LIBRARY COPY
DO NOT REMOVE

COTTONWOOD CREEK DRAINAGE BASIN PLANNING STUDY

Prepared for

Nor'Wood Ltd., Inc.
and
LaPlata Investments, Ltd.

Colorado Springs, Colorado

and

City of Colorado Springs

Colorado Springs, Colorado

AYRES ASSOCIATES
P.O. Box 270460
Fort Collins, Colorado 80527
(970) 223-5556, FAX (970) 223-5578

Ayres Project No. 34-0330.00
COTT6TXT.DOC

June 2000

Resolution No. 104-00

A RESOLUTION AMENDING THE COTTONWOOD CREEK DRAINAGE BASIN PLANNING STUDY TO INCLUDE THE PRUDENT LINE CONCEPT, ELIMINATING THE CURRENT DETENTION POND FEES AND THE INTERIM DRAINAGE AND BRIDGE FEES, AND REVISING THE 2000 DRAINAGE AND BRIDGE FEES.

WHEREAS, on April 12, 1994, Resolution No. 60-94 was adopted, including approval of the Cottonwood Creek Drainage Basin Planning Study and establishment of a minimum and maximum Drainage and Bridge Fee on an interim basis, and

WHEREAS, Resolution 60-94 called for further study of the City's drainage criteria and channel development policies including drainage channel concepts such as a "prudent line" concept, and

WHEREAS, Ayres Associates, on behalf of Nor'Wood Development Corporation and LaPlata Investments, submitted an amended Cottonwood Creek Drainage Basin Planning Study, June 2000, that incorporated the "prudent line" concept, and

WHEREAS, the City Engineering Division has reviewed the amended Cottonwood Creek Drainage Basin Planning Study and recommends its approval, and

WHEREAS, on June 15, 2000, the City/County Drainage Board approved the amended Cottonwood Creek Drainage Basin Planning Study to include the "prudent line" concept, eliminated the current Detention Pond Fees and the Interim Drainage and Bridge Fees and revised the 2000 Drainage and Bridge Fees.

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF COLORADO SPRINGS:

Section 1: The amended Cottonwood Creek Drainage Basin Planning Study, including the "prudent line" concept, as submitted by Ayres Associates, June 2000, is approved and adopted.

Section 2: The existing Detention Pond Fees in the Cottonwood Creek Drainage Basin are eliminated.

Section 3: The Interim Drainage and Bridge Fees, established by Resolution No. 60-94, and modified by resolution annually thereafter, are eliminated.

Section 4: The 2000 Drainage and Bridge Fees are revised as follows:
Drainage Fee -- $6714/acre ($5215/acre for capital improvements and $1499/acre for land); the two components will be annually adjusted using different standard procedures and policies but combined together for collection purposes; the total drainage fee includes $372/acre to be paid to the City in cash for cost-sharing of improvements downstream of Rangewood Drive as outlined in the Study.
Bridge Fee -- $582/acre

Dated at Colorado Springs, Colorado this 11th day of July, 2000.

Mayor

ATTEST:

City Clerk

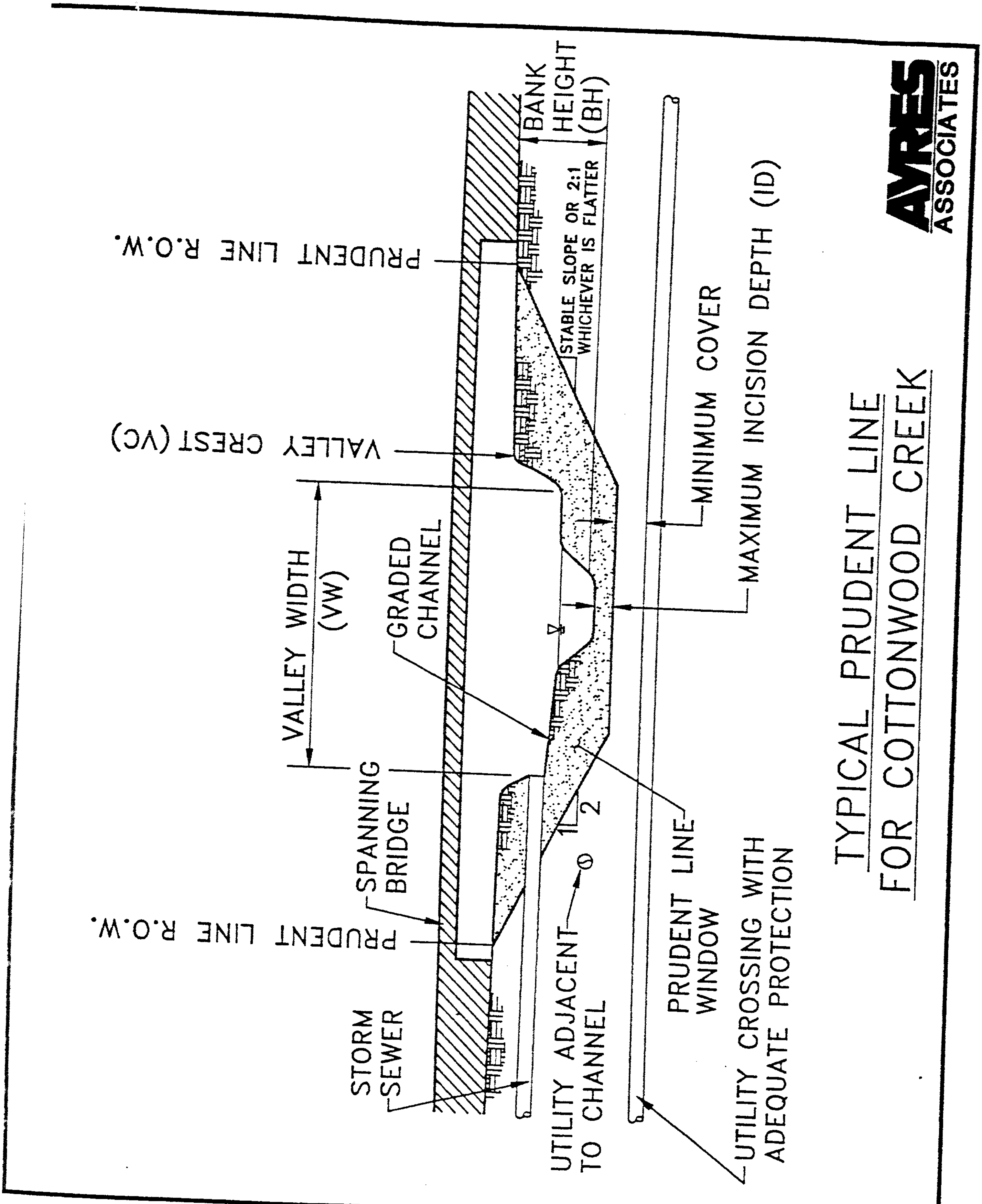

Figure 3.2. Schematic of typical stream cross section depicting prudent line window.

DRAINAGE BOARD AGENDA: June 15, 2000

ITEM NO. 9

COTTONWOOD CREEK DRAINAGE BASIN PLANNING STUDY

Prepared for

Nor'Wood Ltd., Inc.
and
LaPlata Investments, Ltd.

Colorado Springs, Colorado

and

City of Colorado Springs

Colorado Springs, Colorado

AYRES ASSOCIATES

P.O. Box 270460
Fort Collins, Colorado 80527
(970) 223-5556, FAX (970) 223-5578

Ayres Project No. 34-0330.00
COTT6TXT.DOC

June 2000

EXECUTIVE SUMMARY

General

This report addresses the technical and economic feasibility of adopting an erosion risk buffer concept, referred to as the prudent line, as the selected alternative for managing drainage issues in the Cottonwood Creek drainage basin. This concept is a minimum impact option that allows a channel to function in response to natural stimuli by defining a buffer zone within which erosion and flooding can occur without unacceptable impacts on human activities. The prudent line concept is based on a willingness and ability to dedicate sufficient land to allow the stream to function naturally as a trade-off for constructing channel improvements to control the stream. The following Executive Summary presents an overview of this document.

The Cottonwood Creek drainage basin is a rapidly developing 18.6-square-mile area on the north edge of the City of Colorado Springs. It drains a west-facing portion of the larger Monument Creek drainage basin to a confluence west of Interstate 25.

The current Cottonwood Creek Drainage Basin Planning Study (DBPS) was prepared in 1992 for the City of Colorado Springs by URS Consultants (URS 1994). The DBPS was based on current drainage criteria and presented a stream development master plan which was intended to address existing drainage problems and guide construction of new drainage facilities for future land development. The DBPS recommended construction of six regional detention ponds and continuous structural measures (riprap and drop structures) to reduce velocities and stabilize the channel. The high improvement cost associated with the DBPS and the resulting suggested basin fee, together with other factors, resulted in the adoption of the DBPS as an interim plan that is effective until these issues are resolved. This report presents an alternative master plan that addresses some of these unresolved issues in a manner which will lead to full acceptance of a modified DBPS.

Four primary areas were addressed in this report: (1) hydrology, (2) the prudent line alternative, (3) DBPS modifications, and (4) implementation. Each area is summarized individually in the following sections.

This document was prepared with private funds, for Nor'Wood Ltd., Inc. and LaPlata Investments, Ltd., by Ayres Associates of Fort Collins, in association with J.R. Engineering of Colorado Springs.

Hydrology

One of the issues concerning the DBPS was the predicted values of the 100-year streamflow rates adopted as the basis for the master plan. Some people felt that the flow rates were too high, a possible reason for the high channel improvement costs. In order to address this issue, the hydrology was computed for existing land use conditions, then recomputed for future land use conditions. The 100-year peak flow for future land use conditions, as measured at the confluence, dropped from 17,400 to 10,738 cfs. Hydrology is further addressed in Section 2 of this report and supported by Appendix A.

The Prudent Line

Hydraulic and geomorphic studies revealed that floodplain encroachment in the basin is not a major problem. As an unintended result, the development that occurred in accordance with the institutional requirements has, in effect, a prudent line through most of the developed area downstream of Rangewood Drive. In most areas, the channel has sufficient room for lateral movement and flood conveyance. The channel is actively degrading in most areas and a large portion of the suggested improvements in this report are intended to fix the channel's vertical grade.

The position of the prudent line has been computed as part of this project and is shown on the accompanying drawings. Approximately 240 acres of land (excluding land within the 100-year floodplain) will need to be dedicated to accompany the prudent line concept. Since the channel has adequate conveyance, the value of stormwater detention was not found to be cost-effective and a recommendation has been made to delete the regional detention proposed in the DBPS. In addition, most of the channel structures proposed in the DBPS are to "stabilize the channel" or "reduce velocities," but without a specific identified benefit to these costs. This report suggests the elimination of all but a few channel structures which are clearly needed to provide defined benefits and is consistent with the minimum impact prudent line concept.

DBPS Modifications

An alternative master plan was developed, in which the prudent line is the central concept. The elements of this plan are described in Sections 3, 4, and 5 of this document and are depicted on the accompanying plan drawings. Costs of that plan were estimated and allocated to the appropriate responsible entities. A total cost reduction of approximately $11.4 million (January 1992 dollars) is realized from the current DBPS (this figure includes $4.2 million saved by removing all proposed detention ponds. This reduction results in savings to both the public and private landowners. The resulting basin fee is reduced from $5,247 (channel improvement and land acquisition) to $4,757, and the detention fee of $333 has been eliminated. This is a very significant cost savings, and as such, proves the prudent line concept worthy of full consideration for adoption as the DBPS-selected alternative.

Implementation

The prudent line is a concept that is consistent with the manner in which the basin has developed and is applicable to areas to be developed. Its adoption will result in significant cost savings. There are some institutional issues which need to be resolved to permit its equitable application, considering earlier development that has occurred under other criteria.

This document has been reviewed by the City of Colorado Springs and El Paso County. Their comments have been addressed and are included where appropriate. The plan was presented to the City/County Drainage Board in January 1997 and conditionally approved. The final step is to present this report to the City Council for final approval and adoption.

Drainage Board Agenda - June 15, 2000

Item No. 9

Background Information

A prior version of a proposed amendment to the Cottonwood Creek Drainage Basin Planning Study (DBPS), including the prudent line concept, was presented to the Drainage Board in October 1996 and January 1997. The Drainage Board approved the proposed DBPS in January 1997; however, there was no quorum of Drainage Board members. The proposed Study was never taken to City Council for formal action due to City Engineering staff concerns on several issues.

Since then, revisions have been made to key issues noted below:

- Unplatted basin acreage: The Study has been revised to exclude prudent line land, park land and channel/open space land for which developers do not want to pay fees; the revised acreage is 5877 as of the beginning of the last Cottonwood Creek DBPS approval date - 1994. Approximately 240 acres of prudent line land (outside of the 100-year floodplain) will be reimbursable, based on the Park Land Dedication Fee rate. City Engineering will require that all land be platted, even though fees may not be required for a portion of the land being platted.
- Improvements downstream of Rangewood Drive: It was agreed improvements would be equally cost-shared, with 50% of the improvement costs incorporated into the Basin fees and 50% a public cost responsibility. The majority of the improvements in these reaches are adjacent to existing development. Table 5.1 of the Study denotes those improvements for which a separate cash fee will be collected and accounted for by the City of Colorado Springs as a part of the required total drainage fee obligation. These cash fees total $372/acre (2000 fees). These cash fees will be utilized by the City to construct the necessary drainage improvements as specified in Table 5.1.
- Response to environmental comments from the Corps of Engineers (COE) relating to aesthetics, water quality and costs for maintenance road and access easements: The response to these comments are included in section 7 of the Study (pg. 7.1 and 7.2)
- Encroachments/structures within the prudent line: Encroachments including trails and landscaping will be allowed within the prudent line. Parking lots and other structures or encroachments will not be allowed. Other potential encroachments, due to unusual or special circumstances, will require a request to the City Engineer who will make a final decision.

Recommendation

Approve the amended Cottonwood Creek Drainage Basin Planning Study, to include the prudent line concept, as submitted by Ayres Associates, June 2000. Eliminate the current Detention Pond Fee (land and facilities) and the Interim Drainage and Bridge Fees and revise the 2000 Drainage and Bridge Fees as follows:

- Drainage Fee -- $6714/acre: $5215/acre for capital improvements and $1499/acre for land; these two components will be annually adjusted by different methods but combined together for collection purposes (includes $372/acre to be paid to the City in cash for cost-sharing of improvements downstream of Rangewood Dr.)
- Bridge Fee -- $582/acre

COTTONWOOD CREEK DRAINAGE BASIN PLANNING STUDY

Prepared for

Nor'Wood Ltd., Inc.
and
LaPlata Investments, Ltd.

Colorado Springs, Colorado

and

City of Colorado Springs

Colorado Springs, Colorado

AYRES
ASSOCIATES

P.O. Box 270460
Fort Collins, Colorado 80527
(970) 223-5556, FAX (970) 223-5578

Ayres Project No. 34-0330.00
COTT6TXT.DOC

June 2000

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

General

This report addresses the technical and economic feasibility of adopting an erosion risk buffer concept, referred to as the prudent line, as the selected alternative for managing drainage issues in the Cottonwood Creek drainage basin. This concept is a minimum impact option that allows a channel to function in response to natural stimuli by defining a buffer zone within which erosion and flooding can occur without unacceptable impacts on human activities. The prudent line concept is based on a willingness and ability to dedicate sufficient land to allow the stream to function naturally as a trade-off for constructing channel improvements to control the stream. The following Executive Summary presents an overview of this document.

The Cottonwood Creek drainage basin is a rapidly developing 18.6-square-mile area on the north edge of the City of Colorado Springs. It drains a west-facing portion of the larger Monument Creek drainage basin to a confluence west of Interstate 25.

The current Cottonwood Creek Drainage Basin Planning Study (DBPS) was prepared in 1992 for the City of Colorado Springs by URS Consultants (URS 1994). The DBPS was based on current drainage criteria and presented a stream development master plan which was intended to address existing drainage problems and guide construction of new drainage facilities for future land development. The DBPS recommended construction of six regional detention ponds and continuous structural measures (riprap and drop structures) to reduce velocities and stabilize the channel. The high improvement cost associated with the DBPS and the resulting suggested basin fee, together with other factors, resulted in the adoption of the DBPS as an interim plan that is effective until these issues are resolved. This report presents an alternative master plan that addresses some of these unresolved issues in a manner which will lead to full acceptance of a modified DBPS.

Four primary areas were addressed in this report: (1) hydrology, (2) the prudent line alternative, (3) DBPS modifications, and (4) implementation. Each area is summarized individually in the following sections.

This document was prepared with private funds, for Nor'Wood Ltd., Inc. and LaPlata Investments, Ltd., by Ayres Associates of Fort Collins, in association with J.R. Engineering of Colorado Springs.

Hydrology

One of the issues concerning the DBPS was the predicted values of the 100-year streamflow rates adopted as the basis for the master plan. Some people felt that the flow rates were too high, a possible reason for the high channel improvement costs. In order to address this issue, the hydrology was computed for existing land use conditions, then recomputed for future land use conditions. The 100-year peak flow for future land use conditions, as measured at the confluence, dropped from 17,400 to 10,738 cfs. Hydrology is further addressed in Section 2 of this report and supported by Appendix A.

The Prudent Line

Hydraulic and geomorphic studies revealed that floodplain encroachment in the basin is not a major problem. As an unintended result, the development that occurred in accordance with the institutional requirements has, in effect, a prudent line through most of the developed area downstream of Rangewood Drive. In most areas, the channel has sufficient room for lateral movement and flood conveyance. The channel is actively degrading in most areas and a large portion of the suggested improvements in this report are intended to fix the channel's vertical grade.

The position of the prudent line has been computed as part of this project and is shown on the accompanying drawings. Approximately 240 acres of land (excluding land within the 100-year floodplain) will need to be dedicated to accompany the prudent line concept. Since the channel has adequate conveyance, the value of stormwater detention was not found to be cost-effective and a recommendation has been made to delete the regional detention proposed in the DBPS. In addition, most of the channel structures proposed in the DBPS are to "stabilize the channel" or "reduce velocities," but without a specific identified benefit to these costs. This report suggests the elimination of all but a few channel structures which are clearly needed to provide defined benefits and is consistent with the minimum impact prudent line concept.

DBPS Modifications

An alternative master plan was developed, in which the prudent line is the central concept. The elements of this plan are described in Sections 3, 4, and 5 of this document and are depicted on the accompanying plan drawings. Costs of that plan were estimated and allocated to the appropriate responsible entities. A total cost reduction of approximately $11.4 million (January 1992 dollars) is realized from the current DBPS (this figure includes $4.2 million saved by removing all proposed detention ponds. This reduction results in savings to both the public and private landowners. The resulting basin fee is reduced from $5,247 (channel improvement and land acquisition) to $4,757, and the detention fee of $333 has been eliminated. This is a very significant cost savings, and as such, proves the prudent line concept worthy of full consideration for adoption as the DBPS-selected alternative.

Implementation

The prudent line is a concept that is consistent with the manner in which the basin has developed and is applicable to areas to be developed. Its adoption will result in significant cost savings. There are some institutional issues which need to be resolved to permit its equitable application, considering earlier development that has occurred under other criteria.

This document has been reviewed by the City of Colorado Springs and El Paso County. Their comments have been addressed and are included where appropriate. The plan was presented to the City/County Drainage Board in January 1997 and conditionally approved. The final step is to present this report to the City Council for final approval and adoption.

1. INTRODUCTION

Concern over the high cost of drainage basin development fees and on-site drainage features, as described in the DBPS, motivated land developers and property owners in the basin to commission several studies to explore additional, potentially cost-effective drainage-handling options. Predecessor reports addressed the DBPS and associated design criteria (RCE 1994) and a DBPS alternative based on channel stability (Ayres Associates 1995). These reports led to the current evaluation of the feasibility and cost-effectiveness of implementing a minimum impact DBPS alternative referred to as the prudent line or erosion risk buffer concept.

The study addresses the use of a prudent line concept as applied to the main channel of Cottonwood Creek and its major tributaries as described in the DBPS, but does not include South Pine Creek. It describes reaches where this concept can be applied and the associated channel modifications. It also offers refinements to drainage handling techniques in developed and developing reaches where the prudent line cannot be fully implemented.

This evaluation builds upon the information of its two preceding reports (RCE 1994; Ayres Associates 1995) and relies heavily on the basic information in the current DBPS, most of which is incorporated by reference. This existing information has been supplemented by limited field surveying, updated land use and development patterns information, updated mapping (where available), field inspections, updated utility information, and miscellaneous current information. A re-analysis of the DBPS hydrology was performed and hydraulics recomputed accordingly. The revised hydraulics completes the technical background for a qualitative and quantitative evaluation of geomorphic and channel stability as the basis for locating the prudent line. The resulting prudent line is described in this narrative and the general location delineated on the accompanying drawings. The location of the prudent line should be finalized in the subdivision drainage report. The prudent line effectiveness depends upon the use of selected channel improvements which have been approximately located and sized. The final location and size of the channel improvements will need to be included in the subdivision drainage report. The construction, construction-related, and land-associated costs with this concept have been estimated on the same basis as the current DBPS and a revised basin fee was computed.

2. HYDROLOGY

2.1 Introduction

Hydraulic information for a large range of flows is required for estimating needed structural channel stability when using geomorphic techniques in combination with the prudent line concept. This range of flows is produced by hydrologic modeling of various frequency floods for both existing and future land use conditions. Also, in order to evaluate the economic feasibility of detaining flows, as suggested in the Cottonwood Creek DBPS, hydrologic models are needed for future land use conditions configured both with and without proposed detention. Since the DBPS describes only hydrology for future land use conditions and some of the DBPS hydrologic parameters were questioned (RCE 1994; Ayres Associates 1995), a reevaluation of the hydrologic modeling was conducted. In order to provide maximum continuity with the City of Colorado Springs and El Paso County Drainage Criteria (HDR 1991) and the DBPS, the hydrologic model developed for the DBPS was used as a framework for the subject hydrologic modeling.

The hydrology described in this section is based upon the Soil Conservation Service (SCS) Design Storm method, using the U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package (USACOE 1990). Maximum use is made of other completed studies on Cottonwood and Monument Creeks, available rainfall and flow information, and a variety of other flow estimation techniques to provide calibration information and supplementary reference checks on the computed hydrologic values.

2.2 Design Storm Hydrologic Analysis

2.2.1 General

Design storm hydrologic analysis incorporates the use of a design rainfall depth and distribution to produce runoff utilizing knowledge of the basins physical characteristics. As stated in Section 2.1, the HEC-1 model developed for the DBPS was utilized as a framework for the analysis with specific refinements. In this section, all references and comparisons made between the subject model and DBPS model are based on an interim model run that was supplied to Ayres Associates (URS 1994). The interim model predicted a flow of 13,406 cfs at design point 21 (which is the confluence with Monument Creek) with detention pond 12CP removed. Flows of 17,378 and 11,173 cfs were predicted at DP21 for the undetained and detained model runs as shown in the DBPS (URS 1994); Ayres was not supplied with this final model.

The specific refinements of the hydrologic parameters were made to the base model as discussed in this section. For clarity of explanation, the physical parameters and design assumptions used in the DBPS model will be described in their entirety followed by the refinements made to the base model. Hydrologic support information is provided in **Appendix A**.

The hydrologic model of the Cottonwood Creek drainage basin, as developed in the DBPS, consisted of the following design parameters and assumptions:

- The Cottonwood Creek drainage basin encompasses 18.6 square miles.

- The drainage basin was divided into 132 subbasins of approximately 100 acres each.
- Time of concentration (T_c) values were either (1) a summation of overland flow, street and/or storm sewer travel times, or (2) computed from an SCS equation based on subbasin length and elevation difference with the longer of the two methods used.
- Average densities were assumed for projected land use type.
- Existing, major detention facilities used the elevation, volume, discharge curves shown on construction plans from City of Colorado Springs records.
- The design storm was the 100-year, 24-hour event distributed as a Type IIA distribution.
- The total design 100-year rainfall depth of 4.4 inches was reduced to 4.136 inches using an area reduction factor of 94 percent.
- Antecedent Moisture Condition II was chosen.
- SCS hydrologic soil group A was analyzed as soil group B.
- Computer-generated hydrographs were based on 5-minute time intervals.
- The kinematic wave-routing method was utilized for channel routing.

Refinement of the design storm model focused on four major areas: (1) routing method and routing section geometry, (2) SCS curve numbers based on existing and future land uses, (3) physically based time of concentration values, and (4) no proposed detention. Each of these refinements will be discussed in the following paragraphs.

2.2.2 Routing Method and Routing Section Geometry

The kinematic wave and Muskingum-Cunge routing techniques have been successfully used to route upstream hydrographs through channel reaches. In general, the Muskingum-Cunge is a superior and more widely accepted technique than the kinematic wave method for channel routing, particularity for applications in a steep channel and for when there is no lateral inflow to the channel. The required parameters for kinematic wave and Muskingum-Cunge routing are the same, except the Muskingum-Cunge method allows for the inclusion of an 8-point cross section.

The model developed as part of this study changed the routing method to Muskingum-Cunge and used physically-based, 8-point cross sections along the channel mainstem, certain tributaries and outlying reaches. Eight-point cross sections developed for the channel mainstem originated from 1989 FIMS mapping. Routing elements outside the channel mainstem were estimated by a trapezoidal geometric shape of varying bottom width (and side slope for some reaches), depending on the order of the reach. Where existing concrete channels or storm sewers were encountered, the geometric shape was estimated to reflect the existing feature as closely as possible. In certain reaches, the storm sewers and streets were estimated as an 8-point cross section to reflect the portion of the flow that will be carried in the street during the 100-year event.

By changing the routing method and cross-sectional geometry, not only was the calculated peak flow at the confluence reduced as will be described later, but unreasonably high flood-routing velocities encountered in the DBPS model were greatly attenuated. The DBPS model calculated a maximum wave celerity of 36.5 feet per second (fps) on the channel mainstem while the refined model calculated a maximum value of 19.6 fps. These maximum calculated wave celerity values are in different reaches, due to the routing section geometry changes. Calculated wave celerities for the refined model were still relatively high in a few reaches, but these problems were judged insignificant, and no further routing element changes were made to the model.

The sensitivity of these changes were estimated by changing only the routing method (from kinematic wave to Muskingum-Cunge) in the DBPS model (with all detention removed, 18,934 cfs at DP21) while using the DBPS-routing elements. This was easily accomplished by changing the RK cards in the DBPS model to an RD. This change alone produced a 13 percent reduction in calculated peak flow at design point 21 (16,406 cfs at DP21). Refining the model further by adding physically based 8-point cross sections in appropriate reaches, with the Muskingum-Cunge routing option, produced a total reduction of 28 percent in calculated peak flows at design point 21 (13,672 cfs at DP21). This model was refined even further as discussed in the following sections.

2.2.3 SCS Curve Numbers

Existing land use and proposed future land use were updated to reflect changes that may have occurred since the completion of the previous study. SCS curve numbers for existing and future land use conditions were computed by the criteria in **Table 2.1**. An assumption was made that undeveloped areas of the basin that currently contain SCS hydrologic soil group A were modeled as such in the existing conditions model. For the future conditions model, these areas were changed to SCS hydrologic soil group B in accordance with the requirements of the Drainage Criteria Manual (HDR 1991), even though after full development, it is likely that portions of group A soil will remain undisturbed or will be replaced.

Table 2.1. SCS Curve Numbers.

Land Use	Hydrologic Soil Group			
	A	B	C	D
>= 5 acres	39	61	74	80
21/2 - 5 acres	44	65	77	82
1/2 - 21/2 acres	51	68	79	84
1/8 - 1/2 acres	61	75	83	87
<= 1/8	77	85	90	92
SC, AF	68	79	86	89
IND/GOV	81	88	91	93
COM/BUS	89	92	94	95

Estimated SCS curve numbers for each subbasin used in both the existing and future land use conditions model are included in Appendix A.

2.2.4 Time of Concentration and Lag

Time of concentration (T_c) values were computed by summation of actual overland, channel, and pipe flow paths derived from 1 inch = 200 feet and 1 inch = 1,000 feet topographic maps. Actual flow velocities based on flow path slope were determined using Figure 3-1 of the Procedures for Determining Peak Flows in Colorado (SCS 1984). Therefore, basin travel times are believed to be physically based being derived from actual topography. Basin lag time was calculated based on its relationship with the time of concentration using the following equation:

$$T_{lag} = 0.6\ T_c \qquad (2.1)$$

Basin lag values calculated for both the existing and future land use conditions models are included in Appendix A.

2.2.5 Detention Facilities

Proposed detention ponds were removed except for the constructed Fairfax Pond. Its constructed location and actual elevation, volume, and discharge curves were included in both the existing and future conditions models.

2.2.6 Other Physical Components of Model

All other physical components (subbasin breakdown, subbasin area, design storm distribution and area reduction, antecedent moisture condition, hydrograph time interval, etc.) of the DBPS model were not changed for the subject hydrologic modeling.

2.3 Streamflow Statistical Analysis

Flood-flow frequency curves can be estimated from statistics based on annual peak flow records from stream-gaging stations. A log-Pearson Type III frequency analysis was performed on stream gage information in accordance with the U.S. Water Resources Council Bulletin #17B (HECWRC 1981). This analysis was accomplished with the aid of the U.S. Army Corps of Engineers, Flood Frequency Analysis Program (FFA) (USACOE 1995).

Stream gage discharge records are available from the U.S. Geological Survey (USGS) for two stations located within the Cottonwood Creek drainage basin.

Gage number 07103980 (Woodmen gage) is located on Cottonwood Creek immediately downstream of Woodmen Road and approximately 5.0 miles upstream of the confluence with Monument Creek. The period of record extends from May 1992 to the present. Bulletin #17B (HECWRC 1981) recommends that a minimum of 10 years of record be available in order to perform a flood-flow frequency analysis. This statistical analysis was not performed on the Woodmen gage because of insufficient length of record.

Gage number 07103990 (Pikeview gage) is located on Cottonwood Creek near Pikeview, approximately 0.3 mile upstream of the confluence with Monument Creek. The Pikeview gage covers a period of record from December 1985 to the present. The record is not lengthy, but was considered sufficient for the completion of a log-Pearson Type III flood-frequency analysis. The frequency analysis for the Pikeview gage produced the Q_{100} results listed in **Table 2.2**.

Table 2.2. Statistical Analysis Peak Flow.		
Expected Probability	Confidence Limits	
cfs	0.05	0.95
3,400	5,200	1,610

Historical information consisting of estimated data or indirect observations from outside the gage period of record were not available for the Cottonwood Creek drainage basin to supplement this recorded information.

2.4 Regional Hydrologic Analysis

Individual drainage basins may have insufficient historic flooding or period of record information. Transposing information from other meteorologically and physiographically similar drainage basins is an acceptable hydrologic technique of supplementing site-specific data with information from areas which are more statistically complete. Regional hydrologic analyses consulted as part of this study are described in the following paragraphs.

2.4.1 Technical Manual No. 1

Technical Manual No. 1 (CWCB 1976) is one regional hydrologic method that was developed for the estimation of flood characteristics of natural-flow streams in Colorado. This manual contains methods for calculating 10-, 50-, 100-, and 500-year peak discharges and flood depths. This procedure is referenced because it is a well known regional method. Limitations to this method are summarized as follows:

- The equations are not applicable to urban areas unless the effects of urbanization on flood characteristics are insignificant.
- The equations are not applicable to streams where man-made structures have a significant effect on flood discharges or depths.
- The estimating techniques in this manual are not applicable to streams in mixed-population flood areas.
- The regression equations are only applicable at ungaged sites having similar basin and climatic parameters as those sites that were included in the derivation of the equations.

Even though Technical Manual No. 1 is not necessarily suited for the Cottonwood Creek basin, a value was calculated to provide an additional piece of data for general comparison purposes.

According to Technical Manual No. 1, Colorado Springs in located within the Plains Region of Colorado. The Plains Region regression equation for the 100-year recurrence interval is:

$$Q_{100} = 1770\ A^{0.463}\ S_B^{0.154} \qquad (2.2)$$

where:

A = Total area of the basin contributing to flood discharges measured, in square miles

S_B = Basin channel slope as measured between two points along the main channel, at 10 and 85 percent of the channel length

This method estimated a 100-year peak flow of 10,190 cfs for existing land use conditions.

2.4.2 National Flood Frequency Program

The USGS, in cooperation with the Federal Highway Administration (FHWA) and the Federal Emergency Management Agency (FEMA), have complied all of the current (September 1993) statewide and metropolitan area regression equations into a computer program. This computer program is entitled the National Flood Frequency Program (NFF). Colorado has been divided in three general flood regions which are subsequently subdivided into subregions as follows:

- Mountain Region
  - Rio Grande Region
  - Mountain Region
- Plateau Region
  - Northwest Region
  - Southwest Region
- Eastern Colorado Plains Region
  - Sandhills Region
  - Non-Sandhills Region

The computer program also includes regression equations that have been developed exclusively for the Colorado Front Range.

Ayres analysis included use of the regression equations for the Eastern Colorado Plains Region and the Colorado Front Range.

The Eastern Colorado Plains Region regression equations were developed for basin drainage areas less than 20 square miles by Livingston and Minges (1987). These regression equations were developed from rainfall-runoff data collected from 35 gaging stations operated in Colorado from 1969 through 1979, and peak-discharge data obtained from 17 gaging stations in adjoining states, and long-term climatological records. The 100-year reoccurrence interval regression equation is:

$$Q_{100} = 4.41 + 0.33\ (\text{Log RF})\ (\text{Log } 124 - 100) - 1.85\ AE^{-0.25} \qquad (2.3)$$

where:

RF = Termed the relief factor which is calculated as the difference, in altitude between the highest point within the effective drainage basin and the point of interest minus 18 feet

I24-100 = 100-year, 24-hour rainfall, in inches

AE = Effective drainage area, in square miles

This regression equation estimated a 100-year peak flow of 14,100 cfs.

The Front Range Region regression equations were developed by Jarrett and Costa (1988). These equations were based on a multidisciplinary study of precipitation, streamflow data, and paleoflood studies of channel features. The 100-year reoccurrence interval regression equation is:

$$Q_{100} = 302\,(AB8)^{0.86} \qquad (2.4)$$

where:

AB8 = Drainage area below 8000 feet elevation, in square miles

This regression equation estimated a 100-year peak flow of 3,730 cfs for existing land use conditions.

2.5 Comparable Drainage Studies

Three previous studies of the Cottonwood Creek drainage basin were reviewed as a comparison to the new HEC-1 model described in this document. Underlying assumptions and methodologies for these models differed to a minor extent from our model as described in the following paragraphs.

The first Cottonwood Creek DBPS (Lincoln DeVore 1979) utilized the SCS Type IIA storm of 6-hour duration for 5- and 100-year recurrence intervals. Hand methods, as opposed to digital computer technology, were used in this study to compute the peak flows and routing through the basin. The peak flow value of 10,419 cfs is for fully developed land use conditions.

A second Cottonwood Creek DBPS, prepared by DMJM, which was not completed or approved, also utilized the SCS Type IIA storm of 6-hour duration for 5- and 100-year recurrence intervals (URS 1994). The U.S. Army Corps of Engineers HEC-1 computer program was used to compute hydrographs and routing for the basin. The peak flow value of 11,329 cfs, calculated as part of this study, was for fully developed conditions.

Flood insurance maps were developed for Cottonwood Creek (URS 1994). It is not known precisely where the hydrology for this study originated, but the maps were developed for the existing land use conditions at the time of the study. A peak flow value of 10,000 cfs (at the confluence with Monument Creek) was used by FEMA for the development of their flood insurance maps.

The Monument Creek DBPS (CH2M Hill 1994), completed concurrently with the Fountain Creek DBPS (Muller 1994), used a more complex rainfall evaluation because of the large size of the basin areas. Hydrometeorological Reports (HMR) 51 and 52 were used to compute and position several isohyetal storm patterns over the applicable basin areas. The rainfall amount used in the model varied from subbasin to subbasin. The HEC-1/SCS Design Storm method was used to compute flows for both existing and proposed conditions. The flows generated were only applicable to Monument Creek itself due to the large basin rainfall approach. Smaller basins are subject to more intense rain over shorter periods, but not all the smaller basins experience this same storm at the same time. Consequently, peak flows for individual tributaries would be expected to be higher than those the Monument Creek model computed. The Cottonwood Creek portion of the Monument Creek DBPS model was separated and rerun with a higher, uniform rainfall (while retaining the Type II rainfall distribution and all other original variables) over this smaller Cottonwood Creek basin. This resulted in a calculated peak flow of 5,019 cfs for existing land use conditions and 7,465 cfs for future land use conditions. These values along with the estimated values, described in the previous section (Section 2.4), are contained in **Table 2.3** for comparison.

Table 2.3. Cottonwood Creek at Monument Creek Confluence Q_{100} Flood Peaks From Various Sources.

Source	Flow (cfs)
Technical Manual #1 Plains Region Regression Equation - Existing Conditions	10,190
NFF Front Range Regression Equation - Existing Conditions	3,730
NFF Eastern Plains Region Regression Equation	14,100
Cottonwood Creek DBPS (Lincoln DeVore, approved 1979) Future Conditions	10,419
DRAFT Cottonwood Creek DBPS (DMJM 1984 not approved) Future Conditions	11,329
FEMA Cottonwood Creek Flood Insurance Maps (1986) Existing Conditions	10,000
CH2M Hill Existing Conditions Model (Cottonwood Creek Portion)	5,019
CH2M Hill Future Conditions Model (Cottonwood Creek Portion)	7,465

2.6 Relevant Miscellaneous Information

In addition to flow information available from the USGS stream-gaging stations, El Paso County installed and maintained recording rain gages, located throughout the Colorado Springs area, as part of their flood-warning system. Evaluation of data from the rain gages indicates an absence of significant rainfall events: large rainstorms (greater than 1 inch of total rainfall), widespread rainfall (as indicated by most rain gages recording about the same amount of rain over a greater than 4-hour time period) and intense rainfall (as indicated by greater than 1 in./hr for a minimum of 15 minutes) during the 10-year period of record. Stream gage peak flow records confirm this by the absence of large peak streamflow values. This is typical of the region (semi-arid) where records of streamflow and runoff are needed over a much longer period in order to develop a true picture of rainfall-runoff relationships. This is also a consistent representation of the lack of significant rainfall-runoff events over this specific geographic area during this specific time period. The two most significant rainfall events and related peak flows for both gages occurred in 1993. Neither is usable for temporal or quantity calibration due to data inadequacies, leaving only normal mean annual peak flow events for possible calibration. Spatial variation of rainfall-runoff in this area was demonstrated by the 1993 events where peak annual flow at the Pikeview gaging station (the largest flow in the gage life) occurred on a different day and month (for a different event) than the annual peak flow at the Woodmen gage.

2.7 Hydrologic Model Revisions

2.7.1 Revisions Based on City Engineering Division Comments

A draft of this report was submitted to the City of Colorado Springs, City Engineering Division, for review and comment (Ayres Associates, May 1996). Comments were provided in a letter addressed to Mr. Scott Smith (LaPlata Investments) and Mr. Kent Petre (Nor'Wood Ltd., Inc.) on July 5, 1996. A meeting was held September 4, 1996, between the City of Colorado Springs engineering staff and Ayres Associates to discuss technical issues in regard to the draft report. This section summarizes the revisions made to the hydrologic model based on this meeting. Most of the meeting focused on the hydrologic parameters and routing used in the HEC-1 model. As a result of the meeting, the following topics were addressed:

- SCS curve numbers and basin lag times were revised as agreed upon at the meeting
- Calculated wave celerities in the DBPS and Ayres Associates hydrologic models were compared to Ayres Associates future conditions, HEC-2 calculated channel velocities

Table 2.4 summarizes the revisions that were made to the hydrologic parameters of the existing (currently developed basins) and future (currently undeveloped basins) conditions hydrologic model. Note that the basin lag time for subbasin T2 was not changed. This basin is fully developed; therefore, the lag time is believed to be correct.

The estimated flow at design point 21 for future land use conditions, as a result of these changes, increased from 10,381 to 11,166 cfs (an increase of 7.6%). Therefore, we can conclude that the revisions to the hydrologic parameters of the model will not make a substantial difference in the estimated peak flow at design point 21. The changes made to the existing conditions model resulted in a decrease from 5,325 to 5,179 cfs (a decrease of 2.7 percent). This can be attributed to the changes being made to subbasins on the lower portion of the basin. The hydrograph peaks, for the updated subbasins, were already routed through the system before the upper portion of the basin was contributing the peak flow at design point 21.

Since the SCS curve number and basin lag times do not amount to a significant change in the estimated peak flow, attention must be given to the routing method and section geometry. **Figure 2.1** contains a plot of the routing reach from design point 19 to 20, the plots for the remaining routing elements along Cottonwood Creek that were represented by 8-point cross sections are in Appendix A. All the plots contain the HEC-2 cross sections, the HEC-1 8-point cross sections used in the Ayres Associates model, and the trapezoidal shape used in the DBPS model (URS 1994). The HEC-2 cross sections were taken directly from the 1995 FIMS mapping in digital format. Some of the routing elements used in the DBPS model are significantly different than actual cross-sectional geometry of the channel, an example is the routing reach from design point 19 to 20 shown on Figure 2.1. The change in routing element geometry would contribute to considerable attenuation of the flood wave peak. It has already been agreed that the Muskingum-Cunge routing method is more applicable to the channel; therefore, the reduction in the peak flow is due the routing method and element geometry.

Table 2.4. Revisions to Hydrologic Models.			
Basin ID	Ayres Value	Revised Value	Description of Change
SCS Curve Numbers For Currently Undeveloped Basins			
C1	63.1	67.5	URS Value
C12	76.9	81.2	URS Value
C13	65.6	69.8	URS Value
D1	75.0	83.0	Hydrologic Soil Group B Changed to Group C
H3	75.4	80.2	URS Value
H4	75.0	77.5	Average of URS and Ayres
H8	76.2	80.9	URS Value
H9	75.2	80.3	URS Value
H10	80.6	84.8	URS Value
H17	77.2	81.2	URS Value
H18	75.6	80.5	URS Value
K1	76.3	85.8	Changed 1/8-1/2 Acre Residential to <=1/8
Basin Lags For Currently Undeveloped Basins			
A1	0.78	0.45	Overland Bare Ground Flowline Length to Grassed Channel
A2	0.86	0.53	Overland Bare Ground Flowline Length to Grassed Channel
A3	0.61	0.38	Overland Bare Ground Flowline Length to Grassed Channel
A4	0.79	0.46	Overland Bare Ground Flowline Length to Grassed Channel
A5	0.69	0.41	Overland Bare Ground Flowline Length to Grassed Channel
A6	0.67	0.40	Overland Bare Ground Flowline Length to Grassed Channel
A7	0.66	0.40	Overland Bare Ground Flowline Length to Grassed Channel
A8	0.82	0.45	Overland Bare Ground Flowline Length to Grassed Channel
A9	0.56	0.33	Overland Bare Ground Flowline Length to Grassed Channel
A10	0.62	0.34	Overland Bare Ground Flowline Length to Grassed Channel
A11	0.75	0.42	Overland Bare Ground Flowline Length to Grassed Channel
A12	0.49	0.29	Overland Bare Ground Flowline Length to Grassed Channel
A13	0.78	0.46	Overland Bare Ground Flowline Length to Grassed Channel
B3	0.63	0.22	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
B4	0.60	0.22	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
B9	1.04	0.33	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
C11	0.68	0.27	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
C12	0.63	0.20	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
C18	0.49	0.41	Overland Bare Ground Flowline Length to Grassed Channel
C20	0.55	0.36	Overland Bare Ground Flowline Length to Grassed Channel
D3	0.47	0.32	Overland Bare Ground Flowline Length to Grassed Channel
D5	0.52	0.21	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
H1	0.45	0.40	Overland Bare Ground Flowline Length to Grassed Channel
H5	0.52	0.40	Overland Bare Ground Flowline Length to Grassed Channel
H15	0.65	0.45	Overland Bare Ground Flowline Length to Grassed Channel
H20	0.37	0.26	Overland Bare Ground Flowline Length to Grassed Channel
H22	0.43	0.17	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
K4	0.51	0.36	Overland Bare Ground Flowline Length to Grassed Channel
SCS Curve Numbers For Currently Developed Basins			
G6	75.9	78.1	Average of URS and Ayres
K3	81.2	82.9	Average of URS and Ayres
L1	77.8	80.0	Average of URS and Ayres
L2	70.0	71.8	Average of URS and Ayres
Basin Lags For Currently Developed Basins			
G7	0.42	0.29	Bare Ground to Grassed Channel; Grassed Channel to Gutter
J3	0.47	0.20	HEC-2 Est. Velocity and Added Gutter
L2	0.51	0.21	HEC-2 Est. Velocity and Added Gutter
M4	0.47	0.43	Overland Bare Ground Flowline Length to Grassed Channel
Q6	0.46	0.33	Overland Bare Ground Flowline Length to Grassed Channel
Q8	0.52	0.16	HEC-2 Est. Velocity and Added Gutter
T2	0.39	0.39	No Change
V2	0.61	0.09	HEC-2 Est. Velocity; Added Overland Grass and Pasture
W1	0.41	0.15	HEC-2 Est. Velocity; Added Gutter and Overland Grass and Pasture
W2	0.48	0.12	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek
W3	0.34	0.11	HEC-2 Est. Velocity for Flowline Length Along Cottonwood Creek

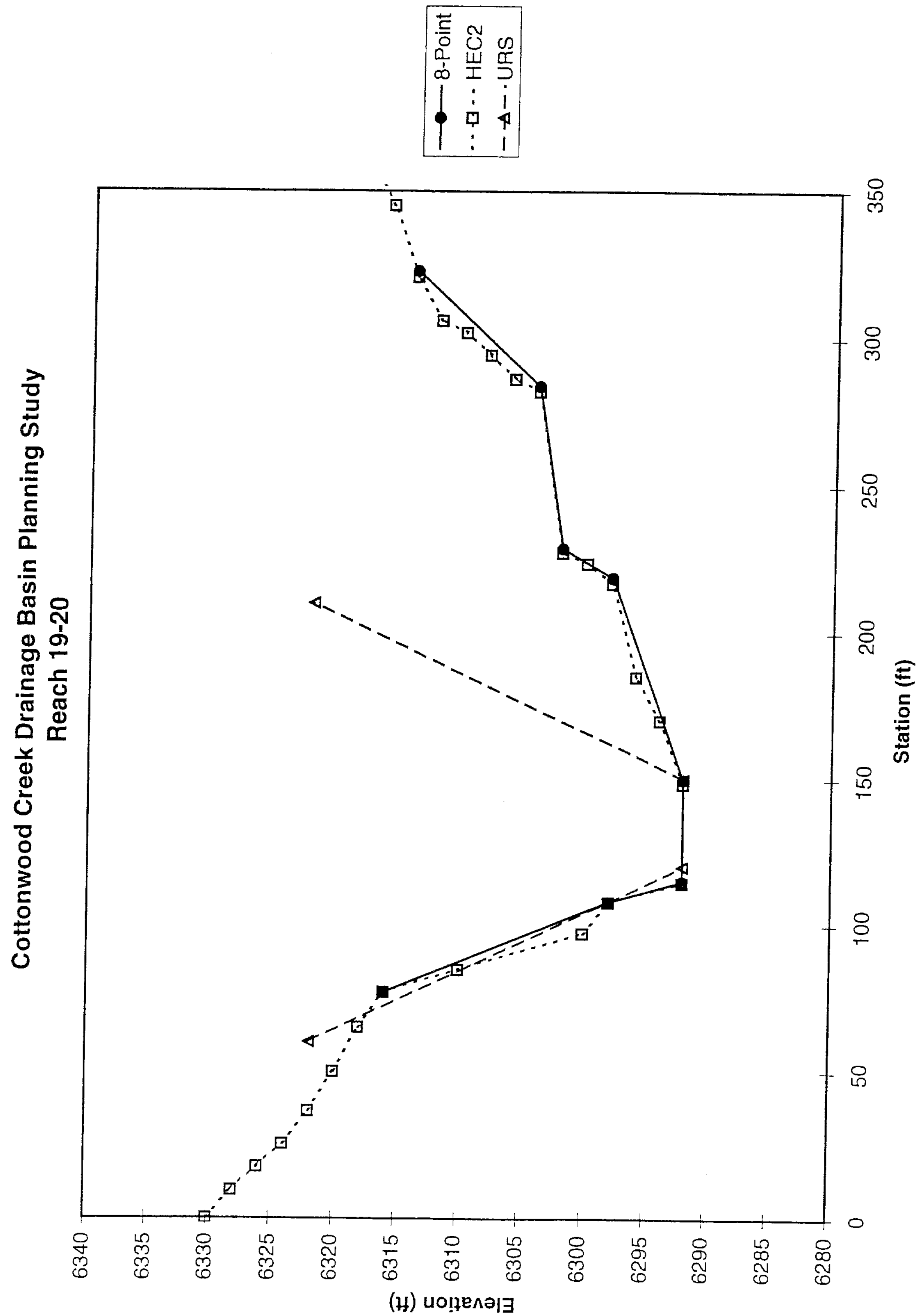

Figure 2.1. Routing element geometry for reach 19-20.

The second topic agreed upon was to compare wave celerity to calculated channel velocity. **Table 2.5** contains the wave celerities calculated by URS's future conditions hydrologic model (including proposed detention) and the Ayres Associates revised future hydrologic model (no proposed detention). These wave celerities are compared to the average channel velocities computed by the Ayres Associates 100-year, future conditions hydraulic model, which was updated to reflect the revised hydrology. The HEC-2 velocities are the average of each cross section channel velocity corresponding to the HEC-1 routing reaches (excluding bridge cross sections).

Table 2.5. Wave Celerities vs. Channel Velocities.

Routing Reach	URS Celerity-Proposed Detention	Ayres Celerity-No Proposed Detention	HEC-2 Average Velocity
7-8	11.44	7.37	7.00
8-9	13.45	10.63	10.33
9-10	17.00	10.90	10.75
10-11	17.28	11.66	10.23
11-12	20.65	10.63	10.91
12-13	22.63	11.37	10.74
13-14	24.52	10.41	10.23
14-15	22.54	14.67	12.02
15-16	22.66	14.47	11.66
16-17	25.71	14.24	13.85
17-18	30.90	17.28	13.45
18-19	35.73	16.87	14.25
19-20	36.48	15.66	13.62
20-21	33.57	19.55	13.25

In all reaches, the Ayres Associates celerities are closer to the hydraulically modeled velocities than the DBPS values. From the routing section geometry plots, it can be seen that high-wave celerities in the URS model are partially a function of the routing element geometry. Notice that the element with the greatest geometric difference, routing reach 19 to 20 shown on Figure 2.1, corresponds to the highest celerity in the DBPS model.

2.7.2 Revisions Based on Future Land Use Changes

Further revisions to the hydrologic model were made based on approved changes to the future land use conditions in the vicinity of Tributary 1. The areas of subbasins H5 and D3 were changed because stormwater for a portion of H5 was routed under Woodman Road to subbasin D3. The subbasins were renamed H5A and D3A, respectively. Subbasin H8 was divided into H8A and H8B at Oakwood. New curve numbers were developed for H5A, H6, H7, H8A, and H8B to reflect the land use changes. These changes reduced the previously revised flow of 11,166 cfs at design point 21 to 10,738 cfs (a reduction of 3.8 percent).

2.8 Hydrologic Summary

As previously stated, the design storm model was created from the basic DBPS model. Input variables were either checked and used or changed, if judged necessary, using the best available information. Changed values were physically based, consistently determined and without a conservative bias to compensate for uncertainties. The emphasis was to create the truest physical model. Ideally, the model developed for existing land use conditions should be calibrated to a real event or events to confirm its representation of the physical drainage basin. This would be best accomplished using between a 10- and 100-year event. With many assumptions in the model (uniform rainfall distribution, antecedent moisture condition, etc.), several physical processes which can combine in different ways and a lack of acceptable data, calibration to a real event is an imperfect process. As previously mentioned, the two best events for calibration have data discrepancies and cannot be used at this time. The model was run with a 2-year rainfall and yielded an 842 cfs peak flow value, a number within the confidence interval of the statistically generated 2-year flood (558-933 cfs; 740 cfs mean). While slightly on the high side, the model was considered close enough to the relatively stable mean annual peak flow to not require a model adjustment.

The other hydrologic methods were compared qualitatively, taking into consideration their applicability to this drainage basin and were plotted on log Probability paper, **Figure 2.2**, to consider them in composite form. As expected and previously mentioned, the statistical analysis results constitute the low range of flows. The grouping of three other values between 3,500 to 5,500 cfs for the 100-year event, encompassing the 5,200 cfs upper limit of the confidence interval of the statistical analysis, leads to the conclusion that the model generated 100-year event of 5,179 cfs for existing conditions is reasonable.

The existing conditions model was therefore accepted without further modification and was modified to simulate the basin as fully developed under future land use conditions, not including any proposed detention features. The model basin lag and SCS curve numbers were altered in a manner consistent with the past basin development and model rerun. A 100-year peak flow value of 10,738 cfs resulted for the basin at design point 21. While significantly less than the Cottonwood DBPS value of 17,400 cfs (38.3 percent), it falls into a range of similar values from other analyses (CH2M Hill modified, 7,465 cfs; Lincoln DeVore, 10,419 cfs; and DMJM, 11,329 cfs). The 100-year HEC-1 run of the refined model is included in Appendix A.

It is meaningful to note the correspondence between the hydrologic values in this document and that of the DBPS. This report describes a future conditions peak flow reduction of approximately 6,600 cfs from that described in the DBPS. Approximately 28 percent of the future conditions peak flow reduction can be attributed to changing the routing method and routing element sectional geometries. The remaining 10 percent reduction can be attributed to the overall changes in weighted SCS curve numbers, physically based subbasin lag times, and other minor revisions such as the inclusion of the existing Fairfax Pond. The individual percent reductions of each of these minor refinements were not estimated.

Peak flows and hydrographs were generated by the revised model for the 5-, 10-, 25-, 50-, and 100-year rainfall events for existing and future land use conditions (with and without proposed detention) for use in the prudent line hydraulic analysis. Rainfall amounts were estimated from the NOAA Atlas 2 (Miller et al. 1973) and adjusted by the same reduction factor used in the DBPS, namely 94 percent. **Table 2.6** contains the rainfall amounts used in the revised model and **Table 2.7** provides the model-generated flows for use in the prudent line hydraulic analysis.

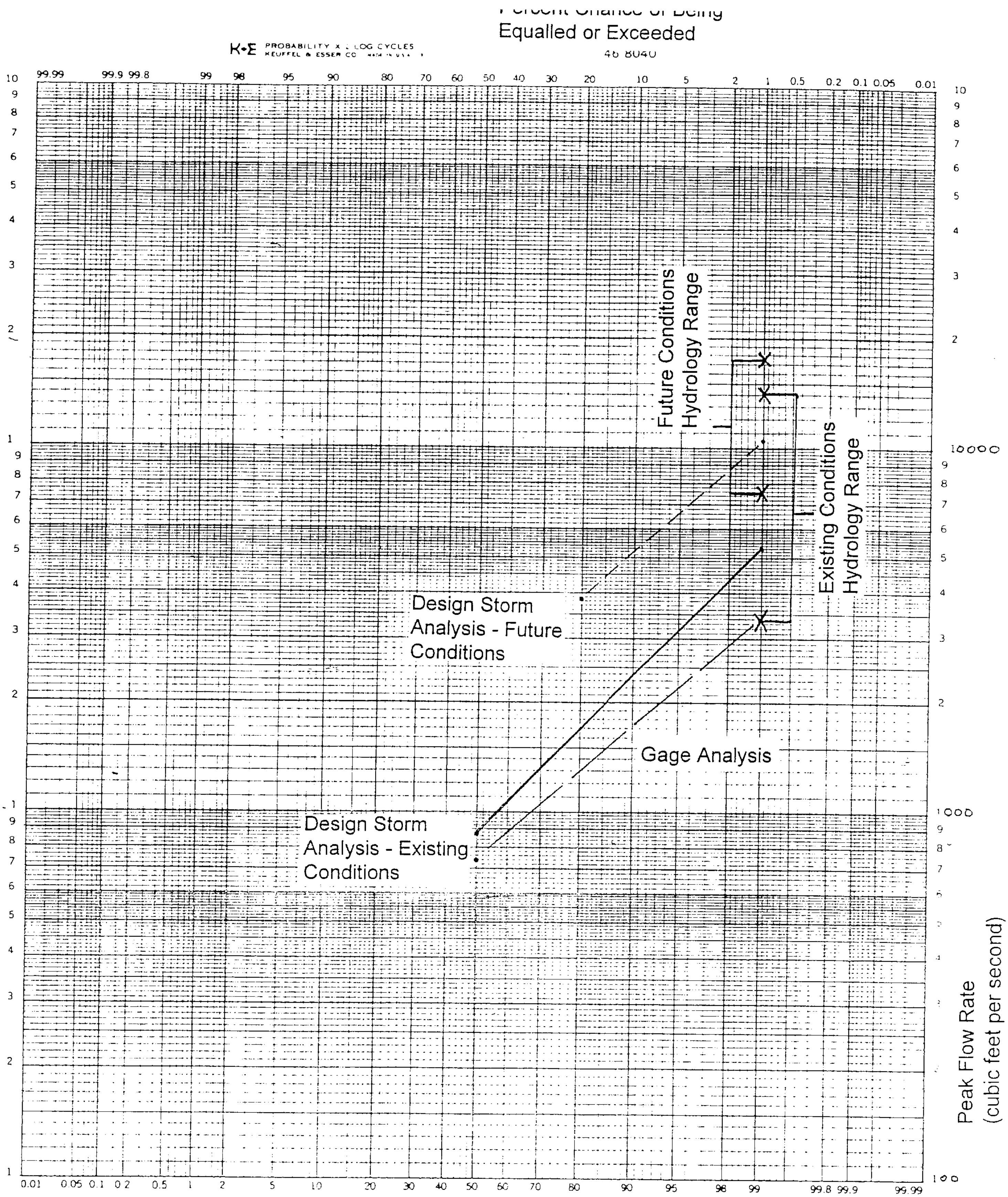

Figure 2.2. Peak flow frequency.

Table 2.6. Design Storm Rainfall Amounts.		
Design Storm Frequency	Rainfall Depth (in.)	Adj. Rainfall Depth (in.)
5-year	2.750	2.585
10-year	3.200	3.008
25-year	3.700	3.478
50-year	4.000	3.760
100-year	4.400	4.136

Table 2.7. Hydrologic Model Peak Flows.			
Design Storm Frequency	Existing Land Use (Fairfax Pond Only) Flow (cfs)	Future Land Use (Fairfax Pond Only) Flow (cfs)	Future Land Use (DBPS Proposed Detention) Flow (cfs)
5-year	1516	3844	2712
10-year	2318	5384	3956
25-year	3510	7383	5598
50-year	4211	8700	6659
100-year	5179	10738	8134

3. OVERVIEW OF THE PRUDENT LINE CONCEPT

3.1 Introduction

The prudent line defines a buffer zone for erosion and flooding potential within which development would not be considered prudent if the channel is to remain in a natural state. The basic concept is to trade the cost of land adjacent to the channel (to provide room for the channel to move laterally) with the cost of channel stabilization alternatives that fix the channel in place, typical components of which are described in **Appendix B**. A prudent line channel concept was essentially one of the alternatives considered in the DBPS (Alternative A channel).

Implementing a prudent line channel concept requires defining the limits of future potential erosion and flooding. For flood risk, the National Flood Insurance Program (NFP) established as a precedent that it is generally not sound to accept a degree of risk greater than that associated with the 100-year event. By definition, a 100-year event is that event which occurs, on average, once every 100 years. This does not mean that this event will occur exactly once every 100 years, but rather, in a 1,000-year period such an event would occur randomly at about 10 different times. More specifically, based on probability and risk concepts, there is a 90 percent certainty that the 100-year event will not occur in any given 10-year period, and a 74 percent certainty that it will not occur in any given 30-year period. Conversely, this implies an accepted risk of 10 percent in a 10-year period, and a 26 percent risk in a 30-year period.

While the damages due to flooding are generally associated with a single, short-term event, the impacts of erosion are often cumulative over the long-term. Consequently, one must address the erosion potential not only of a single event, such as the 100-year flood, but also the cumulative impact of a series of smaller flows. The definition of the erosion potential must include the duration over which the cumulative long-term erosion effects are considered. Based on the single-event probability of occurrence of a 100-year flood in a 30-year period (26 percent), previous applications of the prudent line concept to alluvial channels have been based on the cumulative erosion in a 30-year period (Lagasse et al. 1994), on the assumption that this represents a reasonable degree of risk.

By applying sediment transport calculation procedures, the extent of erosion over a 30-year period can then be estimated. This erosion can occur in either a vertical direction (degradation or channel incision) or in a horizontal direction (lateral erosion or bank erosion). In the context of a prudent line, lateral erosion or lateral stability is most important in defining the prudent line. The prudent line is then typically defined by an enveloping curve, based on the greater of either the flood or lateral erosion risk.

3.2 Lateral Stability

Lateral migration and widening of natural channels occurs through bank retreat resulting from two primary mechanisms: (1) grain-by-grain erosion, and (2) mass failure. Commonly, mass-wasting and grain-by-grain erosion act in concert: fluvial erosion scours the toe of the bank, and mass failure follows (Simon et al. 1991). Removal of the failed material from the bed of the channel occurs through fluvial erosion and the process is repeated.

The bank erosion process can result from (1) channel incision (degradation), (2) flow around bends, (3) flow deflection due to local deposition or obstructions, (4) aggradation, or (5) a combination of the above. Channel incision creates bank heights that exceed the maximum stable bank height causing mass failure and bank retreat. Flow around a bend causes erosion of the toe on the outside of the bend and the loss of upper bank stability, resulting in mass-wasting. Local deposition and aggradation create mid-channel bars that can deflect flow into the bank also creating toe erosion and mass-wasting failures.

The specific type of bank failure at any one location depends on the type of bank material. Noncohesive materials tend to be removed grain-by-grain, while cohesive materials tend to fail by mass-wasting processes. Grain-by-grain erosion can be significant in areas of concentrated flow (e.g., on the outside of a bend); however, studies of bank erosion processes in both perennial and ephemeral streams indicate that mass failure and subsequent fluvial transport of the failed material is the primary mechanism by which lateral adjustments occur. Therefore, it is apparent that the analysis of the potential for lateral migration and channel widening must include bank stability considerations and the resulting potential for mass failure.

The most accurate means of evaluating bank stability uses site-specific data to develop a relationship between bank angle and height. When site-specific data are not available, analytical relationships can be used to evaluate bank stability for alluvial channel conditions (e.g., Ponce 1978; Little et al. 1982; Osman and Thorne 1988). However, even for the most cohesive soil conditions, these relationships predict stable bank heights that are typically no more than about 18 feet (e.g., RCE 1994; Figure 3.20). When bedrock conditions are present, stable bank heights can be much greater. Given the stable bank height, either empirically or analytically, the amount of bank retreat given a certain amount of channel incision can be evaluated.

3.3 Maintenance

The prudent line concept allows the stream to function naturally within the constraints of protecting existing infrastructure. Future development, including infrastructure, is provided for by keeping a safe distance horizontally and vertically from the creek and protecting it structurally when needed (i.e., when channel movement reaches a maintenance line within the prudent line boundary the planning concept for the creek changes from natural to naturalistic with a selective erosion barrier provided).

This proactive approach which includes proper location of infrastructure combined with selective structural measures as needed, avoids the need and cost for continuous structural improvements. The cost of structural channel improvements occurs over time as needed, rather than initially. Current experience with sandbed channels in New Mexico indicate that the cost of these periodic improvements over time would not amount to more than the costs needed to replace damaged components of alternatives with continuous structural improvements. As will be discussed in more detail in Section 5.6, the Urban Drainage and Flood Control District (UD&FCD) has found that natural channels require much less maintenance than structural channels.

The natural concept of a prudent line requires, by its very nature, less routine operation and maintenance because it has fewer constructed features to maintain; however, as stated above, it can involve the need for construction of erosion protection in areas where the exposed features are potentially vulnerable. Long-term operation and maintenance is judged to be equal to structural intensive concepts, but it may involve annual carryover of funds because of the more periodic nature of needed maintenance. However, annual carryover of funds has not been allowed by the City of Colorado Springs in the past.

The width of the maintenance line and the wider prudent line provide more room than required for conventional structural improvements, thereby accounting for adequate space for access and construction where needed. With more space, a greater range of repair options is also available.

3.4 Application to Cottonwood Creek

3.4.1 General

In order to determine the location for a prudent line on Cottonwood Creek, one must take into consideration bedrock geology (both in terms of location and competence), bank heights, channel and valley widths, channel stability, topography, possible future changes, and existing development. A primary difference between Cottonwood Creek and other channels where the prudent line concept has been applied is the extent of bedrock located at or near the surface of the Cottonwood Creek channel. Other applications have been in more alluvial channels with greater potential for erosion and more rapid channel changes. Given the presence of bedrock, a slightly different procedure is necessary to define the prudent line from what has been applied in other more alluvial channel applications. The following discussion provides a quantitative determination for a minimum setback of a prudent line based on both quantitative and qualitative information taken from existing topographic maps of the Cottonwood Creek watershed. The area requiring a prudent line determination extends from Rangewood Drive to Black Forest Road.

Figure 3.1 represents a schematic and formula proposed for use in defining the prudent line setback location for much of Cottonwood Creek. The accompanying plan set shows the top of bank along the creek as a solid line (upstream of Rangewood Drive). The bank line is represented by very closely spaced contours along the valley margins. This steep slope is different from the valley wall slope, in that the valley wall slope contours are not as closely spaced. The valley wall crest is represented by a significant change in the closeness in contour spacing.

Upstream of Rangewood Drive, Cottonwood Creek flows within a stable, narrow valley with shallow or exposed bedrock along much of its length. This bedrock is fairly competent as indicated by the lack of lateral channel migration seen in the aerial photography over time. An analysis of the bank slopes and heights in this upper area indicates that even the highest banks are often quite steep and stable, which is a direct result of the bedrock control. In this type of material, large failures are infrequent, and will likely occur as rotational or slab failures with vertical or near vertical failure planes.

Given these conditions, a 2H:1V bank slope would conservatively estimate the extent of bank widening that might occur from bank failure. The bank height (BH) is defined as the height from the toe to the top of the bank as determined from the contour maps. This height along with an expected maximum incision depth (ID) are added together to define the maximum bank height. The incision depth is calculated from sediment continuity results. Using a 2H:1V bank slope with this maximum bank height defines the channel widening that might occur from a bank failure as a result of incision.

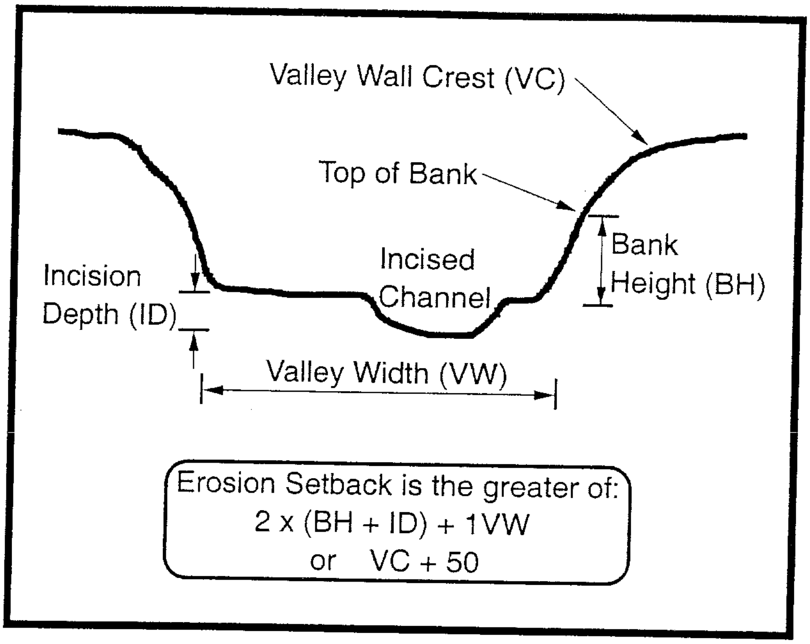

Figure 3.1. Erosion setback definition sketch.

However, possible future lateral migration must be accounted for as well. Based on historical conditions, there has not been significant change over time in channel planform. Historic aerial photography indicates minimal lateral instability over time. However, to account for potential channel migration, it is recommended that a minimum of one valley floor width be added to the above product to account for migration. The total setback will then be equal to 2*(BH+ID)+1VW measured from the toe of slope for each side.

The other factor contributing to bank line instability in Cottonwood Creek is the effect of overwatering, with excess irrigation water seeping out some of the bank lines. An example of severe slope erosion, slope retreat, and property loss resulting from subsurface irrigation seepage can be found near the headwaters of Tributary 1 (south of Rangewood Dr.). Landscaping ends at the near vertical face of the tributary valley and seepage resulting from lawn irrigation is causing the valley wall to slowly erode and retreat. This seepage and increased subsurface moisture may also increase the chance of large rotational or slab failures of the valley wall. The increase in moisture in the subsurface can result in an increase in the shear stresses on the parent material because of the combination of gravity, bank height, and bank loading and a concomitant reduction in the shear strength of the bank because of an increase in pore water pressures, possible failure plane lubrication by subsurface waters, and possible piping. Therefore, controlling this seepage is important to maintaining bank stability, particularly along high bank lines.

To account for seepage caused erosion and bank instability, it is recommended that the minimum setback distance should extend out past the valley wall crest (VC) by at least 50 feet. This distance will provide a buffer for slope and bank erosion that could occur as a result of subsurface seepage and flow relating to lawn irrigation, as well as an area of native vegetation and soils that might infiltrate and evapotranspirate some of the excess lawn irrigation.

Therefore, for purposes of calculating the prudent line along Cottonwood Creek upstream of Rangewood Drive, an enveloping curve should be used based on the greatest of (1) the 100-year floodplain, (2) the calculated setback based on bank slope and height considerations, or (3) the setback based on valley wall crest plus 50 feet.

An exception to the above formula is the reach just upstream of Rangewood Drive where the channel and valley floor are fairly wide. The right bank is protected by rock riprap. The left bank is defined by the left valley wall which is unprotected, but is gently sloping. Bedrock does not appear to be controlling the form of the creek at this location; however, the reach is stable and will likely remain stable or may become slightly incised. In either case, the prudent line location in this reach will be different. Because of the bank protection and stability of the reach, the prudent line along the right bank in this reach could be located about 50 feet back from the top of the riprap, assuming long-term maintenance of this riprap. Along the left bank, the prudent line should be defined by 2 times the bank height plus 50 feet, or 50 feet from the top of the valley wall crest, whichever extends further from the valley wall crest.

Also, it should be noted that upstream of Rangewood on the left bank and on Tributary 1, the backwater effect of the Rangewood culverts control the 100-year flood elevations, which in turn set the prudent line limits beyond the setback criteria.

It is important to note that the prudent line has a vertical as well as a horizontal component creating a prudent line window. **Figure 3.2** represents a schematic of a typical stream cross section with the vertical extent of the prudent line shown. Infrastructure (i.e., bridges, sanitary sewers, water lines, utilities) that lie outside the window are assumed to be generally consistent with the prudent line. New infrastructure should not be proposed within this window. Existing infrastructure that lies within this window may need to be relocated or protected. Storm sewer outlets may be located within the prudent line window, but may need periodic maintenance (either lengthening or shortening pipe) as the channel migrates.

3.4.2 Grade Control Structures

To better ensure long-term performance of the prudent line, as designated above, soil cement grade control structures are recommended for use as vertical grade control (see Channel Stabilization Alternatives for a discussion of soil cement grade control structures). Generally speaking, these structures should be installed with an invert elevation at the existing grade, as their purpose is to maintain grade and not to re-establish new gradeline. This helps avoid the necessity of complete channel reconstruction and regrading in areas where there is not a specific need for channel work. As constructed, they will provide a hardpoint in the channel to prevent any incision or headcut that might develop from continuing for a long distance. Grade control structures are also recommended in the reach downstream of Rangewood, based on the need to protect existing structures and development, and to limit any further incision.

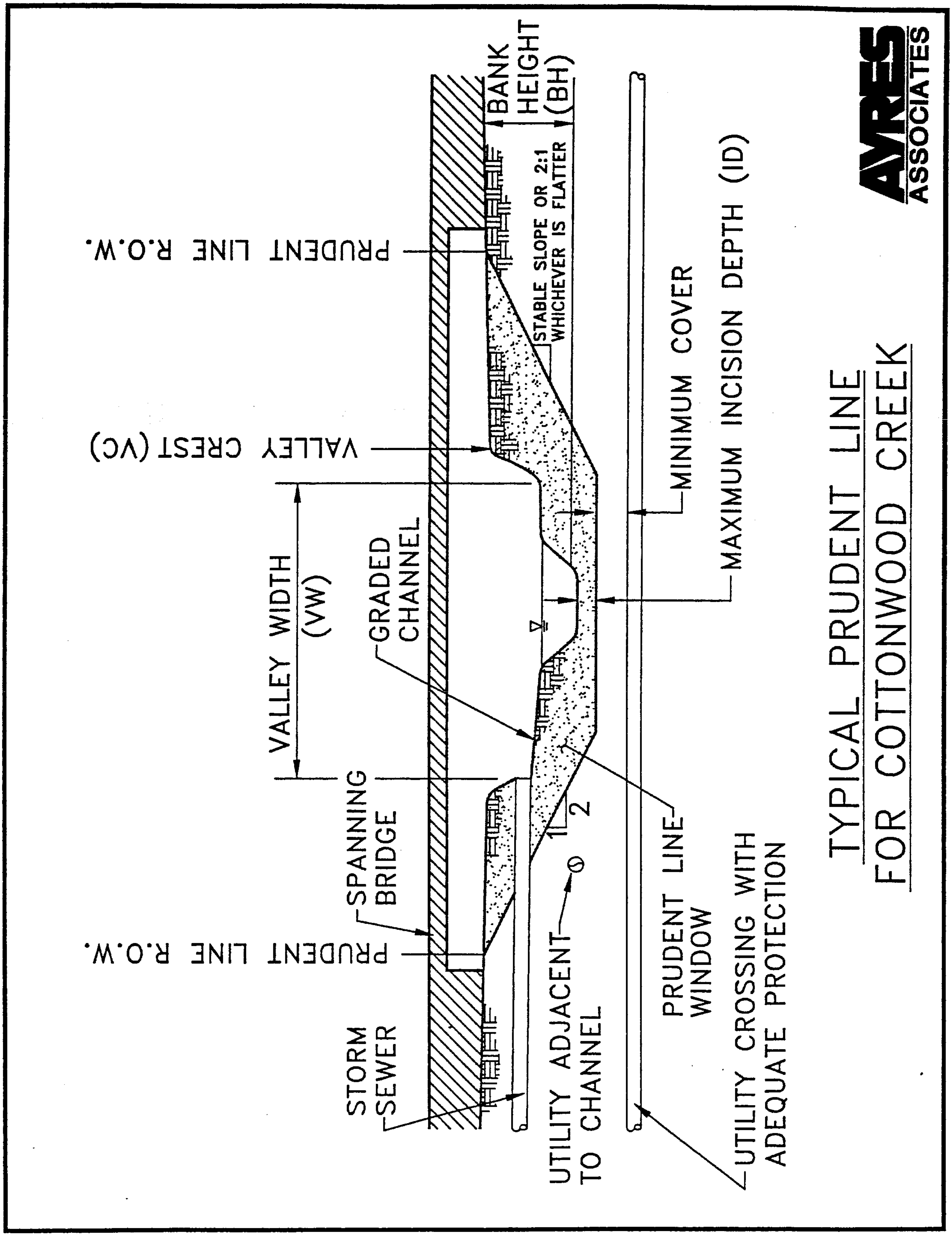

Figure 3.2. Schematic of typical stream cross section depicting prudent line window.

While there is considerable bedrock exposure within the entire length of the channel, this bedrock does not provide adequate grade control (Ayres Associates 1995). This is particularly true over the long-term with the effects of urbanization. The general channel lowering that has occurred since 1961, downstream of Rangewood Drive, is probably the direct result of increased flows and decreased sediment yield from urbanization in the lower portion of the watershed. However, where this incision has occurred into bedrock (e.g., below Academy), a relatively narrow, incised channel has developed with little impact on bank stability. Utility structures can be threatened by this degradation, but the effects on lateral stability and a prudent line location are limited. With properly designed and located grade control structures, this incision can be controlled.

As a minimum, grade control structures should be placed downstream of every bridge to ensure the long-term safety and integrity of the bridge, below tributary confluences, and below utility crossings to proactively protect existing features from further erosion or to reestablish conditions which can be protected. Other locations should be considered based on a desire to provide a maximum spacing of about 1,000 to 2,000 feet.

The invert elevations for the proposed grade control structures were qualitatively defined based on existing channel conditions, and in particular, the lowest terrace elevation in those reaches where some incision has already occurred. When the invert is set at the terrace elevation, which represents the channel invert prior to the incision episode, a physical drop will exist where the low-flow channel is located and a ponded area will occur upstream. Over time, this ponded area will fill with sediment and the pre-incision channel condition will be reestablished upstream of the drop.

3.4.3 Bank Protection

While the basic concept of a prudent line is to establish a zone around the channel which permits the channel to exist in its natural state, it is acknowledged that existing encroachments and utilities may require protection. One or more of the channel stabilization measures will be recommended to protect existing infrastructure, as required.

3.4.4 Other Structures

Bridge and utility construction, which is consistent with this concept, may involve longer spans, greater bury depths over longer lengths, and other techniques which avoid conflict with the creek's expected movement patterns. The crossings are more costly for this reason, but reduce the need for future relocation or expensive protective works.

4. HYDRAULIC AND SEDIMENT CONDITIONS UNDER A PRUDENT LINE CONCEPT

4.1 Existing Hydraulic Conditions

To provide a baseline for comparison and evaluation of the proposed improvements, the existing hydraulic conditions were first evaluated using the U.S. Army Corps of Engineers HEC-2 computer model. Geometric data were taken from the 1995 FIMS mapping. The 1995 FIMS mapping is updated from the 1989 mapping; however, not all the panels were updated, nor was all the information on a given panel changed. In particular, the channel topography for Cottonwood Creek was only updated in one location (above the temporary Haul Road), even though there were other more extensive changes to channel geometry in other reaches. Therefore, even though the mapping was dated 1995, it represented 1989 conditions in Cottonwood Creek.

Cross-section locations were defined at about 500- to 1000-foot intervals. Using the digital database, cross sections were cut, using Microstation, directly into HEC-2 GR card format. Field-surveyed cross sections were used to define bridge conditions. Normal depth bridge modeling was used for all bridges. Channel n values were 0.04 and overbank values were 0.05. Manning's n value selection was based, in part, on the assumption that supercritical flow will not occur in natural channels, except for short distances, as a direct result of additional energy dissipation from factors such as hydraulic jumps, turbulence, bedforms and obstructions (for example, Trieste 1992). With a channel n of 0.04, flow conditions were generally at or near-critical conditions, which was considered a physically realistic flow regime for Cottonwood Creek. Technical support information is provided in **Appendix C**.

4.2 Future Hydraulic Conditions

In the future condition model, the cross-section geometry was adjusted to reflect the proposed grade control structures. The invert elevation of each grade control structure was qualitatively established based on field observations of existing conditions and terrace elevations. In order to model the proposed grade control geometry, a sediment elevation was specified for the cross sections located at the grade control structures (using field 2 of the HEC-2 X3 card) to create a level profile at the proposed invert elevation. Note that these invert elevations were qualitatively set for purposes of master planning and should not be used for final design without more detailed engineering analyses.

Furthermore, note that grade control structures in the prudent line reach (above Rangewood Drive) were not proposed to change (or flatten) the channel grade, but rather to maintain existing conditions and provide hardpoints to limit the progression of headcuts and other incision events. Nonetheless, some adjustment in channel slope will occur between the grade control structures under future conditions. In order to account for these changes in the future condition hydraulic analyses, a 5-foot drop was assumed to develop below each grade control structure. This drop height was based primarily on field observations that found the incision depth of most of the existing headcuts in the sandstone bedrock material to be about 5 feet.

The channel slope in the reach downstream of each drop was lowered based on linear interpolation (given a 5-foot drop immediately below a given grade control structure and no change immediately upstream of the next downstream drop). For purposes of this analysis, the channel cross sections in the downstream reach were uniformly adjusted by the calculated amount using field 9 on the HEC-2 X1 card. A minimum slope of 1.0 percent was assumed to avoid flattening the slope too much in reaches were the drops are closely spaced. The grade control structures in the reach below Rangewood Drive were located primarily to protect existing facilities and control tributary confluences. However, again, some change in channel profile is expected over time and the same criteria was applied in this reach. Technical support information is provided in Appendix C.

4.3 Hydraulic Results

The model was run for existing and future runoff conditions (with and without proposed detention facilities). A total of five discharges were analyzed (5-, 10-, 25-, 50-, and 100-year flows). The trends in the hydraulic conditions in this section are discussed in terms of the 5- and 100-year flows. Note that the HEC-2 model was primarily developed to provide insight on hydraulic conditions in Cottonwood Creek, and in particular an understanding of the relative changes from existing to future conditions. For purposes of a master planning study, the assumptions used may be simplified over what might be appropriate when the objective is floodplain mapping or final engineering design. In particular, more detailed bridge modeling, different n value and bank station definition, and more accurate adjustment of channel geometry to reflect future conditions would be necessary for floodplain mapping and/or final design of any proposed improvements.

The modeling results indicated that the primary flow regime was subcritical flow; however, there were a number of cross sections where critical depth was assumed, suggesting that supercritical flow might be occurring. Recognizing that supercritical flow is generally not sustained for any great distance in natural, or unlined, channels, and given that the primary objective of the hydraulic modeling was to define reach-averaged hydraulics and general trends for use in evaluating future conditions, these results were acceptable.

Figure 4.1 illustrates the velocity variation with distance for the 5-year event. A sixth order polynomial curve fit was used to describe the trend line for each run. The existing condition results provide the baseline condition, and suggest velocities in the range of 5 to 8 fps, which are typical of a low-flow type event. At the other extreme, the future condition runoff without detention and a discharge greater than twice as large as existing conditions, indicates an increase of about 2 to 4 fps, to values as high as 11 fps. In between are the results for the future condition runoff with detention.

For comparison, the DBPS HEC-2 model was run with the revised future land use conditions hydrology. The future conditions hydrology with detention was used to be consistent with the recommended DBPS alternative. Results indicate that under the recommended DBPS future conditions, channel velocities (with grade control limiting channel slope to 1.5 percent and four major detention facilities) are slightly higher than existing condition velocities.

Figure 4.2 illustrates the velocity variation with distance for the 100-year event. The general trends and conclusions between the different conditions are similar to the 5-year results, except that overall, the velocities are about 2 to 3 fps greater.

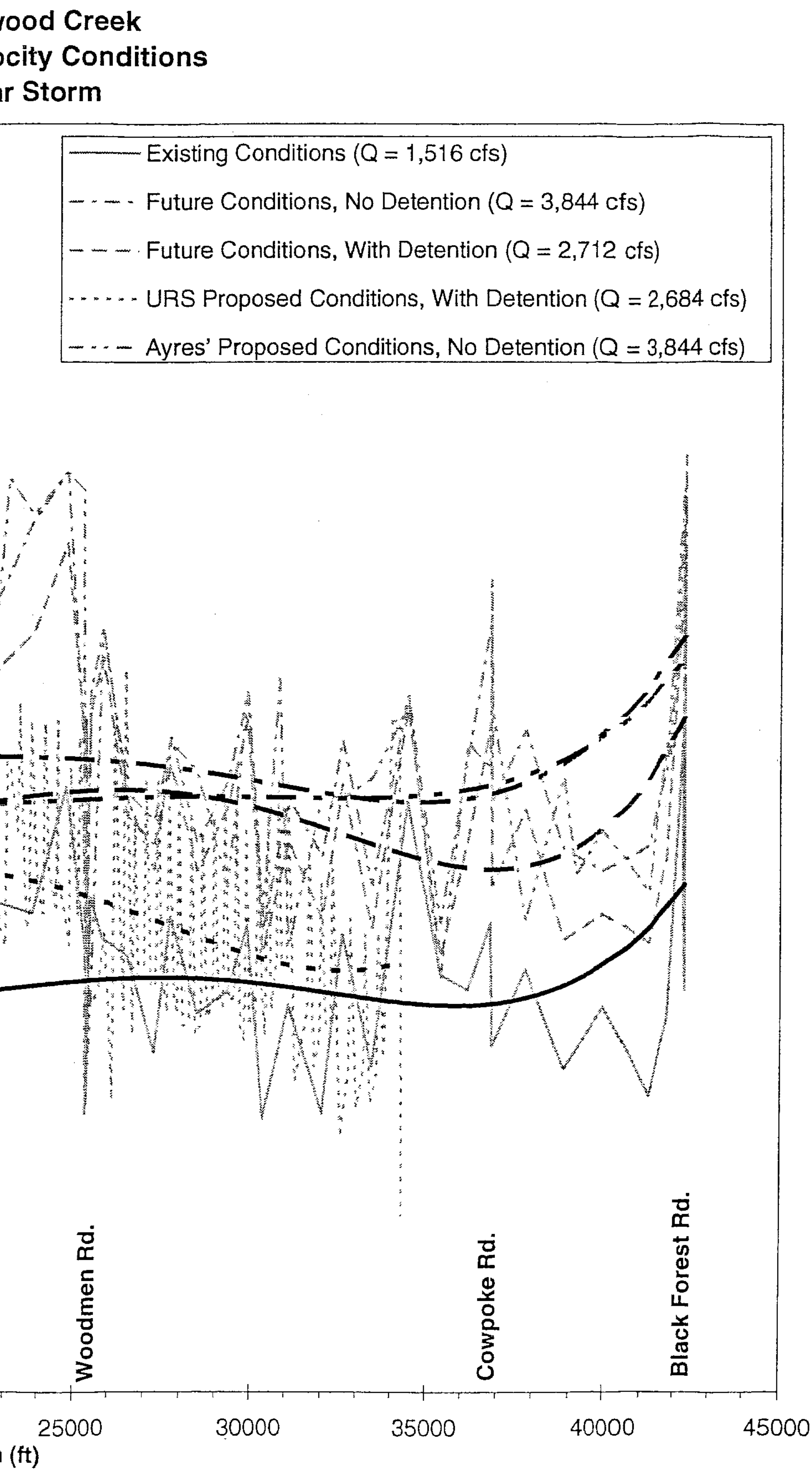

Figure 4.1. Cottonwood Creek, average velocity conditions, 5-year storm.

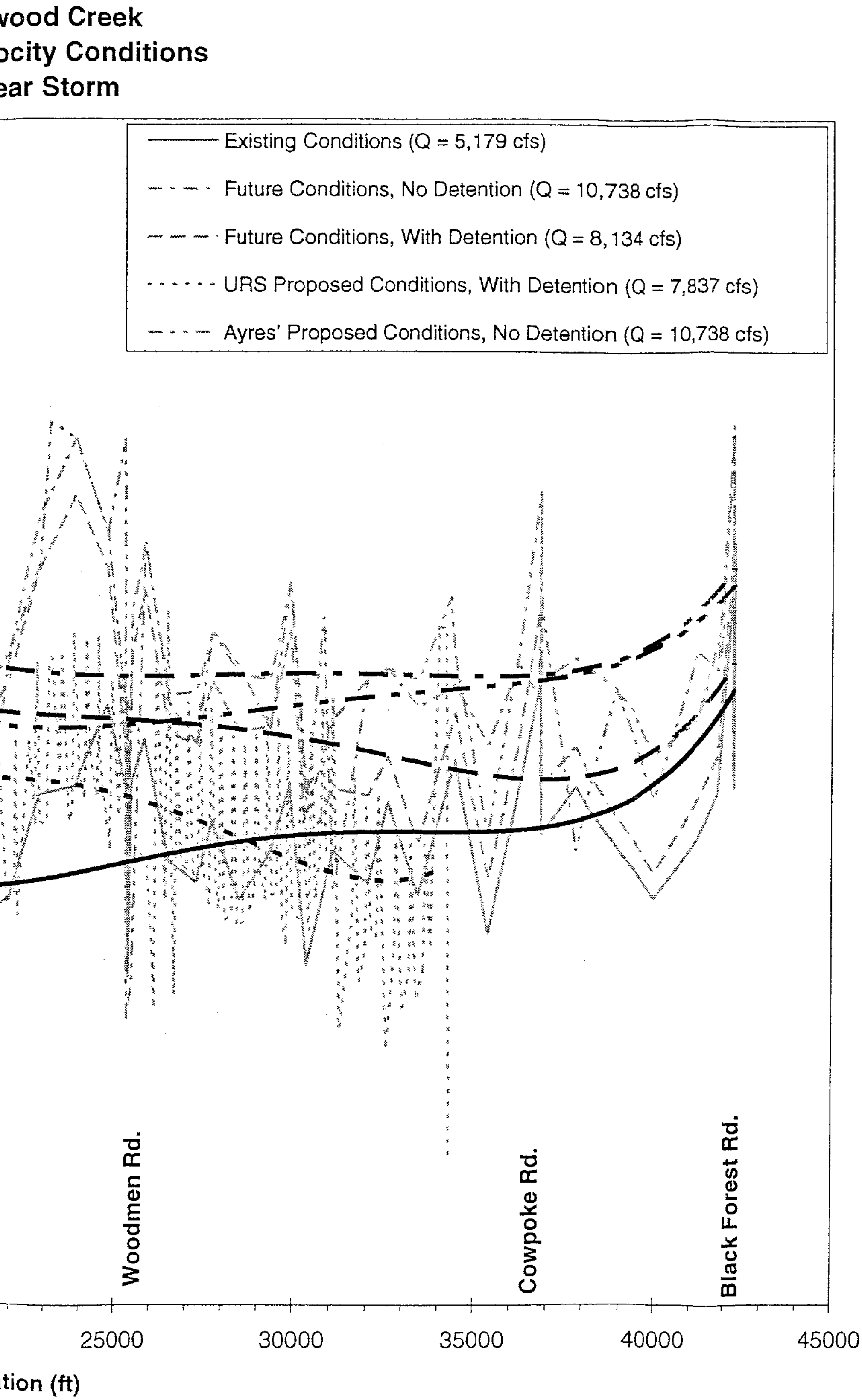

Figure 4.2. Cottonwood Creek, average velocity conditions, 100-year storm.

4.4 Existing Sediment and Water Quality Conditions

Sediment carried by water is often described as a physical characteristic in terms of suspended sediment concentration in mg/l. It also appears in water quality testing as a component of grit, turbidity, and suspended solids (SS) (or fixed suspended solids (FSS)). There are no specific physical sediment yield, turbidity or suspended solids limitations placed on flows originating in the Cottonwood Creek or at its confluence with Monument Creek. Both waterways probably carry above-average suspended solids and judging from basin soils; historical levels were also probably high. State water quality standards related to instream sediment are generic, refer to sources of human origin which are detrimental to beneficial use, and provide no numeric definition.

Background suspended sediment levels are undocumented, but agricultural practices, mining, and urban development, which have been experienced since the middle of the 19th century, increased soil erosion in the Cottonwood Creek basin. In addition, higher base flows in combination with higher volumes and rates of runoff associated with development have provided more water to carry the resulting sediment. In recent years (the last 10 ±), better construction control of sediment sources and conversion of exposed ground to a more erosion-resistant urbanized condition has tended to reduce sediment sources.

4.5 Future Sediment and Water Quality Conditions

A fundamental concept in sediment transport is the sediment continuity principle. The amount of material transported, eroded, or deposited in an alluvial channel is a function of the sediment supply and sediment transport capacity of the channel. Sediment supply is provided by the watershed and any erosion in the upstream channel. Sediment transport capacity is a function of the size of sediment, the discharge and geometric and hydraulic principles of the channel. When the transport capacity equals the sediment supply, a state of equilibrium exists. If the sediment supply is greater than the transport capacity, sediment deposition will occur to re-establish a balanced condition, and if the sediment supply is less than the transport capacity, erosion will occur to make up the deficit.

Sediment supply areas under natural conditions can be generally classified as watershed or channel derived. Watershed sediments are derived from overland flow erosion, which contributes primarily fine-grained sediments to the channel network. The channel network, including the main channel and its tributaries, is a source area for coarser-grained material (e.g., from gully erosion in the headwaters area to bank sloughing and failure in the main channel) that is eroded and deposited along the channel creating sandbars and other deposits.

As urbanization progresses the supply of watershed-derived sediments is decreased, as a direct result of increasing impervious area and conversion of native vegetation to urban landscaping. During construction associated with urbanization, sediment yields can increase without proper on-site erosion control; however, the net long-term effect is a reduction of watershed sediment yield. Channel-related sediment yield also tends to decrease with urbanization, due to conversion of small tributaries and gullies to urban storm drains, and stabilization of the major channels.

According to the sediment continuity principle, this decrease in sediment supply will result in erosion to make up the deficit. If the major channel network is not stabilized, sediment can be eroded from the bed and banks, resulting in channel instability. Compounding this effect is the increased runoff, in terms of peak flows and volumes, that often results with urbanization. This increased flow creates additional sediment transport capacity over natural conditions.

In the case of Cottonwood Creek, there is a significant sediment supply located in the terraces deposits in the bed of the channel. Therefore, as the upstream sediment supply is diminished from effects of urbanization, the channel will begin to erode these terrace deposits to maintain a balance between sediment supply and transport capacity. However, over time, these terrace deposits will be completely eroded and the channel will become supply limited; that is, the transport capacity will exceed the sediment supply and the concentration of sediment carried by Cottonwood Creek, and delivered to downstream channels will be decreased over historic conditions.

Note that with removal of the terrace deposits, erosion of the underlying bedrock might occur and could supply some of the deficit; however, the much slower erosion rate of the bedrock material limits its ability to satisfy the demand established by the transport capacity. The erosion of this bedrock will result in vertical incision into the bedrock, with limited lateral erosion, ultimately creating a more deeply inset channel. This vertical incision can be controlled with grade control structures, which further limits the sediment supply. The end result will be a supply-limited channel that has lower sediment concentrations than existed naturally. Assuming adequate on-site erosion control during urbanization, the interim sediment concentrations will not be much different from natural conditions as the channel satisfies it inherent transport capacity by eroding the terrace deposits.

Therefore, the implementation of a prudent line concept with grade control will not cause an increase in sediment delivery, or degradation of physical water quality over historic conditions. Implementation of a more structural bed and bank stabilization would reduce the source of stream sediments faster than a prudent line concept, but the long-term fully developed basin sediment yield will be about the same. The DBPS mentions no numerical goals or specific benefits associated with sediment reduction. Also, there has been no specific study made in the downstream impacts (costs and benefits) associated with sediment reduction, including the potential for increased erosion in downstream channels (e.g., Monument Creek) caused by the reduction in supply from Cottonwood Creek.

4.6 Sediment Concerns

4.6.1 Introduction

Should the prudent line concept be adopted as the basis for the drainage basin master plan for Cottonwood Creek, the City of Colorado Springs' staff has stated that the water quality may be compromised as a result of sediment transport. Under the National Pollutant Discharge Elimination System (NPDES) stormwater quality regulations, the City of Colorado Springs and other permitted cities/counties in Colorado are required under their permits to incorporate Best Management Practices (BMP's) to control and limit pollutants (including sediment) to their drainage systems. Also, there is concern that increased sediment loads resulting from the prudent line will impact aquatic habitat on Monument Creek and will be detrimental to the City's water supply intake on Monument Creek. These three issues are addressed below. The basic assumption behind most of the water quality comments is that application of the prudent line concept will result in increased sediment load in the channel.

The first question about that assumption is what is the base line being compared - existing channel conditions or future conditions with a totally lined channel? This question is difficult to answer for the following reasons:

1. The urbanization of a watershed will increase the impervious area and landscape most of the remaining land area thus reducing the watershed sediment supply to the stream.

2. The decreased sediment load in the stream will result in increased sediment being eroded from the stream bed and banks if the material is available for sediment transport. In this case the bed and banks are bedrock that, although erodible, limits the supply; and as a result, the increase in flows does not result in an increase in total sediment load at the mouth.

3. The prudent line proposed grade control above Rangewood is for the sole purpose of maintaining the historic velocities in an attempt to control the sediment transport capacity.

4. The Ayres Associates proposed channel improvements for the lower reach of Cottonwood Creek from Rangewood to Monument Creek are similar to those proposed in the DBPS. Therefore, in the lower 4 miles of channel, the sediment transport capacity will not change from the DBPS.

4.6.2 NPDES Requirements

We understand the City of Colorado Springs is required to control and limit sediment along with other pollutants to its drainage system under its municipal Stormwater Discharge Permit. A better understanding may be necessary to determine what environmental implications there are to the sedimentation processes. In fact, total sediment removal may have a greater environmental impact. Presented below is a description of the sedimentation process and possible methods of controlling the urbanization impacts on the sedimentation process.

Sediment is defined as a solid fragment or fragments that come from the weathering of rock and as such is almost always inorganic in nature, but can be organic. Sediment is distinguished from organic nutrients, which are associated with live or dead particles derived directly from the surrounding environment (microscopic organisms, algae, pine needles, leaves, etc.). It is important to note that organic nutrients may attach to sediment or show up as part of turbidity or suspended solids in an aqueous solution, but they are not sediment.

The State of Colorado has no numerical standards with respect to sediment in streams and the related standards, which exist relate to human-caused sources (personal communications with Sara Johnson and John Scherschligt). Other states, which do address sediment as a water quality issue (i.e., Wyoming), only consider sediment at some level above the natural background level as a concern. There are water quality issues associated with sediment, including metals and organic material, which commonly become attached to sediment. In addition, the fine particle components of sediment can affect aquatic organisms' respiration and reproduction, photosynthesis, color and clarity contribute to the dirty water or polluted water aesthetic image, which sediment laden water has. Control of sediment can help improve the water quality, but it is really the control of defined pollutants at their source that has the most impact on water quality.

Sediment in Cottonwood Creek originates from upland soil and rock exposed to weathering by wind and rain runoff, from the action of flowing water on the bed and banks of Cottonwood Creek, from material deposited directly in the Creek, and from anthropogenic sources (asphalt roof tiles erosion, fossil fuel vehicle byproducts, etc.). Sediment can be removed from the water, but much of the sediment in Cottonwood Creek is naturally available. As long as the water has the energy to pick up the sediment from the bed and banks, the sediment level in the water will be quickly returned to its natural background level. In other words, removing sediment causes the water to be sediment hungry and results in additional bed/bank erosion downstream to re-acquire its sediment load.

The solution to the sediment problem with respect to water quality is not to simply remove sediment or prevent natural erosion along the creek, but to focus on human-caused sources of water quality degradation above the natural background levels. This involves measures to control and limit pollutants both at the source and in-stream, including:

- Developing a plan for handling increased (above natural) baseflows associated primarily with irrigation return flows and similar sources associated with land development that can mobilize sediment by increasing the flow/duration pattern of the creek
- Removing anthropogenic waste at its source (street sweeping, litter maintenance, building/grounds and vehicle maintenance, etc.)
- Controlling/covering outside materials storage areas and materials transportation
- Controlling waste storage, collection, and transportation
- Implementing a public awareness/education program concerning human impacts on the creek
- Developing an aggressive enforcement of material dumping in and adjacent to the creek
- Minimizing in-stream bed and banks disturbance wherever possible

In addition, off-stream drainage practices need to be addressed. To reduce sediment sources and runoff volume/rates associated with land development, off-stream drainage practices need to be implemented and include the following:

- Minimize the area and time of bare soil exposure
- Minimize vegetation disturbance and plant vegetation
- Utilize vegetation buffer strips to remove overland flowing sediment
- Minimize overland flow velocity by using flat surface slopes
- Use every opportunity to increase water infiltration, keep impermeable areas to a minimum, and minimize directly connected impermeable areas
- Maintain vegetated riparian and upland buffer areas along the creek and its tributaries
- Minimize the impact of storm sewers discharging into the channel by setting outlets and at the creek level provide adequate energy dissipation devices

Removal of sediment below natural background levels is not possible short of 100% hard surfacing all sediment sources. This is not economical, not without adverse impact on downstream areas (increased bed and bank erosion), and not justified from an ecological standpoint. Sediment and its movement by water is a complex subject involving both water quality and physical impacts on the stream environment. It should be handled on a watershed and a stream continuity basis using numerical criteria when possible. Issues of storm water, such as voluntary controls of non-point pollution, should be addressed on a scientific basis focusing on specific problems, which can realistically be solved in an effective manner resulting in measurable improvements in water quality and without unacceptable secondary impacts.

4.6.3 Aquatic Habitat on Monument Creek

There is concern about the impact of the prudent line on aquatic habitat in Monument Creek. This concern is based upon the assumption that adoption of the prudent line will increase sediment loads from Cottonwood Creek, which is not necessarily the case as discussed above. It was discovered that the main concern has to do with low flood flows. Apparently there is a significant change in aquatic habitat conditions in Monument Creek that occur near the confluence of Cottonwood Creek. It is felt that the habitat change is due to the increased turbidity and sediment from Cottonwood Creek.

The apparent changes in water quality at Monument Creek near the Cottonwood confluence appear to be related to low flows (flows less than the 2-year event and not necessarily related to large storm events). This problem has not been addressed by either the current DBPS or Ayres Associates' proposed alternatives. If low-flow water quality is a concern, then there are several ways to address the problem that would not affect the application of the prudent line. Some of these items may include the following:

- Monitoring water quality in Cottonwood Creek by using existing gaging stations on Cottonwood Creek (at the mouth and at Woodmen Road)
- Incorporating low-flow water quality enhancement systems into the channel improvements in the lower reaches of Cottonwood Creek (downstream of Union)

This problem can be addressed as part of the implementation of the DBPS. Currently the majority of other DBPS's in the City of Colorado Springs have not included the cost of water quality enhancement in the master plan drainage fees. The funding of water quality enhancement will need to be addressed for all basins if those types of improvements are required in the future.

4.6.4 Water Diversion from Monument Creek

The final area concerning sediment is the City of Colorado Springs' water intake structure on Monument Creek. This problem is not only affected by Cottonwood Creek but also by Monument Creek as a whole. The Monument Creek DBPS states the long-term concern on Monument Creek is the increase in storm water runoff and resulting degradation of the channel. This problem will be exacerbated by eliminating sediment from Cottonwood Creek.

Again, this may be more of a problem resulting during low-flow periods and needs to be addressed as discussed for aquatic habitat problems. If the problem is high-flow sediments, then this problem cannot be solved unless all tributaries and the entire channel of Monument Creek were improved. In this case, channel degradation may become a major problem threatening the intake structure and will not be solved by either alternative of the Cottonwood Creek DBPS.

5. PRUDENT LINE BASED MASTER PLAN RECOMMENDATION

5.1 Introduction

It is recommended that the DBPS channel Alternative A, a prudent line channel, be implemented upstream of Rangewood Drive. Urbanization has not yet encroached significantly on the channel in this reach and a prudent line channel could be implemented at this time. Furthermore, the long-term stability of Cottonwood Creek upstream of Rangewood Drive suggests that a prudent line channel would be an effective alternative. The prudent line was calculated according to the criteria previously defined and delineated on the plan view sheets. Recommended grade control locations and other improvements are also shown.

To evaluate the land area that must be reserved to accommodate the prudent line, the area between the prudent line and the 100-year floodplain was calculated. The 100-year floodplain was based on existing channel conditions and future flow conditions without detention. Existing channel conditions were used to be consistent with FEMA floodplain mapping procedures. FEMA mapping is always based on existing channel conditions and does not include any proposed future improvements out of concern that these improvements might not be built in the future.

Downstream of Rangewood Drive, an implied prudent line generally exists in many reaches, and where it does not, channel improvements are typically in place. It is recommended that the existing setback and channel improvements in this reach be maintained. In some reaches, it is recommended that the existing improvements be extended to provide necessary channel stability. The plan view sheets summarize the recommended improvements.

5.2 Stormwater Detention

Since the prudent line concept is largely based on providing adequate channel conveyance, the need for stormwater detention was carefully scrutinized.

Using the future conditions hydrologic values of this study, floodplain limits were calculated and the extent of property flooding estimated. The hydrologic model was reconfigured and rerun with the DBPS proposed detention facilities included and floodplain limits recalculated. No significant identifiable areas of property flooding reduction were identified which would justify the need for the detention facilities. Likewise, the number and size of stream improvements on Cottonwood Creek were unaffected by reduction in flows provided by the detention facilities. It is expected that some savings in costs for the conveyance facilities located immediately below each detention facility is a benefit attributable to the detention facilities. However, in a prudent line concept, even this is of a minor value as fewer conveyance facilities exist that could be reduced as a result of lower flows.

Since the prudent line is configured well outside of the 100-year floodplain limits and is determined largely by physical characteristics rather than by flood-flow rates, a reduction in future conditions flood-flow rates does not impact the prudent line location. Detention, therefore, is unnecessary.

Another common benefit of detention is reduced streamflow velocities which result from a reduction in peak flows. A comparison of velocities for detained and undetained flows revealed a velocity reduction of 0.5 to 1.5 fps as a result of detention. This magnitude of reduction is not sufficient to result in any meaningful reductions in structural conveyance facilities.

5.3 Improvements Upstream of Rangewood Drive

5.3.1 Rangewood Drive to Woodmen Road

Just upstream of Rangewood Drive, the channel and valley transition to hilly topography and the channel constricts and deepens. Small floodplain remnants are located along the channel suggesting some incision in the past. The channel bed transitions from a sandy material to a relatively competent bedrock with small headcuts and one relatively high knickzone. The knickzone and headcuts do not appear to be moving and may be relicts of past incision. Just downstream of Woodmen Road, the channel appears to be eroding its bed and banks. Possibly a consequence of being in a bend with relatively restricted flow on bedrock.

A USGS gaging station and small drop structure are located just downstream of Woodmen Road. A large gully has formed along the right bank within the southwest roadway embankment as a result of flow concentration along the roadway and its diversion into the channel. Better control of roadway drainage should be provided at this bridge.

This reach is relatively stable according to the profile comparisons (Ayres Associates 1995). The downstream half of the reach appears relatively unchanged over time while the upstream half may have undergone some incision prior to 1975. The channel appears to have recovered by 1989. However, present bed elevations may be closer to those of 1975 as indicated by the exposed bedrock in the channel and the low terrace remnants along the channel margins.

In this reach, a total of two grade control structures are recommended. The area impacted by the prudent line includes 22 acres of developable land.

5.3.2 Upstream of Woodmen Road

Upstream of Woodmen Road, the channel is generally well-defined and inset into hilly topography. The channel is restricted to a narrow valley with fairly high bedrock walls and a narrow, well vegetated floodplain. Where the channel impinges against the valley walls, bedrock is exposed and appears as a relatively high, raw, eroding bank. However, comparison of past photography indicates that retreat of the eroding bedrock banks is extremely slow. Erosion primarily occurs by slope wash and sloughing, but some channel undercutting and gravity failure is occurring.

A large, deeply incised gully that was present in 1989 on the right bank at the apex of the bend, downstream of the temporary haul road, has subsequently been backfilled. However, the backfill is unprotected and eroding and small gullies are developing along the top of the bank. Groundwater is seeping from the toe and adding to the erosion as well. A toe drain should be installed to control this seepage and minimize bank instability. Another large gully is developing just downstream of this site on the right bank because of flow from a small unprotected outfall pipe which drains the subdivision to the north. Better control of storm drain runoff should be provided, including better energy dissipation measures at outlets.

Upstream of the temporary haul road, the valley has a swaled appearance with a small, shallow channel meandering along the valley floor. The swaled appearance is likely due to the healing of the valley walls. The valley walls were being eroded by a wide, shallow channel that extended across the width of the valley floor in 1955 (Ayres Associates 1995). Since then, the channel has narrowed and no longer impinges on the valley walls. Slope wash and sloughing with a buildup of a colluvial wedge at the toe of the wall have effectively reduced the bank height and angle and allowed the bank to be stabilized with grasses. Upstream of the proposed Powers Road alignment, the valley is much more deeply inset into the hilly terrain until near the Cowpoke Road bridge. The channel appears as a narrow, deep channel constrained by very high valley walls or relatively high terrace remnants. However, the channel appears to be relatively stable at the present time.

At the Black Forest Road crossing, the channel has recently incised into relatively soft bedrock. The incision does not appear to have migrated upstream more than a few hundred feet. Just downstream of the bridge, a bend was cutoff in the 1970s effectively straightened the reach through and downstream of the bridge. The purpose was probably to convey flow more effectively through the bridge. The channel presently appears as a narrow, deep channel inset into a swale. A drop structure with an invert at the elevation of the terrace is recommended to promote upstream deposition and stabilization of the straightened reach.

Six grade control structures are recommended between Woodmen and Black Forest Roads, and 4 more upstream of Black Forest Road. The area impacted by the prudent line includes 122 acres of developable land. Note that the 1995 FIMS mapping was not available upstream of Black Forest Road, and therefore it was not possible to map the prudent line or locate drop structures. However, to be consistent with the DBPS study reach, an estimate of the land area lost and the number of drop structures required were included in the totals for this reach. For a distance extending about 2 miles above Black Forest Road, the developable land area lost to the prudent line were estimated based on the acreage/mile calculated below Black Forest Road, (the resulting value is included in the 122 acres). Similarly, based on USGS mapping and a limited field reconnaissance of this reach, 4 grade control structures were identified.

5.3.3 Tributaries

Tributary 1, located upstream of Rangewood Drive, enters Cottonwood Creek on the left bank. The tributary bifurcates into 2 primary channels just upstream of its confluence. The southern fork flows primarily from the southeast and the northern fork flows from the east. The prudent line was extended further up the northern fork of Tributary 1 since the first submittal of this document (Ayres Associates, May 1996). This report includes the improvements recommended for the extension, which are also depicted on sheet 12A of the accompanying drawings.

The southern fork, near the headwaters (south of Rangewood Dr.), has undergone severe gullying in the past (Ayres Associates 1995). At the present time, extensive development of the area has occurred with landscaped portions of the property ending at the crest of the valley wall. Irrigation of lawns along the top of the valley walls is creating seepage along the wall and increasing the frequency and rate of slumping, sloughing, and slope retreat along

the valley margins. In turn, this is increasing the amount of sediment supplied to the channel. This sediment is presently being deposited on the upstream side of the Rangewood Drive culvert. This seepage should be controlled to stabilize the valley walls and improve channel stability.
In this tributary, a total of 9 grade control structures are recommended. The area impacted by the prudent line includes 40 acres of developable land.

Tributary 2 flows southward toward Cottonwood Creek from headwaters located on the north side of the basin. The confluence of this tributary is on the right bank of Cottonwood Creek just upstream of the Woodmen Road bridge. The channel appears to have undergone recent incision with the formation of a deep, narrow channel inset into a narrow valley. Incision extends about 1,600 feet upstream where the present natural channel has been replaced by a trapezoidal, concrete channel which extends to the headwaters. It is recommended that the concrete-lined channel be continued downstream with an energy dissipator at the confluence with Cottonwood Creek,

Tributary 3 flows from its headwaters in the north and has its confluence on the right bank of Cottonwood Creek just upstream of the Haul Road crossing. The confluence consists of a rock riprap-lined outfall area from a detention pond. No further improvements are required on this tributary.

Tributary 4 has its headwaters in the northern part of the basin, flows to the south, and has its confluence on the right bank of Cottonwood Creek just upstream of the Cowpoke Road bridge. Based on historical aerial photography, this channel and its basin may have been significant contributors of sediment in the past and could be a major contributor of sediment in the future if gulling and erosion were allowed to occur during future development of the area (Ayres Associates 1995). In this tributary, a total of 4 grade control structures are recommended. The area impacted by the prudent line includes 56 acres of developable land.

5.4 Improvements Downstream of Rangewood Drive

The recommended improvements proposed in the following 3 sections are for the purpose of mitigating existing and/or future channel degradation and to protect existing structures (i.e., bridges, sewer crossing, and etc.). Mitigation in these reaches are needed apart from the type of channel improvements implemented upstream of Rangewood Dr.

This study proposes the improvements described in the following three sections be equally cost-shared with one-half of the improvement costs incorporated into the basin fee and one-half a public cost responsibility. The majority of the improvements in these reaches are adjacent to existing development. Improvements in these reaches will require a separate cash fee to be collected and accounted for by the City of Colorado Springs as part of the required total drainage fee obligation. These cash fees will be utilized by the City to construct the necessary drainage improvements as specified in this DBPS.

5.4.1 Confluence to Academy Boulevard

Throughout much of this reach, the channel is deeply inset into the surrounding topography and little lateral migration is likely. While there has been incision and degradation into the bedrock composing the channel bottom (particularly in the last 30 years and most likely from the increased flows from urbanization), this has not precipitated any significant lateral instability. In some cases, any lateral instability that exists is the result of excess irrigation slowly eroding and destabilizing the high banks and promoting bank retreat. The installation of subdrains along the toe of the slope would control this type of lateral instability.

The measures recommended for this reach are primarily grade control as shown on the plan view sheets. Since the section between Vincent Drive and the confluence has recently undergone incision and is presently widening, no grade control measures would normally be needed. However, given the possibility that base-level lowering on Monument Creek may occur, it is recommended that a low grade control structure be installed just downstream of the Corporate Road bridge. This would also help stabilize the channel bed below the I-25 bridges.

The failing 4-foot high structure just upstream of the Vincent Drive bridge is threatening to undermine the old railroad bridge just upstream and further undermine the Vincent Drive bridge. Therefore, it is recommended that this structure be left in place and a new structure of similar height be installed just downstream of the Vincent Drive bridge. The intervening area between the structures should be backfilled with a suitable material. This structure would not only maintain the existing grade, but would provide the bridges protection from further scour and undermining and halt migration of the low knickzone located downstream.

Another area of concern is the failing drop structure downstream of Academy Boulevard, as previously noted (Ayres Associates 1995). This structure is the lowermost structure in a series of grade control structures upstream and downstream of the bridge, and if it fails a domino effect will begin upstream. Any existing utilities in this reach, including the new sewer line project, may require additional grade control structures.

A total of 7 grade control structures are recommended for this reach.

5.4.2 Academy Boulevard to Union Boulevard

The reach from Academy Boulevard to the existing large drop structure 0.5 mile upstream is presently incising and widening. Just above the existing lined channel (the riprap and grade control that begins downstream of Academy Boulevard terminates about 300 feet upstream of Academy), the unprotected banks are raw and unvegetated. These banks are primarily silt, sand, and gravel sitting at the angle-of-repose with some cohesive outcroppings of floodplain alluvium. Bank protection will be required in this reach, extending at a minimum upstream to where the channel transitions into bedrock, composed of mudstone, shale, and sandstone.

The incision and channel widening in this reach may be due, in part, to setting the invert of the grade control structure too high. **Figure 5.1** shows the profile plot for this reach (from Ayres Associates 1995). The invert was set 5 to 6 feet above the channel invert in 1986, which probably caused the deposition upstream of the structure and the erosion downstream. This structure is slowly being undermined and should be lowered or rebuilt.

The area between the high grade-control structure and Union Boulevard is aggraded. The banks along the lower part of this reach are riprapped and stable. The banks upstream are near vertical or at angle of repose and eroding, particularly along the left bank. These banks should be reshaped and bank protection provided. Subdrains may be required along the right bank because of extensive seepage along the alluvium-fill dirt contact at mid-bank.

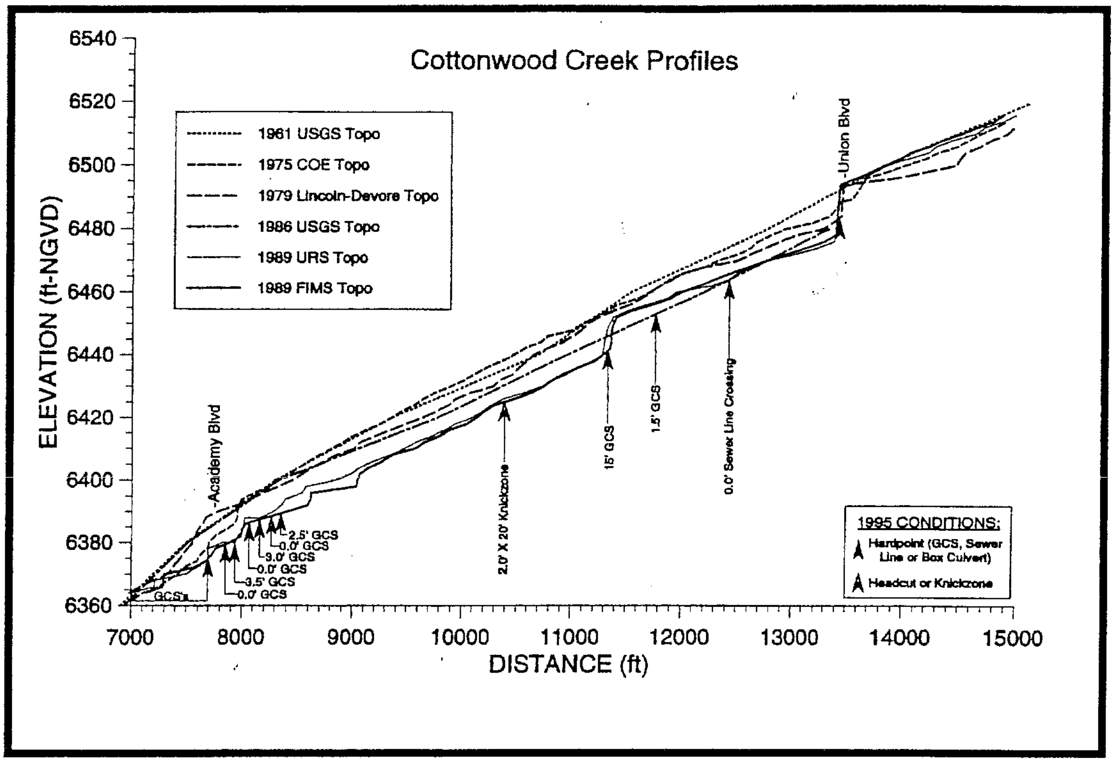

Figure 5.1. Channel profile from Academy to Union (from Ayres Associates 1995).

5.4.3 Union Boulevard to Rangewood Drive

One area of significant concern is the loss of channel capacity due to sediment deposition upstream of Union Boulevard, and the integrity of the existing right bank and in some cases levee. Based on historic channel profiles, it appears that the invert for the Union Crossing was set too high causing deposition upstream of the bridge and incision downstream (Figure 5.1). The Union Boulevard crossing invert is at, or slightly higher than, the 1961 channel elevation. The bridge culvert is threatened by undermining and scour because of the high drop on the downstream side of the culvert. The wingwalls are also threatened with failure because of undermining from toe scour, slope wash, and bank erosion. Bank protection measures will protect the wingwalls from bank erosion. Slope wash can be fixed with a paved drain channel. However, scour and undermining of the bridge culvert will require extensive countermeasures, such as a series of drop structures. The reach just upstream of the bridge is relatively narrow, aggraded, and highly susceptible to flooding. Bridge and roadway overtopping are possible and probable. All these factors make lowering the bridge invert desirable.

Considering the overall channel profile through this reach over time, a better invert elevation might have been as much as 5 to 10 feet lower. It is recommended that the invert at this bridge be lowered and a pilot channel cut upstream of the bridge to initiate a controlled channel incision that will reestablish channel capacity upstream of the bridge.

Lowering of the invert should be accomplished in conjunction with extensive bank protection upstream and the installation of a grade control structure downstream. Bank protection is required because once the invert is lowered, the channel will incise and then widen in an attempt to adjust to the new base level. Since both existing banks are relatively low and there is very little setback of existing property along the bank lines, extensive bank protection will be required. A grade control structure will also be required upstream to halt the migration of incision further upstream. The structure could be installed just upstream of the apartment complex where bank heights are much higher and the channel and floodplain are at their narrowest.

The other alternative recommendation for the area immediately upstream of Union Boulevard is to enlarge the bridge opening and build a well-protected high levee on the right bank for the entire length of the bank adjacent to the apartment complex. Enlargement of the bridge opening would require raising the height of the road grade and replacing the existing bridge culvert with a taller culvert. In either case, the downstream side of the culvert would require extensive protection from scour and erosion.

From about midreach to Rangewood Drive, the channel is stabilizing and shifting from a shallow braided channel into a narrower, deeper well-defined channel. Both banks are riprapped, but the development into a well-defined meandering channel has resulted in impingement of the channel on the left bank and caused the bank protection to fail. The riprap along this bank should be replaced and any further encroachment on the channel or floodplain throughout this reach should be discouraged. A total of 3 grade control structures are recommended in this reach.

5.5 Preliminary Cost Estimate

5.5.1 Introduction

Preliminary cost estimates were developed as a result of this study for proposed drainage improvements and right-of-way acquisition costs associated with the prudent line concept. These costs were estimated for the mainstem of Cottonwood Creek and two major tributaries that have not yet been encroached upon by development. For the portion of the drainage basin where the prudent line concept is not suggested for use, drainage improvement concepts and estimated costs were taken directly from the DBPS. The resulting estimated costs were then compared to cost information included in the DBPS (both cost estimates are on a January 1992 basis). A new drainage basin fee was calculated based on 5,877 acres of revised unplatted acreage as determined by JR Engineering. This revised 1994 acreage excludes prudent line land, parkland, and channel and open space land for which fees will not be required. Platting of such land will be required.

5.5.2 Cost Estimate

The prudent line concept is recommended for the channel upstream of Rangewood Drive where urbanization has not yet encroached significantly on the channel. Downstream of Rangewood Drive, an implied prudent line exists for most of the reach. This encroachment restriction indicates both the natural physical exclusion of development and excellent floodplain planning practices on the part of the City of Colorado Springs. Where the implied prudent line does not exist, channel improvements are typically in place. In some reaches, it is recommended that channel improvements be extended or added to improve channel stability and protect existing bridges, utility crossings, and property adjacent to the channel bank. The previously recommended improvements which lie outside of the prudent line were taken directly from Table 6 of the DBPS with their estimated costs, including improvements associated with the Pine Creek drainage basin (these were included to facilitate comparison on an equitable basis only).

Drainage improvement costs are associated with improving the existing drainageway to handle proposed future development design flows and establish channel stability in areas that are currently developed and that have degraded or are currently degrading. Examples of these costs include grade control structures, bank protection, groundwater interceptor drains (subdrains), reinforcing of existing utility crossings, pipes, box culverts, non-arterial bridges, and other related costs. A summary of the costs (January 1992 dollars) on a reach-by-reach basis are provided in **Table 5.1** (see Section 5.4 for a discussion of the cost sharing of channel improvements downstream of Rangewood Drive). Individually significant items and quantities of similar items which were identifiable were included as a line item in Table 5.1. The components of each line item were then used as the basis for determining the line item unit costs for the cost estimate. For purposes of this study, unit costs were estimated for soil cement grade control structures, subdrains, riprap bank protection, spur dikes, excavation and waste of streambed materials, relocation or rehabilitation of sewer and waterlines, and reinforcing of existing sewer lines in place. All other drainage improvements were taken from the DBPS which are italicized on Table 5.1. **Table 5.2** provides these unit costs in tabular fo0rm. Significant common construction costs such as handling of water during construction, mobilization and demobilization, unlisted items, and others, were estimated as a percentage and applied as a multiplier to the unit costs. The unit costs in Table 5.2 reflect this percentage multiplier. The following paragraphs will describe how each unit cost was estimated for each improvement.

Soil cement grade control structures were assumed to be placed a minimum of 15 feet below existing channel bed elevation, contain a 10 foot top width, 1:1 downstream slope and 0.5:1 upstream slope. Each structure then extends to the desired elevation that will achieve upstream channel stability. Therefore, the cost of each structure depends not only on the length perpendicular to the channel, but also on the overall height of the structure. The grade control structures were also assumed to extend a minimum of 10 feet into each bank to prevent flanking by design flows during the expected life of the structure. Each grade control structure will be capped with reinforced concrete tied into the soil cement to minimize degradation of the crest of the structure due to continuous baseflows.

Subdrains were assumed to be constructed of a 2-foot wide excavation extending a minimum of 8 feet below grade, and contain a perforated drain pipe surrounded by granular bedding material which is enclosed in a geotextile wrap. The geotextile wrap was assumed to envelope the pipe and granular bedding material approximately 1 foot above and below the drain pipe and contain ample overlap to ensure that fine-grained material would not penetrate the geotextile. The remaining excavation was then assumed to be backfilled with more granular bedding material to within 1 foot of the surface followed by topsoil.

Riprap bank protection was assumed to be constructed of a geotextile filter fabric, a 1-foot layer of granular drainage material, and a minimum of 3 feet of properly sized rock riprap. The banks were assumed to be graded at a 2:1 slope with the bank protection extending a minimum of 3 feet below existing channel bed elevation to minimize scour of the toe and extend up the bank a minimum of 10 vertical feet or the 100-year floodplain elevation, whichever is greater. The unit cost of riprap bank protection for this study is believed to be higher than the unit cost used in the DBPS.

Table 5.1. Drainage Improvement Costs.							
Drainage Feature/DBPS Reach Designation	Station	Quantity	Total Cost Capital/Land ($)	Capital Basin Fee Cost ($)	Land Basin Fee Cost ($)	Capital Public Cost ($)	Land Public Cost ($)
CONFLUENCE TO ACADEMY BOULEVARD (URS Design Points 18 to 21)							
Soil Cement Grade Control Structure (19 ft)	02+40	70 LF	61,600	30,800*	N/A	30,800	N/A
Soil Cement Grade Control Structure (20 ft)	13+60	100 LF	96,250	48,125*	N/A	48,125	N/A
Excavate & Waste Old Railroad Abutments	15+40	150 yd^3	1,320	660*	N/A	660	N/A
Soil Cement Grade Control Structure (19 ft)	34+20	100 LF	88,000	44,000*	N/A	44,000	N/A
Riprap to Protect Sewer Crossing (Toe in)	35+80 to 36+40	60 LF	8,580	4,290*	N/A	4,290	N/A
Reinforce Existing Sewer In-Place	35+80 to 36+40	60 LF	1,650	825*	N/A	825	N/A
Protect Stormdrain Outlet	40+70	70 LF	10,010	5,005*	N/A	5,005	N/A
Soil Cement Grade Control Structure (20 ft)	44+00	100 LF	96,250	48,125*	N/A	48,125	N/A
Reinforce Sewer In-Place	45+40 to 46+90	150 LF	4,125	2,063*	N/A	2,063	N/A
Reinforce Sewer In-Place	50+00 to 52+00	200 LF	5,500	2,750*	N/A	2,750	N/A
Soil Cement Grade Control Structure (20 ft)	53+20	90 LF	86,625	43,313*	N/A	43,313	N/A
Subdrain (Left Bank)	58+00 to 61+50	350 LF	28,875	14,438*	N/A	14,438	N/A
Soil Cement Grade Control Structure (19 ft)	61+20	90 LF	79,200	39,600*	N/A	39,600	N/A
Soil Cement Grade Control Structure (20 ft)	66+70	120 LF	115,500	57,750*	N/A	57,750	N/A
ROW Land Cost			*264,460*	*N/A*	*132,230**	*N/A*	*132,230*
		SUBTOTAL	**947,945**	341,743	132,230	341,743	132,230
ACADEMY BOULEVARD TO UNION BOULEVARD (URS Design Points 16 to 18)							
Riprap (Both Banks: 1,100 feet each)	84+00 to 95+00	2,200 LF	314,600	157,300*	N/A	157,300	N/A
Soil Cement Grade Control Structure (15 ft)	91+80	140 LF	92,400	46,200*	N/A	46,200	N/A
Soil Cement Grade Control Structure (18 ft)	101+60	145 LF	118,030	59,015*	N/A	59,015	N/A
Protect Stormdrain Outlet	102+50	60 LF	8,580	4,290*	N/A	4,290	N/A
Protect Stormdrain Outlet	110+00	60 LF	8,580	4,290*	N/A	4,290	N/A
Lower Existing Drop Structure	113+70	1 EA	10,000	5,000*	N/A	5,000	N/A
Soil Cement Grade Control Structure (15 ft)	133+40	130 LF	85,800	42,900	N/A	42,900	N/A
Riprap (Both Banks: 900 feet each)	125+00 to 134+00	1,800 LF	257,400	128,700	N/A	128,700	N/A
Subdrain (Right Bank)	125+00 to 134+00	1000 LF	82,500	41,250	N/A	41,250	N/A
Relocate or Rehabilitate Water Line		200 LF	50,000	25,000*	N/A	25,000	N/A
Relocate or Rehabilitate Water Line		200 LF	50,000	25,000*	N/A	25,000	N/A
		SUBTOTAL	**1,077,890**	538,945	0	538,945	0
UNION BOULEVARD TO RANGEWOOD DRIVE (URS Design Points 13 to 16)							
Excavate & Waste Pilot Channel	135+50 to 158+20	9,200 yd^3	80,960	40,480*	N/A	40,480	N/A
Riprap (3,200 R. Bank; 2,500 L. Bank)	135+50 to 167+50	5,700 LF	815,100	407,550*	N/A	407,550	N/A
Soil Cement Grade Control Structure (15 ft)	146+50	180 LF	118,800	59,400*	N/A	59,400	N/A
Soil Cement Grade Control Structure (15 ft)	158+20	140 LF	92,400	46,200*	N/A	46,200	N/A
Soil Cement Grade Control Structure (15 ft)	171+30	170 LF	112,200	56,100*	N/A	56,100	N/A
		SUBTOTAL	**1,219,460**	609,730	0	609,730	0
RANGEWOOD DRIVE TO WOODMEN ROAD (URS Design Points 12 to 13)							
Soil Cement Grade Control Structure (15 ft)	230+80	70 LF	46,200	23,100	N/A	23,100	N/A
Soil Cement Grade Control Structure (15 ft)	252+40	70 LF	46,200	23,100	N/A	23,100	N/A
Land Set Aside for Prudent Line		22 AC	308,000	N/A	308,000	N/A	N/A
		SUBTOTAL	**400,400**	46,200	308,000	46,200	0

Table 5.1. Drainage Improvement Costs.							
Drainage Feature/DBPS Reach Designation	Station	Quantity	Total Cost Capital/Land ($)	Capital Basin Fee Cost ($)	Land Basin Fee Cost ($)	Capital Public Cost ($)	Land Public Cost ($)
UPSTREAM OF WOODMEN ROAD (URS Design Points 1 to 12)							
Soil Cement Grade Control Structure (15 ft)	284+70	120 LF	79,200	39,600	N/A	39,600	N/A
Protect Stormdrain Outlet	292+00	80 LF	11,440	5,720	N/A	5,720	N/A
Subdrain (Right Bank)	292+50 to 294+50	200 LF	16,500	8,250	N/A	8,250	N/A
Soil Cement Grade Control Structure (15 ft)	308+00	95 LF	62,700	31,350	N/A	31,350	N/A
Soil Cement Grade Control Structure (19 ft)	343+30	60 LF	52,800	52,800	N/A	0	N/A
Soil Cement Grade Control Structure (19 ft)	367+70	80 LF	70,400	70,400	N/A	0	N/A
Soil Cement Grade Control Structure (19 ft)	377+40	100 LF	88,000	88,000	N/A	0	N/A
Soil Cement Grade Control Structure (18 ft)	392+40	90 LF	73,260	73,260	N/A	0	N/A
Soil Cement Grade Control Structure (17 ft)	419+30	60 LF	44,550	44,550	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	no mapping	60 LF	39,600	39,600	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	no mapping	60 LF	39,600	39,600	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	no mapping	60 LF	39,600	39,600	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	no mapping	60 LF	39,600	39,600	N/A	0	N/A
Land Set Aside For Prudent Line		122 AC	1,708,000	N/A	1,708,000	N/A	0
		SUBTOTAL	**2,365,250**	572,330	1,708,000	84,920	0
TRIBUTARY ONE							
Soil Cement Grade Control Structure (15 ft)	09+00	100 LF	66,000	66,000	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	11+60	60 LF	39,600	39,600	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	39+70	60 LF	39,600	39,600	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	57+15	50 LF	33,000	33,000	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	70+86	50 LF	33,000	33,000	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	75+27	50 LF	33,000	33,000	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	84+98	50 LF	33,000	33,000	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	100+95	50 LF	33,000	33,000	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	116+13	50 LF	33,000	33,000	N/A	0	N/A
13Q to 13R Prudent Line			***0***	*0*	*0*	*0*	*0*
13P to 13O			*267,200*	*267,200*	*0*	*0*	*0*
13J/M to 13N Prudent Line			***0***	*0*	*0*	*0*	*0*
13NP to 13O Prudent Line			***0***	*0*	*0*	*0*	*0*
13L to 13M			*375,864*	*375,864*	*0*	*0*	*0*
13K to 13L			*192,200*	*192,200*	*0*	*0*	*0*
13I to 13J Prudent Line			***0***	*0*	*0*	*0*	*0*
13H to 13I Prudent Line			***0***	*0*	*0*	*0*	*0*
13F to 13G		*Alt. B*	*431,592*	*431,592*	*0*	*0*	*0*
13D to 13E		*84" RCP*	*552,000*	*552,000*	*0*	*0*	*0*
H2 to 13D		*72" RCP*	*350,640*	*350,640*	*0*	*0*	*0*
13B to 13C		*Alt. B*	*473,991*	*473,991*	*0*	*0*	*0*
13C to 13H		*Alt. B*	*163,949*	*163,949*	*0*	*0*	*0*
H5 to 13B		*Alt. B*	*412,710*	*412,710*	*0*	*0*	*0*
H6 to 13B		*Alt. B*	*217,440*	*217,440*	*0*	*0*	*0*
Land Set Aside For Prudent Line		40 AC	560,000	N/A	560,000	N/A	0
		SUBTOTAL	**4,340,786**	3,780,786	560,000	0	0
TRIBUTARY TWO							
12C to 12CP		*Alt. C/D*	*130,000*	*130,000*	*0*	*0*	*0*
12CP to 12		*unknown*	*149,136*	*149,136*	*0*	*0*	*0*

Table 5.1. Drainage Improvement Costs.

Drainage Feature/DBPS Reach Designation	Station	Quantity	Total Cost Capital/Land ($)	Capital Basin Fee Cost ($)	Land Basin Fee Cost ($)	Capital Public Cost ($)	Land Public Cost ($)
12B to 12C		*Existing*	*0*	*0*	*0*	*0*	*0*
G2 to 12B		*Existing*	*0*	*0*	*0*	*0*	*0*
G1 to 12A		*Trap Chnl*	*189,000*	*189,000*	*0*	*0*	*0*
		SUBTOTAL	**468,136**	468,136	0	0	0
TRIBUTARY THREE							
11F to 11P Completed		*Alt. B*	*318,480*	*318,480*	*0*	*0*	*0*
11P to 11 Completed		*48" RCP*	*140,892*	*140,892*	*0*	*0*	*0*
E6 to 11E		*54" RCP*	*149,110*	*149,110*	*0*	*0*	*0*
11D to 11F		*Alt. C*	*303,428*	*303,428*	*0*	*0*	*0*
E2 to 11C		*Alt. B*	*481,400*	*481,400*	*0*	*0*	*0*
11A to 11B		*Alt. B*	*473,800*	*473,800*	*0*	*0*	*0*
E1 to 11A		*Alt. B*	*242,200*	*242,200*	*0*	*0*	*0*
		SUBTOTAL	**2,109,310**	2,109,310	0	0	0
TRIBUTARY FOUR							
Soil Cement Grade Control Structure (15 ft)	(g)	90 LF	59,400	59,400	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	(h)	60 LF	39,600	39,600	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	(i)	70 LF	46,200	46,200	N/A	0	N/A
Soil Cement Grade Control Structure (15 ft)	(j)	50 LF	33,000	33,000	N/A	0	N/A
B5 to 8H			*787,200*	*787,200*	*0*	*0*	*0*
8G to 8 Prudent Line			***0***	*0*	*0*	*0*	*0*
C5 to 8F			*770,712*	*770,712*	*0*	*0*	*0*
8E to 8G Prudent Line			***0***	*0*	*0*	*0*	*0*
8C to 8D			*599,400*	*599,400*	*0*	*0*	*0*
8A to 8B			*674,560*	*674,560*	*0*	*0*	*0*
C2 to 8A			*189,000*	*189,000*	*0*	*0*	*0*
Developable Land Set Aside For Prudent Line		56 AC	784,000	N/A	784,000	N/A	0
		SUBTOTAL	**3,983,072**	3,199,072	784,000	0	0
OTHER							
T4B to 19G		*Existing*	*150,700*	*0*	*0*	*150,700*	*0*
19E to 19F		*Existing*	*0*	*0*	*0*	*0*	*0*
19D to 19E		*Existing*	*0*	*0*	*0*	*0*	*0*
19B to 19C		*Existing*	*0*	*0*	*0*	*0*	*0*
Q1 to 19A		*Existing*	*89,100*	*0*	*0*	*89,100*	*0*
T4A to 18A		*Existing*	*0*	*0*	*0*	*0*	*0*
17A to 17		*Existing*	*0*	*0*	*0*	*0*	*0*
T2 to 17A		*Existing*	*116,208*	*0*	*0*	*116,208*	*0*
P2 to 16C		*Existing*	*0*	*0*	*0*	*0*	*0*
M4 to 16B		*Existing*	*0*	*0*	*0*	*0*	*0*
M3 to 16		*Existing*	*9,600*	*0*	*0*	*9,600*	*0*
M1 to 14C		*Existing*	*193,680*	*0*	*0*	*193,680*	*0*
O1 to 14B		*Existing*	*0*	*0*	*0*	*0*	*0*
L1 to 14A		*Existing*	*50,400*	*0*	*0*	*50,400*	*0*
J1 to 13S			*183,996*	*35,879*	*0*	*148,117*	*0*
D3 to 12D		*54" RCP*	*172,050*	*172,050*	*0*	*0*	*0*

Table 5.1. Drainage Improvement Costs.							
Drainage Feature/DBPS Reach Designation	Station	Quantity	Total Cost Capital/Land ($)	Capital Basin Fee Cost ($)	Land Basin Fee Cost ($)	Capital Public Cost ($)	Land Public Cost ($)
OTHER (continued)							
C16 to 11G		*54" RCP*	*482,216*	*482,216*	*0*	*0*	*0*
9A to 9B			*1,140,720*	*1,140,720*	*0*	*0*	*0*
C14 to 9A			*242,100*	*242,100*	*0*	*0*	*0*
B2 to 6A			*400,320*	*400,320*	*0*	*0*	*0*
5A to 5			*318,700*	*318,700*	*0*	*0*	*0*
Dublin Blvd (DP 19F)			*0*	*0*	*0*	*0*	*0*
Dublin/Turret (DP 19F19E)			*0*	*0*	*0*	*0*	*0*
Dublin/Lemonwood (DP 19F19E)			*0*	*0*	*0*	*0*	*0*
Academy Blvd (DP 19E)			*0*	*0*	*0*	*0*	*0*
Lehman Dr (DP 19E19D)			*0*	*0*	*0*	*0*	*0*
Hollow Tree Ct (DP 19D)			*0*	*0*	*0*	*0*	*0*
Tuckerman Ln (DP 19C)			*0*	*0*	*0*	*0*	*0*
Dublin Blvd (DP 13Q)			*0*	*0*	*0*	*0*	*0*
Austin Bluffs (DP 13M)			*224,070*	*224,070*	*0*	*0*	*0*
Balsam St (DP 13G)	*2 - 12'x8' CBC*		*150,090*	*150,090*	*0*	*0*	*0*
Powers Blvd (DP H5)			*148,851*	*0*	*0*	*148,851*	*0*
Powers Blvd (DP H6)			*203,952*	*0*	*0*	*203,952*	*0*
Dublin (DP 13B) N. Side	*2 - 10'x6' CBC*		*119,102*	*119,102*	*0*	*0*	*0*
Dublin (DP 13B) S. Side			*91,778*	*91,778*	*0*	*0*	*0*
Rangewood Dr (DP 13P)	*Exist. 72" RCP*		*14,526*	*14,526*	*0*	*0*	*0*
Meadow Ridge Dr (DP 12C)			*0*	*0*	*0*	*0*	*0*
Research Pkwy (DP 12A)			*0*	*0*	*0*	*0*	*0*
Powers Blvd (DP 11D)			*248,640*	*248,640*	*0*	*0*	*0*
Research Pkwy (DP 11F)			*144,150*	*144,150*	*0*	*0*	*0*
Briargate Pkwy (DP 8E)			*105,288*	*105,288*	*0*	*0*	*0*
Research Pkwy (DP 6)			*83,654*	*83,654*	*0*	*0*	*0*
Briargate Pkwy (DP 5)			*106,788*	*106,788*	*0*	*0*	*0*
Union Blvd (DP 16B)			*31,968*	*0*	*0*	*31,968*	*0*
Oakwood (DP 13B)	*3 - 12'x6' CBC*		*81,749*	*81,749*	*0*	*0*	*0*
Tobin Rd (Above DP 5)			*34,596*	*34,596*	*0*	*0*	*0*
McFerran Rd (DP 3)			*23,376*	*23,376*	*0*	*0*	*0*
Hungate Rd (Above Dp 3)			*23,376*	*23,376*	*0*	*0*	*0*
Burgess Rd (DP 2)			*6,779*	*6,779*	*0*	*0*	*0*
Herring Rd (DP 1)			*4,320*	*4,320*	*0*	*0*	*0*
		SUBTOTAL	**5,396,843**	4,254,267	0	1,142,576	0
PINE CREEK							
32 to 31			*218,640*	*9,839*	*0*	*208,801*	*0*
31 to 30			*298,533*	*7,010*	*3,597*	*148,773*	*76,343*
30 to 29			*78,000*	*3,510*	*0*	*74,490*	*0*
U4B to 31			*678,200*	*212,277*	*0*	*465,923*	*0*
U4A to 30			*278,261*	*278,261*	*0*	*0*	*0*
SUM13 to 29			*861,874*	*38,784*	*0*	*823,090*	*0*
28 to 29			*0*	*0*	*0*	*0*	*0*

Table 5.1. Drainage Improvement Costs.

Drainage Feature/DBPS Reach Designation	Station	Quantity	Total Cost Capital/Land ($)	Capital Basin Fee Cost ($)	Land Basin Fee Cost ($)	Capital Public Cost ($)	Land Public Cost ($)
PINE CREEK (continued)							
28B to 28			*119,880*	*0*	*0*	*119,880*	*0*
28A to 28B			*155,840*	*0*	*0*	*155,840*	*0*
U1 to 28A			*0*	*0*	*0*	*0*	*0*
28E to 28F			*144,000*	*0*	*0*	*144,000*	*0*
28D to 28E			*0*	*0*	*0*	*0*	*0*
R2 to 28D			*18,000*	*0*	*0*	*18,000*	*0*
28C to 28E			*198,489*	*18,261*	*0*	*180,228*	*0*
R1 to 28C			*268,240*	*268,240*	*0*	*0*	*0*
27 to 28G LOW			*0*	*0*	*0*	*0*	*0*
26 to 27			*0*	*0*	*0*	*0*	*0*
26A to 26B			*128,051*	*0*	*0*	*128,051*	*0*
N1 to 26A			*0*	*0*	*0*	*0*	*0*
25 to 26			*0*	*0*	*0*	*0*	*0*
24 to 25			*92,685*	*0*	*0*	*92,685*	*0*
23 to 24			*0*	*0*	*0*	*0*	*0*
23A to 23			*38,093*	*0*	*0*	*38,093*	*0*
I4 to 23A			*19,200*	*0*	*0*	*19,200*	*0*
22 to 23			*0*	*0*	*0*	*0*	*0*
I2 to 22A			*0*	*0*	*0*	*0*	*0*
I1 to 22			*0*	*0*	*0*	*0*	*0*
28H to 28			*0*	*0*	*0*	*0*	*0*
27 to 28G UP			*145,260*	*0*	*0*	*145,260*	*0*
Walmart Center No. 2			*25,460*	*25,460*	*0*	*0*	*0*
Academy Blvd (DP U4B)			*17,205*	*0*	*0*	*17,205*	*0*
Academy Blvd Middle (DP 28F)			*0*	*0*	*0*	*0*	*0*
Academy Blvd South (DP 28G)			*0*	*0*	*0*	*0*	*0*
Union Blvd (DP 24)			*0*	*0*	*0*	*0*	*0*
Lexington (DP 23) N. Side			*0*	*0*	*0*	*0*	*0*
Lexington (DP 23) S. Side			*82,620*	*0*	*0*	*82,620*	*0*
		SUBTOTAL	**3,803,721**	861,642	3,597	2,862,139	76,343
SUBTOTAL CONSTRUCTION/LAND COSTS			26,112,813	16,782,161	3,495,827	5,626,253	208,573
Engineering (10%)				1,678,216	N/A	562,625	N/A
Contingency (5%)				923,019	N/A	309,444	N/A
City Fund Balance (owed)				5,097,000	N/A	N/A	N/A
County Fund Balance (owed)				(19,045)	N/A	N/A	N/A
Total Construction Related Costs (1992$)				24,461,350	3,495,827	6,498,322	208,573
				CAPITAL	**LAND**	**TOTAL**	
			BASIN FEE	4,162	595	4,757	

*A separate cash fee will be required by the City of Colorado Springs, accounted for separately and used by the City to construct these needed amounts. See Table 5.6 for each fee amount.

Table 5.2. Unit Costs.		
Drainage Improvement	Cost ($)	Unit
Soil Cement Grade Control Structure (15-16 feet)	660	LF
Soil Cement Grade Control Structure (17 feet)	743	LF
Soil Cement Grade Control Structure (18 feet)	814	LF
Soil Cement Grade Control Structure (19 feet)	880	LF
Soil Cement Grade Control Structure (20 feet)	963	LF
Soil Cement Grade Control Structure (21 feet)	1,045	LF
Subdrain	83	LF
Riprap	143	LF
Excavation and Waste	9	Yd^3
Relocate or Rehabilitate Sewer	165	LF
Reinforce Sewer In-Place	28	LF
Land Set Aside for Prudent Line	14,000	AC
Relocate or Rehabilitate Water Line	250	LF

It should be understood that the geometry of these structures (i.e., soil cement grade control structures, subdrains, and riprap,) are only for costing purposes, not for actual design. The actual structures may vary in size depending on site-specific conditions.

Unit costs for excavation and waste of materials, sewer line relocation or rehabilitation, and sewer line reinforcement in-place were estimated from similar planning studies and current design/construction experience.

Right-of-way acquisition costs were assumed to be the cost of the land area impacted by the prudent line in acres. These right-of-way costs must be included in the project construction cost estimate as a line item to enable the comparison of the prudent line approach with the DBPS proposed improvements. This land area is defined as the acreage between the prudent line and the 100-year floodplain. The 100-year floodplain was based on existing channel conditions and future flow conditions without detention.

5.5.3 Detention Facilities Costs

As described previously, additional stormwater detention facilities are not felt to be necessary in areas managed by the prudent line, to otherwise mitigate conveyance cost or reduce the extent of flooding. Therefore, no costs are included for stormwater detention facilities. Costs proposed in the DBPS for detention facilities were approximately $4.2 million, and their deletion results in significant savings for this proposed plan.

5.5.4 Bridge Costs

Arterial bridges in the drainage basin are considered a separate fee structure than drainage improvement costs. All the existing arterial bridges located within the drainage basin have adequate hydraulic capacity to handle the design flows without overtopping except the bridge at Black Forest Road. A much longer span has already been proposed in the DBPS for this bridge and figured into the bridge replacement cost. Moderate backwater effects were also noted upstream of the Rangewood Drive bridge during the 100-year design storm event. The 100-year floodplain just upstream of the bridge, including the confluence of Tributary 1, is greater than the calculated prudent line. The 100-year floodplain will therefore govern the limits of development in this area.

For future channel crossings or when existing bridges are replaced within the areas of the prudent line, the bridge design should not encroach on the channel so as to cause backwater effects. This type of bridge design may be more expensive in some cases, but as mentioned above, all the arterial bridges in the drainage basin are considered to contain adequate hydraulic capacity, and will not need to be replaced to accommodate the prudent line concept.

All the costs associated with bridges (except Black Forest Road) in the DBPS are for either widening or upgrading existing structures for increased traffic needs, not for hydraulic purposes. For these reasons, no alterations of the existing bridge costs are recommended. **Table 5.3** contains the bridge costs taken from Table 5 of the DBPS, including bridges located within the Pine Creek drainage basin.

5.6 Operation, Maintenance, and Replacement Costs

Operation, maintenance, and replacement costs (OM&R) on drainage improvements can be significant. While the current DBPS does not address this issue, the OM&R costs associated with the prudent line are a significant consideration that must be given some attention.

Inherent to the prudent line is the concept that to the extent possible, the waterway is allowed enough room to function under normal, natural physical cause/effect relationships. Stream instability or problems usually occur when human activity is inconsistent with natural forces. Minimizing human impacts is now widely recognized as the most intelligent way to avoid unnecessary capital costs as well as to minimize OM&R costs. The cost of dedicating more land as a buffer to avoid spending money to construct, operate, and maintain water conveyance works can be looked at several ways. Allowing enough room for a stream to act naturally has, ideally, no OM&R costs. Conversely, as soon as something is built to control the stream, there is a corresponding need to maintain it. Conventional structural channel improvements require 1 to 2 percent per year OM&R costs. By comparison, Ayres Associates' experience with prudent line channels containing minimal structural improvements is that they require approximately 0.5 percent/year OM&R costs.

The prudent line saves capital costs by not striving to eliminate all natural hazards by structural means. Safety issues such as hydraulic hazards and slope stability are provided for in the prudent line concept, a certain level of degradation/erosion is accepted as natural and expected. The prudent line concept thereby also saves OM&R expenses. A less structural channel may present the possibility of more capital costs being expended later (deferred capital costs) when the problem gets bad enough and has a possibly higher catastrophic risk. This is accommodated by a prudent line channel which can accept more impact without requiring repair (e.g., a prudent line with a narrower maintenance line signals when repairs should be initiated) and/or maintaining a casualty cash reserve which can also serve as a contingency to protect against the greater unpredictability (unknowns) of periodic unplanned expenses.

The Urban Drainage and Flood Control District (UD&FCD) prefers natural channels with appropriate grade control and bank stabilization to a conventional structural channel. The UD&FCD maintains close maintenance records by channel type. **Table 5.4** presents results of channel maintenance costs for channels ranging from totally natural (Bear Creek) to urbanized and landscaped channels (Cherry Creek).

Table 5.3. Bridge Costs.			
Bridge Location	Bridge Cost ($)	Bridge Fee ($)	Public Cost ($)
CDOT Bridges			
I-25 (DP 21)	1,075,998	0	1,075,998
I-25 (DP 31)	1,484,406	0	1,484,406
TOTAL STATE COST	**2,560,404**	**0**	**2,560,404**
City Bridges			
Corporate Drive (DP 21)	0	0	0
Vincent Drive (DP 20)	1,291,463	820,743	470,720
Current Access Rd. (DP 20	0	0	0
Academy Blvd. (DP 18)	0	0	0
Union Blvd. (DP 16)	926,888	589,050	337,838
Rangewood Drive (DP 13)	0	0	0
Woodmen Road (DP 12)	1,417,185	673,906	743,279
Austin Bluffs (DP 12)	1,417,185	673,906	743,279
Powers Blvd. (DP 9)	505,796	383,193	122,603
Dublin Blvd. (DP 130)	62,370	45,582	16,788
Austin Bluffs (DP 13J)	790,020	628,547	161,473
Research Pkwy. (DP 8G)	314,944	223,960	90,984
Pine Creek Rd. (DP 31)	0	0	0
Old Railroad Grade (DP 31)	0	0	0
Academy Blvd. N (DP SUM13)	778,863	689,487	89,376
TOTAL CITY COSTS	**7,504,713**	**4,728,374**	**2,776,339**
CITY BRIDGE FEE		**464**	
County Bridges			
Black Forest Road (DP 7)	457,380	457,380	0
County Bridge Fund Balance	(2,077)	(2,077)	
TOTAL COUNTY COST	**455,303**	**455,303**	**0**
COUNTY BRIDGE FEE		**255**	

Table 5.4. UD&FCD Channel Maintenance Costs.							
		Channel	Right of Way	Years of Record/Cost/Ft/Yr			
Channel	Type	Width	Width	Routine[1]	Restoration[2]	Rehabilitation[3]	Total
Bear Creek	Natural channel and floodway	45	65	13/$0.35	6/$0.75	1/$3.04	14/$0.72
Cherry Creek	Concrete walls, Boulder edged trickle channel	35	80	15/$3.46	10/$1.13	12/$13.47	15/$14.98
Meadwood Drain	Riprapped banked low-flow channel grass lined floodway	25	150	10/$1.64	3/$0.38	5/$21.41	14/$8.90
Niver Creek	Natural trickle channel with riprapped bank floodway	--	80	15/$1.63	3/$0.88	0/0	15/$1.80
Weir Gulch	Natural channel and natural trickle channel	10-15	100	15/$1.69	9/$1.68	5/$2.68	15/$3.59

[1]Routine – several mowings, trash and debris pickup during growing season; small revegetation operations and limited weed control

[2]Restoration - isolated or small-scale drainage problems, local erosion problems including earthwork, riprap and/or concrete; repair existing erosion protection or drainage structures, thinning trees, removing sediment deposits, revegetation

[3]Rehabilitation - extensive erosion problems on particular reaches of unimproved channel or failed improvements on an improved channel; reconstructing deteriorated or inadequate drainage structures channel improvements; rebuilding channel side - slopes and overbanks to restore channel capacity; improvements to existing drainage facilities to enhance stability and maintainability; participation in trail projects to improve maintenance access.

In discussions with City Utilities personnel, the most troublesome problem in the past has been preventative maintenance of utilities. Funding is not available for preventative maintenance. The prudent line concept as proposed is preventative, and will greatly reduce maintenance costs over the long-term. Therefore, it seems to be a matter of proper design and adequate funding rather than the type of channel improvements. The initial construction cost for utility crossing within the prudent line window are more, but in the past, the utilities have been installed in anticipation that the channel will be stable and lack of maintenance of the channel has resulted in failure of the utilities.

With limited maintenance budgets, the only type of channel the city can afford to maintain is a natural channel. Adoption of the prudent line concept would most likely provide significant operation and maintenance cost savings.

5.7 Cost Comparison

Construction costs of the two alternatives were compared on a reach-by-reach basis. **Table 5.5** contains the construction cost estimates for each reach of the channel and the 4 major tributaries. There is a significant savings attributable particularly in the cost of improvements upstream of Rangewood Drive on the mainstem of the channel. Values are taken directly from Table 6 of the DBPS and Table 5.1 of this document (both cost estimates are on a January 1992 basis).

Proposed basin fees were calculated for subsequent years since 1994 using the annual percentage increase provided by the City of Colorado Springs. Table 5.6 contains the interim basin fees compared to the proposed basin fee based on the prudent line concept.

Table 5.5. Comparison of DBPS and Prudent Line Costs.		
Reach	Subtotals	
	Prudent Line ($)	DBPS ($)
Confluence to Academy Boulevard (URS Design Points 18 to 21)	947,945	1,768,871
Academy Boulevard to Union Boulevard (URS Design Points 16 to 18)	1,077,890	2,199,340
Union Boulevard to Rangewood Drive (URS Design Points 13 to 16)	1,219,460	1,433,041
Rangewood Drive to Woodmen Road (URS Design Points 12 to 13)	400,400	1,359,373
Upstream of Woodmen Road (URS Design Points 1 to 12)	2,365,250	6,209,084
Tributary 1	4,340,786	4,497,400
Tributary 2	468,136	393,568
Tributary 3	2,109,310	2,109,310
Tributary 4	3,983,072	4,095,832
Other	9,200,564	9,200,564
TOTAL	**26,112,813**	**33,266,383**

Table 5.6. Basin Fees.						
Year	Inflation Rate	Land Fee	Capital Basin Fee	Land Basin Fee	Total Basin Fee	Interim Fee Range
1994		$14,000	$4,162[1]	$595[2]	$4,757	$4,663 - $5,247
1995	3%	$15,900	$4,287	$676	$4,963	$4,803 - $5,404
1996	4%	$16,700	$4,459	$710	$5,168	$4,995 - $5,620
1997	4%	$25,000	$4,637	$1,062	$5,699	$5,195 - $5,845
1998	5%	$32,000	$4,869	$1,360	$6,228	$5,455 - $6,137
1999	4%	$33,600	$5,064	$1,428	$6,491	$5,673 - $6,382
2000	3%	$35,280	$5,215[1]	$1,499[2]	$6,714[3]	$5,843 - $6,573

[1]Includes $1,475,592 or $251/acre in 1994 ($315/acre in 2000) for facilities downstream of Rangewood Drive, as designated in Table 5.1, that will be paid as cash fees and used by the City to construct those facilities as needed.

[2]Includes $132,230 or $23/acre in 1994 ($57/acre in 2000) for land downstream of Rangewood Drive, as designated in Table 5.1, that will be paid as cash fees and used by the City for land as needed.

[3]Includes cash fee of $372/acre that will be paid to the City as described in 1 and 2 above.

5.8 Prudent Line Management/Administration

The concepts of how to manage and administer the prudent line will need to be developed in cooperation with the City of Colorado Springs. Issues that will need to be resolved include, but are not limited to:

- The subdivision drainage report should include the final location of the prudent line based on the criteria presented in Chapter 3 of this report. The plan set included with this report provides a general location of the prudent line for planning purposes only.

- The prudent line should be thought of as the building line. In some cases, building structures could be built adjacent to the prudent line. Encroachments including trails and landscaping could be allowed within the prudent line. All other potential encroachments will require a request to the City Engineer who will make a final decision.

- Monitoring and performing maintenance within the prudent line including utilizing a maintenance line should be addressed. A maintenance line within the prudent line should be established to allow for maintenance of the channel within limits inside the prudent line to prevent emergency maintenance problems

- Criteria should be developed to make changes or amendments to the prudent line. In general, questions arise, particularly at tributary areas and where structural improvements are desired along one side of the channel. The prudent line should only be allowed on a continuous reach only, not on a parcel-by-parcel basis. For example, a tributary that has the prudent line would be administered as a prudent line from the mouth to a point where structural channel or pipes control. If one parcel on the reach uses channelization, then the structural approach should be adopted from that point on upstream for both sides of the channel

- Criteria should be developed to extend prudent line into currently unmapped areas

- Design guidelines should be developed for infrastructure such as trails, bridges, sanitary sewer crossings and alignment, waterline crossings and alignment, and utilities. It is recommended that utilities, roads, and private improvements not be allowed in the prudent line window. Trails and other minor facilities that are not vital can be located within the prudent line, but the structures should not retard the natural erosion process and should be designed for erosion damage to occur

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. Development in the basin has occurred largely out of the floodplain creating an undesignated, unofficial prudent line.

2. Flooding problems in the basin are largely local and the main drainageways have adequate conveyance, thereby eliminating the need for regional stormwater detention.

3. The physical and geologic characteristics of undeveloped land in the basin are economically and aesthetically manageable under a prudent line concept. In fact, there is a clear reduction in capital costs while also minimizing operation and maintenance costs for both the basin property owners and the public.

4. The facilities and related costs where associated with stabilization or velocity reduction, can be significantly reduced where no demonstrated public health/safety issues are involved, to facilitate conversion of land to common public use areas, and/or where not cost-effective (channel types D through G of the DBPS for the most part).

5. The development of initial system drainage facilities remains unchanged.

6. The area of additional unplatted lands removed from development and from consideration as developable acreage by the prudent line concept is approximately 240 acres (excluding land within 100-year floodplain).

6.2 Recommendations

1. Developments currently underway should be completed as planned, designed, and approved.

2. Undeveloped areas as highlighted in this report should be developed under the prudent line concept.

3. Areas upstream of prudent line reaches and other reaches so designated in this report should be developed utilizing conventional urban drainage techniques as is compatible with the projected land use and the existing DBPS.

4. No further regional detention facilities should be constructed as part of the DBPS and any local detention facilities should be designed/constructed with proper sediment handling.

5. A program of proactive infrastructure repair and replacement associated with both the public and private components of the DBPS should be instituted to develop the proposed drainage-related infrastructure in parallel with the related basin development.

6. Cottonwood Creek corridor infrastructure (utilities, trails, maintenance access, etc.) should be minimized and where necessary, placed at the edge of the corridor to minimize disturbance and reduce the chance of their disturbance by normal stream movement.

7. FEDERAL AGENCY REVIEW

7.1 Introduction

The Cottonwood Creek drainage basin is located partly within the City of Colorado Springs and in unincorporated El Paso County. The City of Colorado Springs, City Engineering Division and the El Paso County Department of Public Works have responsibility for implementation of the DBPS. The U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the Colorado Division of Wildlife also have interest in the implementation of the DBPS.

The alternative DBPS (Ayres Associates, October 18, 1996) was reviewed by several City of Colorado Springs departments and El Paso County. Comments from the City of Colorado Springs and El Paso County have already been addressed in several meeting, correspondence, and changes have been included in this document. The following sections summarize the concerns of federal agencies and responses to those concerns.

7.2 Federal Agency Concerns

The representatives of the following federal agencies were solicited for review and comment of the prudent line alternative for Cottonwood Creek:

- Anita Culp - U.S. Army Corps of Engineers
- Tony Gurzick - Colorado Division of Wildlife
- Peter Plage - U.S. Fish and Wildlife Service
- Sarah Fowler - U.S. Environmental Protection Agency

A meeting was held on November 5, 1996 where the prudent line concept was presented for discussion. This meeting was attended by the following:

- Anita Culp, U.S. Army Corps of Engineers
- Sarah Fowler, U.S. Environmental Protection Agency
- Dave Frick, Ayres Associates
- Bruce Thorson, City Engineering Division
- Kenneth Sampley, City Engineering Division

The U.S. Army Corps of Engineers detailed their concerns in a letter dated January 9, 1998 from Mr. James M. Townsend to Mr. David M. Frick (Ayres Associates). A copy of this letter is contained in **Appendix D**. Their concerns are summarized below with our responses.

1. The Corps states that the 100-year developed flows were not calculated with the assumption of a shrub-vegetated floodway, thus the calculated flood elevations may be too low.

The only section of Cottonwood Creek where the 100-year water surface was greater than the prudent line setback was just upstream of Rangewood Drive at the confluence with the major tributary. The valley crest is well above the 100-year flood elevations for all other areas of Cottonwood Creek, therefore the prudent line is well beyond the influence of the 100-year flood elevations even with dense vegetation located in the waterway.

2. The existing and future sections of steep unvegetated banks may not be acceptable to the City for safety, aesthetics, water quality, or other reasons.

The DBPS, as adopted, did not address the issues of safety, aesthetics or water quality either. In fact, in the upper reaches of the basin, where the prudent line is proposed, the DBPS only proposes acquisition of ROW to the top of channel lining, which is located at the limit of the 100-year floodplain (possibly including freeboard). In areas where vertical banks exist, the DBPS allows development to extend up to the top of the vertical bank, similar to what has occurred between Academy and Vincent Drives.

The prudent line recommendations and costs include acquisition of ROW at a minimum of 50 feet beyond the top of the valley crest. This is sufficient to place a trail on either side of the valley crest. The DBPS assumes no ROW acquisition costs in any areas above Rangewood Drive. Future trails above Rangewood Drive. would need to be placed in the 100-year floodplain or additional ROW would need to be acquired (which is not reflected in the basin costs of the DBPS).

Trails could be placed anywhere within the prudent line ROW, but the potential for losing a trail is greater when placed near the active floodplain areas. **Figure 7.1** shows a typical cross section of the prudent line window with potential trail locations. There are problems with the steep banks, but as mentioned, the DBPS does not address these concerns either. With trails on top of the valley crest, there could be at least 50 feet between the trail and the steep banks. Hand railing could be installed in areas where the trail alignment is close to a steep bank or the banks could be regraded if desired. Also, more ROW could be purchased in specific areas to accommodate the trail; however, these cost are not included in the proposed plan.

Sediment issues with respect to the prudent line concept are discussed in detail in Sections 4.4, 4.5, and 4.6.

3. Maintenance roads and recreation trails should be placed outside the prudent line ROW.

There is no reason for maintenance roads and trails to be placed outside the prudent line ROW. As already discussed, with trails on top of the valley crest, there would be at least 50 feet between the trail and the valley crest. The current plan does not provide any maintenance road or trail ROW.

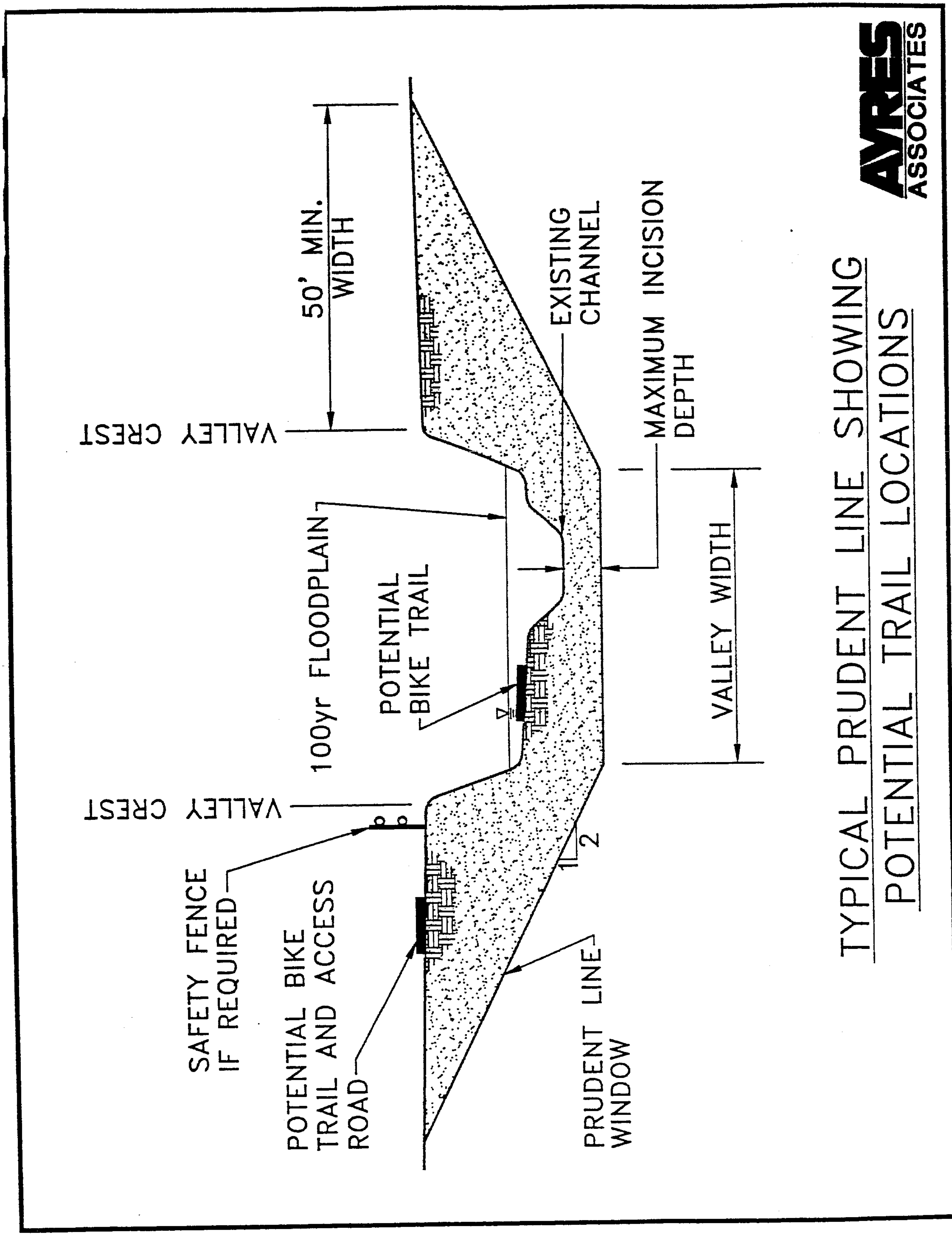

Figure 7.1. Prudent line window with possible trail locations.

8. REFERENCES

Ayres Associates, 1995. Preliminary Channel Stability Assessment of Cottonwood Creek. Report prepared for the Colorado Springs Engineering Division, Dept. of Public Works.

Ayres Associates, May 1996. Draft Final Cottonwood Creek Drainage Basin Planning Study, report prepared for Nor'Wood Development, Inc., and City of Colorado Springs.

Ayres Associates, October 18, 1996. Cottonwood Creek Drainage Basin Planning Study, report prepared for Nor'wood Development, Inc., LaPlata Investments, Ltd. and City of Colorado Springs.

CH2M Hill, 1994. Monument Creek Drainage Basin Planning Study, Volume I Report, prepared for the City of Colorado Springs, Planning, Development, and Finance Department.

City of Colorado Springs/El Paso County, 1987. Drainage Criteria Manual.

Federal Highway Administration, 1991. Stream Stability at Highway Structures, Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, prepared by P.F. Lagasse, J.D. Schall, F. Johnson, E.V. Richardson, J.R. Richardson, and F. Chang.

HDR Infrastructure, Inc., 1991. Drainage Criteria Manual prepared for the City of Colorado Springs and El Paso County, Colorado.

Hansen, K.D. and Lynch, J.B., 1995. Controlling Floods in the Desert with Soil-Cement. Draft paper prepared for publication.

Jarrett, R.D. and Costa, J.E., 1988. "Evaluation of the Flood Hydrology in the Colorado Front Range Using Precipitation, Streamflow, and Paleoflood Data for the Big Thompson River Basin," U.S. Geological Survey, Water-Resources Investigations Report 87-4117.

Lincoln-DeVore, 1979. Engineering Study of Cottonwood Creek Drainage Basin, Colorado Springs, Colorado, prepared for: Director of Public Works and Drainage Board of the City of Colorado Springs, CO.

Little, W.D., Thorne, C.R., and Murphy, J.B., 1982. Mass Bank Failure Analysis of Selected Yazoo Basin Streams. Trans. of the ASAE, vol. 25, No. 5, pp. 1321-1328.

McCain, J.F. and Jarrett, R.D., 1976. Manual for Estimating Flood Characteristics of Natural-Flow Streams in Colorado, Technical Manual No. 1, Colorado Water Conservation Board, Colorado Department of Natural Resources.

McLaughlin Water Engineers, 1986. Evaluation and Design Recommendations for Drop Structures in the Denver Metropolitan Area, prepared for the Denver Urban Drainage and Flood Control District.

McLean, F.G. and Hansen, K.D., 1993. Roller Compacted Concrete for Embankment Overtopping Protection. Geotechnical Practice for Dam Rehabilitation, Proceedings of an ASCE Conference, Raleigh, NC, pp. 188-209.

Miller, J.F., Frederick, and Tracey, R.J., 1973. Precipitation-Frequency Atlas of the Western United States, NOAA Atlas 2.

National Weather Service, 1982, Hydrometeorological Branch, Office of Hydrology, 1982. Hydrometeorological Report No. 52, Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian, U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of the Army Corps of Engineers.

Osman, A.M. and Thorne, C.R., 1988. Riverbank Stability Analysis I: Theory Journal of Hydraulic Engineering, ASCE, HY2, vol. 114, pp. 134-150.

Ponce, V.M, 1978. Generalized Stability Analysis of Channel Banks. Journal of Irrigation and Drainage Division, ASCE, vol. 104, No. 1R4, pp. 343-350.

Resource Consultants & Engineers, Inc., 1994. Review of Cottonwood Creek Drainage Basin Planning Study and Associated Design Criteria, Fort Collins, CO.

Richardson, E.V. and Simons, D.B., 1984. Use of Spurs and Guidebanks for Highway Crossings, Transportation Research Board, vol. 950, No. 2, Transportation Board, Washington, D.C., pp. 184-193.

Simon, A., Wolfe, W.J., and Molinas, A., 1991. Mass-wasting Algorithm in an Alluvial Channel Model. Proceedings of the 5th Federal Interagency Sedimentation Conference, Las Vegas, NV, pp. 8.22-8.29.

Trieste, D.J., 1992. Evaluation of Supercritical/subcritical Flows in High-Gradient Channel. ASCE Journal of Hydraulic Engineering, vol. 118, No. 8, August.

URS Consultants, 1994. Cottonwood Creek Drainage Basin Planning Study, City of Colorado Springs and El Paso County and Colorado Springs, CO.

U.S. Army Corps of Engineers, 1990. HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1995. Installation Instructions for Microcomputer Version of HEC-FFA, Flood Frequency Analysis.

U.S. Department of Agriculture, Soil Conservation Service, 1984. Procedures for Determining Peak Flows in Colorado, includes and supplements Technical Release No. 55, Urban Hydrology for Small Watersheds.

U.S. Water Resources Council, 1981. Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Committee.

APPENDIX A
Hydrology

SCS Curve Number Calculations
Existing Land Use Conditions

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN	Hydrologic Soil Group											
A1	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A2	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A3	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A4	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A5	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A6	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A7	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
A8	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN A9	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN **61**

BASIN A10	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN **61**

BASIN A11	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN **61**

BASIN A12	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN **61**

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN	Hydrologic Soil Group											
A13	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
B1	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
B2	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
B3	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN B4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN B5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN B6	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN B7	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**86.5**	61	5276.5	**13.5**	74	999	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	86.5		5276.5	13.5		999	0		0
% Basin Area			100									
WEIGHTED CN			62.755									

BASIN	Hydrologic Soil Group											
B8	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	100	61	6100	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			**61**									

BASIN	Hydrologic Soil Group											
B9	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	16.2	61	988.2	83.8	74	6201.2	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	16.2		988.2	83.8		6201.2	0		0
% Basin Area			100									
WEIGHTED CN			**71.894**									

BASIN	Hydrologic Soil Group											
C1	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	100	61	6100	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			**61**									

BASIN	Hydrologic Soil Group											
C2	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	100	61	6100	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			**61**									

BASIN C3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN C4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN C5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN C6	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN	Hydrologic Soil Group											
C7	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
C8	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**92.7**	61	5654.7	**7.3**	74	540.2	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	92.7		5654.7	7.3		540.2	0		0

% Basin Area 100

WEIGHTED CN 61.949

BASIN	Hydrologic Soil Group											
C9	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**95**	61	5795	**5**	74	370	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	95		5795	5		370	0		0

% Basin Area 100

WEIGHTED CN 61.65

BASIN	Hydrologic Soil Group											
C10	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**89.5**	61	5459.5	**10.5**	74	777	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	89.5		5459.5	10.5		777	0		0

% Basin Area 100

WEIGHTED CN 62.365

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN C11	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**4.8**	39	187.2	**34.6**	61	2110.6	**60.6**	74	4484.4	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	4.8		187.2	34.6		2110.6	60.6		4484.4	0		0
% Basin Area			100									
WEIGHTED CN			67.822									

BASIN C12	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**62.6**	39	2441.4	**5.4**	61	329.4	**32**	74	2368	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	62.6		2441.4	5.4		329.4	32		2368	0		0
% Basin Area			100									
WEIGHTED CN			51.388									

BASIN C13	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN C14	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN	Hydrologic Soil Group											
C15	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	100	61	6100	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
C16	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	100	61	6100	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
C17	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	4	39	156	96	61	5856	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	4		156	96		5856	0		0	0		0

% Basin Area 100

WEIGHTED CN 60.12

BASIN	Hydrologic Soil Group											
C18	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	15.1	39	588.9	82.9	61	5056.9	2	74	148	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	15.1		588.9	82.9		5056.9	2		148	0		0

% Basin Area 100

WEIGHTED CN 57.938

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN	Hydrologic Soil Group											
C19	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**7.8**	39	304.2	**92.2**	61	5624.2	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	7.8		304.2	92.2		5624.2	0		0	0		0
% Basin Area			100									
WEIGHTED CN			59.284									

BASIN	Hydrologic Soil Group											
C20	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**9.6**	39	374.4	**74.4**	61	4538.4	**16**	74	1184	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	9.6		374.4	74.4		4538.4	16		1184	0		0
% Basin Area			100									
WEIGHTED CN			60.968									

BASIN	Hydrologic Soil Group											
D1	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**8**	39	312	**0**	61	0	**92**	74	6808	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	8		312	0		0	92		6808	0		0
% Basin Area			100									
WEIGHTED CN			71.2									

BASIN	Hydrologic Soil Group											
D2	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**4**	39	156	**15**	61	915	**81**	74	5994	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	4		156	15		915	81		5994	0		0
% Basin Area			100									
WEIGHTED CN			70.65									

BASIN D3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**33**	39	1287	**0**	61	0	**67**	74	4958	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	33		1287	0		0	67		4958	0		0

% Basin Area 100

WEIGHTED CN 62.45

BASIN D4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**49.7**	39	1938.3	**40.6**	61	2476.6	**9.7**	74	717.8	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	49.7		1938.3	40.6		2476.6	9.7		717.8	0		0

% Basin Area 100

WEIGHTED CN 51.327

BASIN D5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**19**	39	741	**81**	61	4941	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	19		741	81		4941	0		0	0		0

% Basin Area 100

WEIGHTED CN 56.82

BASIN E1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN E2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN E3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

BASIN E4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**70.4**	61	4294.4	**29.6**	74	2190.4	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	70.4		4294.4	29.6		2190.4	0		0
% Basin Area			100									
WEIGHTED CN			64.848									

BASIN E5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0
% Basin Area			100									
WEIGHTED CN			61									

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN E6	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN E7	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**22**	39	858	**17**	61	1037	**61**	74	4514	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	22		858	17		1037	61		4514	0		0

% Basin Area 100

WEIGHTED CN 64.09

BASIN E8	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN E9	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**97**	61	5917	**3**	74	222	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	97		5917	3		222	0		0

% Basin Area 100

WEIGHTED CN 61.39

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN E10	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	53	61	3233	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	32	75	2400	0	83	0	0	87	0
<=1/8	0	77	0	15	85	1275	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		6908	0		0	0		0
% Basin Area			100									
WEIGHTED CN			**69.08**									

BASIN E11	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	90	39	3510	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	10	75	750	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	90		3510	10		750	0		0	0		0
% Basin Area			100									
WEIGHTED CN			**42.6**									

BASIN F1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	65	39	2535	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	35	75	2625	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	65		2535	35		2625	0		0	0		0
% Basin Area			100									
WEIGHTED CN			**51.6**									

BASIN G1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	48.4	39	1887.6	0	61	0	51.6	74	3818.4	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	48.4		1887.6	0		0	51.6		3818.4	0		0
% Basin Area			100									
WEIGHTED CN			**57.06**									

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN G2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**100**	74	7400	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	0		0	100		7400	0		0

% Basin Area 100

WEIGHTED CN 74

BASIN G3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**2.6**	61	158.6	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**39.9**	75	2992.5	**53.2**	83	4415.6	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**4.3**	86	369.8	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	42.5		3151.1	57.5		4785.4	0		0

% Basin Area 100

WEIGHTED CN 79.365

BASIN G4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**14.5**	75	1087.5	**14**	83	1162	**0**	87	0
<=1/8	**0**	77	0	**22.5**	85	1912.5	**4**	90	360	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**24.5**	92	2254	**20.5**	94	1927	**0**	95	0
SUM	0		0	61.5		5254	38.5		3449	0		0

% Basin Area 100

WEIGHTED CN 87.03

BASIN G5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**86.6**	75	6495	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**13.4**	85	1139	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		7634	0		0	0		0

% Basin Area 100

WEIGHTED CN 76.34

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN G6	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**91.3**	75	6847.5	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**8.7**	85	739.5	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		7587	0		0	0		0

% Basin Area 100

WEIGHTED CN 75.87 ***Avg. with URS Value (80.4): 78.1***

BASIN G7	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**100**	39	3900	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	100		3900	0		0	0		0	0		0

% Basin Area 100

WEIGHTED CN 39

BASIN G8	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**58.2**	75	4365	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**28.6**	85	2431	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**13.2**	92	1214.4	**0**	94	0	**0**	95	0
SUM	0		0	100		8010.4	0		0	0		0

% Basin Area 100

WEIGHTED CN 80.104

BASIN H1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**91**	39	3549	**9**	61	549	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	91		3549	9		549	0		0	0		0

% Basin Area 100

WEIGHTED CN 40.98

BASIN H2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**100**	39	3900	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	100		3900	0		0	0		0	0		0

% Basin Area 100

WEIGHTED CN 39

BASIN H3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**55**	39	2145	**45**	61	2745	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	55		2145	45		2745	0		0	0		0

% Basin Area 100

WEIGHTED CN 48.9

BASIN H4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**58**	39	2262	**42**	61	2562	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	58		2262	42		2562	0		0	0		0

% Basin Area 100

WEIGHTED CN 48.24

BASIN H5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**82**	39	3198	**0**	61	0	**18**	74	1332	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	82		3198	0		0	18		1332	0		0

% Basin Area 100

WEIGHTED CN 45.3

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN	Hydrologic Soil Group											
H6	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**100**	39	3900	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	100		3900	0		0	0		0	0		0
% Basin Area			100									
WEIGHTED CN			39									

BASIN	Hydrologic Soil Group											
H7	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**92**	39	3588	**8**	61	488	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	92		3588	8		488	0		0	0		0
% Basin Area			100									
WEIGHTED CN			40.76									

BASIN	Hydrologic Soil Group											
H8	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**48**	39	1872	**52**	61	3172	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	48		1872	52		3172	0		0	0		0
% Basin Area			100									
WEIGHTED CN			50.44									

BASIN	Hydrologic Soil Group											
H9	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**92**	39	3588	**8**	61	488	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	92		3588	8		488	0		0	0		0
% Basin Area			100									
WEIGHTED CN			40.76									

BASIN H10	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	60	39	2340	40	61	2440	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	60		2340	40		2440	0		0	0		0
% Basin Area			100									
WEIGHTED CN			47.8									

BASIN H11	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	100	39	3900	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	100		3900	0		0	0		0	0		0
% Basin Area			100									
WEIGHTED CN			39									

BASIN H12	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	100	39	3900	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	100		3900	0		0	0		0	0		0
% Basin Area			100									
WEIGHTED CN			39									

BASIN H13	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	88	39	3432	12	61	732	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	0	75	0	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	88		3432	12		732	0		0	0		0
% Basin Area			100									
WEIGHTED CN			41.64									

EXISTING LAND USE CONDITIONS SUB-BASIN SCS WEIGHTED CURVE NUMBER CALCULATIONS

BASIN H14	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**100**	39	3900	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	100		3900	0		0	0		0	0		0

% Basin Area 100

WEIGHTED CN 39

BASIN H15	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**50**	39	1950	**50**	61	3050	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	50		1950	50		3050	0		0	0		0

% Basin Area 100

WEIGHTED CN 50

BASIN H16	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**8**	39	312	**92**	61	5612	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	8		312	92		5612	0		0	0		0

% Basin Area 100

WEIGHTED CN 59.24

BASIN H17	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**3**	39	117	**97**	61	5917	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	3		117	97		5917	0		0	0		0

% Basin Area 100

WEIGHTED CN 60.34

BASIN	Hydrologic Soil Group											
H18	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**80**	39	3120	**20**	61	1220	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	80		3120	20		1220	0		0	0		0

% Basin Area 100

WEIGHTED CN 43.4

BASIN	Hydrologic Soil Group											
H19	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**85**	39	3315	**15**	61	915	**0**	74	0	**0**	80	0
2 1/2 - 5	0	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	85		3315	15		915	0		0	0		0

% Basin Area 100

WEIGHTED CN 42.3

BASIN	Hydrologic Soil Group											
H20	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**100**	61	6100	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		6100	0		0	0		0

% Basin Area 100

WEIGHTED CN 61

BASIN	Hydrologic Soil Group											
H21	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**30**	39	1170	**70**	61	4270	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	0	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	30		1170	70		4270	0		0	0		0

% Basin Area 100

WEIGHTED CN 54.4

BASIN H22	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**50**	39	1950	**50**	61	3050	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	50		1950	50		3050	0		0	0		0
% Basin Area			100									
WEIGHTED CN			50									

BASIN H23	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**50**	39	1950	**50**	61	3050	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	50		1950	50		3050	0		0	0		0
% Basin Area			100									
WEIGHTED CN			50									

BASIN J1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**51.9**	75	3892.5	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**44**	85	3740	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**4.1**	92	377.2	**0**	94	0	**0**	95	0
SUM	0		0	100		8009.7	0		0	0		0
% Basin Area			100									
WEIGHTED CN			80.097									

BASIN J2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**97.8**	88	8606.4	**0**	91	0	**2.2**	93	204.6
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	97.8		8606.4	0		0	2.2		204.6
% Basin Area			100									
WEIGHTED CN			88.11									

BASIN J3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**84.6**	88	7444.8	**0**	91	0	**15.4**	93	1432.2
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	84.6		7444.8	0		0	15.4		1432.2
% Basin Area			100									
WEIGHTED CN			88.77									

BASIN K1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**67**	61	4087	**33**	74	2442	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	67		4087	33		2442	0		0
% Basin Area			100									
WEIGHTED CN			65.29									

BASIN K2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**8**	39	312	**27**	61	1647	**65**	74	4810	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	8		312	27		1647	65		4810	0		0
% Basin Area			100									
WEIGHTED CN			67.69									

BASIN K3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**37.3**	75	2797.5	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**16.9**	85	1436.5	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**22.3**	79	1761.7	**6.9**	86	593.4	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**16.6**	92	1527.2	**0**	94	0	**0**	95	0
SUM	0		0	93.1		7522.9	6.9		593.4	0		0
% Basin Area			100									
WEIGHTED CN			81.163									

Avg. with URS Value (84.6): 82.9

BASIN K4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**45.2**	61	2757.2	**10.2**	74	754.8	**44.6**	80	3568
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**0**	75	0	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	45.2		2757.2	10.2		754.8	44.6		3568

% Basin Area 100

WEIGHTED CN 70.8

BASIN L1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**66.9**	75	5017.5	**31.9**	83	2647.7	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**1.2**	92	110.4	**0**	94	0	**0**	95	0
SUM	0		0	68.1		5127.9	31.9		2647.7	0		0

% Basin Area 100

WEIGHTED CN 77.756 ***Avg. with URS Value (82.2): 80.0***

BASIN L2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**48.6**	61	2964.6	**0**	74	0	**29.6**	80	2368
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**18.6**	75	1395	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**3.2**	85	272	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	70.4		4631.6	0		0	29.6		2368

% Basin Area 100

WEIGHTED CN 69.996 ***Avg. with URS Value (73.5): 71.8***

BASIN M1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**21.7**	75	1627.5	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**78.3**	92	7203.6	**0**	94	0	**0**	95	0
SUM	0		0	100		8831.1	0		0	0		0

% Basin Area 100

WEIGHTED CN 88.311

BASIN M2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**60.8**	75	4560	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**6**	85	510	**0**	90	0	**7.2**	92	662.4
SC, A.F.	**0**	68	0	**12.1**	79	955.9	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**13.9**	92	1278.8	**0**	94	0	**0**	95	0
SUM	0		0	92.8		7304.7	0		0	7.2		662.4

% Basin Area 100

WEIGHTED CN 79.671

BASIN M3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**9.7**	68	659.6	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**43.5**	75	3262.5	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**28.8**	85	2448	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**18**	92	1656	**0**	94	0	**0**	95	0
SUM	0		0	100		8026.1	0		0	0		0

% Basin Area 100

WEIGHTED CN 80.261

BASIN M4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**44.6**	68	3032.8	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**52.7**	75	3952.5	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**2.7**	92	248.4	**0**	94	0	**0**	95	0
SUM	0		0	100		7233.7	0		0	0		0

% Basin Area 100

WEIGHTED CN 72.337

BASIN M5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**11.7**	68	795.6	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**71**	75	5325	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**17.3**	85	1470.5	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		7591.1	0		0	0		0

% Basin Area 100

WEIGHTED CN 75.911

BASIN M6	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	7.8	68	530.4	0	79	0	0	84	0
1/8 - 1/2	0	61	0	36.5	75	2737.5	0	83	0	0	87	0
<=1/8	0	77	0	55.7	85	4734.5	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		8002.4	0		0	0		0

% Basin Area 100

WEIGHTED CN 80.024

BASIN O1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	18.5	75	1387.5	50.3	83	4174.9	0	87	0
<=1/8	0	77	0	11.8	85	1003	12.8	90	1152	0	92	0
SC, A.F.	0	68	0	6.6	79	521.4	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	36.9		2911.9	63.1		5326.9	0		0

% Basin Area 100

WEIGHTED CN 82.388

BASIN O2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	23.5	75	1762.5	46.9	83	3892.7	15.7	87	1365.9
<=1/8	0	77	0	0	85	0	0	90	0	13.9	92	1278.8
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	23.5		1762.5	46.9		3892.7	29.6		2644.7

% Basin Area 100

WEIGHTED CN 82.999

BASIN P1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	3.6	61	219.6	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	33.5	75	2512.5	19.3	83	1601.9	34.8	87	3027.6
<=1/8	0	77	0	2.6	85	221	4.9	90	441	1.3	92	119.6
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	39.7		2953.1	24.2		2042.9	36.1		3147.2

% Basin Area 100

WEIGHTED CN 81.432

BASIN P2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	100	75	7500	0	83	0	0	87	0
<=1/8	0	77	0	0	85	0	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	0	92	0	0	94	0	0	95	0
SUM	0		0	100		7500	0		0	0		0
% Basin Area			100									
WEIGHTED CN			75									

BASIN P3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	83	75	6225	6.6	83	547.8	0.8	87	69.6
<=1/8	0	77	0	4.8	85	408	0	90	0	0	92	0
SC, A.F.	0	68	0	0	79	0	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	4.8	92	441.6	0	94	0	0	95	0
SUM	0		0	92.6		7074.6	6.6		547.8	0.8		69.6
% Basin Area			100									
WEIGHTED CN			76.92									

BASIN Q1	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	50.1	75	3757.5	0	83	0	0	87	0
<=1/8	0	77	0	38.9	85	3306.5	0	90	0	0	92	0
SC, A.F.	0	68	0	2.9	79	229.1	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	8.1	92	745.2	0	94	0	0	95	0
SUM	0		0	100		8038.3	0		0	0		0
% Basin Area			100									
WEIGHTED CN			80.383									

BASIN Q2	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	0	39	0	0	61	0	0	74	0	0	80	0
2 1/2 - 5	0	44	0	0	65	0	0	77	0	0	82	0
1/2 - 2 1/2	0	51	0	0	68	0	0	79	0	0	84	0
1/8 - 1/2	0	61	0	85	75	6375	0	83	0	0	87	0
<=1/8	0	77	0	1.8	85	153	0	90	0	0	92	0
SC, A.F.	0	68	0	4	79	316	0	86	0	0	89	0
IND/GOV	0	81	0	0	88	0	0	91	0	0	93	0
COM/BUS	0	89	0	9.2	92	846.4	0	94	0	0	95	0
SUM	0		0	100		7690.4	0		0	0		0
% Basin Area			100									
WEIGHTED CN			76.904									

BASIN Q3	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**63.2**	75	4740	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**18.8**	79	1485.2	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**18**	92	1656	**0**	94	0	**0**	95	0
SUM	0		0	100		7881.2	0		0	0		0
% Basin Area			100									
WEIGHTED CN			78.812									

BASIN Q4	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**5.6**	75	420	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**67.6**	85	5746	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**26.8**	92	2465.6	**0**	94	0	**0**	95	0
SUM	0		0	100		8631.6	0		0	0		0
% Basin Area			100									
WEIGHTED CN			86.316									

BASIN Q5	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**100**	75	7500	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**0**	85	0	**0**	90	0	**0**	92	0
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**0**	92	0	**0**	94	0	**0**	95	0
SUM	0		0	100		7500	0		0	0		0
% Basin Area			100									
WEIGHTED CN			75									

BASIN Q6	Hydrologic Soil Group											
	A			B			C			D		
Land Use	%	CN	Product	%	CN	Product	%	CN	Product	%	CN	Product
>= 5	**0**	39	0	**0**	61	0	**0**	74	0	**0**	80	0
2 1/2 - 5	**0**	44	0	**0**	65	0	**0**	77	0	**0**	82	0
1/2 - 2 1/2	**0**	51	0	**0**	68	0	**0**	79	0	**0**	84	0
1/8 - 1/2	**0**	61	0	**21.8**	75	1635	**0**	83	0	**0**	87	0
<=1/8	**0**	77	0	**4.9**	85	416.5	**0**	90	0	**2.1**	92	193.2
SC, A.F.	**0**	68	0	**0**	79	0	**0**	86	0	**0**	89	0
IND/GOV	**0**	81	0	**0**	88	0	**0**	91	0	**0**	93	0
COM/BUS	**0**	89	0	**68.3**	92	6283.6	**0**	94	0	**2.9**	95	275.5
SUM	0		0	95		8335.1	0		0	5		468.7
% Basin Area			100									
WEIGHTED CN			88.038									