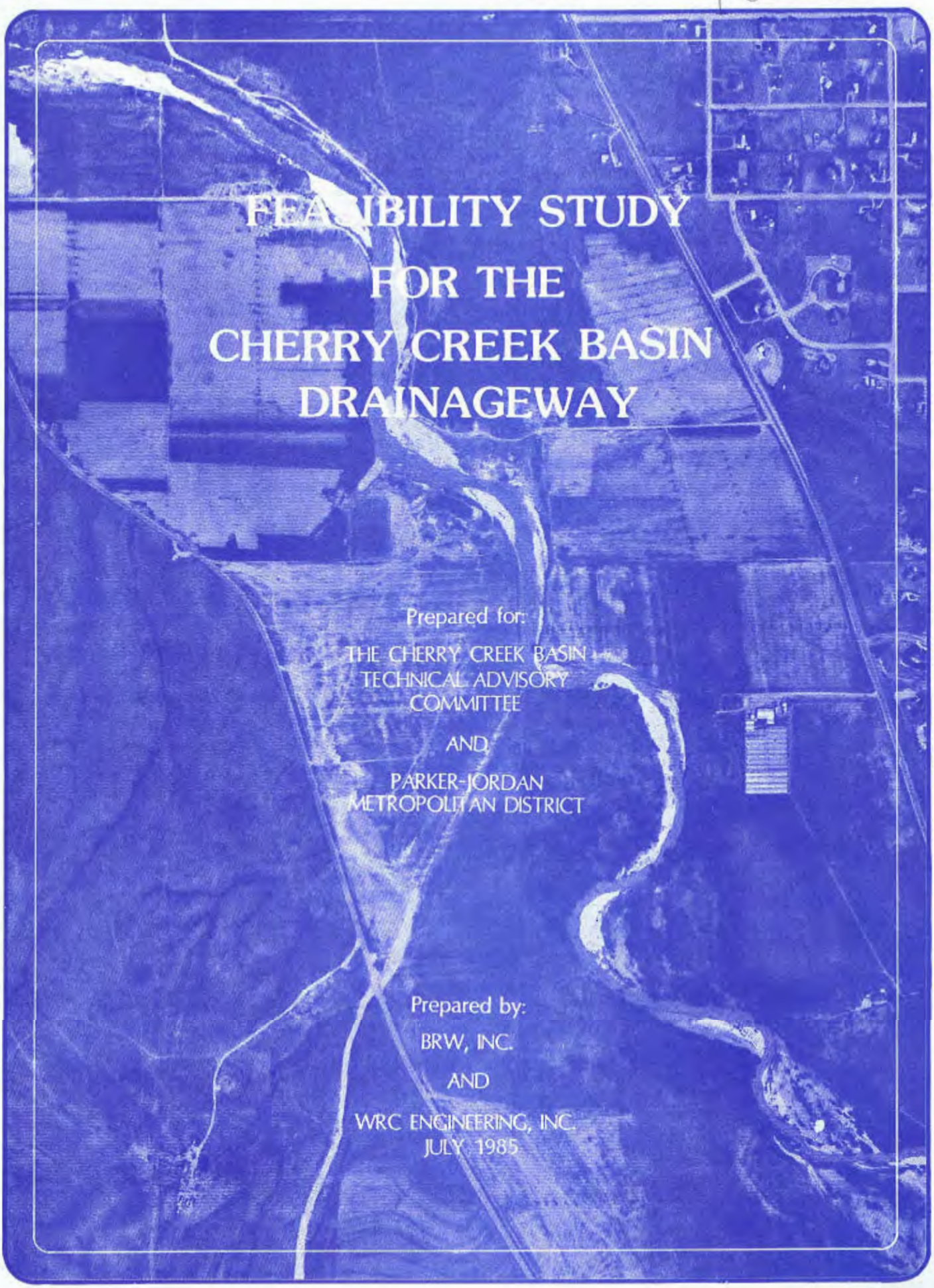


FEASIBILITY STUDY FOR THE CHERRY CREEK BASIN DRAINAGEWAY

Prepared for:

THE CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE

AND

PARKER-JORDAN METROPOLITAN DISTRICT

Prepared by:

BRW, INC.

AND

WRC ENGINEERING, INC.

JULY 1985

BRW

PLANNING
TRANSPORTATION
ENGINEERING
ARCHITECTURE

BRW, INC. 7208 S. TUCSON WAY SUITE 291 ENGLEWOOD, COLORADO 80112 PHONE 303/790-0923

July 31, 1985

Mr. David Ray
Manager, Parker-Jordan Metropolitan District
7951 E. Maplewood Avenue, Suite 300
Englewood, Colorado 80111

Dear Mr. Ray:

On behalf of BRW, Inc. and WRC Engineering, Inc., I am pleased to forward the final draft of the Feasibility Study for the Cherry Creek Basin Drainageway (from Arapahoe Road south to the Arapahoe-Douglas County Line). The study identifies proposed improvements to Cherry Creek, with the goals of 1) maximizing land use, 2) minimizing cost of stream improvements, 3) satisfying the concerns of regulatory agencies, and 4) minimizing the risks of upstream and downstream problems.

The selected plan consists of approximately 10,200 feet of channelization upstream of Arapahoe Road and revetments to stabilize the channel in the upper reaches of the study area. Filling of the flood fringe (1/2 foot floodway) allows for potential reclamation of 215 acres of floodplain property. Aesthetic and recreational improvements within the floodplain are also part of the plan.

The selected plan proposed in this study will be submitted to Arapahoe County for adoption as the master plan to guide drainage improvements within the study area. Arapahoe County will also request concurrence of the Urban Drainage and Flood Control District in the plan. These and other governmental agencies will be involved in approving the implementation of specific segments of the overall plan in the future.

I would like to express thanks to all of the parties who contributed to this unique study. I believe that the selected plan provides a creative guide to the safe use and protection of lands along the Cherry Creek drainageway.

Sincerely,

BRW, Inc.

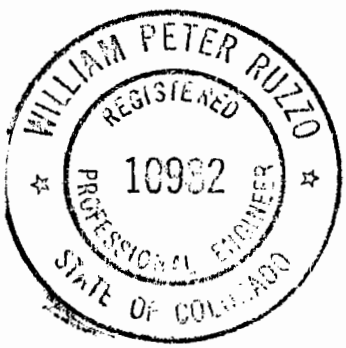
Donald E. Hunt
Vice President

CERTIFICATION

I DO HEREBY CERTIFY THAT THIS REPORT WAS PREPARED UNDER US AND UNDER OUR DIRECT SUPERVISION FOR THE OWNER'S THEREOF.

George Prine, P.E., 19688

Vice President, BRW, Inc.



William P. Ruzzo, P.E., 10982

Vice President, WRC Engineering, Inc.

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SYNOPSIS

This report presents the results of a feasibility analysis to identify improvement options for the reach of Cherry Creek from Arapahoe Road to the Douglas County line. The work was performed under contract with the Cherry Creek Basin Technical Advisory Committee/Bill L. Walters Companies by the joint venture of BRW, Inc. and WRC Engineering, Inc. The scope of the analysis is summarized as follows:

1. Collect and analyze existing hydrologic and hydraulic data for the purpose of defining constraints and identifying problems of developing property adjacent to Cherry Creek.

2. Perform a qualitative analysis of the river morphology and sedimentation characteristics of Cherry Creek to define additional constraints for improvements to Cherry Creek.

3. Develop and evaluate alternative solutions that maximize land use, minimize cost of improvements, satisfy concerns of regulatory agencies, and minimize the chances for upstream and downstream problems.

4. Prepare preliminary design and cost estimates of the selected alternative and document the results in a report.

The project area consists of 3.3 stream miles of Cherry Creek upstream of Arapahoe Road and is bounded by Parker Road, Jordan Road, the Douglas County line and Arapahoe Road. Cherry Creek drains approximately 336 square miles at the downstream limit of the project area. The present land use in the area is mainly small farms. The proposed land use is mostly a residential mixture with larger tracts for retail, commercial and business.

A review of the river morphology and sedimentation characteristics of Cherry Creek was performed using historic streamflow and runoff data, aerial photographs before and after various floods, samples from the creek bed, and

analysis of horizontal and vertical movement trends. Three important factors were revealed. First, the largest flood of record had only minimal effect on the horizontal alignment of the active creek bed. Most of the horizontal movement occurred during intermediate flows. Second, the bed level degraded considerably in local areas during major floods and generally aggraded during intermediate flows. Finally, an analysis of the 100 year floodplain revealed that the flow conditions for approximately 6,000 feet upstream of Arapahoe Road are really two separate hydraulically disconnected flood profiles.

Using the above findings, various alternatives were developed to stabilize the creek bed movement and to increase land utilization. The alternatives ranged from status quo or do-nothing to channelization and other major structural options. The alternative plans were evaluated and schematic plans prepared and presented to the Technical Advisory Committee and property owners. Individual meetings were then held with each of the major impacted land owners to develop the final selected alternative plan. Preliminary design drawings and cost estimates were prepared for the selected plan. In addition, the maintenance requirements, the impact on water quality and existing wells, and a recreation plan were defined for the selected plan.

The selected plan consists of approximately 10,200 feet of channelization upstream of Arapahoe Road and revetments to stabilize the channel in the upper reaches of the study area. Filing of the flood fringe (1/2 foot floodway) allows for the reclamation of 215 acres of floodplain property, which includes the reclaimed area adjacent to the channelization reach.

Implementation of the selected plan requires dredge and fill permits (Section 404, Water Quality Act) and a Colorado Department of Health Water Quality Certification (Section 401). However, filling of the flood fringe can be done prior to receiving the permits, but there is a high risk of horizontal channel movement eroding the banks of the fill in certain areas because of the lack of bank protection.

Since it is unlikely that the entire project would be constructed at once, then phasing of the construction will be required. A detailed discussion of the sequence and constraints on the phasing is presented in Section VI-A of

this report. In any event, communication between the various property owners will be required in order to obtain approval and to coordinate the construction phasing.

I. INTRODUCTION

A. Authorization

The work on the Feasibility Study for Cherry Creek Basin Drainageway was authorized by contract between the Cherry Creek Basin Technical Advisory Committee/Bill L. Walters Companies (herein called the Technical Advisory Committee - TAC) and the joint venture firms of BRW, Inc. and WRC Engineering, Inc. (herein called CONSULTANT), dated August 24, 1984. Work commenced on the project on August 7, 1984 when the available basic data for the project was transmitted to the CONSULTANT by Greiner Engineering Sciences, Inc.

B. Purpose and Scope

The purpose of the feasibility study was to identify improvement options for Cherry Creek within the project area. These options were then combined to formulate an overall drainage plan for Cherry Creek and its floodplains. The objectives of the plan were as follows:

- Maximize land use
- Minimize the cost of stream improvements
- Satisfy the concerns of regulatory agencies
- Minimize the risks of upstream and downstream problems

The scope of services was defined in detail by the contract. The project area was defined as the portion of Cherry Creek from Arapahoe Road to the Douglas County Line between Jordan Road and Parker Road. A summary of the work items is presented below:

1. Data collection and project coordination.

2. Contact interested parties and jurisdictional agencies.

3. Review and utilize appropriate governmental criteria.

4. Review and utilize hydrology developed by U.S. Army Corps of Engineers, and hydraulic calculations for the floodplain/floodway by Greiner Engineering Sciences.

5. Complete the hydraulic analysis of Cherry Creek to determine the capacity and general condition of all drainage features.

6. Define drainage problems and flood hazards for the purpose of formulating alternatives.

7. Prepare hydraulic calculations to evaluate the best alternative plans.

8. Review and evaluate impacts of present Federal Emergency Management Agency (FEMA) policies.

9. Consider operation and maintenance aspects of the best alternatives.

10. Perform a qualitative analysis of the river morphology and sedimentation characteristics.

11. Consider impact of each alternative on the water quality in the basin.

12. Conduct a benefit/cost analysis for the alternatives.

13. Prepare a report summarizing the above work.

During the course of the work, two major changes to the scope of services occurred. First, the benefit/cost analysis effort (item 12) was reduced from that specified by the contract due to the problems associated with identifying land values for each parcel. Alternatives were compared on the basis of costs and a qualitative analysis for each benefit was performed to aid in the review of the alternatives. Second, due to the potential impact of the selected alternative on the existing Aurora well field and other wells in the area, the

scope of services was expanded to include an analysis of the impact. This work was performed by Bishop, Brogden, and Rumph, Inc. under sub-contract to the TAC and coordinated by the CONSULTANT. A summary of the results of this analysis are also included in this report.

C. Basic Data

Considerable information was provided to the CONSULTANT by Greiner Engineering Sciences, Inc. (technical coordinator for the TAC). A list of the information is presented in Appendix-A. In addition, as part of the analysis of the river morphology, the CONSULTANT obtained aerial photographs of the project area on the following dates October 15, 1964; August 10, 1971; July 5, 1978; and October 1983. Samples from the river bed and banks were taken and gradation analysis performed (see Chapter III). Information obtained from the United States Geological Survey (USGS) included summary of discharges, annual peak flow, monthly flows,and stage discharge tabulations for the Melvin Streamgage (Station 06712500).

The mapping provided for the project consisted of a composite of 1-foot and 2-foot contour interval mapping listed below:

Sections 0 to 4,440: Northway - Gestalt, Topographic Mapping Viehmann, Martin Site 1' = 100', 2-foot contour intervals, 1981.

Sections 4,840 to 11,020: Analytical Surveys, Inc., Topographic Mapping, River Run Project, Digitized Sections Only, 1984.

Sections 11,600 to 17,300: Northway - Gestalt, Topographic Mapping Ashbrook Site, 1" = 100', 2-foot contour intervals, 1981, and U.S. Army Corps of Engineers and, Cherry Creek Floodplain Information Report Mapping, 1" = 200' contour intervals, flown April 1975.

The section numbers refer to the cross sections used for the hydraulic analysis (see Figure-5).

D. Method of Analysis

In general, the method of analysis followed the scope of services summarized in Section I-B above. After collection and review of the basic data, the sedimentation characteristics and the historic channel movements were noted from the aerial photographs and field investigations. This information was combined with the evaluation of the existing flooding and stream stability problems to develop various alternatives. The alternatives were discussed at the September 20, 1984 meeting with the TAC and the various property owners. The alternatives were then combined to form the best alternative plans which were presented to the TAC and the property owners on October 18, 1984. At the meeting, the potential sedimentation effects, the maintenance requirements, relative capital costs, and the pro's and con's of each plan were discussed. Individual meetings were then held with the primary impacted property owners to aid in the selection of the best alternative. These alternatives were then combined into the Selected Alternative Plan and a preliminary design with cost estimates was prepared. A draft report was prepared and distributed to all parties on May 1, 1985. Written comments on the report were received from Arapahoe County, the Urban Drainage and Flood Control District, and several property owners and their representatives. A final TAC meeting was held on June 18, 1985, to review all the comments and proposed changes with the committee. These comments have been incorporated into this final report.

To keep all the study participants informed of the progress and the decisions, minutes of the meetings between the TAC and the CONSULTANT were distributed to all the participants. A list of the participants is presented in Appendix-B and a copy of all meeting minutes is included in Appendix C.

E. Acknowledgements

The preparation of this report involved the efforts of many individuals including the CONSULTANTS staff, representatives of the TAC, property owners and other parties with interests in the project.

II. GENERAL STUDY AREA DESCRIPTION

II. GENERAL STUDY AREA DESCRIPTION

A. Study Area

The study area consists of the reach of Cherry Creek from Arapahoe Road to the Arapahoe/Douglas County Line, approximately 3.3 stream miles. The primary affected property owners are those adjacent to the creek between Jordan Road on the west and Parker Road on the east (see Figure-1).

Cherry Creek in this area has a sinuosity of 1.50 based on a valley distance of 2.2 miles. The streambed drops a total distance of 64 feet for a slope of 19.5 feet per mile. There are presently no drop structures affecting the bed profile.

There is one major drainageway, Happy Canyon Creek, that is tributary to Cherry Creek in this reach. The remainder of the drainage enters Cherry Creek by way of smaller gullies or sheet flow.

The Cherry Creek drains approximately 336 square miles (Reference-1) at the downstream limit of the study (Arapahoe Road). At the upstream limit (Douglas County Line), the drainage area is approximately 309 square miles. The Happy Canyon Creek confluence is approximately half the way between the upstream and downstream study limits and drains 17.24 square miles (Reference-2).

For the purpose of this study, Cherry Creek was divided into two reaches (see Figure 2). Reach A begins at Arapahoe Road and extends upstream a distance of approximately 6,800 feet along the creek bed. Reach B is the remainder of the study reach (10,600 feet).

B. Land Use

The present land use in the study area consists mainly of small farms with the exception of a small area of industrial uses at Jordan Road and Arapahoe

Road, and some private residences located along Parker Road. A portion of the area adjacent to Arapahoe Road is still used as soccer fields and as a well field for the City of Aurora.

The existing property boundaries and proposed land use within the study area are presented on Figure-2, Project Area Map. The proposed uses consist primarily of single family residential and a large regional commercial retail area at the intersection of Arapahoe Road and Parker Road. A portion of the study area is also proposed for small business centers.

C. Previous Investigations

The Cherry Creek 100-year floodplain has been previously defined by the U.S. Army Corps of Engineers (Reference-1). This work was recently updated by Greiner Engineering Sciences, Inc. (Reference-3) utilizing more detailed and current mapping (see Section II-D). Channelization for Cherry Creek from Arapahoe Road to approximately station 61+50 has been investigated by Law Engineering, Inc. (see Appendix-A). This information was utilized in the development and evaluation of alternatives (see Chapter IV). A flood hazard area delineation report has been prepared for Happy Canyon Creek delineating the 100-year floodplain (Reference-2). All the above referenced studies addressed the floodplain only and did not investigate alternatives for the drainage problems in Cherry Creek on a regional basis.

Other reports with smaller study areas have been prepared for several of the proposed developments within the study (see Appendix-A). In most cases, these studies addressed the local drainage problems and solutions and generally did not get involved with solutions for Cherry Creek.

D. Floodplain Analysis

Greiner Engineeering Sciences, Inc. (GREINER) has recently updated the Corps of Engineers (CORP) floodplain (Reference-3). In addition, GREINER has prepared and submitted (March 1, 1985) to FEMA for review and approval a flood-

way for Cherry Creek based on a maximum rise of 1 foot in the water surface. This was submitted in conjunction with a Letter of Map Revison (LOMR) to revise the FEMA floodpain to match the CORP floodplain. This work was provided to the CONSULTANT as basic data for use in the feasibility study (see Figure-7). The backwater analysis to define the flood profile was initiated at the upstream face of the Arapahoe Road bridge using the Corps of Engineers 100-year water surface elevation at this section. The 100-year flood peak is 49,490 cubic feet per second (Greiner, 1984). An analysis of the Corp of Engineers work by the CONSULTANT showed that the waterway opening for the bridge was improperly modelled. The actual waterway opening was found to be approximately 450 square feet larger. The CONSULTANT corrected the HEC-2 model and recomputed the back-water analysis. The analysis calculated the 100-year water surface upstream of Arapahoe Road was found to be 0.6-feet lower than the Corps of Engineers at the bridge and tapering off to zero in approximately 2000 feet. This difference was considered insignificant and the Greiner Engineering Sciences, Inc. data was used in this study.

The work by Greiner Engineering Sciences, Inc. also included a floodway analysis based on a maximum of 1/2-foot rise in the 100-year water surface (see Figure-7). The floodway was also based on equal conveyance encroachment into the floodplain on both sides of the Creek except for realignment of the floodway within the River Run project. The floodway work by Greiner Engineering Sciences, Inc. for the most part was also used by the CONSULTANT. In areas where the floodway line was drawn within the channel area, the line was moved to the top of the bank. A summary of the floodplain and floodway area by property owner is shown on Table-1.

The following representatives of the TAC contributed to this report:

Ernest Hamilton, Director of Engineering, Arapahoe County
William Rothenmeyer, Arapahoe County
William DeGroot, Urban Drainage and Flood Control District
Stephen Prokopiak, Greiner Engineering Services, Inc.

The following individuals on the staff of BRW and WRC, contributed to this report:

Donald Hunt, Vice President, BRW, Inc.
Stephen Wilensky, BRW, Inc.
William Ruzzo, Vice President, WRC, Inc.
Alan J. Leak, WRC, Inc.
Michael A. Stevens, Consultant

The following private consultants also provided information used in this report:

Law Engineering and Testing Company
Bishop, Brogden and Rumph, Inc.
Merrick and Company

III. FLUVIAL MORPHOLOGY AND SEDIMENT TRANSPORT

III. FLUVIAL MORPHOLOGY AND SEDIMENT TRANSPORT

A. Hydrology

1. Basin Description

Cherry Creek is a right-bank plains tributary of the South Platte River, entering the river in a highly developed business and industrial area of Denver. The Cherry Creek basin is about 54 miles long and averages 10 miles in width. The total drainage area to the downstream study limit is approximately 336 square miles. The creek flows north-northwest from the upper end of the basin located about 10 miles northeast of Colorado Springs, to its confluence with the South Platte River.

Upstream of Franktown, the Cherry Creek basin has steeply to moderately rolling topography with ponderosa pine growing on the higher ridges. The Cherry Creek valley is, in general, "v" shaped. In the reach from near Franktown to near Parker, Cherry Creek courses through a broader valley bordered by steep to rolling ridges and hills. Downstream from Parker, the uplands become less rough and the basin lies in a rolling plains area. The basin slopes northward from elevations of about 7700 feet above mean sea level at the source of Cherry Creek to about 5600 feet at the upstream end of Cherry Creek Lake state recreation area.

From Franktown to the Cherry Creek Reservoir, the stream channel averages 200 feet in width and ranges from 2 to 10 feet in depth. The bed has an average slope of 25 feet per mile. The channel is alluvial, flat bottomed, and follows a meandering course.

From the headwaters to Cherry Creek Lake, the basin area is approximately 74 percent open space (park, vacant and agricultural areas), 23 percent residential and 3 percent commercial and industrial (USGS, 1983).

The reach of Cherry Creek studied in this report lies between the Arapahoe-Douglas County Line and Arapahoe Road, for a total distance of 2.20 miles along the valley. Figure-1 shows the total drainage area of Cherry Creek and the location of the study reach.

2. Climate

The Cherry Creek basin climate is semi-arid. Warm summers and mild to cold winters occur. Intense thunderstorm rainfall, sometimes of cloudburst intensity, occurs during the summer months.

3. Dams and Reservoirs

No major flood protection structures exist in the Cherry Creek basin upstream of the study area. The Soil Conservation Service has completed construction of 32 floodwater retarding structures as part of the "Franktown-Parker Tributaries of Cherry Creek Watershed" and "West Cherry Creek Watershed" projects. The structures were constructed for design floods having a 25-year recurrence interval. These reservoirs generally affect only the normal flow on Cherry Creek and offer limited flood protection downstream of the dams. The dams have little or no effect on major floods in Cherry Creek at Arapahoe Road.

The Cherry Creek Dam was completed in 1953. This dam and reservoir controls the runoff from the 386 square miles of high plains catchment. The total storage capacity in the lake behind the dam is 228,400 acre-feet. The flood control storage is 70,960 acre-feet, the multi-purpose storage is 13,960 acre-feet and the surcharge storage is 134,500 acre-feet (Corps of Engineers, 1974). Water was first stored in the lake in 1957.

4. Streamflow

A summary of available stream gaging records for Cherry Creek near Melvin is presented in the following paragraphs. In general, most of the disastrous floods in the Cherry Creek basin have been caused by intense thunderstorm rainfall. Snowmelt augmented by general spring rains can also produce serious

flooding due to the high volume of runoff associated with this type of event. However, the threat to human life is minimal because of the long lead time available for dissemination of flood warning information.

(a) Annual Streamflow

Annual streamflow measurements have been made at the U.S. Geological Survey's streamgaging station in the Cherry Creek near Melvin starting in 1939 and discontinued in 1969. The gage was located one mile downstream from Arapahoe Road until October 1960 and moved to Araphaoe Road thereafter. These annual flows are plotted in Figure-4. The average for the 30-year period of record is 11.8 cubic feet per second. The largest annual streamflow was in 1942 when the average for the year was 51.5 cubic feet per second. The lowest was 1954 with only 0.62 cubic feet per second.

The mean annual streamflow record is not homogeneous. Prior to 1950, streamflow was much larger. From 1940 to 1949, the annual mean was 22.6 cubic feet per second. Thereafter, the mean dropped to 6.33 cubic feet per second, only 28 percent of that of the prior 10 years.

(b) Monthly Streamflow

The average monthly streamflow in the Cherry Creek near Melvin for the period 1939 to 1969 is as follows:

AVERAGE MONTHLY STREAMFLOW

(UNITS ARE FT^3/S AND % OF ANNUAL)

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
2.98	3.49	3.14	3.73	14.7	29.7	20.2	17.6	13.7	11.5	18.8	2.55	11.8
2.1	2.4	2.3	2.7	9.6	21.3	14.0	12.6	9.5	8.2	13.5	1.8	100.0%

March has the most streamflow on the average. The highest monthly streamflow was in April 1942, for which the average was 204 cubic feet per second. The lowest monthly streamflow was zero in many months in many years. The averages for all months are ploted in Figure-4.

5. Floods

Historically, the principal cause of flooding within the drainage basin of the Cherry Creek has been intense thunderstorms during the late spring and summer months. Runoff from melting snow does not contribute to major flooding because the altitude of the catchment is low. During the period from May to August, warm moist air from the Gulf of Mexico combines with cool dry air along the eastern plains causing a deflection upward where the unstable air is cooled and precipitates over the front range. These storms are characterized by high rainfall intensities of short duration which produce high peak flows and moderate volumes of water. The largest floods occur when severe thunderstorms pass over areas previously saturated by rain.

The history of flooding along Cherry Creek dates back to Indian accounts of debris left by the retreating waters in the top of cottonwoods on the banks of the harmless looking gulles. The earliest recorded flood occurred in May 1864, five years after Denver was settled. Other major floods have occurred in May 1876, May 1878, July 1885, July 1912, July 1922, August 1933, July 1946, June 1965 and May 1973.

The annual peak flood record for Cherry Creek at Melvin is shown in Figure-4. The June, 1965 flood is the largest flood to have occurred in the Cherry Creek basin this century. On the 16th of June, 1965, a major storm centered over the Plum Creek and Cherry Creek basins produced rainfall up to 10 inches in a 3 hour period. The recorded flows along the upper Cherry Creek basin included 1,000 cubic feet per second upstream of Franktown, 39,000 cubic feet per second near Melvin and 58,000 cubic feet per second at Cherry Creek Dam. The heavy runoff caused major flooding along the main stem of Cherry Creek from the vicinity of Franktown to Cherry Creek Reservoir. About 2,720 acres was reportedly flooded. Most of the bridges across Cherry Creek were damaged or destroyed. Flood damages totaled $1,306,000 (Reference-2).

The flood frequency curves for annual peak discharges and for the partial duration series for Cherry Creek at Arapahoe Road are shown in Figure-4. The expected value of the 100-year flood is 49,490 cubic feet per second according

to the extrapolation of the partial duration series. The annual series differs from the partial duration series as shown in the figure.

6. New Records

On the 8th of June, 1982, the Melvin gage was reactivated (Gibbs et.al., 1983). The gage is located approximately 30 feet upstream from Arapahoe Road. Data collected consists of storm runoff, water quality, stream discharge (determined from current meter measurements, estimates, and previous ratings), precipitation, and sub-basin characteristics. The 1983 records are not yet published.

B. Sediment Transport

1. Bed Materials

Samples of sediment were taken from the active portion of the bed of Cherry Creek at these four locations:

a. Crossing of the parks recreation road around Cherry Creek Lake.

b. Crossing of Arapahoe Road.

c. Southwest quarter of Section 32, Township 5 South, Range 67 West.

d. Crossing of West Parker Road.

The samples were taken from the surface of the bed at four places in the cross section. Equal volumes of the four samples were then combined into one, representing the entire cross section.

In the study reach, the bed material is medium sand with a median sieve size of 0.6 millimeters. The gradation coefficient is 2.3. The results of the sieve analysis is shown in Figure-5. There is no significant difference in the

sizes of the samples taken at the four locations listed above. All samples contain less than 2 percent gravel or silt and clay.

2. Bank Materials

The soils in the Cherry Creek valley in Arapahoe County were surveyed by the U.S. Department of Agriculture, Soil Conservation Service (Larson and Brown, 1971). Their maps indicate that in the study reach, the bank materials are mostly sandy and loamy alluvial soils. At the sharp bend immediately upstream from Arapahoe Road, Cherry Creek cuts into a high terrace escarpment composed of deep stratified calcareous clay and sand.

In other locations, the stream is cutting laterally into the Nunn loam terraces of eolean and alluvial deposits generally grading coarse in the downward direction.

The terrace soils are usually more resistant to erosion than the newer alluvial soils. The sandy alluvial lands are mostly on the inside of bends and are the most recent alluvial deposits.

3. Suspended Sediment

Numerous suspended sediment measurements were taken in Cherry Creek by the Denver District of the U.S. Army Corps of Engineers in the period between 1941 and 1951 (Stevens, 1983). Thereafter, the Denver District was disbanded and the measuring program ceased. The records of these measurements are in the archives of the Corps and are not readily available.

At the Melvin streamgaging station at Arapahoe Road, 1,083 suspended sediment observations were made from July 1941 to October 1951. The catchment area upstream from the gage is 336 square miles. A minimum of one sample per week was taken. During changing stage, supplemental observations were made. The Corps of Engineers (Stevens, 1983) has computed the suspended sediment load of Cherry Creek at Melvin to be 722 tons per square mile per year for the period 1942 to 1948.

$600 \frac{T}{mi^2} \times 336 mi^2 \times 2000 \frac{lbs}{T} \times \frac{1}{60 lbs/ft^3} \times \frac{1}{43560 ft^3/AF} = 154 AF/YR$

$\frac{3035 AF}{17.4} = 174 AF/YR$

60 pcf = 1.03 lbs/F

174 - 154 = 20 AF/YR

4. Sediment Yield

Sediment yield is greater than the suspended sediment load by an amount equal to the bedload transport. Almost all of the sediment derived from the Cherry Creek catchment is stored in the lake behind Cherry Creek Dam. The Corps of Engineers has measured these deposits to be 3035 acre-feet in volume deposited in 17.4 years (Stevens, 1983). A large portion of this sediment came with the June 1965 flood which also contributed an immense quantity of trees and driftwood which was subsequently burned and burried. The volume of sediment is equivalent to a sediment yield of approximately 600 tons per square mile per year. The measured dry unit weight of the deposits is 60 pounds per cubic foot.

For the purpose of this study, it is assumed that the sediment yield is 600 tons per square mile per year and that the amount of sediment being deposited in and immediately upstream from the Cherry Creek lake is 175 acre-feet per year (Ref. 4). Most of this is probably sand.

$175 \frac{AF}{YR} \times \frac{43560 ft^2}{Ac} \times 60 lbs/ft^3 \times 2000 lbs/T \times \frac{1}{336 mi^2} = 680 T/mi^2/YR$

C. Fluvial Morphology

The morphology of Cherry Creek in the alluvial section upstream from Cherry Creek reservoir is the result of the water and sediment supplied to the reach and the backwater influence on the Cherry Creek dam. At the present time, the influence of the dam has not reached upstream as far as Arapahoe Road.

1. General Plan

The study reach of Cherry Creek is from the County Line to Arapahoe Road. The plan view is shown in Figure-3. The location of the riverbed was traced from the 1-inch equals 400-feet scale aerial photograph taken in October, 1983.

The river meanders through its own alluvium and terraces on a valley floor with an average width of approximately two-thirds of a mile.

There is one sizable tributary, Happy Canyon Creek, which enters Cherry Creek about midway in the study reach. On the October 1983 aerial photograph, the channel of this left bank tributary is shown where it crosses the floodplain of Cherry Creek. Also, where the tributary had previously entered Cherry Creek, there was a head cut working its way back up the channel fill. The former bed profile of Happy Canyon Creek is shown on the 1977 Flood Hazard Area Delineation Map (Howard, Needles, Tammen and Bergendorf, 1977).

From County Line to Arapahoe Road, the low-flow channel of Cherry Creek is 3.3 miles long. The valley length is 2.2 miles making the sinuosity 1.5. There are 13 bends of various shapes. These are described in detail later in this report.

0.0026

2. Profile

The profile of the thalweg and banks of Cherry Creek in the study reach are shown in Figure-6. The thalweg elevations were obtained from the 1983 1-foot and 2-foot contour topographic maps. The river bend drops 64 feet in its 3.3 mile meander length making the average slope 19.4 feet per mile. At Arapahoe Road, the riverbed elevation is 5631 feet above mean sea level. Locally, there are flatter and steeper reaches.

Another 1.6 miles downstream, Cherry Creek meanders into Cherry Creek Lake with a maximum flood pool elevation of 5596 feet. The normal pool level is 5548 feet which is maintained for recreational purposes.

The Cherry Creek Lake creates a backwater effect on flow in Cherry Creek upstream. The effect is to decrease the velocity of the flow and results in the deposit of sediment on the streambed. The July 1978 aerial photograph indicates deposits had not yet occurred beyond the maximum pool elevation. According to the vegetation pattern on the photograph, deposits extended upstream 1.4 miles from the normal pool level. The valley distance from Arapahoe Road to the normal pool level at the delta is 3.2 miles.

3. Bankfull Width

The bankfull width of Cherry Creek in the study reach is approximately 450 feet. However, this dimension varies greatly from 150 feet in Bend No. 5 (see Figure-3) to 1000 feet in the region of Bend No. 4. The bankfull width is the width of the water surface, normal to the direction of flow, immediately before the river begins to spill over its banks. In the upstream portion of the study reach, there are appreciable shrubs and trees in the bankfull width. (See Figure 14 for definition of terms).

4. Active Bed Width

The active bed is that portion of the riverbed which transports bed load during floods and is not covered with herbaceous (leafy) vegetation. In the study reach, the active bed width is approximately 230 feet but varies from 150 to 450 feet.

5. Bankfull Depth

Most of the banks of Cherry Creek are terraces. Where the banks are recent alluvium, the bank height is on the order of 3 to 5 feet high. In the entire study reach, the average bank height is approximately 7 feet, ranging from 3 to 13 feet. The highest bank heights are along the terrraces.

6. Width-to-Depth Ratio

For the active bed, the width-to-depth ratio is 33. Using bankfull width, the ratio increases to 64.

7. Bends

As shown in Figure-3, there are 13 bends in the study reach. The curvature and deflection angle of each have been estimated from the October 1983 aerial photograph. The data are summarized below.

PLANFORM OF BENDS

BEND NO.*	RADIUS OF CURVATURE (FT)	DEFLECTION ANGLE (DEG.)	MATERIAL ON CONCAVE BANK
1	440	135	Terrace
2	540	95	Floodplain
3	400	80	Terrace
4	440	125	Terrace, Floodplain
5	640	50	Terrace, Floodplain
6	370	90	Terrace
7	290	100	Terrace
8	580	110	Floodplain
9	800	60	Terrace
10	1,130	50	Floodplain
11	2,530	35	Floodplain
12	330	135	High Terrace
13	1,630	60	Bridge, Terrace

NOTES:
1. Bend numbers are shown in Figure-3
2. Deflection angles have been rounded to the nearest 5 degrees.

Bends with small radii of curvature and large deflection angles have chutes. Bends with large radii of curvature and small deflection angles have very small or no point bars. Bends eroding into recent floodplain material, mainly sand, migrate rapidly downstream. The two most upstream bends are this type. Bends with concave (outside) banks in older floodplain alluvium erode more slowly. Terrace materials erode more slowly than floodplain materials. Bankline movements are illustrated in Figure-3 and are described in the next section.

8. River Alignment

The planform of the active bed in 1937 and 1983 are compared in Figure-3. These were obtained from aerial photographs taken in July, 1937 and October, 1983. The prints are with scale of 1 inch = 400 feet, approximately. The main features are:

1. Bends No. 1, 2, and 3 have migrated downstream distances of approximately 1100, 500, and 1200 feet, respectively. The river can move rapidly here because it is cutting into low banks of sand.

2. The crossing from Bend No. 3 to No. 4 has remained essentially unchanged. The river has widened slightly here.

3. Bend No. 4 has migrated laterally (west) approximately 350 feet.

4. The concave (outside) banks of Bends No. 5, 6, and 7 were heavily treed in 1937. The first did not move appreciably. The latter eroded approximately 50 feet on the concave bank.

5. The river made a chute cutoff at Bend No. 8 sometime between August, 1971 and July, 1978. Prior to 1971, the bend had been migrating downstream.

6. The concave bank of Bend No. 9 moved laterally (west) approximately 150 feet.

7. The river at Bends No. 10 and 11 decreased in width. Both the concave and convex banks moved towards the centerline

8. Bend No. 12 did not migrate appreciably as it is cutting into the high terrace composed of tough material.

9. Bend No. 13 migrated laterally approximately 100 feet, all or most of that prior to the construction of Arapahoe Road and its bridge.

10. There are 2 linear anomolies on the bankline on the 1983 photographs. These are downstream from Bends No. 7 and 9 where the banks are parallel to the property lines.

Aerial photographs taken on the 15th of October, 1964 were compared to those taken on the 10th of August, 1971 to assess the impact of the June, 1965 flood on bend migration. In this period of time, the following occurred.

a. Bend No. 1 moved downstream and widened.

b. A chute opened up in Bend No. 4 but the concave bank moved very little.

c. Bend No. 8 moved downstream two-thirds of a channel width.

d. The remaining 10 bends were essentially unchanged in this 7 year period.

The conclusion is that the largest flood in the period of record did not cause appreciable movement of the river in the study reach.

9. Vertical Stability

The records of the discharge measurements taken in Cherry Creek near Melvin were examined to determine whether the streambed is aggrading, degrading, or remaining fixed with respect to time. The rating curves prepared by the USGS from the measurements are shown in Figure-5.

Prior to the 1st of October, 1960, the streamgage was located at a site one mile downstream from Arapahoe Road. The gage datum (elevation of the zero point on the water level gage) was 5608.21 feet above mean sea level. According to the rating curves, the zero flow level at this site varied from elevation 5608.7 to 5610.4 feet; that is, the bend could have changed approximately 1.7 feet in elevation. These changes did not correlate with the annual streamflow or with peak floods.

From October, 1960 to June, 1965, the zero flow level for the site on the right bank on the downstream side of Arapahoe Road was at elevation 5628.5 feet above mean sea level. The flood of June, 1965 degraded the bed of Cherry Creek downstream from Arapahoe Road so that the zero flow level dropped 2.7 feet to elevation 5625.8. Thereafter, the bed aggraded approximately 0.3 feet to elevation 5626.1 feet and remained that way until the gage was discontinued in 1969.

In 1983, the bed level at the bridge was elevation 5631.0 feet indicating that since 1964, the streambed had risen 2.5 feet and since 1965, 4.9 feet.

According to the USGS topographic map (10-foot contour interval), the riverbed elevation at Arapahoe Road was 5632 feet in 1964. This value is 3.5 feet higher than indicated by the streamgage records, which could be accounted for by the accuracy of interpolation.

Using the map records, the conclusion is that the streambed has degraded 1-foot between 1964 and 1983. Using the streamgage records, the conclusion is that the streambed has aggraded 2.5 feet in the same period. The streamgage records were considered to be more accurate and were used to develop general trends for Cherry Creek.

D. Expected Changes

1. Effects on Urbanization on Hydrology

As reported above, the Melvin gage was reactiviated in 1982. These meaurements will enable one to assess the long term impacts of the upstream development, but data must be collected for at least a period of 10 years or more. Howerver, some estimates of the impact can be made, based on previous hydrological analysis.

As development occurs in the basin and additional farm land is removed from the land use, the base flows are expected to increase, possibly increasing the annual streamflow. Certain sub-basins tributary to Cherry Creek will develop more than others which could result in higher annual peak discharge values from the localized storms that do not cover the entire basin.

The development projections for the basin by DRCOG (Reference-17) are presented below.

Year	% Imperviousness
1985	13
1990	16
2000	19
2010	23

By the year 2010, the percent imperviousness will increase by 77%, mostly in the lower reaches of the basin. Assuming no regional runoff controls are required, this development could result in a significant increase of the low to moderate floods (i.e. 2 year to 10 year) generated by more localized storms centered over the lower portions of the basin. The increase in the major floods will be highly dependent on the nature of the storm. If the storm were to track from the upper basin to the lower basin, very significant increase in flooding would result, otherwise only small increases in flooding would be experienced.

2. Effects of Urbanization on Sediment Transport

Urbanization can effect the sediment transport in two ways. First, urbanization can increase base flows in the creek (assuming additional diversions from the system do not take place) or increase the low to intermediate flood peaks as discussed in the previous section. These flow increases can carry a greater total sediment load. The source of the materials would be the unprotected or unstable bed and bank areas. If the main channel areas are protected as recommended herein, then the changes in the sediment transport through this reach are expected to be minimal.

Secondly, urbanization can increase the surface erosion contribution to the sediment by stripping of the land during construction, which can be a major contribution to the sediment in the creek. Both Arapahoe County and Douglas County have proposed strict control of the erosion and sedimentation occuring during construction in the draft Storm Drainage Design and Technical Criteria. If approved and administered, these requirements will substantially reduce this source of sediment to Cherry Creek. In either case, the removal of sediment from the creek has been included in the annual maintenance requirements as discussed in Section V-C.

IV. ALTERNATIVE INVESTIGATION

IV. ALTERNATIVE INVESTIGATION

A. General Description

Based upon an analysis of the floodplain and the sediment transport regime, the existing and potential future drainage problems for Cherry Creek were assessed. Various alternatives were devised to address each problem area or channel reach. These alternatives were reviewed at a meeting with the TAC and property owners to eliminate those options which were not considered viable alternatives. The CONSULTANT then assembled the viable alternatives together to form alternative plans. These plans were also presented to the TAC and property owners along with a discussion of the pro's and con's of each plan. Afterwords, individual meetings were held with the property owners to determine which plan best suits their needs. The final plan as presented in this report is called the selected plan.

Presented in this section are the details and procedures for developing the selected plan.

B. Constraints and Impacts

The first step in developing alternatives for the drainage problems was to identify the constraints imposed on the alternatives by the various physical features. The constraints identified were the sediment transport, the river morphology, the existing and proposed water wells, the alignment of the future Dry Creek Road crossing, and the existing sanitary sewer.

As discussed in Chapter III, Cherry Creek transports an appreciable amount of sediment within the local South Platte River system. Any changes to Cherry Creek will effect the sediment load and therefore erosion and sedimentation of the channel. For instance, if the flow velocities are increased, additional erosion is possible unless the banks are protected. However, if the source of sediment is reduced then the river will make up for this loss of sediment by eroding the downstream channel. If the flow velocities are decreased, then

deposition would occur locally, and erosion would occur downstream. In some instances, the changes in the sediment transport are minor, allowing for improvements to the channel without significant local or offsite impact. In general, the creek will continue to move horizontally unless restrained by revetments or natural soils conditions. Also, the creek bed is subject to high local scour and deposition which dictates the need for adequate maintenance for proposed improvements along the banks.

The alignment of Cherry Creek is determined in part by the local soils and geology and the past flood history. A review of the aerial photographs shows areas of movements in the past (see Figure-3). Near the Douglas County Line (Reach B), Cherry Creek has changed significantly. However, closer to Arapahoe Road, the alignment has remained essentially the same in the last 40 years. This lack of movement is due to the more erosive resistant soils in this reach (Reach A). The potential for movement described above illustrates the need to control the channel alignment in some areas, especially if development encroaches (i.e., fill) into the floodplain.

Shown on Figure-2 is the location of the existing and proposed water wells and the sanitary sewer. The impact of any proposed improvements to the creek on these facilities has been addressed. In some cases, the impact was significant to impose a constraint on the alternatives. The impact of the wells on the selected plan is discussed further in Chapter V-E.

C. Alternative Categories

All the alternatives developed address either the stabilization of the channel or increased land utilization.

1. Stable Creek Bed

The alternatives developed to stabilize the Cherry Creek bed are presented below.

"A" - Meander Belt (Figure-7): This alternative is the "status quo" or "do nothing" alternative. The channel is allowed to move within its historic meander belt as defined by the aerial photographs, soils information, and field observations (see Figure-3). This alternative is the least costly but would require adjustment to the floodway area, since the channel could move outside the floodway in certain areas, which essentially relocates the floodway.

"B" - Stabilize Existing Alignment (Figure-8): This alternative uses revetment (i.e., riprap) to protect and stabilize the critical or outside banks of the channel. Since the channel is unstable in certain areas, a substantial or heavy revetment would be required to maintain the existing alignment. This alternative allows full use of the 1/2-foot floodway.

"C" - Construct Stable Alignment (Figure 9): This alternative reconstructs a channel with more stable geometry (i.e., degree of curvature, radius, and distance between curves). The advantage of this approach is that a lesser degree of protection (revetment) is required for the outside bends and the channel would have better flood conveyance. The cost of the excavation work would determine if this alternative would be less costly then alternative "B". A disadvantage of this alternative is the steeper bed profile, which would have some offsite effects of sediment deposition and onsite erosion.

2. Increased Land Utilization

The alternatives developed to increase the land utilization are as follows:

"D" - Flood Fringe Filling (1/2-foot floodway): This alternative uses the typical floodplain management approach of leaving a floodway (the channel and the floodplain area required for the safe passage of the 100-year flood) and reclaiming the fringe of the floodplain by filling with earth. The Arapahoe County floodplain regulations require that the filling of the floodplain fringe does not increase the 100-year water surface by more than 1/2-foot. This alternative has relatively low cost, but does not reclaim a substantial amount of property, relative to other alternatives. The area reclaimed with this approach is presented in Table-1.

"E" - Flood Fringe Filling (1-foot floodway): This alternative is essentially the same as alternative "D" except that the water surface is allowed to raise 1 foot, which is the present FEMA policy. This alternative would reclaim more land than alternative "D", but would require special approval from Arapahoe County. In either case, the floodway must transition into the floodplain at the upstream end of the project area, since the floodway would impact the Cottonwood Development, which is immediately upstream.

"F" - Arapahoe Road Bridge Enlargement: Several increased span widths were investigated for Arapahoe Road bridge (from 50 feet to 200 feet) to determine the full impact of the bridge backwater. The 200-foot increased span would lower the 100-year water surface for a distance of approximately 200 to 300 feet upstream of the bridge. This was considered to be an insignificant benefit and the alternative was not considered further.

"G" - Arapahoe Road Bridge Replacement: This alternative required the replacement of the existing bridge to span the 100-year floodplain, approximately 700 to 800 feet wide. Also required was channelization upstream and downstream of Arapahoe Road to transition the channel and obtain the maximum reduction in flooded property. A conservative estimate for the bridge construction alone was placed at four million dollars, and the alternative was not considered further for this reason.

"H" - Excavation to Contain Flood: There are two approaches to channelization for Cherry Creek that were found to be satisfactory. One approach (alternate #1) excavates a trapezoidal section outside the existing main channel area (see Figure-14 for definition of terms). The excavation would take place at approximately the depth in the main channel which carries the 10 year flood, (i.e. the bankfull depth). This approach results in a floodplain/floodway width of around 800 to 900 feet.

The second approach (alternate #2) consists of a cross section which has a larger main channel in generally the same location as the existing channel and an "overbank excavation" area to accomodate larger floods. The main channel cross section for this option was developed using the results of the fluvial

morphology work presented in Section III-C. The section is comprised of a 230 feet wide main channel area approximately 4 to 5 feet deep and a total floodplain/floodway width of around 700 feet and 9 feet deep. The main channel configuration aproximates the existing shape that nature has preferred in the project area, and has a capacity around the 10-year flood.

A third approach, consisting of a simple trapezoidal section was also investigated. This option was not found to be acceptable due to the potentially unstable hydraulic conditions which resulted in supercritical flow and standing waves. To resolve this instability problem, a flatter channel grade and a check structure was required. However, the flatter grade changed the sediment transport characteristics of the creek, which would deposit large amounts of sediment in the channel area. This condition was considered undesireable due the maintenance, flood control, and cost factors therefore this option was not recommended.

"K" - Levees to Contain Flood: This alternative consists of constructing berms or levees along the channel bank to contain the 100-year flood. The levees, however, create local flood problems and require special approval by the County, the Urban Drainage and Flood Control District (UD&FCD), and FEMA and therefore were not investigated further.

3. Evaluation of Channelization Alternative

Because of the potential benefits of channelization for reclaiming floodplain property, a detailed analysis of the hydraulic and sedimentation conditions was performed. The analysis included an investigation of the effects of channelization on roughness, flow stability, history of creek bed movement, and definition of the floodplain.

To determine the appropriate roughness factor (Mannings n-value) for the HEC-2 analysis, calculations were performed using the methods described in Reference-11 and the grain size data obtained for the sedimentation analysis (Chapter III). The calculated n-values ranged from 0.013 to 0.015. After review of the assumptions and adjustment for velocity and depth of flow, the n-value of 0.20 was considered appropriate for the main channel area and 0.025

for the overbank areas to analyze flow stability. For capacity purposes, the values of 0.040 and 0.065 were used.

Further analysis of the history of Cherry Creek and the floodplain revealed three important factors. First, a review of the aerial photographs showed that the largest flood (i.e., June, 1965) had only minor effect on the horizontal alignment of the channel. Most of the horizontal movement probably occurred at intermediate flows. Flow instability is more of a concern in the main channel area than in the overbank area. This factor was confirmed by the field measurements of past floods. The highest bankfull measurement was 4000 cfs with an average velocity of 12 fps. The Froude Number was estimated to be in the transitional range (i.e., $0.8 < Fr < 1.2$). To maintain a fixed alignment at bankfull discharges, the main channel would be excavated to more closely match the average active bed width (i.e., 230 feet) and the banks would be protected by revetment where required.

The second factor was that the bed elevation changed considerably in local areas during major floods (i.e., degraded approximately 2.7 feet at Arapahoe Road during the 1965 flood). This would increase the depth of flow during the flood and therefore decrease the instability of the flow since the Froude Number is inversely proportional to the depth. The bed level subsequently rose due to the deposition of materials carried by lesser flows.

Thirdly, a detailed analysis of the currently defined 100-year floodplain (Greiner, 1984) revealed that the flow conditions are really two separate, hydraulically disconnected flood profiles for Reach A only. When modelled using HEC-2 (a quaisi-two dimensional analysis) to more closely match the actual flow conditions, the 100-year water surface profile in the main channel was found to be generally higher than previously predicted. Also considerably less flow was found to be in the right (east) overbank area. The analysis was performed using both the high and low n-values to determine the worst conditions.

Using the above findings, the preliminary design approach for overbank channelization with improvements to the main channel was revised from that previously discussed at the progress meetings for the project. Channel improvements were considered which shaped the main channel to more closely match the average active bed width for Cherry Creek or left the main channel in essentially the present condition, and excavated the overbank area to provide additional capacity. Both configurations were evaluated in detail and recommended for portions of the study area.

The proposed channel for Reach A more closely matches the existing channel and therefore the sedimentation and erosion characteristics are similar to the present conditions and will have minimal impact on downstream property owners. Since the unstable flow conditions are in the main channel, the channel banks must be protected at the critical location. Whereas an unprotected artificial channel would not be as stable as the natural channel, a program of regular maintenance combined with bank protection at the critical areas will address this concern.

The channelization recommended for portions of Reach B included excavation for the overbank area and revetments for the existing bends in the main channel. By leaving the main channel in its historic configuration, the changes in the sedimentation characteristics are minimal for low to intermediate flows (up to the 10-year flood). For larger floods, the increased overbank depths and removal of existing vegetation increases the potential for erosion. To minimize this potential, the overbank areas must be revegetated in accordance with the program outlined in Section V-F.

D. Alternative Plan Selection

After the alternatives presented in Section IV-C were reviewed by the TAC and the property owners, the CONSULTANT then assembled the alternatives into several plans for further consideration. The effects of each plan on the sediment transport (and therefore maintenance requirements and offsite impacts) were evaluated along with the relative capital costs. These plans were then graphically illustrated and presented at a joint meeting of the TAC and the property owners. A summary of the alternative plans is presented in Table-2.

Subsequent to the general presentation of the alternative plans, individual meetings were held between the primary effected property owners to discuss the plans further. Based upon the meetings, a selected plan was assembled, which is illustrated in Figure-10. A preliminary design was then prepared for the selected alternative plan (see Chapter V).

V. PRELIMINARY DESIGN OF SELECTED ALTERNATIVE

V. PRELIMINARY DESIGN OF SELECTED ALTERNATIVE

A. Description

The total study reach was subdivided into two sub-reaches, A and B, which generally coincides with the historic meandering area of the main channel (see Figure-7). Reach A begins at Arapahoe Road and extends approximately 6,800 lf upstream along the channel bed. Reach A includes the Aurora, Eagle Creek Assoc., Viehmann-Martin, Cherry Creek Business Center and a portion of the River Run properties (see Figure-2). Reach B extends, from the upstream limits of Reach A to the Douglas County line, a distance of approximately 10,600 LF. This reach includes the remaining portions of River Run, the Tagawa Rose Farm, the Dransfeldt, the Ashbrook and the Hutkin Ltd. properties.

A schematic drawing of the selected alternative plan is shown in Figure-10. The elements of the plan are summarized in the table below.

SUMMARY OF SELECTED ALTERNATIVE PLAN

REACH	DISTANCE UPSTREAM FROM ARAPAHOE RD	AFFECTED PROPERTY OWNERS	DESCRIPTION
A	0 to 6,800 feet	East Arapahoe Aurora Viehman Martin Cherry Creek Business Center River Run	Overbank channelization, main channel widening, and filling to 1/2 foot floodway
B	6,800 to 10,200	River Run Ashbrook Tagawa Dransfeldt	Overbank channelization, revetments for existing channel area, and filling to 1/2 foot floodway
B	10,200 to 17,400	Dransfeldt Tagawa Hutkin	Stabilization of existing channel with revetments and filling to 1/2-foot floodway

Plan, profile, cross sections, and detail drawings have been prepared for the preliminary design of the selected alternative and are presented in Appendix-D to this report.

As an option to the recommendation for Reach A, the excavation on the Aurora property could be deleted (partial channelization) as shown by the quasi-two dimensional analysis performed for the channelization alternative (Section IV-C-3). If this option is to be pursued, a full two-dimensional analysis should first be performed and then reviewed by the UDFCD and FEMA to obtain conceptual approval. The analysis should include a comparison of water surfaces between the partial channelization and the two dimensional analysis. If the differences are acceptable and the two dimensional analysis is accepted by FEMA and the UDFCD, then the partial channelization can be incorporated into the master plan, subject to approval by the Parker Jordan Metro District and other jurisdictional agencies.

B. Design and Construction

The criteria for preliminary design was obtained from the Urban Storm Drainage Criteria Manual (Reference-10), U.S. Army Corps of Engineers (Reference-8), and work by Dr. Michael A. Stevens (Reference-4 and recommendations made for this study). The USDCM was used for riprap size and gradation, bedding requirements, and layer thickness. The configuration for heavy revetments was obtained from the CORP report. The requirements for heavy or light revetments was based in part on historic trends of the creek and the measure of alignment stability for the South Platte River recommended by Dr. Stevens. The criteria for limiting velocities was to compare the Froude number of the recommended channel configuration to that for the present channel configuration. Where the Foude numbers were higher, heavy revetments were recommended. In most cases, the overbank velocities before and after improvements are in excess of 7 fps and revegetation of the overbank area will be required.

1. Stable Creek Channel

A centerline alignment was established from the existing Cherry Creek channel. The alignment is presented in Table-3 for the radius, the deflection angle (delta), the bend length, and the distance between two bends (crossing length). Next the creek bed width was measured at several locations to obtain the average active bed width of 230 feet (see Figure-14). The average measurements reflect natures preference for a certain width.

The data in Table-3 was then compared to the recommended stable alignment for the South Platte River (Reference-4). Whereas the flow regime and sediment transport for the South Platte River is different than Cherry Creek, the comparison does provide an indication as to the stability of the existing alignment for Cherry Creek. Using this approach, bends 2, 3, 4 & 5 were considered relatively stable and therefore only require "light revetment." All remaining bends were designed for heavy revetment in accordance with the work by the Corps of Engineers (Reference-8). Minor excavation of the creek bed to the existing average bed width is also recommended for certain areas of Reach B. The creek bed width of 230 feet was used for the channelization in Reach A.The riprap requirements for both heavy and light revetments were obtained using procedures described above.

2. Channelization

The channelization for Reach A was designed using the Army Corps of Engineers backwater program HEC-2. Calculations were performed by Law Engineering and Testing Company (Reference-13 & -14) and incorporated into the design recommendations by the CONSULTANT.

The channelization for portions of Reach B were performed by the CONSULTANT. Floodplain elevations were computed for two main channel roughness coefficients, n=0.020 and n=0.040. The higher roughness coefficient was used to compare the floodplain elevations to the published natural conditions. If the increase in elevations was more than 1/2-foot, then the channelization was modified until this criteria was met. Comparison of the velocity head was also made for both roughness coefficients. If the velocity head increased by more

than 20% at the higher roughness coefficients, then the channelization was modified until the criteria was met. The higher velocity values for the lower roughness coefficient were used to identify area where vegetation requirements would be more critical.

3. Confluence Requirements

Throughout the Cherry Creek channel lateral flow enters the creek from many tributaries, the largest being Happy Canyon Creek. The recommendations for the confluence area protection are presented in Figure 15 and include both open channel and storm sewer tributaries. The riprap requirements assume an unprotected bank of Cherry Creek. If revetments are required, then revetments have priority in the detail.

There are different requirements for inside bends and crossing areas than for outside bends. For storm sewers at an inside bend or a crossing, the invert is set 18" above the invert of Cherry Creek to allow for deposition of sediment without effecting the pipe outlet. For outside bends the pipe is set at the invert of Cherry Creek. Also, the length of minimum riprap protection is greater for outside bends than for inside bends and crossings due to the greater erosion potential for outside bends.

4. Permitting Requirements

A Corp of Engineers 404 permit will be required since riprap and earth will be placed within the normal high water line of Cherry Creek in excess of 200 cubic yards. These materials are required in the construction of the revetments specified to stabilize the channel. However, the earth fill required to reclaim land within the floodplain to the limits of the 1/2 foot floodway does not require a 404 permit since the materials are not placed within the normal high water line. Either 4:1 sloped embankments and vegetation or revetments are recommended to protect the fill and subsequent development. The minimum fill requirements have been calculated for each property owner to reclaim the floodplain area. The fill quantities were allocated according to the "typical Cross Section" shown on drawing 5 in Appendix C.

A 401 State Water quality certification will be required from the State Health Department since the construction activities will introduce sediment into Cherry Creek.

C. Maintenance Requirements

The maintenance requirements for the channel will be approximately the same in Reach A (channelization) versus Reach B (channelization and stabilized channel).

The general maintenance requirements consists of trash and debris removal, riprap placement, sediment removal, trail and landscape maintenance. Artificial channel banks without revetments are not as stable as natural banks and a greater maintenance frequency may be required for the channelized Reach A. However, the major maintenance items are highly dependent on the hydrological conditions in the basin and only average needs can be defined.

The routine annual maintenace requirements are defined in Table 10. The details are defined in the footnotes and describe the basis for the estimated quantity and unity cost. Most of the items are straight forward and do not require further explanation. However, sediment removeal takes into account the total yield at Cherry Creek (600 tons/sq. mile/year), the main channel stabiziation recommendation herein, and on estimate of the deposition that might occur. Two areas were considered the most likely areas for sediment removal: the confluence of Happy Canyon Creek and at the Arapahoe Road Bridge. The area of deposition was estimated to be around 6 acres at a depth of 6 inches or 5000 cubic yards. Most of this sediment would occur during major floods, which generally do not occur annually. For this study, 1,000 cubic yards of sediment removal per year was estimated for maintenance budgetting.

The effort required for rehabilitation maintenance after a major flood is highly dependent on the flood frequency. Since the main channel area will essentially carry the 10-year flood, then an estimate of the maximum exposure is the cost of the channel stabilization, estimated at $3,300,000 for the entire reach. Provided the routine maintenance is performed, then a reasonable

estimate of the 10-year flood damage is around 5% of the maximum exposure, or $438,000.

An estimate of the maximum exposure for floods greater than the 10 year is the entire project area, including creek stabilization and the landscape/ recreational facilities. Since the amount of facilities which could be damaged is greater for major floods, then the damage is expected to be a higher percentage of the maximum exposure. A reasonable estimate is 10% or approximately $875,000.

D. Water Quality Impact

There are two aspects of water quality that are addressed: one deals with construction activities and the effect of the improvements after completion, and the other deals with non-point source pollution from urban runoff.

The selected plan will require a Corps of Engineers' 404 permit and a state water quality certification since the construction activities will effect the turbidity and sediment load in the creek. This impact will be limited, however, to the construction period, after which the turbidity will return to normal levels.

The other aspect of water quality is non-point source pollution from urban runoff. In August 1984, the Water Quality Control Commission (WQCC) set an in-lake total phosphorous standard for Cherry Creek Reservoir and directed DRCOG to use this standard in developing point and non-point control strategies as part of the Clean Water Plan Amendment. The revision to the Clean Water Plan is now in progress and the draft report for public review will be available by July 1985. The methodology recommended for urban runoff is either detention followed by sand filtration, or rapid infiltration alone, where the soils are suitable. The basin wide goal is 50% phosphorous removal on an annual basis. The details of the requirements will be published in the final Clean Water Plan under the direction the DRCOG, by July 31, 1985.

BMPs can be classified as either structural or non-structural. Structural controls are usually "effect-oriented" such as detention systems, whereas non-

structural controls are usually "cause-oriented" such as erosion control ordinances. Because non-point source pollution is varied in nature and impact, no individual BMP will fit all situations. The BMPs must be tailored to fit the needs of particular sources and circumstances. A cost-effective approach to controlling pollution from urban stormwater runoff is a combination of structural and non-structural control measures.

Whereas the control of non-point pollution from urbanization will not impose any direct requirements on the selected plan for Cherry Creek, the development within the district will be required to comply with the final adopted criteria.

BMP procedures for stream bank stabilization have not been well established at this time and will be determined during the permitting process.

E. Impact on Existing Wells

During the alternative investigation of channelization for the properties located upstream of Arapahoe Road, the potential impact on the existing wells in the area was identified. At the request of the CONSULTANT a proposal to investigate the wells was submitted by Bishop, Brogden and Rumph, Inc. to the TAC. The scope of services included the following items:

1. Analyze current ground water conditions in the alluvial aquifer.

2. Inventory wells completed in the alluvium including The City of Aurora Well field.

3. Analyze ground water conditions after the channelization is completed.

4. Determine the possible effect on the wells in the area.

5. Investigate and recommend solutions to mitigate the impacts of channelization.

The location of the existing wells in the area are shown in Figure-2 and on Drawings 1 to 4. Only those wells within the influence area of channelization were investigated as to the impact and solutions required. All wells, however, were used to obtain the groundwater conditions. The wells which are within the area of channelization are listed below.

NAME	PERMIT#	TYPE	DEPTH
AURORA WELL #5	3085F	ALLUVIAL	97 FT
MARDOCK WELL #1	RF770	ALLUVIAL	61 FT

A report was prepared and published (Reference-15) and a supplemental letter (Reference-16) was issued to discuss the selected channelization alternative. The results and conclusions of the analysis are as follows:

1. Based upon the current ground water elevations and the proposed elevation and location of the channel, the resulting change in the ground water table was estimated. The study revealed that there will be very little change in the water table as a result of the channelization as proposed. Therefore, the channelization will not adversely effect the capacity of the existing wells.

2. The 100-year flood level after channelization of Reach A will continue to encroach in the area of Aurora Well No. 5 and Murdock Well No. 1. The wells and associated equipment may be damaged by flooding. Three solutions were identified and costs to mitigate the potential impacts were estimated.

    a. The wells could be relocated and redrilled outside of the 100-year flood levels at a cost of $46,600 to $57,600 for Aurora Well No. 5 and $20,200 to $31,200 for Murdock Well No. 1. This estimate includes construction, engineering and legal costs. The relocation of the wells requires approval of the water courts and represents a substantial unknown in estimating the feasibility and cost.

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The alternative of not redrilling the wells and utilizing a modification of the well heads, motors and controls to be above the 100-year flood elevation (Alternate-A) is the least costly and has no impact on surrounding wells. However, exposed equipment may make this alternative undesirable. Relocating and redrilling the wells (Alternate-B) has some impact on the nearby wells and is the most costly alternative. The best alternative is considered to be the modification of the well heads to be watertight below the 100-year flood level and to equip the wells with submersible pumps (Alternate-C). This alternative has no impact on other wells in the area, does not require any water rights legal work, and there is no pumping equipment exposed to cold weather operation or potential vandalism. In addition, this alternative avoids the potential problem of relocating a well and not being able to devleop the same amount of well discharge from the aquifer. It is also reocmmended that a review of water level records for wells in the area be completed after the new channel is constructed. This monitoring program would help to confirm the estimates of the effect of the rechannelization on the alluvial ground water system.

F. Landscape/Recreation Aspects

1. Landscape Concept

This section describes the recreation and landscape concepts appropriate for the Cherry Creek floodplain within the 1/2 foot floodway limits. Land uses adjacent to the recreation corridor consists of residential development, a large regional retail center and business park development.

The intent of the recreation corridor is to provide an amenity corridor for adjacent development and to develop a link in a potential regional trail along Cherry Creek. This 700 to 900 foot wide corridor along the stream valley lends itself to landscape improvements that improve the visual quality and a variety of recreational opportunities.

A hierarchy of improvements is outlined in the following landscape zone approach. Briefly, the zone improvements define different density levels for proposed plantings, the intended character to be developed and other amenitites to be included. Beyond the substantial amount of proposed landscape improvements, the establishment of a pathway will provide for activities such as walking, cycling or cross country skiing. Picnic facilities and open spaces will allow for other recreational activities.

The landscape concept for Cherry Creek Basin is based on findings from field investigations, soil testing, identification of plant material, and existing and proposed site conditions. A zone approach was taken to prioritize site improvements and criteria.

The following landscape zone system defines the proposed character of each zone providing a variety of experiences from one zone to the next. Zone recommendations vary due to site constraints, plant selection, placement of vegetation masses and additional amenities. The proposed landscape zones are:

- Limited Zone
- Intermediate Zone

- Major Zone
- Buffer Zone
- Infill Zone
- Renewal Zone
- Preservation Zone
- Amenity Zone
- Activity Zone
- Slope Stabilization Zone

Each zone has a unique combination of degree of landscape openness defined by vegetation density and placement, canopy, referring to the effect of branching height on the overhead plane and amount of understory.

Extensive plantings will function to define the creek corridor, screen or frame off-site views, add color, texture and form variations. The recommended plant materials are aplicable for all zones. The plant selection is compolsed of native material and hardy, drought-tolerant introduced plants. Plants species were chosen with knowledge that they would receive little maintenance, that the soil texture ranging from sand to clay loam was suitable and that the area is within the floodway. The individual zone summaries specify plant types to be used.

The meandering path takes advantage of the varied character along the recreation corridor. Diversity is created through path alignment, a change in plant densitites and cluster size. Figure-12 illustrates the pedestrian bridge at Happy Canyon Creek that provides continued access along the west side of Cherry Creek. Access across Cherry Creek also occurs within this area to reach the activity zone on the east side. The park-like setting provides picnic areas and play fields for soccer, softball and a hard court play surface. Development along the creek corridor has convenient access to the recreational opportunities and amenities. As the path continues to meander upstream, Figure 11 depicts the features clustered to create an activity node. These include a picnic shelter sited to take advantage of views, play equipment and additonal picnic facilities along the creek. Table 7 summarizes the amount of acreage within each of the ten landscape zones.

2. Landscape Zone Descriptions

The overall landscape plan is shown in Figure-11. The zones are described in more detail below. A list of recommended plant materials is presented in Table 8.

A. Limited Zone

CHARACTER: Deciduous trees grouped in clusters of 3 or more at a density 14 trees per acre.

INTENT: Limit improvements to preserve the openness of the native grasses. Small clusters of high canopy trees will provide occasional height variation and shade.

Openness - Open
Canopy - High
Understory - Dense

B. Intermediate Zone

CHARACTER: Deciduous trees grouped in clusters of 6 or more at a density of 22 trees per acre to create spaces, provide accent, and variety.

INTENT: Locate vegetation masses along the pathway to create blind corners, direct views, and provide occasional shade. In open areas, locate vegetation masses randomly ranging from 10' to 35' of separation.

Openness - Open
Canopy - High
Understory - Dense

C. Major Zone

CHARACTER: Deciduous trees and shrubs in clusters of 9 or more at a density of 34 trees per acre and 100 shrubs per acre.

INTENT: Vegetation masses are to create focal points and provide greater diversity by varying the feeling of enclosure or openness. Along pathway, create opportunitities for stopping points. As distance from path increases, the distance between clusters should range from 15' to 20'.

Openness - Varies
Canopy - Medium
Understory - Dense

D. Renewal Zone

CHARACTER: Currently this area is primarily fallen dead vegetation requiring removal.

INTENT: Plant material is to be established such that a it matures it will reflect the character of the adjacent wooded area to the south. Reestablish zone with randomly placed deciduous trees of 2-3" caliber at a density of 34 trees per acre. Revegetation of understory with native grasses will also be necessary to restore intended character.

Openness - Semi-Open
Canopy - Medium
Understory - Low

E. Buffer Zone

CHARACTER: Mixture of deciduous trees and shrubs and evergreen trees in clusters of 12 or more at a density of 26 deciduous trees per acre, 16 evergreen trees per acre and 160 large deciduous

shrubs per acre.

Vegetation masses are to be dense random clusters of 15 or more separated by distances ranging from 5' to 20'.

INTENT: Group plant types in mixtures offering variations in height, color, texture and form. Locate clusters in a random staggard format creating some depth perception while screening off site views.

Openness - Dense
Canopy - Low
Understory - Dense

F. Infill Zone

CHARACTER: Deciduous bare root trees at a density of 26 trees per acre as infill planting. Removal of large dead plant material will be necessary.

INTENT: Additional plantings will insure continued growth as older vegetation begins to decline and to increase the density of younger established vegetation masses.

Openness - Semi-Open
Canopy - Med-High
Understory - Dense

G. Amenity Zone

CHARACTER: Mixture of ornamental trees and deciduous shrubs at a density of 36 trees per acre and 120 shrubs per acre.

INTENT: Ornamental trees are to be grouped in clusters of 5 or more on the edge and among existing vegetation to enhance the park-like setting and a distinct zone image. Shrubs should

be low growing under the trees and around picnic and bench locations to create a sense of space.

Locate a picnic shelter as focal point and a small area for a play structure. Additional picnic table pads and benches should be situated among the mature vegetation and areas offering good views.

Openness - Dense
Canopy - Low
Understory - Dense

H. Preservation Zone

CHARACTER: Disturbance of existing plant material or additional planting is not permitted.

Exception: Where path crosses through preservation area, any disturbed areas must be revegetated with similar materials.

INTENT: Encroachment of the wooded area is discouraged to allow the wildlife habitat and feeding areas to remain unchanged. The preservation zone just to the north of the amenity zone is being reserved as an informal open space.

Openness - Dense
Canopy - Medium
Understory - Low

I. Activity Zone

CHARACTER: Mixture of deciduous trees, shrubs and ornamental trees at a density of 31 deciduous trees per acre, 21 ornamental trees and 150 shrubs per acre, and irrigated turf in the field games area.

INTENT: Create a park-like setting on the east side of the creek corridor by clustering a mixture of plant types in groups of 15 or more separated by a distance ranging from 5' to 15'. Locate picnic table pads and benches to take advantage of views.

Plantings should be established 50 feet back of creek edge to avoid flood damage. This area closer to the creek is suited for a combination softball/soccer fields and a half court basketball play surface.

Openness - Dense
Canopy - Medium
Understory - Low

J. Slope Stabilization Zone

CHARACTER: Generally these zones are restricted and require special attention to establish the pathway on the side of the existing slope.

INTENT: Erosion control measures are necessary to contain the maximum allowable slope of 2:1. Options offering different desirable appearances for controlling erosion include:

1) hydroseeding and mulching with erosion control fabric,
2) erosion control netting with low growing shrubs planted at a density of 200 per 10,000 s.f.

Openness - Open
Canopy - None
Understory - Dense

G. Construction and Maintenance Costs

A detailed cost estimate of the improvements for the selected alternative plan was prepared by calculating quantities from the prelimniary design drawings. The costs were divided into the following categories:

1. Construction - capital costs to construct the facilities.

2. Contingency - 15% contingency was applied to the construction costs to account for unknown and variability of unit costs.

3. Admnistrative - costs for the District to administer the contracts and maintenance work. A value of 5% was applied to the construction costs.

4. Engineering and Construction Supervision - costs to design and inspect the construction - a value of 15% was applied to the construction costs.

5. Recreational Costs - costs for landscape and recreational facilities. A detailed quantity list and cost estimate for landscaping and recreational facilities is presented in Table-9.

6. Operation and Maintenance - annual costs to perform the tasks outlined in Section V-C and presented in Table 10.

A summary of the costs for the project are presented in Table-5, based upon the unit prices of Table-4.

V. PRELIMINARY DESIGN OF SELECTED ALTERNATIVE

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A. Description

The total study reach was subdivided into two sub-reaches, A and B, which generally coincides with the historic meandering area of the main channel (see Figure-7). Reach A begins at Arapahoe Road and extends approximately 6,800 lf upstream along the channel bed. Reach A includes the Aurora, Eagle Creek Assoc., Viehmann-Martin, Cherry Creek Business Center and a portion of the River Run properties (see Figure-2). Reach B extends, from the upstream limits of Reach A to the Douglas County line, a distance of approximately 10,600 LF. This reach includes the remaining portions of River Run, the Tagawa Rose Farm, the Dransfeldt, the Ashbrook and the Hutkin Ltd. properties.

A schematic drawing of the selected alternative plan is shown in Figure-10. The elements of the plan are summarized in the table below.

SUMMARY OF SELECTED ALTERNATIVE PLAN

REACH	DISTANCE UPSTREAM FROM ARAPAHOE RD	AFFECTED PROPERTY OWNERS	DESCRIPTION
A	0 to 6,800 feet	East Arapahoe Aurora Viehman Martin Cherry Creek Business Center River Run	Overbank channelization, main channel widening, and filling to 1/2 foot floodway
B	6,800 to 10,200	River Run Ashbrook Tagawa Dransfeldt	Overbank channelization, revetments for existing channel area, and filling to 1/2 foot floodway
B	10,200 to 17,400	Dransfeldt Tagawa Hutkin	Stabilization of existing channel with revetments and filling to 1/2-foot floodway

Plan, profile, cross sections, and detail drawings have been prepared for the preliminary design of the selected alternative and are presented in Appendix-D to this report.

As an option to the recommendation for Reach A, the excavation on the Aurora property could be deleted (partial channelization) as shown by the quasi-two dimensional analysis performed for the channelization alternative (Section IV-C-3). If this option is to be pursued, a full two-dimensional analysis should first be performed and then reviewed by the UDFCD and FEMA to obtain conceptual approval. The analysis should include a comparison of water surfaces between the partial channelization and the two dimensional analysis. If the differences are acceptable and the two dimensional analysis is accepted by FEMA and the UDFCD, then the partial channelization can be incorporated into the master plan, subject to approval by the Parker Jordan Metro District and other jurisdictional agencies.

B. Design and Construction

The criteria for preliminary design was obtained from the Urban Storm Drainage Criteria Manual (Reference-10), U.S. Army Corps of Engineers (Reference-8), and work by Dr. Michael A. Stevens (Reference-4 and recommendations made for this study). The USDCM was used for riprap size and gradation, bedding requirements, and layer thickness. The configuration for heavy revetments was obtained from the CORP report. The requirements for heavy or light revetments was based in part on historic trends of the creek and the measure of alignment stability for the South Platte River recommended by Dr. Stevens. The criteria for limiting velocities was to compare the Froude number of the recommended channel configuration to that for the present channel configuration. Where the Foude numbers were higher, heavy revetments were recommended. In most cases, the overbank velocities before and after improvements are in excess of 7 fps and revegetation of the overbank area will be required.

1. Stable Creek Channel

A centerline alignment was established from the existing Cherry Creek channel. The alignment is presented in Table-3 for the radius, the deflection angle (delta), the bend length, and the distance between two bends (crossing length). Next the creek bed width was measured at several locations to obtain the average active bed width of 230 feet (see Figure-14). The average measurements reflect natures preference for a certain width.

The data in Table-3 was then compared to the recommended stable alignment for the South Platte River (Reference-4). Whereas the flow regime and sediment transport for the South Platte River is different than Cherry Creek, the comparison does provide an indication as to the stability of the existing alignment for Cherry Creek. Using this approach, bends 2, 3, 4 & 5 were considered relatively stable and therefore only require "light revetment." All remaining bends were designed for heavy revetment in accordance with the work by the Corps of Engineers (Reference-8). Minor excavation of the creek bed to the existing average bed width is also recommended for certain areas of Reach B. The creek bed width of 230 feet was used for the channelization in Reach A.The riprap requirements for both heavy and light revetments were obtained using procedures described above.

2. Channelization

The channelization for Reach A was designed using the Army Corps of Engineers backwater program HEC-2. Calculations were performed by Law Engineering and Testing Company (Reference-13 & -14) and incorporated into the design recommendations by the CONSULTANT.

The channelization for portions of Reach B were performed by the CONSULTANT. Floodplain elevations were computed for two main channel roughness coefficients, n=0.020 and n=0.040. The higher roughness coefficient was used to compare the floodplain elevations to the published natural conditions. If the increase in elevations was more than 1/2-foot, then the channelization was modified until this criteria was met. Comparison of the velocity head was also made for both roughness coefficients. If the velocity head increased by more

than 20% at the higher roughness coefficients, then the channelization was modified until the criteria was met. The higher velocity values for the lower roughness coefficient were used to identify area where vegetation requirements would be more critical.

3. Confluence Requirements

Throughout the Cherry Creek channel lateral flow enters the creek from many tributaries, the largest being Happy Canyon Creek. The recommendations for the confluence area protection are presented in Figure 15 and include both open channel and storm sewer tributaries. The riprap requirements assume an unprotected bank of Cherry Creek. If revetments are required, then revetments have priority in the detail.

There are different requirements for inside bends and crossing areas than for outside bends. For storm sewers at an inside bend or a crossing, the invert is set 18" above the invert of Cherry Creek to allow for deposition of sediment without effecting the pipe outlet. For outside bends the pipe is set at the invert of Cherry Creek. Also, the length of minimum riprap protection is greater for outside bends than for inside bends and crossings due to the greater erosion potential for outside bends.

4. Permitting Requirements

A Corp of Engineers 404 permit will be required since riprap and earth will be placed within the normal high water line of Cherry Creek in excess of 200 cubic yards. These materials are required in the construction of the revetments specified to stabilize the channel. However, the earth fill required to reclaim land within the floodplain to the limits of the 1/2 foot floodway does not require a 404 permit since the materials are not placed within the normal high water line. Either 4:1 sloped embankments and vegetation or revetments are recommended to protect the fill and subsequent development. The minimum fill requirements have been calculated for each property owner to reclaim the floodplain area. The fill quantities were allocated according to the "typical Cross Section" shown on drawing 5 in Appendix C.

A 401 State Water quality certification will be required from the State Health Department since the construction activities will introduce sediment into Cherry Creek.

C. Maintenance Requirements

The maintenance requirements for the channel will be approximately the same in Reach A (channelization) versus Reach B (channelization and stabilized channel).

The general maintenance requirements consists of trash and debris removal, riprap placement, sediment removal, trail and landscape maintenance. Artificial channel banks without revetments are not as stable as natural banks and a greater maintenance frequency may be required for the channelized Reach A. However, the major maintenance items are highly dependent on the hydrological conditions in the basin and only average needs can be defined.

The routine annual maintenace requirements are defined in Table 10. The details are defined in the footnotes and describe the basis for the estimated quantity and unity cost. Most of the items are straight forward and do not require further explanation. However, sediment removeal takes into account the total yield at Cherry Creek (600 tons/sq. mile/year), the main channel stabiziation recommendation herein, and on estimate of the deposition that might occur. Two areas were considered the most likely areas for sediment removal: the confluence of Happy Canyon Creek and at the Arapahoe Road Bridge. The area of deposition was estimated to be around 6 acres at a depth of 6 inches or 5000 cubic yards. Most of this sediment would occur during major floods, which generally do not occur annually. For this study, 1,000 cubic yards of sediment removal per year was estimated for maintenance budgetting.

The effort required for rehabilitation maintenance after a major flood is highly dependent on the flood frequency. Since the main channel area will essentially carry the 10-year flood, then an estimate of the maximum exposure is the cost of the channel stabilization, estimated at $3,300,000 for the entire reach. Provided the routine maintenance is performed, then a reasonable

estimate of the 10-year flood damage is around 5% of the maximum exposure, or $438,000.

An estimate of the maximum exposure for floods greater than the 10 year is the entire project area, including creek stabilization and the landscape/ recreational facilities. Since the amount of facilities which could be damaged is greater for major floods, then the damage is expected to be a higher percentage of the maximum exposure. A reasonable estimate is 10% or approximately $875,000.

D. Water Quality Impact

There are two aspects of water quality that are addressed: one deals with construction activities and the effect of the improvements after completion, and the other deals with non-point source pollution from urban runoff.

The selected plan will require a Corps of Engineers' 404 permit and a state water quality certification since the construction activities will effect the turbidity and sediment load in the creek. This impact will be limited, however, to the construction period, after which the turbidity will return to normal levels.

The other aspect of water quality is non-point source pollution from urban runoff. In August 1984, the Water Quality Control Commission (WQCC) set an in-lake total phosphorous standard for Cherry Creek Reservoir and directed DRCOG to use this standard in developing point and non-point control strategies as part of the Clean Water Plan Amendment. The revision to the Clean Water Plan is now in progress and the draft report for public review will be available by July 1985. The methodology recommended for urban runoff is either detention followed by sand filtration, or rapid infiltration alone, where the soils are suitable. The basin wide goal is 50% phosphorous removal on an annual basis. The details of the requirements will be published in the final Clean Water Plan under the direction the DRCOG, by July 31, 1985.

BMPs can be classified as either structural or non-structural. Structural controls are usually "effect-oriented" such as detention systems, whereas non-

structural controls are usually "cause-oriented" such as erosion control ordinances. Because non-point source pollution is varied in nature and impact, no individual BMP will fit all situations. The BMPs must be tailored to fit the needs of particular sources and circumstances. A cost-effective approach to controlling pollution from urban stormwater runoff is a combination of structural and non-structural control measures.

Whereas the control of non-point pollution from urbanization will not impose any direct requirements on the selected plan for Cherry Creek, the development within the district will be required to comply with the final adopted criteria.

BMP procedures for stream bank stabilization have not been well established at this time and will be determined during the permitting process.

E. Impact on Existing Wells

During the alternative investigation of channelization for the properties located upstream of Arapahoe Road, the potential impact on the existing wells in the area was identified. At the request of the CONSULTANT a proposal to investigate the wells was submitted by Bishop, Brogden and Rumph, Inc. to the TAC. The scope of services included the following items:

1. Analyze current ground water conditions in the alluvial aquifer.

2. Inventory wells completed in the alluvium including The City of Aurora Well field.

3. Analyze ground water conditions after the channelization is completed.

4. Determine the possible effect on the wells in the area.

5. Investigate and recommend solutions to mitigate the impacts of channelization.

The location of the existing wells in the area are shown in Figure-2 and on Drawings 1 to 4. Only those wells within the influence area of channelization were investigated as to the impact and solutions required. All wells, however, were used to obtain the groundwater conditions. The wells which are within the area of channelization are listed below.

NAME	PERMIT#	TYPE	DEPTH
AURORA WELL #5	3085F	ALLUVIAL	97 FT
MARDOCK WELL #1	RF770	ALLUVIAL	61 FT

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1. Based upon the current ground water elevations and the proposed elevation and location of the channel, the resulting change in the ground water table was estimated. The study revealed that there will be very little change in the water table as a result of the channelization as proposed. Therefore, the channelization will not adversely effect the capacity of the existing wells.

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CHARACTER: Deciduous bare root trees at a density of 26 trees per acre as infill planting. Removal of large dead plant material will be necessary.

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Locate a picnic shelter as focal point and a small area for a play structure. Additional picnic table pads and benches should be situated among the mature vegetation and areas offering good views.

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Openness - Dense
Canopy - Medium
Understory - Low

I. Activity Zone

CHARACTER: Mixture of deciduous trees, shrubs and ornamental trees at a density of 31 deciduous trees per acre, 21 ornamental trees and 150 shrubs per acre, and irrigated turf in the field games area.

INTENT: Create a park-like setting on the east side of the creek corridor by clustering a mixture of plant types in groups of 15 or more separated by a distance ranging from 5' to 15'. Locate picnic table pads and benches to take advantage of views.

Plantings should be established 50 feet back of creek edge to avoid flood damage. This area closer to the creek is suited for a combination softball/soccer fields and a half court basketball play surface.

Openness - Dense
Canopy - Medium
Understory - Low

J. Slope Stabilization Zone

CHARACTER: Generally these zones are restricted and require special attention to establish the pathway on the side of the existing slope.

INTENT: Erosion control measures are necessary to contain the maximum allowable slope of 2:1. Options offering different desirable appearances for controlling erosion include:

1) hydroseeding and mulching with erosion control fabric,
2) erosion control netting with low growing shrubs planted at a density of 200 per 10,000 s.f.

Openness - Open
Canopy - None
Understory - Dense

G. Construction and Maintenance Costs

A detailed cost estimate of the improvements for the selected alternative plan was prepared by calculating quantities from the prelimniary design drawings. The costs were divided into the following categories:

1. Construction - capital costs to construct the facilities.

2. Contingency - 15% contingency was applied to the construction costs to account for unknown and variability of unit costs.

3. Admnistrative - costs for the District to administer the contracts and maintenance work. A value of 5% was applied to the construction costs.

4. Engineering and Construction Supervision - costs to design and inspect the construction - a value of 15% was applied to the construction costs.

5. Recreational Costs - costs for landscape and recreational facilities. A detailed quantity list and cost estimate for landscaping and recreational facilities is presented in Table-9.

6. Operation and Maintenance - annual costs to perform the tasks outlined in Section V-C and presented in Table 10.

A summary of the costs for the project are presented in Table-5, based upon the unit prices of Table-4.

VI. ADMINISTRATION OF MASTER PLAN

VI. ADMINISTRATION OF MASTER PLAN

A. Phasing of Improvements

The master plan was developed on the basis of the needs of each landowner but within the constraints of the requirements for the entire study reach of Cherry Creek. Recognizing that construction of the entire plan at one time is unlikely, then phasing of the construction will be required. However, there are limitations on the phasing that must be considered.

The proposed master plan has four levels of improvements required, all with different impacts on adjacent land owners and different approvals required. In order of increasing impact, the levels of improvements and the impacts are presented below.

1. Level 1 construction is filling of the floodplain to the floodway limits (proposed throughout the project). The upstream end of the project near the county line requires transitioning of the fill limits so the flood elevations for the Cottonwood development are not increased. This effects the Ashbrook and the Hutkin Ltd. properties. The same type of transitioning is required of other property owners (Dransfeldt, Walters-Banbury, Tagawa, Viehmann-Martin, and Aurora) if the floodplain filling is not performed at the same time or if an agreement between owners cannot be reached. However, floodplain filling requires the least governmental approvals (i.e., UDFCD, Arapahoe County, Parker-Jordan Metropolitan District).

   Since the existing creek bed has meandered close to the floodway limits in certain areas, the filling of the floodplain must be performed in conjunction with construction of the revetments to protect the fill for these areas. This requirement is for bends 1a, 3, and 4 only, which are the bends with the most historic movement. Otherwise, the filling of the floodplain is independent of other construction. Generally fill construction would require some type of transitioning at the project limits, with the transition protected by

riprap. The locations of the transition are somewhat flexible, either taking place entirely within the subject property or partially on adjacent property, which effects other landowners.

2. Level 2 construction includes (1) the revetments for specific bends to control horizontal movement and (2) minor excavation of the main channel to improve low to intermediate flood conveyance (proposed throughout the project). The revetment improvements must be completed for the entire bank area to be effective; and therefore, transitioning possibilities are less flexible. The construction of the following revetments would require cooperation between landowners: bends 1a, 2, 6, 7, 10, and 11.

   The construction of the revetments for bends 1a, 3, and 4 is required before filling of the floodplain, as previously discussed. Otherwise, the revetments can be constructed as required to develop the land. The priority on the revetments construction is bends 1, 1a, 2, 3, and 4, since these bends have the greatest history of movement. The next priority would be for bends 6 and 8 due to the present erosion of the outer banks.

   The construction of all revetments will require approvals of the UDFCD, Arapahoe County the Parker-Jordan Metropolitan District and the Army Corps of Engineers. Both a Section 404 and Section 208 permit would be required as discussed in Section V-D.

3. Level 3 construction consists of (1) the excavation of the overbank area and (2) minor excavation (not for widening) in the main channel area to improve flood conveyance and allow for greater areas of reclaimed land (proposed for the Walters-Banbury property). The work must be done in conjunction with revetment protection to assure protection of the outer fill banks. Some transitioning of the channel as now proposed is necessary, which will require cooperation with the Dransfeldt, Tagawa and Viehmann-Martin properties. The channelization could be transitioned within the property limits, eliminating the impact on the 3 property owners, but would result in less

reclaimed area. The channelization also requires construction on the Ashbrook property, which is necessary for reclamation of floodplain land.

Approval of the UDFCD, Arapahoe County, the Parker-Jordan Metropolitan District, FEMA, CWCB, and the Army Corps of Engineers will be required. Both a Section 404 permit and Section 401 Water Quality certification will be required as discussed in Section V-D.

4. Level 4 construction consists of (1) the excavation of the overbank area and (2) widening of main channel area to improve flood conveyance (proposed for the Viehmann-Martin and Aurora properties). In order to reclaim the floodplain area, the entire reach from Arapahoe Road to approximately 6,800 LF upstream must be constucted at one time. Due to the divided flow condition, the channelization must extend into the River Run property in order to contain the flood. Work must also be done on the Aurora property to contain the flood, such that the floodplain can be reclaimed.

   The construction of this channelization will require approvals of the UDFCD, Arapahoe County, the Parker-Jordan Metropolitan District, FEMA, the CWCB and the Corps of Engineers. Both a Section 404 permit and Section 401 Water Quality certification will be required as discussed in Section V-D.

B. Recommended Policies and Procedures

Policies and procedures have been developed to assure the successful implementation and long-term performance of the master plan. The following policies and procedures are suggested:

1. Officially adopt this master plan.

2. Encourage the cooperation between landowners to minimize temporary construction, unneccessary transitions and piecemeal facilities that adversely effect the function and performance of Cherry Creek within

the District.

3. Promote standardization of analysis, design and construction by preparing criteria and specifications to be followed by all landowners.

4. Discourage changes to the master plan which may not be in the best interest of the District.

5. Require revegetation of exposed areas to the standards of the District as soon thereafter as practical.

6. Begin a regular program of maintenance and monitoring of the performance of the improvements to incorporate improvements of the criteria as soon as possible. Assess the requirements for maintenance on a regular basis.

7. Review all local drainage designs for impact on the proposed Cherry Creek master plan.

8. Require all proposed improvements to Cherry Creek to be in accordance with the following procedures:

   a. Meet with the Parker-Jordan Metropolitan District and the District Drainage Engineer to discuss concepts and general requirements of the District.
   b. Require the applicant to coordinate design with appropriate reviewing agencies during the course of the analysis and design.
   c. Submit analysis, design, and specifications for review and recommendation by the District Engineer. Based on a recommendation, the Board will approve or reject proposal.
   d. If the proposal is approved by the Board, the applicant will be required to obtain all permits or governmental approvals.
   e. Board to authorize construction based on permits and approvals obtained.

REFERENCES

REFERENCES

1. "Flood Plain Information Cherry Creek", Department of the Army, Omaha District, Corps of Engineer's, October 1976.

2. "Flood Hazard Area Delineation Happy Canyon Creek, et al", Howard, Needles, Tammen, and Bergendorf, November 1977.

3. "Cherry Creek Floodplain Study, Arapahoe Road to County Line, Arapahoe County, Colorado", Greiner Engineering Sciences, Inc., Denver, Colorado, July 1984 (Job No. 5136706).

4. Stevens, Michael A. "Stream Stability Investigation, South Platte River, Chatfield Dam to Baseline Road", November 1983.

5. Larson, L.S. and Brown, J.B., "Soil Survey of Arapahoe County, Colorado", U.S. Department of Agriculture, Soil Conservation Service, March 1971.

6. Aerial Photographs, July 17, 1937, October 1983, The National Achiever.

7. Aerial Photographs October 15, 1964, August 10, 1971, July 5, 1978, National Cartographic Information Center, Rocky Mountain Region, Box 25046 Federal Center MS504, Denver, Colorado 80225.

8. "Final Report to Congress, The Streambank Erosion Control Evaluation and Demonstration Act of 1974 Section 32, Public Law 93-251", U.S. Army Corps of Engineer's, December 1981.

9. Data from the USGS for the Melvin Gage 106712500 "Summary of Discharges, Annual Peak Flow, Monthly Peak Flow, and Statge Discharge Tabulation".

10. "Urban Storm Drainage Criteria Manual", DRCOG, Denver, Co. 1969 currently revs.

11. Vanone, Vito (Ed.) Sedimentation Engineering, ASCE, M & R No. 54, New York, N.Y., 1975.

12. Gibbs, J.W., Arnold, L.M., and Reed, R.L., "Hydrologic Data for the Drainage Basins of Chatfield and Cherry Creek Lakes, Denver Metropolitan Area Colorado", U.S. Geological Survey, Open-File.

13. "Evaluation of Options for Improvements of Cherry Creek Channel Adjacent to the Rich Center Property" Law Enginering Testing Company, Engelwood, Co. Jan. 1985.

14. Supplemental HEC-2 Analysis for Selected Alternative Adjacent to the Rich Center Property, Law Engineering Testing Company - Feb. 1985.

15. "Cherry Creek Ground Water Investigation, Arapahoe County, Colorado" Bishop, Brogden, & Ramph, Inc. Feb. 1985.

16. Letter from Bishop, Brogden, & Ramph, Inc. "Supplemental Letter to Final Report" Feb. 1985.

17. "Cherry Creek Reservoir Clear Lakes Study," DRCOG, Denver, Co., April, 1984.

TABLES

TABLE-1

CHERRY CREEK BASIN
FEASIBILITY STUDY

FLOODPLAIN AREA
EXISTING CONDITION

PROPERTY OWNER	AREA IN FLOODPLAIN (ACRES)	AREA IN[1] FLOODWAY (ACRES)	RECLAIMED[2] AREA (ACRES)
Eagle Creek Assoc.	13	10	3
Rich and Company	4	4	0
City of Aurora	59	47	12
Viehmann-Martin	125	96	29
Cherry Creek Bus. Ctr.	17	5	12
River Run	115	85	30
Dransfeldt	113	84	29
Tagawa Rose Farm	5	1	4
Sheldon-Banbury[3]	62	43	19
Hutkin Development[3]	10	4	6
AW & S.D.	2	2	0
TOTAL	525	381	144

NOTE:
1. 1/2 foot rise in the water surface
2. property reclaimed by filling up to the floodway limits
3. floodway area based on transition of floodway limits to the Cottonwood development

TABLE-2
CHERRY CREEK
FEASIBILITY STUDY
ALTERNATIVE PLAN ANALYSIS

PLAN NO.	OPTION REACH A*	OPTION REACH B*	POTENTIAL SEDIMENTATION EFFECTS U/S	POTENTIAL SEDIMENTATION EFFECTS D/S	POTENTIAL SEDIMENTATION EFFECTS WITHIN SITE	MAINT-REQ	CAPITAL COSTS	PRO'S	CON'S
1	A & D or E	A & D or E	S.Q.	S.Q.	S.Q.	Low	Very low	-Least govern approval (except "E")	-Does not improve present condition -Minimal reclaimed area -Requires county policy change ("E")
2	B & D or E	B & D or E	S.Q.	Minor Degrade	Minor Degrade	Moderate	Moderate	-Improves creek bed -Improves passive recreation potential	-Minimal reclaimed area -Requires county policy change ("E")
3	C & D or E	C & D or E	Minor Degrade	Minor Aggrade	Minor Degrade	Moderate	Moderate	-Improves creek bed -Improves passive recreation potential	-Minimal reclaimed area -Requires county policy change ("E")
4	H Alt.#1	H Alt.#2	S.Q.	Minor Degrade	Minor Degrade	Moderate	Moderate to High	-Provides fill dirt -Increase in Reclaimed Area	-Requires Abutment/pier protection

NOTE: Description of Options

"A" - Meander Belt
"B" - Stabilize Existing Alignment
"C" - Construct Stable Alignment
"D" - 1/2 foot Floodway
"E" - 1 foot Floodway
"H" - Channel Excavation - Alt. 1, With Main Channel Excavation
"H" - Channel Excavation - Alt. 2, Without main Channel Excavation

* Reach A - From Arapahoe Road 6,800 LF upstream along the creek bed - (approximately the center of River Run property)
Reach B - From the upstream end of Reach A to the Douglas County line, approximately 10,600 LF along the creek bed

TABLE-3
CHERRY CREEK BASIS
FEASIBILITY STUDY

PROPOSED CREEK BED ALIGNMENT

BEND NUMBER	RADIUS OF CURVATURE (FT.)	DEFLECTION ANGLE (DEG)	LENGTH OF BEND (FT.)	CROSSING DISTANCE (FT.)
1	620	62	670	
				120
1a	180	73	230	
				630
2	540	95.5	900	
				0
3	395	81.5	560	
				780
4	380	127	840	
				360
5	640	127	565	
				500
6	375	92	600	
				370
7	220	88	340	
				600
8	650	58	655	
				305
9	800	61.5	860	
				550
10	1,200	64	1,340	
				810
11	2,550	27.5	1,225	
				420
12	300	137.5	720	
				550
13	1,500	73	1,910	

TABLE-4
CHERRY CREEK BASIN
FEASIBILITY STUDY

CONSTRUCTION COSTS
UNIT PRICE DATA
JANUARY 1985

CHANNEL STABILIZATION	COST
Heavy Revetment	$220/LF
Light Revetment	$125/LF
Main Channel Excavation:	$4/CY
Main Channel Fill (1)	$6/CY
Floodplain Reclamation:	
Excavation of Overbanks	$2.50/CY
Fill of Floodway Fringe (1)	$1.25/CY

(1) Includes compaction of Fill Material, assuming adequate material is available on site.

TABLE-5

CHERRY CREEK BASIN
FEASIBILITY STUDY

COST SUMMARY
SELECTED ALTERNATIVE

CAPITAL IMPROVEMENTS
(SEE TABLE 9)

Construction Costs:		
Recreational Facilities & Landscaping		$ 1,116,940
Channel Stabilization Features		2,435,450
Floodway Fringe Reclamation		2,910,850
	Sub-Total:	$ 6,463,240
Contingency (15%)		$ 969,486
Administrative (5%)		$ 323,160
Engineering and Construction Observation (15%)		$ 969,480
	Sub-Total:	$2,262,130
	CAPITAL IMPROVEMENTS TOTAL:	$ 8,725,370

ANNUAL OPERATION AND MAINTENANCE
(SEE TABLE 10)

Channel Improvements		$ 80,200
Land/Recreation		$ 116,100
	ANNUAL O & M TOTAL:	$ 196,300

* Distance upstream from Arapahoe Road

TABLE-6

CHERRY CREEK BASIN
FEASIBILITY STUDY

FLOODPLAIN AREA
SELECTED ALTERNATIVE

PROPERTY OWNER	AREA IN FLOODPLAIN (ACRES)	AREA IN FLOODWAY (ACRES)	RECLAIMED AREA (ACRES)
Eagle Creek Assoc.	13	3	10
Rich and Company	4	4	0
City of Aurora	59	47	12
Viehmann-Martin	125	37	88
Cherry Creek Bus. Ctr.	17	5	12
River Run	115	75	40
Dransfeldt	113	84	29
Tagawa Rose Farm	5	1	4
Sheldon-Banbury	62	43	19
Hutkin Development	10	4	6
AW & S.D.	2	2	0
TOTAL	525	305	220

TABLE-7

CHERRY CREEK BASIN

FEASIBILITY STUDY

LANDSCAPE ZONE AREA SUMMARY

Landscape Zone	Area (Acres)
A. Limited Zone	104.0
B. Intermediate Zone	61.0
C. Major Zone	22.0
D. Renewal Zone	6.0
E. Buffer Zone	19.0
F. Infill Zone	9.0
G. Amenity Zone	6.0
H. Preservation Zone	32.0
I. Activity Zone	9.0
J. Slope Stabilization Zone	11.0
Total:	**279.0**

TABLE-8
CHERRY CREEK BASIN
FEASIBILITY STUDY

RECOMMENDED PLANT MATERIALS LIST

A. Deciduous Trees
Box Elder - Acer negundo
Silver Maple - Acer Saccharinum
Buckeye - Aesculus glabra
Catalpa - Catalpa speciosa
Hackberry - Celtis occidentalis
Kentucky Coffeetree - Gymnocladus/dioicus
Green Ash - Fraxinus pennsylvanica
Honeylocust - Gleditsia triacanthos
Black Walnut - Juglans nigra
Cottonwood - Populus sp. (seedless)
Silver Poplar - Populus alba
Narrowleaf Cottonwood - Populus angustifolia
Quaking Aspen - Populus tremuloides
Bur Oak - Quercus macrocarpa
Siberian Elm - Ulmus pumila

B. Ornamental Trees
Rocky Mountain Maple - Acer glabum
Amur Maple - Acer ginnala
Rocky Mountain Alder - Alnus tenuifolia
Serviceberry - Amelanchier
Rocky Mountain Birch - Betula occidentalis
Russian Olive - Elaegnus angustifolia
Crabapple - Maulus sp.
American Plum - Prunus americana
Rocky Mountain White Oak - Quercus gambelii

C. Evergreen Trees
Colorado Spruce - Picea pungens
Lodgepole Pine - Pinus contorta
Pinyon Pine - Pinus edulis
Limber Pine - Pinus flexilis
Austrian Pine - Pinus nigra
Ponderosa Pine - Pinus ponderosa
Scotch Pine - Pinus sylvestris

D. Deciduous Shrubs
Tall Western Sage - Artemisa tridentata
Barberry - Berberis sp.
Siberian Peashrub - Caragana arborescens
Red Oiser Dogwood - Cornus stolonifera
Peking Cotoneaster - Cotoneaster acutifolia
Hawthorn - Crataegus sp.
Mountain Privet - Foresteria neomexicana
Forsythia - Forsythia suspensa
Apache Plume - Fallugia paradoxoa
Juniper - Juniperus sp.
Honeysuckle - Lonicera sp.
Creeping Mahonia - Mahonia repens
Potentilla - Potentilla fruticosa
Chokecherry - Prunus virginiana demissa
Pyracantha - Pyracantha coccinea
Buckthorn - Rhamnus cathoritica
Fragrant Sumac - Rhus aromatica
Staghorn Sumac - Rhus typhina
Rogosa Rose - Rosa rogosa
Alpine Currant - Ribes alpinum
Common Lilac - Syringa vulgaris
Spirea - Spiraea sp.
Viburnum - Viburnum sp.
Glauca Yucca - Yucca glauca

COSTS

TABLE-9
CHERRY CREEK BASIN
FEASIBILITY STUDY

A. Construction Costs

Quantity	Item	Estimated Cost
4,523	Deciduous Trees 11/2"-2" B&B	$407,070
304	Evergreen Trees 4' - 6'	30,400
405	Ornamental Trees 11/2"-2"	46,580
234	Bare Root Trees	2,340
7,310	Deciduous Shrubs	131,580
30,000	S.Y. Concrete Path	150,000
1	Picnic Shelter	8,000
30	Picnic Tables	9,000
15	Benches	3,000
30	Trash Receptacles	2,400
4	Bike Racks	600
2	Playground Equipment Set	12,000
1	Break Away Bridge 225 LF	60,000
1	Pedestrian Bridge	2,000
4,462	S.F. Concrete (Picnic Tables/Shelter,Benches)	11,150
260	S.Y. Asphalt for Hard Court Surface	2,600
4.7	Ac. Erosion Control Netting & Shrubs	73,800
1.8	Ac. Hydroseeding/Mulching With Fabric	65,340
6	Ac. Turf (acres)	73,180
6	Ac. Irrigation for Turf Area	104,540
	Truck Watering -- 5,466 Trees	160,700
	Truck Watering -- 11,410 Shrubs	167,730
	TOTAL CONSTRUCTION COSTS	$1,116,940

B. Channel Stabilization Construction

Curve 1 & 1a	- 1100 LF Heavy Revetment @ $220/LF	=	242,000
Curve 2	- 950 LF Light Revetment @ $125/LF	=	118,800
	- 2200 CY Fill @ $6/CY	=	13,200
Curve 3	- 650 LF Light Revetment @ $125/LF	=	81,300
	- 1600 CY Fill @ $6/CY	=	9,600
Curve 3 to 4	- 1800 CY Excavation @ $4/CY	=	7,200
Curve 4	- 1200 LF Light Revetment @ $125/LF	=	150,000
	- 3500 CY Fill @ $6/CY	=	21,000
Curve 5	- NO WORK		
Curve 6	- 950 LF Heavy Revetment @ $220/LF	=	209,000
	- 2700 CY Fill @ $6/CY	=	16,200
Curve 6 to 7	- 5600 CY Excavation @ $4/CY	=	22,400
Curve 7	- 700 LF Heavy Revetment @ $220/CY	=	154,000
Curve 8	- 1000 LF Light Revetment @ $125/LF	=	125,000
	- 1000 CY Fill @ $6/CY	=	6,000
	- 2100 CY Excavation @ $4/CY	=	8,400

TABLE 9 CONTINUED

Curve 9	- 950 LF Light Revetment @ $125/LF	= 118,800
	-10800 CY Excavation @ $4/CY	= 43,200
	- 4900 CY Fill @ $6/CY	= 29,400
Curve 9 to 10	-14700 CY Excavation @ $4/CY	= 58,800
Curve 10	- 1260 LF Heavy Revetment @ $220/LF	= 277,200
	-14025 CY Excavation @ $4/CY	= 56,100
Curve 10 to 11	-12695 CY Excavation @ $4/CY	= 50,800
Curve 11	- 750 LF Light Revetment @ $125/LF	= 93,800
	-25615 CY Excavation @ $4/CY	= 102,500
Curve 12	- 5000 CY Excavation @ $4/CY	= 20,000
	- 1200 LF Heavy Revetment @ $220/LF	= 264,000
Curve 13	- Spur Dykes @ Arapahoe Road Bridge	= 136,750
	SUB-TOTAL Σ ex = 92,335 Σ fill = 15,900	= 2,435,450

C. Floodplain Reclamation

Excavation 369,400 CY @ $2.50	= 923,500
Fill 1,563,000 CY @ $1.25	= 1,953,750
Well Protection (See Section V-E for Details on Cost)	= 33,600
SUB-TOTAL	= 2,910,850
TOTAL	= 6,463,240
ADMINISTRATION, ENGINEERING, CONSTRUCTION OBSERVATIONS & CONTINGENCIES	= 2,262,130
GRAND TOTAL:	= **8,725,370**

Σ ex = 461,700
Σ FILL = 1578,900
BALANCE: 1,117,200

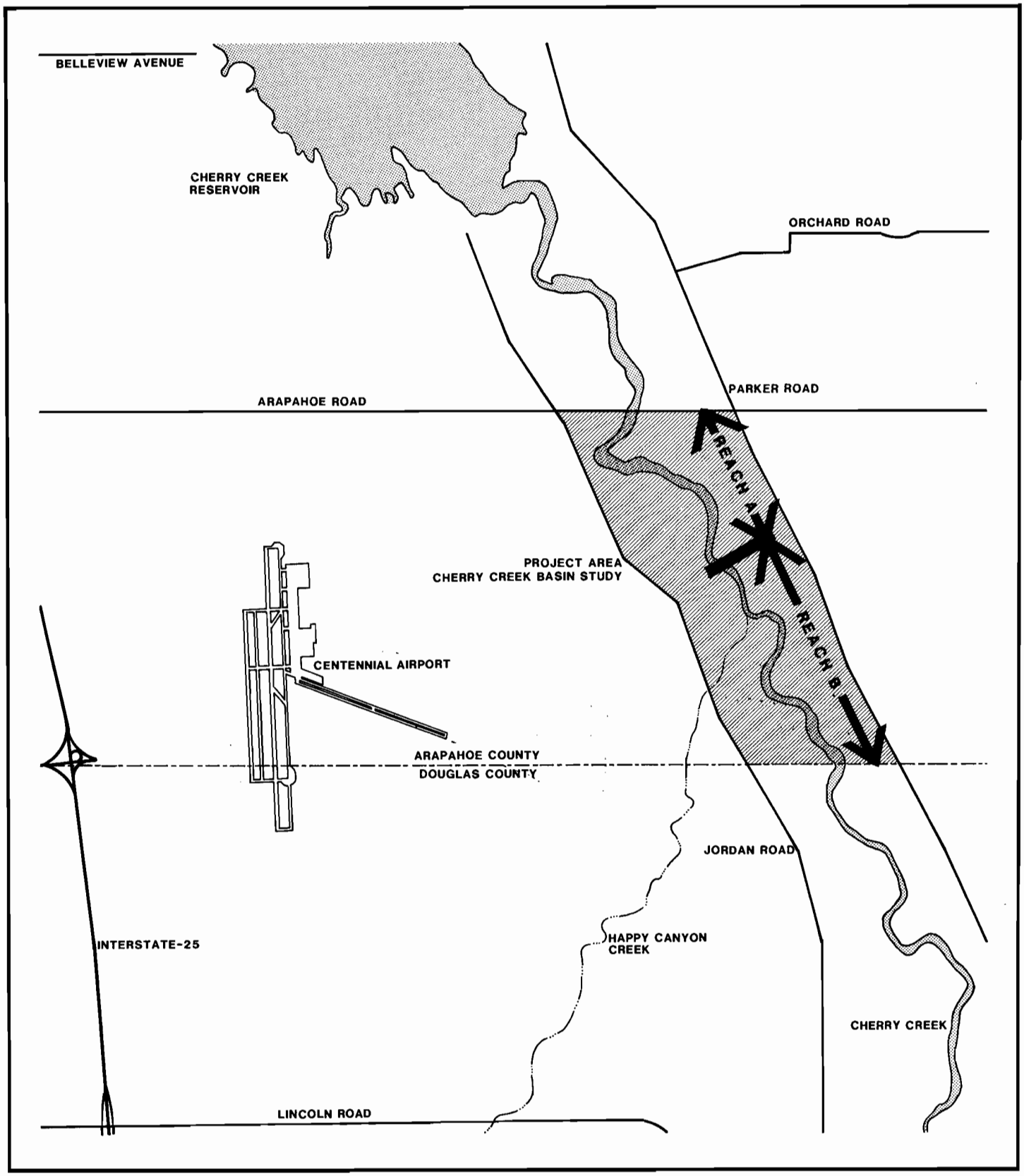
TABLE 10

DETAILS OF MAINTENANCE COSTS

ITEM	ESTIMATED QUANTITY		UNIT COST	COST PER MONTH	ANNUAL[4] COST
1 - 6 Irrigated Acres[1]	261,360	FT^2	.015/FT^2	$3,920	$27,440
2 - Trees[2]	5,466	EA	.75/EA	$4,100	$28,700
3 - Shrubs[1]	11,410	EA	.30/EA	$3,420	$23,940
4 - Debris pick-up[3]	92,928	LF/MO	.02/EA	$1,860	$13,020
5 - Plant Restoration					$23,000
SUB-TOTAL					**$116,100**
B. Channel Maintenance					
6 - Riprap Repair[5]					
A) Heavy Revetments	273	LF	$170/LF		= 46,400
B) Light Revetments	220	LF	$90/LF		= 19,800
7 - Bank Repairs[6]	25,000	LF	0.24/LF		= 6,000
8 - Sediment Removal	1000	CY	8.00/CY		= 8,000
SUB-TOTAL					**= 80,200**
TOTAL ANNUAL MAINTENANCE					**= 196,300**

1. Maintenance Includes: Mowing, fertilization, insect and weed control and irrigating with a previously installed automatic system.
2. Maintenance Includes: Insect and weed control, pruning, and fertilizing.
3. 4.4 miles x $.02/LF weekly ($465 weekly).
4. Annual Cost of Landscaping items are for a 7 month period.
5. Riprap repair assumed to be 5% of both heavy revetment and light revetment lengths on an annual basis.
6. Repair of unprotected banks.

FIGURES



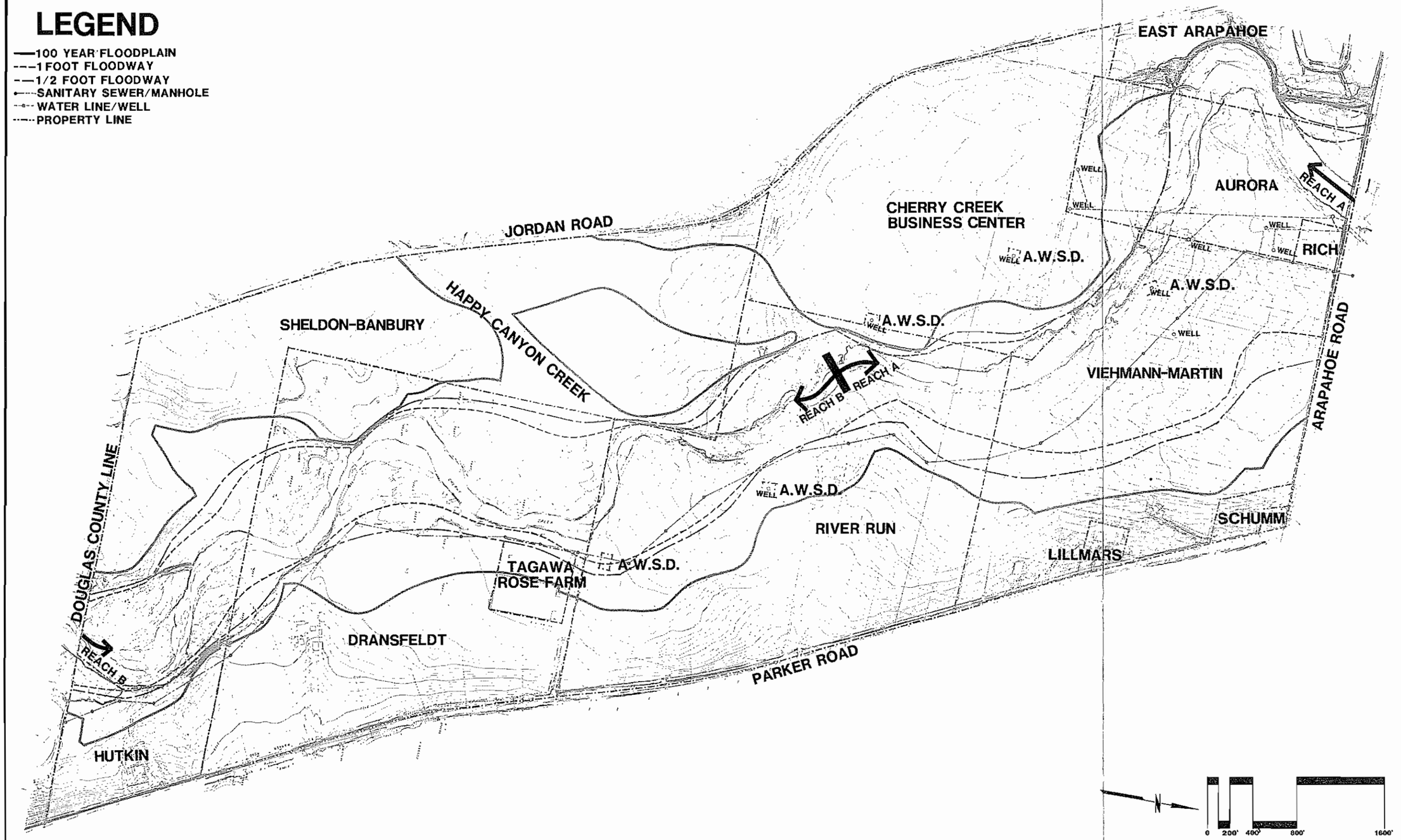
GENERAL LOCATION MAP
CHERRY CREEK BASIN STUDY

FIGURE NUMBER 1

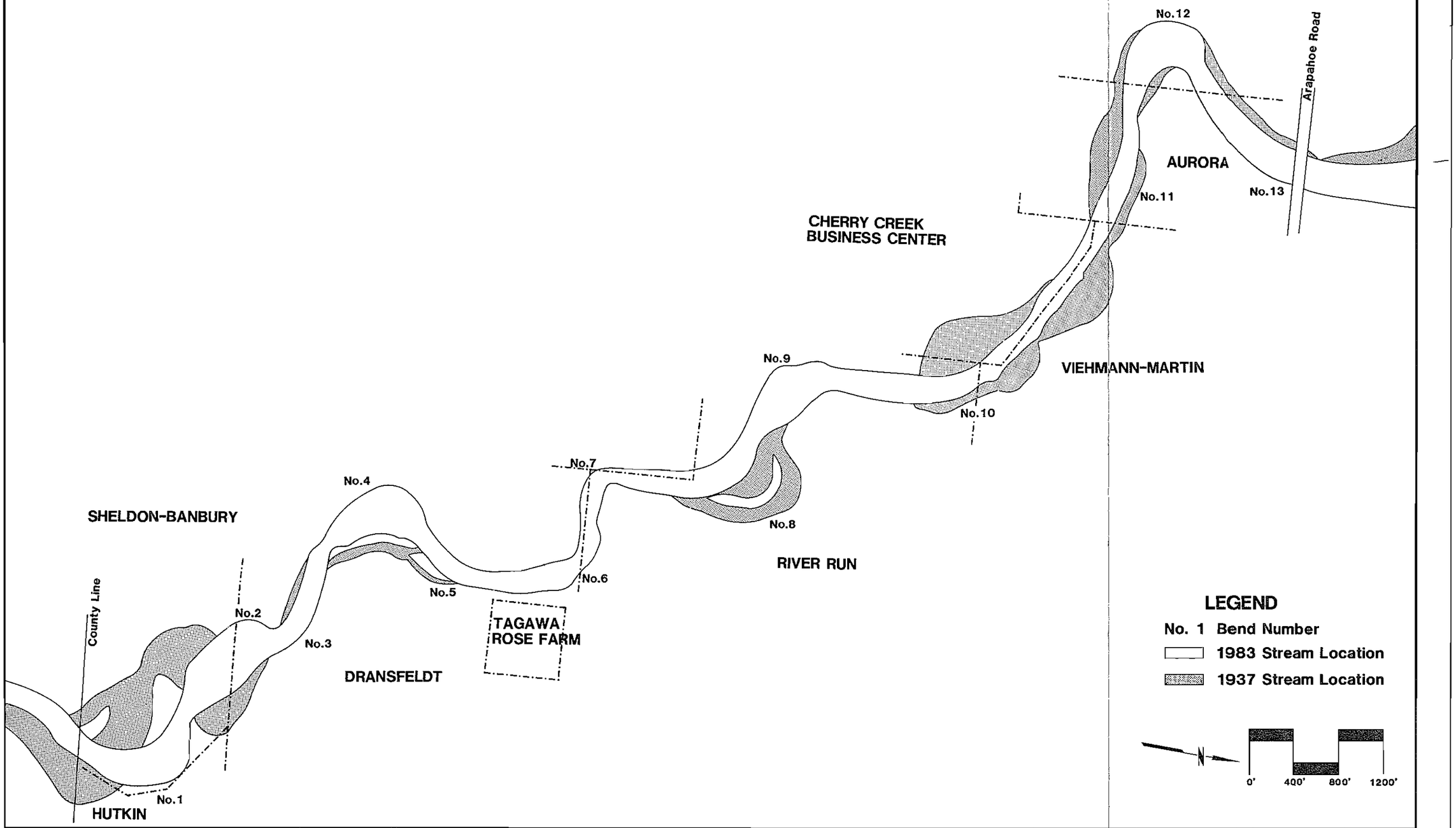
0 1/4 1/2 1MILE NORTH

LEGEND

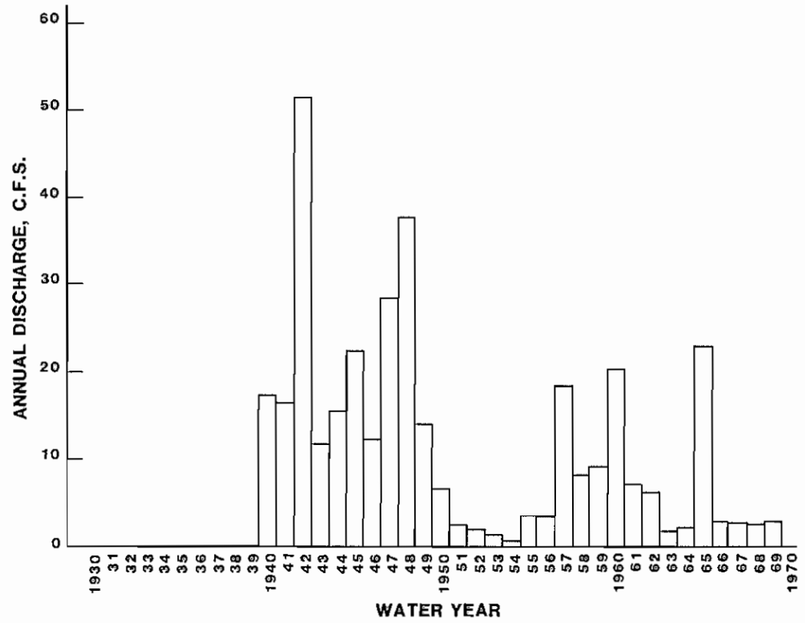
—100 YEAR FLOODPLAIN
– – –1 FOOT FLOODWAY
– – –1/2 FOOT FLOODWAY
•—•—SANITARY SEWER/MANHOLE
—o—o— WATER LINE/WELL
—•—•— PROPERTY LINE



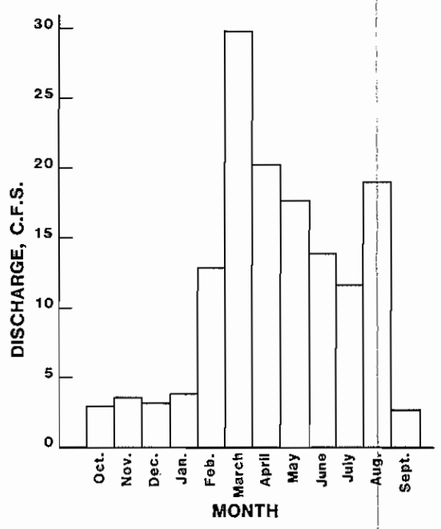
BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE BRW, INC 7200 S. TUCSON SUITE 231 ENGLEWOOD, CO 80112	WRC ENGINEERING, INC. 1660 SOUTH ALBION STREET SUITE 500 DENVER, COLORADO 80222 (303) 757-9513	CHERRY CREEK BASIN STUDY	PROJECT AREA MAP	PROJECT NUMBER	FIGURE NUMBER 2



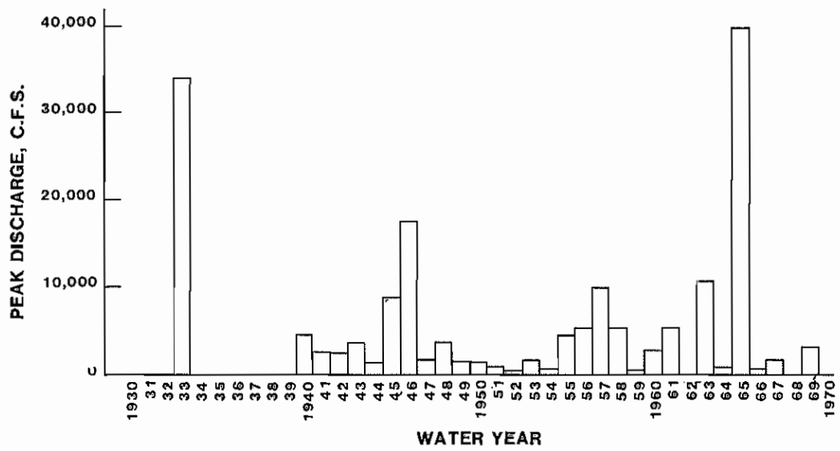
BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE	WRC ENGINEERING, INC. 1660 SOUTH ALBION STREET SUITE 500 DENVER, COLORADO 80222 (303) 757-8513	CHERRY CREEK BASIN STUDY	CHERRY CREEK - RIVER MORPHOLOGY	PROJECT NUMBER	FIGURE NUMBER 3



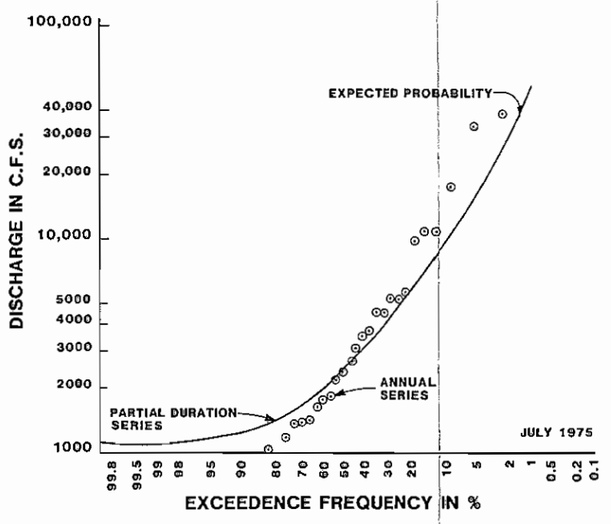
A. ANNUAL STREAMFLOW



C. MEAN MONTHLY STREAMFLOW

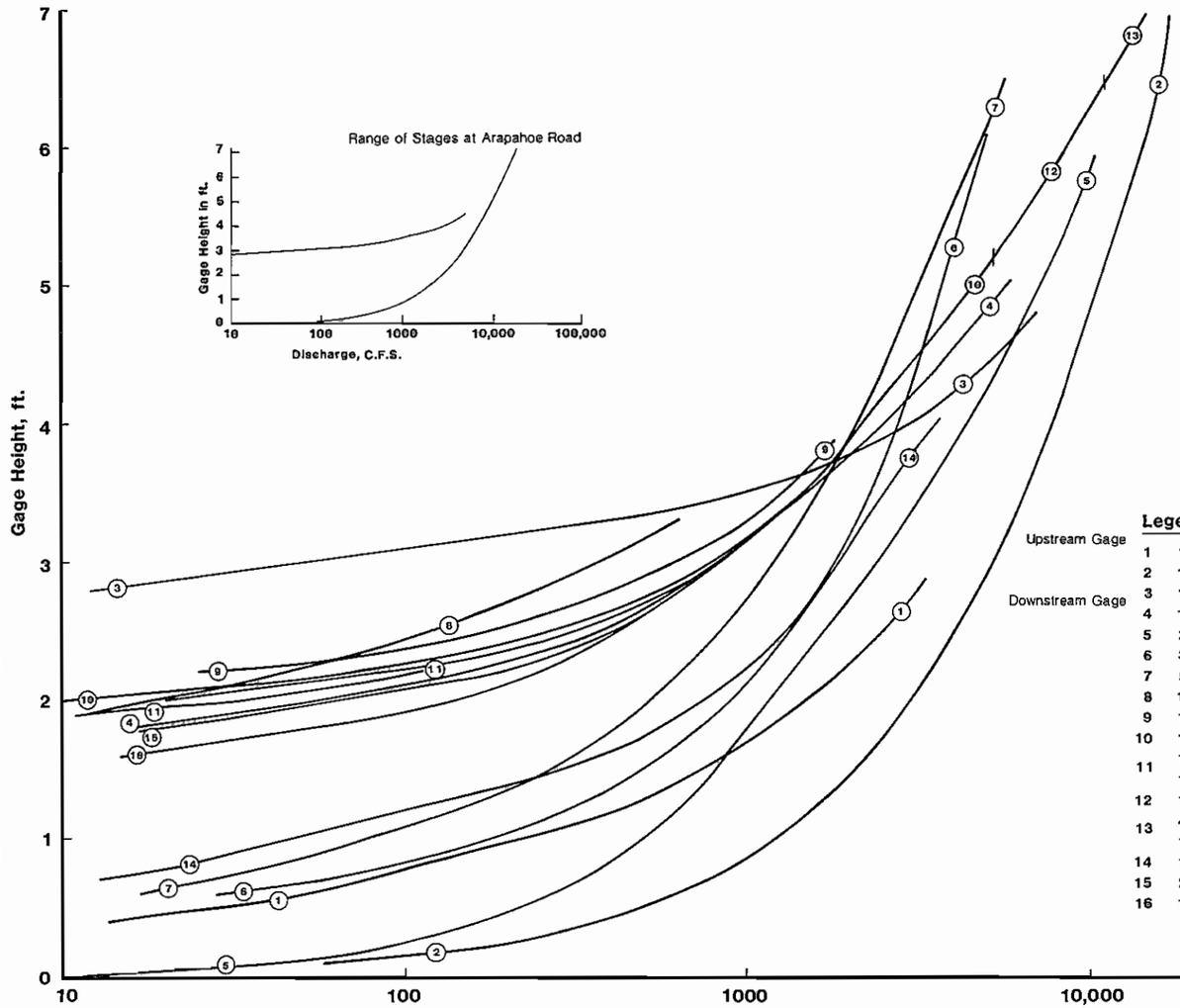


B. ANNUAL PEAK DISCHARGE



D. ANNUAL PEAK DISCHARGE PROBABILITY

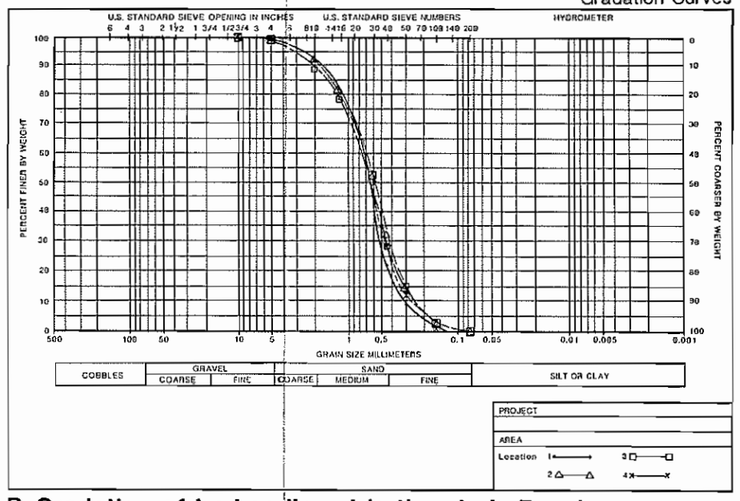
BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE	WRC ENGINEERING, INC. 1660 SOUTH ALBION STREET SUITE 500 DENVER, COLORADO 80222 (303) 757-8513	CHERRY CREEK BASIN STUDY	HYDROLOGY CHERRY CREEK NEAR MELVIN	PROJECT NUMBER / FIGURE NUMBER 4



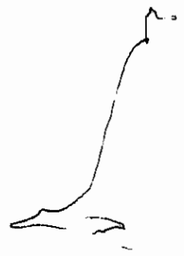
A. Stage versus discharge curves for Cherry Creek near Melvin

NOTE: On 1 October 1960, the gage was moved upstream 1 mile to Arapahoe Road changing the gage datum from 5608.21 to 5625.81 feet above mean sea level

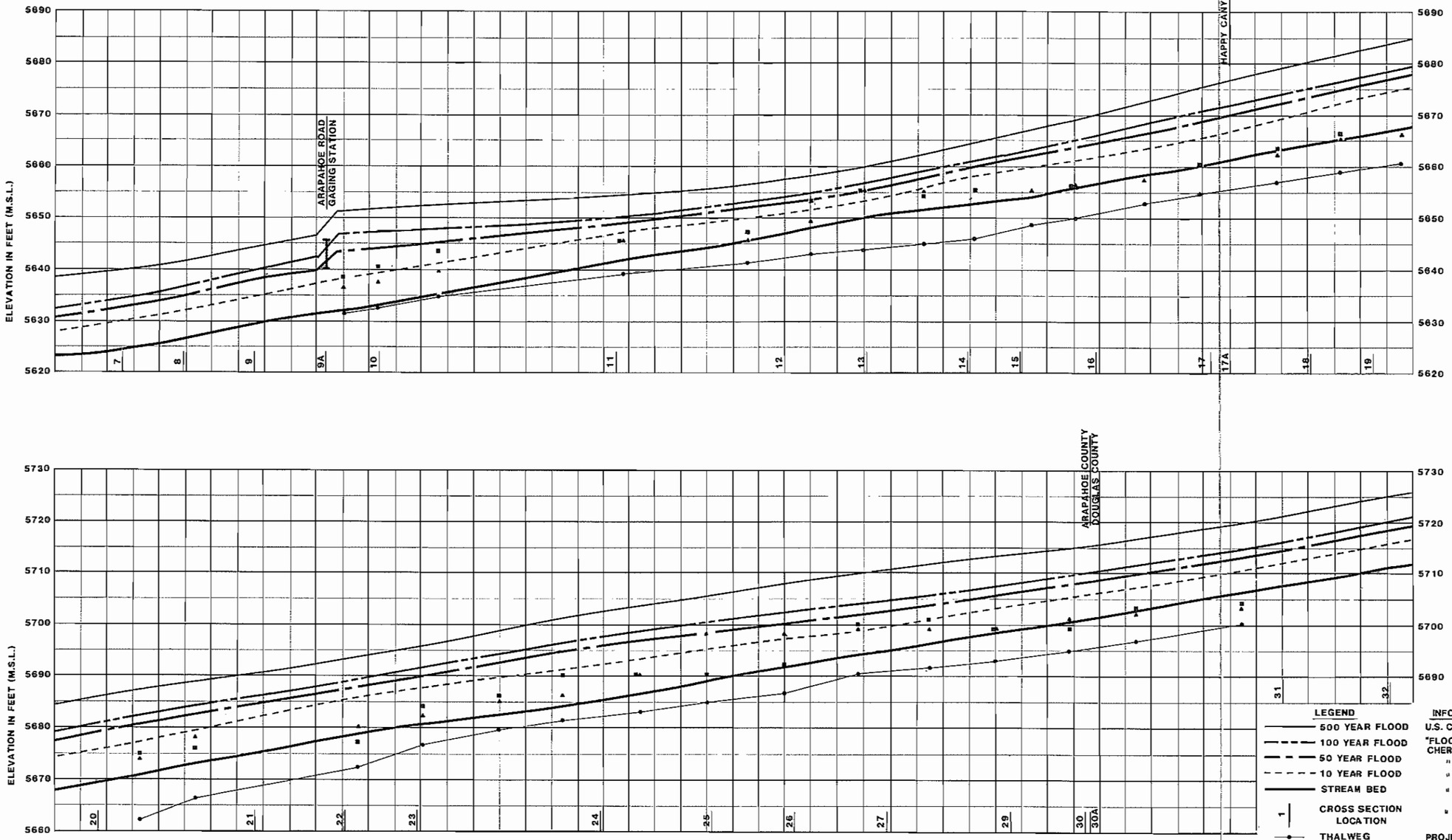
Gradation Curves



B. Gradation of bed sediment in the study Reach



BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE	WRC ENGINEERING, INC. 1660 SOUTH ALBION STREET SUITE 500 DENVER, COLORADO 80222 (303) 757-8513	CHERRY CREEK BASIN STUDY	SEDIMENTATION DATA	PROJECT NUMBER	FIGURE NUMBER 5



NOTE: DISTANCES ALONG STREAM BED DIFFER FROM U.S. CORPS OF ENGINEERS PROFILE

WRC ENGINEERING, INC.
1660 SOUTH ALBION STREET SUITE 500
DENVER, COLORADO 80222
(303) 757-8513

CHERRY CREEK BASIN STUDY

CHERRY CREEK BANK & BED PROFILE

PROJECT NUMBER

FIGURE NUMBER 6

LEGEND

- 100 YEAR FLOODPLAIN
- 1 FOOT FLOODWAY
- 1/2 FOOT FLOODWAY
- SANITARY SEWER/MANHOLE
- WATER LINE/WELL
- PROPERTY LINE
- MEANDER BELT - APPROXIMATE AREA OF POSSIBLE CREEK BED MOVEMENT DUE TO SOILS AND HISTORIC TRENDS

N

0 200' 400' 800' 1600'

BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE
BRW, INC. 7200 S. TUCSON SUITE 291 ENGLEWOOD, CO 80112

WRC ENGINEERING, INC.
1660 SOUTH ALBION STREET SUITE 500
DENVER, COLORADO 80222
(303) 757-8513

CHERRY CREEK BASIN STUDY

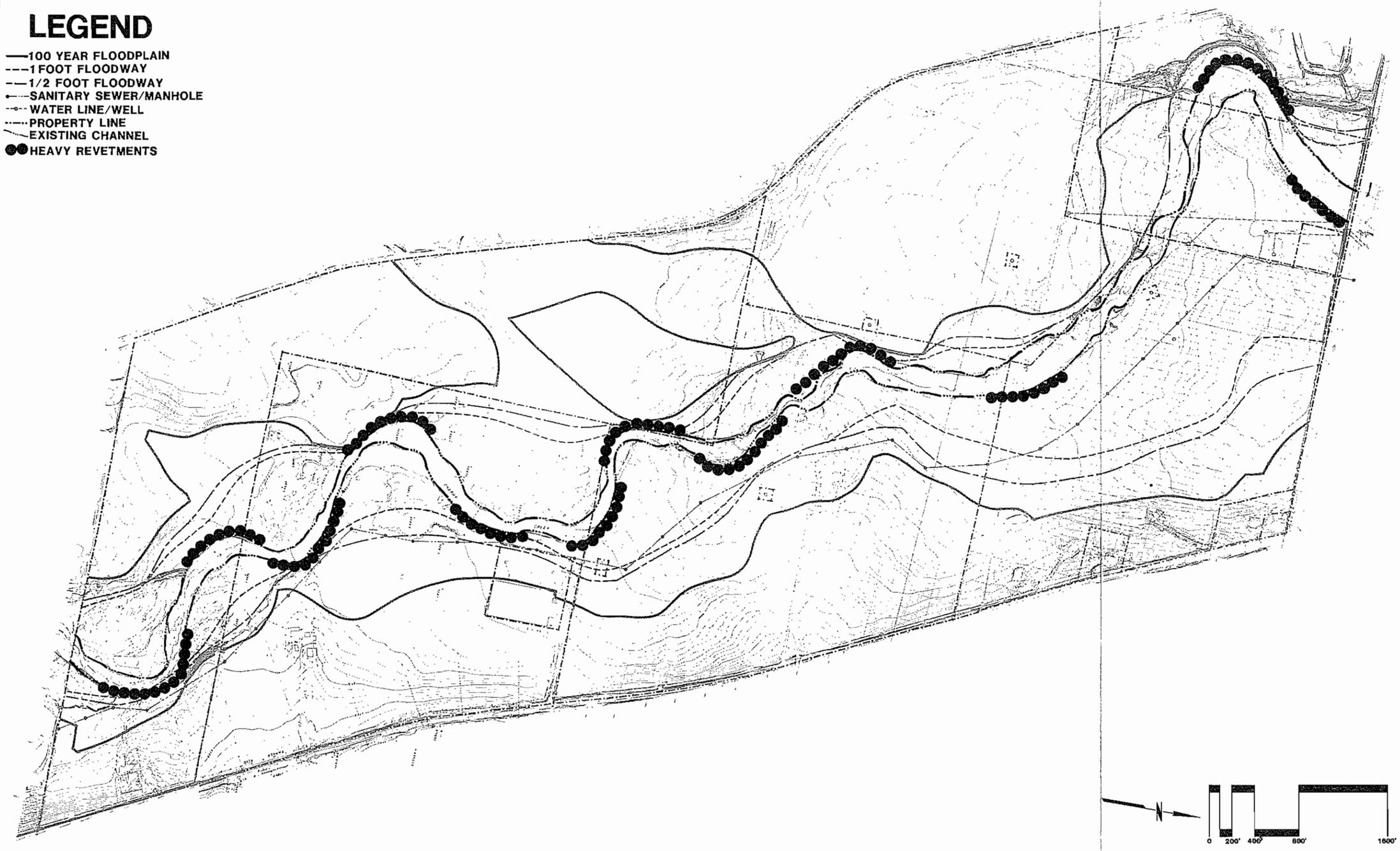
MEANDER BELT

PROJECT NUMBER

FIGURE NUMBER 7

LEGEND

- 100 YEAR FLOODPLAIN
- 1 FOOT FLOODWAY
- 1/2 FOOT FLOODWAY
- SANITARY SEWER/MANHOLE
- WATER LINE/WELL
- PROPERTY LINE
- EXISTING CHANNEL
- HEAVY REVETMENTS



N

0 200' 400' 800' 1600'

BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE BRW, INC. 7200 S. TUCSON SUITE 291 ENGLEWOOD, CO 80112	WRC ENGINEERING, INC. 1660 SOUTH ALBION STREET SUITE 500 DENVER, COLORADO 80222 (303) 757-6513	CHERRY CREEK BASIN STUDY	STABILIZE EXISTING ALIGNMENT	PROJECT NUMBER FIGURE NUMBER 8

LEGEND

- 100 YEAR FLOODPLAIN
- 1 FOOT FLOODWAY
- 1/2 FOOT FLOODWAY
- SANITARY SEWER/MANHOLE
- WATER LINE/WELL
- PROPERTY LINE
- PROPOSED CHANNEL
- LIGHT REVETMENTS

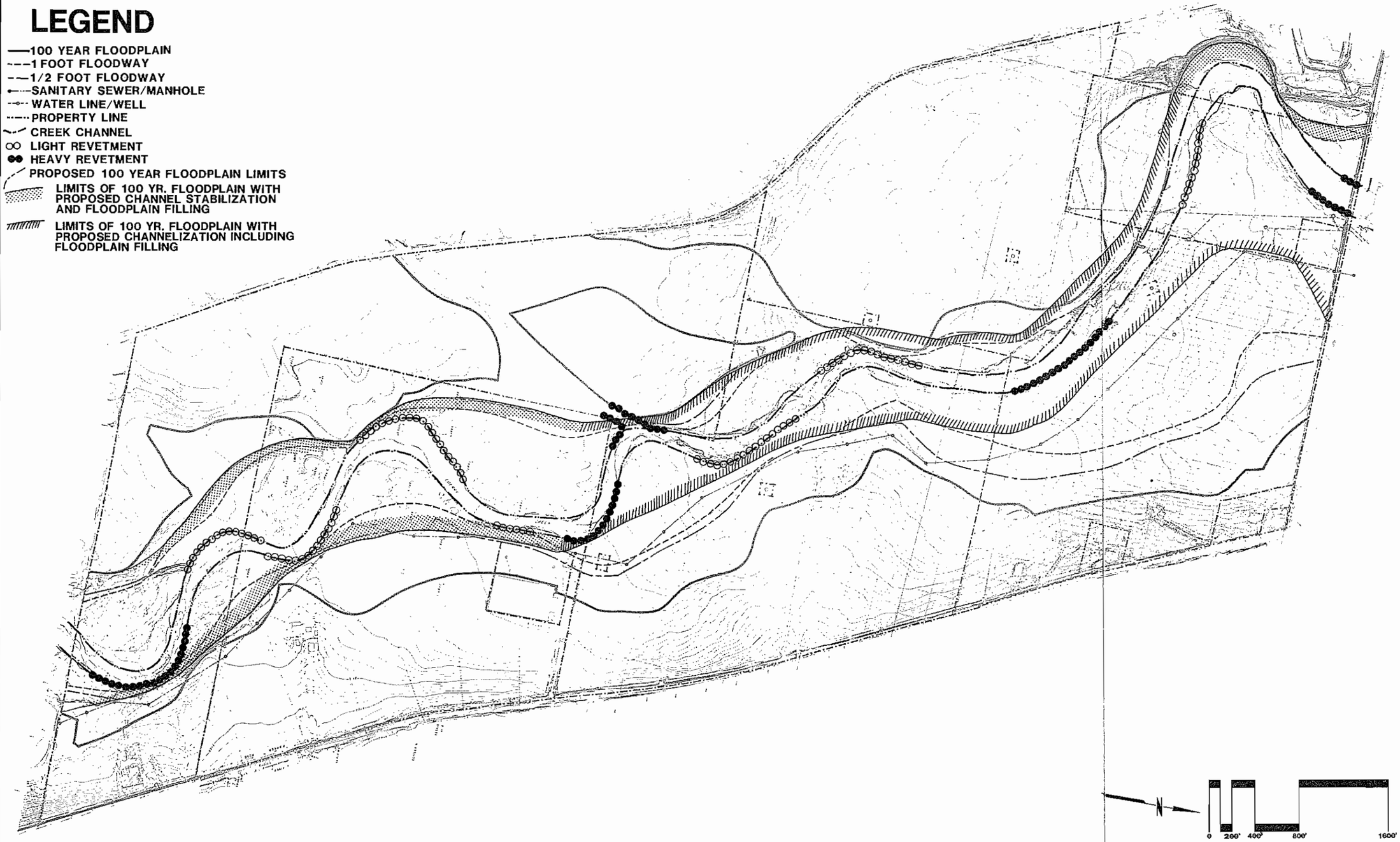
N

0 200' 400' 800' 1600'

BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE DENV. WC 7200 S. TUCSON WAY, STE 251, ENGLEWOOD, CO 80112	WRC ENGINEERING, INC. 1660 SOUTH ALBION STREET SUITE 500 DENVER, COLORADO 80222 (303) 757-8513	CHERRY CREEK BASIN STUDY	CONSTRUCT STABLE ALIGNMENT	PROJECT NUMBER	FIGURE NUMBER 9

LEGEND

- 100 YEAR FLOODPLAIN
- 1 FOOT FLOODWAY
- 1/2 FOOT FLOODWAY
- SANITARY SEWER/MANHOLE
- WATER LINE/WELL
- PROPERTY LINE
- CREEK CHANNEL
- LIGHT REVETMENT
- HEAVY REVETMENT
- PROPOSED 100 YEAR FLOODPLAIN LIMITS
- LIMITS OF 100 YR. FLOODPLAIN WITH PROPOSED CHANNEL STABILIZATION AND FLOODPLAIN FILLING
- LIMITS OF 100 YR. FLOODPLAIN WITH PROPOSED CHANNELIZATION INCLUDING FLOODPLAIN FILLING



0 200' 400' 800' 1600'

BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE
BRW, INC 7200 S TUCSON SUITE 201 ENGLEWOOD CO 80112

WRC ENGINEERING, INC.
1660 SOUTH ALBION STREET SUITE 500
DENVER, COLORADO 80222
(303) 757-9513

CHERRY CREEK BASIN STUDY

SELECTED ALTERNATIVE SCHEMATIC PLAN

PROJECT NUMBER

FIGURE NUMBER 10

LEGEND

- 100 YEAR FLOODPLAIN
- 1 FOOT FLOODWAY
- 1/2 FOOT FLOODWAY
- SANITARY SEWER/MANHOLE
- WATER LINE/WELL
- PROPERTY LINE
- A LIMITED ZONE
- B INTERMEDIATE ZONE
- C MAJOR ZONE
- D RENEWAL ZONE
- E BUFFER ZONE
- F INFILL ZONE
- G AMENITY ZONE
- H PRESERVATION ZONE
- I ACTIVITY ZONE
- J SLOPE STABILIZATION ZONE
- ACCESS POINT
- PATHWAY
- REVETMENT
- ZONE BOUNDARY
- PEDESTRIAN CROSSING

BRW PLANNING TRANSPORTATION ENGINEERING ARCHITECTURE
BRW, INC. 7218 S TUCSON SUITE 291 ENGLEWOOD, CO 80112

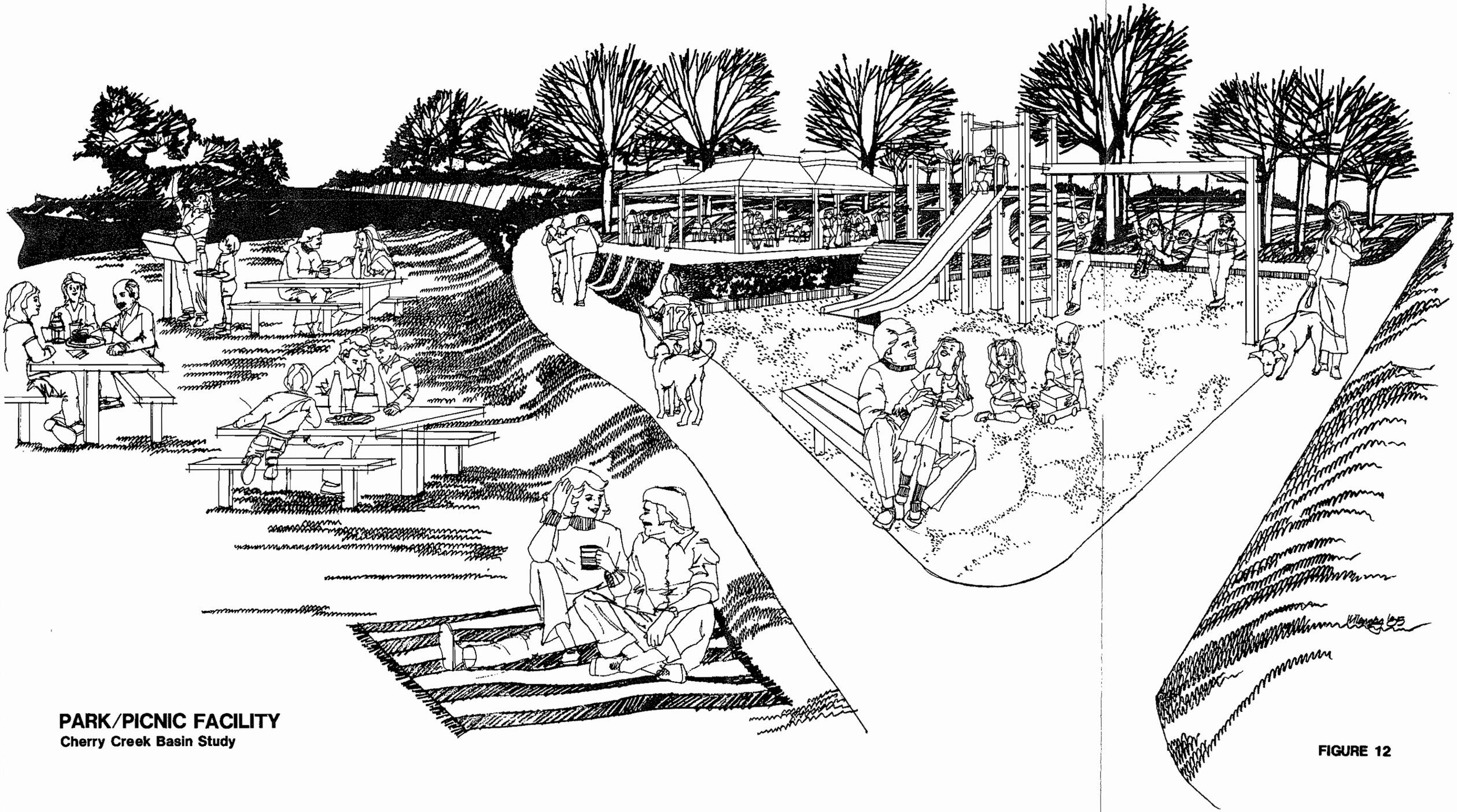
WRC ENGINEERING, INC.
1660 SOUTH ALBION STREET SUITE 500
DENVER, COLORADO 80222
(303) 757-8513

CHERRY CREEK BASIN STUDY

LANDSCAPE & RECREATION PLAN

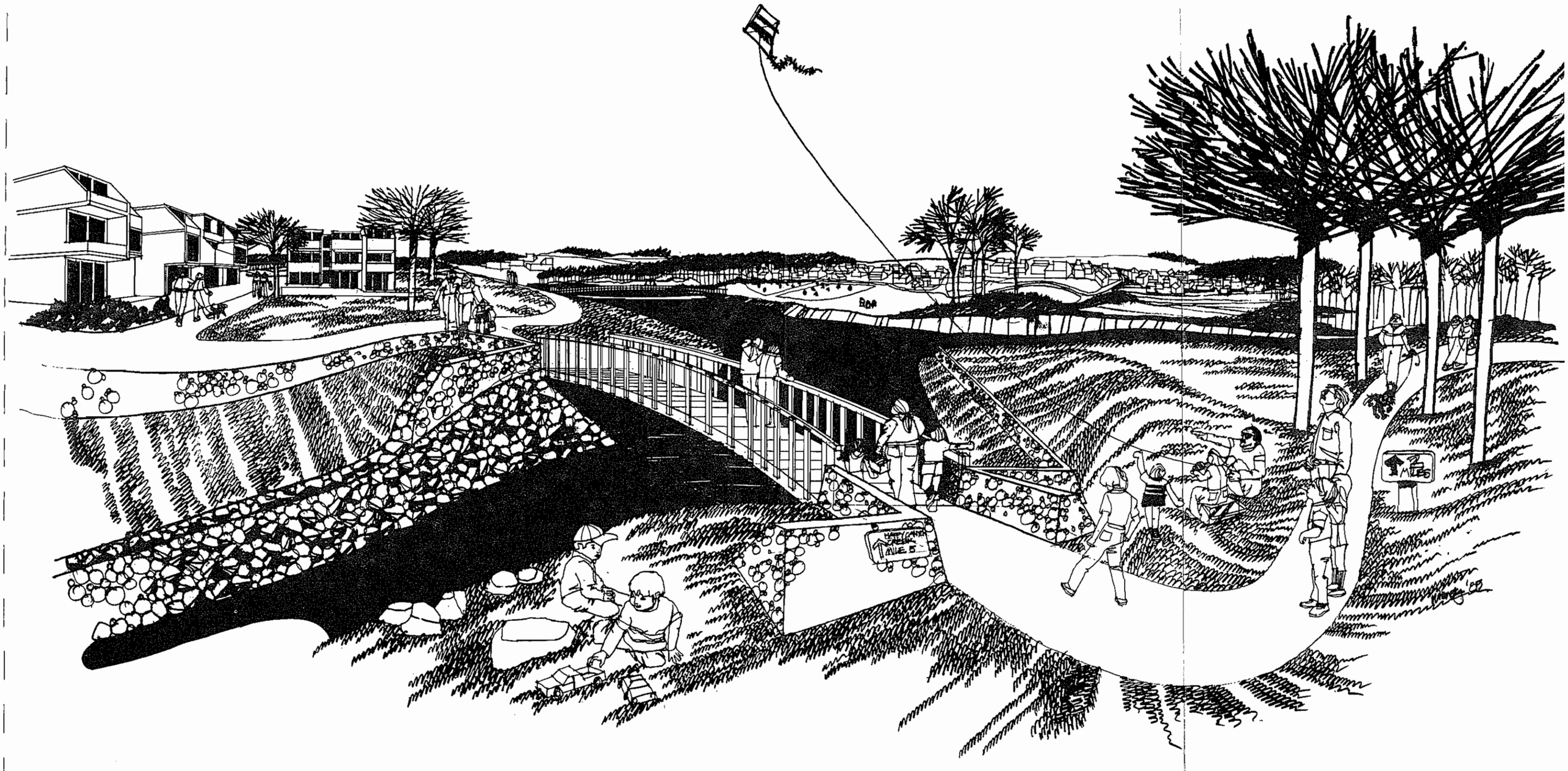
PROJECT NUMBER

FIGURE NUMBER 11



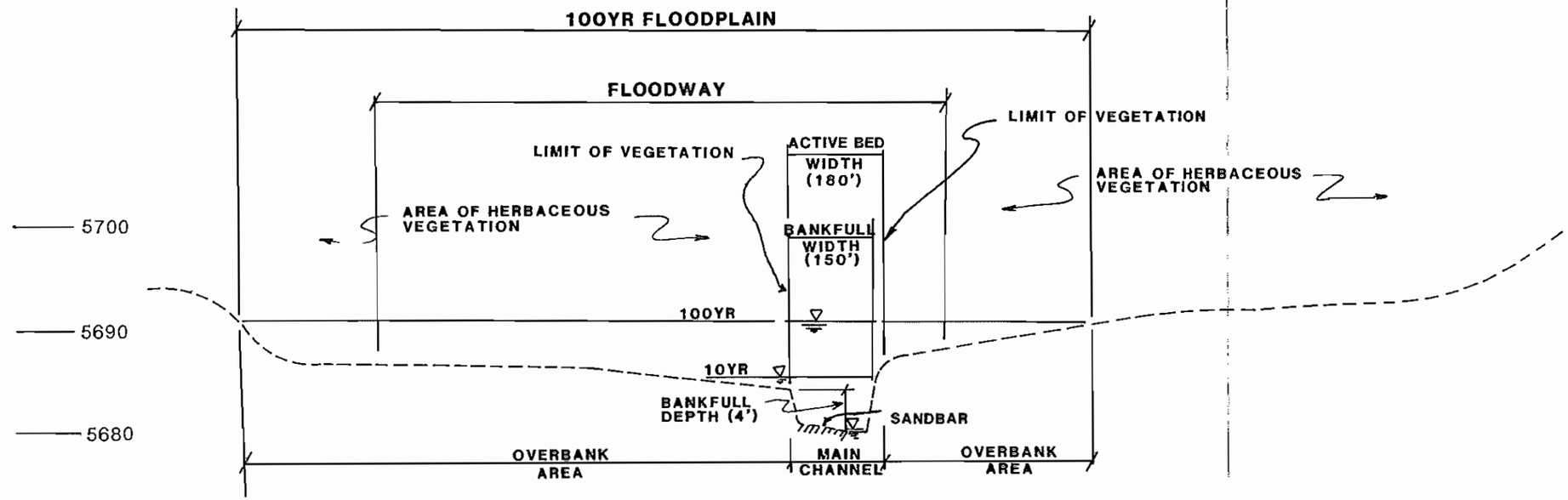
PARK/PICNIC FACILITY
Cherry Creek Basin Study

FIGURE 12

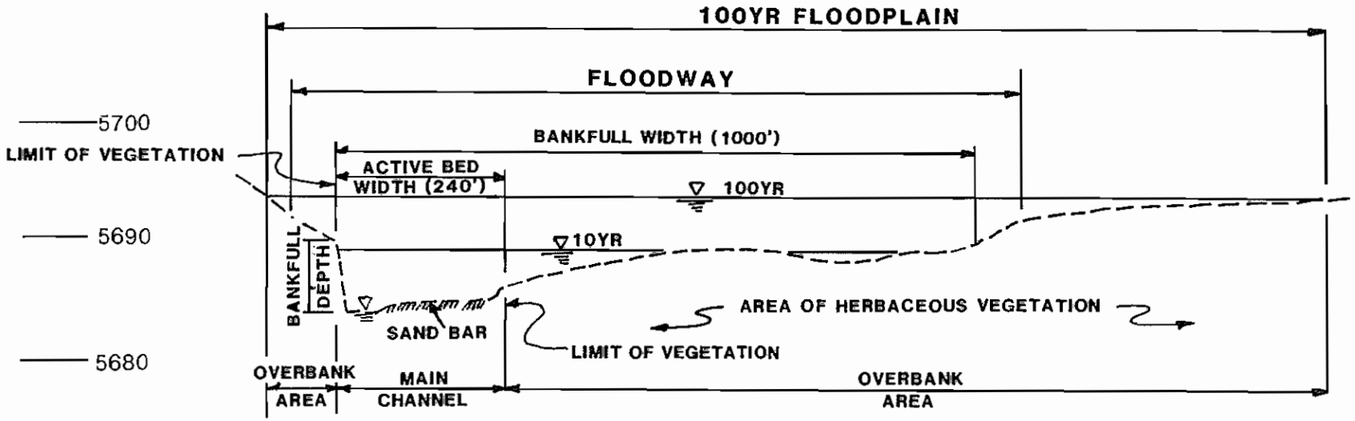


HAPPY CANYON CREEK CROSSING
Cherry Creek Basin Study

FIGURE 13



STA 116 - 00 - CURVE #5



STA 127 - 00 - CURVE #4

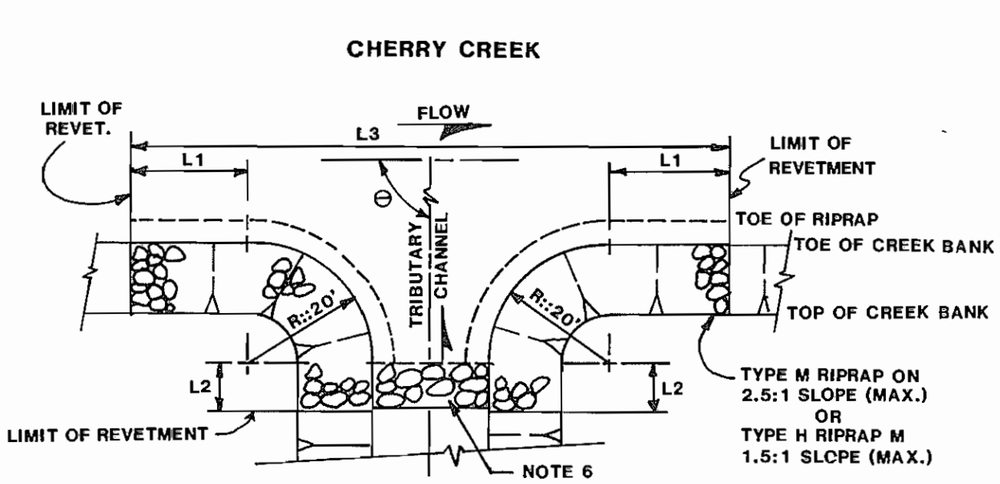
WRC ENGINEERING, INC.
1660 SOUTH ALBION STREET SUITE 500
DENVER, COLORADO 80222
(303) 757-8513

CHERRY CREEK BASIN STUDY

DEFINITION OF TERMS

PROJECT NUMBER

FIGURE NUMBER 14

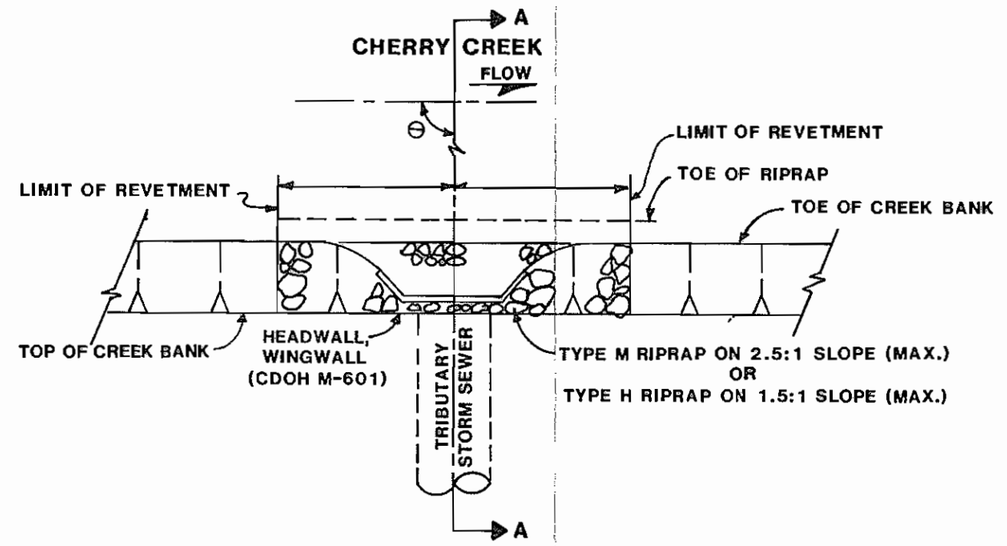


PLAN

NOTES:

1. L1 :: 10' MIN FOR INSIDE BEND OR CROSSING AREA OR :: 25' MIN FOR OUTSIDE BEND
2. L2 :: 10' MIN
3. θ :: 45° TO 90°
4. PROJECT OPPOSITE BANK OF CHERRY CREEK A DISTANCE OF L3
5. FOOT OF BRIDGE CROSSING AT TRIBUTARY CHANNEL MAY BE REQUIRED
6. 4.0' LAYER TYPE M RIPRAP

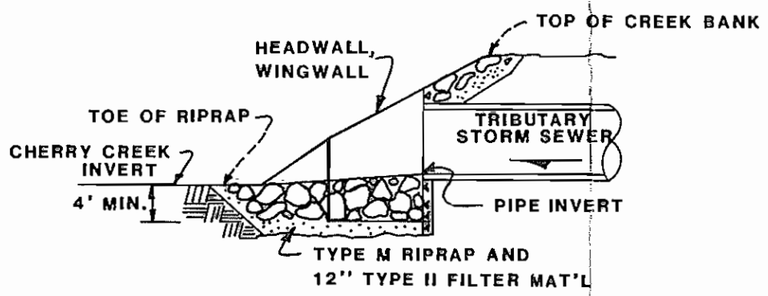
CHANNEL CONFLUENCE REQUIREMENTS



PLAN

NOTES:

1. L1 :: 15' MIN FOR INSIDE BEND OR CROSSING AREA OR :: 30' MIN FOR OUTSIDE BEND
2. θ :: 45° TO 90°
3. PIPE INVERT OF 18" ABOVE CREEK INVERT FOR INSIDE BEND AND CROSSING, OR AT INVERT FOR OUTSIDE BEND
4. PROTECT OPPOSITE BANK A DISTANCE OF 2 X L2



SECTION A-A

STORM SEWER CONFLUENCE REQUIREMENTS

BRW
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DENVER, COLORADO 80222
(303) 757-8513

CHERRY CREEK BASIN STUDY

CONFLUENCE REQUIREMENTS

PROJECT NUMBER

FIGURE NUMBER 15

APPENDIX - A

LIST OF BASIC DATA

BASIC DATA

1. August 3, 1984 letter from Law Engineering transmitting data for Cherry Creek North of Arapahoe Road.

   a. Topographic Mapping (1 sheet).
   B. HEC-2 computer printouts based on existing conditions and based on proposed improvements (2 computer printouts).
   C. Plots of cross section improvements (1sheet)

2. Eight blueline sheets of existing topographic maps and proposed grading plans for the Cottonwood project located upstream of the study reach.

3. Preliminary Final Plat for "Cherry Creek Business Center" (3 sheets)

4. Preliminary Plat "Country Club Executive Park" (1 sheet)

5. Zoning maps through the study reach (4 sheets)

6. Viehmann-Martin site plan (1 sheet)

7. Preliminary Construction Plans for Cherry Creek through Viehmann-Martin Site (5 sheets)

8. Reports

   A. Preliminary Drainage Study for the River Run Subdivision
   B. Preliminary Soil Investigation, Rich Center Project
   C. USDA Soil Survey, Arapahoe County, Colorado
   D. USDA Soil Survey, Castle Rock area, Colorado (Douglas County)
   E. Final Report "Stream Stability, Investigation, South Platte River, Chatfield Dam to Baseline Road", November 1983

F. "Flood Plain Information, Cherry Creek, Cherry Creek Lake through Franktown, Colorado, October 1976

G. Flood Hazard Area Delineation, Happy Canyon Creek, November 1976

9. Floodplain Report for Cherry Creek, Arapahoe Road to County Line, Greiner Engineering Sciences, Inc., 1984

10. Three grain size distribution graphs from Law Engineering

11. Original Mylar Maps

A. 1" = 200' original topographic mapping (1 sheet)

B. 1" = 100' original topographic mapping (3 sheets)

12. Aerial Photographs

A. October 1983, Aerial Photograph (1 sheet)

B. 1937 Aerial Photography (available 8/15)

C. 1964 Aerial Photography

13. Correspondance Files

APPENDIX - B
STUDY PARTICIPANTS

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Arapahoe County Engineering
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5334 South Prince
Littleton, CO 80166

Arapahoe County Engineering
Mr. Dave Schmidt
5334 South Prince Street
Littleton, Colorado 80120

Arapahoe County Planning Department
Mr. Ed Clark
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Littleton, CO 80120

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Northglenn, CO 80234

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Aurora, CO 80012

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Aurora, CO 80014

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Colorado Department of Highways - District 1
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District Engineer
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Division of Wildlife
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Hutkin Development
Mr. David Hutkin
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Mr. Ralph S. Perkins, Jr. and
Mr. William L. Coyle and
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Aurora, CO 80015

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Mrs. Gunhild R. Dransfeldt
Mr. Fred Dransfeldt
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Parker, CO 80134

Quadanska Ltd.
Nancy Hopf
1650 Washington
Denver, CO 80203

Rich Center Joint Venture
P.O. Box 1113
Englewood, CO 80150

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Mr. Melvin Rich
15290 East Arapahoe Road
Aurora, CO 80016

Saunders Construction, Inc.
Ms. Bonnie Cook
3013 S. Robin Way
Denver, CO 80222

Stanley A. and Ethel R. Schumn
1308 Rollingwood
Fort Collins, CO 80521

Strafet Designs/Originals by Josie
Mr. John R. Fetters
Joanne Dransfeldt Fetters
P.O. Box 20115
Denver, CO 80220

Tagawa Rose Farms, Inc.
7711 S. Parker Road
Aurora, CO 80016

Turnmar Development
Mr. Kirk Proctor
Jordan Road Limited Partnership
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Englewood, CO 80112

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Broomfield, CO 80020

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Mr. Scott Tucker
2480 West 26th Avenue, Suite 1560
Denver, CO 80211

Ms. Marguerite A. Vaughn
5976 D. Bannock Street
Littleton, CO 80120

Viehman, Martin and Associates
Mr. Joe LeDuc
2402 East Arizonia Biltmore Circle
Phoenix, Arizona 85016

Viehman, Martin and Associates
Mr. Ronald Loser
3333 S. Bannock #690
Englewood, CO 80110

The Bill Walters Companies
Mr. Pete Kost
Mr. David Ray
Mr. John Beauparlant
Ms. Molly Thomasch
7951 East Maplewood, #300
Englewood, CO 80111

Water Quality Control Division
4210 East 11th Avenue
Denver, CO 80220

Woodco Partnership
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Denver, CO 80209

WRC Engineering
Mr. A. S. Andrews
Mr. Bill Ruzzo
1660 South Albion Street, Suite 500
Denver, Colorado 80222

APPENDIX - C
TAC MEETING MINUTES

MEETING MINUTES
CHERRY CREEK BASIN STUDY

September 6, 1984
Arapahoe County Engineering Department Offices

Agenda for the meeting is attached along with the roster of those in attendance at the meeting.

Project Manager Lande advised the group as to work done to date.

- Mr. Stevens has walked the study area and gathered samples of sediment.
- Project Team is working on streamflows.
- Project Team is working on stereo photography of the 1964, 1971, and 1978 floods on Cherry Creek.
- Project Team is gathering stream gaging data to determine if the stream is in an aggradation or degradation status.
- A program bar chart was passed out. A copy of said bar chart is included in these meeting minutes.

Team requested certain additional information, the plotting of the HEC-2 cross-sections and printouts of cross-sections for other frequencies. These will be provided by Greiner Engineering at cost.

- The Team requested the property ownership map which was given to us at the meeting. The map we received in entitled "Parker Jordan Metropolitan District Service Plan" as prepared by Kirkam Michael & Associates.
- In data provided to the study team by Greiner several weeks ago, there was a reference to the report prepared by Dr. Stevens at an earlier date. The team was unable to locate said report and Steve Prokopiak said this had not been given to us since Grenier Engineering assumed Mr. Stevens already had a copy of his own report.

- The request regarding land values in the study area for our damage analysis was resolved as follows: BRW will transmit a separate letter to each landowner requesting the dollar value they desire to use for the study. We fully understand the land values given by the property owners will be a function of land use and should be determined in terms of the property being totally built out but then backed into 1984 dollar values.

- There was discussion regarding land values and specifically what baseline value should be used in the determination of the benefit-cost analysis. Specifically there was a discussion on the effects of the damage analysis with respect to Arapahoe Road. Arapahoe Road certainly has a potential impact on the determination of the baseline cost with respect to damages, since any modification of the bridge or elevation of the roadway would impact the overall flood plain.

- It was determined that the study team would contact Mr. Steve Prokopiak of Greiner on any questions relating to damages and development of the benefit-cost ratio.

- An additional item of information necessary will be that of the determination of the discount rates to be used for the damage analysis on land values. It is understood that the Walters Companies will be providing the discount rates for us.

The Work Program for the next two weeks.

- The team will continue the evaluation of the flood hazard and the status quo damages.

- The team will continue its efforts in gathering data from the Highway Department, from the State Engineer's Office in terms of wells and water rights, in terms of Arapahoe Water and Sanitation District, in terms of the soil conservation service, and in terms of the corps of engineers. We concluded that all contact with the Corps of Engineers should be done through Mr. Scott Tucker of the Urban Drainage and Flood Control District.

- There was extensive discussion regarding FEMA and whether or not as a result of this study changes would have to be made to the FEMA flood plain limits. Mr. Prokopiak indicated that Greiner Engineering has asked for a LOMA on the River Run Subdivision asking that the Corps of Engineers flood plain be concurrent with the FEMA flood plain through this area. It is hoped that a similar situation can result from the Cherry Creek Basin Study.

- It was indicated that FEMA will receive minutes of all project meetings for reference and that no specific contacts need to be made with FEMA representatives at this time.

A question was raised by Mr. Randy Krueger of Black and Veach who was at the meeting representing the Arapahoe Water and Sanitation District. Mr. Krueger's question is--How is the water quality being analyzed from the 208 point of view. Mr. Ruzzo answered the question as follows:

- This study will address stabilizing the aggradation/degradation of the Cherry Creek and as a result of the stabilization we should improve the water quality.

- From an individual development standpoint, the County has been designated as the administrator of non-point source solutions. A separate Douglas/Arapahoe County currently is being done.

A question from the Representative of Law Engineering--To what extent will tributaries be studied? The answer was that we will meet the vertical grades and horizontal alignment of the tributaries in the design but it is not the intent of the study to analyze the tributary streams.

A second question by Representative of Law Engineering--On sediment studies will an analysis be made to determine the depth of the erosion potential? The answer was that the study team will address general local scour.

A third question by Representative of Law Engineering--How far will the study go towards determining earthwork quantities? Channelization is certainly one alternative to be studied by the team but, it is not the intent of this analysis to determine overall earthwork quantities.

Study Team received as part of the land ownership map, a listing of all property owners within the study area. Mr. Lande will prepare and transmit a letter to all property owners asking for the land values they expect to use for purposes of the study.

The next meeting will be held at the Arapahoe County Offices, September 20, 1984 at 3:00 p.m.

CHERRY CREEK BASIN STUDY
AGENDA
SEPTEMBER 6, 1984

1. Introductions

2. Work To Date

   A. Sedimentation Studies

      - USGS Data
      - Stereo Photos 1964, 1971, 1978
      - Gaging Data

   B. Outline Steps of the Program

3. Request for Additional Information

   A. Plotting of HEC-2 Cross Sections
   B. Printouts for Other Frequencies
   C. Property Owners Map
   D. Stevens' Report
   E. Land Values for Damages Analysis

4. Work Program for Next Two Weeks

   A. Evaluation of Flood Hazard and Status Quo Damages

   B. Continued Agency Contact

      - CDOH
      - State Engineer's Office
      - Arapahoe Water and Sanitation District
      - SLS
      - Corps of Engineers
      - USGS
      - FEMA
      - Other

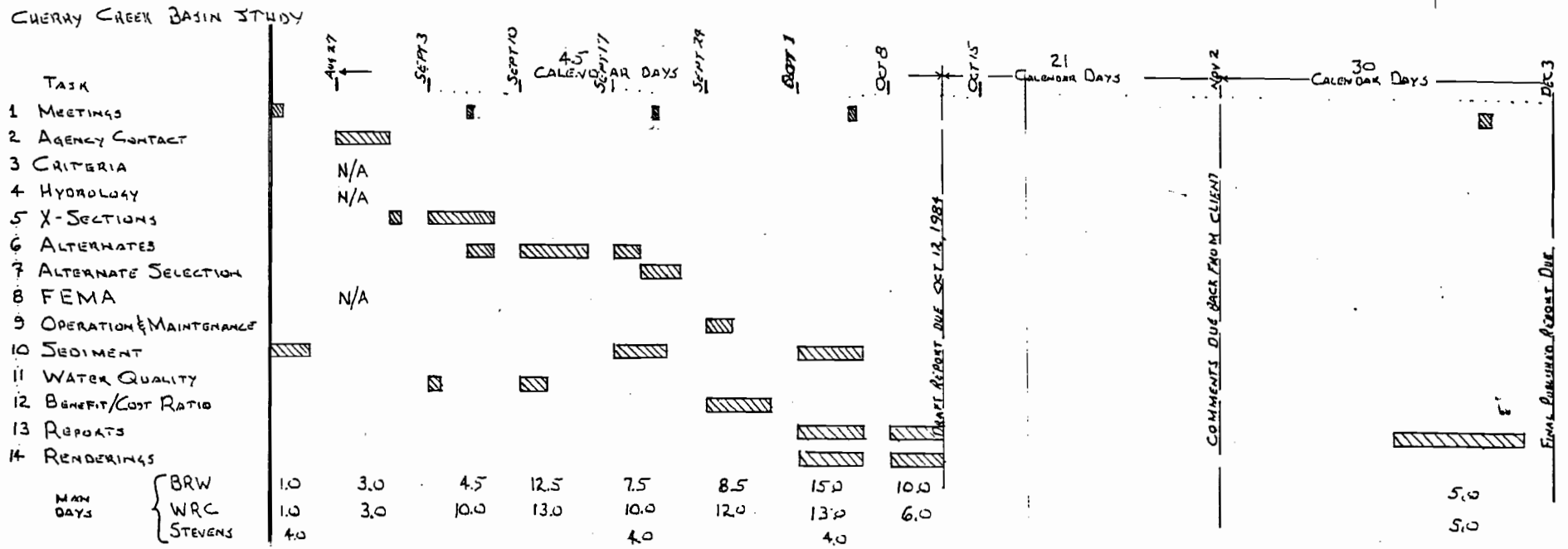
5. Other

   A. Purchase Order for Invoice

6. Next Meeting

   September 20, 1984
   3:00 p.m.
   Arapahoe County

CHERRY CREEK BASIN STUDY



	Task								
1	Meetings								
2	Agency Contact								
3	Criteria		N/A						
4	Hydrology		N/A						
5	X-Sections								
6	Alternates								
7	Alternate Selection								
8	FEMA		N/A						
9	Operation & Maintenance								
10	Sediment								
11	Water Quality								
12	Benefit/Cost Ratio								
13	Reports								
14	Renderings								
Man Days	BRW	1.0	3.0	4.5	12.5	7.5	8.5	15.0	10.0
	WRC	1.0	3.0	10.0	13.0	10.0	12.0	13.0	6.0
	Stevens	4.0				4.0		4.0	

5.0
5.0

MINUTES
CHERRY CREEK BASIN STUDY

September 20, 1984

1. Mr. Lande reviewed Work-to-Date, as per the agenda.

2. Mr. Ruzzo discussed problems with the Corps of Engineers base data for modeling the Cherry Creek floodplain. The Corps had improperly sized the Arapahoe Road bridge opening. WRC modified the input data and re-ran the HEC-2 model. There is minimal effect due to the change, lowering the 100-year flood level by up to ½ foot for 100-200 feet upstream.

   By increasing the Arapahoe bridge span to 300 feet, 100-year floodplain levels would be lowered by one foot for 300-400 feet upstream. CDH used a 100-year flood flow of 37,000 cfs rather than the projected 100-year flow of 50,000 cfs used by the Corps.

3. Mr. Ruzzo discussed the results of Steven's sediment study. The movement of the channel has been considerable over recent history. The bed is uniform sands which are quite mobile. Stevens feels that if the channel is excavated for capacity, the bed will fill up once again.

4. Mr. Ruzzo described possible project alternatives:

   a. Floodplain Zoning
   b. Selected Structural--fill to reclaim some lands with bank revetments in critical areas
   c. Selected Structural Plus Levees--revetments in critical areas with levees to minimize flood hazards
   d. Selected Structural, Levees, and Selected Realignment -- more emphasis on creek channel realignment
   e. Excavation for Capacity--revetments, excavation of channel, and "armor-plating" of bed; channel will refill with sediment
   f. Realignment With Concrete Banks--channel will degrade

   These alternatives increase in project cost and floodplain reclamation benefits.

5. Several questions were put forth on how the alternatives will be applied to specific reaches. The specific mix of alternatives will be discussed at the next meeting.

   What if nothing is done? The channel will continue to move horizontally. If the movement is within the floodplain, it may or may not be an acceptable solution.

   What would be downstream effects of excavation and concrete banks? Heavy sedimentation downstream would occur.

   What would be the effects of increasing the bridge span and straightening the channel just upstream? Flood levels could increase downstream.

   Will the report consider maintenance responsibilities/costs? The report will establish costs, and the client will discuss responsibility.

6. The representative from Urban Drainage stated that levees are considered poor public policy. There is a burdensome maintenance responsibility with levees.

7. The representative from Viehmann-Martin stated that excavation would be preferable for their property to reduce the floodplain area.

8. Mr. Lande discussed the potential Dry Creek Road crossing of Cherry Creek. The best guess location is the Jamison Road R.O.W. in River Run. Property owners in this area will meet to provide input on the crossing for this study.

9. The next meeting was set for October 11, 1984, at which time the alternative projects by reach will be discussed. Another meeting will be held October 18, 1984, to further evaluate alternatives.

ATTENDEES
CHERRY CREEK BASIN STUDY

September 20, 1984

Bill Ruzzo, WRC Engineering
Don Hunt, BRW
Kent Lande, BRW
Stephen Prokopiak, Greiner Engineering
Ronald Losen, Viehmann-Martin
Gunhild Dransfeldt, Quadanska
Daniel Murdock
William Bahr
Bill DeGroot, Urban Drainage
Pete Kost, Walters
Bill Rothenmeyer, Arapahoe County
Gray Pierson

AGENDA
CHERRY CREEK BASIN STUDY

September 20, 1984

1. INTRODUCTIONS

2. REVIEW OF MINUTES OF SEPTEMBER 13, 1984

3. WORK DONE TO DATE

   A. LETTERS WERE SENT TO ALL PROPERTY OWNERS REQUESTING LAND VALUES. TO DATE NO RESPONSE HAS BEEN RECEIVED.

   B. WE HAVE RECEIVED FROM WALTERS CO. THE INTEREST RATE OF 10% TO BE USED AS COST OF MONEY IN ALL COMPUTATIONS FOR THE CHERRY CREEK BASIN PROJECT.

   C. WE HAVE RECEIVED FROM GREINER ENGINEERING SCIENCES, INC. PLOT OF ALL THE CROSS-SECTIONS FOR THE 100-YEAR STORM THAT ARE ADEQUATE FOR OUR USE TO COMPLETE TASK 5. WE HAVE OBTAINED RUNS FOR THE 10-YEAR AND 50-YEAR FREQUENCY AS PART OF TASK 5. DURING OUR EVALUATION OF THE CROSS-SECTIONS WE HAVE DETERMINED THAT THE BACKWATER CURVE THAT THE CORPS OF ENGINEERS USED AT THE BRIDGE IS NOT ENTIRELY CORRECT AND WE ARE CURRENTLY REWORKING THIS DATA BY USING SEVERAL ADDITIONAL DOWNSTREAM CROSS-SECTIONS AND THEN PROCEEDING UPSTREAM. THIS TENDS TO ~~RAISE~~ LOWER THE WATER ELEVATION APPROXIMATELY 0.5 FEET FOR A SHORT DISTANCE UPSTREAM AS A RESULT OF THE DISCREPANCY IN THE CORPS OF ENGINEER DATA. WE CURRENTLY FEEL THAT TASK 5 HAS BEEN COMPLETED.

   D. WE HAVE RECEIVED DATA RELATIVE TO THE PROJECT FROM BOTH THE ARAPAHOE WATER AND SANITARY DISTRICT AND THE COLORADO DEPARTMENT OF HIGHWAYS. WE CURRENTLY FEEL THAT TASK 2 IS 90% COMPLETE.

   E. WE ARE CURRENTLY PLATTING PLANS AND PROFILES, DEFINING THE VARIOUS REACHES BOTH BY PROPERTY OWNERSHIP AND BY STREAM CONFIGURATION AND WE ARE COMPLETING THE SEDIMENTATION ANALYSIS. WE HAVE HELD THREE SEPARATE MEETINGS WITH MR. AL STEVENS AND HAVE THE GRADIATION ANALYSIS. CURRENTLY WE ARE WORKING WITH MR. STEVENS ON STREAM ALTERNATIVES AS A RESULT OF HIS SEDIMENTATION ANALYSIS.

4. ITEMS FOR DISCUSSION

   A. ALTERNATIVES

      1. DO NOTHING

      2. DEVELOP A NATURAL SELF-STABILIZING CREEK
         STABLE CHANNEL, BENDS, ETC. WITH ARMOR PLATE ONLY AT CRITICAL BANKS. USE THE NATURAL FORCE OF THE CREEK TO ESTABLISH A CHANNEL.

      3. PARTIAL INFRINGEMENT INTO THE FLOODWAY

      4. TOTAL INFRINGEMENT INTO THE FLOODWAY

      5. OTHER

B. CONSULTANT DESIRES DISCUSSION AND DIRECTION REGARDING STATUS OF THE DRY CREEK CROSSING PER THE 1982 AIA TRANSPORTATION STUDY.

C. FOR INFORMATION ONLY

DELAYS ENCOUNTERED TO DATE:
USGS--ACQUISITION OF DATA
CORPS OF ENGINEERS--APPRECIABLE DISCREPENCIES BETWEEN CORPS OF ENGINEERS BRIDGE SECTION AND DATA THE CONSULTANT IS CURRENTLY USING
LAND VALUES (POTENTIAL DELAY)
SEDIMENT ANALYSIS--OTHER COMMITMENTS OF MR. AL STEVENS' TIME

5. CONSULTANT'S EVALUATION OF WORK COMPLETED TO DATE

TASK NUMBER	% COMPLETE
1	33%
2	90%
3	--
4	--
5	100%
6	33%
7	10%
8	0%
9	0%
10	40%
11	0%
12	0%
13	0%
14	0%

6. OTHER ITEMS

10/25 ~~AHA~~
WR

CHERRY CREEK BASIN STUDY
MEETING MINUTES

October 18, 1984

I. INTRODUCTION

A. Don Hunt of BRW reviewed the purpose of the meeting--to evaluate design options for the Cherry Creek Basin, and to begin formulation of an overall Comprehensive Plan for drainage. Each of the attendees indicated whom they were representing.

B. Participants:
Bill Ruzzo; WRC Engineering
Don Hunt; BRW, Inc.
Bob Berryhill; Turnmar
Gray Pearson; Law Engineering
Stephen Prokopiak; Greiner Engineering
David Bowles; Law Engineering
Rich Horstmann; Water Quality Control, Colorado Department of Health
Bill DeGroot; UDFCD
John Crowley; Dransfeldt
Don Paul; Viehmann-Martin
Joe LeDuc; Viehmann-Martin
Pete Kost; Walters
Fred Dransfeldt
Gunhild R. Dransfeldt
Bill Rothenmeyer; Arapahoe County Engineering Department

II. SEDIMENTATION ANALYSIS

A. Bill Ruzzo of WRC reviewed the sedimentation analysis (Section II of Agenda).

III. ALTERNATIVES

A. Mr. Ruzzo discussed potential project objectives, design options, and alternative plans, as per the agenda and handouts.

B. Questions/Answers

1. Q: How many acres are reclaimed by Plan #1?
   A: The areas have not yet been computed. The areas will be determined for use in the meetings with individual owners.

2. Q: What would be the design requirements of the potential Dry Creek crossing?
   A: The bridge and fill for the approaches would have to respect the ½ foot floodway.

3. Q: Could channelization be extended to Reach B?
   A: It could be, if desired by property owners. It will depend on the upcoming property owners meetings.

4. Q: What will be the sedimentation impacts downstream, including the Cherry Creek Reservoir?
   A: Qualitative sedimentation impacts will be described in the report. Under Plan #4, sediment transport to the Reservoir could be reduced.

5. Q: How does the Study relate to control of non-point source runoff quality?
   A: The Study will address the issue in a general way. Arapahoe County is developing design criteria for site runoff quality control.

IV. FUTURE PROJECT TASKS

1. BRW and WRC will meet with individual property owners during the week of October 22.

2. Based on property owner input and if overall plan concensus can be achieved, a Draft Report will be issued for review. If plan concensus cannot be reached through individual meetings, another advisory committee meeting will be scheduled prior to issuance of a Draft Report.

CHERRY CREEK BASIN STUDY
AGENDA

October 18, 1984

I. INTRODUCTION

A. Participants

B. Alternatives Phase:
define, evaluate & select

C. IDENTIFY FEATURES ON MAP

II. SEDIMENTATION ANALYSIS SUMMARY

A. Regimes – water below ground

1. less mobile creekbed (200' to 300' width)
REACH A: Station 0 + 00 (Arapahoe Rd.) to 88 + 60

2. more mobile creekbed (800' to 900' width)
REACH B: Station 88 + 60 to 173 + 00 (County Line)

B. Creek Bed in general state of bed stability (longitudinal profile) -- subject to severe local scour, but generally fills back up to same level.

C. Bed material is uniform throughout (d_{50} = 0.6 mm) consisting of medium sand, subject to high local scour.

D. Bank Materials

1. sandy -- alluvial soils -- erosive

2. calcereous clay and sand terrace -- errosive resistant

E. Suspended Sediment

sediment yield at Cherry Creek Reservoir = 175 AF/year
(600 tons/sq. mile/year at 60 pcf) – high yield basin

F. SUMMARY

- horizontal movement will continue
- bed profile ~~with~~ subject to change but stable
- high maint. potential

OVERALL APPROACH
1 - Many options
2 - Narrow options
3 - formulate plans

III. ALTERNATIVES

A. Potential Project Objectives

1. to minimize impact of eroding creek bed on property

2. to formulate a comprehensive drainage plan for the basin consistent with development objectives

3. to minimize costs, both capital and maintenance

B. Options for Stable Creek Bed

"A" Meander Belt (do-nothing) -- allowed to move within designated area (status-Quo)

"B" Stabilize Existing Alignment -- heavy revetments required in some areas

"C" Construct Stable Alignment -- requires excavation and light revetments

C. Options for Increasing Land Utilization

"D" Flood Fringe Filling -- ½ Ft. Floodway

"E" Flood Fringe Filling -- 1 Ft. Floodway and split flow analysis -- requires special approval by County and UDFCD

"F" Arapahoe Road Bridge Enlargement (200' Extension)

"G" Arapahoe Road Bridge Replacement (raise over floodplain)

"H" Excavation to Contain Flood (Earth Banks) -- requires drop structure to stabilize flow

"J" Excavation to Contain Flood (Hardlined Banks) (i.e.: concrete, timber wall, etc.) -- requires drop structure to stabilize flow

"K" Levees to Contain Flood

D. Option Discussion and Elimination

1. "F" -- Bridge Enlargement -- hydraulic analysis indicates minimal inpact (i.e. lowers flood profile ½ foot for 200 to 300 feet).

2. "G" -- Bridge Replacement -- estimated cost 4.0 million dollars -- significant downstream impact

3. "J" -- Excavation with hard lined banks -- considerable additional cost over option "H" with little increase in benefits.

4. "K" -- Levees -- creates local drainage problem and requires special acceptance by County, UDFCD & FEMA

E. Alternative Plan Combinations
MIXING OF ALTERNATIVES

Plan 1 -- Option A & D or E (Meander Belt and Fill to Floodway)

Plan 2 -- Option B & D or E (Stabilize Existing Alignment and Fill to Floodway)

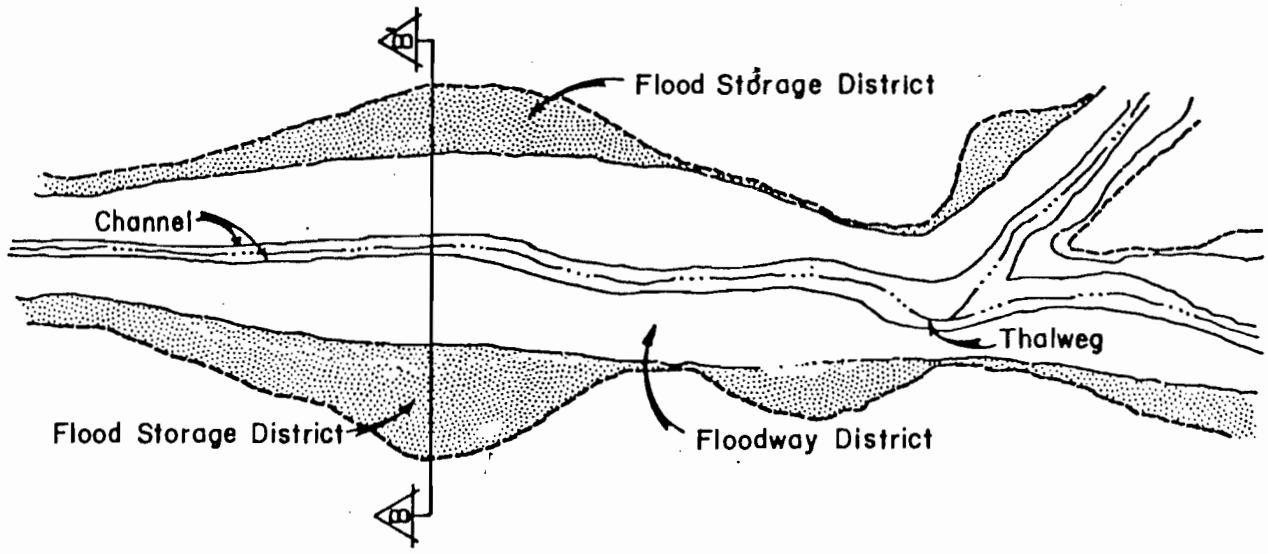
Plan 3 -- Option C & D or E (Construct Stable Channel and Fill to Floodway)

Plan 4 -- Option H for Reach A, plus Plan 1, 2, or 3 for Reach B (Excavate to Contain Flood in Reach A)
Ex of maximum reclamation of land

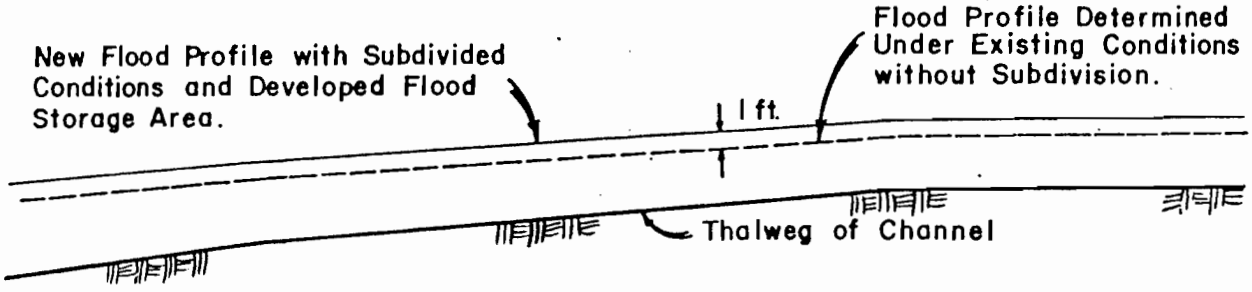
IV. FUTURE PROJECT TASKS

A. Alternative Selection (Individual Meetings)

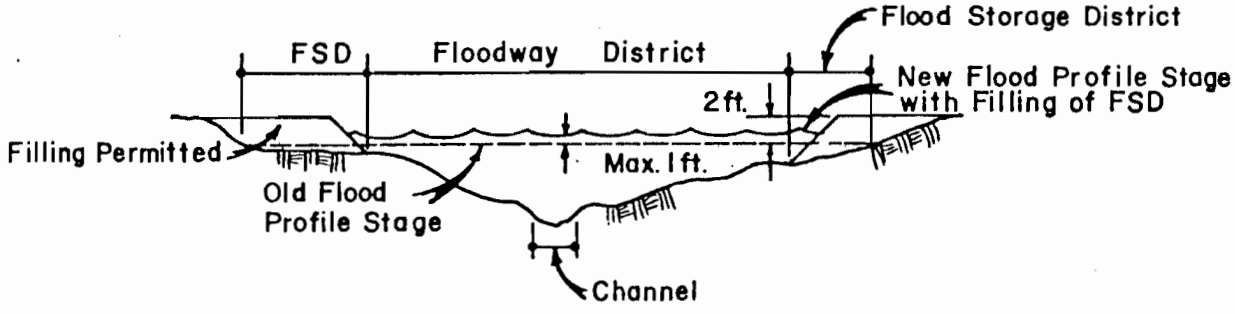
B. Draft Report



PLAN



PROFILE



SECTION B-B'
CROSS SECTION

GRAPHIC REPRESENTATION OF

FLOOD PLAIN REGULATION

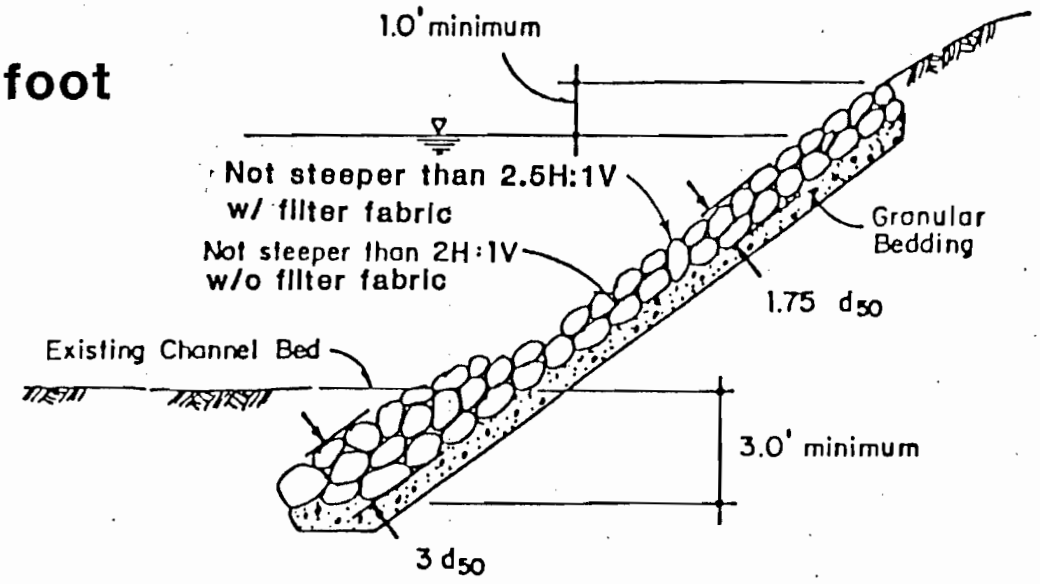
FLOOD REGULATORY DISTRICT
FLOODWAY DISTRICT
FLOOD STORAGE DISTRICT

FIGURE 8-1

LIGHT REVETMENTS

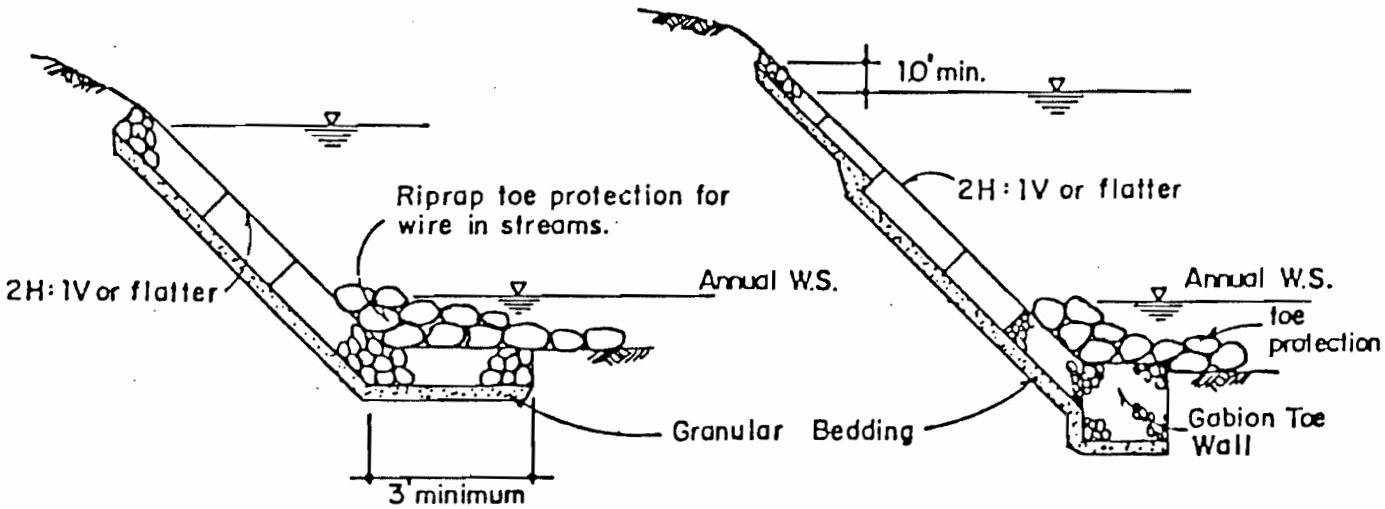
TYPE 'A'

$155/lineal foot



TYPE 'B'

$210/lineal foot



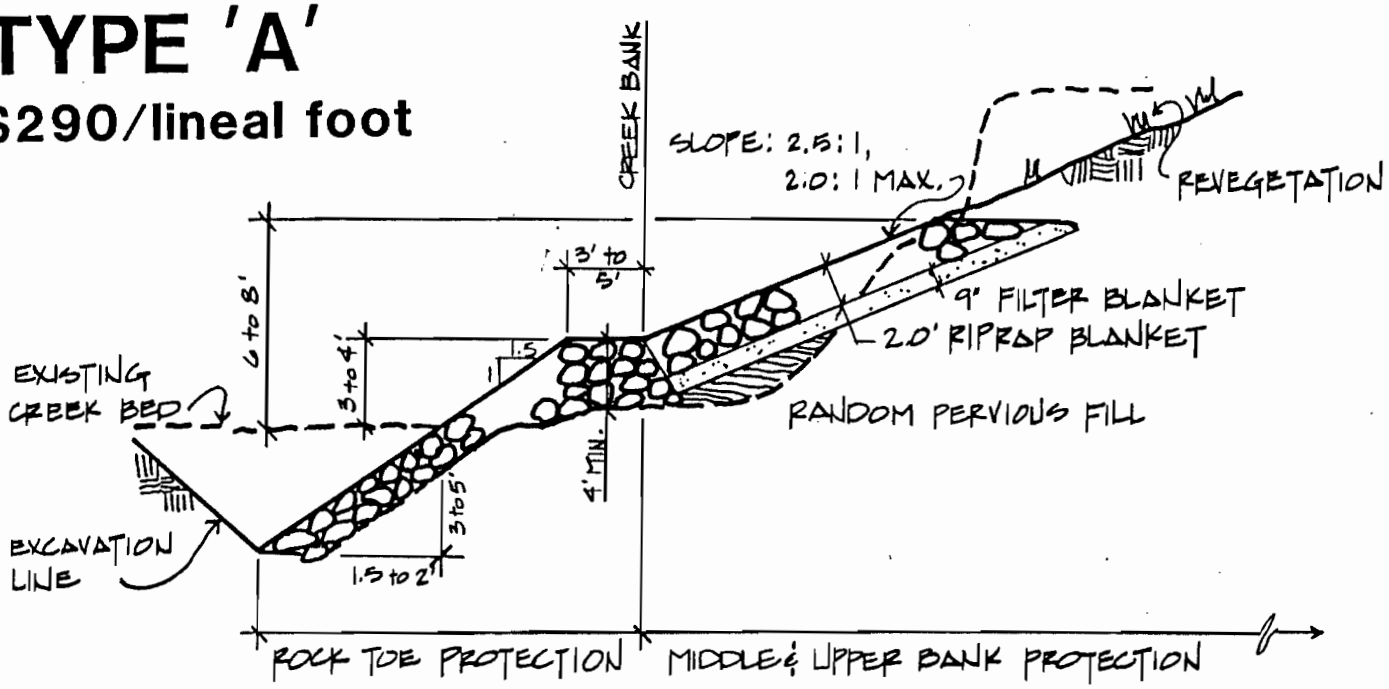
BRW
PLANNING
TRANSPORTATION
ENGINEERING
ARCHITECTURE
BRW INC. 7208 S. TUCSON SUITE 291 ENGLEWOOD, CO 80112

WRC
CONSULTING ENGINEERS
WATER AND
LAND RESOURCES

HEAVY REVETMENTS

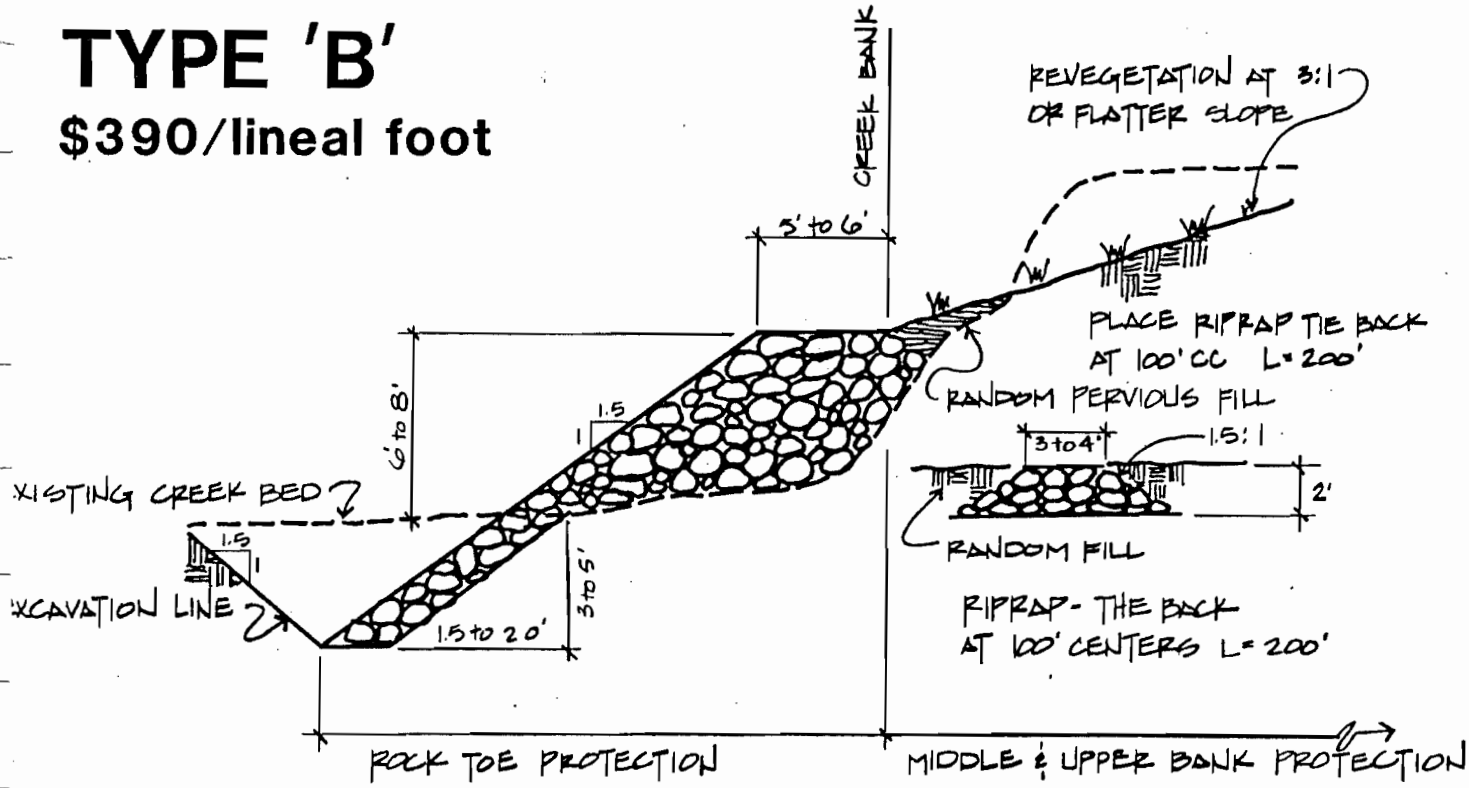
TYPE 'A'

$290/lineal foot



TYPE 'B'

$390/lineal foot



BRW
PLANNING
TRANSPORTATION
ENGINEERING
ARCHITECTURE
BRW, INC. 7208 S. TUCSON SUITE 291 ENGLEWOOD, CO 80112

WRC
CONSULTING ENGINEERS
WATER AND
LAND RESOURCES

Cherry Creek Basin
Drainageway Study
Technical Advisory Committee
Meeting Minutes
June 18, 1985

Attendees:

Bill Ruzzo	WRC Engineering
Stephen Prokopiak	Greiner Engineering
Bill Rothenmeyer	Arapahoe County
Chuck Esterly	City of Aurora
Scott Tucker	UDFCD
Gunhild R. Dransfeldt	Quadanska Ltd.
Fred Dransfeldt	Quadanska Ltd.
Bill Degroot	USFCD
Dave Peterson	Arapahoe County
Pete Kost	Walters Company
Rich Horstmann	Colorado Department of Health
John Liou	Federal Emergency Mgmt Agency
Wayne Dunkle	Merick & Company
Jeff Kraus	Parker Road Association
Ed Clark	Arapahoe County Planning
Molly Thomasch	Deutsch & Sheldon

Don Hunt, BRW, called the final meeting of the Cherry Creek Basin TAC to order at 2:15 p.m.. Mr. Hunt reported on the overall progress of the project, and described the recommended plan.

Bill Ruzzo, WRC, responded to comments which had been received on the draft report. He noted that all comments not specifically addressed at this meeting were of lesser concern, and the final report could be modified to include the concerns without discussion.

Mr. Ruzzo then explained the following concerns:

A. Owners of Eagle Creek's property requested a minor channel alignment change so that the rear portions of their property could be accessed. Mr. Ruzzo did not believe that there would be additional project costs associated with this realignment. The TAC concurred with the realignment, but noted that if there were additional costs, the costs should be allocated to the owner.

B. Mr. Ruzzo explained the potential area for a future Dry Creek Road crossing. The TAC noted that the crossing should be discussed in the text in the final report, but not shown on the plan.

C. Transitions and phasing were discussed by Mr. Ruzzo. Specific project approval by the Parker - Jordan Metropolitan District and Arapahoe County will ensure that project phasing is done in a safe, effective manner.

D. Level 3 vs. Level 4 improvements were discussed. The report will continue to differentiate the difference in channelization in the Level 4 improvements in the lower stretch of the study area.

E. Mr. Ruzzo discussed the need for additional flow analysis on the Aurora property if the channelization is not carried through the Aurora site.

F. Mr. Ruzzo discussed the request for realigning Happy Canyon Creek. He proposed that an addendum to Cherry Creek Study be prepared to address the realignment of Happy Canyon. Mr. Tucker stated that the primary purpose of the Cherry Creek Study was not to study tributaries, but rather the main channel. Mr. Hunt noted the need for landowner consent in such a realignment before a report addendum could be prepared.

G. Mr. Ruzzo noted that the cost of land reclamation, that is fill to the 1/2 foot floodway, had been included as a potential project cost. The TAC concurred that, while land reclamation is an individual owner option, it is a reasonable item to be included in assessing overall project benefits.

Mr. Hunt and Mr. Ruzzo explained the approved process. The final report will be submitted to Arapahoe County and the Urban Drainage and Flood Control District for adoption. As individual channel projects are proposed, a floodplain amendment will be requested from FEMA.

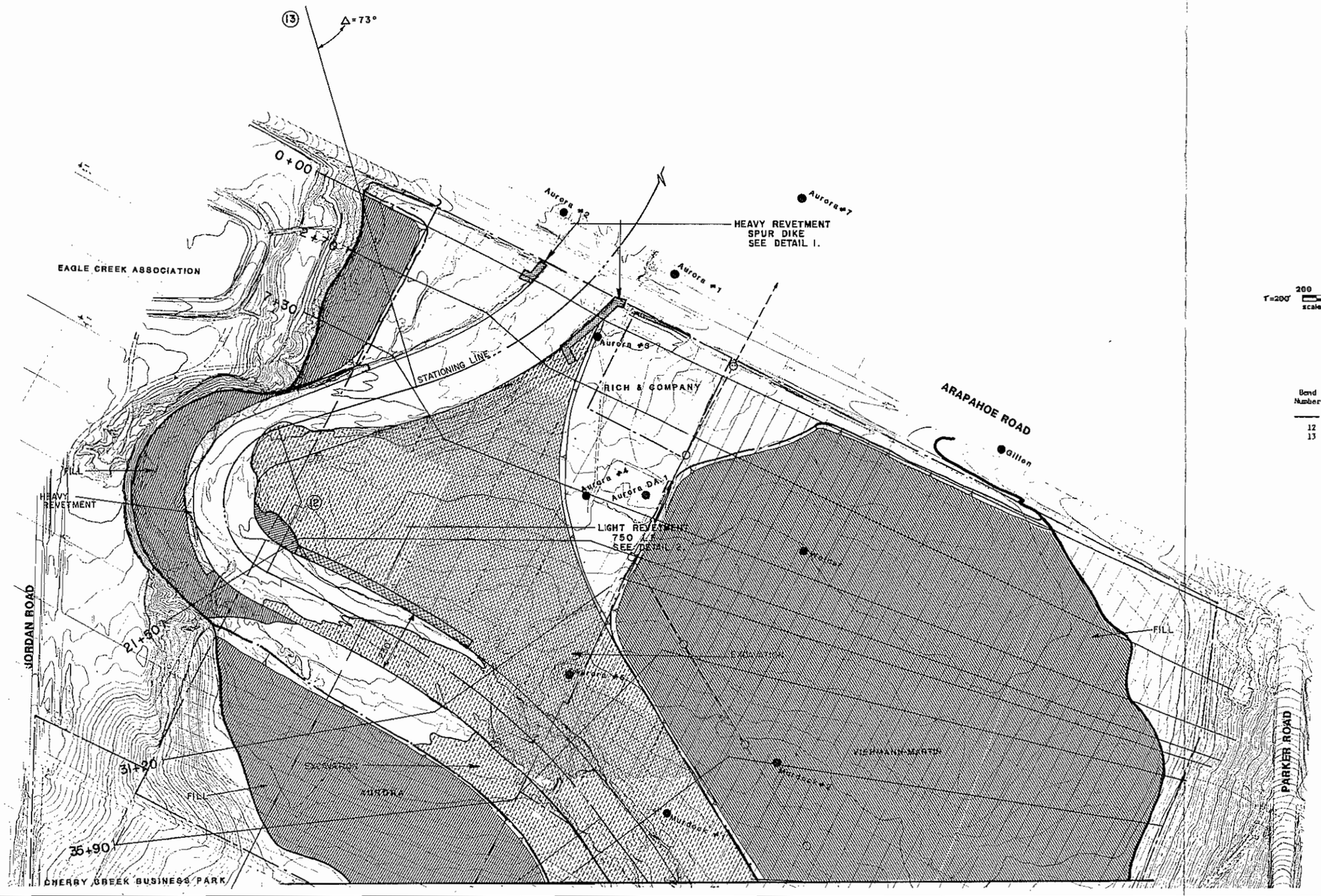
Capital cost funding will be provided by the Parker-Jordan Metropolitan District. Cost apportionment methods are currently under discussion. Maintenance funding will also be provided by the Parker-Jordan Metro District, but hopefully under the direct administration of UDFCD. This approach is being considered by the UDFCD Board.

Gunhild Dransfeldt noted that she had been considering a straightened Cherry Creek alignment through her property, but was satisfied that the current plan was best for all owners.

The meeting was adjourned.

APPENDIX - D

PRELIMINARY DESIGN DRAWINGS



N

1"=200' scale 200 0 200 400 feet

CURVE DATA

Bend Number	Radius of Curvature (Ft)	Deflection Angle (Deg)	Length of Curve (Ft)
12	300	137	720
13	1520	73	1940

BRW
WRC ENGINEERING, INC.
WRITERS' TOWER SUITE 500
1660 SOUTH ALBION STREET
DENVER, COLORADO 80222
PHONE NO: (303) 757-8513

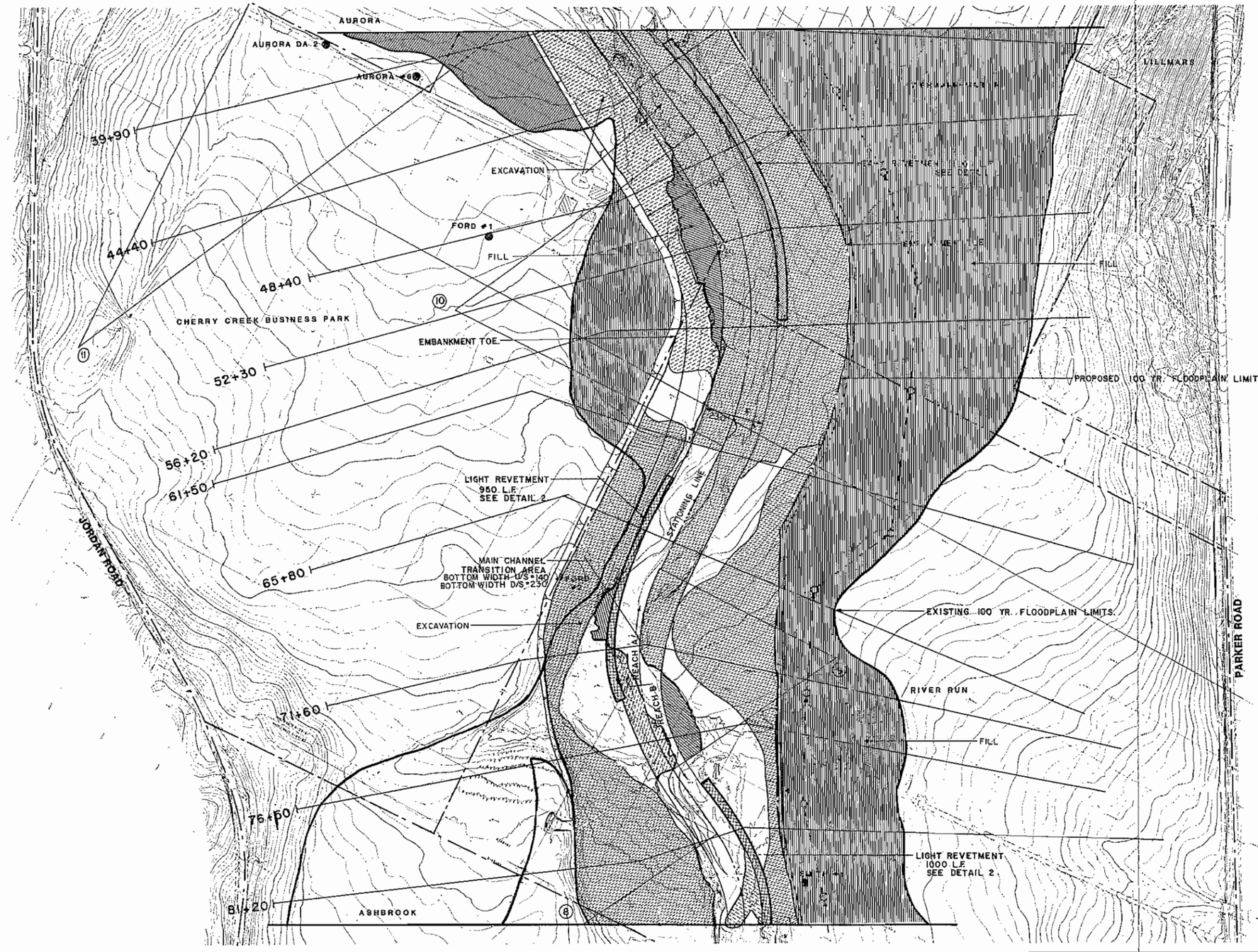
DESIGNED	AJL	DATE 7/85
DRAWN	TP	DATE 2/86
CHECKED	AJL	DATE 4/86
REVISED	WKP	DATE 7/86

CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE

FEASIBILITY STUDY
CHERRY CREEK BASIN
DRAINAGEWAY

PLAN SHEET

DRAWING 1 OF 9

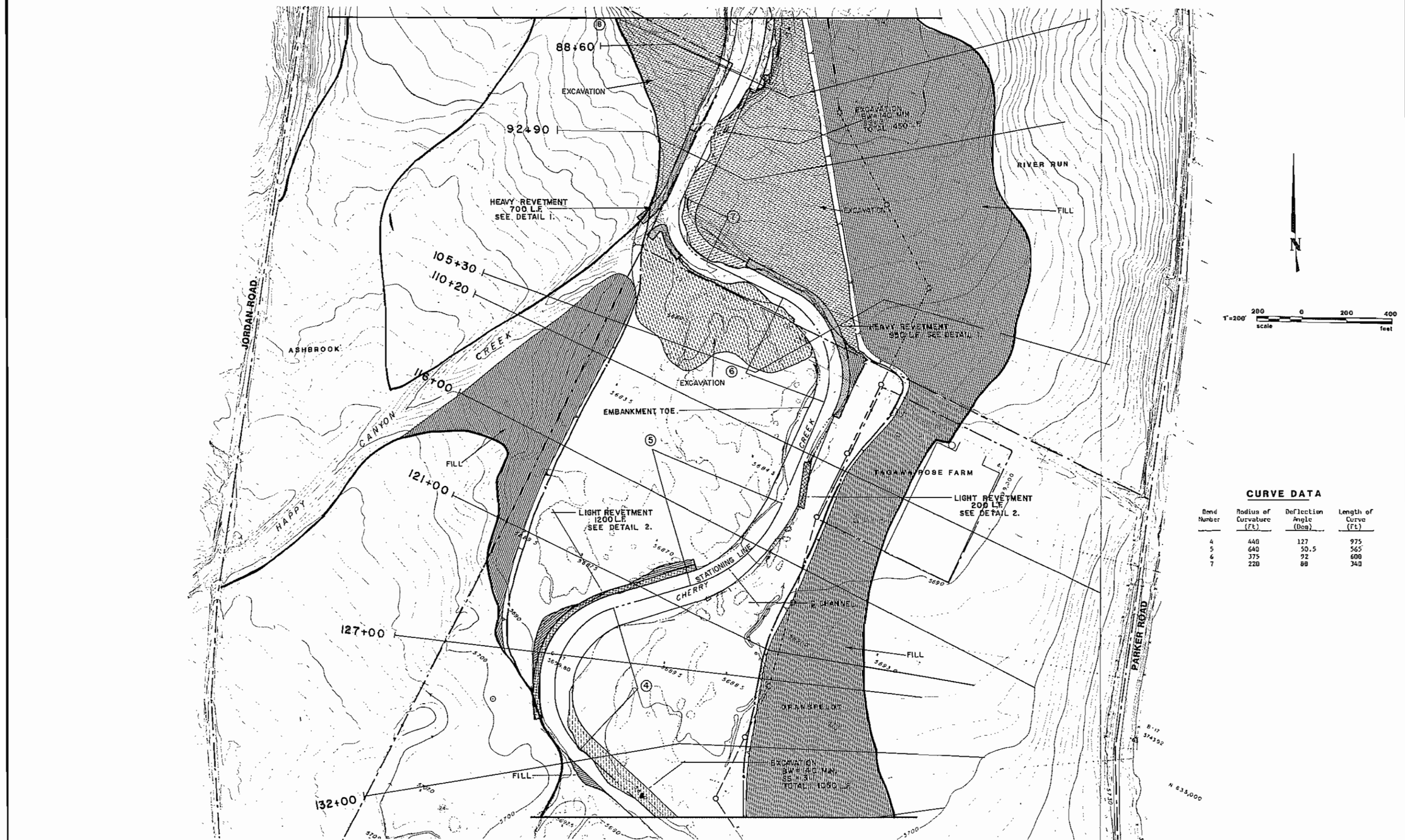


CURVE DATA

Bend Number	Radius of Curvature (Ft)	Deflection Angle (Deg)	Length of Curve (Ft)
8	650	58	655
9	800	61.5	860
10	1210	62	1310
11	2530	27	1190

BRW	WRC ENGINEERING, INC. WRITERS' TOWER SUITE 500, 1660 SOUTH ALBION STREET, DENVER, COLORADO 80222, PHONE NO: (303) 757-8613	DESIONED AJL DATE 2/85 DRAWN TP DATE 2/85 CHECKED AJL DATE 4/85 REVISED HR-TP DATE 7/85	CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE	FEASIBILITY STUDY CHERRY CREEK BASIN DRAINAGEWAY	PLAN SHEET	DRAWING 2 OF 9

1522



CURVE DATA

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4	440	127	975
5	640	50.5	565
6	375	92	600
7	220	88	340

BRW

WRC ENGINEERING, INC.
WRITERS' TOWER SUITE 500
1660 SOUTH ALBION STREET
DENVER, COLORADO 80222
PHONE NO: (303) 757-8513

DESIGNED	AJL	DATE	2/85
DRAWN	TP	DATE	3/85
CHECKED	AJL	DATE	4/85
REVISED	AJL TP	DATE	7/85

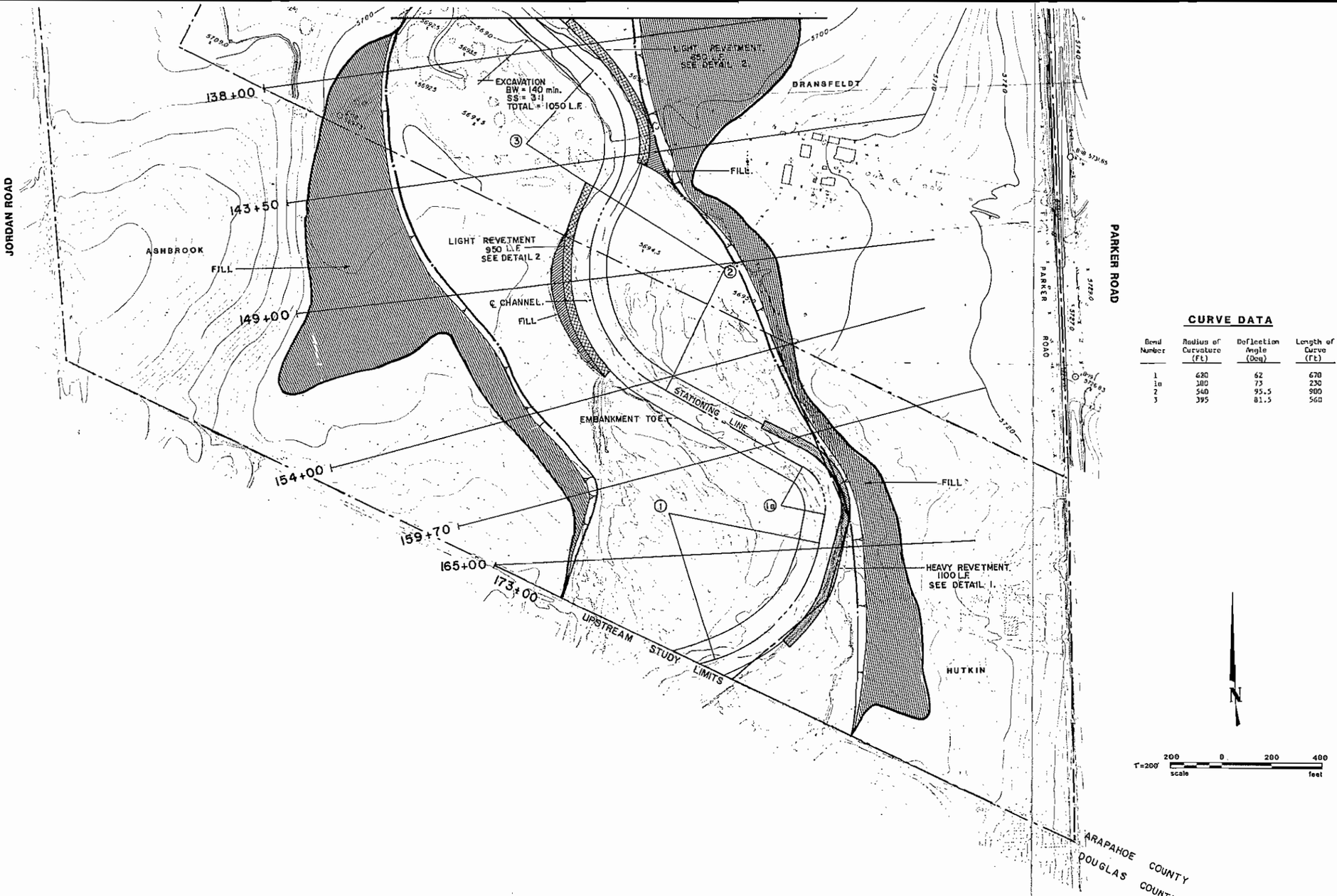
CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE

FEASIBILITY STUDY CHERRY CREEK BASIN DRAINAGEWAY

PLAN SHEET

DRAWING 3 OF 9

1622



CURVE DATA

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1	620	62	670
1a	180	73	230
2	540	95.5	900
3	395	81.5	560

BRW

WRC ENGINEERING, INC.
WRITERS' TOWER SUITE 500
1660 SOUTH ALBION STREET
DENVER, COLORADO 80222
PHONE NO: (303) 757-8513

DESIGNED	AJL	DATE	2/85
DRAWN	TP	DATE	2/85
CHECKED	AJL	DATE	4/85
REVISED	AR-TP	DATE	7/85

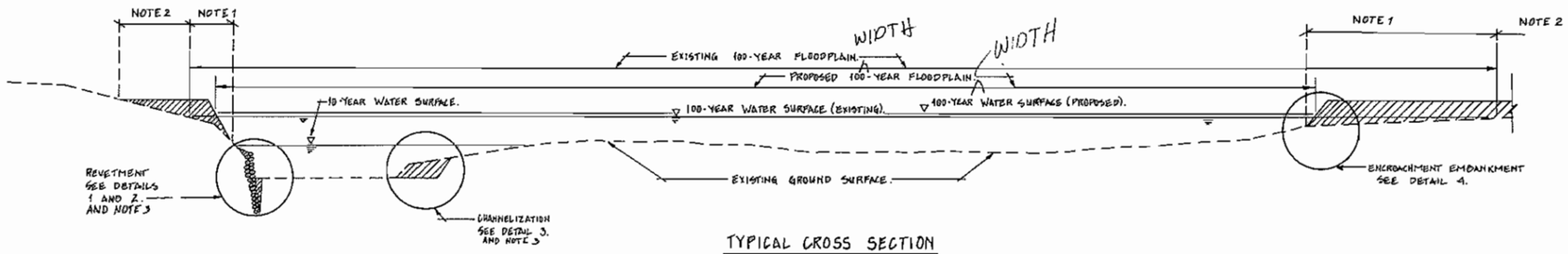
CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE

FEASIBILITY STUDY
CHERRY CREEK BASIN
DRAINAGEWAY

PLAN SHEET

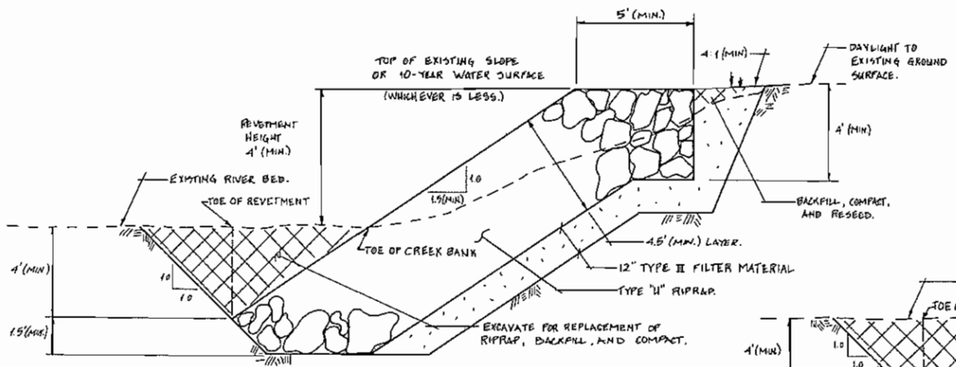
DRAWING 4 OF 9

1522



TYPICAL CROSS SECTION

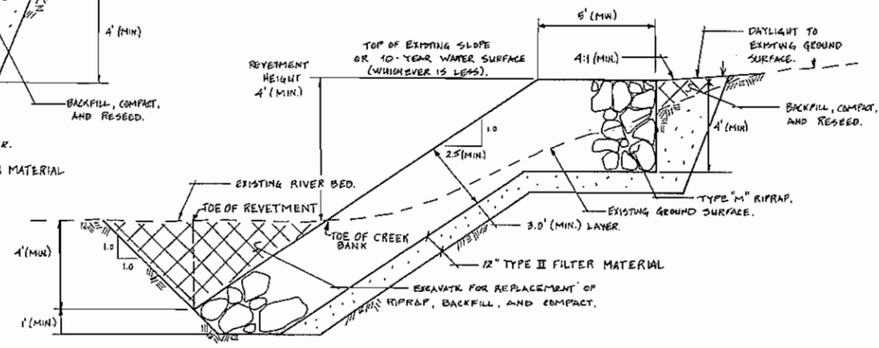
SCALE: HORIZ.: 1" = 10'; VERT.: 1" = 50'



HEAVY REVETMENT

NOT TO SCALE.

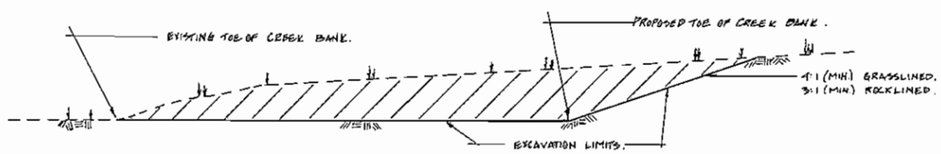
DETAIL 1



LIGHT REVETMENT

NOT TO SCALE.

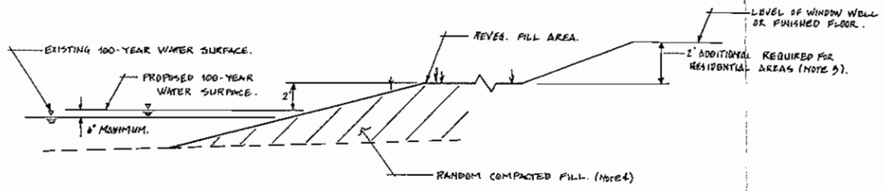
DETAIL 2



CHANNELIZATION

NOT TO SCALE.

DETAIL 3



ENCROACHMENT EMBANKMENT

NOT TO SCALE.

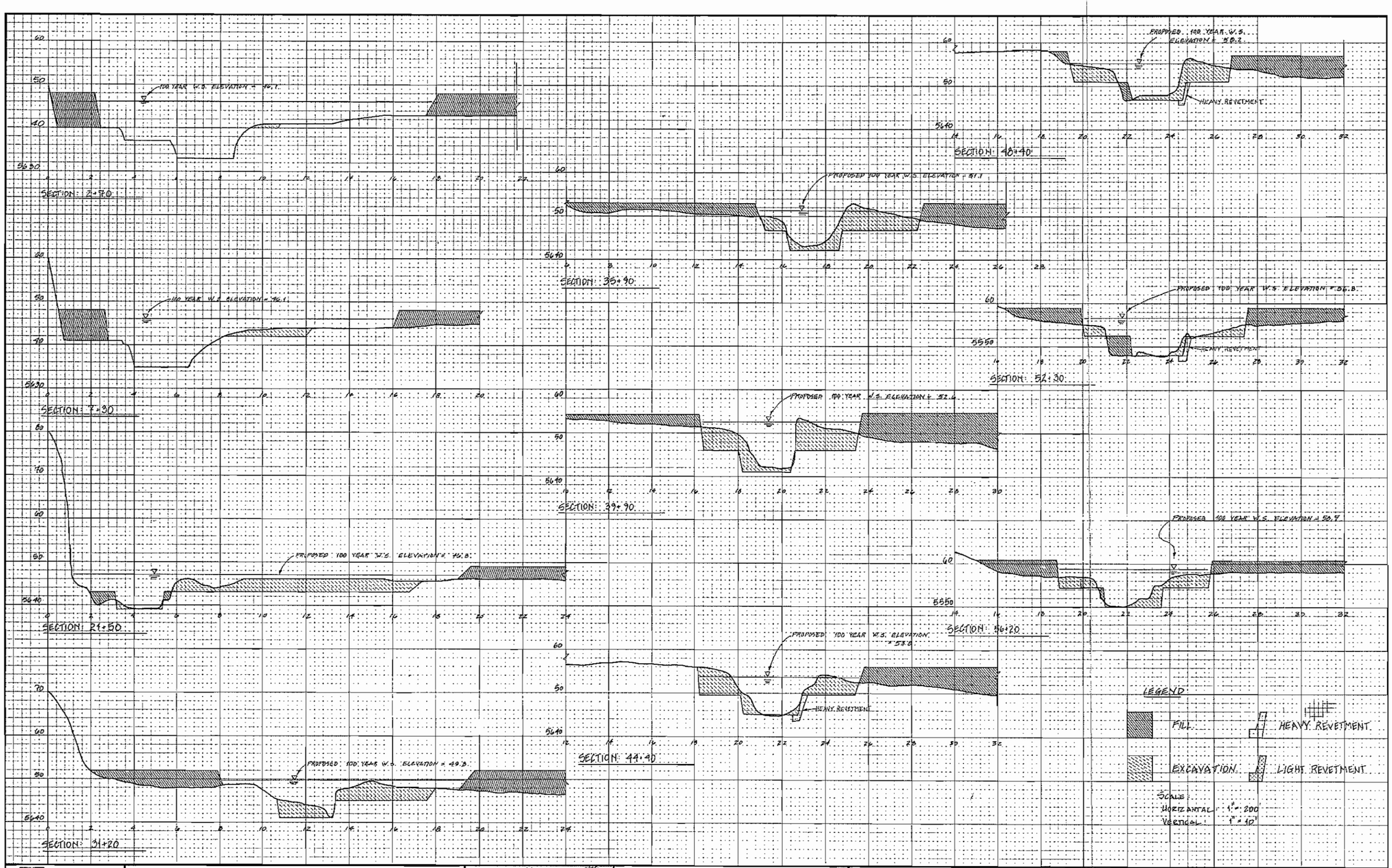
DETAIL 4

GENERAL NOTES

1. QUANTITY OF CUT OR FILL ALLOCATED TO THE CHERRY CREEK DRAINAGEWAY AND INCLUDED IN THE COST ESTIMATE
2. QUANTITY OF FILL ALLOCATED TO THE OVERLOT GRADING OF THE PROPERTY AND EXCLUDED FROM THE COST ESTIMATE
3. CONSTRUCTION ALLOCATED TO CHANNEL STABILIZATION AND INCLUDED IN THE COST ESTIMATE
4. RIPRAP OR OTHER REVETMENT REQUIRED FOR EMBANKMENT SLOPES STEEPER THAN 4:1. VEGETATION REQUIRED FOR SLOPES 4:1 AND FLATTER.
5. REFERENCE: CHERRY CREEK COMPREHENSIVE PLAN.

BRW	WRC ENGINEERING, INC. WRITERS' TOWER SUITE 500, 1660 SOUTH ALBION STREET, DENVER, COLORADO 80222, PHONE NO: (303) 757-8513	DESIGNED AJL DATE 2/05 DRAWN TP DATE 2/05 CHECKED AJL DATE 2/05 REVISED TP DATE 4/05	CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE	FEASIBILITY STUDY CHERRY CREEK BASIN DRAINAGEWAY	IMPROVEMENT DETAILS	DRAWING 5 OF 9

1622



BRW

WRC ENGINEERING, INC.
WRITERS' TOWER SUITE 500
1660 SOUTH ALBION STREET
DENVER, COLORADO 80222
PHONE NO: (303) 757-6513

DESIGNED	AJL	DATE 2/85
DRAWN	T.F.	DATE 2/85
CHECKED	AJL	DATE 4/85
REVISED		DATE

CHERRY CREEK BASIN
TECHNICAL ADVISORY
COMMITTEE

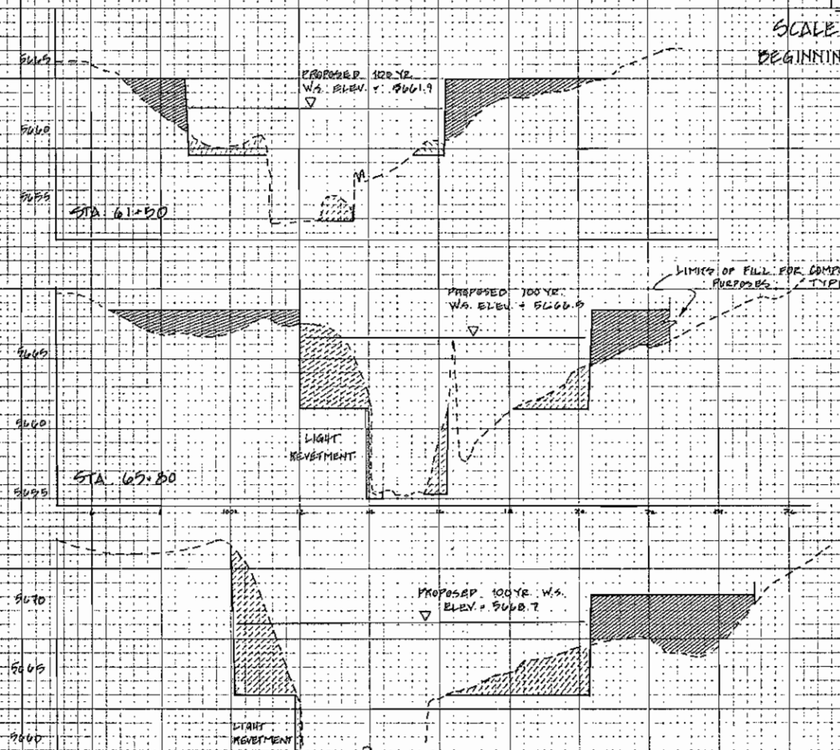
FEASIBILITY STUDY
CHERRY CREEK BASIN
DRAINAGEWAY

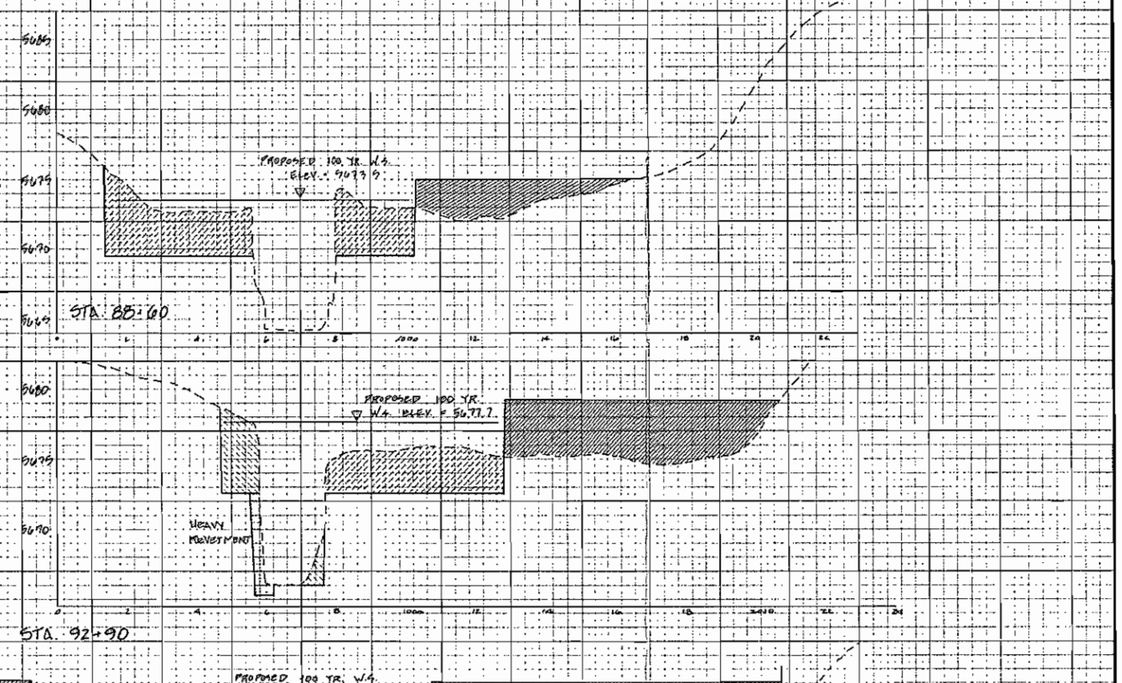
CROSS
SECTIONS

DRAWING 6 OF 9

1522

NOTE:
SCALE CHANGE
BEGINNING THIS SHEET.

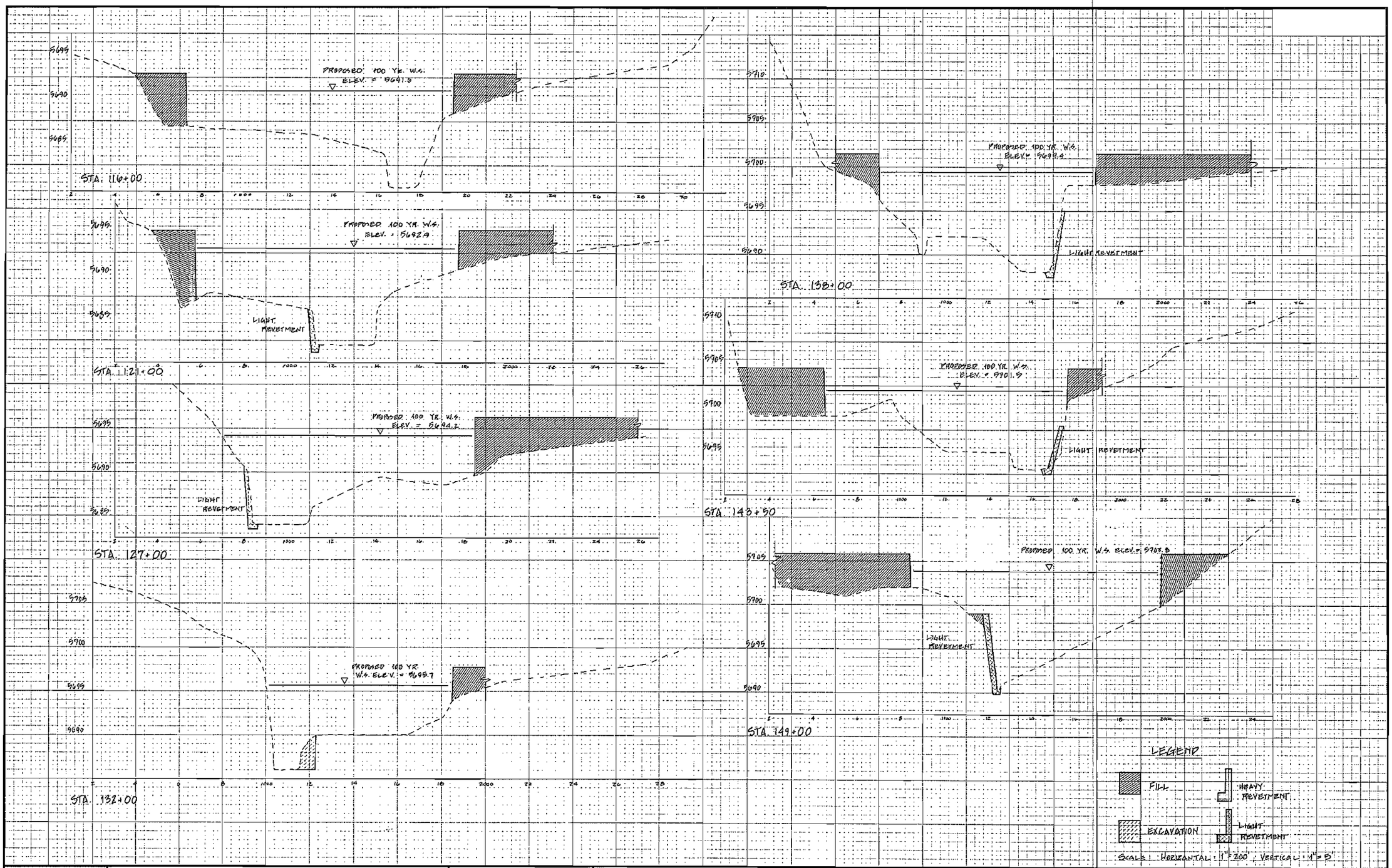




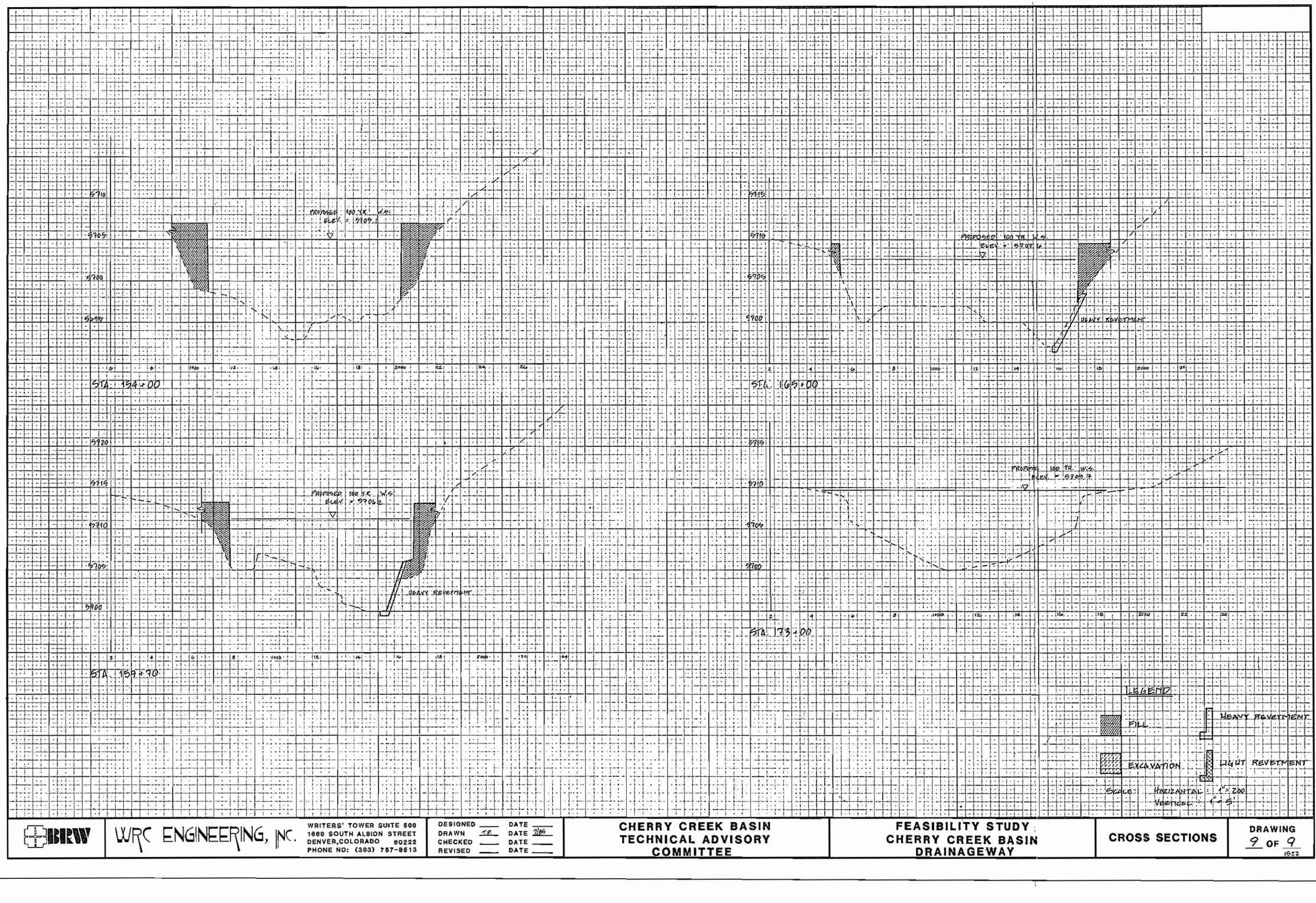
LEGEND
- FILL
- EXCAVATION
- HEAVY REVETMENT
- LIGHT REVETMENT

SCALE:
HORIZONTAL: 1" = 200'
VERTICAL: 1" = 5'

BRW	WRC ENGINEERING, INC. WRITERS' TOWER SUITE 500, 1660 SOUTH ALBION STREET, DENVER, COLORADO 80222, PHONE NO: (303) 757-8513	DESIGNED ___ DATE ___ DRAWN TP DATE 7/82 CHECKED ___ DATE ___ REVISED ___ DATE ___	CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE	FEASIBILITY STUDY CHERRY CREEK BASIN DRAINAGEWAY	CROSS SECTIONS	DRAWING 7 OF 9 1922



BRW	WRC ENGINEERING, INC. WRITERS' TOWER SUITE 500, 1660 SOUTH ALBION STREET, DENVER, COLORADO 80222, PHONE NO: (303) 757-8513	DESIGNED — DATE — DRAWN — DATE — CHECKED — DATE — REVISED — DATE —	CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE	FEASIBILITY STUDY CHERRY CREEK BASIN DRAINAGEWAY	CROSS SECTIONS	DRAWING 8 OF 9



UDFCD	WRC ENGINEERING, INC. WRITERS' TOWER SUITE 500 1660 SOUTH ALBION STREET DENVER, COLORADO 80222 PHONE NO: (303) 757-8613	DESIGNED ___ DATE ___ DRAWN TR DATE 7/86 CHECKED ___ DATE ___ REVISED ___ DATE ___	CHERRY CREEK BASIN TECHNICAL ADVISORY COMMITTEE	FEASIBILITY STUDY CHERRY CREEK BASIN DRAINAGEWAY	CROSS SECTIONS	DRAWING 9 OF 9 1622