Urban Drainage and Flood Control District

Annual Seminar

April 29, 2010

Trends and Developments in Stormwater & Floodplain Management

UDFCD Annual Stormwater and Floodplain Management Seminar

Program for April 29, 2010

7:15 – 8:00 AM	Check-In	
8:00 – 8:15 AM	Welcome	Paul A. Hindman, Executive Director
8:15 – 8:45 AM	The New Urban Storm Drainage Criteria Manual Volume 3	Holly Piza
8:45 – 9:15 AM	Construction Best Management Practices	Andrew Earles, PhD, Wright Water Engineers Matt Czahor, CDPHE
9:15 – 10:00 AM	Pedestrian “Below Grade” Crossing Considerations	Jeff Fisher Laura Kroeger
10:00 – 10:15 AM	**Break**	
10:15 – 11:00 AM	Design, **CONSTRUCTION*** *maintenance	Barbara Chongtoua Mike Sarmento
11:00 – 11:45 AM	Effectiveness of Regional Detention on Flood Control and Water Quality	Shea Thomas Derek Rapp, Wright Water Engineers Melanie Chenard, Muller Engineering
11:45 – 1:00 PM	**Lunch**	
1:00 – 1:45 PM	Guidelines For Electronic Submittal of Letters of Map Change Requests	Bill DeGroot David Mallory
1:45 – 2:20 PM	Accessing Our Documents and Data on the Web	Kevin Stewart Julia Bailey
2:20 – 3:00 PM	Design, Construction, and Maintenance Program Highlights	David Bennetts Laura Kroeger
3:00 – 3:15 PM	**Break**	
3:15 – 3:55 PM	Post-Construction Best Management Practices	Holly Piza
3:55 – 4:35 PM	Street Inlets – Results of Our Research	James Guo, PhD, University of Colorado Ken MacKenzie
4:35 – 4:40 PM	Closing Remarks, Q&A	Paul Hindman

THE NEW URBAN STORM DRAINAGE CRITERIA MANUAL, VOLUME 3

Holly Piza, UDFCD

The Urban Storm Drainage Criteria Manual (USDCM) Volume 3 *Best Management Practic*es (BMPs) was first published in 1992. The manual was updated in 1999 with several BMPs added. Now in 2010, we are wrapping up a rewrite which will also include new BMPs. The process began with a survey of over 200 Volume 3 users, from which the goals of the rewrite were developed. This presentation will revisit those goals and will prepare the users of Volume 3 with an introduction to the new manual. The presentation will highlight significant changes, additions, and new tools including:

- ✓ New Organization,
- ✓ Increased Emphasis of the Four Step Process,
- ✓ BMP Selection including Whole Life Cycle Cost considerations,
- ✓ Calculation of Volume Reduction with LID practices,
- ✓ Treatment BMPs,
- ✓ Source Control BMPs,
- ✓ Construction BMPs, and
- ✓ BMP Maintenance.

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The New Urban Storm Drainage Criteria Manual, Volume 3

Holly Piza, UDFCD

Notes:

CONSTRUCTION BEST MANAGEMENT PRACTICES

Andrew Earles, PhD, Wright Water Engineering
Matt Czahor, Colorado Department of Public Health and Environment

ABSTRACT:

Andrew Earles is working with UDFCD to update the Urban Storm Drainage Criteria Manual, Volume 3. There have been many changes to the way construction sites must be managed and many more on the way, as the Clean Water Act rules grow ever more restrictive, (and in many cases, prescriptive). Andrew will go over the highlights of what is going into the new chapter on construction best management practices, and the theory and reasoning behind the changes.

Matt Czahor has been with the Colorado Department of Public Health and Environment (CDPHE) for several years and is an expert in what does and what does not work regarding construction site stormwater runoff quality. Matt has given extremely valuable input into the construction chapter development and we at UDFCD are honored to have his assistance in this important work.

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Construction Best Management Practices

Andrew Earles, PhD, Wright Water Engineers,

Matt Czahor, CDPHE

Notes:

Pedestrian Below Grade Crossing Maintenance Considerations

Laura Kroeger, UDFCD & Jeff Fisher, UDFCD

There are hundreds of miles of trails in the metro area and many are adjacent to drainageways. When the drainageway crosses under a roadway, pedestrian below grade crossings are often considered. There are many advantages to this arrangement such as traffic safety, continuous trail connection and multi-use of a structure. But what many people do not recognize is the maintenance component of these crossings.

This discussion will not focus on the inherent public safety concerns regarding people near drainageways and in a confined space during a flood event. What will be discussed are ways to maintain and retrofit existing pedestrian below grade crossing to alleviate continuous maintenance problems. The most frequent problem with these systems is water and/or sediment on the trail. This leads to unsafe trail conditions for pedestrian users.

The District does not currently have design criteria for below grade pedestrian crossing, but there is a preference to use a bridge structure. A bridge option can span the floodplain and also provide space underneath for a trail. The advantage to this choice is that the trail is not confined by walls on both sides, allowing the trail to drain freely. If a box culvert must be used, the preference is for a large single cell (as opposed to one cell for the stream and one for pedestrians). This again allows for the trail to drain back into the drainageway.

Most maintenance problems occur when the trail is placed in a cell of its own and is confined on both sides. Due to the general layout of pedestrian below grade crossings they are in the low point of the surrounding area where everything drains towards them. Managing the stormwater as well as groundwater is challenging and often times overlooked in design.

The District has retrofitted many below grade crossing over the years to improve the drainage and maintenance of these structures. Typical tools we employ in this work include:

- Routine sediment removals,
- Construction of stem walls,
- Regrading and/or realigning the channel, and
- Installation of trench drains.

Often, a combination of tools is needed to alleviate the problem.

Our goal of this talk is to share our experiences and make designers aware of the maintenance issues that accompany these structures, such that designers may incorporate solutions to these challenges in their designs. We also want to give good practical examples to public works officials who maintain these crossings and who may be looking for solutions to existing pedestrian below grade crossing maintenance problems.

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April 29, 2010

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Pedestrian "Below Grade" Crossing Maintenance Considerations

Laura Kroeger, UDFCD

Jeff Fisher, UDFCD

Notes:

Design,

CONSTRUCTION*

***(maintenance)**

Barbara Chongtoua, UDFCD
Mike Sarmento, UDFCD

ABSTRACT:

What is the DCM Program? What are some of the challenges and solutions? The "natural" flow is design, construct, and maintain. What are the benefits of "reverse" engineering from maintenance to design?

Our Maintenance challenge: Is maintenance ever routine? What facilitates good maintenance? Maintenance is rarely routine for the District. Steep banks, limited access, and other challenges confront District maintenance contractors. Keeping these challenges in mind during design can reduce costs and improve service to our local governments.

Maintenance is dependent upon good Construction. Revegetation and landscaping are not the final part of the of the design or construction process. Successful revegetation and efficient, low-cost maintenance depend on careful design and consideration throughout the design and construction process. Design drainageway improvements with Maintenance contractor in mind.
What do we mean by the Construction in the DCM program? Challenges during Construction. Designer, contractors, and inspectors learn by "stubbing their toes" how to build a good project. What is a "good" drainageway project? Should Construction be used as the catch-all? (We'll fix or figure that out when we go to construction!!). The main complaints of the Construction Contractor on drainageway projects are water control, access and staging, permit compliance, and construction specifications. What can the District, local governments, and consulting engineers do to reduce these problems and contain costs?
Design "Remedies". How do we design a project for better construction and simpler maintenance? This presentation will answer these questions.

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Design, CONSTRUCTION*

*(maintenance)

Barbara Chongtoua, UDFCD

Mike Sarmento, UDFCD

Notes:

EFFECTIVENESS OF REGIONAL DETENTION

ON FLOOD CONTROL AND WATER QUALITY

**Shea Thomas, UDFCD, Derek Rapp, Wright Water Engineers,
Melanie Chenard, Muller Engineering**

ABSTRACT:

UDFCD has been advocating for regional flood control detention since its inception in 1969 as a means for reducing peak flows to prevent flooding and reduce the conveyance capacity required immediately downstream. Many local communities have adopted the policy and have implemented regional detention facilities. The Big Dry Creek Major Drainageway Plan, by Wright Water Engineers, analyzes a 67 square mile watershed including 22 major drainageway tributaries with 69 outfalls to the main stem of Big Dry Creek. Incorporated into the baseline hydrologic model were 73 existing regional detention facilities – 70 located on tributaries and only 3 on the Big Dry Creek main stem. The effect of regional detention facilities on the major drainageway immediately downstream has always been apparent in modeling and in practice. What the Big Dry Creek Major Drainageway Plan has shown is the effect that implementation of a regional detention policy in a watershed has on the receiving waters at a point 23 miles downstream.

In 2007, the concept of Full Spectrum Detention was added to the Urban Storm Drainage Criteria Manual to reduce stormwater runoff flow rates for the larger design storms as well as for the smaller, more frequent storms. Full Spectrum Detention involves capturing a volume of runoff defined as the Excess Urban Runoff Volume (or the difference between urban and pre-development runoff volumes) and releasing it over 72 hours. The concept was developed by Urbonas and Wulliman and tested through modeling of a generic watershed. The Cottonwood Creek Outfall Systems Plan, by Muller Engineering Company, recommends building 9 new EURV detention facilities and retrofitting 12 existing detention facilities to incorporate the EURV. The results from modeling these facilities show the effect of Full Spectrum Detention on peak flows in a drainageway in comparison to historic flows for six different return periods.

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Effectiveness of Regional Detention on Flood Control and Water Quality

Shea Thomas, UDFCD,

Derek Rapp, Wright Water Engineers,

Melanie Chenard, Muller Engineering

Notes:

Submittal Guidelines
For
Digital Letters of Map Change

Bill DeGroot, UDFCD
David Mallory, UDFCD
Craig Jacobson, ICON Engineering, Inc.

ABSTRACT:

In ancient times, consulting engineers had to first grow a tree in order to make the reams of paper necessary to print the HEC-RAS results, forms and all the other required components of a Letter of Map Revision (LOMR) submittal. A new age has dawned. While the Federal Emergency Management Agency (FEMA) must still accommodate hard copy submittals, the District has developed a procedure for largely digital submittals that will save time on submittal preparation, but more importantly improve the quality of submittals. Anyone who has submitted a LOMR or a conditional LOMR (CLOMR) will report that inevitably they must redo and resubmit at least some items before the technical review commences.

The digital letter of map change (DLOMC) procedure includes:

- Standardized report text and FEMA forms in pdf format
- Electronic submittal of hydrologic/hydraulic models with a specified file structure and user-generated reports
- Construction plans (both proposed and as-built) submitted in pdf format
- Supporting documentation, including property owner notifications submitted in pdf format
- Electronic and hardcopy submittal of workmaps and annotated FIRMS

We will introduce the use of comparison tables, agreement tables and submittal checklists. These items are all related to quality control, this means the submittal will be checked by the engineer before it reaches us. The digital submittals coupled with improved quality of submittals will save time and money on both sides of the review. We are hopeful this initiative will serve as a national model.

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Submittal Guidelines for Digital Letters of Map Change

Bill DeGroot, UDFCD

David Mallory, UDFCD

Craig Jacobson, ICON Engineering, Inc.

Notes:

Accessing Our Documents and Data on the Web

Kevin Stewart, UDFCD
Julia Bailey, UDFCD

ABSTRACT:

Since 2008 the Electronic Data Management (EDM) interface has been a major aspiration of the District. District staff, local governments and consultants often make use of reports and design drawings available at the District's website. The majority of these documents pertain to specific geographic locations which are categorized and searched through a web-based mapping interface.

With the help of CH2M Hill, the District has been able to produce critical base layers to support development of the EDM interface. Base layers include: stream network, basin boundaries, and hyperlinks representing individual design drawing pages on the map.

Late in 2009 an EDM mapping interface was built in ESRI's ArcGIS Server using Adobe's Flex Viewer technology. The main webpage will eventually include a series of tabs dedicated to the various District programs.

The first task in the project involved creating a document search tab. Much like a Google Maps interface, users can easily zoom and pan through the District boundary or enter an intersection or address to zoom to. In addition, stream confluences and road crossings can also be entered to quickly find documents of interest.

Clicking anywhere on the map will query a MySQL database used for accessing documents and return search results related to that area. Once the search results window appears, the user is able to sort or narrow the search by document type, year, drainageway, basin, sponsor and author. A keyword search is also available if the user prefers not to navigate the map.

The EDM webpage is a work in progress with new functionality and information being added for years to come. User feedback is always welcome and encouraged.

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Accessing Our Documents and Data on the Web

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Julia Bailey, UDFCD

Notes:

HIGHLIGHTS OF THE DESIGN, CONSTRUCTION, AND MAINTENANCE PROGRAM

David Bennetts, UDFCD
Laura Kroeger, UDFCD

ABSTRACT:

Storm Sewer Pipe Material Technical Memorandum:

In March of 1998 the District partnered with several local governments in the metro area in updating the "Storm Sewer Pipe Material Technical Memorandum", the original memorandum was published in 1987. Since that update there have been changes to the products being offered on the market and several local governments have expressed an interest in updating the report. The District, again working with several local governments and pipe manufacturers, is in the process of completing a second update to the memorandum. The primary purpose of the latest update is to include new products that have been introduced in the region and provide guidance in selecting the right pipe material for the project. This update will also include new case studies, as well as follow-ups to the previous studies. It is anticipated that this project will be complete and posted on the District's website by August 2010.

DCM Research Topics:

The DCM Program created a budget for research in 2009 to study design and construction techniques that are of interest to the District. Topics that are currently under study include vegetated drop structures, log drop structures, vinyl sheet pile, outlet structure configurations, void filled riprap, porous landscape detention, and full spectrum detention. This presentation will provide an update on these research topics.

Routine Maintenance Changes:

The DCM Program is in the process of changing the way we provide routine maintenance services to the drainageways in the Metro area. The goal is to shift away from heavily manicured environments toward restoring the natural look and functions of the drainageways. The changes will provide better services to the local governments, make better use of limited resources, improve water quality and habitat, and provide maintenance services in a more sustainable manner. An outline of these proposed changes will be presented.

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Design, Construction, and Maintenance Program Highlights

David Bennetts, UDFCD

Laura Kroeger, UDFCD

Notes:

POST-CONSTRUCTION BEST MANAGEMENT PRACTICES

Holly Piza, UDFCD

This presentation will include an overview of updates and additions to the post-construction BMPs in Volume 3 of the Urban Storm Drainage Criteria Manual (USDCM). In addition to new recommendations in design criteria, the UD-BMP workbook has been significantly modified to both incorporate the new criteria and follow the same design steps outlined in the text of the manual. The presentation will specifically highlight changes and provide background information relevant to:

- ✓ Grass Buffers and Swales,
- ✓ Extended Detention Basins,
- ✓ Porous Landscape Detention/Rain Gardens,
- ✓ Permeable Pavements, and
- ✓ Sand Filters.

In addition to changes for the above listed BMPs, new BMPs to the manual consisting of Green Roofs and Underground BMPS will be presented.

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Post-Construction Best Management Practices

Holly Piza, UDFCD

Notes:

The Continuing Saga of the UDFCD Street Inlet Study: The Final Chapter (or is it?)

James C.Y. Guo, PhD & P.E., University of Colorado at Denver,
Ken A. MacKenzie, UDFCD

ABSTRACT:

In 2005, UDFCD set out on an ambitious mission – to quantify the interception capacity of three inlets commonly used in Colorado. Up to that time, the best guidance available was from the Federal Highway Administration, namely the "Urban Drainage Design Manual" (Hydraulic Engineering Circular No. 22, 2002, a.k.a. HEC-22).

In Colorado, the three most commonly used inlets are:

- CDOT Type 13, in valley or combination with curb opening
- Denver No. 16, in valley or combination with curb opening
- CDOT Type R curb opening (and its cousin the Denver No. 14 curb opening)

The problem with using HEC-22 to size these inlets is that the FHWA physical modeling that was the basis for their inlet sizing procedures was not done on any inlets that are representative of those we use. A literature search indicated that no one else had better data.

UDFCD sought and received numerous donations from local governments in 2005 to make this $200,000 project a reality (see presentation for full list).

In 2006 a contract was signed with the Colorado State University. From that time until December 2009, UDFCD, CSU, and Dr. James Guo with the University of Colorado at Denver have been working together to model street inlets in sump conditions and in "on-grade" conditions. We have learned a lot about the behavior of these inlets and are currently updating the inlet sizing program "UD-Inlet" to more economically size street inlets. This new program will be ready in June 2010.

This presentation will summarize what we learned and how we are going to better size inlets in the future.

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Street Inlets – Results of Our Research

James Guo, PhD, University of Colorado

Ken MacKenzie, UDFCD

Notes:

The New USDCM Volume 3

Prepared by Holly Piza, P.E.

Presented by Ken Mackenzie, P.E. and
Jane Clary, Wright Water Engineers

The Process

Technical Advisory Committee (TAC)
- Core Groups
  - Permeable Pavements
  - Vegetated BMPs
  - Detention\Retention\Wetland Ponds
  - Manufactured BMPs
  - Decision Support System (DSS)
  - Credits (LID)
  - Construction BMPs

UDFCD

WWE Consultant Team

Draft Documents

Posted for Stakeholder Review

Lots of Comments

Goals

(Based on a survey of over 200 respondents)

- Format
- Content
- Software

Extended Detention Basin (EDB) T-5

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Sheet 1 of 4

Designer:
Company:
Date: January 15, 2010
Project:
Location:

010 Urban Drainage and Flood Control District EDB-11
Urban Storm Drainage Criteria Manual Volume 3

Green Roof T-4

Photo GR-1. EPA Region 8 building in downtown Denver. Photo courtesy Weston Solutions.

Overview	Green Roof
Functions	
Pretreatment	◐
LID/Volume Red.	●
WQCV	◐
WQCV+Detention	○
Typical Effectiveness for Targeted Pollutants	
Sediment/Solids	◐
Nutrients	◐
Total Metals	◐
Bacteria	○
Other Considerations	
Land Req.	Low
Capital Costs	High
Life-cycle Costs	Med
Maintenance Frequency/Costs	Med

See Table 4-1 for key to ratings

Description

Green roofs can be defined as "contained" living systems on top of human-made structures. This green space can be below, at or above grade involving systems where plants are not planted in the "ground". (Source: Green Roofs for Healthy Cities)

A green roof system contains a high quality water proofing membrane and root barrier system, drainage system, filter fabric, a lightweight growing medium and plants. Green roof systems can be modular layered systems already prepared in trays, including drainage layers, growing media and plants, or, each component of the system can be installed separately on top of the structure

It should be noted that the U.S. Green Building Council LEED rating system recognizes a second kind of "green roof" that includes reflective, high albedo roof materials that are not designed for stormwater purposes.

As Low Impact Development (LID) strategies have been increasingly emphasized throughout the U.S., green roofs have been implemented in some parts of the country, most frequently in areas with humid climates and relatively high annual rainfall. Although there are some green roofs in Colorado, they have not been widely installed, and research is in progress regarding the best design approach and plant list for the metro Denver climate. Because the technical community has expressed interest in exploring the water quality and volume reduction benefits of this technique, information on Green Roofs is provided in this data sheet based on industry literature and academic research.

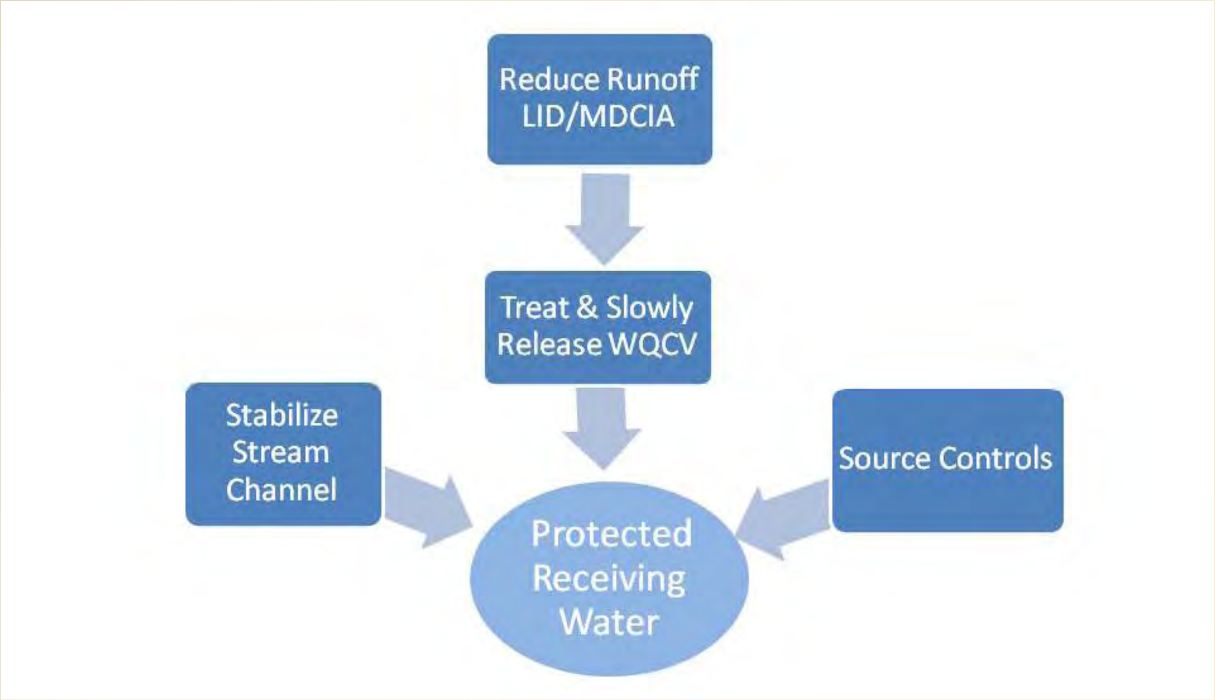
The design of a green roof involves many disciplines in addition to stormwater engineers including structural engineers, architects, landscape architects, horticulturists, and others. This data sheet is intended only to provide an overview of green roof information relative to stormwater quality and quantity management that is applicable in the Denver Metropolitan area. *Design Guidelines and BMP/Maintenance Manual for Green Roofs in the Arid West* prepared by the University of Colorado

April 2010 Urban Drainage and Flood Control District GR-1

DRAFT

USDCM Volume 3 History and Fundamentals

- First Release in 1992
- No Change in Concept



The Four Step Process

Overview of Manual

1. Stormwater Management and Planning
2. BMP Selection
3. Water Quality Capture Volume (WQCV) and Runoff Reduction
4. Treatment BMPs
5. Source Control BMPs
6. Construction BMPs
7. Maintenance

Also Supporting Materials (spreadsheets, etc.)

New Features/Enhancements

- Builds on existing technical foundation AND remains a technical manual
- Updated criteria/new technical information where needed
- More on site selection, designing for maintenance, construction considerations, sustainability
- Self-contained Fact Sheets

Treatment BMPs

- Grass Swales
- PLD
- EDB
- (*and so on*)

Source Control BMPs

- Covering Storage & Handling Areas
- Disposal of Household Waste
- (*and so on*)

Construction BMPs

- Inlet Protection
- Stockpile Storage
- Sediment Basins
- (*and so on*)

Other New Features

- *Supplemental* information provided in call-outs
  - Key references for more information
  - “Green” tips
  - Supplemental explanation
  - Installation tips to avoid common problems
- More photos

Examples of Stormwater “Hotspots”

- Fleet storage areas
- Solid waste facilities
- Wastewater treatment plants
- Composting facilities
- (etc.)

Phosphorus

Phosphorus is commonly overused and application should always be based on soil tests. Phosphorus washing into surface waterbodies leads to excessive algae growth. Phosphorous does not move out of the soil like nitrogen, so constant additions are unnecessary.

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Integrating Recent Research

- BMP Performance
  - UDFCD / local experience
    - Design
    - Installation
    - Maintenance
    - Monitoring
  - Intl. Stormwater BMP Database
  - Roesner/Olson—CSU Life Cycle Costs
  - Barriers to LID

Overview	Extended Detention Basin
Functions	
Pretreatment	○
LID/Volume Red.	◐
WQCV	●
WQCV+Detention	●
Typical Effectiveness for Targeted Pollutants	
Sediment/Solids	●
Nutrients	◐
Total Metals	◐
Bacteria	○
Other Considerations	
Land Req.	High
Capital Costs	High
Life-cycle Costs	Med
Maintenance Frequency/Costs	Med

BMP Selection

Site Conditions

- Size
- Soils
- Contributing Drainage Area
- Groundwater
- Base flows
- Watershed Development Activities

Treatment Processes

- Sedimentation
- Straining
- Infiltration or filtration
- Evapotranspiration
- Biological Uptake

Land Use

- Ultra Urban
- High Density Mixed Used
- Campus
- Industrial
- Low Density Mixed Use
- Residential
- Parks and Open Space

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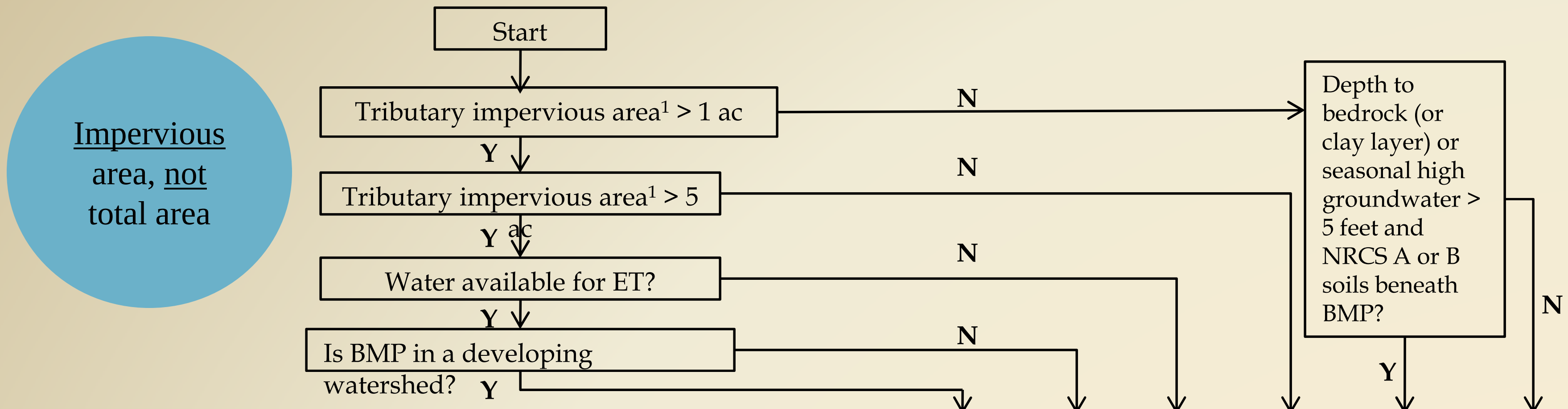
Decision Tree Identifying Potential BMPs for Conventional Sites

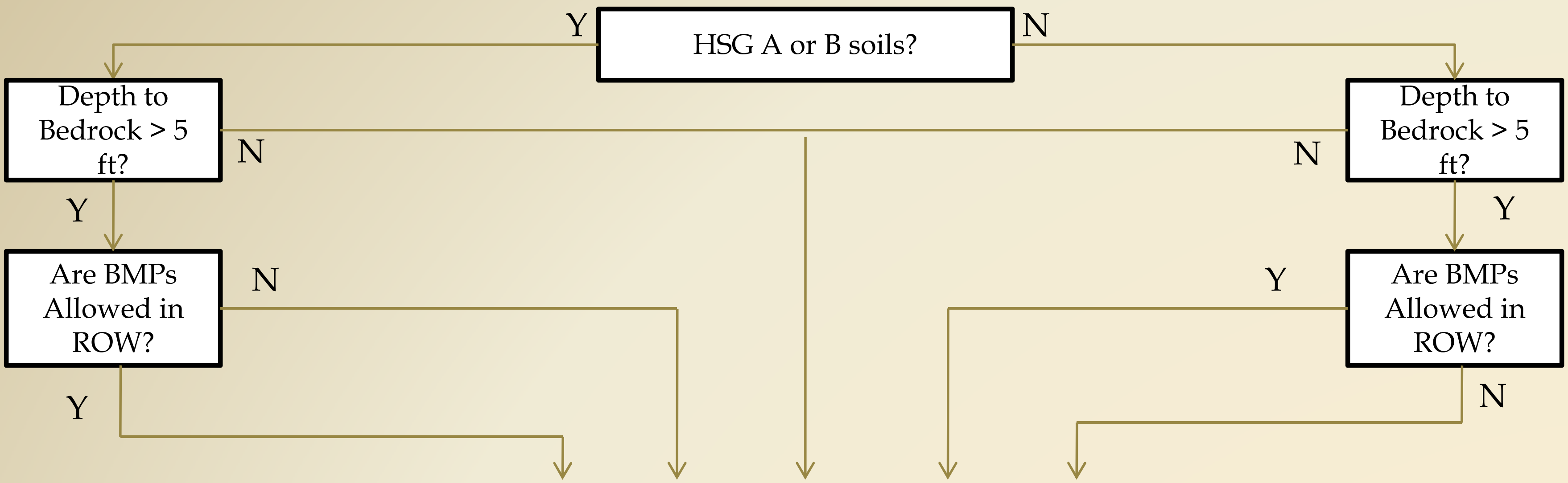


Step 1--MDCIA/Volume Reduction--No WQCV						
Grass Swale	●	●	●	●	●	●
Grass Buffer					●	●
Constructed Wetland Channel[2]	●[2]	●[2]	●[2]	●[2]	●[2]	●[2]
Permeable Pavement Partial or No WQCV—Full Infiltration[5,6]					●	
Permeable Pavement with Partial or No WQCV—No Infiltration or Partial Infiltration[5,6]						●
Green Roof with Partial WQCV[5]					●[3]	●[3]
Step 2—WQCV						
Permeable Pavement with Full WQCV—Full Infiltration[6]					●	
Permeable Pavement with Full WQCV--No Infiltration or Partial Infiltration[6]						●
Bioretention—Full Infiltration[6]					●	
Bioretention—No Infiltration or Partial Infiltration[6]						●
Extended Dry Detention Basin	●	●	●	●		
Constructed Wetland Basin[2]	●	●				
Retention Pond	●	●				
Sand Filter Extended Detention		●	●	●	●	●
Green Roof with Full WQCV					●[3]	●[3]
Regional Water Quality Treatment	●[4]	●[4]	●[4]	●[4]	●[4]	●[4]

Notes

[1] "Tributary impervious area" refers to the impervious area draining to the BMP, **not** the total area of the project site.
[2] For a successful wetland channel or basin, a water source (groundwater or baseflow) will be required.
[3] In the Front Range of Colorado, irrigation, at least periodically in dry times, will be required to sustain a green roof.
[4] If a regional facility will be used to provide the WQCV, some degree of onsite treatment/MDCIA will still likely be required.
[5] For some types of BMPs, including permeable pavements and green roofs, the BMP may provide the full WQCV, a portion of the WQCV or no WQCV depending on the design. For a BMP to satisfy Step 2 requirements, the full WQCV must be provided.
[6] No Infiltration = underdrain and liner, Partial Infiltration = underdrain and no liner, Full Infiltration = no underdrain and no liner

BMP Selection Flow Chart for Highly Urbanized Sites



Step 1--MDCIA/Volume Reduction--No WQCV					
Permeable Pavement with Partial or No WQCV—Full Infiltration[4,5]	●	●			
Permeable Pavement with Partial or No WQCV—Partial Infiltration or No Infiltration[4,5]			●	●	●
Green Roof with Partial WQCV[4]	●	●[1]	●[1]	●[1]	●[1]
Step 2—WQCV					
Permeable Pavement with Full WQCV—Full Infiltration[5]	●	●			
Permeable Pavement with Full WQCV--Partial Infiltration or No Infiltration[4,5]			●	●	●
Bioretention—Full Infiltration[5]	●	●			
Bioretention—Partial Infiltration or No Infiltration[4,5]			●	●	●
Green Roof with Full WQCV	●[1]	●[1]	●[1]	●[1]	●[1]
Underground BMPs with Full WQCV		●[2]			●[2]
Regional Water Quality Treatment	●[3]	●[3]	●[3]	●[3]	●[3]

Notes

[1] In the Front Range of Colorado, irrigation, at least periodically in dry times, will be required to sustain a green roof.

[2] Underground BMPs should only be considered when surface-based BMPs are not practicable. See the Underground BMP Fact Sheet for additional restrictions on use.

[3] If a regional facility will be used to provide the WQCV, some degree of onsite treatment/MDCIA will still likely be required.

[4] For some types of BMPs ,the BMP may provide the full WQCV, a portion of the WQCV or no WQCV depending on the design. For a BMP to satisfy Step 2 requirements, the full WQCV must be provided.

[5]No Infiltration = underdrain and liner
Partial Infiltration = underdrain and no liner
Full Infiltration = no underdrain and no liner

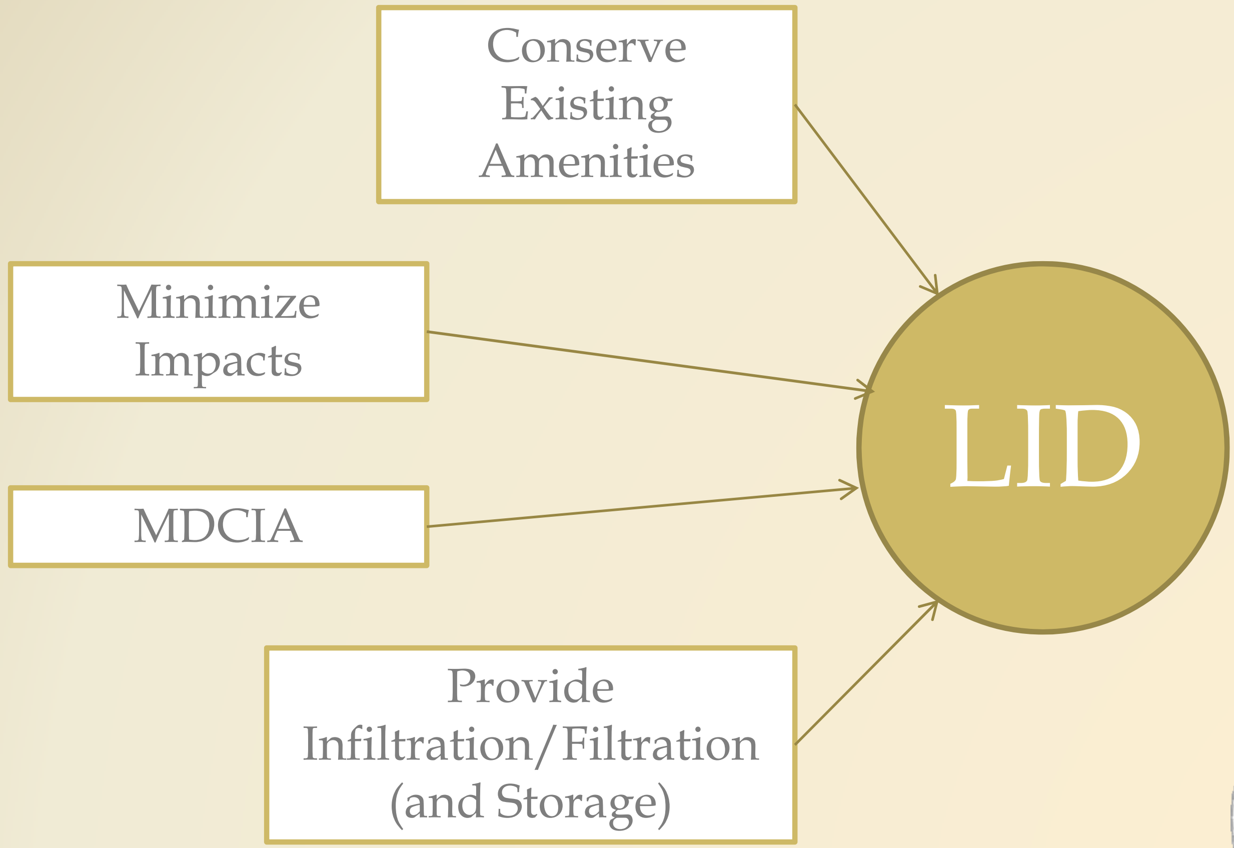
Design Procedure Form: Deciderator (DSS)

Designer: ______
Company: ______
Date: April 20, 2010
Project: ______
Location: ______

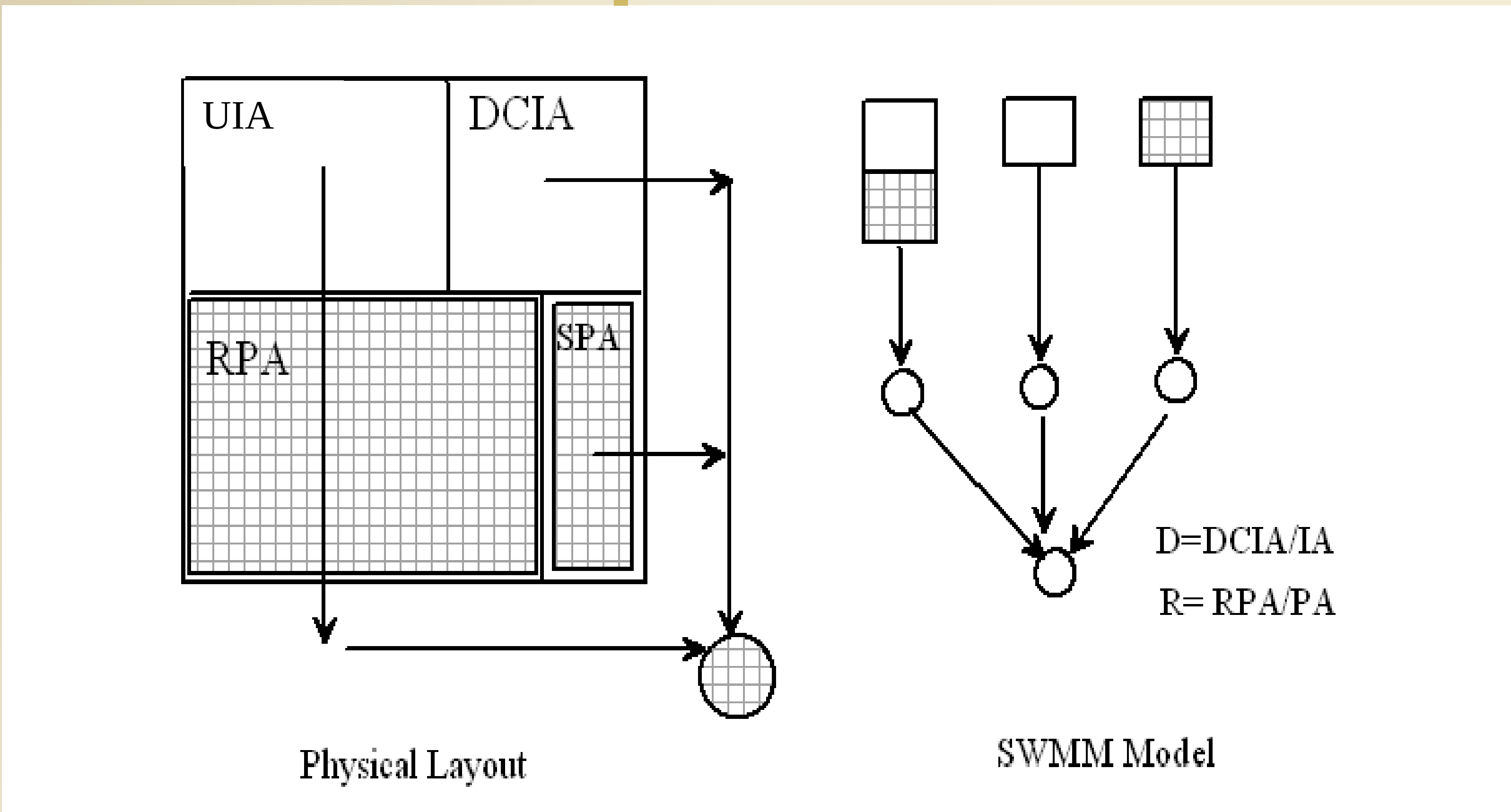
1. Is the site highly urbanized? (Transit oriented development or lot line to lot line)	Choose One: O YES O NO
2. Is the site comprised of Hydrologic Soil Group A or B soils?	Choose One: O YES O NO
3. Is the depth to groundwater greater than 5 feet?	Choose One: O YES O NO
4. Is the depth to bedrock greater than 5 feet?	Choose One: O YES O NO
5. Are BMPs allowed in the right-of-way?	Choose One: O YES O NO
6. Is the tributary impervious area greater than 1 acre?	Choose One: O YES O NO
7. Is the depth to bedrock (or clay layer) or seasonal high groundwater greater than 5 feet **AND** Hydrologic Soil Group A or B soils beneath the BMP?	Choose One: O YES O NO
8. Is the tributary impervious area greater than 5 acres?	Choose One: O YES O NO
9. Is water available for evapotranspiration (ET)?	Choose One: O YES O NO
10. Is the BMP in a developing watershed?	Choose One: O YES O NO
11. Step 1: MDCIA / Volume Reduction - No WQCV BMPs	
12. Step 2: WQCV BMPs	

Notes: ______

Effective Impervious Calculations and LID



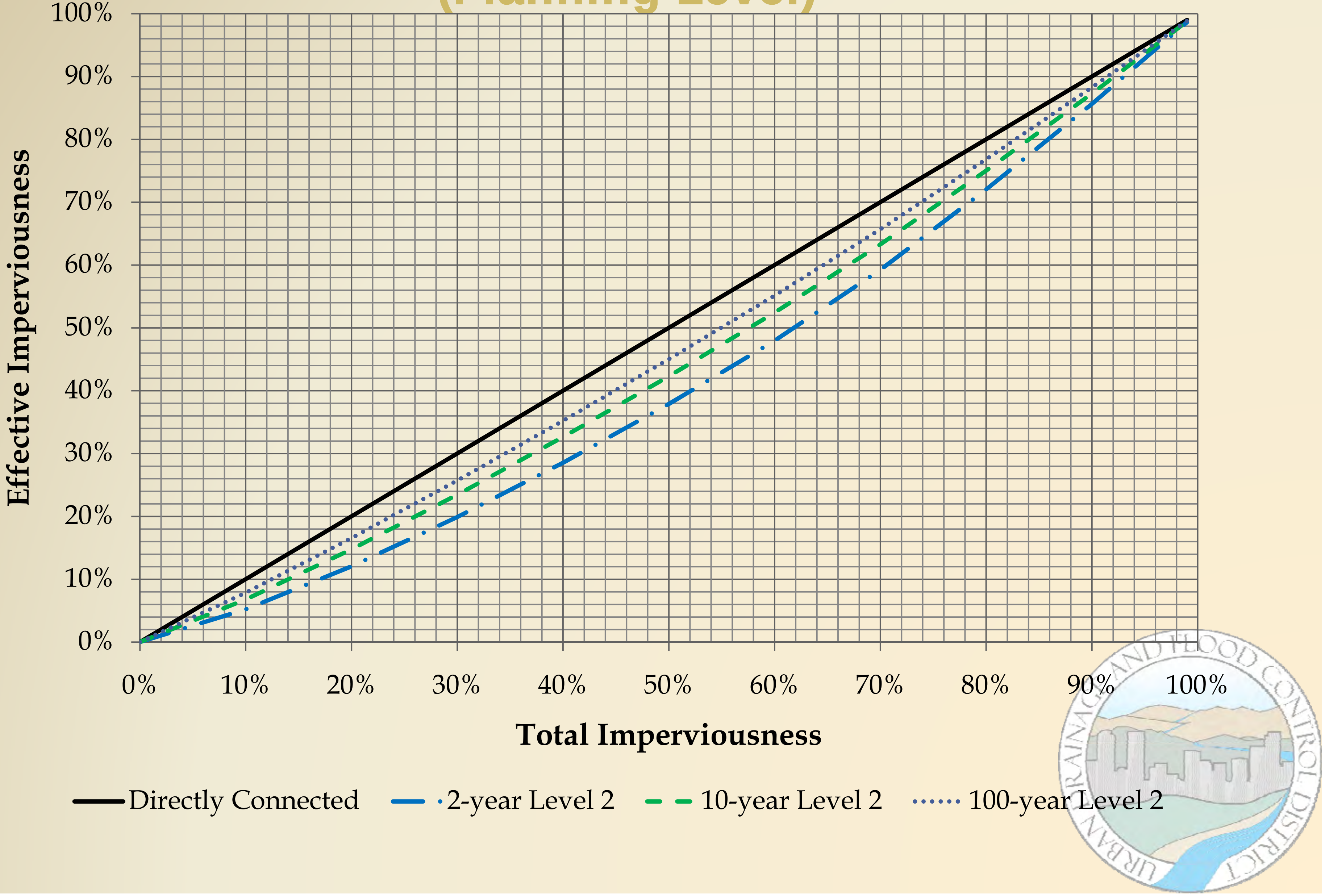
Conceptual Model



UIA = Unconnected Impervious Area
DCIA = Directly Connected Impervious Area

RPA = Receiving Pervious Area
SPA = Separate Pervious Area

Effective Imperviousness Adjustments for Level 2 MDCIA
(Planning Level)



Dimensionless Analysis

- Conveyance-based BMPs:

$$K = Fct(\frac{F_d}{P}, A_r) = Fct(\frac{f}{I}, A_r)$$

- Storage-based BMPs:

$$K = Fct(\frac{F_d}{P}, A_r, A_d \frac{WQCV}{P})$$

K = Imperviousness reduction factor

F_d = Pervious area infiltration loss (in)

f = Pervious area infiltration rate (in/hr) corresponding to saturated hydraulic conductivity

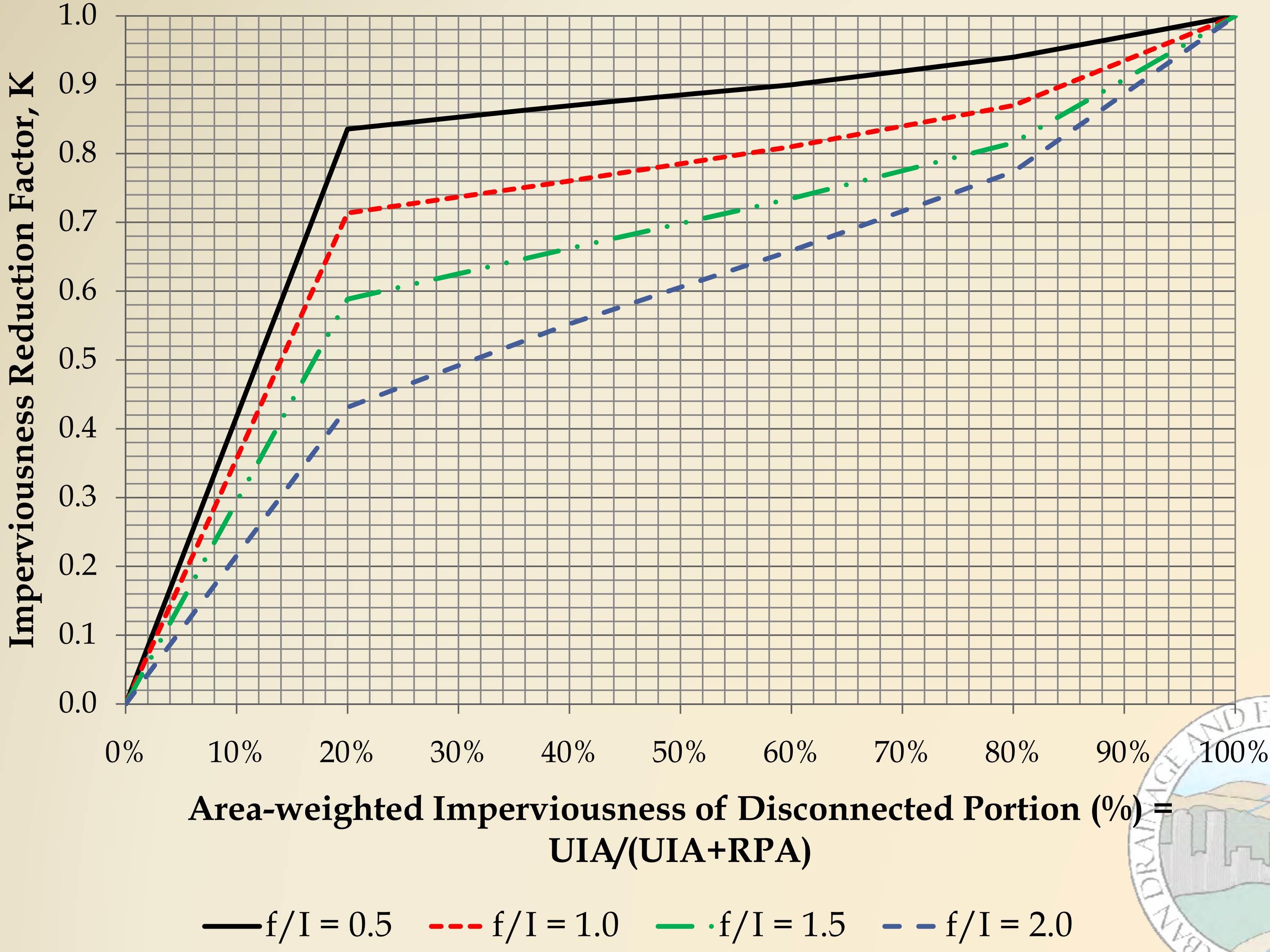
P = Design rainfall depth (in)

I = Rainfall intensity (in/hr)

A_r = RPA/UIA

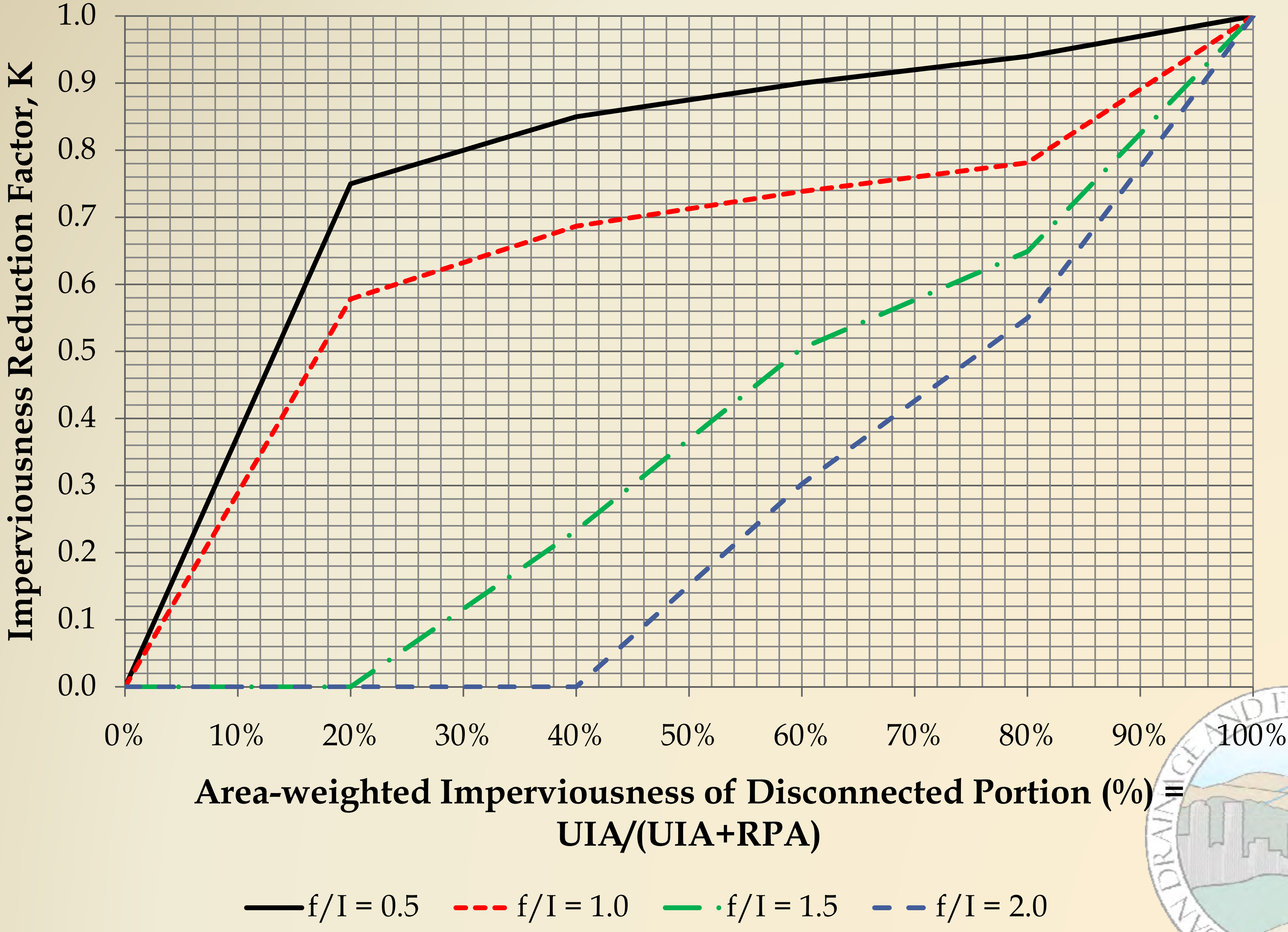
A_d = RPA

Conveyance-based Imperviousness Reduction Factor (Site Level)



URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

Storage-based Imperviousness Reduction Factor (Site Level)



More on Volume 3

CASFM 2010

UWRI 9/30/2010 - 10/1/2010

hpiza@udfcd.org

Urban Drainage and Flood Control District (UDFCD) Volume 3 Update Construction BMPs

Ken Mackenzie, P.E. & Holly Piza, P.E.
UDFCD
&
Andrew Earles, Ph.D., P.E., CPESC & Jane Clary, CPESC, LEED AP
Wright Water Engineers, Inc.

April 29, 2010

Scope of Update

- Look consistent with BMP Fact Sheet approach in rest of Volume 3.
- "Best of the Best" BMP Details from existing manuals and recent manuals in metro area (Aurora, Douglas County, Arapahoe County, Parker and others).
- USLE guidance.
- "Double Duty" Stormwater Management Plan (SWMP) guidance.

Scope of Update (cont.)

- Guidance on new Effluent Limitation Guidelines (ELGs).
- Advanced Treatment Systems/Chemical Treatment.
- Improved Guidance on BMPs and construction phasing.
- Construction dewatering.
- Working in waterways.
- Linear projects.

Description

Check dams are temporary grade control structures placed in drainage channels to limit the erosivity of stormwater by reducing flow velocity. Check dams are typically constructed from rock, gravel bags, sand bags or sometimes proprietary devices. Reinforced check dams are typically constructed from rock and wire gabion. Although the primary function of check dams is to reduce the velocity of concentrated flows; a secondary benefit is sediment trapping upstream of the structure.

Photographs CD-1 and CD-2. Rock check dams in a roadside ditch and reinforced rock check dam in a small drainage swale. (Photo Sources: WWE; Douglas County)

Appropriate Uses

Use as a grade control for temporary drainage ditches or swales until final soil stabilization measures are established upstream and downstream. Check dams can be used on mild or moderately steep slopes. Check dams may be used under the following conditions:

- As temporary grade control facilities along waterways until final stabilization is established.
- Along permanent swales that need protection prior to installation of a non-erodible lining.
- Along temporary channels, ditches or swales that need protection where construction of a non-erodible lining is not practicable.
- Reinforced check dams should be used in areas subject to high flow velocities.

Check Dams	
Functions	
Erosion Control	●
Sediment Control	◐
Site/Material Management	○
Other Considerations	
General Effectiveness	High
Cost	Med
Maintenance Requirements	Med
Additional Permitting	Low

Design and Installation

Place check dams at regularly spaced intervals along the drainage swale or ditch. Check dams heights should allow for pools to develop upstream of each check dam, extending to the downstream toe of the check dam immediately upstream.

When rock is used for the check dam, place rock mechanically or by hand. Do not dump rocks into the drainage channel. Where multiple check dams are used, the top of the lower dam should be at the same topographical elevation as the toe of the upper dam.

When reinforced check dams are used, install erosion control fabric

under and around the check dam to prevent erosion on the up and down stream side. Each section of the dam should be keyed in to reduce the potential for washout or undermining. A rock apron upstream and downstream of the dam may be necessary to further control erosion.

Design details with notes are provided for the following types of check dams:

- Rock Check Dams (CD-1)
- Reinforced Check Dams (RCD-1)

Sediment control logs may also be used as check dams; however, silt fence is not appropriate for use as a check dam. Many jurisdictions also prohibit or discourage use of staw bales for this purpose.

Maintenance and Removal

Replace missing rocks causing voids in the check dam. If gravel bags or sandbags are used, replace or repair torn or displaced bags.

Remove accumulated sediment when the sediment depth upstream of the check dam is within ½ of the crest height. Remove accumulated sediment prior to mulching, seeding or chemical soil stabilization. Removed sediment can be incorporated into the earthwork with approval from the Project Engineer, or disposed of at an alternate location in accordance with the standard specifications.

Check dams constructed in permanent swales should be removed when perennial grasses have become established, or immediately prior to installation of a non-erodible lining. All of the rock and accumulated sediment should be removed, and the area seeded and mulched, or otherwise stabilized.

Erosion Controls

- EC- 1 Surface Roughening (SR)
- EC-2 Seeding (TS or PS)
  - TS.1 Temporary Seeding
  - PS.1 Permanent Seeding
- EC-3 Soil Binders (SB)
- EC-4 Mulch (MU)
  - MU.1 Hydraulic Mulch
  - MU.2 Straw Mulch
  - MU.3 Wood Mulch
- EC-5 Compost Blanket and Berms (CB)
- EC-6 Erosion Control Blanket and Geotextile Mats (ECB/TRM)
- EC-7 Temporary Slope Drains (TSD)
- EC-8 Terracing (TER)
- EC-9 Check Dams (CD)/ Reinforced Check Dams (RCD)
- EC-10 Streambank Stabilization (STR)
- EC-11 Wind Erosion Control/Dust Control (WEC)

Sediment Controls

- SC-1 Silt Fence (SF)
- SC-2 Sediment Control Log/Wattle (SCL)
- SC-3 Straw Bale Barrier (SBB)
- SC-4 Brush Barrier (BB)
- SC-5 Rock Socks (as Perimeter Control) (RS)
- SC-6 Inlet Protection (IP)
    - IP.1 Block and Rock Sock Inlet Protection for Sump or On-grade Inlets
    - IP.2 Curb (Rock) Socks Upstream of Inlet Protection, On-grade
    - IP.3 Rock Sock Inlet Protection for Sump/Area Inlet
    - IP.4 Silt Fence Inlet Protection for Sump/Area Inlet
    - IP.5 Overexcavation Inlet Protection
    - IP.6 Staw Bale Inlet Protection for Sump/Area Inlet
    - IP.7 Culvert Inlet Protection
- SC-7 Outlet Protection (OP)
- SC-8 Rough Cut Street Control (RCS)
- SC-9 Earth Dikes and Drainage Swales (ED/DS)
- SC-10 Sediment Basin (SB)
- SC-11 Sediment Trap (ST)
- SC-12 Vegetative Buffers (VB)
- SC-13Chemical Treatment/ATS (ATS)

Site Management and Other Specific Practices

SM-1 Construction Scheduling (SCHED)

SM-2 Protection of Existing Vegetation (PRO VEG)

SM-3 Construction Fence (CF)

SM-4 Stabilized Construction Entrance &Exit/Vehicle Tracking Control (VTC)

VTC.1 Crushed Rock

VTC.2 Mud Mat

VTC.3 Cattle Guard

VTC.4 Turf Reinforced Mat

VTC.5 Vehicle Tracking Control with Tire Wash (VTCW)

SM-5 Stabilized Construction Roadway (SCR)

SM-6 Stabilized Staging Area (SSA)

SM-7 Street Sweeping and Vacuuming (SWP)

SM-8 Demolition Adjacent to Water (DEMO)

SM-9 Temporary Diversion Channel (DC)

SM-10 Dewatering Operations (DW)

SM-11 Temporary Stream Crossing (TSC)

TSC.1 Temporary Stream Crossing with Culvert/Bridge

TSC.2 Temporary Stream Crossing with Ford

SM-12 Temporary Batch Plants (TBP)

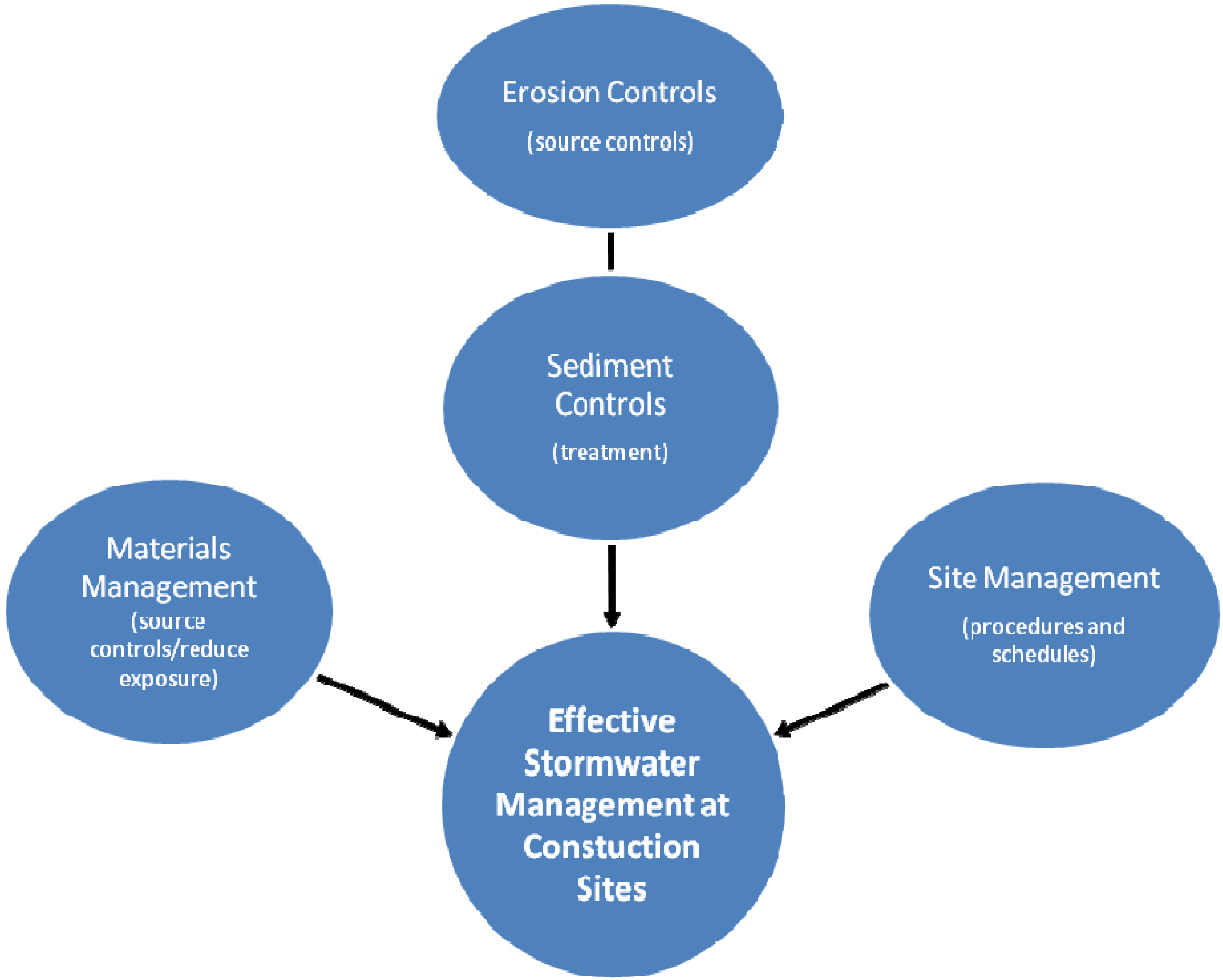
SM-13 Paving and Grinding Operations (PAV)

Materials Management

MM-1 Stockpile Management (STP)

MM-3 Concrete Waste Management Area (CWA)

MM-3 Good Housekeeping (GH)


Erosion Controls
(source controls)
Sediment Controls
(treatment)
Materials Management
(source controls/reduce exposure)
Site Management
(procedures and schedules)
Effective Stormwater Management at Constuction Sites

Pre-Construction

Develop Site Plan

Obtain Site Survey, Hydrology and Soils Information

Prepare SWMP

Obtain Stormwater Construction Permits

(State and Local)

Obtain Other Relevant Permits (e.g., 404, Floodplain, Dewatering)

Construction Phase

Representative Phases:

Clearing and Grubbing

Rough Grading

Road Construction

Utility and Infrastructure Installation

Vertical Construction (Buildings)

Final Grading

Phase Construction Activities to Minimize Disturbed Area at a Given Time

Sequence Contruction within Phases to Avoid Idle Disturbed Areas

Install, Inspect and Proactively Maintain BMPs Appropriate for Each Phase of Construction

Maintain and Update SWMP as Construction Progresses

Final Stabilization

Revegetate Site

Activate Post Construction BMPs

(e.g., convert sediment basin to extended detention basin)

Remove Temporary BMPs

Closeout Local Stormwater Permit

File Inactivation Notice with CDPHE

BMP Selection Guidance

Erosion Control BMPs											
	Surface Roughening	Temporary/ Permanent Seeding	Soil Binders	Mulch	Compost Blankets and Berms	Erosion Control Blanket and Geotextiles Mats	Temporary Slope Drains	Terracing	Check Dams/ Reinforced Check Dams	Streambank Stabilization	Wind Erosion Control/Dust Control
Functions											
Erosion Control	●	●	●	●	●	●	●	●	●	●	●
Sediment Control	○	○	◐	◐	◐	◐	○	◐	◐	○	○
Site/Material Management	◐	◐	○	○	○	○	○	○	○	○	◐
Other Considerations											
General Effectiveness	Med	High	Med	High	Med	High	High	High	High	High	High
Cost	Low	High	High	Med	Med	High	Med/High	Med	Med/High	High	Med
Maintenance Requirements	Low	Med	Med	Med	Med	Med	Med	Low	Med/Low	Med	Med
Additional Permitting	Low	Low	Med	Low	Low	Low	Low	Low	Low	Med	Low/Med

Revised Universal Soil Loss Equation

$$A = R \times K \times L \times S \times C \times P \qquad \text{Equation 7-1}$$

where:

A = Computed spatial average soil loss and temporal average soil loss per unit of area, expressed in the units selected for K and for the period selected for R. Typically, A is expressed in tons per acre per year.

R = Rainfall-runoff erosivity factor – the rainfall erosion index plus a factor for any significant runoff from snowmelt.

K = Soil erodibility factor – the soil-loss rate per erosion index unit for a specified soil.

L = Slope length factor – the ratio of soil loss from the field slope length to soil loss from a 72.6 ft length under identical conditions.

S = Slope steepness factor – the ratio of soil loss from the field slope gradient to soil loss from a 9 percent slope under otherwise identical conditions.

C = Cover-management factor – the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in a bare condition. Values range from 0.01 to 1.

P = Erosion control practice factor – the ratio of soil loss with a certain conservation practice (erosion control BMP) to that of no practice. Values range from 0.8 to. 1.2.

Questions and Acknowledgements

- UDFCD reviewers
- CDPHE
- Excellent local criteria manuals & construction site programs
- WWE construction BMP project team: Jon Jones, P.E., Jennifer Keyes, CPESC, Hayes Lenhart, EIT, Shannon Tillack, EIT

Below Grade Pedestrian Crossing Maintenance Considerations

Jeff Fisher
Construction Manager
Design, Construction & Maintenance Program

Laura Kroeger
Assistant Manager
Design, Construction & Maintenance Program

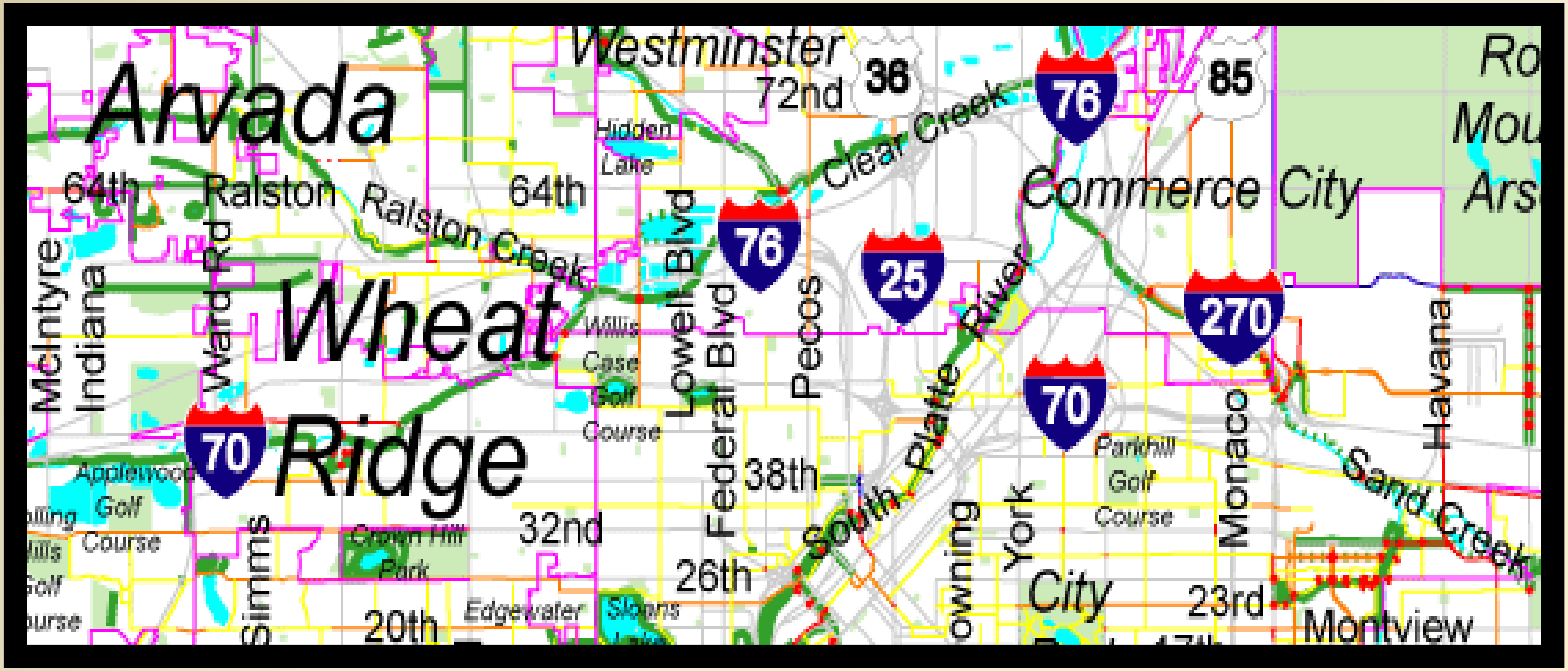
Below Grade Pedestrian Crossing Maintenance Considerations

- Introduction to Below Grade Pedestrian Crossings
- Description of Maintenance Problem
- Tools to ~~Solve~~ Alleviate Problem
- Permitting
- Project Solutions

Disclaimer

- There is an inherent danger in having people near streams and being in a confined space during a flood event.
- District does not currently have design criteria for below grade pedestrian crossings.
- Focus will be on sharing our experience in resolving frequent maintenance problems

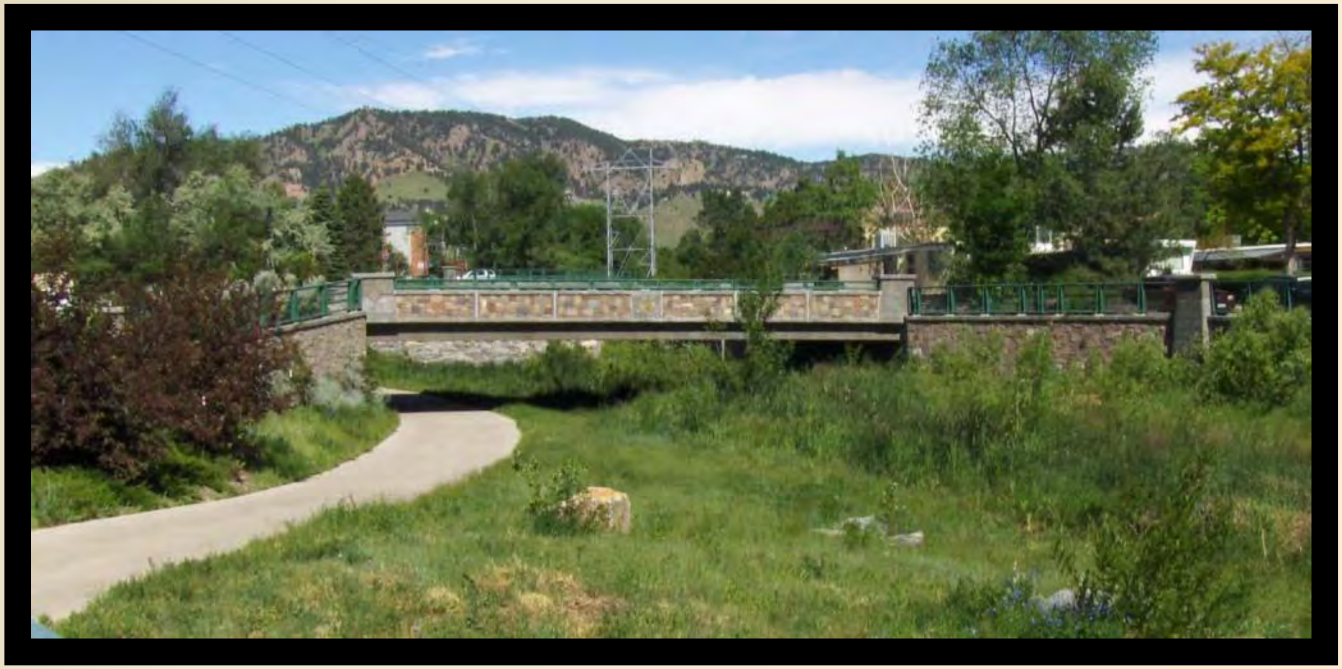
Below Grade Pedestrian Crossing



Trails follow Drainageways

Below Grade Pedestrian Crossing

- Drainageway crossings under roads provide opportunity to also bring trails below grade
  - Safer Pedestrian/Traffic Crossing
  - Continuous Movement along Trail
  - Multi-Use of Structure



Description of Maintenance Problem

- Since 2007 – 8 priority requests from local governments in Jefferson and Douglas Counties
- Water and Sediment Frequently Inundates Trails causing
  - Mud
  - Slimy Surface
  - Ice
  - Unsafe Conditions

Description of Maintenance Problem

- Why
  - Trail in low area, everything drains to it
  - High water table
  - Height Constraints of Road Profile

Description of Maintenance Problem

- Channel Condition

Tools to ~~Solve~~ Alleviate Problem

- Maintenance Preferences
  - Bridges
  - Single Cell Box Culverts

Tools to ~~Solve~~ Alleviate Problem

- Sediment Removal

Restore Conveyance

Keep water moving

Tools to ~~Solve~~ Alleviate Problem

- Re-establish Channel Alignment and Grades

Redirect Flow Away from Trail

Grade Downstream to keep water moving

Tools to ~~Solve~~ Alleviate Problem

- Stem Wall

Not recommended for new design

Create separation between channel and trail

Need to provide drainage

Tools to ~~Solve~~ Alleviate Problem

- Trench Drain

Collect nuisance water

Needs an outfall

Tools to ~~Solve~~ Alleviate Problem

- Trench Drain

Tools to ~~Solve~~ Alleviate Problem

- Drain Valve

Tools to ~~Solve~~ Alleviate Problem

- Drain Pan

Cross slope into pan

Pan longitudinal Slope to drain

Keeps nuisance water off trail

Need to provide outfall

Tools to ~~Solve~~ Alleviate Problem

- Combine Tools for Results

404 Permitting

- **Unregulated Activity – Upland to Upland Removal**

Equipment is out of the ordinary high water mark

Scooping out and placing in an upland area/haul off

No filling or moving soil around

404 Permitting

- **Regulated Activity – Everything Else…**
- Nationwide Permit No. 3 – Maintenance
  - No. 3 A - Repair of an Existing Structure
    - Needs NO Notification (unless disturbing wetland)
  - No. 3 B - Sediment Removal
    - Needs Notification, allows riprap placement 200 ft either direction
- Nationwide Permit No. 18 – Minor Discharges/Excavation
    - Discharge Less than 25 cy below Ordinary High Water Mark (OHWM)
    - Needs Notification if discharge exceeds 10 cy OHWM or in wetlands

Best Management Practices (BMPs)

- Review as-built drawings if available
- Understand design elevation in relation to existing conditions
- Isolate work area from active flows
- Install temporary BMPs as needed
  - Vehicle tracking pad
  - Silt fence
  - Isolation barriers, i.e. plastic lined jersey barriers
  - etc.
- Inspect and maintain all temporary BMPs during construction

Requirements for Retrofitting Existing Crossings

- Activity may require permitting under the 404
- Always notify the Corps of Engineers of your plan
- Identify and comply with local government requirements
- Create a traffic plan specifically identifying pedestrian detour routes
- Close the trail if you have any doubts about public safety
- Choose your contractor carefully for this type of project

Winter Work

Sediment Removal

Temporary Separation Barrier

Walk behind skid steer

Sediment Removed

Stem Wall

Good Time To Inspect

Concrete and Boulders

Boulders

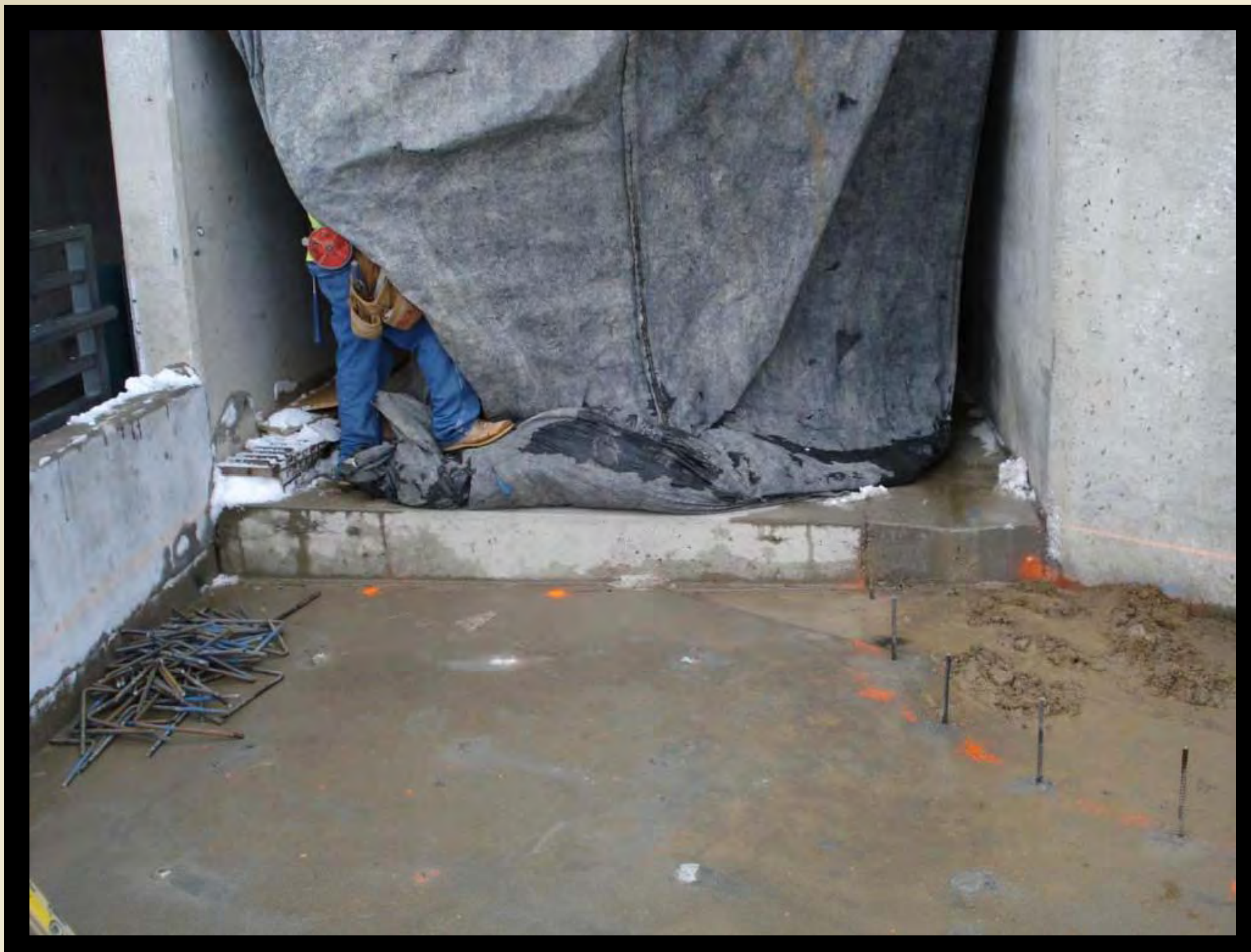
Alignment of Stem Wall

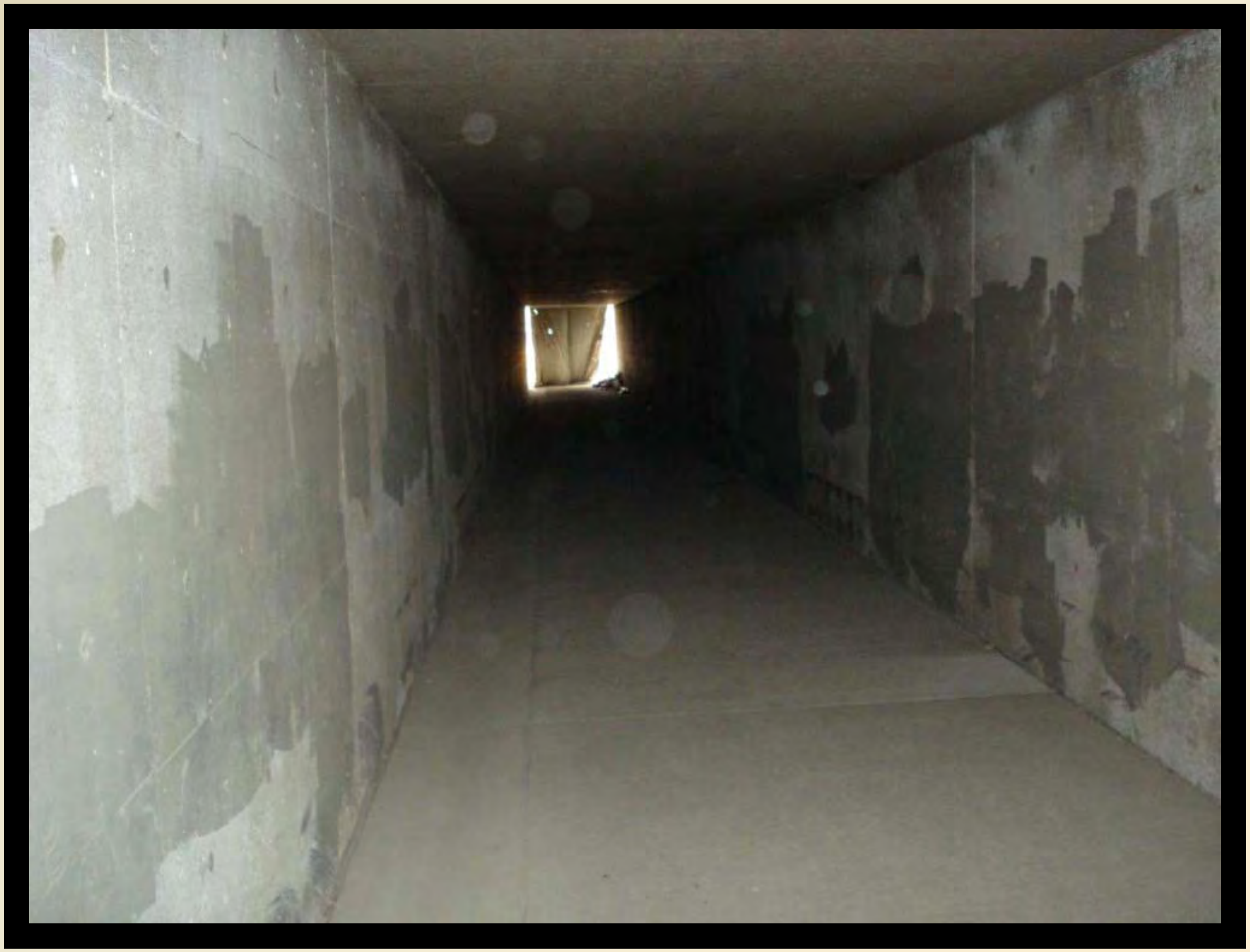
Establish Channel Alignment and Grade

Inlet/Trench Drain

Winter Work

Drain Pans





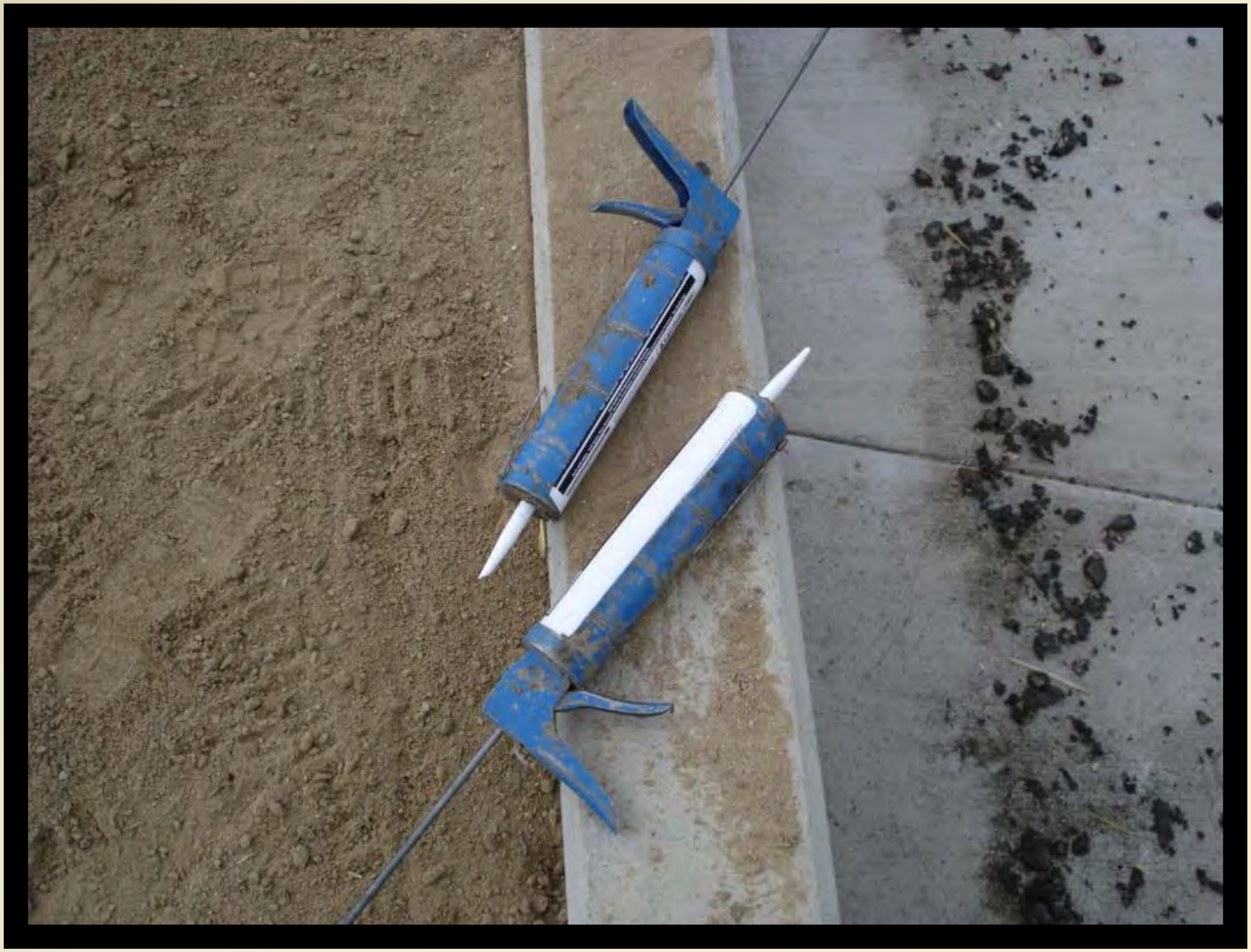

WBH-16

Drain Valve


Tideflex

Deflection Plate

Sealing the Joint



Questions ?

Design, Construction*

(or How To Design with Maintenance in Mind)

Michael Sarmento, Senior Construction Manager
Barbara Chongtoua, Senior Project Engineer

***Maintenance**

1. **Introductions**
    a. DCM = Design, Construction, and Maintenance Program
2. **Maintenance**
    a. **The Ailments**
        i. Is maintenance “Routine”?
        ii. Maintaining maintenance
        iii. The Numbers
3. **Construction**
    a. **The Symptoms**
        i. Revegetation
        ii. Utilities
        iii. Dewatering and SWMP
        iv. Permits
        v. Contract Documents
        vi. Communication
4. **Design**
    a. **The Remedy**
        i. Maintenance Plan

What is the DCM Program?

- DCM program responsible for all Capital, Restoration, and Maintenance projects within District boundary.

- Teams consist of a Project Engineer, Construction Manager, and Intern. Teams assigned to specific counties and all municipalities within those counties. Program guided by a Manager & Assistant Manager.

- DCM uses consulting engineering firms to design the majority of drainage improvements. All construction and maintenance projects performed by private contractors.

- For smaller projects DCM contracts annually with two on-call engineering firms and several construction/ maintenance companies. DCM provides accelerated service to the local government and community.

"What is Maintenance and Why Do We Do It?"

District contracts with maintenance contractors to perform annual maintenance. Contractors uniquely qualified to work in drainageways.

Most visible program within UDFCD. Operates within residential greenbelts, parks, and open space.

Maintenance Program contracts for debris removals and mowing, revegetation, weed control, and other misc. work items.

Service provided to the local government and community which provides a system of regularly maintained drainageways and other flood control facilities.

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

“What is Maintenance and Why Do We Do It?”

Multi-jurisdictional boundaries

“Institutional Knowledge” of most drainageways due to design and construction

Provide rapid response to as-needed maintenance requests.

Inspectors and Contractors serves as the “eyes and ears” for the local government and community.

“What is Maintenance and Why Do We Do It?”

Restoration projects may consist of sediment removals, tree thinning, bank and channel stabilization, and other structural work.

DCM has annual contracts with approximately ten private contractors to provide construction, revegetation, and utility locating services.

DCM contractors are pre-qualified to conduct drainageway maintenance and repairs. This provides rapid, and cost-efficient response to ordinary and emergency situations.

Vegetation Maintenance

Native vegetation requires less maintenance (and less resources such as water, fertilizer, etc.) = sustainability!

Tree thinning maintains hydraulic efficiency and promotes better maintenance

General Maintenance

Tree removal prevents blockages and damage to structures

Tree trimming around base to 4-5 feet above grade.

Fence Repair for Public Safety
(but how do we get down to the channel?)

Our Latest "on-call" Project

"The Ailments"

Is Maintenance Ever Routine ??

The Contractor's "Wish-List"

#1. Access, access, and more access.
#2 Water Control or "How much water comes Thru Here?"
3 "We Can Talk Volumes About Debris"

The "Numbers" or "What does Maintenance cost?"

DO we design for maintenance??

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

CONSTRUCTION or "The Symptoms"

Drainageway construction ***IS*** different (and often difficult)

What is a good project? Depends on who you ask!

Good Construction Leads to Better Maintenance!

Design Modification
Or
"We'll Fix That When We Get To Construction"

CONSTRUCTION or "The Symptoms"

II. Utilities :
"It's ***NOT*** Where They Said It Would Be"

I. Reveg:

"Can't See The Forest for the Trees and the Grass Just Won't Grow"

III. Permits:

"How Do I Bid This Thing?
or
"I Have to Do ***WHAT***?"

IV. Contract Documents: "Where Does It Say ***THAT***??"

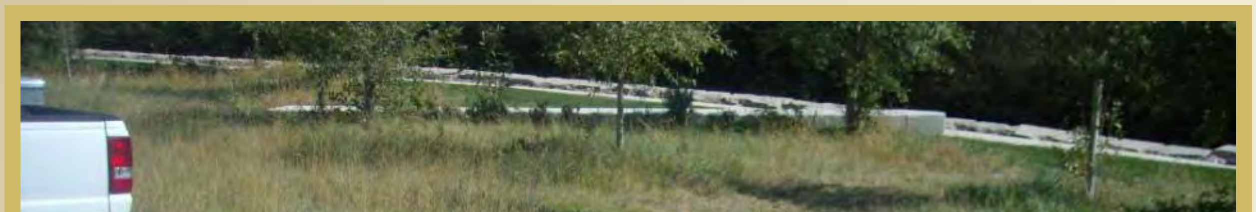
V. Communication: "Nuff Said"

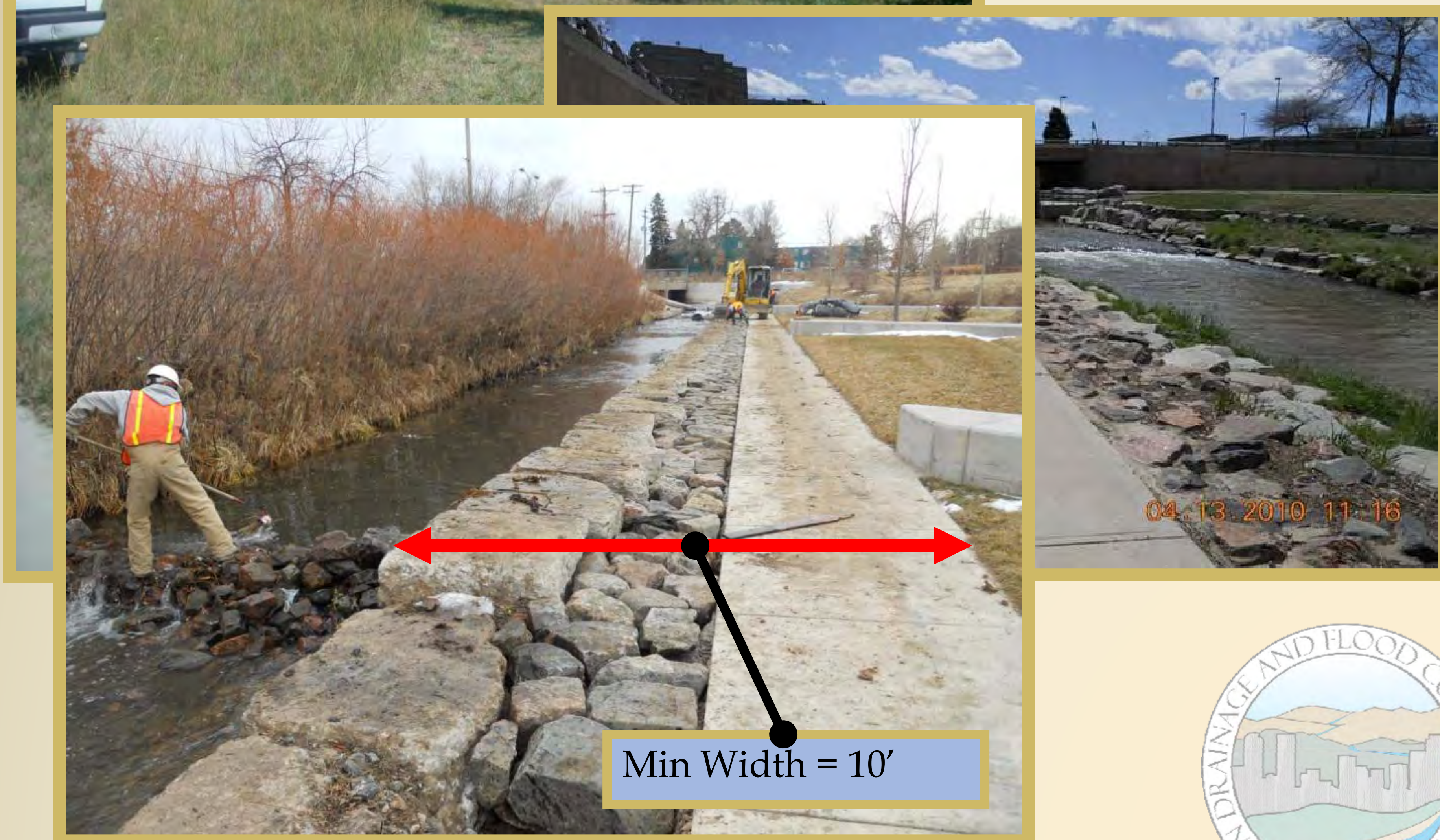
Design, Construction*

Is the *Access* accessible?

*Maintenance

Appropriate *Access*
Appropriate ?





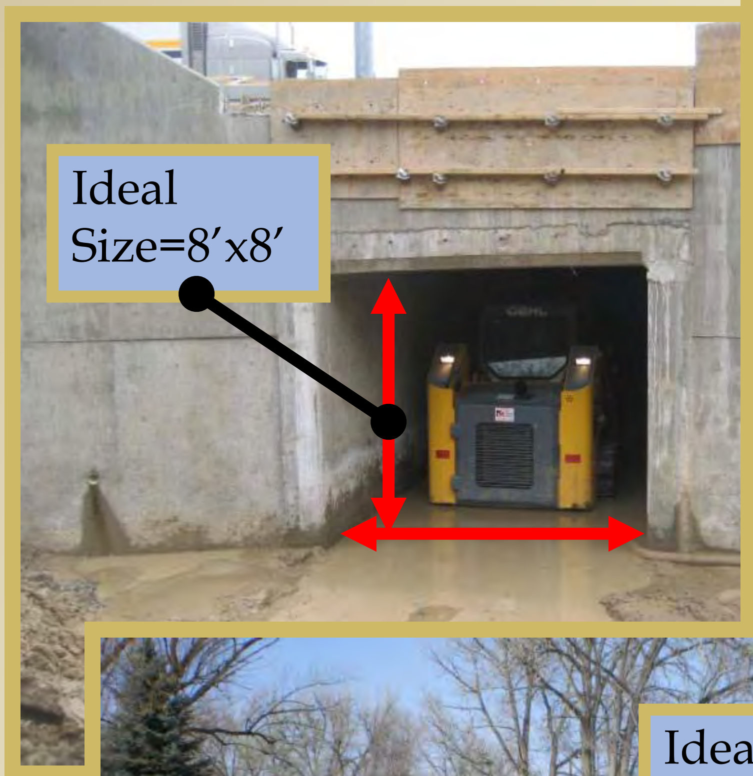


Vegetation Management Manageable?

We can talk volumes about Debris?

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

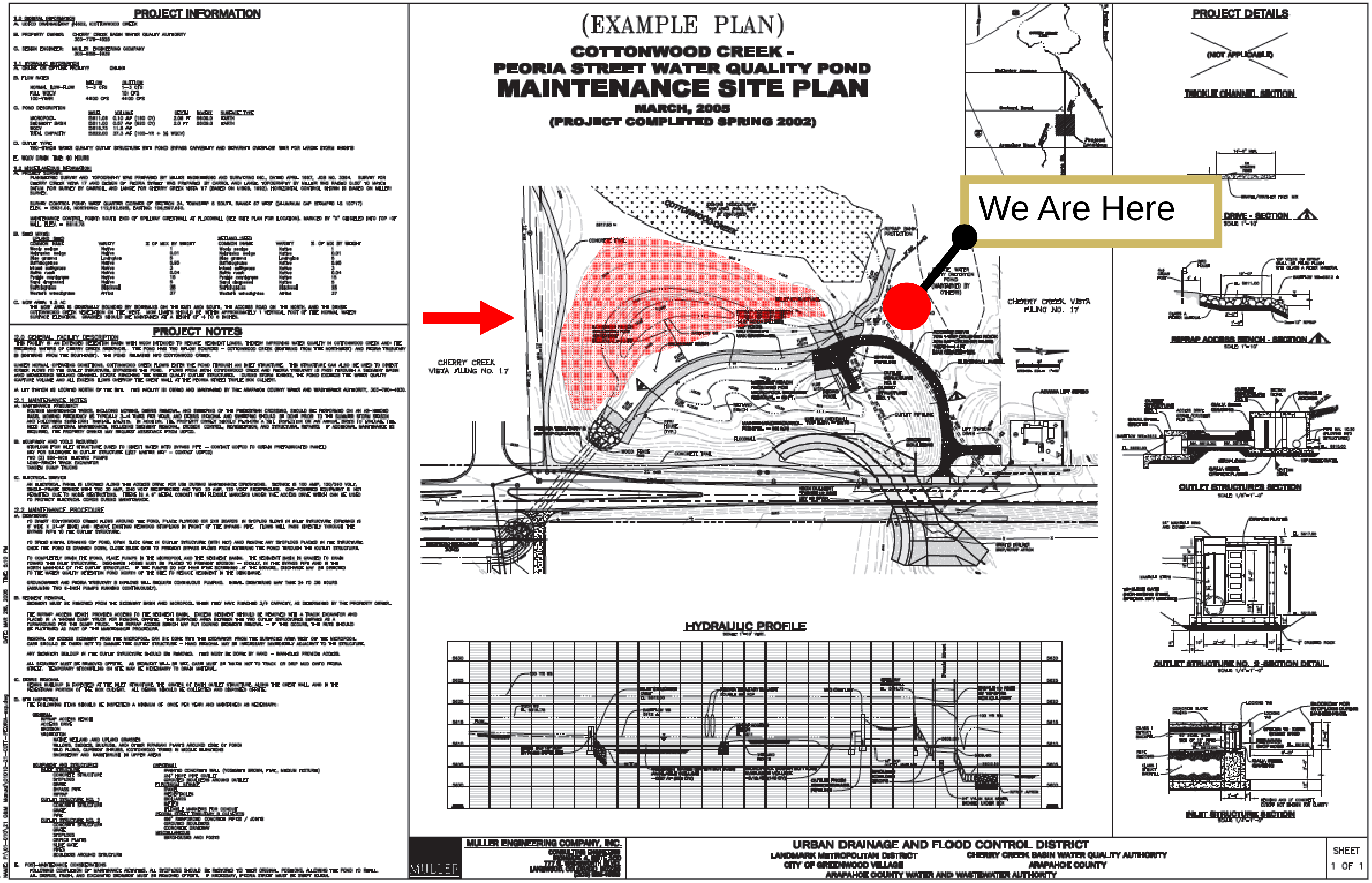
We can talk volumes about Debris?



Managing Sediment

Managing Sediment

Maintenance Site Plan

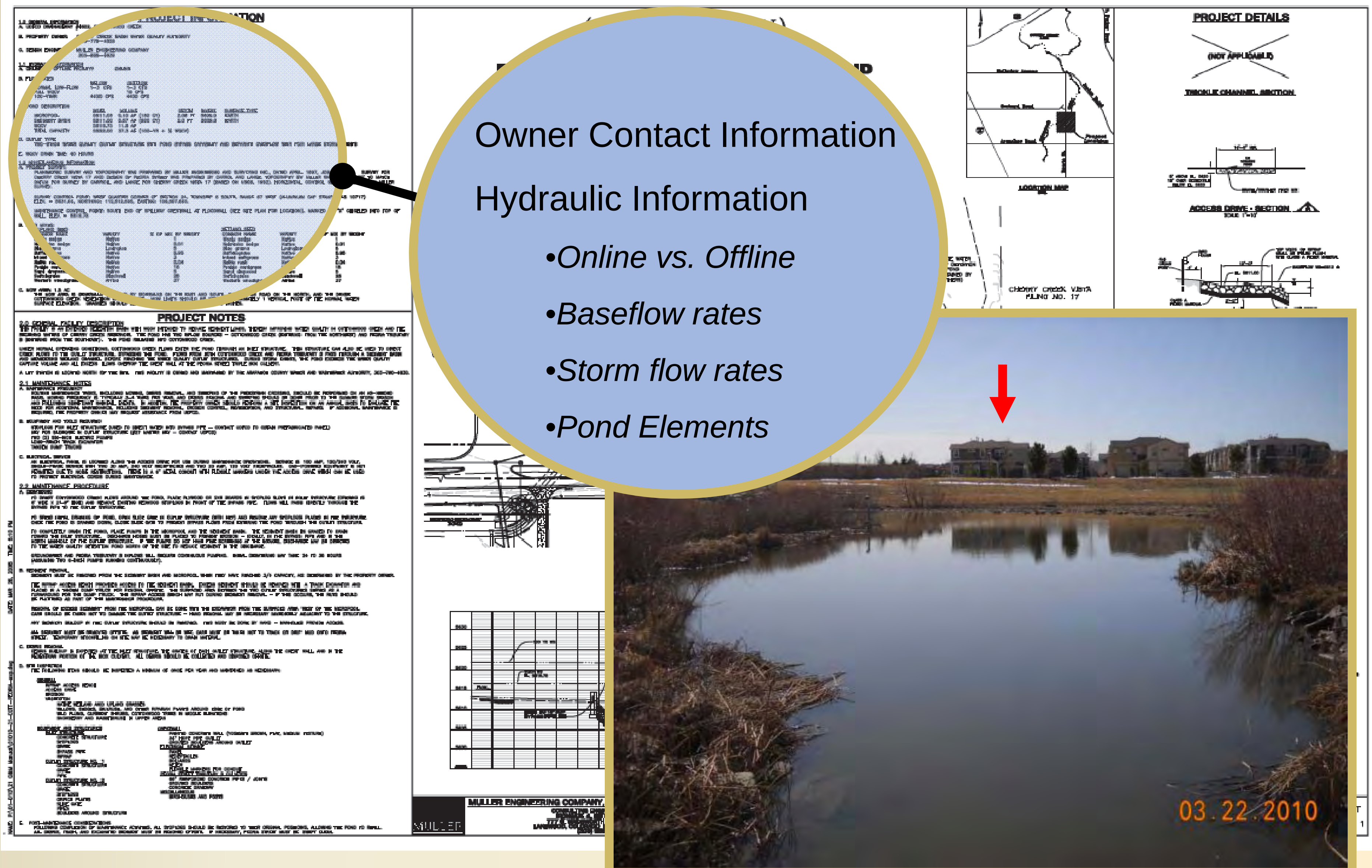


Maintenance Site Plan

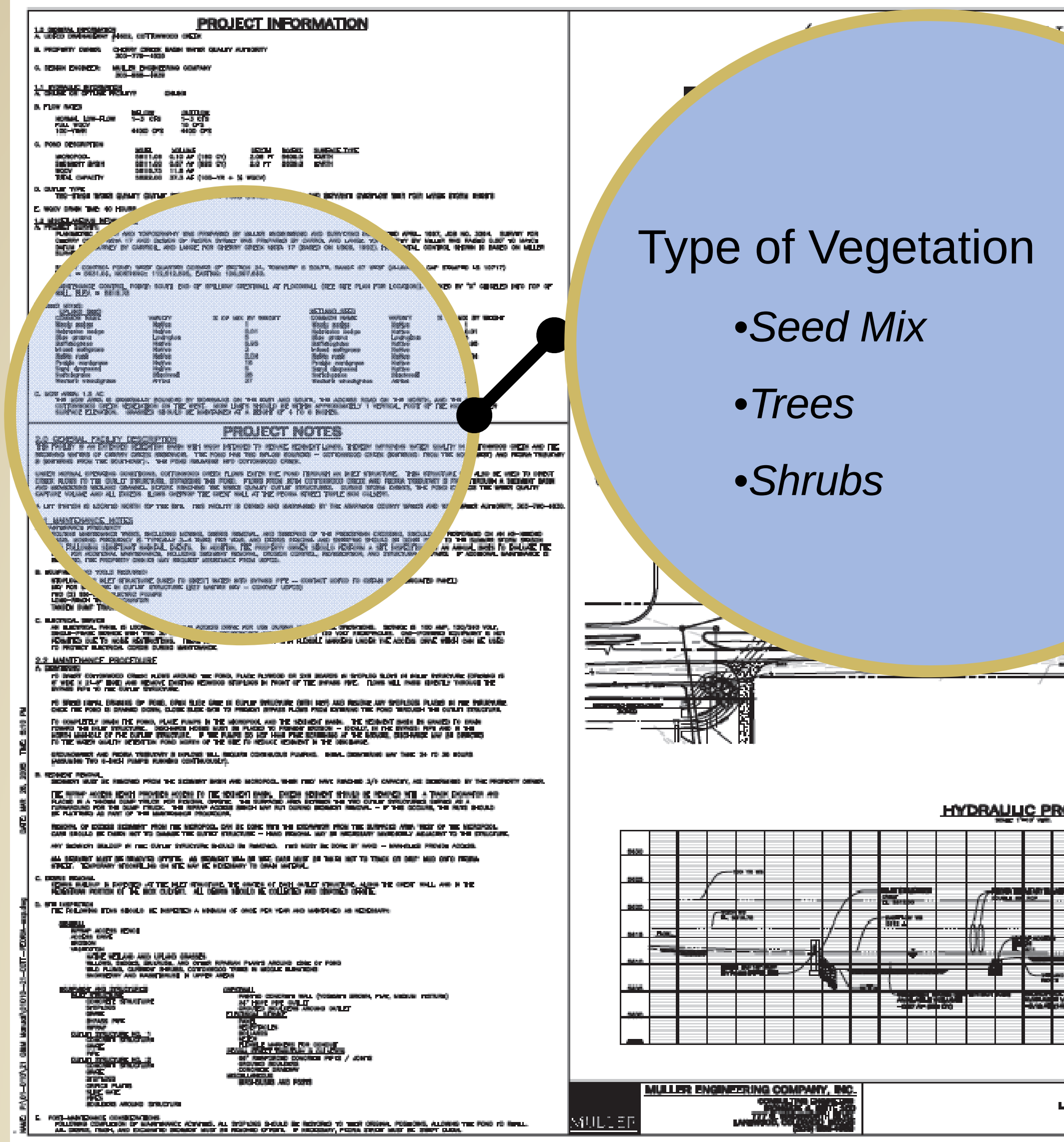
Owner Contact Information

Hydraulic Information

- *Online vs. Offline*
- *Baseflow rates*
- *Storm flow rates*
- *Pond Elements*



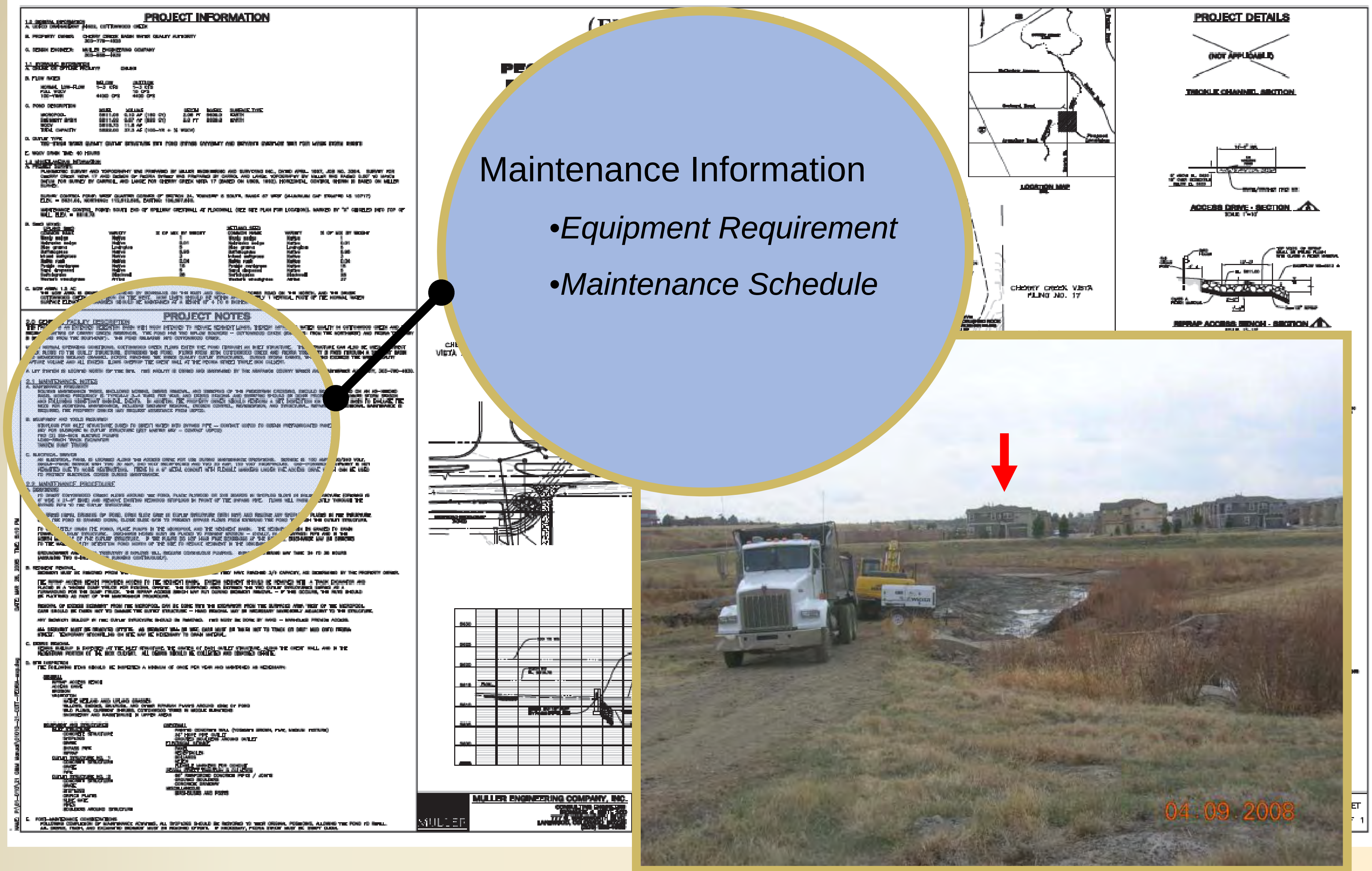
Maintenance Site Plan



Type of Vegetation

- *Seed Mix*
- *Trees*
- *Shrubs*

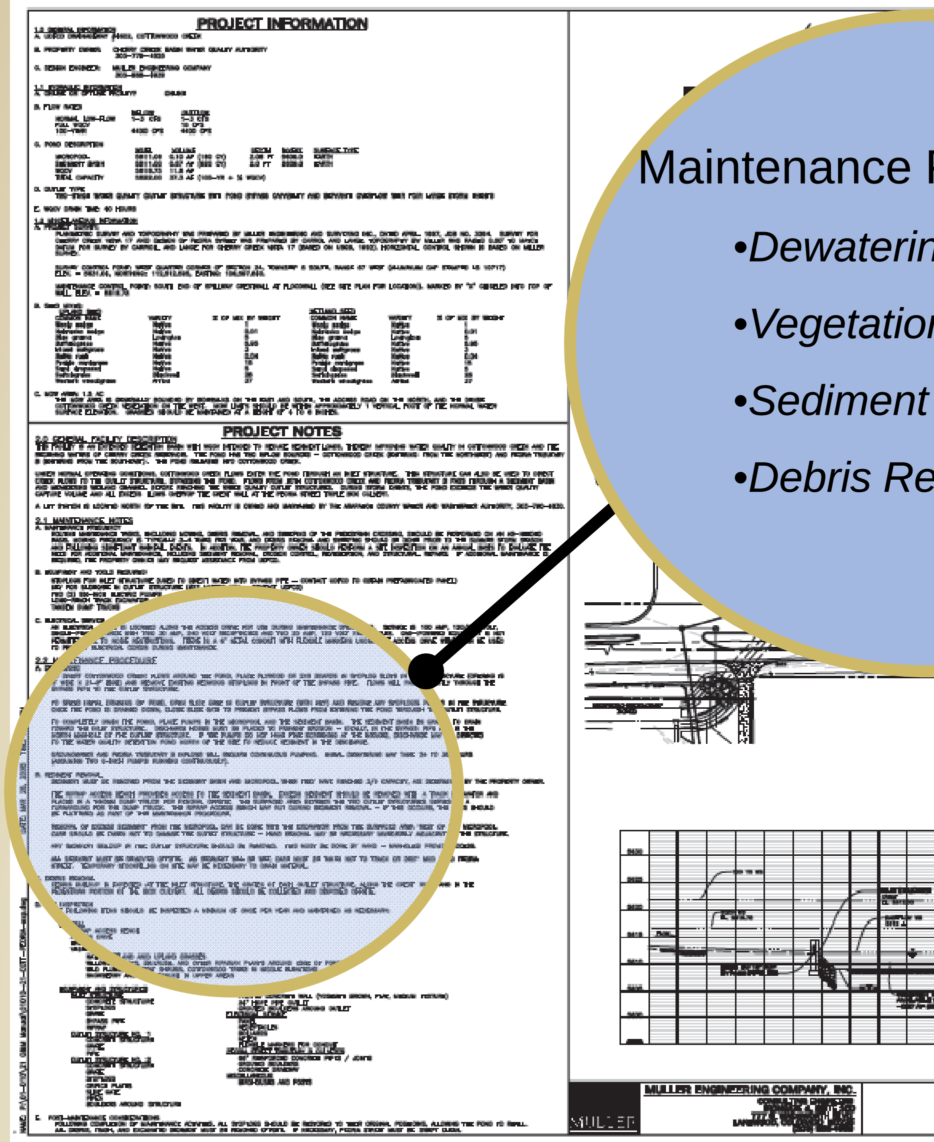
Maintenance Site Plan



Maintenance Information

- *Equipment Requirement*
- *Maintenance Schedule*

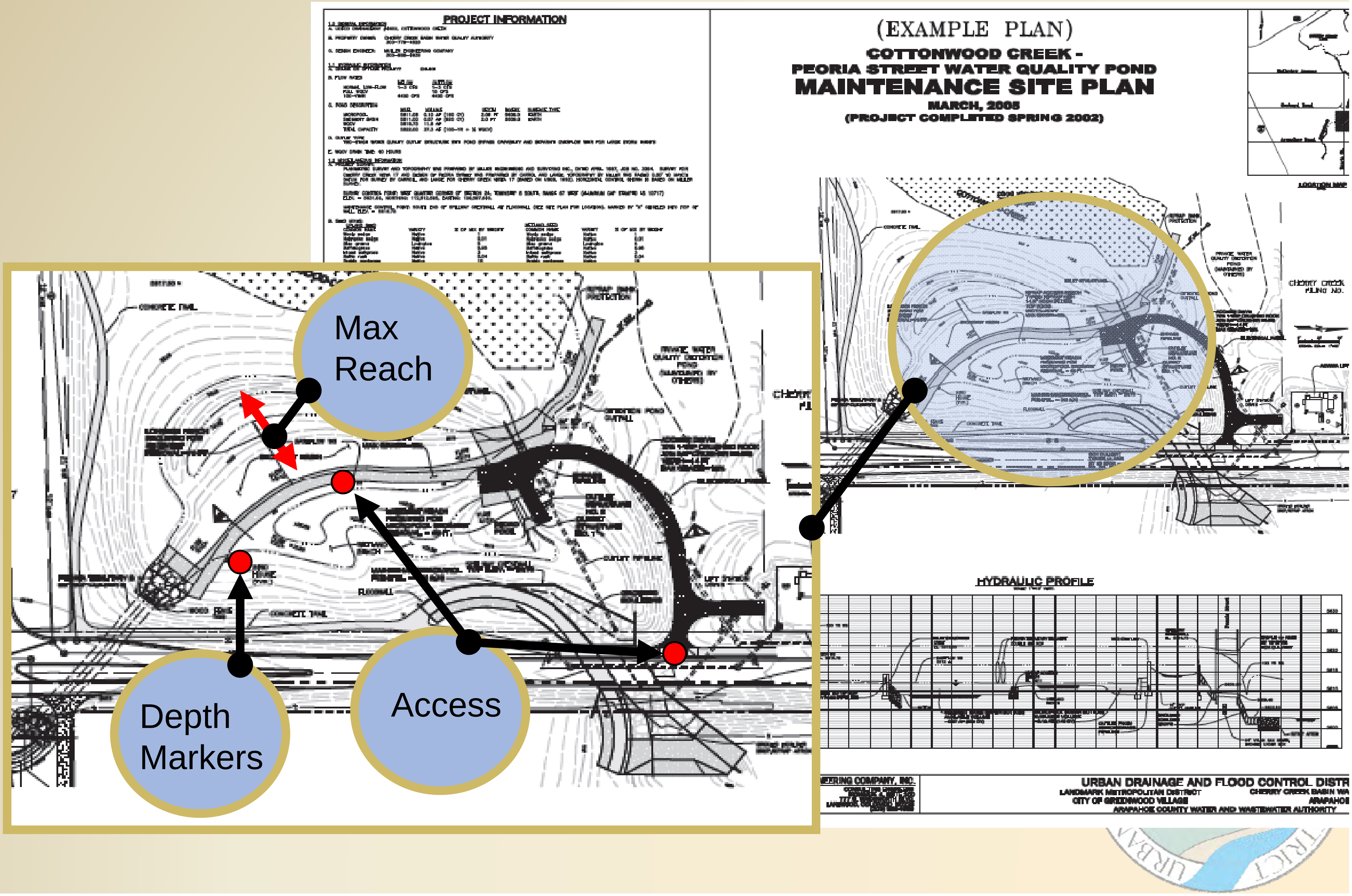
Maintenance Site Plan



Maintenance Procedure

- *Dewatering*
- *Vegetation Management*
- *Sediment Removal*
- *Debris Removal*

Maintenance Site Plan



“Q” AND “A”

We Take Drainageway Maintenance A Few Steps Further!

EFFECTIVENESS OF REGIONAL DETENTION ON FLOOD CONTROL AND WATER QUALITY

Shea Thomas, UDFCD

Derek Rapp, Wright Water Engineers

Melanie Chenard, Muller Engineering Company

Flood Control

Big Dry Creek Major Drainageway Plan

<u>Project Sponsors</u>

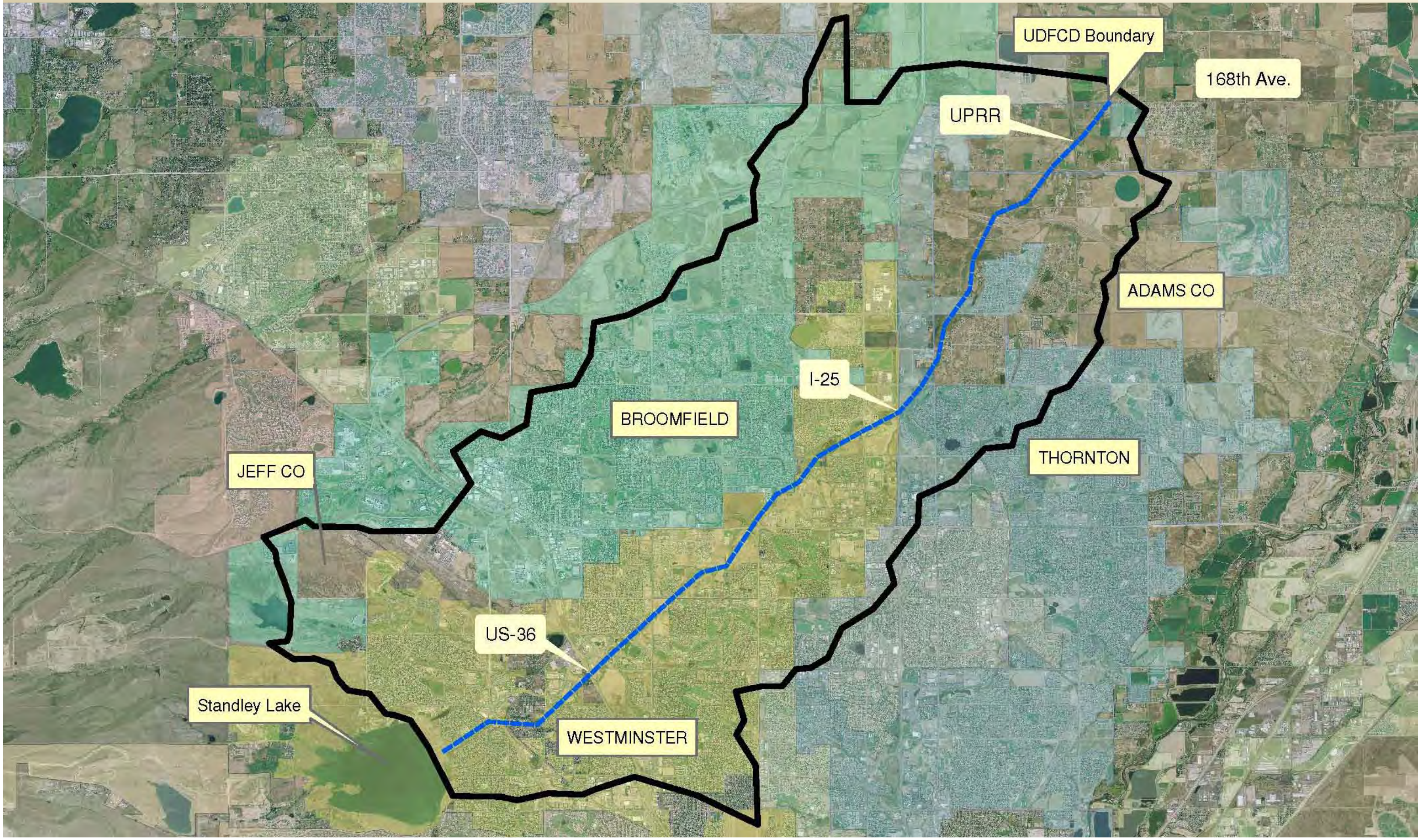
UDFCD

City of Westminster

City of Thornton

Adams County

Study Area

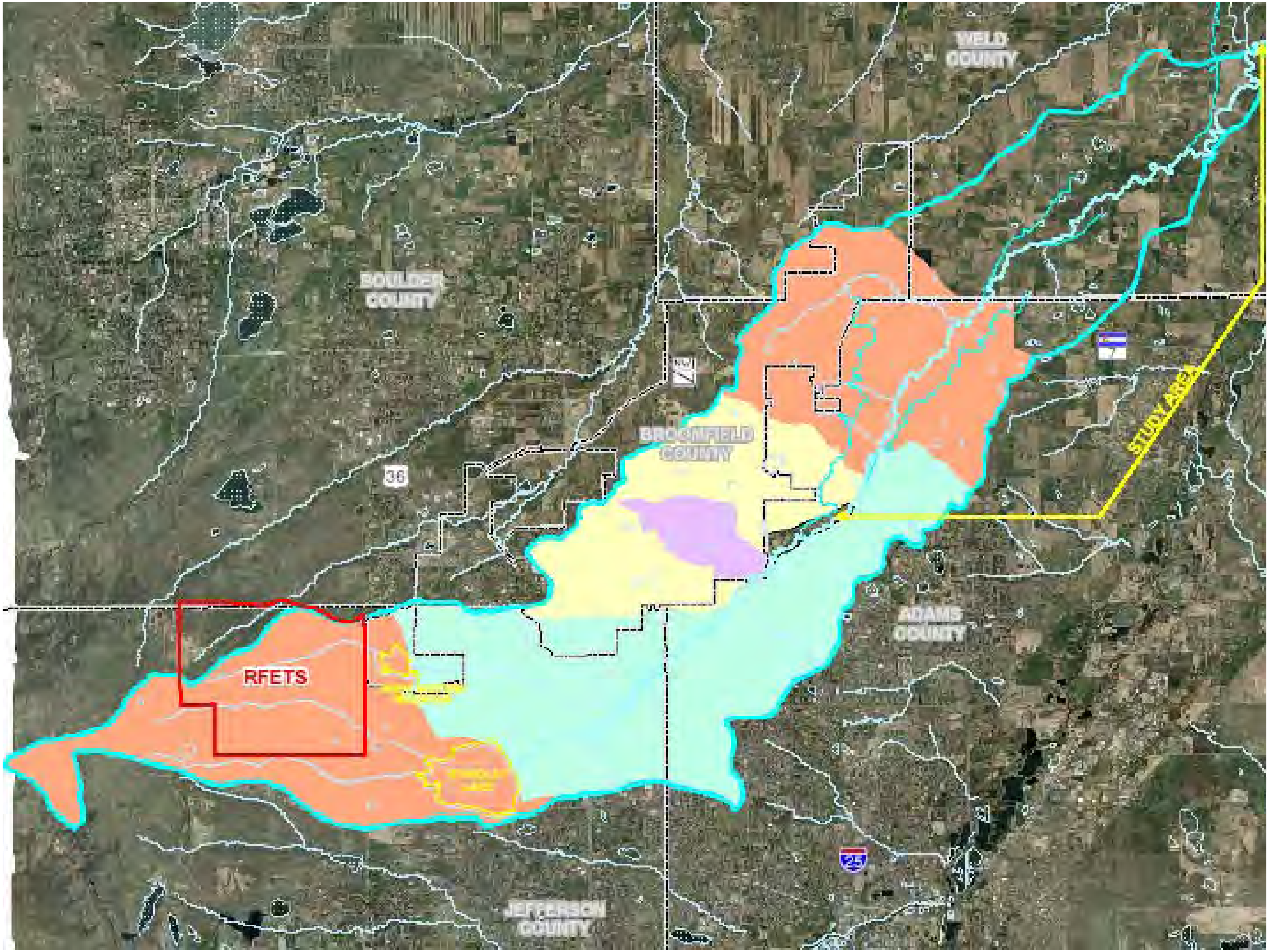

UDFCD Boundary
168th Ave.
UPRR
ADAMS CO
I-25
BROOMFIELD
THORNTON
JEFF CO
US-36
Standley Lake
WESTMINSTER

Statistics

- Watershed Area – 67 square miles
- Main Stem Length - 23 miles
- Major Drainageway Tributaries - 22
- Outfalls to BDC - 69
- Structure Crossings of Main Stem - 56

Previous Studies

- Big Dry Creek Main Stem
  - 1973 Big Dry Creek Master Plan
  - 1986 Big Dry Creek FHAD (I-25 to 168th Avenue)
  - 1986/1988 Big Dry Creek FHAD (Standley Lake to I-25)
- Tributaries to Big Dry Creek
  - 1979 FHAD/1985 OSP for Gay Res., Westlake, Windmill
  - 1989 OSP for Southern Tributaries
  - 2001 OSP for Quail Creek and McKay Lake Basins
  - 2006 OSP for City Park Basin & Drainageway 3207
  - 2007 OSP for Northern Tributaries


WELD COUNTY
BOULDER COUNTY
BROOMFIELD COUNTY
36
STUDY AREA
7
RFETS
ADAMS COUNTY
25
JEFFERSON COUNTY

Complications

- Previous studies
- Rainfall adjustment

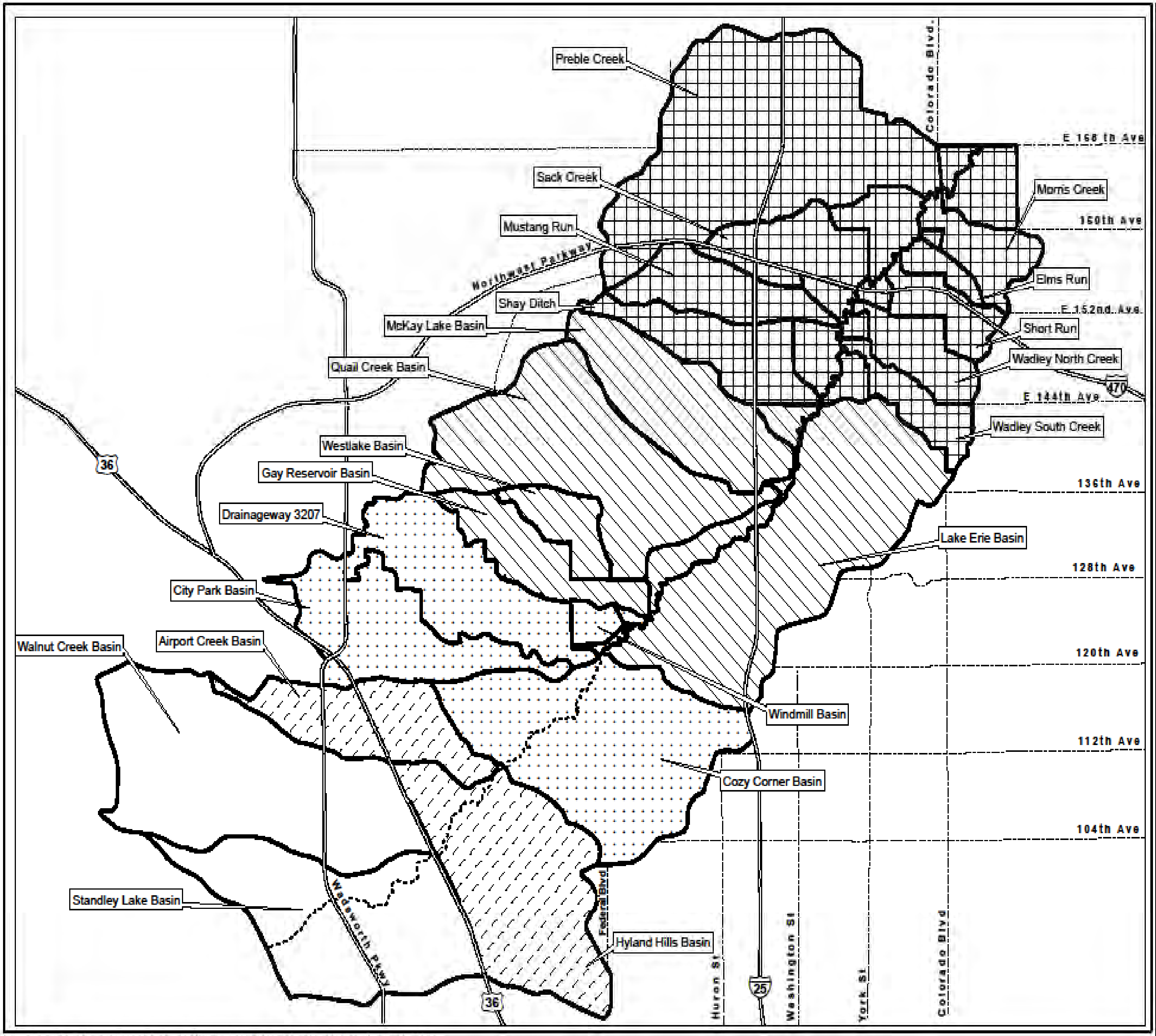


Figure 5

RAINFALL DISTRIBUTION AREA ADJUSTMENT ZONES

Legend

Tributary Watersheds
Big Dry Creek
Roads
Highways

Area Adjustments for Rainfall Distributions

0-10 sq. mi.
10-20 sq. mi.
20-30 sq. mi.
30-50 sq. mi.
50-75 sq. mi.

N W E S

1 inch = 6,000 feet

0 3,000 6,000 12,000 Feet

BIG DRY CREEK

MAJOR DRAINAGEWAY PLAN

WWE

WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

Complications

- Previous studies
- Rainfall adjustment
- Calibration of tributaries
- Detention

Detention Considered

- Exists at time of study
- Adequate assurance it will exist and be maintained in perpetuity
  - Owned by or dedicated to local government
  - Maintained by local government or has a legally enforceable mechanism
- Other study-specific rules of thumb
  - Tributary drainage area > 100 acres
  - Reliable stage-area-volume-discharge information
  - Volume and release rate sufficient to impact peak flows on BDC main stem

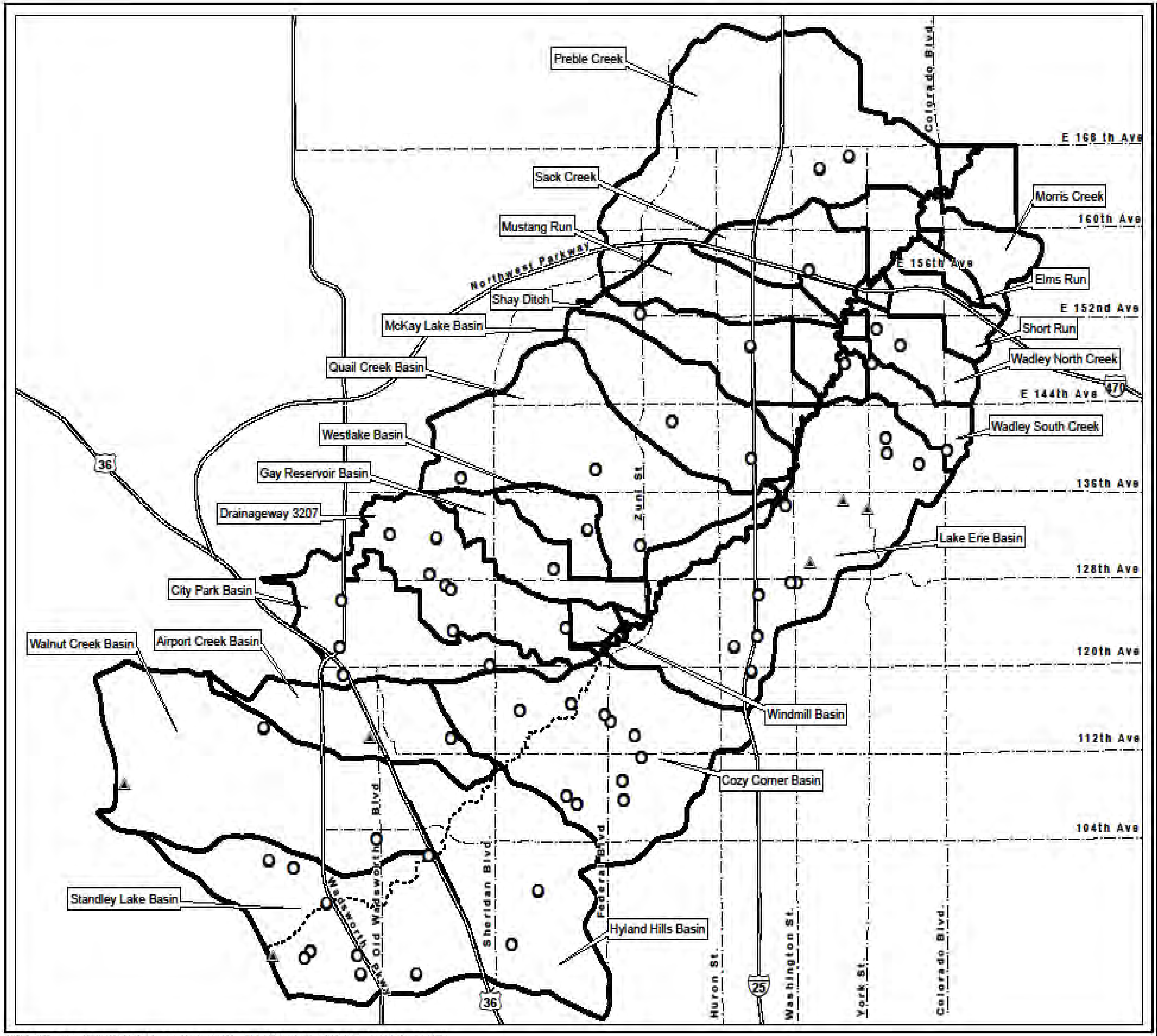


Figure 1.3

OVERVIEW OF PROJECT AREA WITH DETENTION PONDS & INFLOW HYDROGRAPHS

Legend

- Tributary Watersheds
- Big Dry Creek
- Roads
- Highways
- Detention Locations
- Inflow Hydrograph Locations

1 inch = 6,000 feet

0 3,000 6,000 12,000 Feet

BIG DRY CREEK

MAJOR DRAINAGEWAY PLAN

WWE

WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

Complications

- Previous studies
- Rainfall adjustment
- Calibration of tributaries
- Detention
- Reservoir release
- Mainstem calibration

Results

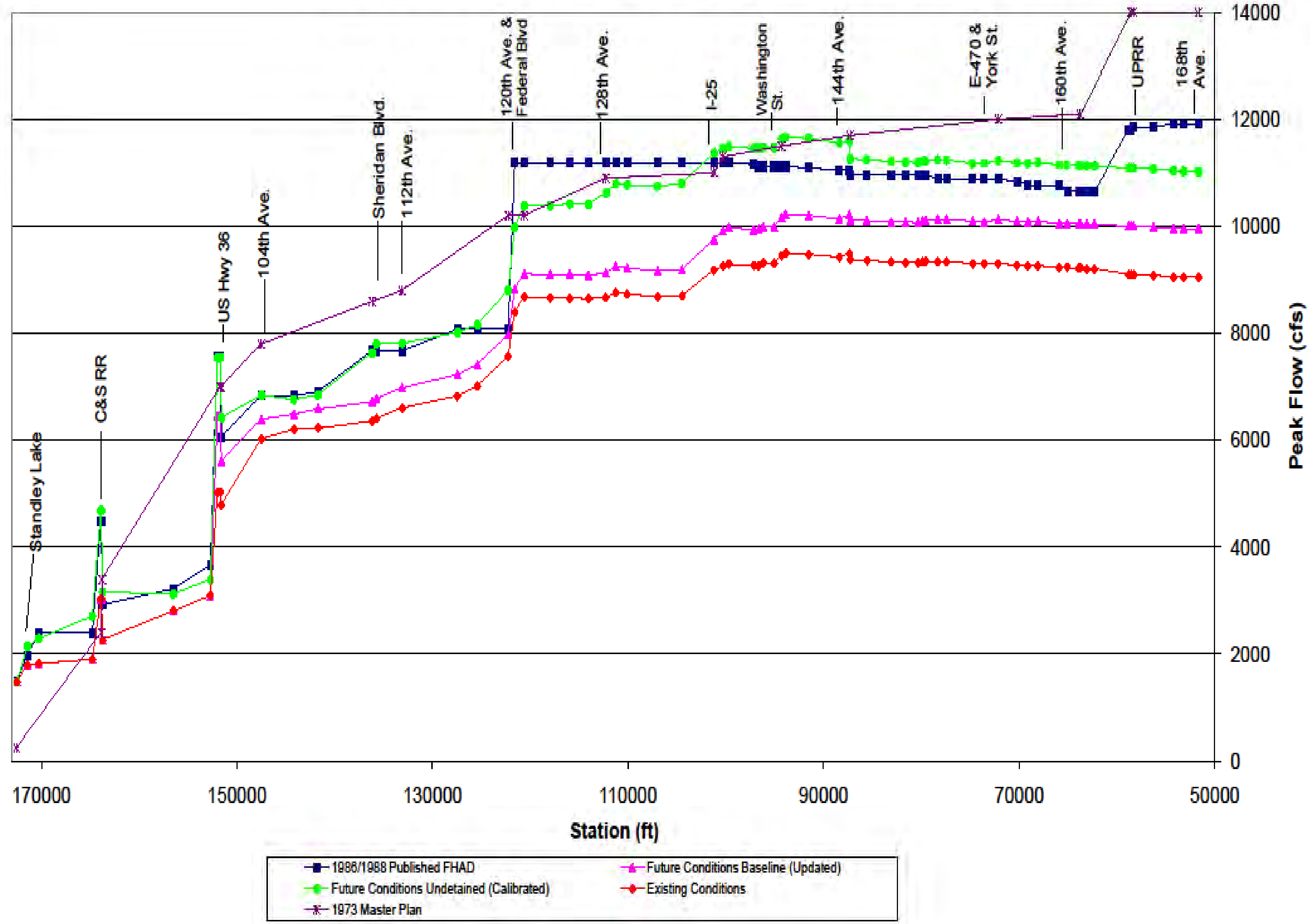
- Average reduction on tributary outfalls: 40%

Tributary Watershed	Undetained (cfs)	Detained (cfs)	Reduction (%)
Ketner Tributary	1698	585	66%
Airport Creek	3332	1550	52%
Cozy Corner Tributary 3	1857	279	85%
Drainageway 3207	3002	1620	44%
Gay Reservoir & Westlake	2101	694	67%
Quail Creek	4215	1343	68%
Lake Erie Tributary 4	1342	554	58%
McKay Lake Basin	2348	901	60%
Lake Erie Tributary 1	2361	1108	53%
Sack Creek	2670	1409	47%

Results

- Average reduction on tributary outfalls: 40%
- Average reduction on main stem: 12%

Figure 7.
100-year Peak Flow Profile Comparison with Previous Studies



Results

- Average reduction on tributary outfalls: 40%
- Average reduction on main stem: 12%
- Reduction at UPRR: 30%

Water Quality

Cottonwood Creek Outfall Systems Plan

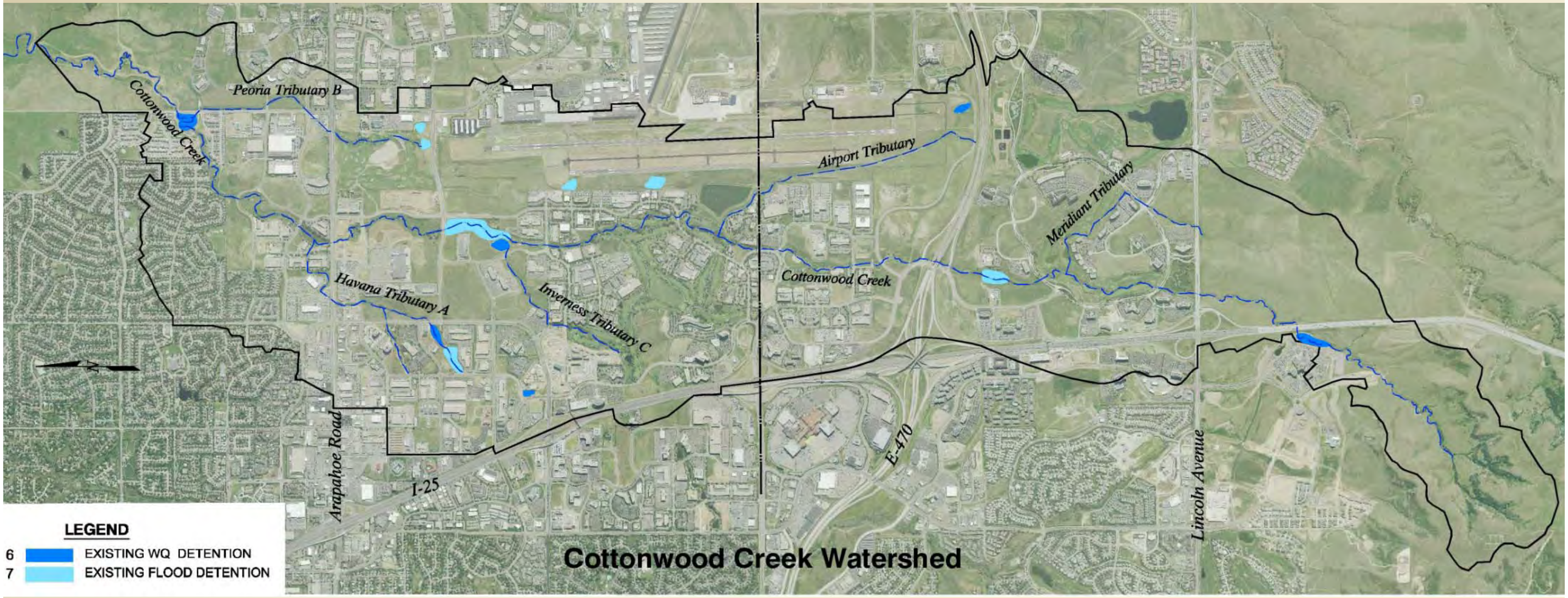
<u>Project Sponsors</u>

UDFCD

Southeast Metro Stormwater Authority

Douglas County

Study Area



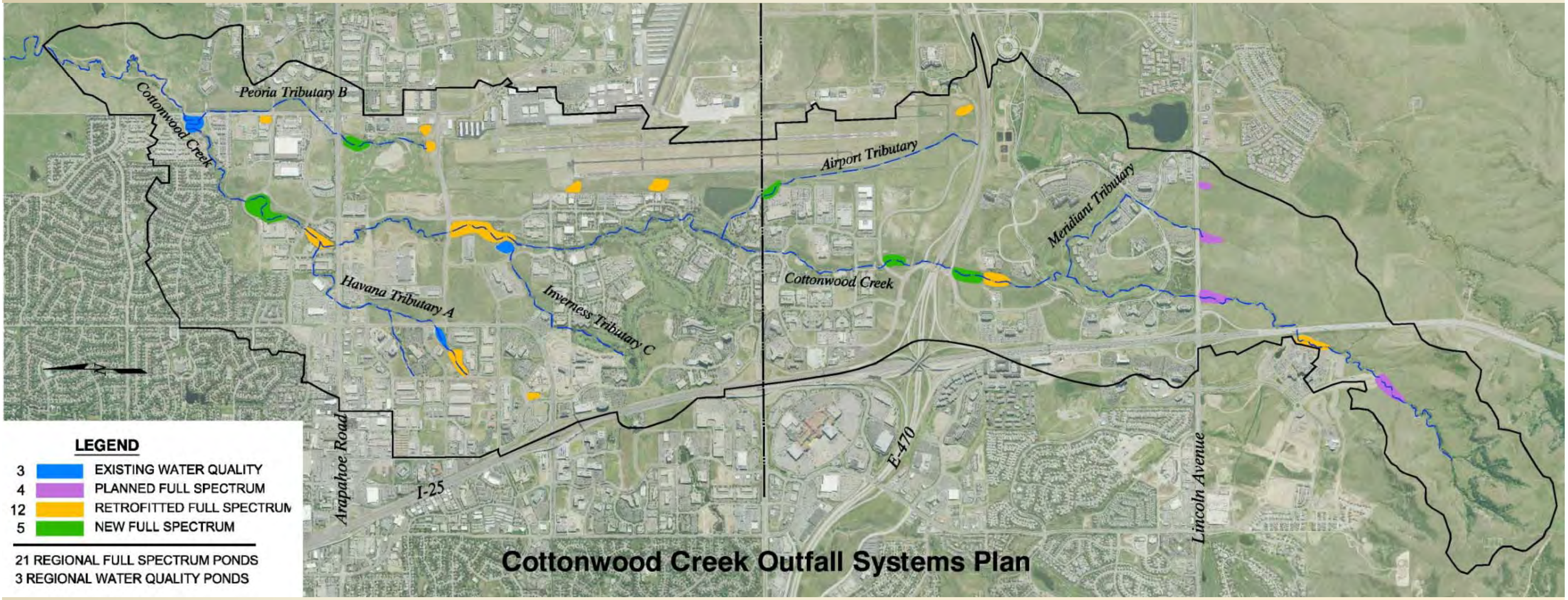
Peoria Tributary B
Cottonwood Creek
Airport Tributary
Meridiant Tributary
Cottonwood Creek
Havana Tributary A
Inverness Tributary C
Arapahoe Road
I-25
E-470
Lincoln Avenue
LEGEND
6 EXISTING WQ DETENTION
7 EXISTING FLOOD DETENTION
Cottonwood Creek Watershed

Full Spectrum Detention

Excess Urban Runoff Volume (EURV) – *difference between urban and pre-development runoff volume*

- SEMSWA and Douglas County criteria
- Tributary to Cherry Creek Reservoir
- Easily retrofit existing ponds
- Implement for entire watershed

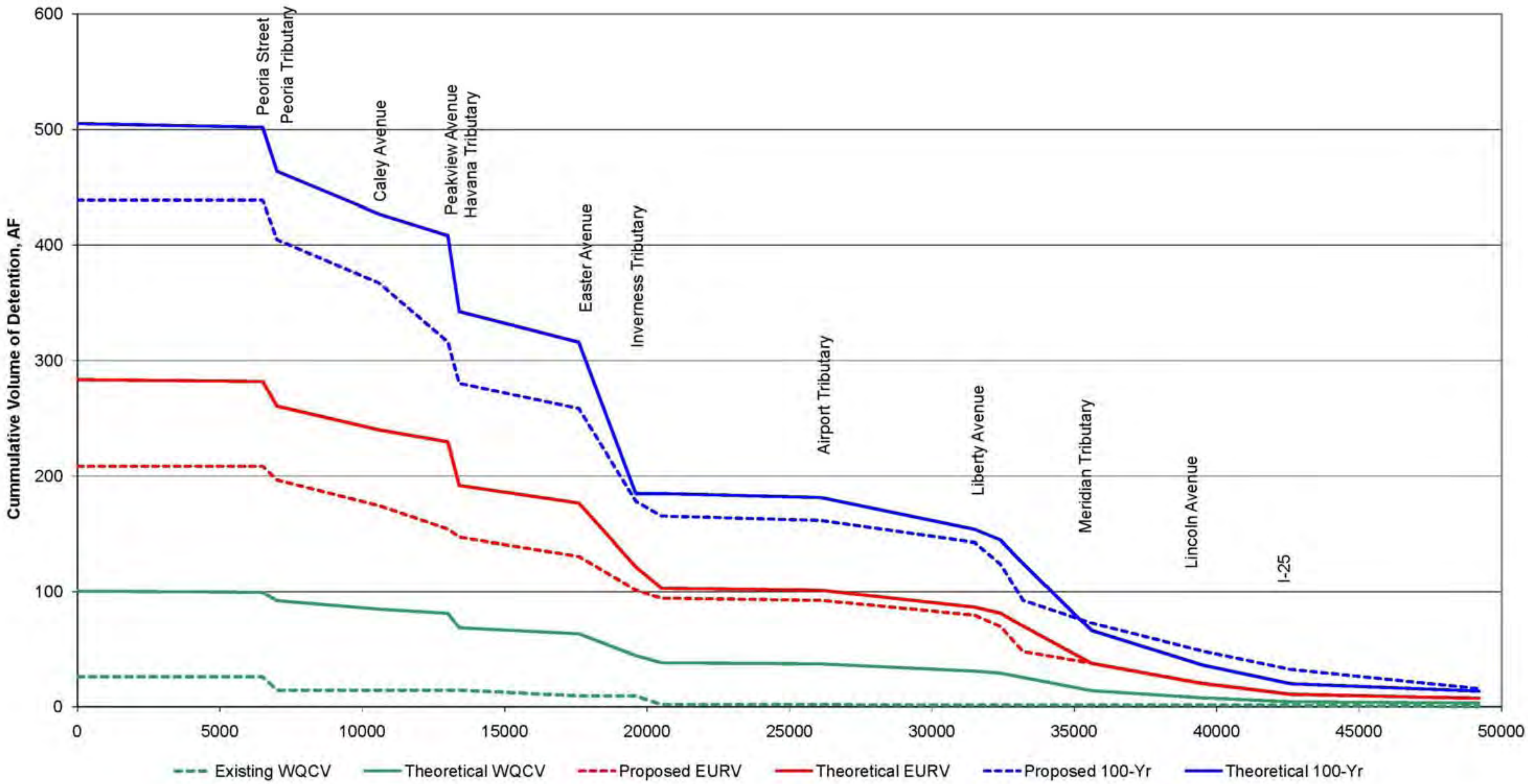
Master Plan


Peoria Tributary B
Cottonwood Creek
Airport Tributary
Meridiant Tributary
Cottonwood Creek
Havana Tributary A
Inverness Tributary C
Arapahoe Road
I-25
E-470
Lincoln Avenue
LEGEND
3 EXISTING WATER QUALITY
4 PLANNED FULL SPECTRUM
12 RETROFITTED FULL SPECTRUM
5 NEW FULL SPECTRUM
21 REGIONAL FULL SPECTRUM PONDS
3 REGIONAL WATER QUALITY PONDS
Cottonwood Creek Outfall Systems Plan

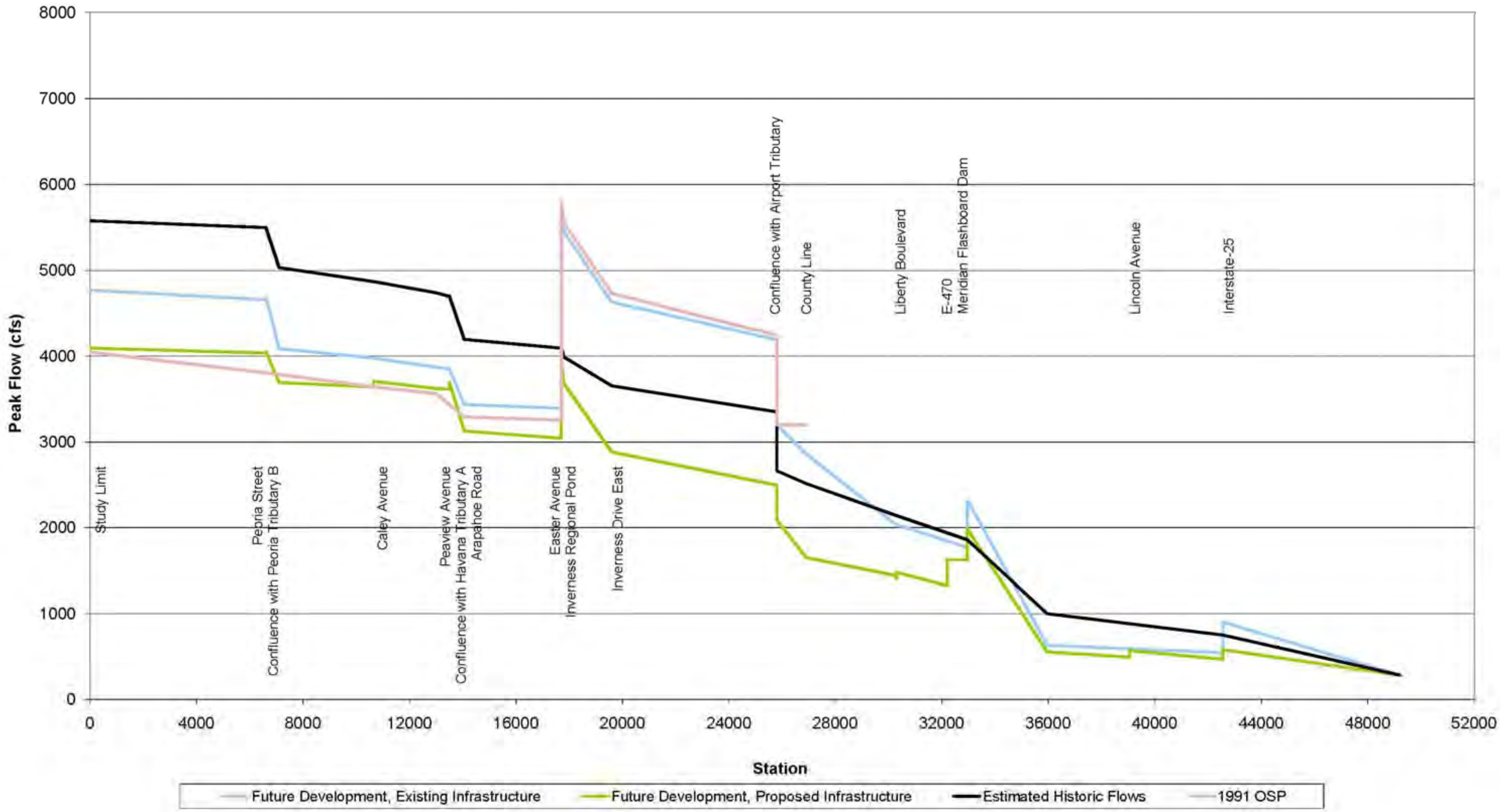
Master Plan Detention

- 3 existing WQ ponds to remain
- 12 existing ponds retrofit to FSD ponds
- 4 planned FSD ponds upstream of study limits
- 5 new FSD ponds

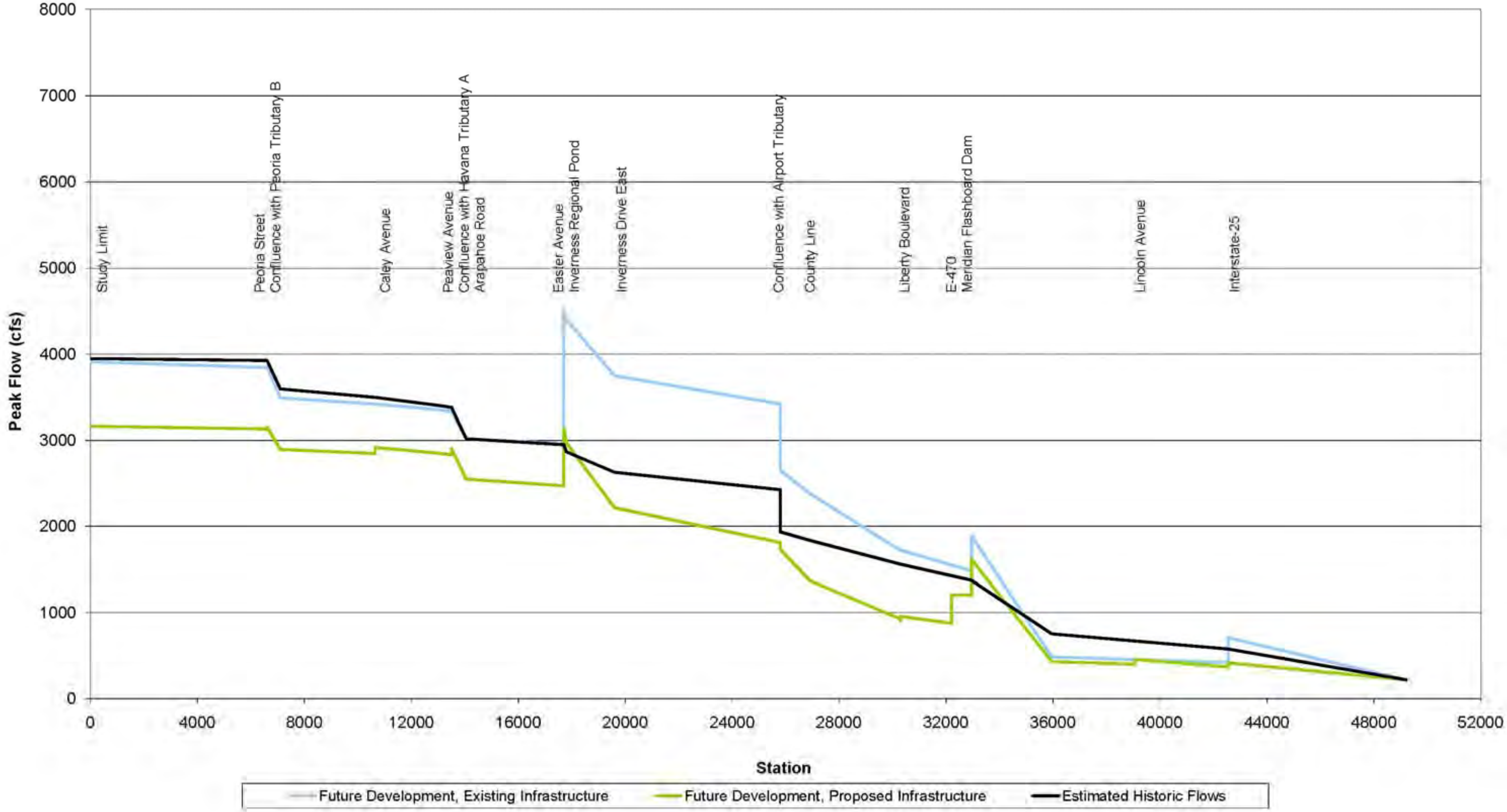
Detention Provided



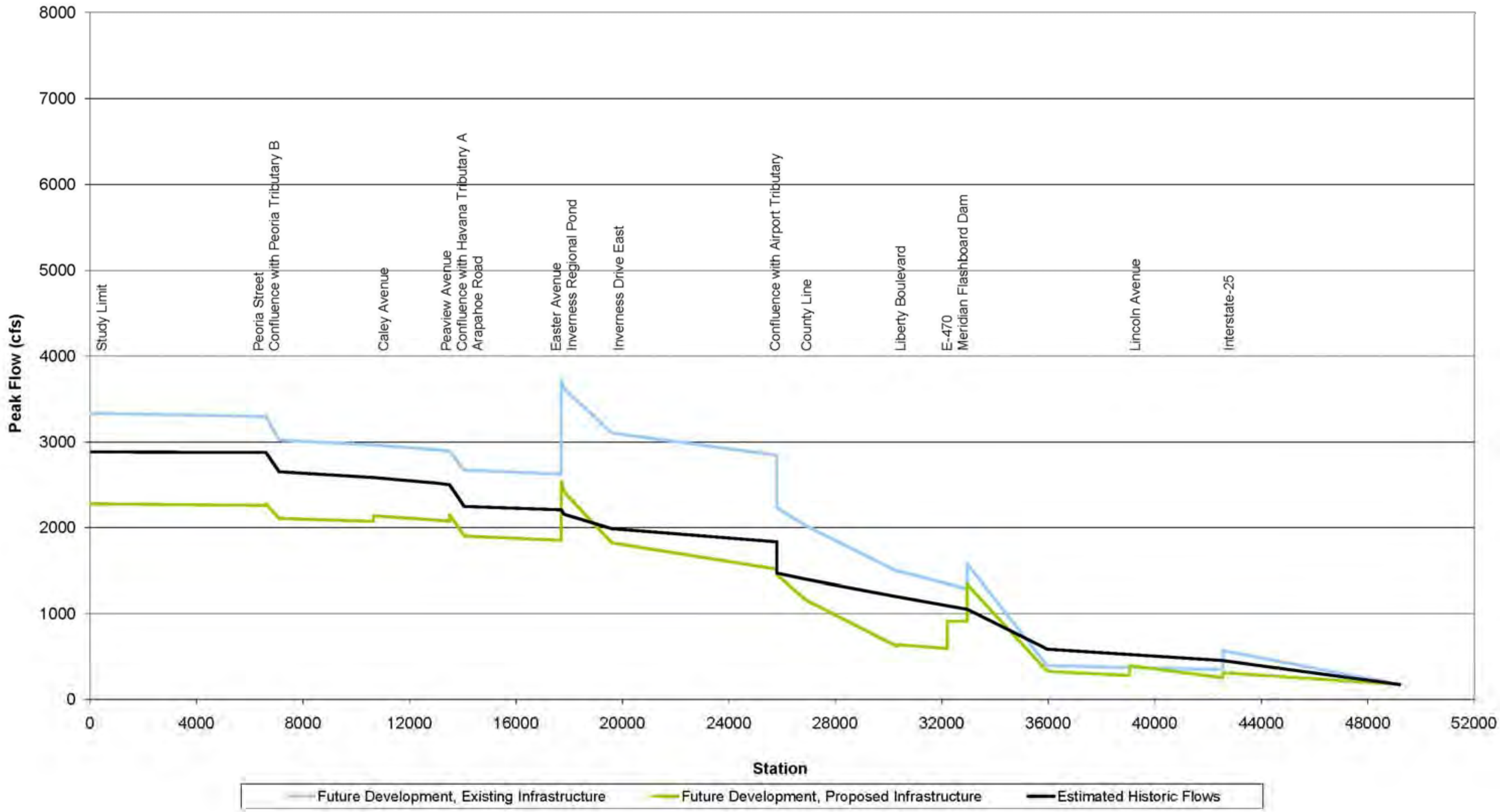
100-Year Results



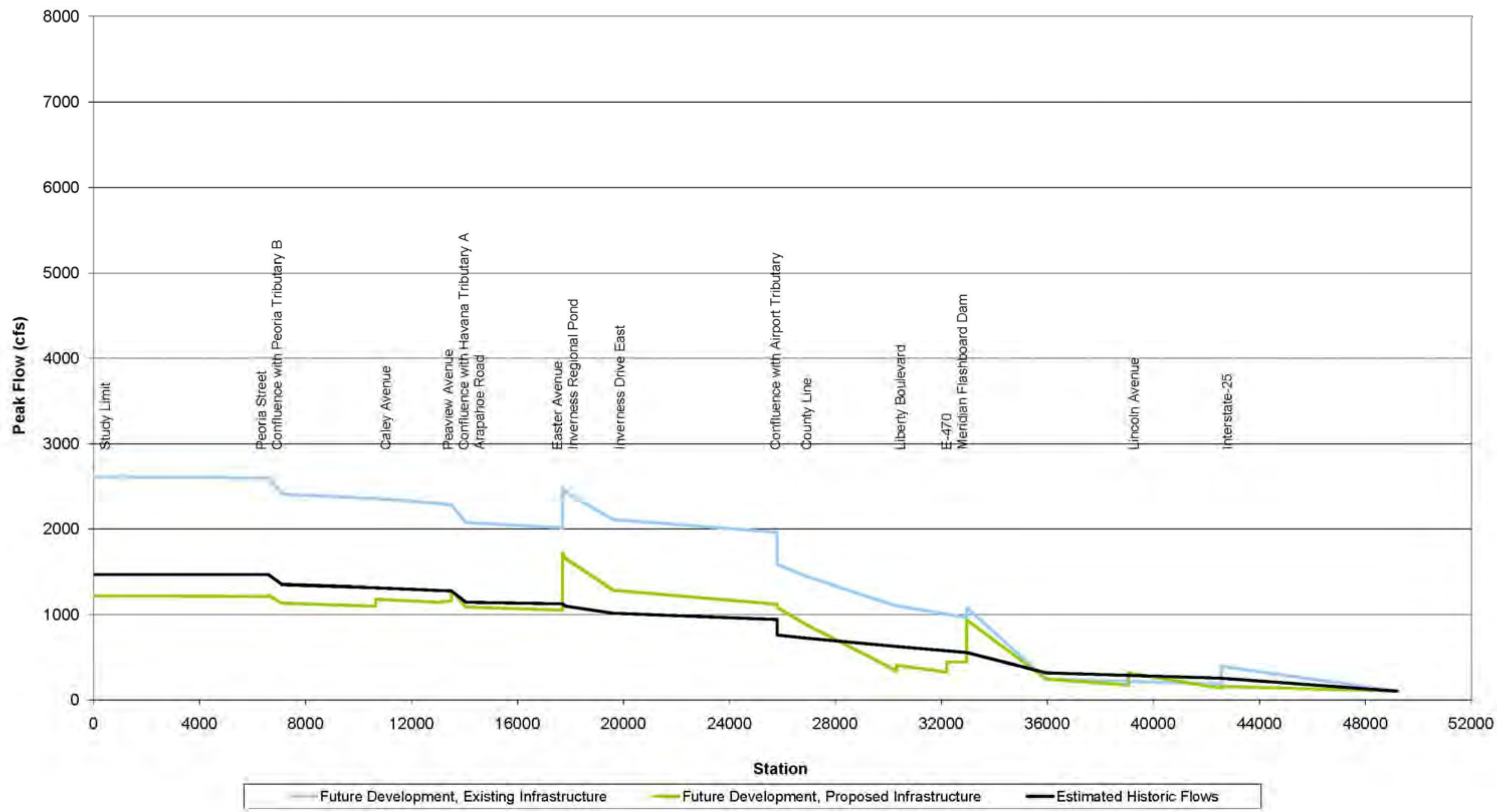
50-Year Results



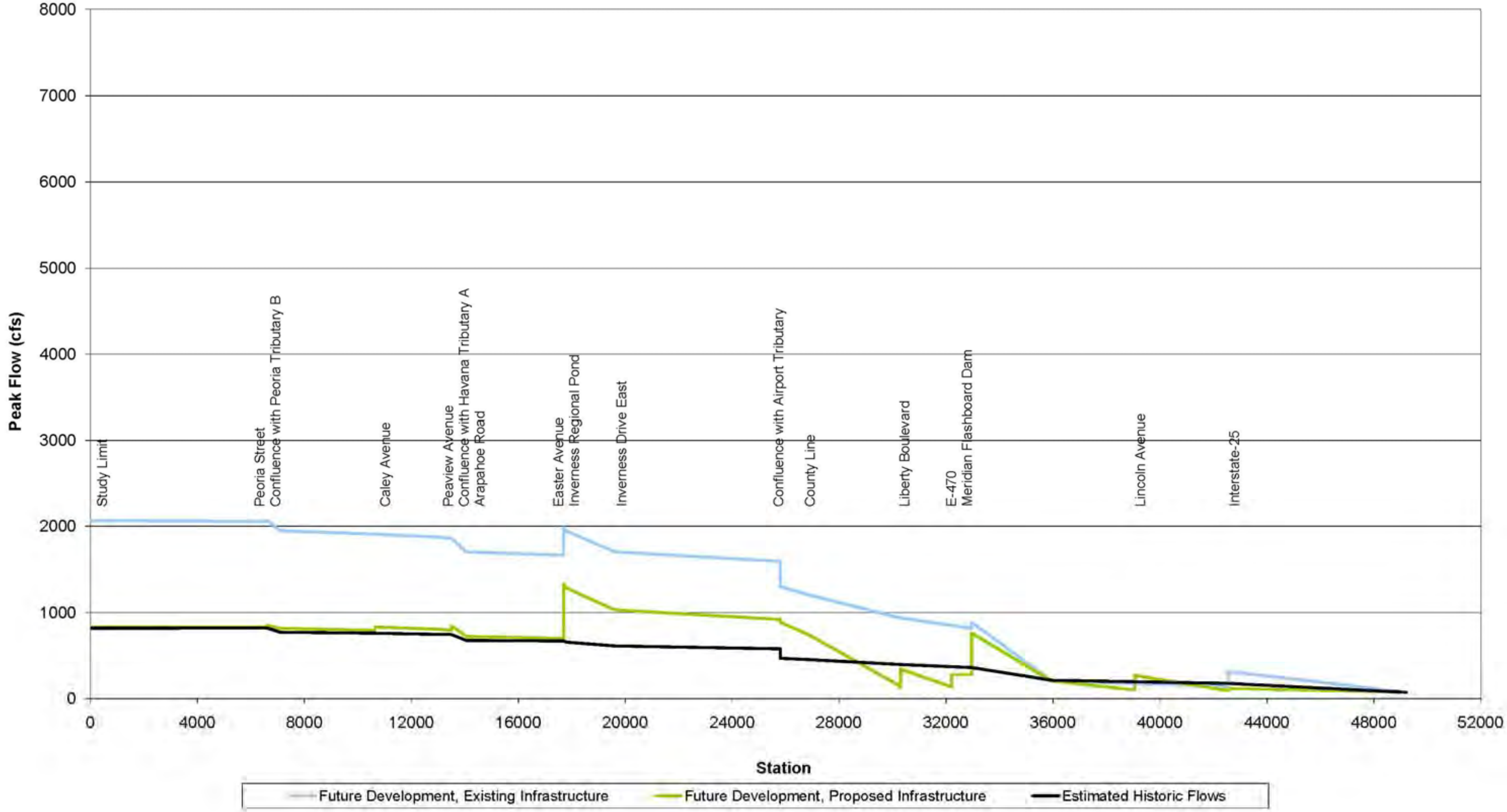
25-Year Results



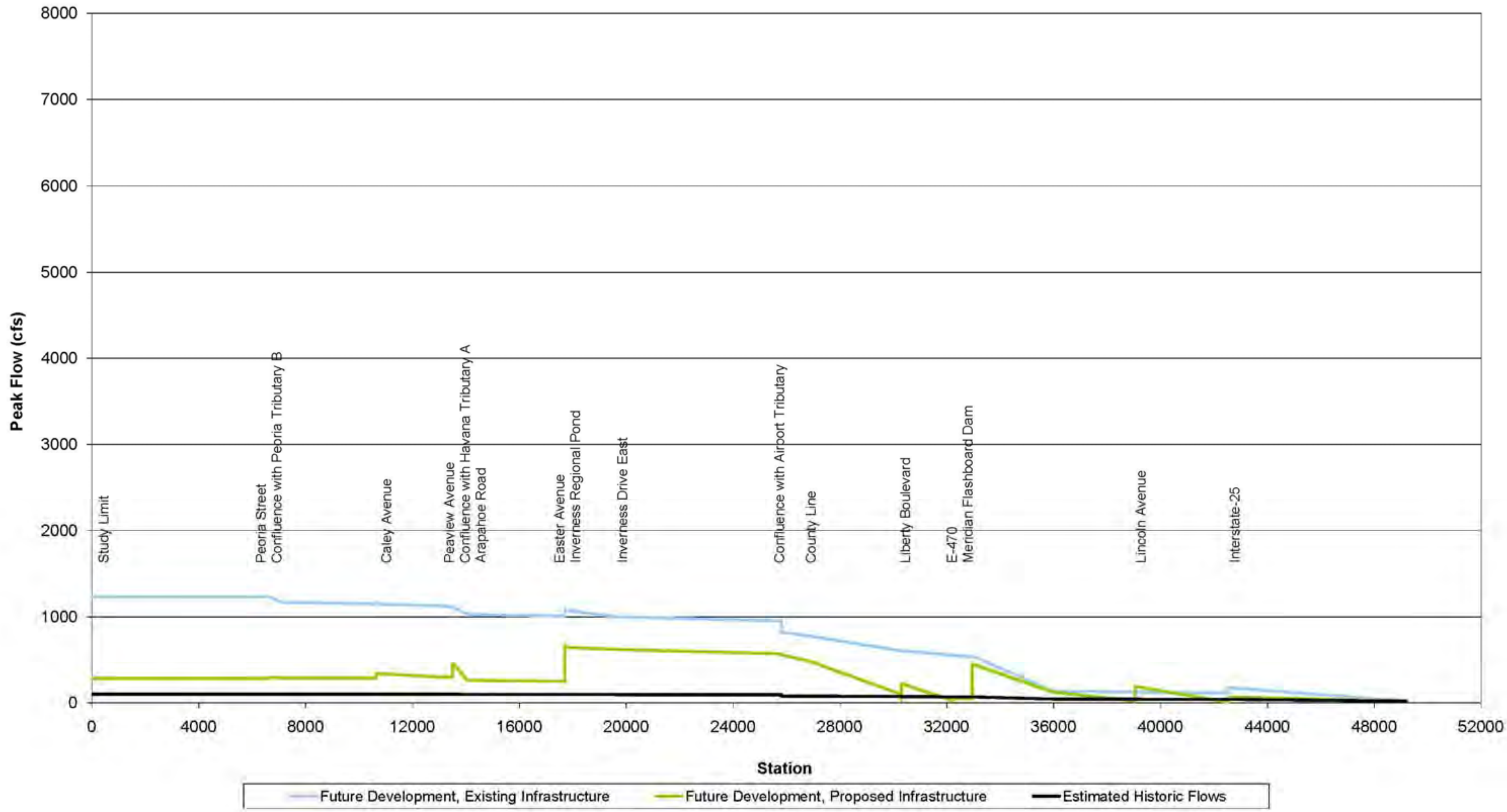
10-Year Results



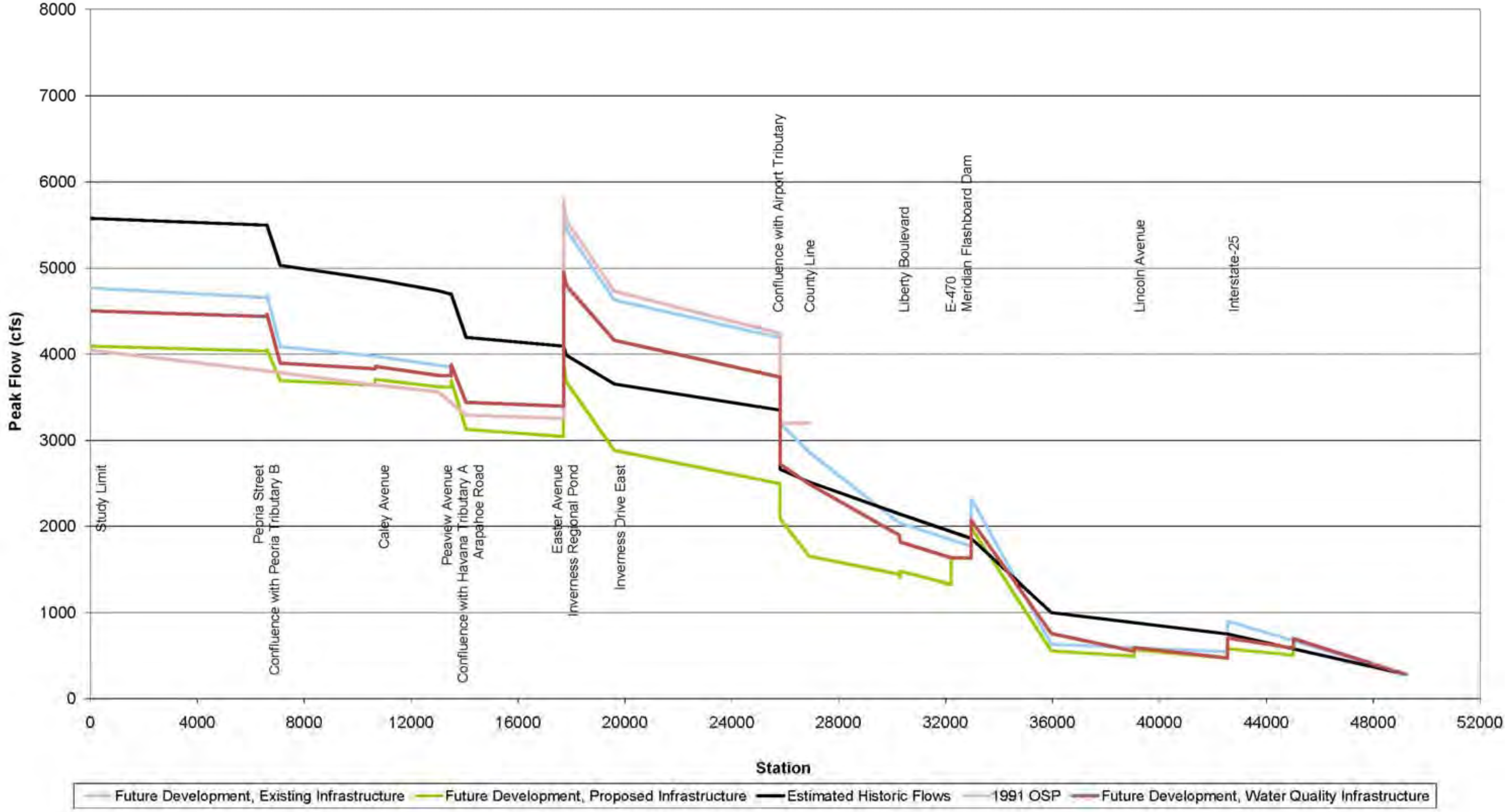
5-Year Results



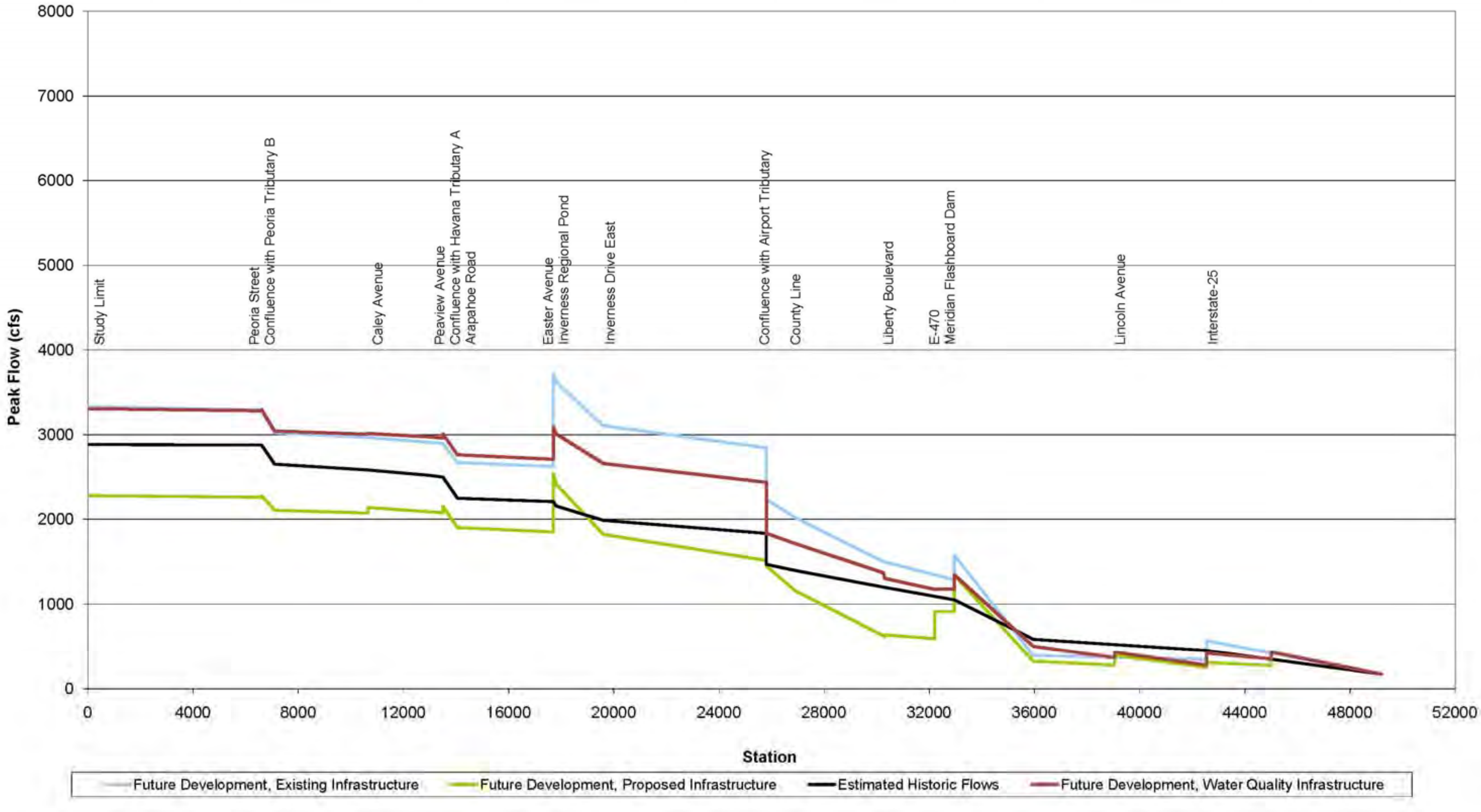
2-Year Results



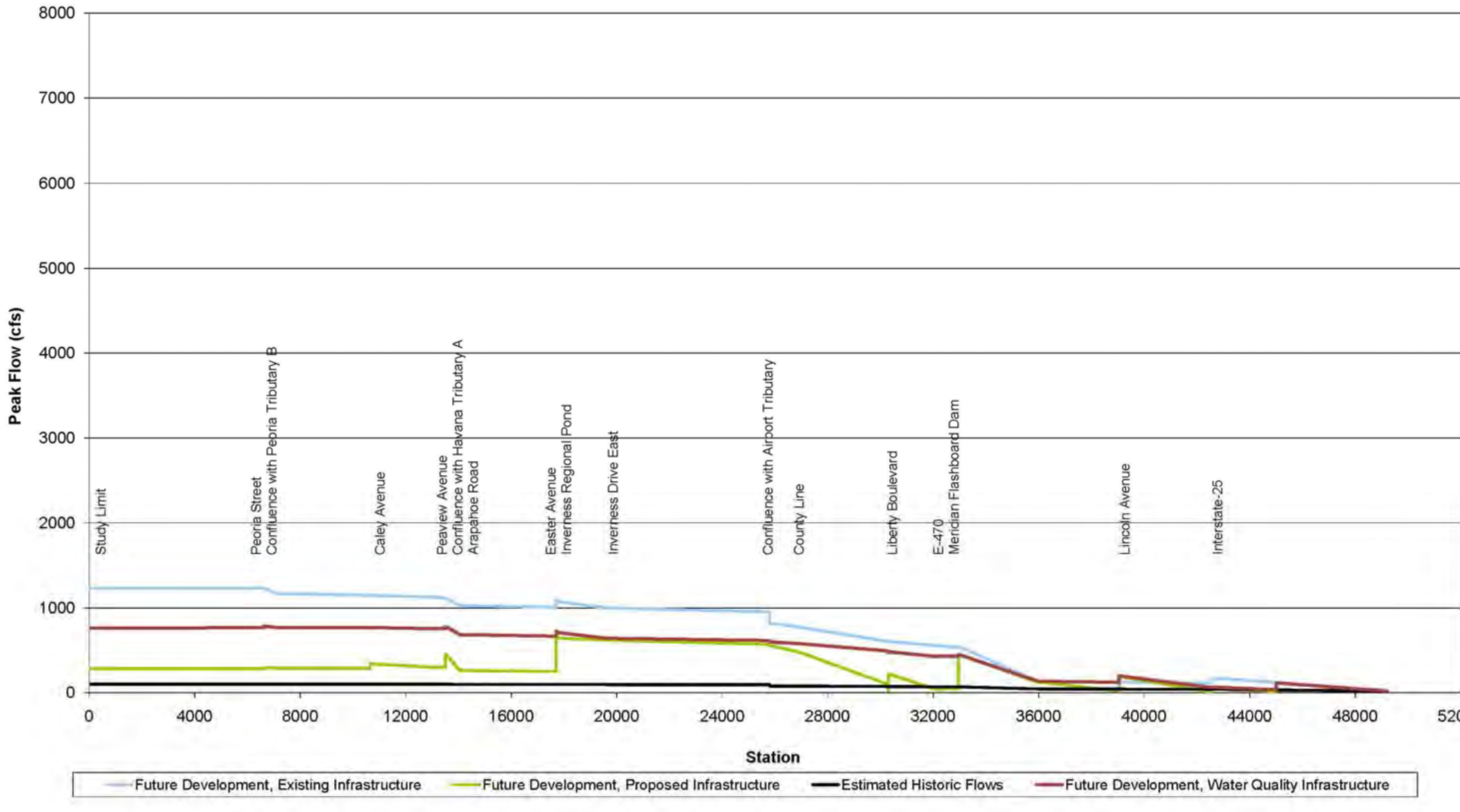
100-Year FSD vs. WQCV



25-Year FSD vs. WQCV



2 - Year FSD vs. WQCV



PROJECT WEBSITES

- Big Dry Creek

  www.bigdrycreek.org/majordrainageplan/home.html

- Cottonwood Creek

  projects.udfcd.org/lowercottonwood/

QUESTIONS?

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DIGITAL LETTER OF MAP CHANGE GUIDELINES

April 29, 2010

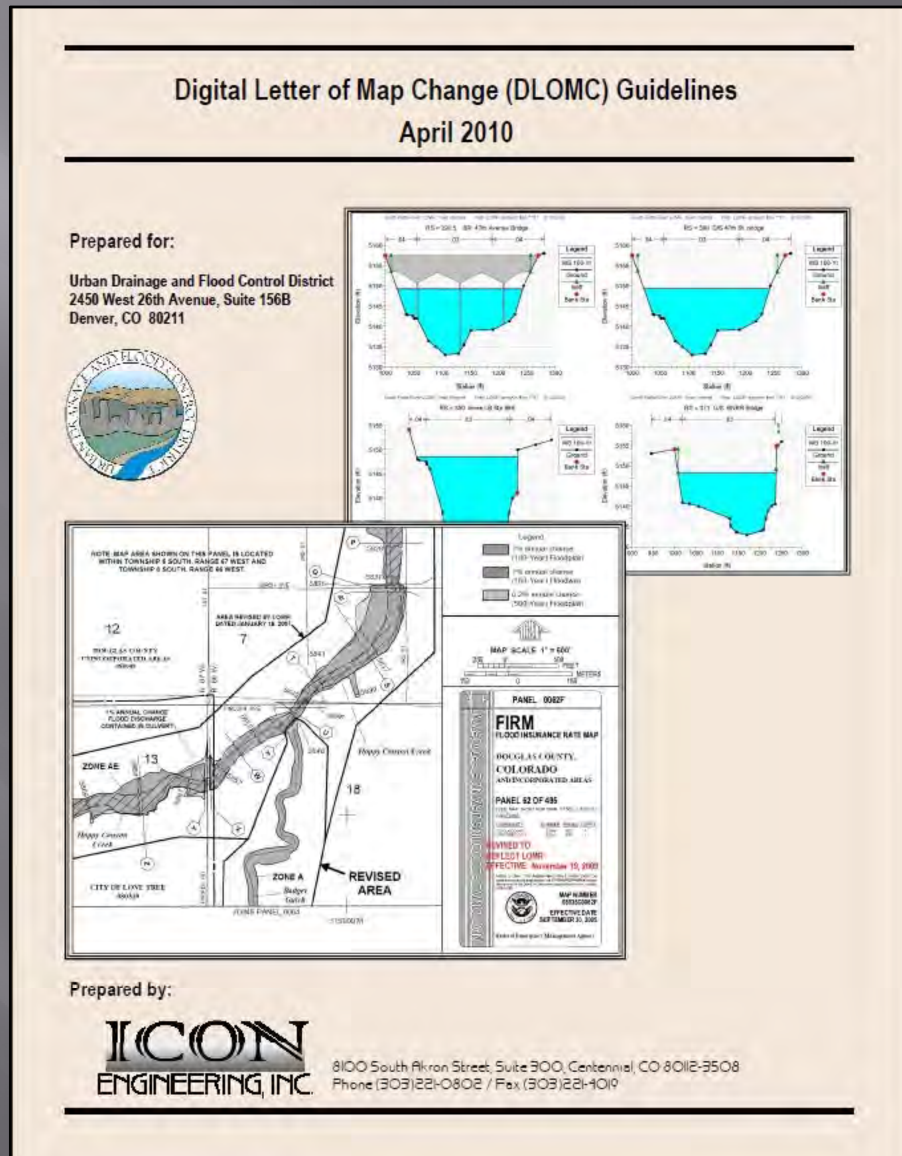
Introduction

- For anybody who didn't know this, we have been reviewing Letters of Map Change (LOMC's) for FEMA since 2001.
- LOMC's are either Letters of Map Revision (LOMR's) or Conditional Letters of Map Revision (CLOMR's)
- We do not review any other types of requests, such as LOMR-F's or LOMA's

The Problem

The Problem

The Solution



Digital Letter of Map Change (DLOMC) Guidelines

April 2010

Prepared for:

Urban Drainage and Flood Control District
2450 West 26th Avenue, Suite 156B
Denver, CO 80211

Prepared by:

ICON ENGINEERING, INC.

8100 South Akron Street, Suite 300, Centennial, CO 80112-3508
Phone (303)221-0802 / Fax (303)221-4019

Purpose

- Save applicants time and money in preparing complete applications
- Save the District time and money in conducting technical reviews and preparing LOMC exhibits
- Allow FEMA to issue LOMC's quicker
- Allow projects to move forward sooner
- Save the trees

Procedures

- Submit two copies of everything and a check made out to National Flood Insurance Program to the Floodplain Management Program
- A link to the current fee schedule is included in the guidelines

Submittal Items

- Report text
- Hydrologic and/or Hydraulic Models

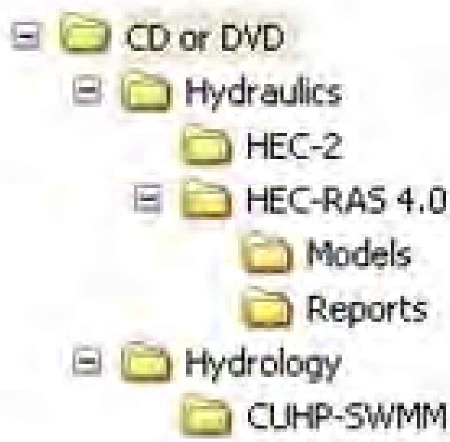


Figure 3.2.1 – Recommended Model File Structure

Submittal items

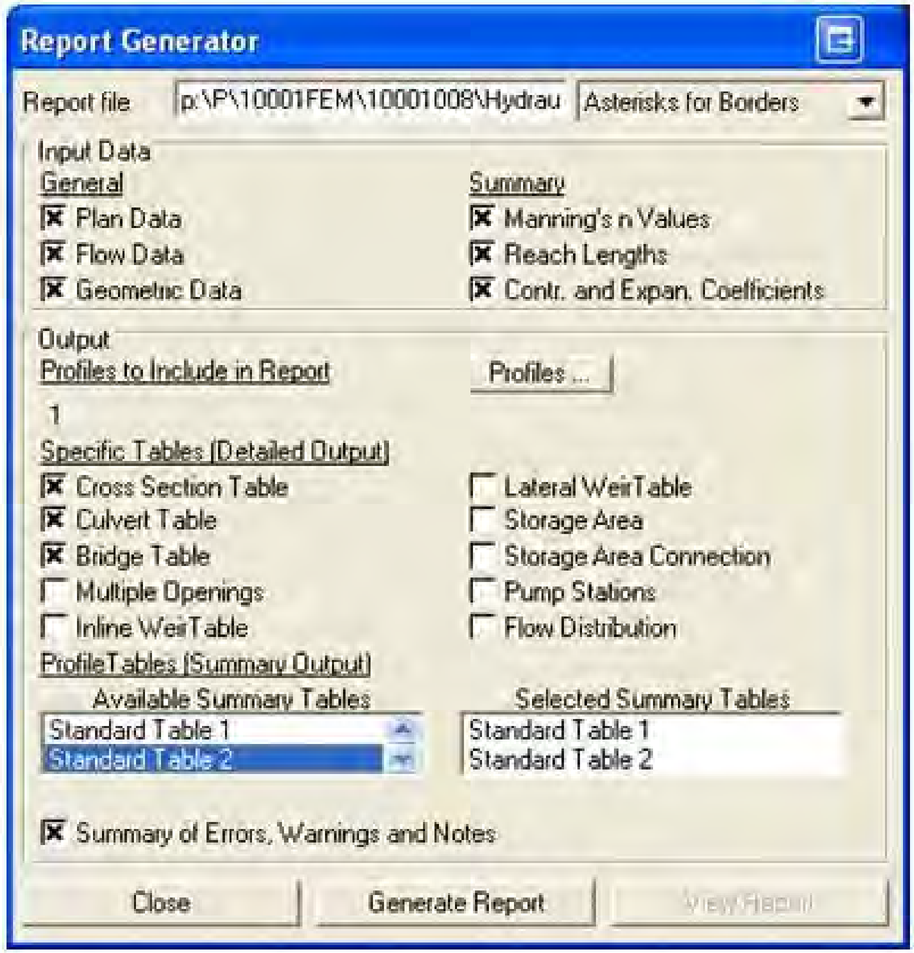


Figure 3.2.2 – Recommended HEC-RAS Report Generator Settings

Submittal Items

- Proposed Construction Plans (CLOMR’s)
- As-Built drawings, signed and sealed by a Colorado PE (LOMR’s)
- FEMA MT-2 forms
- Evidence that NFIP requirements have been met (links to key requirements are provided)
- Floodplain workmaps

Submittal items

FLOOD HAZARD FEATURES	LAYER/SHAPE NAME	COLOR	LINETYPE
Effective 100-YR Floodplain	100-YEAR-EFF	Orange	Dashed
Existing 100-YR Floodplain	100-YEAR-EX	Red	Hidden
Proposed 100-YR Floodplain	100-YEAR-PP	Cyan	Continuous
Effective 500-YR Floodplain	500-YEAR-EFF	Light Grey	Dashed
Proposed 500-YR Floodplain	500-YEAR-PP	Green	Continuous
Effective Regulatory Floodway	FLDWY-EFF	Dark Grey	Dashed
Proposed Regulatory Floodway	FLDWY-PP	Yellow	Continuous
Hydraulic Cross-Sections	XSECTION	Magenta	Continuous
Base Flood Elevation (BFE)	BFE	Red	Zigzag
Stream Centerline	CHANNEL	Blue	Center
Culverts	CULVERT	Black	Continuous
Bridges	BRIDGE	Black	Continuous
Footbridges	FOOTBRIDGE	Black	Continuous
Community Boundaries	BNDRY-COMMUN	Thick Black	Phantom
Property Boundaries	BNDRY-PROPERTY	Purple	Phantom

Submittal items

- Annotated FIRM panels
- Comparison Tables (example to follow)
- Annotated Floodway Data Table
- Agreement Checklists (example to follow)
- Other items
  - Previous studies
  - Correspondence
  - Etc.

CD/DVD Media

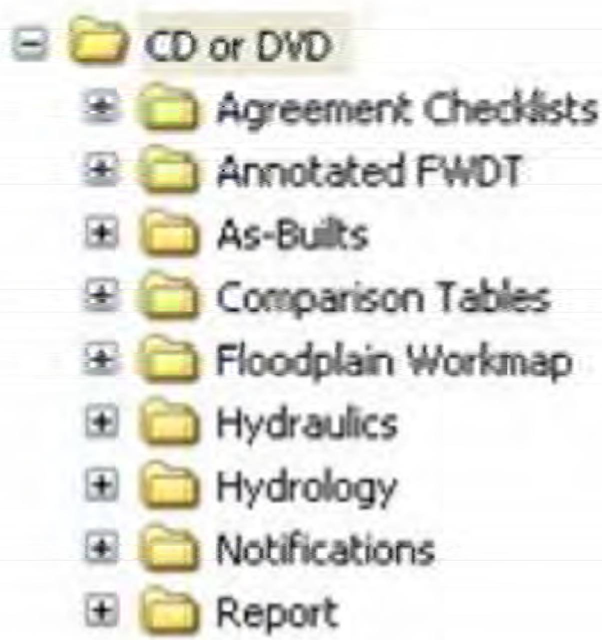
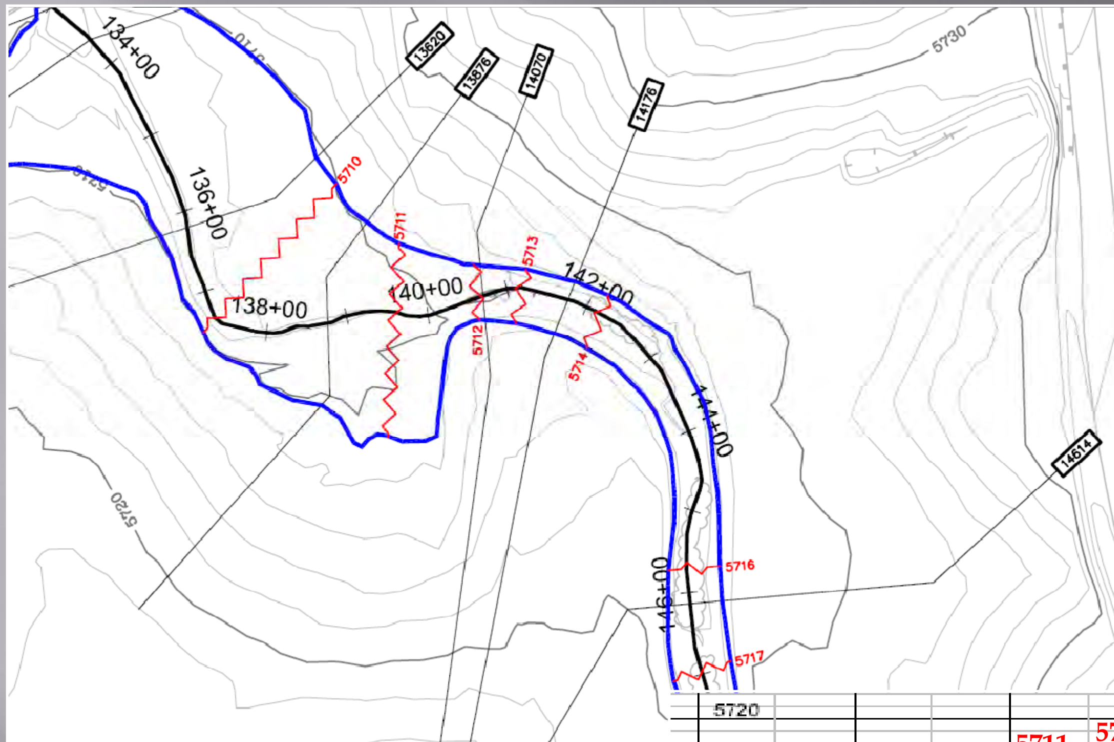


Figure 3.12.1 – Recommended CD/DVD File Structure


134+00
136+00
138+00
140+00
142+00
144+00
146+00
13620
13876
14070
14176
14614
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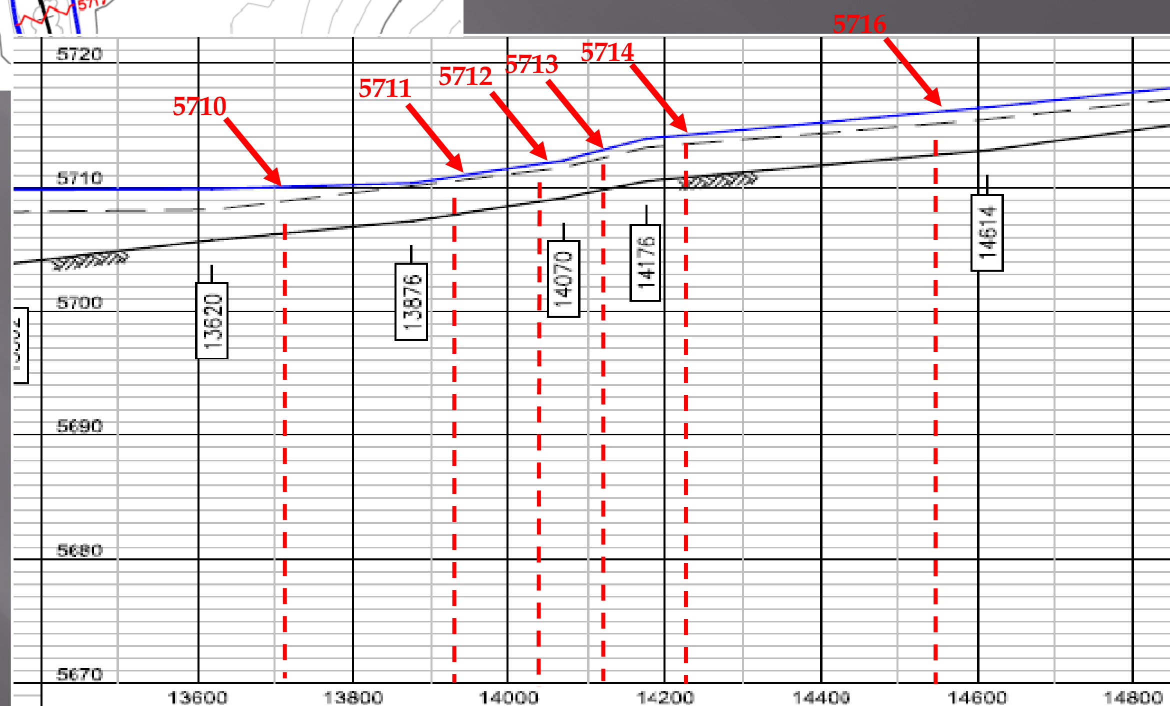
5711
5712
5713
5714
5716
5717
5720
5730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5670
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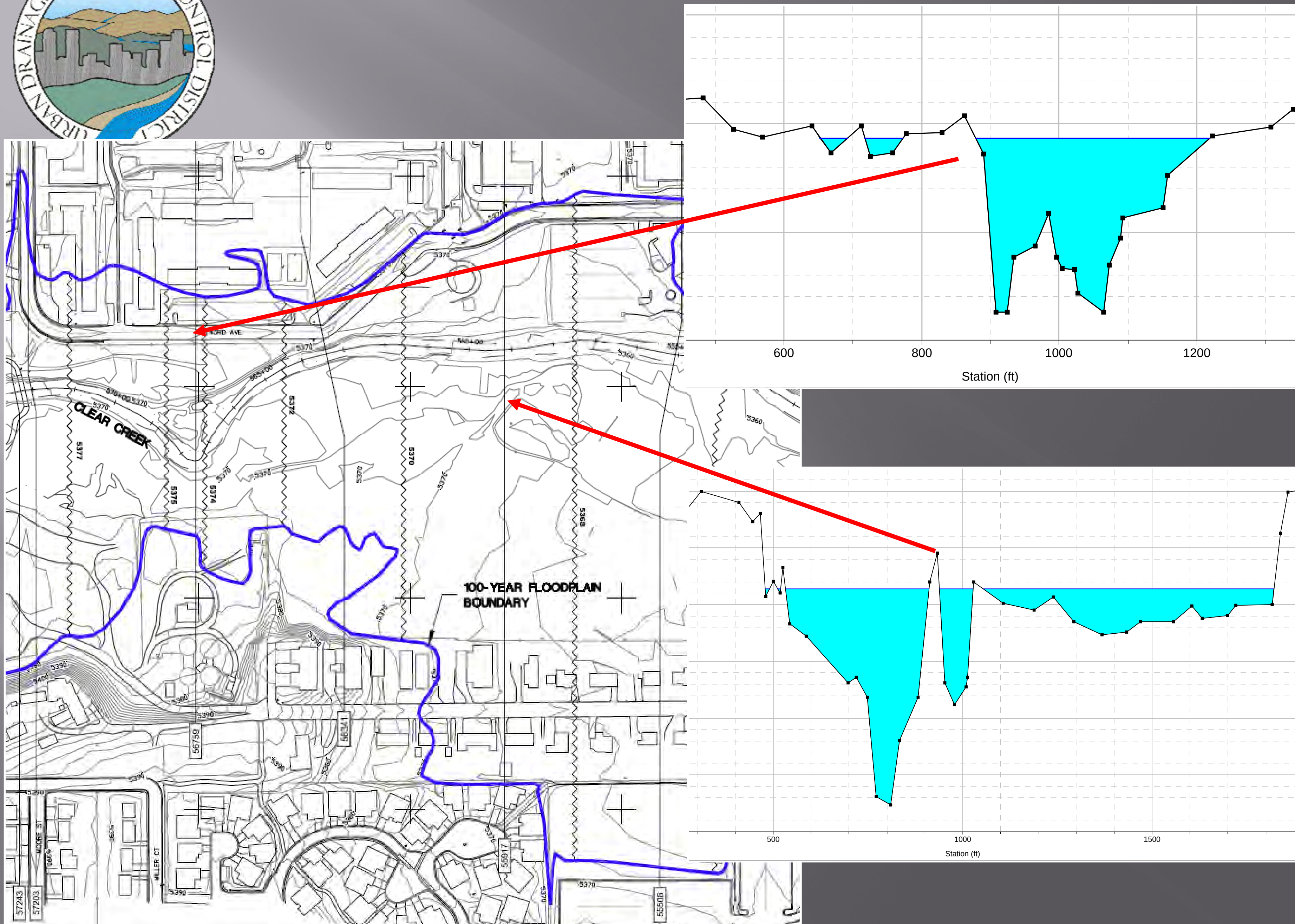
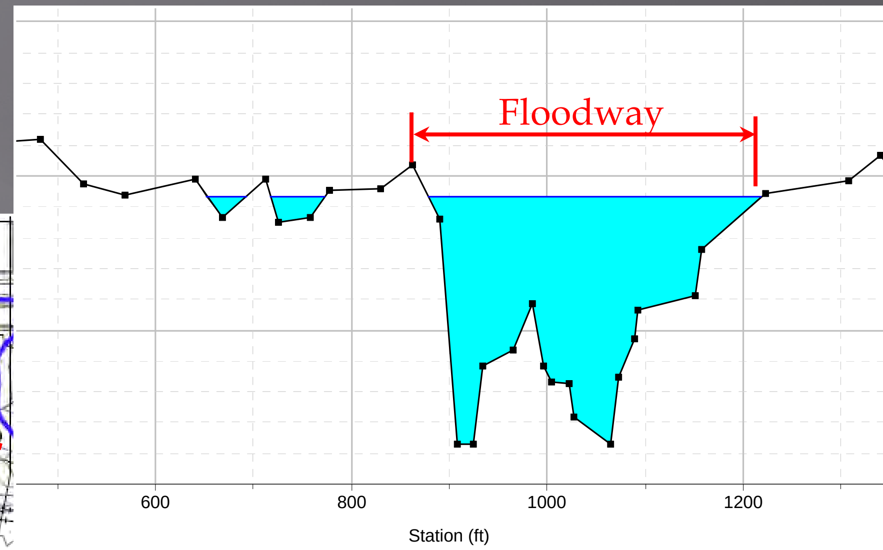
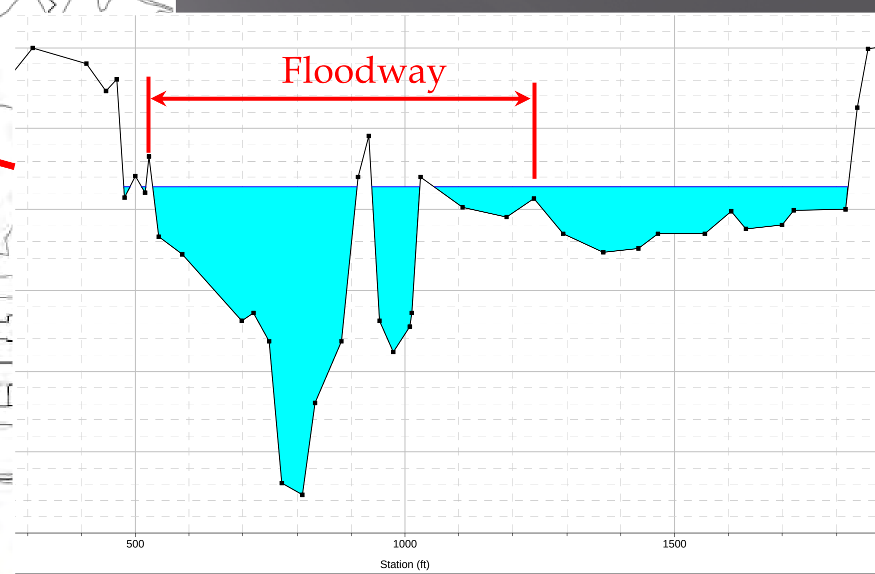
14200
14400
14600
14800


URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
CLEAR CREEK
100-YEAR FLOODPLAIN BOUNDARY
600
800
1000
1200
Station (ft)
500
1000
1500
Station (ft)

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT





Agreement Table

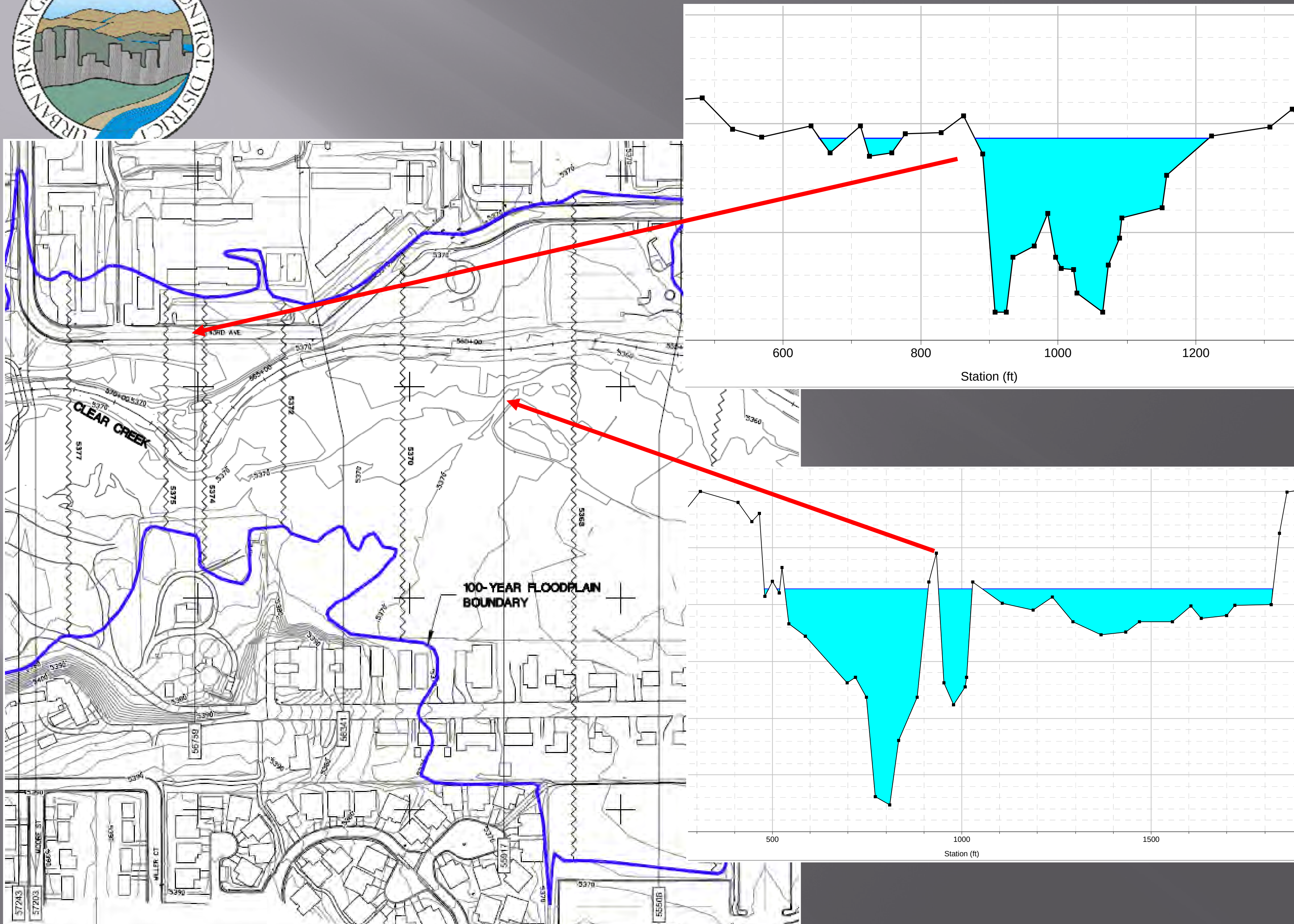
UDFCD LOMC AGREEMENT TABLE

PROJECT NAME: Todd Creek CLOMR
COMPANY: ICON Engineering, Inc.
COMPLETED BY: Justen Hamann, P.E.

Community(ies): City of Thornton & Adams County, CO
Flooding Source(s): Todd Creek

Page: 1 **of** 1
Date: 3/18/2010

Reference Location	Stream Station	Cross Section #	Channel Distance (ft)			Cumulative Channel Distance (ft)			Base Floodplain Width (ft)			Floodway Width (ft)			Comments
			Model	Map	% Difference	Model	Map	% Difference	Model	Map	Difference (ft)	Model	Map	Difference (ft)	
Todd Creek, D/S Tie-in Location	480.2	480	15	15	0%	15	15	0%	25	25	0	25	25	0	
	490.4	490	50	51	2%	65	66	2%	62	60	2	55	60	5	
	500.1	500	780	782	0%	845	848	0%	75	80	5	60	60	0	
	510.0	510	710	718	1%	1555	1566	1%	87	85	2	68	60	8	
	520.2	520	370	350	5%	1925	1916	0%	135	130	5	85	80	5	
	530.3	530	435	430	1%	2360	2346	1%	120	125	5	80	80	0	
	539.9	540	575	580	1%	2935	2926	0%	99	100	1	80	80	0	
D/S XS - Yosemite St. Bridge	550.0	550	460	450	2%	3395	3376	1%	112	110	2	55	60	5	
U/S XS - Yosemite St. Bridge	550.8	551	73	72	1%	3468	3448	1%	162	190	28	100	100	0	Island not plotted on workmap
	560.1	560	45	44	2%	3513	3492	1%	132	130	2	132	130	2	
	569.6	570	87	90	3%	3600	3582	1%	116	120	4	116	120	4	
	570.5	571	61	60	2%	3661	3642	1%	114	110	4	114	110	4	
	580.3	580	323	327	1%	3984	3969	0%	87	90	3	87	90	3	
	590.0	590	432	435	1%	4416	4404	0%	83	80	3	78	80	2	
U/S XS - Pedestrian Bridge	590.7	591	157	161	3%	4573	4565	0%	66	70	4	66	70	4	
D/S XS - Pedestrian Bridge	591.5	591.5	35	35	0%	4608	4600	0%	88	80	8	80	80	0	
	592.4	592	20	20	0%	4628	4620	0%	90	95	5	80	80	0	
	600.1	600	78	80	3%	4706	4700	0%	81	80	1	81	80	1	
	629.6	630	118	120	2%	4824	4820	0%	70	70	0	70	70	0	
	645.4	645	95	90	5%	4919	4910	0%	72	75	3	72	75	3	
Todd Creek, U/S Tie-in Location	700.0	700	290	291	0%	5209	5201	0%	80	80	0	80	80	0	
ACCEPTABLE TOLERANCES =			+/- 10% of Model			+/- 5% of Model			+/- 25 Feet						


100-YEAR FLOODPLAIN BOUNDARY
CLEAR CREEK
600
800
1000
1200
Station (ft)
500
1000
1500
Station (ft)

Agreement Table

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Page: 1 **of** 1
Date: 3/18/2010

Reference Location	Stream Station	Cross Section #	Channel Distance (ft)			Cumulative Channel Distance (ft)			Base Floodplain Width (ft)			Floodway Width (ft)			Comments
			Model	Map	% Difference	Model	Map	% Difference	Model	Map	Difference (ft)	Model	Map	Difference (ft)	
Todd Creek, D/S Tie-In Location	480.2	480	15	15	0%	15	15	0%	25	25	0	25	25	0	
	490.4	490	50	51	2%	65	66	2%	62	60	2	55	60	5	
	500.1	500	780	782	0%	845	848	0%	75	80	5	60	60	0	
	510.0	510	710	718	1%	1555	1566	1%	87	85	2	68	60	8	
	520.2	520	370	350	5%	1925	1916	0%	135	130	5	85	80	5	
	530.3	530	435	430	1%	2360	2346	1%	120	125	5	80	80	0	
	539.9	540	575	580	1%	2935	2926	0%	99	100	1	80	80	0	
D/S XS - Yosemite St. Bridge	550.0	550	460	450	2%	3395	3376	1%	112	110	2	55	60	5	
U/S XS - Yosemite St. Bridge	550.8	551	73	72	1%	3468	3448	1%	162	190	*28*	100	100	0	Island not plotted on workmap
	560.1	560	45	44	2%	3513	3492	1%	132	130	2	132	130	2	
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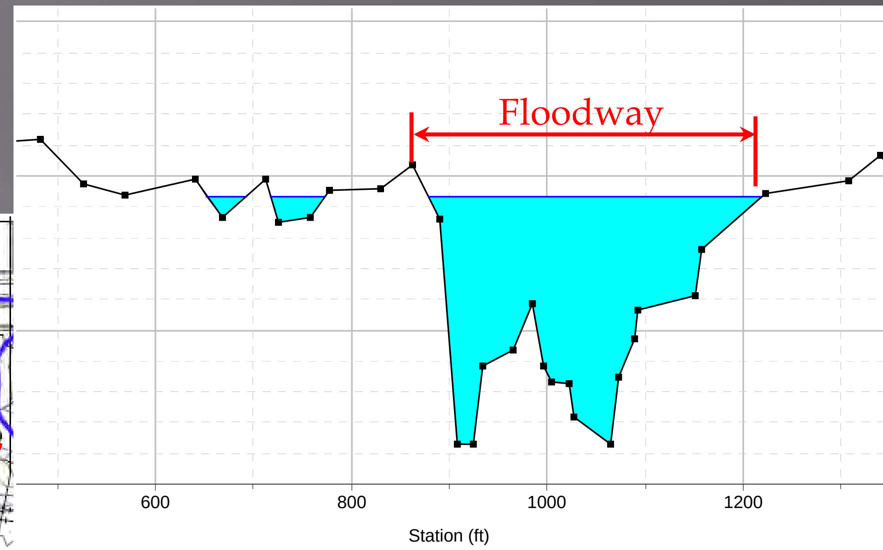
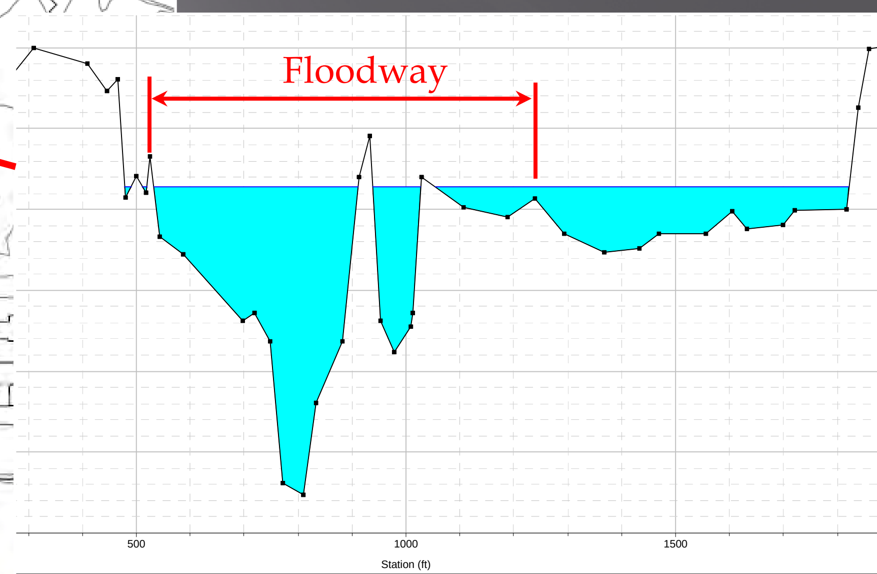
	570.5	571	61	60	2%	3661	3642	1%	114	110	4	114	110	4	
	580.3	580	323	327	1%	3984	3969	0%	87	90	3	87	90	3	
	590.0	590	432	435	1%	4416	4404	0%	83	80	3	78	80	2	
U/S XS - Pedestrian Bridge	590.7	591	157	161	3%	4573	4565	0%	66	70	4	66	70	4	
D/S XS - Pedestrian Bridge	591.5	591.5	35	35	0%	4608	4600	0%	88	80	8	80	80	0	
	592.4	592	20	20	0%	4628	4620	0%	90	95	5	80	80	0	
	600.1	600	78	80	3%	4706	4700	0%	81	80	1	81	80	1	
	629.6	630	118	120	2%	4824	4820	0%	70	70	0	70	70	0	
	645.4	645	95	90	5%	4919	4910	0%	72	75	3	72	75	3	
Todd Creek, U/S Tie-In Location	700.0	700	290	291	0%	5209	5201	0%	80	80	0	80	80	0	
ACCEPTABLE TOLERANCES =			+/- 10% of Model			+/- 5% of Model			+/- 25 Feet						


CLEAR CREEK
100-YEAR FLOODPLAIN
BOUNDARY
43RD AVE
MOORE ST
MILLER CT


Floodway
600
800
1000
1200
Station (ft)


Floodway
500
1000
1500
Station (ft)

BFE Comparison Table

UDFCD DLOMC Submittal - BFE Comparison Table

Project Name :	Noname Creek CLOMR
Flooding Source:	Noname Creek
Company:	ICON Engineering, Inc.
Completed By:	Justen Hamann, P.E.

SOURCE DATA											COMPARISONS				
HYDRAULIC CROSS-SECTION INFO.						BASE FLOOD ELEVATIONS (NAVD)									
Effective Cross-Section ID (Letter)	Corrected Effective Cross-Section ID	Corrected Effective Stream Station	Existing Cross-Section ID	Proposed Cross-Section ID	Proposed Stream Station	EFFECTIVE	DUP. EFF.	COR. EFF.	EXISTING	PROPOSED	DUP. EFF vs. EFF.	COR. EFF. vs. EFF.	EX. vs. COR. EFF.	PP. vs. COR. EFF.	PP. vs. EFF.
						BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE
300 (A)	300	300	--	300	300	5205.50	5205.50	5205.50	--	5205.50	0.00	0.00	--	0.00	0.00
--	450	450	--	450	450	*5207.10*	*5207.16*	5206.25	--	5206.25	0.06	-0.85	--	0.00	-0.85
605	605	605	--	605	605	5208.10	5208.13	5208.17	--	5208.17	0.03	0.07	--	0.00	0.07
710 (B)	710	710	--	710	710	5208.40	5208.46	5208.80	--	5208.60	0.06	0.40	--	-0.20	0.20
--	900	900	--	900	900	*5208.52*	*5208.52*	5209.05	--	5208.70	0.00	0.53	--	-0.35	0.18
--	--	--	--	930	930	*5208.60*	*5208.62*	*5209.18*	--	5209.55	0.02	0.58	--	0.37	0.95
--	--	--	--	1055	1055	*5209.94*	*5209.95*	*5209.98*	--	5210.60	0.01	0.04	--	0.62	0.66
--	--	--	--	1075	1075	*5210.12*	*5210.08*	*5210.42*	--	5210.60	-0.04	0.30	--	0.18	0.48
1010	1166	1166	--	1150	1150	5211.20	5211.12	5211.14	--	5211.36	-0.08	-0.06	--	0.22	0.16
1300	--	--	--	--	--	5212.63	5212.53	*5211.80*	--	*5211.75*	-0.10	-0.83	--	-0.05	-0.88
--	1357	1357	--	--	--	*5212.68*	*5212.62*	5212.44	--	*5212.32*	-0.06	-0.24	--	-0.12	-0.36
--	--	--	--	1370	1370	*5213.80*	*5213.78*	*5213.72*	--	5213.67	-0.02	-0.08	--	-0.05	-0.13
1650 (C)	1672	1672	--	1656	1656	5214.57	5214.56	5216.97	--	5216.84	-0.01	2.40	--	-0.13	2.27
--	--	--	--	1840	1840	*5217.21*	*5217.21*	*5218.66*	--	5218.96	0.00	1.45	--	0.30	1.75
--	--	--	--	2050	2050	*5219.30*	*5219.30*	*5220.63*	--	5220.31	0.00	1.33	--	-0.32	1.01
2115	2136	2136	--	2120	2120	5220.30	5220.30	5221.27	--	5223.68	0.00	0.97	--	2.41	3.38
--	--	--	--	2227	2227	*5222.56*	*5222.64*	*5222.41*	--	5225.20	0.08	-0.15	--	2.79	2.64
2371	--	--	--	--	--	5224.60	5224.71	*5224.62*	--	*5227.53*	0.11	0.02	--	2.91	2.93
--	--	--	--	2302	2302	*5225.34*	*5225.34*	*5226.20*	--	5228.63	0.00	0.86	--	2.43	3.29
--	--	--	--	2327	2327	*5225.98*	*5225.99*	*5227.71*	--	5229.87	0.01	1.73	--	2.16	3.89
--	--	--	--	2370	2370	*5227.46*	*5227.46*	*5228.43*	--	5230.37	0.00	0.97	--	1.94	2.91
--	--	--	--	2390	2390	*5232.47*	*5232.46*	*5232.88*	--	5234.48	-0.01	0.41	--	1.60	2.01
--	--	--	--	2460	2460	*5234.54*	*5234.54*	*5233.12*	--	5234.65	0.00	-1.42	--	1.53	0.11
--	2545	2545	--	--	--	*5236.20*	*5236.20*	5233.46	--	*5234.90*	0.00	-2.74	--	1.44	-1.30
2705 (D)	2745	2745	--	2701	2701	5237.48	5237.48	5237.20	--	5236.50	0.00	-0.28	--	-0.70	-0.98
--	2989	2989	--	2945	2945	*5239.40*	*5239.40*	5238.77	--	5238.74	0.00	-0.63	--	-0.03	-0.66
3130	3170	3170	--	3126	3126	5240.80	5240.80	5240.16	--	5240.16	0.00	-0.64	--	0.00	-0.64
--	3422	3422	--	3378	3378	*5245.20*	*5245.20*	5244.62	--	5244.62	0.00	-0.58	--	0.00	-0.58
3580 (E)	3620	3620	--	3576	3576	5248.42	5248.44	5248.13	--	5248.13	0.02	-0.29	--	0.00	-0.29

-- = Not applicable or no direct comparison available

5225.98 = Interpolated value or value pulled directly from the effective FIS profile

Submittal Checklist

UDFCD DLOMC SUBMITTAL CHECKLIST

PROJECT NAME:	
COMPANY:	
COMPLETED BY:	

DLOMC Submittal Item		Requirements			What Is Submitted	
Item No.	Item (include 2 complete copies)	Digital Optional	Digital Required	Hard Copy Required	Digital	Hard Copy
3.1	Report Text	X				
3.2.a	Hydraulic and/or Hydrologic Models		X			
3.2.b	Hydraulic and/or Hydrologic Reports and Cross-Sections	X				
3.3	Proposed Construction Plans and/or As-Built Survey Information	X				
3.4	FEMA MT-2 Forms			X		
3.5	NFIP Regulation Requirements/Notifications	X				
3.6	Floodplain Workmaps		X	X		
3.7	Annotated FIRM Panels			X		
3.8.a	Comparison Tables	X				
3.8.b	Comparison Profile	X				
3.9	Annotated Floodway Data Table	X				
3.10	Agreement Checklists	X				
3.11	Other Items	X				
3.12	CD/DVD Media			X		

4/22/2010 10:31 AM

C:\Users\dmallory\Desktop\DLOMC Presentation\Submittal Checklist.xls

Summary

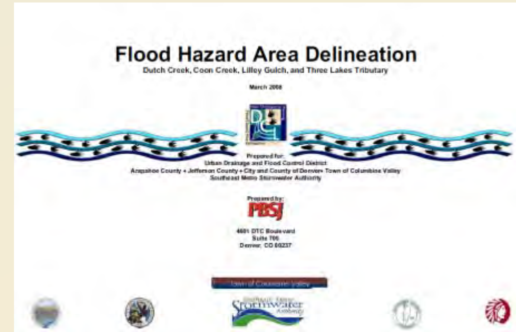
- Consultants will be able to prepare a complete submittal quicker and cheaper
- We will be able to complete our technical reviews quicker and cheaper
- We will be able to prepare the LOMC exhibits and submit to FEMA quicker and cheaper
- FEMA will be able to issue the LOMC's sooner, and…

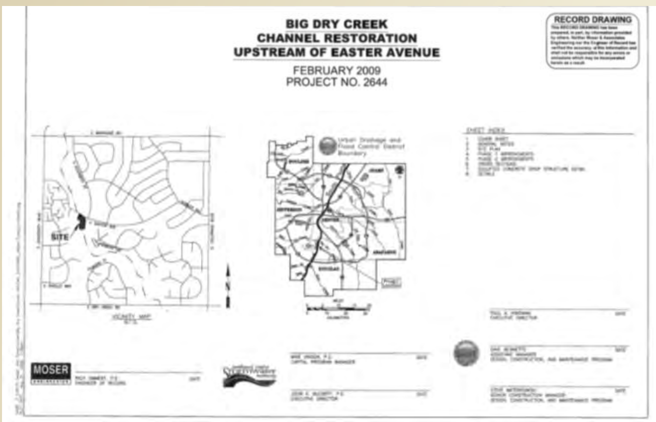
Results

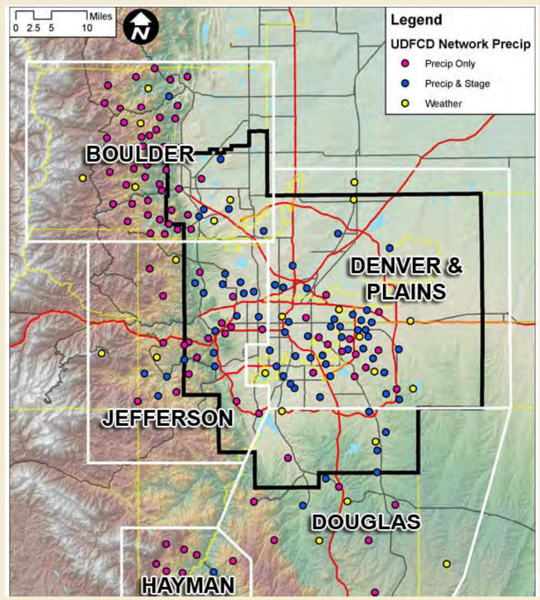
REQUEST FOR A
LETTER OF MAP REVISION
FOR
PINEY CREEK
AND
SAMPSON GULCH
CITY OF AURORA, COLORADO

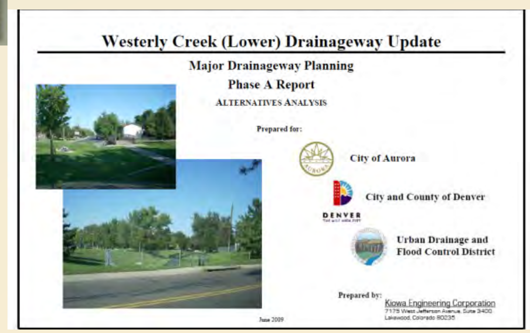
Kevin Stewart, Manager
Julia Bailey, Information Services Engineer
Information Services and Flood Warning Program
Urban Drainage and Flood Control District

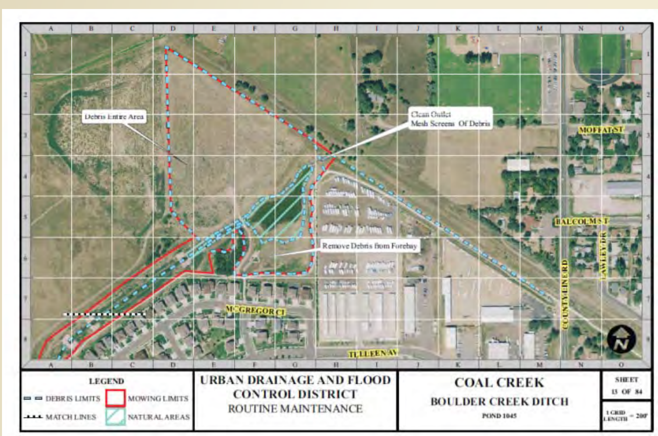
Accessing our documents and data on the web











ID NO	PROJECT NAME	TRIBUTARY	CONCEPT OK?	CONCEPT DATE	DESIGN OK?	DESIGN DATE	CNSTRCTN OK?	CNSTRCTN DATE

Urban Drainage and Flood Control District Maintenance Eligibility Program
Status of Projects by Local Government

Boulder

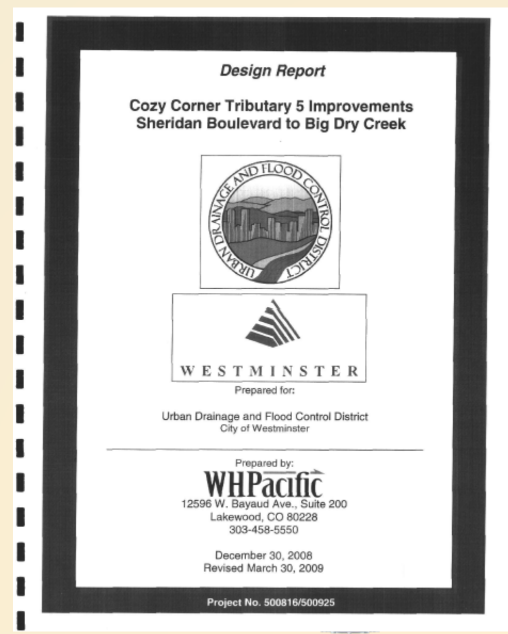
07-Apr-2010

BEAR CANYON CREEK

ID NO	PROJECT NAME	TRIBUTARY	CONCEPT OK?	CONCEPT DATE	DESIGN OK?	DESIGN DATE	CNSTRCTN OK?	CNSTRCTN DATE
287	CU President's House		☑	6/9/1986	☐		☐	
3046	CU Williams Village		☑	10/7/2002	☑	10/7/2002	☑	4/24/2003

DRY CREEK NO. 2

ID NO	PROJECT NAME	TRIBUTARY	CONCEPT OK?	CONCEPT DATE	DESIGN OK?	DESIGN DATE	CNSTRCTN OK?	CNSTRCTN DATE
201	Flatiron Industrial Park		☐	6/28/1985	☐	6/28/1985	☐	



Urban Drainage and Flood Control District
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
Home
Current Projects
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About Us
FAQ's
Mission Statement
www.udfcd.org
Working with you
Criteria Manual
Floodplain Preservation Brochure
District Boundary (GIS)
District Logo
Guidelines/Forms
Monuments
Threatened Species Map
Publications
Software
Technical Papers/Manuals
Activity Summary
As-Builts
Design Reports
Flood Hazard News
Flood Hazard Area Delineation Reports
Major Drainageway Planning Reports
Outfall Systems Planning Reports
Special Reports and Miscellaneous Publications
Flood Information
live in or near a floodplain. Search by
Real-time flood
Board Meetings
April 15, 2010 - Board Meeting
-Agenda
-Resolutions
-Meeting Minutes
to view past board
information
Maintenance Eligibility
Local governments, businesses, organizations and individuals concerning the eligibility status of various projects reviewed UDFCD's Floodplain Management Program.
Design, Construction and Maintenance
Detailed information about program activities
Stormwater Quality
Stormwater Quality
Research and Activities that promote the improvement of stormwater.
Draft USDCM Volume 3 Documents
Registration is now closed. Click here to view the seminar program
FEMA issues revised fee schedule for processing map change requests, effective January 13, 2010
District Adopts Westerly Creek Dam Development and Operation Regulations
Moratorium on Porous Concrete Pavement LIFTED
Criteria Manual III updates coming soon. Click here for details.

Urban Drainage and Flood Control District

Home | Current Projects | Downloads | Calendar | Resources & Links | About Us | FAQ's | Mission Statement

OUTFALL SYSTEMS PLANNING

Hyperlink	Basin Number	Major Drainageway	Engineering Firm	Year
54th and Pecos OSP Ph A 1988	4300	Clear Creek	Hydro-Triad, Ltd.	1988
54th and Pecos OSP Ph B 1989	4300	Clear Creek	Hydro-Triad, Ltd.	1989
Applewood OSP Ph A 2001	4300	Clear Creek	Kiowa Engineering Corporation	2001
Applewood OSP Ph B 2003	4300	Clear Creek	Kiowa Engineering Corporation	2003
Arapahoe and Magpie Gulch OSP Ph A 1995	4300	Clear Creek	WRC Engineering Inc	1995
Arapahoe and Magpie Gulch OSP Ph B 1997	4300	Clear Creek	WRC Engineering Inc	1997
Basin 4100 and DFA 0056 OSP Ph A 2001	4100	Basin 4100 Drain	Kiowa Engineering Corporation	2001
Basin 4100 and DFA 0056 OSP Ph B 2002	4100	Basin 4100 Drain	Kiowa Engineering Corporation	2002
Basin 4100 DFA 0056 OSP 1986	4100	Basin 4100 Drain	J. S. Griffith, P.E.	1986
Bear Creek Academy Park Trib OSP Ph A 1997	5500	Bear Creek	Kiowa Engineering Corporation	1997
Bear Creek Academy Park Trib OSP Ph B 1999	5500	Bear Creek	Kiowa Engineering Corporation	1999
Bear Creek Pinehurst Trib OSP Ph A 1999	5500	Bear Creek	Kiowa Engineering Corporation	1999

Past Online Access to Data

- Limited organization capabilities
  - Categorized by document type
  - Listed by document name

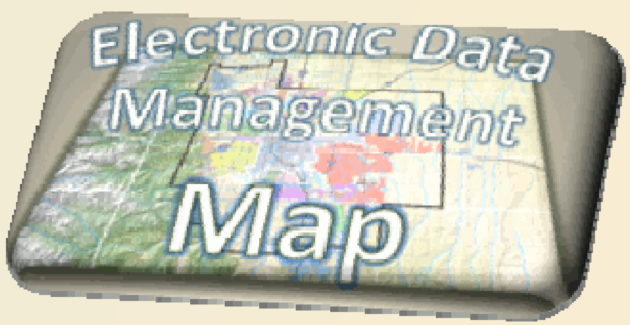
- Where would you go if you were looking for all documents related to a single stream? Authored by a consulting firm? Sponsored by a local government?

Initial Goals

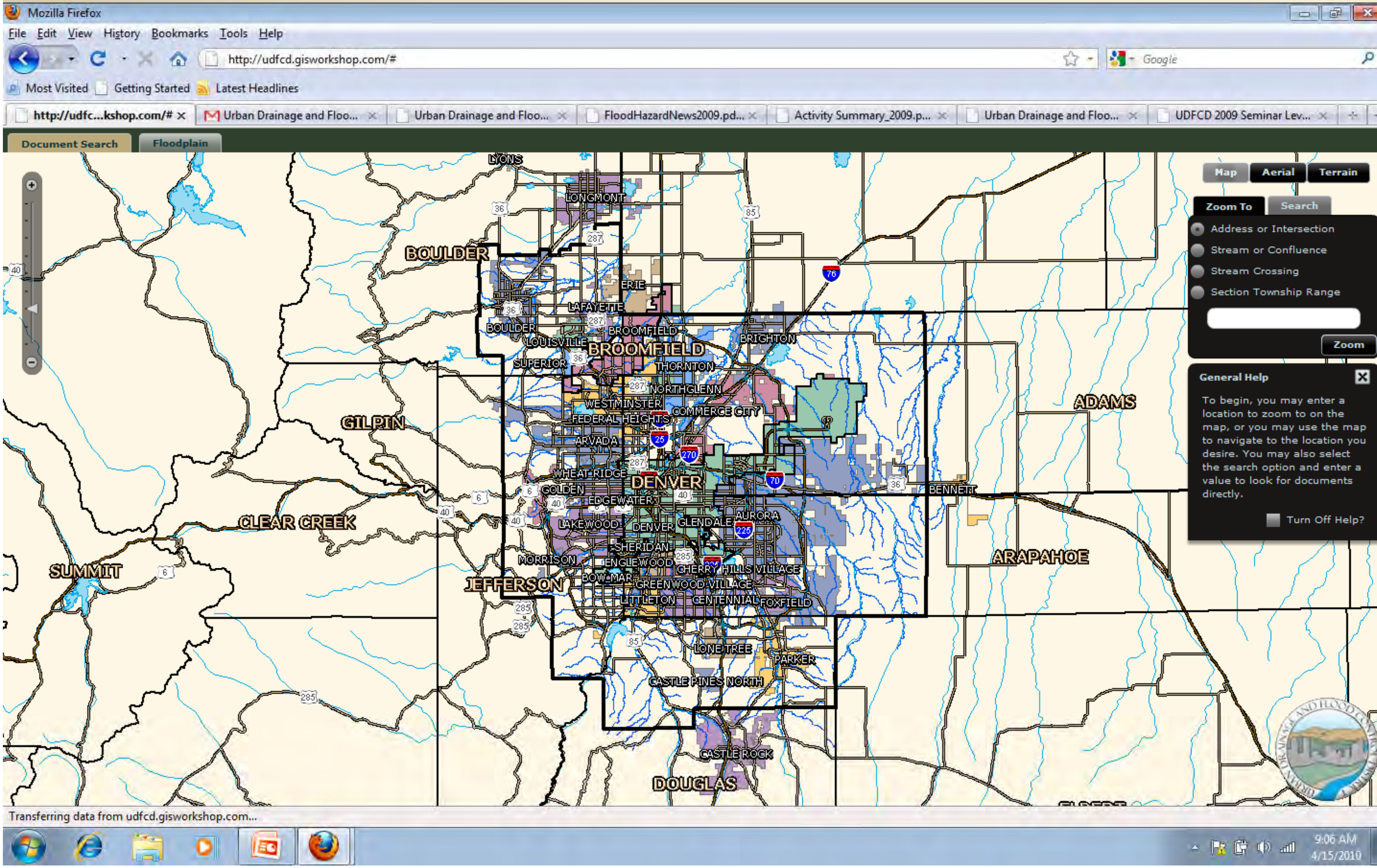
- Employ Geographic Information Systems (GIS) for effective data management
  - Spatial query for documents
  - Keyword search of metadata
  - Map navigation
- Electronic Data Management (EDM) application

Progress

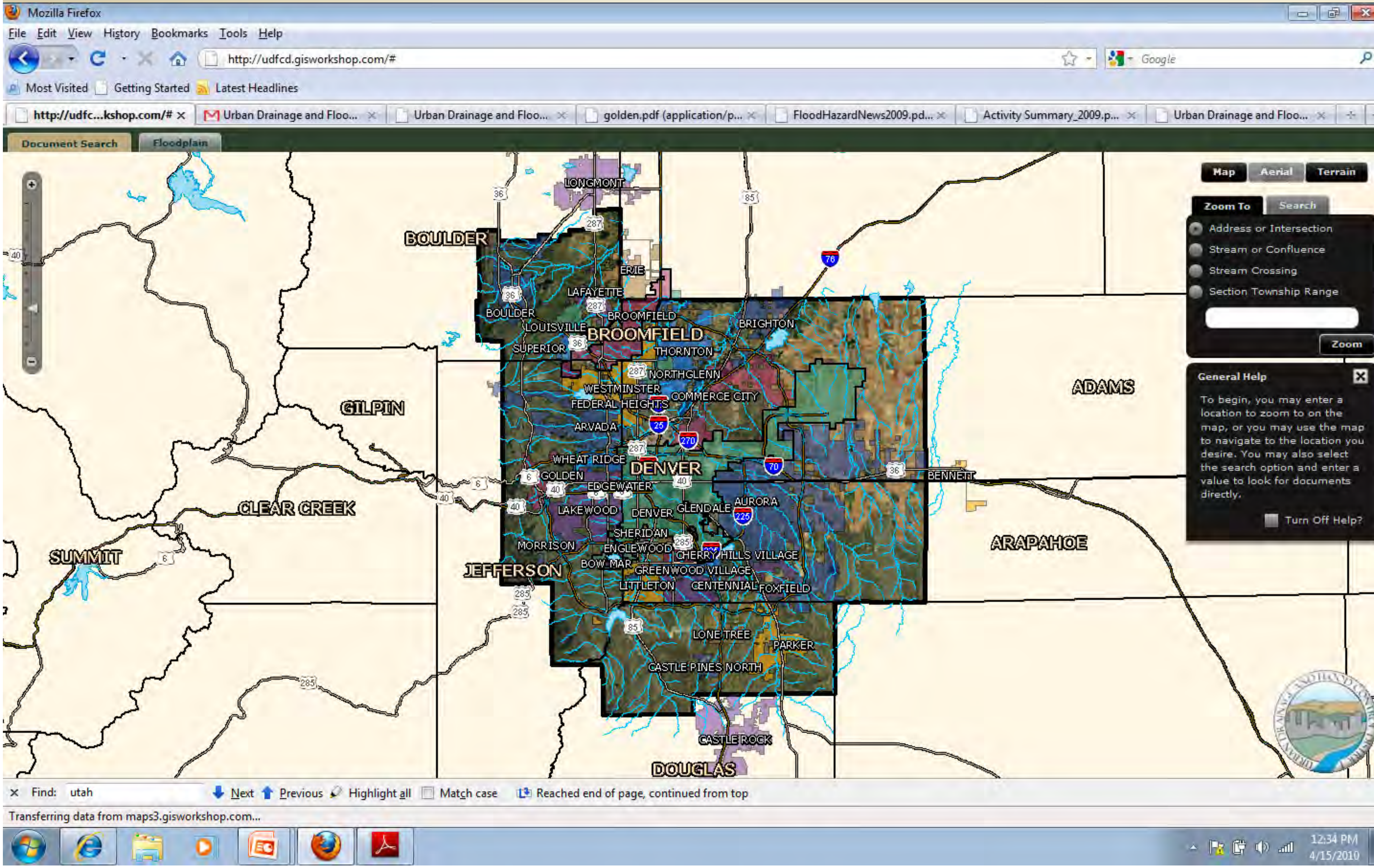
- With the help of CH2MHILL
  - Critical data layer development
  - Document organization
- Contracted GIS Workshop late in 2009
- EDM Webpage – Document Search going live
- Front page button link at udfcd.org



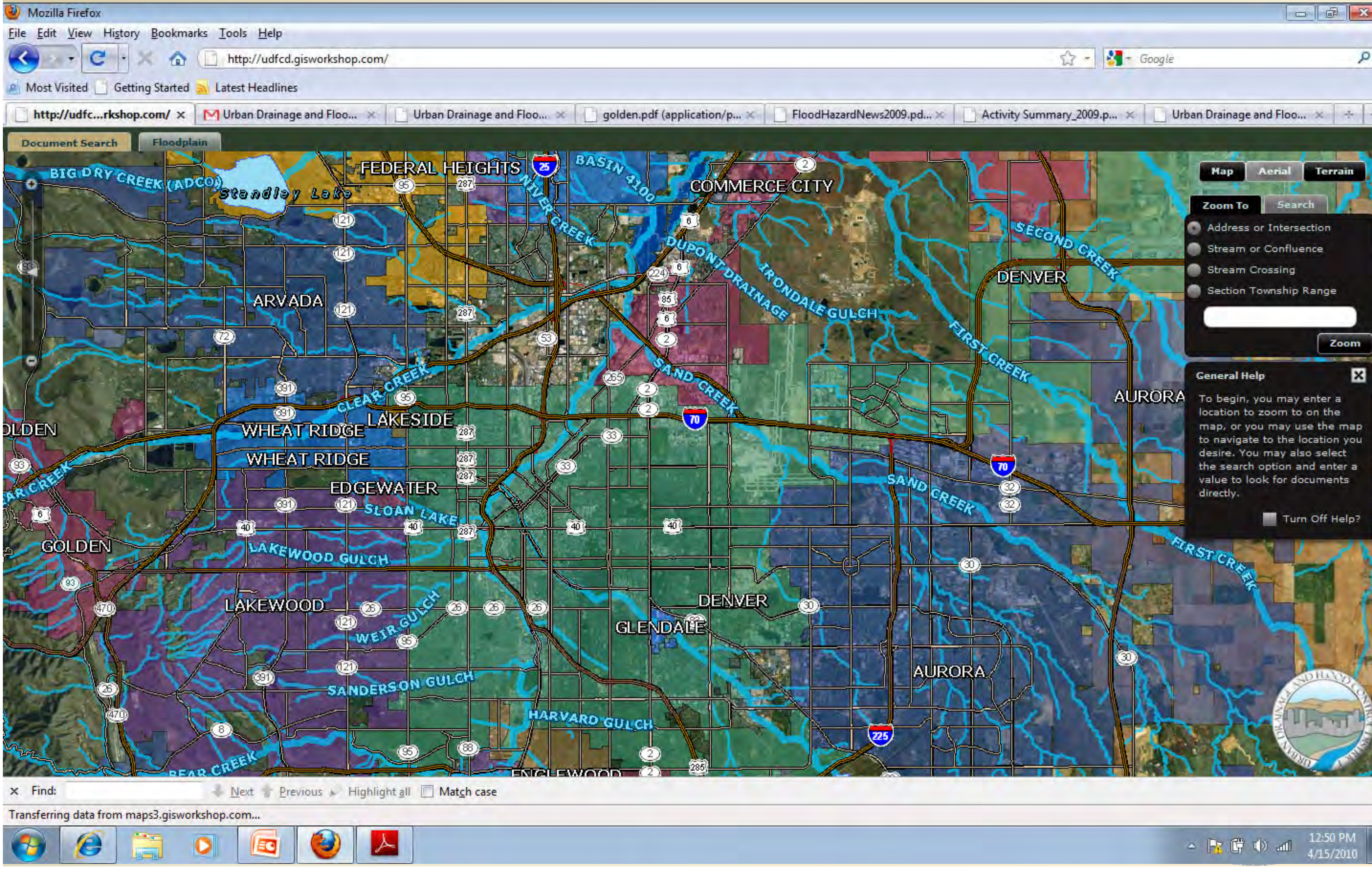
EDM First View and Tools



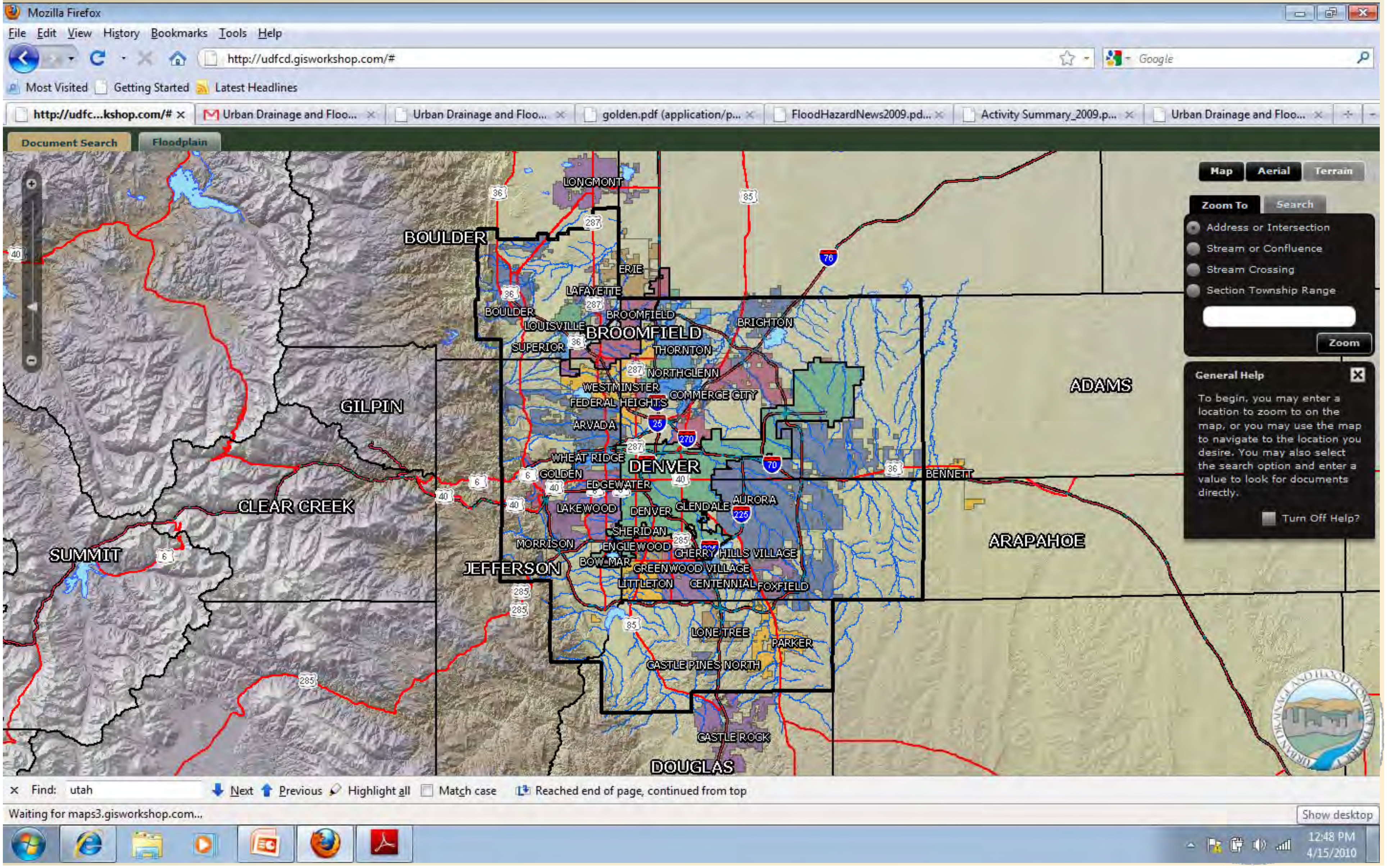
EDM Aerial View



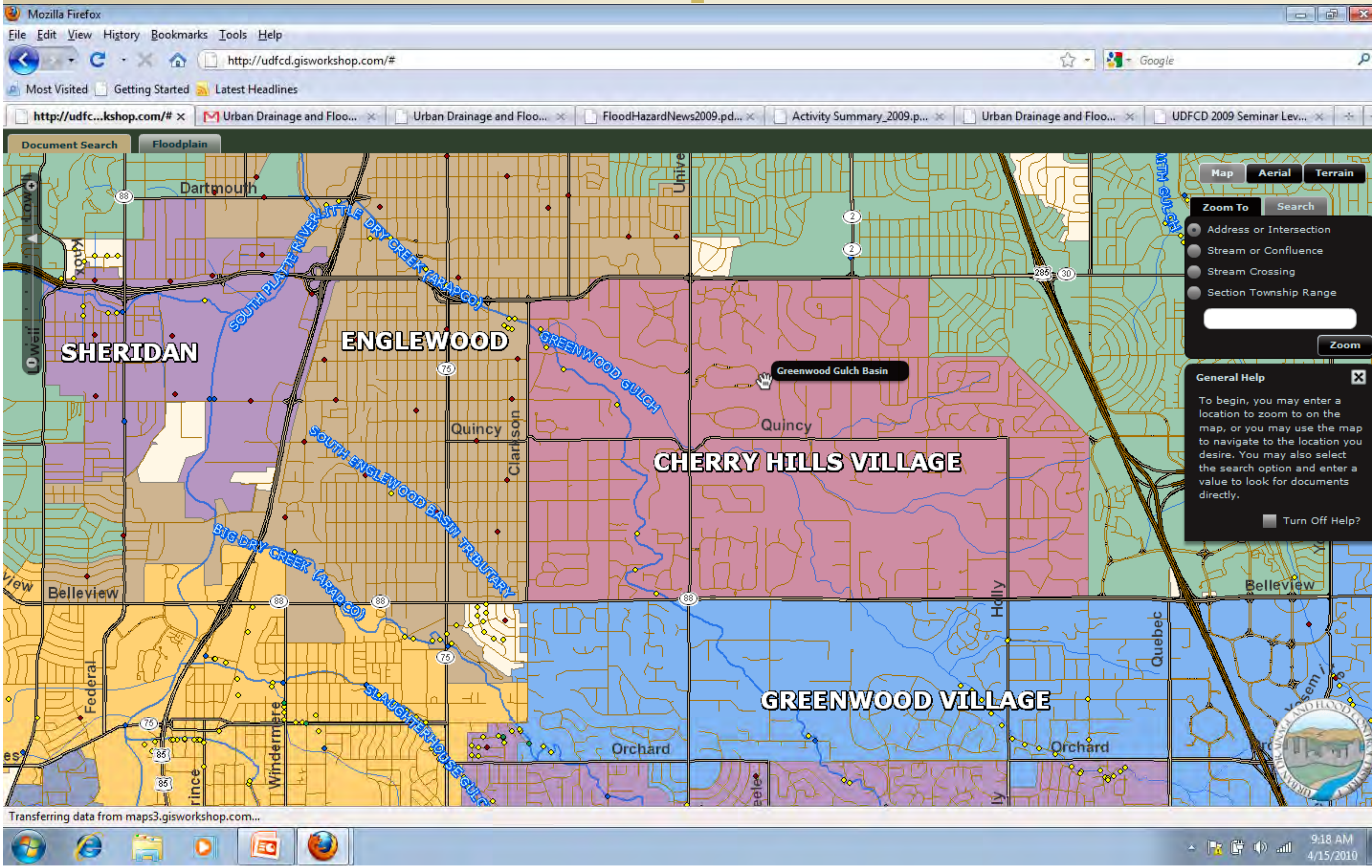
EDM Aerial View



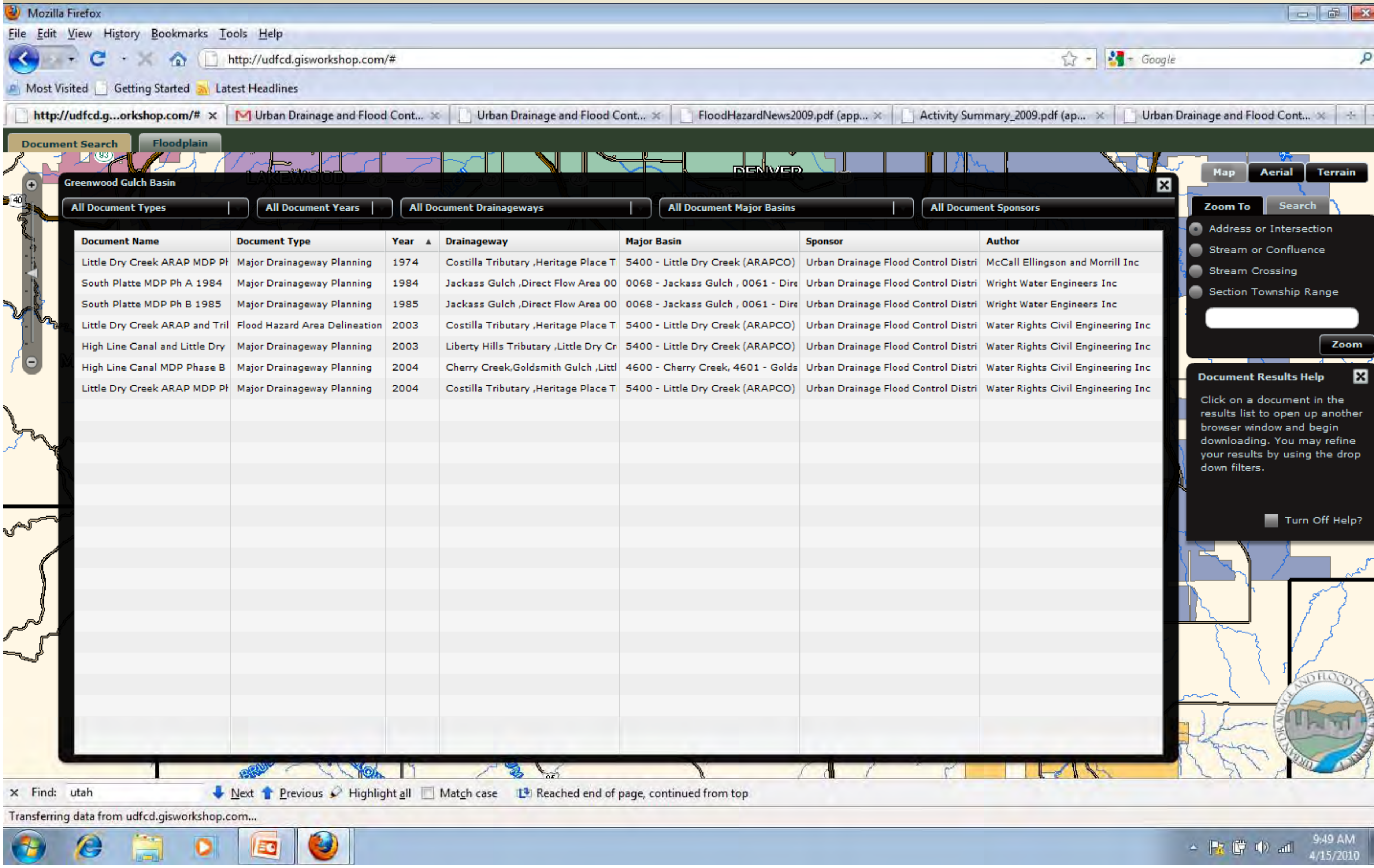
EDM Terrain View



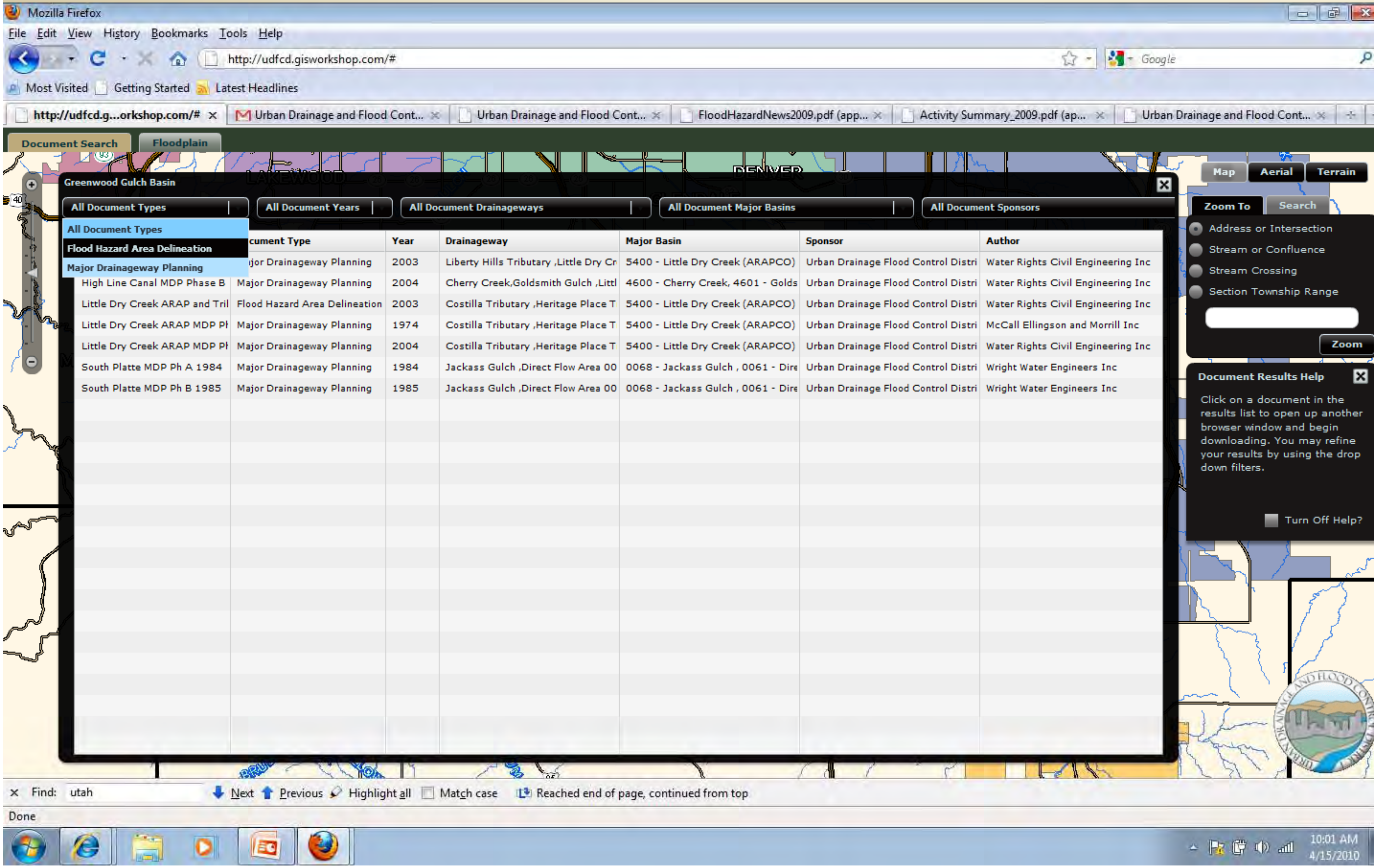
EDM Map Search



EDM Search Results



EDM Search Results



Work in Progress

- Additional data and features for the document search tab
  - Legend
  - Highlighting map features that return data
  - Clickable streams that retrieve related docs
  - Zoom to blink indicator
  - Zoom to municipality or county
  - Button to clear narrowed search results
  - Acronyms possible keyword in text search
  - "Loading …" splash screen

Future Development

- Consolidated floodplain
- Routine maintenance
  - Searchable for maintenance inspection records
- Maintenance eligibility

Consolidated Floodplain and Maintenance Eligibility Tabs

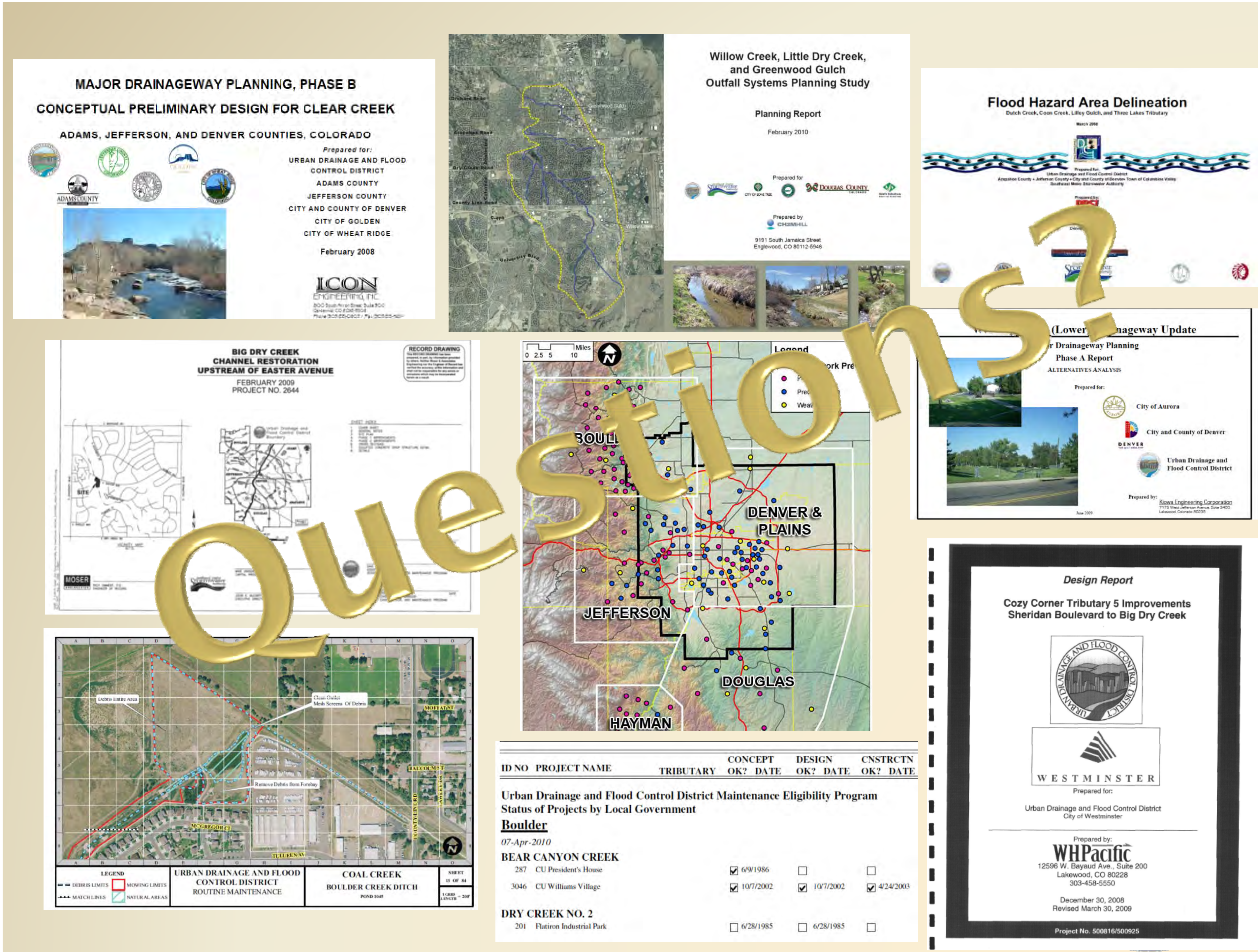
- Floodplain layer – *"unofficial"*
  - Currently available at udfcd.org in SVG or KML formats
  - Address locator
  - Transparency controlled by slider bar
- Maintenance eligibility layers
  - Acceptance symbology
  - Legend

Routine Maintenance Tab

- Display layers
  - Debris Pick-up
  - Mowing
- Record Database
- Click a feature for maintenance inspection records

Comments and Suggestions

- User feedback is always welcome and encouraged
- Please email jbailey@udfcd.org with your ideas


Questions?
MAJOR DRAINAGEWAY PLANNING, PHASE B
CONCEPTUAL PRELIMINARY DESIGN FOR CLEAR CREEK
ADAMS, JEFFERSON, AND DENVER COUNTIES, COLORADO
Prepared for:
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
ADAMS COUNTY
JEFFERSON COUNTY
CITY AND COUNTY OF DENVER
CITY OF GOLDEN
CITY OF WHEAT RIDGE
February 2008
ICON ENGINEERING, INC.
Willow Creek, Little Dry Creek, and Greenwood Gulch Outfall Systems Planning Study
Planning Report
February 2010
Prepared for
Prepared by
CH2MHILL
9191 South Jamaica Street
Englewood, CO 80112-5946
Flood Hazard Area Delineation
Dutch Creek, Coon Creek, Lilley Gulch, and Three Lakes Tributary
BIG DRY CREEK
CHANNEL RESTORATION
UPSTREAM OF EASTER AVENUE
FEBRUARY 2009
PROJECT NO. 2644
RECORD DRAWING
MOSER
Miles
0 2.5 5 10
Legend
BOULDER
DENVER & PLAINS
JEFFERSON
DOUGLAS
HAYMAN
(Lower ... nageway Update
... Drainageway Planning
Phase A Report
ALTERNATIVES ANALYSIS
Prepared for:
City of Aurora
City and County of Denver
Urban Drainage and Flood Control District
Prepared by:
Kiowa Engineering Corporation
June 2009
Debris Entire Area
Clean Outlet Mesh Screens Of Debris
Remove Debris from Forebay
MOFFAT ST
FAUCOLM ST
MCGREGOR CT
LEGEND
DEBRIS LIMITS
MOWING LIMITS
MATCH LINES
NATURAL AREAS
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
ROUTINE MAINTENANCE
COAL CREEK
BOULDER CREEK DITCH
ID NO PROJECT NAME TRIBUTARY CONCEPT OK? DATE DESIGN OK? DATE CNSTRCTN OK? DATE
Urban Drainage and Flood Control District Maintenance Eligibility Program
Status of Projects by Local Government
Boulder
07-Apr-2010
BEAR CANYON CREEK
287 CU President's House 6/9/1986
3046 CU Williams Village 10/7/2002 10/7/2002 4/24/2003
DRY CREEK NO. 2
201 Flatiron Industrial Park 6/28/1985 6/28/1985
Design Report
Cozy Corner Tributary 5 Improvements
Sheridan Boulevard to Big Dry Creek
WESTMINSTER
Prepared for:
Urban Drainage and Flood Control District
City of Westminster
Prepared by:
WHPacific
12596 W. Bayaud Ave., Suite 200
Lakewood, CO 80228
303-458-5550
December 30, 2008
Revised March 30, 2009
Project No. 500816/500925

Highlights of the Design, Construction, and Maintenance Program

David Bennetts
Laura Kroeger

Highlights of the Design, Construction, and Maintenance Program

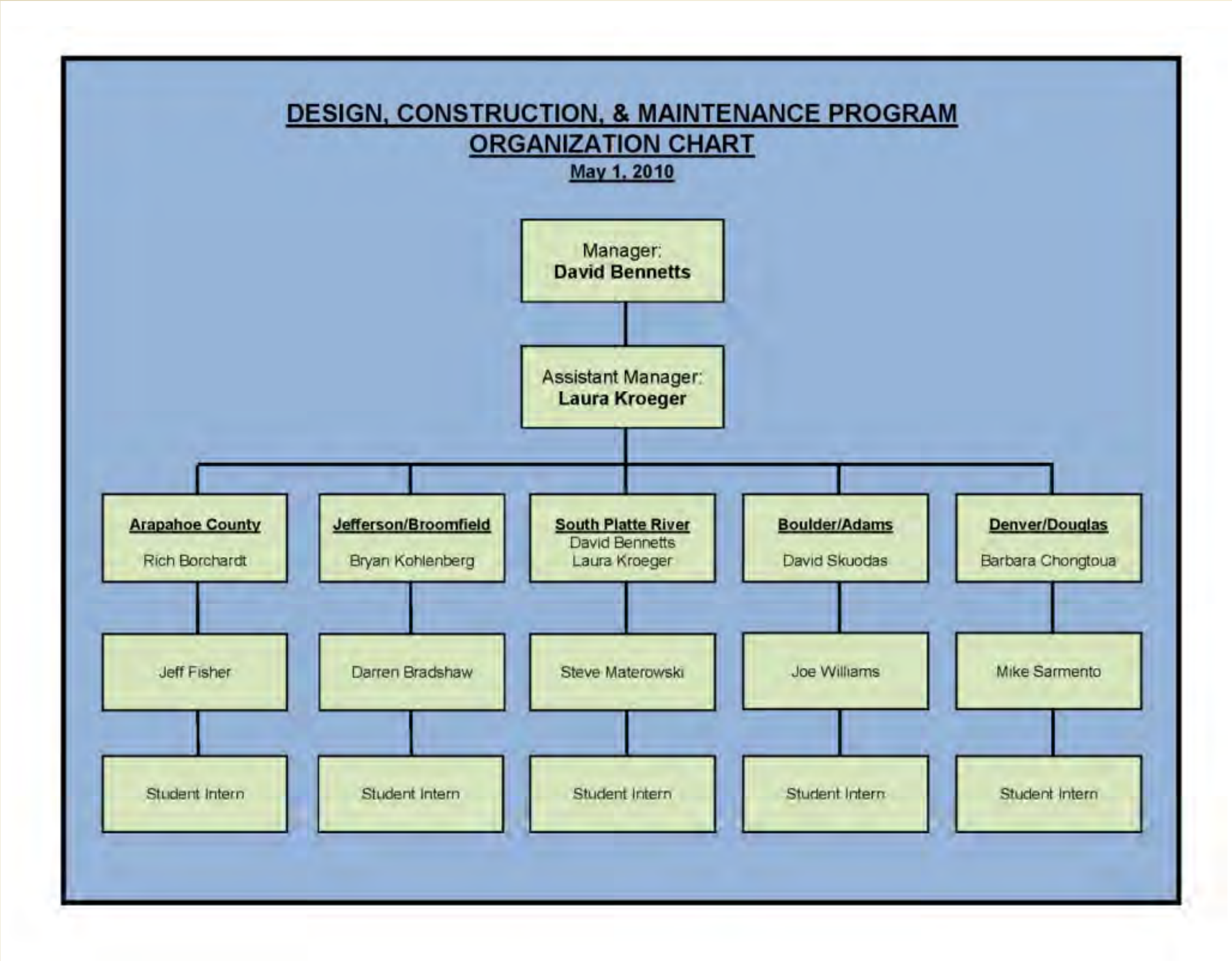
DCM Program Reorganization

Pipe Material Technical Memorandum

DCM Research Update

DCM Sustainability Efforts

Design, Construction, and Maintenance Reorganization



Storm Sewer Pipe Material Technical Memorandum Update

- Purpose of Memorandum
- New Materials Added
- Highlights of Updates
- USDCM Volume 2
- Moving Forward

Burns & McDonnell
SINCE 1898

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

Pipe Material Technical Memorandum

- Not CRITERIA
- Purpose
  - Establishes a systematic and consistent approach to pipe material selection for designers, inspectors, review agencies, and local governments
  - Provides
    - Background information and in ground history for selected materials
    - Pipe material selection guides
    - Specific design and service characteristics for each material
    - Standard specifications and details
    - Installation guide with inspection checklists

Pipe Material Technical Memorandum

- Highlights
  - Listing of Pipe Materials marketed in the Denver area that have an AASHTO and ASTM standard

    Reinforced Concrete Pipe (RCP)

    Aluminized Steel Pipe (ASP)

    Polymer Coated Steel Pipe (PCSP) – New

    Corrugated Aluminum Pipe (CAP) - New

    Polyvinyl Chloride Pipe (PVC)

    High Density Polyethylene Pipe (HDPE)

Pipe Material Technical Memorandum

- Highlights
  - Comparison Table

    Minimum – Maximum Pipe Size (Inches)

    AASHTO and ASTM Standard

    Manning's "n" Value

    Joints

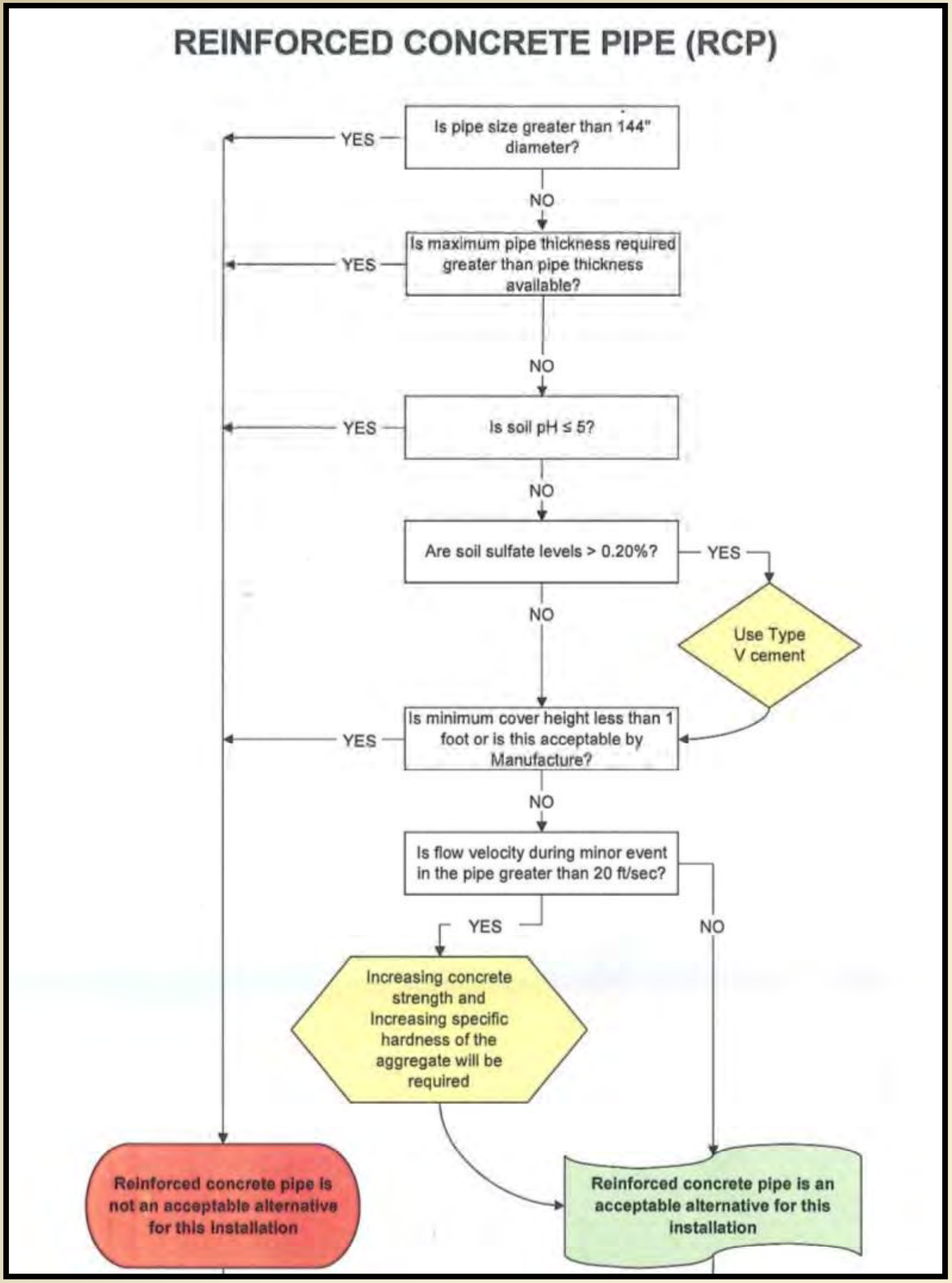
    Typical Manufactured Length (feet)

    Minimum Stiffness (psi)

    Minimum and Maximum Bury Depth (Feet)

    Chemical, Abrasion and Corrosion Resistance

    Connection



Pipe Material Selection Guide Flow Chart

Selection Questions?

Pipe greater than 144” diameter

Fill Height
Permitted by wall thickness

Soil pH

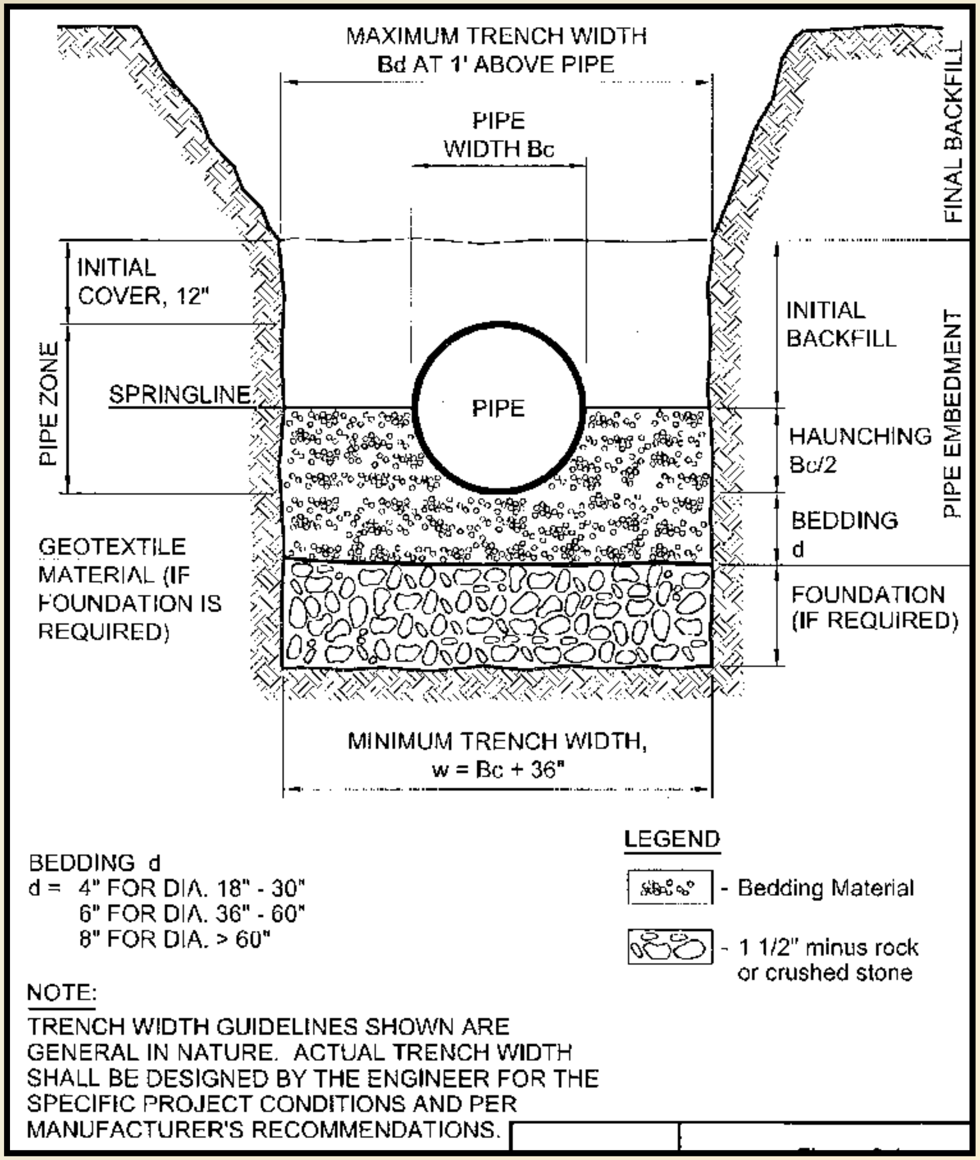
Soil Sulfate Level

Minimum Cover

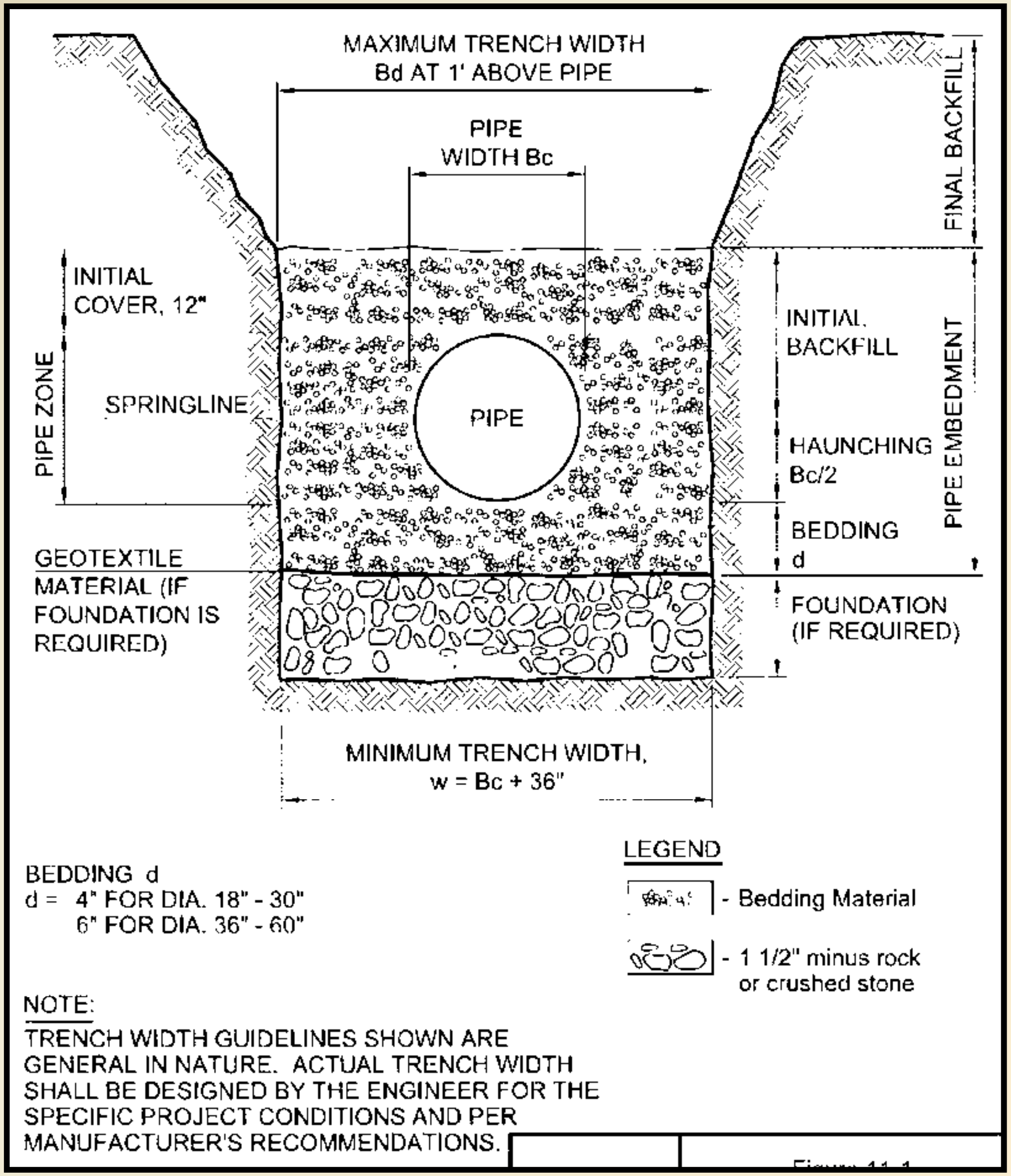
Velocity during minor event

*Acceptable, means meets AASHTO & ASTM National Standard, still needs Local Gov. or CDOT approval

Bedding Detail RCP



Bedding Detail HDPE



Pipe Material Technical Memorandum

- Highlights
  - Listing of Pipe Materials marketed in the Denver area that have AASHTO and ASTM standards
  - Pipe Material Selection Guide - Flow Chart
  - Bedding Detail
  - Follow up to case studies on
    - Reinforced Concrete Pipe (RCP)
    - High Density Polyethylene Pipe (HDPE)
    - Aluminized Steel Pipe (ASP)

Drainage Criteria Manual

- Purpose of the Criteria is to provide Minimum Standards, additional design is always encouraged

- Urban Storm Drainage Criteria Manual Volume 2 will address
  - Maximum Velocities
  - RCP is tried and true
  - Provide Bedding Detail

Moving Forward

- Memorandum will be available soon on website
- What was not done?
  - Literature search on new studies that have been completed by others since 1998
  - Did not specifically coordination with CDOT on their new Pipe Material Selection Policy, December 2009
- When will new materials get in memorandum?
  - Took 10 years to do this update…

DCM Research Update

DCM Research Update

Case Studies

Criteria

DCM Research Topics

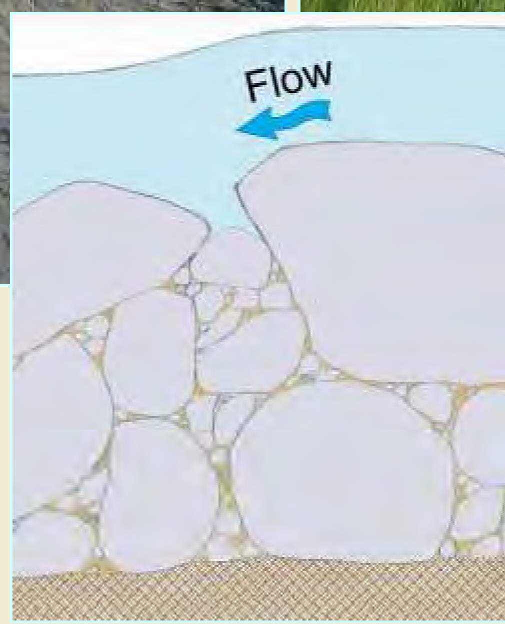
Criteria:

Void Filled Riprap
Riffle Drops
Sculpted Concrete Drop Structures

Addendum to Criteria Manual
Next Year

DCM Research Topics

Void Filled Riprap



DCM Research Topics

Riffle Drops

DCM Research Topics

Sculpted Concrete Drop Structures

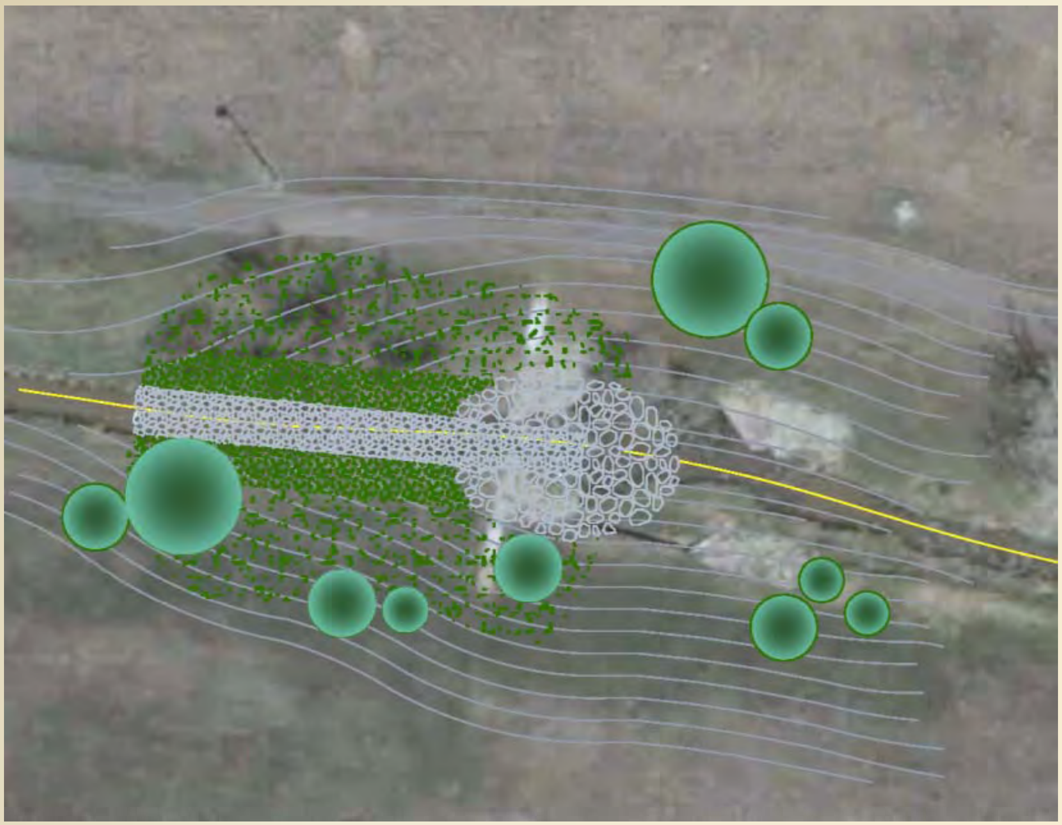
DCM Research Topics

Case Studies:

Hybrid Drop Structures
Log Drop Structures
GFRC Panels in Drops
Floating Vegetated Island
Outlet Structure Configurations

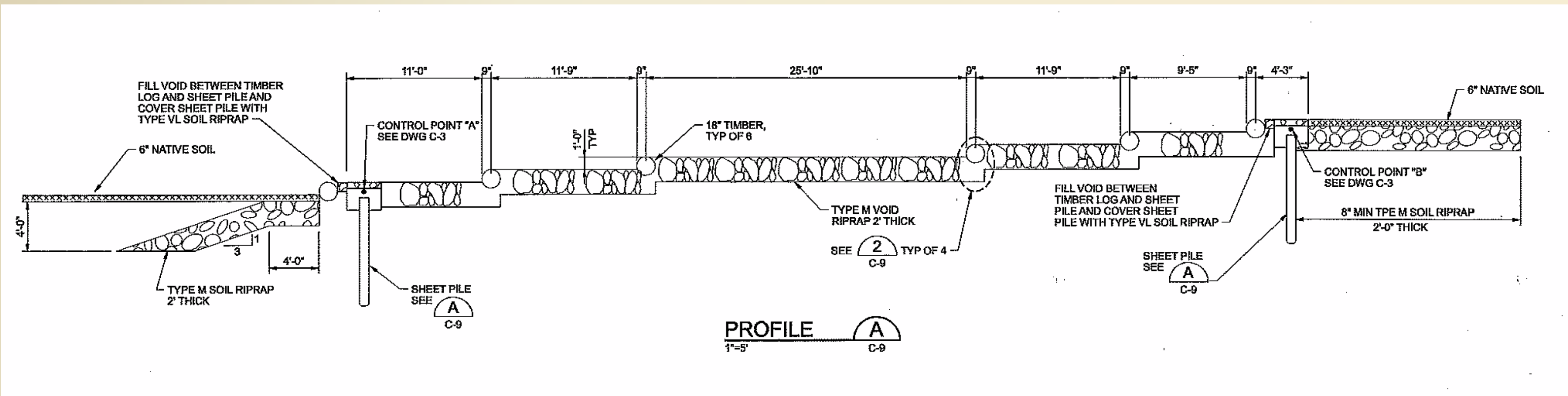
DCM Research Topics

Hybrid Drop Structures



DCM Research Topics

Log Drop Structures



DCM Research Topics

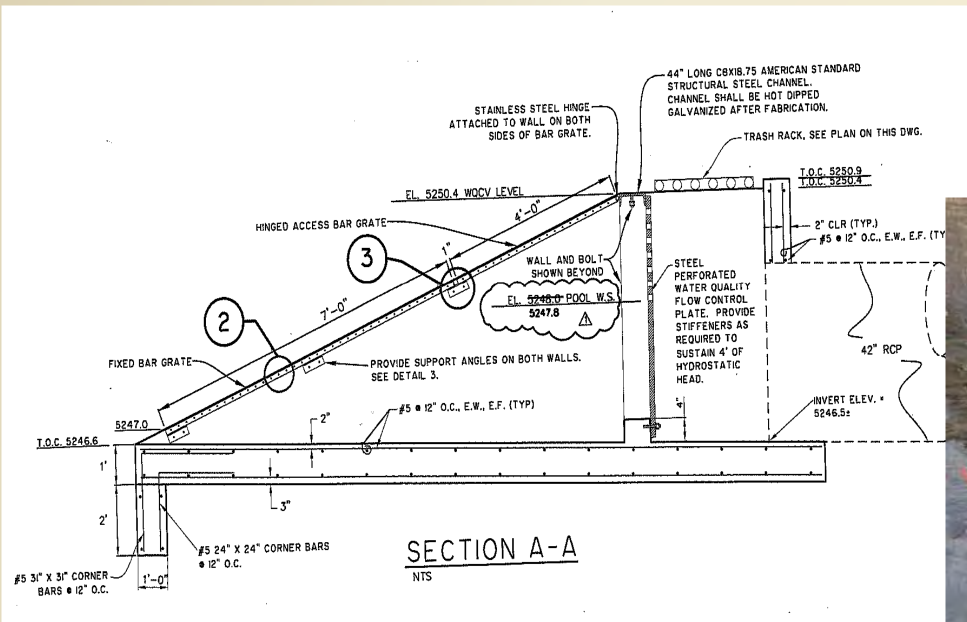
GFRC Panels in Drops

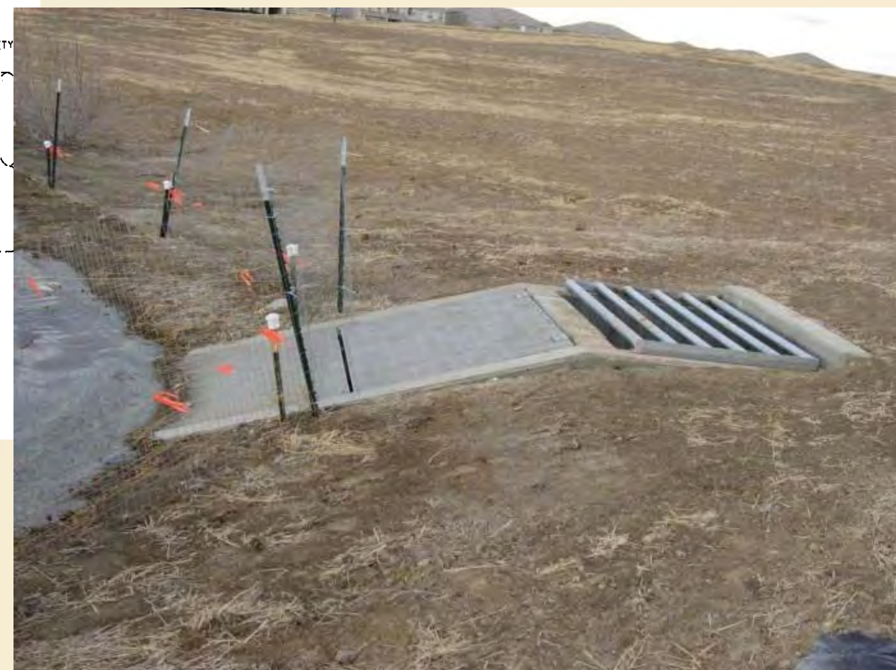
DCM Research Topics

Floating Vegetated Island

DCM Research Topics

Outlet Structure Configurations





District Sustainability

Mission Statement

Achieve a sustainable network of safe, efficient, and environmentally sensitive drainage and flood control facilities to best serve an urban community that is aware of its flood risks. Lead the region and the nation by implementing innovative thinking and technology and by promoting wise use of public and private lands, while providing unsurpassed service to the community

District Sustainability

A.S.C.E.

Sustainable civil infrastructure provides environmental, economic and social well-being, now and for the future.

A.P.W.A.

The fundamentals of sustainability center on creating balanced solutions, solutions that deliver services at levels citizens expect; doing so in an environmentally and socially responsible way and that insuring the best economic choice in the long term.

District Sustainability

Floodplain Preservation Brochure

District Sustainability

Urban Drainage and Flood Control District

SUSTAINABILITY ON A LARGE SCALE

Action: In 1972 the Board of Directors of the Urban Drainage and Flood Control District decided to pursue a two-pronged approach of remedial and preventive actions to contain flood losses.

Outcome: The population of the District has tripled since the action described above but there are 5000 fewer structures (units) in the mapped 100-year floodplains than there were in 1970.

April, 2010

Introduction
In 1965 the Denver metropolitan area was hit with a devastating flood on the South Platte River. Following the flood an organization of county engineers began meeting to find ways to address drainage problems that crossed jurisdictional boundaries. By 1969, they had enlisted an influential state senator to draft and introduce the Urban Drainage and Flood Control Act in the Colorado General Assembly. The story goes that the act was stuck in a committee and likely headed for defeat when the 1969 South Boulder Creek flood occurred in Boulder. Following that event the legislation passed.

The legislation established the Urban Drainage and Flood Control District for the purpose of assisting local governments in the Denver metropolitan area with multi-jurisdictional drainage and flood control problems. The District boundaries have changed since the original legislation, and it now covers an area of 1608 square miles and includes Denver, parts of the 6 surrounding counties, and all or parts of 33 incorporated cities and towns. There are about 1600 miles of "major drainageways" which are defined as draining at least 1000 acres. The population of the District is approximately 2.7 million people.

Governing Body
The District is an independent agency governed by a twenty-three member Board of Directors. The make-up of the Board is unique, in that twenty-one members are locally elected officials (mayors, county commissioners, city council members) who are appointed to the board. These twenty-one members select two registered professional engineers to fill out the Board.

Funding
District funds come from four different property tax mill levies. The mill levies are earmarked for specific programs that are detailed in the following sections. The total mill levy cannot exceed one mill.

Staff
The concept of the District is to keep the staff small and to utilize private consultants and contractors as much as possible. As a result the District operates a $22 million annual program with only 23 full time employees and 8 part-time college student interns. The staff is responsible for management of all project funds; supervision of all work done by consulting engineers; and coordination of all planning, design, construction and floodplain management efforts with local governments.

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."

Programs
The District operates four programs: Master Planning; Floodplain Management; Design, Construction and Maintenance; and Information Services and Flood Warning. A brief description of each program is provided later.

APWA Framework for Sustainability

DCM Sustainability Efforts

Routine Maintenance

DCM Sustainability Efforts

Routine Maintenance

DCM Sustainability Efforts

DCM Sustainability Efforts

DCM Sustainability Efforts

DCM Sustainability Efforts

Post-Construction BMPs

Holly Piza, P.E.

Chapter 4, Treatment BMPs

Overview	Grass Swale	Grass Buffer	Constructed Wetland Channel	Permeable Pavement (no storage)	Permeable Pavement (with storage)	Bioretention	Extended Detention Basin	Sand/Media Filter Extended Detention	Retention	Constructed Wetland Basin	Green Roof	Underground BMPs
Functions												
Pretreatment	●	●	●	○	○	○	○	○	○	○	◐	●
LID/Volume Red.	◐	◐	◐	●	●	●	◐	●	◐	●	●	○
WQCV	○	○	○	○	●	●	●	●	●	●	◐	Var.
WQCV+Detention	○	○	○	○	●	●	●	●	●	●	○	○
Typical Effectiveness for Targeted Pollutants												
Sediment/Solids	◐	◐	◐	◐	◐	●	●	●	●	●	◐	Var.
Nutrients	◐	◐	◐	◐	◐	●	◐	◐	●	◐	◐	Var.
Total Metals	◐	◐	◐	◐	◐	●	◐	●	●	◐	◐	Var.
Bacteria	○	○	◐	○	○	◐	○	◐	◐	◐	○	○

● Good—Capable of serving function and BMP is generally effective for removing targeted pollutant.

◐ Moderate—Provides moderate function or pollutant removal.

Var. = Highly variable based on the design or device.

○ Poor—Does not provide function. Pollutant removal effectiveness not demonstrated by data.

Grass Swale

Increase Flexibility while
Maintaining Existing Criteria

Design Summary				
Design Flow	Residence Time	Maximum Froude Number	Maximum Velocity	Maximum Flow Depth
2-year event	5 Minutes*	0.5	1 fps	1 foot

Grass Buffer

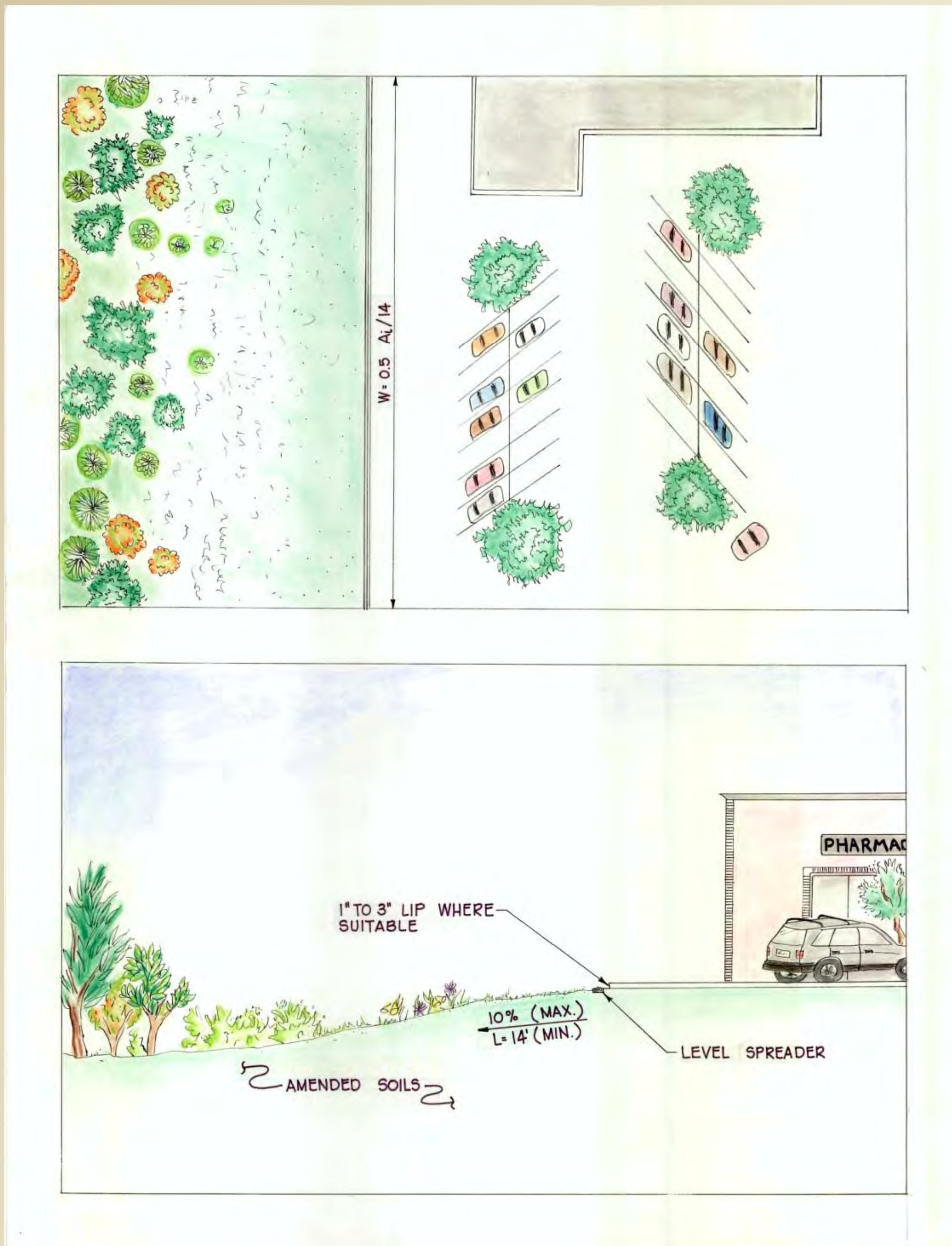


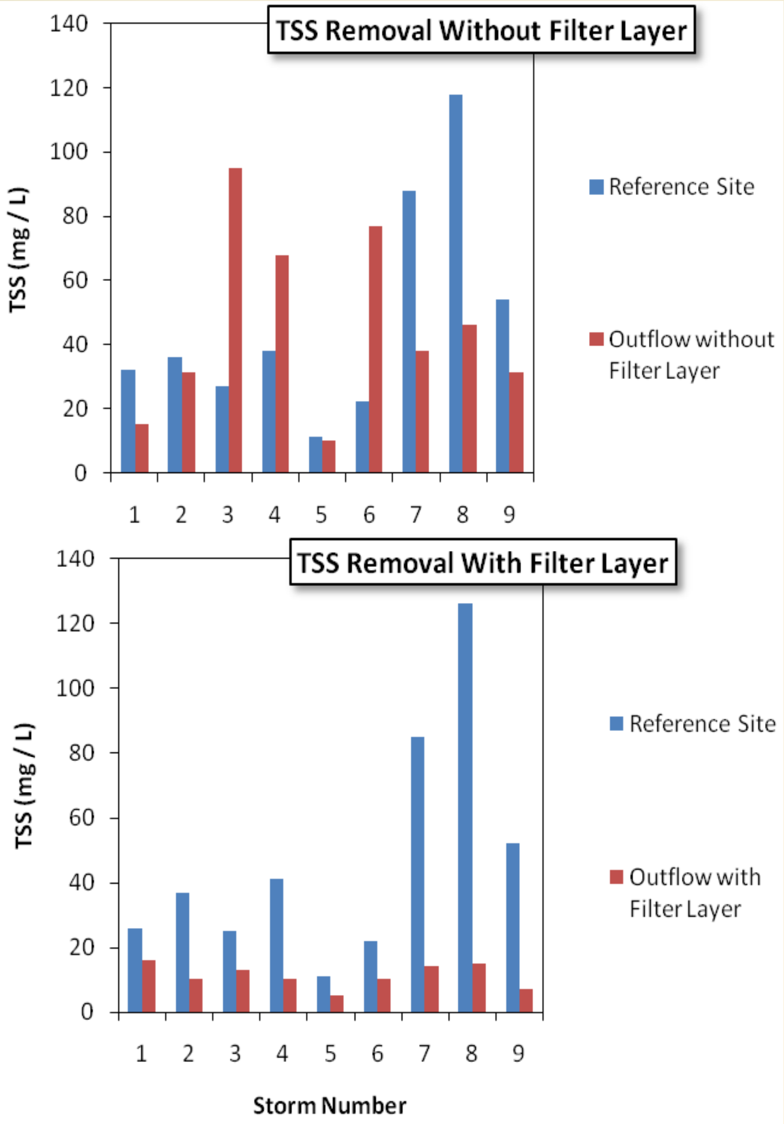
Photo Courtesy Muller Engineering

Simplify the Design

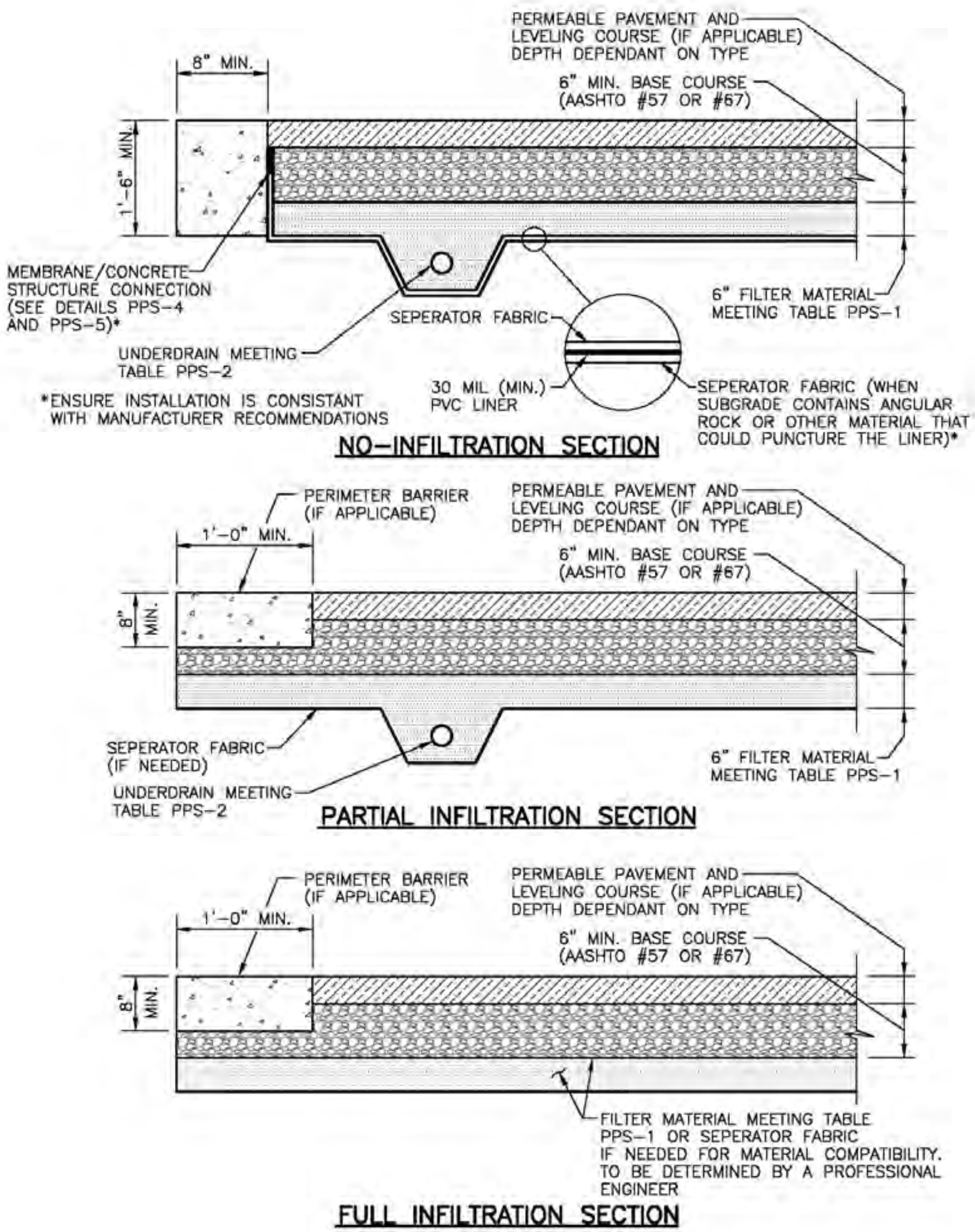
Include Guidance for When a Level Spreader may be Needed

Permeable Pavement Systems

Photo Courtesy SEH



Filter and Drain Design



Class C Filter Material

Sieve Size	Mass Percent Passing Square Mesh Sieves
19.0 mm (3/4")	100
4.75 mm (No. 4)	60 – 100
300 µm (No. 50)	10 – 30
150 µm (No. 100)	0 – 10
75 µm (No. 200)	0 - 3

Slotted Pipe Dimensions

Pipe Size	Slot Length	Slot Width	Slot Centers	Open Area
4"	1-1/16"	.031"	.413"	1.90
6"	1-3/8"	.031"	.516"	1.98

Filter and Drain Design

U.S. Army et al (1971)

$$\frac{D85}{Slot\ Width} > 1.2$$

U.S. Bureau of Reclamation (1973)

$$\frac{D85}{Slot\ Width} > 2$$

Class C Filter Material
D85 (min) = 2.60 mm
D85 (max) = 11.00 mm

Maximum acceptable slot width based on U.S. Reclamation criteria is 0.051″

Sand Filters

Photo Courtesy Fred Bromberger

Bioretention (Rain Gardens or PLDs)

Bioretention

Why not Peat?

- Environmental Impacts
- Peat is not produced in Colorado

Why Paper?

- Compost alone leaches more nutrients than desired
- Paper captures nutrients from the compost for slow release to roots
- Paper temporarily slows the infiltration rate of the media and retains moisture

Extended Detention Basin (EDB)

- Expand criteria for various size EDBs
  - Primarily related to forebay size, depth and outlet into the trickle channel
- Include guidance on Full Spectrum Detention
  - Includes integration with UD-BMP
- Increase Flexibility
  - Guidance on Soft Bottom Trickle Channels and Micropools

Extended Detention Basin (EDB)

Most Common Mistakes

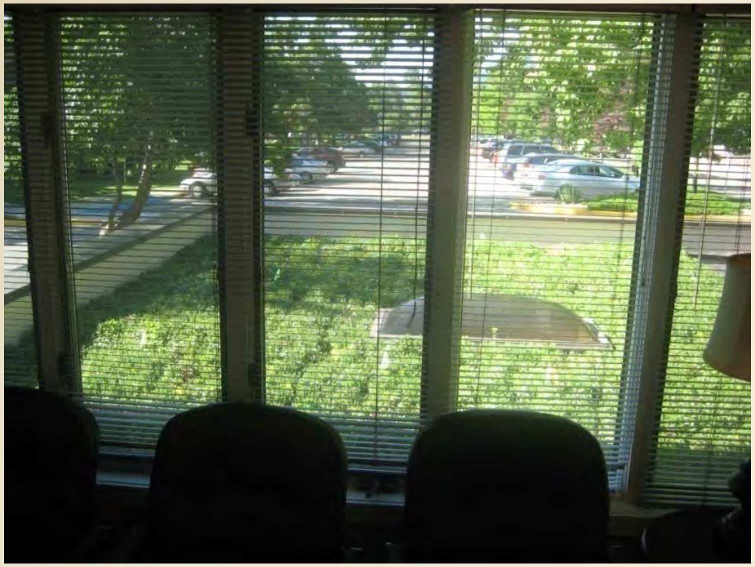
- No micropool
- Well Screen does not extend into the micropool
- No bottom Stage (initial surcharge volume)

Full Spectrum Detention

Most Common Misconceptions

- Does not result in a larger pond
- UDFCD does not recommend adding part or all of the WQCV (or the EURV) to the 100-yr detention volume
- Recommended drain times are approximate
- Specific design for metering other storm events is not necessary

Green Roofs



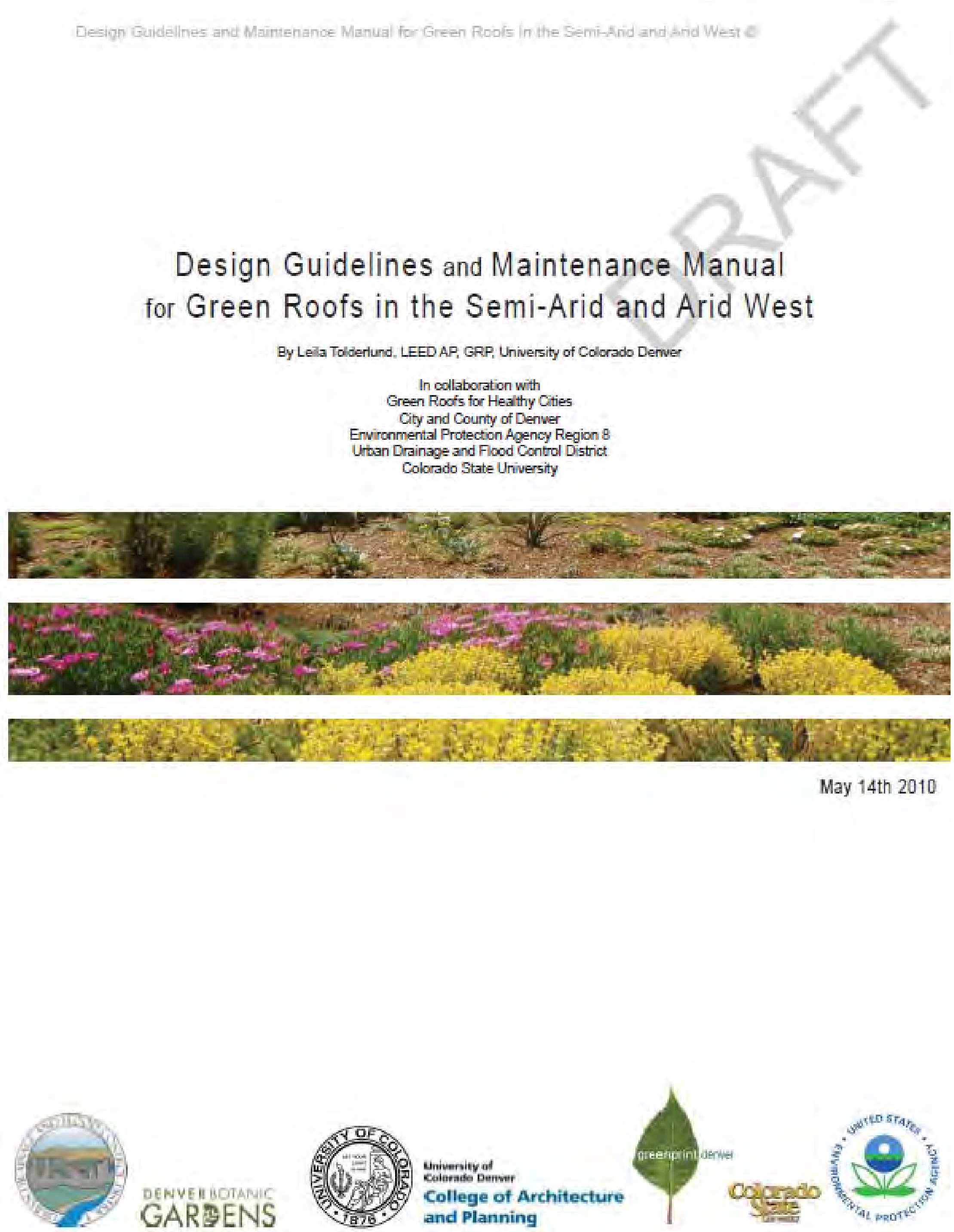
Green Roofs

Design and Maintenance Guidelines for Green Roofs in the Arid and Semi-Arid West

Includes a quote from EPA, Region 8 on using green roofs to satisfy capture of the WQCV

Contains over a dozen Denver area green roofs case studies including:

- Residential (SF and MF)
- Commercial
- Municipal
- Federal



Design Guidelines and Maintenance Manual for Green Roofs in the Semi-Arid and Arid West ©

DRAFT

Design Guidelines and Maintenance Manual for Green Roofs in the Semi-Arid and Arid West

By Leila Tolderlund, LEED AP, GRP, University of Colorado Denver

In collaboration with
Green Roofs for Healthy Cities
City and County of Denver
Environmental Protection Agency Region 8
Urban Drainage and Flood Control District
Colorado State University

May 14th 2010

Underground BMPs

- Not all BMPs are created equal
- Why underground BMPs have not previously been included
- When should underground BMPs be considered
- Guidance on evaluating data
  - TARP Tier 2 (field data)
  - What's included:

Monitoring Plan Element
Number of storm events
Parameters
Quality Assurance/Quality Control (QA/QC)—monitoring plan
QA/QC—laboratory analyses
Representativeness—sampling method
Representativeness—storm characteristics
Representativeness—precipitation depth
Representativeness—antecedent dry period
Data Analysis

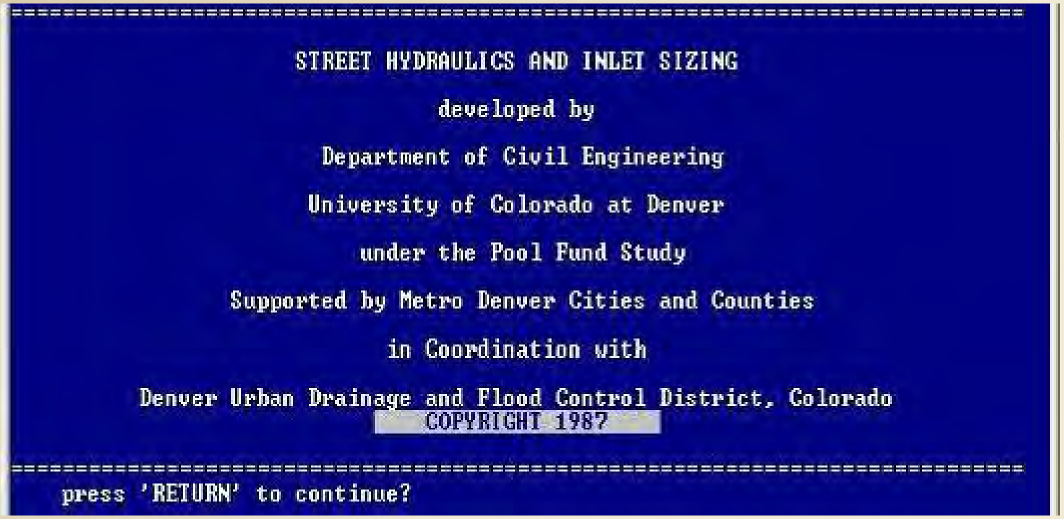
Thank you!

¿Questions?

The UDFCD Street Inlet Study

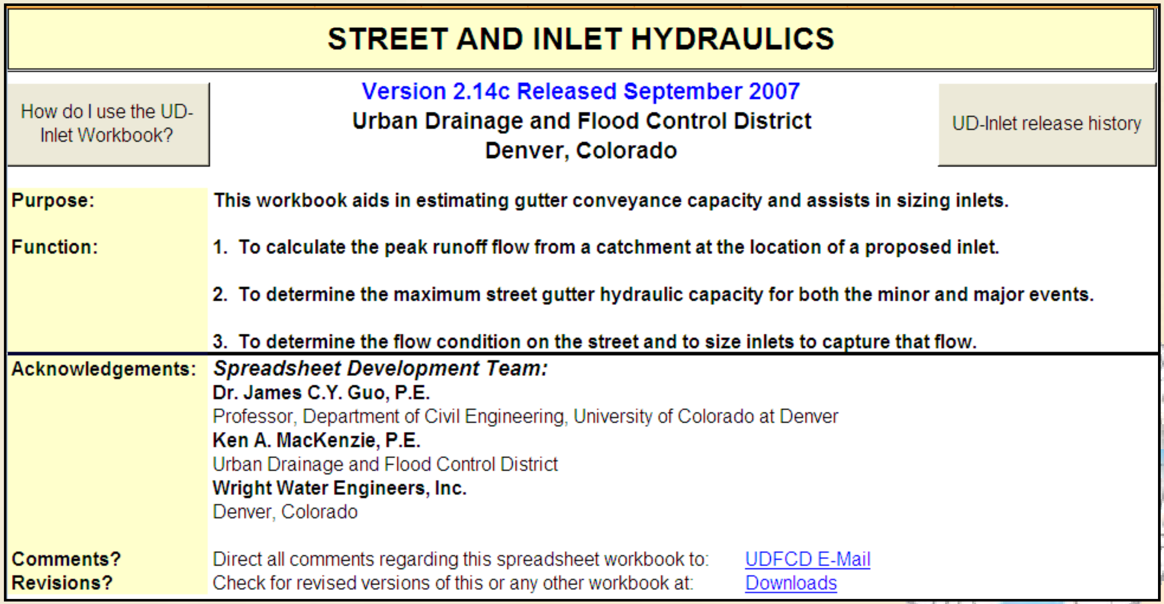
Ken MacKenzie, P.E., CFM
Urban Drainage and Flood Control District
and
James C.Y. Guo, PhD & P.E.
University of Colorado Denver

A Little History…



In 2001 we converted the 1987 UD-Inlet computer program to an Excel-based application.

The performance parameters and math came from the FHWA HEC-22 publication.


STREET AND INLET HYDRAULICS

How do I use the UD-Inlet Workbook?

Version 2.14c Released September 2007
Urban Drainage and Flood Control District
Denver, Colorado

UD-Inlet release history

Purpose:	This workbook aids in estimating gutter conveyance capacity and assists in sizing inlets.
Function:	1. To calculate the peak runoff flow from a catchment at the location of a proposed inlet. 2. To determine the maximum street gutter hydraulic capacity for both the minor and major events. 3. To determine the flow condition on the street and to size inlets to capture that flow.
Acknowledgements:	*Spreadsheet Development Team:* **Dr. James C.Y. Guo, P.E.** Professor, Department of Civil Engineering, University of Colorado at Denver **Ken A. MacKenzie, P.E.** Urban Drainage and Flood Control District **Wright Water Engineers, Inc.** Denver, Colorado
Comments? Revisions?	Direct all comments regarding this spreadsheet workbook to: UDFCD E-Mail Check for revised versions of this or any other workbook at: Downloads

A Little History…

HEC-22 came from HEC-12.

HEC-12 came from a 1977 Physical model study.

“Someone” questioned the validity of the underlying assumptions we borrowed from FHWA HEC-22.

Publication No. FHWA-NHI-01-021
August 2001

U.S. Department
of Transportation

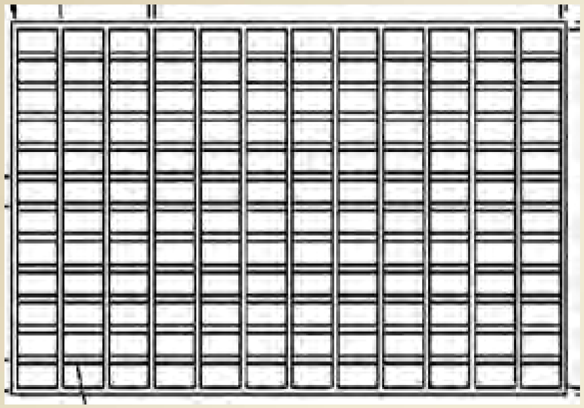
Federal Highway Administration

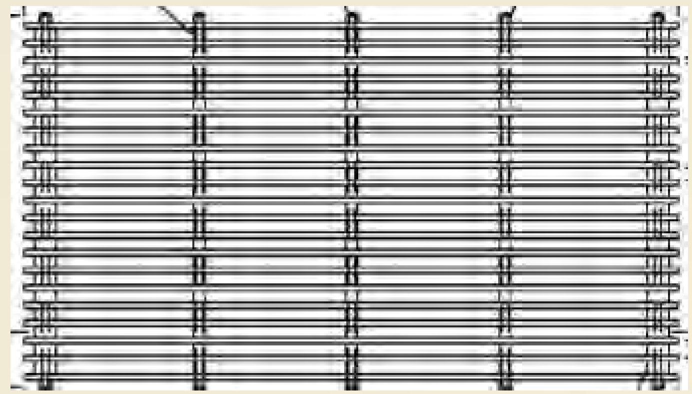
Drainage of Highway Pavements
HEC 12
March 1984

Hydraulic Engineering Circular No. 22, Second Edition

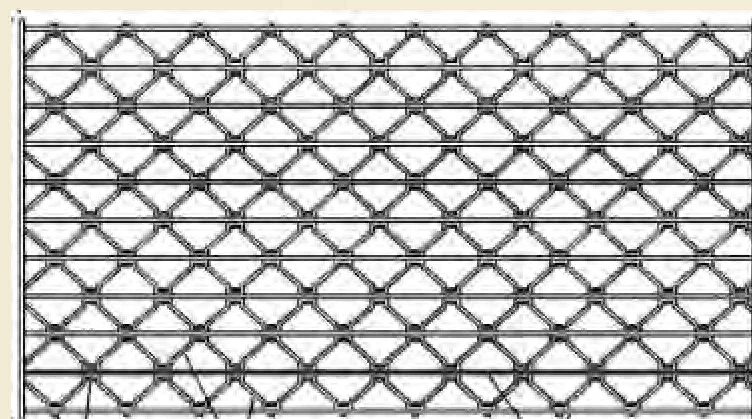
URBAN DRAINAGE DESIGN MANUAL

A Little History…





These inlet grates just don't look like the inlets we most commonly use today…at least on the Colorado front range.



A Little History…

These are what most of us use around here.

A Little History…

Our inlets are not those for which the FHWA (or anyone else) has data.

Which means we don't know the level of risk we are assuming with our inlet sizing:

- Are we under-sizing, therefore taking on unnecessary risk?
- Or, are we over-sizing, therefore spending unnecessary tax dollars on inlets?

A Little History…

So how do we get from here…

Publication No. FHWA-NHI-01-021
August 2001

U.S. Department
of Transportation

Federal Highway Administration

Hydraulic Engineering Circular No. 22, Second Edition

URBAN DRAINAGE DESIGN MANUAL

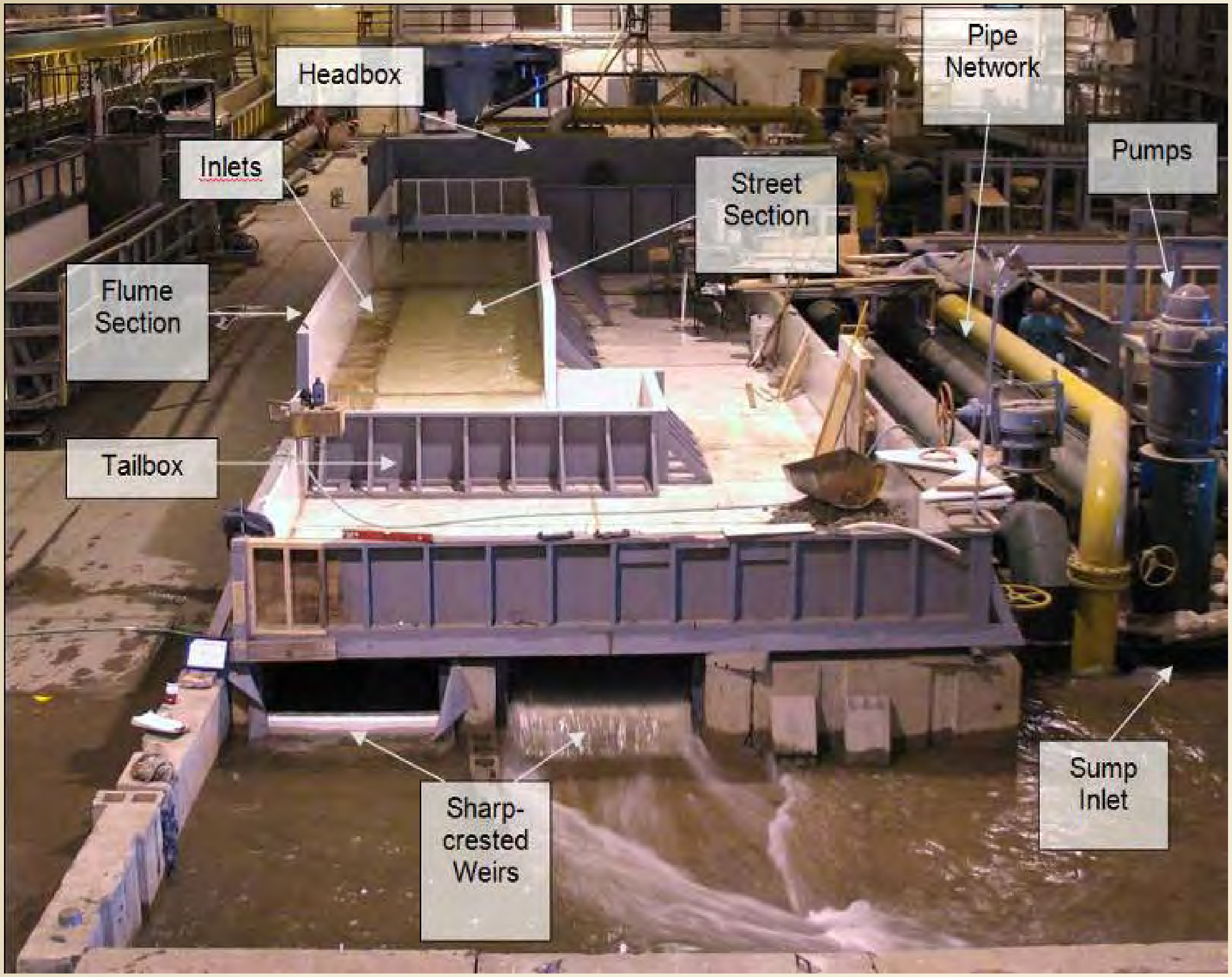
To here?

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

We Need Research Study - - $$$

UDFCD	$75,000
CDOT	$40,000
Denver	$20,000
Adams County	$10,000
Arapahoe County	$10,000
Arvada	$10,000
Douglas County	$10,000
Jefferson County	$10,000
Boulder	$5,000
Golden	$5,000
Lafayette	$5,000
Lakewood	$5,000
Littleton	$5,000
Lone Tree	$2,500
TOTAL	**$212,500**

We build a model.



Circulation System
Flow Measurement

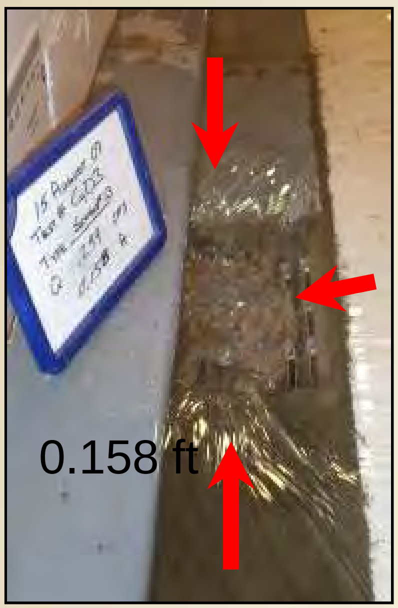
Sump Inlet
100% collection

On-grade Inlet
Collection vs Bypass

Scale?

1/3 Scaled Model Inlets

Changes of Flow Pattern on Type 13 Bar Grate



Weir Flow

Mixing Flow

Orifice Flow

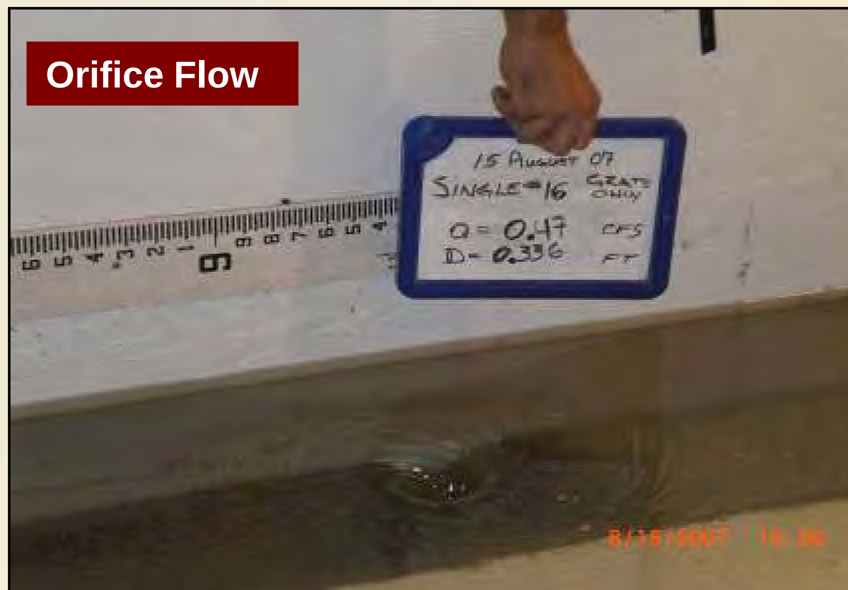
Orifice +Vortex Flow

Observation of Type 13 Inlet Hydraulics in Field

Changes of Flow Pattern on Type 16 Grate Inlet

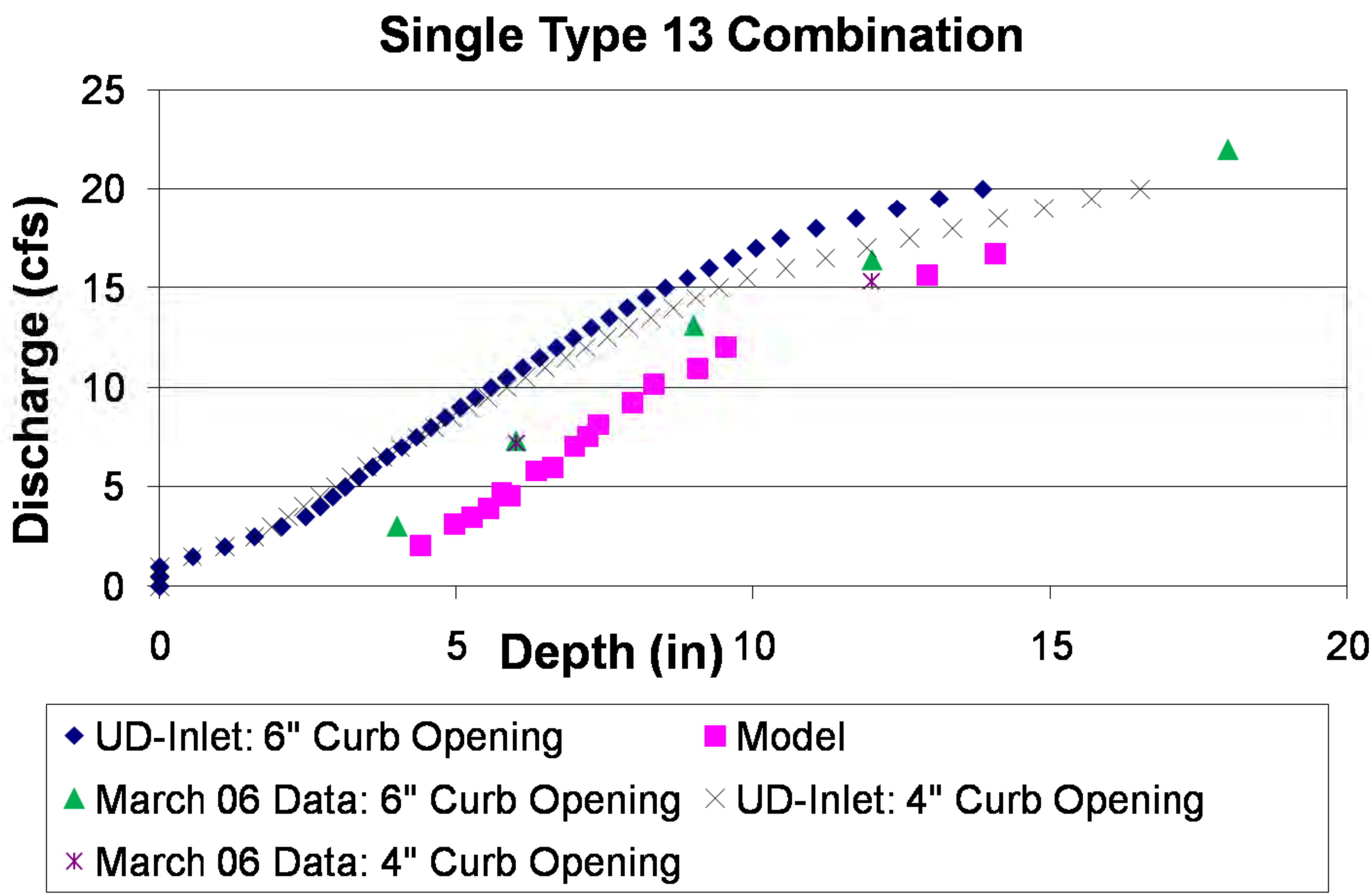
Weir Flow

Mixing Flow

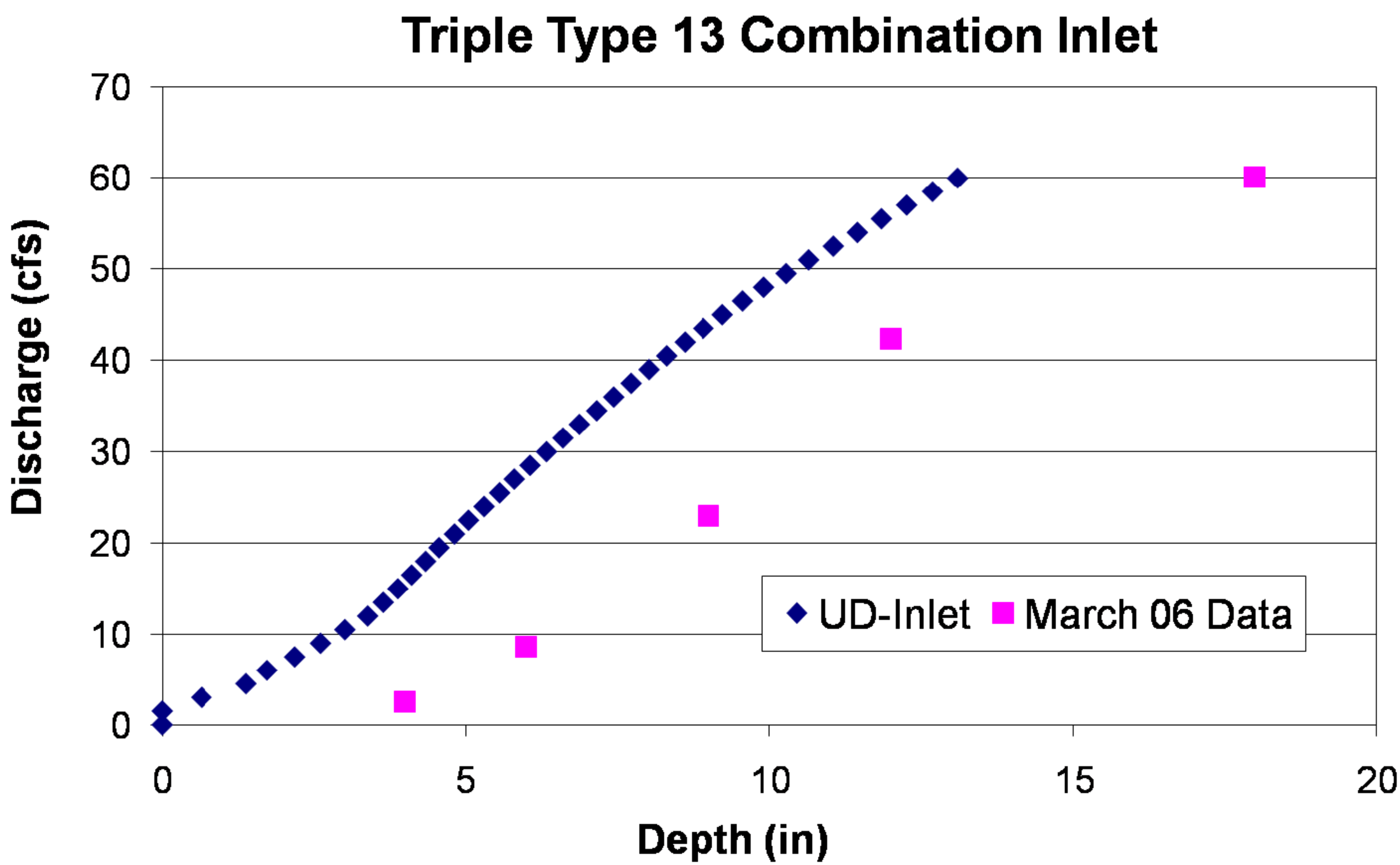


Orifice Flow

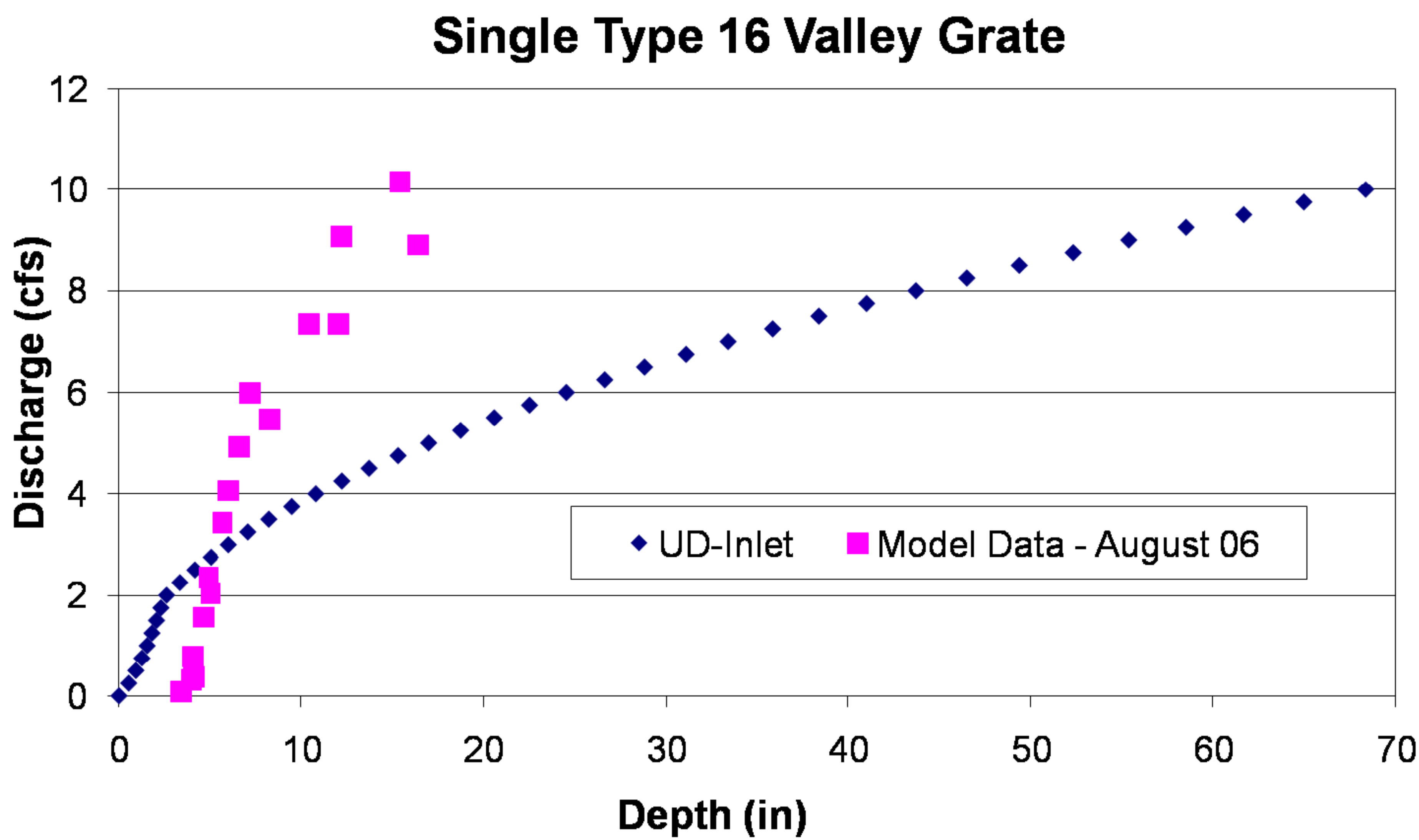
Observed vs. UD-Inlet: Sump



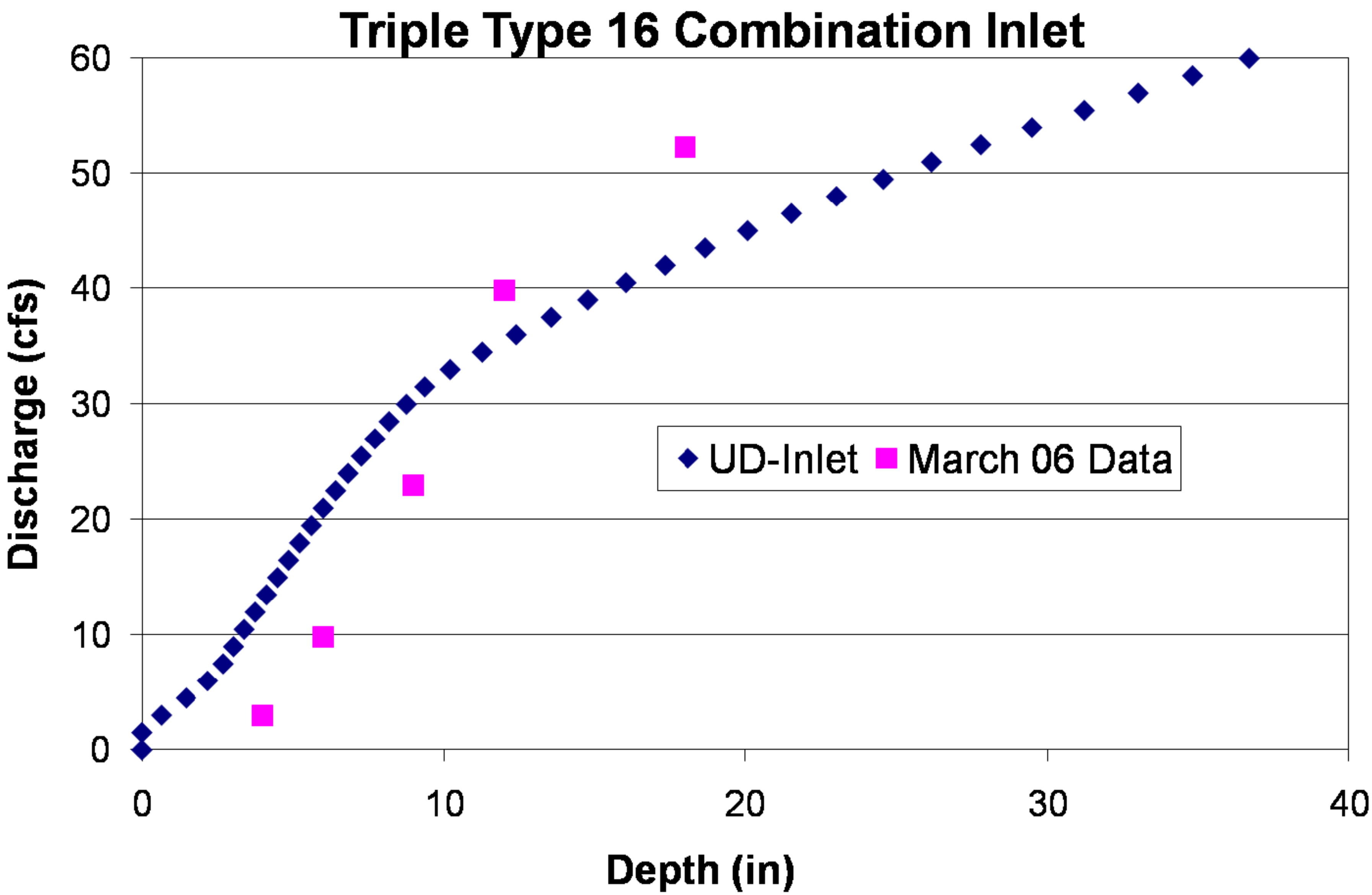
Observed vs. UD-Inlet: Sump



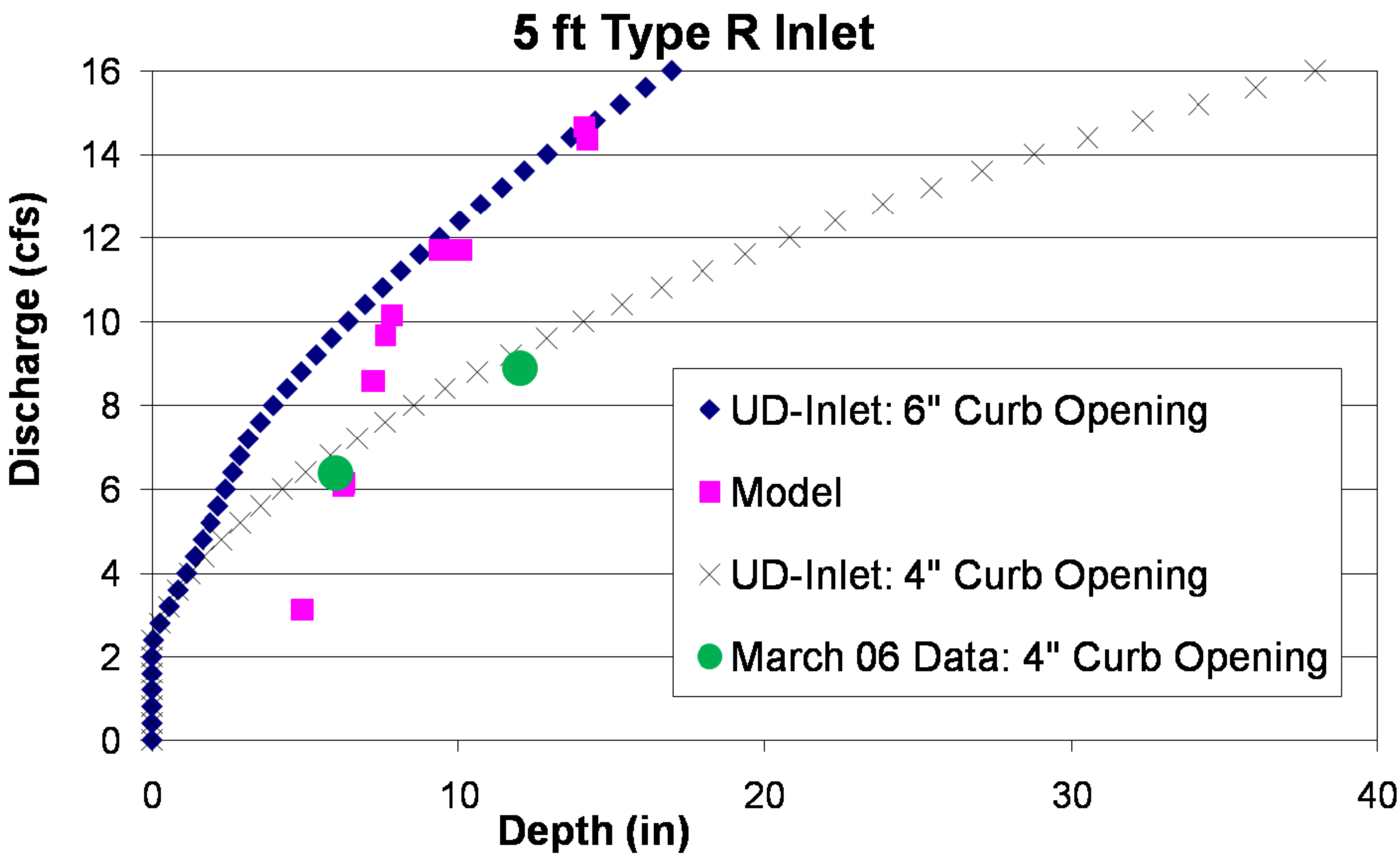
Observed vs. UD-Inlet: Sump



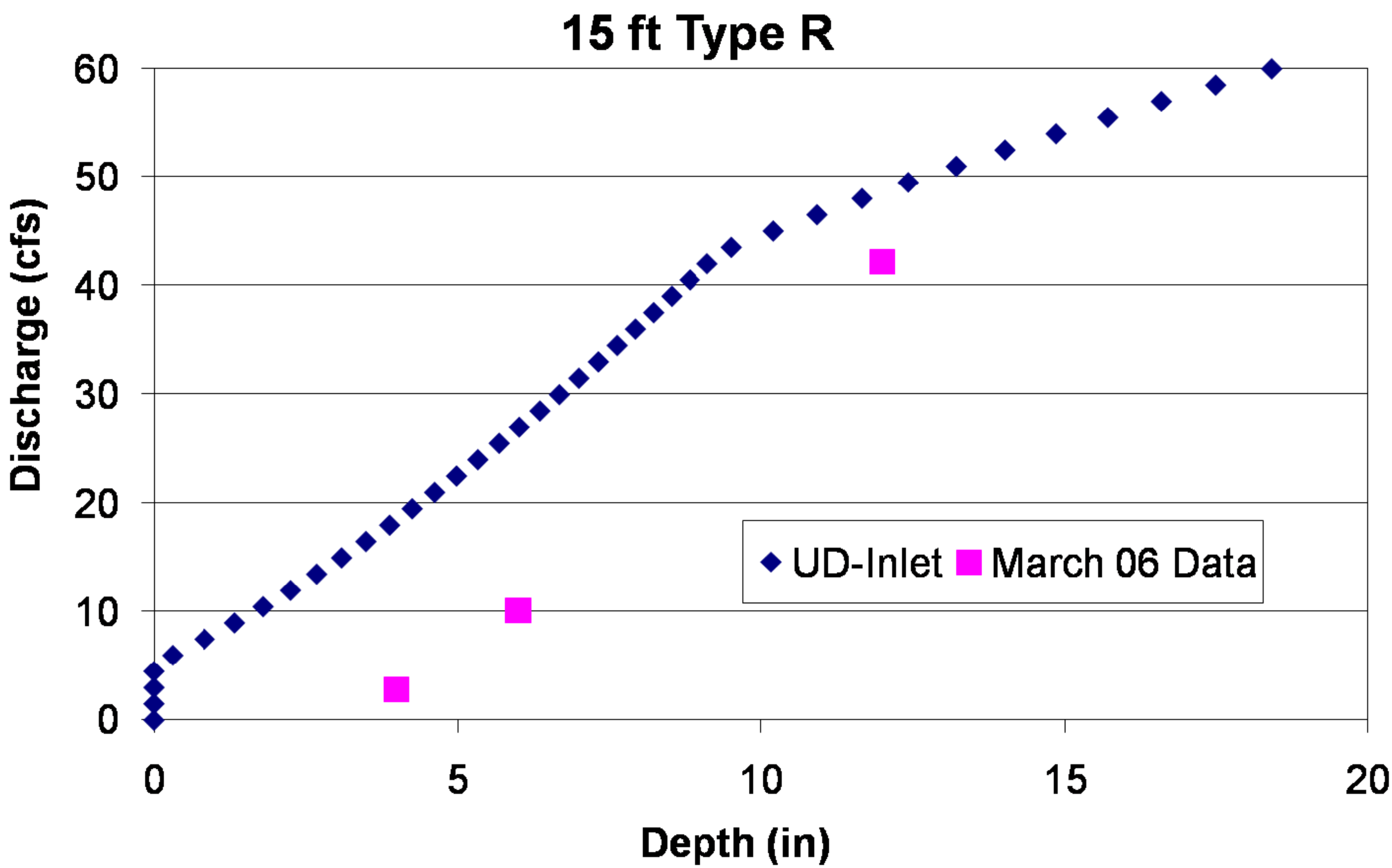
Observed vs. UD-Inlet: Sump



Observed vs. UD-Inlet: Sump



Observed vs. UD-Inlet: Sump



New UD-Inlet Equations…

For CDOT Type 13 and Denver No. 16 grates in sump condition:

$$Q = \min(Q_w, Q_m, Q_o)$$

$$Q_w = C_w N_w W d^{3/2}$$

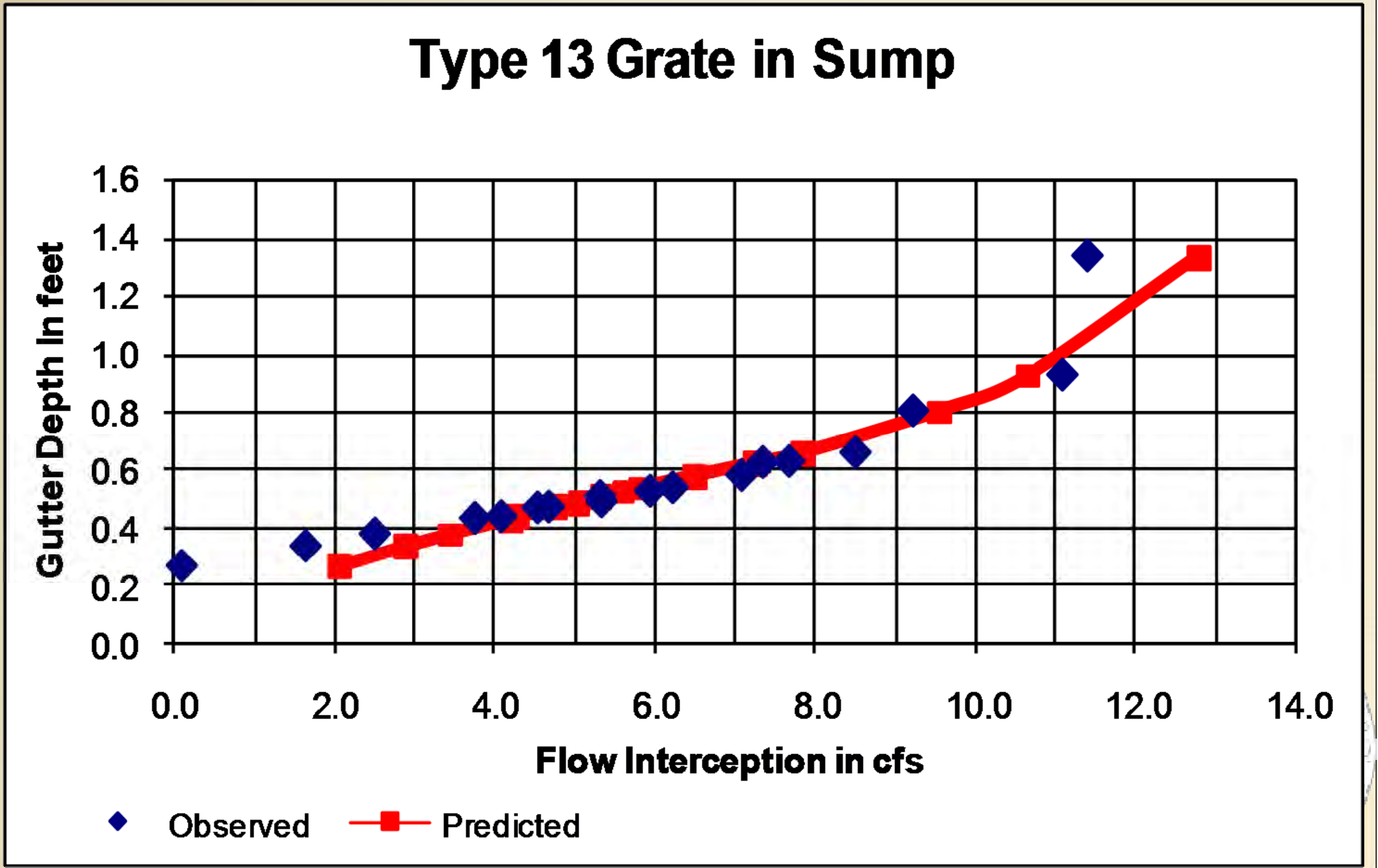
$$Q_m = C_m \sqrt{Q_w Q_o}$$

$$Q_o = C_o N_a A \sqrt{2gd} \quad \text{(>10 inches)}$$

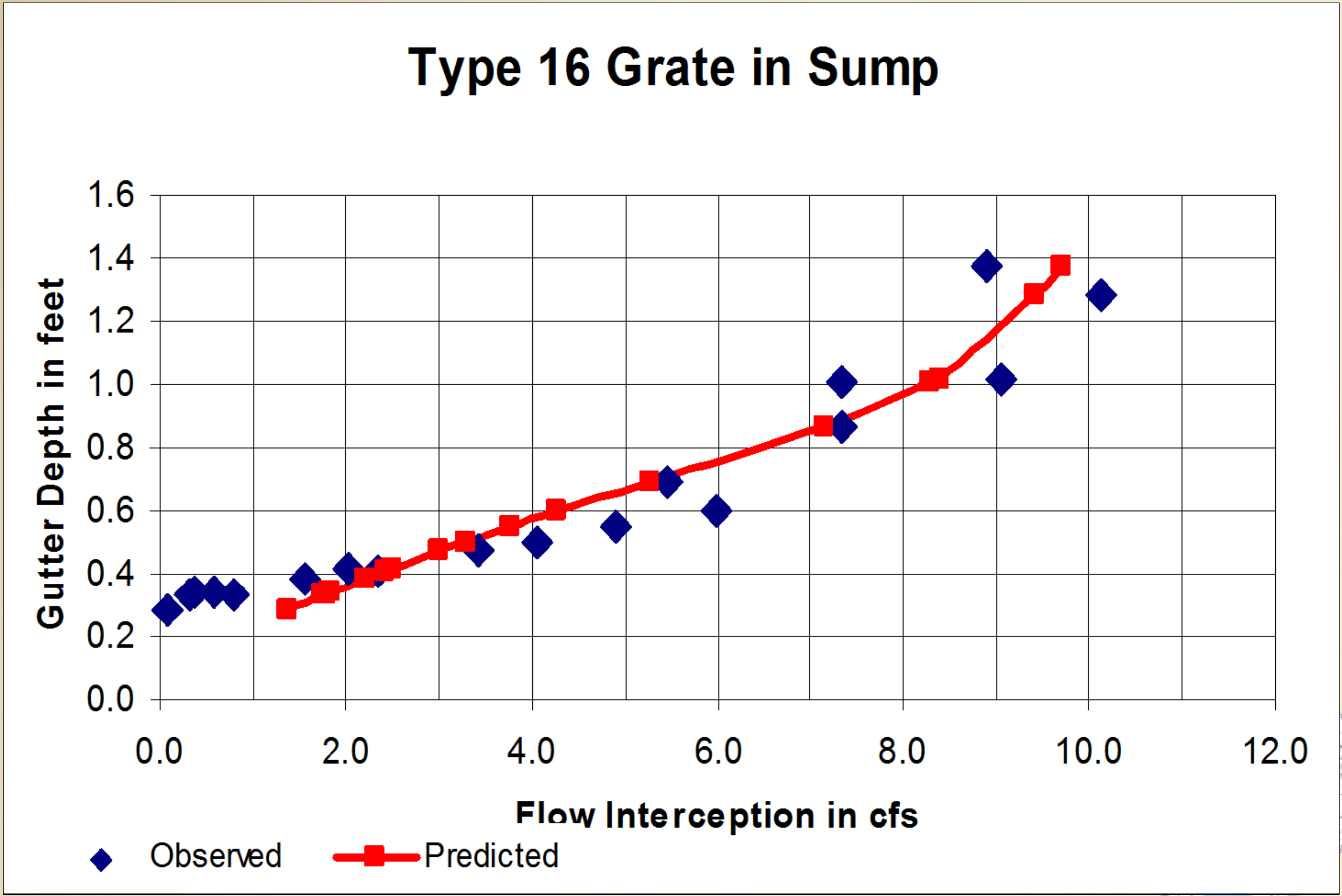
$$Q_C = Q_G + Q_{OP} - K\sqrt{Q_G Q_{OP}}$$

Guo, James C.Y. and McKenzie, K, and Mommandi, A. (2008)
"*Sump Inlet Hydraulics*", ASCE J. of Hydraulic Engineering, Vol 135, No 1, Nov.

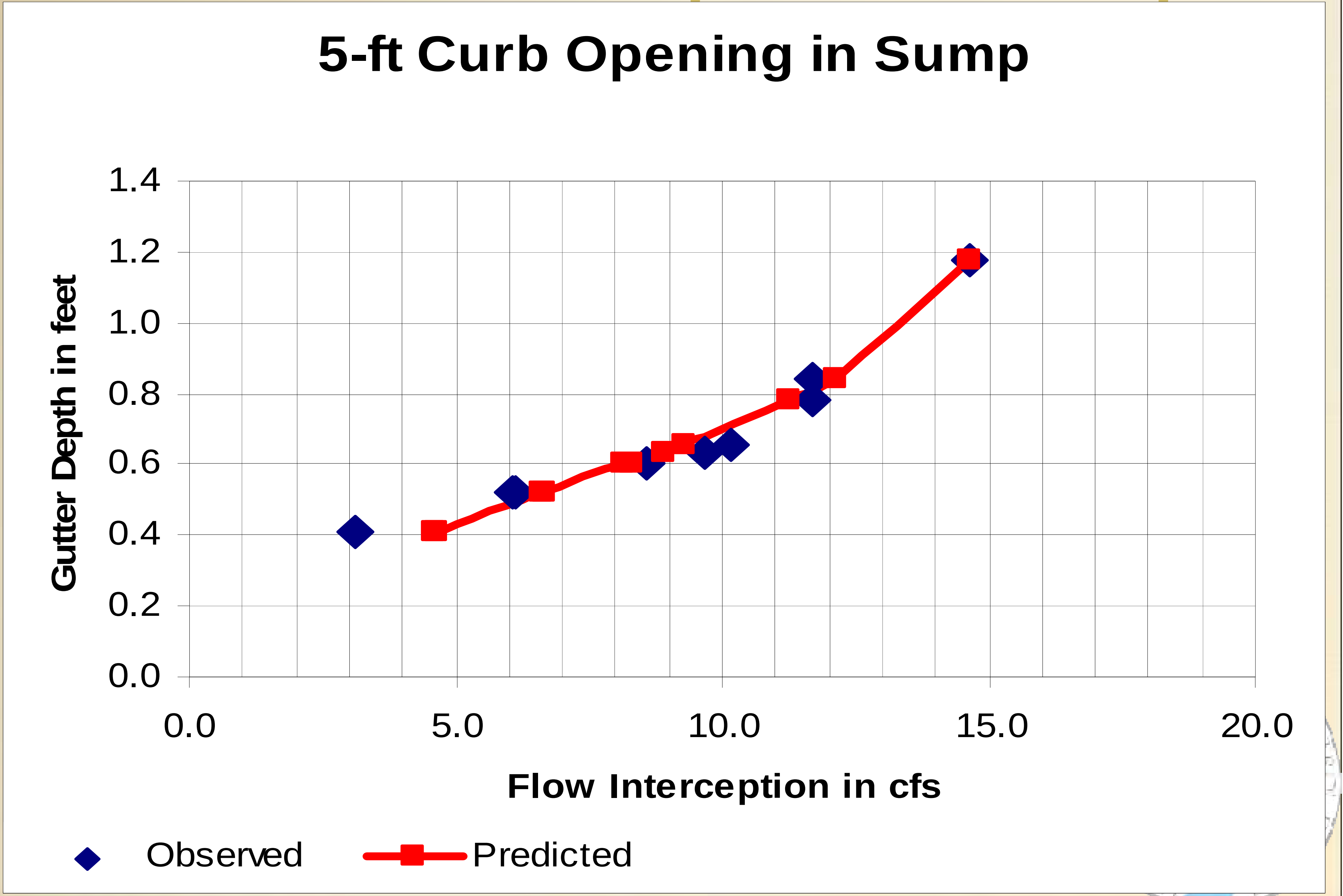
New UD-Inlet Equations : Sump



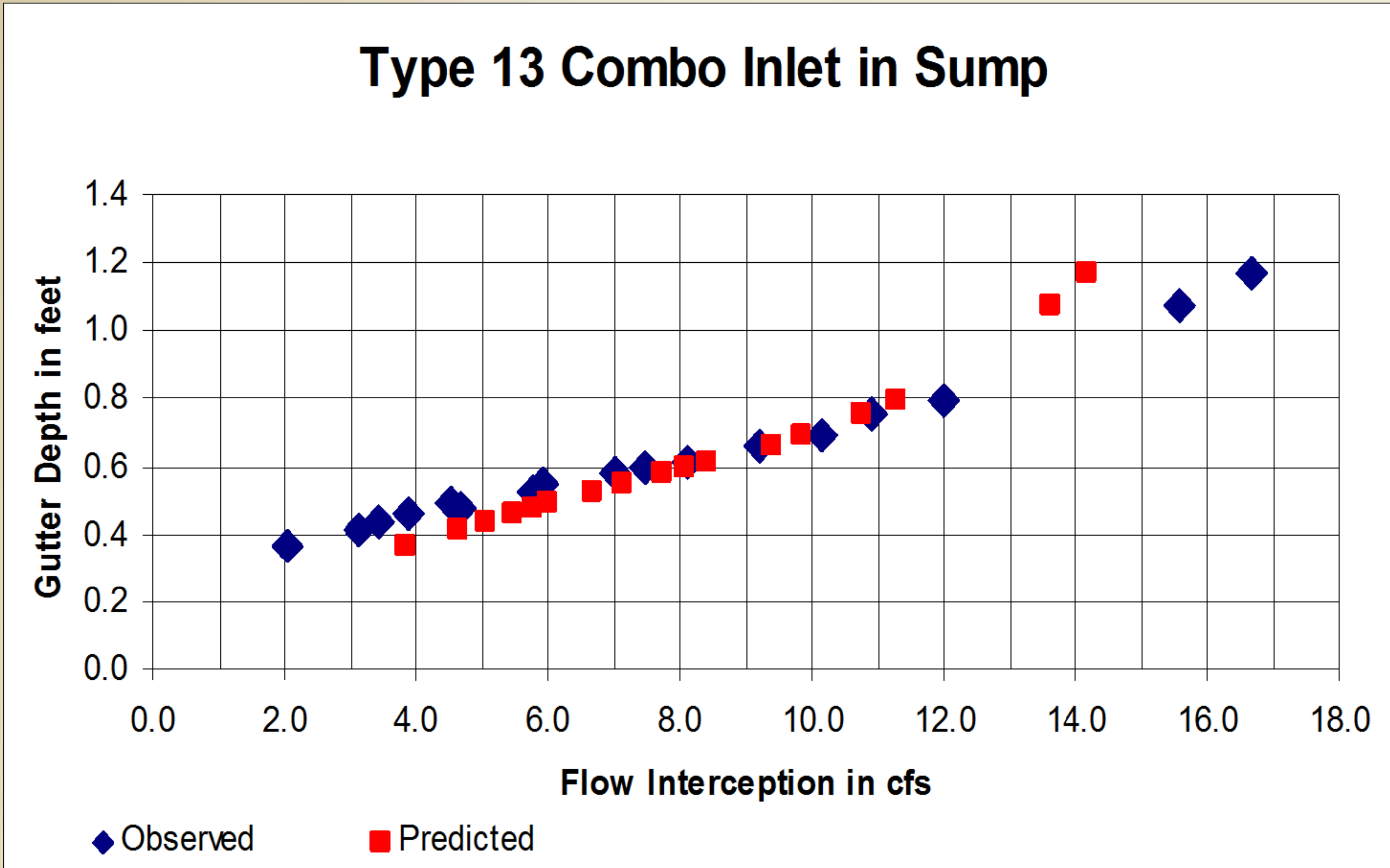
New UD-Inlet Equations : Sump



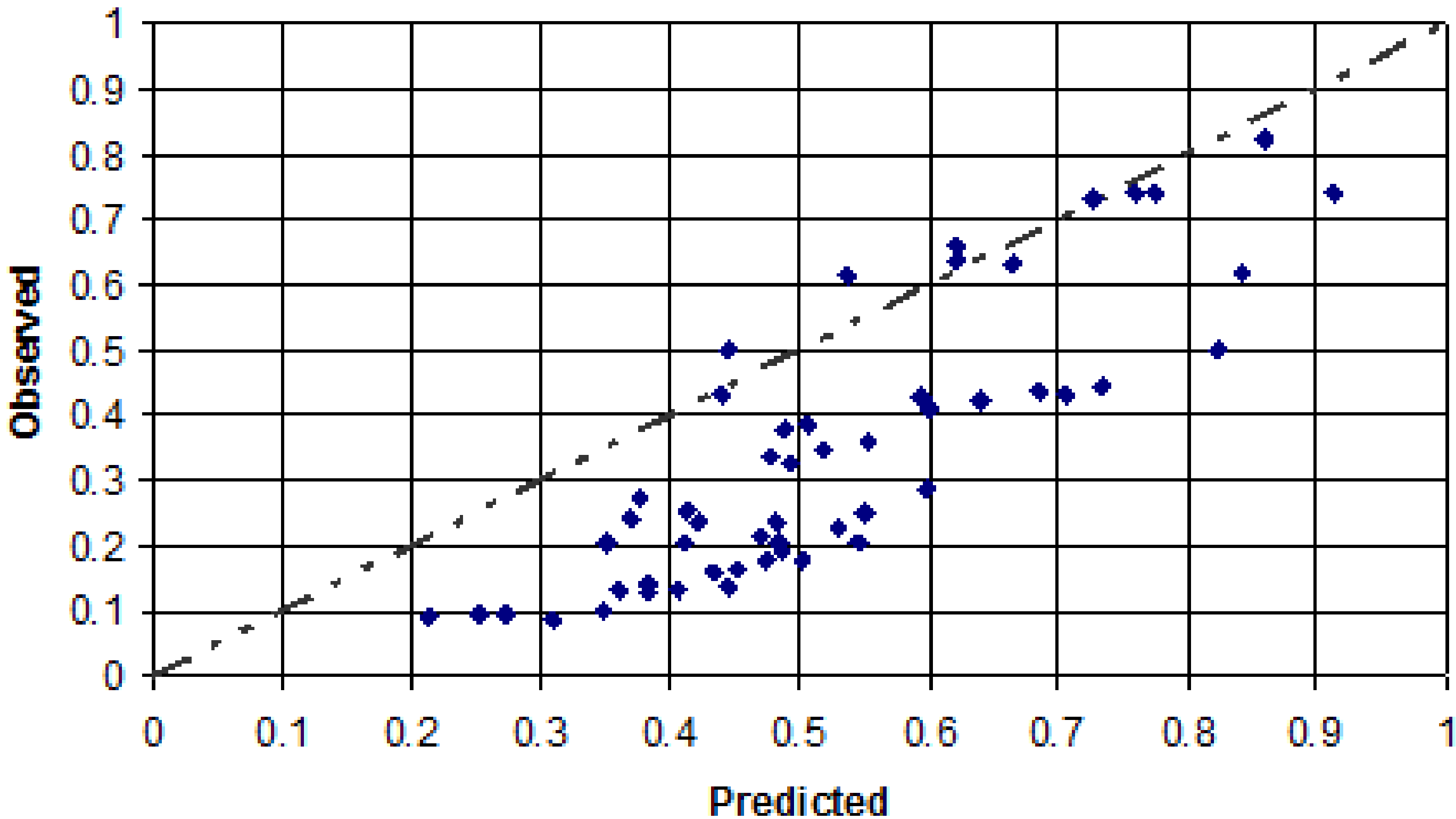
New UD-Inlet Equations : Sump



New UD-Inlet Equations: Sump



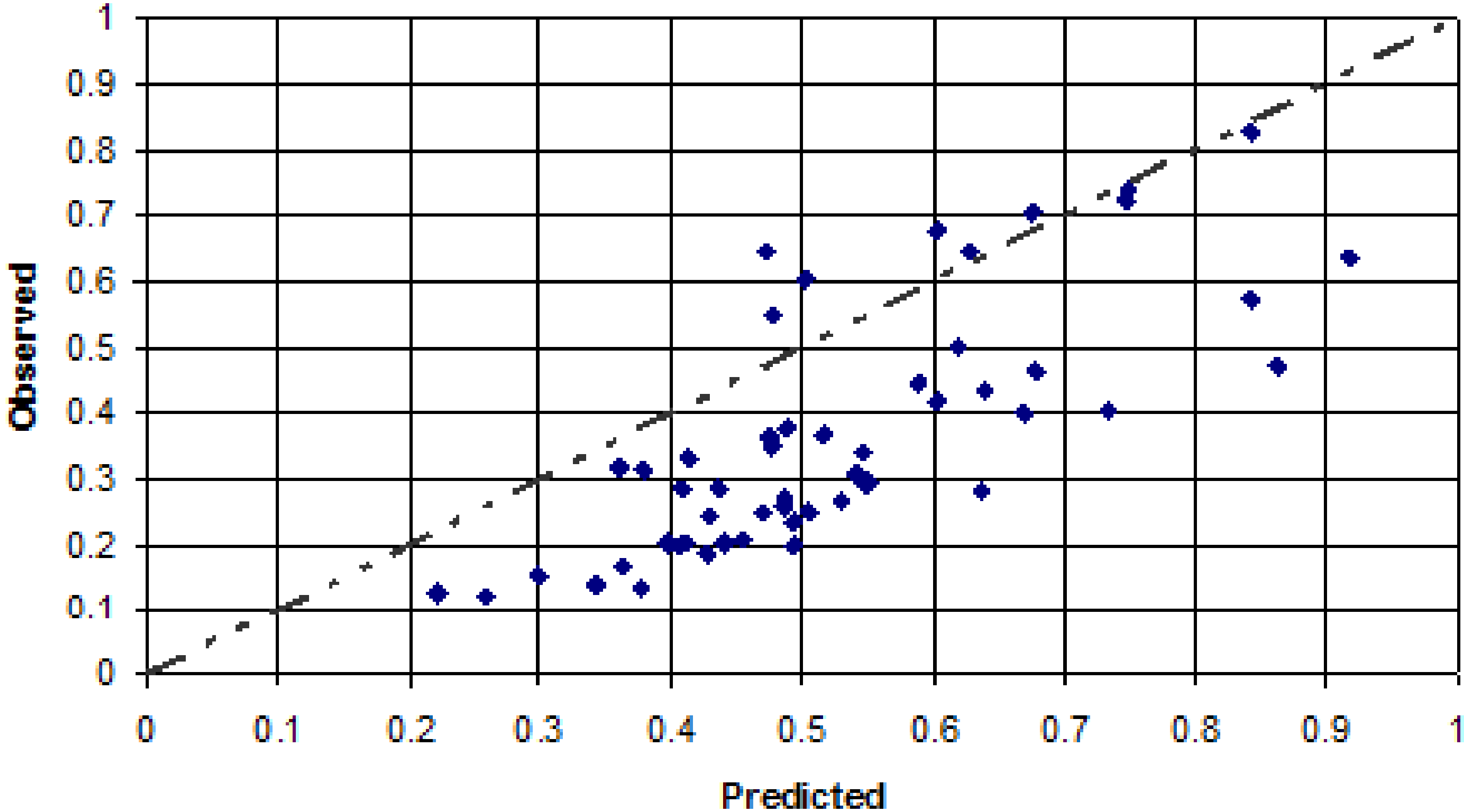
Observed vs. UD-Inlet: On Grade



R^2	Average efficiency error (%)	Maximum efficiency error (%)
0.719	18.8	34.0

Figure 5-2: Predicted vs. observed efficiency for Type 13 combination inlet

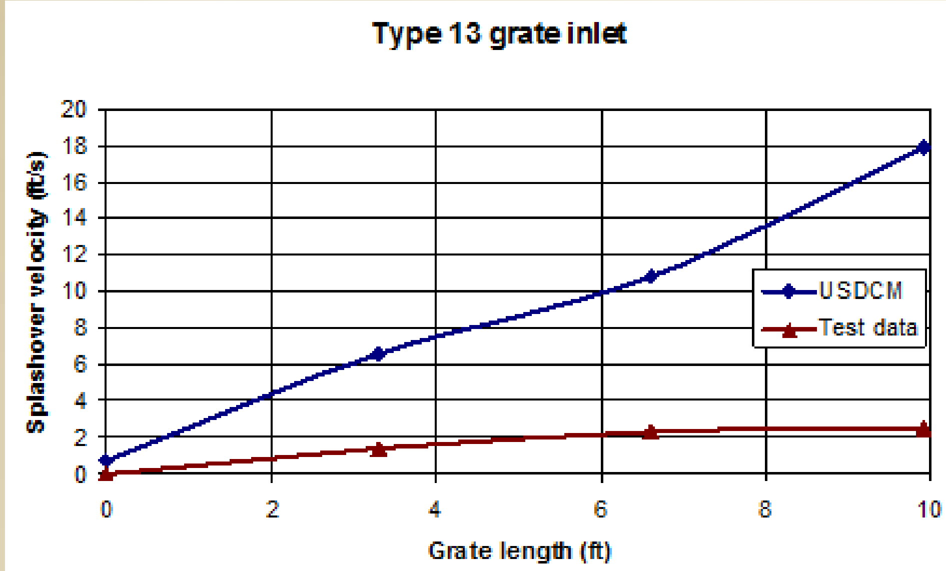
Observed vs. UD-Inlet: On Grade

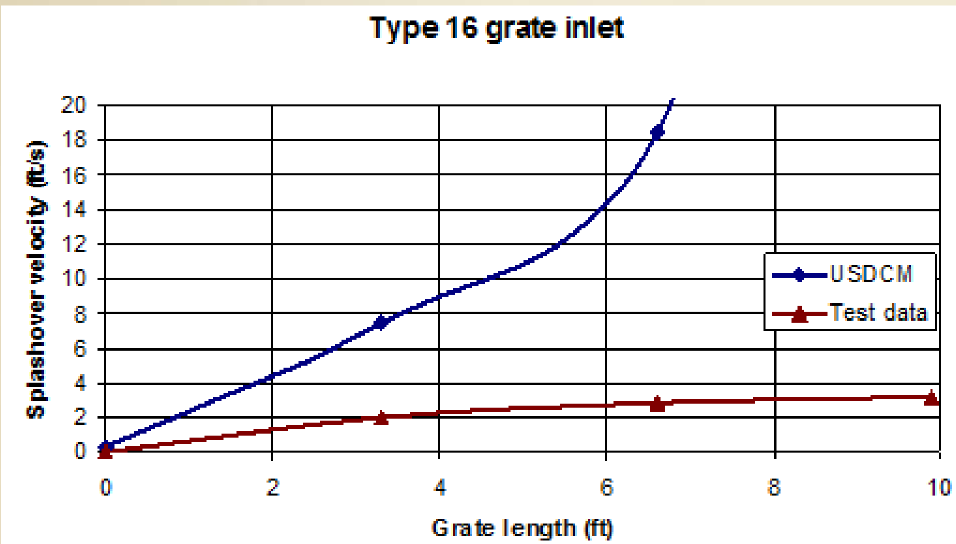


R^2	Average efficiency error (%)	Maximum efficiency error (%)
0.574	17.7	39.0

Figure 5-3: Predicted vs. observed efficiency for Type 16 combination inlet

New Splash-over Velocity Formula for 13 and 16 Grate inlets.

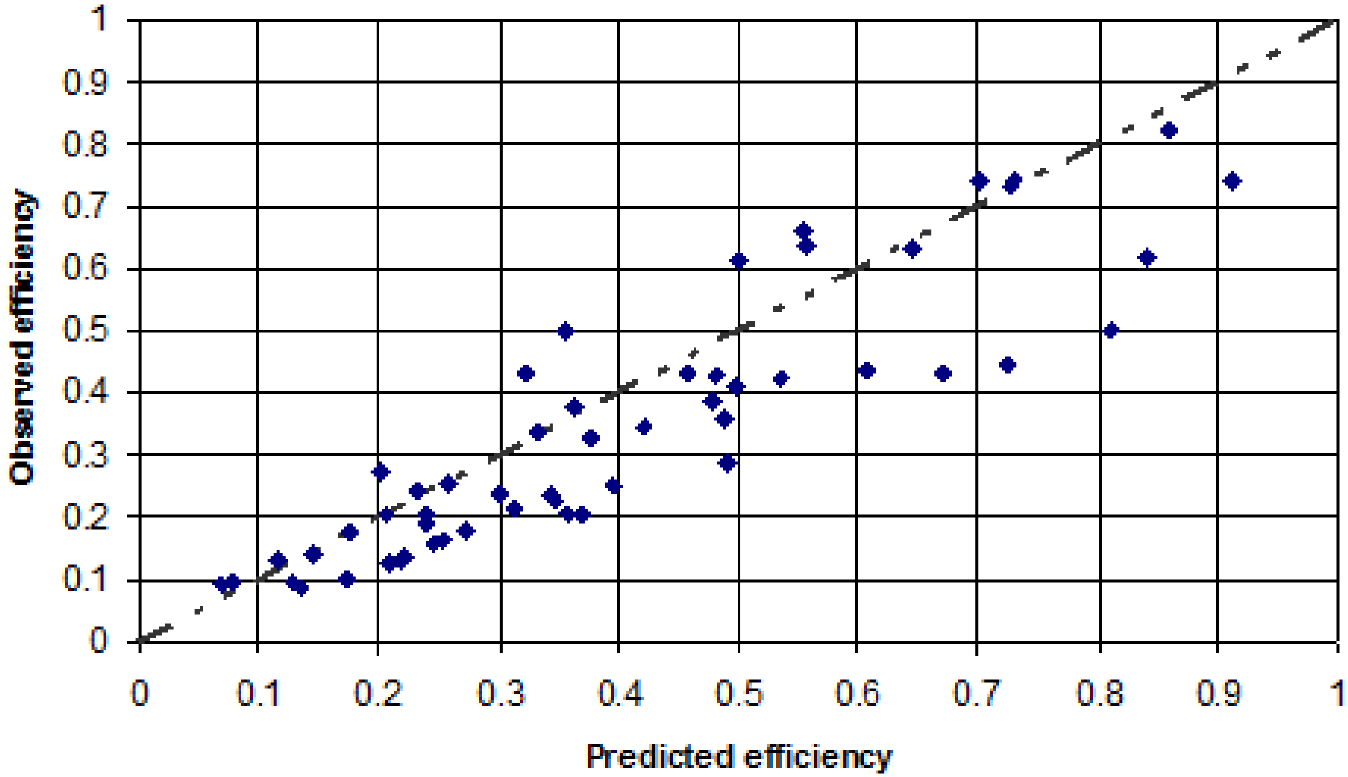




Grate	α	β	γ	η	R^2
Type 13	0	0.583	0.030	0.0001	0.43
Type 16	0	0.815	0.074	0.0024	0.24

where: $V_o = \alpha + \beta L_e - \gamma L_e^2 + \eta L_e^3$

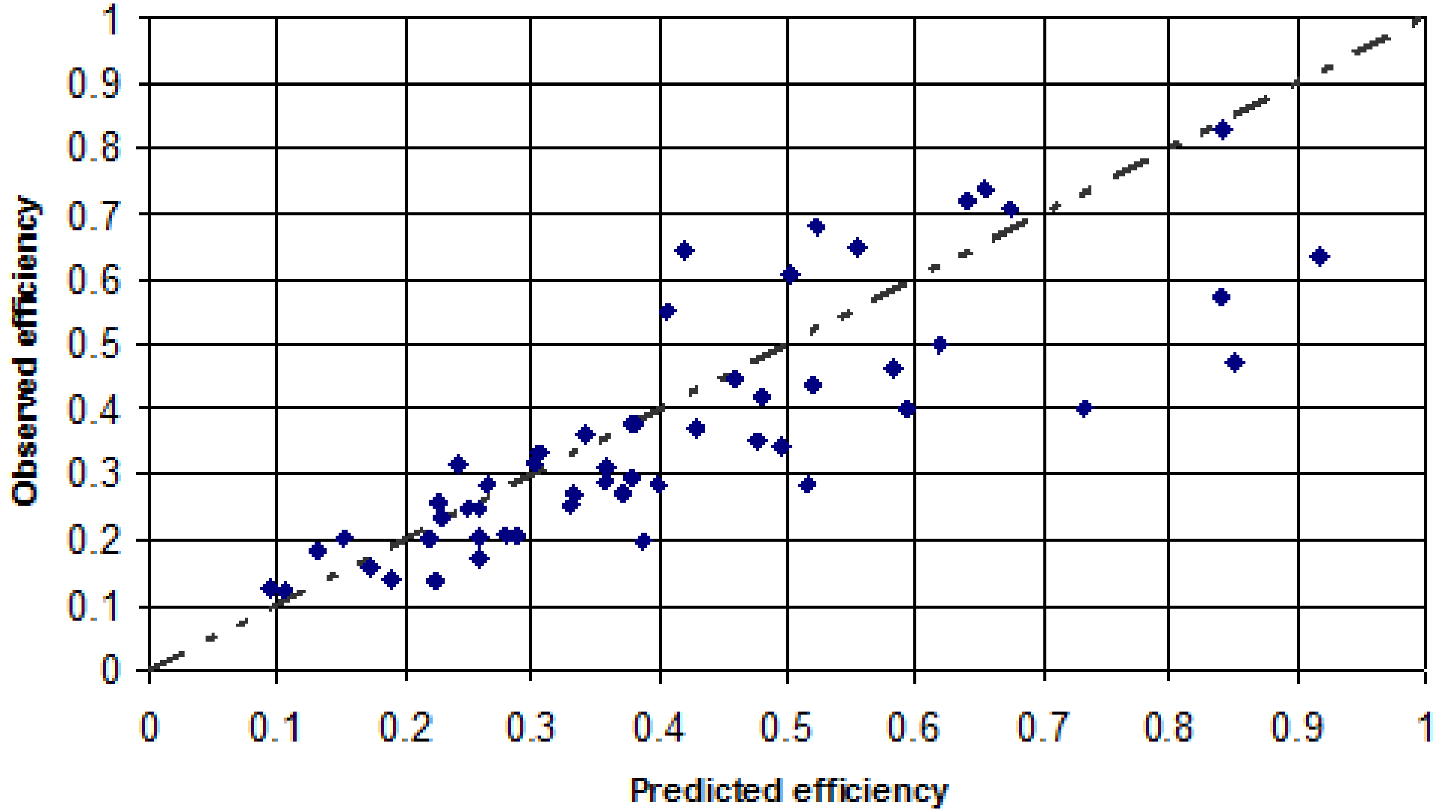
Comparison between UDINLET and Observed Data using the new empirical formula for splash-over velocity



R^2	Average efficiency error (%)	Maximum efficiency error (%)
0.804	8.6	31.0

Predicted vs. observed efficiency for Type 13 combination inlet from improved UDFCD methods

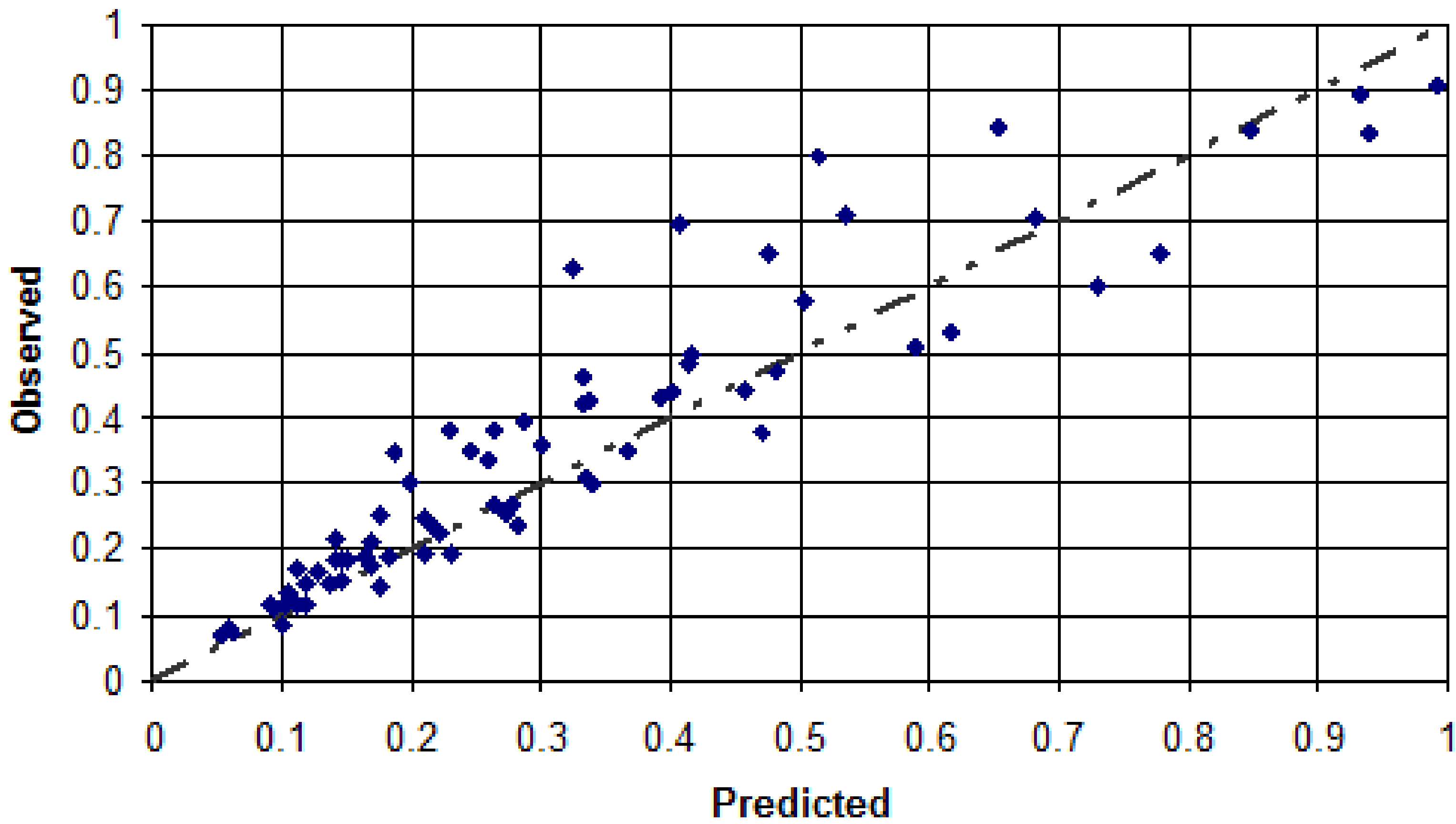
Comparison between UDINLET and Observed Data using the new empirical formula for splash-over velocity



R^2	Average efficiency error (%)	Maximum efficiency error (%)
0.644	13.6	39.0

: Predicted vs. observed efficiency for Type 16 combination inlet from improved UDFCD methods

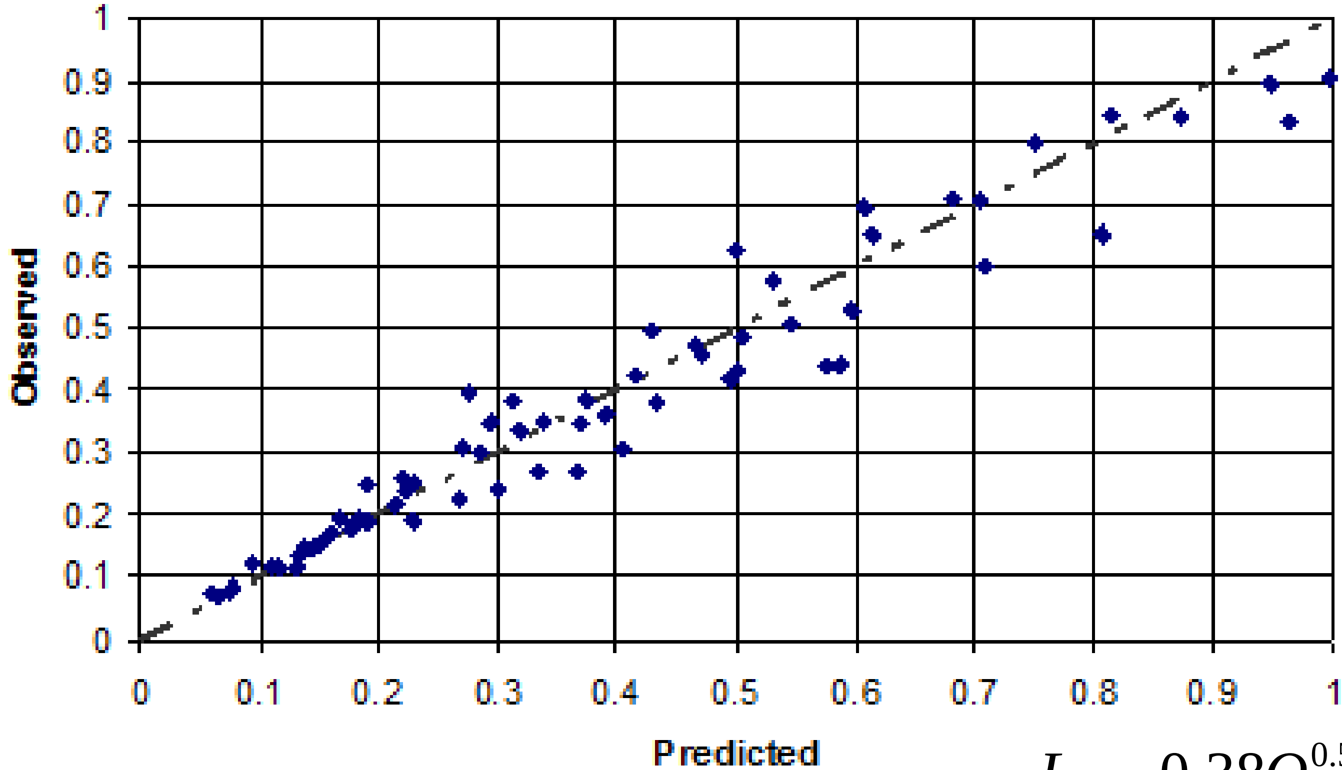
Observed vs. UD-Inlet: On Grade



R^2	Average efficiency error (%)	Maximum efficiency error (%)
0.861	6.5	30.2

Figure 5-4: Predicted vs. observed efficiency for Type R curb inlet

Comparison between UDINLET and Observed Data using the new empirical formula



$$L_T = 0.38Q^{0.51}S_L^{0.058}\left(\frac{1}{nS_e}\right)^{0.46}$$

R^2	Average efficiency error (%)	Maximum efficiency error (%)
0.948	3.8	15.7

Predicted vs. observed efficiency for Type R inlet from improved UDFCD methods

Clogging Factor?

Guo, James C.Y. (2006). "*Decay-based Clogging Factor for Curb Inlet Design*", Vol 132, No. 11, ASCE J. of Hydraulic Engineering, November.

Guo, James C.Y. (2000). "*Street Storm Water Conveyance Capacity,*" ASCE J. of Irrigation and Drainage Engineering, Vol 126, No 2, Mar/Apr,

Guo, James C.Y. (2000). "*Street Storm Water Storage Capacity*", J. of Water Environment Research, Vol 27, No 6., Sept./Oct.

Guo, James C.Y. (2000). "*Design of Grate Inlets with a Clogging Factor*," Advances in Environmental Research, Vol 4, Elsvier Science, Ireland.

More Work to do

Research Report
Collection of Feedback
Revision of Drainage Manual
Revision of UD-INLET
Implementation of New Methods

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT