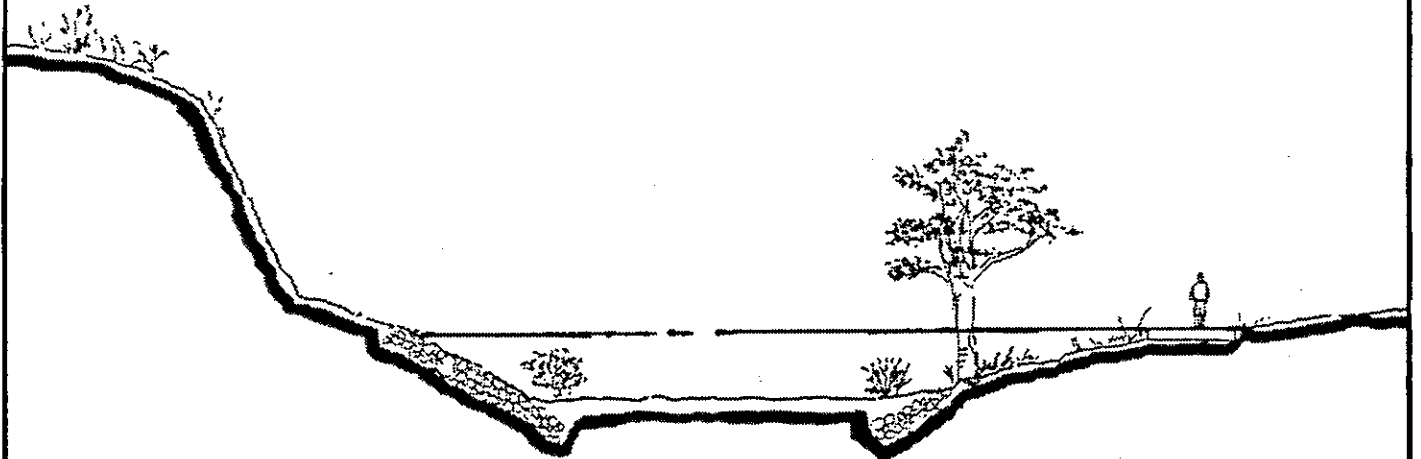


Drainage Basin Planning Study

Dirty Woman Creek and Crystal Creek El Paso County, Colorado



Prepared for:

El Paso County Department of Public Works
3105 North Stone
Colorado Springs, Colorado 80907

Prepared by:

Kiowa Engineering Corporation
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September, 1993

RETURN WITHIN 2 WEEKS TO:
CITY OF COLORADO SPRINGS
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**DIRTY WOMAN CREEK
and
CRYSTAL CREEK
DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN REPORT**

Prepared for:

El Paso County Department of Public Works
Stormwater Management Division
3105 North Stone
Colorado Springs, CO 80907

Prepared by:

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KIOWA Project No. 91.07.17
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February 1993
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I. INTRODUCTION

Authorization

The preliminary design of the drainageway and roadway crossing facilities within the Dirty Woman and Crystal Creek Drainage Basins was authorized under the terms of the Agreement between El Paso County (County) and Kiowa Engineering Corporation. The agreement was approved by the El Paso County Board of County Commissioners on July 22, 1991.

Purpose and Scope

The purpose of the study is to identify feasible stormwater management plans to satisfy the existing and future needs within the Dirty Woman and Crystal Creek Drainage Basins. The specific scope of work for this study included the following tasks:

1. Meet with the County to: insure compliance with the services required by this agreement, obtain existing data and general information from participating entities, solicit desires of participating entities and other interested agencies or groups in order to develop alternate plans, procure current information relative to development plans in the basin, procure information relative to right-of-way limitations, proposed stormwater projects, potential hazards due to flooding, and avoid duplication of effort whenever possible by utilizing existing information available from other agencies.
2. Contact the County, Town of Monument, individuals, and other agencies who have knowledge and/or interest in the study area.
3. Utilize City/County drainage policies and criteria and applicable information wherever possible.
4. Perform hydraulic and hydrologic analyses within the study area.
5. Identify environmental setting of basin.
6. Identify existing and potential drainage and/or flooding problems.
7. Develop improvement alternatives to reduce existing and potential flooding problems, and to mitigate the impact of stormwater runoff upon environmentally significant areas along the drainageway(s).
8. Examine the operation and maintenance aspects of feasible alternatives.
9. Conduct an economic analysis of each alternative.
10. Recommend and prepare a preliminary design for a selected alternative plan.

11. Prepare documentation and summary report(s) sufficient for the review and processing of a Letter of Permission (LOP) through the Corps of Engineers.
12. Develop drainage and bridge fees for the basin.
13. Prepare a written report discussing all items examined in the study.
14. Conduct presentations to public and private entities in order to define project goals, and to involve agencies with specific interest to help define feasible alternatives.

Summary of Data Obtained

Listed below are the technical reports collected for the review as part of preparing this study:

1. *Soil Survey for El Paso County, Colorado*, dated June 1981.
2. *City of Colorado Springs/El Paso County Drainage Criteria Manual*, prepared by City of Colorado Springs, El Paso County, and HDR Infrastructure, Inc., dated May 1987.
3. *Flood Insurance Studies for Colorado Springs, and El Paso County, Colorado*, prepared by the Federal Emergency Management Agency (FEMA), revised 1989.
4. *Flood Insurance Restudy, Dirty Woman and Crystal Creeks*, prepared by RCI, Inc., 1989.
5. *Floodplain Information Report*, prepared by the Colorado Water Conservation Board (CWCB), dated July, 1985.
6. General Well Location Site Information and Water System Layout, prepared by the Woodmoor Water and Sanitation District.
8. Woodmoor Subdivision Drainage Plans, dated 1971 - 1988.

In addition to the above listed reports there were a number of drainage study reports, sketch plans, preliminary and final design drawings, land use and zoning maps, development plans, and existing drainage facility maps that were collected from the Town of Monument, El Paso County, and other local agencies.

The report entitled, *Dirty Woman Creek and Crystal Creek Drainage Basin Planning Study Development of Alternatives*, was prepared prior to this report. This report was prepared as a part of the overall planning effort and has been referred to throughout this report. The Development of Alternatives report evaluated the various combinations of drainageway improvements for the basin, taking into account environmental, cost, construction, right-of-way,

maintenance, and implementation factors for each feasible alternate plan. This report is on file with El Paso County Department of Public Works, along with its associated technical addendum.

Mapping and Surveying

Mapping used in the planning effort consisted of USGS 7-1/2 minute quadrangles; and 2-foot contour interval, 1-inch to 200-foot scale planimetric topographic strip maps for the major drainageways; and 4-foot contour interval, 1-inch to 400-foot scale planimetric topographic maps of the entire watershed. The aerial mapping was compiled in August of 1991, by Landmark Mapping Ltd., of Lakewood, Colorado. The aerial topographic mapping was used in the drainage inventory, hydrologic/hydraulic analyses, alternative planning phases, and the preliminary design of this project. All topographic mapping was based upon USGS vertical datum.

Drainageway site inspections were conducted throughout the study area, and photographs were taken documenting the key drainage features.

Project Coordination

Throughout the course of this study, meetings were held with representatives of the County, State and Federal agencies with an interest in drainageway planning in general. The primary reason for the coordination effort was to obtain technical information and to identify concerns with regard to the development of drainageway facilities within the basin. During the course of preparing the Development of Alternatives report, the planning constraints and concepts were discussed with the agencies and interested individuals. Their input was used to refine the feasible alternatives and to eventually identify a recommended drainageway plan for further design evaluation. A public meeting was held to present the Development of Alternatives report and solicit ideas and information from the general public regarding the drainageway plan. The mailing list, public meeting minutes, and project correspondence is contained in Appendix A of this report.

Acknowledgements

During the preparation of the study, several government agencies and interested individuals were routinely involved in the coordination activities. Representatives from the Colorado Division of Wildlife, U.S. Army Corps of Engineers (COE), and various County Departments provided valuable information and commentary during the development of these

reports. A listing of the individuals and agencies routinely coordinated with during the study has been presented below:

<u>Name</u>	<u>Agency</u>
Alan Morrice	El Paso County Department of Public Works
Ken Rowberg	El Paso County Land Use Department
Rick O'Conner	El Paso County Land Use Department
Dwight Whitney	Town of Monument
Jerry Standard	Town of Monument
Phil Steineger	Woodmoor Water and Sanitation
John Sterling	Woodmoor Improvement Association
Bruce Goforth	Colorado Division of Wildlife
Dan Bunting	Regional Building Department
Sarah Fowler	Environmental Protection Agency
John Liou	Federal Emergency Management Agency
Dave Frick	RCI, Inc., Fort Collins, Colorado
Bill Noonan	U.S. Fish and Wildlife
Anita Culp	U.S. Army Corps of Engineers
Brian Hyde	Colorado Water Conservation Board
Bob Torres	Colorado Department of Transportation

II. STUDY AREA DESCRIPTION

Ever since we first saw the name "Dirty Woman Creek" on an El Paso County map we have wondered how the stream happened to acquire that name. Was she a woman whose body was physically unclean? Was she filthy mouthed? Did she possess a dirty mind, or did her morals earn her the unkind appellation?...

...The creek (Dirty Woman Creek) was named for a dirty woman. Whether or not she was old, we'll never know. If it referred to her physical, mental or moral being why should we care? None of us are wholly pure. And with everyone throwing dirty poison and debris into the streams these days any creek could be labeled "Dirty Creek." She simply set a precedent.

"Dirty Woman Creek" is the first creek crossed when entering Monument. It is just south of the Monument school and is a branch of Monument Creek.

Mrs. Lucille Lavelett, whose grandfather, John Olfs, homesteaded near what is now the Woodmoor TownHouse subdivision, about 12 miles from Monument, told us how the creek came to receive its name.

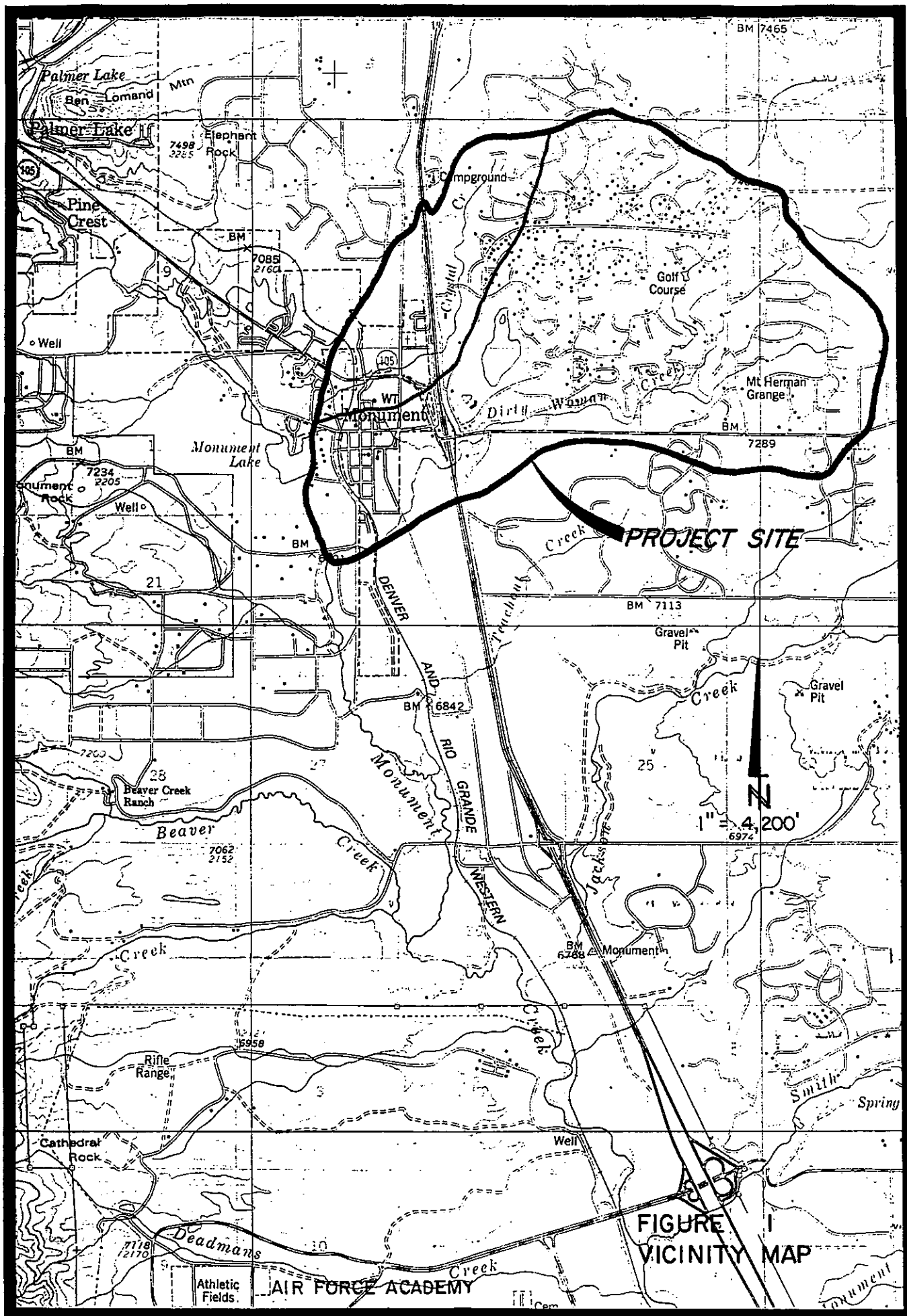
She told us that back in the 1870s the first Monument schoolhouse was built near the creek. Her mother and an aunt attended it, and her aunt said that down near the stream lived a woman in a little shack. The old lady kept a bunch of goats, chickens, and other animals on the place and didn't keep it or herself very clean, so in speaking of the stream the kids called it the "Dirty Woman Creek."...

The above is an excerpt from the column "Harold's Haunts" written by H. H. Hartman and appearing in the *Gazette Telegraph* on August 8, 1971.

The Dirty Woman and Crystal Creek drainage basins are right-bank tributaries to Monument Creek in El Paso County, Colorado. Dirty Woman and Crystal Creek's drainage area at Monument Creek is approximately 6.59 square miles of which approximately 5.04 square miles are included in the Dirty Woman drainage basin. The basin is divided into seven major sub-basins, Dirty Woman Creek mainstem, Crystal Creek mainstem, Lake Fork of Dirty Woman Creek, North Fork of Dirty Woman Creek, Middle Fork of Dirty Woman Creek, Upper Dirty Woman Creek, and South Fork of Dirty Woman Creek. Figure 1 shows the location of the Dirty Woman and Crystal Creek basins.

Basin Description

The Dirty Woman and Crystal Creek drainage basins cover a total of 6.6 square miles in El Paso County including the Town of Monument. The basin(s) trend in generally a east to west or southwesterly direction, entering Monument Creek in two locations. Crystal Creek enters Monument Creek at Monument Lake, just west of the Town of Monument. Dirty Woman Creek enters Monument Creek just southwest of the Town of Monument near its crossing with Mt. Herman Road. Development has occurred throughout the entire basin. Large-lot single family residential development has occurred throughout most of the basin areas with some higher



density development along Interstate 25 and within the Town of Monument. Development of the basins is approximately 85-90 percent complete.

The maximum basin elevation is approximately 7,505 feet above mean sea level, and falls to approximately 6,860 feet at the lower confluence with Monument Creek. The headwaters of the basins originate in conifer covered areas near the Palmer Divide.

Climate

This area of El Paso County can be described, in general as high plains, with total precipitation amounts typical of a semi-arid region. Winters are generally cold and dry. Precipitation ranges from 14 to 16 inches per year, with the majority of this precipitation occurring in spring and summer in the form of rainfall. Thunderstorms are common during the summer months, and are typified by quick-moving low pressure cells which draw moisture from the Gulf of Mexico into the region. Average temperatures range from about 30°F in the winter to 75°F in the summer. The relative humidity ranges from about 25 percent in the summer to 45 percent in the winter.

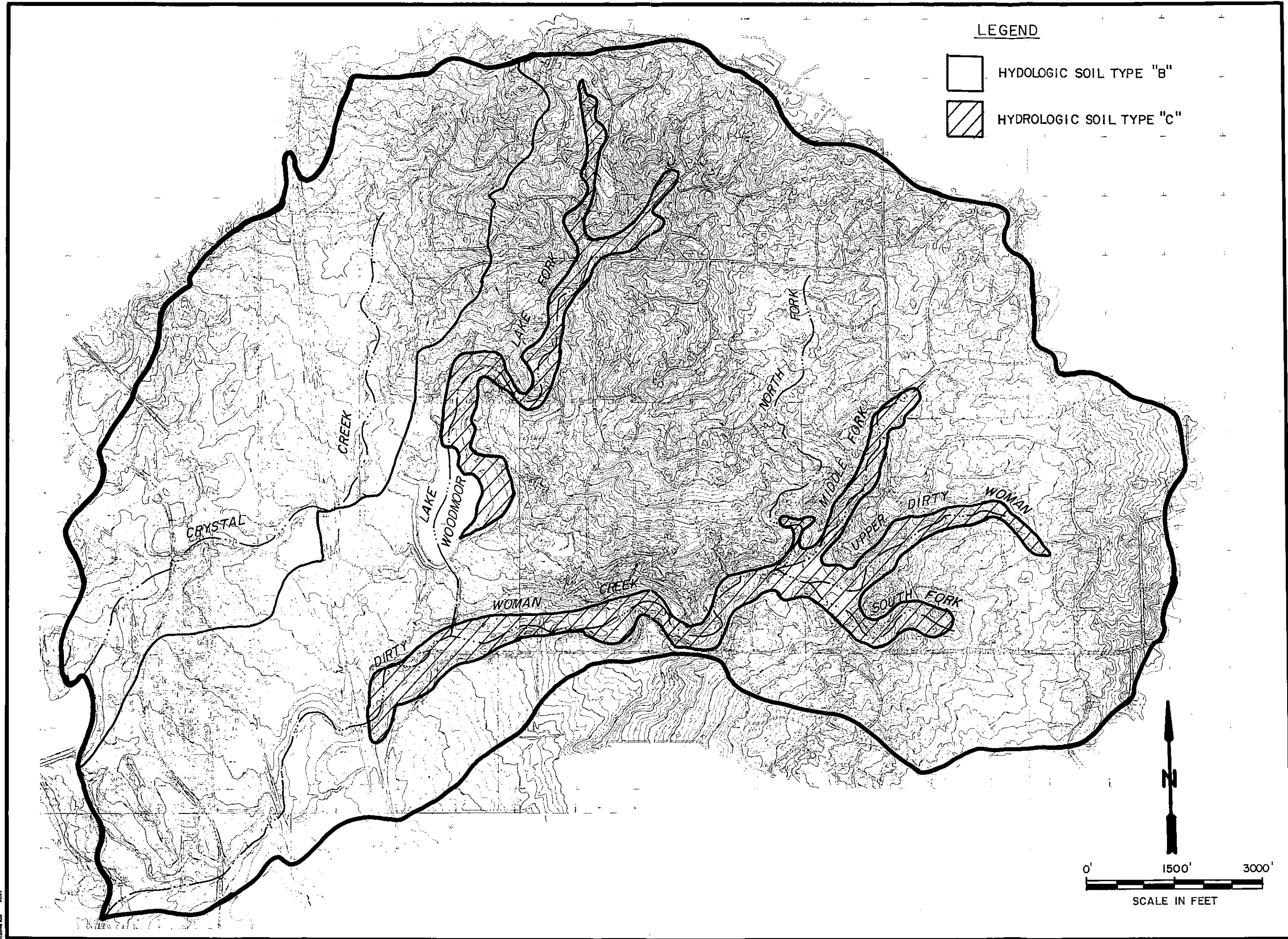
Soils and Geology

Soils within the Dirty Woman and Crystal Creek basins are generally hydrologic soil type B with some scattered hydrologic soil type C along the drainages, as identified by the U. S. Department of Agriculture, Soil Conservation Service. With the predominance of type B soil, these basins will tend to develop a lower runoff per unit area rate as compared to basins dominated by Type C & D soils. Presented on Figure 2 is the Hydrologic Soil distribution map for the Dirty Woman and Crystal Creek basins.

Property Ownership and Impervious Land Densities

Property ownership along the major drainageways within the Dirty Woman and Crystal Creek basins are mostly private. Along the developed reaches, drainage right-of-ways and greenbelts have been dedicated during the development of the adjacent residential land. Where development has not occurred, the drainageways remain under private ownership with no delineated drainage right-of-way or easements. Dirty Woman Park abuts the mainstem of Dirty Woman Creek near its confluence with Monument Creek. Both creeks have been impacted quite heavily by roadway construction.

Land use information for the existing and future conditions were reviewed as part of the planning effort. This information is used in the hydrologic analysis to predict runoff rates and volumes for the purposes of facility evaluation. The identification of land uses abutting the drainageways is also useful in the identification of feasible plans for stabilization and aesthetic



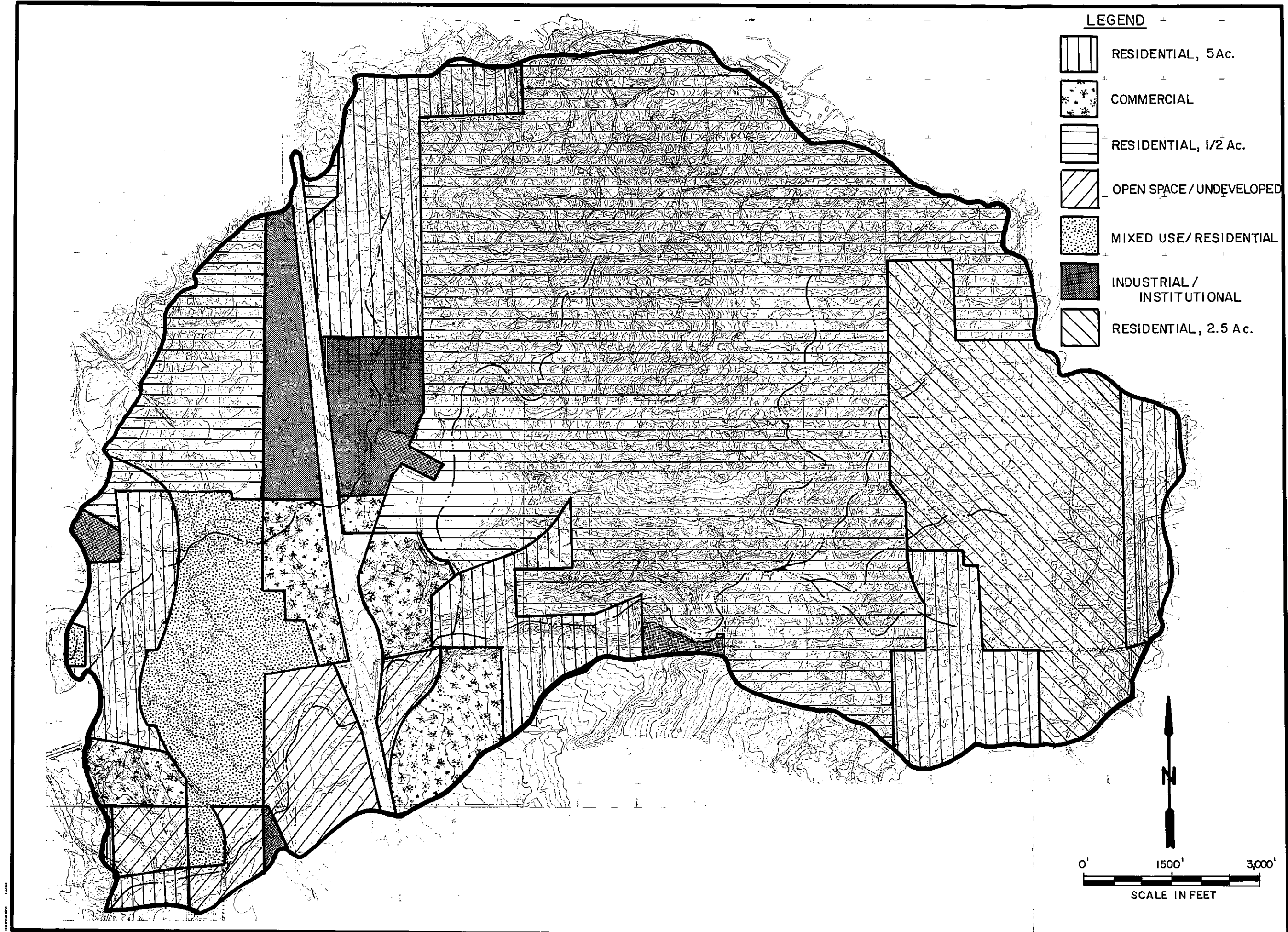
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DIRTY WOMAN CREEK & CRYSTAL CREEK
DRAINAGE BASIN PLANNING STUDY
HYDROLOGIC SOILS MAP

Project No. 91-07-17
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FIG 2

treatment of the creek. Presented on Figure 3 is the Proposed Land Use Map used in the evaluation of impervious land densities discussed in the hydrologic section of this report. Figure 3 is not intended to reflect the future zoning for land use policies of the Town or the County.



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DIRTY WOMAN CREEK & CRYSTAL CREEK
 DRAINAGE BASIN PLANNING STUDY
 PROPOSED LAND USE MAP

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FIG 3

III. HYDROLOGIC ANALYSIS

A hydrologic analysis was conducted in order to determine peak discharges and runoff volumes for various storm types, and basin development conditions. This data was used in the evaluation of existing flooding problems and in the evaluation of alternative plans. A Technical Addendum has been prepared in association with the *Development of Alternatives* report. Detailed information with respect to the hydrologic analysis is contained within the Addendum along with hydraulic information on the basin. The Technical Addendum is on file with El Paso County.

Previous Studies

Various hydrologic studies have been prepared for Dirty Woman and Crystal Creeks. These studies are *Flood Hazard Identification Report, Crystal Creek and Dirty Woman Creek, Monument, Colorado* prepared by the Colorado Water Conservation Board (CWCB) in February 1987, the *FEMA Flood Insurance Study*, prepared in 1986, a study by Tri-Consultants on Crystal Creek through Casey's Subdivision, and an ongoing study by Resource Consultants, Inc. which included overall hydrology for Dirty Woman and Crystal Creeks.

The *Flood Insurance Study* has been recently updated. The revised *FEMA Flood Insurance Study, El Paso County, Colorado Unincorporated Areas* was revised on September 30, 1992.

Runoff Model

The runoff model used to determine the peak flows and volumes within the study area is the HEC-1 computer program developed by the COE Hydrologic Engineering Center. The use of this hydrological model is in conformance with the City of Colorado Springs/El Paso County Drainage Criteria Manual. The HEC-1 hydrologic modeling was approved by El Paso County for use in this Drainage Basin Planning Study.

Basin Characteristics

The study area subject to this hydrologic evaluation is the Dirty Woman and Crystal Creek Drainage Basins. The Dirty Woman and Crystal Creek Basins were divided into seven major regional basins for analysis purposes. Dirty Woman Creek includes the main stem, Lake Fork, Middle Fork, North Fork, South Fork, and Upper Dirty Woman Creeks. Crystal Creek is a regional sub-basin itself. The major regional basins are shown in Exhibit 1 in the map pocket. The regional basins were further subdivided into sub-basins.

Hydrologic data for each sub-basin was developed using the Soil Conservation Service (SCS) Dimensionless Hydrograph Model within HEC-1. Basin characteristics required for the SCS Dimensionless Hydrograph Method using HEC-1 are area, curve number, and SCS lag time (T_{lag}). Basin areas were planimeted to determine their area in square miles. Curve numbers were determined for each sub-basin utilizing the hydrologic soil type, ground cover (both existing and proposed), and Tables 5-4 and 5-5 of the *City/County Criteria Manual*. The calculation of the SCS lag time was based upon its relationship to time of concentration (t_c). The time of concentration for each sub-basin was determined by adding travel times for overland flow, channel flow, and pipe flow from the hydrologically most distant point in the basin to the outfall point. The parameters used in these calculations were determined from available topographic maps, soils maps, aerial photography, land use maps, and field investigation. Figure 2 shows the hydrologic soil types and Figure 3 shows the proposed land use types within the Dirty Woman and Crystal Creek drainage basins.

Sub-basin flows were routed and/or combined with other sub-basin flows to establish discharges at various points throughout the drainage basin. Routing of flows was accomplished using the kinematic wave method. The kinematic wave method is based upon characteristics of each reach including length, slope, Manning's roughness, type of channel, bottom width of channel, and channel side slope. Flows from upstream sub-basins or design points (points of combined flow) were routed through the channel reach determining the channel storage and lag time for the routing. At design points, two or more hydrographs were combined to determine the outflow hydrograph at that particular point.

Impervious Land Density

Land use for existing and future basin conditions were determined using a combination of zoning maps, City/County Comprehensive Plan(s), aerial photographs, transportation plan(s), and other related land use documents. Land use density and corresponding curve numbers were determined in accordance with the *City/County Drainage Criteria Manual*. Soil Conservation Service (SCS) curve numbers for both the existing and future conditions for both Dirty Woman and Crystal Creeks are presented in the previously mentioned Technical Addendum.

Design Rainfall

The *City/County Drainage Criteria Manual* identifies a number of procedures to be used in developing storm rainfall for input into hydrologic models. The criteria manual stipulates that two storm durations (2-hour and 24-hour) be checked to determine the critical design storm (the storm producing the greatest peak discharge) and recommends that the SCS Type IIA distribution be used to represent the 24-hour rainfall pattern. A rainfall distribution for 2-hour

storms is also included in the *Criteria Manual*. Rainfall depths shown in the criteria manual are based on *National Oceanographic and Atmospheric Administration (NOAA) Atlas 2*. Rainfall depths used in the model are 4.40 inches and 2.88 inches for the 24-hour and 2-hour, 100-year storms respectively. It was determined through analysis that the 2-hour storm was the critical storm. The rainfall depth for the 2-hour, 10-year storm used in the analysis is 1.94 inches. The use of the 2-hour storm is consistent with the ongoing FEMA Restudy of Dirty Woman and Crystal Creeks.

The *City/County Criteria* was subsequently changed during the course of this study to exclude the use of the 2-hour storm and AMC-III. Because the hydrology was completed under then current criteria, the decision was made to utilize the 2-hour storm hydrology. The use of this storm type is comparable to the previous studies by CWCB and FEMA. The soil and basin conditions of Dirty Woman and Crystal Creeks lends itself to the use of the AMC-III condition. The relatively small size of the drainage basins, under 6 square miles, lends itself to the use of AMC-III. The AMC-III provides a method to better depict the infiltration rates during intense rain events. These were all factors in utilizing the 2-hour storm hydrology.

Hydrologic Modeling

The hydrologic model consists of 95 sub-basins linked by drainageways or "reaches". Presented on Exhibit 1 (in map pocket) is the Hydrologic Basin Map which shows the sub-basins analyzed.. Hydrographs are accumulated at design points along the major drainages. A hydrologic flow chart was developed and is presented in Figure 4. Both the existing and future development condition hydrologic models are based on the current configuration of both Dirty Woman and Crystal Creeks and their tributary drainages.

The hydrologic model for the basin is based upon the 1-inch to 200-foot topographic mapping prepared by Landmark Mapping, Ltd. for this project. Basin areas, lengths, slopes, and flow patterns were determined using these maps.

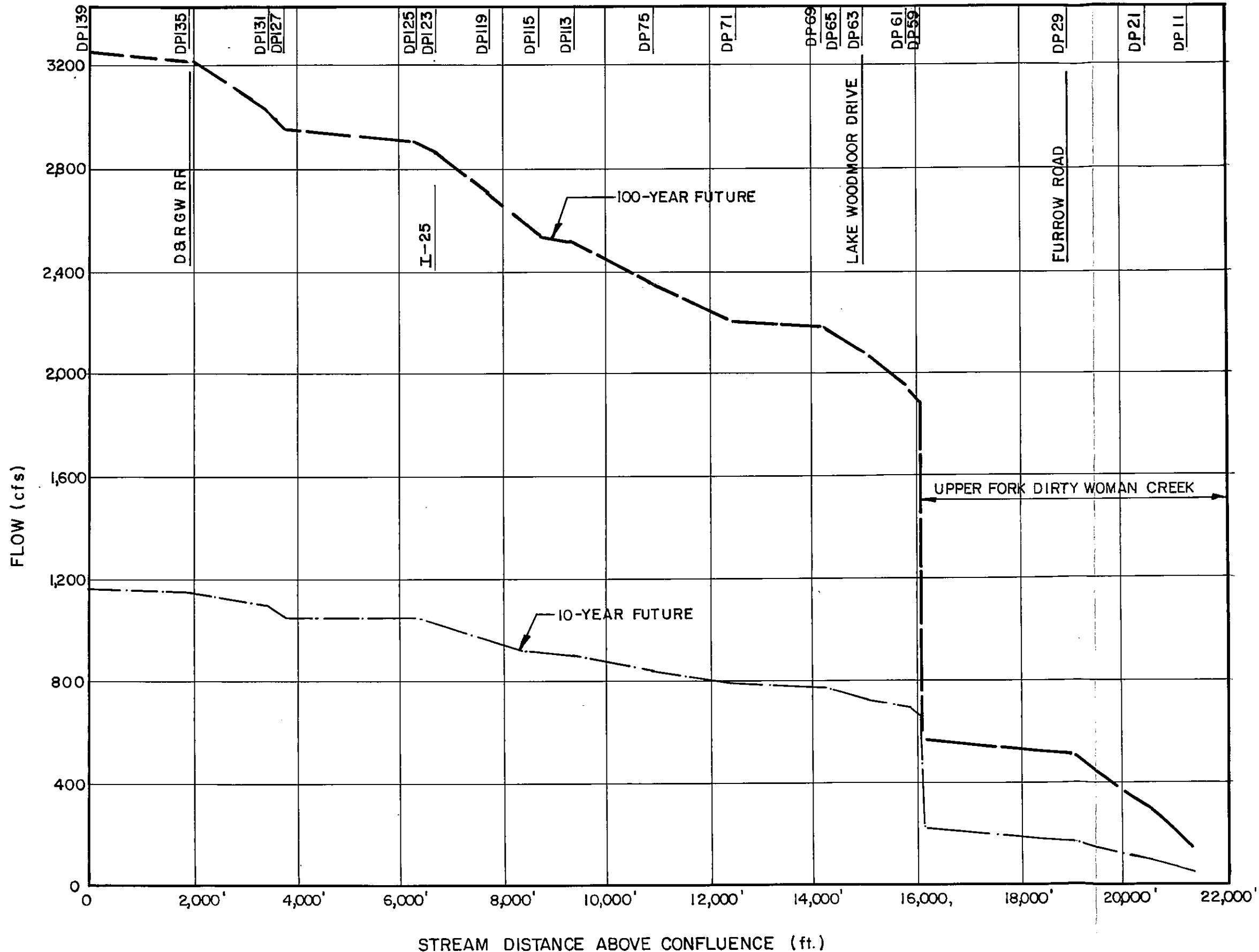
Results

The results of the hydrologic analysis have been presented in several formats. A basin hydrologic map which contains the basin boundary, regional basins, channel routing scheme, sub-basin locations, and design points is shown on Exhibit 1 which is contained in a map pocket attached to this report. Flood discharge profiles for the various storm types analyzed are shown on Figures 5 through 7. Summarized on Table 1 is the sub-basin peak discharge information. Presented on Table 2 are the peak discharges for the key design points in the basin.

The flows generated by the 2-hour storm were greater than those generated by the 24-hour storm for both drainage basins. The decision was made in the technical review meetings to use the 2-hour storm for this drainage basin planning study.

The differences in the existing and future flow conditions were minimal. The reaches in the upper end of the basin show no difference between the existing and future flow conditions. The difference between flow rates is generated by the potential future development along the Interstate 25 corridor and within the general area of the Town of Monument. The hydraulic analysis and drainageway planning utilized the future condition flow rates due to the small difference between future and existing flow rates. The use of the future flow rates will prevent proposed structures from becoming hydraulically inadequate as development in the basin proceeds.

DIRTY WOMAN CREEK



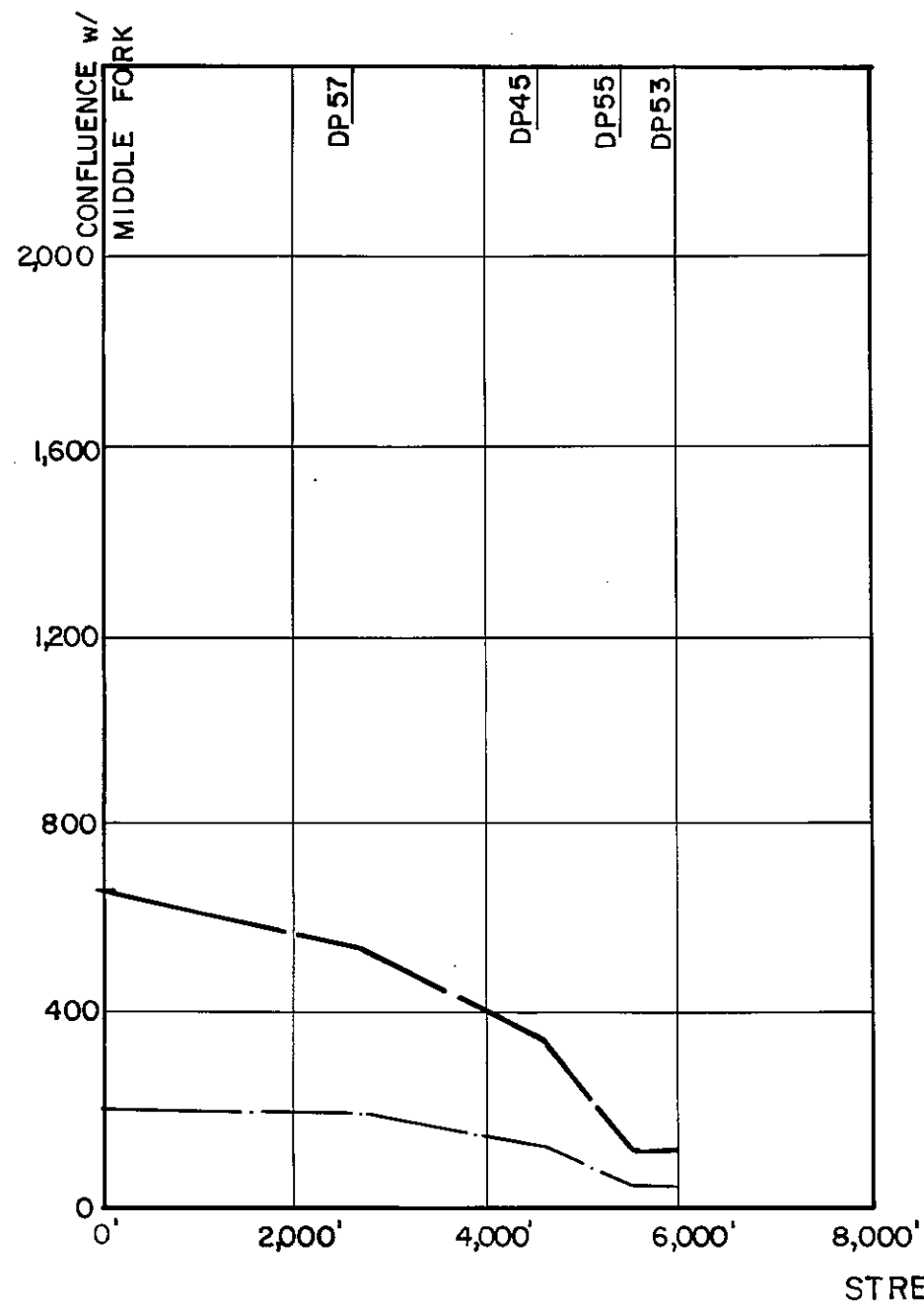
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DIRTY WOMAN CREEK & CRYSTAL CREEK DRAINAGE BASIN PLANNING STUDY FLOOD DISCHARGE PROFILE

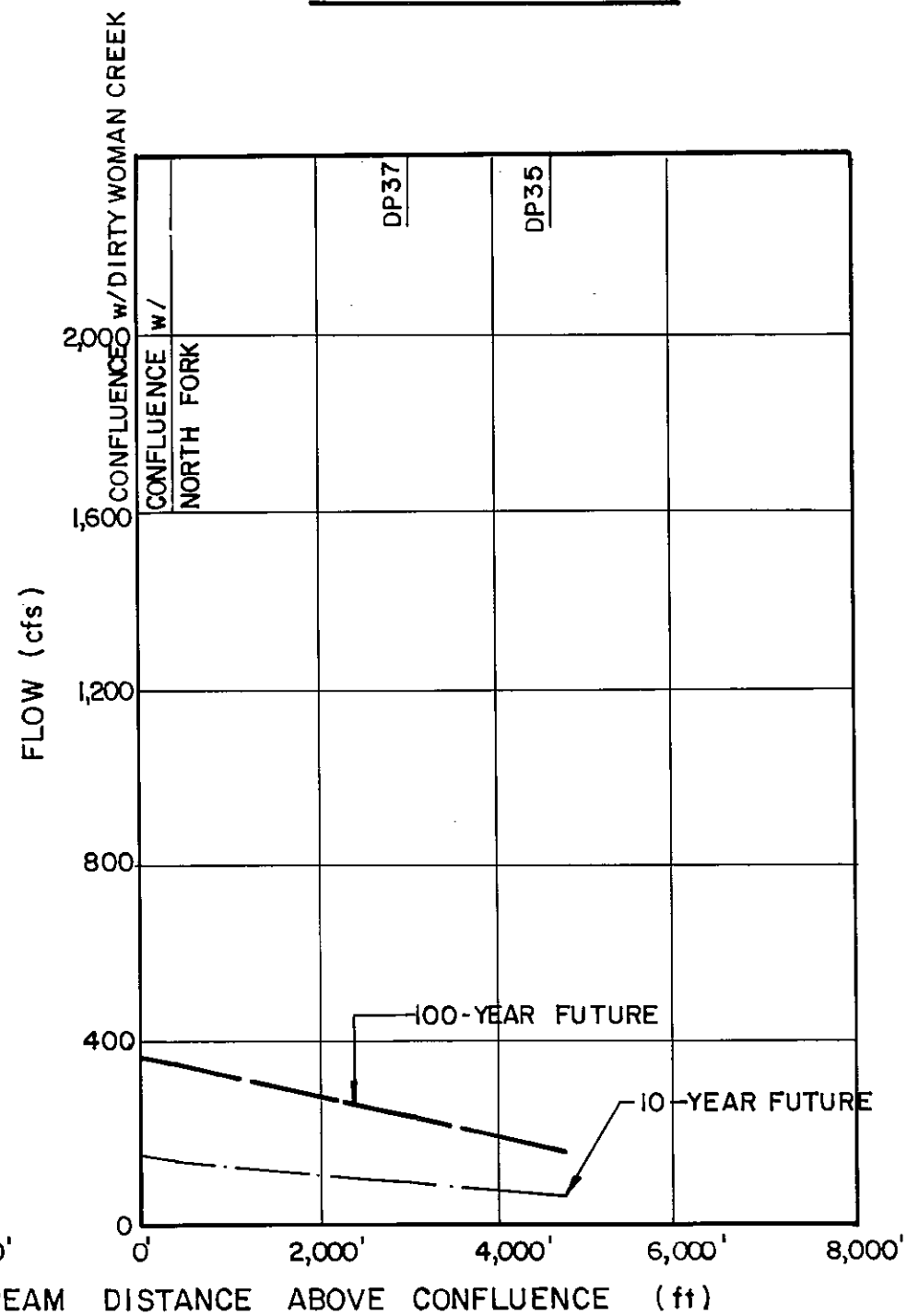
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FIG. 5

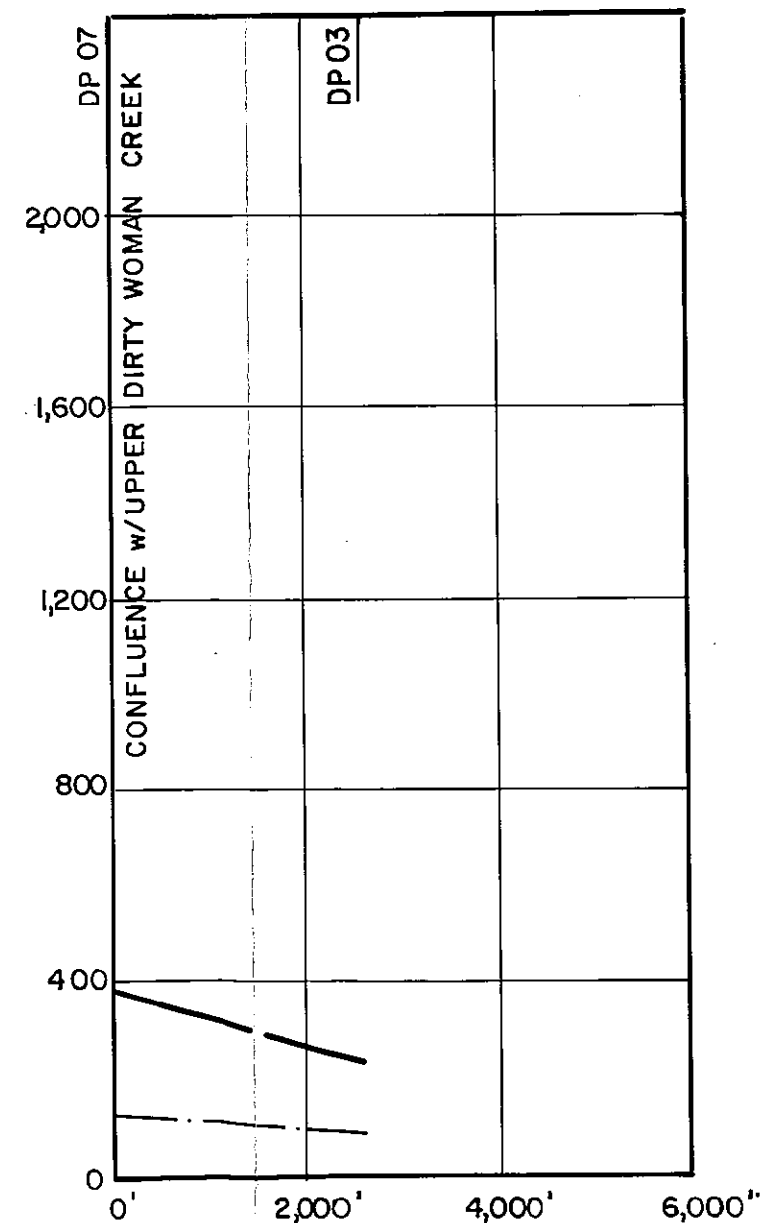
NORTH FORK



MIDDLE FORK



SOUTH FORK



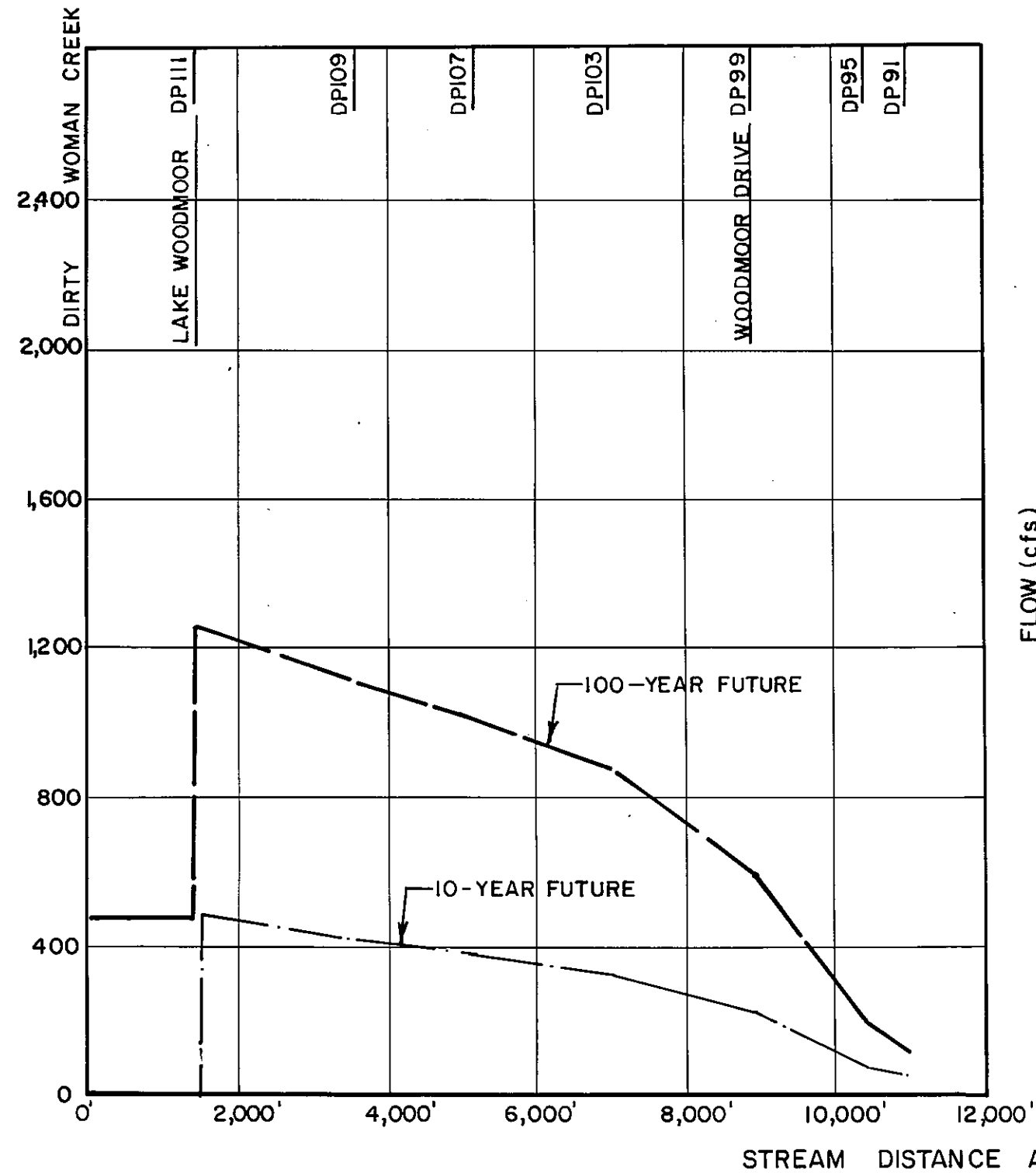
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DRAINAGE BASIN PLANNING STUDY
FLOOD DISCHARGE PROFILE

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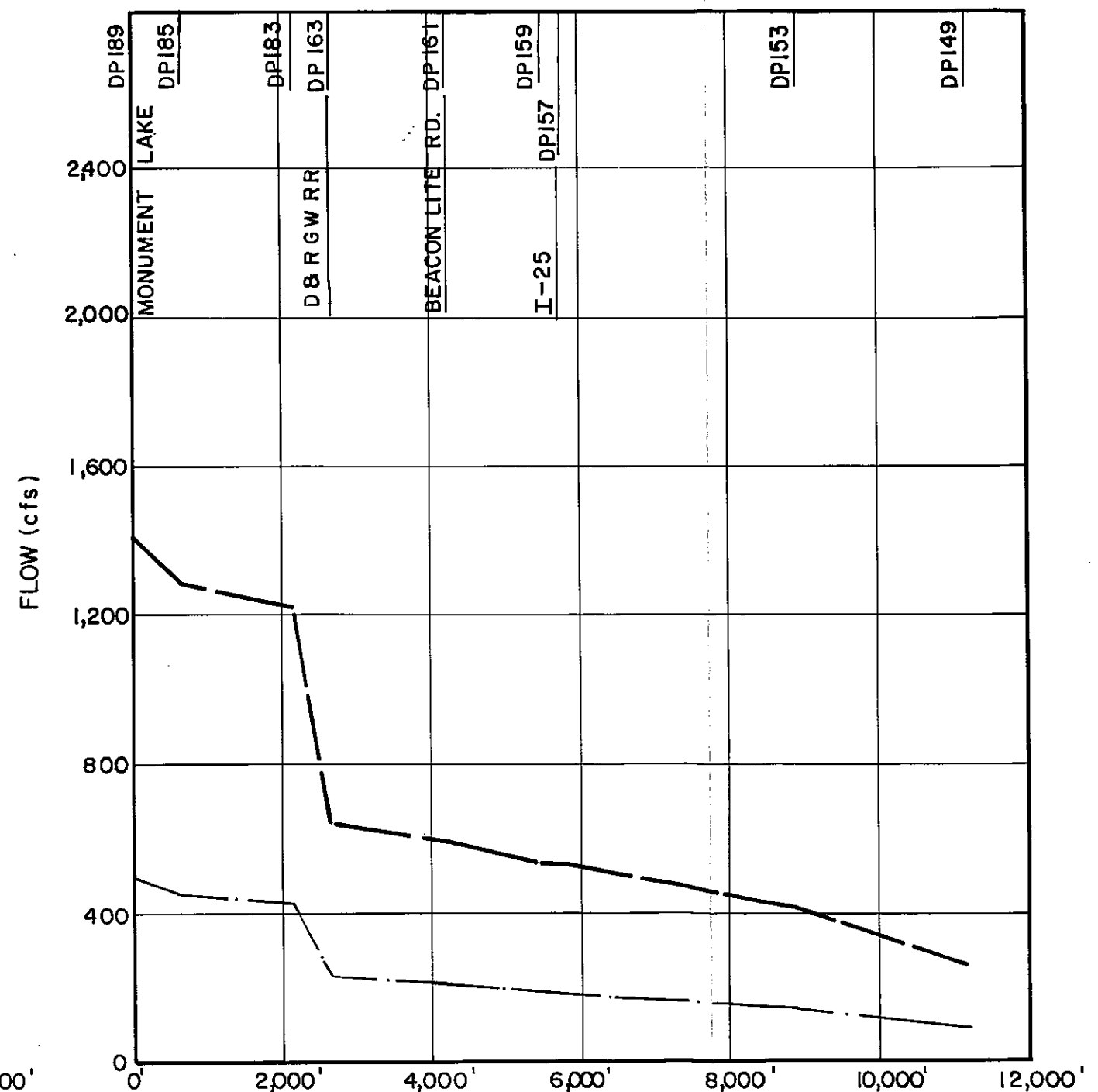
FIG. 6

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LAKE FORK



CRYSTAL CREEK



DIRTY WOMAN CREEK & CRYSTAL CREEK
DRAINAGE BASIN PLANNING STUDY
FLOOD DISCHARGE PROFILE

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FIG. 7

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TABLE 1
Summary of Sub-basin Peak Discharges

Basin Designation	Future 100 Year 2 Hour	Future 10 Year 2 Hour	Basin Designation	Future 100 Year 2 Hour	Future 10 Year 2 Hour	Basin Designation	Future 100 Year 2 Hour	Future 10 Year 2 Hour
SDW01	147	49	DWC79	118	42	CC157	111	46
SDW03	90	31	LDW81	136	54	CC159	22	9
SDW05	120	40	LDW83	74	28	CC161	132	57
SDW07	91	38	LDW85	47	18	CC163	127	51
UDW09	103	34	LDW87	112	43	CC165	121	52
UDW11	57	20	LDW89	94	35	CC167	116	49
UDW13	32	12	LDW91	26	10	CC169	119	37
UDW15	76	25	LDW93	46	18	CC171	90	40
UDW17	26	9	LDW95	53	20	CC173	56	24
UDW19	33	11	LDW97	50	19	CC175	46	15
UDW21	47	16	LDW99	57	25	CC177	89	32
UDW23	24	8	LDW101	170	66	CC179	42	13
UDW25	44	15	LDW103	136	50	CC181	49	15
UDW27	80	29	LDW105	95	38	CC183	136	50
UDW29	80	27	LDW107	47	18	CC185	111	36
UDW31	82	35	LDW109	131	53	CC187	96	37
MDW33	131	47	LDW111	215	89	CC189	64	23
MDW35	33	11	DWC113	44	15			
MDW37	81	29	DWC115	91	40			
MDW39	116	46	DWC117	198	84			
NDW41	146	56	DWC119	72	31			
NDW43	61	23	DWC121	211	88			
NDW45	87	33	DWC123	77	34			
NDW47	62	23	DWC125	73	31			
NDW49	14	5	DWC127	102	32			
NDW51	32	12	DWC129	137	58			
NDW53	17	6	DWC131	58	18			
NDW55	18	7	DWC133	102	38			
NDW57	153	57	DWC135	81	26			
NDW59	129	50	DWC137	65	25			
DWC61	76	29	DWC139	117	47			
DWC63	130	50	DWC141	79	32			
DWC65	59	23	DWC143	101	38			
DWC67	42	15	CC145	89	33			
DWC69	41	17	CC147	103	35			
DWC71	72	29	CC149	69	22			
DWC73	81	30	CC151	114	38			
DWC75	153	61	CC153	77	29			
DWC77	50	19	CC155	43	19			

TABLE 2
Summary of Peak Discharges

Design Point	Creek Symbol	Existing 100 Year 2 Hour	Existing 10 Year 2 Hour	Future 100 Year 2 Hour	Future 10 Year 2 Hour
Dirty Woman Creek					
11	UDW	150	50	150	50
21	UDW	308	103	308	103
29	UDW	514	172	514	172
53	NFDW	108	40	108	40
55	NFDW	117	43	117	43
45	NFDW	354	132	354	132
57	NFDW	501	186	501	186
35	MFDW	156	55	156	55
37	MFDW	235	84	235	84
3	SFDW	229	77	229	77
7	SFDW	377	127	377	127
59	DWC	1,876	663	1,876	663
61	DWC	1,952	692	1,952	692
63	DWC	2,075	735	2,075	735
65	DWC	2,126	756	2,126	756
69	DWC	2,175	777	2,175	777
71	DWC	2,202	791	2,202	791
75	DWC	2,335	836	2,337	838
91	DWC	112	41	112	41
95	DWC	198	74	198	74
83	DWC	195	75	195	75
99	DWC	594	226	594	226
103	DWC	883	334	883	334
107	DWC	1016	381	1016	381
109	DWC	1107	417	1107	417
111	DWC	1240	413	1240	413
113	DWC	2,513	896	2,515	898
115	DWC	2,539	908	2,541	910
119	DWC	2,679	960	2,686	694
123	DWC	2,810	1,000	2,868	1,031
125	DWC	2,850	1,015	2,909	1,046
127	DWC	2,879	1,028	2,943	1,057
131	DWC	2,989	1,068	3,055	1,098
135	DWC	3,142	1,124	3,212	1,154
139	DWC	3,192	1,136	3,258	1,170
Crystal Creek					
149	CC	260	90	260	90
153	CC	416	142	416	142
157	CC	527	185	527	185
159	CC	536	188	536	188
161	CC	594	211	594	211
163	CC	644	231	644	231
177	CC	188	70	188	70
179	CC	202	74	202	74
181	CC	232	81	232	81
167	CC	303	126	317	135
169	CC	397	148	412	157
183	CC	1,213	423	1,223	430
185	CC	1,277	442	1,288	450
189	CC	1,394	481	1,406	487

IV. HYDRAULIC ANALYSIS AND FLOODPLAIN DESCRIPTION

A hydraulic analysis was conducted to ascertain the conveyance capacity of hydraulic structures along the major drainageways of Dirty Woman and Crystal Creeks and to identify flood-prone areas along the drainageways. Field verifications of major roadway crossing and channel improvements were conducted and the general physical condition of the structure(s) noted. The hydraulic analysis was conducted using the U. S. Army Corps of Engineers (COE) HEC-2 water surface profiles program and/or the Federal Highway Administration's (FHWA) HY-8 Culvert Analysis computer program. Cross section data for the analysis was obtained by using the two-foot contour interval planimetric topographic mapping referenced earlier in this report. The capacity of the major roadway crossing structures were estimated using the HEC-2 water surface profile data and supplemented by the FHWA HY-8 Culvert Analysis calculations.

Shown on the preliminary design plans is the 100-year floodplain for the future development hydrologic condition. The floodplains have been delineated for Dirty Woman Creek along with all five of its 'forks,' Lake Fork, North Fork, Middle Fork, Upper Fork, and South Fork. The floodplain information shown on the preliminary design plans has been primarily used for identification of flood-prone areas and for assistance in the development of alternative plans. **The floodplain data contained herein is not intended to replace the information presented in the El Paso County Flood Insurance Study.** A Floodplain Delineation Technical Addendum containing the hydrologic and hydraulic computer input and output was submitted to the County as part of this study.

Floodplain preservation and regulation has been recommended in conjunction with selective channel and bank improvements for many reaches of both drainageways in the selected plan. Due to this, the location of the 100-year floodplain is important since it denotes the limit of allowable encroachment. Often times the zone of the 100-year floodplain contains higher quality riparian and wetland habitat. These areas were determined to be desirable areas to preserve during the alternative planning process. It is recommended that at the time of development, areas which contain Dirty Woman Creek or Crystal Creek should have the 100-year floodplain limits verified using the hydrology summarized in this report as a part of the initial process of the land development planning. For areas where no floodplains have been delineated as a part of this report or in the Flood Insurance Study, determination of the 100-year floodplain should be required utilizing methods similar to those applied in this study. This requirement will be needed primarily in the upper reaches of Dirty Woman and Crystal Creek and in the northwestern portion of the Crystal Creek basin.

Reach Delineation and Descriptions

Reaches were delineated for various segments of Dirty Woman Creek and Crystal Creek. The reaches were determined based upon the existing physical condition of the low flow, floodplain, and overbanks along the drainageways. The reach limits are shown on Figure 8 and on the preliminary design drawings. Descriptions of the reaches along with environmental review of each reach were conducted using field visits. This information has previously been presented in the Development of Alternatives report.

Flood History

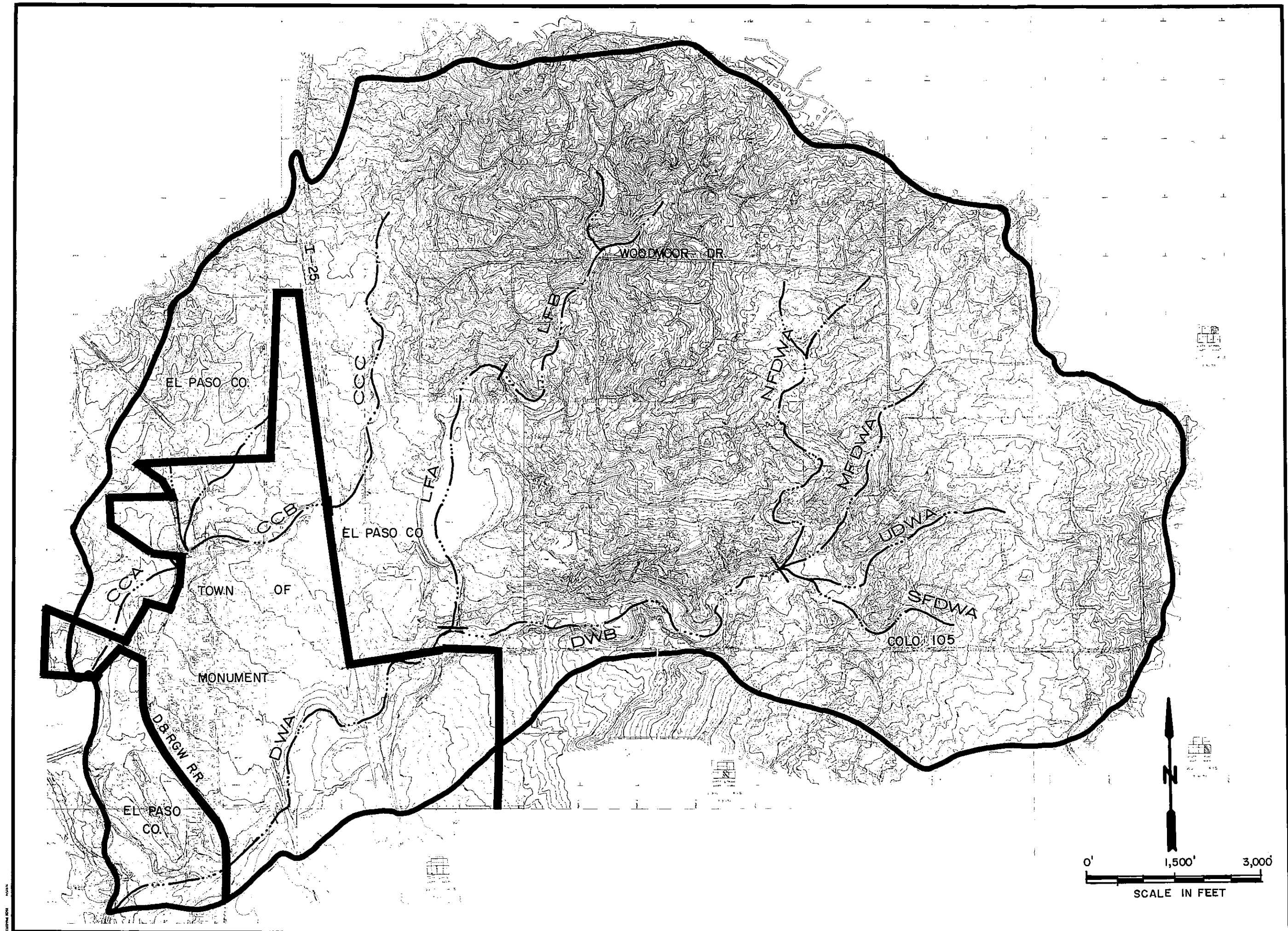
The flood history of the two basins within the study area is not known. Newspaper articles of past flood events along either of the creeks could not be found. There are no clear high water marks along the drainageways.

The potential for flash flooding will not increase significantly as urbanization continues. This is because of the numerous natural and incidental storage areas which occur along both creeks. In addition to the natural floodplain storage, the future land use will not cause a significant rise in the flood discharges. A constant base flow does exist in Dirty Woman Creek. Much of this base flow is transmitted to Lake Woodmoor via a gravity pipe system and infiltration galleries situated along the creek low flow channel. Lake Woodmoor is a private reservoir. Woodmoor Water and Sanitation District supplies raw water to the reservoir. During the hydrology analysis, the storage in Lake Woodmoor between the maximum operating level and the emergency spillway was assumed to be available for flood water storage. The State Engineer records indicate a 5.5 foot difference between the maximum operating level and the spillway.

Hydraulic Structure Inventory

As part of the field investigation, the existing drainage facilities were verified and inventoried. The size, type, and condition was recorded for all the bridges, culverts, channels, inlets, pipes, and miscellaneous drainage features in the basin. Hydraulic capacities were estimated for the culverts and bridges over the major drainageways. An inventory of the major structures is presented on Table 3. Hydraulic capacity of a structure was assumed to be reached when the hydraulic grade line equalled the adjacent road surface.

In addition to the bridge and culvert inventory, the existing storm sewer facilities were field verified and tabulated. The structures were measured and their condition noted. Maps showing the facilities have been prepared along with a tabular listing and are contained under a separate cover.



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 80905-1308

DIRTY WOMAN CREEK & CRYSTAL CREEK
 DRAINAGE BASIN PLANNING STUDY
 REACH DELINEATION MAP

Project No: 91-07-17
 Date: 3/92
 Design: AWMc
 Drawn: EAK
 Check:
 Revisions:

FIG. 8

TABLE 3
Major Structure Inventory
Dirty Woman/Crystal Creek Drainage Basin Planning Study

Reach No.	Creek/ Station	Roadway	Existing Culvert Size	Q100 Q10 (cfs)
DW-A	Dirty Woman 11+30	Mitchell Street	72" CMP	3,258
	Dirty Woman 18+20	D&RGW RR	16"x18" Stone Arch	1,170
	Dirty Woman 32+30	Old Denver Highway	64" CMP	3,212
	Dirty Woman 34+30	Santa Fe Trail	23"x30" Stone Arch	1,154
	Dirty Woman 65+40	I-25	8"x8" CBC	3,055
	Dirty Woman 85+60	Colorado Hwy 105	4"x64" Conc. Bridge	1,098
	Dirty Woman 107+70	Knollwood Drive	36" CMP	2,541
	Dirty Woman 142+80	South Park Drive	24" CMP	910
	Dirty Woman 148+60	Lake Woodmoor Drive	(2)-24" CMP	2,337
	Dirty Woman 155+00	Augusta Drive	(2)-24" CMP	838
DW-B	Upper Dirty Woman 188+30	Furrow Road	(3)-48" RCP	2,126
	North Fork Dirty Woman 5+80	Augusta Drive	? CMP	756
	North Fork Dirty Woman 60+50	Tam-O-Shanter Way	Plugged	2,075
NFDW-A	North Fork Dirty Woman 69+70	Woodmoor Drive	? Plugged	735
	Middle Fork Dirty Woman 14+00	Will O The Wisp Way	18" CMP	514
MFDW-A	Middle Fork Dirty Woman 33+00	Lost Creek way	24" CMP	172
	Middle Fork Dirty Woman 37+30	Furrow Road	24" CMP	627
	Middle Fork Dirty Woman 45+00	Ajo Way	18" CMP	186
	South Fork Dirty Woman 10+30	Windine Meadows Way	24" CMP	117
SPDW-A	South Fork Dirty Woman 10+90	Winding Meadows Way	14"x22" Arch CMP	43
	South Fork Dirty Woman 26+20	Furrow Road	36" CMP	108
	South Fork Dirty Woman 42+00	Martingale Road	18" CMP	40
	Lake Fork Dirty Woman 52+60	Autumn Way	24" CMP	349
	Lake Fork Dirty Woman 63+50	Deer Creek Road	24" CMP	129
LFDW-B	Lake Fork Dirty Woman 87+60	Deer Creek Road	18" CMP	235
	Lake Fork Dirty Woman 93+20	Woodmoor Drive	24" CMP	84
	Crystal Creek 5+90	N Monument Lake Road	(2)-72" CMP	235
	Crystal Creek 25+20	D&RGW RR	14"x16" Stone Arch	84
CC-A	Crystal Creek 28+70	Washington Street	(2)-90" CMP	235
	Crystal Creek 31+70	Colorado Hwy 105	8.5"x30" Conc. Bridge	229
	Crystal Creek 34+50	Santa Fe Trail	10"x10" Stone Arch	77
	Crystal Creek 43+00	Beaconlite Road	36" CMP	90
	Crystal Creek 56+40	I-25	10"x14" CBC	31
CC-B	Crystal Creek 58+50	Frontage Road	24" RCP	1,016
	Crystal Creek 63+30	Willow Park Way	42" CMP	381
	Crystal Creek 83+70	Deer Creek Road	60" CMP	883
	Crystal Creek 89+80	Immigrant Trail East	(2)-24" CMP	334
				594
CC-C				226
				1,288
				450
				644
				231

Floodplains

Floodplains for the 100-year existing and future condition discharges have been delineated for Dirty Woman Creek and Crystal Creek. The floodplain was estimated in order to assess where hydraulic inadequacies exist along the major drainageways. Floodways were also delineated as part of the hydraulic analysis. This analysis assumed rigid boundary conditions to exist along the channel cross sections. The field inventory supplied roughness and bridge opening data for use in the HEC-2 modeling. These floodplains are presented on the Preliminary Design drawings. The previously mentioned technical addendum contains input and output data for the hydrology, floodplain and floodway analyses.

The most significant areas of existing flood hazard occurs along I-25, between Crystal Creek and Dirty Woman Creek. An inadequate capacity culvert under the I-25 Frontage Road forces the 100-year discharge in Crystal Creek to be diverted south along I-25 and into Dirty Woman Creek. Though no structures are threatened, Colorado Highway 105 and the northbound I-25 embankment could be eroded. The crossing of I-25 by Dirty Woman Creek will overtop the roadway in its current configuration. No structures are threatened, but the potential for erosion and localized roadway destruction is great. Elsewhere along Dirty Woman Creek, a single family residence in the vicinity of Augusta Drive lies within the 100-year floodplain. The floodplain at this location is wide because of the inadequate culverts under Augusta Drive and Lake Woodmoor Drive. Along Crystal Creek, there are two locations in which flooding potentially threatens a structure. The crossings of Crystal Creek at both Willow Park Way and Emigrant Trail East pose potential flooding problems. In general, habitable structures adjacent to Dirty Woman and Crystal Creeks have been elevated above the 100-year water surface.

V. EVALUATION OF CONCEPTUAL ALTERNATIVES

Introduction

Alternative drainageway improvement concepts have been examined that address the existing and future stormwater management needs of the basin. Alternatives have been identified for each reach of the Dirty Woman and Crystal Creek drainageways. Quantitative and qualitative comparisons were presented, and a recommendation made as to which concepts were most feasible to advance to preliminary design and eventually to implementation. The majority of the alternative analysis is presented in the *Development of Alternatives* report.

The general planning goals to be achieved during the alternative evaluation phase were:

1. Identify stormwater facilities which will reduce existing floodplains and flooding problems within urbanized areas;
2. Provide stormwater management within developing areas of the basin in order to reduce the detrimental effects of runoff and sedimentation from disturbed areas;
3. Provide stormwater facilities which preserve and/or enhance the existing drainageway and areas adjacent to the drainageway which provide an environmental resource in the area;
4. Identify facilities which will minimize future operations and maintenance costs; and
5. Provide stormwater management facilities which will at least maintain and/or enhance the water quality characteristics of the basin.

The *City/County Drainage Criteria Manual* was used as a guide in the conceptual sizing of facilities. Planning goals were developed through the agency/individual coordination process. Common and/or mutual goals of the interested agencies were identified prior to the initiation of the alternative evaluation phase.

Evaluation Parameters

Coordination meetings were held throughout the planning process in order to discuss the overall goals of the study and to solicit specific concerns from governmental agencies, individuals, and private community groups. One result of this coordination effort was the

development of the following list of parameters which should be considered when evaluating alternatives.

* Flood Control	* Open Space/Aesthetics
* Erosion Control	* Land Use
* Operation and Maintenance	* Water Quality
* Recreation	* Habitat
* Right-of-Way	* Construction Cost
* Transportation (Roadway and Trails)	* Administration and Implementation

By reviewing the relative impact of future stormwater runoff upon the major drainageways, each of the evaluation parameters were ranked. A minimal impact was assumed wherever the future flows were considered to cause little physical change with respect to a specific parameter. Neutral impact upon a given parameter was considered wherever the negative effects of future flows could be planned for and mitigated. High impact was considered wherever the existing channel section would be rendered unsuitable to provide for a given parameter in the future flow condition. Using the input from the individuals and agencies who participated in the meetings and field reviews, flood hazard, operations and maintenance, habitat preservation, open space/aesthetics, and water quality were judged to be of high concern in the Dirty Woman and Crystal Creek drainage basins.

Environmental Review of Dirty Woman Creek and Crystal Creek Drainage Basins

The environmental review conducted as a part of this project consisted of a description and compilation of the biological and land use resources in the basin, their present condition, and an analysis of abiotic and human factors affecting the environment. A reconnaissance survey was conducted during which the environmental conditions were studied by driving and walking the areas and drainageways in the basin. The area was mapped and interpreted in the field based on 7-1/2 minute topographic maps and ortho-corrected aerial photographs at a scale of 1-inch to 400 feet. Particular attention was given to conditions in the drainages and spring/seep areas for biological resources in the riparian zones and wetlands. Dominant plant species for each habitat type were observed and recorded.

The Dirty Woman and Crystal Creek drainage basins trend in a west to southwest direction from their headwaters in the Black Forest/Palmer Divide area. Dirty Woman Creek extends about 5 miles to its confluence with Monument Creek. Crystal Creek extends about 3 miles to its confluence with Monument Creek just upstream of Monument Lake. These areas are in the transition zone of high plains grasslands and wetlands to the foothills and lower montane pine forests. The drainage basins have a mixture of semi-natural vegetation and habitats

somewhat altered by development, specifically transportation corridors, and commercial and residential development.

The basin has a history of human activity and disturbance. The western, lower drainage area has supported the Town of Monument and was and continues to be a major north-south roadway and railroad corridor for traffic between Denver and Colorado Springs. The eastern, upper drainage, area has historically been a ranching district with evidence of heavy livestock grazing and stock pond construction still present. Interstate 25 (I-25) has replaced the old roadway, and commercial and business development along the frontage road has occurred. East of I-25, a large lot residential community, Woodmoor, has been developed along with a country club and golf course.

Portions of the Dirty Woman/Crystal Creek Drainage Basin west of and along I-25 has been highly developed for residential and commercial use and other businesses. Access roads and residential lots were developed east of the interstate, and further development in this area is expected to be minimal and localized. The Town of Monument is also located west of I-25 with surrounding businesses and large lot residential areas. The Town was founded during the last century, and is well established but without current plans for expansion. The I-25 interchange at Monument is considered inadequate and may require replacement in the near future. This would affect the drainages of Dirty Woman Creek in the vicinity of the interchange freeway crossings.

Immediately east of I-25 a water supply reservoir (Lake Woodmoor), has been constructed on the Lake Fork of Dirty Woman Creek, and on other small tributaries drain into this reservoir. Roads and some of the residential lots occur in the drainages, and have interfered with the water regime and flow and the associated wetlands. The major land uses that presently affect the natural resources, riparian zones and habitats along drainages and wetlands are commercial, transportation corridors, roads and residential. There is at present little agriculture or livestock grazing in this basin.

The approximately one acre residential lots in the upper reaches of the drainage east of the interstate have disturbed the natural setting the least and have semi-natural vegetation and habitats. In most cases, the drainages have been undisturbed by construction and removal of grazing has allowed the vegetation to establish to productive riparian, wetlands and wet meadow habitats. Exceptions to this are the golf course along the North Fork Dirty Woman Creek and several homesites along the upper portion of Crystal Creek immediately south of Woodmoor Drive. The freeway and the Town of Monument occupy the southwestern lower areas in the drainage basin(s).

A more thorough description of the environmental resources identified during the preparation of the planning study is contained within the *Development of Alternatives* report. Both qualitative and quantitative assessments are presented which were used in the

determination of relative impact for each feasible plan identified in the alternative evaluation process.

There are no known threatened or endangered plant or animal species specifically identified for these drainage basins. Peregrine falcons are known to nest along portions of the Front Range, and this area is possibly within the hunting territory of this raptor. Migratory waterfowl may seasonally use the reservoir in the lower portion of the Lake Fork of Dirty Woman Creek, and may land on the small stock or constructed ponds in the upper drainage near the golf course.

Preliminary Matrix of Conceptual Alternatives

The alternative planning process began with the evaluation of general drainageway planning alternatives. Alternatives which are generally available when planning urban drainageways include:

1. Floodplain preservation (do nothing alternative)
2. Channelization, using various materials and varying capacity
3. Detention, on-site or regional
4. Selective stabilization
5. Combinations of the above.

These concepts were qualitatively evaluated for each reach of the basin. The qualitative assessments were made using the information gathered in the field, and using input provided by the various agencies and individuals who participated in the coordination meetings.

Drainageway System Alternatives

A review of each drainageway alternative with respect to the evaluation parameters listed earlier was conducted. Based upon the technical work, field visits, and meetings with the interested agencies and individuals, the alternative drainage concepts have been developed. Alternatives for floodplain and channel sections have been evaluated and are discussed in detail in the *Development of Alternatives* report.

Evaluation of Concepts

Presented in the *Development of Alternatives* report are qualitative and quantitative comparisons of the floodplain preservation (do nothing), channelization and selective improvement concepts. Each alternative was compared with respect to flood hazard, habitat loss, operations and maintenance, open space/aesthetics and water quality. Each alternate's relative impact upon the drainage planning parameters was assessed. The areal impact upon the habitat resources within each reach have been categorized as minimal (less than 30 percent

disturbance), moderate (30 to 60 percent disturbance), and major (greater than 60 percent disturbance).

Conclusions

Based upon the concept evaluation discussed and summarized in the Development of Alternatives report, the following findings were established:

1. Regional detention, except that currently being provided by Lake Woodmoor, is not feasible from the flood control and peak flow reduction standpoints. The storage behind man-made embankments (roadways and ponds), in combination with the floodplain overbank storage is providing a sufficient amount of long-term stormwater storage in the basin(s). On site detention for new commercial or residential areas within the Town of Monument is desirable from the localized erosion and water quality control viewpoints. On site detention and its effect upon peak discharges in Dirty Woman or Crystal creeks is not significant.
2. Feasible channel section alternatives for the mainstem of Dirty Woman and Crystal creeks range from the floodplain preservation, or "do nothing" alternate to selective riprap bank linings. The feasibility of channelization concepts decreases within the upper reaches of the basin(s).
3. Habitat disturbances due to channelization of the Dirty Woman and Crystal creeks would be significant and would have to be replaced elsewhere along the drainageways. In some locations the channelization of runoff could have the effect of "drying up" the natural base flow and thereby having a negative impact upon the vegetative and wildlife habitat.
4. Long-term maintenance concerns make the implementation of a 100-year or 10-year contiguous channelization concept difficult. The acquisition of property along the drainages would have to occur if a channelized concept was advanced to implementation.

VI. DEVELOPMENT OF ALTERNATIVES AND RECOMMENDED PLAN

The concepts which are available for handling stormwater runoff within the Dirty Woman and Crystal Creek basins have been presented and discussed in detail in the *Development of Alternatives* report. The process of combining the various channel treatment options and roadway crossing structures into a contiguous plan for all of the reaches is presented in this chapter of the report. As a result of the evaluation of the flood control, habitat, open space, operations and maintenance, and water quality concerns within the basins, the following concepts were identified as having sufficient feasibility to warrant further evaluation and review:

Channel Concepts:	Floodplain Preservation
	Channelization, 10- or 100-year
	Selective Improvements

Channel Concepts: The channel concepts listed above have been evaluated with respect to the parameters listed in the previous chapter and in the *Development of Alternatives* report. A concept's feasibility depends upon its impact, positive or negative, upon the evaluation parameters. *The Floodplain preservation* concept has been considered to be the same as the "*do-nothing*" alternative. The floodplain preservation concept would involve the regulation of the floodplain limits, generally as depicted on the El Paso County Flood Insurance Rate Maps and as further refined by this drainage basin plan. Regulation of the floodplain so that future encroachments are minimized and the floodproofing of structures which are currently within the 100-year floodplain would presumably be the methods used to address the flood hazard concerns along the drainageways. *Channelization* would involve the lining of the creek into a more confined flow area, and could be done for either the *100-year or 10-year* flood discharges. Several typical channel concepts have been evaluated. The primary bank lining material would probably be riprap. Grade control and/or drop structures would be required in a channelization concept so that the flood velocities could be controlled to a level requiring medium to heavy riprap. The preservation of invert vegetation upstream of grade controls or checks would help to minimize the amount of invert riprapping for the channel concept. Revegetation would occur wherever the native vegetation was disturbed by the channel construction. Willows at the toe of the riprap banks would be a minimum replacement. *Selective improvement concept* would involve the construction of grade controls, drop structures, bank linings, low flow channel linings, and storm sewer outlet control structures selectively sited to resist stream erosion or to reduce potential flooding

damages while minimizing habitat impacts. Areas of future concern such as at the outside bends of the drainageways and the outlets of roadway bridges, culverts, or reservoirs would be the areas primarily subject to selective improvements.

Channel Alternatives

All reaches of Crystal Creek and Dirty Woman Creek had at least three alternatives analyzed. Presented on Tables 4 through 6 are comparative evaluations of the floodplain preservation, channelization, and selective improvements concepts by reach. The purpose of the evaluation process was to identify the relative advantages and disadvantages of each concept within each reach. For the channelization and selective improvement concepts, a cost comparison has been completed. The cost evaluation and detailed discussion relating to the various concepts are contained within the Development of Alternatives report. The costs do not include an allowance for land acquisition for channel improvements, or for the relocation of utilities associated with the construction of channel improvements.

Culvert Alternatives

Throughout the Dirty Woman and Crystal Creek drainageways, roadway crossings have been constructed. In some locations such as at the major roadway crossings, the existing crossings are of 100-year capacity. In many other locations, particularly within the Woodmoor subdivision, the existing culverts are very small, most having less than a 10-year flow capacity. The crossings with inadequate capacity culverts generally have a wide floodplain upstream of the roadway embankment. In addition to wide floodplains, wetland and riparian zones exist which could be negatively impacted by increasing the capacity of the roadway culvert. The *Development of Alternatives* report contains a detailed analysis of the culvert crossings.

Impact Upon Habitat

For each of the channel alternatives evaluated an estimate of each alternative's potential for disturbance of the habitat was made. The acreages presented on Table 7 summarized the acreages associated with wetland and riparian areas. The areas mainly lie within the floodplain of the drainageways. Since it is the goal of this planning process to identify concepts which will avoid disturbances to the existing habitat wherever practical, alternatives which would have a greater level of disturbance compared to another must have provisions for mitigating the disturbance. Typical disturbances caused by channelization would include loss of native toe and/or bank vegetation, filling of

TABLE 4: Evaluation of Channel Alternatives

Major Drainageway: Dirty Woman Creek / Crystal Creek
Alternative Concept: Floodplain Preservation (do-nothing)

Parameter	Flood Hazard		Habitat			Operations and Maintenance		Open Space/Aesthetics			Water Quality		Comments	
	No Impact	Reduced Hazard/ Increased Hazard	Impact			Mitigation/Enhancement Opportunities	Reduced effort	Increased effort	Low Visual Quality	No Impact	Visually Enhanced	Degrades Quality		No Impact or Enhancement
			Minimal	Moderate	Major									
DW-A	Parkland lies within 100-yr Flood plain. Structures are currently outside 100-yr floodplain.	Unstable channel banks could create flood damage in this reach.		X		Bank instability remains potential for enhancement.		Channel bank erosion in areas with regular sedimentation will cause higher annual maintenance costs as this area develops.	Area between RR & 1-25 could let area visually brighten if left alone.	Opportunities exist to enhance the entire length of the reach. Portions of the reach are of high visual value currently.	Area between RR & 1-25 could cause water quality problems due to erosion.	Existing wetland areas provide significant water quality enhancement.	Portions of the reach, upper & lower, have excellent wetland habitats. The middle portion of the reach is currently experiencing bank erosion. Future CDDOT plans could destroy prime wetland areas.	
DW-B	One residence is currently within the 100-year floodplain.	Future flood hazards can be reduced using floodplain regulation.	X					Maintenance costs could increase as development occurs in lower portion of reach.	Development without floodplain control in lower portion of reach could reduce aesthetics.	Opportunities exist to enhance the Open Space & aesthetics of the reach. High quality currently exists in the reach.		Existing wetland areas provide significant water quality enhancement.	The lower portion of the reach is subject to development which could encroach upon the creek.	
UPDW-A	No structures are currently within the 100-year floodplain.	Undersized culverts are potentially dangerous.	X					Increased O & M costs due to undersized roadway culverts.	Buildout is nearly complete. Most of the floodplain is privately owned.	Short term construction activity & roadway erosion impact water quality.	Existing wetland areas provide significant water quality enhancement.	Areas tributary to this reach are near complete buildout. Undersizing of roadway culverts is biggest problem.		
SFDW-A	No structures are currently within the 100-year floodplain.	Undersized culverts are potentially dangerous.	X					Increased O & M costs due to undersized roadway culverts.	Floodplain is privately owned.	Short term construction activity & roadway erosion impact water quality.	Existing wetland areas provide water quality enhancement.	Undersizing of roadway culverts is biggest problem in this reach.		
MFDW-A	No structures are currently within the 100-year floodplain.	Undersized culverts are potentially dangerous. Furrow Road is constraint to flood flow.	X					Increased O & M costs due to undersized roadway culverts.	Floodplain is privately owned.	Short term construction activity & roadway erosion impact water quality.	Existing wetland areas provide water quality enhancement.	Undersized & improperly located culverts are detrimental to flood flow in this reach particularly at Furrow Road.		
NFDW-A	No structures are currently within the 100-year floodplain.	Undersized culvert at Augusta Dr. creates flooding hazard.	X			Existing floodplain is well vegetated and stable.		Increased O & M costs due to undersized roadway culverts & inlets.	Floodplain is within drainage/preservation easement.		Existing wetland areas provide water quality enhancement.			
NFDW-B	Golf course occupies the majority of floodplain in this reach.	Undersized culverts are constraints and are potentially hazardous.	X					Increased O & M costs due to undersized roadway culverts & inlets.	Floodplain is privately owned, majority by Woodmoor CC.	Opportunities exist to enhance the Open Space & aesthetics of the reach afforded by this concept.	Existing wetland areas provide water quality enhancement.	Most of the reach is within Woodmoor CC and is currently a golf course. Undersized culverts are detrimental to flood flow particularly at Woodmoor Drive.		
LFDW-A	Lake Woodmoor reduces the flood hazard in this reach. Some structures have been built on stilts over the lake.	Lake Woodmoor spillway is potentially hazardous at road crossing.		X				Increased O & M costs caused by spillway erosion.	Low water level in Lake Woodmoor.	Opportunities exist to enhance the Open Space & aesthetics of the reach afforded by this concept.	Lake Woodmoor is water supply reservoir.	Spillway and area below Lake Woodmoor is actively headcutting.		
LFDW-B	No structures are currently within the 100-year floodplain.	Undersized & improperly located culverts are potentially hazardous.	X					Increased O & M costs due to undersized & improperly located roadway & driveway culverts.	Buildout is nearly complete. Most of the floodplain is privately owned.	Opportunities exist to increase water quality which directly enters reservoir.	Existing wetland areas provide water quality enhancement.	Roadway and driveway culverts currently are detrimental to flood flow in the reach. Since water directly enters water storage reservoir, water quality should be a major concern.		
CC-A	No structures are currently within the 100-year floodplain.	Undersized culverts at N. Monument Lake Rd are constraint.	X					Increased O & M costs due to roadway crossings.	Floodplain is privately owned.	Opportunities exist to enhance the Open Space & aesthetics of the reach afforded by this concept.	Existing wetland areas provide water quality enhancement.	If farmland develops, floodplain regulation is essential. Culverts at N. Monument Lake Road are not adequate for 100-year flow.		
CC-B	Future flood hazards can be reduced using floodplain regulation.	Future development will increase flows.	X				O & M costs should remain relatively the same.		Development without floodplain control could reduce aesthetics.	Opportunities exist to enhance the Open Space & aesthetics of the reach afforded by this concept.	Development in area could result in loss of water quality.	Monument currently has a detention and "no build" in floodplain policy in effect.		
CC-C	No structures are currently within the 100-year floodplain.	Existing dam embankments could cause localized flooding if breached. Roadway crossings are undersized.	X					Increased O & M costs due to roadway crossings.		Opportunities exist to enhance the Open Space & aesthetics of the reach afforded by this concept.	Existing wetland areas provide water quality enhancement.	Undersized culvert at Promont Road is single biggest concern in the reach.		

TABLE 5: Evaluation of Channel Alternatives

Major Drainageway: Dirty Woman Creek / Crystal Creek

Alternative Concept: Selective Channel Improvements

Parameter Impact	Flood Hazard		Habitat			Operations and Maintenance		Low Visual Quality	Open Space/Aesthetics		Water Quality		Comments
	No Impact	Reduced Hazard/ Increased Hazard	Impact			Mitigation/Enhancement Opportunities	Reduced effort	Increased effort	No Impact	Visually Enhanced	Degrades Quality	No Impact or Enhancement	
Reach No.			Minimal	Moderate	Major								
DW-A	Structures are currently outside 100-yr floodplain	Potential exists to reduce bank erosion in middle portion of the reach	X			Mitigation of degraded segments possible by stabilization of banks and stream.	Channel bank erosion can be reduced or eliminated		Portions of the reach are of high visual quality currently	Area between RR & I-75 can be enhanced using selective improvements		Flow can be reduced considerably which will create better water quality. Existing wetland areas should remain	Selective improvements would be concentrated in the middle portion of the reach where the creek is relatively unstable
DW-B		One structure within 100-yr floodplain may be removed from floodplain with improvements	X					Maintenance costs could increase as development occurs in lower portions of the reach	Portions of the reach are of high visual quality currently	Opportunities exist to enhance the Open Space & aesthetics of the reach		Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	This reach appears relatively stable, however there is potential for high intensity development in lower portion of reach
UPDW-A	Structures are currently outside 100-yr floodplain	Providing properly sized culverts will reduce flooding potential	X				Reduced O & M costs due to proper roadway culvert sizing		Bedrock is nearly complete. Most of the floodplain is privately owned		Short term construction activity & roadway erosion impact water quality	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	Roadway culvert sizing needs to be evaluated. Roadway erosion and sedimentation needs to be addressed. Minimal improvements appear necessary
SFDW-A	Structures are currently outside 100-yr floodplain	Providing properly sized culverts will reduce flooding potential. Pond outlet improvements would reduce flood hazard	X				Reduced O & M costs due to proper roadway culvert sizing		Most of the floodplain is privately owned	High quality Open Space & aesthetics exist within the reach currently	Short term construction activity & roadway erosion impact water quality	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	Roadway culvert sizing should be increased. The overflow of the pond should be improved to reduce flooding potential. Minimal improvements appear necessary
MPDW-A	Structures are currently outside 100-yr floodplain	Providing properly sized culverts will reduce flooding potential	X				Reduced O & M costs due to proper roadway culvert sizing		Most of the floodplain is privately owned	High quality Open Space & aesthetics exist within the reach currently	Short term construction activity & roadway erosion impact water quality	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	Minimal improvements appear necessary within the reach. Roadway culverts should be sized
NPDW-A	No structures within 100-year floodplain.		X				Culvert at Augusta Dr. would reduce O & M costs.		Most of floodplain within easement or private property.				Culvert at Augusta Drive should be replaced.
NPDW-B	Structures are currently outside 100-yr floodplain		X				Reduced O & M costs due to proper roadway culvert sizing. Most of the floodplain is owned by Woodmoor CC		Most of the floodplain is privately owned	High quality Open Space & aesthetics exist within the reach currently	Short term construction activity & roadway erosion impact water quality	Relatively fewer wetland areas in this reach, however the ponds provide a positive impact on water quality	Culverts at Woodmoor Drive should be improved. Most of the reach is controlled by Woodmoor CC
LFDW-A	Lake Woodmoor reduces the flood hazard in this reach. Some structures have been built on stilts over the lake		X				Improvements to spillway & channel could reduce O & M costs			Improvements to the spillway channel would improve aesthetics		Improvements to spillway channel would reduce erosion	Headcutting (erosion) of the spillway channel should be stopped. Habitat, aesthetics & water quality would all be increased
LFDW-B	Structures are currently outside 100-yr floodplain	Providing properly sized culverts will reduce flooding potential	X				Reduced O & M costs due to proper roadway culvert sizing		Most of the floodplain is privately owned	High quality Open Space & aesthetics exist within the reach currently	Opportunities exist to enhance water quality which directly enter reservoir.	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	Water quality should be a major concern in this reach. Roadway & driveway culverts are a hindrance to flood flow and should be upgraded
CC-A	Structures are currently outside 100-yr floodplain	Improvements through the existing farmland would improve flood hazards as that area develops		X		Replacement of disturbed vegetation/habitat is possible throughout reach		As the undeveloped land develops, O & M costs will increase	Development without floodplain control could reduce aesthetics	Opportunities exist to enhance the Open Space & aesthetics of the reach	Development in the reach could result in loss of water quality	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	Existing farm/ranch land in reach is key. The reach is relatively stable as it exists, however development could change that. Culverts at N. Monument Lake Road will not pass the 100-yr flow
CC-B	Structures are currently outside 100-yr floodplain	Future development will increase flood flows		X		Replacement of disturbed vegetation/habitat is possible throughout reach	O & M costs should remain the same or lower slightly		The reach is currently characterized with areas of Open Space & good habitat	Opportunities exist to enhance the Open Space & aesthetics of the reach	Development in the reach could result in loss of water quality	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	Monument's detention policy should keep the flood flows near existing. Culvert along at Beacon Lane Road needs to be evaluated.
CC-C	Structures are currently outside 100-yr floodplain	Improvements at existing embankments & roadway culverts will reduce flooding hazards	X				Reduced O & M costs due to proper roadway culvert sizing			Opportunities exist to enhance the Open Space & aesthetics of the reach	Development in the reach could result in loss of water quality	Existing wetland areas provide significant water quality enhancement. Wetland areas should remain	The characteristics of this reach closely resemble the characteristics of the forks of Dirty Woman Creek. The Frontage Road culvert is grossly undersized & needs replacement

TABLE 6: Evaluation of Channel Alternatives

Major Drainageway: Dirty Woman Creek / Crystal Creek
Alternative Concept: Channelization

Parameter	Flood Hazard		Habitat			Operations and Maintenance		Open Space/Aesthetics			Water Quality		Comments	
Impact	No Impact	Reduced Hazard/ Increased Hazard	Impact			Mitigation/Enhancement Opportunities	Reduced effort	Increased effort	Low Visual Quality	No Impact	Visually Enhanced	Degrades Quality	No Impact or Enhancement	
Reach No.			Minimal	Moderate	Major									
DW-A	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining the flow to the channel and culverts.		X			Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction	In the upper & lower segments, channel construction could lower the visual quality		In the middle portion of the reach, channel construction could enhance visual quality	Construction of channels could reduce the impact of the existing wetlands on water quality	The reduction of the channel erosion would increase water quality in the middle portion of the reach.	Channel improvements are seen to be concentrated in the middle portion of the reach where the stream is unstable
DW-B		Property flood hazards & one residential structure will be reduced by confining flow to the channel and culverts.			X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels		Increased O & M costs due to channel construction	Channel construction could lower the high visual quality of the creek			Construction of channels could reduce the impact of the existing wetlands on water quality		100-year channel would negatively impact the existing wetlands, open space and aesthetics of the reach. 10-year channel would reduce negative impacts.
UFDW-A	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining the flow to the channel and culverts.			X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels	Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction	Channel construction could lower the high visual quality of the creek			Construction of channels could reduce the impact of the existing wetlands on water quality		The problems with this reach are associated with roadway culverts not the main channel. Full channelization would not address this problem.
SFDW-A	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining flow to the channel and culverts.			X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels	Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction	Channel construction could lower the high visual quality of the creek			Construction of channels could reduce the impact of the existing wetlands on water quality		Channelization of the main stream will not address the main problem of undersized roadway culverts
MFDW-A	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining the flow to the channel and road culverts.			X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels	Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction	Channel construction could lower the high visual quality of the creek			Construction of channels could reduce the impact of the existing wetlands on water quality		Channelization of the main stream will not address the main problem of undersized roadway culverts. Most of the reach is privately owned.
NFDW-A	No structures in 100-year floodplain.	Property flood hazards will be reduced by confining flow to channels and culverts.			X									
NFDW-B	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Limited flood hazards within golf course.		X		Toe vegetation & overbank vegetation can be used to provide habitat areas along channels	Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction	Channel construction could lower the high visual quality & limit the aesthetics of the golf course in this reach			Construction of channels could reduce the impact of the existing wetlands on water quality		Most of the reach is privately owned. Channelization already exists through most of the golf course.
LFDW-A	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining flow to the channel and road culverts.		X		Toe vegetation & overbank vegetation can be used to provide stabilization & habitat areas along and near the channel	Spillway maintenance would be reduced with the construction of a channel				Construction of a spillway channel would enhance the reach		The reduction of the channel erosion would increase water quality	Headcutting (erosion) of the channel spillway should be stopped, this would increase aesthetics, water quality and flooding hazards
LFDW-B	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining flows to the channel and culverts.		X			Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction	Channel construction could lower the high visual quality of the creek			Construction of channels could reduce the impact of the existing wetlands on water quality		Channel construction does not address the problem of water quality and culvert undersizing in this reach
CC-A	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining flow to the channel and culverts.			X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels		As this reach develops O & M costs will increase	Channel construction could lower the visual quality of the creek			Construction of channels could reduce the quality of water in the reach		As development of the existing farmland proceeds, channelization becomes more feasible
CC-B	Structures are currently outside 100-yr floodplain; No structural flood hazard exists				X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels		As this reach develops O & M costs will increase	Channel construction could lower the high visual quality of the creek	A portion of the reach is already channelized. The remaining portion deeply incised.			Relatively no impact on quality	Existing lined channel and the depth of the existing channel lends itself to channelization.
CC-C	Structures are currently outside 100-yr floodplain; No structural flood hazard exists	Property flood hazards will be reduced by confining the flood flow to the channel			X	Toe vegetation & overbank vegetation can be used to provide habitat areas along channels	Proper sizing of culverts for new channels will reduce O & M	Increased O & M costs due to channel construction				Construction of channels could reduce the impact of the existing wetlands on water quality		Channelization does not address the problems of this reach.

TABLE 7

Calculated Acreage for Resources Along Dirty Woman and Crystal Creeks

REACH	MRW (acres)	IRW (acres)	RS (acres)	RG (acres)	HW (acres)	TOTAL (acres)
DW-A	6.91		5.47		1.03	13.41
DW-B	1.03		6.10		12.78	19.91
UFDW-A			3.05		11.97	15.02
SFDW-A					7.90	7.90
MFDW-A			0.15		6.02	6.17
NFDW-A			2.94			2.94
LFDW-A			0.44		3.75	4.19
LFDW-B			0.15		1.95	2.10
CC-A		0.37			4.66	5.03
CC-B	0.29		1.76		1.91	3.96
CC-C			0.59		2.17	2.76
TOTAL	8.23	0.37	20.65	0.00	54.14	83.39

LEGEND

MRW	Mature Riparian Woodland Riparian - hydrologically associated with a waterway
IRW	Immature Riparian Woodland Immature trees - typically less than 5 years old
RS	Riparian Shrubland Shrubland - very little or no tree overstory
RG	Riparian Grassland Mostly grasses, some forbs
HW	Herbaceous Wetland Mostly forbs (sedges, spike rushes, etc.), some grasses

historic (physiographic) floodplains which may contain wetland or riparian habitat, or degradation of water quality to downstream areas resulting from flow concentrations within unlined areas. Selective improvements could create disturbances similar to channelization, however because the improvements can be selectively sited, avoidance of disturbances is easier to achieve.

A comparison of potential habitat disturbances for each of the concepts was conducted. With the exception of the channelization concept(s), the alternatives would cause minimal disturbances to the habitat if implemented. The disturbance of habitat areas would be mitigated by replanting native species after construction. It is not anticipated that implementation of any of the alternates would result in a loss of habitat value. Most disturbance would be temporary in nature, mostly occurring at the time of construction. The floodplain preservation concept has the potential for causing the least amount of habitat disturbance, however losses which could occur include the loss of toe and bank vegetation over time from natural erosion of the invert and unlined banks. There are currently several locations along the major drainageways where this is the situation.

The least total areal disturbance results from the floodplain preservation or selective improvement concept. Loss of habitat would occur naturally, mainly along the toe and at low channel benches due to the long-term degradation of the invert, and localized bank erosion. Water quality for the downstream reaches would not necessarily be improved by a floodplain preservation concept alone because of the potential for sediment deposition due to natural erosion processes. For the floodplain preservation concept it was considered that after a bank or invert failure, a portion of the native vegetation might eventually replace itself over a period of years.

Implementation of a selective improvement plan could result in an increase in habitat value as compared to the floodplain preservation concept. This is because selective improvements, if constructed prior to the onset of active natural bank and invert erosion, would prevent the loss of native habitat along the existing low flow banks and in floodplain areas. Compared to a channelization concept, disturbances due to construction could be better controlled and minimized with a selective improvement concept.

Development of the Recommended Plan

Presented on Table 8 is a matrix representing the recommended plan for each major drainageway reach. The selection of a recommended channel treatment scheme has been based upon the qualitative and quantitative information presented in the *Development of Alternatives* report. Presented on Table 9 is a cost estimate for the

recommended plan. The selected culvert improvements are presented in Section VIII. Shown on Figure 9 are the locations of the various recommended channel treatments. Contained within the Technical Addendum to the *Development of Alternatives* report, is the alternative hydrologic, hydraulic and cost data used in the development and comparison of each of the alternatives.

Discussion of Recommended Plan

The recommendation of a particular method of treatment for each channel segment has been based upon the qualitative and quantitative data presented. For each segment the flood hazard, habitat impacts, operations and maintenance, visual impact, water quality, and cost aspects have been weighed for each alternative concept. The channel segment designations (e.g., DW-A-01, etc.), are coded with the drainageway name (DW or CC for Dirty Woman and Crystal creeks, respectively), the reach, and the channel segment number as shown on the Hydrology Map, Exhibit 1. Section VII Preliminary Design provides a discussion on the implementation of the final plan.

DW-A-01 through DW-A-03: For these segments selective improvements are recommended. Improvements to these segments include a 10'x10' triple concrete box culvert under Mitchell Avenue and an 10'x11' twin concrete box culvert under the Old Denver Highway to carry the 100-year flow. Inlet and outlet improvements are included for the culverts. Inlet improvements in the form of bank slope protection is proposed for the Denver & Rio Grande Western Railroad bridge. The segments also include the installation of five drop structures and four check structures.

DW-A-04: For this segment the floodplain preservation or do-nothing alternative is recommended.

DW-A-05 through DW-A-06: For these segments selective improvements are recommended. Improvements to these segments include 1,620 feet of bank slope protection along with four drop structures and nine check structures. Outlet stabilization at the Highway 105 bridge is also proposed.

DW-B-07 through DW-B-11: For these segments selective improvements are recommended. The improvements proposed for these segments include a 10'x5' twin concrete box culvert at South Park Drive to carry the 10-year flow. In order to carry the 10-year flows. A 10'x4' twin concrete box culvert at Lake Woodmoor Drive and a 12'X4' triple at Augusta Drive has been proposed. Outlet stabilization has been proposed for the South Park and Augusta Drive crossings. Outlet protection along with an 8'X6' twin concrete box culvert with a drop inlet with an overflow grate has been proposed for the Knollwood Drive crossing. Approximately 570 feet of bank slope protection is recommended along with three drop structures and eight check structures. In segment

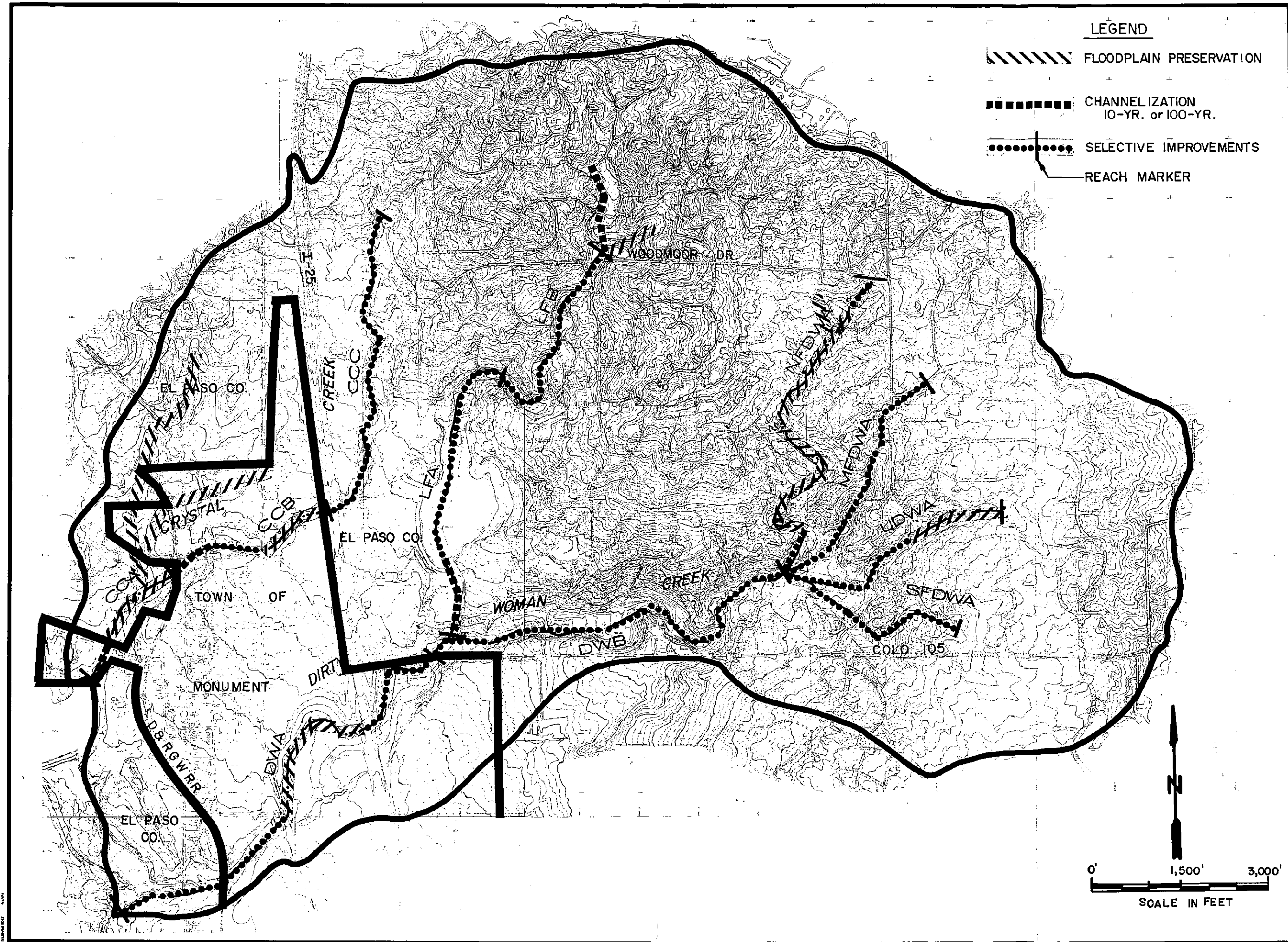
TABLE 8: Matrix of Recommended Plan

Reach (1)	Channel Alternative		
	Floodplain Preservation	Channelization 10 or 100-year	Selective Improvements
DW-A-01			*
DW-A-02			*
DW-A-03			*
DW-A-04	*		
DW-A-05			*
DW-A-06			*
DW-B-07			*
DW-B-08			*
DW-B-09			*
DW-B-10			*
DW-B-11			*
UFDW-A-12			*
UFDW-A-13	*		
SFDW-A-14			*
SFDW-A-15			*
SFDW-A-16			*
MFDW-A-17			*
MFDW-A-18			*
MFDW-A-19			*
MFDW-A-20			*
NFDW-A-21			*
NFDW-B-22	*		
NFDW-B-23			*
NFDW-U-46	*		
LFDW-A-24			*
LFDW-A-25			*
LFDW-B-26			*
LFDW-B-27			*
LFDW-B-28			*
LFDW-B-29			*
LFDW-U-44		*	
LFDW-U-45	*		
CC-A-31		*	
CC-A-32	*		
CC-B-33		*	
CC-B-34		*	
CC-B-35		*	
CC-B-36			*
CC-B-37	*		
CC-C-38			*
CC-C-39			*
CC-C-40			*
CC-U-41	*		
CC-U-42	*		
CC-U-43	*		

(1) Creek - Reach - channel segment # (See Exhibit 1)

TABLE 9
Recommended Plan Cost Summary

Reach	Recommended Channel Alternative	Channels Cost (1) (\$ Thous)	Mitigation Disturbance (ac)	Cost (2)	Comments
DW-A	Selective Floodplain Preservation	766.0	2.40	\$9,582	(1) Land acquisition, utility relocation, engineering and contingency costs not included in totals.
DW-B	Selective	557.8	2.05	\$8,182	
UFDW-A	Selective Floodplain Preservation	165.3	0.52	\$2,084	(2) Mitigation costs determined using unit cost of \$4000 per acre.
SFDW-A	Selective	126.6	0.18	\$707	
MFDW-A	Selective	194.1	0.87	\$3,499	
NFDW-A	Selective	98.1	0.23	\$909	
NFDW-B	Selective Floodplain Preservation	100.3	0.21	\$826	
LFDW-A	Selective	243.4	0.18	\$735	
LFDW-B	Selective	485.9	0.49	\$1,974	
Total Dirty Woman Creek		2737.5	7.12	\$28,498	
CC-A	Selective Floodplain Preservation	103.5	0.92	\$3,669	
CC-B	100yr Channel Selective Floodplain Preservation	246.9	0.54	\$2,163	
CC-C	Selective	154.0	0.22	\$895	
Total Crystal Creek		504.4	1.68	\$6,726	



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80905-1308

**DIRTY WOMAN CREEK & CRYSTAL CREEK
DRAINAGE BASIN PLANNING STUDY
IMPROVEMENT PLAN**

Project No. 91-07-17
Date: 3/92
Design: AWMc
Drawn: EAK
Check:
Revisions:

FIG. 9

DW-B-11 fill will be used to stabilize the creek and confine the flood flow through this area to prevent flooding. Three lots are proposed for acquisition to provide floodplain preservation on both sides of Lake Woodmoor Drive. In segment DW-B-07, spillway protection is recommended for the existing dam. The protection consists of buried riprap.

UFDW-A-12: For this segment selective improvements are recommended. Improvements for this segment include an additional two 36" RCP's at Furrow Road in addition to the three 48" RCP's already existing. Approximately 400 feet of bank slope protection along with six check structures are recommended.

UFDW-A-13: For this segment the floodplain preservation or do-nothing alternative is recommended.

SFDW-A-14 through SFDW-A-16: For these segments selective improvements are recommended. Improvements to these segments include three 36" RCP's with outlet protection at Furrow Road and a 36" CSP with outlet protection at Martingale Road. The Furrow Road culverts are designed to pass the 100-year storm and the Martingale Road culvert is designed to carry the 10-year storm. Three 42" CSP's are recommended under Winding Meadows Road. These culverts are designed to pass the 10-year flow. Outlet protection is also needed at this culvert. Special attention needs to be paid to this culvert due to the close proximity of a small dam embankment just upstream of the roadway. Other provisions may be necessary to provide adequate flow capacity. Three check structures are required for these reaches. These are located downstream of the outlet protection required for the culvert crossings.

MFDW-A-17 through MFDW-A-20: For these segments selective improvements are recommended. The recommended improvements for these segments include two 60" CSP's along with outlet protection at Will O The Wisp Way, a 54" CMP with outlet protection at Lost Creek Way, three 42" RCP's with outlet protection and a headwall at Furrow Road, and a 54" CMP with outlet protection and road alterations at Ajo Way. The CMP's at Will O The Wisp Way, Lost Creek Way and Ajo Way are designed to carry the 10-year flow and the reinforced concrete pipes at Furrow Road is designed to carry the 100-year storm runoff. Other improvements include 1,030 feet of bank slope protection and four check structures all associated with the outlet protection of the culverts.

NFDW-A-21: For this segment selective improvements are recommended. Improvements include a 8'x4' concrete box culvert under Augusta Drive to pass the 10-year storm along with outlet protection. Other improvements include one drop structure and two check structures.

NFDW-B-22: For this segment floodplain preservation is recommended. Bank slope protection is recommended for stabilization of the channel just downstream of the golf course pond embankment near station 27+00. Floodplain preservation is recommended for the remaining portions of the drainageway.

NFDW-B-23: For this segment selective improvements are recommended. Improvements include 210 feet of 53"x34" elliptical reinforced concrete pipe at Tam-O-Shanter Way with outlet protection. A 36" RCP is proposed at the Woodmoor Drive crossing along with outlet protection. The Tam-O-Shanter culvert is designed to convey the 100-year runoff and the Woodmoor Drive culvert is designed to pass the 10-year storm. Floodplain preservation is recommended for the remaining portions of the drainageway.

LFDW-A-24: For this segment, stabilization of the reservoir spillway channel is recommended. This constitutes four drop structures and one check structure. An outlet structure with curved concrete drop structure is recommended to dissipate energy at the bottom of the steep embankment where the spillway enters Dirty Woman Creek.

LFDW-A-25: For this segment selective improvements are recommended. Improvements to this segment includes a 16'x8' concrete box culvert attached to a concrete spillway just below the Lake Wood Moor Dam at Lake Woodmoor Drive. The CBC is designed to convey the 100-year flow of 480 cfs. Some modifications to Lake Woodmoor Drive are necessary to properly install the culvert. Three 60" CMP's with outlet protection is recommended at the Autumn Way crossing. Three check structures are recommended throughout the reach.

LFDW-B-26 through LFDW-B-29: For these segments selective improvements are recommended. Improvements to these segments include 12'x5' twin concrete box culvert at the southern crossing of Deer Creek Road. Four 60" CMP's are recommended for the middle crossing of Deer Creek Road. The northern crossing of Deer Creek Road will require three 72" RCP's. Two 60" and one 72" RCP's are recommended for the crossing of Woodmoor Drive. All four crossings will have outlet protection provided with the culverts. The Deer Creek Road culverts are to provide capacity for the 100-year flood event. The culvert at Woodmoor Drive is designed for the 10-year storm. Headwall are recommended for the two northern crossings of Deer Creek Road and at Woodmoor Drive. Other improvements include 410 feet of low flow channel protection, 260 feet of bank slope protection, five drop structures, and five check structures. In conjunction with the low-flow channel, 130 feet of berm should be constructed on the west side just north of Deer Creek Road. This is to protect the adjacent properties from flooding.

CC-A-31: For this segment 10-year channelization is recommended. The improvements include 450 feet of 10-year low-flow channel with two check structures. Two additional 72" CMP's are recommended to be added to the two existing CMP's under North Monument Lake Road in order to pass the 100-year storm. Outlet protection is recommended for these culverts.

CC-A-32: For this segment floodplain preservation is recommended.

CC-B-33 through CC-B-35: For these segments channelization is recommended. Improvements to these segments include approximately 540 feet of channelization and approximately 230 feet of existing channel repair and stabilization.

CC-B-36: For this segment selective improvements are recommended. Improvements to this segment include two 66" CMP's under the embankment at Beacon Lite Road with outlet protection. Floodplain preservation is recommended for the remaining portions of the drainageway.

CC-B-37: For this segment floodplain preservation is recommended.

CC-C-38 through CC-C-40: For these segments selective improvements are recommended. Improvements to these segments include extending a 10'x5' concrete box culvert from the existing 10'x14' concrete box culvert at the Interstate under the Frontage Road in order to pass the 100-year storm and eliminate the current flow split. One 72" and two 48" CMP's with outlet protection are recommended at Willow Park Way to carry the 10-year storm. An additional 84" CMP at Deer Creek Road with outlet protection is recommended in addition to the existing 60" CMP. This will provide capacity to carry the 100-year storm. Three 48" CMP's are recommended near Emigrant Trail East along with outlet protection to carry the 100-year storm and help reduce the surface flooding around the existing structures. The existing drive will need to be raised in order to accommodate the new culverts.

CCSF: This segment, which is the current flow split, will be eliminated with the construction of the 10'x5' CBC under the Frontage Road at Crystal Creek.

VII. PRELIMINARY DESIGN

The results of the preliminary design analysis are summarized in this section. The alternative improvements have been quantitatively and qualitatively evaluated, and presented to El Paso County and other interested agencies and individuals. Field review of specific areas of concern have been conducted in order to refine the treatments suggested for use along Dirty Woman and Crystal Creeks and its major tributaries. The preliminary plan for the recommended alternative is shown on the drawings contained at the rear of this report. The preliminary design plan reflects the refinement of the recommended plan brought forth in the *Development of Alternatives Report*. The Preliminary Design Plan presented in this section is the plan which is recommended for implementation in both the Dirty Woman Creek and Crystal Creek drainage basins. As with all preliminary designs, further refinement and the need for additional improvements may be needed or identified during the final design stage prior to actual construction. This Preliminary Design Plan is intended for use as a guide in the overall stormwater management plan for the two drainage basins.

Criteria

The *City of Colorado Springs / El Paso County Drainage Criteria Manual* was used in the development of the typical sections and plans for the drainageways within the basins. The *City/County Criteria Manual* was supplemented by various criteria manuals with more specific application. These were:

1. *Storm Drainage Criteria Manual, Town of Monument, Colorado*, prepared by Gelvin Engineering, 1986.
2. *Urban Storm Drainage Criteria Manual, Volumes I, II, and III*, prepared by the Urban Drainage and Flood Control District.

Hydrology

Presented on Table 10 is selected hydrologic data to be used for the sizing of major drainageway improvements within the basins. Peak flow rates for the 10-year and 100-year storm frequency future condition are summarized for key points along the major drainageways. Contained within the Technical Addendum of the *Development of Alternatives* report is a complete listing of peak discharges for all the sub-basins and design points shown on Exhibit 1.

TABLE 10
SUMMARY OF SELECTED PEAK DISCHARGES
Dirty Woman and Crystal Creeks Drainage Basin Planning Study
SELECTED ALTERNATIVE
2-HOUR, AMC III

Design Point	Location	Area s.m.	100-YEAR (CFS)	10-YEAR (CFS)
DIRTY WOMAN CREEK				
45	Woodmoor Country Club	0.36	355	135
57	Woodmoor Country Club	0.50	500	185
59	@ Confluence w/ North Fork	2.03	1,880	665
61	Augusta Drive	2.10	1,950	690
63	Lake Woodmoor Drive	2.23	2,080	735
65	South Park Drive	2.28	2,130	755
71	Between Knollwood & South Park	2.40	2,200	790
75	Knollwood Drive	2.57	2,340	840
113	@ Confluence w/ Lake Fork	3.96	2,520	900
115	State Highway 105	4.00	2,540	910
119	@ Confluence w/ Split Flow	4.17	2,690	965
123	I-25 Inlet	4.36	2,870	1,030
125	I-25 Outlet	4.40	2,910	1,050
131	Santa Fe Trail	4.64	3,060	1,100
135	Railroad	4.85	3,210	1,150
139	@ Confluence w/ Monument Ck	4.93	3,260	1,170
CRYSTAL CREEK				
153	Emmigrant Trail East	0.46	415	140
157	Frontage Road	0.58	525	185
159	I-25	0.59	535	190
161	Beacon Lite Road	0.66	595	210
163	Railroad	0.74	645	230
183	@ Confluence w/ N. Side Trib	1.34	1,225	430
185	North Monument Lake Road	1.43	1,290	450
189	@ Monument Lake Spillway	1.55	1,410	490

Note: See Table 2 for a complete listing of Design Point Discharges

The sizing of the drainageway improvements will need to be verified during the final design and layout of the proposed facilities. Land development activities may alter the location of design points, and therefore slight alterations in a sub-basin's length, slope and area may occur. The methods outlined in the *City/County Drainage Criteria Manual* should be adhered to during final design analysis. The rational method should be used to check the peak flow rates for all drainageways and drainage structures draining areas less than 100 acres in size.

Channels

The recommended drainageway improvements for each reach of Dirty Woman and Crystal Creeks have been outlined in Section VI of this report and are shown in the drawings contained in this report. In general, the Dirty Woman Creek and Crystal Creek channels will be lined with selectively located riprap bank protection such as at outside bends, bridge or culvert outlets, at confluences with side drainages and at dam spillways as shown on the Preliminary Drawings. In conjunction with the selective improvement measures, the 100-year floodplain should be preserved and regulated. Wherever the existing drainageways were judged to be adequate and relatively stable, no improvements have been recommended.

Drop Structures and Check Structures

Drop and check structures have been sited along Dirty Woman and Crystal Creeks in order to slow the channel velocity to the recommended 7 feet per second, and to prevent localized and long-term stream degradation from affecting the drainageway. In localized situations it may be necessary to limit velocities to less than 7 fps. Additional drop structures and checks may be used in these locations to provide adequate protection. In the reaches to be selectively lined, drops and check structures will protect the native vegetation from the detrimental effects of stream invert headcutting. Different types of structures may be considered for these drainageways, however the performance of these structures should be adequate to maintain the intent of this plan. For most channels reinforced concrete drops and checks are recommended. A maximum drop height of four feet is recommended. The methodology recommended for use when designing vertical structures is contained within the *City of Colorado Springs and El Paso County Drainage Criteria Manual* and *Volume II of the Urban Storm Drainage Criteria Manual*.

Detention

This plan does not recommend detention as a basin-wide flood control measure. The difference between the future and existing flow rates is minimal and the downstream structures don't warrant reducing the peak flow. However, on site detention may be used, as approved by the County or Town, to reduce the local storm sewer costs along with providing water quality benefits to the site and the basin. The Town of Monument currently has an on site detention policy in effect. All developed flows within the Town of Monument must be reduced to the existing flow rate. The overall impacts of on-site detention on the major drainages should be evaluated throughout the Town.

Water Quality

Improvement of stormwater quality has become an important issue in drainage basin planning. Many pollutants are naturally associated with sediments that enter sensitive receiving waters. The pollutants are naturally occurring compounds that are carried to the drainageways in storm runoff. Other pollutants are the result of urbanization such as lawn chemicals, oil and grease, pet feces, lawn clippings and other items. Many pollutants can be limited by programs such as erosion control at construction sites, educational programs to inform the public as to the proper use of lawn chemicals, oil recycling programs and street sweeping programs. Even with these programs in place, erosion along the drainageways can generate large quantities of sediment that can settle out along the downstream channel bottoms.

Various methods of water quality enhancement have been identified for use in this preliminary design. Channels are lined to prevent erosion, selective improvements are placed to prevent erosion, and drop/check structures are used to control channel grade. On site detention facilities should be designed not only to reduce flows to historic rates but probably more importantly to improve the stormwater quality. General criteria for designing and sizing a water quality pond can be found in the Urban Drainage and Flood Control District's December 1989 *Flood Hazard News*. The article outlining criteria is called "Sizing a Capture Volume for Stormwater Quality Enhancement," by Urbonas, Guo and Tucker.

Trails

In areas where routine maintenance of the drainageways is necessary, a trail for that purpose should be provided. These maintenance trails, while few in number in this basin, should be evaluated for potential multi-purpose use. The multi-use trails could include hiking, biking

and horse back riding trails. The size and location of trail, if necessary, will be mostly dependent upon the type of development adjacent to that particular drainageway.

Maintenance and Revegetation

Maintenance of drainageway facilities is essential in preventing long term degradation of the creek and its environs. Along the drainageway, clearing of debris and dead vegetation should be considered within the low flow area of the creek and its tributaries. Trimming and thinning of shrubs and trees should be carried out if greater physical access to the creek is desired. On the overbanks and in most drainageways in Dirty Woman Creek and the upper portions of Crystal Creek, limited maintenance of the existing vegetative cover is recommended. Yearly clearing of trash and debris at roadway crossings is strongly recommended to ensure the culvert maintains its full design capacity, and to enhance the surroundings of the area. Sediment removed from all cleaning and maintenance operations should be disposed of properly, not left in an area such as on the stream overbank. This disturbs the native vegetation and creates a potential water quality concern if the dredgings are subsequently washed into the drainageway by natural erosion. In those reaches designated to be selectively lined and the floodplain preserved, maintenance activities should be carried out while minimizing the disturbances to native vegetation.

Right-of-Way

For the most part the main channels within the basin which pass through the developed portions of the basin are contained within previously dedicated drainage tracts, easements or right-of-ways. Where appropriate right-of-ways have not as yet been dedicated such as within the undeveloped portions of the basin, the required right-of-way can be obtained through the land development process. For those segments of the drainageway where floodplain preservation is the recommended plan, a combination of open space dedication (such as parklands and greenbelts), in combination with a more narrow dedicated right-of-way along the low flow area of the drainageway should be obtained through the land development process.

Roadway Bridge and Culvert Replacements

Bridge and culvert replacements shown on the preliminary design drawings have been sized in accordance with the *City/County Drainage Criteria Manual*. Bridges (major crossings) are defined as those structures conveying at least 1500 cubic feet per second, having a flow area

of at least 200 square feet or a span of 20 feet. There are two bridges within this study area, Mitchell Avenue over Dirty Woman Creek and Old Denver Highway over Dirty Woman Creek. Road crossings conveying flows less than 1500 cubic feet per second, smaller than 200 square feet in flow area and less than a 20 foot span have been included in the drainage basin fee evaluation and calculation. Structures over arterial roadways which have been defined as bridges have been included into the bridge fee evaluation and calculation.

Erosion and Sedimentation Control

Areas within the basin are subject to varying degrees of hazard resulting from sediment being transported to the drainageway(s). During the collection of field and drainage inventory data, areas were noted which were being impacted by either erosion (of one form or another), or sediment deposition. The areas impacted ranged from localized bank failures to roadway embankments and crossings. The soils of the basin are generally very erodible when exposed, and this is particularly the case in the upper portions of the drainage basins. The disturbance of the native vegetation and failure to properly revegetate areas has in some cases negatively affected downstream portions of the basin.

In general, it is the responsibility of the entity conducting any land disturbance activity to properly control surface runoff, erosion and sedimentation during and after the activity. Technical criteria identifying measures which help mitigate the impacts of erosion and sedimentation is available and is being used throughout the Front Range area. Minimum requirements must be developed to properly control erosion.

Erosion control is necessary to prevent environmental degradation caused by wind or water-borne soil. The following minimum criteria and standards are intended to prevent excessive erosion. El Paso County as well as other effected agencies reserve the right to enforce the Clean Water Act standards if the planned erosion control measures fail to perform satisfactorily. Evidence of visual erosion will determine the effectiveness (or lack thereof) of erosion control measures. Proper installation and maintenance is necessary to achieve the desired function of erosion control measures. By paying attention to quality and workmanship, reinstallation of the erosion control measures can be avoided. The general requirements for erosion control are as follows:

1. Any land disturbing activity shall be conducted so as to effectively reduce unacceptable erosion and resulting sedimentation.
2. All land disturbing activities shall be designed, constructed, and completed in such a manner that the exposure time of disturbed land shall be limited to the shortest possible period of time.

3. Sediment caused by accelerated soil erosion and runoff shall be intercepted by sediment traps and contained on the site.
4. Any facility designed and constructed to convey storm runoff shall be designed to be non-erosive.
5. Erosion control measures will be used prior to and during construction. Temporary erosion control measures are required during construction, and permanent erosion control measures are required for all developments. Maintenance of erosion control measures is the responsibility of the property owner.

Various structures have been proposed in this plan to control localized erosion and sedimentation problems. **It is important that the required and approved erosion control plan for any land disturbing activity be strictly adhered to, and maintained so that the above minimum criteria can be achieved in the Dirty Woman Creek and Crystal Creek Basins.**

VIII. PLAN IMPLEMENTATION

General

Many of the drainageway sections shown on the plans have to be modified to fit specific site conditions. This will be particularly true in the segments where selective channel treatments are proposed. Drop and check locations are approximate and may be moved to minimize disturbances to existing vegetation, roads, trails, and utilities as well as for optimum performance. Existing right-of-ways will play a key role in the location of future drainageways.

The acquisition of property for the floodplain preservation between South Park Drive and Augusta Drive along Dirty Woman Creek could proceed at any time. It is recommended that funds generated within the basin drainage fee system be used to acquire these three lots. County capital improvement funds could be used with basin fee funds to advance the acquisition of these parcels. If the County agrees to acquire the lots, the owners of the parcels could be in line to receive payment for the lots from the basin drainage fund as the funds become available. The County then would not have to "advance" this money and recoup it later.

Improvements along Dirty Woman Creek within and adjacent to Dirty Woman Park area should be completed with two goals in mind: (1) to provide a more stable drainageway, (2) to maintain and enhance the visual setting of the creek, and (3) preserve or enhance the natural setting of the creek. Construction of drops or checks could be combined with trail crossings of the creek.

In areas where the existing drainage facilities are inadequate, capital improvement projects will be necessary. This is true within both Dirty Woman Creek and Crystal Creek. The bridges are presently inadequate because of hydraulic and/or roadway design deficiencies. These structures will have to be funded through capital improvement or bridge replacement funds.

Cost Estimate

Presented on Table 11 are the unit costs used to estimate for the total construction costs for drainageway and roadway crossing improvements shown on the preliminary design plans. The cost estimates for the drainageways, roadway culverts, miscellaneous improvements and bridges are presented on Tables 12, 13 and 14. The estimates represent total improvement costs for the Dirty Woman and Crystal Creek basins for areas which drain greater than 100 acres. No estimate for local or minor systems has been made, and therefore no costs attributable to local or minor drainage systems have been computed in the estimation of the drainage basin fee. These 'minor system' costs are the responsibility of the owner and/or developer. "Minor systems" are

TABLE 11
Unit Construction Costs

Dirty Woman Creek DBPS - year 1993

Item	Unit	Unit Cost	Comments
CHANNEL AND HYDRAULIC STRUCTURES			
Channel earthwork	CY	\$8	
Filter material	Ton	\$25	
Structural concrete	CY	\$250	
Seeding and mulching	SF	\$0.15	
Riprap Type H	CY	\$30	
Riprap Type M	CY	\$24	
12 foot wide gravel trail	LF	\$15	Maintenance trail
Erosion netting	SY	\$1.75	
Topsoil	CY	\$12	
CULVERTS RCP/CMP			
18-inch	LF	\$20	
24-inch	LF	\$25	
30-inch	LF	\$42	
36-inch	LF	\$58	
42-inch	LF	\$75	
48-inch	LF	\$80	
54-inch	LF	\$100	
53"X 34" Ell	LF	\$110	
60-inch	LF	\$120	
66-inch	LF	\$170	
72-inch	LF	\$200	
84-inch	LF	\$350	
ROADWAY CROSSINGS			
Structural Concrete, in-place	CY	\$300	
Wingwalls/headwalls	EA	\$5,000	
Inlet Structure & Flow Control	EA	\$20,000	
8' x8' CBC	LF	\$350	
4'x16' CBC	LF	\$950	
5'x7' CBC	LF	\$500	
Twin 4' high CBC, 4'-8' wide	LF	\$480-570	
Twin 6'x 10' CBC	LF	\$1125	
Twin 6' high CBC, 8'-15' wide	LF	\$600-1200	
Twin 8'x 10' CBC	LF	\$750	
Twin 5'x12' CBC	LF	\$1190	
Twin 11'x10' CBC	LF	\$1250	
Triple 5'x 8' CBC	LF	\$900	
Triple 4'x 12' CBC	LF	\$1110	
Triple 6'x 14' CBC	LF	\$1410	
Triple 6'x 16' CBC	LF	\$1770	
Triple 8'x 10' CBC	LF	\$1110	
Triple 10'x 10' CBC	LF	\$1260	
MITIGATION (Wetland/Riparian)	AC	\$4,000	
LAND ACQUISITION			
Floodplain Preservation	AC	\$14,700	Based on park land fee.

TABLE 12: DIRTY WOMAN & CRYSTAL CREEKS DRAINAGE BASIN PLANNING STUDY
COST ESTIMATE -- SELECTIVE DRAINAGEWAY IMPROVEMENTS
SELECTED ALTERNATIVE

REACH NUMBER	REACH LENGTH (FT)	NUMBER CHECK STRUCTURES	CHECK LENGTH (FT)	NUMBER DROP STRUCTURES	DROP LENGTH (FT)	LENGTH BANK SLOPE PROTECT (FT)	LENGTH OF 100 YR CHANNEL (FT)	LENGTH OF 10 YR CHANNEL (FT)	LENGTH OF CHNL STAB. & REPAIR (FT)	LENGTH OF OUTLET PROTECT (FT)	LENGTH OF SPILLWAY PROTECT (FT)	LENGTH OF BERM PROTECT (FT)	MITIGATION (AC)	LAND ACQUISITION (AC)	TOTAL COST
DW-A-01	1,095	3	245	1	85	300	130			95			0.70		\$144,182
DW-A-02	625			1	60	300		125					0.38		\$45,672
DW-A-03	1,335	1	60	3	290	1530				80					\$158,690
DW-A-04	120														\$0
DW-A-05	2,870	3	220	3	290	1020				100			0.61		\$190,316
DW-A-06	1,820	6	785	1	65	700							0.71		\$236,752
DW-B-07	2,150	2	185	1	120	370				90	100		0.94		\$129,645
DW-B-08	3,455	5	610	1	120			100		50			0.46		\$211,935
DW-B-09	520			1	120	200				50			0.22	0.742	\$62,391
DW-B-10	585	1	120	1	160					110			0.25	1.265	\$114,250
DW-B-11	490			1	80						50	240	0.16		\$48,512
UFDW-A-12	2,800	6	480	1	40	400				50			0.52		\$148,924
UFDW-A-13	2,335	1	75												\$18,600
SFDW-A-14	1,010	1	95							60			0.11		\$29,290
SFDW-A-15	1,540	1	160							90			0.06		\$47,857
SFDW-A-16	1,905	1	40	3	100					65					\$50,140
MFDW-A-17	1,375	1	100			400				60			0.30		\$40,874
MFDW-A-18	1,855	1	100	1	90	200				60			0.11		\$66,389
MFDW-A-19	375	1	120	1	40	170				70			0.23		\$54,721
MFDW-A-20	1,105	2	80	3	130	520				50			0.23		\$82,488
NFDW-A-21	560	2	190	1	130					70			0.23		\$99,039
NFDW-B-22	5,275	2	140	1	50	200				70	80		0.14		\$80,921
NFDW-B-23	850	2	95	2	80					40			0.07		\$54,955
NFDW-U-46	1,060														\$0
LFDW-A-24	1,265	3	160	6	280					70					\$142,440
LFDW-A-25	1,170	4	490							60	100		0.18		\$149,335
LFDW-B-26	1,035	2	220	1	80					60			0.24		\$88,404
LFDW-B-27	845	1	200	1	110					80	50		0.18		\$106,225
LFDW-B-28	1,460	2	240	1	150					90			0.07		\$119,465
LFDW-B-29	505			3	140			410		90		150			\$115,370
LFDW-B-30	200			1	100										\$34,500
LFDW-U-44	1,560							1250							\$162,500
LFDW-U-45	1,450														\$0
TOTAL DIRTY WOMAN CREEK															\$3,034,789
CC-A-31	565	2	160					450		60			0.92		\$107,129
CC-A-32	1,880														\$0
CC-B-33	290						290								\$79,750
CC-B-34	250						250								\$68,730
CC-B-35	235								230				0.40		\$59,084
CC-B-36	780	1	140							70			0.14		\$41,459
CC-B-37	1,045														\$0
CC-C-38	45														\$0
CC-C-39	2,445	4	330	1	80					90	75		0.22		\$134,605
CC-C-40	550	1	80							60					\$25,120
CC-U-41	4,050	3	300												\$74,400
CC-U-42	3,325														\$0
CC-U-43	3,375	3	300												\$74,400
TOTAL CRYSTAL CREEK															\$664,696

TABLE 13: Recommended Culvert Improvements
Dirty Woman/Crystal Creek Drainage Basin Planning Study

Roadway Location	Reach Number	Creek/ Station	Existing Culvert	Q100 O10	Description	Quantit	Unit	Unit Cost	Amount
Mitchell Avenue	DW-A-01	Dirty Woman 11+30	72" CMP	3,258 1,170	Triple 10'x10' CBC	80	If	\$1,323	\$105,800
Old Denver Highway 1-25	DW-A-03	Dirty Woman 32+30	64" CMP	3,055 1,098	Twin 10'x11' CBC	95	If	\$1,303	\$123,750
Knollwood Drive	DW-A-05	Dirty Woman 65+40	8'x8' CBC	2,868 1,031	Additional 10'x8' CBC	375	If	\$363	\$136,250
South Park Drive	DW-B-07	Dirty Woman 107+70	36" CMP	2,337 838	Twin 12'x8' CBC w/ Drop Itt & Ovrfl	60	If	\$1,433	\$86,000
Lake Woodmod Drive	DW-B-08	Dirty Woman 142+80	24" CMP	2,126 756	Twin 10'x6' CBC	50	If	\$1,225	\$61,250
Augusta Drive	DW-B-09	Dirty Woman 148+60	(2) 24" CMP	2,075 735	Twin 10'x6' CBC	95	If	\$1,441	\$136,875
Furrow Road	DW-B-11	Dirty Woman 155+00	(2) 24" CMP	2,075 735	Triple 12'x4' CBC	60	If	\$1,193	\$71,600
Augusta Drive	UFDW-A-12	Upper Dirty Woman 188+30	(3) 48" RCP	514 172	2-36" RCP (Additional)	60	If	\$116	\$6,960
Tam-O-Shanter Way	NFDW-A-21	North Fork Dirty Wo 5+80	7" CMP	627 186	3-42" CMP	45	If	\$351	\$15,800
Woodmoor Drive	NFDW-A-23	North Fork Dirty Wo 60+50	? CMP	117 43	53"x34" Ell. RCP	210	If	\$110	\$23,100
Heatherdown	NFDW-A-23	North Fork Dirty Wo 69+70	Plugged	7 40	48" RCP	60	If	\$80	\$4,800
Tam-O-Shanter Way	NFDW-U-46	North Fork Dirty Wo 60+50	24" CMP	87 33	3-24" CMP	60	If	\$75	\$4,500
Will O The Wis Way	NFDW-U-46	North Fork Dirty Wo 69+70	18" CMP	87 33	3-24" CMP	60	If	\$75	\$4,500
Lost Creek Way	MFDW-A-17	Middle Fork Dirty W 14+00	18" CMP	349 129	2-60" CSP	80	If	\$303	\$24,200
Furrow Road	MFDW-A-18	Middle Fork Dirty W 33+00	24" CMP	235 84	54" CSP	80	If	\$100	\$8,000
Ato Way	MFDW-A-19	Middle Fork Dirty W 37+30	24" CMP	235 84	3-42" RCP	50	If	\$325	\$16,250
Winding Mead Way	MFDW-A-20	Middle Fork Dirty W 45+00	18" CMP	235 84	Twin 48" CMP	70	If	\$160	\$11,200
Furrow Road	SFDW-A-15	South Fork Dirty Wo 10+30	24" CMP	377 127	3-42" RCP w/ Oilt & Flow Cn	100	If	\$725	\$72,500
Martingale Road	SFDW-A-16	South Fork Dirty Wo 26+20	36" CMP	229 77	Twin 54" RCP	70	If	\$200	\$14,000
Lake Woodmod Drive	SFDW-A-16	South Fork Dirty Wo 42+00	18" CMP	90 31	36" CSP	60	If	\$58	\$3,480
Autumn Way	LFDW-A-24	Lake Fork Dirty Wom 12+50	---	480 0	16'x4' CBC	80	If	\$1,013	\$81,000
Deer Creek Road	LFDW-A-25	Lake Fork Dirty Wom 52+60	24" CMP	1,016 381	3-60" CSP	80	If	\$360	\$28,800
Deer Creek Road	LFDW-B-26	Lake Fork Dirty Wom 63+50	24" CMP	1,016 381	Twin 12'x5' CBC	80	If	\$1,190	\$95,200
Deer Creek Road	LFDW-B-27	Lake Fork Dirty Wom 72+50	24" CMP	1,016 381	4-60" CSP	60	If	\$563	\$33,800
Deer Creek Road	LFDW-B-28	Lake Fork Dirty Wom 87+60	18" CMP	883 334	3-72" RCP	50	If	\$700	\$35,000
Woodmoor Drive	LFDW-B-29	Lake Fork Dirty Wom 93+20	24" CMP	594 226	2-60" RCP 1-72" RCP	50	If	\$540	\$27,000
Broken Fence Way	LFDW-U-44	Upper Lake Fork Dirty Wom	24" CMP	195 75	4-30" RCP	50	If	\$168	\$8,400
Fawnwood Road	LFDW-U-44	Upper Lake Fork Dirty Wom	24" CMP	195 75	4-30" RCP	50	If	\$168	\$8,400

Dirty Woman Creek Total Culvert Costs \$1,248,415

Roadway Location	Reach Number	Creek/ Station	Existing Culvert	Q100 O10	Description	Quantit	Unit	Unit Cost	Amount
N. Monument Road	CC-A-31	Crystal Creek 3+90	(2) 72" CMP	1,288 450	2-72" CSP (Additional)	40	If	\$400	\$16,000
Beaconlite Road	CC-B-36	Crystal Creek 43+00	36" CMP	594 211	2-66" CSP	210	If	\$364	\$76,400
Frontace Road	CC-C-38	Crystal Creek 58+50	24" CMP	527 185	10'x5' CBC	120	If	\$1,042	\$125,000
Willow Park Way	CC-C-39	Crystal Creek 63+30		527 185	42" CSP 2-72" CSP	60	If	\$400	\$24,000
Deer Creek Road	CC-C-39	Crystal Creek 83+70	60" CMP	527 185	84" CSP (Additional)	70	If	\$350	\$24,500
Emmigrant Trail East Highway 105	CC-C-40	Crystal Creek 89+80	(2) 24" CMP	416 139	3-48" CSP	60	If	\$240	\$14,400
Santa Fe Trail	CC-U-41	Upper Crystal Creek	5'x7' CB	630 235	5'x7' CBC (Additional)	120	If	\$542	\$65,000
Beaconlite Road	CC-U-41	Upper Crystal Creek	24" Su	202 74	3-30" CSP	120	If	\$126	\$15,120
	CC-U-42	Upper Crystal Creek	48" CMP	317 135	Twin 7'x4' CBC	80	If	\$613	\$49,000

Crystal Creek Total Culvert Costs \$409,420

those improvements which are needed in areas which do not drain over 100 acres. Costs associated with utility relocation have not been estimated. It appears that the majority of the potential relocations will occur at the roadway crossings.

The costs for habitat mitigation have been included within the miscellaneous drainageway improvement costs. The cost of protection and/or replacement of habitat impacted by the construction of the facilities can be minimized by with strategic siting, construction sequencing and access.

Unplatted Acreage

Using El Paso County Tax Assessor maps, plats, and ownership records, the amount of unplatted acreage was estimated. From these records it was determined that a total of 224.4 acres is unplatted and lying within the Dirty Woman Creek basin, and 126.6 acres are unplatted and lying within the Crystal Creek basin. The unplatted acreages are subject to future development. Park areas have been excluded from the unplatted acreage total, as has acreage within the Town of Monument corporate limits. Property within the Monument corporate limits is currently not subject to the El Paso County drainage or bridge fees. Cost estimates and unplatted area estimates have been included in this study, in case the Town of Monument decides to implement a similar Drainage Basin Fee system.

Drainage and Bridge Fee Calculations

Presented on Tables 15 and 16 are the drainage and bridge fees calculated separately for both the Dirty Woman Creek Basin and Crystal Creek Basin. Unplatted acreage, drainageway costs and culverts costs which are within the corporate limits of the Town of Monument have been specifically excluded from the following County drainage and bridge fee determinations.

The term "reimbursable costs" used on Tables 15 and 16 means those costs which have been used in the estimation of drainage basin fees. Costs considered "non-reimbursable" are costs for the replacement of an existing, undersized culvert, or costs to rehabilitate or maintain an existing lined segment of drainageway. For the most part, the drainageway costs for the mainstem of Dirty Woman Creek and Crystal Creek have been considered as reimbursable. Drainageway improvements which have the potential to be funded in the future by State or Federal funds (such as the I-25 and Highway 105 interchange), have not been included in the reimbursable cost estimate. Localized drainageway and storm sewer improvements shown on the plans which lie within the Town of Monument have not been included in the drainage fee calculations.

The costs associated with bridge replacement have been calculated using the County's methodology as presented in the County Drainage Basin Fee Resolution as adopted by the Board

of County Commissioners. Drainageway facilities which were found to be required due to existing inadequacies have not been included in the drainage basin fee estimate. The cost of land has been based upon the park land dedication fee as described in the Drainage Basin Fee Resolution. The bridge over Dirty Woman Creek at Mitchell Avenue has not been included in the County bridge fee because the bridge lies within the Town of Monument corporate limits.

**TABLE 14: DIRTY WOMAN & CRYSTAL CREEKS DRAINAGE BASIN PLANNING STUDY
OVERALL COST ESTIMATE
SELECTED ALTERNATIVE**

REACH NUMBER	DRAINAGEWAY SUBTOTAL COSTS	CULVERT SUBTOTAL COSTS	OVERALL REACH COSTS	SUGGESTED NON-REIMBURSIBLE COST ALLOCATION			REIMBURSIBLE COSTS
				TOWN OF MONUMENT	CDOT	EL PASO COUNTY	
DW-A-01	\$144,182	\$105,800	\$249,982	\$105,800			\$144,182
DW-A-02	\$45,672	\$0	\$45,672	\$45,672			\$0
DW-A-03	\$158,690	\$123,750	\$282,440			\$123,750 (1)	\$158,690
DW-A-04	\$0	\$0	\$0				\$0
DW-A-05	\$190,316	\$136,250	\$326,566	\$73,490	\$136,250 (2)		\$116,826
DW-A-06	\$236,752	\$0	\$236,752	\$236,752			\$0
DW-B-07	\$129,645	\$86,000	\$215,645			\$135,320	\$80,325
DW-B-08	\$211,935	\$61,250	\$273,185			\$107,050	\$166,135
DW-B-09	\$62,391	\$136,875	\$199,266			\$199,266	\$0
DW-B-10	\$114,250	\$0	\$114,250			\$114,250	\$0
DW-B-11	\$48,512	\$71,600	\$120,112			\$120,112	\$0
UFDW-A-12	\$148,924	\$6,960	\$155,884			\$155,884	\$0
UFDW-A-13	\$18,600	\$0	\$18,600			\$18,600	\$0
SFDW-A-14	\$29,290	\$0	\$29,290			\$29,290	\$0
SFDW-A-15	\$47,857	\$72,500	\$120,357			\$120,357	\$0
SFDW-A-16	\$50,140	\$17,480	\$67,620			\$67,620	\$0
MFDW-A-17	\$40,874	\$24,200	\$65,074			\$65,074	\$0
MFDW-A-18	\$66,389	\$8,000	\$74,389			\$74,389	\$0
MFDW-A-19	\$54,727	\$16,250	\$70,977			\$70,977	\$0
MFDW-A-20	\$82,488	\$11,200	\$93,688			\$93,688	\$0
NFDW-A-21	\$99,039	\$15,800	\$114,839			\$114,839	\$0
NFDW-B-22	\$80,921	\$0	\$80,921			\$80,921	\$0
NFDW-B-23	\$54,955	\$27,900	\$82,855			\$82,855	\$0
NFDW-U-46	\$0	\$9,000	\$9,000			\$9,000	\$0
LFDW-A-24	\$142,440	\$81,000	\$223,440				\$223,440
LFDW-A-25	\$149,335	\$28,800	\$178,135			\$178,135	\$0
LFDW-B-26	\$88,404	\$95,200	\$183,604			\$183,604	\$0
LFDW-B-27	\$106,225	\$33,800	\$140,025			\$140,025	\$0
LFDW-B-28	\$119,465	\$35,000	\$154,465			\$154,465	\$0
LFDW-B-29	\$115,370	\$27,000	\$142,370			\$142,370	\$0
LFDW-B-30	\$34,500	\$0	\$34,500			\$34,500	\$0
LFDW-U-44	\$162,500	\$16,800	\$179,300			\$179,300	\$0
LFDW-U-45	\$0	\$0	\$0				\$0
TOTAL DIRTY WOMAN CREEK			\$4,283,203	\$461,714	\$136,250	\$2,795,641	\$889,598
CC-A-31	\$107,129	\$16,000	\$123,129	\$123,129			\$0
CC-A-32	\$0	\$0	\$0				\$0
CC-B-33	\$79,750	\$0	\$79,750	\$79,750			\$0
CC-B-34	\$68,750	\$0	\$68,750	\$68,750			\$0
CC-B-35	\$59,084	\$0	\$59,084	\$59,084			\$0
CC-B-36	\$41,459	\$76,400	\$117,859	\$117,859			\$0
CC-B-37	\$0	\$0	\$0				\$0
CC-C-38	\$0	\$125,000	\$125,000		\$125,000		\$0
CC-C-39	\$134,605	\$53,300	\$187,905				\$187,905
CC-C-40	\$25,120	\$14,400	\$39,520				\$39,520
CC-U-41	\$74,400	\$20,120	\$154,520	\$107,800			\$46,720
CC-U-42	\$0	\$49,000	\$49,000	\$49,000			\$0
CC-U-43	\$74,400	\$0	\$74,400				\$74,400
TOTAL CRYSTAL CREEK			\$1,078,917	\$605,372	\$125,000	\$0	\$348,545

- (1) A portion of this amount is reimbursible under County Bridge Fee
(2) Considered a bridge by El Paso County

TABLE 15:
 Dirty Woman & Crystal Creeks Drainage Basin Planning Study
 Drainage Basin Fee Estimation

Reimbursable Drainageway Improvments	Reimbursible Construction Costs
Dirty Woman Creek Drainageway	\$889,598
Total Reimbursable Improvements	\$889,598
5% Contingency	\$44,480
10% Engineering	\$93,408
Total Reimbursible Drainage Costs	\$1,027,486
Study Costs	\$59,836
Subtotal	\$1,087,322
Deduct BOCC Fee Waivers	\$51,656
Total	\$1,035,666
Unplatted Acreage El Paso County	224.4
Unplatted Acreage Town of Monument	156.5
Dirty Woman Creek Drainage Basin Fee	\$4,616
Crystal Creek Drainageway	\$348,545
Total Reimbursable Improvements	\$348,545
5% Contingency	\$17,427
10% Engineering	\$36,597
Total Reimbursible Drainage Costs	\$402,569
Study Costs	\$19,147
Subtotal	\$421,716
Deduct BOCC Fee Waivers	\$37,888
Total	\$383,828
Unplatted Acreage El Paso County	126.6
Unplatted Acreage Town of Monument	87.0
Crystal Creek Drainage Basin Fee	\$3,032

TABLE 16:
 Dirty Woman & Crystal Creek Drainage Basin Planning Study
 County Bridge Fee Estimation

ROADWAY	CROSSING TYPE	TOTAL COST	TOTAL CDoT COST	TOTAL MONUMENT COST	TOTAL COUNTY COST (2)
Mitchell Avenue (1)	Triple 10'x10' CBC	\$105,800		\$105,800	\$0
Old Denver Highway	Twin 10'x11' CBC	\$123,750		\$0	\$106,360
Interstate 25	Additional 10'x8' CBC	\$136,250	\$136,250	\$0	\$0
TOTAL BRIDGE CONSTRUCTION COSTS		\$365,800	\$136,250	\$105,800	\$106,360
5% CONTINGENCY		\$18,290	\$6,813	\$5,290	\$5,318
10% ENGINEERING		\$38,409	\$14,306	\$11,109	\$11,168
TOTALS		\$422,499	\$157,369	\$122,199	\$122,846
TOTAL REIMBURSIBLE COSTS					\$20,085
TOTAL UNPLATTED ACREAGE IN EL PASO COUNTY					224.4
DIRTY WOMAN CREEK COUNTY BRIDGE FEE (\$/ACRE)					\$90

(1) Bridge is within jurisdictional limits of the Town of Monument.

(2) County Cost = Total Cost ((Exstg. Flow - Exstg. Capacity)/Future Flow)

APPENDIX A

Summary of Sub-basin Hydrologic Data

Summary of 24 Hr. Peak Discharges

Mailing List

Public Meeting Minutes

Project Correspondence

APPENDIX TABLE 1

Summary of Sub-basin Hydrologic Data

Basin Designation	Area (Acres)	Curve Number	Tc (min)	Basin Designation	Area (Acres)	Curve Number	Tc (min)	Basin Designation	Area (Acres)	Curve Number	Tc (min)
SDW01	119.6	82	39.2	DWC79	78.1	84	32.9	CC157	56.5	88	29.9
SDW03	60.0	83	28.6	LDW81	54.6	86	12.9	CC159	7.8	88	11.6
SDW05	69.7	82	17.5	LDW83	40.5	85	23.8	CC161	47.2	88	12.0
SDW07	37.7	88	18.3	LDW85	24.2	86	24.0	CC163	47.5	86	9.7
UDW09	61.2	82	19.3	LDW87	65.3	86	31.7	CC165	43.2	88	12.0
UDW11	27.2	83	12.6	LDW89	61.8	85	35.8	CC167	45.9	88	16.8
UDW13	18.6	84	23.4	LDW91	11.6	86	16.5	CC169	67.6	80	9.4
UDW15	62.0	82	39.7	LDW93	21.1	86	17.8	CC171	27.3	88	5.5
UDW17	19.6	82	33.3	LDW95	28.7	85	22.9	CC173	20.1	88	11.5
UDW19	23.0	83	32.7	LDW97	17.8	85	6.5	CC175	22.4	82	9.5
UDW21	21.1	83	9.3	LDW99	21.1	88	14.5	CC177	45.6	84	17.2
UDW23	11.9	83	13.8	LDW101	79.9	86	19.7	CC179	37.2	80	37.9
UDW25	33.6	83	39.6	LDW103	81.2	85	29.1	CC181	24.1	80	5.5
UDW27	42.4	84	19.5	LDW105	51.7	87	30.2	CC183	54.3	84	8.2
UDW29	51.1	83	26.8	LDW107	26.8	85	26.7	CC185	53.0	82	8.9
UDW31	30.5	88	14.6	LDW109	55.9	87	17.1	CC187	47.6	86	22.1
MDW33	90.8	84	35.5	LDW111	122.0	88	37.3	CC189	30.6	83	12.2
MDW35	18.1	83	18.6	DWC113	19.6	83	9.0				
MDW37	56.1	84	36.2	DWC115	27.7	88	7.7				
MDW39	58.6	87	26.8	DWC117	79.2	88	17.1				
NDW41	61.8	85	11.0	DWC119	28.2	88	16.6				
NDW43	37.1	85	30.7	DWC121	98.4	88	24.2				
NDW45	56.4	86	39.8	DWC123	21.5	88	3.8				
NDW47	31.2	85	20.4	DWC125	30.2	88	18.6				
NDW49	7.1	85	18.8	DWC127	57.6	81	13.8				
NDW51	23.8	84	40.5	DWC129	58.7	88	20.8				
NDW53	7.5	85	14.7	DWC131	33.7	80	11.8				
NDW55	6.4	85	6.1	DWC133	48.5	85	16.5				
NDW57	89.0	85	27.8	DWC135	54.5	82	26.3				
NDW59	69.2	86	26.9	DWC137	33.9	86	25.2				
DWC61	43.4	86	29.6	DWC139	50.6	87	17.4				
DWC63	81.7	86	36.4	DWC141	29.3	87	10.9				
DWC65	34.4	86	31.7	DWC143	40.2	85	9.7				
DWC67	26.2	85	33.3	CC145	54.8	85	32.0				
DWC69	13.1	87	7.2	CC147	68.8	83	28.8				
DWC71	31.9	87	19.3	CC149	52.1	81	29.1				
DWC73	48.5	85	29.7	CC151	87.6	82	35.0				
DWC75	60.5	86	10.8	CC153	34.0	85	14.2				
DWC77	30.1	85	29.7	CC155	15.5	88	11.3				

APPENDIX TABLE 2
Summary of 24 Hr. Peak Discharges

Design Point	Existing 100 Year 24 Hour	Existing 10 Year 24 Hour	Future 100 Year 24 Hour	Future 10 Year 24 Hour
Dirty Woman Creek				
11	127	42	127	42
21	243	81	243	81
29	421	142	421	142
53	97	38	97	38
55	101	39	101	39
45	322	131	322	131
57	459	178	459	178
35	133	50	133	50
37	202	75	202	75
3	172	55	172	55
7	310	113	310	113
59	1,567	595	1,567	595
61	1,634	622	1,634	622
63	1,736	660	1,736	660
65	1,781	670	1,781	670
69	1,817	678	1,817	678
71	1,828	687	1,830	688
75	1,877	706	1,879	708
91	96	37	96	37
95	177	70	177	70
83	182	76	182	76
99	547	226	547	226
103	809	328	809	328
107	919	373	919	373
109	974	394	974	394
111	1206	469	1206	469
113	2,009	747	2,016	751
115	2,008	745	2,016	750
119	2,079	766	2,102	778
123	2,137	775	2,275	840
125	2,172	788	2,314	855
127	2,158	789	2,308	856
131	2,208	803	2,397	884
135	2,295	821	2,490	904
139	2,302	819	2,495	905
Crystal Creek				
149	209	74	209	74
153	322	111	322	111
157	489	201	489	201
159	502	207	502	207
161	566	238	566	238
163	610	266	610	266
177	198	94	208	101
179	217	95	225	104
181	227	96	236	103
167	323	158	432	240
169	406	175	518	267
183	1,294	542	1,424	639
185	1,313	556	1,449	650
189	1,370	581	1,491	673



DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1580
ALBUQUERQUE, NEW MEXICO 87103-1580
FAX (505) 765-2770

REPLY TO
ATTENTION OF:

January 7, 1993

Construction-Operations Division
Regulatory Branch

EL PASO COUNTY
DEPT OF PUBLIC WORKS
ENGINEERING DIVISION
93 JUN 11 AM 11 19

Mr. Alan Morrice
El Paso County
Department of Public Works
3105 North Stone Avenue
Colorado Springs, Colorado 80907

Dear Mr. Morrice:

Reference is made to your Drainage Basin Planning Study being prepared for the Dirty Woman and Crystal Creek basins near Monument, El Paso County, Colorado (Action No. CO-91-50499).

We have reviewed your development of alternatives which has been done to this point. Based on our preliminary review, if an individual permit action for this study was evaluated, it appears that the basin study activities would meet the Environmental Protection Agency's 404(b)(1) Guidelines.

This basin has important flood plain functions and values such as natural moderation of floods, water quality maintenance, wildlife and plant resources, open space, and natural beauty. We support and encourage your continued consideration of these natural resources during the rest of the study.

Should you have any questions please feel free to write or call Ms. Anita Culp at (719) 543-9459.

Sincerely,

Robert E. Meehan, P.E.
Chief, Construction and Operations
Division

DONALD F. SMITH
MANAGER ENGINEERING DIVISION

MERVIN M. CASEY
SYSTEMS SUPERVISOR

WILLIAM O. CERDA
INSPECTION SUPERVISOR

CARL R. McCLELLAN
SURVEY SUPERVISOR

ALAN B. MORRICE
STORM WATER

DAVID M. WATT
DESIGN ENGINEER



EL PASO COUNTY
DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION
3105 N. STONE AV.
COLORADO SPRINGS, COLORADO 80907

MAX L. ROTHSCHILD, P.E.
DIRECTOR OF PUBLIC WORKS

PHONE (719) 520-6840
FAX (719) 520-6878
24hr. MSG. (719) 520-6460

November 6, 1992

Jim Tounsand
U.S. Army Corps of Engineer
Southern Colorado Regulatory Office
421 N. Main St., Ste. 416
P.O. Box 294
Pueblo, CO. 81002-0294

Dear Mr. Tounsand:

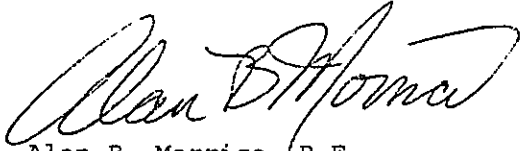
In reference to our conversations regarding the Dirty Woman and Crystal Creeks Drainage Basin Planning Study, we are still awaiting confirmation from the Corps regarding the study's continuation in the Letter of Permission / List of Categories of Activities process. The El Paso County Department of Public Works feels that it is in the community's best interest to proceed with completion of the drainage basin planning study.

As you may be aware, copies of the study Alternative Development Report were sent to the Corps on July 15, 1992, almost four months ago. As has been the case with past studies for the Windmill Gulch and Fishers Canyon (still awaiting final public notice) basins, the County has made every effort to try and facilitate an expedient yet least demanding LOP/LCA process for the Corps of Engineers. The Windmill Gulch Drainage Basin Planning Study which was performed for El Paso County was the first basin in this region to receive LOP/LCA authorization.

We feel it is unfortunate that the Corps finds that LOP/LCA authorizations are not of sufficient importance to receive a higher priority. We thought that a streamlined permitting process, protecting existing environmental assets, and encouraging local participation in the permit program would have been a worthwhile endeavor.

We will continue to maintain the same mailing list which includes all LOP agencies and consider comments from all study participants in a similar manner as previously intended. If I can answer any questions you might have regarding this matter, please do not hesitate to contact me.

Sincerely,







A handwritten signature in cursive script, reading "Alan B. Morrice".

Alan B. Morrice, P.E.
Stormwater Management Supervisor

cc: Max L. Rothschild, P.E.
Donald F. Smith
Richard N. Wray ✓

PRELIMINARY DESIGN OF SELECTED ALTERNATIVE DIRTY WOMAN AND CRYSTAL CREEKS DRAINAGE BASIN PLANNING STUDY

LEGEND

100 YEAR FLOODPLAIN	
FUTURE 100 YEAR FLOODPLAIN	
WETLAND FEATURE	
DROP STRUCTURE	
CHECK DAM STRUCTURE	
MONUMENT CORPORATE LIMITS	

LIST OF ABBREVIATIONS

CBC	CONCRETE BOX CULVERT
WS	WATER SURFACE ELEVATION
FIS	FLOOD INSURANCE STUDY
RCP	REINFORCED CONCRETE PIPE
HGL	HYDRAULIC GRADE LINE
FES	FLARED END SECTION
FB	FREEBOARD
CSP	CORRUGATED STEEL PIPE

GENERAL NOTES

1. THE INFORMATION PRESENTED ON THESE DRAWINGS IS PRELIMINARY IN NATURE AND SHOULD BE USED FOR PLANNING PURPOSES ONLY. THE FACILITIES SHOWN IN THIS MASTER PLAN ARE SUBJECT TO CHANGE AND WILL REQUIRE ADDITIONAL HYDROLOGIC AND HYDRAULIC DESIGN ANALYSIS DURING THE FINAL DESIGN STAGE.
2. MAPPING USED IN THE PREPARATION OF THIS BASIN PLAN HAS BEEN COMPILED FROM AERIAL MAPPING DATED JULY 31, 1991 BY LANDMARK MAPPING, LTD.

SHEET INDEX

SHEET	DESCRIPTION
IS	COVER SHEET
DW1	INDEX SHEET
DW2	DIRTY WOMAN CREEK STA. 0+00 to 25+90
DW3	DIRTY WOMAN CREEK STA. 25+90 to 51+70
DW4	DIRTY WOMAN CREEK STA. 51+70 to 77+90
DW5	DIRTY WOMAN CREEK STA. 77+90 to 105+85
DW6	DIRTY WOMAN CREEK STA. 105+85 to 130+25
UDW1	DIRTY WOMAN CREEK STA. 130+25 to 156+00
UDW2	UPPER DIRTY WOMAN CREEK STA. 156+00 to 184+00
UDW3	UPPER DIRTY WOMAN CREEK STA. 184+00 to 212+00
LF1	LAKE FORK DIRTY WOMAN CREEK STA. 0+00 to 25+40
LF2	LAKE FORK DIRTY WOMAN CREEK STA. 25+40 to 51+50
LF3	LAKE FORK DIRTY WOMAN CREEK STA. 51+50 to 73+75
LF4	LAKE FORK DIRTY WOMAN CREEK STA. 73+75 to 97+00
NF1	NORTH FORK DIRTY WOMAN CREEK STA. 0+00 to 22+00
NF2	NORTH FORK DIRTY WOMAN CREEK STA. 22+00 to 47+00
NF3	NORTH FORK DIRTY WOMAN CREEK STA. 47+00 to 70+00
MF1	MIDDLE FORK DIRTY WOMAN CREEK STA. 0+00 to 23+00
MF2	MIDDLE FORK DIRTY WOMAN CREEK STA. 23+00 to 48+00
SF1	SOUTH FORK DIRTY WOMAN CREEK STA. 0+00 to 20+00
SF2	SOUTH FORK DIRTY WOMAN CREEK STA. 20+00 to 42+00
CC1	CRYSTAL CREEK STA. 0+00 to 22+83
CC2	CRYSTAL CREEK STA. 22+83 to 51+18
CC3	CRYSTAL CREEK STA. 51+18 to 71+45
CC4	CRYSTAL CREEK STA. 71+45 to 91+00
CCSF	CRYSTAL CREEK SPLIT FLOW STA. 0+00 to 30+90
UR1	UPPER REACHES OF DIRTY WOMAN & CRYSTAL CREEKS
MNT	CONCEPTUAL OUTFALL SYSTEM TOWN OF MONUMENT
DTL	DETAIL SHEET

PREPARED FOR:

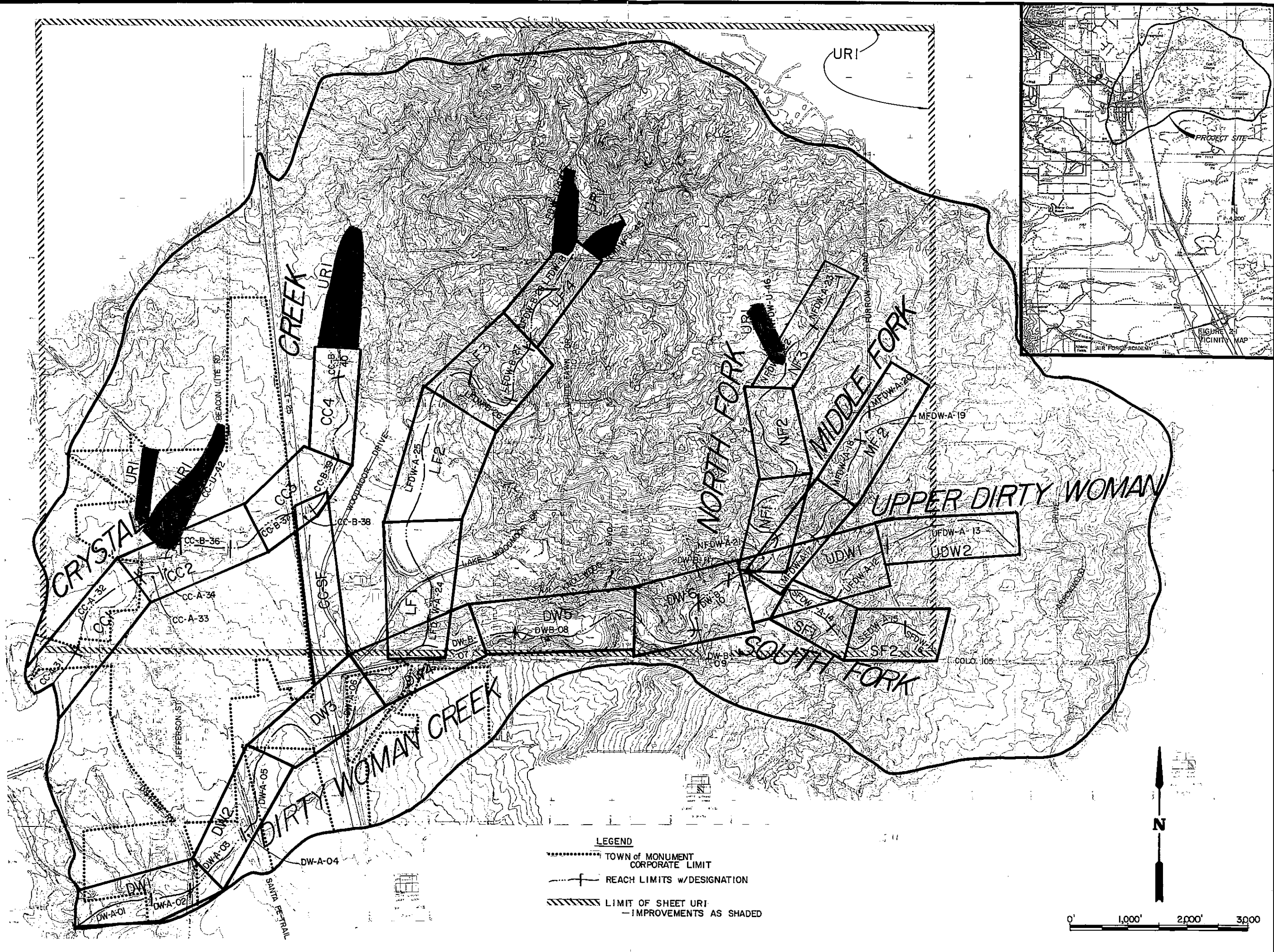
El Paso County Colorado
Department of Public Works
Stormwater Management Division
3105 North Stone
Colorado Springs, Colorado 80907

APRIL 1993

PREPARED BY:

Kiowa Engineering Corporation

419 West Bijou Street
Colorado Springs, Colorado
80905-1308
(719) 630-7342



**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**

PRELIMINARY DESIGN

Index Sheet

Project No.	91-07-17
Date:	1/93
Design:	
Drawn:	EAK
Check:	
Revisions:	

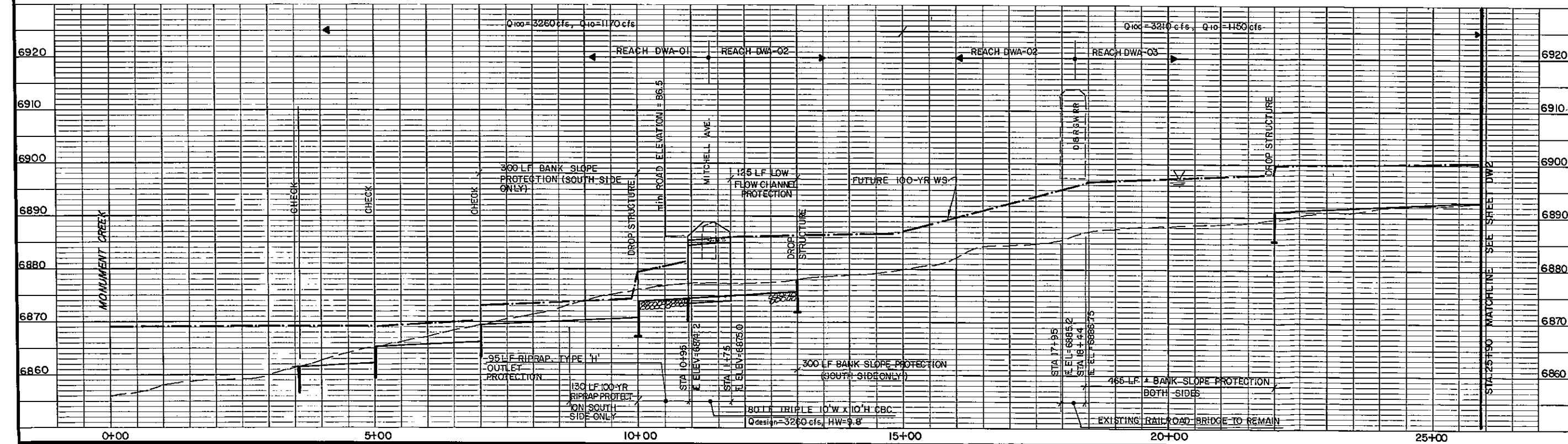
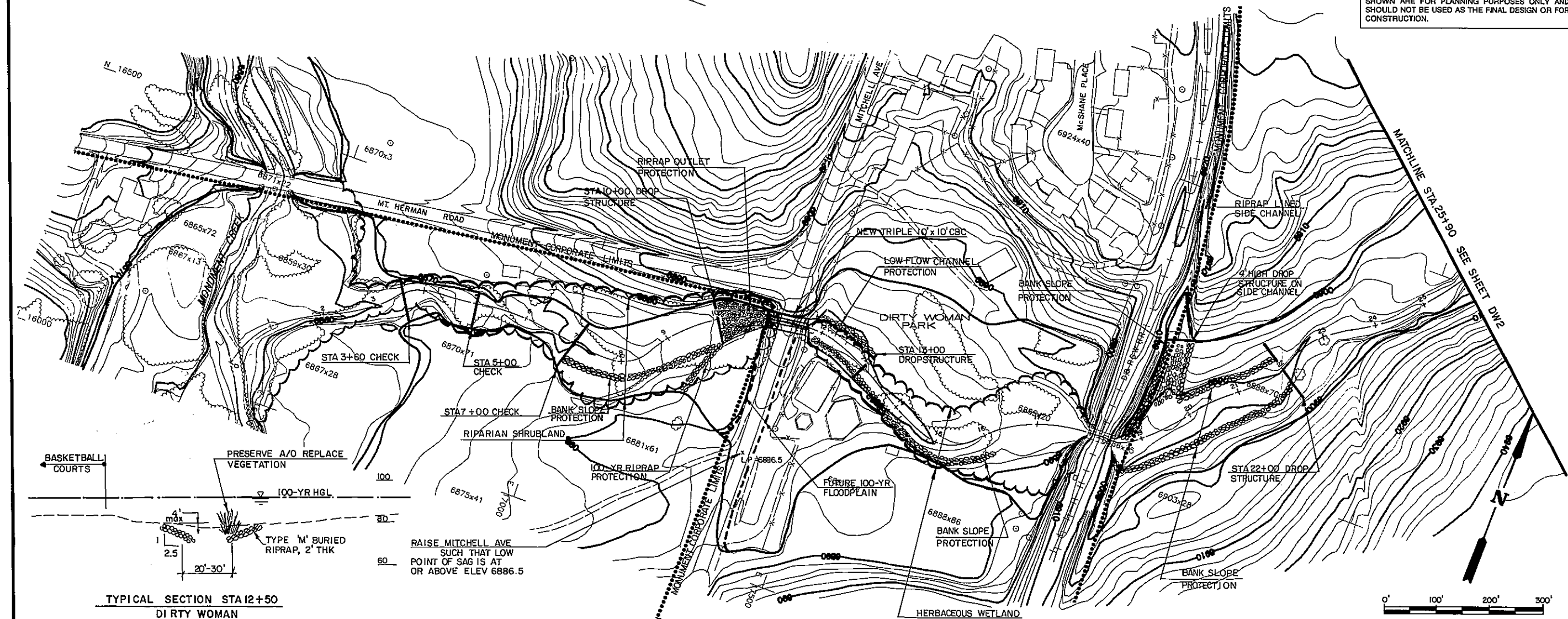
IS

Kiowa Engineering Corporation

419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

El Paso County Department of Public Works Stormwater Management Division

THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL DESIGN ENGINEERING. ALL DRAINAGE FACILITIES SHOWN ARE FOR PLANNING PURPOSES ONLY AND SHOULD NOT BE USED AS THE FINAL DESIGN OR FOR CONSTRUCTION.



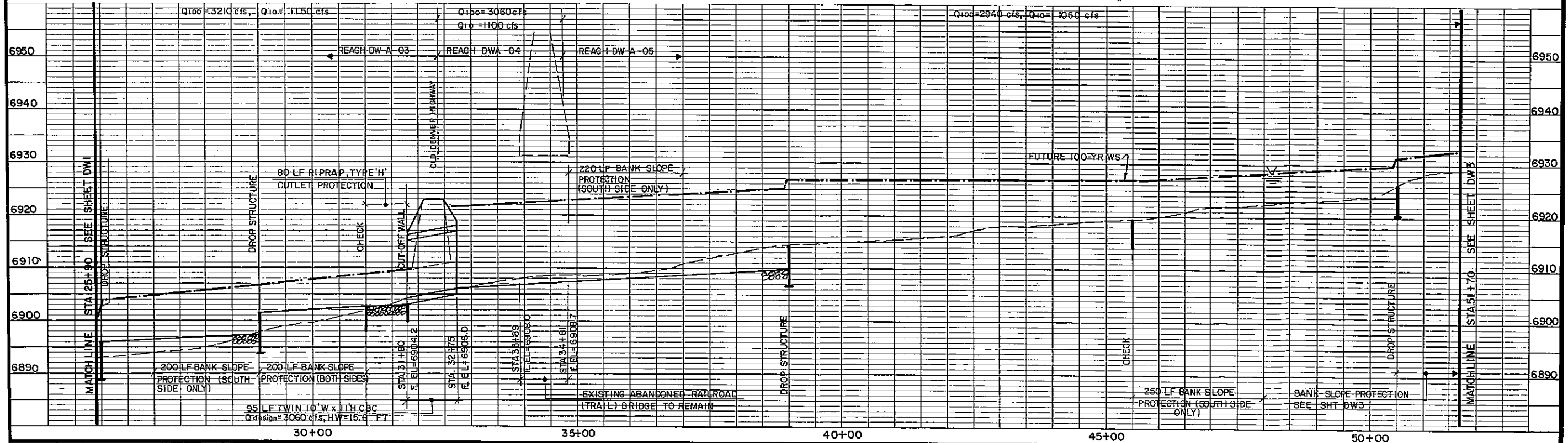
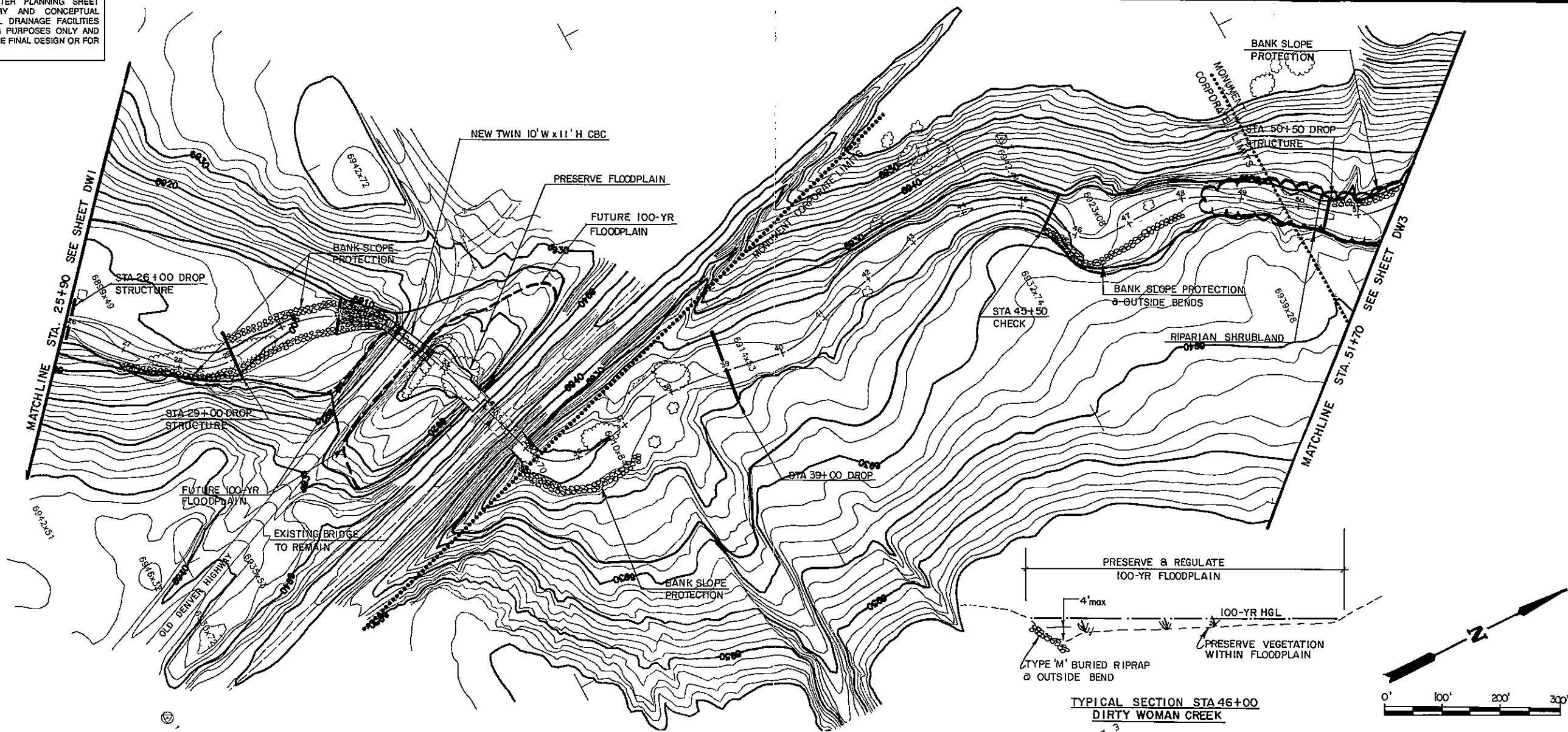
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80905-1308

**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Dirty Woman Creek
Sta. 0+00 to Sta. 25+90

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

DW1

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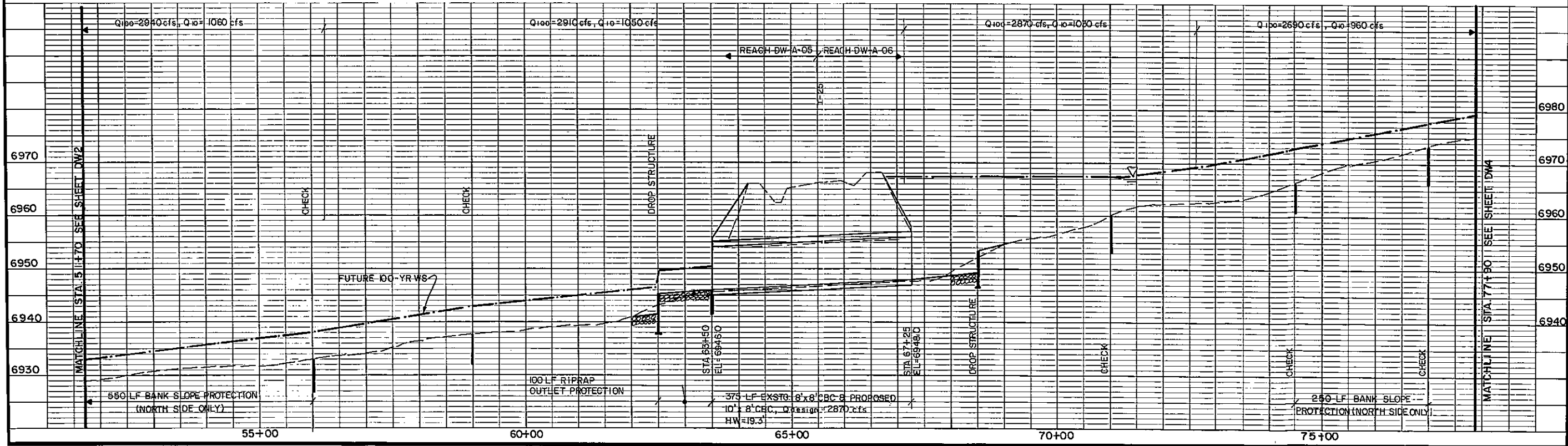
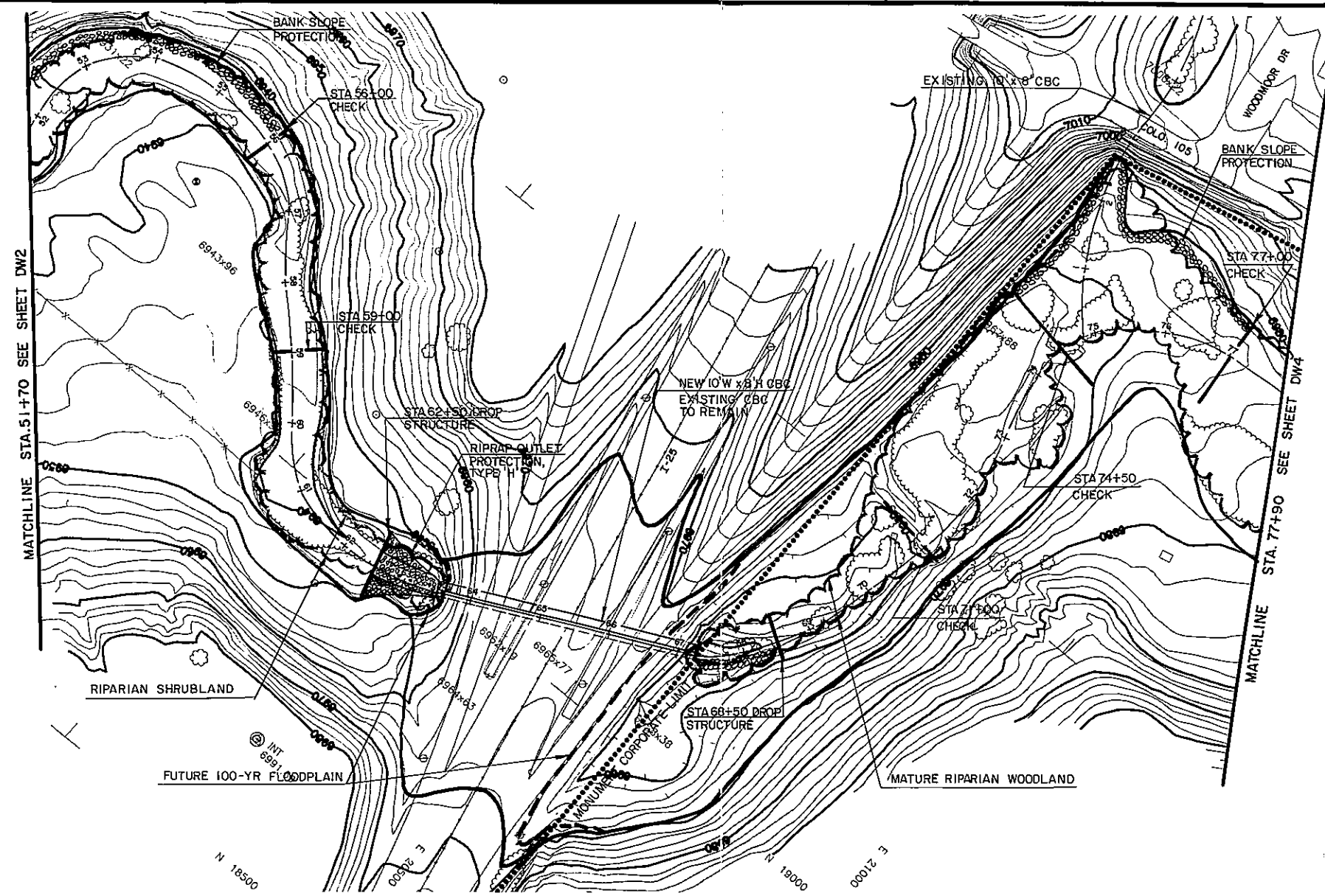
Kiowa Engineering Corporation
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Dirty Woman and Crystal Creeks
Drainage Basin Planning Study
PRELIMINARY DESIGN
Dirty Woman Creek
Sta. 25+90 to Sta. 51+70
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

DW2

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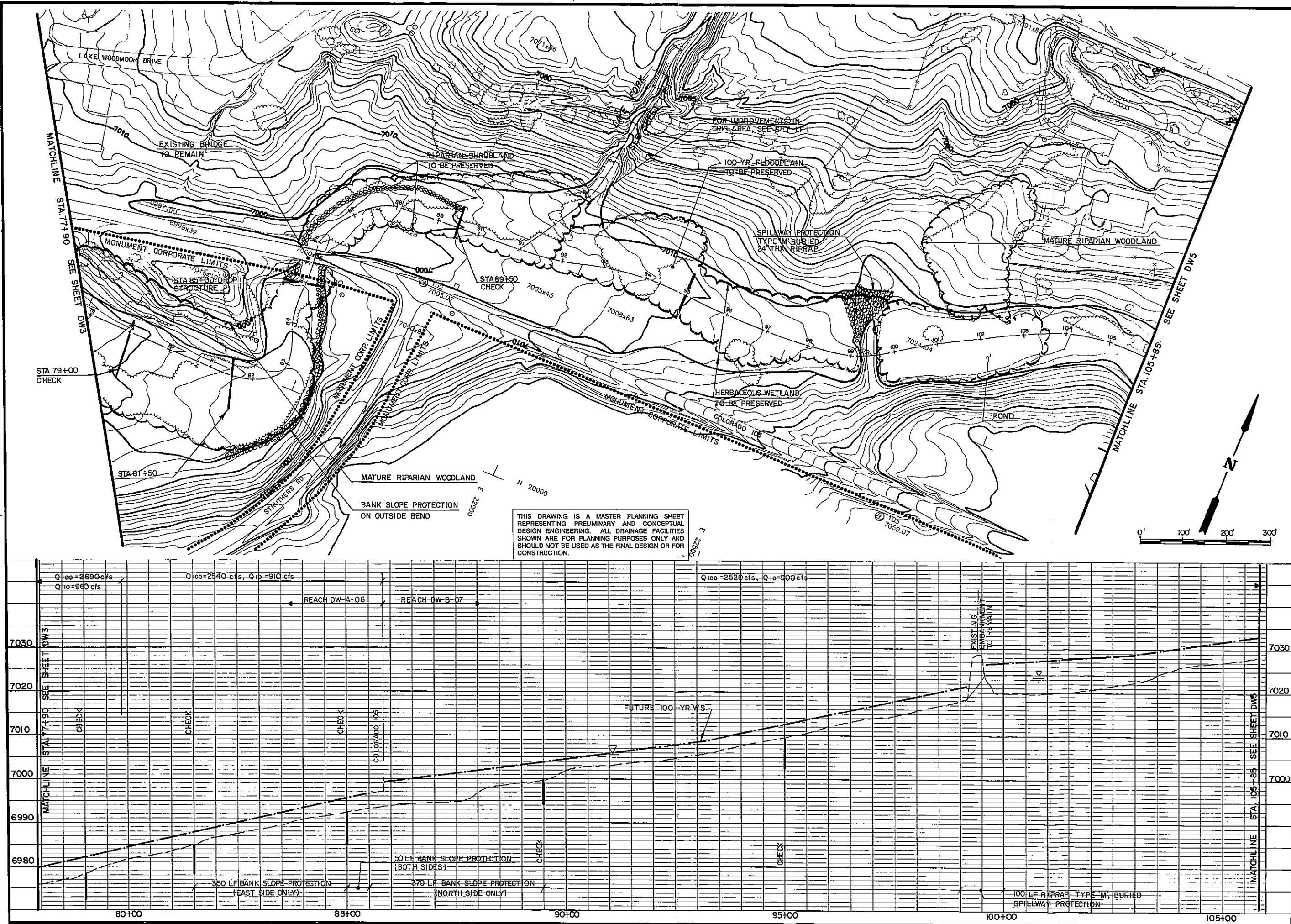
Dirty Woman and Crystal Creeks
Drainage Basin Planning Study
PRELIMINARY DESIGN

Dirty Woman Creek
Sta. 51+70 to Sta. 77+90

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

DW3



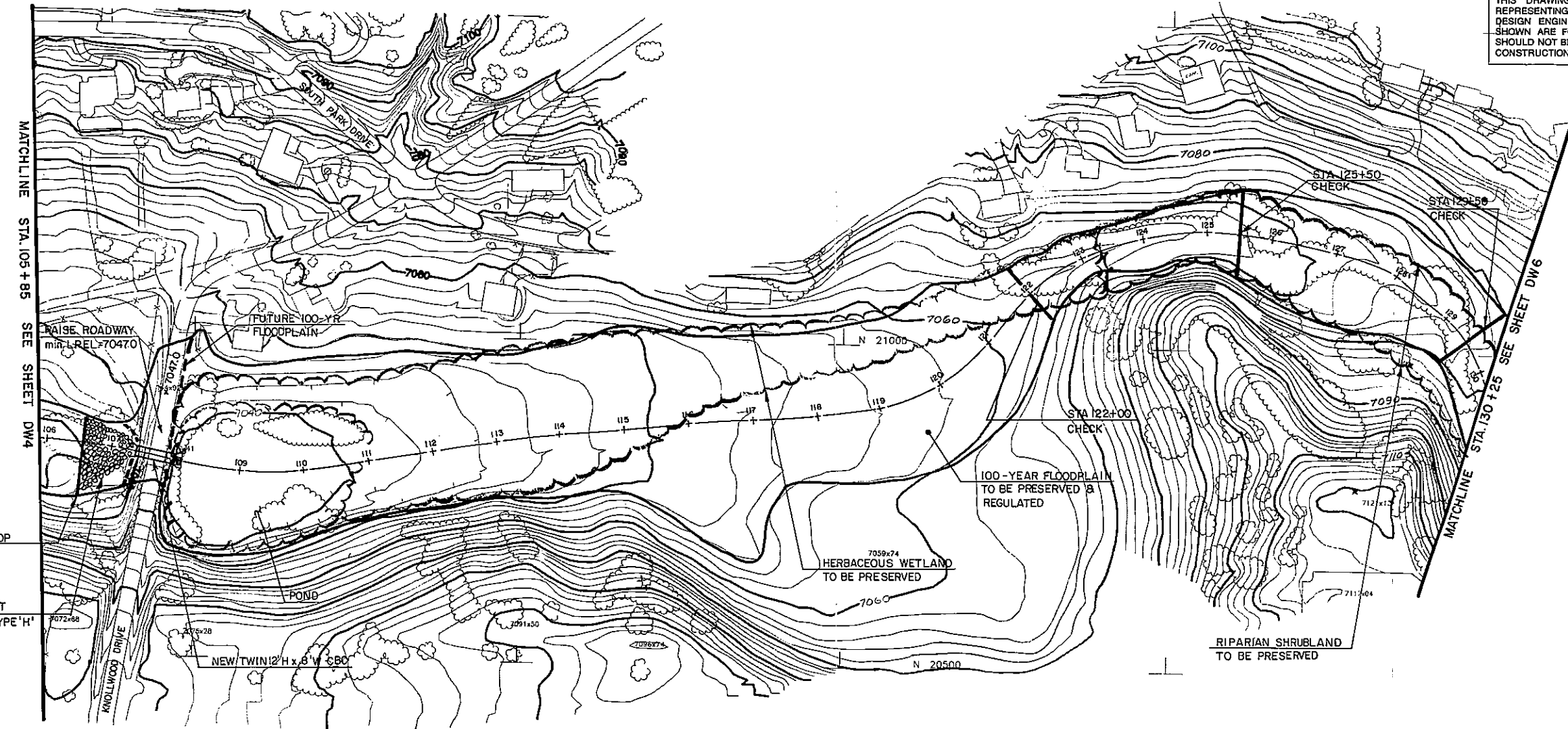
Kiowa Engineering Corporation
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80905-1308

Dirty Woman and Crystal Creeks
Drainage Basin Planning Study
PRELIMINARY DESIGN
Dirty Woman Creek
Sta. 77+90 to Sta. 105+85

Project No. 71-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

DW4

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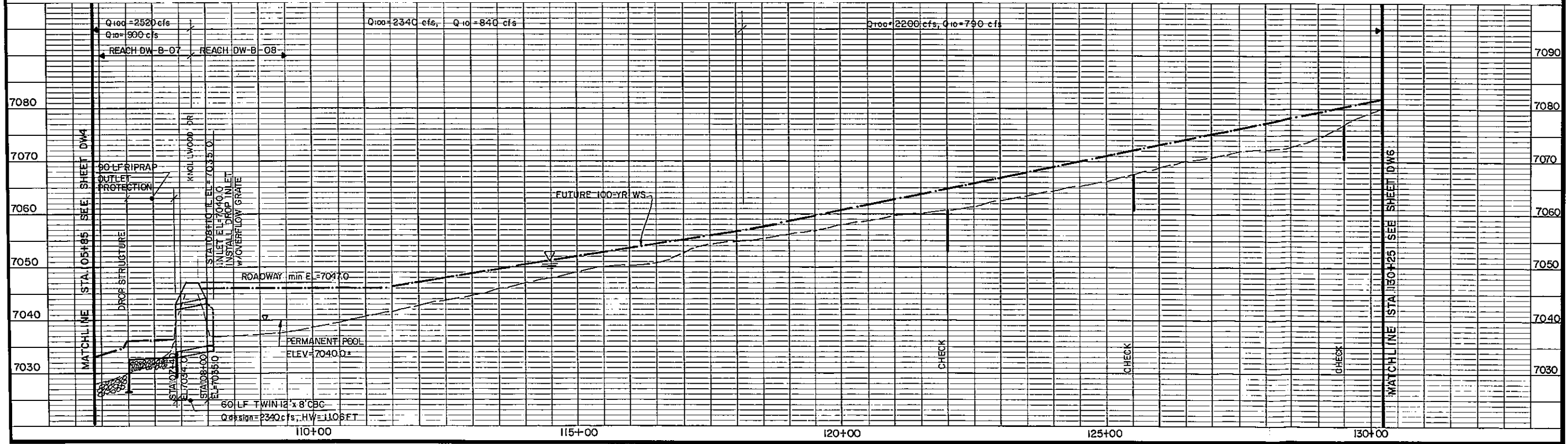
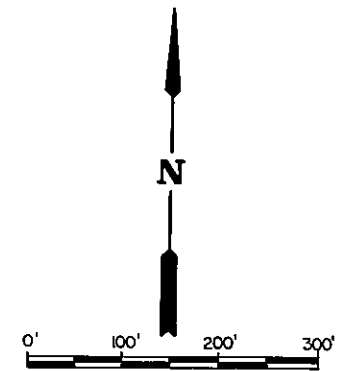


STA 106+50 DROP STRUCTURE

RIPRAP OUTLET PROTECTION, TYPE 'H'

104
7081.94

105
7112.95

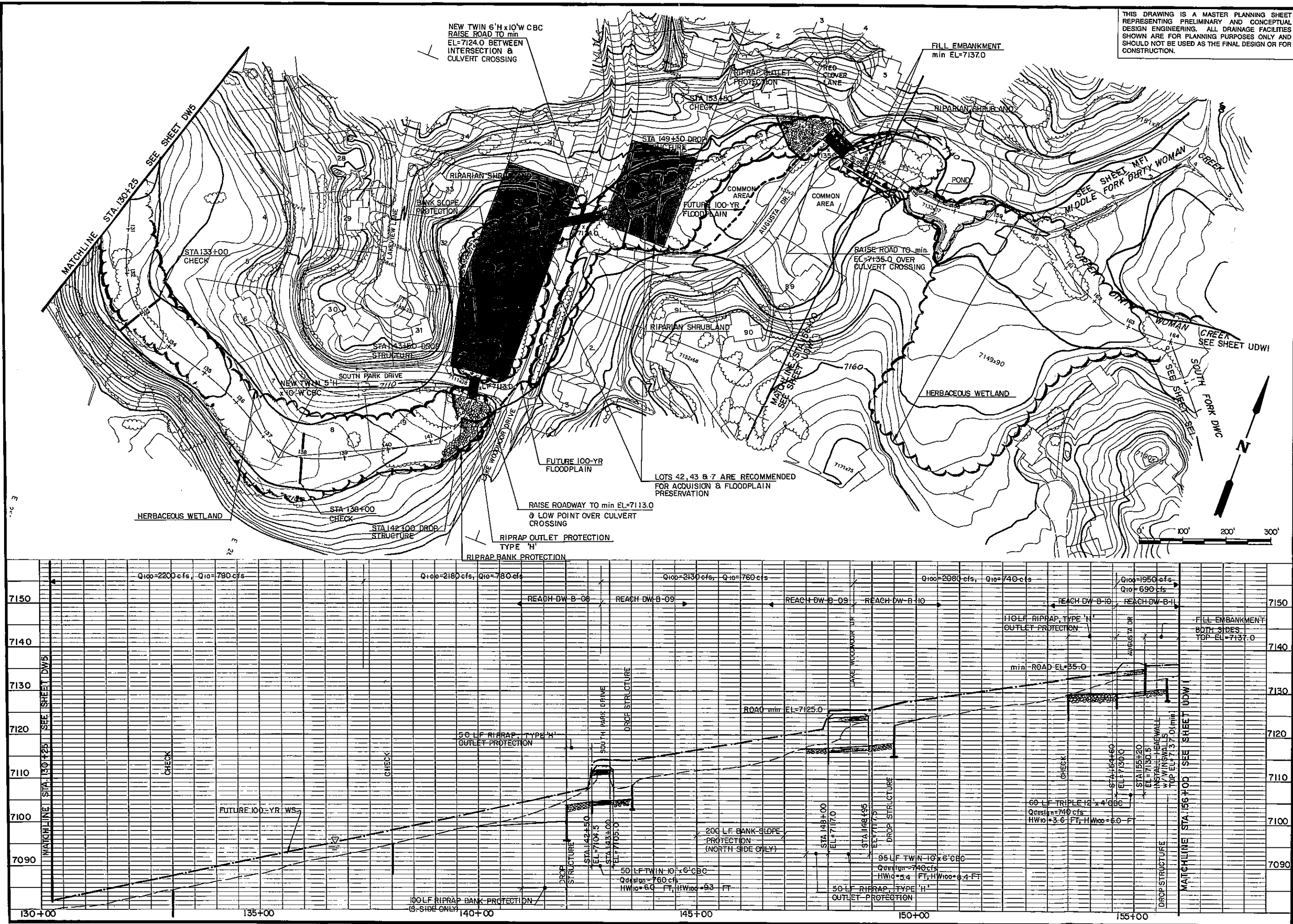


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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Dirty Woman Creek
Sta. 105+85 to Sta. 130+25
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

DW5



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Dirty Woman and Crystal Creeks Drainage Basin Planning Study PRELIMINARY DESIGN

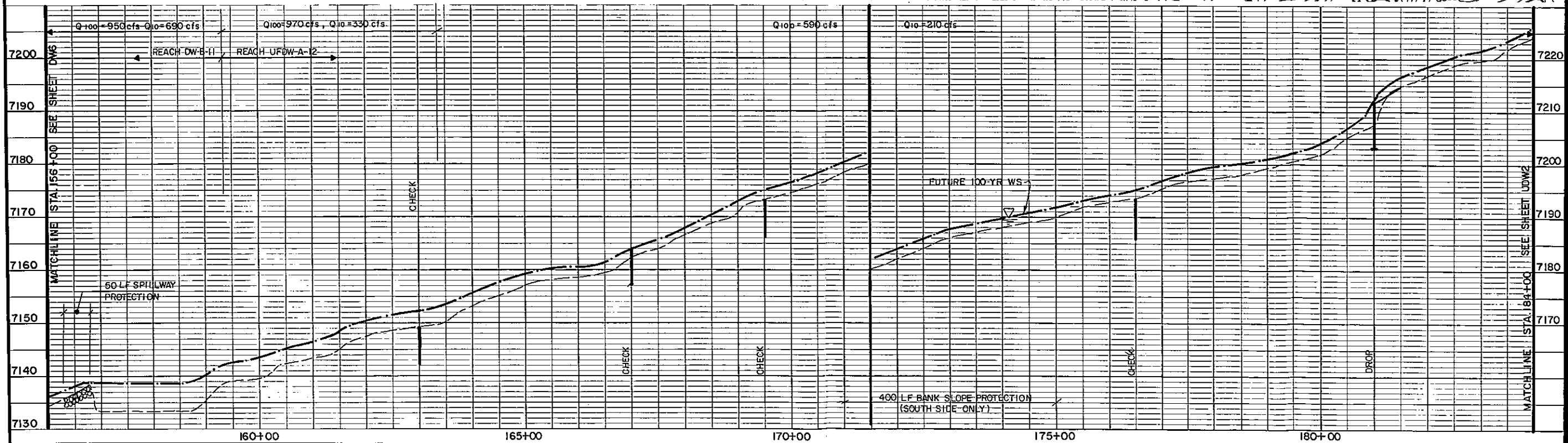
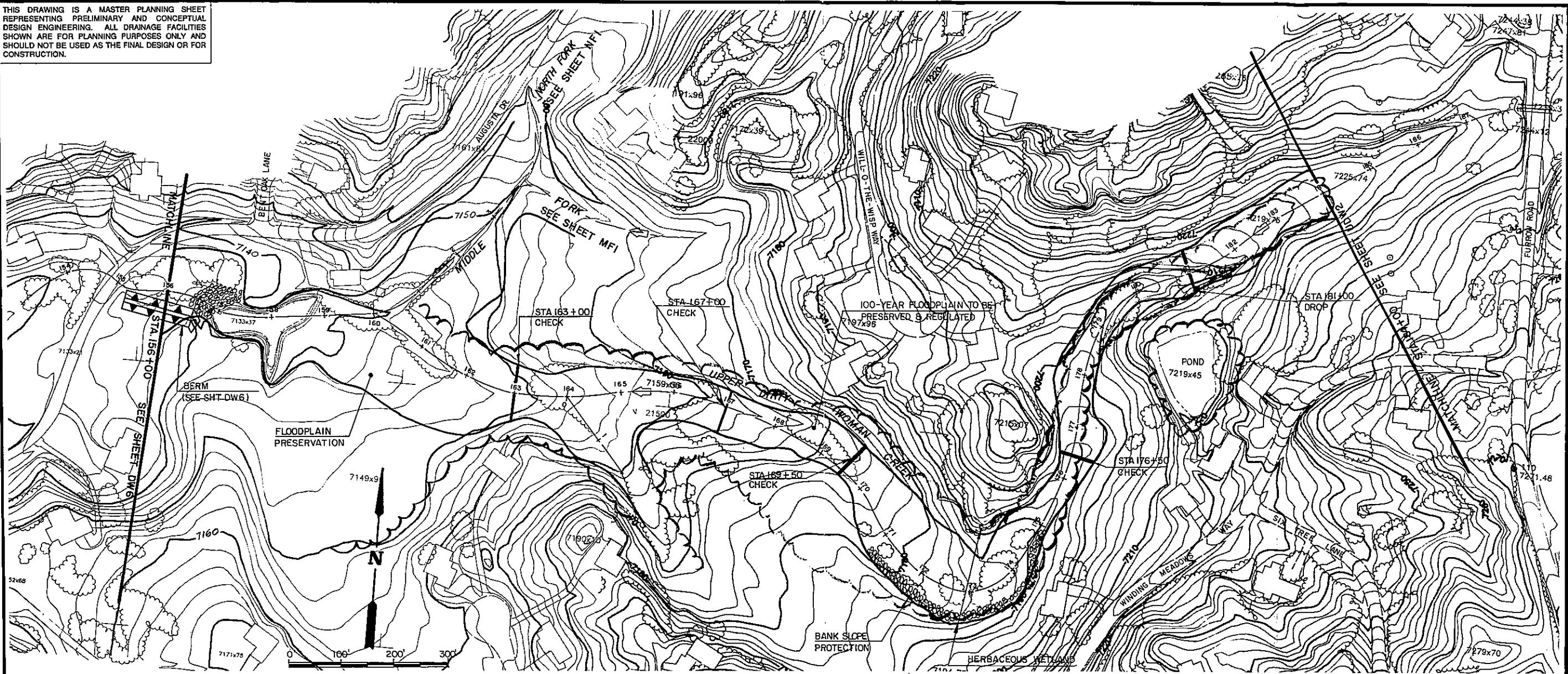
Dirty Woman Creek
Sta. 130+25 to Sta. 156+00

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWM c
Drawn: EAK
Check: RNW
Revisions:

DW6

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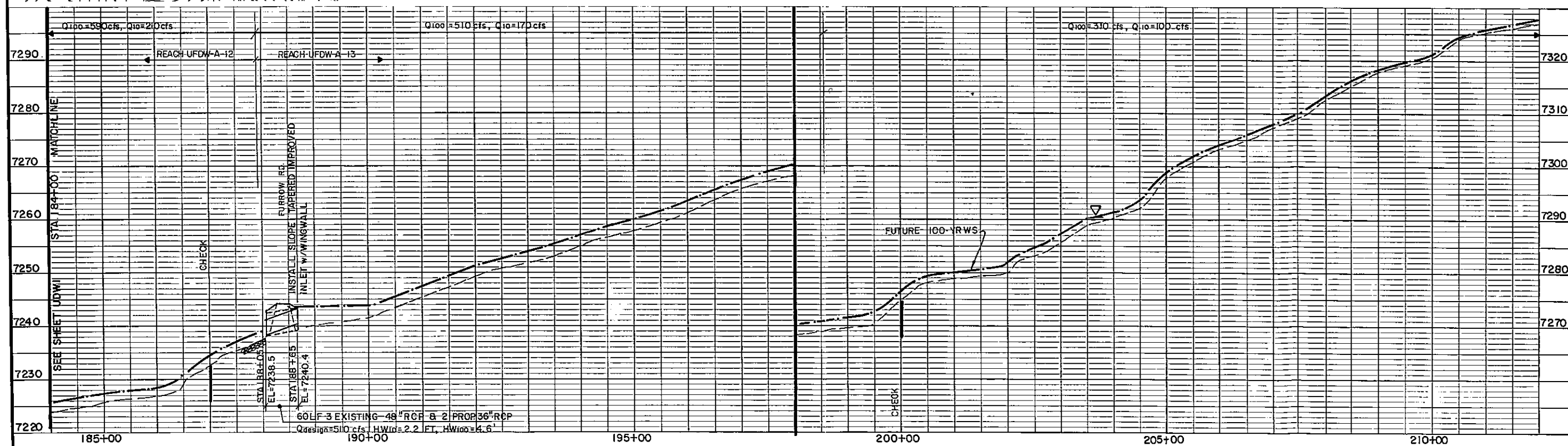
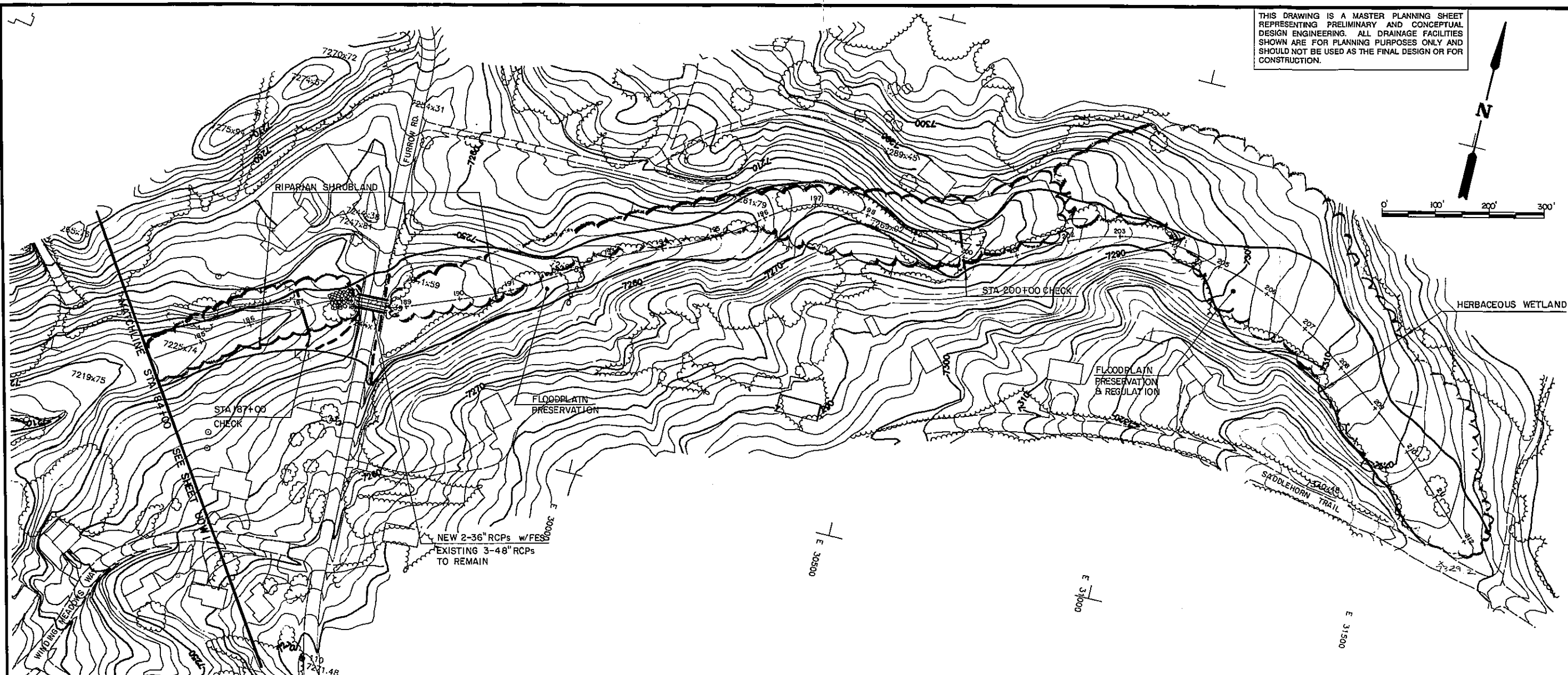
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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

UDW1

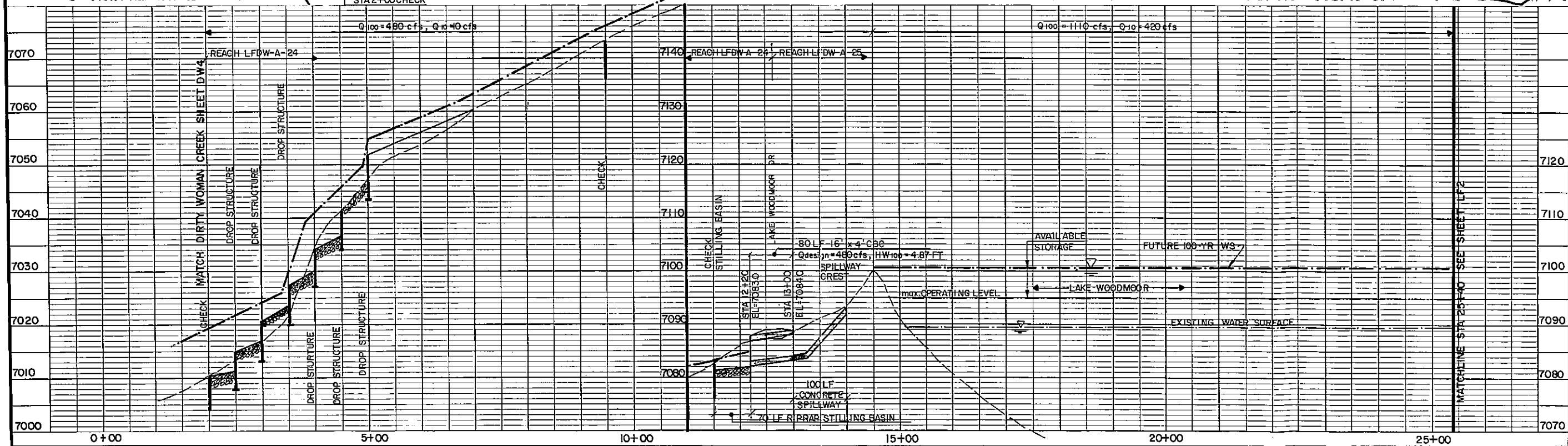
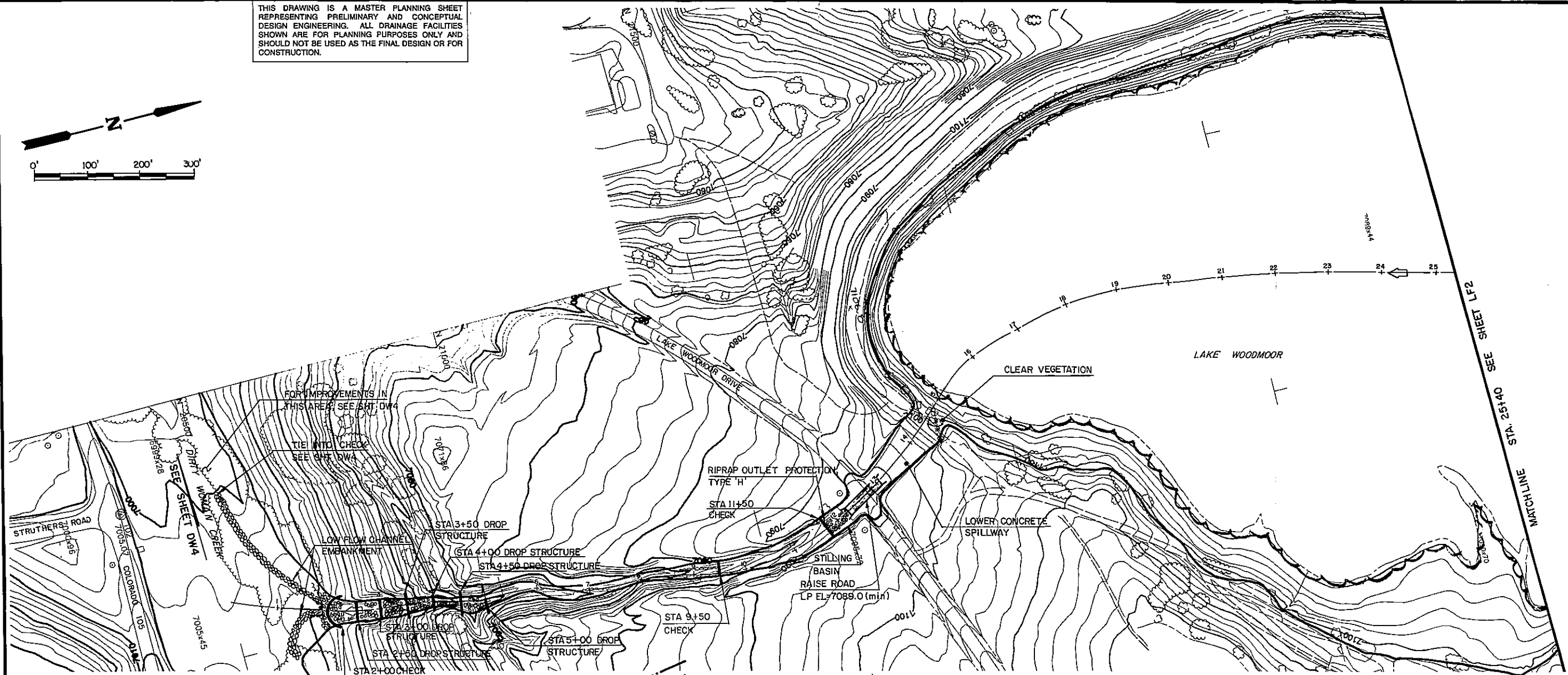
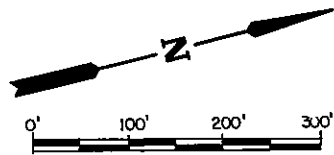


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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Upper Dirty Woman Creek
Sta. 184+00 to Sta. 212+00
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:
**UDW
2**

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Dirty Woman and Crystal Creeks
Drainage Basin Planning Study

PRELIMINARY DESIGN

Lake Fork Dirty Woman Creek

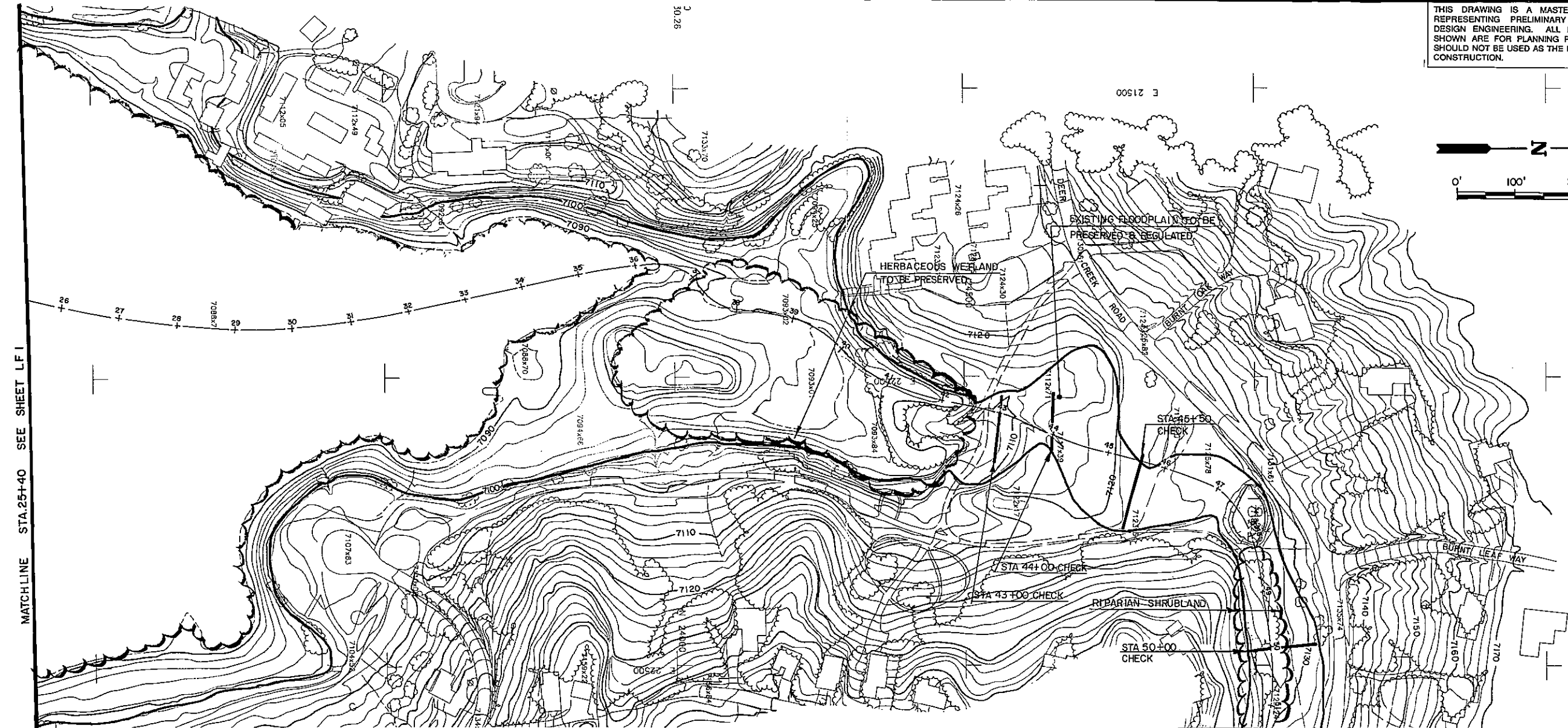
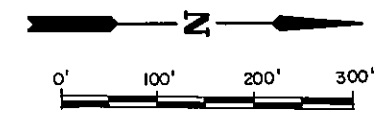
Sta. 0+00 to Sta. 25+40

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
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Check: RNW
Revisions:

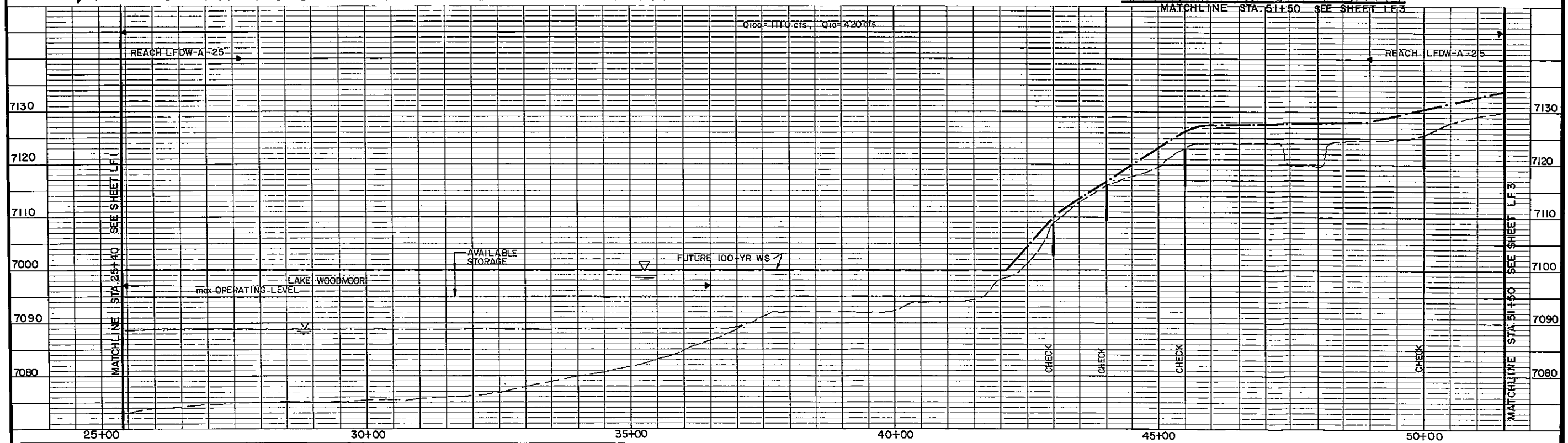
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MATCHLINE STA. 25+40 SEE SHEET LF 1

MATCHLINE STA. 51+50 SEE SHEET LF 3



25+00

30+00

35+00

40+00

45+00

50+00

MATCHLINE STA. 25+40 SEE SHEET LF 1

MATCHLINE STA. 51+50 SEE SHEET LF 3

Dirty Woman and Crystal Creeks Drainage Basin Planning Study

PRELIMINARY DESIGN

Lake Fork Dirty Woman Creek
Sta. 25+40 to Sta. 51+50

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

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LF2

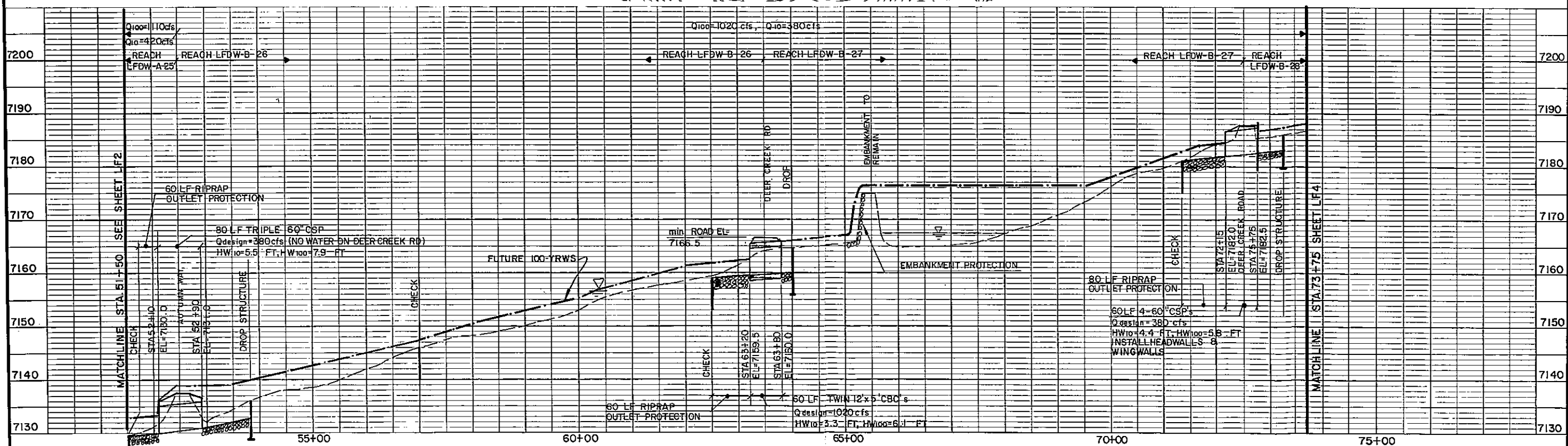
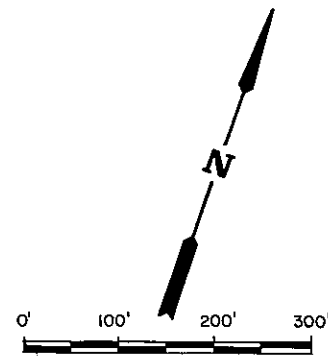
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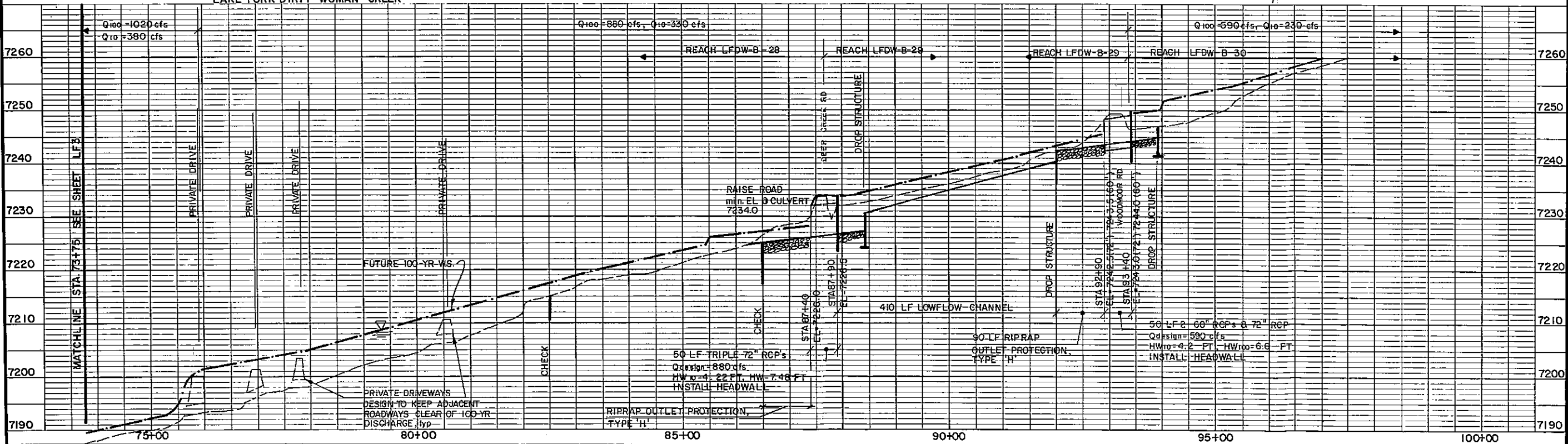
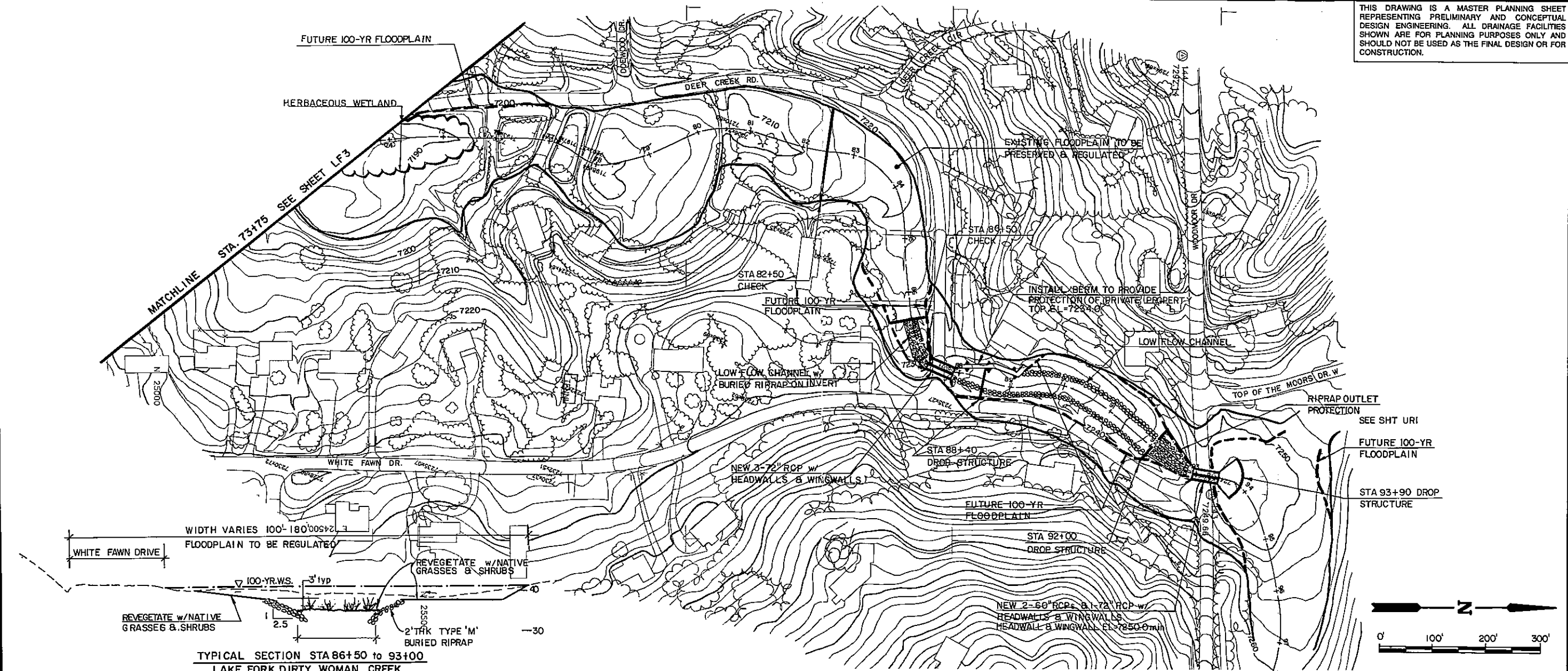
**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Lake Fork Dirty Woman Creek
Sta. 51+50 to Sta. 73+75
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

LF3



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Dirty Woman and Crystal Creeks Drainage Basin Planning Study

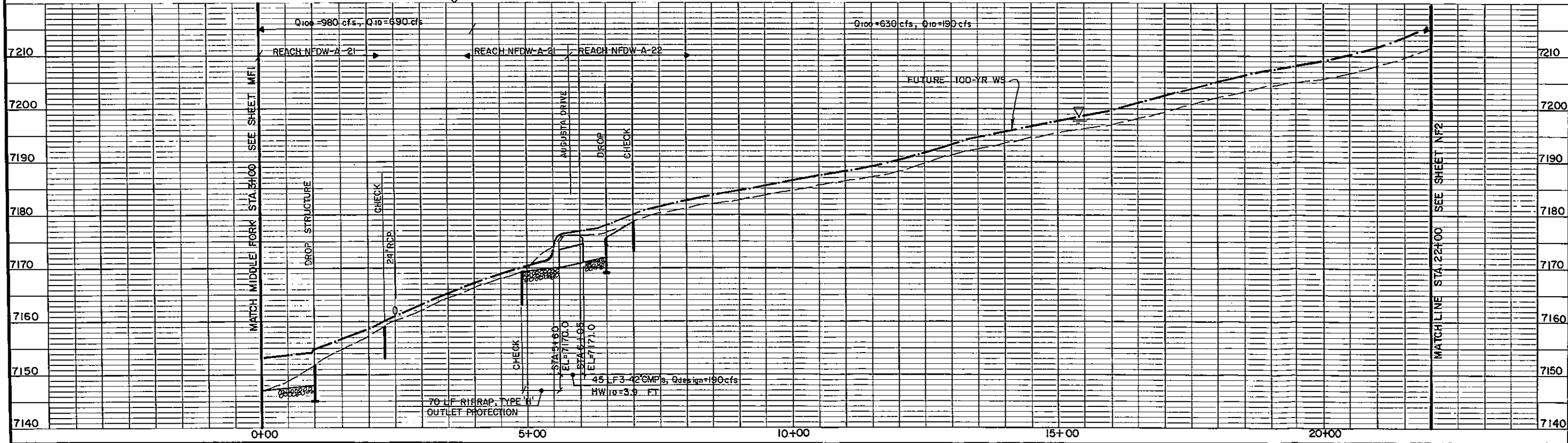
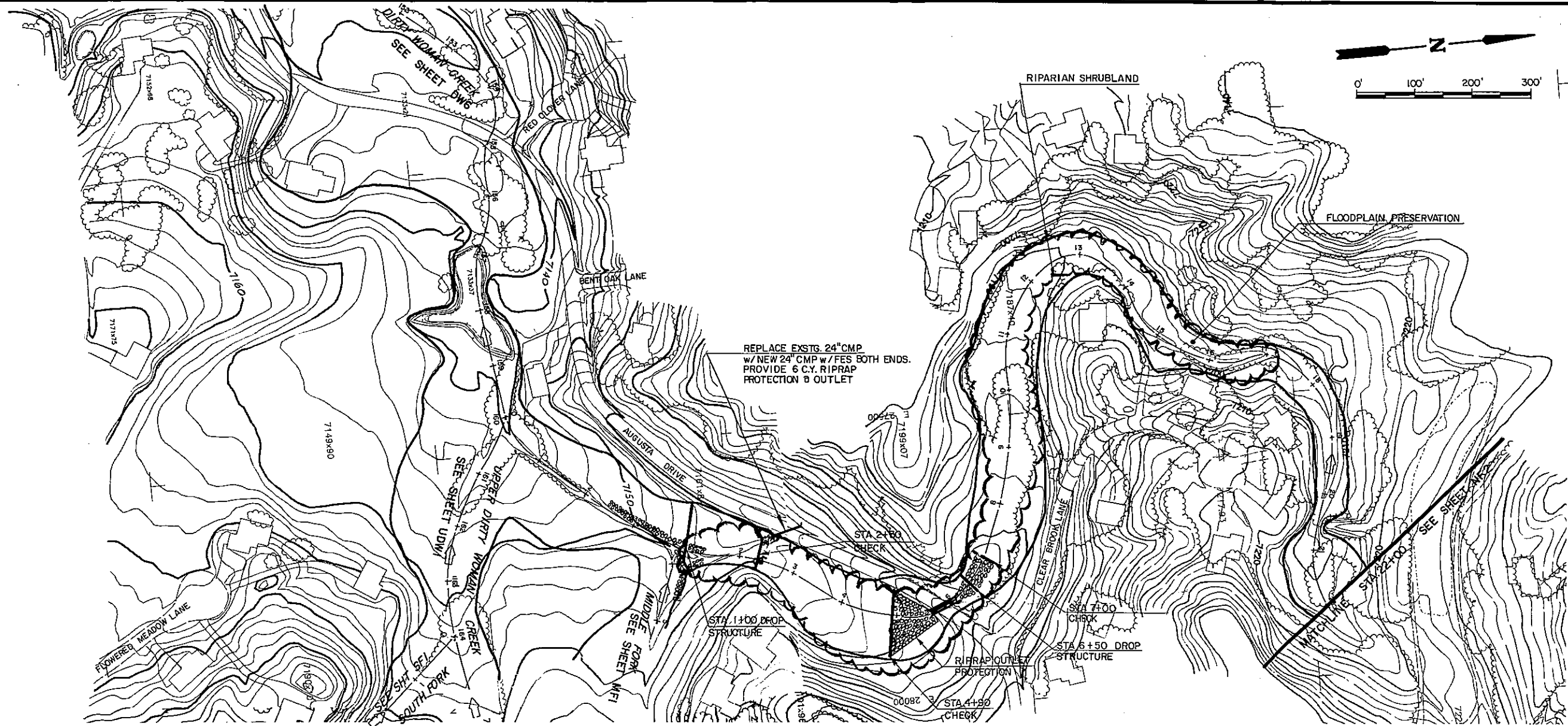
PRELIMINARY DESIGN

Fork Dirty Woman Creek
Sta. 73+75 to Sta. 97+00

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

LF4



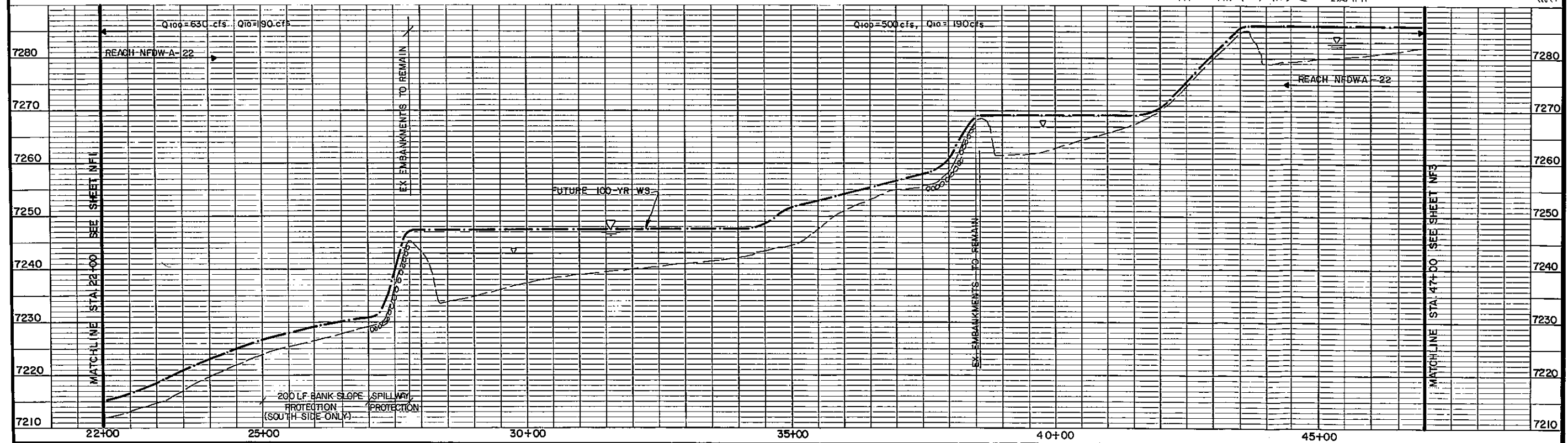
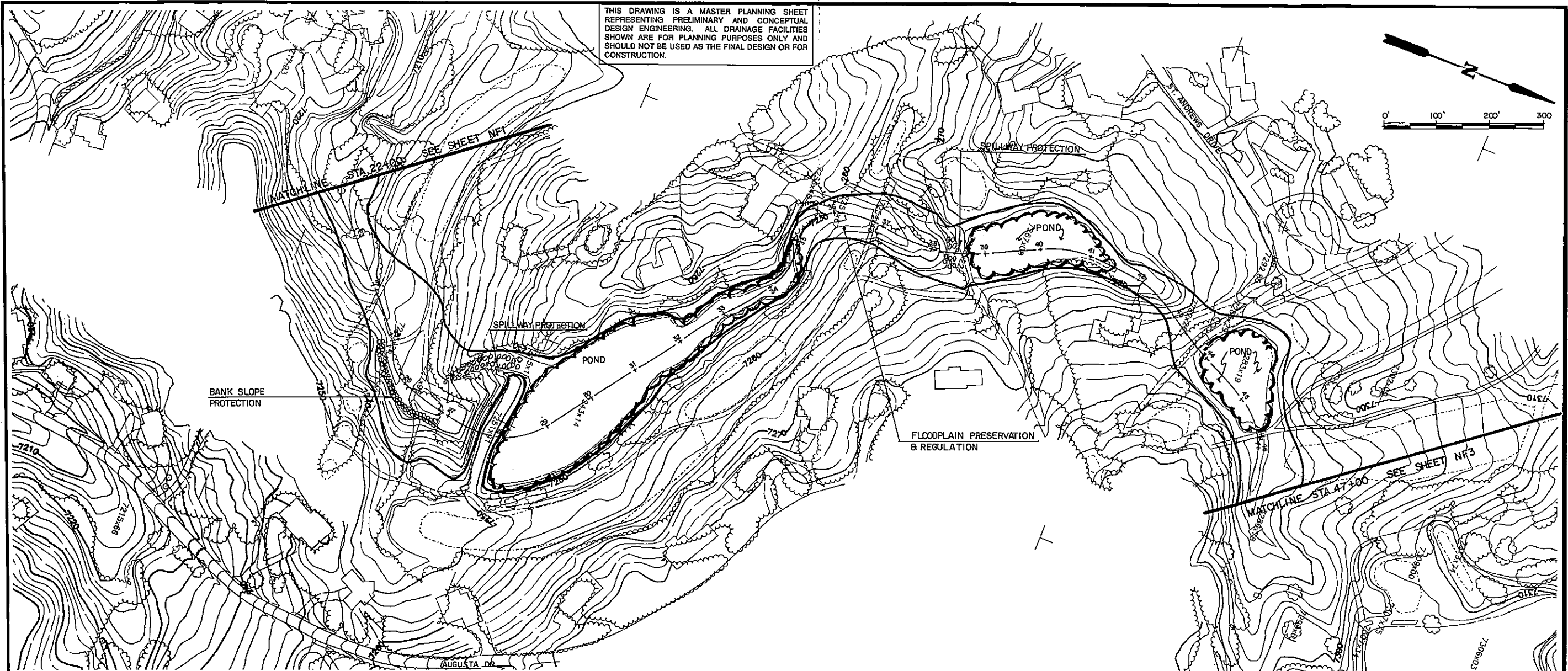
Kiowa Engineering Corporation
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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
North Fork Dirty Woman Creek
Sta. 0+00 to Sta. 22+00

El Paso County Department of Public Works Stormwater Management Division

Project No.	91-07-17
Date:	1/93
Design:	AWMc
Drawn:	EAK
Check:	RNW
Revisions:	

NF1



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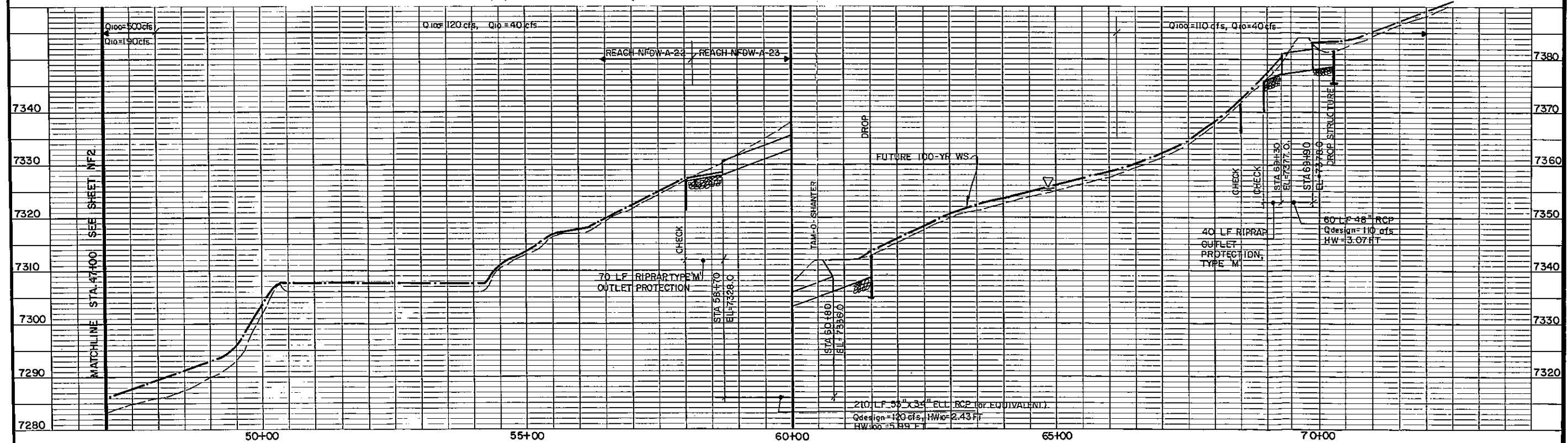
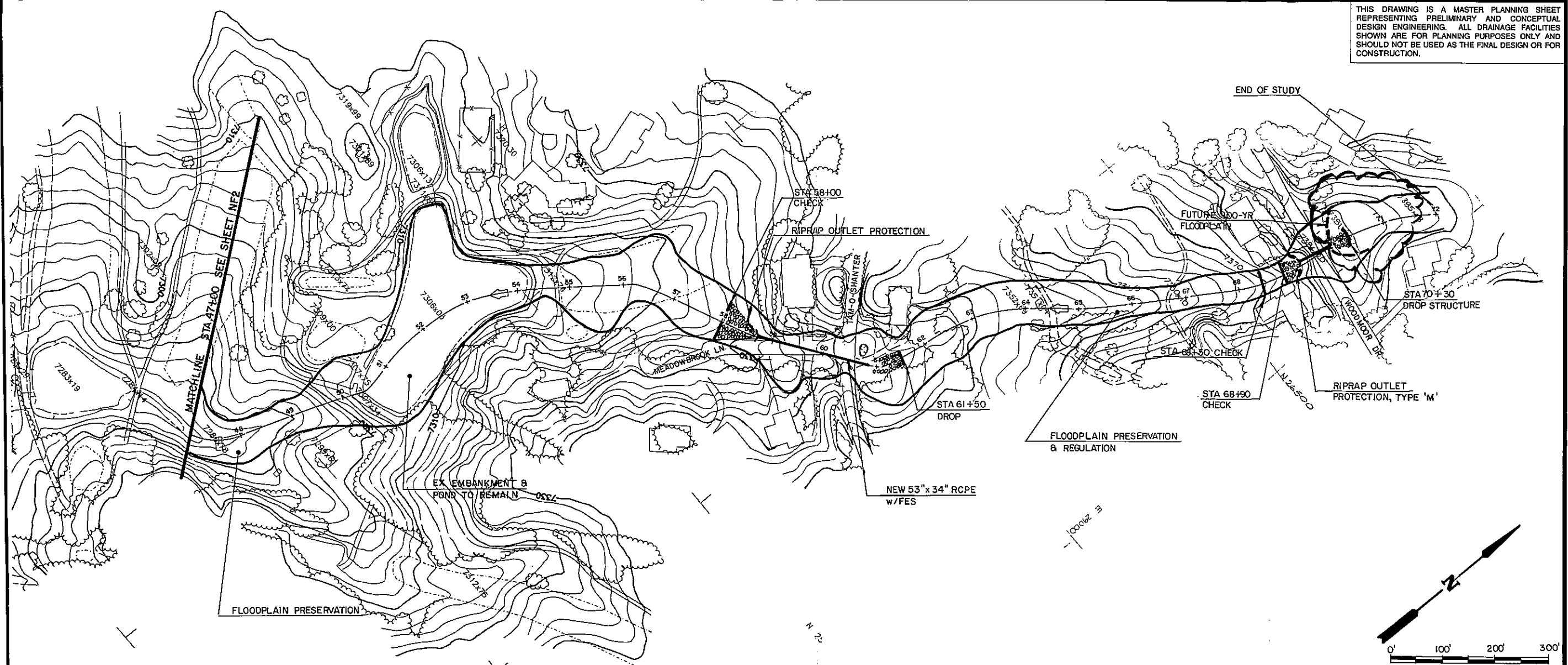
**Dirty Woman and Crystal Creeks
 Drainage Basin Planning Study**
 PRELIMINARY DESIGN
 North Fork Dirty Woman Creek
 Sta. 22+00 to Sta. 47+00

El Paso County Department of Public Works Stormwater Management Division

Project No.	91-07-17
Date:	1/93
Design:	AWMc
Drawn:	EAK
Check:	RNW
Revisions:	

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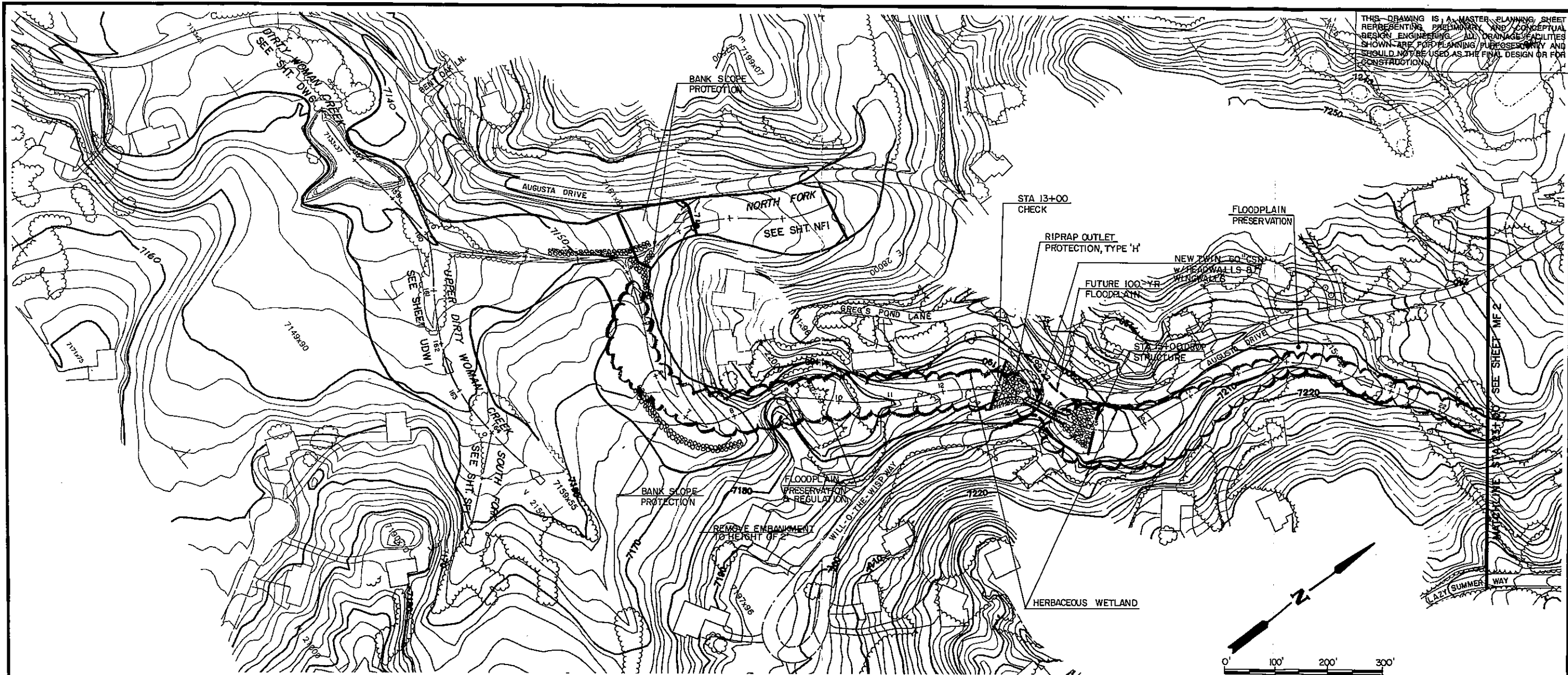
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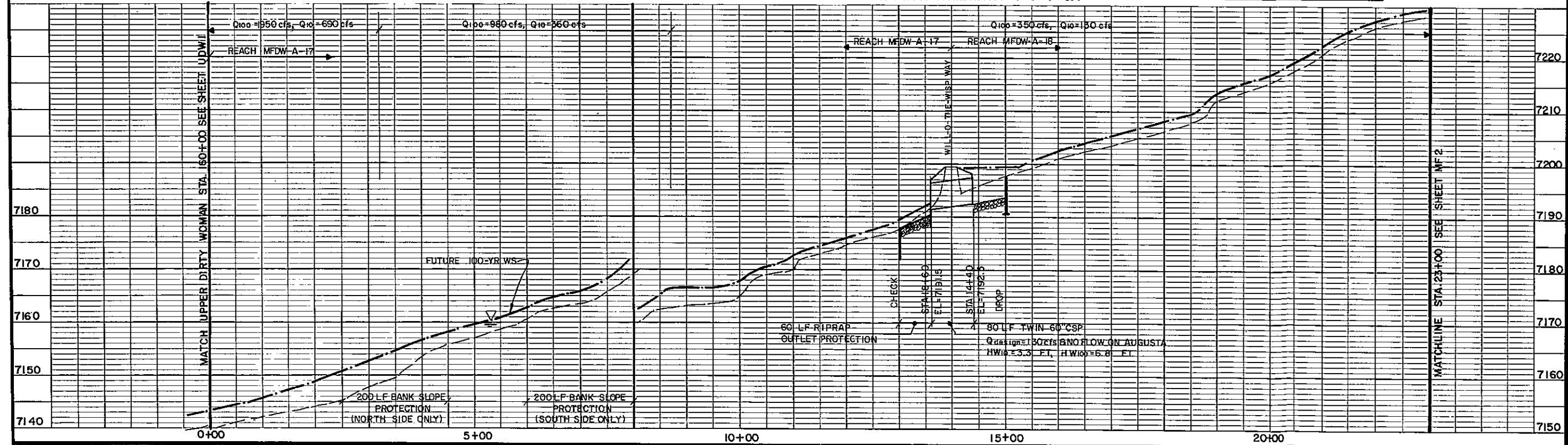
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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
North Fork Dirty Woman Creek
Sta. 47+00 to Sta. 70+00
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:
NF3



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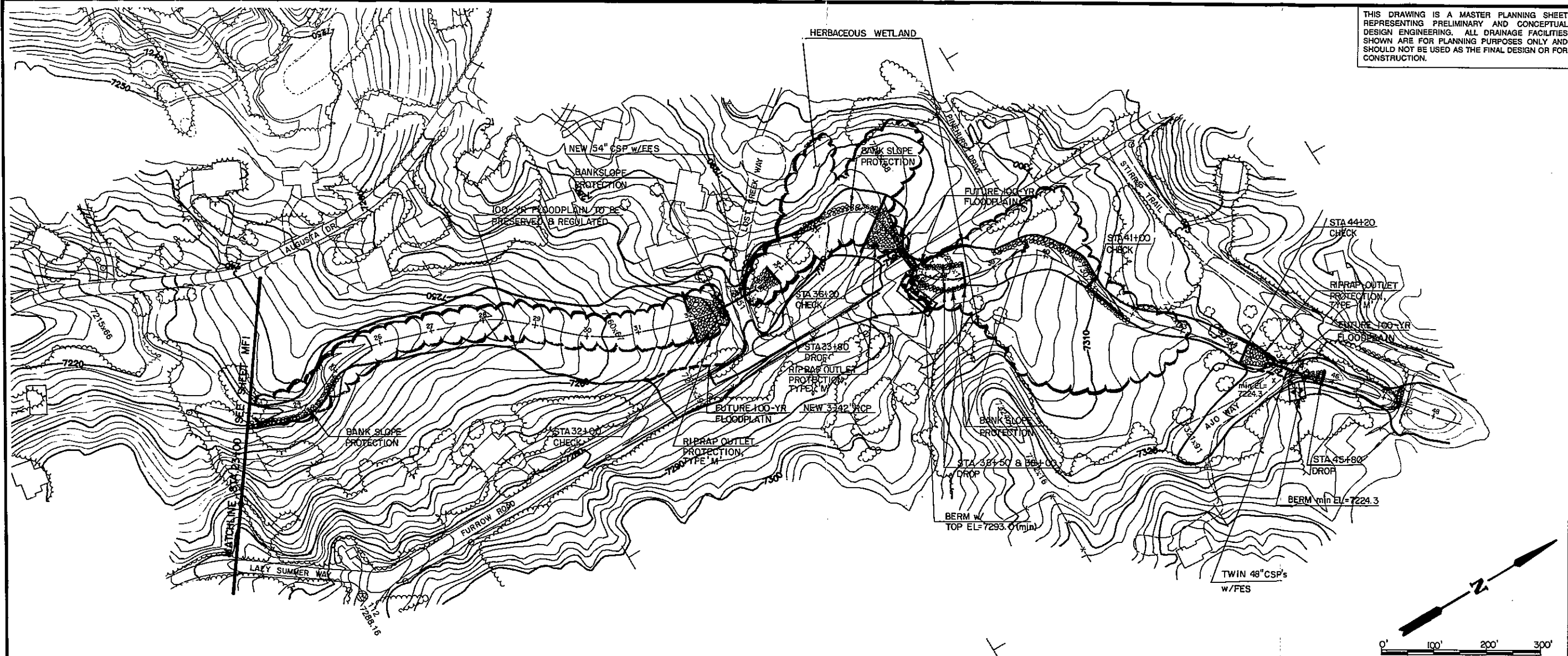
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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Middle Fork Dirty Woman Creek
Sta. 0+00 to Sta. 23+00

El Paso County Department of Public Works Stormwater Management Division

Project No.	910717
Date:	1/93
Design:	AWMc
Drawn:	EAK
Check:	RNW
Revisions:	

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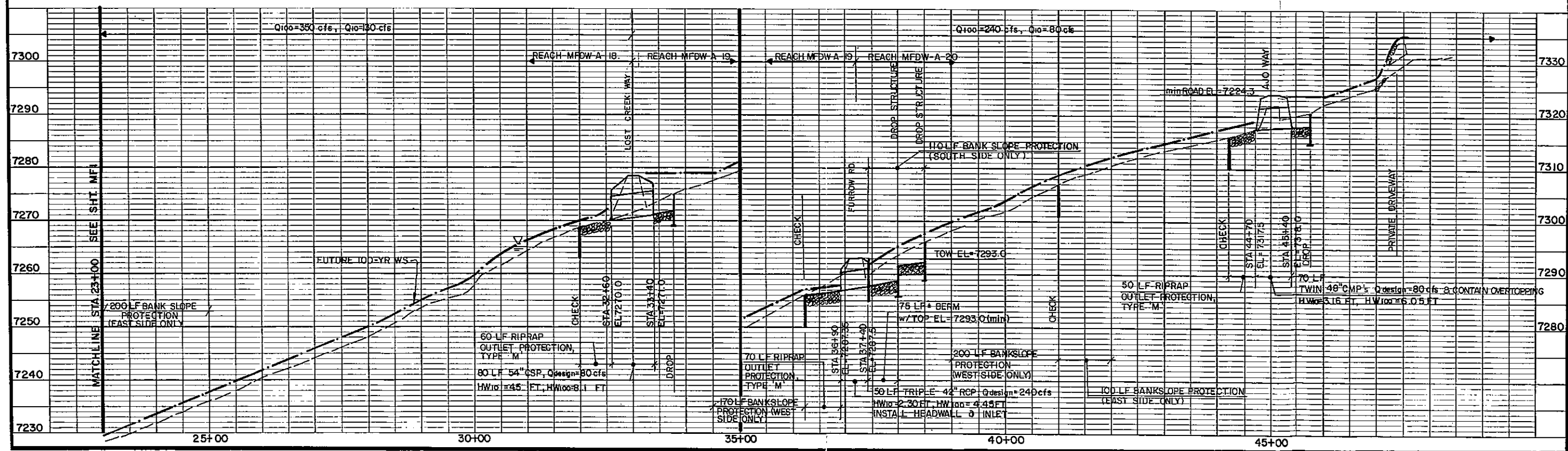


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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Middle Fork Dirty Woman Creek
Sta. 23+00 to Sta. 48+00

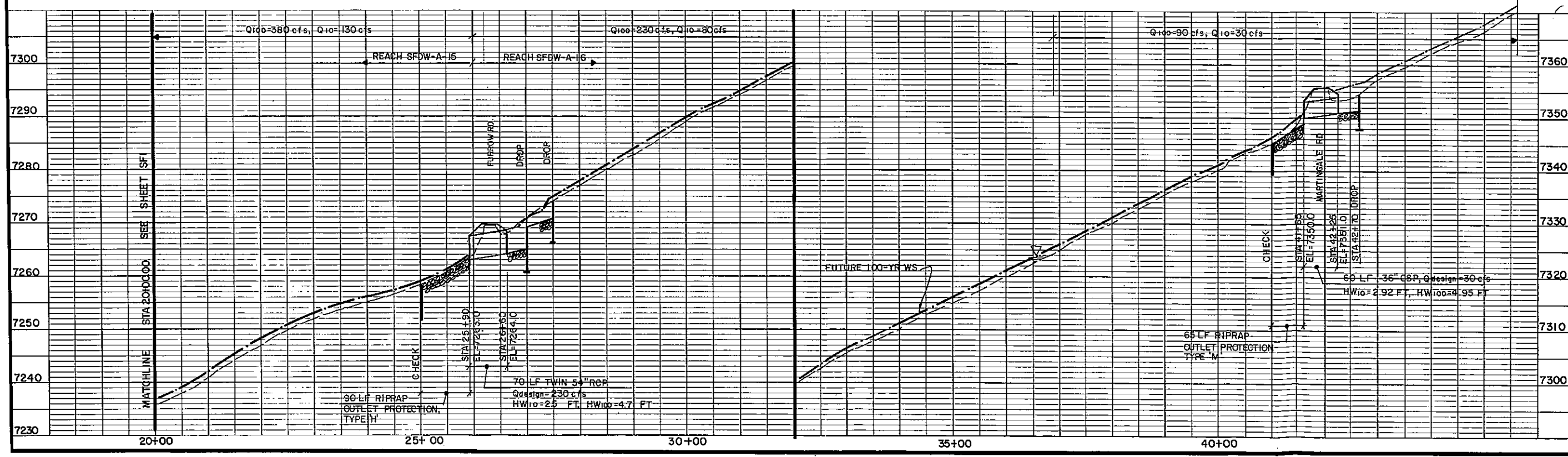
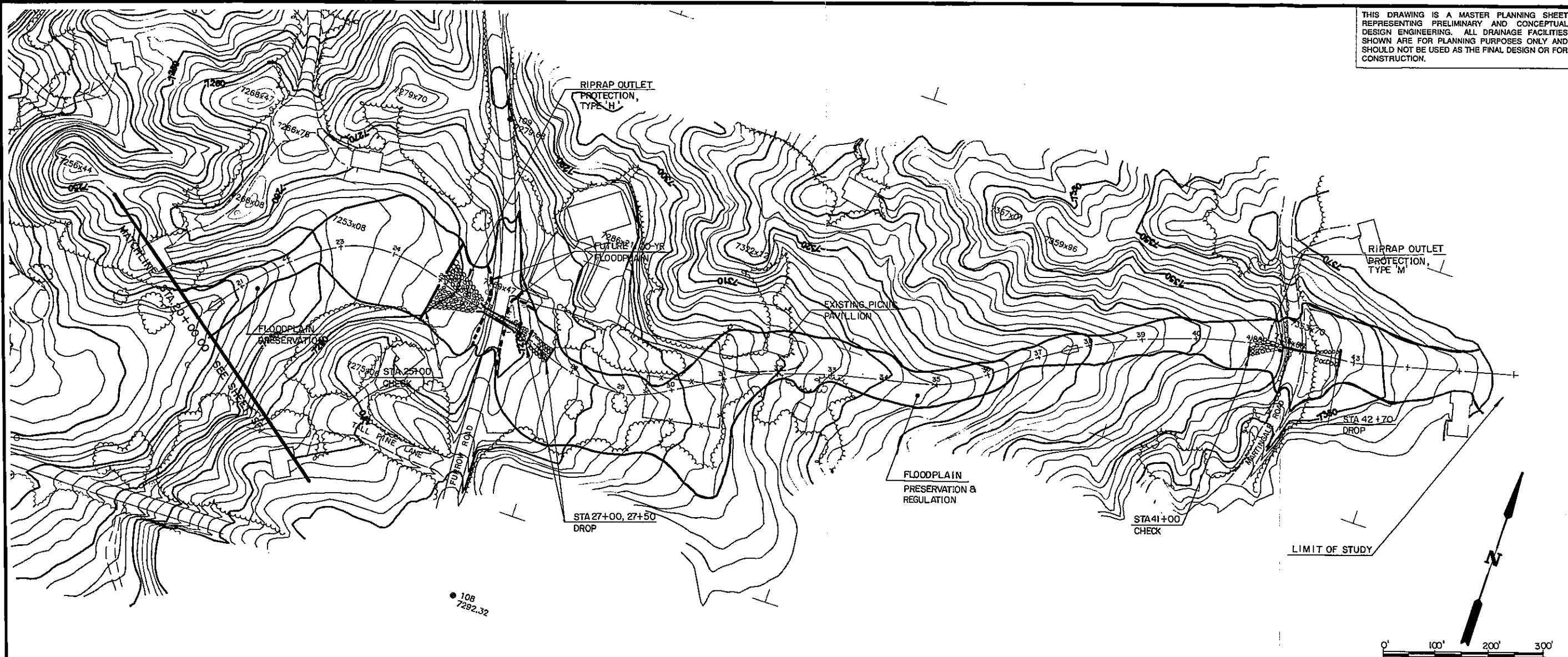
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Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

MF2

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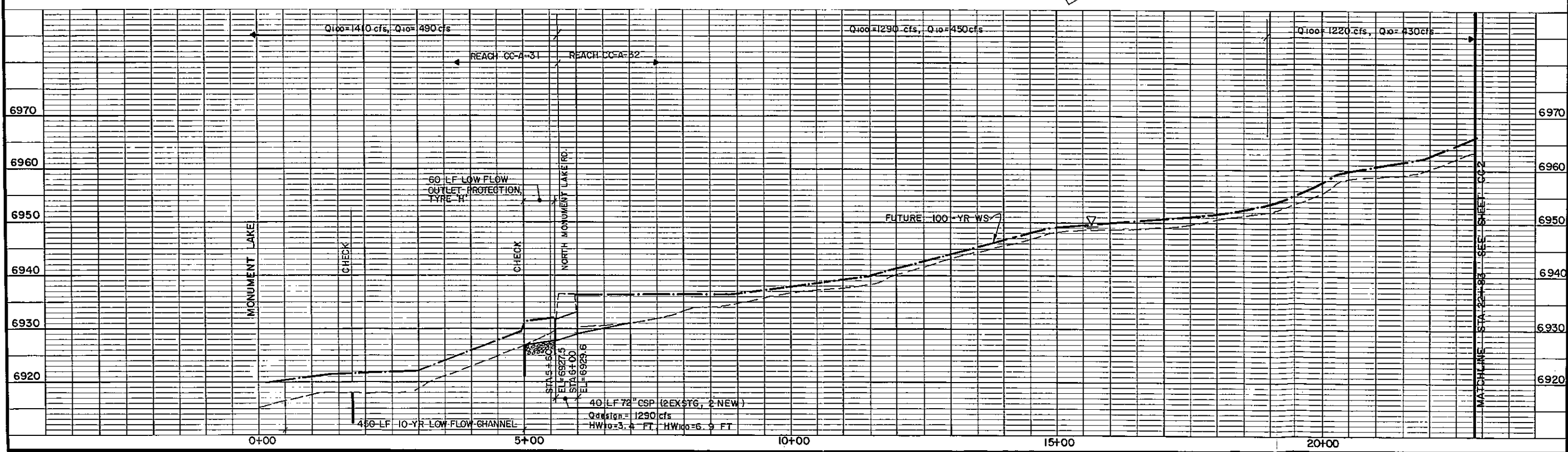
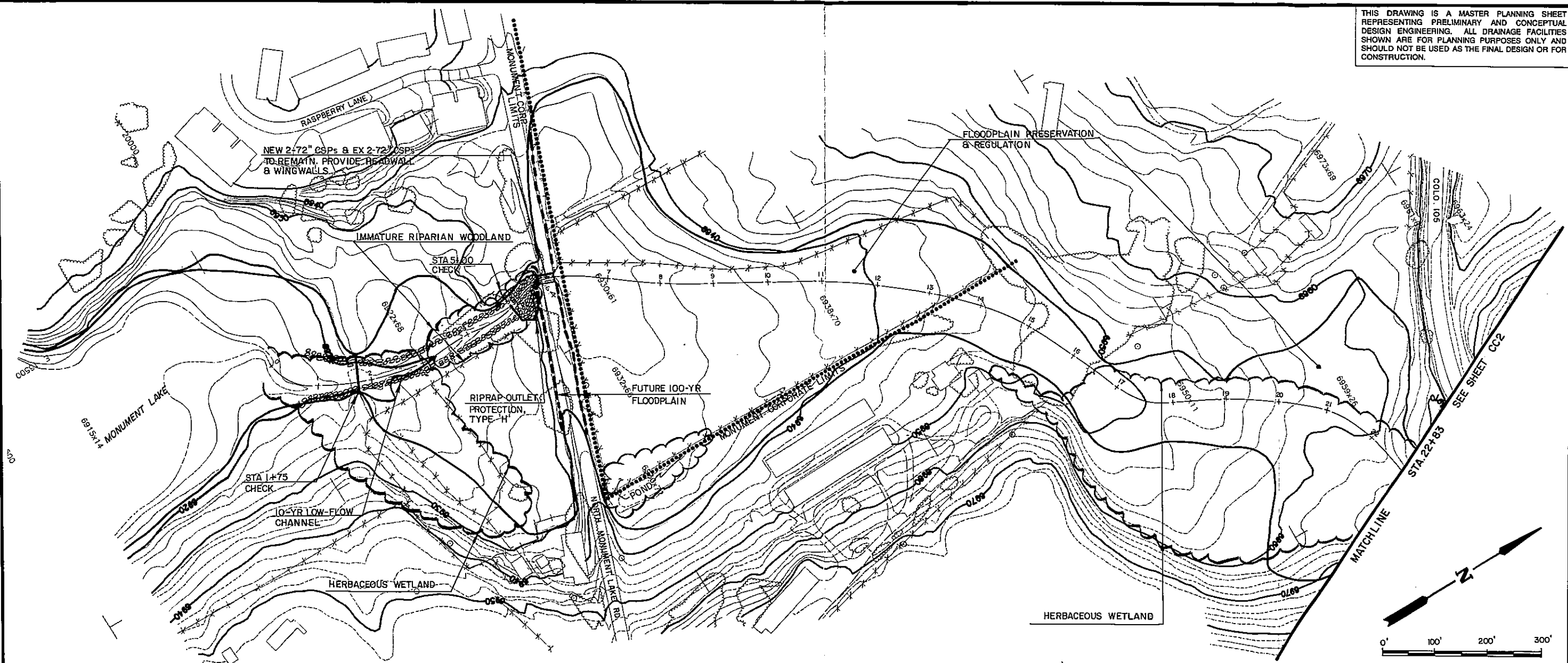
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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
South Fork Dirty Woman Creek
Sta. 20+00 to Sta. 42+00
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

SF2

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Dirty Woman and Crystal Creeks
Drainage Basin Planning Study
PRELIMINARY DESIGN

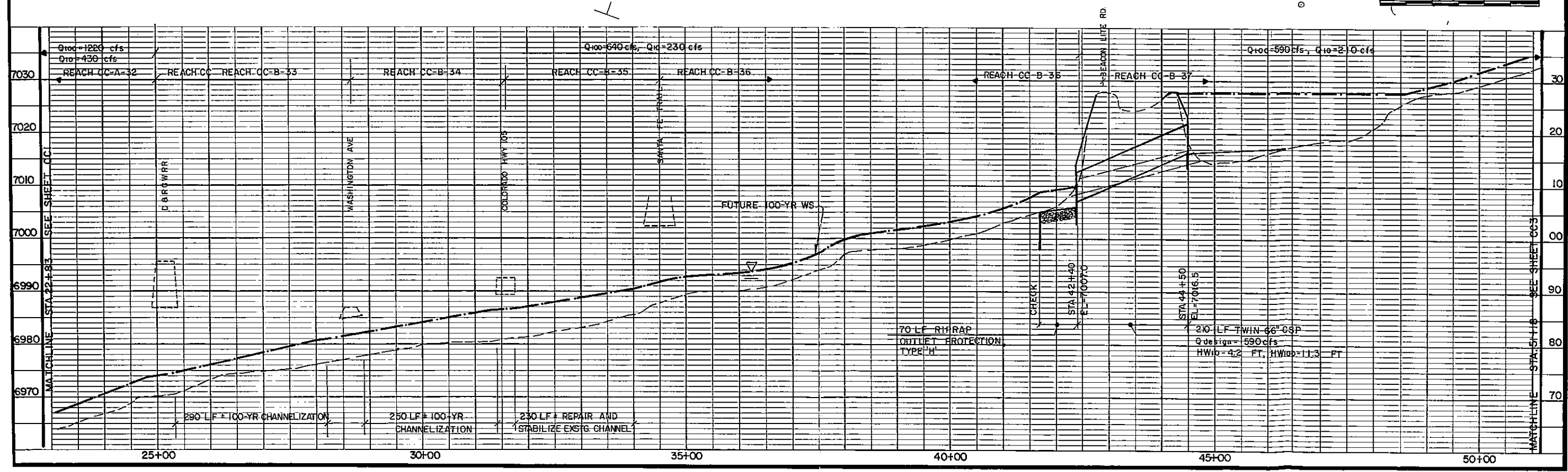
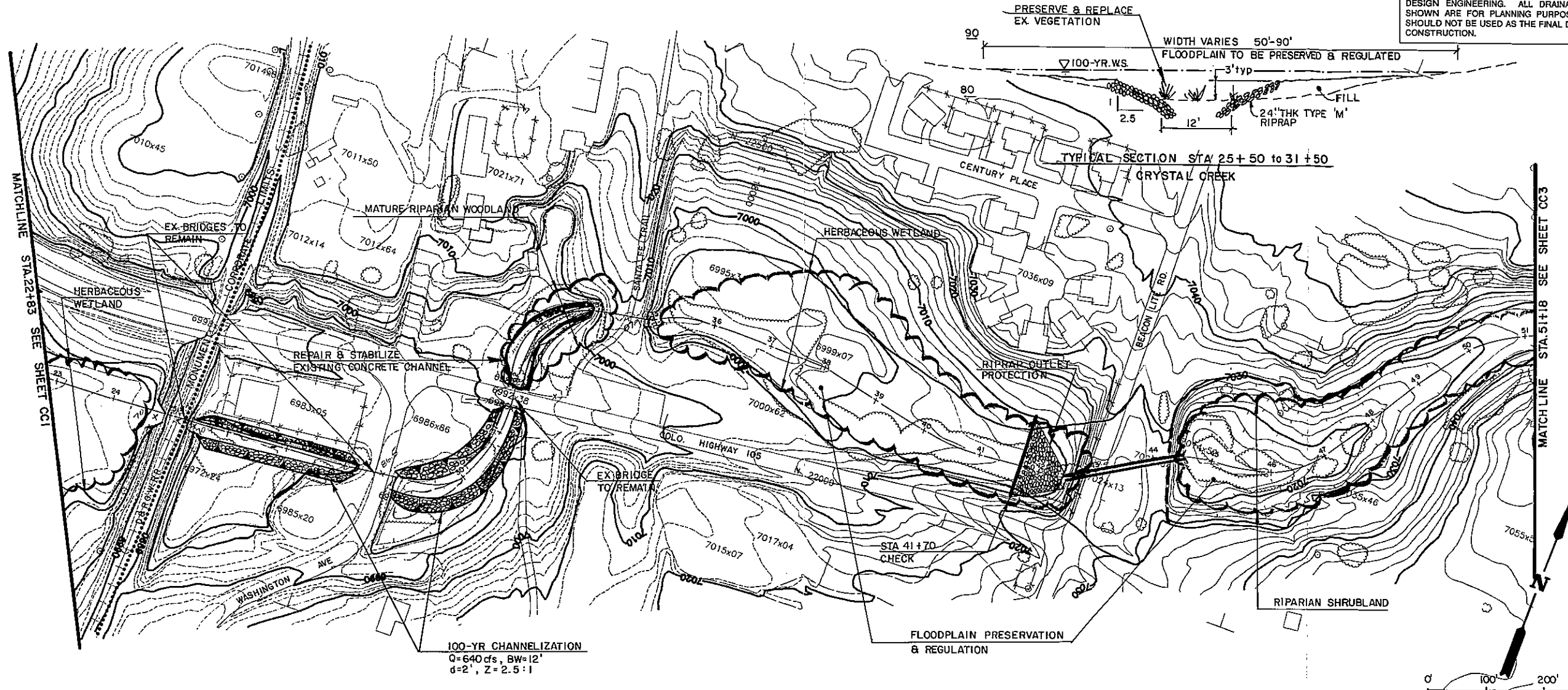
Crystal Creek
Sta. 0+00 to Sta. 22+83

El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

CC1

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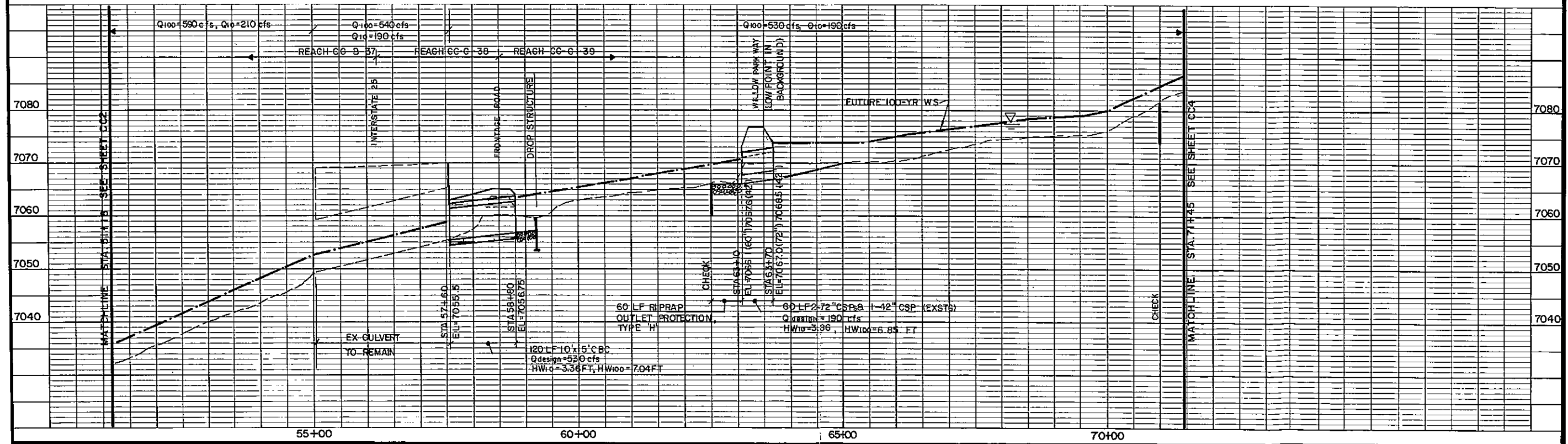
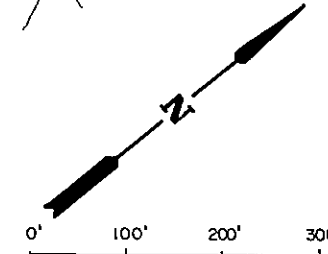
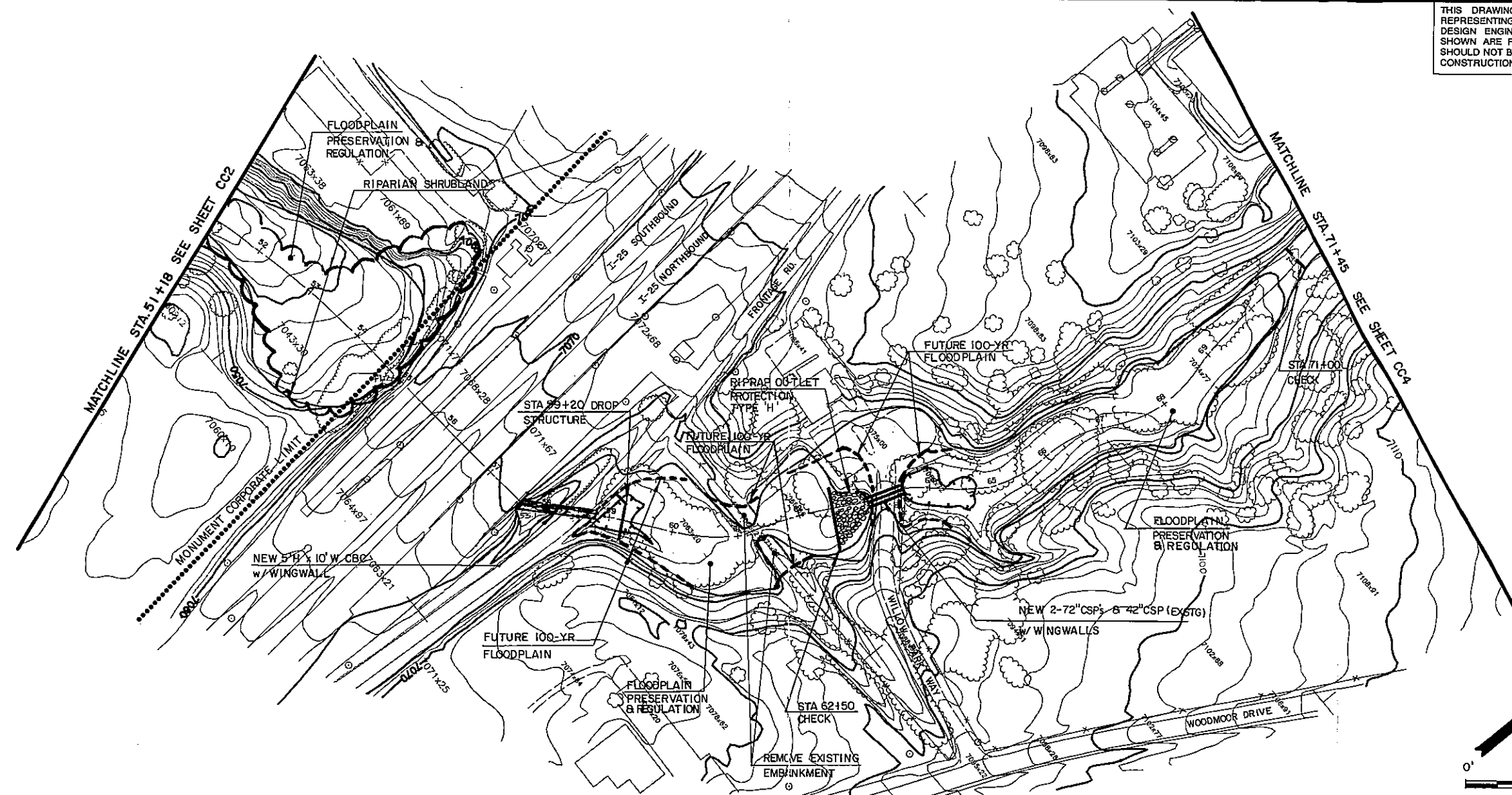
Kiowa Engineering Corporation
419 West Bijou Street
Colorado Springs, Colorado
80905-1308

**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Crystal Creek
Sta. 22+83 to Sta. 51+18
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

CC2

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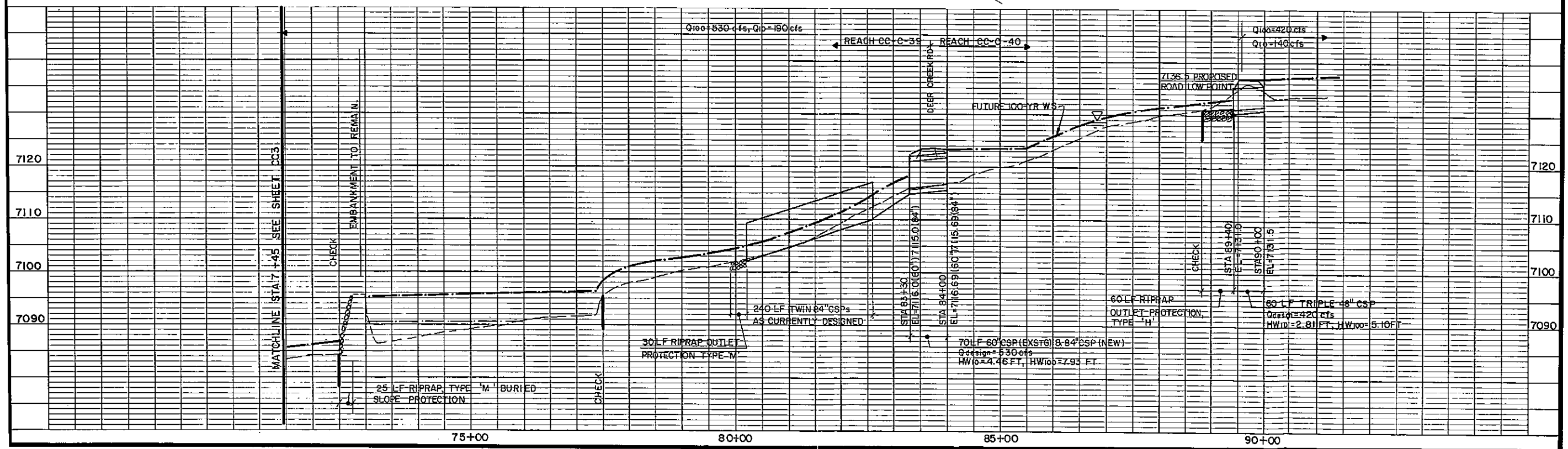
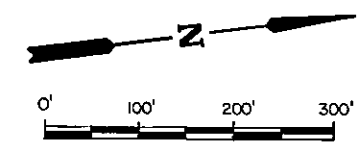
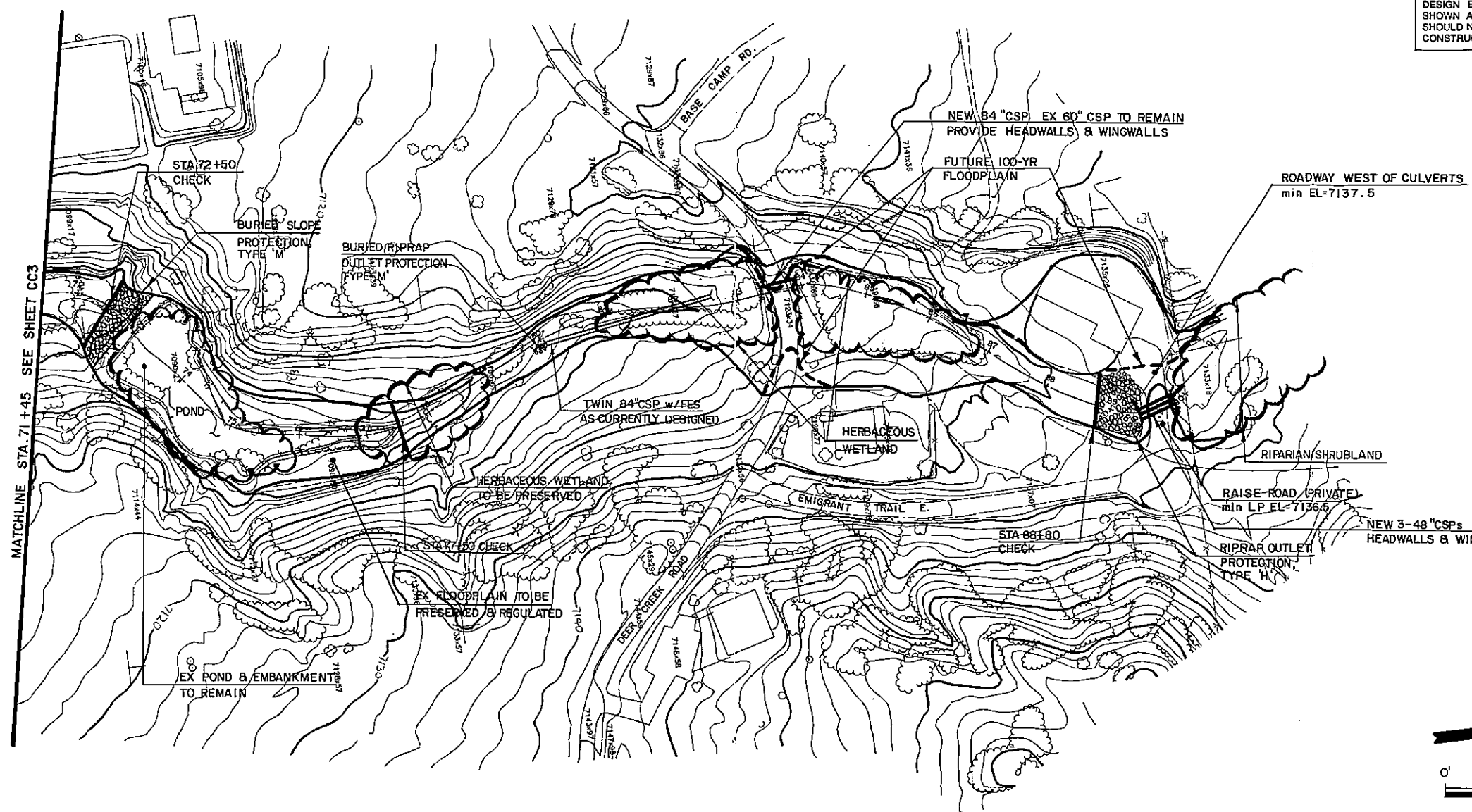


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**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Crystal Creek
Sta. 51+18 to Sta. 71+45
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AW Mc
Drawn: EAK
Check: RNW
Revisions:
CC3

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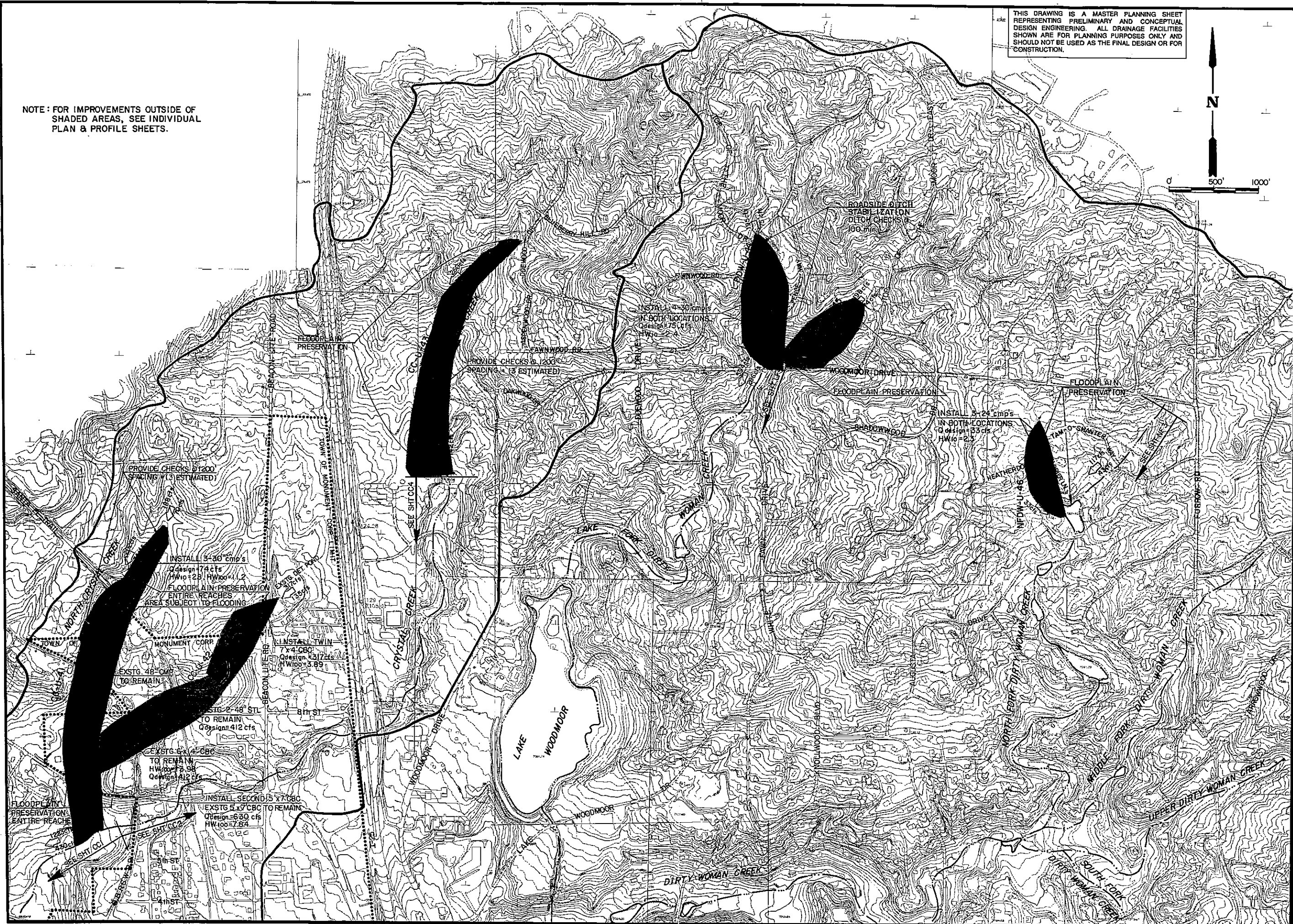
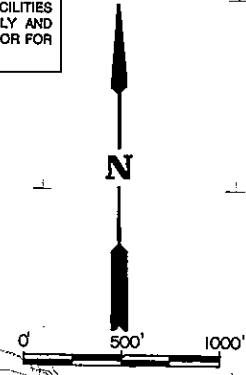
**Dirty Woman and Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN
Crystal Creek
Sta. 71+45 to Sta. 91+00
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 1/93
Design: AWM
Drawn: EAK
Check: RNW
Revisions:

CC4

NOTE: FOR IMPROVEMENTS OUTSIDE OF
SHADED AREAS, SEE INDIVIDUAL
PLAN & PROFILE SHEETS.

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Kiowa Engineering Corporation
4119 West Bijou Street
Colorado Springs, Colorado
80905-1308

**Dirty Woman & Crystal Creeks
Drainage Basin Planning Study**
PRELIMINARY DESIGN

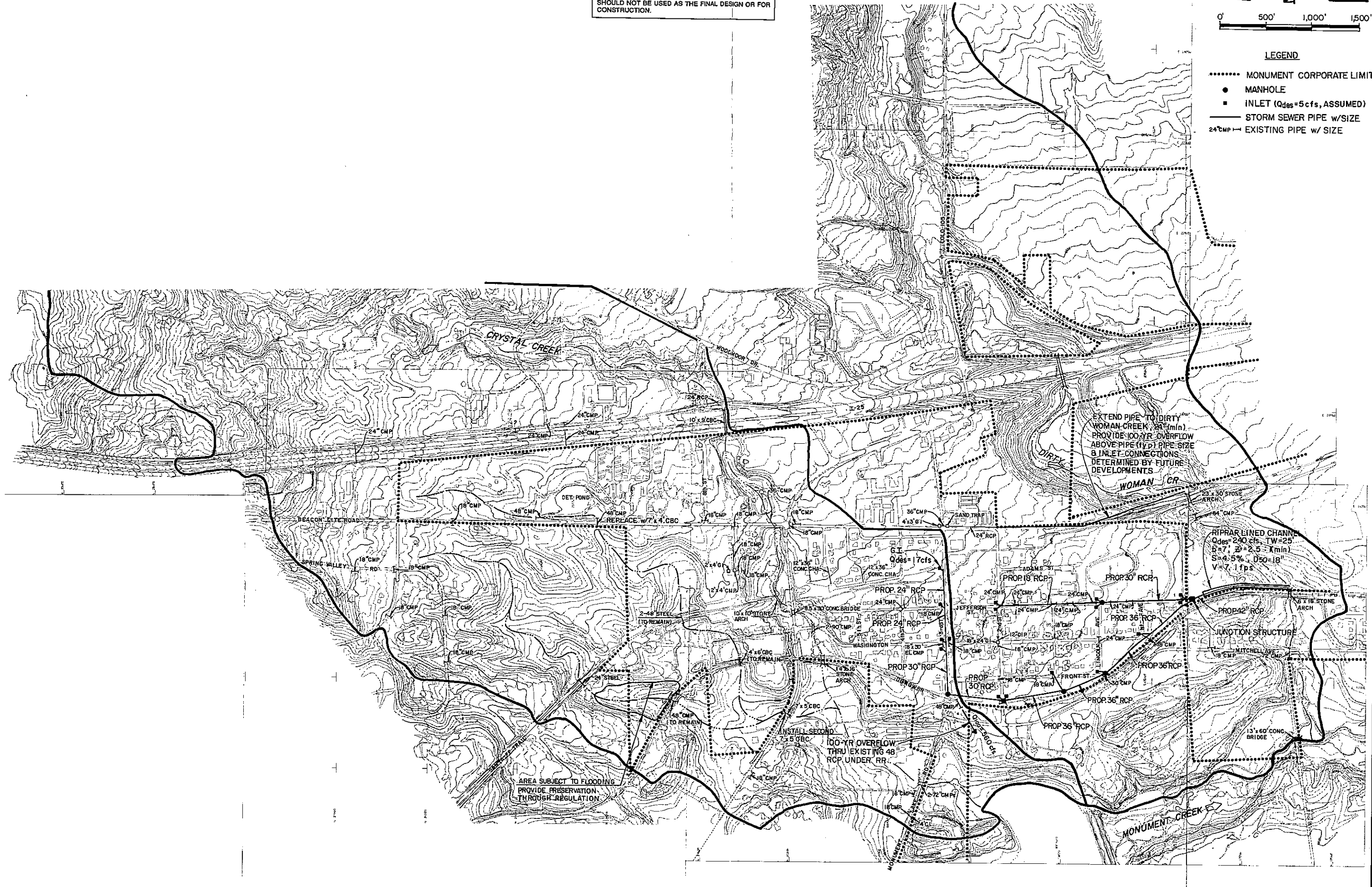
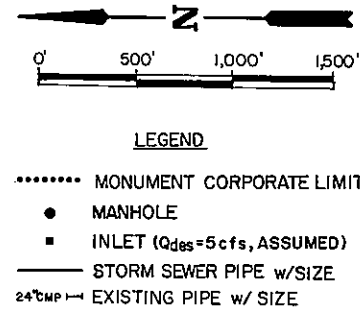
Upper Reaches Dirty Woman & Crystal Creeks

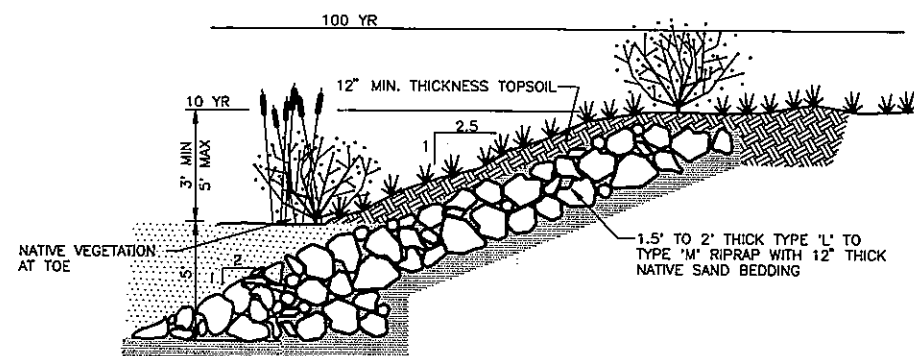
El Paso County Department of Public Works Stormwater Management Division

Project No. 91-07-17
Date: 4/93
Design: AWMc
Drawn: EAK
Check: RNW
Revisions:

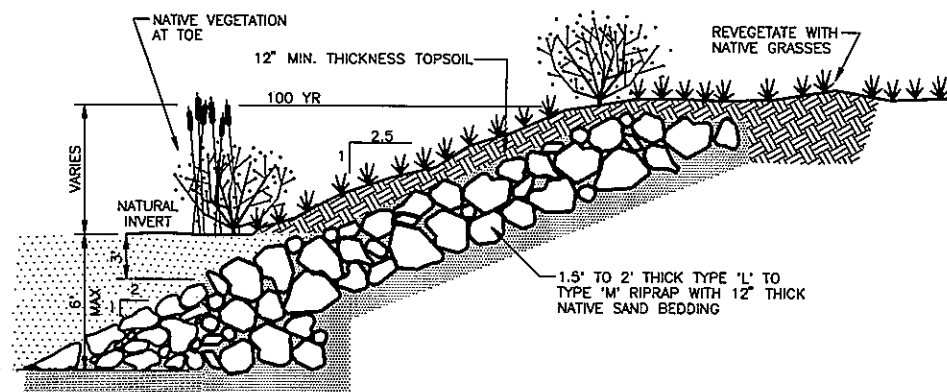
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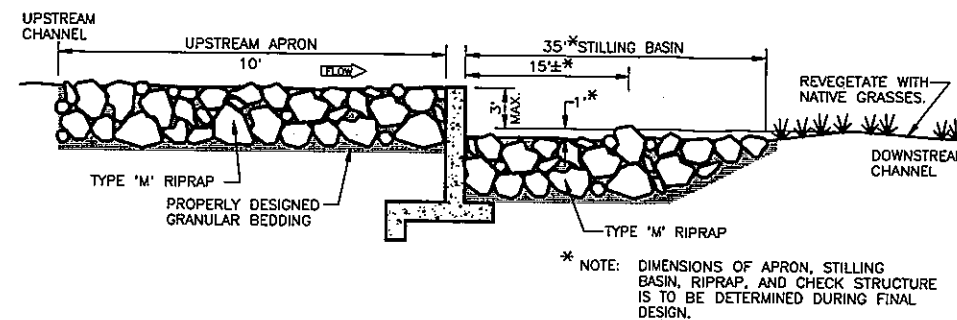




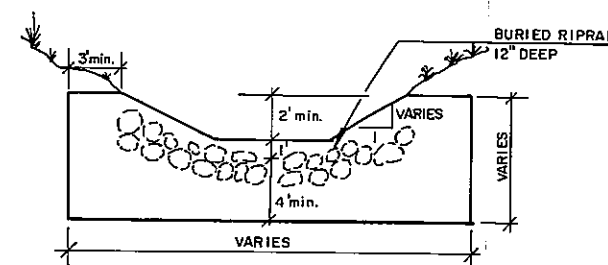
**RIPRAP LINING DETAIL FOR
LOW FLOW AND SELECTIVE
BANK LINING SECTIONS**
NTS



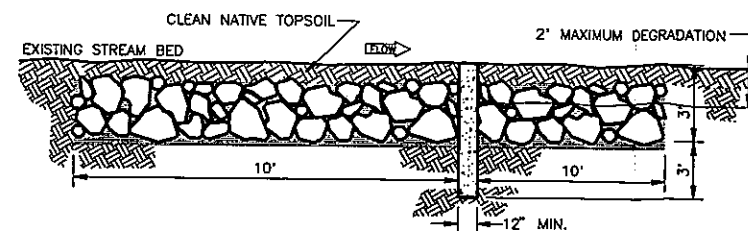
**RIPRAP LINING DETAIL FOR
100 YR CHANNEL SECTIONS**
NTS



**TYPICAL DROP STRUCTURE
GENERALIZED PROFILE**
NTS



CHECK STRUCTURE DETAIL



**TYPICAL EROSION CONTROL
CHECK PROFILE**
NTS

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**Dirty Woman & Crystal Creeks
Drainage Basin Planning Study**

PRELIMINARY DESIGN

Detail Sheet

El Paso County Department of Public Works Stormwater Management Division

Project No.: 91-07-17
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DTL