Welcome to the Urban Drainage and Flood Control District's

2016 Annual Seminar

2016 UDFCD ANNUAL SEMINAR PROGRAM

April 5, 2016 at the OMNI Hotel in Broomfield
500 Interlocken Blvd | Broomfield CO 80021

7:30 AM	8:15 AM	Registration and Continental Breakfast	
8:15 AM	8:20 AM	The Honorable Joyce Downing, Mayor of Northglenn and Chair of UDFCD Board of Directors	Welcome!
8:20 AM	9:10 AM	Paul Hindman, P.E., Scott Tucker, P.E. (UDFCD Retired), Ken Wright, P.E. (Wright Water)	Creating a Safer Community
9:10 AM	9:35 AM	Jane Clary, LEED AP, CPESC (Wright Water)	E. Coli Mitigation Toolbox
9:35 AM	9:55 AM	Morning Networking Break	
9:55 AM	10:35 AM	Kevin Stewart, P.E., Dmitry Smirnov, Ph.D. (Dewberry)	State of the Science (SOS)—Recognizing Flood Threats Hours Before the Rains Come
10:35 AM	11:15 AM	David Mallory, P.E., Jenelle Kreutzer (ERO Resources)	Community CRS Support Initiative and Recent Developments in the LOMC Process
11:15 AM	11:55 AM	Holly Piza, P.E.	Urban Storm Drainage Criteria Manual Volumes 1 and 2 Revisions—What's New?
11:55 AM	12:45 PM	Lunch Buffet, Speaker Kevin Rein, Colorado Division of Water Resources **Presentation of 2016 Friend of UDFCD Award**	
12:45 PM	1:25 PM	David Skuodas, P.E.	Connecting Vegetation Management to the Mapped Flood Risk
1:25 PM	2:10 PM	Joe Williams, Steve Materkowski, EIT, CPESC, Jason Stawski, EIT, Mike Sarmento	**Beyond Design: A Construction Manager's Perspective** - Soil Lifts Top Ten List - FEMA Flood Reimbursement, To Do or Not To Do - MEP Final Acceptance: Site Stability and Revegetation
2:10 PM	2:40 PM	Andrew Earles, P.E., Ph.D (Wright Water), Adam Kremers, P.E. (Wright Water)	Water Balance and Water Rights Analysis of the Effects of Full Spectrum Detention on the Colorado Front Range
2:40 PM	3:00 PM	Afternoon Networking Break	
3:00 PM	3:35 PM	Shea Thomas, P.E.	Adventures in Master Planning
3:35 PM	4:10 PM	Ken MacKenzie, P.E., Gerald Blackler, P.E., Ph.D (Enginuity)	Update on Regional Hydrologic Investigations
4:10 PM	4:15 PM	Paul Hindman, P.E.	Q & A, Closing remarks

SESSION 1

The Urban Drainage and Flood Control District
Creating a Safer Community

By Paul Hindman, UDFCD, Scott Tucker, UDFCD Retired, and Ken Wright, Wright Water Engineers

ABSTRACT:

In 1969 the Colorado State General Assembly created the Urban Drainage and Flood Control District (UDFCD). Early on several guiding principles were developed to lessen the destruction floods cause in the Denver Metro area. The discussion for our session will highlight many of those processes and policies which are integral to good floodplain management. The major items initiated were:

- *Maintenance Eligibility-Encourages local governments to develop within drainageways following District criteria.*
- *Floodplain Preservation-Partners with local governments to purchase flood prone properties*
- *Stream Stabilization-Prevents drainageways from aggrading or degrading so that property during a major flood is not severely damaged*
- *Masterplan to Maintenance-The full cycle of master planning a drainageway, designing improvements, construction, and then maintaining those improvements.*
- *Natural and Beneficial Uses of Floodplains-Incorporating all aspects of floodplains during design to maximize improvements not only financially but socially and environmentally.*
- *Flood Warning-A network of monitoring equipment used by engineering and meteorological professionals to alert first responders of a pending flood.*
- *Floodplain Regulation-Coordinating with local governments to responsibly develop in flood prone areas.*

None of the programs or processes mentioned above could, alone, protect the public from major damage during a flood, but combined the end result was a safer community for all of the citizens within the District boundaries. Our discussion will be presented by current and former founding fathers of UDFCD who made it all work.

SESSION 2

E. coli Mitigation Toolbox

By Jane Clary, Wright Water Engineers

ABSTRACT:

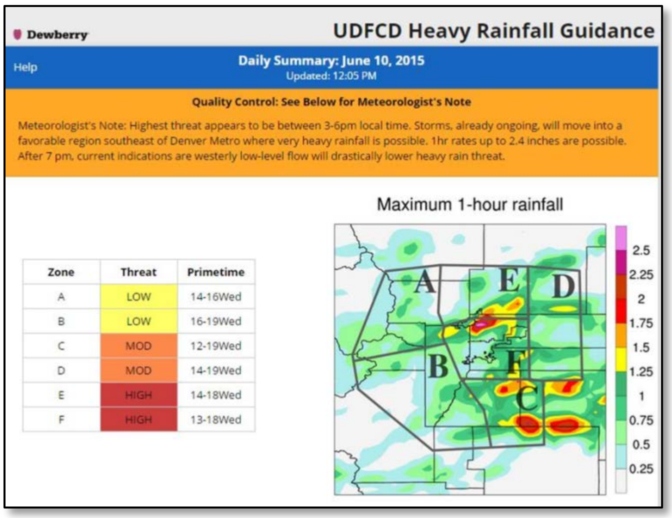
Approximately 70 stream segments in Colorado are currently identified as impaired or in need of additional monitoring and evaluation due to elevated E. coli concentrations relative to recreational water quality standards. For streams identified as impaired on Colorado's "303(d) List," typically the next step is development of a total maximum daily load (TMDL), which determines the load reductions needed to stream to attain recreational water quality standards. In urban areas, municipal separate storm sewer systems (MS4s) may have additional permit requirements to reduce E. coli loading as a result of these TMDLs.

UDFCD and the City and County of Denver along with Wright Water Engineering are developing a "toolbox" to provide a consolidated resource to support MS4s working to reduce E. coli loading to impaired waterbodies. Although the issue of E. coli impairment in urban areas is complex, this toolbox has been kept as simple as possible with the intention of providing readers with a broad range of backgrounds a resource to develop a general understanding of the issues and to provide tools that may be useful for reducing E. coli loads from urban areas.

State of the Science (SOS)—Recognizing Flood Threats Hours before the Rains Come

By Kevin Stewart, UDFCD, and Dima Smirnov, Ph.D., Dewberry

ABSTRACT:



High resolution gridded weather forecast models compete to answer the question…which one is best? Weather news reports frequently call attention to differences between European models and those built in the U.S. Canada offers some nice options too and meteorologists all seem to have their personal preferences. With so much invested in this research, UDFCD chose to take a closer look in 2015 by having meteorologists from Dewberry develop a website that leverages model outputs to advance the art of flash flood prediction. The website presents the collective results from 13 different quantitative precipitation forecast (QPF) models without favoring any particular model. Time series graphics are used to reveal agreement between the models. One-hour rainfall maximums are extracted from the models and presented geographically. Agreement between the models suggests the likelihood for flash flooding by addressing four crucial questions: 1) timing, 2) location, 3) intensity, and 4) confidence. The combined information presents a picture of where and when heavy rainfall is expected hours ahead of storm development and the impact-based threat levels corresponding to pre-defined forecast zones. Further analysis and refinement of this tool is anticipated for 2016.

This presentation will share what was learned from initial testing during the 2015 flood season, which delivered the highest number of heavy rainfall threat days in the past 37 years.

SESSION 4

Community CRS Support Initiative and Recent Developments in the LOMC Process

By David Mallory, UDFCD and Jenelle Kreutzer, ERO Resources

ABSTRACT:

Community CRS Support Initiative

In the last year, UDFCD has taken a more active role in supporting our communities with their own Community Rating System (CRS) efforts. We have an updated UDFCD CRS Assessment Report that reviewed the District's activities and assessed how they currently support community CRS efforts. The new UDFCD CRS Support Committee will be reviewing the recommendations in the report and prioritizing potential projects from it in the upcoming year.

UDFCD also facilitated the formation of the multi-jurisdictional CRS Program for Public Information (PPI) committee that is just finishing up their first PPI plan for coordinated public outreach efforts. The multi-jurisdictional PPI is the first of its kind and required a tremendous coordination effort with the seven communities involved and the National Flood Insurance Program (NFIP) Insurance Specialist Officers that review the PPI for compliance with the guidelines.

Developments in the LOMC Process

FEMA has taken a revised stance on the process for ensuring Endangered Species Act (ESA) compliance with Conditional Letter of Map Change Requests (CLOMRs) over the past year. Documentation of Endangered Species Act Compliance for Conditional Letters of Map Change, was released in November 2015, and outlines the requirements and documentation necessary to meet this requirement depending on whether the proposed project has a federal nexus or is a completely private endeavor.

FEMA is requiring property owner notifications for both changes between effective and proposed conditions, as well as increases in the 1% annual chance (base) water-surface

elevations between existing or pre-project conditions and proposed conditions to be sent at the CLOMR stage. CLOMR notifications are being required for all changes to flood hazard data, no longer only when Section 65.12 is triggered.

FEMA maintains guidelines and standards for the specific implementation of statutory and regulatory requirements for the NFIP in support of the Risk Mapping, Assessment and Planning (RiskMAP) program. Mandatory requirements are found in the Policy for Flood Risk Analysis and Mapping that was published in 2013. There is a maintenance plan in place to issue updates to the RiskMAP Guidelines and Standards on a semi-annual basis.

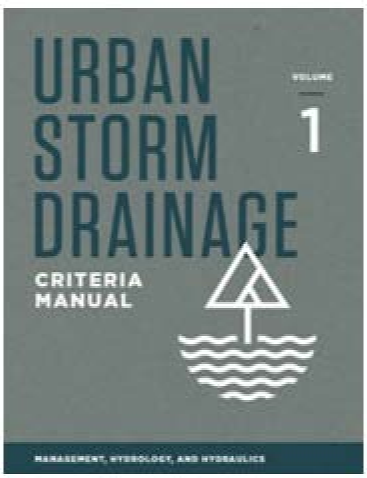
SESSION 5

USDCM Volumes 1 and 2 Revisions – What's New?

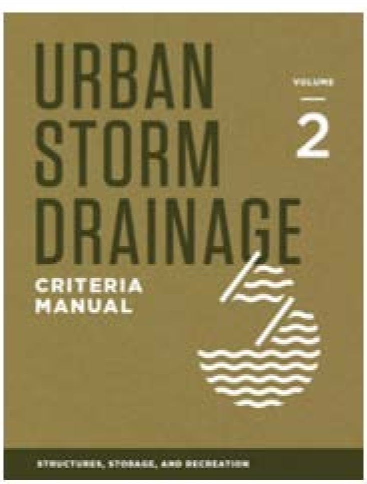
By Holly Piza, UDFCD

ABSTRACT:

Over the last several years, UDFCD has been working on a major update of the Urban Storm Drainage Criteria Manual (USDCM) Volumes 1 and 2. UDFCD developed a group of stakeholders consisting of communities within the region, consultants, and other interested parties. Many provided input and review for the update. This presentation will include a summary of changes throughout the USDCM, which can now be freely downloaded as a PDF or purchased in 3-ring binders from UDFCD.



USDCM, Volume 1
Management, Hydrology and Hydraulics



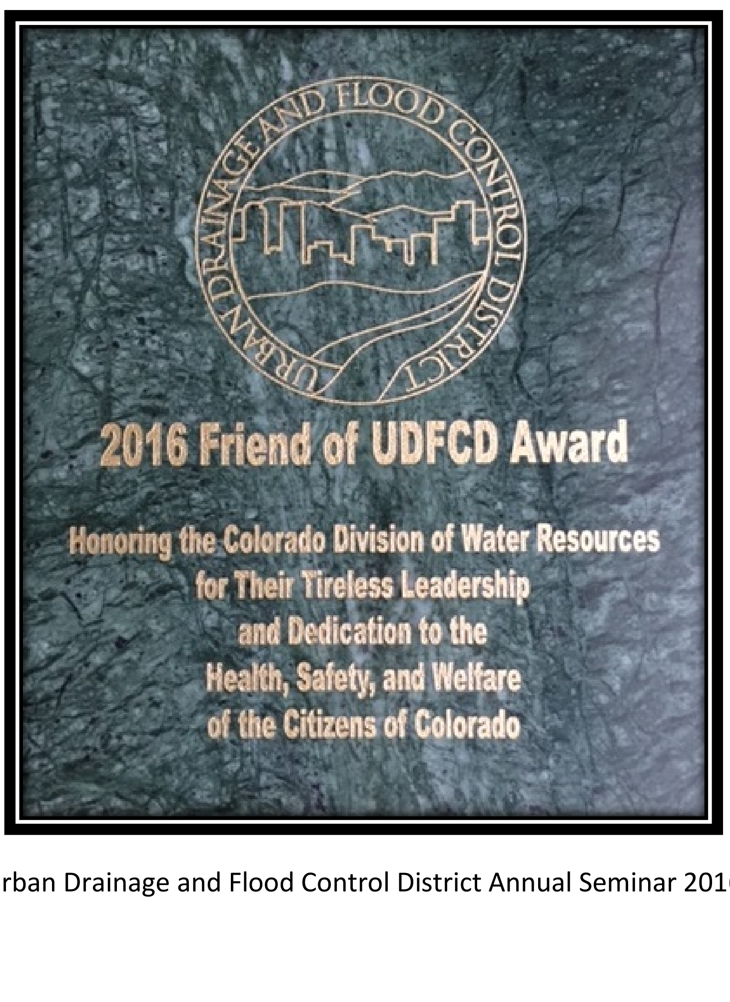
USDCM, Volume 2
Structures, Storage and Recreation

2016 FRIEND OF UDFCD AWARD

UDFCD has a long history of working closely with the Colorado Department of Natural Resources' **Division of Water Resources**. We have partnered on many flood mitigation dams that fall under their jurisdiction, dams that have reduced the flooding risk for thousands of Coloradans.

In 2014 and 2015, UDFCD worked with Kevin Rein, Dick Wolfe, and many others at the Division of Water Resources to enact new Colorado legislation that now protects municipalities and counties across Colorado in fulfilling their duty to provide responsible stormwater management. For their effort on this critical endeavor; and for their tireless leadership and dedication to the health, safety, and welfare of the Citizens of Colorado, we present to them the 2016 Friend of UDFCD Award.

Thank you, Colorado DWR!



SESSION 6

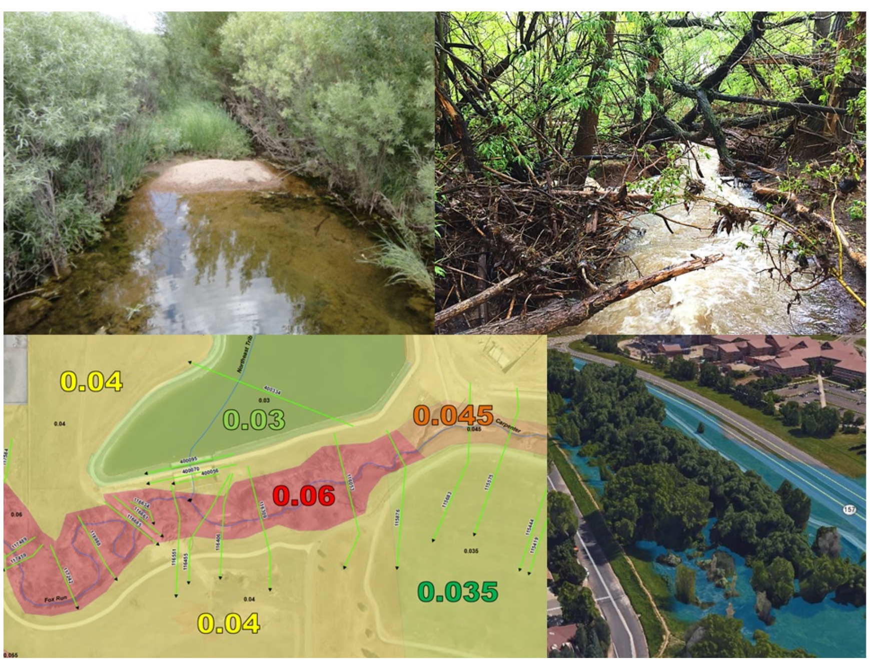
When you Say “Rough”, We Want to Know “How Rough?” Connecting Vegetation Management to the Mapped Flood Risk

By Dave Skuodas, UDFCD

ABSTRACT:

We map floodplains using a flood event based on specific rainfall intensity, volume, and duration, with static topography and fixed roughness values. In reality, flood discharges don’t behave in a nice neat way, geomorphology and erosion lead to topography changes, and vegetation health and density can fluctuate wildly. Vegetation changes are easy to observe, can have a significant impact on roughness values, and are something we should be able to manage to reflect the mapped flood risk. There are frequent disconnects between planned roughness values and how vegetation actually develops in the channel, so how do we reconcile and manage these differences?

This presentation will discuss ways we can be more strategic in modeling roughness values to account for mature vegetation, ideas for documenting roughness values to better inform how we manage vegetation, and will look at case studies of various streams to illustrate how sensitive flood elevations can be to changes in roughness.



SESSION 7

Beyond Design: a Construction Manager's Perspective

By Joe Williams, Steve Materkowski, Jason Stawski, and Mike Sarmento, UDFCD

ABSTRACT:

Many of us don't have the opportunity to go out into the field as much as we would like and we miss out on a very important aspect of our jobs, Construction! Fortunately, at UDFCD we have Construction Managers who have strong field presence and knowledge-base to keep the project team informed and engaged throughout the project life-cycle. During this session we will share a construction perspective on a few relevant topics.

SOIL LIFTS TOP TEN LIST

By Joe Williams

Soil lifts are being incorporated into more designs as they offer a flexible option for bank edge treatment that can adjust to the changes in the stream. The challenge with soils lifts is they are a customized tool based on site conditions, and need to be designed and installed with specific stream goals in mind. With numerous projects in the ground, UDFCD has a good understanding of a successful formula for soil lift installation. Joe Williams will reveal the top ten list of things to consider when implementing soil lifts into your project.

FEMA FLOOD REIMBURSEMENT, TO DO OR NOT TO DO, THAT IS THE QUESTION

By Steve Materkowski, EIT, CPESC, and Jason Stawski, EIT

After the continual high flows experienced on the South Platte River this Spring and large summer storms, several systems suffered considerable damage. The City and County of Denver applied for Federal Emergency Management Agency (FEMA) assistance for their recovery efforts. Since UDFCD, on behalf of Denver, manages several stream management activities that involve the clean-up effort, we have had first-hand experience in the process. FEMA assistance should always be considered in a flood recovery situation, and a more thorough understanding of what is actually involved, the better. Steve Materkowski and Jason Stawski will share their perspective from working to help the City of Denver submit a claim for flood damages, and provide insight to the FEMA reimbursement administration.

MEP FINAL ACCEPTANCE: SITE STABILITY AND REVEGETATION

By Mike Sarmento, SET

There are three phases to receiving maintenance eligibility as a part of the MEP: design approval, construction approval, and final acceptance. Many local governments, developers, and contractors mistakenly believe that once construction approval is received that the project is automatically eligible. Not so!!! Final acceptance may take several years depending on when the site exhibits structural stability and successful revegetation is the key. Mike Sarmento will discuss the importance of this often overlooked component and provide guidance on how to obtain that final certification in an ecologically-sound, as well as cost and time efficient manner.

Analyzing the Effects of Stormwater Detention on Water Balance and Water Rights along the Colorado Front Range

By Andrew Earles, PhD, and Adam Kremers, Wright Water Engineers

ABSTRACT:

This study presents the results of a long-term hydrologic modeling study on the effects of full spectrum detention on downstream water rights users. Full spectrum detention (FSD) is intended to reduce the flooding and stream degradation impacts associated with urban development by controlling peak flows in the stream for a range of events.

FSD addresses limitations of traditional minor and major storm detention by controlling peak discharges over the full spectrum of runoff events from small, frequent storms up to the 100-year flood. FSD facilities produce outflow hydrographs that, other than a small release rate of the excess urban runoff volume (EURV), mimic the shape of pre-development hydrographs. FSD modeling has been shown to reduce urban runoff peaks to levels similar to pre-development conditions over an entire watershed, even with multiple independent detention facilities. Because FSD capture and slowly release runoff, water rights users in the State of Colorado have raised questions related to evaporative losses of stored water and the timing and magnitude of releases.

The objective of this investigation was to perform continuous simulation hydrologic modeling to evaluate changes in hydrology due to development with varying levels of imperviousness with and without FSD and how these changes affect downstream water rights users. Stormwater Management Model (SWMM) simulations were conducted for undeveloped, 20%, 35%, 50%, 65%, and 80% imperviousness scenarios, with and without FSD. The results of these SWMM model scenarios were used to evaluate the site water balance and to develop time series flow data for input into a water rights model to determine how downstream users would potentially be affected by the various scenarios.

Water rights owners along the Front Range of Colorado are collaborating to address the increasing future demands of the over-appropriated South Platte Basin as part of the

Colorado Water Plan. Senate Bill 15-212 has raised concerns that FSD operations may reduce stream flows due to evaporative losses and modify the timing of available water from flood flows for junior water rights users causing increased supply gaps for the most agriculturally productive basin in the state. As a result, this water balance assessment and water rights analysis shows the timing and volume effect of temporary storage of urban runoff peaks for water users in the Big Dry Creek basin that would have otherwise been unable to divert water because of FSD.

SESSION 9

Adventures in Master Planning

By Shea Thomas, UDFCD

ABSTRACT:

There's a lot going on in the world of master planning. As drainage and flood control projects have grown in size and scope, so have the associated components recommended in a master plan. UDFCD rarely manages a construction project that consists only of infrastructure; most projects are multi-functional, multi-purpose ventures that provide various amenities to the community in addition to flood protection. Our relationships with other departments within local government offices have grown, including parks and recreation, transportation and urban planning in an effort to better utilize public space to serve the community with more than just a single purpose.

In recent master plans, we've had to get creative in finding solutions to difficult flooding problems, whether in fully developed urban areas or undeveloped watersheds with unstable drainageways, in order to reduce risk to residents and fulfill our goal of being good stewards of the drainageways by preserving or restoring healthy riparian corridors. This presentation will examine some of the unusual situations and planning elements that have gone into recent master plans that helped the communities involved achieve their goals and may offer insight or ideas for other communities with similar situations. From Aurora to Lakewood, Thornton to Douglas County, local governments have been receptive to trying new approaches to decades-old problems by first developing a plan that we can then implement together in the future.

SESSION 10

Update on Regional Hydrologic Investigations

By Ken MacKenzie, UDFCD and Gerald Blackler, Ph.D, Enginuity

ABSTRACT:

UDFCD and its partner communities along the South Platte River and Clear Creek have recently embarked on major revisions to the hydrologic models that define the regulatory flooding limits on these two major waterways, resulting in two Conditional Letters of Map Revision (CLOMRs). The preliminary results of these CLOMRs show reduced flood flows and will result in more accurate flood predictions and more effective use of flood mitigation tax dollars.

Additionally, work on a major recalibration of the Colorado Urban Hydrograph Procedure (CUHP) continues. This last year's recalibration effort included an extensive review of viable calibration gages, development of storms with Gage Adjusted Radar Rainfall (GARR), and extensive testing of multiple calibration parameters. Rainfall depths from the GARR were put into CUHP to compare computed flows with recorded runoff for an array of basins within the District. Each storm event tested CUHP's performance when a large single or multiple basin analysis is applied versus smaller basins averaging 100 to 120 acres, which are commonly used for Major Drainageway Plans (MDPs) or Outfalls System Plans (OSPs). These results lead to the development of calibration parameters that effect peaking, timing, and also flow routing within CUHP and SWMM. These parameters are currently being tested with design storm events to understand how they compare to the return frequency of design storms commonly used in the planning process. This portion of the presentation will cover steps taken in the re-calibration process, observations noted during the effort, and provide a brief update on the study's progress.

Creating a Safer Community

Paul A. Hindman, Executive Director

Kenneth R Wright, WWE

L. Scott Tucker, Retired

2016 UDFCD Annual Seminar April 5, 2016

1864 Flood

1912 Flood

1933 Flood

1965 Flood

1976 Flood

1997 Flood

2013 Flood

Flood History-Totals

DAMAGES

1. South Platte (1965) - $3b
2. 2013 Flood – $1-3b (TBD)
3. Pueblo (1921) – $1.1b
4. South Platte (1973) - $570m

DEATHS

1. Big Thompson (1974) – 144
2. Pueblo (1921) – 78
3. Bear Creek (1896) – 27
4. Fort Collins (1995) – 21
5. South Platte (1965) – 21

… 2013 Flood - 11

Enjoy the Presentations

Urban Drainage History in the Metro Area

Kenneth R. Wright, P.E.

1864 West Denver

Photo: Denver Public Library

1888 Golden

Photo: UDFCD


GAS
OIL

1894 Boulder Creek at Boulder

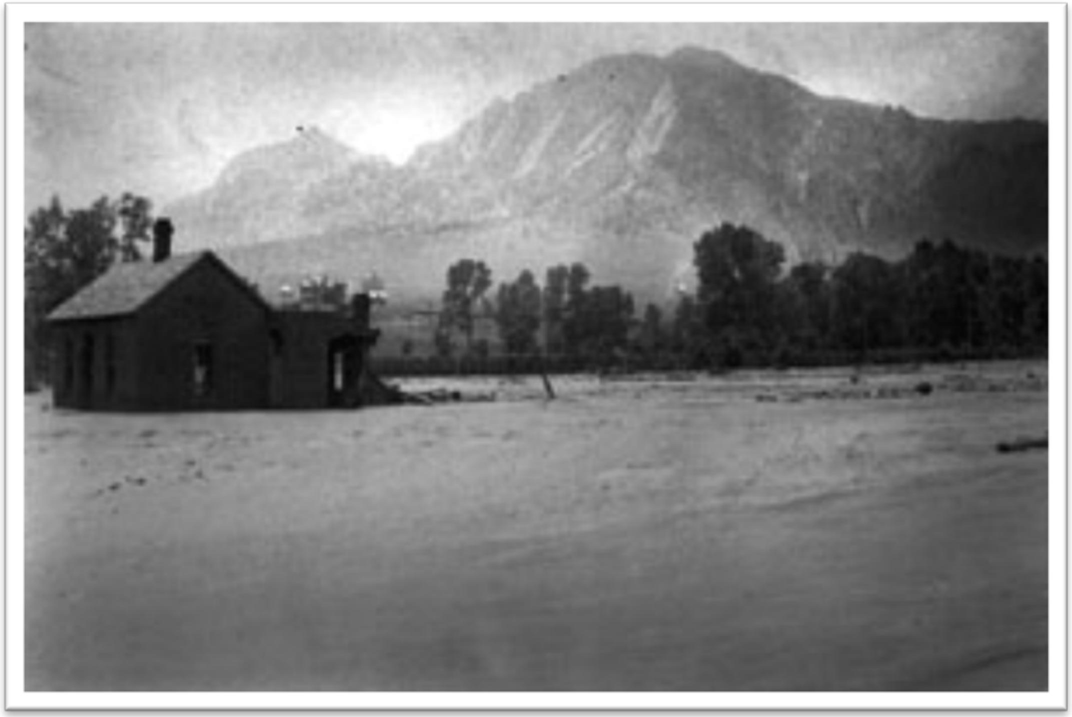


Photo: FloodSafety.com

1894 12th Street, Boulder

Photo: Denver Public Library

1895 Black Hawk

Photo: Denver Public Library

1896 Bear Creek Near Golden

A wall of water roared down Bear Creek

The rain started about 7 p.m. Friday, July 25, 1896.

By 8 p.m. Golden was hit by flood waters and a 30-foot wall of water raged down Tucker Gulch.

About the same time a wall of water roared down Bear Creek, crashing into Morrison.

Sgt. Dennis Potter, of the Jefferson County Sheriff's Department, recently completed a report on the Flood of 1896. The report notes that 50 tents were set up in a public park in Morrison, "all filled with sleeping campers," Potter said.

"Witnesses reported seeing people swept away by the flood waters, screaming, but no one could do anything. At 3 a.m.," he said, "rescue workers were out with lanterns looking for survivors. Twenty-five people were killed in Bear Creek Canyon and Morrison. Five or six were killed in Golden."

Seven people were out on a "romantic buggy ride," Potter said, "and all were killed." Two were the young daughters of a Denver judge.

"Morrison was devastated. It took months to recover. I don't just mean from property damage, but from the tragedy of the deaths. Massive and elaborate funerals went on for months," Potter said.

"It was a freak flood, it all came down at once. It was one of those once-in-a-century things," Potter concluded. "I don't think it will happen again this year."

The 1969 flood is documented in the pages of the Canyon Courier. Four pages of photos printed on May 15, 1969, show extensive damage; there were no deaths.

The flood-damaged area was declared a disaster area. Road damage, alone, was estimated at $3 million.

Not only were roads and bridges washed out, but a 15-ton boulder fell on Highway 74 blocking traffic west of Morrison, schools were closed, businesses flooded, homes crumpled and phone and electrical service failed.

The weather service said, in five days 9.22 inches of rain fell (one-half of that year's rainfall).

Article: UDFCD


SOUTH
INTERSTATE
COLORADO
25
US
87


RS-1447


TEXACO
VALVERDE
RECREATION
CENTER
PECOS
ALAMEDA
FIRE CHIEF
29 9
SKY CHIEF
33 9


McDonald's HAMBURGERS
CORAL MOTEL
Alameda Ave.
EAST
SPEED LIMIT 55
MINIMUM 40
SLOWER TRAFFIC KEEP RIGHT


Why not get the best!
ZENITH
SPEED
LIMIT
55
MINIMUM
40
SLOWER
TRAFFIC
KEEP
RIGHT


MR-8493
ML-6373


22
URNER


1965 South Platte River, Denver
Photo by Ed Maker/The Denver Post

Special Aerial Picture Coverage on Flood-Ravaged Areas

THE DENVER POST

FLOOD FINAL

—The Voice of the Rocky Mountain Empire—

Vol. 73, No. 330 Denver, Colo.—Climate Capital of the World—Thursday, June 17, 1965 10 Cents, 84 Pages

South Platte Torrent Deals Denver Worst Disaster

Navy Jets Down Pair Of MIGs

SAIGON, South Viet Nam—(AP)—Two U.S. Navy Phantom jets shot down two Communist MIG17 fighters in flames Thursday in a dogfight 50 miles south of Hanoi, the North Viet Nam capital.

The clash occurred while the Phantoms, from the carrier Midway, were flying escort for other U.S. warplanes bombing North Viet Nam targets.

A U.S. spokesman said four Communist jets appeared and turned toward the American planes as if they were going to attack. But apparently they were hit before they had a chance to open fire, he said.

PARACHUTE SEEN

One parachute was seen opening, but it was not known what happened to the Communist pilot. The other two MIGs escaped.

Prompt Alarms Keep Toll Low

By LEONARD LARSEN
Denver Post Staff Writer

The flooding South Platte River, fed by cloudbursts south of Denver, ripped through the metropolitan area late Wednesday in the worst natural disaster of the city's history.

The normally placid South Platte and dry-stream tributaries were turned into half-mile-wide torrents which swept out bridges, flooded thousands of homes, business firms and factories and for a time split the capital city.

Fires touched off by electrical shorts, ruptured gas lines and storage tanks burned throughout the night Wednesday and early Thursday along the river as it roared out of its banks, sweeping tons of debris into the industrial area and railroad yards in central Denver.

Miraculously—and because police and volunteers labored to warn persons in its path—the Denver area flood took a limited human toll.

One man was found dead in three feet of water in the Globeville area of north Denver—either from a heart attack or drowning—and a handful of victims were reported treated at area hospitals for injuries, shock and exposure.

There were uncomfirmed reports, however, of other persons missing and possibly killed by the flood violence.

A State Highway Department

Flood Final

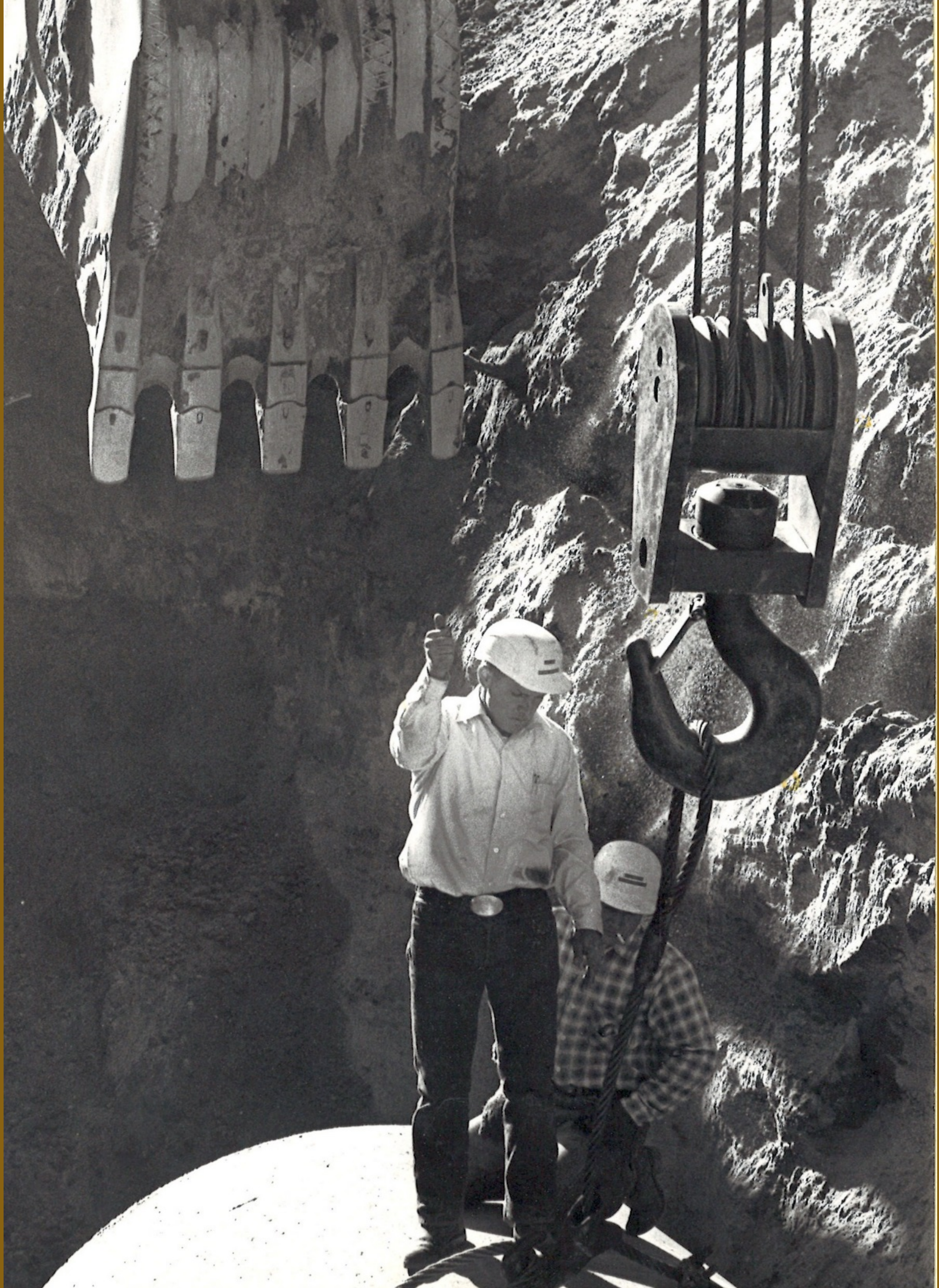
As a special service to our readers, most of the coverage on the disastrous Denver flood will be found in this first section of today's Flood Final. In addition, readers' attention is called to pages 33, 34, 37, 84.

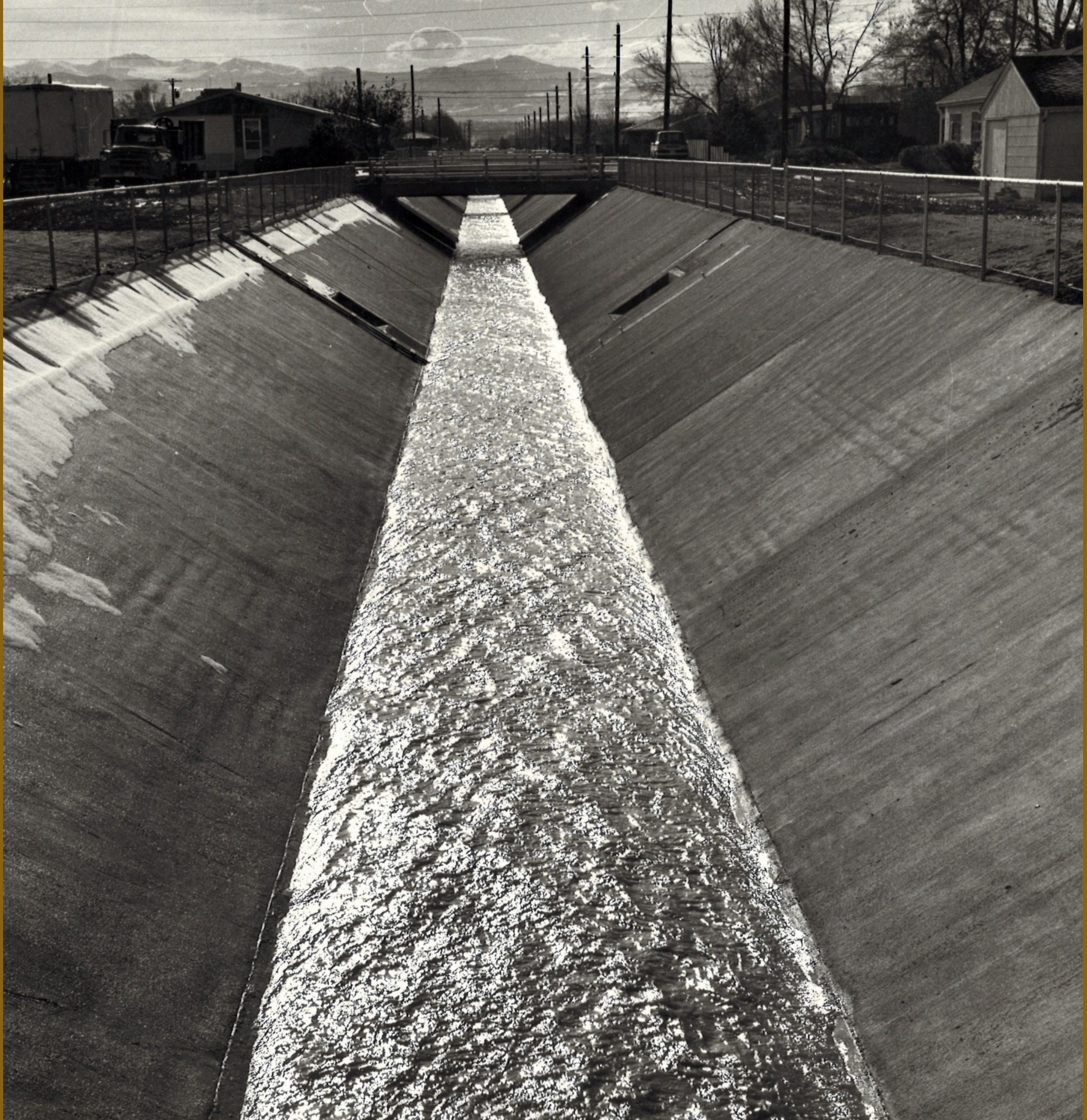

6TH AVE
VALLEY HWY.

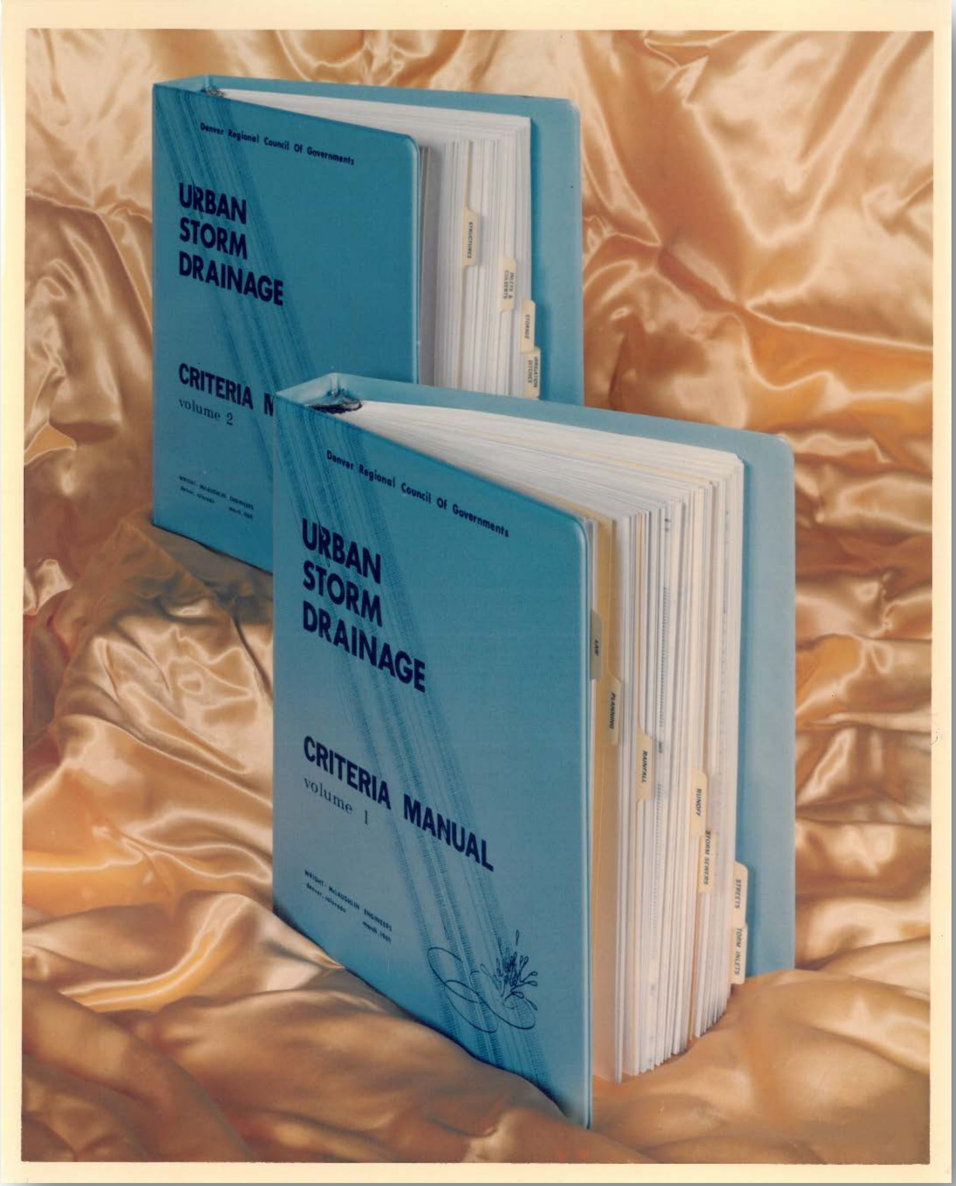

CONSTRUCTED WITH BOND FUNDS MADE AVAILABLE BY THE CITIZENS OF DENVER
JUNE 30, 1964
HARVARD GULCH
FLOOD CONTROL FACILITIES
CONTRACTORS
LEON K. SUHM, INCORPORATED
PETER KIEWIT SONS' COMPANY
CONSULTANTS
WRIGHT McLAUGHLIN ENGINEERS
SUPERVISION
ENGINEERING DIVISION, DEPARTMENT OF PUBLIC WORKS
DEDICATED
THOMAS G. CURRIGAN, MAYOR
APRIL 23, 1967


DENVER Builds NOW for the future
CITY AND COUNTY OF DENVER SEAL
Consulting Engineers
Wright-McLaughlin Eng.
Contractor
Leon K. Suhm
Project No. 9203
Harvard Gulch Flood Control
Phase 3, Cost $662,352
Total Cost Phase 1,2,3=2.3 Million
Thomas G. Currigan, Mayor

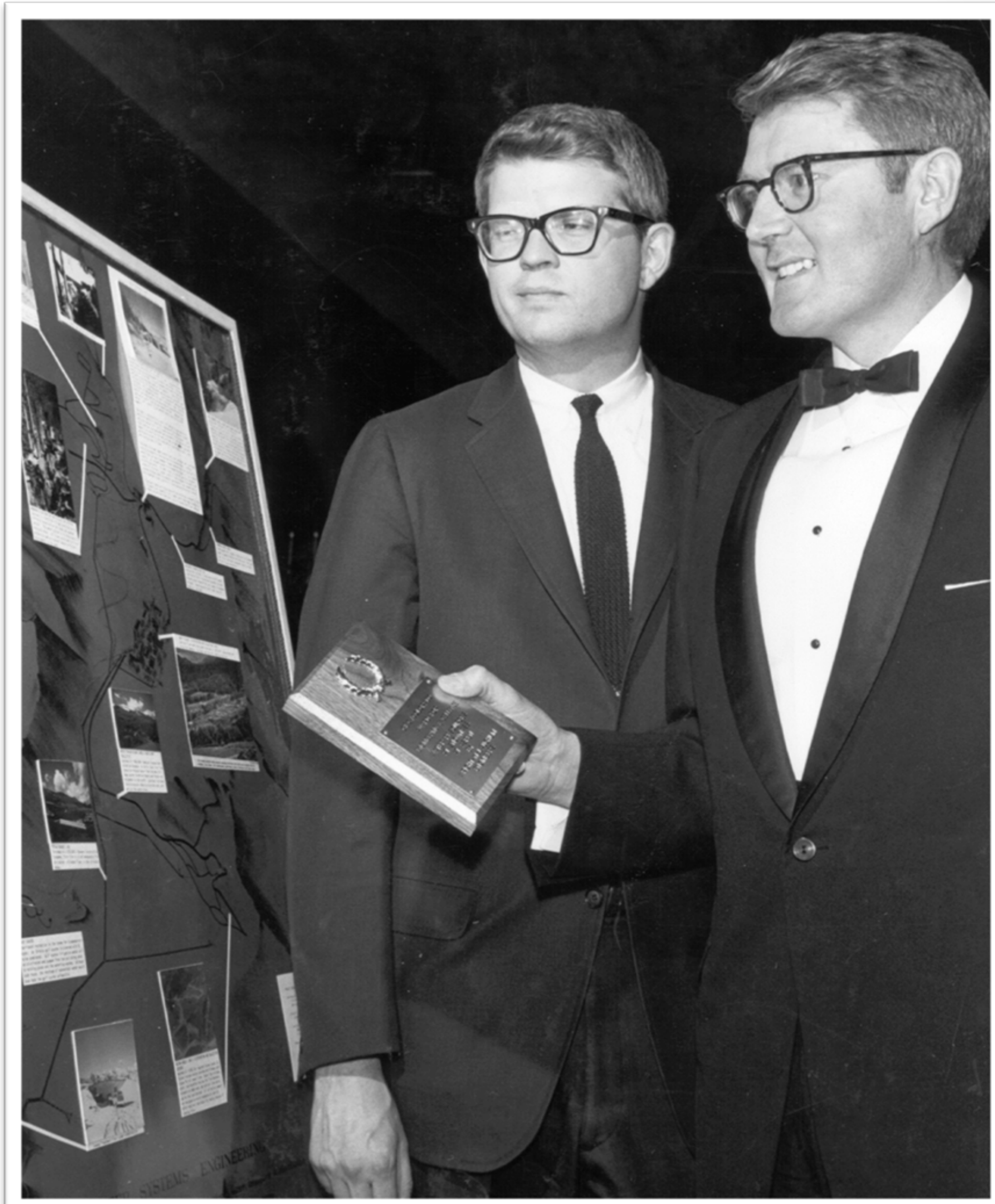

FURNISHED
FURNITURE
DEPT STORE
Coors
KOEHRING 505
FORD 5500
FORD



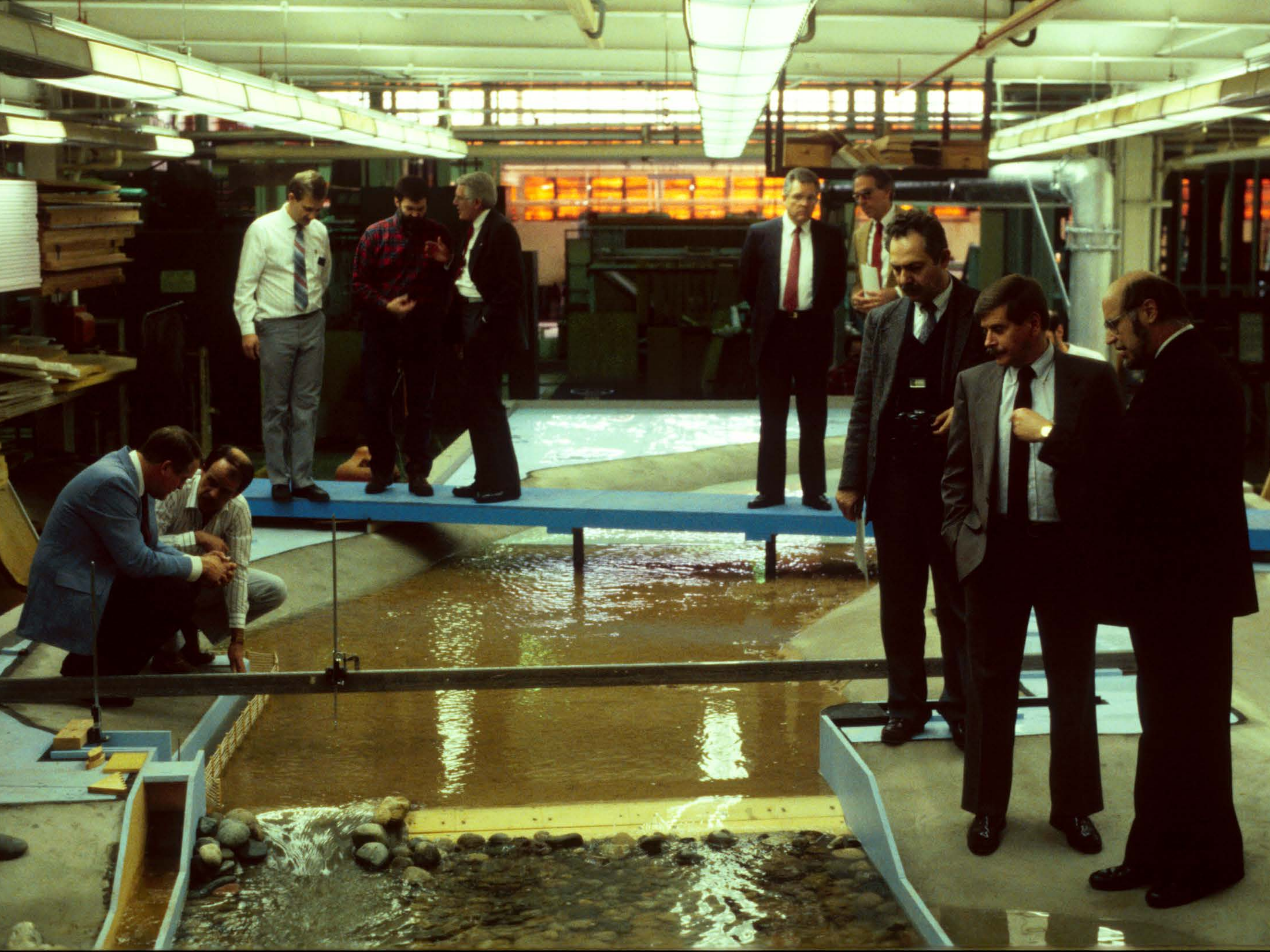




Denver Regional Council Of Governments
URBAN
STORM
DRAINAGE
CRITERIA MANUAL
volume 1
volume 2


SYSTEMS ENGINEERING


Colorado
Guest



Colorado Revised Statutes

ARTICLE 11

Urban Drainage and Flood Control Act

PART 1

GENERAL PROVISIONS

32-11-101. Short title. This article shall be known and may be cited as the "Urban Drainage and Flood Control Act".

32-11-102. Legislative declaration. (1) The general assembly hereby determines, finds, and declares that:

(a) All property to be acquired by the district under this article shall be owned, operated, administered, and maintained for and on behalf of all of the people of the district;

(b) The creation of the district by this article promotes the health, comfort, safety, convenience, and welfare of all the people of the state and is of special benefit to the inhabitants of the district and the property therein;

(c) The provisions in this article of the purposes, powers, duties, privileges, immunities, rights, liabilities, and disabilities concerning the district serve a public use;

(d) The district created by this article is a body corporate and politic, a political subdivision of the state, and a municipal corporation with the powers provided in this article;

(e) Any notice provided for in this article for any purpose is reasonably calculated to inform each person of interest in any proceedings under this article which may directly and adversely affect his legally protected interests, if any;

(f) The necessity for this article results from the large population growth in the urban area included by this article within the district constituting a major portion of the state's population, from the numerous capital improvements and large amount of improved real property situated within such urban area, from the torrential storms occurring sporadically and intermittently in the urban area and other areas draining into such urban area, from the increasing danger of floods therein and the resultant risks to the property and to the health and safety of the persons within the urban area, from the division of the urban area into large areas of incorporated areas and unincorporated areas, from the fragmentation and proliferation of powers, rights, privileges, and duties pertaining to water, flood control, and drainage within such urban area among a substantial number of public bodies, and from the resultant inabilities of such public bodies to acquire suitable capital improvements for the alleviation of such dangers and

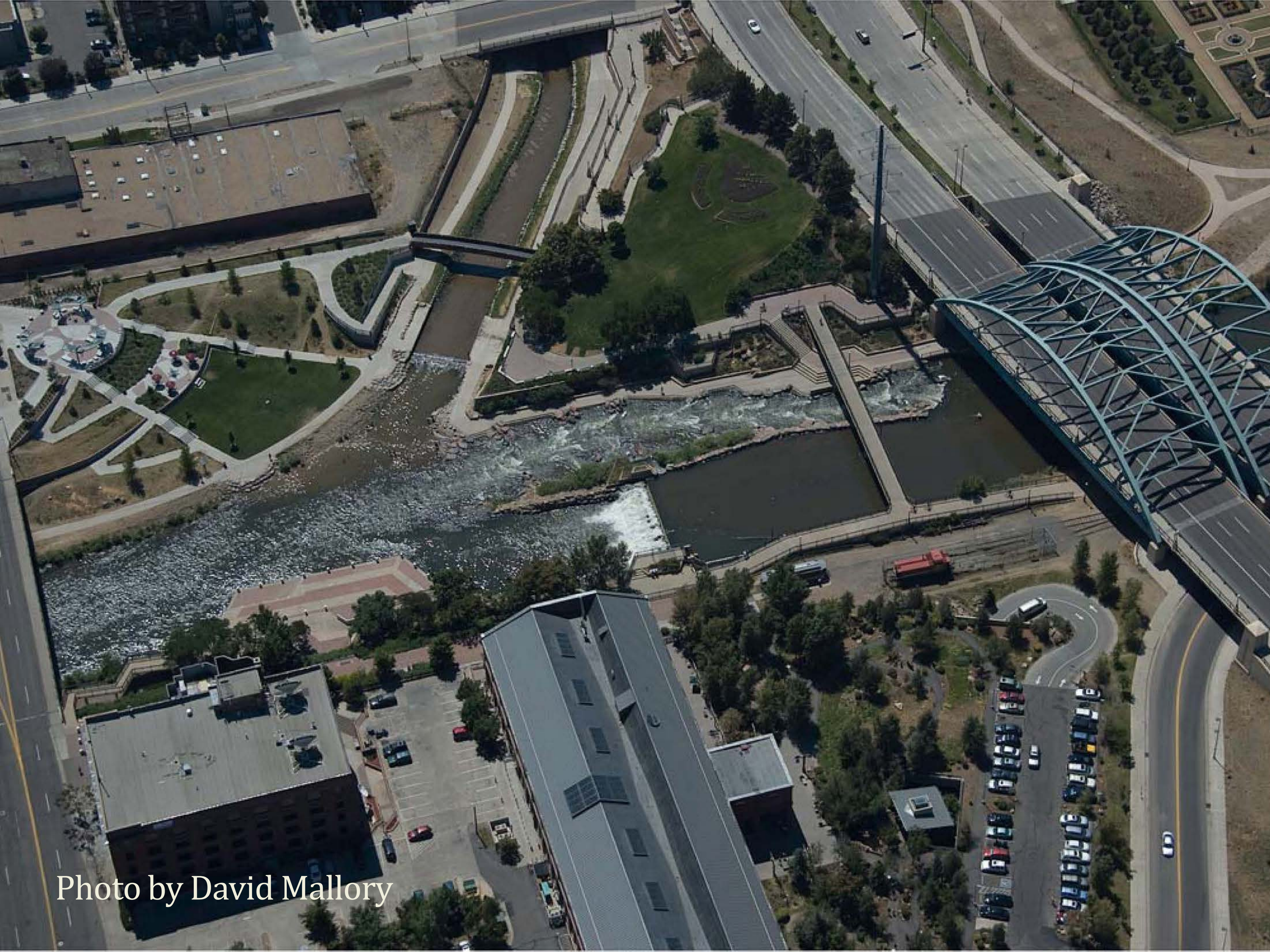


Photo by David Mallory

Photo by David Mallory

FLOODPLAIN PRESERVATION & MITIGATION IN ACTION DURING THE SEPTEBER 2013 FLOOD

Paul A. Hindman
Executive Director

2016 UDFCD Annual Seminar April 5, 2016

UDFCD Mission Statement

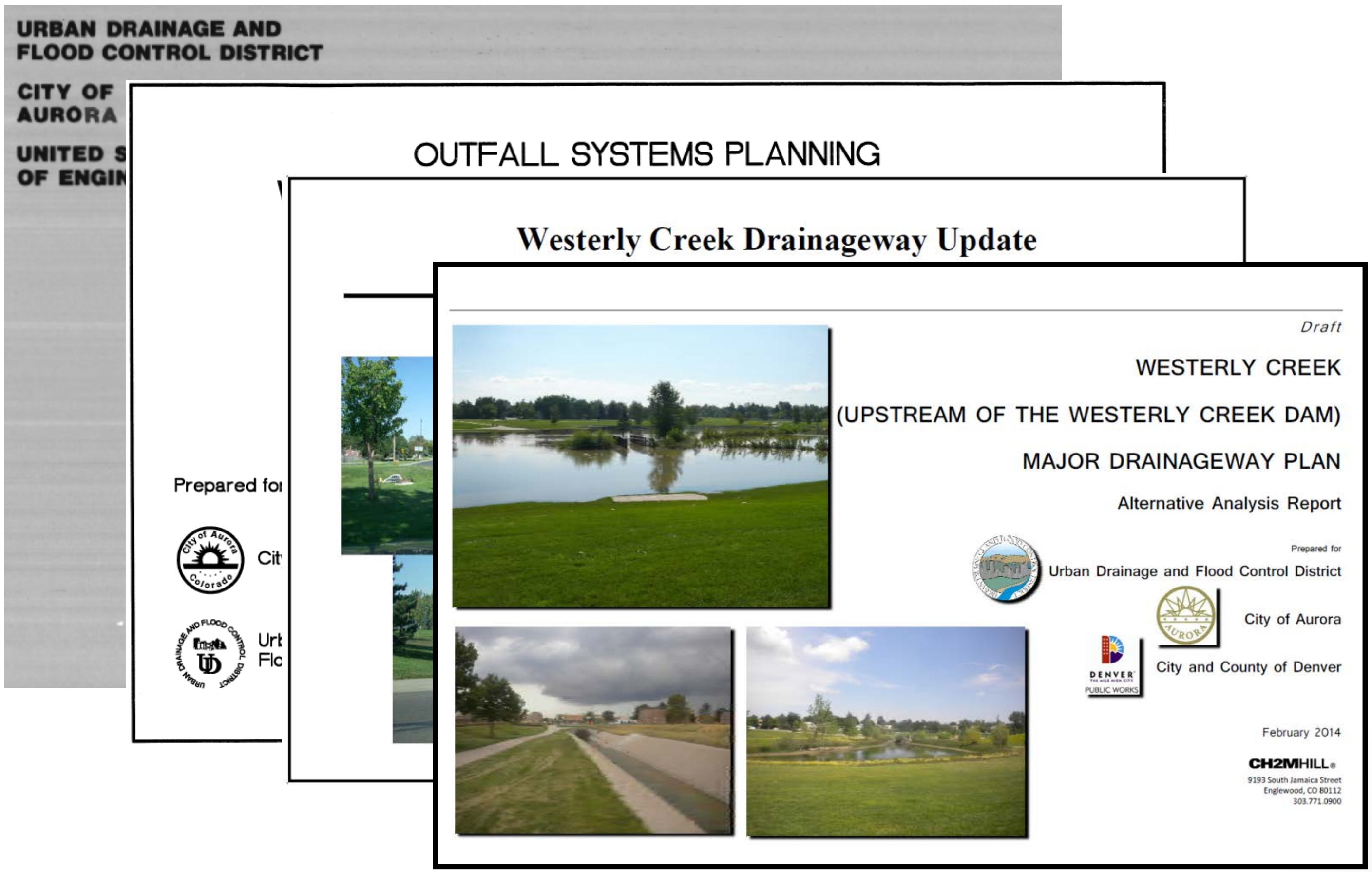
The Urban Drainage and Flood Control District works with local governments to address multi-jurisdictional drainage and flood control challenges in order to protect people, property, and the environment.

Two-Pronged Approach

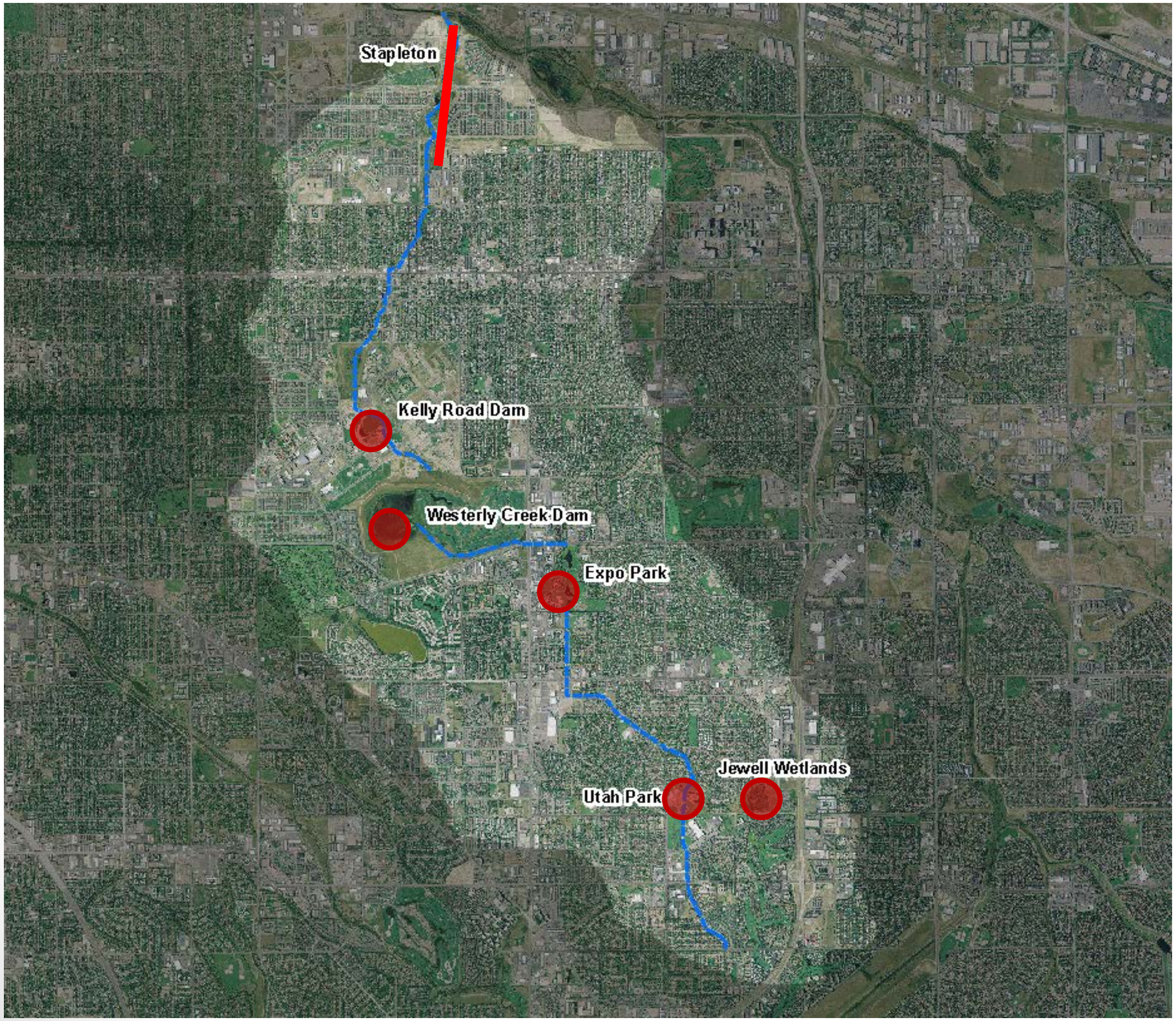
Preservation

Mitigation

Case Study-Westerly Creek



Westerly Creek, Aurora

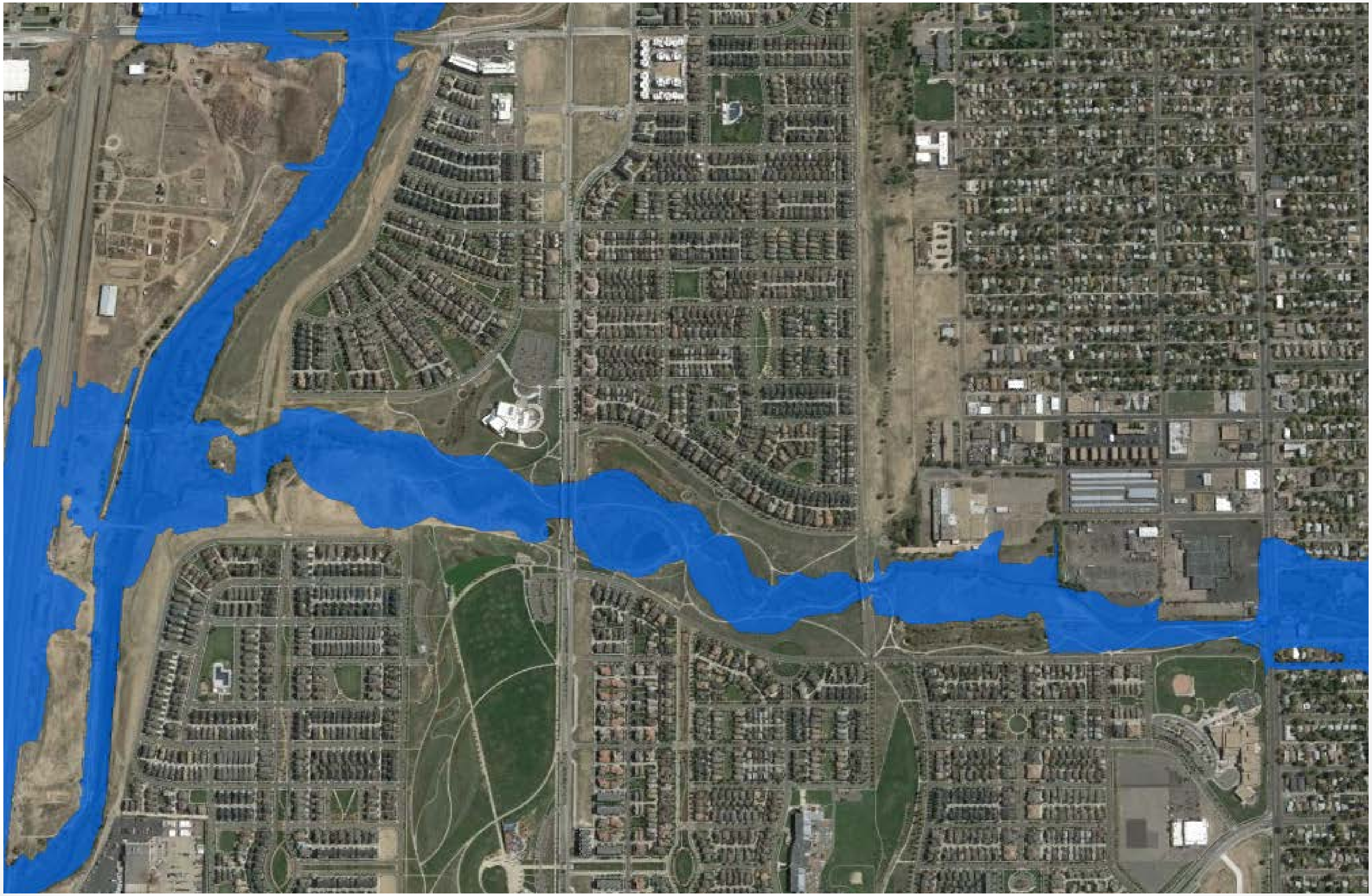


Mitigation-
Detention Basin

Preservation-
Open Space

PRESERVATION

Stapleton Redevelopment 2012

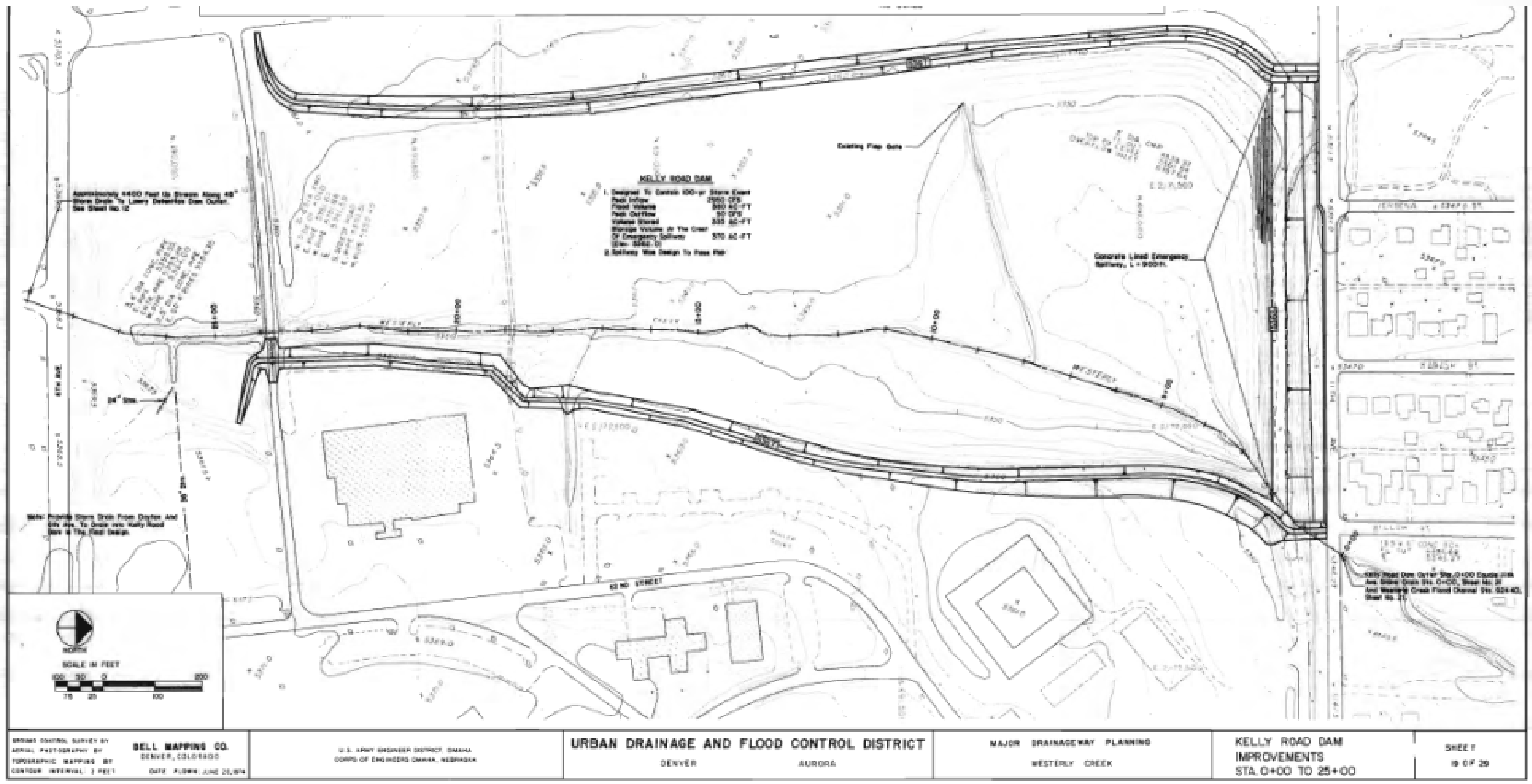


Stapleton Greenway

Stapleton Greenway-2013

MITIGATION

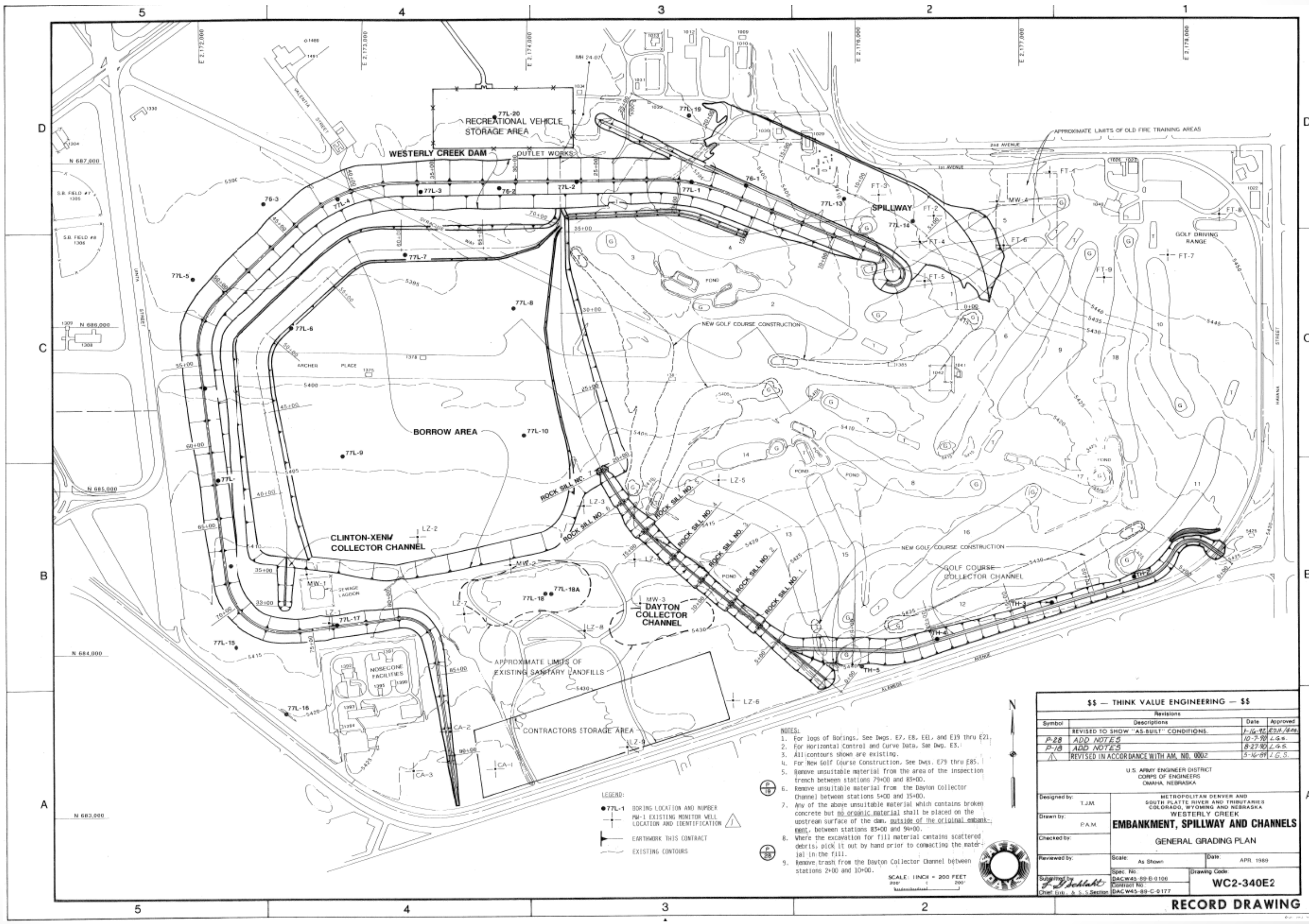
Kelly Road Dam Detention 1950's, Rehab 1994



Kelly Road Dam Detention

Kelly Road Dam Detention-2013

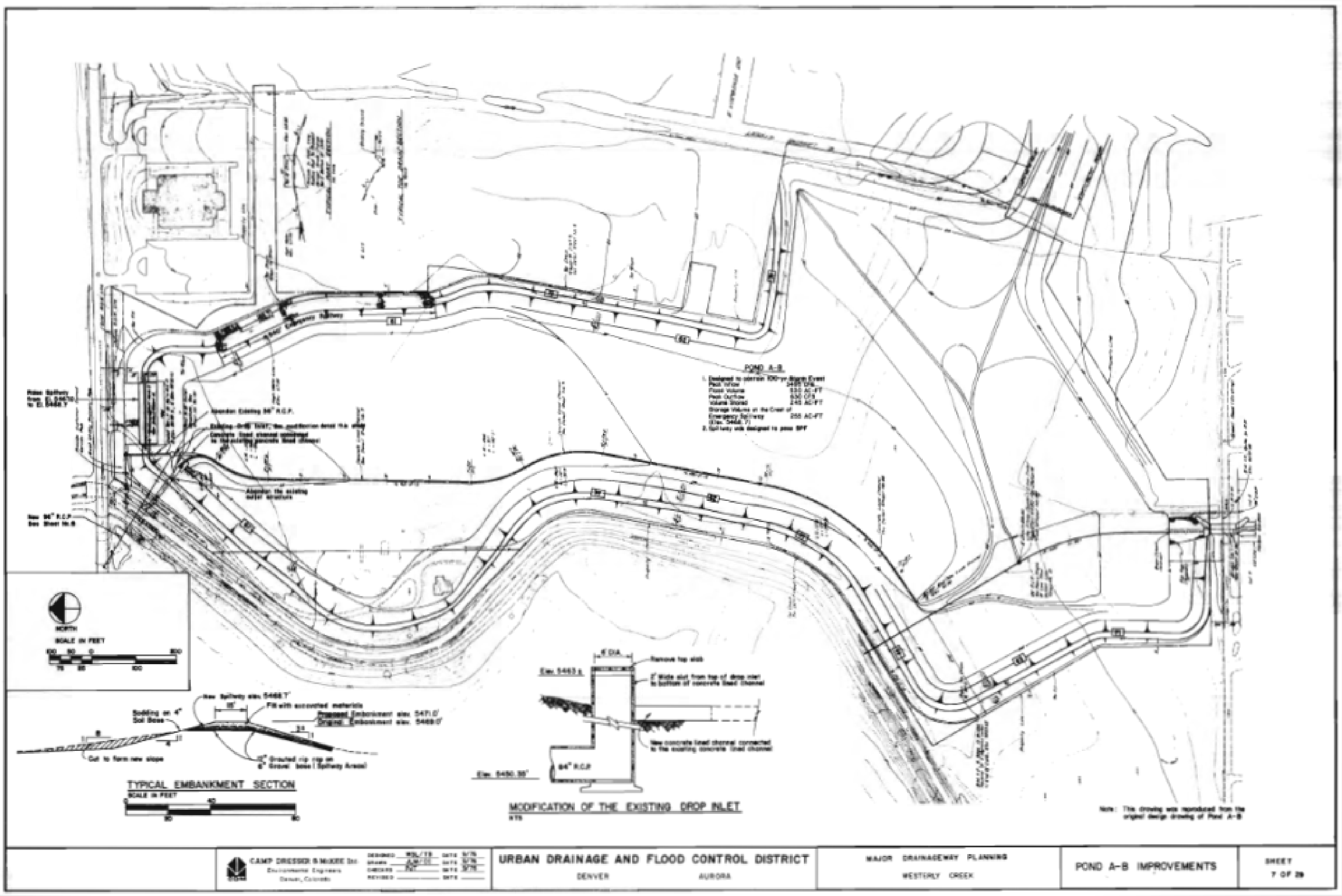
Westerly Creek Dam-Detention 1989



Westerly Creek Dam

Westerly Creek Dam-2013

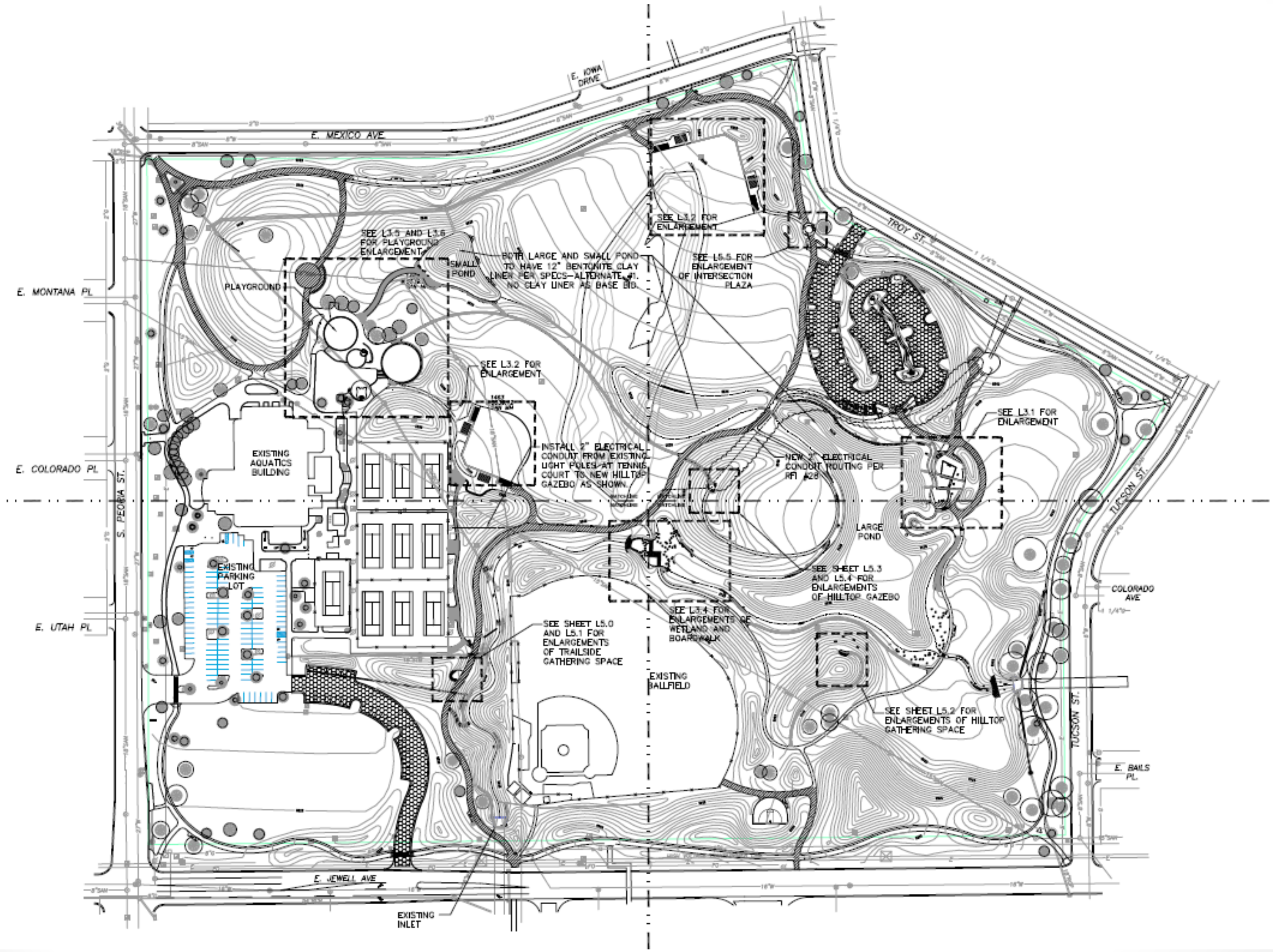
Expo Park Detention-2000



Expo Park Detention

Expo Park Detention-2013

Utah Park Detention-2009



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Utah Park Detention

Utah Park Detention-2013

Jewell Wetlands Detention-2001

Jewell Wetlands Detention

Jewell Wetlands Detention-2013

Damages-Utah Park Spillway

Other areas without M&P- 2013

Other areas without M&P-2013

Political Choice

Colorado *E. coli* Toolbox: A Practical Guide for MS4s

Jane Clary, Wright Water Engineers
Brandon Steets, P.E., Geosyntec Consultants

Sponsored by
Urban Drainage and Flood Control District
City and County of Denver

Overview

- Introduction
  - Colorado regulations
  - Extent of problem
  - TMDLs
- Finding the sources
- Developing a control strategy
  - Progression of controls
  - Modeling
- Source controls
- Structural BMPs
- Regulatory considerations/site-specific standards

Colorado *E. coli* Toolbox: A Practical Guide for Colorado MS4s (DRAFT)

Prepared by
Wright Water Engineers, Inc.
Geosyntec Consultants

Prepared for
Urban Drainage and Flood Control District
City and County of Denver

Understanding Stream Standards and Impairment

- Fecal indicator bacteria vs. pathogens (e.g., *E. coli* O157:H7)
- EPA 2012 Recreational Water Quality Criteria
- Colorado stream standards
  - Magnitude: 126 cfu/10 mL
  - Duration: Bimonthly
  - Frequency: Geometric mean not allowed to exceed standard
- 303(d) List updated biennially: over 70 segments in Colorado impaired on M&E list for *E. coli*

Colorado Use Classification	*E. coli* (cfu/100 mL)
Class E - Existing Primary Contact	126
Class P - Potential Primary Contact	205
Class N - Not Primary Contact	630
Class U - Undetermined	126

Total Maximum Daily Loads (TMDLs) & Implications for MS4s

TMDL = ΣWLA + ΣLA + MOS

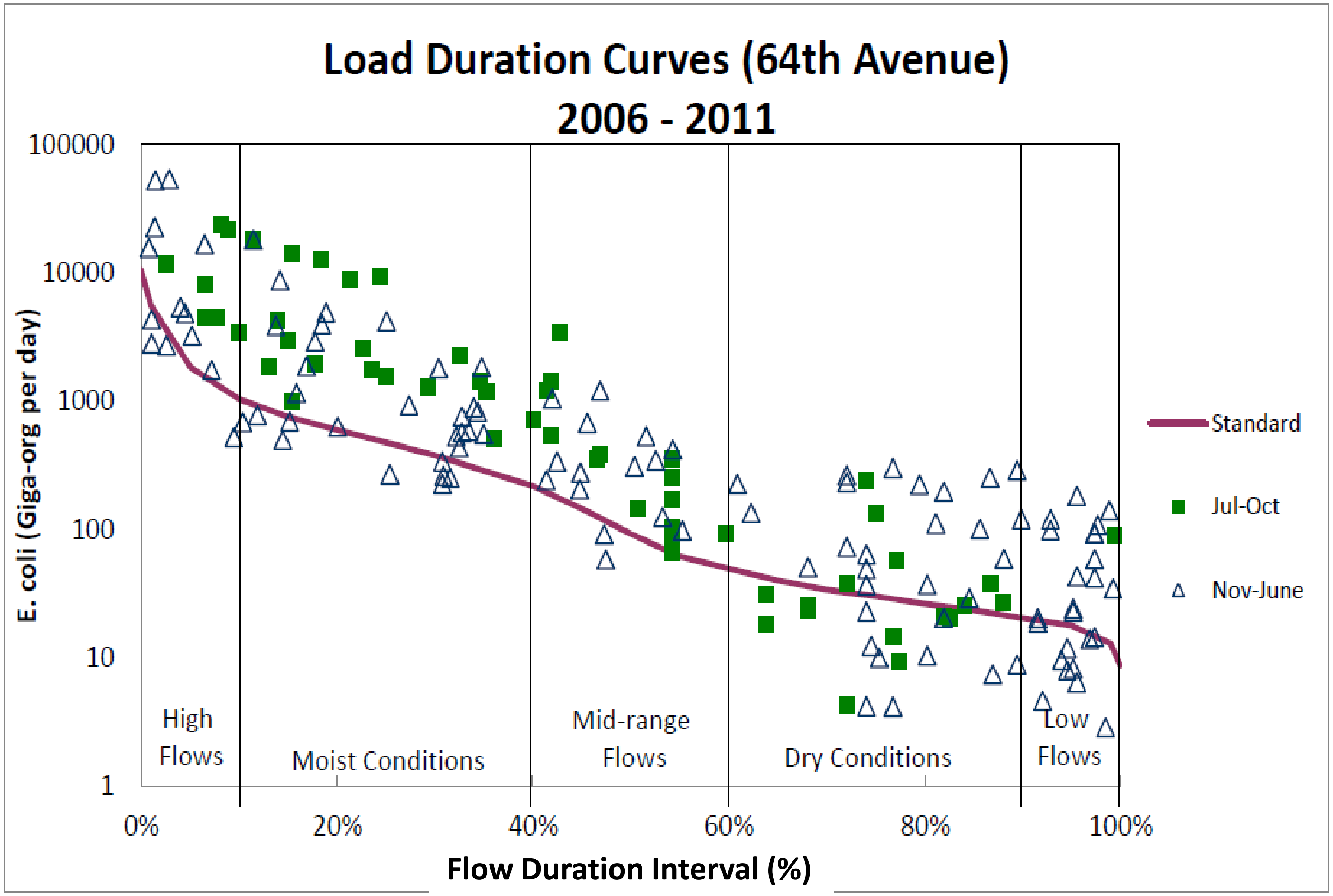
Where:

- WLA =the sum of wasteload allocations (point sources such as permitted wastewater and stormwater discharges)
- LA= the sum of load allocations (nonpoint sources and background)
- MOS=the margin of safety

- WWTPs typically not the source in Colorado
- MS4s likely to have requirements in CDPS permits due to TMDLs
- Nonpoint sources often significant
- Alternatives to TMDL approach being explored on Lower Bear Creek

Load Duration Curves

(a common characterization tool for Colorado TMDLs)



Partners for Developing Effective *E. coli* Control Strategies

Local Goverment

- Wastewater/Utilities
- Water Providers
- Stormwater/MS4
- Parks and Open Space
- Social/Community Services
- Police

State/Federal Government

- Water Quality Control Division
- Parks and Wildlife
- U.S. EPA Region 8

Non-Governmental Organizations/Non-profits

- Watershed Groups
- Environmental Organizations
- Coalitions for Homeless

Community: Businesses & Residents

- Restaurants
- Private Garbage Collection Services
- Recreators (e.g., kayakers)
- Homeowners/ Residents

Long List of Potential Sources

- Leaking sanitary infrastructure
- Pets & wildlife
- Dumpsters/trash
- Mobilizing flows (e.g., irrigation)
- MS4 infrastructure issues (e.g., illegal sanitary connections)
- Hobby farms/horses
- Open Space
- Naturalized sources (e.g., soil, decaying plants)

General Category	Source/Activity
Municipal Sanitary Infrastructure (piped)	Sanitary sewer overflows (SSOs)
	Leaky sewer pipes (Exfiltration) (see Sercu et al. 2011)
	Illicit Sanitary Connections to MS4
	WWTPs (if inadequate treatment or upsets)
Other Human Sanitary Sources (some also attract urban wildlife)	Leaky or failing septic systems
	Homeless encampments
	Porta-Potties
	Dumpsters (e.g., diapers, pet waste, urban wildlife)
	Swimmers/bathers, boaters, trail users (e.g., hikers, runners)
	RVs (mobile)
	Trash cans
	Garbage trucks
Domestic Pets	Dogs, cats, etc.
Urban Wildlife (naturally-occurring and human attracted)	Rodents/vectors (rats, raccoons, squirrels, opossums)
	Birds (gulls, geese, ducks, pigeons, swallows, etc.)
	Open space (coyotes, foxes, beavers, feral cats, etc.)
Other Urban Sources (including areas that attract vectors)	Landfills
	Food processing facilities
	Outdoor dining
	Restaurant grease bins
	Bars/stairwells (washdown areas)
	Green waste, compost/mulch
	Animal-related facilities (e.g., pet boarding, zoos, off-leash parks)
Urban Non-stormwater Discharges (Potentially mobilizing surface-deposited FIB)	Power washing
	Excessive irrigation/overspray
	Car washing
	Pools/hot tubs
	Reclaimed water/graywater (if not properly managed)
MS4 Infrastructure	Illegal dumping
	Illicit sanitary connections to MS4 *(also listed above)*
	Leaky sewer pipes (exfiltration) *(also listed above)*
	Biofilms/regrowth
	Decaying plant matter, litter and sediment in the storm drain system
Agricultural Sources (potentially including ranchettes within MS4 boundaries or areas in urban growth boundaries)	Livestock, manure storage
	Livestock, pasture
	Livestock, corrals
	Livestock, confined animal feeding operations (CAFO) (NPDES-regulated)
	Manure spreading, pastures/crops
	Municipal biosolids re-use
	Reclaimed water (if not properly managed)
	Irrigation tailwater
	Slaughterhouses (NPDES-regulated)
Natural Open Space/Forested Areas	Wildlife populations
	Grazing
	Natural area parks, off-leash areas
Other Naturalized Sources	Decaying plants/algae, sand, soil (naturalized FIB)

Prioritizing Sources for Investigation

- Dry vs. wet weather
- Human health risk
    - Human origin (i.e., from the human body)
    - Anthropogenic, non-human origin (resulting from human activities, but not the human body)
    - Non-anthropogenic origin (independent of human activity)
- Magnitude of loading
- Geographical distribution relative to recreational use locations
- Controllability/Ability to Implement (technical/design/fiscal/organizational)
- Potential benefits (beyond bacteria)
- Frequency of standards exceedances

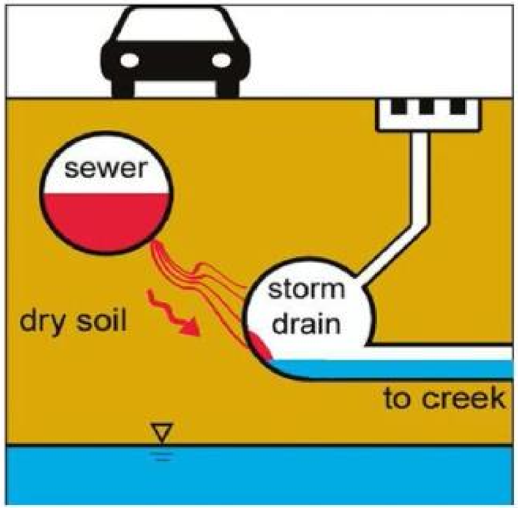


Figure 3-1. Leaking Sanitary Sewer Exfiltrating to Storm Sewer (Source: Sercu et al. 2011[4])

Investigating Sources: 6-Step Process
(following "SIP" by Griffith et al. 2013)

STEP 1. GATHER INFORMATION TO FORMULATE HYPOTHESES ABOUT POTENTIAL FECAL SOURCES

↓

STEP 2. USE FIB DATA TO EVALUATE HYPOTHESES AND PRIORITIZE SOURCES FOR FURTHER INVESTIGATION

↓

STEP 3. APPLY TRADITIONAL METHODS FOR IDENTIFYING LEAKS IN SANITARY SEWER AND ON-SITE WASTEWATER TREATMENT SYSTEMS

↓

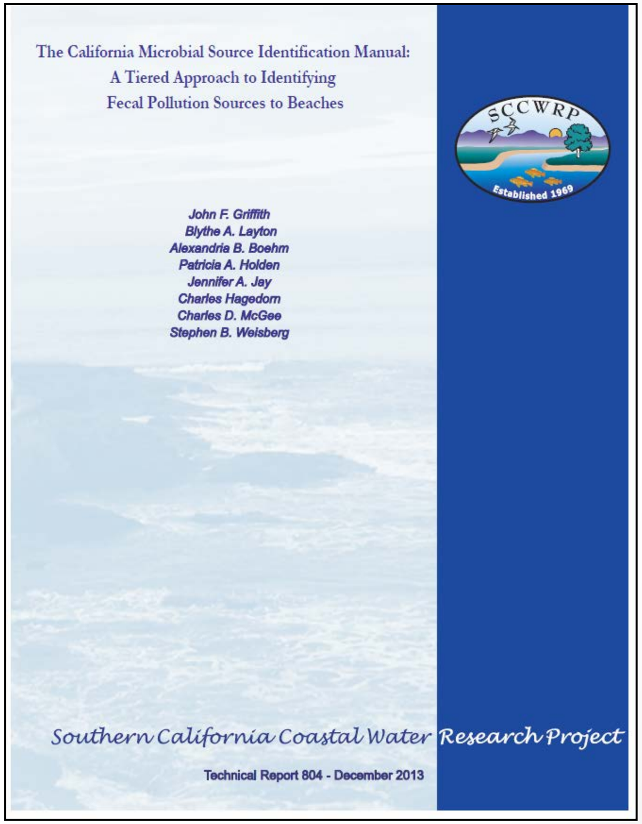
STEP 4. APPLY MOLECULAR METHODS TO IDENTIFY INDICATORS OF HUMAN FECAL POLLUTION

↓

Step 5. APPLY MOLECULAR METHODS TO IDENTIFY NON-HUMAN SOURCE-ASSOCIATED MARKERS

↓

Step 6. CONDUCT MICROBIAL COMMUNITY ANALYSIS



Source Identification Tools: Simple [$] to Complex [$$$$]

- Visual Surveys of Potential Sources
- GIS
- Dry Weather Outfall Screening FIB (E. coli)
- Chemical Indicators (Basic Flow Fingerprinting)
- Chemical Indicators (Advanced Markers)
- Canine Scent Tracking
- CCTV
- Electric Current Flow Method
- Basic Dye Test
- Smoke Test
- Dye with Rhodamine Probe
- Automated continuous flow gauges and autosamplers
- Temperature Probes
- Human-specific waste markers (DNA)
- Other Emerging Advanced Technique (e.g., phylochip)

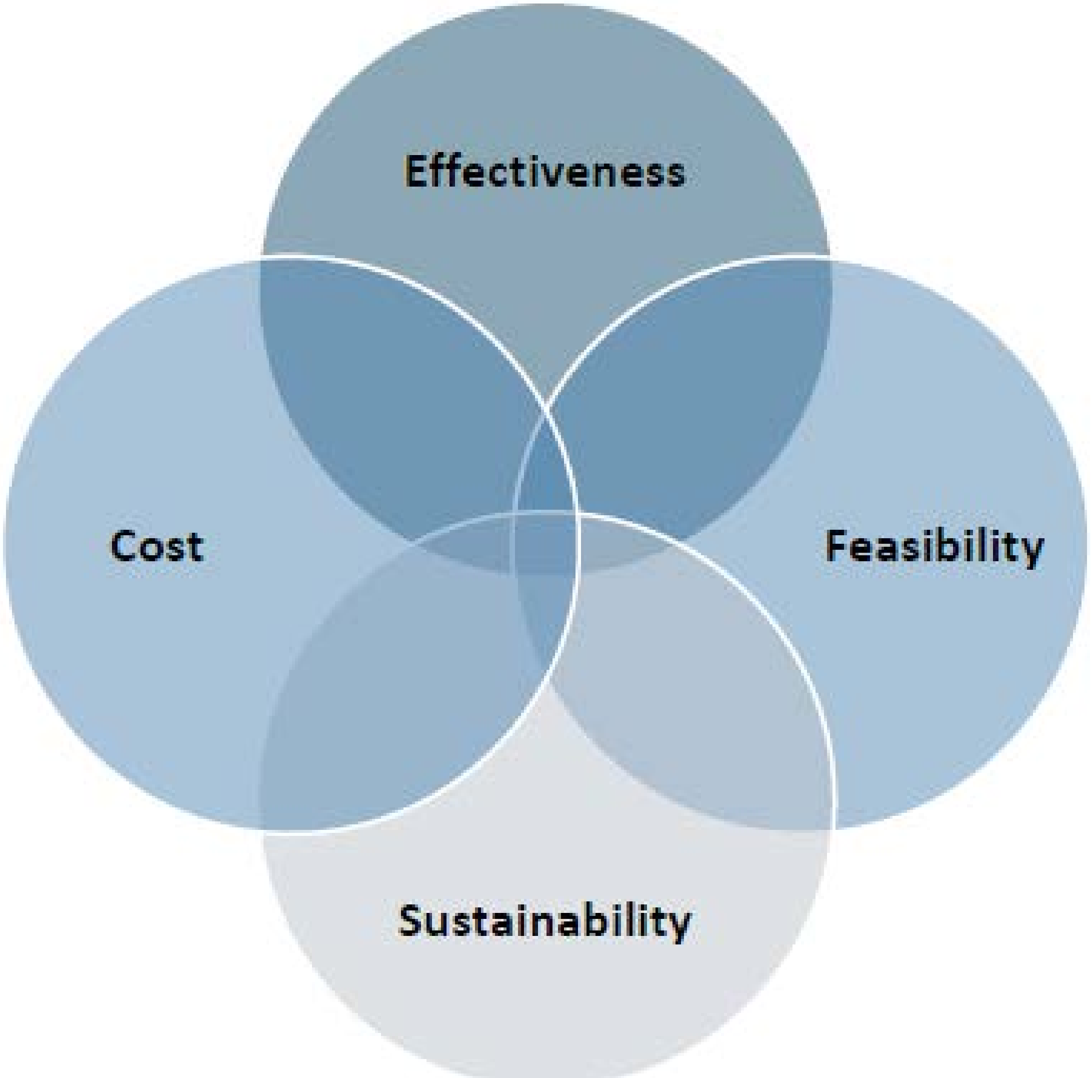
Raccoons in an urban storm drain manhole. Photo Courtesy: Andy Taylor, City of Boulder, CO.

Fecal waste in a storm drain (Geosyntec Consultants)

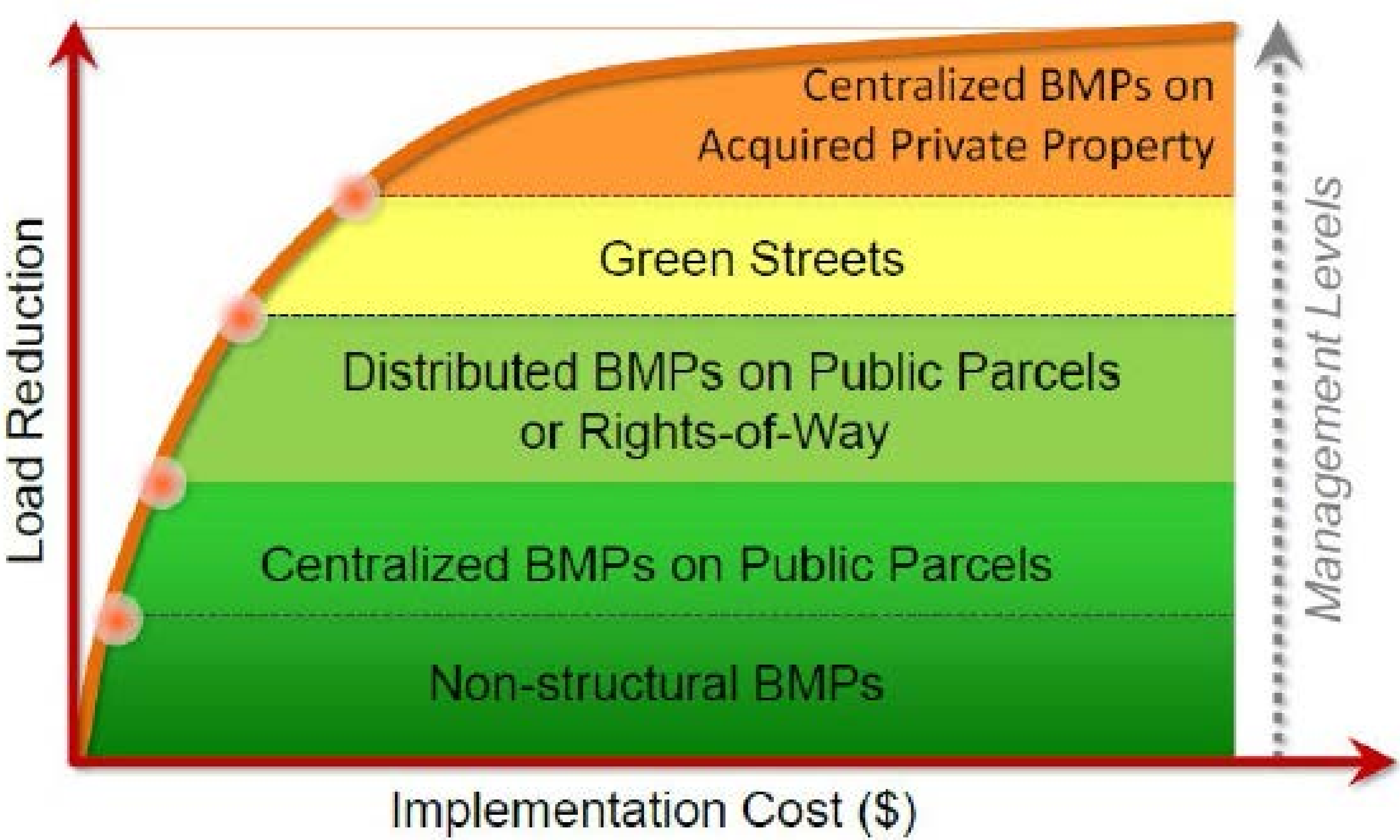
Developing a Control Strategy

General Themes:

- Address human source first, then other sources
- Address dry weather first, then wet weather
- Implement nonstructural/source controls, then structural



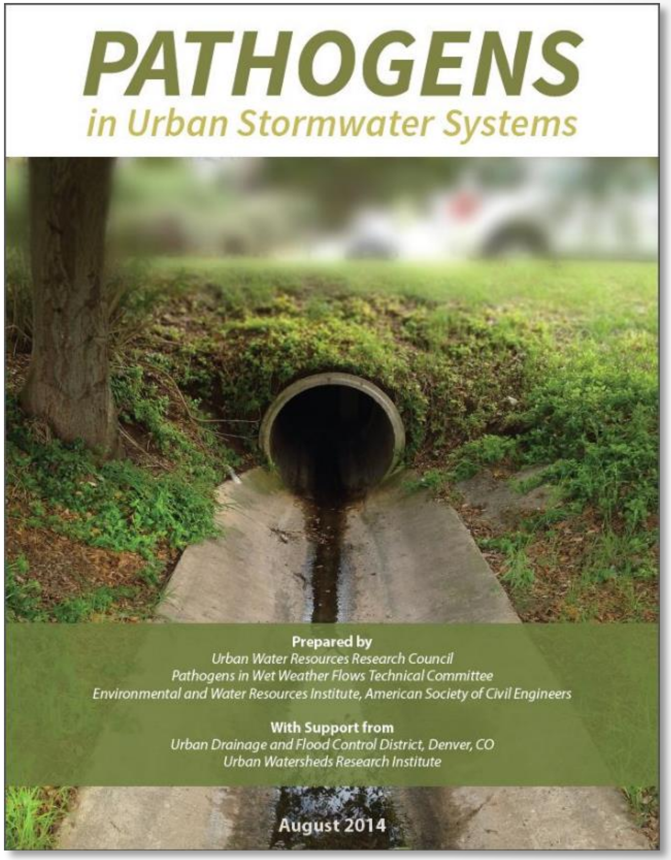
Conceptual Progression of Costs and Management Levels



Source: Source: San Diego River Watershed Comprehensive Load Reduction Plan Phase II [TetraTech 2013])

Use of Models to Support BMP Implementation

- "What is the best way to solve this water quality problem?" --Daren Harmel, USDA-ARS
  - What are the important contributors to this problem?
  - What are the best practices to implement?
  - Where are the best locations to install these practices?
  - How can practice effectiveness be evaluated (post-implementation)?
- Understanding the limits of models and accounting for uncertainty are fundamental to developing a model useful for management decisions.
- Model outputs should include estimates of uncertainty and should be treated as a planning resource, subject to change as more is learned.



Source Control BMPs

- Education and Outreach
- Repair of Aging Infrastructure and Correcting Illicit Connections
- Maintenance of Storm Sewers and Stormwater Controls
- Street Cleaning
- Downspout Disconnections/MDCIA
- Pet Waste Disposal and Pet Control Ordinances & Enforcement
- Animal Facilities Management (Doggy Daycares, Hobby Farms)
- Bird Controls

Drawing upon existing Fact Sheets in UDFCD's Volume 3, Colorado Stormwater Council, Others

- Urban Wildlife (Mammals)
- Irrigation, Car Washing, Power Washing
- Good Housekeeping/Trash Management (Dumpsters, Restaurants, Garbage Cans)
- Mobile Sources of Human Waste: Portable Toilets and RV Dumping
- Septic Systems /OWTSs
- Homeless Encampment Outreach and Enforcement
- River Cleanup

Sanitary Sewer Lining

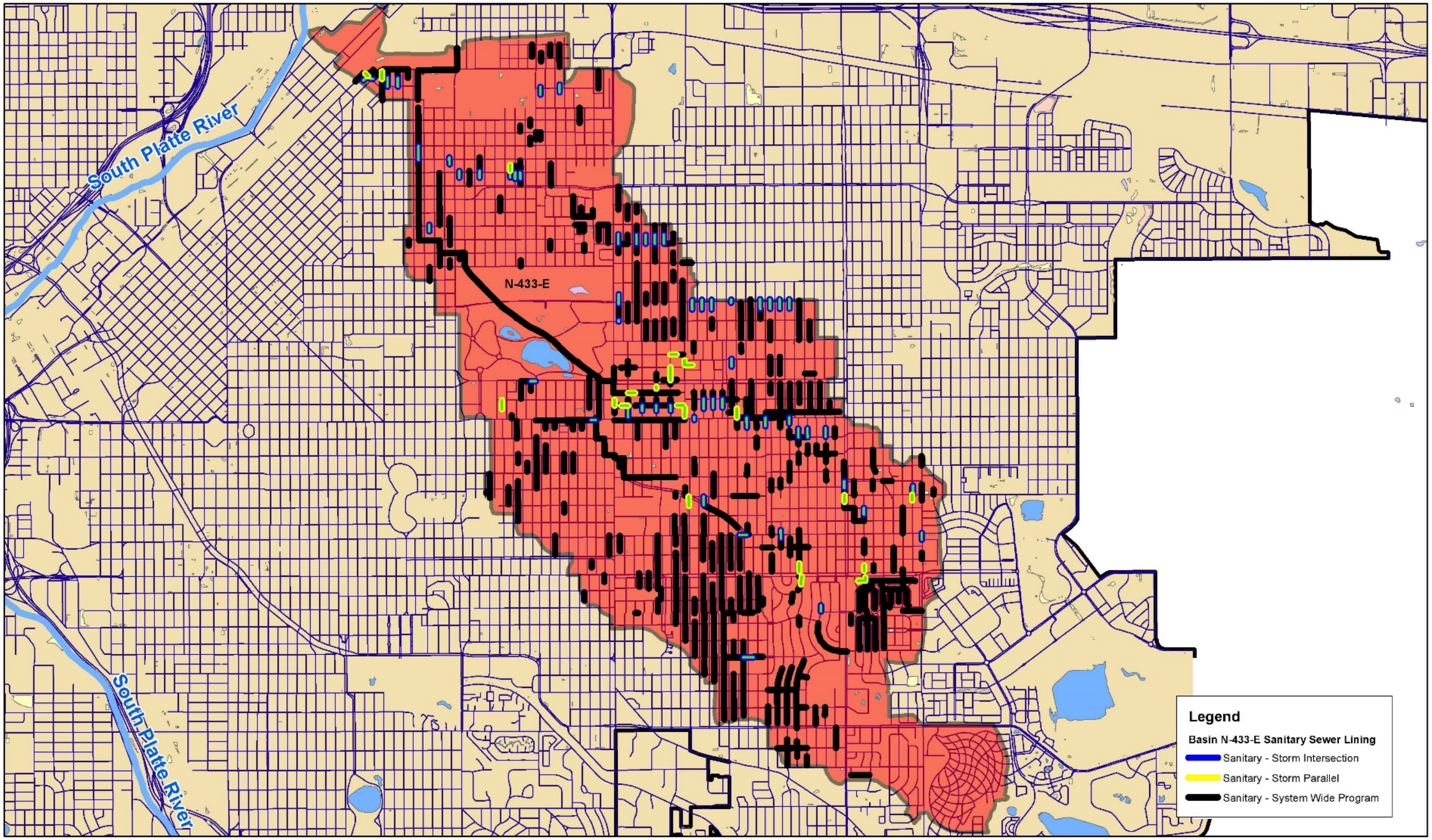
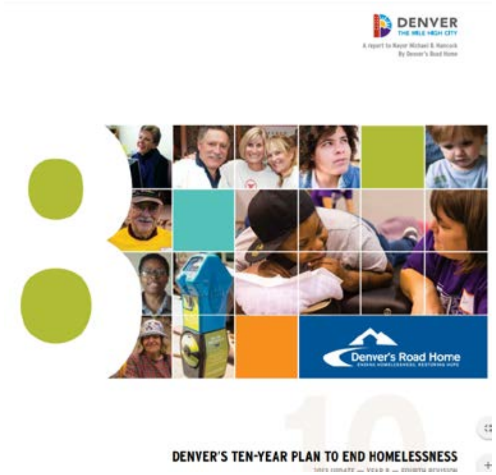


Figure B - 1
Sanitary Sewer Lining for Basin N-433-E

Other Examples of Source Controls



Public education campaigns.

Program to end homelessness.

Remote controlled goose hazing device, "Goosinator," used to deter resident waterfowl in Denver Parks.

Waste management/trash collection programs, City and County of Denver.

Pet waste stations in parks.

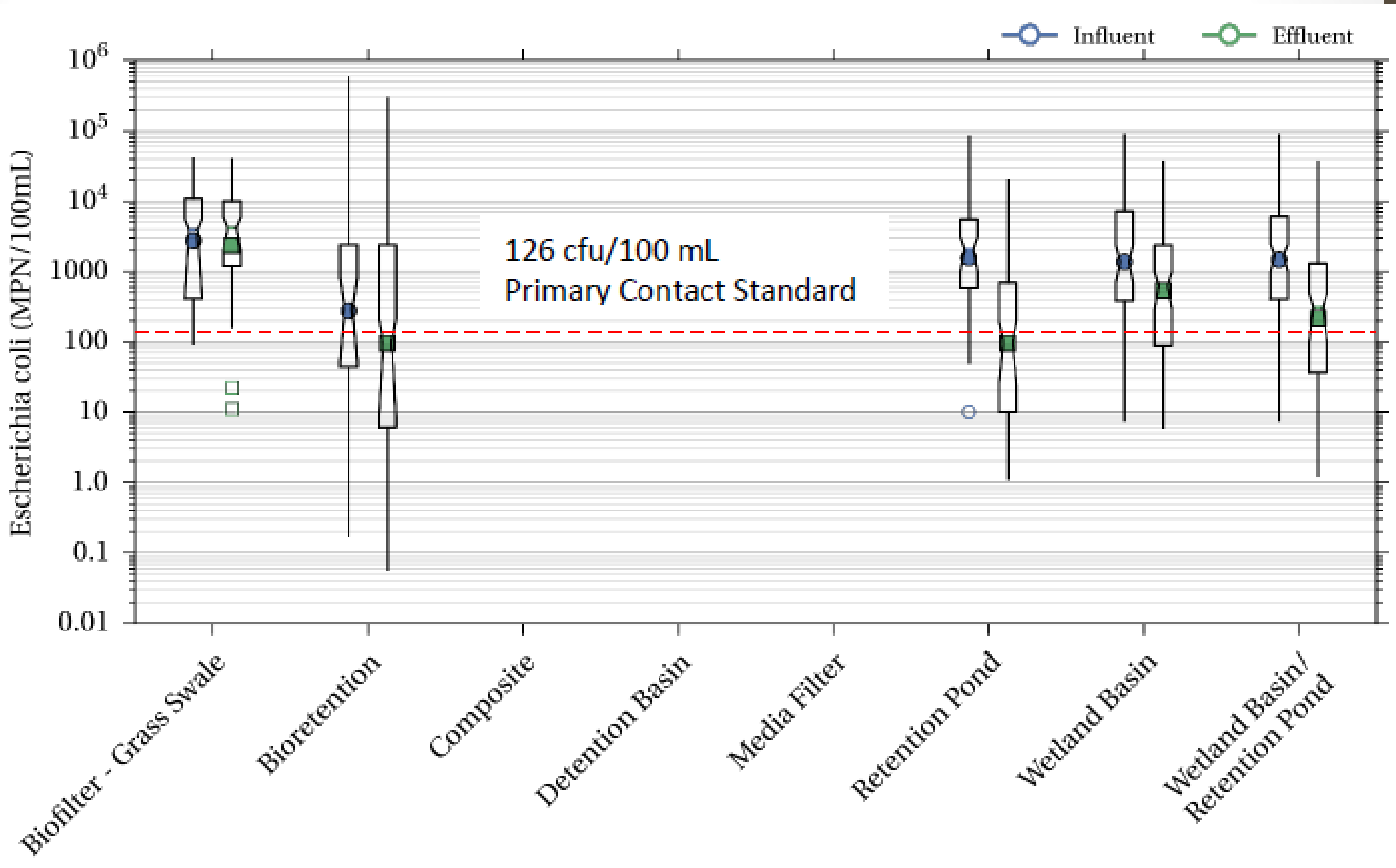
Retrofitted storm drain inlet, City of Boulder, CO

Structural Control Practices

- Passive Stormwater Structural BMPs
  - Urban Stormwater BMPs and Expected Effectiveness for Bacteria
  - BMP Performance Findings from the International Stormwater BMP Database
  - Optimizing BMP Designs to Enhance Bacteria Removal
- Considerations for Evaluating Proprietary Devices
- Low-Flow Diversions for Dry Weather Flows to Sanitary
- Active Disinfection Practices

Treatment Systems Being Pilot Tested in Denver

International Stormwater BMP Database: E. coli

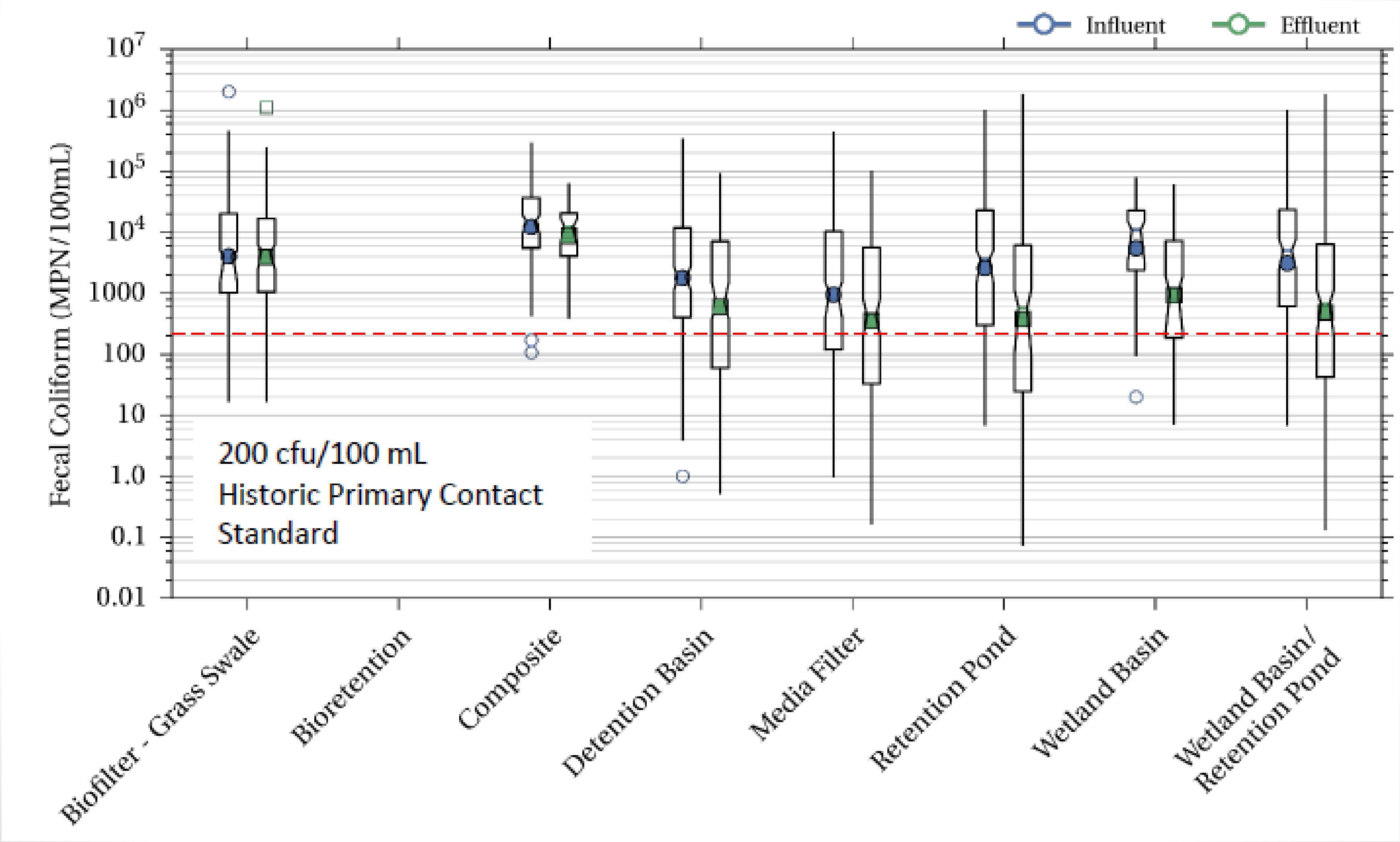


International Stormwater BMP Database: E. coli (tabular results)

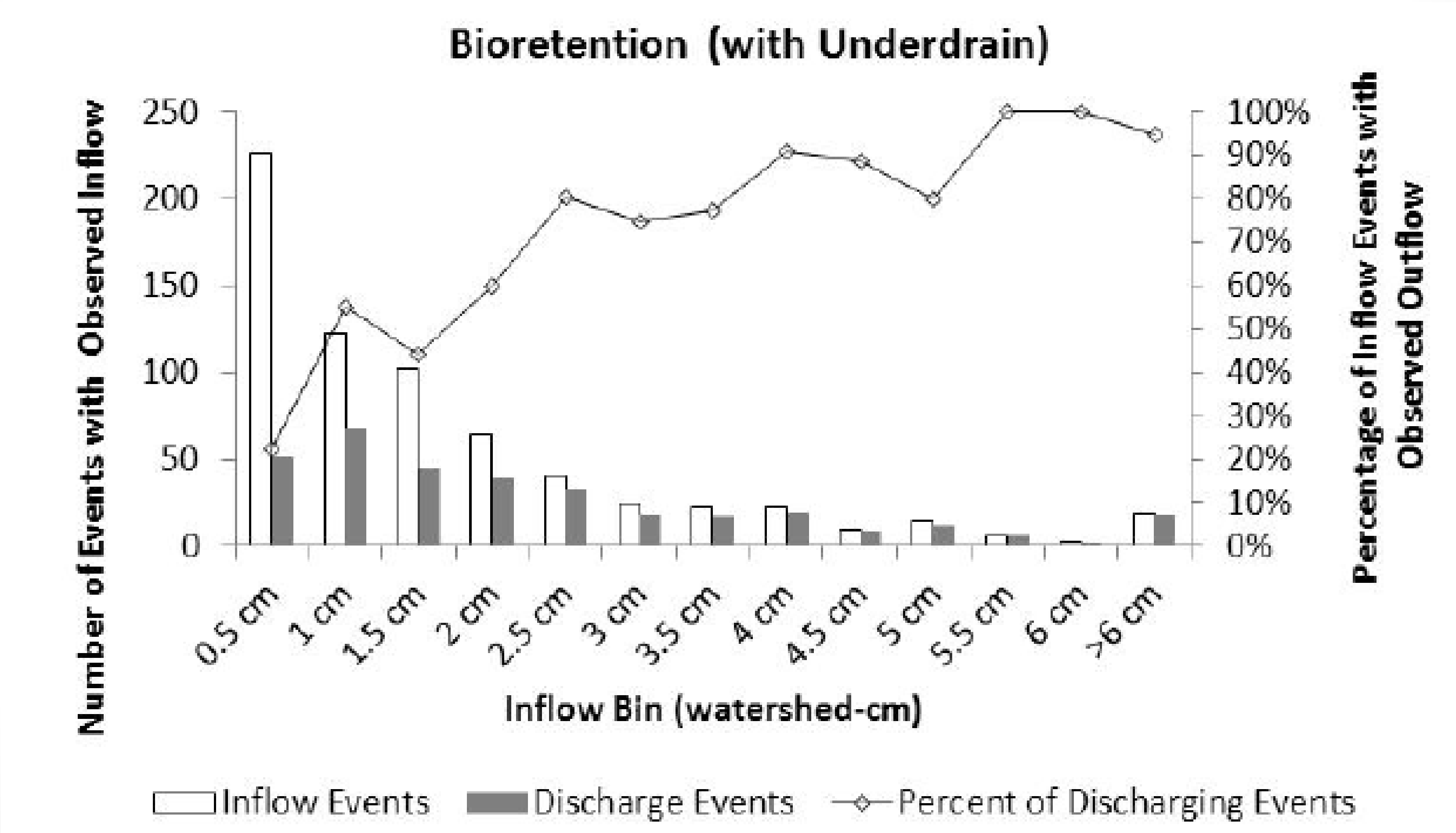
BMP Type	Count of Studies and EMCs		25th Percentile		Median (95% Conf. Interval)*		75th Percentile	
	In	Out	In	Out	In	Out	In	Out
Biofilter - Grass Strip	NA	NA	NA	NA	NA	NA	NA	NA
Biofilter - Grass Swale	5; 39	5; 39	411	1200	3998 (411, 5600)	4201 (1200, 5900)	11000	10000
Bioretention***	4; 61	4; 61	44.0	6.0	295 (52, 820)	**100 (8, 213)****	2400	2400
Composite	NA	NA	NA	NA	NA	NA	NA	NA
Detention Basin	NA	NA	NA	NA	NA	NA	NA	NA
Media Filter	NA	NA	NA	NA	NA	NA	NA	NA
Porous Pavement	NA	NA	NA	NA	NA	NA	NA	NA
Retention Pond	4; 69	4; 65	582	10	2069 (988, 3106)	**99.6 (20, 200)****	5500	697
Wetland Basin	5; 60	5; 59	383	88	1379 (690, 2346)	**636 (279, 988)****	7169	2376
Wetland Basin/Retention Pond	9; 129	9; 124	403	36	1713 (988, 2433)	**311 (100, 485)****	6100	1300
Wetland Channel	NA	NA	NA	NA	NA	NA	NA	NA

NA – not available or less than 3 studies for BMP/constituent.
*Computed using the BCa bootstrap method described by Efron and Tibishirani (1993).
**Hypothesis testing in Geosyntec and WWE (2014) shows statistically significant decreases for this BMP category.
***Due to the unusually low influent concentrations for the bioretention data set, additional results from more studies are needed to draw conclusions regarding statistically significant *E. coli* reductions from bioretention.

International Stormwater BMP Database: Fecal Coliform



Reducing Loads through Volume Reduction



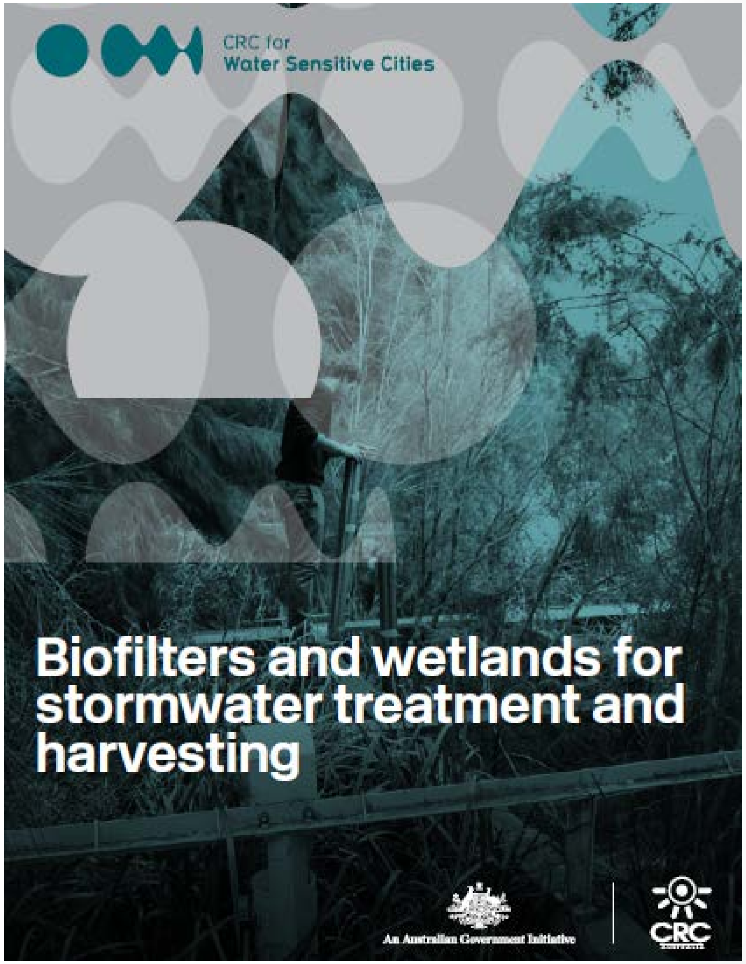
Source: Geosyntec and WWE 2011, www.bmpdatabase.org

Volume 3 BMPs: Expected Performance for Bacteria

UFFCD Vol. 3 BMP	Expected Effectiveness	Dominant Removal Processes
Grass Buffer	Poor	Infiltration
Grass Swale	Poor	Infiltration
Bioretention	Moderate to High	Infiltration, Filtration Biological Processes
Green Roof	Not Well Characterized	Evaporation, Filtration Biological Processes
Ext. Detention Basin	Poor to Moderate (variable)	Sedimentation Infiltration (limited)
Sand Filter	Moderate	Filtration
Retention Pond	Moderate	Sedimentation Biological Processes
Constructed Wetland Pond	Moderate	Sedimentation Biological Processes
Const. Wetland Channel	Poor to High, depending on design	Sedimentation Biological Processes
Permeable Pavement	Not Well Characterized	Infiltration Filtration
Underground/ Proprietary	Variable	Device-dependent

Improving BMP Performance for Bacteria: Optimizing Filtration Media and Design

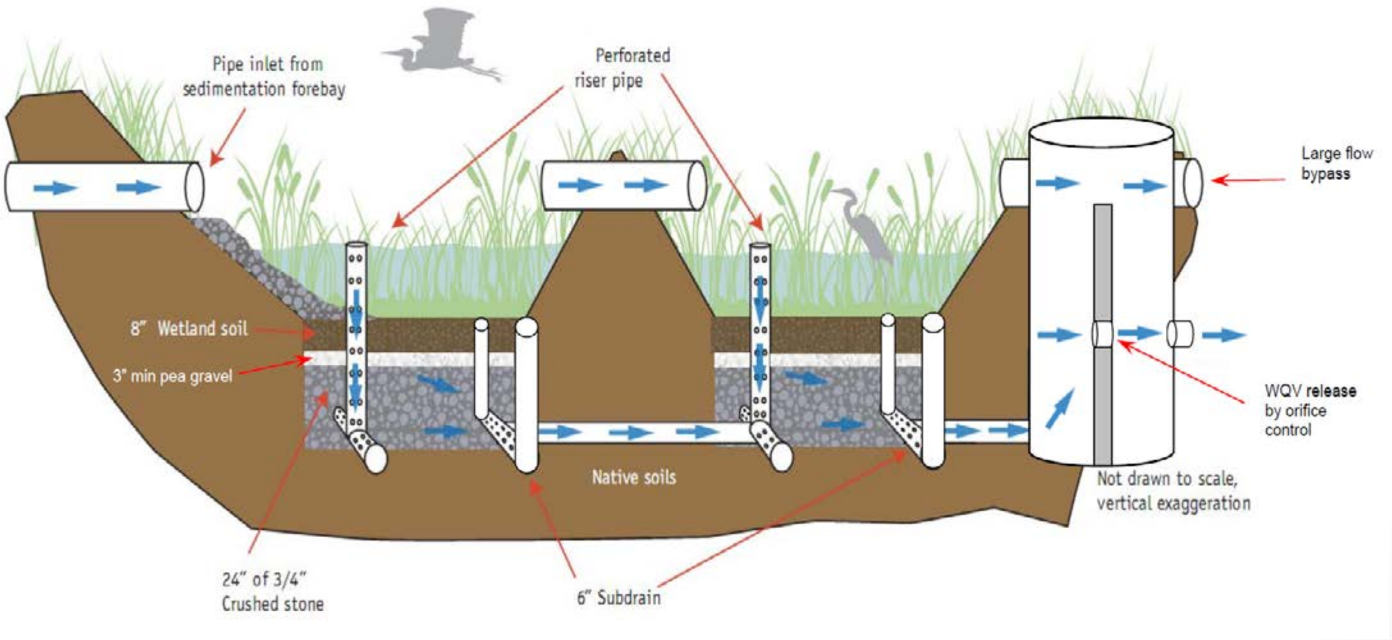
- Media amendments such as biochar and zeolite.
- Vegetation with specific root structures to promote pollutant removal and infiltration.
- Outlet control with sufficient contact time.
- Presence of a saturated zone. ("internal water storage zone")



Deletic et al. 2014, Monash University

Subsurface Flow Wetlands

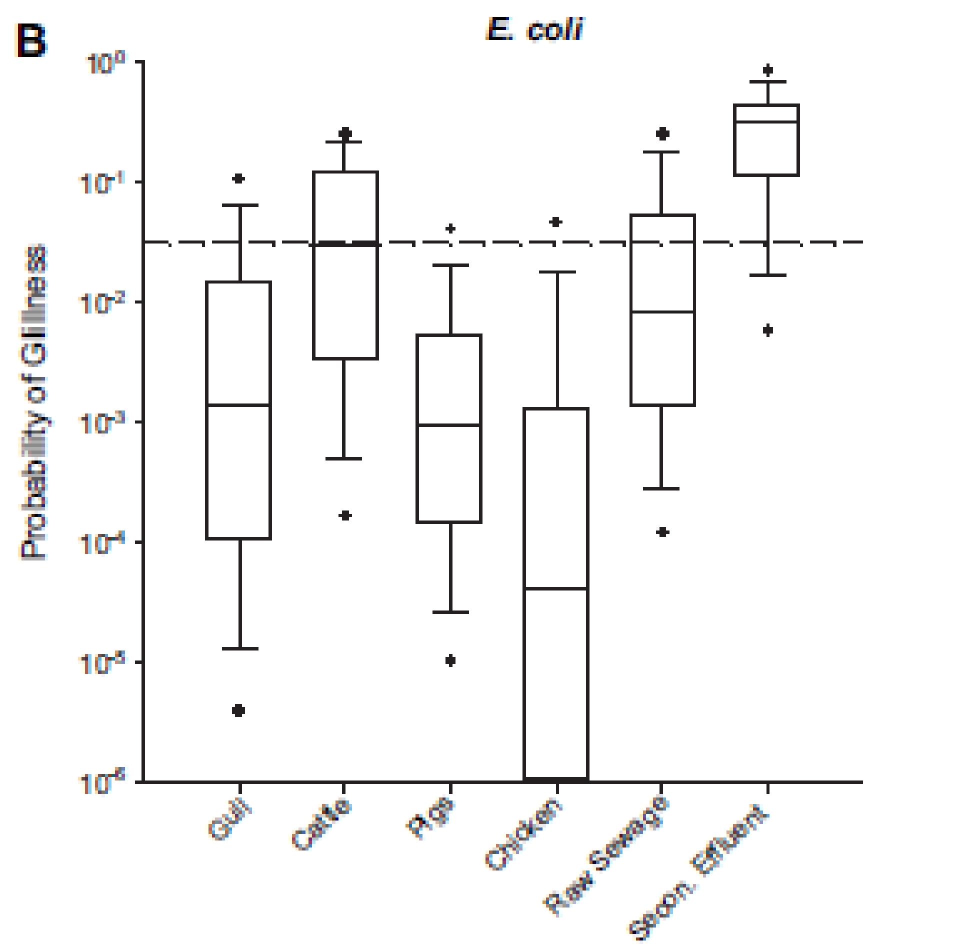
- Often recommended in California CLRPs.
- Have been successfully used for wastewater.
- Various constraints in Colorado (e.g., consistent supply of water (& water rights) to maintain aerobic conditions and support vegetation, adequate land area for equalization basins).



Conceptual Subsurface Flow Wetlands (Source: Geosyntec 2015)

Regulatory Considerations/Site-Specific Standards (EPA 2012 RWQC)

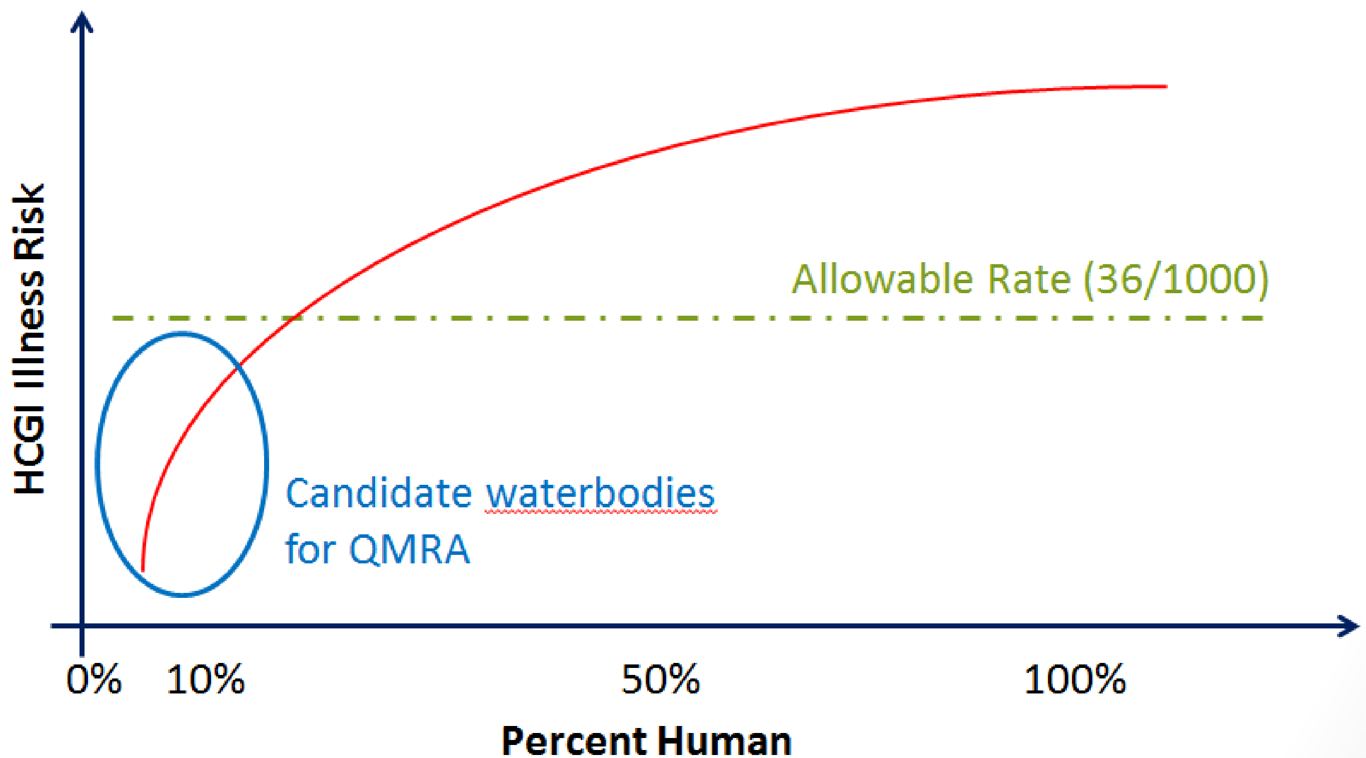
1. Epidemiological studies
2. Quantitative Microbial Risk Assessment (QMRA)
   - EPA's Framework for Use of QMRA for Developing Site-Specific Standards
   - Practical Considerations for Monitoring to Support QMRA
3. Alternative Indicators or Methods



Source: Soller et al. 2010

QMRA/Site-specific Standard Candidates

At 126 MPN/100mL *E. coli*:



Conclusions

- An *E. coli* TMDL is likely coming soon to a community near you!
- *E. coli* issues are complicated, not easily solved and potentially very expensive for local governments.
- The Toolbox is a resource intended to support strategies to identify sources and work towards control of *E. coli*.
- The Toolbox can provide a common foundation to support discussions and planning among multiple municipal departments and organizations.
- Additional monitoring of source area runoff and BMP performance for *E. coli* is needed in Colorado.

Questions?

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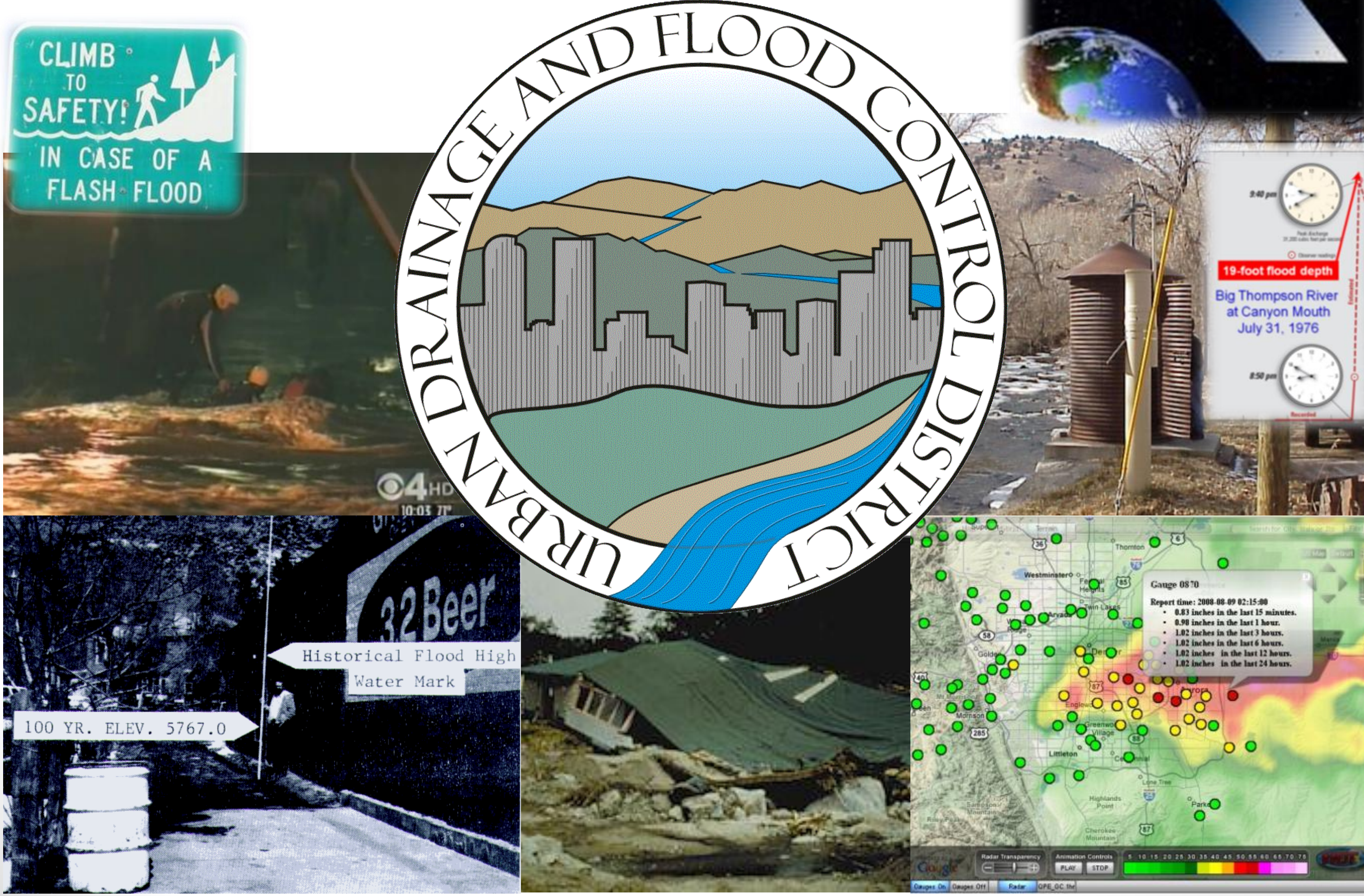
State of the Science (SOS)—*Recognizing flood threats hours before the rains come*

Kevin Stewart, PE, Program Manager
Dmitry “Dima” Smirnov, Ph.D., Meteorologist, Dewberry

Flood Warning Program



2016 UDFCD Annual Seminar April 5, 2016

Focusing on PREDICTION

The ALERT System | HOME | DISCLAIMER | MAPS | TABLES | HYDROMODELS | F2P2 | SUBSCRIBE | MORE...

REAL-TIME FLOOD DETECTION & FORECASTS

UDFCD
Flood Warning Program

Welcome to UDFCD's ALERT System. This website is designed to accommodate handheld devices such as smartphones, Apple iPads and Windows Tablets. Some webpages at this site still require Adobe Flash. Apple and Android users will not be able to view these pages. A few other pages designed primarily for desktop use also work with smaller devices. In time these tools will become more handheld-friendly.

Source: NCAR

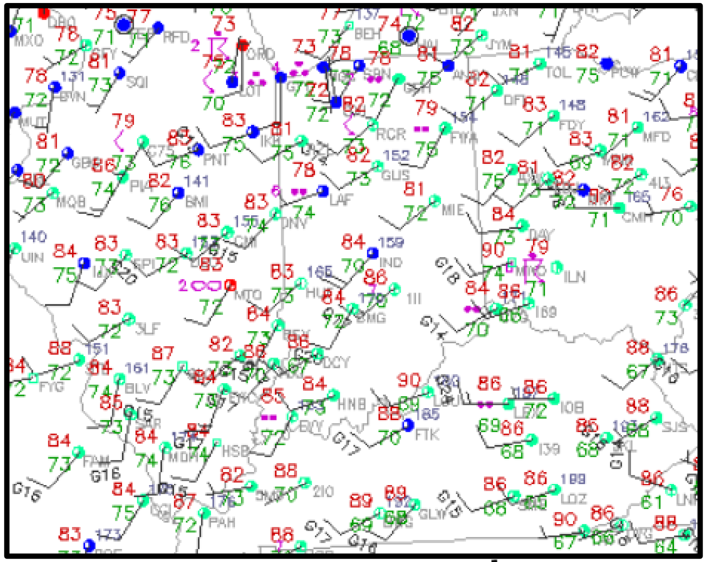
Using High-Resolution Quantitative Precipitation Forecasts for Heavy Rainfall Prediction in Colorado

Dmitry Smirnov, Ph.D.
Kevin Stewart, P.E.
Stu Geiger, C.F.M.

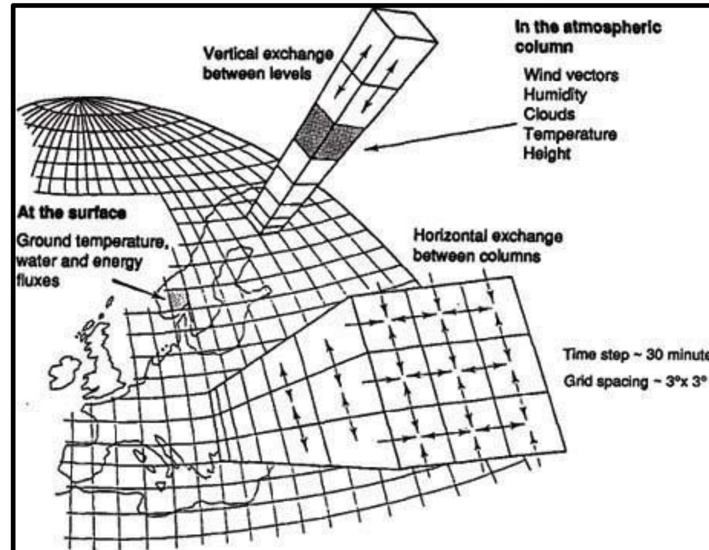
UDFCD Annual Seminar 2016

What makes a good forecast?

OBSERVATIONS



WEATHER MODELS



HYDRO-
METEOROLOGISTS

Outline

- ❑ Brief primer on weather models
  - ❑ Importance of resolution
  - ❑ Defining an "Ensemble"
- ❑ Applying models. Two real-world examples:

1. Colorado Flood Threat Bulletin
2. Urban Drainage and Flood Control District Heavy Rainfall Guidance

- **WHERE?**
- **WHEN?**
- **HOW MUCH?**
- **HOW SURE ARE YOU?**

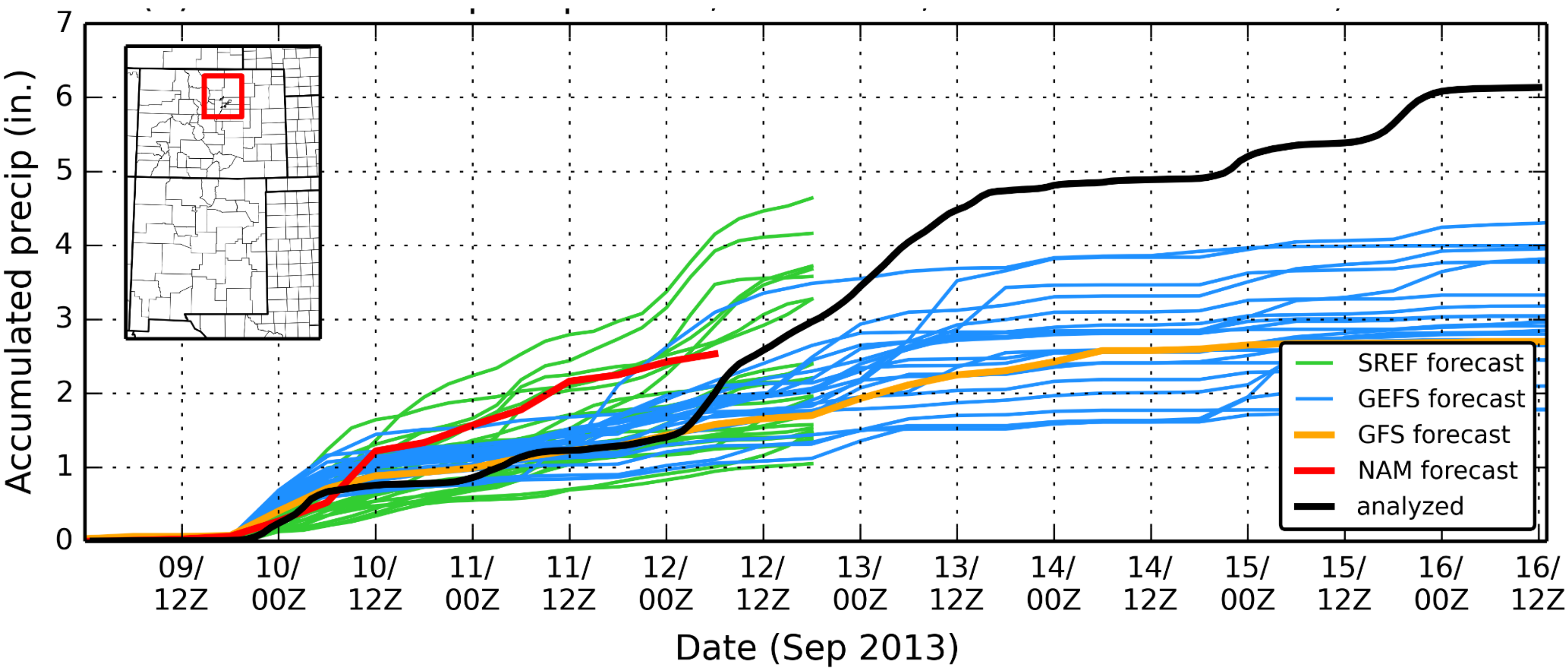
Lots of data!

MODEL	RESOLUTION	RUNS / DAY	LEAD TIME	ENS
Nested NMM-B	1.33k	2	36H	---
Univ. of Arizona WRF	1.8			2 or 3
NCAR DART Ensemble				10
High Resolution Rapid Refresh (HRRR)				---
NSSL-WRF				8
NCEP HIRES WRF (ARW & NMM)				2
Dewberry Colorado WRF				---
Canadian GEM	10km	4	87H	---
North American Mesoscale	12km	4	84H	---
Rapid Refresh				---
Short-Range Ensemble Forecasts				21
CMC NAEFS				20
Global Forecast System	1			21
ECMWF	1			51
NCEP Climate Forecast System				4
ECMWF	70km	1/month	7M	51

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Dewberry

What is an ensemble?



Thanks to: Tom Hamill, NOAA-ESRL

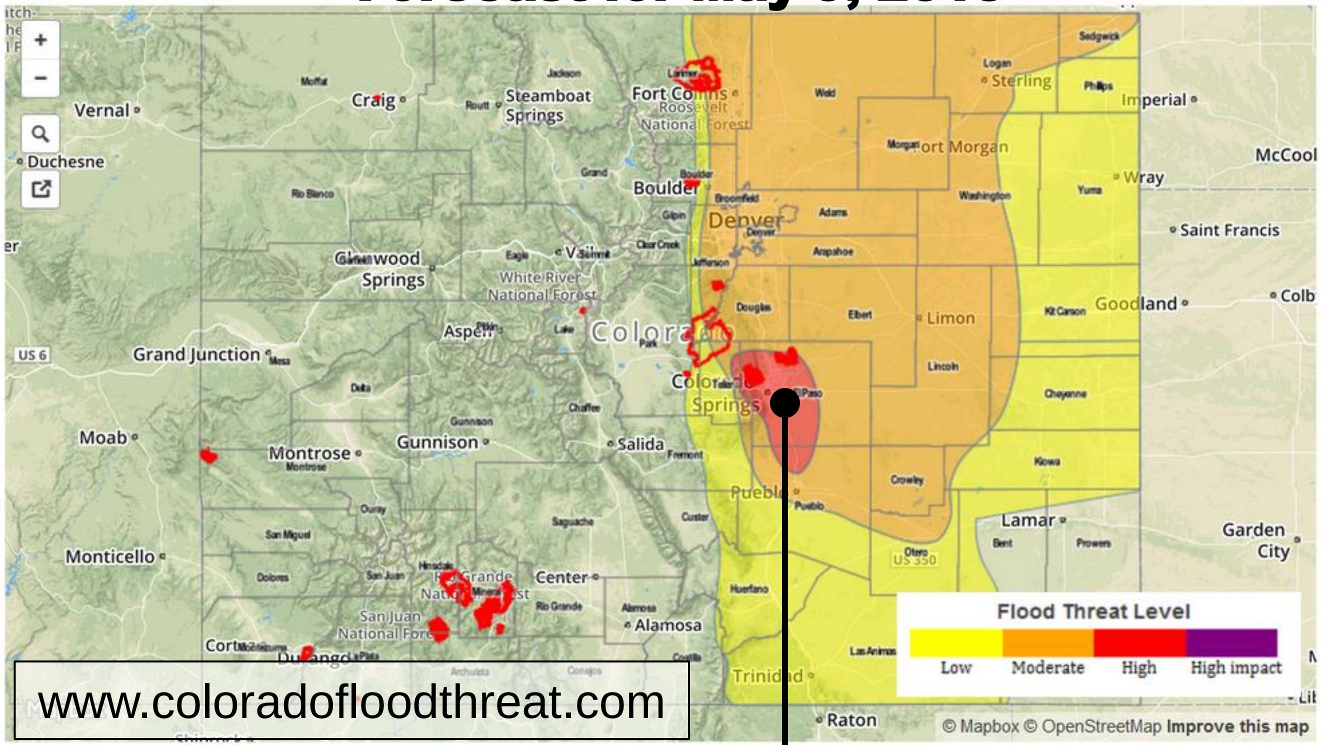
1. Colorado Flood Threat Bulletin

Colorado Flood Threat Bulletin

@COFloodUpdates

- Specifies:
  - Location
  - Timing
  - Intensity
  - Confidence
- Includes:
  - Riverine flooding
  - Flash flooding
    (esp. urban)
  - Snow-melt
  - Drought
- Tools:
  - Processed high-res model guidance

Forecast for May 9, 2015



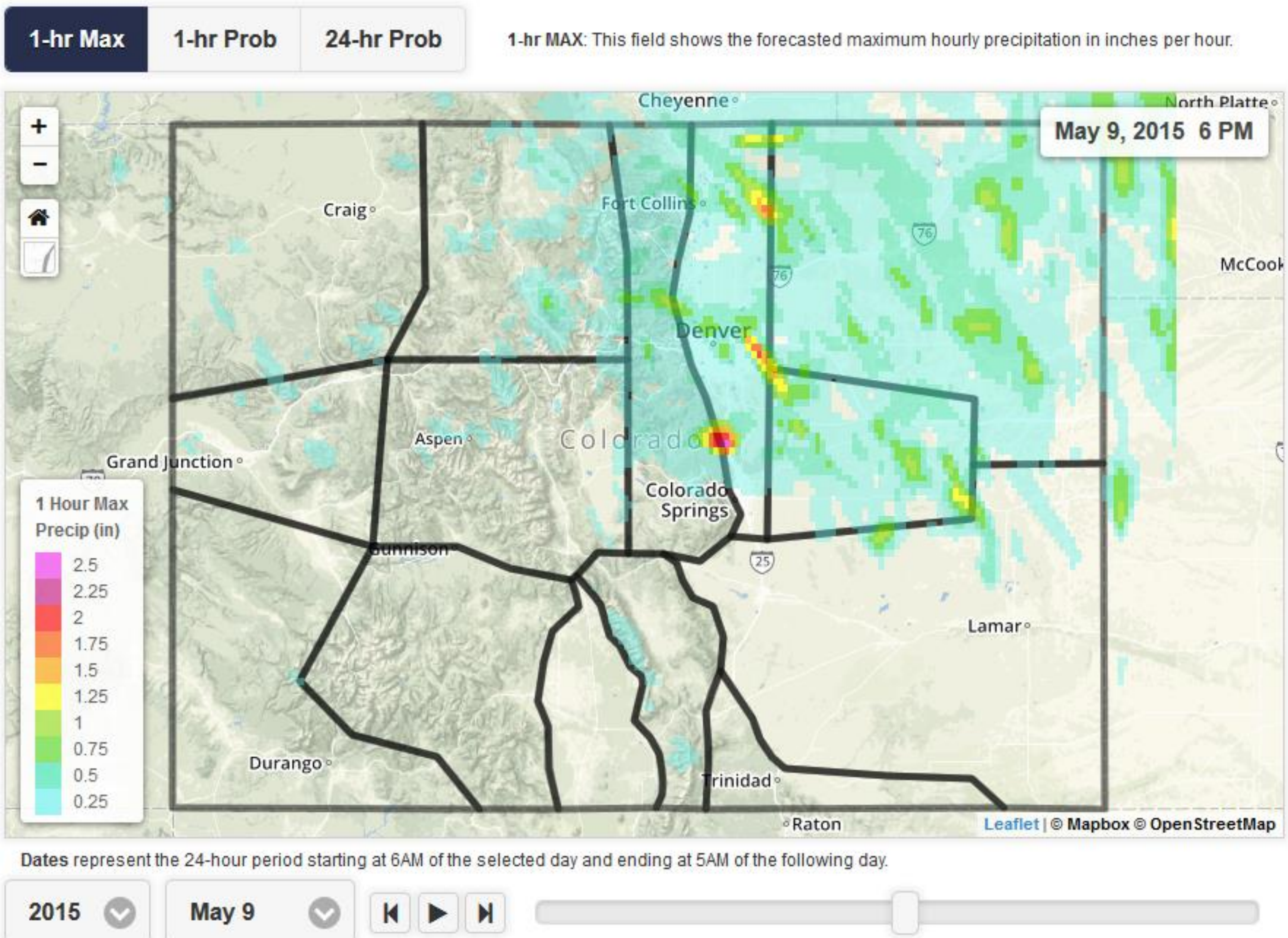
www.coloradofloodthreat.com

Chance of Precip	Prime Time	Discussion
>90%	11AM – 1AM	**HIGH flash flood threat:** High antecedent rainfall along with 2-3 inches of additional rainfall will cause widespread street and stream flooding.

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Dewberry

Flood Threat Bulletin QPF Viewer



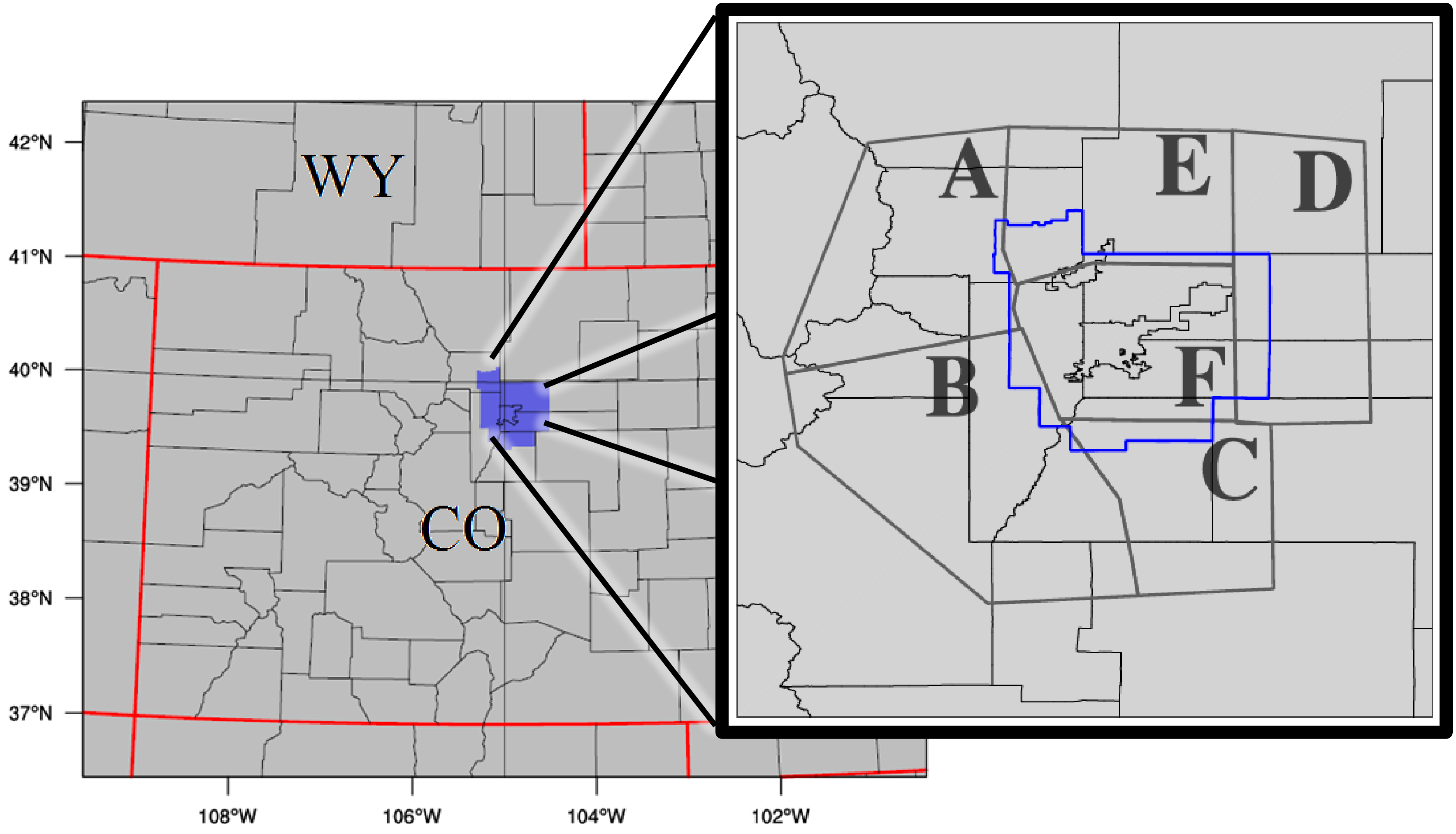
www.coloradofloodthreat.com

2. Heavy Rainfall Guidance Tool

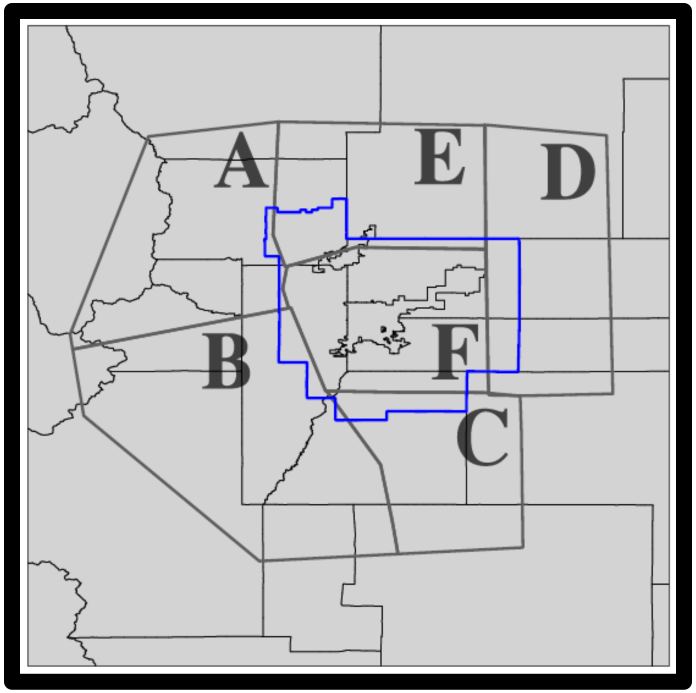
- Overview & Features
- Overall performance in 2015
- Examples of several events
- Improvements for 2016

Domain

District domain ~1,600 sq. miles
Tool domain ~7,650 sq. miles



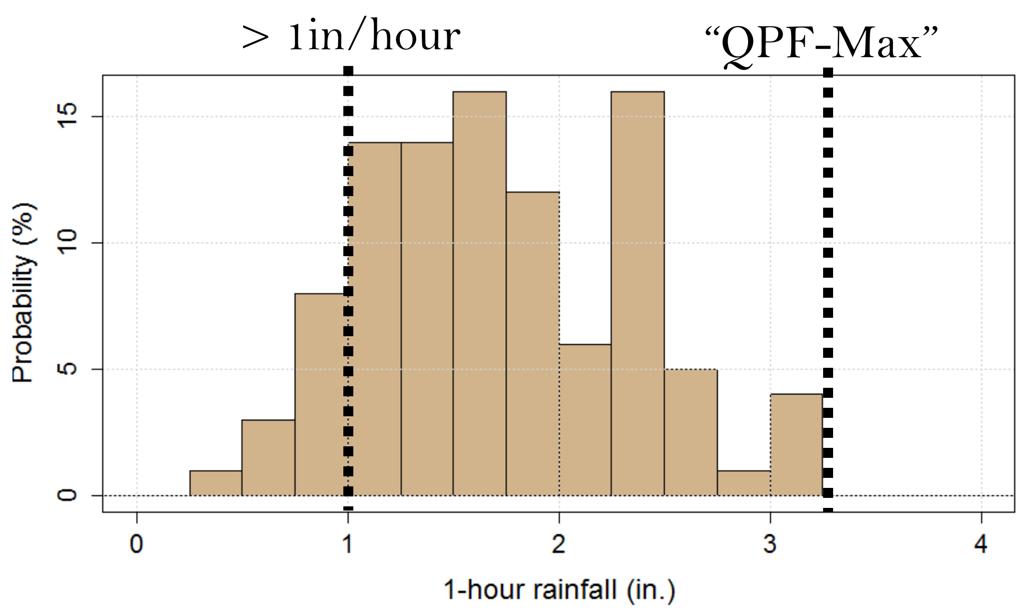
Forecast Zones



Forecast Zone	Area (sq. mi.)	# of ALERT gauges
(A) Northern Foothills	1,316	49
(B) Southern Foothills	2,029	38
(C) Palmer Divide	933	22
(D) Plains	1,283	0
(E) Northern Metro	1,053	14
(F) Central Metro	1,043	97
All Zones	**7,657**	**220**

Data & Methods Used

- 13 operational and research weather models
- Spatial resolution: 4km (2.5 miles)
- Time resolution: 1 hour
- Lead time: 24 hours
- Ensemble processing techniques



QPF = Quantitative Precipitation Forecast

Translating rainfall to threat

Duration	Intensity Threshold
1-hour	1 inch
3-hour	2.5
6-hour	3.5
24-hour	4.5

Threat	Intensity	Probability of Exceedance
LOW	At least 1 threshold is broken	---
MODERATE	i) At least 1 threshold is broken AND	>50%
	ii) More than 1 threshold is broken AND	>40%
HIGH	More than 1 threshold is broken AND	>60%
VERY HIGH	More than 1 threshold is broken AND	>80%

Tool Overview: Daily Summary

Dewberry

UDFCD Heavy Rainfall Guidance

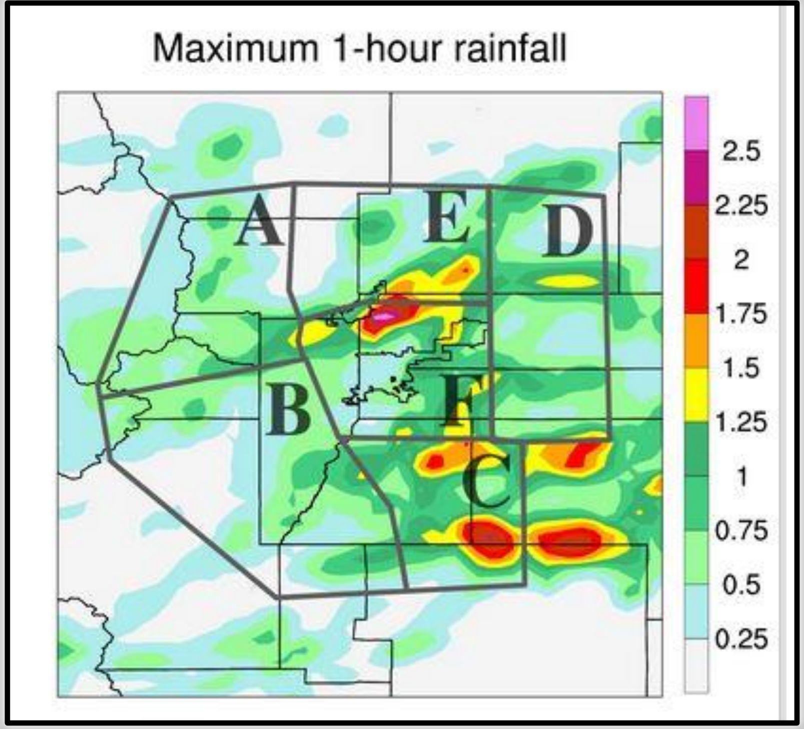
Help

Daily Summary: June 10, 2015
Updated: 12:05 PM

Quality Control: See Below for Meteorologist's Note

Meteorologist's Note: Highest threat appears to be between 3-6pm local time. Storms, already ongoing, will move into a favorable region southeast of Denver Metro where very heavy rainfall is possible. 1hr rates up to 2.4 inches are possible. After 7 pm, current indications are westerly low-level flow will drastically lower heavy rain threat.

Zone	Threat	Primetime
A	LOW	14-16Wed
B	LOW	16-19Wed
C	MOD	12-19Wed
D	MOD	14-19Wed
E	HIGH	14-18Wed
F	HIGH	13-18Wed

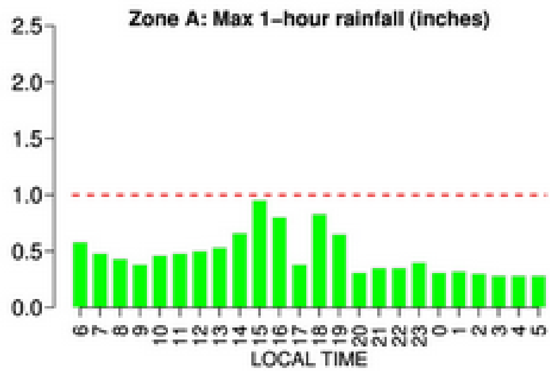


Tool Overview: Zone forecasts

Zone-specific Forecasts

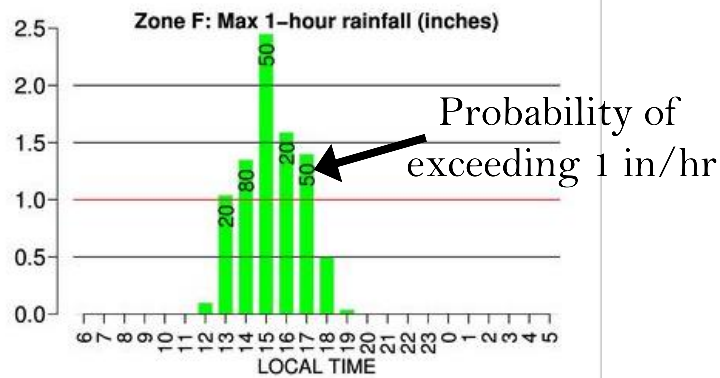
Zone A: Northern Foothills

ZONE A: Overall Threat	NONE
% precipitation	>90%
% exceeding 1in. per 1hr	<10%
% exceeding 2.5in. per 3hr	<10%
% exceeding 3.5in. per 6hr	<10%
% exceeding 4.5in. per 24hr	<10%
Primetime	---



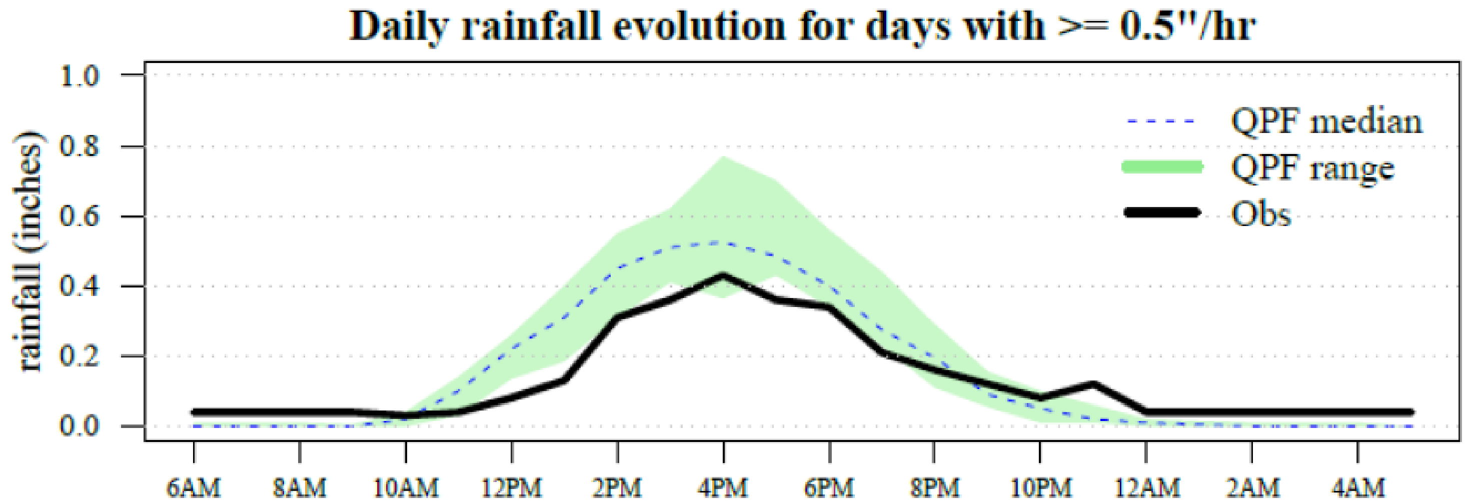
Zone F: Central Metro

ZONE F: Overall Threat	HIGH
% precipitation	>90%
% exceeding 1in. per 1hr	>90%
% exceeding 2.5in. per 3hr	25%
% exceeding 3.5in. per 6hr	25%
% exceeding 4.5in. per 24hr	<10%
Primetime	13-18Wed

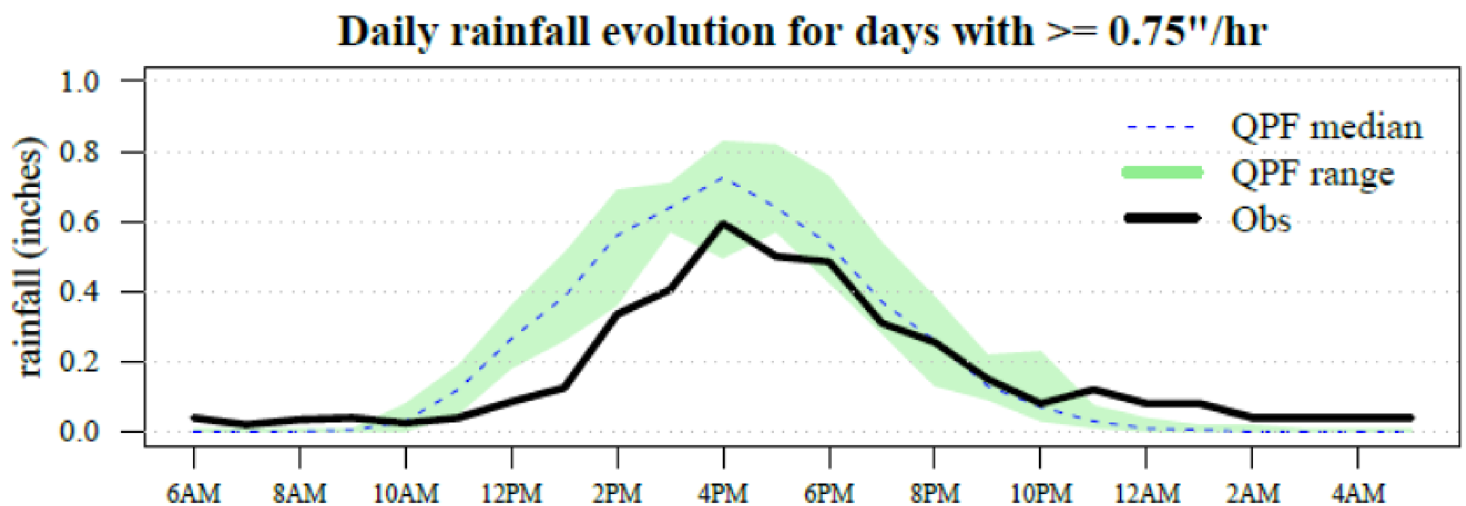


Performance in 2015

Timing



Daily rainfall evolution for days with >= 0.5"/hr
rainfall (inches)
1.0
0.8
0.6
0.4
0.2
0.0
6AM
8AM
10AM
12PM
2PM
4PM
6PM
8PM
10PM
12AM
2AM
4AM
QPF median
QPF range
Obs



Daily rainfall evolution for days with >= 0.75"/hr
rainfall (inches)
1.0
0.8
0.6
0.4
0.2
0.0
6AM
8AM
10AM
12PM
2PM
4PM
6PM
8PM
10PM
12AM
2AM
4AM
QPF median
QPF range
Obs

Location

		Heavy Rainfall Forecasted	
		NO	YES
Heavy Rainfall Observed	NO	HIT	FALSE ALARM
	YES	MISS	HIT

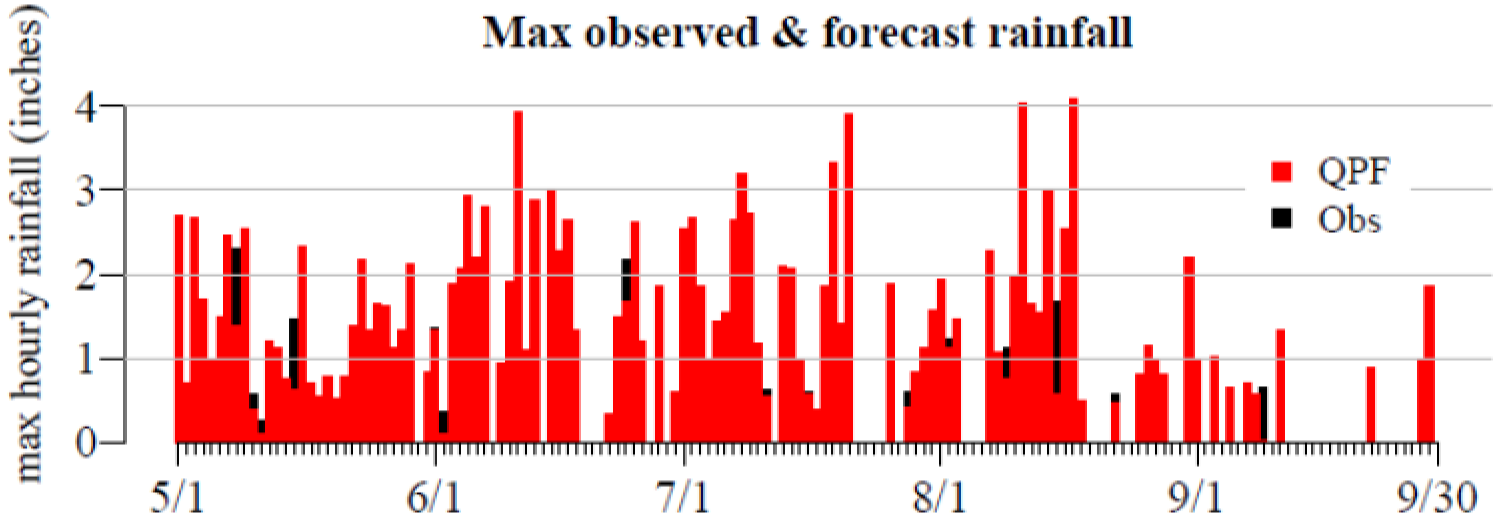
Heavy Rainfall Forecasted

	a)Zone A	NO	YES	Accuracy: 76%
Heavy Rainfall	NO	114 (74.5%)	35 (22.9%)	False Alarm: 23%
Observed	YES	1 (0.7%)	3 (2%)	Misses: 1%

	b)Zone B	NO	YES	Accuracy: 71%
Heavy Rainfall	NO	100 (65.4%)	42 (27.5%)	False Alarm: 28%
Observed	YES	2 (1.3%)	9 (5.9%)	Misses: 1%

	c)Zone C			Accuracy: 75%
Heavy Rainfall	NO	99 (64.7%)	34 (22.2%)	False Alarm: 22%
Observed	YES	5 (3.3%)	15 (9.8%)	Misses: 3%

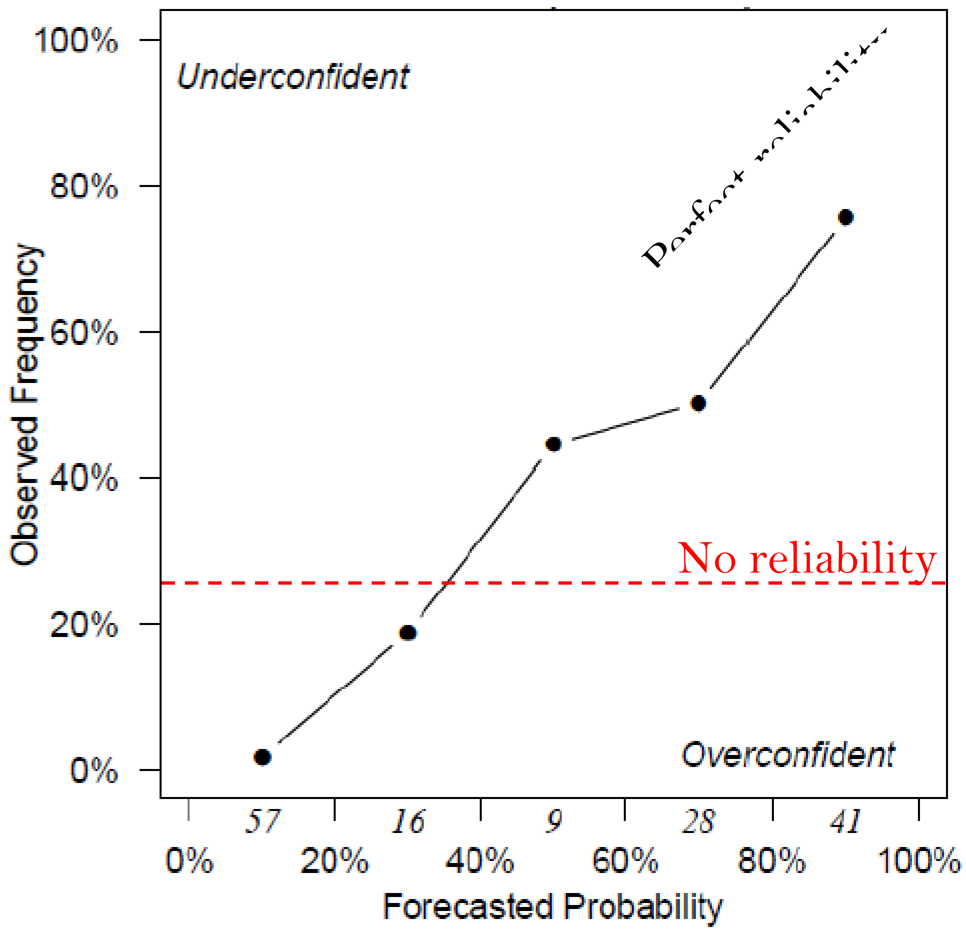
Intensity



Zone	Absolute timing	+/- 2 hours
A	69%	96%
B	78%	98%
C	64%	93%
D	61%	94%
E	55%	93%
F	52%	84%
All Zones	76%	97%

Confidence: Reliability Diagram

If the forecast for exceeding 0.5 inches per hour today is X%, how often is that forecast actually observed?

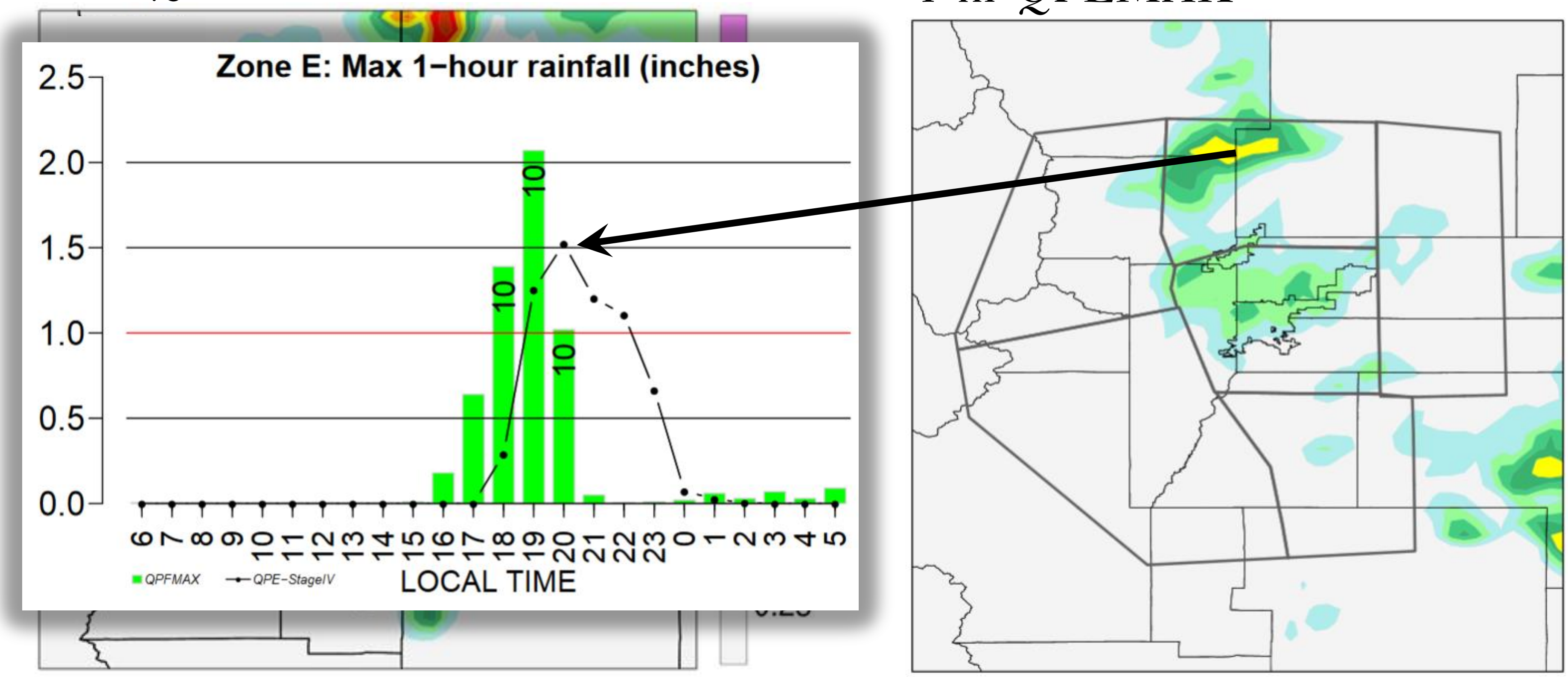


Examples of specific events

June 4, 2015

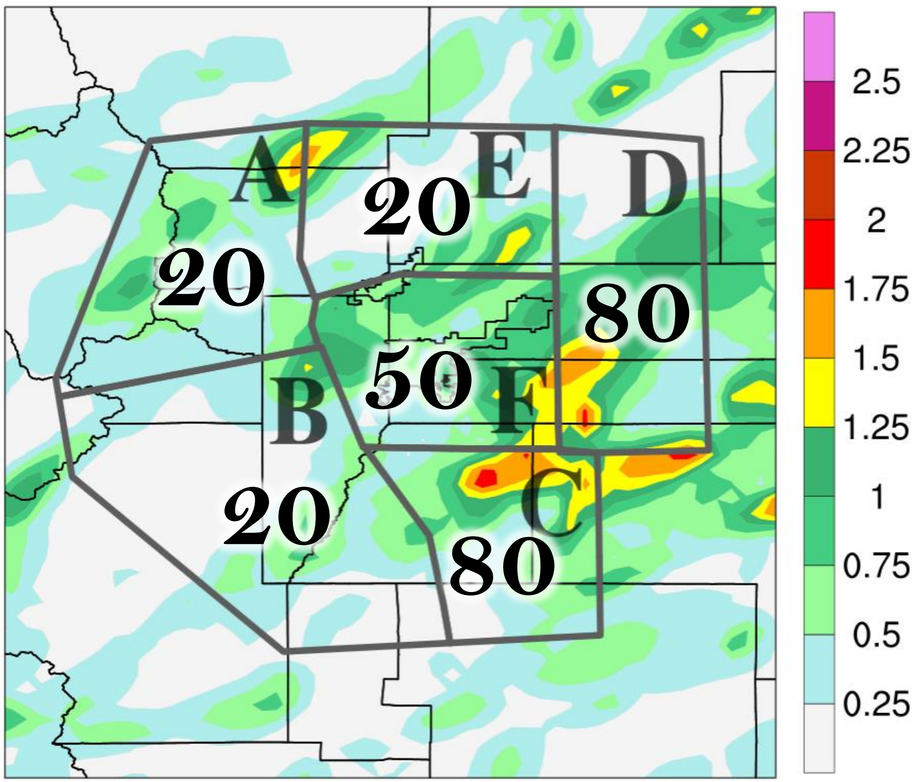
1-hr QPFMAX

1-hr QPEMAX

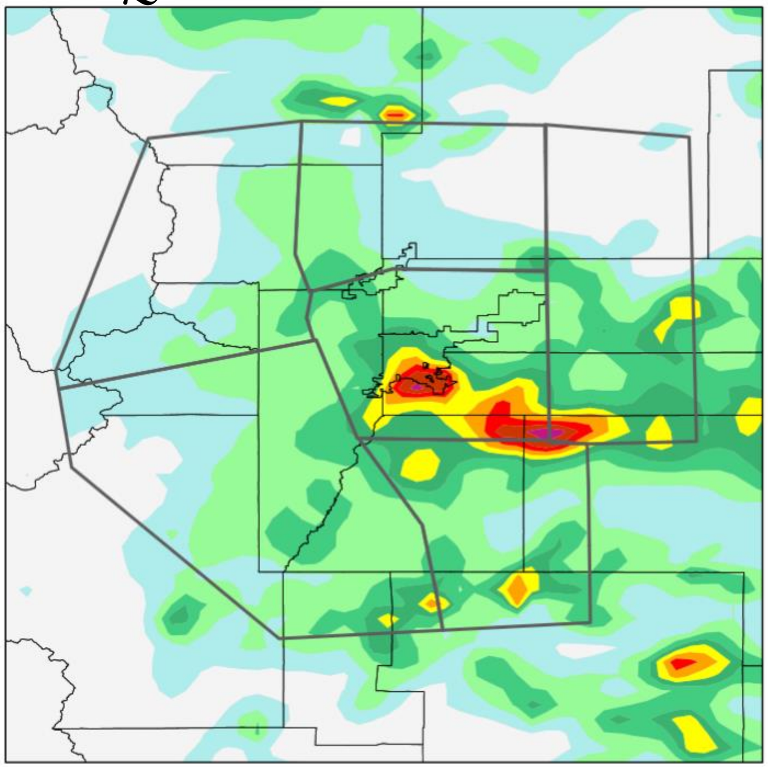


June 10, 2015

1-hr QPFMAX

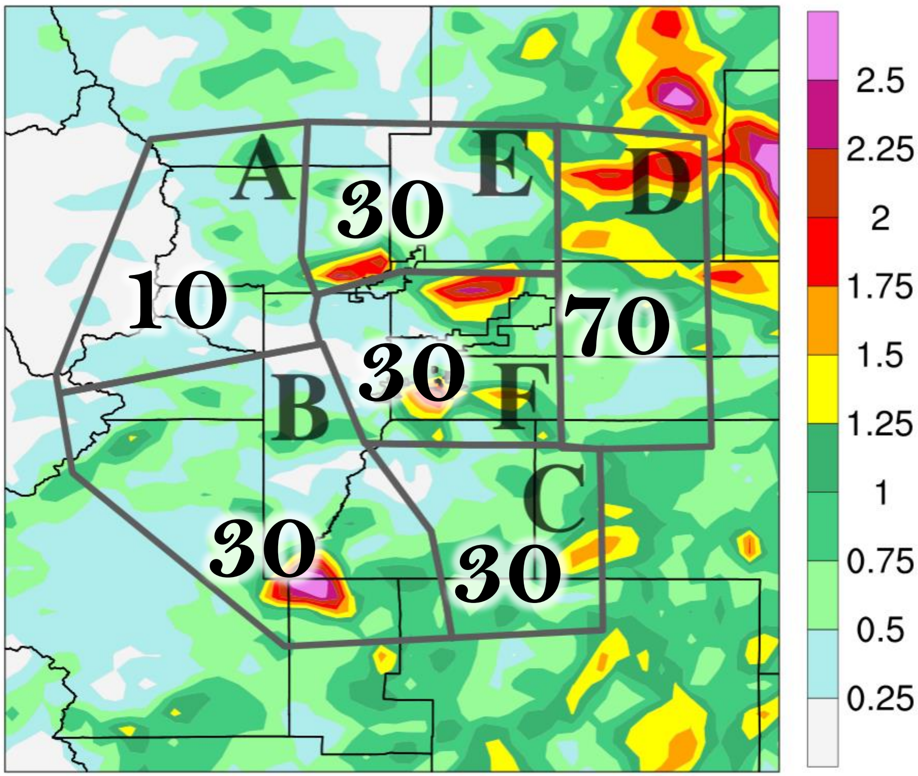


1-hr QPEMAX

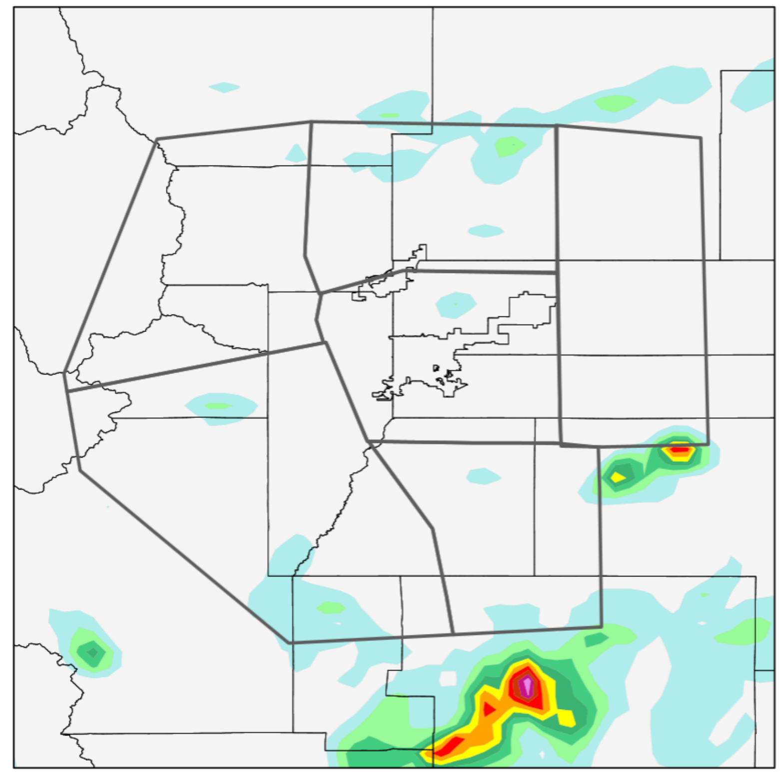


June 15, 2015

1-hr QPFMAX



1-hr QPEMAX



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Department of Natural Resources

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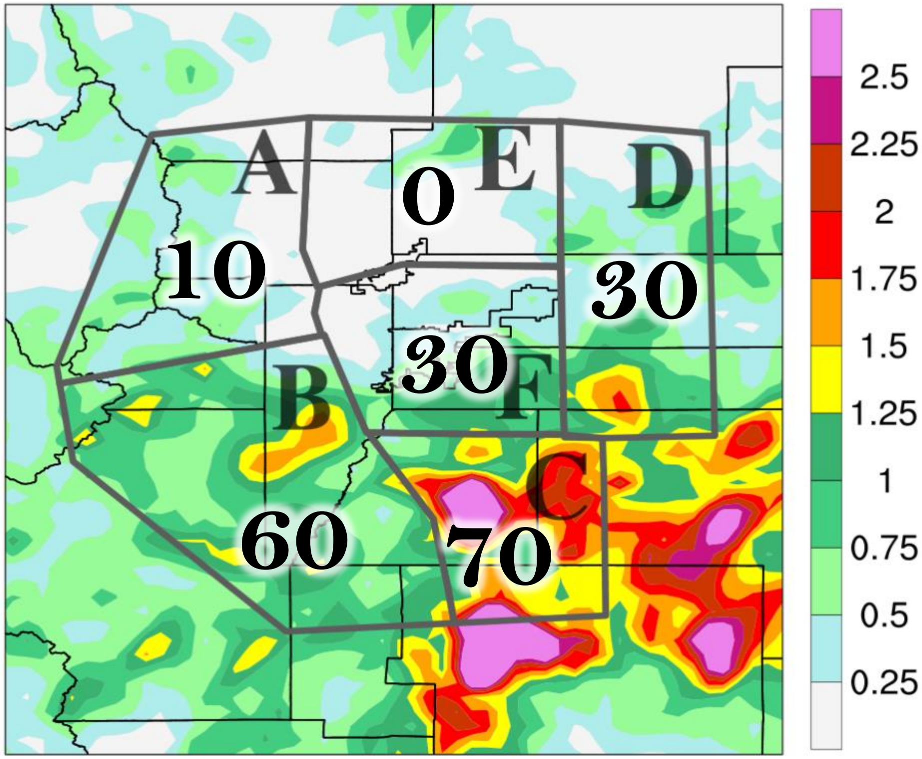
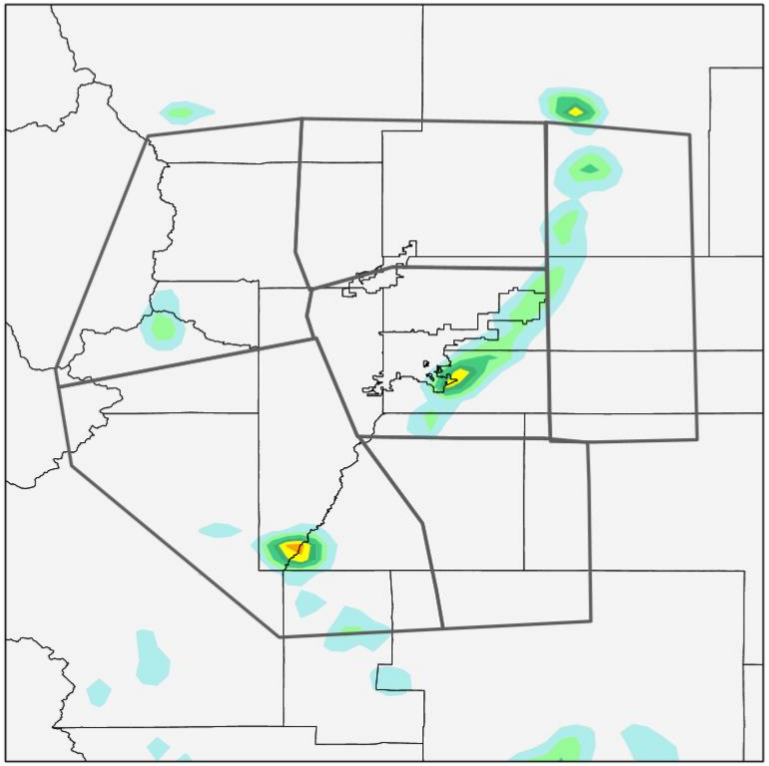
August 11, 2015

1-hr QPFMAX



1-hr QPEMAX



Take-aways

- Tool has so far achieved one of its main goals: provide an realistic estimate of the daily "worst-case scenario"
- Spatial accuracy is not perfect, but can be greatly supplemented with knowledge of probability
- Analysis of timing, location, intensity and confidence verification showed favorable results for first year in real-time setting

Improvements are underway

1. **Model Weighting**: Is there evidence to move away from "every model is equally realistic?"
2. **Historically-based Bias Correction:** Post-process model output using historical observations over the 1980-2015 period (e.g. precipitable water)
3. **(2017) Sub-hourly guidance:** Use archived ALERT data to develop 5-, 15- and 30-minute guidance

http://alert5.udfcd.org

The ALERT System HOME DISCLAIMER MAPS TABLES HYDROMODELS F2P2 SUBSCRIBE MORE...

Questions?

REAL-TIME FLOOD DETECTION & FORECASTS

UDFCD Flood Warning Program

Welcome to UDFCD's ALERT System. This website is designed to accommodate handheld devices such as smartphones, Apple iPads and Windows Tablets. Some webpages at this site still require Adobe Flash. Apple and Android users will not be able to view these pages. A few other pages designed primarily for desktop use also work with smaller devices. In time these tools will become more handheld-friendly.

Community CRS Support & Recent Developments in the LOMC Process of Interest to YOU

Jenelle Kreutzer, ERO Resources
David Mallory, Floodplain Management Program

Adam Thane Paterson

Great Smoky Mountains NP

Here's What We Thought Would be of Interest to Y'all

- Community Rating System (CRS) Support Initiative
- Program for Public Information (PPI) Committee
- How You comply with the Endangered Species Act (ESA) when you submit a Conditional Letter of Map Revision (CLOMR)
- Recent Changes in Property Owner Notification requirements for CLOMRs
- A Few Words on Revisions to FEMA's Mapping Guidelines and Specifications

Community Rating System

- Voluntary Incentive Program
- Part of National Flood Insurance Program (NFIP)
- Reduced flood insurance premiums for better floodplain management

3 Goals

- Reduce and avoid flood damage to insurable property
- Strengthen and support insurance aspects of the NFIP
- Foster comprehensive floodplain management

CRS Rating

CRS Points

4,500+ points = **Class 1**

<500 points = **Class 10**

Insurance Rates

0% Reduction = **Class 10**

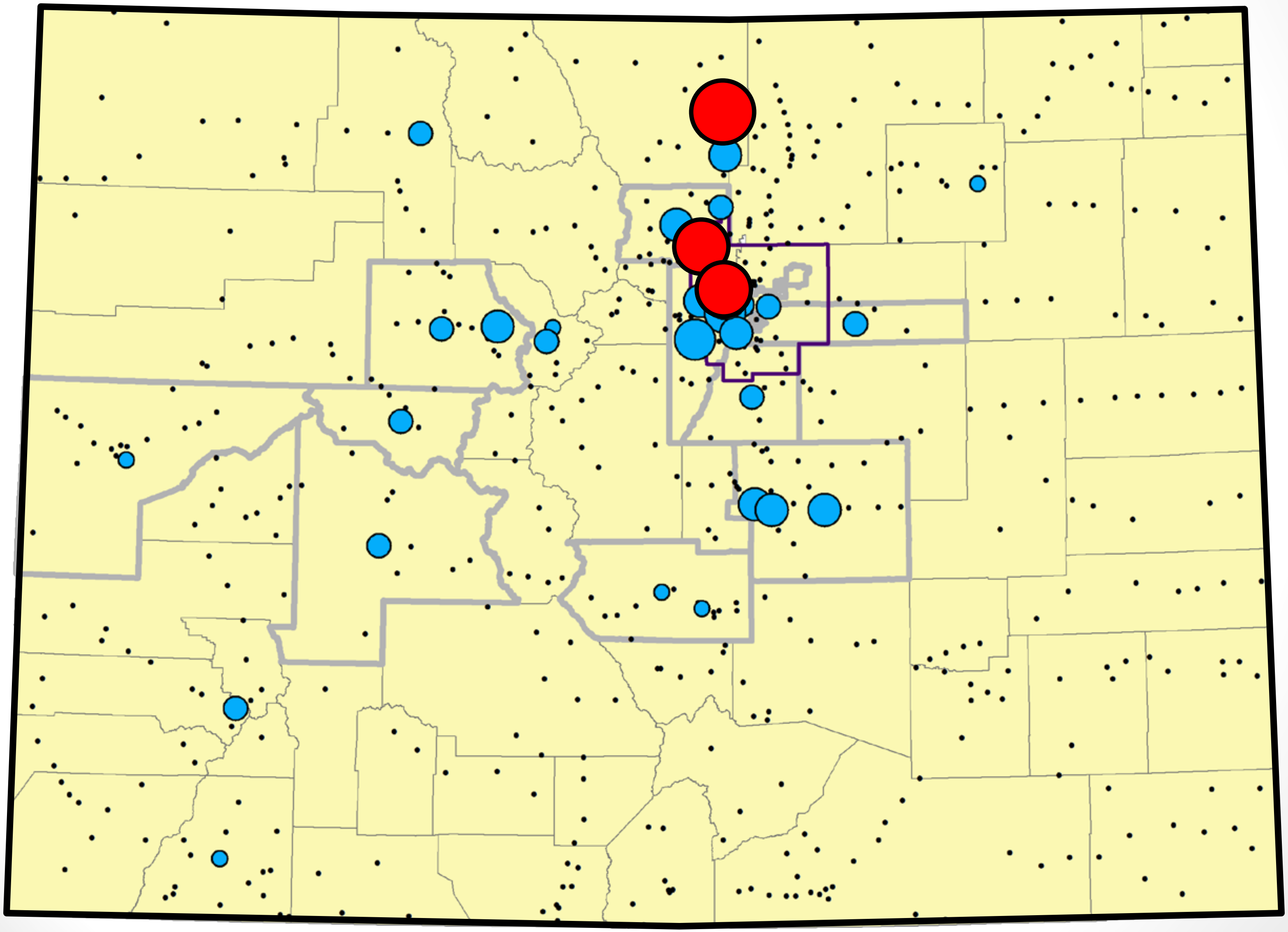
45% Reduction = **Class 1**

Activities

Public Information	Mapping & Regulations
Flood Damage Reduction	Flood Preparedness

CRS

Colorado CRS Communities



Colorado CRS Savings

POLICIES	PREMIUM	CRS SAVINGS
15,000	$11.5 million	$1.5 million

Other rewards

- Raise risk awareness
- Increase public safety
- Reduced damages
- Evaluate floodplain program

Resources

- **CRS Resources**
  - CRS Manual
  - Webinars

- **Emergency Management Institute**
  4-Day CRS class – **FREE** to government
- **CASFM**
  - CRS Committee

CASFM

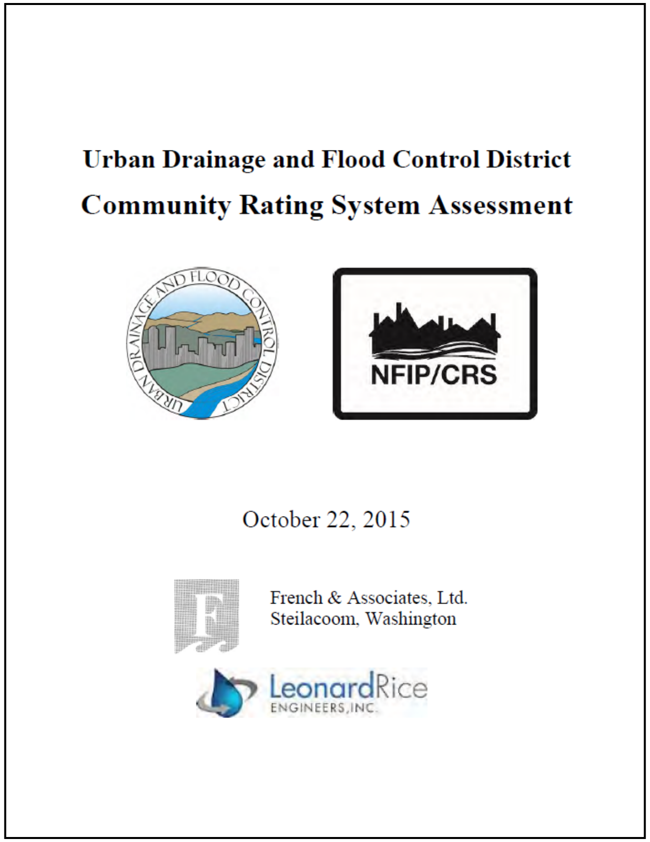
Community CRS Support

Community CRS Support

- UDFCD Adapting to Flood Insurance Changes
- CRS credits for UDFCD Activities
- Point of contact: CRS Support Committee

Credit for UDFCD Activities

- Floodplain Mapping
- Public Information Activities
- Geographic Information System
- Website
- Flood Warning
- Stormwater Management
- Water Quality Activities
- Watershed Planning
- Flood Protection Projects
- Stream Corridor Maintenance Activities


Urban Drainage and Flood Control District

Community Rating System Assessment

October 22, 2015

French & Associates, Ltd.
Steilacoom, Washington

LeonardRice
ENGINEERS, INC.

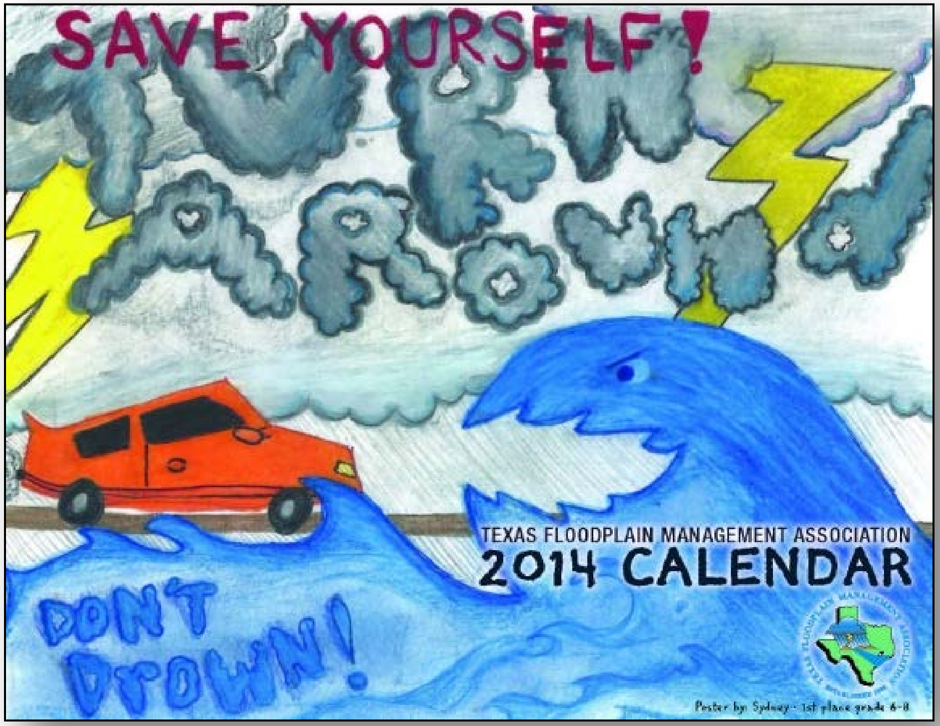
http://udfcd.org/services/floodplain-mapping/

Program for Public Information (PPI)

- Public Outreach Plan
- Defined Messaging

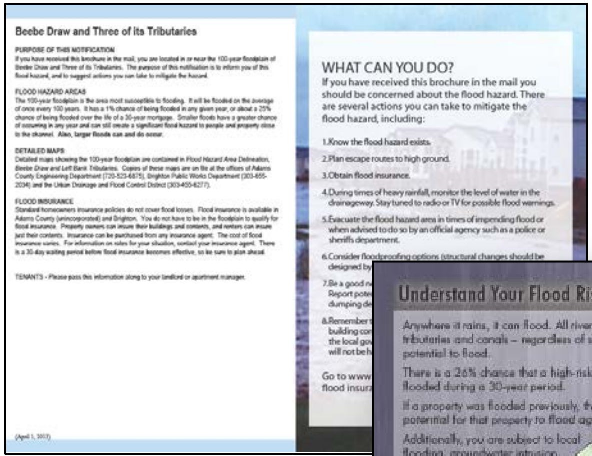
Program for Public Information (PPI)

- CRS Extra Credit! – Outreach & Flood Response




S HOLLY ST
Englewood Dam
Homestead Tributary
Little Dry Creek (ARAPCO)
Costilla Tributary
S QUEBEC ST
Dam Inundation
School

Annual Flood Risk Brochure



Beebe Draw and Three of its Tributaries

PURPOSE OF THIS NOTIFICATION

If you have received this brochure in the mail, you are located in or near the 100-year floodplain of Beebe Draw and Three of its Tributaries. The purpose of this notification is to inform you of this flood hazard, and to suggest actions you can take to mitigate the hazard.

FLOOD HAZARD AREAS

The 100-year floodplain is the area most susceptible to flooding. It will be flooded on the average of once every 100 years. It has a 1% chance of being flooded in any given year, or about a 25% chance of being flooded over the life of a 30-year mortgage. Smaller floods have a greater chance of occurring in any year and can still create a significant flood hazard to people and property close to the channel. Also, larger floods can and do occur.

DETAILED MAPS

Detailed maps showing the 100-year floodplain are contained in *Flood Hazard Area Delineation, Beebe Draw and Left Bank Tributaries*. Copies of these maps are on file at the offices of Adams County Engineering Department (720-523-6875), Brighton Public Works Department (303-655-2034) and the Urban Drainage and Flood Control District (303-455-6277).

FLOOD INSURANCE

Standard homeowners insurance policies do not cover flood losses. Flood insurance is available in Adams County (unincorporated) and Brighton. You do not have to be in the floodplain to qualify for flood insurance. Property owners can insure their buildings and contents, and renters can insure just their contents. Insurance can be purchased from any insurance agent. The cost of flood insurance varies. For information on rates for your situation, contact your insurance agent. There is a 30-day waiting period before flood insurance becomes effective, so be sure to plan ahead.

TENANTS - Please pass this information along to your landlord or apartment manager.

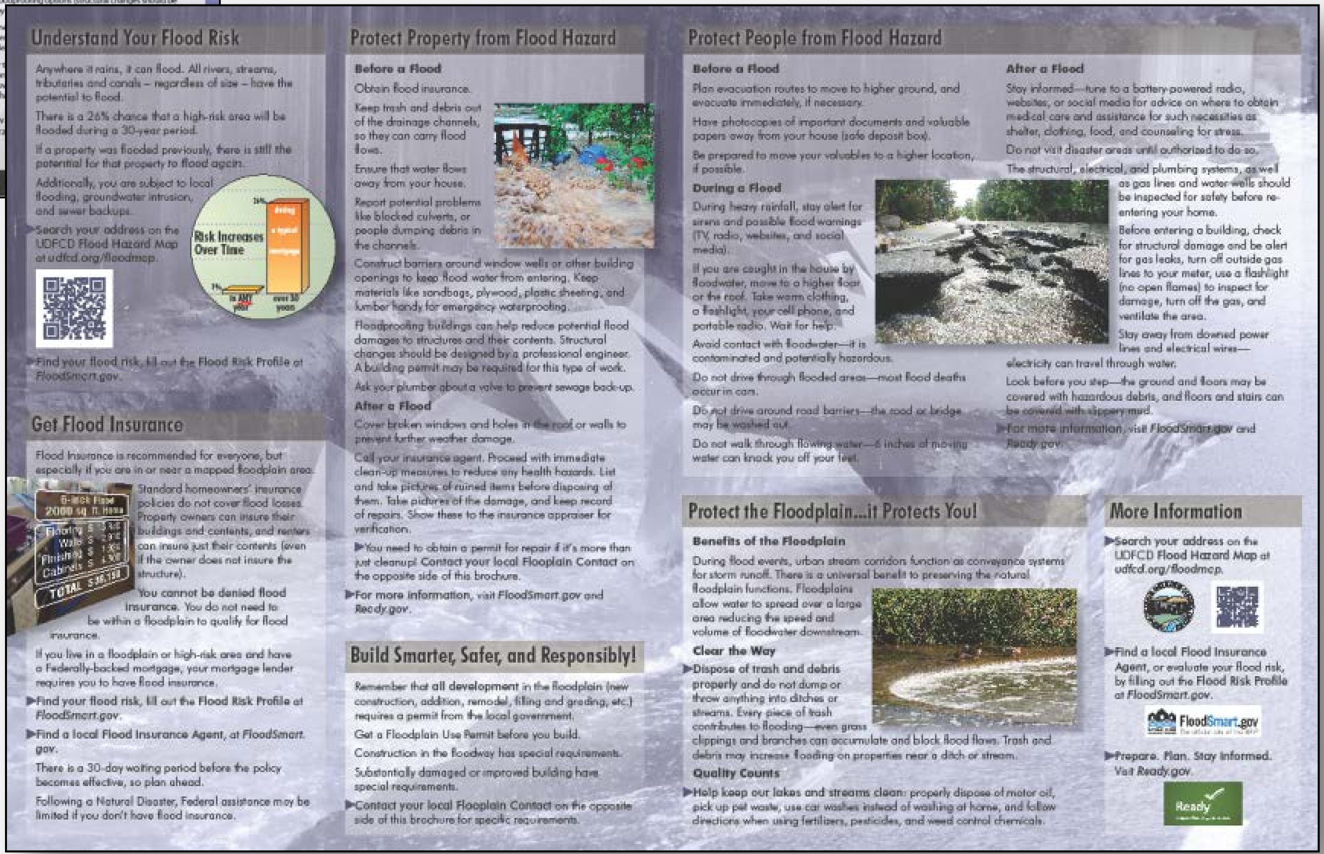
(April 1, 2013)

WHAT CAN YOU DO?

If you have received this brochure in the mail you should be concerned about the flood hazard. There are several actions you can take to mitigate the flood hazard, including:

1. Know the flood hazard exists.
2. Plan escape routes to high ground.
3. Obtain flood insurance.
4. During times of heavy rainfall, monitor the level of water in the drainageway. Stay tuned to radio or TV for possible flood warnings.
5. Evacuate the flood hazard area in times of impending flood or when advised to do so by an official agency such as a police or sheriffs department.
6. Consider floodproofing options (structural changes should be designed by
7. Be a good ne… Report pote… dumping de…
8. Remember t… building con… the local gov… will not be h…

Go to www… flood insura…



Understand Your Flood Risk

Anywhere it rains, it can flood. All rivers, streams, tributaries and canals – regardless of size – have the potential to flood.

There is a 26% chance that a high-risk area will be flooded during a 30-year period.

If a property was flooded previously, there is still the potential for that property to flood again.

Additionally, you are subject to local flooding, groundwater intrusion, and sewer backups.

▶Search your address on the UDFCD Flood Hazard Map at udfcd.org/floodmap.

▶Find your flood risk, fill out the Flood Risk Profile at *FloodSmart.gov*.

Get Flood Insurance

Flood Insurance is recommended for everyone, but especially if you are in or near a mapped floodplain area.

Standard homeowners' insurance policies do not cover flood losses. Property owners can insure their buildings and contents, and renters can insure just their contents (even if the owner does not insure the structure).

You cannot be denied flood insurance. You do not need to be within a floodplain to qualify for flood insurance.

If you live in a floodplain or high-risk area and have a Federally-backed mortgage, your mortgage lender requires you to have flood insurance.

▶Find your flood risk, fill out the Flood Risk Profile at *FloodSmart.gov*.

▶Find a local Flood Insurance Agent, at *FloodSmart.gov*.

There is a 30-day waiting period before the policy becomes effective, so plan ahead.

Following a Natural Disaster, Federal assistance may be limited if you don't have flood insurance.

Protect Property from Flood Hazard

Before a Flood

Obtain flood insurance.

Keep trash and debris out of the drainage channels, so they can carry flood flows.

Ensure that water flows away from your house.

Report potential problems like blocked culverts, or people dumping debris in the channels.

Construct barriers around window wells or other building openings to keep flood water from entering. Keep materials like sandbags, plywood, plastic sheeting, and lumber handy for emergency waterproofing.

Floodproofing buildings can help reduce potential flood damages to structures and their contents. Structural changes should be designed by a professional engineer. A building permit may be required for this type of work.

Ask your plumber about a valve to prevent sewage back-up.

After a Flood

Cover broken windows and holes in the roof or walls to prevent further weather damage.

Call your insurance agent. Proceed with immediate clean-up measures to reduce any health hazards. List and take pictures of ruined items before disposing of them. Take pictures of the damage, and keep record of repairs. Show these to the insurance appraiser for verification.

▶You need to obtain a permit for repair if it's more than just cleanup! **Contact your local Flooplain Contact** on the opposite side of this brochure.

▶For more information, visit *FloodSmart.gov* and *Ready.gov*.

Build Smarter, Safer, and Responsibly!

Remember that **all development** in the floodplain (new construction, addition, remodel, filling and grading, etc.) requires a permit from the local government.

Get a Floodplain Use Permit before you build.

Construction in the floodway has special requirements.

Substantially damaged or improved building have special requirements.

▶Contact your local Flooplain Contact on the opposite side of this brochure for specific requirements.

Protect People from Flood Hazard

Before a Flood

Plan evacuation routes to move to higher ground, and evacuate immediately, if necessary.

Have photocopies of important documents and valuable papers away from your house (safe deposit box).

Be prepared to move your valuables to a higher location, if possible.

During a Flood

During heavy rainfall, stay alert for sirens and possible flood warnings (TV, radio, websites, and social media).

If you are caught in the house by floodwater, move to a higher floor or the roof. Take warm clothing, a flashlight, your cell phone, and portable radio. Wait for help.

Avoid contact with floodwater—it is contaminated and potentially hazardous.

Do not drive through flooded areas—most flood deaths occur in cars.

Do not drive around road barriers—the road or bridge may be washed out.

Do not walk through flowing water—6 inches of moving water can knock you off your feet.

After a Flood

Stay informed—tune to a battery-powered radio, websites, or social media for advice on where to obtain medical care and assistance for such necessities as shelter, clothing, food, and counseling for stress.

Do not visit disaster areas until authorized to do so.

The structural, electrical, and plumbing systems, as well as gas lines and water wells should be inspected for safety before re-entering your home.

Before entering a building, check for structural damage and be alert for gas leaks, turn off outside gas lines to your meter, use a flashlight (no open flames) to inspect for damage, turn off the gas, and ventilate the area.

Stay away from downed power lines and electrical wires—electricity can travel through water.

Look before you step—the ground and floors may be covered with hazardous debris, and floors and stairs can be covered with slippery mud.

▶For more information, visit *FloodSmart.gov* and *Ready.gov*.

Protect the Floodplain...it Protects You!

Benefits of the Floodplain

During flood events, urban stream corridors function as conveyance systems for storm runoff. There is a universal benefit to preserving the natural floodplain functions. Floodplains allow water to spread over a large area reducing the speed and volume of floodwater downstream.

Clear the Way

▶**Dispose of trash and debris** properly and do not dump or throw anything into ditches or streams. Every piece of trash contributes to flooding—even grass clippings and branches can accumulate and block flood flows. Trash and debris may increase flooding on properties near a ditch or stream.

Quality Counts

▶**Help keep our lakes and streams clean:** properly dispose of motor oil, pick up pet waste, use car washes instead of washing at home, and follow directions when using fertilizers, pesticides, and weed control chemicals.

More Information

▶Search your address on the UDFCD Flood Hazard Map at *udfcd.org/floodmap*.

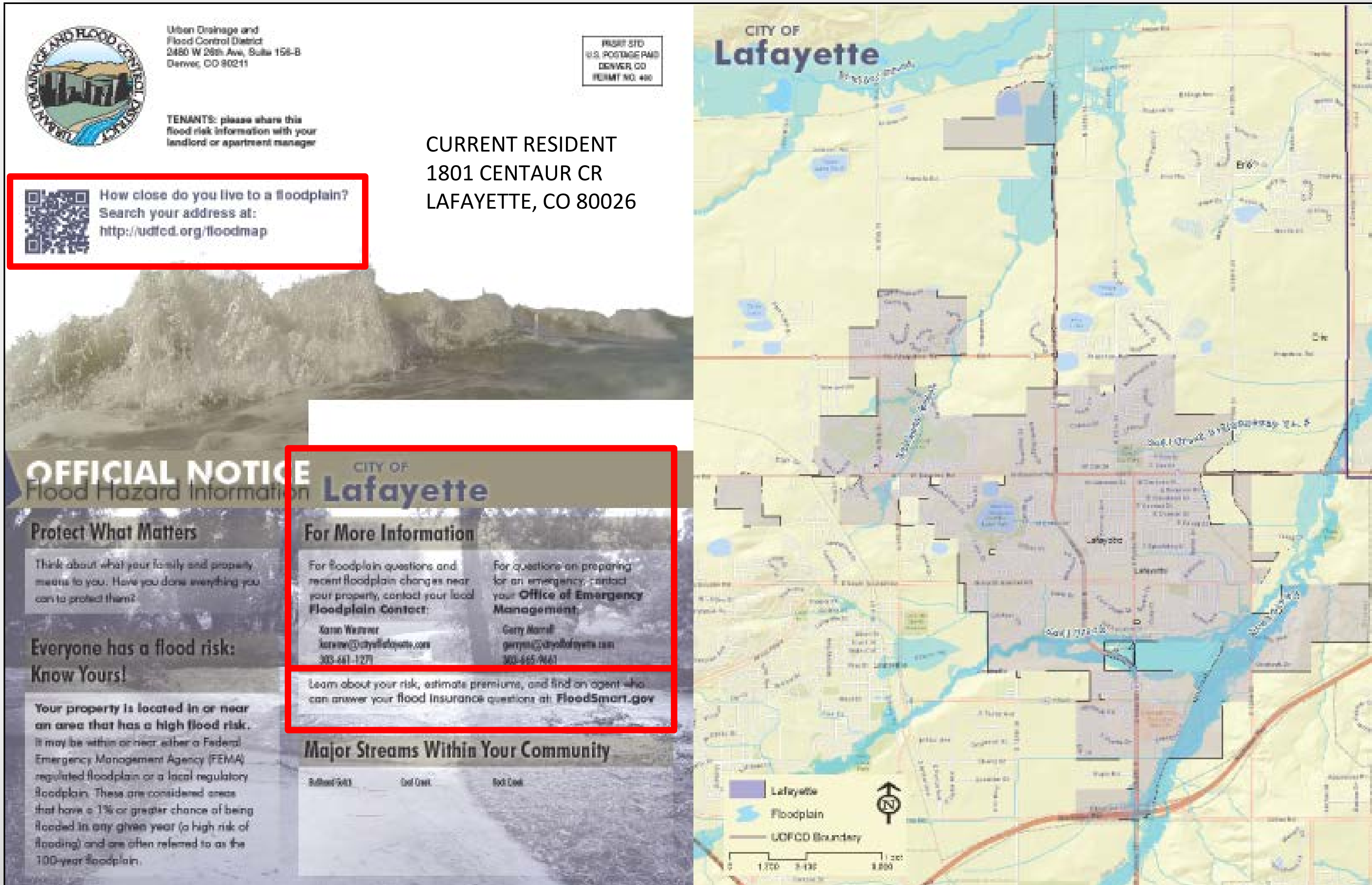
▶Find a local Flood Insurance Agent, or evaluate your flood risk, by filling out the Flood Risk Profile at *FloodSmart.gov*.

FloodSmart.gov

▶Prepare. Plan. Stay Informed. Visit *Ready.gov*.

Ready

Community side



Messaging

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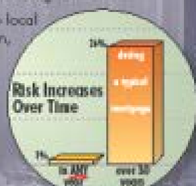

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▶**Find a local Flood Insurance Agent, at** ***FloodSmart.gov*****.**

There is a 30-day waiting period before the policy becomes effective, so plan ahead.

Following a Natural Disaster, Federal assistance may be limited if you don't have flood insurance.

Protect Property from Flood Hazard

Before a Flood

Obtain flood insurance.

Keep trash and debris out of the drainage channels, so they can carry flood flows.

Ensure that water flows away from your house.

Report potential problems like blocked culverts, or people dumping debris in the channels.

Construct barriers around window wells or other building openings to keep flood water from entering. Keep materials like sandbags, plywood, plastic sheeting, and lumber handy for emergency waterproofing.

Floodproofing buildings can help reduce potential flood damages to structures and their contents. Structural changes should be designed by a professional engineer. A building permit may be required for this type of work.

Ask your plumber about a valve to prevent sewage back-up.

After a Flood

Cover broken windows and holes in the roof or walls to prevent further weather damage.

Call your insurance agent. Proceed with immediate clean-up measures to reduce any health hazards. List and take pictures of ruined items before disposing of them. Take pictures of the damage, and keep record of repairs. Show these to the insurance appraiser for verification.

▶You need to obtain a permit for repair if it's more than just cleanup! **Contact your local Flooplain Contact** on the opposite side of this brochure.

▶**For more information**, visit *FloodSmart.gov* and *Ready.gov*.

Build Smarter, Safer, and Responsibly!

Remember that **all development** in the floodplain (new construction, addition, remodel, filling and grading, etc.) requires a permit from the local government.

Get a Floodplain Use Permit before you build.

Construction in the floodway has special requirements.

Substantially damaged or improved building have special requirements.

▶**Contact your local Flooplain Contact** on the opposite side of this brochure for specific requirements.

Protect People from Flood Hazard

Before a Flood

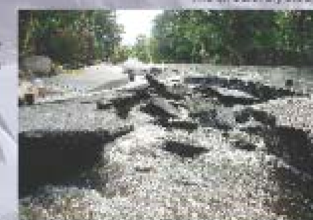
Plan evacuation routes to move to higher ground, and evacuate immediately, if necessary.

Have photocopies of important documents and valuable papers away from your house (safe deposit box).

Be prepared to move your valuables to a higher location, if possible.

During a Flood

During heavy rainfall, stay alert for sirens and possible flood warnings (TV, radio, websites, and social media).



If you are caught in the house by floodwater, move to a higher floor or the roof. Take warm clothing, a flashlight, your cell phone, and portable radio. Wait for help.

Avoid contact with floodwater—it is contaminated and potentially hazardous.

Do not drive through flooded areas—most flood deaths occur in cars.

Do not drive around road barriers—the road or bridge may be washed out.

Do not walk through flowing water—6 inches of moving water can knock you off your feet.

After a Flood

Stay informed—tune to a battery-powered radio, websites, or social media for advice on where to obtain medical care and assistance for such necessities as shelter, clothing, food, and counseling for stress.

Do not visit disaster areas until authorized to do so.

The structural, electrical, and plumbing systems, as well as gas lines and water wells should be inspected for safety before re-entering your home.

Before entering a building, check for structural damage and be alert for gas leaks, turn off outside gas lines to your meter, use a flashlight (no open flames) to inspect for damage, turn off the gas, and ventilate the area.

Stay away from downed power lines and electrical wires—electricity can travel through water.

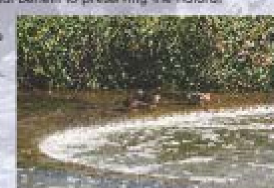
Look before you step—the ground and floors may be covered with hazardous debris, and floors and stairs can be covered with slippery mud.

▶For more information, visit *FloodSmart.gov* and *Ready.gov*.

Protect the Floodplain...it Protects You!

Benefits of the Floodplain

During flood events, urban stream corridors function as conveyance systems for storm runoff. There is a universal benefit to preserving the natural floodplain functions. Floodplains allow water to spread over a large area reducing the speed and volume of floodwater downstream.



Clear the Way

▶**Dispose of trash and debris properly** and do not dump or throw anything into ditches or streams. Every piece of trash contributes to flooding—even grass clippings and branches can accumulate and block flood flows. Trash and debris may increase flooding on properties near a ditch or stream.

Quality Counts

▶**Help keep our lakes and streams clean:** properly dispose of motor oil, pick up pet waste, use car washes instead of washing at home, and follow directions when using fertilizers, pesticides, and weed control chemicals.

More Information

▶**Search your address** on the UDFCD **Flood Hazard Map** at *udfcd.org/floodmap*.

▶**Find a local Flood Insurance Agent**, or evaluate your flood risk, by filling out the **Flood Risk Profile** at *FloodSmart.gov*.

▶**Prepare. Plan. Stay Informed.** Visit *Ready.gov*.

How Do I Get on the Right Side of the Endangered Species Act?

Navigating ESA Compliance

- **What Are The Regulations?**
  - Endangered Species Act
  - FEMA's guidance documents
    - Private Actions vs Non-FEMA Federal Actions
  - USFWS Colorado Field Office Guidance
    - Federal Nexus
    - Lead Federal Agency
- **How Do We Navigate The Process?**
  - Available Tools
  - Compliance Scenarios
- **Take Away Message**
  - Resources and Timing

What Are The Regulations?

What Is The Endangered Species Act?

The ESA was passed in 1973 to provide protections to species of wildlife and plants (listed as endangered or threatened) and the ecosystems upon which these species depend

- The USFWS and the NMFS are the agencies responsible for implementing the ESA
- Mandates all ***Federal Departments and Agencies*** to conserve listed species and to utilize their authorities in furtherance of the purposes of the ESA (Section 7)
- Private individuals, State, and Local Governments must comply with the ESA (Section 7/10)

What Are The Regulations?

ESA - Section 7

- Requires federal agencies to develop a conservation program for listed species *(Section 7(a)(1))*
- Requires a federal agency to insure that ***any action it authorizes***, funds, or carries out is not likely to jeopardize the continued existence of any listed species or result in adverse modifications of designated critical habitat *(Section 7(a)(2))*

What Are The Regulations?

ESA - Section 7 Cont.

- Effects determination:
  - No effect
  - May affect, but not likely to adversely affect
  - May affect, likely to adversely affect
- No species or critical habitat “No Effect” = no further consultation required
- May affect = consultation required (informal or formal process)

What Are The Regulations?

ESA - Section 7 Cont.

- May affect, but not likely to adversely affect
  - Beneficial, discountable, or insignificant
  - Informal process – No Biological Opinion (BO) required
  - No “take” can occur under this category

What Are The Regulations?

ESA - Section 7 Cont.

- May affect, likely to adversely affect
  - Formal consultation with USFWS required
  - Consultation would be concluded with the USFWS issuing a BO

What Are The Regulations?

ESA - Section 9

Prohibits against "take of" or "harming" listed species of wildlife and plants

- Harm can arise from habitat modifications that could significantly impair behavior patterns of a listed species
- If an action might harm a species, an incidental take authorization is required
  - Incidental Take Statement - Section 7
  - Incidental Take Permit - Section 10

What Are The Regulations?

ESA - Section 10

If a non-federal action will result in “take” or “harm” of a listed species, a permit from the USFWS is required

- Provides guidelines under which a permit may be issued to non-federal parties to authorize prohibited activities
- Requires a Habitat Conservation Plan (HCP)
- Time and labor intensive process

What Are The Regulations?

FEMA ESA Compliance - Prior to 2010

What’s ESA Compliance?

What Are The Regulations?

FEMA – ESA Compliance

April 2010 – Procedure Memorandum 64

- Address potential adverse impacts to listed species *before* construction activities occur
- Required a Requestor to provide ESA compliance documentation from USFWS
- FEMA's role "action" in ESA compliance (Section 7) vs the Requestor's role in the process (Section 10)

What Are The Regulations?

USFWS – Denver Field Office

June 2015 – Regional Guidance

- Is there a Federal "action" and who is the Lead Federal Agency?
  - Section 404 Permit – Corps
  - CLOMR – FEMA
- Will no longer providing Technical Assistance directly to a non-federal entity
- Requires the Lead Federal Agency (Corps or FEMA) to name a non-federal designee to do parts or all of the Section 7 consultation with the USFWS on the lead agencies' behalf

What Are The Regulations?

FEMA – ESA Compliance

November 2015 – Clarifications to Memo 64

- Defines Roles and Responsibilities
  - Will no longer act as a facilitator
  - Will still require documentation of ESA compliance for the proposed project *before* processing a request
  - ***Private Actions*** and ***Non-FEMA Federal actions***—compliance the sole responsibility of the Requestor

What Are The Regulations?

Summary - FEMA ESA Compliance Process

FEMA Actions	→	Provides comments Not approvals – No ESA Compliance
Private Actions or Non-Federal Actions	→	Section 9 - No "take" or Section 10 - HCP
Non-FEMA Federal Actions Corps – Section 404 Permit	→	Section 7

What Are The Regulations?

What is the USFWS' Position on FEMA's Memorandum 64?

What Are The Regulations?

USFWS’ Position on FEMA’s Memorandum 64?

FEMA Actions → **Provides comments**
Not approvals
No ESA Compliance

Private Actions
Non-Federal Actions → **Section 9 - No “take” or**
Section 10 - HCP

Non-FEMA Federal Actions → **Section 7**

“FEMA is responsible for demonstrating compliance with Section 7 for all projects proposed within Special Flood Hazard Areas where a CLOMR or CLOMR-F request is made for FEMA’s review”

Navigating ESA Compliance

- **Tips and Tools to Address ESA Compliance**
- **Consultation Scenarios**
- **Take Away Message**

Navigating ESA Compliance

How do I determine if there are threatened or endangered species or critical habitat in my project area?

- Websites:
  - Species present in the county where the project is taking place: http://ecos.fws.gov/ecp/
  - ITPs and USFWS: www.fws.gov/endangered/what-we-do/hcp-overview.html
  - Data is only useful if you know what is means and how it is applied
- Contact the USFWS Directly:
  - USFWS Office Directory: www.fws.gov/offices/
  - Very slow response time

Navigating ESA Compliance

Consultation Scenarios

Scenario 1 - The project area associated with the CLOMR has **no habitat for any threatened or endangered species**

Scenario 2 - The project area associated with the CLOMR **has the potential to impact habitat for a PMJM**, but the impact is likely "***insignificant and discountable***"

Scenario 3 - The project area associated with the CLOMR **will impact habitat for a threatened or endangered species**, such as Preble's, and **no Corps action** (i.e., 404 permit) is needed

Navigating ESA Compliance

Consultation Scenarios

Scenario 1 - The project area associated with the CLOMR has **no habitat for any threatened or endangered species**.

- Submit a HA letter requesting no further consultation required (“no effect”) and get the stamped letter back from the Service indicating “no concerns”.
  - Provide a copy of the original HA letter and the stamped letter correspondence from the Service to FEMA.
  - Based on the Service’s response, translate it into the “no take” language, if required by FEMA.

Navigating ESA Compliance

Consultation Scenarios

Scenario 2 - The project area associated with the CLOMR **has the potential to impact habitat for a PMJM**, but the impact is likely "***insignificant and discountable***"

- The project is not at the "take" level, which would require an Incidental Take Permit (Section 9) from the Service, but it also doesn't fit the "no take" category
- FEMA will accept an "***insignificant and discountable***" effects determination from the USFWS
- Assumes the USFWS will provide technical advice on ESA compliance for the project without knowing if there is another federal agency involved
- Non-federal entities legally can't make effects determinations, including take or no take statements

Navigating ESA Compliance

Consultation Scenarios

Scenario 3 - The project area associated with the CLOMR **will impact habitat for a threatened or endangered species**, such as Preble's, and **no Corps action** (i.e., 404 permit) is needed

- FEMA's guidance requires applicant to go through Section 10 consultation, which would require a Habitat Conservation Plan (HCP)
- Similar to FEMA, the local Service office has limited resources and staff available to address the volume of applications this level of consultation would require
- Currently, the HCP process takes several years to permit through the Service and this timeline would likely increase if more CLOMR projects have to go through the Section 10 consultation process
- What happens if the Service does not concur with FEMA's guidance?
- The local Service field office views CLOMRs as a federal action that would require FEMA to consult with them directly under Section 7 of the ESA
- Projects could result in a stalemate
- Potential for legal actions

Agencies don't agree on ESA process

Seek Professional Services early in the process

Build extra time and money in the compliance review process

Questions For Jenelle?

Property Owner Notification Requirements for CLOMRs

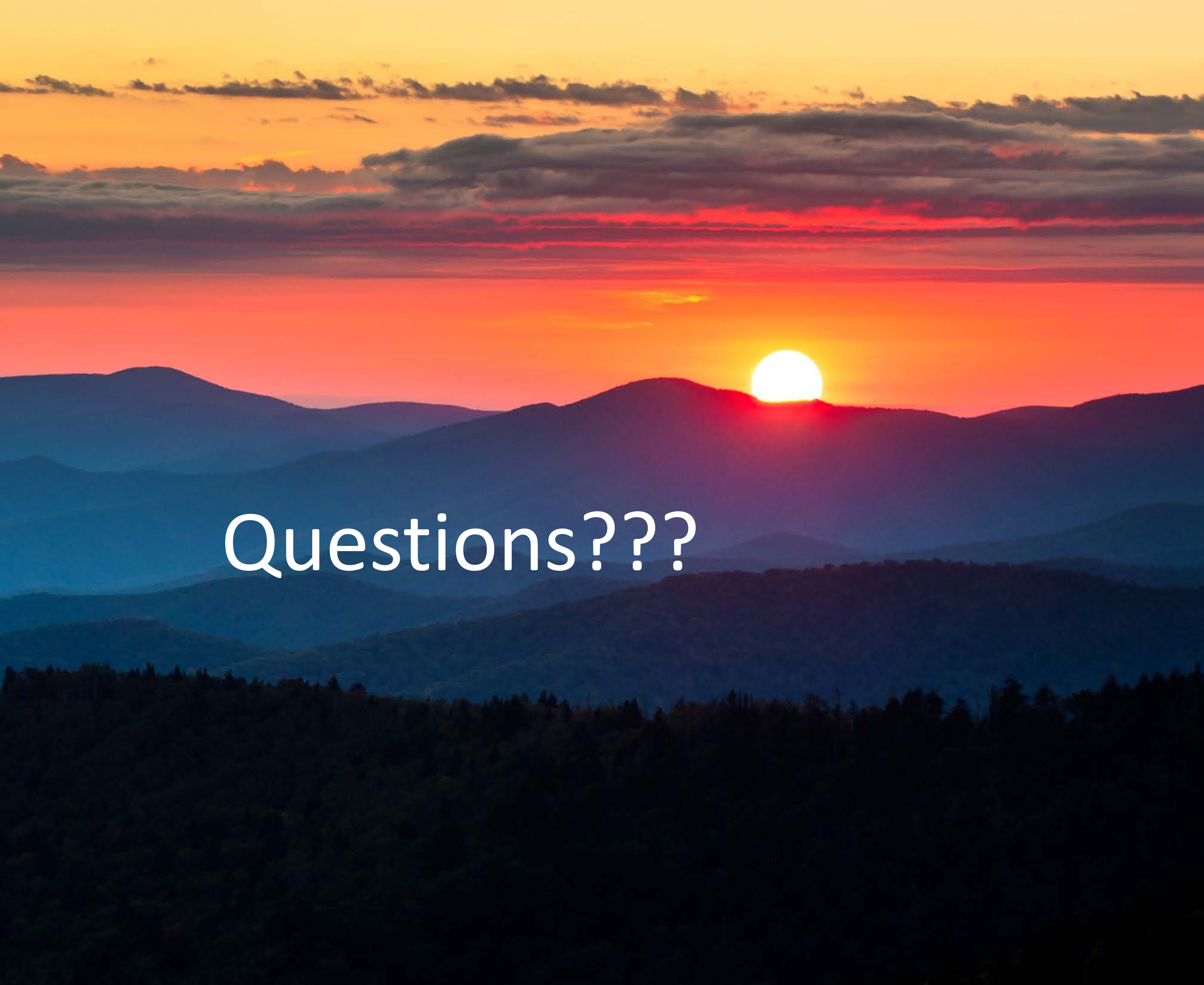
- Previously Focused on Pre-Project to Post-Project changes
- Now includes Effective to Post-Project changes
- Notifications include:
  - Individual Legal Notifications for properties affected by proposed work in the floodway (NFIP 65.12). Requester can certify.
  - All property owners adversely affected by increases in the SFHA or BFEs. Can be public notice, certified by requester or community.
  - All property owners affected by floodway changes. Can be public notice, certified by the community.

Operation & Maintenance Plans Detention Basins

- Any new or revisions to existing Regional Detention Basins that attenuate peak flow rates require an O & M Plan
- Please utilize the O & M template on the UDFCD website

Revisions to FEMA's Mapping Guidelines and Standards

- FEMA has separated Guidelines (friendly suggestions) from Standards (must do unless granted a variance from FEMA Headquarters)
- Guidelines and Standards are updated twice a year, fall and spring
- The November 2015 cycle included the latest guidance on ESA compliance discussed in Jenelle's remarks
- Proposed May cycle changes were distributed for comment
- Expect an emphasis on Community Engagement and Risk Communication
- https://www.fema.gov/guidelines-standards-maintenance


Questions???

USDCM Volumes 1 and 2 Revisions – What’s New

Holly Piza, PE, Project Manager

The Team

WRIGHT WATER ENGINEERS, INC.

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

MULLER ENGINEERING COMPANY

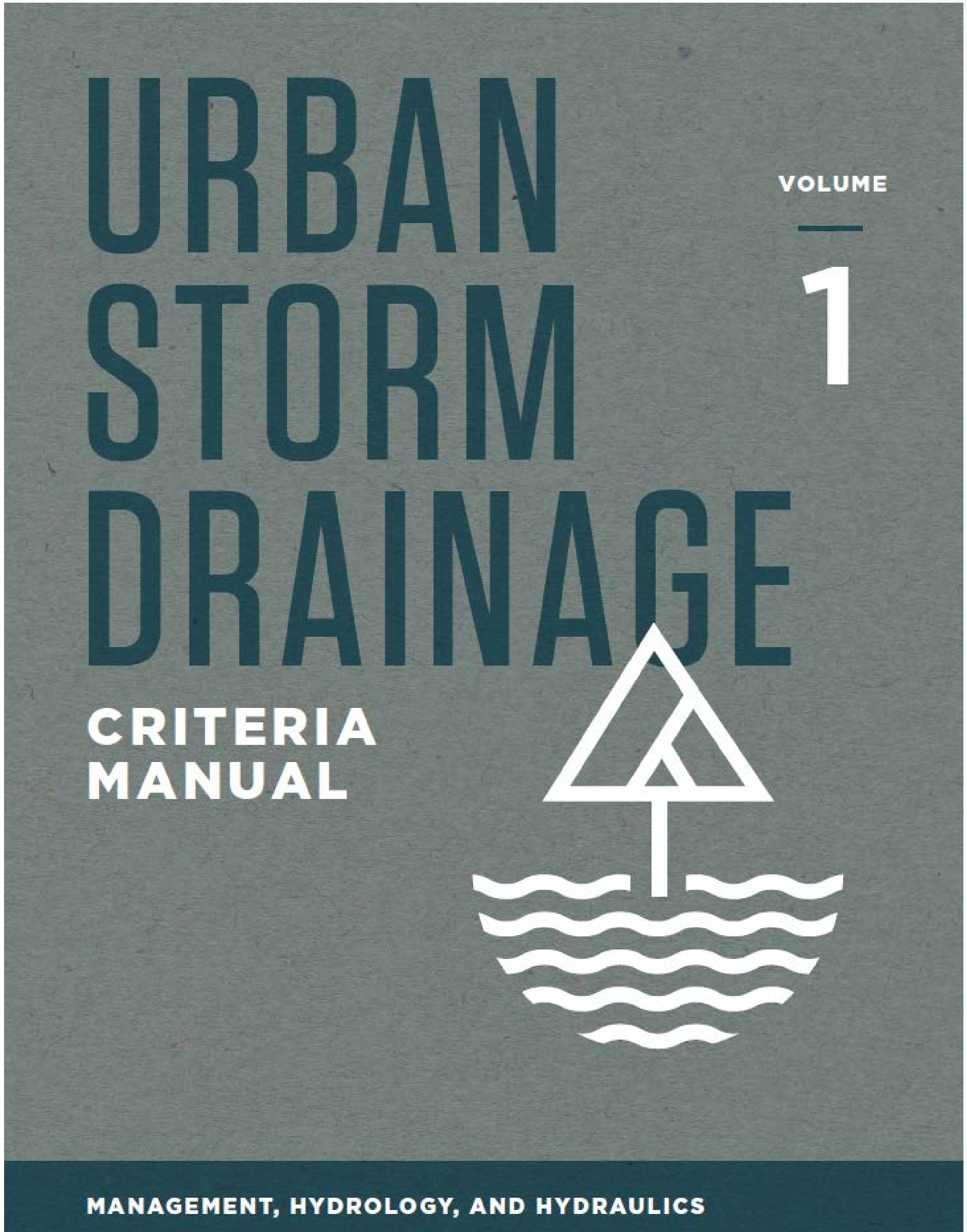
VALERIAN

McLaughlin Whitewater design group
A DIVISION OF MERRICK & COMPANY

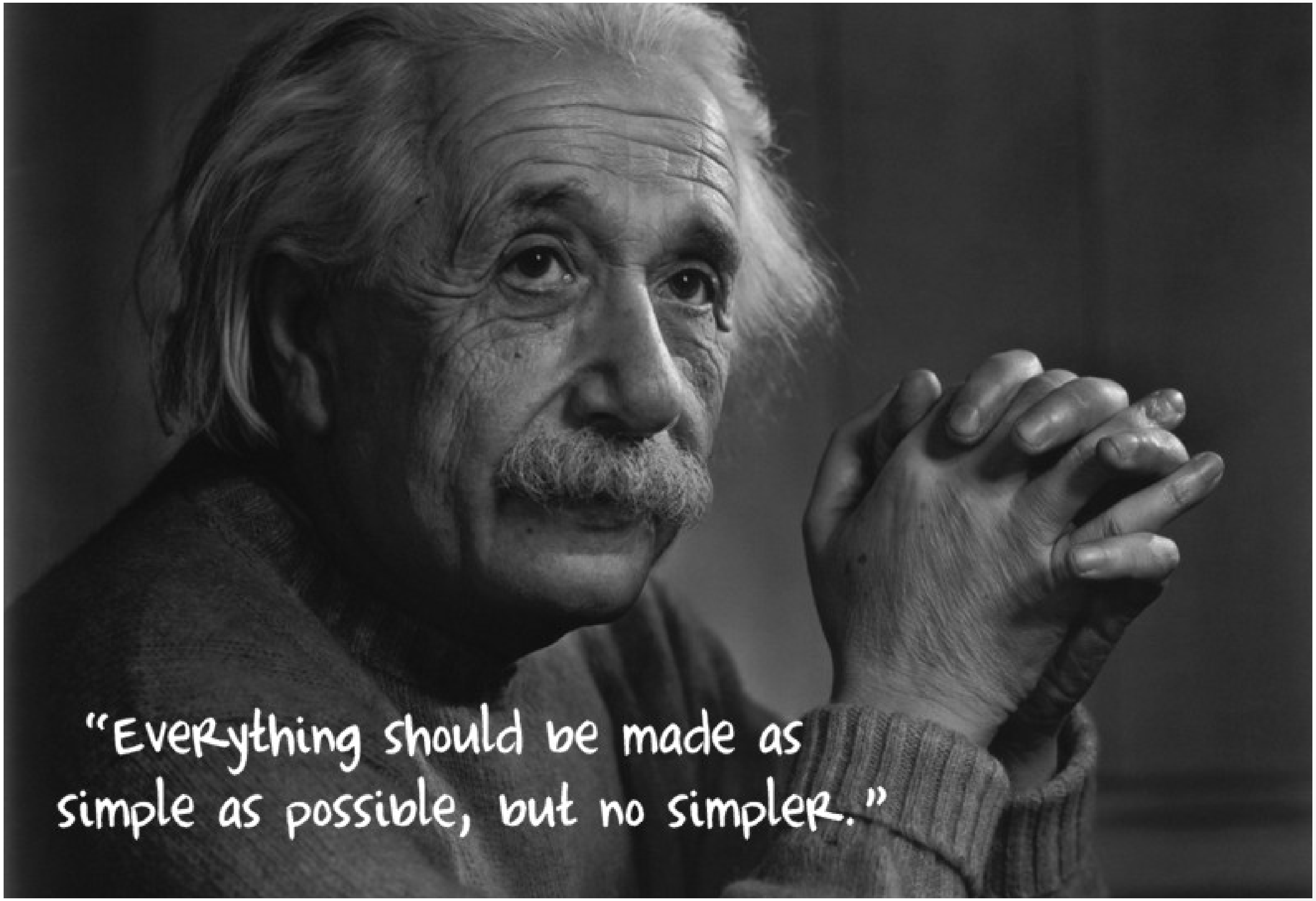
IRIS Mitigation and Design, Inc.
Environmental Consulting

28 Public Agency Contributors

108 Individuals


URBAN STORM DRAINAGE
CRITERIA MANUAL
VOLUME
1
MANAGEMENT, HYDROLOGY, AND HYDRAULICS

Chapter 1, Policy

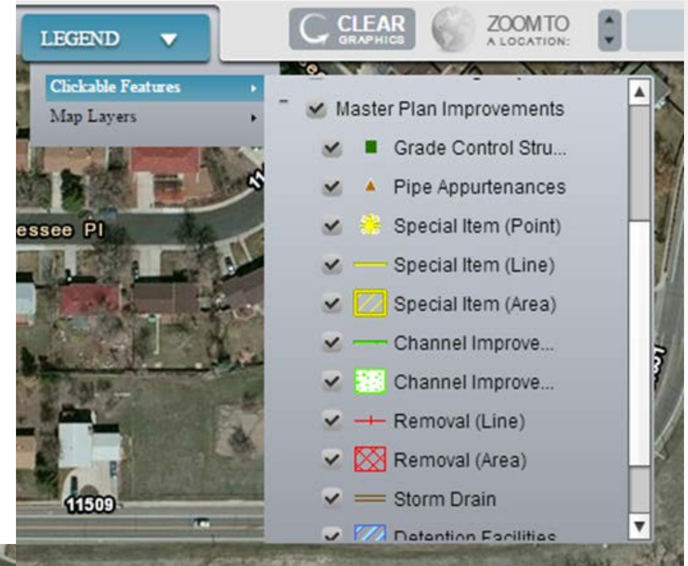


Also in Policy…

Master Plan Floodplain Easements

Also in Policy…

Publically Accessible UDFCD Library



Chapter 2, Law

- Reviewed and Updated case law.
- Added CRS 37-92-602 (8).

Chapter 2, Law

- Added CRS 37-92-602 (8).

Stormwater Detention and Infiltration Design Data Sheet

Workbook Protected Worksheet Protected

Stormwater Facility Name:

Facility Location & Jurisdiction:

User Input: Watershed Characteristics

Watershed Slope =		ft/ft
Watershed Length =		ft
Watershed Area =		acres
Watershed Imperviousness =		percent
Percentage Hydrologic Soil Group A =		percent
Percentage Hydrologic Soil Group B =		percent
Percentage Hydrologic Soil Groups C/D =		percent

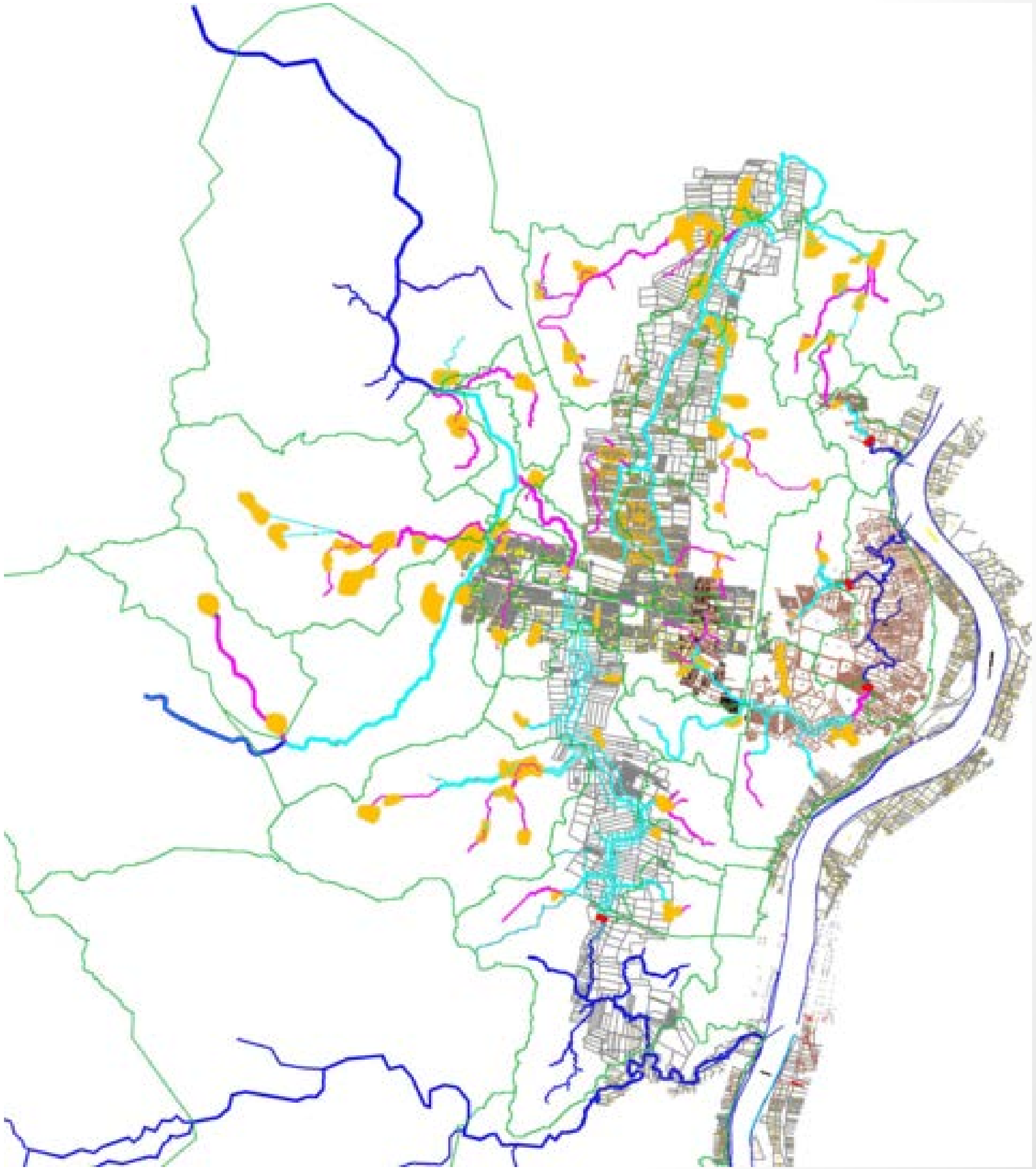
Location for 1-hr Rainfall Depths (use dropdown):

UDFCD Default

User Defined Stage [ft]	User Defined Area [ft^2]	User Defined Stage [ft]	User Defined Discharge [cfs]
0.00		0.00	

Chapter 3, Planning

- Master planning process

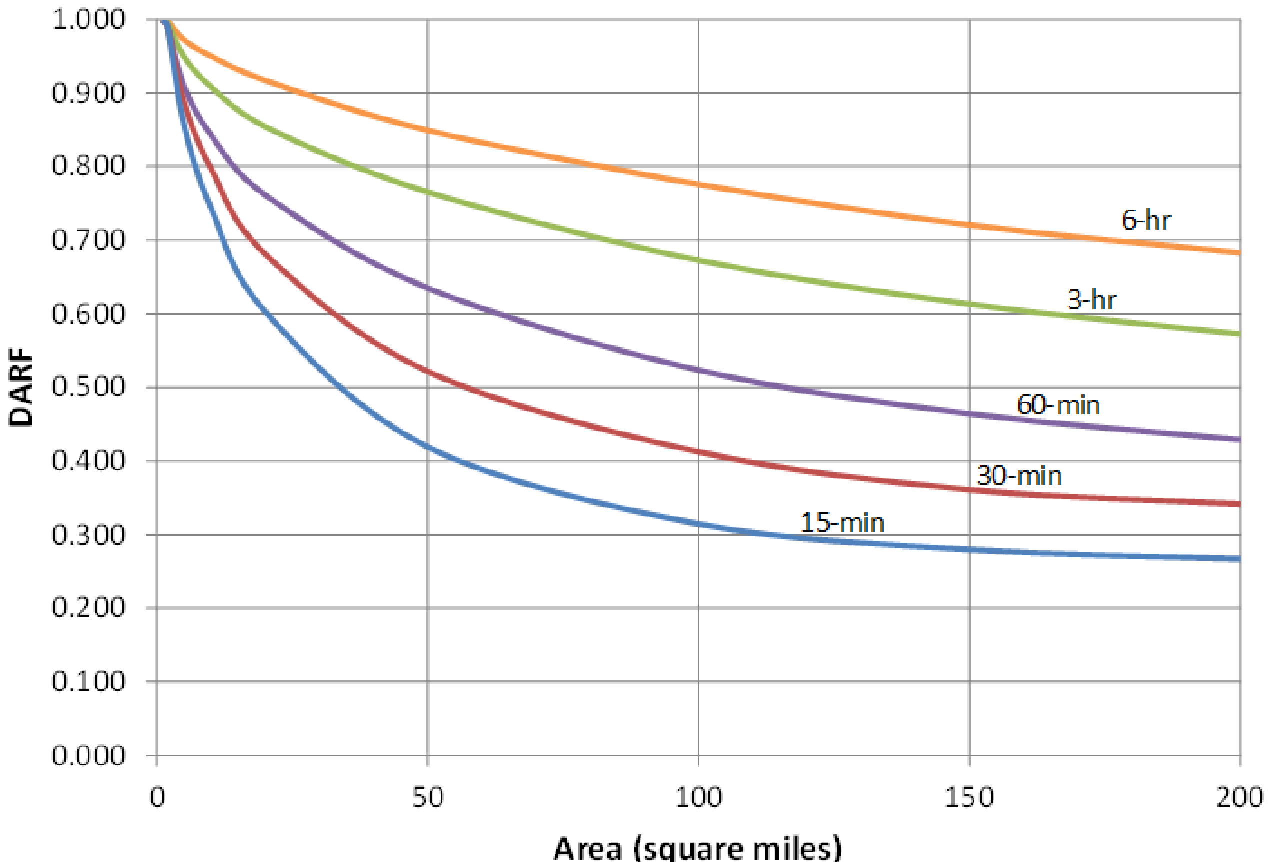


Chapter 4, Flood Risk Management

- Fundamentals of floodplain management
- Floodplain mapping changes and admin.
- Flood insurance
- UDFCD, Local, and State programs
- Floodproofing
- Assistance for property owners

Chapter 5, Rainfall

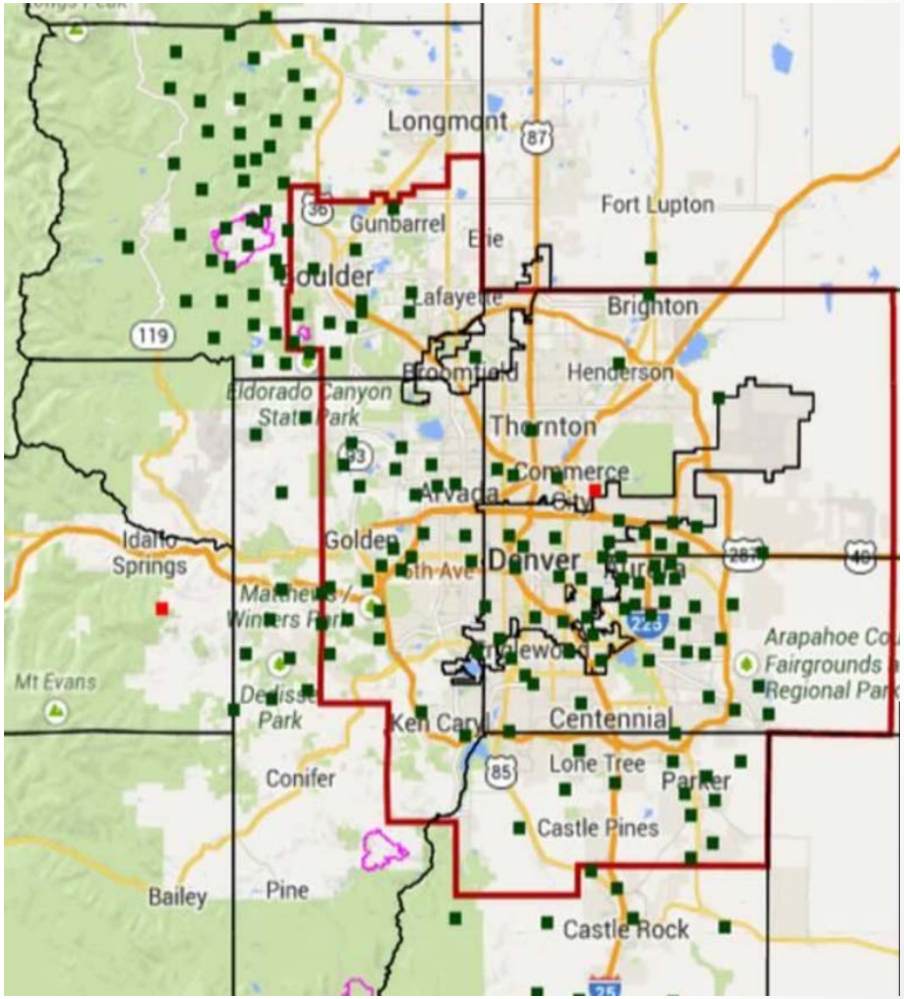
New depth reduction factors (DRFs) for frequent events



Carlton 2010

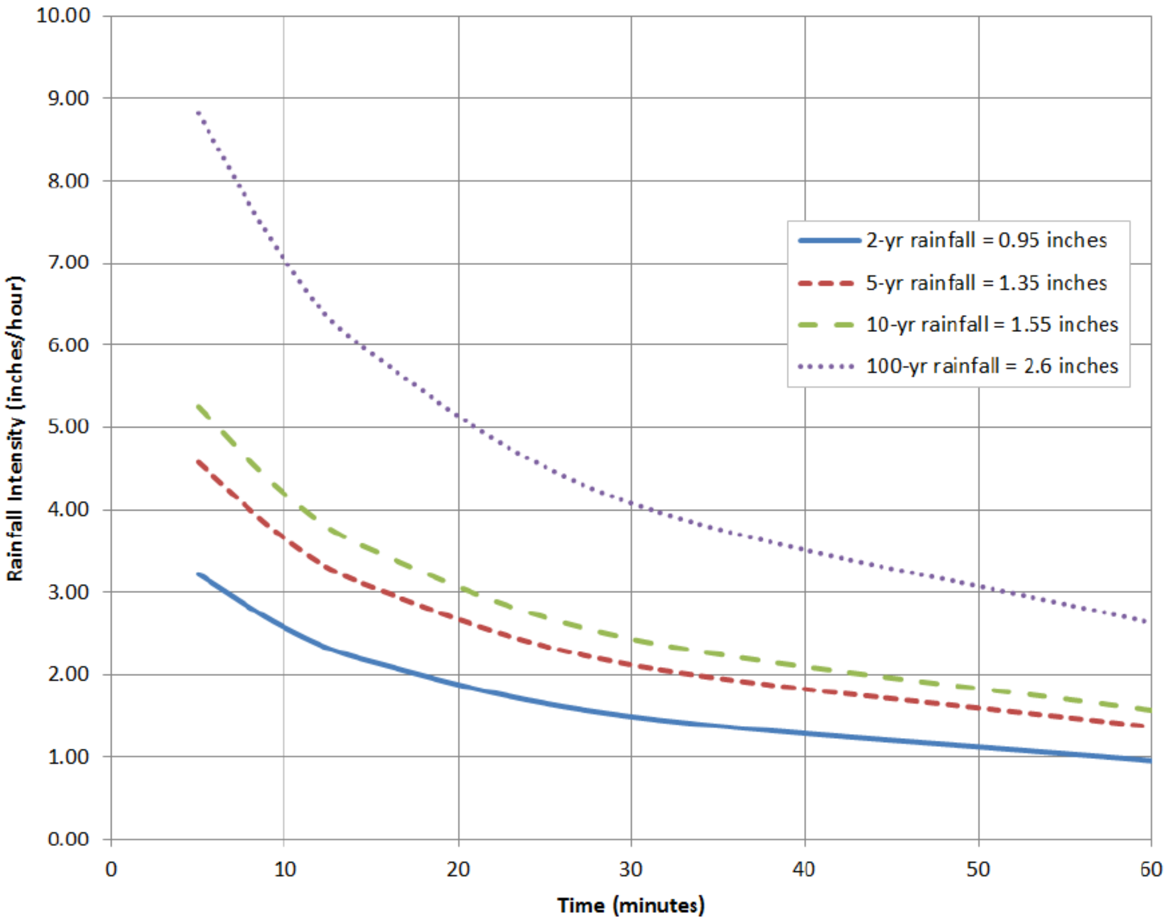
Chapter 5, Rainfall

Continued use of NOAA Atlas 2 rainfall.



Chapter 5, Rainfall

New UD-Rain workbook



Chapter 6, Runoff

- New runoff coefficients
- New time of concentration equation
- (peak flow and volume comparisons between Rational/FAA and CUHP)

Chapter 6, Runoff

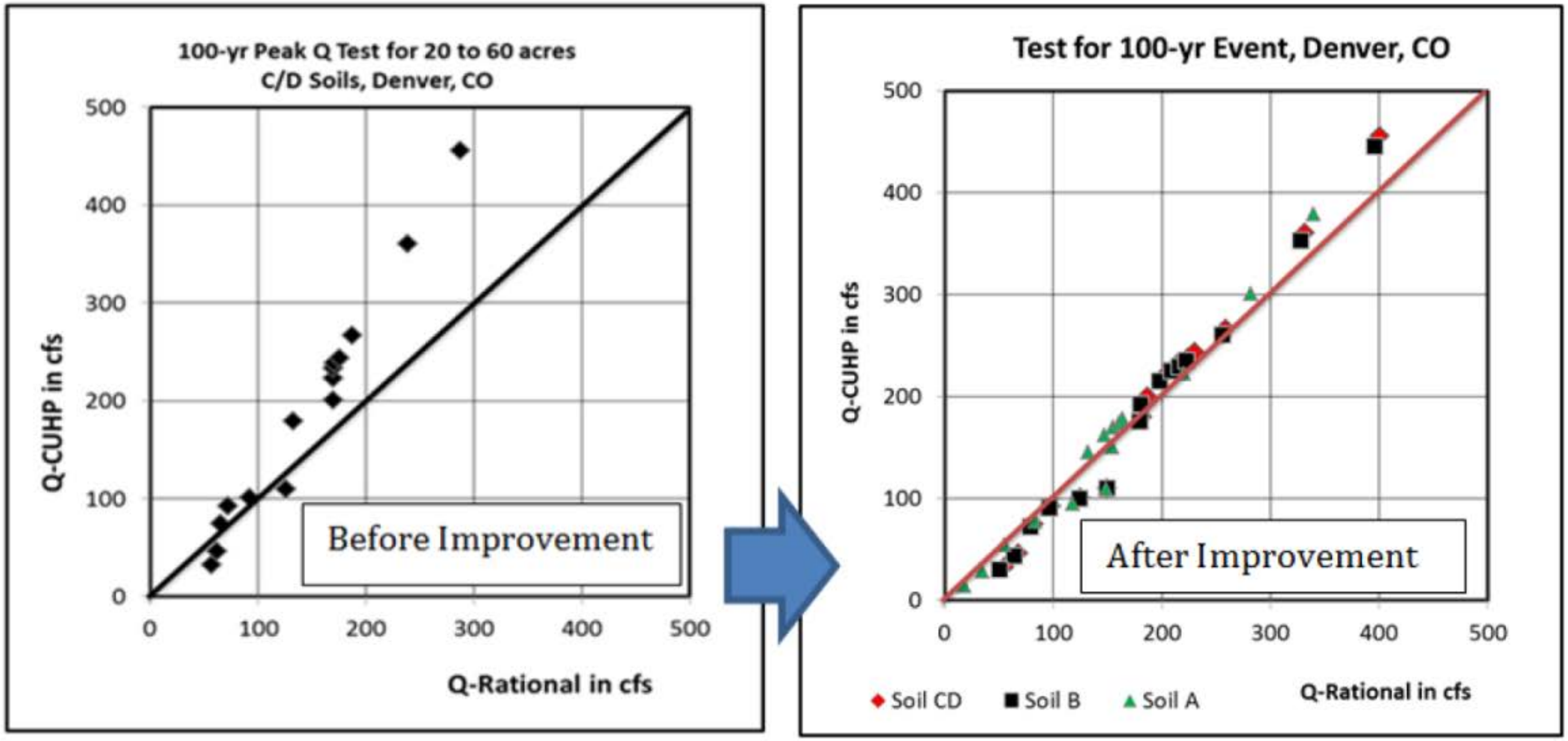


Figure 7.3 Improvements on Modeling Consistency for 100-yr Peak Flows

Chapter 6, Runoff

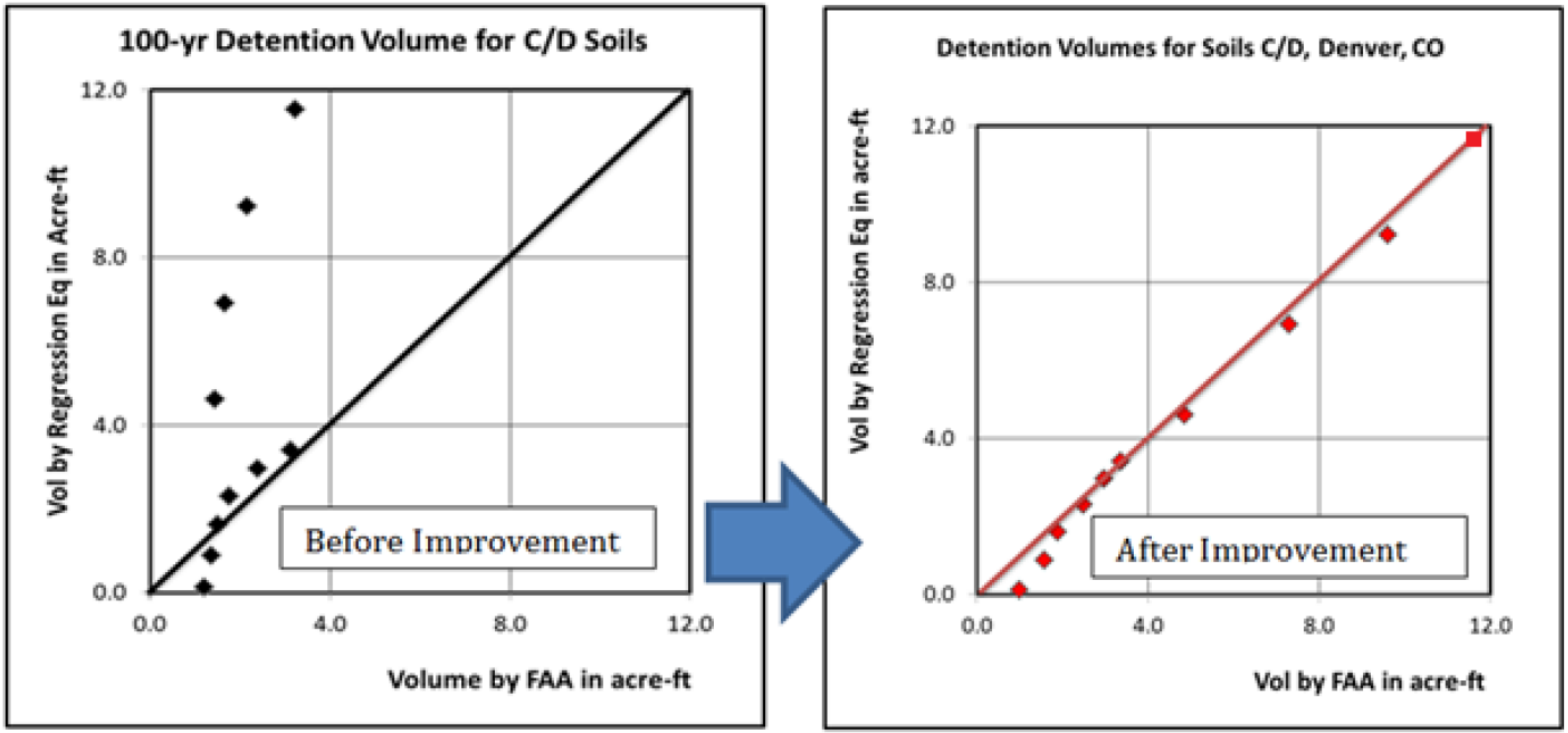
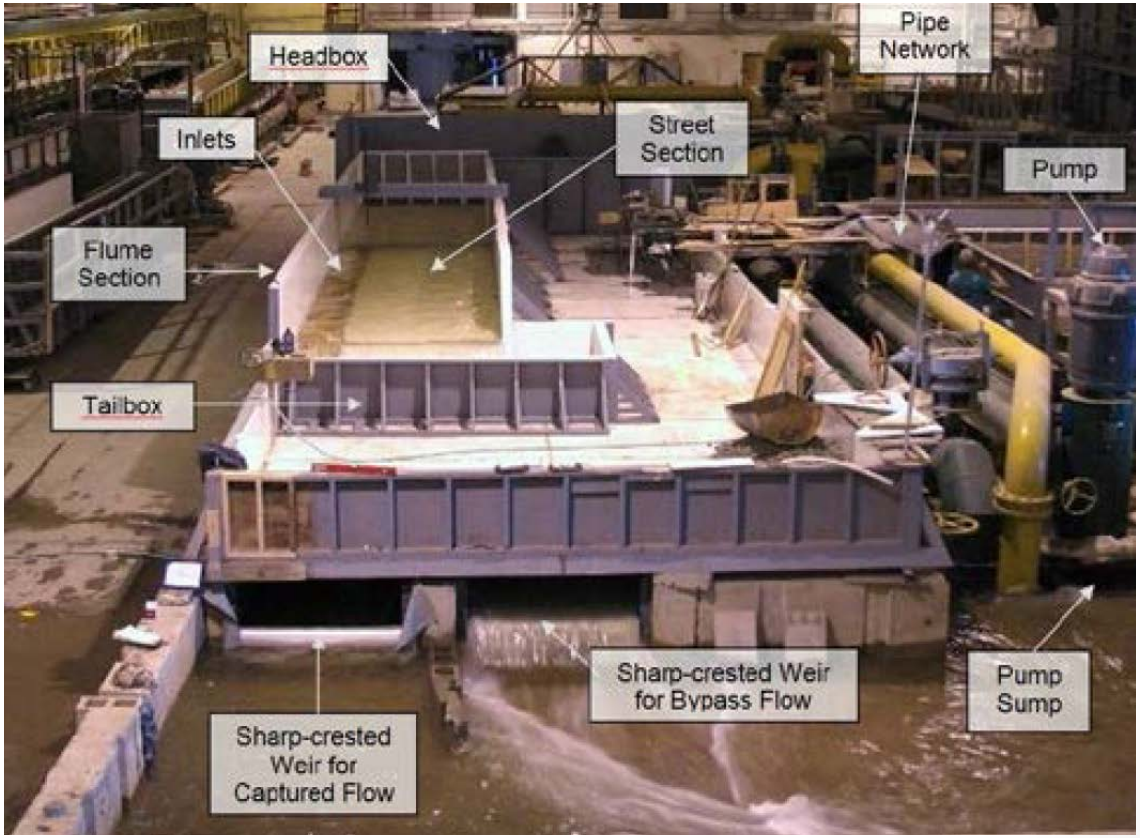


Figure 8.1 Improvements to Modified FAA Method

Chapter 7, Streets, Inlets, and Storm Drains

Integration of physical model results



Chapter 7, Streets, Inlets, and Storm Drains

Improvements to UD-Inlet

Inlet Management

Worksheet Protected

	Delete	Delete	Delete
INLET NAME	Inlet 1	Inlet 2	Inlet 3
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT — Show Input Details

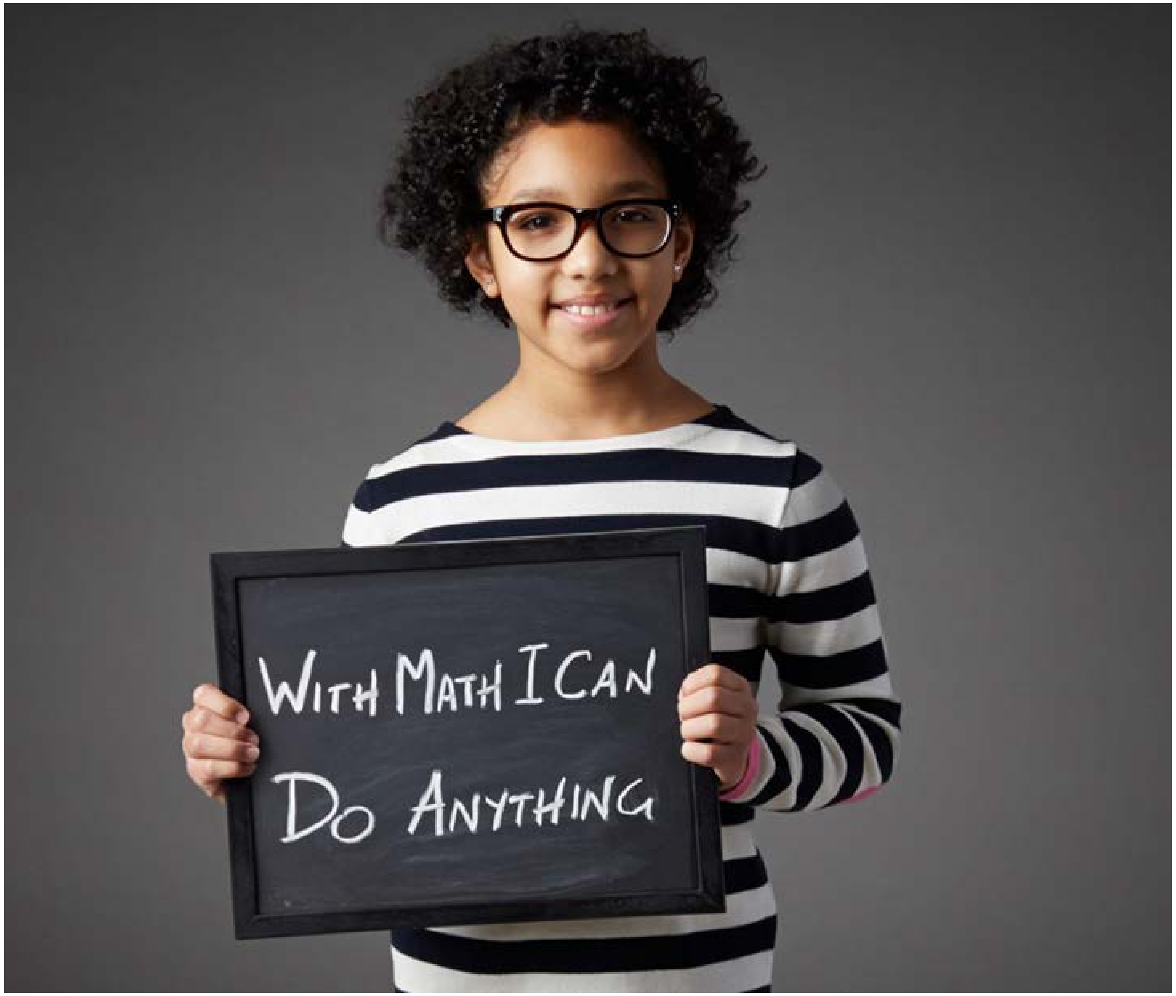
Receive Bypass Flow from:		Inlet 1	Inlet 2
Minor Q_{Known} (cfs)			
Major Q_{Known} (cfs)			
Minor Bypass Flow, Q_b (cfs)	0.0	0.3	0.5
Major Bypass Flow, Q_b (cfs)	0.0	2.0	4.2
Watershed Characteristics			
Subcatchment Area (acres)	0.7	0.85	0.85
Percent Impervious	75	75	75
NRCS Soil Type	C	C	C
Watershed Profile			
Overland Slope (ft/ft)	0.03	0.03	0.03
Overland Length (ft)	136	136	136
Channel Slope (ft/ft)	0.02	0.02	0.02
Channel Length (ft)	157	240	240
Minor Storm Rainfall Input			
Design Storm Return Period, T_r (years)	5	5	5
One-Hour Precipitation, P_1 (inches)	1.35	1.35	1.35
Major Storm Rainfall Input			
Design Storm Return Period, T_r (years)	100	100	100
One-Hour Precipitation, P_1 (inches)	2.61	2.61	2.61

CALCULATED OUTPUT — Show Output Details

Minor Total Design Peak Flow, Q	**2.1**	**2.8**	**2.9**
Major Total Design Peak Flow, Q	**4.8**	**7.7**	**9.9**

Chapter 8, Open Channels

“Helpful Mindsets”



Chapter 8, Open Channels

Swales (not "major" drainage)

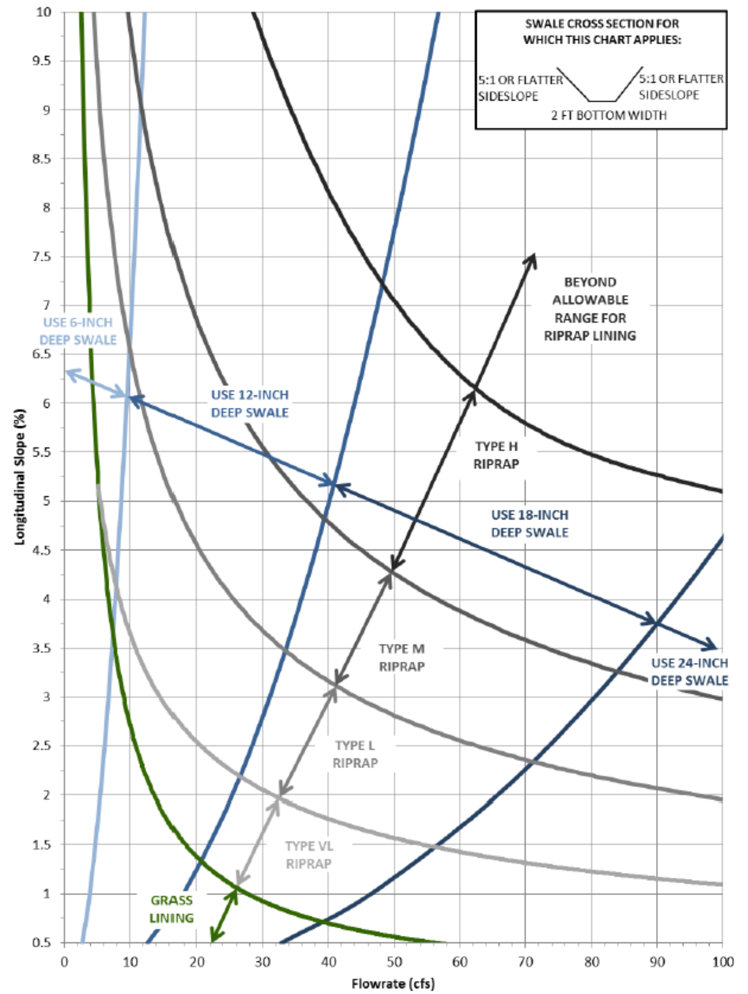
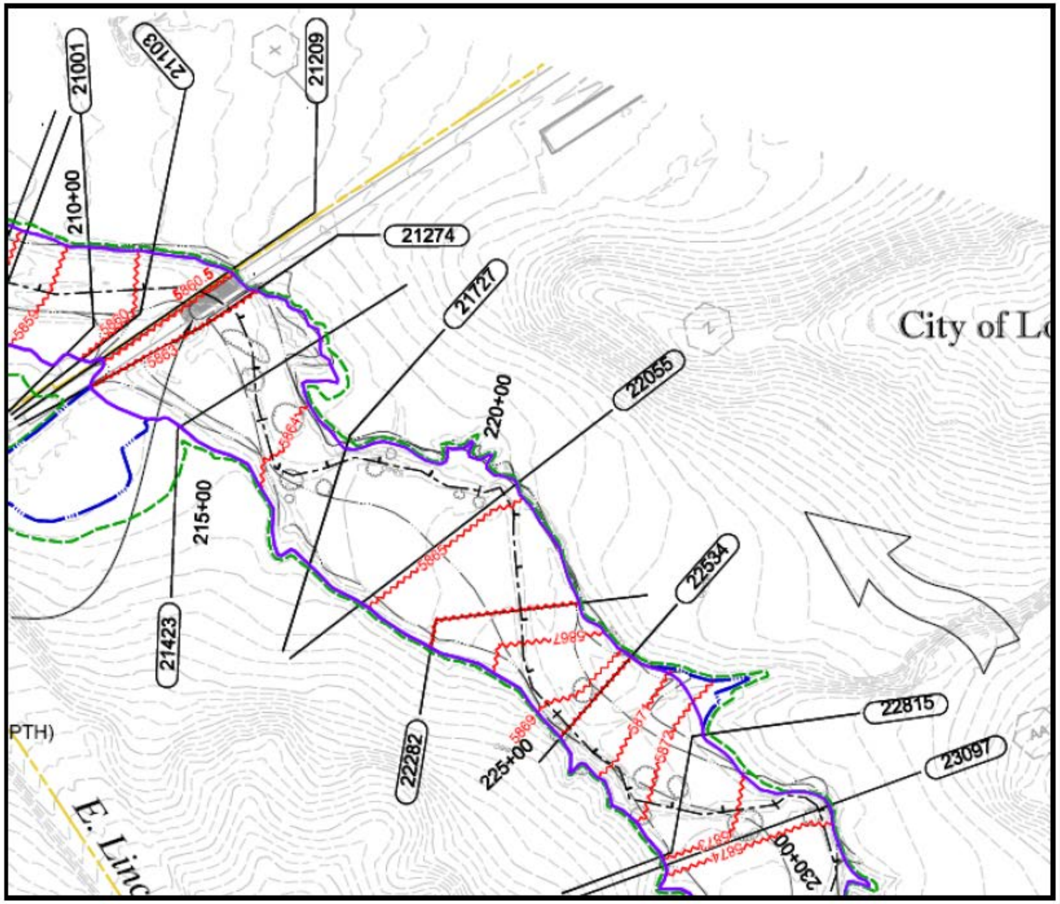


Figure 8-22. Swale stability chart; 2- to 4-foot bottom width and side slopes between 5:1 and 10:1 (Note: Riprap classifications refer to gradation for riprap used in soil riprap or void-filled riprap. See Figure 8-34 for gradations.) (Source: Muller Engineering Company)

Chapter 8, Open Channels

- Guidance for HEC RAS users
- Detail on evaluating roughness coefficients

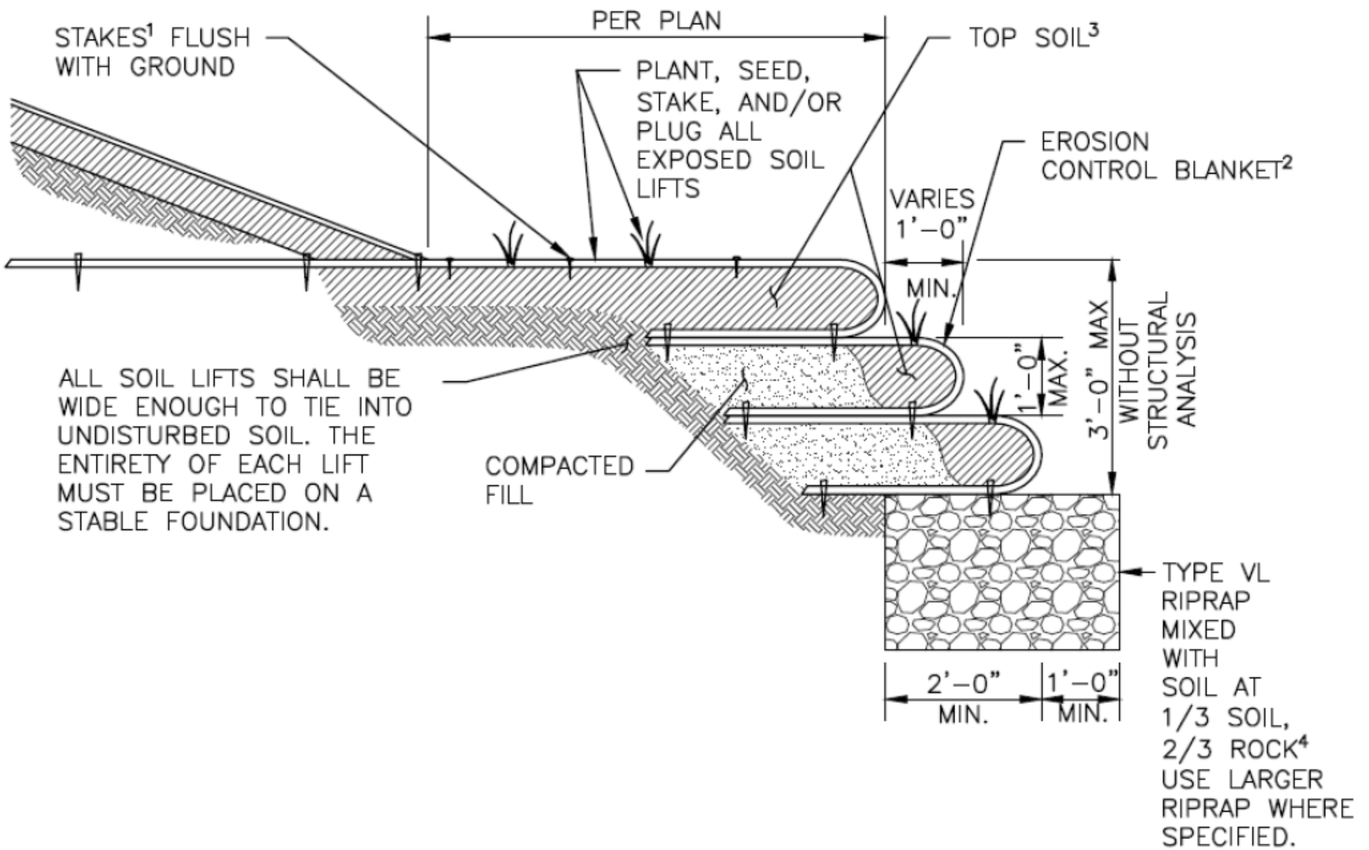


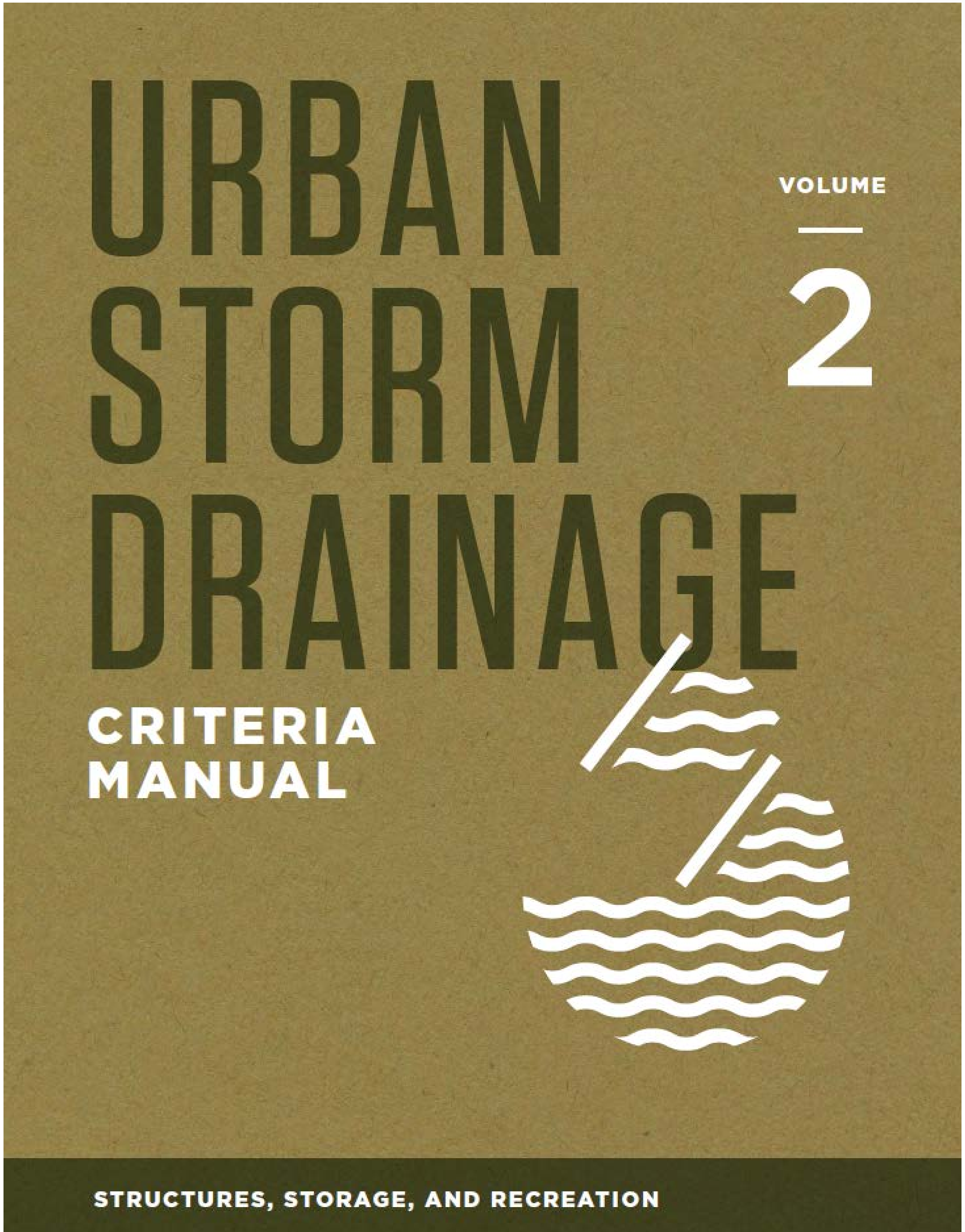
Chapter 8, Open Channels

- Void-filled riprap
- Mild and steep slope riprap sizing

Chapter 8, Open Channels

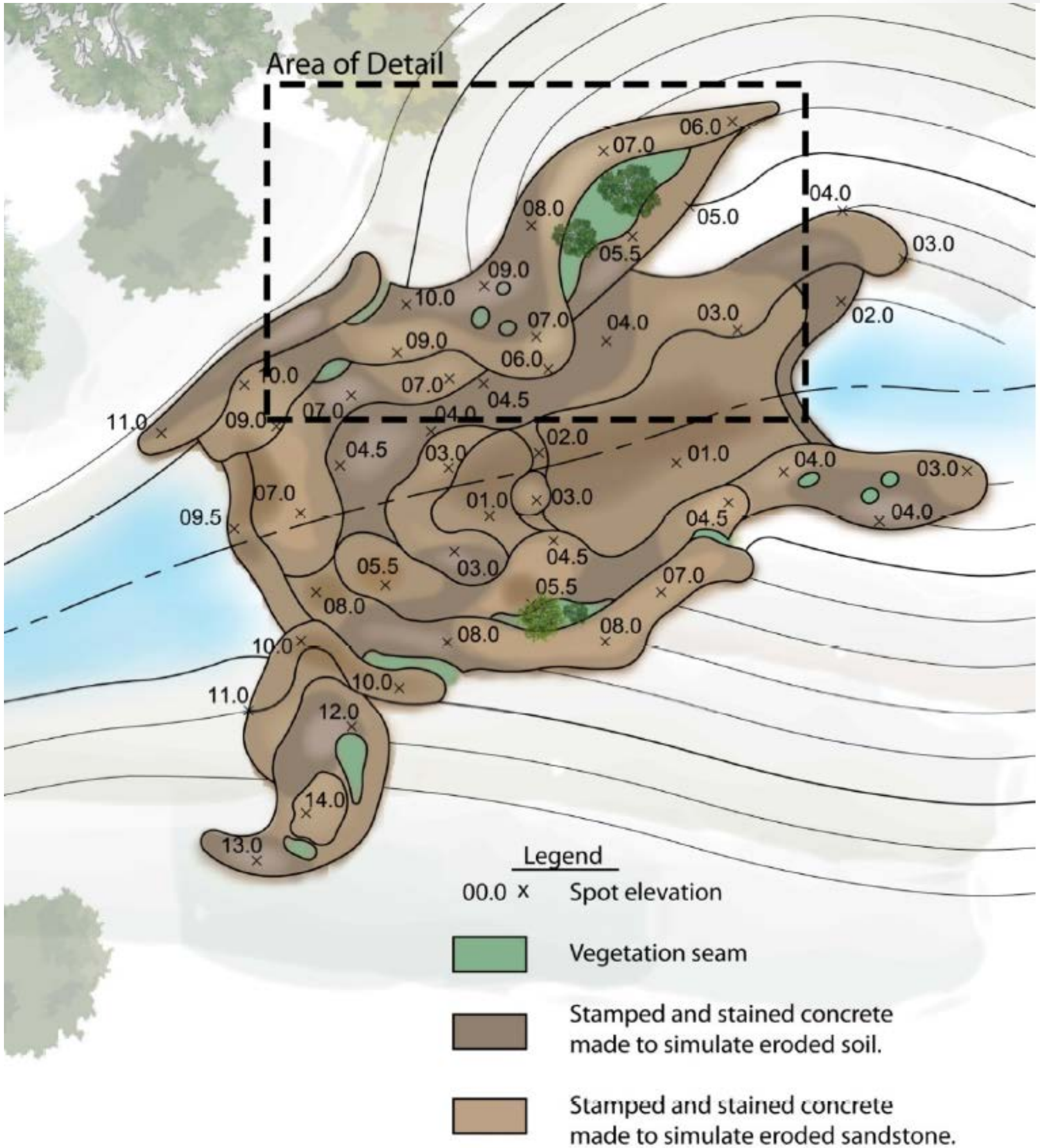
Expanded guidance on bank protection




URBAN
STORM
DRAINAGE
CRITERIA
MANUAL
VOLUME
2
STRUCTURES, STORAGE, AND RECREATION

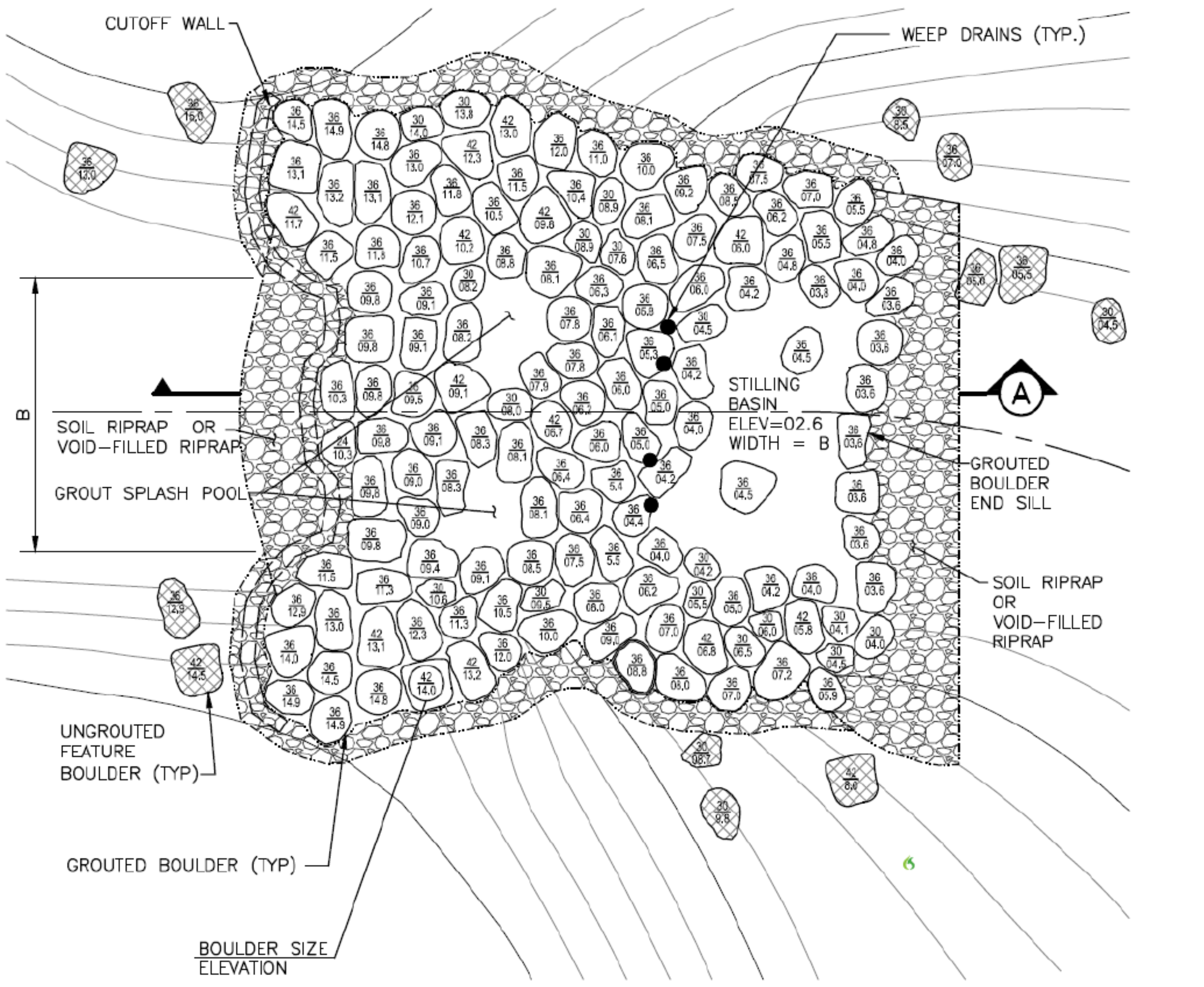
Chapter 9, Hydraulic Structures

Added Sculpted Concrete Drop structures



Chapter 9, Hydraulic Structures

Updated concepts and figures



Chapter 9, Hydraulic Structures

Better defined when the simplified method for design is appropriate.

Chapter 10, Stream Access and Recreational Channels

- Design of paths adjacent to streams
- Other safety related criteria

Chapter 10, Stream Access and Recreational Channels

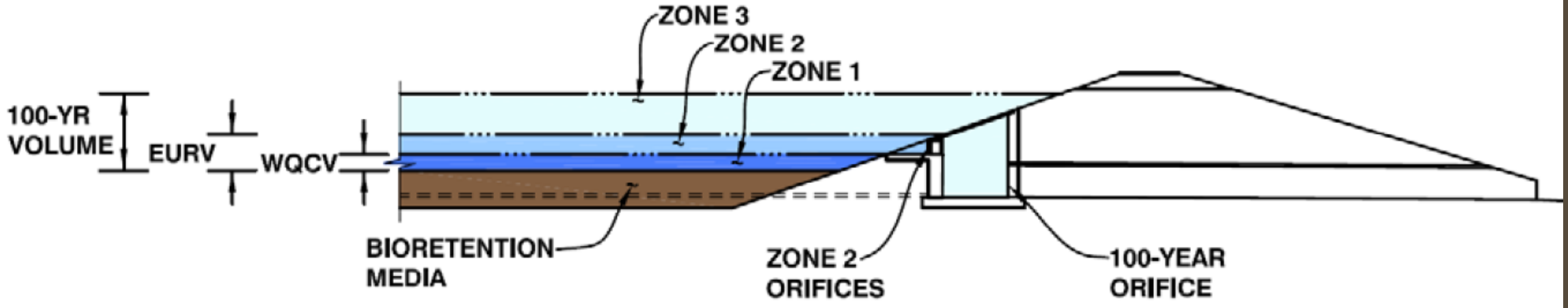
Boatable channels

Chapter 11, Culverts and Bridges

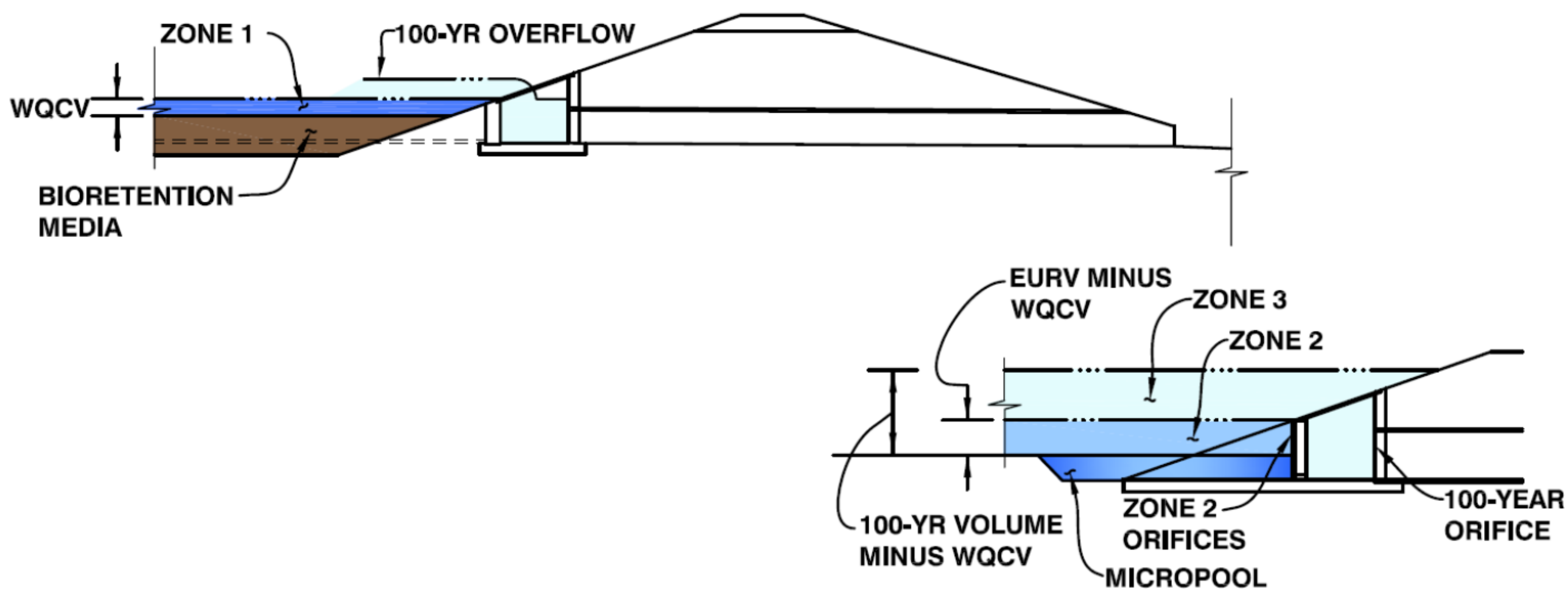
Clarified safety grate recommendations

Chapter 12, Storage

Added guidance for incorporating FSD within different WQ BMPs.



Chapter 12, Storage



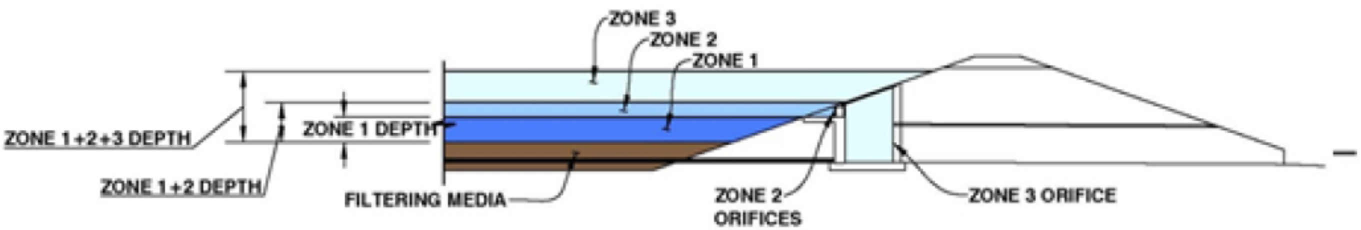
Chapter 12, Storage

Table 12-4. Sand filter or bioretention facility combined with full spectrum detention

Zone	Volume	Drain Time of Zone, hrs	Maximum Release Rate
1	12-hr WQCV	12	Based on drain time
2	EURV minus 12-hr WQCV	12 to 32[1]	Based on drain time
3	100-yr minus EURV	Based on release rate	0.9(predevelopment Q_{100})

[1]Colorado law requires 97% of the 5-year event to drain within 72 hours.

New Tools for *Storage*



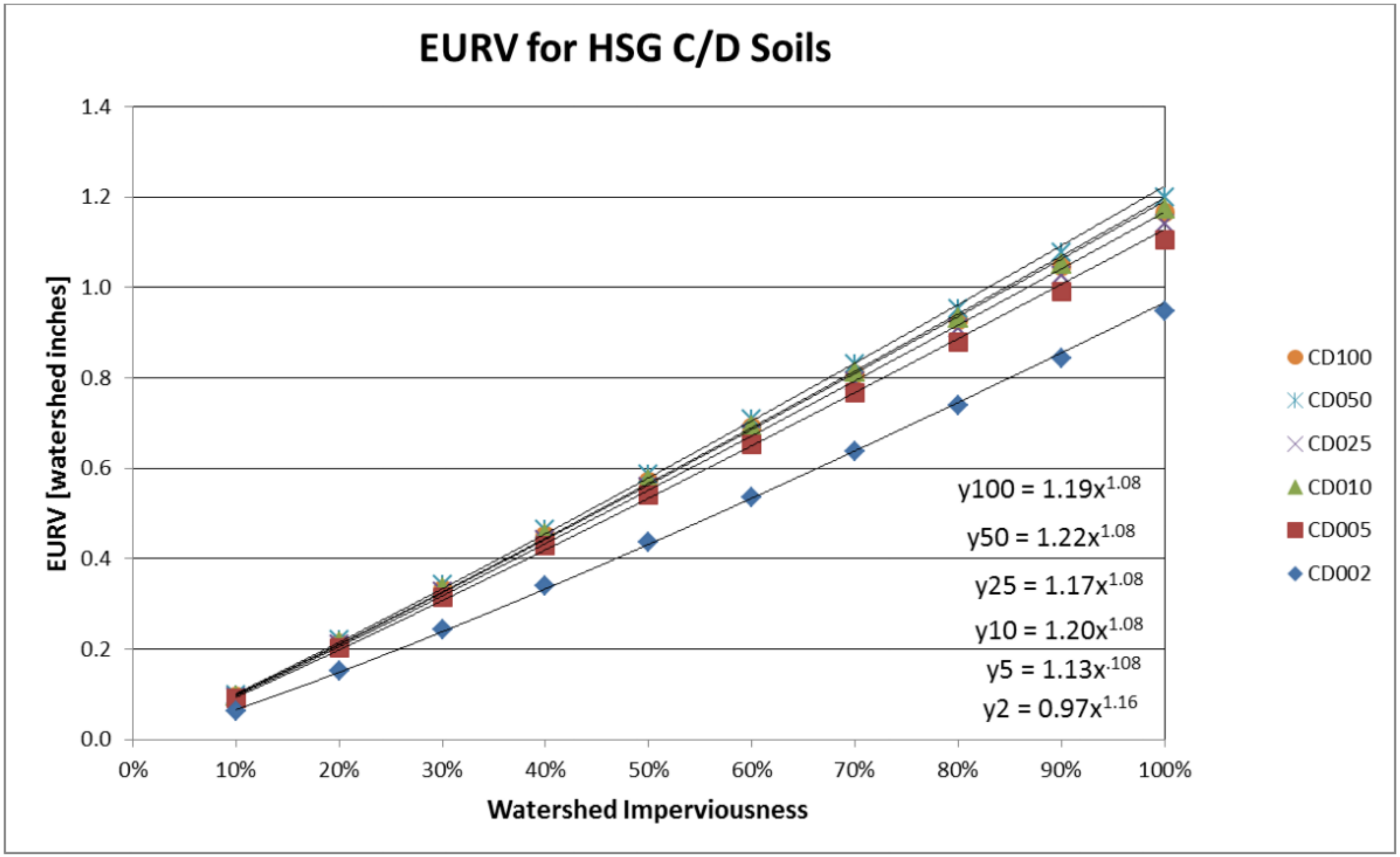
FILTERING BMP WITH 3 ZONES

Required Volume Calculation

Sand Filter (SF) =	SF	
Watershed Area =	20.00	acres
Watershed Length =	1,300	ft
Watershed Slope =	0.005	ft/ft
Watershed Imperviousness =	75.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Desired WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths =	Denver - Capitol Hill	

Other changes in *Storage*

- New predevelopment runoff equations
- New EURV equations



Chapter 13, Revegetation

Upland/Riparian/Wetland

- Site Prep
- Plant Material and Installation
- Mulching
- Maintenance
- Post-Construction Monitoring

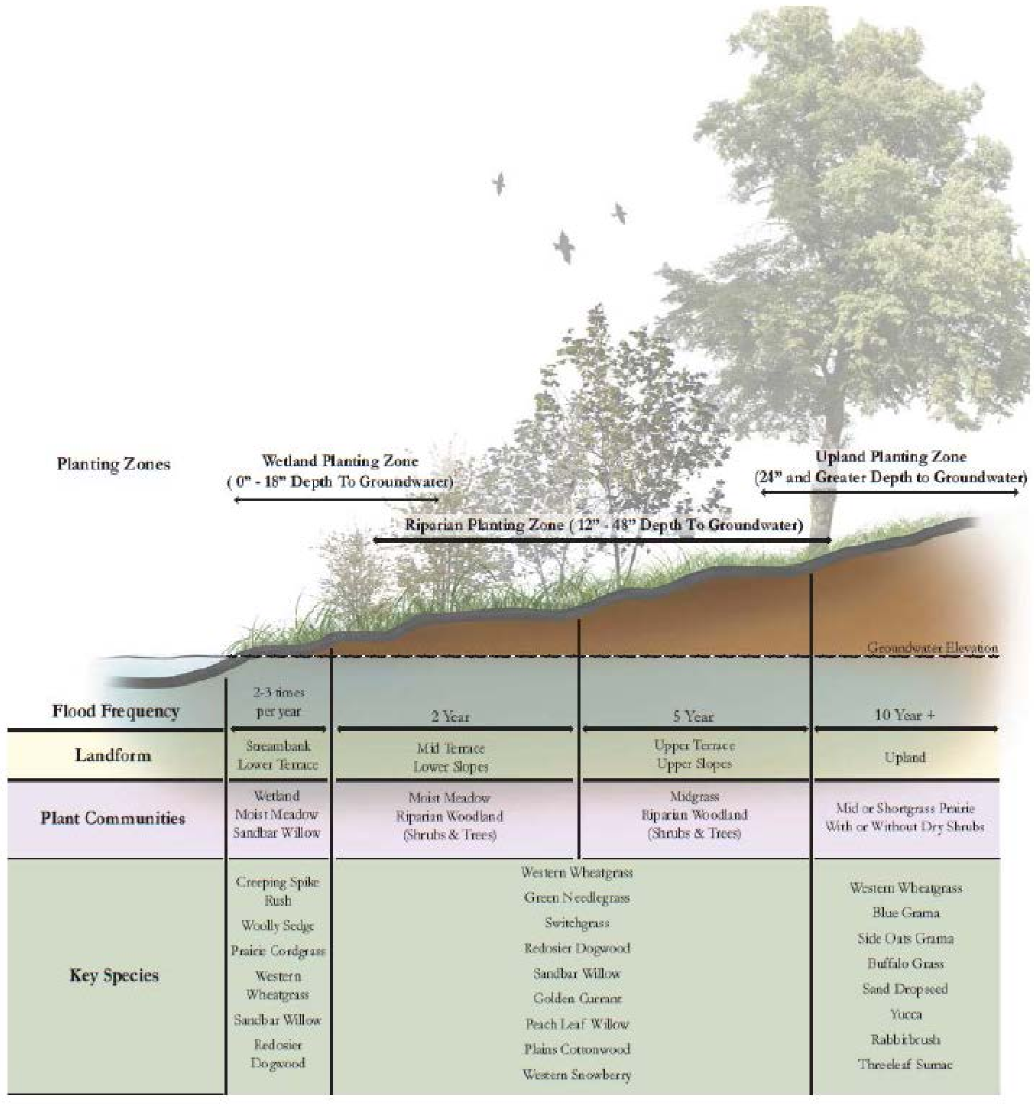


Figure 13-1. Wetland, riparian and upland habitats and planting zones

Next steps:

- Education and outreach
- Three-minute workbook videos
- UD-Rational

Holly Piza, UDFCD
hpiza@udfcd.org

Thank You!

Flood Documentation

David Skuodas, PE, Project Manager

2016 UDFCD Annual Seminar April 5, 2016

A SEPTEMBER TO REMEMBER

THE 2013 COLORADO FLOOD WITHIN THE URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

By Urban Drainage and Flood Control District and Wright Water Engineers, Inc.

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UDFCD Flood Photo Guidelines



Purpose: To document stream conditions and other flow paths during and following major flow events.

This information will be used:

- As historical record
- To record the extent of the flooding footprint, damages that may have occurred, condition of the ground and other infrastructure once water recedes, changes in channel geometry (morphology)
- Identify problem areas
- Validate the results of existing and future flood mapping studies

What to Document:

- High Water (active)
- High Water Marks/Debris Lines (along banks, trees, fences, etc.)
- Flood related damage to roads, structures, utilities, etc.
- Debris and Sedimentation
- Bank Erosion
- Headcuts
- Overtopping of roads, trails, spillways, etc.
- Levees
- Bridges and Culverts
- Drop Structures
- Street inlets for regional storm drains (during active flow and post event)
- Detention Basins (outlet works, forebays, spillways, etc.)
- Water Quality Features (during active flow and post event)
- Headgates, diversions, ditch crossings, etc.

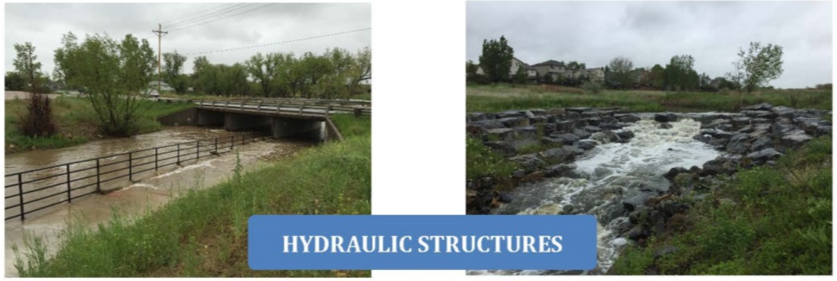
Photos will be stored in GIS, so only georeferenced photos will be accepted by UDFCD (i.e. taken by a GPS enabled camera or a smartphone with the location turned on).

How to Document It:

- Use people, objects, or other features to show a sense of scale
- Land marks (signs, structures, buildings, addresses) help confirm photo location
- Use same vantage point as a pre-flood photo if you have one
- Photos during and after the flood (safety first)

- NO DUPLICATES of same vantage point
- Only send us your best photos (don't give us ALL of your photos)

Good Example Photos




Z by Author




High Water

Source: OMEGA

High Water

High Water

Flood Damage

Flood Damage

High Water Marks

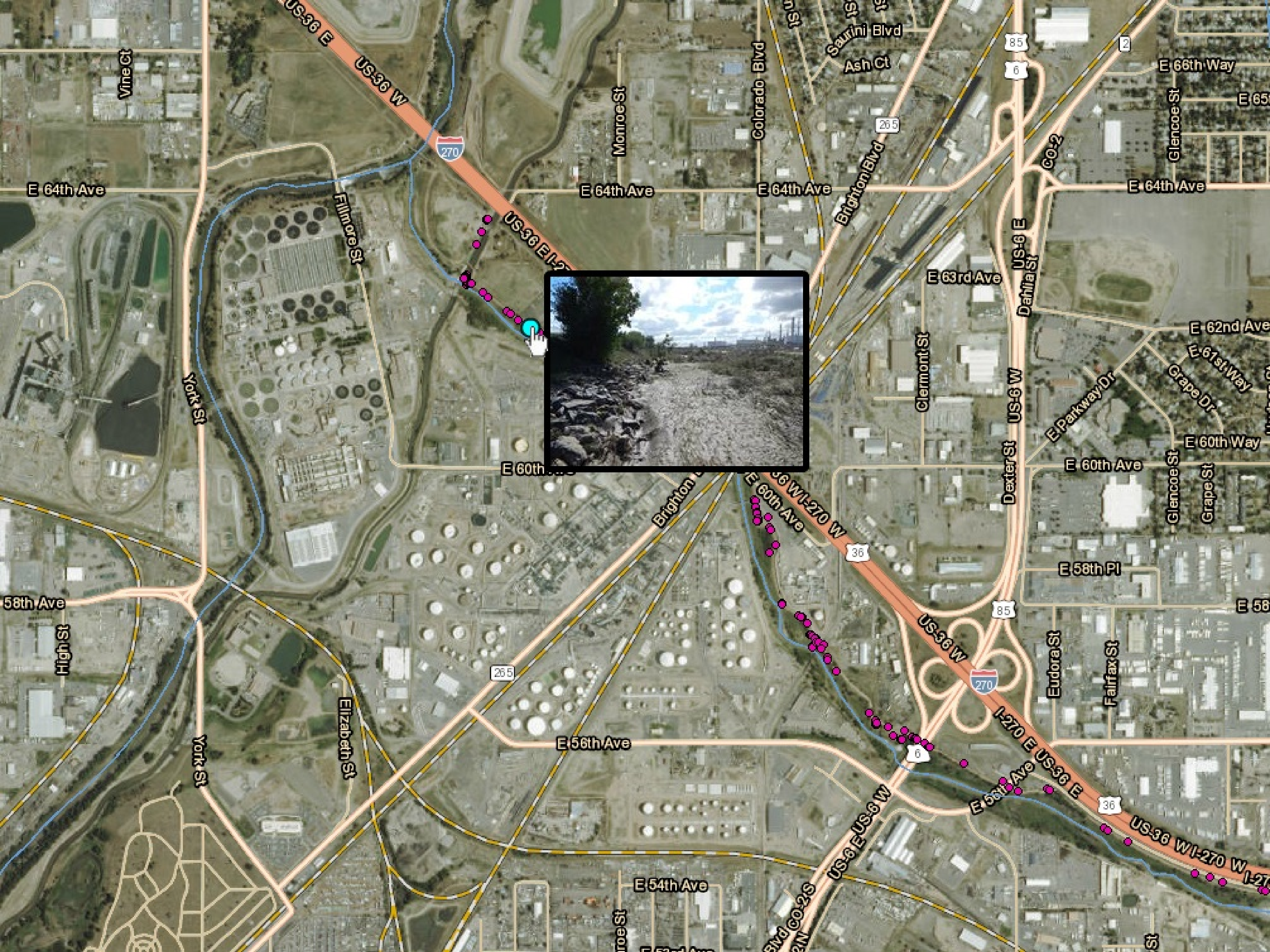

Post Flood Stream Conditions

Sediment Deposition


Debris

Debris

Hydraulic Structures



US-36 E
US-36 W
270
Vine Ct
E 64th Ave
Fillmore St
York St
Monroe St
Colorado Blvd
Brighton Blvd
Saurini Blvd
Ash Ct
265
85
6
2
E 66th Way
Glencoe St
CO-2
US-6 E
Dahlia St
E 63rd Ave
E 62nd Ave
E 61st Way
Grape Dr
E Parkway Dr
Clermont St
US-6 W
Dexter St
E 60th Way
E 60th Ave
Grape St
E 58th Pl
36
US-36 W
Eudora St
Fairfax St
58th Ave
High St
Elizabeth St
E 56th Ave
I-270 E US-36 E
US-36 W I-270 W
E 54th Ave
US-6 E US-6 W

Flood Videos

Flood Videos

UDFCD Flood Photo Guidelines



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- NO DUPLICATES of same vantage point
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Good Example Photos





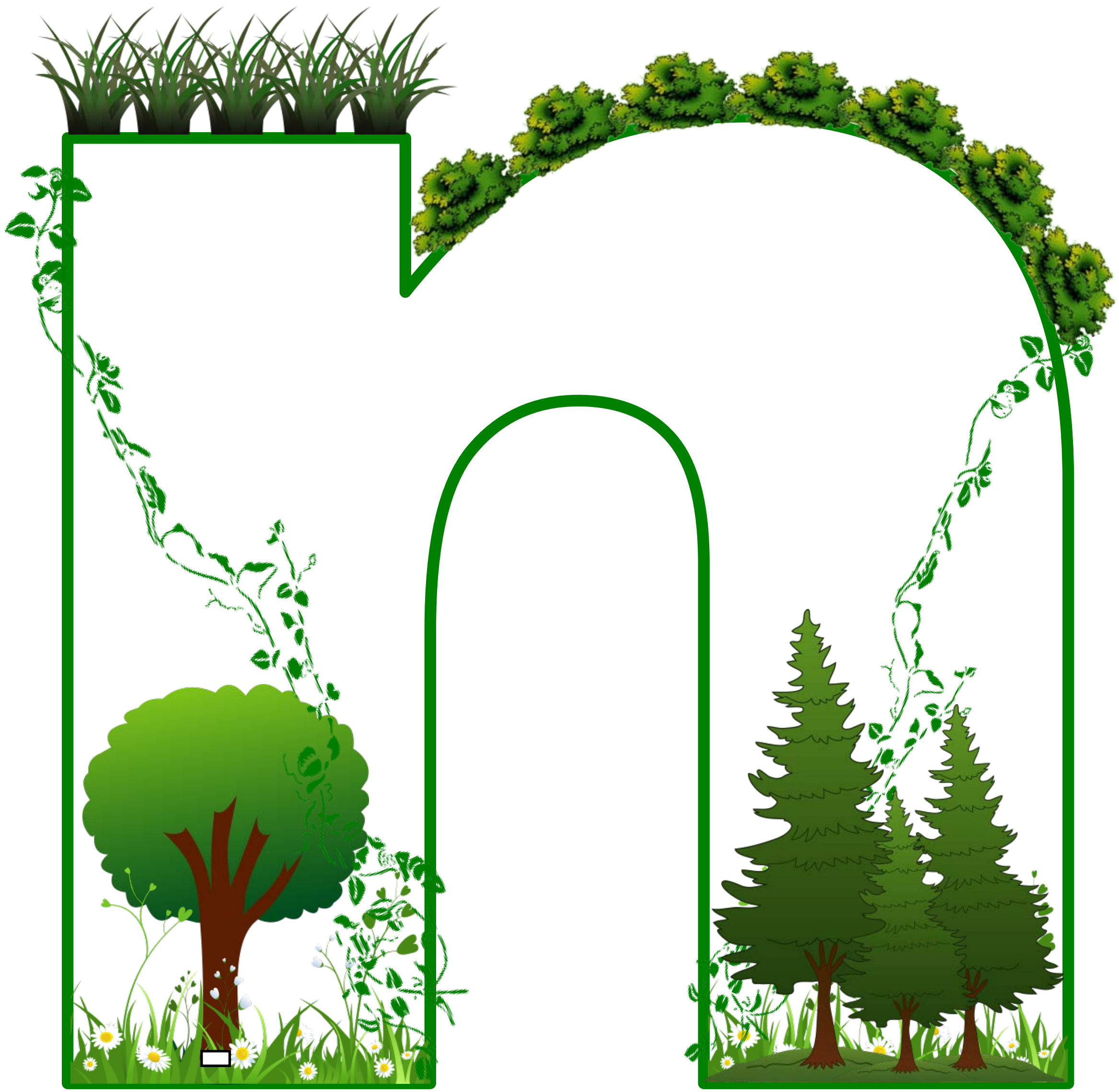
NEXT STEPS…

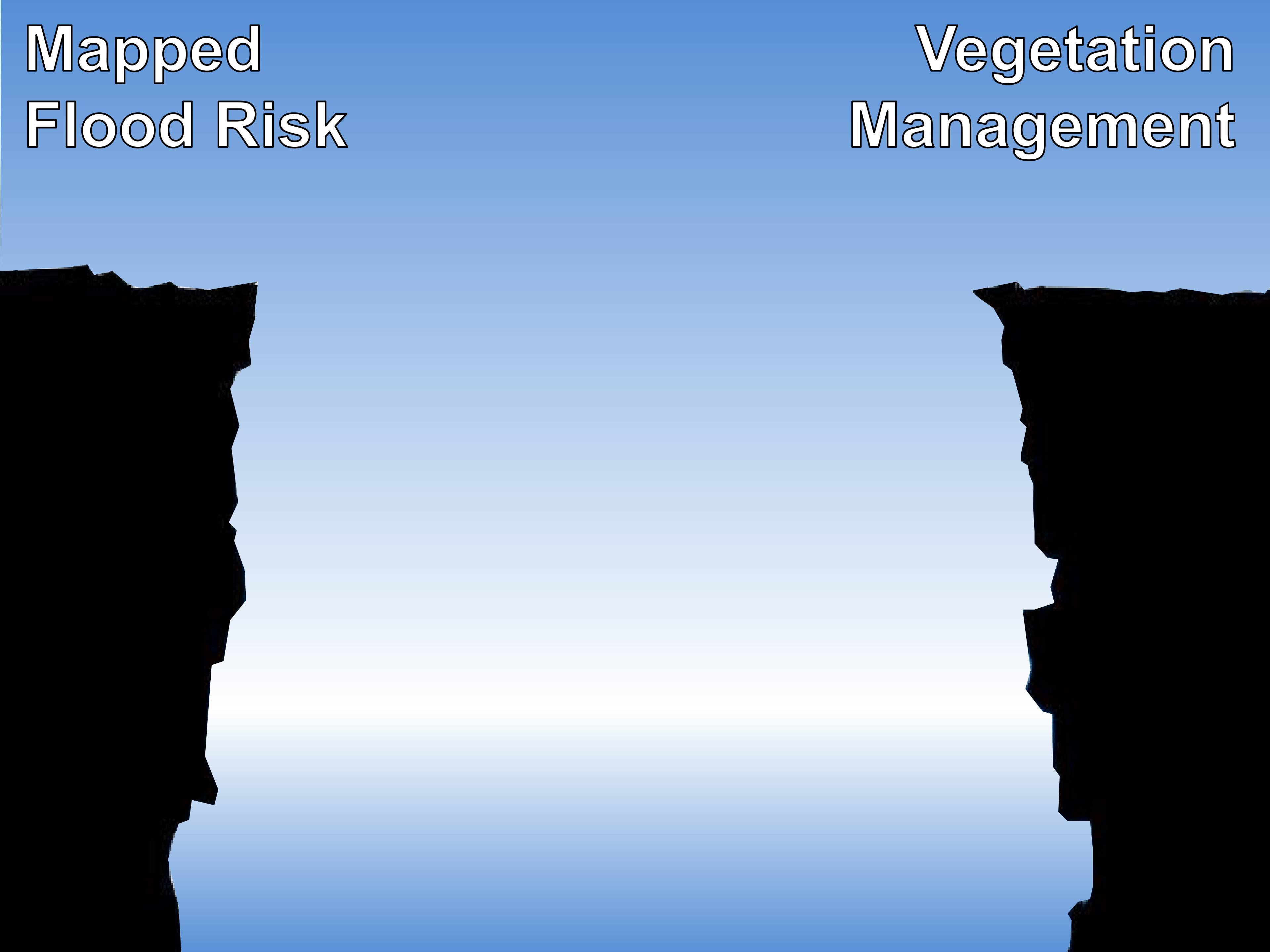
High Water Mark Survey Performance Spec

When you Say “Rough”, We Want to Know “How Rough?”

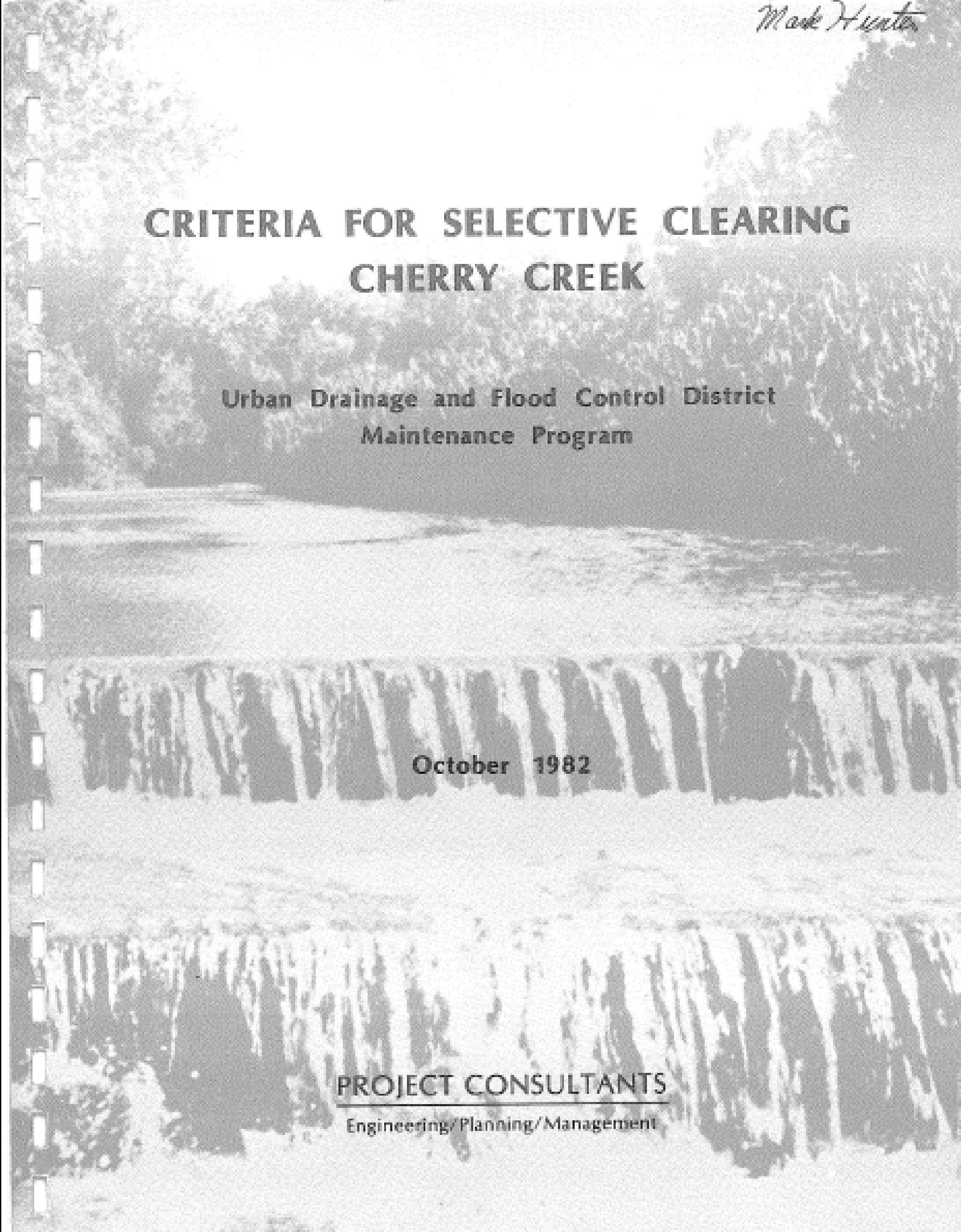
Connecting Vegetation Management to the Mapped Flood Risk

David Skuodas, PE, Project Manager




Mapped
Flood Risk
Vegetation
Management

Mark Hunter



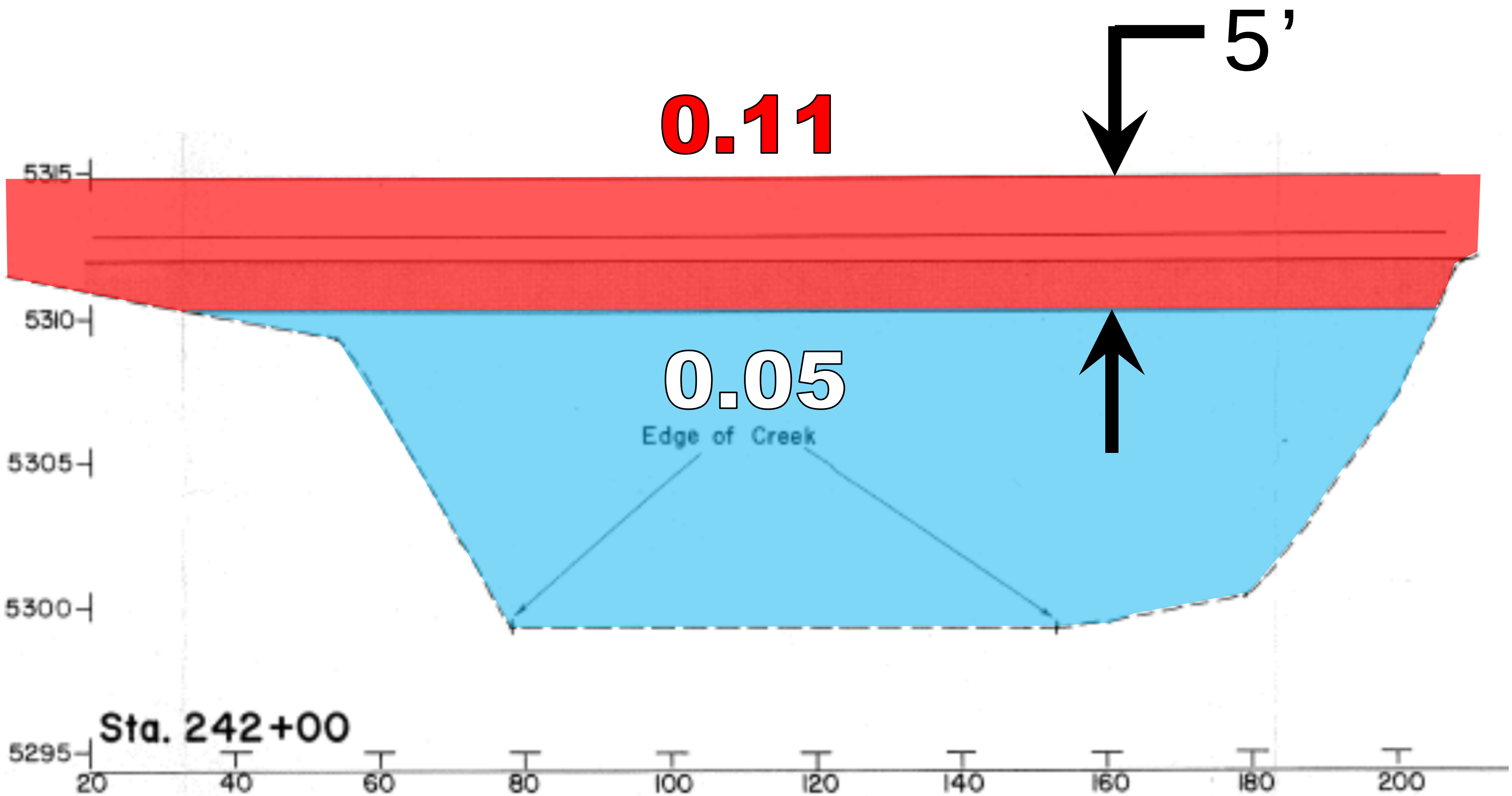
CRITERIA FOR SELECTIVE CLEARING CHERRY CREEK

Urban Drainage and Flood Control District
Maintenance Program

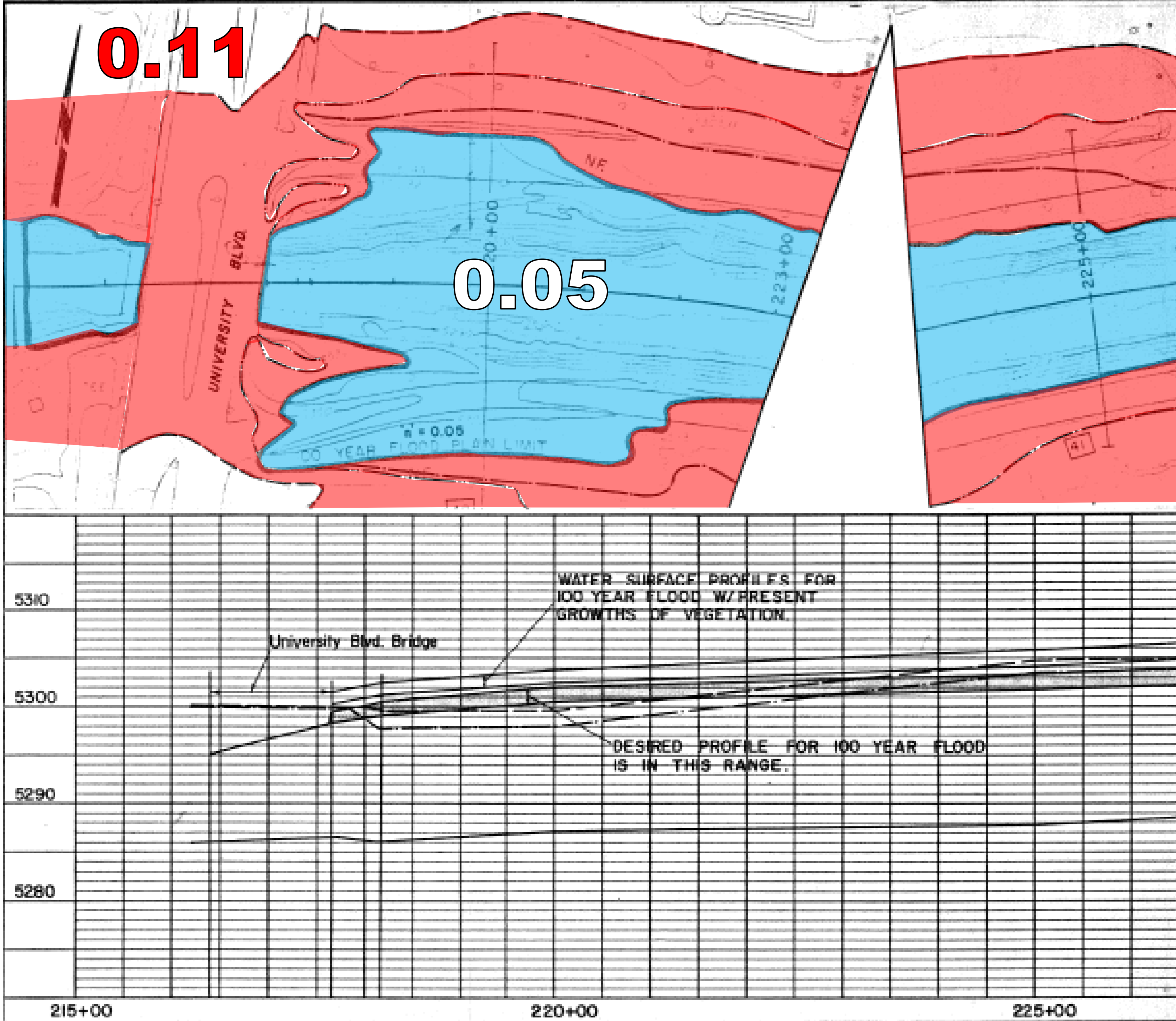
October 1982

PROJECT CONSULTANTS

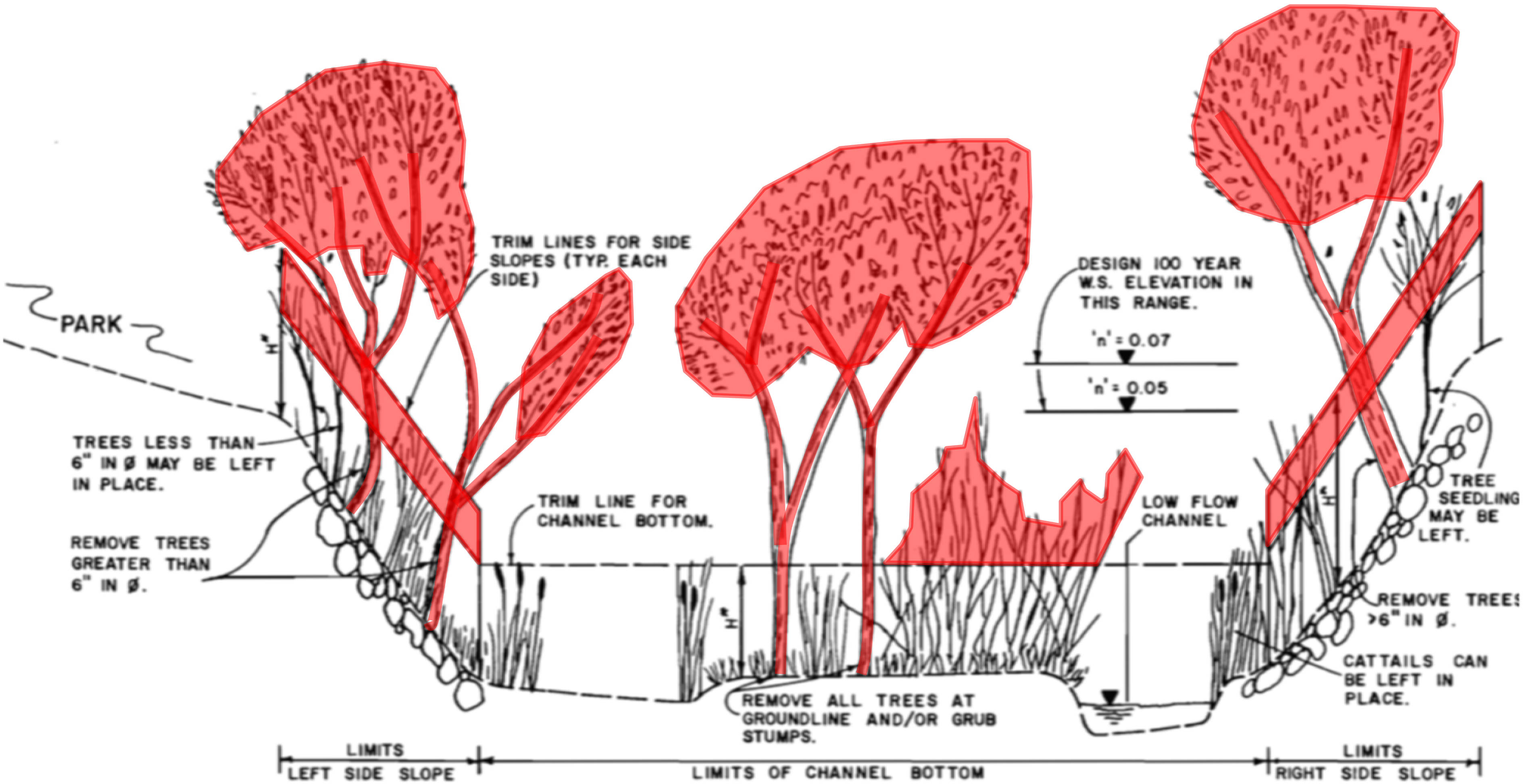
Engineering/Planning/Management



5'
0.11
0.05
Edge of Creek
5315
5310
5305
5300
5295
Sta. 242+00
20
40
60
80
100
120
140
160
180
200



0.11
0.05
UNIVERSITY BLVD
NF
220+00
223+00
225+00
"n" = 0.05
100 YEAR FLOOD PLAIN LIMIT
5310
5300
5290
5280
WATER SURFACE PROFILES FOR 100 YEAR FLOOD W/PRESENT GROWTHS OF VEGETATION.
University Blvd. Bridge
DESIRED PROFILE FOR 100 YEAR FLOOD IS IN THIS RANGE.
215+00
220+00
225+00



H* = 4' FOR BIENNIAL CLEARING TO
MAX. 6' FOR ANNUAL CLEARING –
CHANNEL BOTTOM SHOULD BE GRUBBED & RESEEDED
IF FREQUENCY OF CLEARING IS TO BE LESS.

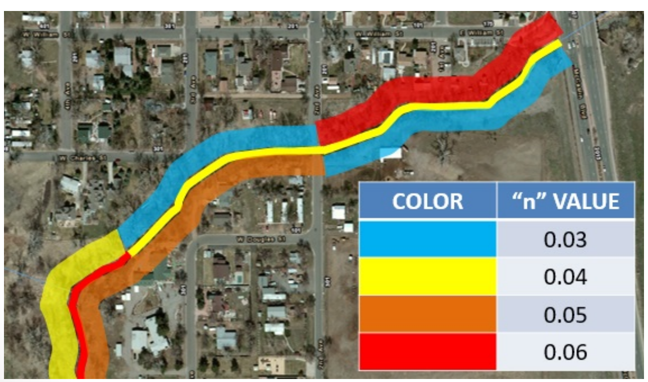
FIGURE 2

DIAGRAM OF CHERRY CREEK CLEARING

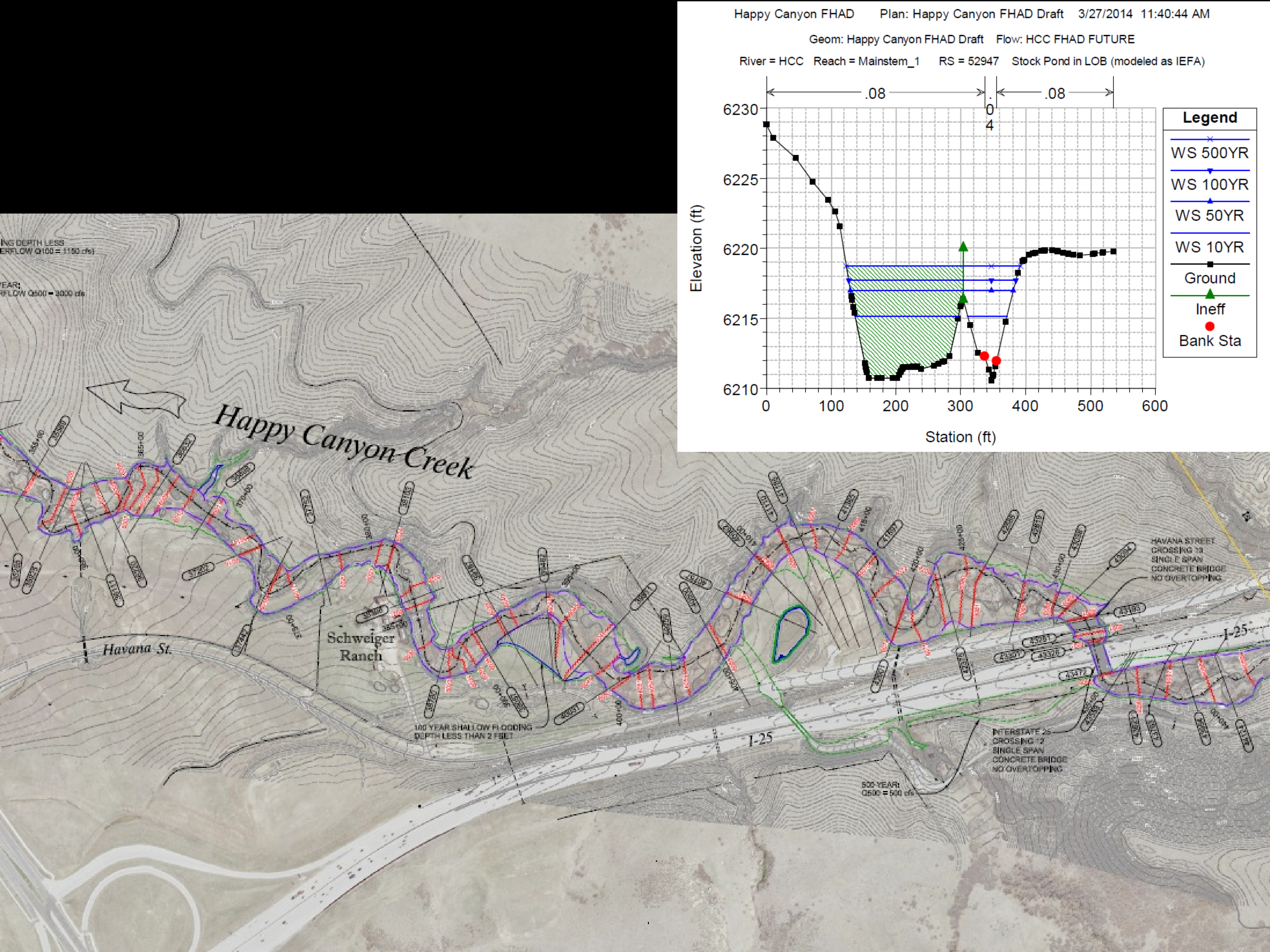
Scale: (H) 1" = 20'; (V) 1" = 5'.

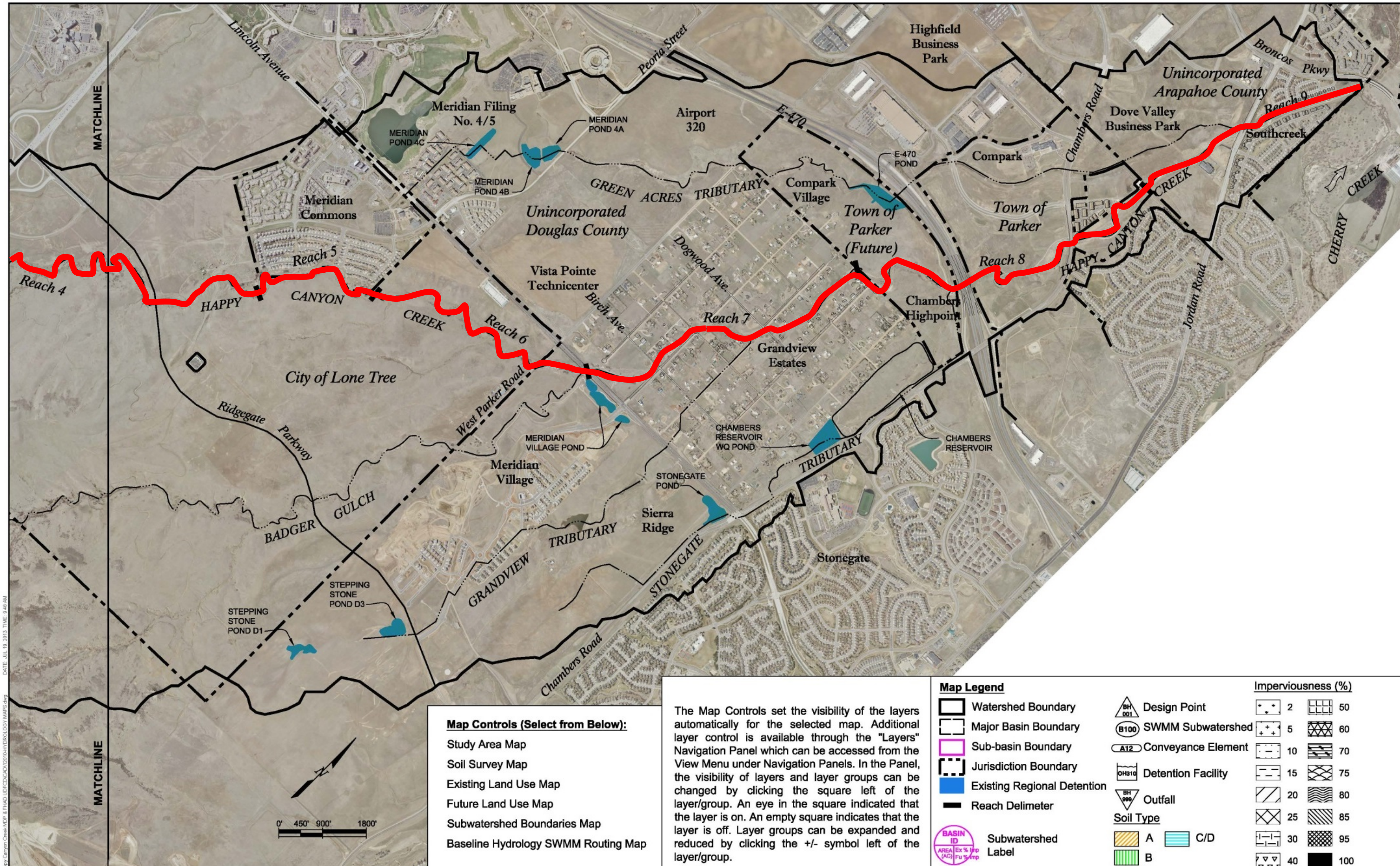
Modeling Roughness

Case Studies



Documenting & Using Roughness Values


Happy Canyon FHAD Plan: Happy Canyon FHAD Draft 3/27/2014 11:40:44 AM
Geom: Happy Canyon FHAD Draft Flow: HCC FHAD FUTURE
River = HCC Reach = Mainstem_1 RS = 52947 Stock Pond in LOB (modeled as IEFA)
.08
.04
.08
Elevation (ft)
6230
6225
6220
6215
6210
0
100
200
300
400
500
600
Station (ft)
Legend
WS 500YR
WS 100YR
WS 50YR
WS 10YR
Ground
Ineff
Bank Sta
Happy Canyon Creek
Schweiger Ranch
Havana St.
I-25
I-25
HAVANA STREET
SINGLE SPAN
CONCRETE BRIDGE
NO OVERTOPPING
INTERSTATE 25
SINGLE SPAN
CONCRETE BRIDGE
NO OVERTOPPING
100 YEAR SHALLOW FLOODING DEPTH LESS THAN 2 FEET
500 YEAR: Q500 = 500 cfs



Map Controls (Select from Below):

Study Area Map
Soil Survey Map
Existing Land Use Map
Future Land Use Map
Subwatershed Boundaries Map
Baseline Hydrology SWMM Routing Map

The Map Controls set the visibility of the layers automatically for the selected map. Additional layer control is available through the "Layers" Navigation Panel which can be accessed from the View Menu under Navigation Panels. In the Panel, the visibility of layers and layer groups can be changed by clicking the square left of the layer/group. An eye in the square indicated that the layer is on. An empty square indicates that the layer is off. Layer groups can be expanded and reduced by clicking the +/- symbol left of the layer/group.

Map Legend

- Watershed Boundary
- Major Basin Boundary
- Sub-basin Boundary
- Jurisdiction Boundary
- Existing Regional Detention
- Reach Delimeter
- BASIN ID / AREA (AC) / Ex % Imp / Fu % Imp — Subwatershed Label
- BH 001 — Design Point
- B100 — SWMM Subwatershed
- A12 — Conveyance Element
- OH319 — Detention Facility
- BH 999 — Outfall

Soil Type

- A
- B
- C/D

Imperviousness (%)

2, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 95, 100

No.	DATE	REVISIONS	APPR.

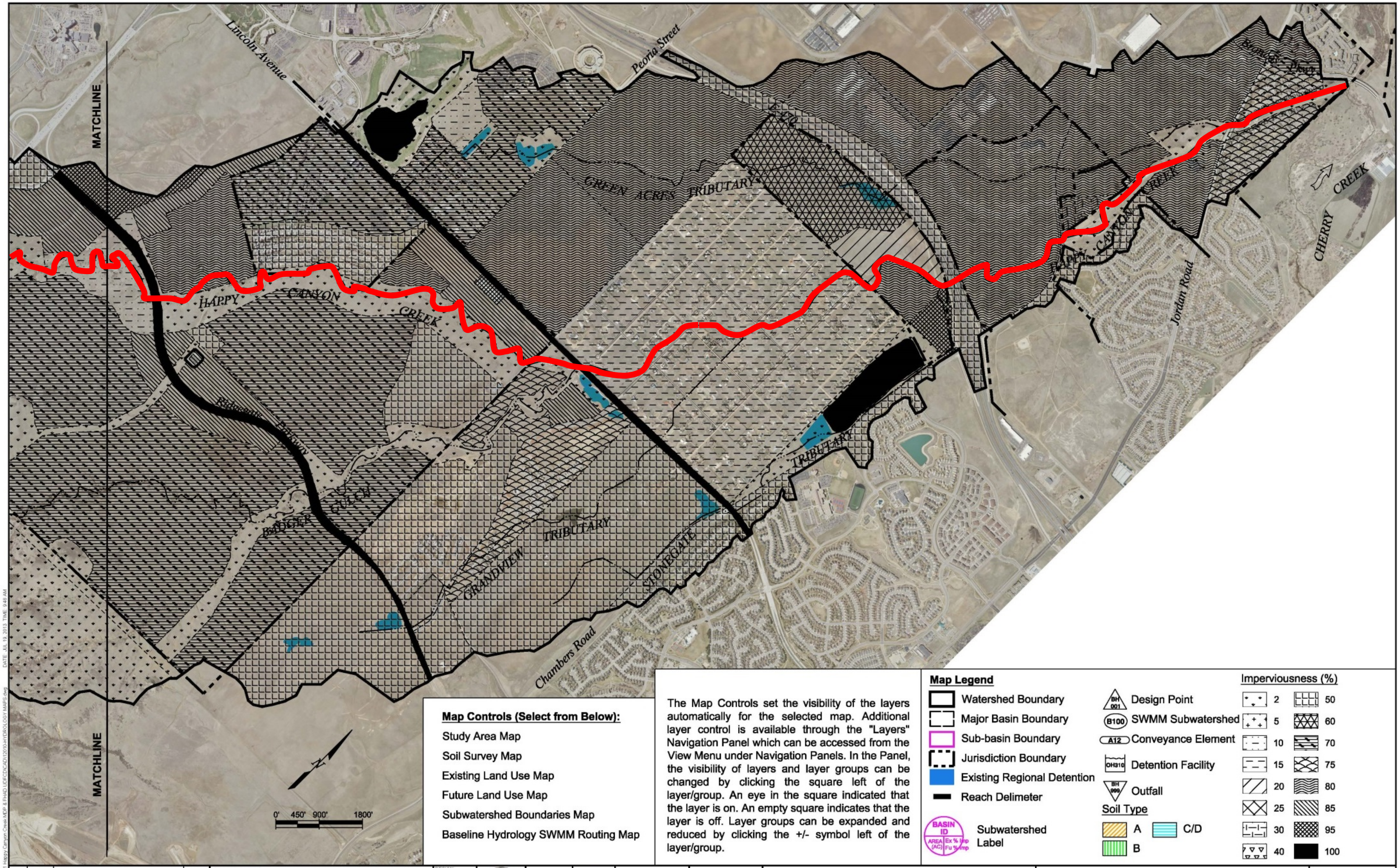
MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226 (303) 988-4939
PROJECT NO. 12-010.01

DESIGN MDC
DRAWN JHK
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

INTERACTIVE HYDROLOGY MAP
STUDY AREA

DATE JULY 2013
FIGURE NO. B-2



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Map Legend

Watershed Boundary
Major Basin Boundary
Sub-basin Boundary
Jurisdiction Boundary
Existing Regional Detention
Reach Delimeter
BASIN ID AREA (AC) Ex % Imp Fu % Imp — Subwatershed Label

BH 001 Design Point
B100 SWMM Subwatershed
A12 Conveyance Element
OH310 Detention Facility
BH 990 Outfall

Soil Type

A
C/D
B

Imperviousness (%)

2, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 95, 100

No.	DATE	REVISIONS	APPR.

MULLER

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-010.01

DESIGN MDC
DRAWN JHK
CHECK JTW

Town of Parker COLORADO

Southeast Metro Stormwater Authority

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

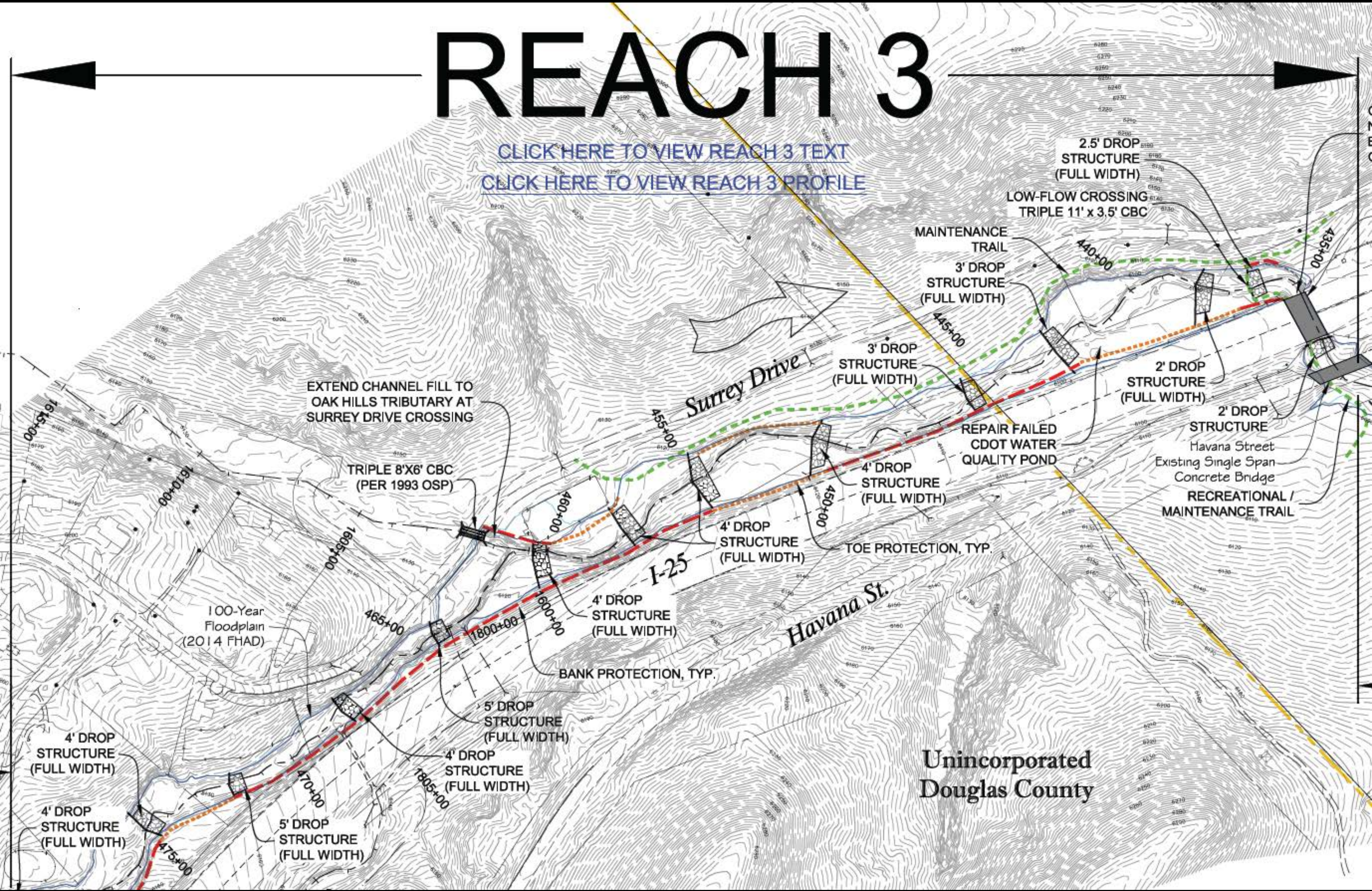
INTERACTIVE HYDROLOGY MAP
FUTURE LAND USE

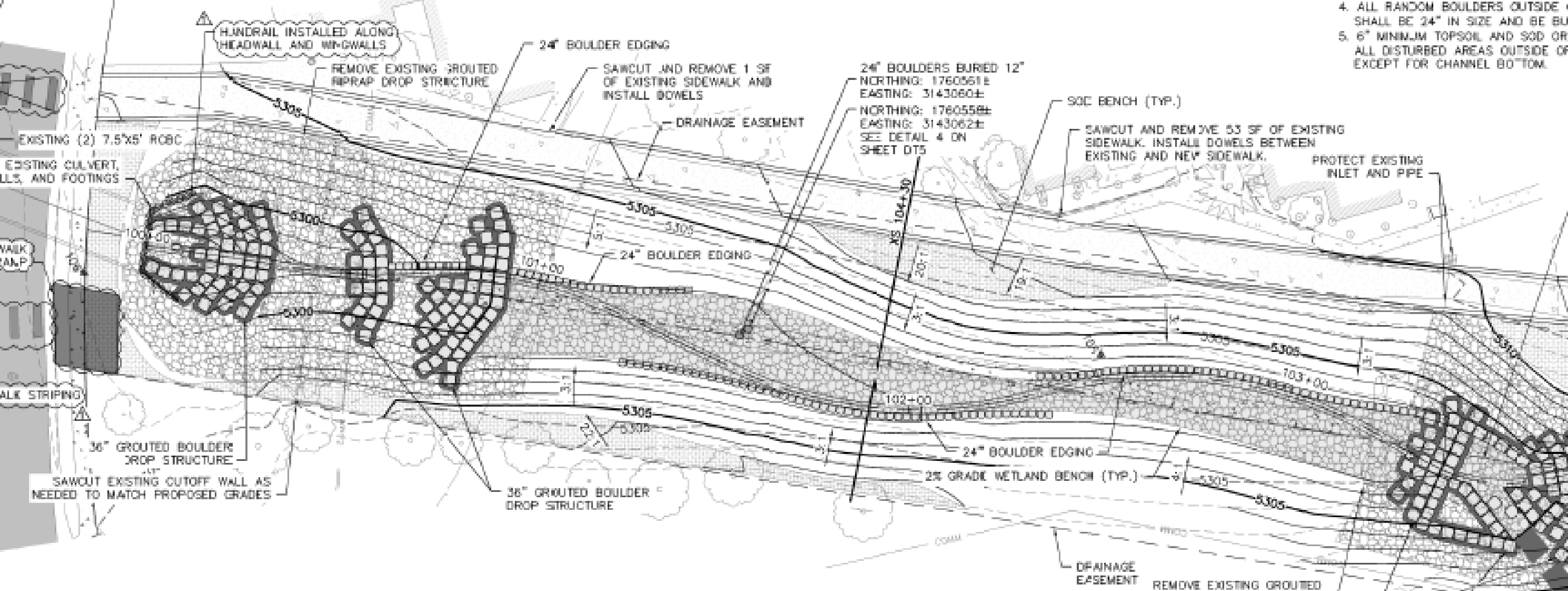
DATE JULY 2013

FIGURE NO. B-2

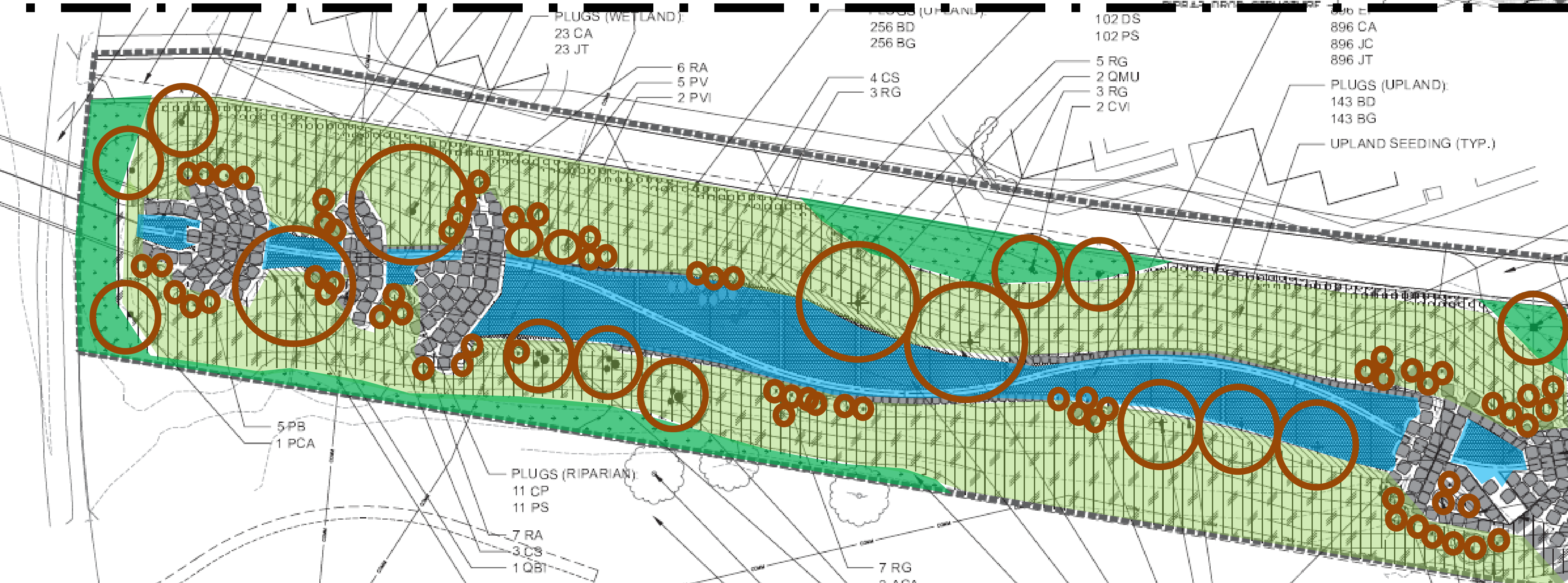
REACH 3

[CLICK HERE TO VIEW REACH 3 TEXT]
[CLICK HERE TO VIEW REACH 3 PROFILE]





4. ALL RANDOM BOULDERS OUTSIDE
SHALL BE 24" IN SIZE AND BE BU
5. 6" MINIMUM TOPSOIL AND SOD OR
ALL DISTURBED AREAS OUTSIDE OF
EXCEPT FOR CHANNEL BOTTOM.
HANDRAIL INSTALLED ALONG
HEADWALL AND WINGWALLS
24" BOULDER EDGING
REMOVE EXISTING GROUTED
RIPRAP DROP STRUCTURE
SAWCUT AND REMOVE 1 SF
OF EXISTING SIDEWALK AND
INSTALL DOWELS
24" BOULDERS BURIED 12"
NORTHING: 1760561±
EASTING: 3143060±
NORTHING: 1760558±
EASTING: 3143062±
SEE DETAIL 4 ON
SHEET DT5
SOD BENCH (TYP.)
SAWCUT AND REMOVE 53 SF OF EXISTING
SIDEWALK. INSTALL DOWELS BETWEEN
EXISTING AND NEW SIDEWALK.
PROTECT EXISTING
INLET AND PIPE
DRAINAGE EASEMENT
EXISTING (2) 7.5'X5' RCBC
EXISTING CULVERT,
LLS, AND FOOTINGS
24" BOULDER EDGING
XS 104+10
100+00
101+00
102+00
103+00
5305
5300
ALK STRIPING
36" GROUTED BOULDER
DROP STRUCTURE
SAWCUT EXISTING CUTOFF WALL AS
NEEDED TO MATCH PROPOSED GRADES
36" GROUTED BOULDER
DROP STRUCTURE
24" BOULDER EDGING
2% GRADE WETLAND BENCH (TYP.)
DRAINAGE
EASEMENT
REMOVE EXISTING GROUTED



PLUGS (WETLAND):
23 CA
23 JT
256 BD
256 BG
102 DS
102 PS
896 CA
896 JC
896 JT
6 RA
5 PV
2 PVI
4 CS
3 RG
5 RG
2 QMU
3 RG
2 CVI
PLUGS (UPLAND):
143 BD
143 BG
UPLAND SEEDING (TYP.)
5 PB
1 PCA
PLUGS (RIPARIAN):
11 CP
11 PS
7 RA
3 CS
1 QBI
7 RG

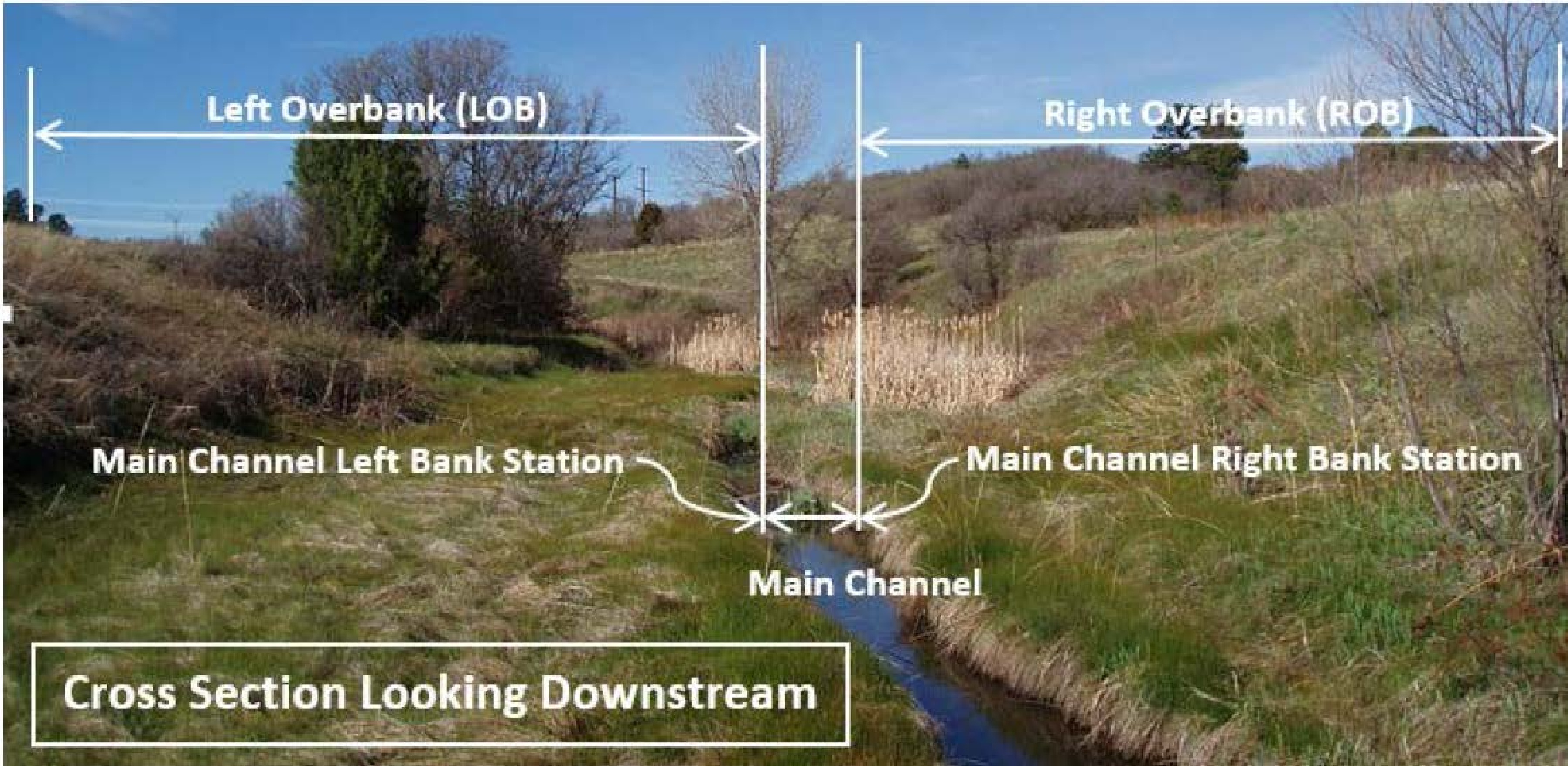
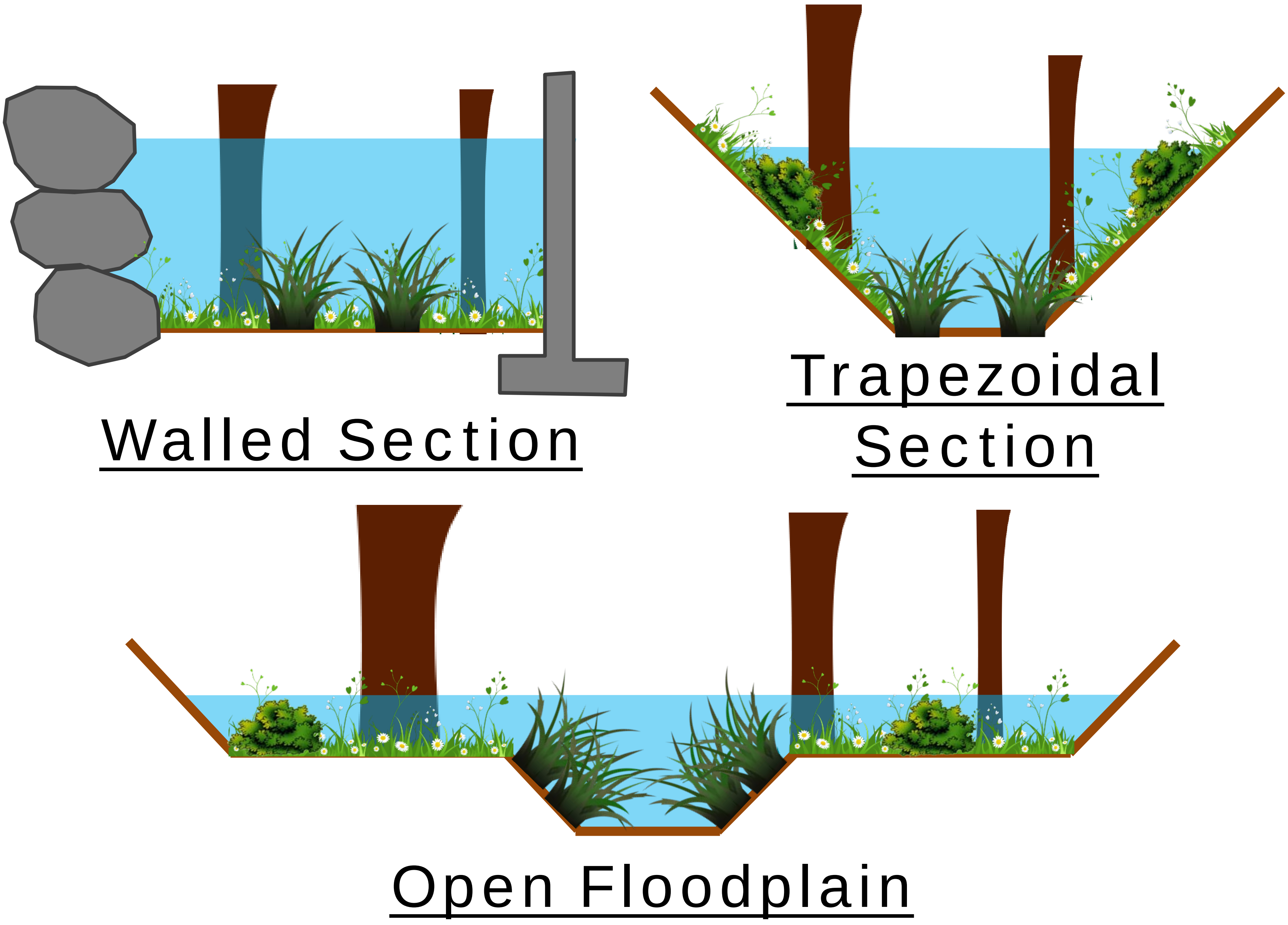


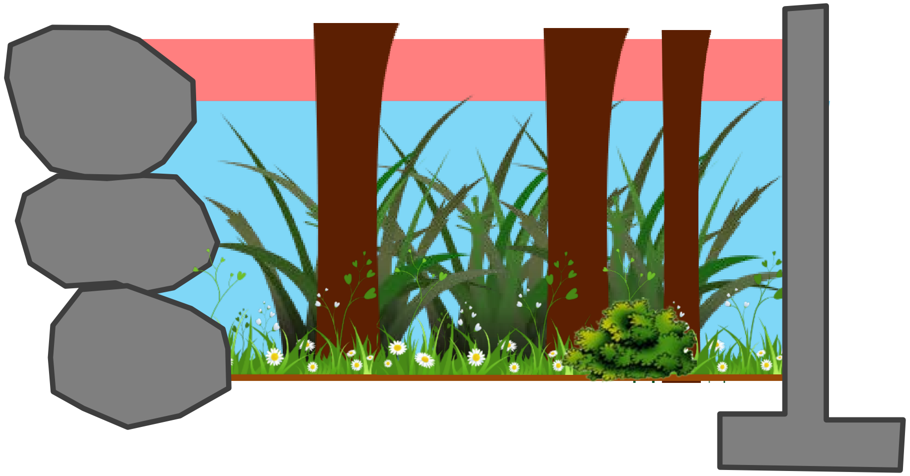
Figure 8-27. HEC-RAS cross section definitions

Table 8-5. Recommended roughness values

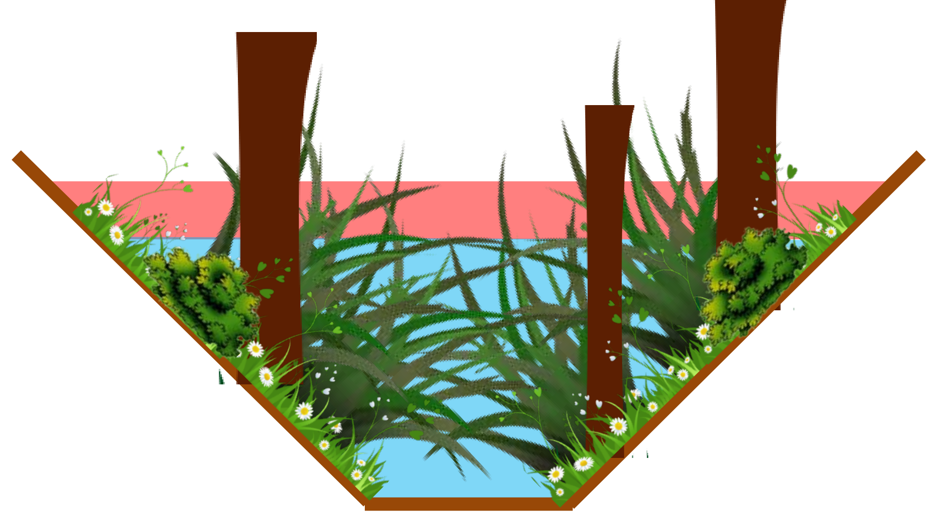
Location and Cover	**When Assessing Velocity, Froude No., Shear Stress**	**When Assessing Water Surface Elevation and Water Depth**
Main Channel (bankfull channel)		
Sand or clay bed	0.03	0.04
Gravel or cobble bed	0.035	0.07
Vegetated Overbanks		
Turfgrass sod	0.03	0.04
Native grasses	0.032	0.05
Herbaceous wetlands (few or no willows)	0.06	0.12
Willow stands, woody shrubs	0.07	0.16

(Source: Chow 1959, USDA 1954, Barnes 1967, Arcement and Schneider 1989, Jarrett 1985)

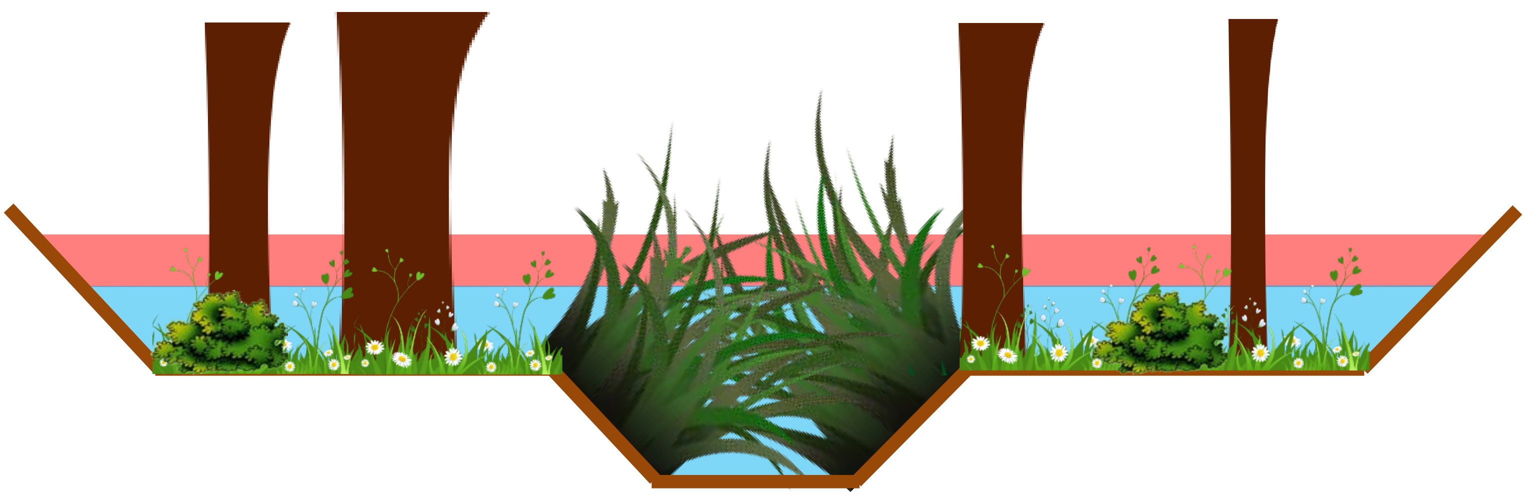

Walled Section
Trapezoidal Section
Open Floodplain



Walled Section

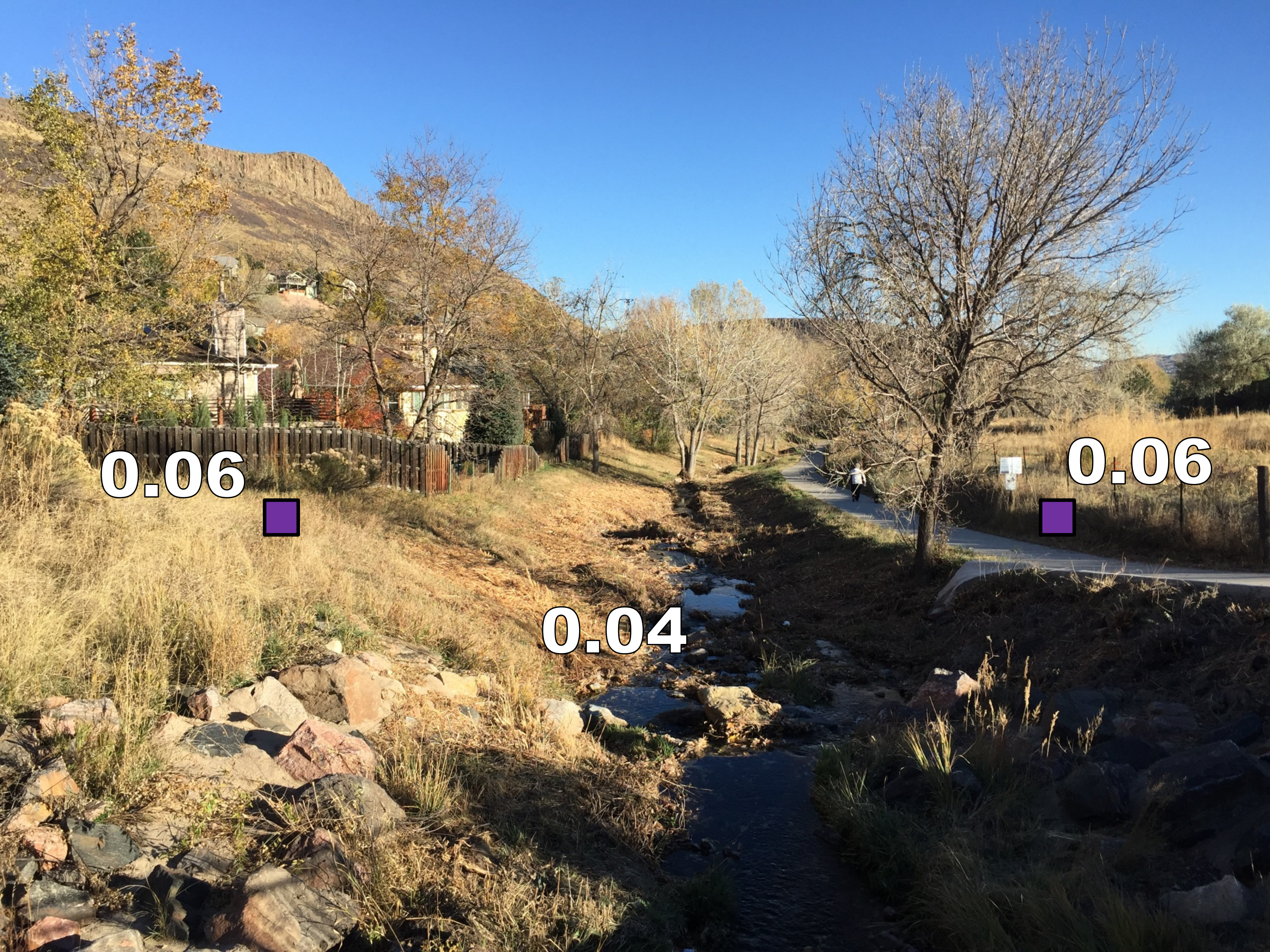


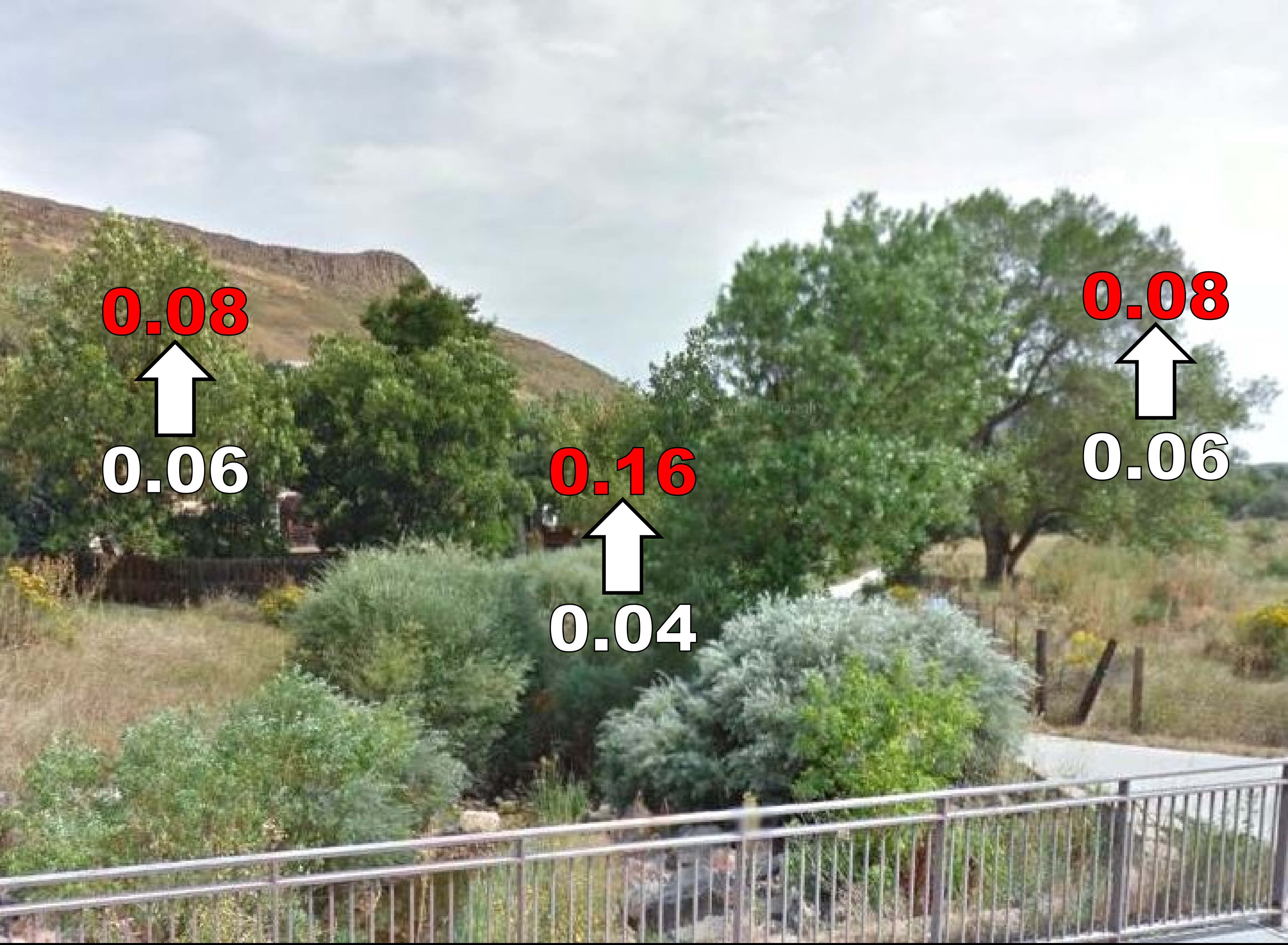
Trapezoidal Section



Open Floodplain

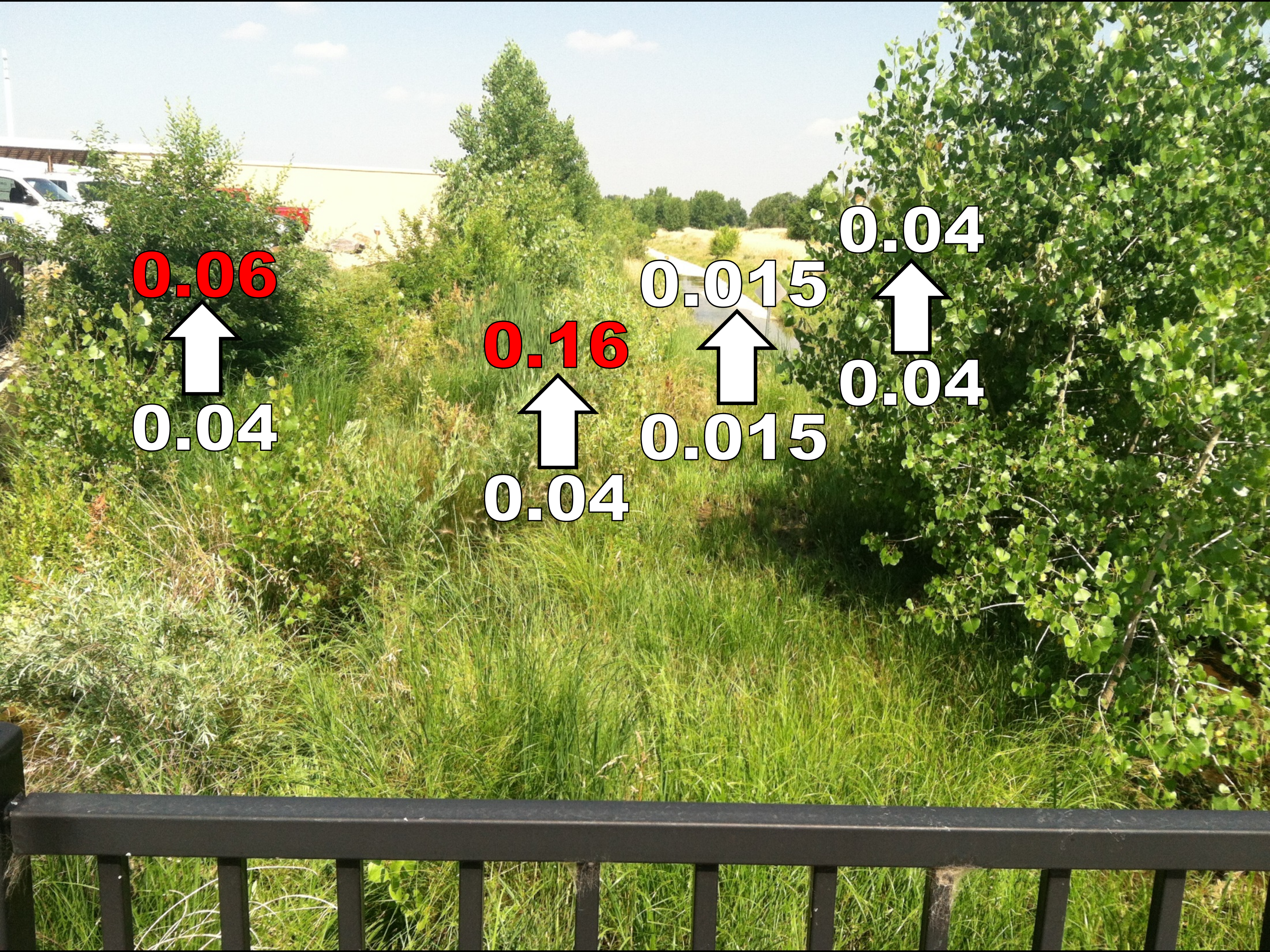
Tucker Gulch DS of Ford Street


0.06
0.06
0.04


0.08
0.06
0.16
0.04
0.08
0.06

Reach CC10 US of County Line Rd

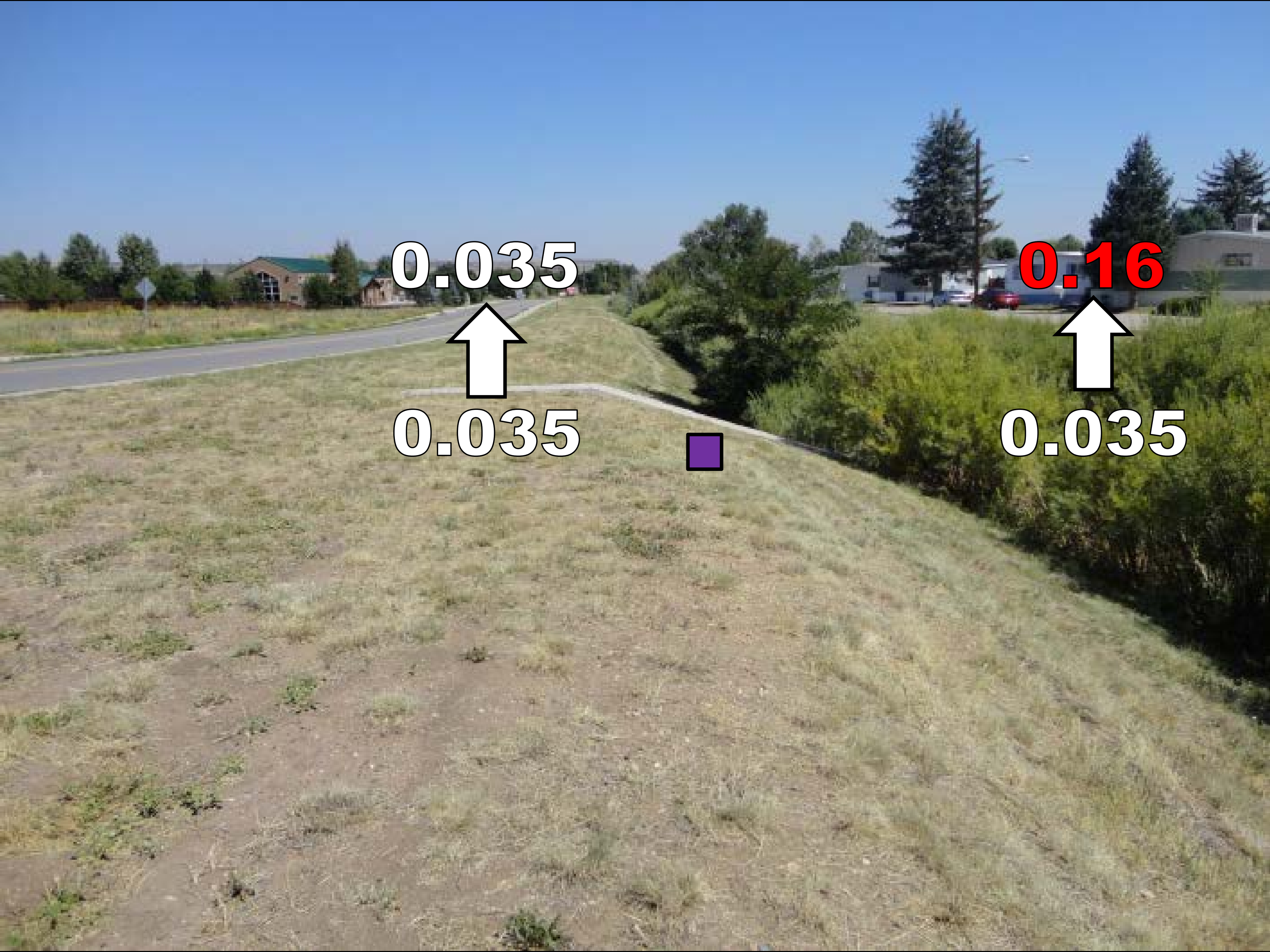

0.04
0.015
0.04
0.04


0.06
0.04
0.16
0.04
0.015
0.015
0.04
0.04


0.04
0.04
0.015
0.04

Lena Gulch DS of Ulysses St


0.035
0.035
0.035


0.035
0.16
0.035
0.035

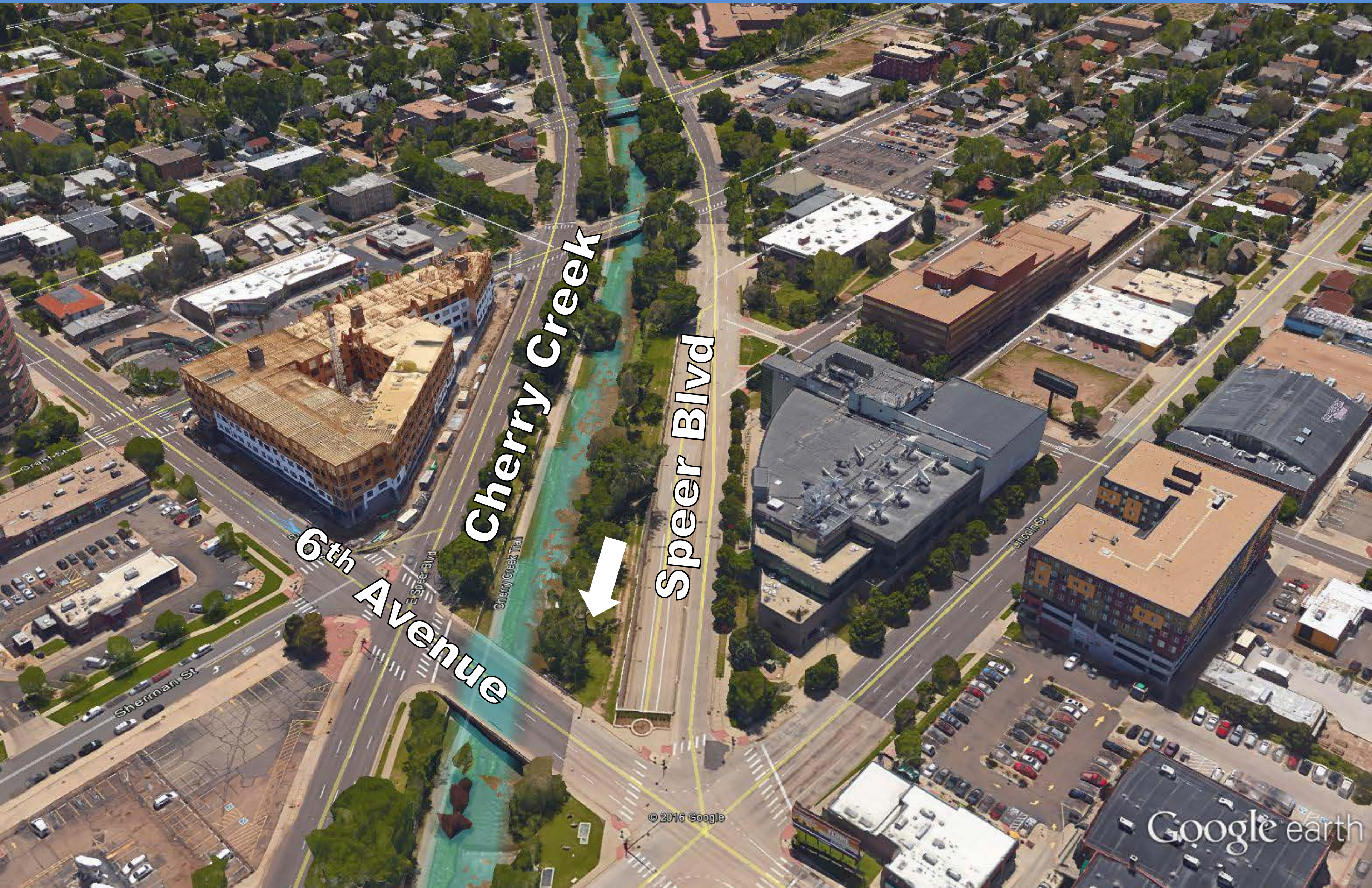

0.16
0.035

0.035
0.035
0.035

Elmer's Twomile US of Valmont

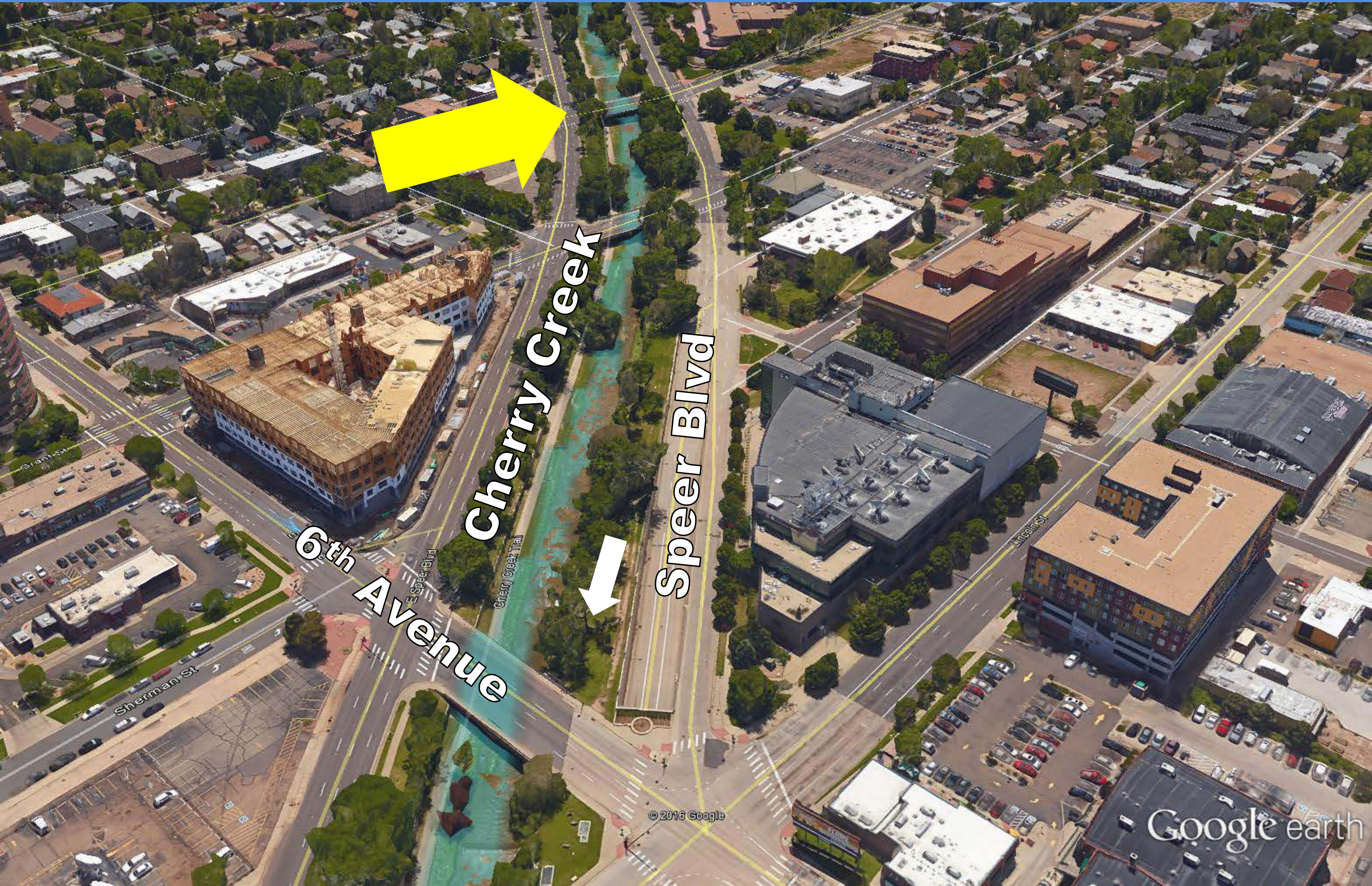
0.047
0.039
0.16
0.042
0.035
0.035

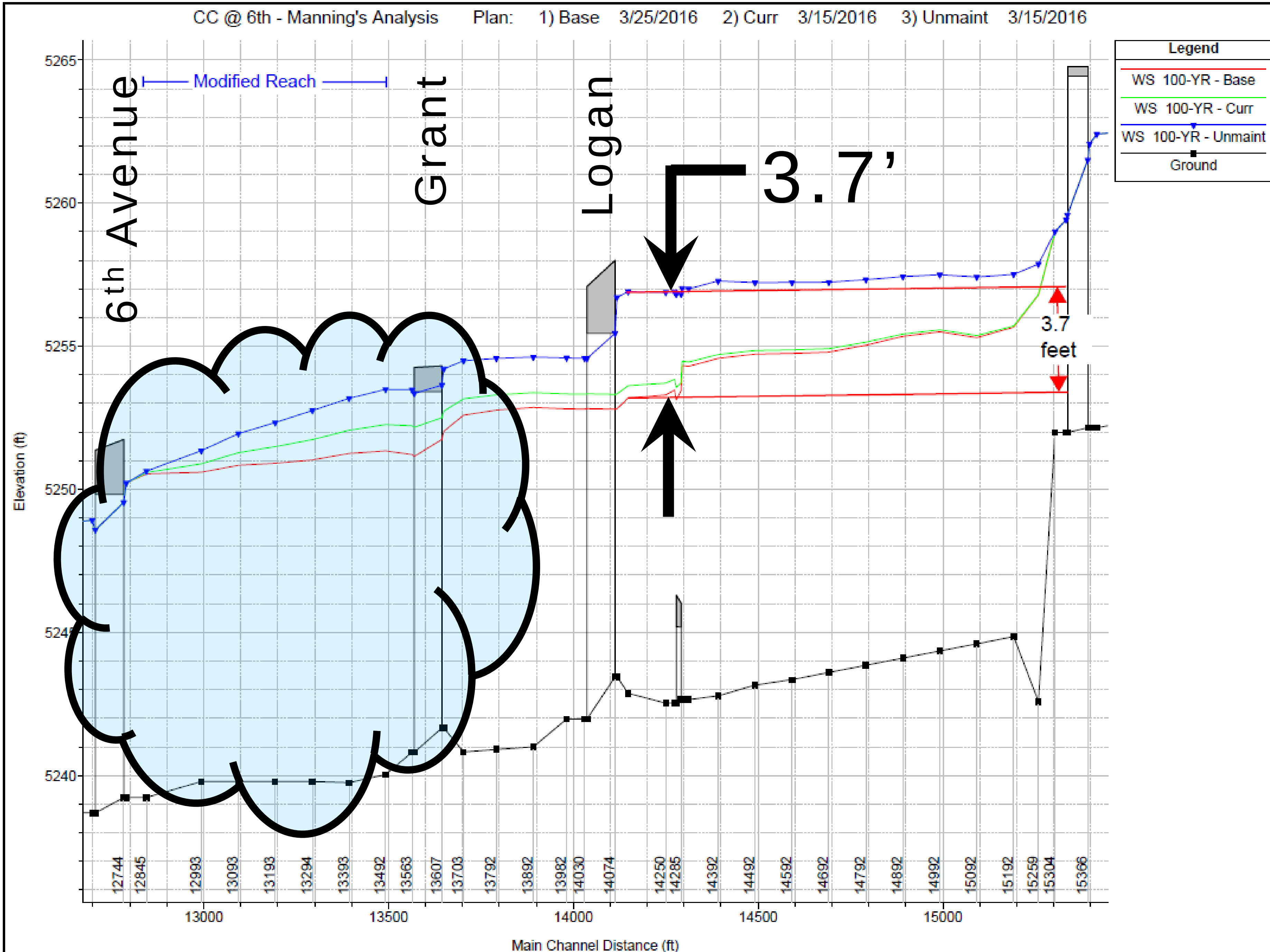
Cherry Creek US of 6th Ave




0.07
0.04
0.05
0.024
0.07
0.04

Cherry Creek US of 6th Ave





CC @ 6th - Manning's Analysis Plan: 1) Base 3/25/2016 2) Curr 3/15/2016 3) Unmaint 3/15/2016
Legend
WS 100-YR - Base
WS 100-YR - Curr
WS 100-YR - Unmaint
Ground
Modified Reach
6th Avenue
Grant
Logan
3.7’
3.7
feet
Elevation (ft)
Main Channel Distance (ft)
5265
5260
5255
5250
5240
13000
13500
14000
14500
15000
12744
12845
12993
13093
13193
13294
13393
13492
13563
13607
13703
13792
13892
13982
14030
14074
14250
14285
14392
14492
14592
14692
14792
14892
14992
15092
15192
15259
15304
15366

Wonderland Creek DS of Kalmia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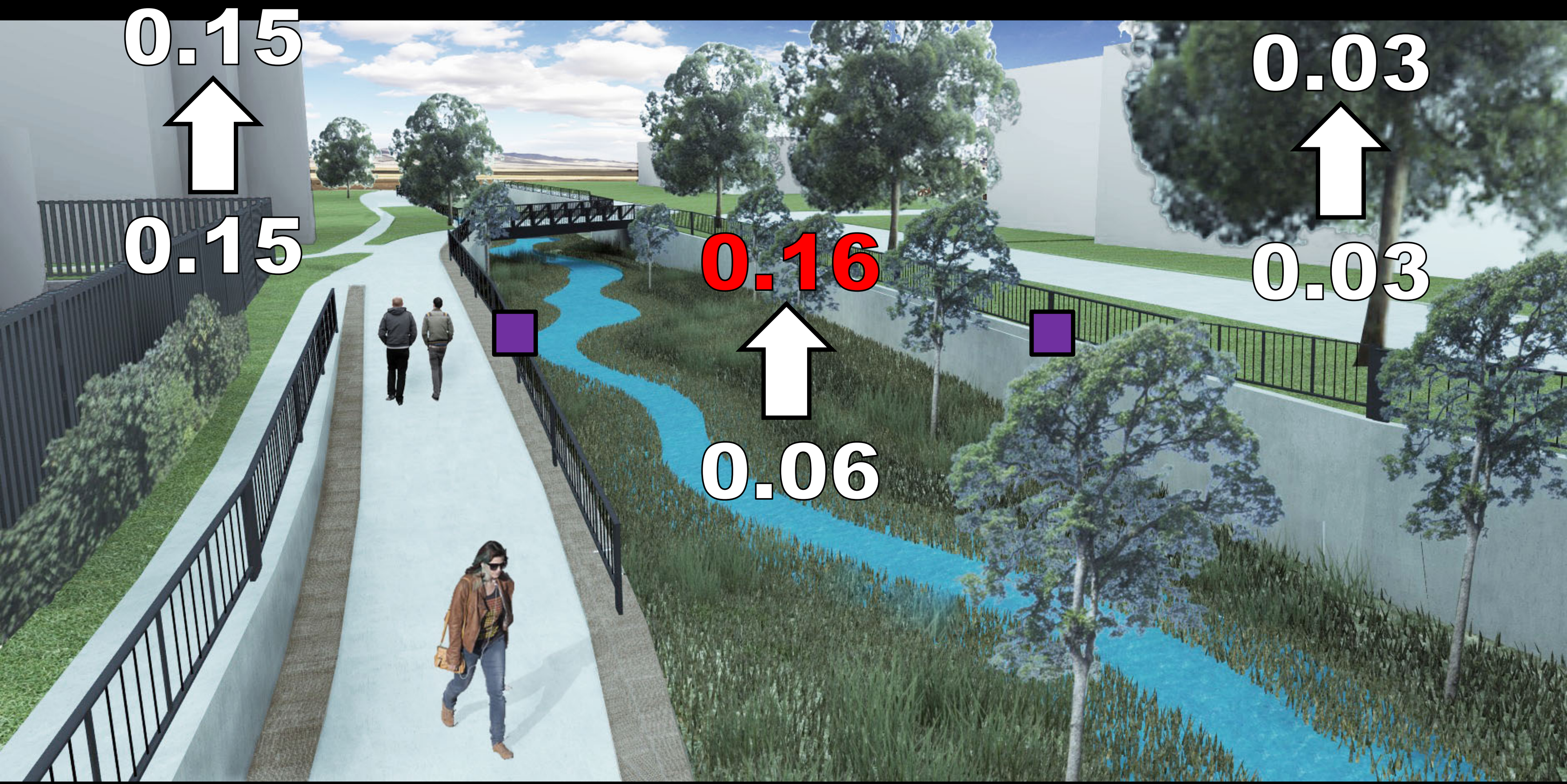
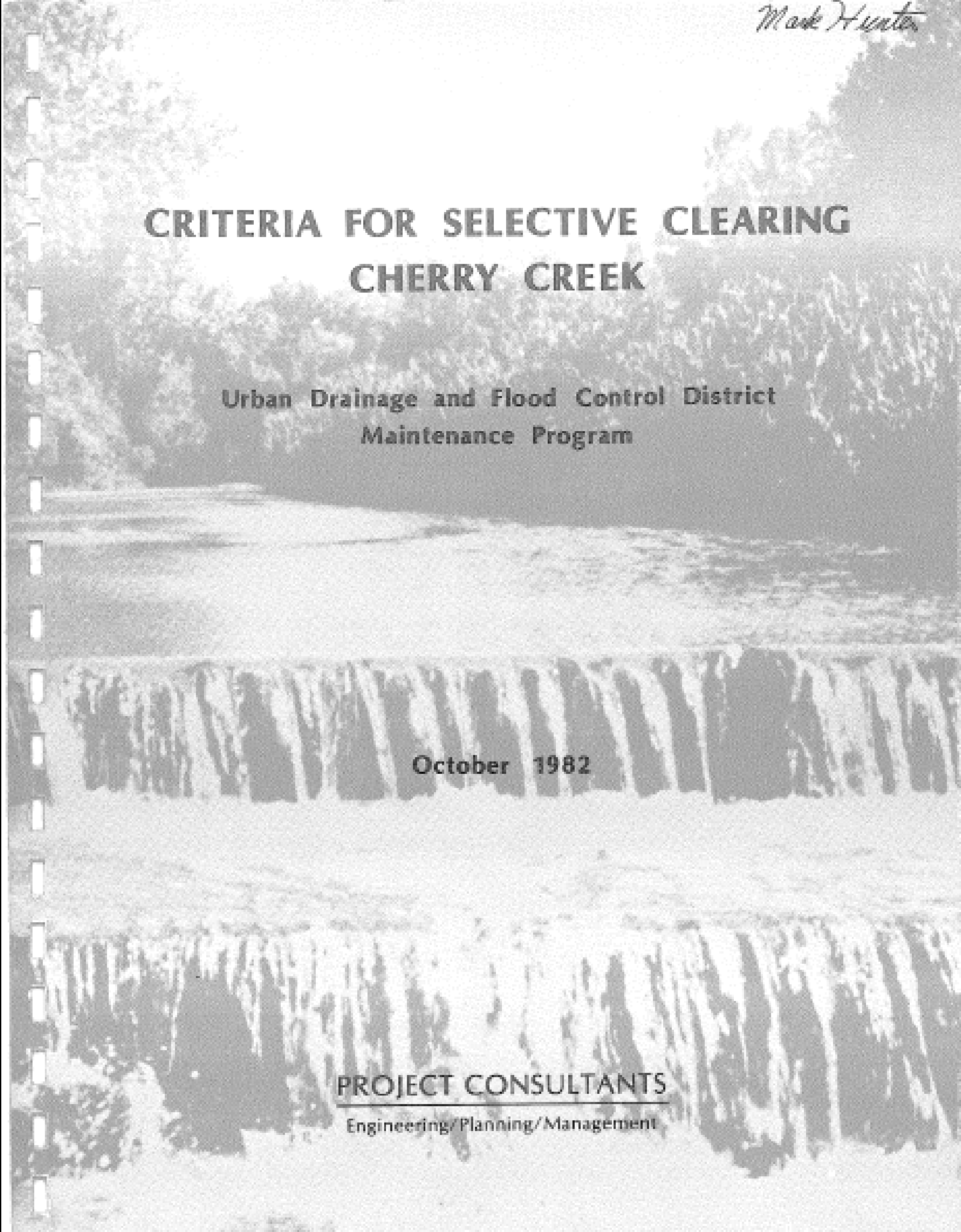
© 2016 Google


OAD
OSED
Wonderland Creek Greenway Trail


0.15
0.15
0.16
0.06
0.03
0.03

Mark Hunter



CRITERIA FOR SELECTIVE CLEARING
CHERRY CREEK

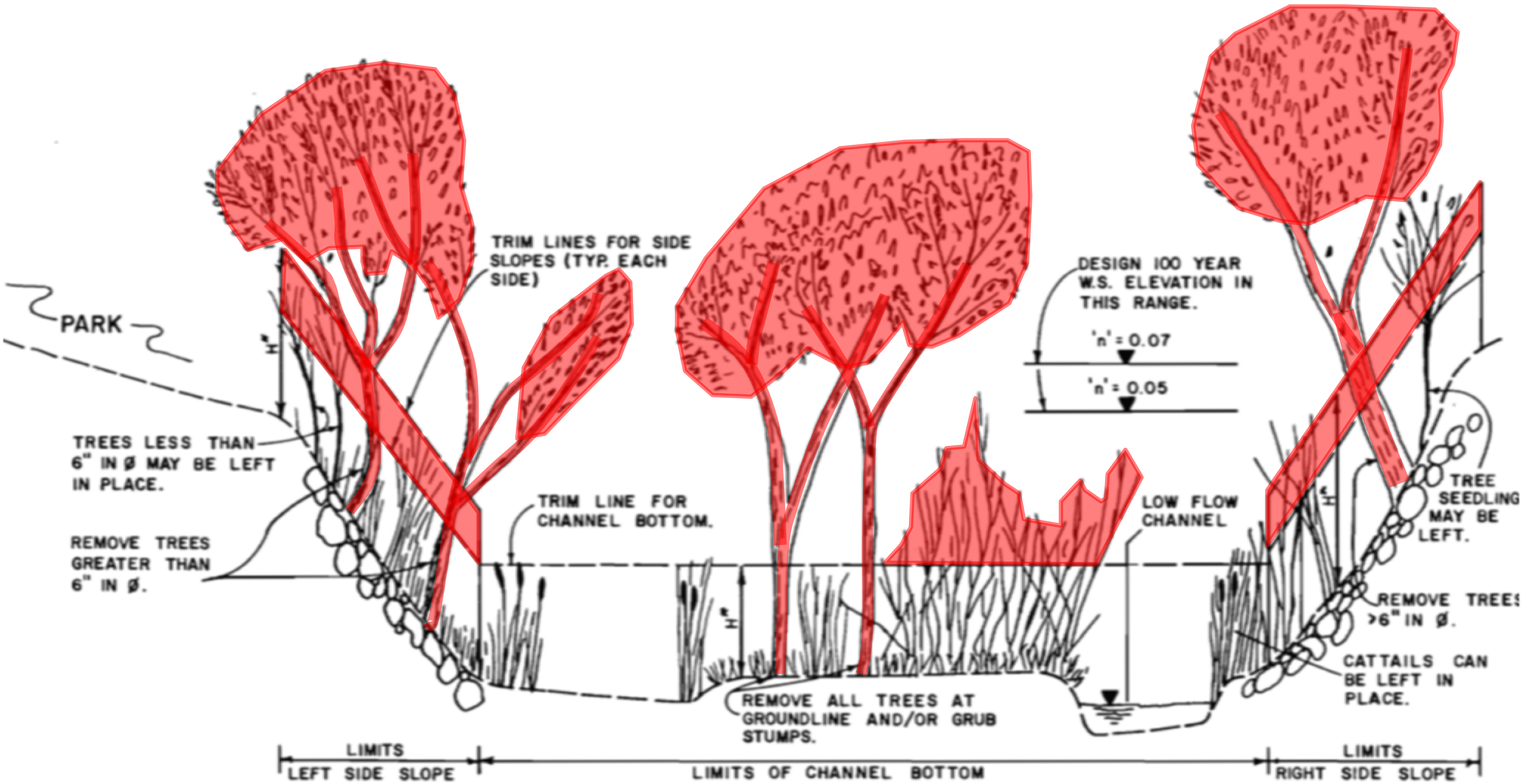
Urban Drainage and Flood Control District
Maintenance Program

October 1982

PROJECT CONSULTANTS

Engineering/Planning/Management

Cherry Creek US of University Blvd

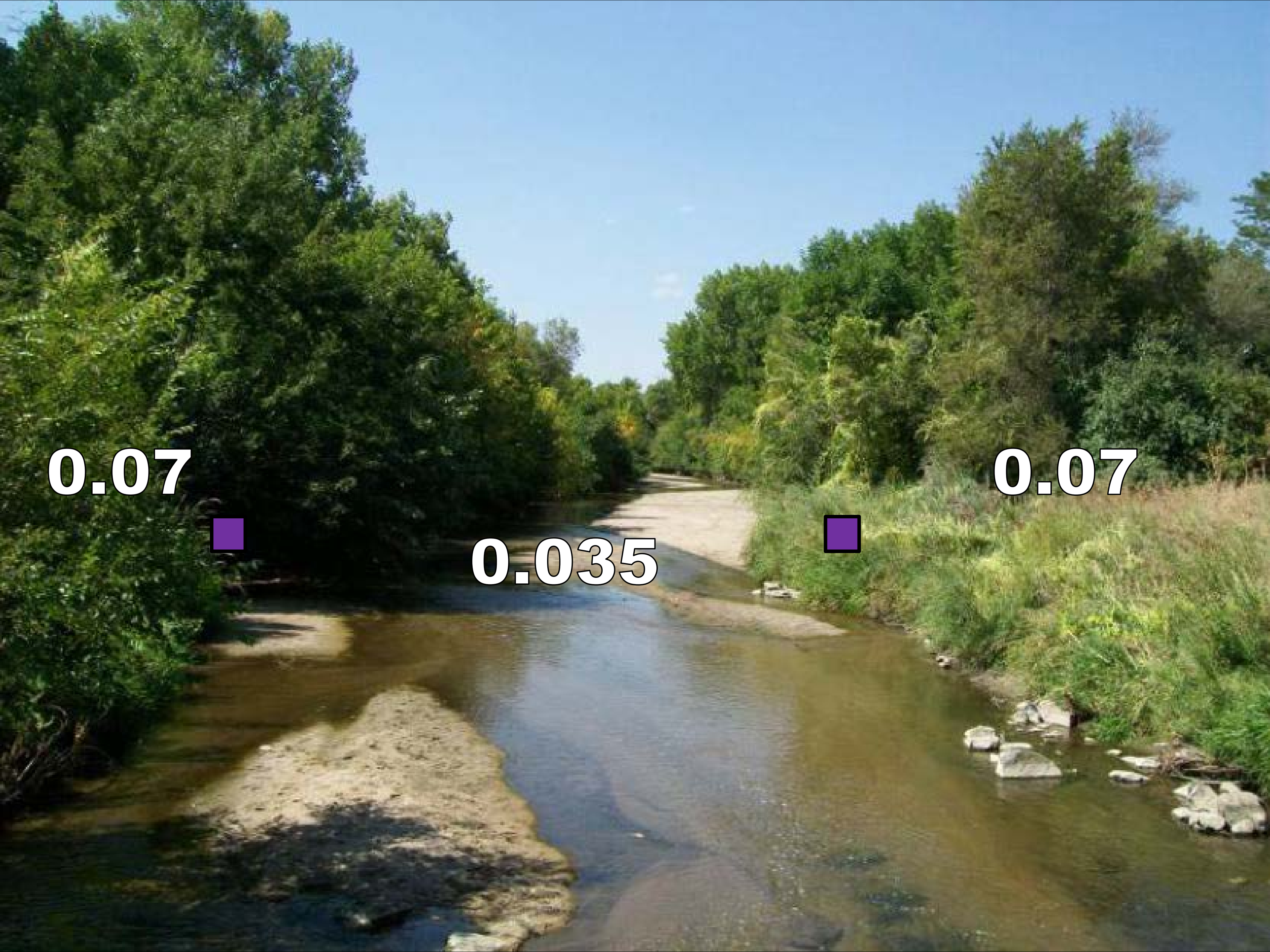


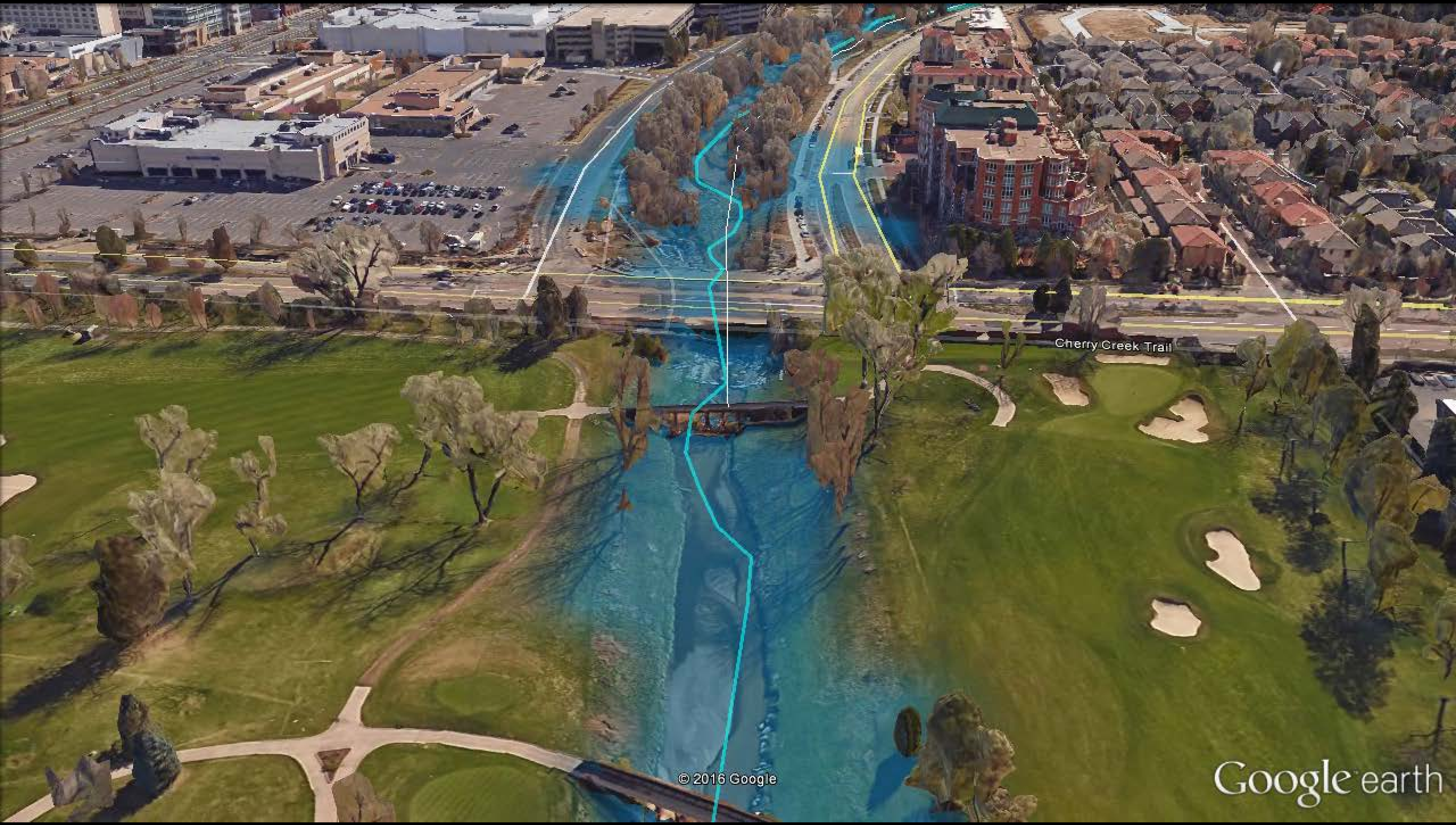
H* = 4' FOR BIENNIAL CLEARING TO MAX. 6' FOR ANNUAL CLEARING - CHANNEL BOTTOM SHOULD BE GRUBBED & RESEEDED IF FREQUENCY OF CLEARING IS TO BE LESS.

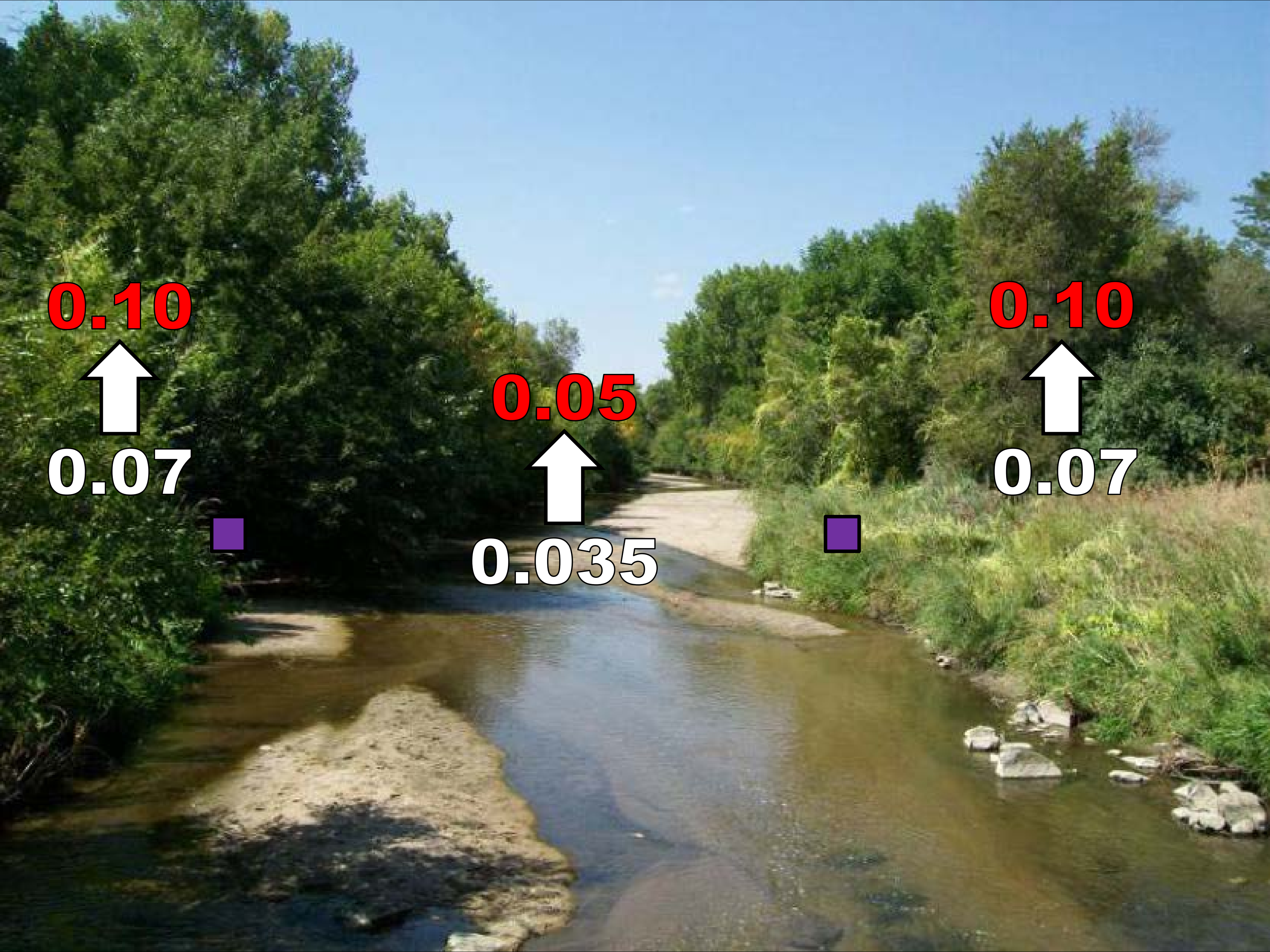
FIGURE 2

DIAGRAM OF CHERRY CREEK CLEARING

Scale: (H) 1" = 20'; (V) 1" = 5'.


0.07
0.035
0.07


Cherry Creek Trail
© 2016 Google
Google earth



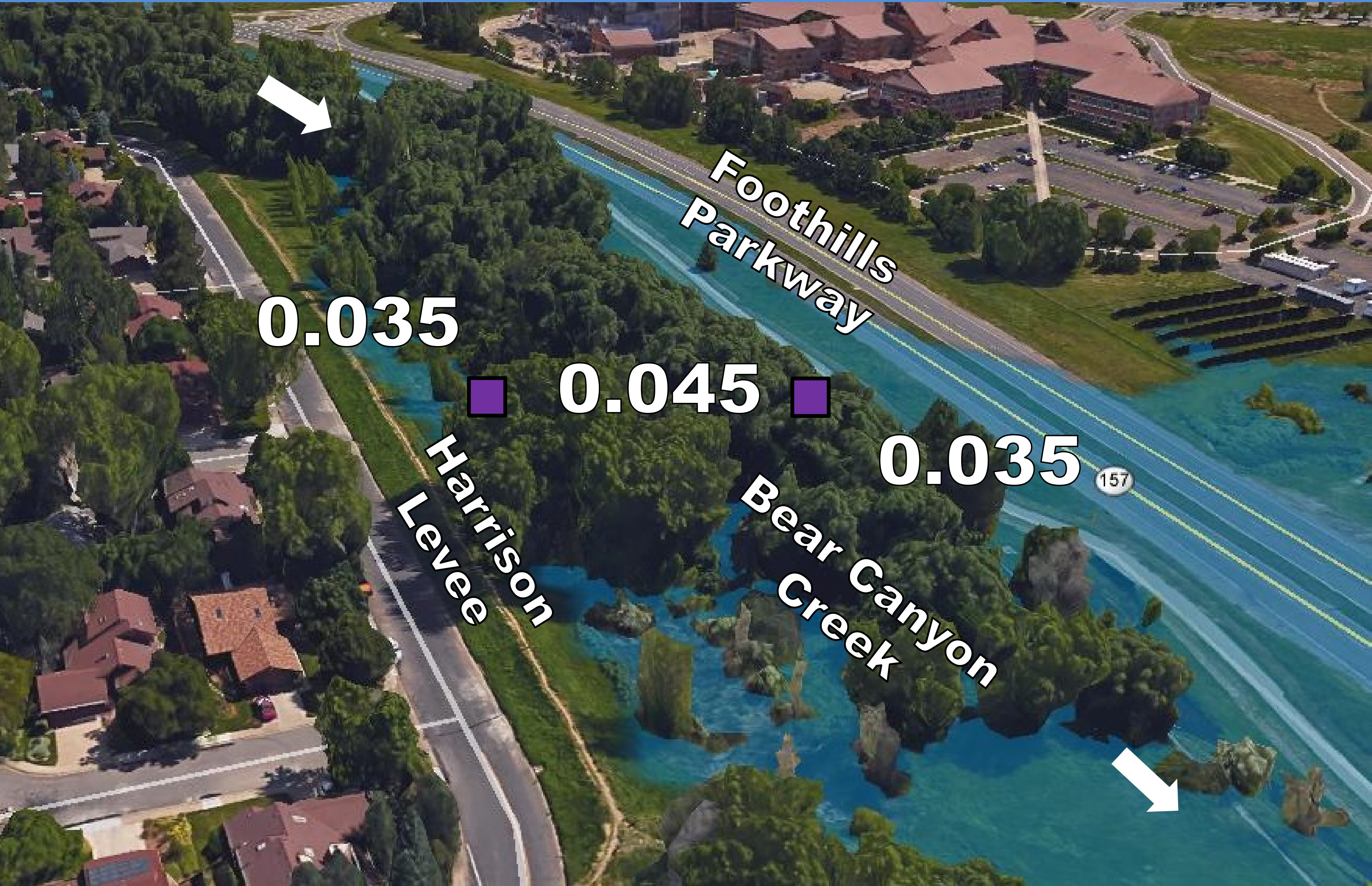
0.10
0.07
0.05
0.035
0.10
0.07

Cherry Creek DS of Broncos Pkwy


0.08
0.06
0.057
0.049
0.05
0.045

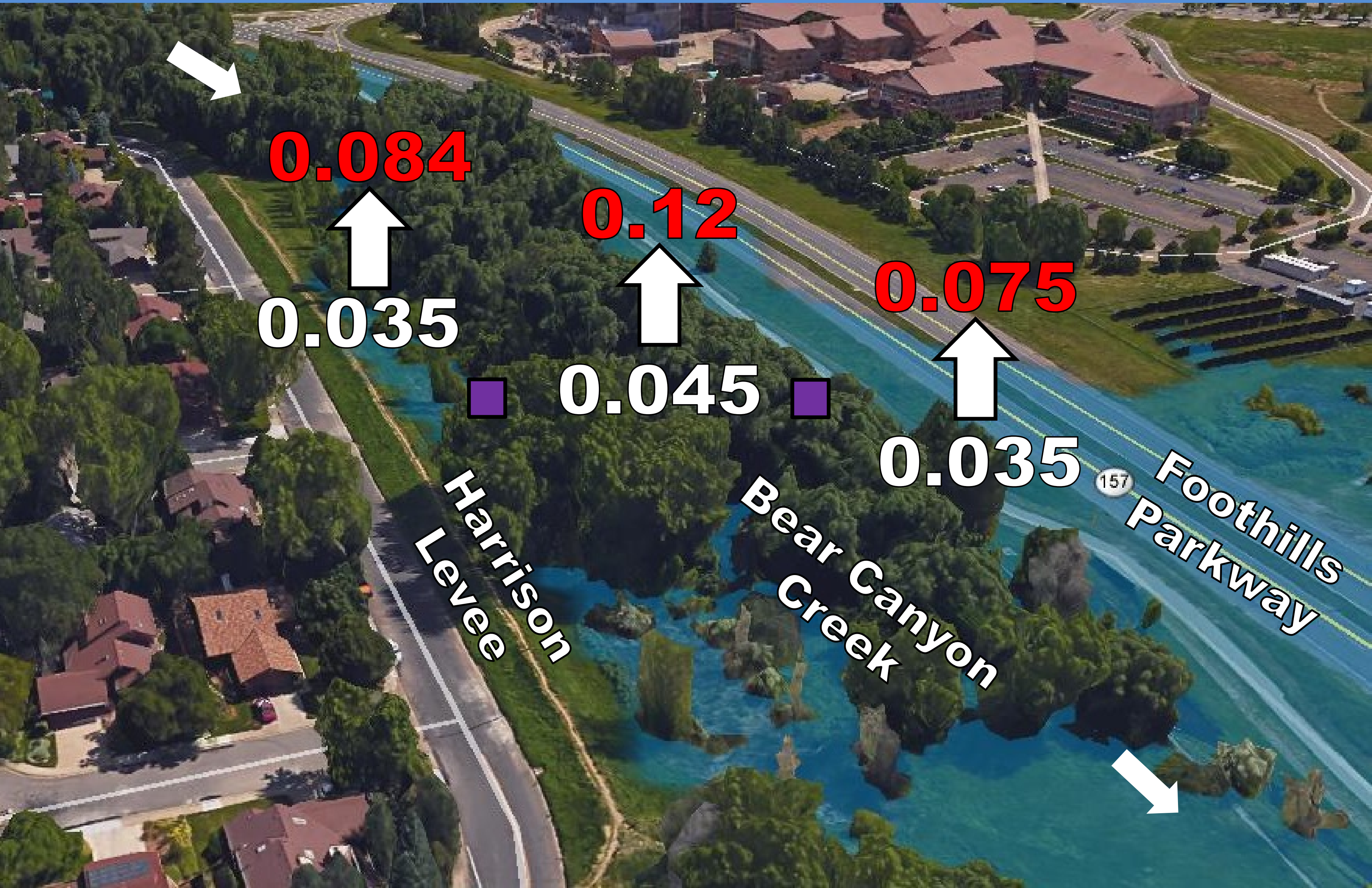
Cherry Creek DS of Broncos Pkwy

Bear Canyon Ck DS of Foothills

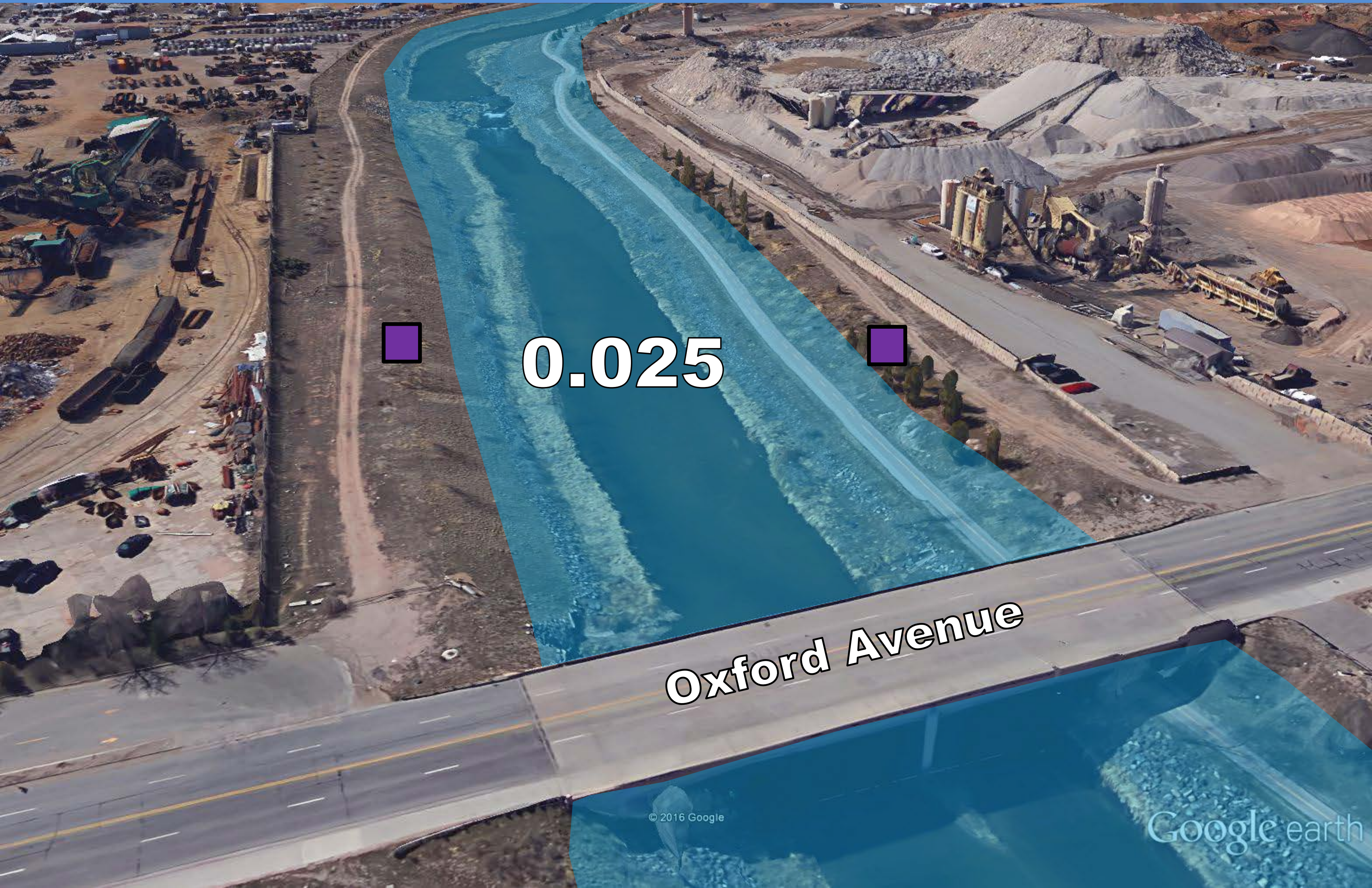



0.12
0.045

Bear Canyon Ck DS of Foothills



South Platte River Corps Channel

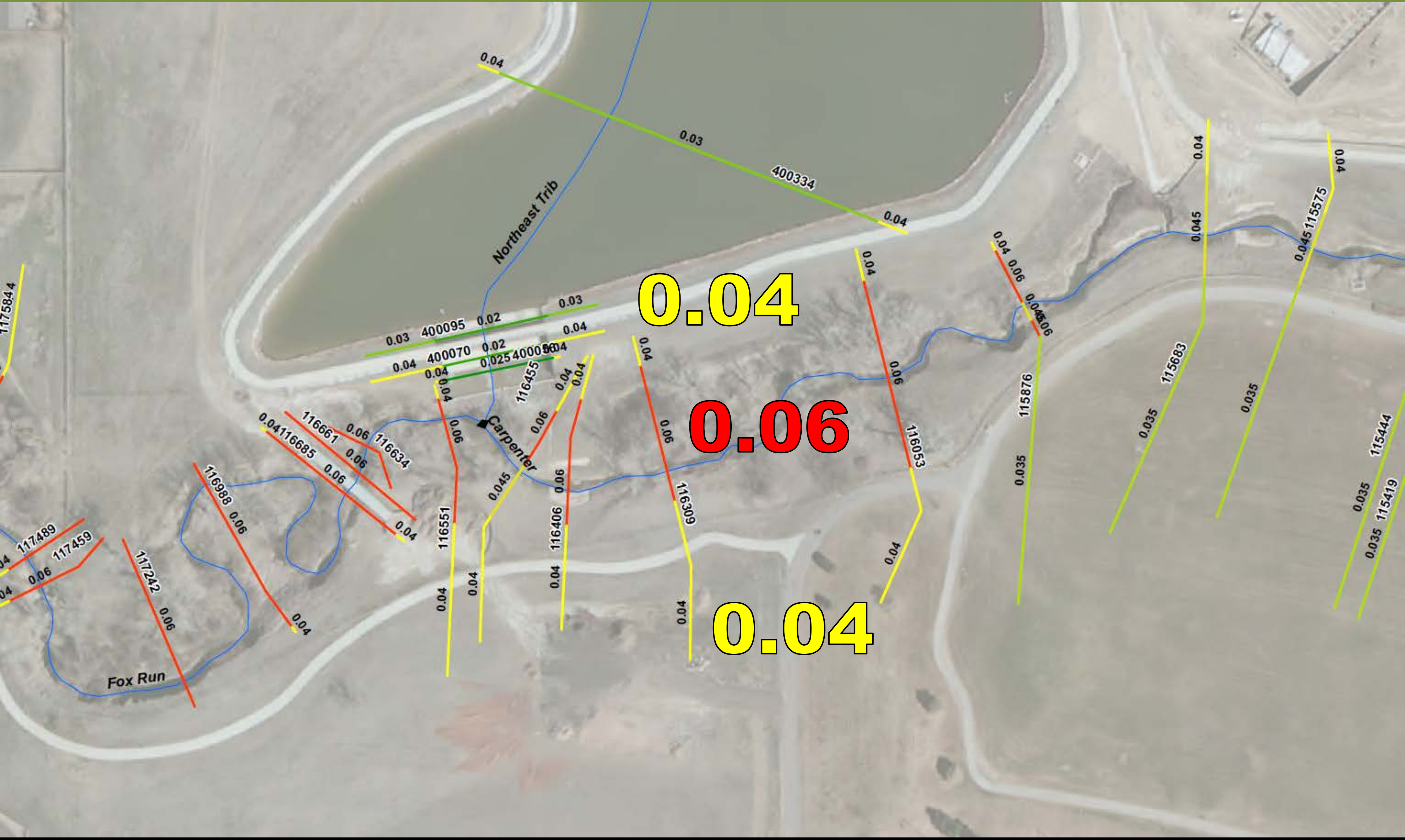



0.025
6/3/2009

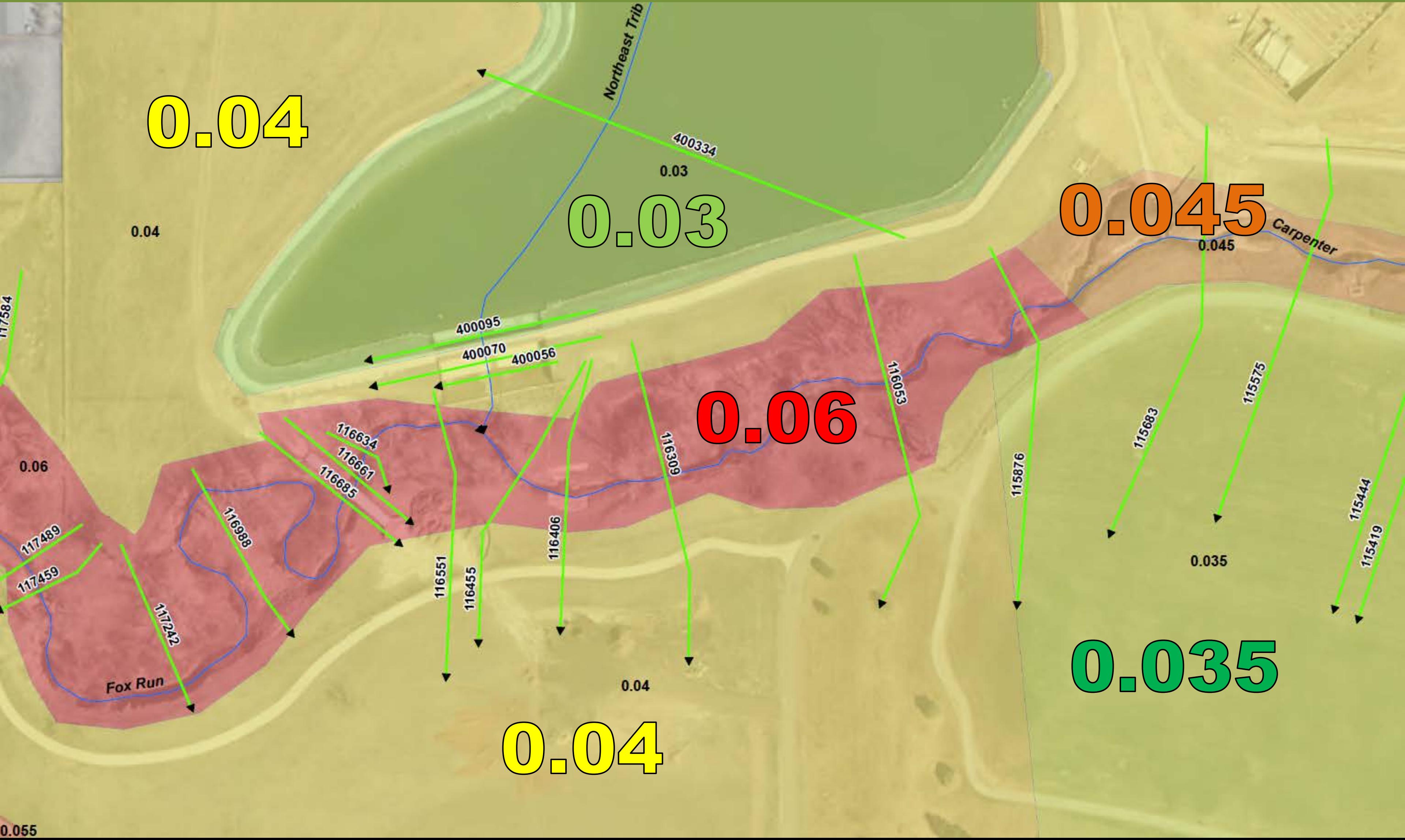
Documenting “n” Values

Documenting “n” Values

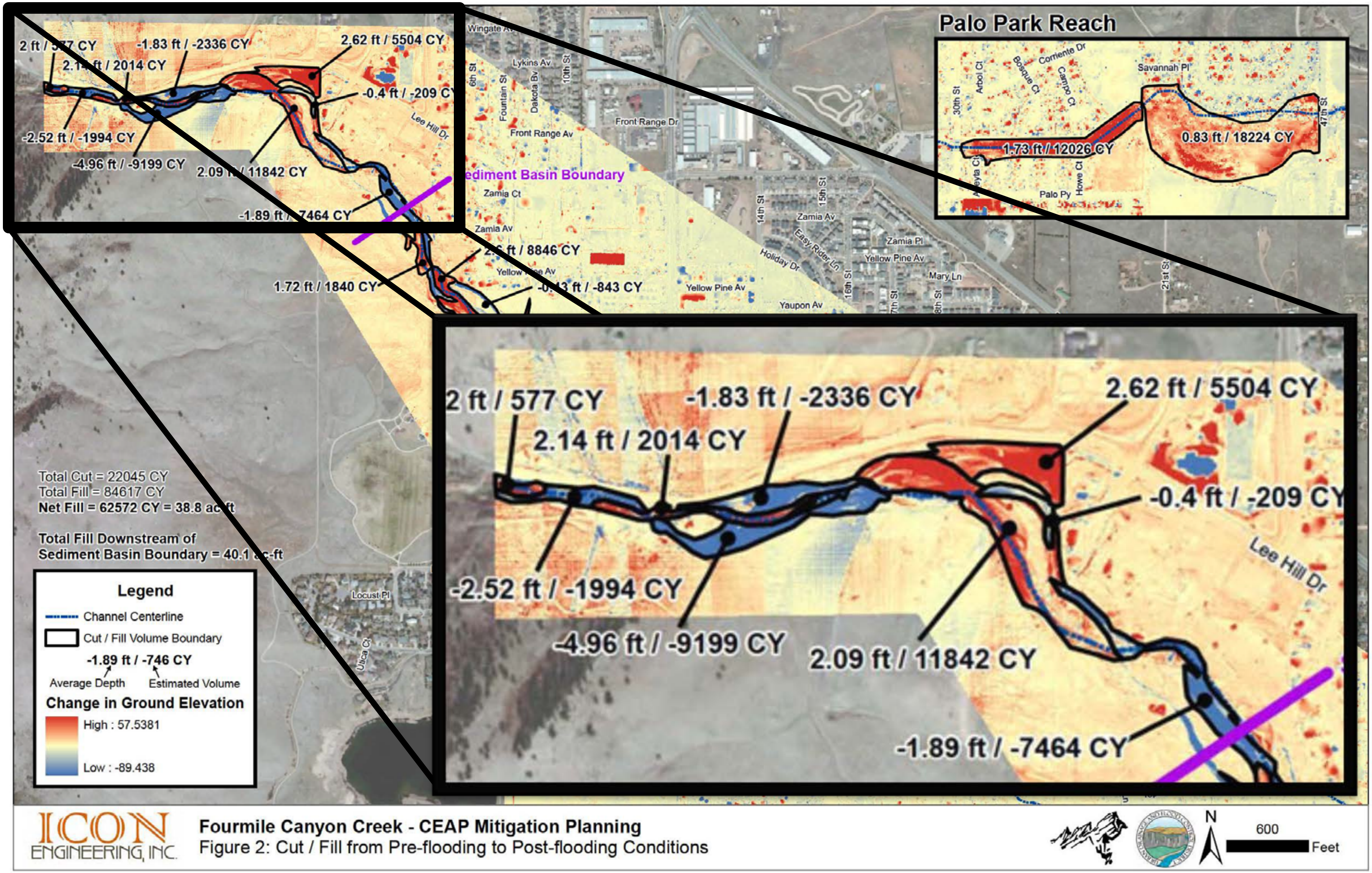
Documenting "n" Values

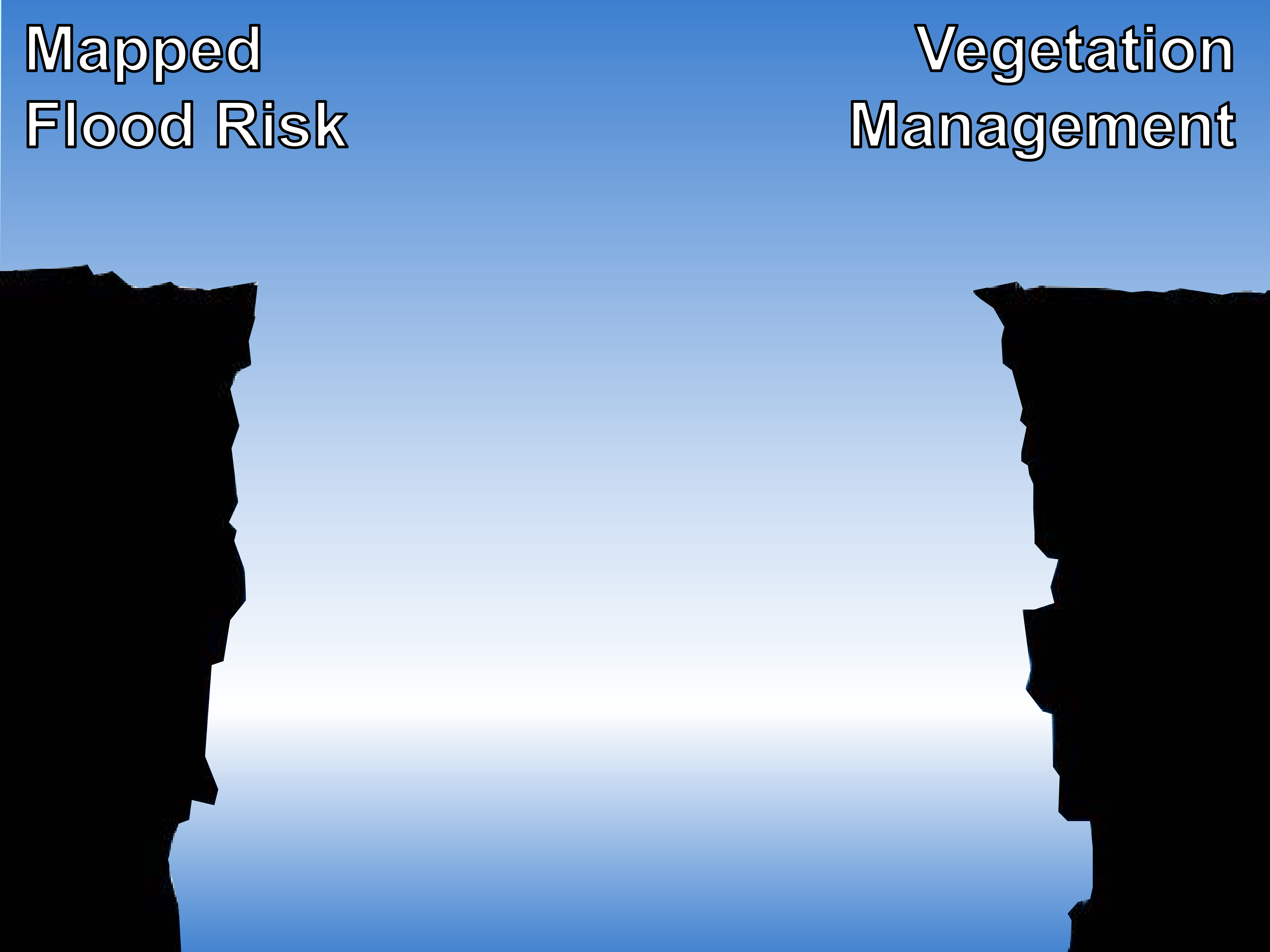


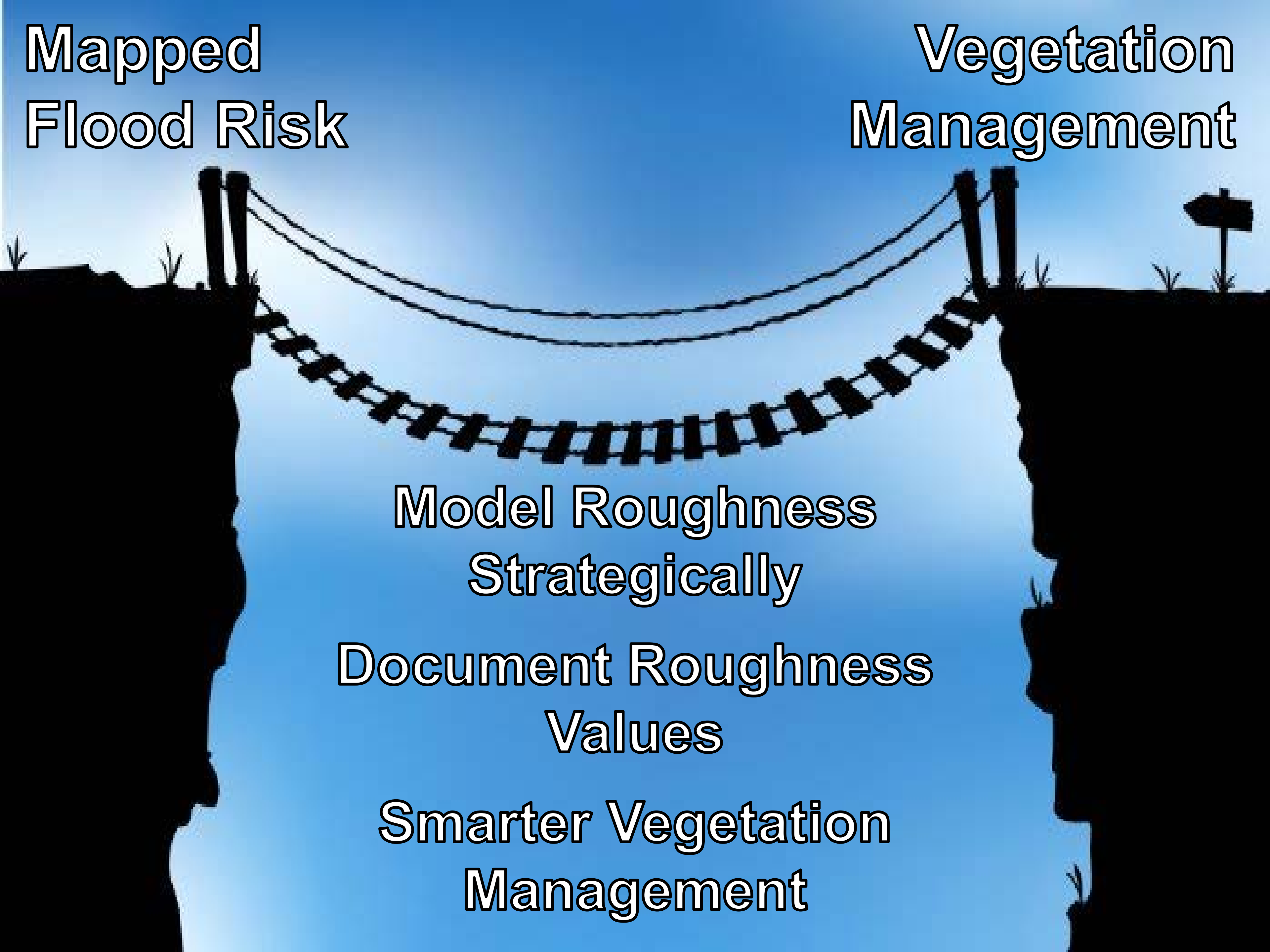
Documenting “n” Values



Documenting Sediment Deposition




Mapped
Flood Risk
Vegetation
Management


Mapped
Flood Risk
Vegetation
Management
Model Roughness
Strategically
Document Roughness
Values
Smarter Vegetation
Management

When you Say "Rough", We Want to Know "How Rough?"

Connecting Vegetation Management to the Mapped Flood Risk

David Skuodas, PE, Project Manager

THE DAILY NEWS

www.dailynews.com THE WORLD'S FAVORITE NEWSPAPER - Since 1879

ENGINEER SAYS: "NO COMMENT"

Lorem Ipsum In libris graecis appetere mea. At vim odio lorem omnes, pri id iuvaret partiendo. Vivendo menandri et sed. Lorem volumus blandit cu has.Sit cu alia porro fuisset.

Ea pro natum invidunt repudiandae, his et facilisis vituperatoribus. Mei eu ubique altera senserit, consul eripuit accusata has ne.

In libris graecis appetere mea. At vim odio lorem omnes, pri id iuvaret partiendo. Vivendo menandri et sed.

In libris graecis appetere mea. At vim odio lorem omnes, pri id iuvaret partiendo. Vivendo menandri et sed. Lorem volumus blandit cu has.Sit cu alia porro fuisset.

Ea pro natum invidunt repudiandae, his et facilisis vituperatoribus. Mei eu ubique altera senserit, consul eripuit accusata has ne.

Ea pro natum invidunt repudiandae, his et facilisis vituperatoribus.


129 A


DON’T GET THROWN
IN A
BAFFLE CHUTE DROP

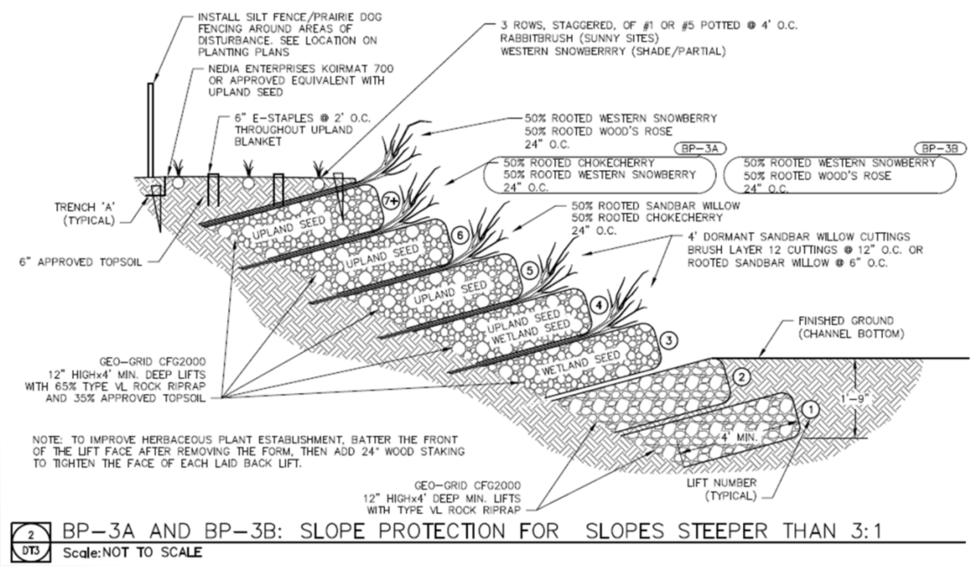
Soil Lift's Top Ten List

(Just a discussion)

Joe L. Williams, Jr., Senior Construction Manager

2016 UDFCD Annual Seminar April 5, 2016

What goes into making one happen?



Soil Lifts Top 10 List

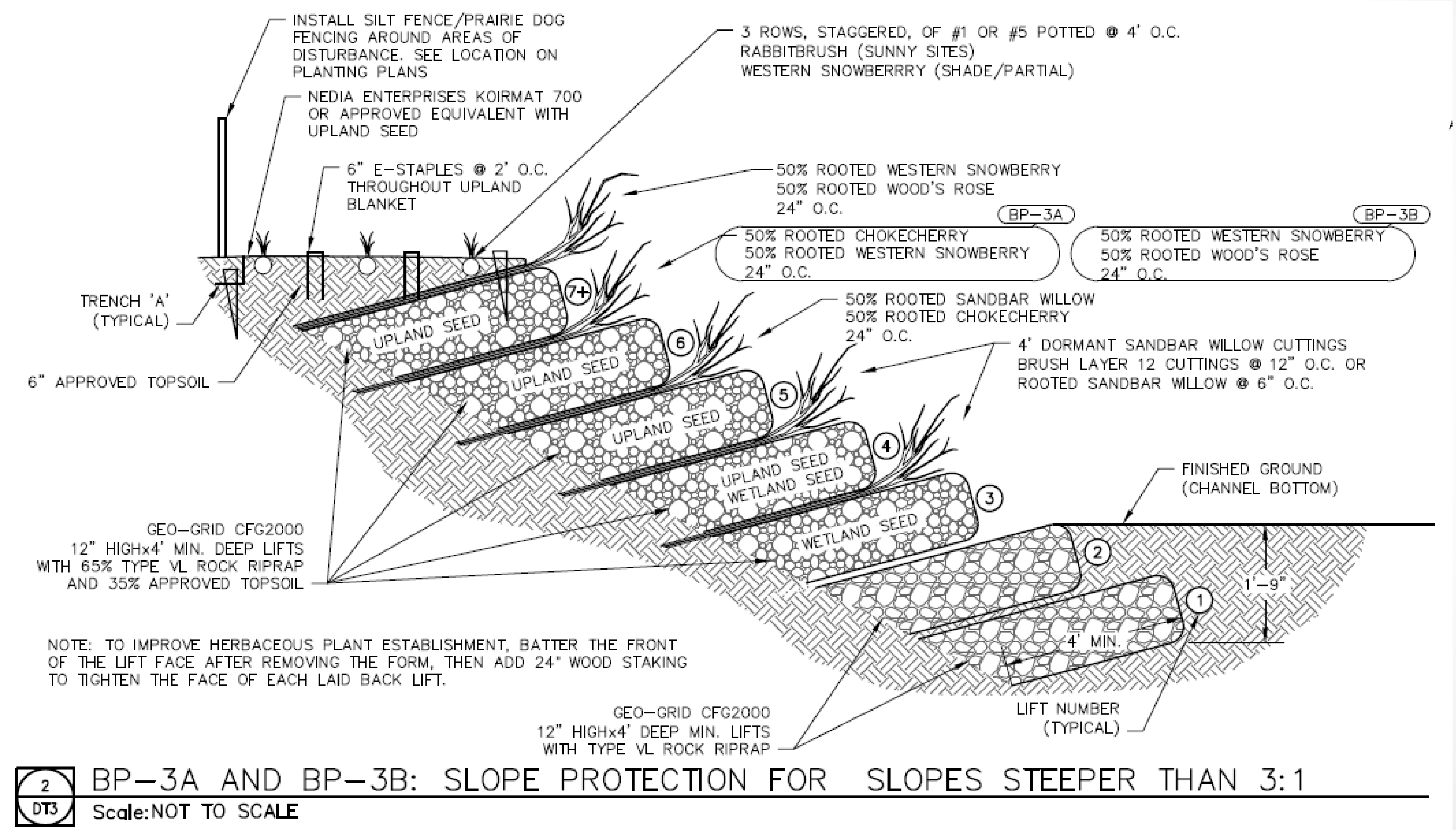
1. Communication
2. Layout
3. Foundation
4. Soil Conditions
5. Fabric
6. Lift filler material
7. Transitions
8. End Treatments
9. Growing Media
10. Long Term Management

Preconstruction meeting

- Are all of the needed materials on site?
- Overall layout of soil lifts.
- Transition points.
- Time frame for completing the section(s) of soil lifts?
- Discussion of worse case scenarios.
- Daily communication.
- Review the layout of the soil lifts with contractor.
- Tie in points of the lift section end.
- The first soil lifts dictates the entire look of the soil lift sections.

Grange Hall Creek at 108th Avenue

Grange Hall Creek at 108th Avenue



Foundation, foundation, foundation!

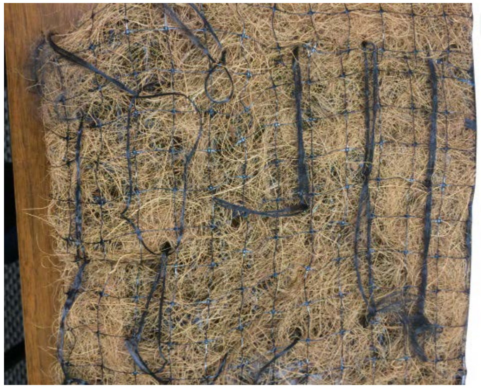
The first one counts!

Soil Conditions

Forms, Fabric and growing media

Fabric


10 28 2010




Excel CC-4 All Natural™
IECA
Specifications
Western Excelsior manufactures a full line of Rolled Erosion Control Products (RECPs). EXCEL CC-4 All Natural Extended Term Erosion Control Blanket consists entirely of coconut fibers manufactured into a matrix of uniform thickness and coverage. The coconut matrix is confined by a biodegradable, jute/scrim net on top and bottom, mechanically (stitch) bound on two inch centers with a biodegradable, cotton thread. Excel CC-4 All Natural is intended for slope and channel erosion control applications requiring up to thirty-six months of functional longevity. Actual field longevity is dependent on soil and climatic conditions.
Each roll of EXCEL CC-4 All Natural is made in the USA and manufactured under Western Excelsior's Quality Assurance Program to ensure a continuous distribution of fibers and consistent thickness. Verifiable values are provided in Table 1 and product characteristics are provided in Table 2.
Table 1 - Specified Expected Values
Tested Property | Test Method | Value
Tensile Strength (MD) x (TD) | ASTM D6818 | 16.0 lb/in (2.8 kN/m) x 11.0 lb/in (1.9 kN/m)
Elongation (MD) x (TD) | ASTM D6818 | 20 % x 20 %
Mass Per Unit Area | ASTM D6475 | 9.5 oz/yd^2 (322 g/m^2)
Thickness | ASTM D6525 | 0.26 in (7 mm)
Light Penetration | ASTM D6567 | 15 % open
Water Absorption | ASTM D1117 | 250 %
Table 2 - Netting
Top Net Type | Biodegradable, Jute Scrim Leno Weave
Bottom Net Type | Biodegradable, Jute Scrim Leno Weave
Top Net Opening Dimensions | 0.5 in (13 mm) x 1.0 in (25 mm)
Bottom Net Opening Dimensions | 0.5 in (13 mm) x 1.0 in (25 mm)
Excel CC-4 All Natural is available in multiple roll sizes ranging in width from 8.0 ft to 16.0 ft. and 112.5 ft to 600 ft in length. Standard roll sizes are 100 square yards, measuring 8.0 ft wide by 112.5 ft long. Custom roll sizes are available upon request.
Document # WE_EXCEL_CC4AN_SPEC. This document has been developed to provide the characteristic properties of the product described. For questions, to request performance data or installation recommendations, contact Western Excelsior at 866-540-9810 or wexcotech@westernexcelsior.com. Updated 8/19/2015.

Growing media

Lift filler material

Transition points

Long Term Management

Before and After

Before and After

Soil Lifts Top 10 List revised 4/5/16!

1. ~~In Lieu of Other Bank Protection Measures~~
2. ~~To Take Up Grade at a Steeper Slope (2:1)~~
3. ~~Foundation~~
4. ~~Fabric~~
5. ~~Transitions and End Treatments~~
6. ~~Soil Conditions (not too wet, not too dry)~~
7. ~~Growing Media~~
8. ~~Plant Selection and Care~~
9. ~~Layout~~
10. ~~Long Term Management~~
11. If you don’t install soil lifts correctly…

You too, like Dave

Could end up in a Baffle Chute Drop

The End

(In more ways than one!)

FEMA FLOOD REIMBURSMENT

TO DO OR NOT TO DO?

Steve Materkowski, EI, CPESC, Senior Construction Manager
Jason Stawski, EI, CFM, Construction Manager

OVERVIEW

- Introduction
- June/July 2015 Disaster Declaration
- FEMA Process
- Procurement Standards

June/July 2015

RAIN

FLOOD

DAMAGE

NOW WHAT?

GOLDSMITH GULCH

LAKEWOOD GULCH

MONTBELLO

CHERRY CREEK

CHERRY CREEK

CHERRY CREEK

SOUTH PLATTE RIVER

Who's This?

SOUTH PLATTE RIVER

SOUTH PLATTE RIVER

- June 24, 2015: Peak at Confluence Park approx. 15,000 cfs
- June 5, 2015: Peak at Dartmouth approximately 6,000 cfs
- Chatfield releases, May – July ranged 2,000-4500 cfs
- Releases + Increased Rainfall = Higher sustained flows

SOUTH PLATTE RIVER

SOUTH PLATTE RIVER

SOUTH PLATTE RIVER

SOUTH PLATTE RIVER

SOUTH PLATTE RIVER

SOUTH PLATTE RIVER

THE FEMA PROCESS

is not like……….

THE FEMA PROCESS

- Pre-event Conditions
- Document Event (might there be a Disaster Declaration?)
- Document post-event
  - Georeferenced photos or GPS
  - Tree sizes (base diameters)
  - Damage quantities (CY, SY, LF, etc.)
  - Debris within 100 yards upstream of improved structure qualifies
  - Debris adjacent to areas of public use (i.e. improved trails) qualifies

THE FEMA PROCESS

- Preliminary Damage Assessment (PDA)
- If you get a Declaration, you will have to go back in this process (i.e. Pre-event conditions, event conditions, etc.)
- Trash/Debris/Tree removal
  - Cubic Yard calculations
  - Dump tickets
  - Invoices
- **Document everything**

PROCUREMENT STANDARDS

2 C.F.R. § 200.318 – 326 & Appendix II

GENERAL PROCUREMENT STANDARDS

COMPETITION

METHODS OF PROCUREMENT

Size of Contract or Purchase Thresholds and Requirements

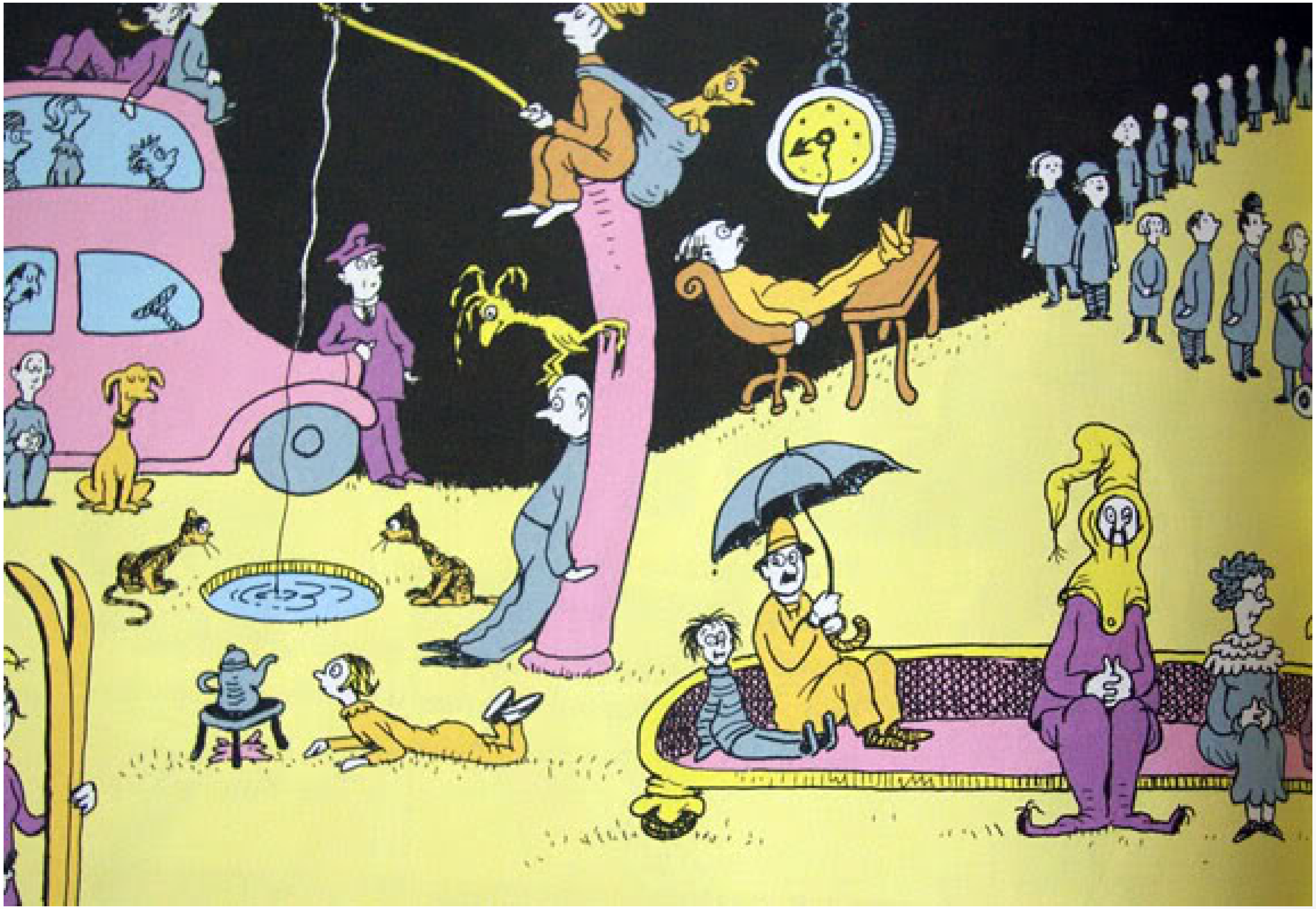
Category of Purchase	Size of Contract or Purchase	Required Documentation	Detailed Guidance
Micro Purchases	<$3,000	Cost Estimate made by Subgrantee from Catalog or other public sources	• New authorization in 2 C.F.R. 200.320 • Micro-purchases may be awarded without soliciting competitive quotations if the non-Federal entity considers the price to be reasonable. • To the extent practicable, the non-Federal entity must distribute micro-purchases equitably among qualified suppliers.
All Except A/E Services	Old: 44 CFR 13.36: $0-$150k New: 2 CFR 200: $3k-$150k	Quotes Required	• Quotes must have written documentation which includes a description of the following: – Services/Supplies needed – List of contractors contacted – Price quotes obtained – Rationale for procurement method • Quotes will be the basis for contractor selection and contract price
	$150k+	3 Formal Bids Required	• Bid process requires signed, bids with description, scope, and pricing from vendor. • Invitation to Bid or Request for Proposal (RFP) is required for purchases greater than $150k. – RFP must be publicly advertised for no fewer than 3 days. – Lowest bidder that meets criteria/restrictions for bidders must be documented. – A documented no-bid response constitutes a response. • Contract is required for purchases greater than $150k. • For split purchases, the value of goods purchased in the same fiscal year is combined. • Sole source requirements: price, signature, what is being quoted, rationale for why it is cost reasonable.
A/E Services	$0-$150k[3]	Quotes Required	• Quotes must have written documentation which includes a description of the following: – Services/Supplies needed – List of contractors contacted – Price quotes obtained – Rationale for procurement method • Quotes will be the basis for contractor selection and contract price
	$150k+	3 Formal Bids / RFQ Required	• Bid process requires signed, bids with description, scope, and pricing from vendor. • Invitation to Bid or Request for Proposal (RFP) is required for purchases greater than $150k. – RFP must be publicly advertised for no fewer than 3 days. – Lowest bidder that meets criteria/restrictions for bidders must be documented. – A documented no-bid response constitutes a response. • Contract is required for purchases greater than $150k. • Sole source requirements: price, signature, what is being quoted, rationale for why it is cost reasonable. • May use competitive proposal procedures for qualifications-based procurement of A/E services where most qualified competitor is selected.

CONTRACT COST AND PRICE

OTHER PROCUREMENT SECTIONS

- Contracting with small and minority businesses, women’s business enterprises, and labor surplus area firms
- Procurement of recovered materials
- Awarding agency and pass-through entity review
- Bonding requirements
- Contract provisions

THE WAITING PLACE

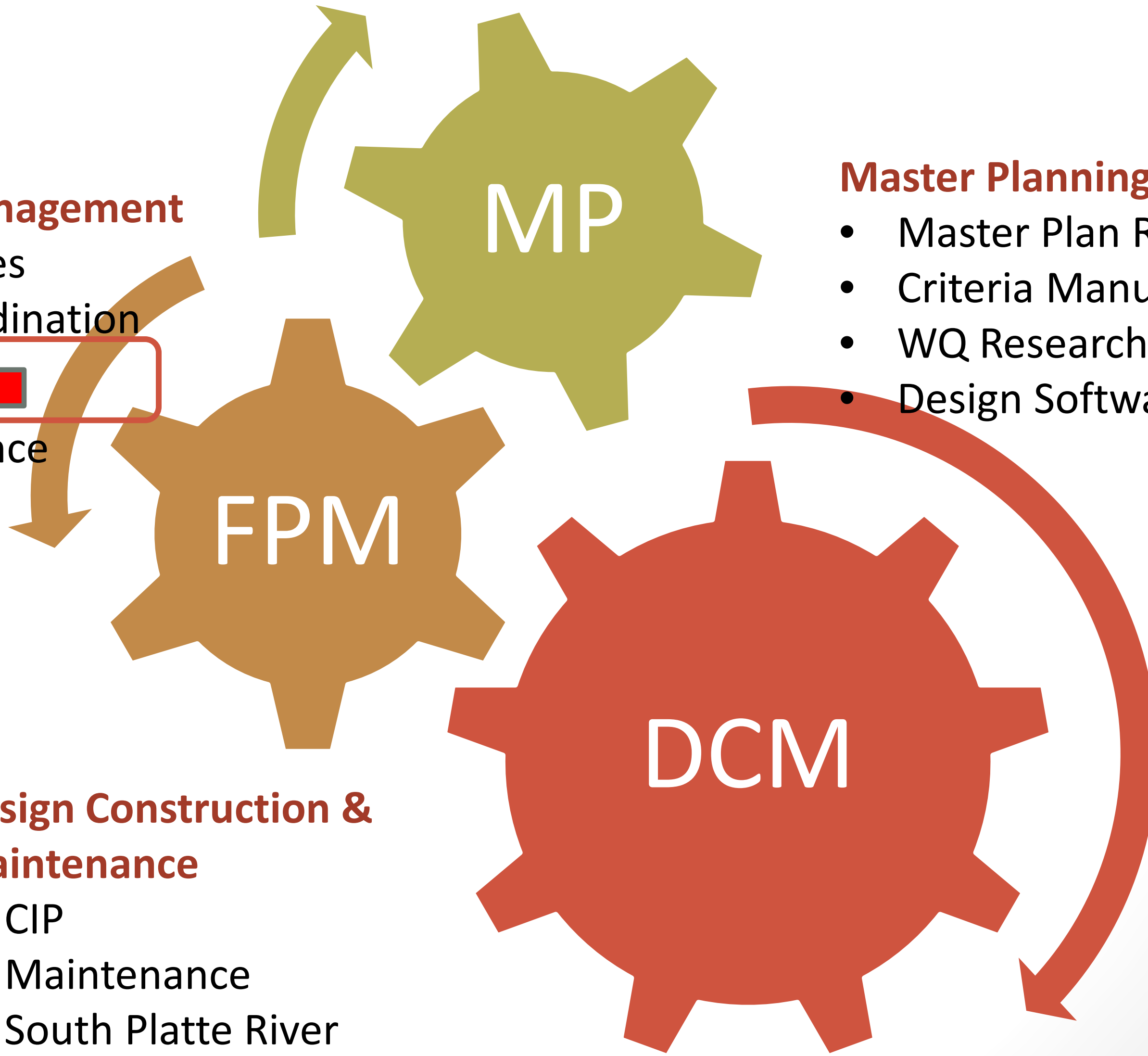


MEP Final Acceptance: Site Stability and Revegetation

Mike Sarmento, Senior Construction Manager
msarmento@udfcd.org

UDFCD Organization

Floodplain Management
- FHAD Studies
- LOMC Coordination
- **MEP**
- CRS Assistance



Master Planning
- Master Plan Reports
- Criteria Manual
- WQ Research
- Design Software

Design Construction & Maintenance
- CIP
- Maintenance
- South Platte River

Maintenance Eligibility Policy

*“Facilities constructed by or approved for construction by a **local public body** after March 1, 1980, must be approved by the District in order for these facilities to be eligible for District maintenance assistance.”*

MEP specifically deals with developer and local government projects and should NOT be confused with DCM-constructed projects which are automatically MEP eligible.

MEP Phases

Phase 1 – Referral

- Plats,
- Site Plans
- Zoning Plans

David

Phase 2 – Design Approval

- Construction Plans

Teresa

Phase 3 – Construction Approval

- Construction

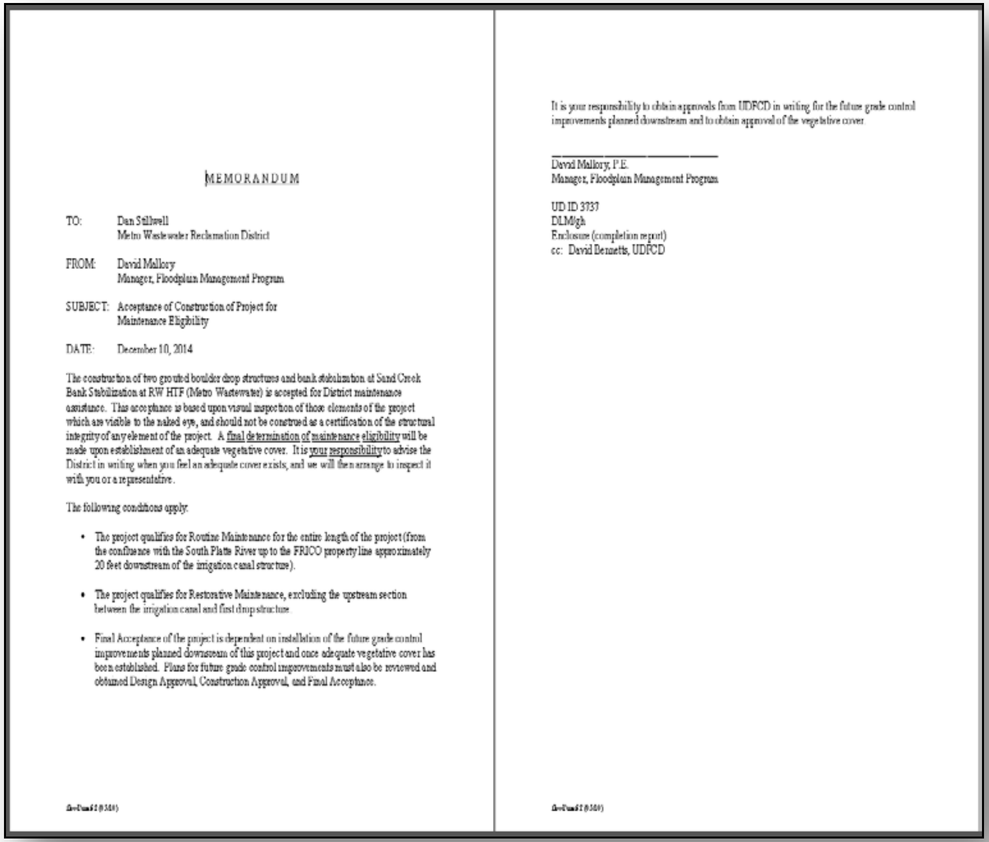
Mike

Phase 4 – Final Acceptance

- Vegetation Established/Site Stabilized

Mike & Teresa

Construction Approval Letter



MEMORANDUM

TO: Dan Stillwell
Metro Wastewater Reclamation District

FROM: David Mallory
Manager, Floodplain Management Program

SUBJECT: Acceptance of Construction of Project for Maintenance Eligibility

DATE: December 10, 2014

The construction of two grouted boulder drop structures and bank stabilization at Sand Creek Bank Stabilization at RW HTF (Metro Wastewater) is accepted for District maintenance assistance. This acceptance is based upon visual inspection of those elements of the project which are visible to the naked eye, and should not be construed as a certification of the structural integrity of any element of the project. A final determination of maintenance eligibility will be made upon establishment of an adequate vegetative cover. It is your responsibility to advise the District in writing when you feel an adequate cover exists, and we will then arrange to inspect it with you or a representative.

The following conditions apply:

- The project qualifies for Routine Maintenance for the entire length of the project (from the confluence with the South Platte River up to the FRICO property line approximately 20 feet downstream of the irrigation canal structure).
- The project qualifies for Restorative Maintenance, excluding the upstream section between the irrigation canal and first drop structure.
- Final Acceptance of the project is dependent on installation of the future grade control improvements planned downstream of this project and once adequate vegetative cover has been established. Plans for future grade control improvements must also be reviewed and obtained Design Approval, Construction Approval, and Final Acceptance.

It is your responsibility to obtain approvals from UDFCD in writing for the future grade control improvements planned downstream and to obtain approval of the vegetative cover.

David Mallory, P.E.
Manager, Floodplain Management Program

UD ID 3737
DLM/gh
Enclosure (completion report)
cc: David Bennetts, UDFCD

SPECIAL NOTE: Construction Acceptance does NOT mean you've achieved Final Acceptance for MEP!

Structural Integrity: What are We Looking for?

- Stream improvements and adjacent disturbed areas!
- Structural integrity
  - Damage
  - Overall Stability
- Maintenance
  - Sediment removal

Keys to Success for Site Stability

- MONITOR the site
- Set an inspection schedule
- Types of Problems: design/construction, unanticipated disturbances
- Communicate issues
- Site Remediation prior to acceptance

Final Stabilization Examples

The Good

The Bad

Keys to Success for Revegetation

- Pre-construction site survey
- Formal restoration plan
- Avoid canned/"cookbook" seed mixes
- Monitor construction progress
- Review final grades before equipment demobilized
- Use a QUALIFIED revegetation contractor

Keys to Success for Reveg (Cont.)

- Monitor the Reveg installation
- Post-revegetation monitoring
- Replace dead/severely stressed trees PRIOR to the warranty inspection
- Replace mulch and/or repair blankets
- UNDERSTAND that it takes time!

Other Examples

- Bear Creek upstream of Lowell Blvd

- Goldsmith Gulch at Cook park

A Word on Weed Management

- #1 - Disturbance promotes weed growth!
- Plan Ahead!
- Weeds are the competition!
- Bare areas are anchor opportunities
- Constant vigilance pays off!

Weeds Won't Work !

Final Acceptance Issues

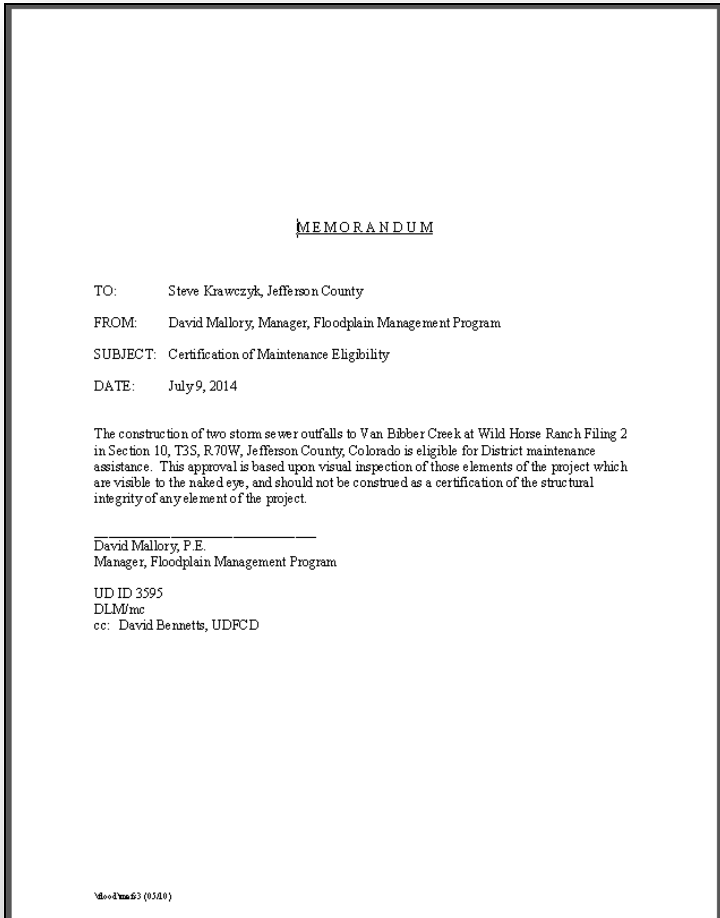
- Requesting final acceptance before site is ready:
  - Vegetation too sparse
  - Bank erosion and/or channel erosion/sedimentation
  - Dead/dying trees and shrubs

- Sediment accumulation in WQ structures

Final Acceptance! Now what?

- Eligible for maintenance assistance from UDFCD
- Local Government MUST request and submit a maintenance request to UDFCD's DCM program.
- Acceptance based on:
  - Local Government prioritization
  - DCM Program funding

What's Our Goal:
The Final Acceptance Letter



MEMORANDUM

TO: Steve Krawczyk, Jefferson County

FROM: David Mallory, Manager, Floodplain Management Program

SUBJECT: Certification of Maintenance Eligibility

DATE: July 9, 2014

The construction of two storm sewer outfalls to Van Bibber Creek at Wild Horse Ranch Filing 2 in Section 10, T3S, R70W, Jefferson County, Colorado is eligible for District maintenance assistance. This approval is based upon visual inspection of those elements of the project which are visible to the naked eye, and should not be construed as a certification of the structural integrity of any element of the project.

____
David Mallory, P.E.
Manager, Floodplain Management Program

UD ID 3595
DLM/mc
cc: David Bennetts, UDFCD

\flood\mafs3 (05/10)

=

15

Full Spectrum Detention and Water Rights

Ken MacKenzie, P.E., UDFCD, Master Planning Program Manager
&
Dr. Andrew Earles, P.E. and Adam Kremers, P.E., Wright Water Engineers, Inc.

April 5, 2016

Overview of Presentation

- Objectives and Approach
- SWMM Water Balance Modeling
- Water Rights Analysis
- Conclusions

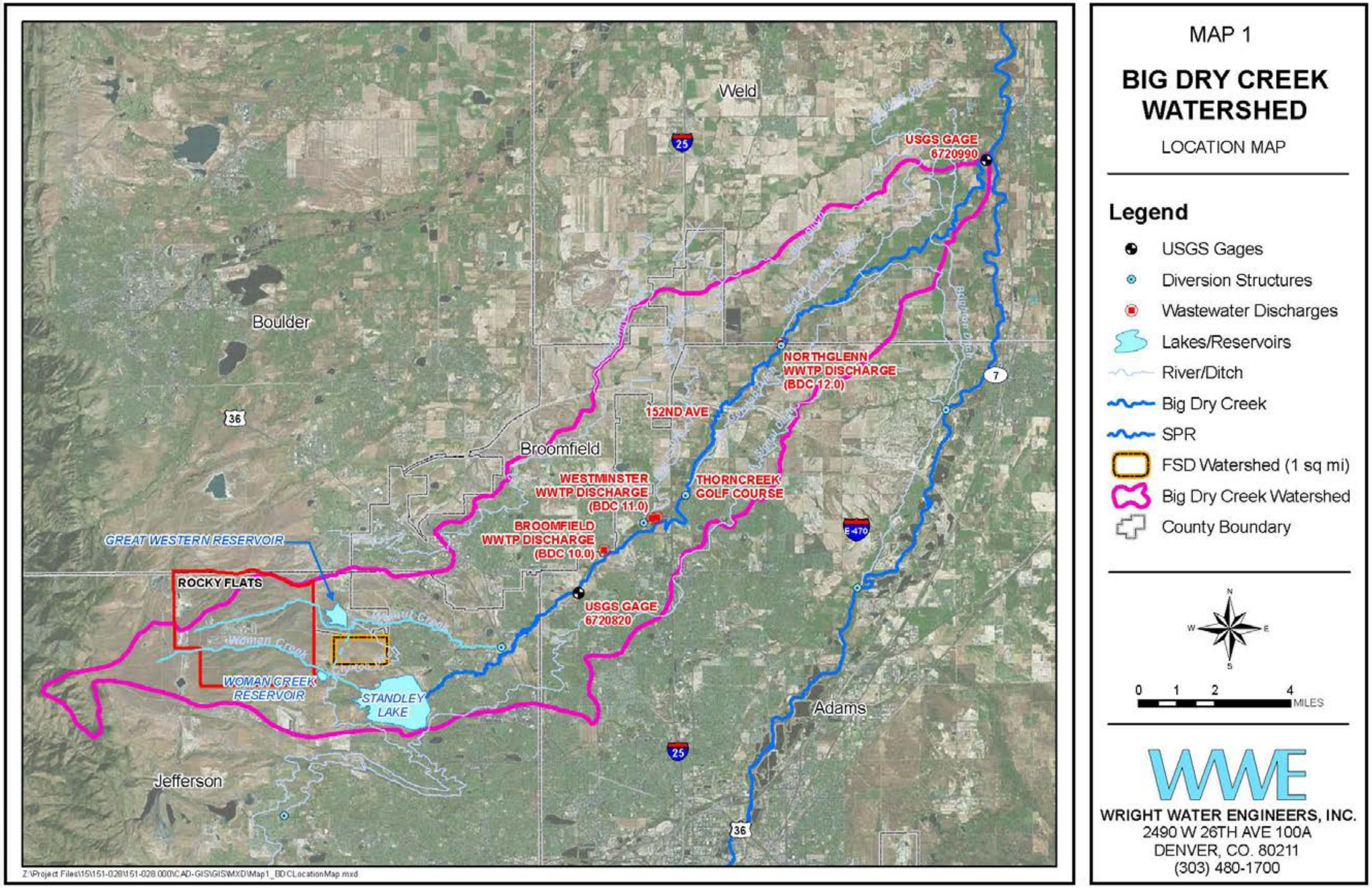
OBJECTIVES & APPROACH

Colorado Revised Statute (CRS) §37-92-602 (8)

- UDFCD legislative effort in 2015 session
- Provides legal protection for stormwater detention and infiltration facilities meeting criteria:
  1. Owned or operated by a governmental entity or subject to oversight by governmental entity (e.g., required under MS4 permit)
  2. Continuously releases or infiltrates at least 97% of all runoff from a rainfall event < = 5-year storm within 72 hours after the end of the event
  3. Continuously releases or infiltrates as quickly as practicable, but in all cases releases or infiltrates at least 99% of the runoff within 120 hours after the end of events > = 5-year storm
  4. It operates passively and does not subject the stormwater runoff to any active treatment process
  5. If located in Fountain Creek watershed (tributary to the Arkansas River), facility must be required by or operated in compliance with MS4 permit

Objectives

- Conduct long-term water balance analysis to quantify changes to the quantity and timing of water available to water rights users.
- Quantification of water balance differences between undeveloped, developed, and developed with FSD.
- Evaluation of changes in balance (evaporation, ET, infiltration, surface runoff) for varying levels of imperviousness.
- Examine effects of timing of runoff/releases from FSD facilities.
- Evaluate effects on downstream water users.


MAP 1
BIG DRY CREEK WATERSHED
LOCATION MAP
Legend
USGS Gages
Diversion Structures
Wastewater Discharges
Lakes/Reservoirs
River/Ditch
Big Dry Creek
SPR
FSD Watershed (1 sq mi)
Big Dry Creek Watershed
County Boundary
0 1 2 4 MILES
WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700
Weld
Boulder
Broomfield
Adams
Jefferson
USGS GAGE 6720990
NORTHGLENN WWTP DISCHARGE (BDC 12.0)
152ND AVE
WESTMINSTER WWTP DISCHARGE (BDC 11.0)
THORNCREEK GOLF COURSE
BROOMFIELD WWTP DISCHARGE (BDC 10.0)
GREAT WESTERN RESERVOIR
ROCKY FLATS
USGS GAGE 6720820
WOMAN CREEK RESERVOIR
STANDLEY LAKE
Z:\Project Files\15\151-028\151-028.000\CAD-GIS\GIS\MXD\Map1_BDCLocationMap.mxd

Approach

- Combine hydrology model (SWMM) with water rights model (spreadsheet)
- Model “typical” developments scenarios for hypothetical watershed (range of imperviousness)
- UDFCD spreadsheets for conceptual FSD sizing
- Water Rights model to assess downstream effects of SWMM scenarios

Watershed Parameters

- 1-square mile “typical” watershed
- Imperviousness 2%, 20%, 35%, 50%, 65%, 80%
- Sub-basin parameters from 2006 Big Dry Creek Northern Tributaries OSP
- Horton infiltration using parameters from USDCM

Climate Data

- Hourly Precipitation
- Daily Min and Max Temperatures
- Wind Speed
- Evaporation/ET calculated by model

Aquifer Parameters

- Porosity
- Field Capacity
- Wilting Point
- Upper/ lower zone water availability for ET

SWMM

Daily Time Series Output from SWMM

- Outflow
- Evaporation/ET
- Storage

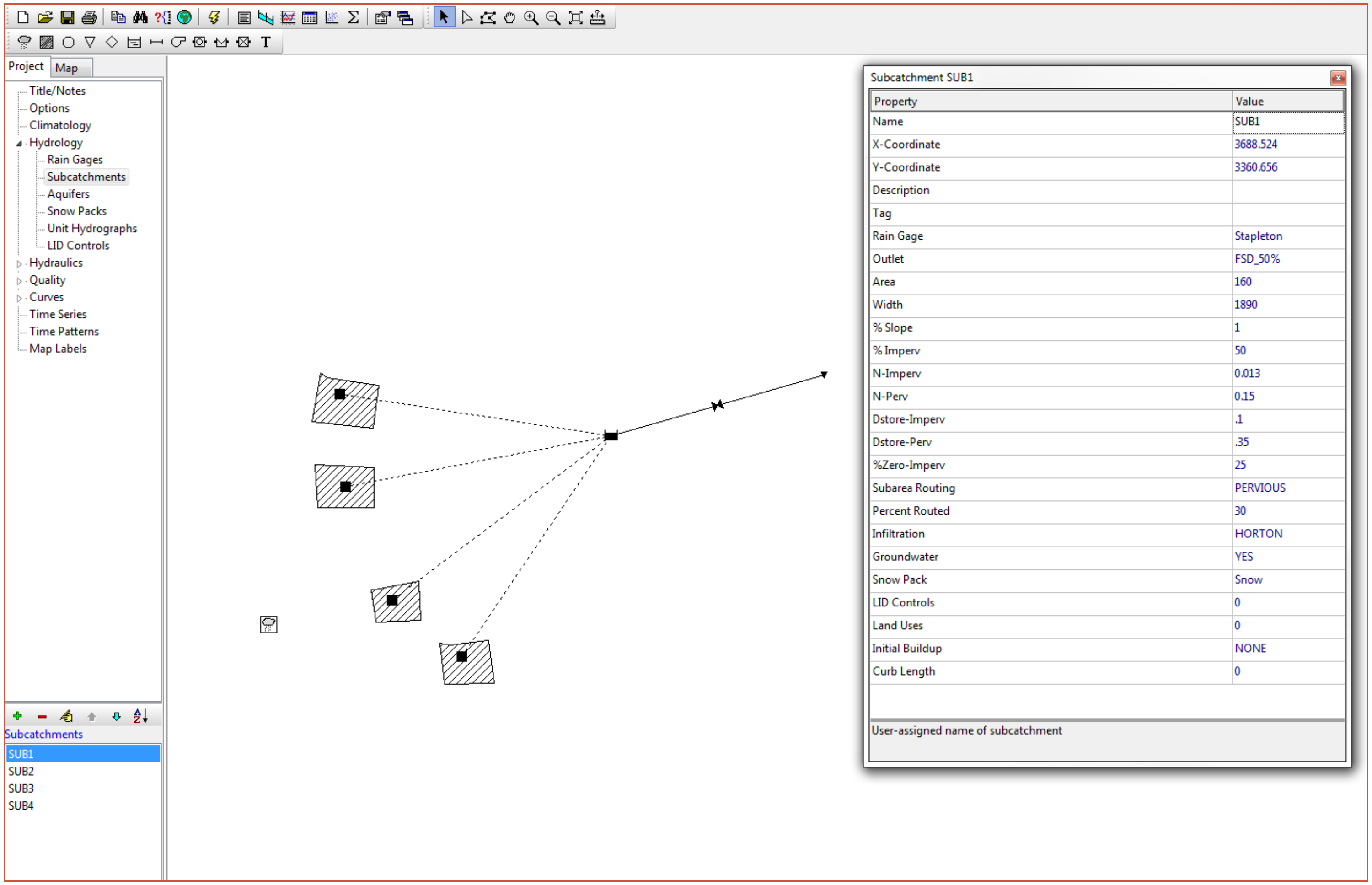
Water Rights Accounting

- Streamflow
- Diversion Records
- Return Flows
- Calls

Water Rights Spreadsheet

Output from Water Rights Spreadsheet

Water shortage or water surplus



SWMM WATER BALANCE MODELS

Fundamental Model Assumptions

- One square mile watershed (major drainage scale, typical of large scale development projects)
  - Use Big Dry Creek Northern Tributaries OSP as starting point for "typical" model parameterization
  - 160 acre sub-basins (similar to UDFCD master plan modeling)
  - Assume directly tributary to waterway
- Imperviousness varied from undeveloped (2%) to dense development (80%)
- Climate data (hourly rainfall, temperature, wind speed, etc.) from NOAA GHCN-D climate data files

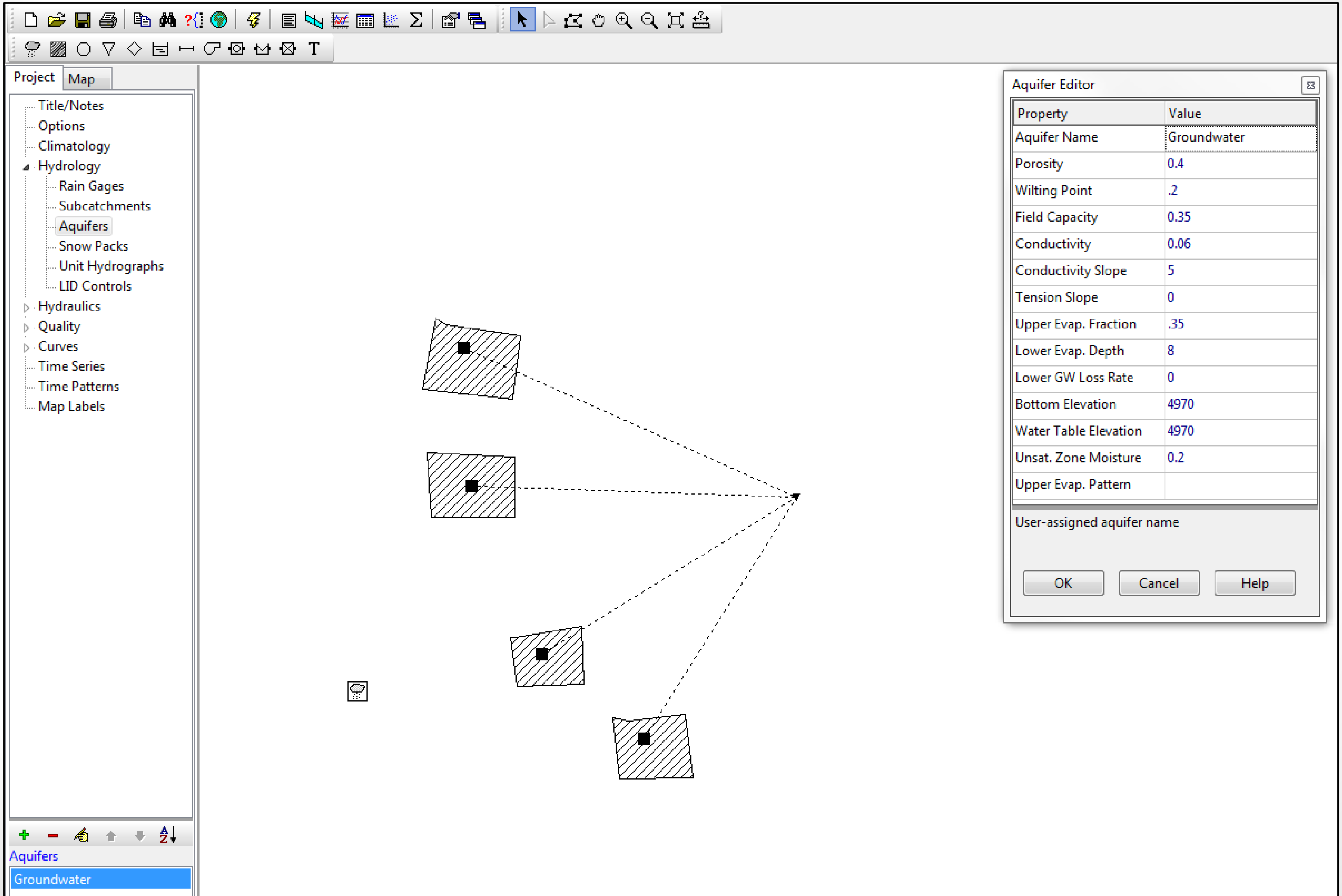
Fundamental Model Assumptions (cont.)

- Horton Loss parameters (guidance from USDCM), assume HSG C.
- Evaporation occurs from surface water (e.g. depression storage, runoff).
- Shallow aquifer beneath site – fraction of water in upper soil zone is available for ET between events:
  - Aquifer is “bucket” and change in aquifer storage represents shallow (tributary) groundwater recharge or depletion
  - Aquifer ET parameters “calibrated” for undeveloped scenario to yield results where ET ~ PET for native plants, with infrequent runoff.
- Snowmelt incorporated for runoff timing effects – not a sensitive parameter.

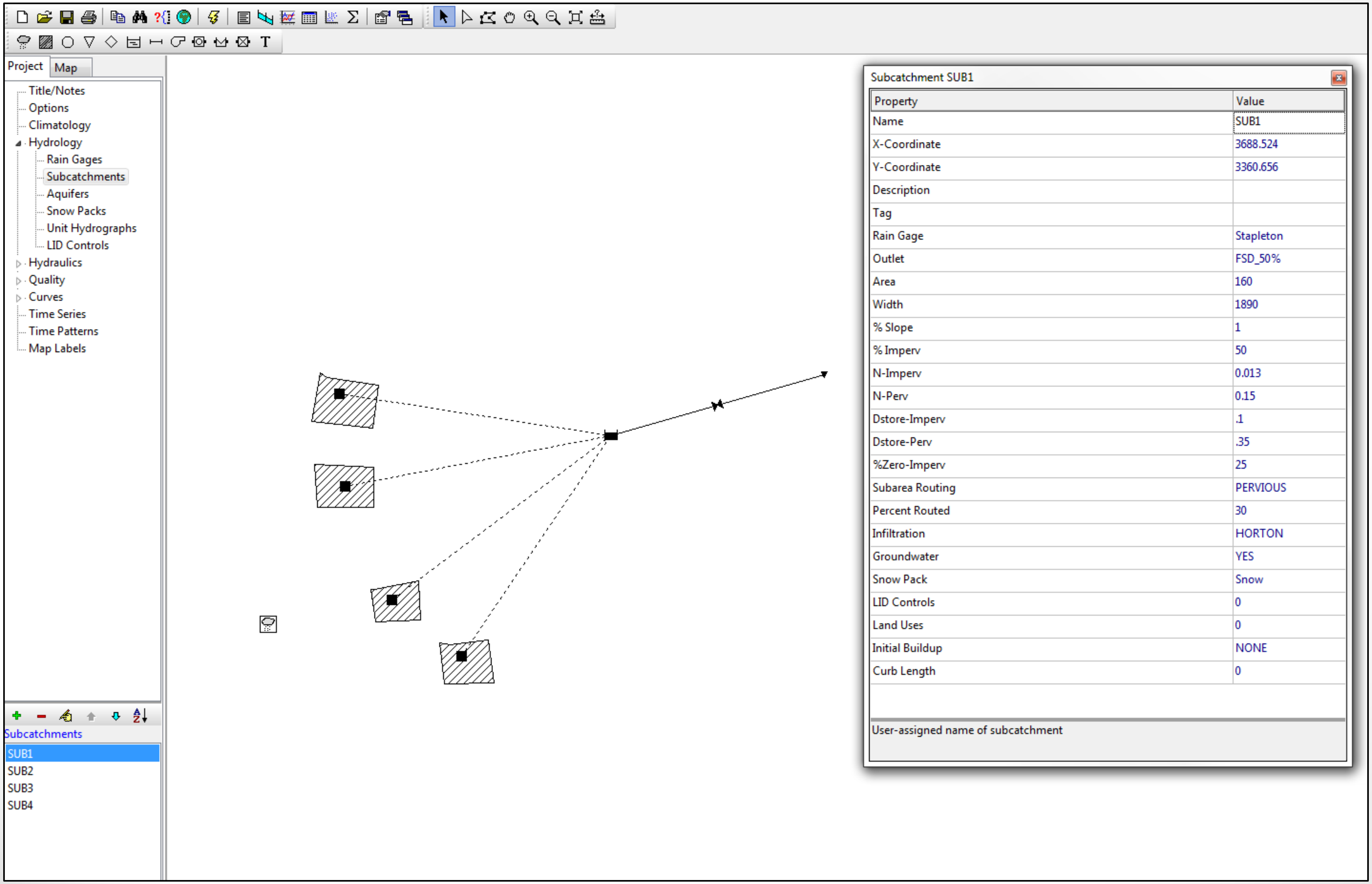
Fundamental Model Assumptions (cont.)

- Assumes dry land/native land use prior to development.
- Additional irrigation water not accounted for in model:
  - Model provides capabilities to evaluate alternate scenarios, including return flows from irrigated land; however, scope of this assessment did not include irrigation.
- Results from 1 square mile are scalable to larger areas.

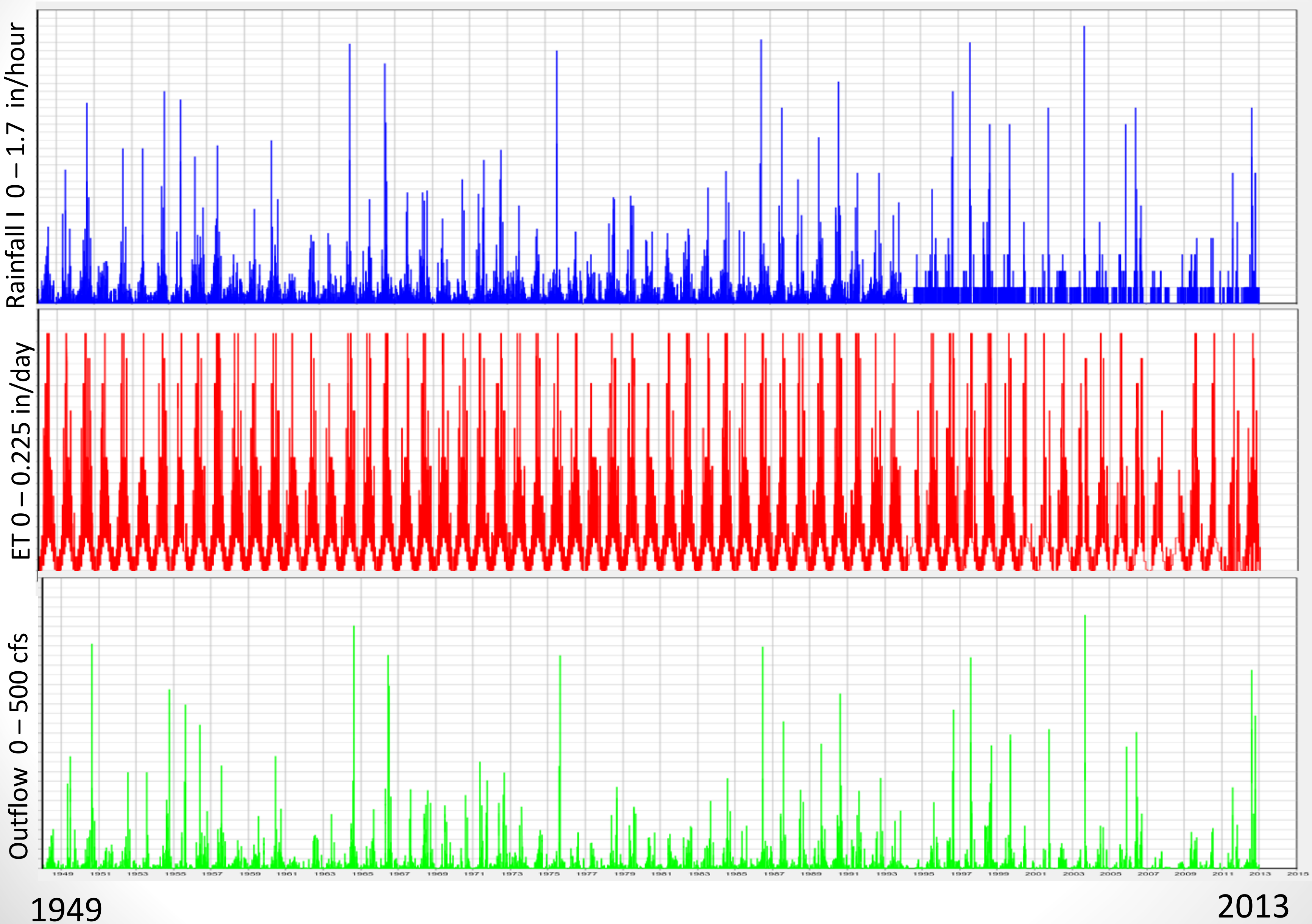
SWMM Layout for Model with No FSD



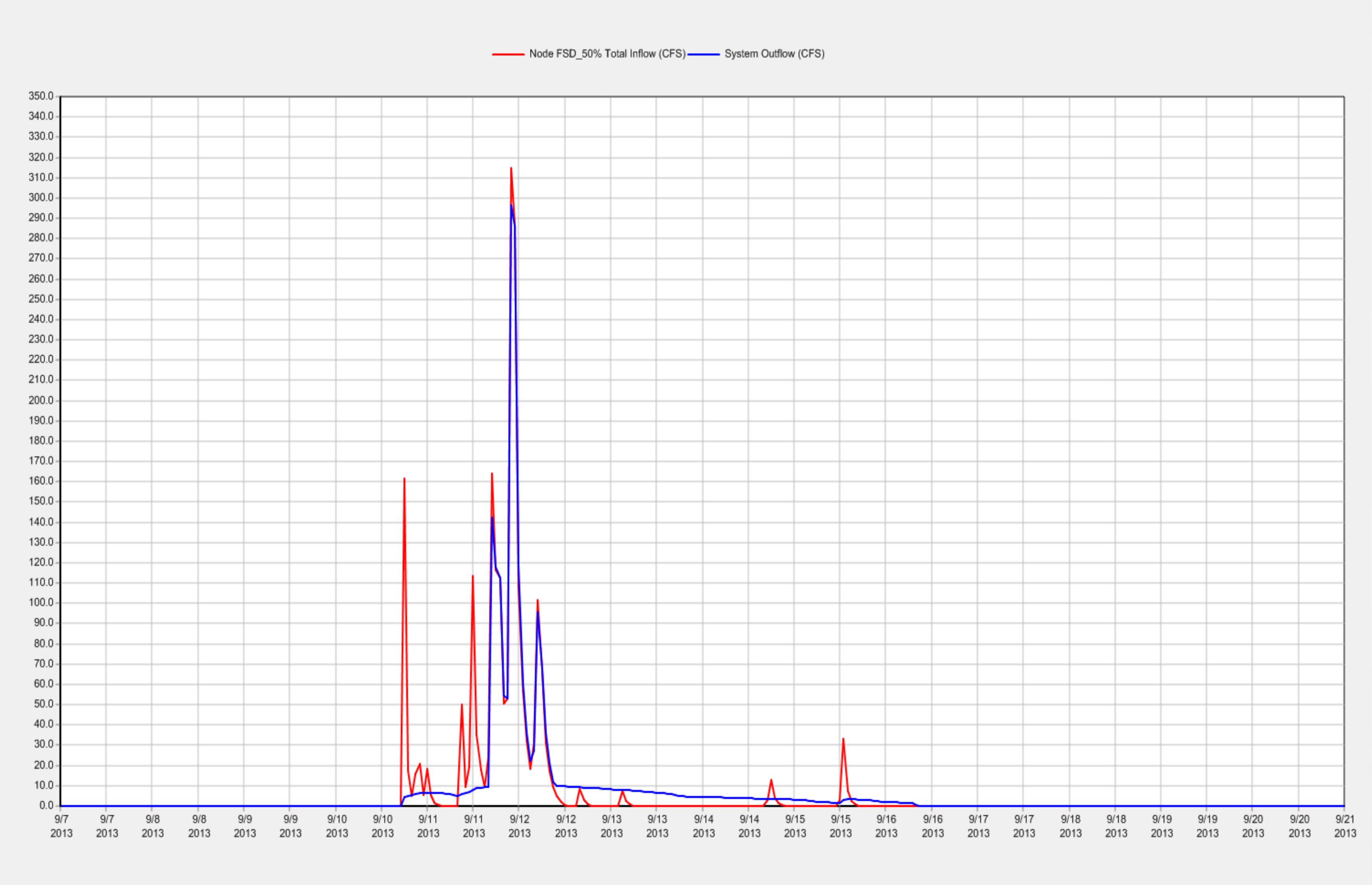
SWMM Model Layout with FSD



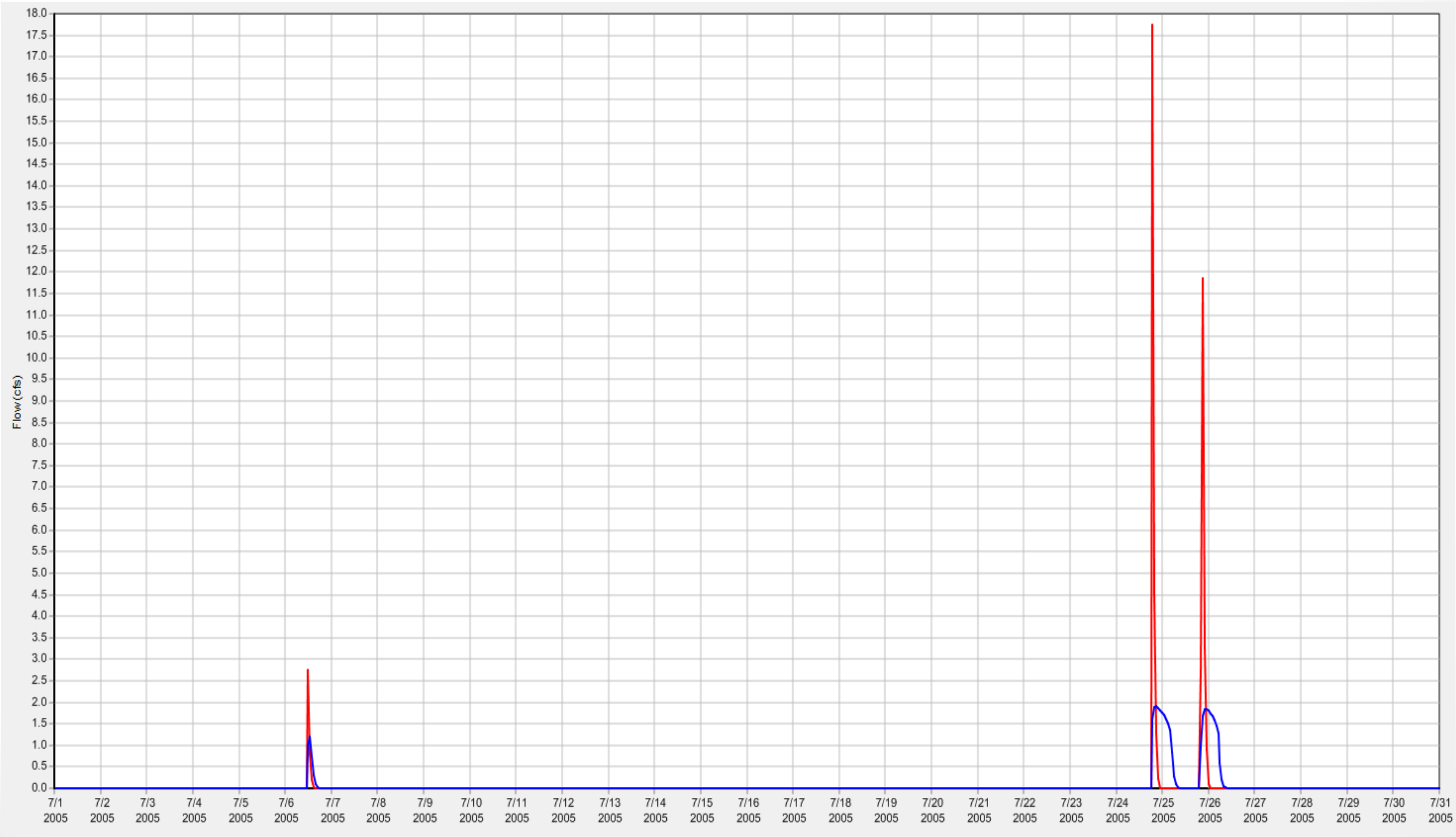
Precipitation, ET & System Outflow, 1949 - 2013

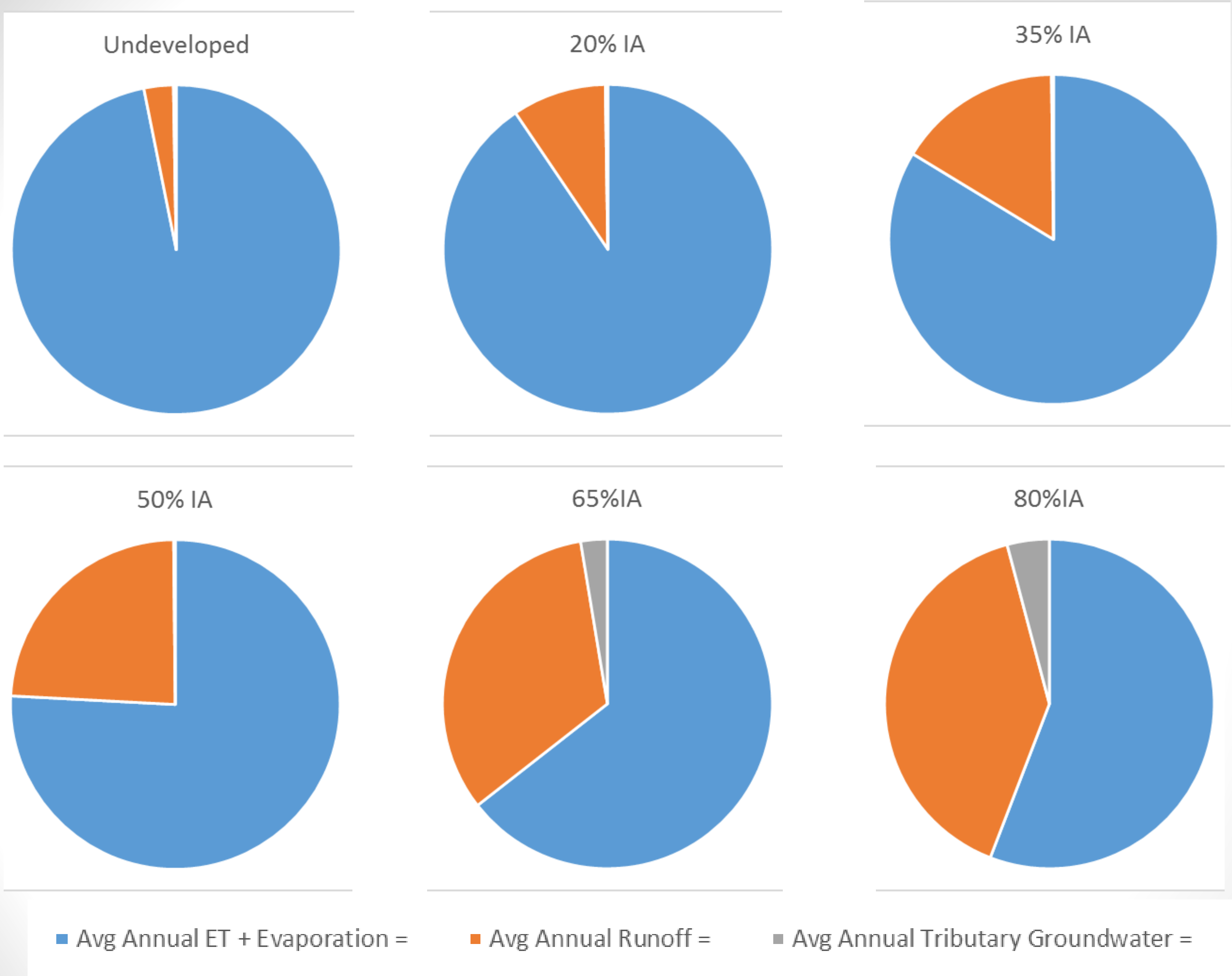


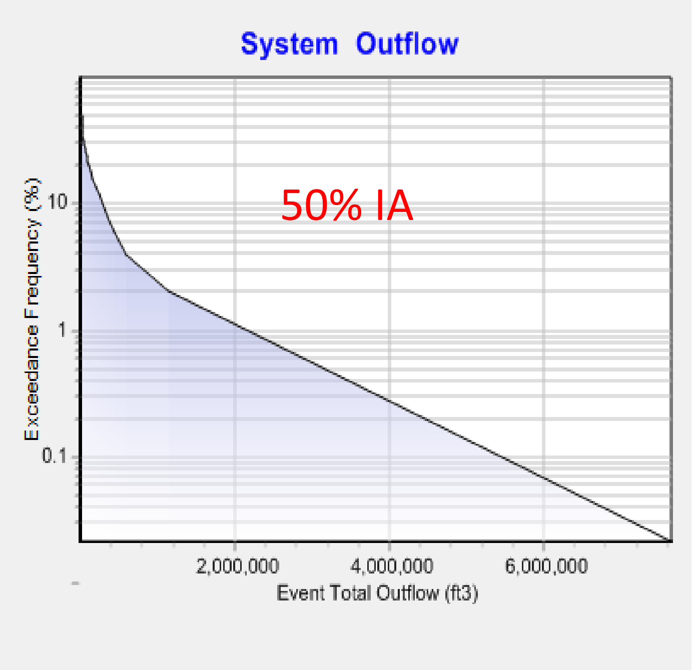
FSD Inflow and Outflow September 2013, 50% IA



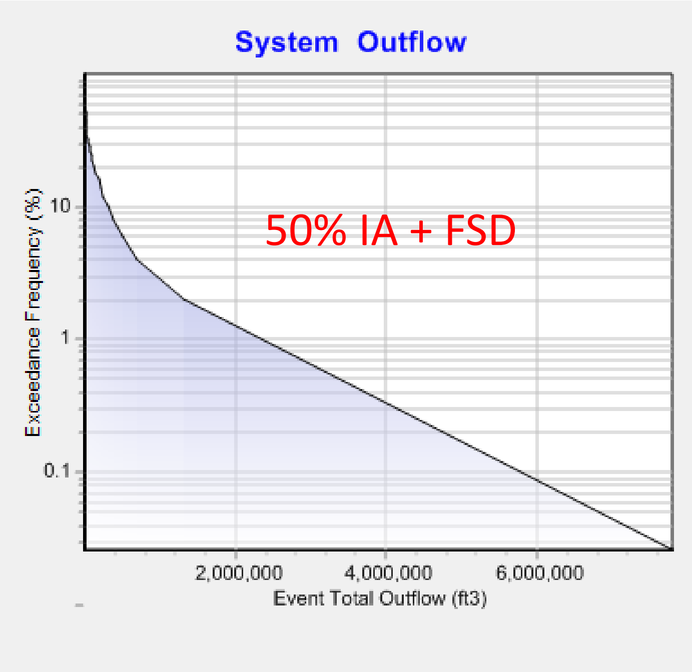
Modeled FSD Inflow and Outflow, July 2005, 50% IA



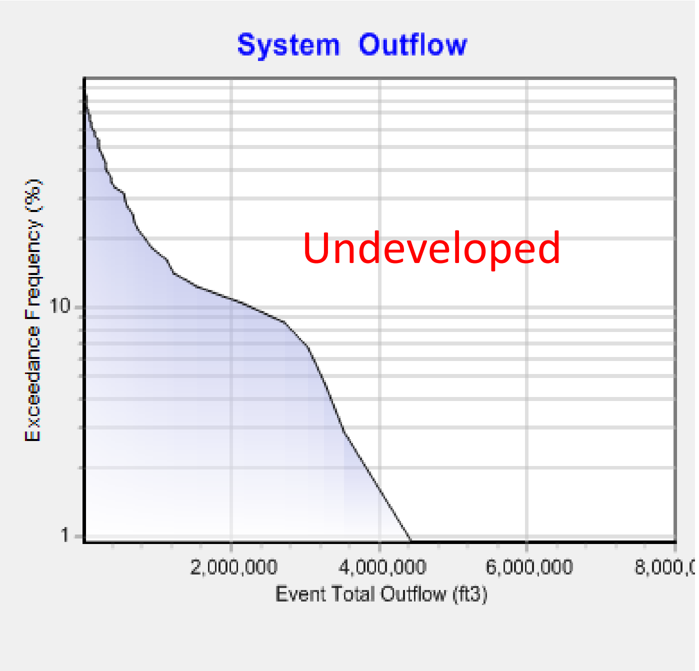

Undeveloped
20% IA
35% IA
50% IA
65%IA
80%IA
Avg Annual ET + Evaporation =
Avg Annual Runoff =
Avg Annual Tributary Groundwater =



System Outflow
50% IA
Exceedance Frequency (%)
10
1
0.1
2,000,000
4,000,000
6,000,000
Event Total Outflow (ft3)

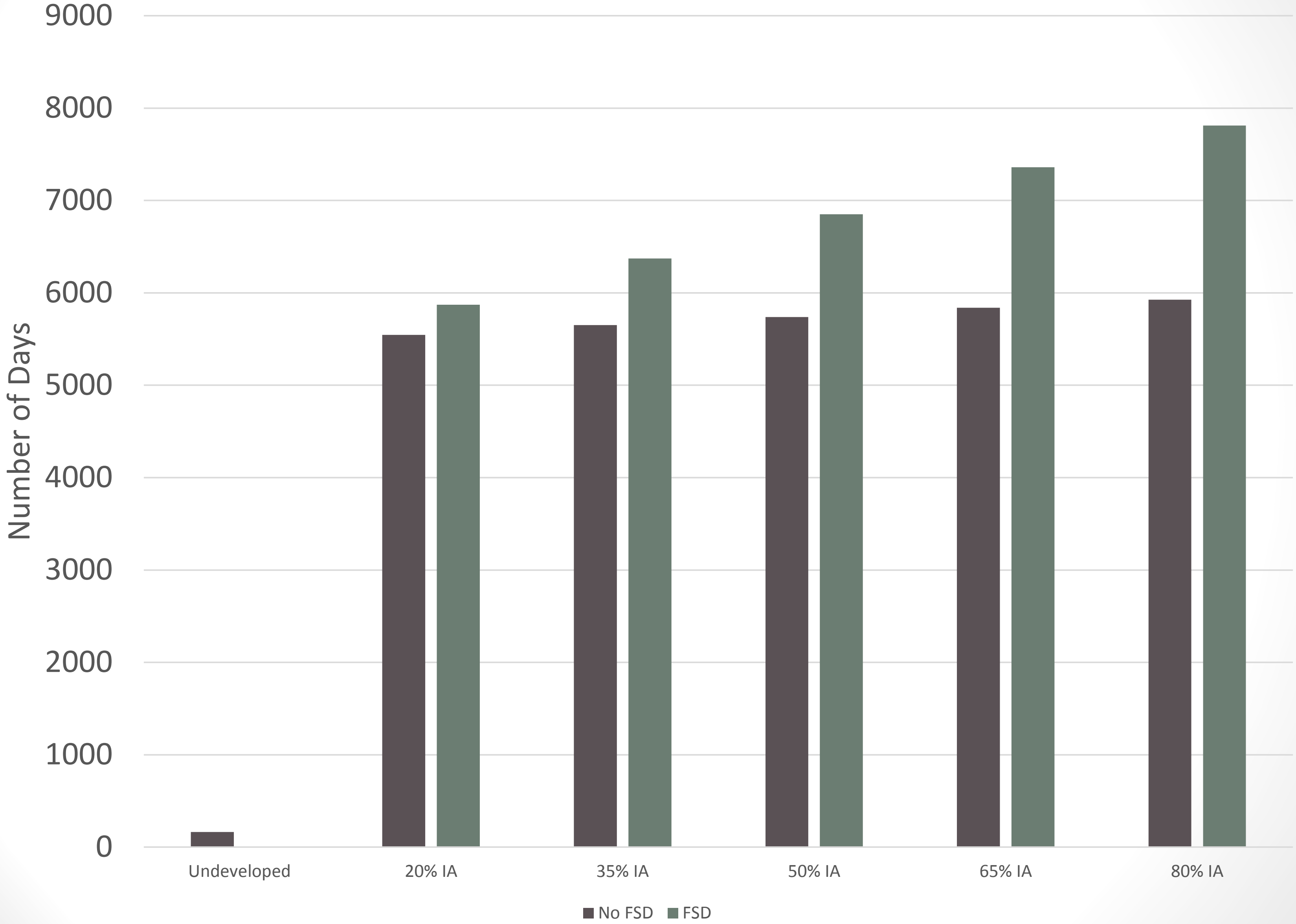


System Outflow
50% IA + FSD
Exceedance Frequency (%)
10
1
0.1
2,000,000
4,000,000
6,000,000
Event Total Outflow (ft3)

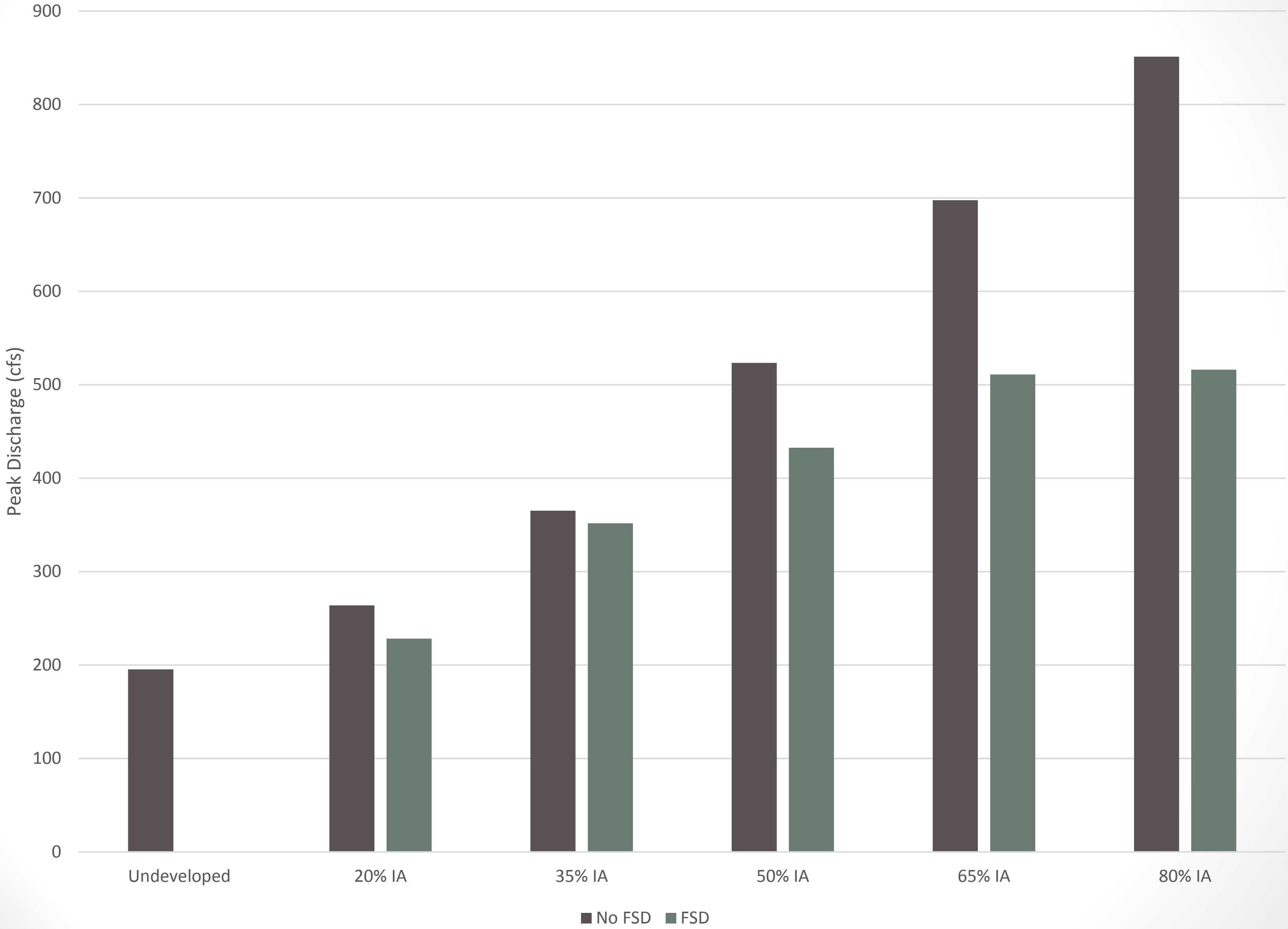


System Outflow
Undeveloped
Exceedance Frequency (%)
10
1
2,000,000
4,000,000
6,000,000
Event Total Outflow (ft3)

Number of Days with System Outflow



Peak Outflow Rates with and without FSD



Results – Precipitation & Outflow

Precipitation											
Variables	**Undev**	**20% IA**	**20% IA + FSD**	**35% IA**	**35% IA + FSD**	**50% IA**	**50% IA + FSD**	**65% IA**	**65% IA + FSD**	**80% IA**	**80% IA + FSD**
Number of Events	4931	4931	4931	4931	4931	4931	4931	4931	4931	4931	4931
Mean Daily Precip (in)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Max Daily Precip (in)	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39

System Outflow											
Variables	**Undev**	**20% IA**	**20% IA + FSD**	**35% IA**	**35% IA + FSD**	**50% IA**	**50% IA + FSD**	**65% IA**	**65% IA + FSD**	**80% IA**	**80% IA + FSD**
Number of Events	163	5545	5871	5652	6372	5738	6852	5838	7361	5927	7812
Mean Daily Outflow (cfs)	12.2	1.3	0.6	2.1	0.9	3.0	1.2	3.9	1.4	4.4	1.7
Peak Daily Outflow (cfs)	196	264	228	365	352	523	433	697	511	851	516
Mean Daily Outflow (ac-ft)	8.9	0.9	0.7	1.5	1.2	2.2	1.7	2.9	2.2	3.5	2.6
Max Daily Outflow (ac-ft)	77	94	72	113	96	129	102	144	125	158	133

Results – Evaporation/ET and Storage

Evaporation											
Variables	**Undev**	**20% IA**	**20% IA + FSD**	**35% IA**	**35% IA + FSD**	**50% IA**	**50% IA + FSD**	**65% IA**	**65% IA + FSD**	**80% IA**	**80% IA + FSD**
Number of Events	20689	22032	22833	22443	22443	23529	23529	23707	23707	23707	23707
Daily Mean Evap (in)	0.043	0.036	0.036	0.042	0.042	0.038	0.038	0.038	0.038	0.039	0.039
Peak Daily Evap (in)	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228

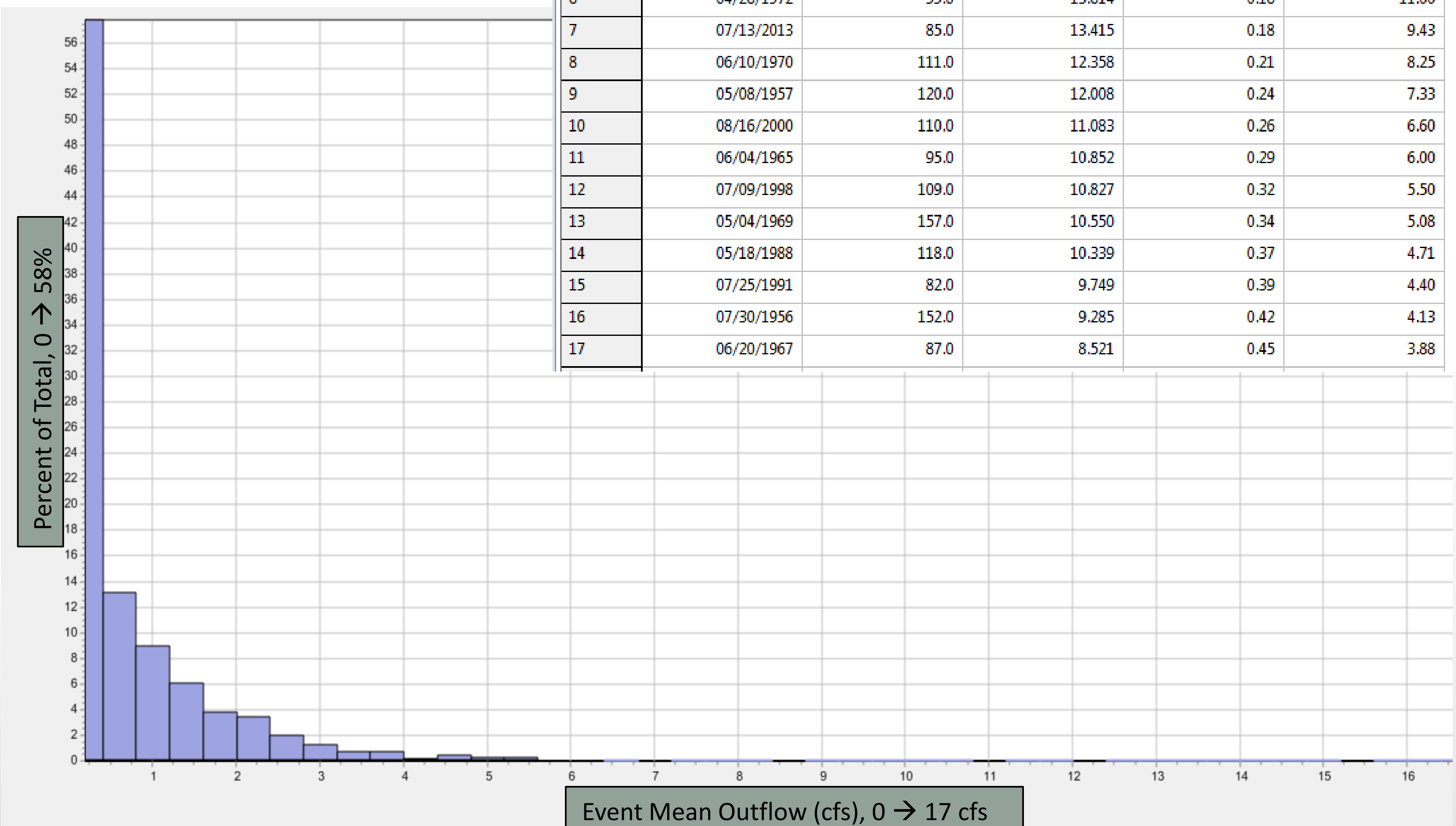
Storage											
Variables	**Undev**	**20% IA**	**20% IA + FSD**	**35% IA**	**35% IA + FSD**	**50% IA**	**50% IA + FSD**	**65% IA**	**65% IA + FSD**	**80% IA**	**80% IA + FSD**
Number of Events	0	0	6080	0	6569	0	7044	0	7858	0	7972
Daily Mean Storage (ac-ft)	0	0.0	0.2	0.0	0.6	0.0	1.1	0.0	1.4	0.0	1.9
Daily Peak Storage (ac-ft)	0	0	12	0	23	0	35	0	47	0	59

System Outflow Histogram & Data

Statistics - System Outflow

Summary | Events | Histogram | Frequency Plot

Rank	Start Date	Event Duration (hours)	Event Mean (CFS)	Exceedance Frequency (percent)	Return Period (years)
1	08/18/2004	89.0	17.018	0.03	66.00
2	08/02/1951	93.0	16.512	0.05	33.00
3	05/05/1973	105.0	15.584	0.08	22.00
4	09/10/2013	141.0	15.366	0.11	16.50
5	04/13/1967	100.0	14.653	0.13	13.20
6	04/26/1972	99.0	13.614	0.16	11.00
7	07/13/2013	85.0	13.415	0.18	9.43
8	06/10/1970	111.0	12.358	0.21	8.25
9	05/08/1957	120.0	12.008	0.24	7.33
10	08/16/2000	110.0	11.083	0.26	6.60
11	06/04/1965	95.0	10.852	0.29	6.00
12	07/09/1998	109.0	10.827	0.32	5.50
13	05/04/1969	157.0	10.550	0.34	5.08
14	05/18/1988	118.0	10.339	0.37	4.71
15	07/25/1991	82.0	9.749	0.39	4.40
16	07/30/1956	152.0	9.285	0.42	4.13
17	06/20/1967	87.0	8.521	0.45	3.88



WATER RIGHTS ANALYSIS

Objectives

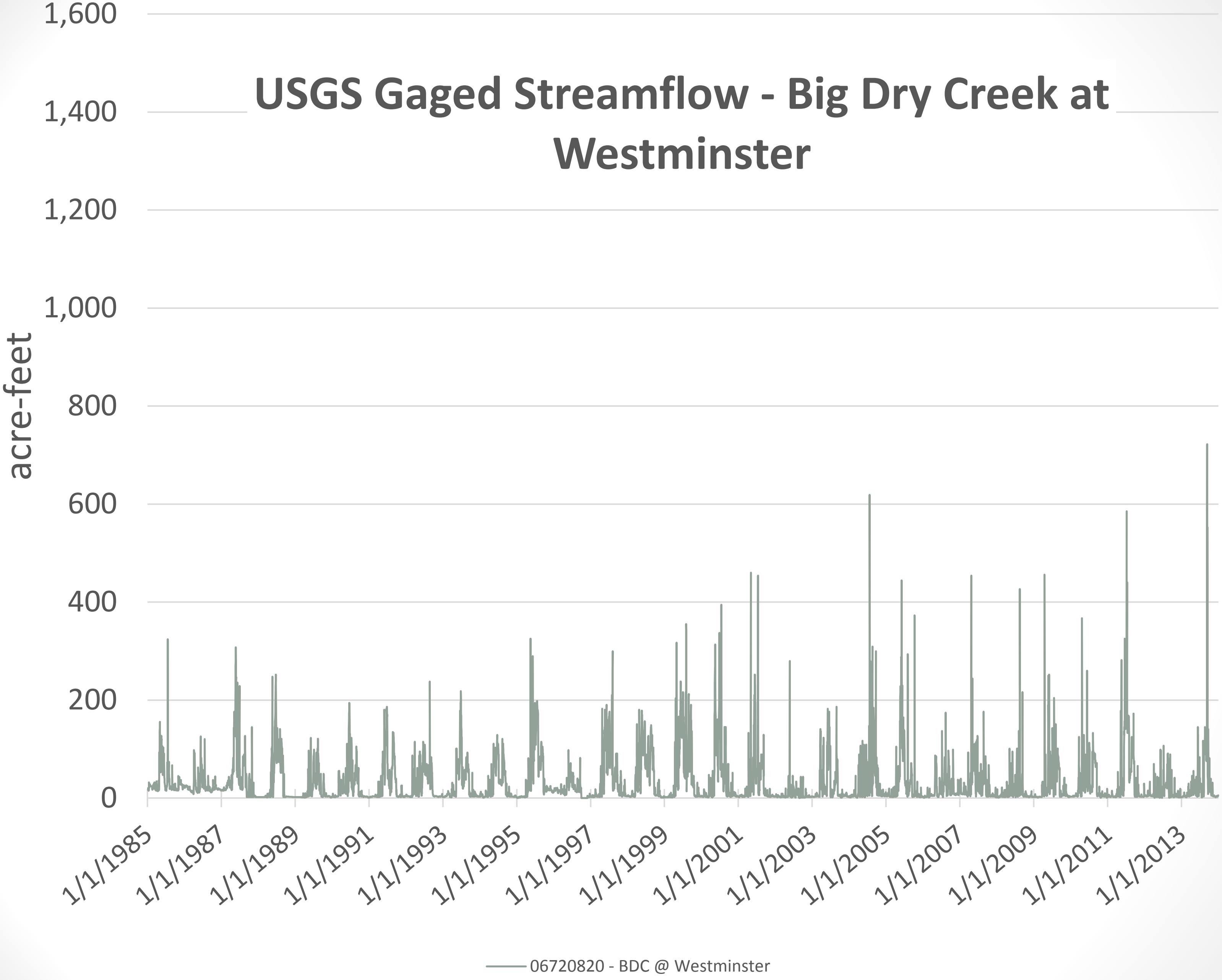
- There's more water, but is there really?
  - Colorado's water landscape depends on snowpack, runoff and return flows for a healthy watershed.
- Big Dry Creek flows support South Platte River diversions
- Historical river calls impact on Big Dry Creek
- Water rights holders and Big Dry Creek diversions
- Who benefits from FSD as a result of recent legislation?

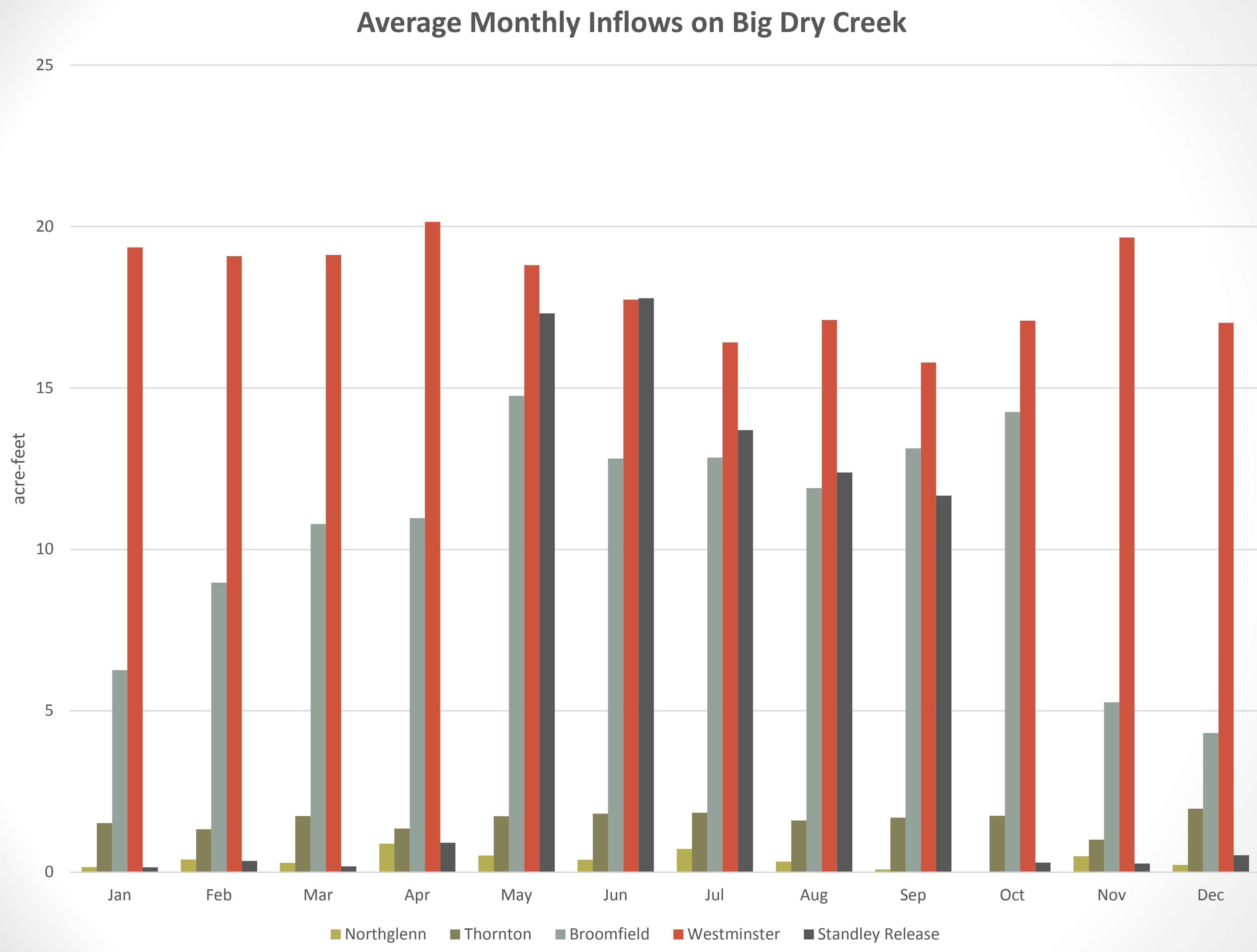
Where is the Water on Big Dry Creek?

- USGS & DWR stream gages in Westminster and Ft. Lupton.
  - Gaining reach due to non-native flows.
- Transbasin diversions, reservoir releases and municipal waste water treatment effluent.
- No river calls on Big Dry Creek.
- Big Dry Creek serves as a conduit for augmentation deliveries and releases made to the South Platte.
- Big Dry Creek diversion structures divert both native and non-native flows.

Where is the Water on Big Dry Creek?

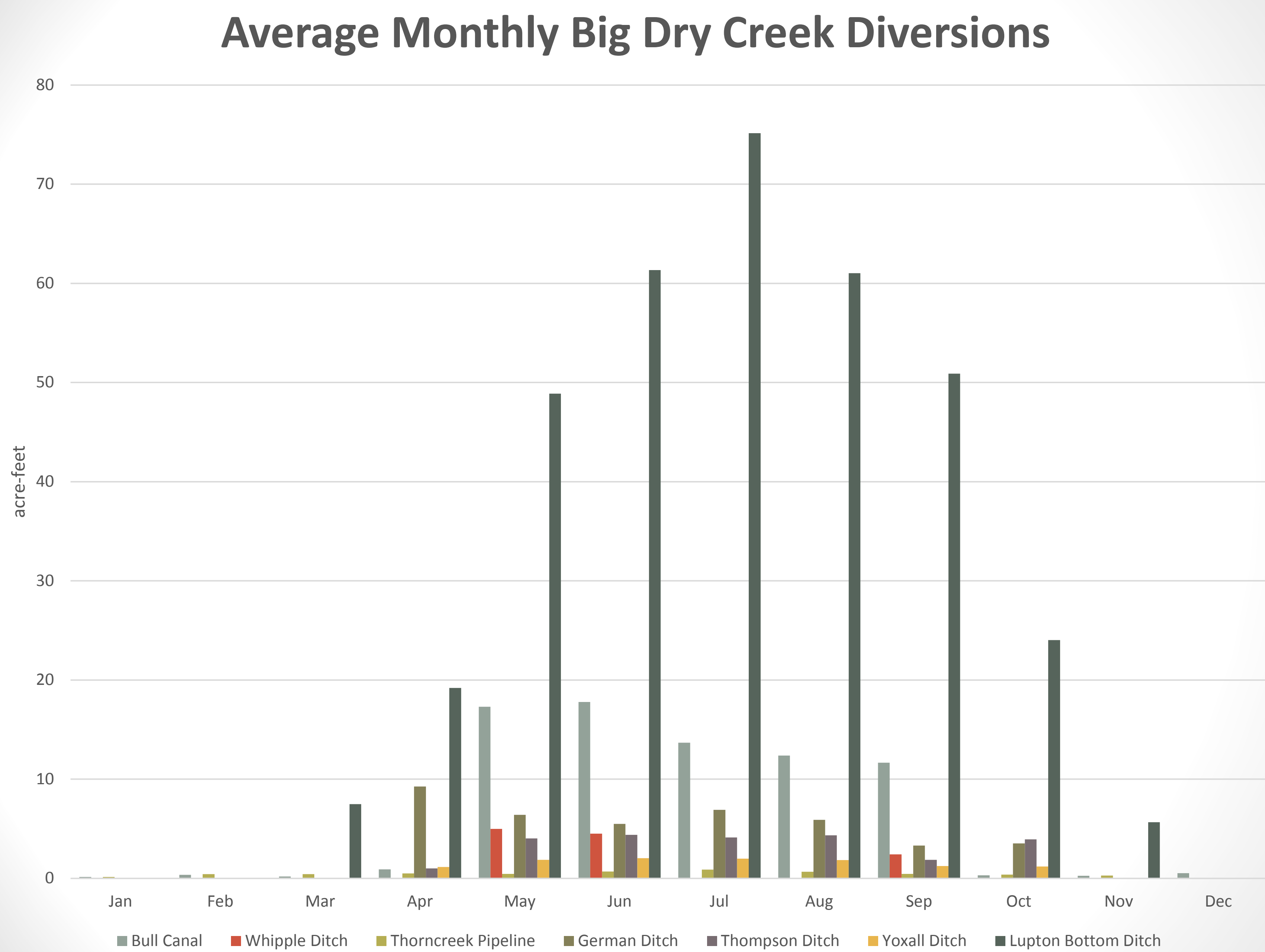
- Colorado’s Decision Support System
  - State supported and publicly available data for Colorado’s climate, streamflow and diversion records
  - Water rights related transactions and net decreed amounts relative to the Big Dry Creek system
- Colorado’s Division of Water Resources
  - Call chronology of Colorado’s river basins
  - South Platte River Basin’s Division 1 office for municipalities accounting submittals
- Outflow from full spectrum detention and runoff as a result of development in the Big Dry Creek basin
- Evapotranspiration from rainfall events
- Lagged groundwater returns to Big Dry Creek and the South Platte River

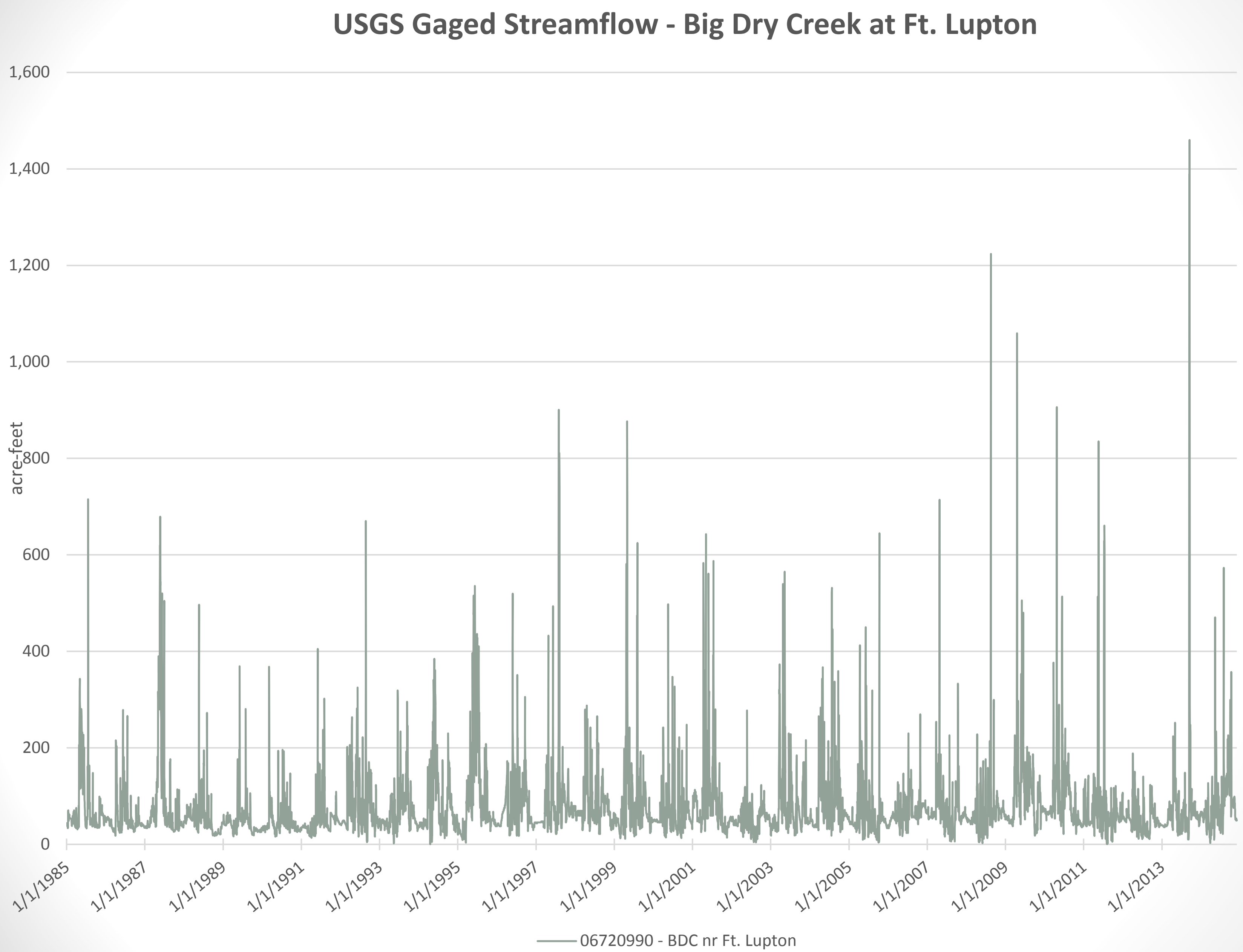

USGS Gaged Streamflow - Big Dry Creek at Westminster
acre-feet
1,600
1,400
1,200
1,000
800
600
400
200
0
1/1/1985
1/1/1987
1/1/1989
1/1/1991
1/1/1993
1/1/1995
1/1/1997
1/1/1999
1/1/2001
1/1/2003
1/1/2005
1/1/2007
1/1/2009
1/1/2011
1/1/2013
06720820 - BDC @ Westminster


Average Monthly Inflows on Big Dry Creek
25
20
15
10
5
0
acre-feet
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Northglenn
Thornton
Broomfield
Westminster
Standley Release

Water Rights on Big Dry Creek

						Decreed Amount (cfs)		
Structure ID	Water Right Name	Appropriation Date	Administration No.	Case No	Decreed Use	Absolute	Conditional	Alternate Point
872	German Ditch	1885-11-30	13118.00000	CA8568	Irrigation	0.99		
871	Bull Canal (Whipple Ditch)	1885-12-31	13149.00000	CA8568	Irrigation	0.99		
871	Bull Canal (Whipple Ditch)	1884-09-01	15895.12663	CA54658	Irrigation	5		
872	German Ditch	1885-11-25	15895.13113	01CW0273	Irrigation	40		
873	Big Dry Creek Ditch	1889-12-15	15895.14594	CA54658	Irrigation	36.66		
874	Yoxall Ditch	1896-07-27	17010.00000	CA40750	Irrigation	16.8		
880	Thornton Golf Course Pipeline	1987-12-10	50382.00000	96CW0244	Irrigation, Recreation, Other Beneficial Uses	5		140
880	Thornton Golf Course Pipeline	1996-12-31	53691.00000	96CW1116	Municipal			130
871	Bull Canal (Whipple Ditch)	2004-11-15	56567.00000	04CW0310	Municipal		31	
871	Bull Canal (Whipple Ditch)	2004-12-20	56602.00000	04CW0310	Municipal			21


Average Monthly Big Dry Creek Diversions
acre-feet
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Bull Canal
Whipple Ditch
Thorncreek Pipeline
German Ditch
Thompson Ditch
Yoxall Ditch
Lupton Bottom Ditch



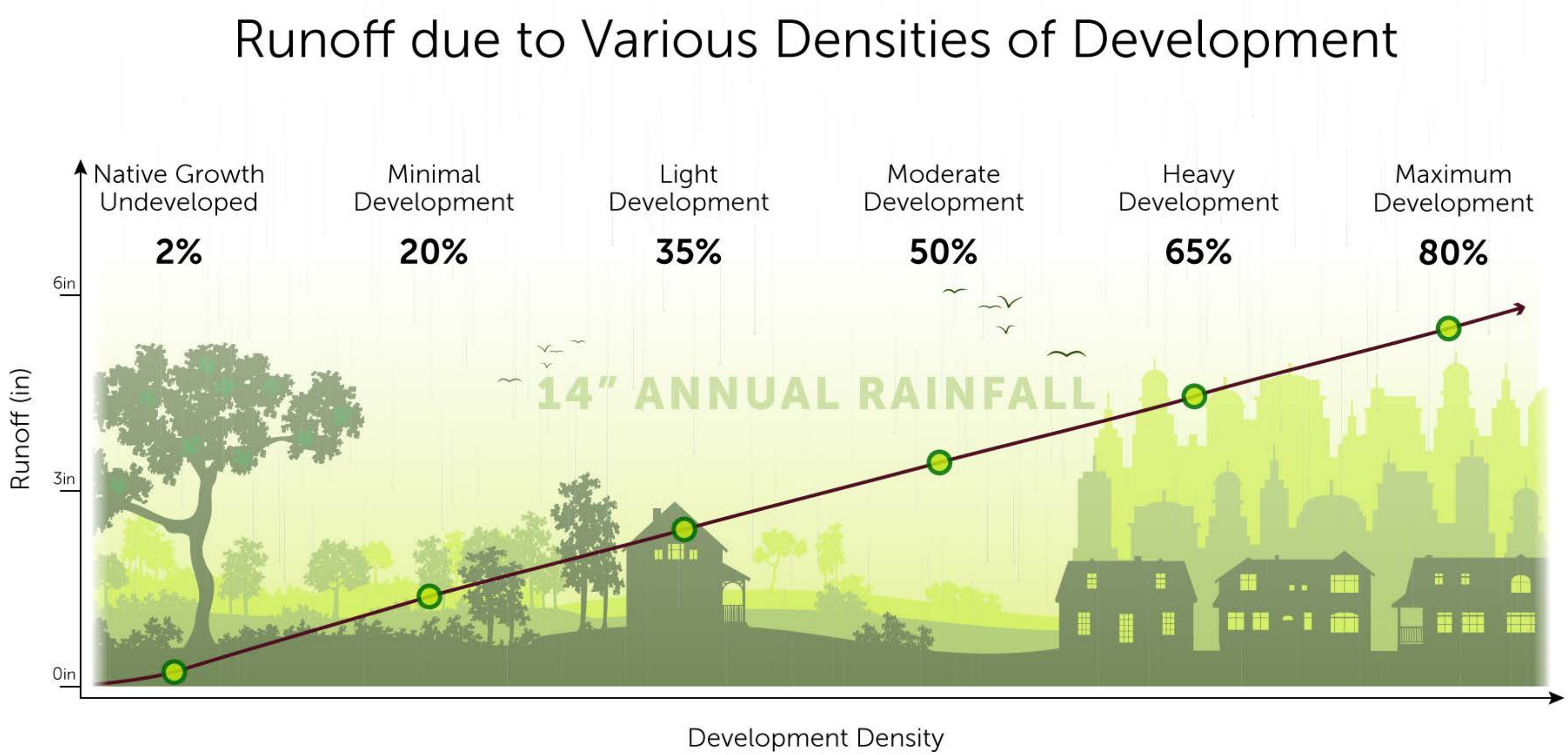
USGS Gaged Streamflow - Big Dry Creek at Ft. Lupton
acre-feet
0
200
400
600
800
1,000
1,200
1,400
1,600
1/1/1985
1/1/1987
1/1/1989
1/1/1991
1/1/1993
1/1/1995
1/1/1997
1/1/1999
1/1/2001
1/1/2003
1/1/2005
1/1/2007
1/1/2009
1/1/2011
1/1/2013
06720990 - BDC nr Ft. Lupton

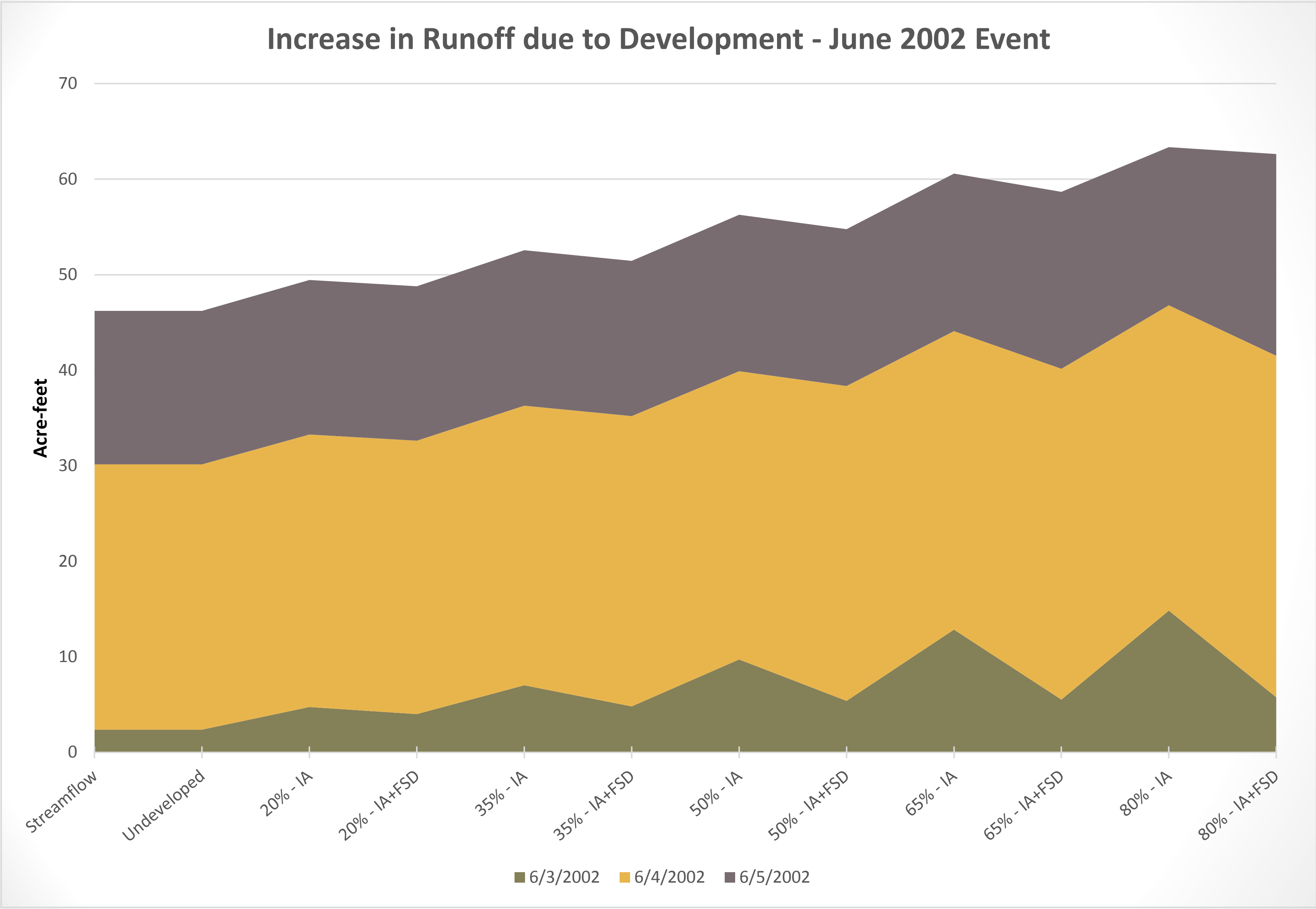
Return Flow and ET

- Colorado water rights holders depend on subsurface flows as a result of rainfall, reservoir seepage and irrigation use.
  - Farm irrigation is large contributor to groundwater return flows.
  - Undeveloped scenario losses are a result of evapotranspiration.
- Development removes the lagged component of native ET from the system.
  - Long-term ET is re-timed through FSD and available to water rights holders in greater and more immediate quantities.
  - The lagged component returning to the stream is de minimis relative to an undeveloped area.

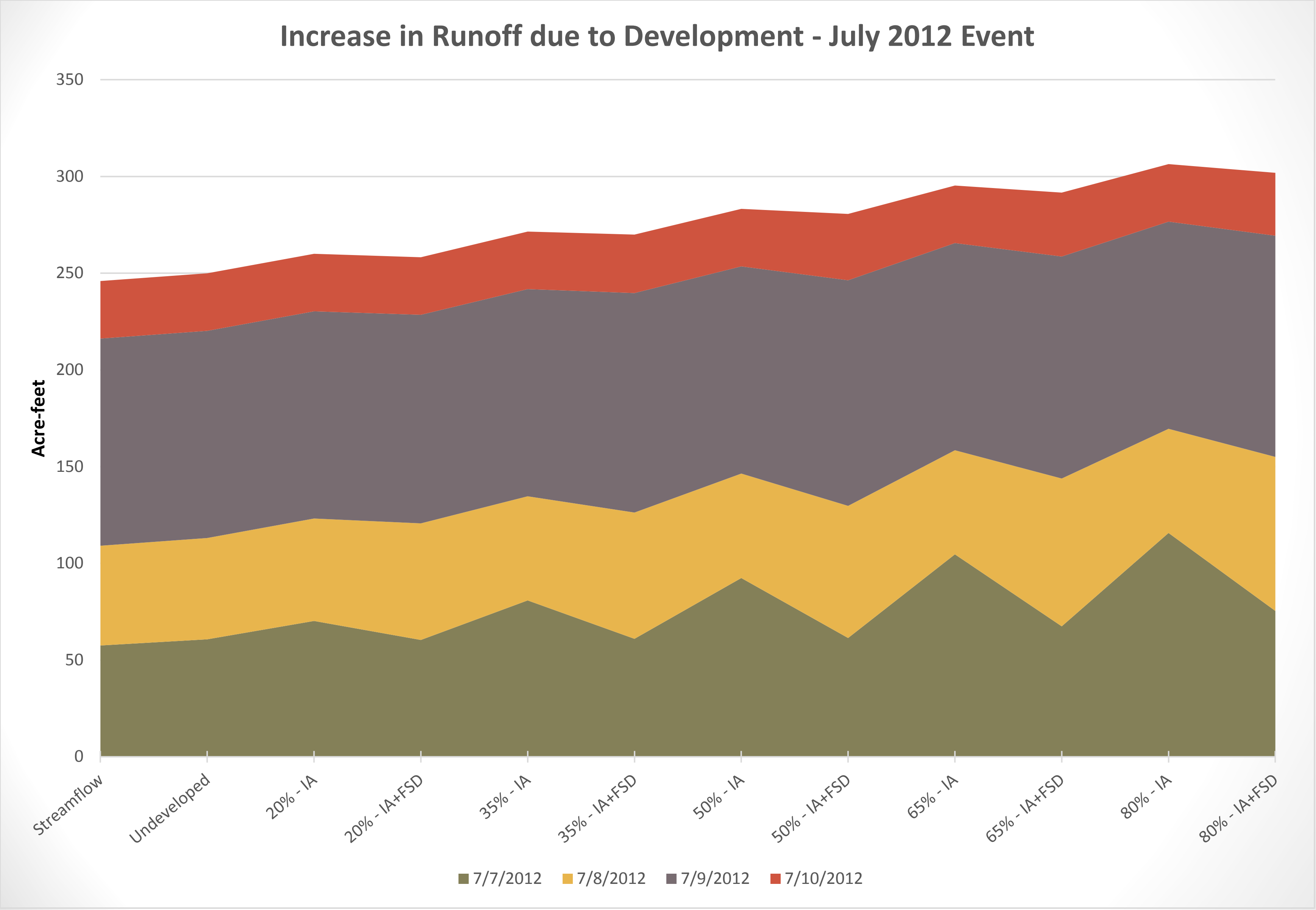
Effects of FSD

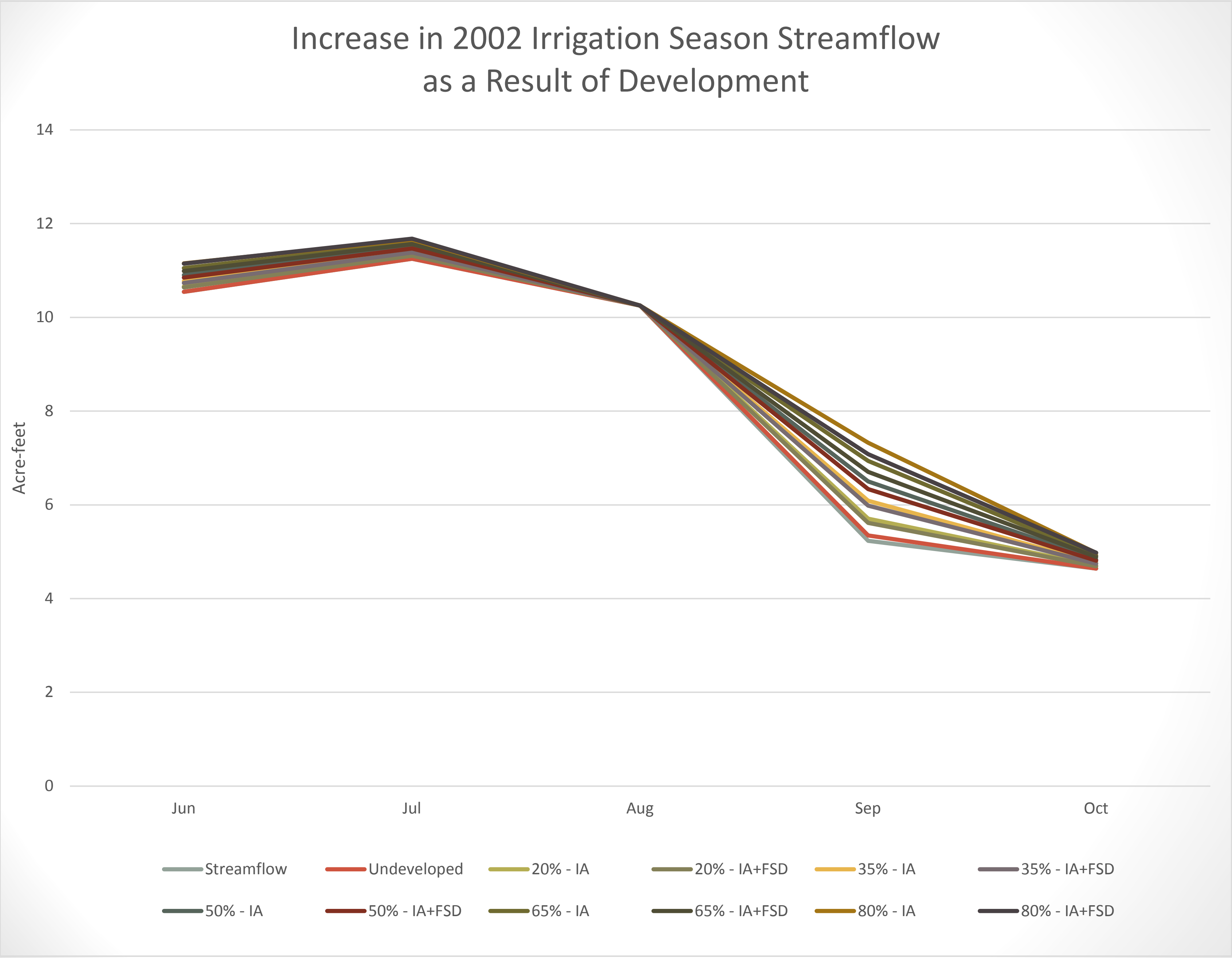
- Colorado water rights holders
    - Municipalities
    - Augmentation Plans
- Peak flow from rainfall events increase physical flow in subsequent days
- Big Dry Creek and South Platte River water rights may divert more water


Runoff due to Various Densities of Development
Native Growth
Undeveloped
2%
Minimal
Development
20%
Light
Development
35%
Moderate
Development
50%
Heavy
Development
65%
Maximum
Development
80%
14" ANNUAL RAINFALL
6in
3in
0in
Runoff (in)
Development Density



Increase in Runoff due to Development - June 2002 Event
70
60
50
40
30
20
10
0
Acre-feet
Streamflow
Undeveloped
20% - IA
20% - IA+FSD
35% - IA
35% - IA+FSD
50% - IA
50% - IA+FSD
65% - IA
65% - IA+FSD
80% - IA
80% - IA+FSD
6/3/2002
6/4/2002
6/5/2002

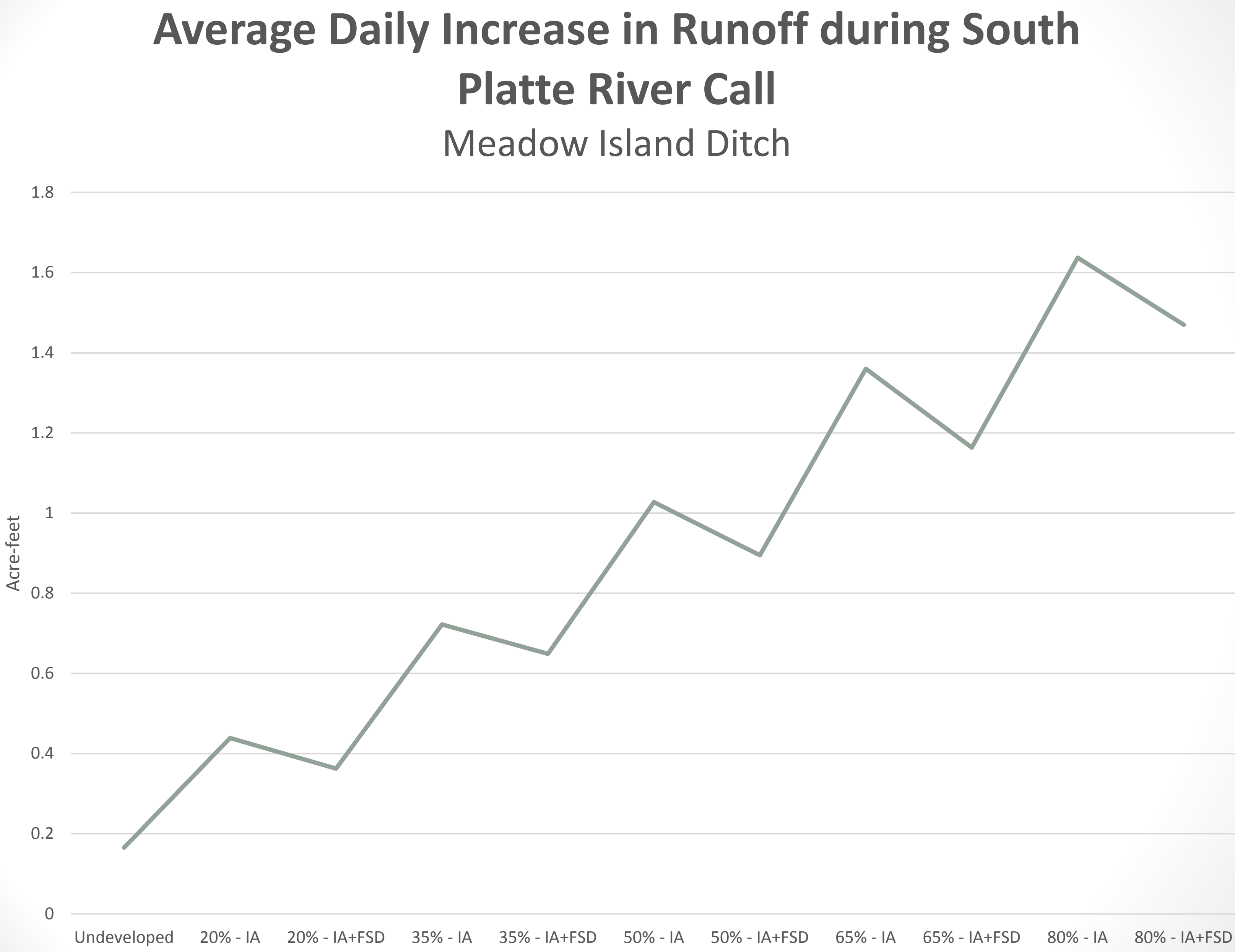

Increase in Runoff due to Development - July 2012 Event
Acre-feet
350
300
250
200
150
100
50
0
Streamflow
Undeveloped
20% - IA
20% - IA+FSD
35% - IA
35% - IA+FSD
50% - IA
50% - IA+FSD
65% - IA
65% - IA+FSD
80% - IA
80% - IA+FSD
7/7/2012
7/8/2012
7/9/2012
7/10/2012


Increase in 2002 Irrigation Season Streamflow
as a Result of Development
Acre-feet
14
12
10
8
6
4
2
0
Jun
Jul
Aug
Sep
Oct
Streamflow
Undeveloped
20% - IA
20% - IA+FSD
35% - IA
35% - IA+FSD
50% - IA
50% - IA+FSD
65% - IA
65% - IA+FSD
80% - IA
80% - IA+FSD

Runoff during South Platte River Calls as a Result of Development

Units in acre-feet

Group	Admin #	Call Structure	Days	Percent	Undeveloped	20% - IA	20% - IA+FSD	35% - IA	35% - IA+FSD	50% - IA	50% - IA+FSD	65% - IA	65% - IA+FSD	80% - IA	80% - IA+FSD
	No Call		13,883	60%	728	2,553	2,380	4,512	4,583	6,762	7,003	9,328	9,622	11,297	12,498
German Ditch - 1st Priority; Bull Canal - 1st Priority	5803.00000	FARMERS INDEPENDENT DITCH	50	0.22%	0	3	1	5	2	8	3	11	4	13	6
	5965.00000	MEADOW ISLAND 1 DITCH	190	0.82%	18	46	39	76	67	107	89	142	124	170	161
	5967.00000	MEADOW ISLAND DITCH	143	0.61%	24	63	52	103	93	147	128	195	166	234	210
	5969.00000	HEWES COOK DITCH	146	0.63%	0	12	9	24	17	39	26	56	34	67	44
	7671.00000	PLATTEVILLE DITCH	10	0.04%	0	0	0	0	0	0	0	0	0	0	0
	7739.00000	LUPTON BOTTOM DITCH	1	0.00%	0	0	0	0	0	0	0	0	0	0	0
	7892.00000	HEWES COOK DITCH	126	0.54%	5	23	13	43	19	62	24	83	43	100	67
	7948.00000	EVANS NO 2 DITCH	1,476	6.35%	145	343	265	552	446	782	594	1,039	796	1,236	1,038
	7975.00000	BRIGHTON DITCH	375	1.61%	0	37	28	73	54	117	86	167	127	205	175
	8127.00000	FARMERS HIGHLINE CNL	53	0.23%	0	12	10	25	21	41	32	60	45	75	59
	8218.00000	BRANTNER DITCH	32	0.14%	0	2	2	4	3	6	7	8	10	10	11
	8659.00000	LUPTON BOTTOM DITCH	136	0.58%	65	111	87	161	128	213	151	270	191	317	237
	8689.00000	PLATTEVILLE DITCH	109	0.47%	55	87	66	121	94	157	111	195	144	226	181
	9075.00000	UNION DITCH	196	0.84%	12	48	35	88	65	128	93	173	136	209	186
	9597.00000	MEADOW ISLAND DITCH	3	0.01%	0	0	0	0	0	0	0	0	0	1	1
	9686.00000	FULTON DITCH	501	2.15%	12	98	68	189	120	292	177	406	271	497	386
	9821.00000	FARMERS INDEPENDENT DITCH	271	1.17%	0	34	28	67	61	107	100	154	132	189	171
	10180.00000	LOWER LATHAM DITCH	243	1.05%	48	141	92	238	157	345	212	460	289	558	371
	10184.00000	CHURCH DITCH	1	0%	0	0	0	0	0	0	0	0	0	0	0
	10215.00000	MEADOW ISLAND DITCH	26	0.11%	0	2	2	4	3	6	5	9	7	10	9
	10480.00000	DENVER CONDUIT NO 20	2	0.01%	0	0	0	0	0	0	0	0	0	0	0
	10546.00000	CHURCH DITCH	1	0%	0	0	0	0	0	0	0	0	0	0	0
	10610.00000	HIGHLINE CNL	93	0.40%	87	133	122	187	183	237	213	290	281	332	328
	10901.00000	FULTON DITCH	15	0.06%	0	7	2	15	3	24	5	34	9	43	17
	11139.00000	DENVER CONDUIT NO 20	5	0.02%	0	1	0	1	1	2	1	2	2	3	2
	11338.00000	BRANTNER DITCH	68	0.29%	0	3	3	6	7	10	14	15	19	17	23
	11620.00000	LOWER LATHAM DITCH	156	0.67%	2	32	27	63	57	99	92	140	131	173	171
	11629.00000	UNION DITCH	2	0.01%	0	0	0	0	0	0	0	0	0	0	0
	11807.00000	MEADOW ISLAND 1 DITCH	15	0.06%	0	0	0	0	0	0	0	0	0	0	0
	13108.00000	BURLINGTON D RIVER HEADGATE	2,164	9.31%	63	409	360	769	698	1,187	1,063	1,665	1,435	2,031	1,899
Bull Canal Pr2	14423.00000	CHEESMAN RES	106	0.46%	0	13	9	25	17	41	26	59	37	72	53
	14519.00000	DENVER CONDUIT NO 20	0	0.00%	0	0	0	0	0	0	0	0	0	0	0
	15585.00000	DENVER CONDUIT NO 20	6	0.03%	0	0	0	0	0	0	0	0	0	0	0
BDC Ditch	15973.00000	CHEESMAN RES	23	0.10%	75	90	75	108	106	123	121	138	137	151	156
Thorncreek Pipeline; Bull Canal	18018.00000	DENVER CONDUIT NO 20	26	0.11%	0	0	0	0	0	0	0	0	0	0	0
	19055.00000	CROKE CANAL	18	0.08%	0	0	0	0	0	0	1	0	2	0	3
	21150.00000	BURLINGTON D RIVER HEADGATE	21	0.09%	0	1	1	2	1	2	2	3	3	4	4
	21252.00000	BURLINGTON D RIVER HEADGATE	102	0.44%	0	13	11	25	21	41	33	59	46	71	59
	21562.00000	BURLINGTON D RIVER HEADGATE	1,313	5.65%	4	141	132	283	280	453	465	649	673	798	891
	21698.00000	MILTON RES	139	0.60%	0	6	6	12	12	20	20	29	32	35	46
	21709.00000	EVANS NO 2 DITCH	9	0.04%	0	0	0	1	1	1	1	1	1	1	2
	22239.00000	BURLINGTON D RIVER HEADGATE	115	0.49%	0	2	2	4	4	7	6	9	9	11	11
	22254.00000	DENVER CONDUIT NO 20	20	0.09%	0	0	0	0	0	0	0	0	0	0	0
	22355.00000	HORSE CREEK RES	48	0.21%	0	6	6	11	17	18	27	26	37	31	48
	22370.00000	MARSTON RES FROM (SEE 0903501)	15	0.06%	0	4	2	8	5	13	9	19	15	23	23
	25050.21709	EVANS NO 2 DITCH	33	0.14%	0	6	7	13	18	21	30	30	31	38	39
	46748.00000	CHATFIELD RESERVOIR	137	0.59%	5	32	27	61	59	92	92	126	117	153	143
	47481.40987	DENVER CONDUIT NO 20	7	0.03%	0	0	0	0	0	0	0	0	0	0	0
	48974.00000	BURLINGTON D RIVER HEADGATE	12	0.05%	0	2	2	4	3	6	6	9	7	11	9


Average Daily Increase in Runoff during South Platte River Call
Meadow Island Ditch
Acre-feet
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Undeveloped
20% - IA
20% - IA+FSD
35% - IA
35% - IA+FSD
50% - IA
50% - IA+FSD
65% - IA
65% - IA+FSD
80% - IA
80% - IA+FSD

CONCLUSIONS

Conclusions

- Development increases impervious area which decreases evaporation/ET and increases runoff
- Surface water yield from undeveloped to developed conditions changes dramatically, more so at higher impervious levels
- Evaporation/ET in model is not sensitive to effects of FSD
  - Depression storage following rainfall
  - Soil moisture availability for ET (upper aquifer zone)
- FSD attenuates peak discharges and extends release hydrographs

Conclusions

- SWMM Model trends follow expected patterns with increasing imperviousness
- FSD primarily affects the timing of runoff (relative to same scenario) without FSD, quantity effects are minor
- Increased flow along the Front Range is coveted and will help water rights holders reduce the supply/demand gap
- Following rainfall events in dry years, water rights holders will benefit from increased flow in subsequent days as a result of FSD

Questions & Comments?

ADVENTURES IN MASTER PLANNING

Shea Thomas, PE
Project Manager

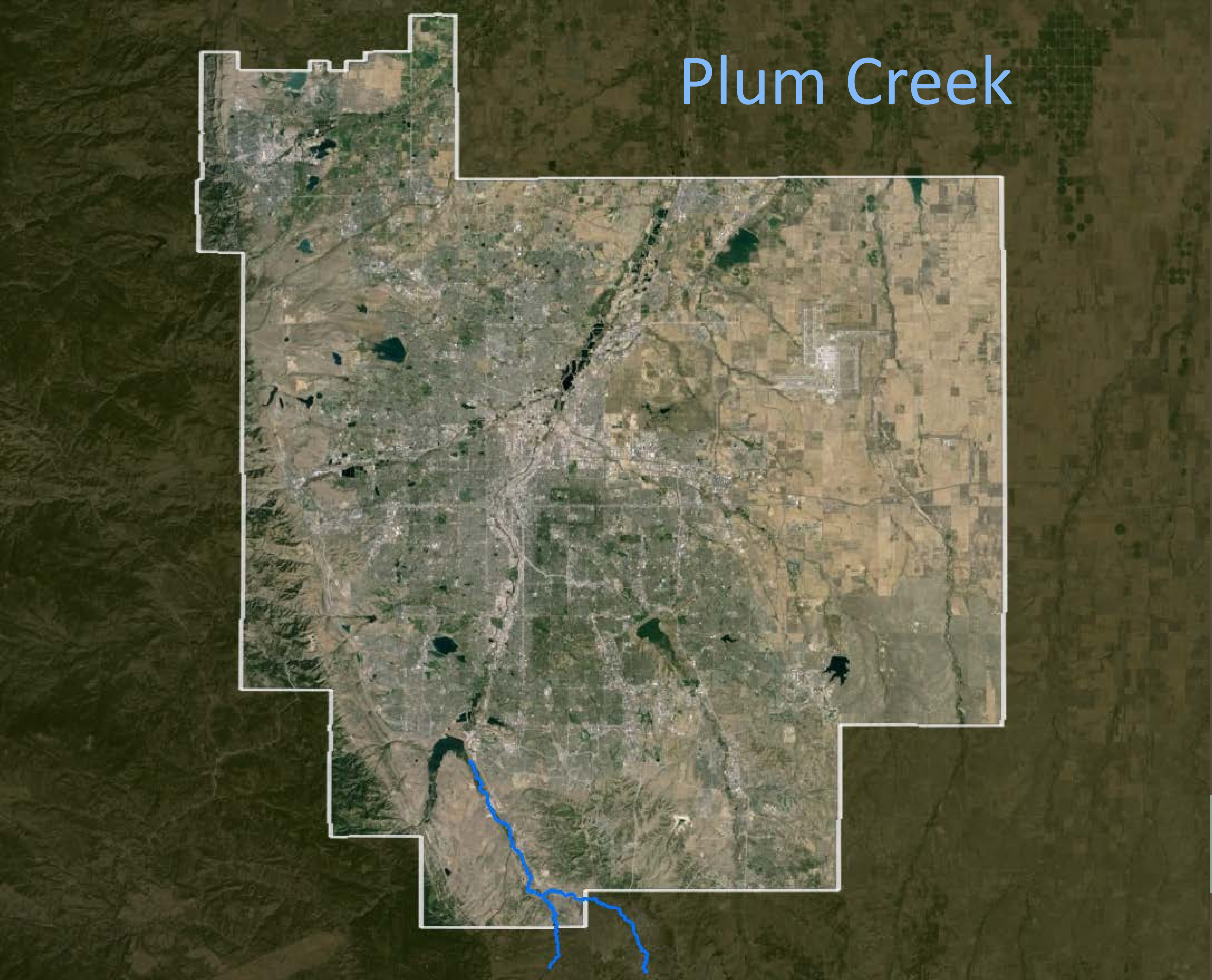
2016 UDFCD Annual Seminar April 5, 2016


A goal
without a plan
is just a wish.
-Antoine de Saint-Exupery

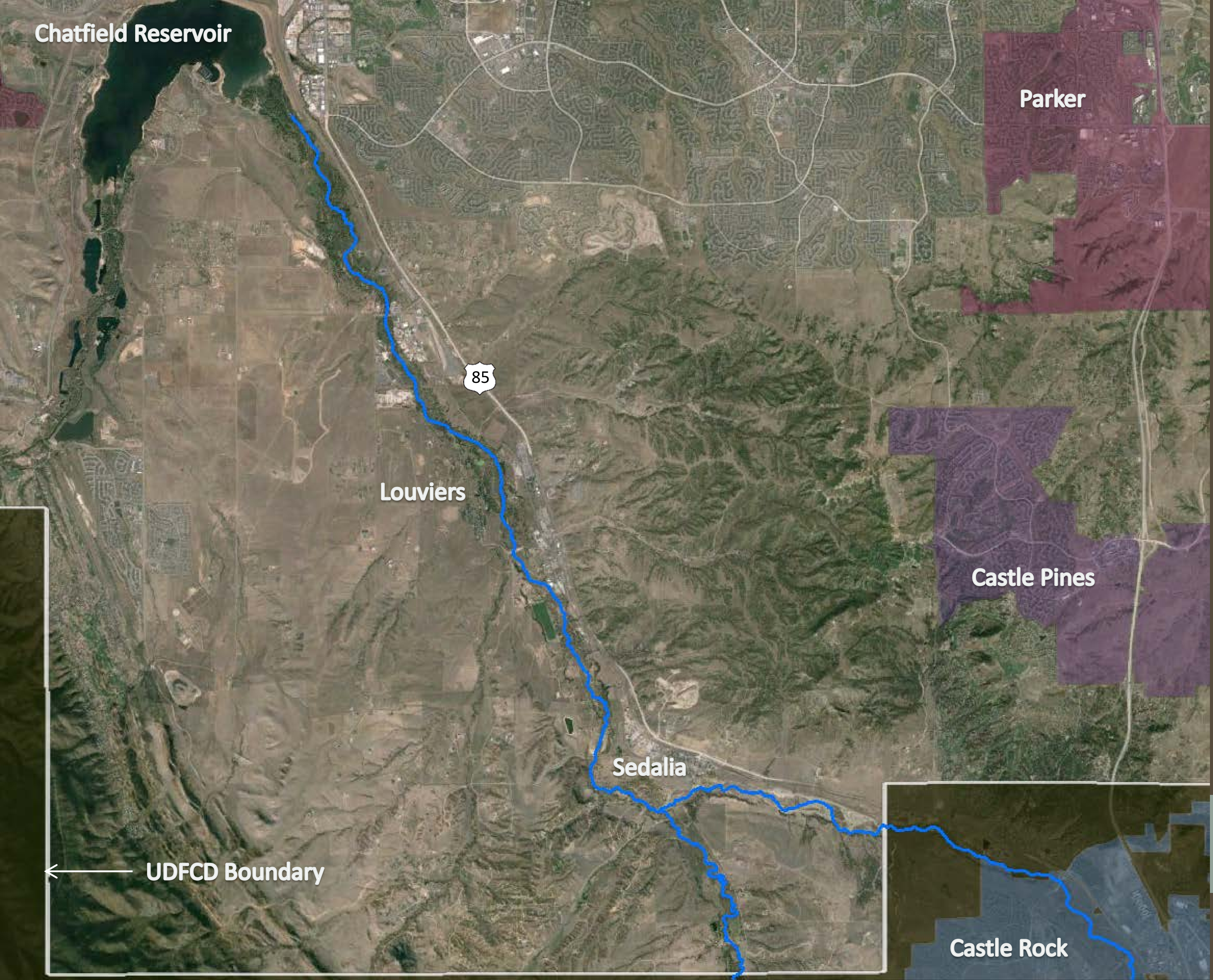
Preservation Mitigation

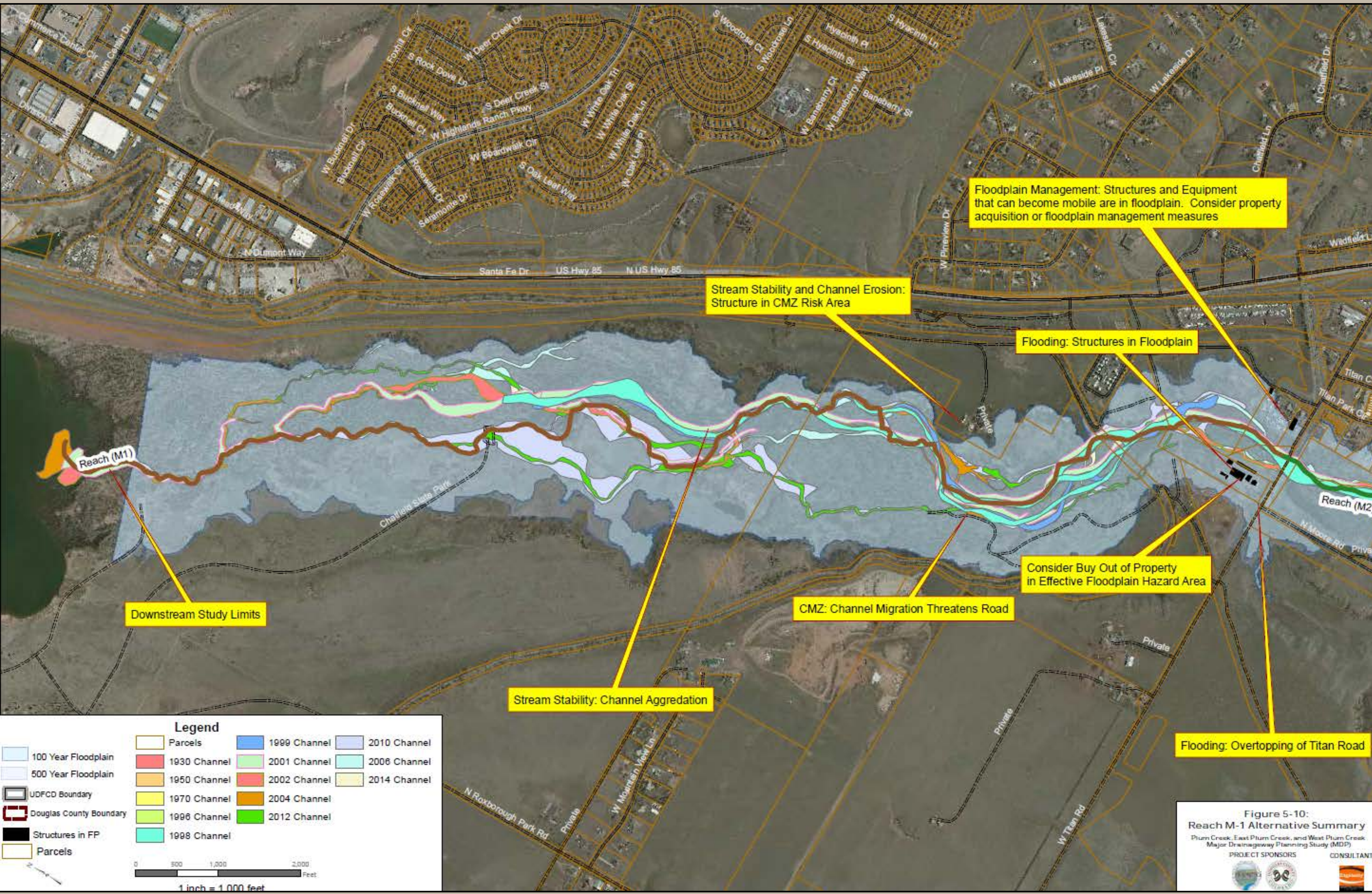
Douglas County: Duke of Hazards

Plum Creek

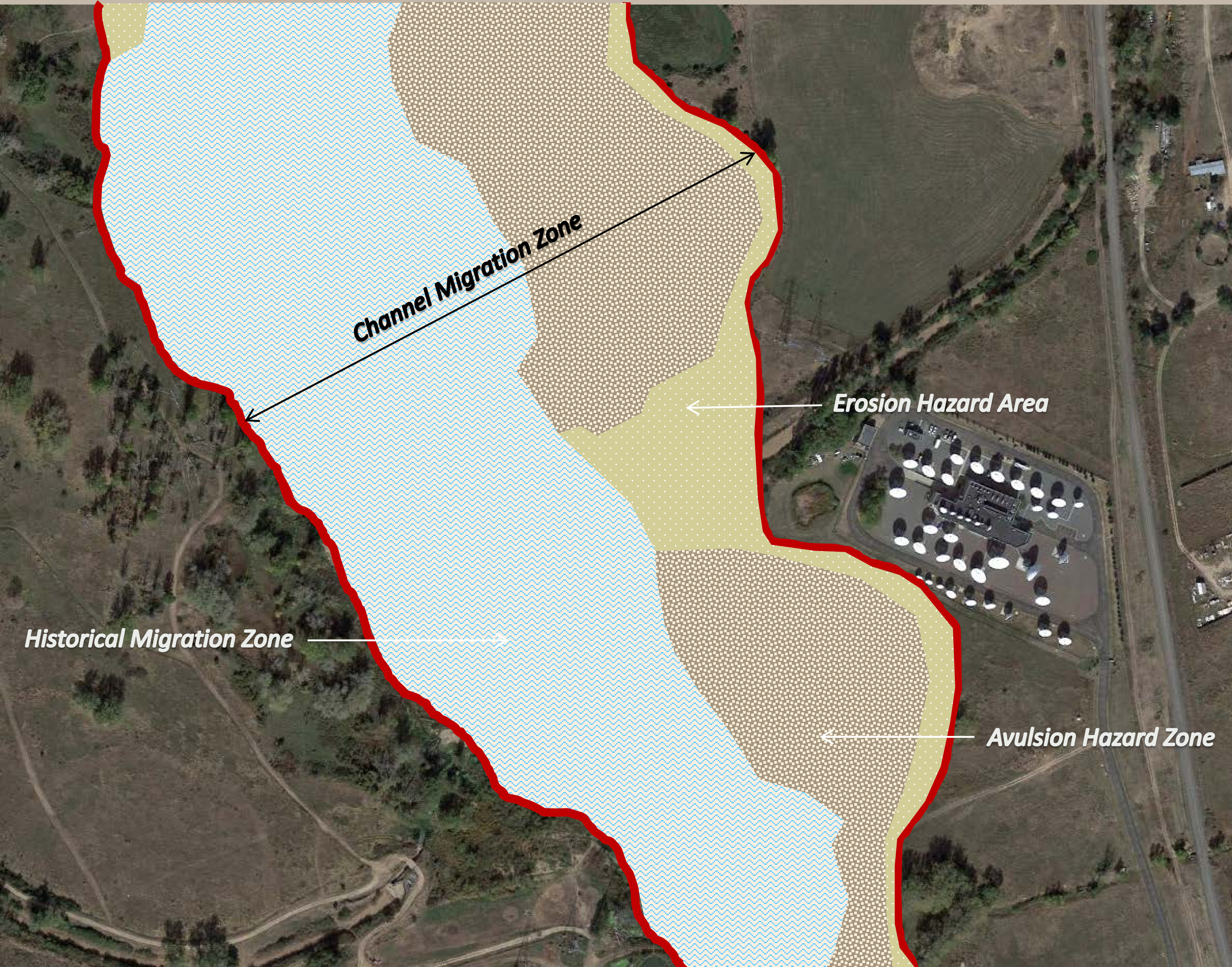


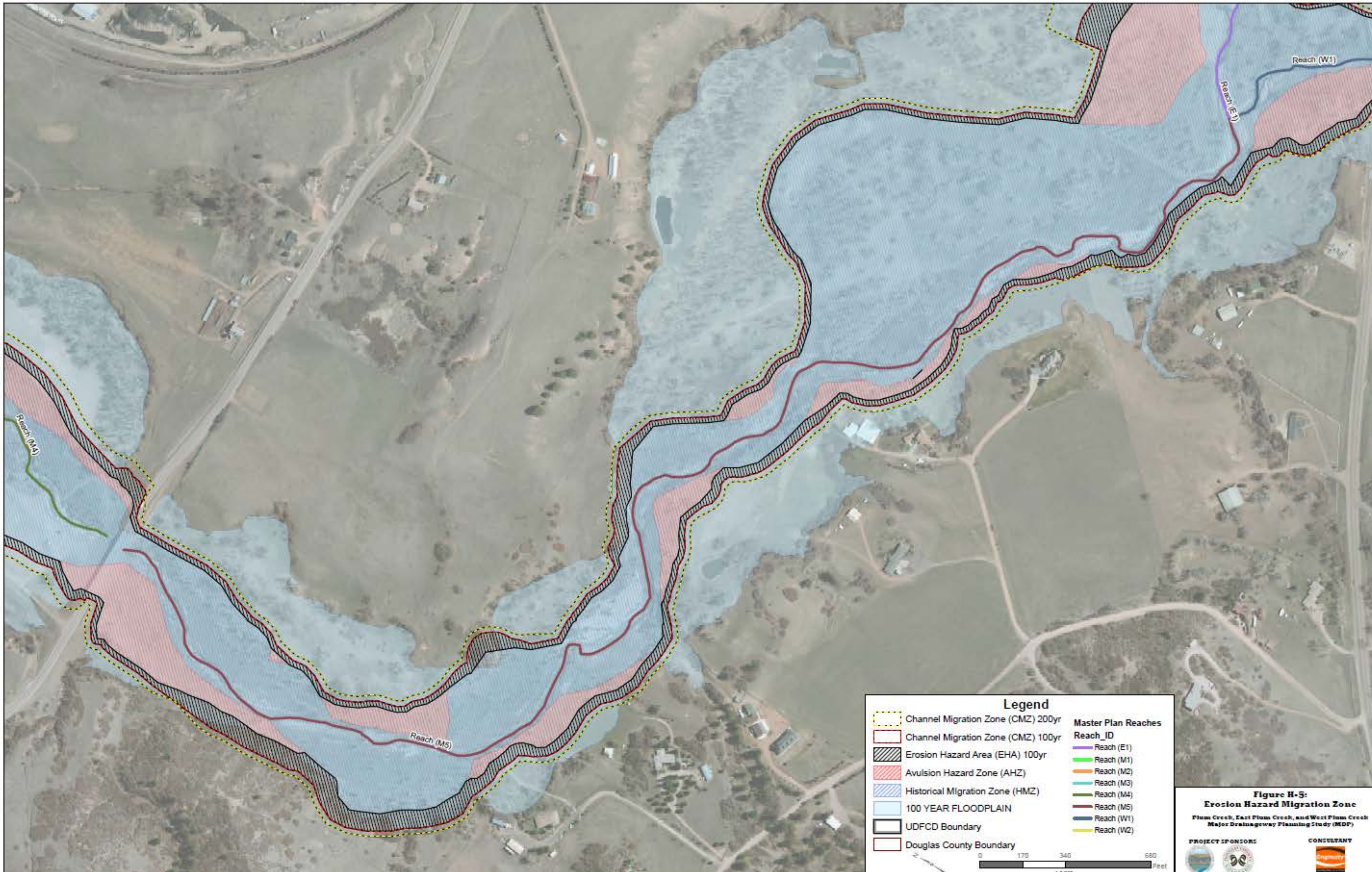
2016 UDFCD Annual Seminar April 5, 2016


Chatfield Reservoir
Parker
85
Louviers
Castle Pines
Sedalia
UDFCD Boundary
Castle Rock

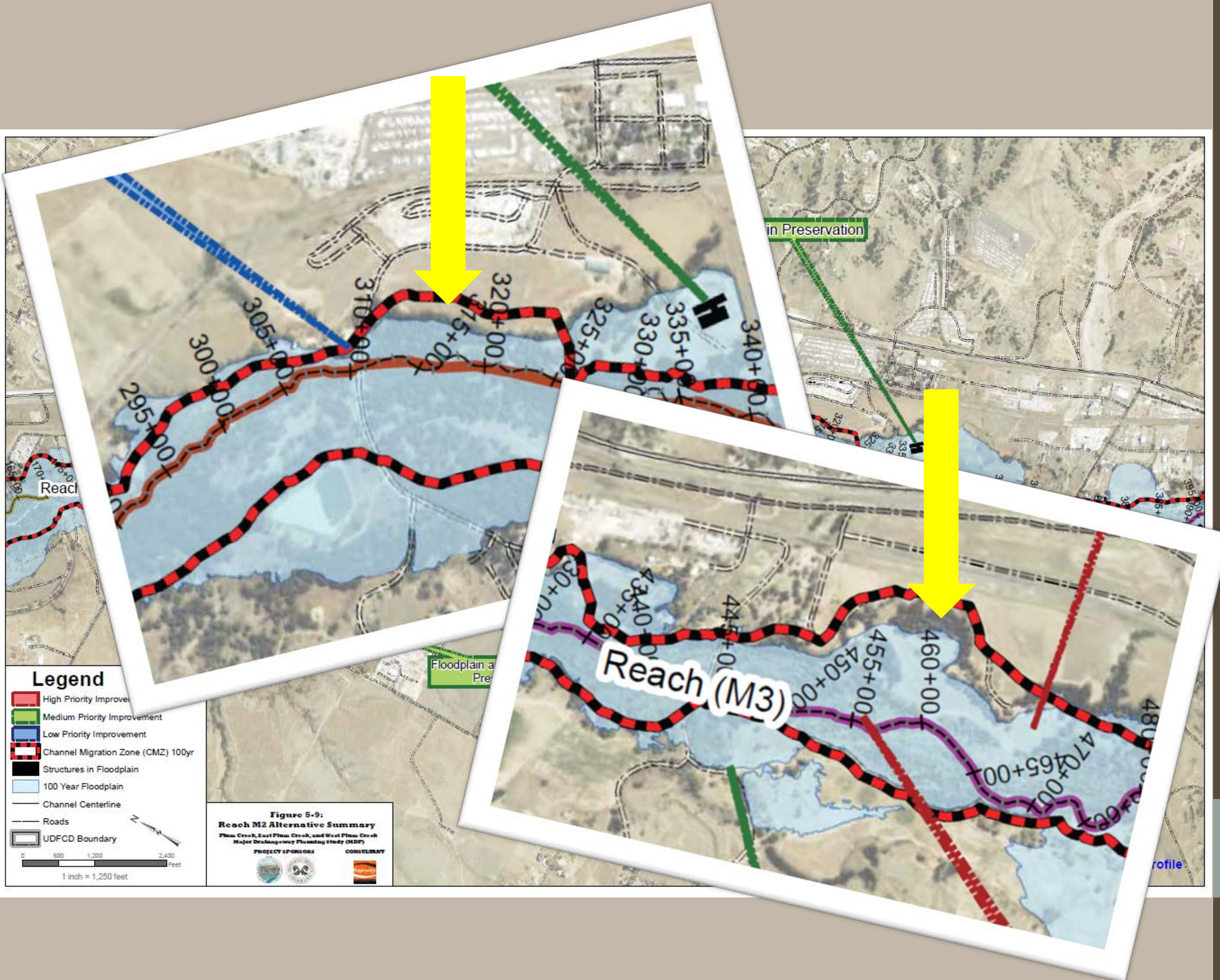


2016 UDFCD Annual Seminar April 5, 2016

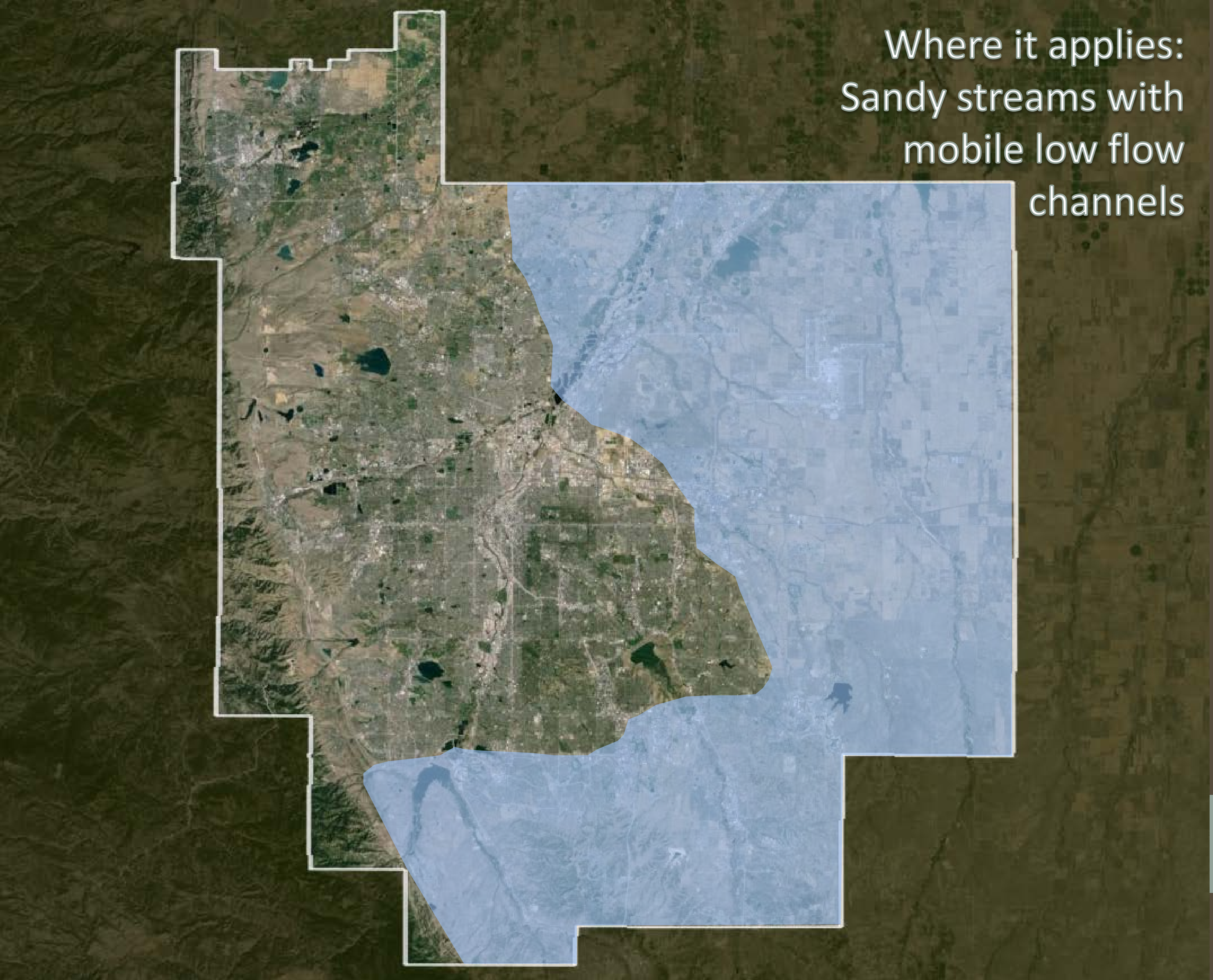

Channel Migration Zone
Erosion Hazard Area
Historical Migration Zone
Avulsion Hazard Zone



Reach (W1)
Reach (E1)
Reach (M4)
Reach (M5)
Legend
Channel Migration Zone (CMZ) 200yr
Channel Migration Zone (CMZ) 100yr
Erosion Hazard Area (EHA) 100yr
Avulsion Hazard Zone (AHZ)
Historical Migration Zone (HMZ)
100 YEAR FLOODPLAIN
UDFCD Boundary
Douglas County Boundary
Master Plan Reaches
Reach_ID
Reach (E1)
Reach (M1)
Reach (M2)
Reach (M3)
Reach (M4)
Reach (M5)
Reach (W1)
Reach (W2)
0
170
340
680
Feet
1:2,000
Figure H-5:
Erosion Hazard Migration Zone
Plum Creek, East Plum Creek, and West Plum Creek
Major Drainageway Planning Study (MDP)
PROJECT SPONSORS
CONSULTANT

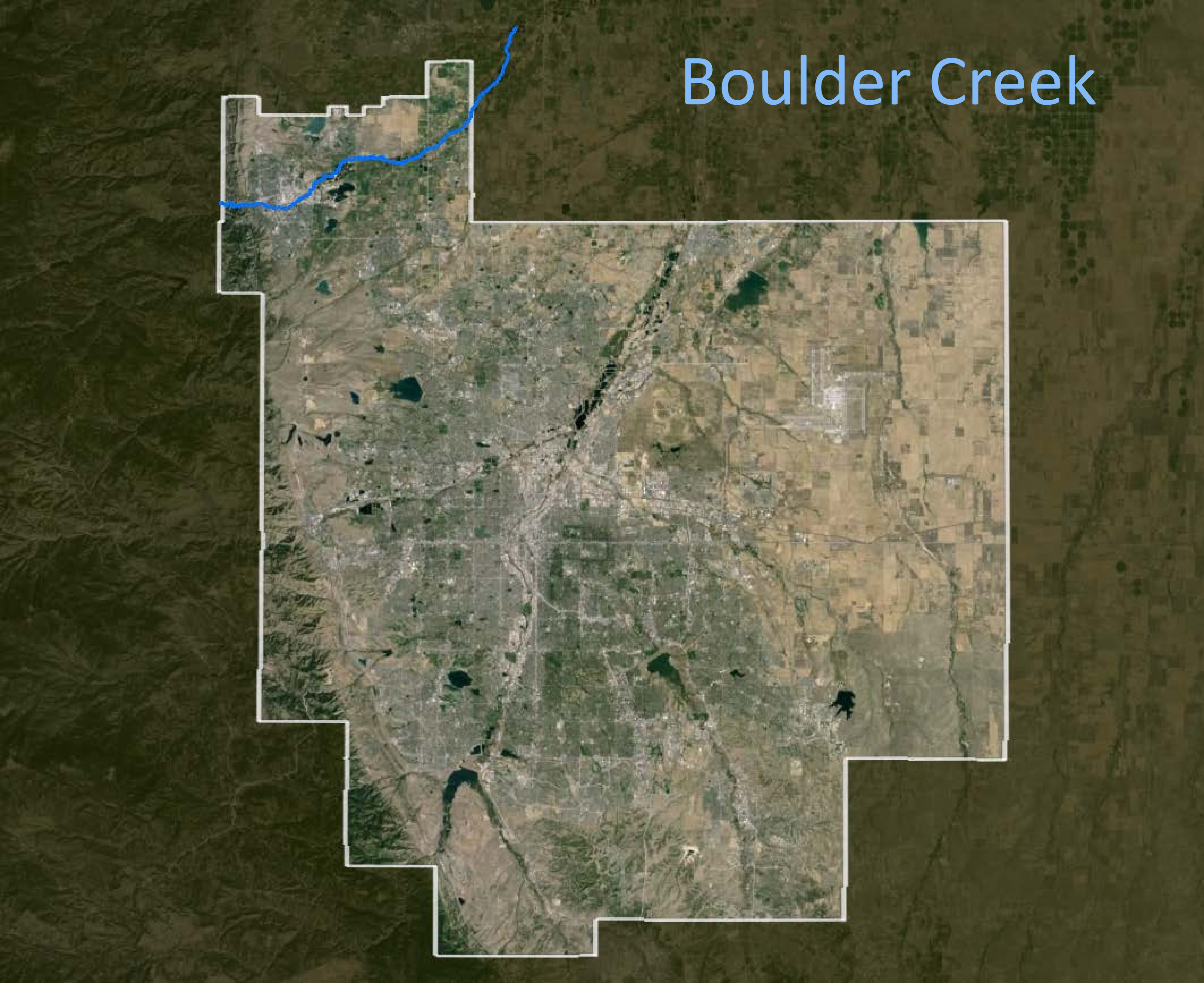

Legend
High Priority Improvement
Medium Priority Improvement
Low Priority Improvement
Channel Migration Zone (CMZ) 100yr
Structures in Floodplain
100 Year Floodplain
Channel Centerline
Roads
UDFCD Boundary
1 inch = 1,250 feet
Figure 5-9:
Reach M2 Alternative Summary
Reach (M3)
295+00
300+00
305+00
310+00
320+00
325+00
330+00
335+00
340+00
450+00
455+00
460+00
465+00
470+00
in Preservation
Floodplain a
Pre
Reach
rofile

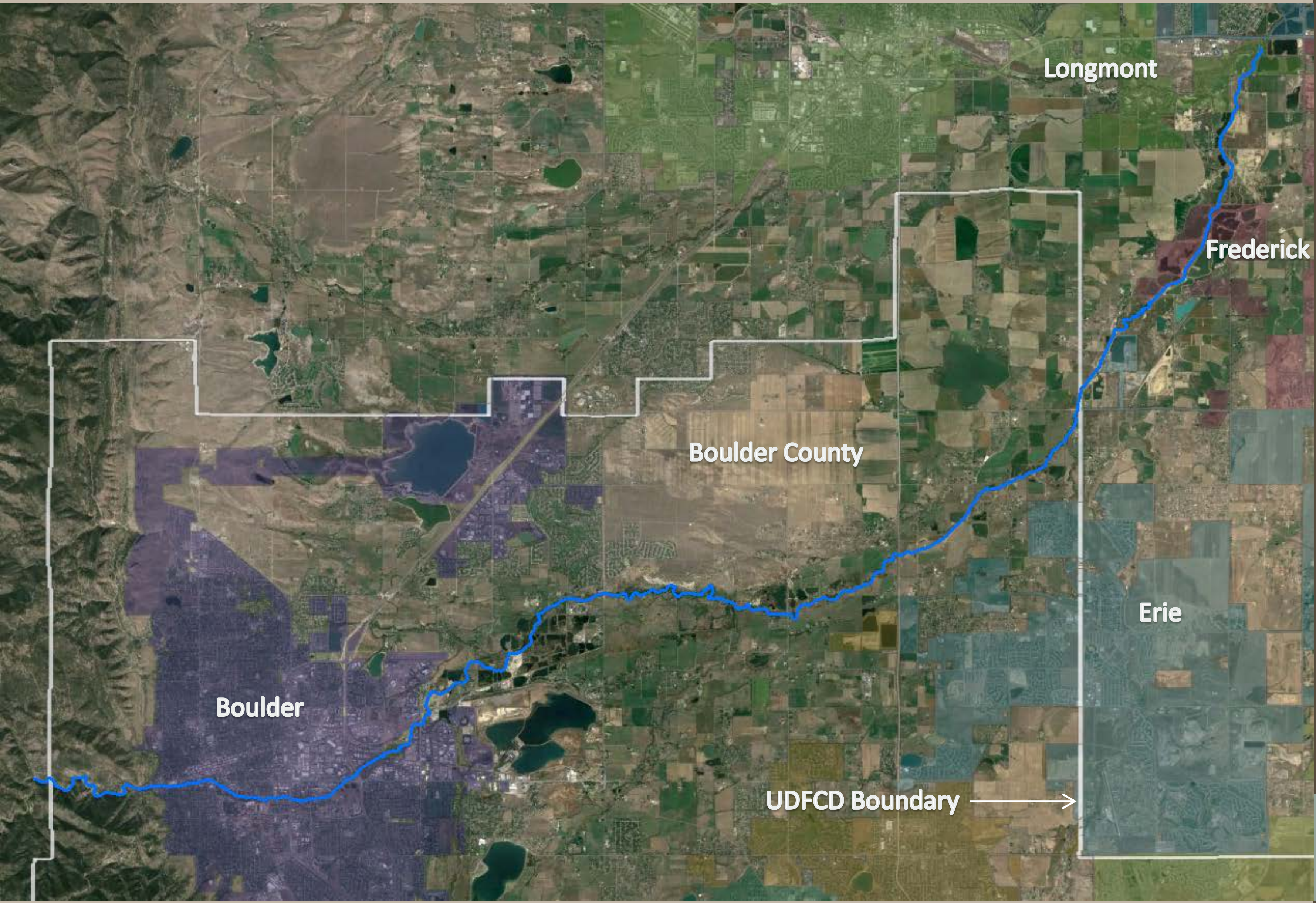
Where it applies: Sandy streams with mobile low flow channels



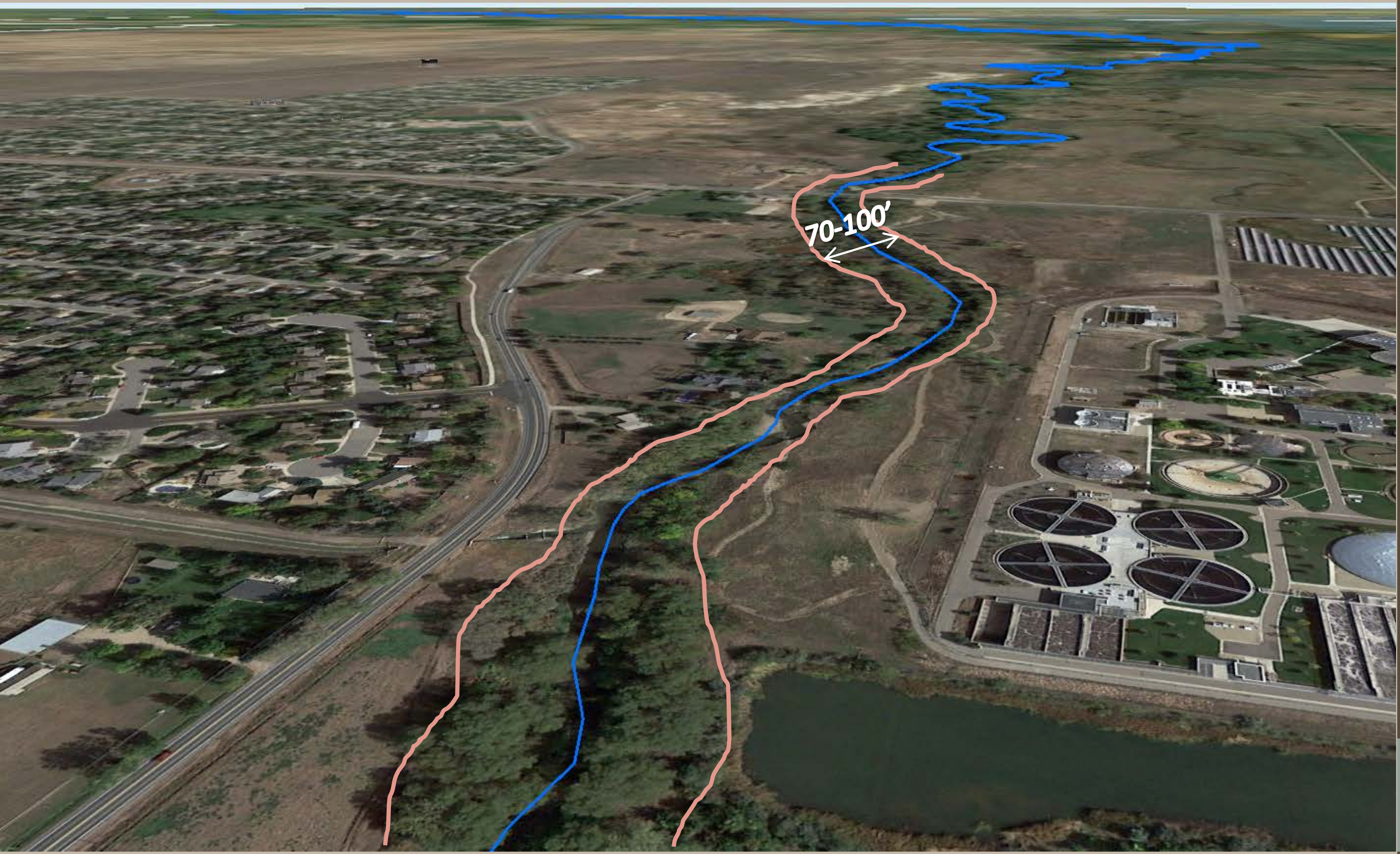
Boulder County: Back to the Future

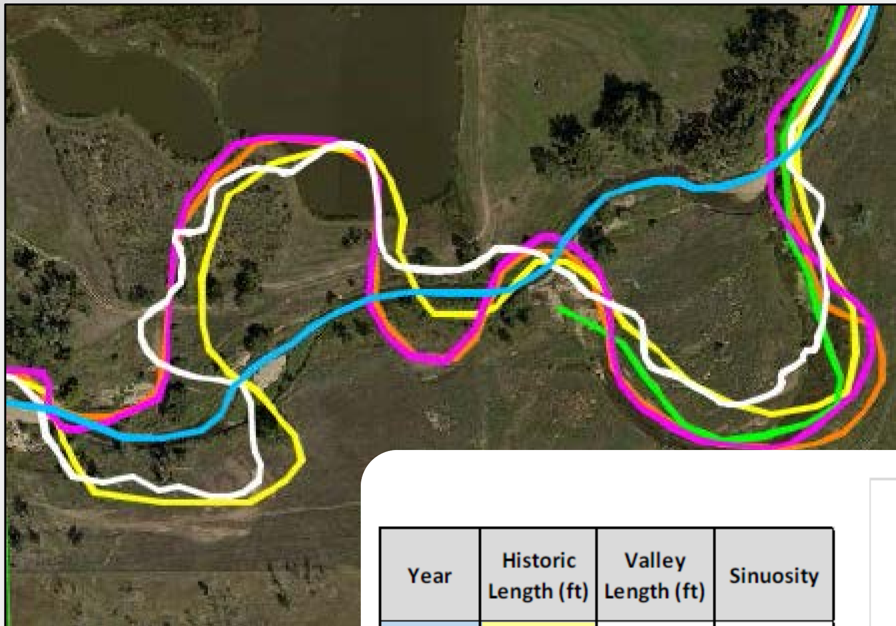
Boulder Creek

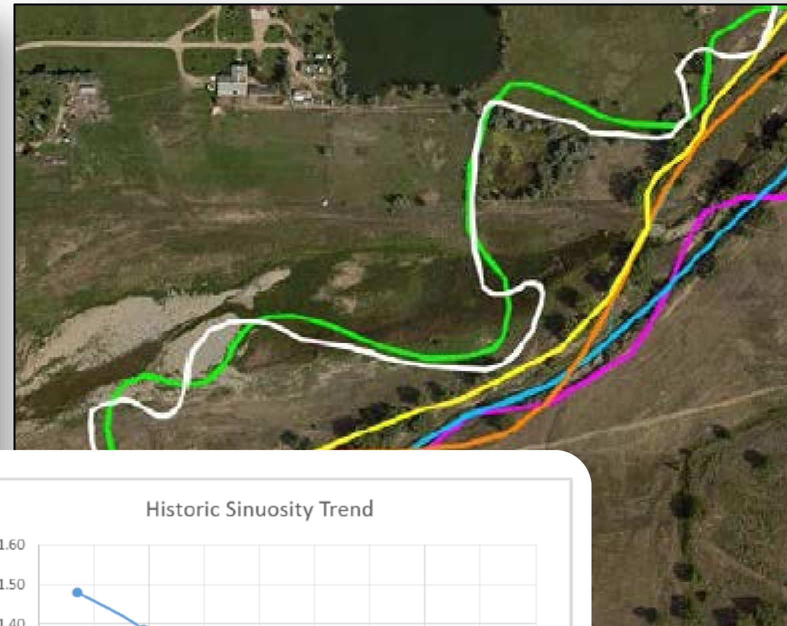



Longmont
Frederick
Boulder County
Erie
Boulder
UDFCD Boundary

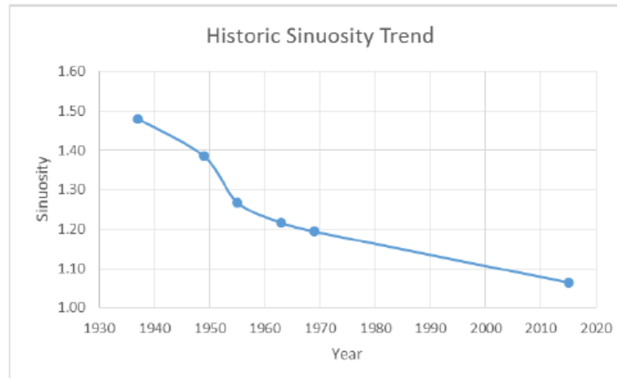

300-500’

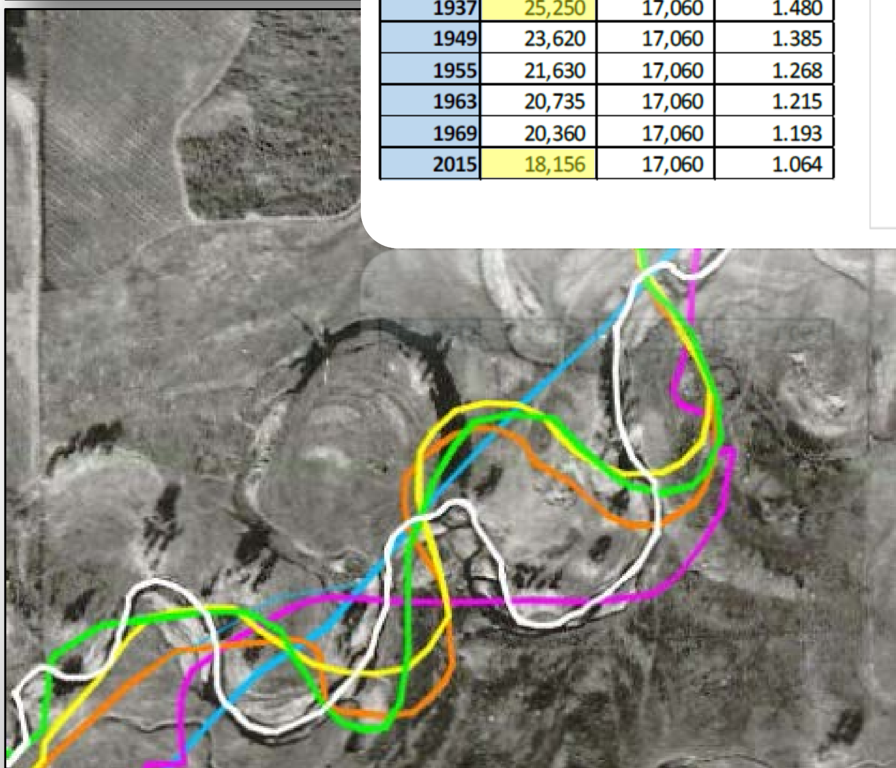

70-100′





Year	Historic Length (ft)	Valley Length (ft)	Sinuosity
1937	25,250	17,060	1.480
1949	23,620	17,060	1.385
1955	21,630	17,060	1.268
1963	20,735	17,060	1.215
1969	20,360	17,060	1.193
2015	18,156	17,060	1.064





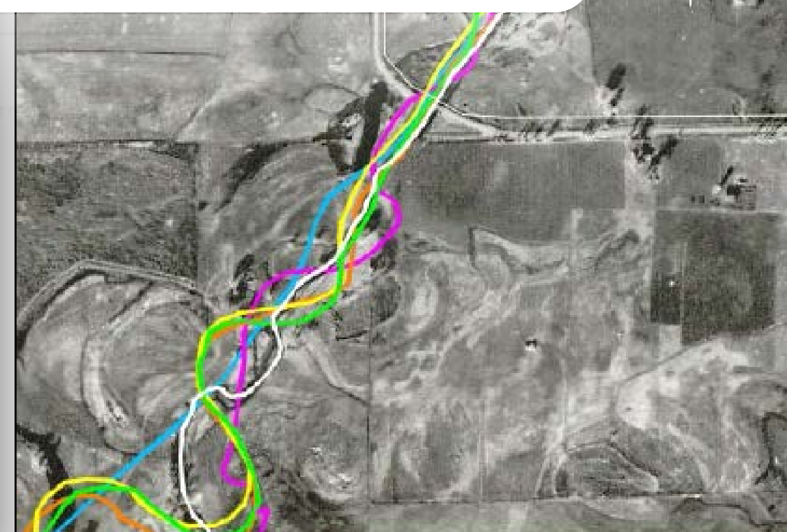
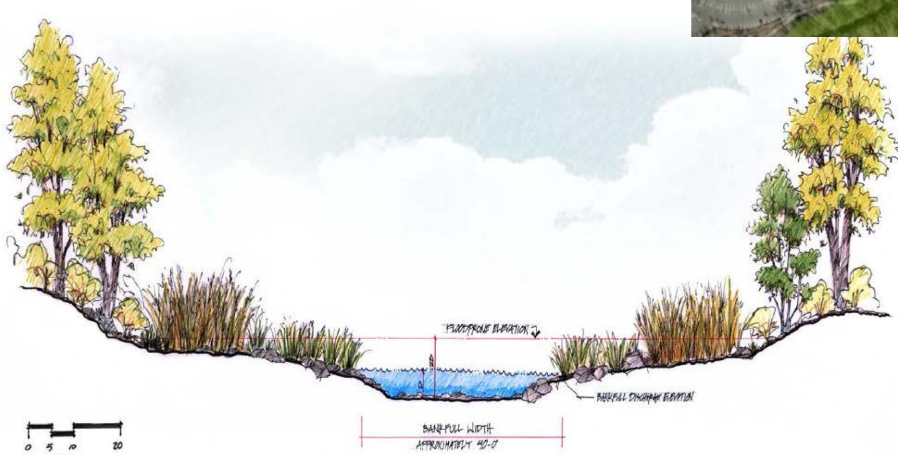
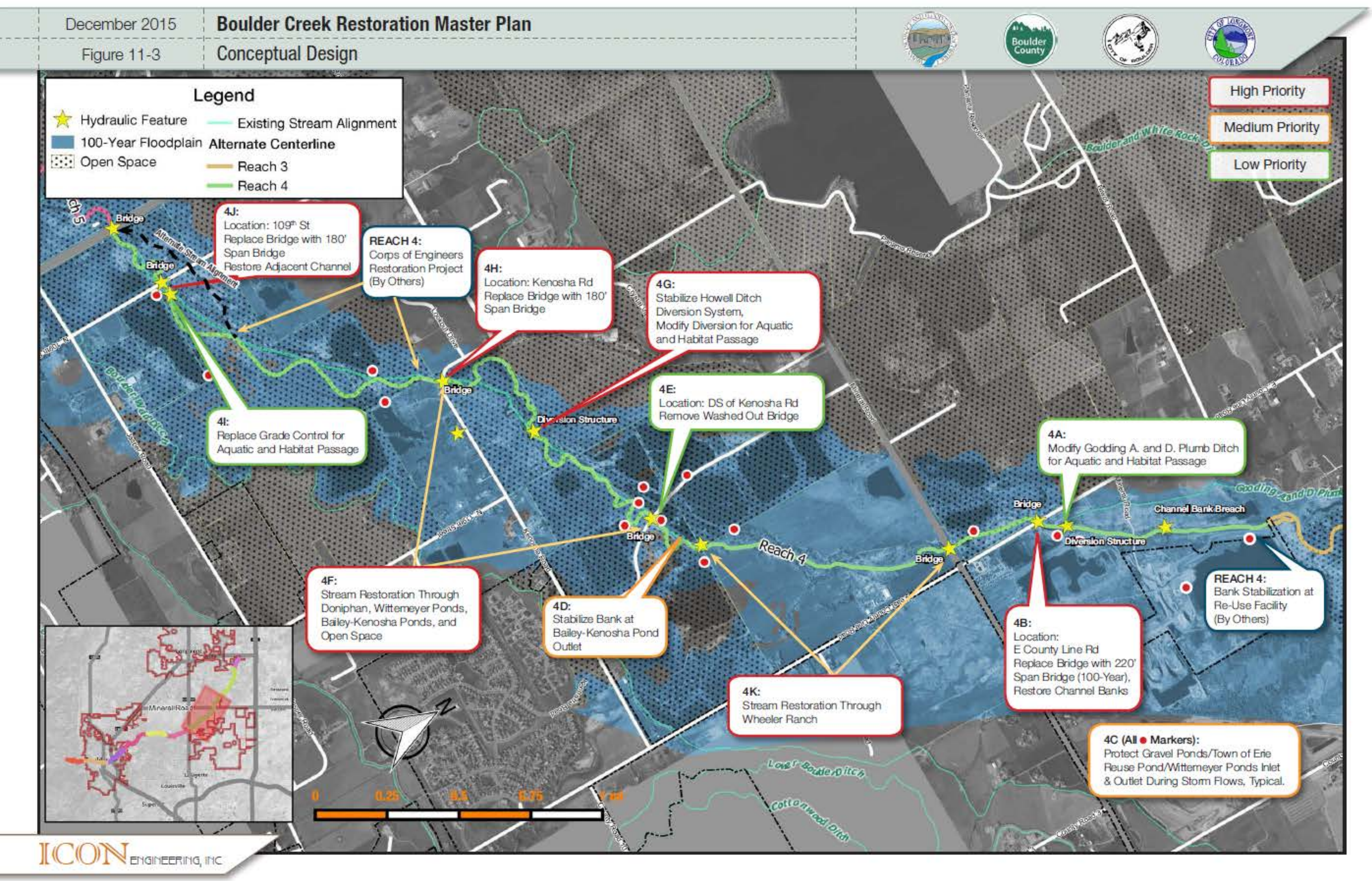


Table 11-2: Recommended Geometries for Primary Stream Types

Reach	Assumed Sinuosity	Slope (%)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)
1	1.6	0.20%	40	3	140
2	1.6	0.19%	40	3	140
3	1.6	0.29%	40	3	140
4	1.6	0.22%	40	3	140
5	1.6	0.24%	40	3	140
6	1.6	0.36%	40	3	140
7	1.6	0.30%	40	3	140
8	1.6	0.46%	40	3	140
9	1.4	0.81%	40	2.5	140
10	1.3	2.60%	30	2	54

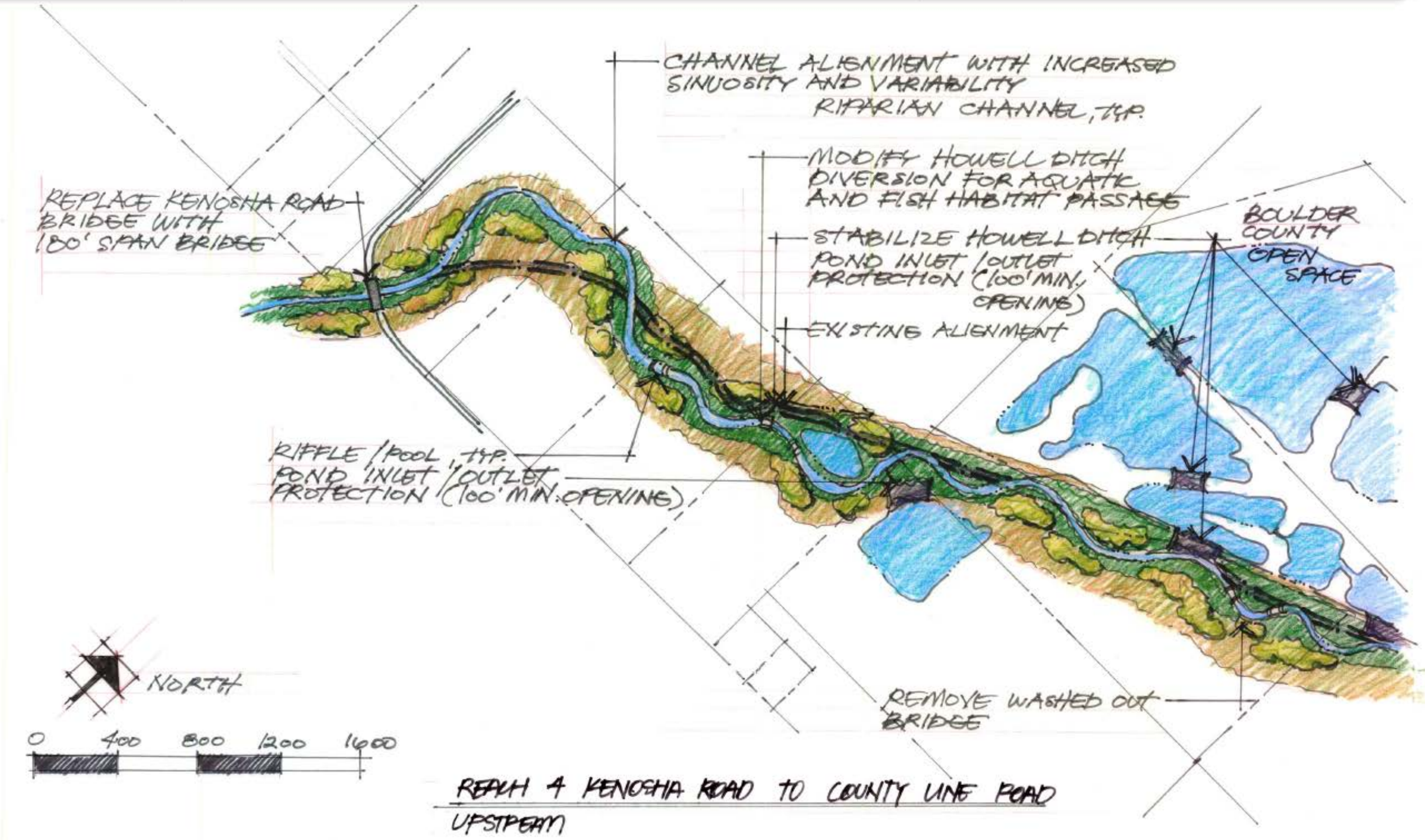




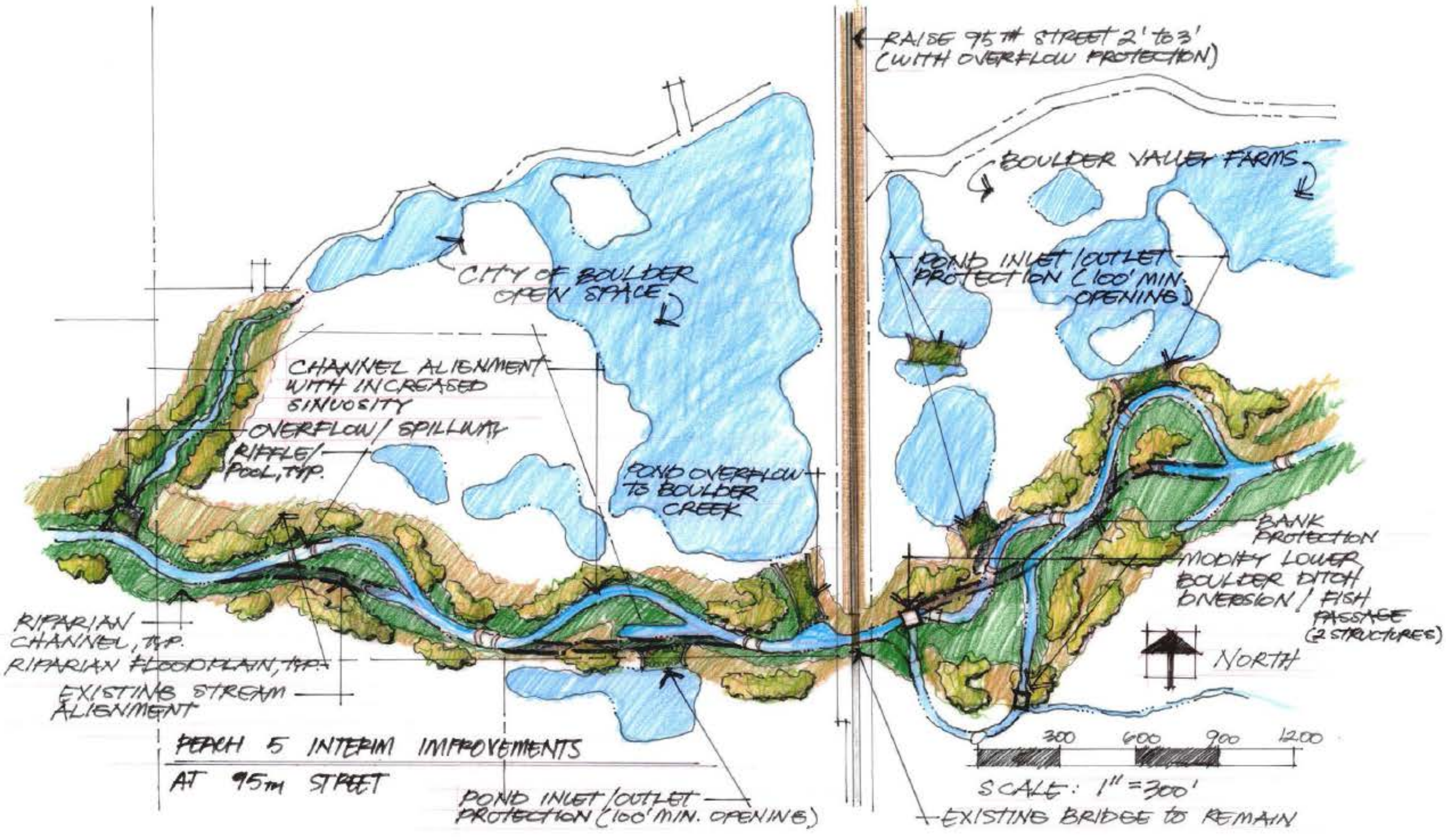
December 2015
Boulder Creek Restoration Master Plan
Figure 11-3
Conceptual Design
Legend
Hydraulic Feature
100-Year Floodplain
Open Space
Existing Stream Alignment
Alternate Centerline
Reach 3
Reach 4
High Priority
Medium Priority
Low Priority
4J: Location: 109th St Replace Bridge with 180' Span Bridge Restore Adjacent Channel
REACH 4: Corps of Engineers Restoration Project (By Others)
4H: Location: Kenosha Rd Replace Bridge with 180' Span Bridge
4G: Stabilize Howell Ditch Diversion System, Modify Diversion for Aquatic and Habitat Passage
4E: Location: DS of Kenosha Rd Remove Washed Out Bridge
4I: Replace Grade Control for Aquatic and Habitat Passage
4A: Modify Godding A. and D. Plumb Ditch for Aquatic and Habitat Passage
4F: Stream Restoration Through Doniphan, Wittemeyer Ponds, Bailey-Kenosha Ponds, and Open Space
4D: Stabilize Bank at Bailey-Kenosha Pond Outlet
4K: Stream Restoration Through Wheeler Ranch
4B: Location: E County Line Rd Replace Bridge with 220' Span Bridge (100-Year), Restore Channel Banks
REACH 4: Bank Stabilization at Re-Use Facility (By Others)
4C (All ● Markers): Protect Gravel Ponds/Town of Erie Reuse Pond/Wittemeyer Ponds Inlet & Outlet During Storm Flows, Typical.
Bridge
Diversion Structure
Channel Bank Breach
Reach 4
0
0.25
0.5
0.75
1 mi
ICON ENGINEERING, INC

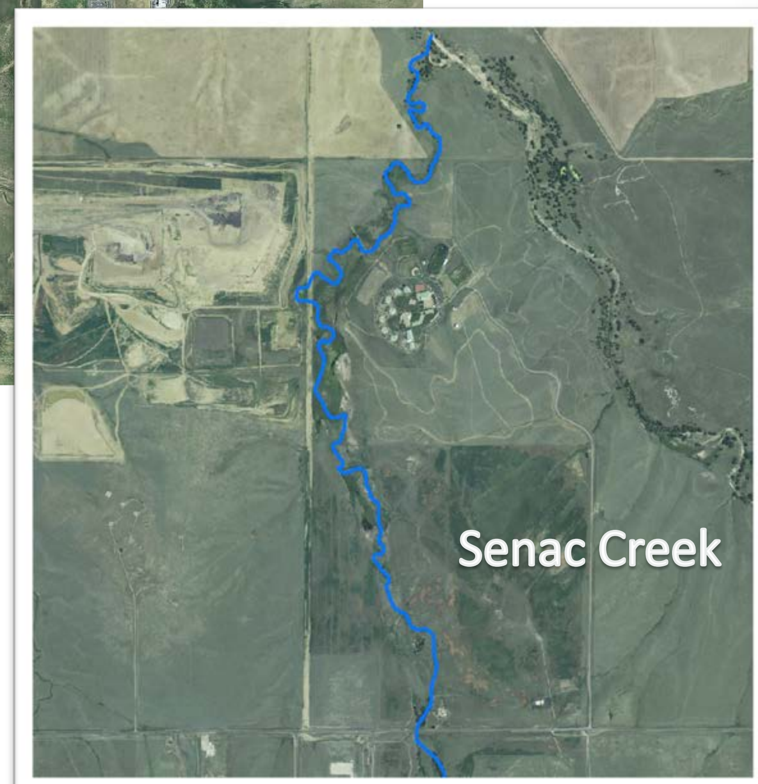
December 2015 **Boulder Creek Master Plan**

Figure 11-12 Conceptual Design Rendering - Reach 4 (Sheet 2)



ICON ENGINEERING, INC

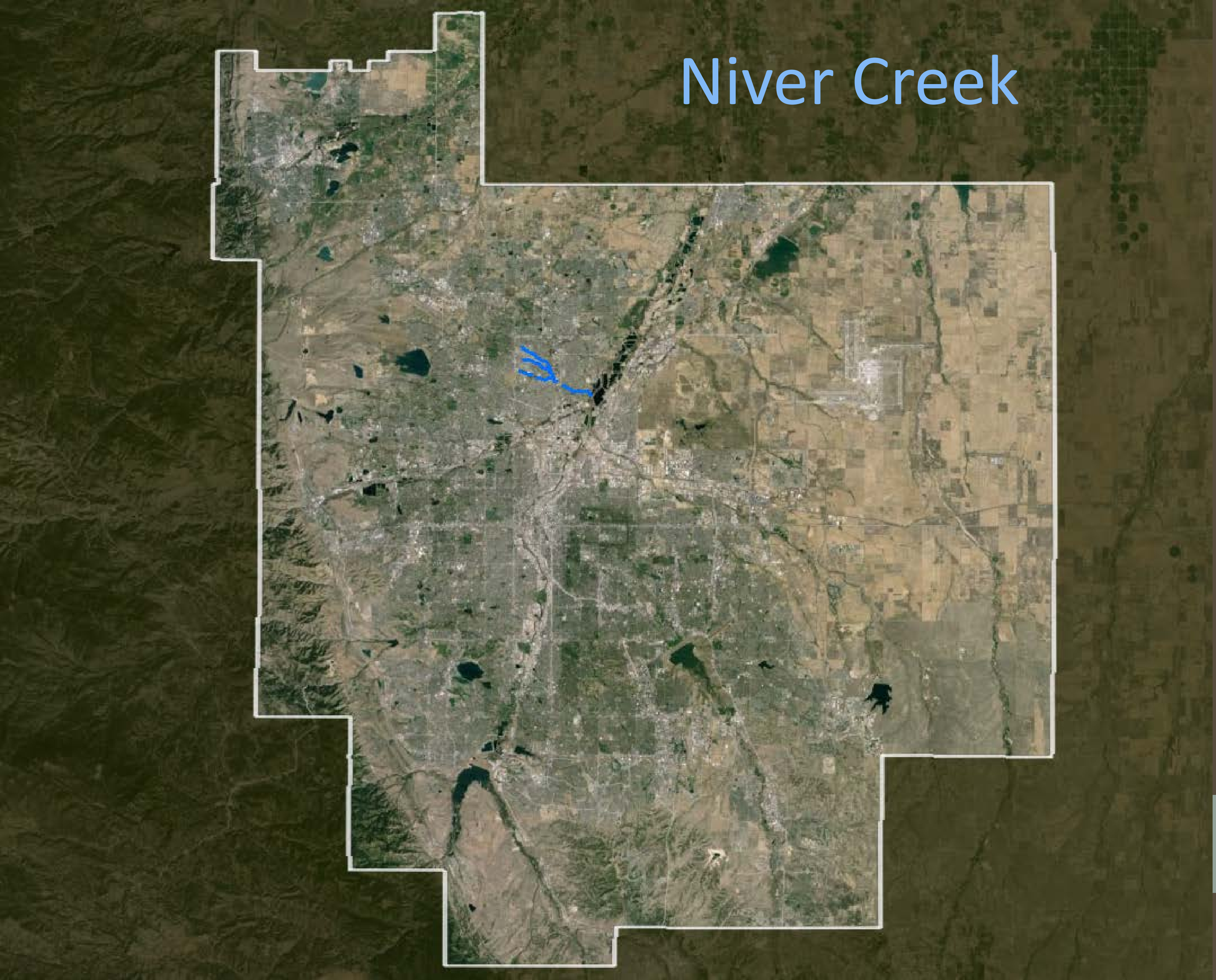

RAISE 95TH STREET 2' TO 3' (WITH OVERFLOW PROTECTION)
BOULDER VALLEY FARMS
CITY OF BOULDER OPEN SPACE
POND INLET/OUTLET PROTECTION (100' MIN. OPENING)
CHANNEL ALIGNMENT WITH INCREASED SINUOSITY
OVERFLOW/SPILLWAY
RIFFLE/POOL, TYP.
POND OVERFLOW TO BOULDER CREEK
BANK PROTECTION
MODIFY LOWER BOULDER DITCH DIVERSION/FISH PASSAGE (2 STRUCTURES)
NORTH
RIPARIAN CHANNEL, TYP.
RIPARIAN FLOODPLAIN, TYP.
EXISTING STREAM ALIGNMENT
REACH 5 INTERIM IMPROVEMENTS
AT 95TH STREET
300 600 900 1200
SCALE: 1" = 300'
POND INLET/OUTLET PROTECTION (100' MIN. OPENING)
EXISTING BRIDGE TO REMAIN

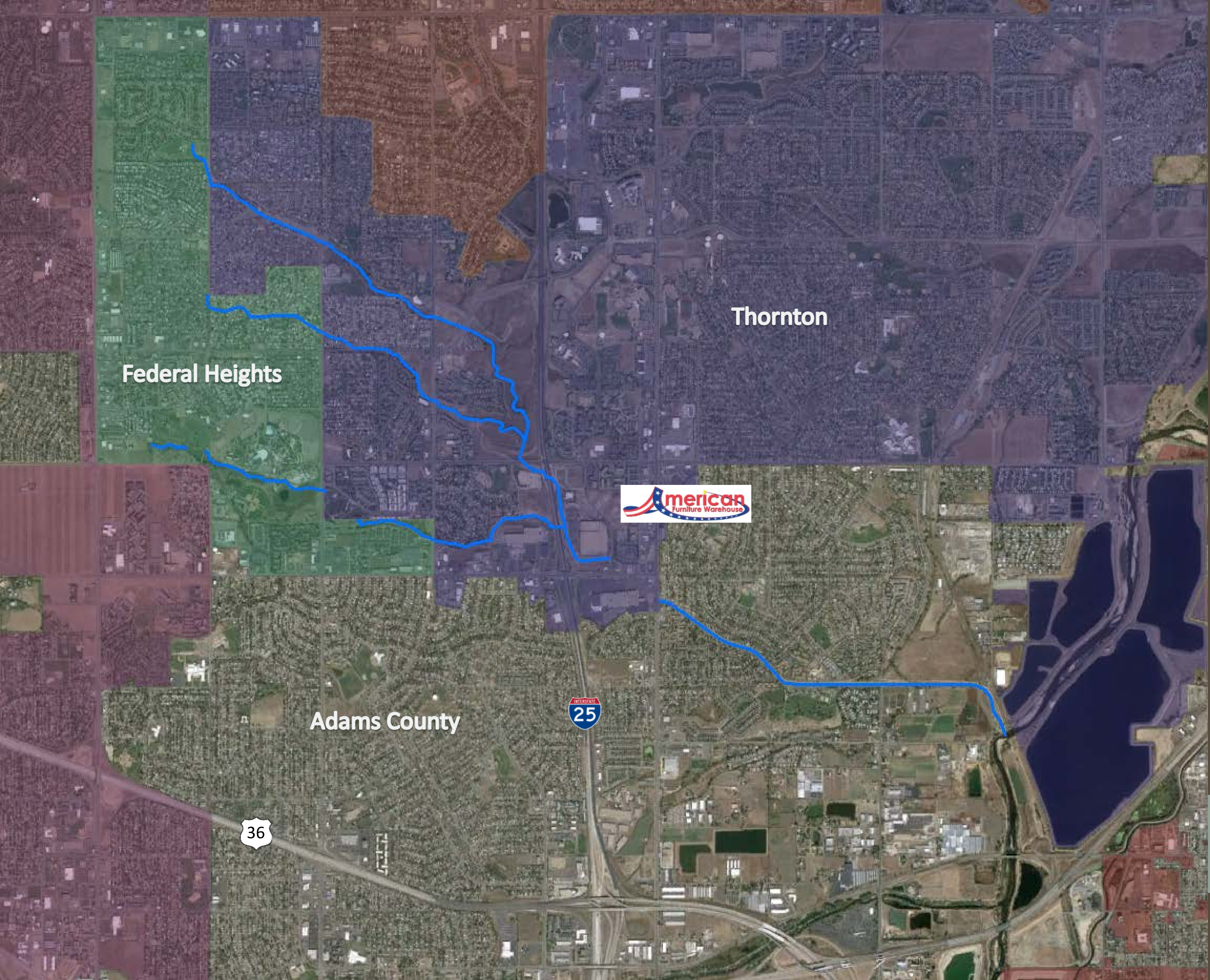


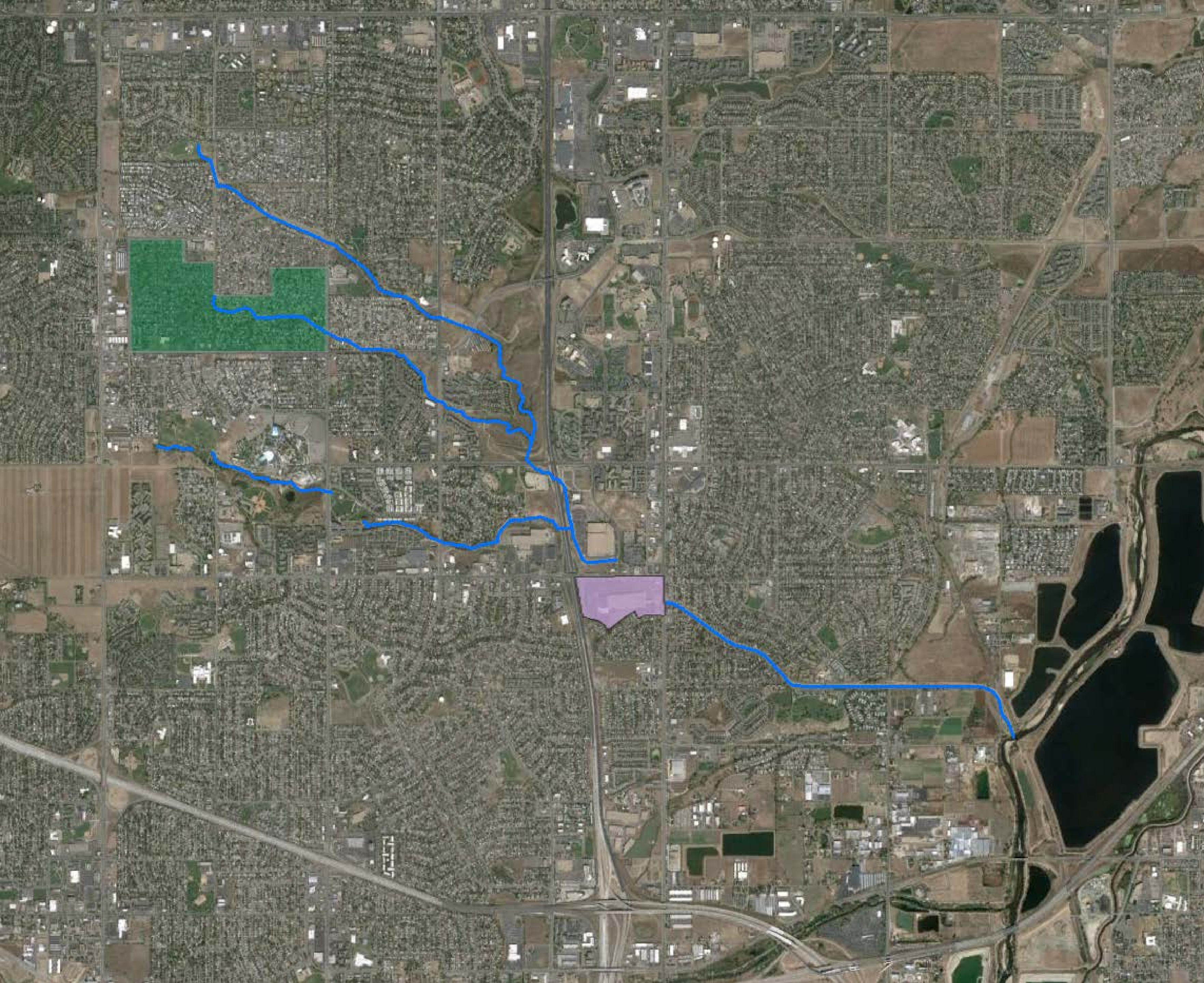
Where it applies: Straight segments in open corridors

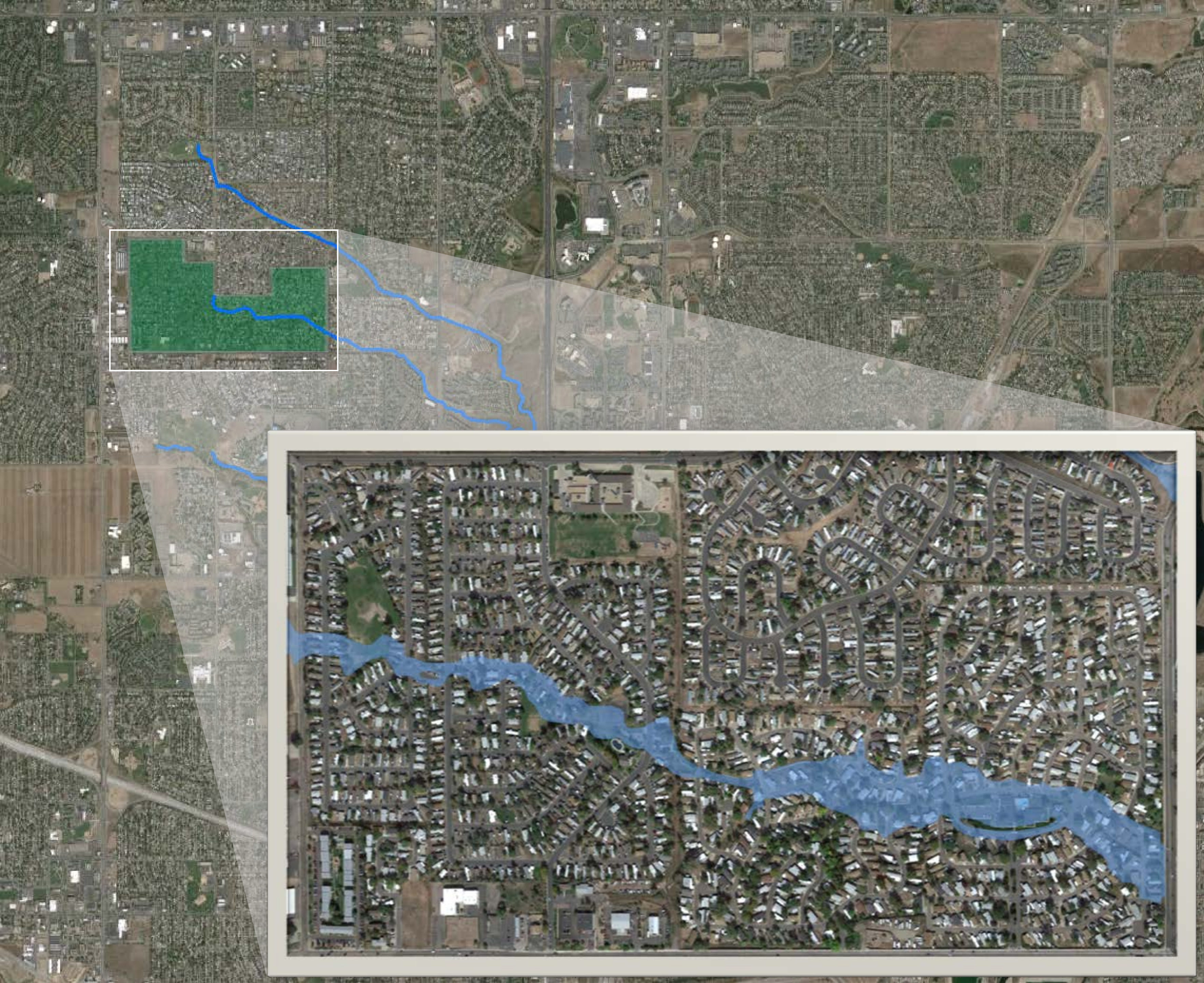
Federal Heights/Thornton: Predicting the Future

Niver Creek




Federal Heights
Thornton
American Furniture Warehouse
Adams County
INTERSTATE 25
36





2016 UDFCD Annual Seminar April 5, 2016

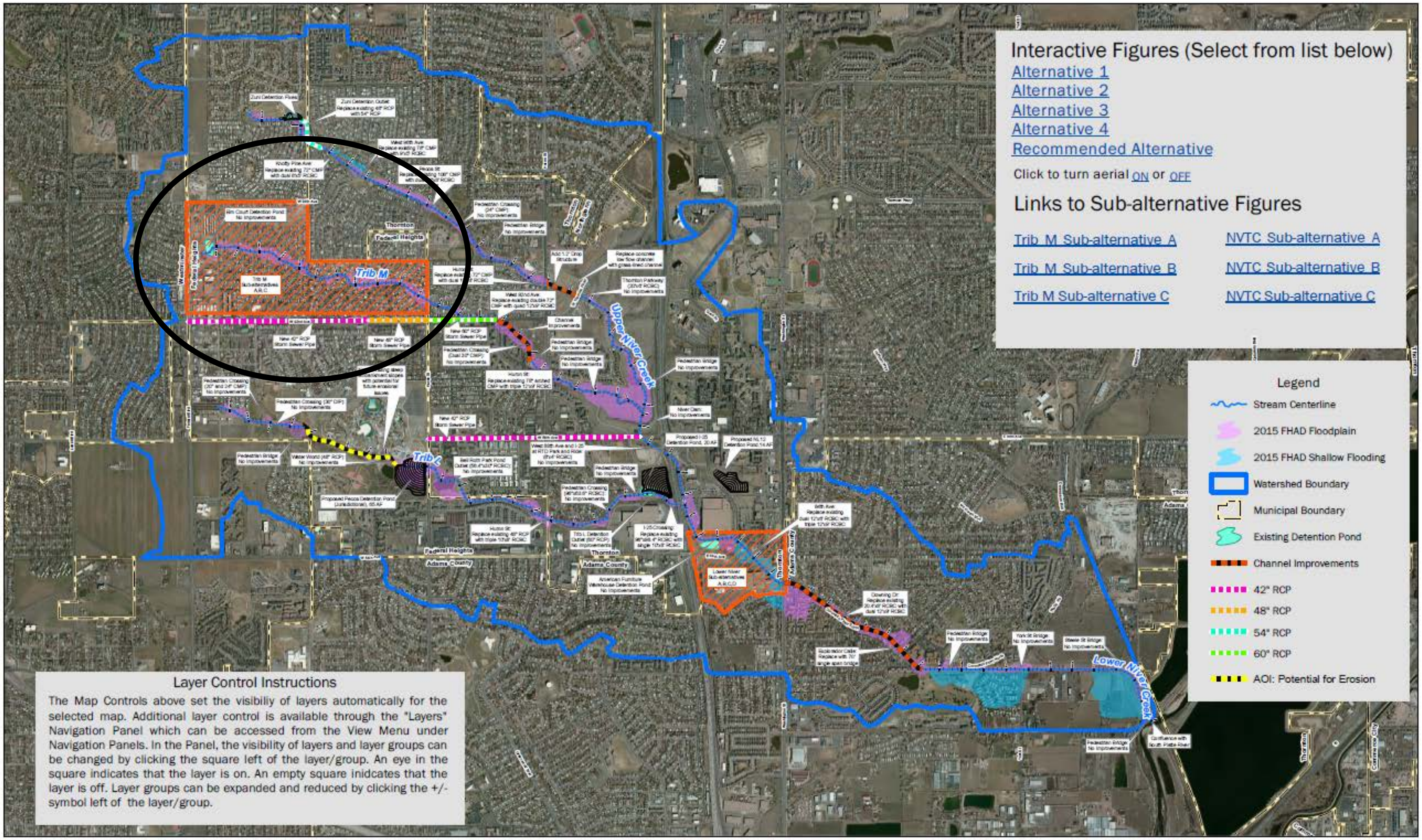


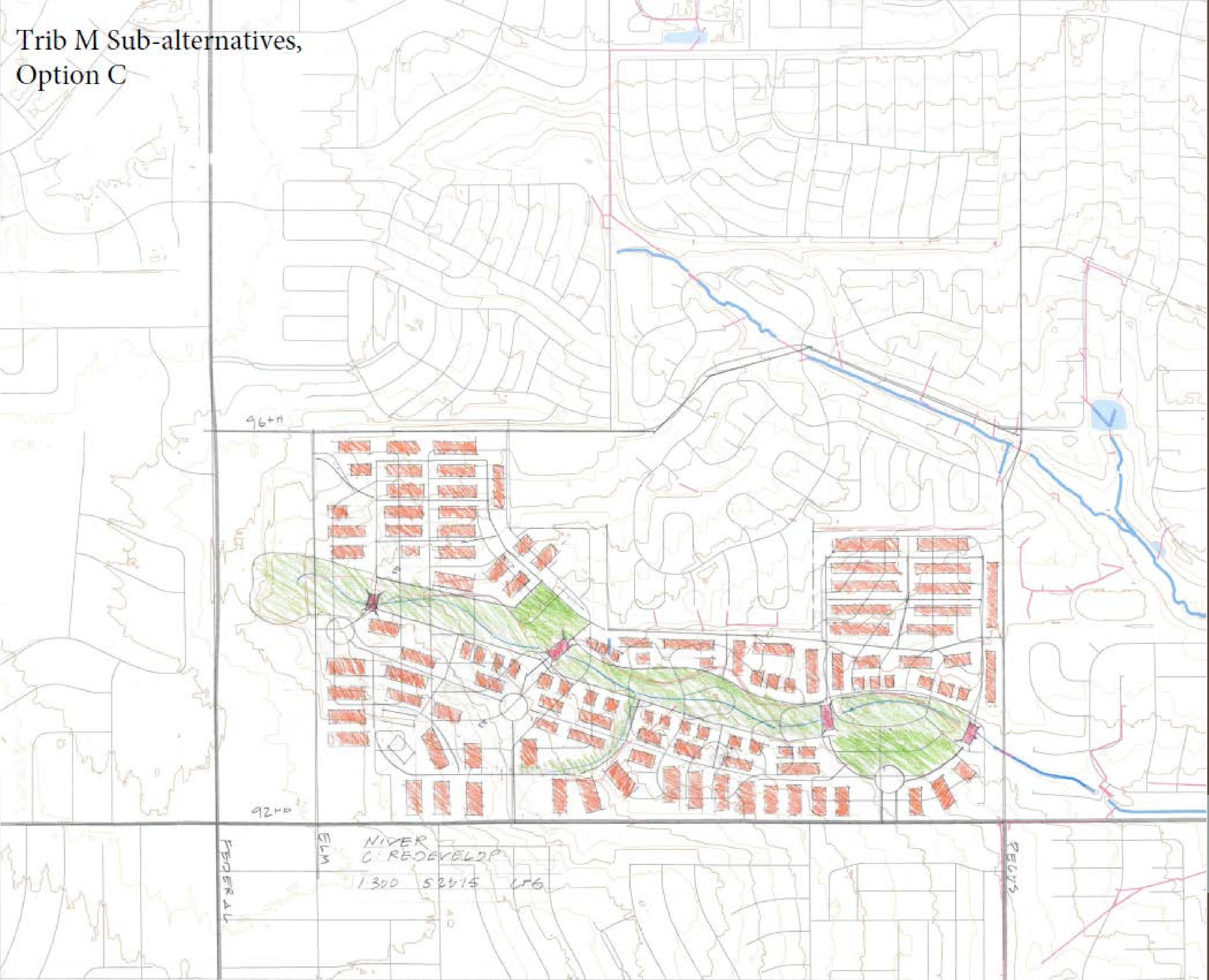
Figure 5-1. Alternatives Map

Urban Drainage and Flood Control District
Niver Creek MDP and FHAD
October 2015

Notes:
1. Projection: NAD 1983 CO State Plane (US Feet)

0 2,000 4,000 Feet

Trib M Sub-alternatives, Option C



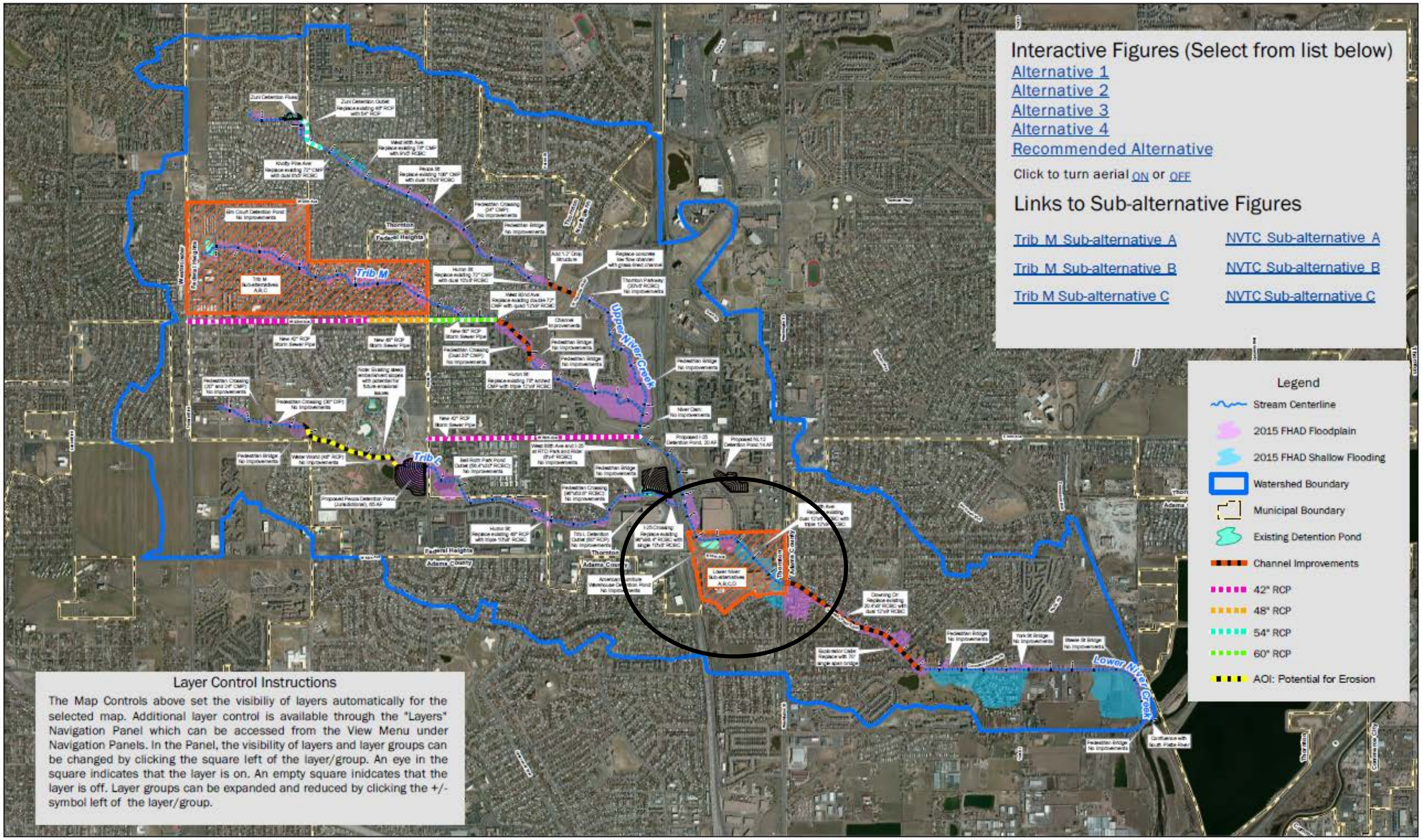


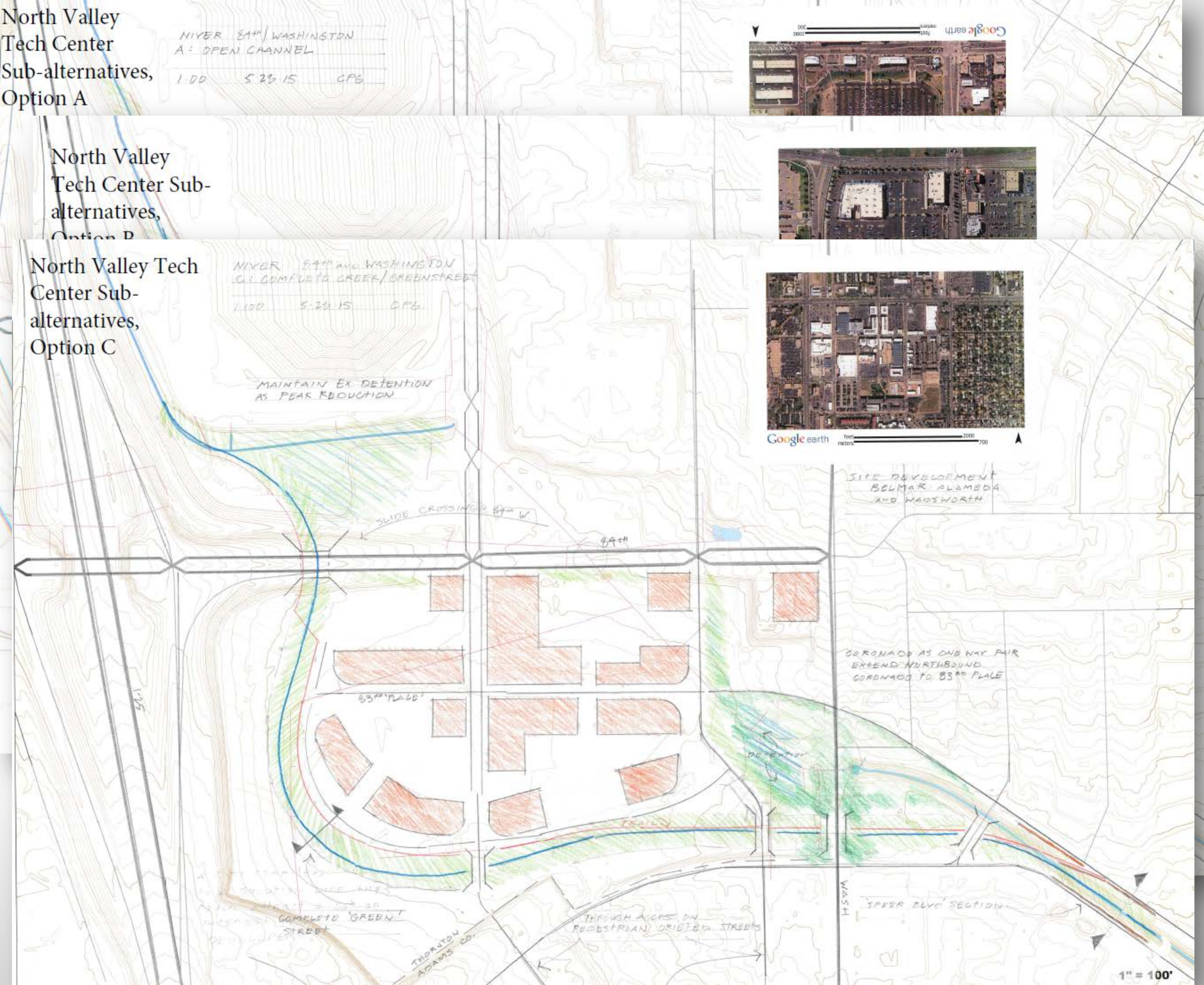
Figure 5-1. Alternatives Map

Urban Drainage and Flood Control District
Niver Creek MDP and FHAD
October 2015

Notes:
1. Projection: NAD 1983 CO State Plane (US Feet)

0 2,000 4,000 Feet N

ch2m

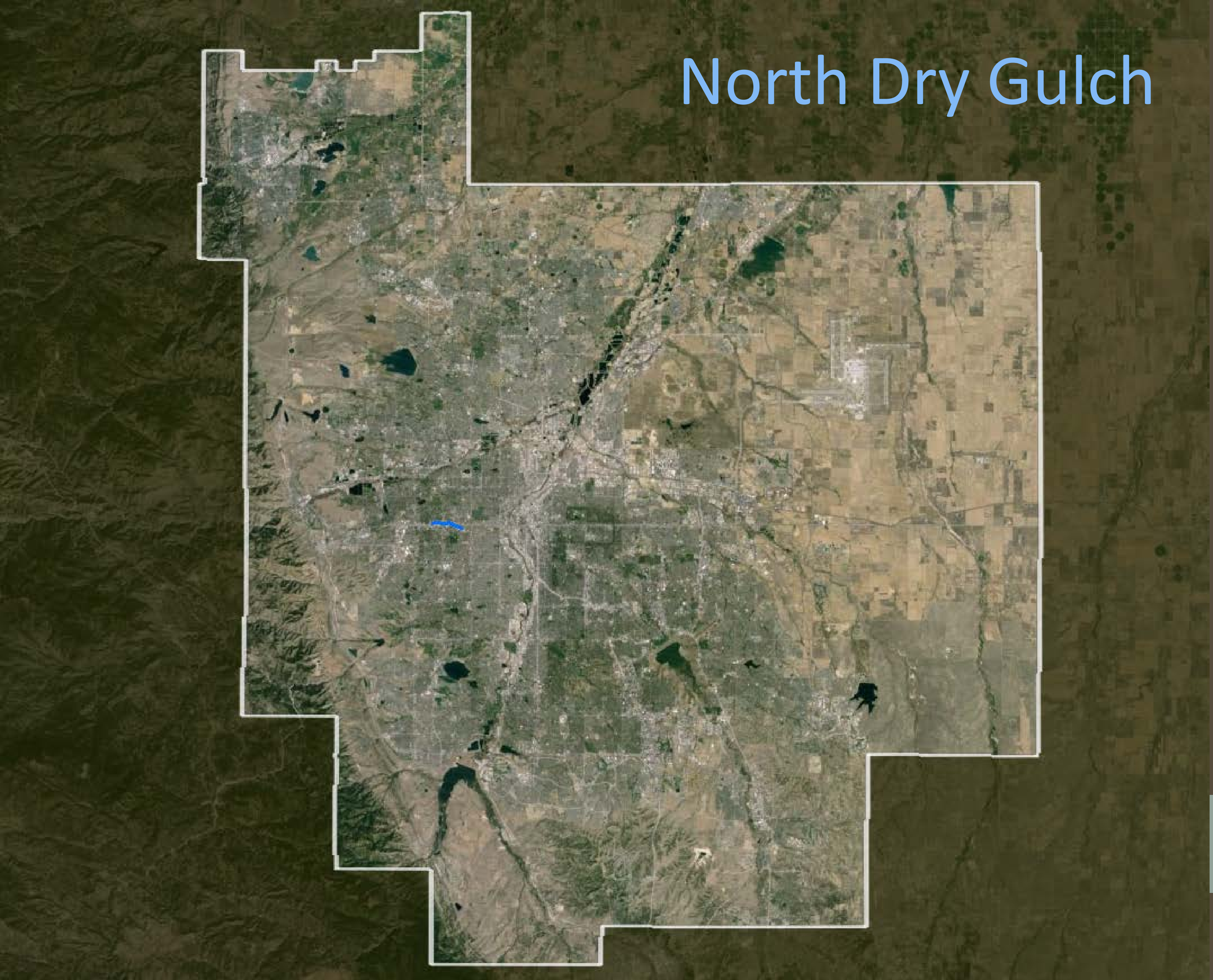


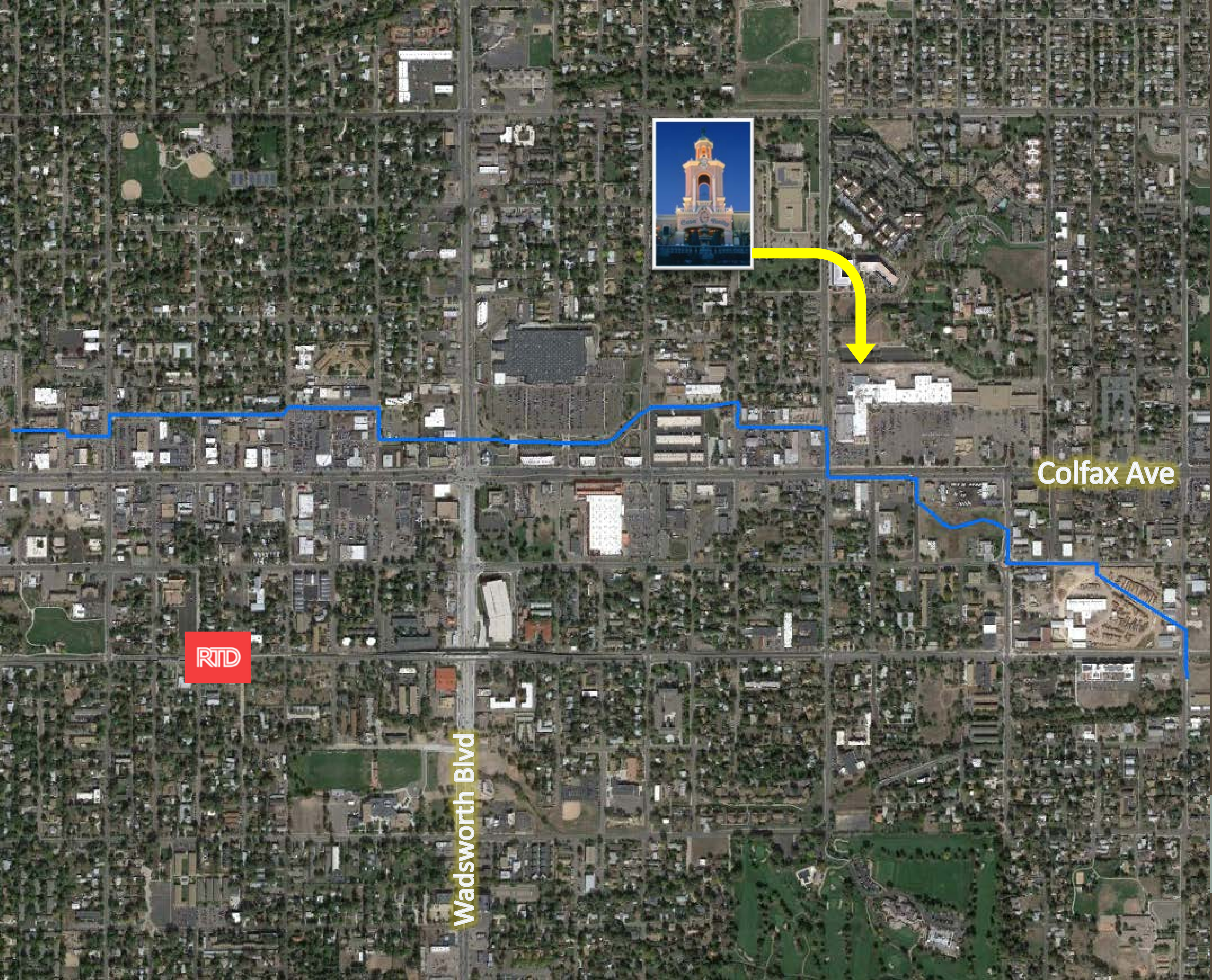
North Valley Tech Center Sub-alternatives, Option A
NIVER 84th / WASHINGTON
A: OPEN CHANNEL
1:100 5.23.15 CPG
Google earth
North Valley Tech Center Sub-alternatives, Option B
North Valley Tech Center Sub-alternatives, Option C
NIVER 84th and WASHINGTON
C: COMPLETE CREEK/GREENSTREET
1:100 5.23.15 CPG
Google earth
MAINTAIN EX. DETENTION AS PEAK REDUCTION
SLIDE CROSSING @ 84th W
84th
83RD PLACE
SITE DEVELOPMENT BELMAR ALAMEDA AND WADSWORTH
CORONADO AS ONE WAY PAIR EXTEND NORTHBOUND CORONADO TO 83RD PLACE
DETENTION
TRAIL
WASH
SPEER BLVD SECTION
COMPLETE 'GREEN' STREET
THROUGH ACCESS ON PEDESTRIAN ORIENTED STREETS
THORNTON ADAMS CO.
1" = 100'

Where it applies:
Aging developments;
Stream in private property;
Large parcels with single or few owners

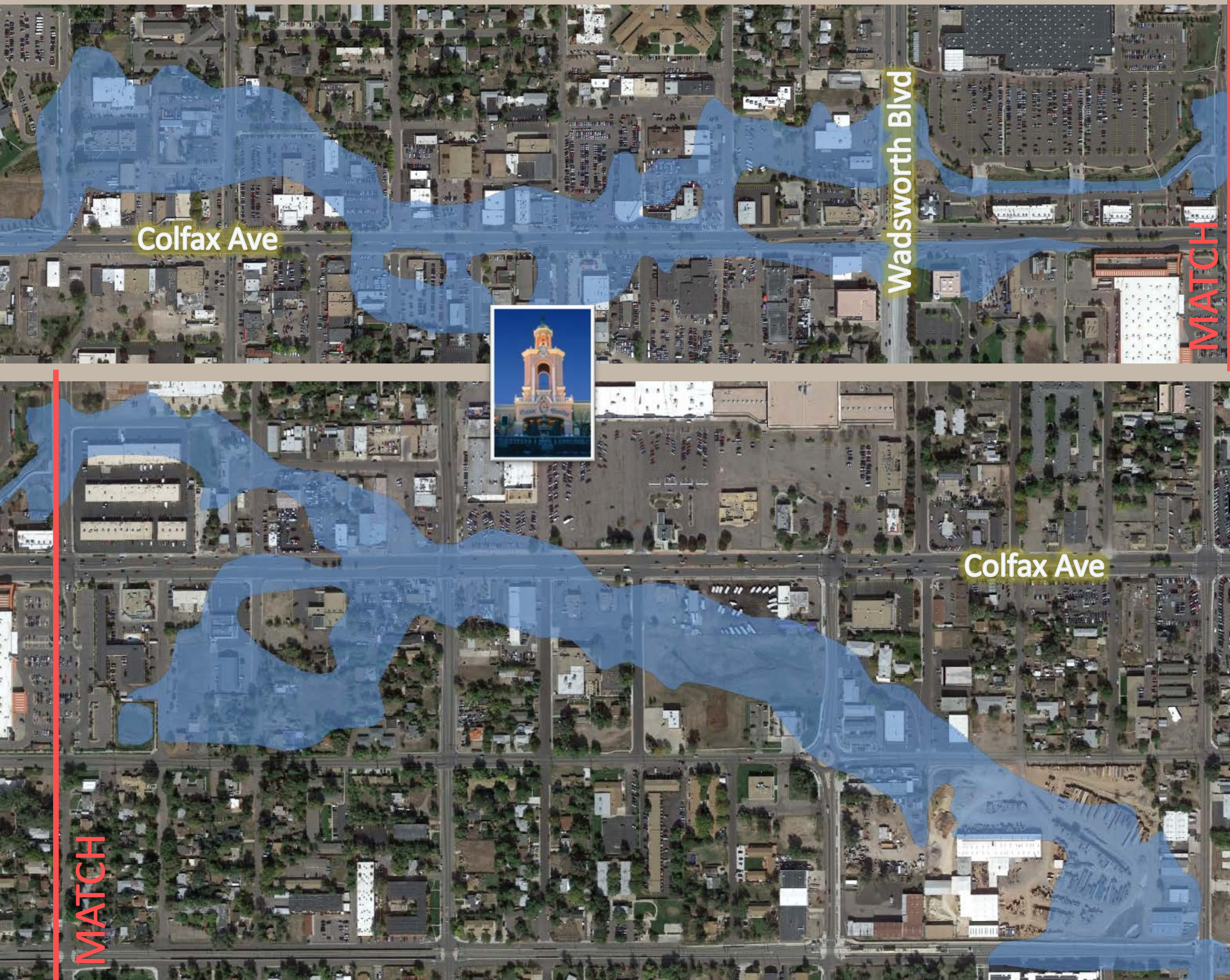
Lakewood: All In

North Dry Gulch




Colfax Ave
Wadsworth Blvd
RTD


Colfax Ave
Wadsworth Blvd


Colfax Ave
Wadsworth Blvd
MATCH
MATCH
Colfax Ave


Colfax Ave

Benefits of open channels:

Public awareness

Increased safety

Groundwater recharge

Overbank storage

Freeboard

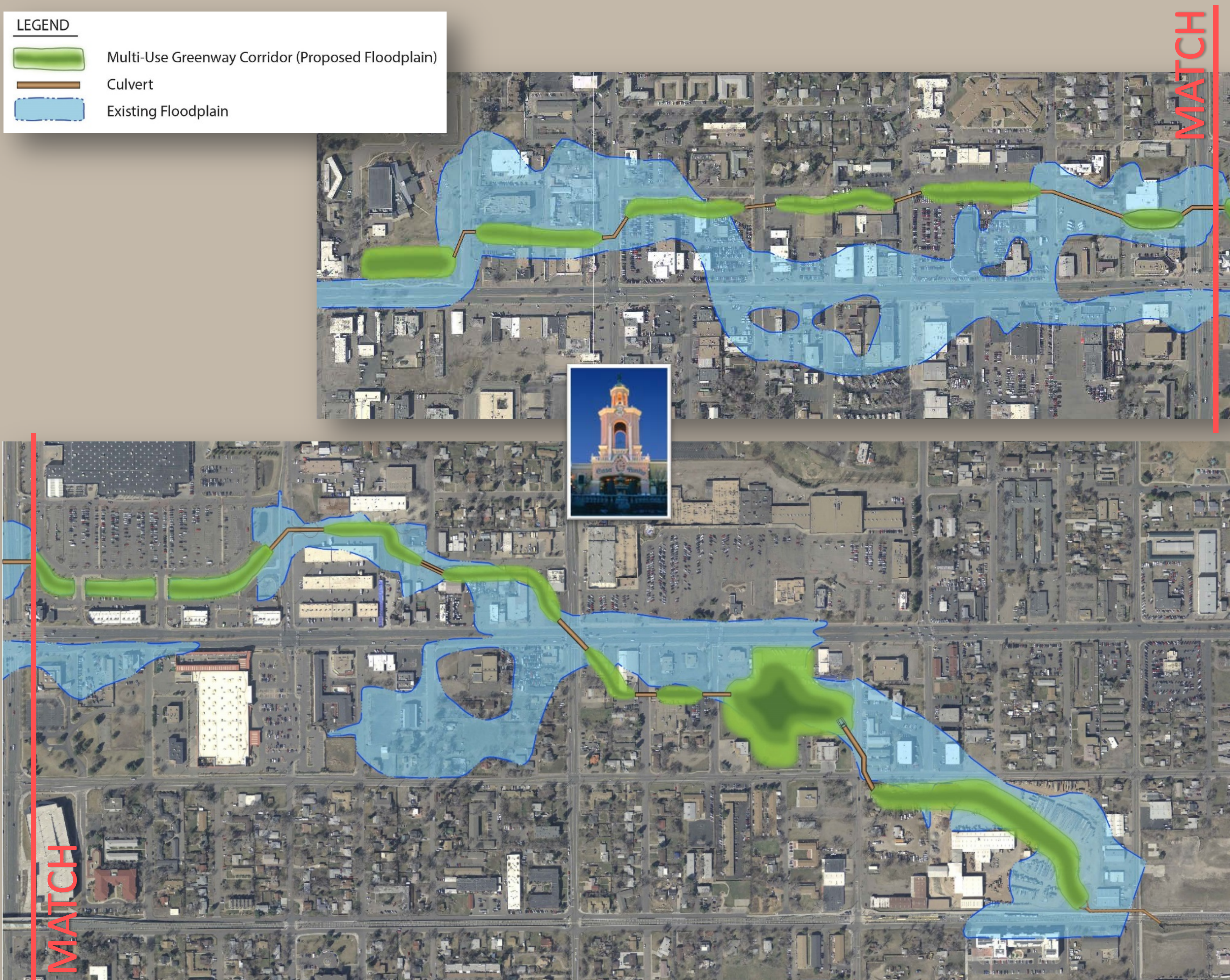
Water quality

Trail connectivity

Reduced blockage

Riparian habitat

Education


LEGEND
Multi-Use Greenway Corridor (Proposed Floodplain)
Culvert
Existing Floodplain
MATCH
MATCH

Where it applies:
Anywhere an undersized pipe/culvert has been installed to convey major drainageway flows

Thank you.
Questions?

yaaaaaaaay

Shea Thomas
sthomas@udfcd.org

Update on Regional Hydrologic Investigations

Ken A. MacKenzie, P.E., UDFCD
Gerald Blackler, P.E., PhD, Enginuity


EVENING POST
An Illust Weekly
Founded A.º D.º Benj. Franklin
OCTOBER 3, 1936
5cts. THE COPY

Typical Municipal Criteria:

Flood Channels:

- Freeboard: 1-2 feet

Detention Basins:

- May only include ½ WQCV (or EURV) in 100-Year Volume
- Freeboard: 1 foot

Channel Freeboard

- 1’ of freeboard ≈ 140% increase in capacity
- 2’ of freeboard ≈ 190% increase in capacity

100-Year Channel Becomes?

- 1’ of freeboard ≈ 500-year channel
- 2’ of freeboard ≈ 1,000-year channel

Freeboard is a Safety Factor

Detention Freeboard

- ½ WQCV & 1’ freeboard ≈ 140% increase
- ½ EURV & 1’ freeboard ≈ 160% increase

100-Year Detention Becomes?

- ½ WQCV & 1’ of freeboard ≈ 500-year storage
- ½ EURV & 2’ of freeboard ≈ 1,000-year storage

Conservativism vs. Accuracy

Hydraulics:

- We want to be <u>conservative</u>
- i.e., safety factor to hedge uncertainty

Hydrology:

- We want to be <u>accurate</u>
- i.e., right, based on known events

Conditional Letters of Map Revision (CLOMRs) based on Hydrology

3 Methods:

1. Statistical extrapolation of gage data
2. Regression equations
3. Rainfall—runoff models

Conditional Letters of Map Revision (CLOMRs) based on Hydrology: Partners

South Platte River

- Adams County
- Arapahoe County
- Brighton
- Columbine Valley
- Commerce City
- Denver
- Douglas County
- Englewood
- Fort Lupton
- Jefferson County
- Littleton
- Sheridan
- Thornton
- Weld County

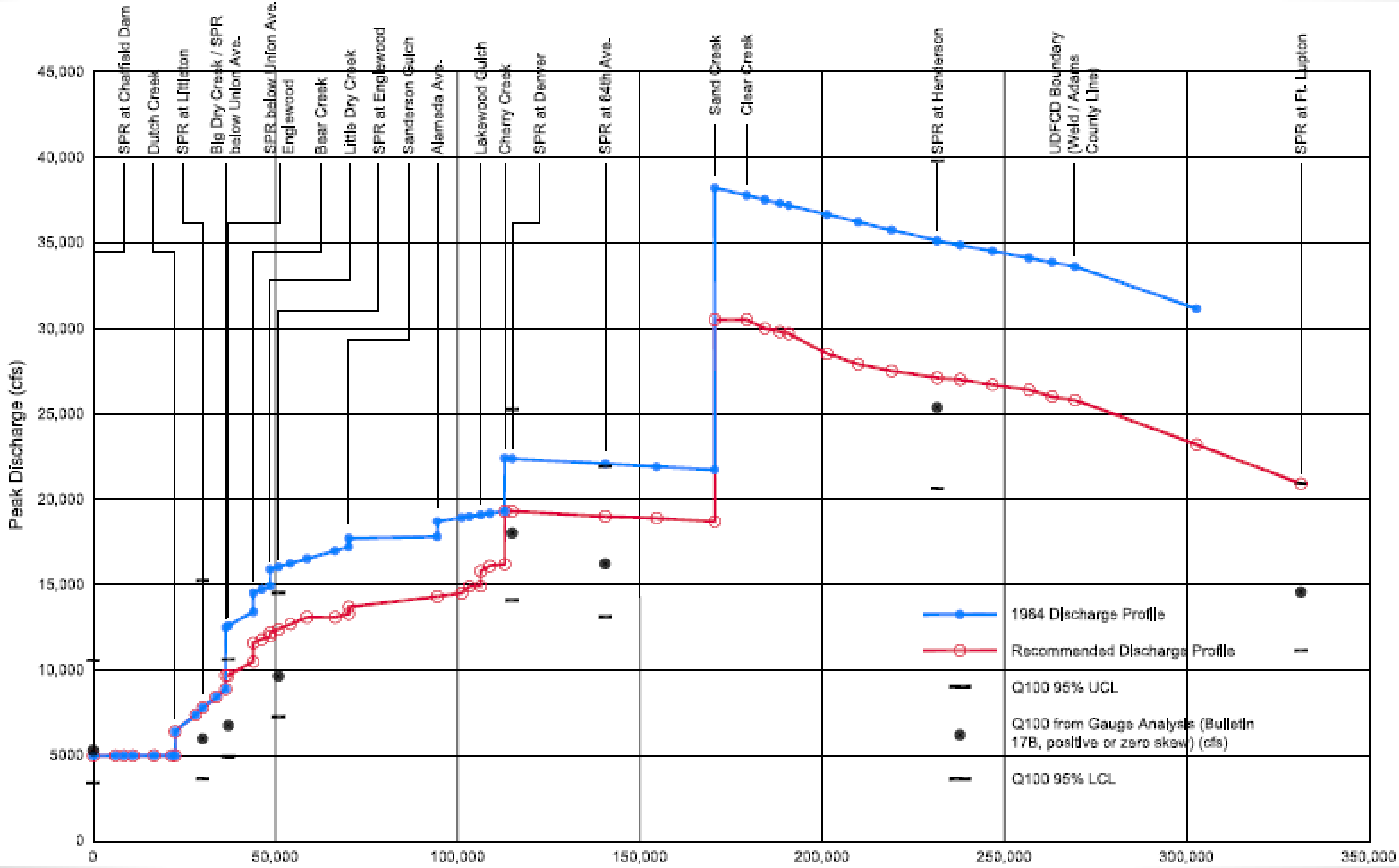
Clear Creek

- Adams County
- Arvada
- Denver
- Golden
- Jefferson County
- Wheat Ridge

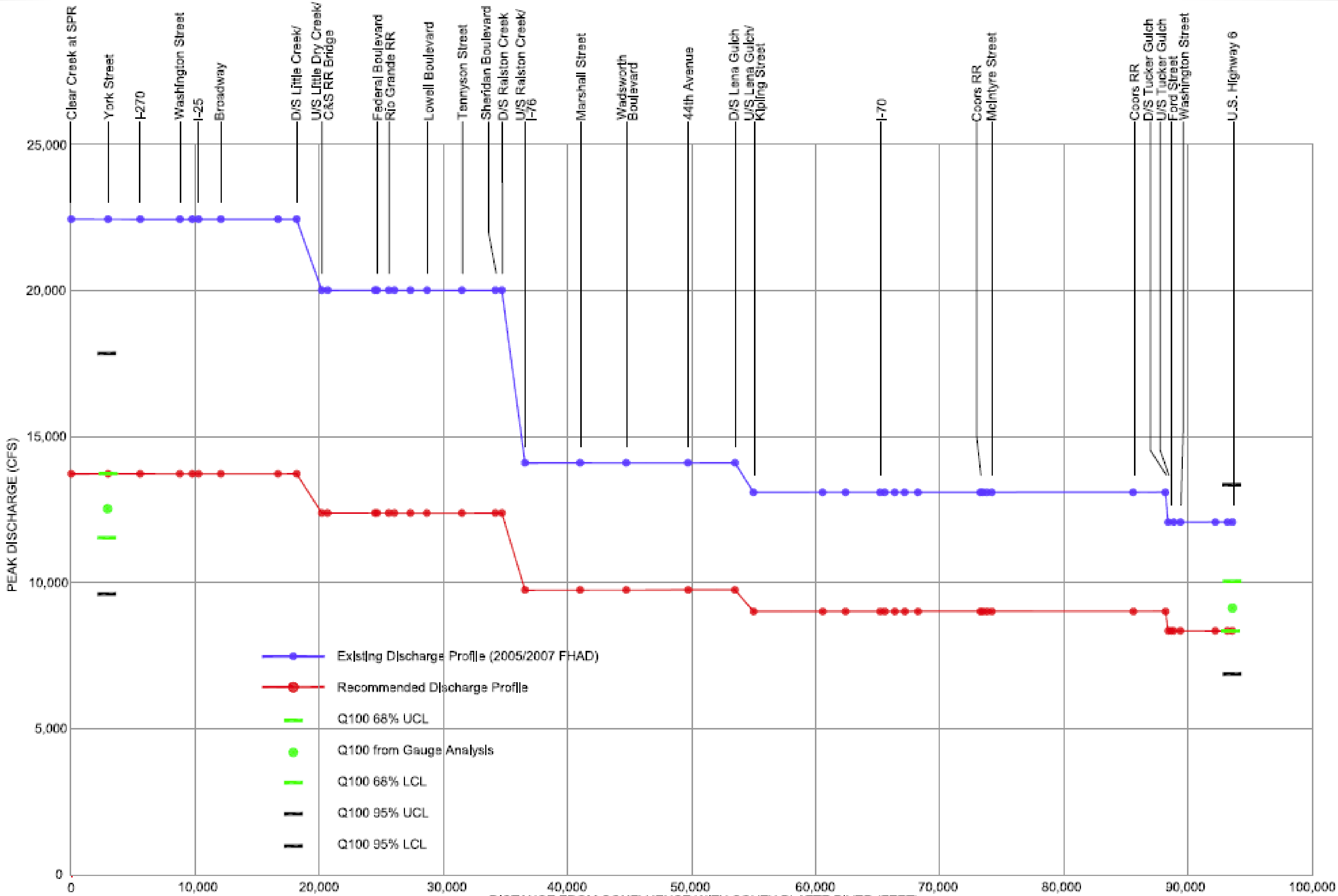
Both

- CWCB
- FEMA
- USGS

South Platte River CLOMR



Clear Creek CLOMR

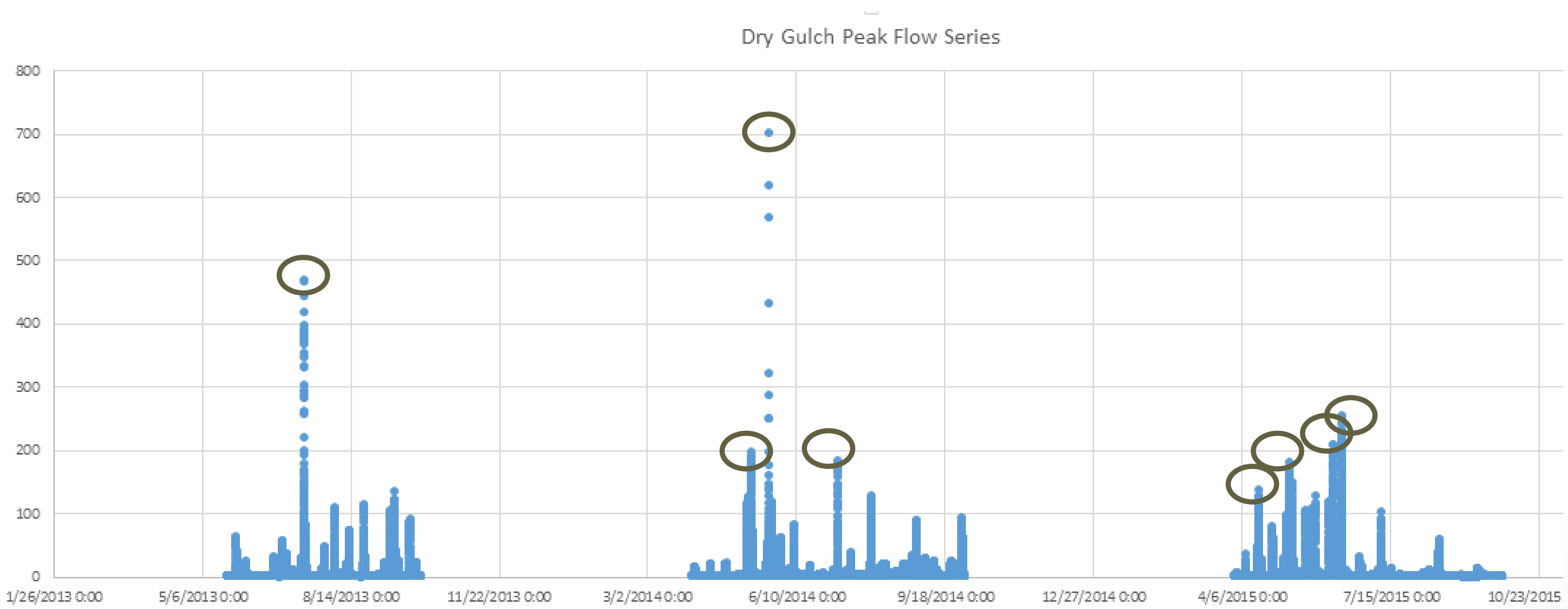


CUHP Update (Year's Progress)

- 10 basins were tested using GARR Rainfall Developed by Rainvieux.
- Each analysis compared:
  - Larger CUHP Basins,
  - Smaller basins averaging 100 acres,
  - New calibrated Cp and Ct values,
  - Testing the effects of Routing.
- This resulted in over 60 storms being analyzed between 2013 and 2015 for each scenario creating more than 240 comparisons.
- Data was paired down based on correlation between rainfall, runoff, and some were eliminated by obvious gage recording errors.
- Paired down data results in 41 data sets to date of ***Selected Data***.

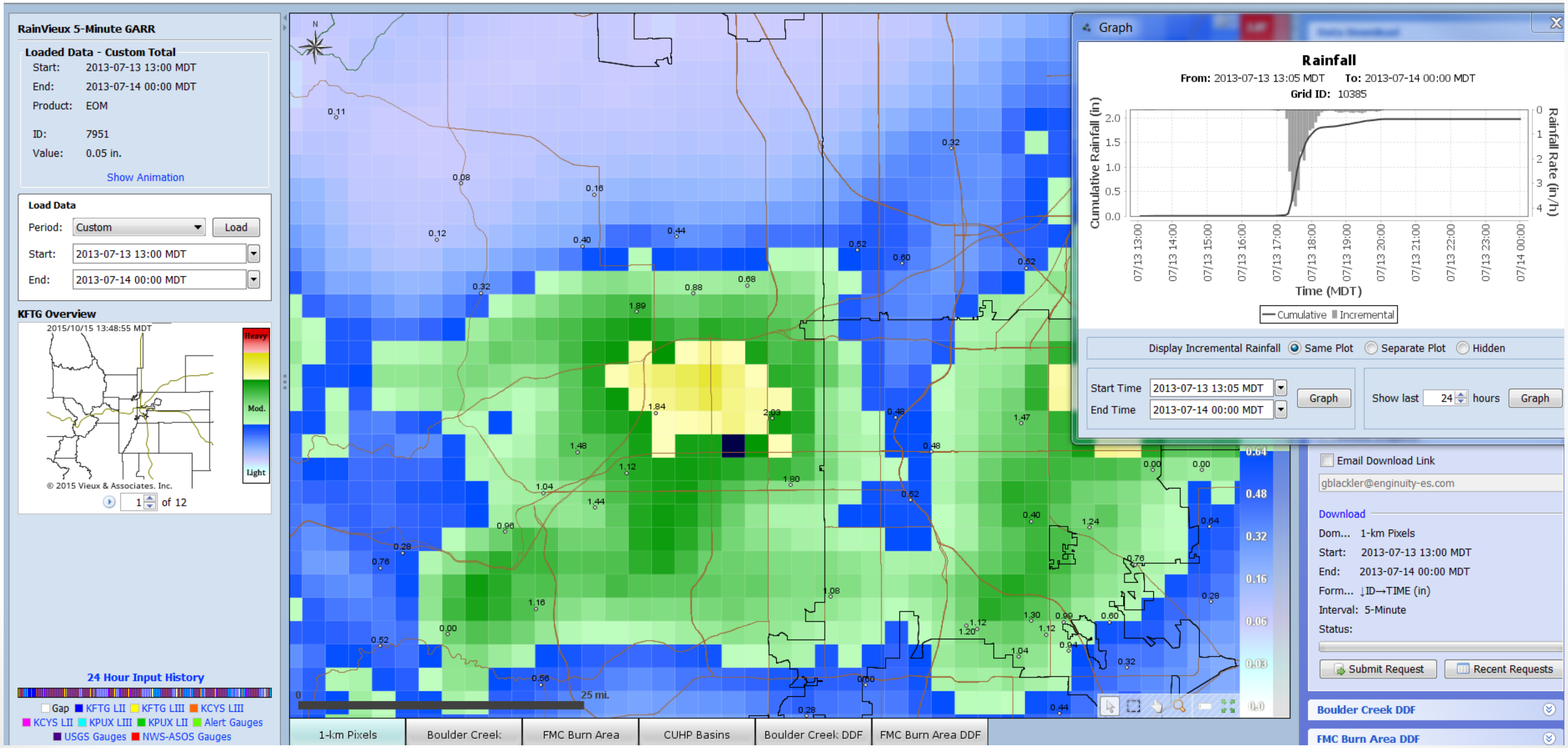
Calibration Process

1. Select Recorded Flows of Interest



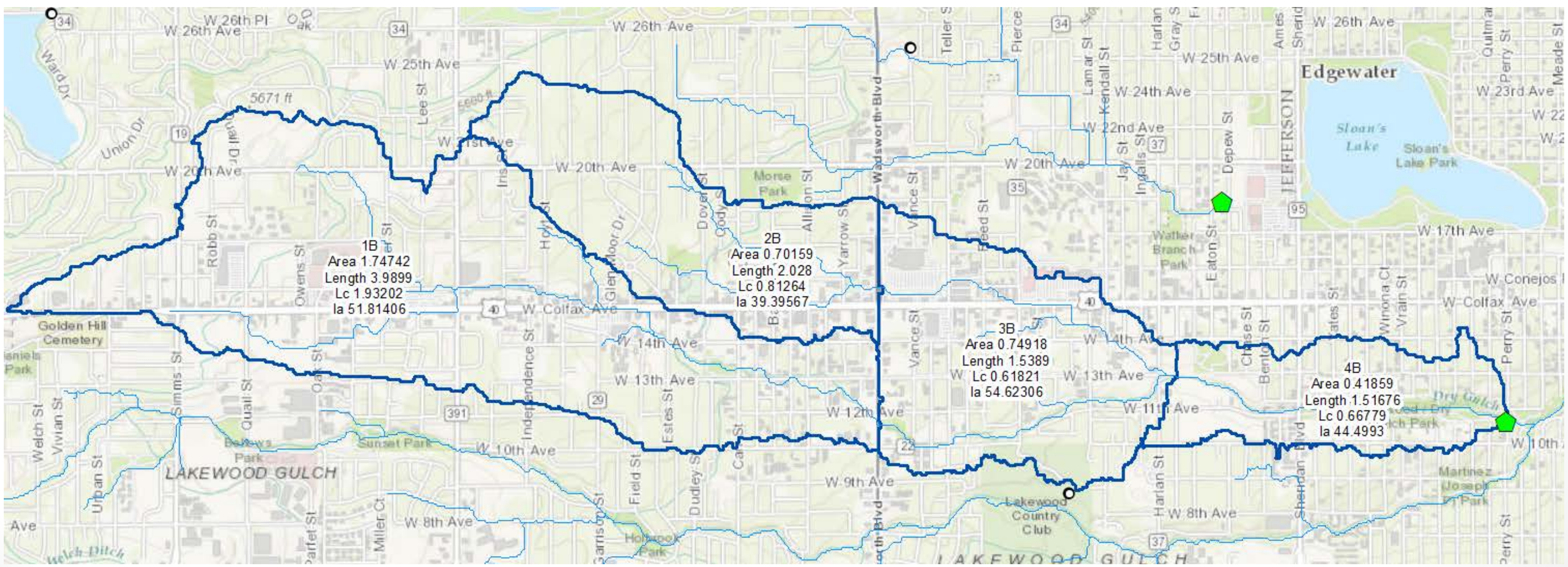
Calibration Process

2. Compare GARR Rainfall with Selected Flows



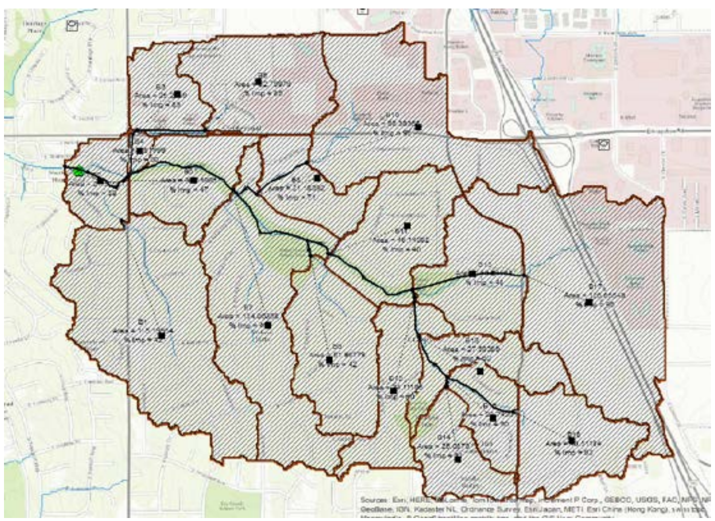
Calibration Process

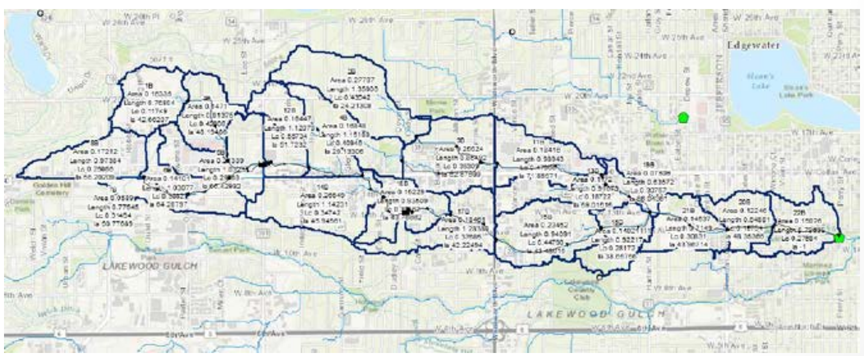
3. Develop Single Basin Model
   - Develop basins that are not greater than 5 square miles and are within reasonable shapes (L^2/A)



Calibration Process

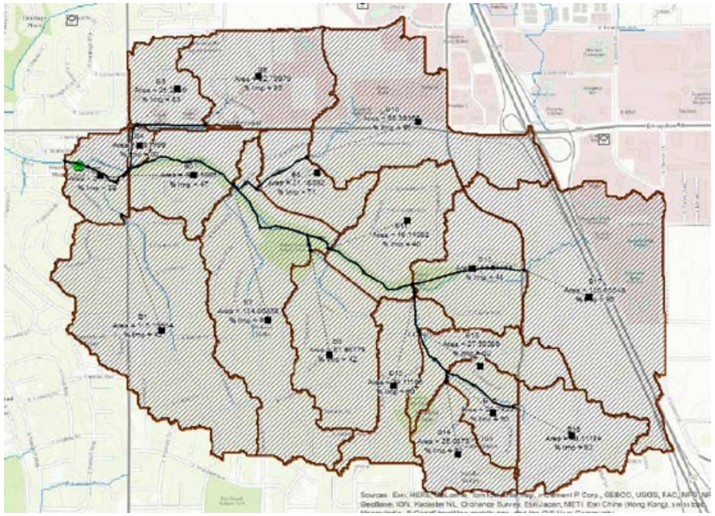
4. Review MDP / OSP Small Basin Model
   - If model needs re-developed, develop a new small basin model averaging 100 acres per UDFCD Standards.

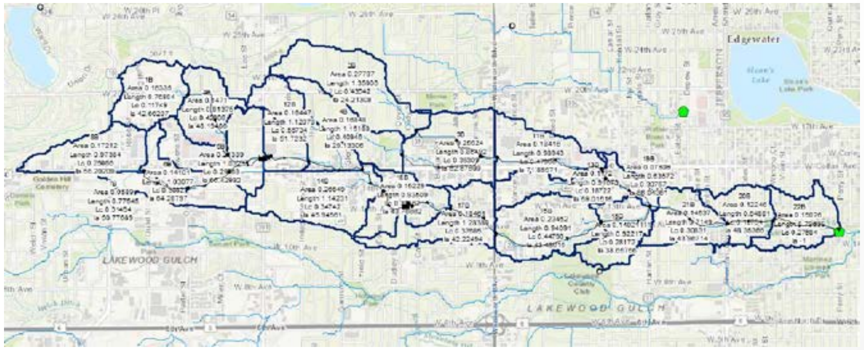




Calibration Process

5. Develop a Dynamic Model from MDP / OSP Kinematic Wave Model to compare Routing Sensitivity





Calibration Process

6. Run CUHP Models and Selected Storms for the Following:
    1. Single / Large Basin Analysis
    2. MDP / OSP Small Basins
    3. MDP / OSP Small Basins with Adjusted Cp and Ct

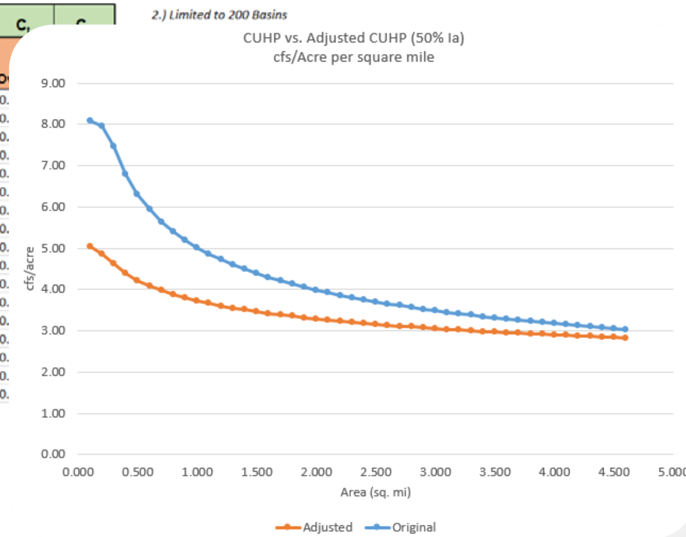
This workbook is developed as part of the 2015 CUHP Calibration Efforts and is for testing only.

Developed by: **Gerald Blackler, PhD, PE - Enginuity Engineering Solutions**

Notes:
1.) After first run check effective impervious values in CUHP and re-compute Cp and Ct if they are significantly different than the percent impervious used.
2.) Limited to 200 Basins

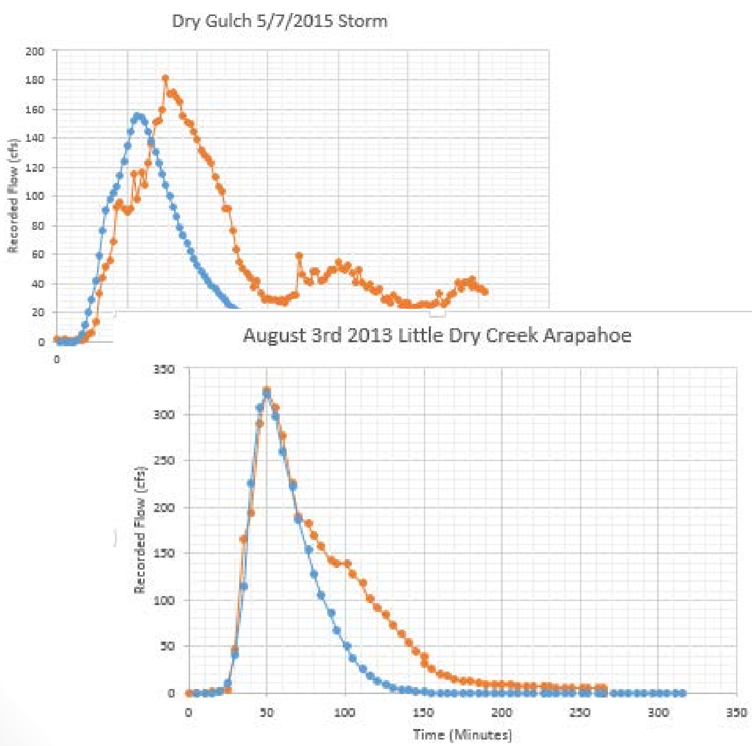
Paste the Input for CUHP Below

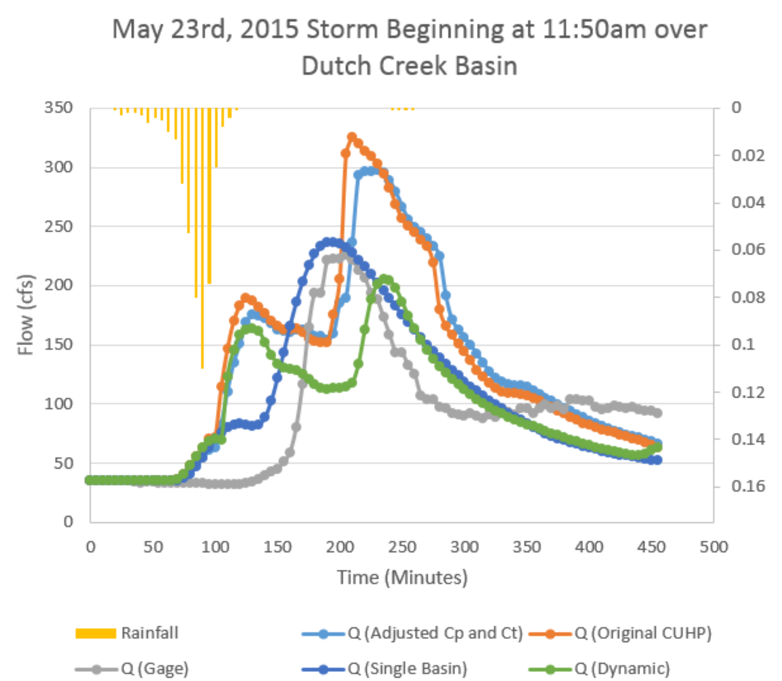
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (mi^2)	Length to Centroid (mi)	Length (mi)	Slope (ft/ft)	Percent Imperviousness	C_T Override	O
3B	3B	Storm9	0.1471	0.42808	0.81375	0.014812193	48.19486	0.089061	0.
14B	14B	Storm9	0.26649	0.34742	1.14231	0.018120104	45.94561	0.090164	0.
12B	12B	Storm9	0.16447	0.55734	1.12078	0.021365169	51.7232	0.087398	0.
10B	10B	Storm9	0.0837	0.19186	0.60443	0.030228419	62.65416	0.082768	0.
2B	2B	Storm9	0.27787	0.43542	1.35006	0.018103356	24.21308	0.105247	0.
4B	4B	Storm9	0.16848	0.40946	1.15188	0.021649759	29.13306	0.100263	0.
18B	18B	Storm9	0.15229	0.39062	0.93509	0.016409127	43.76662	0.091264	0.
17B	17B	Storm9	0.18461	0.37685	1.28388	0.014976517	42.22494	0.092062	0.
9B	9B	Storm9	0.25524	0.35309	0.86492	0.01175528	62.67699	0.082759	0.
13B	13B	Storm9	0.1172	0.18722	0.91679	0.01387642	59.01515	0.084222	0.
11B	11B	Storm9	0.18416	0.47956	0.98943	0.013124674	71.89571	0.079469	0.
16B	16B	Storm9	0.23452	0.44798	0.94091	0.013650259	43.48615	0.091408	0.
15B	15B	Storm9	0.14021	0.28172	0.92217	0.010462811	38.65756	0.093778	0.
19B	19B	Storm9	0.07309	0.30757	0.63572	0.014517653	66.04361	0.081493	0.
21B	21B	Storm9	0.14537	0.30831	0.7149	0.015375034	30	0.0995	0.
20B	20B	Storm9	0.12246	0.19754	0.64881	0.025871886	32	0.097872	0.
22B	22B	Storm9	0.15076	0.27584	0.78639	0.022907174	35	0.095775	0.



Calibration Process

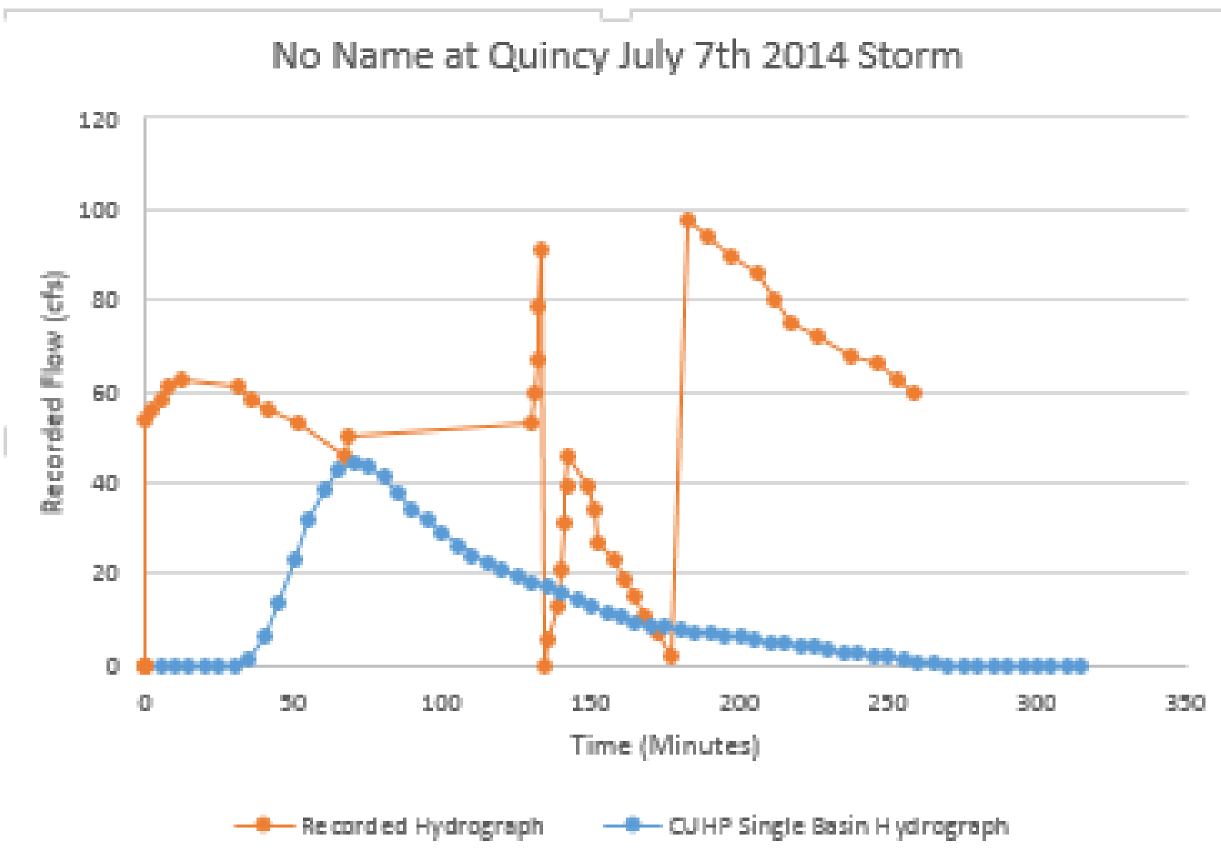
7. Compare Computed Peak Flows with Recorded Flows





Calibration Process

8. Review Recorded Data for Consistency, Eliminate Bad Data



Preliminary Results

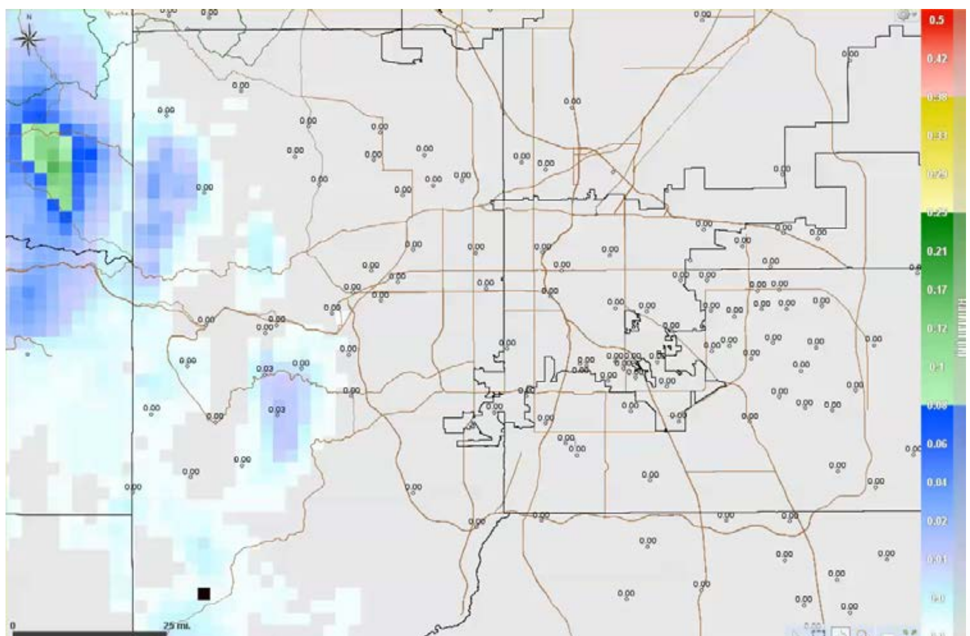
- Even with the large amount of gauges available, only six (6) so far were considered viable:
  - Period of record with GARR
  - Location and placement of gauge (Example, ponds)

Image of Gauge Location for No Name at Quincy Drainageway

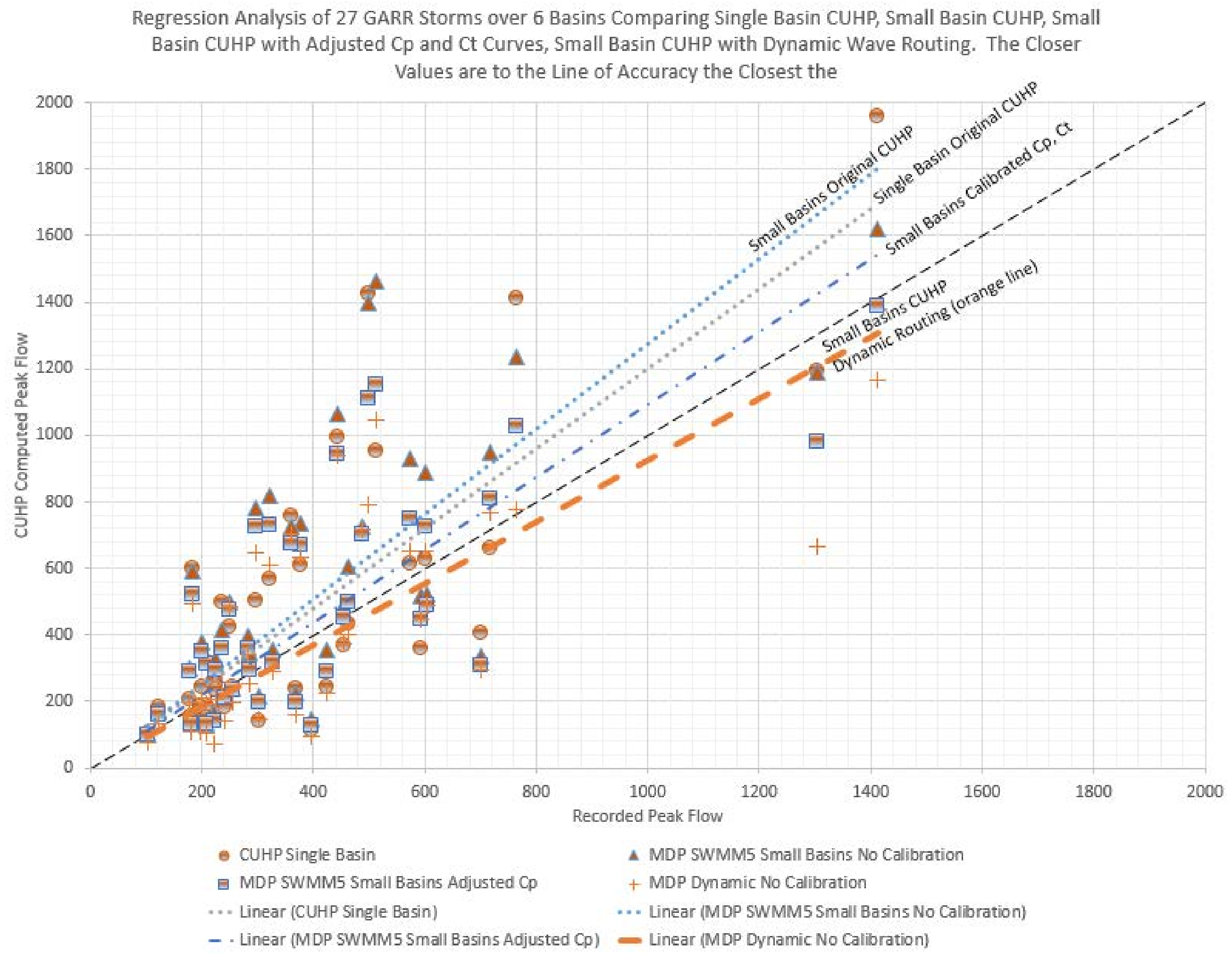
Preliminary Results

- Large deviation of data:
  - Can sometimes be a gauge reading or measurement error
  - GARR reduces rainfall error, but storms still move more dynamically than 1 or 2 hyetographs can represent.

VIEUX, INC.



Preliminary Results



Ongoing Work

- Currently Testing a few Recommendations and Hypotheses with storm frequency.
- General Findings:
  - The original calibration of CUHP produced a good product that is unique and specific to Denver.
  - Re-examination of CUHP did not produce any startling results (Good Job Ben!).
  - The usage of small basins in our MDP process does appear to increase flows when compared to the gauges.
- What to expect:
  - No major decisions have been made at this time.
  - It is likely that there will be some modifications, how big or small those are is still being decided.