the limits of areas of out-of-bank flooding. Since a majority of this right-of-way represents floodplain, it is anticipated that development consisting of homes and the placement of fill material will not occur as quickly within these areas. Any development in these corridors will require substantial mitigation and coordination with the appropriate regulatory/governmental agencies. In order to implement this plan element, it is necessary to reserve the right-of-way in some fashion in order to limit or restrict development within the extents of these corridors.

One alternative for implementing this plan element is to request the appropriate easements from the landowner as development occurs in the adjacent area. Another alternative would be to have the appropriate entity such as the Harris County Flood Control District acquire the appropriate right-of-way through the fee title, easement, or setback. However, this would severely tax the funding source of the district if implemented on a wide basis. Another alternative would be to allow adjacent developments to construct mitigation facilities such as detention basins and water basins (that are a requirement of the development process) within these corridors, and to have the use of the corridors for recreational features such as hiking trails. No other portions of the

development would be allowed within the corridors. Restrictions would have to be placed on the construction of these facilities so that they did not overly disturb the stream habitat that is to be preserved in the corridors.

3.2 New Lateral Channels/Channel Extensions

A channel corridor is proposed along Wunsche Gully from upstream of Interstate 45 to Spring-Stuebner Road, an approximate length of 5700 feet. This channel corridor width incorporates a channel with a composite, terraced section and allows for multiple uses (see **Figure 1**). The recommended plan proposes a 300-foot right-of-way width along this alignment. There is an existing right-of-way width of 70 feet along this channel length.

The recommended implementation of the channel corridors would consist of having the Harris County Flood Control District prioritize (as best as possible) the immediate need for these channels, and proceed with the acquisition of a portion of the proposed right-of-way along the proposed channel corridor alignments. This portion of the right-of-way width would be the minimum (approximately 150 feet) necessary to implement a typical trapezoidal channel with the appropriate depth for outfall. Additional right-of-way and construction of the channel would be provided by adjacent properties of new development as they occur. Alternative right-of-way acquisition strategies are similar to those already discussed in the previous section and consist of requiring dedication of larger easements, purchasing the land outright, or entering into an agreement with the proposed development to share the land.

3.3 Detention Facilities

A detention facility was identified within the recommended plan for the Lemm Gully watershed. The detention basin K120#B1 has a tract area of 22 acres and is located along the left bank of Senger Gully downstream of Cypresswood Drive.

The facility K120#B1 is proposed as part of the recommended plan for flow reduction within the watershed. Therefore, it will likely not be feasible to allow developers to mitigate individual developments by excavating in the facilities. Implementation of the detention facility elements of the recommended plan will consist of the actual purchase of the land and construction of the facility by public agencies such as the HCFCD. It should be noted that the recommended plan advocates the use of on-site detention as a requirement of development.

3.4 Channel Crossings

As noted earlier, several major thoroughfares cross the channels in the Lemm Gully watershed. A few of these major thoroughfares have been identified for future expansion or extending within the Lemm Gully watershed.

Spring-Cypress Road has been identified for future widening as part of the major thoroughfare plan. The existing crossing over Senger Gully is a dual culvert bridge. The crossing would be improved with an additional two lanes. The current structure has capacity and should only be extended, with mitigation elements, for the proposed roadway expansion.

A new alignment for Sawmill is proposed as part of the major thoroughfare plan. This new alignment crosses Wunsche Gully. This crossing is planned as part of the major thoroughfare plan and will cross a proposed channel corridor of this recommended plan. Using the baseline condition flow, a preliminary size for the opening area was determined. If the new structure is designed to pass the 100-year flows in the tributary channel (approximately 1140 cfs) with a minimal (less than 0.5 foot) amount of head losses, a minimum opening of approximately 270 square feet will be necessary.

There may be crossings that are constructed as part of developments or as revisions to the major thoroughfare plan. Channel crossings must be considered in light of the goals for the "frontier program" in each of these watersheds. For example, a new bridge spanning an area of high-quality habitat protection, such as the lower portion of the watershed, would need to be built to preserve the habitat quality of the area. This would include longer spans or additional spans to clear more of the conveyance area of the channel, limited clearing of trees along the right-of-way and storm water quality features at any outfalls proposed with the crossing. Proposed crossings of the channel extension or new tributary channel included in the recommended plan could be designed in a more conventional manner; however, care must be taken to ensure that the storage of the channel is not impacted by the construction of a too-narrow structure.

3.5 Cost Analysis

Costs were identified for implementation of the recommended plan. These costs consider acquisition of right-of-way, engineering, and construction of the plan elements. It should be noted that the bridge crossing information included above was not included in the recommended plan cost because the crossings were not implemented as part of the recommended plan, but as part of the county's transportation plan. However, the bridge replacements identified within the recommended plan have been included within the cost estimates. The table below shows the plan elements, the identified right-of-way, the unit costs, and total costs for the project. The total cost when fully implemented is approximately $13.0 million, with the bulk of the cost in voluntary structural buyout, land acquisition, and excavation costs.

Table B6 – Estimated Recommended Plan Costs for Lemm Gully				
Description	**Unit**	**Quantity**	**Unit Cost**	**Cost**
1. Mobilization	Each	2	$10,000	$20,000
2. Clearing & Grubbing	Acre	61	$1,500	$91,950
3. Excavation & Haul	Ac-Ft	294.2	$5,000	$1,471,000
4a. Bridge Concrete Installation	S.F.	0	$60	$0
4b. Weir Concrete Installation	S.F.	5040	$60	$302,400
5a. Culvert Boxes	L.F.	180	$600	$108,000
5b. Culvert Pipes	L.F.	180	$100	$18,000
5c. Flapgates	Each	2	$9,000	$18,000
6. Drop/Control Structures	L.S.	0	$100,000	$0
7. Backslope Drains	Each	8	$3,000	$24,000
8. Utilities Relocation	Each	0	$100,000	$0
9. Right-of-Way	Acre	52	$15,000	$781,500
10. Seeding & Mulching	Acre	61	$1,000	$61,300
11. Tree/Shrub Planting	Acre	5.2	$10,000	$52,000
SUB TOTAL				$2,948,150
Contingencies (15%)				$442,223
Engineering and Administration (10%)				$294,815
SUBTOTAL CONSTRUCTION COST				$3,685,188
VOLUNTARY STRUCTURAL BUYOUT				$8,440,000
STREAM HABITAT PRESERVATION CORRRIDOR				$893,750
TOTAL				**$13,018,938**

3.6 Implementation Phasing

Implementation of the recommended plan features is suggested to occur in phases so that appropriate funding can be identified for each fiscal year. First priority should be given to implementing projects that result in flood reduction benefits to existing flood-prone structures. In the Lemm Gully watershed this would mean a priority for the Senger Gully detention basin, K120#B1 and voluntary buyouts. Second priority should be given to acquiring right-of-way ahead of new development, to ensure that future drainage projects can be implemented accordingly. The channel corridor along Wunsche Gully fits this category. Final priority should be placed on an ongoing land acquisition program to purchase right-of-way for stream corridor preservation projects and for remaining recommended plan elements. The floodplain preservation area at the confluence of Lemm Gully and Senger Gully would fit this category.

The first priority category of the recommended plan should be implemented when possible to relieve some of the existing flooding problems. The second and final priority categories can be delayed until there is development pressure on areas slated for improvements. The recommended plan is estimated to take approximately two years to implement. The order of implementation would be to construct K120#B1 within the first year of implementation. The proposed detention facility K120#B1 would be constructed as soon as land is acquired. The channel corridor for

Wunsche Gully should be identified and right-of-way secured as development begins to occur in the adjacent areas.

3.7 Identification of Possible Funding Sources

Implementation of the plan is dependent upon the cooperation of other stakeholders in addition to the Harris County Flood Control District. The District's primary role is to implement flood reduction projects. The construction of parks and the creation of mitigation for new development cannot be implemented with District funds.

It is anticipated the implementation of parks or trails within the drainage corridor right-of-way could proceed through agreements between the District and the appropriate stakeholders. Such stakeholders could include the Texas Parks and Wildlife, Legacy Land Trust, Harris County, and the various civic associations located throughout the watershed. Management of these uses and respective maintenance of the facilities would also be performed by the stakeholders. The District could enter into an agreement to construct the necessary detention or flood-reduction drainage element with consideration for multiple uses such that the stakeholder will take over maintenance of the facility.

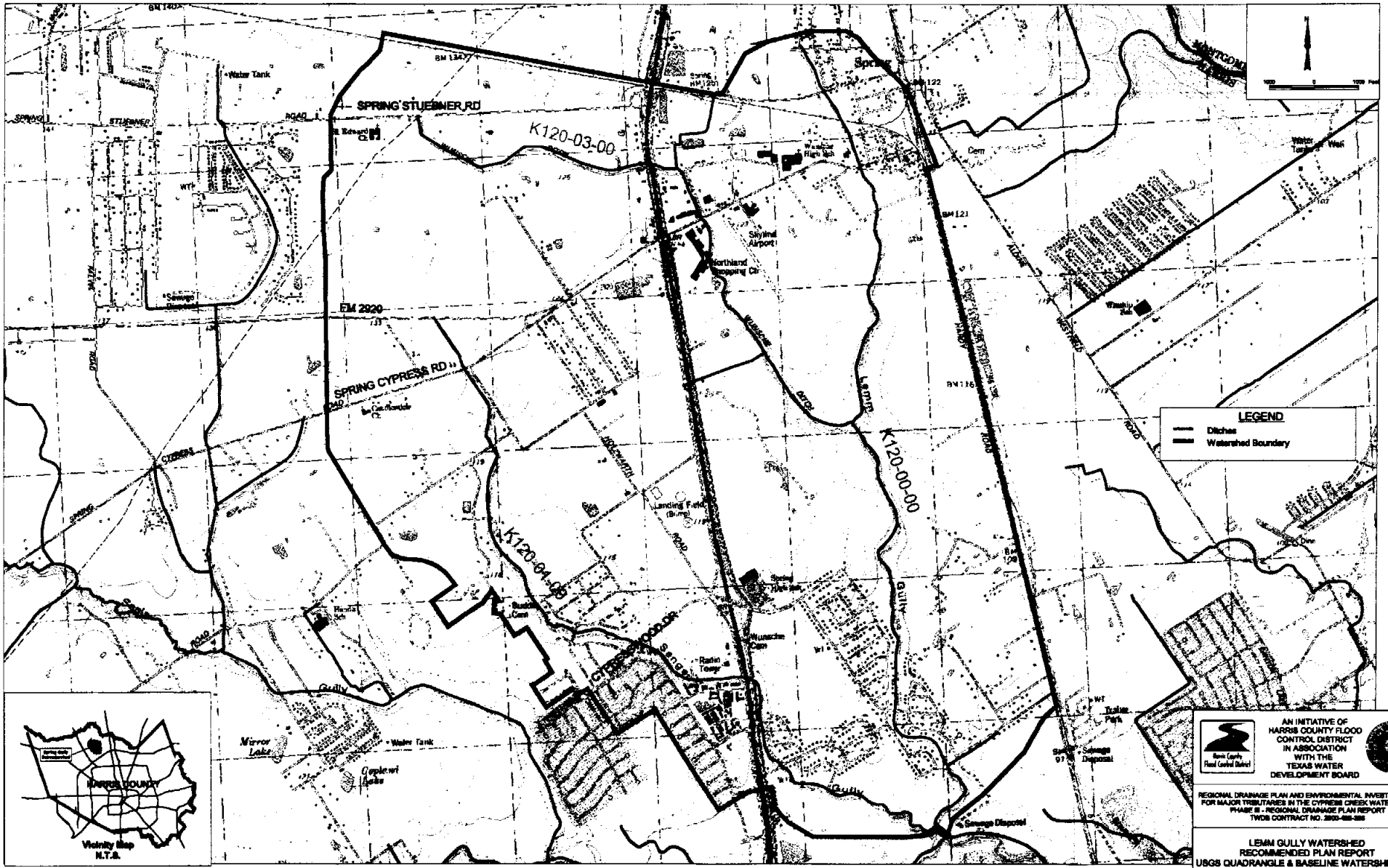
Harris County currently has a Parks & Recreation Master Plan that identifies corridors for proposed bikeway trails. Several of these proposed corridors are within the Lemm Gully watershed and it may be possible to extend the bikeways from Cypress Creek into desirable portions of the watershed using the funding identified for the bikeway program.

The construction of the necessary roadway crossing of the channels will be funded through the appropriate stakeholder responsible for the project, such as Harris County Public Infrastructure Department for county roads, Texas Department of Transportation for state roads, and developers for their respective developments that include roadway channel crossings.

4.0 CONCLUSIONS

The recommended plan identified in this report represents a feasible solution to provide flood reduction benefits, guidance for drainage planning of new development projects and the major thoroughfare plan, preservation and enhancement of stream habitat and water quality, opportunities for multi-use, reduction of peak flows to Cypress Creek, and acceptance by the public. Existing environmental conditions of the watershed are considered in the plan so they are preserved to the extent possible and, at a minimum, that they are not further degraded. Further, when implemented, the plan should have the ability to accommodate multiple recreational uses and result in reduced stormwater peak flows into Cypress Creek, suggesting that the plan will also result in flood reduction benefits for existing developments along Cypress Creek.

Implementation of the plan will have to occur over many years and will require the cooperation of additional stakeholders. Prioritization of the plan elements has been performed, and land acquisition or reservation should be initiated immediately for the recommended plan features within Lemm Gully watershed. It is estimated, once begun, it would take approximately two years to implement the entire plan, with an average expenditure of $6.5 million per year.

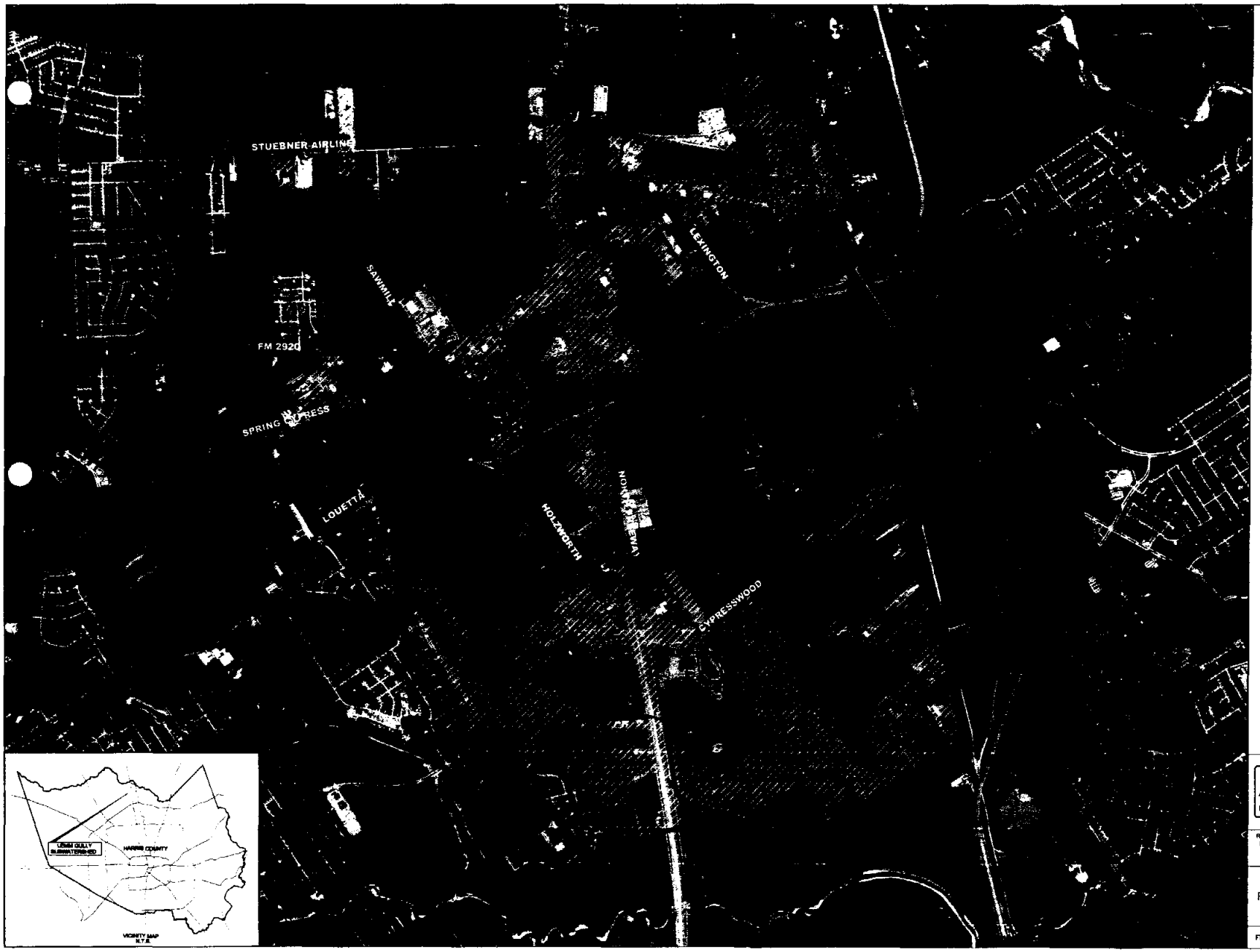


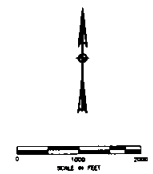
AN INITIATIVE OF
HARRIS COUNTY FLOOD
CONTROL DISTRICT
IN ASSOCIATION
WITH THE
TEXAS WATER
DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION
FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-486-386

LEMM GULLY WATERSHED
RECOMMENDED PLAN REPORT
USGS QUADRANGLE & BASELINE WATERSHED MAP

FEBRUARY 2003	K120-00-00	EXHIBIT B1





LEGEND

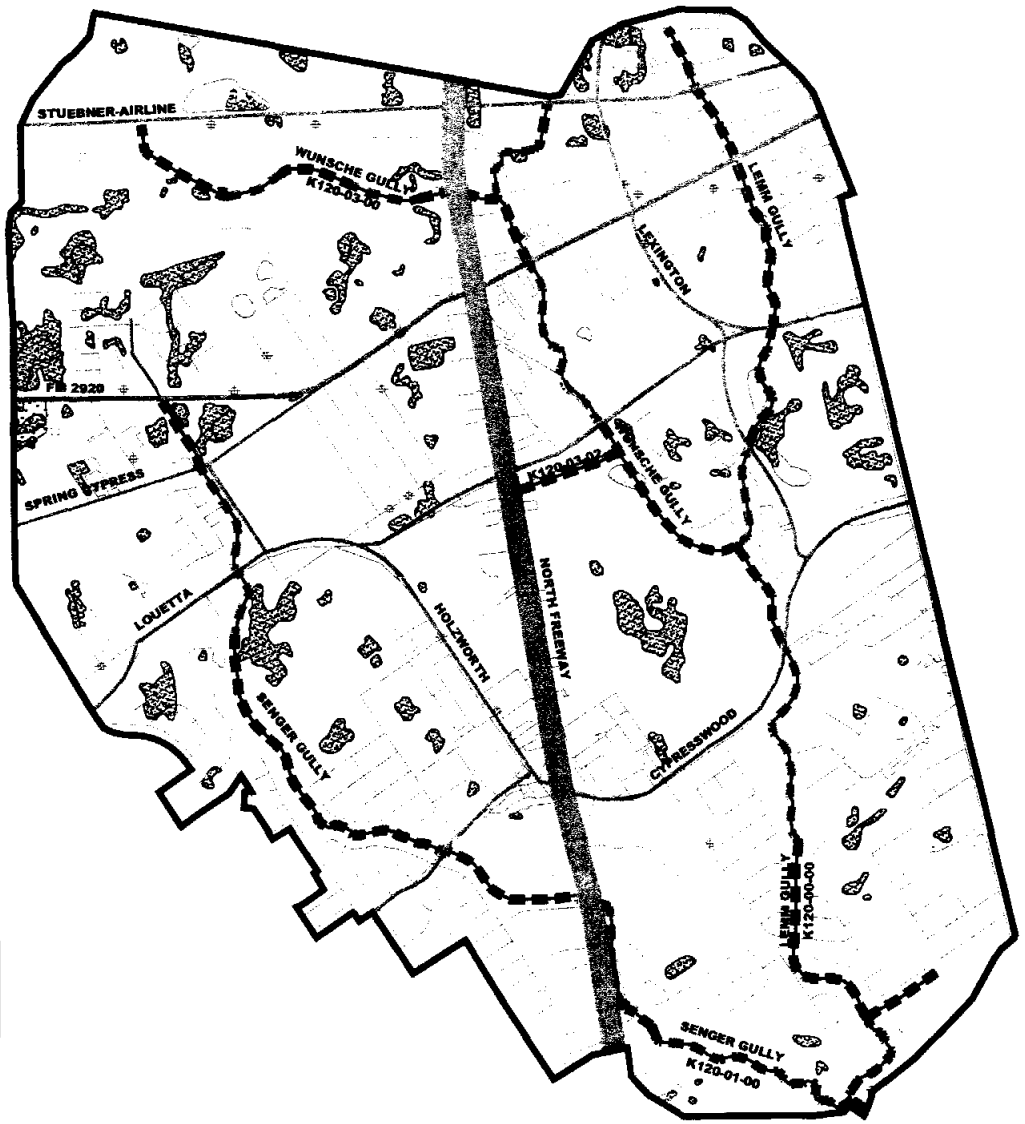
- Street
- Major Road
- Stream
- Watershed Boundary
- Recommended Plan Sub Watershed Boundary
- 1984 Developed Areas
- HCFCD Right-Of-Way
- Hydrologic Nodal Points

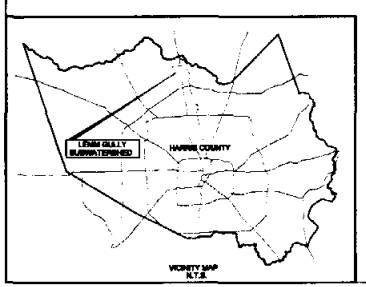
AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-358

LEMM GULLY WATERSHED REGIONAL DRAINAGE PLAN REPORT 1999 AERIAL WATERSHED MAP

FEBRUARY 2003	K120-00-00	EXHIBIT B2





LEGEND

- Street
- Major Road
- Stream
- Watershed Boundary
- Potential Wetlands
- Natural Prairies
- Wetlands
- Known Historical Sites
- Hazardous Material Sites

STREAM HABITAT QUALITY

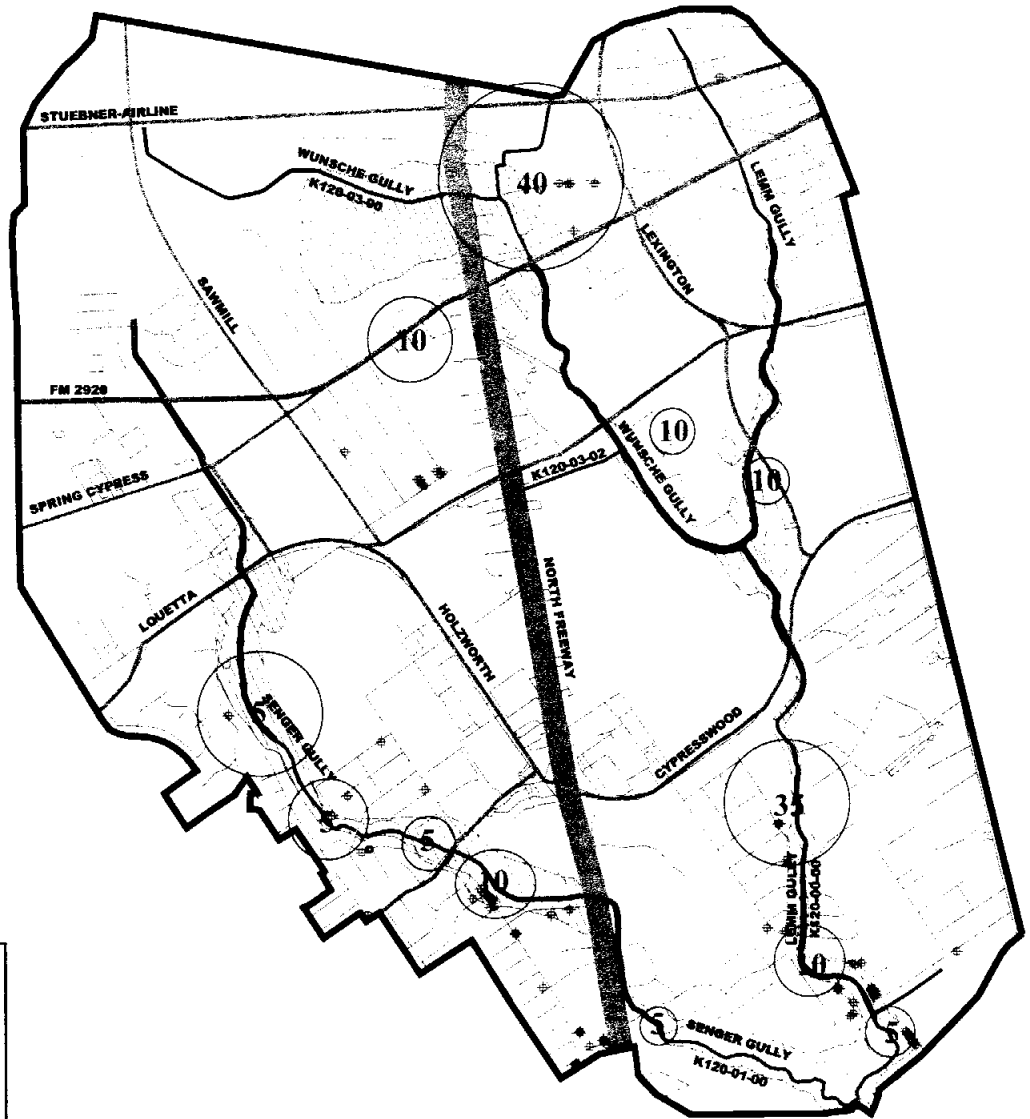
- Low
- Medium
- High

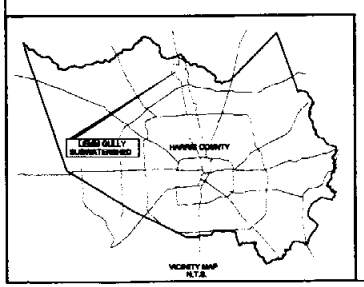
AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

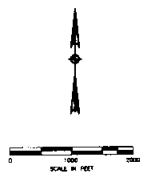
REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-366

LEMM GULLY WATERSHED REGIONAL DRAINAGE PLAN REPORT ENVIRONMENTAL CONSIDERATIONS

FEBRUARY 2003	K120-00-00	EXHIBIT B3







LEGEND

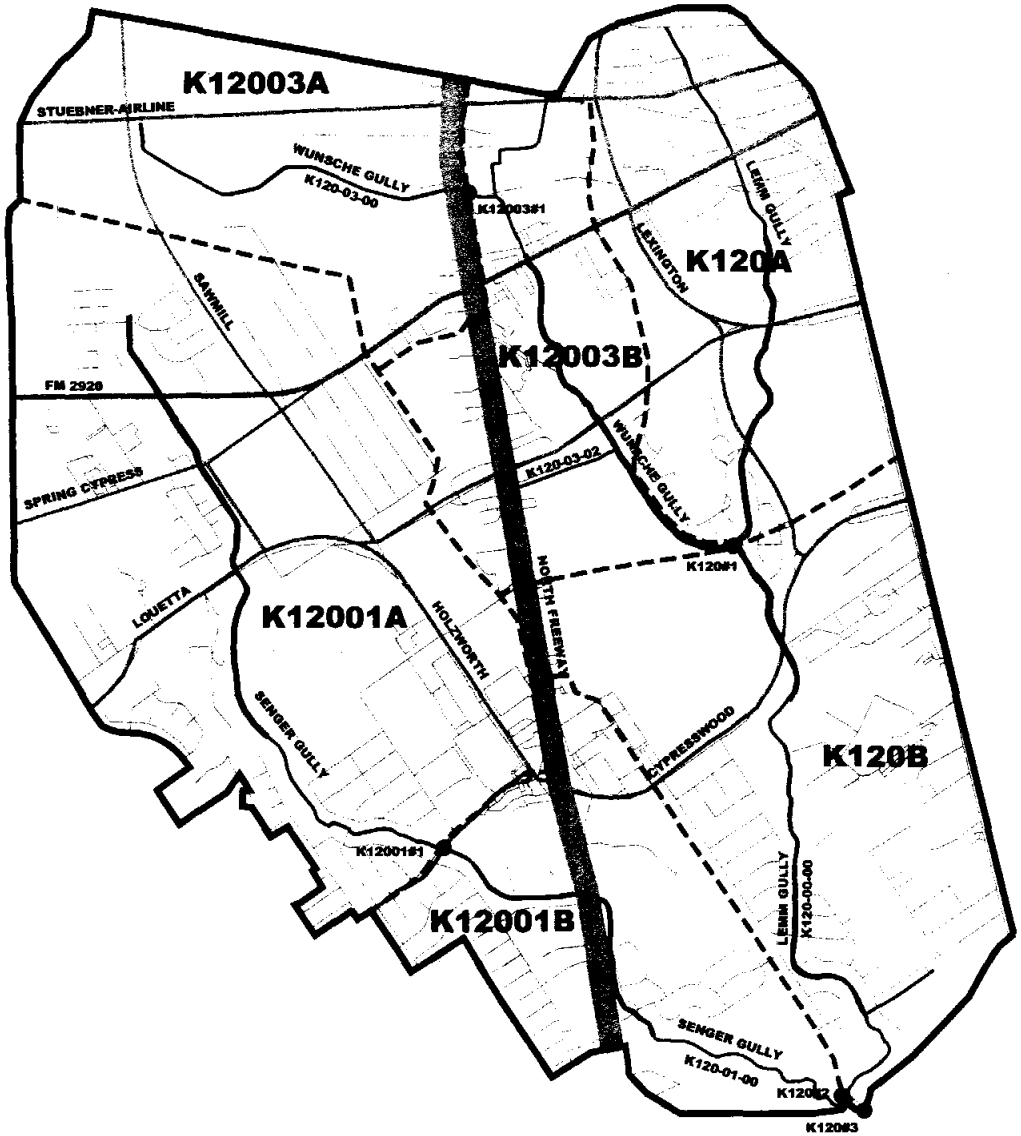
- AREAS OF DOCUMENTED FLOOD DAMAGE
- COMMENTS FROM PUBLIC MEETINGS
- (10) AREAS OF POTENTIAL STRUCTURAL FLOODING
- STREAMS ALIGNMENTS
- MAJOR ROADWAYS
- STREETS
- BASELINE FLOODPLAIN
- WATERSHED BOUNDARY

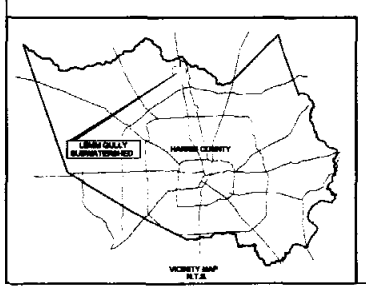
AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

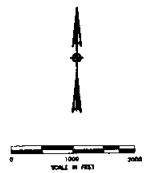
REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
STRUCTURAL FLOODING CONCERNS

FEBRUARY 2003	K120-00-00	EXHIBIT B4







LEGEND

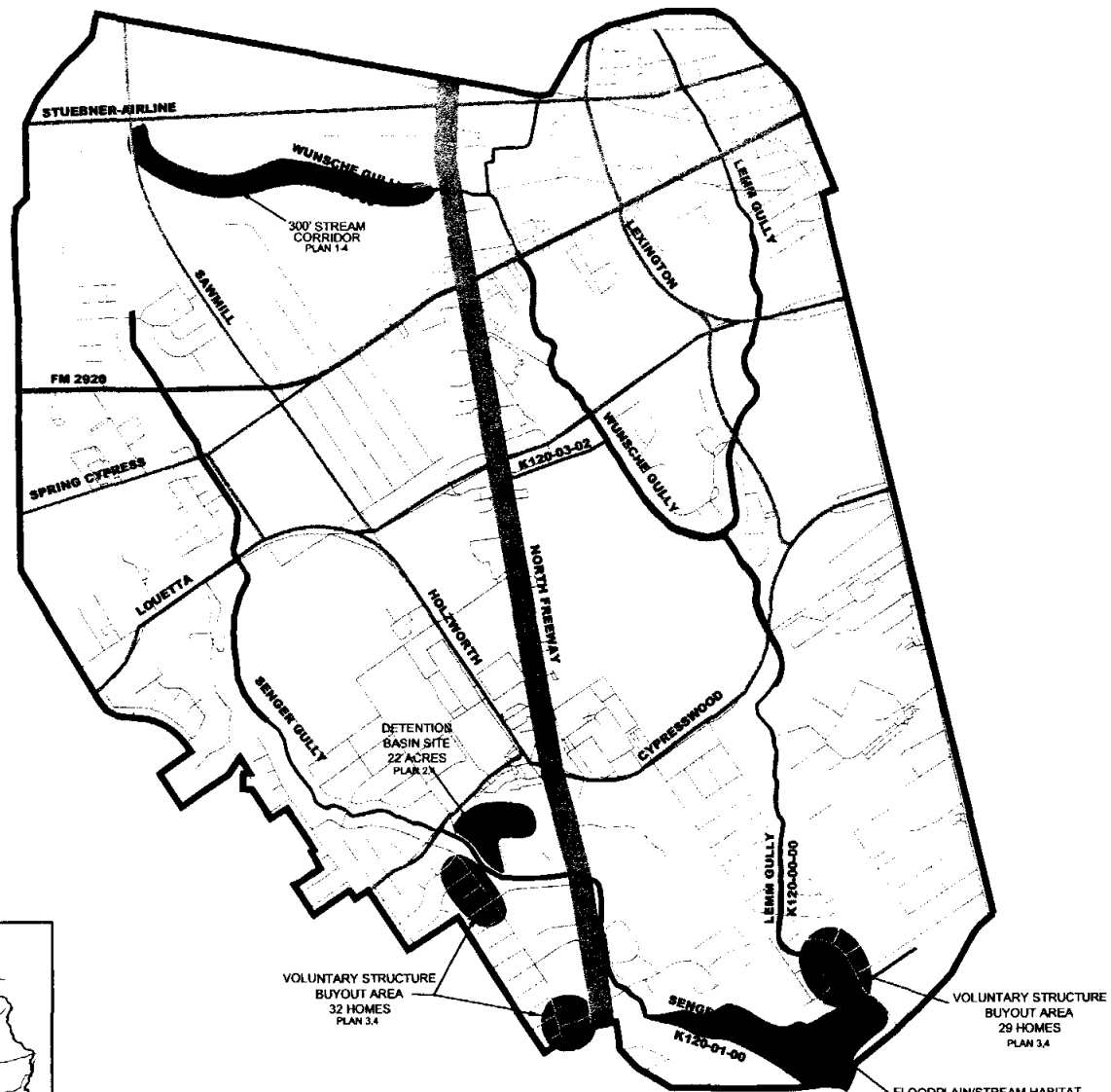
- Street
- Major Road
- Stream
- Watershed Boundary
- Recommended Plan Sub Watershed Boundary
- Baseline Report Sub Watershed Boundary
- Hydrologic Nodal Points

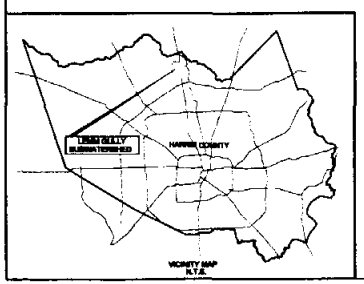
AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

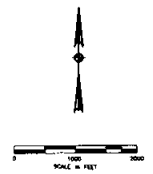
REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-368

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
WATERSHED DELINEATION COMPARISON

FEBRUARY 2003	K120-00-00	EXHIBIT 85







LEGEND

- Street
- Major Road
- Stream
- Watershed Boundary

PLAN COMPONENTS

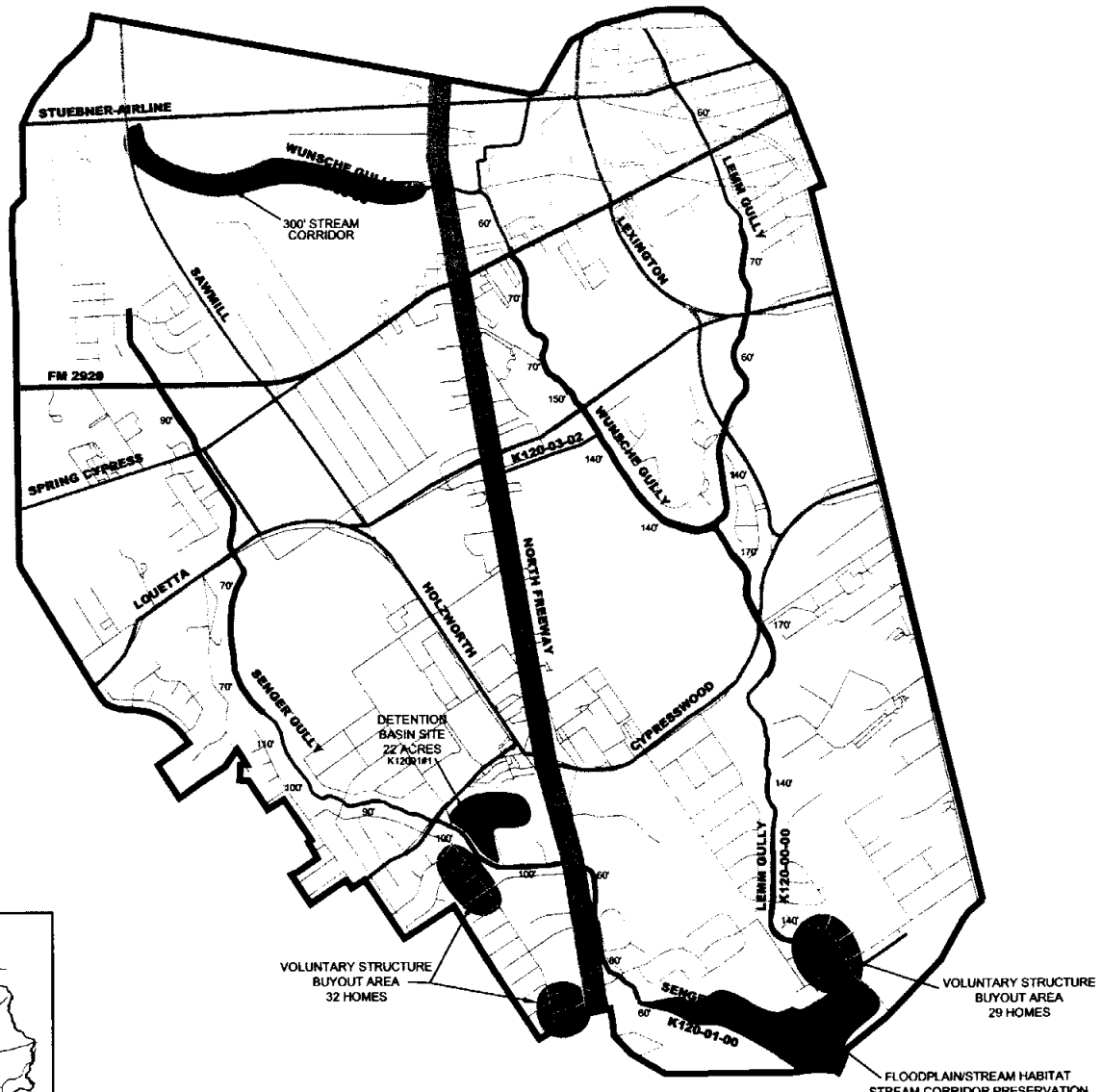
- Proposed Detention Basin
- Proposed Channel Corridor
- Proposed Floodplain/Stream Habitat Preservation
- Voluntary Buyout of Historic Flood Prone Structures
- Proposed Bridge Modification

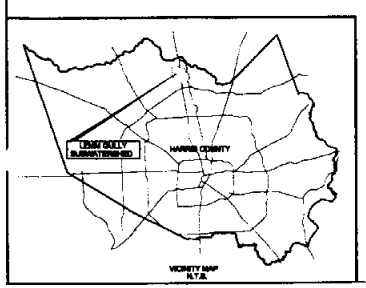
AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

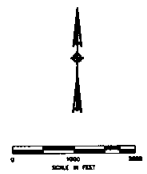
REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED REGIONAL DRAINAGE PLAN REPORT COMBINED ALTERNATIVES FEATURES

FEBRUARY 2003	K120-00-00	EXHIBIT 86







LEGEND

- Street
- Major Road
- Stream
- Watershed Boundary

PLAN COMPONENTS

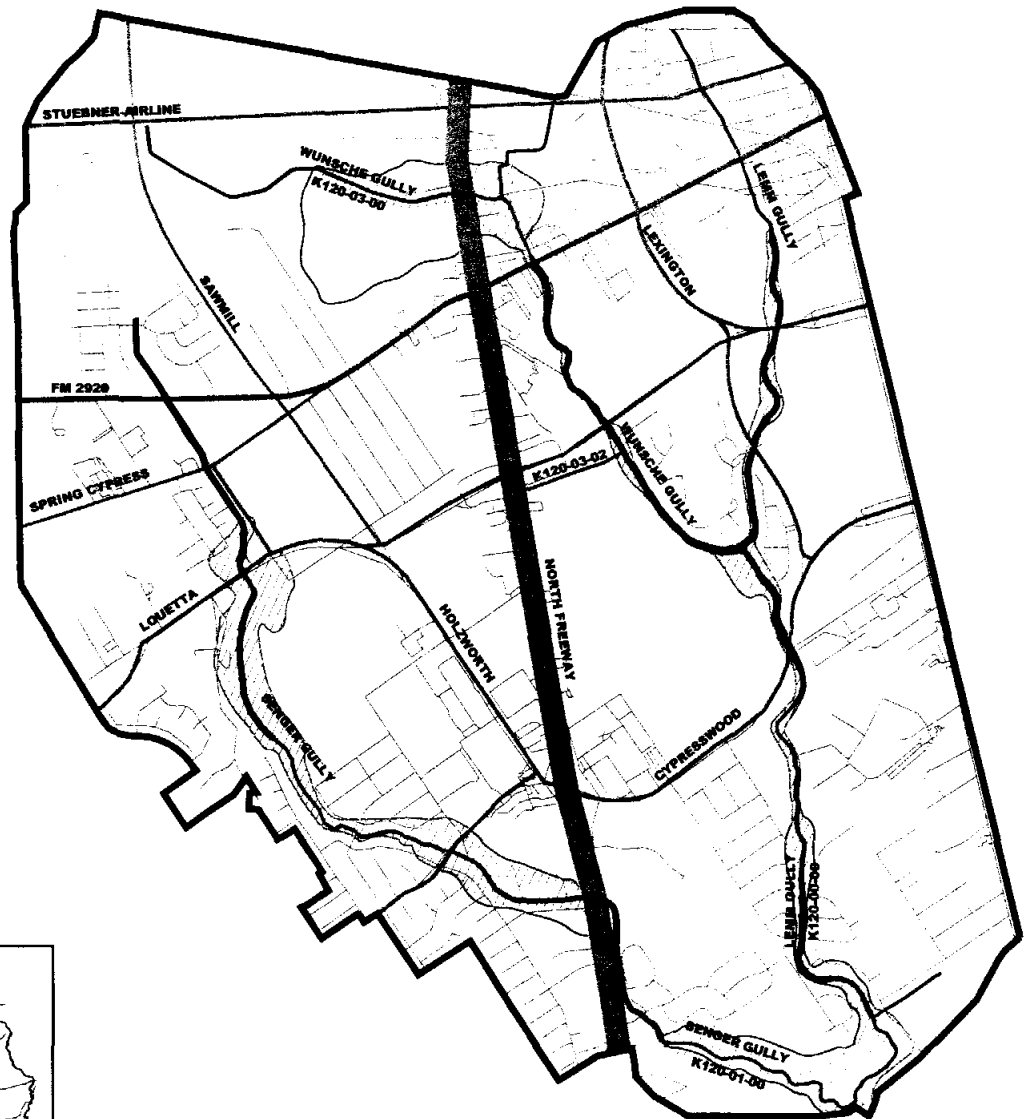
- Proposed Detention Basin
- Proposed Channel Corridor
- Proposed Floodplain/Stream Habitat Preservation
- Voluntary Buyout of Historic Flood Prone Structures
- Proposed Bridge Modification

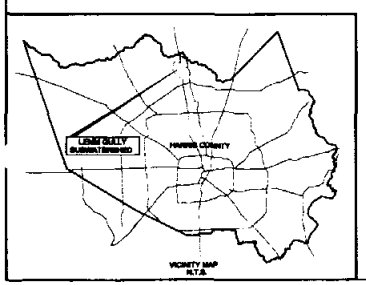
AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-358

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
RECOMMENDED PLAN FEATURES

FEBRUARY 2003	K120-00-00	EXHIBIT 37





LEGEND

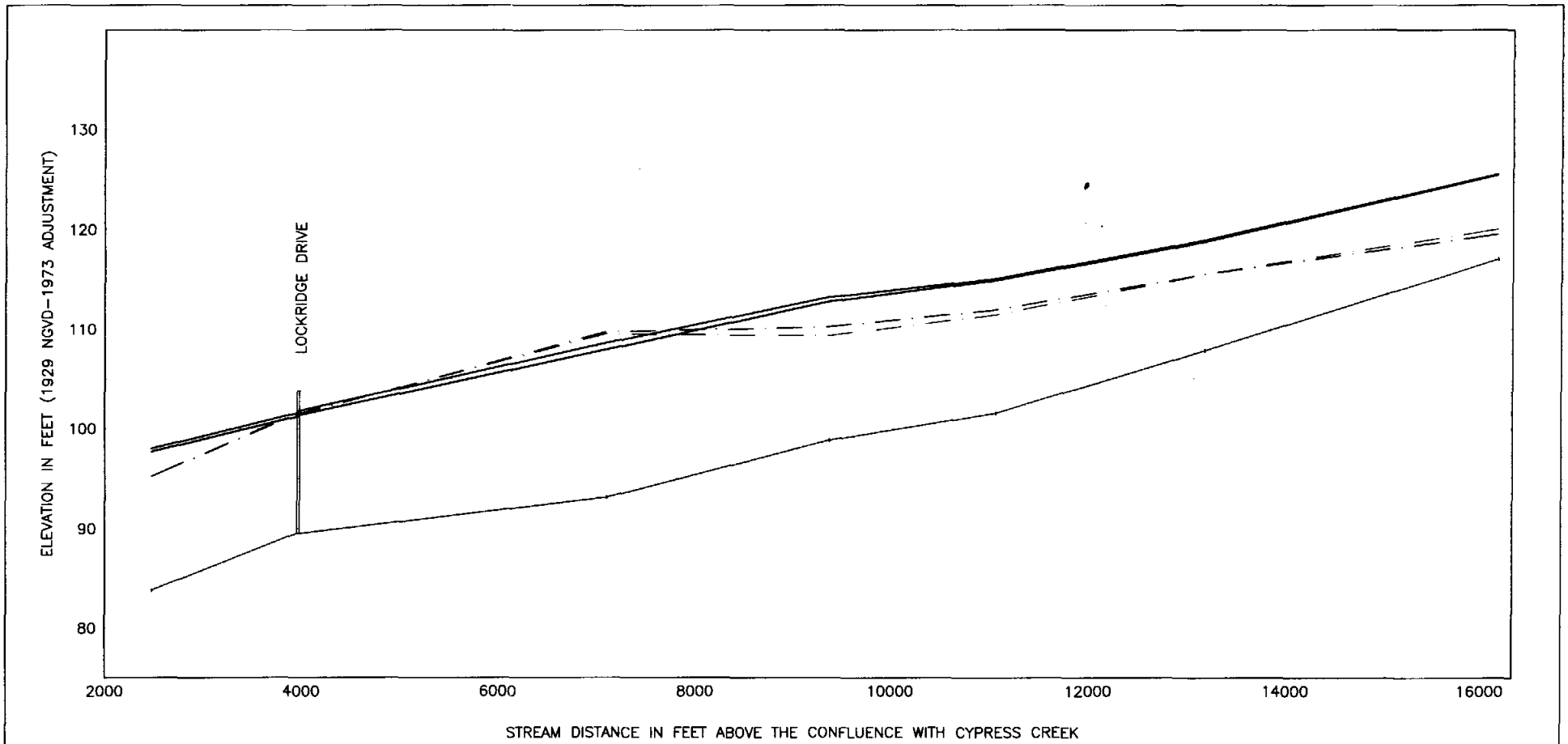
- Street
- Major Road
- Stream
- Watershed Boundary
- Baseline Floodplain
- Recommended Plan Floodplain

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED REGIONAL DRAINAGE PLAN REPORT BASELINE AND RECOMMENDED PLAN FLOODPLAIN MAP

FEBRUARY 2003	K120-00-00	EXHIBIT 38



LEGEND

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

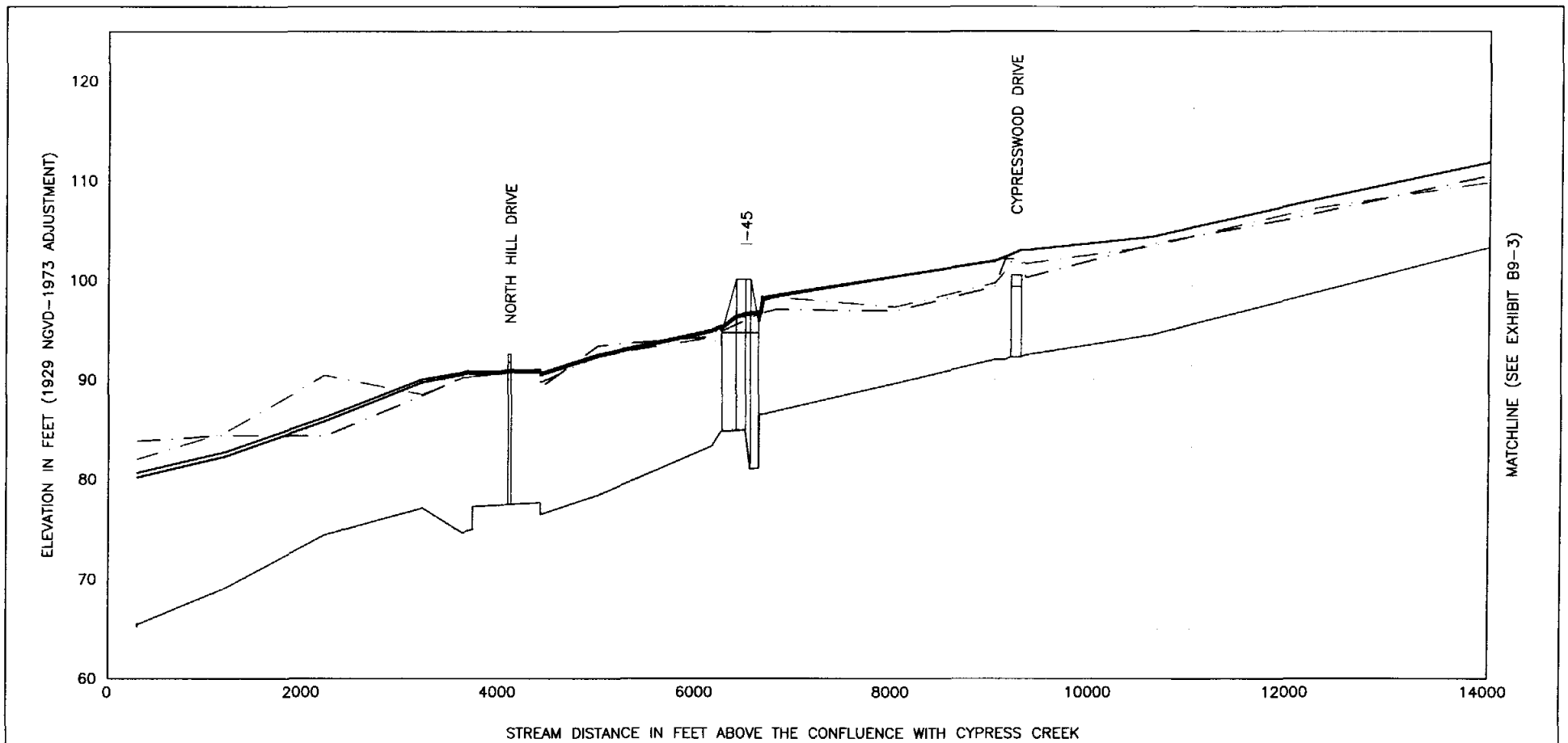
WATER SURFACE PROFILES
- 100-YEAR BASELINE
- 100-YEAR RECOMMENDED PLAN

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LEMM GULLY WATER SURFACE PROFILES
BASELINE AND RECOMMENDED PLAN

FEBRUARY 2003	K120-00-00	EXHIBIT: B8-1



LEGEND

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

WATER SURFACE PROFILES

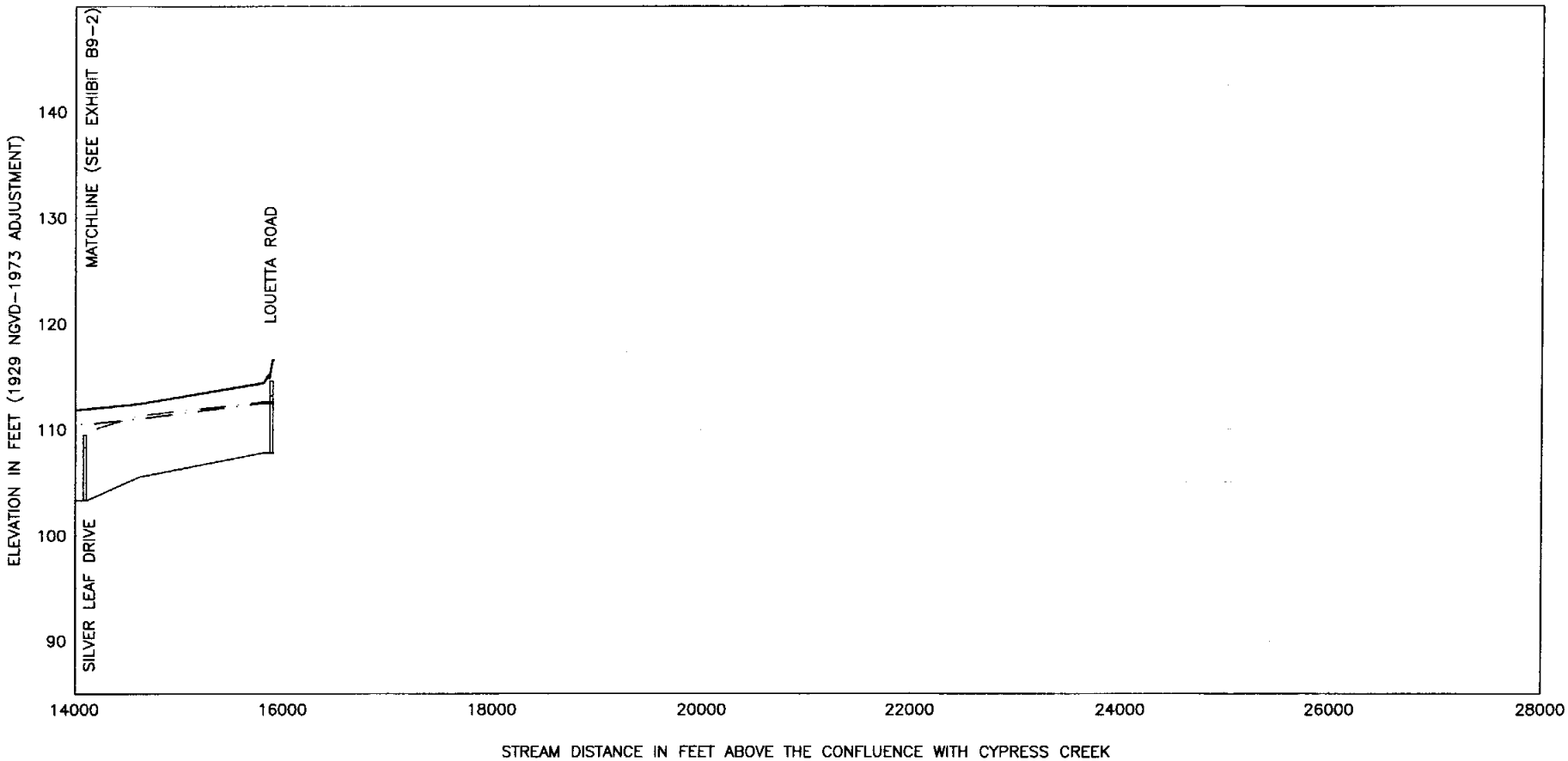
- 100-YEAR BASELINE
- 100-YEAR RECOMMENDED PLAN

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
SENGER GULLY WATER SURFACE PROFILES
BASELINE AND RECOMMENDED PLAN

FEBRUARY 2003	K120-01-00	EXHIBIT: B9-2



LEGEND

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

WATER SURFACE PROFILES

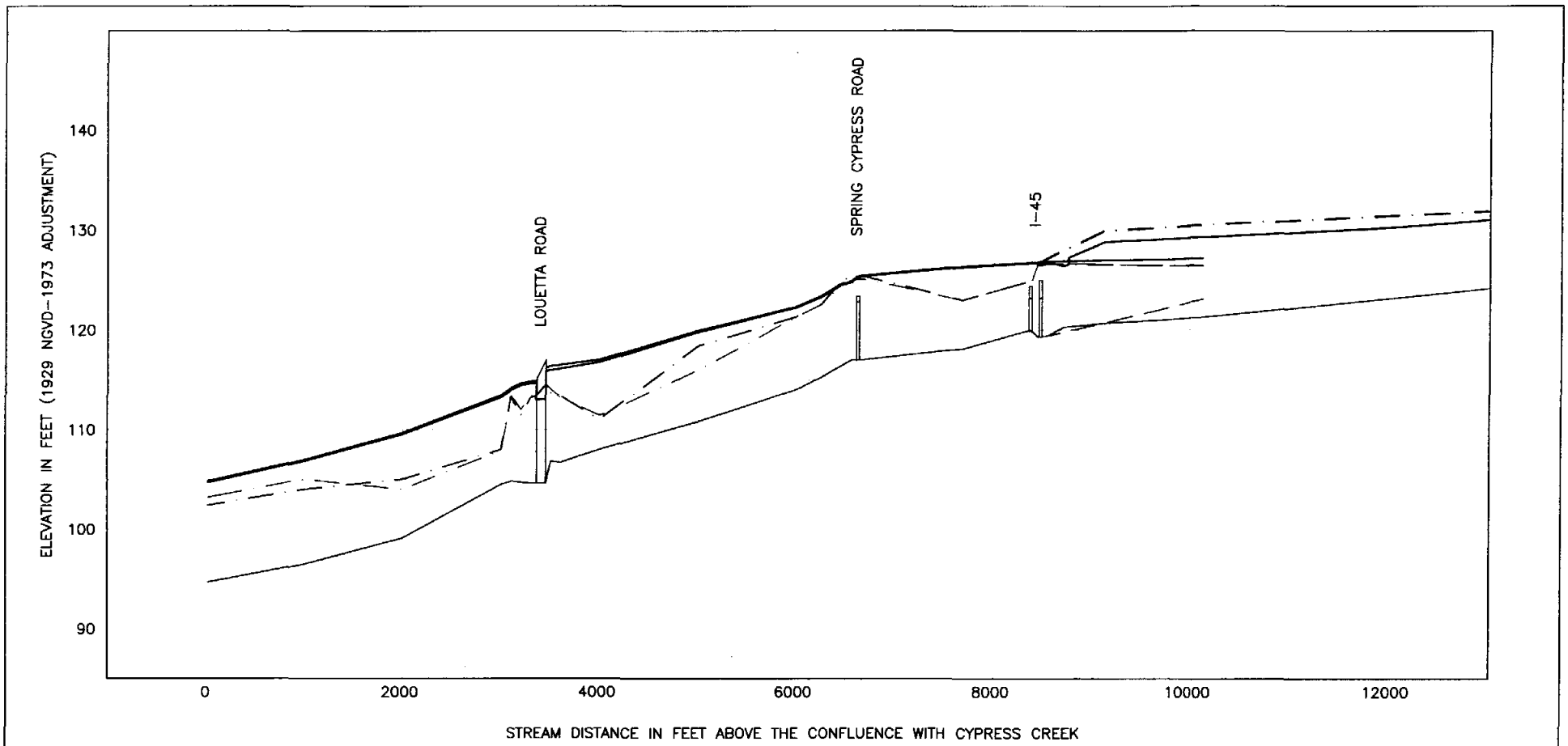
- 100-YEAR BASELINE
- 100-YEAR RECOMMENDED PLAN

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
SENGER GULLY WATER SURFACE PROFILES
BASELINE AND RECOMMENDED PLAN

FEBRUARY 2003	K120-01-00	EXHIBIT: B9-3



LEGEND

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

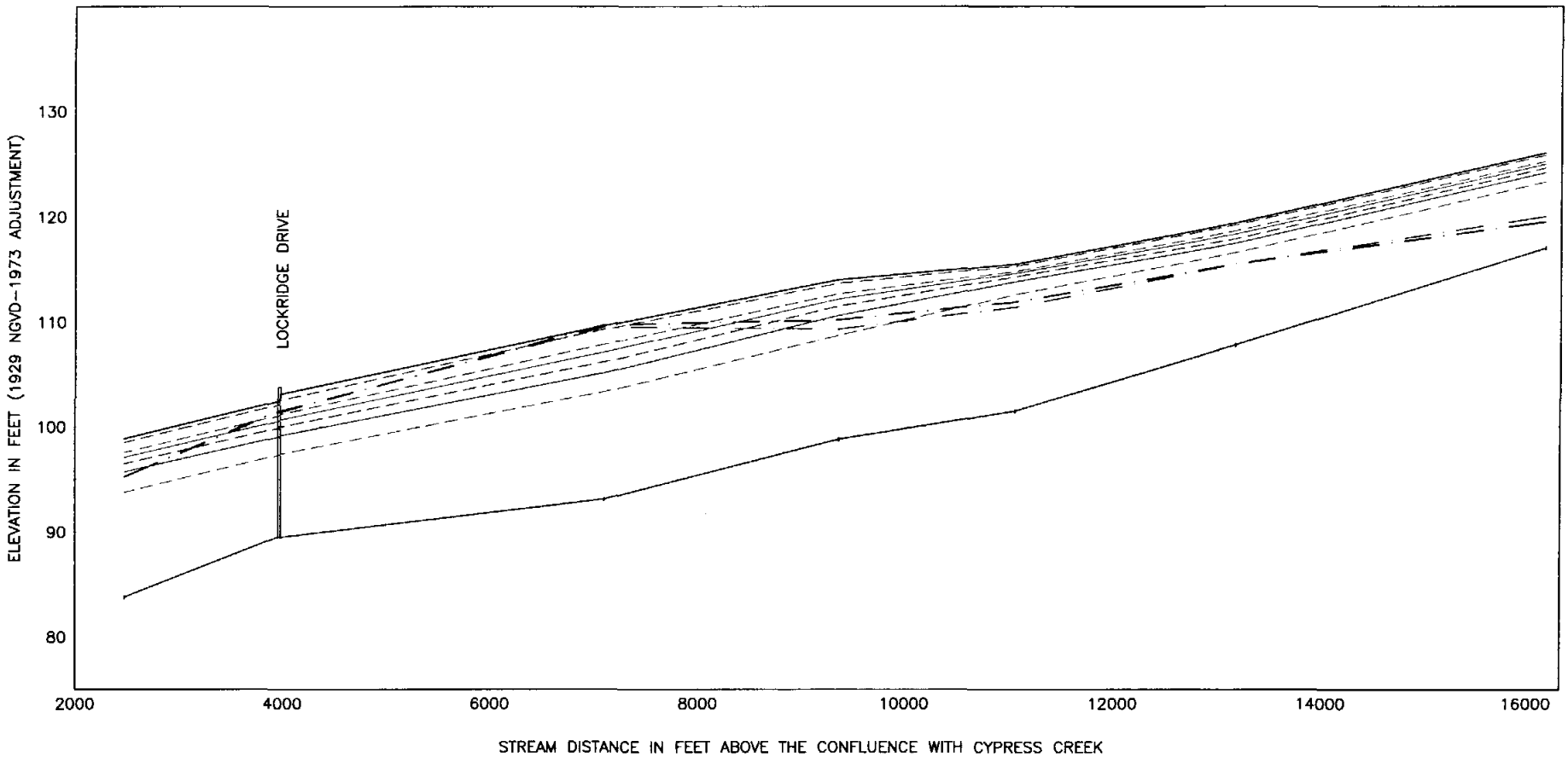
WATER SURFACE PROFILES
- 100-YEAR BASELINE
- 100-YEAR RECOMMENDED PLAN

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
WUNSCHE GULLY WATER SURFACE PROFILES
BASELINE AND RECOMMENDED PLAN

FEBRUARY 2003 | K120-03-00 | EXHIBIT: III-4



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

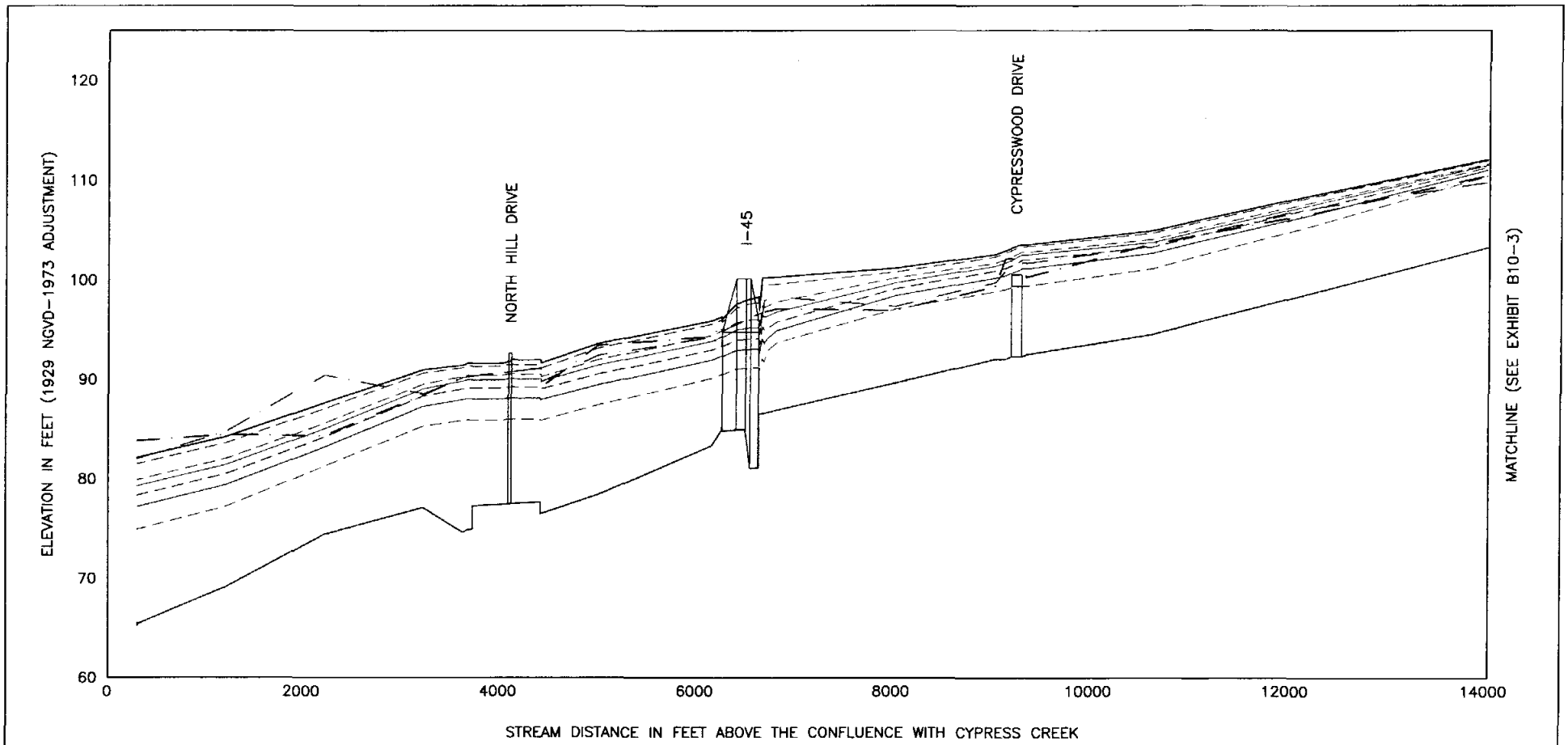
- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-556

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LEMM GULLY WATER SURFACE PROFILES
BASELINE CONDITION MULTIPLE FREQUENCIES

FEBRUARY 2003	K120-00-00	EXHIBIT: B10-1



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

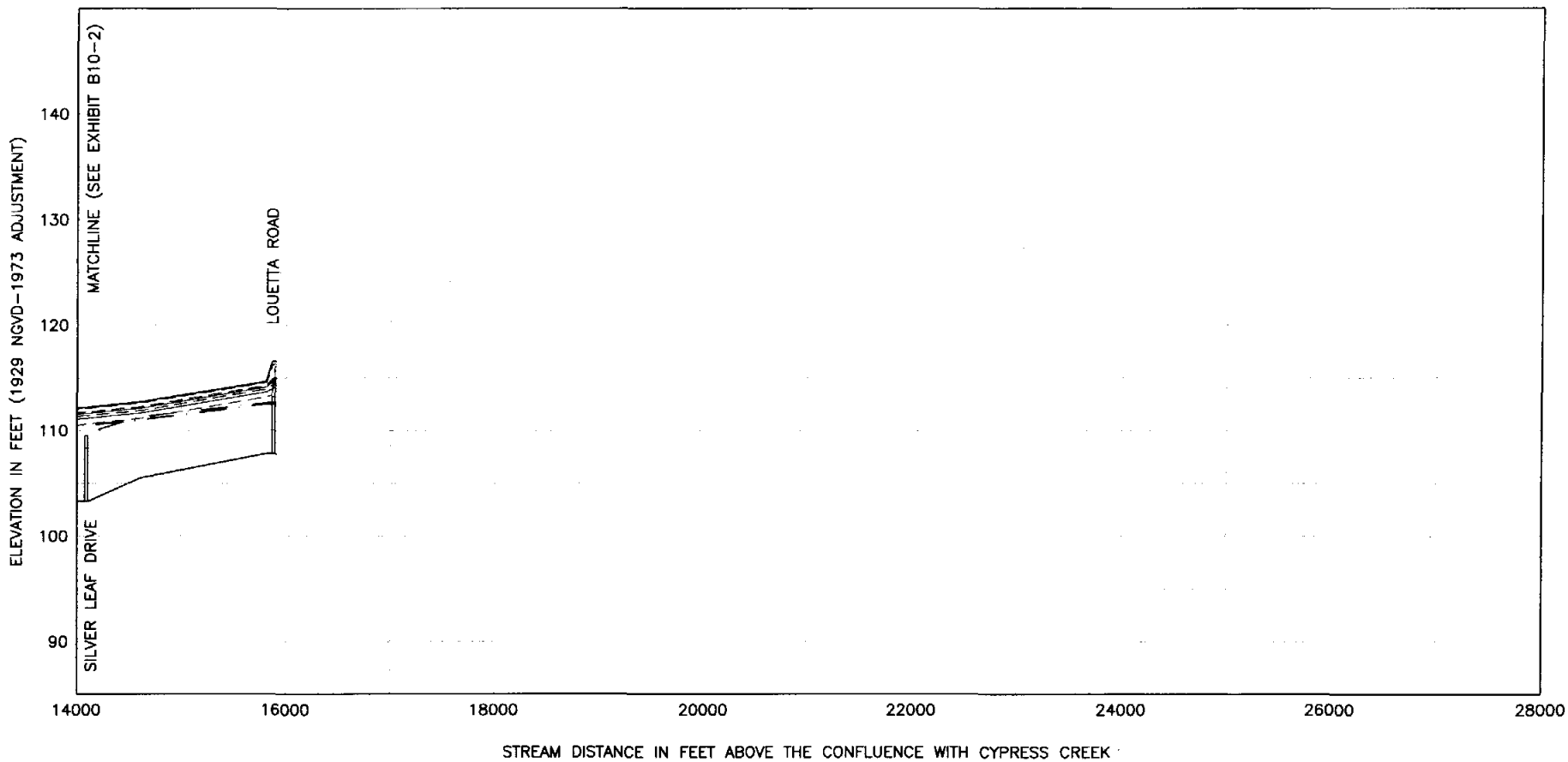
- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2001-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
SENGER GULLY WATER SURFACE PROFILES
BASELINE CONDITION MULTIPLE FREQUENCIES

FEBRUARY 2003	K120-01-00	EXHIBIT: B10-2



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

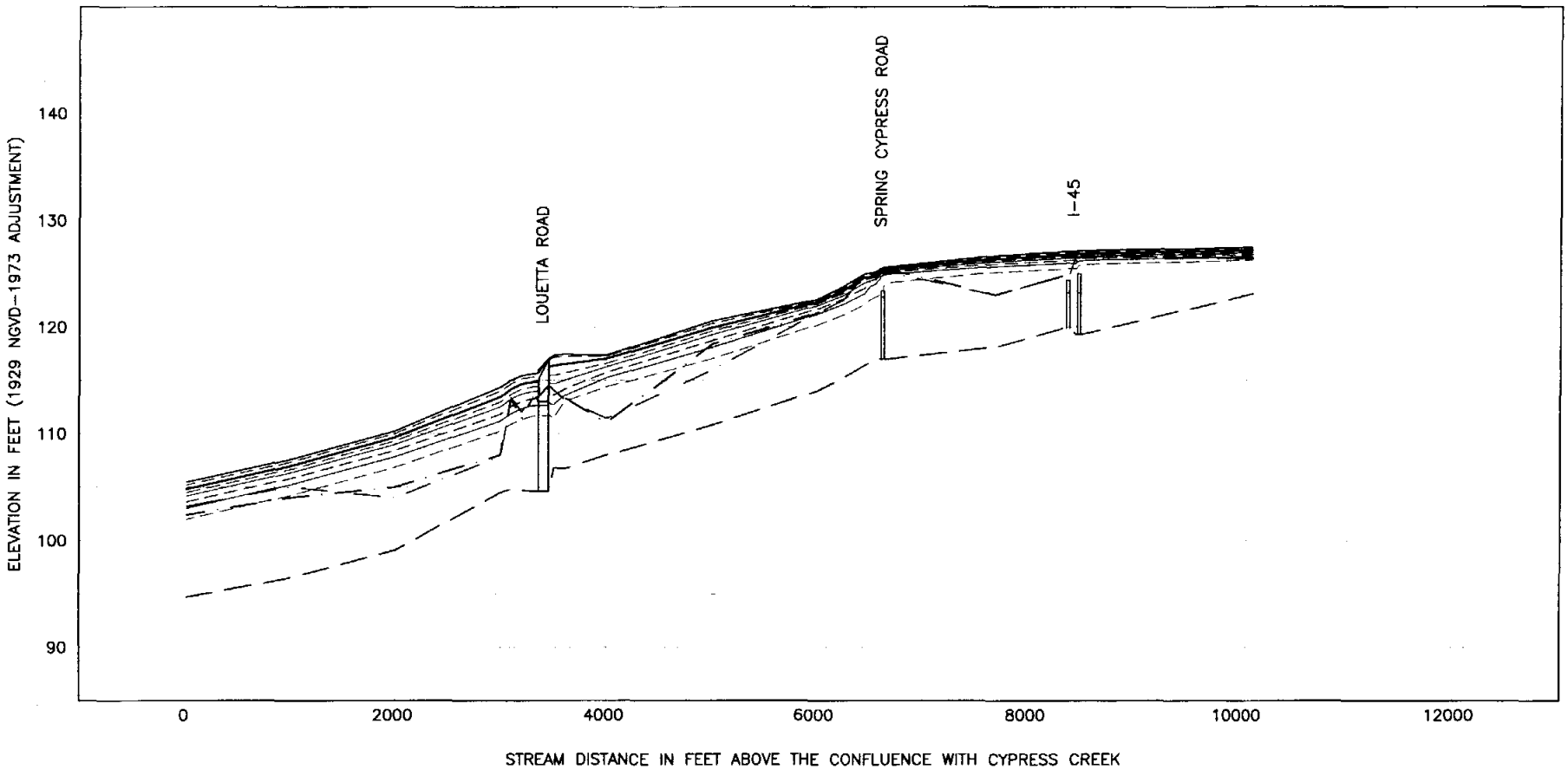
- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
SENGER GULLY WATER SURFACE PROFILES
BASELINE CONDITION MULTIPLE FREQUENCIES

FEBRUARY 2003	K120-01-00	EXHIBIT: B10-3



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE

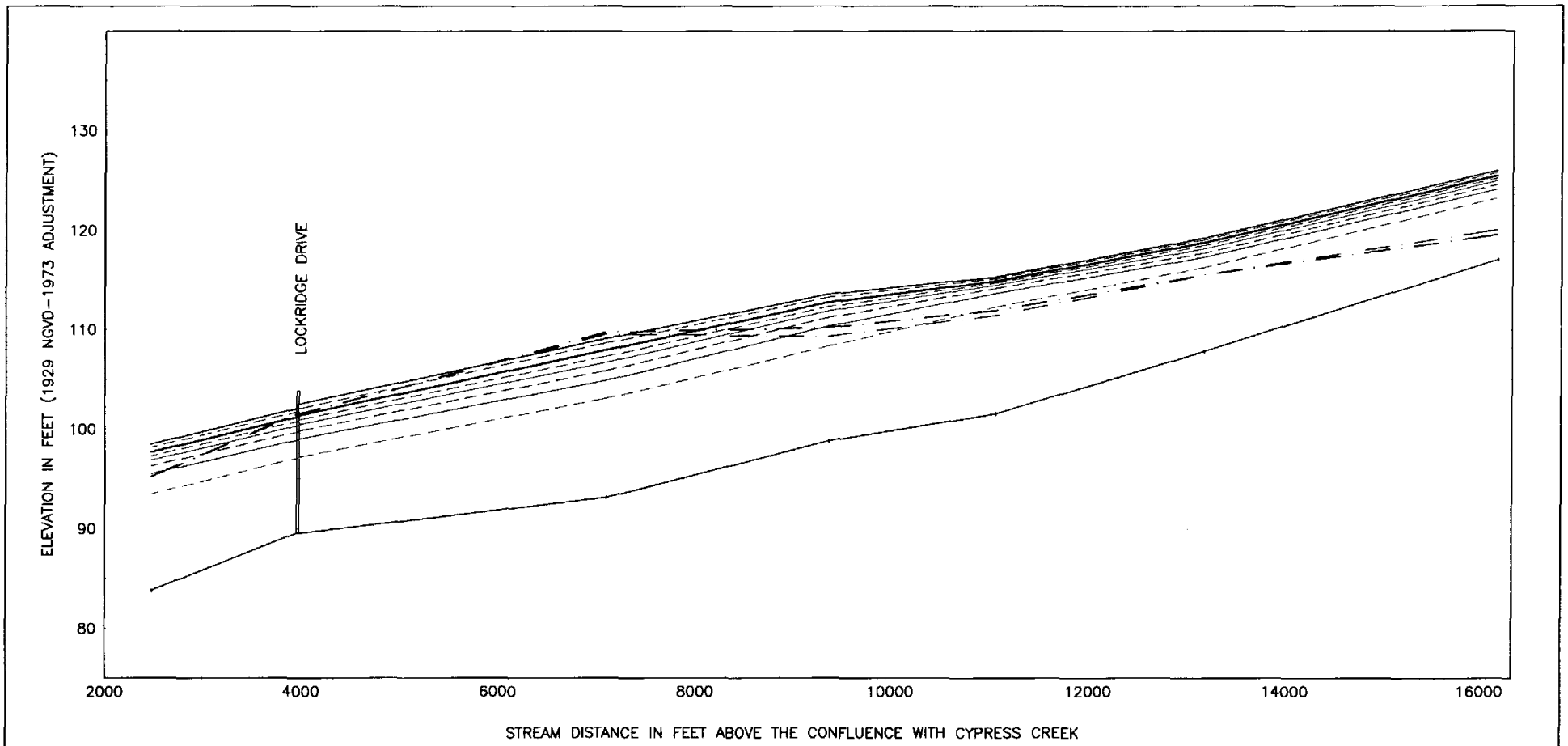
Harris County Flood Control District

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-336

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
WUNSCHE GULLY WATER SURFACE PROFILES
BASELINE CONDITION MULTIPLE FREQUENCIES

FEBRUARY 2003	K120–03–00	EXHIBIT: 810–4



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

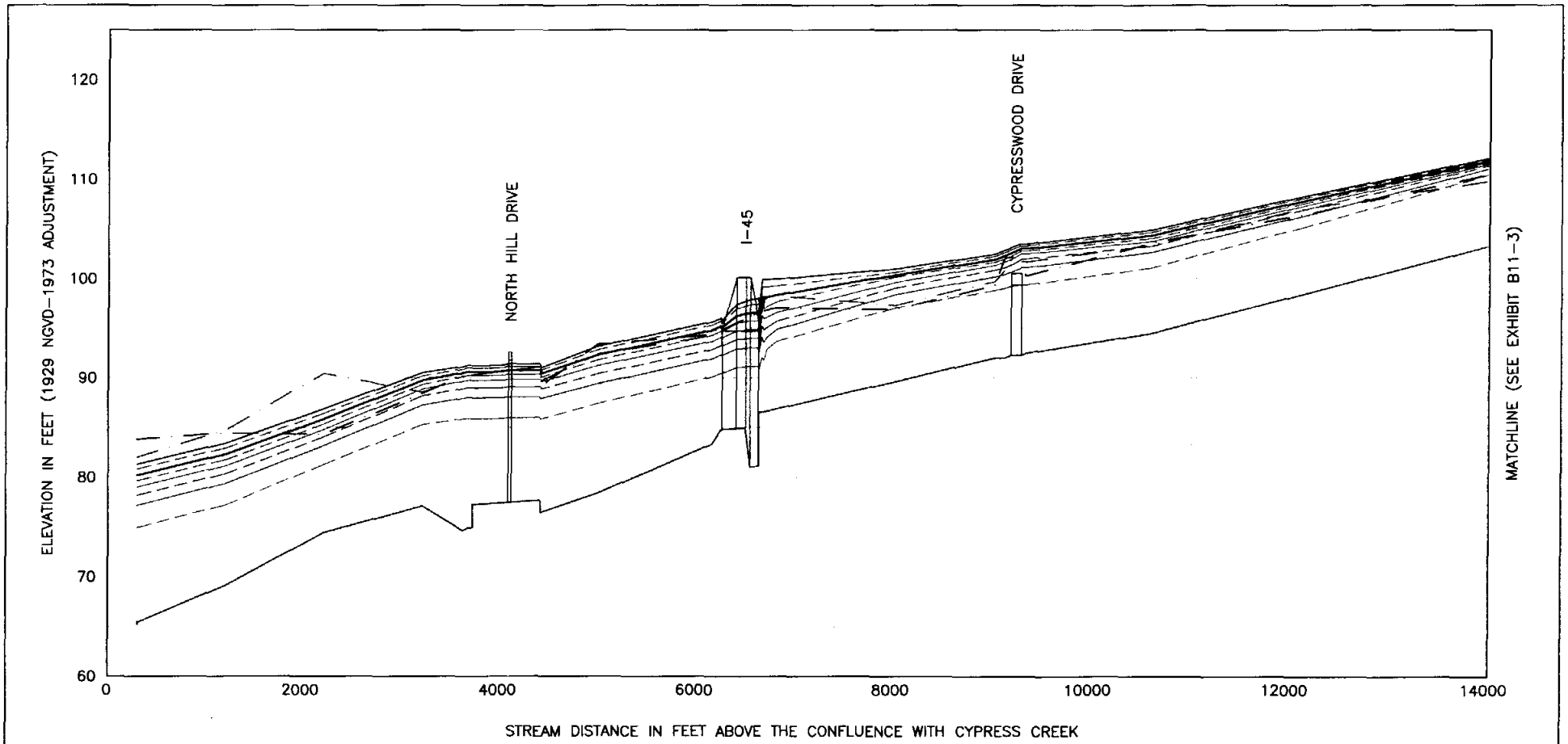
- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
LEMM GULLY WATER SURFACE PROFILES
RECOMMENDED PLAN MULTIPLE FREQUENCIES

FEBRUARY 2003	K120-00-00	EXHIBIT: B11-1



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

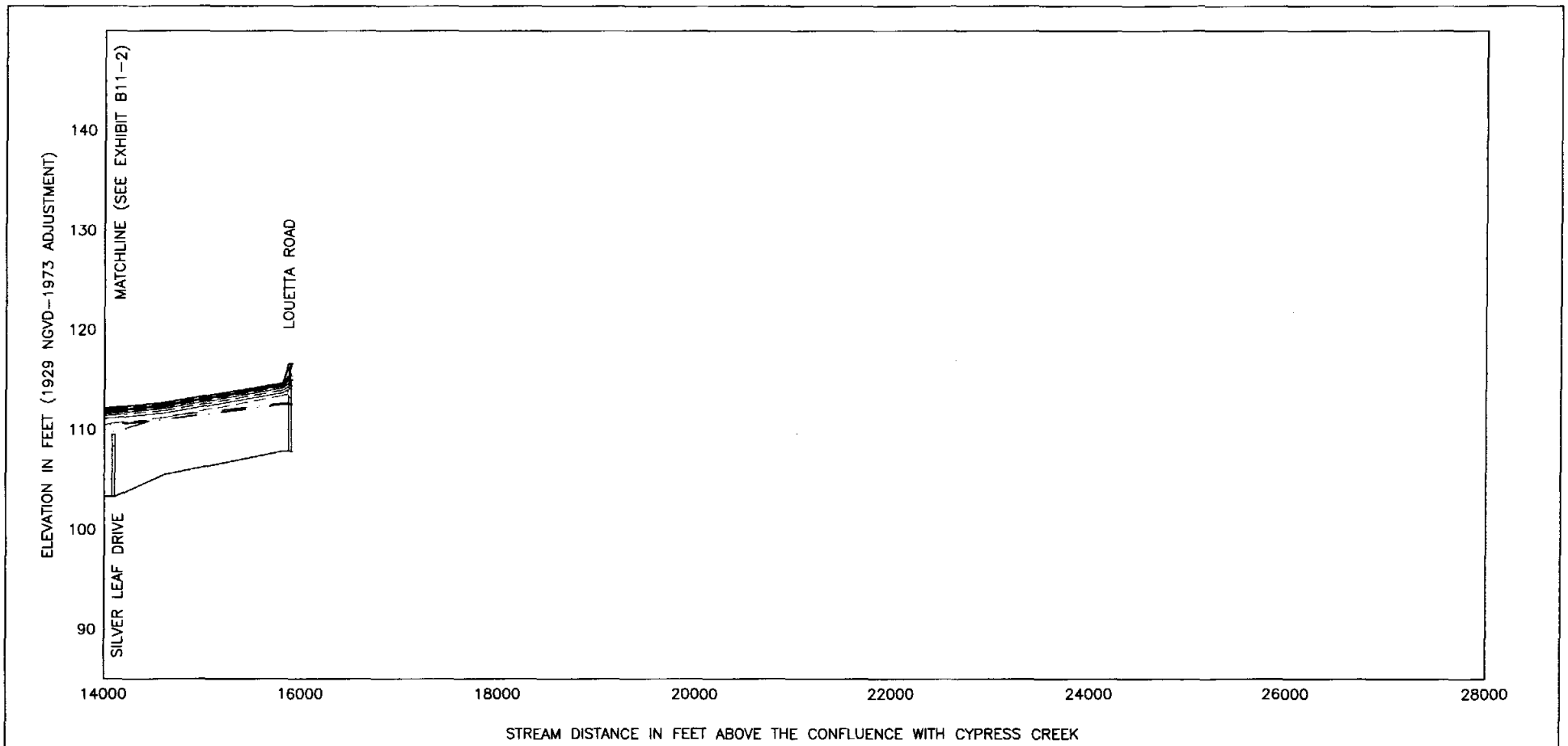
- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
SENGER GULLY WATER SURFACE PROFILES
RECOMMENDED PLAN MULTIPLE FREQUENCIES

FEBRUARY 2003	K120–01–00	EXHIBIT: B11–2



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

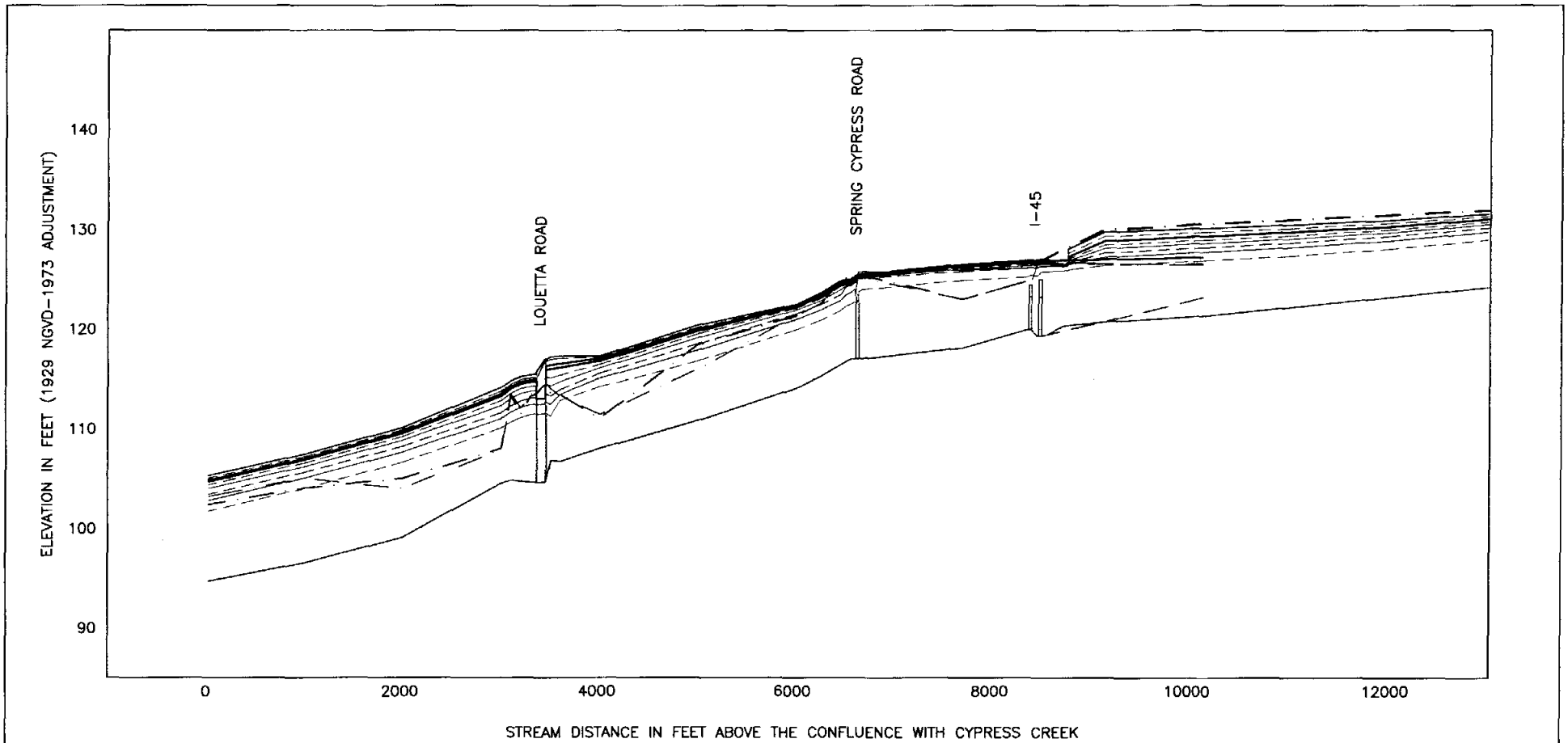
Harris County Flood Control District

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
SENGER GULLY WATER SURFACE PROFILES
RECOMMENDED PLAN MULTIPLE FREQUENCIES

FEBRUARY 2003	K120-01-00	EXHIBIT: B11-3



LEGEND

WATER SURFACE PROFILES

- 500-YEAR
- 250-YEAR
- 100-YEAR
- 50-YEAR
- 25-YEAR
- 10-YEAR
- 5-YEAR
- 2-YEAR

- BRIDGES
- LEFT BANK
- RIGHT BANK
- BASELINE FLOWLINE
- RECOMMENED PLAN FLOWLINE

Harris County Flood Control District

AN INITIATIVE OF HARRIS COUNTY FLOOD CONTROL DISTRICT IN ASSOCIATION WITH THE TEXAS WATER DEVELOPMENT BOARD

REGIONAL DRAINAGE PLAN AND ENVIRONMENTAL INVESTIGATION FOR MAJOR TRIBUTARIES IN THE CYPRESS CREEK WATERSHED
PHASE III - REGIONAL DRAINAGE PLAN REPORT
TWDB CONTRACT NO. 2000-483-356

LEMM GULLY WATERSHED
REGIONAL DRAINAGE PLAN REPORT
WUNSCHE GULLY WATER SURFACE PROFILES
RECOMMENDED PLAN MULTIPLE FREQUENCIES

FEBRUARY 2003	K120-03-00	EXHIBIT: B11-4

TABLE OF CONTENTS

EXHIBITS

TABLES

DEFINITIONS

Baseline Conditions or Baseline Model - Conditions identified for the watershed from which future planning efforts and the recommended plan will be compared to determine if the study goals and objectives will be met. This condition considers the watershed 100% developed, with new development after 1984 consistent with current HCFCD criteria for on-site storm water detention in the determination of the appropriate baseline hydrologic processes. Further, this condition considers the information identified in the environmental baseline report.

Plan Conditions or Plan Model - The baseline conditions model modified to reflect the land-use conditions and recommended plan elements identified for the recommended regional drainage plan for the watershed.

ELECTRONIC FILES

File Name:	Description
HEC-1 Models:	
K124B02.ih1	Baseline Conditions 2-year Flows
K124B05.ih1	Baseline Conditions 5-year Flows
K124B10.ih1	Baseline Conditions 10-year Flows
K124B25.ih1	Baseline Conditions 25-year Flows
K124B50.ih1	Baseline Conditions 50-year Flows
K124B100.ih1	Baseline Conditions 100-year Flows
K124B250.ih1	Baseline Conditions 250-year Flows
K124B500.ih1	Baseline Conditions 500-year Flows
K124R02.ih1	Recommended Plan 2-year Flows
K124R05.ih1	Recommended Plan 5-year Flows

ELECTRONIC FILES *(continued)*

File Name:	Description
HEC-1 Models:	
K124R10.ih1	Recommended Plan 10-year Flows
K124R25.ih1	Recommended Plan 25-year Flows
K124R50.ih1	Recommended Plan 50-year Flows
K124R100.ih1	Recommended Plan 100-year Flows
K124R250.ih1	Recommended Plan 250-year Flows
K124R500.ih1	Recommended Plan 500-year Flows
HEC-RAS Models:	
K12400.prj	Project File—Seals Gully
K12400.p01	Baseline Multiprofile Plan – Seals Gully
K12400.p04	Recommended Multiprofile Plan – Seals Gully
K12402.prj	Project File—Kothman Gully
K12402.p05	Baseline Multiprofile Plan – Kothman Gully
K12402.p07	Recommended Multiprofile Plan – Kothman Gully

1.0 INTRODUCTION

The information presented in this appendix report intends to document the process of developing the recommended regional drainage plan for the Seals Gully watershed. The plan elements identified for the recommended plan are presented, along with the recommended funding and implementation strategies identified for the plan. All supporting regional-plan modeling information for the Seals Gully watershed is included in this report.

1.1 Project Location

The Seals Gully watershed is located in northwest Harris County and is a subwatershed of the Cypress Creek watershed. A vicinity map of the watershed is provided in **Exhibit 1** of the main text report. The 7.7 square mile watershed drains in a southerly direction from Spring-Stuebner Road to Cypress Creek. As seen in **Exhibit C1** and **Exhibit C2**, the watershed is bounded by Spring-Stuebner Road on the north, Kuykendahl Road on the west, Senger Gully watershed on the east, and Cypress Creek on the south.

The Seals Gully watershed includes one main stem (Seals Gully, K124-00-00), a main tributary lateral Kothman Gully (K124-02-00), and a number of tributary ditches constructed to serve various developments throughout the watershed. Only the main stem and Kothman Gully are included as part of the Flood Insurance Study (FIS) and this updated report. The main stem of Seals Gully crosses Rhodes Road, Spring-Cypress Road, Louetta Road, and Cypresswood Drive. Seals Gully has a studied length of approximately 4.1 miles and outfalls into Cypress Creek just upstream of IH-45.

1.2 Background Information

HCFCD intends to prepare a storm water management and flood protection plan for nine tributary watersheds located within the Cypress Creek watershed. The Seals Gully watershed is one of the nine watersheds. The studies conducted within the Seals Gully watershed at varying levels and are identified in Appendix C of the February 2002 *Regional Drainage Plan and Environmental Investigation for Major Tributaries in the Cypress Creek Watershed, Phase I – Hydrologic and Hydraulic Baseline Report.*

The baseline watershed boundary is shown on **Exhibit C1,** with the existing development conditions shown on **Exhibit C2**. The information identified on these exhibits was generated as part of the Phase I study efforts, and was used to assist in identification of the appropriate regional drainage plan for the Seals Gully watershed.

An assessment of the environmental baseline conditions of the Seals Gully watershed was prepared as part of the Phase II – Environmental Baseline Report study efforts. The information presented in this report was used to help identify the recommended regional drainage plan and

appropriate plan elements for the watershed. The lower portions of the main stem of Seals Gully are identified as having good stream corridor habitat beneficial for wildlife and water quality. Further, scattered wetlands have been identified in the upper portions of the watershed. However, some of the wetlands and areas of high-quality stream habitat have been replaced or impacted by development since the Environmental Baseline Report was completed. Environmental considerations for the Seals Gully watershed are shown on **Exhibit C3**.

1.3 Flood Hazard

Flood hazards along Seals Gully, which existing model information was available, were identified for the baseline conditions. These flood hazards were identified by modifying the current effective hydrologic models for the watershed to reflect appropriate baseline land-use conditions, with the resulting storm flows incorporated into the appropriate hydraulic model reflecting the current conditions of the channel system. The 1-percent storm flood profile information resulting from the hydraulic model was used in conjunction with existing digital terrain model produced from LIDAR-obtained ground elevation information to produce a flood-hazard boundary map. The result of this mapping is shown on **Exhibit C8**.

1.4 Summary of Baseline Conditions

The results of the study efforts for identifying the baseline conditions indicate that the 1% storm flood boundary is different from the current effective Federal Emergency Management Agency regulatory flood boundary. This is predictable since updated information about the watershed and its studied streams has been used in the identification of the baseline conditions. The information prepared in the identification of the baseline conditions flood hazards and environmental baseline conditions is suitable for use in identifying the appropriate regional drainage plans.

2.0 REGIONAL DRAINAGE PLAN FORMULATION

The objectives of this Phase III study are to develop Regional Drainage Plans to guide future development of the watershed and to address existing flooding issues. The sections below detail the methodology of the plan formulation steps, the watershed resources and alternate plans developed for the Seals Gully watershed.

2.1 Methodology

The formulation of the recommended regional drainage plan used an approach that considered the information prepared as part of the Phase I and Phase II study efforts. Further, information concerning the proposed major roadway thoroughfare alignments was also used to help in the identification of recommended alignments for lateral channels that could serve as outfall drainage for these roadways. A series of public meetings and coordination through advisory committee meetings helped in providing direction for identifying a recommended plan.

Hydrologic and hydraulic models prepared as part of the baseline study effort were modified appropriately to reflect alternate plans for the watershed. Alternate plans were identified and the results measured against each other to determine which alternate represented the best plan for the watershed.

2.2 Watershed Description

The Seals Gully watershed is situated in the mid-reaches of Cypress Creek. The Seals Gully watershed as delineated within the baseline study encompasses approximately 7.7 square miles and has drainage length of 4.7 miles from its watershed divide to its mouth. The watershed is bounded by Spring-Stuebner Road on the north, Kuykendahl Road on the west, Senger Gully watershed on the east, and Cypress Creek on the south. Within the Cypress Creek drainage basin, the Lemm Gully watershed lies to the east, and the Spring Gully lies to the west of Seals Gully. To the north lie the J121-00-00 watershed of Spring Creek and the M101-00-00 watershed of Willow Creek.

The watershed has a gentle, mild slope from the northwest to the southeast along Seals Gully and from the north to the south along Kothman Gully. The watershed drainage system contains one main stem (K124-00-00), one major tributary (K124-02-00), and several lateral ditches.

The watershed contains primarily single-family developments with some scattered commercial development. Most of this development lies within the lower reache of Seals Gully and the upper reaches of Kothman and Seals Gully. The existing land uses and development (1999) in the watershed is shown in **Exhibit C2**.

This analysis used the baseline conditions model subbasins and modified the hydrologic parameters of each accordingly to reflect alternate plan scenarios. In some instances, the baseline subbasins were further subdivided in order to more accurately model particular plan elements. The subbasins can be described as follows:

- K124A – Upstream western subarea of the Seals Gully (1056 acres), includes areas upstream of Spring-Cypress Road along Seals Gully.
- K12405A – Upstream eastern subarea of the Seals Gully (476 acres), includes areas upstream of Spring-Cypress Road along K124-05-00.
- K124B – Mid-reach subarea of the Seals Gully (685 acres), includes areas between K124-05 and K124-02. This reach extends from Spring-Cypress Road to Louetta Road.
- K124C – Mid-reach subarea of the Seals Gully (590 acres), includes areas between K124-02 and Devonshire Subdivision.
- K124D – Downstream subarea of the watershed (391 acres), includes areas between Devonshire Subdivision and Cypress Creek.
- K12402A – Upstream subarea of the Kothman Gully Watershed (1083 acres), includes areas upstream of FM 2920.
- K12402B – Downstream subarea of the watershed (664 acres), includes areas between FM 2920 and confluence with Seals Gully.

Seals Gully discharges into Cypress Creek (HCFCD Unit K100-00-00) just upstream of Interstate Highway 45. **Exhibit C2** shows Seals Gully Watershed subareas with location and station of each routing node along with sub-basin names.

2.2.1 Stream Identification

The Seals Gully watershed includes one main stem Seals Gully (K124-00-00), a major tributary Kothman Gully (K124-02-00), and a number of lateral ditches. Of these laterals, some have been constructed to serve various developments throughout the watershed, while several are still in a natural state. As noted earlier, only Seals Gully and Kothman Gully were the subjects of the previous baseline study. Seals Gully has a studied length of approximately 4.1 miles and outfalls into Cypress Creek just upstream of IH-45. The studied length of Kothman Gully is 2.8 miles and outfalls into Seals Gully just downstream of Louetta Road.

Seals Gully and Kothman Gully are almost completely rectified with only a portion of the mid-reach of Seals Gully remaining in its natural state. The secondary laterals within the watershed are mostly un-constructed with laterals K124-05-00 and K124-02-03 having had some prior rectification. The following is an inventory of the other laterals: K124-01-00, K124-04-00, K124-05-00, K124-02-01, K124-02-02, and K124-02-03.

2.3 Basin Resource Inventory

Information was obtained for the watershed concerning existing and planned land use, transportation facilities, structure values and economic investment, floodplains, environmental resources, geology and soils, etc. This information was used to develop a general understanding of the natural resources, area development, and economic investment necessary to identify the problems and needs of the watershed and how best they should be considered in the overall planning efforts.

2.3.1 Stream Habitat Quality

The Environmental Baseline Report (EBR) qualitatively established stream habitat quality rankings based upon characteristics of the stream channel such as channelization, vegetation, and urban density. The ranking system is shown in the EBR and was based solely on color infrared aerial photos and local knowledge of the streams. The stream quality designations are shown on **Exhibit C3**. The goal of the regional drainage planning effort was to attempt to preserve areas of high-quality stream habitat in order to enhance the environmental benefits of the plan.

Most of Seals Gully has been identified as has having a low-quality stream habitat. This is consistent with the extensive channelization of the stream within these reaches. The reach of Seals Gully between Louetta and Spring-Cypress Roads is labeled as having a medium-quality stream habitat. The tributary K124-01 is identified as having a medium-quality stream habitat for the lower two-thirds of its reach. The upper portion is listed as a low habitat stream. The tributary K124-04 is identified as a low habitat stream. Tributary K124-05 is identified has having a low stream habitat for the upper reaches. The middle reach is identified has having a high stream habitat. However, this reach has been channelized and should no longer be viewed as a high stream habitat. The lower reach was identified as a low habitat stream. The entire reach of Kothman Gully and its tributaries have been labeled as having a low-quality stream habitat.

The EBR also identified areas of natural prairies and wetlands as well as know historical sites and hazardous material sites. Within the Kothman Gully sub-watershed, there are areas that are identified as wetland and natural prairies areas. However, a good portion of these areas has been lost to residential development. There are areas identified as wetlands within the K124-04 subarea, the upper Seals Gully area, and in the upper K124-05 drainage area upstream of FM 2920. Also identified in the upper drainage area of K124-05 are areas of natural prairies.

2.3.2 Land Uses in the Watershed

The Seals Gully watershed contains primarily single-family developments with some scattered commercial development. Most of this development lies within the lower reaches of Seals Gully and the upper reaches of Kothman and Seals Gully. The watershed was considered 30 percent developed in 1984. The development within the watershed based on 1999 conditions was 38 percent. This level of development for the watershed is illustrated on **Exhibit C2**. Based on field investigations performed in 2002, it is estimated that the current level of development is approximately 43 percent.

The watershed was previous developed along the lower reaches of Seals Gully and the upper reaches of Seals and Kothman Gullies. Along Seals Gully the development was typically gathering downstream of Louetta Road as well as upstream Spring-Cypress Road along Rhodes and Kuykendahl Roads. Along Kothman Gully, the concentration of development occurred upstream of FM 2920. The current areas of development are occurring within the mid-reaches of both streams. Based on the pattern, the final stage of full development for the watershed will occur in the upper reaches of Seals Gully, along Seals Gully un-constructed laterals, and the lower reaches of Kothman Gully.

Along Seals Gully near Cypresswood Drive, Enchanted Oaks and Devonshire Woods subdivisions lie on the left banks. Downstream of Louetta Road, Cypress and Candlelight Park are along the rightbank, while Candlight Hills is on the left bank. In between Kothman and Seals Gullies, upstream of Louetta Road is Wel Don Forest. Bainbridge Estates and Brandywine Pines lie along the right bank of Seals Gully. Upstream of Spring-Cypress Road, Bridgestone Subdivision lies on both sides of the banks of Seals Gully. Along Kothman Gully, Normandy Forest and Convington Bridge Subdivisions are upstream of Spring-Cypress Road Upstream of FM2920, Dove Meadow, Windsor Forest, and Northwood Park drain into Kothman Gully and K124-02-03. Upstream of Spring-Stuebner Road, Forest North Subdivision drains into Kothman Gully.

2.3.3 Structure Inventory

An inventory of structures that might be affected by flooding along the main stem was performed. The purpose of the inventory was to identify and estimate the economic value or benefit if the structures were either removed or protected from flooding by the regional plans. In the Seals Gully watershed, approximately 677 structures were identified that might be affected by flooding from the main stem and tributaries. The general location of these structures is shown on **Exhibit C4**. In order to estimate the value of these structures, a search of the Harris County Appraisal District (HCAD) records was performed using a GIS file supplied by HCFCD. Using HCAD data, it is estimated that the total value of the 677 structures is approximately $18,000,000.

2.3.4 Economic Factors for the Watershed

The Seals Gully watershed is typical of the tributary watersheds in the lower portions of the Cypress Creek watershed. The development within the watershed is mostly residential. The remaining undeveloped areas will lend to more residential development. The pressure for development will require the extension and development of the tributary network within the watershed. Although current development regulations are written to ensure that new structures are not place in areas without adequate flood protection, there are numerous structures currently located in flood-prone areas. There are also several documented flood damaged structures. Therefore, structural damage prevention is an economic factor within the Seals Gully watershed.

2.4 Problems and Opportunities Identification

The flood hazard information identified in the Phase I study efforts was used to determine the areas within the watershed most susceptible to out-of-bank flooding. Additionally, opportunities for enhancement of the watershed through the reduction of existing flooding and preservation of environmental features in the design of the regional plans were identified.

2.4.1 Economic Flood Damage Analysis

In the Seals Gully watershed, 677 structures were identified as being susceptible to receiving flood damage during a 100-year event at a cost of approximately $18 million. The general location of these structures is shown on **Exhibit C4**. Of these structures, 658 are located within the contiguous areas shown in **Exhibit C4**. The remaining 19 structures are scattered, likely isolated likely incidences of flooding. The dollar amount specified will be the likely benefit of any plan implemented that eliminates the 100-year floodplain.

An economic analysis was carried out for a 50-year period with a most likely start date of 2010. Using the federal interest rate for fiscal year 2002 of 6.125 percent, it is expected that average annual equivalent damages to structure and content in the watershed will be $4.4 million if the current (baseline) drainage conditions remain unchanged. An average of $3.4 million annual damages will be attributed to Kothman Gully alone. The section of Kothman Gully upstream of FM2920 accounts for 60% of Kothman Gully damages.

2.4.2 Identification of Flood-Prone Areas

As shown on **Exhibit C4**, flood prone areas as determined from the LIDAR-based HEC-FDA analysis of baseline conditions, can be seen to occur more in the most upstream reaches of Kothman and Seals Gully. This can be attributed to the low capacity (below 50-year) reaches draining areas of large development.

2.4.3 Summary of Public Comments Received

Three public meetings have been held to discuss this project, and public comment on existing drainage problems, plan alternates, and the recommended plan have been solicited. A summary of public comments received regarding the Seals Gully watershed is shown below.

First Public Meeting (August 2001)
Three comments were received, indicating that poor planning, insufficient maintenance and continued development is contributing to the flooding conditions.

Second Public Meeting (October 2002)
No comments were received for Seals Gully watershed during this second public meeting.

Third Public Meeting (April 2003)
One comment was received indicating a general acceptance of the recommended plan for the watershed.

2.4.4 Summary of Repetitive Flood Loss Data

Data on structures that have experienced repetitive flood losses was collected for Harris County. This data, provided by FEMA and the local floodplain administrators, includes flood insurance damage claims. The information also included flooding claims from Tropical Storm Allison of June 2001. Approximately 3000 properties are listed in the database of information obtained.

Within the Seals Gully watershed there are 93 such documented structures. Of these properties identified within the Seals Gully watershed, 66 structures are grouped within the Enchanted Oaks and Devonshire Subdivisions along the lower reaches of Seals Gully near Cypresswood Drive. There is also a group of structures within the Northwood Park Subdivisions along K124-03-00 in the upper portions of Kothman Gully watershed. There also is some documented historic flooding within the Forest North subdivision in the upper reaches of Kothman Gully as well as in some scattered areas within the Bridgestone subdivision in the upper reaches of Seals Gully. The locations of these previously flooded structures are indicated on **Exhibit C4**.

2.4.5 Opportunities for Watershed Enhancement

This drainage study presents an opportunity to provide for future dual-use facilities such as parks and sports fields that also serve as detention facilities and preserve any areas for environmental conservation. Hike and bike trails along the existing channels have been

identified within the Harris County Parks Masterplan. These trails are potential multi-use aspects for the watershed.

There are several areas available within the watershed that may be beneficial to preserve and to enhance in order to benefit the community. As noted above, there are areas of high-quality stream habitat, especially in the lower reach of Seals Gully, that are not under development pressure and can be preserved to enhance the environmental quality of the watershed. There are also large open areas near the main channel that may be available for dual-use facilities such as parks and sports fields that also serve as detention facilities. The upper reach of Seals Gully contains a sand pit that appears to no longer be in use. This area may also be available for use as a storm water detention facility.

2.4.6 Identification of Major Thoroughfare Outfalls

The major roads through the watershed are shown in **Exhibit C5**. Road crossings of the main stem, Seals Gully, include: Rhodes Road, Bridgeview Lane, Spring-Cypress Road, Ella Boulevard, Louetta Road, Mirror Lake Road, Candle Creek Drive, and Cypresswood Drive. The road crossings of Kothman Gully include: Spring-Stuebner Road, Green Lake Drive, FM 2920, Spring-Cypress Road, and Louetta Road.

Future roadway expansions and extensions include Ella Road, Spring-Cypress Road, and Kuykendahl Road. Ella Road, which has recently been extended from Louetta Road to Falvel Road, will be extended further north along Falvel to Spring-Stuebner Road. Also Spring-Cypress Road will be expanded from 2 lanes to 4 lanes along its entire reach through the watershed. The expansion of Kuykendahl Road from Spring-Cypress Road north to FM 2920 is nearing completion. The Gosling Road extension will connect Northpointe Road at Kuykendahl to the existing Gosling Road north of Spring-Stuebner Road.

2.4.7 Storm Water Quality Issues

As part of new regulations enacted by Harris County in October 2001, all new development that outfalls into Seals Gully will be required to provide storm water quality protection for the outfall drainage. This includes roadway projects, subdivisions and other development of 5 acres or more. The regional plans evaluated as part of this project are planned to provide general water quality benefits, as will be discussed later, but do not specifically address individual developments or roadway projects. Additional storm water quality features will have to be designed for these projects, in order to comply with the new effective regulations.

2.5 Alternate Drainage Plan Formulation

A series of alternative drainage plans were formulated for the Seals Gully watershed. The formulation of the alternative plans was performed towards the achievement of stated goals and objectives identified for the study effort. The general objectives include the alleviation of existing drainage problems and to construct a plan to provide the necessary drainage infrastructure for future roadways and development that the watershed may incur. Also within the objectives is applied a consideration of the environmental concerns as well as provisions for multi-use facilities that could, in addition to flood control, provide other benefits such as recreation and aesthetics.

Generally, plan formulation alternatives for the watershed were developed by considering elements that include channel modifications alternatives, detention alternatives, and non-structural and "no-action" alternatives. The principal components of each alternative scenario included a single opportunity for each reach or a combination of these opportunities, especially in the consideration of multi-use facilities. The following section presents a description of each alternative investigated. The investigation of these scenarios for practicality and benefit is presented in **Section 2.6**.

2.5.1 Common Features to Alternate Plans

Each of the alternate plans presented below are combinations of these elements. Although the alternates differ somewhat in their features, there are common elements to all the plans presented in this study.

Emphasis was placed on preserving areas of high-quality stream habitat and providing a multiple-use as well as implementing a flood control facility. Where new channels (or channel extensions) have been recommended, the channel design is based on a larger section, incorporating more aesthetics and providing opportunities for multiple uses. This section has flat side slopes and large benches for vegetation and recreational usages. This section also tends to require less maintenance and is less susceptible to erosion. A typical cross-section of this channel is shown in **Figure 1** of the main report. For the analyses, a standard design for this channel will consist of conveyance and storage element sections. The conveyance element will consist of a meandering vegetated channel section. The channel will be approximately four feet deep with 6-foot bottom width. The storage element will consist of a 100-foot bench section, within which the channel shall meander. The bench section will be approximately 6 feet deep and have a minimum of 8:1 side slopes. The bench section will also have a multiple usage emphasis. A 30-foot maintenance berm is reserved on either side of the banks. This typical channel design calls for a 300-foot wide waterway corridor. Where a detention basin has been recommended, this facility considers opportunities for multiple uses. A typical layout of a detention basin is shown in **Figure 2** of the main report.

Due to the emphasis of the planning process, each of the alternatives below includes similar elements. These elements include the proposed channel corridors along K124-04-00, K124-05-00, and a new lateral K124#C1. These channels will lie in a 300-foot wide waterway corridor as described above. Also included is the channel extension of K124-02-03. These channels are to provide the drainage infrastructure required for new development and roadways within the watershed.

There are several bridges that are to be removed or replaced along Seals Gully and Kothman Gully. The modification of these bridges will improve the conveyance capacity of the streams. These structures include the Candle Creek and Mirror Lake bridges crossing Seals Gully downstream of Kothman Gully. Also along Seals Gully, there are three private wooden bridges that cross the stream in the upper reaches of the watershed; these structures should be removed. Along Kothman Gully, the Green Lake and Spring Stuebner Road bridges should be replaced to increase the streams capacity.

The current regulations requiring storm water detention to serve new development are assumed to remain in place for this analysis, unless otherwise noted. The plans described below provide benefits in addition to the on-site requirements and the aforementioned channel corridors. Each alternative plan elements are shown on **Exhibit C6**.

2.5.2 Alternate 1 Features and Benefits

Alternative 1 features a linear channel concept to fulfill the analysis goals. It consists of channel improvements along the lower reaches of Seals Gully to lower the water surface elevation through this reach. The improvements will run from the mouth of Seals Gully upstream to Castle Creek Bridge. The plan includes bridge replacements and removals to benefit the capacity of the channels. A 26-acre detention basin is proposed downstream of Cypresswood Drive to mitigate the channel improvements. These elements are inclusive of the channel corridors previously described. Multiple-use opportunities with this alternative include bikeways and trails along the channel right-of-way for recreation as well as parks within the mitigation basin. The elements of this alternative are presented on **Exhibit C6**.

This plan provides benefits in reducing peak flows at each node along Seals Gully. The following table shows the peak flows at each hydrologic computational node in the baseline and alternate condition. The alternative as noted has the effect of lowering flows at the mouth by approximately 7 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 1 is $8,200,000.

Alternative 1 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 1 Flow (cfs)**	**Benefit (cfs)**
K12402#1	Kothman Gully at FM 2920	2073	2073	0
K12402#2	Kothman Gully Confluence with Seals Gully	2445	2445	0
K124A	Seals Gully Upstream of K124-05-00	1784	1614	-170
K124#1	Seals Gully and K124-05-00	2278	1901	-377
K124#2	Seals Gully Upstream of Kothman Gully	2933	2454	-479
K124#2	Seals Gully and Kothman Gully	5234	4837	-397
K124#3	Seals Gully Upstream of Devonshire Subdivision	5989	5717	-272
K124#4	Seals Gully Confluence with Cypress Creek	6448	5597	-854

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

2.5.3 Alternate 2 Features and Benefits

Alternative 2 features a detention concept to fulfill the analysis goals. This alternative presents detention options that will lower the channel water surface elevation and provide relief of the existing flooding problems as well as reduce flows entering into Cypress Creek. The detention basin is located along Seals Gully downstream of Cypresswood Drive. These elements are inclusive of the channel corridors previously described. Multiple-use opportunities with this alternative include bikeways and trails along the channel right-of-way for recreation as well as parks within the detention basins. The elements of this alternative are presented on **Exhibit C6.**

This plan provides benefits in reducing peak flows at each node along Seals Gully. The table below shows the peak flows at each hydrologic computational node in the baseline and alternate condition.

Alternative 2 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 2 Flow (cfs)**	**Benefit (cfs)**
K12402#1	Kothman Gully at FM 2920	2073	2073	0
K12402#2	Kothman Gully Confluence with Seals Gully	2445	2445	0
K124A	Seals Gully Upstream of K124-05-00	1784	1614	-170
K124#1	Seals Gully and K124-05-00	2278	1901	-377
K124#2	Seals Gully Upstream of Kothman Gully	2933	2456	-477
K124#2	Seals Gully and Kothman Gully	5234	4842	-392
K124#3	Seals Gully Upstream of Devonshire Subdivision	5989	5569	-420
K124#4	Seals Gully Confluence with Cypress Creek	6448	5433	-1015

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

The alternative as noted has the effect of lowering flows at the mouth by approximately 16 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 2 is $9,317,000.

2.5.4 Alternate 3 Features and Benefit

Alternative 3 features non-structural elements to fulfill the analysis goals. It consists of proposed voluntary buyouts of previously flooded structures within the Enchanted Oaks and Devonshire Woods subdivisions. A floodplain preservation corridor is proposed along the mid-reach of Seals Gully between Louetta Road and Ella Boulevard. These elements are inclusive of the channel corridors previously described. Multiple-use opportunities with this alternative include bikeways and trails along the channel right-of-way for recreation as well as parks within the corridor sections. The elements of this alternative are presented on **Exhibit C6**.

This plan provides benefits in reducing peak flows at each node along Seals Gully. The following table shows the peak flows at each hydrologic computational node in the baseline and alternate condition.

Alternative 3 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 3 Flow (cfs)**	**Benefit (cfs)**
K12402#1	Kothman Gully at FM 2920	2073	2073	0
K12402#2	Kothman Gully Confluence with Seals Gully	2445	2445	0
K124A	Seals Gully Upstream of K124-05-00	1784	1614	-170
K124#1	Seals Gully and K124-05-00	2278	1901	-377
K124#2	Seals Gully Upstream of Kothman Gully	2933	2456	-477
K124#2	Seals Gully and Kothman Gully	5234	4842	-392
K124#3	Seals Gully Upstream of Devonshire Subdivision	5989	5569	-420
K124#4	Seals Gully Confluence with Cypress Creek	6448	6027	-421

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

The alternative as noted has the effect of lowering flows at the mouth by approximately 7 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 3 is $7,426,000 plus $9,130,000 for voluntary structural buyout. This a total estimate cost of $16,556,000.

2.5.5 Alternative 4 Features and Benefits

Alternative 4 features a multiple element concept to fulfill the analysis goals. It consists of providing a detention basin along the lower reaches of Seals Gully to reduce flows and lower the water surface elevation through this reach. The plan also calls for voluntary buyouts of previously flooded structures within the Enchanted Oaks and Devonshire Woods subdivisions. A floodplain preservation corridor is proposed along the mid-reach of Seals Gully between Louetta Road and Ella Boulevard. The plan also includes bridge replacements to benefit the

capacity of the channels. These elements are inclusive of the channel corridors previously described. Multiple-use opportunities with this alternative include bikeways and trails along the channel right-of-way for recreation as well as parks within the corridor sections. The elements of this alternative are presented on **Exhibit C6**.

This plan provides benefits in reducing peak flows at each node along Seals Gully. The following table shows the peak flows at each hydrologic computational node in the baseline and alternate condition. The alternative as noted has the effect of lowering flows at the mouth by approximately 16 percent. This alternative will offset the effects of full development with onsite detention in the watershed and reduces peak flows into Cypress Creek. The estimated cost for implementing Alternative 4 is $10,126,009 plus $9,130,000 for voluntary structural buyout. This a total estimate cost of $19,436,009.

Alternative 4 Benefits (100-Year Flows)				
Node	**Location**	**Baseline Flow (cfs)**	**Alt 4 Flow (cfs)**	**Benefit (cfs)**
K12402#1	Kothman Gully at FM 2920	2073	2073	0
K12402#2	Kothman Gully Confluence with Seals Gully	2445	2445	0
K124A	Seals Gully Upstream of K124-05-00	1784	1614	-170
K124#1	Seals Gully and K124-05-00	2278	1901	-377
K124#2	Seals Gully Upstream of Kothman Gully	2933	2456	-477
K124#2	Seals Gully and Kothman Gully	5234	4842	-392
K124#3	Seals Gully Upstream of Devonshire Subdivision	5989	5569	-420
K124#4	Seals Gully Confluence with Cypress Creek	6448	5433	-1015

* The flow from the baseline model with subbasins revised as noted in Part 2.2 of this report.

2.5.6 Public Input on Alternate Plans

On October 8, 2002, a public meeting was held to describe the progress of the project and to inform the public regarding the alternative plans being proposed for the watershed. No comments regarding alternatives for Seals Gully watershed were received. Generally the public in response to questionnaires showed they were not averse to channel improvement projects. Multiple-use facilities incorporating recreation was popular with the respondents. Respondents were evenly split on whether they favored the use of voluntary buyouts as a flood-control measure.

2.5.7 Screening of Alternates

In order to determine the recommended plan for the Seals Gully watershed, a number of criteria were screened to determine which of the alternatives best met the goals of the watershed and the HCFCD. This screening was performed on a relative basis. The following criteria matrix was used when evaluating the alternative plans identified for this watershed. The ability of the plan alternative to meet each criteria was ranked from 0 to 10, with 0

indicating that the criteria is not met, and 10 indicating that the criteria is met to the best of its ability. Relative weights were then set for each of the criteria as shown below based on the stated goals of the study.

Table C1 – Screening Matrix for Seals Gully Watershed

Criteria	Weight	Plan			
		ALT 1	ALT 2	ALT 3	ALT 4
Minimal Construction Cost	0.2	8	7	4	5
Provides Aesthetics	0.5	5	7	8	9
Ease of Implementation	0.8	7	7	5	4
Flood Protection within Tributary Watershed	1	8	9	8	9
Ability to Accommodate Multiple Uses	0.5	9	10	9	10
Preserves/Enhances Water Quality	0.8	6	8	9	8
Preserves/Enhances Stream Habitat Quality	0.5	6	7	9	9
Ease of Maintenance	0.8	5	5	8	7
Reduction of Peak Flows into Cypress Creek	1	6	10	6	10
Outfalls for Future Roadways/Development	0.8	10	10	10	10
Acceptable to the Public	0.8	6	8	7	8
TOTAL	-----	**76**	**88**	**83**	**89**
WEIGHTED TOTAL	**77(max)**	**53**	**63**	**59**	**64**

2.6 Recommended Plan and Identification of Elements

Based on the criteria noted above, a plan was recommended that will meet the needs of the watershed as noted in this report. The recommended plan is described in detail in the following sub-sections.

2.6.1 Determination of Recommended Plan

Alternative 4 was chosen as the recommended plan, primarily due to the fact that it will meet all the criteria of the study and provides a significant reduction of flows to Cypress Creek. The downstream Seals Gully detention basin site may prove highly useful in reducing Cypress Creek flooding. This plan also provides for the voluntary buyout of the historic flooded homes within the Enchanted Oaks and Devonshire Wood subdivisions, since most of these structures are flooded due to the waters of Cypress Creek. Also, the floodplain preservation area along the mid-reach of Seals Gully will provide environmental benefit and protect the floodplain areas of Seals Gully.

Alternative 2 provides a similar level of protection and reduction of flows entering Cypress Creek, but does not include the non-structural elements. The non-structural alternative presented as Alternative 3 scored about the same as Alternative 2 because of the non-structural elements presented. However, the alternative did not provide as much reduction of flows to Cypress Creek, and buyouts are inherently difficult to implement. Alternative 1 scored lower because it only provides a minimum level of protection along Seals Gully and minimal

reduction of flows entering Cypress Creek. Also the channel improvements of the lower reaches of Seals Gully seem unfavorable to the goals of this analysis.

2.6.2 Recommended Plan Features

The recommended plan consists of features that preserve areas of good quality stream habitat, provide outfall drainage for future development, address existing flooding in the watershed, and provide flow reduction to Cypress Creek. The features of the plan, beginning at the mouth, consist of the elements outlined in Section 2.5.5 (Alternative 4 Features and Benefits) and further described below.

There are four channel corridor systems proposed for improvement and extension within the recommended plan. The channel systems include the extension and improvements to K124-02-03 and proposed channel corridors along K124-04-00, K124-05-00, and the new lateral K124#C1. The recommended plan proposes a 300-foot right-of-way width along these alignments. These channel corridor width incorporates a channel with a composite, terraced section and allows for multiple uses (see **Figure 1**).

The Kothman Gully lateral, K124-02-03, is to be extended to meet Falvel Road. This roadway is identified as an expansion alignment for Ella Boulevard. Currently, the roadway drains via roadside ditches through the Northwood Park Subdivision into K124-02-03. Several historical flooded structures are documented within this subdivision. The extension of the channel is to provide outfall depth for the proposed roadway expansion as well as to alleviate the existing flooding problems within the adjacent Northwood Park subdivision. Due to the limited amount of available right-of-way along the channel, a more constricted section was considered. A 200-foot wide channel corridor is proposed for this channel. It will run from its confluence with Kothman Gully upstream to Falvel Road for a total length of approximately 2,700 feet.

Along the K124-04-00 alignment, the channel will lie in a 300-foot wide waterway corridor and run from Seals Gully near Ella Boulevard upstream to Spring-Cypress Road for a total length of approximately 5400 feet. This component is designed to provide outfall depth for potential new development and roadways within its drainage area. The channel section will also provide storage to mitigate any impacts due to the channelization of the subarea. Near Spring Cypress Road, the channel corridor will run along Klein Park, providing additional recreational possibilities to an existing facility.

Along the K124-05-00 alignment, the channel will lie in a 300-foot wide waterway corridor and run from upstream of the Klein Collins High School to north of FM 2920. An additional corridor will run from downstream of the Klein Collins High School to the confluence with Seals Gully. This component is designed to provide outfall depth for potential new

development and roadways within its drainage area. Because the channel has recently been rectified through its mid-reach for the construction of the high school, this reach was proposed for a channel corridor. The channel crossings at FM 2920, Bridgestone Road, and Spring-Cypress Road will require replacement to accommodate the proposed channel corridor. The channel can also provide recreational uses for the high school. The portions of the channel to be constructed has a length of approximately 8000 feet.

A new channel lateral, K124#C1, is proposed for the upper portion of the watershed. This channel will run from Seals Gully, upstream of Rhodes Road, northward to FM 2920. This channel will lie in a 300-foot waterway corridor and have an approximate length of 4,400 feet. This component is designed to provide outfall depth for potential new development and roadways within the drainage area.

Bridge modifications along Seals Gully and Kothman Gully are proposed. These modifications include removal of the private wooden bridges crossing the streams as well as the replacement of several roadway bridges. The roadway bridges include Candle Creek and Mirror Lake along Seals Gully as well as Green Lake and Spring Stuebner Road along Kothman Gully.

The plan also calls for voluntary buyouts of previously flooded structures within the Enchanted Oaks and Devonshire Woods subdivisions. A floodplain preservation corridor is proposed along the mid-reach of Seals Gully between Louetta Road and Ella Boulevard.

2.6.3 Recommended Plan Benefits

Taken together, these elements make up the recommended plan for the Seals Gully watershed and satisfy the criteria for this study while providing quantifiable benefits to the watershed. Some recreational elements will be necessary to add to the plan features to fully meet the desired goal for dual-use facilities. The somewhat fragmented nature of the plan elements will make a recreational feature such as a continuous trail system infeasible. However, trails in the upper reaches of Seals Gully are feasible in combination with the proposed channel corridors. Developments served by the proposed channel corridors would be encouraged to incorporate trails along the bayous as a recreational amenity for the development. Also the area of the detention basin along Seals Gully will be encouraged for use as a park or for soccer and baseball fields.

Hydrologic benefits due to the plan elements were summarized earlier in the alternate plan formulation section of this report. In order to maintain consistency with the Phase I report, the flows calculated as a result of the more detailed modeling were compared with the revised baseline flows, then the prorated decrease (or increase) resulting from the modeling of the recommended plan was applied to the original baseline flows to create an adjusted plan flow.

The adjusted plan flows were used as the basis for the HEC-RAS modeling and floodplain mapping for the recommended plan. The revised Tc and R parameters for the recommended plan compared to the baseline are shown in **Table C2**. The resulting 100-year flows comparing the baseline conditions to the recommended plan conditions are presented in **Table C3** of this report. **Table C4** of this report presents the HEC-1 peak flows resulting from the recommended plan for various storm frequencies. The 100-year recommended plan and baseline condition floodplains are shown on **Exhibit C8**. A comparison between the recommended plan and baseline condition 100-year storm event flood profiles for Seals Gully is presented in **Exhibits C9-1** and **C9-2**. The Seals Gully and Kothman Gully eight frequencies storm event profiles for the recommended plan are presented in **Exhibits C11-1** and **C11-2**.

The plan reduces peak flows downstream at the nodes of Seals Gully and Kothman Gully, and reduces flows entering into Cypress Creek. Additionally, water surface elevations are lowered in conjunction with the lower flows. As shown in **Table C5**, the 100-year flood water surface elevations decrease along Seals Gully by as much as a foot. As noted earlier, the goal of this plan was not to bring all areas of out-of-bank flooding to within the banks. The goal was to preserve some areas of out-of-bank flooding that occurs in areas that are beneficial to the watershed and to address out-of-bank flooding in areas where it causes existing or projected flooding problems outside of the stream corridor areas. Finally, the plan provides environmental benefits by preserving identified areas of good stream habitat as well as preserving some naturally flood-prone areas, as noted above.

Table C2: Watershed Physical Characteristics (Baseline & Recommended Plan Conditions)

Subarea Name	Drainage Area		Watershed Length	Length to Centroid	Channel Slope	Overland Slope	Urban Dev. *	Watershed Dev. *	Channel Imp.	Channel Conv.	Ponding
	(Acre)	(Sq.Mi)	(mi)	(mi)	(ft/mi)	(ft/mi)	(%)	(%)	(%)	(%)	(%)
Baseline Condition											
K12402A	1083	1.69	2.06	0.93	16.1	10	55.6	86.7	100	100	0
K12402B	664	1.04	1.92	0.95	12.5	10	0	70.0	100	100	0
K124A	1056	1.65	2.23	1.28	13.5	10	42.6	82.8	100	100	0
K12405A	476	0.74	2.3	1.38	7.0	10	0	0	0	100	0
K124B	685	1.07	2.52	1.13	19.4	10	12.1	23.2	28	100	0
K124C	590	0.92	1.49	0.71	13.7	30	34.4	29.2	27	100	0
K124D	391	0.61	1.74	0.73	16.1	30	43.0	82.9	100	100	0
Recommended Plan Condition											
K12402A	1083	1.69	2.06	0.93	16.1	10	55.6	86.7	100	100	0
K12402B	664	1.04	1.92	0.95	12.5	10	0	70.0	100	100	0
K124A1	240	0.38	1.10	0.63	5.3	10	0	0	0	100	0
K124A2	816	1.28	2.23	1.28	13.5	10	42.6	82.8	100	100	0
K12405A	476	0.74	2.30	1.38	7.0	10	0	0	0	100	0
K124B1	297	0.46	1.69	0.93	5.3	10	12.1	3.63	0	100	0
K124B2	388	0.61	2.52	1.13	19.4	10	12.1	23.2	28	100	0
K124C	590	0.92	1.49	0.71	13.7	30	34.4	29.2	27	100	0
K124D	391	0.61	1.74	0.73	16.1	30	43.0	82.9	100	100	0

* % based on development in place prior to implementation of HCFCD on-site detention policy (1984)

Table C2 (continued)

Tc & R Values
Baseline Conditions

Subarea Name	Tc	R	RTIMP
	(hrs)	(hrs)	(%)
K12402A	0.34	2.09	35
K12402B	0.42	4.70	35
K124A	0.49	2.59	35
K12405A	1.08	4.73	35
K124B	0.75	5.43	35
K124C	0.70	1.99	35
K124D	0.43	2.14	35

Tc & R Values
Recommended Plan Conditions

Subarea Name	Tc	R	RTIMP
	(hrs)	(hrs)	(%)
K12402A	0.34	2.09	35
K12402B	0.42	4.70	35
K124A1	0.50	2.96	35
K124A2	0.49	2.59	35
K12405A	1.08	4.73	35
K124B1	0.98	4.86	35
K124B2	0.75	5.43	35
K124C	0.70	1.99	35
K124D	0.43	2.14	35