Final Drainage Letter

WHMD RWRF STORMWATER IMPROVEMENTS
El Paso County, Colorado

Prepared for:
Woodmen Hills Metropolitan District
8046 Eastonville Road
Peyton, CO 80831
(719) 495-2500
Contact: Wally Eaves

Prepared by:
Kimley-Horn and Associates, Inc.
2 North Nevada Avenue, Suite 900
Colorado Springs, Colorado 80903
(719) 453-0180
Contact: Kevin Kofford, P.E.

KH Project #: 196013004

PCD Filing No.: SFXXXX

Prepared: June 22, 2026

Kimley»Horn

CERTIFICATION

DESIGN ENGINEER'S STATEMENT

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparation of this report.

SIGNATURE (Affix Seal): ____

Kevin Kofford, P.E. Date

OWNER/DEVELOPER'S STATEMENT

I, the developer, have read and will comply with all of the requirements specified in this Drainage Report and Plan.

____
Name of Developer

____
Authorized Signature Date

____
Printed Name

____
Title

____
Address

EL PASO COUNTY

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code as amended.

____________________________________ ____________________

Joshua Palmer, P.E. Date
County Engineer/ ECM Administrator

Conditions:

TABLE OF CONTENTS

INTRODUCTION

PURPOSE AND SCOPE OF STUDY

The purpose of this Final Drainage Letter ("FDL") is to document the proposed improvements to the drainage design to the Woodmen Hills Metropolitan District Regional Water Reclamation Facility ("WHMD RWRF"). The Project is located within the jurisdictional limits of El Paso County ("the County"). Therefore, the hydrologic and hydraulic design is based on the County's criteria which is described in further detail within the report.

LOCATION

The Project Site ("Site") is located in the northeast corner of Meridian Ranch Boulevard and Stapleton Drive within El Paso County, Colorado including parcel 4230312001. More specifically, the site is a Portion of the southwest ¼ of the southeast ¼ and southeast ¼ of the southwest ¼ of Section 30, Township 12 South, Range 64 West of the 6th PM, Count of El Paso, State of Colorado. North and east of the Project is the Antler Creek Golf Course, south of the Project is Stapleton Drive, and west of the Project is Meridian Ranch Boulevard. The Site consists of an existing facility building, existing storage building, an existing aerated sludge basin, existing nutrient removal basins, three existing holding ponds, and an existing chlorine contact basin. A vicinity map has been provided in the **Appendix** of this report.

The Site is currently owned by Woodmen Hills Metropolitan District ("WHMD") and improvements to the Site will be by WHMD.

DESCRIPTION OF PROPERTY

The entire WHMD RWRF Site is approximately 13.96 acres consisting of existing treatment facilities to process wastewater, gravel road, existing underground utilities, and native vegetation. The Site currently routes all storm to roadside ditches in Stapleton Drive, which eventually are captured and flow into the Bennett Ranch Regional Detention Pond.

The existing topography consists of slopes ranging from 1% to 40%, with steeper slopes towards the northwest corner of the Site where a retaining wall extension is proposed. Flows in the existing conditions run off site into existing infrastructure and culverts under Stapleton Road. Detailed description of the existing major drainage basin can be found later in the report.

According to NRCS soil mapping data, USCS Type A soils are the primary soil type within the site. Type A soils have a high infiltration rate when thoroughly wet and have a low runoff potential. These consist of deep, well drained soils that have fine texture. Soil mapping information has been provided in the **Appendix**.

The Project will consist of proposed storm infrastructure, grading, drainage swales, pavement, retaining wall improvements, and curb & gutter to improve the drainage issues happening at the current facility. These improvements are not in coordination with any other site changes but are intended as standalone drainage improvements to enhance the drainage conveyance around the property.

FLOODPLAIN STATEMENT

The Site is located outside the 100-year floodplain and within Zone X (an area of minimal flood hazard) as noted on the FEMA FIRM Map No. 08041C0551G revised on December 7, 2018 (See **Appendix**).

DRAINAGE BASINS

MAJOR BASIN DESCRIPTIONS

The Project Site is tributary to a major drainage basin in the El Paso County Drainage Basin Map, Bennett Ranch. This drainage basin is located in the north central portion of El Paso County. The Site is tributary to the Bennett Ranch Regional Detention Pond located within the Bennett Ranch major drainage basin.

The Bennett Ranch DBPS has been provided in the **Appendix**. A summary of flows in existing and proposed conditions has been added to the **Appendix**.

COMPLIANCE WITH DBPS

The Site is located within the “Bennett Ranch Pilot Project Drainage Basin Planning Study” by Stormwater & Environmental Consultants, Inc. approval date November, 2001, was submitted to the County. Further discussion on compliance with water quality requirements can be found in step 2 of the 4-step process.

EXISTING SUB-BASIN DESCRIPTIONS

Historically the runoff from the Site ultimately drains into the Bennett Ranch Regional Detention Pond. Slopes vary from 1-40% throughout the site with various culverts conveying water offsite to Stapleton Drive and connecting to the storm main in Stapleton Drive. The Site has been divided into 19 onsite basins, EX-1 – EX-19, and 6 offsite basins OF-1 – OF-6. The offsite basins are located generally on the northwest and south sides of the property line where flows are entering the Site. The Site generally flows from the northwest to the southeast towards existing stormwater infrastructure. Descriptions for each individual sub-basin can be found below.

In existing conditions, flows within the existing sub-basins are either collected in existing stormwater infrastructure or bypass the Site. An existing drainage map and hydrologic calculations can be found in the **Appendix.**

Table 1: Existing Stormwater Runoff Calculation and Sub-Basin Outfall Descriptions

DESIGN POINT	TRIBUTARY BASINS	AREA (AC)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)	% IMPERV.	IMMEDIATE OUTFALL				ULTIMATE OUTFALL
						CONVEYANCE	CONVEYANCE DIRECTION	LOCATION	TYPE	
EX-1	EX-1	0.03	0.01	0.09	0%	OVERLAND	SOUTHWEST	OFFSITE	EX. 5' TYPE R INLET	Bennett Ranch Regional Detention Pond
EX-2	EX-2	0.23	0.09	0.69	0%	OVERLAND	SOUTH	EX-1	N/A	Bennett Ranch Regional Detention Pond
EX-3	EX-3	0.03	0.01	0.08	0%	OVERLAND	SOUTHWEST	EX-2	N/A	Bennett Ranch Regional Detention Pond
EX-4	EX-4	0.74	0.19	1.39	0%	OVERLAND	SOUTHWEST	OFFSITE	MERIDIAN RANCH BLVD	Bennett Ranch Regional Detention Pond
EX-5	EX-5	0.84	0.35	1.95	5%	OVERLAND	SOUTHEAST	EX-10	N/A	Bennett Ranch Regional Detention Pond
EX-6	EX-6	1.23	1.26	3.98	26%	OVERLAND	SOUTHEAST	EX-10	N/A	Bennett Ranch Regional Detention Pond
EX-7	EX-7	0.61	0.73	2.06	33%	OVERLAND	SOUTHEAST	EX-14	N/A	Bennett Ranch Regional Detention Pond
EX-8	EX-8	0.35	1.34	2.49	90%	OVERLAND	NORTH	EX-7	N/A	Bennett Ranch Regional Detention Pond
EX-9	EX-9	0.54	2.50	4.48	100%	OVERLAND	N/A	N/A	SANITATION TREATMENT BASIN	Bennett Ranch Regional Detention Pond
EX-10	EX-10	1.37	1.63	4.38	35%	OVERLAND	SOUTHEAST	EX-15	EX. 12" CMP CULVERT	Bennett Ranch Regional Detention Pond
EX-11	EX-11	0.16	0.76	1.37	100%	OVERLAND	N/A	N/A	SANITATION TREATMENT BASIN	Bennett Ranch Regional Detention Pond
EX-12	EX-12	0.45	0.22	1.01	8%	OVERLAND	EAST	EX-15	EX. 15" CMP CULVERT	Bennett Ranch Regional Detention Pond
EX-13	EX-13	0.07	0.03	0.21	0%	OVERLAND	SOUTHEAST	OFFSITE	MERIDIAN RANCH BLVD	Bennett Ranch Regional Detention Pond
EX-14	EX-14	0.77	0.51	1.76	18%	OVERLAND	EAST	EX-17	N/A	Bennett Ranch Regional Detention Pond
EX-15	EX-15	2.28	2.83	7.02	46%	HOLDING POND	SOUTHEAST	N/A	SANITATION TREATMENT HOLDING POND	Bennett Ranch Regional Detention Pond
EX-16	EX-16	1.43	3.62	7.20	80%	HOLDING POND	SOUTHWEST	N/A	SANITATION TREATMENT HOLDING POND	Bennett Ranch Regional Detention Pond
EX-17	EX-17	1.74	0.75	3.42	10%	HOLDING POND	SOUTH	N/A	SANITATION TREATMENT HOLDING POND	Bennett Ranch Regional Detention Pond
EX-18	EX-18	0.44	0.32	1.20	17%	OVERLAND	SOUTHEAST	OFFSITE	EX. 24" RCP CULVERT	Bennett Ranch Regional Detention Pond
EX-19	EX-19	0.62	0.30	1.44	8%	OVERLAND	EAST	OFFSITE	EX. 24" RCP CULVERT	Bennett Ranch Regional Detention Pond
OF-1	OF-1	0.27	0.11	0.78	0%	OVERLAND	SOUTHEAST	EX-2	N/A	Bennett Ranch Regional Detention Pond
OF-2	OF-2	0.05	0.02	0.16	0%	OVERLAND	SOUTH	EX-6	N/A	Bennett Ranch Regional Detention Pond
OF-3	OF-3	0.54	0.13	0.98	0%	OVERLAND	SOUTHEAST	EX-7	N/A	Bennett Ranch Regional Detention Pond
OF-4	OF-4	0.11	0.04	0.29	0%	OVERLAND	SOUTHEAST	EX-14	N/A	Bennett Ranch Regional Detention Pond
OF-5	OF-5	0.06	0.02	0.13	0%	OVERLAND	SOUTH	EX-18	N/A	Bennett Ranch Regional Detention Pond
OF-6	OF-6	0.12	0.03	0.19	0%	OVERLAND	EAST	EX-19	N/A	Bennett Ranch Regional Detention Pond
Total		**15.10**								

PROPOSED SUB-BASIN DESCRIPTIONS

For the proposed condition, stormwater will generally maintain historic flow patterns. The proposed paving and grading will alter some of the existing flow paths. Proposed swales and inlets will capture runoff from the proposed improvements and be routed into a proposed manhole connection to an existing storm main located in Stapleton Drive. The storm main within Stapleton Drive is owned and maintained by El Paso County.

The proposed Site has been divided into 23 onsite basins, P-1 – P-8 and OS-1 – OS-15. The basins with "P" labels are proposed onsite improvements that will be captured within proposed storm infrastructure. The basins with "OS" labels are onsite basins where there are no improvements proposed. Runoff from basins with this label will either be captured in existing storm infrastructure or bypass the site per existing conditions. Additionally, there are 6 offsite basins, OF-1 – OF-6. These are basins that offsite flowing onsite.

In the proposed conditions, flows within the proposed sub-basins are captured by inlets, swales, and a French drain system. The proposed drainage map and hydrologic analysis can be found in the **Appendix.** Flows will generally follow historic drainage patterns and be captured by proposed storm infrastructure that ties into the existing storm main located in Stapleton Drive.

Table 2: Proposed Stormwater Runoff Calculation and Sub-Basin Outfall Descriptions

DESIGN POINT	TRIBUTARY BASINS	AREA (AC)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)	% IMPERV.	IMMEDIATE OUTFALL					EMERGENCY OVERFLOW PATH	LOCATION	ULTIMATE OUTFALL
						CONVEYANCE	CONVEYANCE DIRECTION	INLET TYPE	PROPOSED VS EXISTING	PUBLIC VS PRIVATE			
P-1	P-1	0.87	2.85	5.75	68%	C/G	EAST	TYPE C AREA INLET	PROPOSED	PRIVATE	P3	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-2	P-2	0.14	0.04	0.31	0%	CONCRETE PAN	WEST	NYOPLAST AREA INLET	PROPOSED	PRIVATE	P1	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-3	P-3	0.36	0.12	0.90	0%	SWALE	EAST & NORTH	TYPE C AREA INLET	PROPOSED	PRIVATE	P4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-4	P-4	1.08	2.32	5.33	50%	C/G	WEST & NORTH	TYPE D AREA INLET	PROPOSED	PRIVATE	P6	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-5	P-5	0.78	0.28	1.71	3%	SWALE	SOUTHEAST	TYPE C AREA INLET	PROPOSED	PRIVATE	P4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-6	P-6	0.15	0.09	0.40	9%	SWALE	SOUTH	TYPE C AREA INLET	PROPOSED	PRIVATE	P7	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-7	P-7	0.53	0.84	2.22	39%	SWALE	EAST	TYPE C AREA INLET	PROPOSED	PRIVATE	OS-4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-8	P-8	0.04	0.04	0.14	19%	OVERLAND	EAST	FRENCH DRAIN	PROPOSED	PRIVATE	P-6	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-1	OS-1	0.08	0.06	0.26	9%	SWALE	EAST	TYPE C AREA INLET	PROPOSED	PRIVATE	OS-3	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-2	OS-2	0.35	1.29	2.40	90%	ROOF DRAIN	NORTH	ROOF DRAIN	EXISTING	PRIVATE	OS-1	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-3	OS-3	0.77	0.40	1.59	15%	SWALE	EAST	N/A	N/A	N/A	OS-6	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-4	OS-4	2.28	2.61	6.45	46%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-8	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-5	OS-5	1.43	3.81	7.58	80%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-8	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-6	OS-6	1.74	0.70	3.17	10%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-7	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-7	OS-7	0.44	0.43	1.59	17%	OVERLAND	SOUTH	EX. 24" RCP CULVERT	EXISTING	PRIVATE	STAPLETON DRIVE	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-8	OS-8	0.62	0.26	1.26	8%	OVERLAND	SOUTH	EX. 24" RCP CULVERT	EXISTING	PRIVATE	STAPLETON DRIVE	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-9	OS-9	0.45	0.22	1.04	8%	OVERLAND	WEST	EX. 15" CMP CULVERT	EXISTING	PRIVATE	OS-4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-10	OS-10	0.74	0.19	1.40	0%	OVERLAND	SOUTH	N/A	N/A	N/A	STAPLETON DRIVE	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-11	OS-11	0.07	0.03	0.21	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	STAPLETON DRIVE	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-12	OS-12	0.03	0.01	0.09	0%	OVERLAND	WEST	EX. 5' TYPE R INLET	EXISTING	PUBLIC	MERIDIAN RANCH BLVD	ON-GRADE	BENNETT RANCH REGIONAL DETENTION POND
OS-13	OS-13	0.25	0.09	0.65	0%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-10	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-14	OS-14	0.16	0.76	1.37	100%	SEWER TREATMENT TANK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OS-15	OS-15	0.57	2.64	4.73	100%	SEWER TREATMENT TANK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OF-1	OF-1	0.06	0.02	0.14	0%	OVERLAND	WEST	N/A	N/A	N/A	OS-7	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-2	OF-2	0.12	0.03	0.19	0%	OVERLAND	NORTH	N/A	N/A	N/A	OS-8	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-3	OF-3	0.27	0.08	0.61	0%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-13	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-4	OF-4	0.12	0.05	0.37	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	P-1	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-5	OF-5	0.47	0.14	1.04	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	P-2	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-6	OF-6	0.11	0.04	0.29	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	OS-3	N/A	BENNETT RANCH REGIONAL DETENTION POND
Total		15.10											

DESIGN POINT COMPARISON ANALYSIS

Ultimate Design Point

The ultimate design point is the Bennett Ranch Regional Detention Pond. As shown in the chart below, the flows in the 5-year and the 100-year increase slightly between the existing and proposed conditions. Although there is a slight increase, per the Bennett Ranch DBPS, the Bennett Ranch Regional Detention Pond was sized to handle a larger runoff from the Site.

Table 3: Design Point Analysis

ULTIMATE DESIGN POINT	TRIBUTARY BASINS (EXISTING)	AREA (AC)	EXISTING 5-YR FLOW (CFS)	EXISTING 100-YR FLOW (CFS)	TRIBUTARY BASINS (PROPOSED)	AREA (AC)	PROPOSED 5-YR FLOW (CFS)	PROPOSED 100-YR FLOW (CFS)
Bennett Ranch Regional Detention pond	EX1-19, OF1-6	15.10	17.81	48.76	P1-8, OS1-15, OF1-6	15.10	20.44	53.21

DRAINAGE DESIGN CRITERIA

DEVELOPMENT CRITERIA REFERENCE

The proposed storm facilities are designed to be in compliance with El Paso County “Drainage Criteria Manual (DCM)” dated October 2018 (”the MANUAL”), El Paso County “Engineering Criteria Manual” (“the Engineering Manual”), Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs Drainage Criteria Manual dated May 2014 (“the Colorado Springs MANUAL”), and Mile High Flood District (MHFD), Urban Drainage and Flood Control District Drainage Criteria Manuals (UDFCDCM), (Volumes 1, 2 and 3), prepared by Wright-McLaughlin Engineers, June 2001, with latest revisions.

Site drainage is not significantly impacted by such constraints as utilities or existing development.

HYDROLOGIC CRITERIA

The 5-year and 100-year design storm events were used in determining rainfall and runoff for the proposed drainage system per chapter 6 of the CRITERIA. Table 6-2 of the CRITERIA is the source for rainfall data for the 5-year and 100-year design storm events. Design runoff was calculated using the Rational Method for developed conditions as established in the CRITERIA and MANUAL. Runoff coefficients for the proposed development were determined using Table 6-6 of the CRITERIA by calculating weighted impervious values for each specific site basin as outlined.

HYDRAULIC CRITERIA

The proposed drainage facilities are designed in accordance with the CRITERIA and the MANUAL. Hydraulic calculations for inlet and street capacity were computed using MHFD spreadsheets for the 5-year and 100-year design storm events. The inlet size needed per basin to meet the basin’s developed flow was determined the calculated capacities. The inlet capacity calculations are provided in the **Appendix**.

Pipe flows, capacities, and hydraulic grade line calculations were computed for the 5-year and 100-year design storm events using StormCAD implementing the standard method headloss coefficients from the CRITERIA.

Kimley»Horn

TAILWATER CONDITIONS

County as-built drawings or final drainage report for the existing public storm system is unavailable. Therefore, conservative assumptions were made to approximate the minor or major tailwater elevations of the existing public storm sewer system at the proposed private storm sewer outfall. The tailwater elevation utilized for the 5-year storm was determined using 80% of full flow depth of the existing 48" storm main (7,045.14') and the 100-year storm event was determined using a full flow depth of the existing 48" storm main (7,045.94').

THE FOUR STEP PROCESS

The Project was designed in accordance with the four-step process to minimize adverse impacts of urbanization, as outlined in the El Paso County Engineering Manual for BMP selection as noted below:

Step 1. **Employ Runoff Reduction Practices** – The Project is proposing stormwater improvements to the existing Site to better enhance runoff and conveyance throughout the Site. One way these drainage improvements increase runoff reduction is by adding natural swales on the edge if parking and drive isles to convey stormwater to area inlets by using natural swales, allowing for more percolation and infiltration. The proposed improvements are not anticipated to have negative impacts to downstream infrastructure.

Step 2. Provide a Water Quality Capture Volume – The use of the existing Bennett Ranch Regional Detention Pond will provide permanent water quality. Per table 7.2 and Figure 2-4 in the DBPS, the planned imperviousness for the Site is 95% with a commercial land use and flows are tributary to the Bennett Ranch Regional Detention Pond. The Bennet Ranch DBPS can be found in the **Appendix.** In existing conditions, the imperviousness onsite is 34.03%, and with the proposed improvements, the imperviousness onsite is 36.47%. Since the overall imperviousness is below the 95% threshold that was planned for the Site, the Bennett Ranch Regional Detention Pond has the capacity to accommodate the additional imperviousness and therefore, runoff proposed.

Per ECM Appendix I Section 1.7.C.1.a., 20% of the development site or less than 1 acre can be excluded from providing water quality. From site calculations, 0.011 acres (490.05 sq ft) of disturbed area will not be able to be treated which is 0.64% of the disturbed area, meeting the requirement that less than 20% of the overall site can be excluded.

Step 3 Stabilize Drainageways– The site is located more than 500 feet away from any major drainageways so channel stabilization will not be provided with the improvements.

Step 4. Implement Site Specific and Other Source Control BMPs – The erosion control construction BMPs of the Project were designed to reduce contamination. Source control BMPs include the use of vehicle tracking control, culvert protection, stockpile management, and stabilized staging areas.

DRAINAGE FEES

FEES

The Project is within the Bennett Ranch (CHWS1200) Drainage Basin and since the Site has already been platted, El Paso County Drainage Basin fees do not apply.

SUMMARY

This report has been prepared in accordance with El Paso County stormwater criteria. It outlines the Site design for the 5-year and 100-year storm events drainage system. The drainage design presented within this report conforms to the criteria presented in the MANUAL. Additionally, the Site runoff will not adversely affect the downstream and surrounding developments.

REFERENCES

1. El Paso County “Engineering Criteria Manual” Volumes 1 & 2, dated October 31, 2018

2. Natural Resources Conservation Service, Web Soil Survey, dated June 2, 2026.

3. Urban Drainage and Flood Control District Drainage Criteria Manuals (UDFCDCM), (Volumes 1, 2 and 3), prepared by Wright-McLaughlin Engineers, June 2001, with latest revisions.

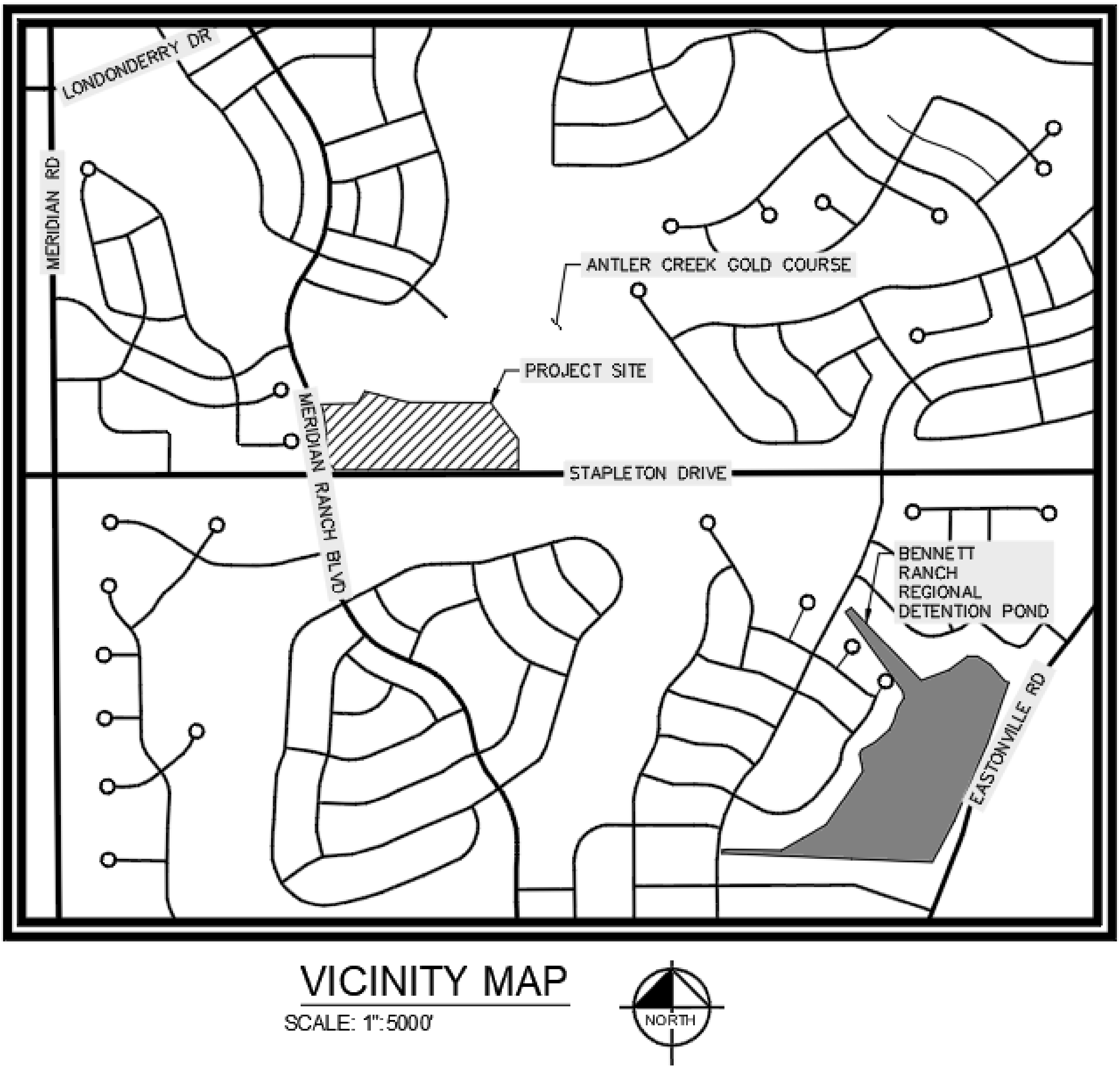
4. Flood Insurance Rate Map, El Paso County, Colorado and Incorporated Areas, Map Number 08041C0551G, Effective Date December 7, 2018, prepared by the Federal Emergency Management Agency (FEMA).

5. Bennett Ranch Pilot Project Drainage Basin Planning Study, by Stormwater & Environmental Consultants, Inc., Dated November 2001.

6. Draft Geotechnical Engineering Study Woodmen Hills Metro District Regional Water Reclamation Facility Stormwater Improvements, by Kumar & Associates, Inc., Dated June 19, 2026.

APPENDIX

APPENDIX A – VICINITY MAP



VICINITY MAP

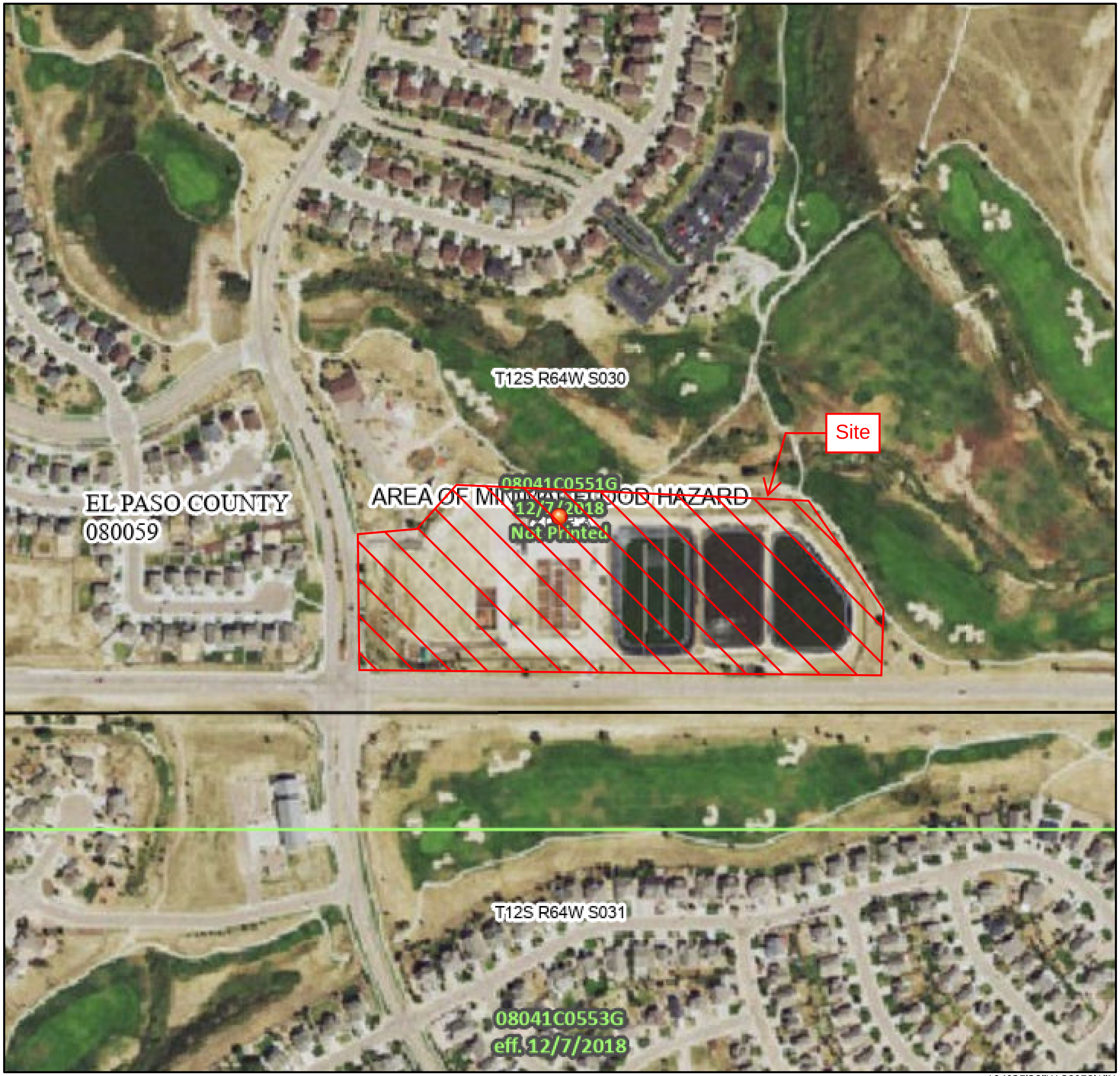
SCALE: 1":5000'

APPENDIX B – FEMA FIRM MAP

National Flood Hazard Layer FIRMette

FEMA

104°36'16"W 38°58'29"N



104°35'38"W 38°58'1"N

Feet 0 250 500 1,000 1,500 2,000

1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 6/3/2026 at 3:58 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX C – USGS SOILS MAP AND GEOTECHNICAL REPORT

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

El Paso County Area, Colorado

June 2, 2026

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

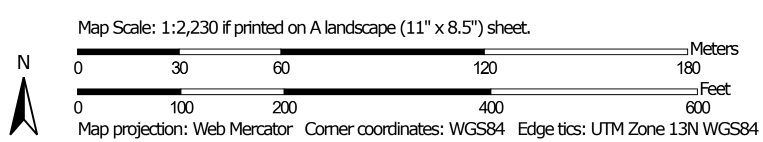
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


104° 36' 4" W
104° 35' 44" W
38° 58' 19" N
38° 58' 8" N
534560
534610
534660
534710
534760
534810
534860
534910
534960
535010
4313740
4313690
4313640
4313590
4313540
4313490
4313440
Meridian Ranch
19
Soil Map may not be valid at this scale.


N
Map Scale: 1:2,230 if printed on A landscape (11" x 8.5") sheet.
0 30 60 120 180 Meters
0 100 200 400 600 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 23, Aug 29, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 23, 2024—Aug 4, 2024

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
19	Columbine gravelly sandy loam, 0 to 3 percent slopes	14.0	100.0%
Totals for Area of Interest		**14.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

El Paso County Area, Colorado

19—Columbine gravelly sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 367p
Elevation: 6,500 to 7,300 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 46 to 50 degrees F
Frost-free period: 125 to 145 days
Farmland classification: Not prime farmland

Map Unit Composition

Columbine and similar soils: 97 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Columbine

Setting

Landform: Fans, Fan terraces, Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 14 inches: gravelly sandy loam
C - 14 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.5 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: R049XY214CO - Gravelly Foothill
Hydric soil rating: No

Minor Components

Fluvaquentic haplaquolls

Percent of map unit: 1 percent
Landform: Swales
Hydric soil rating: Yes

Other soils

Percent of map unit: 1 percent
Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

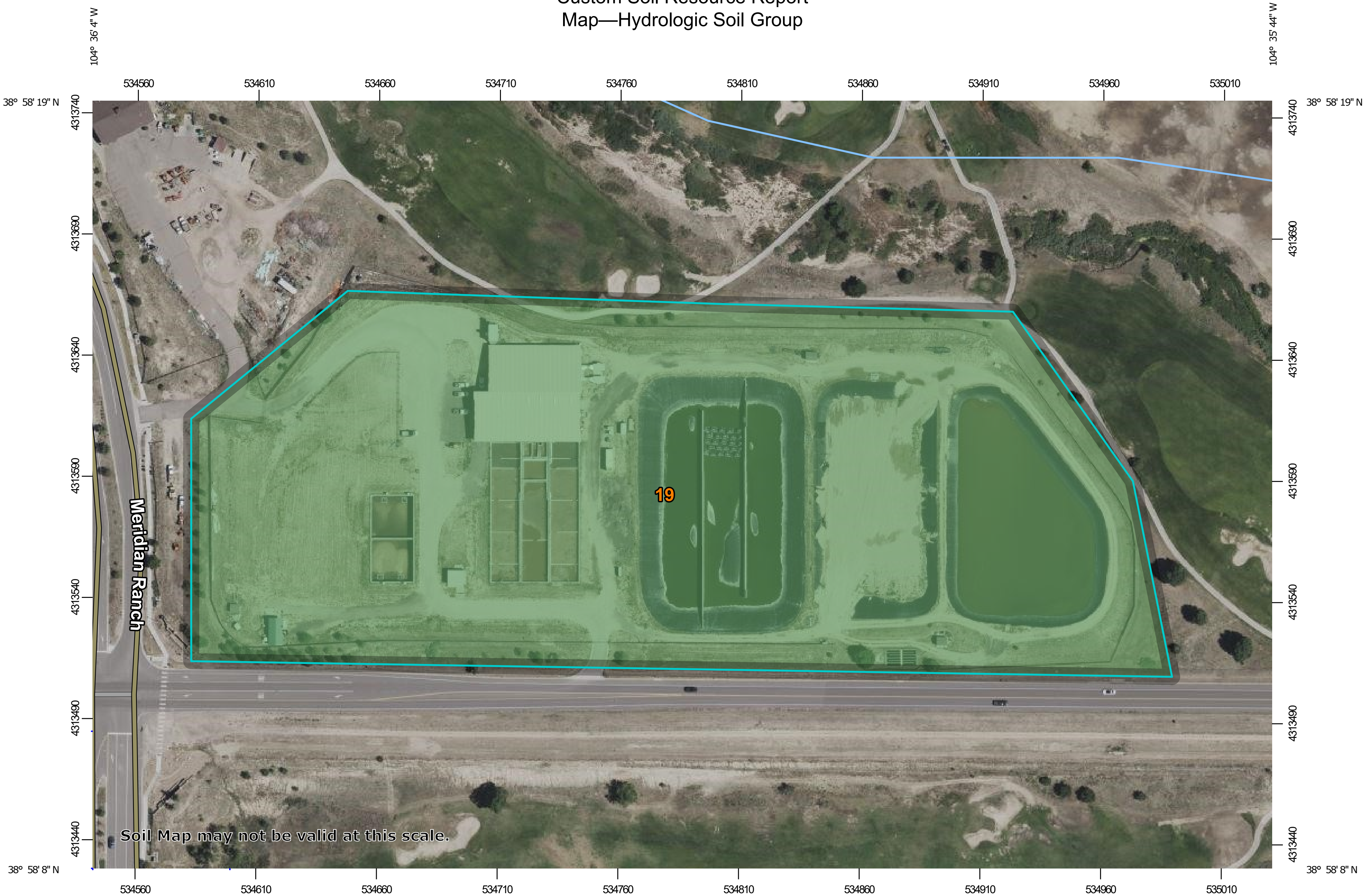
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group



Map Scale: 1:2,230 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 30, 60, 120, 180

Feet: 0, 100, 200, 400, 600

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 23, Aug 29, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 23, 2024—Aug 4, 2024

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
19	Columbine gravelly sandy loam, 0 to 3 percent slopes	A	14.0	100.0%
Totals for Area of Interest			**14.0**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Kumar & Associates, Inc.®
Geotechnical and Materials Engineers
and Environmental Scientists

6735 Kumar Heights
Colorado Springs, CO 80918
phone: (719) 632-7009
email: kacolospgs@kumarusa.com
www.kumarusa.com

An Employee Owned Company

Office Locations: Denver (HQ), Parker, Colorado Springs, Fort Collins, Glenwood Springs, and Summit County, Colorado

DRAFT GEOTECHNICAL ENGINEERING STUDY
WOODMEN HILLS METRO DISTRICT
REGIONAL WATER RECLAMATION FACILITY
STORMWATER IMPROVEMENTS
11866 STAPLETON DRIVE, PEYTON, COLORADO

Prepared By:

Arben F. Kalaveshi, P.E.

Reviewed By:

____

Duane P. Craft, P.E.

Prepared For:

Kimley-Horn
2 North Nevada Avenue, Suite 900
Colorado Springs, Colorad0 80903

Attn: Katy Corkill, P.E.

Project No: 26-2-169

June 19, 2026

TABLE OF CONTENTS

SUMMARY

1. At the client's request, this draft report has been issued prior to the completion of our laboratory testing and should be used for preliminary information only. The information presented herein may change in the final draft.

2. A total of 6 borings were drilled for this study, including 3 for the proposed stormwater line, and 3 for proposed paved areas.

   Below an intermittent layer of topsoil, existing fill was encountered in all of the borings and extended to depths of 1 to 7 feet below the existing ground surface. The underlying native soils were predominately clean to silty sand but also included zones/lenses of sandy lean clay and clayey sand. Bedrock consisted of sandstone and claystone and was found at depths ranging from 10 to 21 feet. Bedrock extended to the maximum depth explored of 25 feet where it was encountered.

3. Groundwater was encountered in Borings 5 and 6 when measured the day of drilling. Follow-up water measurements will be included with the final draft.

4. Existing undocumented fill is present at this site and should be entirely removed and replaced where it is encountered below new construction such as the proposed RCP storm drain. No over-excavation will be necessary if such structures bear on native soils. Since pavements can generally tolerate settlement better than structures, and are easier to repair if movement occurs, a reduced over-excavation depth of 12 inches can be considered in these areas. Based on the samples of fill collected, it should be suitable for reuse if it is processed, moisture conditioned, and recompacted as described in the "Site Grading and Earthwork" section of this report.

5. For the design of the pipeline and drainpipe, we recommend a horizontal modulus of soil reaction (E') of 2,000 psi be used for initial deflection of the pipe zone material that has been compacted in accordance with the specifications listed in the "Site Grading and Earthwork" section.

6. Above a depth of 10 feet, thrust blocks used to resist thrust forces at horizontal bends in the pipe should be designed using a passive bearing pressure based on an equivalent fluid density of 250 pcf. The passive pressure should be calculated by multiplying the equivalent fluid density value by the depth in feet below the ground surface corresponding to the midpoint height of the face of the thrust block. For thrust blocks with a midpoint depth of 10 feet or more, a maximum allowable soil bearing pressure of 2,500 psf should be used.

7. The following pavement section (HMA over ABC, and PCC over ABC) were determined using the AASHTO 1993 design method for flexible and rigid pavements. Details regarding binder type, and other considerations can be found within the body of this report.

Area	HMA[1] over ABC[2] (inches)	PCCP[3] over ABC[2] (inches)
Site Pavements	5 over 6	6 over 4

1: HMA = Hot mix Asphalt
2: ABC = Aggregate base course
3: PCC = Portland cement concrete pavement

PURPOSE AND SCOPE OF STUDY

This draft report presents the preliminary results of a geotechnical engineering study for the regional water reclamation facility expansion project. The project location is shown on Figure 1. The study was conducted in general accordance with the scope of work in our Proposal No. C26-173.R, dated April 14, 2026 for the purpose of providing geotechnical recommendations related to the proposed improvements.

This report has been prepared to summarize the data obtained during this study, and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to the proposed construction are included in the report.

PROPOSED CONSTRUCTION

We understand that the site improvements will include about 1,029 lineal feet of new 18 to 24-inch diameter RCP storm line, which will have invert elevations ranging from about 5 to 20 feet below the ground surface. Paved drive areas will encompass the facility, and will include three connecting paths.

If the proposed construction varies significantly from that described above or depicted herein, we should be notified to reevaluate our recommendations.

SITE CONDITIONS

The existing site is located at the northeast corner of Meridian Ranch Boulevard and Stapleton Drive, and is about 12 acres in area. The native topography generally consists of rolling hills and prairie land, but the site has been graded flat to accommodate the facility. Slopes at the pond basins are about 3:1, and a shallower embankment slope exists around the north perimeter of the site. An operations and mechanical building is located near the northeast corner of the site, and is just north of concrete-walled treatment areas. Three aeration basins/polishing ponds are located to the east. An ephemeral tributary branch of the Gieck Ranch Drainage Basin is located just north of the site.

SUBSURFACE CONDITIONS

The field exploration for this study was conducted on June 8, 2026. Six exploratory borings were drilled at the locations shown on Fig. 1 to explore subsurface conditions and estimate groundwater levels. The borings conducted for this study were advanced through the soils and into the underlying bedrock with 4-inch diameter continuous flight augers. The borings were logged by a representative of Kumar & Associates, Inc.

Samples of the soils and bedrock materials were taken with a 2-inch I.D. California barrel sampler. The sampler was driven into the various strata with blows from a 140-pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM Method D 1586. Penetration resistance values, when properly evaluated, indicate the relative density or consistency of the soils. Depths at which the samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Fig. 2.

Measurements of the water level were made in the borings by lowering a weighted tape measure into the open hole. Measurements were made shortly after completion of drilling, and will be made again at a later date. The additional water levels will be presented in the final draft of this report. The depths at which water was encountered are shown on the following table. Groundwater will fluctuate over time due to seasonal and other factors. Additionally, perched groundwater may develop within the granular soils overlying the less permeable bedrock, especially during wetter seasons, or after precipitation events.

Table: Measured Water Levels

Boring	Water Level at Time of Drilling (feet)	Water Level During Final Measurement (feet)
1	(dry)	(backfilled)
2	(dry)	(TBD)
3	(dry)	(backfilled)
4	(dry)	(backfilled)
5	19.0	(TBD)
6	14.0	(TBD)

Below an intermittent layer of topsoil, existing fill was encountered in all of the borings, and extended to depths of 1 to 7 feet below the existing ground surface. The underlying native soils were predominately clean to silty sand but also included zones/lenses of clayey sand and sandy lean clay. Bedrock consisted of sandstone and claystone and was found at depths ranging from 10 to 21 feet. Bedrock extended to the maximum depth explored of 25 feet where it was encountered. The following paragraphs provide more detailed descriptions of the major soil and bedrock types encountered. Figs 2 and 3 provide additional information, and detailed depictions of the depths at which each material was encountered.

The existing fill included clayey sand, silty sand, and well graded gravel with silt. These soils were fine to coarse grained, and included gravel. They were dry to moist, and mottled browns and grays. The exact vertical and lateral extents of the existing fill are unknown, and were not considered the scope of this study.

The predominant soil type encountered was well graded sand with silt. This soil was fine to coarse grained, medium dense to dense, moist to wet, and light brown to gray. Occasional lenses/zones of sandy lean clay, clayey sand, and silty sand were also encountered throughout the overburden layer. The sandy lean clay was fine to coarse grained with occasional gravel, medium stiff to very stiff, moist, and dark brown in color. The clayey sand was fine to coarse grained, medium dense, moist to wet, and light gray to brown. The silty sand was fine to coarse grained, loose, moist, and light gray.

The underlying bedrock was predominantly sandstone, but claystone was found near the bottom of Boring 5. The sandstone was poorly cemented, fine to coarse grained, hard to very hard, moist to very moist, and light gray to brown. The claystone was fine grained, very hard, moist, and blue-gray.

GEOTECHNICAL CONSIDERATIONS

Based on the data collected during our subsurface exploration, the subsurface materials do not appear to present a significant risk of heave related movement, but this will be confirmed with laboratory testing.

Existing undocumented fill is present at this site, and should be entirely removed and replaced where it is encountered below new construction such as the proposed RCP storm drain. No over-excavation will be necessary if such structures bear on native soils. Since pavements can generally tolerate settlement better than structures, and are easier to repair if movement occurs, a reduced over-excavation depth of 12 inches can be considered in these areas. Based on the samples of fill collected, it should be suitable for reuse if it is processed, moisture conditioned, and recompacted as described in the "Site Grading and Earthwork" section of this report. If minor amounts of clay are encountered, it should be thoroughly mixed with the sand to provide a consistent material, but where large zones of clay is encountered, it should be removed, and should not be reused under pipelines, or other structures that are sensitive to movement.

PIPELINE DESIGN PARAMETERS

As discussed in this report, we understand that the new stormwater line will be an 18 to 24-inch diameter RCP line installed using traditional cut and cover trenching methods. We recommend a horizontal modulus of soil reaction (E') of 2,000 psi be used for initial deflection of the pipe zone material that has been compacted in accordance with the specifications listed in the "Site Grading and Earthwork" section below.

Above a depth of 10 feet, thrust blocks used to resist thrust forces at horizontal bends in the pipe should be designed using a passive bearing pressure based on an equivalent fluid density of 250 pcf. The passive pressure should be calculated by multiplying the equivalent fluid density value by the depth in feet below the ground surface corresponding to the midpoint height of the face of the thrust block. For thrust blocks with a midpoint depth of 10 feet or more, a maximum allowable soil bearing pressure of 2,500 psf should be used.

Where clay is encountered at the base of the proposed pipeline excavation, it should be removed and replaced with suitable material to a depth of at least 3 feet. Clay fill should only be reused if it can be demonstrated to meet the requirements listed in Item 6 (Material Suitability) of the "Site Grading and Earthwork" section.

SITE GRADING AND EARTHWORK

Fill Material Specifications: The following material specifications are presented for fills on the project site.

1. *Select Fill*: The on-site soils, including minor amounts of clay will be suitable for reuse as select fill. Import soils if used, should consist of a non-expansive soil, consisting of a minus 2-inch material that has a maximum of 35 percent passing the No. 200 sieve, and a maximum plasticity index of 15. New fill should extend down from the edges of the foundations at a minimum 1:1 horizontal to vertical projection.

2. *Common Fill*: The sands and clays encountered at this site will be suitable for reuse as backfill material within areas where no structures or movement sensitive construction will occur if it is properly processed and adequately moisture conditioned and compacted. If imported material is needed for common fill areas, additional testing may be necessary to ensure it meets the suitability requirements outlined in Item 6 below.

3. *Pipe Bedding Material*: The use and requirements for bedding material should be in accordance with the pipe manufacturer's recommendations, local building authority, or utility district requirements. In the absence of such guidance, we recommend the pipe bedding consist of imported granular bedding material intended for bedding and pipe embedment zone fill. Bedding and embedment zone material may consist of a rounded granular gravel or sand with a maximum size of 3/8 inch, less than 25% passing the No. 50 sieve, and less than 5% passing the No. 200 sieve. The on-site soils encountered do not meet these criteria. The bedding layer should be of adequate thickness to fully support the pipes when seated on top of the bedding.

4. *Pipe Zone Backfill:* The pipe-zone material placed above the bedding and surrounding the pipe should consist of granular material similar to that described above for pipe bedding, and should be compacted to at least 75% relative density (as determined by ASTM D 4253 and ASTM D 4254), and in accordance with requirements of the pipe manufacturer, to provide the required support around the pipe and to help mitigate potential bedding settlement zones. Portions of the pipeline bedding not below current or proposed roadways should be compacted to at least 70% relative density. Special care should be taken to provide adequate compaction below the haunches of the pipe using a concrete vibrator, vibratory plates or other light compaction equipment as needed. In confined areas of the pipeline where compaction is difficult, placement of a cementitious flowable fill around the pipe should be considered. Seepage collars should also be considered in trenches where a significant flow path may develop.

5. *Trench Backfill:* The on-site soils or suitable soil imported to the site can be used as backfill above the pipe zone. Clays should not be placed within 2 feet below pavement subgrade. The use of claystone bedrock that does not break down into a soil-like material may be considered as trench backfill above the embedment material in undeveloped areas where a greater amount of heave can be tolerated at the surface. The backfill should be compacted according to the specifications listed in the "Compaction Requirements"

subsection below. The moisture content of the in-situ materials will need to be adjusted prior to placement.

6. *Material Suitability*: Unless otherwise defined herein, all fill material should be non- to low-swelling, free of vegetation, brush, sod, trash and debris, and other deleterious substances, and should not contain rocks or lumps having a diameter of more than 4 inches. A fill material should be considered non-expansive if the swell potential under a 200 psf surcharge pressure does not exceed ½ percent when a sample remolded to 95 percent of the standard Proctor (ASTM D 698) maximum dry density at optimum moisture content is wetted.

7. *Subgrade Preparation*: The ground surface shall be stripped of all vegetation/organics or other deleterious material prior to fill placement. The resulting ground surface should be scarified to a depth of 12 inches, moisture conditioned as necessary, and compacted in a manner specified below for the subsequent layers of fill. Loose or unstable soils shall be removed, where present, in order to provide a stable platform prior to placement of fill. Scarification and re-compaction will not be necessary at the bases of trenches.

<u>Compaction Requirements</u>: A representative of the geotechnical engineer should observe fill placement operations on a full-time basis. We recommend the following minimum compaction criteria be used on the project.

Table: Compaction Specifications

Area	Percentage of Proctor Maximum Dry Density	
	Standard (ASTM D698)	Modified (ASTM D1557)
Aggregate Base Course	-	95%
Utility Trenches, Exterior Flatwork, Fill placed for Site Grading, and Beneath Paved Areas	95%	90%
Landscape and Other Misc. Overlot Fill Areas	95%	90%
Compaction of fill materials should be achieved at a moisture content within +0 to +3% of the optimum moisture content for cohesive soils, and within -2 to +2 percent for granular soils.		

<u>Grading During Inclement Weather</u>: If grading occurs during the time of year with freezing temperatures, fill should not contain frost or be placed on frozen ground. A loose lift or blanket of

soil should be placed on prepared subgrade at the end of day to protect against frost, and the presence of frost should be checked at the beginning of each day. Any frost should be removed prior to placement of new fill. During periods of precipitation, excessive wetting of building pad and pavement subgrades should be avoided. Measures should be implemented to keep surface runoff from ponding in subgrade areas, to include usage of diversion berms, creation of temporary low areas where water can be directed and removed by pumping, or other methods as appropriate.

Permanent Cut and Fill Slopes: Permanent unretained cuts in the soils and bedrock may be constructed at slopes of up to 3 horizontal to 1 vertical. The risk of slope instability will be significantly increased if seepage is encountered in cuts. If seepage is encountered, we should be retained to evaluate if the seepage will adversely affect the slope stability cut slopes. No formal stability analyses were performed to evaluate the slopes recommended above. Published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety. If a detailed stability analysis is required, we should be notified.

To provide a uniform base for fill placement, the ground surface underlying all fills should be carefully prepared as specified in this section (Subgrade Preparation, above). Fills should be benched into cuts or natural slopes exceeding 4H:1V. Vertical bench heights should be between 2 and 4 feet.

Good surface drainage should be provided around all permanent cuts and fills to direct surface runoff away from the slope faces. Fill slopes cut slopes and other stripped areas should be protected against erosion by revegetation or other methods.

Excavation Considerations: It is our opinion that the soils and bedrock can be excavated with conventional heavy-duty equipment. Specialized excavation methods such as pneumatic chiseling may be necessary for confined areas, or if well cemented bedrock is encountered.

All excavations should be made in accordance with OSHA, State, and local requirements. The contractor should follow appropriate safety precautions. The following guidelines are provided for planning purposes. Actual soil conditions should be verified at the time of excavation. If subsurface conditions that are different from those indicated in this report are encountered, the OSHA soil type may vary, and the required cut slopes may need to be adjusted. The contractor's "competent person" should make decisions regarding excavation slopes.

Based on the subsurface conditions encountered in our borings, the soils will generally classify as Type C materials. The bedrock will likely classify as a Type B material. Per OSHA criteria, temporary unretained excavations should have slopes no steeper than those listed in the following table for each soil type.

Table: Maximum Temporary Cut Slopes

OSHA Soil Type	Maximum Temporary Cut Slope (H:V)
A	¾:1
B	1:1
C	1½:1

A properly braced excavation or the use of an approved trench box should be used where the indicated unretained slopes cannot be accommodated. Flatter slopes will be required where groundwater seepage or fissuring is encountered, or where static or vibratory loads are present. OSHA regulations require that excavations greater than 20 feet in depth be designed by a professional engineer.

Groundwater will likely be a consideration during excavation in some areas, and a dewatering system may be necessary. A dewatering system consisting of trenches flowing into sumps where the water can be discharged using pumps will likely be adequate, but a more robust system such as well points may be necessary if high volumes of water are encountered.

It is assumed site dewatering would occur in advance of the excavation and be maintained the entire duration that the excavation is open. Surface drainage should be diverted away from all temporary cut slopes in order to reduce the potential for slope erosion and instability.

Subgrade Stabilization: Unstable subgrade material is not anticipated, but may be encountered at the base of the proposed fill in some areas. Unstable soils may be stabilized by scarifying/ripping the subgrade and allowing them to dry, or by over-excavation and replacement of the subgrade with suitable, imported, angular, well-graded materials if they are encountered. Other alternatives include the use of Type 2 biaxial geogrid reinforcement in combination with a layer of Class 6 aggregate base course. It has been our experience that the use of a crushed concrete product meeting a Class 6 gradation can perform well when trying to achieve stabilization. Specific stabilization requirements should be evaluated at the time of construction.

Proof Rolling: Wherever possible, the foundation subgrade should be proof rolled with a heavily loaded pneumatic-tired vehicle with a gross vehicle weight of at least 50,000 pounds, a single axle weight of 18,000 pounds, and a tire pressure of 100 psi. Pavement design procedures assume a stable subgrade. Areas that deform under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade.

WATER SOLUBLE SULFATES

The concentration of water-soluble sulfates will be determined via laboratory testing and will be presented in the final draft of this report.

PAVEMENT DESIGN

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils, pavement section, and traffic loadings. The number and magnitude of wheel loads are major factors for pavement design.

Subgrade Materials: For the purpose of this draft report, a resilient modulus of 3,562 psi, based on an estimated R-value of 10 was used for design of the flexible sections, and a corrected modulus of subgrade reaction of 23 pci was used for the design of rigid sections.

Design Traffic: For the purpose of our study, we have considered an 18-kip, 20 year ESAL value of 73,000 based on the assumption that traffic would largely consist of automobiles and light trucks, with occasional heavy trucks and service vehicles. If it is determined that actual traffic volume is significantly different from the estimated values presented, we should be contacted to reevaluate the pavement thickness design presented in this report.

Pavement Sections: The following pavement section (HMA over ABC, and PCC over ABC) were determined using the AASHTO 1993 design method for flexible and rigid pavements.

Table: Flexible Pavement Section Thickness

Area	HMA[1] over ABC[2] (inches)	PCCP[3] over ABC[2] (inches)
Site Pavements	5 over 6	6 over 4

1: HMA = Hot mix Asphalt
2: ABC = Aggregate base course
3: PCC = Portland cement concrete pavement

Pavement Materials: The asphalt pavement should consist of a bituminous material which meets the local jurisdictional requirements, and CDOT Specifications for Road and Bridge Construction. Aggregate base course should meet the requirements of a CDOT Class 6. A Superpave S or SX mix with a design gyration N value of 75, and a binder performance grade of 58-28 should be used.

A minimum lift thickness of 2-inches for SX and 3-inches for S mixes are recommended. Lift thickness should not exceed 3 inches unless pneumatic or vibratory rollers are used.

SURFACE DRAINAGE

The collection and diversion of surface drainage away from paved and constructed areas is extremely important to their satisfactory performance. Drainage design should provide for the removal of water from paved areas and prevent the wetting of the subgrade soils both during and after construction, and should follow recommendations provided by local, state and national entities. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying of the pavement subgrades should be avoided both during and after construction. It may be necessary to grade temporary drainage paths, and to construct berms to facilitate this during construction.

2. Good surface drainage should be provided within all ground surfaces and pavements, and around all cuts and fills to direct surface runoff away from these areas. Slopes and other stripped areas should be protected against erosion by paving, re-vegetation or other means.

DESIGN AND SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in this report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project and, if necessary, perform additional studies to accommodate any changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document that the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study.

LIMITATIONS

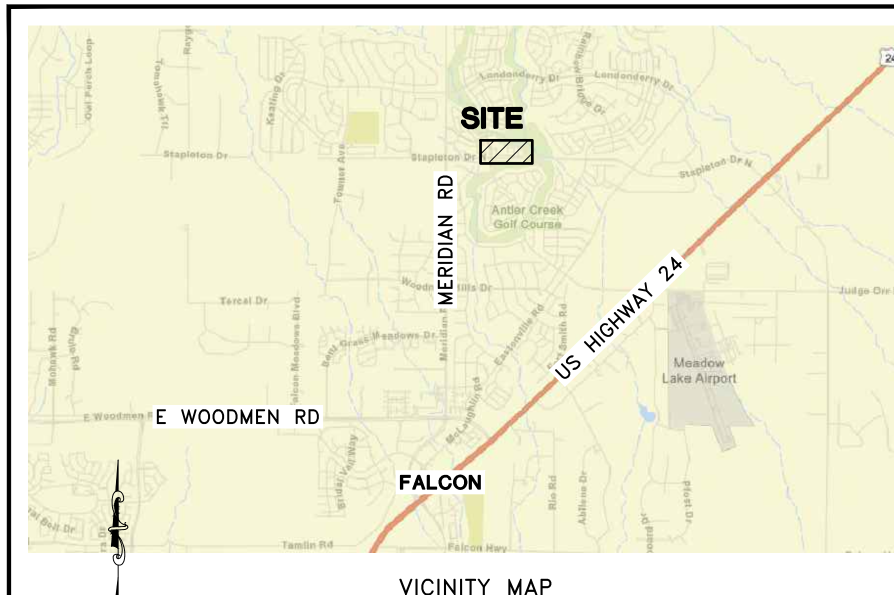
This study has been conducted for exclusive use by the client for geotechnical related design and construction criteria for the project. The preliminary conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Fig. 1 or as described in the report, and the proposed type of construction. This report may not reflect subsurface variations that occur between the exploratory borings, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions, or the presence, prevention or possibility of mold or other biological contaminants (MOBC) developing in the future. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

AFK/sw

60 0 60 120

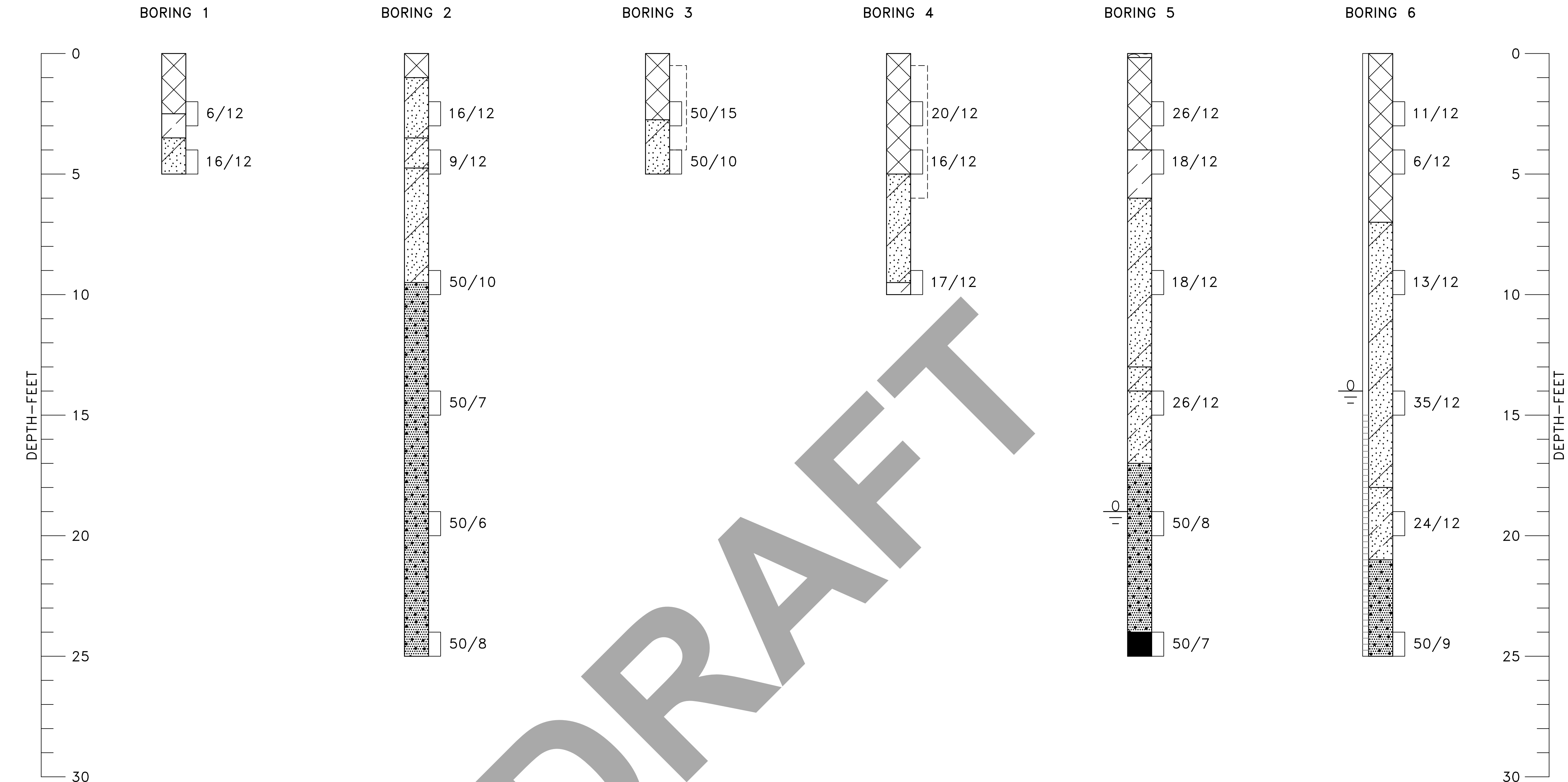
APPROXIMATE SCALE–FEET



VICINITY MAP
NOT TO SCALE

26–2–169	Kumar & Associates		LOCATION OF EXPLORATORY BORINGS	Fig. 1

June 19, 2026 – 09:03am
V:\Projects\Den Current 2026– (ENG)\2026\26–2–169 WHMD RWRF\Drafting\262169–01.dwg



26–2–169	Kumar & Associates		LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

TOPSOIL.

FILL: CLAYEY SAND (SC), SILTY SAND (SM), WELL GRADED GRAVEL WITH SILT (GW–GM), FINE TO COARSE GRAINED WITH GRAVEL, DRY TO MOIST, MOTTLED BROWNS AND GRAYS.

SANDY LEAN CLAY (CL), FINE TO COARSE GRAINED, WITH OCCASIONAL GRAVEL, MEDIUM STIFF TO VERY STIFF, MOIST, DARK BROWN.

CLAYEY SAND (SC), FINE TO COARSE GRAINED, MEDIUM DENSE, MOIST TO WET, LIGHT GREY TO BROWN.

SILTY SAND (SM), FINE TO COARSE GRAINED, LOOSE, MOIST, LIGHT GRAY.

WELL GRADED SAND WITH SILT (SW–SM), WITH OCCASIONAL LENSES OF CLAY, FINE TO COARSE GRAINED, MEDIUM DENSE TO DENSE, MOIST TO WET, LIGHT BROWN TO GRAY.

SANDSTONE BEDROCK, FINE TO COARSE GRAINED, HARD TO VERY HARD MOIST TO VERY MOIST, LIGHT GRAY TO BROWN.

CLAYSTONE BEDROCK, FINE GRAINED, VERY HARD, MOIST, BLUE–GRAY.

DRIVE SAMPLE, 2–INCH I.D. CALIFORNIA LINER SAMPLE.

DISTURBED BULK SAMPLE.

INDICATES PERFORATED PVC PIPE INSTALLED IN BORING TO DEPTH SHOWN.

6/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 6 BLOWS OF A 140–POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

0 DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON JUNE 8, 2026 WITH A 4–INCH–DIAMETER CONTINUOUS–FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY HANDHELD GPS DEVICE.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.
4. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
5. GROUNDWATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
6. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D2216);
   DD = DRY DENSITY (pcf) (ASTM D2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D6913);
   –200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
   LL = LIQUID LIMIT (ASTM D4318);
   PI = PLASTICITY INDEX (ASTM D4318);
   NV = NO LIQUID LIMIT VALUE (ASTM D4318);
   NP = NON–PLASTIC (ASTM D4318);
   WSS = WATER SOLUBLE SULFATES (%) (CP–L 2103).

APPENDIX D – HYDROLOGY

NOAA Atlas 14, Volume 8, Version 2
Location name: Peyton, Colorado, USA*
Latitude: 38.9709°, Longitude: -104.5991°
Elevation: 7053 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.238 (0.191-0.299)	0.290 (0.232-0.365)	0.380 (0.303-0.480)	0.459 (0.364-0.582)	0.575 (0.443-0.760)	0.670 (0.503-0.895)	0.769 (0.557-1.05)	0.874 (0.607-1.23)	1.02 (0.682-1.47)	1.14 (0.738-1.66)
10-min	0.349 (0.279-0.438)	0.425 (0.340-0.535)	0.557 (0.444-0.702)	0.673 (0.533-0.852)	0.842 (0.648-1.11)	0.980 (0.736-1.31)	1.13 (0.816-1.54)	1.28 (0.889-1.80)	1.50 (0.998-2.16)	1.66 (1.08-2.43)
15-min	0.425 (0.341-0.535)	0.518 (0.414-0.652)	0.679 (0.541-0.856)	0.820 (0.650-1.04)	1.03 (0.791-1.36)	1.20 (0.897-1.60)	1.37 (0.995-1.88)	1.56 (1.08-2.19)	1.82 (1.22-2.63)	2.03 (1.32-2.96)
30-min	0.609 (0.487-0.765)	0.741 (0.593-0.933)	0.970 (0.773-1.22)	1.17 (0.928-1.48)	1.46 (1.13-1.93)	1.70 (1.28-2.27)	1.95 (1.41-2.67)	2.22 (1.54-3.11)	2.59 (1.73-3.73)	2.88 (1.87-4.19)
60-min	0.780 (0.624-0.981)	0.935 (0.748-1.18)	1.21 (0.967-1.53)	1.46 (1.16-1.86)	1.84 (1.43-2.45)	2.16 (1.63-2.90)	2.50 (1.82-3.44)	2.87 (2.00-4.05)	3.40 (2.27-4.91)	3.82 (2.48-5.56)
2-hr	0.951 (0.767-1.19)	1.13 (0.910-1.41)	1.46 (1.17-1.82)	1.76 (1.40-2.21)	2.23 (1.74-2.95)	2.62 (1.99-3.50)	3.06 (2.24-4.18)	3.53 (2.48-4.95)	4.20 (2.84-6.05)	4.76 (3.11-6.88)
3-hr	1.04 (0.846-1.30)	1.22 (0.991-1.52)	1.57 (1.26-1.95)	1.89 (1.52-2.37)	2.41 (1.90-3.20)	2.86 (2.19-3.82)	3.36 (2.48-4.59)	3.91 (2.76-5.47)	4.70 (3.20-6.76)	5.36 (3.52-7.73)
6-hr	1.21 (0.990-1.49)	1.40 (1.15-1.73)	1.78 (1.45-2.20)	2.16 (1.74-2.67)	2.76 (2.20-3.64)	3.29 (2.54-4.37)	3.88 (2.90-5.28)	4.55 (3.25-6.34)	5.52 (3.79-7.89)	6.33 (4.20-9.07)
12-hr	1.40 (1.15-1.71)	1.63 (1.34-1.99)	2.06 (1.69-2.53)	2.49 (2.03-3.06)	3.17 (2.55-4.15)	3.77 (2.94-4.97)	4.44 (3.34-5.98)	5.18 (3.73-7.16)	6.26 (4.33-8.88)	7.16 (4.79-10.2)
24-hr	1.62 (1.34-1.96)	1.90 (1.57-2.30)	2.41 (1.99-2.93)	2.90 (2.38-3.53)	3.65 (2.95-4.71)	4.31 (3.37-5.60)	5.02 (3.80-6.69)	5.80 (4.21-7.94)	6.93 (4.83-9.74)	7.86 (5.30-11.1)
2-day	1.88 (1.57-2.25)	2.22 (1.85-2.66)	2.82 (2.35-3.39)	3.37 (2.79-4.07)	4.20 (3.40-5.34)	4.90 (3.86-6.29)	5.65 (4.30-7.44)	6.46 (4.72-8.75)	7.61 (5.35-10.6)	8.55 (5.82-12.0)
3-day	2.06 (1.73-2.46)	2.43 (2.04-2.90)	3.08 (2.58-3.69)	3.67 (3.05-4.41)	4.55 (3.70-5.74)	5.29 (4.19-6.75)	6.08 (4.65-7.96)	6.93 (5.08-9.33)	8.13 (5.73-11.3)	9.10 (6.23-12.7)
4-day	2.22 (1.87-2.64)	2.60 (2.19-3.09)	3.28 (2.75-3.91)	3.89 (3.25-4.66)	4.81 (3.92-6.04)	5.57 (4.43-7.09)	6.39 (4.90-8.34)	7.27 (5.35-9.76)	8.52 (6.03-11.8)	9.52 (6.54-13.3)
7-day	2.62 (2.23-3.10)	3.03 (2.57-3.58)	3.75 (3.17-4.44)	4.40 (3.70-5.23)	5.37 (4.41-6.70)	6.18 (4.95-7.81)	7.05 (5.45-9.15)	7.99 (5.92-10.7)	9.31 (6.64-12.8)	10.4 (7.19-14.4)
10-day	2.98 (2.54-3.50)	3.42 (2.92-4.02)	4.20 (3.56-4.95)	4.89 (4.13-5.79)	5.92 (4.88-7.34)	6.78 (5.44-8.52)	7.69 (5.96-9.92)	8.66 (6.45-11.5)	10.0 (7.19-13.7)	11.1 (7.75-15.4)
20-day	3.99 (3.43-4.64)	4.59 (3.95-5.35)	5.61 (4.81-6.56)	6.49 (5.52-7.62)	7.73 (6.39-9.44)	8.73 (7.04-10.8)	9.75 (7.61-12.4)	10.8 (8.11-14.2)	12.3 (8.86-16.6)	13.4 (9.43-18.4)
30-day	4.80 (4.15-5.56)	5.54 (4.79-6.42)	6.76 (5.82-7.86)	7.78 (6.66-9.09)	9.19 (7.61-11.1)	10.3 (8.32-12.6)	11.4 (8.91-14.4)	12.5 (9.40-16.3)	14.0 (10.1-18.8)	15.1 (10.7-20.7)
45-day	5.80 (5.04-6.68)	6.70 (5.81-7.72)	8.13 (7.03-9.40)	9.30 (8.00-10.8)	10.9 (9.03-13.0)	12.1 (9.80-14.7)	13.2 (10.4-16.6)	14.4 (10.9-18.6)	15.9 (11.6-21.2)	17.0 (12.1-23.2)
60-day	6.64 (5.79-7.62)	7.64 (6.65-8.77)	9.23 (8.01-10.6)	10.5 (9.06-12.2)	12.2 (10.1-14.5)	13.4 (10.9-16.3)	14.7 (11.5-18.3)	15.8 (12.0-20.3)	17.3 (12.6-23.0)	18.4 (13.1-25.0)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

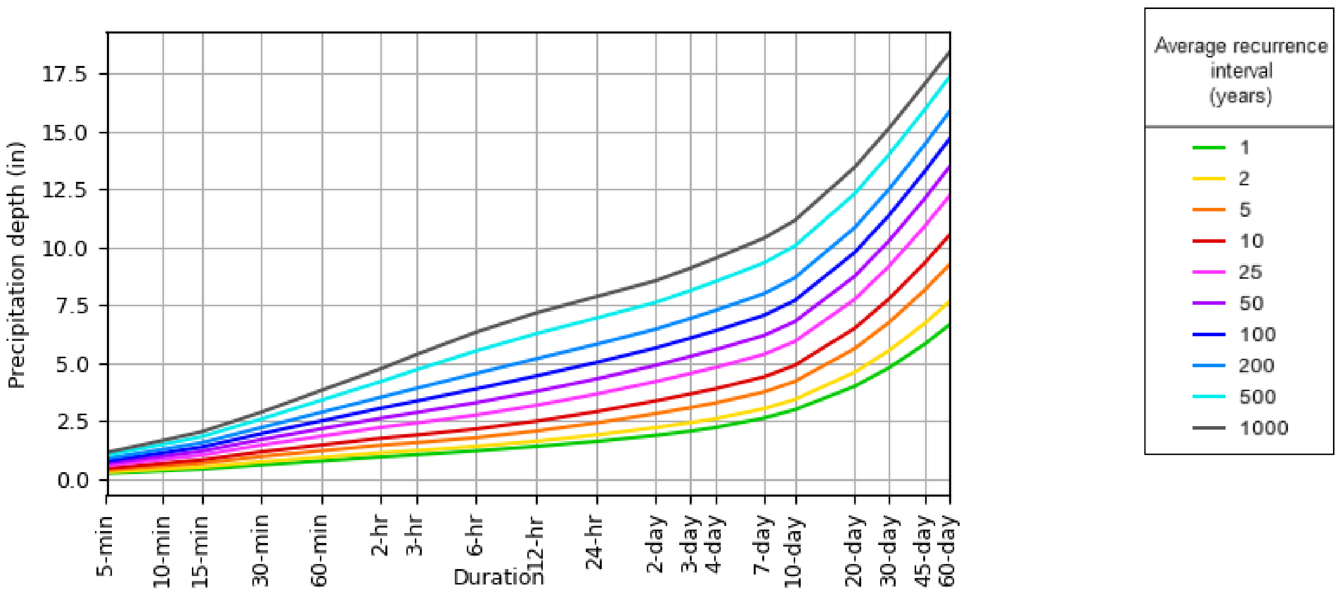
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

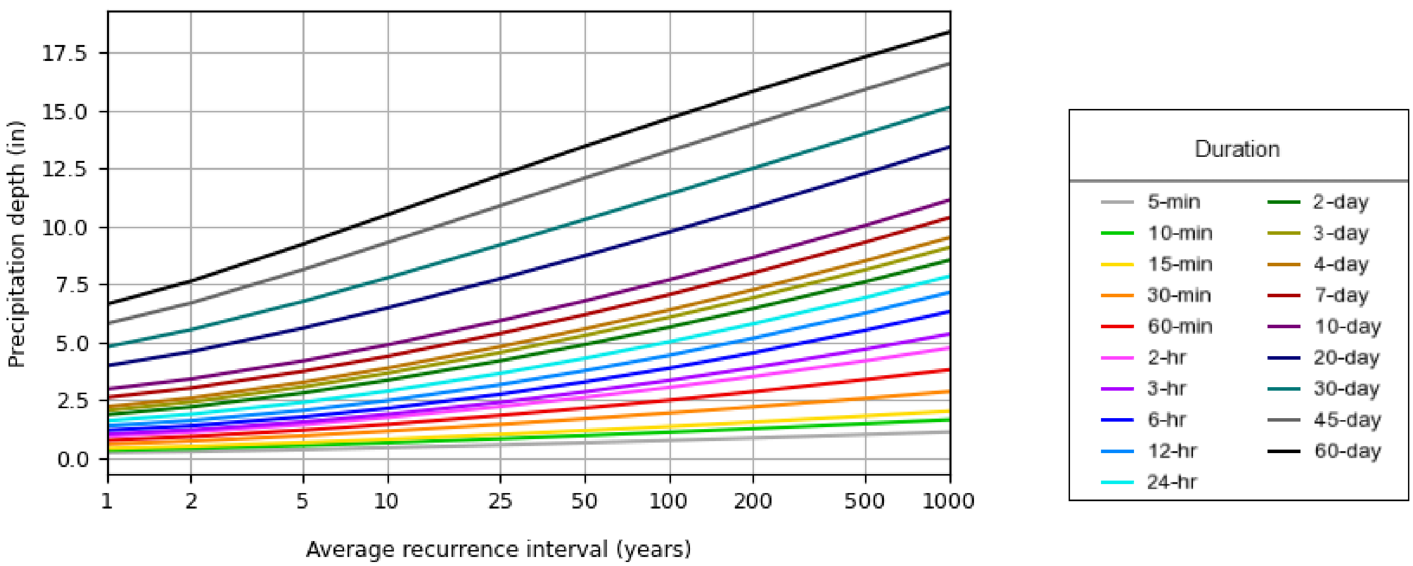
Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 38.9709°, Longitude: -104.5991°





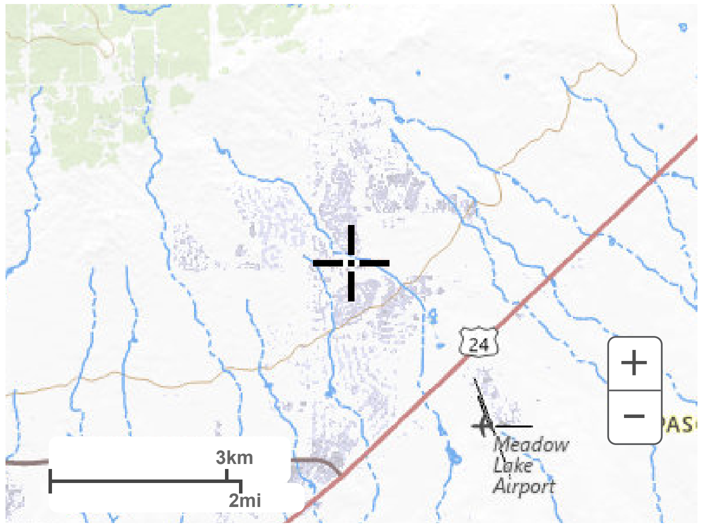
NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Mon Jun 15 17:59:24 2026

Back to Top

Maps & aerials

Small scale terrain



Large scale terrain

Large scale map

Large scale aerial

Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Kimley»Horn

STANDARD FORM SF-1 (EXISITNG CONDITIONS)
RUNOFF COEFFICIENTS - IMPERVIOUS CALCULATION

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 296082000
CALCULATED BY: PLH
CHECKED BY: MEO

HYDROLOGIC SOIL GROUP: A

Impervious values and runoff coefficients are taken from the Colorado Springs Drainage Criteria Manual (Vol. 1) - Table 6-6

LAND USE (HSG A/B):	PAVEMENT	ROOF	GRAVEL	LANDSCAPE
2-YEAR COEFF.	0.89	0.71	0.57	0.02
5-YEAR COEFF.	0.90	0.73	0.59	0.08
10-YEAR COEFF.	0.92	0.75	0.63	0.15
100-YEAR COEFF.	0.96	0.81	0.70	0.35
IMPERVIOUS %	100%	90%	80%	0%

DESIGN BASIN	DESIGN POINT	PAVEMENT AREA (SF)	ROOF AREA (SF)	GRAVEL AREA (SF)	LANDSCAPE AREA (SF)	TOTAL AREA (SF)	TOTAL AREA (AC)	C(2)	C(5)	C(10)	C(100)	Imp %	HSG
Basins													
EX-1	EX-1				1,355	**1,355**	**0.03**	0.02	0.08	0.15	0.35	0%	A
EX-2	EX-2				9,852	**9,852**	**0.23**	0.02	0.08	0.15	0.35	0%	A
EX-3	EX-3				1,183	**1,183**	**0.03**	0.02	0.08	0.15	0.35	0%	A
EX-4	EX-4				32,282	**32,282**	**0.74**	0.02	0.08	0.15	0.35	0%	A
EX-5	EX-5			2,307	34,290	**36,597**	**0.84**	0.02	0.11	0.18	0.37	5%	A
EX-6	EX-6			17,689	36,076	**53,764**	**1.23**	0.02	0.25	0.31	0.47	26%	A
EX-7	EX-7	625		10,294	15,564	**26,482**	**0.61**	0.04	0.30	0.35	0.50	33%	A
EX-8	EX-8		15,427			**15,427**	**0.35**	0.71	0.73	0.75	0.81	90%	A
EX-9	EX-9	23,425				**23,425**	**0.54**	0.89	0.90	0.92	0.96	100%	A
EX-10	EX-10	7,167	380	17,155	35,131	**59,833**	**1.37**	0.13	0.33	0.38	0.53	35%	A
EX-11	EX-11	7,159				**7,159**	**0.16**	0.89	0.90	0.92	0.96	100%	A
EX-12	EX-12	755	558	441	17,933	**19,687**	**0.45**	0.07	0.14	0.21	0.39	8%	A
EX-13	EX-13				3,002	**3,002**	**0.07**	0.02	0.08	0.15	0.35	0%	A
EX-14	EX-14	4,718	145	1,491	27,395	**33,750**	**0.77**	0.14	0.22	0.28	0.45	18%	A
EX-15	EX-15	2,430		53,591	43,218	**99,239**	**2.28**	0.04	0.38	0.43	0.55	46%	A
EX-16	EX-16	648		61,851		**62,499**	**1.43**	0.03	0.59	0.63	0.70	80%	A
EX-17	EX-17			9,799	66,181	**75,979**	**1.74**	0.02	0.15	0.21	0.40	10%	A
EX-18	EX-18	615	144	3,092	15,363	**19,213**	**0.44**	0.05	0.19	0.26	0.43	17%	A
EX-19	EX-19	651		1,878	24,610	**27,139**	**0.62**	0.04	0.13	0.20	0.39	8%	A
OF-1	OF-1				11,667	**11,667**	**0.27**	0.02	0.08	0.15	0.35	0%	A
OF-2	OF-2				2,352	**2,352**	**0.05**	0.02	0.08	0.15	0.35	0%	A
OF-3	OF-3				23,451	**23,451**	**0.54**	0.02	0.08	0.15	0.35	0%	A
OF-4	OF-4				4,841	**4,841**	**0.11**	0.02	0.08	0.15	0.35	0%	A
OF-5	OF-5				2,595	**2,595**	**0.06**	0.02	0.08	0.15	0.35	0%	A
OF-6	OF-6				5,176	**5,176**	**0.12**	0.02	0.08	0.15	0.35	0%	A
OVERALL SUBTOTAL		**48,192**	**16,654**	**179,588**	**413,516**	**657,949**	**15.10**	**0.25**	**0.30**	**0.35**	**0.50**	**31.44%**	A
		7%	**3%**	**27%**	**63%**	**100%**	**100%**						
OVERALL ONSITE SUBTOTAL		**48,192**	**16,654**	**179,588**	**363,434**	**607,868**	**13.95**	**0.27**	**0.31**	**0.37**	**0.51**	**34.03%**	A
		8%	**3%**	**30%**	**60%**	**100%**	**100%**						

Kimley»Horn

STANDARD FORM SF-2 (EXISTING CONDITIONS)
Time of Concentration

PROJECT NAME: WHMD RWRF Stormwater Improvements
PROJECT NUMBER: 296008000
CALCULATED BY: PLH
CHECKED BY: MEO

SUB-BASIN DATA			INITIAL TIME (T_i)			TRAVEL TIME (T_t)					Tc CHECK (URBANIZED BASINS)					FINAL Tc
DESIGN BASIN (1)	AREA SF (2)	C5 (3)	LENGTH Ft (4)	SLOPE % (5)	T_i Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	C_v (9)	VEL fps (11)	T_t Min. (12)	COMP. tc (13)	TOTAL LENGTH (14)	TOTAL SLOPE (15)	TOTAL IMP. (16)	Tc Min. (17)	Min.
All Basins																
EX-1	1,355	0.08	25	6.7%	4.9	23	10.2%	10.0	3.2	0.1	5.1	47	8.4%	0%	26.3	5.1
EX-2	9,852	0.08	19	7.1%	4.3	103	6.8%	10.0	2.6	0.7	4.9	122	6.9%	0%	26.9	5.0
EX-3	1,183	0.08	16	9.3%	3.6	51	7.9%	10.0	2.8	0.3	3.9	67	8.2%	0%	26.4	5.0
EX-4	32,282	0.08	62	13.5%	6.2	594	0.6%	10.0	0.8	12.4	18.6	656	1.9%	0%	34.9	18.6
EX-5	36,597	0.11	77	3.3%	10.7	247	2.6%	10.0	1.6	2.6	13.2	324	2.8%	5%	28.5	13.2
EX-6	53,764	0.25	57	5.9%	6.5	325	2.4%	10.0	1.6	3.5	10.0	382	3.0%	26%	24.4	10.0
EX-7	26,482	0.30	80	7.0%	6.9	249	1.2%	10.0	1.1	3.8	10.6	329	2.6%	33%	22.8	10.6
EX-8	15,427	0.73	87	0.0%	0.0	79	1.0%	20.0	2.0	0.7	0.7	166	0.5%	90%	12.6	5.0
EX-9	23,425	0.90	66	0.0%	0.0	151	1.0%	20.0	2.0	1.3	1.3	217	0.7%	100%	10.9	5.0
EX-10	59,833	0.33	78	9.6%	5.9	534	1.2%	10.0	1.1	8.2	14.1	613	2.3%	35%	24.8	14.1
EX-11	7,159	0.90	54	0.0%	0.0	74	1.0%	20.0	2.0	0.6	0.6	128	0.6%	100%	10.2	5.0
EX-12	19,687	0.14	98	8.2%	8.6	407	0.7%	10.0	0.9	7.9	16.5	504	2.2%	8%	30.2	16.5
EX-13	3,002	0.08	14	3.5%	4.6	46	7.6%	10.0	2.8	0.3	4.9	60	6.6%	0%	26.4	5.0
EX-14	33,750	0.22	21	1.7%	6.2	678	0.6%	10.0	0.7	15.1	21.3	699	0.6%	18%	36.1	21.3
EX-15	99,239	0.38	80	12.9%	5.1	318	0.2%	10.0	0.4	12.2	17.2	398	2.7%	46%	20.8	17.2
EX-16	62,499	0.59	108	7.5%	4.9	213	0.7%	10.0	0.8	4.3	9.2	321	3.0%	80%	13.9	9.2
EX-17	75,979	0.15	39	0.8%	11.8	334	0.3%	10.0	0.6	10.0	21.8	373	0.4%	10%	34.2	21.8
EX-18	19,213	0.19	105	6.9%	8.9	228	1.0%	10.0	1.0	3.8	12.8	333	2.9%	17%	26.0	12.8
EX-19	27,139	0.13	65	6.2%	7.8	635	2.2%	10.0	1.5	7.1	14.9	699	2.6%	8%	31.8	14.9
OF-1	11,667	0.08	23	8.1%	4.4	163	3.8%	10.0	2.0	1.4	5.8	185	4.3%	0%	27.6	5.8
OF-2	2,352	0.08	18	9.1%	3.8	47	10.7%	10.0	3.3	0.2	4.1	65	10.3%	0%	26.4	5.0
OF-3	23,451	0.08	52	0.6%	16.4	278	1.8%	10.0	1.3	3.4	19.8	330	1.6%	0%	30.8	19.8
OF-4	4,841	0.08	27	8.7%	4.7	158	0.6%	10.0	0.8	3.3	8.0	185	1.8%	0%	28.6	8.0
OF-5	2,595	0.08	76	2.9%	11.4	102	3.5%	10.0	1.9	0.9	12.3	178	3.2%	0%	27.8	12.3
OF-6	5,176	0.08	97	0.9%	19.4	573	1.8%	10.0	1.4	7.0	26.4	670	1.7%	0%	35.5	26.4

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t}$$

$$t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

Kimley»Horn

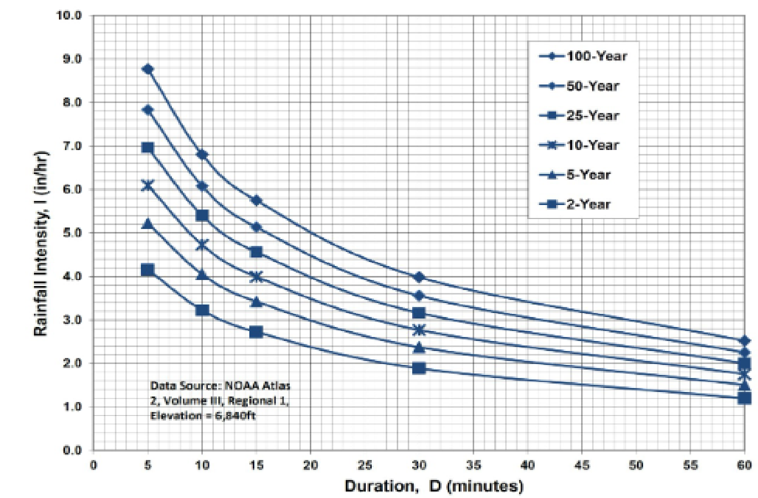
STANDARD FORM SF-3 (EXISTING CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 5 YEAR EVENT

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 296008000
CALCULATED BY: PLH
CHECKED BY: MEO

P_1 (1-Hour Rainfall) = **1.21**

		DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
STORM LINE	DESIGN POINT	DESIGN BASIN	AREA (AC)	RUNOFF COEFF	tc (min)	C*A(ac)	I (in/hr)	Q (cfs)	tc(max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
	EX-1	EX-1	0.03	0.08	5.1	0.00	5.15	0.01					
	EX-2	EX-2	0.23	0.08	5.0	0.02	5.17	0.09					
	EX-3	EX-3	0.03	0.08	5.0	0.00	5.17	0.01					
	EX-4	EX-4	0.74	0.08	18.6	0.06	3.20	0.19					
	EX-5	EX-5	0.84	0.11	13.2	0.09	3.71	0.35					
	EX-6	EX-6	1.23	0.25	10.0	0.31	4.13	1.26					
	EX-7	EX-7	0.61	0.30	10.6	0.18	4.04	0.73					
	EX-8	EX-8	0.35	0.73	5.0	0.26	5.17	1.34					
	EX-9	EX-9	0.54	0.90	5.0	0.48	5.17	2.50					
	EX-10	EX-10	1.37	0.33	14.1	0.45	3.61	1.63					
	EX-11	EX-11	0.16	0.90	5.0	0.15	5.17	0.76					
	EX-12	EX-12	0.45	0.14	16.5	0.06	3.38	0.22					
	EX-13	EX-13	0.07	0.08	5.0	0.01	5.17	0.03					
	EX-14	EX-14	0.77	0.22	21.3	0.17	2.99	0.51					
	EX-15	EX-15	2.28	0.38	17.2	0.86	3.31	2.83					
	EX-16	EX-16	1.43	0.59	9.2	0.85	4.25	3.62					
	EX-17	EX-17	1.74	0.15	21.8	0.25	2.96	0.75					
	EX-18	EX-18	0.44	0.19	12.8	0.09	3.76	0.32					
	EX-19	EX-19	0.62	0.13	14.9	0.08	3.53	0.30					
	OF-1	OF-1	0.27	0.08	5.8	0.02	4.94	0.11					
	OF-2	OF-2	0.05	0.08	5.0	0.00	5.17	0.02					
	OF-3	OF-3	0.54	0.08	19.8	0.04	3.10	0.13					
	OF-4	OF-4	0.11	0.08	8.0	0.01	4.46	0.04					
	OF-5	OF-5	0.06	0.08	12.3	0.00	3.82	0.02					
	OF-6	OF-6	0.12	0.08	26.4	0.01	2.67	0.03					

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

STANDARD FORM SF-3 (EXISTING CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 100 YEAR EVENT

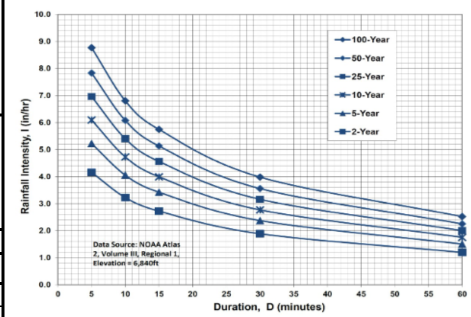
Kimley»Horn

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 296008000
CALCULATED BY: PLH
CHECKED BY: MEO

P_1 (1-Hour Rainfall) = 2.5

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF	tc (min)	C*A(ac)	I (in/hr)	Q (cfs)	tc(max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
	EX-1	EX-1	0.03	0.35	5.1	0.01	8.65	0.09					
	EX-2	EX-2	0.23	0.35	5.0	0.08	8.68	0.69					
	EX-3	EX-3	0.03	0.35	5.0	0.01	8.68	0.08					
	EX-4	EX-4	0.74	0.35	18.6	0.26	5.37	1.39					
	EX-5	EX-5	0.84	0.37	13.2	0.31	6.23	1.95					
	EX-6	EX-6	1.23	0.47	10.0	0.57	6.94	3.98					
	EX-7	EX-7	0.61	0.50	10.6	0.30	6.78	2.06					
	EX-8	EX-8	0.35	0.81	5.0	0.29	8.68	2.49					
	EX-9	EX-9	0.54	0.96	5.0	0.52	8.68	4.48					
	EX-10	EX-10	1.37	0.53	14.1	0.72	6.06	4.38					
	EX-11	EX-11	0.16	0.96	5.0	0.16	8.68	1.37					
	EX-12	EX-12	0.45	0.39	16.5	0.18	5.67	1.01					
	EX-13	EX-13	0.07	0.35	5.0	0.02	8.68	0.21					
	EX-14	EX-14	0.77	0.45	21.3	0.35	5.03	1.76					
	EX-15	EX-15	2.28	0.55	17.2	1.26	5.56	7.02					
	EX-16	EX-16	1.43	0.70	9.2	1.01	7.14	7.20					
	EX-17	EX-17	1.74	0.40	21.8	0.69	4.96	3.42					
	EX-18	EX-18	0.44	0.43	12.8	0.19	6.32	1.20					
	EX-19	EX-19	0.62	0.39	14.9	0.24	5.93	1.44					
	OF-1	OF-1	0.27	0.35	5.8	0.09	8.30	0.78					
	OF-2	OF-2	0.05	0.35	5.0	0.02	8.68	0.16					
	OF-3	OF-3	0.54	0.35	19.8	0.19	5.21	0.98					
	OF-4	OF-4	0.11	0.35	8.0	0.04	7.50	0.29					
	OF-5	OF-5	0.06	0.35	12.3	0.02	6.41	0.13					
	OF-6	OF-6	0.12	0.35	26.4	0.04	4.48	0.19					

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

Note: Values calculated by equations may not precisely duplicate values read from figure.

EXISTING CONDITIONS

WHMD RWRF
Stormwater Improvements

DATE: 2/25/2026

PROJECT NUMBER: 296008000
CALCULATED BY: PLH
CHECKED BY: MEO

EXISTING RATIONAL CALCULATIONS SUMMARY

DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
EX-1	EX-1	0.03	0.01	0.09
EX-2	EX-2	0.23	0.09	0.69
EX-3	EX-3	0.03	0.01	0.08
EX-4	EX-4	0.74	0.19	1.39
EX-5	EX-5	0.84	0.35	1.95
EX-6	EX-6	1.23	1.26	3.98
EX-7	EX-7	0.61	0.73	2.06
EX-8	EX-8	0.35	1.34	2.49
EX-9	EX-9	0.54	2.50	4.48
EX-10	EX-10	1.37	1.63	4.38
EX-11	EX-11	0.16	0.76	1.37
EX-12	EX-12	0.45	0.22	1.01
EX-13	EX-13	0.07	0.03	0.21
EX-14	EX-14	0.77	0.51	1.76
EX-15	EX-15	2.28	2.83	7.02
EX-16	EX-16	1.43	3.62	7.20
EX-17	EX-17	1.74	0.75	3.42
EX-18	EX-18	0.44	0.32	1.20
EX-19	EX-19	0.62	0.30	1.44
OF-1	OF-1	0.27	0.11	0.78
OF-2	OF-2	0.05	0.02	0.16
OF-3	OF-3	0.54	0.13	0.98
OF-4	OF-4	0.11	0.04	0.29
OF-5	OF-5	0.06	0.02	0.13
OF-6	OF-6	0.12	0.03	0.19

Kimley»Horn

STANDARD FORM SF-1 (PROPOSED CONDITIONS)
RUNOFF COEFFICIENTS - IMPERVIOUS CALCULATION

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 196013004
CALCULATED BY: MEO
CHECKED BY: KRK

HYDROLOGIC SOIL GROUP: A

Impervious values and runoff coefficients are taken from the Colorado Springs Drainage Criteria Manual (Vol. 1) - Table 6-6

LAND USE (HSG A/B):	ROOF	PAVEMENT	GRAVEL	LAWN
2-YEAR COEFF.	0.71	0.89	0.57	0.02
5-YEAR COEFF.	0.73	0.90	0.59	0.08
10-YEAR COEFF.	0.75	0.92	0.63	0.15
100-YEAR COEFF.	0.81	0.96	0.70	0.35
IMPERVIOUS %	90%	100%	80%	0%

DESIGN BASIN	DESIGN POINT	ROOF AREA (SF)	PAVEMENT AREA (SF)	GRAVEL AREA (SF)	LAWN AREA (SF)	TOTAL AREA (SF)	TOTAL AREA (AC)	C(2)	C(5)	C(10)	C(100)	Imp %	HSG
Basins													
P-1	P-1		24,851	1,246	11,821	**37,918**	**0.87**	0.47	0.63	0.67	0.76	68%	A
P-2	P-2				6,026	**6,026**	**0.14**	0.02	0.08	0.15	0.35	0%	A
P-3	P-3				15,755	**15,755**	**0.36**	0.02	0.08	0.15	0.35	0%	A
P-4	P-4	4,932	10,777	10,421	20,925	**47,055**	**1.08**	0.27	0.45	0.50	0.62	50%	A
P-5	P-5			1,477	32,415	**33,892**	**0.78**	0.02	0.10	0.17	0.37	3%	A
P-6	P-6	707			6,018	**6,725**	**0.15**	0.11	0.15	0.21	0.40	9%	A
P-7	P-7	1,480		9,437	12,126	**23,043**	**0.53**	0.08	0.33	0.39	0.52	39%	A
P-8	P-8			385	1,269	**1,654**	**0.04**	0.02	0.20	0.26	0.43	19%	A
OS-1	OS-1	340			2,993	**3,333**	**0.08**	0.11	0.15	0.21	0.40	9%	A
OS-2	OS-2	15,423				**15,423**	**0.35**	0.89	0.73	0.75	0.81	90%	A
OS-3	OS-3		199	6,025	27,527	**33,750**	**0.77**	0.02	0.18	0.24	0.42	15%	A
OS-4	OS-4		2,430	53,591	43,218	**99,239**	**2.28**	0.04	0.38	0.43	0.55	46%	A
OS-5	OS-5		648	61,851		**62,499**	**1.43**	0.03	0.59	0.63	0.70	80%	A
OS-6	OS-6			9,799	66,181	**75,979**	**1.74**	0.02	0.15	0.21	0.40	10%	A
OS-7	OS-7	144	615	3,092	15,363	**19,213**	**0.44**	0.05	0.19	0.26	0.43	17%	A
OS-8	OS-8		651	1,878	24,610	**27,139**	**0.62**	0.04	0.13	0.20	0.39	8%	A
OS-9	OS-9	559	705	468	17,955	**19,687**	**0.45**	0.07	0.14	0.21	0.39	8%	A
OS-10	OS-10				32,282	**32,282**	**0.74**	0.02	0.08	0.15	0.35	0%	A
OS-11	OS-11				3,002	**3,002**	**0.07**	0.02	0.08	0.15	0.35	0%	A
OS-12	OS-12				1,355	**1,355**	**0.03**	0.02	0.08	0.15	0.35	0%	A
OS-13	OS-13				11,034	**11,034**	**0.25**	0.02	0.08	0.15	0.35	0%	A
OS-14	OS-14		7,159			**7,159**	**0.16**	0.71	0.90	0.92	0.96	100%	A
OS-15	OS-15		24,707			**24,707**	**0.57**	0.71	0.90	0.92	0.96	100%	A
OF-1	OF-1				2,595	**2,595**	**0.06**	0.02	0.08	0.15	0.35	0%	A
OF-2	OF-2				5,176	**5,176**	**0.12**	0.02	0.08	0.15	0.35	0%	A
OF-3	OF-3				11,667	**11,667**	**0.27**	0.02	0.08	0.15	0.35	0%	A
OF-4	OF-4				5,259	**5,259**	**0.12**	0.02	0.08	0.15	0.35	0%	A
OF-5	OF-5				20,543	**20,543**	**0.47**	0.02	0.08	0.15	0.35	0%	A
OF-6	OF-6				4,841	**4,841**	**0.11**	0.02	0.08	0.15	0.35	0%	A
OVERALL SUBTOTAL		**23,586**	**72,741**	**159,669**	**401,957**	**657,953**	**15.10**	**0.27**	**0.32**	**0.37**	**0.52**	**33.70%**	A
		4%	**11%**	**24%**	**61%**	**100%**	**100%**						
OVERALL ONSITE SUBTOTAL		**23,586**	**72,741**	**159,669**	**351,876**	**607,872**	**13.95**	**0.30**	**0.34**	**0.39**	**0.53**	**36.47%**	A
		4%	**12%**	**26%**	**58%**	**100%**	**100%**						

Kimley»Horn

STANDARD FORM SF-2 (PROPOSED CONDITIONS)
Time of Concentration

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 296008000
CALCULATED BY: **MEO**
CHECKED BY: **KRK**

SUB-BASIN DATA			INITIAL TIME (T_i)			TRAVEL TIME (T_t)					Tc CHECK (URBANIZED BASINS)					FINAL Tc
DESIGN BASIN (1)	AREA SF (2)	C5 (3)	LENGTH Ft (4)	SLOPE % (5)	T_i Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	C_v (9)	VEL fps (11)	T_t Min. (12)	COMP. tc (13)	TOTAL LENGTH (14)	TOTAL SLOPE (15)	TOTAL IMP. (16)	Tc Min. (17)	Min.
All Basins																
P-1	37,918	0.63	40	3.0%	3.7	220	3.0%	20.0	3.5	1.1	4.8	260	3.0%	68%	15.8	5.0
P-2	6,026	0.08	30	0.7%	11.5	60	2.5%	7.0	1.1	0.9	12.4	90	1.9%	0%	27.2	12.4
P-3	15,755	0.08	30	2.2%	7.9	130	5.0%	7.0	1.6	1.4	9.3	160	4.5%	0%	27.4	9.3
P-4	47,055	0.45	33	1.5%	6.0	80	2.3%	20.0	3.0	0.4	6.5	113	2.0%	50%	18.3	6.5
P-5	33,892	0.10	60	2.6%	10.3	250	2.1%	7.0	1.0	4.2	14.4	310	2.2%	3%	29.1	14.4
P-6	6,725	0.15	20	0.6%	9.3	100	1.0%	7.0	0.7	2.4	11.6	120	0.9%	9%	26.4	11.6
P-7	23,043	0.33	25	10.0%	3.3	135	1.0%	7.0	0.7	3.2	6.5	160	2.4%	39%	20.6	6.5
P-8	1,654	0.20	5	7.0%	1.9	10	1.0%	7.0	0.7	0.2	2.2	15	3.0%	19%	23.0	5.0
OS-1	3,333	0.15	8	9.0%	2.4	100	1.0%	7.0	0.7	2.4	4.8	108	1.6%	9%	25.8	5.0
OS-2	15,423	0.73	50	1.0%	4.8	100	1.0%	20.0	2.0	0.8	5.6	150	1.0%	90%	11.9	5.6
OS-3	33,750	0.18	70	11.0%	6.4	470	0.5%	7.0	0.5	15.8	22.2	540	1.9%	15%	29.4	22.2
OS-4	99,239	0.38	90	12.0%	5.5	285	0.2%	7.0	0.3	15.2	20.7	375	3.0%	46%	20.6	20.6
OS-5	62,499	0.59	80	9.0%	4.0	260	2.5%	7.0	1.1	3.9	7.9	340	4.0%	80%	13.8	7.9
OS-6	75,979	0.15	30	2.0%	7.6	331	0.2%	7.0	0.3	17.6	25.2	361	0.3%	10%	34.0	25.2
OS-7	19,213	0.19	56	14.0%	5.2	45	6.1%	7.0	1.7	0.4	5.6	101	10.5%	17%	23.6	5.6
OS-8	27,139	0.13	78	2.9%	11.0	580	2.5%	7.0	1.1	8.8	19.8	658	2.5%	8%	31.5	19.8
OS-9	19,687	0.14	65	6.0%	7.8	340	1.1%	7.0	0.7	7.7	15.5	405	1.9%	8%	29.5	15.5
OS-10	32,282	0.08	100	6.7%	9.9	280	0.6%	7.0	0.6	8.4	18.3	380	2.2%	0%	30.7	18.3
OS-11	3,002	0.08	25	7.0%	4.9	33	6.2%	7.0	1.7	0.3	5.2	58	6.6%	0%	26.4	5.2
OS-12	1,355	0.08	10	8.0%	3.0	25	8.8%	7.0	2.1	0.2	3.2	35	8.6%	0%	26.2	5.0
OS-13	11,034	0.08	60	13.0%	6.2	75	0.5%	7.0	0.5	2.5	8.7	135	6.1%	0%	27.0	8.7
OS-14	7,159	0.90	20	1.0%	1.6	50	1.0%	20.0	2.0	0.4	2.1	70	1.0%	100%	9.5	5.0
OS-15	24,707	0.90	50	1.0%	2.6	200	1.0%	20.0	2.0	1.7	4.3	250	1.0%	100%	10.8	5.0
OF-1	2,595	0.08	61	3.0%	10.1	62	5.2%	7.0	1.6	0.6	10.8	123	4.1%	0%	27.1	10.8
OF-2	5,176	0.08	105	1.4%	17.1	440	2.1%	7.0	1.0	7.3	24.4	545	1.9%	0%	33.3	24.4
OF-3	11,667	0.08	55	3.5%	9.2	113	1.1%	7.0	0.7	2.6	11.7	168	1.9%	0%	28.3	11.7
OF-4	5,259	0.08	30	9.0%	4.9	22	11.0%	7.0	2.3	0.2	5.1	52	9.8%	0%	26.3	5.1
OF-5	20,543	0.08	55	2.9%	9.7	222	2.7%	7.0	1.2	3.2	12.9	277	2.8%	0%	29.1	12.9
OF-6	4,841	0.08	50	5.6%	7.4	30	0.5%	7.0	0.5	1.0	8.5	80	3.7%	0%	26.8	8.5

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}} \qquad t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t} \qquad t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

Kimley»Horn

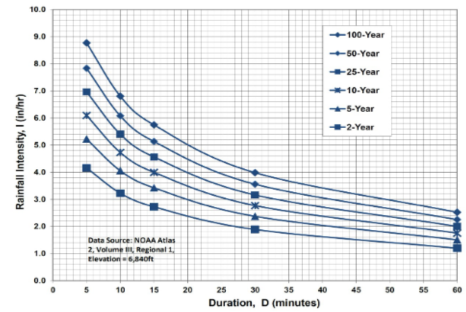
STANDARD FORM SF-3 (PROPOSED CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 5 YEAR EVENT

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 296008000
CALCULATED BY: MEO
CHECKED BY: KRK

P_1 (1-Hour Rainfall) = **1.21**

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF	tc (min)	C*A(ac)	I (in/hr)	Q (cfs)	tc(max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
	P-1	P-1	0.87	0.63	5.0	0.55	5.17	2.85					
	P-2	P-2	0.14	0.08	12.4	0.01	3.80	0.04					
	P-3	P-3	0.36	0.08	9.3	0.03	4.24	0.12					
	P-4	P-4	1.08	0.45	6.5	0.48	4.78	2.32					
	P-5	P-5	0.78	0.10	14.4	0.08	3.58	0.28					
	P-6	P-6	0.15	0.15	11.6	0.02	3.90	0.09					
	P-7	P-7	0.53	0.33	6.5	0.17	4.78	0.84					
	P-8	P-8	0.04	0.20	5.0	0.01	5.17	0.04					
	OS-1	OS-1	0.08	0.15	5.0	0.01	5.17	0.06					
	OS-2	OS-2	0.35	0.73	5.6	0.26	4.99	1.29					
	OS-3	OS-3	0.77	0.18	22.2	0.14	2.93	0.40					
	OS-4	OS-4	2.28	0.38	20.6	0.86	3.05	2.61					
	OS-5	OS-5	1.43	0.59	7.9	0.85	4.48	3.81					
	OS-6	OS-6	1.74	0.15	25.2	0.25	2.74	0.70					
	OS-7	OS-7	0.44	0.19	5.6	0.09	5.00	0.43					
	OS-8	OS-8	0.62	0.13	19.8	0.08	3.11	0.26					
	OS-9	OS-9	0.45	0.14	15.5	0.06	3.47	0.22					
	OS-10	OS-10	0.74	0.08	18.3	0.06	3.22	0.19					
	OS-11	OS-11	0.07	0.08	5.2	0.01	5.11	0.03					
	OS-12	OS-12	0.03	0.08	5.0	0.00	5.17	0.01					
	OS-13	OS-13	0.25	0.08	8.7	0.02	4.34	0.09					
	OS-14	OS-14	0.16	0.90	5.0	0.15	5.17	0.76					
	OS-15	OS-15	0.57	0.90	5.0	0.51	5.17	2.64					
	OF-1	OF-1	0.06	0.08	10.8	0.00	4.02	0.02					
	OF-2	OF-2	0.12	0.08	24.4	0.01	2.79	0.03					
	OF-3	OF-3	0.27	0.08	11.7	0.02	3.89	0.08					
	OF-4	OF-4	0.12	0.08	5.1	0.01	5.14	0.05					
	OF-5	OF-5	0.47	0.08	12.9	0.04	3.75	0.14					
	OF-6	OF-6	0.11	0.08	8.5	0.01	4.38	0.04					

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

Kimley»Horn

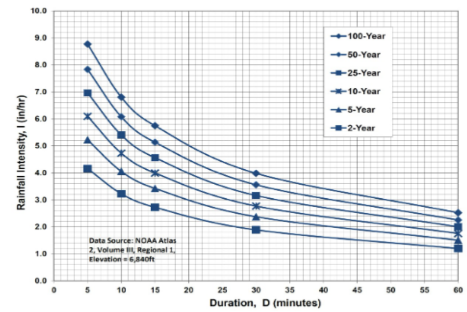
STANDARD FORM SF-3 (PROPOSED CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 100 YEAR EVENT

PROJECT NAME: **WHMD RWRF Stormwater Improvements**
PROJECT NUMBER: 296008000
CALCULATED BY: MEO
CHECKED BY: KRK

P_1 (1-Hour Rainfall) = 2.5

		DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
STORM LINE	DESIGN POINT	DESIGN BASIN	AREA (AC)	RUNOFF COEFF	tc (min)	C*A(ac)	I (in/hr)	Q (cfs)	tc(max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
	P-1	P-1	0.87	0.76	5.0	0.66	8.68	5.75					
	P-2	P-2	0.14	0.35	12.4	0.05	6.38	0.31					
	P-3	P-3	0.36	0.35	9.3	0.13	7.13	0.90					
	P-4	P-4	1.08	0.62	6.5	0.66	8.02	5.33					
	P-5	P-5	0.78	0.37	14.4	0.28	6.01	1.71					
	P-6	P-6	0.15	0.40	11.6	0.06	6.55	0.40					
	P-7	P-7	0.53	0.52	6.5	0.28	8.02	2.22					
	P-8	P-8	0.04	0.43	5.0	0.02	8.68	0.14					
	OS-1	OS-1	0.08	0.40	5.0	0.03	8.68	0.26					
	OS-2	OS-2	0.35	0.81	5.6	0.29	8.38	2.40					
	OS-3	OS-3	0.77	0.42	22.2	0.32	4.92	1.59					
	OS-4	OS-4	2.28	0.55	20.6	1.26	5.11	6.45					
	OS-5	OS-5	1.43	0.70	7.9	1.01	7.52	7.58					
	OS-6	OS-6	1.74	0.40	25.2	0.69	4.60	3.17					
	OS-7	OS-7	0.44	0.43	5.6	0.19	8.40	1.59					
	OS-8	OS-8	0.62	0.39	19.8	0.24	5.22	1.26					
	OS-9	OS-9	0.45	0.39	15.5	0.18	5.83	1.04					
	OS-10	OS-10	0.74	0.35	18.3	0.26	5.41	1.40					
	OS-11	OS-11	0.07	0.35	5.2	0.02	8.58	0.21					
	OS-12	OS-12	0.03	0.35	5.0	0.01	8.68	0.09					
	OS-13	OS-13	0.25	0.35	8.7	0.09	7.29	0.65					
	OS-14	OS-14	0.16	0.96	5.0	0.16	8.68	1.37					
	OS-15	OS-15	0.57	0.96	5.0	0.54	8.68	4.73					
	OF-1	OF-1	0.06	0.35	10.8	0.02	6.74	0.14					
	OF-2	OF-2	0.12	0.35	24.4	0.04	4.68	0.19					
	OF-3	OF-3	0.27	0.35	11.7	0.09	6.53	0.61					
	OF-4	OF-4	0.12	0.35	5.1	0.04	8.64	0.37					
	OF-5	OF-5	0.47	0.35	12.9	0.17	6.30	1.04					
	OF-6	OF-6	0.11	0.35	8.5	0.04	7.35	0.29					

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

Note: Values calculated by equations may not precisely duplicate values read from figure.

Kimley»Horn

PROPOSED CONDITIONS

WHMD RWRF Stormwater Improvements

DATE: 2/25/2026

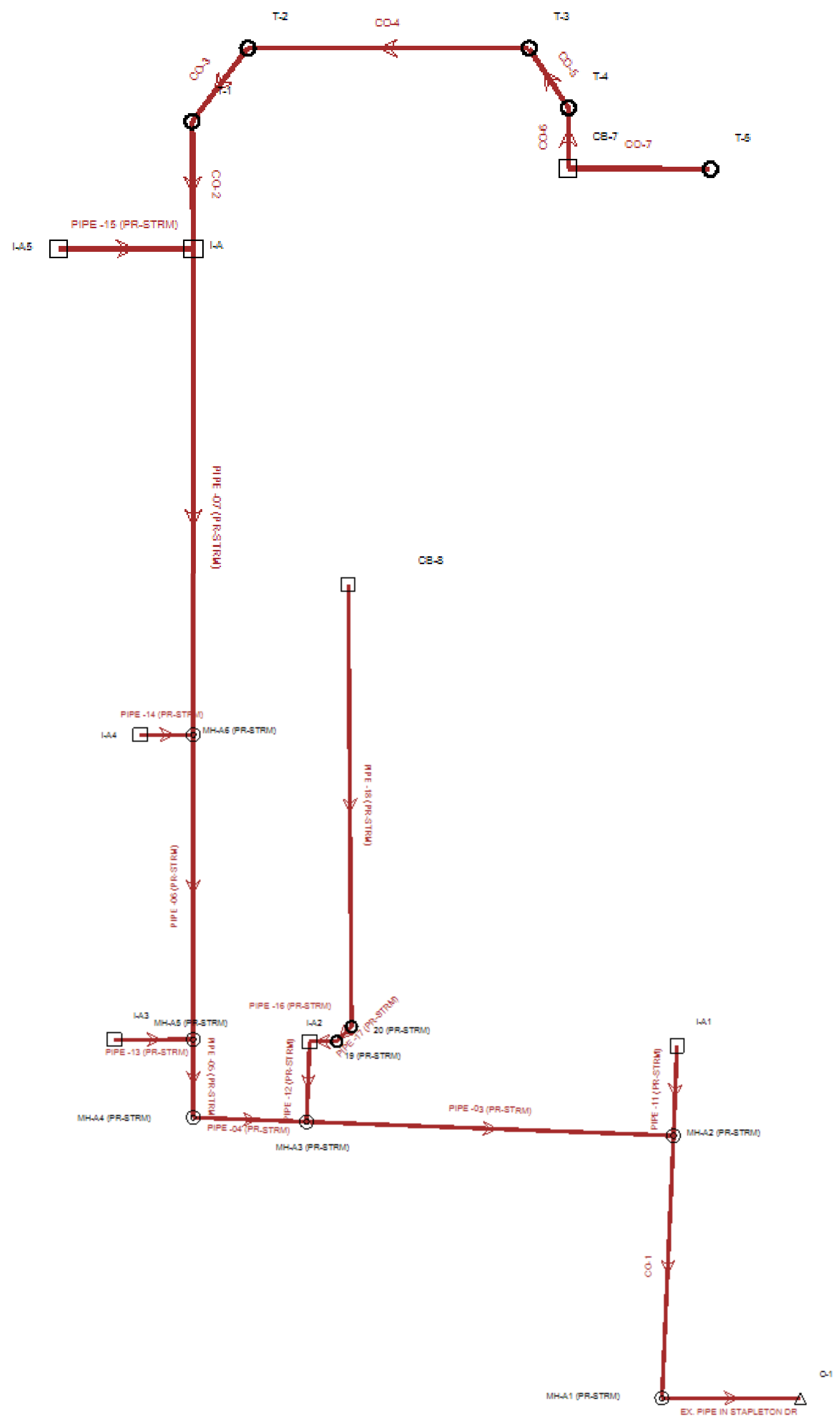
PROJECT NUMBER: 296008000
CALCULATED BY: MEO
CHECKED BY: KRK

PROPOSED RATIONAL CALCULATIONS SUMMARY

DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
P-1	P-1	0.87	2.85	5.75
P-2	P-2	0.14	0.04	0.31
P-3	P-3	0.36	0.12	0.90
P-4	P-4	1.08	2.32	5.33
P-5	P-5	0.78	0.28	1.71
P-6	P-6	0.15	0.09	0.40
P-7	P-7	0.53	0.84	2.22
P-8	P-8	0.04	0.04	0.14
OS-1	OS-1	0.08	0.06	0.26
OS-2	OS-2	0.35	1.29	2.40
OS-3	OS-3	0.77	0.40	1.59
OS-4	OS-4	2.28	2.61	6.45
OS-5	OS-5	1.43	3.81	7.58
OS-6	OS-6	1.74	0.70	3.17
OS-7	OS-7	0.44	0.43	1.59
OS-8	OS-8	0.62	0.26	1.26
OS-9	OS-9	0.45	0.22	1.04
OS-10	OS-10	0.74	0.19	1.40
OS-11	OS-11	0.07	0.03	0.21
OS-12	OS-12	0.03	0.01	0.09
OS-13	OS-13	0.25	0.09	0.65
OS-14	OS-14	0.16	0.76	1.37
OS-15	OS-15	0.57	2.64	4.73
OF-1	OF-1	0.06	0.02	0.14
OF-2	OF-2	0.12	0.03	0.19
OF-3	OF-3	0.27	0.08	0.61
OF-4	OF-4	0.12	0.05	0.37
OF-5	OF-5	0.47	0.14	1.04
OF-6	OF-6	0.11	0.04	0.29

APPENDIX E – HYDRAULICS

WHMD RWRF Stormwater Improvements StormCAD Map



5-YEAR (80% FULL TAILWATER)

Conduit Table - Time: 0.00 hours

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
PIPE -03 (PR-STRM)	MH-A2 (PR-STRM)	7,044.61	MH-A3 (PR-STRM)	7,045.09	160.1	-0.003	0.013	7.05	4.05	22.48	7,046.05	7,045.49
PIPE -11 (PR-STRM)	MH-A2 (PR-STRM)	7,045.61	I-A1	7,045.80	39.1	-0.005	0.013	0.84	2.79	7.44	7,046.14	7,045.95
PIPE -04 (PR-STRM)	MH-A3 (PR-STRM)	7,045.19	MH-A4 (PR-STRM)	7,045.35	49.4	-0.003	0.013	7.01	4.18	23.51	7,046.36	7,046.31
PIPE -12 (PR-STRM)	MH-A3 (PR-STRM)	7,046.19	I-A2	7,046.37	35.0	-0.005	0.013	0.04	1.13	7.55	7,046.45	7,046.31
PIPE -05 (PR-STRM)	MH-A4 (PR-STRM)	7,045.64	MH-A5 (PR-STRM)	7,045.74	34.0	-0.003	0.013	7.01	4.05	22.48	7,046.69	7,046.58
PIPE -06 (PR-STRM)	MH-A5 (PR-STRM)	7,046.40	MH-A6 (PR-STRM)	7,046.80	132.7	-0.003	0.013	6.73	3.82	22.35	7,047.57	7,047.13
PIPE -13 (PR-STRM)	MH-A5 (PR-STRM)	7,046.24	I-A3	7,046.41	34.4	-0.005	0.013	0.28	1.94	15.99	7,046.95	7,046.95
PIPE -15 (PR-STRM)	I-A	7,047.34	I-A5	7,047.57	45.5	-0.005	0.013	0.12	1.46	7.19	7,048.19	7,048.19
PIPE -07 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A	7,047.34	181.1	-0.003	0.013	4.41	3.34	22.61	7,047.96	7,047.80
PIPE -14 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A4	7,046.92	23.2	-0.005	0.013	2.32	3.55	7.16	7,047.81	7,047.80
PIPE -16 (PR-STRM)	I-A2	7,046.86	19 (PR-STRM)	7,046.92	11.8	-0.005	0.010	0.04	1.42	3.27	7,047.00	7,046.94
PIPE -18 (PR-STRM)	20 (PR-STRM)	7,046.97	CB-8	7,047.93	192.5	-0.005	0.010	0.04	1.42	3.28	7,048.01	7,047.06
PIPE -17 (PR-STRM)	19 (PR-STRM)	7,046.92	20 (PR-STRM)	7,046.97	9.2	-0.005	0.010	0.04	1.42	3.28	7,047.05	7,047.01
CO-1	MH-A2 (PR-STRM)	7,044.11	MH-A1 (PR-STRM)	7,043.77	111.5	0.003	0.013	7.89	4.12	36.51	7,045.20	7,045.15
CO-2	I-A	7,048.01	T-1	7,048.16	29.0	-0.005	0.010	1.35	4.01	3.32	7,048.65	7,048.46
CO-3	T-1	7,048.16	T-2	7,048.28	23.6	-0.005	0.010	1.35	4.02	3.33	7,048.77	7,048.73
CO-4	T-2	7,048.28	T-3	7,048.60	62.1	-0.005	0.010	1.35	4.01	3.32	7,049.09	7,048.85
CO-5	T-3	7,048.60	T-4	7,048.67	12.6	-0.005	0.010	1.35	4.02	3.33	7,049.16	7,049.17
CO-6	T-4	7,048.67	CB-7	7,048.75	15.6	-0.005	0.010	1.35	4.01	3.32	7,049.24	7,049.23
CO-7	CB-7	7,049.05	T-5	7,050.00	95.4	-0.010	0.010	0.00	0.00	4.63	7,050.00	7,049.49
EX. PIPE IN STAPLETON DR	MH-A1 (PR-STRM)	7,042.77	O-1	7,041.94	29.8	0.028	0.013	7.89	8.78	240.09	7,045.13	7,045.14

5-YEAR (80% FULL TAILWATER)

Catch Basin Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Additional Subsurface) (cfs)	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
I-A3	7,050.17	7,050.17	7,046.41	0.28	7,046.95	0.050
I-A1	7,049.54	7,049.54	7,045.80	0.84	7,046.15	0.050
I-A2	7,052.04	7,052.04	7,046.37	0.00	7,046.47	1.020
I-A4	7,050.16	7,050.16	7,046.92	2.32	7,047.81	0.000
I-A	7,050.44	7,050.44	7,047.34	2.94	7,048.19	1.320
I-A5	7,051.44	7,051.44	7,047.57	0.12	7,048.19	0.050
CB-7	7,050.80	7,050.80	7,048.75	1.35	7,049.49	1.320
CB-8	7,051.48	7,051.48	7,047.93	0.04	7,048.01	0.000

5-YEAR (80% FULL TAILWATER)

Manhole Table - Time: 0.00 hours

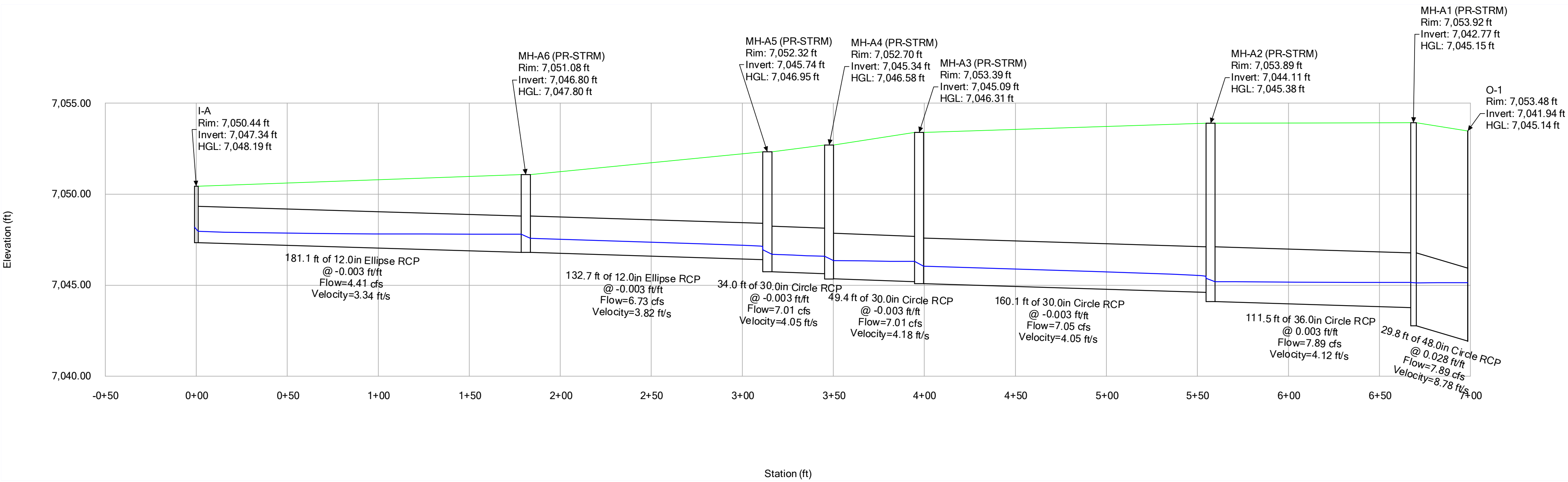
Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert Out) (ft)	Flow (Total Out) (cfs)	Hydraulic Grade Line (Out) (ft)	Headloss Method	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
MH-A2 (PR-STRM)	7,053.89	7,053.89	7,044.11	7.89	7,045.20	Standard	7,045.38	1.020
MH-A3 (PR-STRM)	7,053.39	7,053.39	7,045.09	7.05	7,046.05	Standard	7,046.31	1.020
MH-A4 (PR-STRM)	7,052.70	7,052.70	7,045.35	7.01	7,046.36	Standard	7,046.58	1.020
MH-A5 (PR-STRM)	7,052.32	7,052.32	7,045.74	7.01	7,046.69	Standard	7,046.95	1.020
MH-A6 (PR-STRM)	7,051.08	7,051.08	7,046.80	6.73	7,047.57	Standard	7,047.80	1.020
MH-A1 (PR-STRM)	7,053.92	7,053.92	7,042.77	7.89	7,045.13	Standard	7,045.15	1.020

5-YEAR (80% FULL TAILWATER)

Outfall Table - Time: 0.00 hours

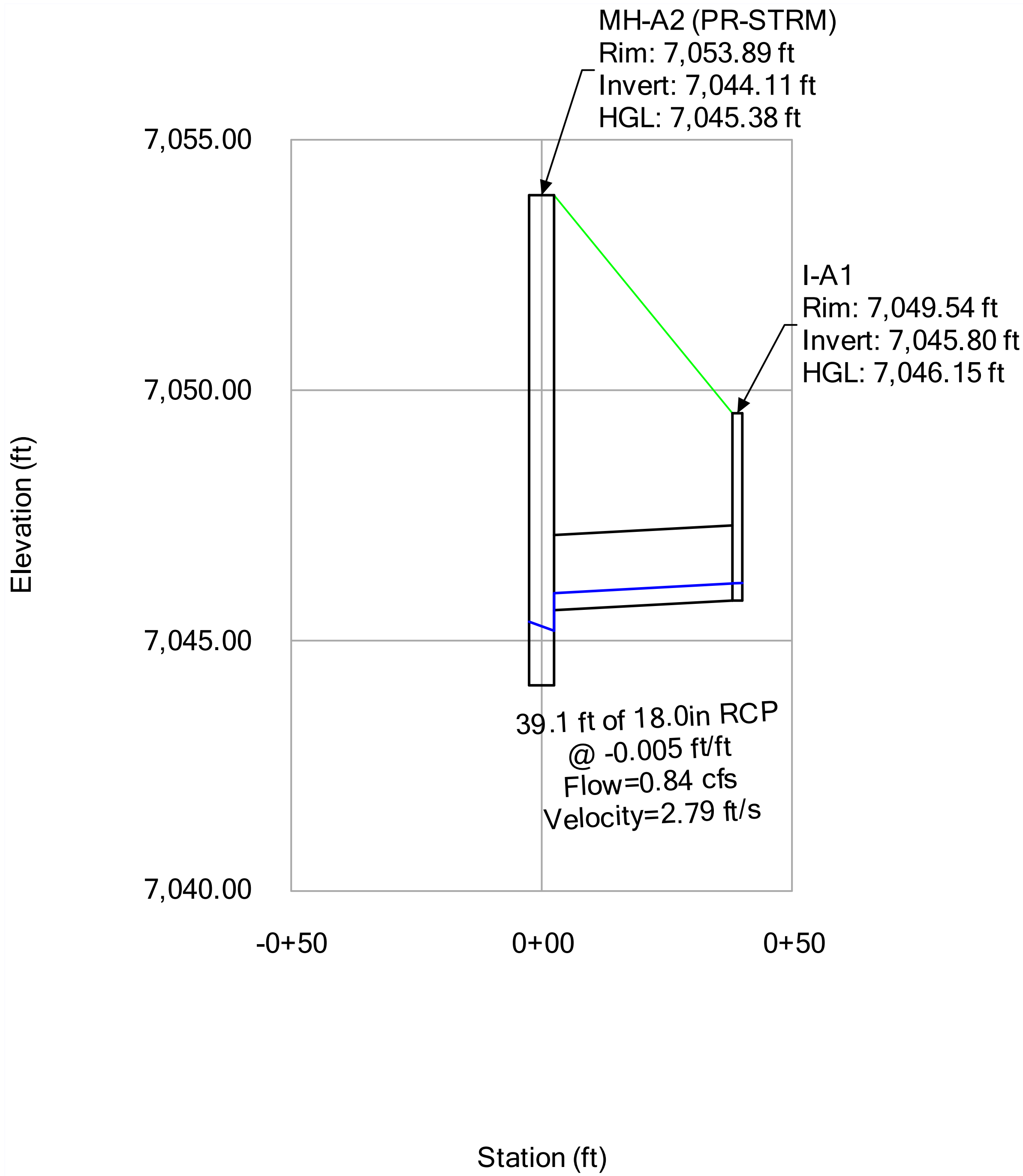
Label	Elevation (Ground) (ft)	Set Rim to Ground Elevation?	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
O-1	7,053.48	True	7,041.94	User Defined Tailwater	7,045.14	7.89

5-YEAR - STRM-A

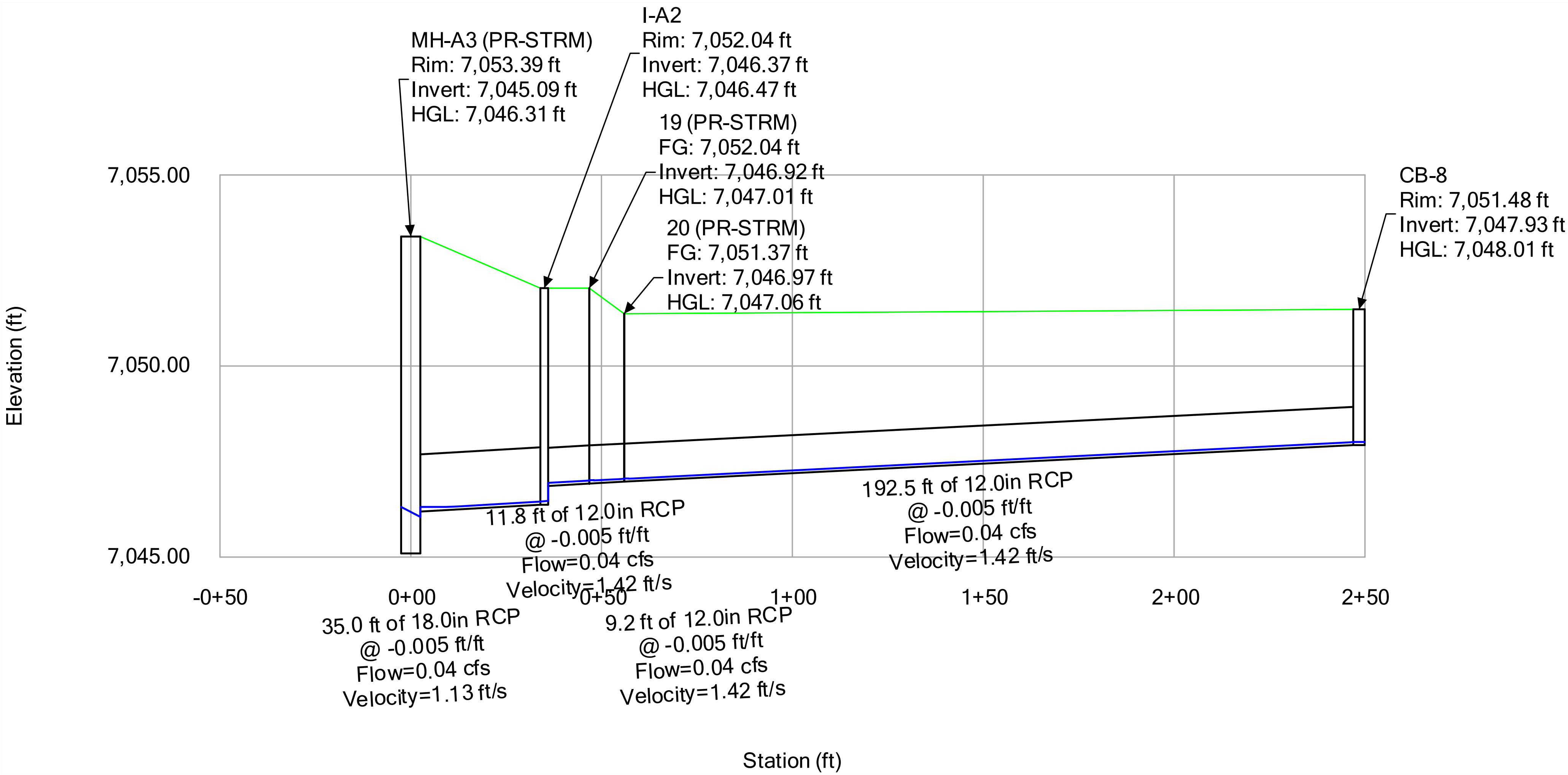


I-A
Rim: 7,050.44 ft
Invert: 7,047.34 ft
HGL: 7,048.19 ft
MH-A6 (PR-STRM)
Rim: 7,051.08 ft
Invert: 7,046.80 ft
HGL: 7,047.80 ft
MH-A5 (PR-STRM)
Rim: 7,052.32 ft
Invert: 7,045.74 ft
HGL: 7,046.95 ft
MH-A4 (PR-STRM)
Rim: 7,052.70 ft
Invert: 7,045.34 ft
HGL: 7,046.58 ft
MH-A3 (PR-STRM)
Rim: 7,053.39 ft
Invert: 7,045.09 ft
HGL: 7,046.31 ft
MH-A2 (PR-STRM)
Rim: 7,053.89 ft
Invert: 7,044.11 ft
HGL: 7,045.38 ft
MH-A1 (PR-STRM)
Rim: 7,053.92 ft
Invert: 7,042.77 ft
HGL: 7,045.15 ft
O-1
Rim: 7,053.48 ft
Invert: 7,041.94 ft
HGL: 7,045.14 ft
181.1 ft of 12.0in Ellipse RCP
@ -0.003 ft/ft
Flow=4.41 cfs
Velocity=3.34 ft/s
132.7 ft of 12.0in Ellipse RCP
@ -0.003 ft/ft
Flow=6.73 cfs
Velocity=3.82 ft/s
34.0 ft of 30.0in Circle RCP
@ -0.003 ft/ft
Flow=7.01 cfs
Velocity=4.05 ft/s
49.4 ft of 30.0in Circle RCP
@ -0.003 ft/ft
Flow=7.01 cfs
Velocity=4.18 ft/s
160.1 ft of 30.0in Circle RCP
@ -0.003 ft/ft
Flow=7.05 cfs
Velocity=4.05 ft/s
111.5 ft of 36.0in Circle RCP
@ 0.003 ft/ft
Flow=7.89 cfs
Velocity=4.12 ft/s
29.8 ft of 48.0in Circle RCP
@ 0.028 ft/ft
Flow=7.89 cfs
Velocity=8.78 ft/s
7,055.00
7,050.00
7,045.00
7,040.00
Elevation (ft)
-0+50
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+50
6+00
6+50
7+00
Station (ft)

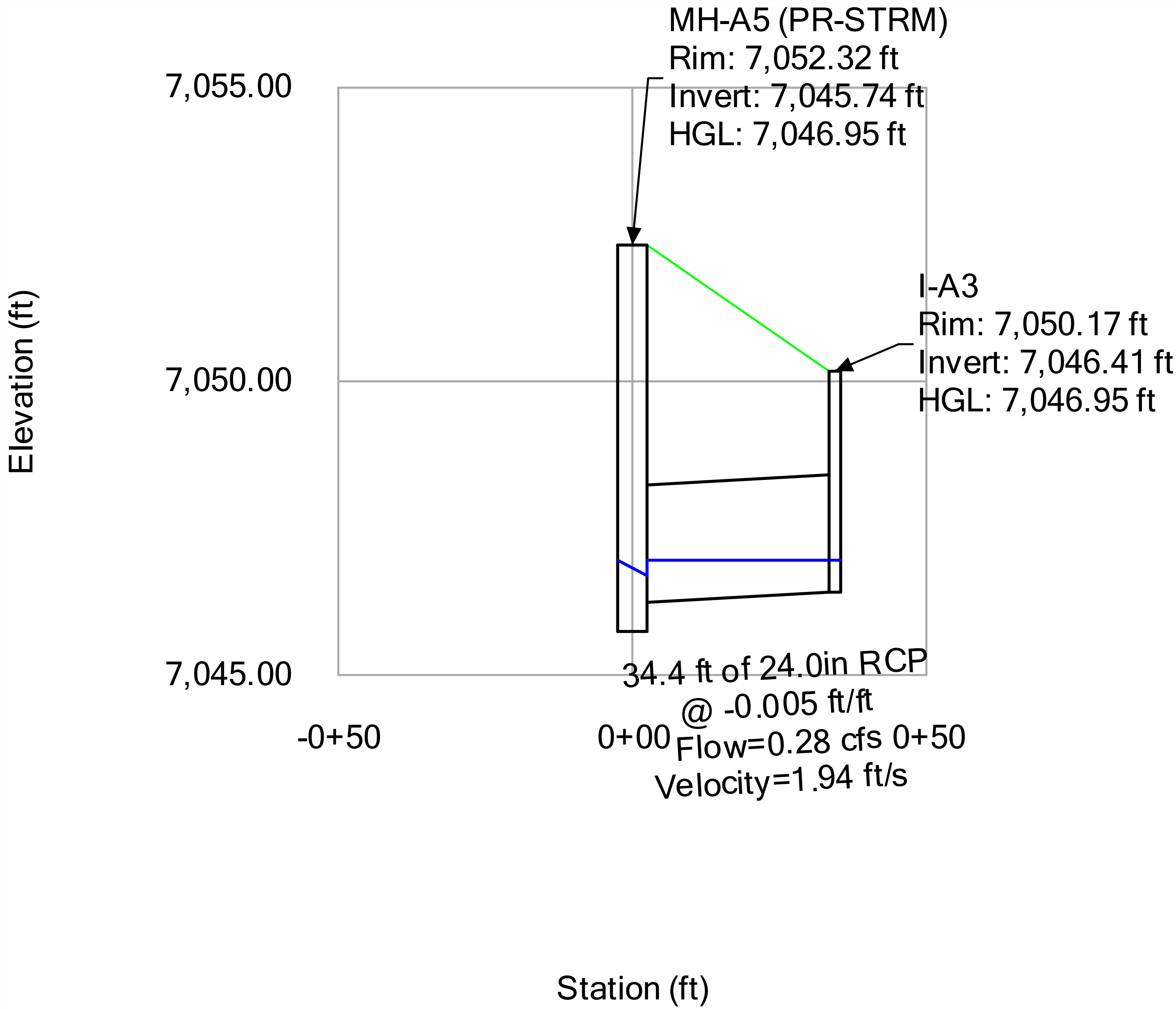
5-YEAR - STRM-A1



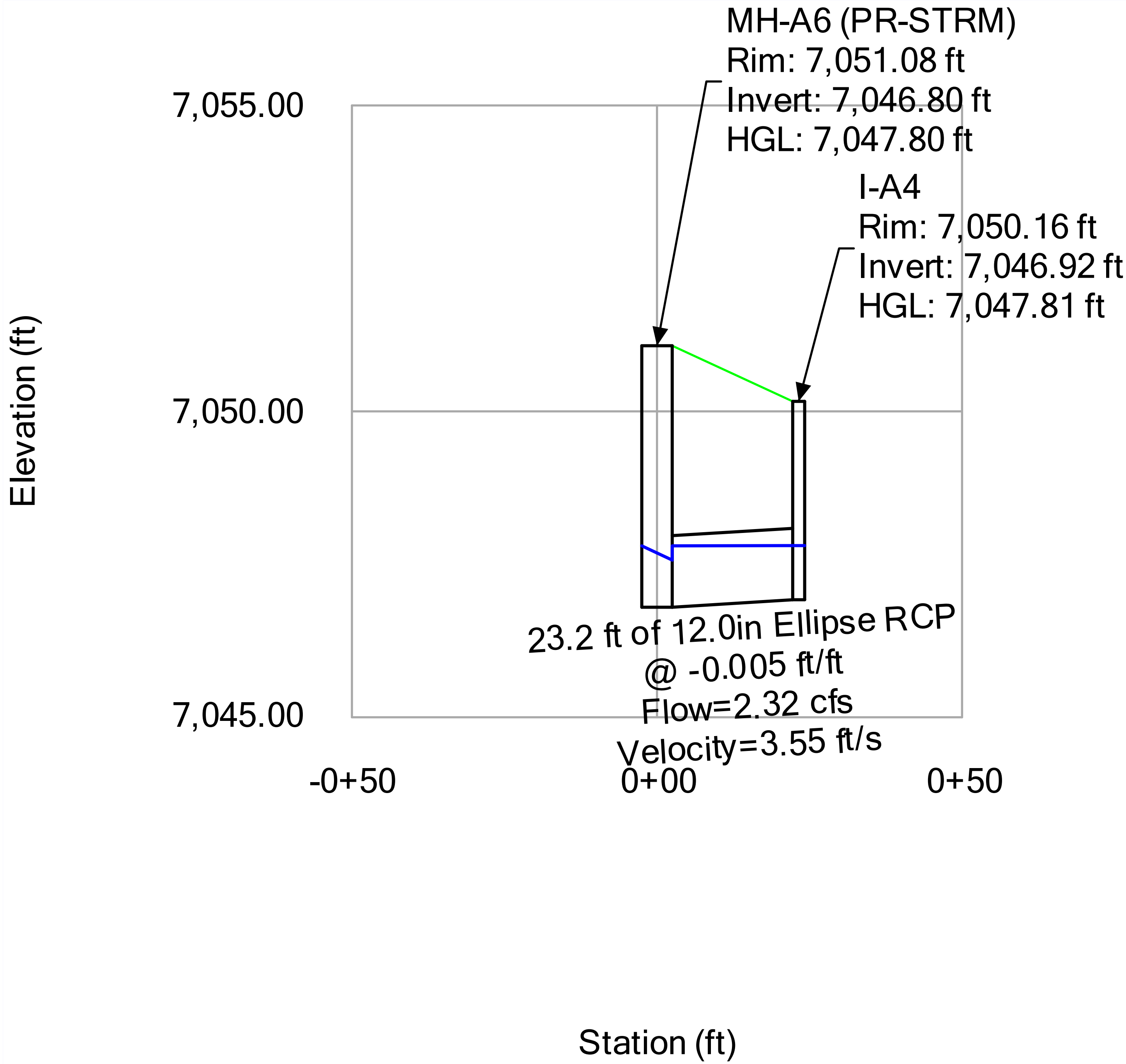
5-YEAR - STRM-A2



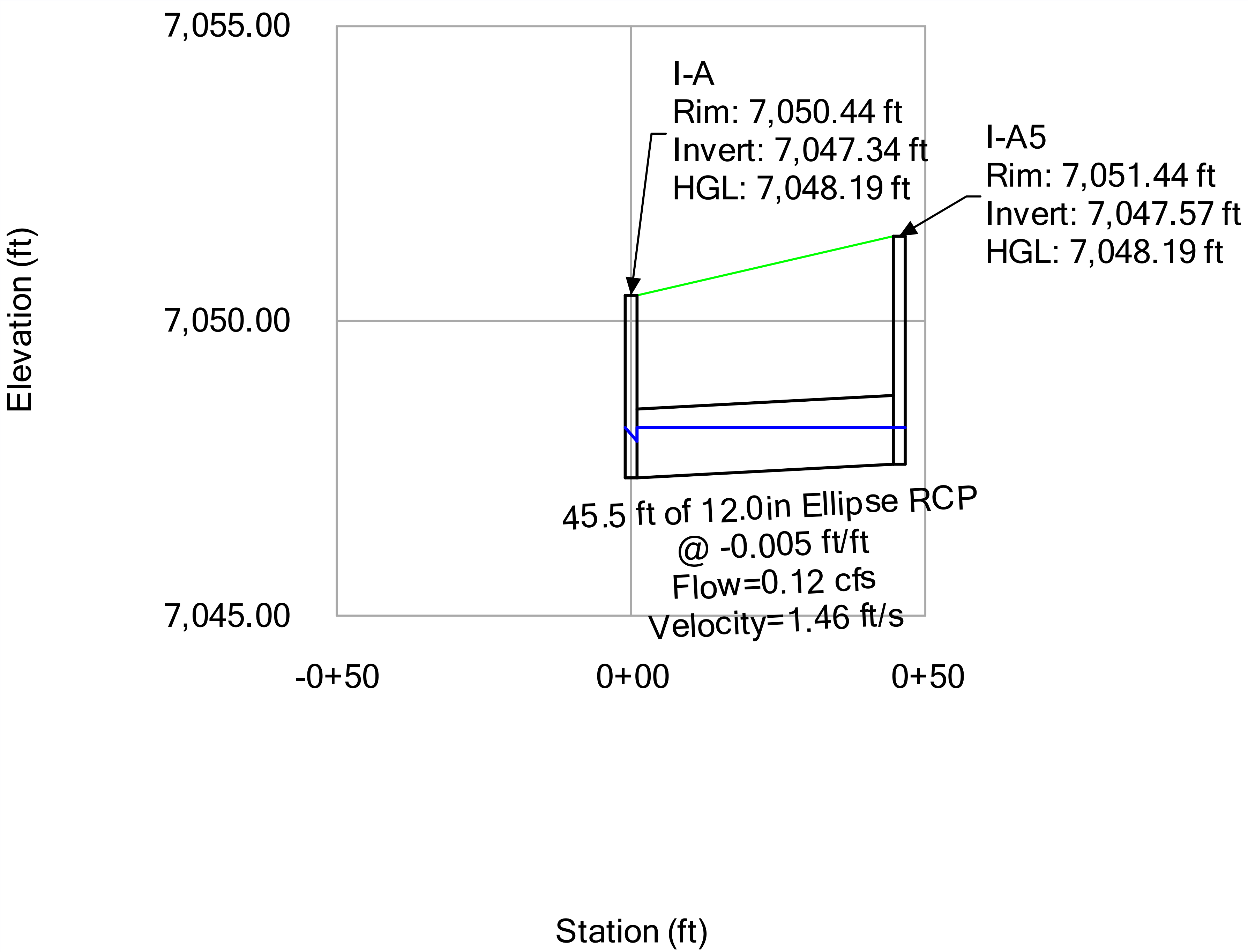
5-YEAR - STRM-A3



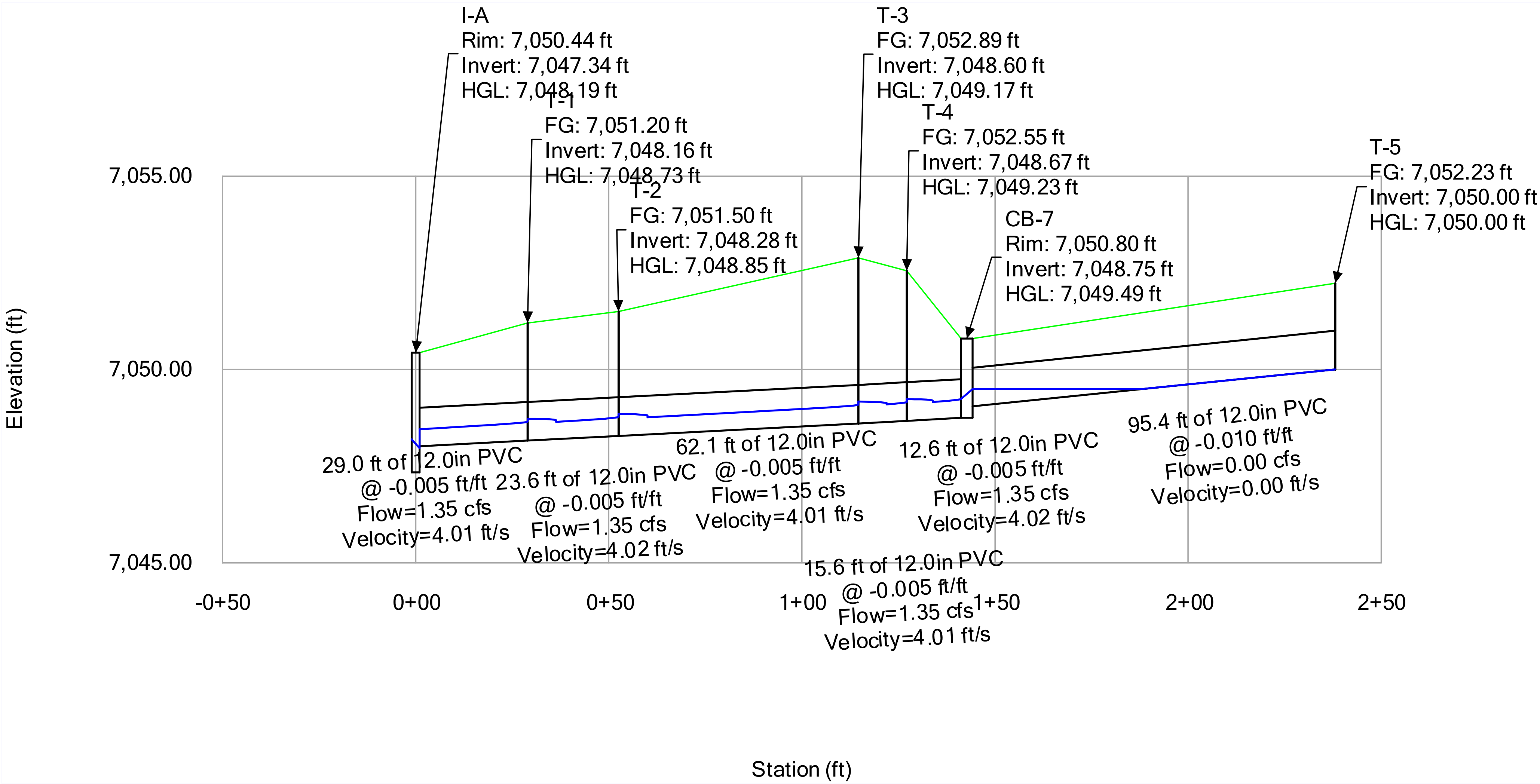
5-YEAR - STRM-A4



5-YEAR - STRM-A5



5-YEAR - STRM-B


I-A
Rim: 7,050.44 ft
Invert: 7,047.34 ft
HGL: 7,048.19 ft
T-1
FG: 7,051.20 ft
Invert: 7,048.16 ft
HGL: 7,048.73 ft
T-2
FG: 7,051.50 ft
Invert: 7,048.28 ft
HGL: 7,048.85 ft
T-3
FG: 7,052.89 ft
Invert: 7,048.60 ft
HGL: 7,049.17 ft
T-4
FG: 7,052.55 ft
Invert: 7,048.67 ft
HGL: 7,049.23 ft
CB-7
Rim: 7,050.80 ft
Invert: 7,048.75 ft
HGL: 7,049.49 ft
T-5
FG: 7,052.23 ft
Invert: 7,050.00 ft
HGL: 7,050.00 ft
29.0 ft of 12.0in PVC
@ -0.005 ft/ft
Flow=1.35 cfs
Velocity=4.01 ft/s
23.6 ft of 12.0in PVC
@ -0.005 ft/ft
Flow=1.35 cfs
Velocity=4.02 ft/s
62.1 ft of 12.0in PVC
@ -0.005 ft/ft
Flow=1.35 cfs
Velocity=4.01 ft/s
15.6 ft of 12.0in PVC
@ -0.005 ft/ft
Flow=1.35 cfs
Velocity=4.01 ft/s
12.6 ft of 12.0in PVC
@ -0.005 ft/ft
Flow=1.35 cfs
Velocity=4.02 ft/s
95.4 ft of 12.0in PVC
@ -0.010 ft/ft
Flow=0.00 cfs
Velocity=0.00 ft/s
Elevation (ft)
7,055.00
7,050.00
7,045.00
-0+50
0+00
0+50
1+00
1+50
2+00
2+50
Station (ft)

100-YEAR (100% FULL TAILWATER)

Conduit Table - Time: 0.00 hours

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
PIPE -03 (PR-STRM)	MH-A2 (PR-STRM)	7,044.61	MH-A3 (PR-STRM)	7,045.09	160.1	-0.003	0.013	18.61	5.12	22.48	7,046.83	7,046.37
PIPE -11 (PR-STRM)	MH-A2 (PR-STRM)	7,045.61	I-A1	7,045.80	39.1	-0.005	0.013	2.22	3.67	7.44	7,046.37	7,046.37
PIPE -04 (PR-STRM)	MH-A3 (PR-STRM)	7,045.19	MH-A4 (PR-STRM)	7,045.35	49.4	-0.003	0.013	18.07	5.28	23.51	7,047.32	7,047.24
PIPE -12 (PR-STRM)	MH-A3 (PR-STRM)	7,046.19	I-A2	7,046.37	35.0	-0.005	0.013	0.54	2.48	7.55	7,047.24	7,047.24
PIPE -05 (PR-STRM)	MH-A4 (PR-STRM)	7,045.64	MH-A5 (PR-STRM)	7,045.74	34.0	-0.003	0.013	18.07	5.09	22.48	7,047.68	7,047.62
PIPE -06 (PR-STRM)	MH-A5 (PR-STRM)	7,046.40	MH-A6 (PR-STRM)	7,046.80	132.7	-0.003	0.013	16.36	5.01	22.35	7,048.16	7,047.99
PIPE -13 (PR-STRM)	MH-A5 (PR-STRM)	7,046.24	I-A3	7,046.41	34.4	-0.005	0.013	1.71	3.32	15.99	7,047.99	7,047.99
PIPE -15 (PR-STRM)	I-A	7,047.34	I-A5	7,047.57	45.5	-0.005	0.013	0.90	0.51	7.19	7,048.81	7,048.81
PIPE -07 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A	7,047.34	181.1	-0.003	0.013	11.03	4.46	22.61	7,048.56	7,048.49
PIPE -14 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A4	7,046.92	23.2	-0.005	0.013	5.33	3.03	7.16	7,048.55	7,048.49
PIPE -16 (PR-STRM)	I-A2	7,046.86	19 (PR-STRM)	7,046.92	11.8	-0.005	0.010	0.14	2.07	3.27	7,047.24	7,047.24
PIPE -18 (PR-STRM)	20 (PR-STRM)	7,046.97	CB-8	7,047.93	192.5	-0.005	0.010	0.14	2.07	3.28	7,048.08	7,047.25
PIPE -17 (PR-STRM)	19 (PR-STRM)	7,046.92	20 (PR-STRM)	7,046.97	9.2	-0.005	0.010	0.14	2.08	3.28	7,047.25	7,047.25
CO-1	MH-A2 (PR-STRM)	7,044.11	MH-A1 (PR-STRM)	7,043.77	111.5	0.003	0.013	20.83	5.33	36.51	7,046.09	7,045.99
CO-2	I-A	7,048.01	T-1	7,048.16	29.0	-0.005	0.010	2.67	4.70	3.32	7,048.86	7,048.81
CO-3	T-1	7,048.16	T-2	7,048.28	23.6	-0.005	0.010	2.67	4.72	3.33	7,049.01	7,048.99
CO-4	T-2	7,048.28	T-3	7,048.60	62.1	-0.005	0.010	2.67	4.70	3.32	7,049.30	7,049.13
CO-5	T-3	7,048.60	T-4	7,048.67	12.6	-0.005	0.010	2.67	4.71	3.33	7,049.44	7,049.43
CO-6	T-4	7,048.67	CB-7	7,048.75	15.6	-0.005	0.010	2.67	4.70	3.32	7,049.57	7,049.55
CO-7	CB-7	7,049.05	T-5	7,050.00	95.4	-0.010	0.010	0.00	0.00	4.63	7,050.00	7,049.88
EX. PIPE IN STAPLETON DR	MH-A1 (PR-STRM)	7,042.77	O-1	7,041.94	29.8	0.028	0.013	20.83	11.72	240.09	7,045.93	7,045.94

100-YEAR (100% FULL TAILWATER)

Catch Basin Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Additional Subsurface) (cfs)	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
I-A3	7,050.17	7,050.17	7,046.41	1.71	7,047.99	0.050
I-A1	7,049.54	7,049.54	7,045.80	2.22	7,046.37	0.050
I-A2	7,052.04	7,052.04	7,046.37	0.40	7,047.24	1.020
I-A4	7,050.16	7,050.16	7,046.92	5.33	7,048.55	0.000
I-A	7,050.44	7,050.44	7,047.34	7.46	7,048.81	1.320
I-A5	7,051.44	7,051.44	7,047.57	0.90	7,048.81	0.050
CB-7	7,050.80	7,050.80	7,048.75	2.67	7,049.88	1.320
CB-8	7,051.48	7,051.48	7,047.93	0.14	7,048.08	0.000

100-YEAR (100% FULL TAILWATER)

Manhole Table - Time: 0.00 hours

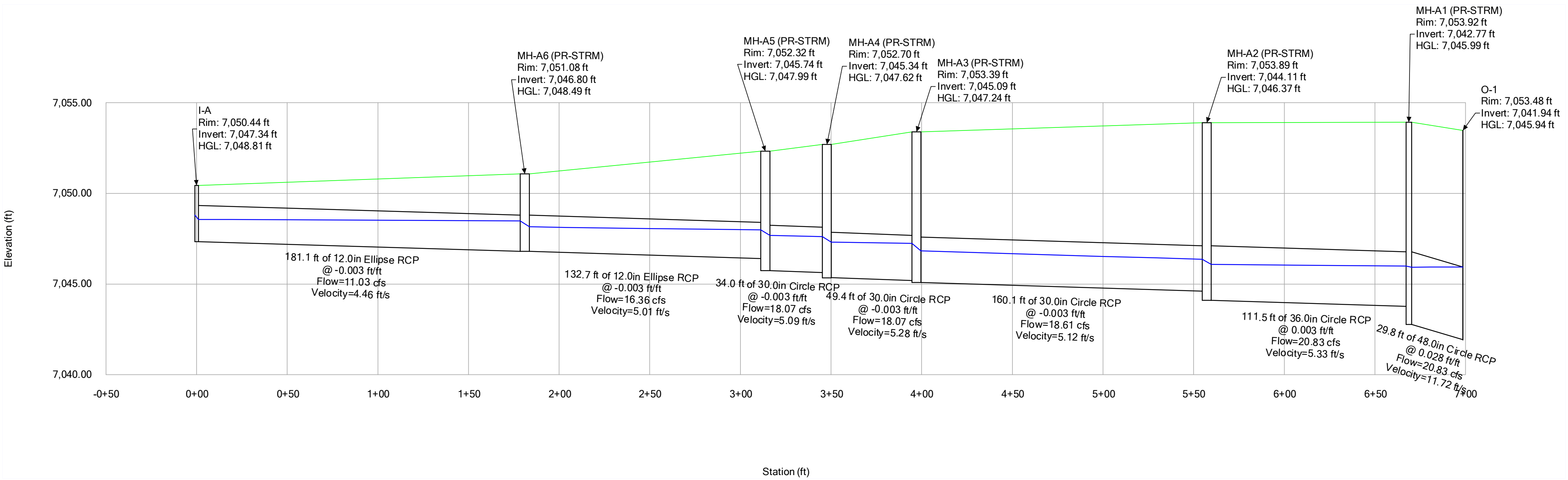
Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert Out) (ft)	Flow (Total Out) (cfs)	Hydraulic Grade Line (Out) (ft)	Headloss Method	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
MH-A2 (PR-STRM)	7,053.89	7,053.89	7,044.11	20.83	7,046.09	Standard	7,046.37	1.020
MH-A3 (PR-STRM)	7,053.39	7,053.39	7,045.09	18.61	7,046.83	Standard	7,047.24	1.020
MH-A4 (PR-STRM)	7,052.70	7,052.70	7,045.35	18.07	7,047.32	Standard	7,047.62	1.020
MH-A5 (PR-STRM)	7,052.32	7,052.32	7,045.74	18.07	7,047.68	Standard	7,047.99	1.020
MH-A6 (PR-STRM)	7,051.08	7,051.08	7,046.80	16.36	7,048.16	Standard	7,048.49	1.020
MH-A1 (PR-STRM)	7,053.92	7,053.92	7,042.77	20.83	7,045.93	Standard	7,045.99	1.020

100-YEAR (100% FULL TAILWATER)

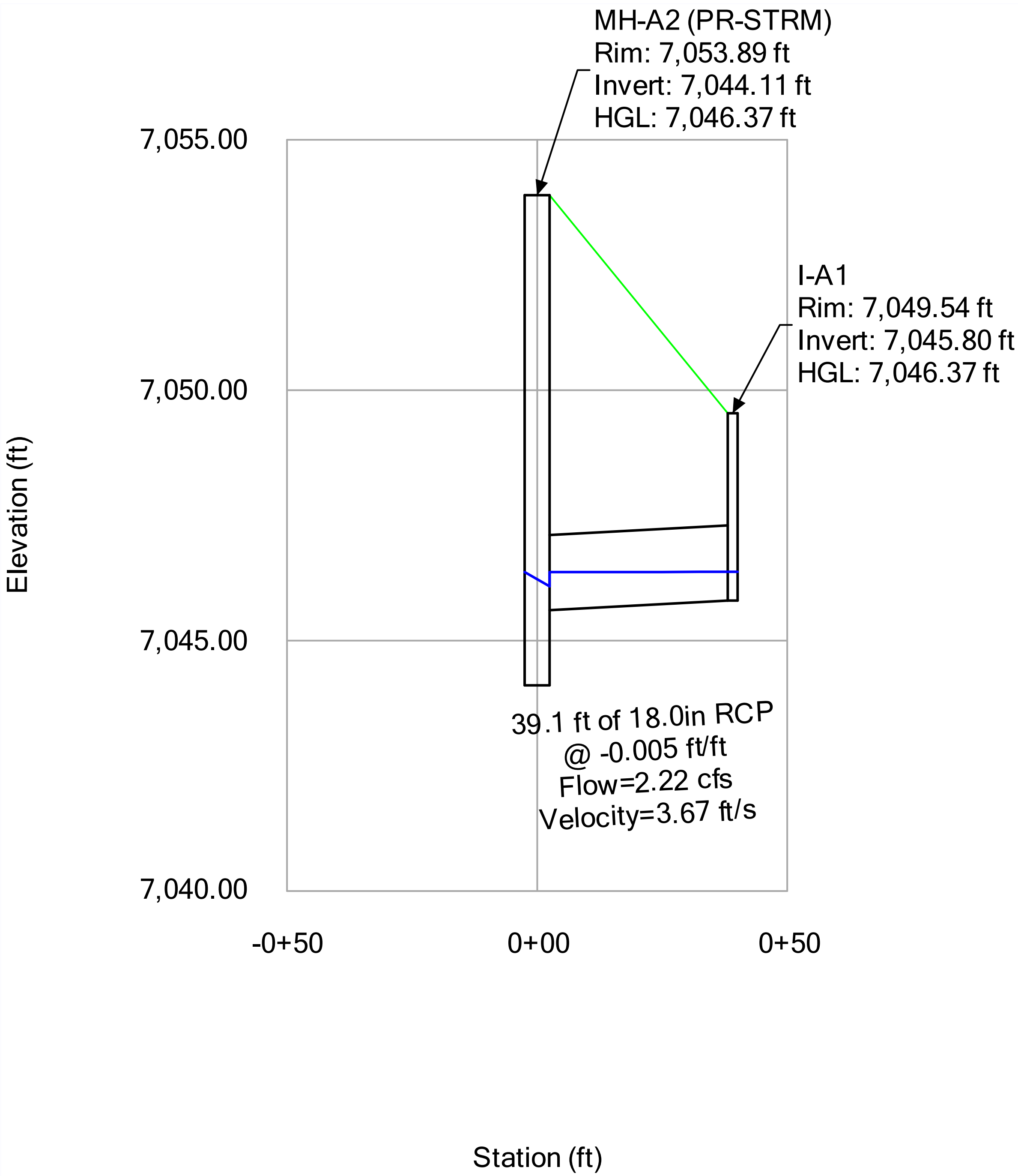
Outfall Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Set Rim to Ground Elevation?	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
O-1	7,053.48	True	7,041.94	User Defined Tailwater	7,045.94	20.83

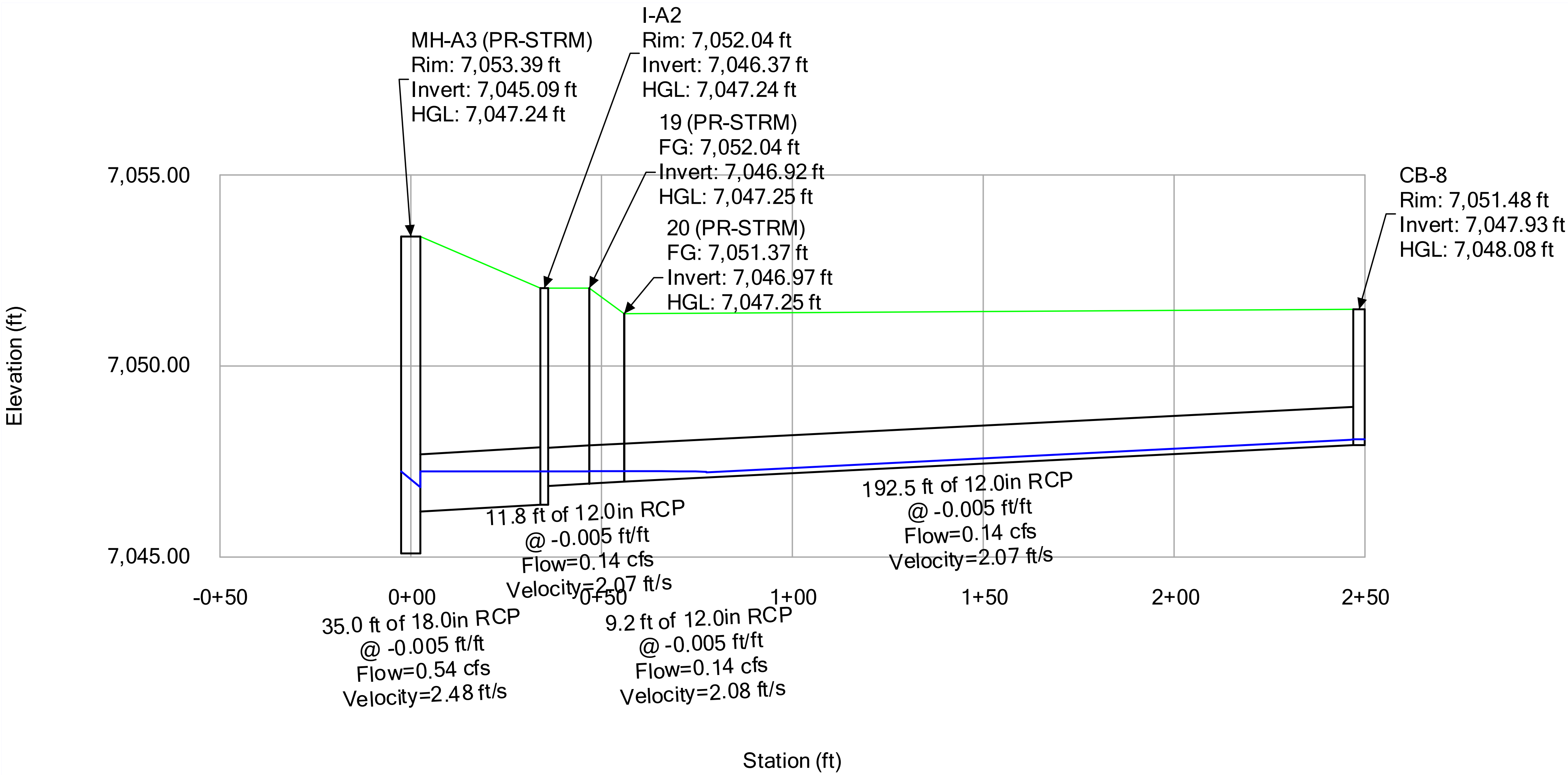
100-YEAR - STRM-A



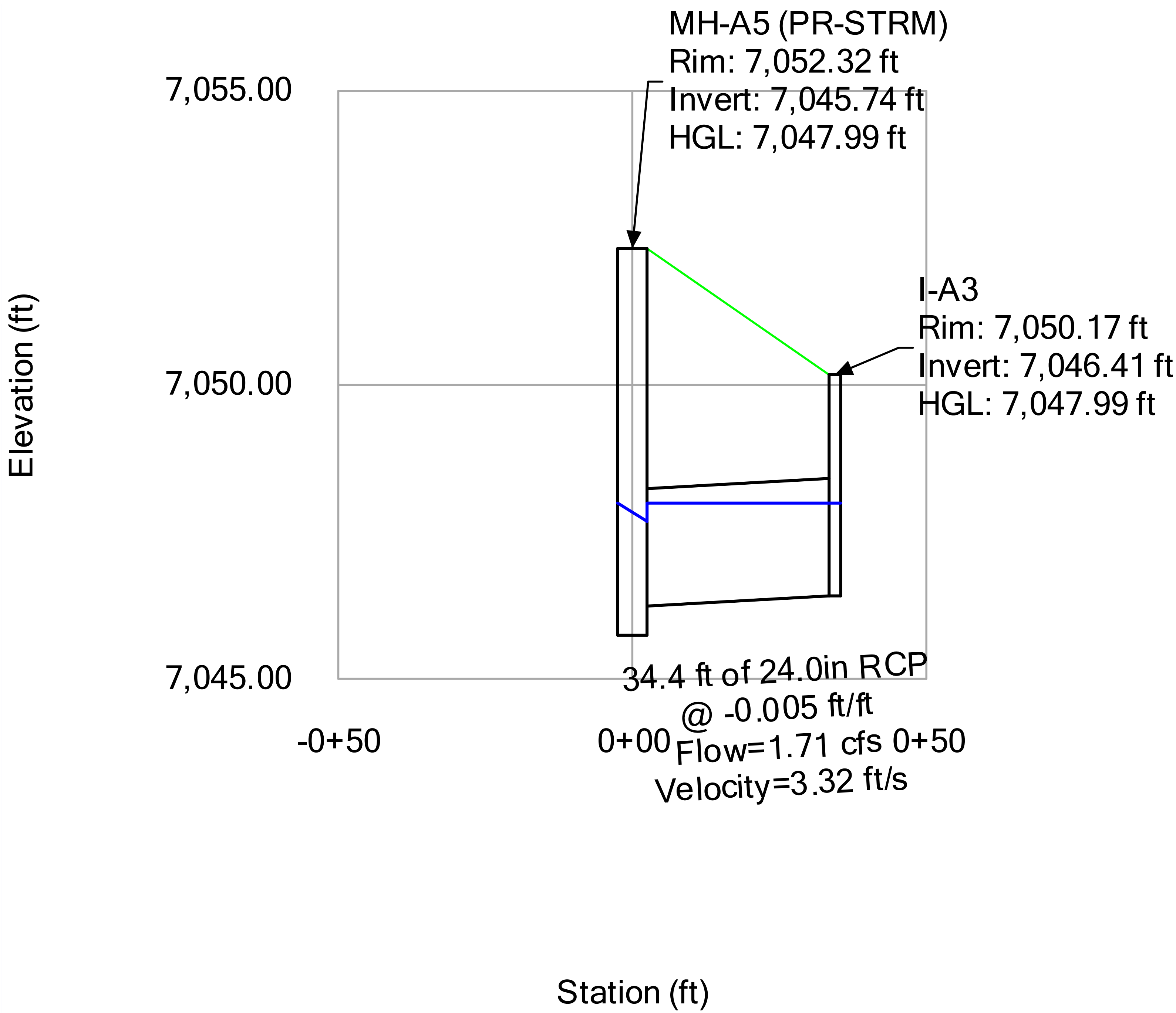
100-YEAR - STRM-A1



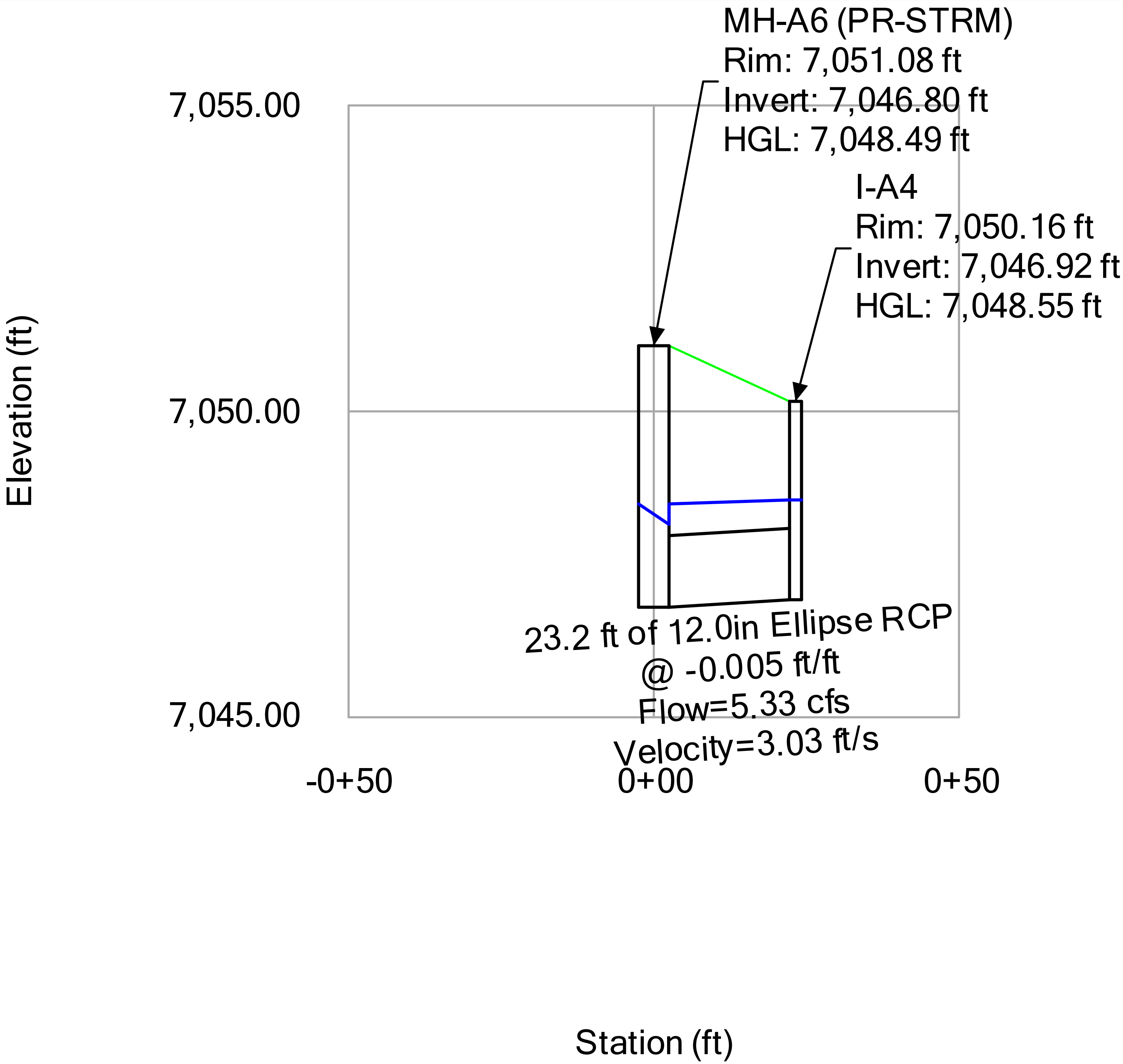
100-YEAR - STRM-A2



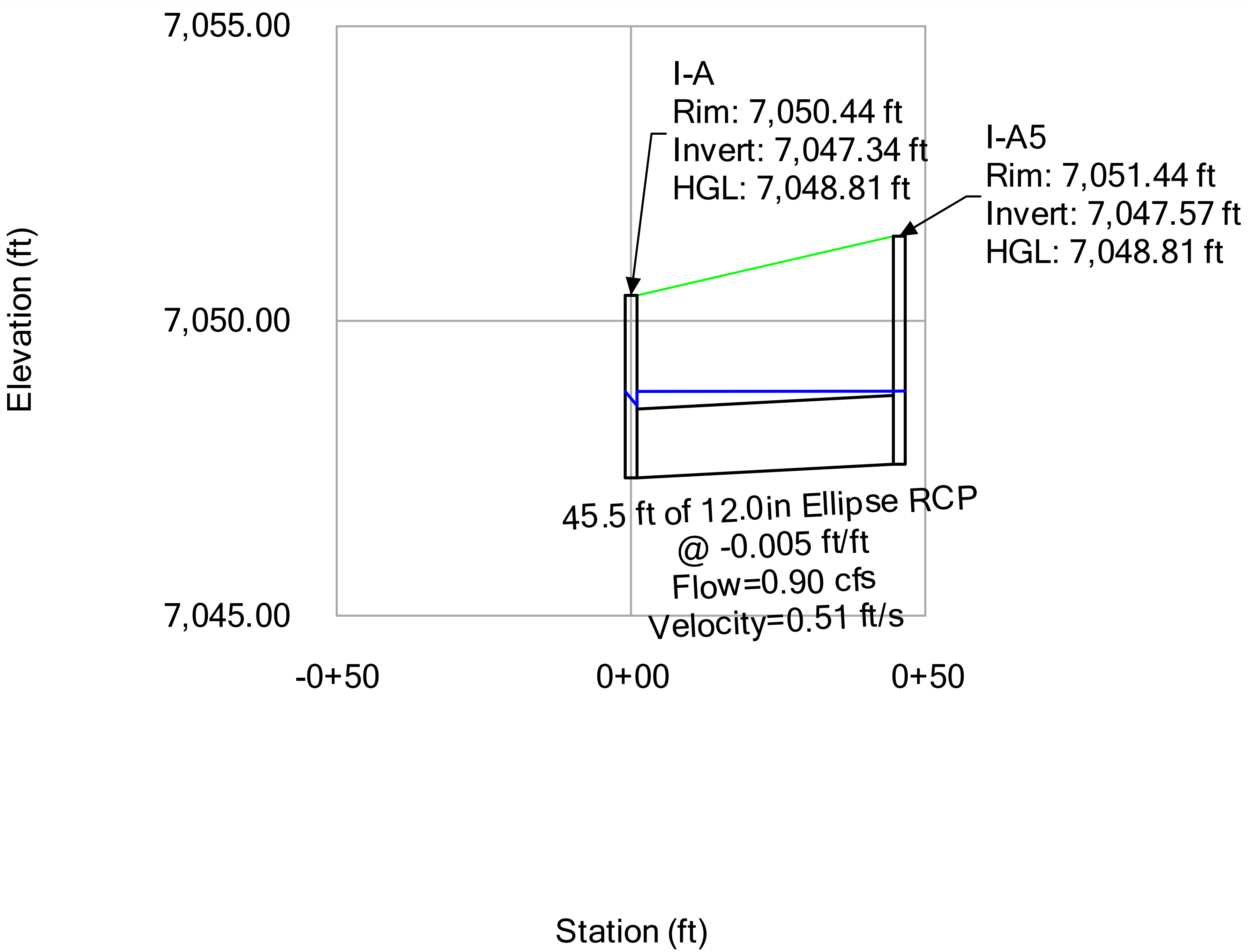
100-YEAR - STRM-A3



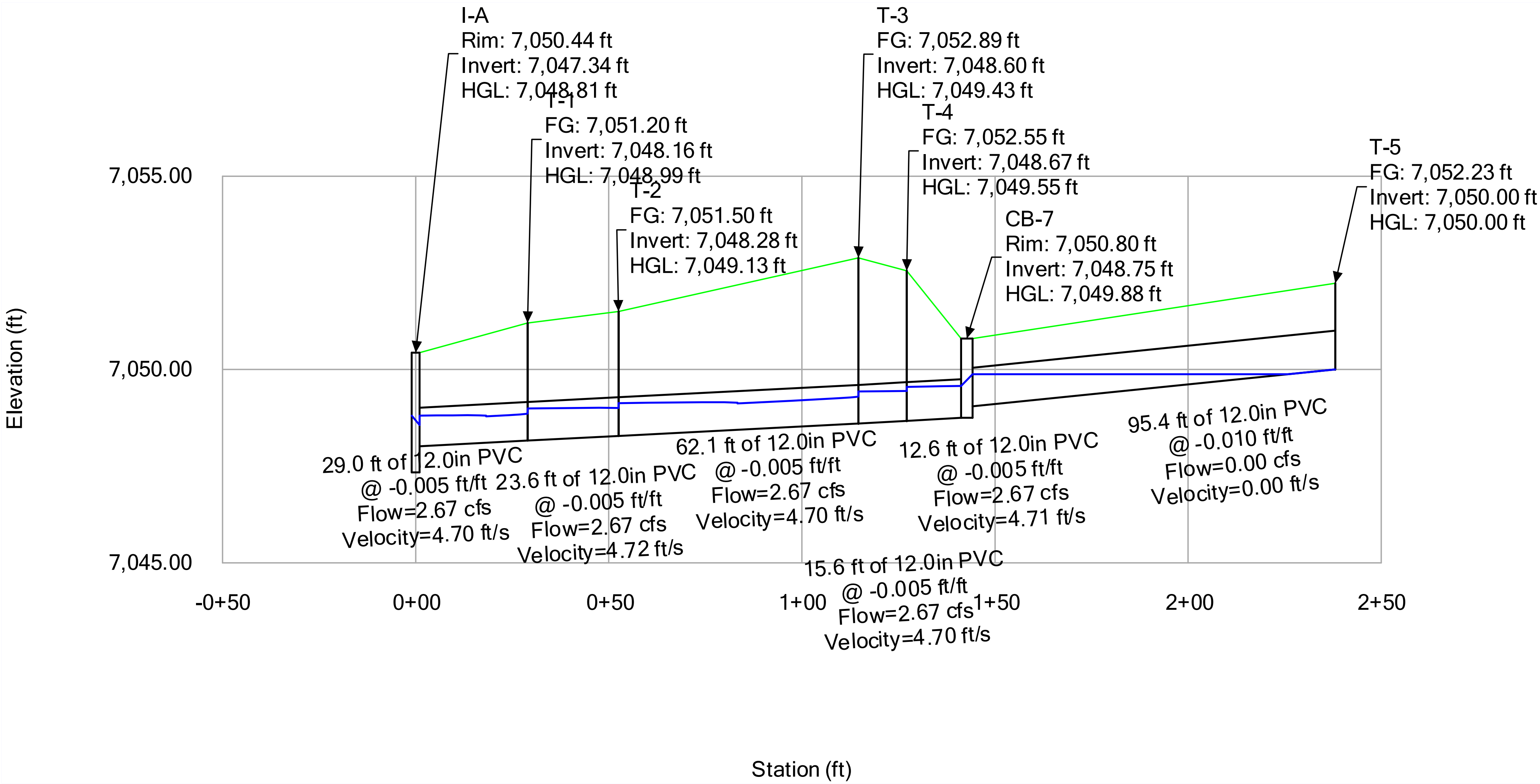
100-YEAR - STRM-A4



100-YEAR - STRM-A5



100-YEAR - STRM-B



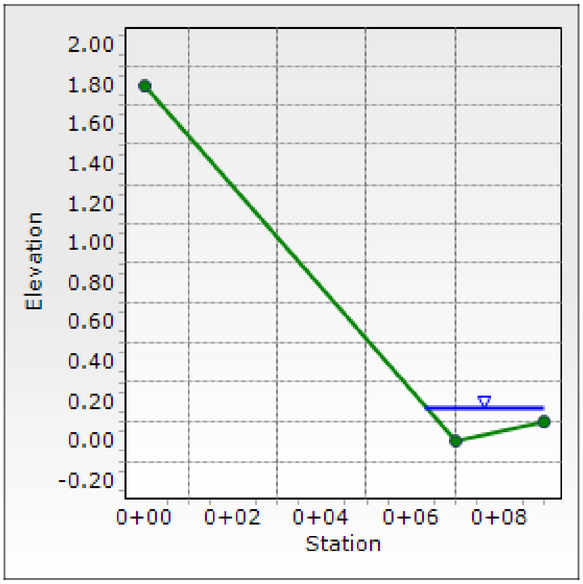
Cross Section for SWALE A - P3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

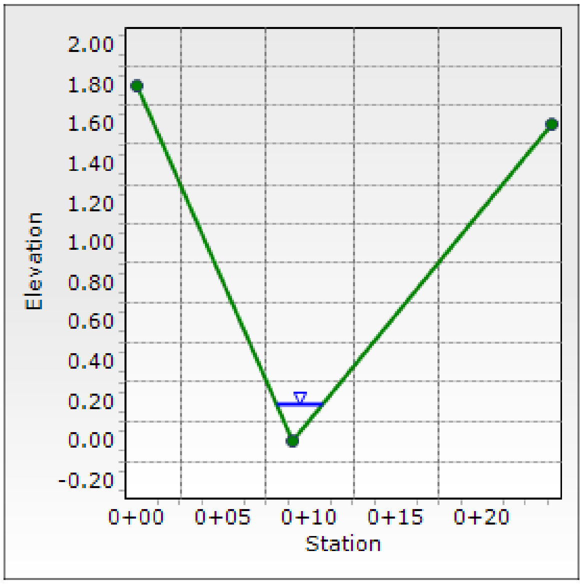
Channel Slope	0.010 ft/ft
Normal Depth	2.0 in
Discharge	0.31 cfs



Cross Section for SWALE B - OS1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

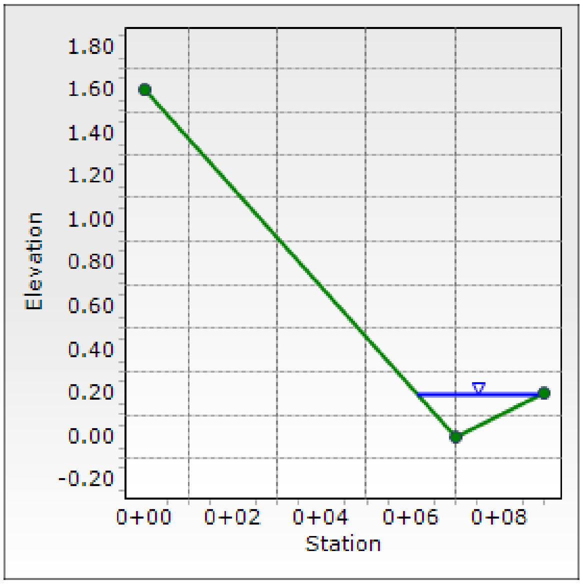
Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	2.2 in
Discharge	0.25 cfs



Cross Section for SWALE C - P4

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.2 in
Discharge	0.31 cfs



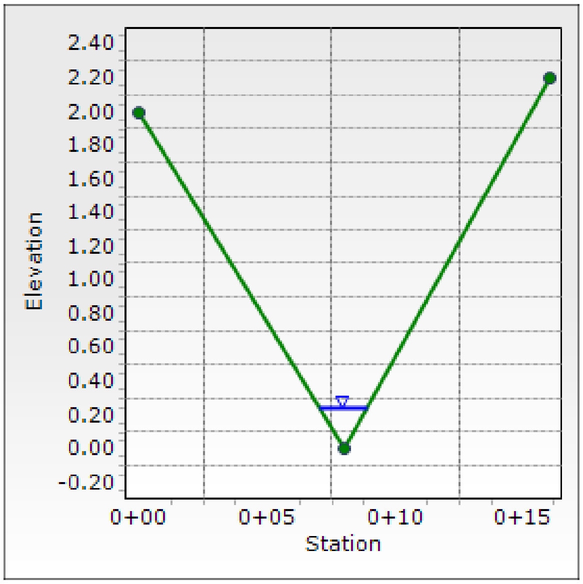
Cross Section for SWALE D - P4

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

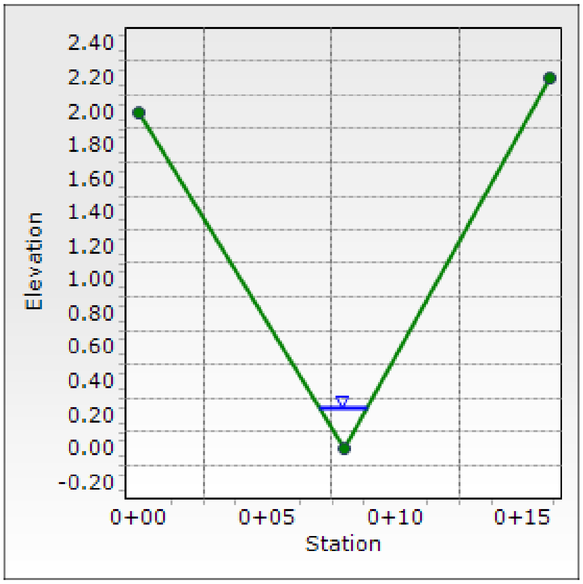
Channel Slope	0.015 ft/ft
Normal Depth	2.9 in
Discharge	0.31 cfs



Cross Section for SWALE E - P5

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

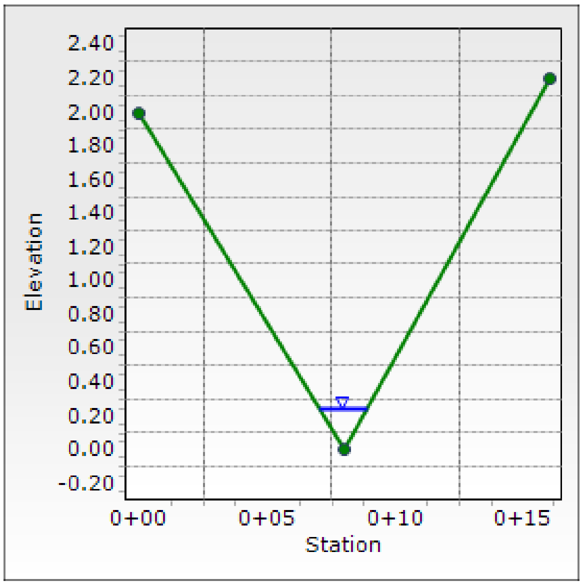
Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.9 in
Discharge	0.31 cfs



Cross Section for SWALE F - P7

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

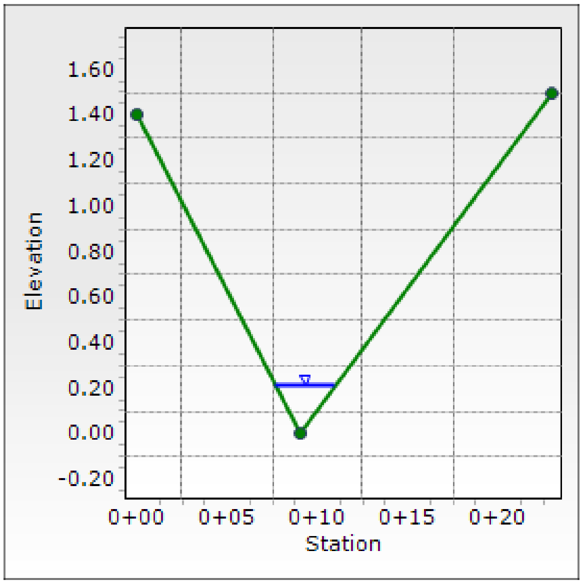
Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.9 in
Discharge	0.31 cfs



Cross Section for SWALE G - P6

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	2.6 in
Discharge	0.40 cfs



MHFD-Inlet, Version 5.03 (August 2023)

INLET MANAGEMENT

Worksheet Protected

INLET NAME	I-A	I-A1	I-A2
Site Type (Urban or Rural)	RURAL	RURAL	RURAL
Inlet Application (Street or Area)	AREA	AREA	AREA
Hydraulic Condition	Swale	Swale	Swale
Inlet Type	CDOT Type C (Depressed)	CDOT Type C	CDOT Type C

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	2.9	0.8	0.1
Major Q_{Known} (cfs)	5.8	2.2	0.4

Bypass (Carry-Over) Flow from Upstream Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**2.9**	**0.8**	**0.1**
Major Total Design Peak Flow, Q (cfs)	**5.8**	**2.2**	**0.4**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0

MHFD-Inlet, Version 5.03 (August 2023)

INLET MANAGEMENT

Worksheet Protected

INLET NAME	I-A3	I-A4	I-A5
Site Type (Urban or Rural)	RURAL	RURAL	RURAL
Inlet Application (Street or Area)	AREA	AREA	AREA
Hydraulic Condition	Swale	Swale	Swale
Inlet Type	CDOT Type C	CDOT Type D (In Series)	CDOT Type C

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	0.3	2.3	0.1
Major Q_{Known} (cfs)	1.7	5.3	0.9

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

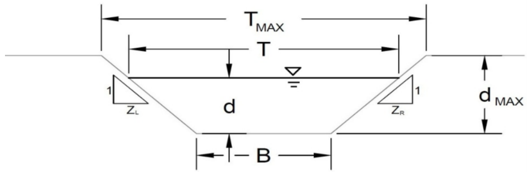
Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**0.3**	**2.3**	**0.1**
Major Total Design Peak Flow, Q (cfs)	**1.7**	**5.3**	**0.9**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0

AREA INLET IN A SWALE

I-A



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =		
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.013	
Channel Invert Slope	S_O =	0.0150	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	50.00	ft/ft
Right Side Sloe	Z2 =	50.00	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**65.00**	**65.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**1.50**	**1.50**	**ft**

Maximum Channel Capacity Based On Allowable Top Width

		Minor Storm	Major Storm	
Maximum Allowable Top Width	T_{MAX} =	**65.00**	**65.00**	**ft**
Water Depth	d =	0.65	0.65	ft
Flow Area	A =	21.13	21.13	sq ft
Wetted Perimeter	P =	65.01	65.01	ft
Hydraulic Radius	R =	0.32	0.32	ft
Manning's n	n =	0.013	0.013	
Flow Velocity	V =	6.63	6.63	fps
Velocity-Depth Product	VR =	2.16	2.16	ft^2/s
Hydraulic Depth	D =	0.33	0.33	ft
Froude Number	Fr =	2.05	2.05	
Maximum Flow Based on Allowable Water Depth	Q_T =	**140.2**	**140.2**	**cfs**

Maximum Channel Capacity Based On Allowable Water Depth

		Minor Storm	Major Storm	
Maximum Allowable Water Depth	d_{MAX} =	**1.50**	**1.50**	**ft**
Top Width	T =	150.00	150.00	ft
Flow Area	A =	112.50	112.50	sq ft
Wetted Perimeter	P =	150.03	150.03	ft
Hydraulic Radius	R =	0.75	0.75	ft
Manning's n	n =	0.013	0.013	
Flow Velocity	V =	11.59	11.59	fps
Velocity-Depth Product	VR =	8.69	8.69	ft^2/s
Hydraulic Depth	D =	0.75	0.75	ft
Froude Number	Fr =	2.36	2.36	
Maximum Flow Based On Allowable Water Depth	Q_d =	**1,303.4**	**1,303.4**	**cfs**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	**140.2**	**140.2**	**cfs**
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	**0.65**	**0.65**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**2.9**	**5.8**	**cfs**
Water Depth	**d =**	**0.15**	**0.20**	**ft**
Top Width	T =	15.08	19.62	ft
Flow Area	A =	1.14	1.93	sq ft
Wetted Perimeter	P =	15.09	19.63	ft
Hydraulic Radius	R =	0.08	0.10	ft
Manning's n	n =	0.013	0.013	
Flow Velocity	V =	2.51	2.99	fps
Velocity-Depth Product	VR =	0.19	0.29	ft^2/s
Hydraulic Depth	D =	0.08	0.10	ft
Warning 04 Froude Number	Fr =	1.61	1.68	

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

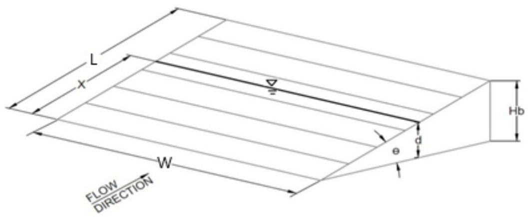
AREA INLET IN A SWALE

I-A

Inlet Design Information (Input)

Type of Inlet	CDOT Type C (Depressed)	Inlet Type =	CDOT Type C (Depressed)

Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.84	
Orifice Coefficient	C_o =	0.56	
Weir Coefficient	C_w =	1.81	

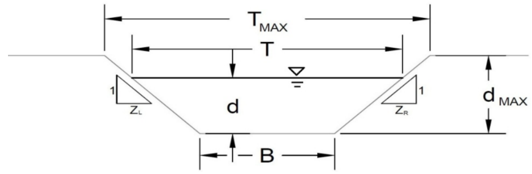


		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.15	1.20	
Grate Capacity as a Weir				
Submerged Side Weir Length	X =	3.00	3.00	ft
Inclined Side Weir Flow	Q_{ws} =	11.7	12.4	cfs
Base Weir Flow	Q_{wb} =	16.7	17.7	cfs
Interception Without Clogggging	Q_{wi} =	40.1	42.5	cfs
Interception With Clogging	Q_{wa} =	20.1	21.3	cfs
Grate Capacity as an Orifice				
Interception Without Clogging	Q_{oi} =	30.5	31.1	cfs
Interception With Clogging	Q_{oa} =	15.3	15.6	cfs
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**15.3**	**15.6**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

Warning 04: Froude No. exceeds USDCM Volume I recommendation.

AREA INLET IN A SWALE

I-A1



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	A	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	see details below	
Channel Invert Slope	S_O =	0.0100	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	4.00	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	**T_{MAX} =**	**23.00**	**23.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	**d_{MAX} =**	**2.00**	**2.00**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**6.3**	**6.3**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	**d_{allow} =**	**2.00**	**2.00**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	**Q_o =**	**0.8**	**2.2**	**cfs**
Water Depth	**d =**	**0.85**	**1.29**	**ft**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

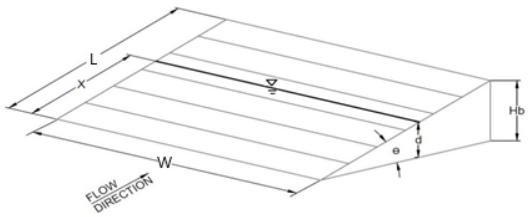
MHFD-Inlet, Version 5.03 (August 2023)

AREA INLET IN A SWALE

I-A1

Inlet Design Information (Input)

Type of Inlet: CDOT Type C — Inlet Type = CDOT Type C

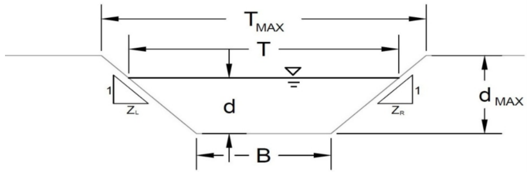


Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.96	
Orifice Coefficient	C_o =	0.64	
Weir Coefficient	C_w =	2.05	

		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.85	1.29	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**14.5**	**18.3**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

I-A2



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	A	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	see details below	
Channel Invert Slope	S_O =	0.0150	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	4.00	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**20.00**	**20.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**1.50**	**1.50**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**3.7**	**3.7**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	d_{allow} =	**1.50**	**1.50**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**0.1**	**0.4**	**cfs**
Water Depth	d =	**0.34**	**0.59**	**ft**

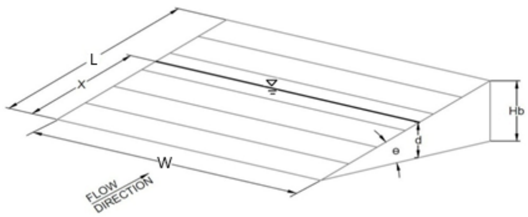
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A2

Inlet Design Information (Input)

Type of Inlet: CDOT Type C — Inlet Type = CDOT Type C

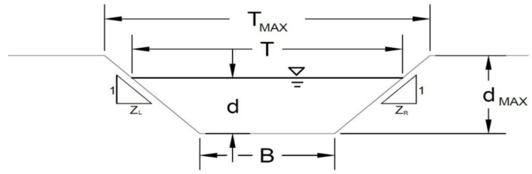


Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.96	
Orifice Coefficient	C_o =	0.64	
Weir Coefficient	C_w =	2.05	

		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.34	0.59	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**3.6**	**8.4**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

I-A3



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	A	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	see details below	
Channel Invert Slope	S_O =	0.0100	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	4.00	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- ☐ **Non-Cohesive**
- ☐ **Cohesive**
- ☐ **Paved**

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**16.00**	**16.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**2.25**	**2.25**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	**6.3**	**6.3**	**cfs**
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	**2.00**	**2.00**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**0.3**	**1.7**	**cfs**
Water Depth	d =	**0.56**	**1.15**	**ft**

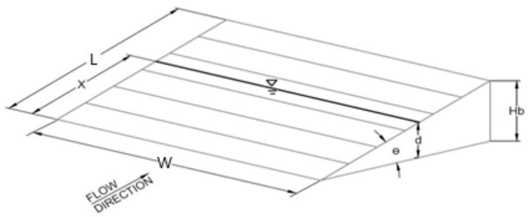
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A3

Inlet Design Information (Input)

Type of Inlet: CDOT Type C — Inlet Type = CDOT Type C

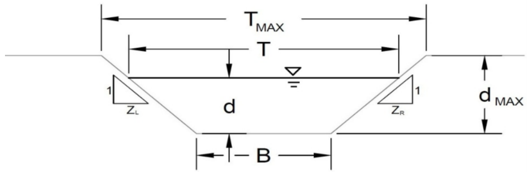


Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.96	
Orifice Coefficient	C_o =	0.64	
Weir Coefficient	C_w =	2.05	

		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.56	1.15	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**7.7**	**17.3**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

I-A4



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	A	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	see details below	
Channel Invert Slope	S_O =	0.0150	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	4.00	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**18.00**	**18.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**2.00**	**2.00**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**7.8**	**7.8**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	d_{allow} =	**2.00**	**2.00**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**2.3**	**5.3**	**cfs**
Water Depth	d =	**1.22**	**1.73**	**ft**

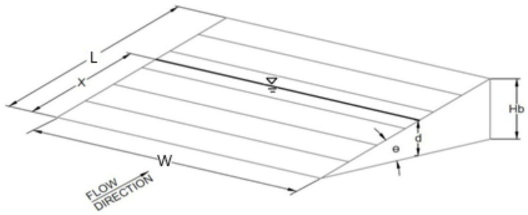
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A4

Inlet Design Information (Input)

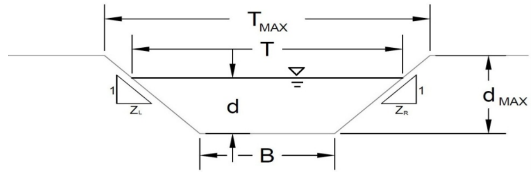
Type of Inlet	CDOT Type D (In Series)	Inlet Type =	CDOT Type D (In Series)	
Angle of Inclined Grate (must be <= 30 degrees)		θ =	0.00	degrees
Width of Grate		W =	3.00	ft
Length of Grate		L =	6.00	ft
Open Area Ratio		A_{RATIO} =	0.70	
Height of Inclined Grate		H_B =	0.00	ft
Clogging Factor		C_f =	0.38	
Grate Discharge Coefficient		C_d =	0.78	
Orifice Coefficient		C_o =	0.52	
Weir Coefficient		C_w =	1.67	



		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.22	1.73	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**36.3**	**43.3**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

I-A5



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	A	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	see details below	
Channel Invert Slope	S_O =	0.0150	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	20.00	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- (●) Non-Cohesive
- ( ) Cohesive
- ( ) Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	2.00	2.00	ft
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	0.20	0.20	ft

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	0.0	0.0	cfs
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	0.08	0.08	ft

Water Depth in Channel Based On Design Peak Flow

	Design Peak Flow	Q_o =	0.1	0.9	cfs
Warning 05	Water Depth	d =	0.25	0.53	ft

WARNING: MINOR STORM max. allowable capacity is less than the design flow given on sheet 'Inlet Management'
WARNING: MAJOR STORM max. allowable capacity is less than the design flow given on sheet 'Inlet Management'

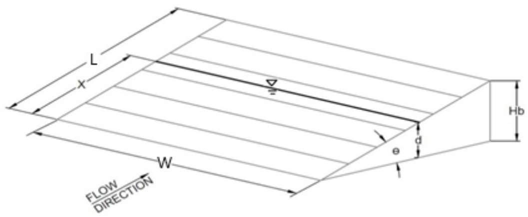
AREA INLET IN A SWALE

I-A5

Inlet Design Information (Input)

Type of Inlet: CDOT Type C — Inlet Type = CDOT Type C

Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.96	
Orifice Coefficient	C_o =	0.64	
Weir Coefficient	C_w =	2.05	



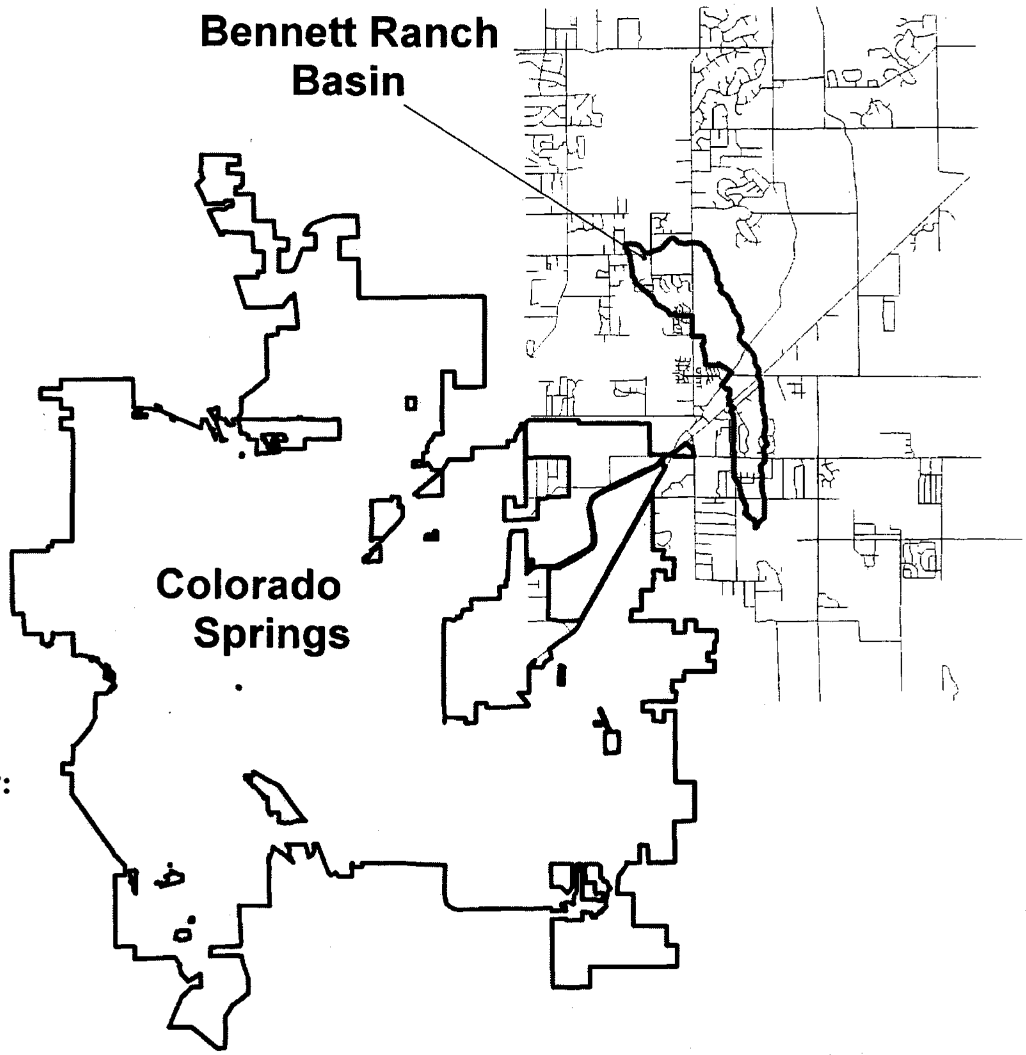
		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.25	0.53	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**2.3**	**7.0**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

Warning 05: Depth (d) exceeds max allowable depth (dmax).
Warning 06: Top Width (T) exceeds max allowable top width (Tmax).

APPENDIX F – BENNETT RANCH DBPS

Bennett Ranch Pilot Project
Drainage Basin Planning Study

November, 2001



Prepared For:

EL PASO COUNTY SEAL COLORADO EST. 1861

3460 Marksheffel Road
Colorado Springs, CO 80922

Prepared By:

STORMWATER
& ENVIRONMENTAL
CONSULTANTS, INC.
A DIVISION OF OLSSON ASSOCIATES

5200 DTC Parkway, Suite 530 • Greenwood Village, Colorado 80111 • (303) 694-3800 • FAX (303) 267-0705
LINCOLN, NE • OMAHA, NE • GRAND ISLAND, NE • HOLDREGE, NE • PHOENIX, AZ • KANSAS CITY, MO

Table of Contents

List of Tables

Table of Figures and Photographs

EXECUTIVE SUMMARY

Contract Authorization

The Bennett Ranch Drainage Basin Planning Study (DBPS) was authorized under terms of an agreement between El Paso County and Stormwater & Environmental Consultants Inc., A Division of Olsson Associates (SEC OA). This agreement was approved by the El Paso County Procurement and Contracts Department on August 17, 2000.

Agency Jurisdictions

The Bennett Ranch Basin is located within unincorporated El Paso County. The El Paso County Department of Transportation has responsibility for implementation of the approved DBPS. A list of agencies and individuals contacted during the basin planning process are listed below:

- Anita Culp — United States Army Corps of Engineers
- Bob McCue, Lee Carlson — United States Fish and Wildlife Service
- Gary Dowler — Colorado Division of Wildlife
- John Liou — Federal Emergency Management Agency
- Larry Lang — Colorado Water Conservation Board
- Bruce Thorson — City of Colorado Springs
- Dan Bunting — Regional Floodplain Coordinator
- John Valentine — National Resources Conservation Service
- Paul Reinswa — Colorado Department of Transportation
- Mark Gebhardt — El Paso County Planning
- Celia Greenman — Colorado Geological Survey

The preceding list of agencies and individual were invited to attend an agency coordination meeting on January 30, 2001. The list was also contacted by telephone in October and November of 2001 to ensure that no outstanding issues existed with the DBPS. Please refer to Appendix A of this report for all agency coordination information.

Scope and Purpose

El Paso County is experiencing rapid growth in areas that lack drainage basin planning studies. In an effort to produce basin drainage plans in an expedited manner, El Paso County contracted SEC OA to conduct a Pilot Project that establishes an accelerated planning process for rural basins. The Bennett Ranch drainage basin study was selected to implement the rural basin planning study approach.

The rural basin planning study approach differs from traditional planning studies in that only existing mapping is used (in this case 20-foot contour interval USGS mapping), concept-level design of alternatives is prepared, and budgetary opinions of improvement costs and drainage basin fees are developed. The objectives of the studies are to provide general guidance to land developers and the County until more detailed studies are completed by landowners. In addition, rural basin plans will not include the delineation of floodplains or wetlands, and will not identify and address detailed environmental issues. Finally, rural basin studies consider the Prudent Line approach as the preferred alternative whenever possible. The Prudent Line approach allows a creek to adjust through erosion and meandering to increased flows from development within a strip of land adjacent to the creek, defined by a "Prudent Line." The hydrology for rural basin planning studies is completed at the same level of detail as conventional DBPS's. Land developers can use the hydrology to delineate floodplains and design improvements based on the concept designs provided in this report.

Existing Conditions

The Bennett Ranch watershed is experiencing rapid development, and peak flows within the watershed are anticipated to increase significantly under future land use conditions. The upper third of the watershed contains a system of well-defined open channel segments with few hydraulic deficiencies. The exception is a set of failing culverts located at Meridian Road.

The middle third of the watershed contains undersized and discontinuous channel segments, undersized culverts and bridges, and all of the reported flood-related problems.

The lower third of the watershed contains continuous and adequately sized channels, one adequately sized bridge, and two undersized culvert crossings.

Hydrology

Estimated 100-year peak flows under current land use conditions is 680 cfs at Meridian Road, 1,420 cfs at Highway 24, and 1,670 cfs at Garrett Road. These flows are estimated to increase to 780 cfs, 1,820 cfs, and 2,210 cfs respectively under future land use conditions if no improvements are made within the basin.

Floodplains

Floodplains are not evaluated in this study. Land developers will be required to delineate floodplains using the hydrology in this report and more detailed mapping, and/or provide a Conditional Letter Of Map Revision (CLOMR).

Approach and Alternatives

The hydrologic model HEC-1 was used to identify and evaluate Prudent Line applicability, system deficiencies, and project alternatives. Study Analysis indicates that the Prudent Line approach is only applicable for use in the upper third of the Bennett Ranch watershed (upstream from Eastonville Road). Over one-half of the evaluated open channel reaches are deficient (25,800 feet of open channel), and nine of the ten existing crossings are deficient (the existing Falcon Highway bridge meets design criteria).

Two alternatives were developed and evaluated. The first alternative upgrades all reaches and hydraulic structures to meet DCM design criteria and/or Prudent Line criteria without providing regional detention storage. The second alternative upgrades all reaches and hydraulic structures by incorporating regional detention upstream of Eastonville Road.

Recommended Alternative and Phasing

The regional detention alternative (second alternative) is the recommended alternative for the Bennett Ranch basin. This alternative is recommended over the first alternative for the following reasons:

- It reflects the detention scenario required by the Board of County Commissioners.
- It requires smaller upgraded structures, smaller cross-sectional area of new channel segments.
- It requires construction of fewer channel check structures.
- It requires less in-stream and riparian-zone construction and associated 404 permitting in the well-established, healthy riparian channels located in the lower 1/3 of the watershed.

The cost of the recommended alternative is estimated at $7.9 million and includes Prudent Line in the upper-most reaches of the watershed, detention ponds and associated transition channel upstream from Eastonville Road, and new channel between Eastonville Road and Drake Pond. It also replaces all nine of the undersized culverts located throughout the length of the drainage way and check structures along channel reaches located between Sunnyslope Drive and the project outfall to maintain a stable channel slope. This alternative allows the existing bridge located at the Falcon Highway and a proposed new CDOT bridge crossing at Highway 24 to remain unchanged.

The following summarizes the recommended phasing of these improvements.

High Priority Improvements

The highest priority improvements are located in the middle of the watershed between Meridian Road and Drake Pond. These improvements include the detention ponds and associated transition channel located upstream of Eastonville Road and the new channel segments and box culverts located between Eastonville Road and Drake pond. The detention ponds and associated transition channel are considered high priority because of the rapidly developing basins upstream of Eastonville Road. Future condition peak flows from these developing basins need to be attenuated in order to minimize downstream impacts. The improvements between Eastonville Road and Drake Pond are considered high priority because there is an existing drainage system discontinuity in this location that causes flooding problems. Constructing these improvements will reduce peak flows and provide a continuous conveyance system through the project watershed. Replacing the failing culverts located at Meridian Road should also be a high priority because the erosion will soon undermine the roadway.

Medium Priority Improvements

Of secondary importance is the upgrading of culvert crossings located at Sunnyslope Drive and Garrett Road. The existing culverts located at these crossing are undersized and should be replaced to meet DCM design standards but are not considered a high priority because there are no reported flood-related problems at these crossings.

Low Priority Improvements

The following improvements upgrade system deficiencies to DCM standards but do not provide flood-reduction benefits and could therefore be constructed last: replacement of the Snowbrush Drive culvert, demolition of the existing berms located at the ponds just downstream from Snowbrush Drive, construction of the check structures along the existing channel located between Sunnyslope Drive and the project outfall, and purchasing of Prudent Line easement from Snowbrush Drive to Meridian Road.

1. SCOPE AND PURPOSE

El Paso County is experiencing rapid growth in areas that lack drainage basin planning studies. In an effort to produce drainage basin plans in an expedited manner and at less cost, El Paso County contracted with SEC OA to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as a watershed that will likely contain impervious areas totaling less than 15% of the land area under full build-out conditions.

El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies. The approach taken to prepare this Pilot Project differs from the approach taken to prepare traditional basin planning studies in several ways. Table 1-1 lists the major differences between a rural basin planning study scope of work and a traditional basin planning study scope.

Table 1-1 - Major Differences in Study Scopes

Rural Basin Studies will:	Rural Basin Studies will not:
• use existing mapping for project topographic information (generally USGS 7.5-minute quadrangle maps with 10 to 20-foot contour intervals). • complete HEC-1 hydrology for existing and future land use conditions. • use GIS to prepare land use and soil themes. These themes can easily be electronically modified, reducing the effort required to recalculate model parameters. • prepare concept-level design of alternatives. • prepare budgetary opinions of cost to implement alternatives. • recommend the Prudent Line Approach as preferred alternative if criteria is met. • generate basin fees.	• complete new aerial photography and contour mapping. • delineate floodplains. • delineate wetlands. • identify or address environmental issues

Issues Requiring Further Consideration

The following list presents topics and report conclusions specific to the Bennett Ranch Pilot Project that will require further analysis during the design phase of project alternatives:

- Wetlands were not delineated in this study. All improvements will require the identification of upland-wetland boundaries to determine 404 permitting requirements and/or any modifications to improvement locations.

- The Bennett Ranch basin may contain habitat or populations of Federally listed threatened or endangered species, including but not limited to the Preble's meadow jumping mouse. Developers will be responsible for complying with the Endangered Species Act.

- Groundwater issues were not evaluated in this study. High groundwater conditions may exist in portions of the Bennett Ranch basin. Developers will be responsible for addressing complications associated with high groundwater, particularly in the design of stormwater detention facilities.

- All new channels and associated check structures are designed based on a flow depth of five feet (El Paso County DCM maximum depth for 100-yr event) and estimated channel slopes based on the USGS mapping. The design assumption of flow depth of five feet should be revisited to optimize channel size when more accurate mapping is completed.

- Design of new channels will require more detailed and current contour mapping to refine sizes, locations, and slopes.

- The alternatives are based on the assumption that new channels can be excavated approximately six feet and still discharge at the watershed outfall to West Squirrel Creek. This assumption needs to be verified with survey information or refined mapping.

- Floodplains were not evaluated in this study. This study assumes that the floodplain covers half of the Prudent Line setback. Cost estimates of Prudent Line easements are based on this assumption. Delineation of the floodplain would allow refinement of the cost associated with purchasing Prudent Line easements.

- Existing utilities were not evaluated in this study. Cost estimates for relocating existing utilities were estimated as five percent of construction costs. More detailed mapping would allow for better estimates of existing utility relocations.

- Prudent Line setbacks are intended to be equal to floodplain limits when the calculated Prudent Line limit falls inside the floodplain limits. However, because floodplains were not evaluated in this study, it was assumed that the Prudent Line setbacks exceed all floodplain limits. Delineation of floodplains would allow more accurate Prudent Line setbacks.

- The peak flows presented in this study for the existing system (i.e. no upgrades to existing culverts or bridges) are affected by the estimated inadvertent storage upstream of road crossings. This storage was estimated using stage-storage-discharge relationships developed based on field observations and the existing 20-foot contour interval USGS mapping. This does not affect the accuracy of the recommended alternative because peak flows used to develop the alternatives are based on upgraded structures sized to adequately convey design flows.

2. WATERSHED CHARACTERISTICS

Introduction

The Bennett Ranch watershed is located approximately 20 miles northeast of downtown Colorado Springs. The western boundary is located two miles east of the town of Falcon. The approximately seven square-mile watershed is long, narrow, and aligned north to south. The existing development in the watershed is comprised mostly of large-lot (greater than 2.5 acres) single-family homes. Large portions of land within the watershed are currently undeveloped and used as pasturelands for grazing. Soils characteristic to the watershed are relatively permeable and are quick to erode when exposed to water.

Storm water runoff generally flows north to south through the watershed in a series of open channels to its confluence with the West Fork of Squirrel Creek. Several major roads cross the watershed including Meridian Road, Eastonville Road, Highway 24, Falcon Highway, and Garrett Road. A number of culverts under these roads have caused water to back up during large events and this has resulted in flooding problems in the middle reaches of the watershed.

Figure 2-1 shows the watershed boundary, major roads within the watershed, and project location relative to Colorado Springs.

Existing Drainage Patterns and Problems

Stormwater runoff within the watershed is conveyed north to south through a series of open channel reaches, culverts, and bridges as shown on Figure 2-2. This section describes the existing conveyance system and associated flood-related problems.

Northern Reaches

Channels located north of Eastonville Road are predominantly steeper in slope, less vegetated, and more defined than in the middle and southern reaches of the watershed. Photograph 2-1 shows a typical upper-reach channel section and Photograph 2-2 shows a typical lower-reach channel section.

There are no reported flooding-related problems within the northern reaches of the watershed. The three 48-inch diameter culverts used to convey storm water under Meridian Road are, however, failing on the downstream end as shown in Photograph 2-3.

Middle Reaches

Drainage ways located between Eastonville Road and Drake Pond are poorly defined, undersized, and discontinuous. It is in this middle portion of the watershed that most of the identified hydraulic deficiencies occur.

Conveyance problems within the watershed begin approximately ½ mile upstream from Eastonville Road at a berm constructed to divert flow from the original channel configuration. Stormwater runoff now flows south from the berm towards Eastonville Road in a poorly defined channel until entering a short segment of recently constructed trapezoidal channel. The new channel segment ends at Eastonville Road and is shown in Photograph 2-4. As shown in the photograph, there is currently no bridge or culvert to convey water across the road and water ponds on the roadway during most rainfall events.

A shallow and undersized channel conveys runoff from the downstream side of Eastonville Road to the upstream side of Orr Road. The defined channel ends at Orr Road and stormwater flows overland (Photograph 2-5) to three obstacles: an abandoned railroad embankment, Highway 24, and Blue Gill Drive. One bridge and eight culverts convey water under the rail line, Highway 24, and Blue Gill Drive. The structures were constructed by different entities at different times and each structure has a unique capacity and alignment. Flooding of property is reported to occur frequently near Blue Gill Drive. Figure 2-2 shows the nine structures and the area of flooding.

Southern Reaches

Downstream from Blue Gill Drive stormwater converges and is routed south in a shallow swale. This swale conveys stormwater past a large privately owned pond (Drake Pond) and south to Falcon Highway. A new bridge sized for the 100-year event (BDG-01) conveys flows under the Falcon Highway to Sunnyslope Drive. A 36-inch diameter culvert (CUL-02) conveys flow under Sunnyslope drive. Downstream from CUL-02, the channel becomes less well defined as shown in Photograph 2-6. The channel continues south past one more road crossing, Garrett Road (CUL-01), to the lower watershed boundary. There are no reported flood-related problems in the southern reaches of the watershed. Culvert crossings and channel segments lack the capacity to convey flows from the future conditions 100-year event. (See Deficiency Identification Section).

Land Use

Figure 2-3 presents existing land use conditions within the project watershed. Approximately half of the basin is currently used for pasturelands or is undeveloped. The remaining portion of the basin is comprised of large-lot single-family homes.

Figure 2-4 presents likely future land use conditions within the project watershed[1]. A comparison of the two land use figures (Existing and Future) shows that the majority of the land use changes are expected to occur between Meridian Road and Highway 24. Most of the land between these roads is currently undeveloped and used for agriculture. It is anticipated that with the development of the Bennett Ranch, Woodmen Hills, and Meridian Subdivisions, nearly all of the land in this area will be developed into medium to high-density single-family homes. In addition, it is anticipated that the basin will include some commercial and industrial development, two highly impervious land uses that do not currently exist within the watershed. Most of the northern 1/3 (upstream) and southern (downstream) portions of the watershed are to be used for large-lot single family homes.

[1] The future land use scenario was updated in February 2001 to reflect recent development changes within the project watershed. All study figures, peak flows, analysis, and alternatives reflect this updated scenario.

Soils

Figure 2-5 presents the hydrologic soil groups located within the watershed. The soil groups are based on the United States Department of Agriculture Soil Survey of El Paso County[2]. The watershed is comprised of predominantly low-runoff potential soils (Groups A and B). Group A hydrologic soils will produce less rainfall induced runoff than Group D soils. There are no Group C hydrologic soils within the project watershed.

The watershed soils were discussed during an agency coordination meeting held on January 30, 2001. The Natural Resource Conservation Service representative at the meeting recommended modifying the HEC-1 model to reflect the saturated soil conditions found adjacent to Highway 24. The USCOE and Colorado Geological Survey representatives concurred. The HEC-1 model initial infiltration rates have been reduced to 0.5 inches in subcatchments 130, 140, 150, 160, 170, and 180 (Figure 3-1) to simulate this area of wet soil conditions. This is less than half of the HEC-1 default infiltration rates.

[2] US Department of Agriculture Soil Conservation Service, 1974, *Soil Survey of El Paso County Area, Colorado.*

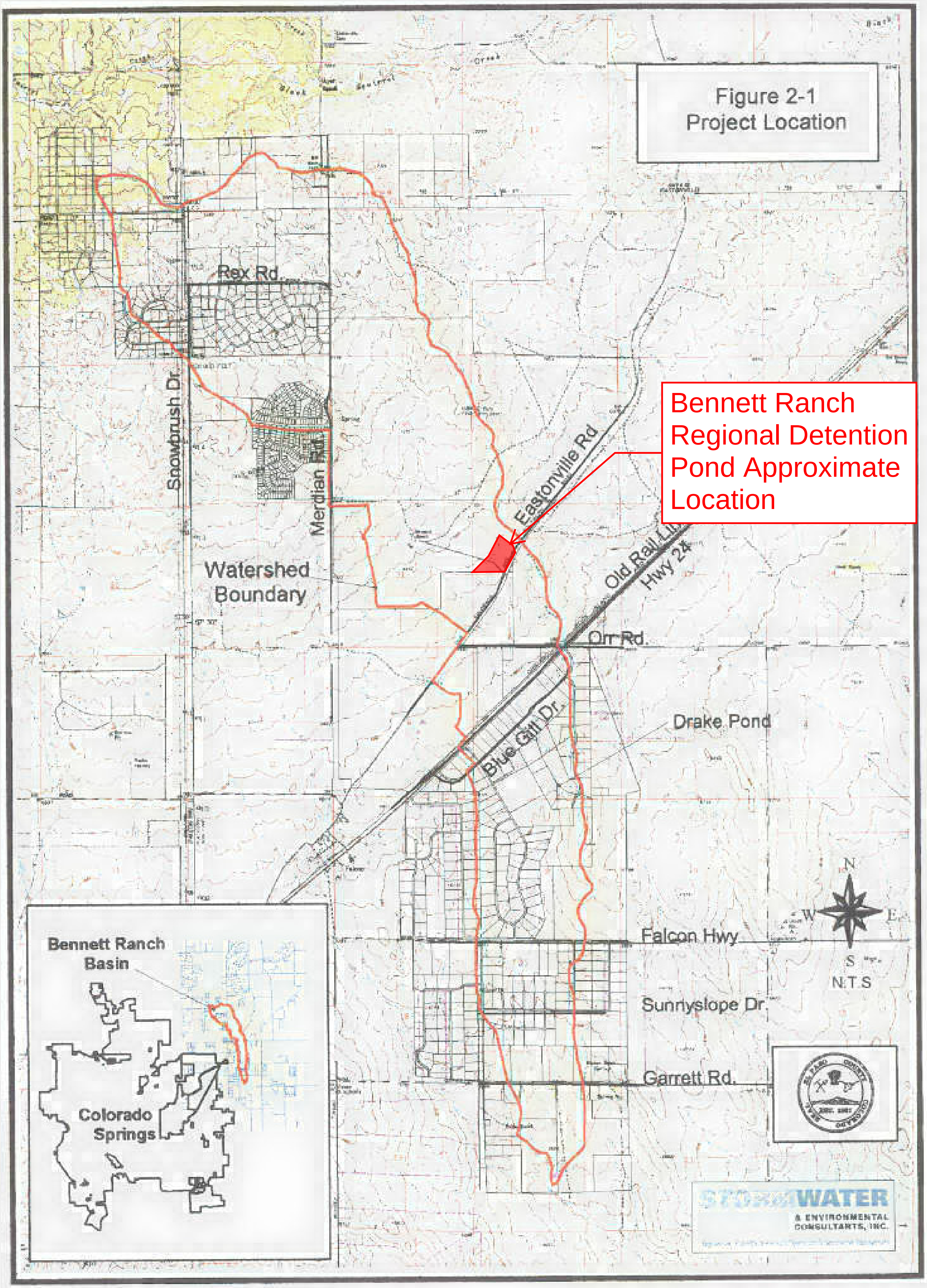


Figure 2-1
Project Location
Bennett Ranch Regional Detention Pond Approximate Location
Rex Rd.
Snowbrush Dr.
Merdian Rd.
Watershed Boundary
Eastonville Rd
Old Rail Li
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
S
W
E
N.T.S
Bennett Ranch Basin
Colorado Springs
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.

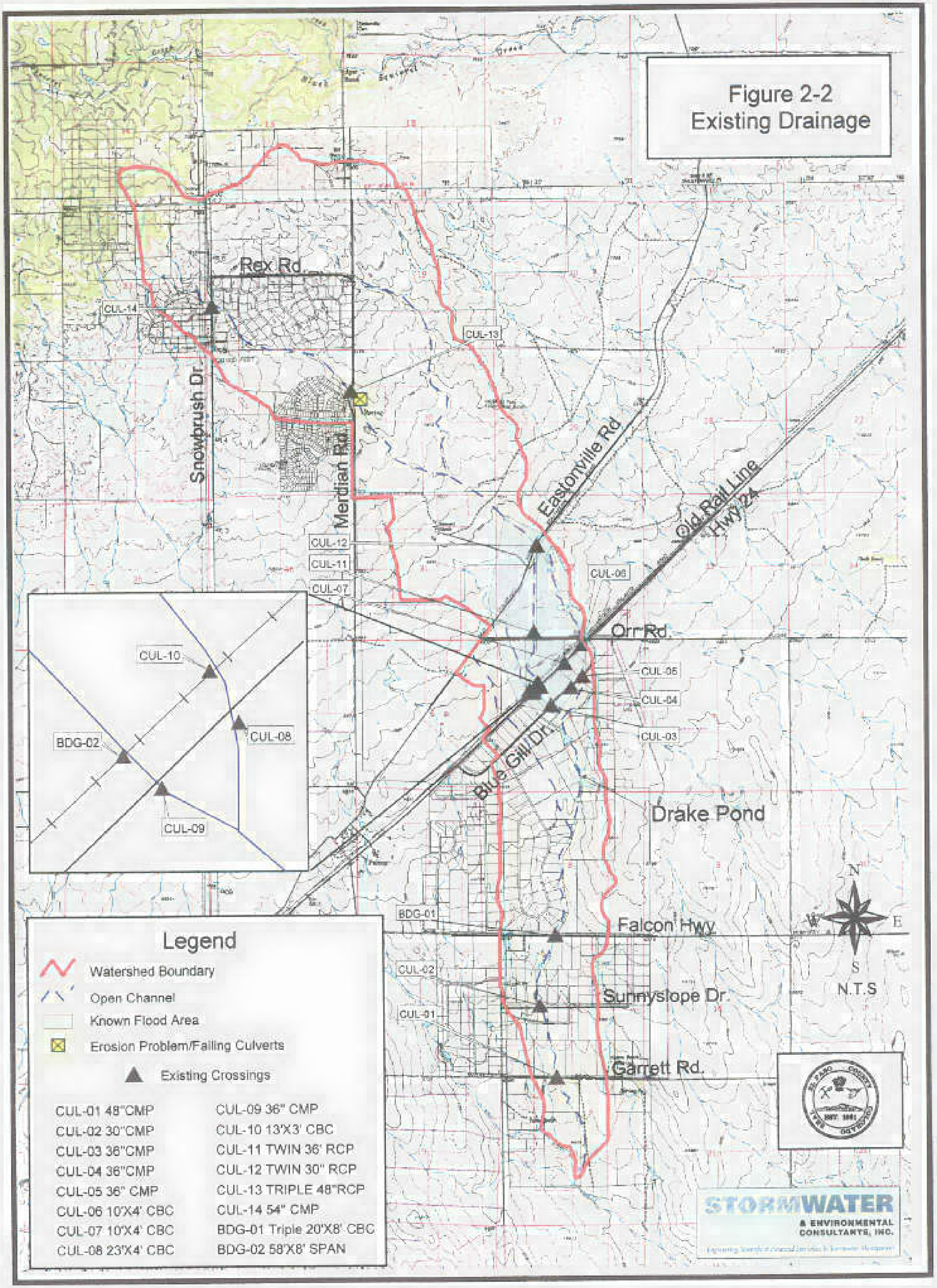
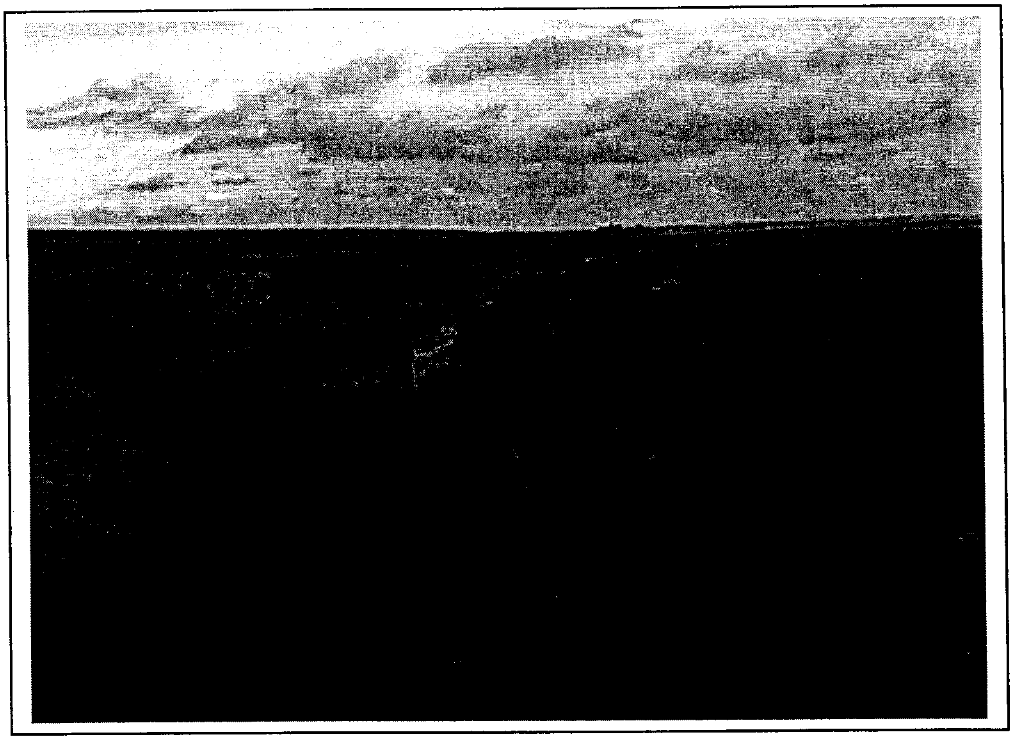
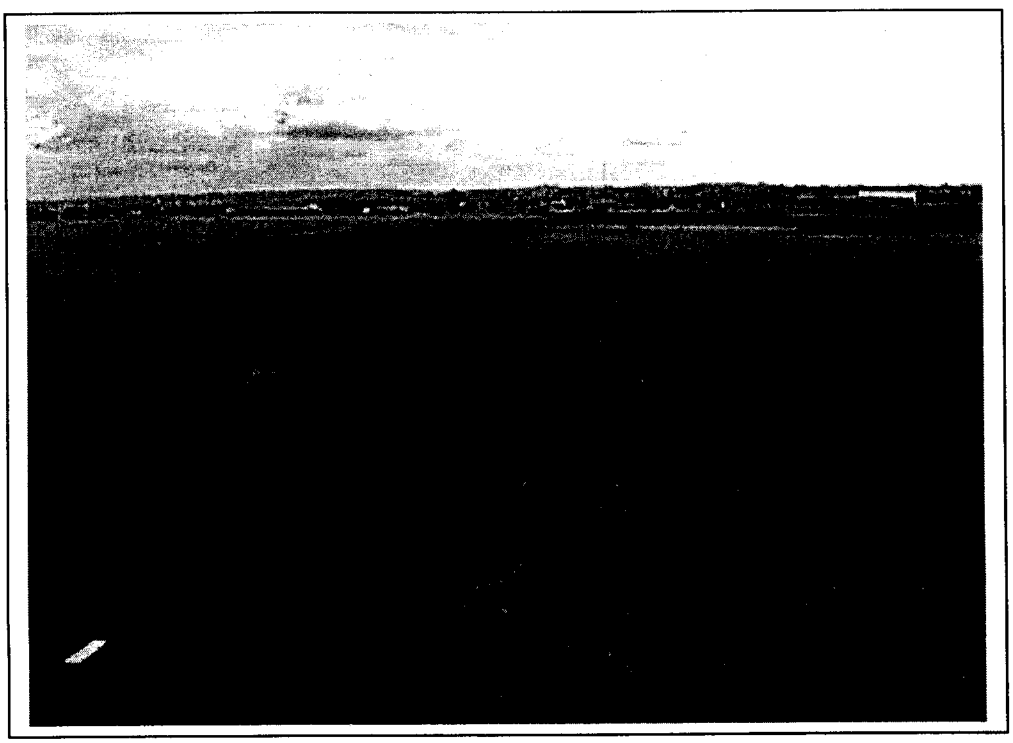


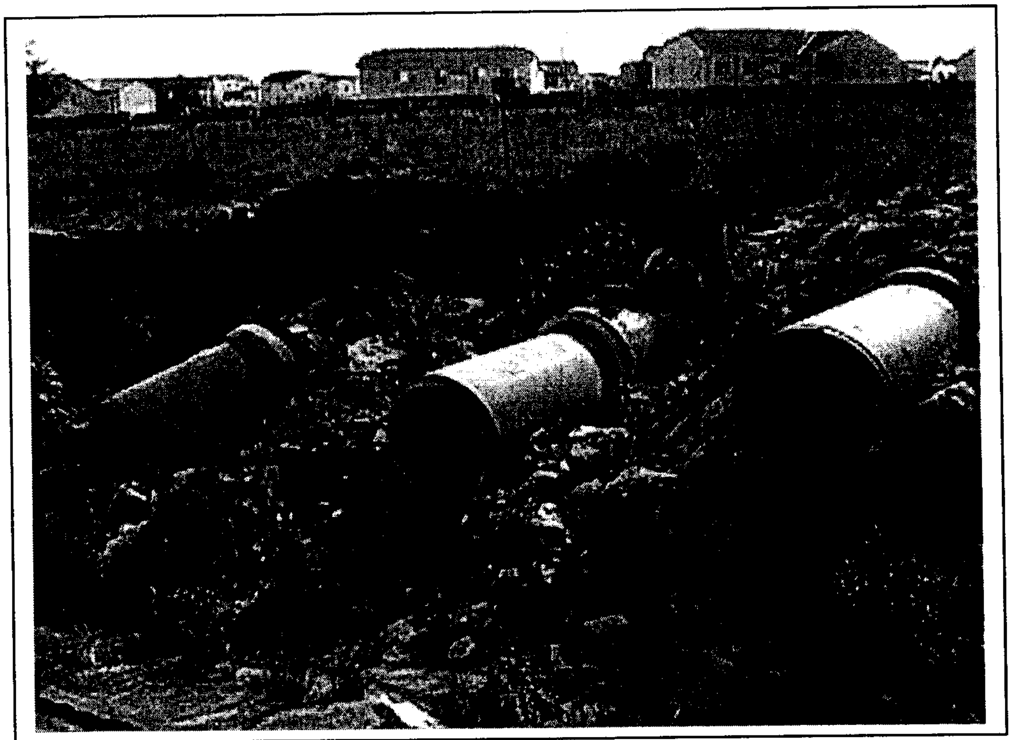
Figure 2-2
Existing Drainage



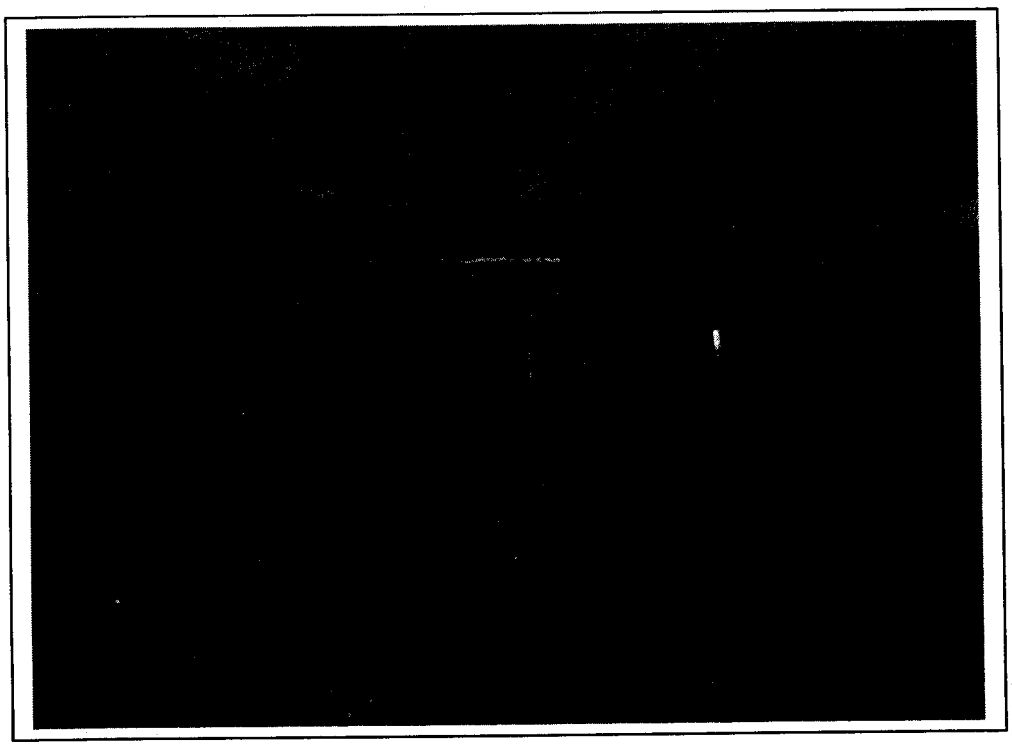
Photograph 2-1:
Looking downstream from Meridian Road at a channel section typical of the upper reaches of the watershed.



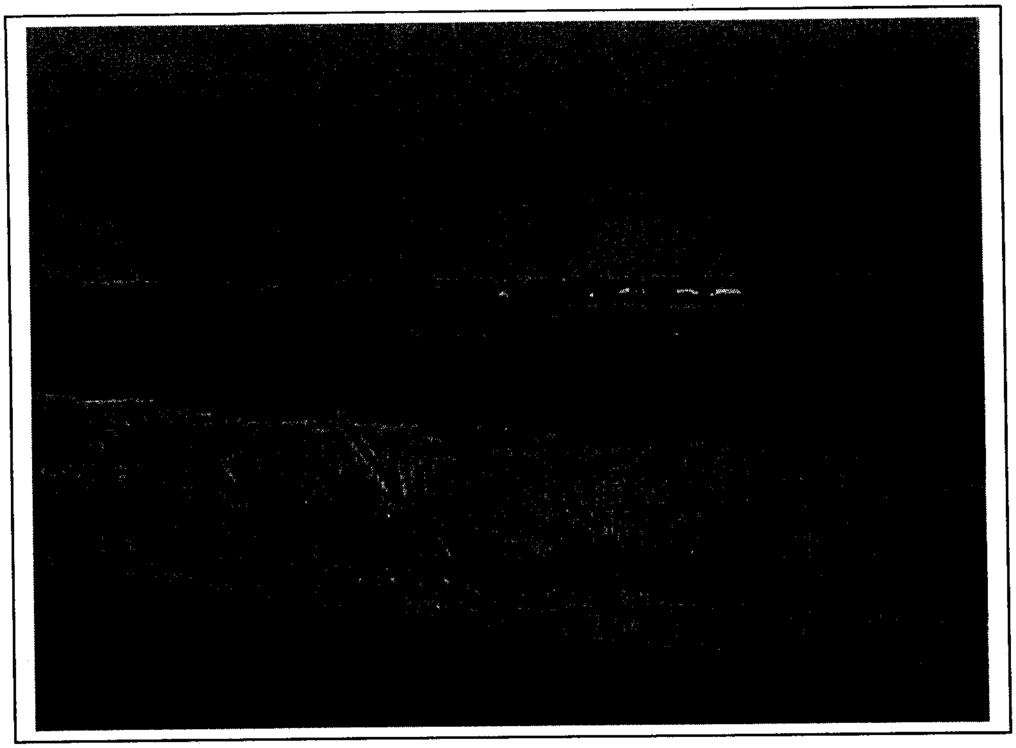
Photograph 2-2:
Looking downstream from Falcon Highway at a channel section typical of the lower reaches of the watershed.



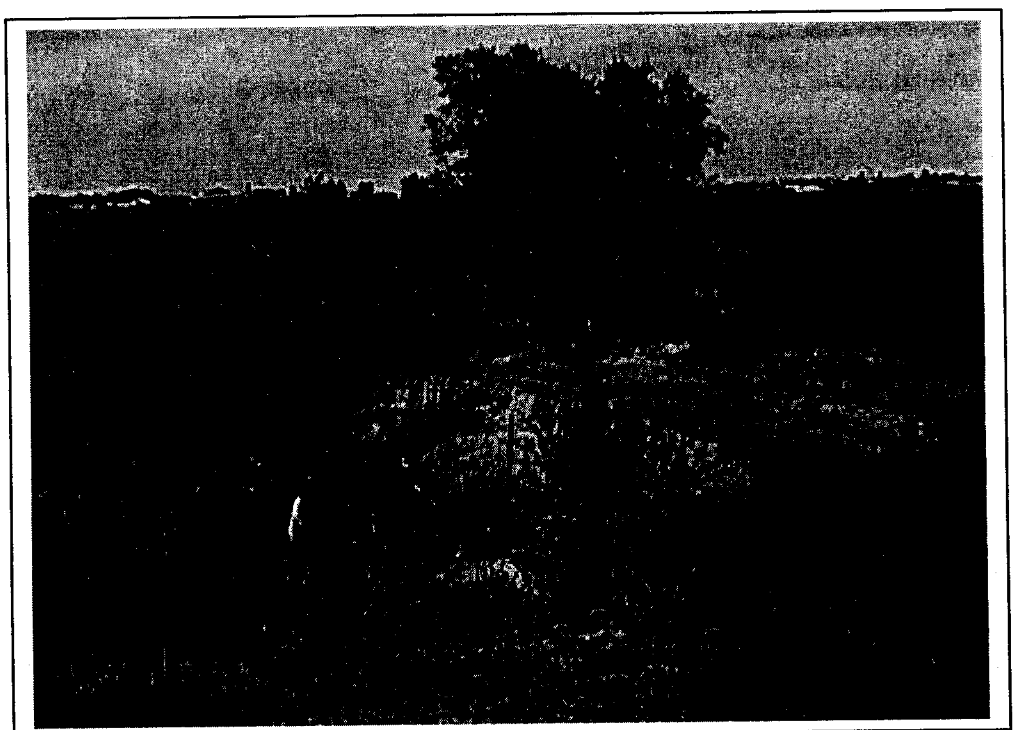
Photograph 2-3:
Downstream ends of failing 48 inch-diameter culverts under Meridian Road.



Photograph 2-4:
Looking upstream at the constructed channel segment from Eastonville Road. There is currently no culvert or bridge under the road to convey the channel flows.



Photograph 2-5:
Looking downstream from Orr Road at undefined drainage way. Highway 24 and the abandoned railroad embankment are on the horizon.



Photograph 2-6:
Looking upstream from Garrett Road towards Sunnyslope Drive. Shows poorly defined channel characteristic of the downstream reaches.

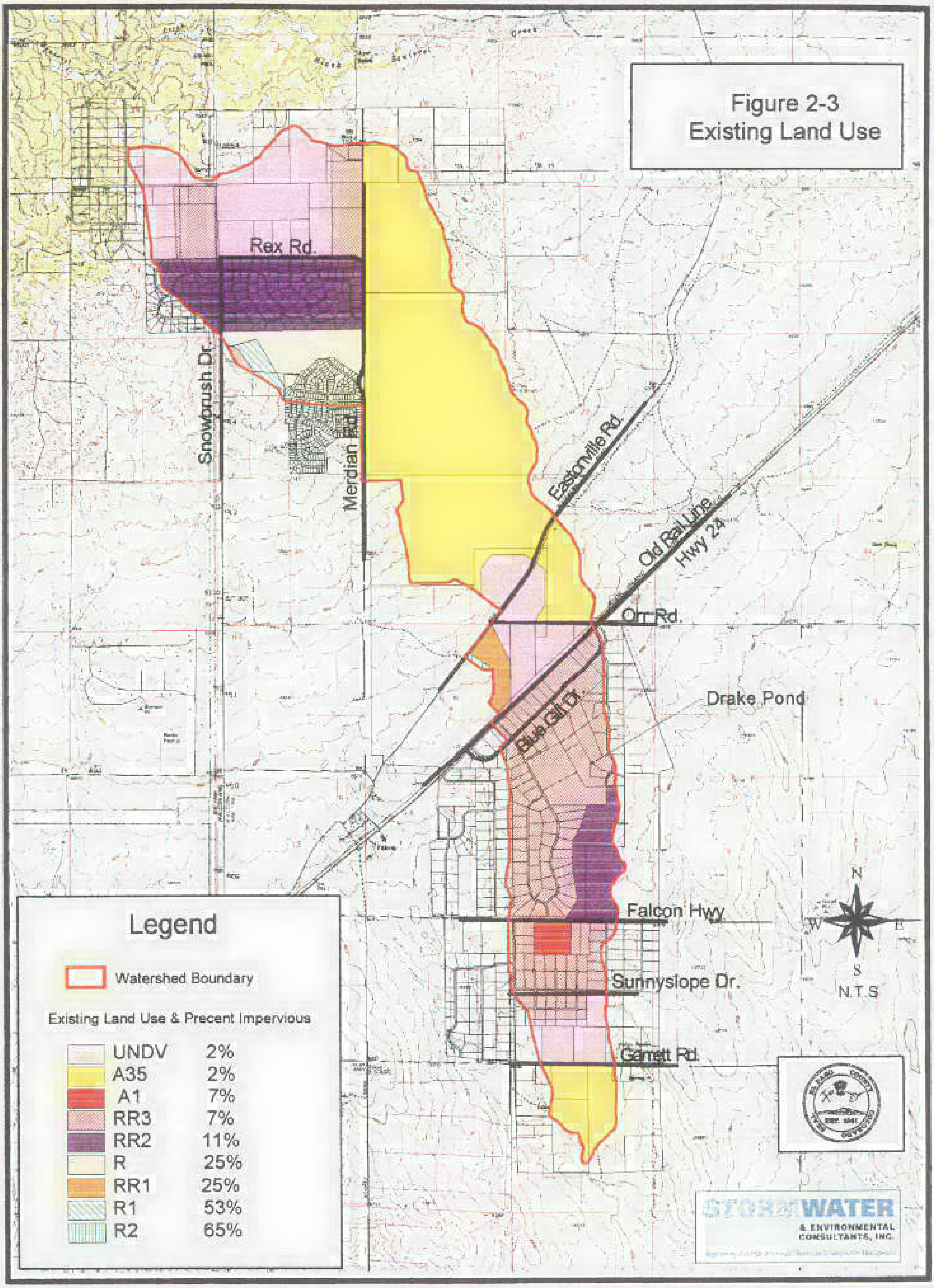


Figure 2-3
Existing Land Use
Rex Rd.
Snowbrush Dr.
Merdian Rd.
Eastonville Rd.
Old Rail Line
Hwy 24
Orr Rd.
Drake Pond
Blue Gill Dr.
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
W
E
S
N.T.S
Legend
Watershed Boundary
Existing Land Use & Precent Impervious
UNDV 2%
A35 2%
A1 7%
RR3 7%
RR2 11%
R 25%
RR1 25%
R1 53%
R2 65%
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.

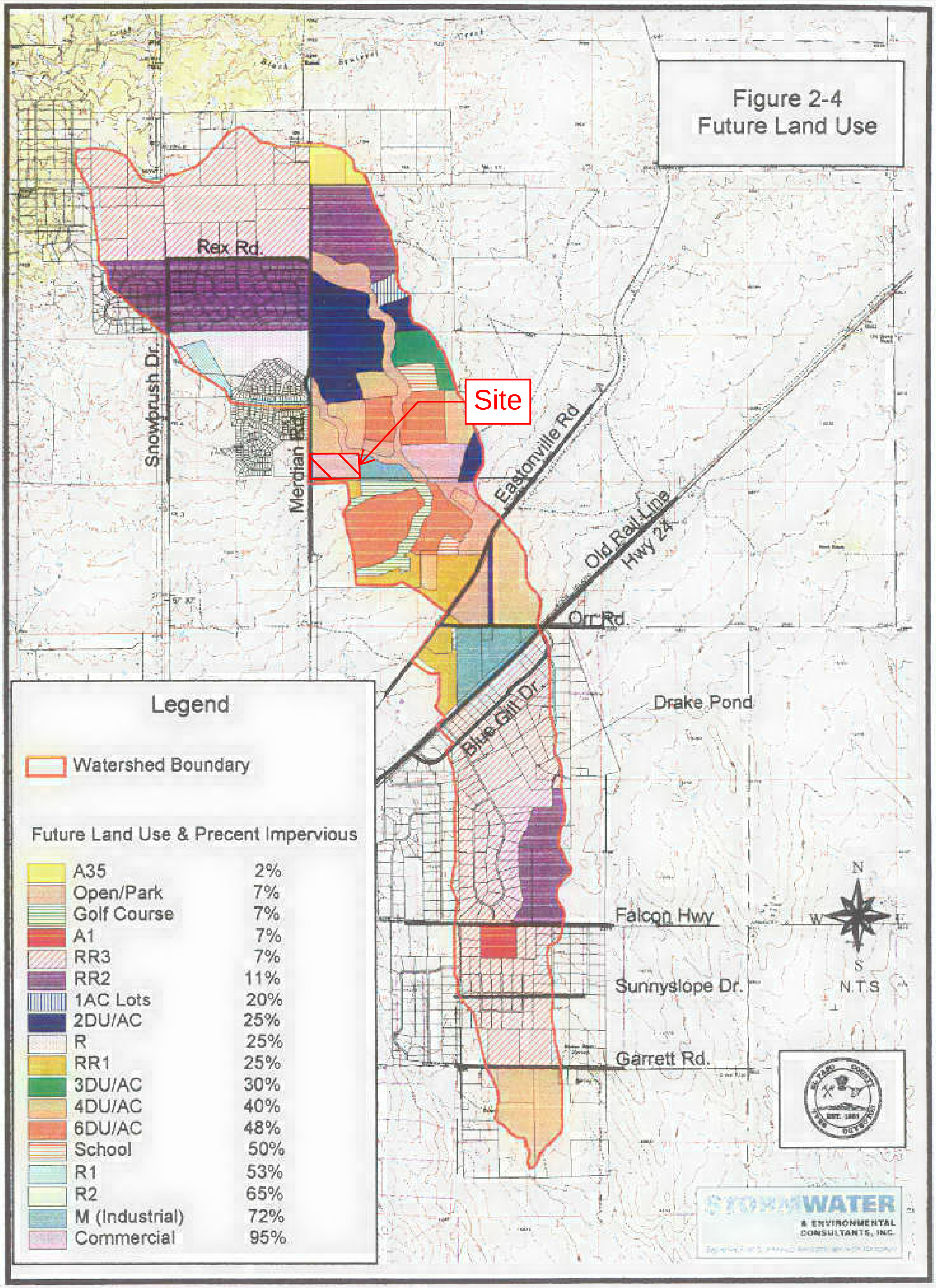


Figure 2-4
Future Land Use
Site
Rex Rd.
Snowbrush Dr.
Meridian Rd
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
W
E
S
N.T.S
Legend
Watershed Boundary
Future Land Use & Precent Impervious
A35 2%
Open/Park 7%
Golf Course 7%
A1 7%
RR3 7%
RR2 11%
1AC Lots 20%
2DU/AC 25%
R 25%
RR1 25%
3DU/AC 30%
4DU/AC 40%
6DU/AC 48%
School 50%
R1 53%
R2 65%
M (Industrial) 72%
Commercial 95%
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.

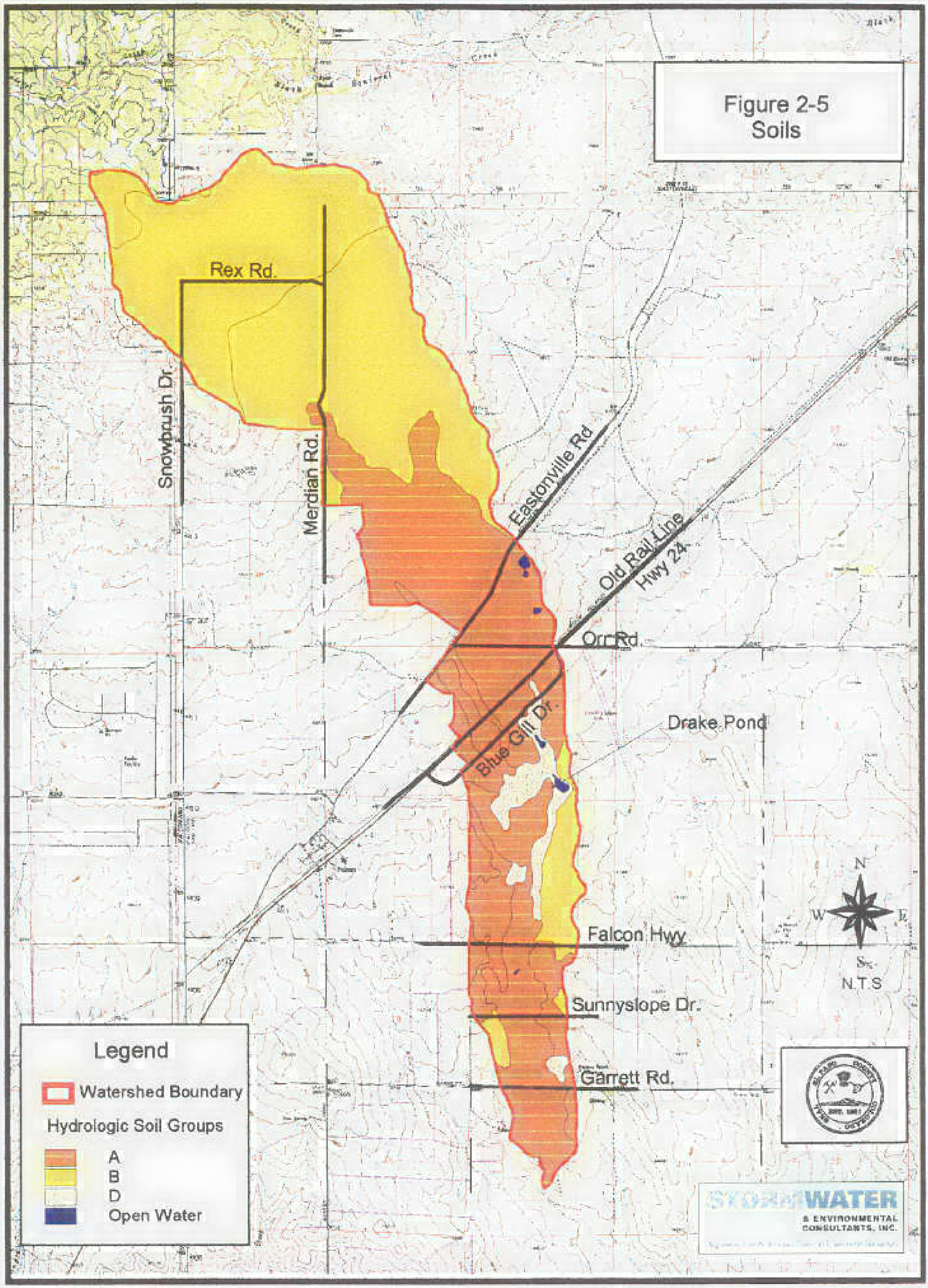


Figure 2-5
Soils
Rex Rd.
Snowbrush Dr.
Merdian Rd.
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
W
E
S
N.T.S
Legend
Watershed Boundary
Hydrologic Soil Groups
A
B
D
Open Water
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.

3. HYDROLOGIC MODELING AND PEAK FLOWS

Introduction

The US Army Corps of Engineers rainfall/runoff model HEC-1 was used to develop runoff hydrographs and peak flows at selected locations within the Bennett Ranch project watershed. This section summarizes how the study models were developed, presents model results, and explains the comparisons used to verify the model results. The Bennett Ranch Pilot Project Technical Appendices (separate document) presents these topics in more detail.

Model Parameters

HEC-1 develops runoff hydrographs based on user input parameters that define basin, routing, and rainfall characteristics. Table 3-1 lists the data source used to develop each of the following input parameters.

Basin Parameters

The USGS 7.5-minute quadrangle maps were used to delineate the approximately 7 square-mile project watershed into 27 subcatchments based on topography. The subcatchment bounds were refined based on land use conditions, structure locations, and desired hydrograph output locations. HEC-1 uses the parameters of Travel Time and SCS Curve Numbers to define the runoff potential for each of the subcatchments. The USGS 7.5-minute quadrangle maps were used to define Travel Times for each of the model subcatchments. The SCS Curve Numbers were developed based on El Paso County DCM guidance criteria and the existing and future land use scenarios presented in Figures 2-3 and 2-4. Figure 3-1 shows the project watershed and model subcatchments.

Note that three of the subcatchments (250, 260, and 270) define land that is hydrologically disconnected from the remainder of the watershed. This area of land is located in the southern end of the Bennett Ranch watershed and discharges runoff directly to the West Fork of Squirrel Creek. Peak flows are reported for these three subcatchments but no further analysis is conducted on this area.

Routing Parameters

HEC-1 routes runoff hydrographs through a series of independent open channel segments, culverts, or bridges. These routing elements are defined by input parameters based on slope, cross section, Manning roughness coefficients, and elevation versus discharge relationships.

Forty different routing elements were developed to simulate conveyance of the storm water runoff hydrographs through the watershed. The USGS 7.5-minute quadrangle maps, field observations, and aerial photographs were used to define the input parameters for these routing elements. Figure 3-2 presents a schematic of the HEC-1 routing system[3] used to simulate conveyance of stormwater through the Bennett Ranch watershed.

[3] The HEC-1 model schematic used to simulate and evaluate the detention alternative is presented in the Technical Appendices.

Rainfall Parameters

The El Paso County DCM requires an evaluation of both the 2-hour and 24-hour rainfall events to determine the design storm for the particular study basin. The standard SCS cumulative rainfall distribution presented in the El Paso County Drainage Criteria Manual was used to define the model rainfall events. An evaluation of both events determined that the 24-hour event defines the design storm for the Bennett Ranch watershed. The SCS unit hydrograph method with a computational time step of 5 minutes was used for all model runs.

Table 3-1 - Model Input Parameters

Parameter	Data Source
Land Use: Existing and Future Conditions	El Paso County, URS Corporation as representatives for the Bennett Ranch and Meridian Subdivision developers
SCS Curve Numbers	El Paso County DCM based on land use designations and hydrologic soil groups
Hydrologic Soils	SCS Soil Survey of El Paso County
Travel Time: distance and slope	USGS 20-foot contour-interval Falcon, Falcon NW, Eastonville, and Black Forest 7.5-minute quadrangle maps
Culvert/Bridge stage discharge relationships	Field observations, aerial photographs, USGS quadrangle maps
Rainfall: 5-year, 24-hour 100-year, 24-hour	NOAA Atlas 2, Volume III and SCS distribution from El Paso County DCM
Manning's n-value	Field observations and aerial photographs
Structure/channel Cross Sections	Field observations

Model Results

The following table (Table 3-2) presents model results as peak flows at major crossings within the project watershed. Model results are presented for both the 5-year and 100-year, 24-hour rainfall events.

The first four columns in the table present peak flows in cubic feet per second based on the capacities and associated backwater effects of the existing culverts and bridges within the watershed. The first and third columns present flow estimates resulting from existing land use conditions.

The second and fourth columns present flow estimates that will likely result under future land use conditions. Comparison of the estimated peak flows from existing land use conditions to corresponding future land use condition flows indicate that flows may increase significantly in the future.

The last column in the table (100-yr DCM) presents peak flows resulting from upgrading all of the culverts and bridges to comply with DCM conveyance capacities. Comparison of this column to the 100-year future land use conditions column shows that the existing culverts and bridges are undersized and provide significant flood peak attenuation.

Peak flows within the watershed are shown in Figure 3-3. Results are also shown graphically in Figure 3-4 as peak flow by stream length. The Bennett Ranch Pilot Project Technical Appendices present the HEC-1 model input and output files.

Table 3-2 - HEC-1 Model Results: Peak Flows at Major Crossings

	Event Peak Flows (cfs)[4]				
Location	5-yr Existing[1]	5-yr Future[2]	100-yr Existing[1]	100-yr Future[2]	100-yr DCM[3]
Snowbrush Drive	29	53	166	223	223
Meridian Road	130	190	680	780	840
Eastonville Road	300	415	1570	1860	1930
Judge Orr Road	300	415	1560	1850	1910
Blue Gill/Hwy 24	300	415	1420	1820	1950
Falcon Highway	340	490	1670	2250	2550
Sunnyslope Drive	335	490	1680	2250	2550
Garrett Road	330	485	1670	2210	2545
Areas Outside Main System:					
Sunnyslope Drive (Subcatchment 250)	-	-	9	9	9
Garrett Road (Subcatchments 250 and 260)	1	3	20	28	28

1 Existing: land use condition and existing conveyance system

2 Future: land use conditions and existing conveyance system

3 DCM: future land use conditions, upgraded conveyance system to El Paso County DCM standards

4 Flows are rounded to the nearest 10 cfs.

Model Verification

The Bennett Ranch Pilot Project HEC-1 model was verified by comparing it to three existing studies: 1) a HEC-1 model prepared by the URS Corporation to simulate development of the Merdian Ranch Subdivision in the Bennett Ranch watershed; 2) a Conceptual Drainage Report completed by URS Corporation for the Colorado Department of Transportation; and 3) a planning study completed by Muller Engineering for El Paso County. All three compare favorably. The remainder of this section summarizes the comparisons.

URS Meridian Subdivision Model

The URS Corporation developed an HEC-1 model in the spring of 2000 as part of the Meridian Ranch Subdivision Master Development Drainage Plan. The URS model simulates a portion of the Bennett Ranch watershed centrally located between Meridian Road and Eastonville Road. Model networks allow comparisons at both Stapleton Road and Eastonville Road. A comparison of results from both models show, even though the models were developed independently, that both existing and future conditions 100-year peak flows are within 2% and 18% of each other.

URS HWY 24 Report

The URS Corporation prepared a Conceptual Drainage Report[4] to support the Colorado Department of Transportation upgrades to Highway 24 between the towns of Falcon and Peyton. The report was prepared in September 1999 and presents a 100-year peak flow estimate of 1,650 cfs at the Highway 24 bridge (Bennett Ranch Pilot Project CUL-08). The Pilot Project estimated a peak flow of 1,820 cfs at this location. The difference in peak flow estimates is likely due to the following reasons:

1) URS performed the hydrologic analysis using SCS curve numbers based on partially developed conditions using SCS curve numbers ranging from 62 to 74.
2) The Pilot Project curve numbers reflect fully developed land and range from 69 to 71.
3) The URS analysis did not consider inadvertent detention within the watershed and approximately 600 cfs of additional runoff from the watershed was routed to two other existing culverts along Highway 24.

Muller Study

Muller Engineering prepared a planning study in 1986 for El Paso County[5]. The study presents average peak discharge rates derived for rural basins located in El Paso County. Muller Engineering derived the discharge curves based on hydrologic data assembled from existing master drainage planning studies for watersheds located in El Paso County. Peak flows from the Pilot Project compare within 6% of the average peak flow derived from the Muller study curves.

---

[4] URS Corporation. September 1999. *SH: 24: Falcon to Peyton Conceptual Drainage Report*

[5] Muller Engineering. 1986. *Drainage Data Base, El Paso County Drainage Basin Identification and Fee Estimation Report.*

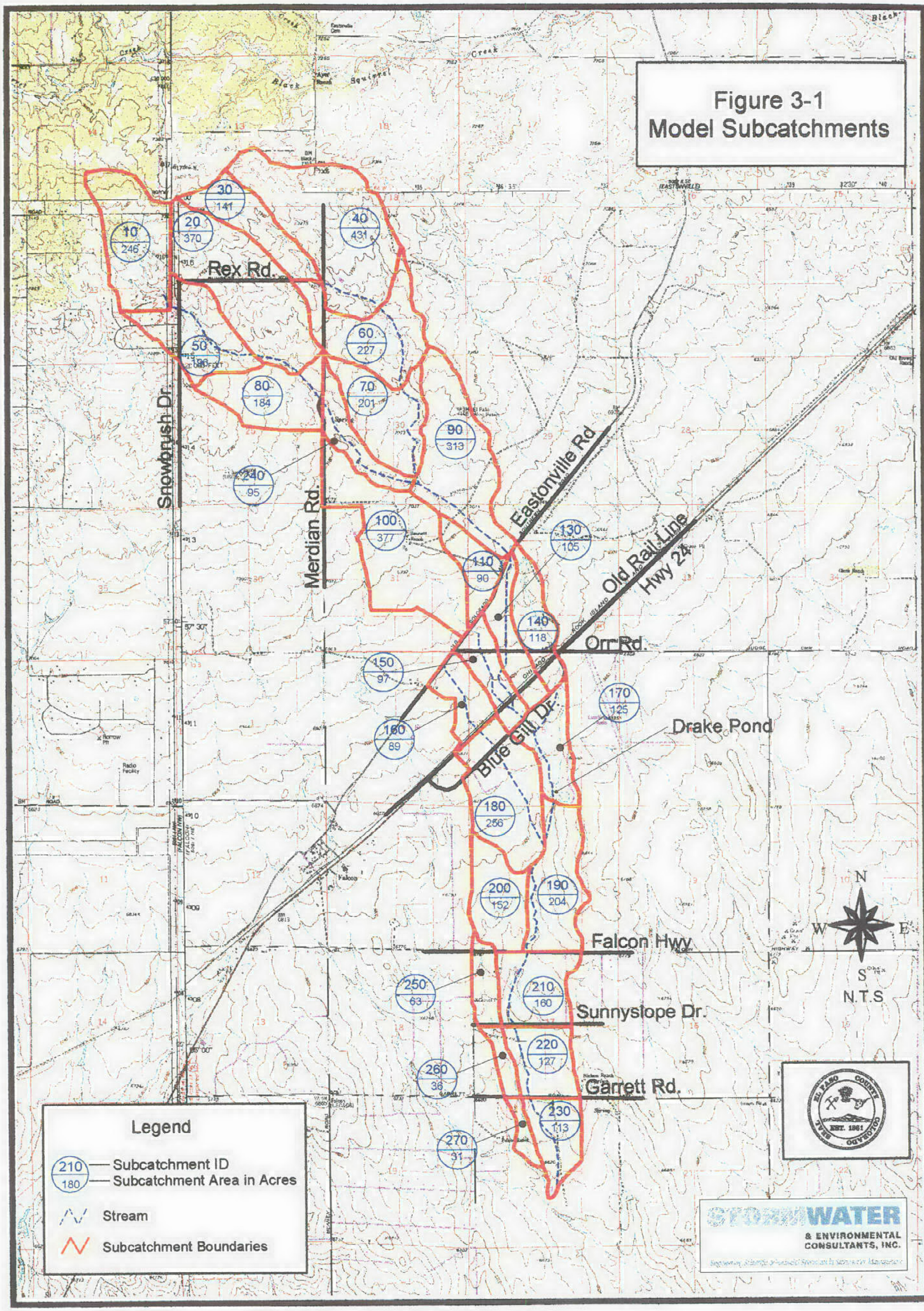
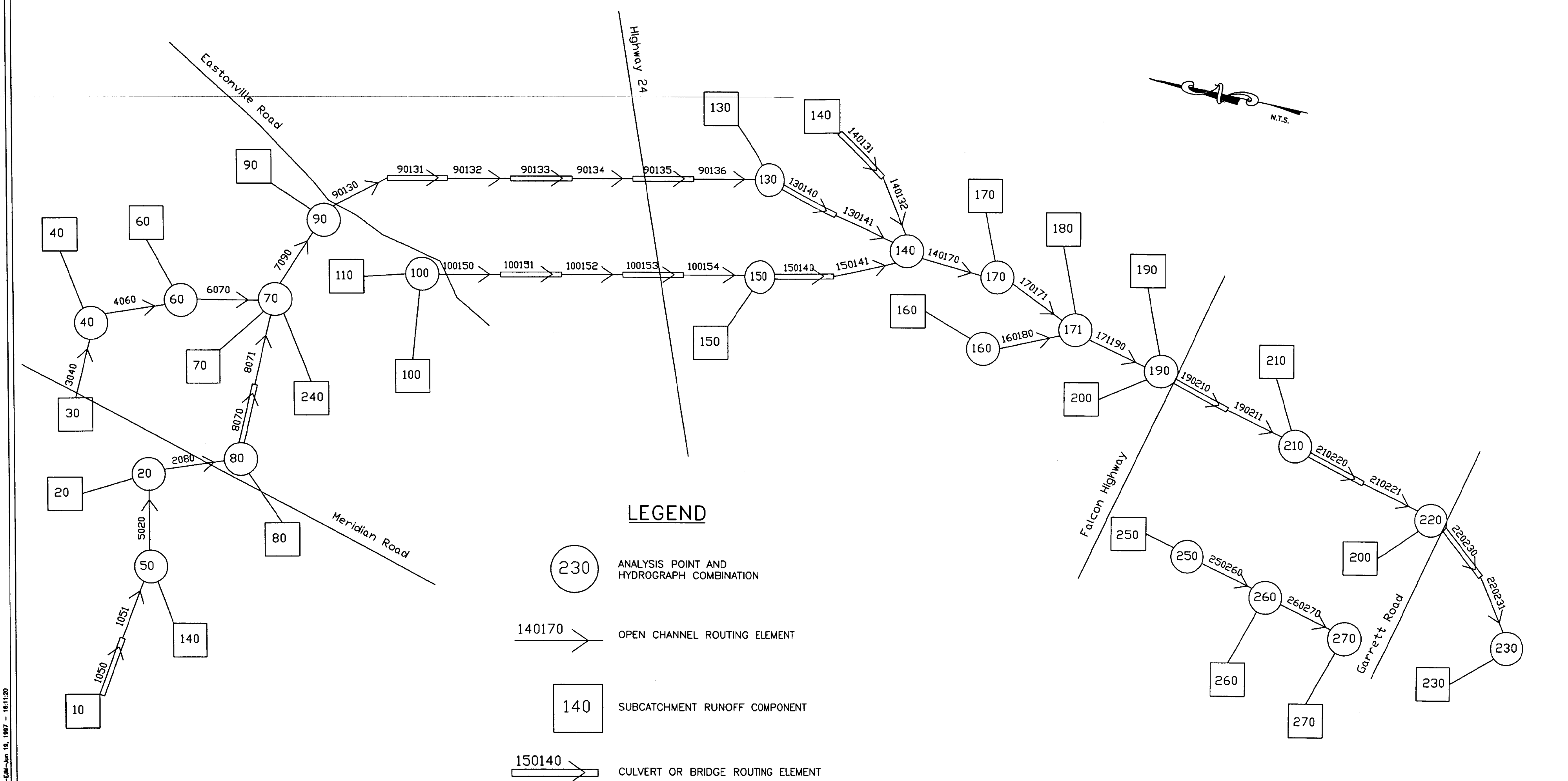


Figure 3-1
Model Subcatchments
Rex Rd.
Snowbrush Dr.
Merdian Rd.
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
10 246
20 370
30 141
40 431
50 198
60 227
70 201
80 184
90 318
100 377
110 90
130 105
140 118
150 97
160 89
170 125
180 256
190 204
200 152
210 160
220 127
230 113
240 95
250 63
260 36
270 31
N
E
S
W
N.T.S
Legend
210 Subcatchment ID
180 Subcatchment Area in Acres
Stream
Subcatchment Boundaries
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.



NOTE: SUBCATCHMENTS 250, 260, & 270 REPRESENT AN AREA OF LAND WITHIN THE BENNETT RANCH WATERSHED THAT DOES NOT CONTRIBUTE STORMWATER RUNNOFF TO THE MAIN DRAINAGEWAY SYSTEM. A SEPARATE HEC-1 MODEL SIMULATES THIS AREA.

JOB#-_ FILENAME.DWG DATE CADD OPER.
C:\ADCADD\CIVIL\P\1852\DWG\18520100-EJM-Jun 19, 1997 - 16:11:20

STORMWATER & ENVIRONMENTAL CONSULTANTS, INC.
5200 DTC PARKWAY SUITE 530
GREENWOOD VILLAGE, CO 80111

DESIGNED KKB DATE 11-2000
DRAWN KKB DATE 11-2000
CHECKED DATE
REVISED DATE

EL PASO COUNTY

BENNETT RANCH PILOT PROJECT

EXISTING CONDITIONS HEC-1 MODEL CONNECTIVITY

FIGURE 3-2

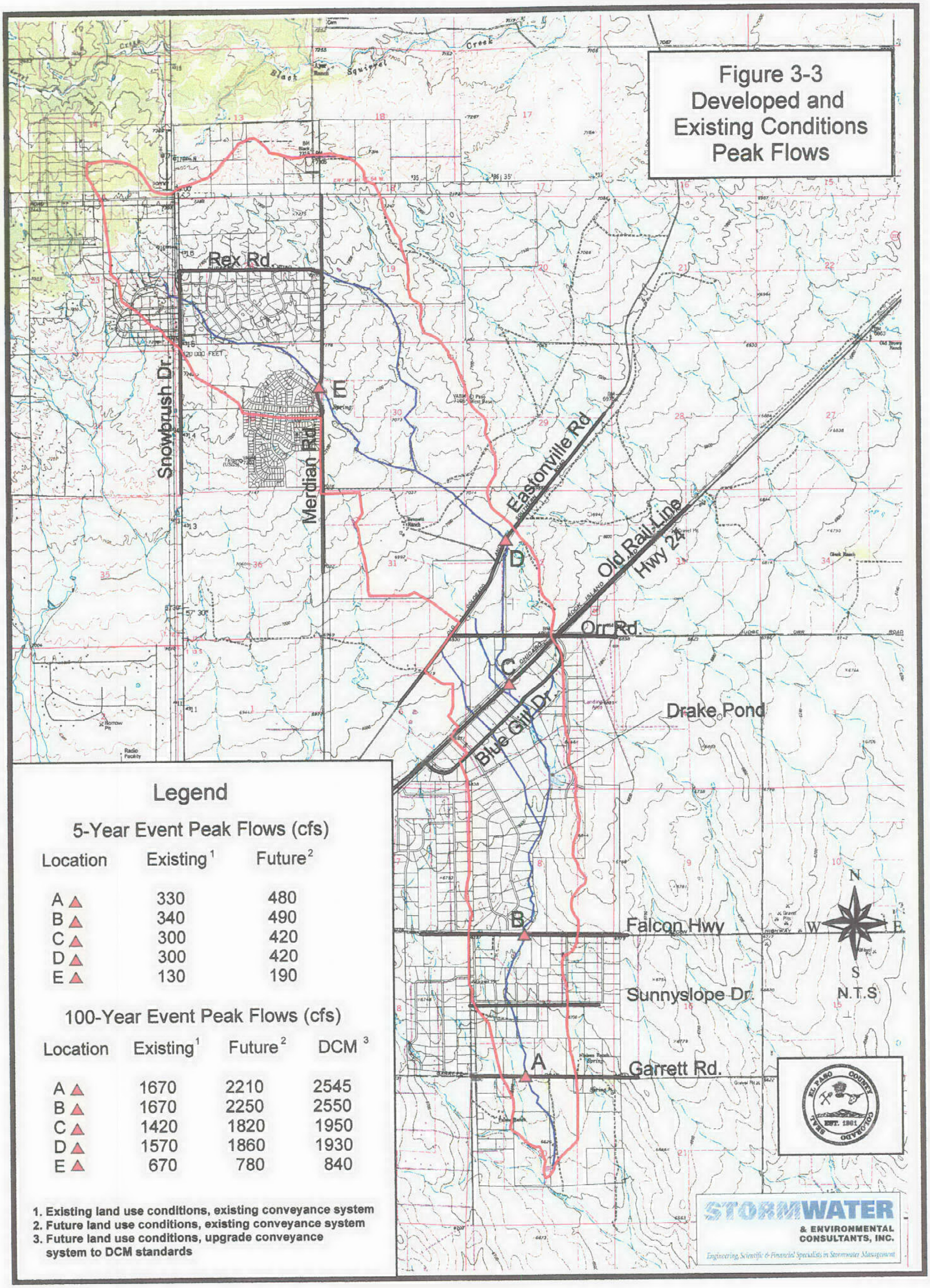


Figure 3-3
Developed and Existing Conditions Peak Flows

Legend

5-Year Event Peak Flows (cfs)

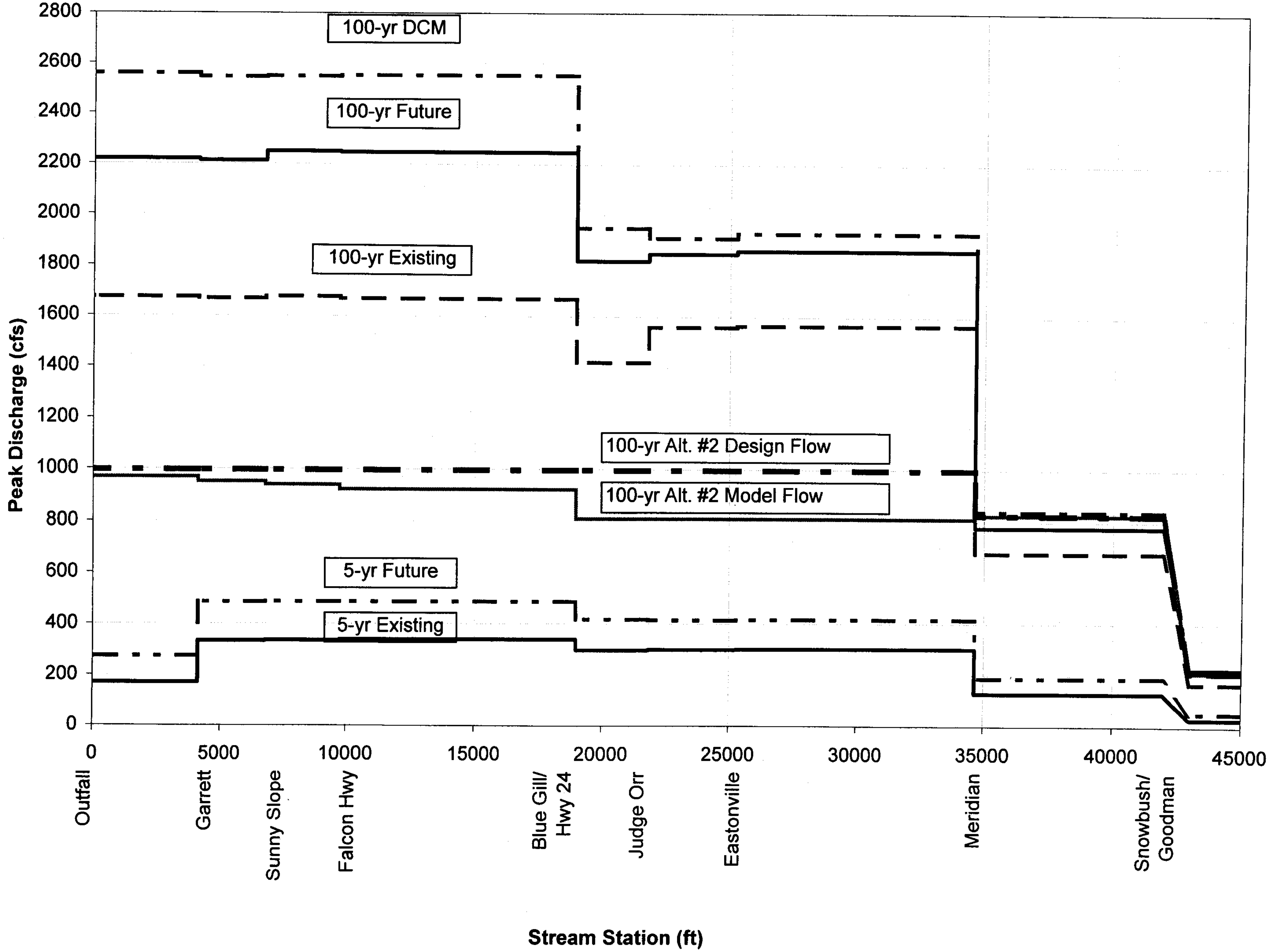
Location	Existing[1]	Future[2]
A ▲	330	480
B ▲	340	490
C ▲	300	420
D ▲	300	420
E ▲	130	190

100-Year Event Peak Flows (cfs)

Location	Existing[1]	Future[2]	DCM[3]
A ▲	1670	2210	2545
B ▲	1670	2250	2550
C ▲	1420	1820	1950
D ▲	1570	1860	1930
E ▲	670	780	840

1. Existing land use conditions, existing conveyance system
2. Future land use conditions, existing conveyance system
3. Future land use conditions, upgrade conveyance system to DCM standards

Figure 3-4
HEC-1 Model Results Peak Flows at Major Crossings



4. PRUDENT LINE

Definition

The Prudent Line approach is an alternative approach to traditional channel improvements. The approach allows a creek to adjust through erosion and meandering to increased flows from lower density development by constructing a limited number of grade control structures and providing a strip of land adjacent to the creek, defined by a "Prudent Line", within which the stream is allowed to move naturally over time. Limited bank stabilization would also be implemented in places where erosion may occur such as on the outside of bends. If future erosion would threaten land beyond the Prudent Line, the County would have the responsibility to stabilize the erosion.

The Prudent Line setback is protected with an easement, similar to a floodplain easement, where development is not allowed and maintenance access is provided. This approach is illustrated in Figure 4-1. The land in the Prudent Line setback can be owned by individual homeowners, by a Homeowners' Association, or can be land dedicated to the County. Lots in the medium density areas (between 0.5 and 2.5 acres) are probably too small for the Prudent Line land to be included in the lot. The larger lots (2.5 acres and greater), however, are large enough that the setback can be included. With the Prudent Line approach, fewer channel stabilization measures are used than in drainages with conventional channel improvements. In most cases, the Prudent Line approach is less costly than the conventional approach. More land is required for the Prudent Line approach and the cost is therefore dependent on land costs.

Table 4-1 presents criteria defining applicability of the Prudent Line approach as outlined in the new addendum to the El Paso County DCM. The Prudent Line approach is the recommended alternative for all rural basins unless the watershed characteristics preclude its use. For further documentation and development policy regarding the Prudent Line approach, see the El Paso County DCM.

Applicability

As presented in Table 4-1, Prudent Line applicability is based on intensity of tributary development and existing channel capacity.

The following process was used to determine Prudent Line applicability within the Bennett Ranch basin:

1) The cumulative percent of impervious land area (based on the Future Land Use scenario presented in Figure 2-4) was calculated along the main channel reaches. All segments located downstream from land having greater than 20% cumulative impervious surface cover were identified as not being applicable for Prudent Line.
2) The existing channel capacities were then estimated along all of the segments meeting the land density criterion.
3) Existing capacities were compared to the estimated future land use conditions; 10-year event flows to determine if the capacity criterion is met.

Results of the analysis show that the main channel segments located upstream from Eastonville Road meet the Prudent Line applicability criteria. Segments located between

Eastonville Road and Drake Pond are discontinuous and/or do not provide adequate capacity to allow the Prudent Line approach. The Prudent Line approach is not appropriate for segments located downstream of Drake Pond because the cumulative percent of impervious land for these segments is greater than 20%. Figure 4-2 graphically summarizes the applicability of the Prudent Line Approach within the Bennett Ranch watershed.

Table 4-1 - El Paso County DCM Prudent Line Applicability Criteria

DCM Prudent Line approach is applicable and recommended for: Open channel segments located downstream from land having less than or equal to 15% cumulative impervious surface cover under future conditions <u>and</u> when the main channel can adequately convey future conditions 10-year event flows.
DCM Prudent Line approach may apply to: Open channel segments located downstream from land having between a 15% and 20% cumulative impervious surface cover under future conditions <u>and</u> when the main channel can adequately convey future conditions 10-year, flows. These reaches require justification for recommending the prudent line approach.
DCM Prudent Line approach is not recommended for: Open channel segments located downstream from land having greater than a cumulative 20% impervious surface cover under future conditions <u>or</u> when the main channel lacks adequate conveyance capacity for the future conditions 10-year flows. However, the Prudent Line may still be considered if a detailed analysis of the Prudent Line is conducted using more advanced analytical techniques. The detailed approach must be completed by a firm that is experienced in conducting this advanced Prudent Line analysis.

Maintenance Notes:
1. The County will be responsible for performing channel rehabilitation measures on the prudent line channel resulting from significant hydrologic events or from long-term erosion.
2. The landowner will be responsible for performing routine maintenance including mowing, weed treatment, trash pickup, etc.
3. The landowner will be responsible for providing protection to his or her structures.
4. Refer to table below for maintenance access requirements

Type of Development	Maintenance Access Requirements	Other Conditions
Lot sizes ≤ 2.5 acres along channel	Provide access to channel at a maximum one-quarter mile interval along lots with a minimum 15-foot-wide easement dedicated to El Paso County	• Property plats to show exact easement locations. • Routine maintenance (mowing, weed treatment, trash pickup) to be responsibility of landowner. • County to be responsible for restoration due to County-sponsored construction activity.
Lot sizes > 2.5 acres along channel	Provide access to channel through each lot via a minimum 15-foot-wide easement dedicated to El Paso County	• Each platted lot to contain a note that a 15-foot-wide easement has been provided to El Paso County. • The lot owner has discretion over the location of the access easement as long as it is passable by typical construction equipment. • Routine maintenance (mowing, weed treatment, trash pickup) to be responsibility of landowner. • County to be responsible for restoration due to County-sponsored construction activity.

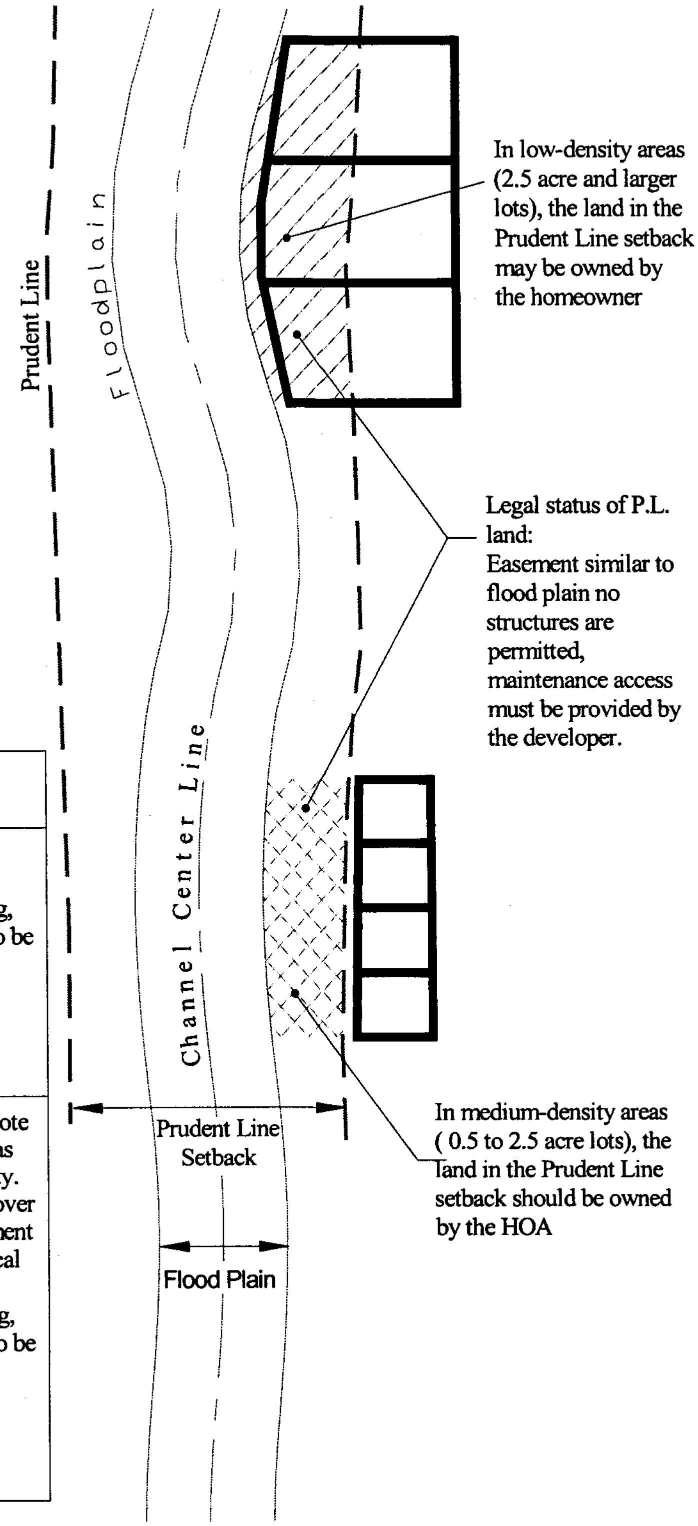


Figure 4-1 Prudent Line Reaches

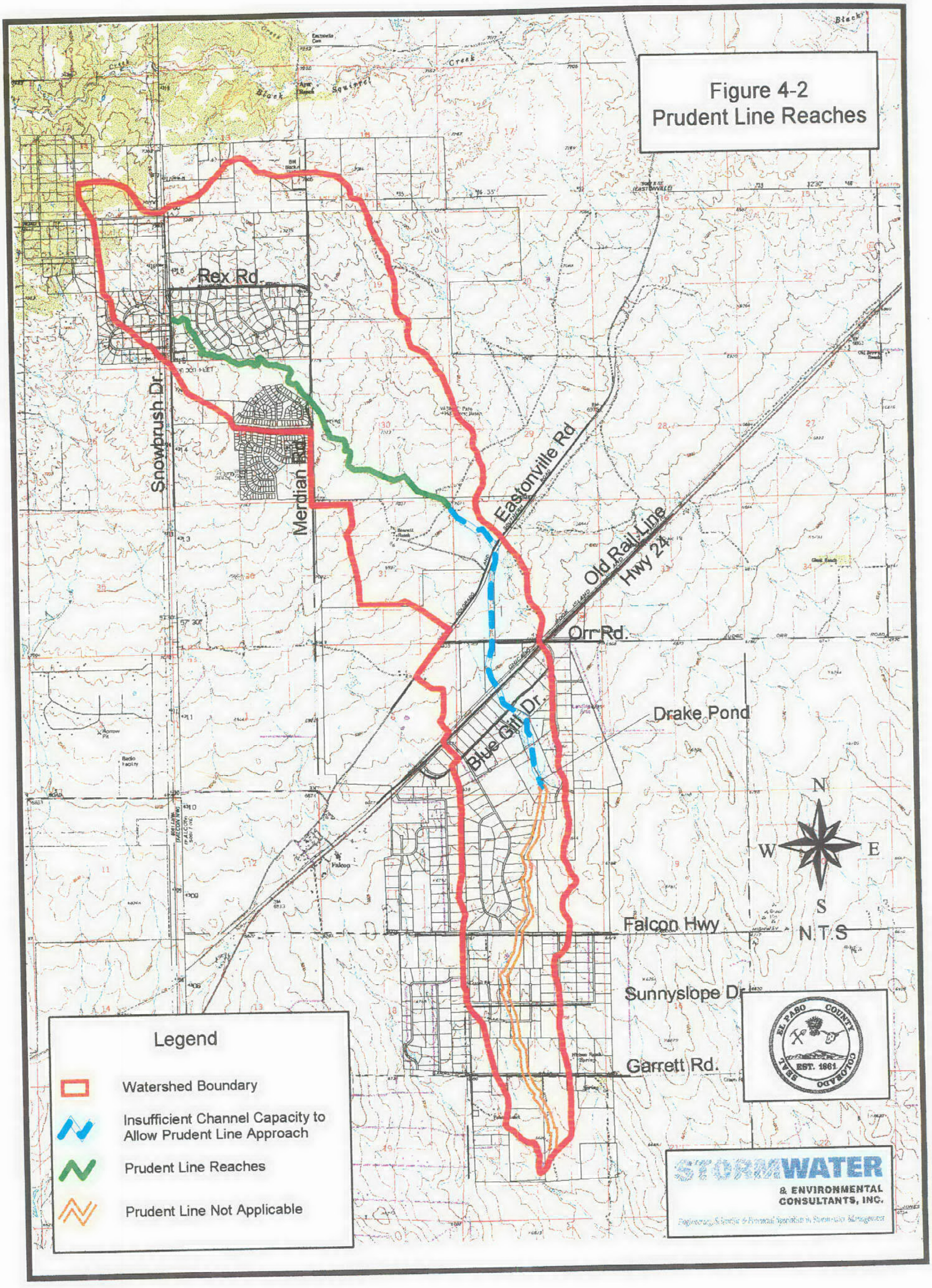


Figure 4-2
Prudent Line Reaches
Rex Rd.
Snowbrush Dr.
Merdian Rd.
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
S
W
E
N.T.S
Legend
Watershed Boundary
Insufficient Channel Capacity to Allow Prudent Line Approach
Prudent Line Reaches
Prudent Line Not Applicable
EL PASO COUNTY COLORADO SEAL EST. 1861
STORMWATER & ENVIRONMENTAL CONSULTANTS, INC.

5. IDENTIFICATION OF DEFICIENCIES

Definition of System Deficiencies

This section defines what constitutes a deficiency for the purposes of this study. Criteria are established to define a deficiency for both hydraulic structures and open channels. Two separate sets of criteria are used to define an open channel deficiency depending on whether it is located along a Prudent Line reach or along a Traditional Improvement reach. Table 5-1 presents deficiency criteria for Prudent Line Channel Reaches. Table 5-2 presents criteria for channel segments that are not applicable for the Prudent Line approach. This set of criteria is based on the El Paso County DCM open channel design criteria. Table 5-3 presents criteria for culverts and bridges and is based on the El Paso County DCM culvert and bridge design criteria.

Table 5-1 - Criteria for Prudent Line Channel Reaches

Location	Classification	Criteria
Snowbrush Drive to Eastonville Road	Prudent Line Reaches	Bank full capacity of channel must convey flows from future land use conditions 10-year event. All upstream culverts and bridges must not significantly alter channel hydraulics (limited backwater effects). Velocities caused by the future land use conditions 100-year event must not increase velocities more than 10% above existing conditions 100-year event velocities.

Table 5-2 - Criteria for Traditional-Improvement Channel Segments (Non-Prudent Line Channels)

Location	Classification	Criteria
Eastonville Road to Watershed Outfall	Major drainage way segment (100-year event flows > 1,500 cfs)	Refer to El Paso County DCM

Table 5-3 - Criteria for Structures

Location	Classification	Criteria
Snowbrush Drive Meridian Road	Culverts located on a collector road within a Prudent Line Reach.	Refer to El Paso County DCM
Judge Orr Road RR Bridge Hwy 24 Blue Gill Drive Falcon Hwy Sunny Slope Road Garrett Road	Structures along a major drainage way (100-year event flows > 1,500 cfs).	Refer to El Paso County DCM

Evaluated Reaches

The El Paso County DCM defines major drainage ways as open channels that convey more than 1,500 cfs under the 100-year event. Just over 40,000 feet of open channel were evaluated for deficiencies (Figure 5-1). These constitute all of the major drainage ways within the project watershed and also approximately 7,300 feet of minor drainage way located between Meridian Road and Snowbrush Drive. All culverts and bridges along these drainage ways were evaluated for system deficiencies. The remainder of this report evaluates alternatives for each of the identified deficiencies.

All other drainage ways located within the project watershed were considered minor reaches and were not evaluated under the scope of this study. Deficiencies that may exist along these minor drainage ways were not identified and corresponding alternatives were not developed or evaluated. However, estimates were created to help quantify the costs associated with improvements for minor drainage systems in the currently developed areas between Highway 24 and 1400-feet downstream of Sunnyslope Drive. It was assumed that further development would not occur in this area; therefore the County would be responsible for upgrading these minor drainage systems.

Identification of System Deficiencies

The Bennett Ranch drainage way system was evaluated to identify deficiencies by comparing estimated future-conditions, 100-year event peak flows to existing open channel, culvert, and bridge capacities. Channel segments and structures that do not meet the design criteria established in Tables 5-1 through 5-3 are considered deficient.

Peak flows used to identify deficiencies were estimated using a HEC-1 model modified by replacing existing culverts and bridges with new structures designed to meet DCM conveyance capacity criteria presented in Table 5-3. Culvert nomographs were used to estimate existing capacities of the culverts and bridges based on inlet control flow conditions. The Haested Methods computer program Flow Master was used to estimate capacities of the open channel segments. Flow Master uses normal depth calculations to estimate flows and does not consider backwater effects.

Based on our analysis, just over one-half of the evaluated open channel reaches are deficient (25,800 feet of open channel). Table 5-4 presents results of the analysis of open channel segments located in Prudent Line reaches. Table 5-5 presents results of the analysis of open channel segments located outside Prudent Line reaches. Nine of the ten existing crossings are deficient (the Falcon Highway bridge meets design criteria). Table 5-6 presents results from the analysis of culverts and bridges. Figure 5-1 graphically presents the locations of system deficiencies within the Bennett Ranch watershed. Full documentation of the deficiency evaluation process is presented in the Technical Appendices.

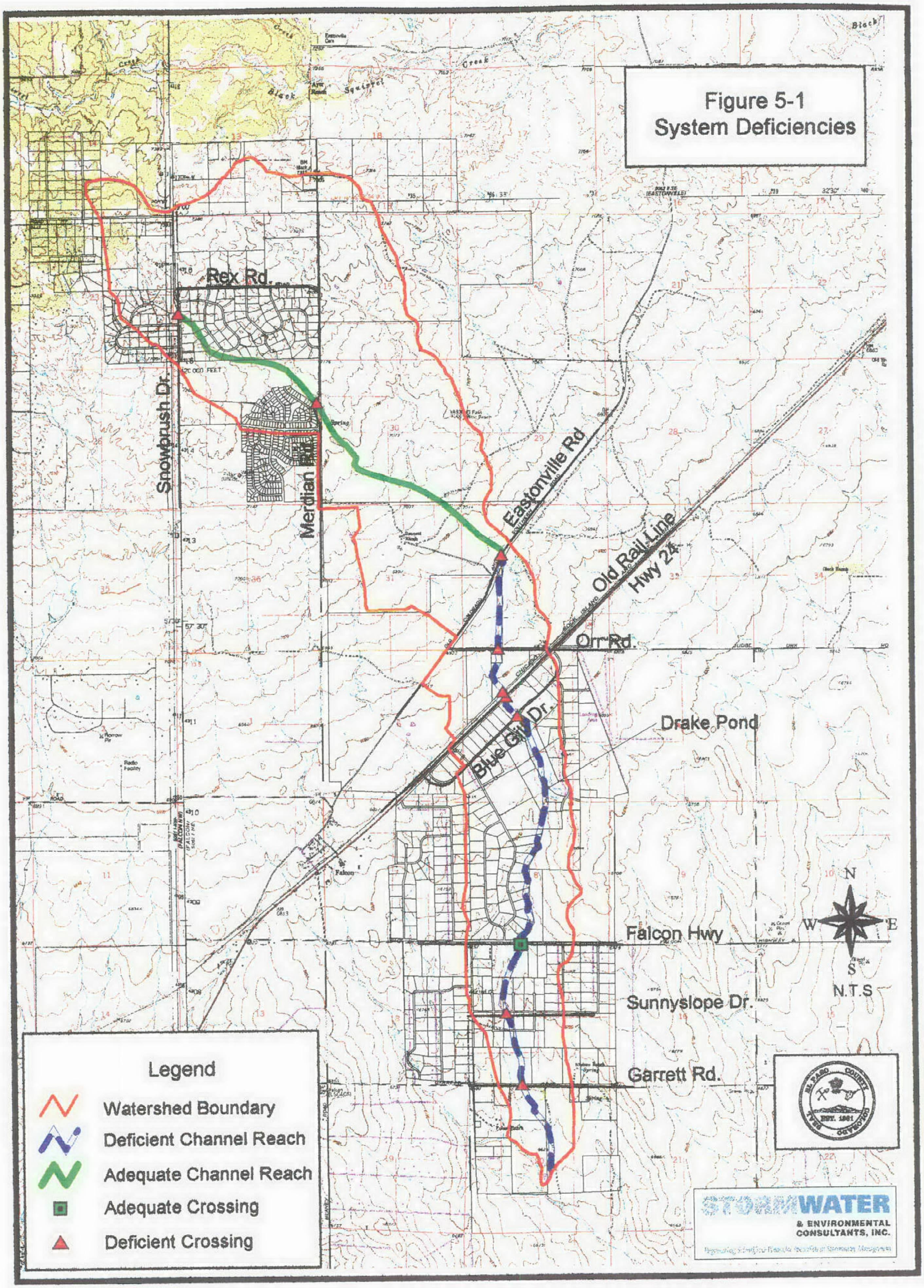


Figure 5-1
System Deficiencies
Rex Rd.
Snowbrush Dr.
Meridian Rd.
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
W
E
S
N.T.S
Legend
Watershed Boundary
Deficient Channel Reach
Adequate Channel Reach
Adequate Crossing
Deficient Crossing
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.

Table 5-4 - Evaluation of Existing Channel Segments
Prudent Line Reaches

Location	HEC-1 SegmentID	Length (feet)	Future 10-yr Peak Flow(cfs)	Estimated Existing Channel Capacity (cfs)	Criteria: must convey 10-year event flows	Existing 100-yr velocity (ft/sec)	Future 100-yr Velocity (ft/sec)	Criteria: velocity cannot change > 10%
Snowbrush Drive to Meridian Road	1051	4305	82	1053	Meets Criteria	4.3	5.0	Meets Criteria
	5020	1765	150	860	Meets Criteria	5.0	5.3	Meets Criteria
	2080	1284	253	860	Meets Criteria	6.0	5.2	Meets Criteria
Meridian Road to Eastonville Drive	8071	5423	310	948	Meets Criteria	6.8	7.4	Meets Criteria
	7090	4468	611	948	Meets Criteria	8.8	9.7	Meets Criteria

Table 5-5 - Evaluation of Existing Channel Segments
Traditional Method Reaches

Location	HEC-1 Segment	Length (feet)	Future Peak Flow (cfs)	Flow Depth (feet)	DCM Maximum Depth	DCM Freeboard	Future 100-yr Velocity (ft/sec)	DCM Velocity	Flow Froude #	Max. DCM Froude # of 0.9
Eastonville Road to Drake Pond Drive	90131	3493	1910	These segments do not contain defined and/or continuous channels and therefore do not meet DCM criteria.						
	90133	1372	1906							
	90135	140	1905							
	90137	912	1897							
	130141	612	1933							
Drake Pond to Falcon Highway	140170	3047	2244	1.4	Meets Criteria	Meets Criteria	5.2	Meets Criteria	.79	Meets Criteria
	170171	1902	2278	3.3	Meets Criteria	Meets Criteria	6.2	Exceeds	.63	Meets Criteria
	171190	4052	2437	3.6	Meets Criteria	Meets Criteria	6.2	Exceeds	.65	Meets Criteria
Falcon Highway to Sunnyslope Road	190211	2875	2534	3.4	Meets Criteria	Likely Meets Criteria	6.9	Exceeds	.73	Meets Criteria
Sunnyslope Road to Garrett Road	210221	2852	2532	3.2	Meets Criteria	Exceeds	8.1	Exceeds	.88	Meets Criteria
Garrett Road to end of watershed	220231	4555	2538	3.1	Meets Criteria	Exceeds	7.8	Exceeds	.87	Meets Criteria

Table 5-6 - Evaluation of Existing Culverts and Bridges

Crossing Location	HEC-1 ID	Structure	Peak Flows 100-yr future (cfs)	Peak Flows 5-yr future (cfs)	Existing Capacity [1] (cfs)	DCM Criteria Met?
Snowbrush Drive	1050	CUL-14: 54" CMP	220	50	85	No[2]
Meridian Road	8070	CUL-13: triple 48" RCP	840	190	240	No[2]
Eastonville Road	90130	CUL-12: twin 30" RCP	1930	420	80	No[3]
Judge Orr Road	90131	CUL-11: twin - 36" CMP	1910	410	76	No[3]
Old Railroad line crossing	90133	CUL-10: RCB: 13' W x 3' H	1950	420	176	No[3]
Highway 24	90135	CUL-08: RCB: 23' W x 4' H	1950	420	460	No[3]
Blue Gill	130140	CUL-04: twin 36" CMP	1950	420	60	No[3]
Falcon Highway	190210	BDG-01: RCB: 60' W x 8' H	2551	490	3900	Yes
Sunnyslope Road	210220	CUL-02: 30" CMP	2550	490	20	No[3]
Garrett Road	220230	CUL-01: 48" CMP	2540	480	70	No[3]

[1] Capacity based on assumed inlet control.
[2] Crossing must not cause significant backwater effects because it is located within a Prudent Line reach.
[3] Crossing must convey 100-year discharge because it is located along a major drainage way (flows > 1,500 cfs).

6. DEVELOPMENT AND EVALUATION OF ALTERNATIVES

Screening of Alternatives

The Prudent Line Approach is the preferred alternative for rural basins and is recommended for all reaches within the Bennett Ranch watershed that meet the Prudent Line Approach criteria (defined in Chapter 4, Prudent Line). When land use or channel conditions preclude the use of this method, other more traditional improvements were considered including:

- Grade and erosion controls
- Upgrading culverts and bridges to increase conveyance capacity
- Upgrading existing channel reaches to increase conveyance capacity
- Constructing new channel segments where channels are currently undefined
- Providing detention storage

The following summarizes the feasible alternatives that will be considered for this project. The alternatives are presented in order from upstream to downstream. Table 6-1 presents a matrix summarizing the screening process used to identify these alternatives.

Snowbrush to Eastonville Road

This approximately two-mile long reach of the watershed meets the land use criteria for the Prudent Line Approach and is therefore the recommended alternative.

An undersized culvert, located at Snowbrush Drive, and two small ponds are located at the upstream end of this reach. The ponds do not appear to have controlled outlets and large amounts of sediment have deposited in the ponds. The Prudent Line Approach will require upgrading the existing 54 inch-diameter culvert at Snowbrush Drive (CUL-14) to a 7' x 5' box culvert and removing the pond berms to allow free passage of channel flows. The channel continues unimpeded downstream from the ponds until reaching Meridian Road.

At Meridian Road, three existing 54-inch diameter culverts (CUL-13) are restricting flows, causing sediment to deposit on the upstream side, and failing due to erosion at the downstream end. The Prudent Line Approach will require upgrading these culverts to a 30' x 7' box culvert and armoring the downstream ends to prevent erosion.

Eastonville Road to Drake Pond

This portion of the watershed does not contain a single, continuous reach of channel. In addition, existing culverts and bridges in this area are undersized and are not aligned with each other. Stormwater currently flows overland using many flow paths through this area of the watershed, resulting in flood-related problems.

The lack of defined channels and configuration of existing culverts and bridges in this area requires more traditional improvement methods including: detention storage, increasing the capacity of existing channel segments, constructing new open channel segments, upgrading existing hydraulic structures, and constructing new structures. Check structures will be required along new channel segments to maintain stream channel grades that will prevent channel erosion and degradation.

Drake Pond to the Watershed Outfall
The downstream section of the watershed contains approximately 7,500 feet of undersized channels. These channels are not applicable for the Prudent Line approach because contributing land has greater than 20% cumulative impervious surface area, and this will require the use of traditional channel improvements. In addition, the existing culverts located at Blue Gill Drive (CUL- 04), Sunnyslope Drive (CUL-02), and Garrett Road (CUL-01) do not meet DCM capacity requirements.

Table 6-1 - Alternative Screening Matrix

Analysis Section	Deficiencies	Prudent Line/grade & erosion control	Improved Crossings	Improve Existing Channel	New Channel	Detention Storage
Snowbrush Drive to Eastonville Road	• Undersized culvert at Snowbrush Dr. (CUL-14)	X[1]	X			
	• Undersized and failing culverts at Meridian Rd. (CUL-13))	X[1]	X			
Eastonville Road to Drake Pond	• Undersized culvert at Eastonville Rd. (CUL-12)		X			
	• Undersized Railroad culvert (CUL-10)		X			
	• Undersized culvert at Hwy 24 (CUL-08)		X			
	• Undersized culvert at Blue Gill Rd. (CUL-04)		X			
	• Undefined/undersized segments of channel			X	X	X
Drake Pond to watershed outfall	• Undersized culvert at Sunnyslope Dr. (CUL-02)		X			
	• Undersized culvert at Garrett Rd. (CUL-01)		X			
	• Undersized channel segments			X		X

X = feasible alternative
[1] Includes removal of berms from existing ponds located downstream from Snowbrush Drive

Development of Alternatives

Two alternatives were developed for further consideration based on the alternatives screening process. Table 6-2 presents the design criteria used to develop the alternatives. The alternatives are based on the assumption that new channels can be excavated approximately six feet below existing ground elevations and still meet the watershed outfall elevation at West Squirrel Creek.

Table 6-2 - Alternative Development Design Criteria

Culverts and Bridges
- Culverts at Snowbrush Drive and Meridian Road sized to pass 100-year event without surcharging
- Bridges to provide 2 feet of freeboard for 100-year event
- Bridges and culverts upstream from Prudent Line reaches designed to have limited backwater effects

Prudent Line Setback Reaches
- Bank-full capacity of the channel must convey flows from future land use conditions 10-year event
- Velocities caused by the future land use conditions 100-year event must not increase more than 10% above existing conditions 100-year event velocities

New Open Channel Segments
- Flow depth = 5 feet
- Manning's roughness coefficient = 0.035
- Velocity = 5 ft/sec or less
- One foot (minimum) of channel bank freeboard
- Channel side slopes of 5V:1H
- Froude Number of 0.9 or less
- 3 foot (maximum) drop at each check structure

Alternative 1

Alternative 1 upgrades all reaches and hydraulic structures to meet DCM design criteria and/or Prudent Line criteria without providing regional detention storage. This alternative includes a combination of the Prudent Line setback in the upper reaches, new channel segments in the middle reaches, and improved channel segments in the downstream reaches of the project watershed. It requires upgrading nine of the ten existing culverts/bridges located along the design drainage way.

The estimated cost to implement this alternative is $7.3 million. Table 6-3 summarizes the specific improvements associated with this alternative. Figure 6-1 presents a schematic of the alternative. Supporting engineering calculations and cost estimates are presented in the Technical Appendices.

Table 6-3 - Alternative 1
Summary of Improvements

Improvement	Estimated Cost[1] ($1000)
Approximately 2.8 miles of Prudent Line reaches	319.0
2 new box culverts	375.6
7 new bridges	2,557.8
3.2 miles of new channel	2,994.0
65 new check structures	471.3
Misc.: Placement of erosion control riprap and removal of existing pond berms	26.8
Upgrade existing minor drainage system	522.0
Total estimated cost	$7.3 million

[1] Includes 15% cost for engineering, 25% contingency factor, and a 5% cost for utilities

Alternative 2

Alternative 2 upgrades all reaches and hydraulic structures to meet DCM design criteria and/or Prudent Line criteria by incorporating regional detention upstream of Eastonville Road. This alternative reflects the El Paso County Board of County Commissioners requirement that both the Bennett Ranch and Meridian Subdivisions detain future conditions storm water runoff to 80 percent of existing 100-year event flows[6].

This alternative incorporates the developer's design concept of five on-line detention ponds located upstream of Eastonville Road. Four of the ponds are to be incorporated into a golf course system and would provide a total storage volume of approximately 90 acre-feet. The developer proposes to modify the existing channels between these ponds as part of the golf course. These channel segments are applicable for Prudent Line and therefore the cost associated with improving the channels are not included in this study. A fifth pond with approximately 50 acre-feet of storage is proposed just upstream from Eastonville Road. All storm water runoff upstream from Eastonville Road would be routed through this pond.

[6] The initial draft of the Bennett Ranch Pilot Project recommended that detention for Alternative 2 be provided in one regional pond located at Eastonville Road. The pond was sized to provide approximately 30 acre-feet of storage and limit peak flows to 1,650 cfs at HWY 24, the design capacity of the new CDOT highway culvert. El Paso County requested that the alternative be modified to reflect the current development scenario that provides over-detention (80% of existing conditions) as required by the Board of County Commissioners.

The approximately 140 acre-feet of detention will eliminate the need to replace the new CDOT culvert located on Highway 24,[7] but still requires the upgrading of eight existing culverts and the construction of a new channel from Eastonville Road to Drake Pond. The estimated cost to implement this alternative is $7.9 million. Figure 6-2 presents a schematic of the alternative. Table 6-4 presents the specific improvements associated with this alternative.

Supporting engineering calculations and cost estimates are presented in the Technical Appendices (separate document).

Table 6-4 - Alternative 2
Summary of Improvements

Improvement	Estimated Cost[1] ($1000)
Approximately 1.4 miles of Prudent Line reaches	159.5
8 new box culverts	2568.0
2.16 miles of new channel	1,469.3
61 new check structures	442.3
Misc.: Placement of erosion control riprap and removal of existing pond berms	26.8
Detention ponds (combined storage of 140 acre-feet)	2,708.6
Upgrade existing minor drainage system	522.0
Total estimated cost	$7.9 million

[1] Includes 15% cost for engineering, 25% contingency factor, and a 5% cost for utilities

Evaluation of Alternatives

Table 6-5 presents a comparison of the two feasible alternatives for the Bennett Ranch pilot project. The Table compares the alternatives based on total estimated project costs, Prudent Line approach applicability, permitting requirements, construction-related issues, maintenance issues, public perceptions and political issues, and easement acquisition needs.

[7] The culvert upgrade is proposed in conjunction with the CDOT widening of Highway 24 from the town of Falcon to the town of Peyton. The new culvert is to be designed to convey 1,650 cfs and replace the existing 23' x 4' box culvert (culvert 0-8 in Figure 2-2).

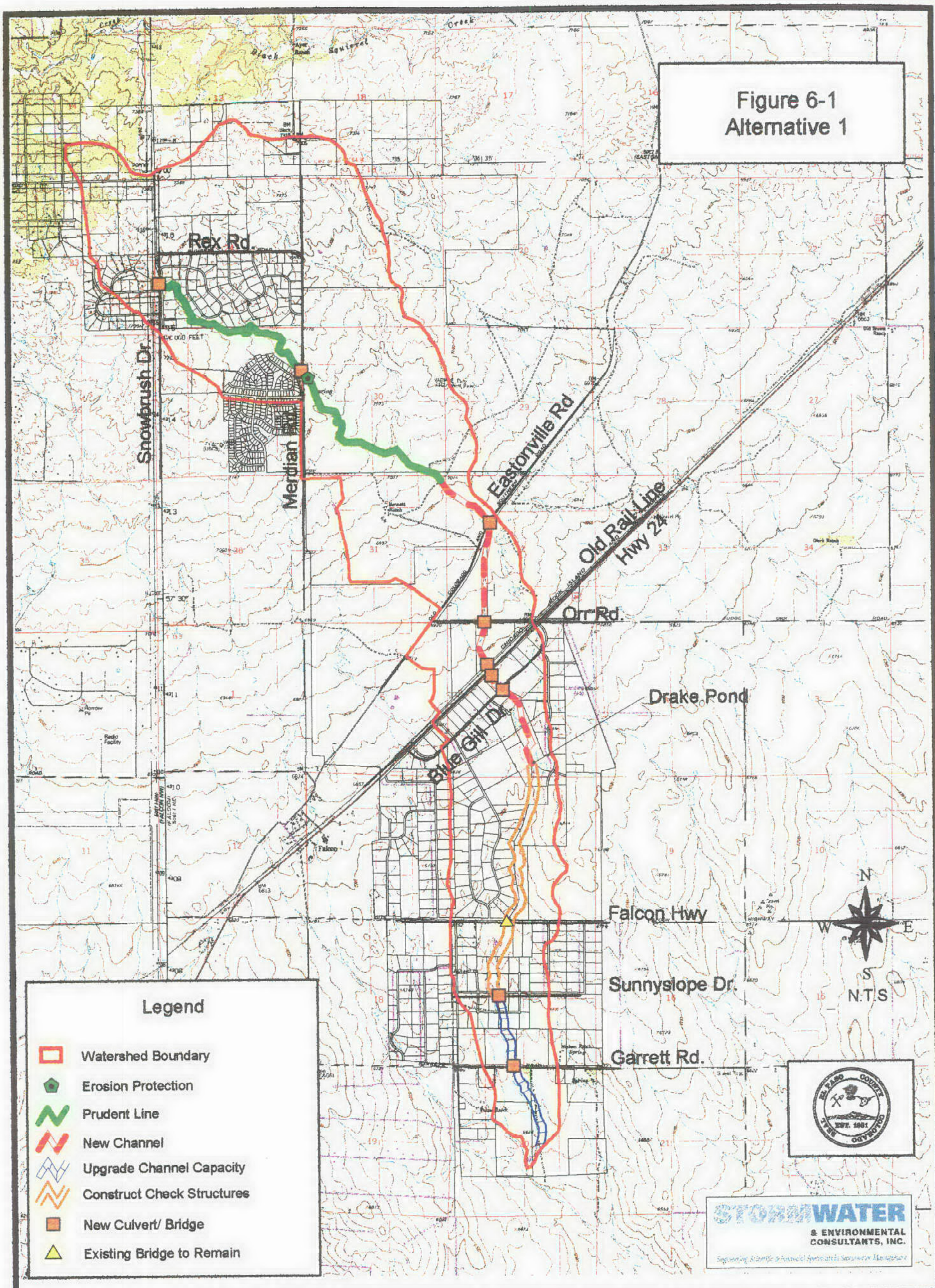


Figure 6-1
Alternative 1

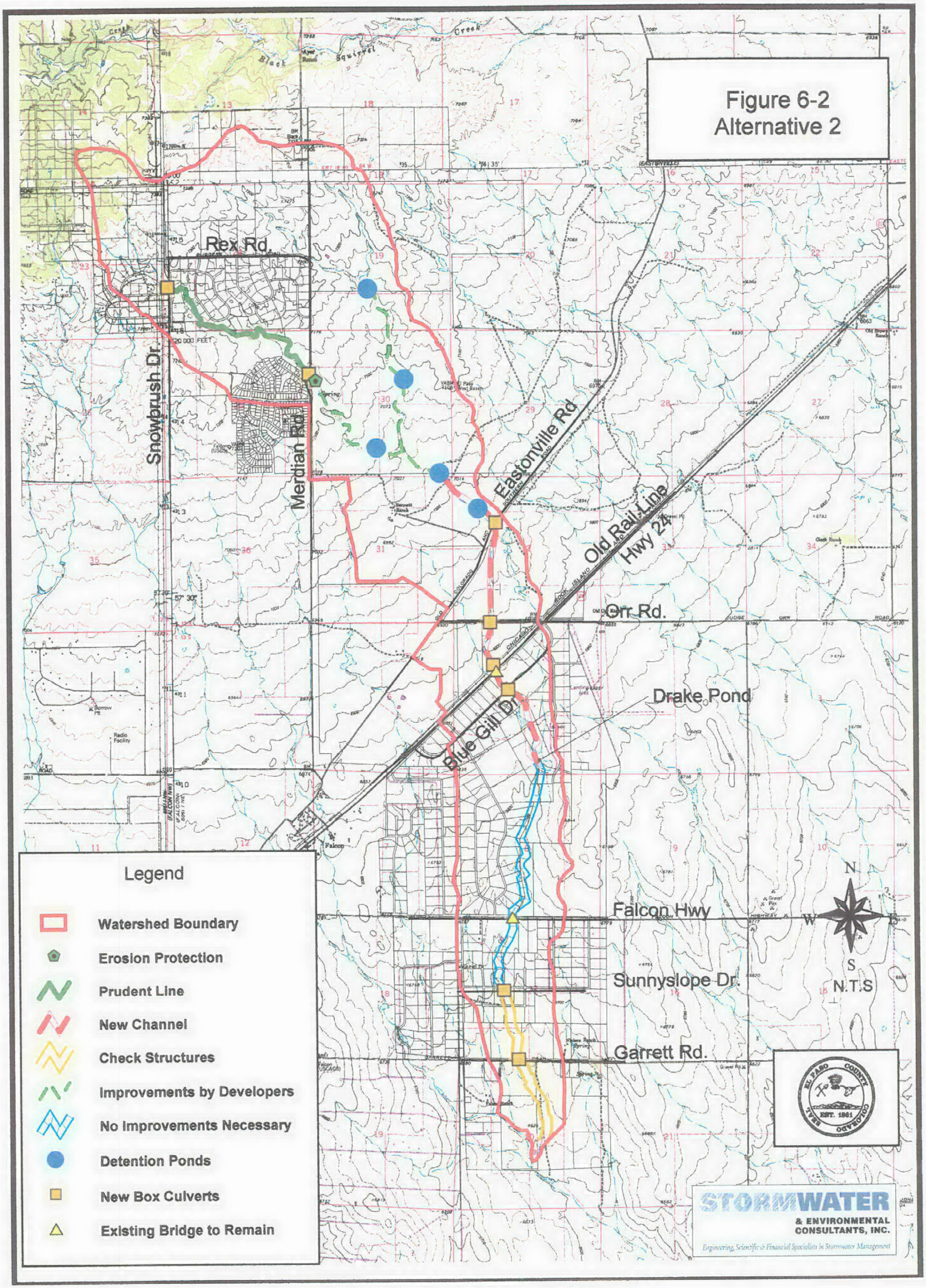


Figure 6-2
Alternative 2
Rex Rd.
Snowbrush Dr.
Meridian Rd
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Drake Pond
Blue Gill Dr.
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
S
E
W
N.T.S
Legend
Watershed Boundary
Erosion Protection
Prudent Line
New Channel
Check Structures
Improvements by Developers
No Improvements Necessary
Detention Ponds
New Box Culverts
Existing Bridge to Remain
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management
EL PASO COUNTY COLORADO
EST. 1861

Table 6-5 - Comparison of Alternatives

Alternative	Total Cost	Prudent Line Applicability	Permitting Issues	Construction Issues	Maintenance Issues	Public Perceptions and Political Issues	Easement Acquisitions
Alternative 1: System upgrade without detention	$7.3 million	Applicable in ~ 1/3 of the system reaches	Greater flows require more extensive upgrades to the system than Alternative 2 and therefore requires more in-stream and riparian-zone work and associated 404 permitting	Greater flows require more extensive construction to upgrade the system than Alternative 2, particularly in the lower 1/3 of the watershed Requires replacing the new CDOT culvert at HWY 24	Likely would require much less maintenance than Alternative 2 because there are more Prudent Line reaches and no detention ponds	Public may prefer the concept of regional detention ponds to mitigate development impacts	Requires securing a total of approximately 44 acres of Prudent Line easements at an estimated cost of $319,000
Alternative 2: System upgrade with regional detention	$7.9 million	Applicable in only ~ 1/6 of the system reaches	Detention greatly reduces the need to construct within the lower 1/3 of the basin.	Detention reduces the number and size of new bridges, reduces the cross-sectional area of new channel segments, and reduces the number of channel check structures from Alternative 1 Requires construction of a total of approximately 140 acre-feet of detention	Detention ponds will require maintenance (sediment transport into the ponds) per El Paso County DCM criteria	Public may perceive detention in a positive light as mitigating development impacts within the watershed Over detention within the watershed was a Board of County Commissioners condition of approval of both the Bennett Ranch and Meridian Ranch Subdivision sketch plans	Requires securing a total of approximately 22 acres of Prudent Line easements at an estimated cost of $159,500 and approximately 25 acres of land for detention at an estimated cost of $300,000.

7. RECOMMENDED ALTERNATIVE

Alternative 2 is recommended for the Bennett Ranch watershed. This alternative is recommended over Alternative 1 because it reflects the detention scenario required by the Board of County Commissioners[8], requires smaller upgraded structures, smaller cross-sectional area of new channel segments, and construction of fewer channel check structures. This alternative will also help protect the existing downstream developments from major event flooding by implementing the BOCC detention scenario. In addition, this alternative will require less in-stream and riparian-zone construction and associated 404 permitting in the well-established, healthy riparian channels located in the lower 1/3 of the watershed (Photograph 2-2).

The cost of the recommended alternative is estimated at $7.9 million and includes Prudent Line in the upper-most reaches of the watershed, detention ponds upstream from Eastonville Road, and new channel between Eastonville Road and Drake Pond. It also replaces all nine of the undersized culverts located throughout the length of the drainage way and check structures along channel reaches located between Sunnyslope Drive and the project outfall to maintain a stable channel slope. This alternative allows the existing bridge located at the Falcon Highway and a proposed new CDOT bridge crossing at Highway 24 to remain unchanged.

Table 7-2 lists the specific improvements associated with Alternative 2. Figure 7-1 graphically presents the recommended improvements as they are located along the drainage way.

Recommended Alternative Hydrology

BOCC requirements indicate that the Bennett Ranch and Meridian Subdivisions must attenuate developed condition flows to 80% of historic condition flows for the 5-year and 100-year events. The developer of these subdivisions has designed detention facilities in accordance with these requirements. The developer's detention scenario as of January 2001 was incorporated into the SEC OA alternative #2 HEC-1 model. Results of this model indicated that peak flows at Eastonville Road and Garrett Road were 810 cfs and 950 cfs respectively. The developer requested that SEC OA use a flow of 996 cfs (80% of developer calculated historic flow at Eastonville Road) to size drainage improvements downstream of Eastonville Road. Refer to Figure 3-4 for the alternative #2 discharge profile.

Drainage Basin and Bridge Fees

Drainage basin and bridge fees presented in this study were calculated by dividing the respective improvement costs by the acreage of impervious land that will be added to the basin when undeveloped areas are constructed. Criteria for determining what improvement costs should be included in the fee calculation are presented in Table 7-1. The approximately seven square mile Bennett Ranch basin currently contains 225 acres of impervious land. An additional 709 acres of

[8] Our initial recommendation for detention in this alternative provided one regional pond located at Eastonville Road. The pond was sized to provide approximately 30 acre-feet of storage and limit peak flows to 1,650 cfs at HWY 24, the design capacity of the new CDOT highway culvert. El Paso County requested that the alternative be modified to reflect the current development scenario that provides over detention (80% of existing conditions) required by the Board of County Commissioners.

impervious land will be added to the basin when the undeveloped areas are constructed. Refer to Table 7-2 for a breakdown of existing and added future development impervious areas; and Table 7-3 for cost estimates, basin fees, bridge fees, and public costs.

Table 7-1 – Improvement Cost Inclusion in Fee Calculations

Included if:	Not included if:
Drainage way Improvements (including Prudent Line)	
• the improvements lie within currently undeveloped land AND are for major drainage ways as identified in a DBPS or a County accepted addendum to a DBPS • the improvements lie within currently developed land or public land downstream of future development that does not attenuate developed peak flows to historic peak flows AND are for major drainage ways as identified in a DBPS or a County accepted addendum to a DBPS	• the improvements lie within currently developed land or public land downstream of future development that attenuates developed peak flows to historic peak flows • the improvements are on drainage ways that are not identified as major drainage ways in a DBPS or a County accepted addendum to a DBPS
Culvert Improvements	
• the selected alternative flow at the culvert is greater than the existing condition flow at the culvert AND the culvert is along a major drainage way as identified in a DBPS or a County accepted addendum to a DBPS	• the selected alternative flow at the culvert is less than or equal to the existing condition flow at the culvert • the culvert is not along a major drainage way as identified in a DBPS or a County accepted addendum to a DBPS • the improvement is to be constructed by the Colorado Department of Transportation
Detention Facilities	
• the detention facility is required in a Drainage Basin Planning Study or a County accepted addendum to a DBPS	• the detention facility is not required in a Drainage Basin Planning Study or a County accepted addendum to a DBPS

Table 7-2 – Existing and Added Future Developed Impervious Area

Area (acres)	Landuse	Percent Impervious	Impervious Area (acres)
Existing Impervious Area in Bennett Ranch Basin			
102	RR3	7%	7
87	RR3	7%	6
402	RR2	11%	44
217	R	25%	54
29	R1	53%	15
7	RR3	7%	1
3	R	25%	1
1	RR3	7%	0
52	RR1	25%	13
880	RR3	7%	62
5	R2	65%	3
145	RR2	11%	16
3	RR3	7%	0
39	A1	7%	3
Sum = 1973			**Sum = 225**
Impervious Area to be Added in Bennett Ranch Basin by Future Development			
492	RR3	7%	34
52	A35	2%	1
181	RR2	11%	20
21	1AC Lots	20%	4
210	2DU/AC	25%	52
22	2DU/AC	25%	6
57	3DU/AC	30%	17
25	SCHOOL	50%	13
26	4DU/AC	40%	11
35	4DU/AC	40%	14
36	6DU/AC	48%	17
35	4DU/AC	40%	14
3	SCHOOL	50%	2
30	4DU/AC	40%	12
24	2DU/AC	25%	6
12	Open/Park	7%	1
38	Commercial	95%	36
10	RR1	25%	2
10	4DU/AC	40%	4
10	SCHOOL	50%	5
51	Open/Park	7%	4
85	RR1	25%	21
16	4DU/AC	40%	6
13	RR1	25%	3
2	RR3	7%	0
2	RR1	25%	0
151	4DU/AC	40%	60
138	Open/Park	7%	10
66	6DU/AC	48%	32
56	Commercial	95%	53
28	M	72%	20

71	GC	7%	5
62	6DU/AC	48%	30
119	6DU/AC	48%	57
56	Open/Park	7%	4
117	4DU/AC	40%	47
107	M	72%	77
116	RR3	7%	8
Sum = 2586			**Sum = 709**

Recommended Phasing of Improvements

The developer of Bennett Ranch and Meridian Subdivisions is currently planning to construct the golf course channel segments, the four high priority golf course detention ponds, and the high priority regional pond at Eastonville Road within the next two years. The new channel segment between Stapleton Drive and Eastonville Road needs to be constructed coincident with the aforementioned improvements to provide a well-defined drainage way to route flows into the pond at Eastonville Road. All of these improvements need to be constructed before or during the initial over lot grading process and be fully operational before any impervious surfacing is constructed.

The new channel segments located between Eastonville Road and Drake Pond are also considered high priority improvements because the current drainage way is discontinuous and not well defined. If this channel system is not constructed before the upstream detention scenario required by the Board of County Commissioners, future development condition major event flow depth impacts to the downstream system would be reduced because the upstream detention system reduces future peak flows below existing peak flows. However, the increased volume of runoff produced under developed conditions will result in increased flow durations in the downstream system for the major and minor events. The frequency of flows less than the minor event will also increase because runoff will be produced under developed conditions for rainfall events that did not produce runoff under historic conditions. Increased flow durations and increased frequency of flow may adversely affect the existing downstream drainage system. If the channel improvements between Eastonville Road and Drake Pond are not constructed prior to the upstream developments, the existing downstream drainage system and adjacent property may experience damage.

The new culverts at Judge Orr Road, the railroad embankment, and Blue Gill Road should be constructed concurrently with the channel improvements between Eastonville Road and Blue Gill Road. Construction of these structures along with the new channel segments in this area will provide a well-defined and continuous drainage way from Eastonville Road to Drake Pond.

Replacing the failing culverts located at Meridian Road should also be a high priority (Photograph 2-3). These culverts are failing at the downstream end and will soon compromise the road subgrade.

Of secondary importance is the upgrading of culvert crossings located at Sunnyslope Drive and Garrett Road. Replacing these culverts would help provide a continuous, adequate conveyance system from the new regional pond at Eastonville Road to the project outfall. Again, similar to the new channel segment between Eastonville and Drake Pond, replacing these structures is not critical because the detention system alone would decrease future conditions major event flows below existing conditions. In addition, there are no reported flood-related problems adjacent to these crossings.

The Snowbrush Drive culvert upgrade and demolition of the existing berms, located at the ponds just downstream from Snowbrush Drive, and purchasing of Prudent Line easement from Snowbrush Drive to Meridian Road, could be constructed last. Similarly, construction of the check structures along the existing channel located between Sunnyslope Drive and the project outfall can be delayed until monitoring of the channel conditions indicate the erosion is occurring or likely to occur.

Figure 7-2 presents the recommended phasing of improvements and associated costs.

Easements and Maintenance

All culvert improvements (including the erosion protection at Meridian Road) identified in this DBPS are located within current El Paso County right-of-way. The County will be responsible for the construction and maintenance of these structures.

The Prudent Line channel located between Snowbrush Drive and Eastonville Road shall follow the maintenance and easement guidelines set forth in Section 4 of this DBPS.

Channel improvements between Stapleton Drive and Highway 24 shall follow the maintenance and easement guidelines set forth in Section 2.9 of the El Paso County Drainage Criteria Manual. Channel improvements between the basin outfall and approximately 1400-feet downstream of Sunnyslope Drive shall also follow these guidelines.

The County shall obtain maintenance and construction easements for the channel improvements between Highway 24 and approximately 1400-feet south of Sunnyslope Drive. The County will be responsible for the construction and the long-term maintenance of these improvements.

The Woodmen Hills Metropolitan District (WHMD) shall maintain the detention facilities proposed in this DBPS. However, a maintenance easement shall be given to the County in the event that WHMD defaults on its maintenance responsibilities.

Miscellaneous Items

Prudent Line was determined as the recommended improvement for the channel reach between Snowbrush Drive and Meridian Road. If future zoning, re-plats, or other planning changes dictate that the Prudent Line is no longer applicable to this channel segment based on the criteria presented in Table 4-1, an alternate improvement will need to be designed and the DBPS will need to be amended.

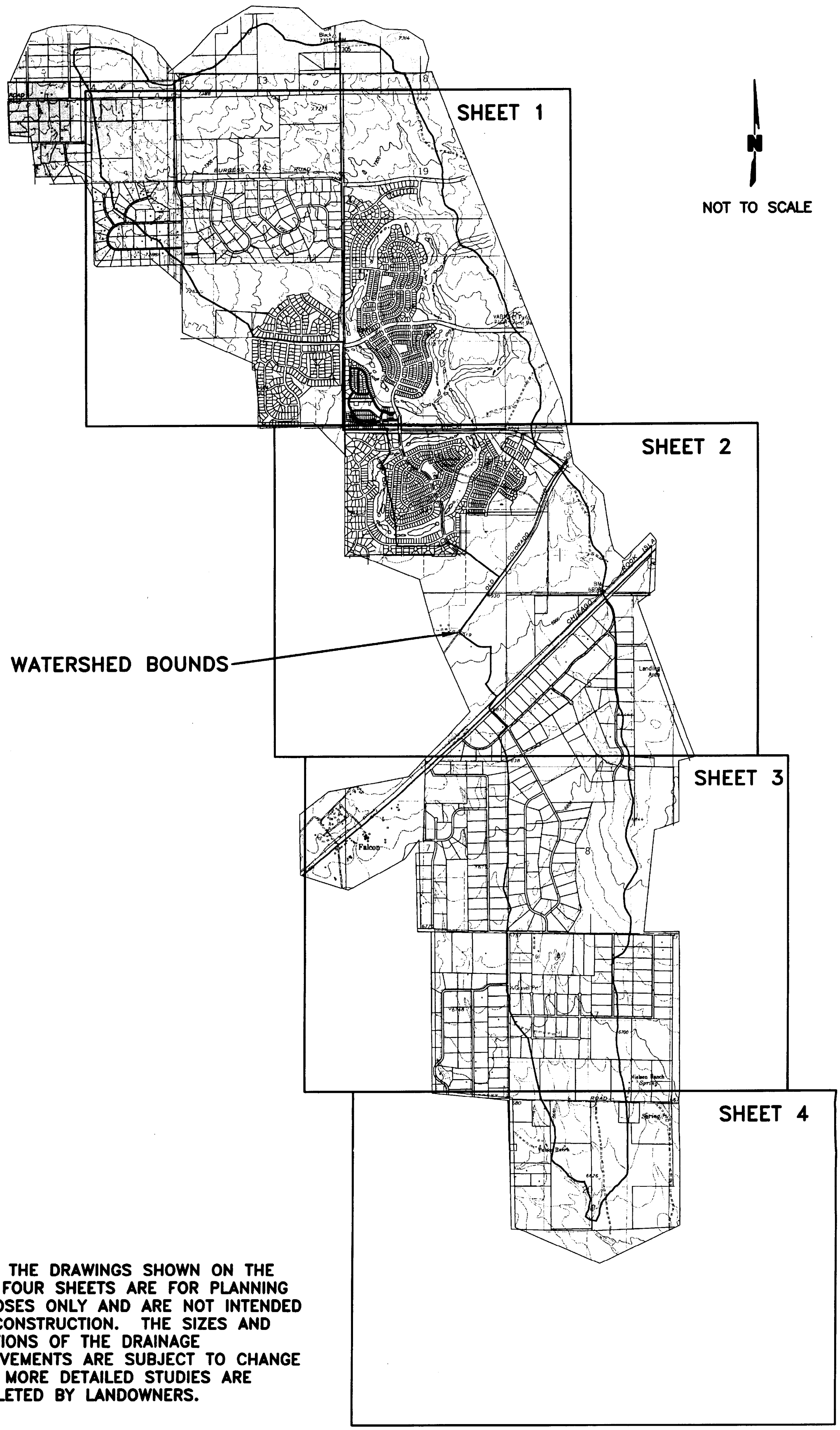
Cost estimates for replacement of culverts were calculated based on a planimetric square footage for the new structure. New culvert widths were determined by hydraulic analysis while new culvert lengths were determined by field measurements of the existing culverts and existing embankments. Future widening of roadways was not considered in determining length of the new structures.

Cost estimates were included for upgrading minor drainage systems for approximately 900 acres of currently developed land between Highway 24 and 1400-feet downstream of Sunnyslope Drive. These improvements were considered public cost improvements constructed by the County. However, developers will be responsible for construction of minor drainage systems within any re-development or new development in this area.

Table 7-3 - Recommended Alternative Improvements

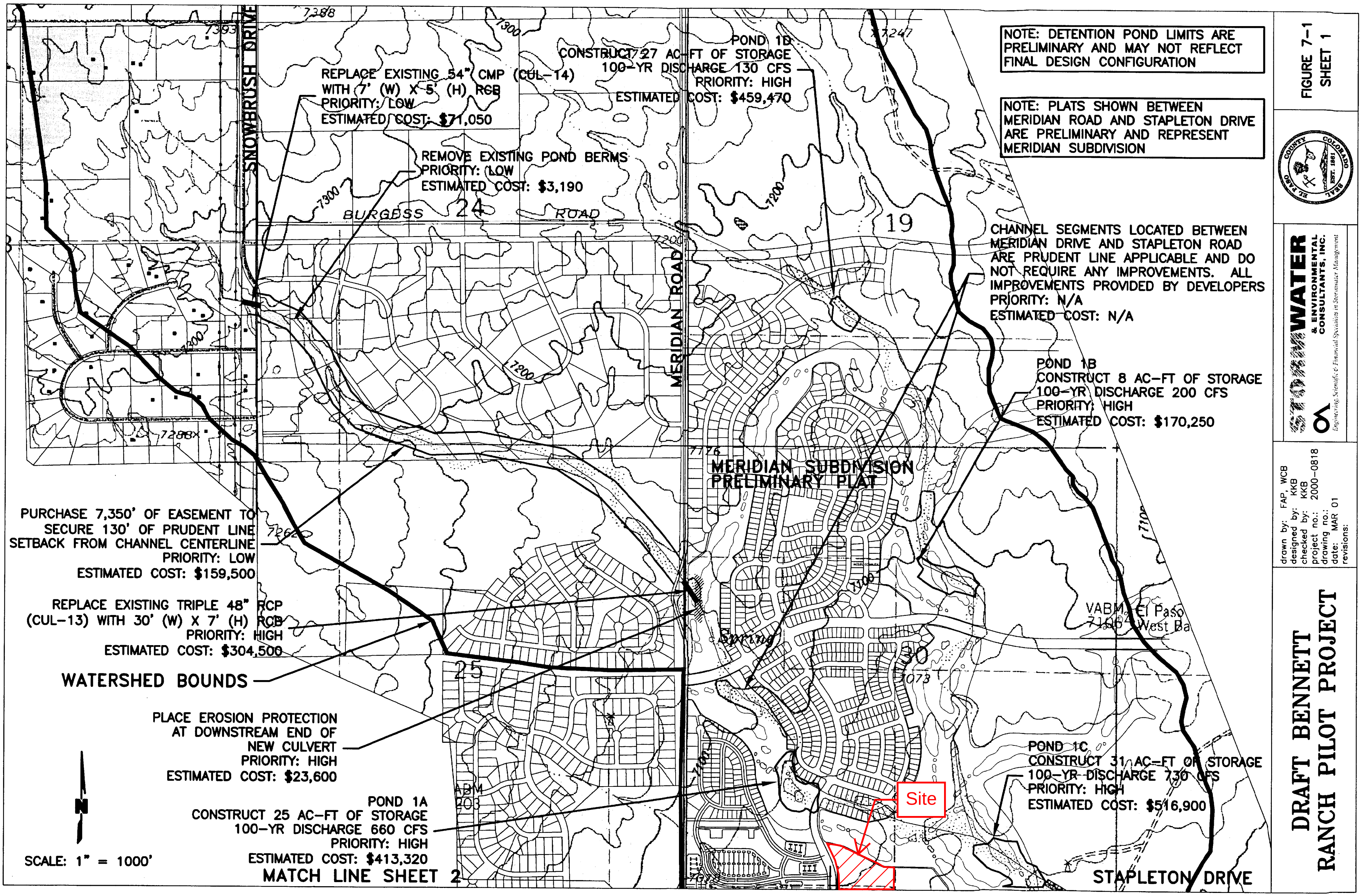
Location	Improvement	Priority	Estimated Cost	Contingen-cies at 25%	Engineer-ing at 15%	Utilities at 5%	Total Estimated Cost	Basin Fee Eligible Cost	Bridge Fee Eligible Cost	Public Cost
Snowbrush Drive to Meridian Road	• Purchase easements to secure approximately 7,350 ft of Prudent Line setback of 130 ft from channel centerline.	Low	110000	27500	16500	5500	159500	159500	0	0
	• Remove berms at ponds located downstream from Snowbrush Drive.	Low	2200	550	330	110	3190	3190	0	0
	• Replace existing 54 inch-diameter CMP at Snowbrush with 7' (W) x 5' (H) x 50' (L) box culvert.	Low	49000	12250	7350	2450	71050	71050	0	0
	• Replace existing triple 48 inch-diameter RCP at Meridian Road with a 30' (W) x 7' (H) x 50' (L) box culvert.	High	210000	52500	31500	10500	304500	0	304500	0
	• Place erosion protection at the downstream end of the new box culvert.	High	16280	4070	2442	814	23606	23606	0	0
Meridian Road to Highway 24	• Construct 7,200 feet of new channel with 31 check structures.	High	795000	198750	119250	39750	1152750	1152750	0	0
	• Construct four ponds with combined detention storage of ~90 ac-ft and one pond with ~50 ac-ft of storage.	High	1868000	467000	280200	93400	2708600	2708600	0	0
	• Construct a new 30' (W) x 7' (H) x 60' (L) box culvert and associated road grade at Eastonville Road.	High	252000	63000	37800	12600	365400	0	0	365400
	• Replace the existing twin 36 inch-diameter CMP at Orr Road with a 30' (W) x 7' (H) x 60' (L) box culvert and associated road grade.	High	252000	63000	37800	12600	365400	0	0	365400
	• Replace existing 13' (W) x 3' (H) box culvert at old rail line with a 30' (W) x 7' (H) x 60' (L) box culvert.	High	252000	63000	37800	12600	365400	0	0	365400
Highway 24 to 1400 ft downstream of Sunny Slope Drive	• Construct 4,200 feet of new channel with 15 check structures.	High	448330	112083	67250	22417	650079	0	0	650079
	• Replace existing 36" CMP at Blue Gill Drive with a 30' (W) x 7' (H) x 60' (L) box culvert.	High	252000	63000	37800	12600	365400	0	0	365400
	• Replace 30" cmp at Sunnyslope Drive with 30' (W) x 7' (H) x 60' (L) box culvert.	Medium	252000	63000	37800	12600	365400	0	0	365400
	• Construct approximately 3 check structures downstream of Sunny Slope Drive to maintain a maximum channel slope of 0.7%.	Low	15000	3750	2250	750	21750	0	0	21750
	• Upgrade existing minor drainage systems (roadside swales) to route flows to the major drainage system.	Low	360000	90000	54000	18000	522000	0	0	522000
1400 ft downstream of Sunny Slope Drive to project outfall	• Replace existing 48" cmp at Garrett Road with a 30' (W) x 7' (H) x 60' (L) box culvert.	Medium	252000	63000	37800	12600	365400	0	0	365400
	• Construct approximately 12 check structures to maintain a maximum channel slope of 0.7%.	Low	60000	15000	9000	3000	87000	87000	0	0
	Subtotal Cost =						7896425	4205696	304500	3386229
	Study Cost =						107194	107194		
	Basin Fee =							6083		
	Bridge Fee =								429	

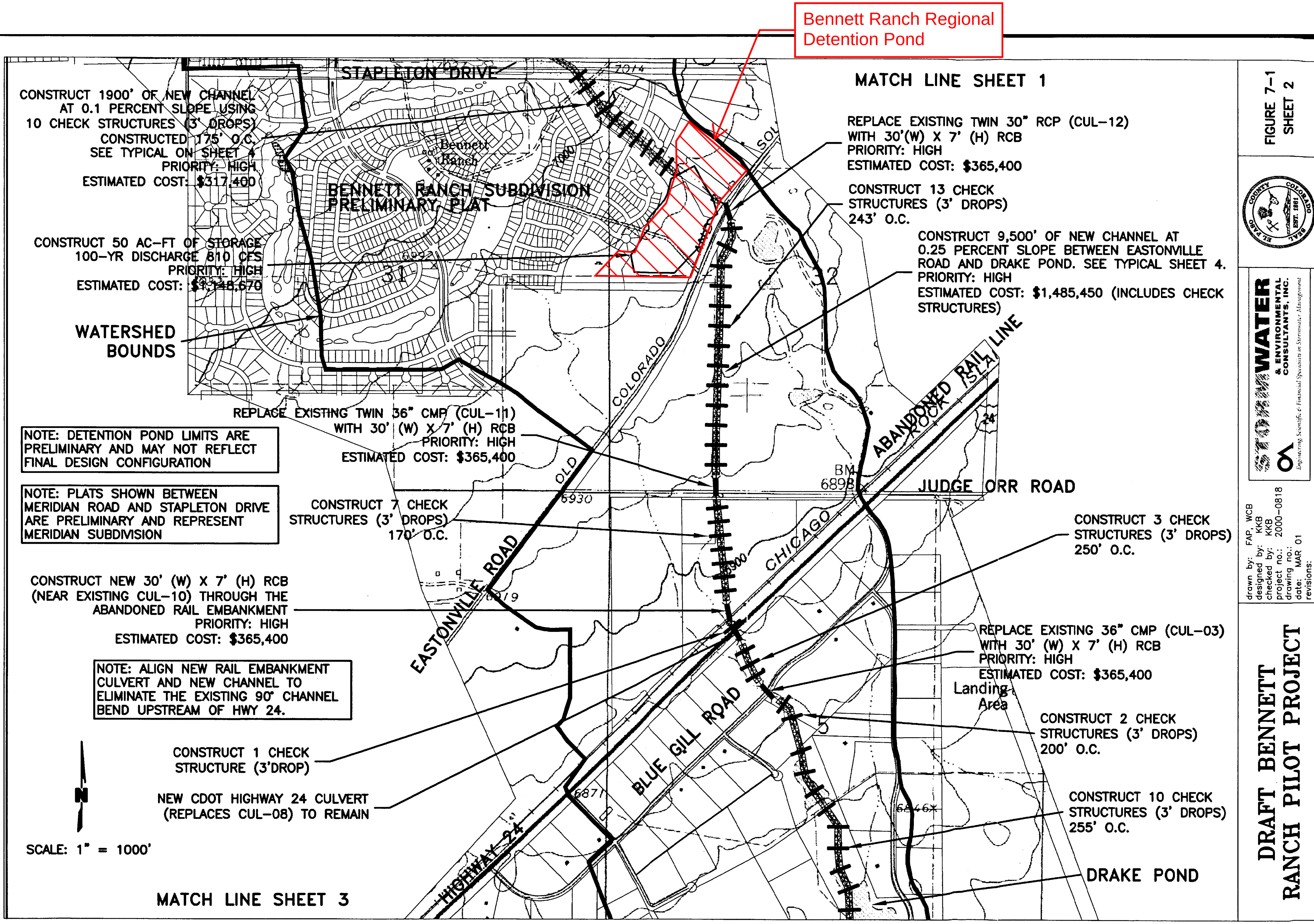
Note: The drainage basin and bridge fees were calculated by dividing the respective improvement costs by the acreage of impervious land that will be added to the basin when undeveloped areas are constructed. The approximately seven square mile Bennett Ranch basin currently contains 225 acres of impervious land. An additional 709 acres of impervious land will be added to the basin when the undeveloped areas are constructed. Therefore, the respective improvement costs were divided by 709 acres to determine the drainage basin and bridge fees in dollars per impervious acre.



NOTE: THE DRAWINGS SHOWN ON THE NEXT FOUR SHEETS ARE FOR PLANNING PURPOSES ONLY AND ARE NOT INTENDED FOR CONSTRUCTION. THE SIZES AND LOCATIONS OF THE DRAINAGE IMPROVEMENTS ARE SUBJECT TO CHANGE ONCE MORE DETAILED STUDIES ARE COMPLETED BY LANDOWNERS.

DRAFT BENNETT RANCH PILOT PROJECT	drawn by: FAP, WCB designed by: KKB checked by: KKB project no.: 2000-0818 drawing no.: date: MAR 01 revisions:	STORMWATER & ENVIRONMENTAL CONSULTANTS, INC. *Engineering, Scientific & Financial Specialists in Stormwater Management*	SEAL EL PASO COUNTY COLORADO EST. 1861	FIGURE 7-1 INDEX SHEET


NOTE: DETENTION POND LIMITS ARE PRELIMINARY AND MAY NOT REFLECT FINAL DESIGN CONFIGURATION
NOTE: PLATS SHOWN BETWEEN MERIDIAN ROAD AND STAPLETON DRIVE ARE PRELIMINARY AND REPRESENT MERIDIAN SUBDIVISION
REPLACE EXISTING 54" CMP (CUL-14) WITH 7' (W) X 5' (H) RCB
PRIORITY: LOW
ESTIMATED COST: $71,050
POND 1D
CONSTRUCT 27 AC-FT OF STORAGE
100-YR DISCHARGE 130 CFS
PRIORITY: HIGH
ESTIMATED COST: $459,470
REMOVE EXISTING POND BERMS
PRIORITY: LOW
ESTIMATED COST: $3,190
SNOWBRUSH DRIVE
BURGESS ROAD
MERIDIAN ROAD
24
19
25
30
7388
7393
7300
7247
7200
7288
7262
7176
7100
7073
CHANNEL SEGMENTS LOCATED BETWEEN MERIDIAN DRIVE AND STAPLETON ROAD ARE PRUDENT LINE APPLICABLE AND DO NOT REQUIRE ANY IMPROVEMENTS. ALL IMPROVEMENTS PROVIDED BY DEVELOPERS
PRIORITY: N/A
ESTIMATED COST: N/A
POND 1B
CONSTRUCT 8 AC-FT OF STORAGE
100-YR DISCHARGE 200 CFS
PRIORITY: HIGH
ESTIMATED COST: $170,250
MERIDIAN SUBDIVISION PRELIMINARY PLAT
PURCHASE 7,350' OF EASEMENT TO SECURE 130' OF PRUDENT LINE SETBACK FROM CHANNEL CENTERLINE
PRIORITY: LOW
ESTIMATED COST: $159,500
REPLACE EXISTING TRIPLE 48" RCP (CUL-13) WITH 30' (W) X 7' (H) RCB
PRIORITY: HIGH
ESTIMATED COST: $304,500
WATERSHED BOUNDS
Spring
VABM El Paso
West Ba
PLACE EROSION PROTECTION AT DOWNSTREAM END OF NEW CULVERT
PRIORITY: HIGH
ESTIMATED COST: $23,600
POND 1A
CONSTRUCT 25 AC-FT OF STORAGE
100-YR DISCHARGE 660 CFS
PRIORITY: HIGH
ESTIMATED COST: $413,320
POND 1C
CONSTRUCT 31 AC-FT OF STORAGE
100-YR DISCHARGE 730 CFS
PRIORITY: HIGH
ESTIMATED COST: $516,900
Site
ABM
7203
N
SCALE: 1" = 1000'
MATCH LINE SHEET 2
STAPLETON DRIVE
FIGURE 7-1
SHEET 1
EL PASO COUNTY COLORADO SEAL EST. 1861
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management
drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:
DRAFT BENNETT RANCH PILOT PROJECT



Bennett Ranch Regional Detention Pond
MATCH LINE SHEET 1
STAPLETON DRIVE
CONSTRUCT 1900' OF NEW CHANNEL AT 0.1 PERCENT SLOPE USING 10 CHECK STRUCTURES (3' DROPS) CONSTRUCTED 175' O.C. SEE TYPICAL ON SHEET 4 PRIORITY: HIGH ESTIMATED COST: $317,400
BENNETT RANCH SUBDIVISION PRELIMINARY PLAT
Bennett Ranch
CONSTRUCT 50 AC-FT OF STORAGE 100-YR DISCHARGE 810 CFS PRIORITY: HIGH ESTIMATED COST: $1,148,670
WATERSHED BOUNDS
REPLACE EXISTING TWIN 30" RCP (CUL-12) WITH 30'(W) X 7' (H) RCB PRIORITY: HIGH ESTIMATED COST: $365,400
CONSTRUCT 13 CHECK STRUCTURES (3' DROPS) 243' O.C.
CONSTRUCT 9,500' OF NEW CHANNEL AT 0.25 PERCENT SLOPE BETWEEN EASTONVILLE ROAD AND DRAKE POND. SEE TYPICAL SHEET 4. PRIORITY: HIGH ESTIMATED COST: $1,485,450 (INCLUDES CHECK STRUCTURES)
REPLACE EXISTING TWIN 36" CMP (CUL-11) WITH 30' (W) X 7' (H) RCB PRIORITY: HIGH ESTIMATED COST: $365,400
NOTE: DETENTION POND LIMITS ARE PRELIMINARY AND MAY NOT REFLECT FINAL DESIGN CONFIGURATION
NOTE: PLATS SHOWN BETWEEN MERIDIAN ROAD AND STAPLETON DRIVE ARE PRELIMINARY AND REPRESENT MERIDIAN SUBDIVISION
OLD COLORADO
ABANDONED RAIL LINE
ROCK ISLAND
JUDGE ORR ROAD
BM 6898
CONSTRUCT 7 CHECK STRUCTURES (3' DROPS) 170' O.C.
CHICAGO
CONSTRUCT 3 CHECK STRUCTURES (3' DROPS) 250' O.C.
EASTONVILLE ROAD
CONSTRUCT NEW 30' (W) X 7' (H) RCB (NEAR EXISTING CUL-10) THROUGH THE ABANDONED RAIL EMBANKMENT PRIORITY: HIGH ESTIMATED COST: $365,400
REPLACE EXISTING 36" CMP (CUL-03) WITH 30' (W) X 7' (H) RCB PRIORITY: HIGH ESTIMATED COST: $365,400
NOTE: ALIGN NEW RAIL EMBANKMENT CULVERT AND NEW CHANNEL TO ELIMINATE THE EXISTING 90° CHANNEL BEND UPSTREAM OF HWY 24.
Landing Area
BLUE GILL ROAD
CONSTRUCT 1 CHECK STRUCTURE (3'DROP)
CONSTRUCT 2 CHECK STRUCTURES (3' DROPS) 200' O.C.
NEW CDOT HIGHWAY 24 CULVERT (REPLACES CUL-08) TO REMAIN
CONSTRUCT 10 CHECK STRUCTURES (3' DROPS) 255' O.C.
HIGHWAY 24
DRAKE POND
N
SCALE: 1" = 1000'
MATCH LINE SHEET 3
FIGURE 7-1 SHEET 2
EL PASO COUNTY COLORADO SEAL EST. 1861
STORMWATER & ENVIRONMENTAL CONSULTANTS, INC.
drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:
DRAFT BENNETT RANCH PILOT PROJECT

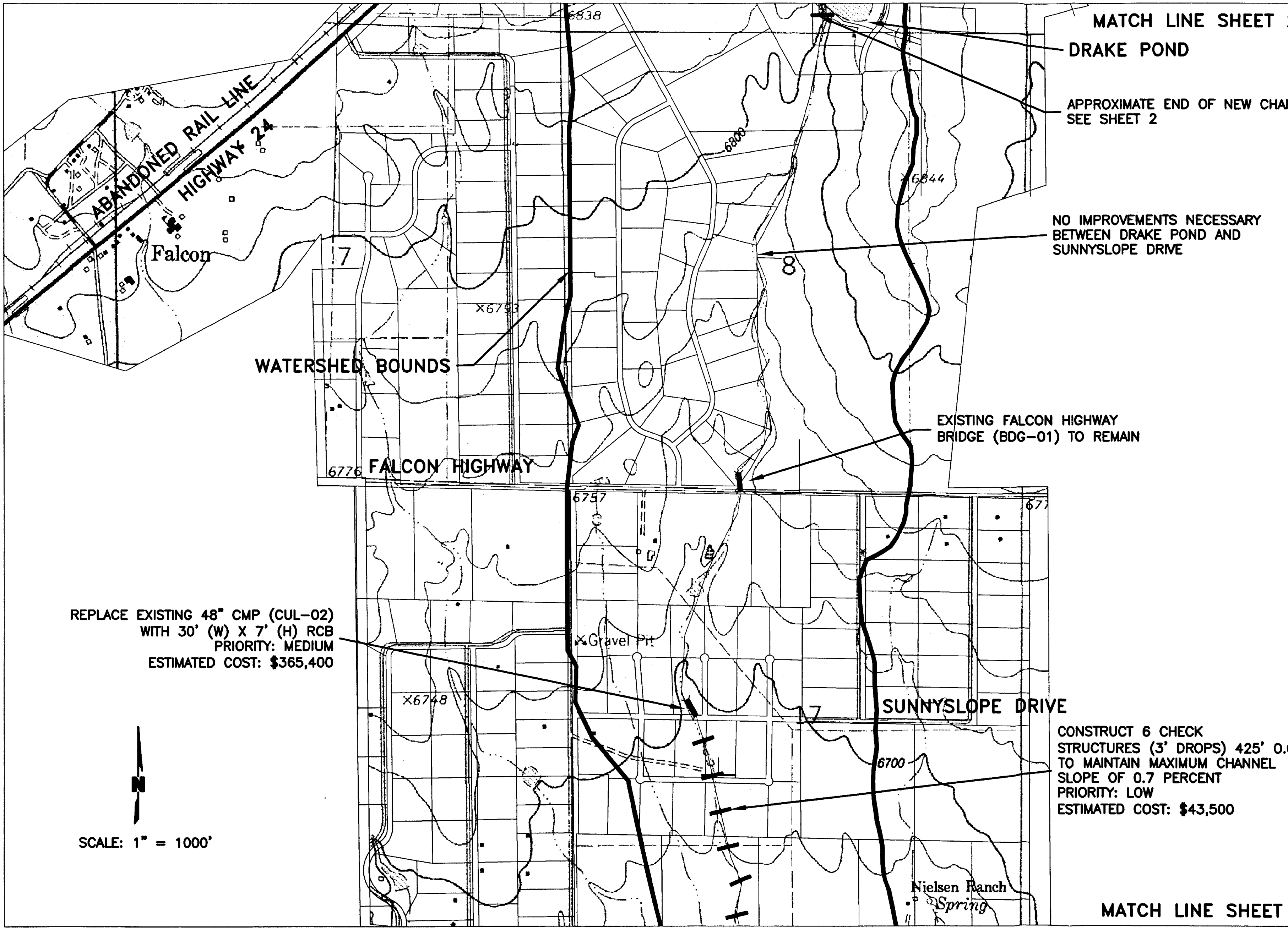
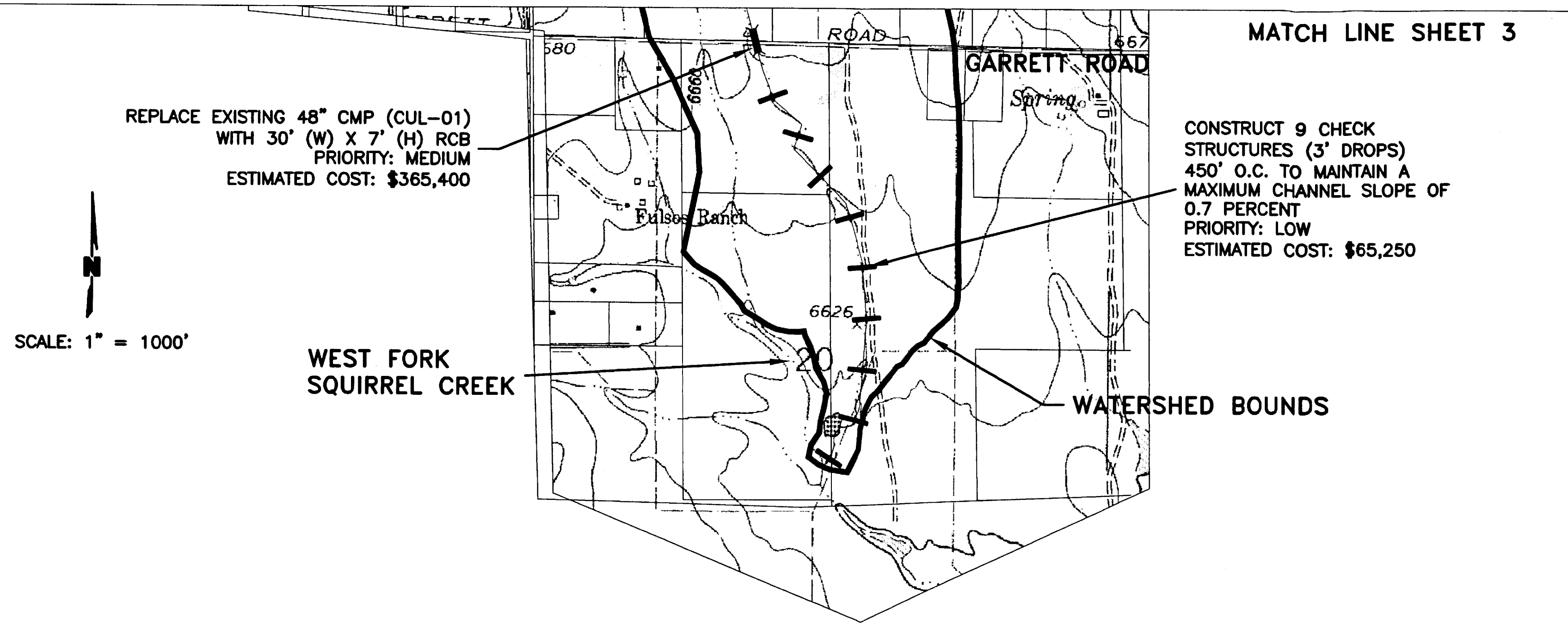


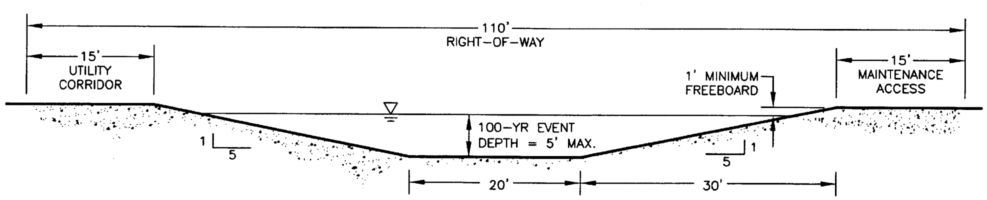
FIGURE 7-1
SHEET 3

STORMWATER & ENVIRONMENTAL CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management

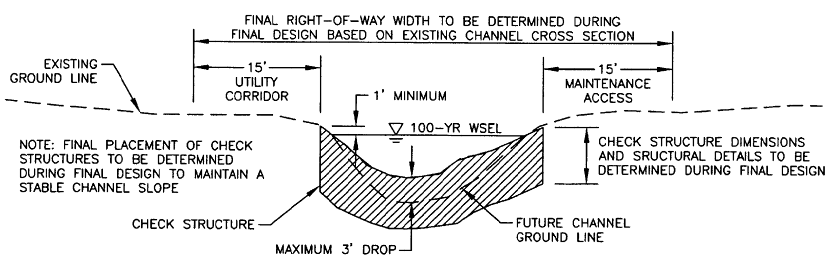
drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:

DRAFT BENNETT
RANCH PILOT PROJECT

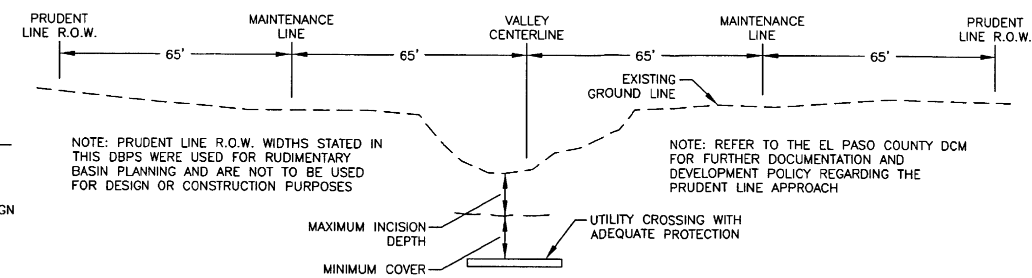




TYPICAL NEW CHANNEL CROSS SECTION
STAPLETON DRIVE TO DRAKE POND
SCALE: 1"=10'



TYPICAL EXISTING CHANNEL CROSS SECTION WITH CHECK STRUCTURES
SUNNYSLOPE DRIVE TO WEST FORK SQUIRREL CREEK
SCALE: 1"=10'



TYPICAL PRUDENT LINE CHANNEL
SNOWBRUSH DRIVE TO MERIDIAN ROAD
NOT TO SCALE

DRAFT BENNETT RANCH PILOT PROJECT

drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:

STORMWATER & ENVIRONMENTAL CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management

EL PASO COUNTY COLORADO SEAL EST. 1861

FIGURE 7-1
SHEET 4

APPENDIX A

Agency Coordination

January 18, 2001

US Army Corps of Engineers
ATTN: Anita Culp
720 N. Main, Rm 205
Pueblo, CO 80103-3046

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Ms. Anita Culp:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

US Fish and Wildlife
ATTN: Bob McCue
PO Box 25486
Denver, CO 80225-0486

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. Bob McCue:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

Colorado Division of Wildlife
ATTN: Gary Dowller
2126 N. Weber
Colorado Springs, CO 80907

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. Gary Dowller:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

Federal Emergency Management Agency
ATTN: John Liou
Denver Federal Center
Bldg 710, Box 25267
Denver, CO 80225-0267

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. John Liou:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

Colorado Water Conservation Board
ATTN: Larry Lang
1313 Sherman, Rm 721
Denver, CO 80203

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. Larry Lang:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

City of Colorado Springs
ATTN: Bruce Thorson
101 W. Costilla St.
Colorado Springs, CO 80901

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. Bruce Thorson:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

El Paso County -
Regional Building Department
ATTN: Floodplain Administrator
101 W. Costilla St.
Colorado Springs, CO 80901

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Sir or Madam:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

National Resources Conservation Service
ATTN: John Valentine
1826 E. Platte Ave., Suite 114
Colorado Springs, CO 80909

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. John Valentine:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

Colorado Department of Transportation
ATTN: Paul Reinswa
16 E. Arvada St.
Colorado Springs, CO 80906

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. Paul Reinswa:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

El Paso County Planning
ATTN: Mark Gebhardt
27 E. Vermijo
Colorado Springs, CO 80903

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Mr. Mark Gebhardt:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

January 18, 2001

Colorado Geological Survey
ATTN: Celia Greenman
1313 Sherman, Rm 715
Denver, CO 80902

Subject: Bennett Ranch Pilot Project Agency Coordination Meeting

Dear Ms. Celia Greenman:

El Paso County is experiencing rapid growth in areas that lack drainage basin plans. In an effort to produce basin drainage plans in a timely manner, El Paso County contracted with Stormwater and Environmental Consultants (SEC) to conduct a Pilot Project that establishes an accelerated planning process for rural basins. A rural basin is defined as any basin likely to have less than a cumulative 15% to 20% imperviousness within the entire basin under future land use conditions. El Paso County selected the Bennett Ranch drainage basin for the Pilot Project to define work efforts and formats for future rural drainage basin planning studies.

On behalf of Andre' Brackin, El Paso County Project Manager, we invite you to attend a project agency coordination meeting on January 30, 2001 at 2:00 p.m. The meeting will be held in the El Paso County Planning Department's 5th floor conference room located at 27 East Vermijo, Colorado Springs. Attached is a meeting agenda and information package for your review.

Please contact Andre' Brackin via email at Andre_Brackin@co.el-paso.co.us to let us know if you are able to attend. If you have any questions prior to the meeting, please all me at (303) 694-3800 or Andre' Brackin at (719) 520-6845. We look forward to meeting with you on January 30th.

Sincerely,

Kurt Bauer, P.E.
Project Manager

Jon Sorensen, P.E.
Project Principal

Z:elpa-pmp:pm:agencyltr.doc

Bennett Ranch Pilot Project
Basin Planning Study Summary

Background

The Bennett Ranch watershed is located approximately 20 miles northeast of downtown Colorado Springs (Figure 2-1 Project Location). The western boundary is located just two miles east of the town of Falcon. The approximately seven square-mile watershed is long, narrow, and aligned north to south. Major roads within the watershed include Highway 24, Meridian Road, Eastonville Road, and Falcon Highway.

The majority of the developed land is currently used for large-lot (greater than 2.5 acres) single family homes with large portions of land within the watershed still undeveloped and used as pasturelands for grazing. Three large subdivisions are proposed within the watershed. It is anticipated that with the development of the three subdivisions, future conditions land use will change to higher density land uses.

Stormwater runoff within the watershed is conveyed north to south through a series of open channel reaches, culverts, and bridges. Existing channels are largely adequate to convey stormwater through the northern portion of the watershed and there are no reported flooding-related problems within this area of the watershed. Flood related problems occur in the middle of the watershed near Highway 24. Drainageways located in this area are poorly defined and existing culverts are undersized. Existing culverts and numerous channel segments within the lower portions of the watershed are undersized but no flood related problems are reported.

Prudent Line Approach

The Bennett Ranch Pilot Project includes a channel setback approach to be considered in rural basins. This approach, named the Prudent Line approach, is an alternative to the way the County has traditionally designed channel improvements. The approach allows a creek to adjust to increased flows from lower density development by constructing a limited number of grade control structures and providing a strip of land adjacent to the creek, defined by a "Prudent Line", within which erosion can occur. Limited bank stabilization would also be implemented in places where erosion may occur such as on the outside of bends. If future erosion threatened land beyond the Prudent Line, the County would have the responsibility to stabilize the erosion.

The Prudent Line setback is protected with an easement, similar to a floodplain easement, where structures are not allowed and maintenance access is provided. The land in the Prudent Line setback can be owned by individual homeowners, by a Homeowners' Association, or can be land dedicated to the County. It is only applicable in areas within the watershed that contain lower land use densities (cumulative upstream land use must contain less than 20 percent impervious cover). With the Prudent Line approach, fewer channel stabilization measures are used than in drainages with conventional channel improvements, and, in most cases, the Prudent Line approach is less costly than the conventional approach.

Project Status
Peak flows within the watershed have been developed and are shown on Figure 3-3 Peak Flows. Based on our deficiency analysis, just over one-half of the evaluated open channel reaches are deficient (23,800 feet of open channel). All nine of the evaluated culverts are deficient. One existing bridge, the Falcon Highway bridge, meets design criteria. Figure 5-1 System Deficiencies presents deficient open channel segments and existing culverts or bridges within the watershed.

Alternatives
Two feasible alternatives have been developed. The first alternative, presented in Figure 6-1 Alternative 1, upgrades the entire conveyance system without any detention storage. It includes:

- Approximately 2.8 miles of Prudent Line reaches
- 2 new box culverts
- 7 new bridges
- 3.2 miles of new channel
- 69 new check structures
- Misc.: Placement of erosion control riprap and removal of existing pond berms
- Monitor approximately 1.7 miles of channel to determine future channel improvements

The second alternative, presented in Figure 6-2 Alternative 2, upgrades the entire conveyance system but includes a regional detention pond located in the middle of the watershed. This alternative includes:

- Approximately 5.9 miles of Prudent Line reaches
- 2 new box culverts
- 6 new bridges
- 1.8 miles of new channel
- 53 new check structures
- Misc.: Placement of erosion control riprap and removal of existing pond berms
- Regional detention pond (21 acre-feet storage)

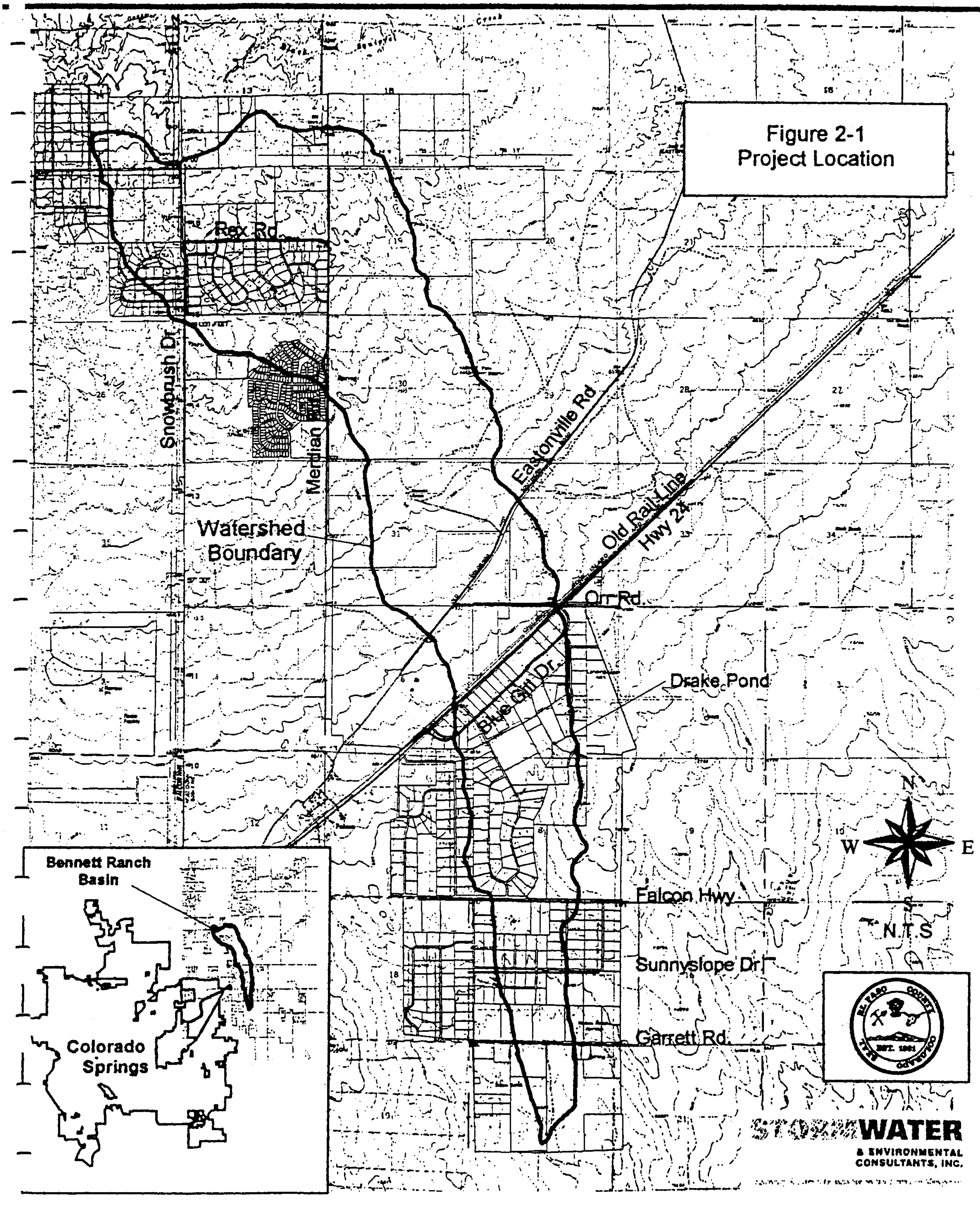
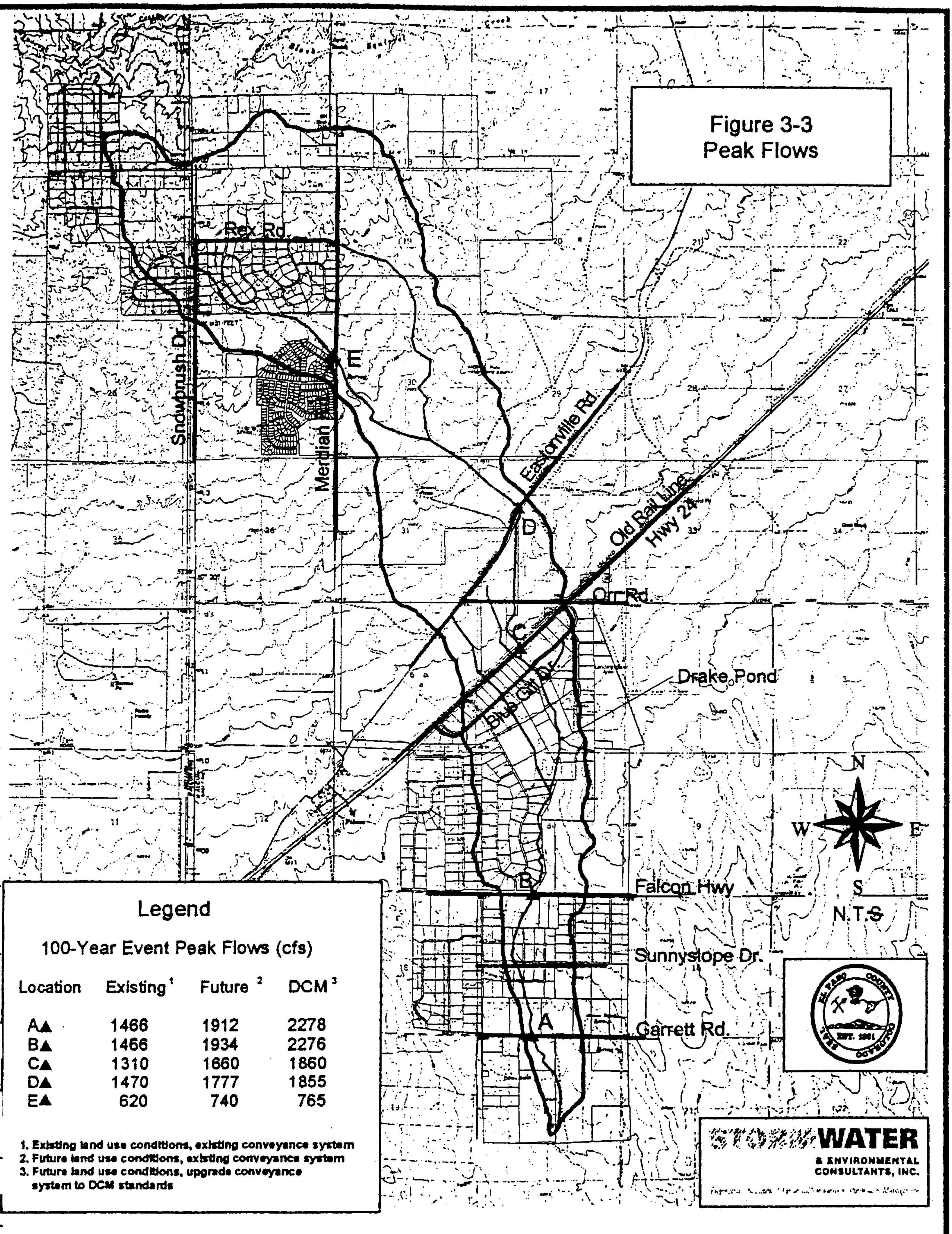


Figure 2-1
Project Location
Rex Rd
Snowbrush Dr.
Meridian Rd
Eastonville Rd
Watershed Boundary
Old Rail Line
Hwy 24
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr
Garrett Rd.
N
W
E
S
N.T.S
Bennett Ranch Basin
Colorado Springs
EST. 1861
WATER
& ENVIRONMENTAL CONSULTANTS, INC.

Figure 3-3
Peak Flows



Legend

100-Year Event Peak Flows (cfs)

Location	Existing [1]	Future [2]	DCM [3]
A▲	1466	1912	2278
B▲	1466	1934	2276
C▲	1310	1660	1860
D▲	1470	1777	1855
E▲	620	740	765

1. Existing land use conditions, existing conveyance system
2. Future land use conditions, existing conveyance system
3. Future land use conditions, upgrade conveyance system to DCM standards

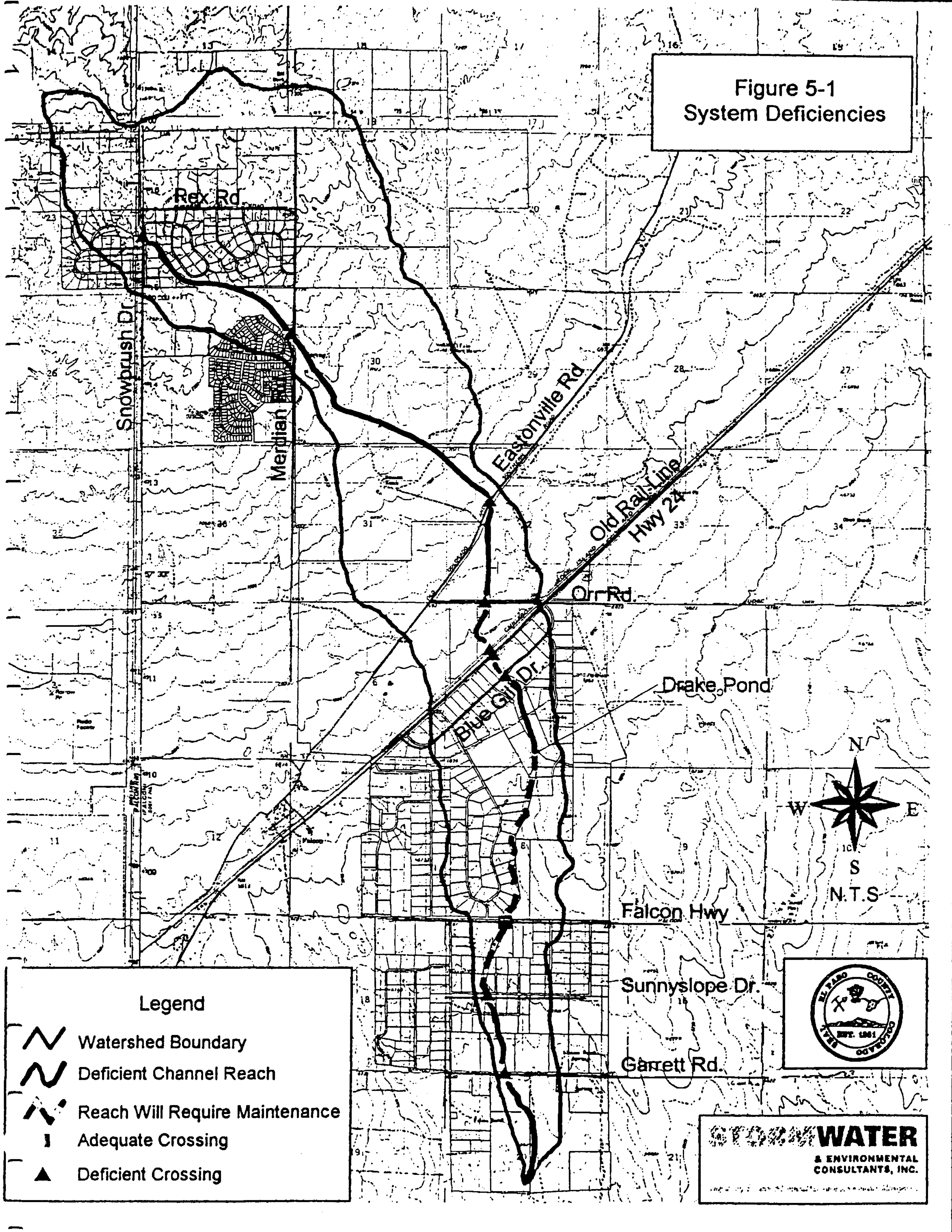


Figure 5-1
System Deficiencies

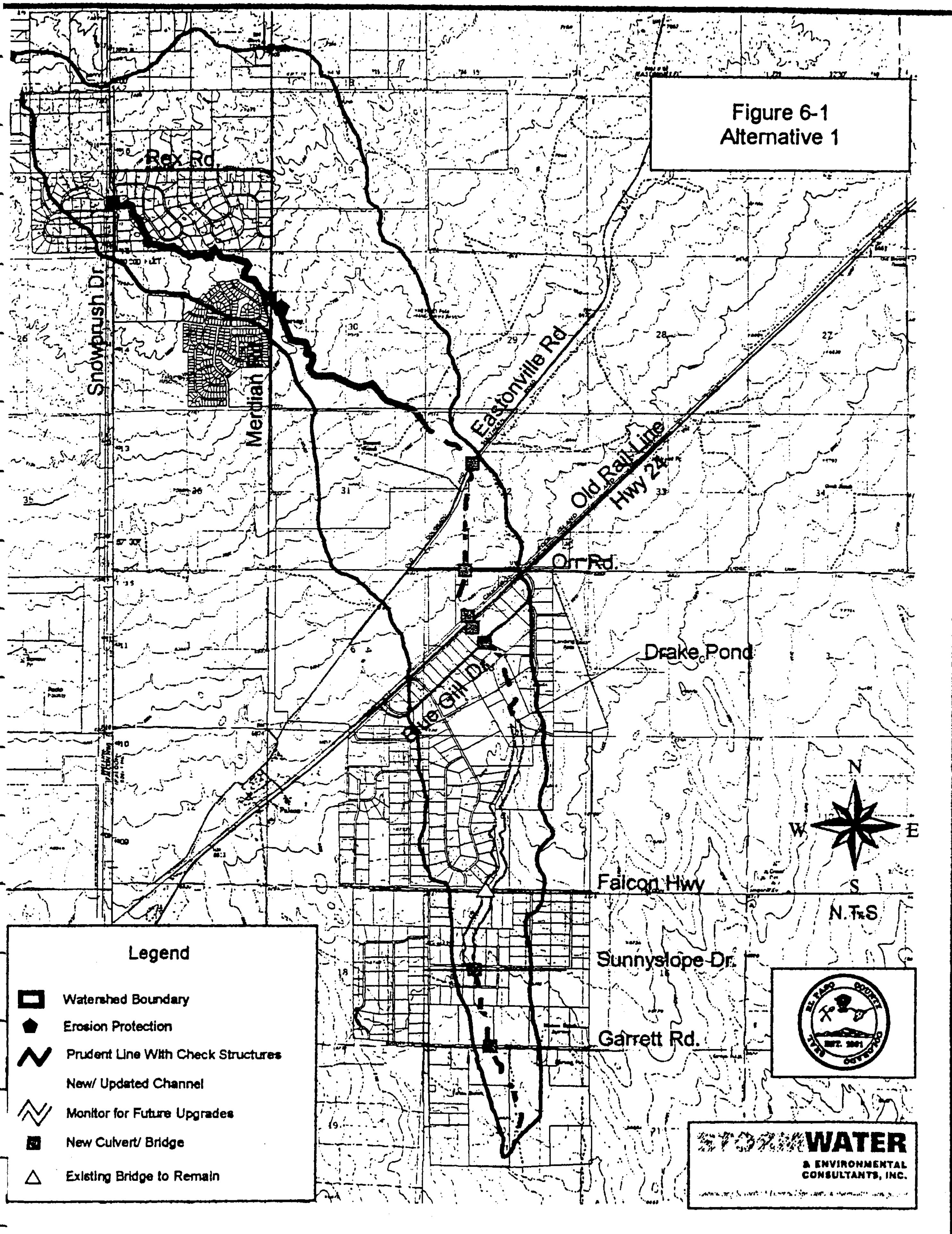


Figure 6-1
Alternative 1
Rex Rd.
Snowbrush Dr.
Meridian Rd.
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Drake Pond
Blue Gill Dr.
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
S
E
W
N.T.S
Legend
Watershed Boundary
Erosion Protection
Prudent Line With Check Structures
New/ Updated Channel
Monitor for Future Upgrades
New Culvert/ Bridge
Existing Bridge to Remain
WATER
& ENVIRONMENTAL
CONSULTANTS, INC.

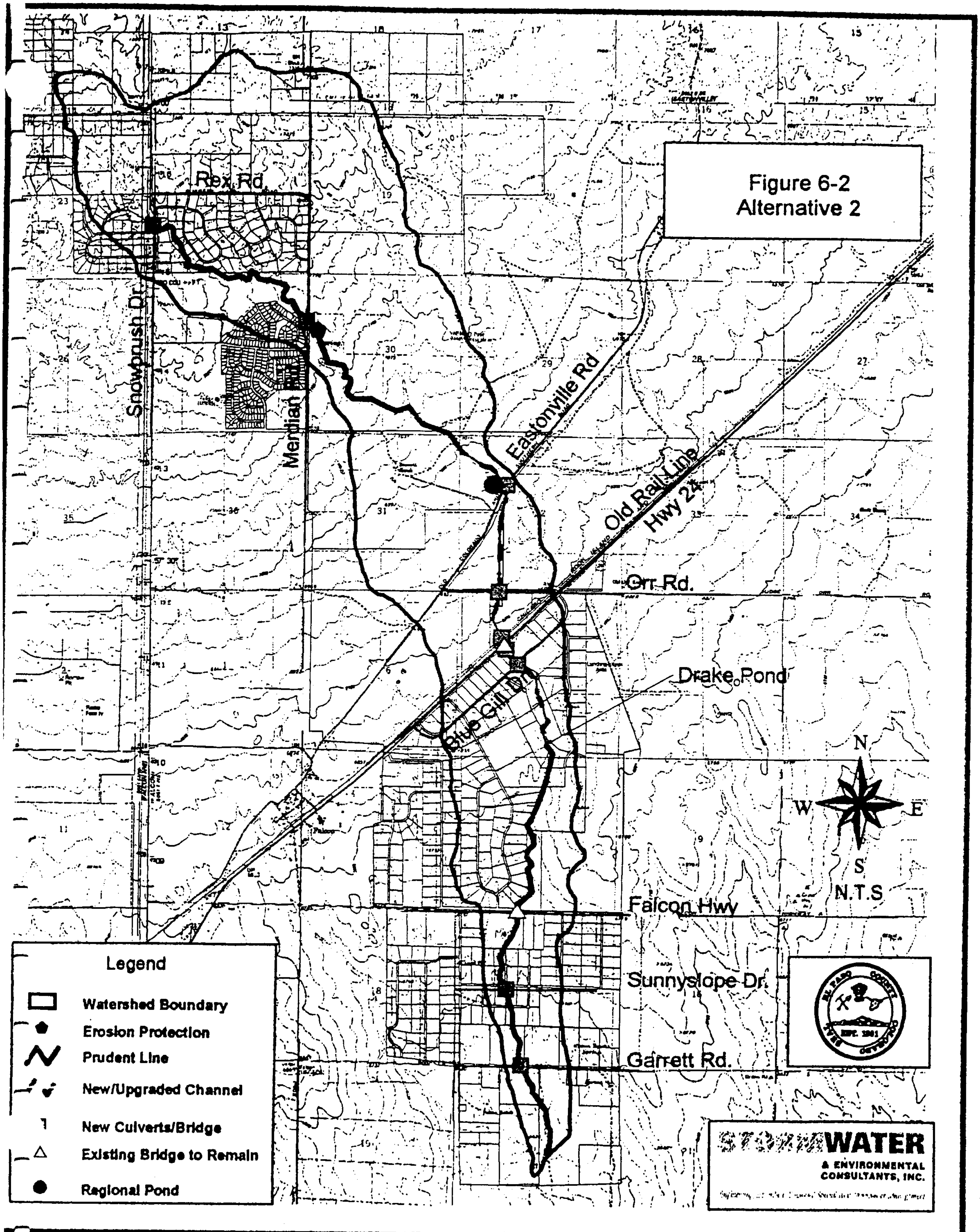


Figure 6-2
Alternative 2
Rex Rd.
Snowbrush Dr.
Meridian Rd.
Eastonville Rd
Old Rail Line
Hwy 24
Orr Rd.
Drake Pond
Blue Gill Dr.
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
N
S
E
W
N.T.S
Legend
Watershed Boundary
Erosion Protection
Prudent Line
New/Upgraded Channel
New Culverts/Bridge
Existing Bridge to Remain
Regional Pond
WATER
& ENVIRONMENTAL CONSULTANTS, INC.

MEETING AGENDA

Bennett Ranch Pilot Project Drainage Basin Planning Study
El Paso County, Colorado
Agency Coordination Meeting

January 30, 2001 2:00 p.m.
5th Floor Conference Room, Planning Department
27 East Vermijo, Colorado Springs

---

1. Rural Basin vs Traditional Basin Planning

A. Rural Planning Goals

1) Prepare rural basin plans for ~50% the current cost of drainage basin studies
2) Prepare rural basin plans in less time (~ 5-6 months)

B. Rural Planning Methods

1) Existing mapping, generally USGS quadrangle maps (electronic)
2) Hydrology with HEC-1 and input parameters generated electronically using AutoCAD Map and ArcView for easier updates/modifications
3) No floodplain delineation (hydrology complete for crossings and channels. Developers can use peak flows to develop floodplains)
4) Concept level design and budgetary opinions of cost
5) Prudent Line as preferred alternative using new El Paso County Rural
6) Basin Methodology developed by Ayres for DCM
7) SIMS will be explored
8) Environmental issues/wetlands

C. Drainage Basin Fees

1) Impervious-based fees

2. Bennett Ranch Pilot Project

A. Status

1) Summary of current schedule and project status
2) Copy of current Bennett Ranch Draft Report

B. Summary

1) Project Location, major features, and land uses
   a. CDOT HWY 24 project
   b. Summary of new subdivision developments
2) Summary of peak flow estimates
3) Prudent Line Applicability
4) System deficiencies/problem areas/public input
5) Presentation of DRAFT Alternatives

3. Agency Comment Period

A. Solicitation of agency questions, concerns, input

B. Future communications and key project milestones

Bennett Ranch Pilot Project
DRAFT Agency Contact List
Modified December 13, 2000

Agency	Contact	Address	Phone Number	Fax Number
US Army Corps of Engineers (USCOE)	Anita Culp	720 N. Main Rm 205 Pueblo, CO 801003-3046	719-543-6914	719-543-9475
Ecological Service US Fish and Wildlife Service (USFWS)	Bob McCue	PO Box 25486 Denver, CO 80225-0486	303-236-7400	
Colorado Division of Wildlife	Gary Dowller Dave Levell	2126 N. Weber Colorado Springs, CO 80907	719-227-5224	719-227-5297
Federal Emergency Management Agency (FEMA)	John Liou	Denver Federal Center Bldg 710 Box 25267 Denver, CO 80225-0267	303-235-4800	303-235-4849
Colorado Water Conservation Board	Larry Lang Bill Green	1313 Sherman Rm 721 Denver, CO 80203	303-866-3441 x320	
City of Colorado Springs	Bruce Thorson	101 W. Costilla St. Suite 113 Colorado Springs, CO 80901	719-385-5054	719-578-6161
Regional Floodplain Coordinator	Dan Bunting	El Paso County Engineering Department of Transportation 3460 Marksheffel Road Colorado Springs, CO 80922	719-578-6230	719-578-6806
National Resources Conservation Service (NRCS)	John Valentine	1826 E. Platte Ave. Suite 114 Colorado Springs, CO 80909	719-632-9598	719-473-7104
Colorado Department of Transportation (CDOT)	Paul Reinswa	16 E. Arvada St. Colorado Springs, CO 80906	719-634-2303	719-632-2172
El Paso County Planning	Mark Gebhardt	27 East Vermijo Colorado Springs, CO 80903	719-520-6300	
Colorado Geological Survey	Celia Greenman	1313 Sherman Street Room 715 Denver, CO 80203	303-866-2611 x2811	303-866-2461

F:elpapmp:correspondence:agencycontacts.doc

Bennett Ranch Pilot Project
Drainage Basin Planning Study
Agency Coordination Meeting

January 30, 2001 2:00 p.m.
5th Floor Conference Room, Planning Department
27 East Vermijo, Colorado Springs

List of Attendees

Name	Organization	Contact Number
ANDRÉ BRACKIN	EPCDOT	719-520-6845 andre_brackin@co.el-paso.co.us
John Valentine	NRCS	719-473-7104 EXT 3 John.Valentine@co.usda.gov
Celia Greenman	Co. Geo Surv.	celia.greenman@state...
JOE GORNEY	EL PASO COUNTY PLANNING DEPT.	719-520-6304 joegorney@elpasoco.com
ROBERT PLESE	PPRBD	327-2906 RLPLESE@PPRBD.ORG
Garth England	URS	303-796-4631 Garth_England@...
Paul REINSMA	CDOT	719-331-5384 Cell 719-634-2323
Bruce Thorson	City Engineering	385-5054
TIM MITROS	" "	385-5061
Jon Sorensen	SEC/OA	303-694-3800
Kurt Bauer	SEC/OA	303-694-3800

Criteria for Prudent Line Channel Reaches

Location	Classification	Criteria
Snowbrush Drive to Eastonville Road	Prudent Line Reaches	• Bank full capacity of channel must convey flows from future land use conditions 10-year event • All upstream culverts and bridges must not significantly alter channel hydraulics (limited backwater effects) • Velocities caused by the future land use conditions 100-year event must not increase velocities more than 10% above existing conditions 100-year event velocities.

Criteria for Traditional-Improvement Channel Segments (Non-Prudent Line Channels)

Location	Classification	Criteria
Eastonville Road to Watershed Outfall	Major drainageway segment (100-year event flows > 1,500 cfs)	• Maximum channel Froude # of 0.9 (unlined channels) for 100-year event • Maximum mean channel velocity of 5 ft/sec (unlined channels with coarse sand or fine gravel or vegetated bottoms) for 100-year event • Minimum one foot of bank freeboard for 100-year event

Criteria for Structures

Location	Classification	Criteria
• Snowbrush Drive • Meridian Road	Culverts located on a collector Road within a Prudent Line Reach	Minimal backwater effects
• Judge Orr Road • RR Bridge • Hwy 24 • Blue Gill Drive • Falcon Hwy • Sunny Slope Road • Garrett Road	Structures along a major drainageway (100-year event flows > 1,500 cfs)	Minimum two feet of freeboard for the 100-year event

El Paso County DCM
Prudent Line Applicability Criteria

DCM Prudent Line approach is applicable and recommended for:

Open channel segments located downstream from land having less than or equal to a cumulative 15% impervious surface cover under future conditions <u>and</u> the main channel can adequately convey future conditions 10-year event flows.

DCM Prudent Line approach may apply to:

Open channel segments located downstream from land having between a cumulative 15% and 20% impervious surface cover under future conditions <u>and</u> the main channel can adequately convey future conditions 10-year, flows. These reaches require justification for recommending the prudent line approach.

DCM Prudent Line approach is not recommended for:

Open channel segments located downstream from land having greater than a cumulative 20% impervious surface cover under future conditions <u>or</u> main channel lacks adequate conveyance capacity for the future conditions 10-year flows. However, the Prudent Line may still be considered if a detailed analysis of the Prudent Line is conducted using more advanced analytical techniques. The detailed approach must be completed by a firm experienced in conducting this advanced Prudent Line analysis.

Comments/Notes from Agency Coord. Mtg.

Andre - should we require the developer to develop flood plain in the planning study / how it relates to the prudent line

- consider not simulating A soil groups because a saturated conditions

- water conservation board
larry lang - same mapping? w/i the basin

* need to state in the study who is to maintain the pond

- stipulate how the pond be constructed
do we or is that covered in the
we need to ID the cost of importing materials to construct the pond i.e. reflect the cost/maintenance of pond in cost estimate.

& ENVIRONMENTAL
CONSULTANTS, INC.

PROJECT ____ TASK ____
BY WWB DATE 1-30-01

* • Keep in the report the no-detention alt.

→ we need to comment @ least on the use of soil type A &/or antecedent moisture conditions.

→ Put Robert Lee Plese Floodplain administrator (719) 327-2906 on the DCM Prudent line review criteria

look @ County geotech logs & also WM Curtis Wells & Co. 1977 GW map.
get from Rich Cooper @ water resources

SHEET 2 OF ____

MEMORANDUM

To: Andre Brackin, Project Manager, El Paso DOT
From: Celia Greenman
Date: February 1, 2001

Re: Bennett Basin Planning Study

I have both general and specific comments to make on the report.

General:

Criteria for the planning study. The Drainage Criteria Manual for Colorado Springs, El Paso County, states in the outline, p. 4-3, that the report should include "drainage criteria and special requirements unique to the basin" and include "subsurface investigations". While I understand that the planning study for a rural basin may omit some of the detail or methodology that is required for an urban area, I believe that conditions in the Bennett Basin necessitate that the effects of groundwater and near-surface geology be studied. These factors play a prominent role in the drainage of the basin, and to ignore them will produce an inadequate picture of how drainage operates and how improvements will perform. There is significant interaction between the bedrock and alluvial aquifers that contributes to the generally high water table, which in turn impedes surface drainage.

> **Response**:
> All criteria and/or design considerations unique to the basin are included in the report, specifically in the Recommended Alternative section. The issue of consideration of groundwater in basin planning studies should be discussed with El Paso County because this is a DCM issue.

I agree with John Valentine, NRCS, on the importance of accurate soil classification. The comment in the draft report that "the watershed contains predominantly low-runoff potential soils" should be examined in light of how grading operations will transform the soil profile in the upstream part of the basin.

> **Response:**
> It is our understanding from the agency coordination meeting that this was really an issue of saturated ground conditions. We have addressed this by decreasing the initial infiltration rate from the HEC-1 default values to 0.5 inches for subcatchments located near Highway 24. All reported flows in the revised draft Bennett Ranch basin study reflect the decreased infiltration rates.

Specific:

Detention and channelization will change a portion of the flows from sheet to concentrated. Has SEC studied how the stream banks may be affected?

> **Response**:
> The Prudent Line approach allows the stream to naturally meander without adversely affecting private or public property. Ayres Associates developed Prudent Line setbacks for this project. All setbacks consider stream meandering and associated effects on stream banks.
>
> All "traditional channel improvements" ie non Prudent Line segments, are designed based on current DCM criteria. The DCM criteria limits velocities in the channel. The velocity limits are based on erosion control. It is recommended in this study to reduce velocities (when they are anticipated to exceed DCM criteria) by constructing check structures. Site-specific erosion problems at Meridian Road are addressed in the study.

In studying the communication between surface water and the alluvial and bedrock aquifers, the contribution of the future wastewater treatment plant at Stapleton Road should not be overlooked. While flows would not be considered the equivalent of storm volumes, they will be consistent, and at buildout are projected at 1.3 mgpd. This is not an insignificant amount of water that will be added to the hydrologic system.
The capacity of detention ponds may be compromised by the buildup of sediment and the inflow of groundwater, particularly if there are prolonged periods of precipitation that cause groundwater to rise.

> **Response**:
> 1.3 MGD = 2 cfs. The 100-year peak flow under future conditions at the downstream end of the project is estimated at 2,544 cfs. The plant would contribute 0.08% of this flow. The estimated future 5-year peak flow is 484 cfs. The plant would contribute 0.4% of this flow. This flow of 2 cfs is well below the accuracy of any HEC-1 model flow estimates. The potential groundwater effects caused by the 2 cfs increase to base flow could be considered in an Environmental Assessment conducted separate from this study.

Flows and soil loss should be calculated for construction periods (overlot grading, bare ground), and temporary detention and sedimentation ponds should be designed accordingly. This is an issue that should be addressed specifically by the Bennett Ranch and Meridian Ranch developments, but the impact of inadequately designed temporary structures will be manifested downstream.

> **Response:**
> Construction-related practices are addressed in development drainage plans.

The Colorado Water Conservation Board should be contacted to see if they can provide assistance in characterization of the floodplain in the area

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 11/7/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Paul Reinsma	Colorado Dept. of Trans.

		TIME
[ ]	MEETING	
[X]	RECEIVED CALL	7:45 a.m.
[ ]	COMPLETED CALL	
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Paul indicated that his only concern is with the proposed detention ponds upstream of Highway 24. Paul said that he was concerned that stored stormwater in the ponds will provide a driving head for the high groundwater in the area, and cause problems similar to the ones experienced near Falcon. Paul would like URS to take measures to prevent this from happening such as lining the ponds or other measures.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 10/22/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Anita Culp	US Army Corps of Engineers

		TIME
[ ]	MEETING	
[X]	RECEIVED CALL	2:00 p.m.
[ ]	COMPLETED CALL	
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Anita returned my call from 10/19/01 and said that she was unable to find the project in her database and couldn't remember what the project was about. She requested that I send her a copy of the agency coordination letter that was sent to her on January 18, 2001.
I over-nighted the letter and its enclosures on 10/22/01.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 10/24/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Gary Dowler	Colorado Division of Wildlife

		TIME
☐	MEETING	
X	RECEIVED CALL	3:00 p.m.
☐	COMPLETED CALL	
☐	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Gary returned my call from 10/19/01 and 10/24/01 and said that he needs to review the Feb. 2001 Draft DBPS before he can say that he has no issues. He asked if we had selected the alternative that included the over-detention scenario required by the BOCC, and I said yes.
Gary indicated that he would also have the habitat dept. review the report, and if I don't hear back from him by 10/26/01, the Colorado Division of Wildlife doesn't have any issues.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 10/25/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Larry Lang	:olorado Water Conservation Boar

		TIME
☐	MEETING	
X	RECEIVED CALL	9:54 a.m.
☐	COMPLETED CALL	
☐	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Larry returned my call from 10/19/01 and 10/24/01 and said that the Colorado Water Conservation Board doesn't have any interest in that area at this time. He said that they were planning to do some flood plain studies in the Black Squirrel Basin in about a year or so, but said he would have no issues with this particular study.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 10/19/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Bruce Thorson	City of Colorado Springs

		TIME
[ ]	MEETING	
[ ]	RECEIVED CALL	
[X]	COMPLETED CALL	8:55 a.m.
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Bruce indicated that the City of Colorado Springs had no outstanding issues in regards to the Bennett Ranch Pilot Project DBPS. Bruce also indicated that he was aware that the Drainage Board had approved the study.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 11/6/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Robert Plese	Regional Floodplain Coordinator

		TIME
[ ]	MEETING	
[ ]	RECEIVED CALL	
[X]	COMPLETED CALL	2:45 p.m.
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: I contacted Robert and he indicated that he had no outstanding issues with the project.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT Bennett Ranch Pilot Project

Job No. 2000-0818
Date 10/24/01
Sheet 1 of 1

NAME(S)	REPRESENTING
John Valentine	tural Resources Conservation Serv

		TIME
[ ]	MEETING	
[X]	RECEIVED CALL	2:30 p.m.
[ ]	COMPLETED CALL	
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: John returned my call from 10/19/01 and said that he had seen the final draft of the DBPS and didn't have any comments or issues with it.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 10/19/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Celia Greenman	Colorado Geological Survey

		TIME
[ ]	MEETING	
[ ]	RECEIVED CALL	
[X]	COMPLETED CALL	9:45 a.m.
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Celia was familiar with the project and was aware that the project went before the Planning Commission last week. I indicated that Kurt Bauer had written responses to the formal comments she made after the January 30, 2001 meeting. Celia indicated that she did not have any outstanding issues regarding the project.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 11/15/01
Sheet 1 of 1

NAME(S)	REPRESENTING
John Liou	FEMA

		TIME
[ ]	MEETING	
[ ]	RECEIVED CALL	
[X]	COMPLETED CALL	3:30 p.m.
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: John informed me that he would need to review the report and our hydrology modeling data and compare the information to a study that FEMA and ACOE is going to do in the Black Squirrel Creek Basin. FEMA and ACOE are planning to do a detailed hydrology and floodplain study of this basin, but are not currently under contract at this time. John indicated that it would be at least 2 or 3 months before FEMA and ACOE were even under contract for the project. John said that whether or not FEMA approves the study would depend on if our hydrology results for the Bennett Ranch Basin match the results FEMA and ACOE get from their study.

CC:

BY: Matt Bachman

Olsson Associates
Engineers - Planners - Scientists - Surveyors
143 South Union Blvd., Suite 700
Lakewood, CO 80228
(720) 962-6072
Fax: 962-6195

COMMUNICATION MEMO

PROJECT: Bennett Ranch Pilot Project

Job No. 2000-0818
Date 11/15/01
Sheet 1 of 1

NAME(S)	REPRESENTING
Lee Carlson	US Fish and Wildlife Service

		TIME
[ ]	MEETING	
[ ]	RECEIVED CALL	
[X]	COMPLETED CALL	3:00 p.m.
[ ]	LEFT MESSAGE	

SUBJECT: Contacting all agencies involved to determine if any outstanding issues exist

NOTES: Lee informed me that the only concern the Fish and Wildlife Service would have would be related to the Preble's meadow jumping mouse and any other threatened or endangered species which may exist within the Bennett Ranch basin. He recommended that the DBPS address this issue.

CC:

BY: Matt Bachman

FACSIMILE TRANSMITTAL HEADER SHEET

For use of this form, see AR 25-11; the proponent agency is ODISC4

COMMAND/ OFFICE	NAME/ OFFICE SYMBOL	OFFICE TELEPHONE NO. (AUTOVON/Comm.)	FAX NO. (AUTOVON/Comm.)
FROM: CORPS OF ENGINEERS	ANITA CULP	719-543-6914	719-543-9475
TO: OLSSON ASSOC	MATT BACHMAN	720-962-6072	720-962-6195

CLASSIFICATION	PRECEDENCE	NO. PAGES (Including this Header)	DATE-TIME	MONTH	YEAR	RELEASER'S SIGNATURE
		3	10-24-01			

REMARKS

Space Below For Communications Center Use Only

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
SOUTHERN COLORADO REGULATORY OFFICE
720 NORTH MAIN STREET, SUITE 205
PUEBLO, COLORADO 81003-3046
FAX (719) 543-9475

October 24, 2001

REPLY TO
ATTENTION OF:

Operations Division
Regulatory Branch

Mr. Matt Bachman
Olsson Associates
143 South Union Boulevard, Suite 700
Lakewood, CO 80228

Dear Mr. Bachman:

This replies to your October 22, 2001 transmittal requesting a review of the Bennett Ranch Pilot Project Basin Planning Study Summary for the Bennett Ranch watershed near Falcon, El Paso County, Colorado. We have assigned Action No. 2001 00718 to this request.

We have studied the project description, other records, and documents available to us. It appears that the drainage basin contains the following water(s) of the United States: numerous unnamed tributaries of West Fork Black Squirrel Creek, adjacent wetlands, ponds created by impounding waterways, and tributary wetlands. It does not appear that there are any isolated waters within the basin. A site visit was not made and other waters of the United States may be located within the basin.

Waters of the United States are regulated under provisions of Section 404 of the Clean Water Act and a Department of the Army permit may be required for the discharge of dredged or fill material into these waters. Most of the actions included in either alternative may involve a regulated discharge into waters. The exception is the Prudent Line reaches where sections of waterways may have no action.

For Prudent Line reaches, we recommend that trails which parallel streams be located outside the prudent line. Locating trails within the line places them at risk from erosion. The typical response to an erosion threat is to hard line the stream bank, thus defeating the purpose of the prudent line concept.

Please be informed that the Black Squirrel Creek basin in El Paso County may contain habitat or populations of the Federally-listed threatened species, Preble's meadow jumping mouse. Potential areas of habitat are streams, wetlands, and riparian and upland areas within 300 feet of streams, wetlands, or flood plains. Before any Section 404 permit can be used for study-recommended activities, the Corps of Engineers must obtain endangered species clearance for the Section 404 activities. Developers are separately responsible for complying with the Endangered Species Act for the portions of developments that are not within the Corps of Engineer's purview.

These comments are provided as a review response only. If you have any questions, please feel free to contact me at (719) 543-6914 or by email at anita.e.culp@usace.army.mil.

Sincerely,

Anita E. Culp
Senior Project Manager

APPENDIX G – DRAINAGE MAPS

WHMD RWRF STORMWATER IMPROVEMENTS

EXISTING DRAINAGE MAP

EXISTING RATIONAL CALCULATIONS SUMMARY				
DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
EX-1	EX-1	0.03	0.01	0.09
EX-2	EX-2	0.23	0.09	0.69
EX-3	EX-3	0.03	0.01	0.08
EX-4	EX-4	0.74	0.19	1.39
EX-5	EX-5	0.84	0.35	1.95
EX-6	EX-6	1.23	1.26	3.98
EX-7	EX-7	0.61	0.73	2.06
EX-8	EX-8	0.35	1.34	2.49
EX-9	EX-9	0.54	2.50	4.48
EX-10	EX-10	1.37	1.63	4.38
EX-11	EX-11	0.16	0.76	1.37
EX-12	EX-12	0.45	0.22	1.01
EX-13	EX-13	0.07	0.03	0.21
EX-14	EX-14	0.77	0.51	1.76
EX-15	EX-15	2.28	2.83	7.02
EX-16	EX-16	1.43	3.62	7.20
EX-17	EX-17	1.74	0.75	3.42
EX-18	EX-18	0.44	0.32	1.20
EX-19	EX-19	0.62	0.30	1.44
OF-1	OF-1	0.27	0.11	0.78
OF-2	OF-2	0.05	0.02	0.16
OF-3	OF-3	0.54	0.13	0.98
OF-4	OF-4	0.11	0.04	0.29
OF-5	OF-5	0.06	0.02	0.13
OF-6	OF-6	0.12	0.03	0.19

LEGEND

A = BASIN DESIGNATION
B = AREA (ACRES)
C = IMPERVIOUSNESS
D = 100-YR DESIGN STORM RUNOFF (CFS)

= DESIGN POINT

EXISTING FLOW DIRECTION

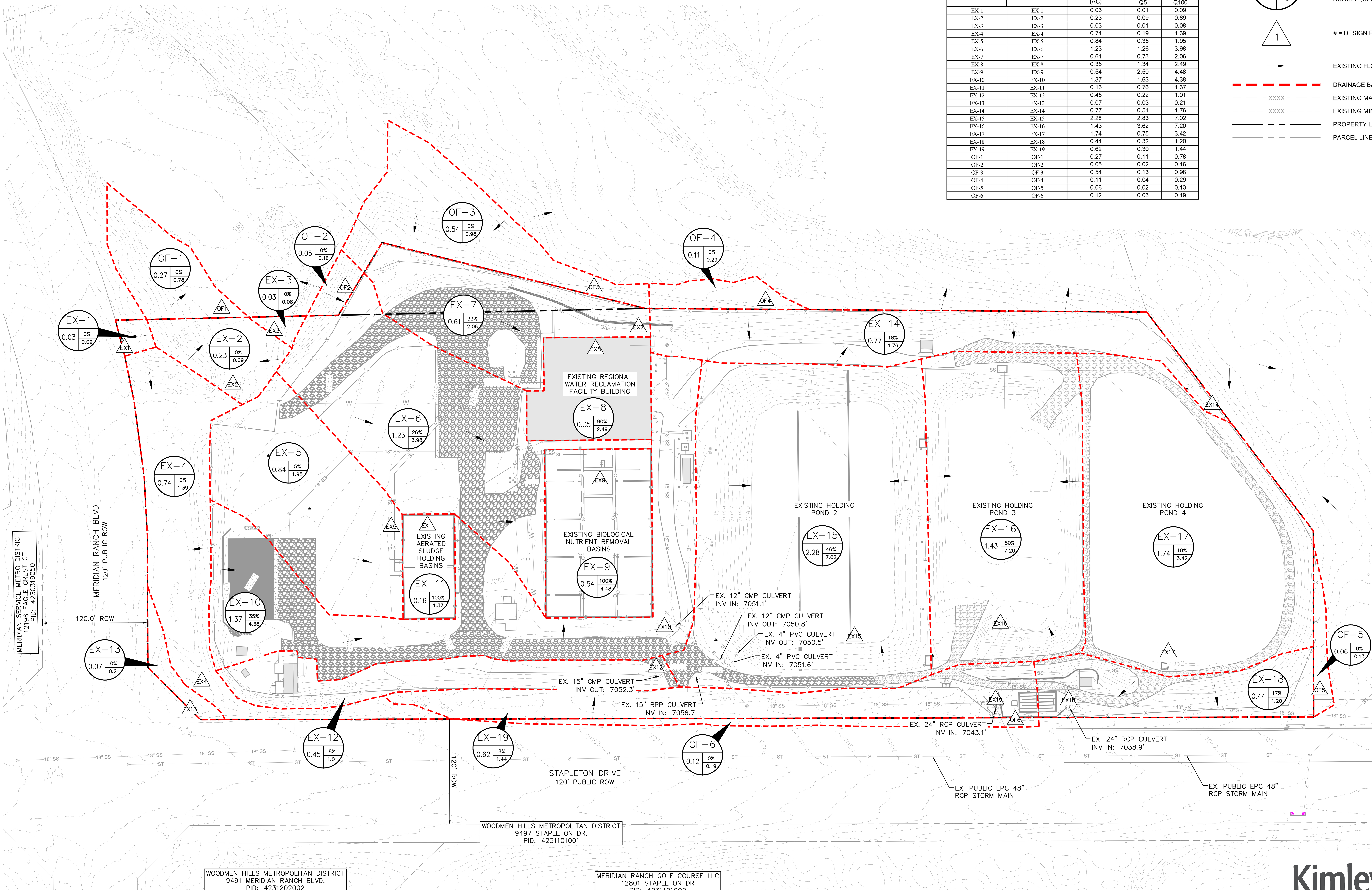
DRAINAGE BASIN BOUNDARY

XXXX EXISTING MAJOR CONTOUR

XXXX EXISTING MINOR CONTOUR

PROPERTY LINE

PARCEL LINE



2 NORTH NEVADA AVENUE, SUITE 900
COLORADO SPRINGS, COLORADO 80903 (719) 453-0180

WHMD RWRF STORMWATER IMPROVEMENTS

PROPOSED DRAINAGE MAP

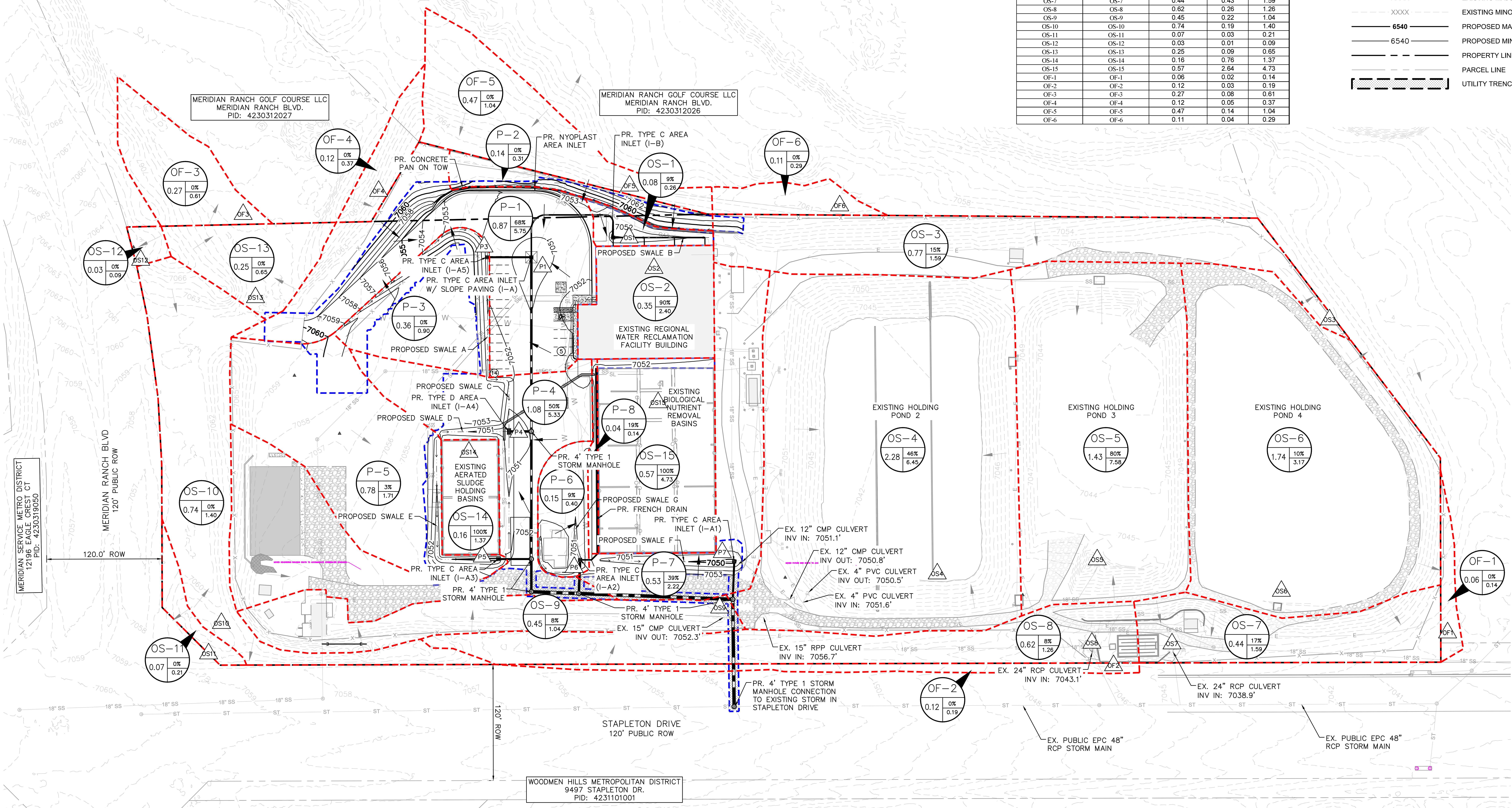
PROPOSED RATIONAL CALCULATIONS SUMMARY				
DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
P-1	P-1	0.87	2.85	5.75
P-2	P-2	0.14	0.04	0.31
P-3	P-3	0.36	0.12	0.90
P-4	P-4	1.08	2.32	5.33
P-5	P-5	0.78	0.28	1.71
P-6	P-6	0.15	0.09	0.40
P-7	P-7	0.53	0.84	2.22
P-8	P-8	0.04	0.04	0.14
OS-1	OS-1	0.08	0.06	0.26
OS-2	OS-2	0.35	1.29	2.40
OS-3	OS-3	0.77	0.40	1.59
OS-4	OS-4	2.28	2.61	6.45
OS-5	OS-5	1.43	3.81	7.58
OS-6	OS-6	1.74	0.70	3.17
OS-7	OS-7	0.44	0.43	1.59
OS-8	OS-8	0.62	0.26	1.26
OS-9	OS-9	0.45	0.22	1.04
OS-10	OS-10	0.74	0.19	1.40
OS-11	OS-11	0.07	0.03	0.21
OS-12	OS-12	0.03	0.01	0.09
OS-13	OS-13	0.25	0.09	0.65
OS-14	OS-14	0.16	0.76	1.37
OS-15	OS-15	0.57	2.64	4.73
OF-1	OF-1	0.06	0.02	0.14
OF-2	OF-2	0.12	0.03	0.19
OF-3	OF-3	0.27	0.08	0.61
OF-4	OF-4	0.12	0.05	0.37
OF-5	OF-5	0.47	0.14	1.04
OF-6	OF-6	0.11	0.04	0.29

LEGEND

A = BASIN DESIGNATION
B = AREA (ACRES)
C = IMPERVIOUSNESS
D = 100-YR DESIGN STORM RUNOFF (CFS)

= DESIGN POINT

EXISTING FLOW DIRECTION
PROPOSED FLOW DIRECTION
DRAINAGE BASIN BOUNDARY
PROPOSED LIMITS OF DISTURBANCE
XXXX EXISTING MAJOR CONTOUR
XXXX EXISTING MINOR CONTOUR
6540 PROPOSED MAJOR CONTOUR
6540 PROPOSED MINOR CONTOUR
PROPERTY LINE
PARCEL LINE
UTILITY TRENCHING AREA



Kimley»Horn

2 NORTH NEVADA AVENUE, SUITE 900
COLORADO SPRINGS, COLORADO 80903 (719) 453-0180