adopted by Resolution Sept. 8, 1957
w/o fee
w/ platting agreement
Old Dry Creek fee left in place
for small subdivisions outside
the platting agreement boundary.

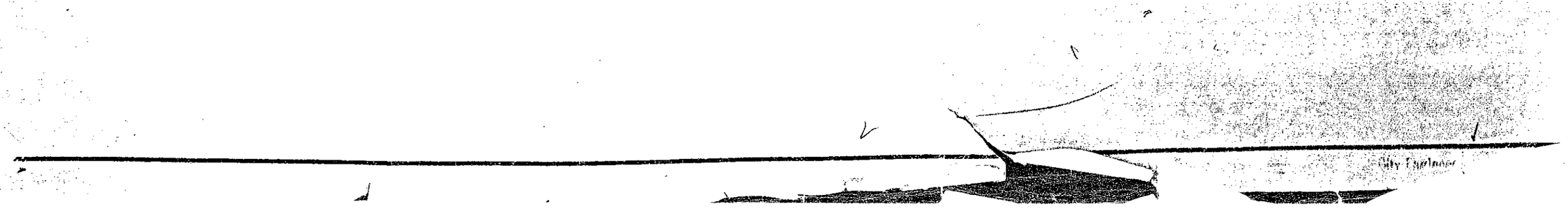
A STUDY OF

THE DRY CREEK DRAINAGE BASIN

JANUARY, 1984

REVISIED: FEBRUARY, 1985

CITY OF COLORADO SPRINGS, COLORADO



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I. TRANSMITTAL LETTER

KKBNA

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March 11, 1985

City of Colorado Springs
Department of Public Works
30 South Nevada
Colorado Springs, Colorado 80901

Re: Dry Creek Drainage Basin Study
Colorado Springs, Colorado

Gentlemen:

As requested, enclosed are 5 copies of the completed re-study of the Dry Creek Drainage Basin. This report is the final draft of Dry Creek Drainage Basin Study which was submitted to the City of Colorado Springs Drainage Board in January of 1984.

This report includes the basin description, hydrology, hydraulics, cost estimate, itemization of recommended improvements, and flood/stage information. This final draft also reflects modifications required as a result of City review, meetings with City personnel, and in-house technical reviews.

This study has been prepared as a master plan guide to coordinate drainage facility construction and repairs within the study area. The intent of this report is to provide preliminary drainage facility design, in accordance with the City of Colorado Springs guidelines. This study also establishes estimated drainage improvement construction costs within the basin. However, due to conflicting opinions regarding the structure of the Dry Creek Basin Drainage fees, no Drainage Basin fees were recommended.

We hope that this submittal satisfactorily addresses the concerns highlighted during the review process. We are prepared to make whatever presentations that you may require for final acceptance of this report. Please feel free to call if any further questions or comments should arise.

Very truly yours,

Gary A. Thomas, P.E.
Associate Principal

Enclosures

GAT/bre

II. ENGINEER'S CERTIFICATE

CERTIFICATION

I, Gary A. Thomas, a Registered Engineer in the State of Colorado, hereby certify that the attached Drainage Study for the Dry Creek Drainage Basin was prepared under my direction and supervision, and is correct to the best of my knowledge and belief. I further certify that the said drainage study is in accordance with all City of Colorado Springs Ordinances, Specifications and Criteria.

Gary A. Thomas, P.E., Colorado 15586

APPROVAL

The City of Colorado Springs Council and Department of Public Works does hereby approve the contents of the attached Dry Creek Drainage Study. The study shall be used as a guide for development of all drainage facilities within the study area.

Department of Public Works

City Council

III. SCOPE AND INTENT OF STUDY

DRY CREEK DRAINAGE BASIN STUDY

SCOPE AND INTENT OF STUDY

The purpose of this study is to review and update the master drainage study for the Dry Creek Drainage Basin, taking into account boundary adjustments for the limits of the study. The scope of work for this study is to: analyze a series of alternative drainage concepts to determine the most cost effective drainage plan for the ultimate development of the basin, determine the existing and estimated fully developed FEMA 100-year and 500-year floodplain elevations and limits, determine adequacy of existing facilities and recommend improvements necessary to correct deficiencies, determine maintenance concerns, to provide a preliminary cost estimate to be used as a basis to structure a Basin Drainage Fee system in the future.

From the alternatives analyzed, an alternative was determined which is the most cost-effective plan for the City of Colorado Springs. The analysis is based on the reduction of damage potential derived from cost comparisons, as well as environmental, operation and maintenance, and intangible considerations. To arrive at this end result, the following generalized steps are employed:

1. Coordination meetings with the City of Colorado Springs.
2. Data collection from appropriate agencies.
3. Analysis of existing facilities.
4. Review of existing reports.
5. Review and compilation of area soil characteristics.
6. Utilization of storm drainage criteria of the City of Colorado Springs and FEMA storm drainage criteria.
7. Definition of the drainage basin and subbasins; hydrologic studies to define runoff for 5-, 100-, and 500-year frequency storms for existing and fully developed conditions.
8. Hydraulic computations defining water surface profiles and floodplains.
9. Development of the most viable alternative plans for consideration by the City.
10. Development of benefit-cost analysis for the most viable alternative plans to arrive at the recommended alternative.
11. Hydrologic and hydraulic calculations for the best alternative plan and mapping for the various frequencies.
12. Consideration of operation and maintenance for the best alternative plan.
13. Cost estimate to provide basis for future fee determination for the best alternative.

IV. GENERAL DESCRIPTION OF THE BASIN

GENERAL DESCRIPTION OF BASIN

Dry Creek Basin

The Dry Creek Basin lies within portions of Sections 1, 2, 3, 4, 5, 10, 11, and 12, Township 13 South, Range 67 West; Sections 32 and 33, Township 12 South, Range 67 West; and Section 7, Township 13 South, Range 66 West, El Paso County, Colorado, and contains approximately 3.5 square miles. Of the total drainage basin area, 2.41 square miles lie within the northwest portion of the corporate limits of the City of Colorado Springs, 0.92 square miles lie within the Pike National Forest, and 0.25 square miles lie within unincorporated El Paso County.

The Dry Creek Basin is bounded on the west by the Front Range of the Rocky Mountains, on the south and north by ridges, and on the east by Monument Creek. The south ridge separates the Dry Creek Basin from Douglas Creek and North Rockrimmon Drainage Basins. The north ridge separates the Dry Creek Basin from the West Monument Creek Basin, as well as a previously unnamed basin, referred to in this report as North Basin. Monument Creek forms the eastern basin boundary and is the major outfall for the Dry Creek Basin.

The Dry Creek Basin slopes from west to east toward Monument Creek, rising from elevation 6250' to elevation 9250'. The western portion of the basin is heavily forested, mountainous terrain, drained by three major tributaries of Dry Creek. These tributaries are steep, well defined ravines which come to a confluence west of the Sisters of Mount Saint Francis Convent. The central portion of the basin is characterized by gently rolling wide valleys, separated by foothill ridges and mesas. Through the central portion of the basin, Dry Creek is poorly defined and flows through broad, gently sloping meadows. The eastern portion of the basin is fully developed, and Dry Creek flows through well defined and eroded channels as well as greenbelt areas. With the exception of nuisance flow, flow in Dry Creek and its tributaries is intermittent.

The central and western portion of the basin, presently, has little development. However, two major developments, Falcon Ridge and Peregrine, are planned for the area. The Falcon Ridge development will occupy approximately 112 acres, formerly know as the Carlson Dairy Farm. This development will consist of approximately 296 single-family and townhouse residential units. The proposed Peregrine development will consist of approximately 1670 single-family, multi-family residential units, and a neighborhood commercial area, occupying approximately 752 acres of the Dry Creek Basin. This land is currently owned by the Sisters of Mount Saint Francis. Upon development, the Sisters will retain approximately 112 acres around their convent.

To date, all major development has taken place in the eastern portion of the Dry Creek Basin. Development in this area ranges from townhouses and condominiums to single-family residential units. Interstate 25 provides the primary access to the basin. Other major streets in the area include Woodmen Road, Rockrimmon Boulevard, Delmonico Drive, and

Big Valley Drive. Local drainage control in this area consists primarily of curb and gutter, storm sewers, and drainage chutes which outfalls to Dry Creek.

North Basin

North Basin, a previously unnamed basin, lies within portions of Sections 1, 2, and 3, Township 13 South, Range 67 West; Sections 34, 35, and 36, Township 12 South, Range 67 West; and Section 6, Township 13 South, Range 66 West, El Paso County, Colorado. It contains approximately 2 square miles, of which, 0.51 square miles lie within the corporate limits of the City of Colorado Springs, 1.35 square miles lie within unincorporated El Paso County, and 0.14 square miles lie within the United States Air Force Academy.

The North Basin is bounded on the south and west by a ridge which separates the North Basin from the Dry Creek Basin. The basin is bounded on the north by a ridge which separates the North Basin from the West Monument Creek Basin. The Denver and Rio Grande West Railroad fill forms the eastern boundary, with Monument Creek being the outfall for the North Basin.

The North Basin slopes from west to east rising from elevation 6295' to elevation 7100' and is characterized by gently rolling, wide valleys, separated by foothill ridges and mesas. Several small, poorly defined, natural drainageways convey storm runoff to Monument Creek. The intermittent flow from these drainageways enter Monument Creek at five separate points.

At present, only the northeastern and southeastern portions of the North Basin are developed. Development in the northeastern portion consists mainly of single-family, 5±-acre lots. Development in the southeastern portion is more extensive and varies from single-family residential units to commercial development. Future land use plans for the North Basin only indicate development in the extreme westerly portion of the basin, where the Peregrine development will occupy approximately 220 acres. This development lies within the corporate limits of the City of Colorado Springs and proposes 817 multi-family and single-family units. The remaining portion of the North Basin which lies within unincorporated El Paso County is zoned A-2 (agriculture and 5-acre lots), but no major land development is presently known.

V. BASIN CHARACTERISTICS

BASIN CHARACTERISTICS

The soil and vegetative cover found in a watershed are important factors to consider when estimating the amount of excess precipitation which will runoff the watershed. In addition, the erodibility of the soil must be considered when designing flood control facilities, as well as other improvements. Soils information was taken from "Soil Survey of El Paso County Area, Colorado," prepared by the Soil Conservation Service (SCS) and from a letter from the National Forest Service to KKBNA dated December 20, 1983.

The soils found in the basins studied range from very shallow gravel overlaying Pikes Peak granite (high runoff potential) to excessively drained sands formed in alluvial deposits (low runoff potential). For soil types and approximate location of soil boundaries, please refer to Appendix 5. Vegetation ranges from Ponderosa pine, Lodgepole and Douglas fir to native grasses and weeds. The following discussion describes the geologic formations, vegetative cover, and runoff and erosion potential of soils found within the basin.

Dry Creek Basin

The steep, mountainous slopes of the uppermost reaches of the Dry Creek Basin are currently covered with a dense stand of Lodgepole and Douglas fir. The soil found in this area is gravelly coarse sandy loam that is developing in deeply weathered Pike's Peak granite. The steep slopes and shallow gravelly soils give these upper reaches a high potential for runoff and make the area extremely susceptible to erosion if the existing ground cover is disturbed.

The wide, gently sloping meadows in the central portion of the basin are covered with native grasses and weeds. The topsoil found in these meadows ranges from gravelly sandy loam to clay loam with a stratified underlying material ranging from heavy clay loam to sand. This soil is well drained and there is no evidence of groundwater to a depth of 60 inches. The gentle slopes and the soils found in these meadows make the runoff potential for this area low and the erosion potential moderate.

The moderately steep to steep slopes in the south central portion of the basin and the ridge that divides the meadow in the central portion of the basin are currently covered with a thin stand of Ponderosa Pine. The soil found in these areas consists of a thin layer of sandy loam overlying hard arkosic sandstone. Rock outcrops are common throughout the area. These steep slopes covered with shallow sandy soil have a high runoff potential and are extremely susceptible to erosion.

The remainder of the Dry Creek Basin is made up of moderately steep slopes that are currently covered by a thin stand of Ponderosa Pine. The soils found in this region include gravelly sandy loam, sandy loam, loamy sand, gravelly loamy sand and clay loam, which were formed in, or are on alluvial fans. The soils and topography throughout this portion of the basin have a moderate runoff potential and are moderately

susceptible to erosion. However, if the ground cover is removed, this soil will become extremely susceptible to erosion.

North Basin

The gently sloping meadows found in the central portion of the basin are covered with native grasses and weeds. The well drained sandy loam that makes up these meadows was formed in sandy alluvium and has a low runoff potential. The erosion potential for this soil is moderate, but is increased when the existing ground cover is disturbed.

The remainder of the basin is made up of moderately steep slopes that are covered by a thin stand of Ponderosa Pine. The soils found in this area range from gravelly sandy loam to gravelly loamy sand, which were formed in, or are on alluvial fans. The soils and topography throughout these areas have a moderate runoff potential and are moderately susceptible to erosion. However, if the ground cover is removed, this soil will become extremely susceptible to erosion.

The method used to determine the runoff from the Dry Creek Basin and the North Basin reflects the soil properties and ground cover found in each watershed. Any improvements made in the watersheds should also consider the soil characteristics and ground cover to ensure compatibility.

VI. BASIN HYDROLOGY

BASIN HYDROLOGY

General

Although flows in the Dry Creek Basin and the North Basin are intermittent, the potential for a damaging flood exists. This flood will likely result from runoff caused by a very intense thunderstorm which occurs during the May through October rainfall season. As development in the basins increase, the existing drainage patterns could change and peak flows could increase. Therefore, it was necessary to predict flood flows for the basin in the projected full build-out state, as well as the existing state of development. The predicted peak flows were then used to analyze the existing and proposed structures.

Four hydrologic alternatives were evaluated to determine peak flows and the associated costs for required improvements. The first hydrologic alternative involved determining peak flows from the basin in its existing state. This alternative was used as a basis of comparison for the remaining alternatives. The remaining three alternatives for the basin were evaluated assuming a fully developed condition. Each subsequent alternate analyzed had a different policy to convey developed stormwaters. The second alternate involved no detention, thus peak flows from the future developments were released unimpeded. The third alternative utilized normal detention to control runoff from the proposed developments. Normal detention would require proposed developments to store increased runoff and to release peak flows at the existing rate. The fourth and final alternative evaluated, required future developments to over-detain and release peak flows at rates less than the existing rate. This alternative was considered due to the inadequacy of many of the drainage facilities in the lower reaches of the basin. Over-detention could possibly reduce release rates to the point that downstream facilities would not require improvements.

Having reviewed the hydrologic and economic impact for each alternative, the second alternative, or the "no detention" option, was selected as the most cost effective alternate. Of major consideration is that the "no detention" alternative requires less maintenance (assuming adequate erosion protection is provided), allows more efficient land use, and avoids liability associated with detention ponds. The remainder of this section compares the hydrologic study of "no detention" to the existing basin condition.

Method

Currently, Dry Creek and its tributaries are not gauged. Therefore, it was necessary to mathematically model the basins to predict peak flows. The computer program distributed by the Soil Conservation Service (SCS) through Technical Release No. 20 (TR-20) entitled "Computer Program for Project Formulation - Hydrology," was used to model the Dry Creek Basin and the North Basin. These basins were broken down into subbasins and TR-20 was used to develop hydrographs for the runoff from each subbasin. The program was then used to route hydrographs through stream reaches and reservoirs, as well as combine hydrographs at specific design

points. TR-20 uses the SCS synthetic unit hydrograph, the convex method of stream flow routing, and the standard method of reservoir routing. In addition, TR-20 uses standard SCS parameters for precipitation and basin hydrologic characteristics.

In determining a design storm for hydrologic analysis, the occurrence of precipitation is defined by frequency, duration, volume, and intensity. For this study, runoff flows were determined for the 5-, 100-, and 500-year frequency storms. The 5-, 100-, and 500-year frequency storms have a 20, 1, and 0.2 percent chance of being exceeded in any given year, respectively. The 100-year frequency storm was used to analyze existing and proposed structures.

The current SCS method of hydrology uses a 24-hour duration storm, which departs from the 6-hour duration storm used in previous drainage studies for the City of Colorado Springs. The 24-hour duration storm was demonstrated to be more conservative for this basin than the 6-hour duration storm which is no longer recognized by the SCS.

The volume of precipitation which falls during a storm of given frequency and duration was interpolated from SCS isopluvial maps for Colorado. This precipitation occurs during the May through October rainfall season. Precipitation volumes of 2.7 inches and 4.3 inches for the 5-year and 100-year, 24-hour duration storms, respectively, were used for the study area. Because no 500-year, 24-hour isopluvial maps are available, the precipitation was determined by plotting the 5-, 10-, 25-, 50-, and 100-year, 24-hour precipitations on Gumbel Extreme Value Distribution paper and extrapolating to determine a 500-year precipitation volume of 5.1 inches. This procedure was suggested by the National Oceanic and Atmospheric Administration (NOAA), the organization which publishes the isopluvial maps which the SCS uses.

The SCS criteria states that for basins in the Arkansas River drainage basin, below the elevation of 8,000 feet, a Type IIA rainfall intensity distribution should be used. Because a majority of the study area falls below the 8,000 foot elevation, a Type IIA distribution was used for this study. The Type IIA distribution is the most intense rainfall distribution used by the SCS and gives the highest runoff peaks.

In addition to precipitation, the SCS method uses a runoff curve number (CN) in determining runoff flows. The curve number reflects the runoff potential for an area and represents the combined hydrologic effects of soil classification, vegetative cover, and land use. The curve numbers vary throughout the basin and were determined using SCS criteria. An antecedent moisture condition of 2 (AMC II), which represents the average moisture condition prior to the storm, was used.

The final basin parameter needed for determining peak flows is the time of concentration (Tc). The time of concentration is the time it takes for runoff to travel from the hydraulically most distant part of the subbasin to the design point. The time of concentration for overland flow, channel flow, and street and gutter flow was determined from SCS nomographs. Because TR-20 computes a runoff hydrograph for an individual subbasin and combines it with other hydrographs to determine

much sooner than Dry Creek itself, resulting in minor increases in peak flows. The South Gulch is the smallest of the tributaries and joins the Main Channel at the convent's power plant (Design Point 17). The South Valley comes to a confluence with Dry Creek at Design Point 21, east of the convent. The combined effect from these two tributaries in an existing 100-year peak flow of 1611 cfs. Like the North Fork, the South Valley has two small reservoirs (Design Points 22 and 24) apparently built by the SCS for erosion protection. These reservoirs fill up during the early part of the storm and have little effect in reducing the peak flow. The third tributary, which flows through the northern portion of the convent, has been designated as the North Channel of Dry Creek. The North Channel joins the Main Channel immediately west of Woodmen Road (Design Point 32), resulting in a combined existing 100-year peak flow of 1724 cfs.

The Peregrine Development proposed Master Plan shows extensive development along the Main Channel of Dry Creek and through South Valley. Because of this extensive development and associated costs of channelization and loss of developable land, it is recommended that main flows of Dry Creek be diverted through the North Channel instead of the Main Channel. Peak flows from the South Valley (Design Point 25) will increase from 229 cfs (existing) to 299 cfs (proposed). The two small dams in the South Valley may be removed by the developer with minimal hydrologic impact. The development of the proposed Peregrine project will increase the 100-year peak flow at Design Point 32 from 1724 cfs (existing) to 2032 cfs (proposed) or an increase of approximately 18 percent.

East of Design Point 32, Dry Creek flows through broad meadows and combines with one small unnamed tributary at Design Point 41, producing a combined 100-year peak flow of 1805 cfs. Flow through Dry Creek is obstructed by a small pond at an existing dairy farm (Design Point 43). The peak flow is not substantially reduced through the pond, and discharges at the 100-year peak rate of 1817 cfs under existing conditions.

The proposed Falcon Ridge Development will occupy most of the area between Design Points 32 and 43. The combined effects of the Falcon Ridge and Peregrine developments will increase the peak flow at Design Point 43 from 1817 cfs (existing) to 2274 cfs (proposed).

The last major tributary, referred to as Big Valley, comes to a confluence with Dry Creek within the Discovery Subdivision at Design Point 45. The existing 100-year peak flow is increased from an upstream flow of 1810 cfs to 1927 cfs at the confluence.

Development along the Big Valley tributary is nearly complete, and the proposed development that could occur would only increase peak flows at Design Point 51 from 529 cfs (existing) to 536 cfs (proposed). The combined effects of all proposed upstream development will increase peak flows from 1927 cfs (existing) to 2479 cfs (proposed) at the Big Valley and Dry Creek confluence (Design Point 45).

As Dry Creek continues to the east, it picks up runoff from the most heavily developed part of the basin. Peak flows through this reach do

a cumulative flow, times of concentration were determined only for individual subbasins. In order to determine times of concentration for future developments, the method suggested by the SCS Technical Release No. 55 for time of concentration adjustment for urbanization was used.

As previously stated, TR-20 routes hydrographs through stream reaches. Input required for the stream flow routing computation includes a stage, discharge, and end area of flow table for a typical stream cross-section in the reach. This table was computed using the "Floodplain Analysis" computer program, which calculates normal depth for an irregular stream section. Input required for reservoir routing includes a stage, discharge, and storage table for each reservoir.

Dry Creek Basin

The Dry Creek Basin was divided into 42 subbasins and 51 design points. Design points were taken at subbasin outfall points, as well as at intermediate points within subbasins for routing purposes. Runoff hydrographs, steam flow routed hydrographs, and reservoir routed hydrographs were combined at design points to determine accumulated peak flows. Individual subbasin peak flows and accumulated peak flows are tabulated in Table 1a. In addition, a schematic diagram of the basin, depicting design points and tributaries, is shown in Figure VI-1.

In the western portion of the basin, peak flows notably increase as the three main tributaries of Dry Creek combine. At Design Point 8, the South and Middle Forks of Dry Creek come to a confluence, producing a 100-year peak flow of 1092 cubic feet per second (cfs). The North Fork of Dry Creek joins the main channel just west of the convent, at Design Point 9, resulting in a peak flow of 1418 cfs. Flow through the North Fork is impeded by two reservoirs at Design Points 12 and 14. The largest and farthest west of these reservoirs (Design Point 12) is one of two reservoirs which once served as water supply reservoirs for the convent. The other water supply reservoir, which is due south of Design Point 12, is off-channel and thus has no effect on the North Fork. Both reservoirs have been drained. The smaller on-stream reservoir (Design Point 14) was apparently built for erosion control. The two on-stream reservoirs have little effect in decreasing peak flows. Because the reservoirs do not have adequate low flow release structures and have relatively low storage volumes, they would fill up during the early portion of the storm, resulting in peak flows being discharged over the dams' emergency spillways virtually unimpeded.

Proposed development along the South and Middle Forks of Dry Creek will slightly increase the peak flows. For example, the 100-year peak flow at Design Point 8 will increase from 1092 cfs (existing flow rate) to 1106 cfs (proposed flow rate). Because of the proposed extensive development along the North Fork, the peak flow at Design Point 9 will increase from 1418 cfs (existing) to 1553 cfs (proposed). The large dam may be removed or lowered by the developer, while the smaller dam, which lies within the Sisters' property, will remain intact.

Farther east, three smaller tributaries of Dry Creek join the main channel. These tributaries have smaller basins and peak flows occur

not significantly increase because the peak runoff from the developments occur much sooner than Dry Creek. In addition, road crossings tend to act as small detention facilities, which keep the peak flow somewhat constant. A small detention dam located near Rockrimmon Elementary (Design Point 53) has little effect decreasing the peak, and discharges at an existing 100-year peak rate of 1939 cfs. Further downstream, however, the road crossing at Dawson Drive (Design Point 55) notably decreases the peak flow. The large roadway fill acts as a large detention facility, and existing 100-year peak flows are decreased from 1933 cfs to 1746 cfs. The final significant change in peak flow occurs at the road crossing within the Corporate Centre business park (Design Point 57). The peak flow is reduced from 1745 cfs to 1692 cfs as Dry Creek discharges into Monument Creek at Design Point 58.

Because the lower portion of the Dry Creek Basin is presently fully developed, all increases in peak flows are due to proposed upstream development of the Peregrine and Falcon Ridge projects. The 100-year peak flow at Pebble Way (Design Point 52) increases from 1920 cfs (existing) to 2509 cfs (proposed), while the peak flow at Rockrimmon Boulevard (Design Point 54) increases from 1921 cfs (existing) to 2527 cfs (proposed). The 100-year peak flow of Dry Creek as it discharges to Monument Creek increases from 1692 cfs (existing) to 2586 cfs (proposed).

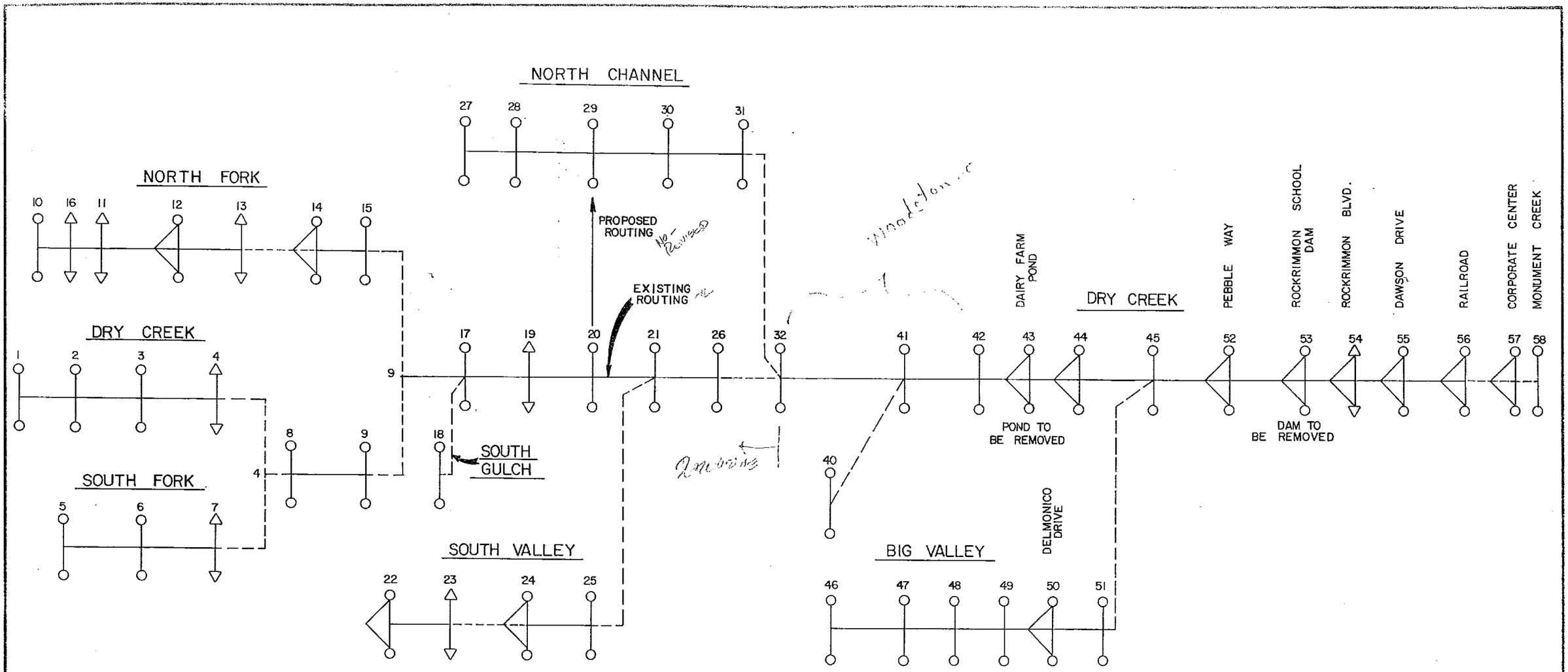
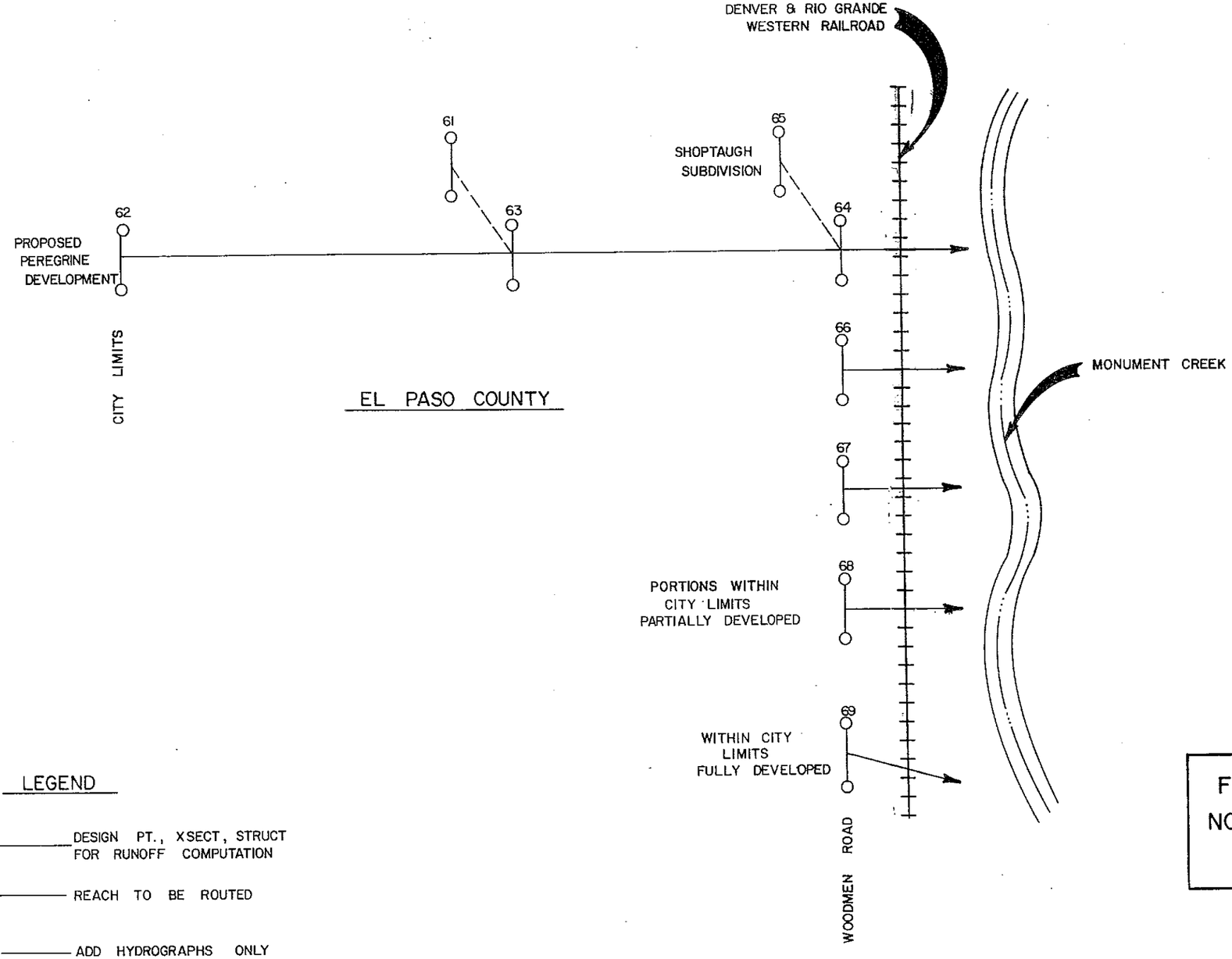


FIGURE VI-1
DRY CREEK BASIN
SCHEMATIC

KKBNA

Incorporated
Consulting Engineers



LEGEND

61 ——— DESIGN PT., XSECT, STRUCT FOR RUNOFF COMPUTATION

——— REACH TO BE ROUTED

- - - - ADD HYDROGRAPHS ONLY

+++++ RAILROAD

FIGURE VI-2
NORTH BASIN
SCHEMATIC

KKBNA

Incorporated
Consulting Engineers

VII. BASIN HYDRAULICS

BASIN HYDRAULICS

Since the Dry Creek Basin's existing storm water management system was designed, changes have occurred in the City's drainage criteria, the extent of development within the basin, and the methods of analyzing watersheds. The reanalysis required due to these changes has indicated the need to provide capacity for greater runoff which will have an impact on some of the existing structures. To determine the adequacy of the present system, and to propose a new system which will comply with current master plans, the existing and fully developed 100-year and 500-year floodplains were mapped and analyzed as follows:

Method

The computer program "HEC-2 Water Surface Profiles" developed through the Hydrologic Engineering Center of the U.S. Army Corps of Engineers' Water Resources Support Center was used to model Dry Creek and its tributaries. HEC-2 uses the standard step method to calculate an unknown water surface elevation at a cross section.

Cross sections, channel and overbank lengths and Manning's n-values are input into HEC-2 and used to define the model of the stream being analyzed. Digitized cross sections were used to model the portion of Dry Creek between Monument Creek and the Peregrine boundary (Reaches 1 and 2). The remaining cross sections and all channel and overbank lengths were taken off a 1"=100' scale, 2' contour interval, topographic map of the basin. The location of each section is noted on the plan and profile sheets in Section IX "Floodplain Limits." See Figure V for sheet index map. Manning's n-values (roughness coefficient), determined through site inspections, were input to reflect the types of channel lining throughout each reach. Reach lengths were defined according to the availability of control sections. Control sections, which usually occurred at road crossings, were used to determine the water surface elevation required to start the backwater calculations for each reach. A stage discharge relationship was determined for each control section using the weir equation, the orifice equation and the Bureau of Public Roads Inlet Control Charts. With the stage discharge relationship defined, backwater curve calculations were started at the stage corresponding to the estimated discharge through the reach. Flows input into the model represented the 5-, 100- and 500-year flows for a 24-hour duration storm and were determined as outlined in Basin Hydrology. Since all the streams modeled within the Dry Creek Basin flow on a supercritical slope, the subcritical flow regime specified results in a conservative estimate of the floodplain width and depth.

Reach 1

Reach 1 falls between Station 0+00 (Monument Creek) and Station 94+00 (Carlson Dairy Farm) and flows through the developed portion of the Dry Creek Basin. See enclosed Master Drainage Map, Figure 4a. This reach was analyzed using creek crossings at Cascade Avenue (Station 1+20), Dawson Drive (Station 26+95), Rockrimmon Boulevard (Station 34+00) and Pebble Way (Station 62+20) as control sections. The channel sections through this reach range from deep, narrow trapezoidal shapes to wide

flat bottom sections with vertical walls. The channel slopes range from approximately 1% to 8%. The roughness coefficients used to represent ground cover ranged from 0.015 for concrete lined channel sections to 0.07 for densely vegetated sections. The average coefficient used was 0.035.

The channel section between Station 1+20 (Cascade Avenue) and Station 5+05 (railroad crossing) is the only undersized channel section within this reach. A concrete lined channel (see Figure 3a) has been proposed to contain the floodplain in this area. The remaining channel sections are adequate to convey the 100-year flood under full build-out conditions. However, the low flows within these sections are undermining the channel embankments. Therefore, we recommend installation of gabion blankets throughout this reach and slope reconstruction where major erosion has occurred (from Station 15+00 to Station 16+00 and from Station 84+00 to 88+00). The costs of these improvements can be found in Table 2c, "Upgrading of Existing System and Maintenance Costs."

Reach 2

Reach 2 falls between Station 94+00 (Carlson Dairy Farm) and Station 145+00 (Woodmen Road crossing), and flows through the area master planned as Falcon Ridge. See enclosed Master Drainage Map, Figure 4a. This reach was analyzed using the existing pond structure (Station 94+00) as the control. The channel through this reach is a wide, grassed meadow with a series of check dams apparently used to convert channel flow to sheet flow. The average channel slope through this reach is 2.5% and an average n-value of 0.035 was used.

The 100-year floodplain mapped for this reach is an extremely wide section and inundates private property directly east of the Woodmen Road crossing and the private property south of the above referenced pond. The Master Plan for Falcon Ridge proposes to contain the floodplain with a lined channel to increase the amount of buildable area within this reach. For cost estimating purposes in this report, we have assumed the typical section shown in Figure 3a. By extending the improved channel to the Woodmen Road crossing (Station 145+00), the private property inundated under existing conditions will be out of the 100-year floodplain. The location of the improved channel shall be determined by the developer. The cost of these channel improvements can be found in Table 2a. From the Falcon Ridge Master Plan, we have determined that three crossings of the main channel are proposed. These crossings will be required to maintain proper access to proposed development during periods of flooding. The estimated size, design flow and cost of the crossings can be found in Table 2b.

Reach 3 ✓

Reach 3 falls between Station 145+00 (Woodmen Road crossing) to the top of the basin and includes the North Channel, South Valley, South Gulch, South Fork and the North Fork of Dry Creek. See enclosed Master Drainage Map, Figure 4b. This reach flows through the area known as Peregrine. The entire North Channel and Main Channel from Station

145+00 to Station 199+00 of Dry Creek were analyzed using the Woodmen Road crossing (Station 145+00) as a control section. The existing channel section through the lower portion of Reach 3 is a continuation of the wide grass lined meadows found in Reach 2. Check dams were also apparently used in this area to promote sheet flow. The average channel slope through this area is 3.5% and an average n-value of 0.035 was used.

The existing 100-year floodplains mapped for both channels are extremely wide. The proposed Master Plan for Peregrine shows development in the existing floodplain for the Main Channel and the North Channel. Therefore, we recommend that the flow in Main Channel be diverted into the North Channel and conveyed in a concrete lined channel (see Figure 3a) to Woodmen Road, thus reclaiming a large portion of the floodplain and conforming to the Proposed Master Plan. This improved channel section should be continued upstream to the confluence of the Main Channel of Dry Creek with the North Fork of Dry Creek. A cost estimate for these channel improvements may be found in Table 2a.

The North Fork of Dry Creek ties into the Main Channel of Dry Creek approximately 700 feet upstream from the Sister's Power Plant (Main Channel Station 210+40). The two onstream dams (North Fork Station 10+00 and Station 26+50) and the road crossing at the confluence with Dry Creek were used as controls sections. The channel section from the confluence (Station 0+00) to the first dam (Station 10+00) is a deep narrow channel with steep side slopes with an average channel slope of 6.7%. The average n-value used was 0.07%. No improvements will be required in this portion of the North Fork.

The channel section upstream from the first dam (Station 10+00) begins as a deep, narrow channel with an average slope of 6.7% and widens out into a meadow without a defined channel. The channel section upstream of the second dam (Station 26+50 to the corporate City limits) is a continuation of the wide grassed meadow with an average slope of 10% and an n-value of 0.035. Since the proposed Peregrine Master Plan shows development above the second dam, we recommend installing a concrete lined channel (see Figure 2) to control the width of the existing floodplain. The improved section should be installed beginning approximately 300' upstream from the first dam (Station 12+00) and continue upstream through the proposed development. The location of the improved channel shall be determined by the developer.

The South Valley ties into the Main Channel of Dry Creek approximately 162 feet upstream from the Woodmen Road crossing. The two onstream dams and the road crossing at the confluence with Dry Creek were used as control sections. The channel section through this reach is a deep, narrow section with an average slope of 4.2% and an n-value of 0.035. The proposed Peregrine Master Plan shows a roadway through this valley. Therefore, due to space restrictions, we recommend the storm sewer system be installed within this proposed roadway. The cost of the proposed channel sections in the North Fork and the proposed storm sewer management system in the South Valley can be found in Table 2a.

The confluence of the South Gulch and the Main Channel is located approximately 200 feet upstream from the Sister's Power Plant (Main Channel Station 187+00). The gulch defines the boundary between two development areas proposed on the Peregrine Master Plan. The drainageway has a heavily vegetated (n=0.045), deep, narrow section with a channel slope of approximately 8%. The existing gulch is currently stable. Since the existing floodplain width is relatively narrow (30'-120') and no substantial change in the floodplain is anticipated due to the development, no channel improvements will be required along this portion of Reach 3.

The South Fork of Dry Creek and the Main Channel of Dry Creek upstream of the confluence of the North Fork and South Fork of Dry Creek are heavily vegetated, deep, narrow channels with steep slopes of approximately 8%. These drainageways skirt the edges of development areas proposed in the Peregrine Master Plan. Since these channels are currently stable, the existing floodplain is narrow (50'+/-), and no substantial change in the floodplain is anticipated due to the proposed development, no channel improvements will be required.

Although no channel improvements have been recommended for the South Fork, the South Gulch or the uppermost portion of the Main Channel of Dry Creek, we do recommend that a minimum setback of 50 feet from existing floodplain limits be used when platting lots in master planned build areas adjacent to the natural channels. The recommended setback limits development to within 50 feet of the natural channel, thus preserving the natural vegetative cover in the channel which holds erosion potential to a minimum. In turn, if erosion should occur, the 50-foot setback will provide a buffer between the development area and the drainageway.

From the proposed Peregrine Master Plan, we have determined approximate locations of probable proposed or existing channel crossings. Crossings will be required since the Main Channel of Dry creek will cross Woodmen Road, the North Channel will cross the master planned collector street twice, the Main Channel will cross a master planned collector street above the small dam, the South Fork will also cross a master planned collector above the small dam, and finally the North Fork will cross a master planned residential street above the large dam. These crossings will be required to maintain access while conveying the 100-year flow under full build-out conditions. The estimated size, location, design flow and cost of each of these crossings can be found in Table 2b.

VIII. AREAS OF CONCERN

North Basin

The North Basin was divided into 9 subbasins and design points. Runoff hydrographs and stream flow routed hydrographs were combined at design points to determine accumulated peak flows. Individual subbasin peak flows, as well as accumulated peak flows are tabulated in Table 1b. In addition, a schematic diagram of the basin, depicting design points and tributaries, is shown in Figure VI-1.

In the north portion of the basin, two main tributaries come to a confluence at Design Point 63, resulting in an existing 100-year peak flow of 311 cfs. At the eastern edge of the basin, flows from Design Points 65 and 64 combine to discharge a peak flow of 373 cfs under the Denver and Rio Grande West Railroad to Monument Creek.

The central portion of the basin is drained by two subbasins, which discharge under the railroad to Monument Creek. Design Points 66 and 67 will discharge 100-year peak flows of 192 cfs and 80 cfs, respectively. The southern portion of the basin is also drained by two subbasins. Design Point 68 will discharge 144 cfs under the railroad to Monument Creek. Design Point 69 will discharge a 100-year peak flow of 95 cfs under the Woodmen Road, Denver and Rio Grande West Railroad intersection.

Planned development in the western portion of the basin will increase peak flows. Development of the Peregrine project will increase the peak flow at Design Point 62 from 129 cfs (existing) to 246 cfs (proposed). Because the channel improvements downstream of the proposed development are not anticipated at this time, detention storage should be provided to limit the peak discharge to the historic rate.

Although the remaining undeveloped portion of the North Basin is zoned A-2 (5-acre estates and agriculture), no development of this area is presently planned. If the basin was developed as presently zoned, peak flows in the basin would slightly increase. For example, 100-year peak flows at Design Point 64 would increase from 373 cfs (existing) to 458 cfs (proposed) assuming no detention by the Peregrine Development. Peak flows at Design Point 66 would increase from 192 cfs (existing) to 223 cfs (proposed), while discharge from Design Point 67 would increase from 80 cfs to 93 cfs. The 100-year peak flow at Design Point 68 would increase from 169 cfs (existing) to 198 cfs (proposed). The subbasin which drains to Design Point 69 is presently fully developed, so no increase in peak flow will occur.

AREAS OF CONCERN

During the course of the study, several components of the existing Dry Creek storm drainage system were found to be inadequate. Some of the inadequacies discussed in this section are due to recalculated flows determined through the use of new design criteria and projected development in the upper basin. Other problems could be attributed to limited maintenance funding. These problems, compounded by the increased flow projections, add to the inadequacy of the system.

The following paragraphs discuss these inadequacies and offer probable solutions, beginning with the confluence at Monument Creek and continuing up the basin. Cost estimates for these improvements may be found in Tables 2b and 2c.

The twin 5'x9' box culverts installed under Cascade Avenue are undersized for current conditions. Access from the Corporate Center development can be gained, however, even if Cascade Avenue is overtopped. Although, no additional structure is proposed, but sufficient armoring of the roadway embankment will be required.

Upstream of Corporate Center, at Dawson Drive, a section of the concrete channel has been undermined by low flows and has begun to crack. This situation should be remedied while the existing channel section is salvageable.

The crossing at Rockrimmon Boulevard is hydraulically inadequate based on existing conditions. Rockrimmon Boulevard is a principal arterial street, requiring a clear lane must be provided at all times for emergency access. Therefore, an additional structure should be installed, which could involve conflicts with existing utilities. In addition, the erosion problem at the outlet of the existing structure should be addressed.

Under full build-out conditions, the earth dam near Rockrimmon Elementary School could be overtopped in a 100-year storm. The existing spillway for the dam is not armored and therefore, very susceptible to erosion. In the event that the dam is overtopped, failure of the embankment is possible. This failure would cause extensive sediment deposition downstream resulting in a reduction of capacity and possible damage to structures. Since the dam provides little attenuation to the peak flow, and to prevent possible damage to the system and private property in the event of failure, we recommend the dam be removed and replaced with a typical channel section. If it is desirable to retain the dam and pond for aesthetic or other reasons, we recommend that the existing spillway and downstream channel be armored extensively to reduce erosion potential.

The twin 5'x9' boxes at Pebble Way are hydraulically inadequate. The 100-year floodplain, under existing conditions, overtops the road and may inundate private property immediately on the south embankment. Since Pebble Way is not a sole source of emergency access to this area, overtopping is acceptable. However, we recommend either floodproofing

the downstream private property or increasing the hydraulic capacity of the existing structure to contain the 100-year floodplain. Increasing the capacity of the existing structure may involve conflicts with existing utilities.

The existing storm sewer system in Big Valley Drive is hydraulically undersized. To prevent serious inundation of private property, we recommend installing approximately 3400 lineal feet of additional storm sewer ranging from 24 inches to 60 inches in diameter. This installation will involve conflicts with existing utilities.

Runoff from the 100-year storm will overtop the existing roadway embankment at the Carlson Dairy Farm. In all conditions analyzed, the dam had little effect on peak runoff. Therefore, due to the potential damage to downstream structures if the embankment should fail, we recommend that the dam be removed and replaced with a typical channel section or armored to prevent damage.

In conclusion, the problems in the Dry Creek Basin which arise due to future development in the basin should be addressed as development progresses. Improvements to currently inadequate structures should be scheduled as soon as possible to decrease the potential for damage to private property and to protect the health and safety of the public. Any new structure should be designed according to flows which reflect the full buildout condition. Finally, a maintenance program should be set up to maintain the drainageway.

IX. FLOODPLAIN LIMITS

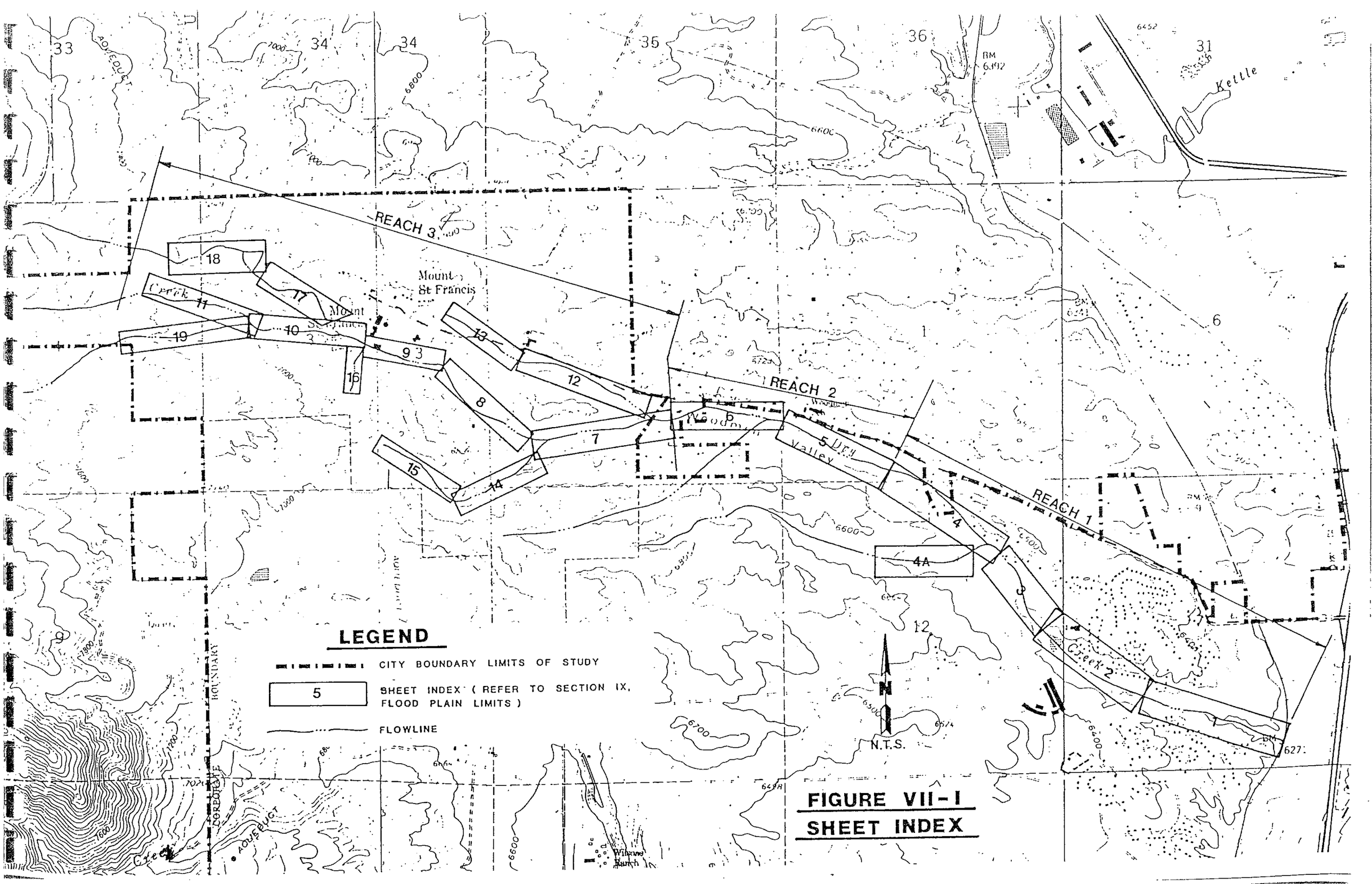


FIGURE VII-1
SHEET INDEX

SECTION IX.

FLOOD PLAIN LIMITS

FOR

DRY CREEK & ITS TRIBUTARIES

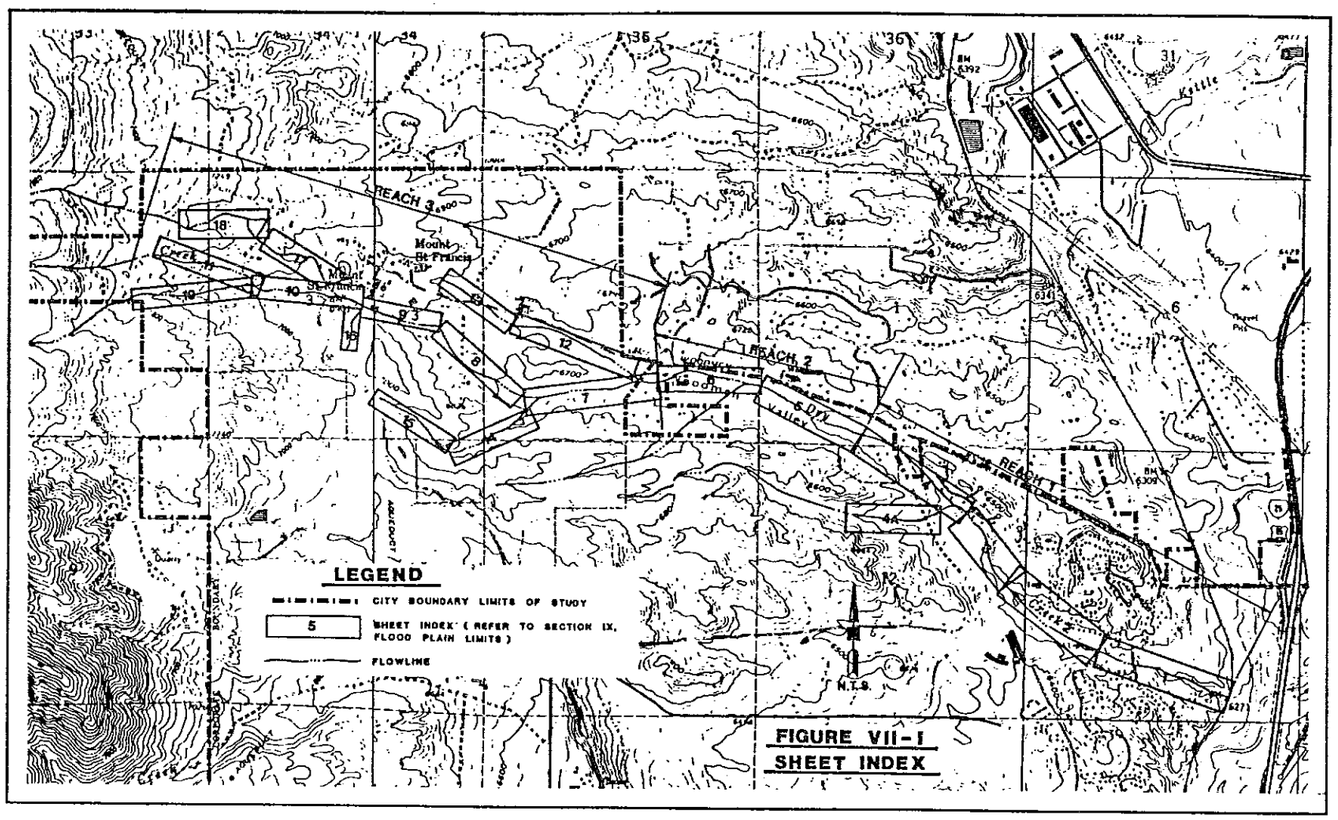


FIGURE VII-1
SHEET INDEX

SHEET INDEX MAP

LEGEND

FULL BUILD OUT 100 YR FLOOD PLAIN LIMITS

100 EXISTING 100-YR FLOOD PLAIN LIMITS

LIMITS OF EXISTING DRAINAGE EASEMENTS

STA. 12+00 LOCATION OF CROSS SECTION USED TO MODEL DRY CREEK

UNCONTROLLED SHEET FLOW

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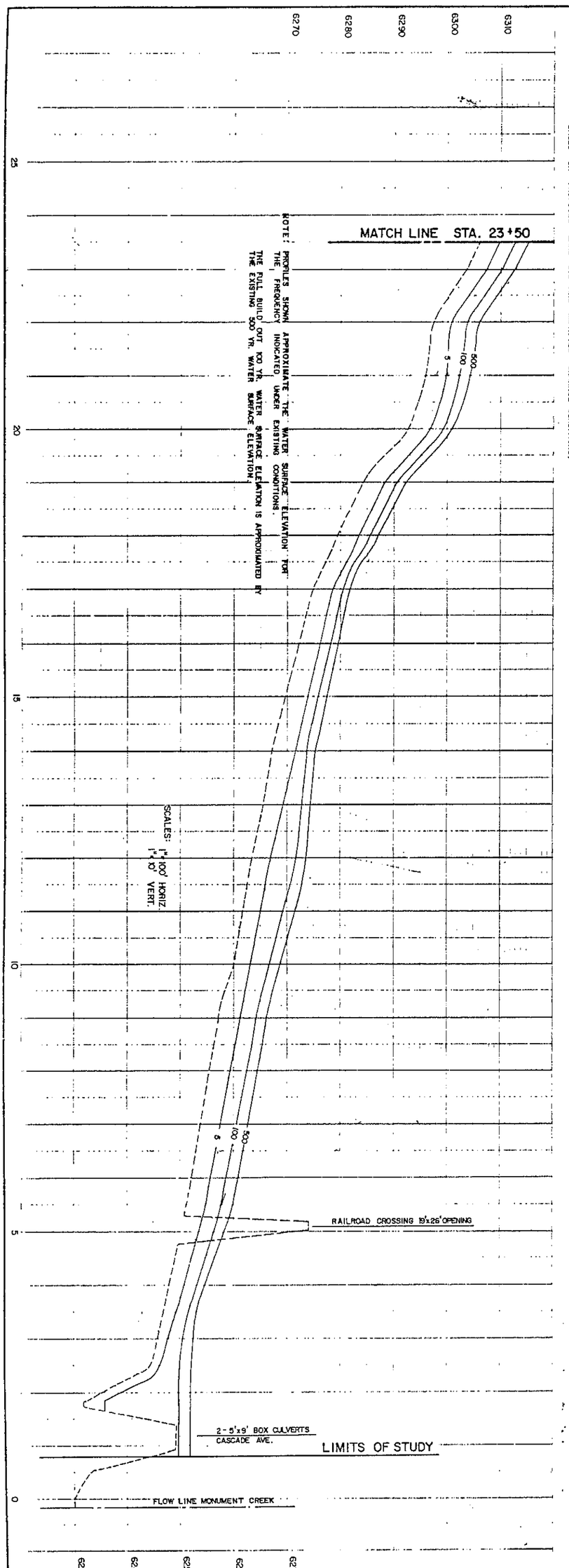
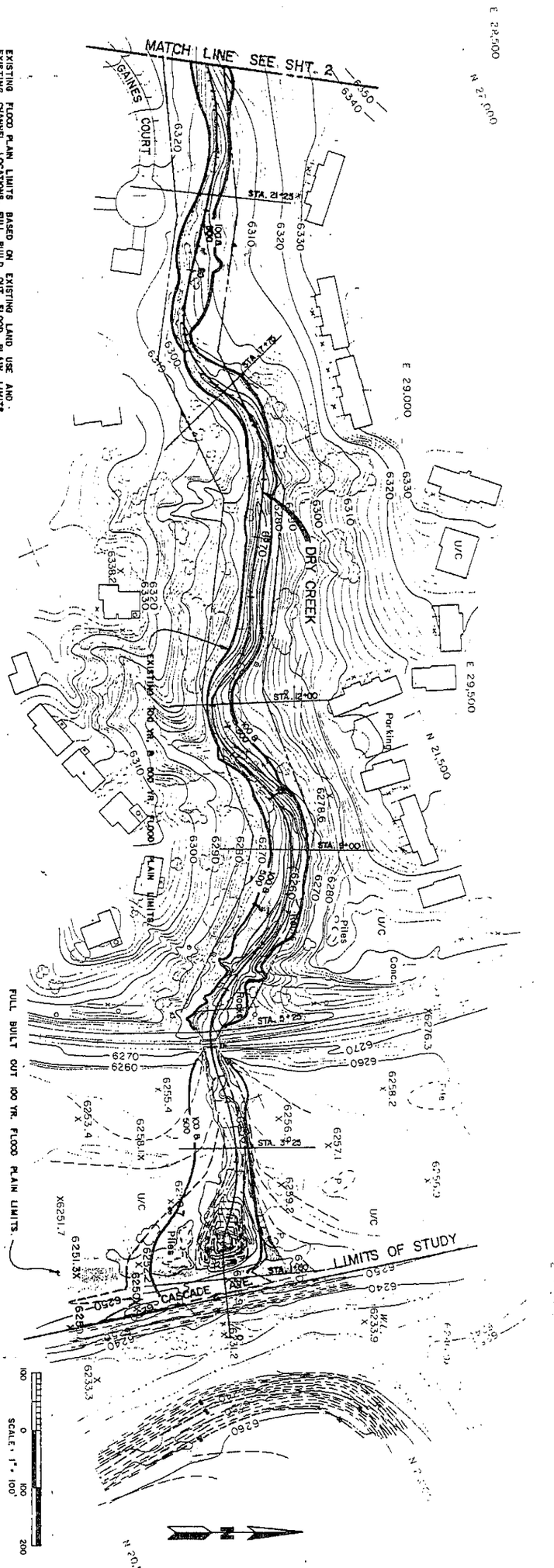
Incorporated
Consulting Engineers

project DRY C
project manager RB
designed by SW, LD job no. 7819.0
drawn by DP sheet no.



EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS. FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS.



sheet number 1	date JAN 6, 1984	no	description of revisions	date	name
	job number 7819.01.01				
	design by				
	drawn by al Pete				
	checked by				

DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK STA. 0+00 - 23+50

PLAN & PROFILE

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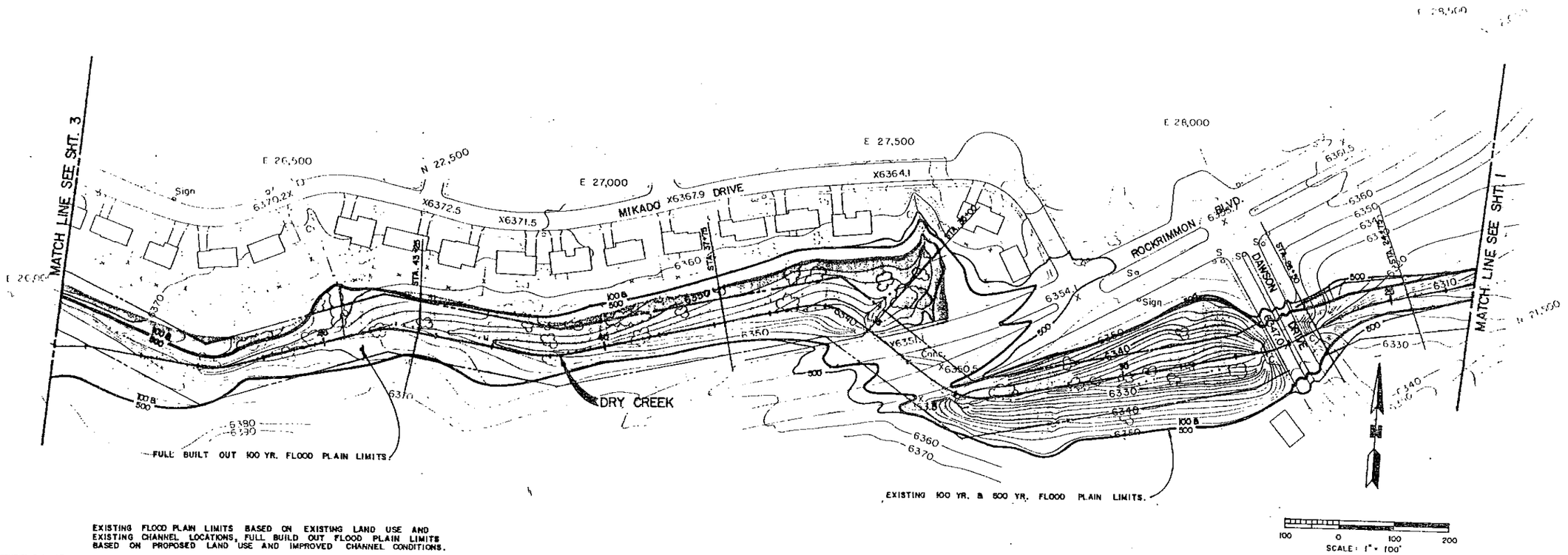
CONSULTING ENGINEERS

project CDBG
project manager RB
designed by SW, LD
drawn by DP
job no. 7815.01
sheet no. 2



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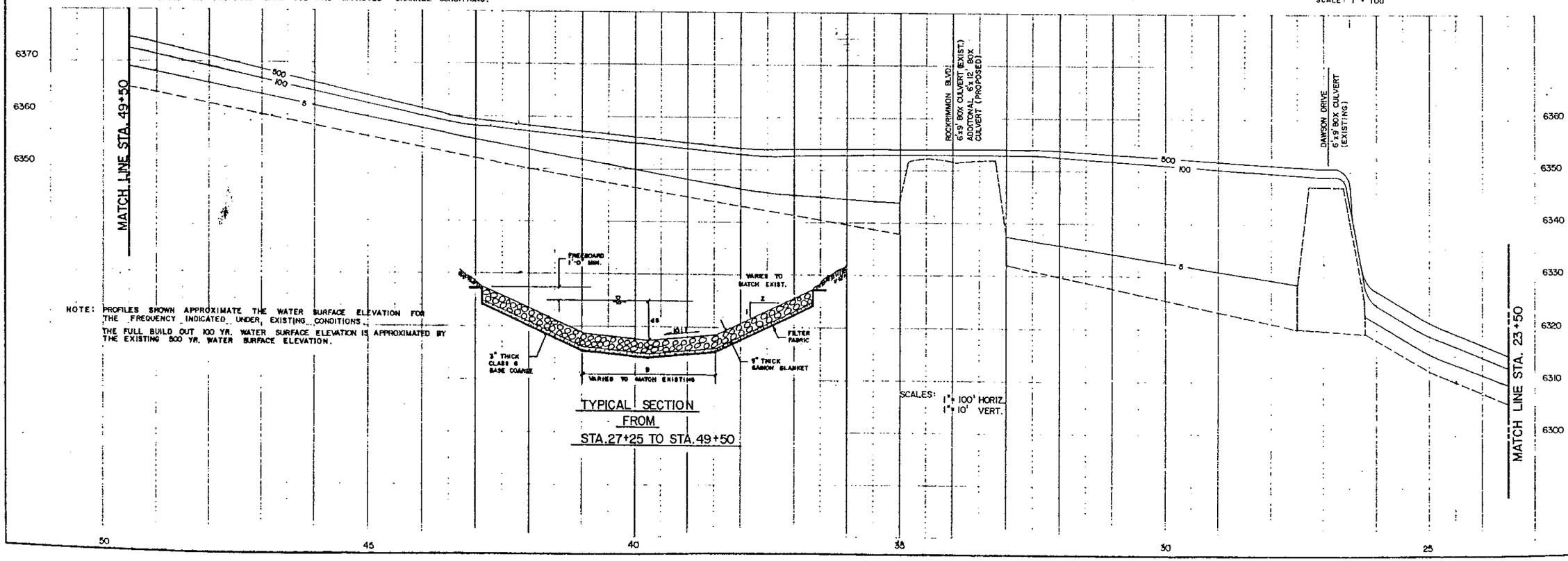

NOTE: PROFILES SHOWN APPROXIMATE THE WATER SURFACE ELEVATION FOR THE FREQUENCY INDICATED UNDER EXISTING CONDITIONS.
THE FULL BUILD OUT 100 YR. WATER SURFACE ELEVATION IS APPROXIMATED BY THE EXISTING 500 YR. WATER SURFACE ELEVATION.

TYPICAL SECTION
FROM
STA. 27+25 TO STA. 49+50

SCALES: 1" = 100' HORIZ.
1" = 10' VERT.

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DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK STA. 23+50 - 49+50

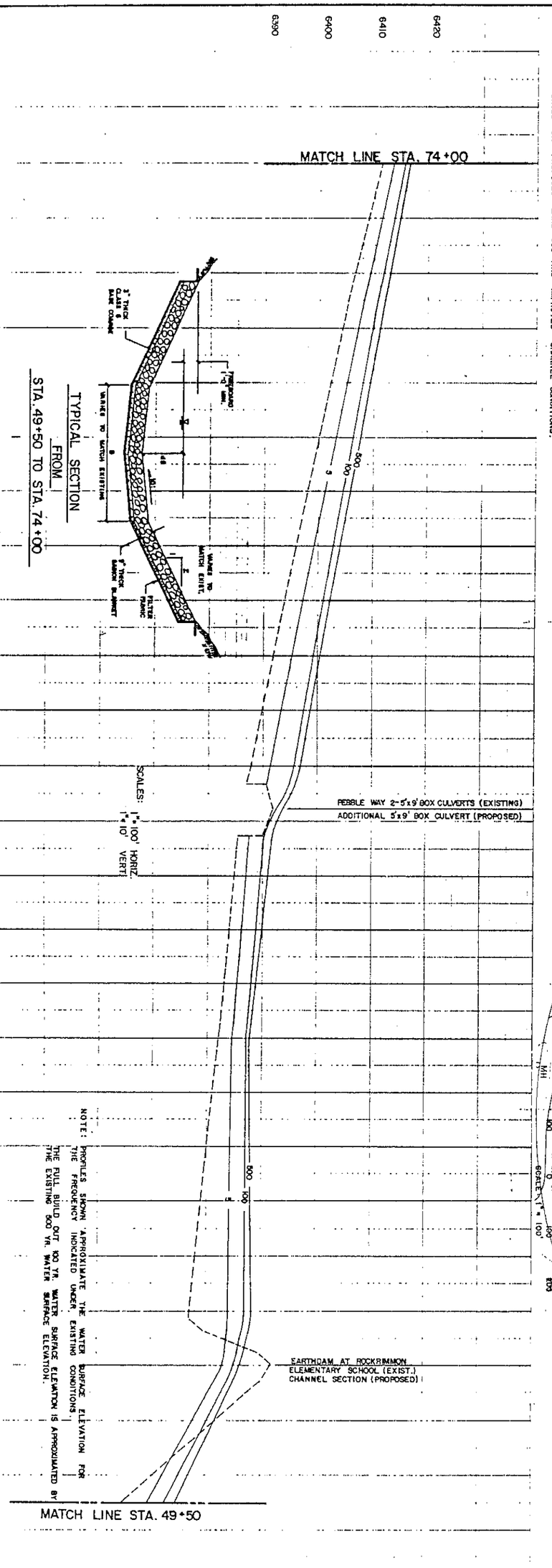
PLAN & PROFILE

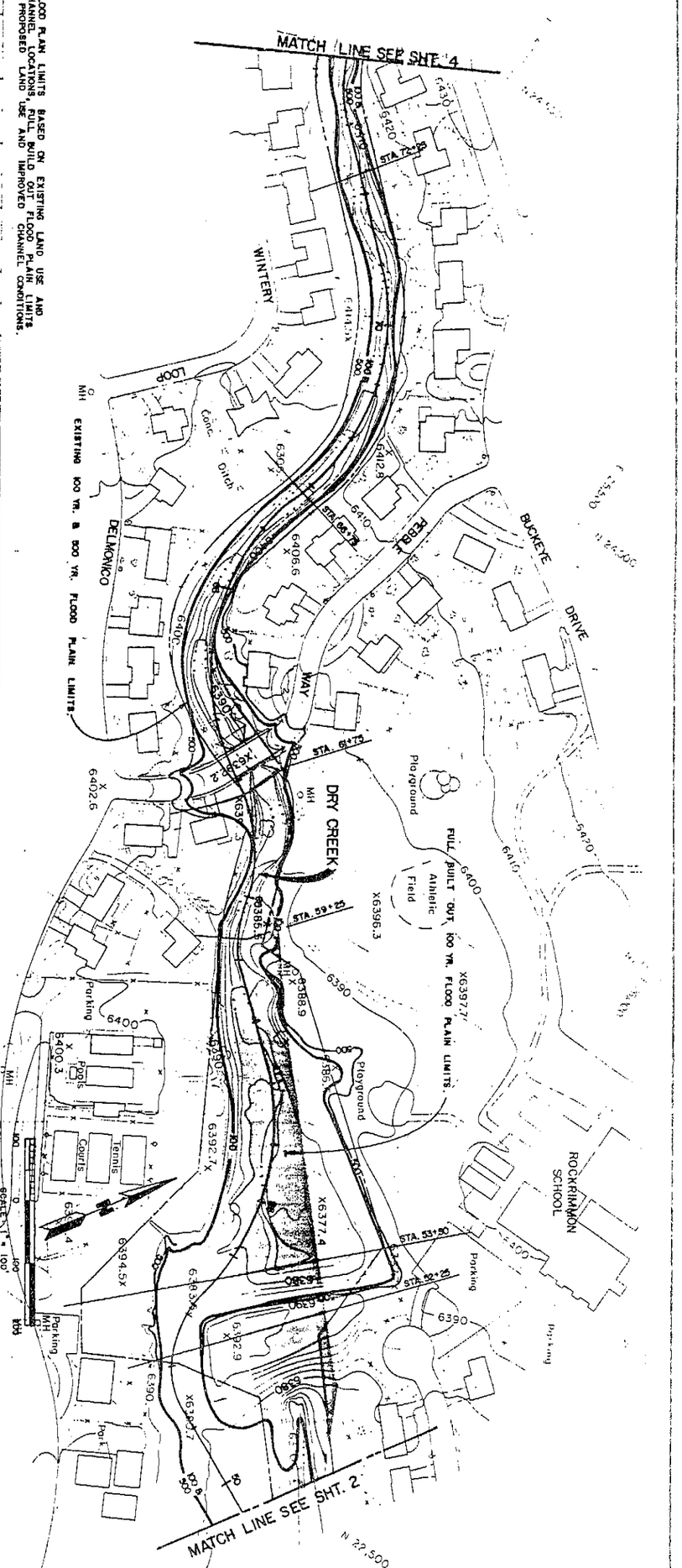
no	description of revisions	date	name

date JAN 6, 1984
job number 7815.01.01
design by
drawn by L. Peter
checked by

sheet number **2**

project DRY CREEK
project manager [illegible]
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 3





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DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK STA. 49+50 - 74+00

PLAN & PROFILE

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CONSULTING ENGINEERS

project _____ job no. _____
designed by SW, LO sheet no. 4
drawn by D.P. checked by R.P.

WOODMEN ROAD

BUCKEYE DRIVE

DRY CREEK

E 23,500 N 26,000

E 24,000 N 25,500

E 24,500 N 25,000

E 25,000

STA. 99+00

STA. 89+79

STA. 84+30

STA. 77+30

STA. 74+00

W.L. 6480

W.L. 6447.4

W.L. 6463.6

6457.5

6502.6

6485.3

6489.9

6499.0x

6489.9x

6483.9x

6469.3

6467.3

6464.6

6450.7x

6449.4

6451.5

6439

6431

Wall

Ruins

Conc. Piles

Found

MATCH LINE SEE SHT. 5

MATCH LINE SEE SHT. 4A

FULL BUILT OUT 100 YR. FLOOD PLAIN LIMITS.

EXISTING 100 YR. & 500 YR. FLOOD PLAIN LIMITS.

EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS, FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS.

SCALE 1" = 100'

6470
6460
6450
6440
6430

MATCH LINE STA. 99+00

500
100
5

500 & 100

BETWEEN STA. 91+00 AND STA. 99+00, THE FULL BUILD OUT FLOOD PLAIN DEPTH CAN BE APPROXIMATED USING THE PROPOSED TYPICAL SECTIONS FOR THE DESIRED FREQUENCY FLOW. ACTUAL WATER SURFACE ELEVATIONS WILL BE DETERMINED BY GRADES SET BY THE DEVELOPER.

TYPICAL SECTION
FROM
STA. 91+00 TO STA. 99+00

TYPICAL SECTION
FROM
STA. 74+00 TO STA. 91+00

SCALE: 1"=100' HORIZ.
1"=10' VERT.

NOTE: PROFILES SHOWN APPROXIMATE THE WATER SURFACE ELEVATION FOR THE FREQUENCY INDICATED UNDER EXISTING CONDITIONS.

THE FULL BUILD OUT 100 YR. WATER SURFACE ELEVATION IS APPROXIMATED BY THE EXISTING 500 YR. WATER SURFACE ELEVATION.

99 95 90 85 80 75 74

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DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK
STA.
74+00 - 99+00
PLAN & PROFILE

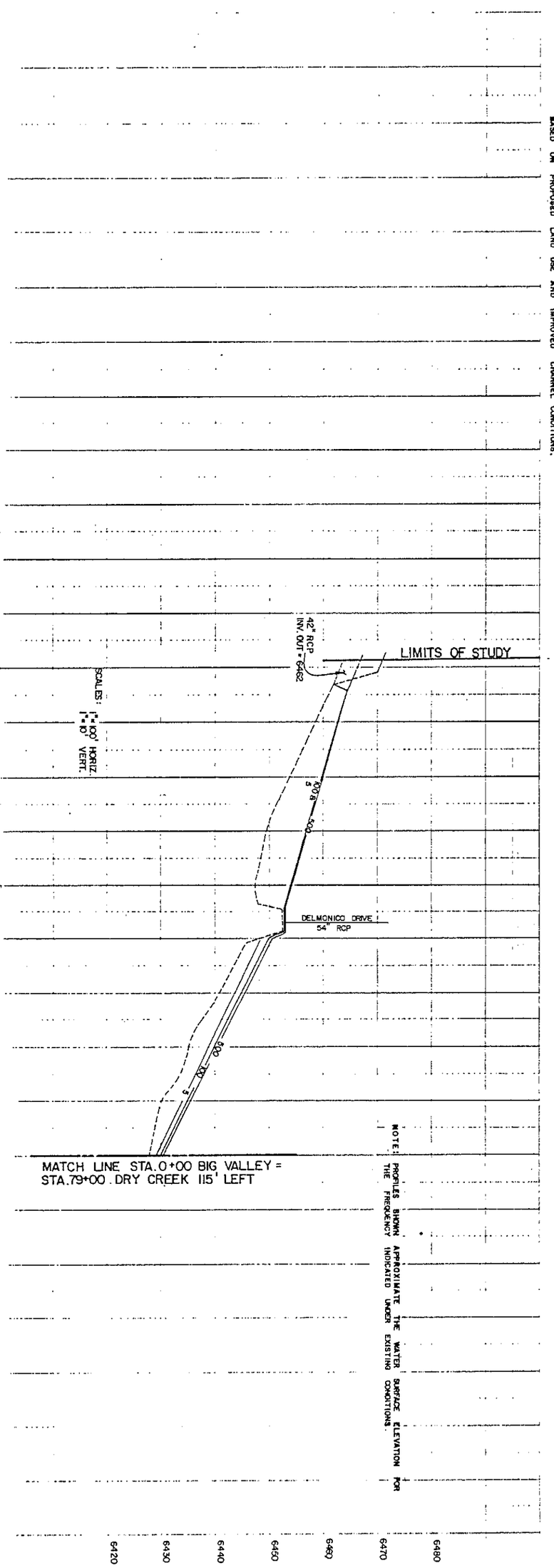
no	description of revisions	date	name

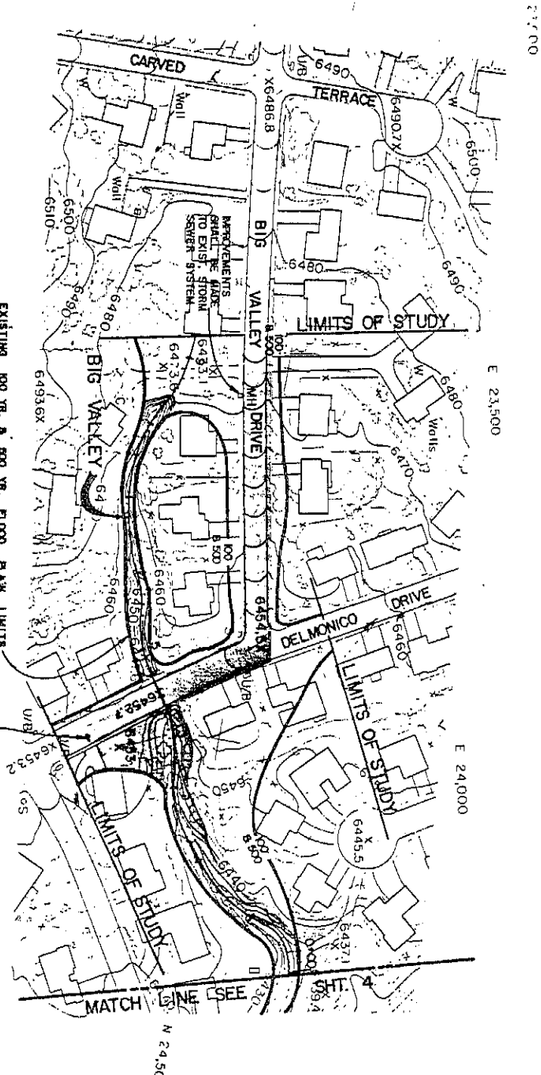
date JAN 6, 1984
job number 7819.01.01
design by
drawn by A Pate
checked by

sheet number
4

project DRY CREEK
project manager RB
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 4A

EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS. FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS.





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job number	7819.01.01
design by	
drawn by	J. Peter
checked by	

no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY

BIG VALLEY STA. 0+00 - 9+25

PLAN & PROFILE

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CONSULTING ENGINEERS

project DRY CREEK
project manager RB
designed by SW, LD
drawn by DP
job no. 7819.01
sheet no. 5

WOODMEN ROAD

EXISTING 100 YR. & 500 YR. FLOOD PLAIN LIMITS.

FULL BUILT OUT 100 YR. FLOOD PLAIN LIMITS.

MATCH LINE SEE SHT. 6

MATCH LINE SEE SHT. 4

DRY CREEK

EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS, FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS.

THE HORIZONTAL ALIGNMENT OF THE PROPOSED CHANNEL IMPROVEMENTS SHALL BE DETERMINED BY THE DEVELOPER.

SCALE 1" = 100'

NOTE: PROFILES SHOWN APPROXIMATE THE WATER SURFACE ELEVATION FOR THE FREQUENCY INDICATED UNDER EXISTING CONDITIONS.

THE FULL BUILD OUT FLOOD PLAIN DEPTH CAN BE APPROXIMATED USING THE PROPOSED TYPICAL SECTIONS FOR THE DESIRED FREQUENCY FLOW. ACTUAL WATER SURFACE ELEVATIONS WILL BE DETERMINED BY GRADES SET BY THE DEVELOPER.

MATCH LINE, STA. 125+00

MATCH LINE STA. 99+00

SCALES: 1"=100' HORIZ.
1"=10' VERT.

TYPICAL SECTION
FROM
STA. 99+00 TO STA. 125+00

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DRY CREEK
MASTER DRAINAGE STUDY

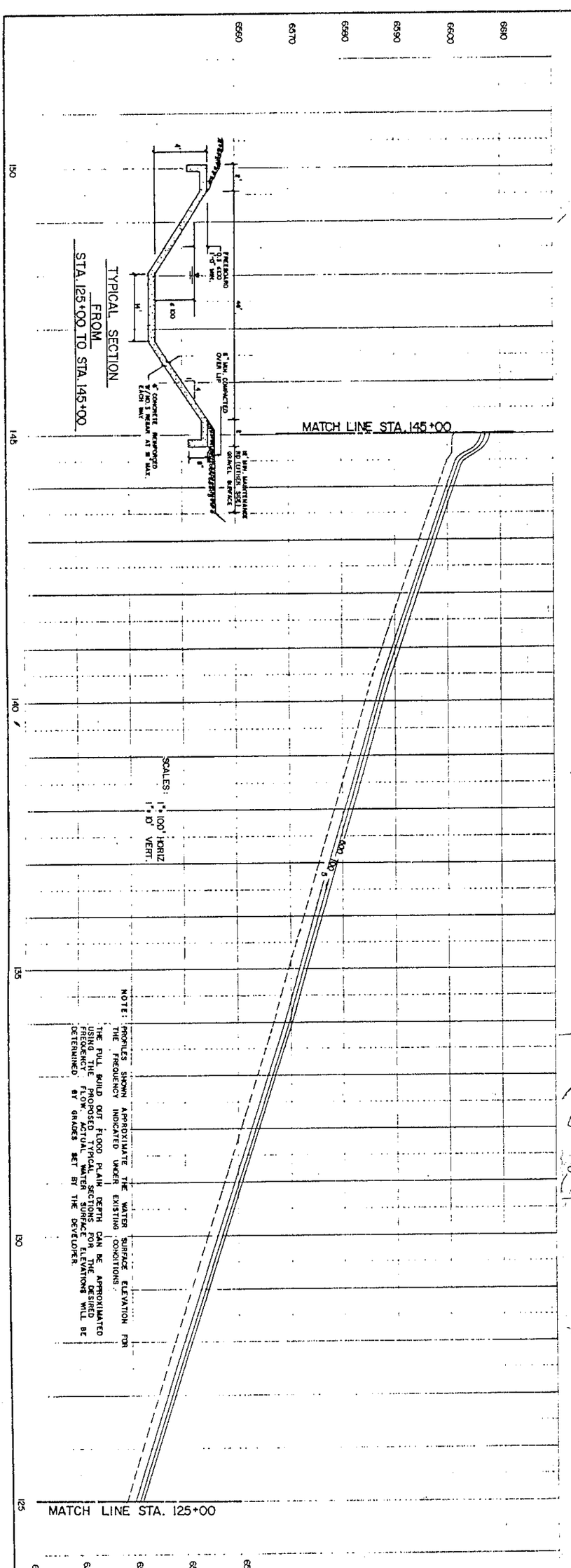
DRY CREEK
STA.
99+00 - 125+00
PLAN & PROFILE

no	description of revisions	date	name

date JAN. 6 1984
job number 7819.01.01
design by
drawn by L. Peter
checked by

sheet number
5

project DRY CREEK
project manager RB
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 6



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	drawn by S. Peter				
	checked by				

DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK STA. 125+00 - 145+00

PLAN & PROFILE

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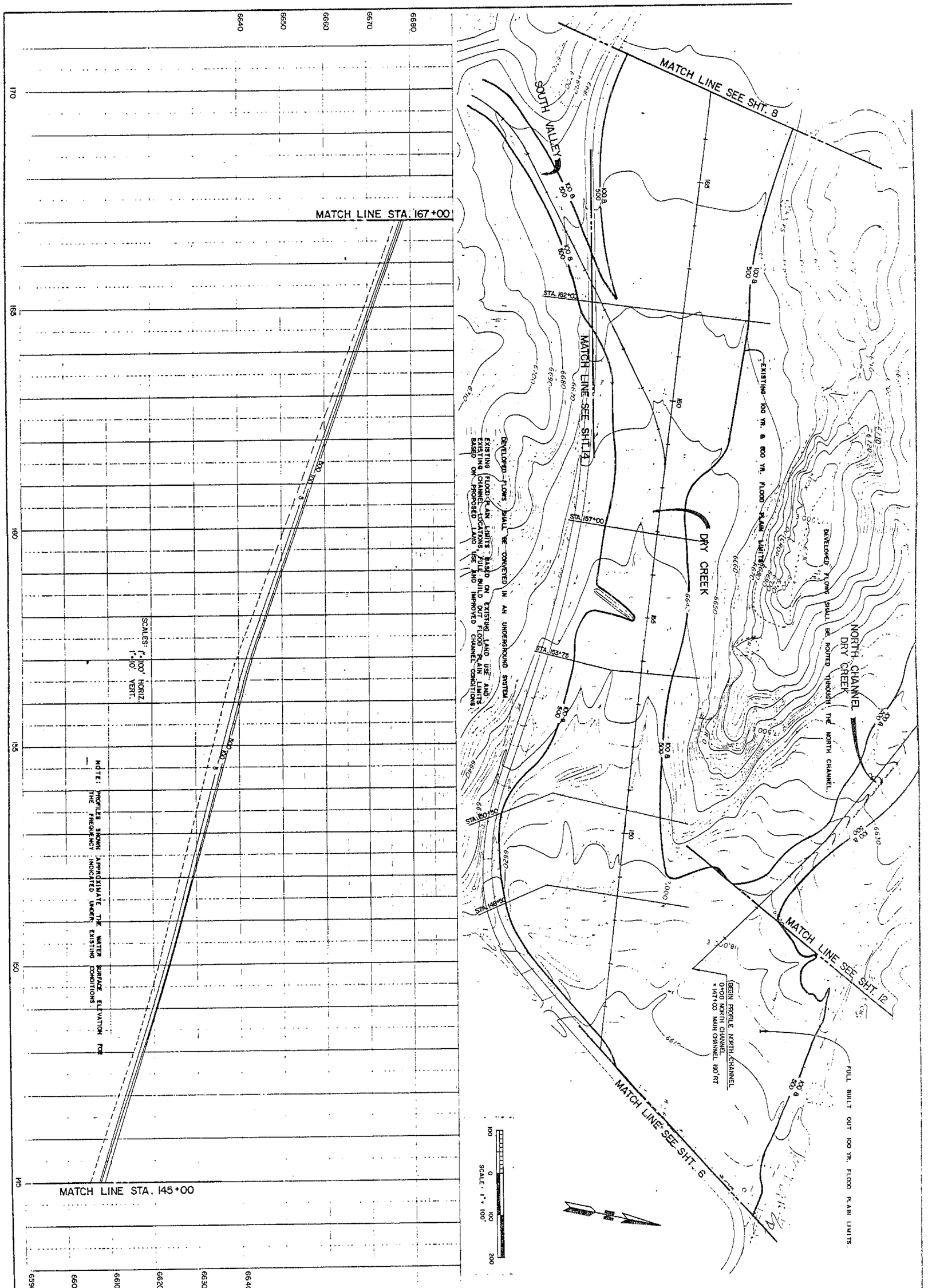
project DRY CREEK
project manager RB
designed by RB SW, LD
drawn by DP
job no. 7819.01



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job number 7819.01.01
design by
drawn by L Peter

no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY
DRY CREEK STA. 145+00 - 167+00
PLAN & PROFILE

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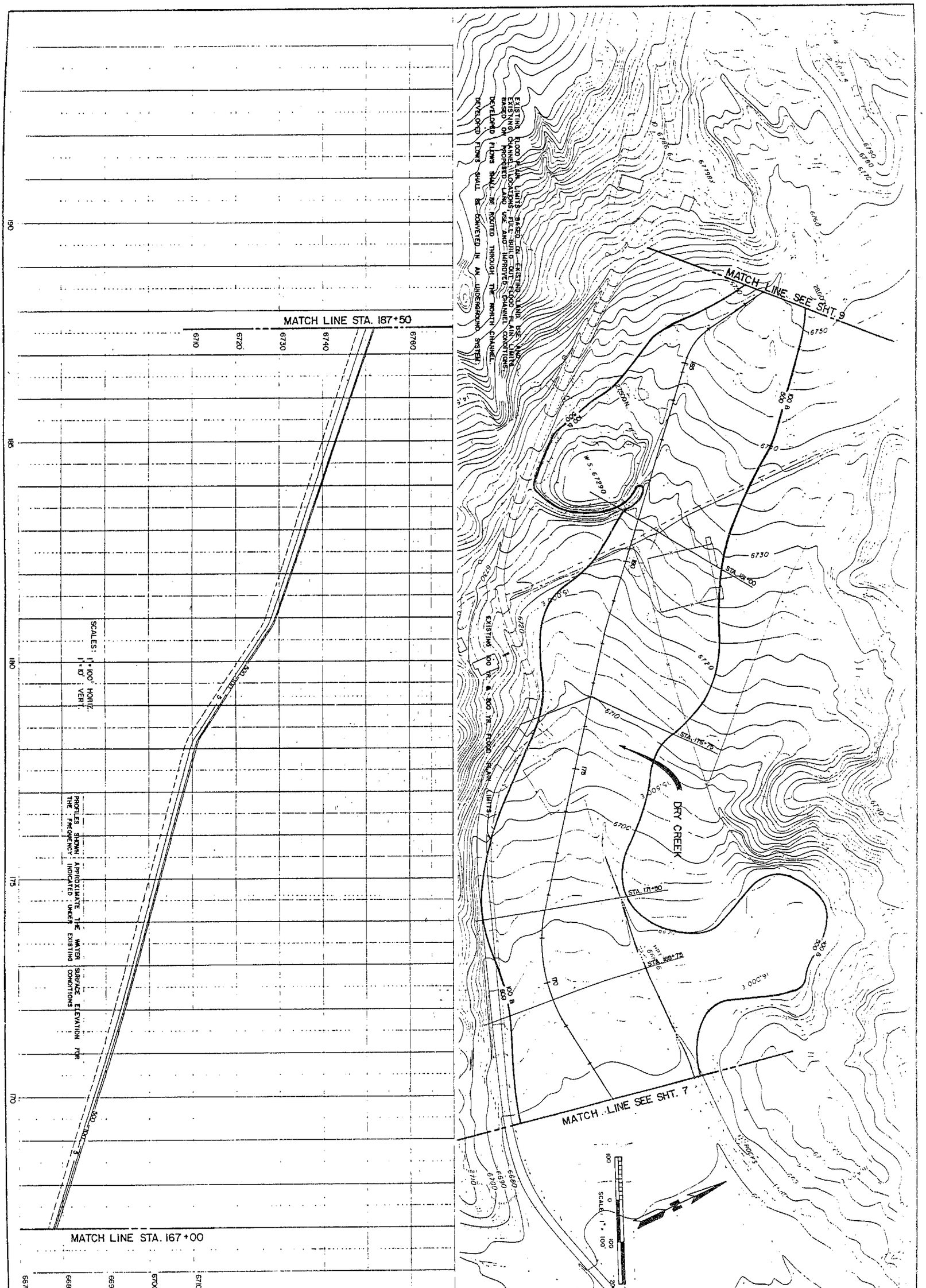
project manager RB
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 8



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date	JAN 6,1984
job number	7819.01.01
design by	
drawn by	A Peth
checked by	

no	description of revisions	date	name

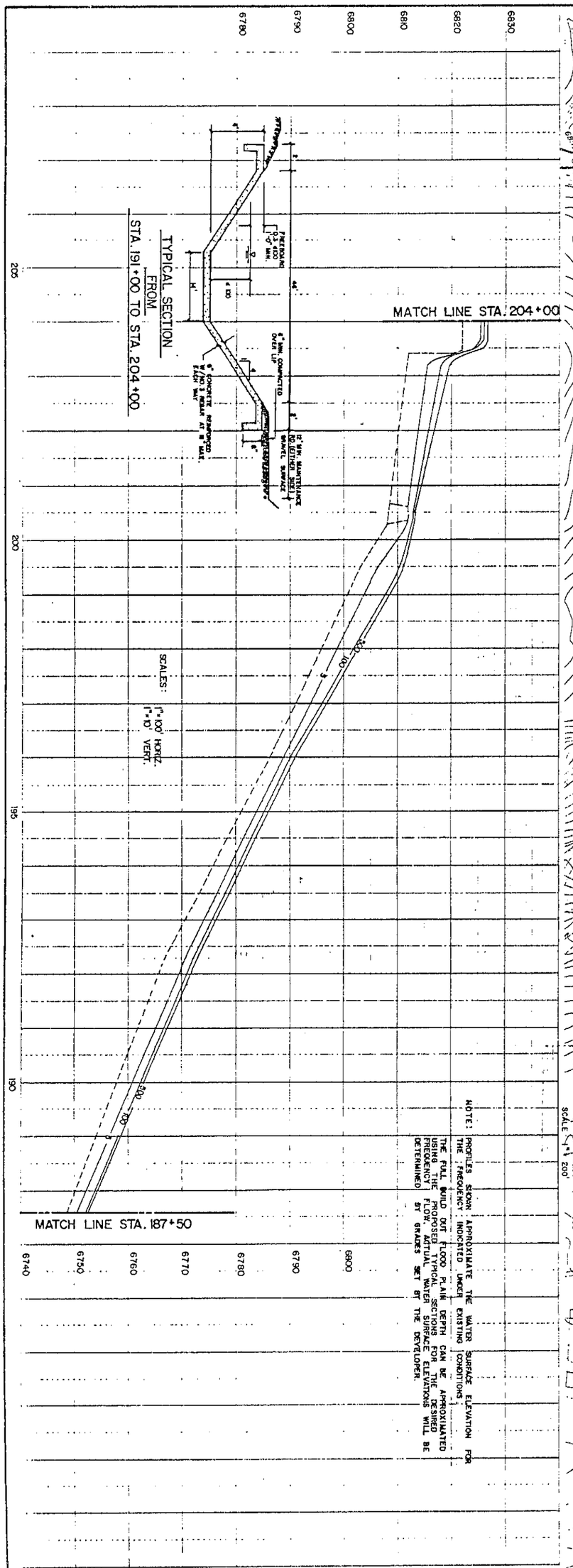
DRY CREEK
MASTER DRAINAGE STUDY

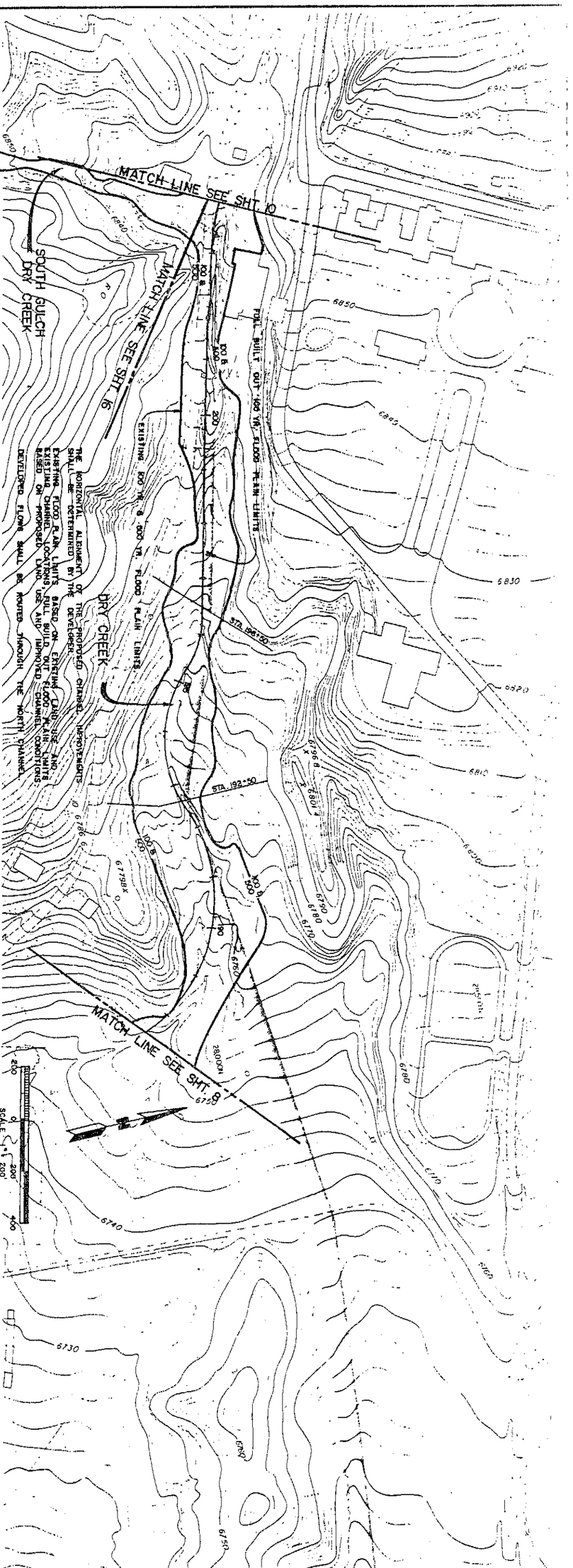
DRY CREEK STA. 167+00 - 187+50

PLAN & PROFILE

KKBNA
INCORPORATED
CONSULTING ENGINEERS

project DRY CREEK
project manager RG
designed by SW, LD job no. 7819 01
drawn by DP sheet no. 9





NOTE: PROFILES SHOWN APPROXIMATE THE WATER SURFACE ELEVATION FOR THE 100 YEAR FREQUENCY FLOOD PLAIN UNDER EXISTING CONDITIONS. THE FULL BUILD OUT FLOOD PLAIN DEPTH CAN BE APPROXIMATED USING THE PROPOSED TYPICAL SECTIONS FOR THE DESIRED FREQUENCY FLOW. ACTUAL WATER SURFACE ELEVATIONS WILL BE DETERMINED BY GRADES SET BY THE DEVELOPER.

THE HORIZONTAL ALIGNMENT OF THE PROPOSED CHANNEL IMPROVEMENTS SHALL BE DETERMINED BY THE DEVELOPER. EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS. FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS. DEVELOPED FLOWS SHALL BE ROUTED THROUGH THE NORTH CHANNEL.

sheet number 6	date JAN 6, 1984	no	description of revisions / date / name
	job number 7819.01.01		
	design by		
	drawn by M. Peter		
	checked by		

DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK STA. 187+50 - 204+00

PLAN & PROFILE

KKBNA
INCORPORATED
CONSULTING ENGINEERS

project manager RB
designed by SW, LJD job no. 7819.
drawn by DP sheet no. 10

MATCH LINE SEE SHT. 11

STA. 227+75

MATCH LINE SEE SHT. 19

EXISTING 100 YR & 500 YR FLOOD PLAIN LIMITS

DRY CREEK

NORTH FORK DRY CREEK

STA. 210+30

SEE SHT. 17

MATCH LINE

FULL BUILT OUT 100 YR. FLOOD PLAIN LIMITS

MATCH LINE SEE SHT. 9

MATCH LINE SEE SHT. 15

SOUTH GULCH

EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS. FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS.

DEVELOPMENT CAUSES NO SUBSTANTIAL CHANGE TO THE FLOOD PLAIN, THEREFORE NO IMPROVEMENTS WILL BE REQUIRED.

THE HORIZONTAL ALIGNMENT OF THE PROPOSED CHANNEL IMPROVEMENTS SHALL BE DETERMINED BY THE DEVELOPER.

SCALE - 1" = 100

MATCH LINE STA. 229+00

MATCH LINE STA. 204+00

SCALES: 1" = 100' HORIZ.
1" = 10' VERT.

TYPICAL SECTION
FROM
STA. 204+00 TO STA. 210+00

FREEBOARD 0.3 d100 1'-0" MIN.

6" MIN. COMPACTED OVER LIP

8" MIN. MAINTENANCE RD (EITHER SIDE) GRAVEL SURFACE

6" CONCRETE REINFORCED W/NO. 3 REBAR AT 18" MAX. EACH WAY

d100

NOTE: PROFILES SHOWN APPROXIMATE THE WATER SURFACE ELEVATION FOR THE FREQUENCY INDICATED UNDER EXISTING CONDITIONS.

THE FULL BUILD OUT FLOOD PLAIN DEPTH CAN BE APPROXIMATED USING THE PROPOSED TYPICAL SECTIONS FOR THE DESIRED FREQUENCY FLOW. ACTUAL WATER SURFACE ELEVATIONS WILL BE DETERMINED BY GRADES SET BY THE DEVELOPER.

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DRY CREEK
MASTER DRAINAGE STUDY

DRY CREEK
STA. 204+00 - 229+00

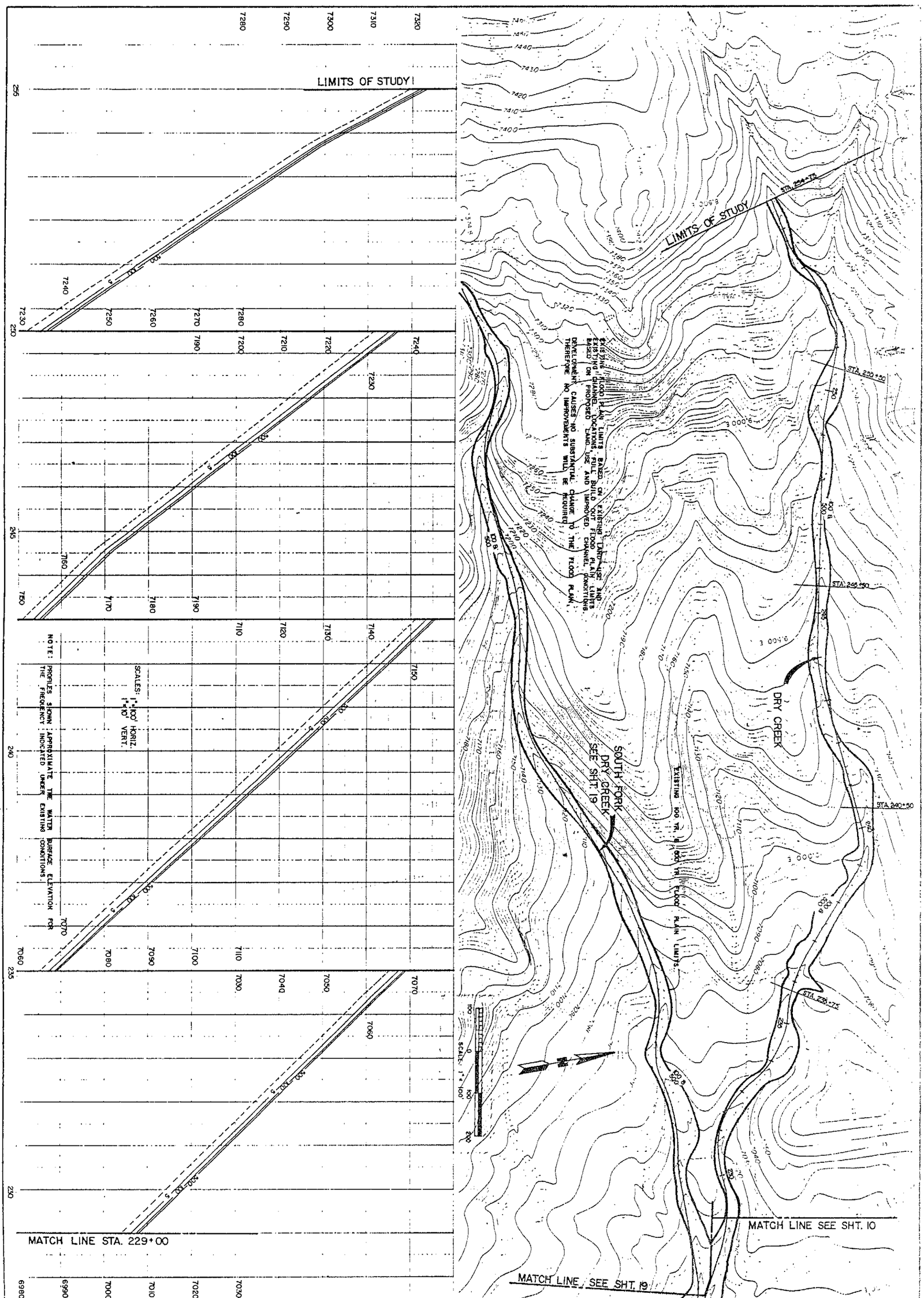
PLAN & PROFILE

no	description of revisions	date	name

date JAN 6, 1994
job number 7819.01
design by
drawn by

sheet number
10

project CREEK
project manager RB
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 11



sheet number 11

date JAN 6, 1984
job number 7819.01.01
design by
drawn by D. Peters
checked by

no	description of revisions	date	name

DRY CREEK RE-STUDY

DRY CREEK STA. 229+00 - 255+00

PLAN & PROFILE

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INCORPORATED
CONSULTING ENGINEERS

project DRY CREEK
project manager RB
designed by SW, LD job no. 7819.01
drawn by J.H. DP

MATCH LINE STA. 27+50

MATCH LINE SEE SHT. 13

STA. 24+00

STA. 19+50

STA. 16+75

STA. 12+75

STA. 10+25

STA. 7+50

STA. 4+25

NORTH CHANNEL DRY CREEK

INCONTROLLED SHEET FLOW

EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING CHANNEL LOCATIONS FULL BUILT OUT 100 YR. FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS

THE HORIZONTAL ALIGNMENT OF THE PROPOSED CHANNEL IMPROVEMENTS SHALL BE DETERMINED BY THE DEVELOPER. FLOWS SHALL BE ROUTED THROUGH THE NORTH CHANNEL DEVELOPED

EXISTING 100 YR. FLOOD PLAIN LIMITS

W.S. 6655.0

FULL BUILT OUT 100 YR. FLOOD PLAIN LIMITS

MATCH LINE SHT. 7

SCALES: 1"=100' HORIZ. 1"=10' VERT.

TYPICAL SECTICAL FROM STA. 0+00 TO STA 27+50

FREEBOARD 0.5' MIN.

6" CONCRETE REINFORCED FLOOR & WEIRS AT 8' MAX.

6" MIN. CONNECTED OVER LAP

8" GRAVEL SURFACE

NOTE: PROFILES SHOWN THE FREQUENCY INDICATED APPROXIMATE THE WATER SURFACE ELEVATION FOR THE FULL BUILD OUT FLOOD PLAIN UNDER EXISTING CONDITIONS. USING THE PROPOSED TYPICAL SECTIONS FOR THE ACTUAL WATER SURFACE ELEVATIONS WILL BE DETERMINED BY GRADES SET BY THE DEVELOPER. FLOW FREQUENCY DEPTH CAN BE APPROXIMATED DESIRED

MATCH LINE: STA. 0+00 NORTH CHANNEL = STA. 147+00 MAIN CHANNEL (190' RT)

sheet number 12

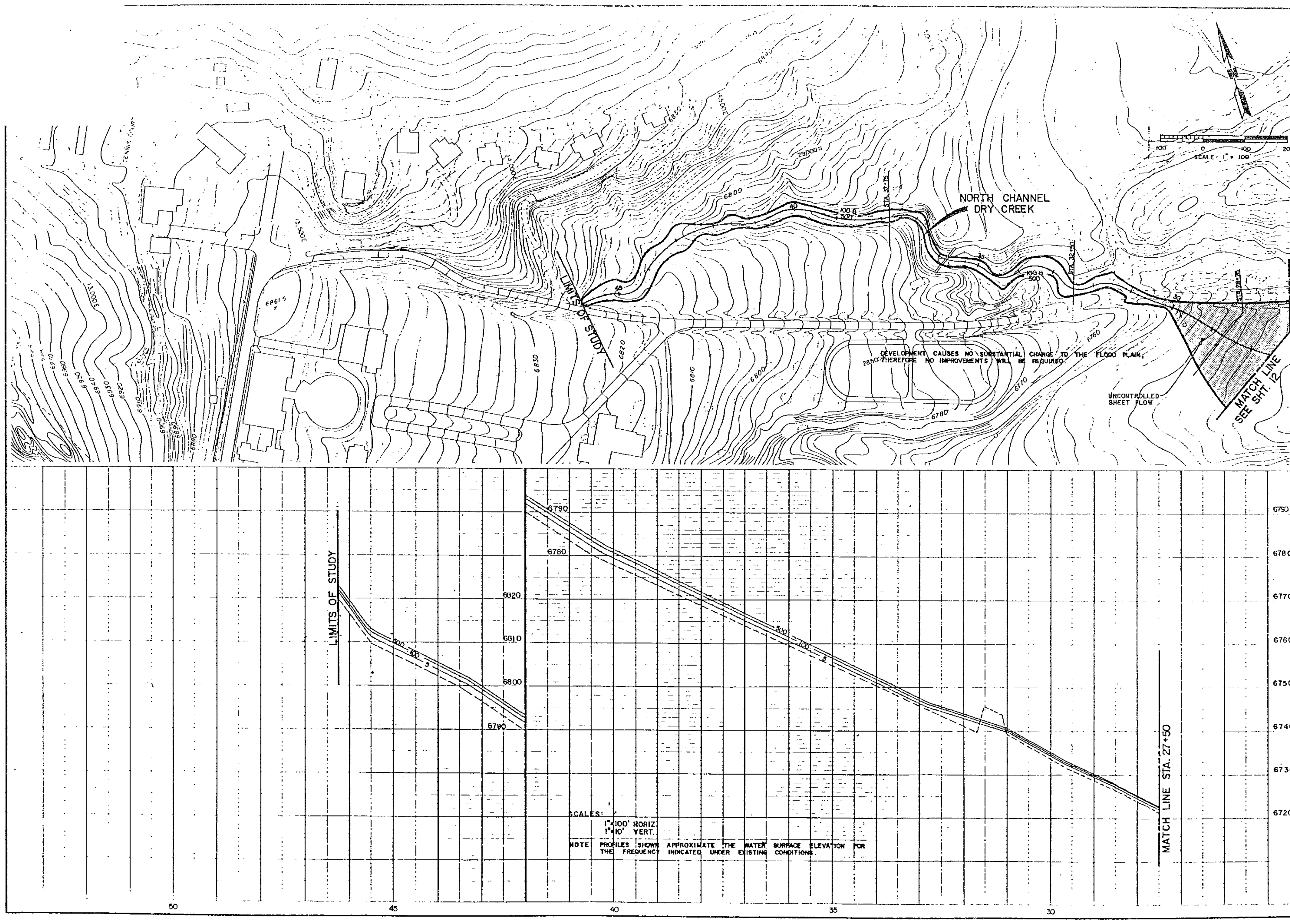
date JAN 6, 1894
job number 7819.01.01
design by
drawn by L. Peter
checked by

no	description of revisions	date	name

DRY CREEK MASTER DRAINAGE STUDY
NORTH CHANNEL STA. 0+00 - 27+50
PLAN & PROFILE

KKBNA
INCORPORATED CONSULTING ENGINEERS

project DRY CREEK
project manager RB
designed by SW, LD
job no. 7819.01
drawn by JH, DP
sheet no. 13



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DRY CREEK
MASTER DRAINAGE STUDY

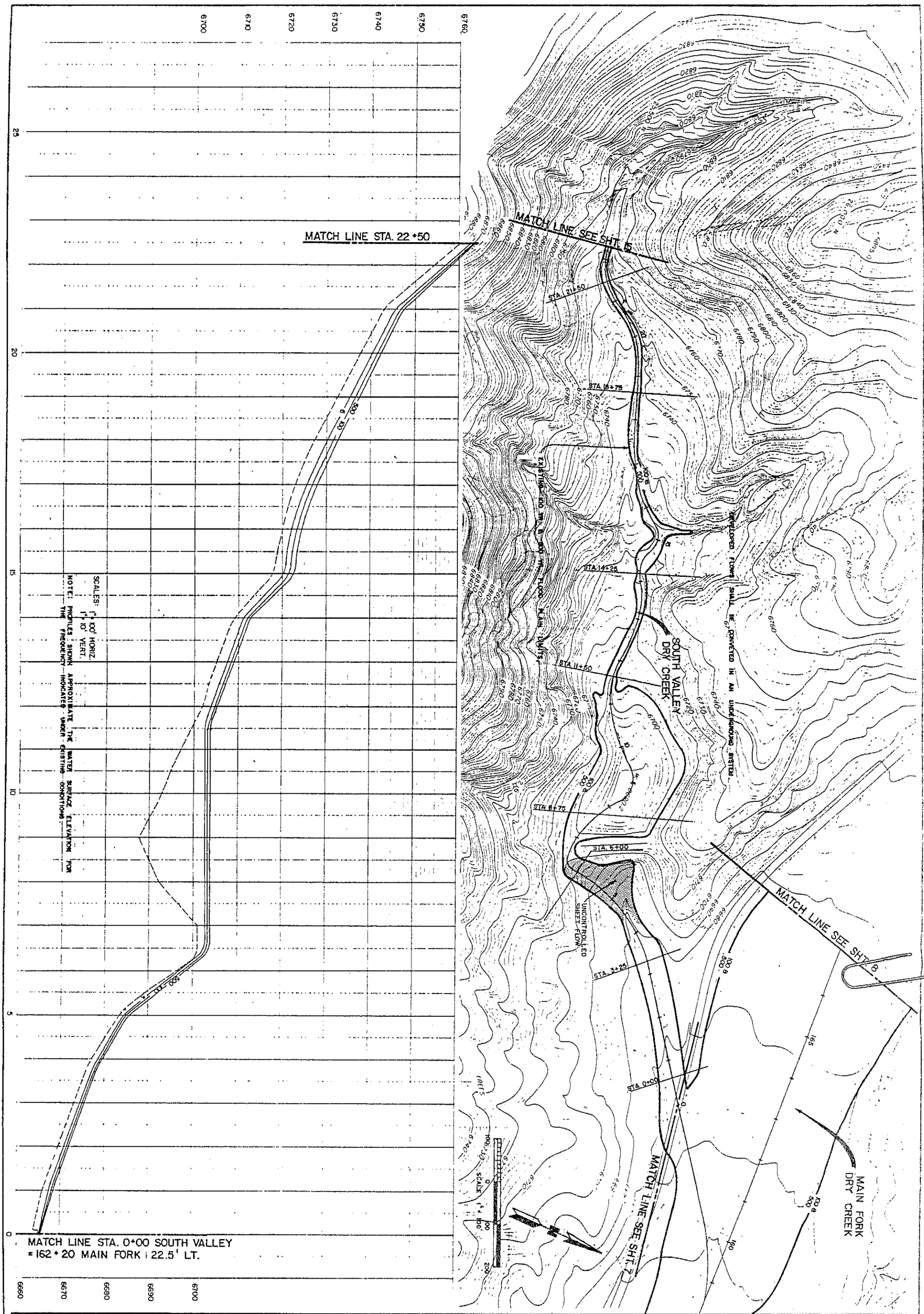
NORTH CHANNEL
STA.
27+50 - 46+25
PLAN & PROFILE

no	description of revisions	date	name

date JAN 6, 1984
job number 7819.01.01
design by
drawn by L Pete
checked by

sheet number
13

project manager RB
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 14



sheet number 14	date JAN 6,1984 job number 7819.01.01. design by drawn by R Peter checked by	no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY
SOUTH VALLEY
STA. 0+00 - 24+00
PLAN & PROFILE

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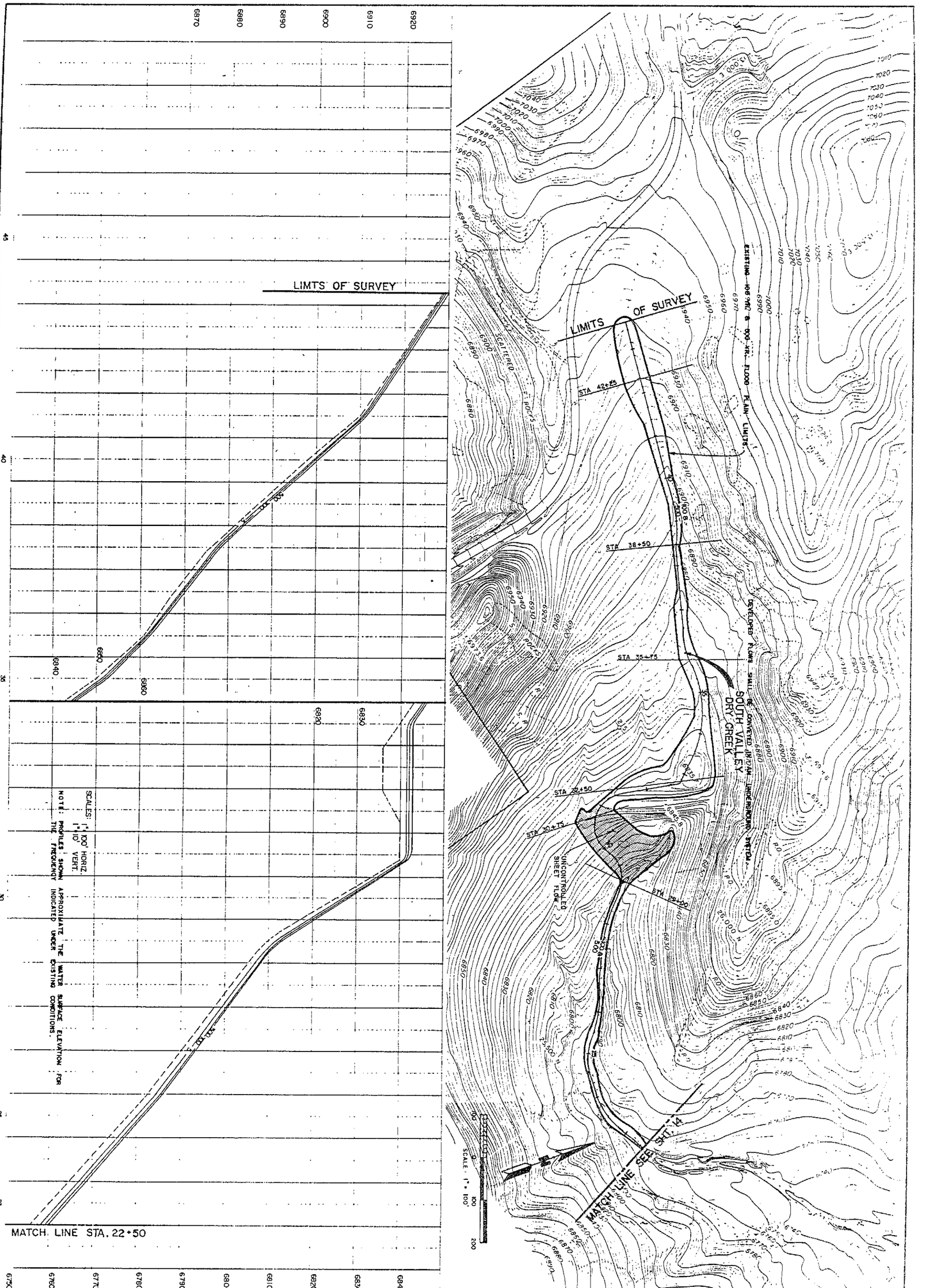
project manager R B
designed by SW, LD job no. 7819.01
drawn by DP sheet no. 15



sheet number 5

date JAN 6, 1984
job number 7819.01.01
design by
drawn by d Pitts
checked by

no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY
SOUTH VALLEY
STA. 24+00 - 44+70
PLAN & PROFILE

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CONSULTING ENGINEERS

project manager RB
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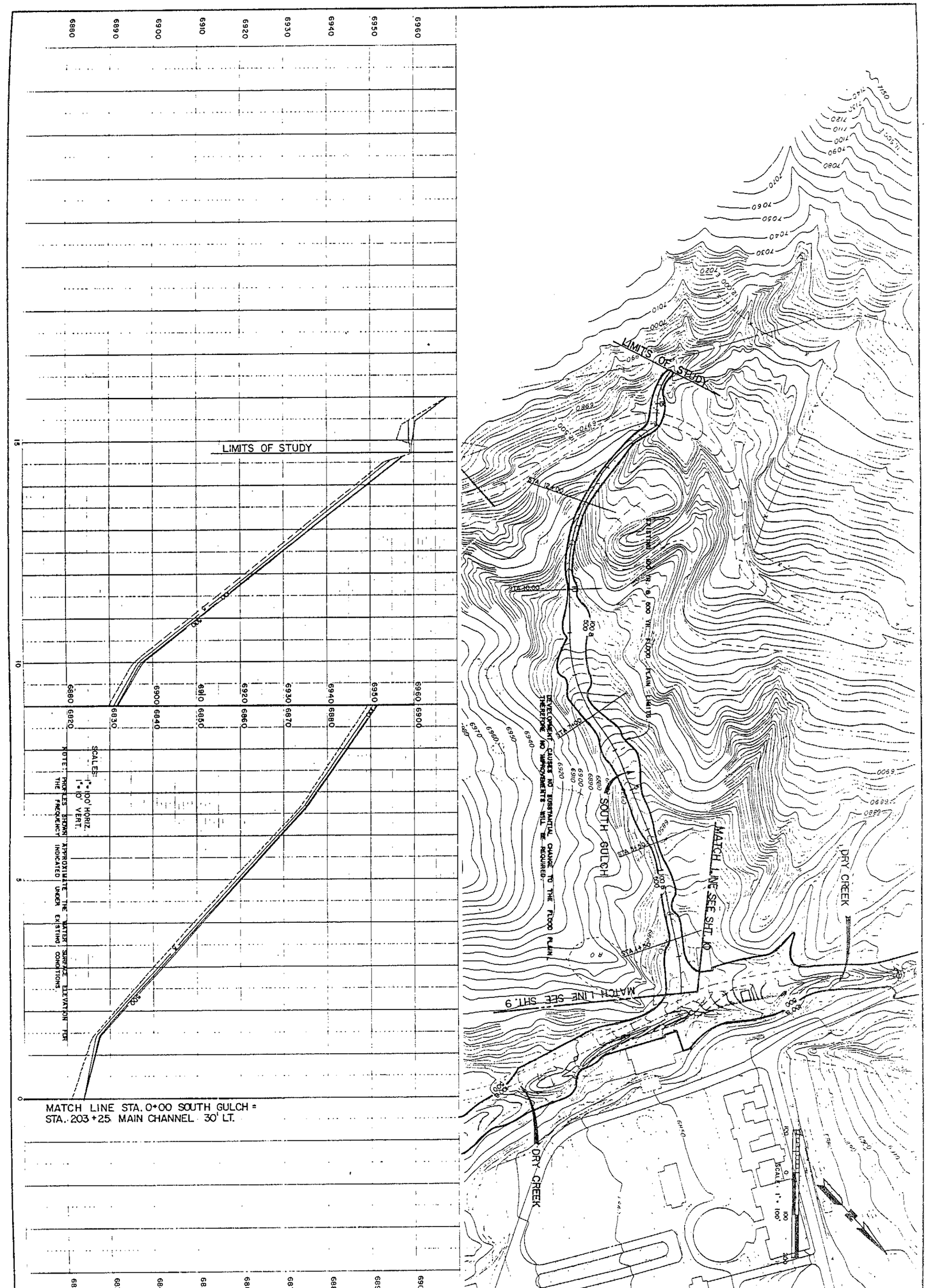
drawn by JH, DP sheet no. 16



sheet number 16

date	JAN 6, 1984
job number	7819.01.01
design by	
drawn by	J. Peter
checked by	

no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY

SOUTH GULCH STA. 0+00 - 15+00

PLAN & PROFILE

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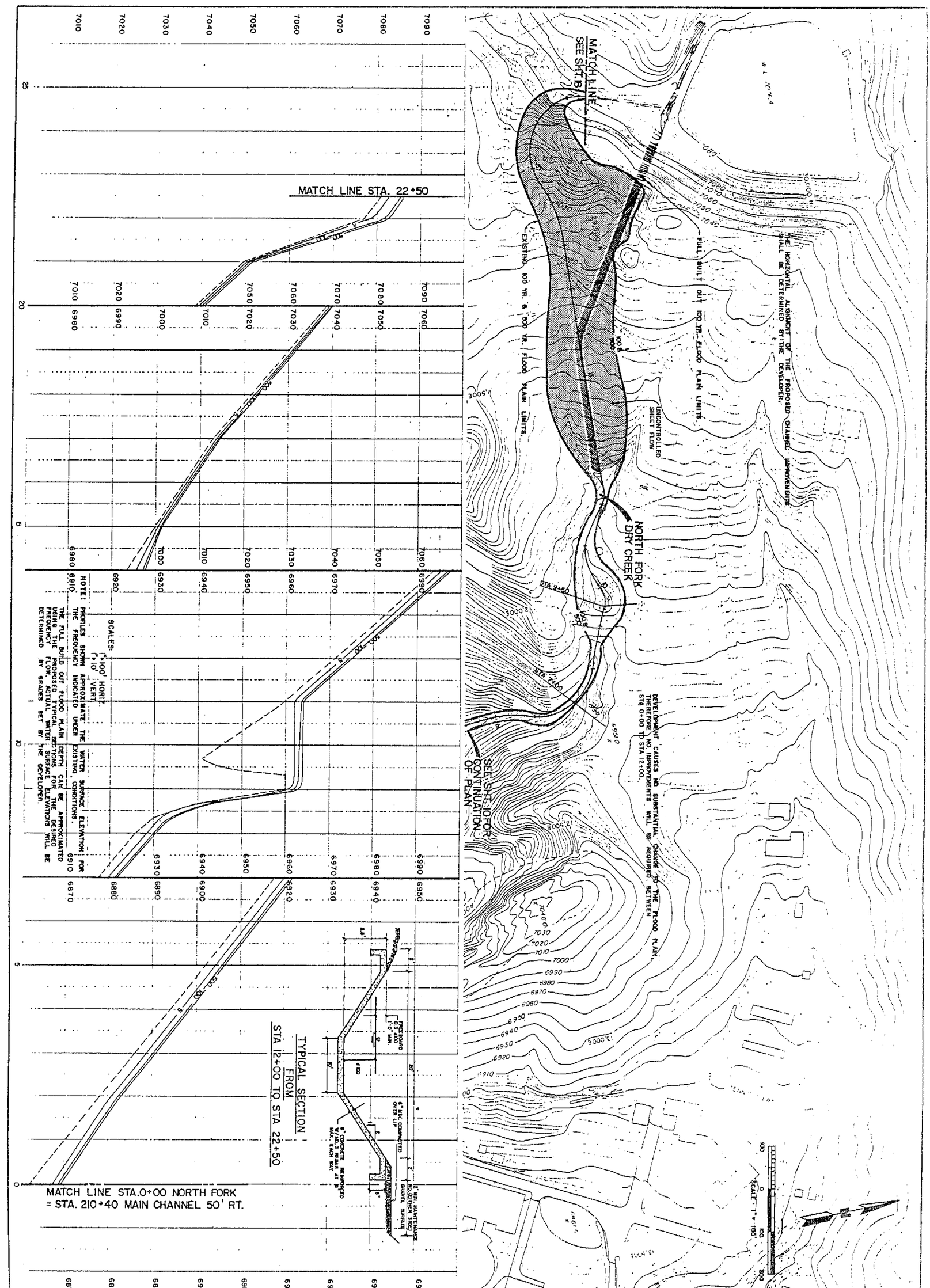
CONSULTING ENGINEERS

project DRY CREEK
project manager RB
designed by SW, LD — job no. 7819.01
drawn by JH, DP — sheet no. 17



sheet number	17
date	JAN 6, 1984
job number	7819.01.01
design by	
drawn by	A. Peter
checked by	

no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY
NORTH FORK STA. 1+00 - 25+00
PLAN & PROFILE

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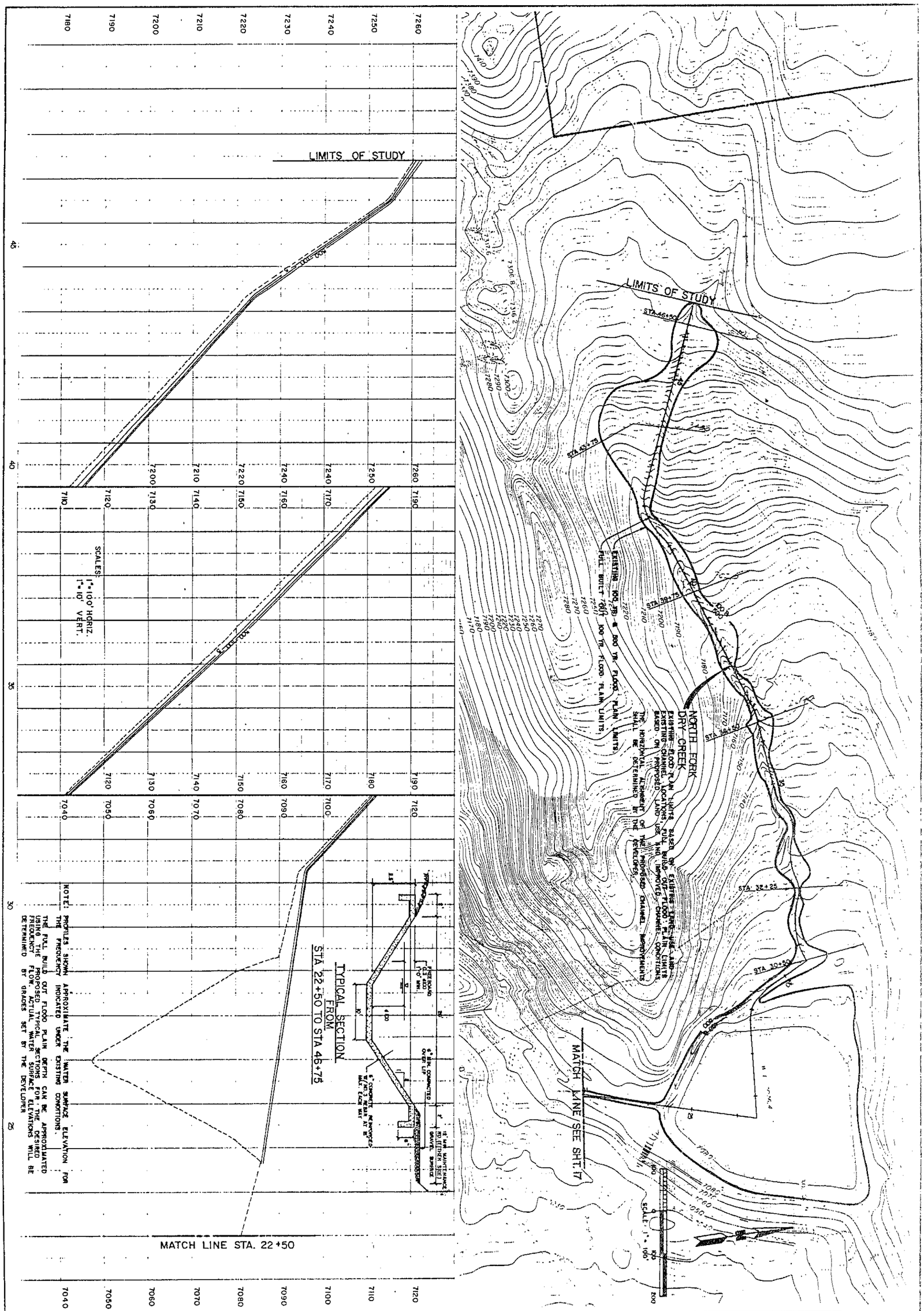
project DRY CREEK
project manager RB
designed by SW, LO job no. 7819.01
drawn by JH, DP sheet no. 18



sheet number 18

date	JAN 6, 1984
job number	7819.01.01
design by	
drawn by	L Peter
checked by	

no	description of revisions	date	name

DRY CREEK
MASTER DRAINAGE STUDY
NORTH FORK STA. 25+00 - 50+00
PLAN & PROFILE

KKBNA
INCORPORATED
CONSULTING ENGINEERS

project DRY CREEK
project manager RB
designed by SW, LD
drawn by DP
job no. 7819.01
sheet no. 19

LIMITS OF STUDY

MAIN CHANNEL
DRY CREEK
SEE SHEET II

SOUTH FORK
DRY CREEK

EXISTING 100 YR. & 500 YR. FLOOD PLAIN LIMITS.

EXISTING FLOOD PLAIN LIMITS BASED ON EXISTING LAND USE AND EXISTING CHANNEL LOCATIONS, FULL BUILD OUT FLOOD PLAIN LIMITS BASED ON PROPOSED LAND USE AND IMPROVED CHANNEL CONDITIONS.

DEVELOPMENT CAUSES NO SUBSTANTIAL CHANGE TO THE FLOOD PLAIN, THEREFORE NO IMPROVEMENTS WILL BE REQUIRED.

MATCH LINE SEE SHT. 10

MATCH LINE SEE SHT. 10

LIMITS OF STUDY

LIMITS OF STUDY

100 & 500

SCALE: 1" = 100'

SCALES:
1" = 100' HORIZ.
1" = 10' VERT.

NOTE: PROFILES SHOWN APPROXIMATE THE WATER SURFACE ELEVATION FOR THE FREQUENCY INDICATED UNDER EXISTING CONDITIONS.

MATCH LINE STA. 0+00 SOUTH FORK
= STA. 227+45 MAIN CHANNEL 45' LT.

KKBNA
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CONSULTING ENGINEERS

DRY CREEK RE-STUDY

SOUTH FORK
STA.
0+00 - 25+38

PLAN & PROFILE

no	description of revisions	date	name

date JAN 6,1984
job number 7819.01.01
design by
drawn by
checked by

sheet number
19

X. COST ESTIMATE SUMMARY AND FEE DETERMINATION

COST ESTIMATE SUMMARY

A detailed cost estimate has been prepared for all proposed drainage facilities and remedial work recommended in this study. The unit prices used in the preparation of this estimate have been prepared based upon discussions with the Public Works Department staff, developers, contractors, and material suppliers, in an attempt to obtain realistic current costs. Basin improvements have been categorized and tabulated in Tables 2a. through 2d. These tables outline proposed facilities with their associated costs, as well as indicate percentage of financial responsibilities that could be shared between Basin Drainage Fee (BDF) and City Capital Improvement Projects (City).

All basin improvements have been based upon City design criteria and would be eligible for basin fee reimbursements. The preliminary designs for structures indicated herein should be verified as to their hydraulic capacities, grades, sizes, right-of-way, etc. during the course of the final design through each developed area. Contingency allowances have been included within the estimate to account for unknown conditions and their associated cost. The construction contingency percentage of 10% covers (realizes) the possibility of increase construction costs of the defined structures, as well as provides for structures not indicated or discovered at the time of this study. Additionally, 10% has been allocated for final design engineering and inspection of the drainage facilities.

The basin area has been determined from the 400-scale ortho photo topography, with developed/undeveloped areas being determined from platting records within the City and County offices. Platted properties have been indicated on the ortho photo topography, as well as been tabulated in Table 6. There are two major unplatted parcels within the City limits of the basin boundaries, those being the Falcon Ridge and Peregrine developments. Other major parcels within the basin included the Pike National Forest, the Sister's of Mount St. Francis Convert, and parcels zoned A-2 within the El Paso County jurisdictions. Of the total basin acreage (Dry Creek and North Basins) of 3352, only 1,123 acres remain unplatted and could be included in a drainage fee structure.

SUMMARY OF COST ESTIMATE

Total Dry Creek & North Basin Drainage Improvement Costs

Total unplatted area within the basins	
Construction Cost Estimate (Developer Cost)	$5,507,600.00
Contingencies at 10%/Engineering at 10%	1,101,520.00
Total Costs	$6,609,120.00

Dry Creek Basin Drainage Improvement Costs Through REACH 2

Reach 2

Total Acreage (Falcon Ridge Development)	112 Acres	
Construction Cost (DP 32 to DP 43)		$1,700,300.00
Upgrade Existing Structures		
$49,450 x [112 acres/(752 + 112 acres)]		6,410.00
Subtotal		$1,706,710.00
Contingencies at 10%/Engineering at 10%		341,342.00
Total Cost		$2,048,052.00

Reach 3

Total Acreage	752 Acres	
Construction Cost (West City Limits to DP 32)		$2,884,450.00
Upgrade Existing Structures		
$49,450 x [752 acres/(752 + 112 acres)]		43,040.00
Subtotal		$2,927,490.00
Contingencies at 10%/Engineering at 10%		585,498.00
Total Cost		$3,512,988.00

North Basin

Total Acreage (within Peregrine)	220 Acres	
8 acres nonplatted require no facilities		
Construction Cost (Minor Systems above DP 62)		$ 761,000.00
Upgrade Existing Structures		None Required
Contingencies at 10%/Engineering at 10%		152,200.00
Total Cost		$ 913,200.00

Lower Basin (Corporate Centre, 10 Ac Immediately West of RR Tracks)

Total Acreage	31 Acres	
Construction Cost		$ 112,400.00
Contingencies at 10%/Engineering at 10%		22,480.00
Total Cost		$ 134,880.00

Recommended Fee = $6,609,120
− 913,200
$5,695,920 (North Basin)

Fee = $5,695,920 ÷ 895 Ac = $6364/acre

SUMMARY OF AREAS

Total Basin Study Area	= 3552 Acres
Total Dry Creek Basin Area	= 2240 Acres
Total North Basin Area	= 1312 Acres
Dry Creek Basin	= 2240 Acres
Area Previously Platted (9-1-83) (within City Limits)	= 487 Acres
Area within Pike National Forest	= 586 Acres
Area within Sisters Property	= 112 Acres
Area With El Paso County	= 160 Acres
Unplatted Area within City Limits	= 895 Acres ✓
North Basin	= 1312 Acres
Area Previously Platted (9-1-83) (within City Limits)	= 128 Acres
Area within El Paso County	= 866 Acres
Area within Air Force Academy	= 90 Acres
Uplatted Area within City Limits	= 228 Acres ✓

Table Xa. Unit Cost Summary

DESCRIPTION	UNIT		UNIT PRICE
Channel Excavation	CY	Varies	$2 - 5.00
Reinforced Concrete	CY		$ 250.00
12" Rock Riprap (includes bedding)	CY		$ 38.00
Gabion Blanket	LF		$ 33.00
6' x 9' Box Culvert	LF		$ 226.00
24" RCP	LF		$ 34.50
36" RCP	LF		$ 50.50
48" RCP	LF		$ 80.00
60" RCP	LF		$ 100.00
Catch Basin	EA		$2,500.00
Manhole	EA		$1,500.00
Concrete Drainage Chute	LF		$ 24.00
Guard Rail	LF		$ 16.00
Asphalt Repair/Replace	SY		$ 15.00
Utility Adjustments			Varies

Note: Costs do not include engineering and contingencies.

XI. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

The Dry Creek Drainage Basin Study covers two distinct drainage basins. The main basin, as drained by Dry Creek, includes extensive areas within the Pike National Forest, as well as developed and nondeveloped areas within the City limits. Through the developed portions of this basin, drainage facilities have been constructed which are generally consistent with the magnitude of flows anticipated for this area. The second basin, referred to in this study as North Basin, generally extends north of Woodmen Road to the Air Force Academy and east from the upper reaches of the Peregrine development to the railroad tracks. This basin includes not only properties within the Colorado Springs City Limits, but also areas zoned A-2 within the unincorporated area of El Paso County. Flows in this basin are considerably less than that of the major Dry Creek drainage area. Minimal improvements have been constructed within the El Paso County portion of this basin, due to the minimal development that has occurred.

The hydrology and hydraulics of this basin are based upon utilizing the 24-hour storm duration runoff information. As a result of our investigations to determine the most cost-effective manner to convey flows throughout the basin, it became apparent that two alternate methods of storm water management should be employed. For the Dry Creek Basin, the most cost-effective method to route storm water through the basin is by utilizing defined channels with minimal detention storage. This conclusion was reached due to the relatively large, uncontrolled flows which enter the basin from the National Forest lands, as well as the inability to provide effective detention facilities within the basin. Storm water management in the North Basin of this study should be regulated in a detention/regulated outflow concept. This is considered the most cost-effective program since the lower portions of the basins are outside the current City limits, and historic flows in these basins have not caused significant flooding or erosion problems to date. A detailed summary of all hydrology and hydraulics is included within the Appendix.

Cost estimates for construction within the proposed developments have been prepared utilizing channelization criteria in accordance with City Standards. In addition to new construction, this report identified several areas of concern regarding existing structures and drainageways. Many of these concerns are a result of the revised criteria to analyze runoff rates, as well as a result of limited funding for maintenance of those structures. These areas of concern should be prioritized and scheduled for improvements within a reasonable course of time to prevent further degradation. The cost estimates presented in this report could be used as a basis for a Basin Drainage Fee structure for the Dry Creek and North Basins.

Channelization has been indicated in those areas of the proposed developments in which existing slopes, thus velocities, would permit. Those areas within the proposed developments where the slopes are extremely steep and where deep channels have been formed, it is recommended that no formal/designed channels should be constructed. In those areas, a 50-foot setback from the existing floodplain should be established at the time of platting, as well as provisions made for the developer and/or his assigns to be responsible for future maintenance.

XII. BIBLIOGRAPHY/REFERENCES

BIBLIOGRAPHY/REFERENCES

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XIII. APPENDICES

1. SUMMARY OF HYDROLOGIC CALCULATIONS

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

5-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 2.7 INCHES

EXISTING CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
1	0.22	77	0.19	160	6.05	0.22	160	6.05	Main Channel on westernmost edge of City limits
2	0.11	73	0.25	53	6.10	0.33	199	6.13	Main Channel
3	0.05	66	0.20	13	6.10	0.38	192	6.18	Main Channel near small dam
5	0.27	77	0.25	179	6.09	0.27	179	6.09	South Fork on Forest Service property
6	0.11	70	0.37	30	6.20	0.38	190	6.16	South Fork near small dam
8	0.06	66	0.22	14	6.11	0.82	378	6.20	Confluence of South Fork and Main Channel near small dam
9	0.07	65	0.33	11	6.20	0.89	363	6.26	Main Channel near confluence with the North Fork
10	0.26	77	0.29	158	6.11	0.26	158	6.11	North Fork on Forest Service property
12	0.16	67	0.50	26	6.32	0.42	161	6.27	North Fork at Upper Reservoir
12	-	-	-	-	-	0.42	151	6.50	Through Upper Reservoir North Fork
14	0.02	62	0.21	3	6.12	0.44	128	6.51	North Fork at Lower Reservoir
14	-	-	-	-	-	0.44	126	6.50	Through Lower Reservoir North Fork
15	0.01	62	0.12	2	6.05	0.45	116	6.57	North Fork near confluence with Main Channel
9	-	-	-	-	-	1.34	376	6.28	Confluence of North Fork and Main Channel
17	0.05	62	0.42	4	6.32	1.39	375	6.33	Main Channel near the Sister's power plant
18	0.12	67	0.34	24	6.19	0.11	24	6.19	South Gulch
17	-	-	-	-	-	1.50	394	6.32	Confluence of Main Channel and South Gulch

DEVELOPED CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
1	0.22	77	0.19	160	6.05	0.22	160	6.05	Main Channel on westernmost edge of City limits
2	0.11	73	0.25	53	6.10	0.33	200	6.13	Main Channel
3	0.05	67	0.18	14	6.08	0.38	193	6.18	Main Channel near small dam
5	0.27	77	0.25	179	6.09	0.27	179	6.09	South Fork on Forsest Service property
6	0.11	71	0.36	34	6.18	0.38	194	6.16	South Fork near small dam
8	0.06	67	0.21	16	6.10	0.82	384	6.20	Confluence of South Fork and Main Channel near small dam
9	0.07	70	0.29	23	6.13	0.89	375	6.25	Main Channel near confluence with North Fork
10	0.26	77	0.29	158	6.11	0.26	158	6.11	North Fork on Forest Service property
12	0.16	70	0.46	38	6.26	0.42	173	6.26	North Fork at Upper Reservoir
14	0.02	62	0.21	3	6.12	0.44	169	6.33	North Fork at Lower Reservoir
14	-	-	-	-	-	0.44	164	6.40	Through Lower Reservoir North Fork
15	0.01	62	0.12	2	6.05	0.45	164	6.38	North Fork near confluence with Main Channel
9	-	-	-	-	-	1.34	522	6.29	Confluence of North Fork and Main Channel
17	0.05	71	0.35	15	6.17	1.39	520	6.32	Main Channel near the Sister's power plant
18	0.12	70	0.31	36	6.14	0.12	36	6.14	South Gulch
17	-	-	-	-	-	1.50	544	6.32	Confluence of Main Channel and South Gulch

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

5-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 2.7 INCHES

EXISTING CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
20	0.05	67	0.20	13	6.09	1.55	384	6.42	Main Channel
21	0.13	74	0.45	49	6.23	1.68	397	6.56	Main Channel
22	0.05	75	0.27	25	6.11	0.04	25	6.11	South Valley at Upper Reservoir
22	-	-	-	-	-	0.04	19	6.30	Through Upper Reservoir in South Valley
24	0.09	77	0.26	56	6.10	0.13	65	6.12	South Valley at Lower Reservoir
24	-	-	-	-	-	0.13	40	6.50	Through Lower Reservoir in South Valley
25	0.02	83	0.14	25	6.00	0.15	45	6.38	South Valley near confluence with Main Channel
21	-	-	-	-	-	1.83	440	6.55	Confluence of Main Channel and South Valley
26	0.05	74	0.27	27	6.11	1.89	433	6.66	Main Channel
27	0.04	63	0.26	6	6.15	0.04	6	6.15	North Channel on the Sister's property
28	0.04	63	0.20	7	6.11	0.08	12	6.13	North Channel on the Sister's property
29	0.03	62	0.20	5	6.12	0.12	12	6.24	North Channel leaving the Sister's property
30	0.07	65	0.62	8	6.47	0.19	19	6.43	North Channel
31	0.08	68	0.31	20	6.15	0.27	30	6.44	North Channel
✓ 32	0.03	66	0.15	7	6.06	2.18	462	6.64	Confluence of Main Channel at eastern End of Reach 3
41	0.14	66	0.47	21	6.31	2.32	466	6.72	Main Channel entering
40	0.10	84	0.26	107	6.08	0.10	107	6.08	Tributary from Mt. Woodmen Estates

DEVELOPED CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
20	0.05	74	0.18	26	6.05	1.55	527	6.39	Main Channel
27	0.04	63	0.26	6	6.15	0.40	6	6.15	North Channel on the Sister's property
28	0.04	63	0.20	7	6.11	0.08	12	6.13	North Channel on the Sister's property
29	0.03	62	0.20	5	6.12	0.12	13	6.24	North Channel on the Sister's property
29	-	-	-	-	-	1.67	527	6.43	Reroute flows historically in the Main Channel through North Channel
30	0.07	72	0.51	19	6.29	1.73	527	6.49	North Channel leaving the Sister's property
31	0.08	74	0.27	41	6.11	1.82	531	6.54	North Channel
22	0.03	80	0.23	38	6.07	0.04	38	6.07	South Valley
24	0.09	82	0.23	82	6.07	0.13	112	6.09	South Valley
25	0.02	87	0.12	33	5.98	0.15	129	6.07	South Valley
21	0.13	79	0.38	80	6.16	0.29	204	6.07	Confluence of Main Channel and South Valley
26	0.05	80	0.23	45	6.07	0.34	207	6.21	Main Channel
✓ 32	0.03	75	0.13	20	6.01	2.18	653	6.50	Confluence of Main Channel and North Channel at the eastern Edge of Reach 3
41	0.14	75	0.38	61	6.18	2.32	670	6.56	Main Channel entering Reach 3
40	0.10	84	0.86	113	6.05	0.10	113	6.05	Tributary from Mt. Woodmen Estates
41	-	-	-	-	-	2.43	694	6.55	Confluence of tributary from Mt. Woodmen Estates and Main Channel
42	0.22	75	0.43	90	6.21	2.65	719	6.67	Main Channel
43	0.02	75	0.17	15	6.04	2.67	721	6.67	Main Channel

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

5 -YR., 24-HR., TYPE IIA STORM, PRECIPITATION 2.7 INCHES

EXISTING CONDITIONS									
SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
41	-	-	-	-	-	2.43	481	6.71	Confluence of tributary from Mt. Woodmen Estates and Main Channel
42	0.22	66	0.54	30	6.36	2.65	488	6.84	Main Channel
43	0.02	64	0.21	4	6.11	2.67	489	6.84	Main Channel at Upper Reservoir
43	-	-	-	-	-	2.67	465	7.10	Through Upper Reservoir Main Channel
44	-	-	-	-	-	2.67	468	7.00	Through Lower Reservoir Main Channel
45	0.04	73	0.31	15	6.13	2.70	466	7.05	Main Channel
46	0.02	83	0.24	19	6.07	0.02	19	6.07	Big Valley
47	0.04	81	0.19	35	6.04	0.06	50	6.07	Big Valley
48	0.06	84	0.25	65	6.07	0.12	109	6.09	Big Valley
49	0.05	85	0.13	65	5.99	0.16	151	6.05	Big Valley
50	0.09	83	0.29	80	6.10	0.25	215	6.14	Big Valley crossing Delmonico Drive
51	0.04	82	0.22	37	6.06	0.29	235	6.15	Big Valley near confluence with Main Channel
45	-	-	-	-	-	2.99	488	7.04	Confluence of Big Valley and Main Channel
52	0.09	82	0.18	87	6.03	3.08	484	7.12	Main Channel at Pebble Way
52	-	-	-	-	-	3.08	483	7.20	Reservoir at Pebble Way Main Channel
53	0.10	80	0.50	55	6.23	3.18	486	7.15	Main Channel at the Earth Dam
53	-	-	-	-	-	3.18	476	7.30	Reservoir at Earth Dam Main Channel
54	-	-	-	-	-	3.18	462	7.50	Reservoir at Rockrimmon Blvd. Main Channel
55	0.16	65	0.38	24	6.23	3.34	463	7.42	Main Channel at Dawson Drive
55	-	-	-	-	-	3.34	452	7.60	Reservoir at Dawson Drive Main Channel
56	0.11	70	0.25	38	6.11	3.45	452	7.56	Main Channel at the Railroad Crossing
56	-	-	-	-	-	3.45	451	7.70	Reservoir at the Railroad Crossing Main Channel
57	0.03	93	0.22	54	6.03	3.48	454	7.50	Main Channel at Cascade Avenue
57	-	-	-	-	-	3.48	453	7.70	Reservoir at Cascade Avenue Main Channel

DEVELOPED CONDITIONS									
SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
44	-	-	-	-	-	2.67	729	6.80	Through Lower Reservoir Main Channel
45	0.04	73	0.31	15	6.13	2.70	711	6.74	Main Channel
46	0.02	86	0.85	24	6.03	0.02	24	6.03	Big Valley
47	0.04	81	0.19	35	6.04	0.06	56	6.06	Big Valley
48	0.06	84	0.25	65	6.07	0.12	115	6.09	Big Valley
49	0.05	85	0.13	65	5.99	0.16	153	6.05	Big Valley
50	0.09	83	0.29	80	6.10	0.25	219	6.14	Big Valley crossing Delmonico Drive
51	0.04	82	0.22	37	6.06	0.29	239	6.15	Big Valley near confluence with Main Channel
45	-	-	-	-	-	2.99	773	6.67	Confluence of Big Valley and Main Channel
52	0.09	82	0.18	87	6.03	3.08	777	6.71	Main Channel at Pebble Way
52	-	-	-	-	-	3.08	776	6.80	Reservoir at Pebble Way Main Channel
53	0.10	80	0.50	56	6.23	3.18	796	6.72	Main Channel
54	-	-	-	-	-	3.18	789	6.90	Reservoir at Rockrimmon Boulevard Main Channel
55	0.16	65	0.38	24	6.23	3.34	795	6.82	Main Channel at Dawson Drive
55	-	-	-	-	-	3.34	778	7.00	Reservoir at Dawson Drive Main Channel
57	0.03	93	0.22	54	6.03	3.48	784	6.98	Main Channel at Cascade Avenue
57	-	-	-	-	-	3.48	784	7.10	Reservoir at Cascade Avenue Main Channel

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

100 -YR., 24-HR., TYPE IIA STORM, PRECIPITATION 4.3 INCHES

EXISTING CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
1	0.22	77	0.19	409	6.03	0.22	409	6.03	Main Channel on westernmost edge of City limits
2	0.11	73	0.25	156	6.08	0.33	537	6.09	Main Channel
3	0.05	66	0.20	51	6.06	0.38	552	6.12	Main Channel near small dam
5	0.27	77	0.25	458	6.07	0.27	458	6.07	South Fork on Forest Service property
6	0.11	70	0.37	102	6.15	0.38	531	6.12	South Fork near small dam
8	0.06	66	0.22	55	6.08	0.82	1093	6.14	Confluence of South Fork and Main Channel near small dam
9	0.07	65	0.33	52	6.14	0.89	1085	6.19	Main Channel near confluence with the North Fork
10	0.26	77	0.29	409	6.09	0.26	409	6.09	North Fork on Forest Service property
12	0.16	67	0.50	106	6.25	0.42	469	6.21	North Fork at Upper Reservoir
12	-	-	-	-	-	0.42	486	6.30	Through Upper Reservoir North Fork
14	0.02	62	0.21	18	6.08	0.44	459	6.30	North Fork at Lower Reservoir
14	-	-	-	-	-	0.44	462	6.40	Through Lower Reservoir North Fork
15	0.01	62	0.12	11	6.01	0.45	453	6.33	North Fork near confluence with Main Channel
9	-	-	-	-	-	1.34	1419	6.23	Confluence of North Fork and Main Channel
17	0.05	62	0.42	25	6.22	1.39	1394	6.26	Main Channel near the Sister's power plant
18	0.12	67	0.34	98	6.14	0.11	98	6.14	South Gulch
17	-	-	-	-	-	1.50	1471	6.25	Confluence of Main Channel and South Gulch

DEVELOPED CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
1	0.22	77	0.19	409	6.03	0.22	409	6.03	Main Channel on westernmost edge of City limits
2	0.11	73	0.25	156	6.08	0.33	537	6.09	Main Channel
3	0.05	67	0.18	55	6.04	0.38	553	6.02	Main Channel near small dam
5	0.27	77	0.25	458	6.07	0.27	458	6.07	South Fork on Forsest Service property
6	0.11	71	0.36	113	6.14	0.38	541	6.12	South Fork near small dam
8	0.06	67	0.21	59	6.07	0.82	1106	6.13	Confluence of South Fork and Main Channel near small dam
9	0.07	70	0.29	77	6.11	0.89	1114	6.18	Main Channel near confluence with North Fork
10	0.26	77	0.29	409	6.09	0.26	409	6.09	North Fork on Forest Service property
12	0.16	70	0.46	134	6.22	0.42	499	6.21	North Fork at Upper Reservoir
14	0.02	62	0.21	17	6.08	0.44	487	6.25	North Fork at Lower Reservoir
14	-	-	-	-	-	0.44	478	6.40	Through Lower Reservoir North Fork
15	0.01	62	0.12	11	6.01	0.45	480	6.29	North Fork near confluence with Main Channel
9	-	-	-	-	-	1.34	1553	6.21	Confluence of North Fork and Main Channel
17	0.05	71	0.35	51	6.14	1.39	1559	6.23	Main Channel near the Sister's power plant
18	0.12	70	0.31	125	6.12	0.12	125	6.12	South Gulch
17	-	-	-	-	-	1.50	1659	6.22	Confluence of Main Channel and South Gulch

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

100 -YR., 24-HR., TYPE IIA STORM, PRECIPITATION 4.3 INCHES

EXISTING CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
20	0.05	67	0.20	49	6.06	1.55	1435	6.31	Main Channel
21	0.13	74	0.45	143	6.20	1.68	1483	6.41	Main Channel
22	0.05	75	0.27	67	6.09	0.04	67	6.09	South Valley at Upper Reservoir
22	-	-	-	-	-	0.04	58	6.30	Through Upper Reservoir in South Valley
24	0.09	77	0.26	143	6.08	0.13	181	6.11	South Valley at Lower Reservoir
24	-	-	-	-	-	0.13	150	6.30	Through Lower Reservoir in South Valley
25	0.02	83	0.14	54	6.00	0.15	162	6.22	South Valley near confluence with Main Channel
21	-	-	-	-	-	1.83	1611	6.40	Confluence of Main Channel and South Valley
26	0.05	74	0.27	77	6.09	1.89	1590	6.46	Main Channel
27	0.04	63	0.26	32	6.11	0.04	32	6.11	North Channel on the Sister's property
28	0.04	63	0.20	36	6.07	0.08	6432	6.10	North Channel on the Sister's property
29	0.03	62	0.20	26	6.08	0.12	75	6.15	North Channel leaving the Sister's property
30	0.07	65	0.62	34	6.36	0.19	100	6.30	North Channel
31	0.08	68	0.31	78	6.12	0.27	140	6.28	North Channel
32	0.03	66	0.15	31	6.02	2.18	1724	6.45	Confluence of Main Channel at eastern edge of Reach 3
41	0.14	66	0.47	90	6.24	2.32	1750	6.50	Main Channel entering Reach 2
40	0.10	84	0.26	228	6.07	0.10	228	6.07	Tributary from Mt. Woodmen Estates

DEVELOPED CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
20	0.05	74	0.18	73	6.03	1.55	1603	6.27	Main Channel
27	0.04	63	0.26	32	6.11	0.40	32	6.11	North Channel on the Sister's property
28	0.04	63	0.20	36	6.07	0.08	64	6.10	North Channel on the Sister's property
29	0.03	62	0.20	26	6.08	0.12	75	6.15	North Channel on the Sister's property
29	-	-	-	-	-	1.67	1632	6.30	Reroute flows historically in the Main Channel through North Channel
30	0.07	72	0.51	61	6.24	1.73	1652	6.34	North Channel leaving the Sister's property
31	0.08	74	0.27	115	6.09	1.82	1653	6.38	North Channel
22	0.03	80	0.23	88	6.05	0.04	88	6.05	South Valley
24	0.09	82	0.23	182	6.05	0.13	259	6.07	South Valley
25	0.02	87	0.12	64	5.97	0.15	299	6.05	South Valley
21	0.13	79	0.38	202	6.14	0.29	484	6.09	Confluence of Main Channel and South Valley
26	0.05	80	0.23	106	6.05	0.34	518	6.16	Main Channel
32	0.03	75	0.13	54	5.99	2.18	2032	6.34	Confluence of Main Channel and North Channel at the eastern edge of Reach 3
41	0.14	75	0.38	173	6.15	2.32	2093	6.38	Main Channel entering Reach 2
40	0.10	84	0.86	240	6.04	0.10	240	6.04	Tributary from Mt. Woodmen Estates
41	-	-	-	-	-	2.43	2158	6.37	Confluence of tributary from Mt. Woodmen Estates and Main Channel
42	0.22	75	0.43	254	6.19	2.65	2265	6.47	Main Channel
43	0.02	75	0.17	40	6.02	2.67	2276	6.47	Main Channel

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

100 -YR., 24-HR., TYPE IIA STORM; PRECIPITATION 4.3 INCHES

EXISTING CONDITIONS

	SUBBASIN RUNOFF					CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
41	-	-	-	-	-	2.43	1806	6.49	Confluence of tributary from Mt. Woodmen Estates and Main Channel
42	0.22	66	0.54	130	6.29	2.65	1853	6.61	Main Channel
43	0.02	64	0.21	20	6.08	2.67	1858	6.61	Main Channel at Upper Reservoir
43	-	-	-	-	-	2.67	1818	6.60	Through Upper Reservoir Main Channel
44	-	-	-	-	-	2.67	1808	6.80	Through Lower Reservoir Main Channel
45	0.04	73	0.31	45	6.11	2.70	1810	6.72	Main Channel
46	0.02	83	0.24	41	6.05	0.02	41	6.05	Big Valley
47	0.04	81	0.19	80	6.02	0.06	113	6.05	Big Valley
48	0.06	84	0.25	138	6.06	0.12	241	6.08	Big Valley
49	0.05	85	0.13	133	5.98	0.16	332	6.04	Big Valley
50	0.09	83	0.29	177	6.08	0.25	476	6.13	Big Valley crossing Delmonico Drive
51	0.04	82	0.22	83	6.04	0.29	529	6.13	Big Valley near confluence with Main Channel
45	-	-	-	-	-	2.99	1927	6.69	Confluence of Big Valley and Main Channel
52	0.09	82	0.18	195	6.01	3.08	1924	6.72	Main Channel at Pebble Way
52	-	-	-	-	-	3.08	1920	6.80	Reservoir at Pebble Way Main Channel
53	0.10	80	0.50	135	6.21	3.18	1959	6.74	Main Channel at the Earth Dam
53	-	-	-	-	-	3.18	1940	6.90	Reservoir at Earth Dam Main Channel
54	-	-	-	-	-	3.18	1921	7.00	Reservoir at Rockrimmon Blvd. Main Channel
55	0.16	65	0.38	111	6.18	3.34	1933	6.88	Main Channel at Dawson Drive
55	-	-	-	-	-	3.34	1746	7.20	Reservoir at Dawson Drive Main Channel
56	0.11	70	0.25	127	6.08	3.45	1744	7.12	Main Channel at the Railroad Crossing
56	-	-	-	-	-	3.45	1724	7.20	Reservoir at the Railroad Crossing Main Channel
57	0.03	93	0.22	95	6.02	3.48	1756	7.13	Main Channel at Cascade Avenue
57	-	-	-	-	-	3.48	1692	7.30	Reservoir at Cascade Avenue Main Channel

DEVELOPED CONDITIONS

	SUBBASIN RUNOFF					CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
44	-	-	-	-	-	2.67	2297	6.60	Through Lower Reservoir Main Channel
45	0.04	73	0.31	45	6.11	2.70	2268	6.51	Main Channel
46	0.02	86	0.85	48	6.02	0.02	48	6.02	Big Valley
47	0.04	81	0.19	80	6.02	0.06	122	6.04	Big Valley
48	0.06	84	0.25	138	6.06	0.12	249	6.08	Big Valley
49	0.05	85	0.13	133	5.98	0.16	340	6.04	Big Valley
50	0.09	83	0.29	177	6.08	0.25	483	6.13	Big Valley crossing Delmonico Drive
51	0.04	82	0.22	83	6.04	0.29	536	6.13	Big Valley near confluence with Main Channel
45	-	-	-	-	-	2.99	2479	6.48	Confluence of Big Valley and Main Channel
52	0.09	82	0.18	195	6.01	3.08	2500	6.50	Main Channel at Pebble Way
52	-	-	-	-	-	3.08	2509	6.60	Reservoir at Pebble Way Main Channel
53	0.10	80	0.50	135	6.21	3.18	2568	6.51	Main Channel
54	-	-	-	-	-	3.18	2526	6.70	Reservoir at Rockrimmon Boulevard Main Channel
55	0.16	65	0.38	111	6.18	3.34	2577	6.58	Main Channel at Dawson Drive
55	-	-	-	-	-	3.34	2598	6.70	Reservoir at Dawson Drive Main Channel
56	0.11	70	0.25	127	6.08	3.45	2587	6.73	Main Channel at the Railroad crossing
56	-	-	-	-	-	3.45	2556	6.80	Reservoir at Railroad crossing Main Channel
57	0.03	93	0.22	95	6.02	3.48	2605	6.74	Main Channel at Cascade Avenue
57	-	-	-	-	-	3.48	2586	6.90	Reservoir at Cascade Avenue Main Channel

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

500-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 5.1 INCHES

EXISTING CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
1	0.22	77	0.19	548	6.02	0.22	548	6.02	Main Channel on westernmost edge of City limits
2	0.11	73	0.25	216	6.07	0.33	727	6.08	Main Channel
3	0.05	66	0.20	75	6.05	0.38	759	6.11	Main Channel near small dam
5	0.27	77	0.25	613	6.07	0.27	613	6.07	South Fork on Forest Service property
6	0.11	70	0.37	149	6.14	0.38	726	6.11	South Fork near small dam
8	0.06	66	0.22	82	6.07	0.82	1512	6.12	Confluence of South Fork and Main Channel near small dam
9	0.07	65	0.33	80	6.13	0.89	1504	6.17	Main Channel near confluence with the North Fork
10	0.26	77	0.29	549	6.09	0.26	549	6.09	North Fork on Forest Service property
12	0.16	67	0.50	157	6.24	0.42	648	6.20	North Fork at Upper Reservoir
12	-	-	-	-	-	0.42	614	6.30	Through Upper Reservoir North Fork
14	0.02	62	0.21	27	6.07	0.44	628	6.26	North Fork at Lower Reservoir
14	-	-	-	-	-	0.44	618	6.40	Through Lower Reservoir North Fork
15	0.01	62	0.12	17	6.00	0.45	621	6.30	North Fork near confluence with Main Channel
9	-	-	-	-	-	1.34	2047	6.21	Confluence of North Fork and Main Channel
17	0.05	62	0.42	39	6.21	1.39	2028	6.23	Main Channel near the Sister's power plant
18	0.12	67	0.34	145	6.13	0.11	145	6.13	South Gulch
17	-	-	-	-	-	1.50	2154	6.22	Confluence of Main Channel and South Gulch

DEVELOPED CONDITIONS

SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
1	0.22	77	0.19	548	6.02	0.22	548	6.02	Main Channel on westernmost edge of City limits
2	0.11	73	0.25	216	6.07	0.33	727	6.08	Main Channel
3	0.05	67	0.18	81	6.03	0.38	760	6.10	Main Channel near small dam
5	0.27	77	0.25	613	6.07	0.27	613	6.07	South Fork on Forsest Service property
6	0.11	71	0.36	160	6.13	0.38	738	6.11	South Fork near small dam
8	0.06	67	0.21	87	6.06	0.82	1528	6.12	Confluence of South Fork and Main Channel near small dam
9	0.07	70	0.29	110	6.10	0.89	1540	6.16	Main Channel near confluence with North Fork
10	0.26	77	0.29	549	6.09	0.26	549	6.09	North Fork on Forest Service property
12	0.16	70	0.46	193	6.21	0.42	685	6.20	North Fork at Upper Reservoir
14	0.02	62	0.21	27	6.07	0.44	675	6.23	North Fork at Lower Reservoir
14	-	-	-	-	-	0.44	661	6.30	Through Lower Reservoir North Fork
15	0.01	62	0.12	17	6.00	0.45	663	6.26	North Fork near confluence with Main Channel
9	-	-	-	-	-	1.34	2154	6.19	Confluence of North Fork and Main Channel
17	0.05	71	0.35	72	6.13	1.39	2175	6.21	Main Channel near the Sister's power plant
18	0.12	70	0.31	178	6.11	0.12	178	6.11	South Gulch
17	-	-	-	-	-	1.50	2323	6.20	Confluence of Main Channel and South Gulch

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

√ 500-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 5.1 INCHES

EXISTING CONDITIONS									
	SUBBASIN RUNOFF					CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
20	0.05	67	0.20	71	6.05	1.55	2066	6.28	Main Channel
21	0.13	74	0.45	198	6.19	1.68	2140	6.36	Main Channel
22	0.05	75	0.27	91	6.08	0.04	91	6.08	South Valley at Upper Reservoir
22	-	-	-	-	-	0.04	81	6.20	Through Upper Reservoir in South Valley
24	0.09	77	0.26	192	6.07	0.13	250	6.10	South Valley at Lower Reservoir
24	-	-	-	-	-	0.13	211	6.22	Through Lower Reservoir in South Valley
25	0.02	83	0.14	69	5.99	0.15	229	6.19	South Valley near confluence with Main Channel
21	-	-	-	-	-	1.83	2341	6.35	Confluence of Main Channel and South Valley
26	0.05	74	0.27	105	6.08	1.89	2314	6.41	Main Channel
27	0.04	63	0.26	49	6.10	0.04	49	6.10	North Channel on the Sister's property
28	0.04	63	0.20	55	6.06	0.08	99	6.09	North Channel on the Sister's property
29	0.03	62	0.20	41	6.06	0.12	122	6.13	North Channel leaving the Sister's property
30	0.07	65	0.62	52	6.34	0.19	157	6.25	North Channel
31	0.08	68	0.31	114	6.11	0.27	225	6.24	North Channel
32	0.03	66	0.15	46	6.01	2.18	2519	6.40	Confluence of Main Channel at eastern edge of Reach 3
41	0.14	66	0.47	136	6.22	2.32	2563	6.44	Main Channel entering Reach 2
40	0.10	84	0.26	292	6.06	0.10	292	6.06	Tributary from Mt. Woodmen Estates

DEVELOPED CONDITIONS									
	SUBBASIN RUNOFF					CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
20	0.05	74	0.18	100	6.02	1.55	2259	6.24	Main Channel
27	0.04	63	0.26	49	6.10	0.40	49	6.10	North Channel on the Sister's property
28	0.04	63	0.20	55	6.06	0.08	99	6.09	North Channel on the Sister's property
29	0.03	62	0.20	41	6.06	0.12	122	6.13	North Channel on the Sister's property
29	-	-	-	-	-	1.67	2297	6.26	Reroute flows historically in the Main Channel through North Channel
30	0.07	72	0.51	87	6.23	1.73	2336	6.30	North Channel leaving the Sister's property
31	0.08	74	0.27	158	6.08	1.82	2343	6.34	North Channel
22	0.03	80	0.23	115	6.05	0.04	115	6.05	South Valley
24	0.09	82	0.23	236	6.04	0.13	338	6.06	South Valley
25	0.02	87	0.12	80	5.97	0.15	390	6.04	South Valley
21	0.13	79	0.38	279	6.13	0.29	648	6.08	Confluence of Main Channel and South Valley
26	0.05	80	0.23	138	6.05	0.34	702	6.14	Main Channel
32	0.03	75	0.13	72	5.99	2.18	2867 ✓	6.30	Confluence of Main Channel and North Channel at the eastern edge of Reach 3
41	0.14	75	0.38	238	6.14	2.32	2970	6.33	Main Channel entering Reach 2
40	0.10	84	0.86	307	6.03	0.10	307	6.03	Tributary from Mt. Woodmen Estates
41	-	-	-	-	-	2.43	3059	6.32	Confluence of tributary from Mt. Woodmen Estates and Main Channel
42	0.22	75	0.43	307	6.03	2.65	3059	6.32	Main Channel
43	0.02	75	0.17	54	6.01	2.67	3232	6.41	Main Channel

2. SUMMARY OF HYDRAULICS AND FACILITIES

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2a. Major Channels, Reaches 2 and 3

DESIGN POINT		DESIGN FLOW (CFS)		LENGTH (FT)	AVERAGE SLOPE (%)	EXISTING FACILITY	REQUIRED FACILITY	ESTIMATED COST	CONSTRUCTION RESPONSIBILITY	COMMENTS
FROM	TO	5-YR	100-YR							
West City Limits	13	170	500	2900	8.3	Natural, wide meadow poorly defined channel, dam and drained res.	Minor concrete chan. B=10, Z=2, D100=1.4	$ 353,800 ($122/lf)	BDF - 100%	Reach 3
9	20	525	1660	2200	6.0	Natural, well defined channel to small improv. stone channel to open meadow	Major concrete chan. B=14, Z=4, D100=2.25	$ 492,800 ($224/lf)	BDF - 100%	Channel borders south property line of convent Reach 3
20	21	525	1600	2300	4.6	Natural, wide meadow poorly defined channel flow to be rerouted	None, flow to be rerouted to DP.29	-	-	Reroute flow from 20 to 29 see next item Reach 3
20	29	520	1600	950	4.4	Natural, wide meadow no defined channel	Major concrete chan. B=14, Z=4, D100=2.5	$ 224,200 ($236/lf)	BDF - 100%	Flow rerouted to avoid development Reach 3
29	32	530	1650	3100	3.85	Natural, wide meadow poorly defined channel	Major concrete chan. B=14, Z=4, D100=2.5	$ 731,600 ($236/lf)	BDF - 100%	Flow through north channel Reach 3
22	25	130	300	3200	6.7	Natural, well defined channel 2 erosion control dams	48 to 60 inch RCP, inlets and manholes	$ 364,000	BDF - 100%	Due to proposed extensive development, system underground Reach 3
25	32	213	520	1800	2.8	Natural, wide meadow poorly defined channel	60 inch RCP inlets and manholes	$ 204,750	BDF - 100%	System underground because of extensive development (proposed) Reach 3
32	43	720	2250	5100	2.5	Natural, wide meadow poorly defined channel	Major concrete chan. B=14, Z=4, D100=3.25	$1,392,300	BDF - 100%	Flow through proposed Development Reach 2

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2b. Road Crossings, Reaches 1 and 2

APPROXIMATE LOCATION	CROSSING	DESIGN FLOW		EXISTING FACILITY	REQUIRED FACILITY	ESTIMATED COST	CONSTRUCTION RESPONSIBILITY	COMMENTS
		5-YR	100-YR					
DP 41	Dry Creek Crossing Dancing Horse Dr. Falcon Ridge	670	2150	None	Triple 6'x9' box w/wingwalls 60 LF	$ 56,000	BDF - 100%	Proposed crossing Reach 2
Between DP 41 & DP 42	Dry Creek Crossing Dairy Ranch Rd. Falcon Ridge	695	2200	None	Triple 6'x9' box w/wingwalls 60 LF	$ 56,000	BDF - 100%	Proposed crossing Reach 2
DP 42	Dry Creek Crossing Carlson Mead. Dr. Falcon Ridge	719	2265	None	Triple 6'x9' box w/wingwalls 60 LF	$ 56,000	BDF - 100%	Proposed crossing Reach 2
DP 52	Dry Creek Crossing Pebble Way	775	2500	Double 5'x9' box w/wingwalls	Add single 5'x9' box Replace wingwalls 45 LF	$ 40,000	BDF - 23% City - 77%	Existing flow = 1924 cfs Development increases flow 23% Reach 1
DP 54	Dry Creek Crossing Rockrimmon Blvd.	790	2550	Double 6'x9' box w/wingwalls	Add 6'x12' box Replace wingwalls 200 LF	$161,000	BDF - 25% City - 75%	Existing flow = 1920 cfs Development increases flow 25% Reach 1

C.H. .77 (40000) = 30800
.75 (161,000) = 120750
151550

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2b. Road Crossings, Reach 3

APPROXIMATE LOCATION	CROSSING	DESIGN FLOW (cfs)		EXISTING FACILITY	REQUIRED FACILITY	ESTIMATED COST	CONSTRUCTION RESPONSIBILITY	COMMENTS
		5-YR	100-YR					
DP 12	N. Fork Crossing residential street Peregrine Proj.	175	500	Dam	Single 6'x9' box w/wingwalls 60 LF	$ 24,600	BDF - 100%	Proposed crossing Reach 3
DP 6	S. Fork Crossing collector Peregrine Proj.	195	550	None	Single 6'x9' box w/wingwalls 60 LF	$ 24,600	BDF - 100%	Proposed crossing Reach 3
DP 3	Dry Creek Crossing collector Peregrine Proj.	195	550	None	Single 6'x9' box w/wingwalls 60 LF	$ 24,600	BDF - 100%	Proposed crossing Reach 3
DP 20	Dry Creek Crossing collector Peregrine Proj.	525	1600	None	Double 6'x9' box w/wingwalls 60 LF	$ 40,750	BDF - 100%	Proposed crossing Reach 3
DP 31	Dry Creek Crossing collector Peregrine Proj.	530	1650	None	Double 6'x9' box w/wingwalls 60 LF	$ 40,750	BDF - 100%	Proposed crossing Reach 3
DP 32	Dry Creek Crossing Woodmen Rd. Peregrine Proj.	650	2030	27" x 43" CMP Arch	3 - 6'x9' box w/wingwalls 60 LF	$ 56,000	BDF - 100%	Proposed crossing Reach 3
DP 29	N. Channel Dry Cr. Crossing collector Peregrine Proj.	13	75	None	1 - 48" RCP w/headwalls 60 LF	$ 7,500	BDF - 100%	Proposed crossing Reach 3

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2c. Upgrading of Existing System and Maintenance Items, Reach 1

APPROXIMATE LOCATION	EXISTING FACILITY AND/OR PROBLEM DESCRIPTION	DESIGN FLOW		FACILITY REQUIRED AND/OR PROPOSED IMPROVEMENT	ESTIMATED COST	CONSTRUCTION RESPONSIBILITY	COMMENTS
		5-YR	100-YR				
DP 56 - DP 57 Channel through Corporate Center	Channel and culverts at Corporate Center undersized	785	2600	Improve channel (350 LF) and armor Roadway embankment at culverts	$112,400	CFD - 100%	Overlot grading in process at time of study, plans show inadequate channel
Between DP 55 & 56 south bank (approx Sta 16+00)	Excessive erosion off channel due to runoff from existing development south of Dry Creek	NA	NA	Fill washout with riprap	$ 54,000	City - 100%	Drainage chute may be necessary upon final design
Downstream of DP 55 concrete channel section	Concrete channel section seperated at joint, section undermined	NA	NA	Pump fill under slab & seal crack w/water-tight expansion joint	$ 8,700	City - 100%	Low flows in channel flow completely underground
Between DP 54 & DP 55 (approx Sta 30+00)	Erosion problem at small concrete drop structure	NA	NA	Fill in around drop to prevent bypass, armor upstream and downstream channel	$ 400	City - 100%	Drop structure may be replaced when gabion blanket is installed
DP 54 to DP 55 channel between Rockrimmon and Dawson	Grass lined channel w/small eroded rock trickle channel	795	2575	Line channel with gabion blanket to contain 5-yr flow (600 LF)	$ 19,800 ($33/LF)	City - 100%	Effects of erosion not yet a problem
Immediately upstream of DP 54	Excessive erosion off channel due to runoff from Mikado Dr. as it drains to main channel	NA	NA	Install 300 LF of concrete trickle channel	$ 7,300 ($24/LF)	City - 100%	Channel should begin at culvert outlet Mikado Dr.
Between DP 53 & DP 54 (approx Sta 41+00)	Gabion drop structure in disrepair	NA	NA	Repair gabion drop structure	$ 1,000	City - 100%	Drop structure may be replaced when gabion blanket is installed

City 91,200

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2c. Upgrading of Existing System and Maintenance Items, Reach 1

APPROXIMATE LOCATION	EXISTING FACILITY AND/OR PROBLEM DESCRIPTION	DESIGN FLOW		FACILITY REQUIRED AND/OR PROPOSED IMPROVEMENT	ESTIMATED COST	CONSTRUCTION RESPONSIBILITY	COMMENTS
		5-YR	100-YR				
DP 53 to DP 54 channel between school & Rockrimmon	Grass lined channel with gabion blanket in bad disrepair	795	2550	Line channel with gabion blanket to contain 5-yr flow (1450 LF)	$ 47,850 ($33/LF)	City - 100%	Existing gabions are broken, concrete "curbs" ineffective
DP 53 earth dam at Rockrimmon School	Ineffective earth dam, erosion problems at channel's banks	795	2570	Remove dam, regrade channel, install gabion blanket, lay back slopes & stabilize	$280,000	City - 100%	If dam is not removed extensive erosion protection must be provided
DP 52 to DP 53 channel between Pebble Way & school	Meandering, sand bottom channel, erosion problems	795	2570	Line channel with gabion blanket to contain 5-yr flow (500 LF)	$ 16,500 ($33/LF)	City - 100%	
Immediately downstream of DP 52 (Pebble Way)	Excessive erosion of north bank downstream of culvert outlet	NA	NA	Lay slope back to 4:1 and seed	$ 2,000	City - 100%	Extension of gabion blanket required if slope cannot be laid back
DP 45 to DP 52 channel between confluence and Pebble Way	Sand bottom channel w/drop structures in disrepair	775	2500	Line channel with gabion blanket to contain 5-yr flow (1500 LF)	$ 49,000	City - 100%	Not needed where channel is concrete lined
Between DP 45 & DP 52 (approx Sta 71+100)	Excessive erosion off channel due to runoff from Buckeye Dr. north of channel	NA	NA	Install 100 LF of concrete trickle channel from storm sewer outlet to channel	$ 2,400	City - 100%	Outlet of storm sewer not located. Field verify for final design

City (all) 397,700

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2c. Upgrading of Existing System and Maintenance Items, Reach 1

APPROXIMATE LOCATION	EXISTING FACILITY AND/OR PROBLEM DESCRIPTION	DESIGN FLOW		FACILITY REQUIRED AND/OR PROPOSED IMPROVEMENT	ESTIMATED COST	CONSTRUCTION RESPONSIBILITY	COMMENTS
		5-YR	100-YR				
DP 48 to DP 50 Big Valley Drive to Delmonico Drive	Undersized storm sewer system	220	480	Install additional storm sewer system, utility relocation	$408,320	City - 100%	Additional system will include storm sewer & inlets in Delmonico Dr.
Between DP 44 & DP 45 near cul-de-sac off Delmonico Ct. (Sta 85+00)	Erosion problems on steep embankment south side of channel	NA	NA	Lay slope back to 4:1 and seed	$ 30,800	City - 100%	Gabion walls or riprap required if slope cannot be laid back
DP 44 to area described above (Sta 85+00)	Wide, grass lined channel	730	2300	Line channel with gabion blanket to contain 5-yr flow (600 LF)	$ 19,800	City - 100%	Gabion blanket not needed where channel is heavily vegetated w/trees and brush
DP 43 dam at dairy farm	Earth dam	720	2275	Remove earth dam regrade channel	$ 40,000	BDF - 100%	Developer may keep pond and road, must install culvert to pass 100-yr flow

CH/ 428,920

SUMMARY OF HYDRAULIC IMPROVEMENTS - DRY CREEK DRAINAGE BASIN

Table 2d. Minor Storm Water Management System, Reaches 2 and 3

APPROXIMATE LOCATION	REQUIRED SYSTEM	STORM SEWER PIPE SIZE (inches)	STORM SEWER PIPE LENGTH (Ft)	COST	MANHOLES NUMBER	MANHOLES COST	INLETS NUMBER	INLETS COST	ESTIMATED TOTAL COST	CONSTRUCTION RESPONSI-BILITY	COMMENTS
Peregrine Development DP 8, 9, 17 & 18 Single Family - 4 DU/AC	Storm Sewer	24	2300	$ 69,000	6	$ 9,000	17	$ 42,500	$120,500	BDF - 100%	Proposed System Reach 3
Peregrine Development DP 21 Single Family - 6 DU/AC	Storm Sewer	24	1800	$ 54,000	4	$ 6,000	13	$ 32,500	$ 92,500	BDF - 100%	Proposed System Reach 3
Peregrine Development DP 26 & 32 Multi Family - 8 DU/AC	Storm Sewer	24	1600	$ 48,000	4	$ 6,000	11	$ 27,500	$ 81,500	BDF - 100%	Proposed System Reach 3
Peregrine Development North Basin Multi Use DP 62	Storm Sewer Detention Pond Cost = $25,000	24 36	7000 7000	$210,000 $315,000	24	$36,000	70	$175,000	$761,000	BDF - 100%	Proposed System (North Basin)
Falcon Ridge Development DP 41, 42, & 43 Multi Use - 2.98 DU/AC	Storm Sewer	24	1800	$ 54,000	4	$ 6,000	16	$ 40,000	$100,000	BDF - 100%	Proposed System Reach 2

TABLE 1a. SUMMARY OF HYDROLOGIC CALCULATIONS, DRY CREEK BASIN

500-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 5.1 INCHES

EXISTING CONDITIONS									
	SUBBASIN RUNOFF					CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
41	-	-	-	-	-	2.43	2642	6.43	Confluence of tributary from Mt. Woodmen Estates and Main Channel
42	0.22	66	0.54	195	6.27	2.65	2726	6.54	Main Channel
43	0.02	64	0.21	30	6.07	2.67	2734	6.54	Main Channel at Upper Reservoir
43	-	-	-	-	-	2.67	2686	6.70	Through Upper Reservoir Main Channel
44	-	-	-	-	-	2.67	2649	6.70	Through Lower Reservoir Main Channel
45	0.04	73	0.31	63	6.10	2.70	2663	6.64	Main Channel
46	0.02	83	0.24	52	6.05	0.02	52	6.05	Big Valley
47	0.04	81	0.19	105	6.02	0.06	147	6.04	Big Valley
48	0.06	84	0.25	177	6.05	0.12	311	6.08	Big Valley
49	0.05	85	0.13	168	5.98	0.16	429	6.03	Big Valley
50	0.09	83	0.29	228	6.08	0.25	615	6.12	Big Valley crossing Delmonico Drive
51	0.04	82	0.22	107	6.04	0.29	687	6.12	Big Valley near confluence with Main Channel
45	-	-	-	-	-	2.99	2847	6.62	Confluence of Big Valley and Main Channel
52	0.09	82	0.18	252	6.01	3.08	2853	6.64	Main Channel at Pebble Way
52	-	-	-	-	-	3.08	2840	6.70	Reservoir at Pebble Way Main Channel
53	0.10	80	0.50	180	6.20	3.18	2906	6.66	Main Channel at the Earth Dam
53	-	-	-	-	-	3.18	2879	6.80	Reservoir at Earth Dam Main Channel
54	-	-	-	-	-	3.18	2827	6.90	Reservoir at Rockrimmon Blvd. Main Channel
55	0.16	65	0.38	168	6.17	3.34	2870	6.77	Main Channel at Dawson Drive
55	-	-	-	-	-	3.34	2862	6.90	Reservoir at Dawson Drive Main Channel
56	0.11	70	0.25	180	6.08	3.45	2854	6.85	Main Channel at the Railroad Crossing
56	-	-	-	-	-	3.45	2851	7.00	Reservoir at the Railroad Crossing Main Channel
57	0.03	93	0.22	115	6.02	3.48	2865	6.87	Main Channel at Cascade Avenue
57	-	-	-	-	-	3.48	2938	7.00	Reservoir at Cascade Avenue Main Channel

DEVELOPED CONDITIONS									
	SUBBASIN RUNOFF					CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
44	-	-	-	-	-	2.67	3228	6.50	Through Lower Reservoir Main Channel
45	0.04	73	0.31	63	6.10	2.70	3218	6.45	Main Channel
46	0.02	86	0.85	61	6.02	0.02	61	6.02	Big Valley
47	0.04	81	0.19	105	6.02	0.06	157	6.04	Big Valley
48	0.06	84	0.25	177	6.05	0.12	320	6.08	Big Valley
49	0.05	85	0.13	168	5.96	0.16	437	6.03	Big Valley
50	0.09	83	0.29	228	6.08	0.25	623	6.12	Big Valley crossing Delmonico Drive
51	0.04	82	0.22	107	6.04	0.29	695	6.12	Big Valley near confluence with Main Channel
45	-	-	-	-	-	2.99	3538	6.42	Confluence of Big Valley and Main Channel
52	0.09	82	0.18	252	6.01	3.08	3564	6.44	Main Channel at Pebble Way
52	-	-	-	-	-	3.08	3560	6.50	Reservoir at Pebble Way Main Channel
53	0.10	80	0.50	180	6.20	3.18	3669	6.45	Main Channel
54	-	-	-	-	-	3.18	3725	6.60	Reservoir at Rockrimmon Boulevard Main Channel
55	0.16	65	0.38	168	6.17	3.34	3747	6.52	Main Channel at Dawson Drive
55	-	-	-	-	-	3.34	3672	6.70	Reservoir at Dawson Drive Main Channel
56	0.11	70	0.25	180	6.08	3.45	3697	6.60	Main Channel at the Railroad crossing
56	-	-	-	-	-	3.45	3687	6.70	Reservoir at Railroad crossing Main Channel
57	0.03	93	0.22	116	6.02	3.48	3704	6.61	Main Channel at Cascade Avenue
57	-	-	-	-	-	3.48	3761	6.70	Reservoir at Cascade Avenue Main Channel

TABLE 1b. SUMMARY OF HYDROLOGIC CALCULATIONS, NORTH DRAINAGE BASIN

5-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 2.7 INCHES

EXISTING CONDITIONS										DEVELOPED CONDITIONS									
SUBBASIN RUNOFF						CUMULATIVE RUNOFF				SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	Σ AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS	DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	Σ AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
61	0.13	66	0.3	25	6.17	0.13	25	6.17	El Paso Co. and portion of Air Force Academy	61	0.13	68	0.29	35	6.14	0.13	35	6.14	El Paso Co. and portion of Air Force Academy
62	0.4	62	0.95	27	6.75	0.4	27	6.75	Upper Portion of Basin within City limits	62	0.4	71	0.78	76	6.53	0.4	76	6.53	Upper Portion of Basin within City limits
63	0.37	64	0.45	42	6.32	0.90	65	6.25	Confluence of 61, 62 & 63 flows to 64 El Paso Co.	63	0.37	66	0.43	57	6.28	0.90	99	6.70	Confluence of 61, 62 & 63 f to 64 El Paso Co.
65	0.20	62	0.45	17	6.35	0.20	17	6.35	Drains portion of Shoptaugh, El Paso Co. flows to 64	65	0.20	63	0.43	21	6.32	0.20	21	6.32	Drains portion of Shoptaugh El Paso Co. flows to 64
64	0.14	66	0.36	24	6.21	1.24	80	6.65	Drains portion of Shoptaugh. Confluence of 63, 64 & 65, discharge to Monument Creek.	64	0.14	68	0.35	32	6.19	1.24	107	6.71	Drains portion of Shoptaugh Confluence of 63, 64 & 65, discharge to Monument Creek
66	0.31	66	0.51	45	6.34	0.31	45	6.34	El Paso County. Discharge to Monument Creek.	66	0.31	68	0.49	58	6.31	0.31	58	6.31	El Paso County. Discharge Monument Creek.
67	0.08	64	0.16	17	6.09	0.08	17	6.09	El Paso County. Discharge to Monument Creek.	67	0.08	66	0.15	22	6.07	0.08	22	6.07	El Paso County. Discharge Monument Creek.
68	0.33	62	0.55	35	6.42	0.33	35	6.42	Drains portions of developments within Colorado Springs. Discharge to Monument Creek.	68	0.33	64	0.53	46	6.35	0.33	46	6.35	Drains portions of develop within Colorado Springs. Discharge to Monument Creek
69	0.09	72	0.38	30	6.19	0.09	30	6.19	Within City limits, fully developed. Discharge at intersection of RR and Woodmen Rd.	69	0.09	72	0.38	30	6.19	0.09	30	6.19	Within City limits, fully developed. Discharge at i section of RR and Woodmen

TABLE 1b. SUMMARY OF HYDROLOGIC CALCULATIONS, NORTH DRAINAGE BASIN

100-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 4.3 INCHES

EXISTING CONDITIONS										DEVELOPED CONDITIONS									
SUBBASIN RUNOFF						CUMULATIVE RUNOFF				SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	Σ AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS	DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	Σ AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
61	0.13	66	0.3	113	6.12	0.13	113	6.12	El Paso Co. and portion of Air Force Academy	61	0.13	68	0.29	134	6.11	0.13	134	6.11	El Paso Co. and portion of Air Force Academy
62	0.4	62	0.95	129	6.64	0.4	129	6.64	Upper Portion of Basin within City limits	62	0.4	71	0.78	246	6.46	0.4	246	6.46	Upper Portion of Basin within City limits
63	0.37	64	0.45	210	6.23	0.90	311	6.20	Confluence of 61, 62 & 63 flows to 64 El Paso Co.	63	0.37	66	0.43	247	6.21	0.90	381	6.20	Confluence of 61, 62 & 63 flows to 64 El Paso Co.
65	0.20	62	0.45	100	6.24	0.20	100	6.24	Drains portion of Shoptaugh, El Paso Co. flows to 64	65	0.20	63	0.43	111	6.23	0.20	111	6.23	Drains portion of Shoptaugh, El Paso Co. flows to 64
64	0.14	66	0.36	104	6.16	1.24	373	6.52	Drains portion of Shoptaugh. Confluence of 63, 64 & 65, discharge to Monument Creek.	64	0.14	68	0.35	124	6.14	1.24	458	6.51	Drains portion of Shoptaugh. Confluence of 63, 64 & 65, discharge to Monument Creek.
66	0.31	66	0.51	192	6.27	0.31	192	6.27	El Paso County. Discharge to Monument Creek.	66	0.31	68	0.49	224	6.24	0.31	224	6.24	El Paso County. Discharge to Monument Creek.
67	0.08	64	0.16	80	6.03	0.08	80	6.03	El Paso County. Discharge to Monument Creek.	67	0.08	66	0.15	93	6.02	0.08	93	6.02	El Paso County. Discharge to Monument Creek.
68	0.33	62	0.55	169	6.31	0.33	169	6.31	Drains portions of developments within Colorado Springs. Discharge to Monument Creek.	68	0.33	64	0.53	198	6.28	0.33	198	6.28	Drains portions of developments within Colorado Springs. Discharge to Monument Creek.
69	0.09	72	0.38	95	6.16	0.09	95	6.16	Within City limits, fully developed. Discharge at intersection of RR and Woodmen Rd.	69	0.09	72	0.38	95	6.16	0.09	95	6.16	Within City limits, fully developed. Discharge at intersection of RR and Woodmen Rd.

TABLE 1b. SUMMARY OF HYDROLOGIC CALCULATIONS, NORTH DRAINAGE BASIN

500-YR., 24-HR., TYPE IIA STORM, PRECIPITATION 5.1 INCHES

EXISTING CONDITIONS										DEVELOPED CONDITIONS									
SUBBASIN RUNOFF						CUMULATIVE RUNOFF				SUBBASIN RUNOFF						CUMULATIVE RUNOFF			
DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	Σ AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS	DESIGN POINT	DRAINAGE AREA (SQ MI)	CN	tc (HR)	Q PEAK (cfs)	tp (HR)	Σ AREA (SQ MI)	Q PEAK (cfs)	tp (HR)	COMMENTS
61	0.13	66	0.3	169	6.11	0.13	169	6.11	El Paso Co. and portion of Air Force Academy	61	0.13	68	0.29	195	6.10	0.13	195	6.10	El Paso Co. and portion of Air Force Academy
62	0.4	62	0.95	200	6.59	0.4	200	6.59	Upper Portion of Basin within City limits	62	0.4	71	0.78	351	6.44	0.4	351	6.44	Upper Portion of Basin within City limits
63	0.37	64	0.45	324	6.22	0.90	479	6.19	Confluence of 61, 62 & 63 flows to 64 El Paso Co.	63	0.37	66	0.43	372	6.20	0.90	579	6.20	Confluence of 61, 62 & 63 flows to 64 El Paso Co.
65	0.20	62	0.45	159	6.22	0.20	159	6.22	Drains portion of Shoptaugh, El Paso Co. flows to 64	65	0.20	63	0.43	174	6.21	0.20	174	6.21	Drains portion of Shoptaugh, El Paso Co. flows to 64
64	0.14	66	0.36	159	6.14	1.24	594	6.45	Drains portion of Shoptaugh. Confluence of 63, 64 & 65, discharge to Monument Creek.	64	0.14	68	0.35	181	6.14	1.24	711	6.44	Drains portion of Shoptaugh. Confluence of 63, 64 & 65, discharge to Monument Creek.
66	0.31	66	0.51	289	6.25	0.31	289	6.25	El Paso County. Discharge to Monument Creek.	66	0.31	68	0.49	329	6.23	0.31	329	6.23	El Paso County. Discharge to Monument Creek.
67	0.08	64	0.16	122	6.02	0.08	122	6.02	El Paso County. Discharge to Monument Creek.	67	0.08	66	0.15	138	6.02	0.08	138	6.02	El Paso County. Discharge to Monument Creek.
68	0.33	62	0.55	260	6.29	0.33	260	6.29	Drains portions of developments within Colorado Springs. Discharge to Monument Creek.	68	0.33	64	0.53	298	6.26	0.33	298	6.26	Drains portions of developments within Colorado Springs. Discharge to Monument Creek.
69	0.09	72	0.38	135	6.15	0.09	135	6.15	Within City limits, fully developed. Discharge at intersection of RR and Woodmen Rd.	69	0.09	72	0.38	135	6.15	0.09	135	6.15	Within City limits, fully developed. Discharge at intersection of RR and Woodmen Rd.

Table 2-2.--Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and I_a = 0.2S)

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUP			
		A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
: with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious).		81	88	91	93
Residential:[3]					
Average lot size	Average % Impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm severs[3]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

FIGURE S-4 RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL-COVER COMPLEXES (Antecedent moisture condition II, and I_a - 0.2 S)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group: A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops 3/	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small 3/ grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods (Isolated groves on farms & ranches)		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		----	74	84	90	92

1/ Close-drilled or broadcast
2/ Including right-of-way
3/ Do not use adjustments for contoured or terraced treatments with storm frequencies greater than 10 years.

then computed by dividing the total overland flow length by the average velocity.

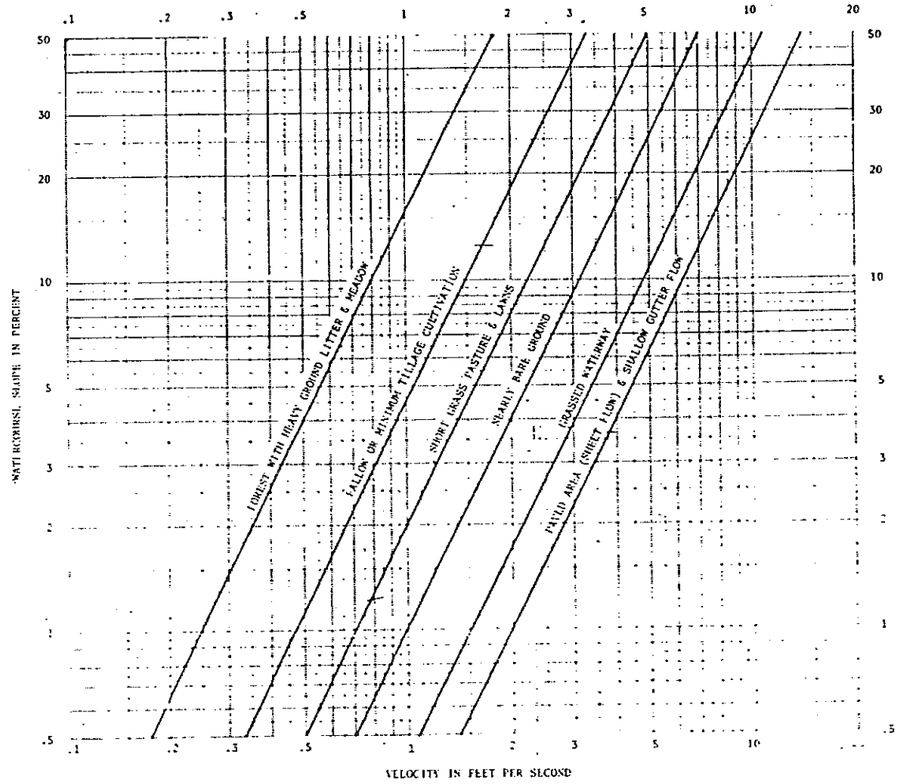
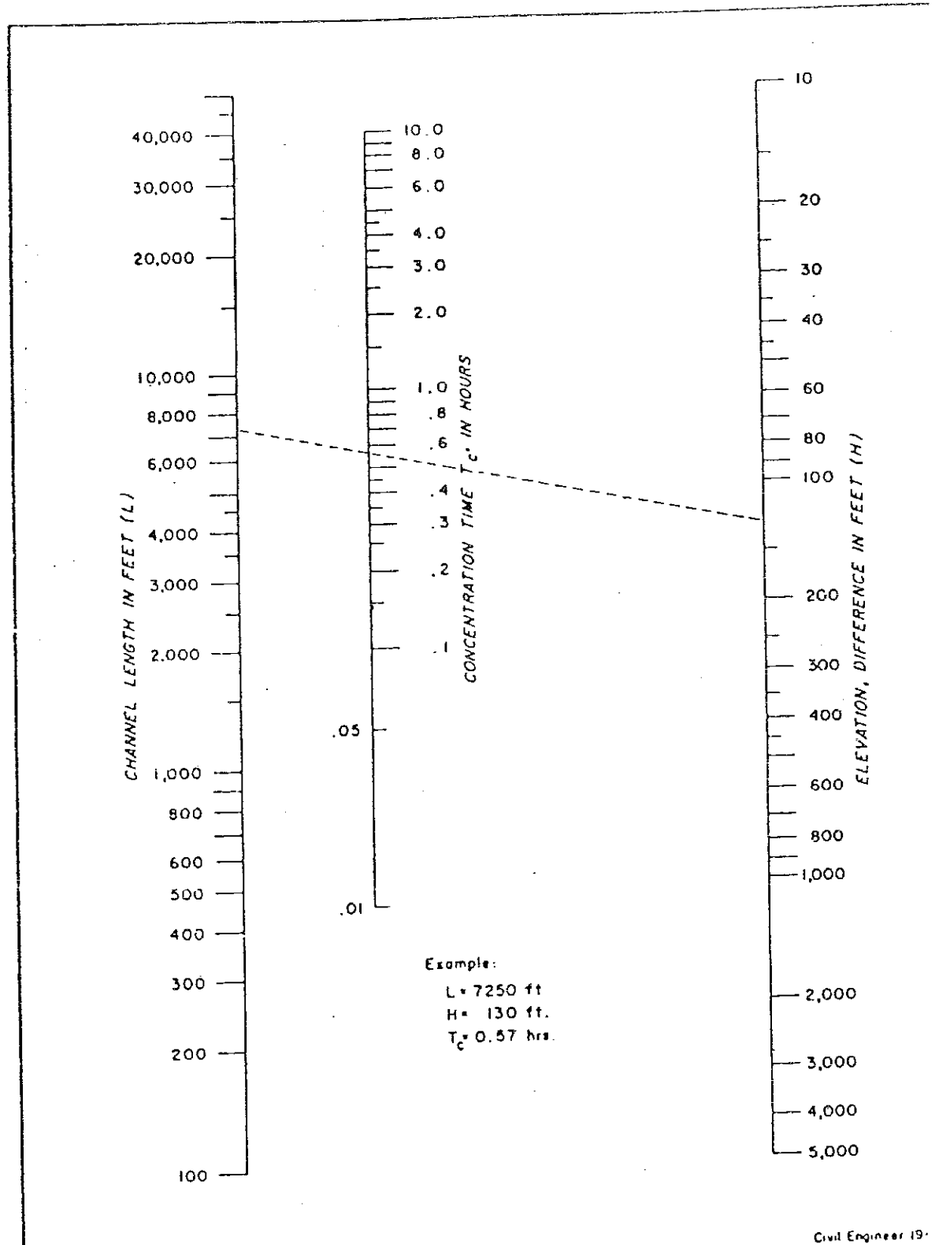


Figure 3-1.--Average velocities for estimating travel time for overland flow.

Storm sewer or road gutter flow

Travel time through the storm sewer or road gutter system to the main open channel is the sum of travel times in each individual component of the system between the uppermost inlet and the outlet. In most cases average velocities can be used without a significant loss of accuracy. During major storm events, the sewer system may be fully taxed and additional overland flow may occur, generally at a significantly lower velocity than the flow in the storm sewers. By using average conduit sizes and an average slope (excluding any vertical drops in the system), the average velocity can be estimated using Manning's formula.

Since the hydraulic radius of a pipe flowing half full is the same as when flowing full, the respective velocities are equal. Travel time may



NOMOGRAPH TO DETERMINE TIME OF CONCENTRATION

For Use on Drainage Areas ≤ 1,000 Acres

FIGURE S-6

The Upland Method

Essentially the same input is required for estimating t_c with the upland, or velocity, method as with the lag method. The velocity method has an intermediate step in which the velocity is estimated with the land use and the slope; Fig. 8 is used to estimate the velocity in feet per second (fps). The time-of-concentration equals the ratio of the hydraulic flow length to the velocity:

$$t_c = \frac{\ell}{V} \qquad (11)$$

If ℓ is measured in feet and V in fps, then the value resulting from Eq. 11 must be divided by 3600 in order to convert t_c from seconds to hours.

Adjustment for Urbanization

The curve number appears not to adequately reflect the effect of the soil cover complex in urban areas on the runoff potential. For composite land use areas where urban land uses provide a more efficient flow pattern than pervious land uses, Eq. 9 overestimates lag. TR-55 provides two figures that can be used to adjust the lag computed by Eq. 9 for the percentages of the hydraulic length that is modified (PHLM) and the impervious areas (PIMP); the lag adjustment factors are used independently, and therefore, both values can be applied on the same project. The lag factor (LF) for each adjustment can be computed using values from the following Equation:

$$LF = 1 - PRCT(-0.006789+0.000335\,CN - 0.0000004298\,CN^2 - 0.00000002185\,CN^3)$$

in which CN is the curve number for future land use conditions and PRCT is either the percent hydraulic length modified (PHLM) or the percent impervious area (PIMP). The lag computed from Eq. 9 is then multiplied by the lag factor from the above equation. If both adjustments are necessary, then the equations are used for both modifications and two lag factors are applied to the lag computed from Eq. 9.

TR-55 provides two important guidelines for use of these adjustment factors:

1. Since the lag factors are used only with future-condition curve numbers, the lag factors cannot be used to directly compute the decrease in lag from present conditions.

2. When only peak discharges are to be computed using the TR-55 methods, lag does not have to be computed; therefore, these lag factor adjustments are not necessary.

FROM: A GUIDE TO HYDROLOGIC ANALYSIS USING SCS METHODS
by Richard H. McCuen

individual overland components of flow, figures 3-4 and 3-5 can be used. Figures 3-4 and 3-5 are approximations at best and have the same limitations and uses as equation 3-2 and figure 3-3.

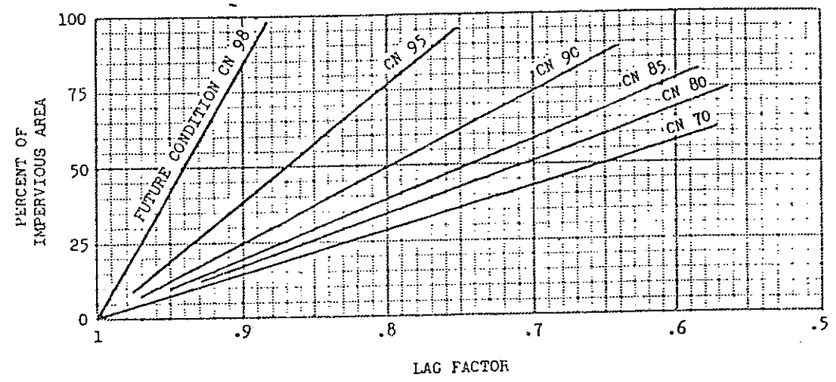


Figure 3-5.--Factors for adjusting lag from equation 3-2 or figure 3-3 when impervious areas occur in the watershed.

Example 3-2

A watershed of 1,000 acres has a present-condition curve number of 75, average watershed slope of 4 percent, and hydraulic length of 13,200 feet. Urban development is expected to modify about 70 percent of the hydraulic length, increase the impervious area to 40 percent, and increase the runoff curve number to 80. Compute the present- and future-condition time of concentration using the curve number method.

1. Present-condition lag from equation 3-2 or figure 3-3 with CN = 75.

$$L = \frac{(13,200)^{0.8}(3.33 + 1)^{0.7}}{1,900(4)^{0.5}} = 1.45 \text{ hr}$$

2. Present-condition time of concentration from equation 3-1.

$$T_c = 1.67(1.45) = 2.42 \text{ hr}$$

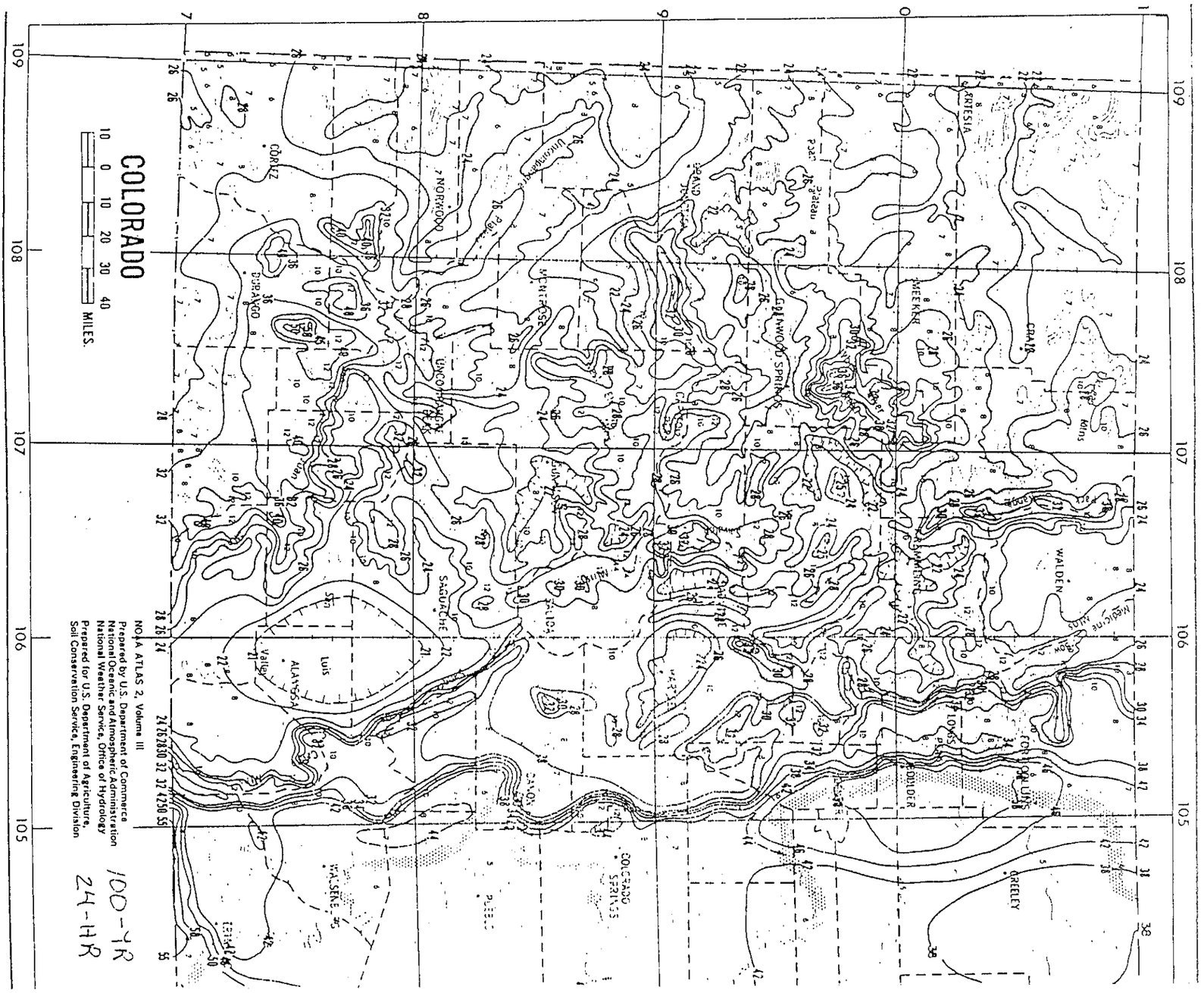
3. Future-condition lag.

   a. Basic future-condition lag with CN = 80:

$$L = \frac{(13,200)^{0.8}(2.5 + 1)^{0.7}}{1,900(4)^{0.5}} = 1.25 \text{ hr}$$

   b. Lag factor for modification of 70 percent of the hydraulic length from figure 3-4: hydraulic-length lag factor = 0.59

FROM: Technical Release No. 55 "Urban Hydrology for Small Watersheds"



NOAA ATLAS 2, Volume III
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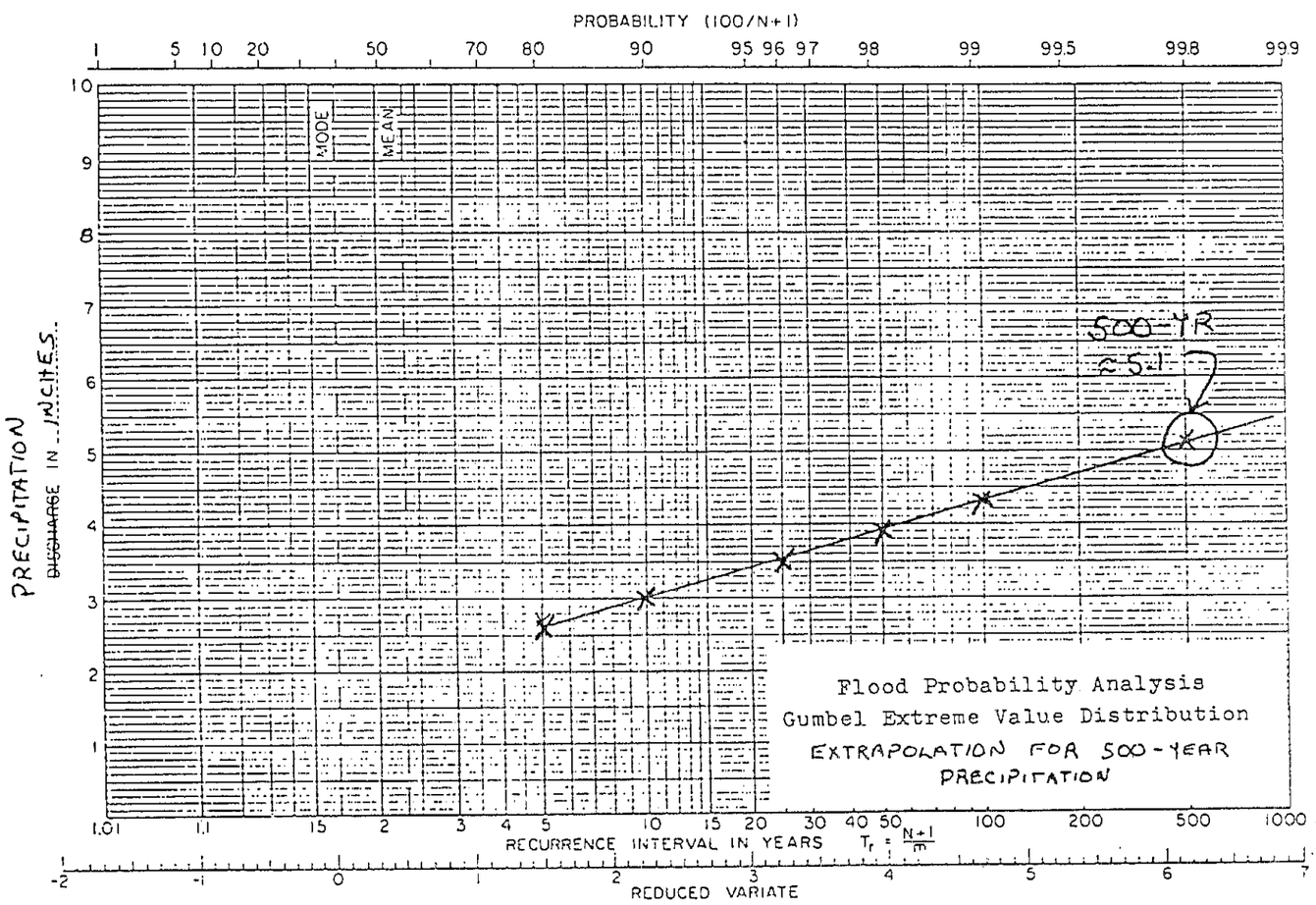
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

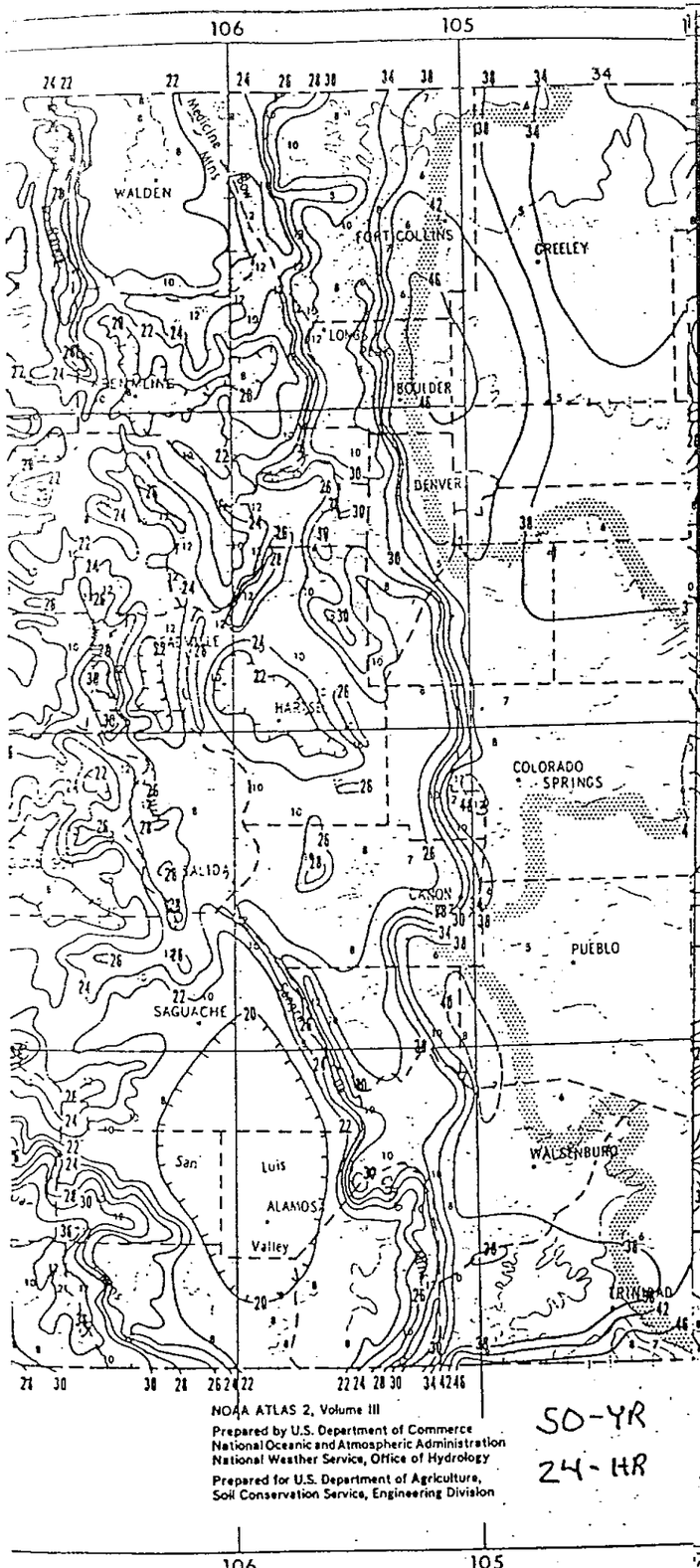
100-YR
24-HR



PRECIPITATION ... INCHES

443

NOTE: METHOD SUGGESTED BY NOAA



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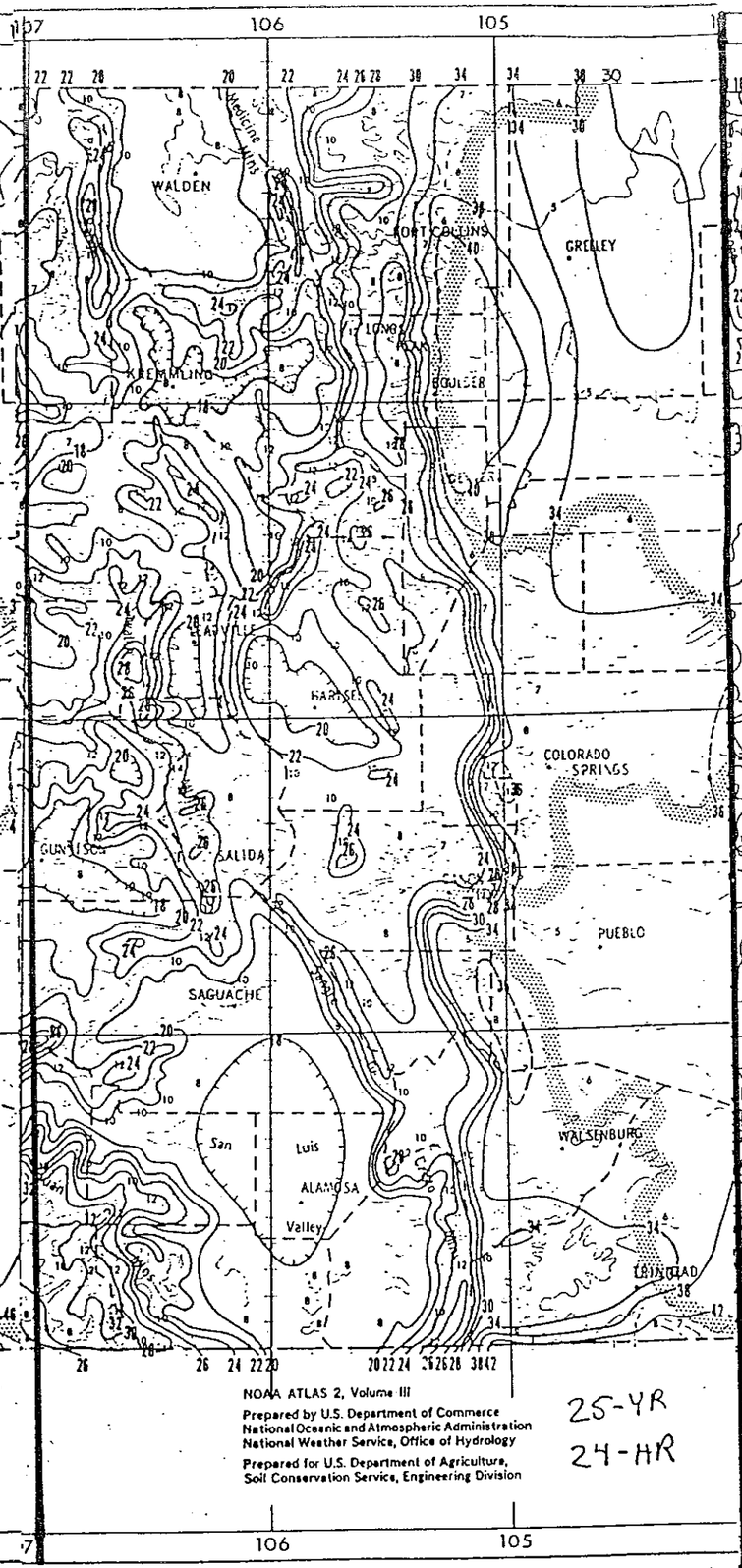
50-YR
24-HR



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National Weather Service, Office of Hydrology

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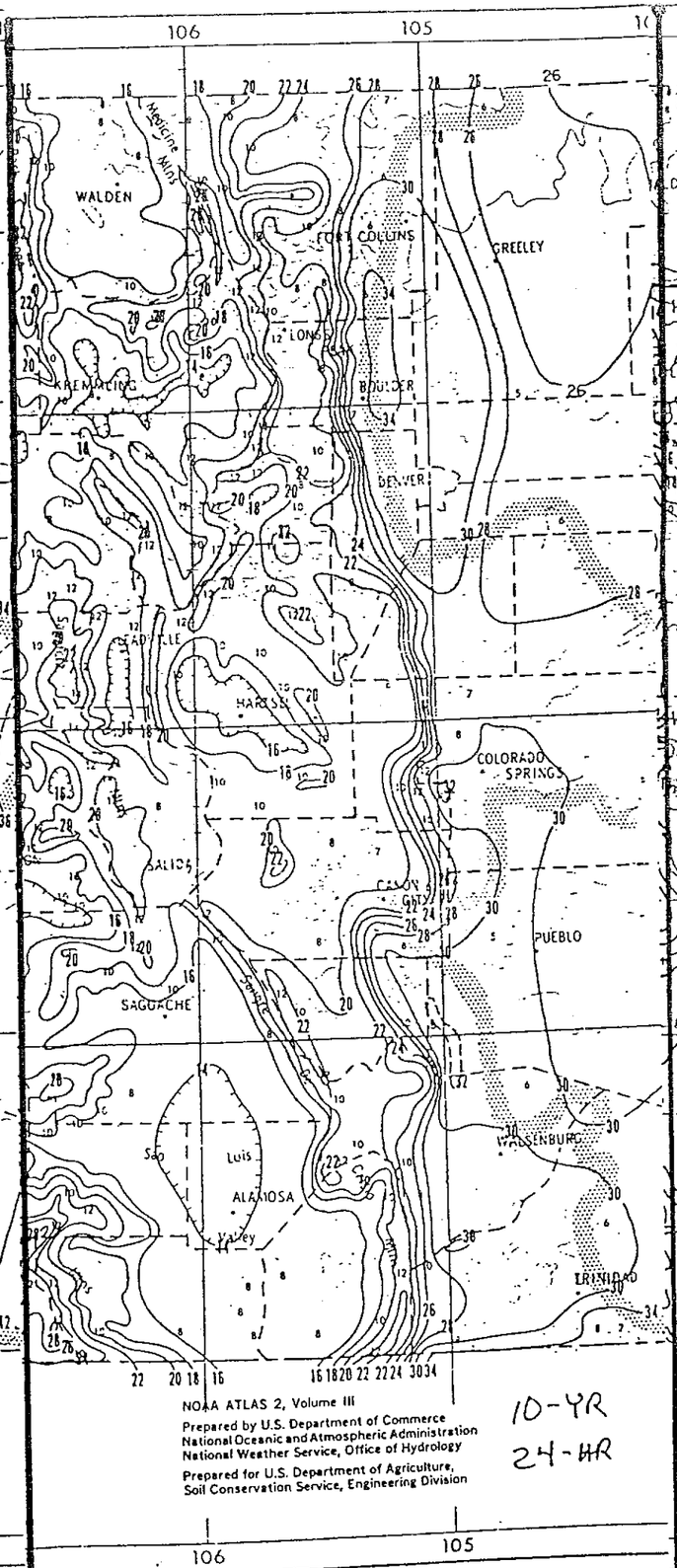
Soil Conservation Service, Engineering Division

25-YR
24-HR



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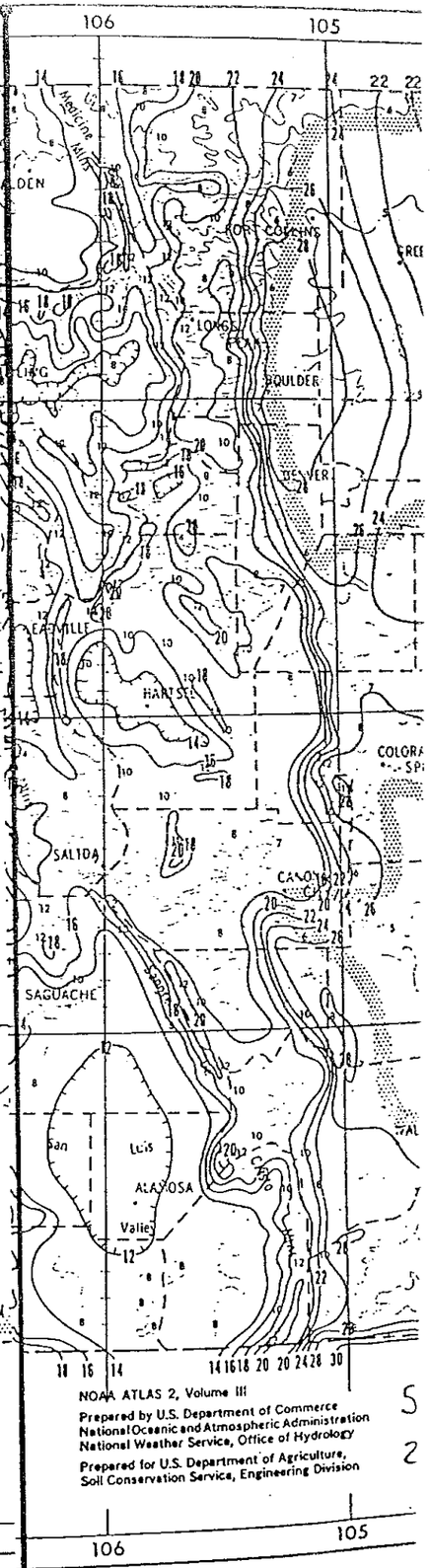
10-YR
24-HR



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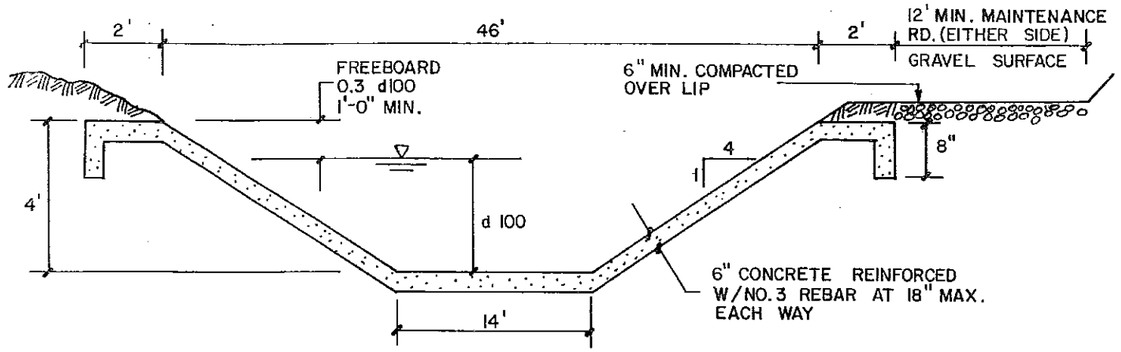
Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

3. TYPICAL DRAINAGE FACILITIES SECTIONS

3a TYPICAL MAJOR CHANNEL SECTION



CHANNEL DESIGN DATA

$Q = A\frac{1.486}{n} R^{2/3} S^{1/2}$

n = 0.015

Vmax = 30 f.p.s.

NOTES

1. ALL FINAL DESIGN AND CONSTRUCTION SHALL BE TO CURRENT CITY OF COLORADO SPRINGS STANDARDS AND SPECIFICATIONS.
2. FINAL CHANNEL SIZING IS SUBJECT TO DETAILED DRAINAGE REPORTS OF THE SUBJECT AREA.
3. CUTOFF WALLS SHALL BE PROVIDED AT MAXIMUM 200 INTERVALS.
4. EXTRA HEIGHT SHALL BE PROVIDED ALONG THE OUTSIDE EDGE OF ALL CURVES.
5. SUITABLE TRANSITIONS IN AND / OR OUT OF CULVERT HEADWALLS OR BOX CULVERTS SHALL BE PROVIDED AT FINAL DESIGN.
6. GUARD RAIL REQUIRED WHEN MAJOR CHANNEL IS ADJACENT TO A PUBLIC STREET.
7. THE REINFORCING AND CONCRETE THICKNESS IS BASED ON A Vmax OF 30 f.p.s. IF LOWER VELOCITIES ARE ATTAINABLE (20 f.p.s.) THESE PARAMETERS ARE SUBJECT TO POSSIBLE CHANGE AT THE DISCRETION OF THE CITY ENGINEER.

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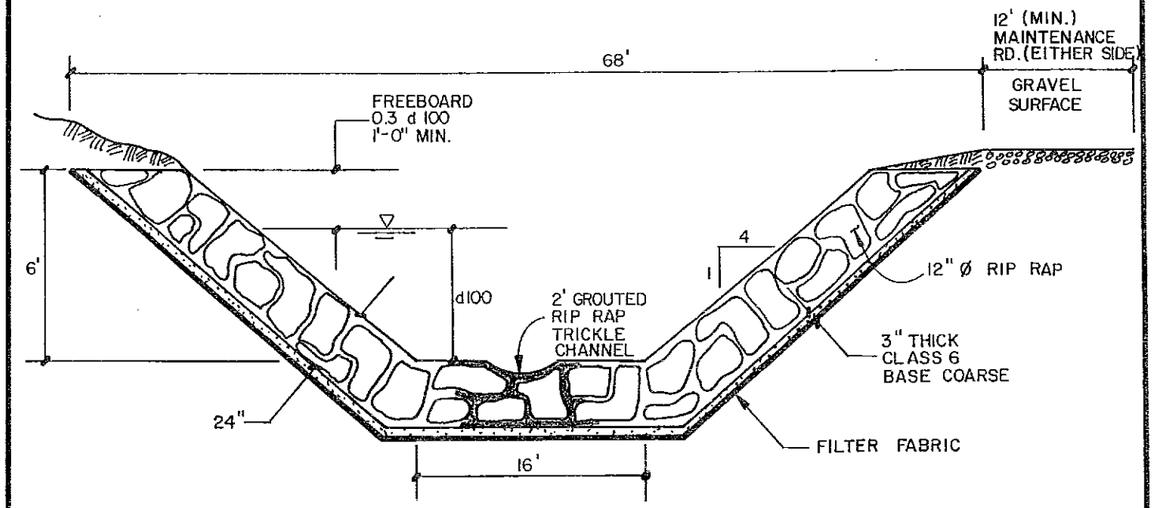
3b ALTERNATE MAJOR CHANNEL SECTION



CHANNEL DESIGN DATA

$Q = A\frac{1.486}{n} R^{2/3} S^{1/2}$

n = 0.045

Vmax = 14 f.p.s. (MEAN CHANNEL VELOCITY)

NOTES

1. ALL FINAL DESIGN AND CONSTRUCTION SHALL BE TO CURRENT CITY OF COLORADO SPRINGS STANDARDS AND SPECIFICATIONS.
2. FINAL CHANNEL SIZING IS SUBJECT TO DETAILED DRAINAGE REPORTS OF THE SUBJECT AREA.
3. CUTOFF WALLS AND TRANSITIONS MAY BE REQUIRED.

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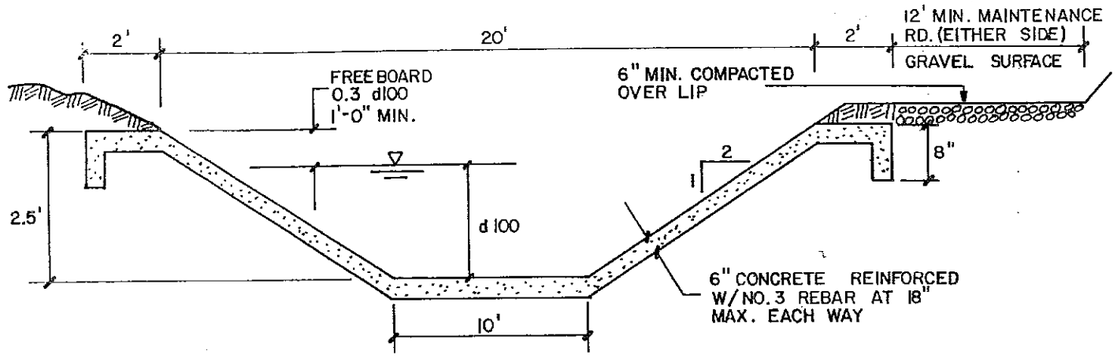
3c TYPICAL MINOR CHANNEL SECTION



CHANNEL DESIGN DATA

$Q = A\frac{1.486}{n} R^{2/3} S^{1/2}$

n = 0.015

Vmax = 25 f.p.s.

NOTES

1. ALL FINAL DESIGN AND CONSTRUCTION SHALL BE TO CURRENT CITY OF COLORADO SPRINGS STANDARDS AND SPECIFICATIONS.
2. FINAL CHANNEL SIZING IS SUBJECT TO DETAILED DRAINAGE REPORTS OF THE SUBJECT AREA.
3. CUTOFF WALLS SHALL BE PROVIDED AT MAXIMUM 200 INTERVALS.
4. EXTRA HEIGHT SHALL BE PROVIDED ALONG THE OUTSIDE EDGE OF ALL CURVES.
5. SUITABLE TRANSITIONS IN AND / OR OUT OF CULVERT HEADWALLS OR BOX CULVERTS SHALL BE PROVIDED AT FINAL DESIGN.
6. GUARD RAIL REQUIRED WHEN MAJOR CHANNEL IS ADJACENT TO A PUBLIC STREET.
7. THE REINFORCING AND CONCRETE THICKNESS IS BASED ON A Vmax OF 25 f.p.s. IF LOWER VELOCITIES ARE ATTAINABLE (20 f.p.s.) THESE PARAMETERS ARE SUBJECT TO POSSIBLE CHANGE AT THE DISCRETION OF THE CITY ENGINEER.

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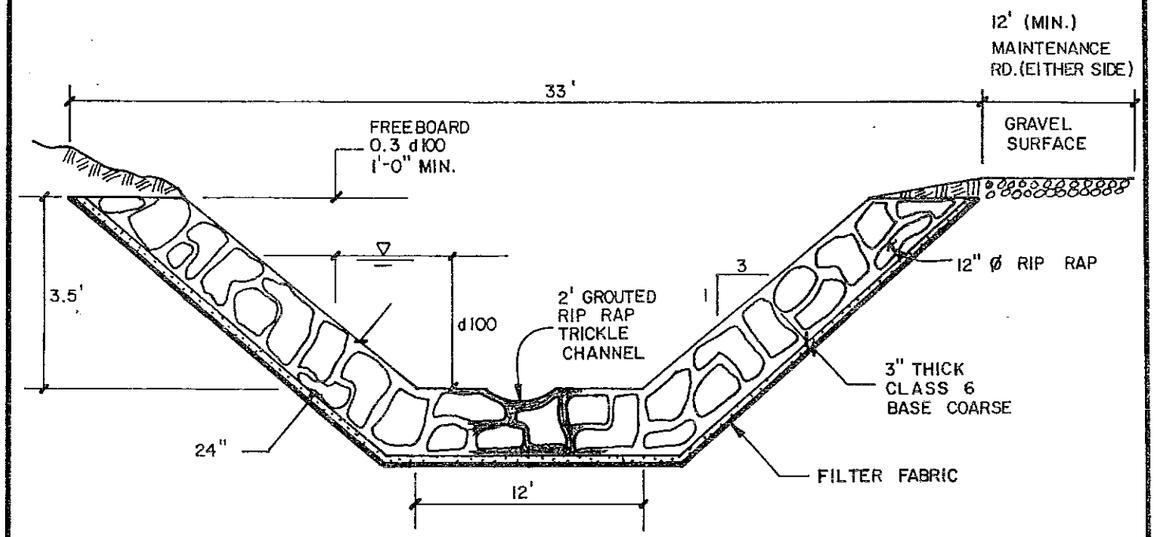
3d ALTERNATE MINOR CHANNEL SECTION



CHANNEL DESIGN DATA

$Q = A\frac{1.486}{n} R^{2/3} S^{1/2}$

n = 0.045

Vmax = 25 f.p.s. (MEAN CHANNEL VELOCITY)

NOTES

1. ALL FINAL DESIGN AND CONSTRUCTION SHALL BE TO CURRENT CITY OF COLORADO SPRINGS STANDARDS AND SPECIFICATIONS.
2. FINAL CHANNEL SIZING IS SUBJECT TO DETAILED DRAINAGE REPORTS OF THE SUBJECT AREA.
3. CUTOFF WALLS AND TRANSITIONS MAY BE REQUIRED.

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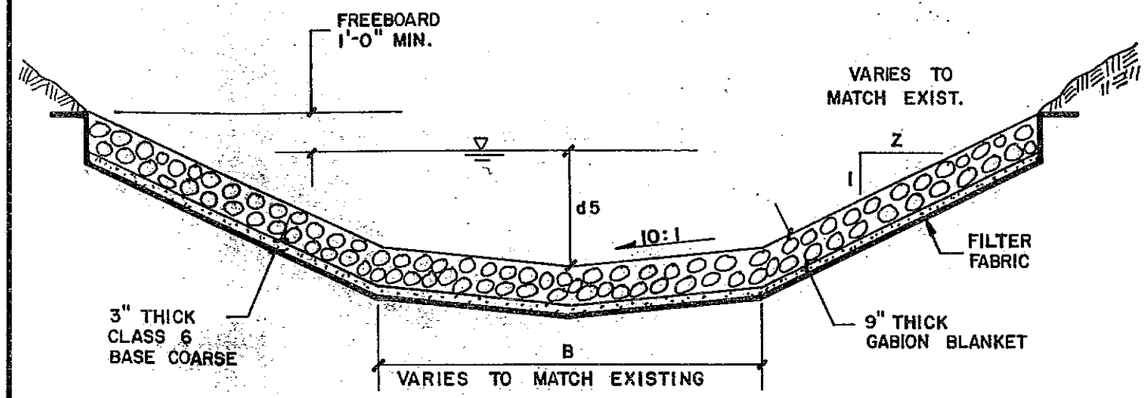
3e CHANNEL LINING FOR EXISTING SECTION



CHANNEL DESIGN DATA

$Q = A \frac{1.486}{n} R^{2/3} S^{1/2}$

n = 0.025

Vmax = 13 f.p.s. (MEAN CHANNEL VELOCITY)

NOTES

1. BOTTOM WIDTH (B) AND SIDE SLOPE (Z) VARIES TO MATCH EXISTING.
2. MAXIMUM SIDE SLOPE (Z) = 2.
3. ALL FINAL DESIGN AND CONSTRUCTION SHALL BE TO CURRENT CITY OF COLORADO SPRINGS STANDARDS AND SPECIFICATIONS.
4. FINAL CHANNEL SIZING IS SUBJECT TO DETAIL DRAINAGE REPORTS OF THE SUBJECT AREA.
5. CUTOFF WALLS AND TRANSITIONS MAY BE REQUIRED.

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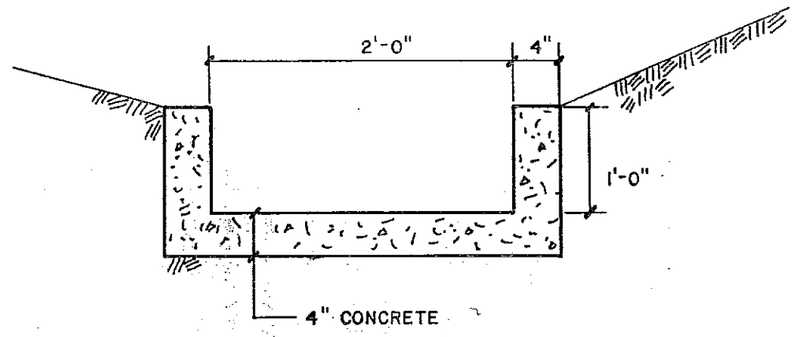
Consulting Engineers

3f TYPICAL DRAINAGE CHUTE SECTION



CHANNEL DESIGN DATA

$Q = A \frac{1.486}{n} R^{2/3} S^{1/2}$

n = 0.015

S & V VARY

NOTES

1. ALL FINAL DESIGN AND CONSTRUCTION SHALL BE TO CURRENT CITY OF COLORADO SPRINGS STANDARDS AND SPECIFICATIONS.
2. FINAL CHANNEL SIZING IS SUBJECT TO DETAILED DRAINAGE REPORTS OF THE SUBJECT AREA.

KKBNA
Incorporated
Consulting Engineers

STANDARD M-601-1

(JANUARY, 1982)

FEDERAL ROAD REGION NO.	DIVISION	PROJ NO.	SHEET NO.	TOTAL SHEETS
VIII	COLORADO			

REVISIONS		

f-BARS (Cont.)

SPAN S	HEADWALL SKEW ANGLE 90° to 75°	74° to 60°	59° to 45°
5' or 6'	#4	#4	#5
7' or 8'	#4	#5	#6
9' or 10'	#5	#6	#7
11' or 12'	#6	#7	#8
13' or 14'	#7	#8	#9

Six f-bars required for each headwall.

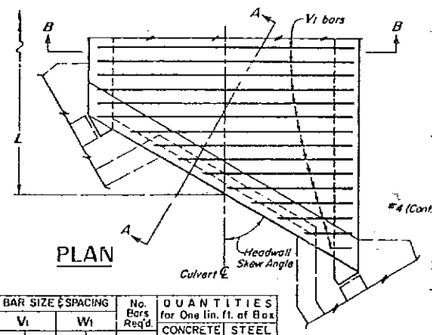
HEADWALL & TOEWALL QUANTITIES

f-BAR SIZE	APPROX. QUANTS. FOR ONE HEADWALL & TOEWALL LBS. PER LINEAR FT.
4	13
5	15
6	18
7	21
8	25
9	29

Concrete = 0.085 cuyds./lin. ft.

▲ Deduct 0.049 cu.yd. Concrete and 3.4 lb. Reinf. Steel from these quantities when Concrete Apron is specified.

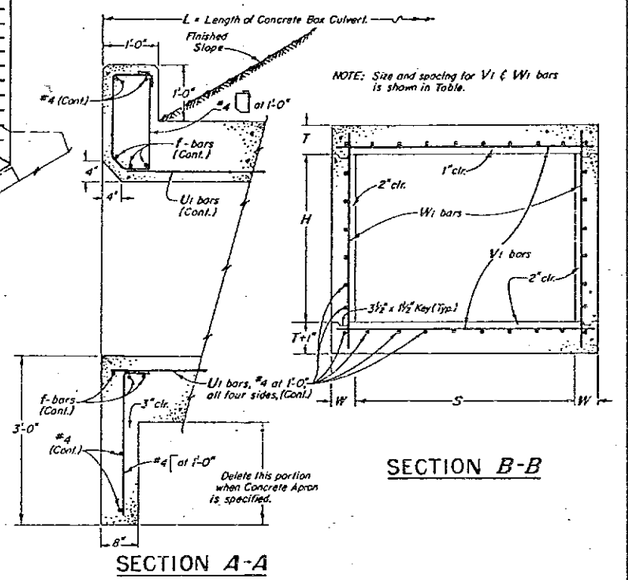
Includes all Headwall and Toewall reinforcing.



DIMENSIONS & QUANTITIES

HEIGHT OF FILL ALLOWED ft.	TYPE	SPAN S	HEIGHT H	SLAB T	WALL W	BAR SIZE & SPACING V1 Size	V1 Spa.	W1 Size	W1 Spa.	No. Bars Req'd. U1	QUANTITIES for One lin. ft. of Box CONCRETE cu. yds.	STEEL lbs.
16	5A	5'	3'	8"	8"	#6	8"	#4	8"	16	0.481	45.3
			4'							18	0.530	48.7
			5'							20	0.579	52.0
20	5B	5'	3'	8½"	8"	#6	8"	#4	8"	16	0.500	45.5
			4'							18	0.549	48.8
			5'							20	0.598	52.2
14	6A	6'	4'	8½"	8"	#6	8"	#4	8"	20	0.605	54.7
			5'							22	0.654	58.1
			6'							24	0.704	61.4
			7'							26	0.753	64.9
20	6B	6'	4'	10"	8"	#7	8"	#5	8"	20	0.671	72.4
			5'							22	0.720	76.9
			6'							24	0.771	81.4
			7'							26	0.820	85.9
12	7A	7'	4'	9"	9"	#6	7"	#4	7"	22	0.720-	68.2
			5'							24	0.776	71.9
			6'							26	0.832	75.5
			7'							28	0.887	79.2
15	7B	7'	4'	10"	9"	#7	8"	#5	8"	22	0.772	81.0
			5'							24	0.827	85.5
			6'							26	0.883	90.0
			7'							28	0.938	94.5
20	7C	7'	4'	11"	9"	#7	7"	#5	7"	22	0.826	91.1
			5'							24	0.881	96.0
			6'							26	0.937	101.0
			7'							28	0.992	106.0
10	8A	8'	4'	9½"	10"	#6	7"	#4	7"	24	0.844	75.8
			5'							26	0.905	79.5
			6'							28	0.966	83.2
			7'							30	1.027	86.8
			8'							32	1.089	90.5
16	8B	8'	4'	11½"	10"	#7	7"	#5	7"	24	0.963	100.9
			5'							26	1.025	105.9
			6'							28	1.086	110.8
			7'							30	1.148	115.8
			8'							32	1.210	120.8
20	8C	8'	4'	12½"	10"	#7	6"	#5	6"	24	1.023	115.6
			5'							26	1.084	121.4
			6'							28	1.146	126.9
			7'							30	1.208	132.5
			8'							32	1.270	138.1
7	9A	9'	5'	10"	11"	#7	8"	#5	8"	28	1.040	102.7
			6'							30	1.108	107.1
			7'							32	1.176	111.6
			8'							34	1.244	116.1
			9'							36	1.311	120.7
14	9B	9'	5'	12"	11"	#7	6"	#5	6"	28	1.174	131.9
			6'							30	1.242	137.5
			7'							32	1.310	143.1
			8'							34	1.378	148.6
			9'							36	1.445	154.2
20	9C	9'	5'	14"	11"	#8	7"	#6	7"	28	1.309	150.4
			6'							30	1.377	156.9
			7'							32	1.444	163.4
			8'							34	1.513	170.0
			9'							36	1.581	176.6
5	10A	10'	6'	10½"	12"	#7	8"	#4	8"	32	1.260	107.7
			7'							34	1.334	111.0
			8'							36	1.408	114.4
			9'							38	1.483	117.8
			10'							40	1.558	121.1

HEIGHT OF FILL ALLOWED ft.	TYPE	SPAN S	HEIGHT H	SLAB T	WALL W	BAR SIZE & SPACING V1 Size	V1 Spa.	W1 Size	W1 Spa.	No. Bars Req'd. U1	QUANTITIES for One lin. ft. of Box CONCRETE cu. yds.	STEEL lbs.
10	10B	10'	6'	12"	12"	#7	7"	#5	7"	32	1.369	130.4
			7'							34	1.443	135.4
			8'							36	1.517	140.4
			9'							38	1.591	145.3
			10'							40	1.665	150.3
16	10C	10'	6'	14"	12"	#8	8"	#6	8"	32	1.518	150.7
			7'							34	1.593	156.6
			8'							36	1.666	162.5
			9'							38	1.741	168.4
			10'							40	1.815	174.3
5	11A	11'	6'	11"	12"	#7	7"	#4	7"	34	1.367	128.6
			7'							36	1.441	132.2
			8'							38	1.515	135.9
			9'							40	1.589	139.6
			10'							42	1.664	143.1
9	11B	11'	6'	12½"	12"	#8	8"	#5	8"	34	1.490	148.3
			7'							36	1.564	156.9
			8'							38	1.639	157.5
			9'							40	1.712	161.8
			10'							42	1.783	166.4
13	11C	11'	6'	14"	12"	#7	6"	#5	6"	34	1.608	159.5
			7'							36	1.682	165.1
			8'							38	1.756	170.7
			9'							40	1.830	176.2
			10'							42	1.904	181.8
5	12A	12'	6'	12"	12"	#7	7"	#4	7"	36	1.503	137.4
			7'							38	1.599	141.0
			8'							40	1.673	144.7
			9'							42	1.747	148.4
			10'							44	1.821	152.0
10	12B	12'	6'	14"	12"	#8	7"	#5	7"	36	1.697	177.7
			7'							38	1.772	182.7
			8'							40	1.846	187.7
			9'							42	1.920	192.6
			10'							44	1.994	197.6
4	13A	13'	6'	12½"	12"	#7	7"	#4	7"	38	1.645	146.0
			7'							40	1.720	149.7
			8'							42	1.794	153.3
			9'							44	1.868	157.0
			10'							46	1.942	160.7
8	13B	13'	6'	14"	12"	#8	7"	#5	7"	38	1.787	188.4
			7'							40	1.861	193.3
			8'							42	1.935	198.3
			9'							44	2.009	203.3
			10'							46	2.083	208.2
4	14A	14'	6'	13½"	12"	#8	8"	#5	8"	40	1.827	177.2
			7'							42	1.901	181.7
			8'							44	1.975	186.2
			9'							46	2.049	190.7
			10'							48	2.123	195.2
8	14B	14'	6'	15"	12"	#8	7"	#5	7"	40	1.975	199.5
			7'							42	2.049	204.5
			8'							44	2.123	209.4
			9'							46	2.198	214.4
			10'							48	2.270	219.4



SECTION B-B

SECTION A-A

GENERAL NOTES

All work shall be done in accordance with the Standard Specifications applicable to the project.

All concrete shall be Class "A" (Box Culvert).

All construction joints shall be thoroughly cleaned before fresh concrete is poured.

Construction joints shall be spaced at 35 foot max. centers and shall extend through the entire cross section of the Box Culvert.

Splice quantities for longitudinal bars are not included.

DESIGN DATA: AASHTO, 1973.
Unit Stresses: f_s = 20,000 psi
f_c = 1,200 psi
n = 10

DESIGN CRITERIA:
Culvert in trench on unyielding subgrade, or culvert untrenched on yielding foundation. For culverts on piles or rock foundations, special design will be required.

LOADING DATA:
Live Load = AASHTO, HS 20-44
Dead Load = Earth Load = 84 lbs./cu.ft. Equivalent Fluid Pressure = 30 lbs./cu.ft.

The minimum splice length for common bar sizes shall be:

BAR SIZE	#4	#5	#6	#7	#8	#9
SPLICE LENGTH	1'-0"	1'-2"	1'-8"	2'-3"	3'-0"	3'-10"

All exposed corners on concrete shall be chamfered ¾".

DEPARTMENT OF HIGHWAYS
STATE OF COLORADO
DIVISION OF HIGHWAYS

SINGLE CONCRETE BOX CULVERT

Designed by J.E.S.	Approved by [signature], P.E.
Made by J.R.B.	Bridge Engineer
Checked by J.R.E.	Date - Sept. 9, 1974

KKBNA
Incorporated
Consulting Engineers

STANDARD M-601-2

(JANUARY, 1982)

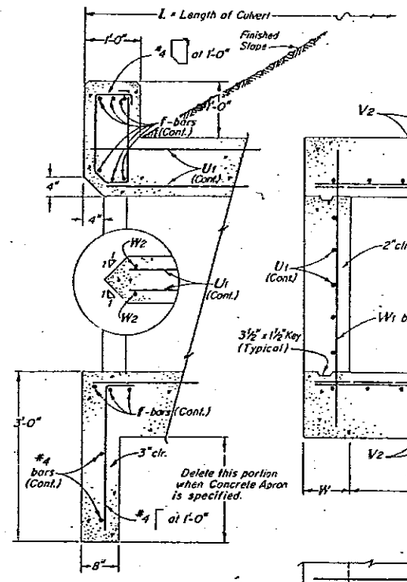
FEDERAL ROAD REGION NO	DIVISION	PROJ NO	SHEET NO	TOTAL SHEETS
STR	COLORADO			

REVISIONS		

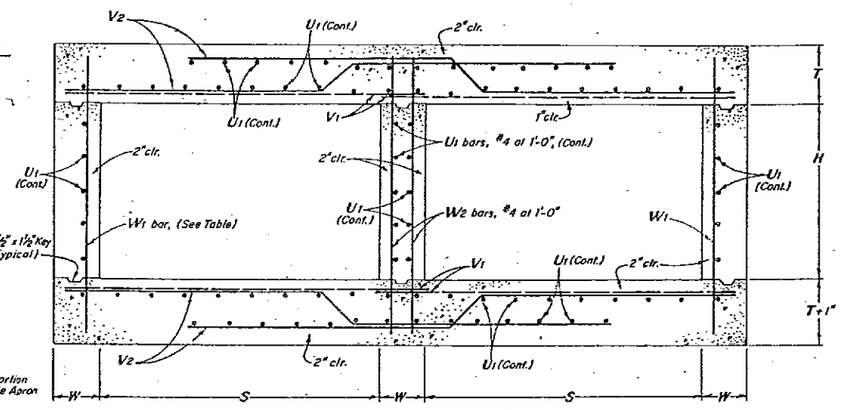
DIMENSIONS & QUANTITIES

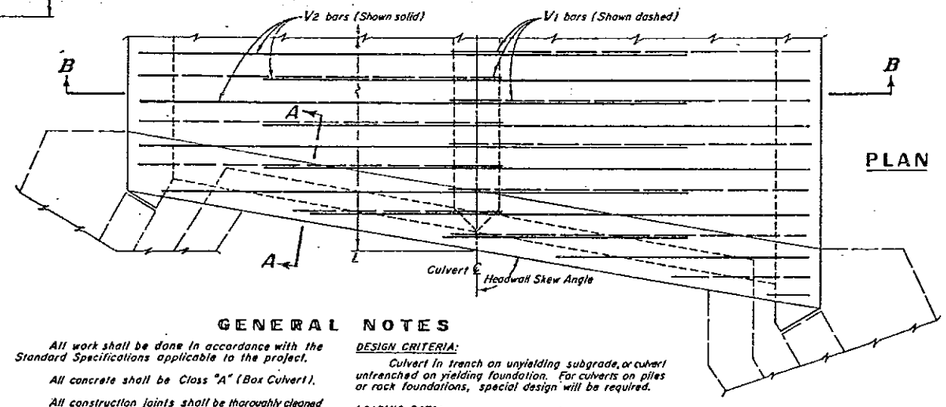
HEIGHT OF FILL ALLOWED	TYPE	SPAN S	HEIGHT H	SLAB T	WALL W	BAR SIZE & SPACING V1	BAR SIZE & SPACING V2	BAR SIZE & SPACING W1 Size	BAR SIZE & SPACING W1 Spa.	No. BARS Req'd. U1	QUANTITIES for One Linear Ft. of Box CONCRETE Cu. Yds.	QUANTITIES for One Linear Ft. of Box STEEL Lbs.
10'	6-6-A	6'	3'	8½"	8"	#4 | #5 Spa. 5½"		#4	12"	48	1.000	112.3
			4'						12"	52	1.073	117.7
			5'						12"	56	1.148	123.1
			6'						12"	60	1.222	128.5
15'	6-6-B	6'	3'	9½"	8"	#4 | #5 Spa. 5"		#4	12"	48	1.087	120.3
			4'						12"	52	1.161	125.7
			5'						12"	56	1.235	131.1
			6'						8"	60	1.309	141.4
20'	6-6-C	6'	3'	10½"	8"	#4 | #5 Spa. 4½"		#4	12"	48	1.173	130.0
			4'						12"	52	1.247	135.4
			5'						10"	56	1.321	142.5
			6'						7"	60	1.395	1524
10'	8-8-A	8'	3'	10"	10"	#5 | #6 Spa. 6"		#4	12"	60	1.477	174.4
			4'						12"	64	1.569	179.8
			5'						12"	68	1.662	185.2
			6'						12"	72	1.755	190.6
15'	8-8-B	8'	3'	11"	10"	#5 | #6 Spa. 5½"		#4	12"	60	1.592	188.6
			4'						12"	64	1.684	192.0
			5'						12"	68	1.777	197.4
			6'						8"	72	1.869	207.9
20'	8-8-C	8'	3'	12½"	10"	#5 | #6 Spa. 5"		#4	12"	60	1.763	202.0
			4'						12"	64	1.956	207.4
			5'						10"	68	1.948	214.6
			6'						7"	72	2.041	225.7
5'	10-10-A	10'	4'	10"	12"	#5 | #7 Spa. 7"		#5	15"	78	1.935	228.3
			6'						15"	86	2.157	239.8
			8'						12"	94	2.380	255.2
			10'						9"	102	2.602	275.5
10'	10-10-B	10'	4'	12"	12"	#5 | #7 Spa. 7"		#5	15"	78	2.220	231.0
			6'						15"	86	2.442	242.5
			8'						12"	94	2.664	258.0
			10'						8"	102	2.886	282.6
15'	10-10-C	10'	4'	14"	12"	#5 | #7 Spa. 6"		#5	15"	78	2.503	260.8
			6'						12"	86	2.725	275.6
			8'						9"	94	2.947	295.0
			10'						6"	102	3.170	325.5
5'	12-12-A	12'	6'	12"	12"	#5 | #7 Spa. 7"		#5	15"	98	2.751	278.9
			8'						12"	106	2.973	294.5
			10'						9"	114	3.195	315.0
10'	12-12-B	12'	6'	14"	12"	#5 | #7 Spa. 6"		#5	15"	98	3.083	313.5
			8'						12"	106	3.305	329.2
			10'						8"	114	3.528	354.1
15'	12-12-C	12'	6'	16"	12"	#5 | #7 Spa. 5"		#5	12"	98	3.416	365.1
			8'						9"	106	3.638	384.7
			10'						6"	114	3.860	415.7
5'	14-14-A	14'	6'	15"	12"	#5 | #7 Spa. 6"		#5	15"	110	3.633	356.2
			8'						12"	118	3.855	372.0
			10'						9"	126	4.077	392.9
10'	14-14-B	14'	6'	16"	12"	#5 | #7 Spa. 5"		#5	15"	110	3.824	409.4
			8'						12"	118	4.046	425.2
			10'						8"	126	4.269	450.5

SECTION A-A



SECTION B-B



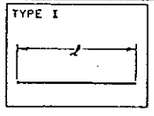


PLAN

BAR LIST

MARK	SIZE	NUMBER REQ'D.	TYPE	L	TOTAL LENGTH
V1	See Table	24 L / Spa. +2	I	S+1.5W+4"	L
V2			II	0.75S+4"	2L+m
W1			I	H+2T-4"	L
W2	#4	2L+2	I	H+2T-4"	L
U1	#4	See Table	I	L	L

TYPE I



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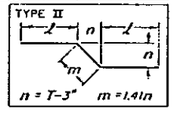


f-BARS (Cont.)

SPAN S	HEADWALL SKEW ANGLE 90° to 75°	74° to 60°	59° to 45°
6'	#4	#4	#5
8'	#4	#5	#6
10'	#5	#6	#7
12'	#6	#7	#8
14'	#7	#8	#9

Nine f-bars required for each headwall.

HEADWALL & TOEWALL QUANTITIES

f-BAR SIZE #	APPROX. QUANTS. FOR ONE Headwall & Toewall [A] lbs. per lin. ft.
4	13
5	17
6	21
7	26
8	31
9	38
Concrete = 0.085 cu.yds./l.f.	

* Includes all Headwall and Toewall reinforcing.

[A] Deduct 0.049 cu. yd. Concrete and 3.4 lb. Reinforcing Steel from these quantities when Concrete Apron is specified.

GENERAL NOTES

All work shall be done in accordance with the Standard Specifications applicable to the project.

All concrete shall be Class "A" (Box Culvert).

All construction joints shall be thoroughly cleaned before fresh concrete is poured.

Construction joints shall be spaced at 35 foot max. centers and shall extend through the entire cross section of the Box Culvert.

Splice quantities for longitudinal bars are not included.

DESIGN DATA: AASHTO, 1973,

Unit Stresses: f_s = 20,000 psi; f_c = 1,200 psi; n = 10

DESIGN CRITERIA:

Culvert in trench on unyielding subgrade, or culvert untrenched on yielding foundation. For culverts on piles or rock foundations, special design will be required.

LOADING DATA:

Live Load = AASHTO, HS 20-44

Dead Load = Earth Load = 84 lbs./cu. ft. Equiv. Fluid Pressure = 30 lbs./cu. ft.

The minimum splice length for common bar sizes shall be:

BAR SIZE	#4	#5	#6	#7	#8	#9
SPLICE LENGTH	1'-0"	1'-2"	1'-8"	2'-3"	3'-0"	3'-10"

All exposed corners on concrete shall be chamfered ¾".

DEPARTMENT OF HIGHWAYS
STATE OF COLORADO
DIVISION OF HIGHWAYS

DOUBLE CONCRETE BOX CULVERT

Designed by J E S	Approved by [signature] P.E.
Made by J R B	Bridge Engineer
Checked by J R E	Date: Sept. 9, 1974

KKBNA

Incorporated
Consulting Engineers

STANDARD M-601-3

(JANUARY, 1982)

FEDERAL ROAD REGION NO	DIVISION	PROJ NO	SHEET NO	TOTAL SHEETS
VIII	COLORADO			

REVISIONS			

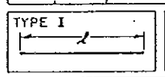
DIMENSIONS & QUANTITIES

HEIGHT OF FILL ALLOWED	TYPE	CLEAR SPAN S1	CLEAR SPAN S2	HEIGHT H	SLAB T	SIZE OF BARS V1 or V3	SPACING OF BARS V	SPACING OF BARS W1	NO. BARS REQ'D. U1	QUANTITIES for One Lin. Ft. of Box CONCRETE Cu yds.	QUANTITIES for One Lin. Ft. of Box STEEL Lbs.
5'	9-12-A	9'	12'	6'	10"	#7	7½"	15"	136	2.948	408.9
				8'				15"	148	3.207	425.6
				10'				11"	160	3.467	449.1
10'	9-12-B	9'	12'	6'	11"	#4	7"	15"	136	3.156	348.4
				8'				12"	148	3.415	369.0
				10'				6"	160	3.647	398.6
15'	9-12-C	9'	12'	6'	12"	#4	5½"	15"	136	3.363	412.5
				8'				9"	148	3.622	439.9
				10'				6"	160	3.881	475.1
5'	11-14-A	11'	14'	6'	11"	#6	6"	15"	156	3.581	513.9
				8'				15"	168	3.841	530.6
				10'				11"	160	4.100	554.3
10'	11-14-B	11'	14'	6'	12½"	#4	5½"	15"	156	3.948	477.1
				8'				12"	168	4.207	497.8
				10'				8"	180	4.467	527.6
15'	11-14-C	11'	14'	6'	14"	#4	5"	15"	156	4.315	515.6
				8'				9"	168	4.574	543.5
				10'				6"	180	4.833	579.1
5'	13-16-A	13'	16'	6'	12½"	#6	5½"	15"	176	4.430	626.6
				8'				15"	188	4.689	643.3
				10'				10"	200	4.948	669.8
10'	13-16-B	13'	16'	6'	14"	#4	5"	15"	176	4.852	583.9
				8'				12"	188	5.111	604.8
				10'				8"	200	5.370	634.7
15'	13-16-C	13'	16'	6'	15½"	#4	4"	15"	176	5.270	697.3
				8'				9"	188	5.530	725.4
				10'				6"	200	5.789	761.3

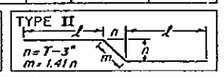
BAR LIST

MARK	SIZE	NUMBER REQUIRED	TYPE	ℓ	TOTAL LENGTH
V1	See Table	24L/Spa. +4	I	S1+1'-9"	ℓ
V2	#7	24L/Spa. +4	II	0.61 S2	2ℓ+m
V3	See Table	12L/Spa. +2	I	S2+1'-10"	ℓ
V4	#7	12L/Spa. +2	III	0.726 S1	3ℓ+2m
W1	#5	24L/Spa. +2	I	H+2T-4"	ℓ
W2	#4	4L+4	I	H+2T-4"	ℓ
U1	#4	See Table	I	L	ℓ

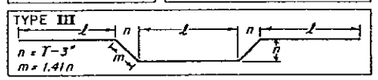
TYPE I



TYPE II



TYPE III



HEADWALL & TOEWALL QUANTITIES

f-BAR SIZE #	APPROX. QUANTS. FOR ONE HEADWALL & TOEWALL LBS. PER LIN. FT.
5	17
6	21
7	26
8	31
9	38
Concrete = 0.065 cuyds./lin.ft.	

* Includes all Headwall and Toewall reinforcing.

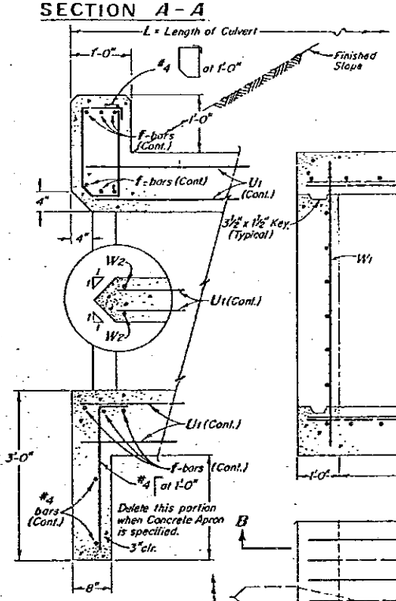
▲ Deduct 0.049 cu. yd. Concrete and 3.4 lb. Reinf. Steel from these quantities when Concrete Apron is specified.

f - BARS (Continuous)

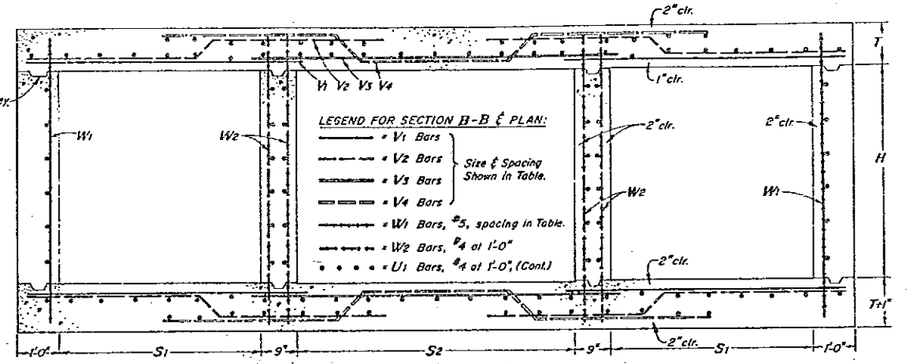
SPAN S2	HEADWALL SKEW ANGLE 90° to 75°	74° to 60°	59° to 45°
12'	#5	#6	#7
14'	#6	#7	#8
16'	#7	#8	#9

Nine f-bars required for each headwall.

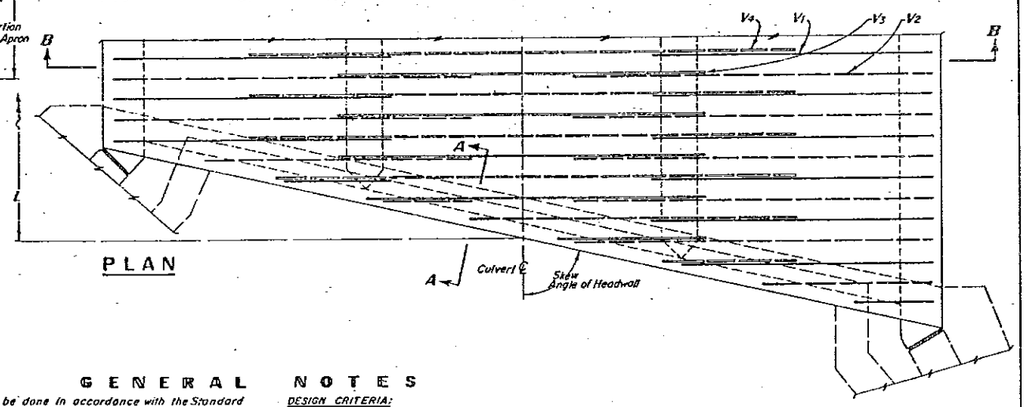
SECTION A-A



SECTION B-B



PLAN



GENERAL NOTES

All work shall be done in accordance with the Standard Specifications applicable to the project.

All concrete shall be Class "A" (Box Culvert).

All construction joints shall be thoroughly cleaned before fresh concrete is poured.

Construction joints shall be spaced at 35 foot max. centers and shall extend through the entire cross section of the Box Culvert.

Splice quantities for longitudinal bars are not included.

DESIGN DATA: AASHTO, 1973.

Unit Stresses: f_s = 20,000 psi
f_c = 1,200 psi
n = 10

NOTES

DESIGN CRITERIA:

Culvert in trench on unyielding subgrade, or culvert untrenched on yielding foundation. For culverts on piles or rock foundations, special design will be required.

LOADING DATA:

Live Load = AASHTO, HS 20-44

Dead Load = Earth Load = 84 lbs./cu.ft.
Equiv. Fluid Pressure = 30 lbs./cu.ft.

The minimum splice length for common bar sizes shall be:

BAR SIZE	#4	#5	#6	#7	#8	#9
SPLICE LENGTH	1'-0"	1'-2"	1'-8"	2'-3"	3'-0"	3'-10"

All exposed corners on concrete shall be chamfered ¾".

DEPARTMENT OF HIGHWAYS
STATE OF COLORADO
DIVISION OF HIGHWAYS

TRIPLE CONCRETE BOX CULVERT

Designed by J.E.S	Approved by [signature] P.E.
Made by J.R.B	Bridge Engineer
Checked by J.R.E	Date: Sept. 9, 1914

KKBNA
Incorporated
Consulting Engineers

4. MASTER DRAINAGE PLAN