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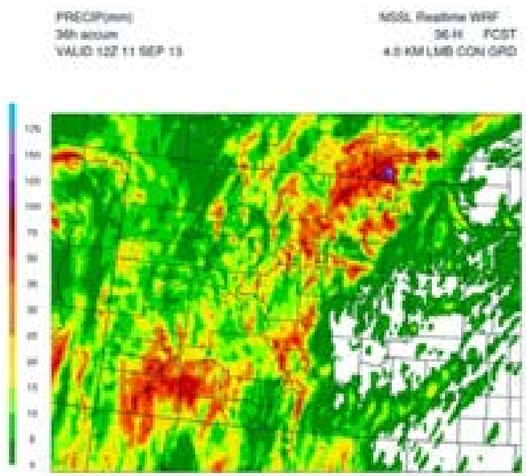
Home Tools 2013_Presentatio

Bookmarks

CASFM 2013 PRESENTATIONS

Bookmarked Tracts:

1. Emergency Preparation
2. Floodplain Management
3. Stormwater Management
4. Stream Restoration
5. Technical Modeling
6. Water Quality
7. Project Awards

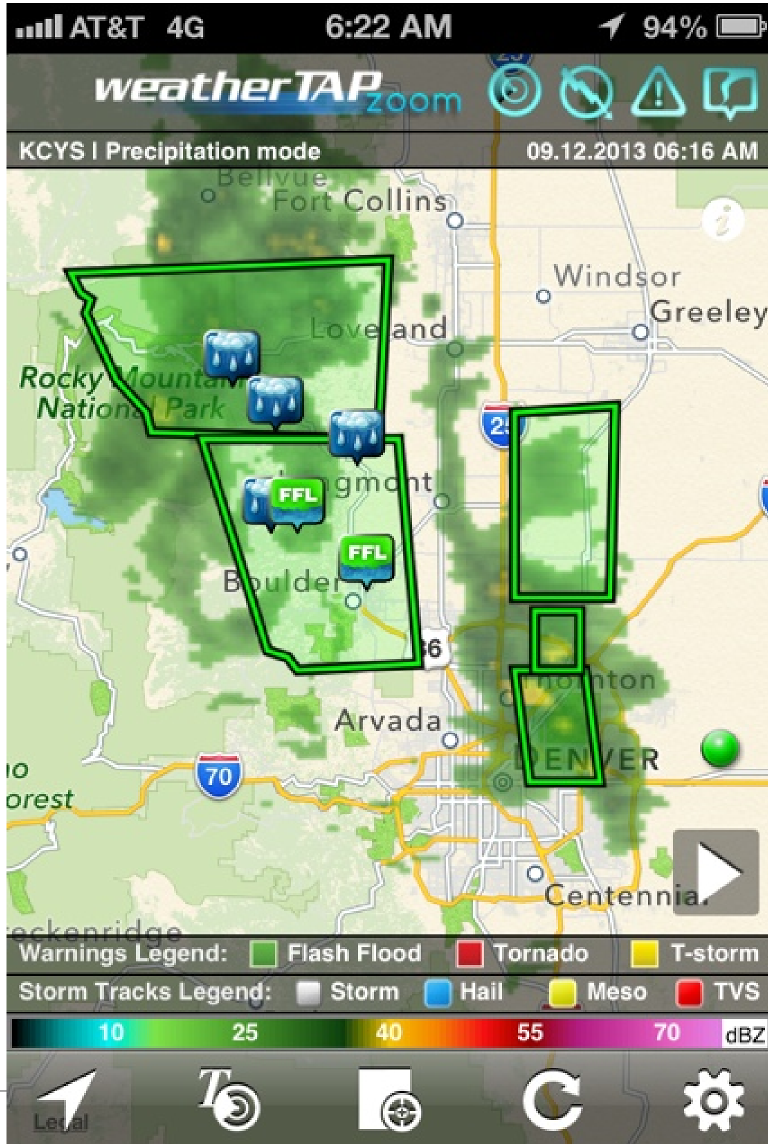


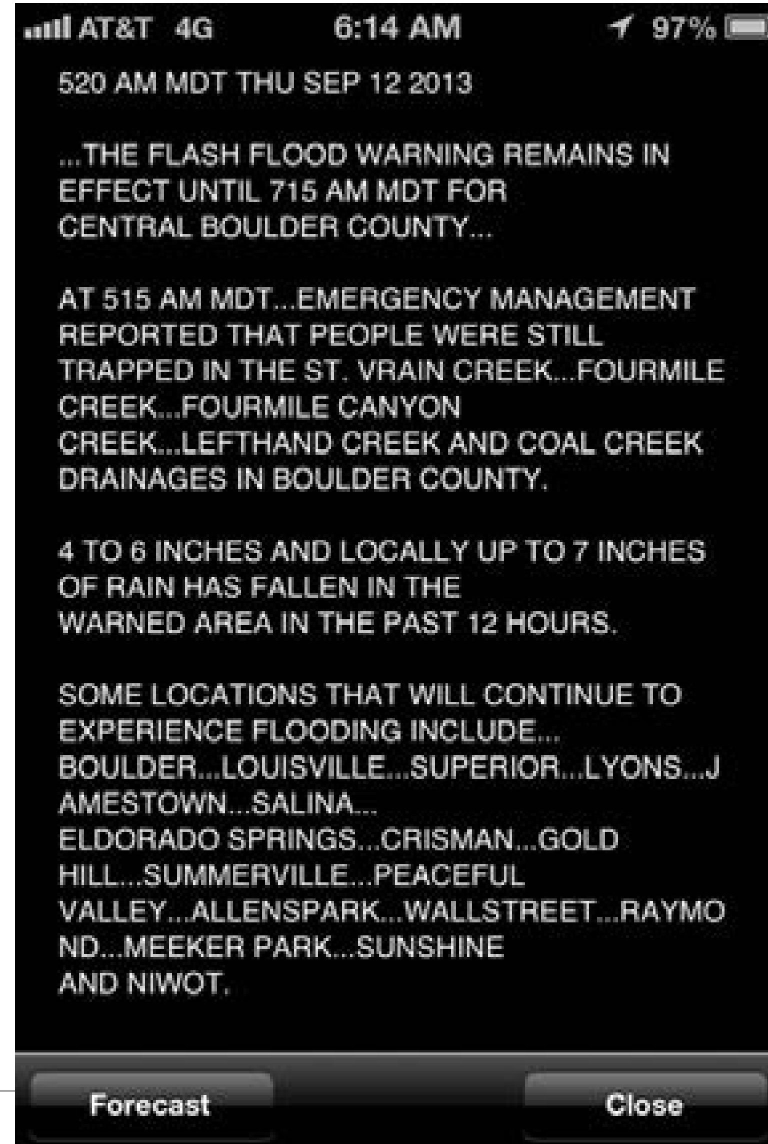
COLORADO FLOOD THREAT BULLETIN PROGRAM:

2012 INNOVATIONS & CHALLENGES AND 2013 OPPORTUNITIES

Kevin Houck, PE, CFM
Section Chief, Watershed & Flood Protection, CWCB
and
Stu Geiger for John F. Henz, CCM, FAMS
Dewberry Consultants, Denver CO/Phoenix AZ

0600 AM September 12, 2013





520 AM MDT THU SEP 12 2013

...THE FLASH FLOOD WARNING REMAINS IN EFFECT UNTIL 715 AM MDT FOR CENTRAL BOULDER COUNTY...

AT 515 AM MDT...EMERGENCY MANAGEMENT REPORTED THAT PEOPLE WERE STILL TRAPPED IN THE ST. VRAIN CREEK...FOURMILE CREEK...FOURMILE CANYON CREEK...LEFTHAND CREEK AND COAL CREEK DRAINAGES IN BOULDER COUNTY.

4 TO 6 INCHES AND LOCALLY UP TO 7 INCHES OF RAIN HAS FALLEN IN THE WARNED AREA IN THE PAST 12 HOURS.

SOME LOCATIONS THAT WILL CONTINUE TO EXPERIENCE FLOODING INCLUDE... BOULDER...LOUISVILLE...SUPERIOR...LYONS...JAMESTOWN...SALINA... ELDORADO SPRINGS...CRISMAN...GOLD HILL...SUMMERVILLE...PEACEFUL VALLEY...ALLENSPARK...WALLSTREET...RAYMOND...MEEKER PARK...SUNSHINE AND NIWOT.

Flood Threat Bulletin
Flood Threat Outlook
24-Hr Radar Precipitation

About:
The CWCB offers a daily assessment of flood potential around the state, issued at 11:00 am each day from May through September.

Daily Statewide Flood Threat Bulletin and Map
This product is issued daily before 11:00 am and is used to identify areas of the state that are at risk of flooding. Updates can be issued as needed by weather situation.

7-15 Day Flood Threat Outlook (Updated Mon. and Thurs.)
This product is an outlook of the flood threat and precipitation amount and chance in the state over the next 15 days.

Statewide 24-hr Precipitation Map
This map is created by merging the 24-hr Storm Total Precipitation (STP) product observed regional WSR-88D and the MADIS observational database. Issued at 9:30 am every day.

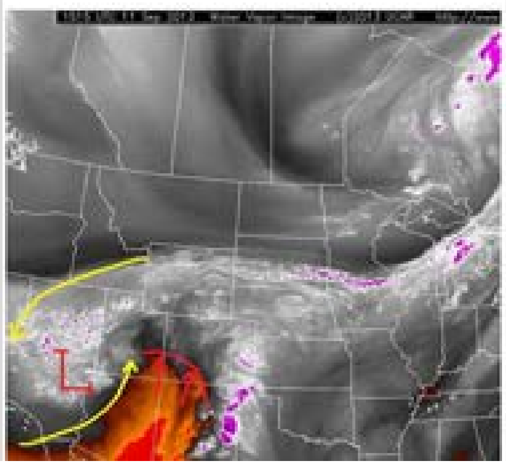
Issue Date: Wednesday, September 11, 2013
Time Issued: 1056 AM MDT
Forecaster: Brad Workman

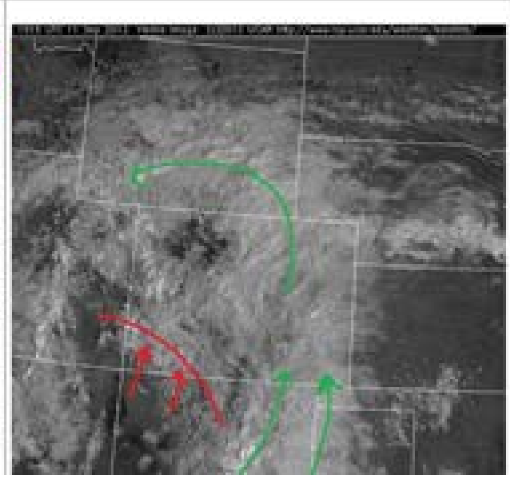
HIGH FLOOD THREAT CONTINUES TODAY, FLASH FLOOD WARNING HAD BEEN ISSUED FOR WALDO CANYON THIS MORNING

A HIGH FLOOD THREAT HAS BEEN ISSUED FOR MOST WESTERN SLOPE COUNTIES NEAR THE CO/UT BORDER. A HIGH FLOOD THREAT HAS BEEN ISSUED FOR TELLER/EL PASO COUNTIES. A MODERATE FLOOD THREAT IS BEING FORECAST FOR SURROUNDING AREAS OF THE WESTERN SLOPE, FOOTHILLS, AND ADJACENT PLAINS. A LOW FLOOD THREAT SURROUNDS THIS AREA, COVERING THE REST OF THE STATE.

Today's flood threat got off to an early start when a Flash Flood Warning was issued by the National Weather Service in Pueblo, CO, for the Waldo Canyon burn scar. The burn scar, as with many other places across the central and western portions of the state, is saturated and any additional rain today will run off quickly. This will cause major concerns for Manitou Springs and Highway 24 near Cave of the Winds as we move through this afternoon and evening.

For the rest of the state, this is how today will shake out: Temperatures below seasonal average, ample moisture for rainfall, and a flood threat (high, moderate, and low) that covers the entire state. The two satellite images that I have included below tell the story very well. The water vapor image on the left shows moisture still existing across much of the state, with a pocket of dry air working its way into SW Colorado. Though this is drier air, it is still plenty moist to create thunderstorms over the Western Slope today, although they will be less numerous. I have included the location of the leading edge of dry air and moisture axis (green arrows) on the visible satellite image on the right, showing what its effects have been this morning. All in all, it looks like another wet day in store for many areas of the state.





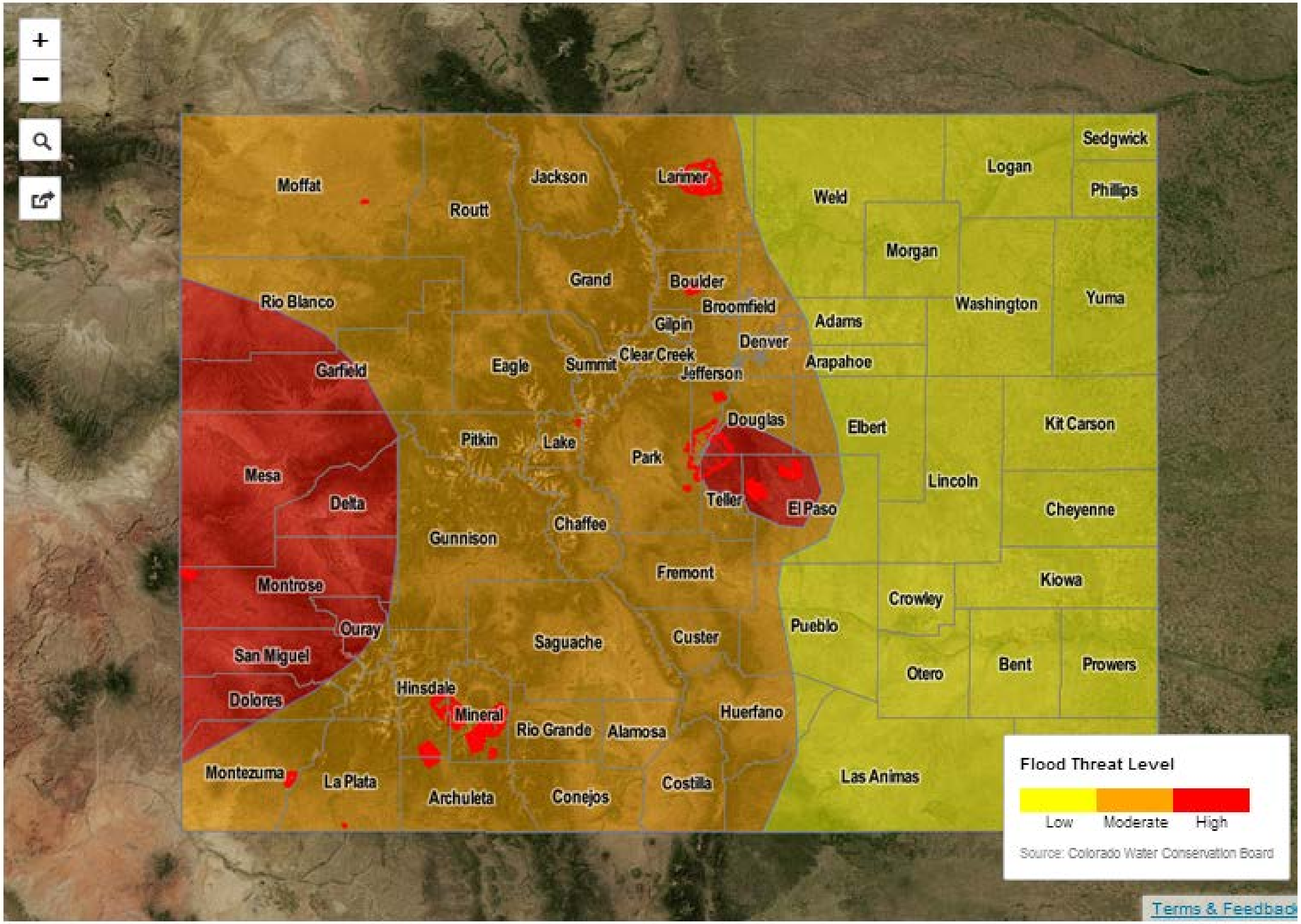
Forecasts Provided By:
Dewberry

Links:
CWCB Home Page
CWCB Flood DSS
NWS Watches and Warnings
Urban Drainage and Flood Control District
Colorado Emergency Managers

NWS Radar:
Denver, CO
Grand Junction, CO
Pueblo, CO
Goodland, KS

Got Comments?
CWCB is always looking for feedback on how to better serve the users of the Flood Threat Portal. Click the link below to submit your suggestions, questions, or concerns.

Hover over your county to read your county-specific flood threat prediction.



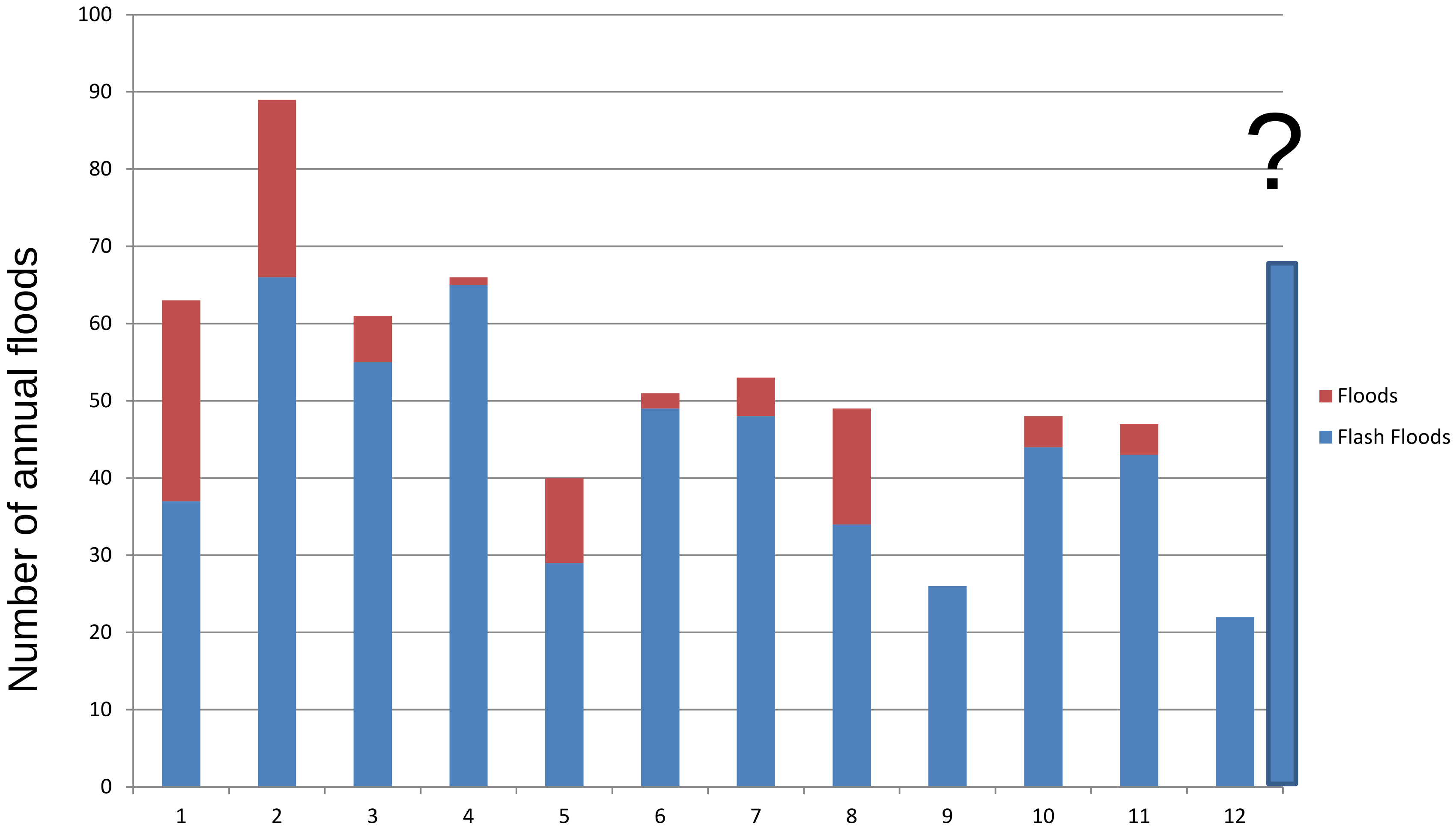
Fire-Burn

FTB HEADLINE: DANGEROUS FLOOD THREAT FOR TELLER COUNTY AND WALDO CANYON

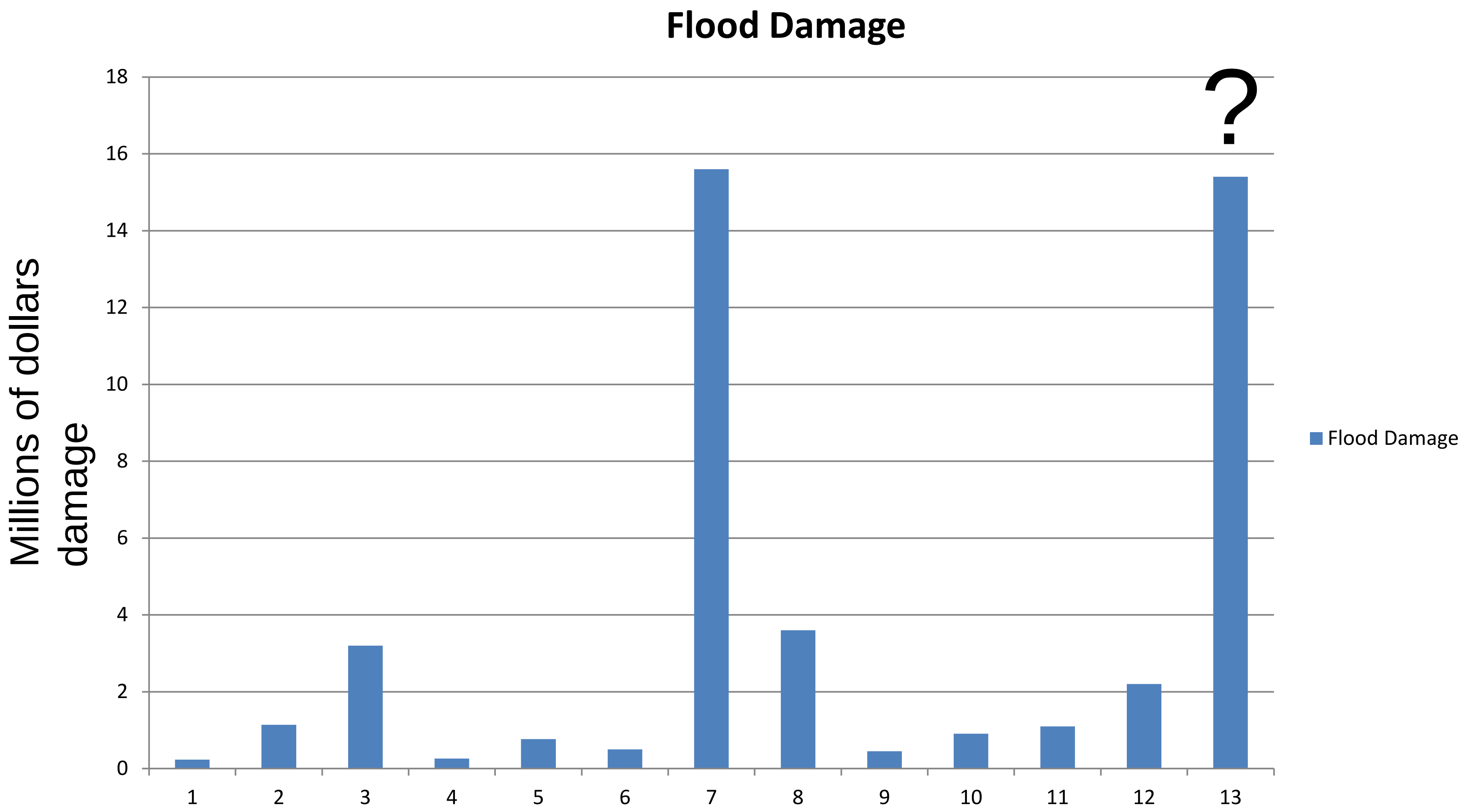
August 8, 2013

Manitou Springs/US 24

CO FF/Floods 2001-2013



CO Flood Damage 2001-2013

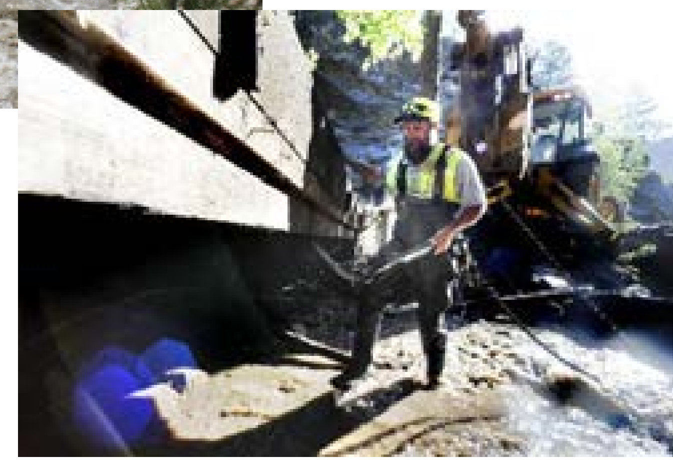


Dewberry

Colorado Flood Threat Bulletin

- Started in 2006 to provide detailed flood threat forecasts on a county level to EM's.
- Runs from May 1 to September 30.
- Issued once daily NLT 1100AM.
- Web-based forecast of snow-melt, river and flash flooding threat.
- Identifies the threat as None, Low, Moderate and High. Compared with NWS WFO's.

“Where, how much, how long, when will it flood?”

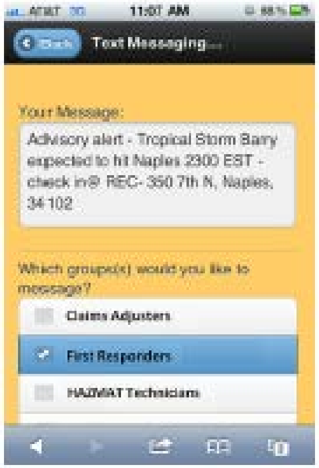


Debris Flows Close Roads In Fourmile Canyon

“Tell me about the flood threat?”

- Enhance public safety
- Communicate with EM community
- Improve hydro-meteorology

Forecast

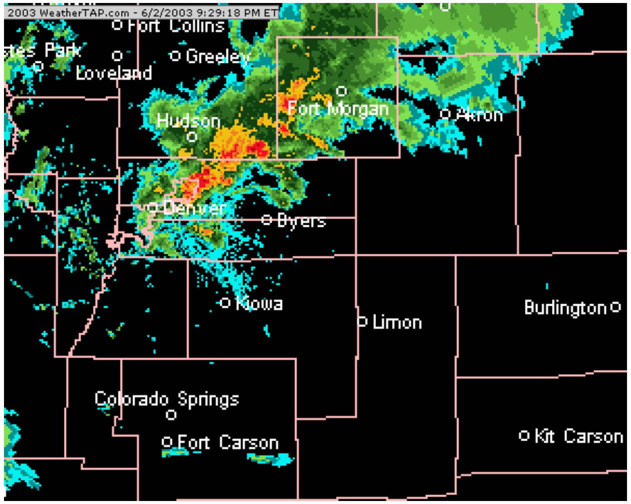


Notify

Prepare

Colorado Water Conservation Board's Flood Threat Bulletin Program provides county-specific forecasts fo EM support

www.coloradofloodthreat.com



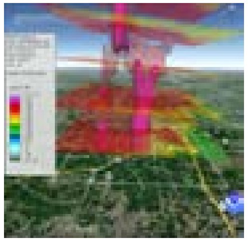
Our Team

John Henz, CCM
Senior Meteorologist

Stuart Geiger, CFM
Flood Risk Advisor

Robert Rahrs, GISP
Meteorologist

Mathew Mampara, PE, CFM
Senior Flood Risk Advisor

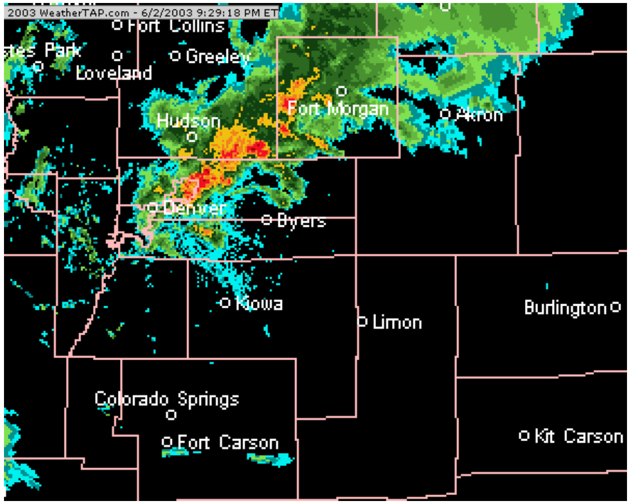


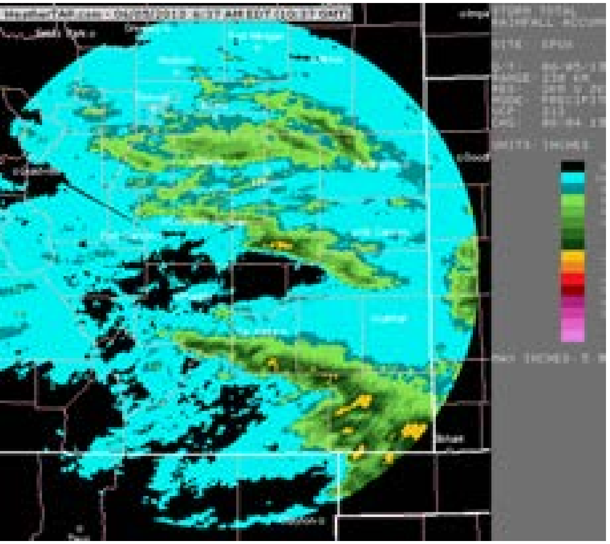
Brad Workman, MS
Meteorologist

Zack Roehr, CFM
Database Analyst

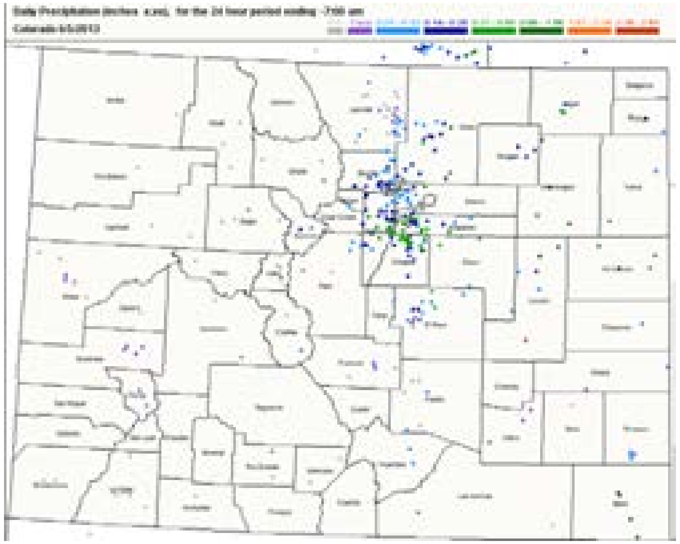
State-wide Precipitation

A 24-hr Google-Earth based mapping of precipitation

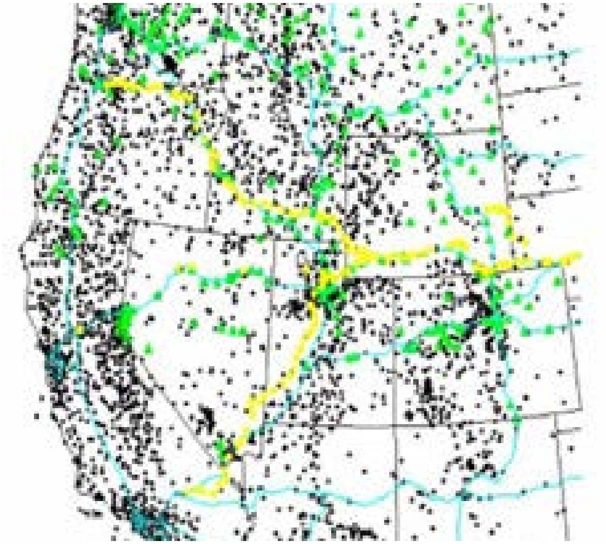




WSR-88D STP



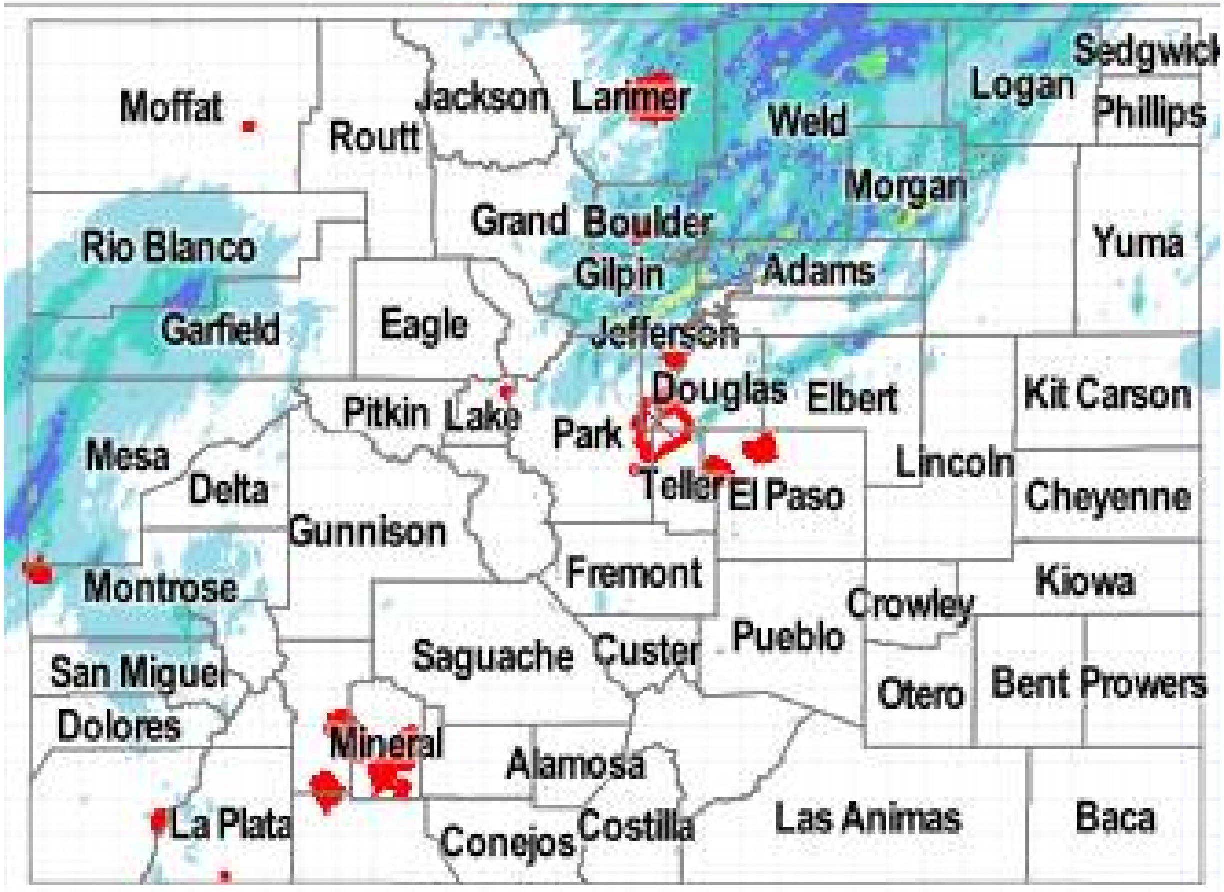
CoCoRAHS Rainfall



MADIS

Storm Total Precipitation Map

Accessing available precipitation obs

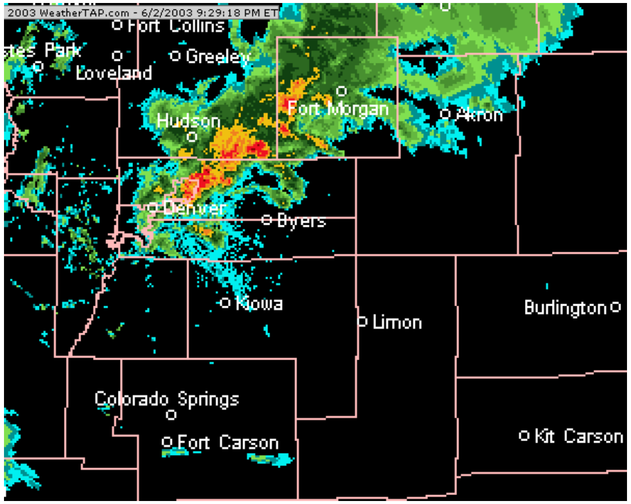


Storm Total Precipitation (STP) overlays Goggle earth

Dewberry's Google-Earth based STP product merges observed National Weather Service WSR-88D Radar Storm Total Precipitation products from the Goodland KS, Front Range CO, Pueblo CO, Grand Junction CO and Cheyenne WY radars. Rainfall < 0.50 inch omitted. MADIS/CoCoRahs provides observed rainfall. Event summaries included. 3-5 day summed precipitation indicates where soil moisture content may be high enough to promote excessive runoff.

Flood Threat Bulletin:

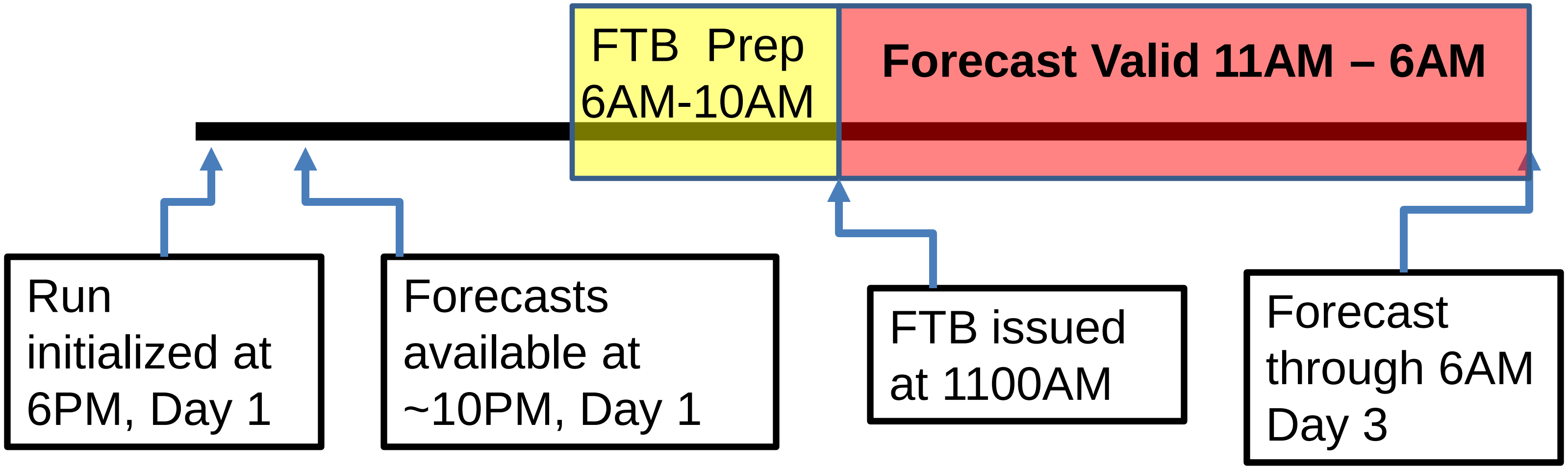
24-hr County-specific flood threat assessment



Dewberry

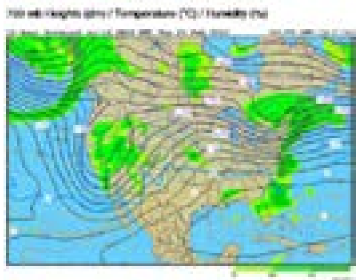
Model output available >12hrs before FTB

- Model run at 00Z (6PM, Day 1); ouput available ~930PM, Day 1; runs 36hrs to 12Z, Day 3.



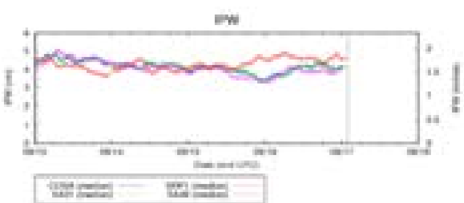
www.coloradofloodthreat.com

Analyze



Surface Observations

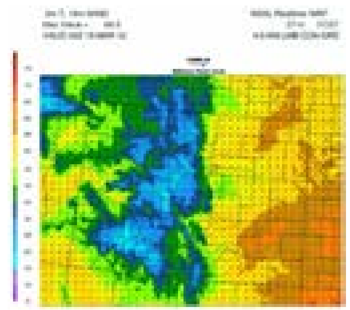
Soundings



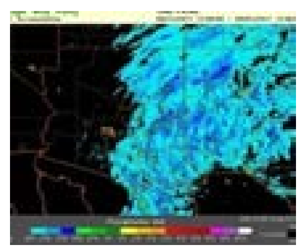
Atmospheric Moisture

Model Ouput

HRRR

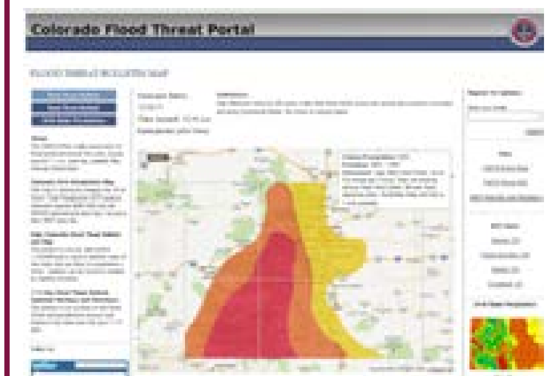


NSSL-WRF



WRF (U of A)

Colorado Flood Threat Bulletin

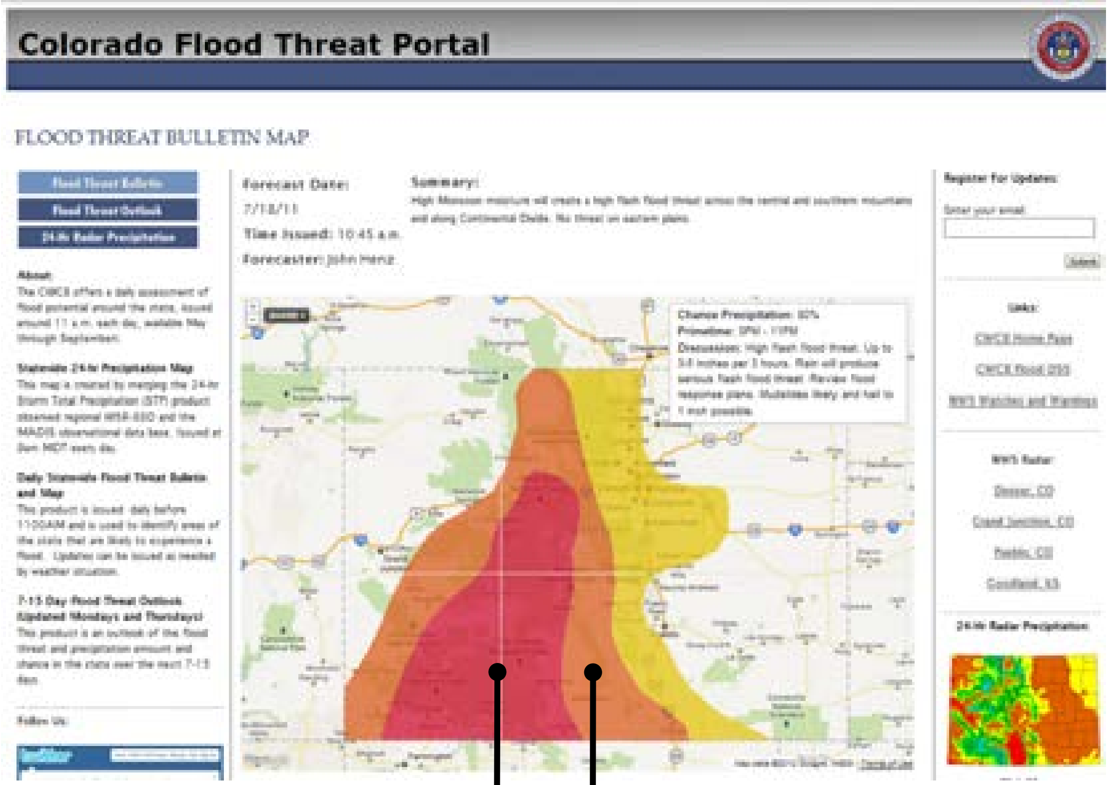


- Experienced analysts
- State of practice models
- Observation-based
- GIS-based for easy sharing

Dewberry
Experience

Flood Threat Bulletin

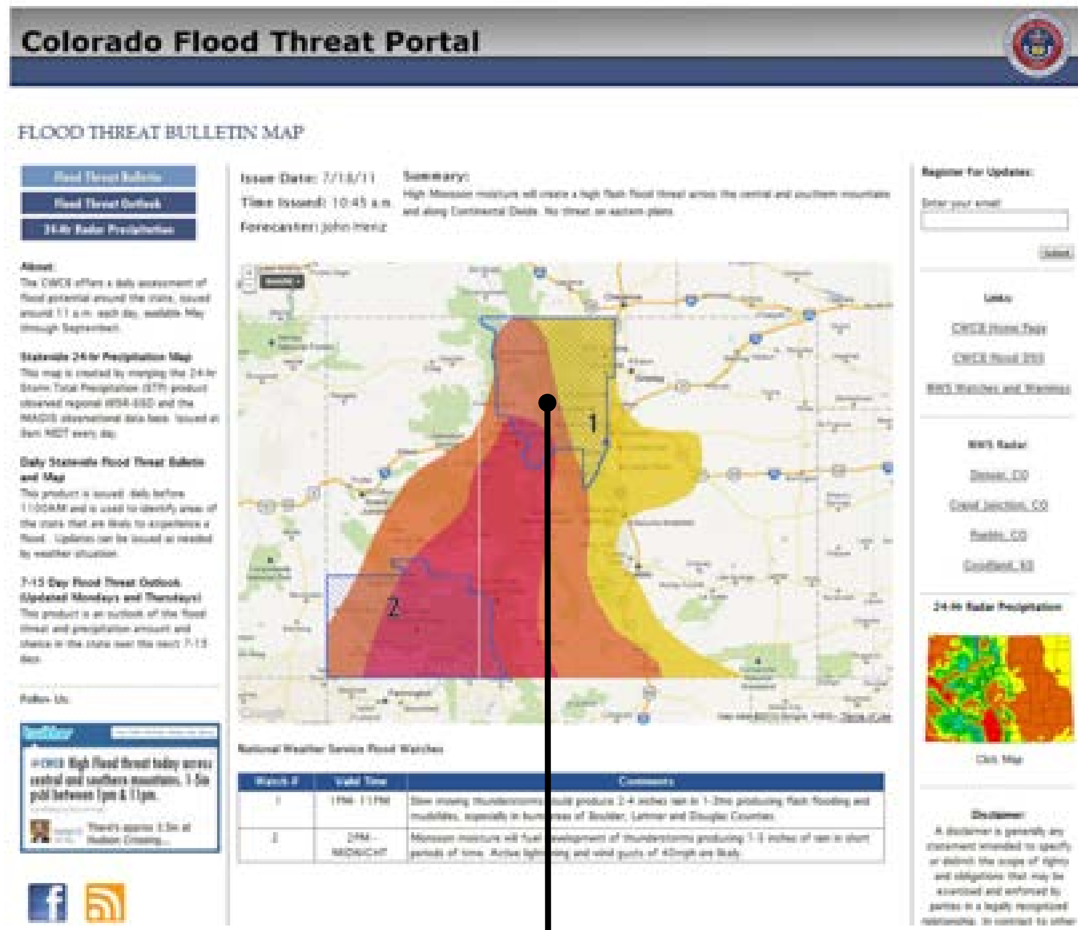
- County-specific forecasts of rainfall and flood threat
- Spatial threat identification
- Prime time for storms
- Storm movement
- Chance of flooding occurrence
- [Web-based](); PDF ready



Chance of Precip.	Prime Time	Discussion
80%	6PM – 11PM	High flash flood threat. Up to 3-5 inches per 3 hours. Rain will produce serious flash flood threat. Review flood response plans. Mudslides likely and hail to 1 inch possible.

FTB: NWS Flood Watches

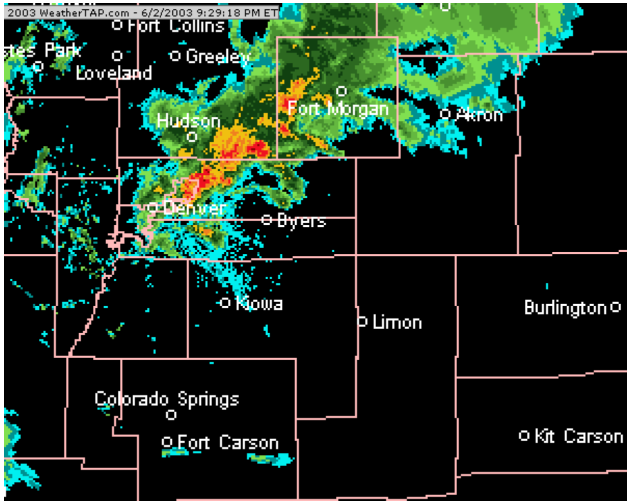
- Incorporation of NWS Web Map Services (WMS)
- Valid times of watches.
- NWS watch comments.
- WMS updated automatically (*Not yet operational*)



Watch #	Valid Time	Comments
1	1PM – 11PM	Slow moving thunderstorms could produce 2-4 inches rain in 1-3hrs producing flash flooding and mudslides, especially in burn areas of Boulder, Larimer and Douglas Counties.

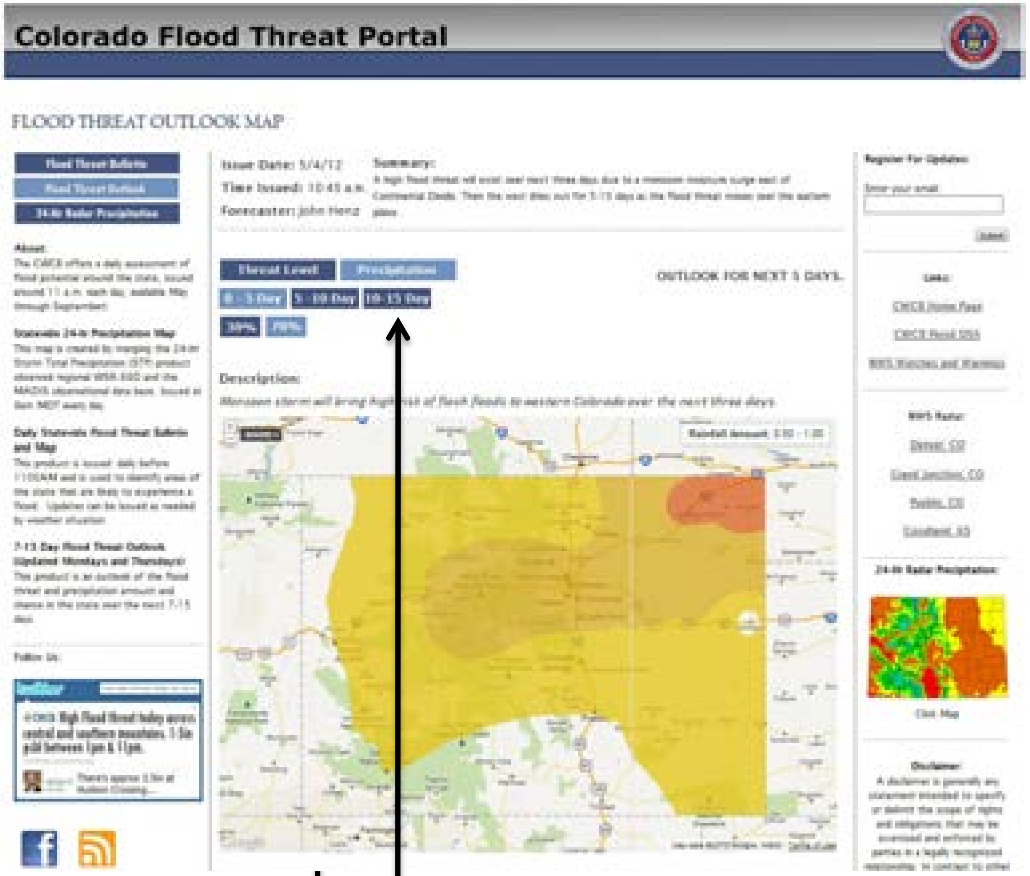
Flood Threat Outlook:

A 15-day look into flood and precipitation potential



FTO: Enhanced Display

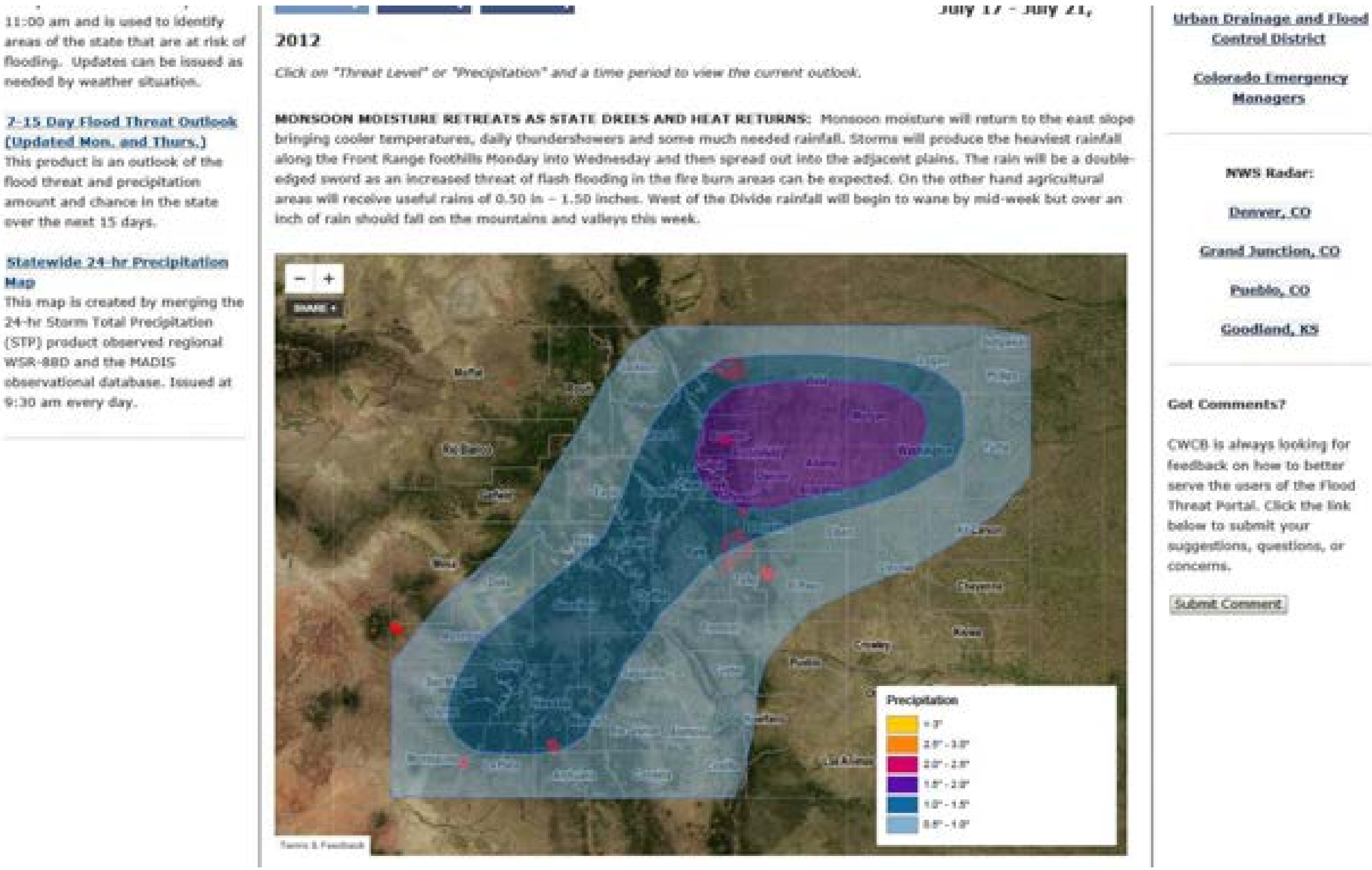
- Interactive navigation
- Categorical flood threat and precip. outlooks
- Valuable for planning by EMs and water supply interests
- Useful to agriculture and recreational groups



View estimated near and long-term outlooks.

Toggle between precipitation amounts of possible (30%) and likely (70%) chance.

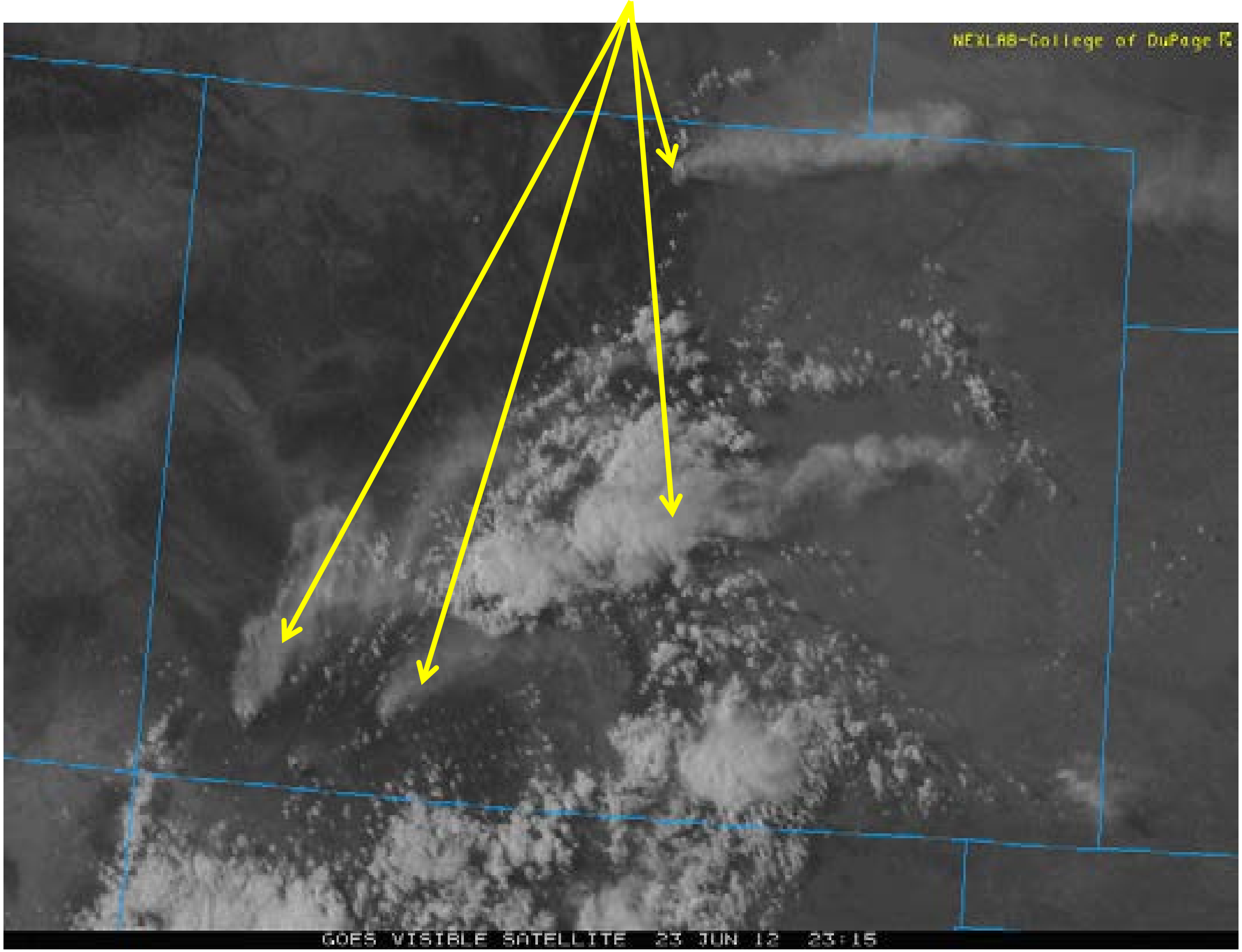
Flood Threat Outlook: an example



Operational Challenges and Innovations

Using fine-mesh experimental storm and precipitation models, IPW and experience to improve flash flood prediction during years of excessive fire threat

Added 2012 complexity: Over a dozen recent fire burn scars = very flashy flood/mudslide issues



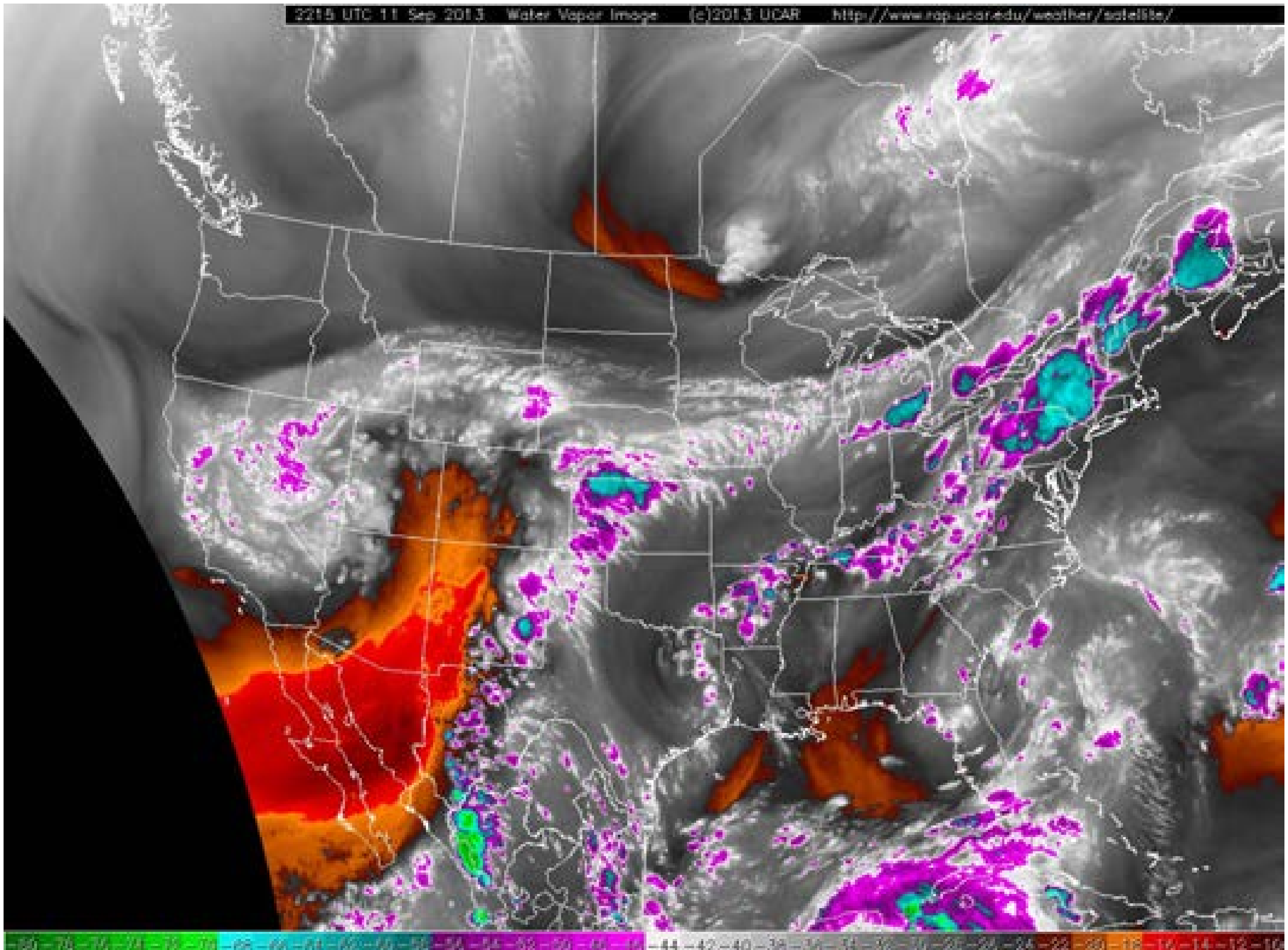
Innovations

- Using Integrated Precipitable Water as a forecast tool.
- Using the National Severe Storms Lab and University of Arizona WRF models to assist in picking county flood threats and timing

Innovation #1: *Use Integrated Precipitable Water (IPW) to identify high flash flood threat days and locations*

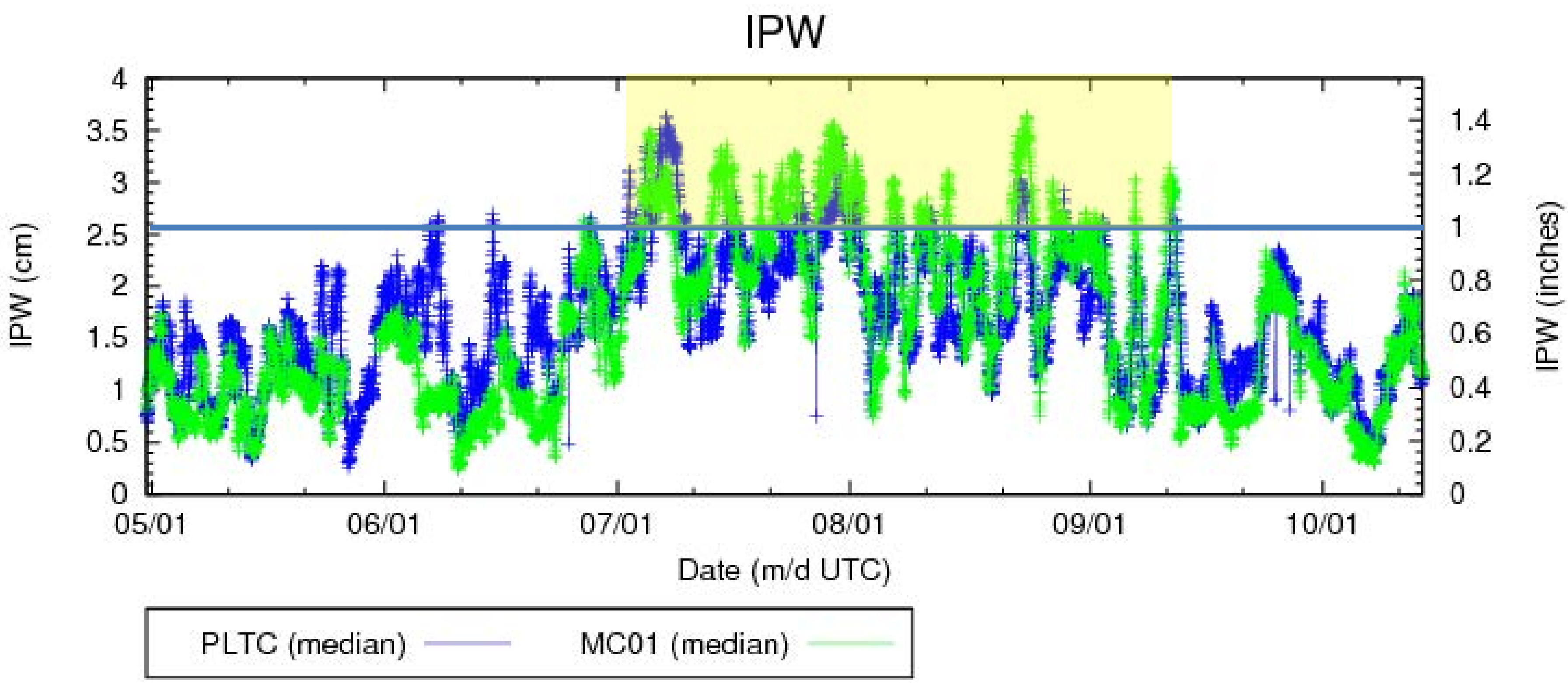
- IPW is measured using the change in speed of travel experienced by GPS network communicating with satellites.
- Previous work identified days with IPW > 1.00 inch = good threat of heavy rain, flash floods.
- Previously IPW measured by balloons 6AM, 6PM only. IPW by GPS monitored continuously.

Water vapor: low IPW = brown; high *vapor* = whites, magentas and greens. 415PM, Sep 11, 2013

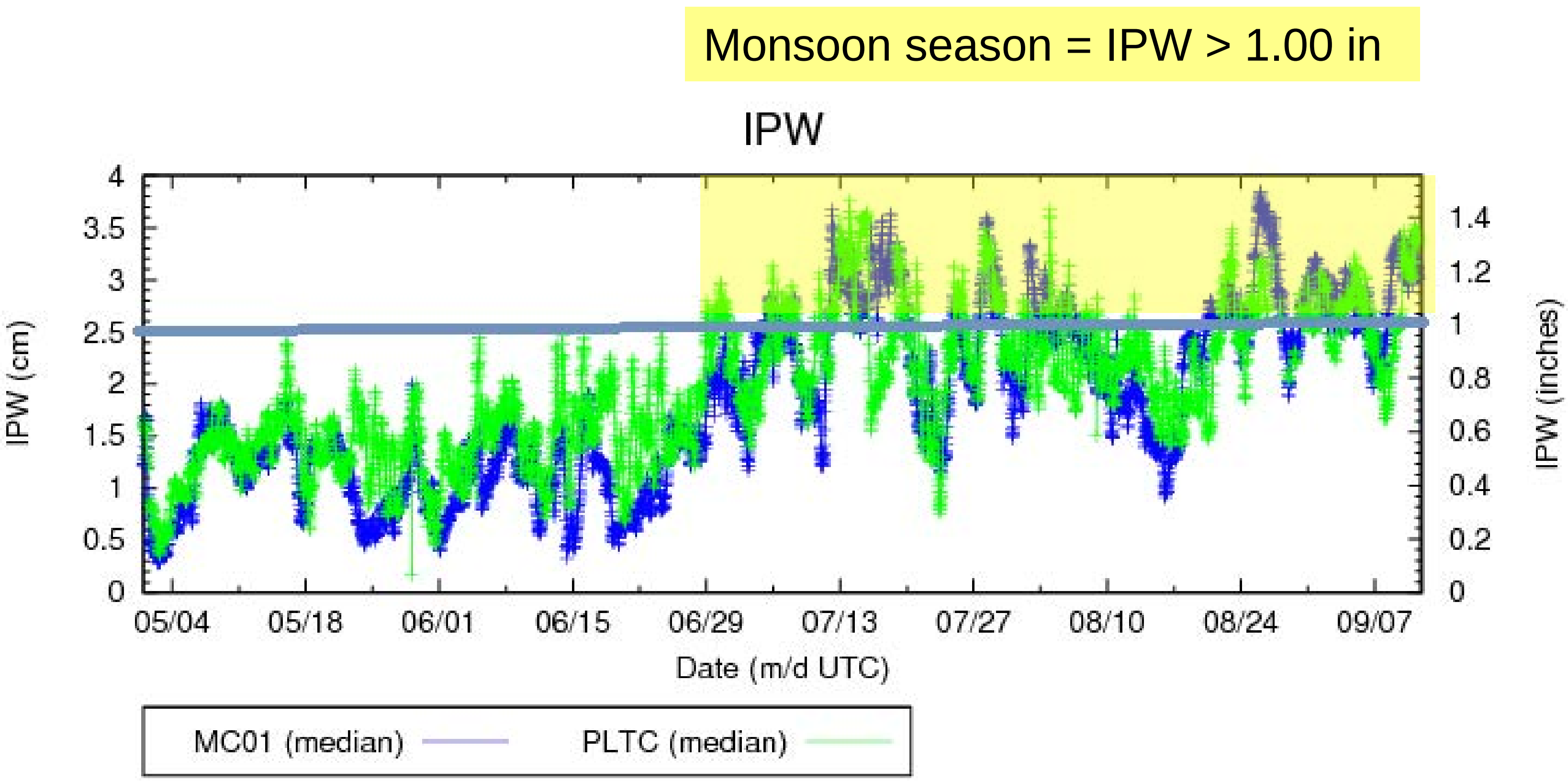


Integrated Precipitable Water (IPW) May 1 – Oct 15, 2012 Grand Junction and Platteville

Monsoon season = IPW > 1.00 in



Integrated Precipitable Water (IPW) May 1 – Sep 10, 2013
Grand Junction and Platteville



IPW looks like a promising tool in forecast tool box

Preliminary values – subject to change

July 1 to September 10, 2012

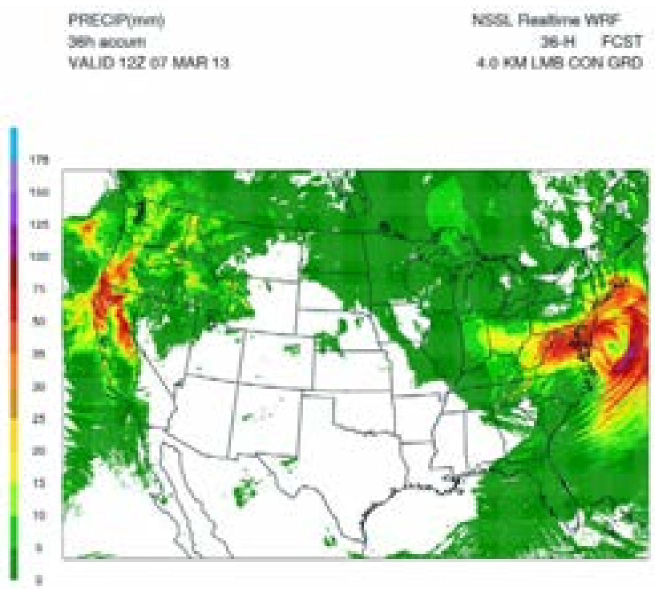
- Flash flood days: 39
- Days IPW >1.00 in: 44
- FFD IPW > 1.00in: 38
- **Prob of Detection: 38/39 = 97%**
- **Over-forecast: 38/44 = 14%**

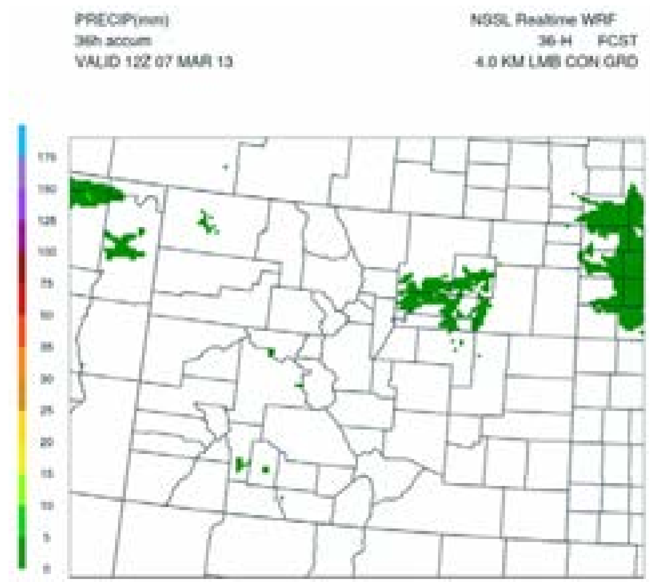
July 1 to September 10, 2013

- Flash flood days: 48
- Days IPW >1.00 in: 51
- FFD IPW > 1.00in: 46
- **Prob of Detection: 46/48 = 96%**
- **Over-forecast: 46/51 = 10%**

May to June large/general storm scale dynamics can overwhelm IPW as a predictor of flood potential at state-wide level.

Dewberry



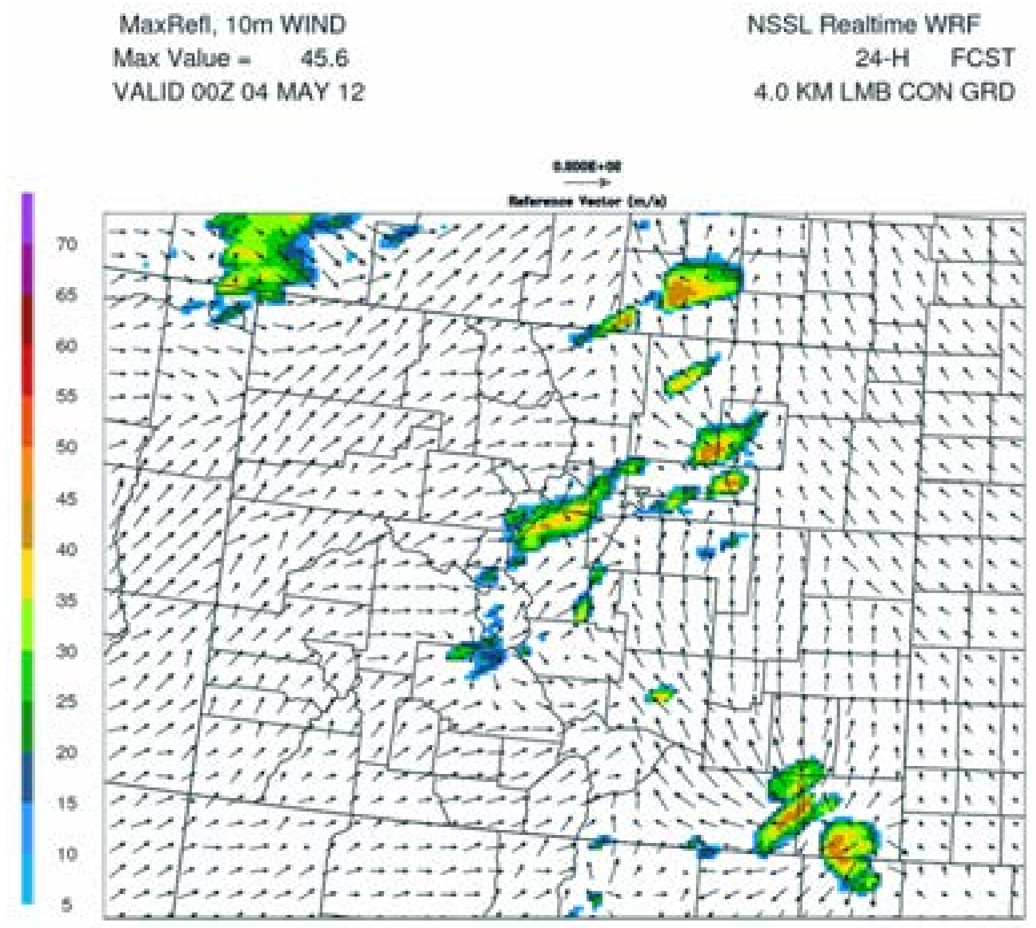


Experience with NSSL-WRF

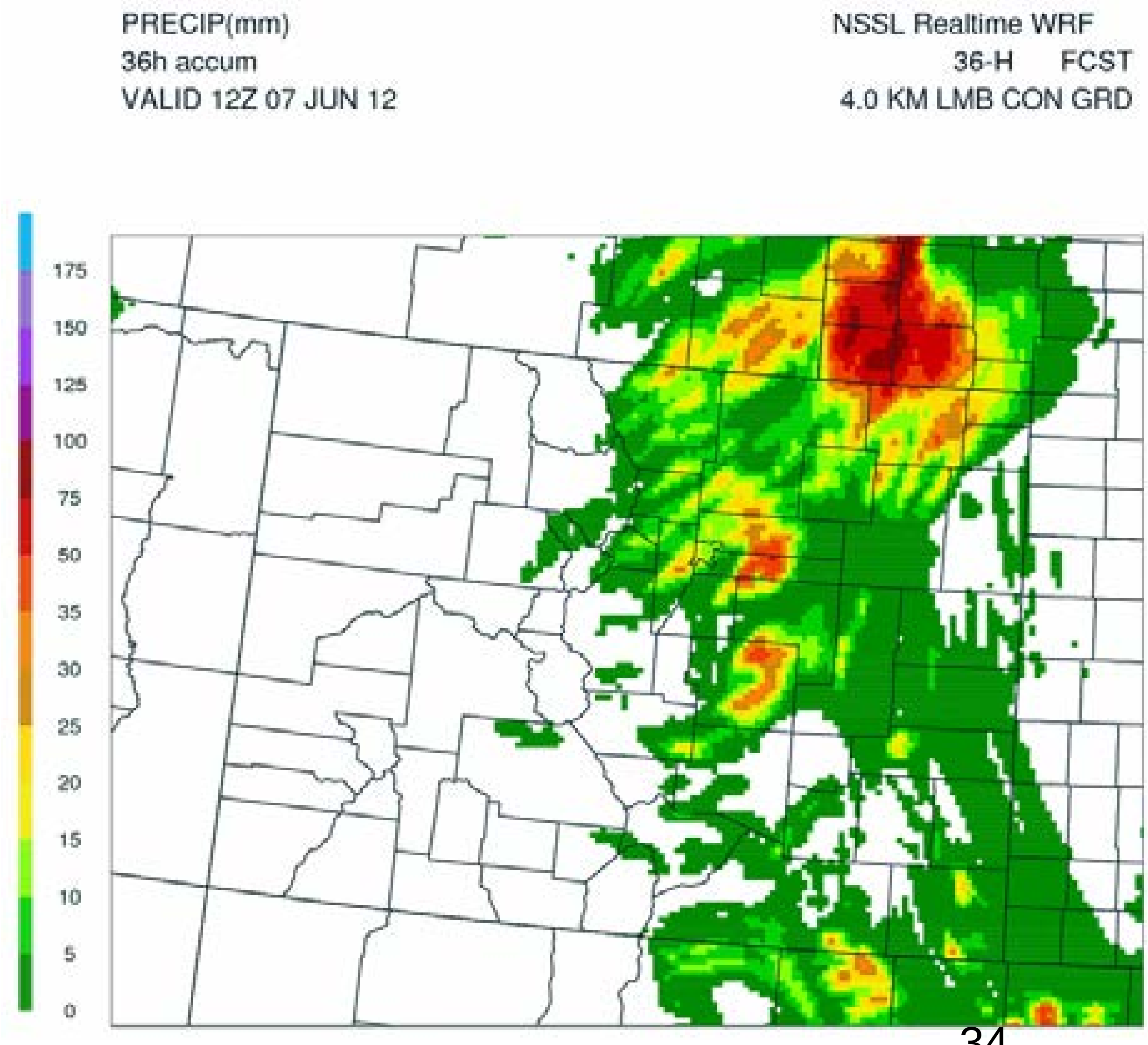
Provide operational meteorologist guidance for a remote and a "rusty" meteorologist. No connections to NSSL community.

NSSL WRF PUB "slice" Colorado specific forecasts

- The WRF model (v3.1.1) configuration includes:
- 15-min radar reflectivity, precipitation and lightning production forecasts for a 36 hour period.
- Forecasts temperature, dew point, winds surface to ~50,000 ft.
- **4 km** grid length (1200x800)
- 35 vertical levels
- Time step 24s
- Run once daily at 00Z for 36 hours at NSSL; available on Web.



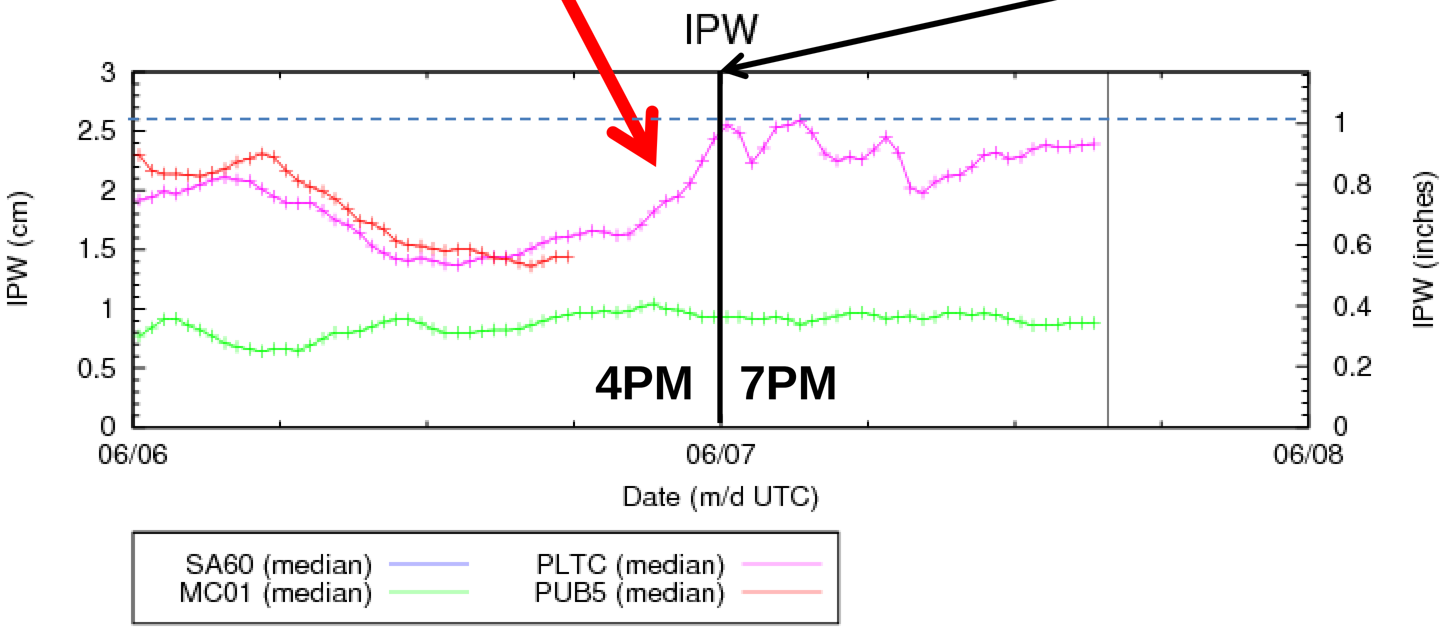
Model QPF for Colorado: can be used to identify counties with higher threat of flash flooding



Three examples

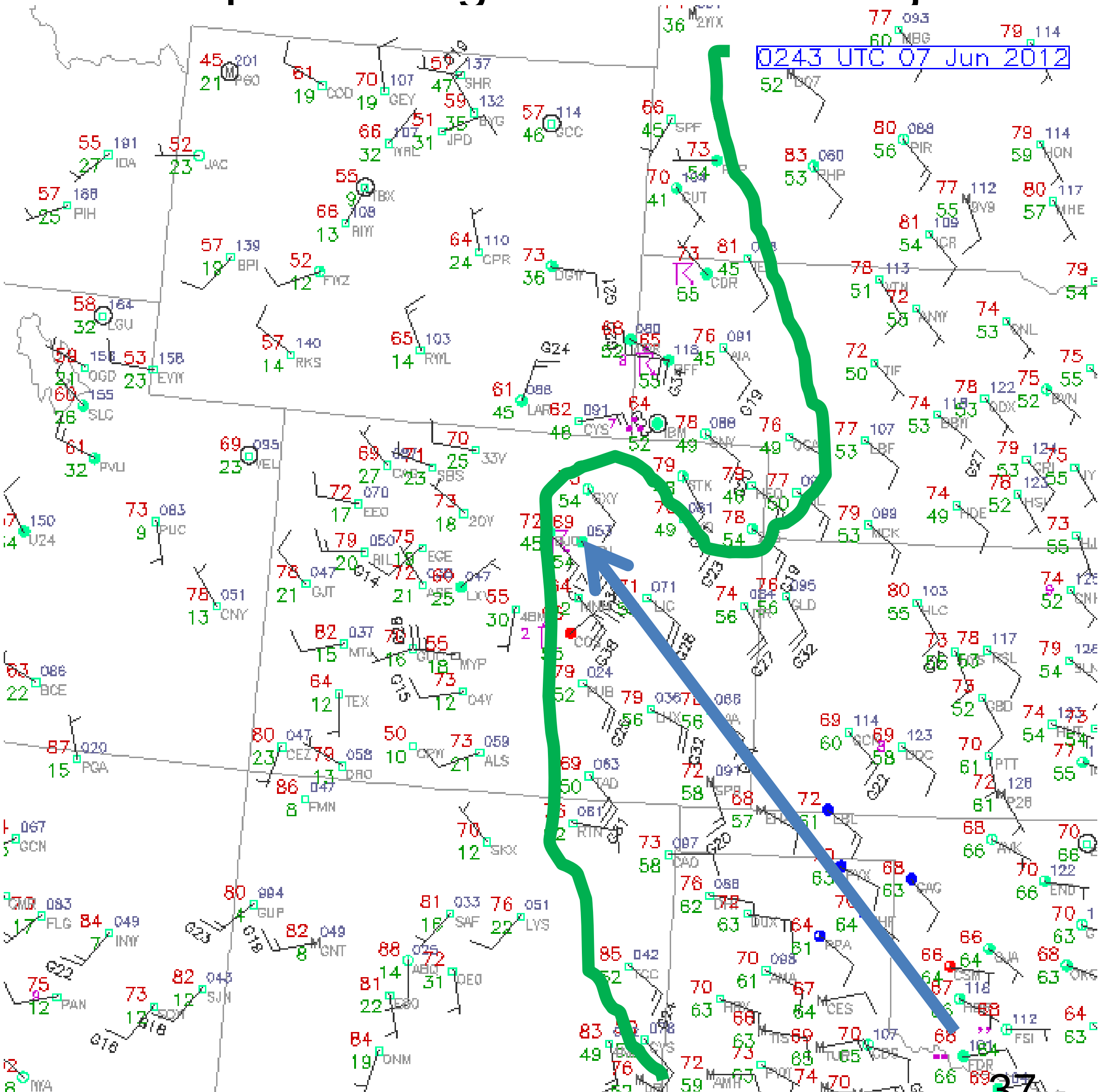
- June 6, 2012 Douglas County south of Denver CO: 4-6in/3hrs rain and flood
- July 17, 2012: High Park Fire Burn area west of Fort Collins CO: Numerous mudslides in 1-2in/1hrs rainfall
- July 31, 2012: Significant flash flooding in Waldo Canyon burn area and Colorado Springs.

Rapid increase in IPW as LLJ imports low level water off the plains into Palmer Ridge and Douglas County by 6PM

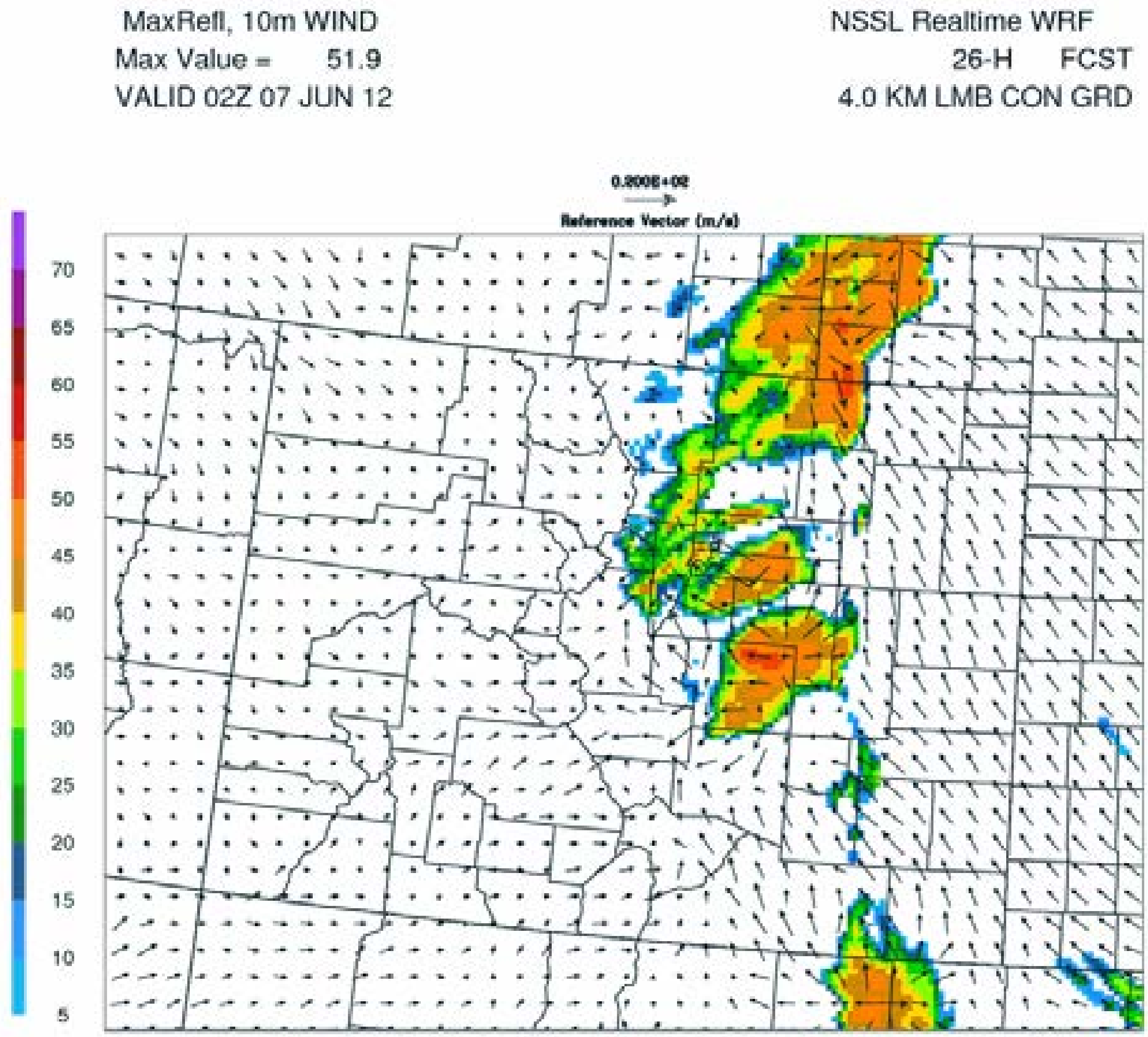


IPW increases from ~0.50 inches to 1.00 inches in 4hrs

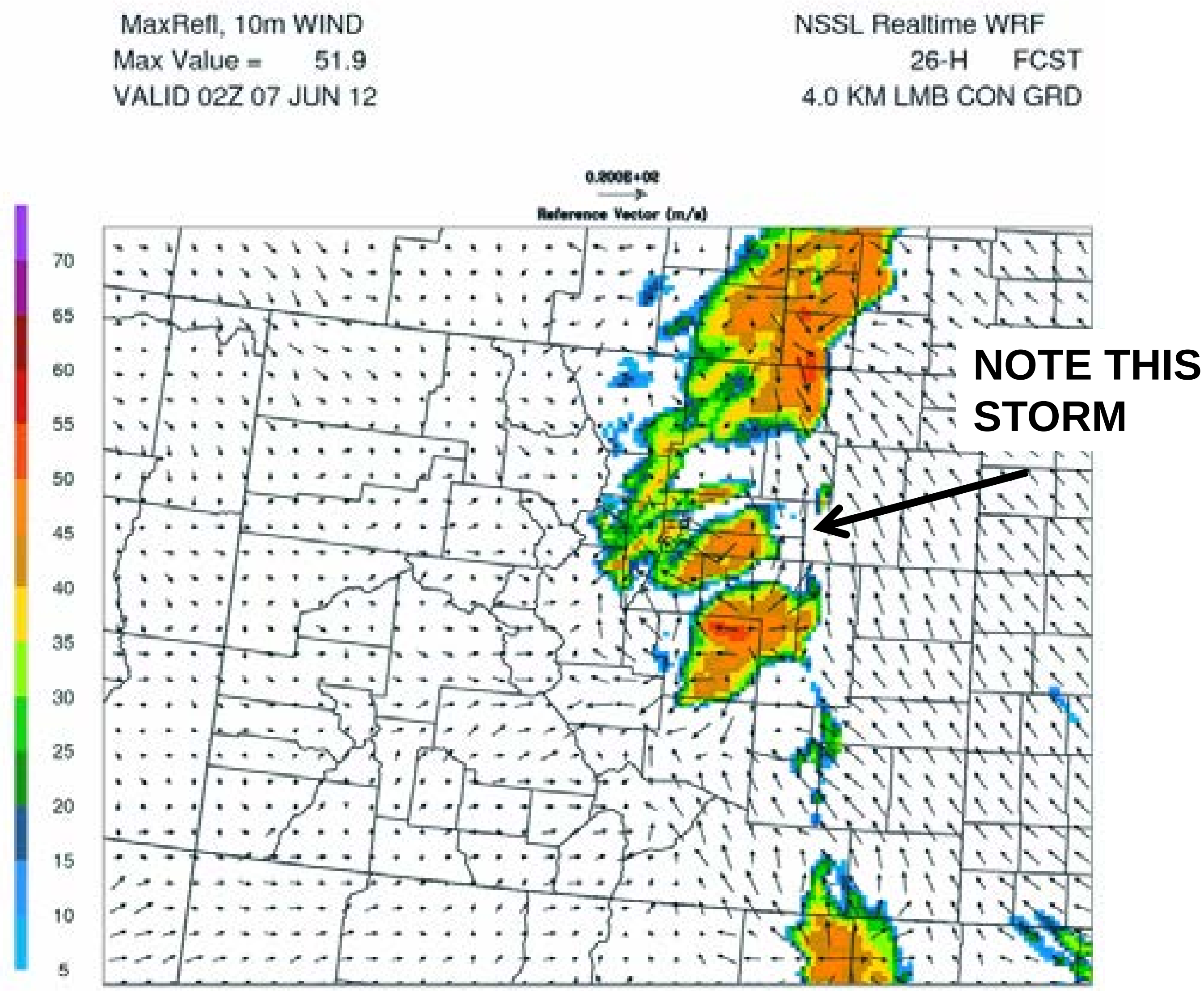
843PM, June 6, 2012 Colorado Surface conditions show why IPW went up – strong moist low level jet



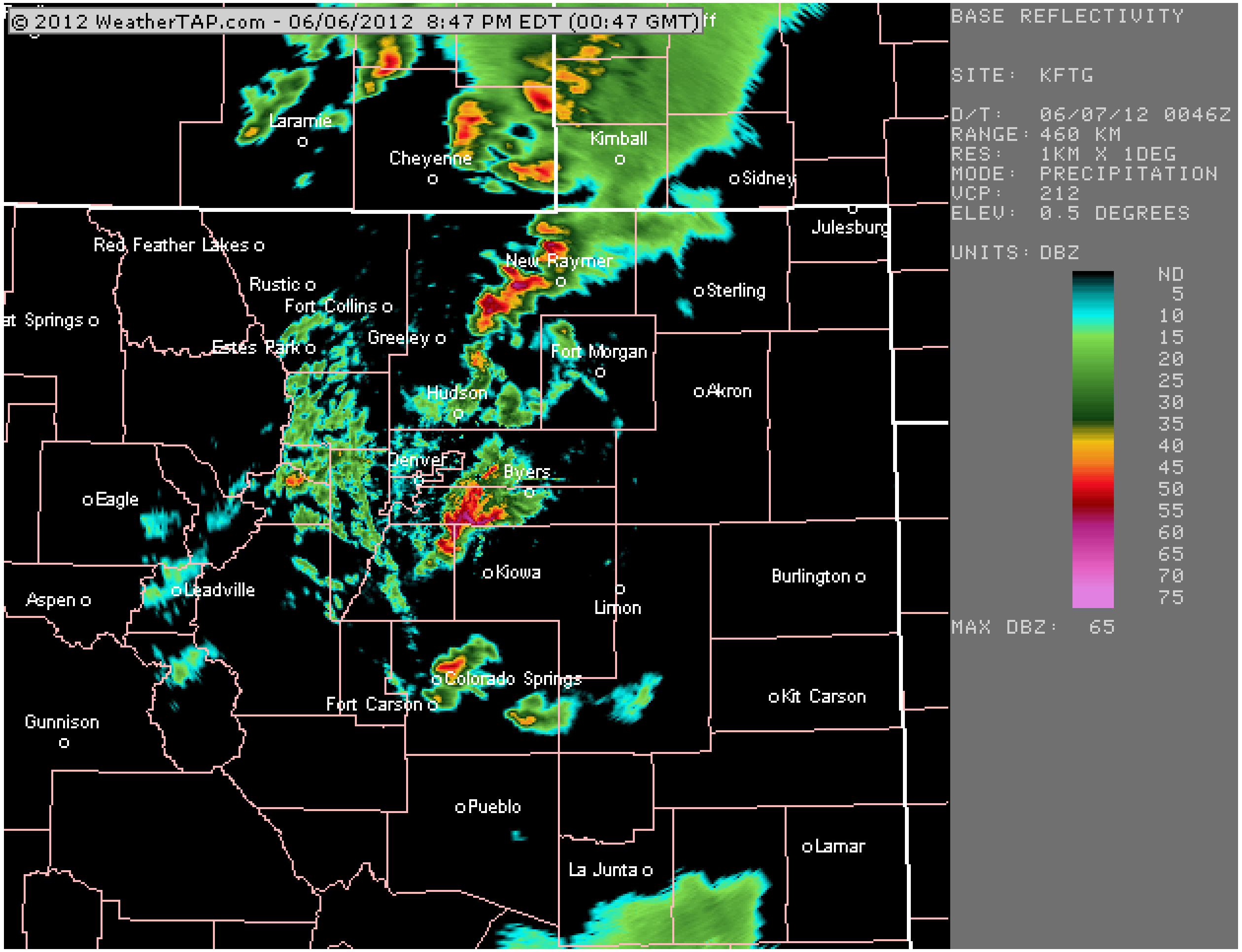
NSSL-WRF predicted radar reflectivity for 800PM 6-06-12



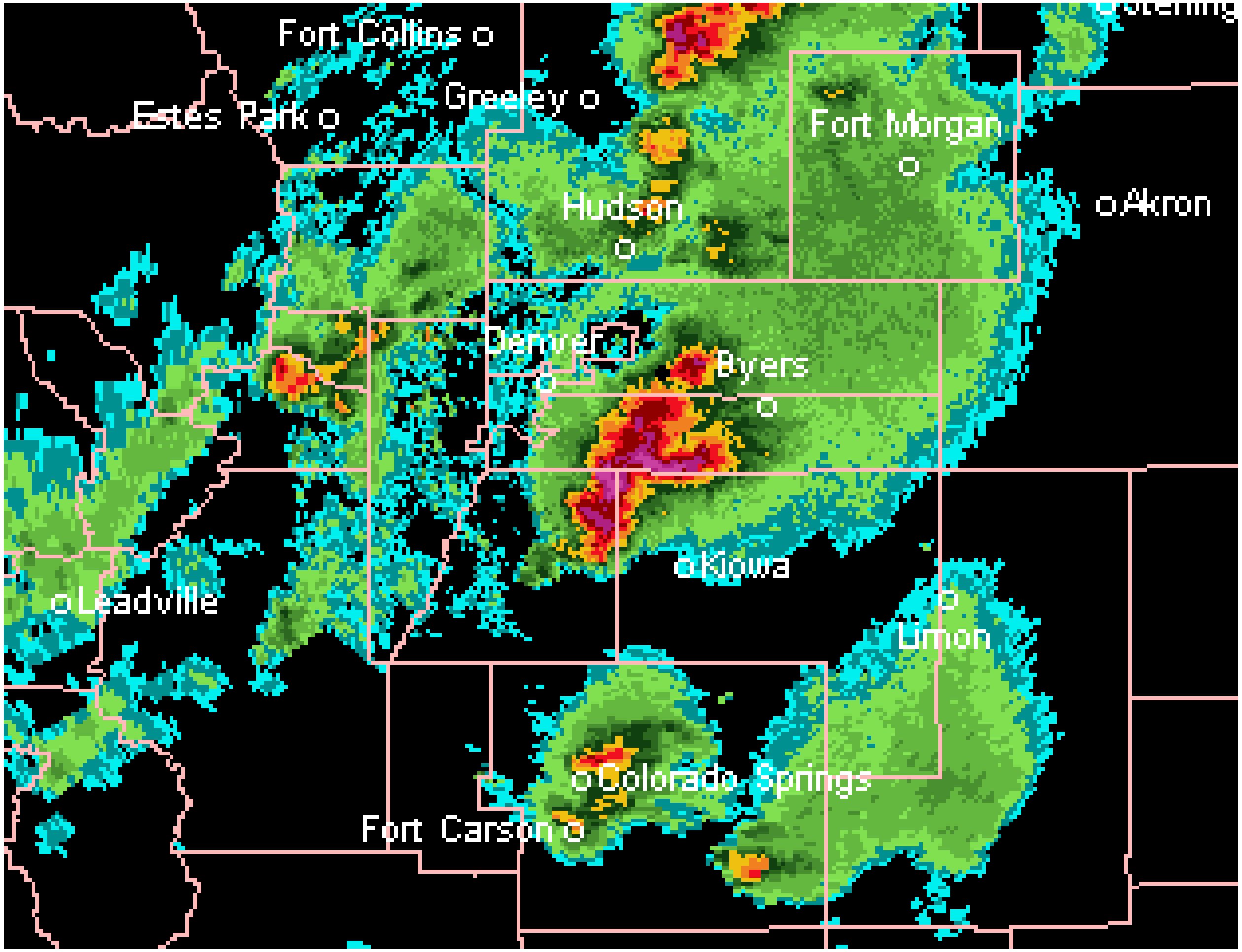
Forecast radar reflectivity for 8PM, June 6, 2012 available ~10PM June 5



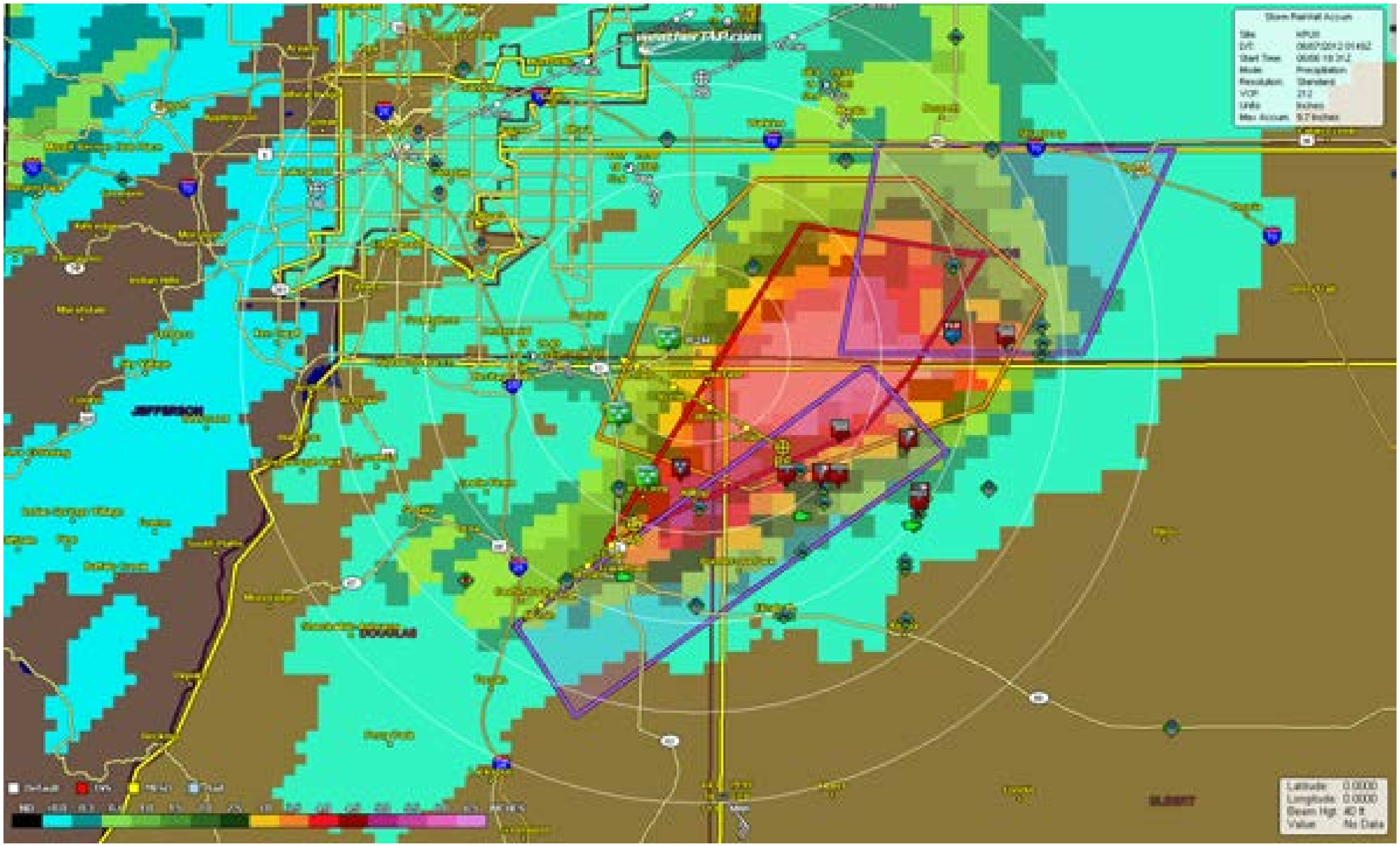
NSSL WRF “hit it”: quite an amazing forecast



Thunderstorm occurs roughly where it was predicted to be



Warnings issued for tornadoes, severe weather and flash flooding that could have been highlighted
as a ***" hot storm area"*** 12 hrs before the event.



Colorado Flood Threat Bulletin July 17, 2012

Flood Threat Bulletin
Flood Threat Outlook
24-Hr Radar Precipitation

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Issue Date: Tuesday, July 17, 2012
Time Issued: 1014 AM MDT
Forecaster: Ryan Towell

SCATTERED STORMS AGAIN THIS AFTERNOON AND EVENING; FLOOD THREAT IN FOOTHILLS

Water vapor satellite imagery this morning indicates drier air moving into the western portions of the State with monsoonal moisture being shunted a bit further east, mainly over central Colorado. With daytime heating, showers and storms will flare once again along the Continental Divide and into the Front Range, particularly after 1pm MDT. Storms will also develop into the foothills and parts of the plains as the afternoon progresses. Storms will generally move toward the east at 5 to 10mph.

The heaviest storms will be capable of cloud-to-ground lightning, hail and rainfall rates of 1.25" or so per hour. The foothills and burn areas, particularly those that received heavy rainfall yesterday including the High Park and Waldo Canyon burn scars, look to be most susceptible to flash flooding today. A Low Flood Threat is posted for the foothills, but a Moderate Flood Threat exists in the burn areas.

Showers and storms will be diurnally driven with much of the activity and the threat for flooding quickly dissipating after sunset.

Hover over the map to see today's flood threat bulletin.

Forecasts Provided By:

Dewberry

Links:

CWCB Home Page

CWCB Flood DSS

NWS Watches and Warnings

Urban Drainage and Flood Control District

Colorado Emergency Managers

NWS Radar:

Denver, CO

Grand Junction, CO

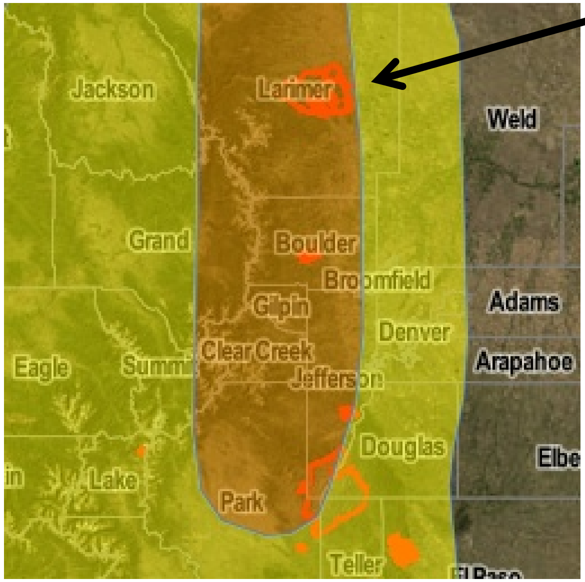
Pueblo, CO

Goodland, KS

Got Comments?

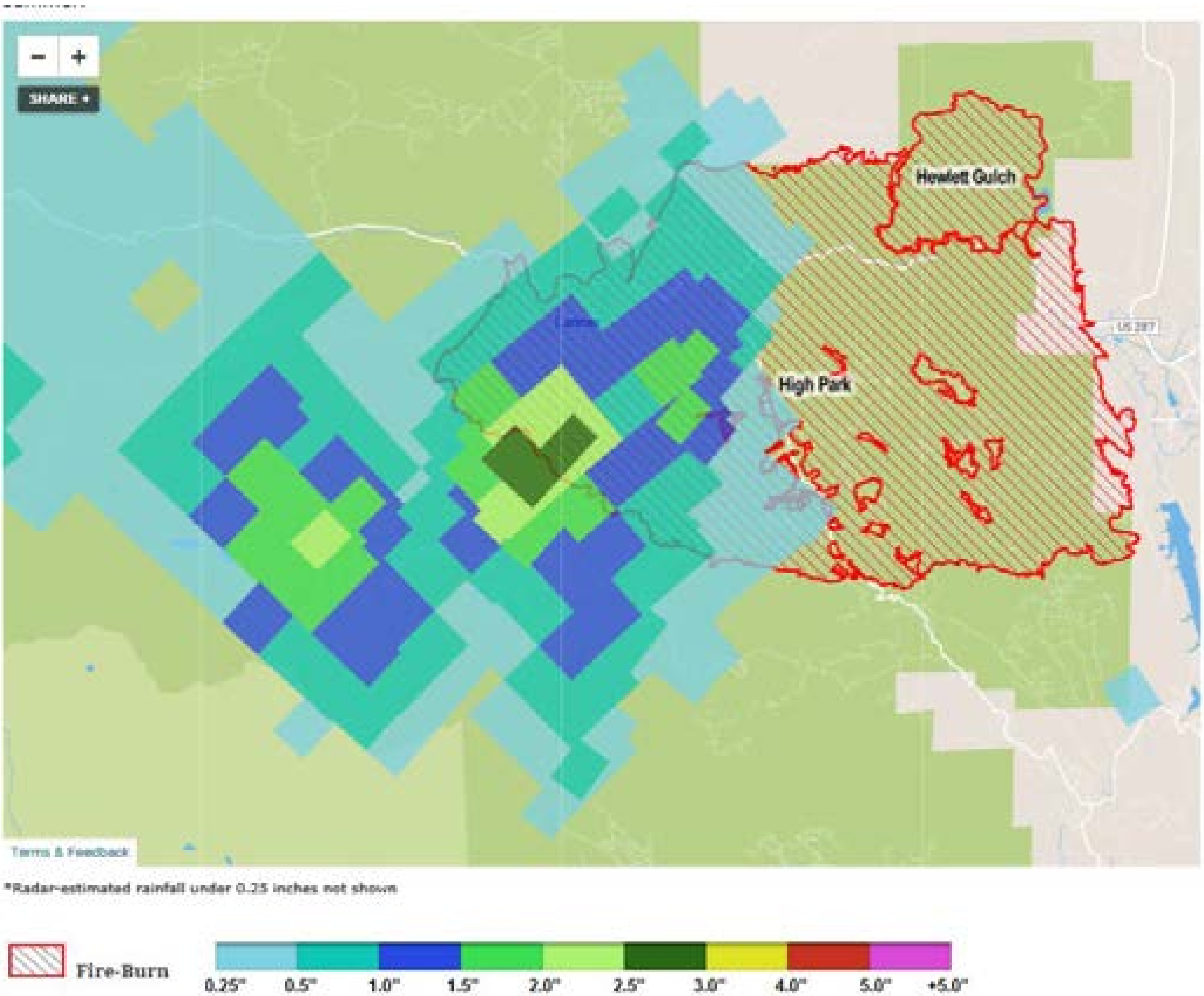
CWCB is always looking for feedback on how to better serve the users of the Flood Threat Portal. Click the link below to submit your suggestions, questions, or

Flooding predicted in High Park Fire Burn Area

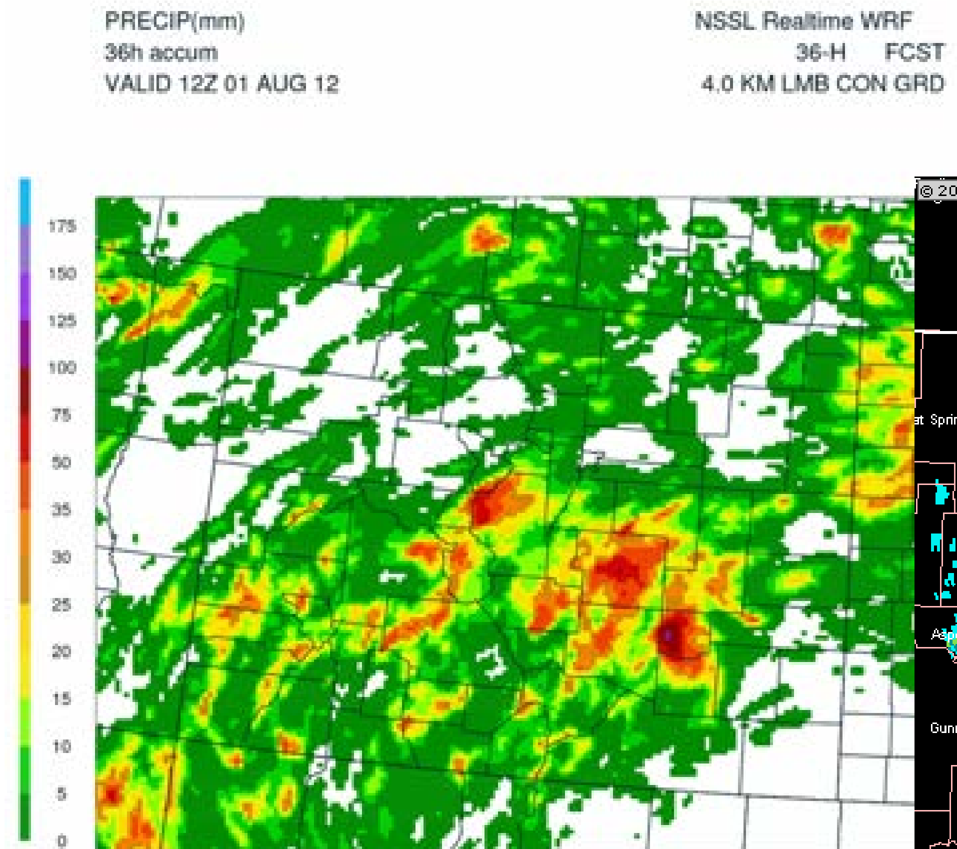


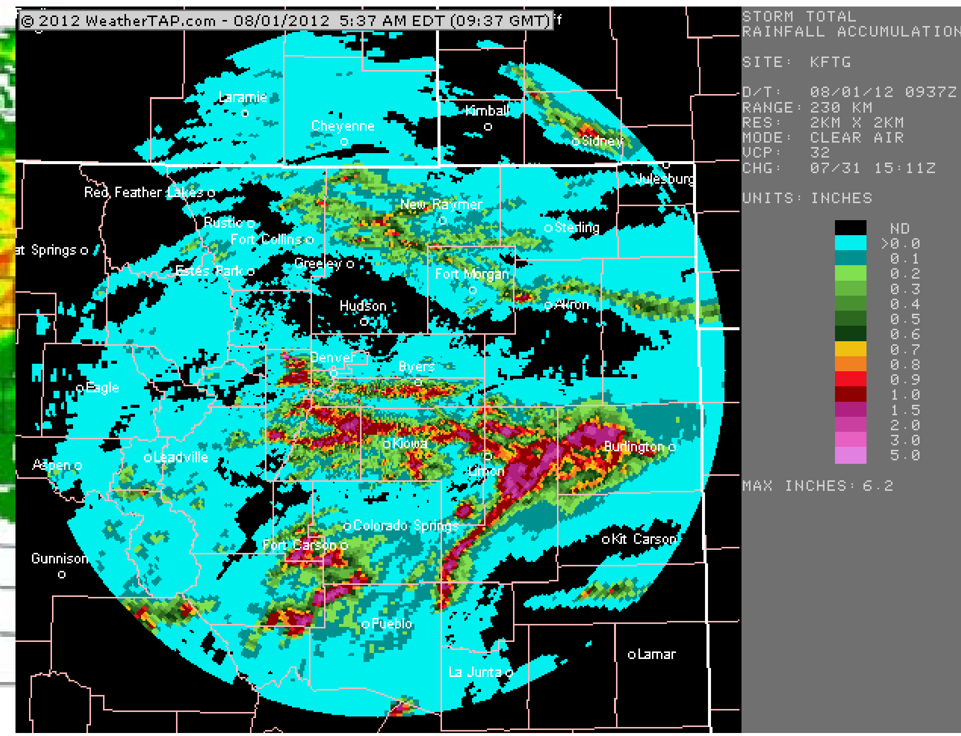
Mudslides and road closures; no lives lost

High Park Flood Thunderstorm Rainfall



“Roughly right; exactly wrong” but served meteorologists to alert them to significant day





Waldo Canyon west of Colorado Springs 7-31-12

$15 Million Damage due to flooding in Colorado Springs on July 31, 2012 plus rare mountain tornado

World’s second highest observed tornado on Mount Evans: > 13,000ft

Performance

www.coloradofloodthreat.com

2012 FTB Forecast Metrics by month

Month	Correct FTB Forecasts	Observed Flood Days missed	Flood Days Forecast that did not occur	Number of flood days per month	Number of observed flood days predicted	Number of observed flood days not predicted
May	26/31	3	2	8	5	3
June	26/30	3	1	13	10	3
July	27/31	1	3	18	17	1
August	25/31	1	5	15	14	1
September	28/30	2	0	10	8	2
Total	132/153 (86%)	10	11	64	54 (84%)	10 (16%)

Preliminary 2013 FTB Forecast Metrics by month

Month	Correct FTB Forecasts	Observed Flood Days missed	Flood Days Forecast that did not occur	Number of flood days per month	Number of observed flood days predicted	Number of observed flood days not predicted
May	28/31	1	2	9	8	1
June	25/30	3	2	11	8	3
July	29/31	1	1	20	19	1
August	29/31	1	1	22	21	1
September	10/10	0	0	6	6	0
Total	121/133 (91%)	6	6	68	62 (91%)	6 (16%)

2012 FTB Program WRF- Assisted Meteorologist Forecast Metrics Improved during storm season.

Month	Correct FTB Forecasts	Observed Flood Days missed	Flood Days Forecast that did not occur	Number of observed flood days per month	Number of observed flood days predicted	Number of observed flood days not predicted
May	26/31	3	2	8	**5 (62%)**	3
June	26/30	3	1	13	**10 (79%)**	3
July	27/31	1	3	18	**17 (94%)**	1
Aug	25/31	1	5	15	**14 (93%)**	1
Sept	28/30	2	0	10	**8 (80%)**	2
Total	**132/153 (86%)**	**10**	**11**	**64**	**54 (84%)**	**10 (16%)**

Table Key weather events for the 2012 FTB program

Month	UDFCD (Denver metro) flood event days	NWS severe days	NWS flash flood days	Number and percent of flood days	Big flood event dates
May	1	8	2	8/31 (25%)	19-25
June	6	11	4	13/30 (40%)	4-8, 12-16
July	10	15	12	18/31 (60%)	3-9, 11-13, 15-17, 27-31
August	2	7	11	15/31 (50%)	9-11, 22-28
Sept	1	4	8	10/30 (30%)	25-29
Total	20	45	37	64/153 (41%)	

Flood day = NWS Flash Flood Obs or other observed flood plus either NWS severe weather day and >1.00in or >2.00in. Burn site exception.

Final thoughts

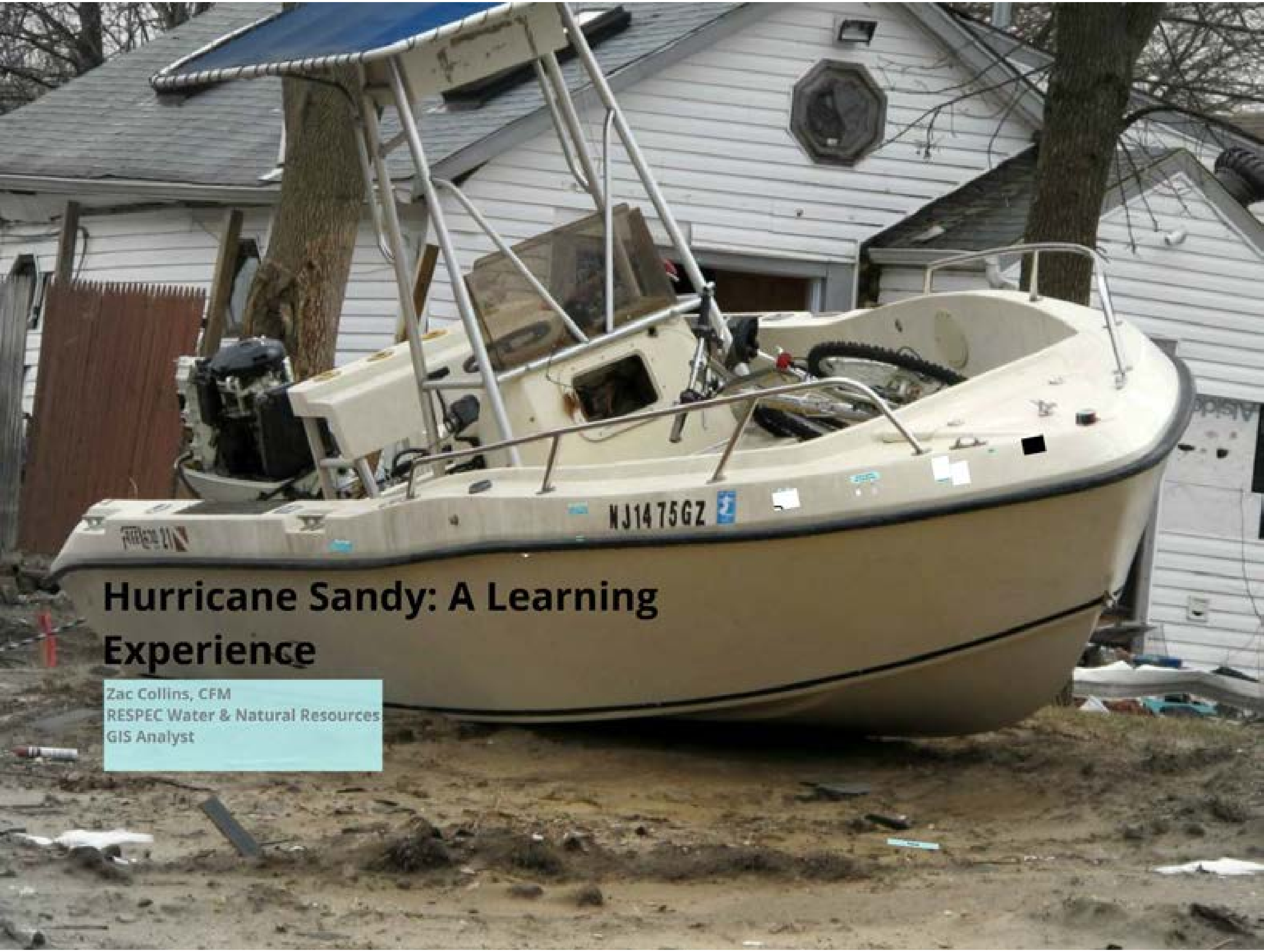
- State-wide county-specific flood threat potential is embraced by EM/response community.
- Timing, spatial coverage, intensity assist planning.
- 15-day flood threat/precipitation outlook assists water supply community + EM’s.
- New model and communications technology driving innovative products.

www.coloradofloodthreat.com

QUESTIONS – Stu Geiger

Email: jhenz@dewberry.com or **sgeiger@dewberry.com**


Hurricane Sandy: A Learning Experience
Zac Collins, CFM
RESPEC Water & Natural Resources
GIS Analyst
NJ1475GZ



Hurricane Sandy: A Learning Experience

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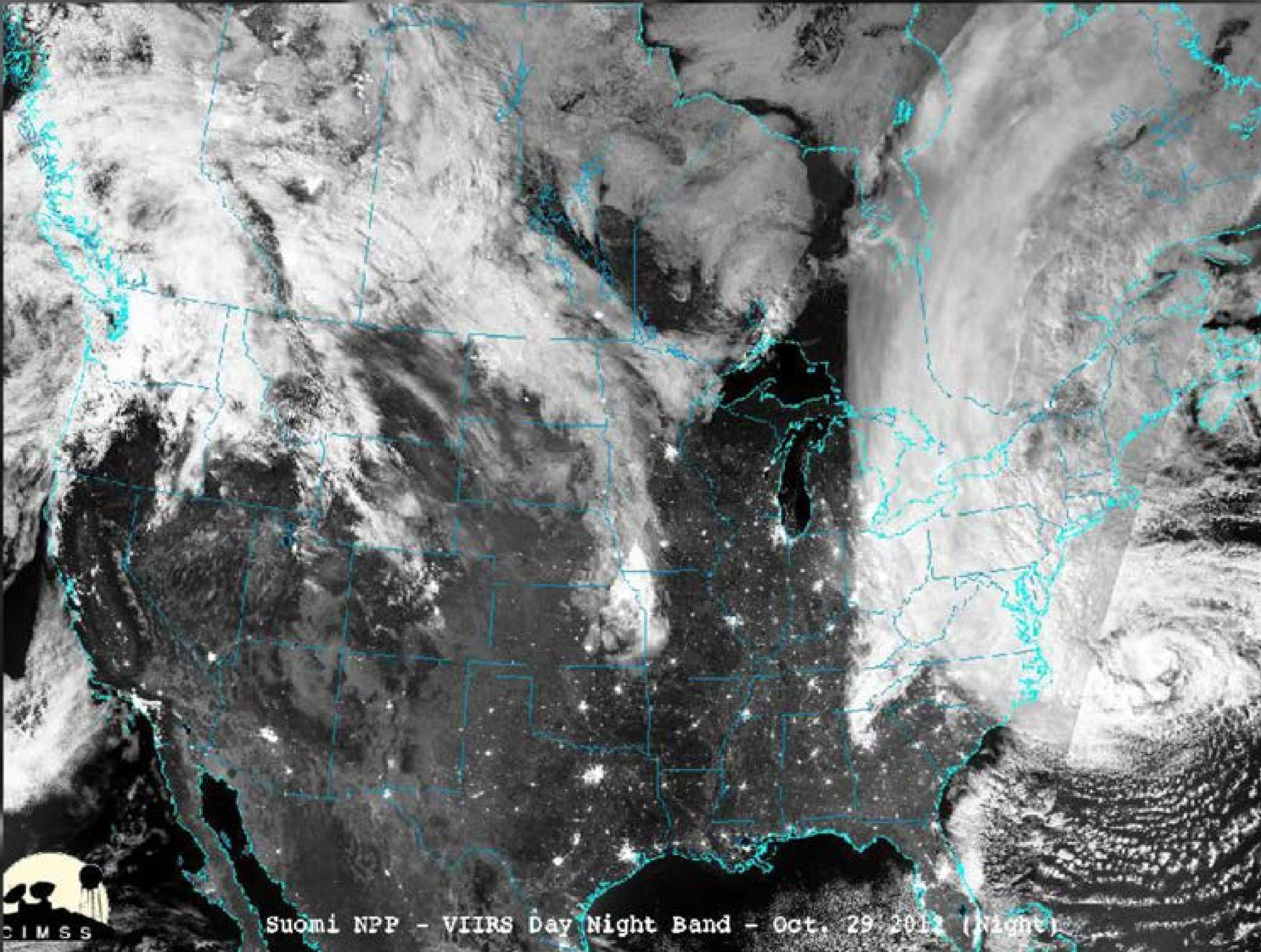

CIMSS
Suomi NPP - VIIRS Day Night Band - Oct. 29 2012 (Night)

Sandy Heights

How did a Montana boy wind up in New Jersey?

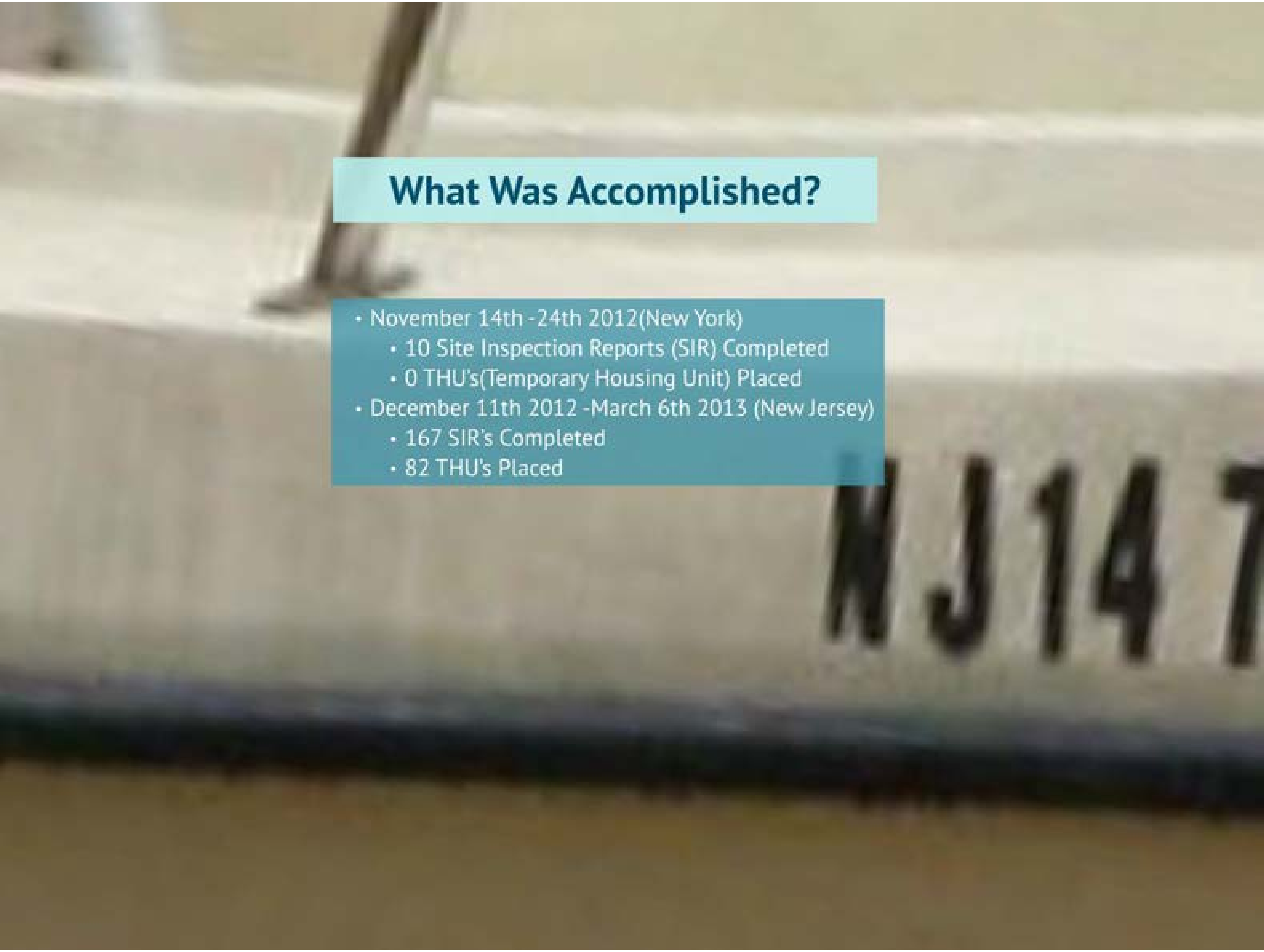
NEW JERSEY RECOVERY FROM HURRICANE SANDY:BY THE NUMBERS

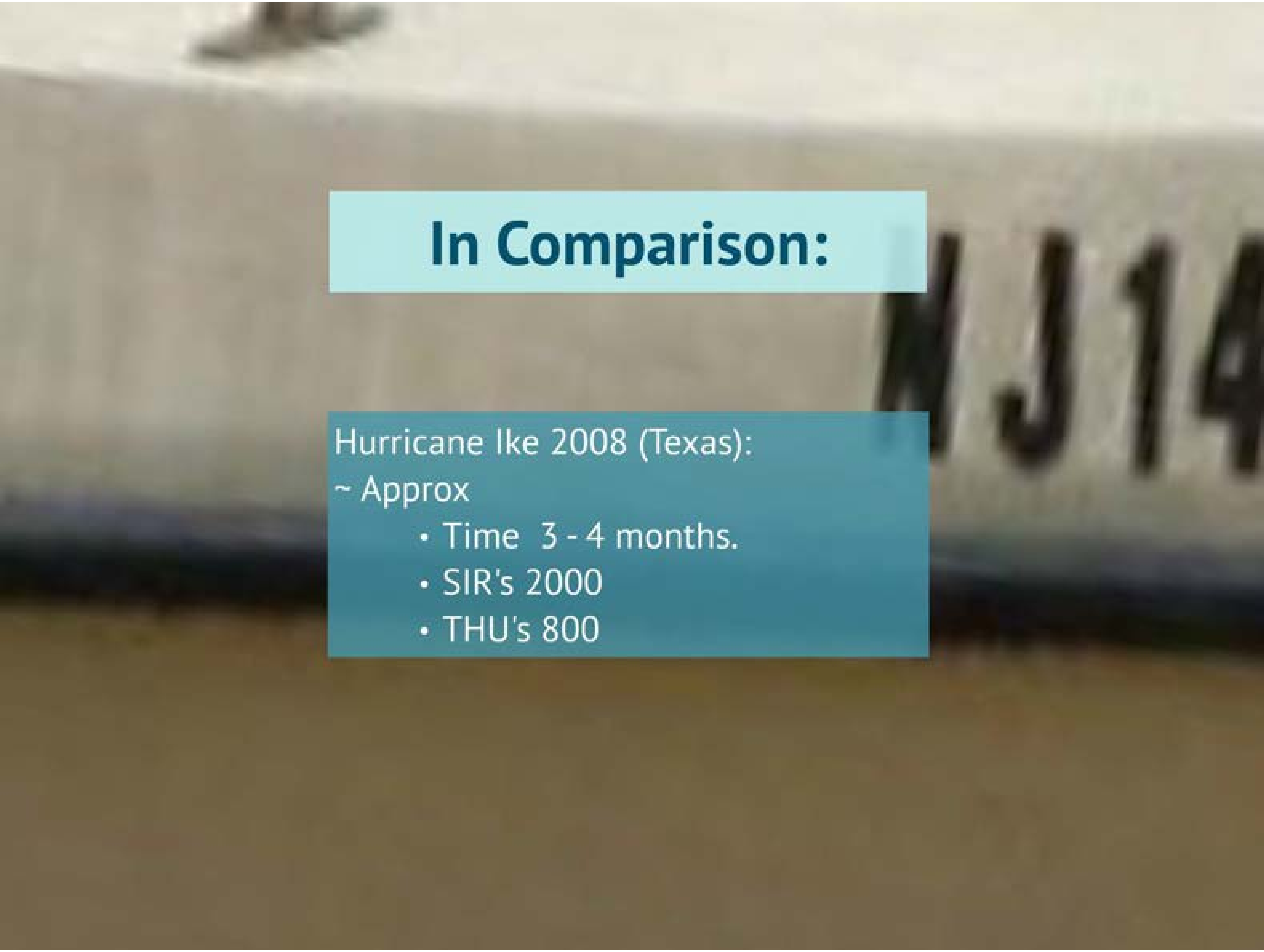
date: March 25, 2013(147 days / 4 Months 25 days since impact)
Number: NJ NR 131
ON, N.J. – Disaster assistance to New Jersey survivors of Hurricane Sandy by the numbers as of March 25:
on in total National Flood Insurance Program payments made on claims to date
illion in FEMA grants approved for individuals and households
million for housing assistance
illion for other needs
million in SBA disaster loans approved for homeowners, renters and businesses
million approved in FEMA Public Assistance grants to communities and some nonprofit organizations that serve th
people contacted FEMA for help or information
housing inspections completed
visits to Disaster Recovery Centers
nters opened to assist survivors who had recovery questions

The Goal Of It All.

What Was Accomplished?

- November 14th -24th 2012(New York)
    - 10 Site Inspection Reports (SIR) Completed
    - 0 THU's(Temporary Housing Unit) Placed
- December 11th 2012 -March 6th 2013 (New Jersey)
    - 167 SIR's Completed
    - 82 THU's Placed





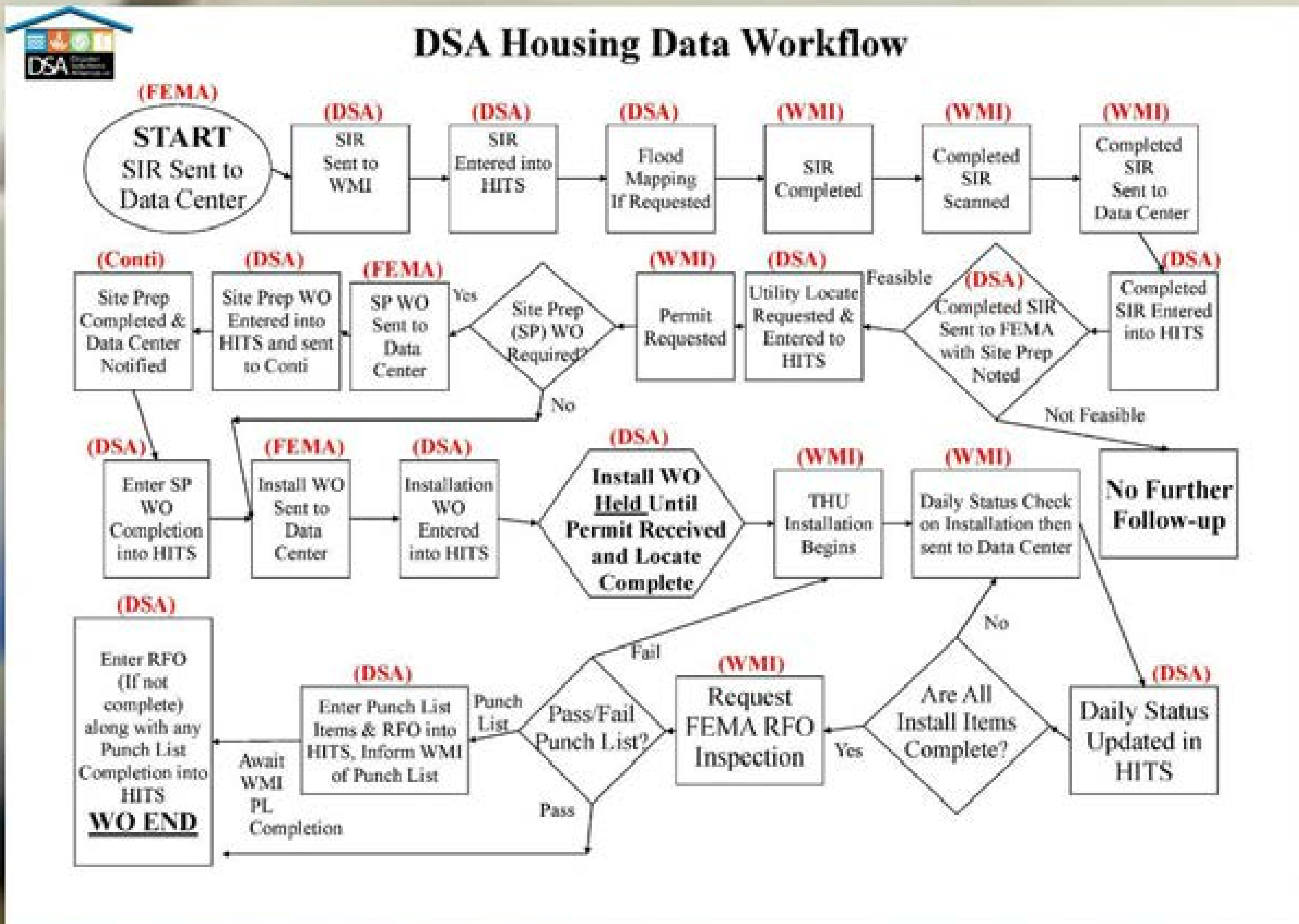
In Comparison:

Hurricane Ike 2008 (Texas):

~ Approx

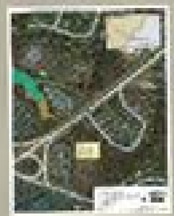
- Time 3 - 4 months.
- SIR's 2000
- THU's 800

Process


DSA Housing Data Workflow
(FEMA)
START
SIR Sent to Data Center
(DSA)
SIR Sent to WMI
(DSA)
SIR Entered into HITS
(DSA)
Flood Mapping If Requested
(WMI)
SIR Completed
(WMI)
Completed SIR Scanned
(WMI)
Completed SIR Sent to Data Center
(DSA)
Completed SIR Entered into HITS
(DSA)
Completed SIR Sent to FEMA with Site Prep Noted
Feasible
Not Feasible
No Further Follow-up
(DSA)
Utility Locate Requested & Entered to HITS
(WMI)
Permit Requested
Site Prep (SP) WO Required?
Yes
No
(FEMA)
SP WO Sent to Data Center
(DSA)
Site Prep WO Entered into HITS and sent to Conti
(Conti)
Site Prep Completed & Data Center Notified
(DSA)
Enter SP WO Completion into HITS
(FEMA)
Install WO Sent to Data Center
(DSA)
Installation WO Entered into HITS
(DSA)
Install WO Held Until Permit Received and Locate Complete
(WMI)
THU Installation Begins
(WMI)
Daily Status Check on Installation then sent to Data Center
(DSA)
Daily Status Updated in HITS
Are All Install Items Complete?
No
Yes
(WMI)
Request FEMA RFO Inspection
Pass/Fail Punch List?
Fail
Pass
Punch List
(DSA)
Enter Punch List Items & RFO into HITS, Inform WMI of Punch List
Await WMI PL Completion
(DSA)
Enter RFO (If not complete) along with any Punch List Completion into HITS
WO END

Finding Suitable: Sites and Occupants

Sites



Occupants

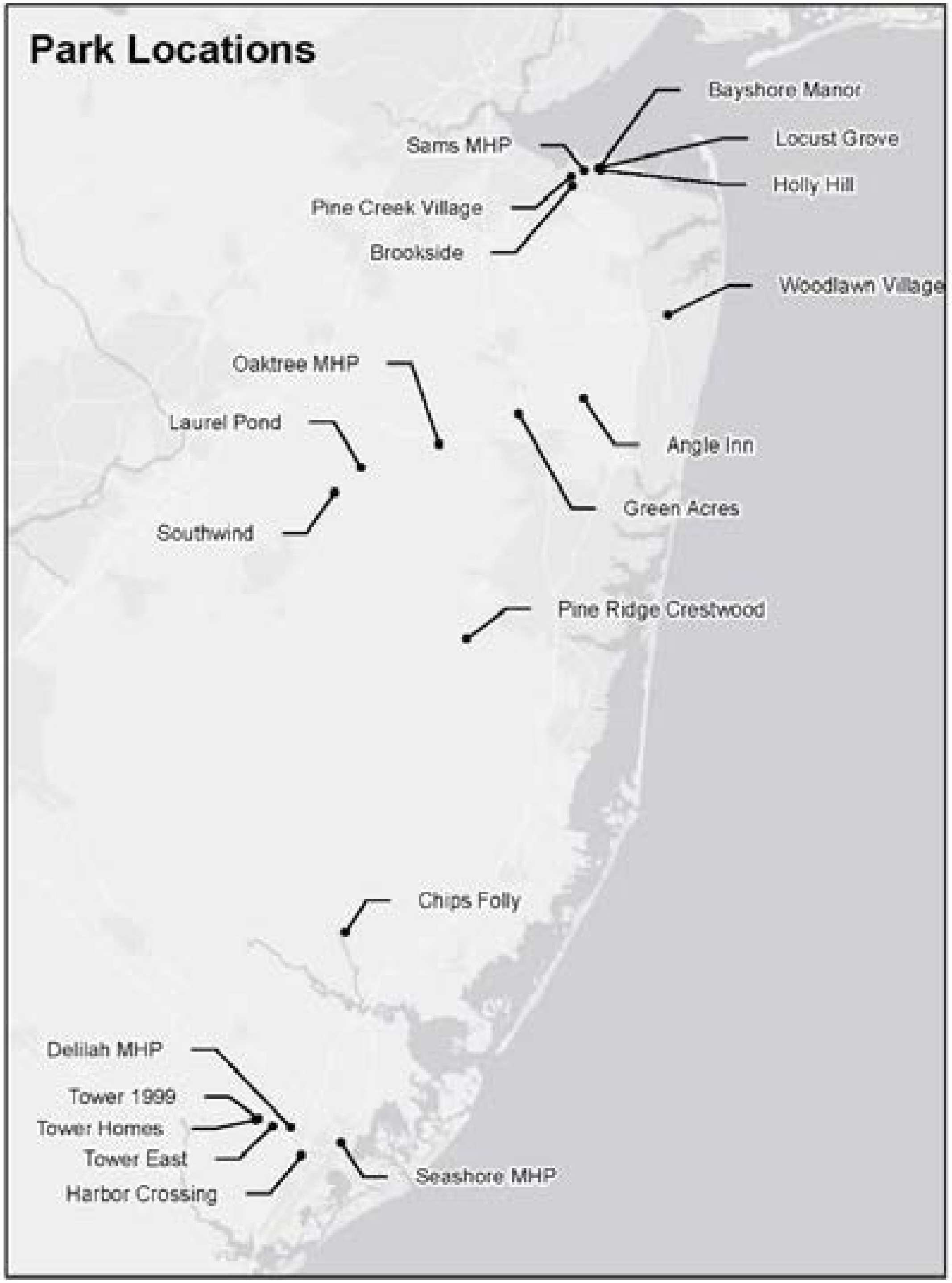
Sites

- Eight + Units On the Property
- Proper Electrical - 200 amp needed most were 120 amp
- Minimal Engineering- Site Upgrades
- Out of the floodplain!


Philadelphia
Atlantic City
AREA MAPPED
0041

Occupants

- Own their House
- Have insurance
- Willing to move to a Trailer Park
  - Unable to move a FEMA trailer to owners site 99% of the time

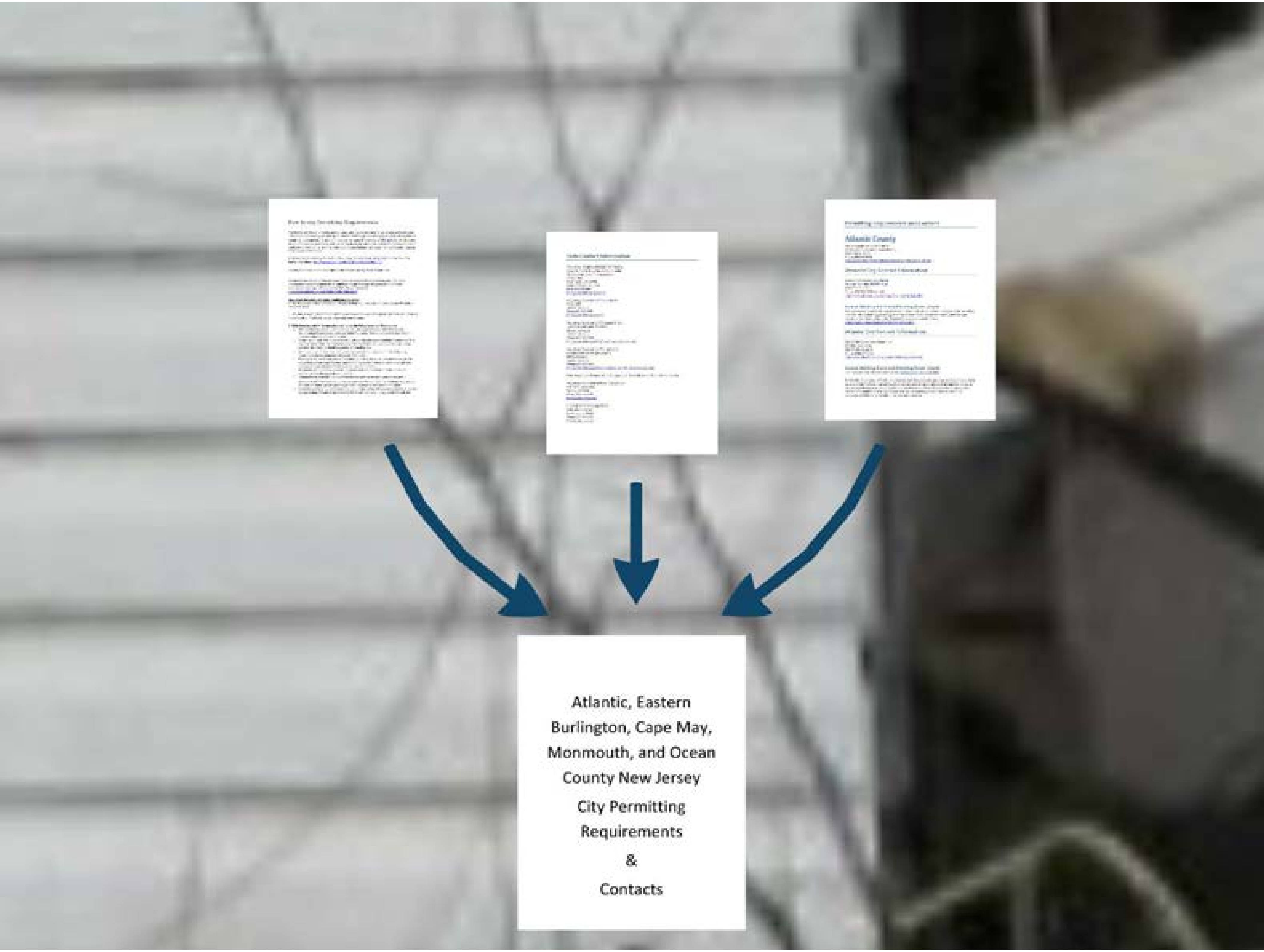

Park Locations
Bayshore Manor
Sams MHP
Locust Grove
Holly Hill
Pine Creek Village
Brookside
Woodlawn Village
Oaktree MHP
Laurel Pond
Angle Inn
Green Acres
Southwind
Pine Ridge Crestwood
Chips Folly
Delilah MHP
Tower 1999
Tower Homes
Tower East
Harbor Crossing
Seashore MHP


What was helpfull?
• City Permitting Requirements & Contacts Document.
• Who Will Do The Work?
• Know the Communities And What Their Needs Are.
• Think Out The Process And Plan Ahead.

"Organizing is what you do before you do something, so that when you do it, it is not all mixed up."

~ A. A. Milne ~


Ron Knepper


Atlantic, Eastern
Burlington, Cape May,
Monmouth, and Ocean
County New Jersey
City Permitting
Requirements
&
Contacts

Atlantic, Eastern Burlington, Cape May, Monmouth, and Ocean County New Jersey

City Permitting Requirements

&

Contacts

New Jersey Permitting Requirements

The New Jersey Division of Codes and Standards sets the requirements for permitting and local codes. In the state of New Jersey, permitting is all handled at the City or Township level. There are no state or county permits required. In addition, the state has a permitting web site NJPermits.Com which covers all required township and city permits. Once registered, the site allows contractors to complete permit applicants online and then print for delivery to the appropriate local departments or in some instances be delivered electronically.

All local jurisdictions follow the State of New Jersey Uniform Construction Code but may have local Zoning restrictions. http://www.state.nj.us/dca/divisions/codes/index.html

Any new septic system requires inspection by the local county Health Department.

The New Jersey Division of Standards and Codes has adopted the Federal Manufactured Home Construction and Safety Standards. No additional regulations regarding manufactured home installations have been instituted by the NJ Codes and Standards.
http://www.state.nj.us/dca/divisions/codes/topics/#12

New Jersey Manufactured Home Installation Standards:

1. The New Jersey Division of Codes and Standards **does not** have oversight over campers/RV units or their installation.

2. The state of New Jersey does not currently have any licensing or oversight in regards to manufactured home installers. Traditional construction requirements apply.

3. **If the housing used will be manufactured homes the following general items apply:**
    a. Manufactured homes built after June 15, 1976 are required to be built to the Federal Manufactured Home Construction and Safety Standards. They are required to have Federal insignia located on the rear of the unit.
    b. A construction permit is required for all on-site construction work required in connection with the installation of the manufactured home. Such work shall include support and anchorage systems, electrical and plumbing systems, site grading, etc.
    c. Permits and permit fees have usually been waived by this division and the local building departments for the temporary setting of FEMA units.
    d. The support and anchorage system, including foundation, for a manufactured home shall be designed by a licensed professional engineer or registered architect in accordance with the corresponding provisions of the Federal standards and the UCC.
    e. The proposed site for installation of a manufactured home shall meet all the applicable requirements for fire separation in the UCC.
    f. Foundations for manufactured home installations must be designed and constructed in accordance with this subpart and must be based on site conditions, home design features, and the loads the home was designed to withstand, as shown on the home's data plate.
    g. Foundation systems that are not pier and footing type configurations may be used when verified by engineering data and designed in accordance with Sec. 3285.301(d), consistent with the

State Contact Information

New Jersey Emergency Management Agency
Major Dennis McNulty, Section Commander
NJ State Police Division Headquarters
PO Box 7068
West Trenton, NJ 08628
Main Office: 609-882-2000
OEM: 609-963-6964
http://www.state.nj.us/njoem/

New Jersey Department of Public Health
PO Box 360
Trenton, NJ 08625
Phone 609-292-7837
http://www.state.nj.us/health

New Jersey Department of Consumer Affairs
Division of Codes and Standards
101 South Broad St
Trenton, NJ 08652
Phone: 609-984-7609
http://www.state.nj.us/dca/divisions/codes/index.html

New Jersey Department of Transportation
Oversized and Overweight Vehicles
225 East State St
Trenton, NJ 08625
Phone: 609-633-9402
http://www.state.nj.us/transportation/freight/trucking/oversize.shtm

Other Associations & Agencies for Transportation & Installation of Manufactured Housing

New Jersey Manufactured Housing Association
2741 Nottingham Way
Trenton, NJ 08619
Phone: 609-588-9040
http://www.njmha.org/

US Department of Transportation
1200 New Jersey Ave
Washington, C 20590
Phone: 202-366-4000
http://www.dot.gov/

Permitting Requirements and Contacts

Atlantic County

Atlantic County Health Department
201 South Shore Road, Stillwater Building
Northfield, NJ 08225
Phone: 609-645-5971
http://www.aclink.org/webadmin/MainPages/Health/Health_svr.asp

Absecon City Contact Information

Absecon Construction Department
Municipal Complex, 500 Mill Road
Absecon, N.J. 08201
Phone: 609-641-0663, ext. 113
http://www.absecon-newjersey.org/abs_construction1.html

General Building/Electrical/Plumbing/Sewer | Septic

Applications and forms for all proposed work must be filled out completely unless specifically waived by Sub-code Official (building, plumbing, electrical and mechanical contractors names, addresses and license numbers must be included). Complete City code is located online at http://clerkshq.com/default.ashx?clientsite=Absecon-nj

Atlantic City Contact Information

Atlantic City Construction Department
1301 Bacharach Blvd.
Atlantic City, NJ 08401
Phone: (609) 347-5660
http://www.cityofatlanticcity.org/divdetails.aspx?dva=cm

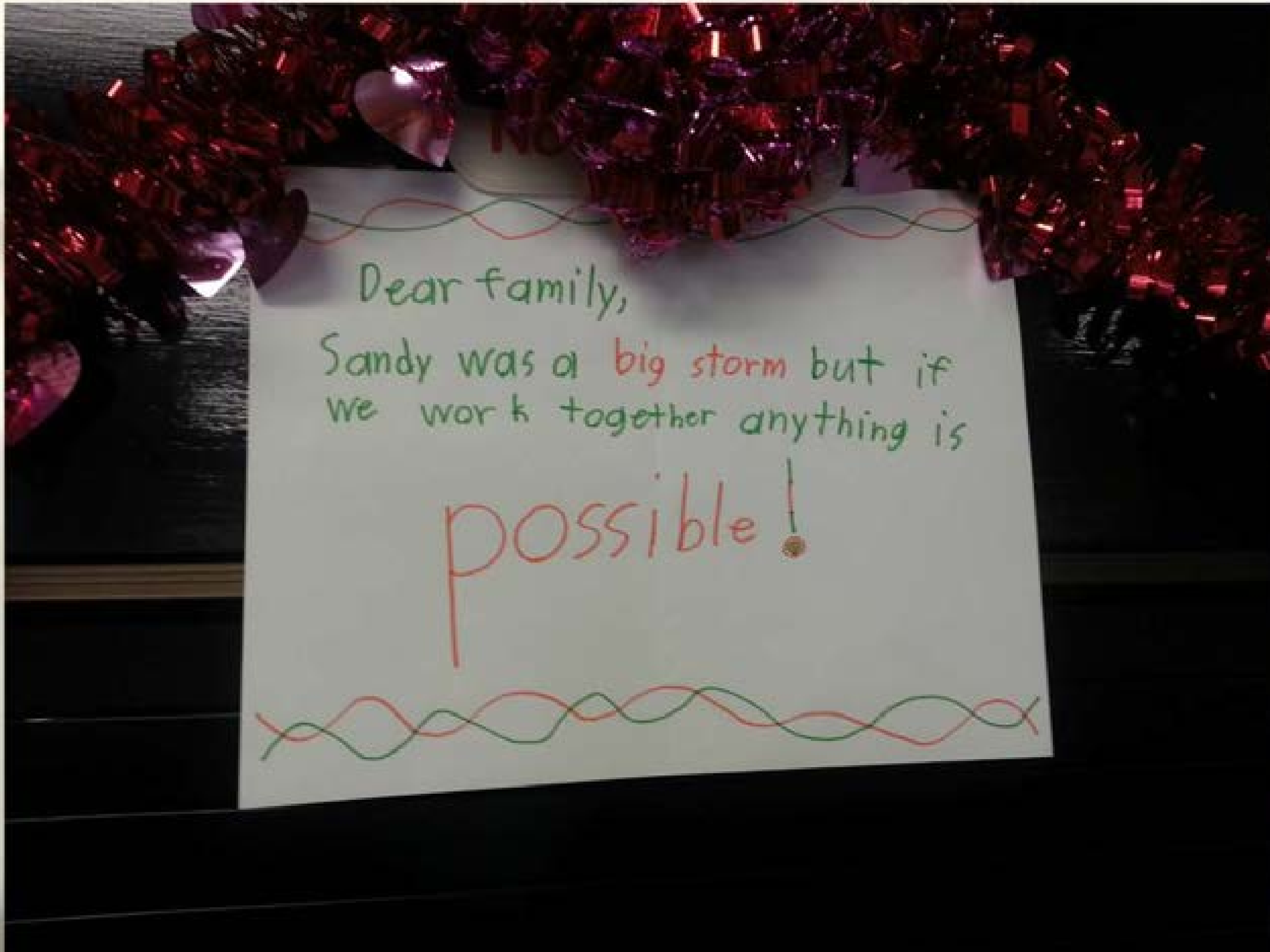
General Building/Electrical/Plumbing/Sewer | Septic

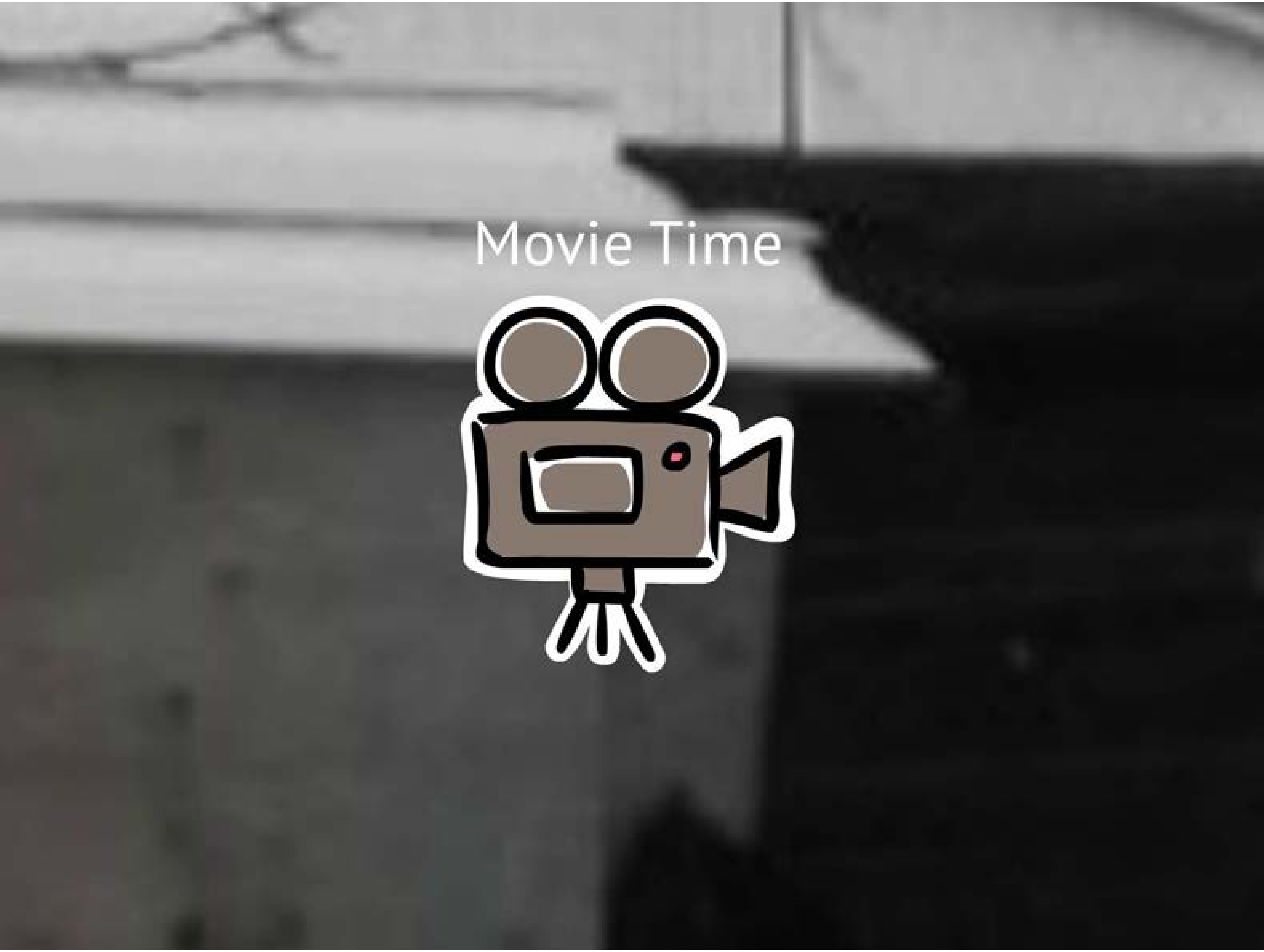
Complete City code is located online at http://www.ecode360.com/AT0848

The Atlantic City Division of Construction has prepared this comprehensive plan review application guide to assist applicants in the plan review and release process. The guide gives step by step instructions to the plan submittal process, including definitions for the various types of construction projects, check lists for both complete plan filings and partial filings, calculation worksheets for fee schedules, addresses, and telephone numbers if there are any questions.

6 Months Later:

"It's eerie here, like a ghost town, especially at night with 2,400 families gone. I don't see the politicians anymore, either," John Nies, a contractor working on homes in Breezy Point


Dear family,
Sandy was a big storm but if we work together anything is
possible!


Movie Time

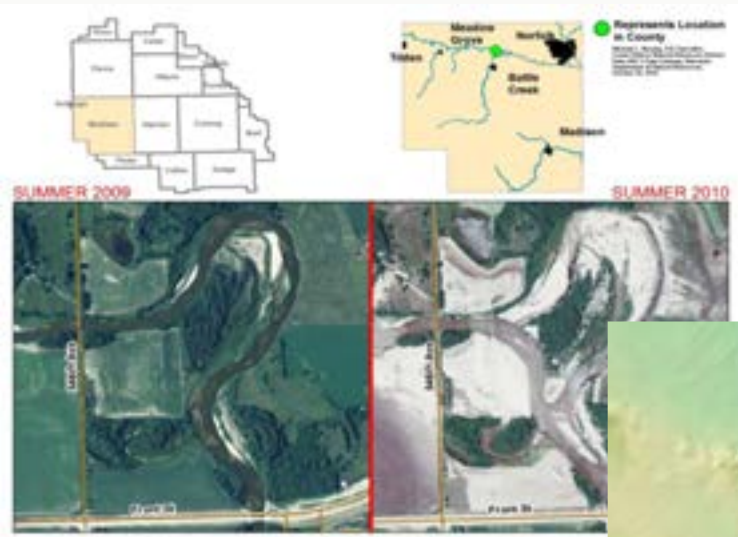
Beehive industries

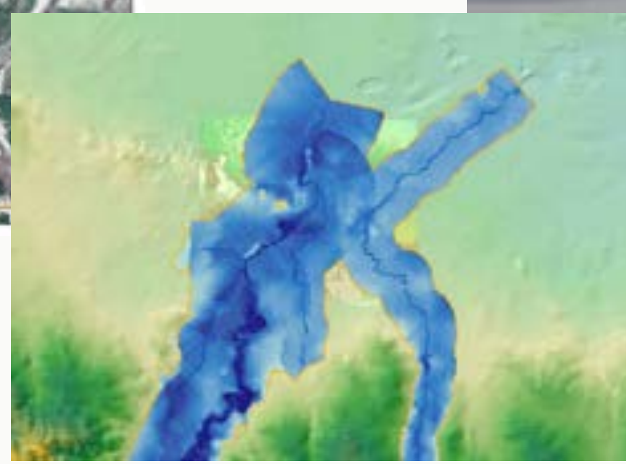
GIS BASED EMERGENCY MANAGEMENT & PLANNING

Mike Schwab
Beehive Industries

GIS BASED EMERGENCY MANAGEMENT & PLANNING

What to Expect?





ABOUT ME

OUR EXPERTISE AND EXPERIENCE

Mike Schwab

GIS Analyst/Business Development

Beehive Industries

402.875.5581 x345

mschwab@beehiveindustries.com

Previous Experience

10 years overall GIS experience

Hazard Mitigation Planning

Floodplain Mapping & Analysis

Consulting and Software

TOPICS FOR THOUGHT

Do we have the appropriate data to make decisions?
Can we predict what is going to happen in a severe event?
Where can we locate temporarily displaced people?
Can we survive with no tech infrastructure (power, internet)?

GOALS FOR TODAY

Find some ideas for new scenarios.
Look at the planning process in a different way.
Leveraging existing sources for data collection.
Collecting freely available data.
Have a new option to try out in the flood fight.

GIS DATASETS

What to look for?
Where are we at?
Do we have what we need?
Where can we find more?

GIS DATASETS

How do we get here?
Do we need to get here?

This

To

This

GIS DATASETS

Do we need to have a ton of GIS data?

If not, what can we do?

Local DNR
FEMA
Etc.

GIS DATASETS

What do we have for options with no existing GIS data?

FEMA HAZUS can be a viable option

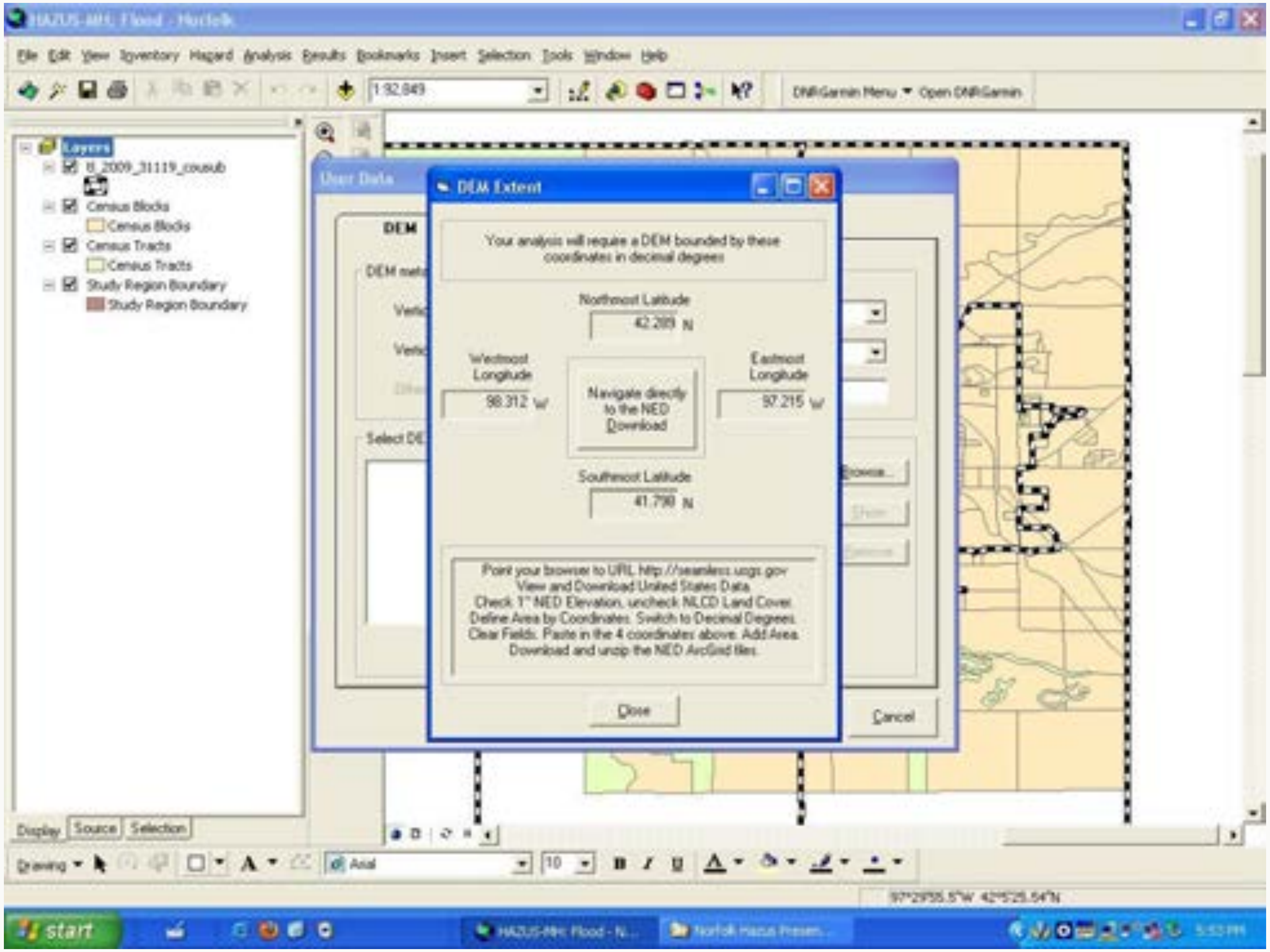
Level 1 HAZUS analysis can be ran with no existing GIS data

HAZUS LEVEL 1 ANAYLSIS

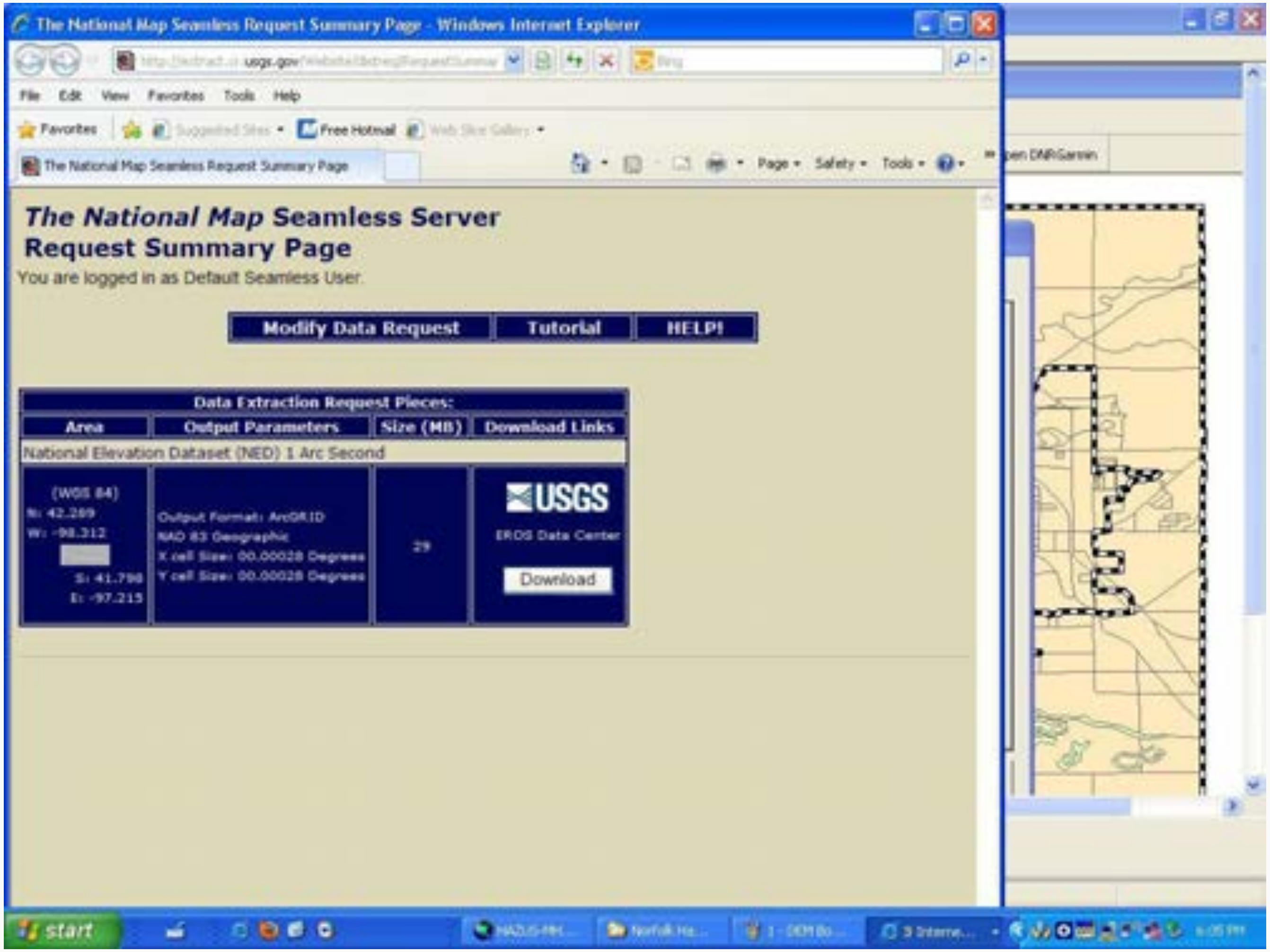
Steps to perform a HAZUS Level 1 Flood Analysis

- Define Topography
- Choose census tracts or blocks to define the study region
- Research USGS DEM Files
- Download USGS DEM files from area surrounding study region
- Clip the portion of the DEM that is needed to perform Flood Modeling
- Choose Riverine Analysis and Generate Stream Network

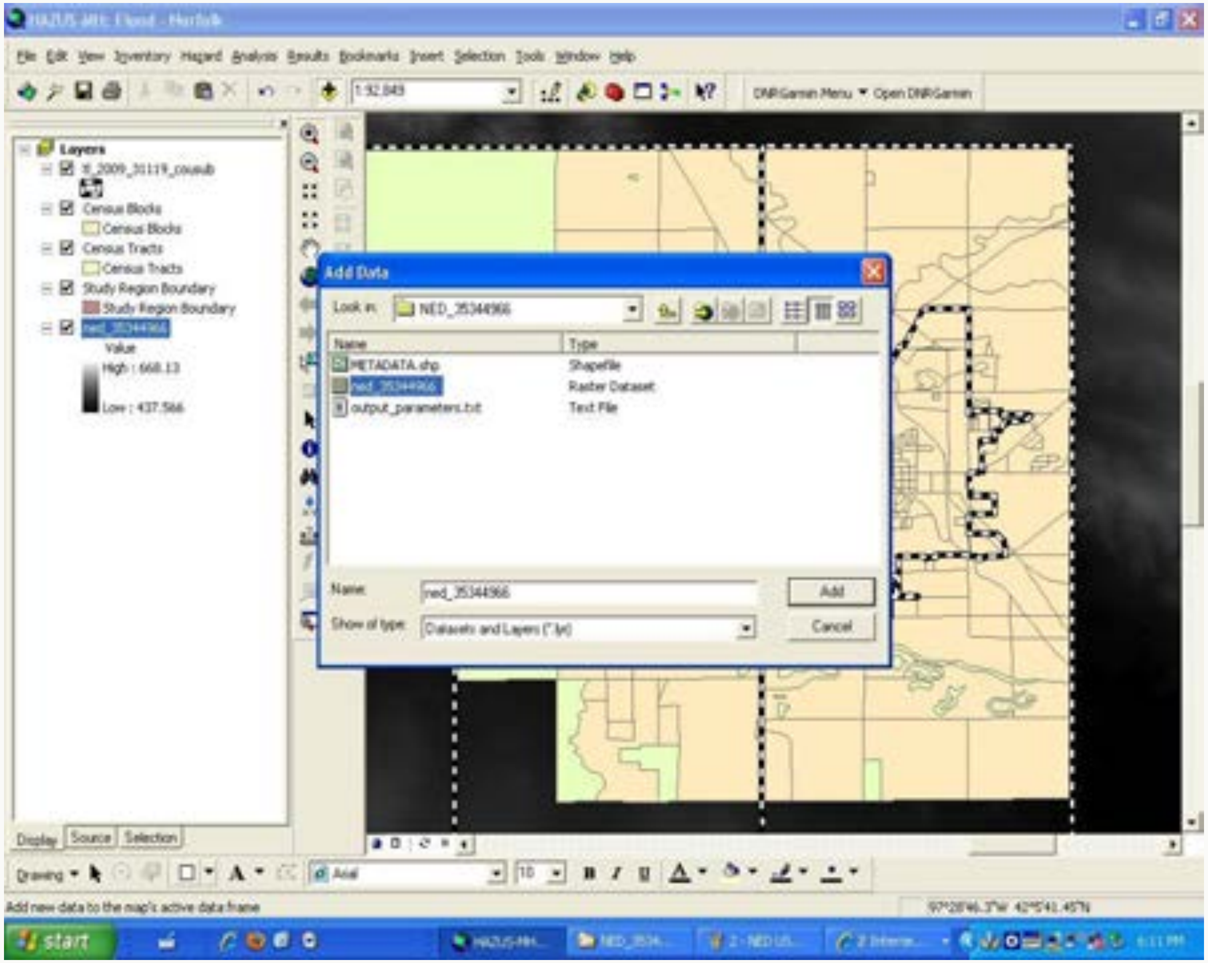
HAZUS LEVEL 1 ANAYLSIS



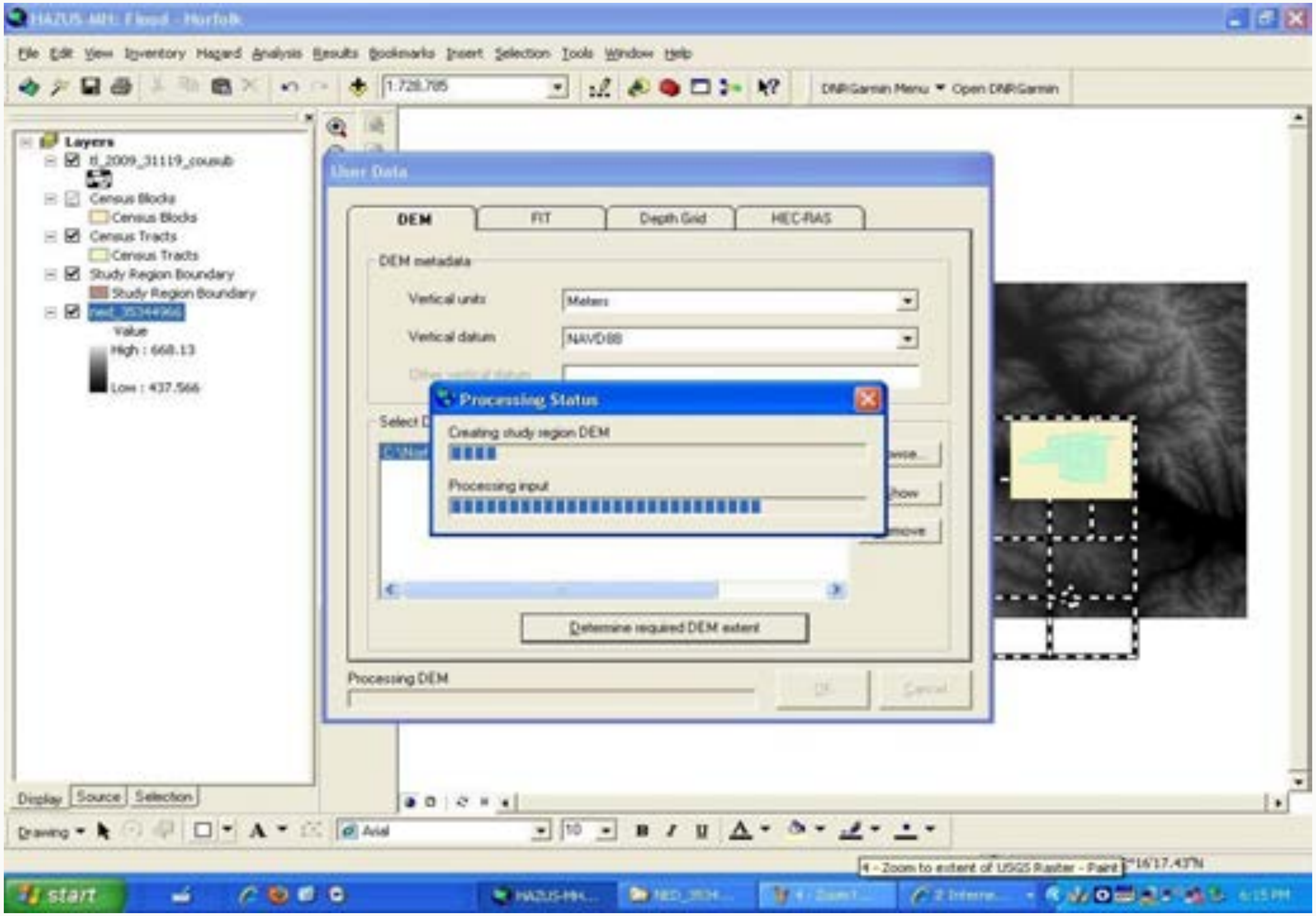
HAZUS LEVEL 1 ANAYLSIS



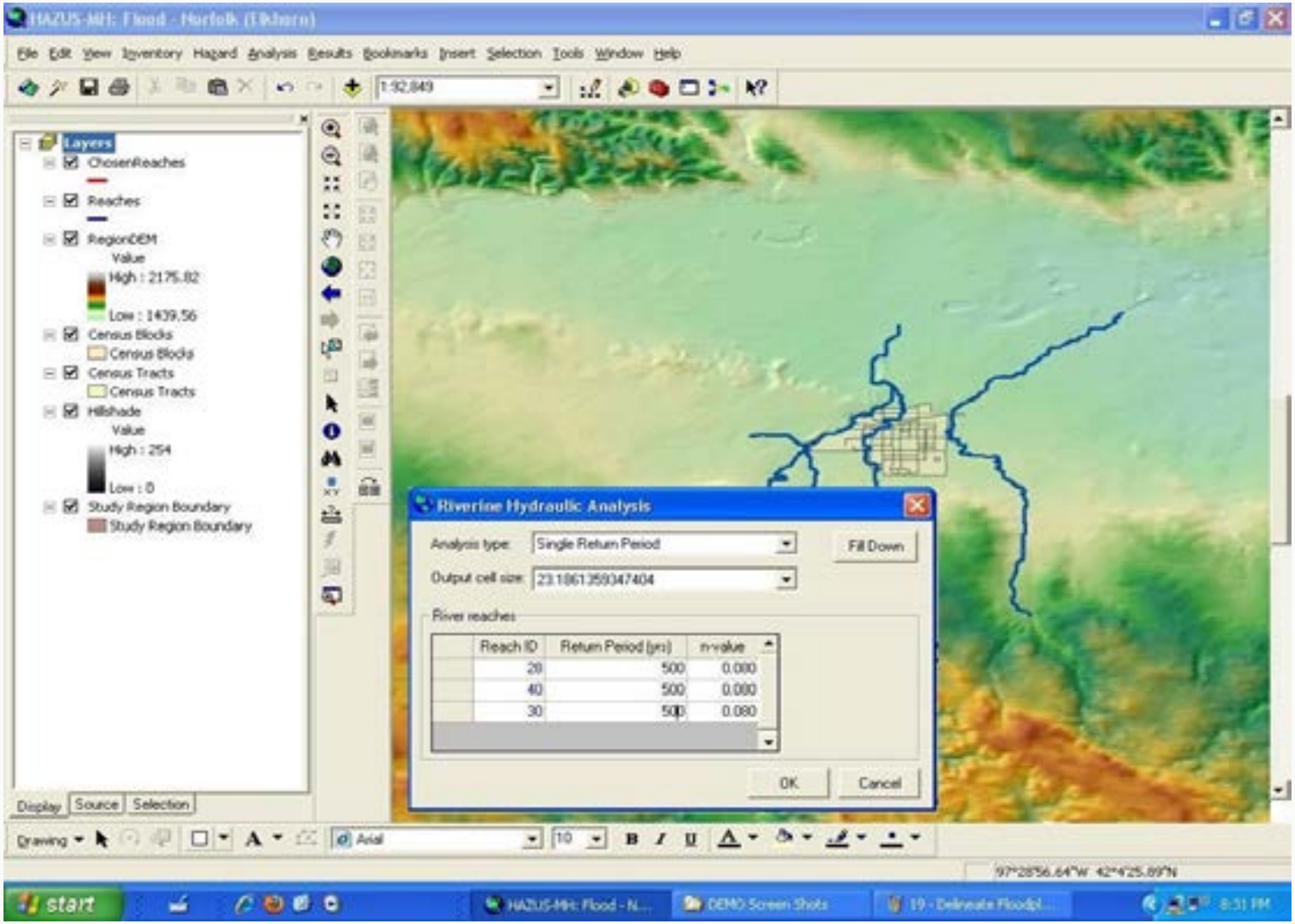
HAZUS LEVEL 1 ANAYLSIS



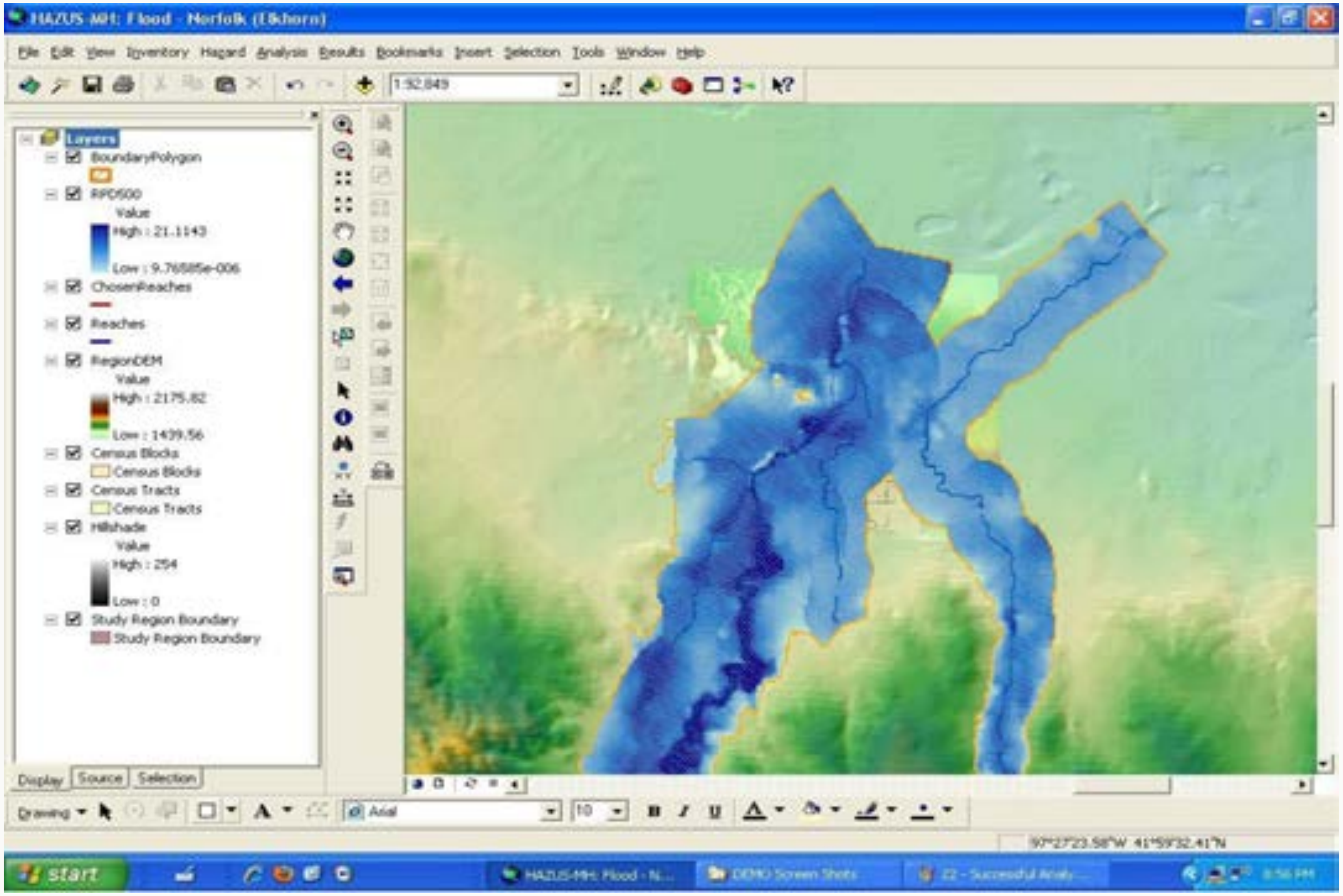
HAZUS LEVEL 1 ANAYLSIS



HAZUS LEVEL 1 ANAYLSIS



HAZUS LEVEL 1 ANAYLSIS



USE CASE: PLACEMENT OF FLOOD SHELTER

Review existing structures in the community

Find structures capable of housing displaced people

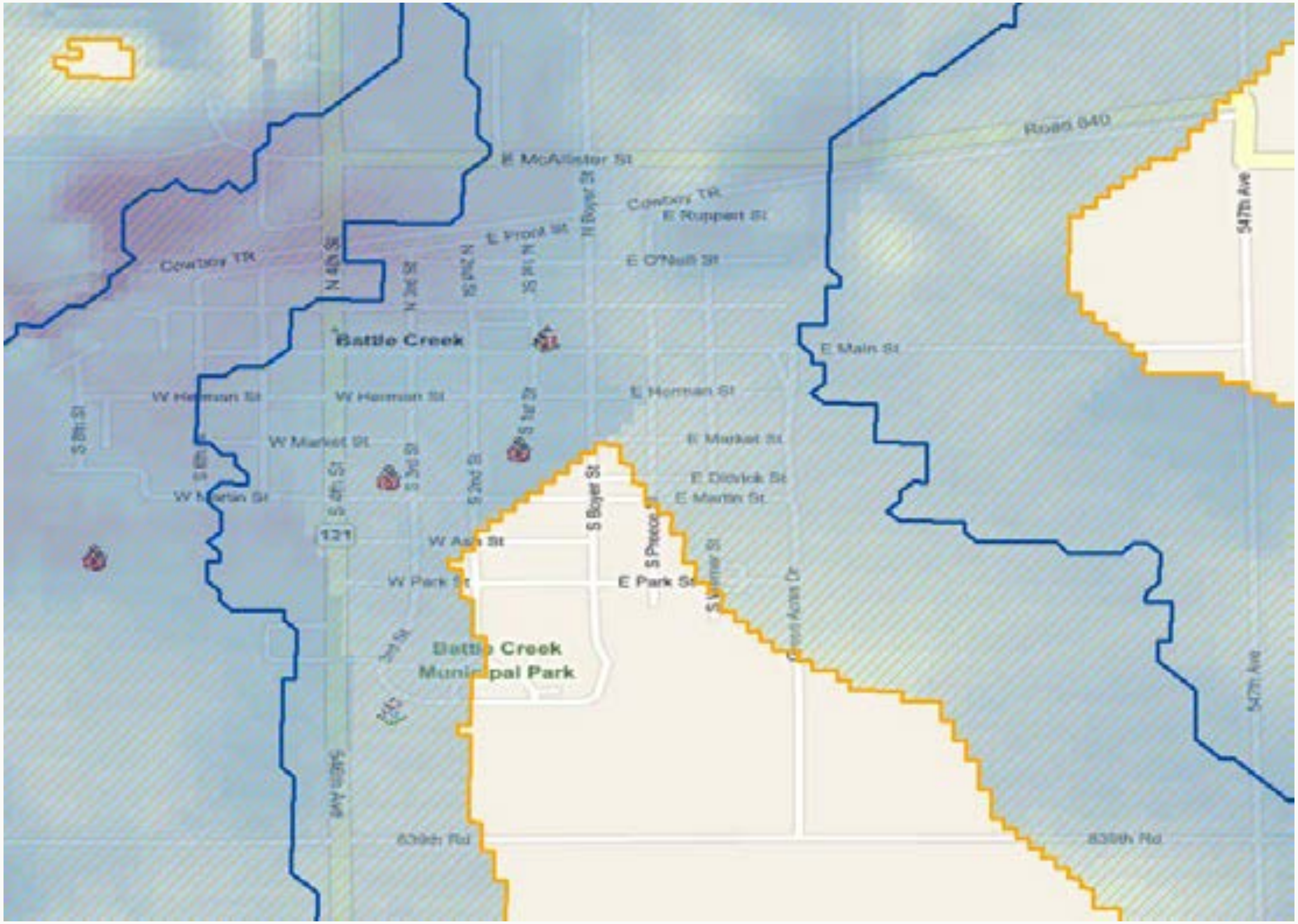
Evaluate their locations

- In current floodplain?
- Easily accessible?

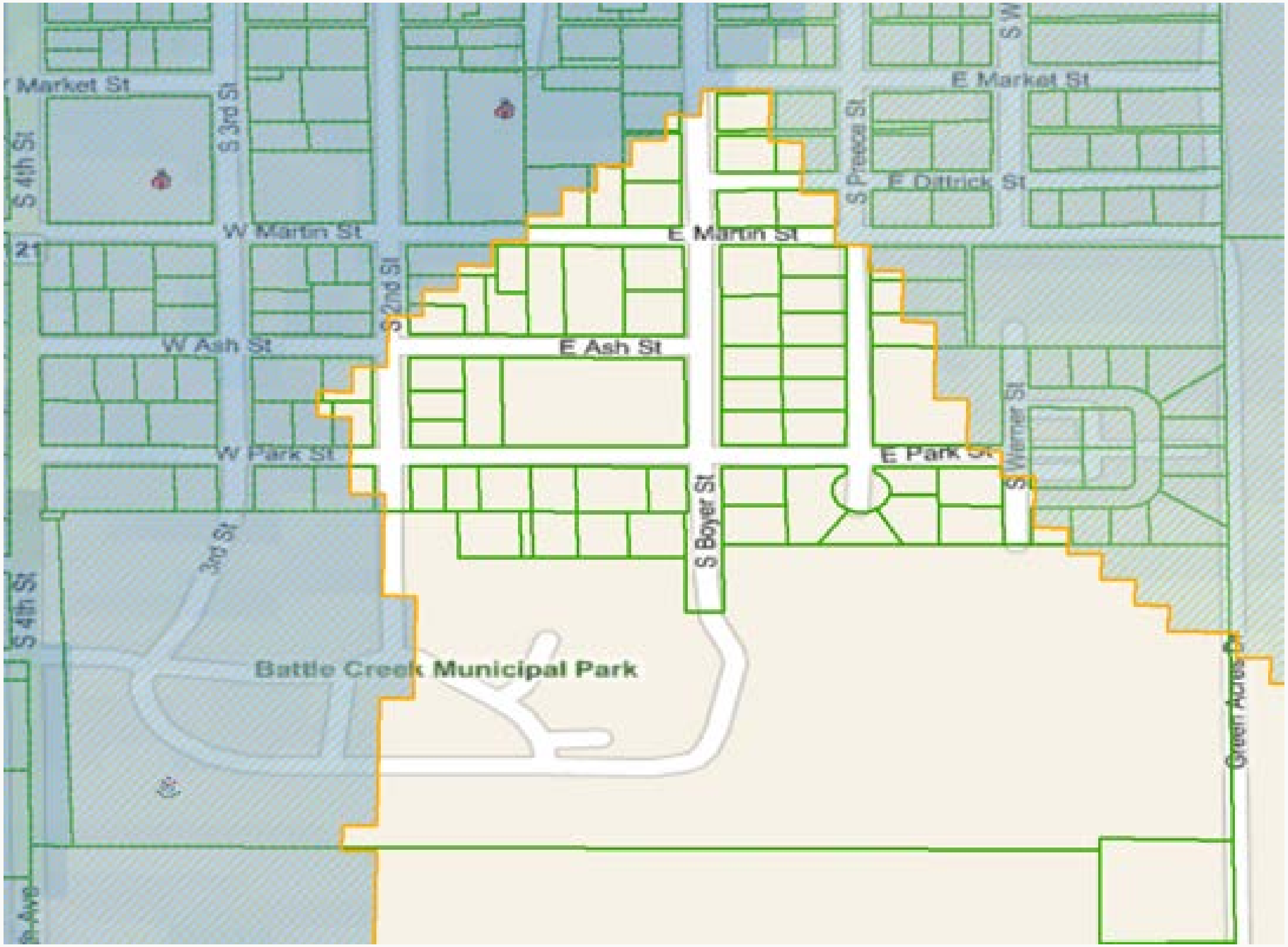
Cross-reference with existing land ownership

Transportation constraints

USE CASE: PLACEMENT OF FLOOD SHELTER



USE CASE: PLACEMENT OF FLOOD SHELTER



USE CASE: PLACEMENT OF FLOOD SHELTER

Location near a main road?

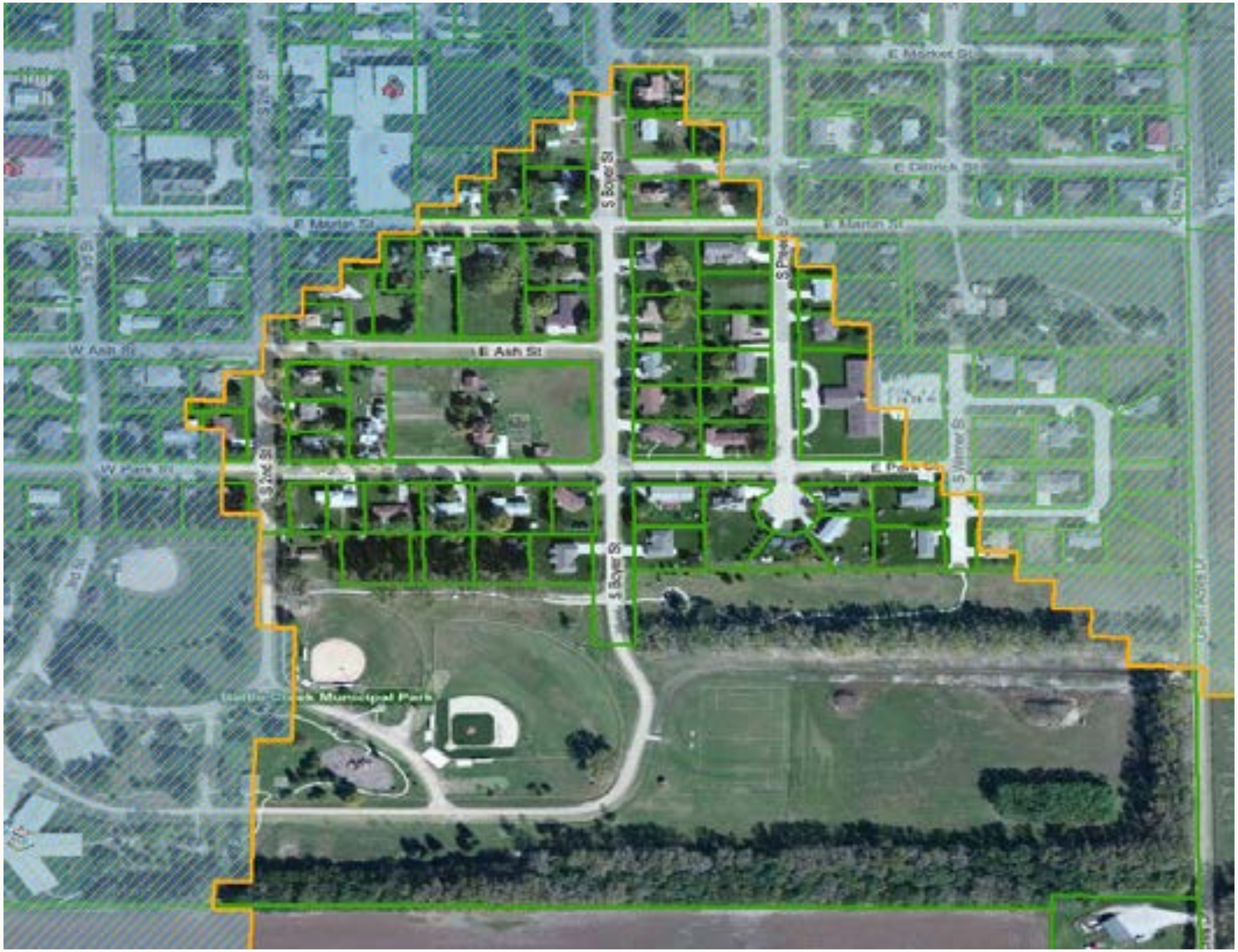
Is there any property acquisition required?

Ease of building at the site?

Are there any existing structures?

Will it fit into the current environment?

USE CASE: PLACEMENT OF FLOOD SHELTER



USE CASE: PLACEMENT OF FLOOD SHELTER

Existing City owned property, acquisition costs required.

Located in City Park, no existing structures.

Existing infrastructure access, off of main road.

Can also be used as multipurpose facility at Park.

HAZARD MITIGATION PLANNING

Thinking about projects in Hazard Mitigation plans.

Plans can be used to create additional data.

Think about setting requirements from consultant to collect data as part of the plan.

Use the plan to generate funding for projects like a shelter.

HAZARD MITIGATION PLANNING

Plan approved project list

		Bancroft	Battle Creek
Goal 2			
Objective 2.1			
Action 2.1.1	Backup Generators	x	x
Action 2.1.2	Storm Shelter/Safe Rooms	x	x
Action 2.1.3	Short Term Residency Shelters		
Action 2.1.4	New Municipal Wells		
Action 2.1.5	Power and Service Lines	x	
Action 2.1.6	NFIP Repetitive Loss Structure Removal/Acquisition		
Action 2.1.7	Levee/ Floodwall Construction and/or Improvements		
Action 2.1.8	River/ Stream Bank Stabilization		
Action 2.1.9	Grade Control Structures		
Action 2.1.10	Stormwater System and Drainage Improvements	x	x
Action 2.1.11	Anchor Fertilizer, Fuel & Propane Tanks		
Action 2.1.12	Protecting the Water Treatment Facility		x
Action 2.1.13	Protect Light Plant Facility		
Action 2.1.14	Water System Improvements		
Action 2.1.15	Review and Upgrade Critical Facilities		
Action 2.1.16	Construct Building in Woodland Park (for equipment)		
Action 2.1.17	Update Bridges		
Action 2.1.18	Improve Backup Systems		
Action 2.1.19	Dredge Maple Creek Channel		
Action 2.1.20	Frasier Creek Flood Prevention Measures		
Action 2.1.21	Maple Creek Recreation Area at Leigh		
Action 2.1.22	Looped Distribution		
Action 2.1.23	Giles Creek Bank Stabilization and Cleanout		
Action 2.1.24	Improve Watershed to protect Tilden		
Action 2.1.25	Madison County's Creek Improvements		
Action 2.1.26	4th and Martin St. Storm Sewer Improvements in Battle Creek		x
Action 2.1.27	4th and Hale St. Storm Sewer Improvements in Battle Creek		x
Action 2.1.28	Battle Creek Flood Diversion Channel		x
Action 2.1.29	Improve Drainage Conveyance from Battle Creek to Elkhorn River		x
Action 2.1.30	Dam upstream of Battle Creek		x
Objective 2.2			
Action 2.2.1	Flood-Prone Property Acquisition	x	x
Action 2.2.2	Randolph Flood-Prone Structure Alleviation Project		
Action 2.2.3	Source Water Contingency Plan		
Action 2.2.4	Create a City/Village wide Master Plan to Prioritize all Flood Related Projects	x	x
Action 2.2.5	Studies to Reduce Floodplain in Developed Areas		

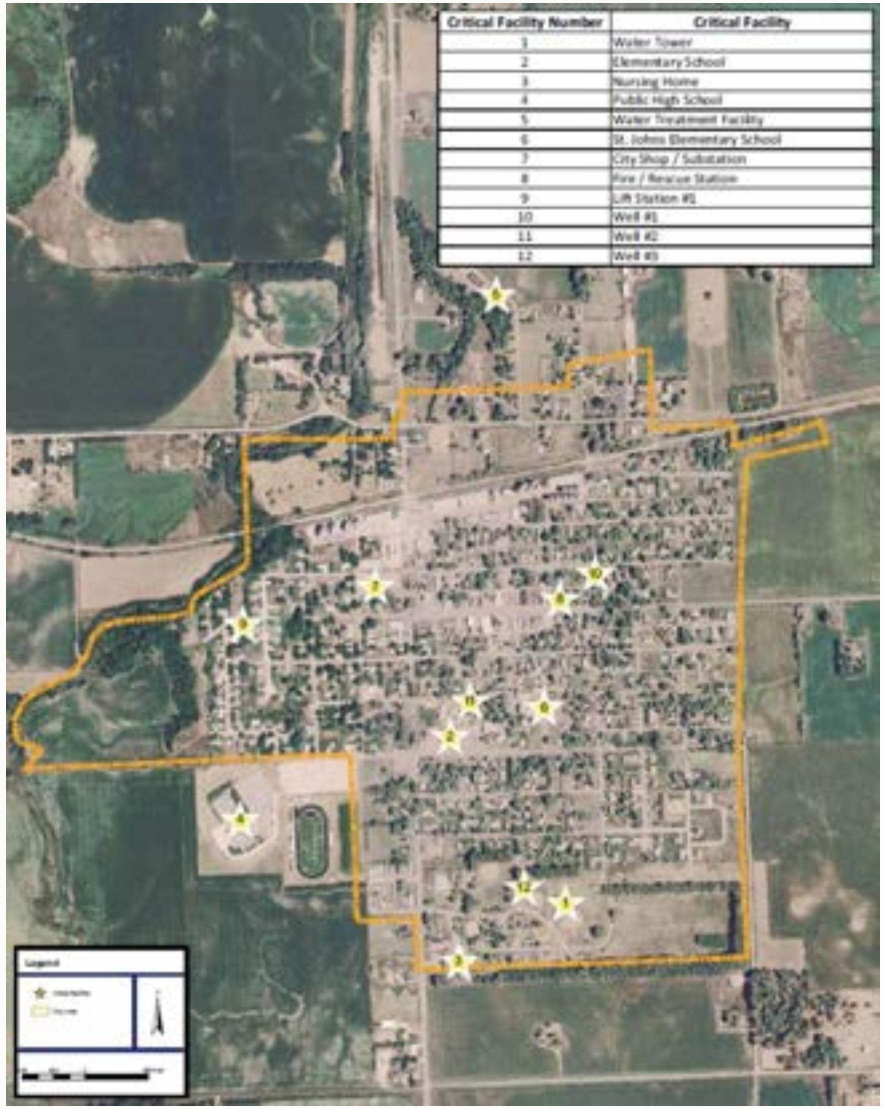
HAZARD MITIGATION PLANNING

Use Hazard Mitigation Plan to create community inventory

- Survey of all structures in town
- Categorized by building type
  - Commercial/Industrial
  - Residential
  - Public/Quasi Public
  - Out-building
- Siren Locations
- Critical Facilities (Churches, Schools, etc.)

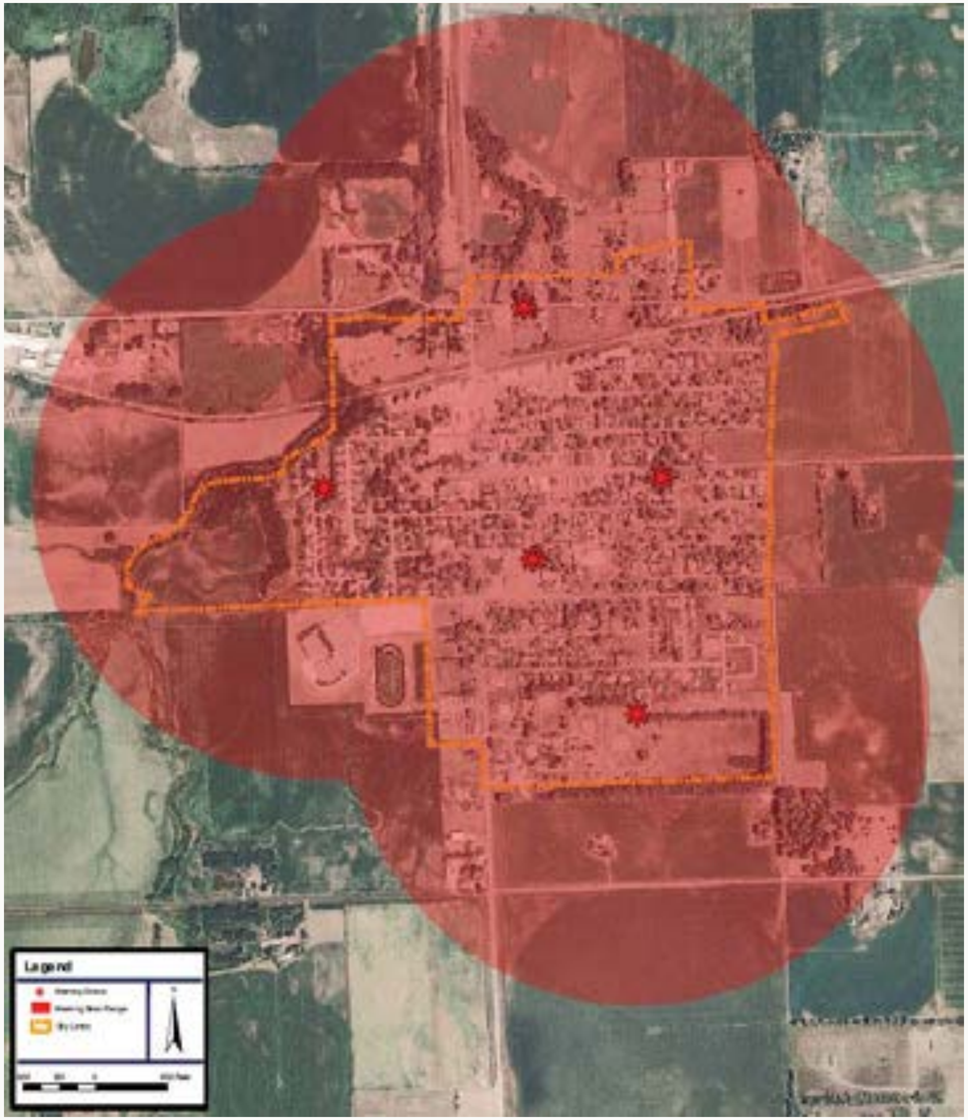
HAZARD MITIGATION PLANNING

HAZARD MITIGATION PLANNING



Critical Facility Number	Critical Facility
1	Water Tower
2	Elementary School
3	Nursing Home
4	Public High School
5	Water Treatment Facility
6	St. Johns Elementary School
7	City Shop / Substation
8	Fire / Rescue Station
9	Lift Station #1
10	Well #1
11	Well #2
12	Well #3

HAZARD MITIGATION PLANNING



HAZARD MITIGATION PLANNING

This data combined with HAZUS results, can create this:

Table BAT.4: Structural Inventory and Valuation Summary

Total Structures		Structure Valuation	
Structure Type	Number of Structures	Total Value	Value per Structure
Commercial/Industrial	21	$4,003,065	$190,622
Out Building	14	$70,000	$5,000
Residential	306	$36,891,143	$120,559
Public/Quasi Public	24	$503,668	$20,986
TOTAL STRUCTUES	**365**	**$41,467,876**	-

HAZUS ANALYSIS: ADDITIONAL USES

Flood prone property acquisition.

- Determine properties
- Calculate values and replacement costs

Modeling effects of flood mitigation efforts.

- Floodwalls, levees, channel improvements

Basis of FEMA Benefit Cost Analysis (BCA).

Support for additional mitigation planning efforts.

LEVEE EVALUATION EXAMPLE

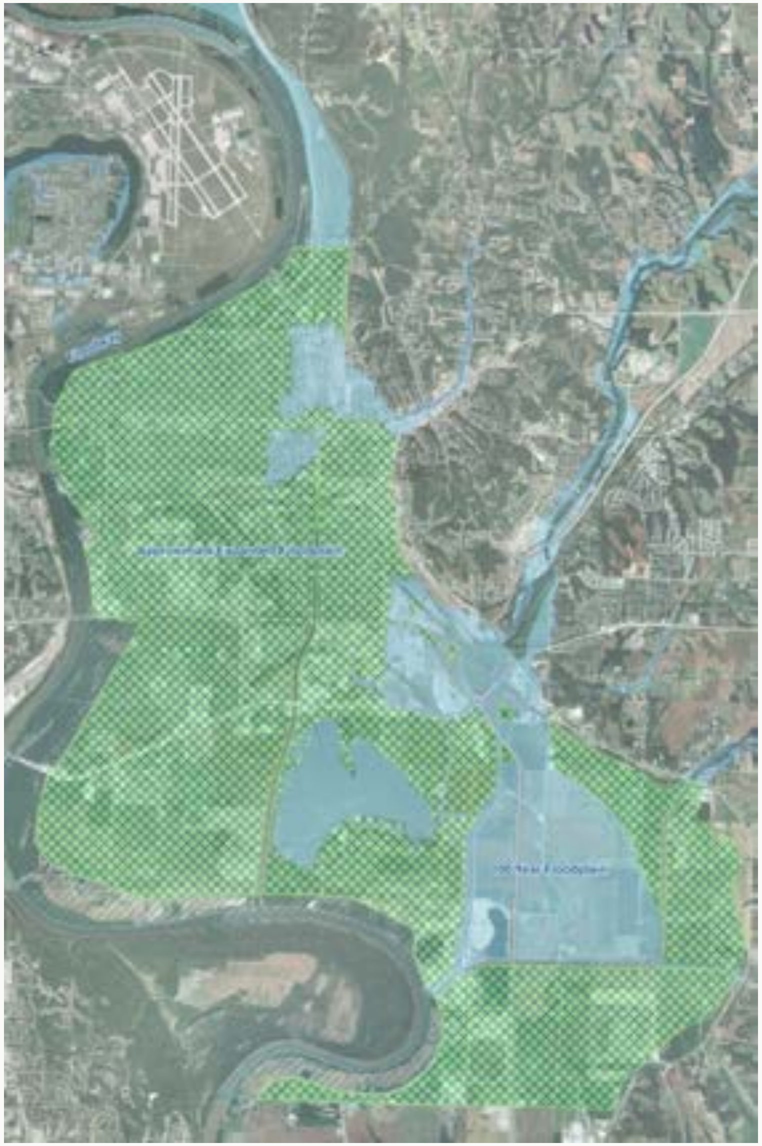
FEMA DFIRM is drawn with levee in place.

Represents floodplain with levee protecting community

LEVEE EVALUATION EXAMPLE

Floodplain drawn through HAZUS with no levee in place

Represents floodplain with levee failure or de-accreditation



HAZUS AND DATA RESOURCES

FEMA Resources - www.fema.gov/plan/prevent/hazus
hz virtualtraining.shtm

ESRI Resources - www.esri.com/support/hazus
And www.esri.com/hazusmhtraining

User Groups – Regional HAZUS User Groups
http://www.usehazus.com

HAZUS AND DATA RESOURCES

FEMA Resources

- HAZUS-MH Overview
- Software Order Forms
- Training / Conference Information
- FAQs

http://www.fema.gov/plan/prevent/hazus/

MOBILE DATA ACCESS

MOBILE

Forget the paper forms.

MOBILE DATA ACCESS

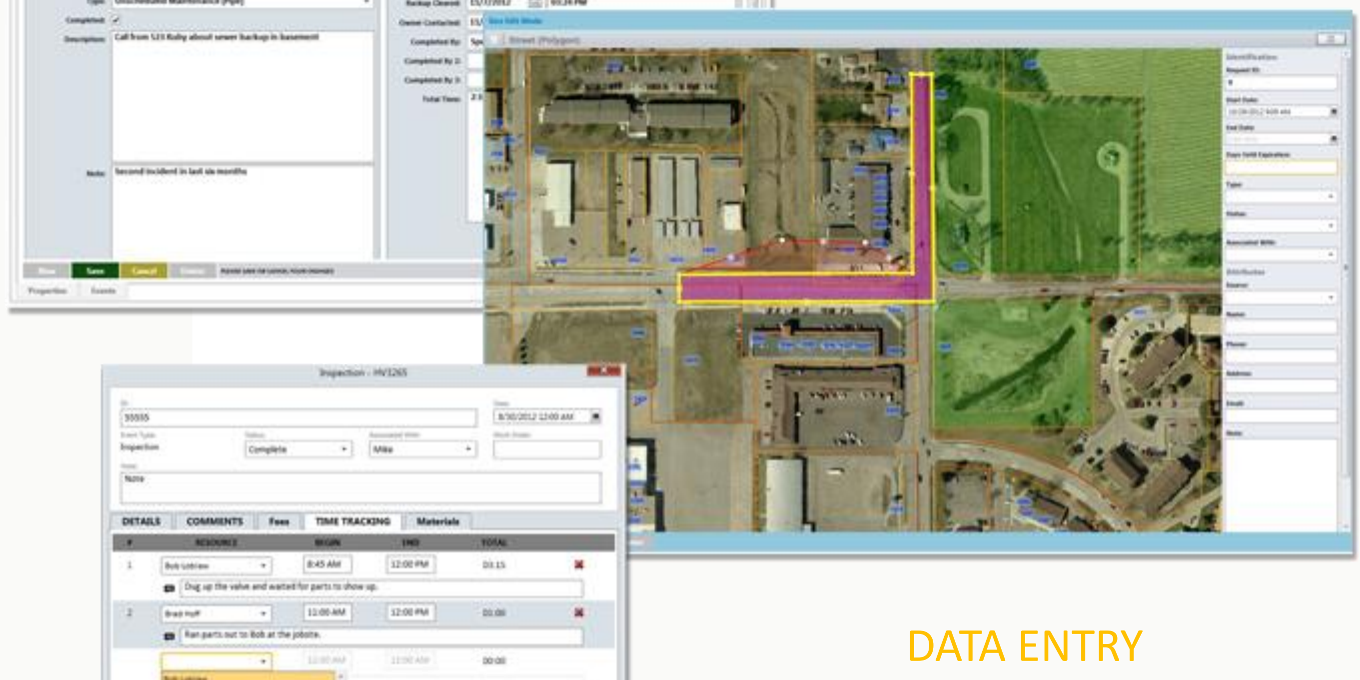
Are you able to access data in a mobile environment?

Are you prepared to check data in an emergency situation?

If an emergency arises, are you able to access data with no technology infrastructure?

Flood, tornado, etc.

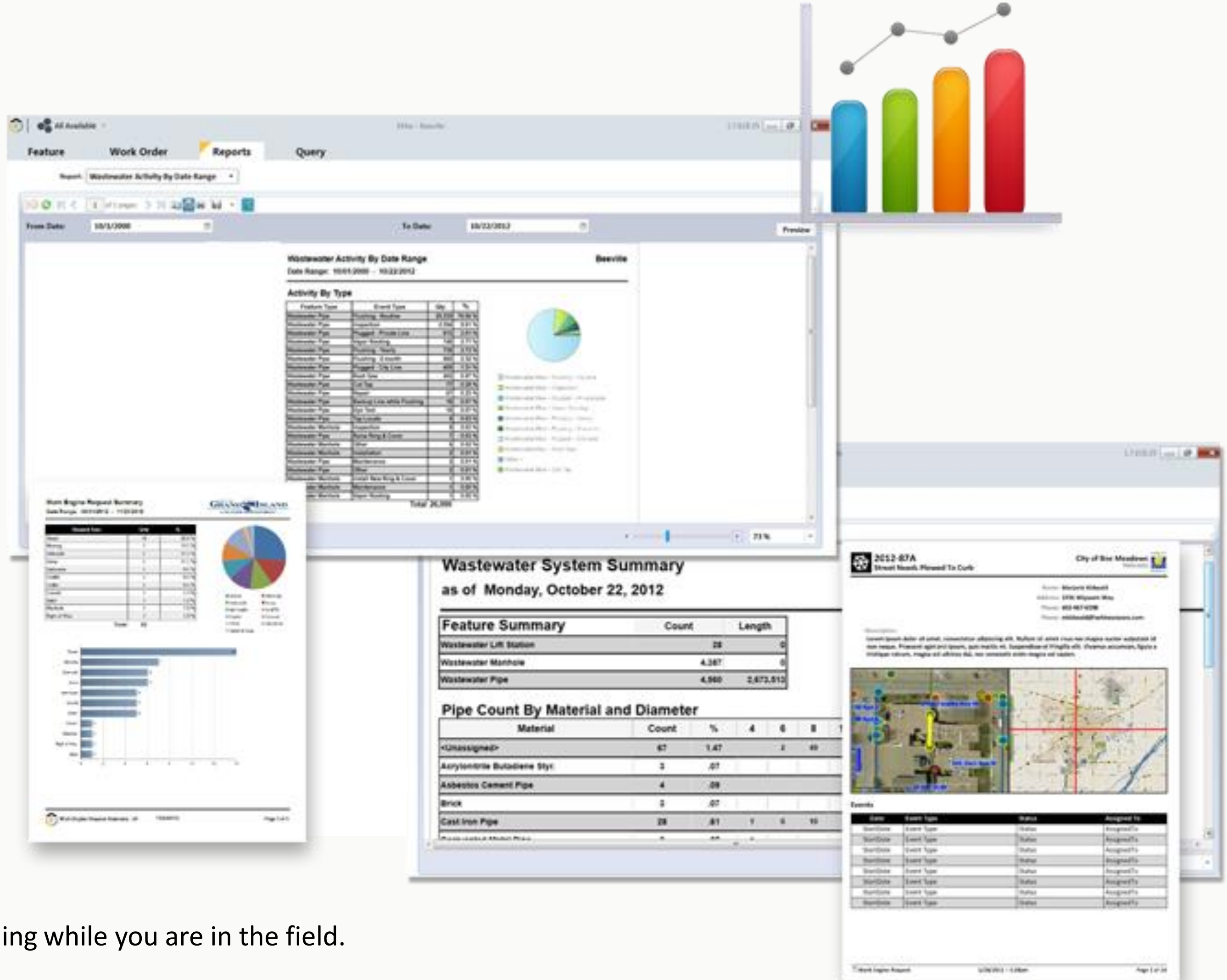
MOBILE FORMS



DATA ENTRY

Enter data and track information in the field. Keep up with information in the middle of a disaster.

MOBILE REPORTS



REPORTS

See what's happening while you are in the field.

SUMMARY

Find some ideas for new scenarios.
Look at the planning process in a different way.
Leveraging existing sources for data collection.
Collecting freely available data.
Have a new option to try out in the flood fight.

QUESTIONS

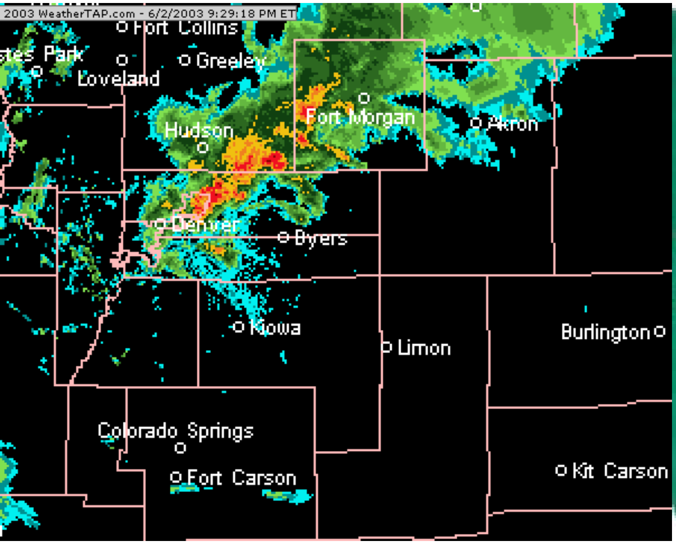
Mike Schwab

GIS Analyst/Business Development

Beehive Industries

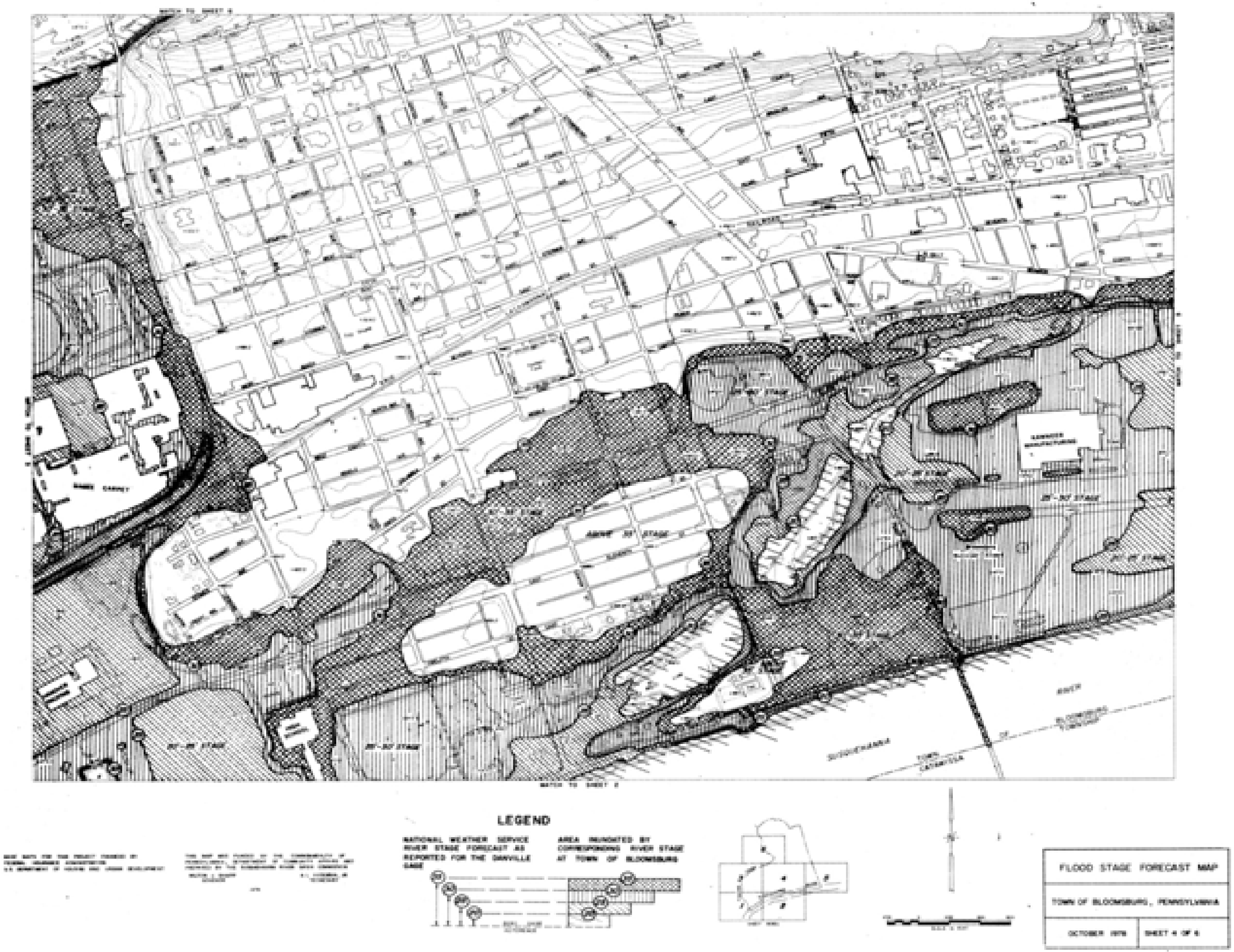
402.875.5581 x345

mschwab@beehiveindustries.com

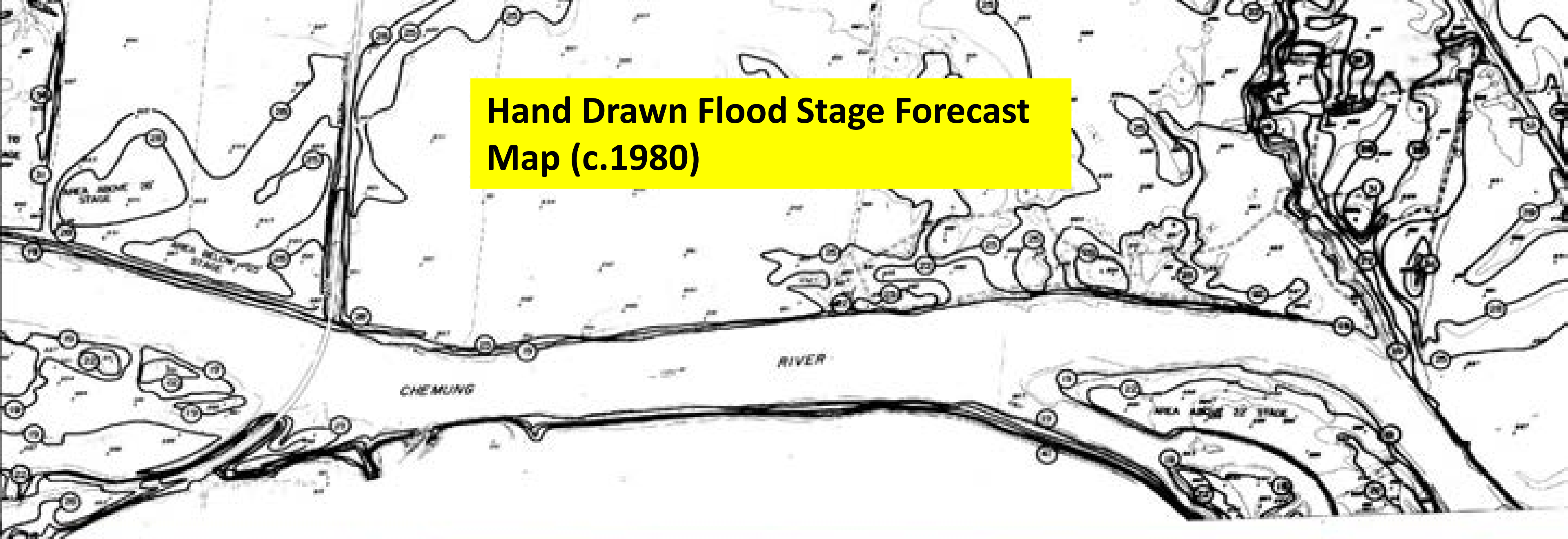


Inundation Mapping as a Multi-Faceted Floodplain Management Tool

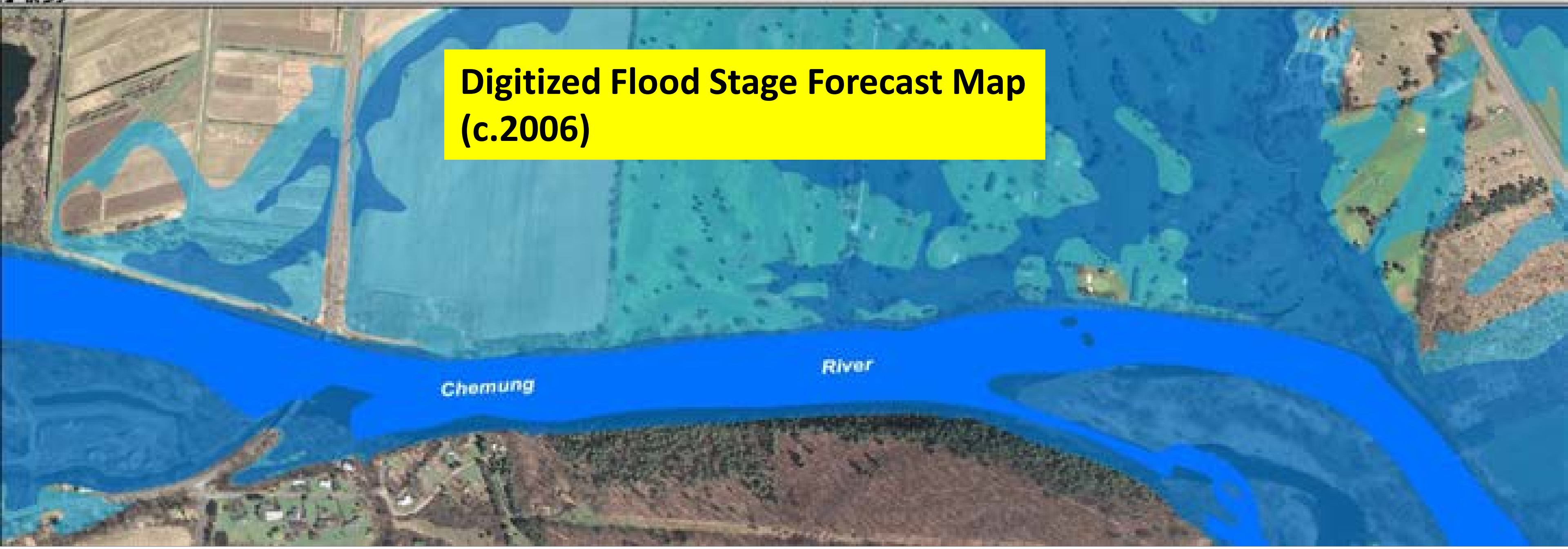
Stuart Geiger, CFM



MATCH TO SHEET 6
MATCH TO SHEET 2
20'-29' STAGE
26'-30' STAGE
ABOVE 30' STAGE
SUSQUEHANNA
RIVER
LEGEND
NATIONAL WEATHER SERVICE RIVER STAGE FORECAST AS REPORTED FOR THE DANVILLE GAGE
AREA INUNDATED BY CORRESPONDING RIVER STAGE AT TOWN OF BLOOMSBURG
FLOOD STAGE FORECAST MAP
TOWN OF BLOOMSBURG, PENNSYLVANIA
OCTOBER 1978
SHEET 4 OF 6



Hand Drawn Flood Stage Forecast Map (c.1980)



Digitized Flood Stage Forecast Map (c.2006)

Flood Inundation at Bloomsburg, Pennsylvania
30' Flood Stage - Susquehanna River - Danville Gage

What is Flood Inundation Mapping?

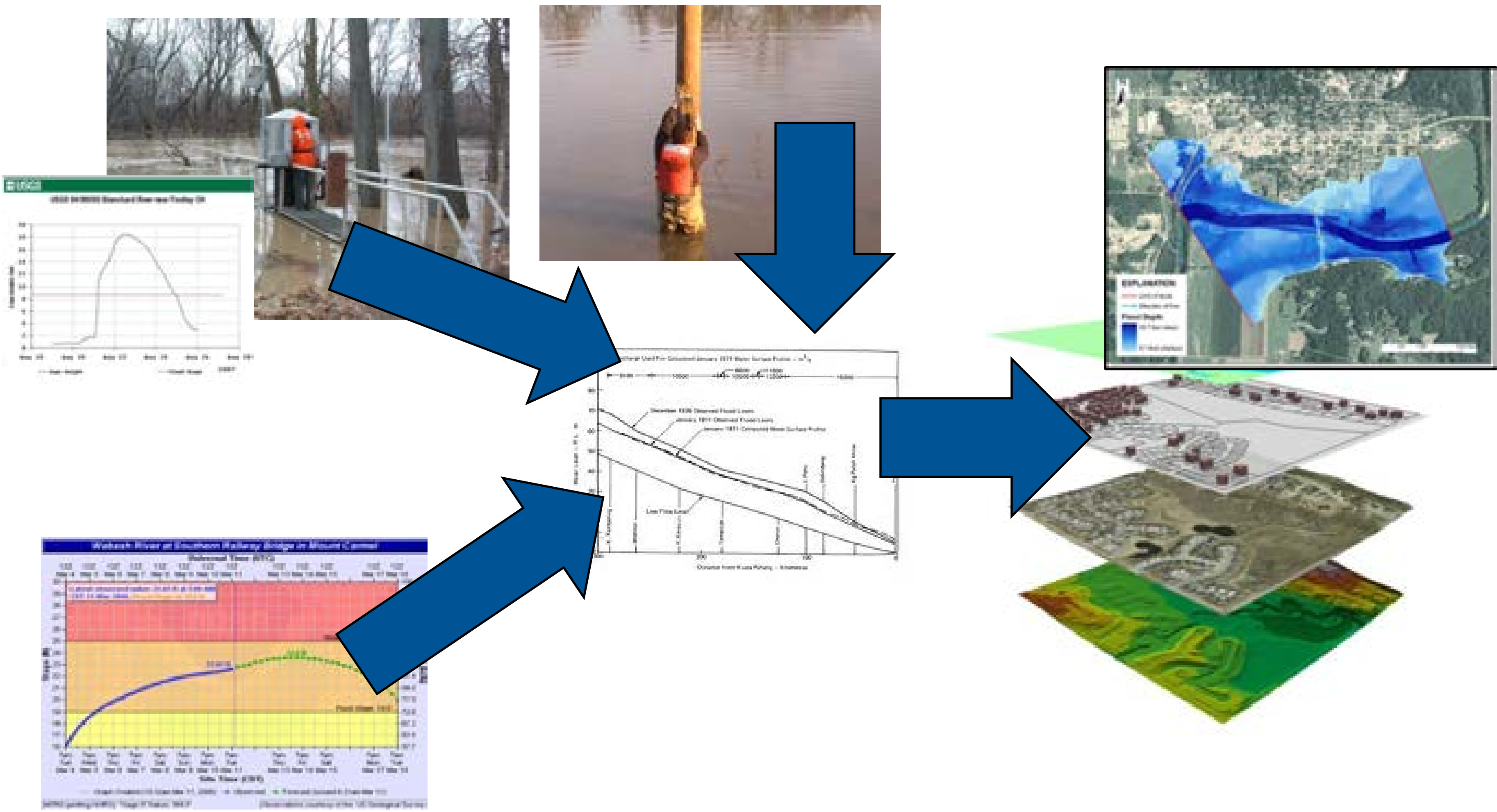
Flood Inundation Mapping (FIM) is a real-time, operational tool that visually relates USGS streamgage readings and NWS river forecasts to flood risk for the primary purpose of ***public safety***, but also has significant benefits of:

- Understanding changing natural processes that produce hazards
- Development of hazard mitigation strategies and technologies
- Effectively reduce vulnerability and repetition of loss to infrastructure
- Promotion of risk-wise behavior

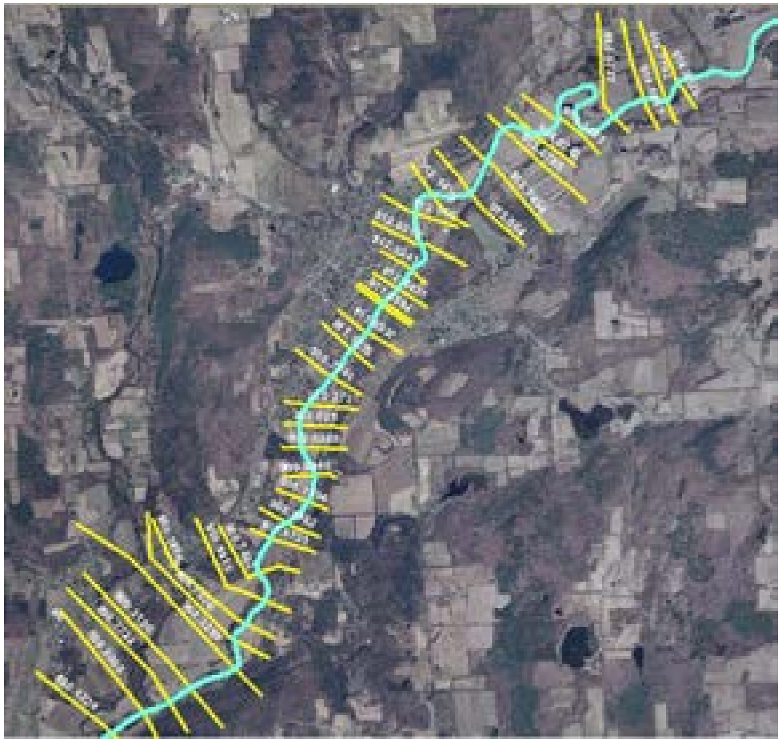
An Inundation Map is a tool for:

- Preparedness
  - “What-if” scenarios
- Response
  - Tied to gage & forecast data
- Recovery
  - Damage assessment

- Mitigation & planning
  - Flood risk analyses
- Environmental & ecological assessments

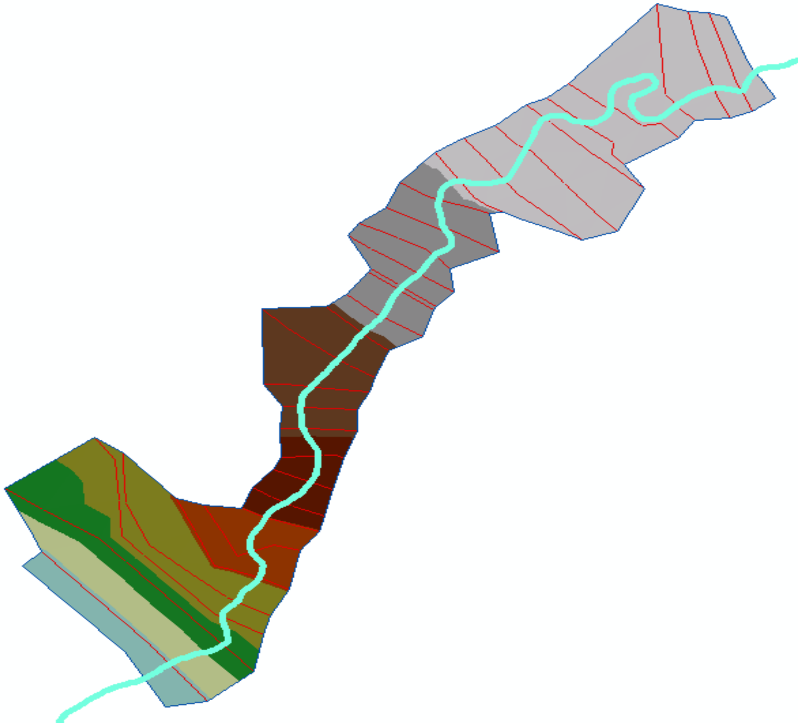

Wabash River at Southern Railway Bridge in Mount Carmel
EXPLANATION

Map Development



Cross-sections from H&H Model

->



WSEL TINs

Generate Depth TINs

- WSEL TIN is evaluated against ESRI Terrain
- Batch Process for Each RFP using Custom DLL

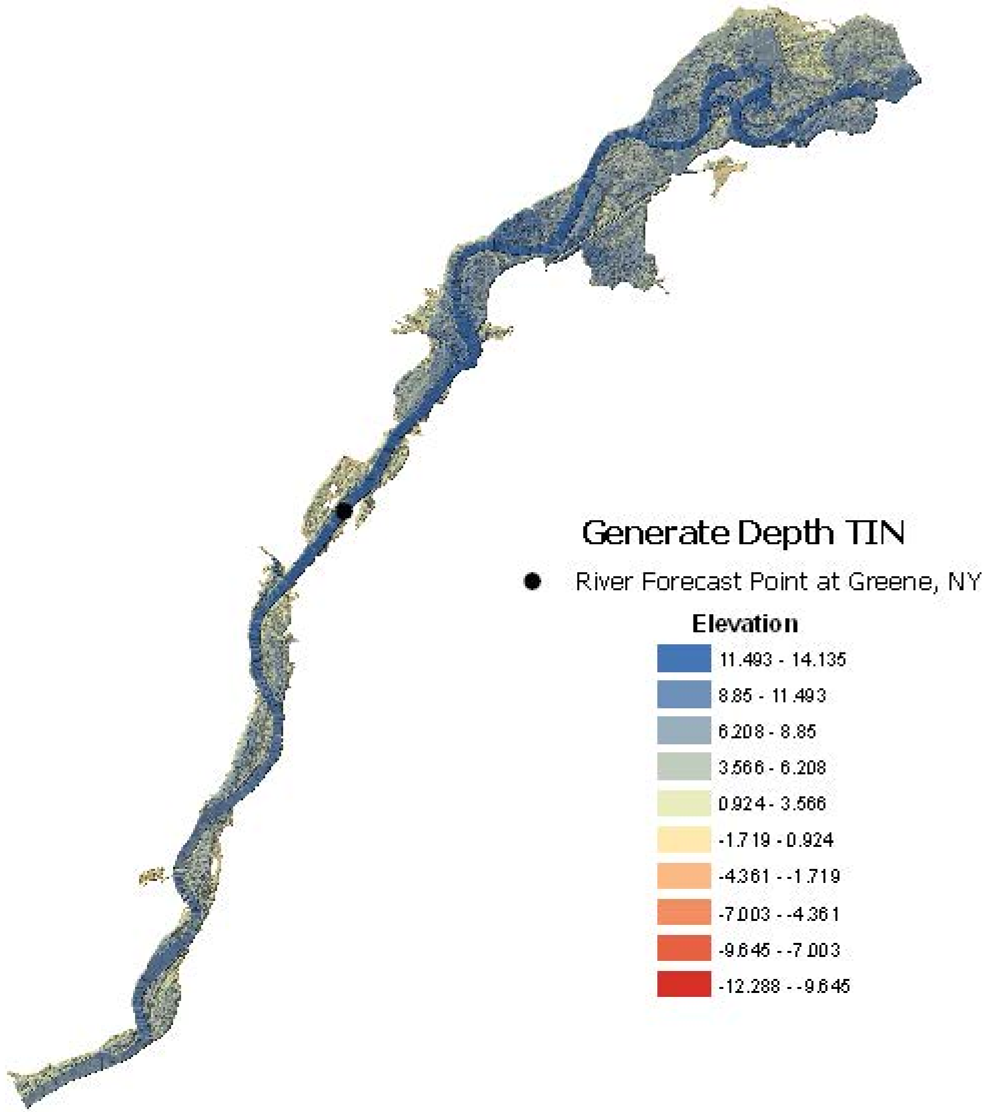
Convert Depth TINs to Depth Rasters

- Standard ESRI Toolbox
- 5 ft. Cellsize

Reclassify Depth Rasters

- Negative Depth for Areas Above WSEL
- Ensures Continuity with Inundation Polygon

Final Depth Raster



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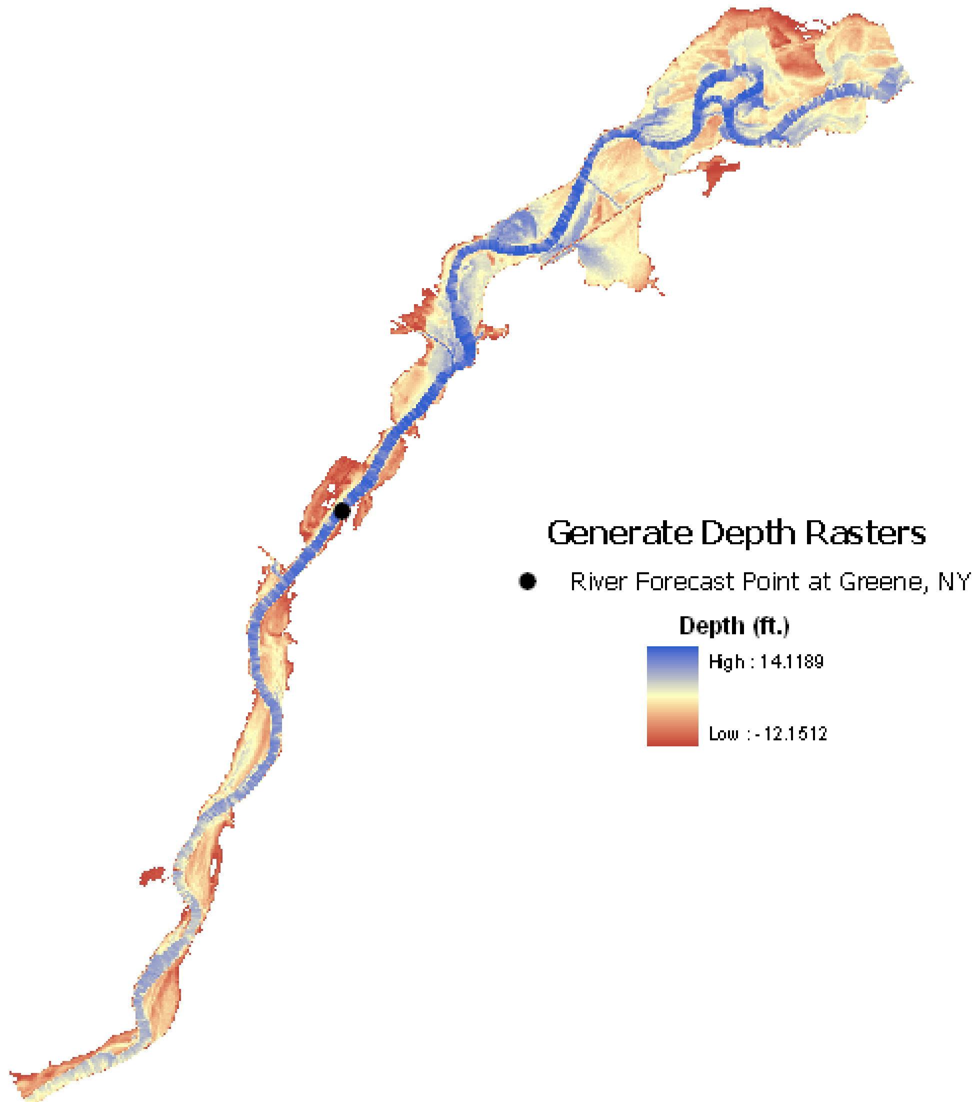

Generate Depth TINs

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↓

Convert Depth TINs to Depth Rasters

- Standard ESRI Toolbox
- 5 ft. Cellsize

↓

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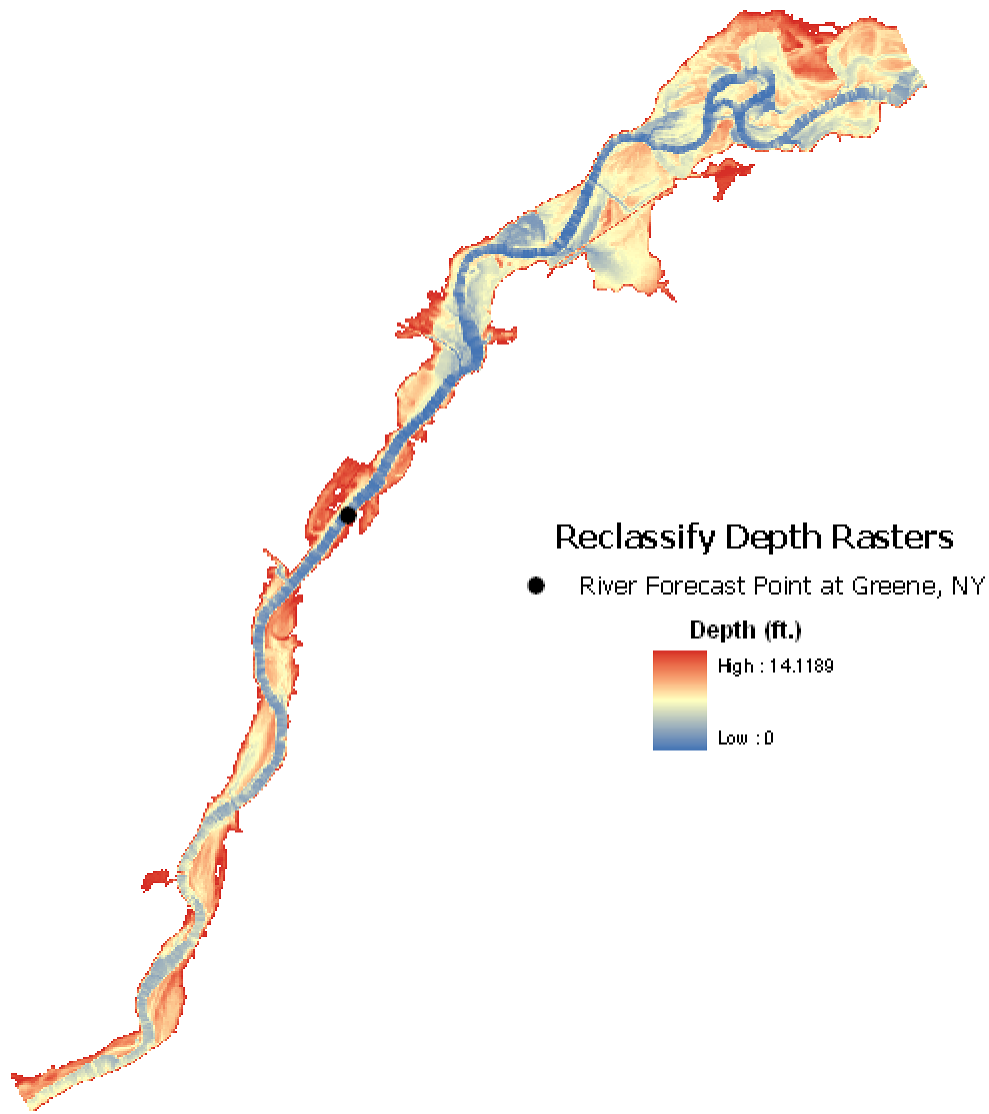
- Negative Depth for Areas Above WSEL
- Ensures Continuity with Inundation Polygon

↓

Final Depth Raster



Generate Depth TINs

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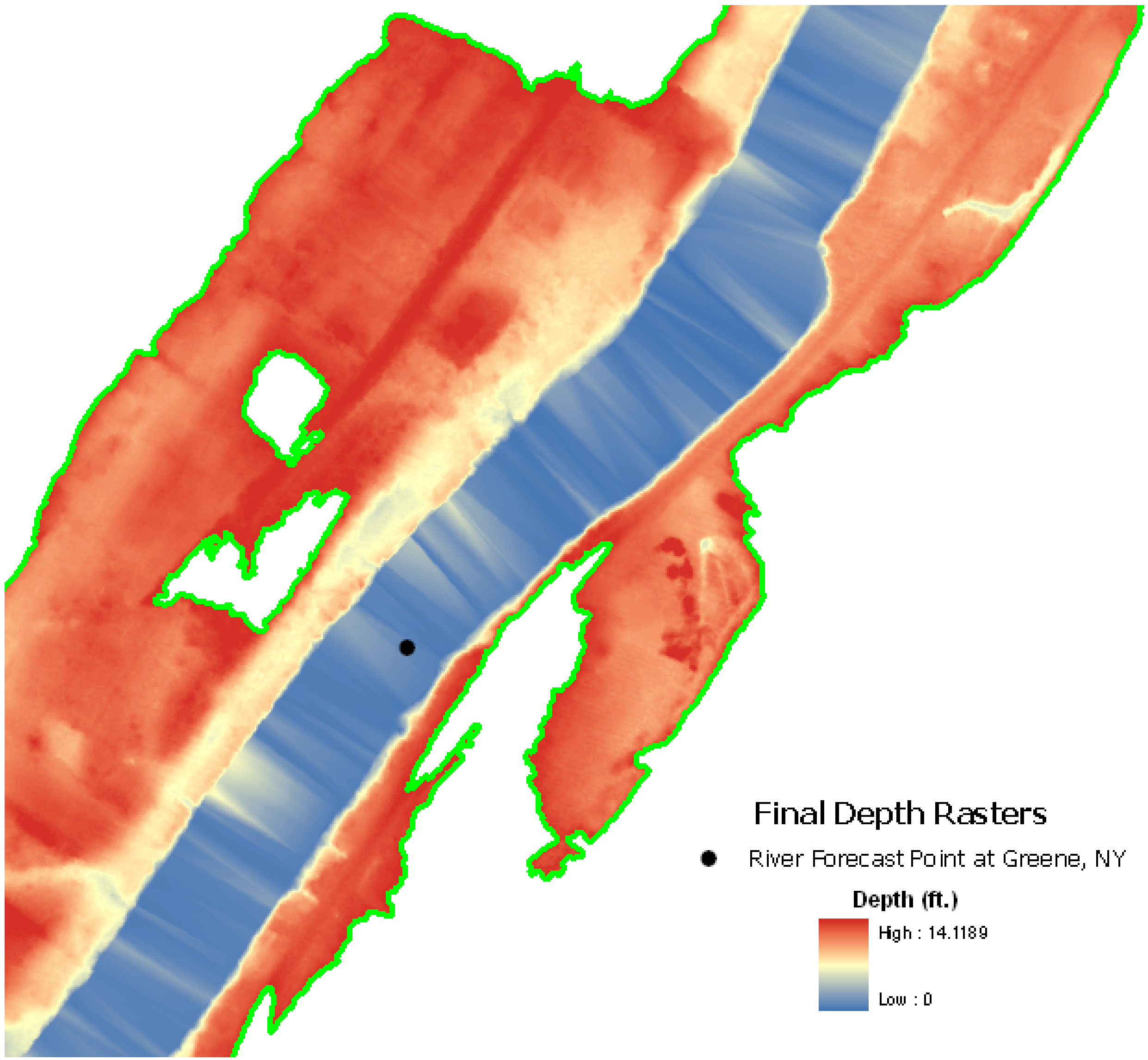
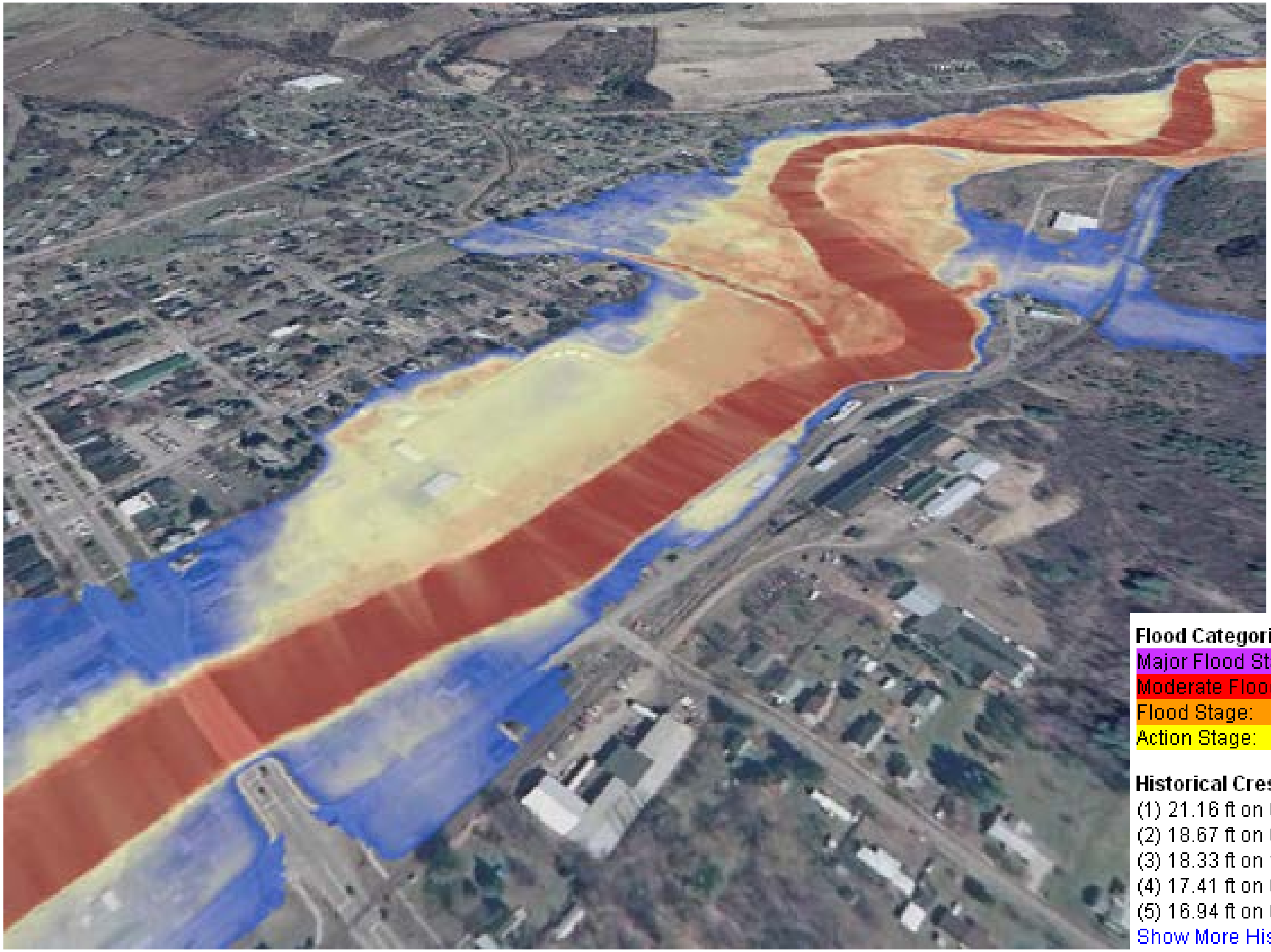
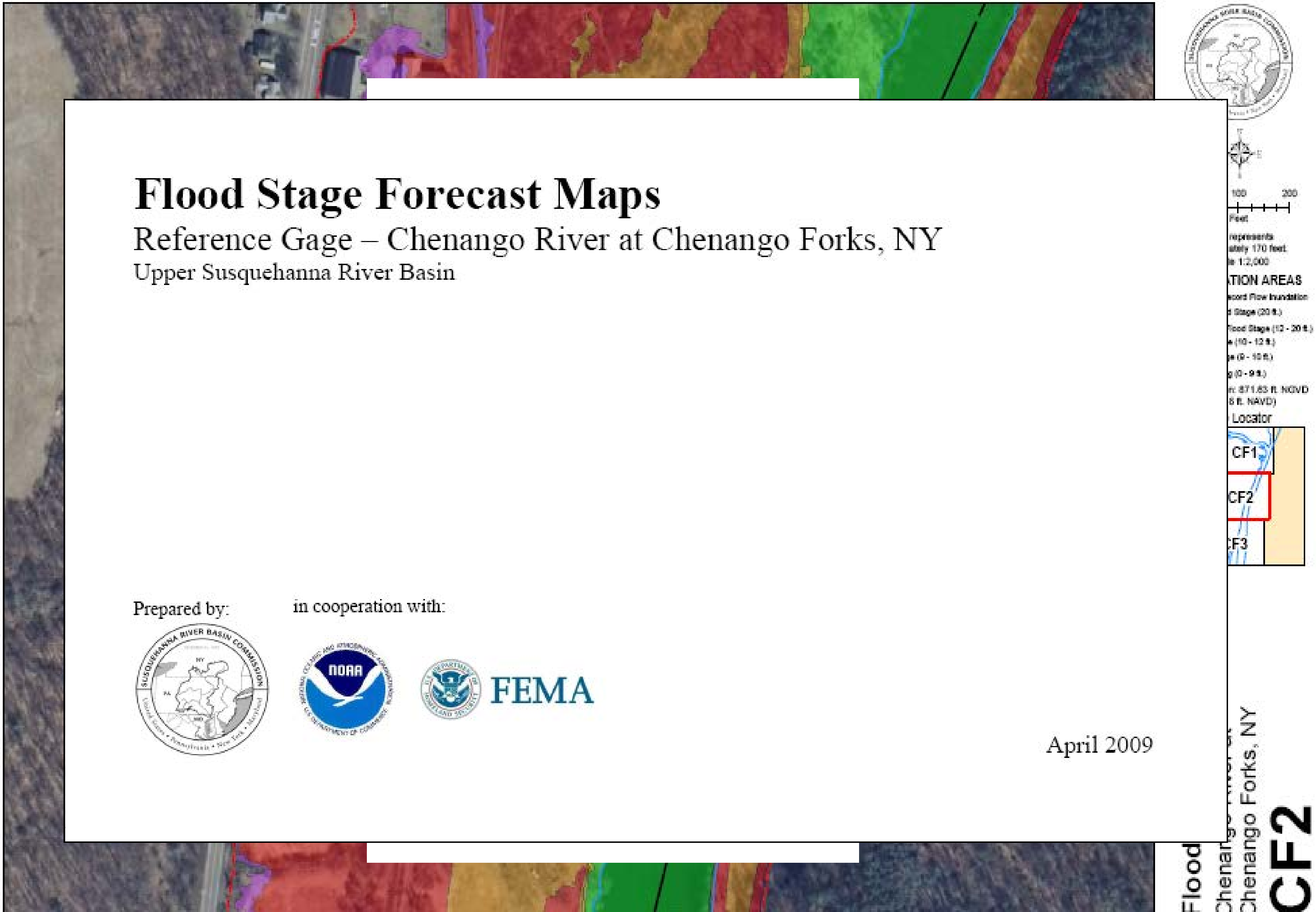
Final Depth Raster





Flood Categories (in feet)
Major Flood Stage: 22
Moderate Flood Stage: 17
Flood Stage: 13
Action Stage: 11
Historical Crests
(1) 21.16 ft on 06/28/2006
(2) 18.67 ft on 04/03/2005
(3) 18.33 ft on 12/31/1942
(4) 17.41 ft on 03/06/1979
(5) 16.94 ft on 03/06/1964
Show More Historical Crests



Flood Stage Forecast Maps

Reference Gage – Chenango River at Chenango Forks, NY

Upper Susquehanna River Basin

Prepared by: in cooperation with:

FEMA

April 2009

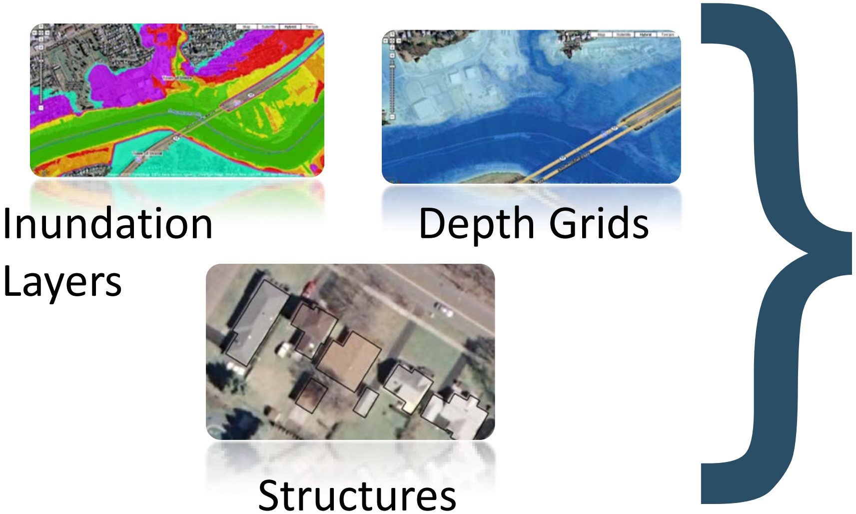
From Paper to Digital

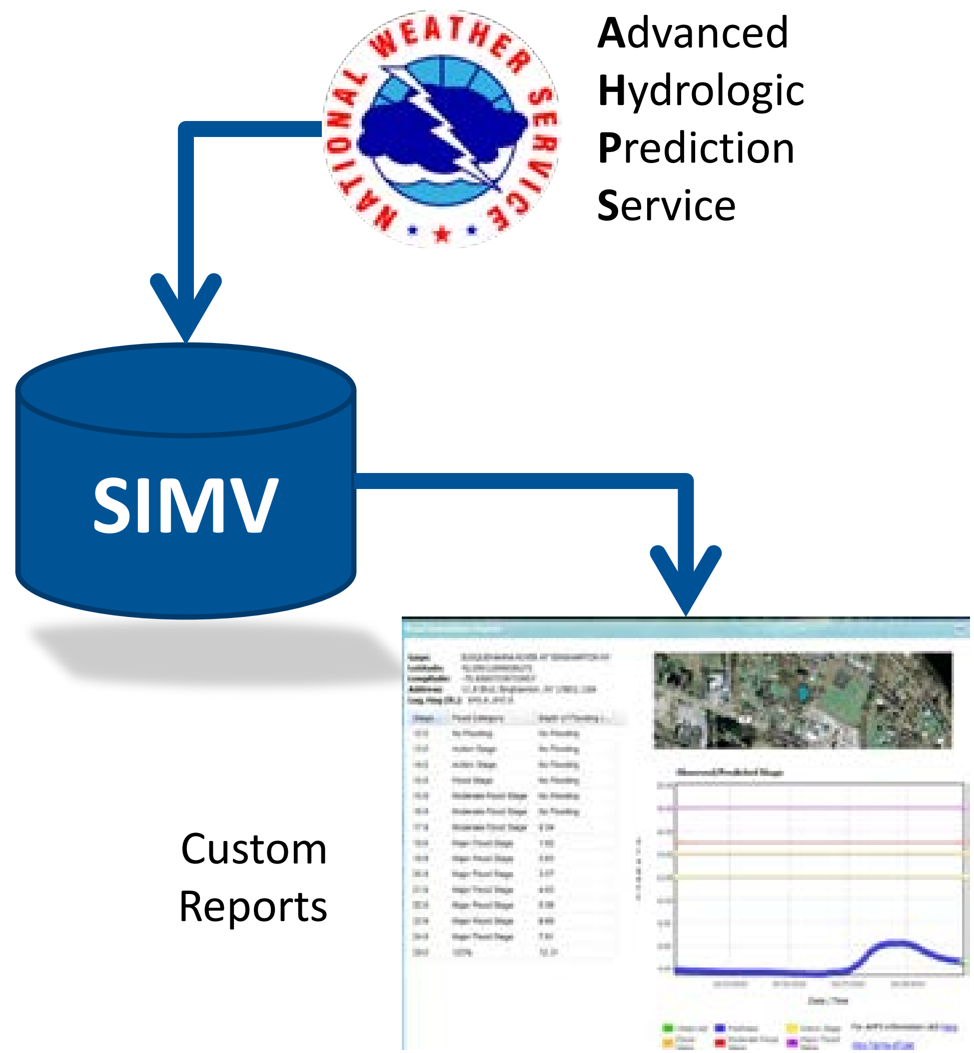
- Need to provide wider-access to flood inundation maps

- NWS AHPS inundation mapping website functionality was not sufficient for needs of the SFFWS
- Development of the Susquehanna Inundation Map Viewer (SIMV)

SIMV

- ArcGIS Server
- Google Maps API

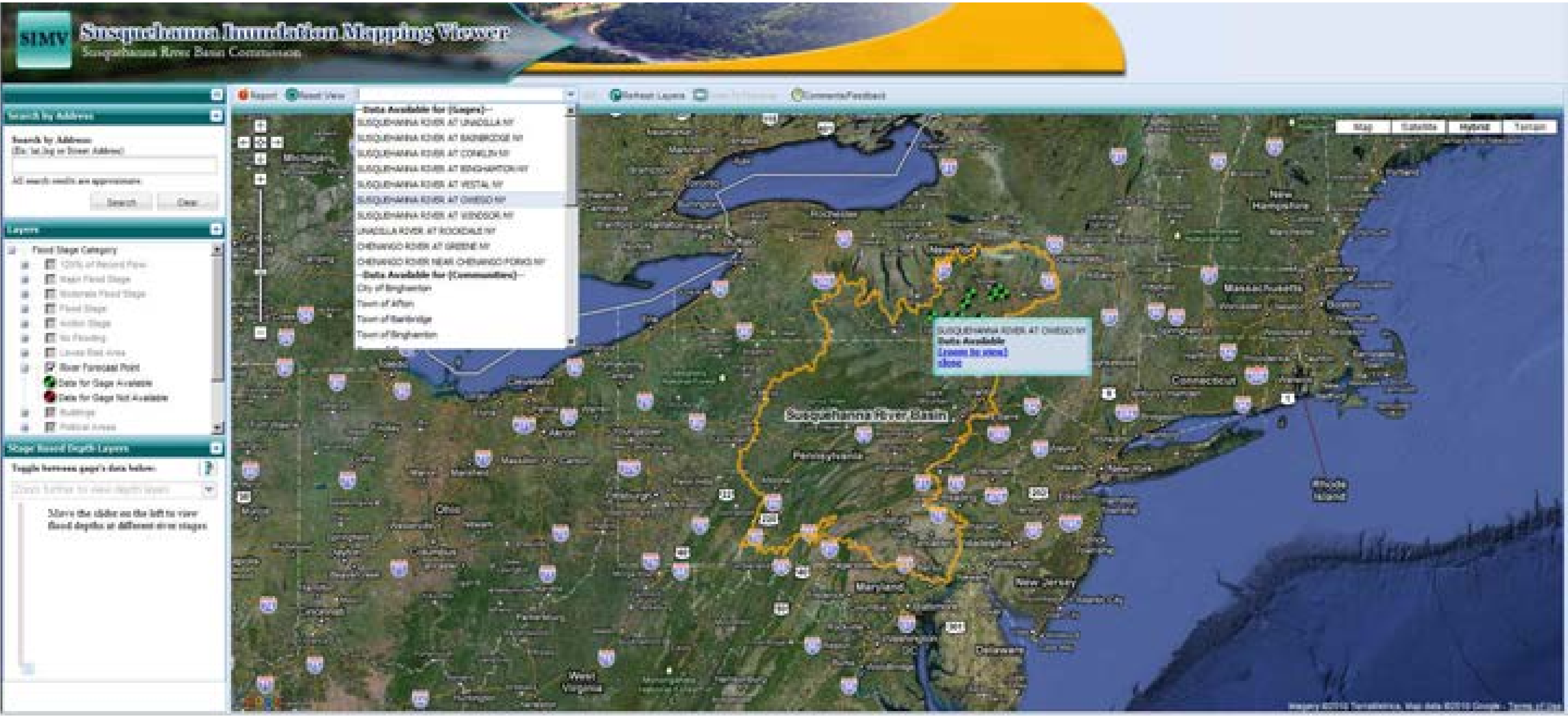




- http://maps.srbc.net

User Interface

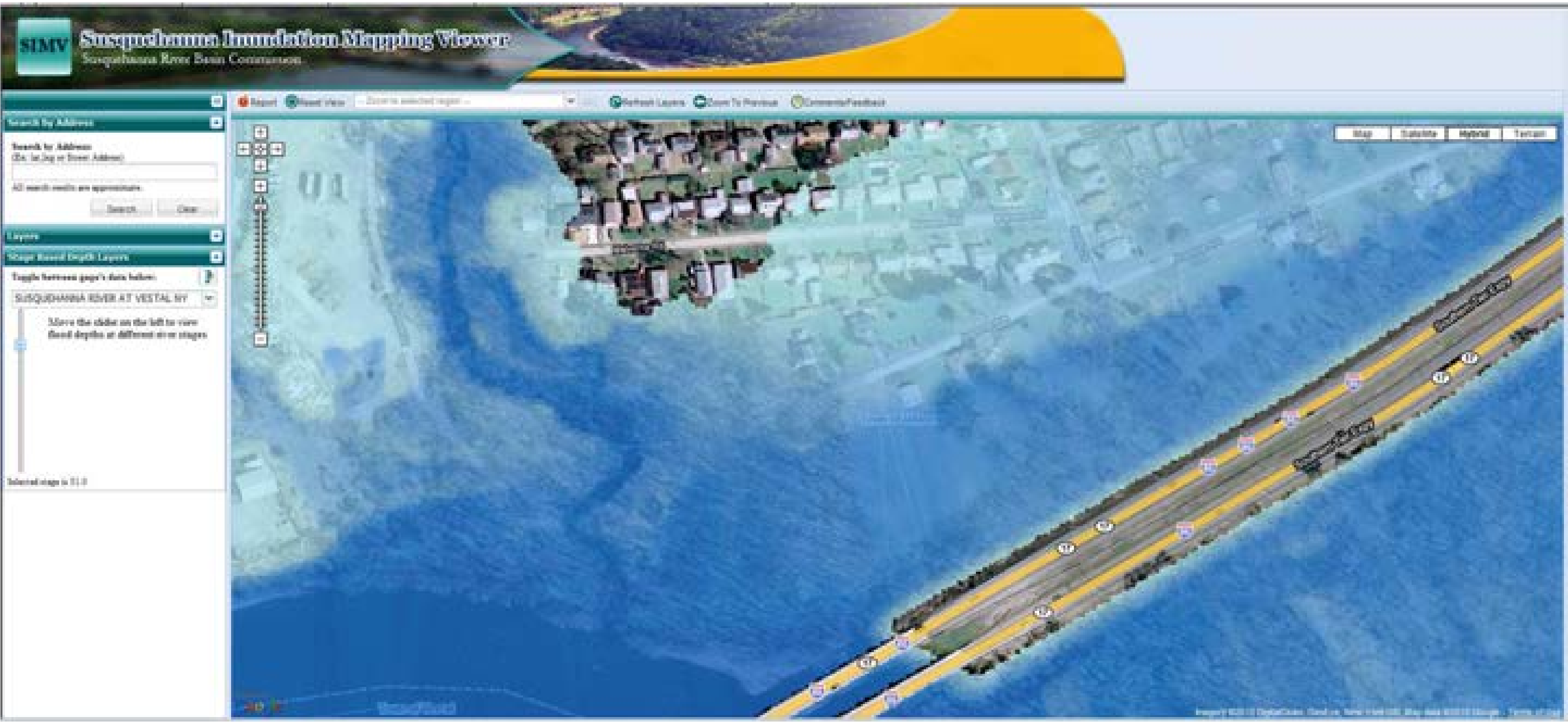
Navigation



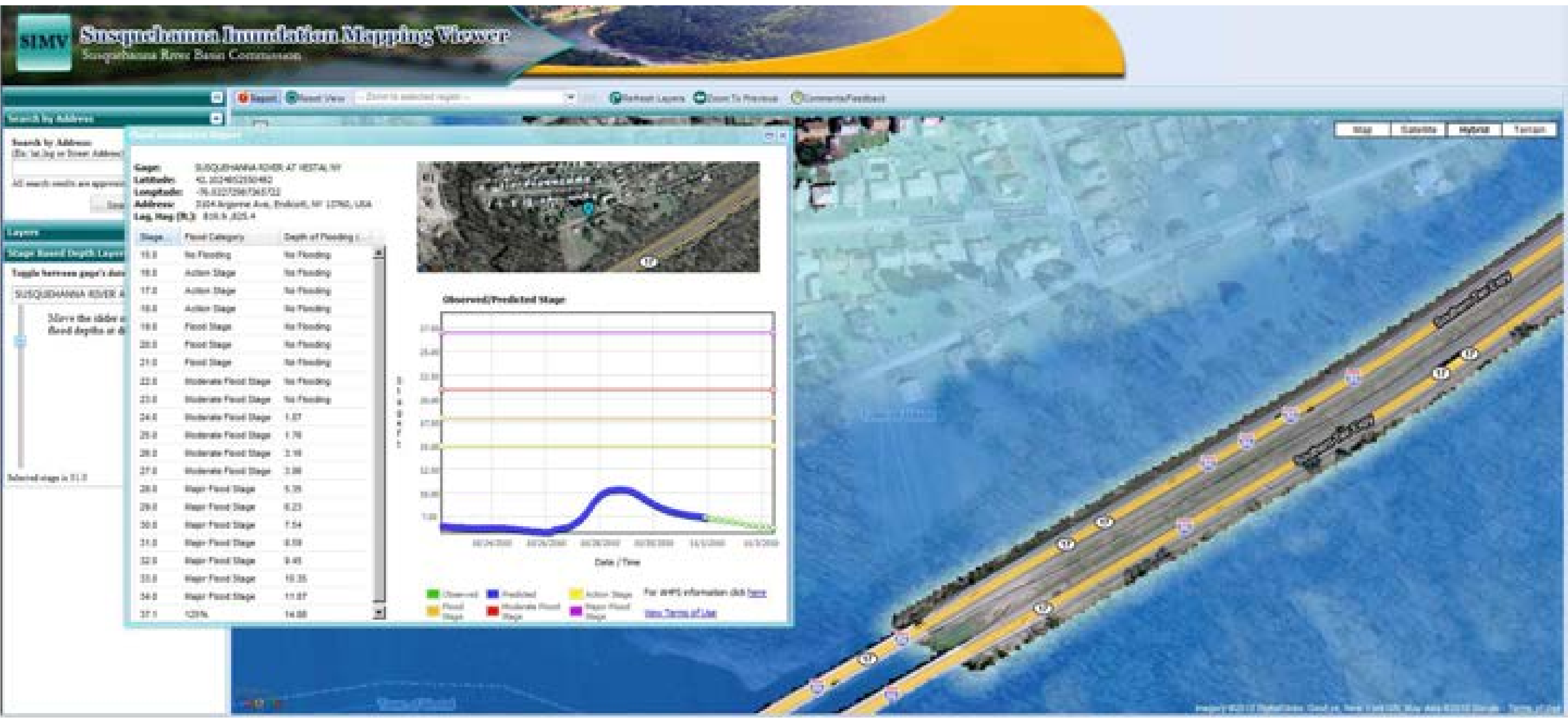
Dewberry

Threat Classes

Water Depths



Flood Impact Reports

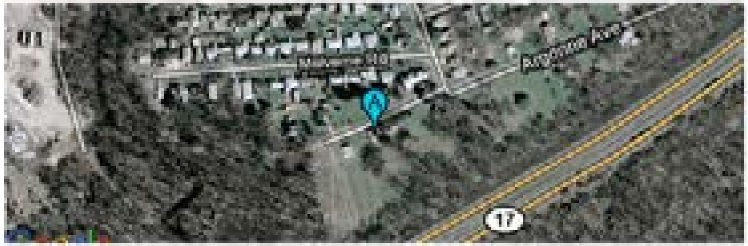


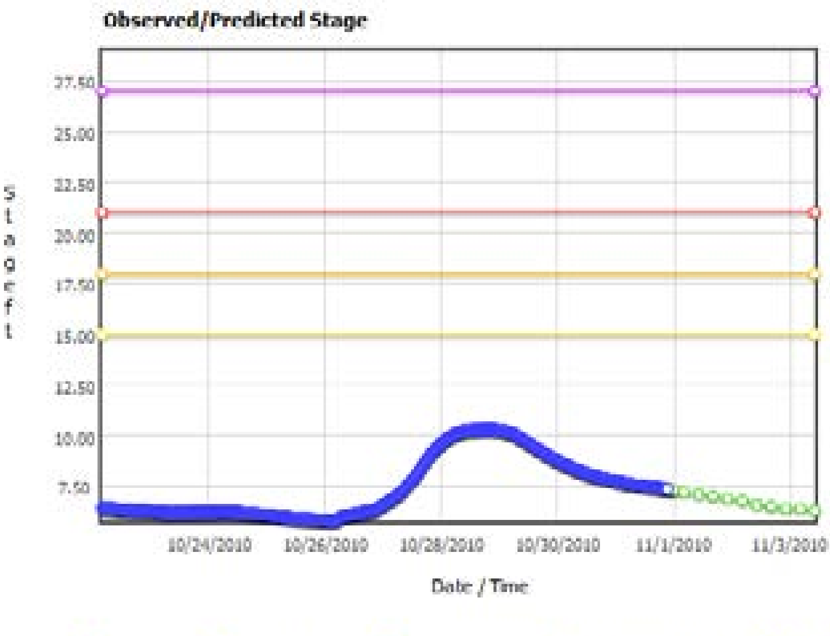
Flood Impact Reports

lood Inundation Report

Gage: SUSQUEHANNA RIVER AT VESTAL NY
Latitude: 42.1024852550482
Longitude: -76.02272987365722
Address: 3104 Argonne Ave, Endicott, NY 13760, USA
Lag, Hag (ft.): 819.9 ,825.4

Stage...	Flood Category	Depth of Flooding (...
15.0	No Flooding	No Flooding
16.0	Action Stage	No Flooding
17.0	Action Stage	No Flooding
18.0	Action Stage	No Flooding
19.0	Flood Stage	No Flooding
20.0	Flood Stage	No Flooding
21.0	Flood Stage	No Flooding
22.0	Moderate Flood Stage	No Flooding
23.0	Moderate Flood Stage	No Flooding
24.0	Moderate Flood Stage	1.07
25.0	Moderate Flood Stage	1.76
26.0	Moderate Flood Stage	3.16
27.0	Moderate Flood Stage	3.86
28.0	Major Flood Stage	5.35
29.0	Major Flood Stage	6.23
30.0	Major Flood Stage	7.54
31.0	Major Flood Stage	8.59
32.0	Major Flood Stage	9.45
33.0	Major Flood Stage	10.35
34.0	Major Flood Stage	11.07
37.1	125%	14.88





For AHPS information click here

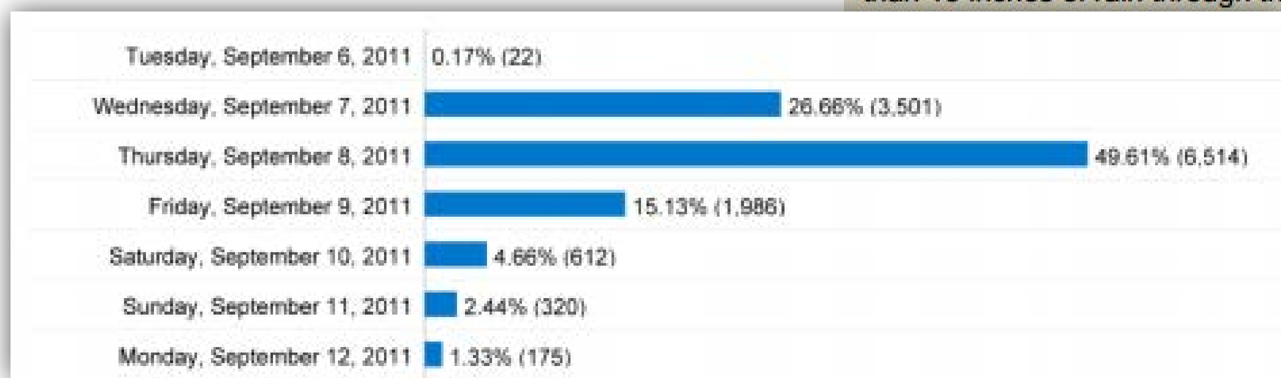
View Terms of Use

Summary (from Nov 2010)

- **JUST HAVING TOOL ISNT ENOUGH**
  - Communication hurdle still exists
- Emergency management tool for all users
  - Enhanced risk communication through web geospatial applications
  - Data rich, yet ease of use
- **Towards scenario-based risk assessment**

Outreach!

- Advertised on WBNG.com and evening news
- 14,700 visits up through peak (70.2% direct through referral)



Leveraging Traditional Broadcast Media to Disseminate Effective Flood Risk Information

Benjamin Pratt, PE, CFM – Susquehanna River Basin Commission, Harrisburg, PA
Stuart Geiger, CFM – Dewberry, Fairfax, VA

The Susquehanna River begins in Cooperstown, New York and flows 440 miles to the Chesapeake Bay. The 27,500 square mile drainage basin is recognized as one of the nation's most flood prone due to the basin's susceptibility to tropical systems and the varied topography of the region. Advanced warning of extreme hydrologic events is disseminated to citizens of the basin by the Susquehanna Flood Forecast and Warning System (SFFWS) through NOAAs National Weather Service. The SFFWS provides a network of stream gages and rain gages that collect and communicate critical data to forecast flood events.

Following catastrophic flooding in June 2006, the Susquehanna River Basin Commission (SRBC) in partnership with the SFFWS and private-sector technical support developed the web-based Susquehanna Inundation Map Viewer (SIMV) to provide a graphical flood inundation display for a gage specific NWS forecast. During recent extreme hydrologic events in the basin, the general public accessed and made use of the web-based SIMV product, clearly demonstrating that the general public will seek and use online risk communication tools to make informed decisions affecting their own life and property.

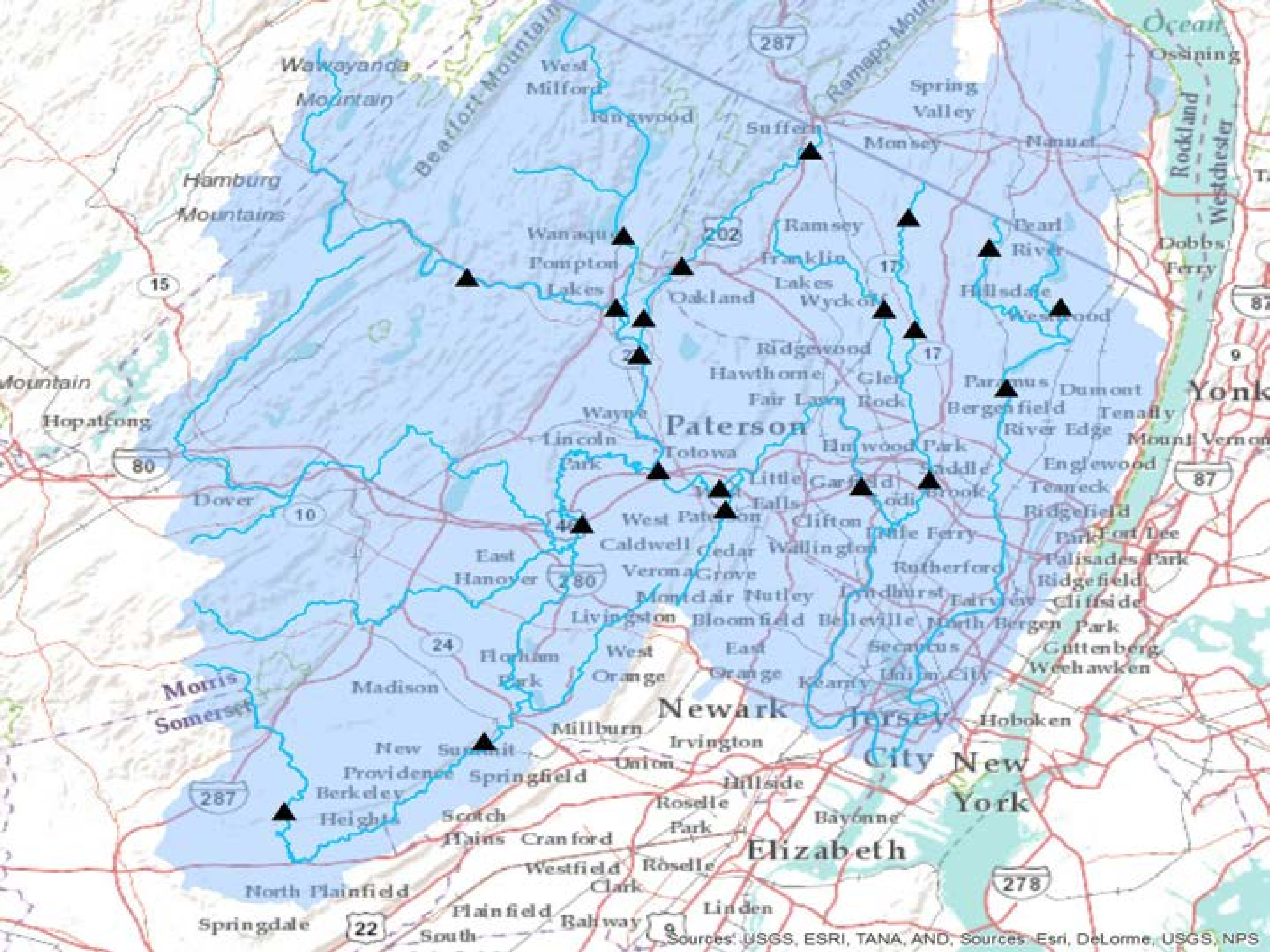
In September of 2011, the remnants of Tropical Storm Lee dumped more than 15 inches of rain through the heart of the basin (Figure 1, Total Rainfall ... once again plagued communities along the ... to Bloomsburg, Pennsylvania. During the ...

... immediately following the passage of Tropical Storm Lee, SRBC evaluated the use of SIMV during the flood event. Since SIMV first went live in April 2010, Google Analytics web tracking ...

Passaic River Basin

- Gov. Christie signs Exec. Order 23 establishing Passaic River Advisory Commission in 2010
- 15 Recommendations
- Inundation Mapping underway at 21 locations
- All locations to receive risk assessment

- Partners



Wawayanda Mountain
Beaufort Mountains
West Milford
Ringwood
287
Suffern
Spring Valley
Monsey
Nanuet
Ossining
Rockland
Westchester
Hamburg Mountains
Wanaque
202
Pompton Lakes
Oakland
Ramsey
Franklin Lakes
Wyckoff
17
Pearl River
Hillsdale
Westwood
Dobbs Ferry
15
87
9
Ridgewood
Hawthorne
Glen Rock
Fair Lawn
Paramus
Dumont
Bergenfield
Tenafly
Mountain
Hopatcong
Wayne
Paterson
Lincoln Park
Totowa
River Edge
Mount Vernon
80
Little Falls
Garfield
Lodi
Englewood
Teaneck
Dover
10
West Paterson
Clifton
Ridgefield Park
Fort Lee
Caldwell
Cedar Grove
Wallington
East Hanover
Verona
280
Rutherford
Palisades Park
Ridgefield
Montclair
Nutley
Lyndhurst
Fairview
Cliffside Park
Livingston
Bloomfield
Belleville
North Bergen
24
Florham Park
West Orange
East Orange
Secaucus
Guttenberg
Weehawken
Madison
Union City
Kearny
Morris
Somerset
Newark
Jersey City
Hoboken
Millburn
New Providence
Summit
Irvington
Union
Springfield
New York
Hillside
287
Berkeley Heights
Roselle Park
Bayonne
Scotch Plains
Cranford
Elizabeth
Westfield
Roselle
Clark
278
North Plainfield
Plainfield
Linden
Springdale
22
South
Rahway
9
Sources: USGS, ESRI, TANA, AND, Sources: Esri, DeLorme, USGS, NPS

Project Process

Data Collection → **Inundation Mapping** → **Risk Assessment**

Data Collection

- H&H Models from ongoing FEMA re-studies
- LiDAR
- NWS Flood Impacts (E-19)

Inundation Mapping

- Calibrate FEMA model to USGS rating curve
- Establish WSEL values for target stages
- Develop inundation maps and depth grids

Risk Assessment

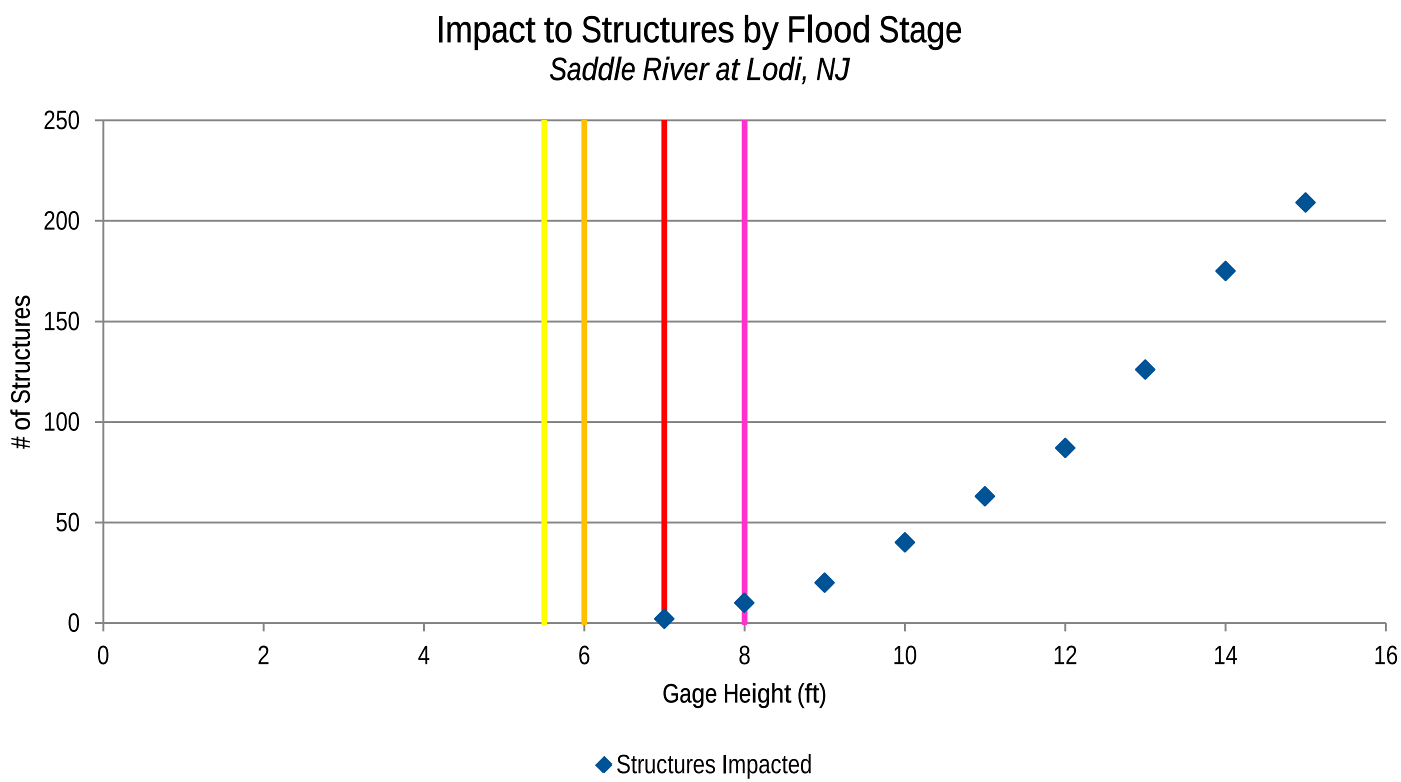
- Develop user-defined facilities from NJ ModIV tax rolls
- Evaluate parcels/structures against FIM depth grids
- Run HAZUS

Saddle River at Lodi, NJ

In Action: Saddle River at Lodi, NJ

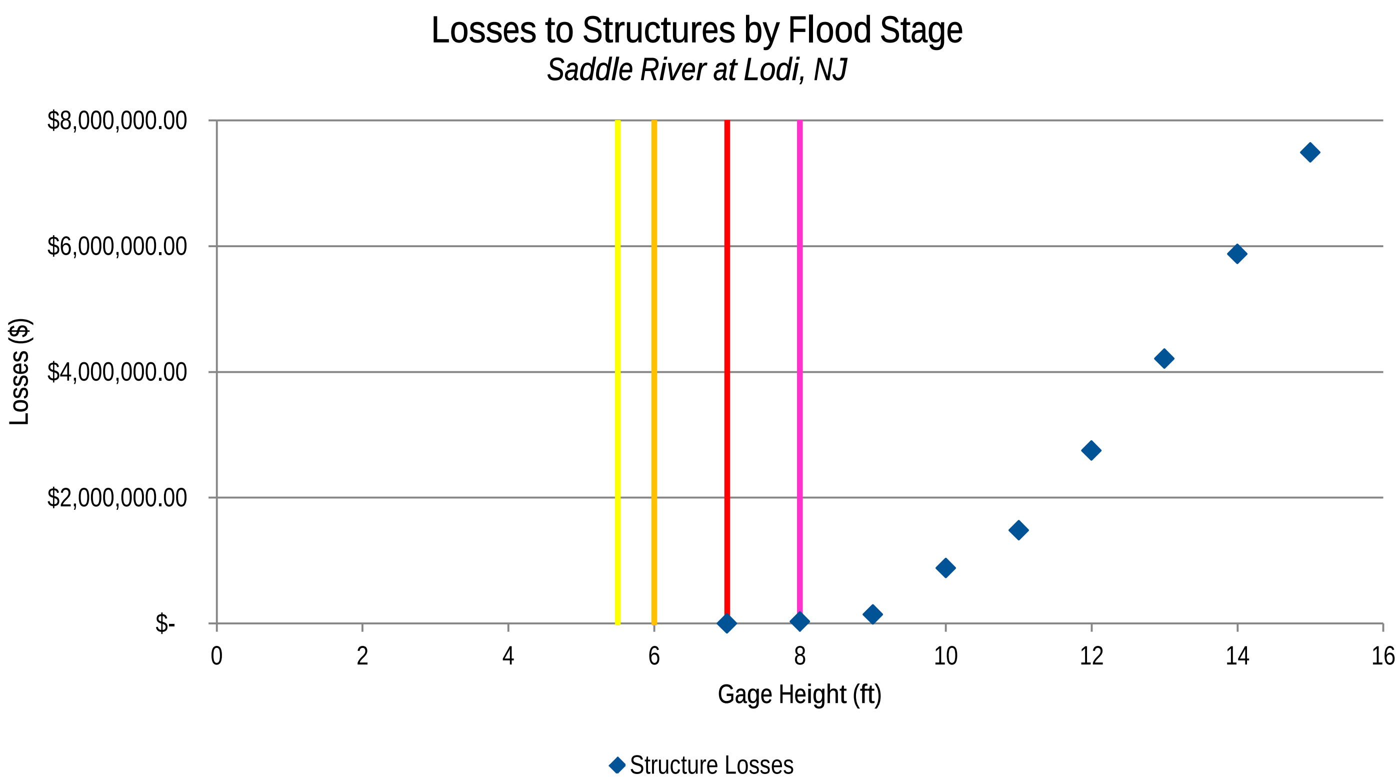
- Approximately 2.5 mile reach
- Approximately 200 at-risk structures
- Two significant floods in last 6 years:
  - August 2011: 13.5 ft
  - April 2007: 12.9 ft
- Flood of record
  - September 1999: 13.9 ft

Structures by Stage



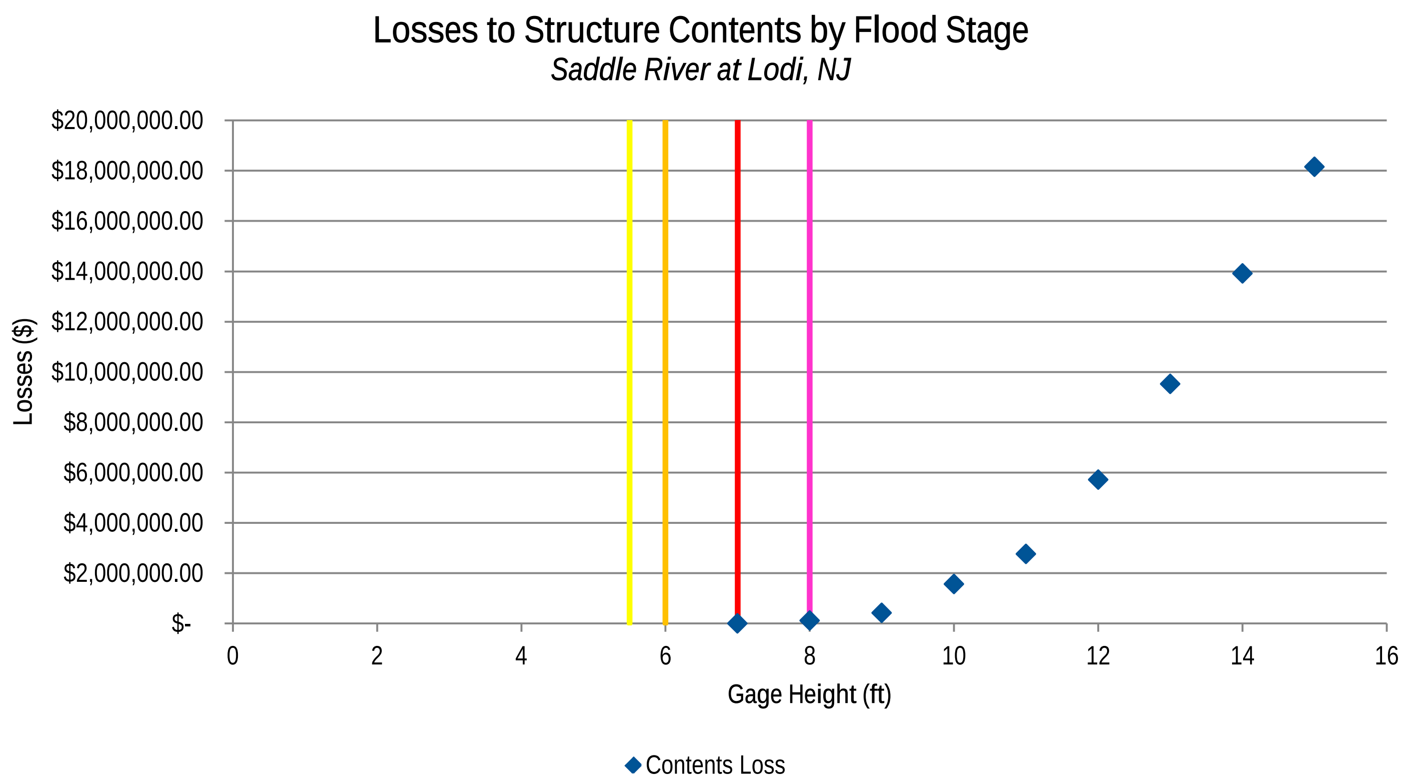
5.5	Action Stage
6	Flood Stage
7	Moderate Flood Stage
8	Major Flood Stage

Financial Losses - Structures



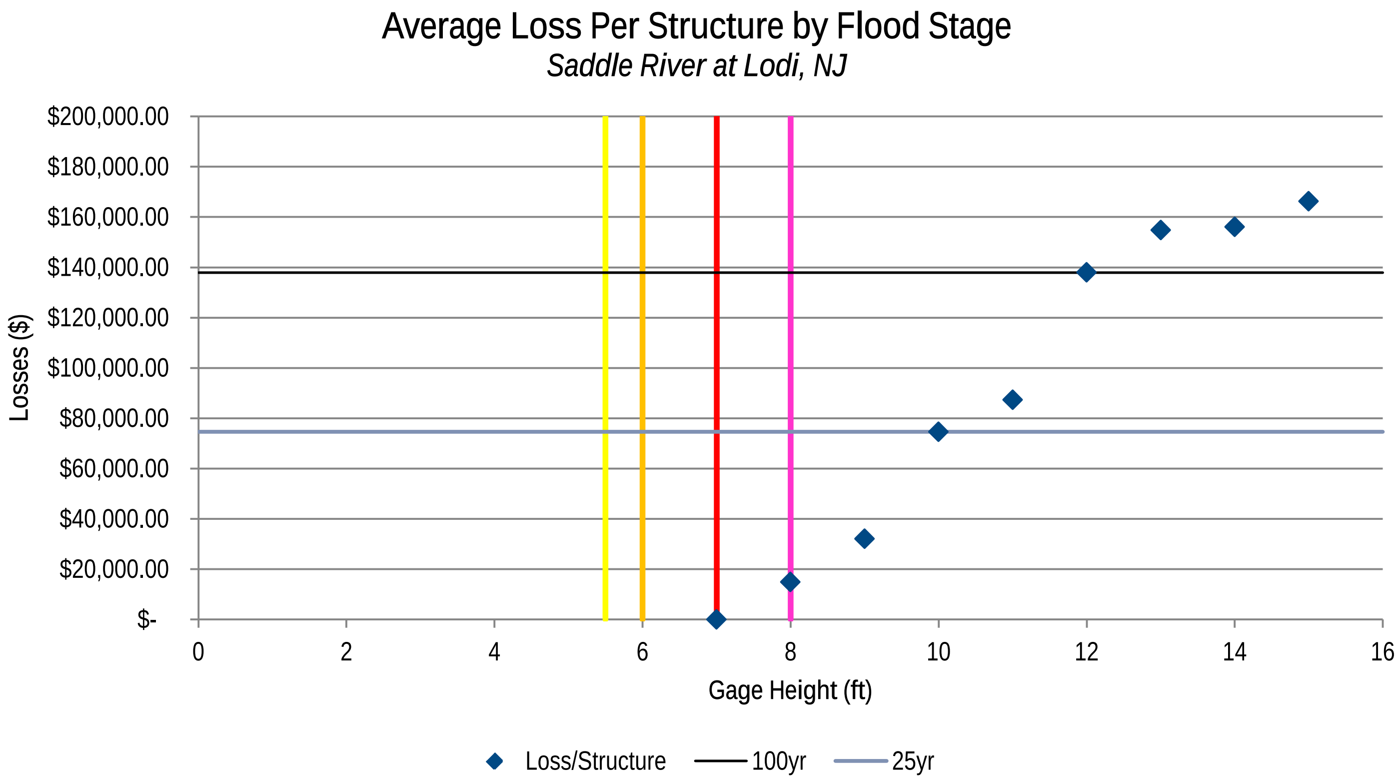
5.5	Action Stage
6	Flood Stage
7	Moderate Flood Stage
8	Major Flood Stage

Financial Losses - Contents



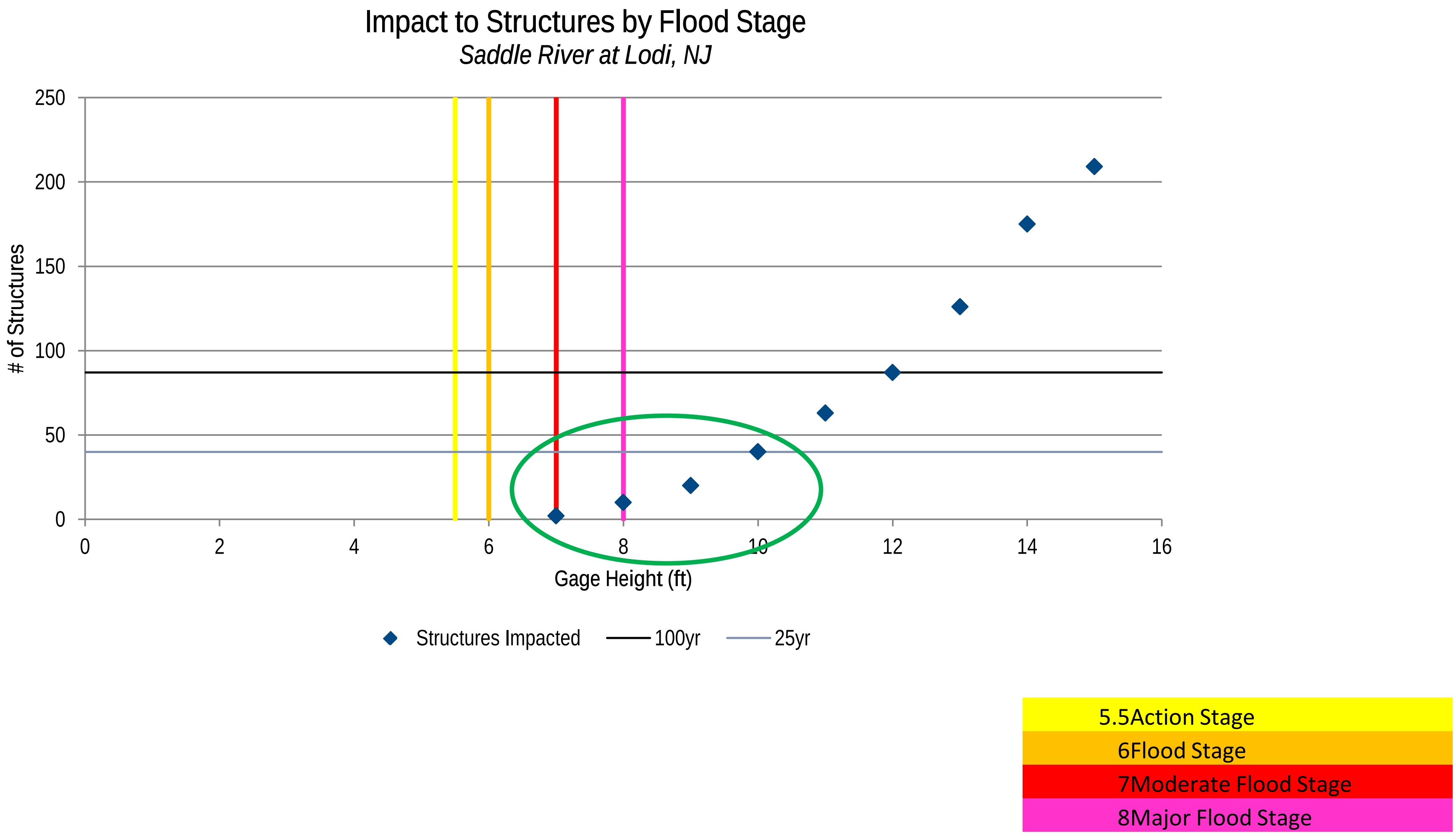
5.5	Action Stage
6	Flood Stage
7	Moderate Flood Stage
8	Major Flood Stage

Finding Natural Breaks



5.5	Action Stage
6	Flood Stage
7	Moderate Flood Stage
8	Major Flood Stage

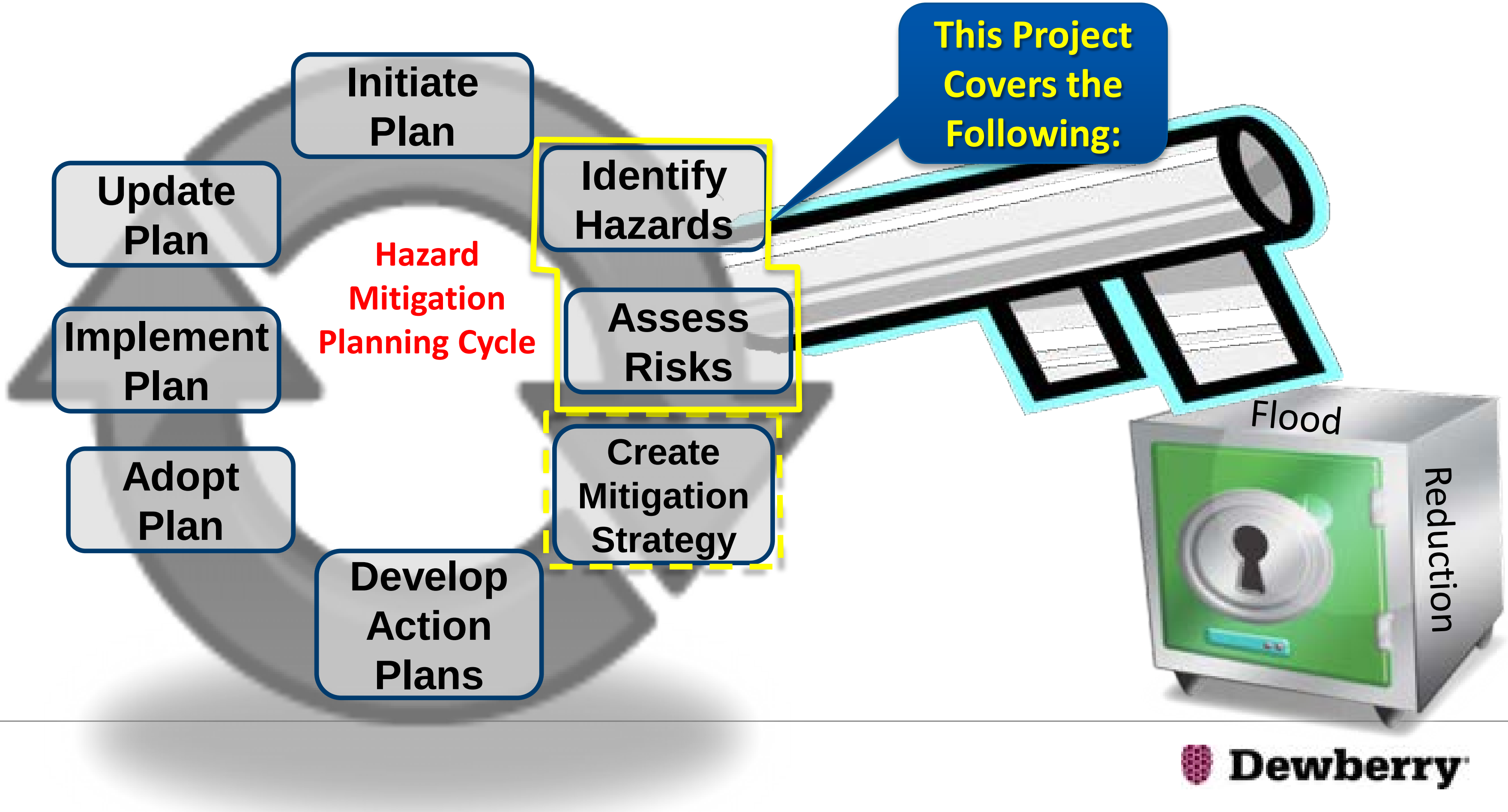
Breaks Identify Potential for Mitigation



Making Use of the Flood Risk Assessment

Mitigation Planning is Key

Hazard Mitigation Planning is part of the overall planning for any community – Comprehensive, economic development, infrastructure, mitigation and emergency planning are all facets of the same process.



Conducting a Flood Risk Assessment

- Risk = Probability x Economic Losses
- Leverage all tools – Map Modernization Program and Risk MAP and now FIM - for flood mapping using today's <u>and</u> tomorrow's technologies.

Tools	**Map Mod**	**Risk MAP**	**FIM**
Flood Data	1% Depth Grid*	0.2%, 1%, 2%, 4%, 10% Depth Grids	Multi-stage depth grids
User-Supplied Data	Depth-Damage Function	Depth-Damage Function	Depth-Damage Function
Results	1% Annual Chance Losses	Annualized Losses	Stage-Based Losses

* Derived from flood hazard data and quality topographical information.

Uses of Inundation Mapping

- Mapped stages cover the areas in between FEMA's standard 1% and 0.2% annual chance delineations
- Understanding the full spectrum of which structures or parcels that are affected by lower inundation levels is important = greater value for mitigation options.

What have we created here?

- Quantitative basin-wide assessment of flood risk in populated areas near gages.
  - Actionable data that can support future mitigation planning efforts and provide BCA justifications
- Developed a repository of structure types and estimated losses
  - Stored in a FEMA Flood Risk Database (FRD) schema (with slight modification)
  - Demonstrates how different programs can talk
- Comprehensive identification and assessment of flood risk that can be used to:
  - Communicate risk
  - Develop tools for decision makers
  - Identify markets and/or targets for mitigation

Uses in CO

- *None right now…but do you have a ready model?*
- Marry it with your flood response plans
- Post-fire hydrology changes – downstream impacts

Questions

- Stuart Geiger
  Dewberry
  sgeiger@dewberry.com
  303.951.0620

- Acknowledgements
  - Ben Pratt, SRBC
  - Joseph Ruggeri, NJDEP
  - Victor Hom, NWS
  - Marie Peppler, USGS

Post-Fire Waldo Canyon Areas of Concern for Potential Flood Inundation

Kevin Houck, PE, Chief, Watershed and Flood Protection

Robert Krehbiel, PE, Matrix Design Group

Matt Simpson, PE, Matrix Design Group

September 12, 2013

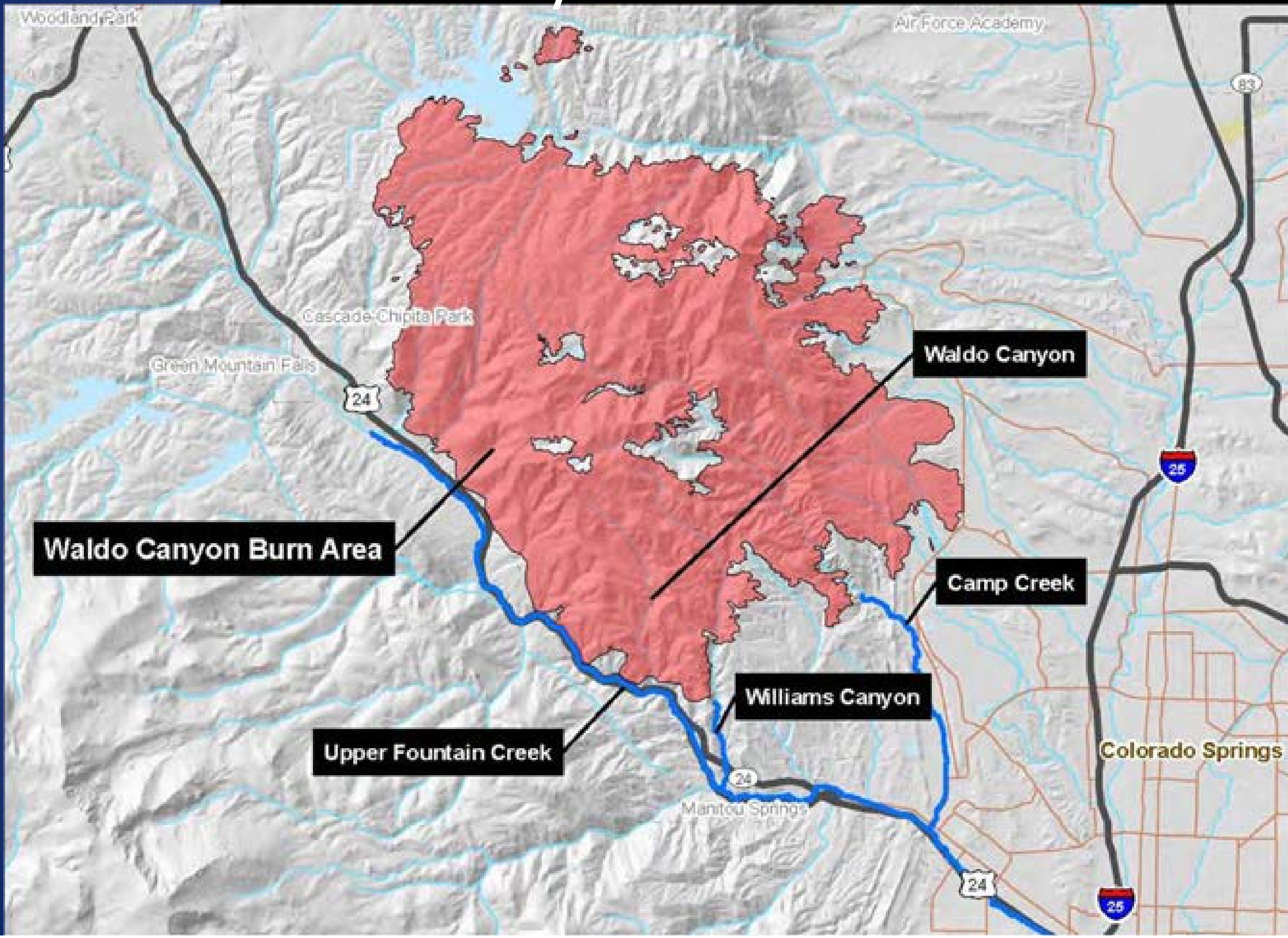
Waldo Canyon Fire – El Paso County

- June 23, 2012 started
- 18,247 acres
- 346 homes burned
- Primary watersheds affected:
  - Waldo Canyon
  - Fountain Creek
  - Williams Canyon
  - Camp Creek
  - North Douglas Creek
  - South Douglas Creek

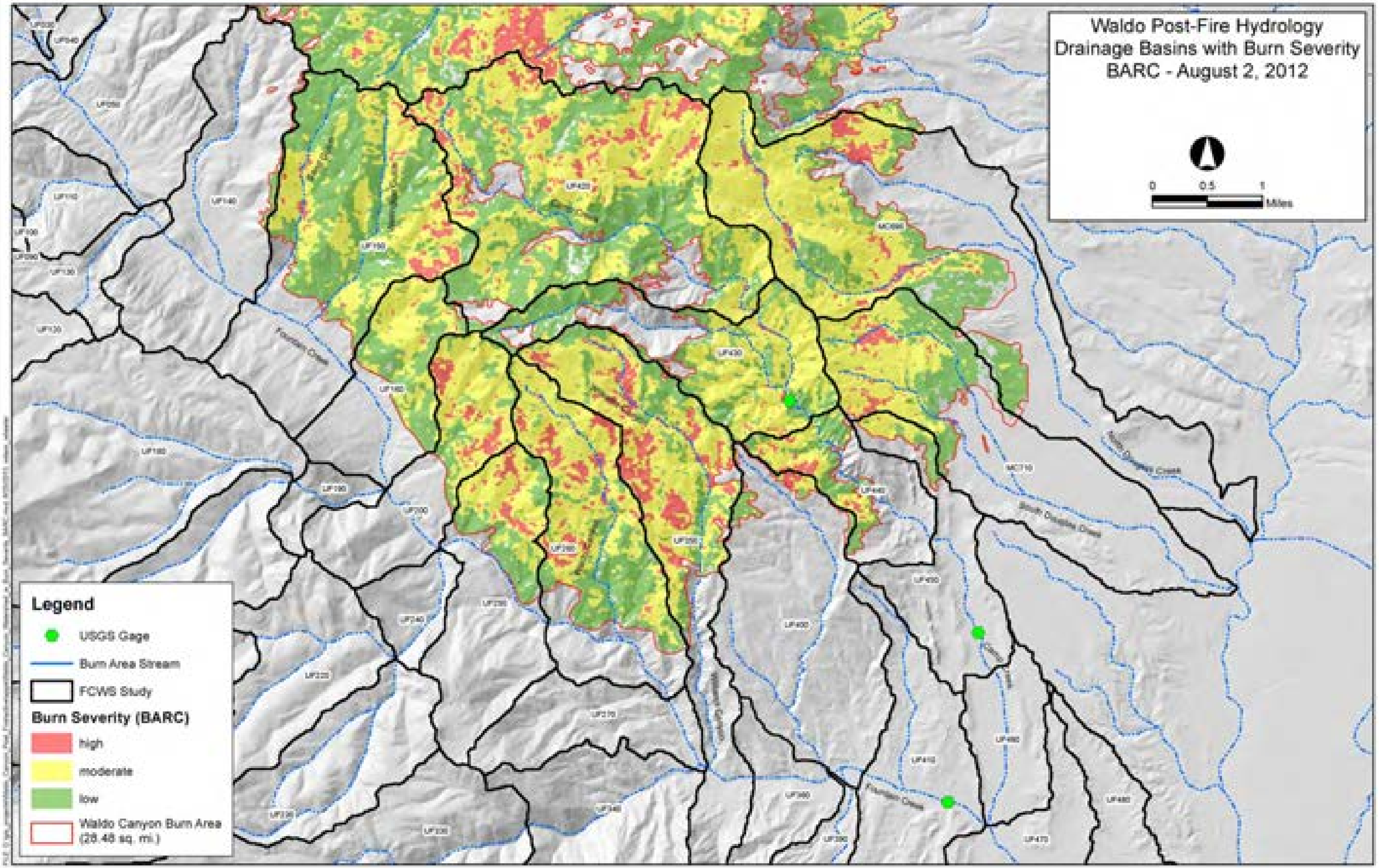
Waldo Canyon Fire Concerns

- Debris: Very High
- Flood: Very High
- Utility Exposure
- Slow Watershed Recovery

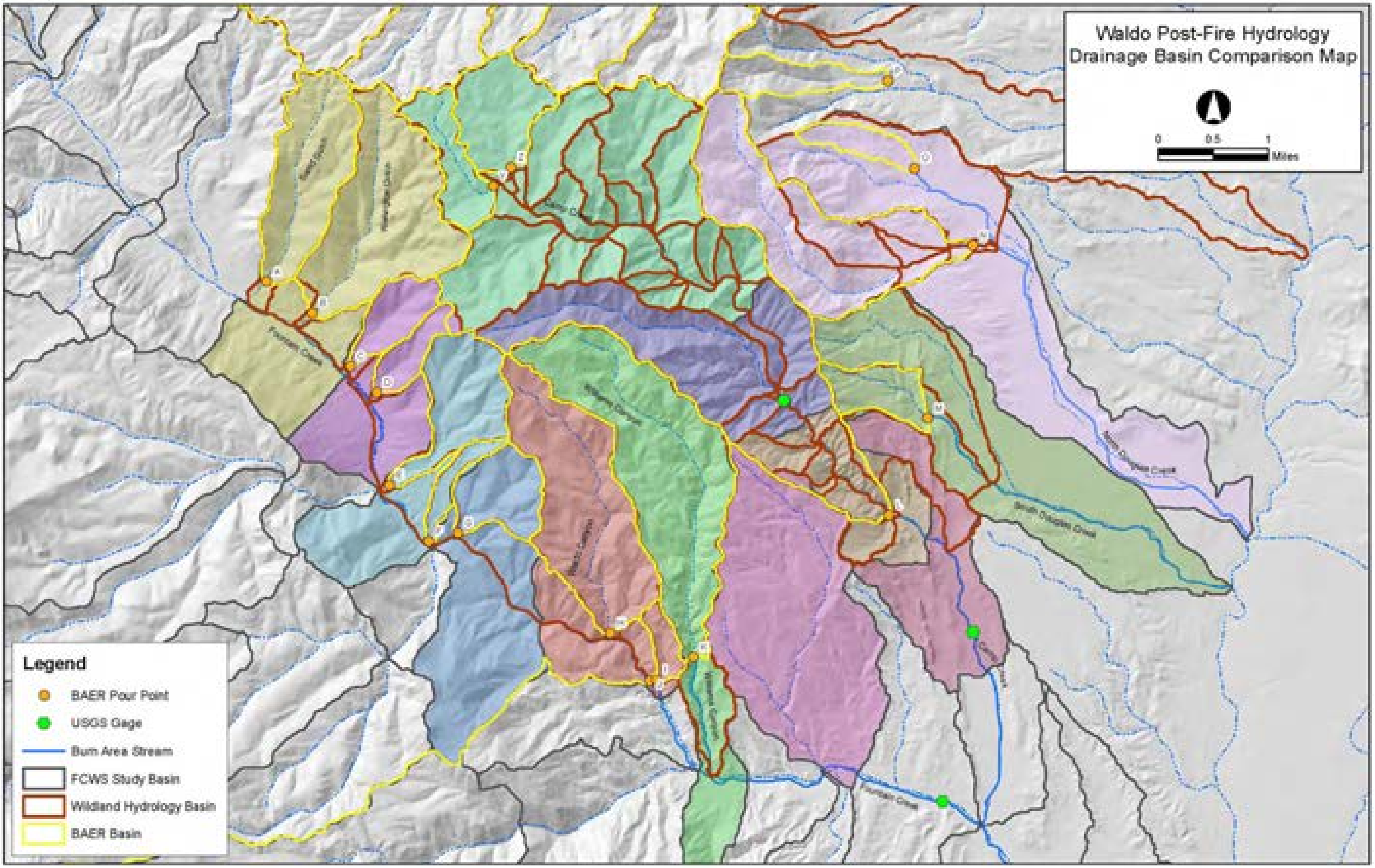
Waldo Canyon Fire Location

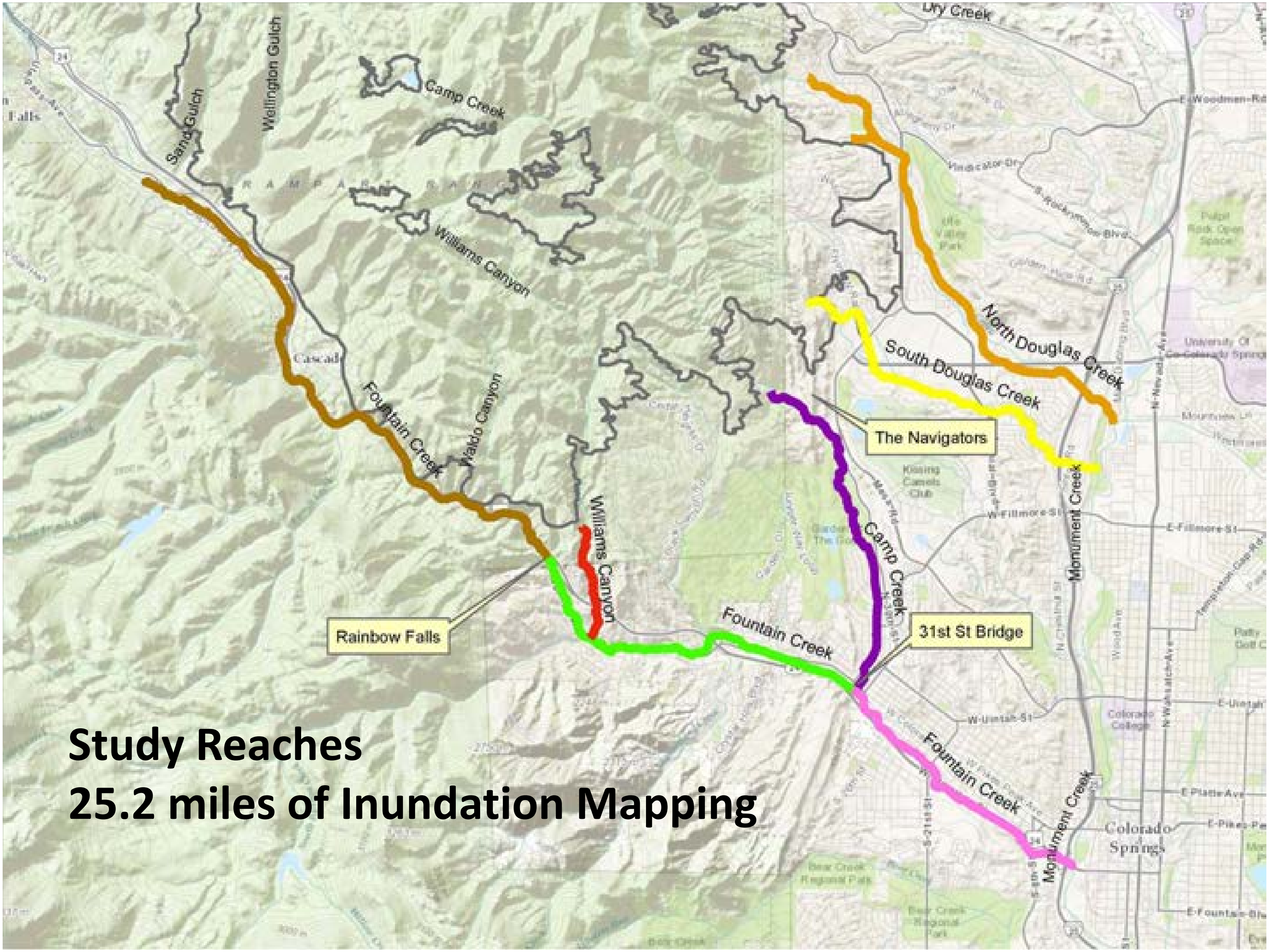


Waldo Canyon Fire Burn Map



Waldo Canyon Impacted Watersheds





Study Reaches
25.2 miles of Inundation Mapping

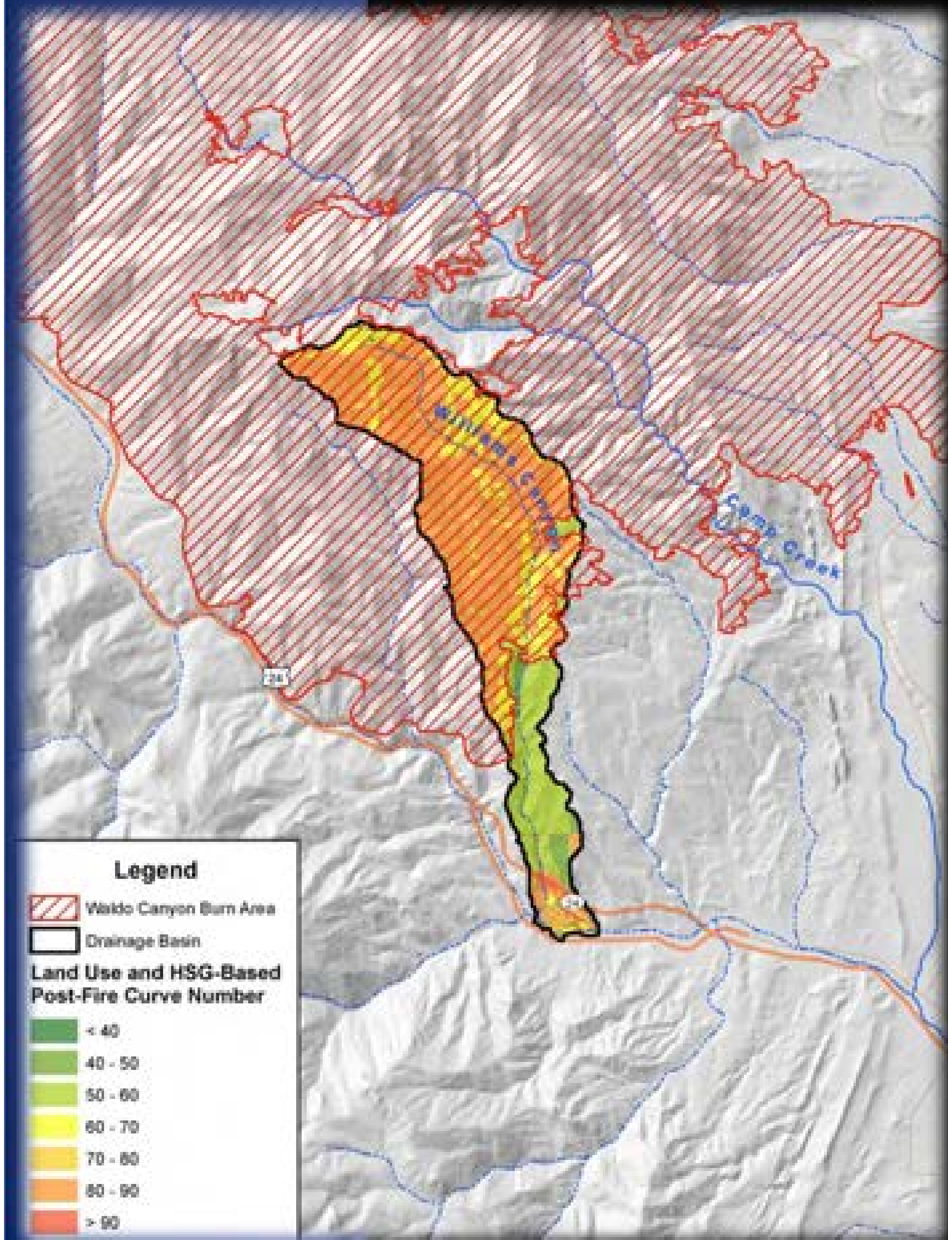
Project Goal

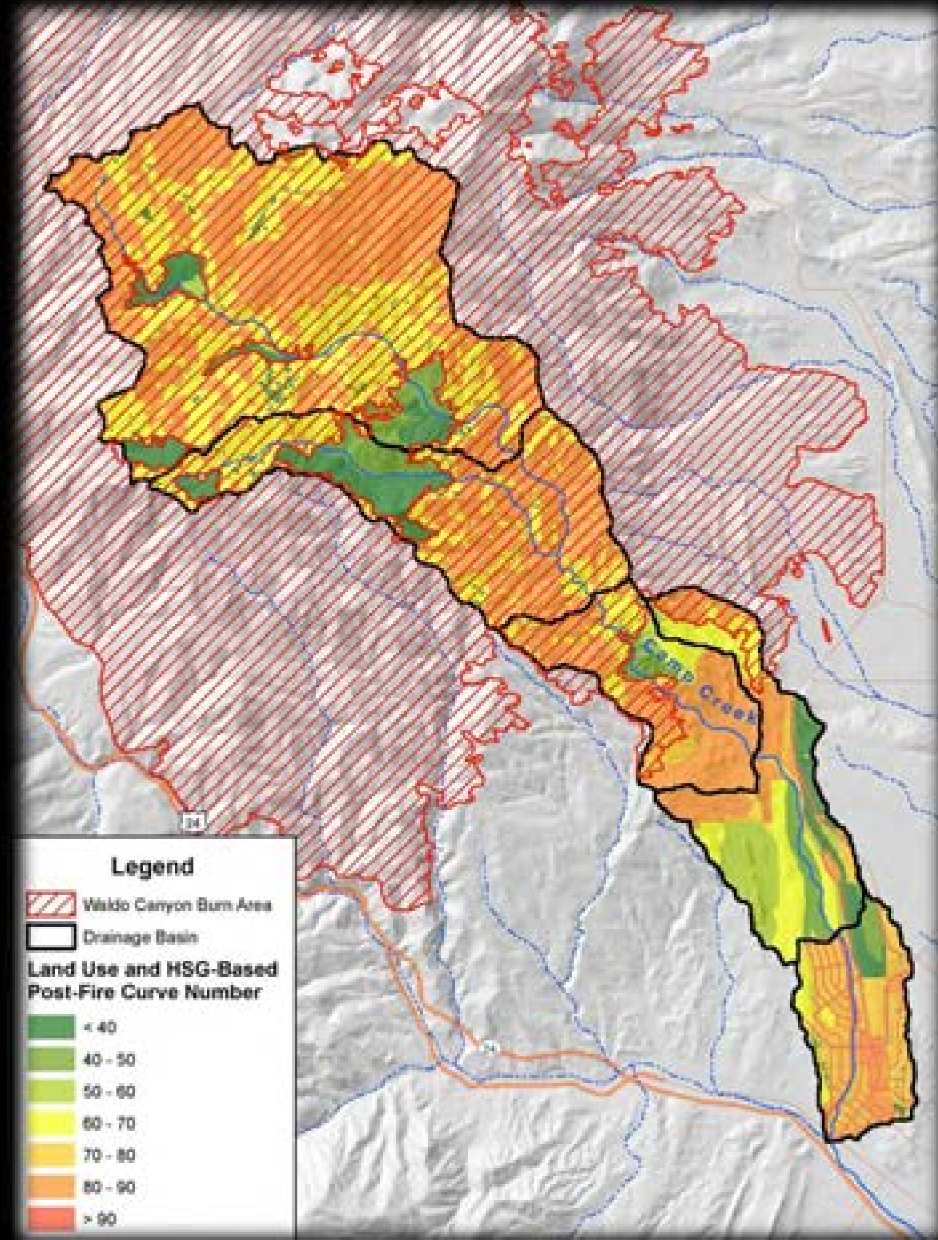
- Emergency Management and Response
- Inform Property Owners of Increased Flood Hazard Potential
- Purchase Flood Insurance

Summary of Work

- Data Gathering / Document Review
  - USGS BAER – Burn Area Emergency Response
  - Wildland Hydrology – WARSSS (Watershed Assessment of River Stability & Sediment Supply)
  - CUSP (Coalition for the Upper South Platte)
- Post-Fire Hydrology
- Hydraulics
- Debris Assessment
- Identify Structures at Risk
- Public Outreach

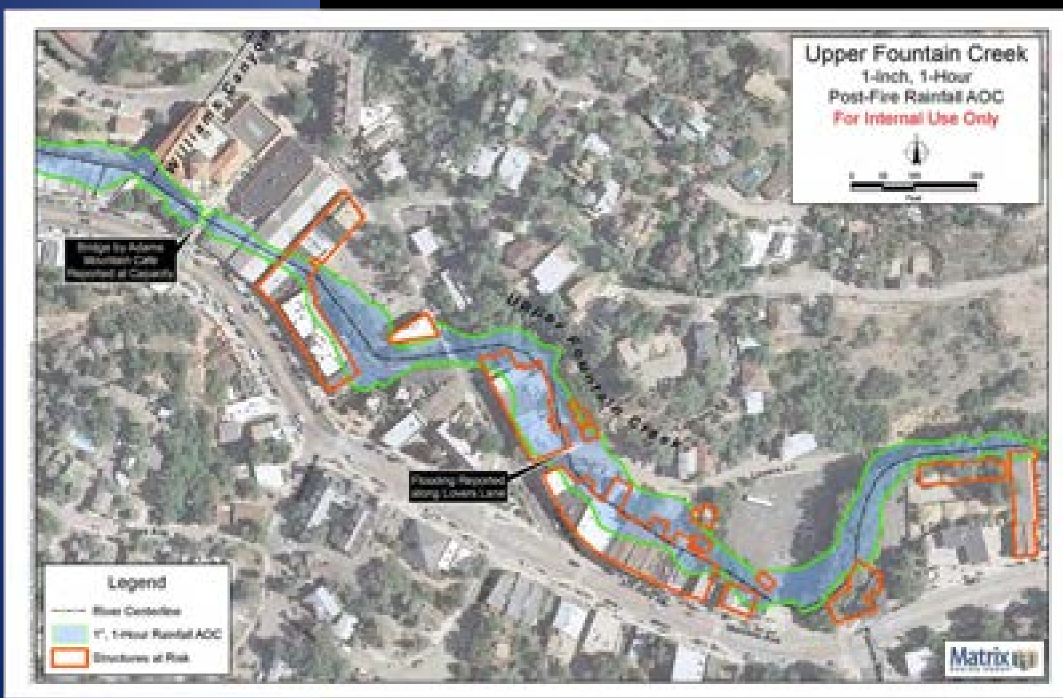
Williams Canyon and Camp Creek

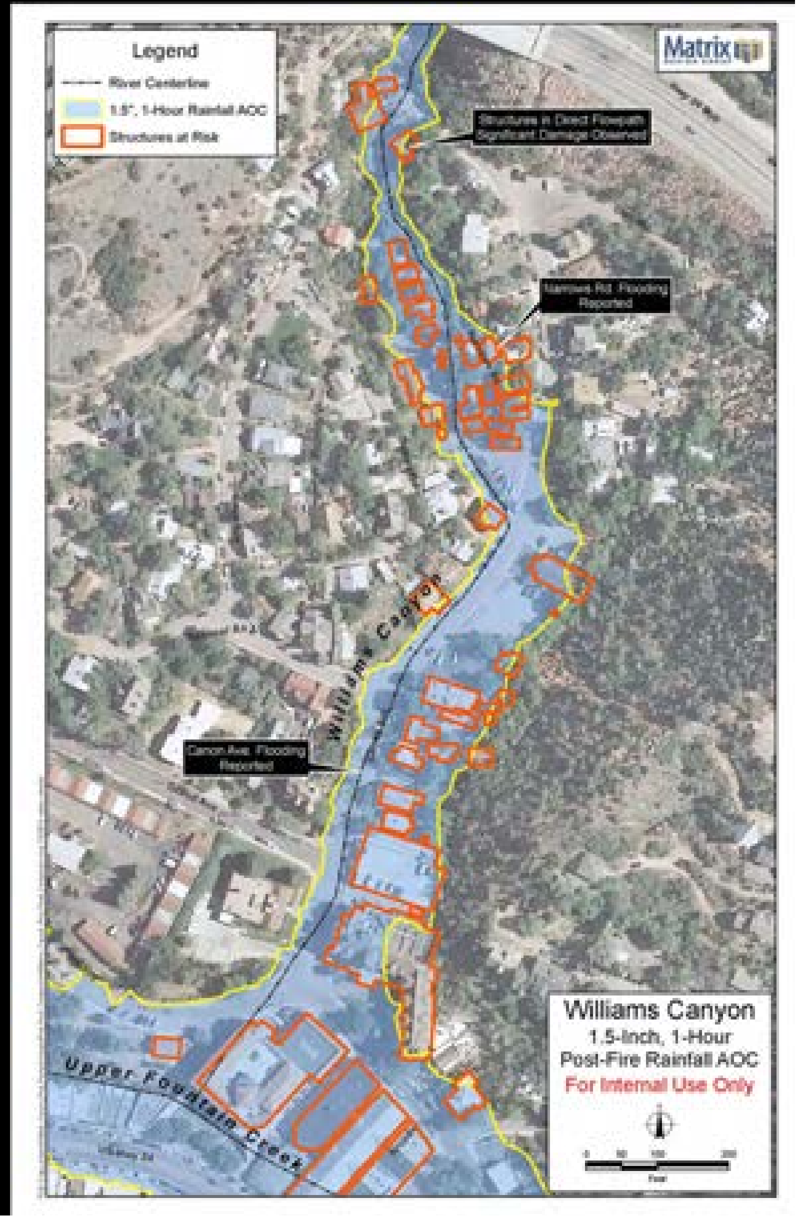




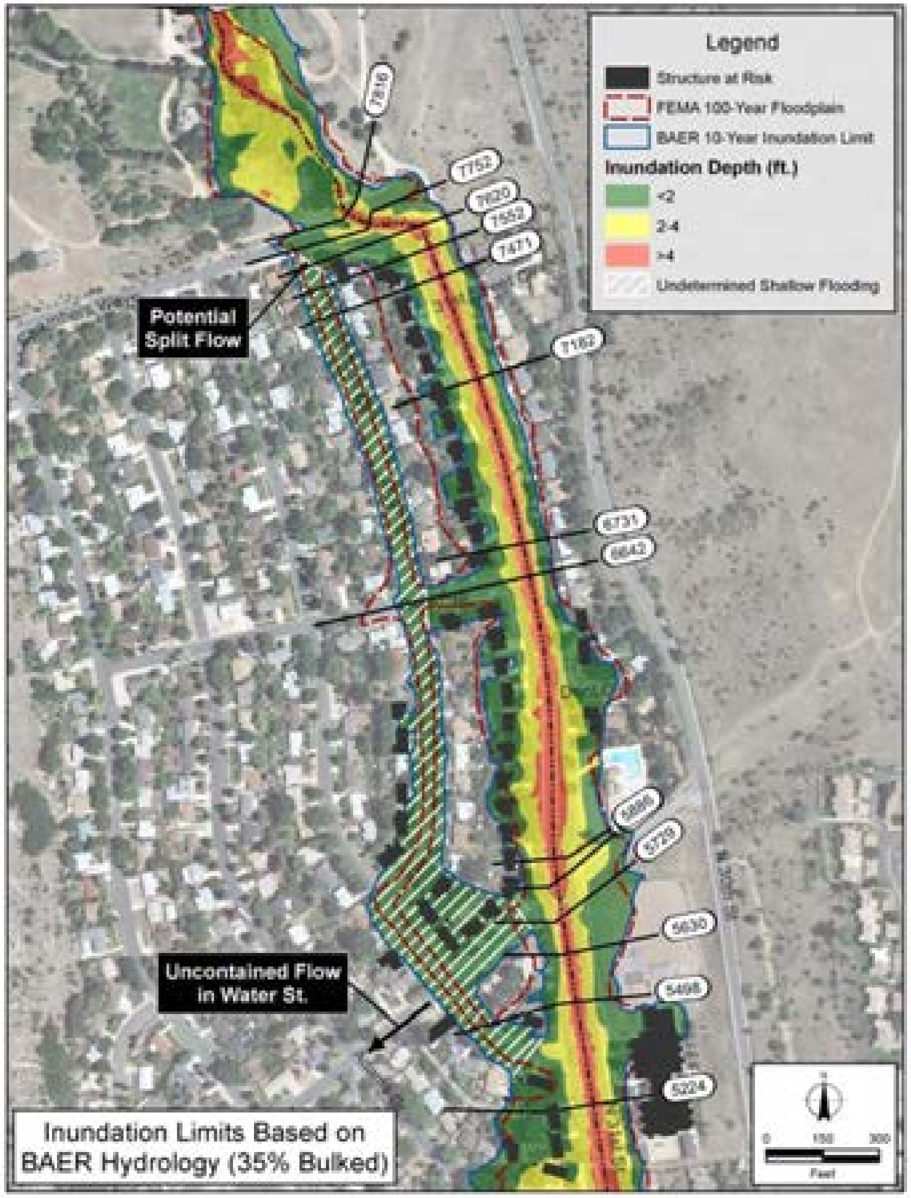
Detailed Inundation Maps

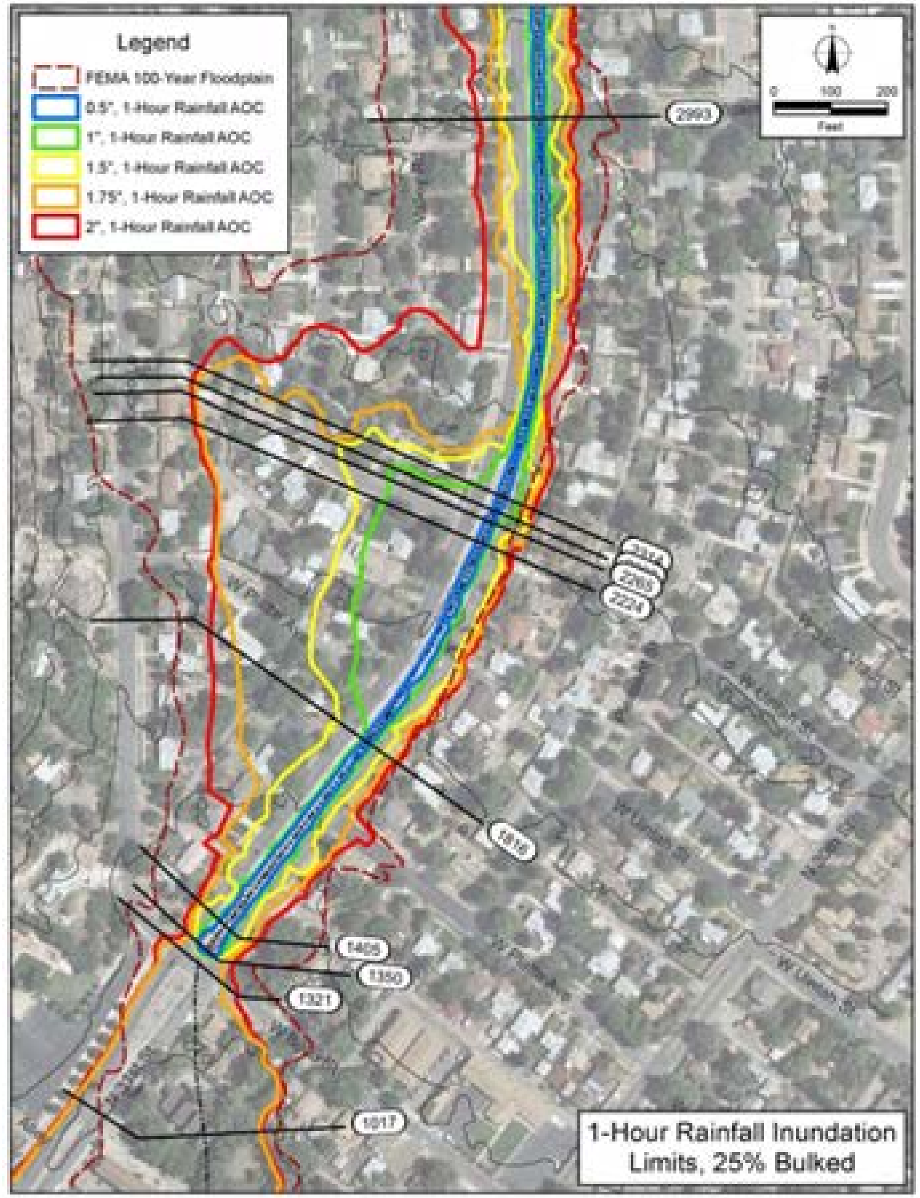
- ½”, 1”, 1 ½”, 1 ¾”, 2” rainfall events (inches in one hour)
- Layered PDFs
- Property Notification





Inundation Mapping





HEC-HMS Hydrologic Model

<u>Pre-Fire</u>

- Fountain Creek Watershed Study Model (2006)
  - ➢ 110 sq. mi.
  - ➢ 48 Subbasins
- Updated Curve Numbers with revised soils data
  - ➢ HSG "D" to HSG "B"
- Calibrated to USGS Gauge (Pre-Fire)
  - ➢ Adjusted CN and Ia ratio
    - ➢ Final CN = 47 (watershed avg.)
    - ➢ Ia Ratio = 0.05

<u>Post-Fire</u>

- Post-Fire Curve Number based on Soil Burn Severity Data
  - – High/ Medium SBS, CN = 86
  - – Low SBS, CN = 66

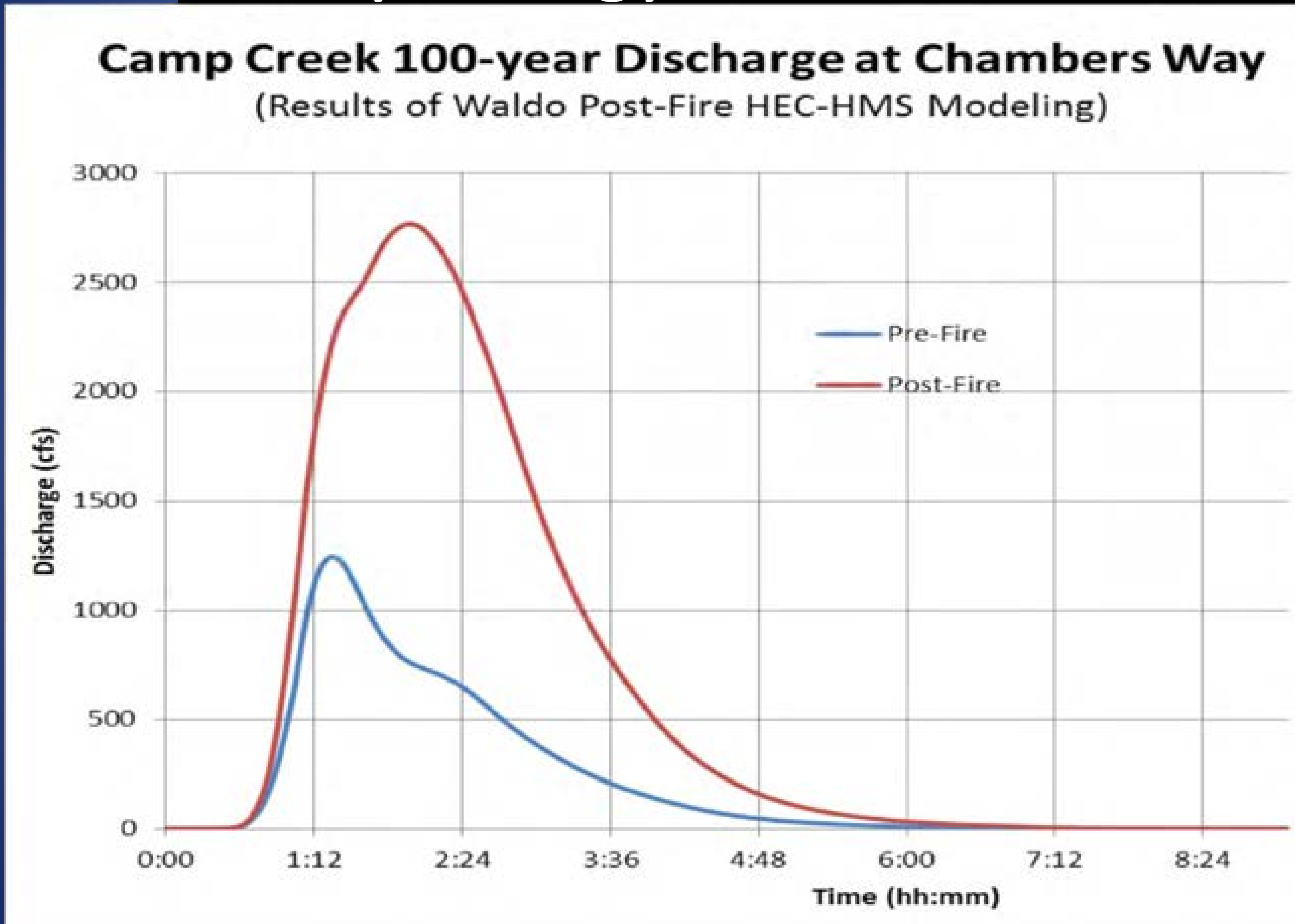
Hydrology Results

- Williams Canyon Subbasin CN:
  - Prefire = 46
  - Postfire = 77

- Williams Canyon 2-yr rainfall now (post-fire) results in 50-yr pre-fire discharge.

- Post/pre-fire peak flow ratio:
  - Generally 2x – 3x
  - Up to 16x for Williams Canyon (2-yr rainfall)

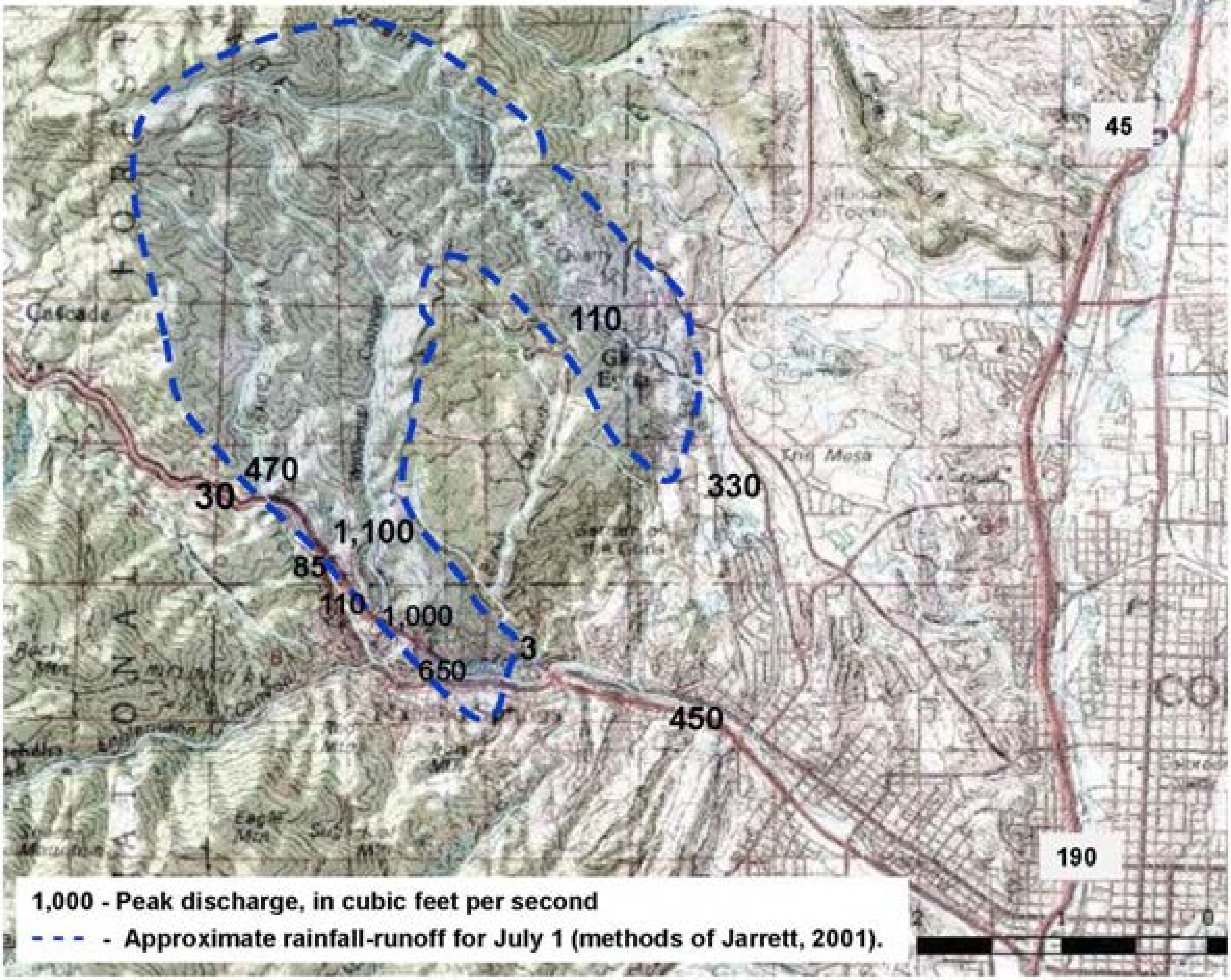
Hydrology Results



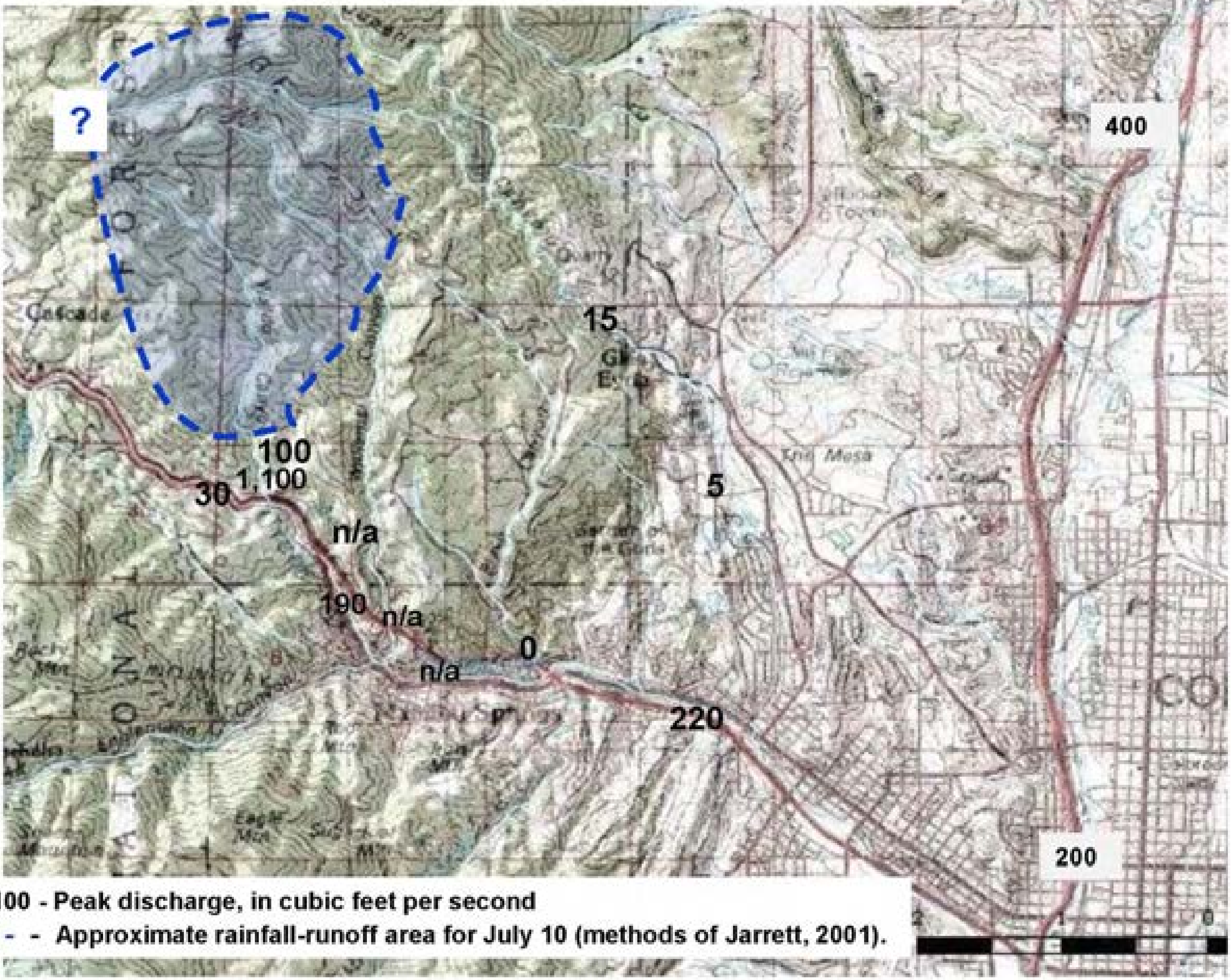
Waldo Canyon Fire
El Paso County

- Significant flooding events of 2013:
  - July 1, 2013 - Manitou Springs
  - July 10, 2013 - Manitou Springs
  - August 9, 2013 - Manitou Springs

Topic 3 cont.) Peak Discharges for the Storm of July 1, 2013



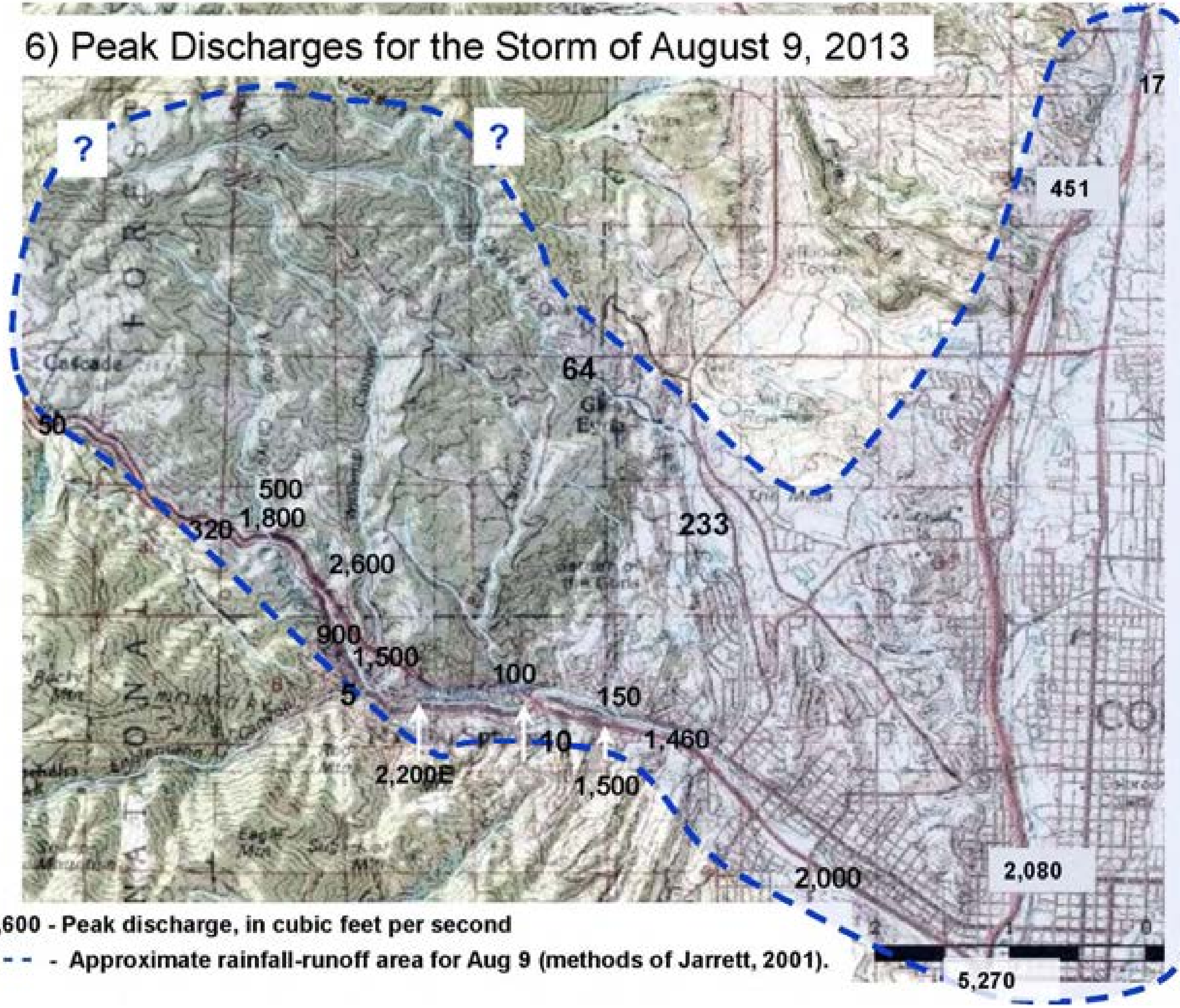
5) Peak Discharges for the Storm of July 10, 2013



1,100 - Peak discharge, in cubic feet per second

- - - - Approximate rainfall-runoff area for July 10 (methods of Jarrett, 2001).

6) Peak Discharges for the Storm of August 9, 2013



2,600 - Peak discharge, in cubic feet per second

- - - - Approximate rainfall-runoff area for Aug 9 (methods of Jarrett, 2001).

Bob Jarrett Documentation

- July 1, 2013:
  - 0.59 inches in 15 minutes
  - Waldo and Williams Canyons
  - Recurrence 2- to 5-yr
- July 10, 2013:
  - 1.02 inches in 30 minutes
  - Waldo Canyon
  - Recurrence 5- to 10-yr
- Aug 9, 2013:
  - 1.38 inches in 35 minutes
  - Waldo and Williams Canyons
  - Recurrence 25-yr

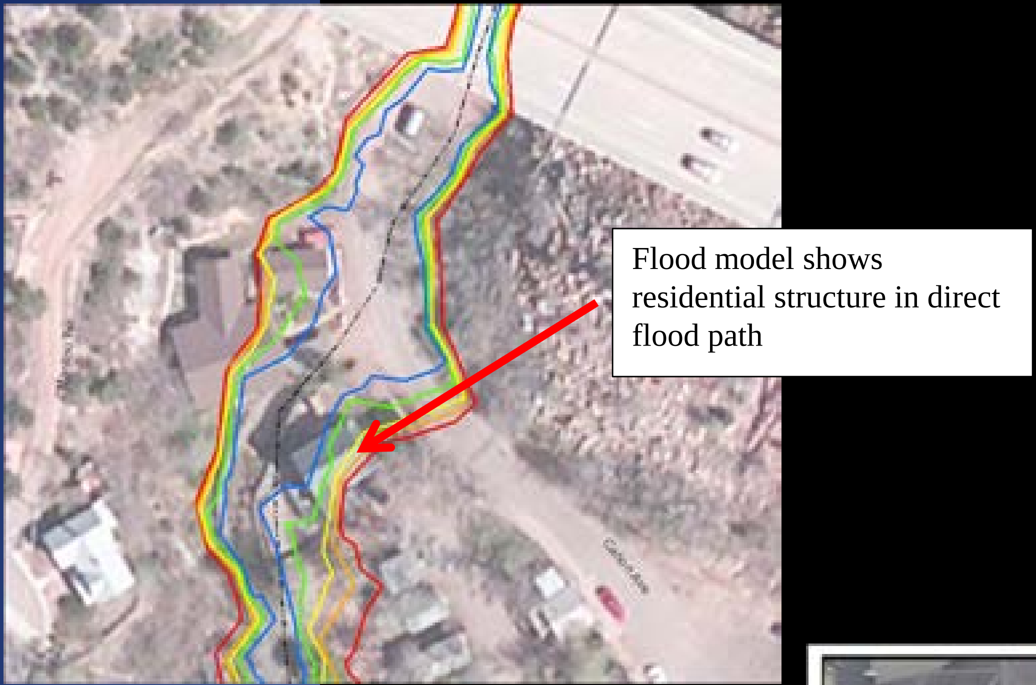
Bob Jarrett Documentation

- Without the 2012 wildfire, there would have been minimal runoff from forested areas for these rainstorms.
- Rainfall to produce runoff 0.25 in/hour.
- Average basin slopes about 50% in Williams and Waldo Canyons. Substantial steeper than other burned basins in the Colorado Front Range.

Bob Jarrett Documentation

- Sections of smaller streams had "wall-of-water flooding."
- Sediment basins substantially reduced upper Waldo flood sediments on Aug 9th.
- Deposition of flood sediments in lower Williams Canyon Creek during the August 9th flood substantially reduced peak discharge from 2,600 to 1,500 cfs.

Williams Canyon



Although mud covered the patio at Adams Mountain Cafe in Manitou Springs, the inside of the restaurant was fine. Daniel Chacon, The Gazette

Lessons Learned

- Wildfire threat is not going away
- Communities downstream must be prepared to deal with flooding immediately following fire
- Burn scars may be Colorado's biggest flood threat for the foreseeable future
- Do not ignore flash flood warnings
- Do not drive in flood waters
- Money may be available for flood mitigation and watershed restoration

The Myth of the Multi-Tasking Engineer

What's Burning Out our Best and Brightest?

September 12, 2013

Jeff Sickles, PE, CFM

Enginuity

ENGINEERING SOLUTIONS

Talent on Demand

A break from the technical…

…to something a little more zen

Are you burned out?

- Long hours?
- Lack of clear career path?
- Too many responsibilities, not enough time?
- Lack of focus on tasks?
- Feeling of too much work for too little pay?
- Corporate problems are your problems?

Is this what you expected?

Do you like what you do?

For many, the answer is YES!

- We get to solve problems…
- We get to see our solutions constructed…
- What we do benefits the community…

Engineering isn't the PROBLEM

This is about ~~my~~ OUR JOURNEY

A short personal journey

The responsibility ladder

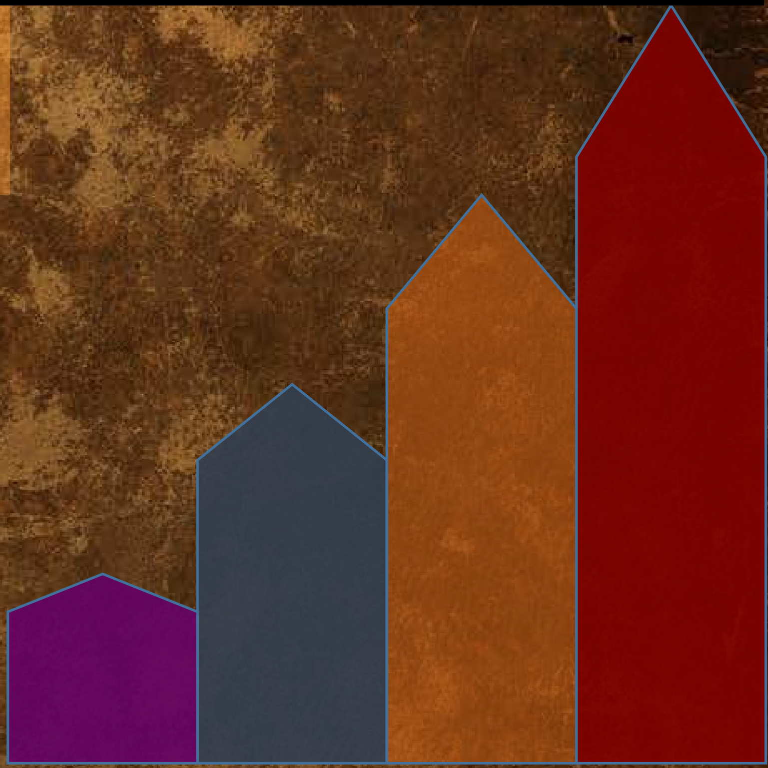
Business Operations

Business Development

Project Manager

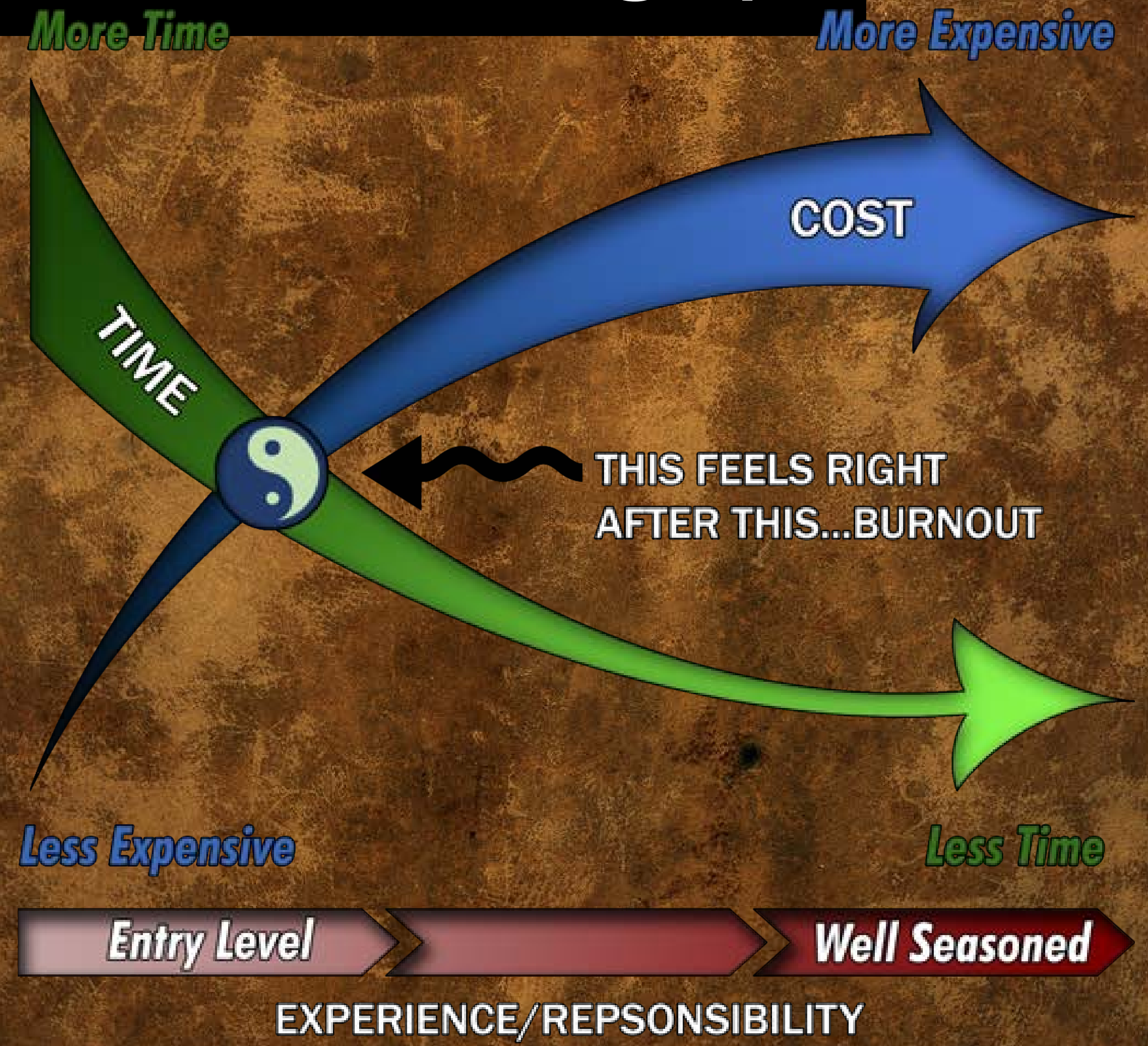
Project Engineer

Graduation



We’re Engineers...

EXPERIENCE VERSUS COST



Can we better define the PROBLEM

Consulting has gone from a wave...

...to a growth curve

Eliminate the wave and you have...

- High chargeability = full-time technical work
- Constant need to be marketing for the next job
- No down time to learn and innovate
- Constant and meticulous management and oversight

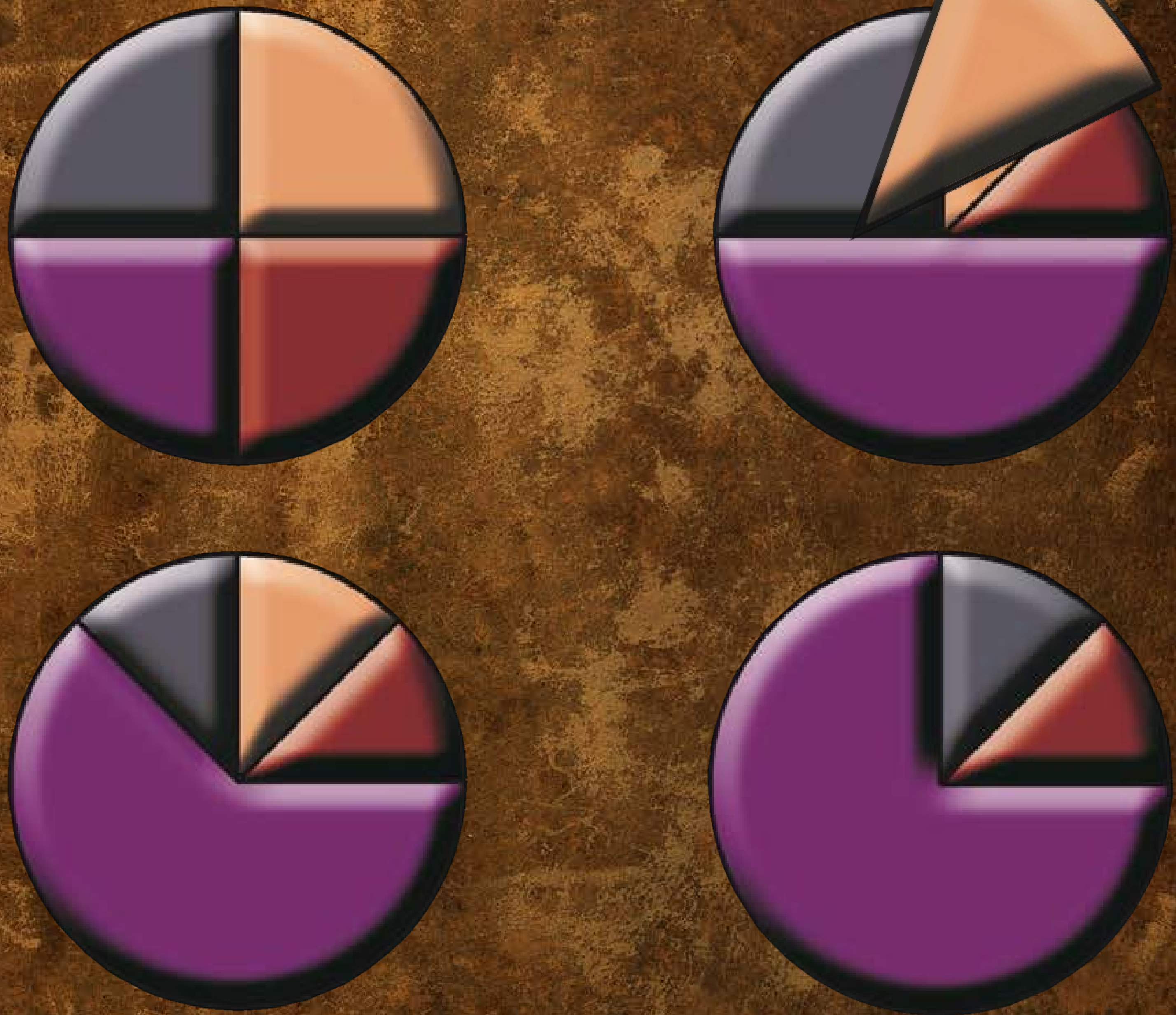
4 distinct jobs...

- Technical Project Engineer
- Project Manager
- Business Development
- Business Operations Manager

4 distinct jobs…

One person

How do you manage your time?



The words most responsible for burnout

SELLER-DOER

It takes time

- To get into the detail and design something correctly
- To understand a model and get the details right
- To meet with clients and pre-wire a project
- To write a proposal
- To understand the numbers

The bottom line = time deficit

So the question is..

Is mediocrity acceptable?

Of Course Not! Something has to change.

There is a SOLUTION

But it involves

RISK and SACRIFICE

It's about

SUSTAINABILITY

What does sustainability look like?

Project Engineering

Leading to

Practicing Technical Professional (PTP)

What does sustainability look like?

Project Engineering

Leading to

Project Management Professional (PMP)

What does sustainability look like?

Full-time

Business Development and Sales

What does sustainability look like?

Business Management Led

Operations Management

Match talent with position

- Do they love technical work? Developing solutions? Wowing clients? Let them!!!
- Do they enjoy organizing tasks, communicating with clients, mentoring staff? Let them!!!
- Do they love business, managing teams, promoting the corporate message? Let them!!!
- Do they have a hunger to win, always have ideas for how to solve problems, want and are willing to meet with clients? Let them!!!

Let them do what they love!!!

The goals…

Increased chargeability

Elimination of “free time”, i.e. let’s get rid of the seller-doer model

More satisfied staff who are doing what they love

Increase chargeability

But….

It can’t work!

It’s not how we do things!

We can’t afford to do it!

Change is the only constant

Your homework assignment

Get out your spreadsheet

Decide what is sustainable

Get creative with compensation

- Brains by the pound is what we sell. Isn't that our most valuable commodity?
- Sales. Base rate plus commission.
- Operations: Look at hiring MBA's and not wasting engineering talent on operations management

Increase chargeability

SUCCESSion training

- Self taught = long, slow, painful process
- Manage your talent to create focus and long-term strategy

Don’t let the pigeons die in their hole

Thank you!

More at:

Blog - www.jeffreysickles.com

Twitter - @jeffreywsickles

Questions

South Platte River Hydraulic Model

Jason Messamer (Olsson Associates)
Shea Thomas (UDFCD)
Bill DeGroot (UDFCD)

The Problem

- Different studies at different times
- Different models (HEC-2, HEC-RAS)
- LOMRs only change reaches of the model

1977 FHAD

1985 FHAD

2005 FHAD

No model available

Ten LOMRs since 2002

Current SPR Projects

- Johnson Habitat
- Grant Frontier project
- CDOT at Alameda, Santa Fe
- Confluence Park Improvements
- 6th Avenue Bridge Replacement
- Weir Gulch Outfall
- Oxford to Union
- South Platte Park – Phase 2 & 3

Why One Model?

- Proposed construction projects
- CLOMR/LOMR preparation
- Different software used for models
- Coordination between projects
- Reduce duplication of efforts
- Numerous effective models

1979 - USACE Original Model

~~1985 - Sand Creek to Oxford MDP~~

~~1998 - USACE Channel Analysis~~

~~2005 - Adams County FHAD~~

~~2009 - Riverpoint LOMR~~

~~2009 - Globeville LOMR~~

~~2009 - Miller Dam LOMR~~

~~2010 - New Pedestrian Bridges LOMRs~~

~~2011 - South Prince to [illegible]C Model~~

~~2011 - Xcel Cherokee LOMR~~

2012 - Speer to Zuni LOMR

2013 - SPR MODEL

"A consultant is someone who saves his client almost enough to pay his fee."

– *Arnold H Glasgow*

Initial Project Steps

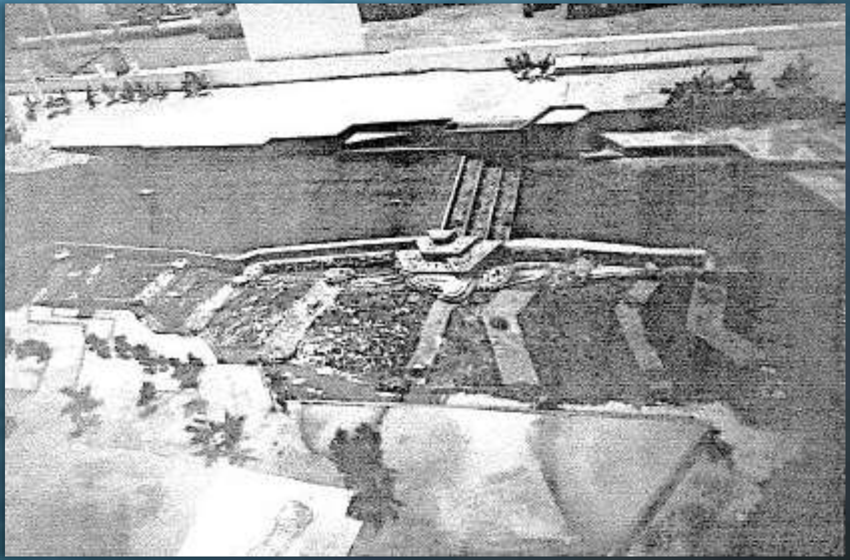
- Gather available models
- Update and combine models
- Run combined model and check results
- Evaluate WSEL changes
- Continue?

"Ambitious."

– David Mallory

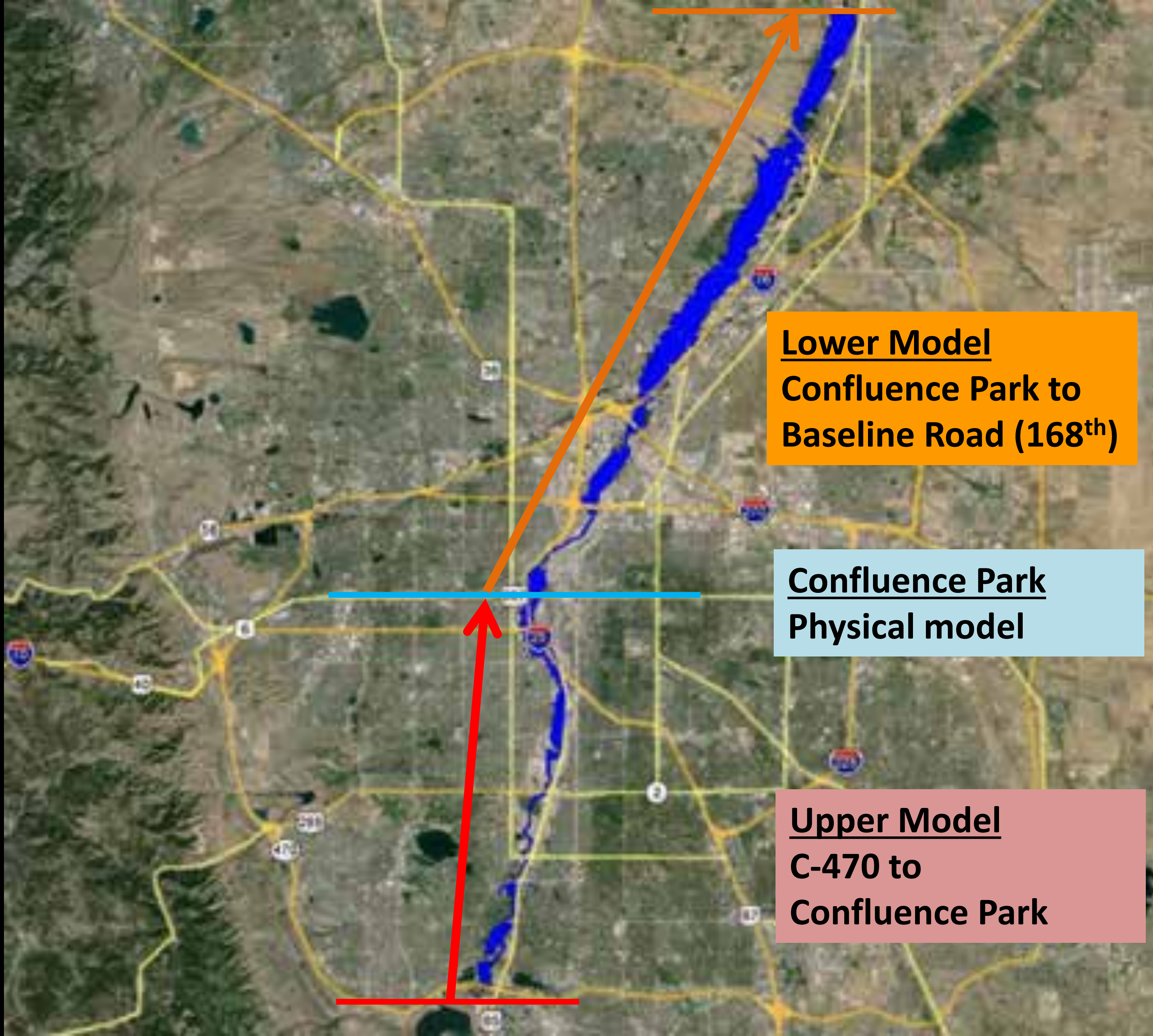
The Model

- Total stream length: 39 miles
- 12 models obtained ***not*** counting:
  - Multiple HEC-2 files
  - Multiple geometry files
  - CLOMRs in the works
  - Areas Olsson is updating
  - Physical model at Confluence Park (1991)



“The secret of all victory lies in the organization of the non-obvious.”

– Marcus Aurelius


Lower Model
Confluence Park to
Baseline Road (168th)
Confluence Park
Physical model
Upper Model
C-470 to
Confluence Park

Upper Model Skittles Chart

Lower Model Skittles Chart

South Platte River Hydraulic Model

OLSSON

Initial Run

- Good results when HEC-RAS models combined
  - 80% of total project working as intended
  - 20% needs to be updated:
    - Some survey required
    - Add missing structures
    - Update topography

- Major updates needed to fix “Bad FHAD”

"Those who fail to learn from history are doomed to repeat it."

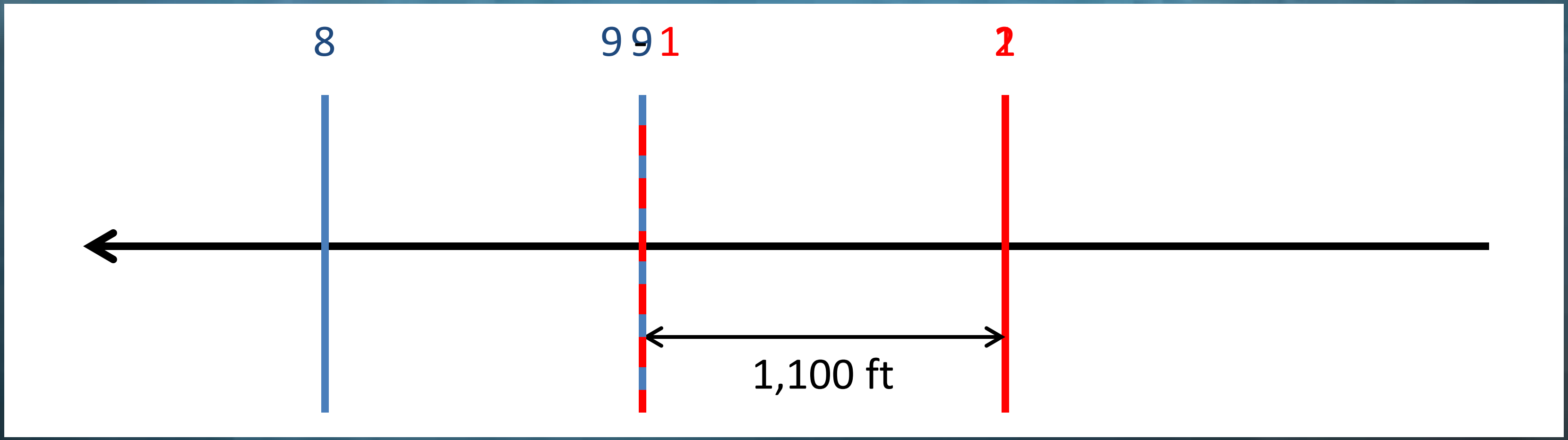
– *Winston Churchill*

Bad FHAD

- ***Disclaimer: best methods available at the time***
- South Platte River Sand Creek to Oxford Ave (1985)
- HEC-2 problems
  – Hard to use
  – Limit size for run time
  – Links between multiple models
  – Trapezoidal approximation for bridges
  – Skewed crossings and special bridges
- Longest study available, most LOMRs tie into it

Linked HEC-2 Models

- Era of punch cards and mainframe computers
- No redundant cross-section used



- 3.5-ft rise in WSE

HEC-2 Bridges

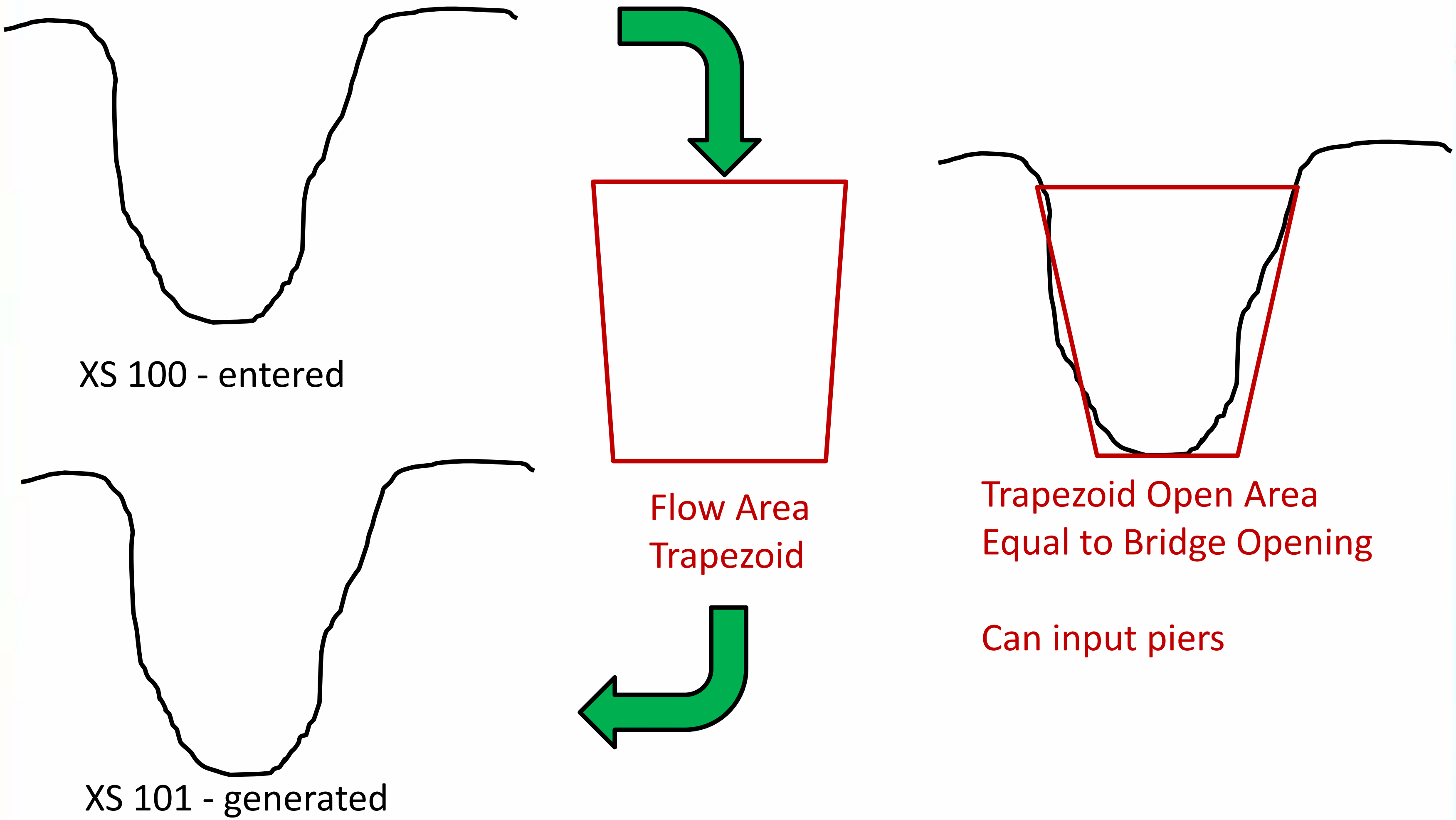
```
X1   1190        42     1795     2184     1050      950      960
X3     10
GR5227.01000.0 05225.2  1103.0 05224.1  1114.0 05224.5  1121.0 05225.8  1127.0
GR5225.41141.0 05224.9  1147.0 05224.8  1179.0 05250.7  1182.0 05250.7  1349.0
GR5226.51358.0 05224.3  1398.0 05224.9  1423.0 05224.5  1450.0 05224.9  1454.0
GR5226.31474.0 05225.8  1491.0 05225.3  1517.0 05226.4  1545.0 05227.3  1676.0
GR5227.81701.0 05227.9  1719.0 05228.9  1737.0 05229.1  1749.0 05235.2  1761.0
GR5231.81771.0 05231.6  1795.0 05228.1  1829.0 05224.2  1856.0 05224.2  1864.0
GR5218.51902.0 05212.3  1927.0 05212.3  2057.0 05213.2  2062.0 05225.7  2099.0
GR5225.92112.0 05234.2  2147.0 05233.8  2157.0 05231.4  2184.0 05231.1  2193.0
GR5230.62196.0 05238.7  2220.0
NC   .048      .045      .03       .1       .5
X1  1200.        45     2818     3237     7350     1250     1300      .75
X3     10                                                        5232.4  5232.4
GR5240.11000.0 05237.9  1056.0 05228.5  1093.0 05228.5  1183.0 05227.2  1192.0
GR5227.21199.0 05228.7  1209.0 05228.8  1215.0 05227.9  1223.0 05227.2  1246.0
GR5255.81265.0 05255.8  1516.0 05227.5  1520.0 05226.5  1525.0 05227.1  1550.0
GR5226.41576.0 05226.9  1586.0 05227.1  1611.0 05231.8  1692.0 05262.8  1697.0
GR5262.81840.0 05230.3  1862.0 05229.6  1890.0 05229.4  1938.0 05229.6  2077.0
GR5268.62090.0 05268.6  2220.0 05227.8  2234.0 05225.7  2297.0 05225.6  2319.0
GR5225.12348.0 05225.4  2361.0 05227.3  2382.0 05227.9  2426.0 05227.3  2464.0
GR5224.22507.0 05227.1  2705.0 05236.1  2761.0 05235.4  2782.0 05233.0  2818.0
GR5213.92868.0 05213.9  3082.0 05219.5  3109.0 05230.6  3115.0 05232.6  3237.0
SB     1.      1.65      2.6        0      380        4     4800        0  5213.9  5213.9
X1  1201.         0        0        0       50       50       50      .75
X2                         1   5230.7   5232.4
X3     10                                                        5232.4  5232.4
BT      7         0   5233.7                130   5236.1              240  5233.5
BT    340    5235.3               450    5234.6                550   5234.1              660
BT5233.9
NC   .048      .045      .03       .1       .3
X1   1210        50     2869     3038      500      90.      260
X3     10
GR5239.91000.0 05237.1  1067.0 05229.3  1120.0 05229.5  1177.0 05228.1  1183.0
GR5228.11192.0 05229.3  1201.0 05229.3  1209.0 05228.7  1212.0 05228.9  1228.0
GR5227.21245.0 05255.9  1262.0 05255.9  1494.0 05230.3  1502.0 05230.0  1509.0
GR5227.01520.0 05227.3  1547.0 05226.7  1576.0 05227.0  1581.0 05267.7  1592.0
GR5267.71715.0 05229.4  1736.0 05229.8  1762.0 05229.4  1792.0 05232.0  1896.0
GR5265.41906.0 05265.4  2219.0 05227.7  2231.0 05226.2  2299.0 05226.0  2353.0
GR5228.72392.0 05229.3  2407.0 05226.8  2445.0 05226.3  2467.0 05225.1  2501.0
GR5227.62508.0 05227.6  2522.0 05225.2  2529.0 05228.6  2760.0 05235.0  2814.0
GR5234.52821.0 05232.0  2869.0 05222.4  2883.0 05222.4  2890.0 05213.9  2912.0
GR5213.93010.0 05230.0  3029.0 05232.2  3038.0 05233.2  3059.0 05232.6  3089.0
X1   1220        57     2876     3107      130      220      220
X3     10
GR5249.71000.0 05237.3  1026.0 05232.6  1079.0 05228.7  1100.0 05228.7  1103.0
GR5230.21112.0 05230.2  1120.0 05229.1  1126.0 05228.8  1136.0 05227.9  1144.0
```

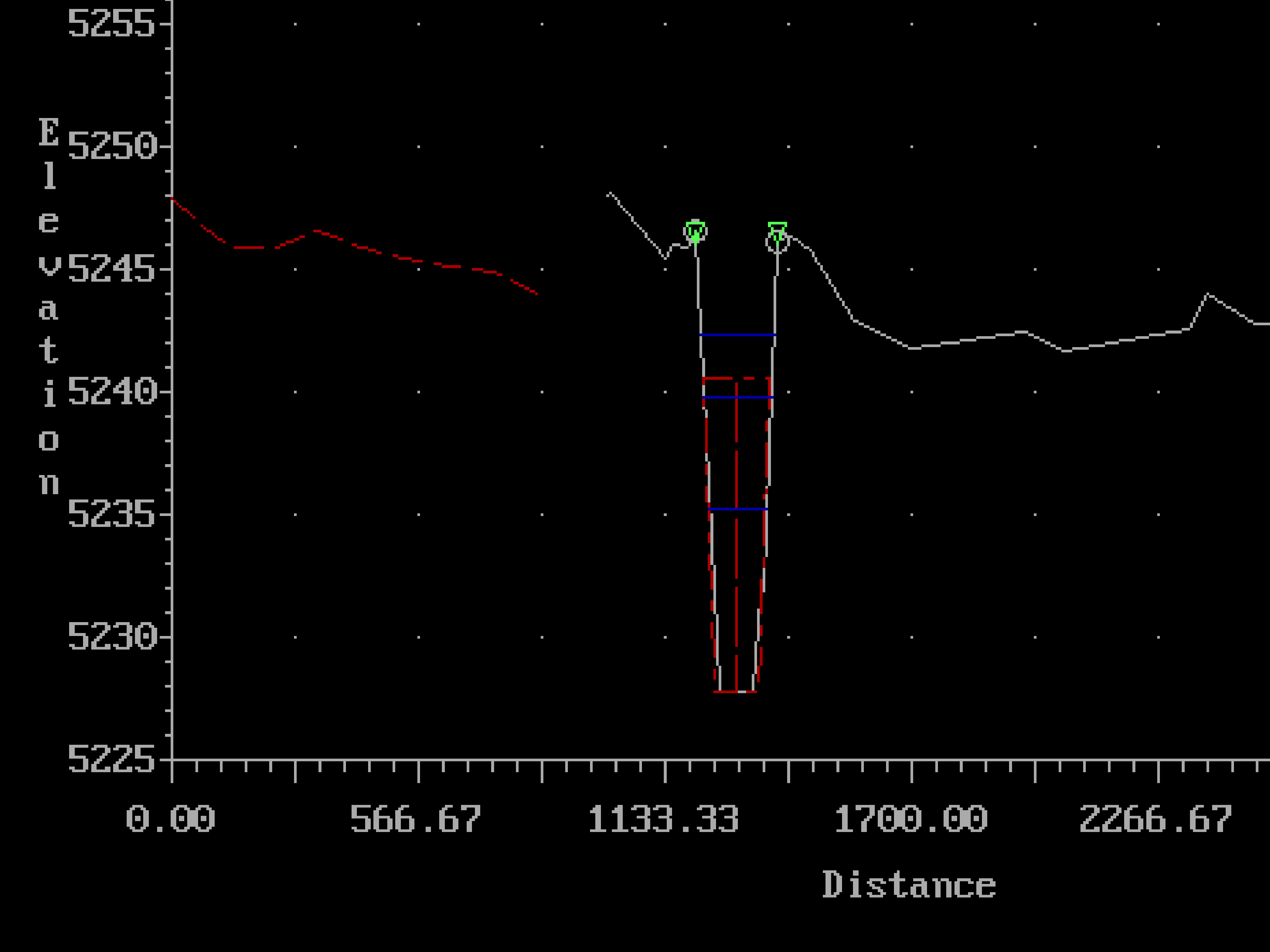
Skew coefficient

Special Bridge

Bridge input and a linked cross section upstream

Trapezoidal Approximation




Elevation
5255
5250
5245
5240
5235
5230
5225
0.00
566.67
1133.33
1700.00
2266.67
Distance

Skewed Bridges

5.6 Bridges on a Skew

Skewed bridge crossings are generally handled by making adjustments to the bridge dimensions to define an equivalent cross section perpendicular to the flow lines. The adjustments can be made in the normal bridge method by multiplying the actual dimensions of the bridge by the cosine of the skew angle. The cosine of the angle is coded on the X1 record (variable PXSECR in Field 8) for the cross section coordinates on GR records and on the X2 record (variable BSQ in Field 9) for the data on the BT records. If the special bridge method is used, the data coded on the SB record must be adjusted prior to input. There is no internal method in the program to adjust the data on the SB record.

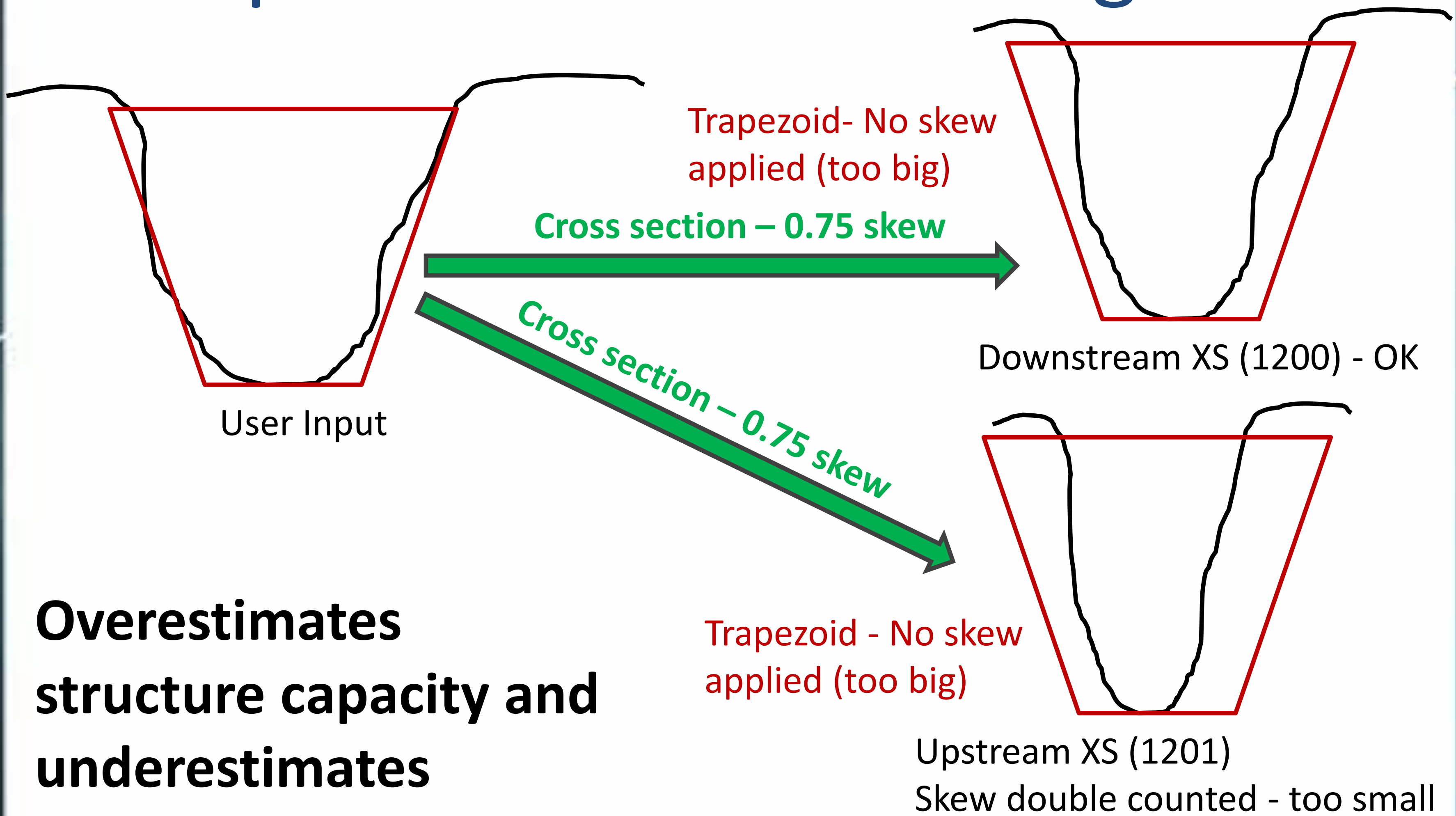
- Can’t have skew for special bridges!

- HEC-2 manual online published 6 years after FHAD published

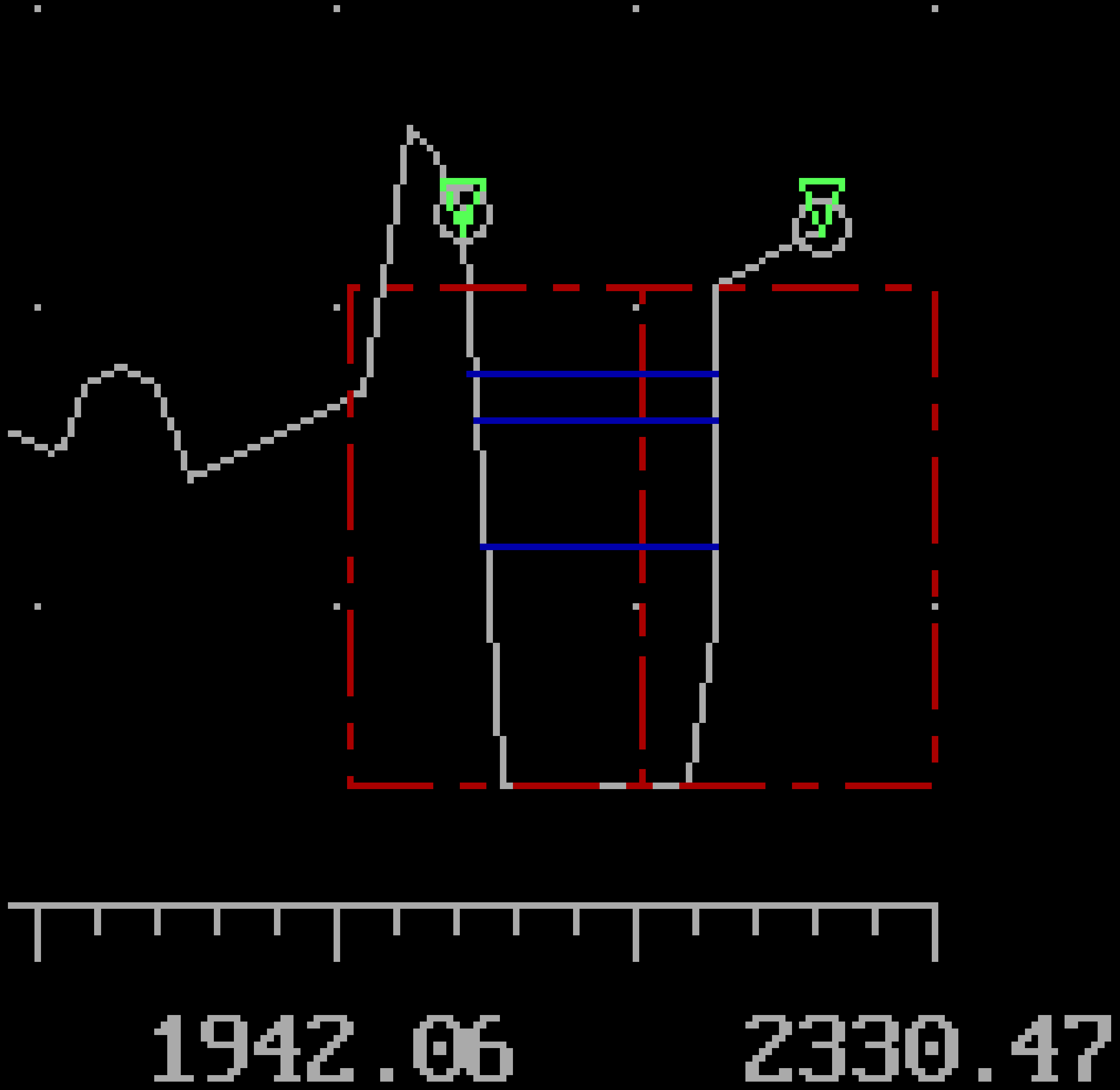
Example – Santa Fe Crossing

South Platte River Hydraulic Model

Example – Santa Fe Crossing



Overestimates structure capacity and underestimates conveyance upstream


1942.06
2330.47

Nearby LOMRs

- LOMR for two bridges
  - Dartmouth pedestrian bridge ties into FHAD
  - Oxford pedestrian bridge ties into Riverpoint LOMR
- Backwater from Dartmouth bridge not considered
  - 0.3 ft higher at Riverpoint LOMR start
  - 0.1 ft higher at US bridge

Riverpoint LOMR
Sheridan

Project Status

- Lower Model mostly done
- Upper Model: on hold
  - Will incorporate ongoing CLOMRs
  - Need some survey
  - Need to update topography in select locations

Takeaways...

- Expect to see combined models for the South Platte River
- Have you done work we missed on the South Platte River?
- Be careful converting from HEC-2, especially if there is a skew and/or bridge
- Watch for adjacent LOMRs

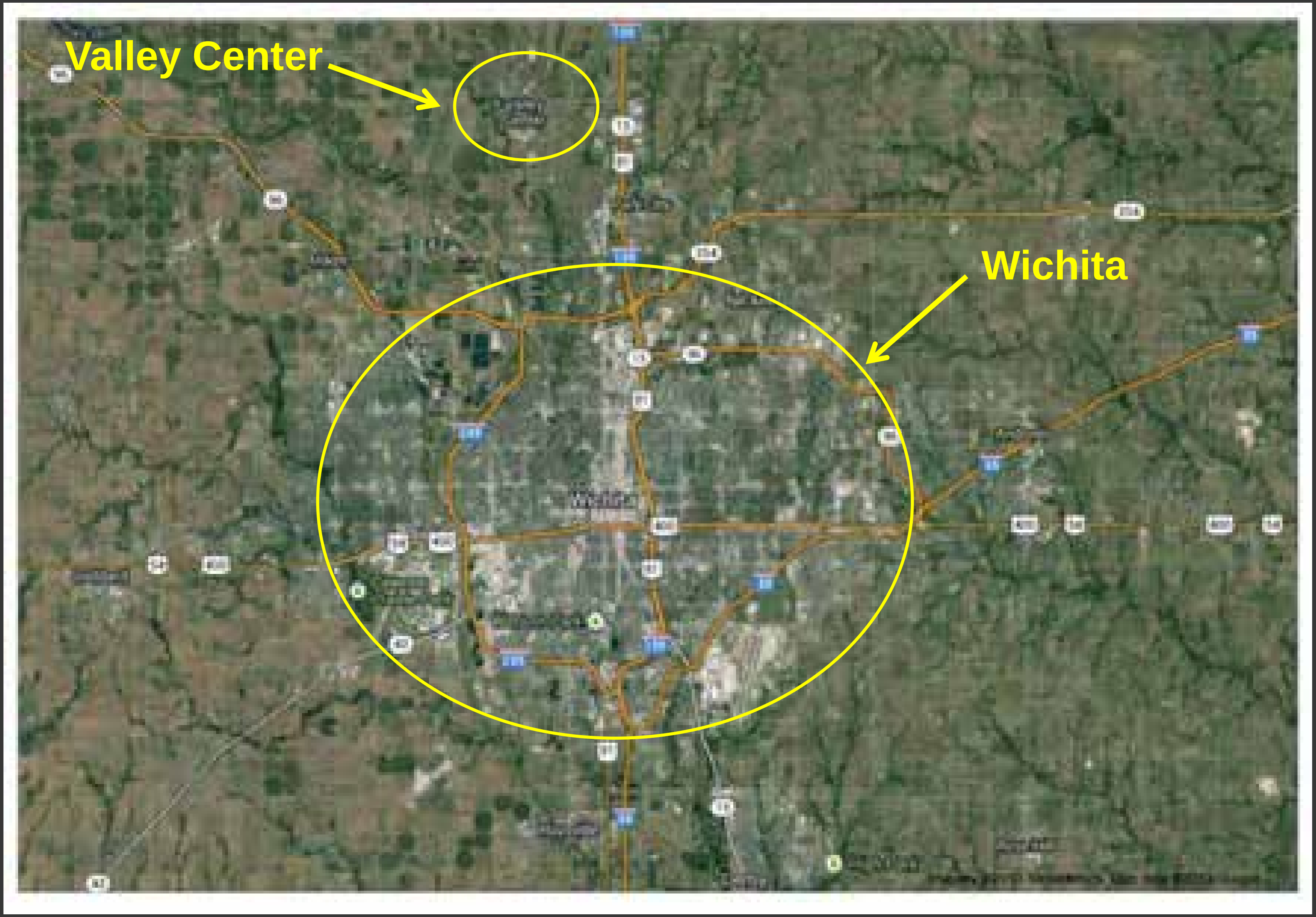
"The only person who likes change is a wet baby."

– Mark Twain

- Questions?

THE ROLE OF THE FLOOD INSURANCE RATE MAP IN A KANSAS FLOODING LAWSUIT

Eliot Wong, CFM
Jonathan Jones, P.E., D.WRE
Wright Water Engineers, Inc.
Denver, Colorado


Valley Center
Wichita

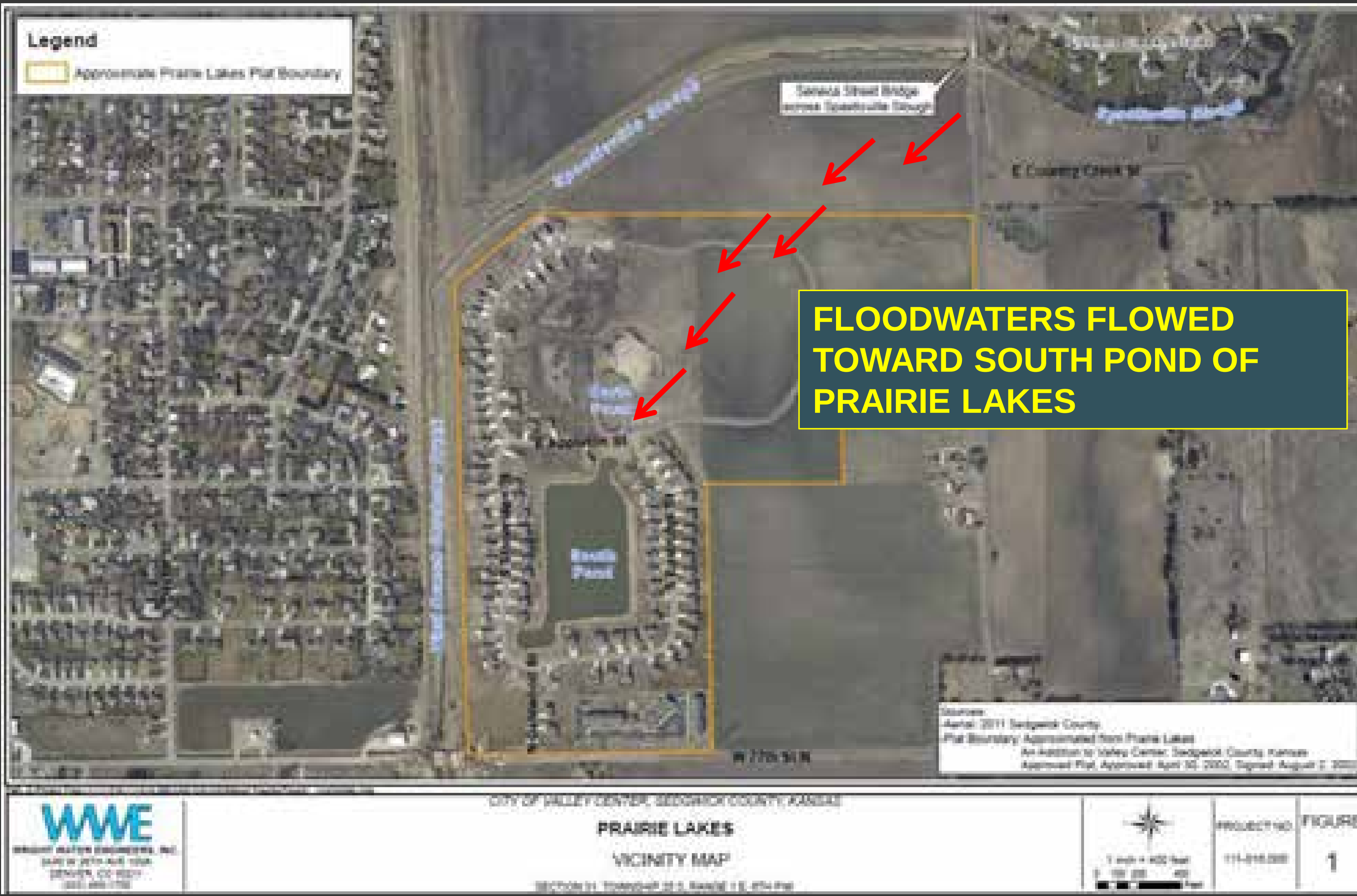
IN SEPTEMBER 2008
A RARE & EXTREME RAIN EVENT OCCURRED

- **10.8 INCHES OF RAIN RECORDED IN 24 HOURS - USGS**
- **9.4 INCHES IN 24 HOURS IS A 500-YEAR EVENT – VALLEY CENTER DESIGN MANUAL**

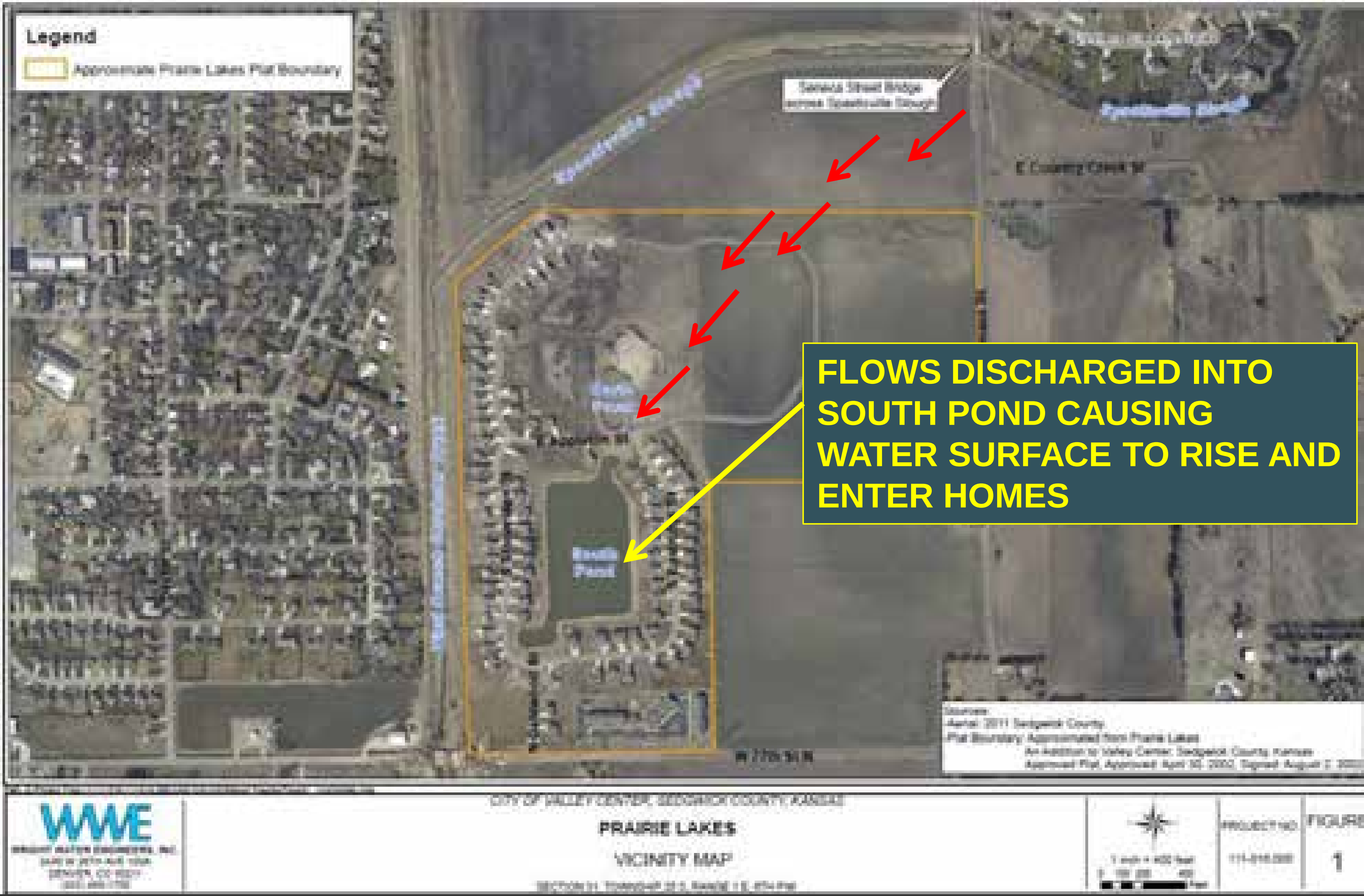
EIGHT HOMES FLOOD…

Legend
Approximate Prairie Lakes Plat Boundary
PRAIRIE LAKES ADDITION
CITY OF VALLEY CENTER,
KANSAS
CITY OF VALLEY CENTER, SEDGWICK COUNTY, KANSAS
PRAIRIE LAKES
VICINITY MAP
FIGURE
1

Legend
Approximate Prairie Lakes Plat Boundary
Seneca Street Bridge
FLOODWATERS ESCAPED BANKS UPSTREAM OF SENECA STREET BRIDGE
PRAIRIE LAKES
VICINITY MAP
FIGURE
1



FLOODWATERS FLOWED TOWARD SOUTH POND OF PRAIRIE LAKES
Legend
Approximate Prairie Lakes Plat Boundary
South Pond
CITY OF VALLEY CENTER, SEDGWICK COUNTY, KANSAS
PRAIRIE LAKES
VICINITY MAP
WWE
FIGURE
1


Legend
Approximate Prairie Lakes Plat Boundary
FLOWS DISCHARGED INTO SOUTH POND CAUSING WATER SURFACE TO RISE AND ENTER HOMES
South Pond
W 77th St N
WWE
CITY OF VALLEY CENTER, SEDGWICK COUNTY, KANSAS
PRAIRIE LAKES
VICINITY MAP
FIGURE
1

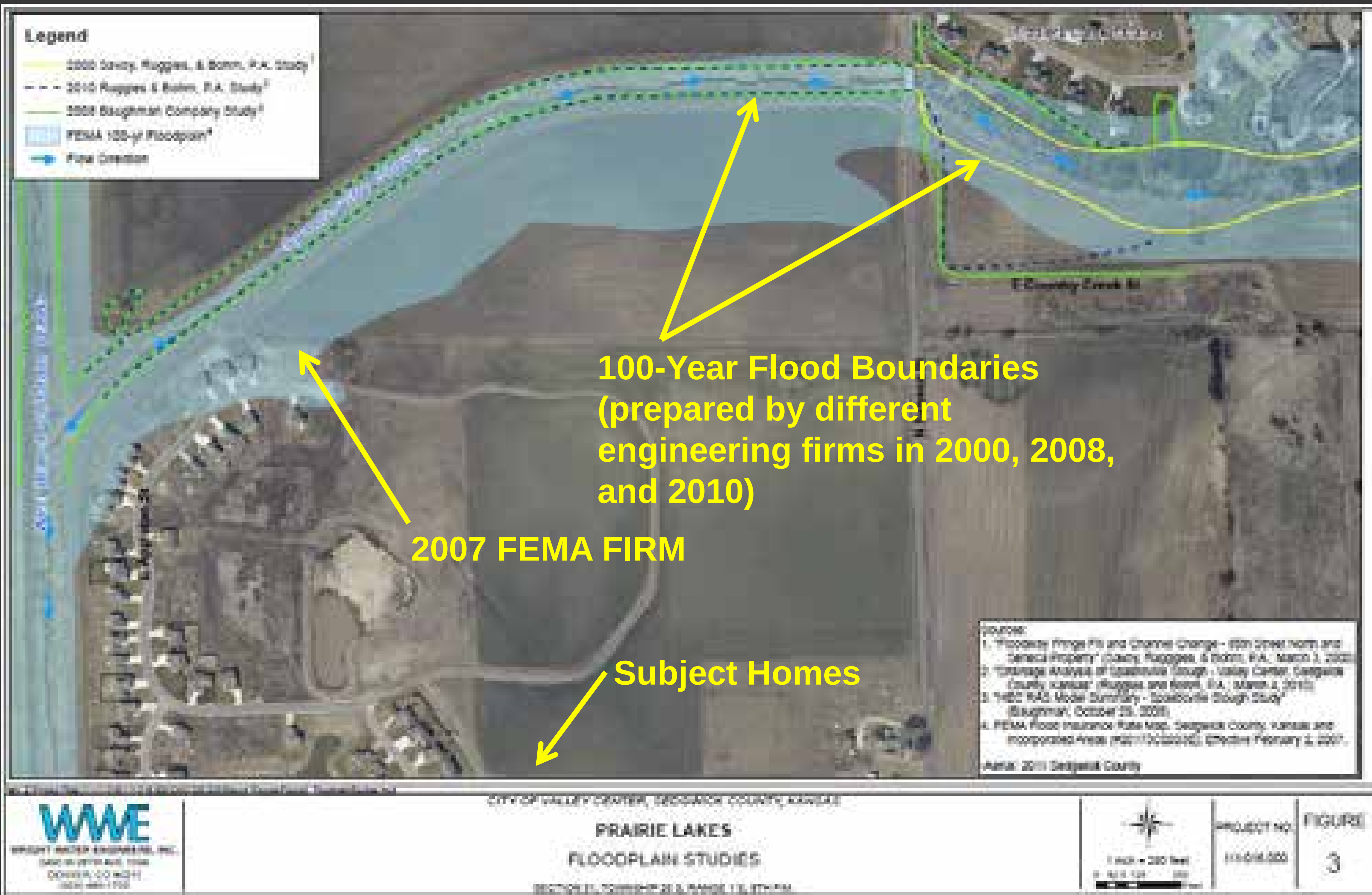
RESIDENTS SUE DEVELOPER ALLEGING…

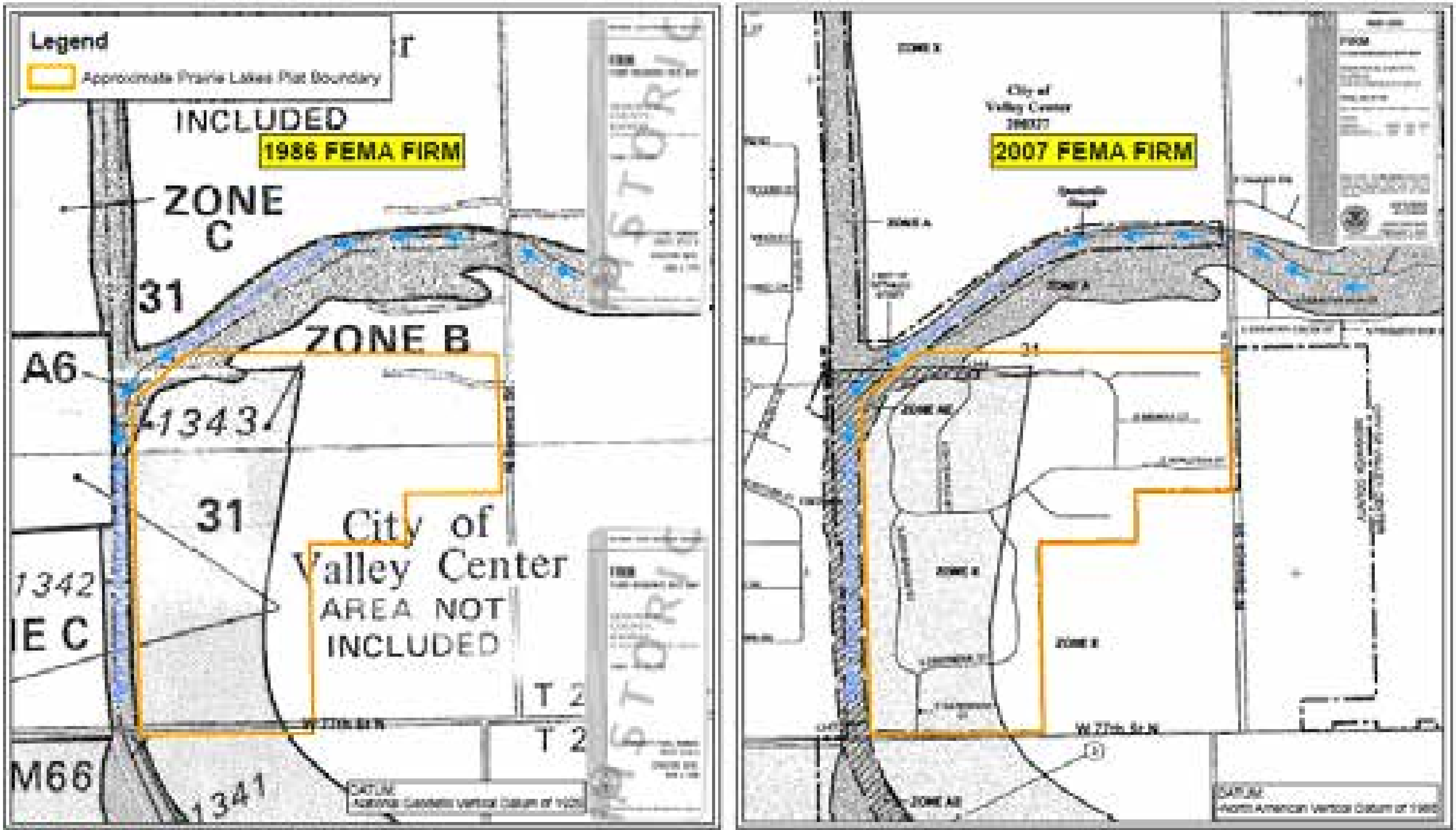
- Developer should have known area was susceptible to flooding and should not have developed
- Development was constructed in high flood hazard area (in the 100-year floodplain)
- Homes flooded due to poor design

APPROACH TO ENGINEERING INVESTIGATION

- Field inspections
- Interviews
- Design & Construction Drawing Review
- Hydraulic Model Review
- Engineering Analysis and Related to Flood Flows and Channel Hydraulics
- FEMA Regulations Review
- Review of Relevant FIRMs and Floodplain Studies
- Miscellaneous Research

1986 FEMA FIRM
Legend
Flow Direction
FEMA 100-yr Floodplain Zone A
FEMA 100-yr to 500-yr Floodplain Zone B
FEMA 100-yr Floodplain Zone AE
Zone A
Zone B
E Appleton St
Sources:
Aerial: 2011 Sedgwick County
PRAIRIE LAKES
1986 FEMA FLOODPLAIN MAPPING
FIGURE
2


Legend
100-Year Flood Boundaries (prepared by different engineering firms in 2000, 2008, and 2010)
2007 FEMA FIRM
Subject Homes
CITY OF VALLEY CENTER, SEDGWICK COUNTY, KANSAS
PRAIRIE LAKES
FLOODPLAIN STUDIES
FIGURE
3



CITY OF VALLEY CENTER, SEDGWICK COUNTY, KANSAS

PRAIRIE LAKES

1986 FEMA FIRM & 2007 FEMA FIRM

FIGURE 4


Top of Spasticville Slough banks


Prairie Lakes Development


WWE Findings

- Site characteristics/topography did not indicate any significant errors on the FIRM.
- FIRM shows 100-year floodplain delineation roughly parallel to channel with no overflow toward development.
- Five different 100-year flood maps have been prepared by 4 different entities – 2 reviewed by FEMA. All indicated development is located outside the 100-year flood boundary.
- The development site was and continues to be outside the 100-year floodplain.

WWE Findings

- The City of Valley Center does not regulate development in shaded or unshaded Zone Xs, which is common.
- Developer was not required to obtain floodplain development permits.
- Overflow calculations indicated that Prairie Lakes would not be subject to inflows from the Seneca Street Bridge during the 100-year event.
- Over 10 public and private entities had responsibility of floodplain delineation and regulation relative to the Prairie Lakes development.

FIRMS are important…

(excerpts from national regulatory and management agencies)

FIRMs show the limits of mapped flood hazard areas in a community.

Using a Flood Insurance Rate Map (FIRM): Home Builder's Guide to Coastal Construction, Technical Fact Sheet No. 3 Federal Emergency Management Agency, no date

Why FIRMs are Important

FIRMs are used by communities to regulate new construction (e.g., foundation type, lowest floor elevation, use of enclosed areas below the lowest floor)

Using a Flood Insurance Rate Map (FIRM): Home Builder's Guide to Coastal Construction, Technical Fact Sheet No. 3 Federal Emergency Management Agency, August 2005

Why FIRMs are Important

FIRMs are used by designers and builders to ascertain flood hazards and plan new construction

Using a Flood Insurance Rate Map (FIRM): Home Builder's Guide to Coastal Construction, Technical Fact Sheet No. 3 Federal Emergency Management Agency, August 2005

Why FIRMs are Important

Private citizens and insurance brokers use the FIRM to locate properties and buildings to determine the amount of flood risk and whether flood insurance is required.

Flood Insurance Rate Maps (FIRMs) Federal Emergency Management Agency, http://www.fema.gov/hazard/map/firm.shtm

Why FIRMs are Important

Planners, local officials, engineers and builders can use the maps to make important determinations about where and how to build new structures and developments.

Mapping the Risk: Flood Map Modernization
New Flood Insurance Rate Maps (FIRMs): What Property Owners Should Know
Johnson County, Kansas, planning.jocogov/…/FEMA%20Notice%20brochure%20JoCo.doc

WRIGHT WATER ENGINEERS, INC.

PARK CITY, SEDGWICK COUNTY, KANSAS

RESIDENTIAL DEVELOPMENT PROTECTED BY BERM OR LEVEE

PROJECT NO.

FIGURE 6B

WWE

WICHITA, SEDGWICK COUNTY, KANSAS

RESIDENTIAL DEVELOPMENT PROTECTED BY BERM OR LEVEE

PROJECT NO

FIGURE 6D

WWE

WRIGHT WATER ENGINEERS, INC.

WICHITA, SEDGWICK COUNTY, KANSAS

RESIDENTIAL DEVELOPMENT PROTECTED BY BERM OR LEVEE

SECTION 22, TOWNSHIP 27 S, RANGE 1 E, 6TH PM

1 inch = 600 feet

PROJECT NO.

FIGURE

6E

WWE
WRIGHT WATER ENGINEERS, INC.

HAYSVILLE, SEDGWICK COUNTY, KANSAS

RESIDENTIAL DEVELOPMENT PROTECTED BY BERM OR LEVEE

PROJECT NO

FIGURE 6F

CITY OF DERBY, SEDGWICK COUNTY, KANSAS

WRIGHT WATER ENGINEERS, INC.

PRAIRIE LAKES

SUBDIVISION COMPARISON - STONE CREEK

PROJECT NO

FIGURE 7A

CITY OF DERBY, SEDGWICK COUNTY, KANSAS

PRAIRIE LAKES

SUBDIVISION COMPARISON - SPRING CREEK

1 inch = 400 feet

PROJECT NO.

FIGURE

7C

WWE

CITY OF WICHITA, SEDGWICK COUNTY, KANSAS

PRAIRIE LAKES

SUBDIVISION COMPARISON - BRIARWOOD ESTATES

PROJECT NO

FIGURE

7D

THANK YOU!

QUESTIONS??

Flood Hazard Area Property Values; Stimulating or Depressing the Economy?

Brian Varrella, P.E., CFM
CASFM Chair
Floodplain Administrator
Fort Collins, Colorado
970-416-2217
bvarrella@fcgov.com

City of Fort Collins

Flood Hazard Area
Property Values

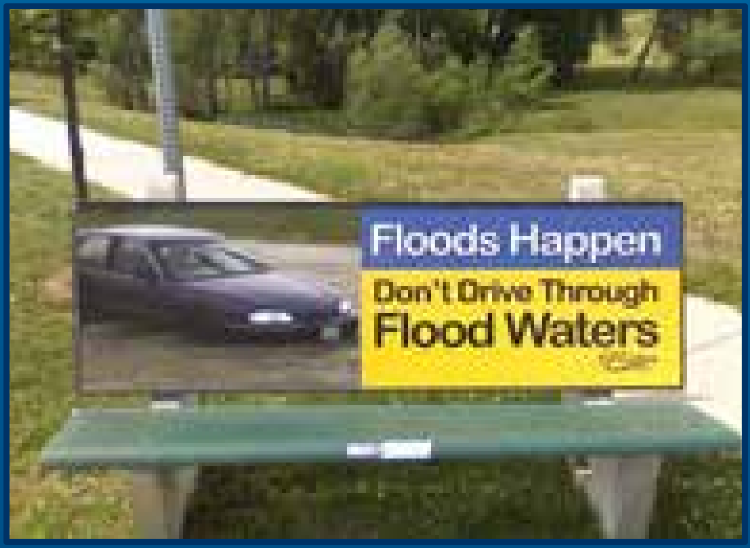
Today's Agenda

1. Start With *Why?*
2. Available Research & Findings
3. Conclusions
4. What Next?

Flood Hazard Area
Property Values

Start With *Why?*:

Why are we having a conversation?



Start With *Why?*

Impetus for Discussion:

City Council in Fort Collins, Colorado began a review of the FC Stormwater program in 2008.

Concern Identified:

A **perception** exists that flood mitigation projects remove flood hazards from private lands with public revenue, thereby removing flood ordinance standards and subsidizing private development.

Start With *Why?*

Staff Action:

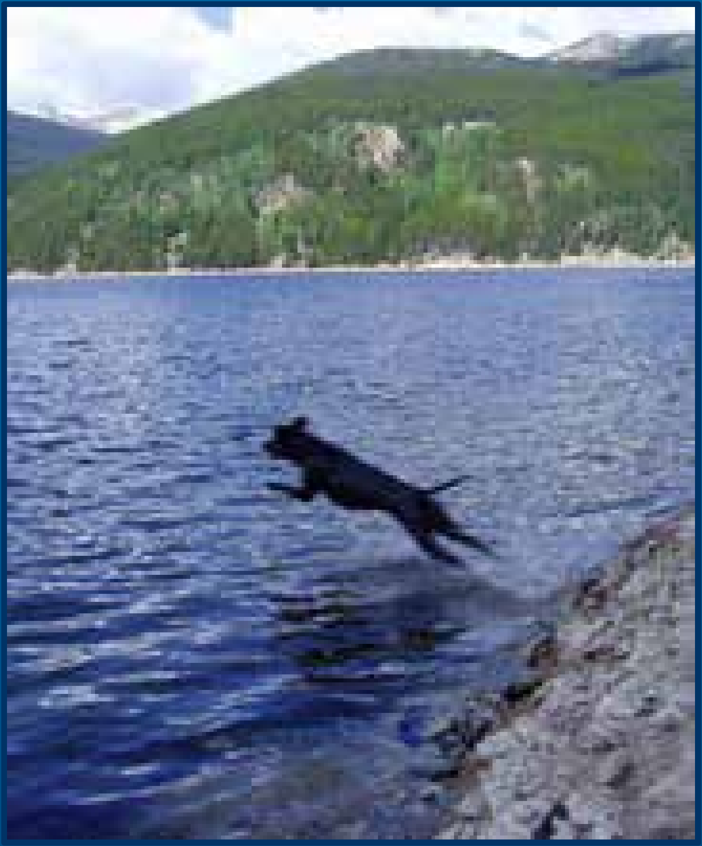
Validate the correlation between flood hazard area delineation and property value with a desktop study.

Desktop Study: *http://www.linkedin.com/in/brianvarrella/*

Flood Hazard Area
Property Values

Available Research And Findings:

Leaping out of my comfort zone



Available Research & Findings

A Forum of Disciplines:

- Get outside my professional circle
- A forum of expertise
  - Certified Appraiser
  - Land Economic Specialist
  - Environmentalist (NBFs)
  - Policy Experts
- Regionally relevant datasets
- Hydrologically similar regions

City of Fort Collins

Available Research & Findings

The Contenders:

1. Chivers and Flores, 2002, *Land Economics*
2. Troy and Romm, 2004, *J. of Environmental Planning and Management*
3. Rosenbaum, 2005, *U. of Florida*
4. Campano, 2004, appraiser, Fort Collins, CO

Started local, moved national

Available Research & Findings

Chivers and Flores, 2002 (1 of 2):

- Success or failure of home purchase info
  - When do people find out about flood risk?
  - How does it affect behavior?
- Boulder, CO – 40 miles from Fort Collins
- Findings
  - Properties in FPs actually tend to have **higher** value
  - Aesthetic appeal of water in arid regions affects price
- **Perception**; water = good

City of Fort Collins

Available Research & Findings

Chivers and Flores, 2002 (2 of 2):

- *When do homebuyers discover mapped flood risk?*
  - 8% = before offer
  - 6% = before closing
  - 60% = at closing
  - 10% = after move-in or a flood
  - 16% = other

$\Sigma = 70\%$

- How do they find out about risk?
  - 58% = Elevation Certificate
  - 30% = MLS
  - 7% = Lender
  - 2% = FIRM … 3% other

City of Fort Collins

Available Research & Findings

Troy and Romm, 2004 (1 of 3):

- Re; Flood Hazard Disclosure Law in California
- Searched for home <u>price</u> + <u>human behavior</u> correlations
- Housing market; So. CA
  - Similar hydrology to CO
  - Similar home value to CO
- Findings
  - Flood risk does not change home prices
  - People don't believe in risk in "*flashy*" watersheds

City of Fort Collins

Available Research & Findings

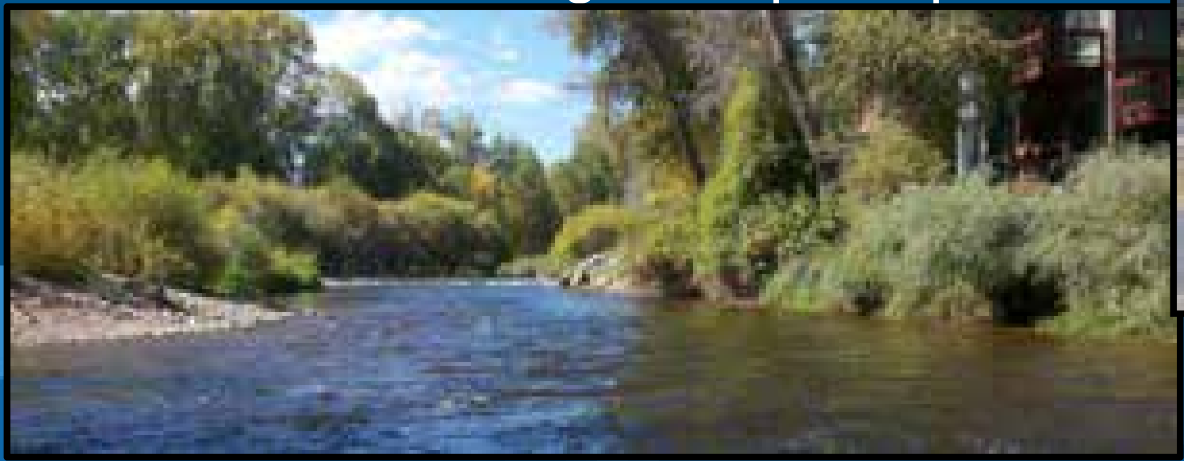
Troy and Romm, 2004 (2 of 3):

- … And why should they believe in risk??
- *http://www.cnt.org/news/2013/05/14/urban-flooding-is-chronic-and-costly-but-not-correlated-with-floodplains/*

Available Research & Findings

Troy and Romm, 2004 (3 of 3):

- *"The West in general has highly seasonal precipitation patterns…that may appear misleadingly dry much of the year*."
- Property value **perceptions** are regionally skewed
  - Midwest / Gulf = FPs depress values
  - Arid West = FPs have affect on value
  - Visual cues change risk perceptions



City of Fort Collins

Available Research & Findings

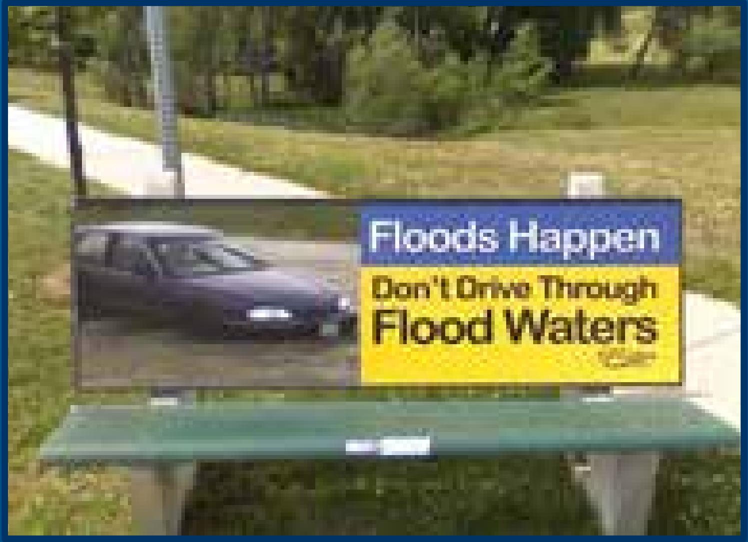
Rosenbaum, 2005 **(1 of 3):**

- Explore environmental impact of NFIP regs
  - Correlated NFIP standards to NBFs
  - Looked at entire nation
- Findings
  - NFIP regulations actually encourage development
  - People ignore high-risk, low-frequency events

Available Research & Findings

Rosenbaum, 2005 (2 of 3):

- "*The literature consistently suggests that many people put their lives and homes in jeopardy because they underestimate the risk to which they are exposed.*"
- NFIP regs have limited impact on property value
  - Public outreach does not change behaviors
  - Learning about risk too late
  - Deal is done… so buyers purchase risky property



Available Research & Findings

Rosenbaum, 2005 (3 of 3):

- Risk is part of our DNA
- Leads to rewards
- Natural hazards are typically **perceived** the same way
  - So we discount them
  - "*Won't happen to me*"

Available Research & Findings

Campano, 2004:

- Professional appraisal
  - Based on comparable properties
  - Specific to Fort Collins, CO

- Findings
  - Agrees with 3 journals
  - "*No price difference is shown for homes located within floodplains.*"
  - Some FP homes actually had **<u>higher</u>** resale values

City of Fort Collins

Flood Hazard Area
Property Values

Conclusions:

What are all these experts collectively telling us?

Available Research & Findings

Primary Conclusion #1:

Mapped flood hazards **do not** depress property value

- **True** in the arid West
  - Water = sparse amenity
  - Perceived beauty has $$$ value
- **False** in the Midwest & Gulf Coast
- People do not believe risk will affect them
  - **Perception**…
  - *"That will happen to someone else on the Weather Channel*"

Available Research & Findings

Primary Conclusion #1:

Mapped flood hazards **do not** depress property value

"*That will happen to someone else on the Weather Channel…*"

http://youtu.be/mv-ozz1Uyzg

Available Research & Findings

Primary Conclusion #2:

Flood mitigation projects are not subsidizing private development with public funds

- Flood management projects provide benefits
  - Public health, safety, welfare
  - Economic vitality of community
  - Similar benefits to other Public Works Projects
- In Colorado, flood projects may <u>reduce</u> prop. value
  - Moving or removing an aesthetic benefit
  - Changing habitat and environmental assets
  - Offsets up-front cost of NFIP compliant construction

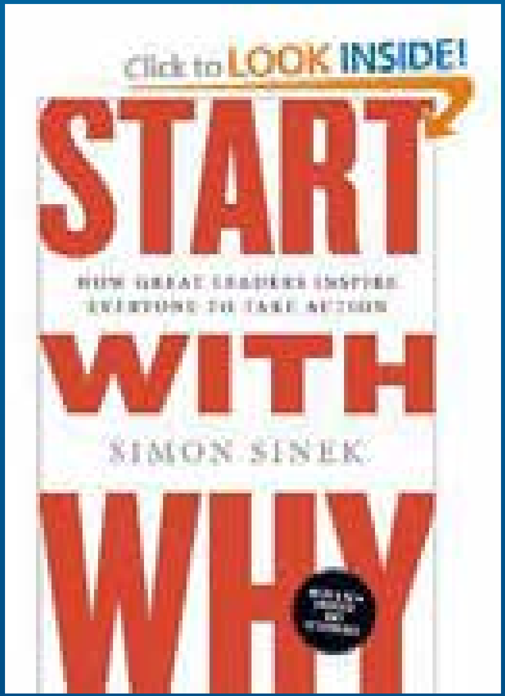
City of Fort Collins

Available Research & Findings

Primary Conclusion #3:

We have a problem of perception

- Behavioral response to risk is a human problem
- Understanding is not fact-based
- Facts are materially irrelevant
  - "Start with Why,"
    - Simon Sinek, 2009
    - ISBN 978-1-59184-280-4
- Decisions made in our "gut"
  - Tough decisions; not logical
  - Must appeal to something else



Flood Hazard Area
Property Values

What Next:

Applied learning recommendations

What Next

Recommendation #1:

FP Managers; we must change our perception of risk – accept it as *natural*

- Our brains like it
- Part of our DNA
- *http://youtu.be/UB3oEHzakOw*

What Next

Recommendation #2:

FP Managers; we must defy logic to change **perception**

- Look for human patterns instead
- Target the decision-making core, not the brain
  - Start with *Why?*

What Next

Recommendation #3:

FP Managers; we must make new friends

- Get outside our own professional group
- Need a dialogue with other professionals
  - Social scientists
  - Psychologists
  - Economists
  - Realtors
- This topic needs further research, **by region**

What Next

Recommendation #4:

FP Managers; we must be persistent

- Lessons from the past will be re-learned
- We survive by forgetting tragic events
- Sometimes people “get it”
  - Then we all forget it
  - Eastern Iowa – 1993, 2008, 2013, & ***20XX***

City of Fort Collins

What Next

Recommendation #5:

FP Managers; we must shift our understanding of *people*

- We can and will forget our history
- Survival requires us to forget trauma

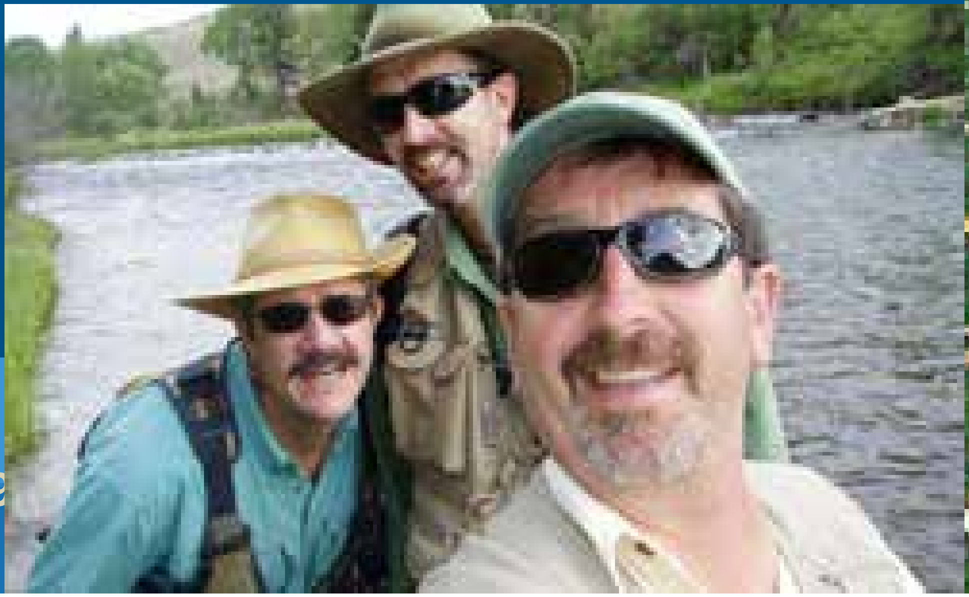
Collins

What Next

Final Thoughts (editorial):

Allstate – "*good life*" ad campaign for risk

- *"All the bad things that can happen in life, they can't stop us from making our lives … good.*"
- *http://youtu.be/kI1bKm22Up0*



What Next

Final Thoughts (editorial):

Let's apply knowledge to manage our **perception** of risk

- *"We love your brain!"*
- *"Risk can be beneficial"*
- *"Let's talk mitigation"*
- *"Let's talk insurance"*
- *"Let's have some fun with this discussion"*
- **MORE RESEARCH**

"All the bad things that can happen in life, they can't stop us from making our lives … good."

City of Fort Collins

Flood Hazard Area Property Values

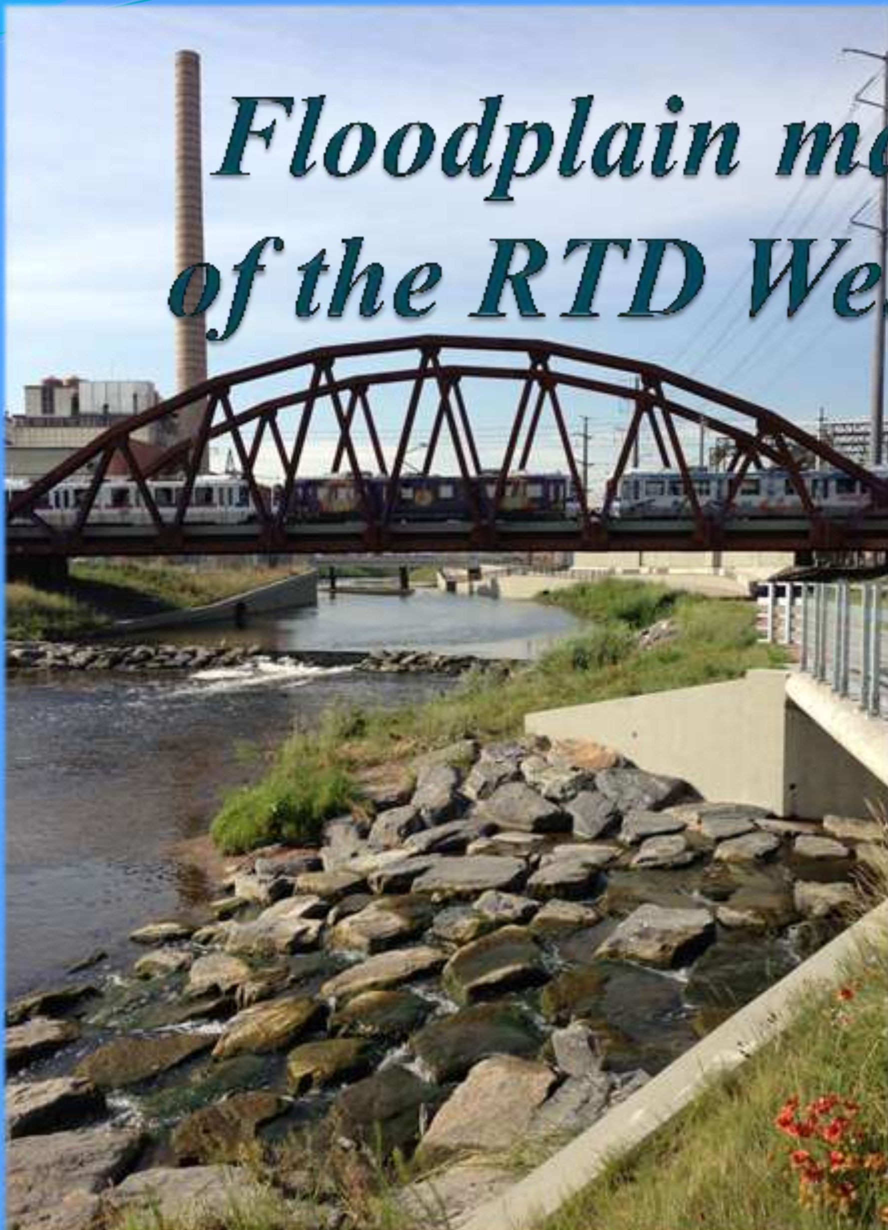
Thanks for Listening

Questions?

Brian Varrella, P.E., CFM
bvarrella@fcgov.com
http://www.linkedin.com/in/brianvarrella/

City of Fort Collins

Floodplain management aspects of the RTD West Corridor project



Presented by:
Bill DeGroot, PE – UDFCD
David Mallory, PE, CFM - UDFCD
Joanna Czarnecka, EIT, CFM - UDFCD

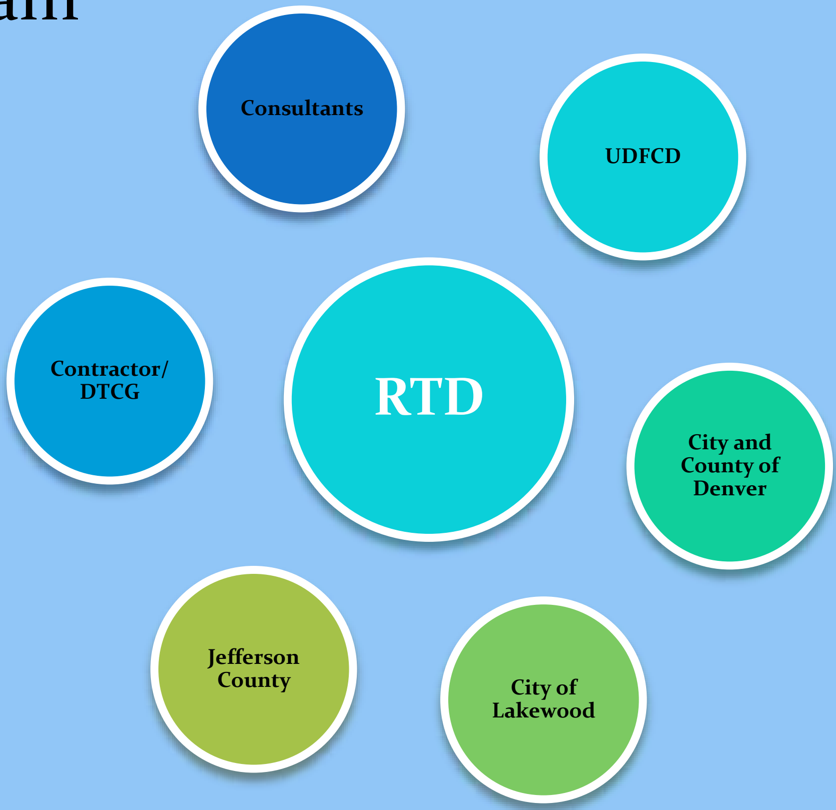
All hands on deck

Floodplain Management aspects of the RTD West Corridor

- Early involvement in planning committee (1994)
- Review of proposed plans: Drainage Criteria Manual, master planning, public safety and beneficial uses of drainageways and floodplains
- NFIP conformance and flood hazard mitigation
- Involvement with construction observation for Maintenance Eligibility Program (MEP)

Areas of Inter-Action

- Consistent Criteria Among Local Jurisdictions
- Capital Construction
- Maintenance Eligibility Program
- Maintenance



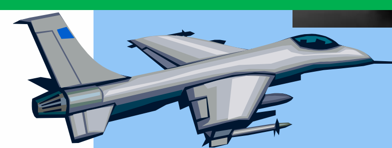
Comments on DEIS

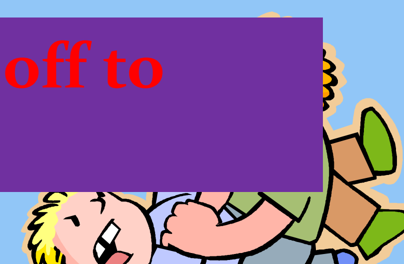
For the most part in the DEIS, where the proposed light rail alignment encroaches into the existing 100-year floodplain and even the channel, RTD's proposed mitigation is the 30-year old single purpose structural solution which either negatively impacts existing values of the drainageway; or would adversely impact any future attempts to enhance the value of the drainageway. For every instance where this issue was raised at the April 1 briefing, the response of RTD and its consultants was that this was the cheapest alternative. It has been our understanding that environmental studies are conducted to identify and mitigate environmental impacts of a given project, and not simply to find the cheapest alternative regardless of the impacts.

Sometime in this period I was assigned as the UDFCD's point person for all FasTracks corridors.

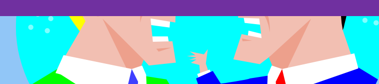
My job was to identify areas of conflict and solutions to those conflicts.

If it was multi-jurisdictional or policy I would keep it.





If it involved a DCM project I would hand it off to DCM as soon as possible.



If it was a MEP project I would assign it to MEP (David Mallory and Joanna Czarnecka) as soon as possible.

Letter to RTD

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

We like to see major drainageways serve as assets to the neighborhoods, and not simply channels that occasionally carry water. Drainageways offer the opportunity for trail systems, linear parks,

Criteria

- All drainage crossings to be 100-year to minimize service disruptions.
- Lakewood Gulch, Dry Gulch and South Platte River interactions to be in compliance with local floodplain regulations.

UDFCD's involvement

- Two capital projects
  - South Platte River and Lakewood Gulch
  - Richey Park detention
- One maintenance project
  - Oxbow area on Lakewood Gulch
- Twelve maintenance eligibility projects

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.

Maintenance Eligibility Program (MEP)

- Facilities constructed by, or approved for construction by, a local government must go through the UDFCD MEP in order to be eligible for UDFCD maintenance assistance.
- RTD had to build some facilities in order to construct their rail corridor, and wanted to turn them over to the local governments.
- The local governments wouldn't accept the facilities unless they were eligible.
- We ended up with 12 MEP projects.

All hands on Deck

ALL HANDS ON DECK

FPM & the West Corridor

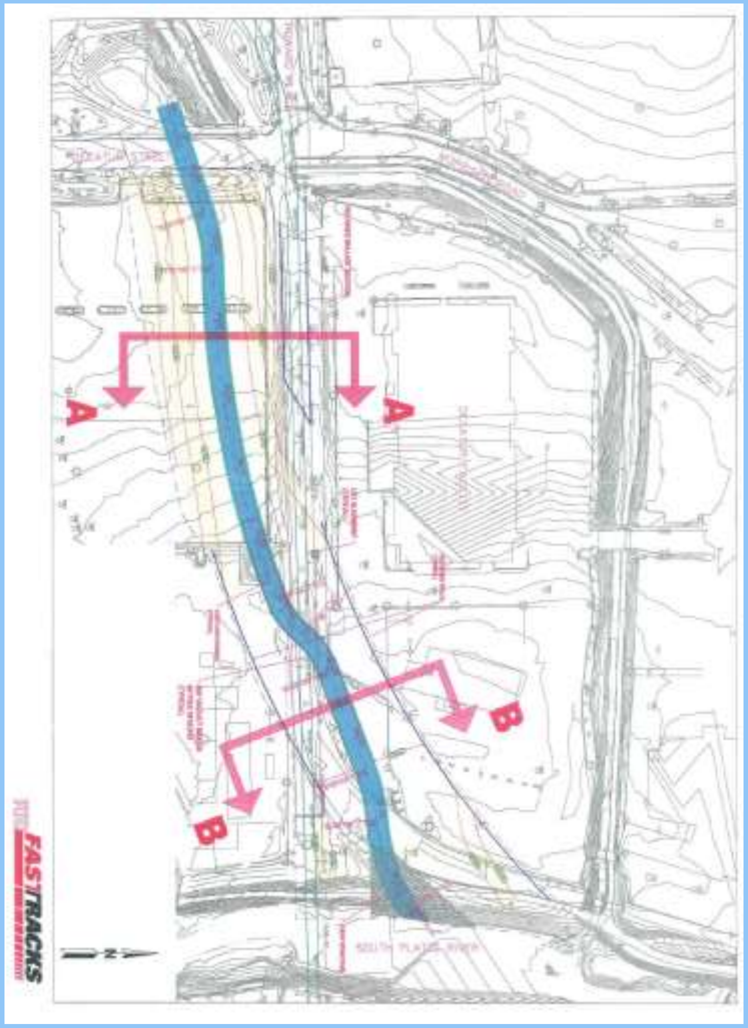
- In the summer of 2004, we started meeting with the RTD, affected local governments and RTD's preliminary design consultant on the numerous unresolved floodplain issues along the West Corridor.
- West Corridor revenue service commenced in April of 2013. A lot of work was accomplished in that nearly **nine-year period** of time. Big opportunities were capitalized upon because the challenges were daunting, the project was large and **the moment was right.**

It was a struggle at times

- Culverts to replace Federal Blvd bridge

It was a struggle at times

- Concrete channel for Lakewood Gulch



It was a struggle at times

Concrete channel for Lakewood Gulch

In summary, RTD continues to present channel options along the LRT alignment that could not be approved because they are considerably substandard with respect to established criteria and customary standard of care.

It was a struggle at times

Implementation of the South Platte River plan

Developed in 1980's

- Proposed crossing matched the ultimate channel section
- However, until the SPR plan was implemented the valley crossing must be elevated
- With Denver's leadership we moved forward with the final phase of the SPR plan

Capital Projects

- Upper Central Platte Valley & Lakewood Gulch

South Platte River and Lakewood Gulch

- Provided RTD with a SPR cross section and BFE so they could design and build their bridge
- Provided a Lakewood Gulch channel from Decatur to the SPR that solved RTD's problem and proposed solution (concrete channel)
- Used for Denver's

  local government match

  - 496 properties removed from floodplain
  - Cost: $35 million design and construction
  - Added new section of trail
  - Created inviting corridor for recreational use

Capital Projects

- Richey Park

Total cost: $600,000
New outlet structure

Richey Park Detention

- Added detention volume to the park
- Reduced the downstream discharge (and conduit size) for RTD's conduit
- Used for Lakewood's local government match

Maintenance Project for Denver

- Lakewood Gulch Oxbow Pipe replacement

Cost $ 125,000 for design and construction

Maintenance Eligibility

- RTD wanted to turn over drainage facilities they built to local governments to own and maintain.
- Local governments wanted the facilities to be eligible for UDFCD maintenance assistance before they would agree.
- The result was nine different areas where we had RTD follow the MEP.

Dennis Cole

- West Corridor Manager
- Principle negotiator for RTD
- Passed away early in the construction phase

All hands on deck

Maintenance Eligibility

By Wikipedia about W line

1. Lakewood Gulch thru the Federal Blvd drop structure
2. Knox Court bridge replacement & station
3. Oxbow (saving the project two bridges)
4. Perry Street culvert
5. Perry Street to Sheridan (East and West Dry Gulch bridges)
6. Harlan Street channel
7. Richey Park storm drain outfall
8. Collins Avenue culvert box
9. Lena Gulch at Ulysses St

Nine areas of interaction with RTD line

MEP Projects Database

ID Number	Project Name	Basin ID	Drainageway	Tributary	Government	County	Last Updated
3627	RTD West -Parking 10th & Sheridan Blvd	4801	DRY GULCH		Denver	Denver	8/22/2012
3574	RTD West Sheridan Blvd to Perry St	4801	DRY GULCH		Denver	Denver	11/15/2012
3572	RTD Fastracks West outlet protection	4801	DRY GULCH		Lakewood	Jefferson	11/14/2012
3571	RTD Fastracks West at Perry Street	4801	DRY GULCH		Lakewood	Jefferson	7/10/2012
3546	RTD West Richey Park culvert outfall	4801	DRY GULCH		Lakewood	Jefferson	12/13/2011
3555	RTD Fastracks West at Harlan Street	4801	DRY GULCH		Lakewood	Jefferson	11/14/2012
3635	RTD Fastracks West outlet protection	4800	LAKEWOOD GULCH		Denver	Denver	11/14/2012
3573	RTD Fastracks West Oxbow Area	4800	LAKEWOOD GULCH		Denver	Denver	5/15/2012
3544	RTD West Collins Street culvert	4800	LAKEWOOD GULCH		Lakewood	Jefferson	7/3/2012
3543	RTD West Knox Court roadway crossing	4800	LAKEWOOD GULCH		Denver	Denver	3/3/2011
3558	RTD Fastracks West at Federal Blvd	4800	LAKEWOOD GULCH		Denver	Denver	7/3/2012
3545	RTD West Lena Gulch – Ulysses St	4310	LENA GULCH		Jefferson County	Jefferson	11/15/2012

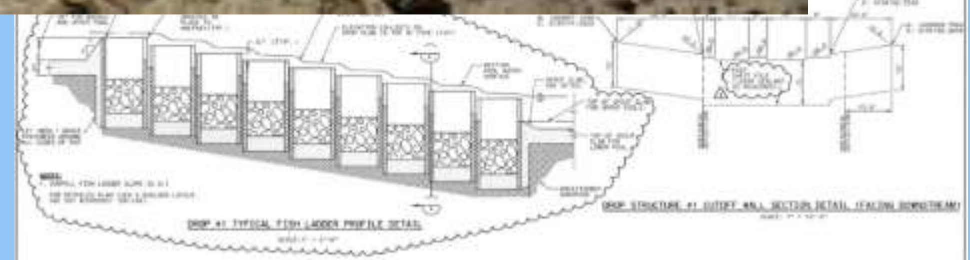
12 projects

Construction meetings

Maintenance Eligibility

- Lakewood Gulch - Decatur bridges, Federal Bridge & Drop structure No.1

Drop Structure No.1



- Various boulder sizes
- Fish ladders
- Fits between MSE walls
- Connects to new Federal Blvd bridge
- UDFCD paid Muller for construction observation

Maintenance Eligibility

Knox Court – new bridge

Lakewood Gulch improvements- Drop No 2&3

Maintenance Eligibility

Dry Gulch improvements: Perry St culvert, Drop No.4, E and W Dry Gulch bridges

Maintenance Eligibility

Dry Gulch and North Dry Gulch improvements: Harlan Street

Maintenance Eligibility

Lakewood Gulch - Collins Avenue Box Culvert

Area

Picture

Lena Gulch at Ulysses St

Area

Picture

Construction mishaps..

Summer storms

5/20/2009
5/28/2009
7/3/2009

Construction mishaps..

Water line break at Knox Ct

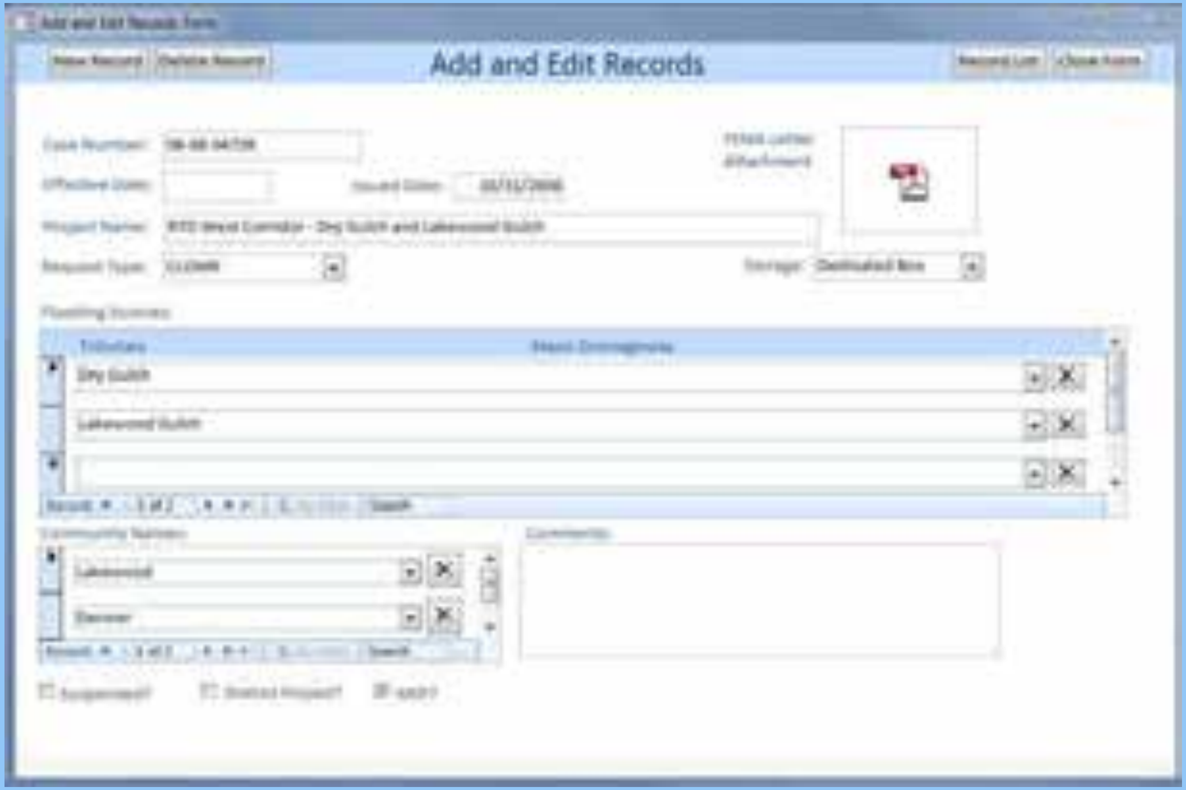
Federal Blvd Drop Structure No. 1

UDFCD Construction Manager visited the site close to **300** times, many times performing weekly walk-throughs with Terry Martin, DTCG representative.

Although we **vocalized** our concerns for active construction during high flow season, ultimately it's up to the contractor to evaluate the site and incorporate any changes.

Here, captured storm from May 12, 2011

LOMCs: CLOMRs

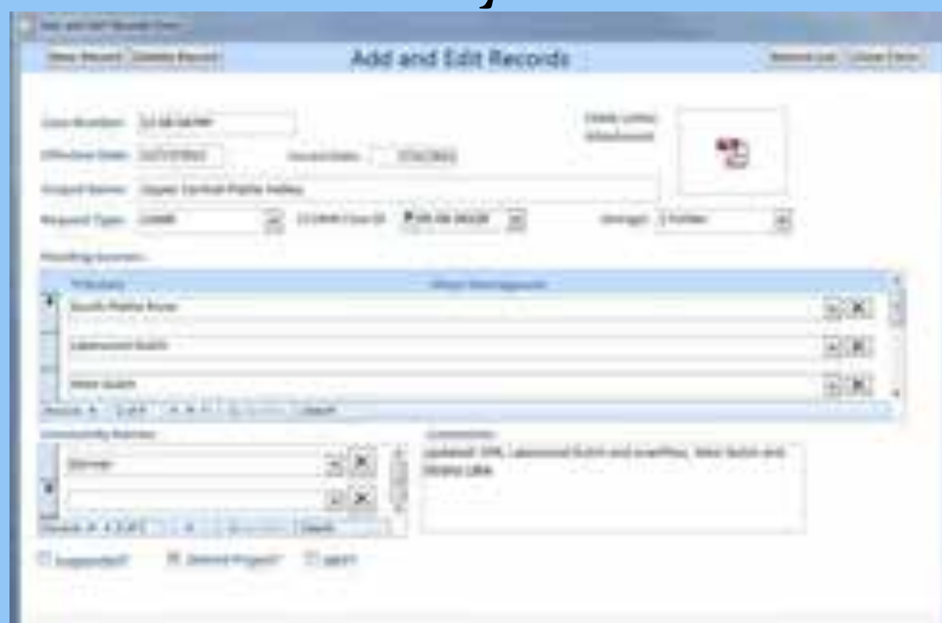


- RTD West Corridor – Dry Gulch and Lakewood Gulch
- One submittal for entire project
- UDFCD contributed funds to incorporate the detention pond built by us

LOMCs: LOMRs

- RTD West Corridor submitted for review by Muller Engineering is in the process now…

- Upper Central Platte Valley effective since 12/17/12



Summary

Trains…oh, trains…hurray!!!

More trains!

Questions ?

Comments ?

Thank You

Adventures in the Last Frontier: Hazard Planning Alaskan Style

Kimberley Pirri, PE, CFM
URS Corporation
CASFM 2013, Steamboat Springs, CO
September 11, 2013

Background

- Project: Update Local Hazard Mitigation Plan Annex
- Place: Seward, Kenai Peninsula Borough, AK
- Purpose:
  - Evaluate All Natural Hazards (Flood, Earthquake, Tsunami, Wildland Fire, etc.)
  - Estimate Potential Damages (Structure & Contents, Loss of Use, etc.)
  - Develop Mitigation Concepts (Acquisition, Flood Control Structures)
  - Prepare Mitigation Plan (Report)
- Denver Tasks: Flood Hazards, Flood & Earthquake HAZUS

Need - Get out of the "Active Mitigation" Business!

URS

The Team

Client

- Daniel Mahalak: SBCFSA Project Manager

URS Team

- Scott Simmons: Project Manager (Anchorage)
- Rich Chamberlain: GIS/Hazus Riverine (Denver)
- Kim Pirri & Adam Lacey: Hydrology and Hydraulics (Denver)
- Jon Philipsborn: Climate Change (Atlanta)
- Shane Parson: Hazus User-Defined Facilities, Tsunami, EQ, (Germantown)

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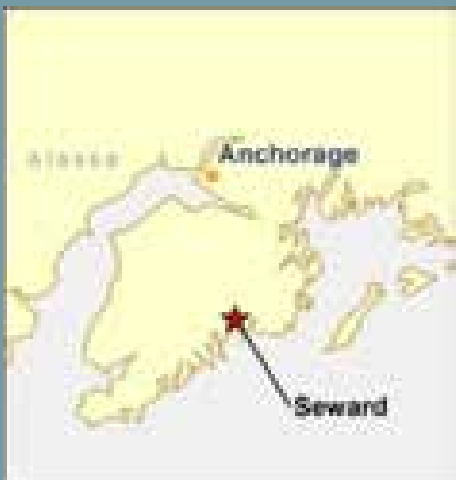
Where are we?



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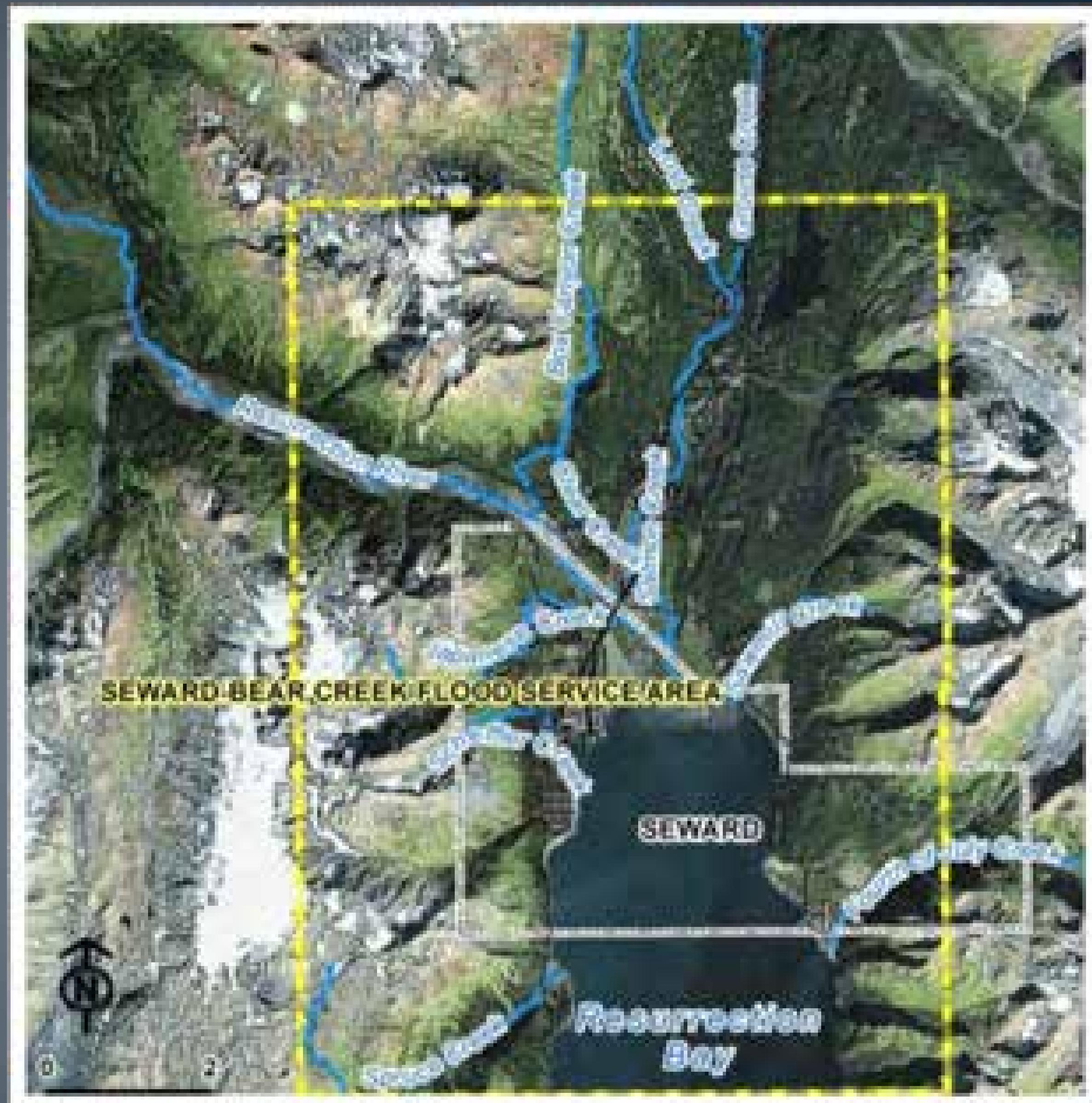
The Study Area:

The SBCFSA

15 watersheds

Total drainage area of 364 mi^2



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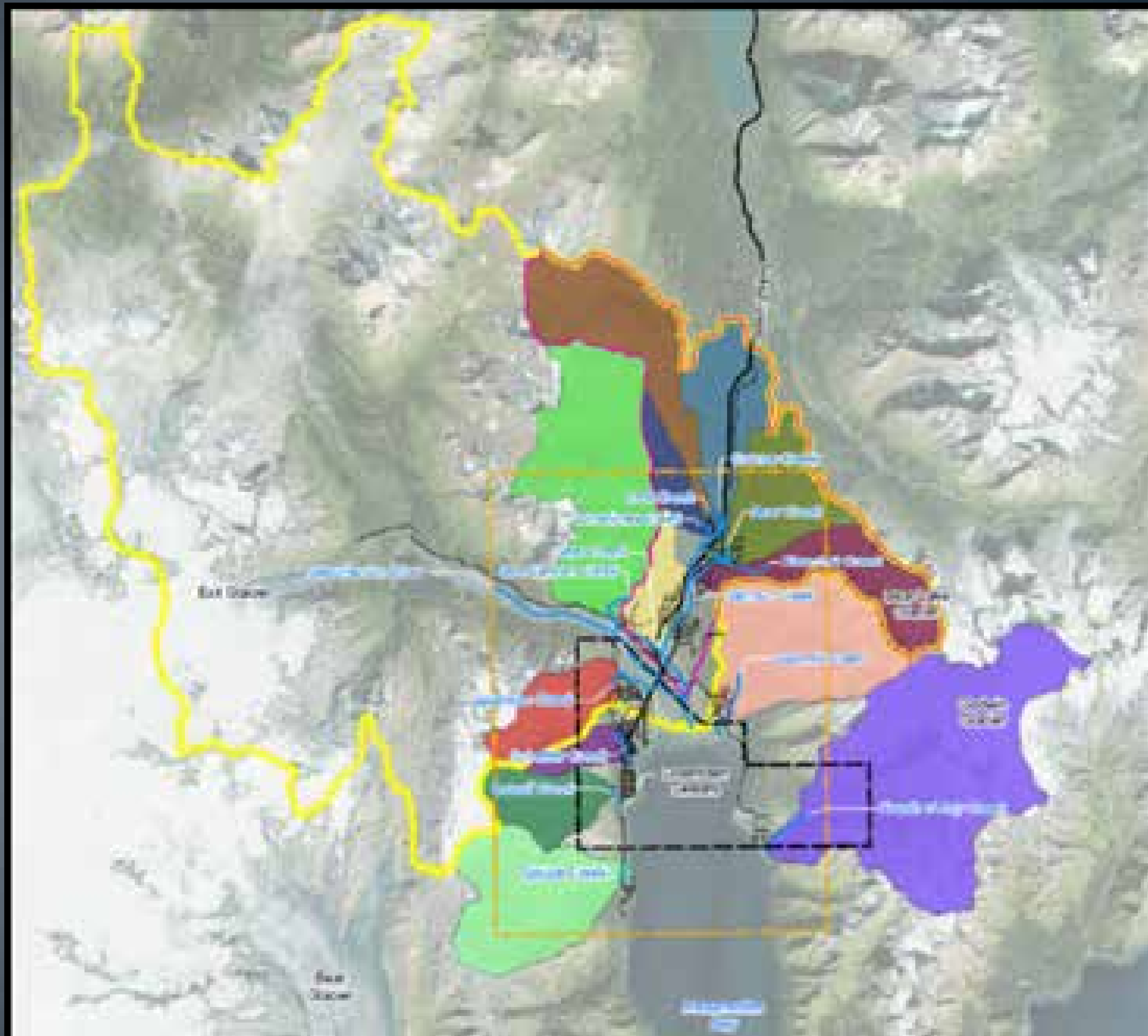

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Let's focus on Riverine Flood Hazard Analysis…

Challenges:

- Census Data Insufficient:
  - Need Inventory data
- Hazus Flood Hydraulics Insufficient:
  - Update FEMA Models
  - Do HEC-RAS Models for Unstudied Streams
- Modeling climate change

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Let's go to Seward…

Original Plan…

- Field Tour w/ client
- Kick-off Meeting
- Field Measure Hydraulic Structures (bridges, culverts)
- Building Stock Evaluation (for structure type & 1st floor elevation)

What really happened…

- Raining…
- Field Tour w/ Client
- More Rain… Flooding…
- Most locals bail on kickoff meeting to respond to flooding
- More Rain… More Flooding…
- See flooding and flood response in action…
- Building Stock Evaluation
- Get the out before the road is closed…

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Field Data Collection… in the Rain!

Rainfall… Excessive Rainfall

Seward

- Annual Average Precipitation = 69 inches
- Week of 9/17-9/21/2012 Rainfall Total ~15 inches
- Month of September 2012 Rainfall Total >30 inches* (it's a record!)

Denver

- Annual Average Precipitation = 15.4 inches

*Source: AlaskaDispatch.com, 9/26/2012

= Flooding

Resurrection River

- NOAA Realtime Gage at Exit Glacier Road, DA= ~155 mi^2
- Flood Stage = 17.5 ft
- Major Flood Stage = 20 ft
- 9/19/12 Peak Stage = 19.97 ft.
- Peak Q = ~16,500 cfs
- About a 10-year Flood Event!*

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*Based on FIS discharges from Kenai Peninsula Preliminary FIS

Seward Highway Milepost 3.5 Overflow ~18" Deep on Thursday

Eventually, ADOT&PF did close the road…


GPS Data Collector

URS


CREEKSIDE
CABINS

User-Defined Facilities

Census-Based Population and Residential Building Inventory Estimates				
	Population		Residential Structures	
Location	2010 Census	DCCED 2012	Total Structure Count	Total Replacement Value of Structures[1]
City of Seward	2,693	2,733	947	$181,824,000
Bear Creek	1,956	1,958	720	$134,064,000
Lowell Point	80	71	71	$9,230,000
Total	4,729	4,762	1,738	$325,118,000

Sources: The SBCFSA, U.S. Census 2010, and 2011 Alaska Department of Labor.
[1] 2010 Dollars. The 2010 US Census estimates residential building values at City of Seward: $192,000, Bear Creek: 186,200, and Lowell Point: $130,000.

Hazus Major Release 2.1 SBCFSA Building Inventory Estimates			
Occupancy Type	Total Structure Count	Total Replacement Value of Structures[1]	Total Replacement Value of Contents[1]
Residential	3,622	$358,755,000	$179,584,000
Commercial and Industrial	143	$108,843,000	$116,838,000
Other[2]	29	$14,618,000	$15,971,000
Total	3,794	$482,216,000	$312,393,000

Source: Hazus Major Release 2.1, General Building Stock data for Census Tract 02122001300.
[1] 2006 Dollars from RSMeans.
[2] Other occupancy types include Government, Education, Religion, and Agriculture.

Hazus User-Defined Facilities Building Inventory Estimates for SBCFSA			
Occupancy Type	Total Structure Count	Total Structure Replacement Value[1]	Total Contents Replacement Value[1]
Residential	1,919	$418,708,000	$209,354,000
Commercial and Industrial	376	$233,424,000	$247,439,000
Other[2]	52	$118,258,000	$139,097,000
Total	2,347	$770,390,000	$595,890,000

Sources: KPB Parcel Data, KPB Building Data, KPB aerial photography, RSMeans 2012 Residential Cost Data and Light Commercial Cost Data, Hazus default data for region, field survey, publically available aerial and street level photography
[1] 2012 Dollars from RSMeans 2012 Residential Cost Data and Light Commercial Cost Data.
[2] Other occupancy types include Government, Education, Religion, and Agriculture.

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Let's focus on Riverine Flood Hazard Analysis…

Challenges:

- Census Data Insufficient:
  - Need Inventory data
- Hazus Flood Hydraulics Insufficient:
  - Update FEMA Models
  - Do HEC-RAS Models for Unstudied Streams
- Modeling climate change

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Current Day Flood Flows

Taken from Existing FEMA HEC-RAS Models

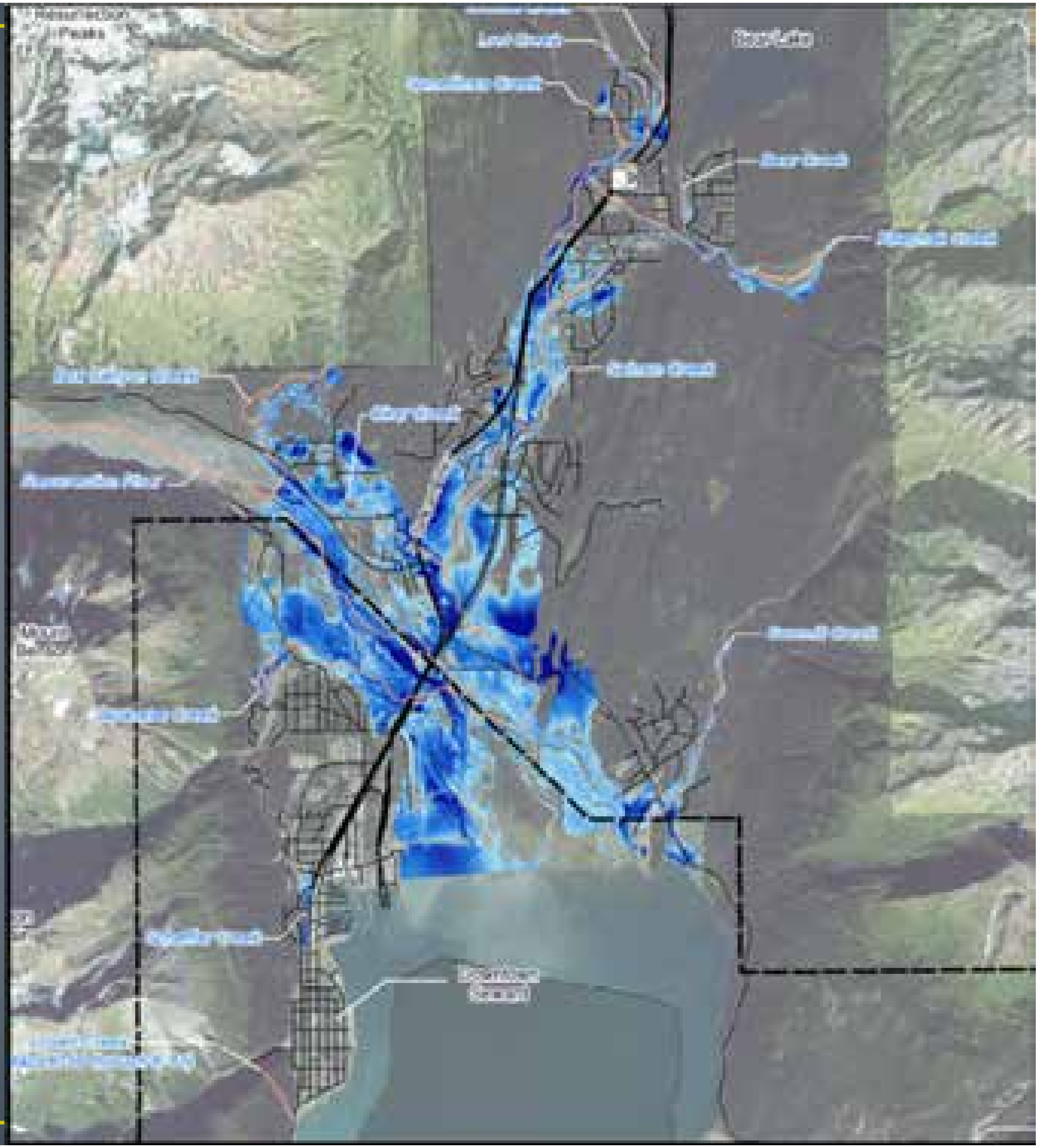
Or…

Estimated using Regional Regression Equations

Watershed	Hydrology Method	Current Flow Data – Current Peak Flow (cfs) 10-Year	50-Year	100-Year	500-Year
Bear Creek	FEMA	440	610	690	880
Box Canyon Creek	RRE	2,174	2,992	3,342	4,216
Clear Creek	RRE	552	764	855	1,082
Fourth of July Creek	RRE	3,540	4,870	5,440	6,860
Grouse Creek	FEMA	740	1,020	1,140	1,450
Japanese Creek	RRE	897	1,220	1,360	1,700
Kwechak Creek	FEMA	1,190	2,140	2,780	5,160
Lost Creek	RRE	1,372	1,905	2,134	2,709
Resurrection River	FEMA	19,230	26,190	29,160	36,570
Salmon Creek	FEMA	2,650	5,170	7,120	15,730
Sawmill Creek	FEMA	1,460	2,350	2,860	4,590
Scheffler Creek	RRE	418	572	673	799
Sometimes Creek	RRE	441	612	685	869
Spruce Creek	RRE	1,050	2,020	2,240	2,790

LiDAR-based Modeling: 100-Year Floodplains

- FEMA Models updated to 2009 LiDAR.
- Original Models created from 2009 LiDAR.



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Hazus UDF Analysis with User-Defined Depth Grids

Scenario Year	Recurrence Interval (yr)	Outlet Discharge (cfs)	Number of Wet Structures	Number of Damaged Structures	Total Structure Damages	Total Contents Damages	TOTAL DAMAGES
Resurrection River							
2012 (Current Day)	10	19,230	10	8	$59,762	$143,019	$202,781
	50	26,190	21	19	$172,668	$320,641	$493,308
	100	29,160	25	23	$277,688	$741,105	$1,018,794
	500	36,570	30	28	$543,318	$1,127,737	$1,671,055

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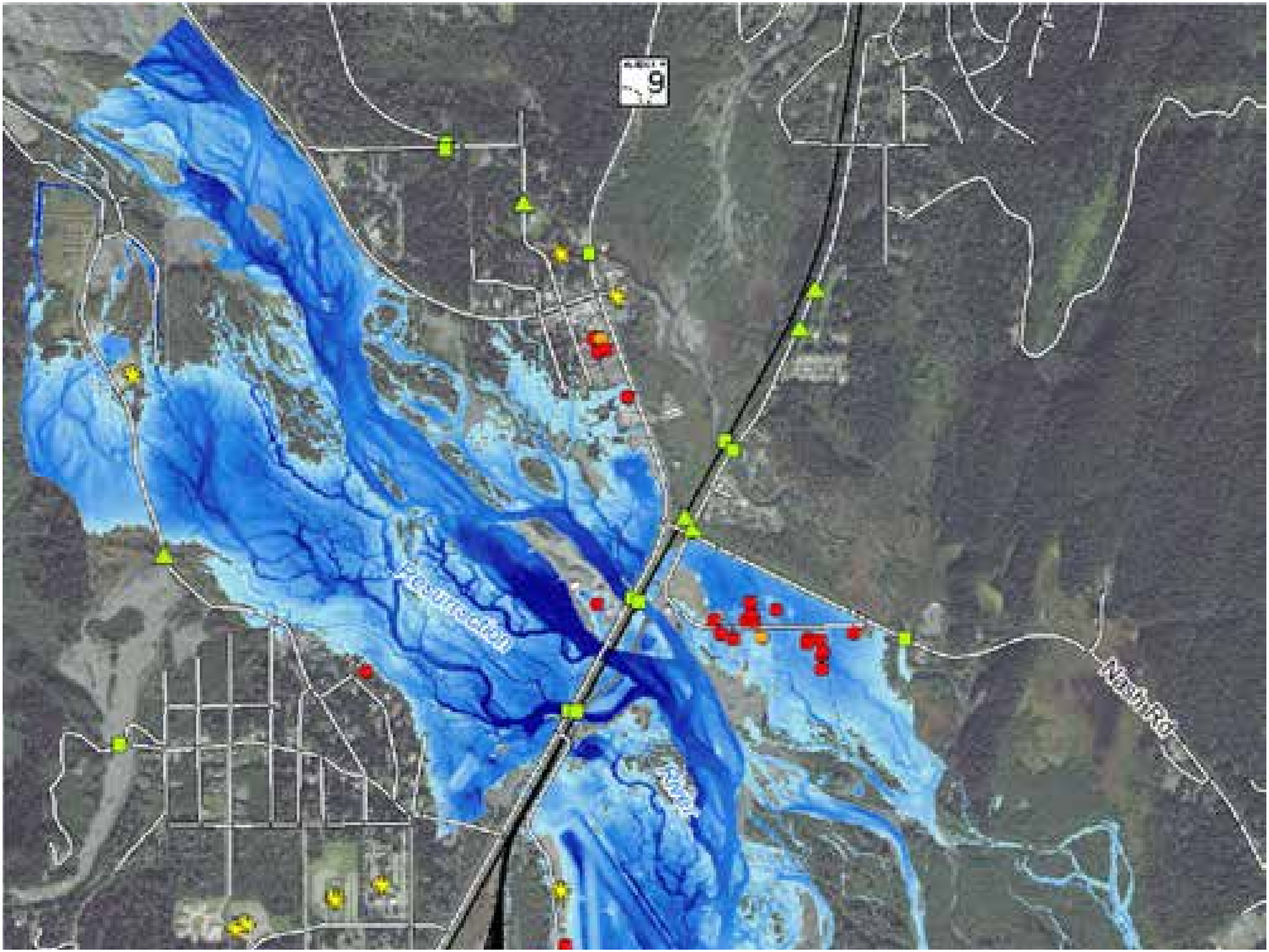
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Let's focus on Riverine Flood Hazard Analysis…

Challenges:

- Census Data Insufficient:
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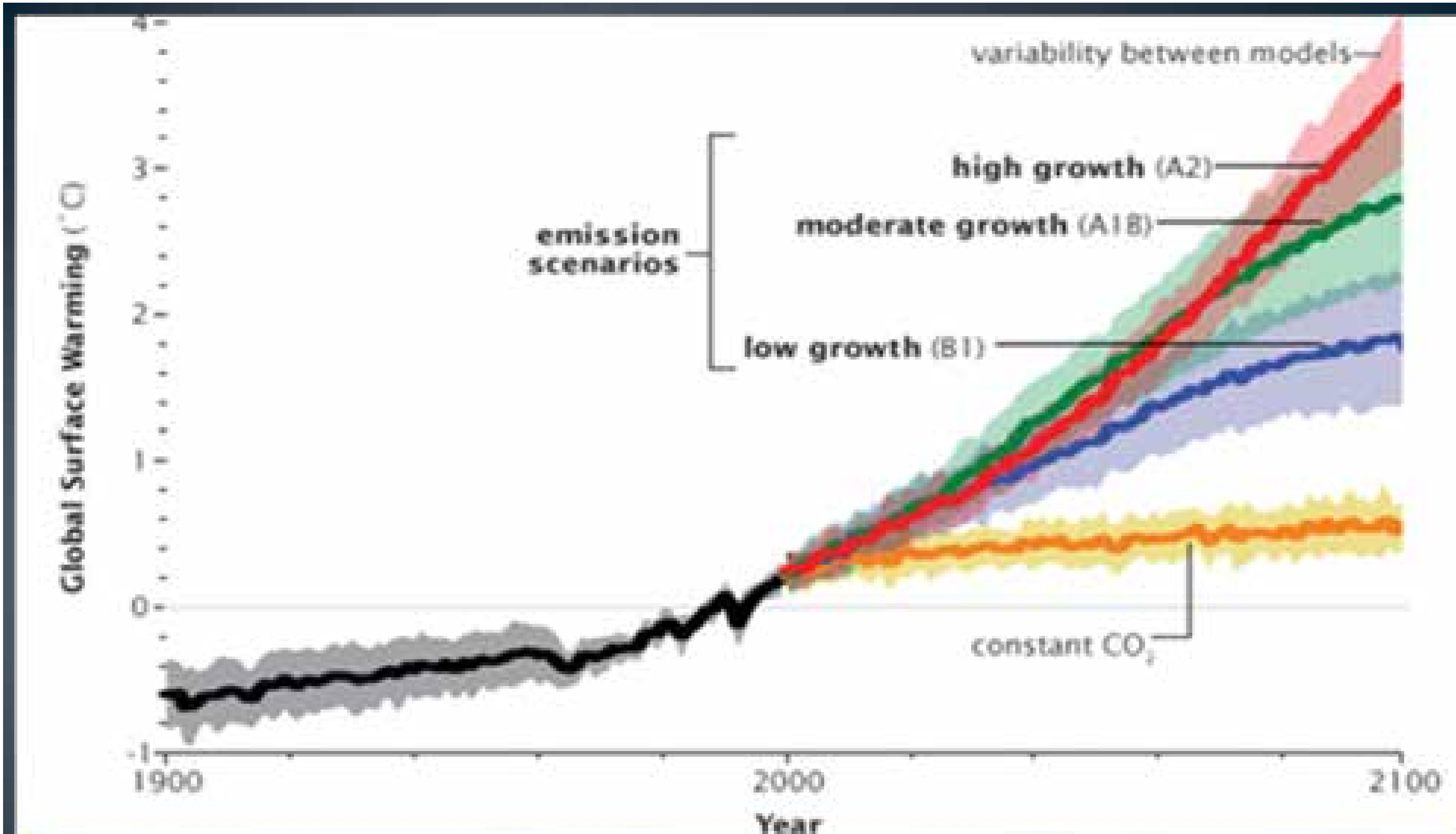
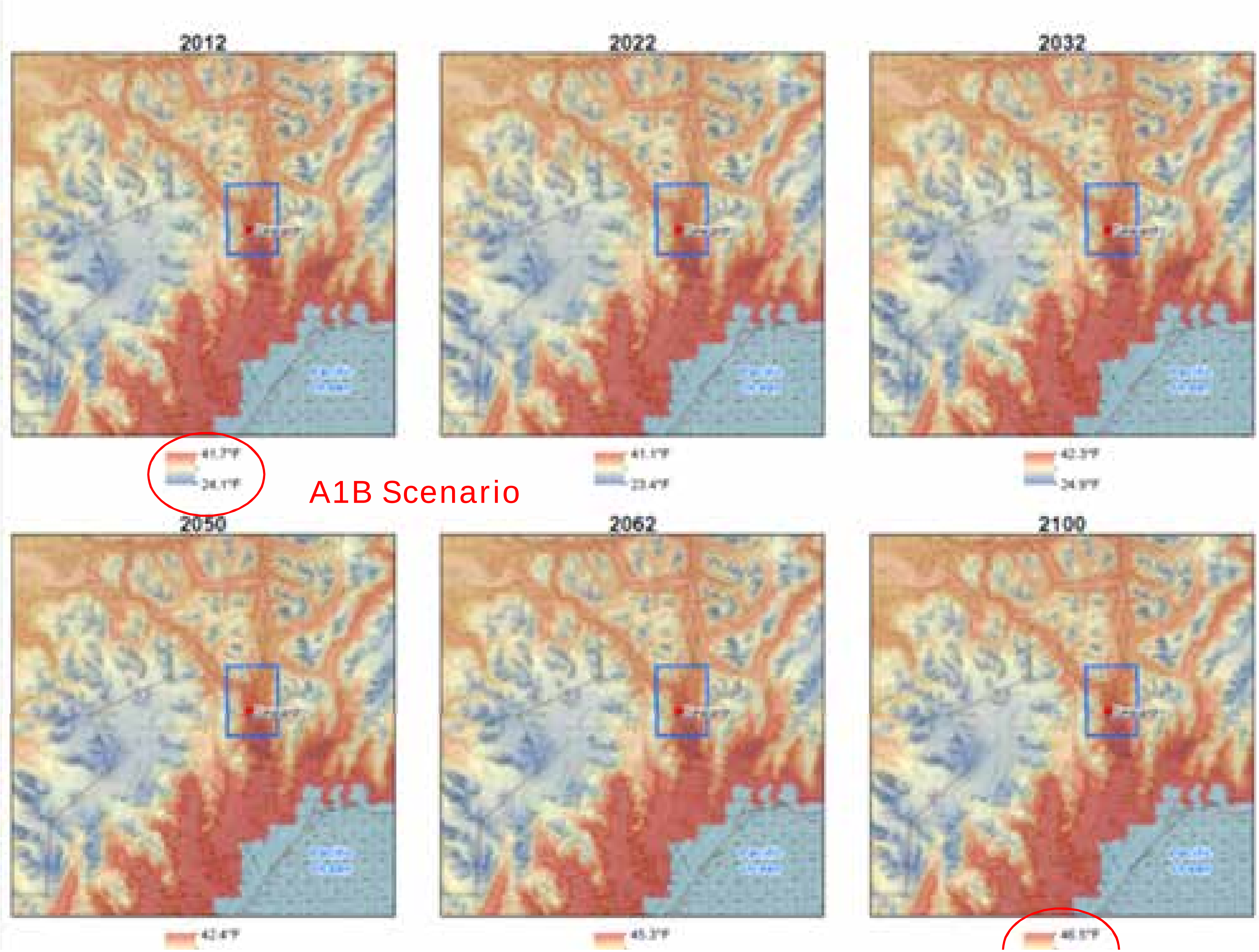
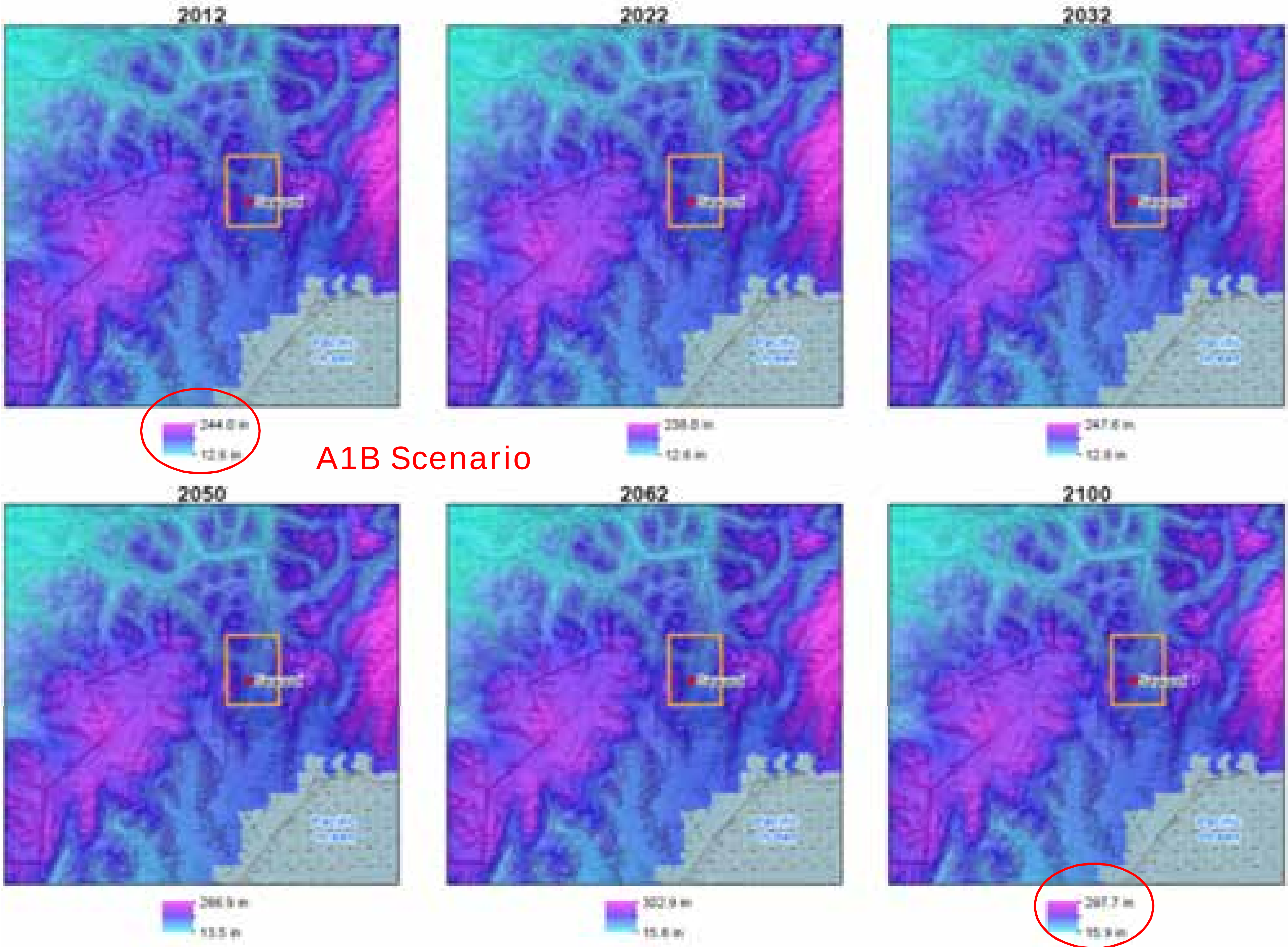
  - Update FEMA Models
  - Do HEC-RAS Models for Unstudied Streams
- Modeling climate change



International Panel on Climate Change Emissions Scenarios


2012
2022
2032
41.7°F
41.1°F
23.4°F
A1B Scenario
2050
2062
2100
42.4°F
45.2°F


2012
2022
2032
A1B Scenario
2050
2062
2100

USGS Regression Equation with Temp. and Precip. Factors

$$Q_{10} = 0.01450\, A^{0.8306}\, (ST+1)^{-0.3691}\, P^{0.7655}\, (J+32)^{1.622}$$

$$Q_{25} = 0.02522\, A^{0.8292}\, (ST+1)^{-0.3697}\, P^{0.7165}\, (J+32)^{1.588}$$

$$Q_{50} = 0.03711\, A^{0.8286}\, (ST+1)^{-0.3693}\, P^{0.6847}\, (J+32)^{1.559}$$

$$Q_{100} = 0.05364\, A^{0.8281}\, (ST+1)^{-0.3683}\, P^{0.6556}\, (J+32)^{1.527}$$

$$Q_{200} = 0.07658\, A^{0.8276}\, (ST+1)^{-0.3669}\, P^{0.6284}\, (J+32)^{1.495}$$

$$Q_{500} = 0.1209\, A^{0.8272}\, (ST+1)^{-0.3646}\, P^{0.5948}\, (J+32)^{1.449}$$

Where:

A = basin area, in square miles

ST = storage (area in lakes and ponds), as a percentage of basin area

P= mean annual precipitation, in inches

J = Mean minimum January temperature, in degrees Fahrenheit

Watershed	Hydrology Method	Current Flow Data											
		Current Peak Flow (cfs)				2022 Peak Flow (cfs)				2032 Peak Flow (cfs)			
		10-Year	50-Year	100-Year	500-Year	10-Year	50-Year	100-Year	500-Year	10-Year	50-Year	100-Year	500-Year
Bear Creek	FEMA	440	610	690	880	515	710	803	1,015	512	706	796	1,008
Box Canyon Creek	RRE	2,174	2,992	3,342	4,216	2,565	3,511	3,910	4,896	2,553	3,490	3,886	4,863
Clear Creek	RRE	552	764	855	1,082	648	892	995	1,251	645	887	990	1,243
Fourth of July Creek	RRE	3,540	4,870	5,440	6,860	4,109	5,628	6,271	7,857	4,100	5,607	6,245	7,819
Grouse Creek	FEMA	740	1,020	1,140	1,450	867	1,190	1,326	1,675	860	1,179	1,314	1,659
Japanese Creek	RRE	897	1,220	1,360	1,700	1,051	1,423	1,582	1,963	1,046	1,414	1,571	1,949
Kwechak Creek	FEMA	1,190	2,140	2,780	5,160	1,392	2,491	3,227	5,948	1,387	2,478	3,210	5,913
Lost Creek	RRE	1,372	1,905	2,134	2,709	1,619	2,236	2,498	3,148	1,609	2,220	2,479	3,123
Resurrection River	FEMA	19,230	26,190	29,160	36,570	22,814	30,894	34,291	42,672	22,718	30,727	34,096	42,410
Salmon Creek	FEMA	2,650	5,170	7,120	15,730	3,110	6,038	8,292	18,190	3,093	5,998	8,236	18,059
Sawmill Creek	FEMA	1,460	2,350	2,860	4,590	1,705	2,732	3,316	5,286	1,699	2,718	3,298	5,255
Scheffler Creek	RRE	418	572	673	799	488	665	780	920	486	661	776	915
Sometimes Creek	RRE	441	612	685	869	519	717	800	1,008	516	711	794	999
Spruce Creek	RRE	1,050	2,020	2,240	2,790	1,218	2,334	2,582	3,195	1,215	2,325	2,570	3,179

Watershed	Hydrology Method	Future Flow Data											
		2050 Peak Flow (cfs)				2062 Peak Flow (cfs)				2100 Peak Flow (cfs)			
		10-Year	50-Year	100-Year	500-Year	10-Year	50-Year	100-Year	500-Year	10-Year	50-Year	100-Year	500-Year
Bear Creek	FEMA	545	746	840	1,058	806	1,081	1,204	1,485	641	867	971	1,211
Box Canyon Creek	RRE	2,702	3,672	4,080	5,084	4,039	5,368	5,905	7,194	3,184	4,273	4,723	5,821
Clear Creek	RRE	684	955	1,041	1,302	1,019	1,362	1,502	1,836	803	1,085	1,201	1,486
Fourth of July Creek	RRE	4,362	5,929	6,588	8,209	6,415	8,530	9,390	11,448	5,079	6,820	7,544	9,303
Grouse Creek	FEMA	914	1,245	1,385	1,740	1,362	1,815	1,999	2,457	1,082	1,454	1,609	1,999
Japanese Creek	RRE	1,111	1,492	1,655	2,044	1,658	2,178	2,391	2,886	1,294	1,718	1,896	2,317
Kwechak Creek	FEMA	1,475	2,617	3,382	6,201	2,180	3,787	4,847	8,695	1,728	3,028	3,894	7,066
Lost Creek	RRE	1,706	2,339	2,606	3,268	2,549	3,419	3,773	4,626	2,023	2,738	3,035	3,763
Resurrection River	FEMA	24,026	32,305	35,769	44,294	36,156	47,522	52,098	63,056	28,355	37,634	41,461	50,778
Salmon Creek	FEMA	3,285	6,330	8,671	18,925	4,883	9,209	12,493	26,668	3,871	7,366	10,041	21,678
Sawmill Creek	FEMA	1,805	2,869	3,474	5,508	2,671	4,154	4,980	7,725	2,113	3,319	3,998	6,274
Scheffler Creek	RRE	516	697	818	958	770	1,018	1,179	1,352	600	802	934	1,084
Sometimes Creek	RRE	548	751	836	1,047	815	1,092	1,205	1,476	645	873	967	1,199
Spruce Creek	RRE	1,291	2,455	2,709	3,334	1,916	3,562	3,891	4,684	1,498	2,815	3,091	3,767

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Scenario Year	Recurrence Interval (yr)	Outlet Discharge (cfs)	Number of Wet Structures	Number of Damaged Structures	Total Structure Damages	Total Contents Damages	TOTAL DAMAGES
Resurrection River							
2012 (Current Day)	10	19,230	10	8	$59,762	$143,019	**$202,781**
	50	26,190	21	19	$172,668	$320,641	**$493,308**
	100	29,160	25	23	$277,688	$741,105	**$1,018,794**
	500	36,570	30	28	$543,318	$1,127,737	**$1,671,055**
2022	10	22,814	19	17	$459,626	$359,998	**$819,624**
	50	30,894	34	32	$854,971	$1,053,638	**$1,908,608**
	100	34,291	36	34	$1,005,982	$1,238,168	**$2,244,150**
	500	42,672	47	43	$1,357,047	$1,791,508	**$3,148,555**
2032	10	22,718	Not Estimated				***$896,398***
	50	30,727	Not Estimated				***$1,804,754***
	100	34,096	Not Estimated				***$2,186,743***
	500	42,410	Not Estimated				***$3,129,663***
2050	10	24,026	Not Estimated				***$1,044,789***
	50	32,305	Not Estimated				***$1,983,626***
	100	35,769	Not Estimated				***$2,376,542***
	500	44,294	Not Estimated				***$3,343,277***
2062	10	36,156	39	37	$1,124,368	$1,373,879	**$2,498,247**
	50	47,522	54	46	$1,563,824	$2,080,301	**$3,644,125**
	100	52,098	62	52	$1,758,582	$2,371,472	**$4,130,054**
	500	63,056	75	69	$2,339,380	$3,195,608	**$5,534,988**

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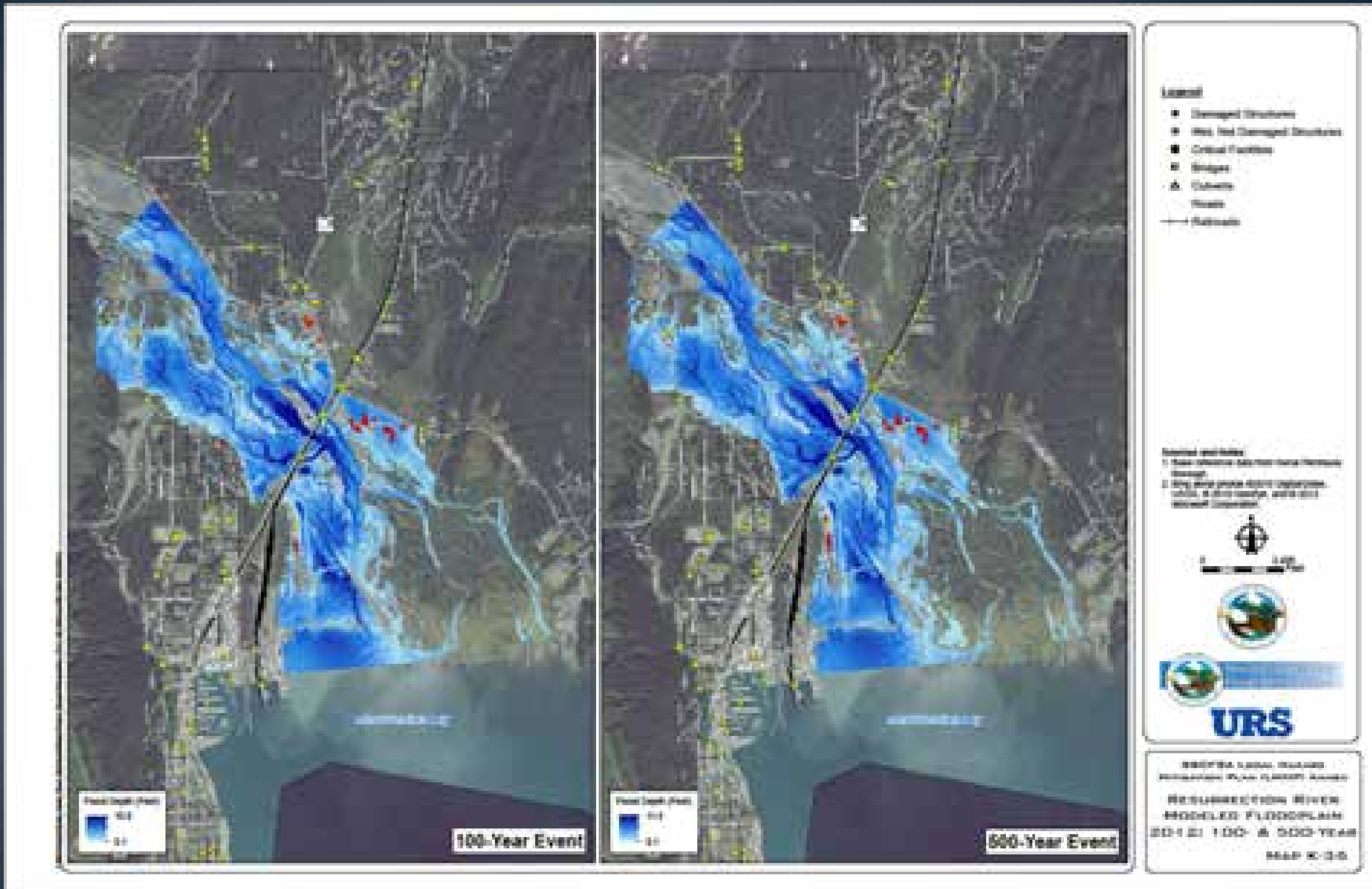

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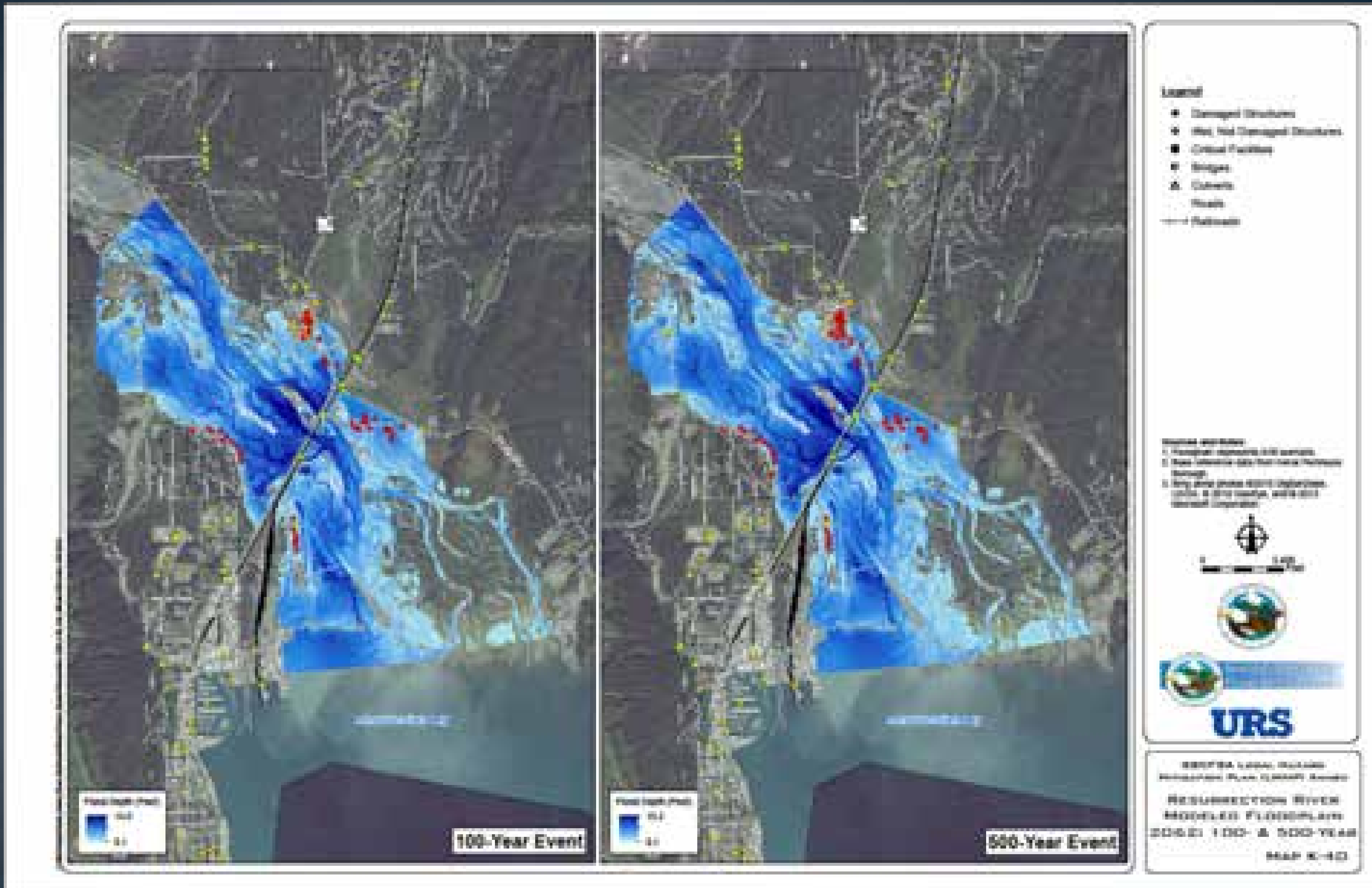

100-Year Event
500-Year Event
URS

But we are in Colorado…

1. Many Colorado communities have GIS data
   - Use to create UDF to better define losses
2. Hazus hydraulics don't work in steep terrain or on alluvial fans
   - Use available FEMA/UDFCD/Community models to define hydraulics and generate depth grids
3. Climate change will be a factor
   - Our water is from snow… early melt, continued drought???
   - Colorado USGS RRE include precip as a parameter, can apply downscaled climate change data & run Hazus for range of flows

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Lowell Creek Flood Control System

- Built by USACE in 1945
- Diverts Lowell Creek from historic path
- Eliminated annual flooding of Downtown Seward
- The was no bridge when the waterfall was built!

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Lowell Creek Waterfall - Tuesday

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Lowell Creek Waterfall

Wednesday

Thursday

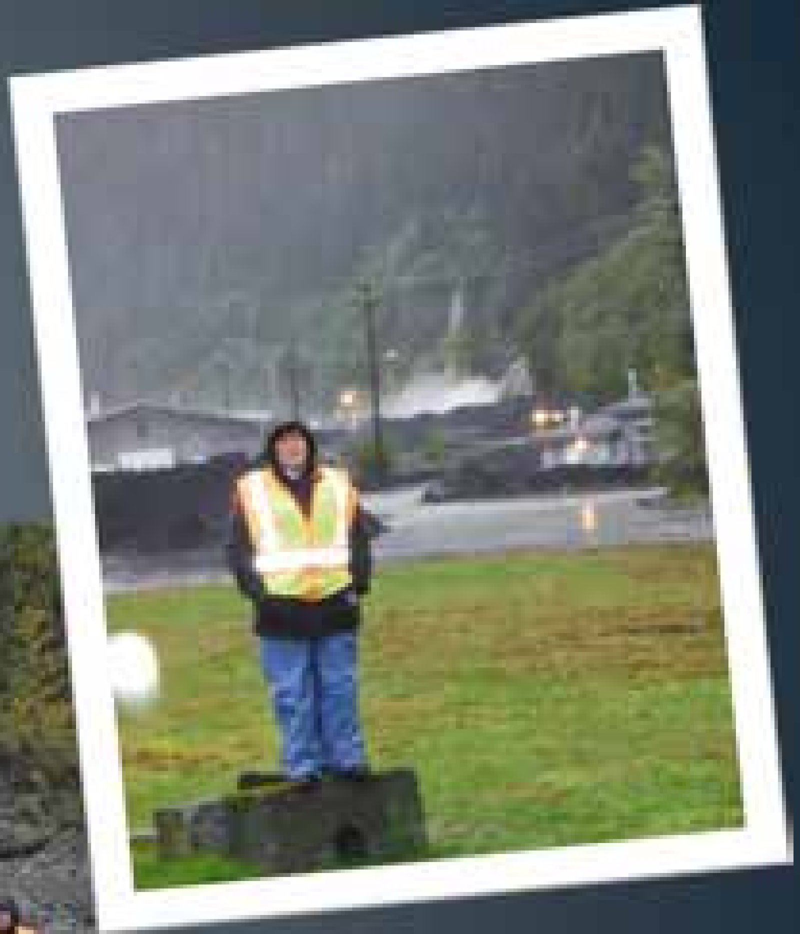
URS

Questions?

Kimberley Pirri

kimberley.pirri@urs.com

303-740-2715



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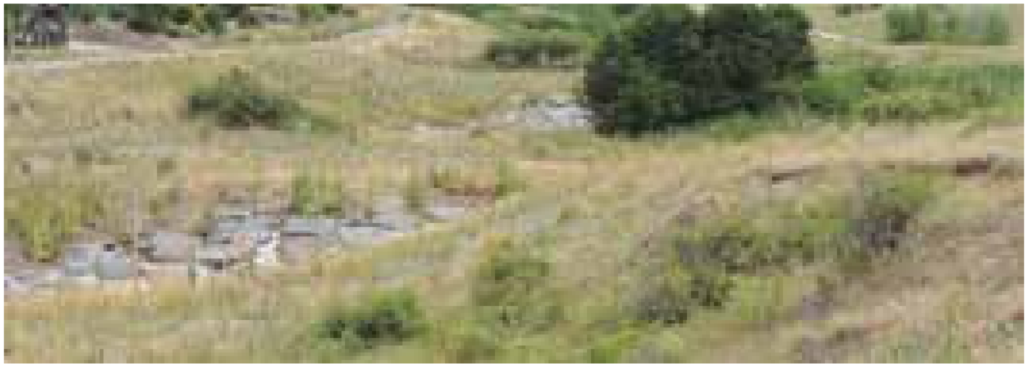



Unconventional Oil and Gas Development

Lessons Learned – Managing Potential Drainage and Flooding Impacts

John Sikora / Sally Cuffin
URS Corporation

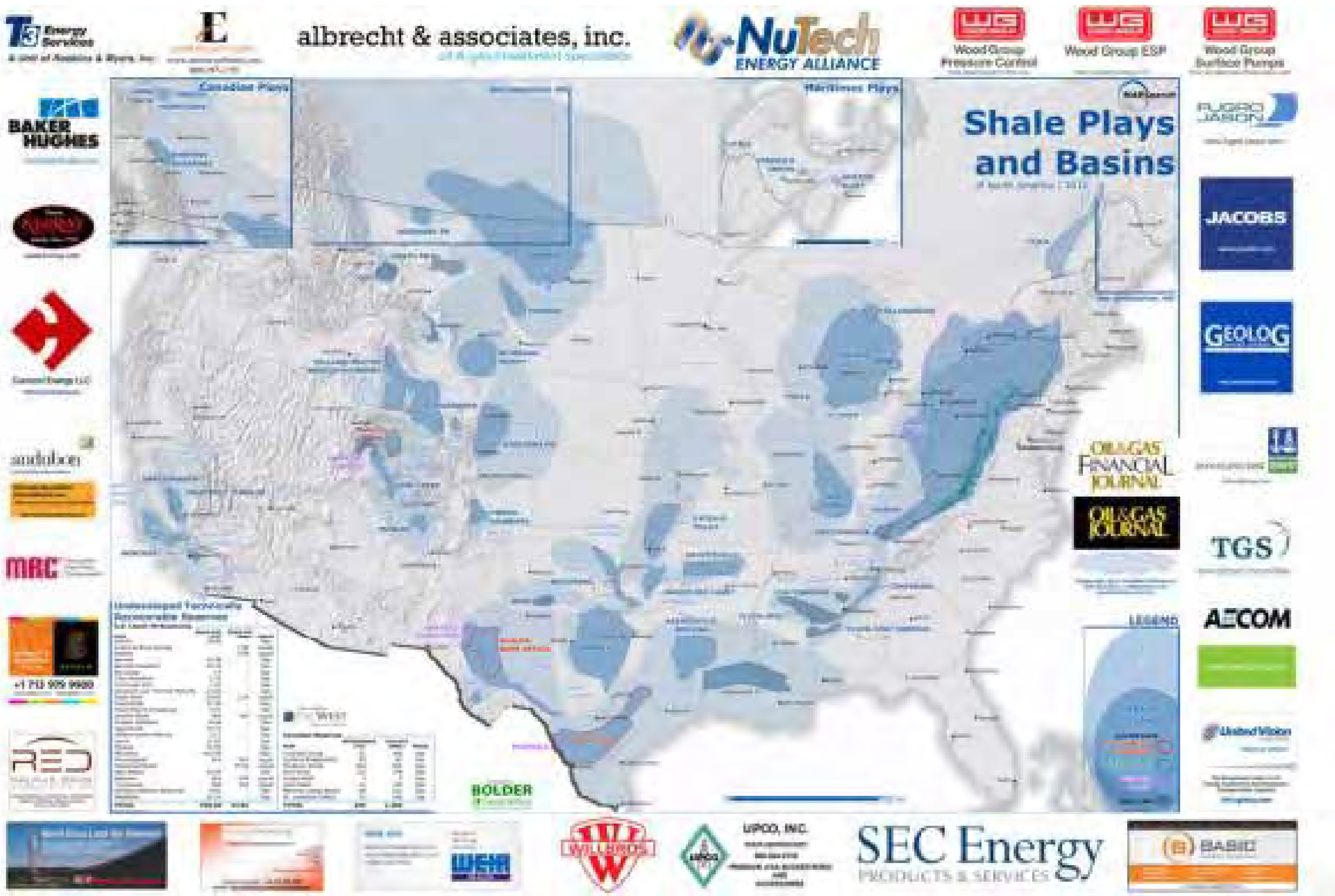
Preview

- Brief summary of development of Unconventional Oil and Gas
- E and P Overview
- Development impacts
- Requirements – storm water discharge (erosion control and drainage) / floodplain
- Challenges
- Looking forward

O&G Development – What Changed, How and When?

- Unconventional development – new techniques allowed access to untapped reserves
- Hydraulic fracturing/directional drilling techniques are refined
  - “Frack” enters the public arena
  - Noticeable E&P operational increase – 2007/2008
- Exploration and production (E&P) ramps up
- Oil and gas prices support increased E&P

O&G Development – Where?

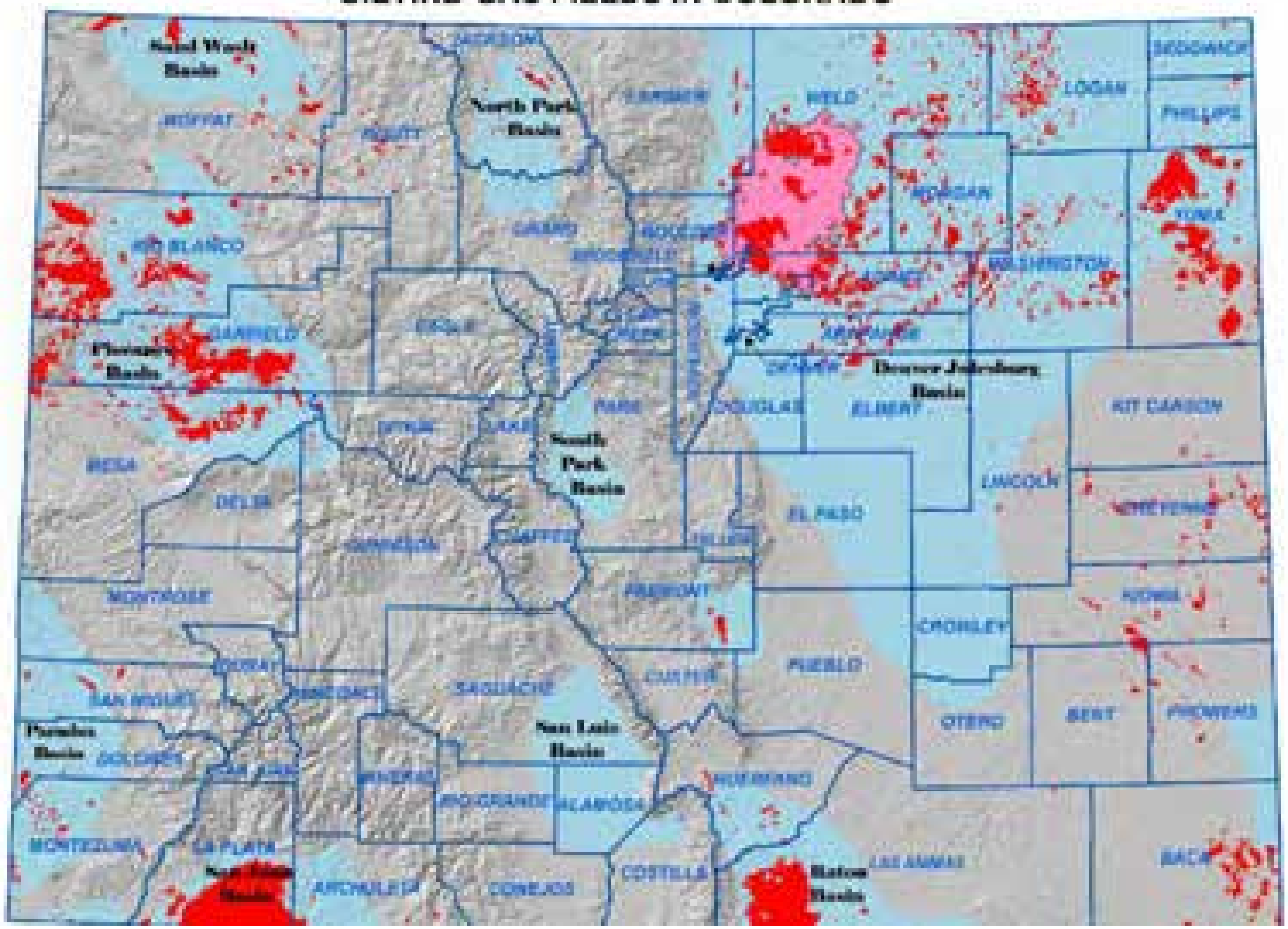


O&G Development – Magnitude?

- Largest growth in oil and gas production than any other oil producing country
- Current US oil demand is 18.55 mbbl/day
- Current US production is 11.12 mbbl/day
- US production is expected to exceed 17 mbbl/day in 2020

O&G Colorado Development

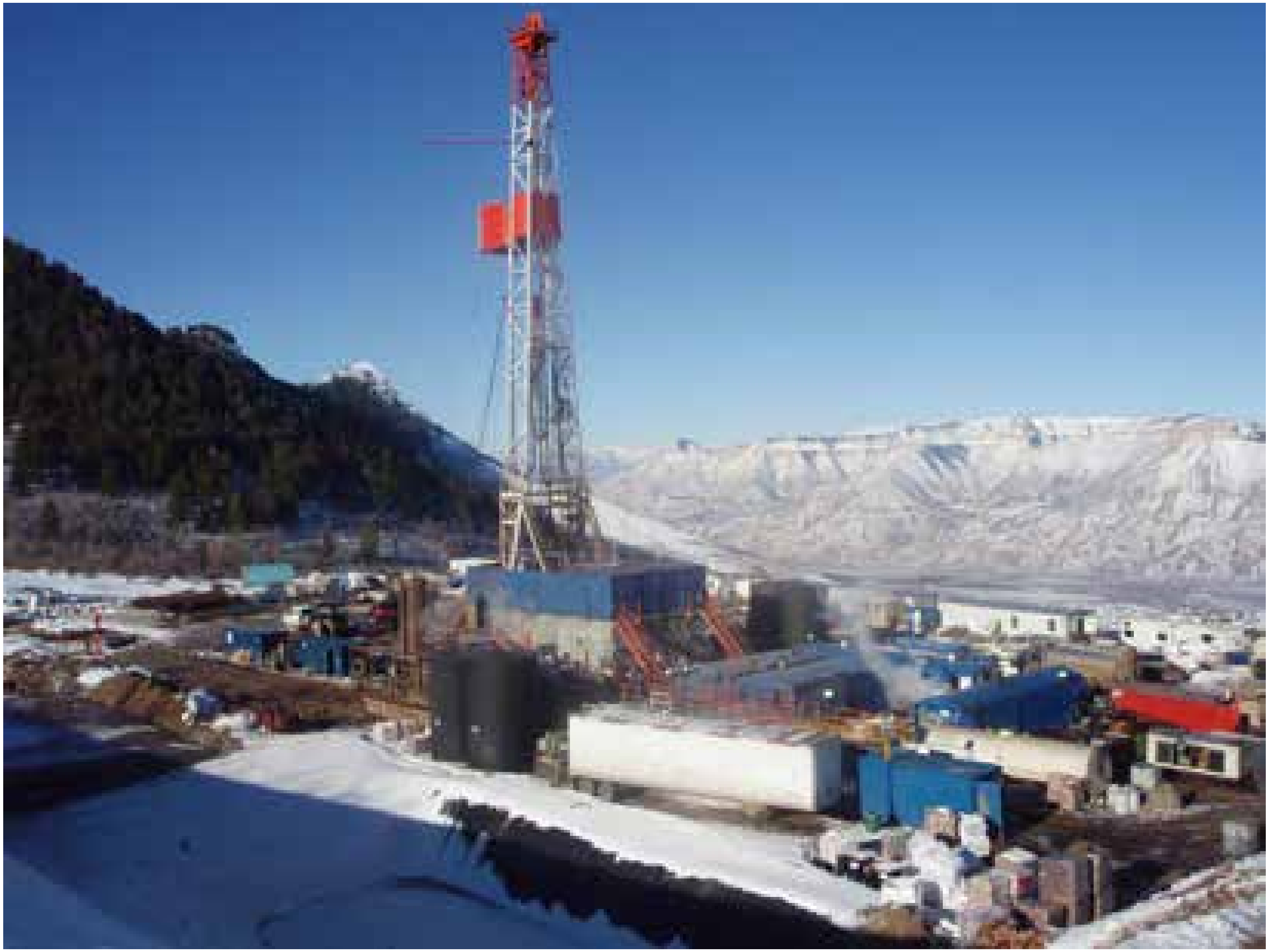
OIL AND GAS FIELDS IN COLORADO



Typical E & P Facilities

- Access roads
- Well pads - one to five acres (newer “super” pads typically larger) – potentially impermeable surfaces and berms surrounding sites
- Exploration equipment
- On pad production equipment
  - Well head
  - Separation, cooling, pumping/compression
  - Storage tanks/ponds for produced water and fluids
  - Chemical tanks

Typical Exploration Pad



Typical Wellhead

Production Equipment

Production Equipment

Storage Tanks

Floodplain Requirements

- FEMA issued interim guidance in 2008
- Requirements for facilities within Special Flood Hazard Area
  - Floodway - proof of no rise
  - Buildings and structures (includes storage tanks) - elevate above base flood elevation (BFE) or floodproof
  - Electrical and mechanical equipment – elevate above (BFE) or floodproof
  - Hazardous and explosive material – protected to at least the 500-year event
  - All other federal, state, and local permits must be in place
  - Emergency plan for removing vehicles and movable equipment, adding floodproofing measures in the event of an imminent flood

Drainage/Flooding Issues

Summary of Flood and Stormwater Risks

- Cuts and fills generally balance
- Generally construct facilities at the same elevation
- Access Roads concentrate drainage flow
- Pads and access road generally constructed with road base
- Increased sediment discharge
- Dust (lots of traffic)
- Well Head (Floating debris)
- Bouyant equipment
- Separation of production equipment resulting in loss of fluids to the environment

Levee Protecting Pad

Lessons Learned

- Cannot realistically protect pads from flooding
- Floodproofing of equipment loss that could result in loss of fluids to the environment
- Protect equipment that can float or shear from production system
- Evaluated typical wellhead against impacts from floating debris and barges
- Need to carefully consider installing non-protected wellheads in areas of large floating debris (barge traffic)
- Well head must be shut in during floods or install downhole shut-off valves

Lessons Learned con’t

- Diffuse drainage through access roads must be reasonably maintained
- Mitigating increased runoff in floodplain areas is a challenge
- Maintaining erosion and sediment control an issue
- E and P operators are exempt from stormwater permitting not from the rules

Floodproofing

PROTECTIVE CAGE

ANCHOR

Floodproofing (continued)

REMOTE/ELEVATED PRODUCTION EQUIPMENT

ELEVATED SITE

Looking Forward

- Regulations are catching up to this fast paced development
- Operators are becoming more savvy about requirements – avoiding floodplains or designing for the requirements

Advancing Stormwater Quality in Denver

Why?

Advance Stormwater Quality

1. Green Community Perspective
2. Fully Built Out Dense Urban Landscape
3. Changing Regulatory Demands
4. Striving for Common Sense Cost Effective Sustainable Solutions

Driving the TimeLine

- CDOT and their Federal Mandates (2003)
  - "Give Me The Money Clause"
  - "You Want to Put That Where Clause"
- Proposed Federal EPA Post-Construction Rules (2009)
  - "Retrofit and Infiltrate Cha Cha Cha!!"
- Regional Storm Basin Pilot Project and Feasibility Analysis (2010)
  - "Give Us an Inch and We'll Treat a Mile^2 Model"

Pilot Project: Sustainable Stormwater

Administrative Pillar

- Policy Development
- Regulator Revision
- MS4 Program Revision
- WQ Accounting Prinicpals
- Fee Structure
- Reporting

Program Planning Pillar

- Capitial Program Development
- Multi-Year Funding
- Strategic Master Plan
- Existing Asset Inventory
- Reporting

Demonstration Site Pillar

- Pilot Project Site Selection
- Design
- Monitoring Plan
- Construction
- Cross Function Utilization
- Analysis
- Reporting

Water Quality Task Force

- CITY ATTORNEY'S OFFICE
  - *Legal Council*
- COMMUNITY PLANNING AND DEVELOPMENT
  - *Neighborhood Planning and Zoning*
- DENVER INTERNATIONAL AIRPORT
  - *Stakeholder*
- DEVELOPMENT SERVICES
  - *Regulating Development*
- ENVIRONMENTAL HEALTH
  - *Permit Compliance, County Health Department*
- MAYOR'S OFFICE
  - *GreenPrint Denver and Sustainability*
- PARKS AND RECREATION
  - *Landowner/Stakeholder*
- PUBLIC WORKS
  - *Infrastructure/Permit Management*

Stormwater Quality PROGRAM DEVELOPMENT

Denver's continuing efforts
to implement a new program
Like a walk in the woods

Hike in Rimrock Ponderosa Pines

Regional Stormwater Quality

- Permanent WQ BMP's required 2010
- Linear Projects constrained for BMP's
- Policy changes required for Regional Approach
- Program Initiatives
  - New Project Manager found in 1/2013
  - Rules and Regulations complete 3/2013
  - WQ Strategic Master Plan begun 2012
  - Regional Pond Project 60% Design Complete

A New Program is like a Pine Tree Growing on a Rock

- Water Quality Task Force
  - Multi-Department Mayor's Office, EH, Parks, CPD, PW, Legal, OED….
- Twice monthly meetings to address program initiatives
  - Educational
  - Policy Discussion
  - Strategy
  - Visioning: Setting Goals and Expectations

It Needs Some Help to Grow

- Management leadership
- Staff commitment
- Project Funding
- Partners – CDOT, RTD, UDFCD, CDPHE, DPS

Lessons Learned

- "NO" was popular response to a question
- Stormwater quality is a City initiative
- It takes time to build a team
- It takes time for a team to act
- Management has to be a champion
- Policy is harder than Projects

Surprise view of Harney Peak

7,244 feet – Highest point between the Rockies and Alps

Stormwater Quality GIS MAPPING INVENTORYING BMPs

Project Objectives

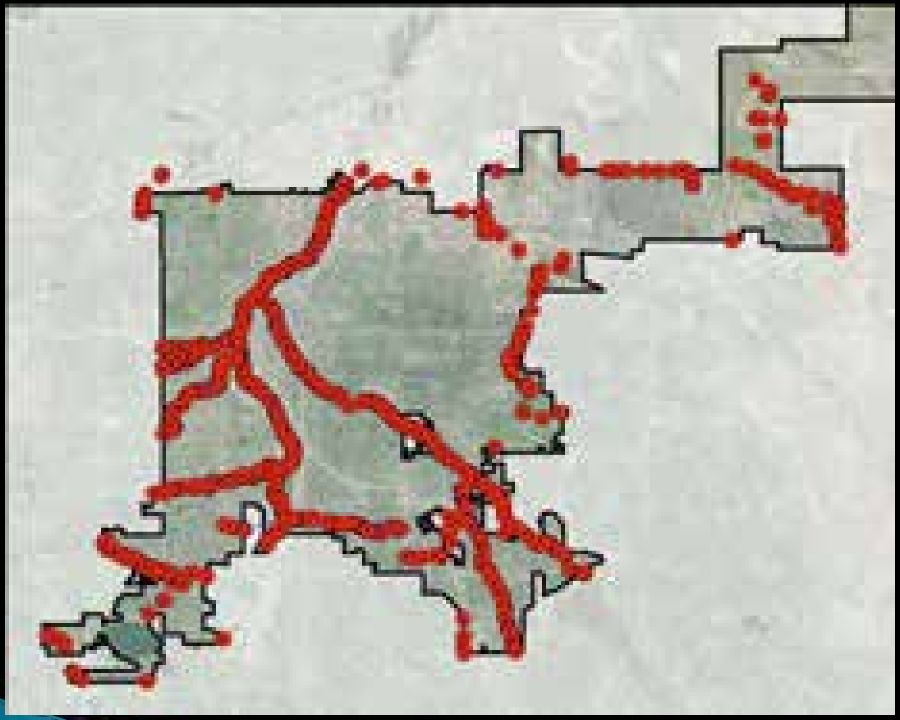
- Inventory all BMPs within the City
  - *Public, private, CDOT, UDFCD, and RTD*
- GIS-based tool to complement the work on regulatory compliance (MS4)
- Better data management practices
- Improve BMP maintenance procedures

Inventory and Mapping Process

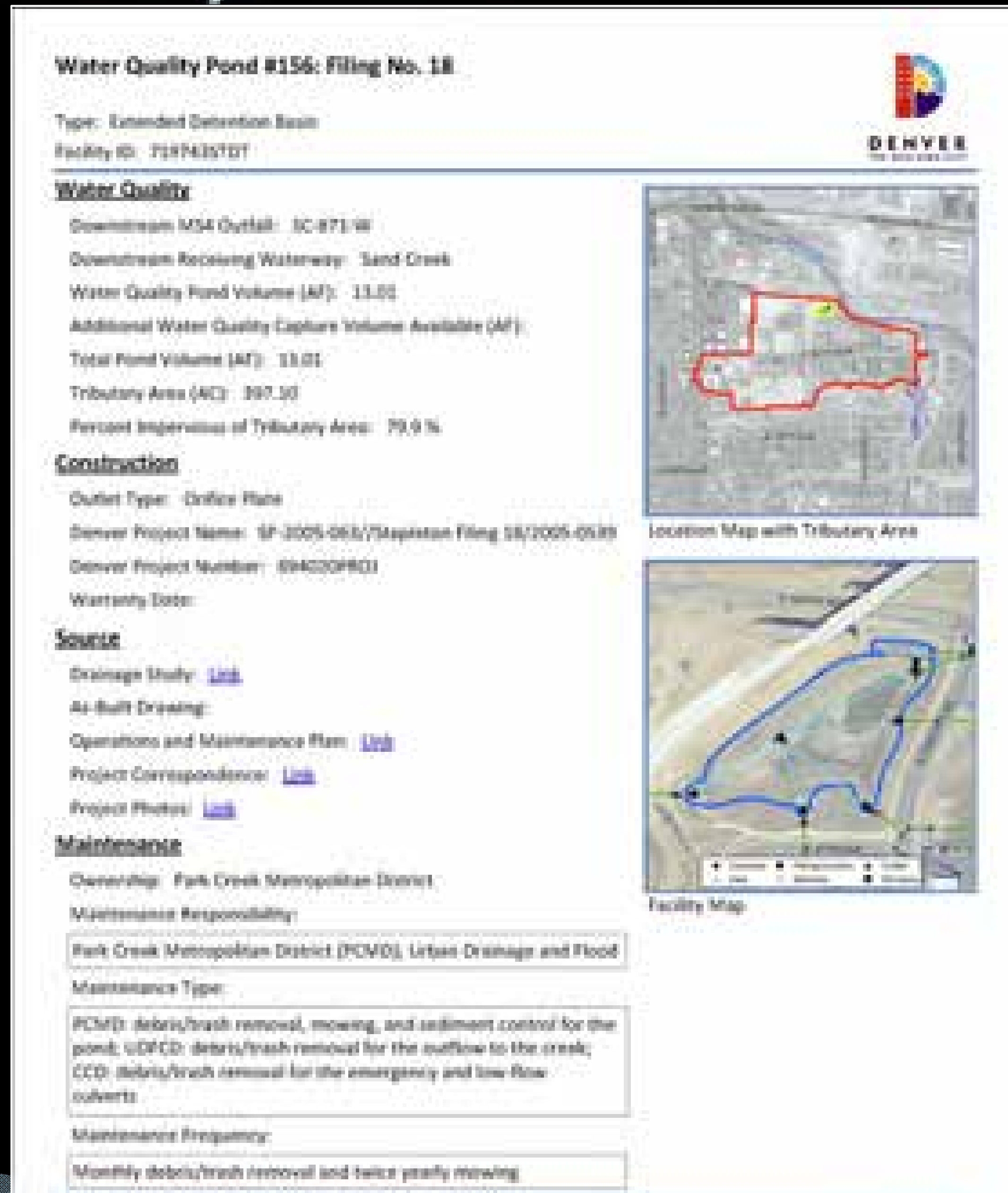
- **Modify/Create WQ pond GIS data**
  - Drainage studies & as-built dwgs
  - Facility inspection photos
  - 2012 aerial photography
- **GIS Attributes**
  - Pond vol., WQ vol.
  - Tributary area
  - Maintenance responsibilities & procedures
  - Links to source documents
- **GIS Mapping and Analysis**
  - Map of treated areas
  - Identify underserved areas
  - Locate potential WQ facilities

MS4 Basin Delineation

- 1,218 MS4 outfalls citywide
- Tributary area supports MS4 permitting process
- Land use summary enables pollutant loading calcs



Prototype WQ Facility Datasheet



Water Quality Pond #156: Filing No. 18

Type: Extended Detention Basin

Facility ID: 7197435707

DENVER

Water Quality

Downstream MS4 Outfall: SC-871-W

Downstream Receiving Waterway: Sand Creek

Water Quality Pond Volume (AF): 13.01

Additional Water Quality Capture Volume Available (AF):

Total Pond Volume (AF): 13.01

Tributary Area (AC): 397.10

Percent Impervious of Tributary Area: 70.9 %

Construction

Outlet Type: Orifice Plate

Denver Project Name: SP-2005-063/Stapleton Filing 18/2005-0539

Denver Project Number: 094020PROJ

Warranty Date:

Source

Drainage Study: Link

As-Built Drawing:

Operations and Maintenance Plan: Link

Project Correspondence: Link

Project Photos: Link

Maintenance

Ownership: Park Creek Metropolitan District

Maintenance Responsibility:

Park Creek Metropolitan District (PCMD), Urban Drainage and Flood

Maintenance Type:

PCMD: debris/trash removal, mowing, and sediment control for the pond; UDFCD: debris/trash removal for the outflow to the creek; CCD: debris/trash removal for the emergency and low-flow culverts

Maintenance Frequency:

Monthly debris/trash removal and twice yearly mowing

Location Map with Tributary Area

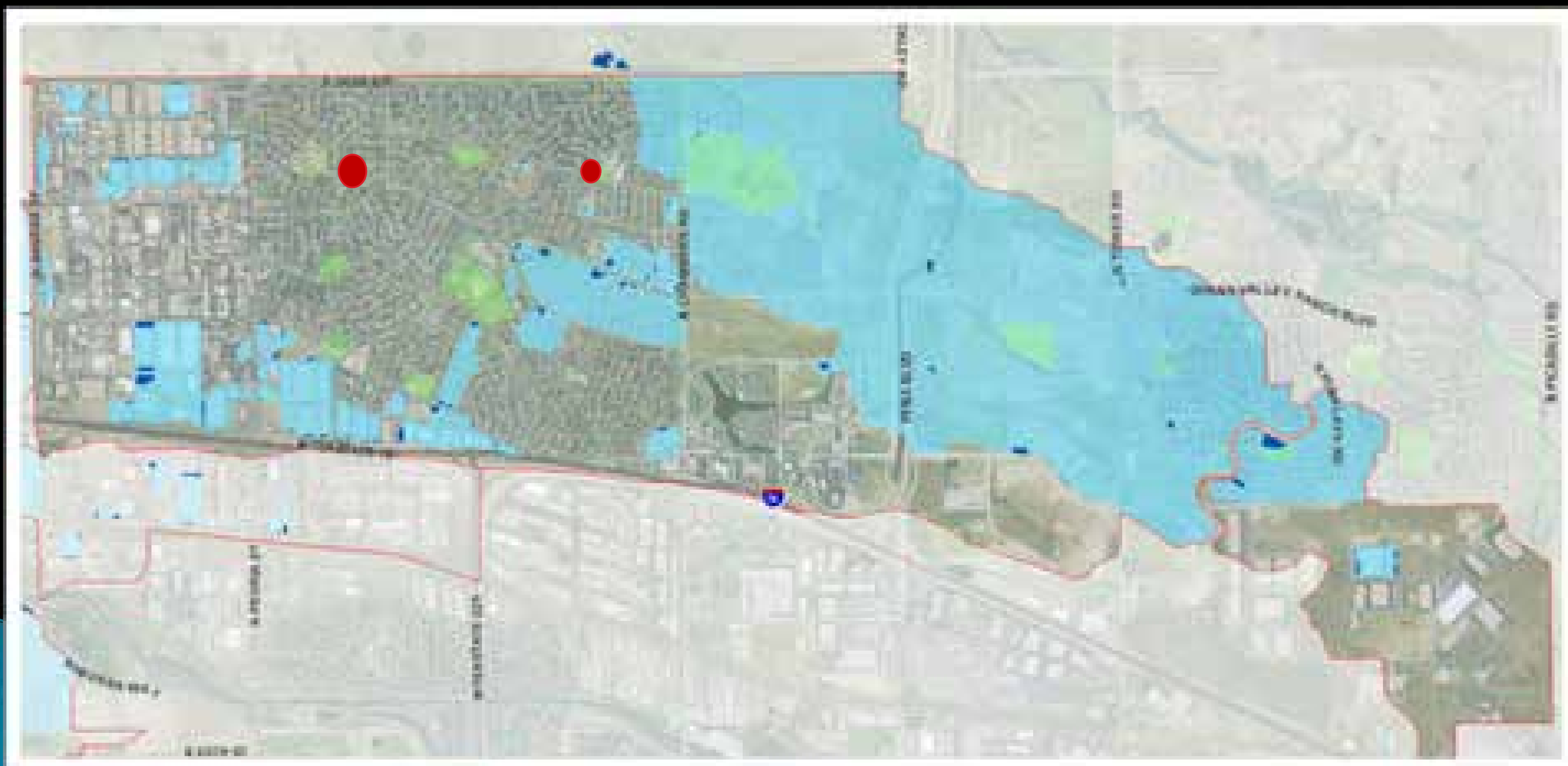
Facility Map

WQ Treatment – Stapleton

- WQ prototype
- Recently constructed
- ~100% of developed area treated

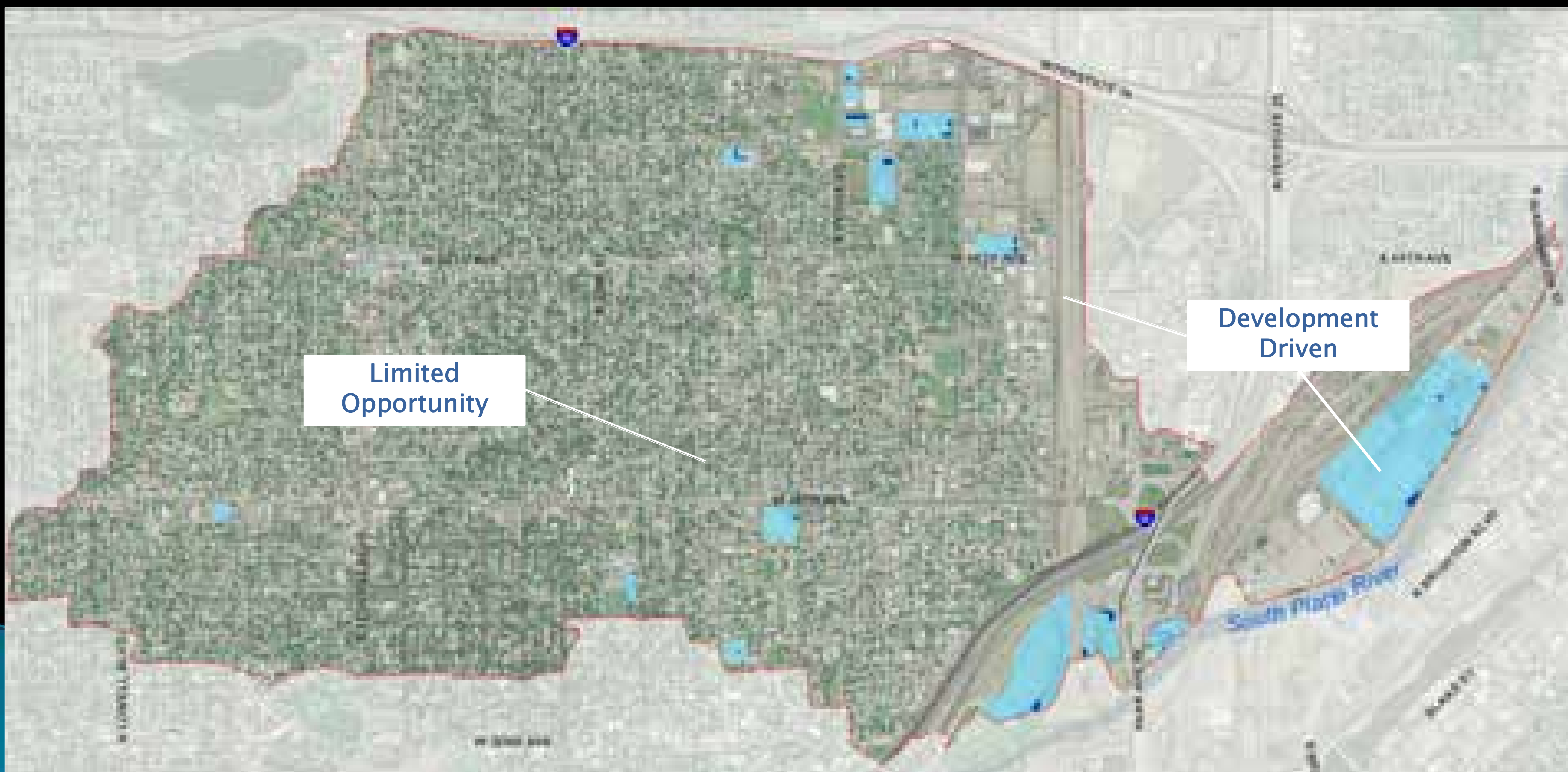
WQ Treatment – Montbello

- ~61% of area treated for WQ
- Regional facility are managing most of the WQ
- Opportunities for additional facilities



WQ Treatment (Infill)

- ~2.9% of area treated for WQ
- Fully developed-limited opportunities for regional WQ treatment
- Redevelopment will bring incremental improvements

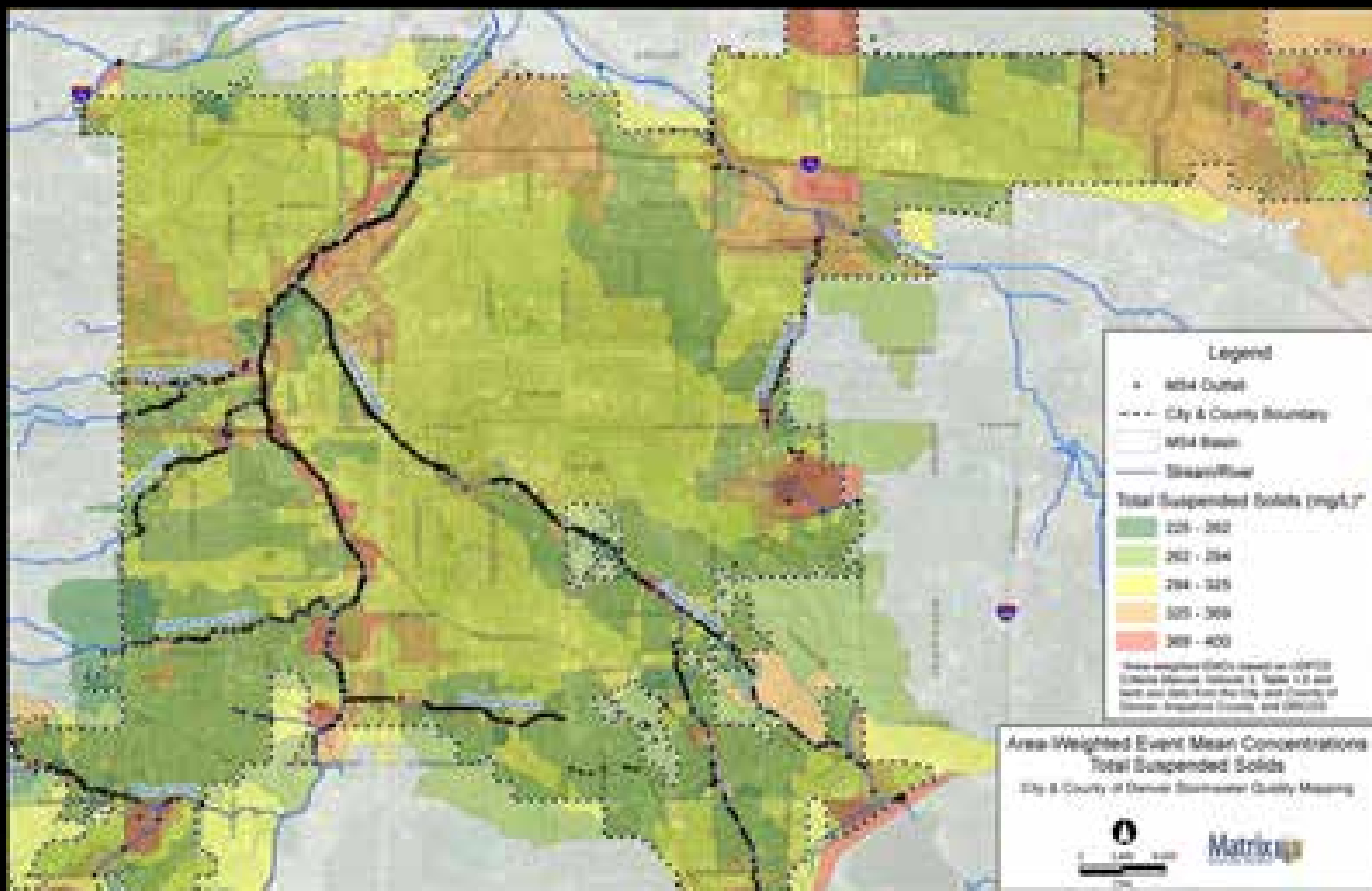


Pollutant Loading Analysis

- Loading Estimates for 1,218 MS4 Outfalls
- GIS-based Approach
  - MS4 basin boundaries and outfalls
  - Land use data
  - Impervious surfaces
  - Event Mean Concentrations from UDFCD Criteria Manual
- Area-weighted EMCs calculated for MS4 Basins

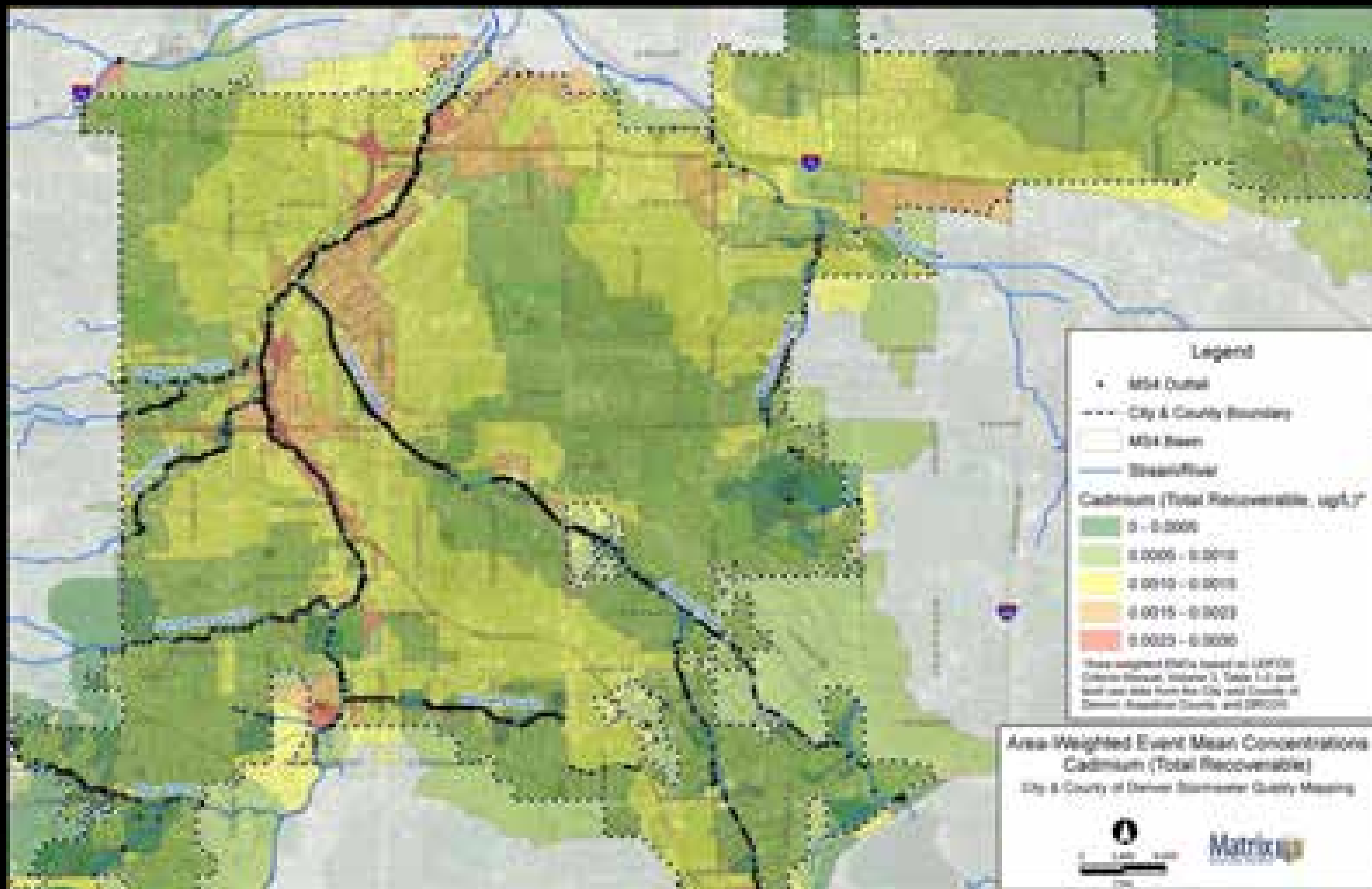
Pollutant Loading Analysis

Area-weighted EMCs – Total Suspended Solids



Pollutant Loading Analysis

Area-weighted EMCs - Cadmium



BMP Maintenance

- Maintenance Responsibilities
  - o *Roles are not well defined for some BMPs (Public Works, Parks, UDFCD)*
- Maintenance Frequency and Procedures
  - o *Vary widely by owner, location and BMP type*
- Link BMP's to a Work Order
  - o *BMP maintenance management system*

BMP Maintenance

Develop operations and maintenance tables specific to each BMP:

- o Responsibility
- o Frequency
- o Procedures
- o Inspection protocols

QUESTIONS?

Please take your seat. You will not have time to read the paper during next 30 min.

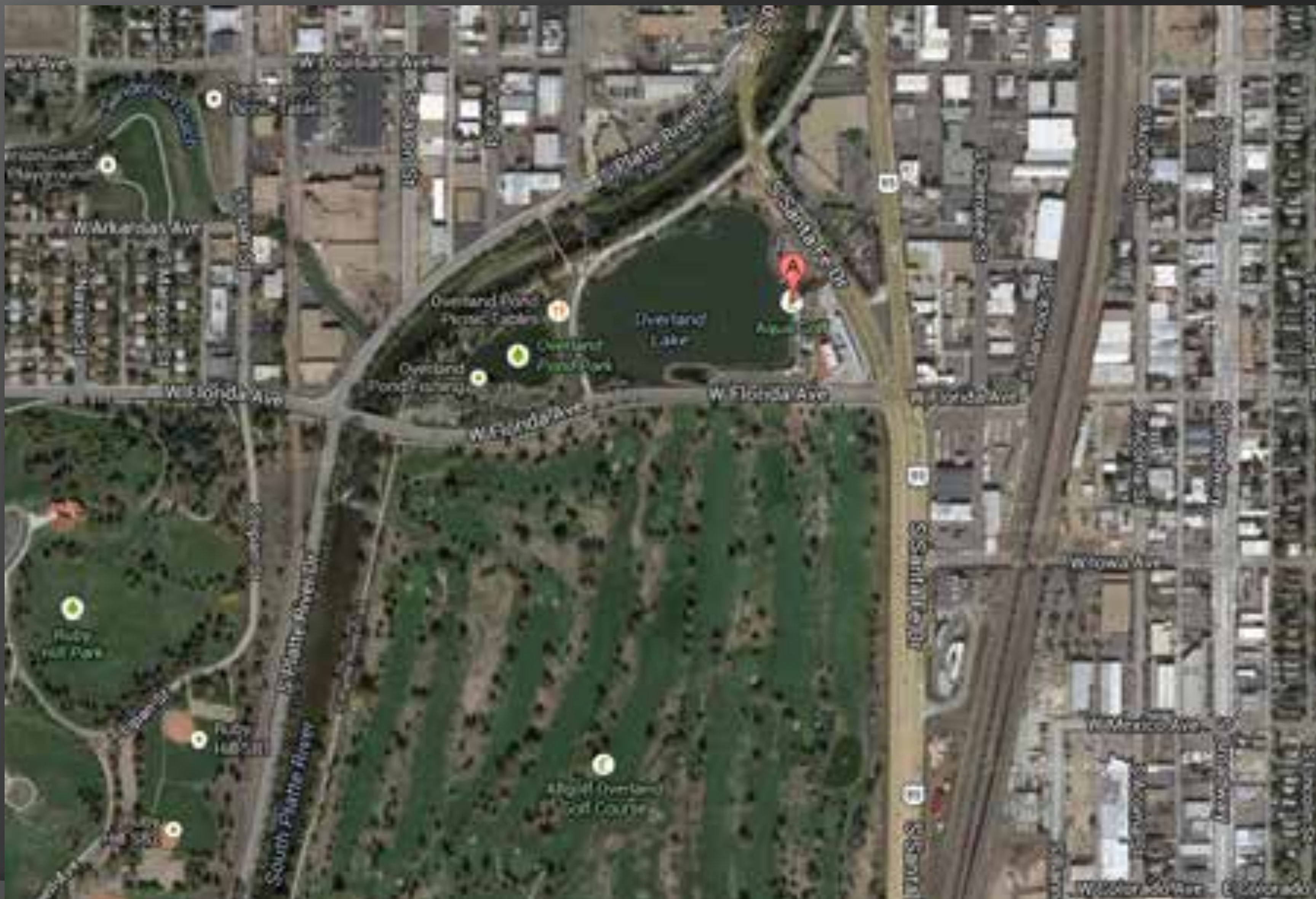
Trash Maintenance at Urban Outfalls

1-block SW of Federal & Alameda - photo from 2010

by Saeed Farahmandi & Bruce Uhernik

1-block SW of Federal & Alameda - photo from 2010

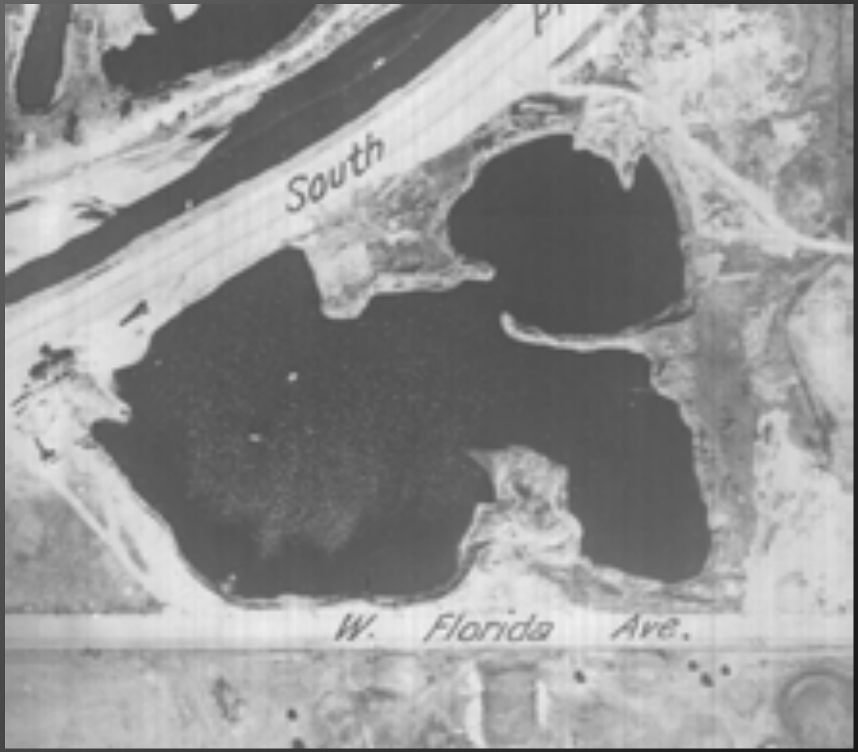
Overland Lake



Aqua Golf


DRIVING RANGE
SMALL
LARGE
X-LARGE
MINIATURE GOLF
ADULTS
JUNIORS
SECOND ROUND
ADULTS
JUNIORS

History



1919: City purchases Overland Park

a. Gravel Pit

b. "Great riverside bathing beach…"

c. Athletic fields

"…where the youth of the nation may secure the athletic development that made the American soldier the wonder and admiration of the Europeans…."

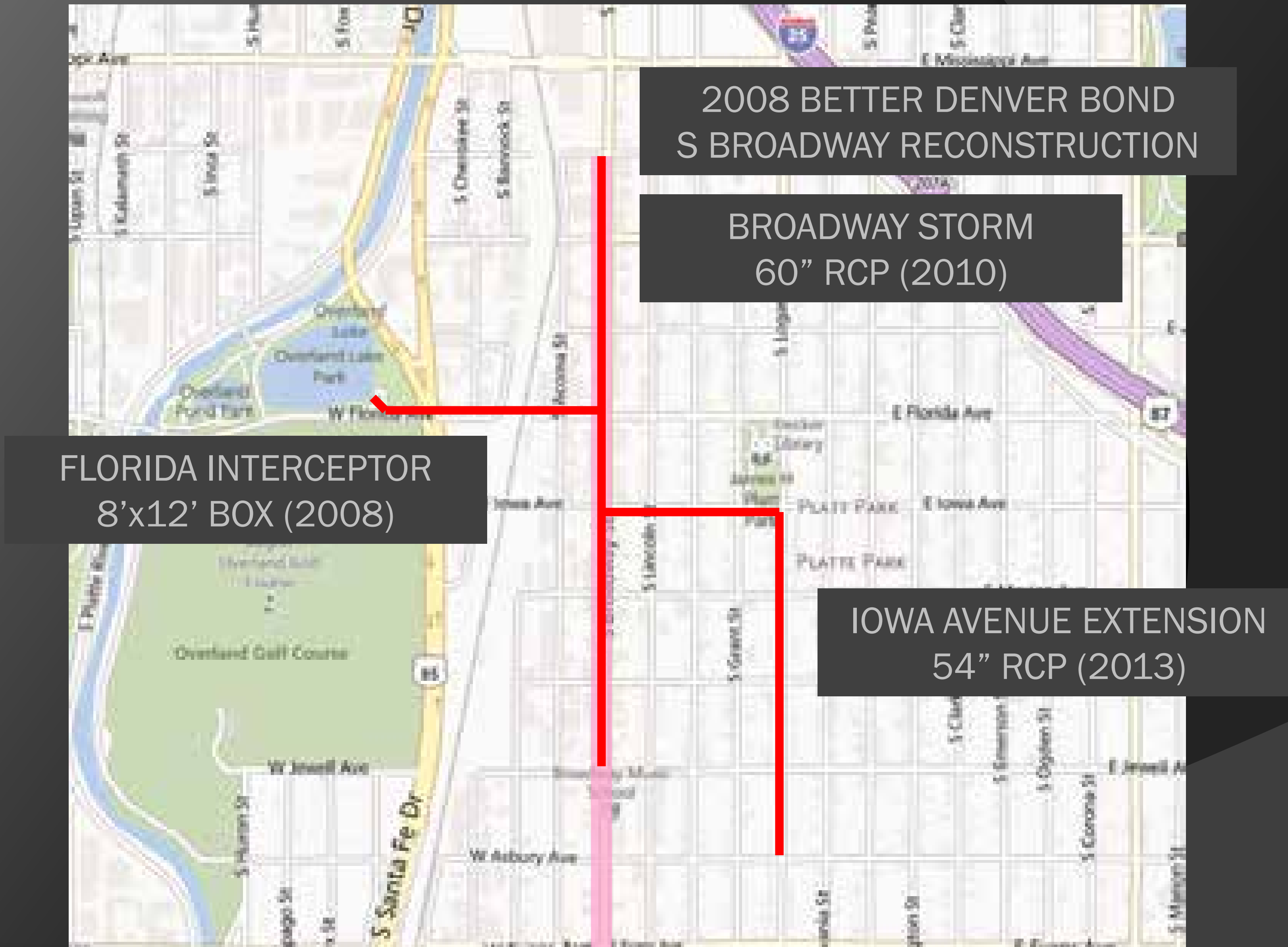
Irrigation Facility…

Photo from 2000

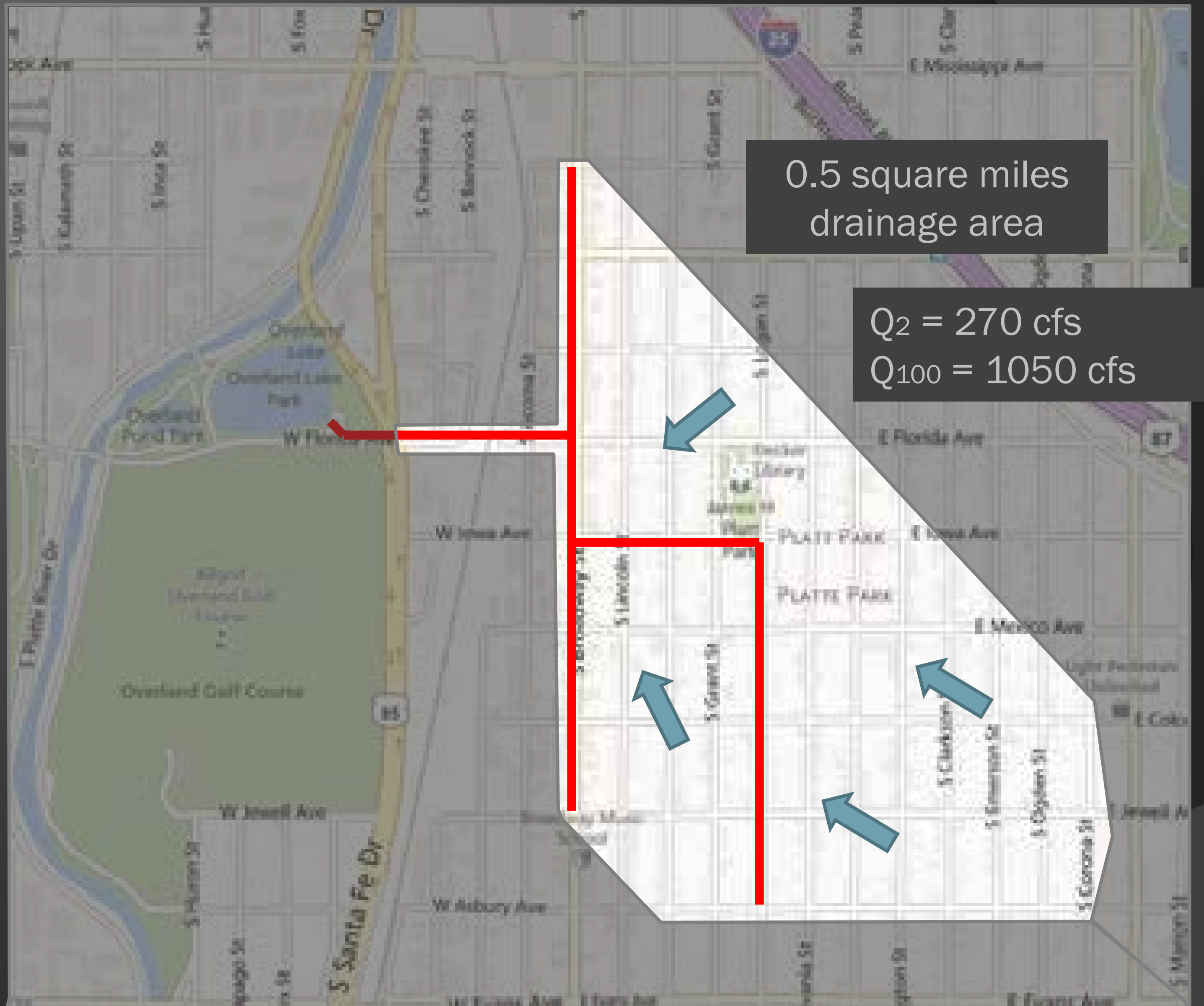
....To Multi Purpose Facility

Photo from 2012

South Broadway Projects



Drainage Area



Overland Lake Forebay

Trash Problem

June 2012

Types of Trash

Parks Netting

June 2012

In Action

In Action

After Storm

Wastewater Plan

August 2012

Test

August 2012

Floatable Rail

October 2012
Mock Up & Test
Wastewater Facility

Testing

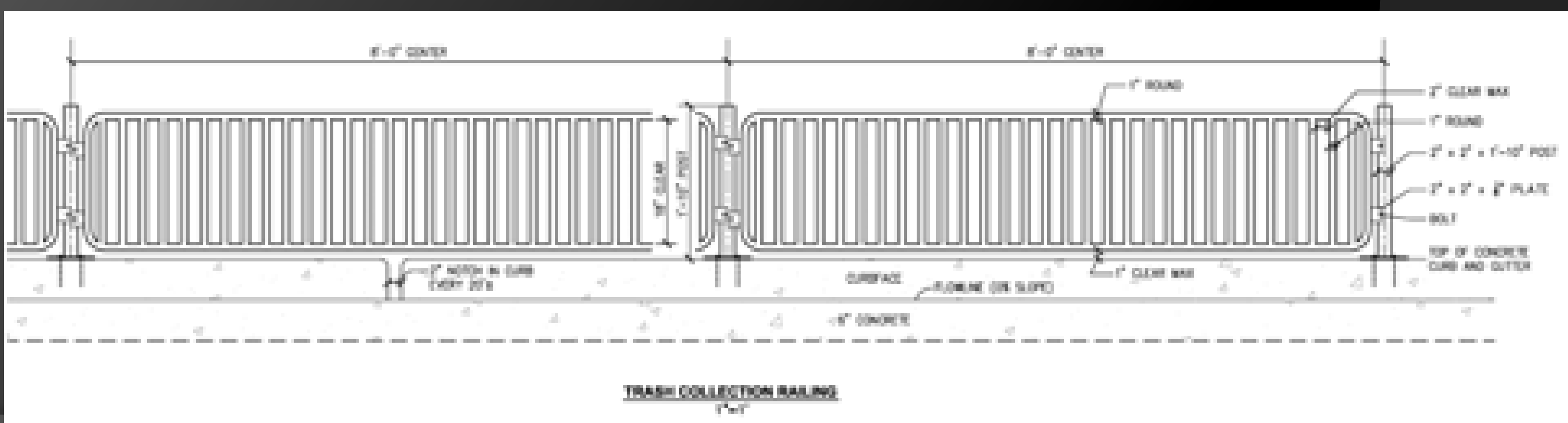
October 15, 2012

WINNER IS…

Fixed Rail

Specifications

- 1” round tube steel
- 18” x 2” openings
- Posts every 8’



Construction

March 2013

Construction

March 2013

April 2013

Construction

April 17, 2013

April 26, 2013

Not finished....

May 8, 2013 - 0.4” rain

Concrete

May 15, 2013

1% Project Art

New Tenants

Railing Installation

230 LF installed

July 3, 2013

Complete ?

July 8, 2013

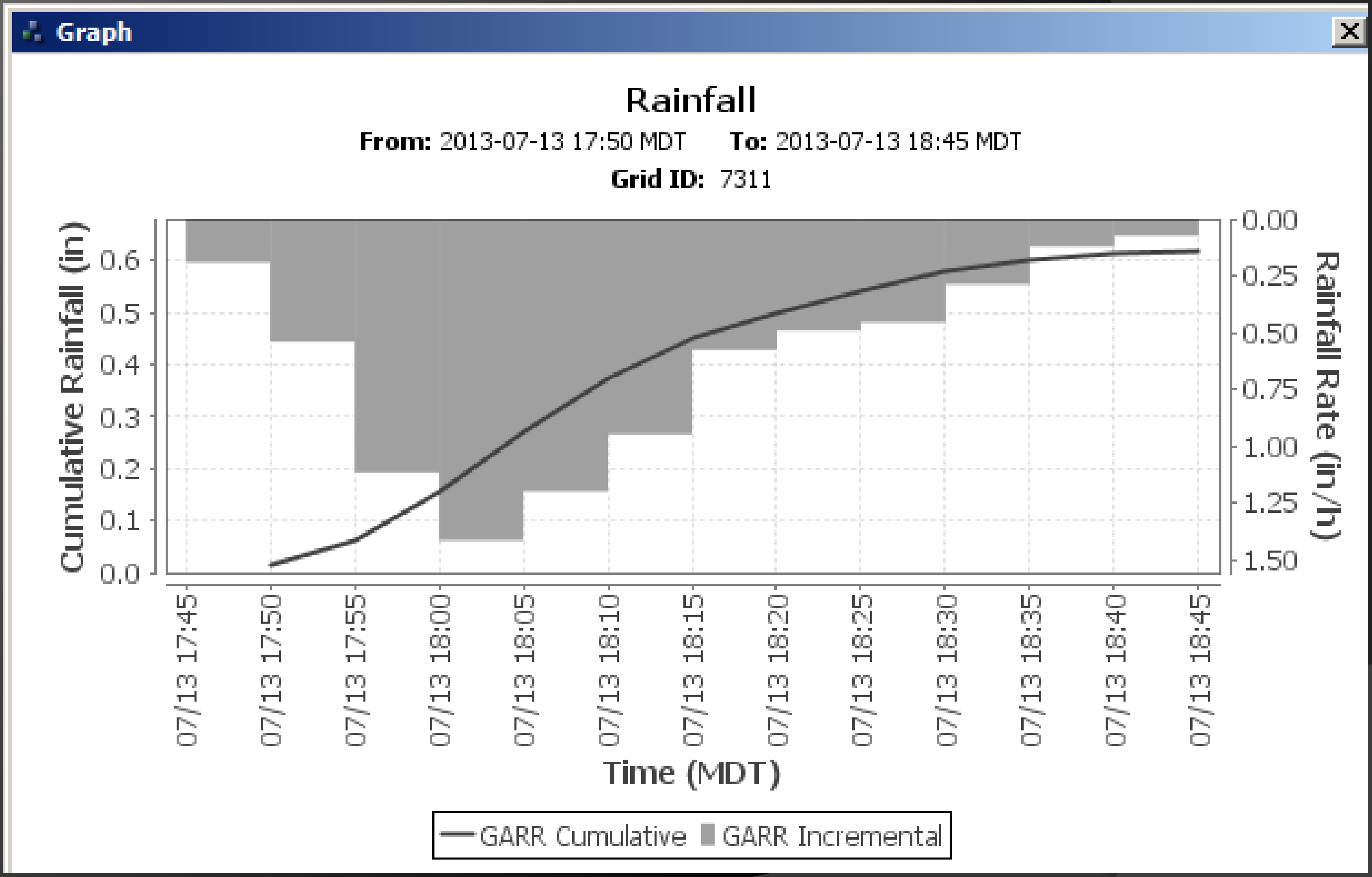
The Gate

July 12, 2013

July 12th

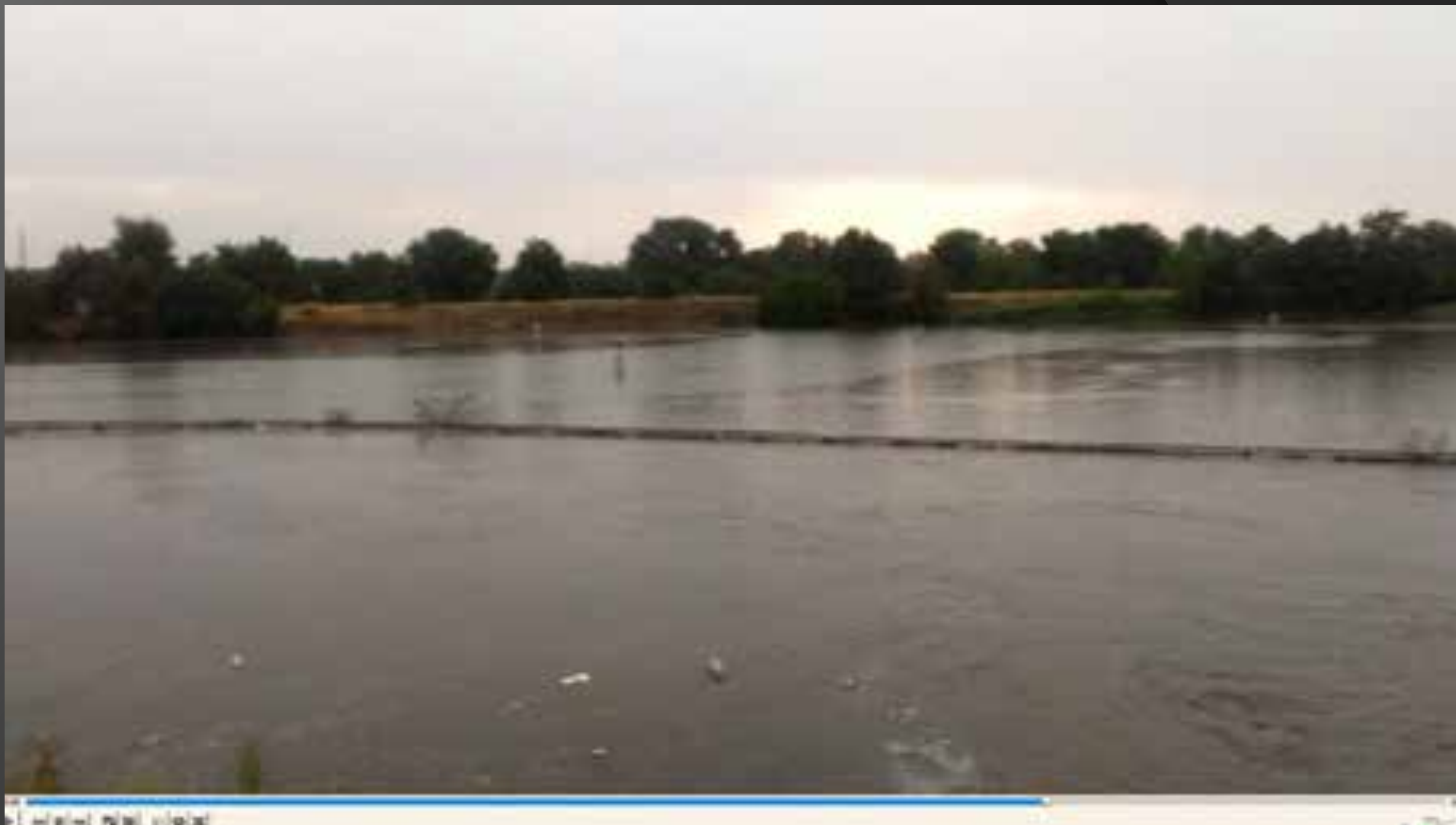
0.04” rain

July 13th



Graph
Rainfall
From: 2013-07-13 17:50 MDT To: 2013-07-13 18:45 MDT
Grid ID: 7311
Cumulative Rainfall (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Rainfall Rate (in/h)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
07/13 17:45
07/13 17:50
07/13 17:55
07/13 18:00
07/13 18:05
07/13 18:10
07/13 18:15
07/13 18:20
07/13 18:25
07/13 18:30
07/13 18:35
07/13 18:40
07/13 18:45
Time (MDT)
GARR Cumulative
GARR Incremental

July 13th



July 13th

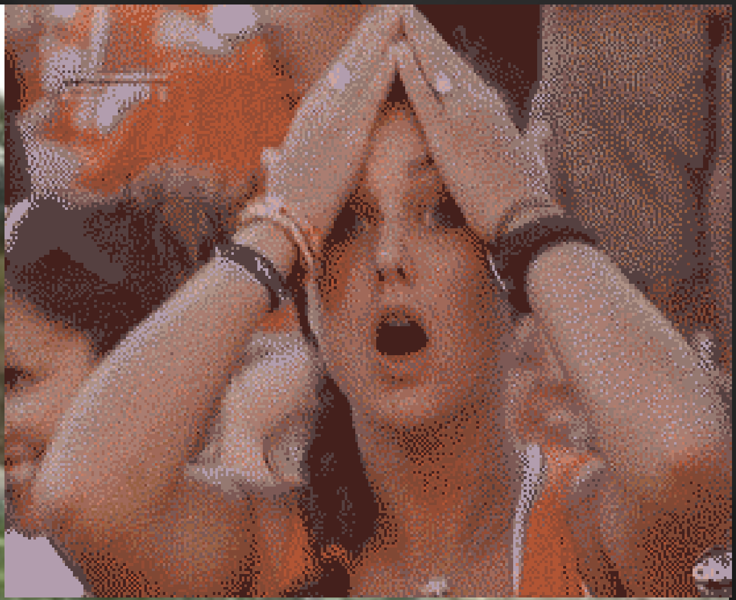
S Logan St

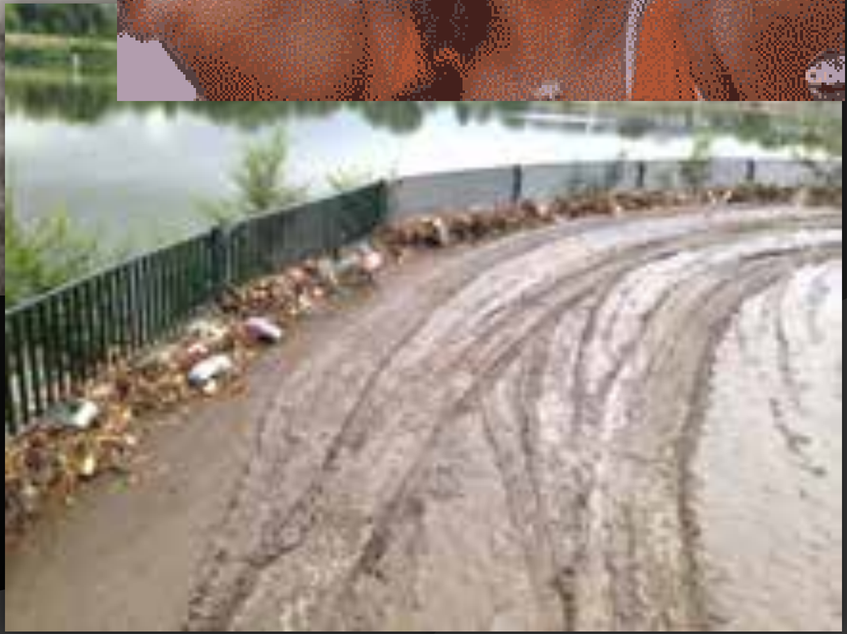
July 13, 2013

S Logan St

July 14, 2013

July 14th





Debris




Debris

Cleanup

July 14, 2013

Cleaned Up

July 14, 2013

Boat Ramp

July 13, 2013

Boat Ramp

July 13, 2013

July 14, 2013

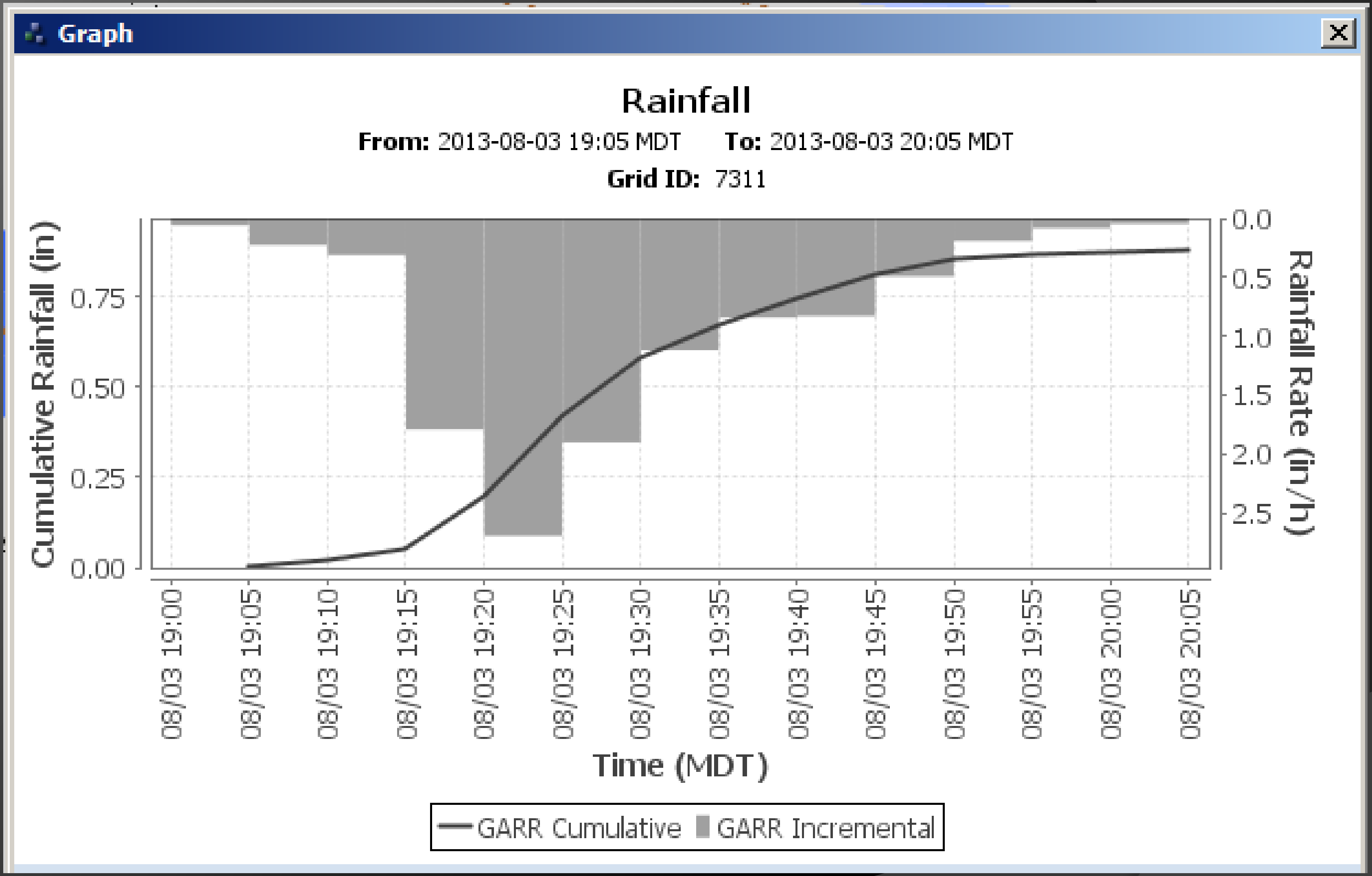
Additional Rip Rap

July 18, 2013

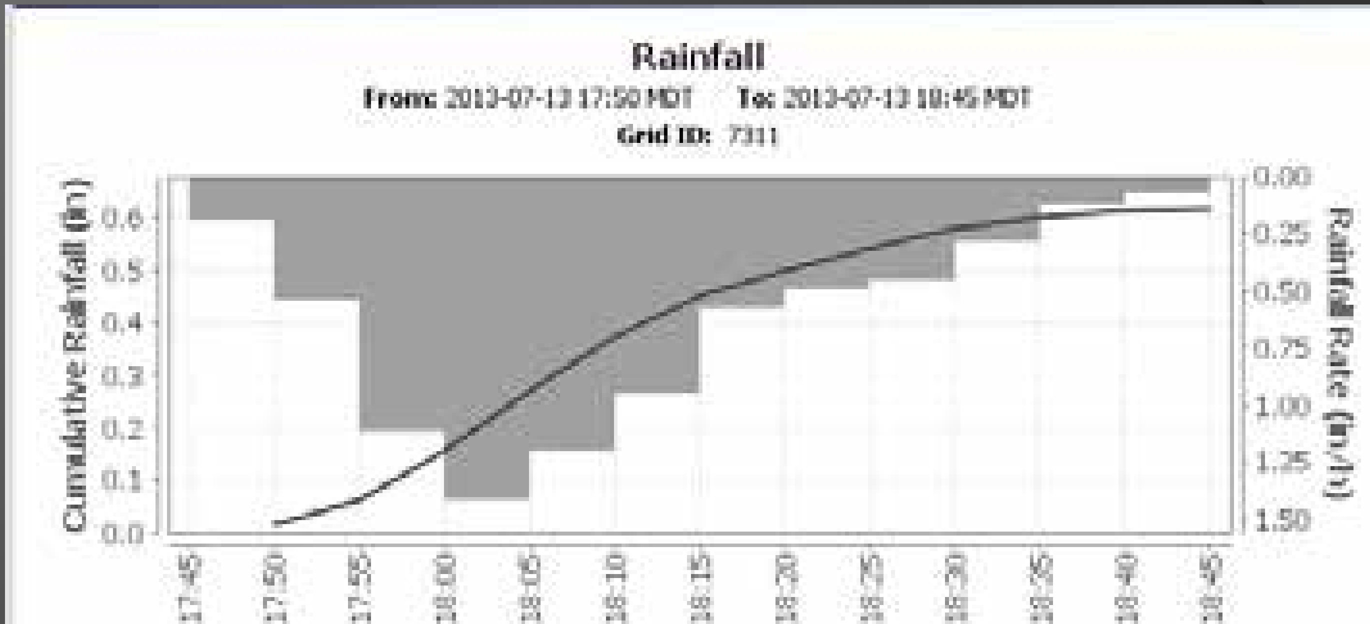
Still a Boat ramp?

Still a Boat ramp?

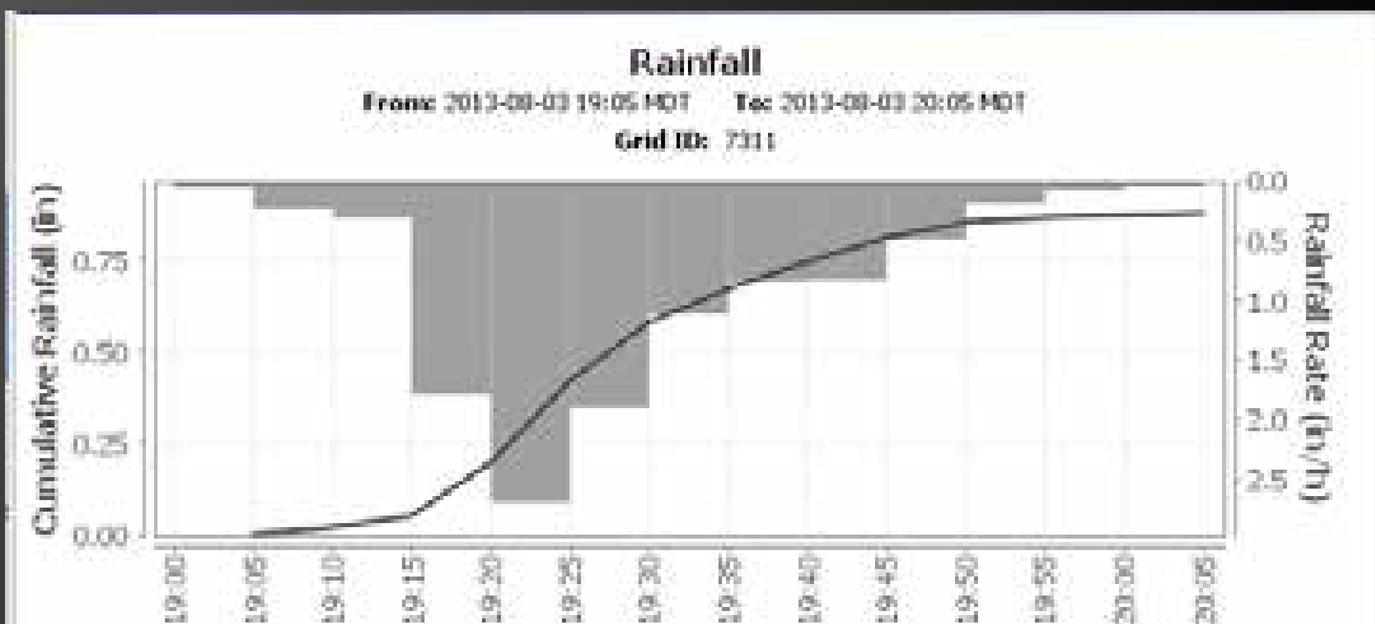
August 3rd



Graph
Rainfall
From: 2013-08-03 19:05 MDT To: 2013-08-03 20:05 MDT
Grid ID: 7311
Cumulative Rainfall (in)
0.75
0.50
0.25
0.00
Rainfall Rate (in/h)
0.0
0.5
1.0
1.5
2.0
2.5
08/03 19:00
08/03 19:05
08/03 19:10
08/03 19:15
08/03 19:20
08/03 19:25
08/03 19:30
08/03 19:35
08/03 19:40
08/03 19:45
08/03 19:50
08/03 19:55
08/03 20:00
08/03 20:05
Time (MDT)
GARR Cumulative
GARR Incremental



July 13th



August 3rd

August 4th

August 4th

Boat Ramp

August 4, 2013

Boat Ramp

Boat Ramp

August 23, 2013

Considerations for Next Site

-Bar spacing

-Post spacing

-Thickened Edge

-Rip-rap sizing

-Access Points

Barnum Park Forebay

Barnum Park

Barnum Park Trash

Forebay Cleaning

Forebay Cleaning

Stockpile

Uh-Oh

Clean Up

Rail Construction – underway

RECAP

REDUCING E. COLI LEVELS IN DRY WEATHER DISCHARGES FROM DENVER'S MS4:
HOW EFFECTIVE ARE SYSTEM MAINTENANCE BMPS AFTER FOUR YEARS OF IMPLEMENTATION?

Jon Novick
Denver Department of Environmental Health

Background

- 1998 – South Platte Segment 14 placed on 303(d) List as impaired by E. coli
- 2007 – South Platte Segment 14 E. coli TMDL Issued
  - Wasteload allocation for Denver's MS4
    - 126 CFU / 100 mL in dry weather discharges
- 2009 – Wasteload Allocation implemented into Denver's MS4 Permit

MS4 Permit Requirements

- Section 1.B.1.f - Special Section on E. coli
  - Monitoring to identify outfalls of concern - "Priority Outfalls"
  - Implement system maintenance program
  - Mark storm sewer inlets
  - Education and outreach
  - Implement other BMPs as needed
  - Conduct annual analysis of monitoring data
- 10 Year Compliance Schedule

System Maintenance Program

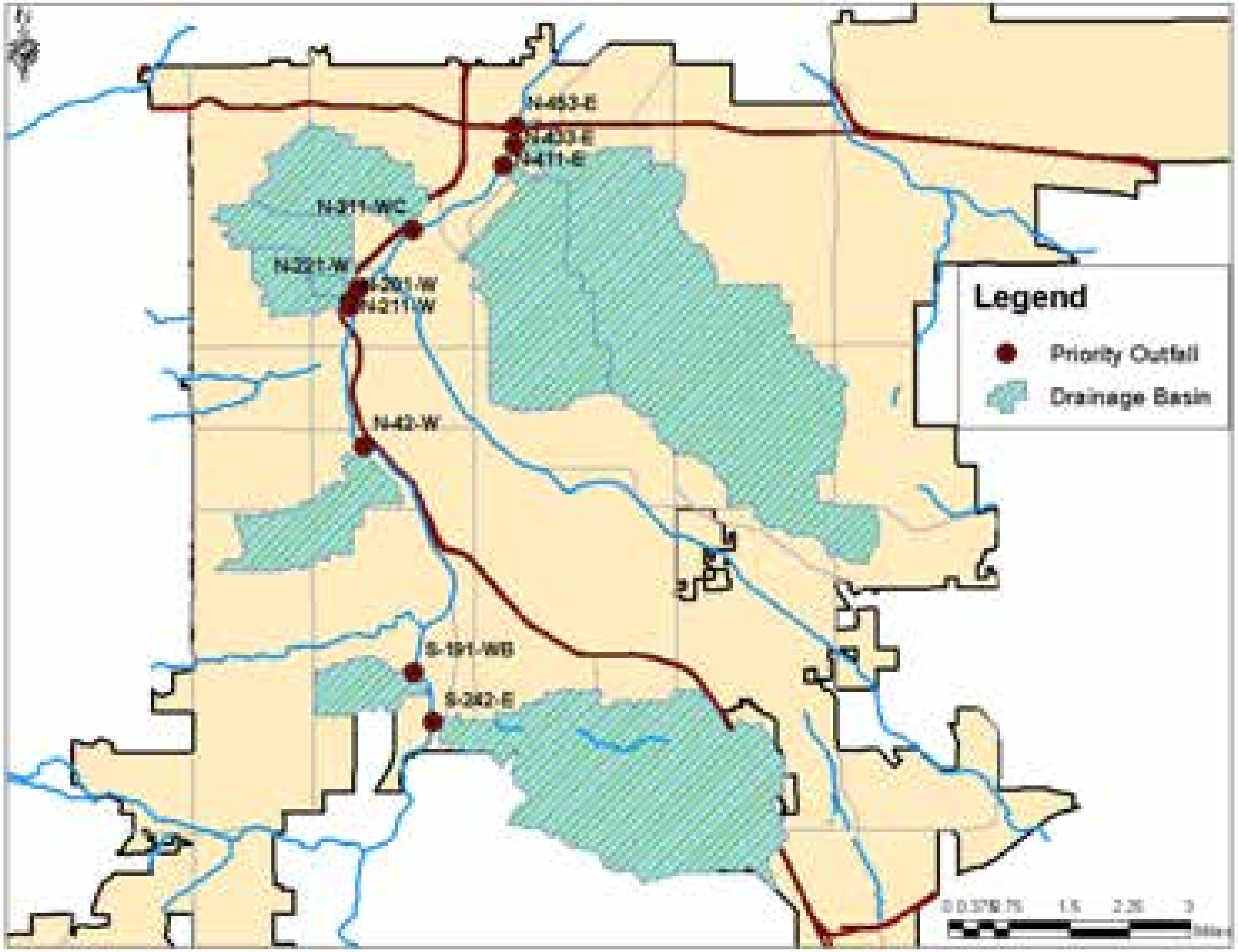
- Clean storm and sanitary sewers
- Eliminate illicit connections to the storm sewers
- Identify and eliminate cross connections between the storm and sanitary sewers
- Repair damaged sanitary infrastructure and disconnected taps

Questions to Answer

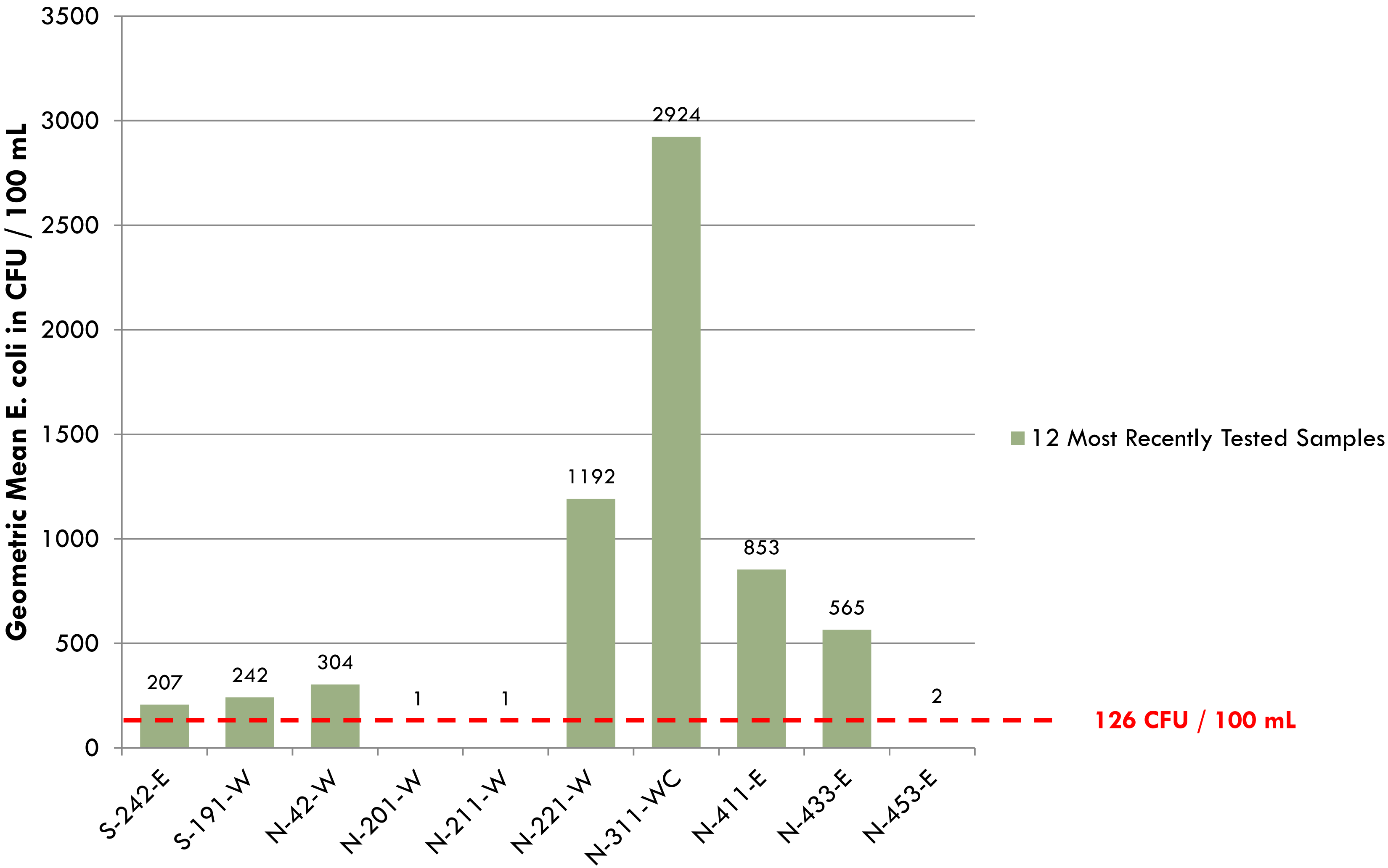
- Do dry weather discharges from storm sewers meet the E. coli wasteload allocation?

- Are mitigation efforts effective at reducing E. coli levels in dry weather discharges from storm sewer outfalls?
  - Which mitigation techniques are most effective at reducing E. coli levels in dry weather discharges?

Which Outfalls are Priorities?

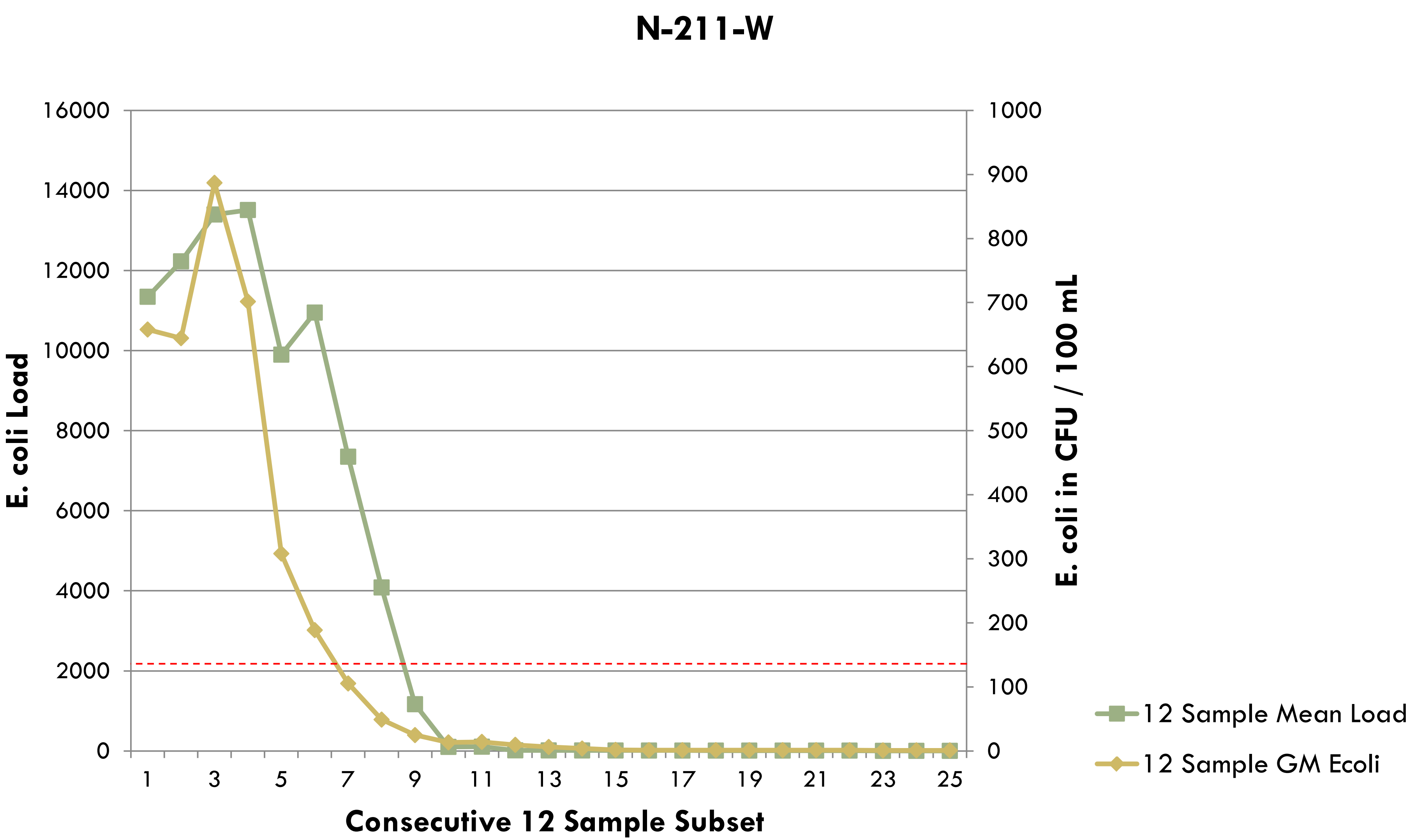


Do E. Coli Discharges Meet the WLA?

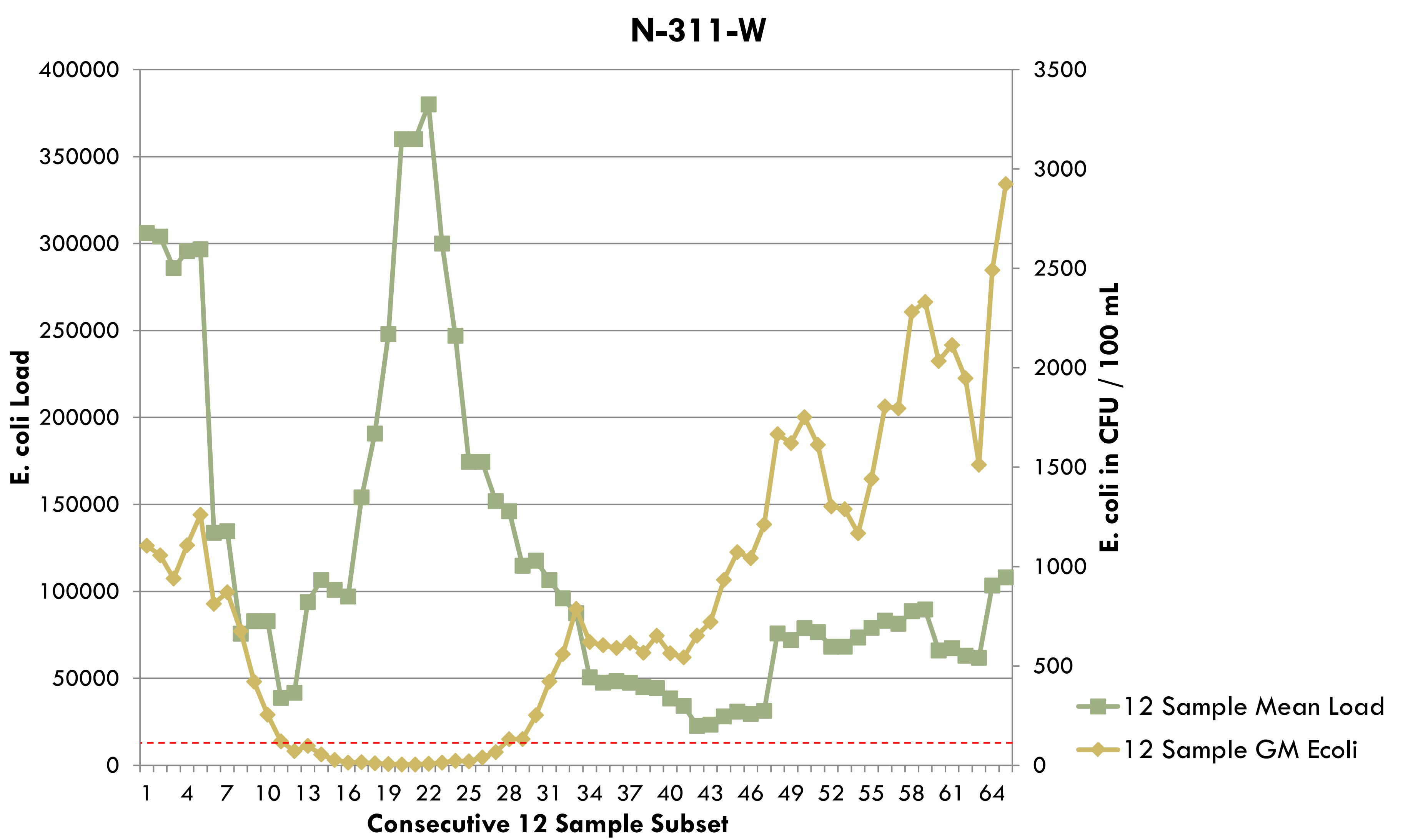


Do BMPs Reduce E. coli levels in Discharges?

Time Series Plots



Time Series Plots



Statistics

	Before Implementation		After Implementation		
	Number of Samples	**Median E. coli (CFU / 100 mL)**	**Number of Samples**	**Median E. coli (CFU / 100 mL)**	**p**
S-242-E	37	200	0	NA	NA
S-191-W	46	240	3	230	0.8380
N-42-W	15	510	9	230	0.2828
N-201-W	**15**	**660**	**38**	**1**	**0.0378**
N-211-W	**13**	**440**	**36**	**1**	**0.0024**
N-221-W	**15**	**3600**	**36**	**710**	**0.0013**
N-311-W	**17**	**6600**	**6**	**810**	**0.0017**
N-411-E	9	1090	60	465	0.4275
N-433-E	17	2700	55	900	0.1264
N-453-E	**25**	**140**	**20**	**1**	**0.0000**

Summary of Findings

		E. coli				E. coli Load	
	Time Series	M-W	Trend		Time Series	M-W	Trend
S-242-E							
S-191-W					X		X
N-42-E							
N-201-W	X	X			X		
N-211-W	X	X			X	X	
N-221-W		X	X		X	X	
N-311-W		X			?	X	
N-411-E							
N-433-E	X		X		X		X
N-453-E	X	X			X	X	

Which BMPs are Most Effective?

- Not able to evaluate current set of BMPs
  - Simultaneous implementation

Conclusions &Recommendations

- Infrastructure Maintenance BMPs
  - Implementation has been successful
    - Recommend continued implementation
  - Many significant challenges remain
    - Recommend considering other options in some basins
      - Focus on biofilm removal

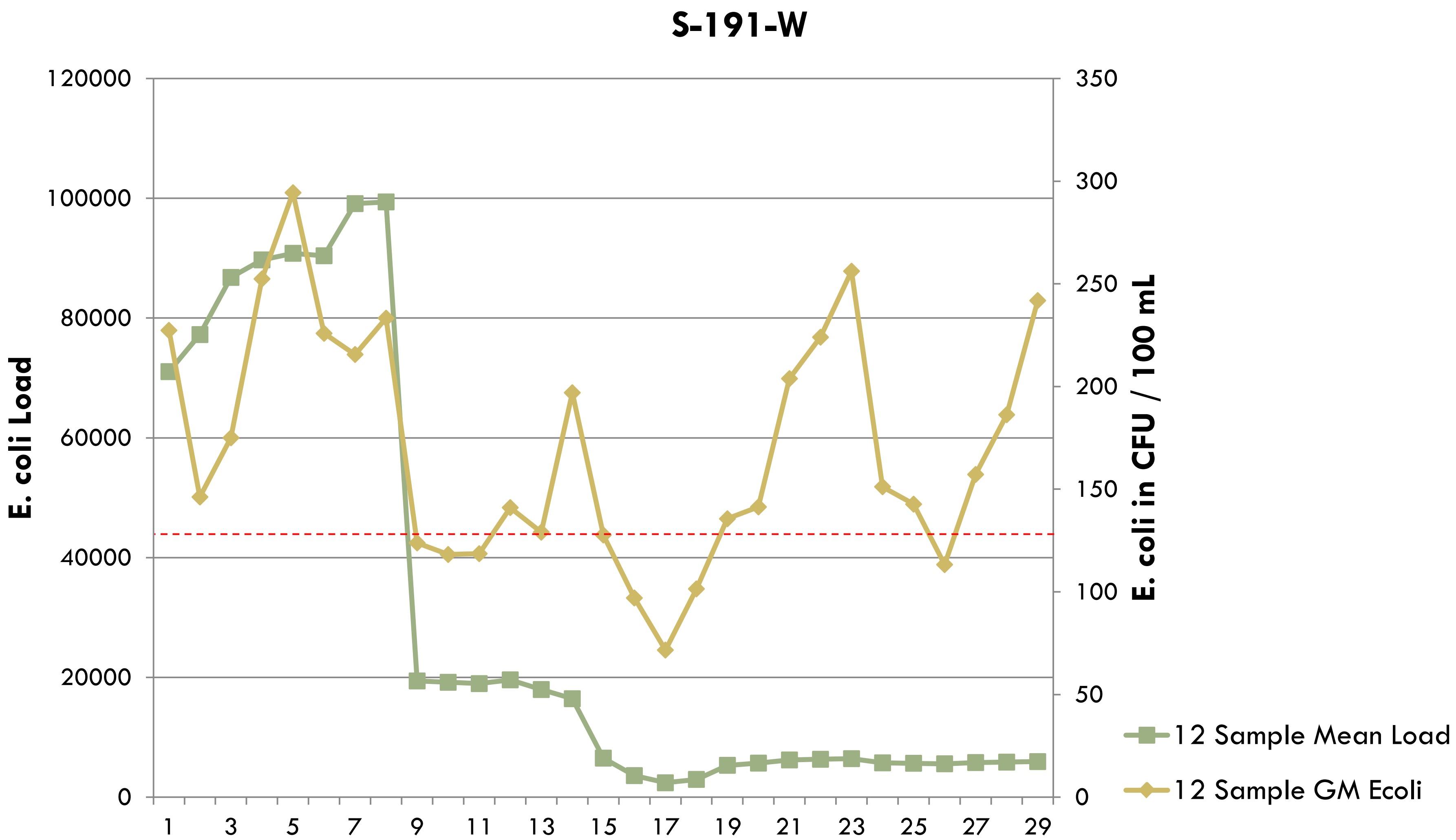
Questions?

Jon Novick
Denver Dept. of Environmental Health

jon.novick@denvergov.org
720/865-5468

Extra Slides

E. coli Load Improved



TUNNELING 101

Dave Skuodas – Urban Drainage & Flood Control District

Nate Soule – Brierley Associates

Brenden Tippets – BT Construction

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

BRIERLEY ASSOCIATES
Creating Space Underground

BTC™
GENERAL CONTRACTORS
HENDERSON, COLORADO


Byesville

Tunneling Basics

- Tunnel = Underground excavation longer than it is wide

Tunneling Basics

- Tunneling = Construction of a tunnel without disturbance of the ground surface. Also, excavation method relies on manned entry

Tunneling Basics

- Trenchless = Remote excavation of a tunnel, no manned entry

Ground Conditions

- Described using the Tunnelman’s Classification System (originally developed by Terzaghi)

- *FIRM* – hard lean clay

- *RAVELING* – moist, dense sand

Ground Conditions

- *SQUEEZING – soft to medium clay under pressure (not common in CO)*

- *RUNNING – dry sand*

Ground Conditions

- *FLOWING – saturated sand*

- *SWELLING – plastic clay*

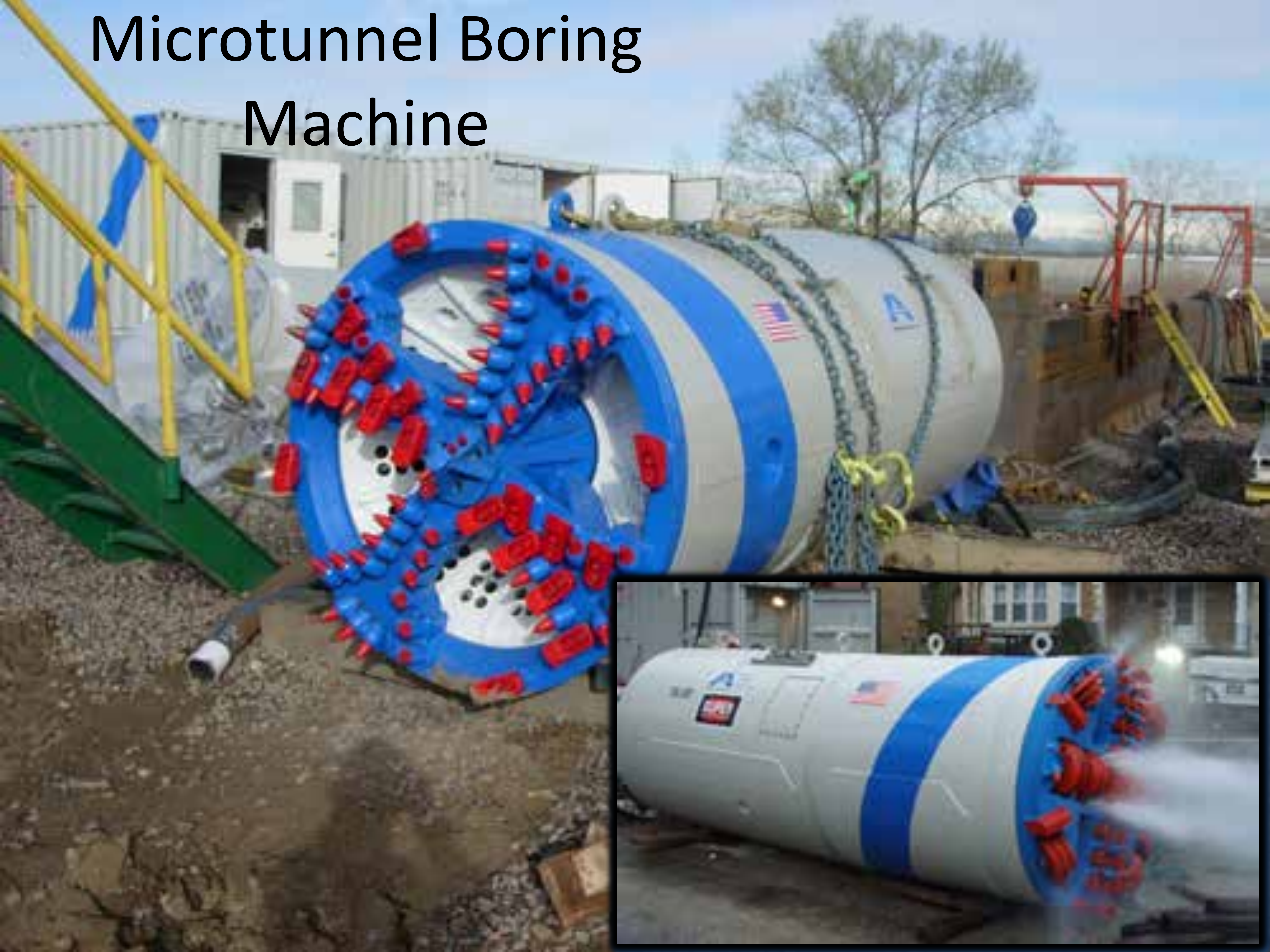
Tunneling/Trenchless Technologies

Open Face TBM

Open Face TBM

Earth Pressure Balance TBM

Microtunnel Boring Machine



Pipe Ram

Pipe Ram

Auger Bore

GBM


Hand mine

Hand mine

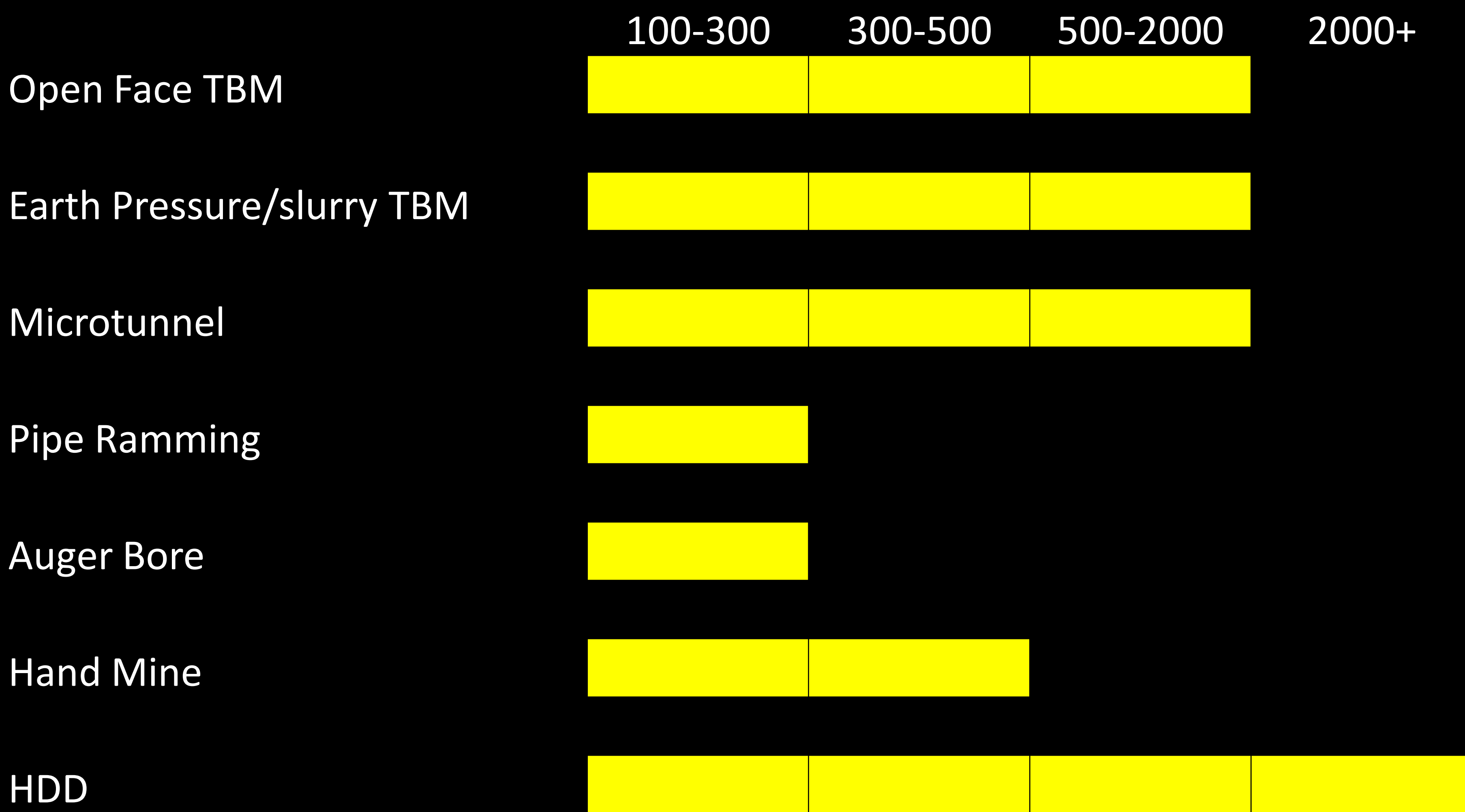
HDD

HDD

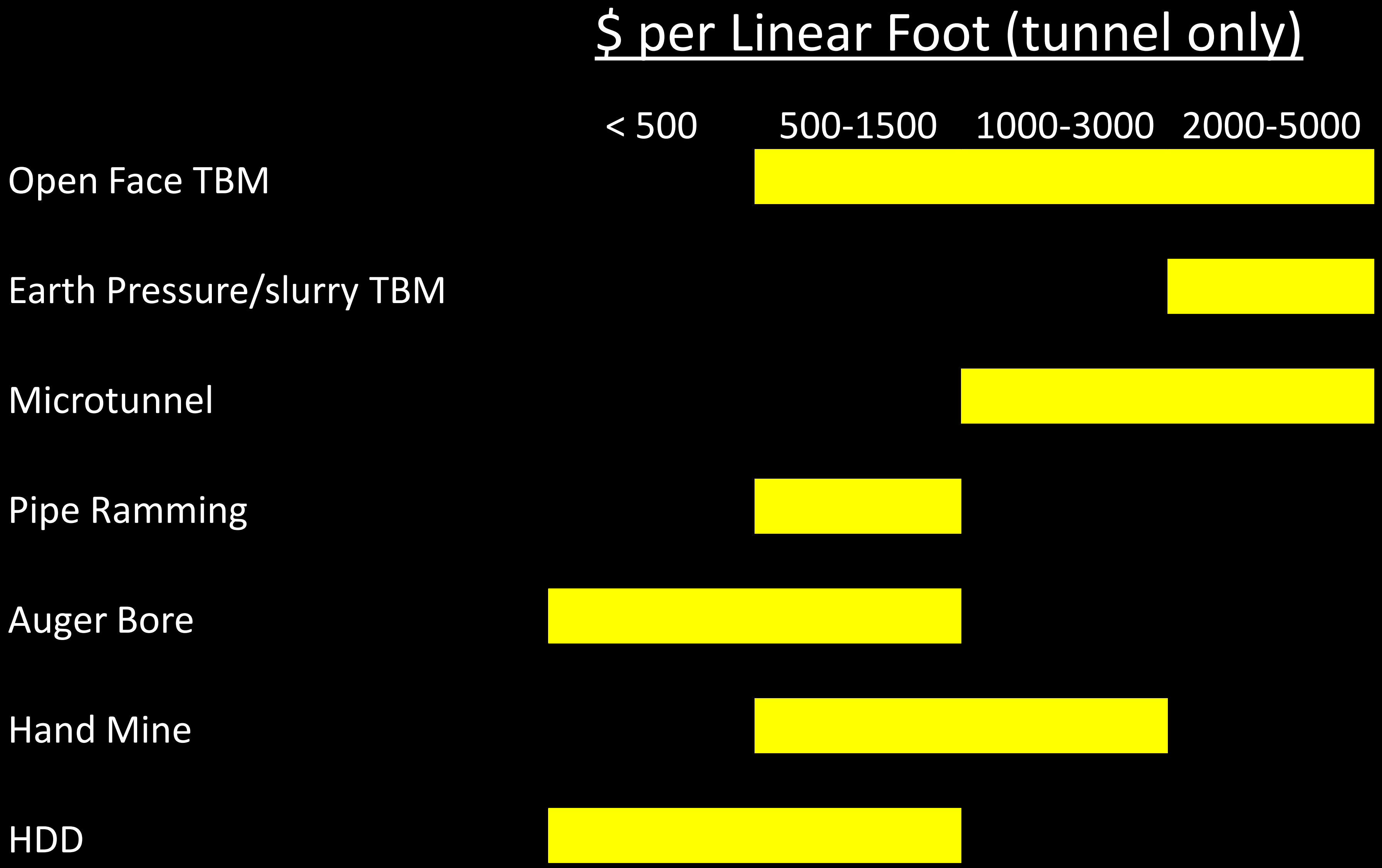
Application of the Methods

Distance Limitations

Max Feet of Tunnel



General Cost of the Methods



Other Factors

- Diameter: cost goes up with diameter
- Grade Tolerance: tighter the requirements, the higher the cost
- Experience: very important. Tunneling is difficult and risky. The for "been there, done that cannot be overstressed"
- Steel Casing: required for most DOTs, RRs, and waterways if a pressurized pipe. Gravity pipes typically can be "direct bury"

Dahlia Ponds
I-76

Project Scope:

- 260 LF of 54” Microtunnel
- Soils-Cobbles, gravels, sands
- Contaminated Ground Water
- Shallow cover under hwy
- Apprx. $4k to $5k per lf

Kenwood Outfall
O'Brian Canal Rescue

Scope:

- Handtunnel 60 LF of 84" and rescue failed previous attempt. in cobbles, gravels, running sands.
- Support 23 mgd sewer line during crossing
- Tight work area for 28 ft deep
- Next to O'Brian Canal and parallel to Hwy
- Apprx. $4k to $5k per lf

Kenwood Outfall
UPRR

Scope:

- 158 LF of GBM Hammer
- Tunnel Underneath RR
- Tightly compacted Sands
- Apprx. $2k to $2.5k per lf

Little Dry Creek
Federal Blvd

Scope:

- 260 LF of 54” Microtunnel
- Tunnel Under State Hwy
- Cobbles, Gravels, and Sands, intermixed with clay pockets
- Apprx. $4k to $5k per lf

Little Dry Creek Federal Blvd

Scope:

- 300 LF of 30” GBM/Auger
- Tunnel Under State Hwy
- Fill, and sands, intermixed with clay pockets
- Apprx. $1k per lf

Little Dry Creek
Federal Blvd

Scope:

- 290 LF of 129” OD TBM
- Tunnel Under State Hwy
- Fill, and sands, intermixed with clay pockets
- Apprx. $5k to $6k per lf

Havana St. Rescue

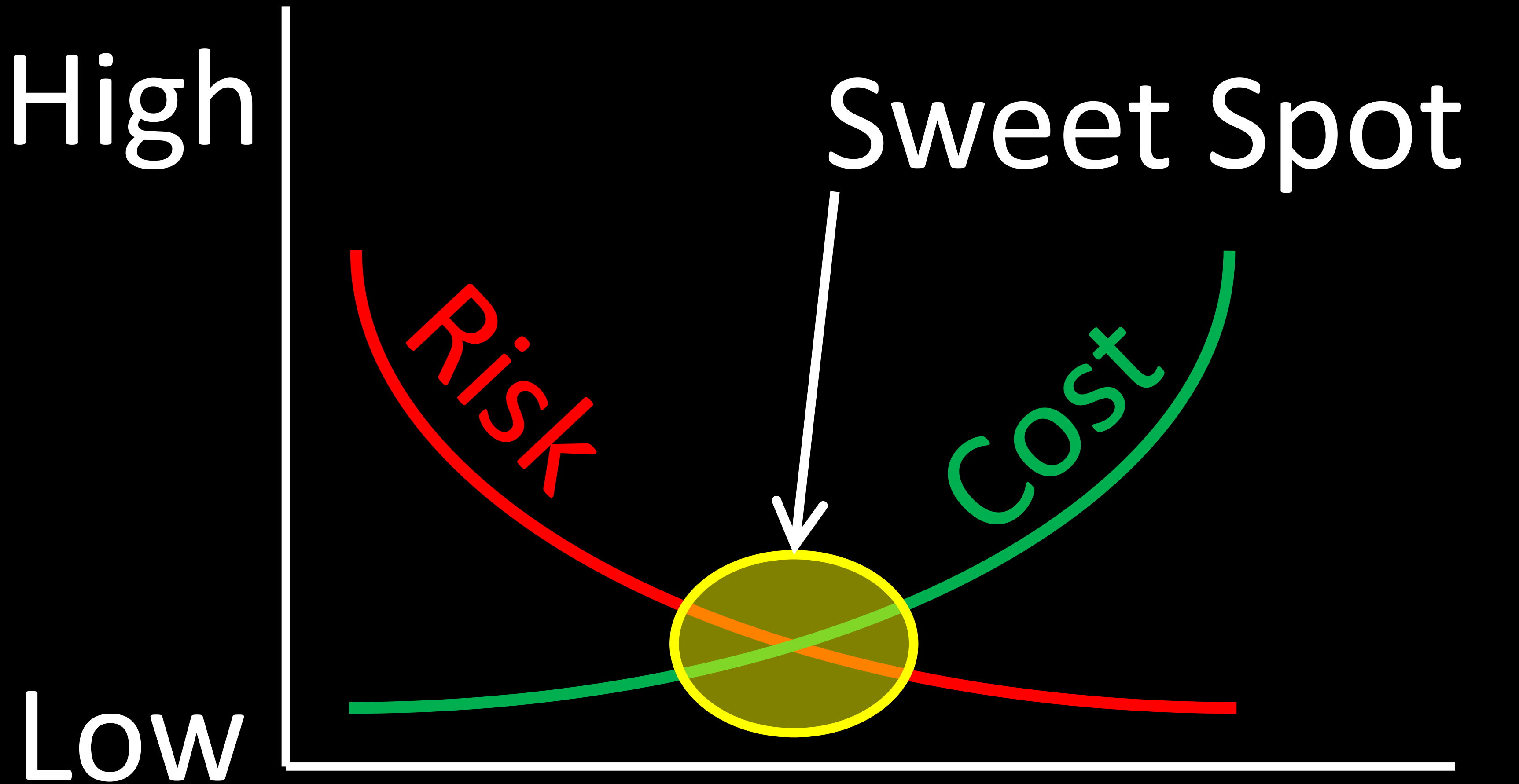
Scope:

- Rescue of previous contractors TBM attempt.
- Hand Tunnel Under RR to connect and realign tunnel
- Running sands
- Apprx. $5k to $6k per lf

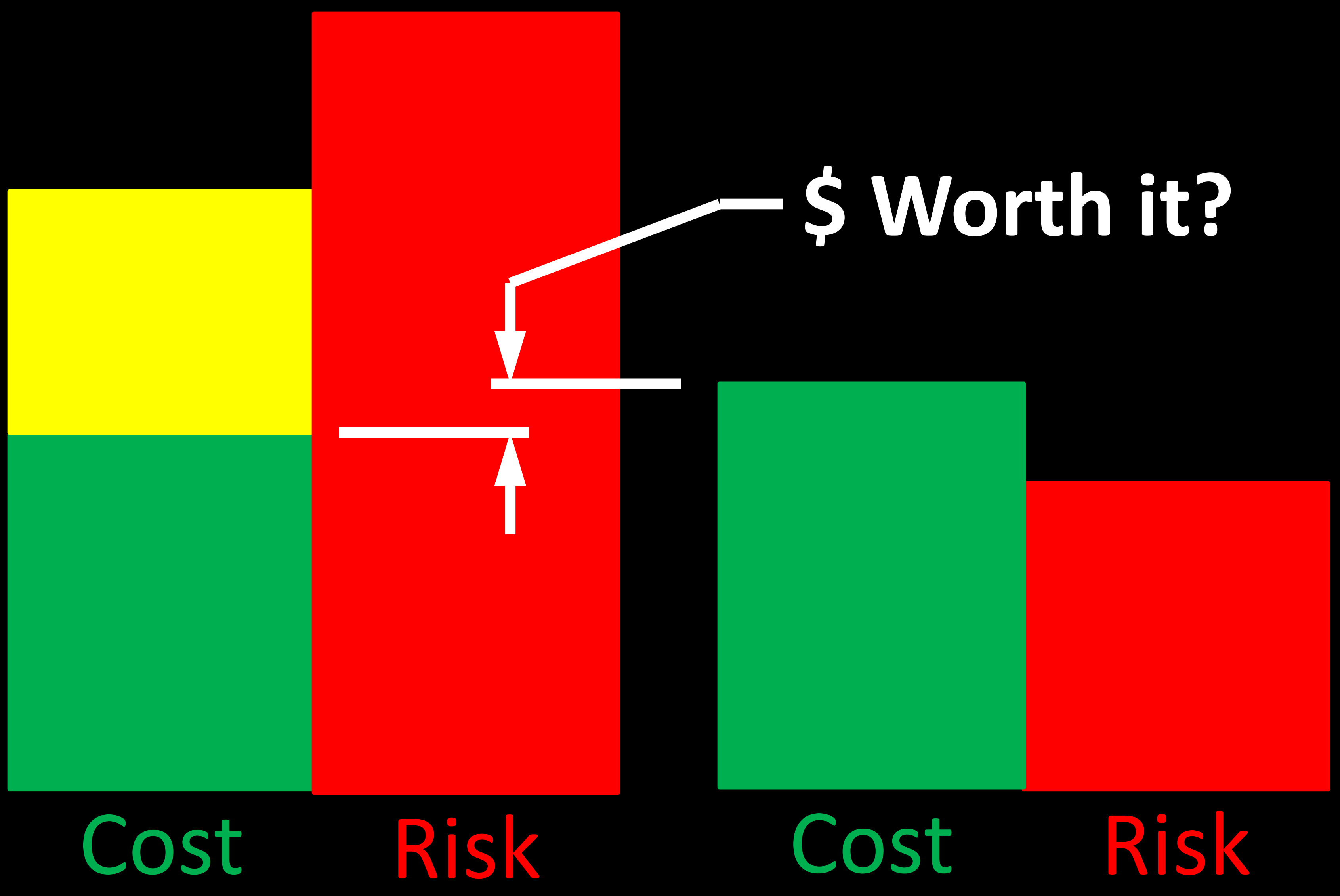
Cost of Our Tunnels

Method	Avg Fixed Costs	$/LF (tunnel only)	$/LF (total)	Sizes and Lengths
Hand Tunnel	$188,500	$1,545	$4,687	84" at 60 LF
Microtunnel	$302,167	$3,043	$4,427	54"-60", 158 LF - 260 LF
GBM/Hammer	$99,630	$1,551	$2,065	42"-60" at 158 LF-290 LF
TBM	$329,620	$4,034	$5,532	108" at 290 LF
GBM/Auger	$80,540	$507	$785	30" at 290 LF


Contracting Strategies



Contracting Strategies



Contracting Strategies

- Open Bid – specify allowable tunneling methods, require previous experience
- Contractor Prequalification
- CM/GC – Hire a contractor directly during design

Shared Risk

3 Major Takeaways:

- Find an Expert to Help You
- Thoroughly Explore Ground Conditions
- Explore Project Delivery Options to Balance Cost & Risk

Questions?

Adam's Rib Water Quality Monitoring and Mitigation Plan in Eagle, Colorado

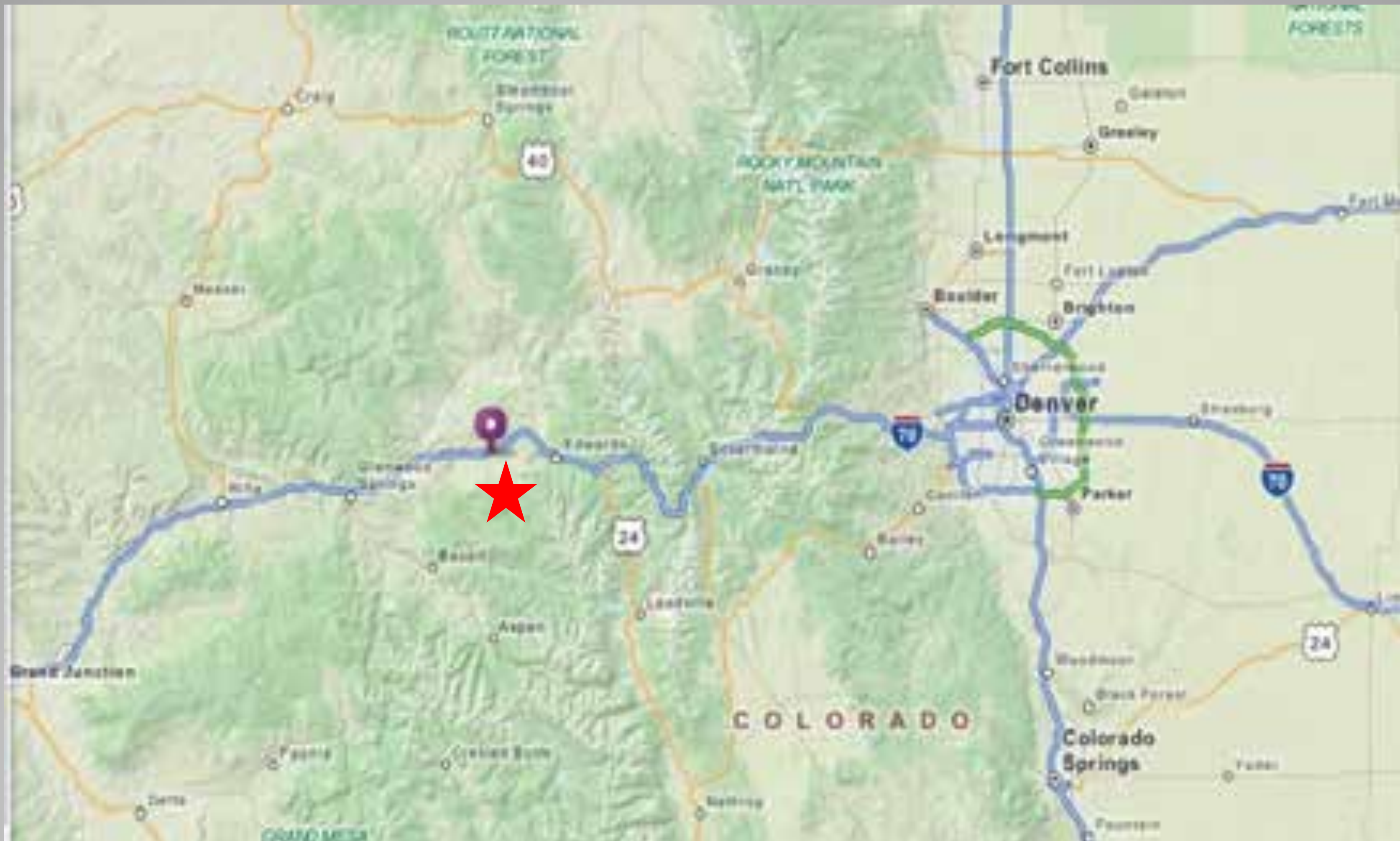
Shannon Tillack, P.E.
Wright Water Engineers

Ray Merry, REHS
Director of Eagle County
Environmental Health Department

EAGLE COUNTY

CASFM

WRIGHT WATER ENGINEERS, INC.



ROUTT NATIONAL FOREST
Craig
Steamboat Springs
40
ROCKY MOUNTAIN NAT'L PARK
Fort Collins
Greeley
Longmont
Granby
Boulder
Brighton
Denver
Edwards
Glenwood Springs
Rifle
70
24
Basalt
Leadville
Aspen
Parker
Grand Junction
COLORADO
Colorado Springs
Black Forest
GRAND MESA

Adam's Rib Recreational Area

- 1970s – Ski Area
  - Adam Mountain and Mt. Eve permitted area to include 3,000 acres of the White River National Forest
  - 3,000 acre Base Area with lodging and commercial space
  - 27-hole golf course

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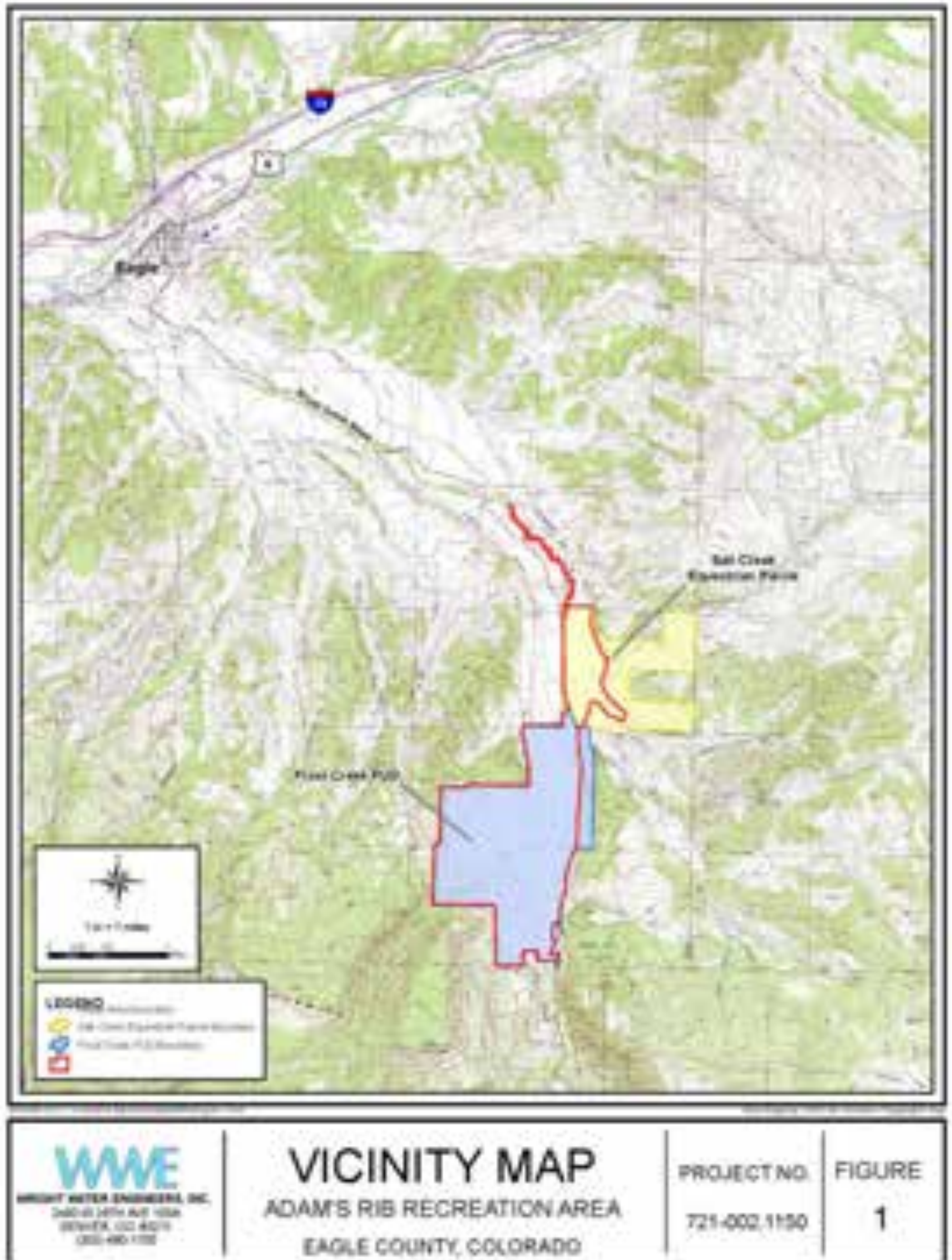
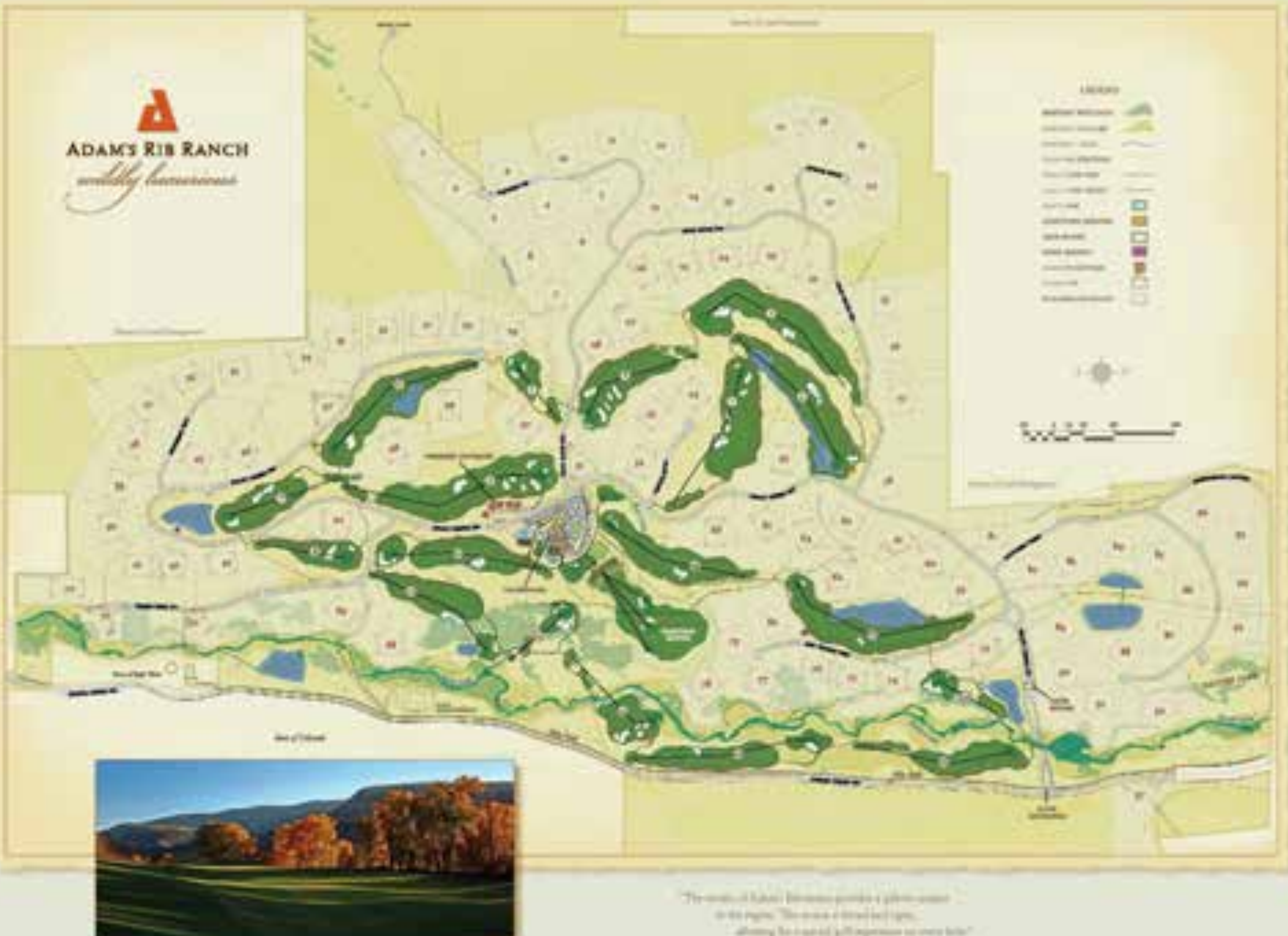

Eagle
WWE
VICINITY MAP
ADAM'S RIB RECREATION AREA
EAGLE COUNTY, COLORADO
PROJECT NO.
721-002.1150
FIGURE
1

CASFM


ADAM'S RIB RANCH
wildly luxurious

Eagle County Land Use, Planned Unit Development (PUD), and 1041 Conditions

- A Water Quality Monitoring and Mitigation Plan shall be prepared to incorporate monitoring groundwater and surface water quality, aquatic life and riparian health.
- Must gather data prior to, during, and after site disturbance
- Quickly identify and eliminate impacts to water quality and to detect and correct adversarial impacts or trends caused by development and urban runoff

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Adam's Rib Water Quality Monitoring and Mitigation Plan

Purpose:

- Develop a program for determining whether development using best management practices (BMPs) would adversely affect water quality or aquatic life

- Allow for detection and correction of degrading water quality or aquatic life that may be caused by development

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Adam's Rib Water Quality Monitoring and Mitigation Plan Components

- Baseline monitoring
- Identification of potential development impacts to water quality
- Water quality monitoring
  - Construction phase
  - Post-construction phase
- Trigger limits
- Plan management and operation

Baseline Monitoring

Surface Water

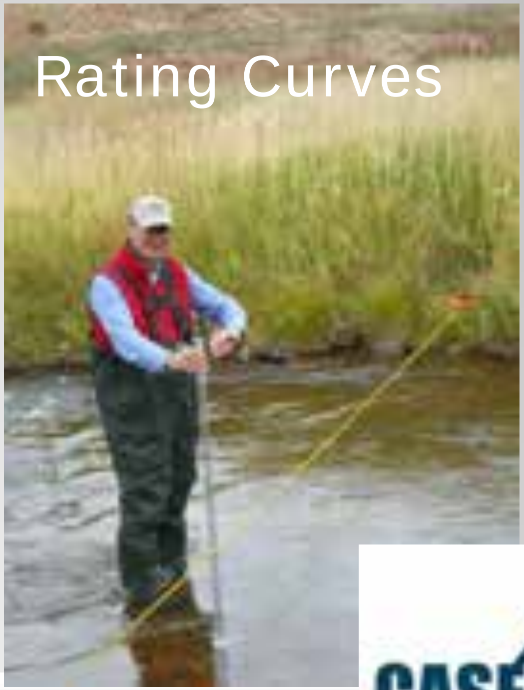
Groundwater

Wetlands/ Riparian

Bioassessments

Baseline Monitoring

Surface Water



Baseline Monitoring

Groundwater

Baseline Monitoring

Wetlands/ Riparian

- Water quality in saturated zone of the wetlands
- Assessment of vegetation density, diversity and percent cover

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WWE
ADAM'S RIB RECREATION AREA
1999 AERIAL
EAGLE COUNTY, COLORADO
Aerial Source: USDA DOQ


WWE
ADAM'S RIB RECREATION AREA
8/24/2011 AERIAL
EAGLE COUNTY, COLORADO
Aerial Source: USDA NAIP

CASFM

Baseline Monitoring

Bioassessments

- Characterize benthic community in the creek in the vicinity of the development

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Potential Impacts to Water Quality from Development

- Construction Phase
  - Soil erosion potential
  - On-site storage of fuel
  - Construction dewatering
  - Stormwater management
- Golf Course
  - Fertilizers/pesticides
- Maintenance Facility
- OWTS


WWE
DRAFT
ADAM'S RIB RANCH
WATER QUALITY MONITORING AND MITIGATION PLAN OVERVIEW MAP
PER MEMORANDUM OF AGREEMENT DATED AUGUST 2011
EAGLE COUNTY, COLORADO
DRAFT
PROJECT NO.
FIGURE 1

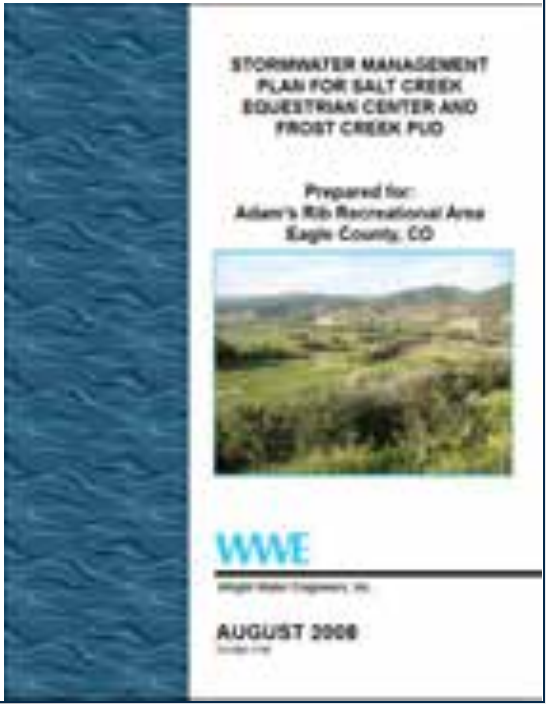
Water Quality Monitoring:

Construction Phase

CASFM

Water Quality Monitoring:

Construction Phase



- Surface Water
  - 4 events annually
  - TSS, TDS, TP, NO_3^-, NO_2^-
- Groundwater and Wetland Monitoring
  - 2 events annually
  - TDS, TP, NO_3^-, NO_2^-, pesticide/fungicide
- Bioassessments
  - Once every 2 years

Water Quality Monitoring:

Post-Construction Phase

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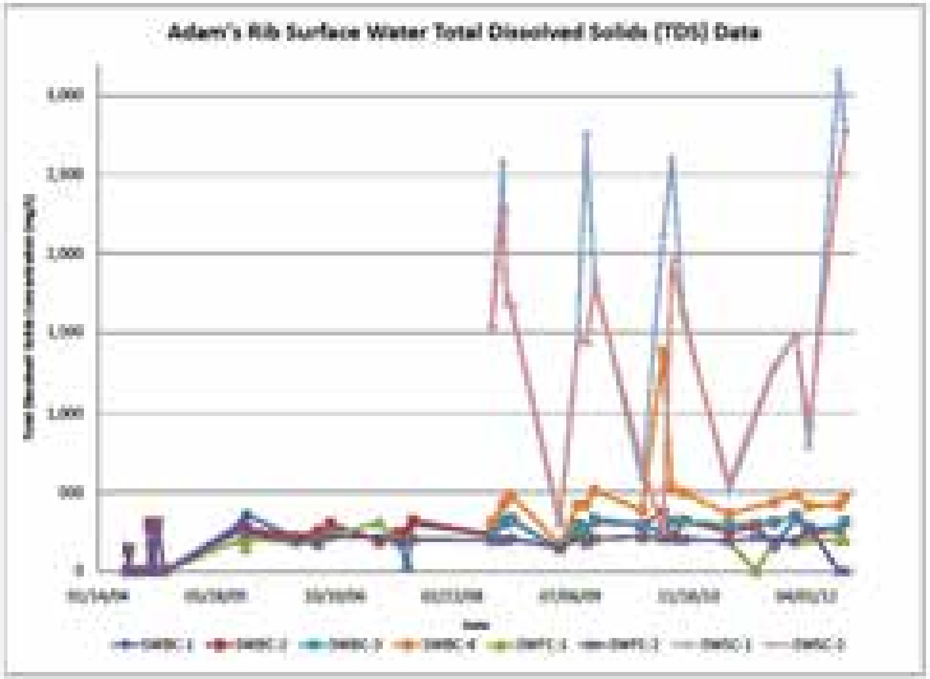
Water Quality Monitoring:

<u>Trigger Limits</u> - Measurable limit on a parameter whose exceedance may cause mitigation measures to be enacted

- <u>Component 1</u>: Compare observed values with the 85th percentile historical values for exceedances
- <u>Component 2:</u> Compare upstream and downstream sampled pairs for potential intermediate sources
- <u>Component 3:</u> Review graphical trends for temporal changes

Water Quality Monitoring:

Trigger Limits



Water Quality Monitoring:

Plan Management and Operation

- Frequent correspondence with Eagle County Health Department
  - Summary of water quality monitoring results
  - Annual report
- Rapid Response Plan
- Golf course Chemical Application Report

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DYNAMIC

The Water Quality Monitoring and Management Plan helps determine if BMPs are effective and allows the flexibility to change the BMPs when they are not effective.

QUESTIONS?

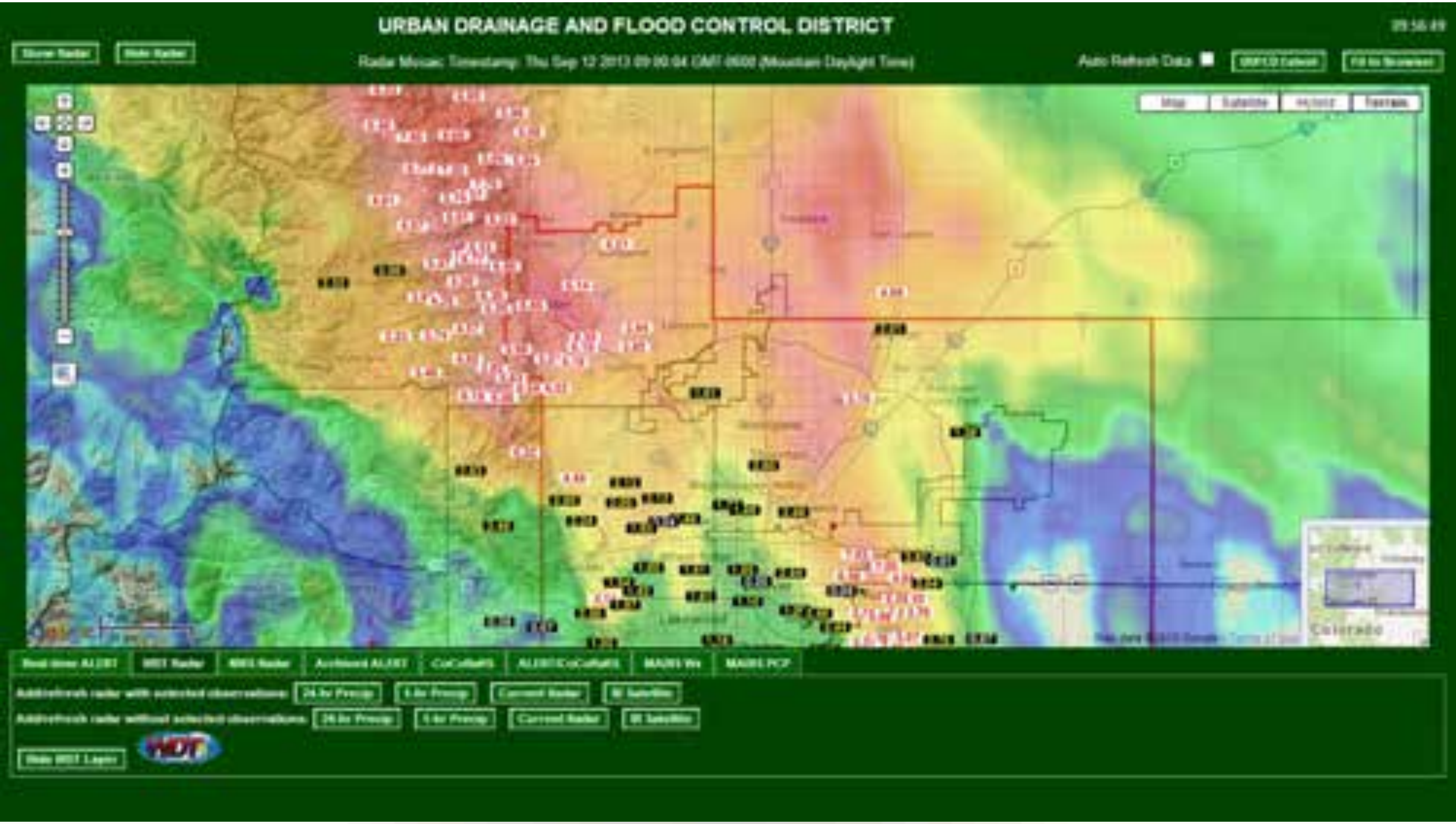
Shannon Tillack
stillack@wrightwater.com

Ray Merry
Ray.merry@eaglecounty.us

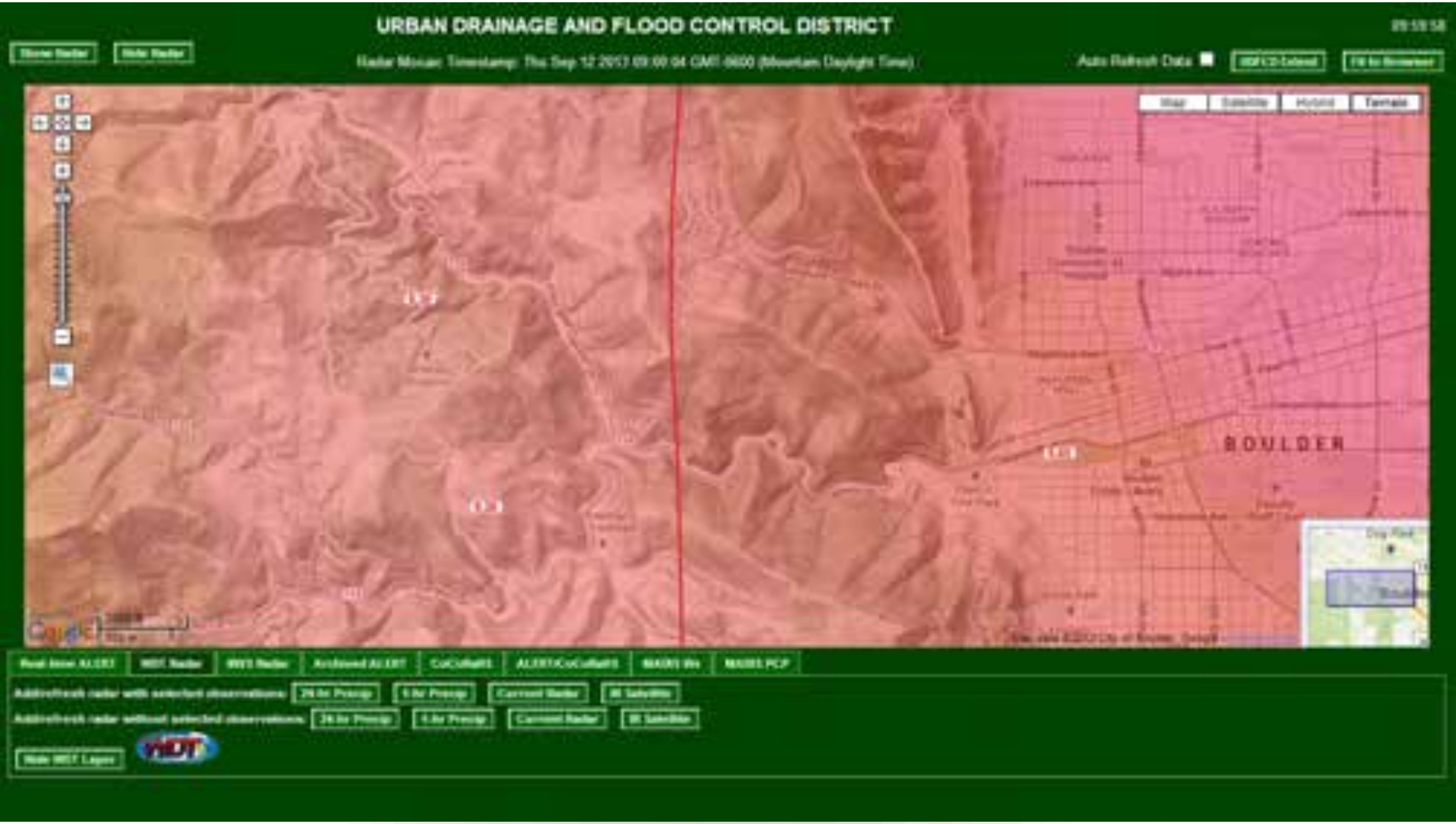
MANAGING STORMWATER COMPLIANCE WITH EMERGING TECHNOLOGIES

Chad Kudym, GISP

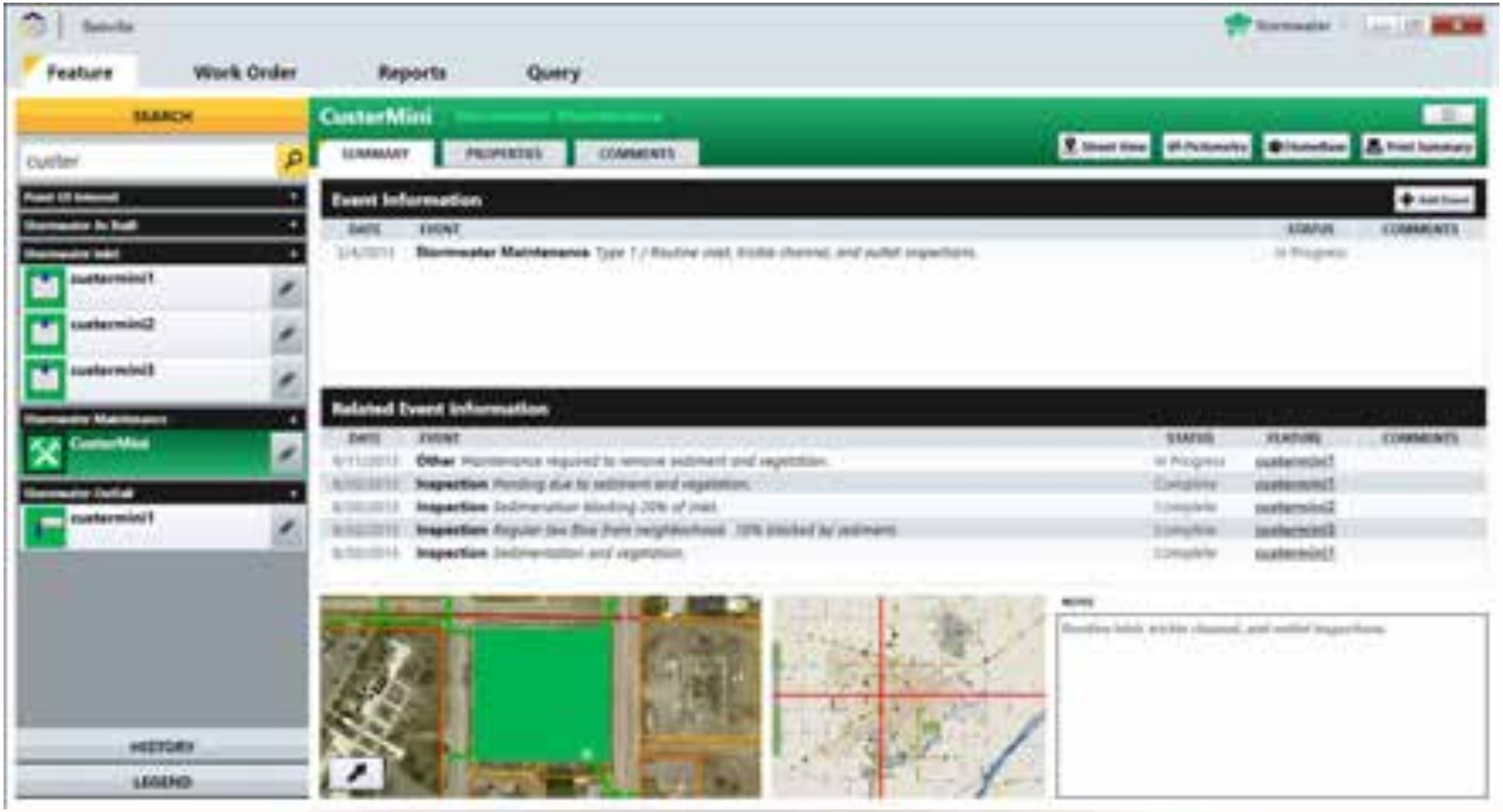
Real-time Data



Real-time Data



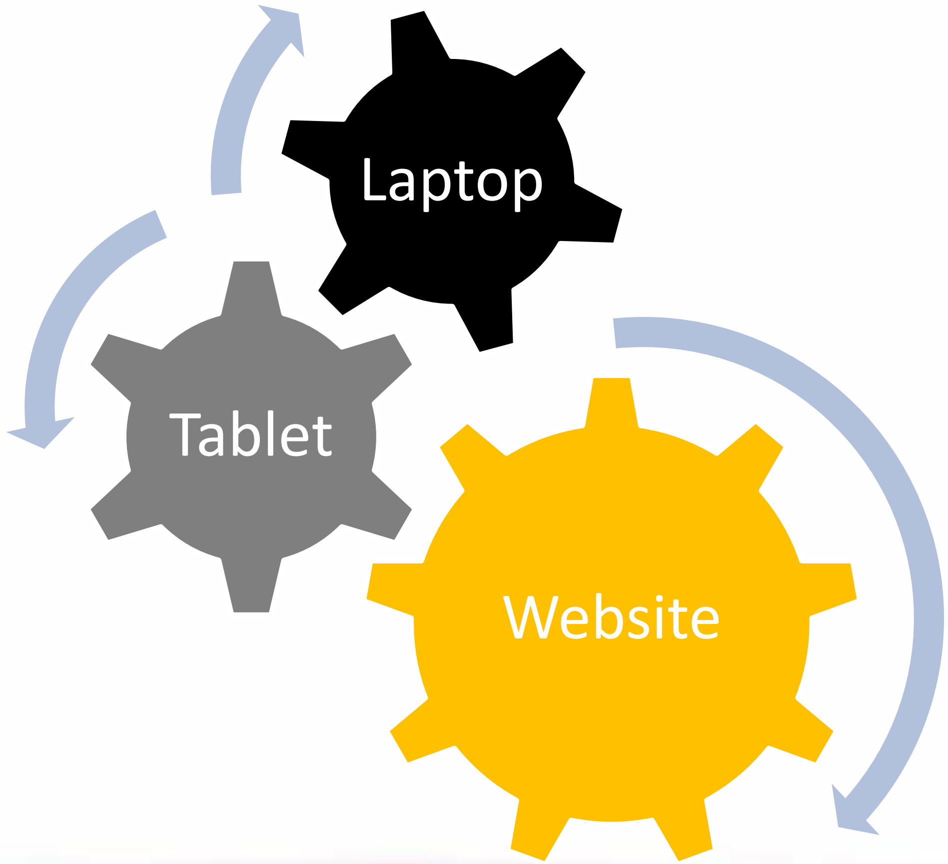
Manage Workflow with Technology



Benefits of Technology

- Increased agency coordination
- High data availability
- Effective documentation
- Improved staff efficiency
- Robust reporting

Coordinated Workflow



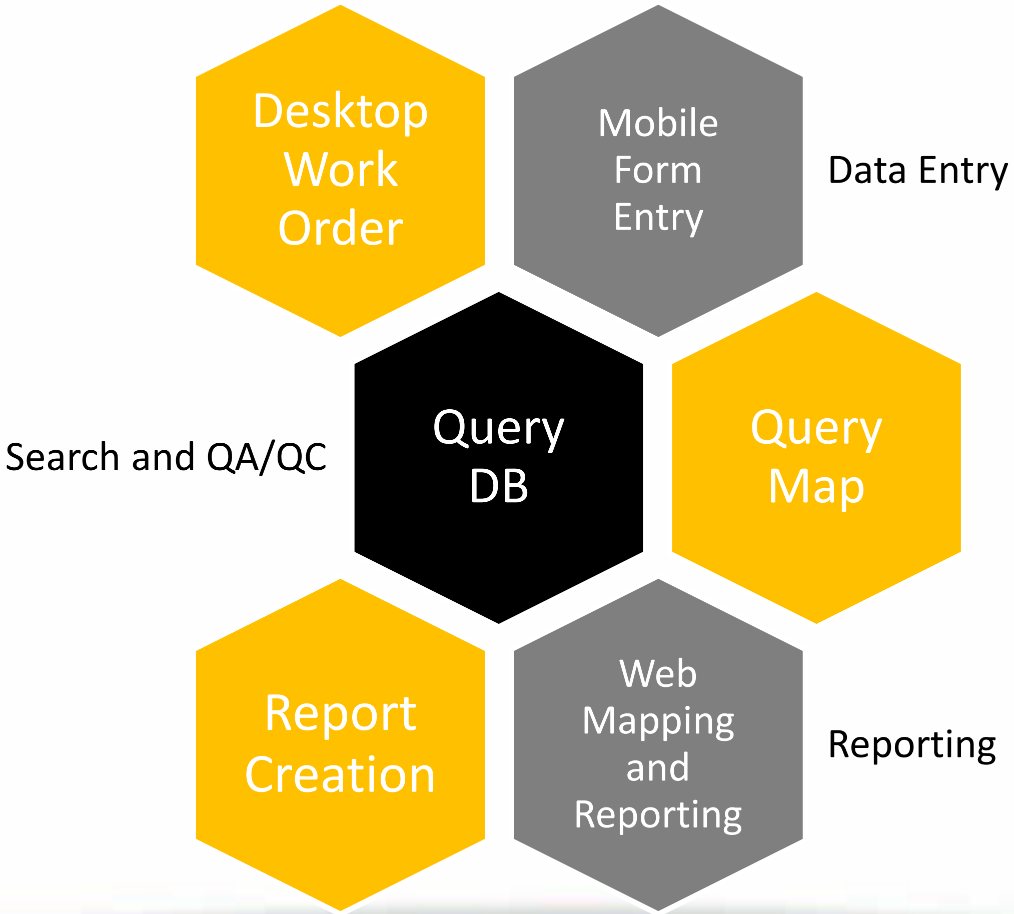
Involves Numerous Departments

- Transportation/Streets
  - Runoff management
  - Maintenance cleaning
- Public Works/Eng/Utilities/Wastewater
  - Managing infrastructure
  - Maintenance

Involves Numerous Departments

- Environmental Services
  - Trash collection
- Mapping
  - Tracking locations of assets, permits, violations
- Inspections and Code Enforcement
  - Building Services
  - Public Works
  - Police

Example Interlocking Workflow



Minimum Control Measures (MCMs)

- Public Education and Outreach
- Public Participation and Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Runoff Control
- Pollution Prevention and Good Housekeeping

Addressing MCMs with Technology

- Document, schedule, track, and report
  - Maintenance
  - Permits
  - Inspections
  - BMPs
  - Monitoring
  - Enforcement
- Reduce risk of non-compliance
- Increase transparency of process
- Records retention

Public Outreach and Education

- Educate the public about specific pollutant sources
  - Community
    - School assembly presentations
    - Science fairs
    - WebGIS interface
  - Annual meeting
    - Discuss and demonstrate performance

Public Involvement and Participation

- Measurable goals
  - Storm drain stenciling
    - Number and locations
    - Track volunteers
  - Adopt-a-park and adopt-a-creek
    - Number, frequency, locations, and extent
  - Annual clean-up
    - Number and location of stream or road miles
    - Number and location of parks
- Annual meeting reporting

Illicit Discharge Detection and Elimination

- Enforcement of illicit discharges and connections
  - Warnings, admin actions, fines, legal action
  - Measurable goals
    - Linear feet of storm drain system inspections
    - Number of new building connection inspections
    - Number of penalties enforced

Illicit Discharge Detection and Elimination

- Storm sewer map
  - Awareness of intake, system and discharge
  - Creeks and watersheds
  - Measurable goals
    - Linear feet of conveyances
    - Number of discharge points
    - Number of dry weather flows eliminated
    - Number of unwarranted connections
    - Number of structural pollution control devices
- Education outreach
  - Citizen reporting
  - Measurable goals
    - Number of unwarranted connections reported
    - Number of illegal dumps reported by citizens

Illicit Discharge Detection and Elimination

- Storm sewer outfall and manhole inspections
  - Annual field inspections during dry-weather flows
    - Document abnormal flows, pungent odors, unusual colors or waste
    - Take photographs
  - Relate inspections to industrial, commercial or older areas of town
  - Trace flow upstream to find sources
  - Measurable goals
    - Number of new buildings inspected
    - Number of illicit connections found, repaired, or replaced
    - Number of penalties enforced

Illicit Discharge Detection and Elimination

- Sanitary sewer overflows
  - Sewer separation and sanitary main restoration projects
  - Continued research to find inlets and cross connections
  - Measureable goals
    - Number of sites repaired
    - Number of overflows that were identified during inspections
    - Number of overflows reported
    - Number of field tests and screens conducted
    - Frequency of routine maintenance activities

Construction Site Runoff Control

- Plan review
  - Internal tracking
  - Maintain records of reviews and approval
  - Measurable goals
    - Number of plans reviewed
      - Approved
      - Rejected

Construction Site Runoff Control

- Site Inspection
  - Tracking new and on-going activities
  - Inspect qualifying sites
  - Issue enforcement actions
  - Document corrective actions
  - Maintain records
  - Annual reporting
  - Measurable goals
    - Number of construction sites permitted
    - Number of sites inspected
    - Number of enforcement actions issued

Construction Site Runoff Control

- Construction community education
  - Develop and distribute educational materials
  - Conduct presentations
  - Annual reporting
  - Measurable goals
    - Maintain distribution list of local construction community

Construction Site Runoff Control

- City owned construction sites
  - Apply for and document federal/state permits
  - Develop inspection forms
  - Maintain compliance records
  - Annual reporting
  - Measurable goals
    - Number of site permitted
    - Number of inspections
    - Retain compliance records

Construction Site Runoff Control

- Construction related public reporting
  - Develop a web page for public input and education
  - Develop an internal tracking system to accept and issue receipt of information from public
  - Review public reports
  - Conduct on-site investigations
  - Annual reporting
  - Measurable goals
    - Number of sites reported by the public
    - Number of resulting sites investigated

Post-Construction Site Runoff Control

- Enforcement
  - Develop list of local storm water quality issues
  - Draft, review, and implement ordinance, guidelines, educational materials, and legal authority
  - Enforce as appropriate
  - Measurable goals
    - List of issues
    - Number of enforcements

Post-Construction Site Runoff Control

- Plan review
  - Develop process to obtain plans
  - Develop internal tracking and plan review process
  - Maintain records of plan review and actions
  - Annual reporting
  - Measurable goals
    - Record maintenance of plan review and actions
    - Number of plans reviewed
      - Approved
      - Rejected

Post-Construction Site Runoff Control

- Inspection Procedures
  - Measurable goals
    - Develop inspection guidelines
    - Develop inspection checklists, forms and procedures
    - Implement final versions

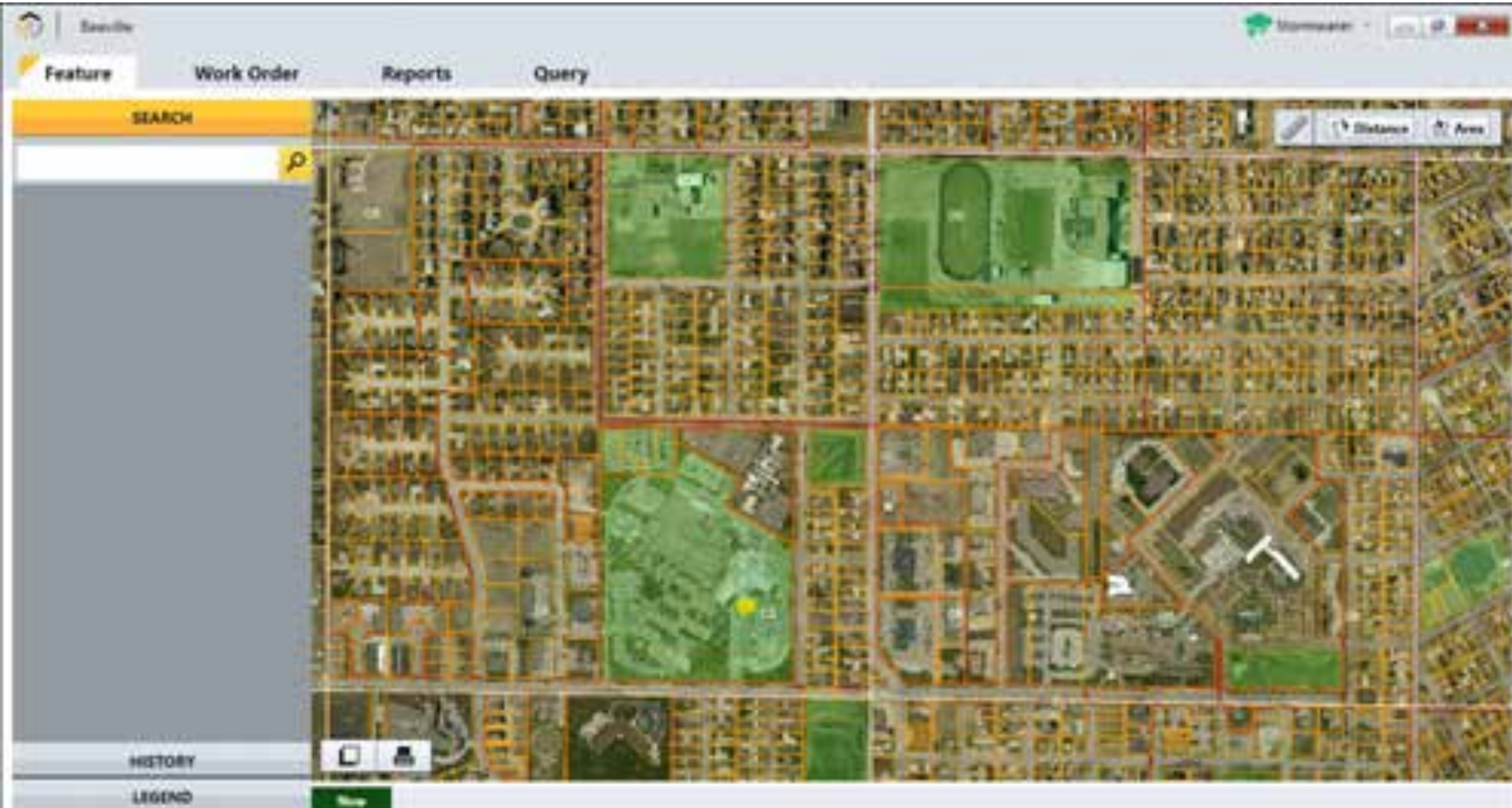
Post-Construction Site Runoff Control

- Inspection Implementation
  - Develop internal tracking procedures
  - Inspect qualifying sites
  - Enforce actions
  - Annual reporting
  - Measurable goals
    - Develop internal tracking procedure
    - Number of sites inspected
    - Number of enforcement actions issued
    - Maintain records of inspections and actions

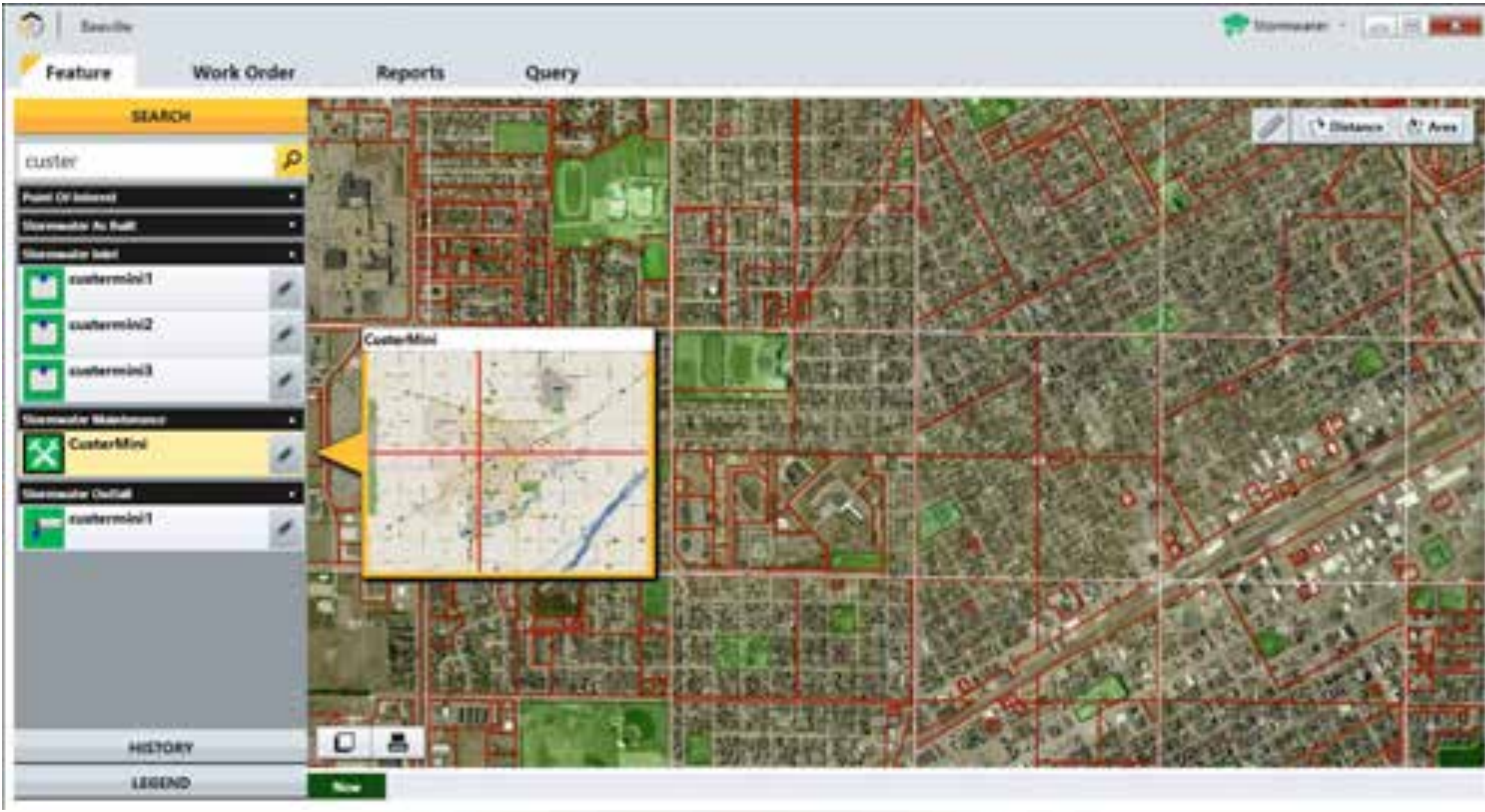
Focus: Pollution Prevention and Good Housekeeping Items

- Track maintenance events on all features within the storm sewer system
- Assign work orders for maintenance of events
- Report on maintenance that has been completed

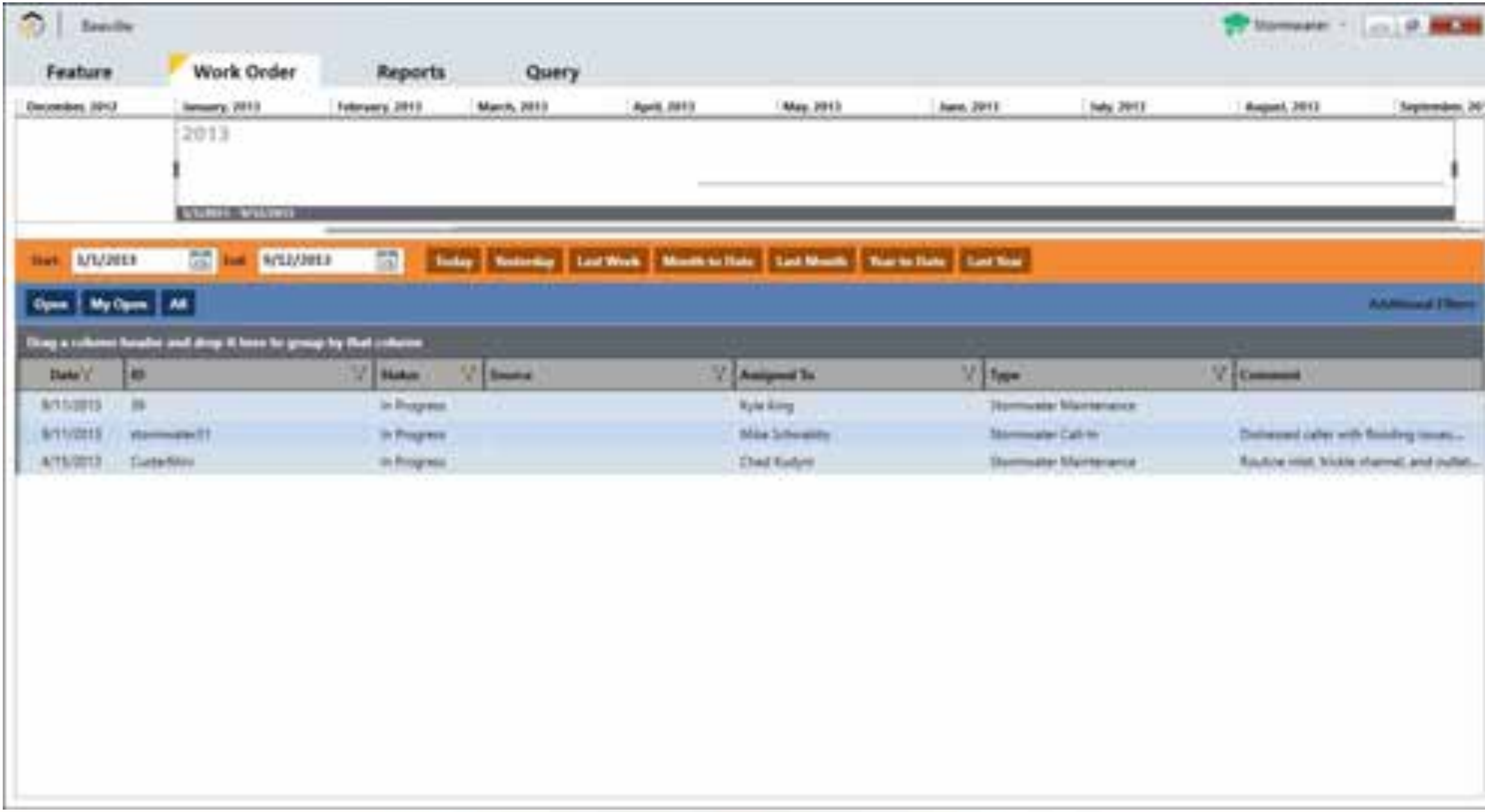
Emerging Technology



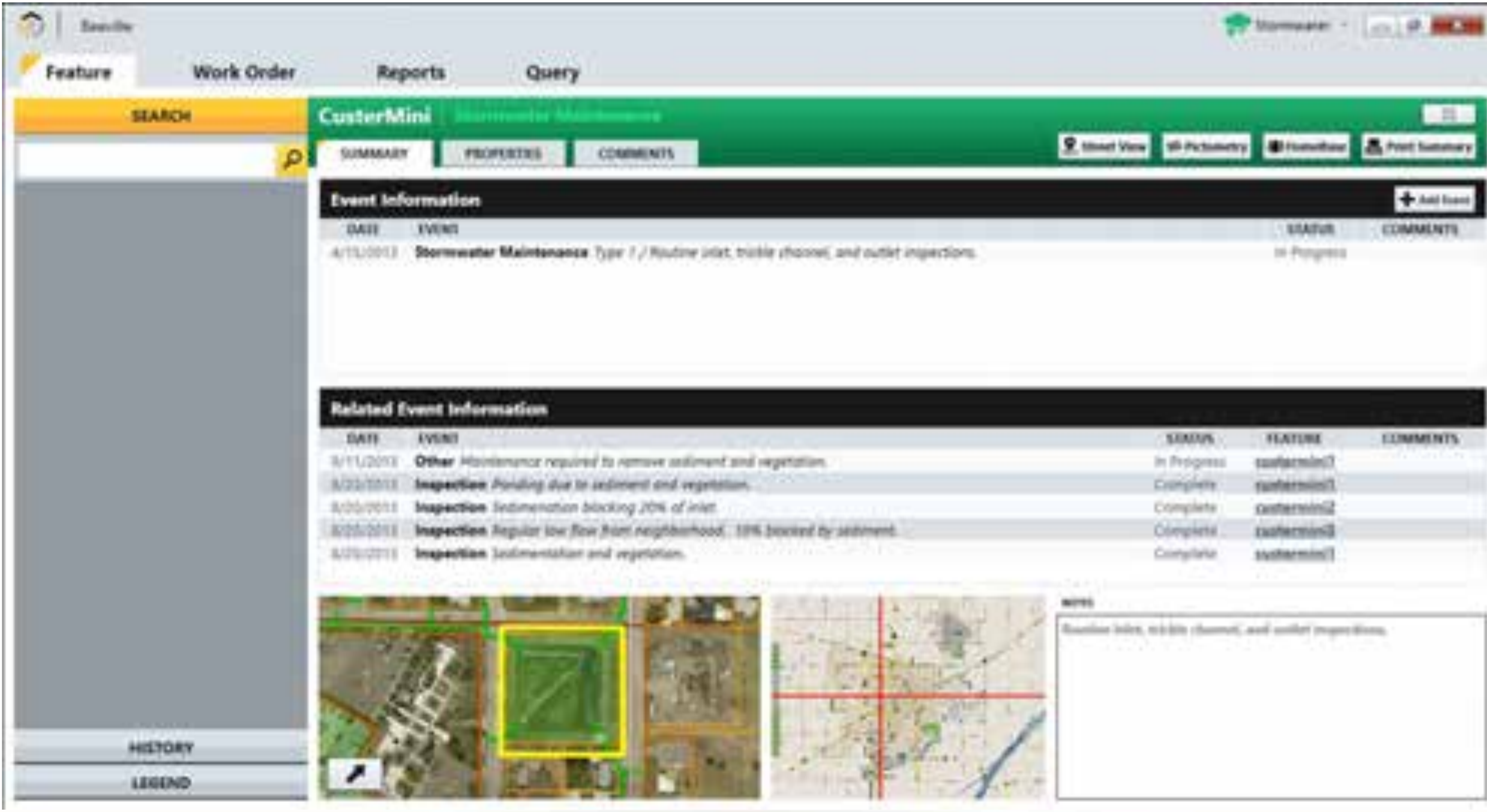
Search for Information



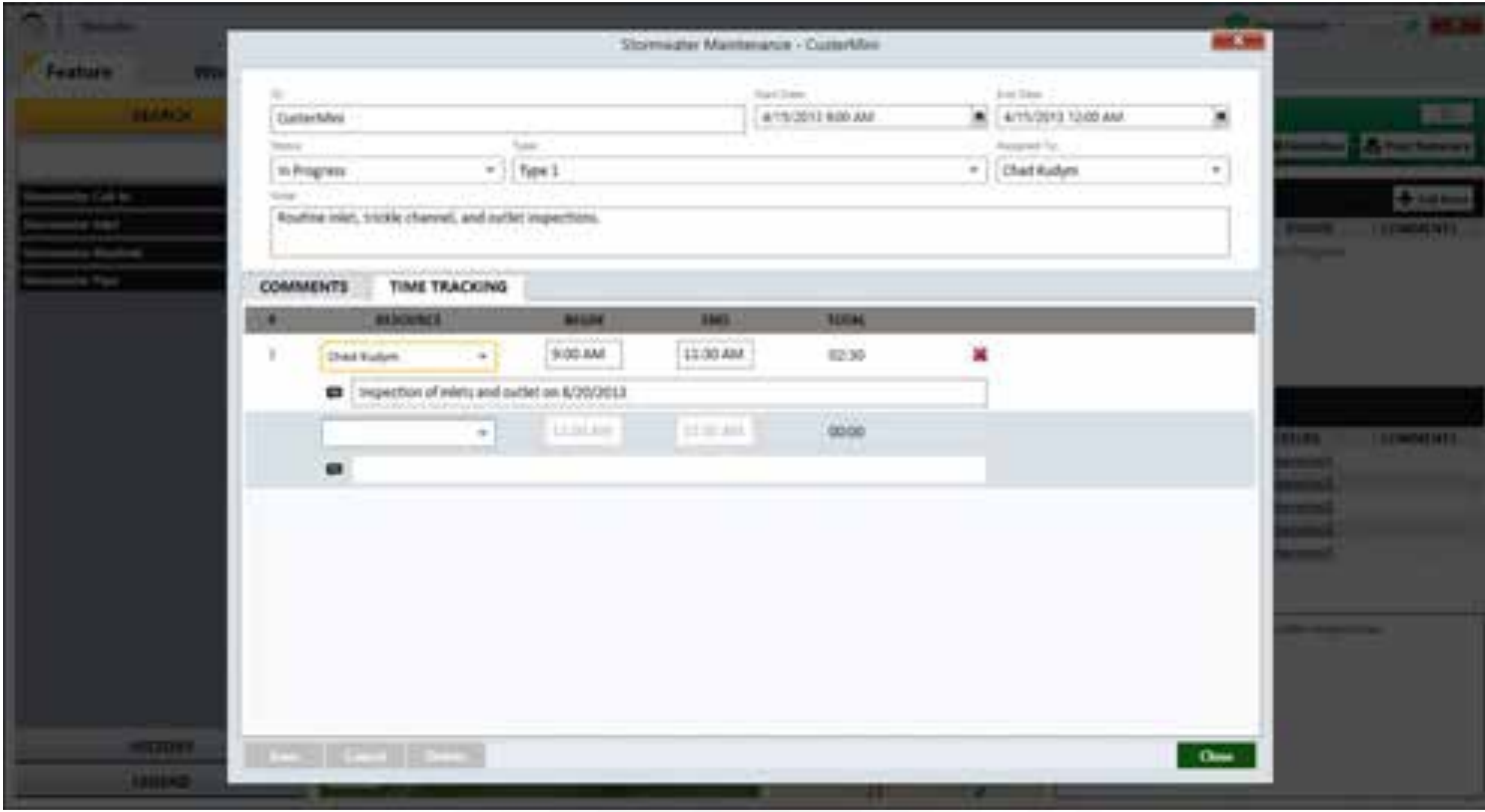
Work Order Tracking



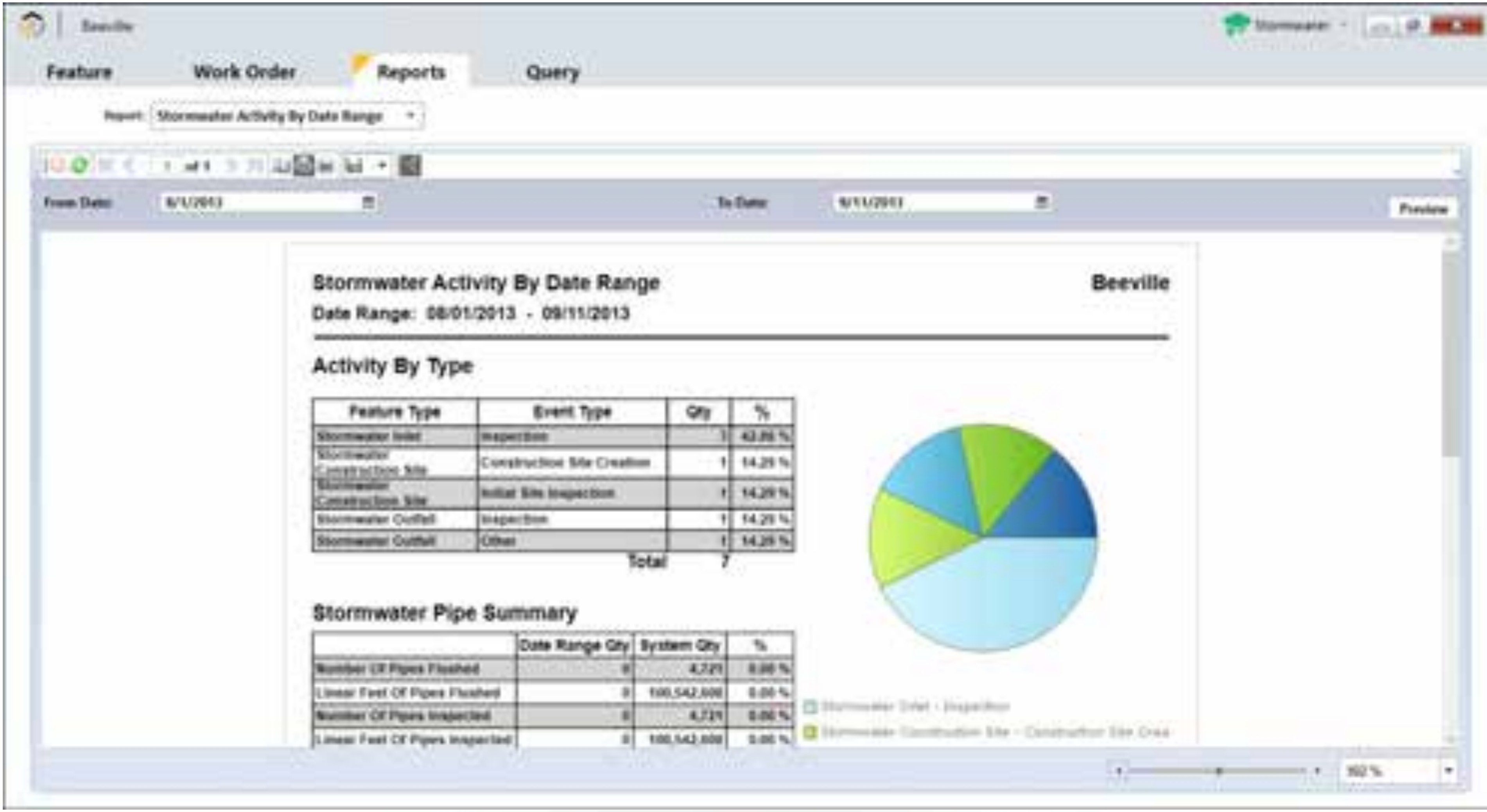
Work Order Tracking



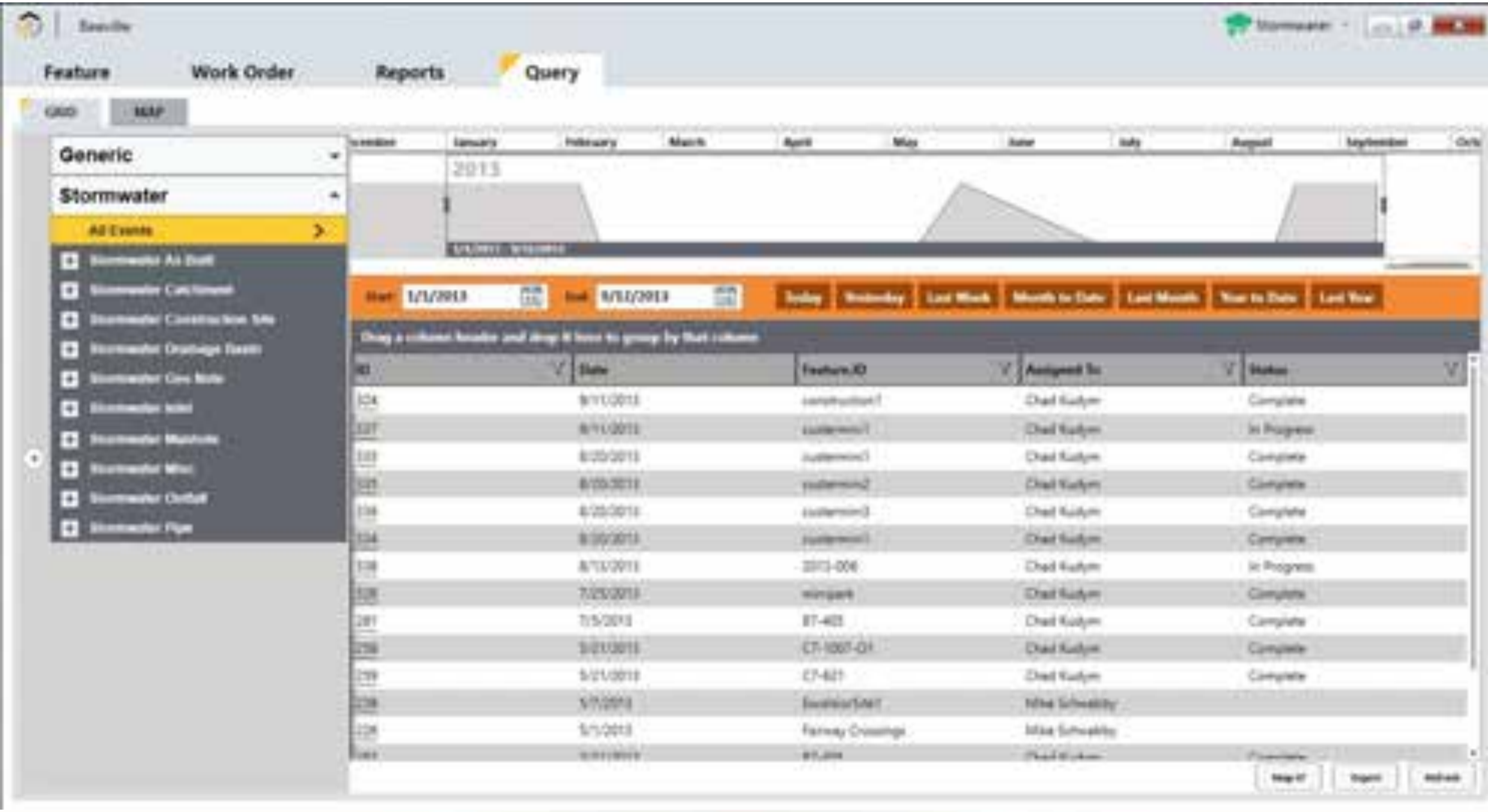
Work Order Tracking



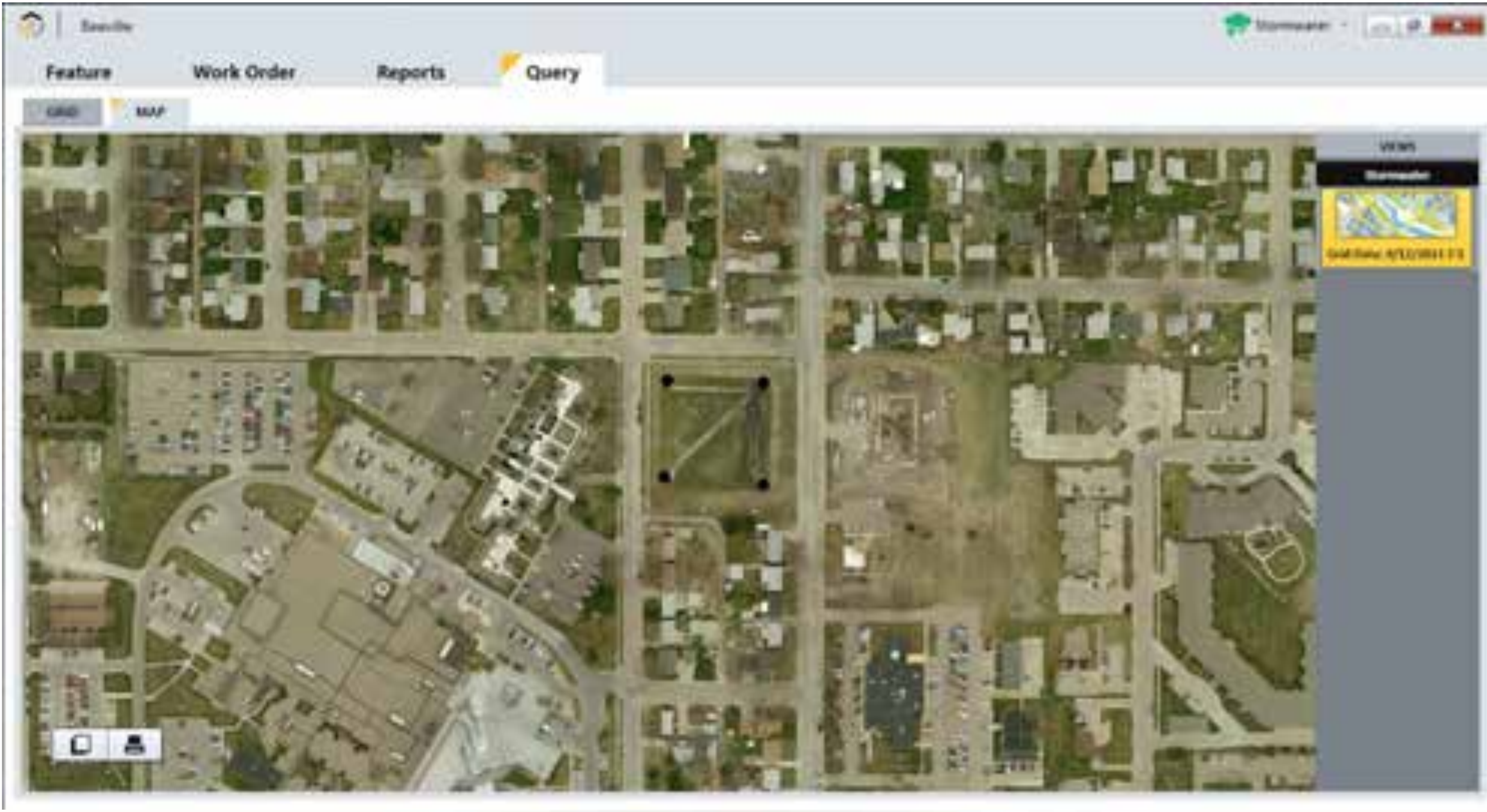
Reporting


Feature
Work Order
Reports
Query
Stormwater Activity By Date Range
Beeville
Date Range: 08/01/2013 - 09/11/2013
Activity By Type
Feature Type
Event Type
Qty
%
Total
7
Stormwater Pipe Summary
Date Range Qty
System Qty
Number Of Pipes Flushed
Linear Feet Of Pipes Flushed
Number Of Pipes Inspected
Linear Feet Of Pipes Inspected

Query Activities

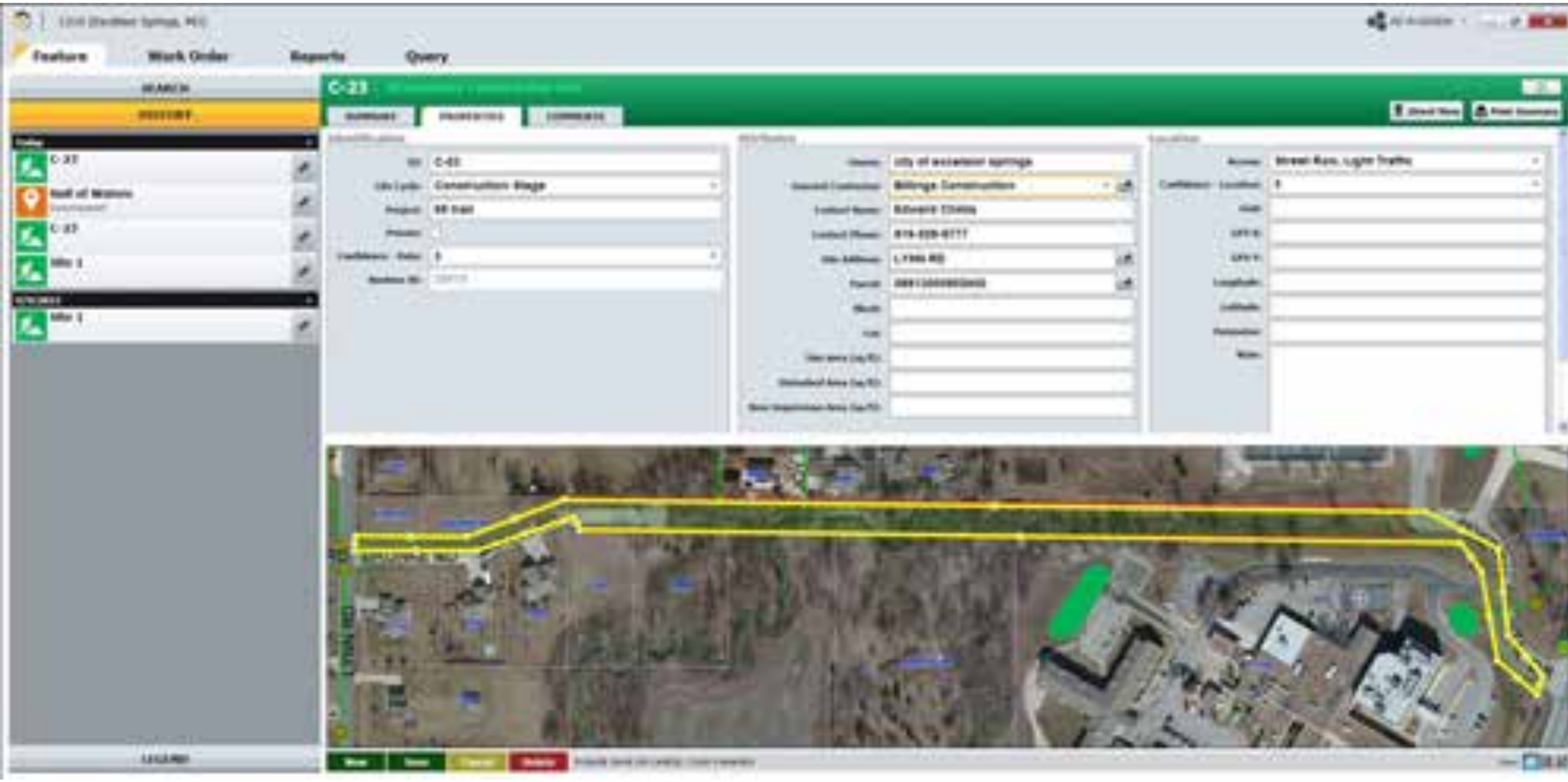


Map Query Results

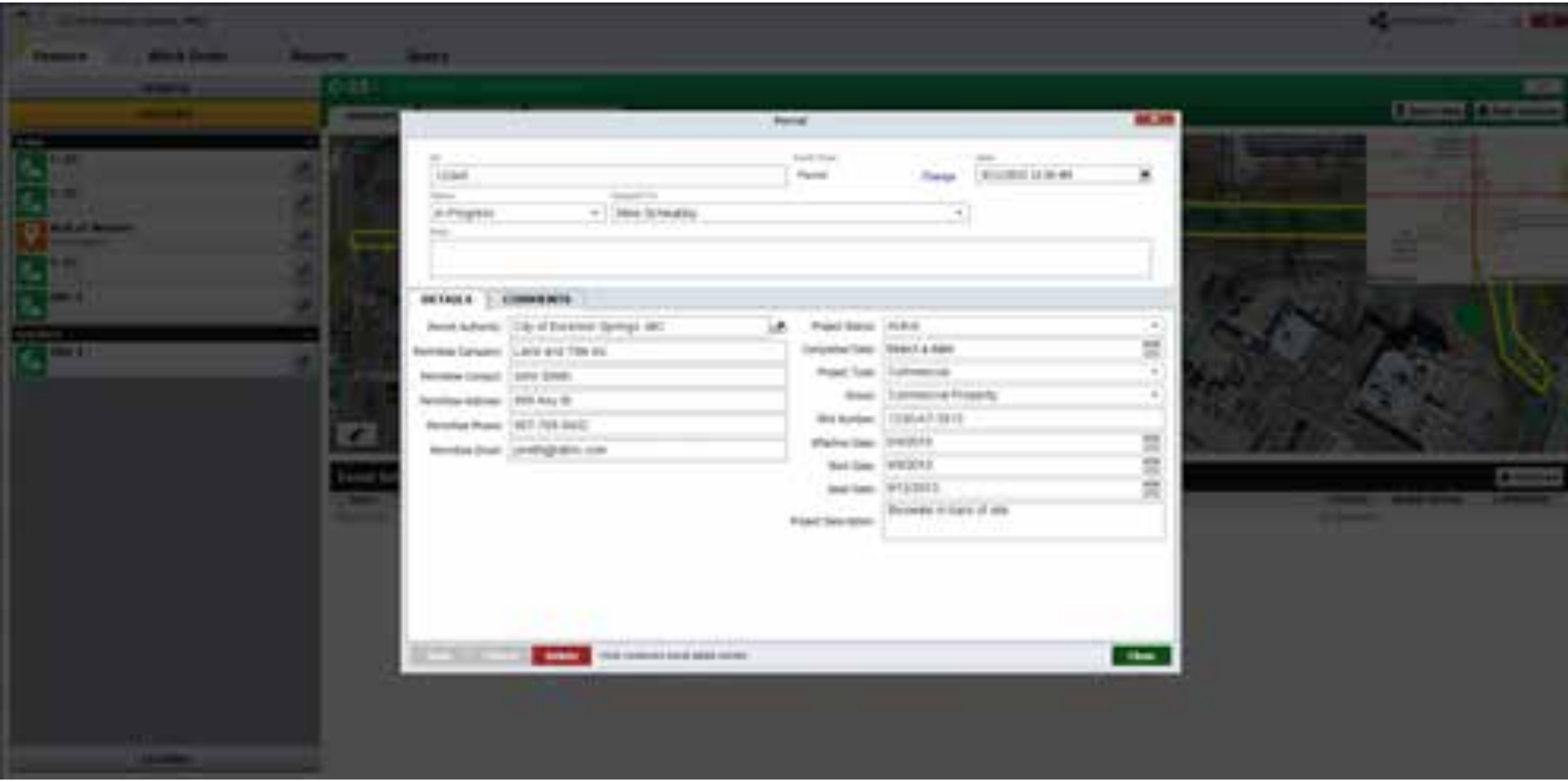


Data Integration

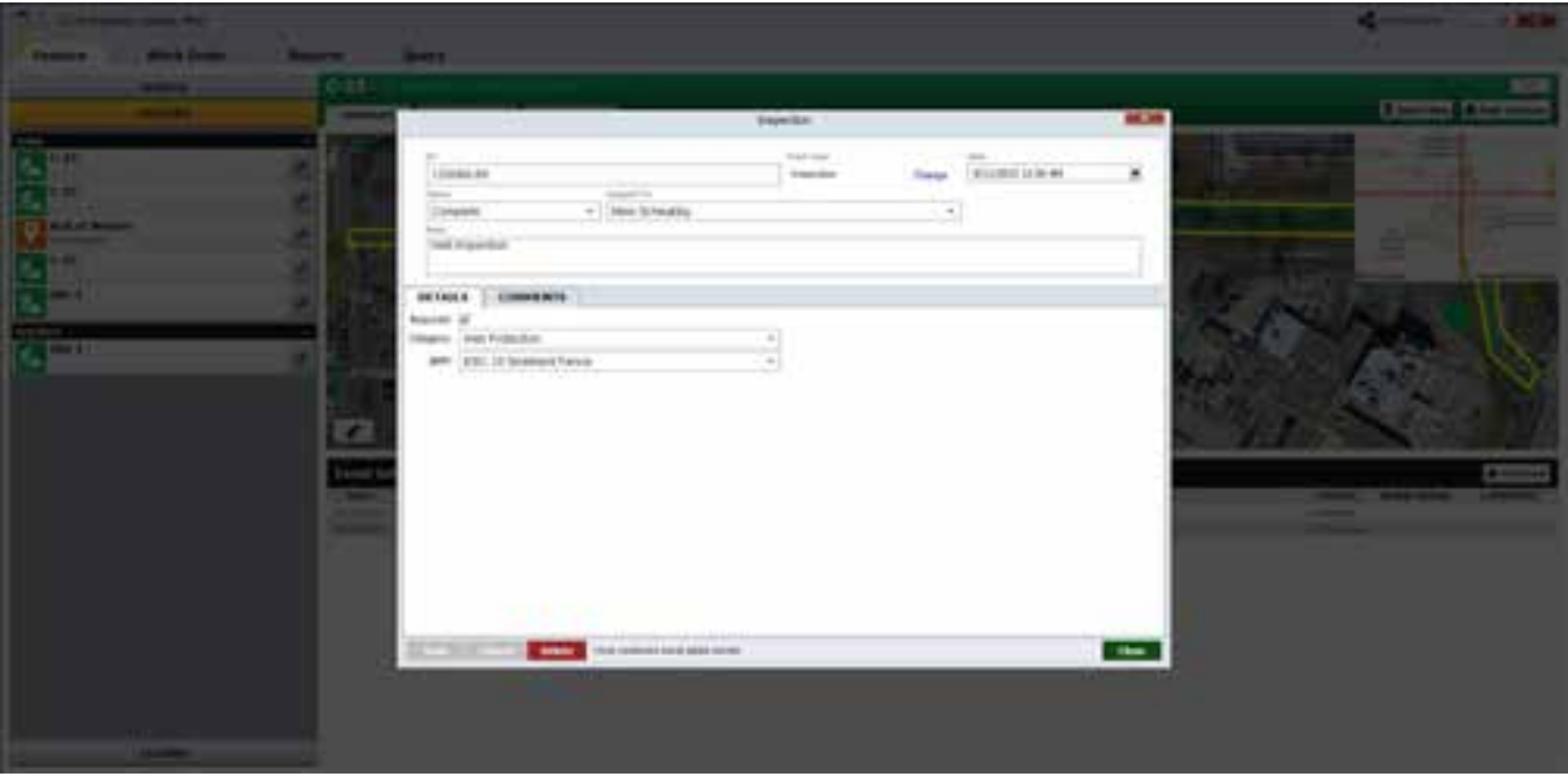
Client Sample



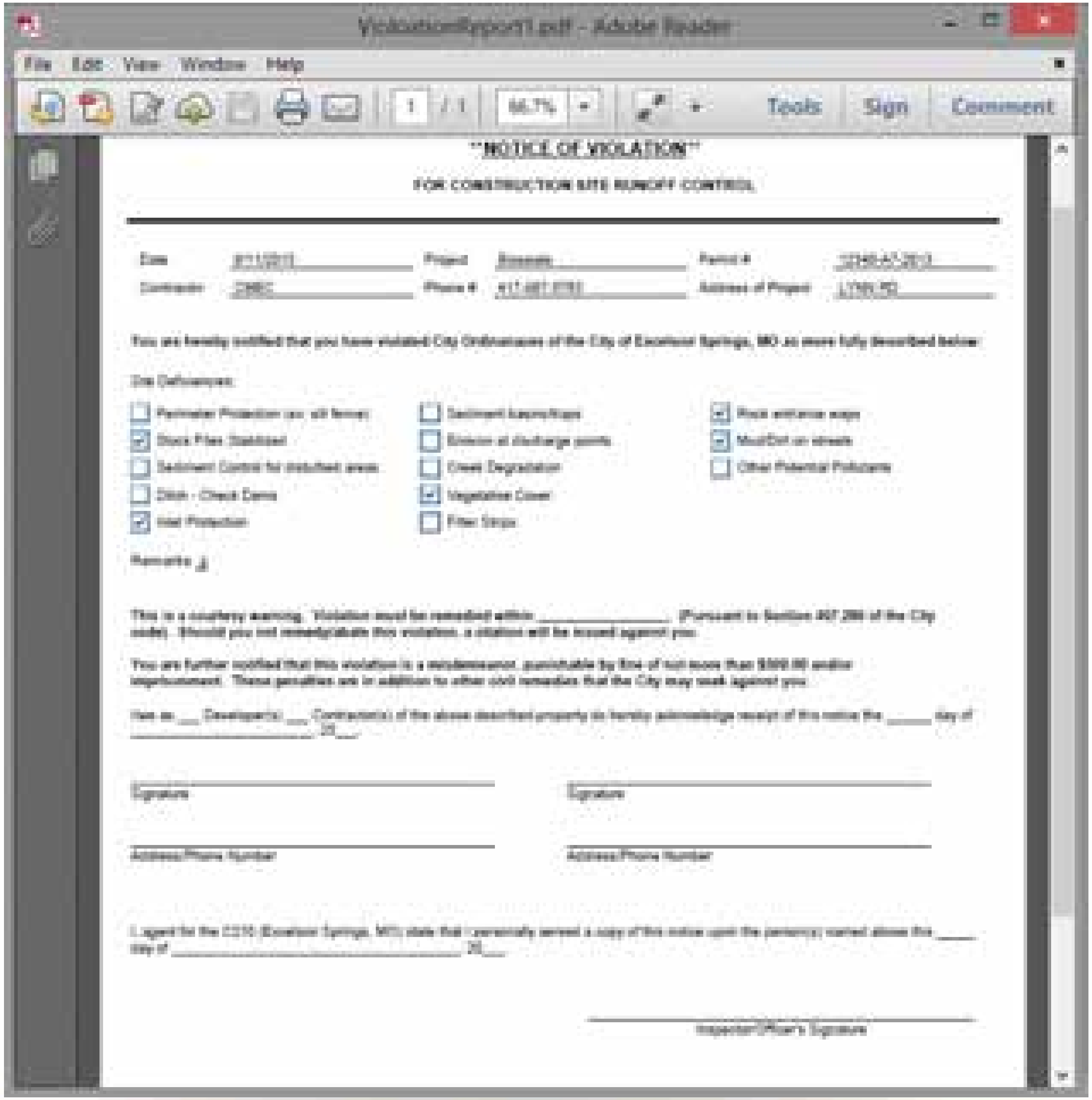
Site Permit



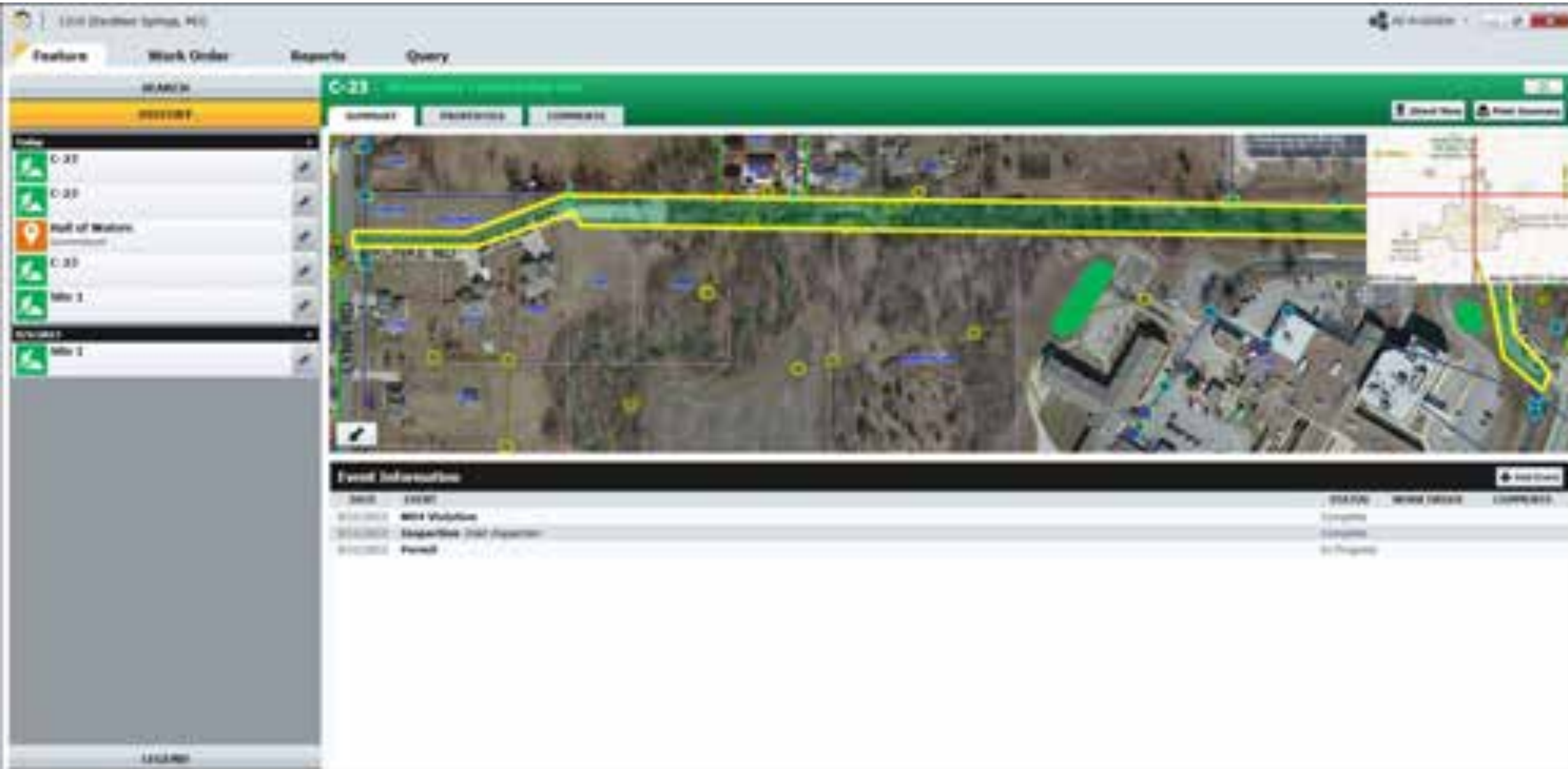
Inspection



Violation


ViolationReport1.pdf - Adobe Reader
File Edit View Window Help
Tools Sign Comment
"NOTICE OF VIOLATION"
FOR CONSTRUCTION SITE RUNOFF CONTROL
Date
Project
Permit #
Contractor
Phone #
Address of Project
You are hereby notified that you have violated City Ordinances of the City of Excelsior Springs, MO as more fully described below:
Site Deficiencies:
Perimeter Protection (silt fence)
Stock Piles Stabilized
Sediment Control for disturbed areas
Ditch - Check Dams
Inlet Protection
Sediment basins/traps
Erosion at discharge points
Creek Degradation
Vegetative Cover
Filter Strips
Rock entrance ways
Mud/Dirt on streets
Other Potential Pollutants
Remarks:
This is a courtesy warning. Violation must be remedied within ________________. Should you not remedy/abate this violation, a citation will be issued against you.
You are further notified that this violation is a misdemeanor, punishable by fine of not more than $500.00 and/or imprisonment. These penalties are in addition to other civil remedies that the City may seek against you.
Signature
Signature
Address/Phone Number
Address/Phone Number
Inspector/Officer's Signature

Site Summary



Additional Capability

- Mobile mapping and data collection
- Internet mapping and public access/input
- Document, photo and video attachment
- Live data feed display
  - Flood warning system
  - SCADA
  - Web cameras
- Equipment and cost tracking
- Maintenance cost forecasting

Beehive Modules

Thank You!

ckudym@beehiveindustries.com

Ideas for Ecological Restoration

"SOMETIMES IT'S THE LITTLE THINGS"

Julie E. Ash, P.E.

Walsh Environmental Scientists & Engineers, LLC

24th Annual CASFM Conference

Steamboat Springs, September 11, 2013

Ecological restoration of stream corridors in urban environments is all about constraints and challenges

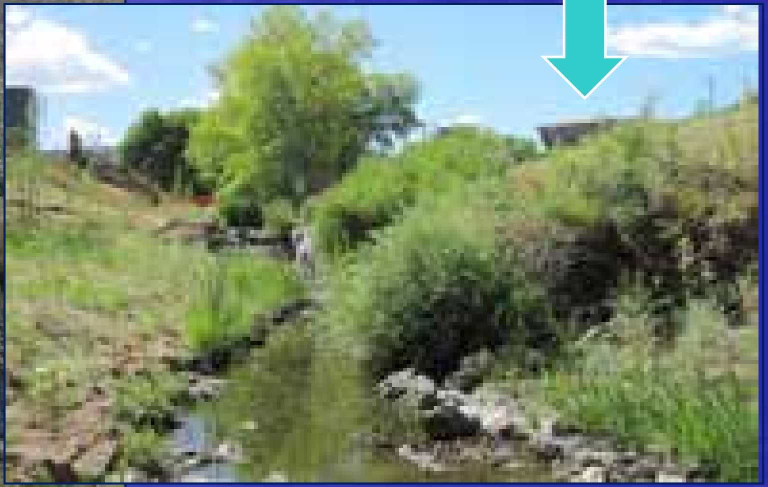
Restoration in urban environments

- Existing infrastructure sets the stage
- Defines and seems to limit restoration potential
- Constraints affect hydraulics, floodplain processes, water quality, wildlife habitat, recreational access…

And constraints are unavoidable

Constraints and Challenges…
Opportunities too!

Combining a thorough understanding of site constraints with a drive to maximize opportunities for ecological improvement, both large and small, is a great path to success for all restoration projects



Small details can add up to meaningful improvement

A story about the importance of a flag…

In ecosystem restoration, as in life,
sometimes it's the little things that really matter

Disclaimer:

This presentation focuses on details that can be added to restoration projects to enhance form, function, and aesthetics…

Nothing here substitutes for the big issues

System understanding that drives proposed treatments and big picture design is the underpinning

LITTLE THING IDEAS:

#1 Preserve what's functional

especially when it can't be quickly replaced

- **Water pockets**
- **Varied planting pockets**
- **Wetland sod**
- **Log ends**
- **Travel corridors**
- **Wildlife species specifics**
- **Noise**
- **Offsets**
- **Pipes**
- **Fabrics & blankets**
- **Weeds**
- **Shrub seed**
- **Well-behaved willows**
- **Challenging soils**
- **Regulatory "little things"**
- **Construction sediment**

Preserve what's functional

(don't do more harm than good)

Grading plan maximized preservation of mature cottonwood stands and large willow complexes in tight space

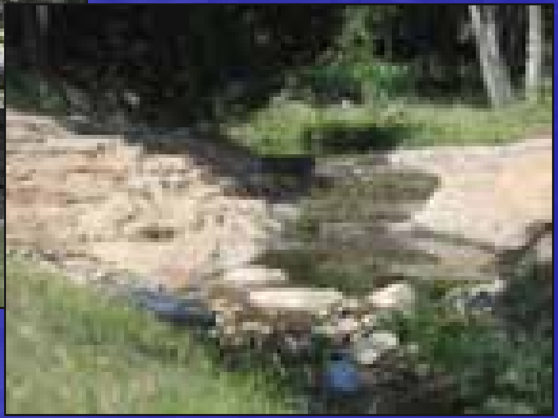
- **Preserved canopy for shading, cooling, and detritus supply**
- **Instant respite from hectic urban surroundings**

McIntyre Gulch at the Denver Federal Center

Water Pockets

Large instream structures are often needed to stabilize urban systems

With thoughtful engineered details, they can mimic natural features and improve habitat too



Sculpted concrete drop structure:

- Steps sized and shaped to mimic exposed bedrock outcrop
- Color match using paint chips
- Indentations built into structure to store rainwater for urban wildlife visitors
- Similar opportunities with other structures

McIntyre Gulch at the Denver Federal Center


Sculpted concrete drop

Varied Planting Pockets

- **Micro-grading for local diversities in soil and water conditions supports specialized plantings**
- **Iterative grading and plantings plans**
- **Opportunistic seed mix**
- **Small rock and log features create local variations**

McIntyre Gulch at the Denver Federal Center

Wetland Sod

- **Instant stabilizing root mass**
- **Virtually no establishment period**
- **Eliminates need to overdesign for (otherwise typical) immediate post-construction condition**

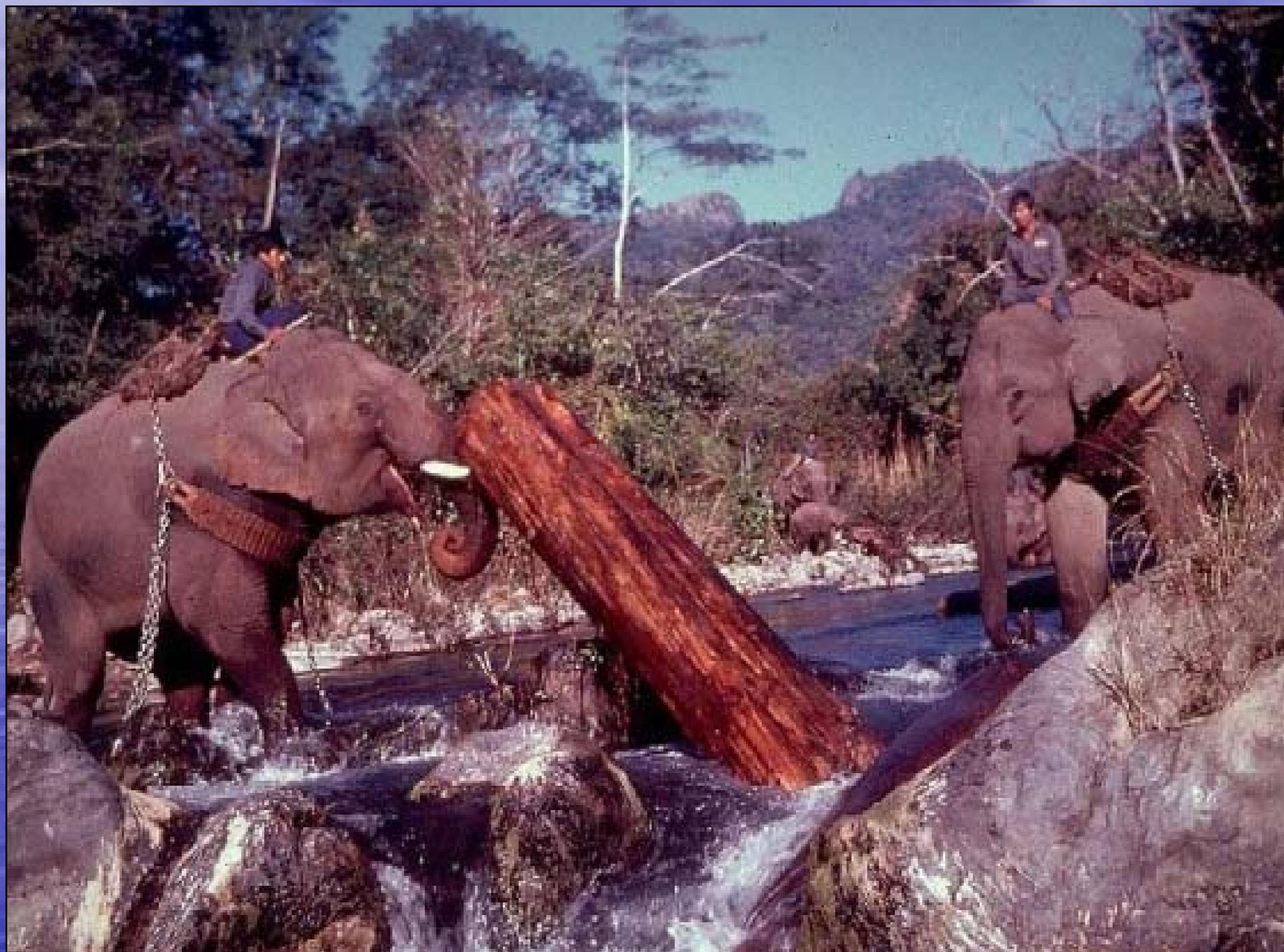
Water Quality Swale at Riverfront at Sheridan Redevelopment

Log Ends

- **Chain saw edge never goes away**
- **Right materials make all the difference, just like boulders**
- **Ask contractor to "chaw" on the exposed ends before install**
- **Laborers with hatchets, etc.**
- **Operator can shake, squash, repeat**

  (stress relief)
- **OR alternate approach…**

Additional benefit: contractor stress relief

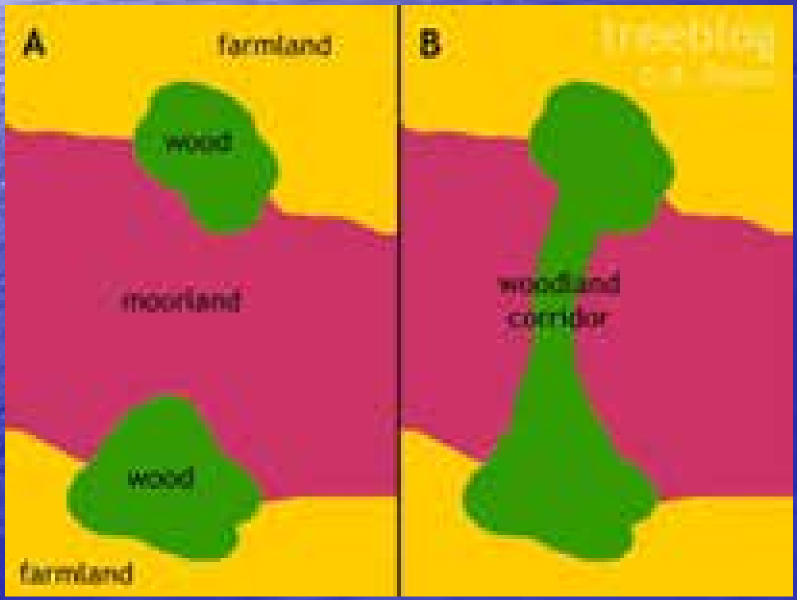


Travel Corridors

What wildlife would use the site?

Reduce habitat fragmentation via:

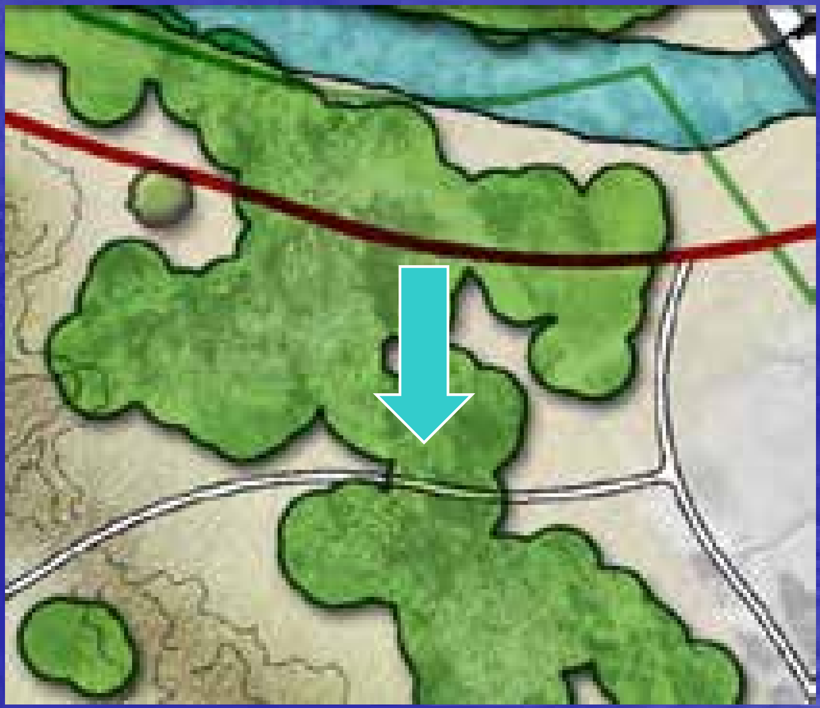
- **Corridor connections for patches**
- **Ledges in culverts for Preble's meadow jumping mice**
- **Drop structures that allow fish passage**
- **Canopy connections**



Travel Corridors

Corridor connections:

- Consider small, medium, and large wildlife needs
- Watch for pinch points in travel corridors
- Combination of trees, shrubs, forbs, and grasses is most conducive to high biodiversity
- Most functional when canopy, shrub, understory strata are all present
- Minimize gaps for trails to width of trail only
- Benefit of "explorer" feel for recreator



Travel Corridors

Build it and they will come…always a good thing?

- Urban settings require us to think about and plan for the result
- Any habitat improvement in urban areas can potentially create wildlife corridors, bird and waterfowl congregation zones, etc.
- Will adjacent landowners be ok with increased waterfowl use or expanded critter travel? More skunks?
- Will education suffice? Provide local contacts, resources
- Some owners amenable to "backyard habitat" programs to further the project's benefits

Wildlife Species Specifics

- **Bridge undersides can be bat habitat**
  pre-made panels for daytime roosting and night-time insect foraging, out-flight at dusk can be an attraction
- **Shrub-dominated habitats for avian native species**
  yellow-breasted chat, gray catbird, common yellowthroat require stretches without dominant overstory
- **Butterfly gardens as amenities**

Noise

- Wildlife abundance and activity is tied to noise levels
- Birds have difficulty breeding where there is loud noise
- Breeding songs cannot be heard, among other things
- Avian species richness typically increases with noise reductions
- Consider opportunities for noise reductions
- Capitalize on areas of less noise under existing conditions

Offsets

- **Can existing offsets or buffers be increased for better filtering and stabilization function?**

  golf course mow line off of edge of lakes

  residential mow line off of creek edge

- **Can new native grass buffers be added?**
- **Can certain trail segments be moved farther off of water or completely out of riparian area?**
- **In more remote areas, some trails can be designated for horseback only for increased viewing of larger wildlife**

  animals sense the horse, not the human

Pipes

- **Avoid vertical pipes to avoid wildlife deaths – or cover**

  snakes, young raccoons frequently found trapped at bottom
- **Avoid open ended pipes – or cap and screen**

  especially small 3" diameter PVC, birds can get in and can't get back out
- **Think of worst-case scenario:**

  will workers remember to always replace the cover?

  will a screen clog, then not be replaced?

  avoidance is better than a control that can go wrong or requires maintenance

Fabrics & Blankets

Not all erosion control fabrics and blankets are created equal

- **So many choices – don't get stuck in a rut!**
- **Woven fabrics need an open enough weave for light penetration**
- **Straw or coconut blankets that are too thick preclude germination and/or emergents can't get through**
- **Photo-deteriorating nylon mesh on some blankets**

plastic doesn't break down quickly in our arid environment

Weeds

Agricultural approach to weed management:

- **Early start – requires multiple season lead time**
- **Multiple forced grow/ treat cycles**

Timing of herbicide application matters:

To exhaust large, stubborn seed banks (like kochia, cheatgrass):

- **scarify/ plow to encourage weed germination**
- **apply herbicide to emergents**
- **Herbicide most effective when the plants are in rapid growth mode (during establishment)**
- **multiple cycles best**

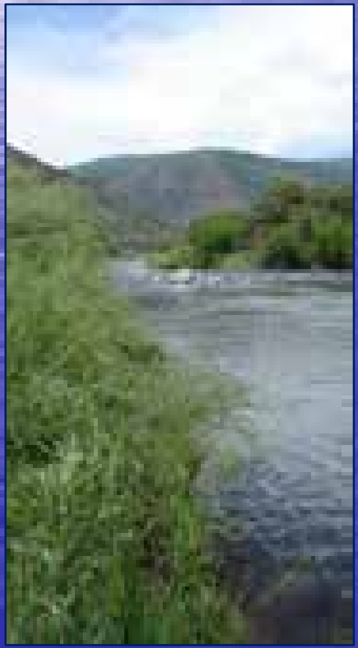
Shrub Seed

- **Shrub seed is good in harsh conditions that will shock nursery stock**

  allow for longer establishment period and anticipate perception challenges
- **Add in native wildflowers**
- **Consider needs of T&E species in the area**

Well-behaved Willows
(and other lovely riparian plants)

- **Select appropriate willow species for desired result**
  for example, coyote willow is an expansionist, but peachleaf willow remains shrub- or tree-like
  (will stay where you put it)
  - **Install in groups with purposeful gaps for fishing access or views, etc.**
  - **Remember other riparian shrubs and trees too…**



Well-behaved Willows
(and other lovely riparian plants)

For continuous willow bank treatments:

- *Bebb's willow*
- *Whiplash willow*
- *Planeleaf willow*

Groups for more localized installations:

Tall Willow Group:

- *Rocky Mountain willow*
- *Whiplash Willow*
- *Planeleaf Willow*
- *Thinleaf alder*

Localized (cont):

Narrowleaf CW Group:

- *Narrowleaf cottonwood*
- *Blue spruce*
- *Thinleaf alder*
- *Red-twig dogwood*
- *Prickly currant*
- *Golden currant*

Shrub Group:

- *Woods rose*
- *Golden currant*
- *Prickly currant*
- *Twinberry honeysuckle*
- *Thinleaf alder*
- *River hawthorn*

Localized (cont):

Mixed Shrub Group

- *Red-twig dogwood*
- *Wood's rose*
- *Golden currant*
- *Prickly currant*
- *Twinberry honeysuckle*
- *Mountain snowberry*
- *Shrubby cinquefoil*
- *Thinleaf alder*
- *River hawthorn*
- *Rocky Mountain Willow*

Challenging Soils

- **Don't forget the soils!**
- **Soil samples guide revegetation**
- **Salty soils are a big challenge - if you have them…**

…put in halophytes (desirables)
…or put in salt-tolerant plants!

Regulatory:
Section 404 NWP/ RGP Thresholds

- **Toe protection options where impacts exceed NWP or RGP thresholds**
- **Log and rock log deflectors can replace soil riprap to reduce impact footprint**
- **Deflectors redirect low flows away from bank**
- **Provide localized low flow diversity**
- **Incorporate woody materials into system**

McIntyre Gulch at the Denver Federal Center

Regulatory: Section 401 Water Quality Certification

- **401 certification is built into NWP and RGP authorizations**
- **WQCD requires weed-free certified seed for 404 Individual Permits**

Construction Sediment

- **Options available for construction sediment control**
- **Structural BMPs – Expensive**

  e.g., Aqua Dam, Floating Silt Curtain

  Eagle River project spent $180K, 10% of construction budget
- **Non-Structural BMPs – Pretty cheap**

  e.g., no equipment tracking in channel,

  spawning monitoring by fly fishing guides

AQUA DAM Water-Controlling Water

Be driven to seek out every last opportunity to improve ecosystem health and resiliency within the given constraints…and turn constraint into opportunity

In ecosystem restoration, as in life, sometimes it's the little things that really matter

THAK YOU!

Contact info:

Julie E. Ash, P.E.
Senior Water Resource Engineer
Direct: 720-308-7840
jeash@walshenv.com

Walsh Environmental Scientists and Engineers, LLC
Boulder, Colorado
http://www.walshenv.com

Natural Bank Protection Treatments

David B. Bennetts, PE, CFM
Manager, DCM Program

Bank Erosion

Bank Erosion

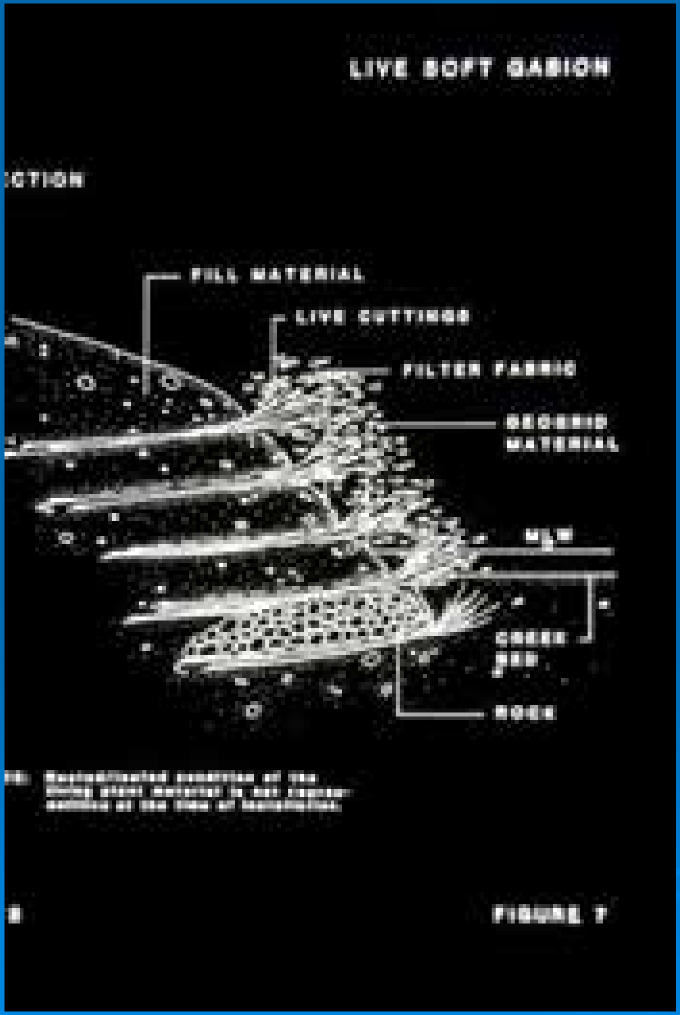
Traditional Bank Protection

Traditional Bank Protection

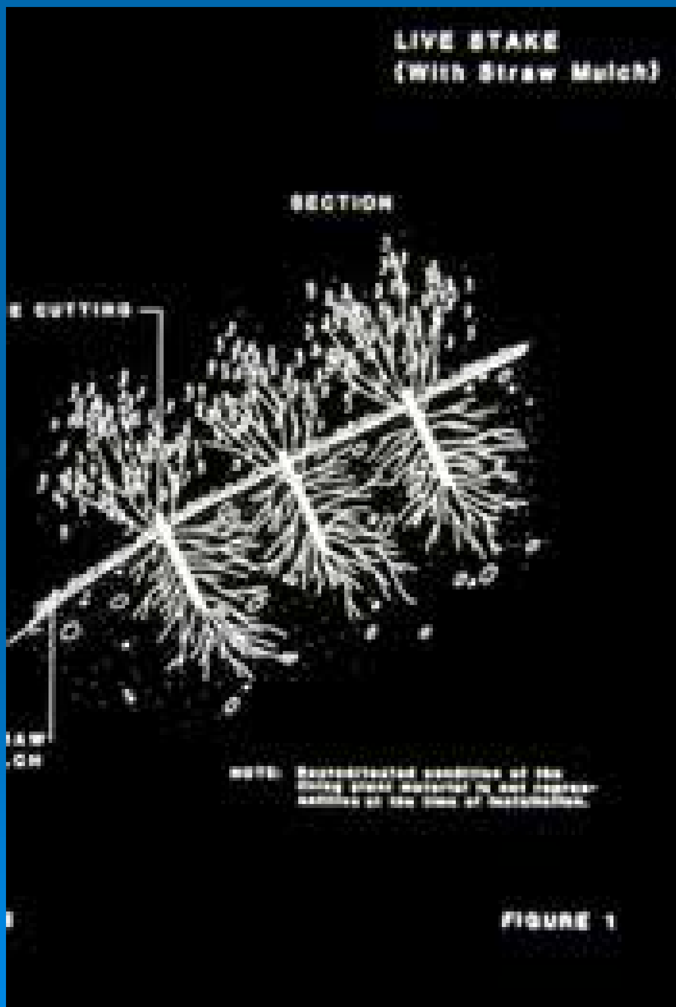
1986 - Bioengineering

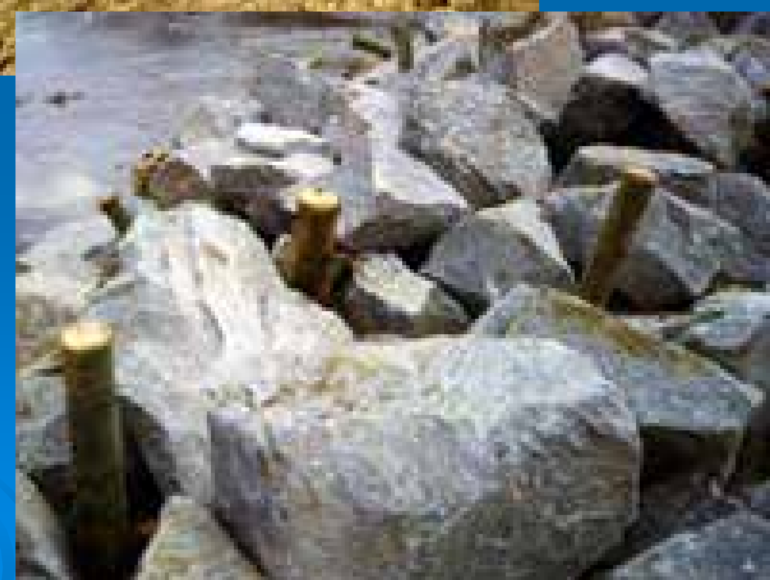
Q_{design} = 300 cfs V_{design} = 4.3 fps
Q_{100} = 5200 cfs V_{100} = 7.2 fps

1986 - Bioengineering



1986 - Bioengineering





1986 - Bioengineering

1986 - Bioengineering

1999 - Willow Creek

Q_{design} = 300 cfs V_{design} = 4.3 fps
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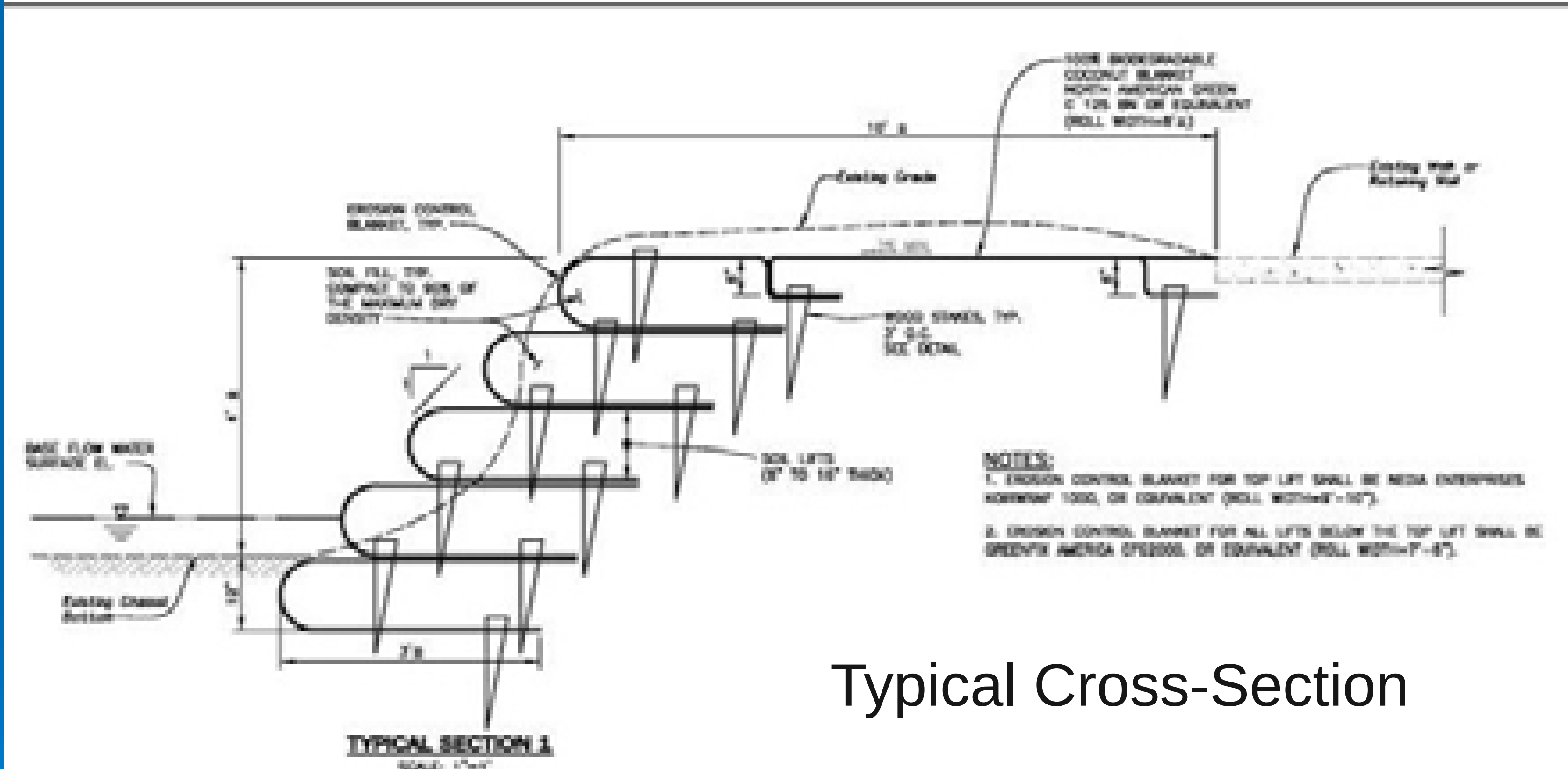
1999 - Willow Creek

Soil Wrapped Lifts



Typical Cross-Section

2004 - Rock Creek

Q_{design} = 2200 cfs V_{design} = 5.3 fps

Q_{100} = 6650 cfs V_{100} = 3.1 fps

Cherry Creek

Q_{design} = 1500 cfs V_{design} = 7.4 fps
Q_{100} = 9700 cfs V_{100} = 11.1 fps

2010 - West Harvard Gulch

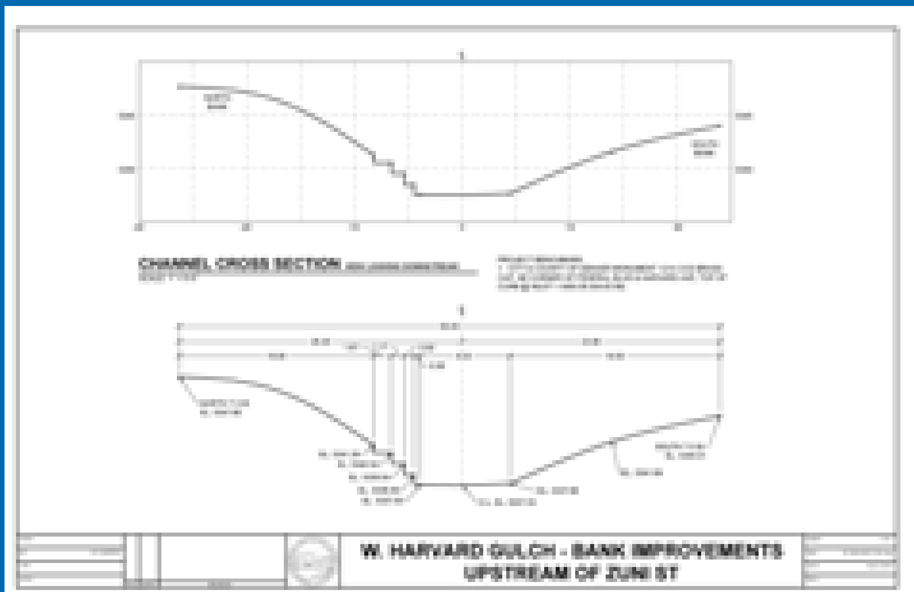
Q_{design} = 375 cfs V_{design} = 3.7 fps
Q_{100} = 1485 cfs V_{100} = 3.2 fps

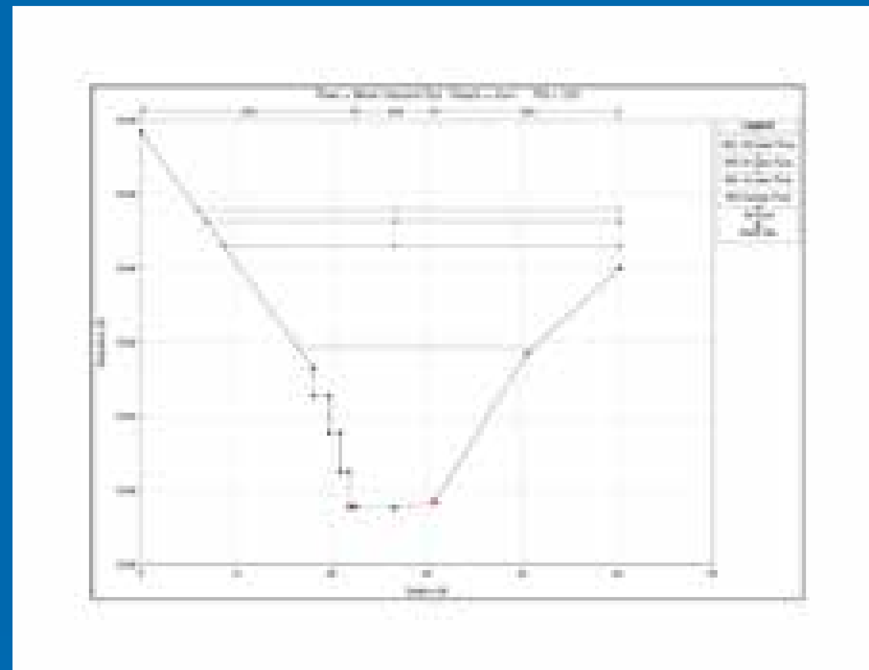
2011 - Bear Creek

Q_{design} = 300 cfs V_{design} = 3.4 fps

Q_{100} = 8150 cfs V_{100} = 8.1 fps

Analysis of Past Sites

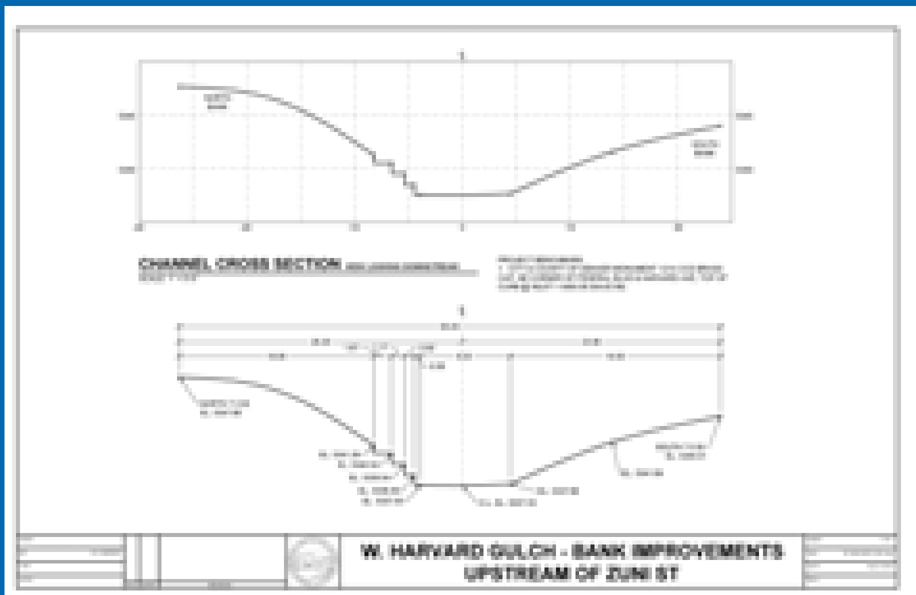


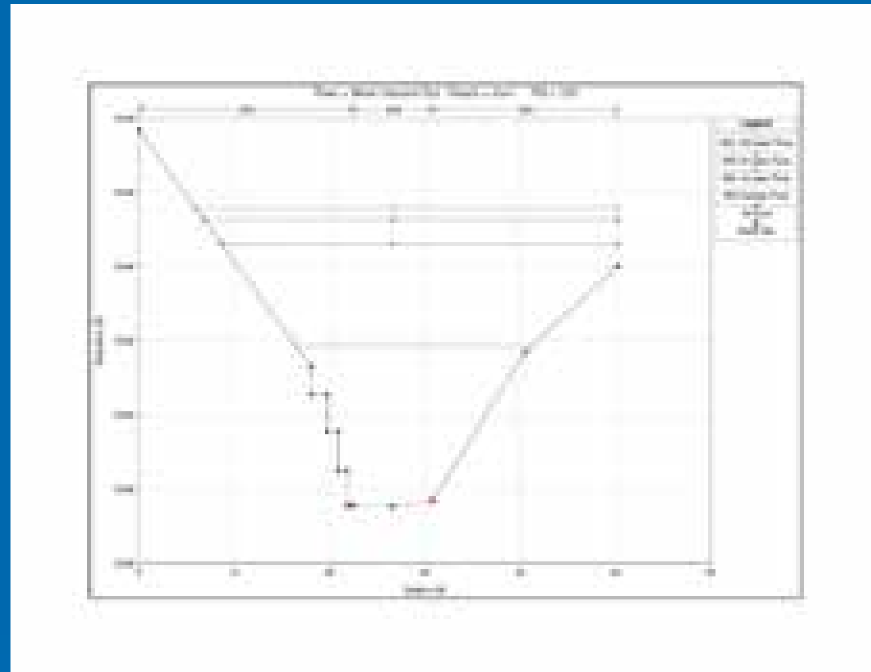


W Harvard - Zuni @ STA 1+50 (2010)

Profile	Q Total	Vel Total	Max Chl Dpth	Mann Wtd Left	Mann Wtd Chnl	Mann Wtd Right	Q Left	Q Channel	Q Right	Vel Left	Vel Chnl	Vel Right	Shear LOB	Shear Chan	Shear ROB
	(cfs)	(ft/s)	(ft)				(cfs)	(cfs)	(cfs)	(ft/s)	(ft/s)	(ft/s)	(lb/sqft)	(lb/sqft)	(lb/sqft)
Design Flow	375	5.56	4.31	0.046	0.036	0.045	26.73	273.23	75.04	2.46	7.68	3.56	0.35	1.33	0.59
10-year Flow	1090	6.75	7.07	0.046	0.036	0.045	142.27	626.94	320.79	3.75	10.71	4.94	0.66	2.19	0.96
50-year Flow	1350	7.11	7.74	0.046	0.036	0.045	194.42	729.55	426.03	4.08	11.38	5.46	0.74	2.4	1.12
100-year Flow	1485	7.28	8.06	0.046	0.036	0.045	223.73	781.14	480.12	4.23	11.69	5.7	0.79	2.5	1.19

Analysis of Past Sites





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	(cfs)	(ft/s)	(ft)				(cfs)	(cfs)	(cfs)	(ft/s)	(ft/s)	(ft/s)	(lb/sqft)	(lb/sqft)	(lb/sqft)
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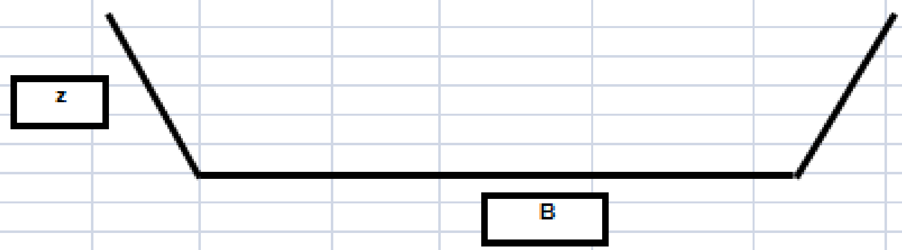
2012 - Sanderson Gulch

Q_{design} = 1100 cfs V_{design} = 14.0 fps
Q_{100} = 2700 cfs V_{100} = 17.9 fps

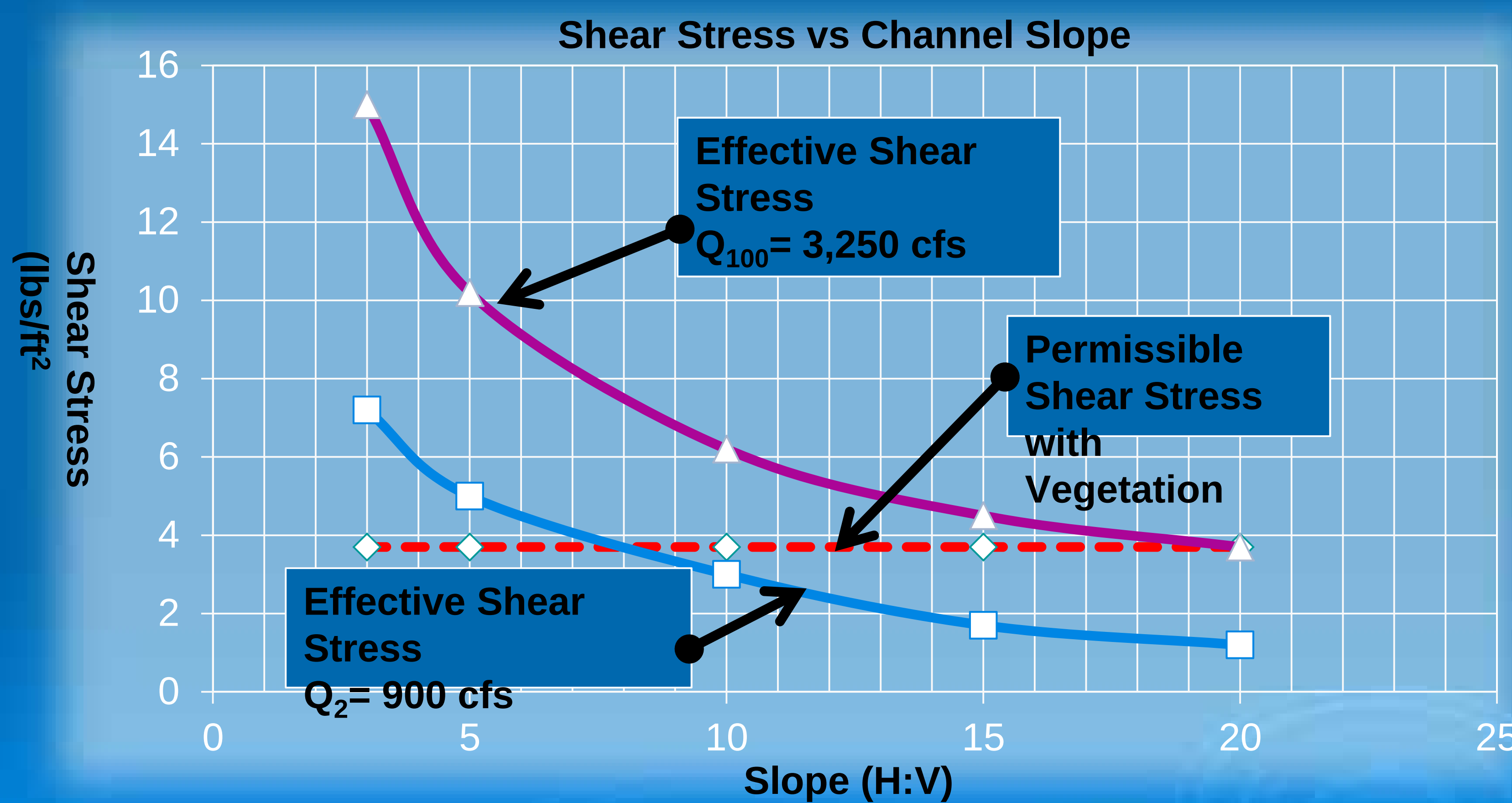
Cross-Sections

Section 3, Drop Structure

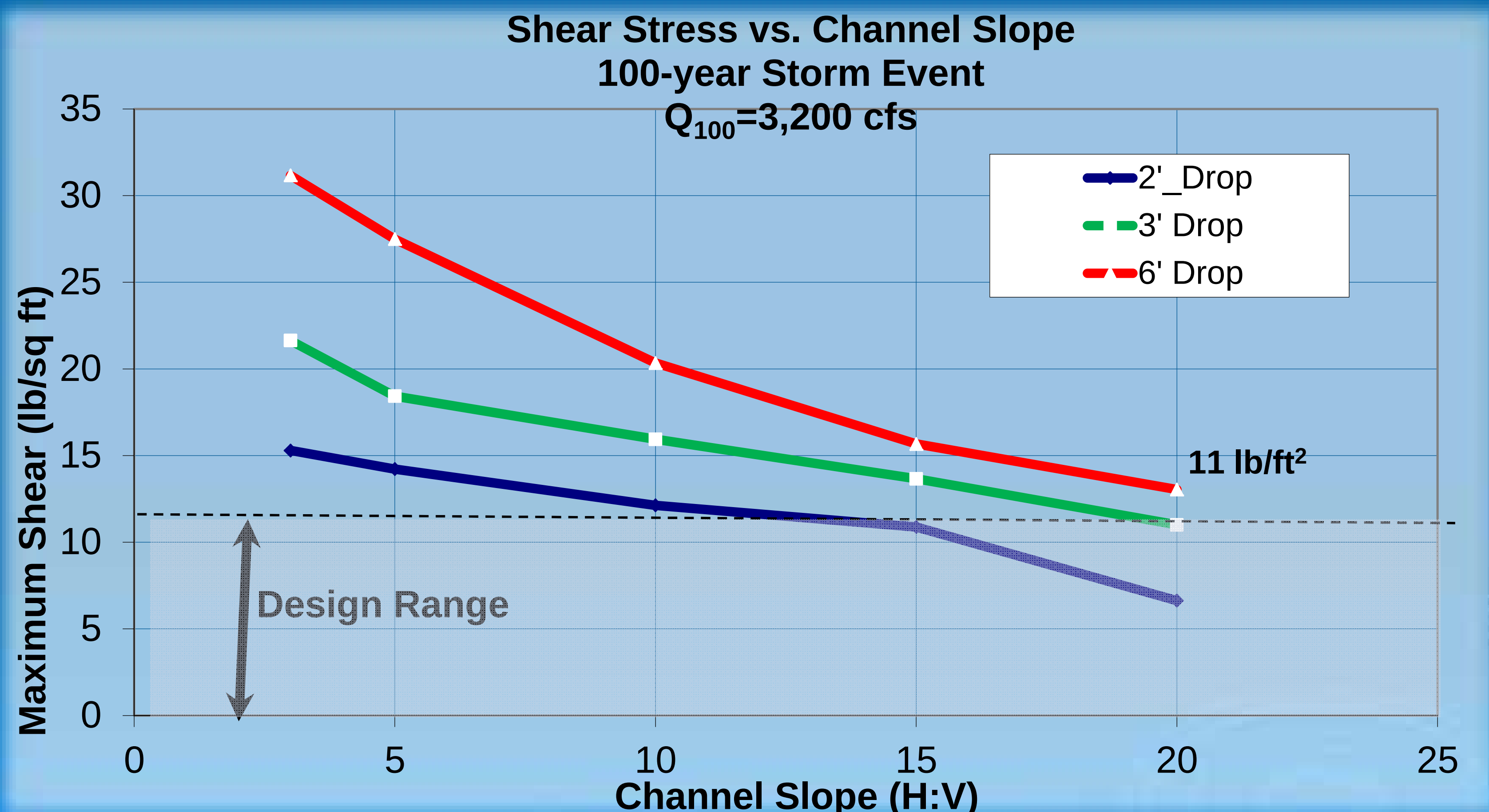
Discharge (Q)=	3200	cfs	Flow Area=	166.5	ft²
Channel Width(B)=	30	ft	Velocity (v)=	19.22	fps
Side slope(z)=	4	:1	Hydraulic Depth(D)=	2.79	
Manning's Coefficient=	0.034		Froude Number (Fr)=	2.03	
Hec 15, Table 4.4 Grass Roughness Coefficient(Cn)=	0.418		Hyraulic Radius R=	2.75	ft
Permissible Soil Shear Stress=	1.2	lbs/ft²	Mean Shear Stress=	8.57	lbs/ft²
Effective Shear Stress at Boundary w/Vegetation=	3.7		**Force per unit width of channel=**	2,357.33	lbs/ft
Permissible Vegetation Shear Stress=	3.74	lbs/ft²			
Grass Cover Factor (Cf_{VEG})=	0.62				
d75=	3	inch			
Soil Grain Roughness=	0.031				
Permissible TRM Shear Stress=	4.2	lbs/ft²			
Permissible Shear of TRM w/o Veg=	15.3	lbs/ft²			
Permissible Shear of TRM w/Veg=	17	lbs/ft²			
Grass Cover Factor with TRM (Cf_{TRM})=	0.658				



Shear Stress vs. Channel Slope



Shear Stress vs. Drop Face Slope



2012 - Sanderson Gulch

2012 - Sanderson Gulch

2010 – Rock Creek

Exploring Future Technologies

2013 – Cape Cod

Initial Lessons Learned

Initial Lessons Learned

- Consider a Team Approach
  - Soils Engineer
  - Hydraulic Engineer
  - Plant ecologist
  - General Contractor
  - Revegetation Contractor
  - Plant supplier – contract grown

Initial Lessons Learned

- Do weed control before you start the project
- Success is very weather dependent
  - Irrigation, if available, is best for establishment
- Long lead time for plant material
  - Plugs – 6 months to grow
  - Pre-vegetated mats – one year
- Consider tiered planting
  - Do your planting over several growing seasons

Lessons Learned

Don’t over plant

Questions

dbennetts@udfcd.org

Riparian Habitat Mitigation Banking and Nutrients

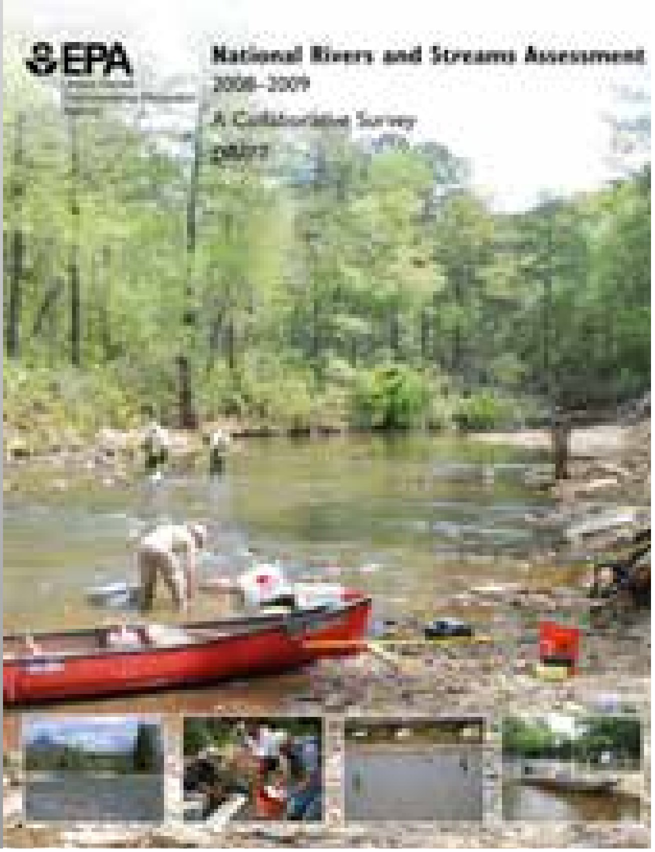
Nutrient Pollution—2013 EPA Report

Key Finding

- 27 percent of nation's rivers have excessive nitrogen and 40 percent have excessive phosphorus

- Nutrient sources include point
and non-point sources

- Excessive nutrients can impair
aquatic life, recreation and
other designated uses



Nutrients in Colorado

- Water Quality Control Commission adopted two nutrient regulatory provisions in 2012
  - Regulation 31; Numeric nutrient standards for rivers/streams and lakes/reservoirs

  Expected to result in significant development of Total Maximum Daily Loads (TMDLs)

  - Regulation 85; Numeric effluent limits for larger wastewater facilities

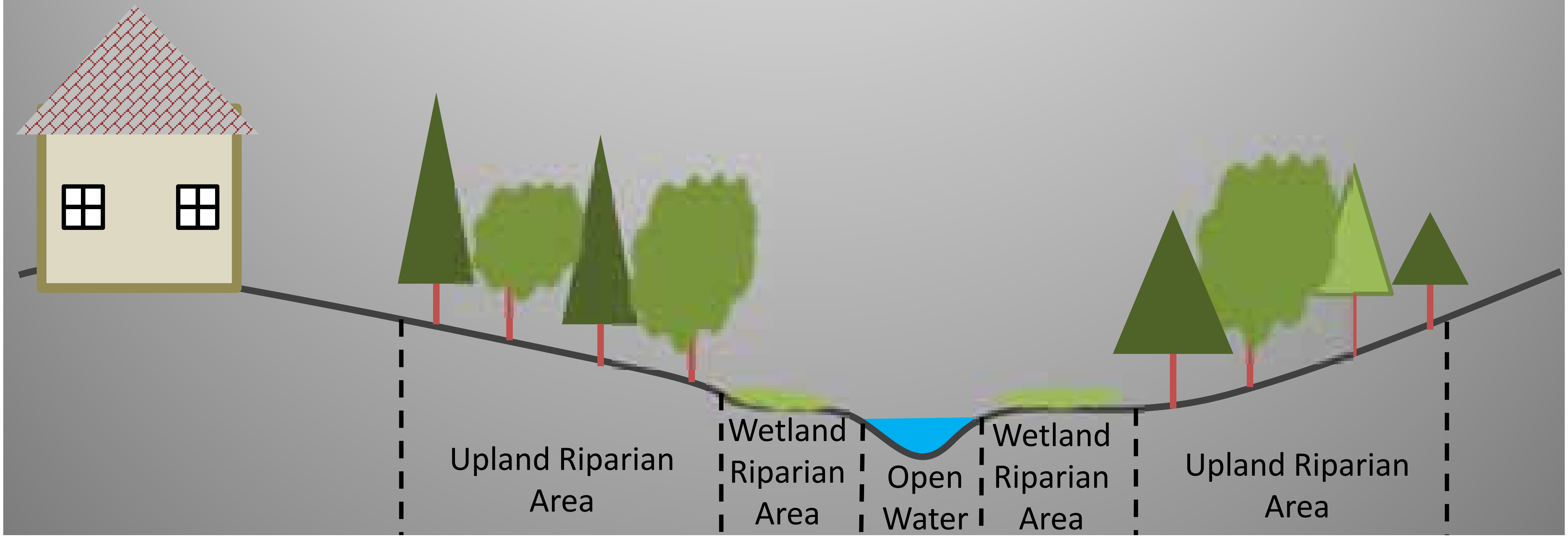
  Expected to require significant investment in infrastructure upgrades

Nutrient Control Measures

- Point Sources
  - Enhanced treatment
  - Stormwater management
- Non-Point Sources
  - Modify land use
    - Agricultural practices
    - LID
  - Riparian corridor conservation and enhancement

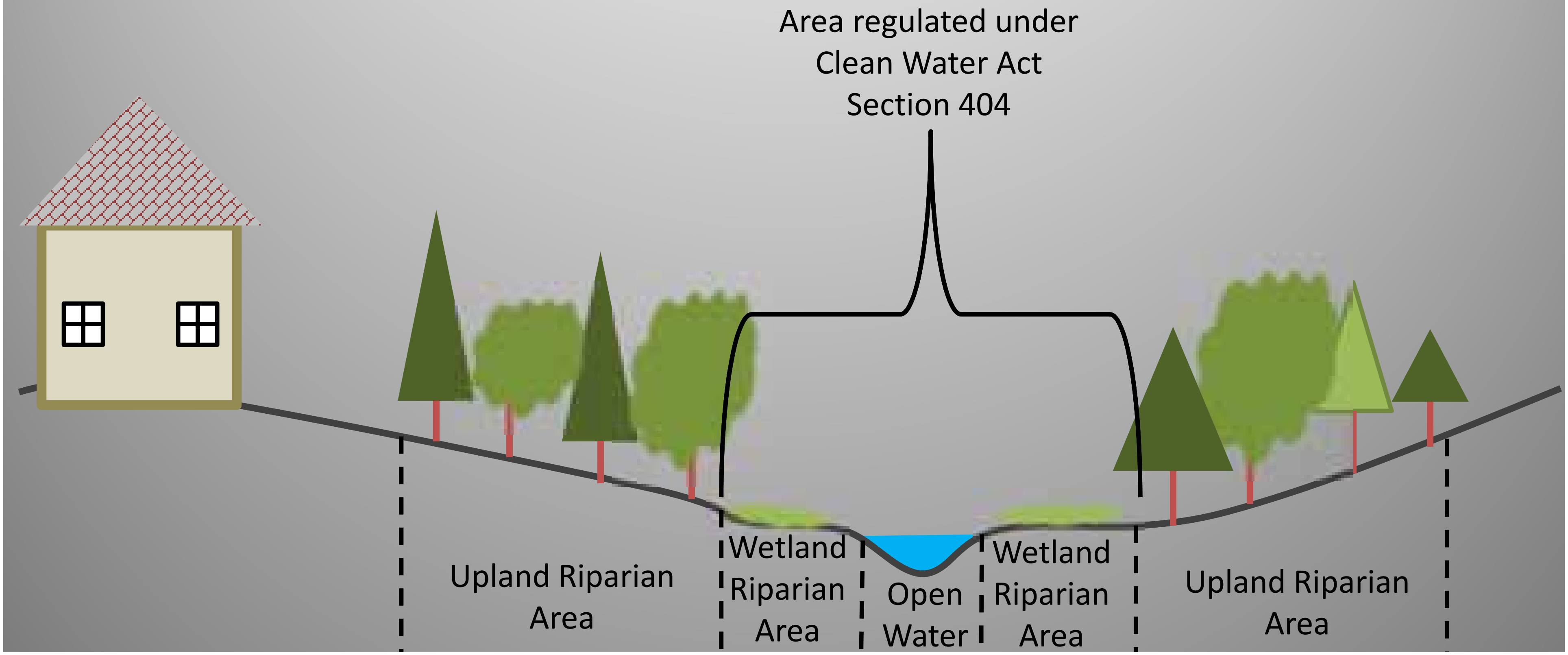
Riparian Corridors and Nutrients

- Vegetated riparian areas can reduce nutrient inputs
- Bank stabilization of open waters can reduce nutrient inputs



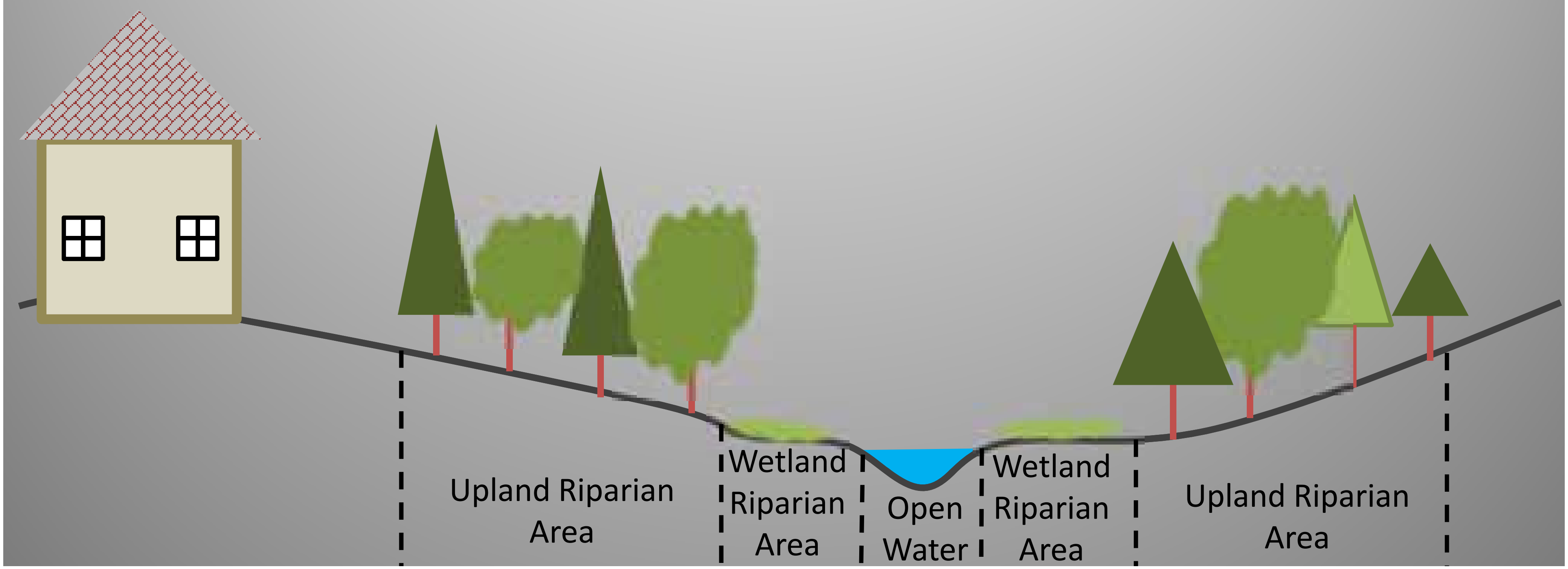
Riparian Corridors and Nutrients

- Only a portion of the riparian corridor is protected from fill discharges by federal environmental regulations



Riparian Corridors and Nutrients

- Degradation of the riparian corridor can diminish nutrient capture

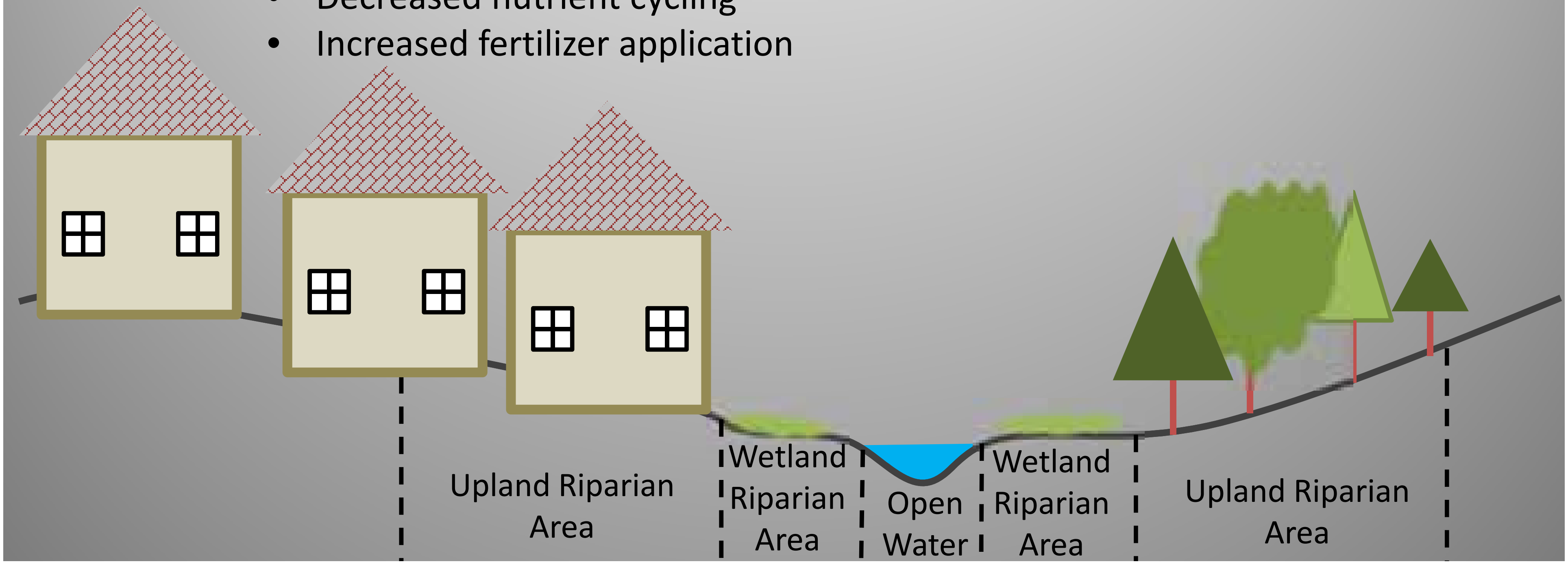


Riparian Corridors and Nutrients

- Degradation of the riparian corridor can diminish nutrient capture

Encroaching Development

- Increased impervious areas
- Decreased nutrient cycling
- Increased fertilizer application



Riparian Corridors and Nutrients

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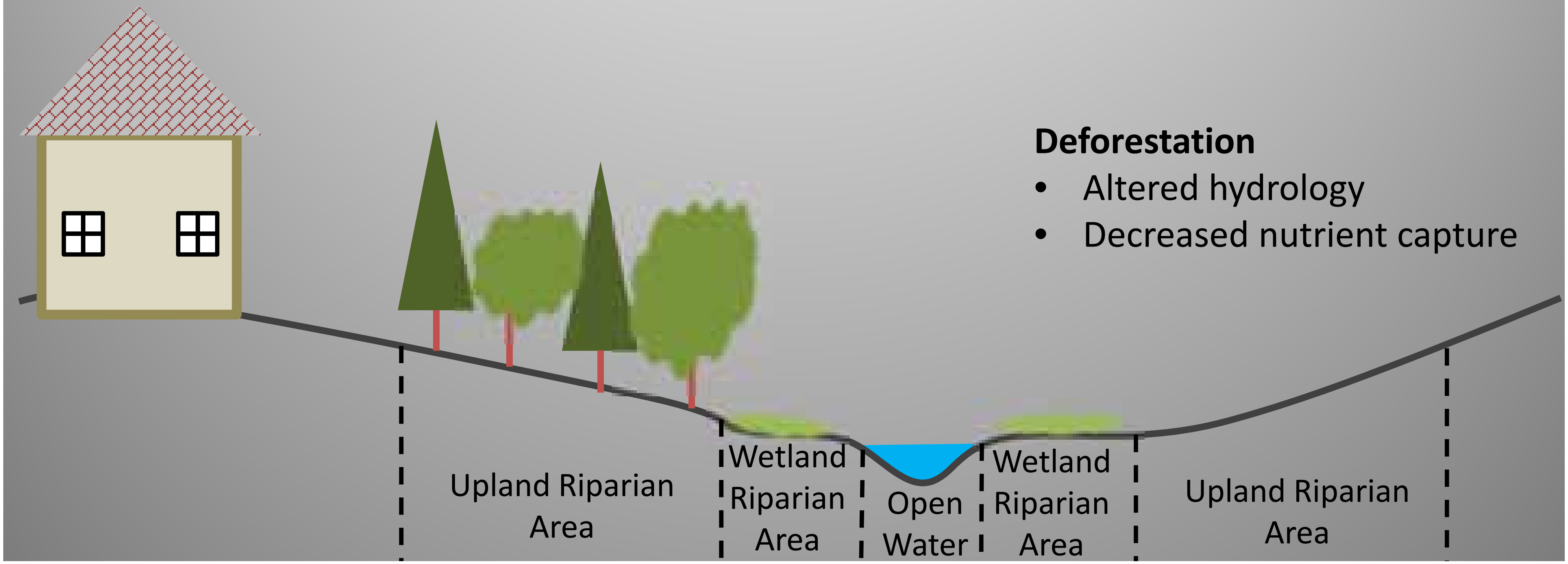
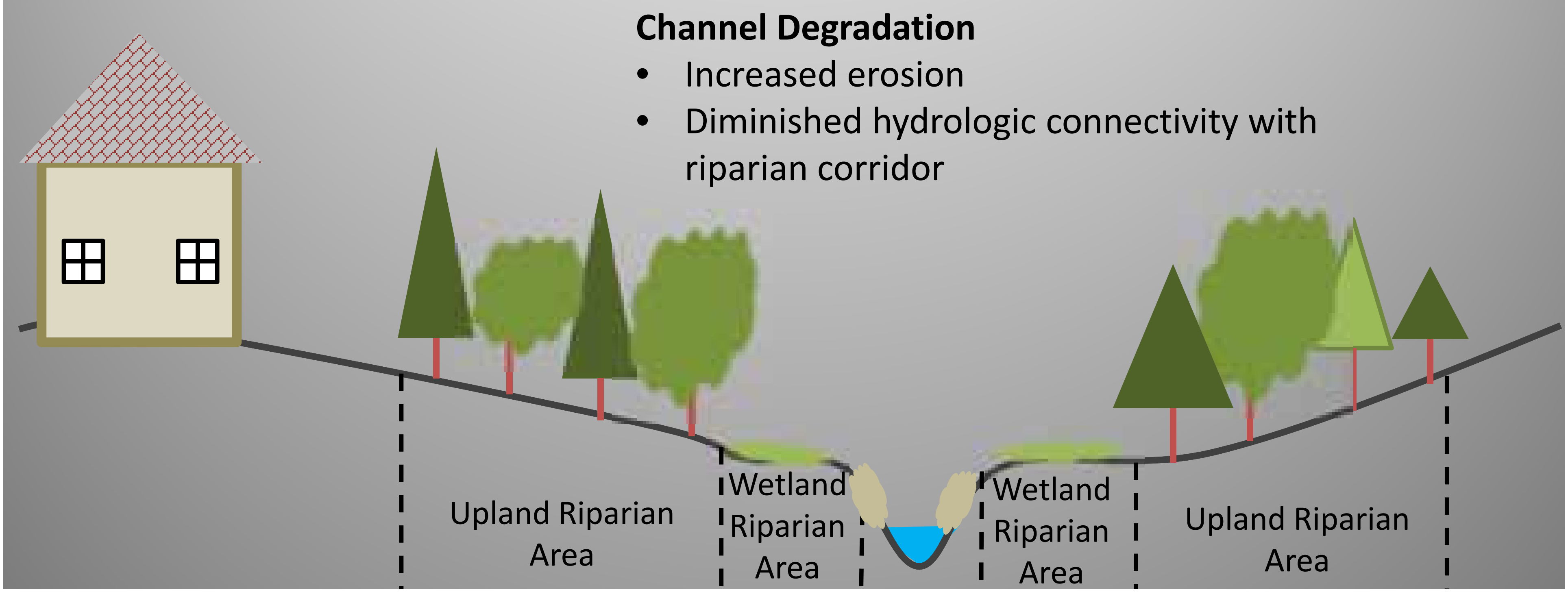


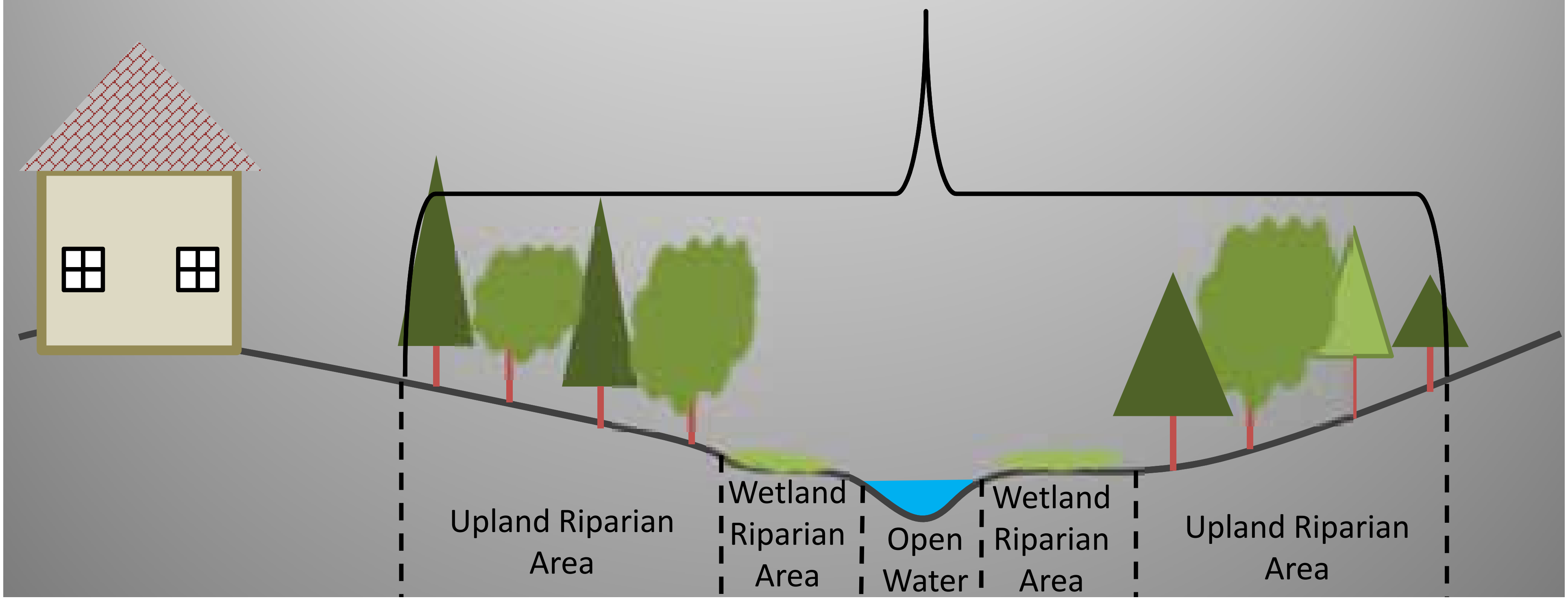
Riparian Corridors and Nutrients

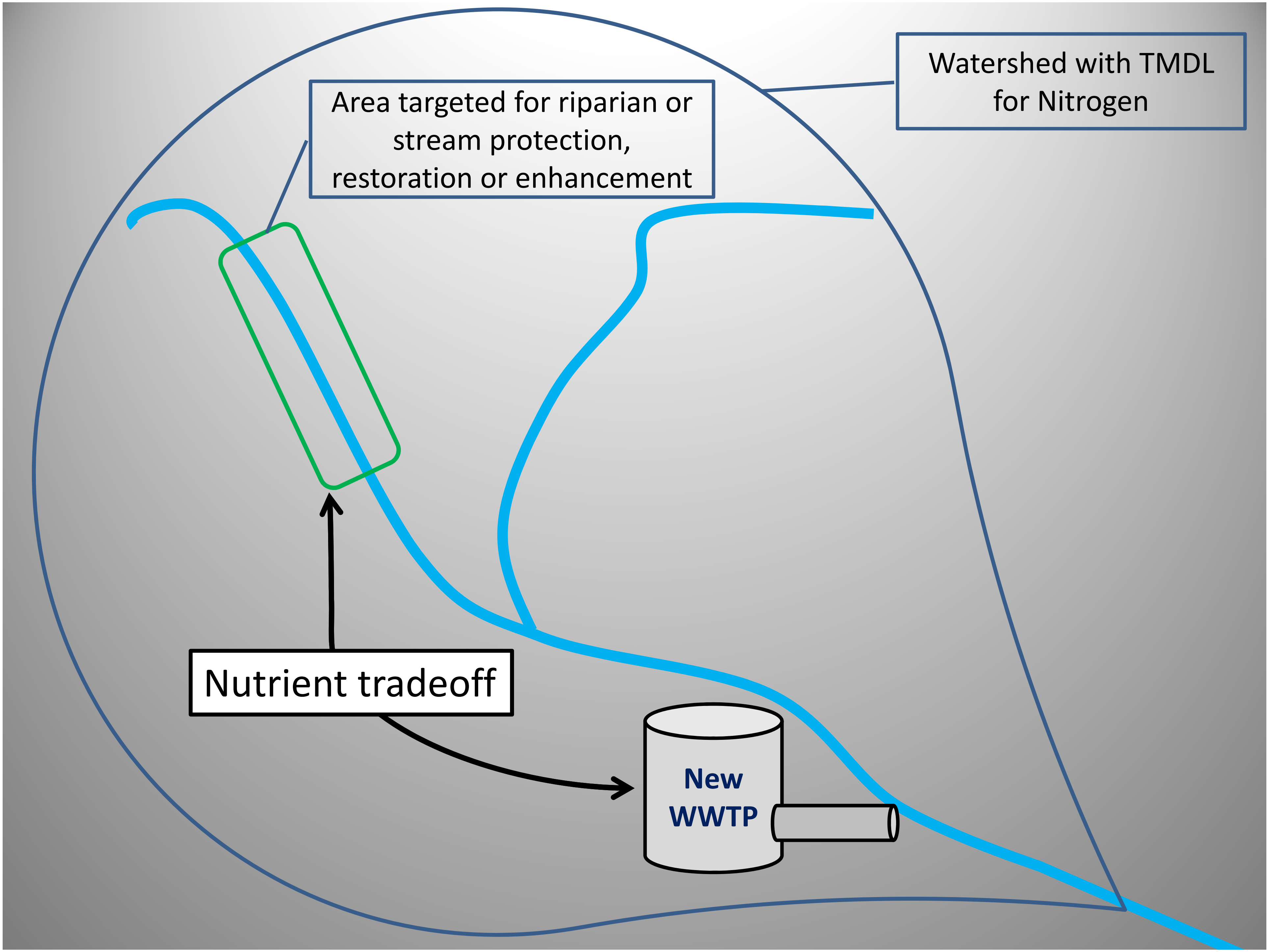
- Degradation of the riparian corridor can diminish nutrient capture



Riparian Corridors and Nutrients

- Maintaining, restoring and enhancing riparian and stream corridor conditions can result in measureable nutrient load reductions



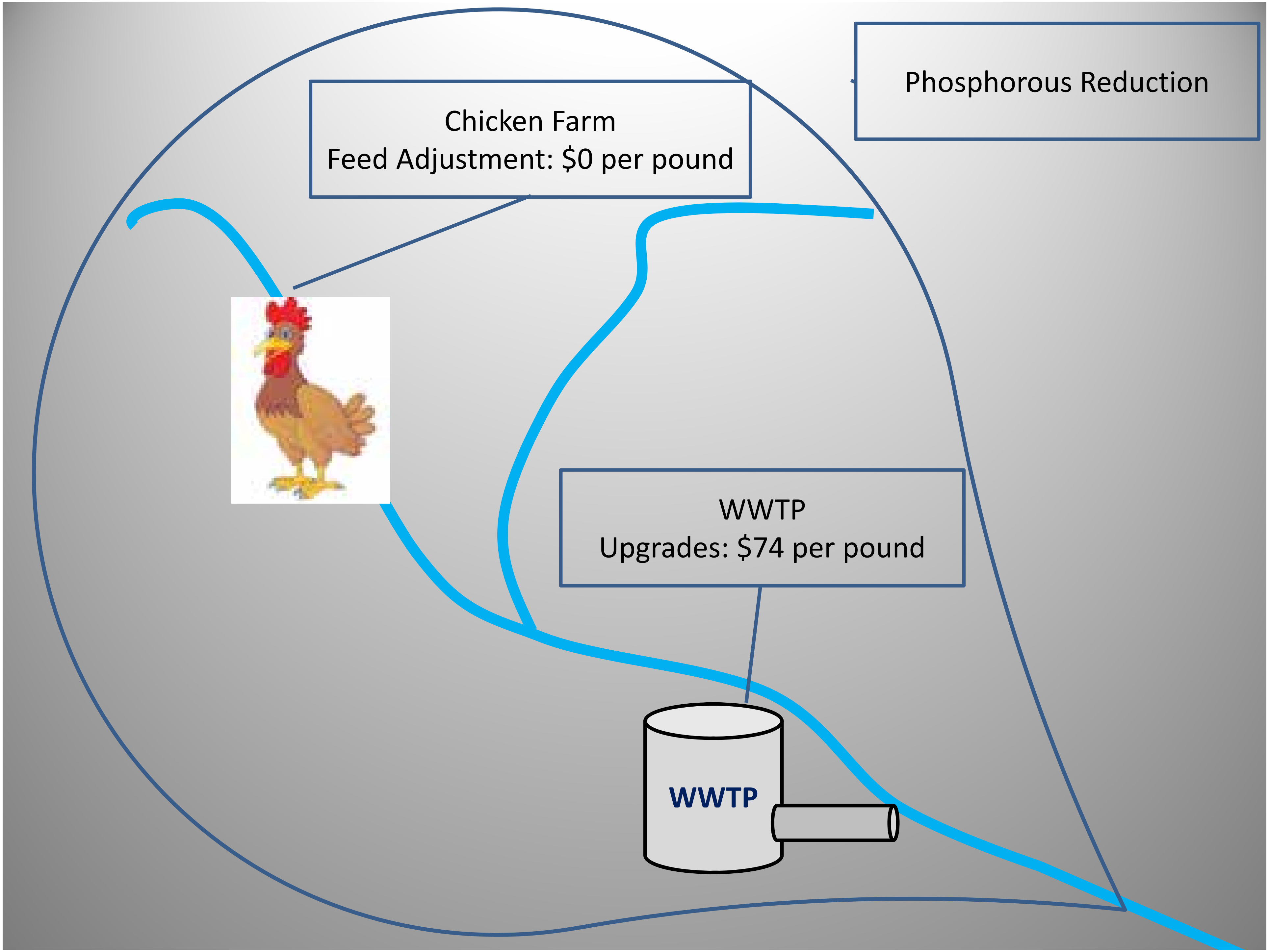


Area targeted for riparian or stream protection, restoration or enhancement
Watershed with TMDL for Nitrogen
Nutrient tradeoff
New WWTP

Why Trade Nutrient

- Some regulated entities may have opportunities to reduce their effluents that are more cost effective than others

- Example of the Chesapeake Bay


Phosphorous Reduction
Chicken Farm
Feed Adjustment: $0 per pound
WWTP
Upgrades: $74 per pound
WWTP

Why Trade Nutrient

- Chicken farms
  - need to reduce by 100,000 tons of phosphorous
  - Reduction costs virtually $0 through diet modification

- WWTP
  - need to reduce by 100,000 tons of phosphorous
  - Reduction costs $74 per pound

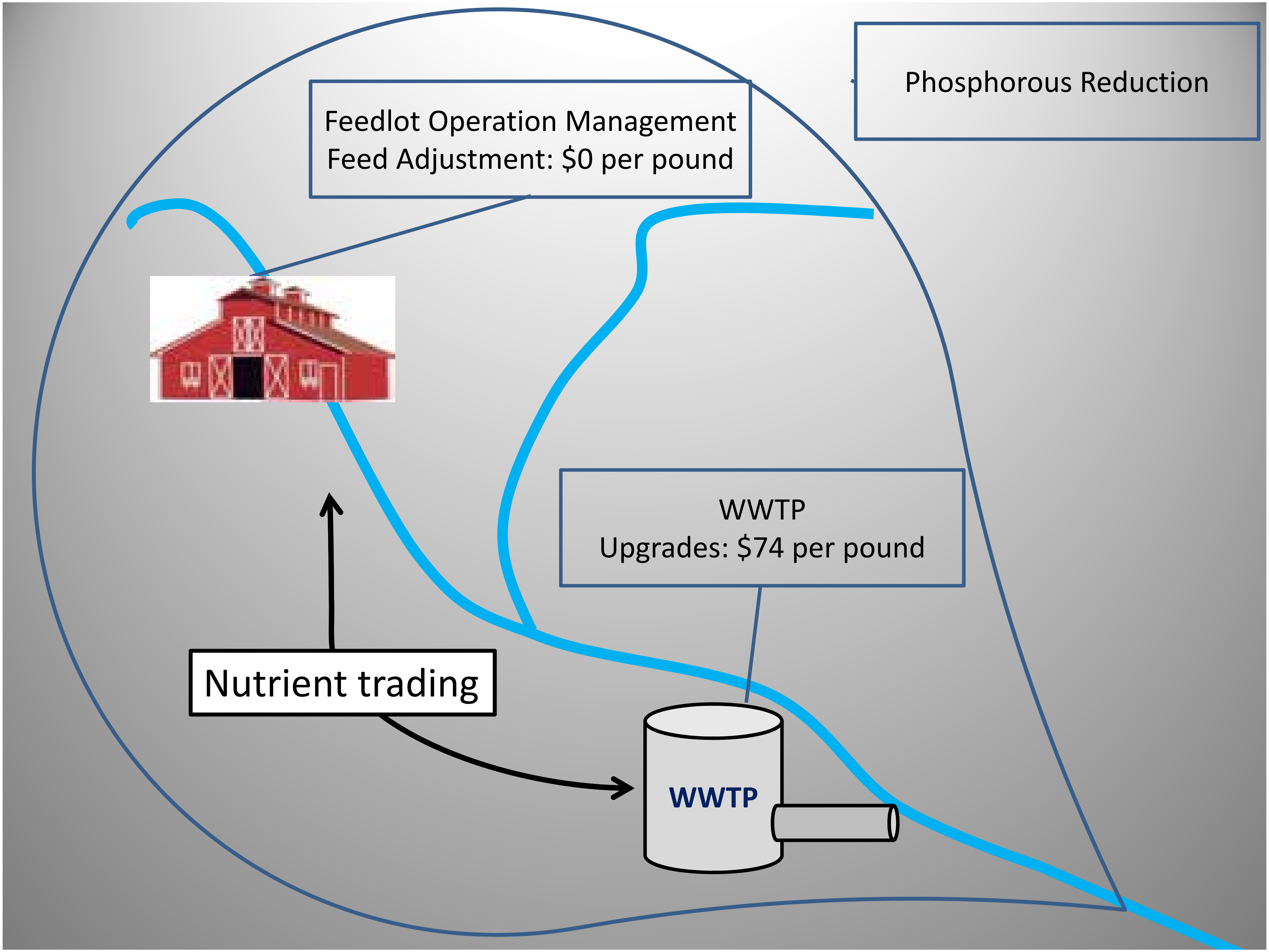
Results without Nutrient Trading

- 200,000 pounds of reduction
- Cost of $7.4 million for the WWTP

Nutrient Trading Rules

- WWTP can source 50% of its needs from other players

- Water quality agencies apply a 100% penalty for the trade
  - You need to buy 2 pounds to fullfil 1 pound of reduction


Phosphorous Reduction
Feedlot Operation Management
Feed Adjustment: $0 per pound
WWTP
Upgrades: $74 per pound
Nutrient trading
WWTP

Result with Nutrient Trading

- 250,000 pounds of reduction
- Cost of $2.35 million for the WWTP

Result with Nutrient Trading

- 250,000 pounds of reduction
- Cost of $2.35 million for the WWTP

Lower cost and Larger impact

- Chesapeake Bay Commission estimated the cost saving potential of nutrient trading to 44%

Finding the Low Cost Solution

Per Pound of Nitrogen

- Urban Storm water BMPs:
  - Cost of retention ponds: $400 to $1,000
  - Cost of urban forest buffer: $200 to $600

- Agricultural BMPs:
  - Cost of grass buffers: less than $50
  - Cost of tree buffers: less than $100

Finding the Low Cost Solution

Per Pound of Nitrogen

- Urban Storm water BMPs:
  - Cost of retention ponds: $400 to $1,000
  - Cost of urban forest buffer: $200 to $600
- Agricultural BMPs:
  - Cost of grass buffers: less than $50
  - Cost of tree buffers: less than $100

From 2 to 20 times cheaper

Limitations

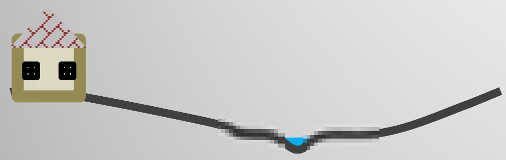
Not Point Source providers are a cheaper solution but present some challenges:

- Limited data available
- Difficulty to find willing landowners
- High coordination, monitoring and transaction costs
- Potential liability

Mitigation Banks

- Concept developed in the 80s
- Currently over 600 banks in operation in the country
- Credit sales represents several $ billion a year
- Main focus wetland, stream and listed species
- Water quality is an emerging field:
  - North Carolina
  - Chesapeake Bay
  - Willamette Valley

Mitigation Banks

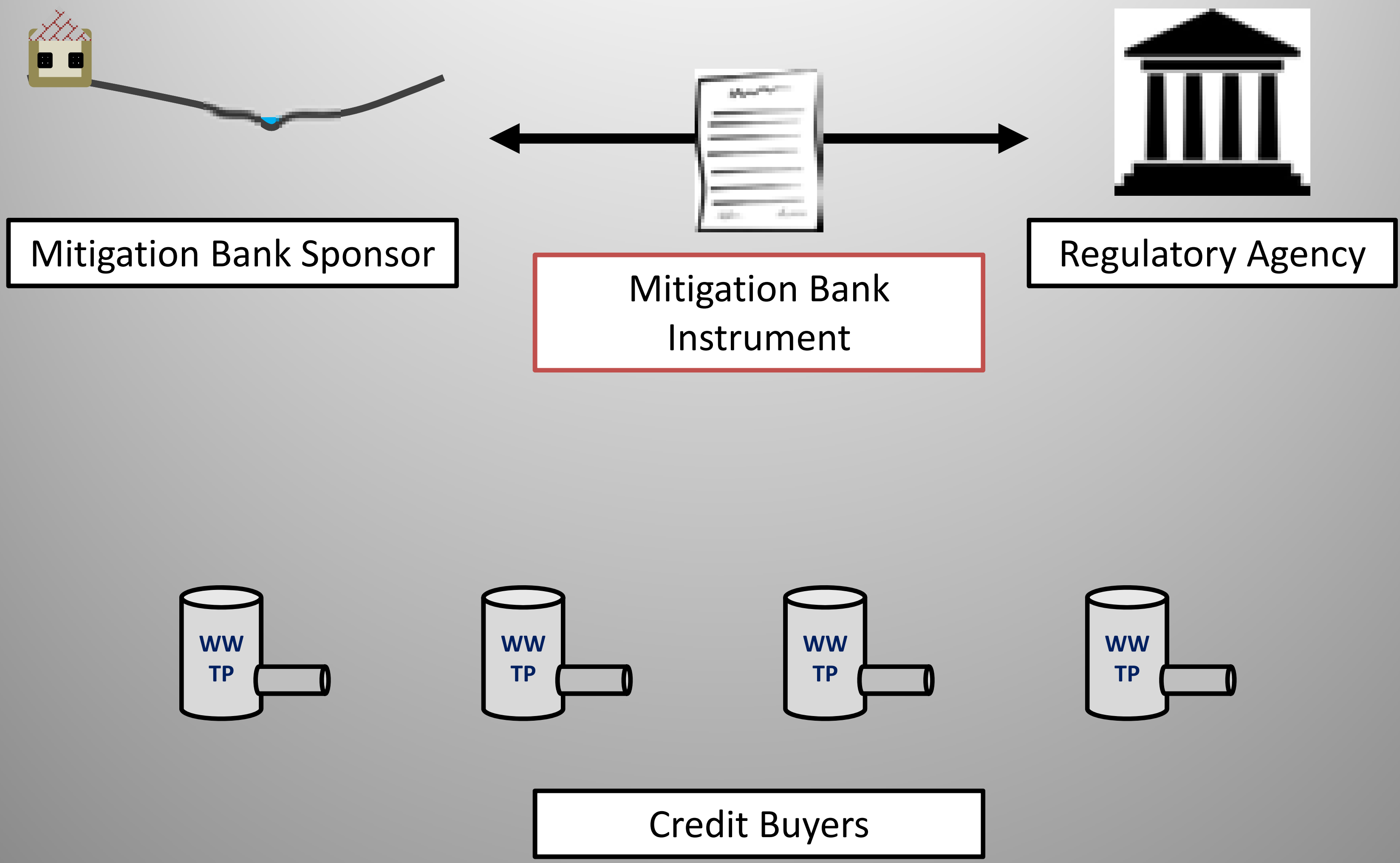


Mitigation Bank Sponsor

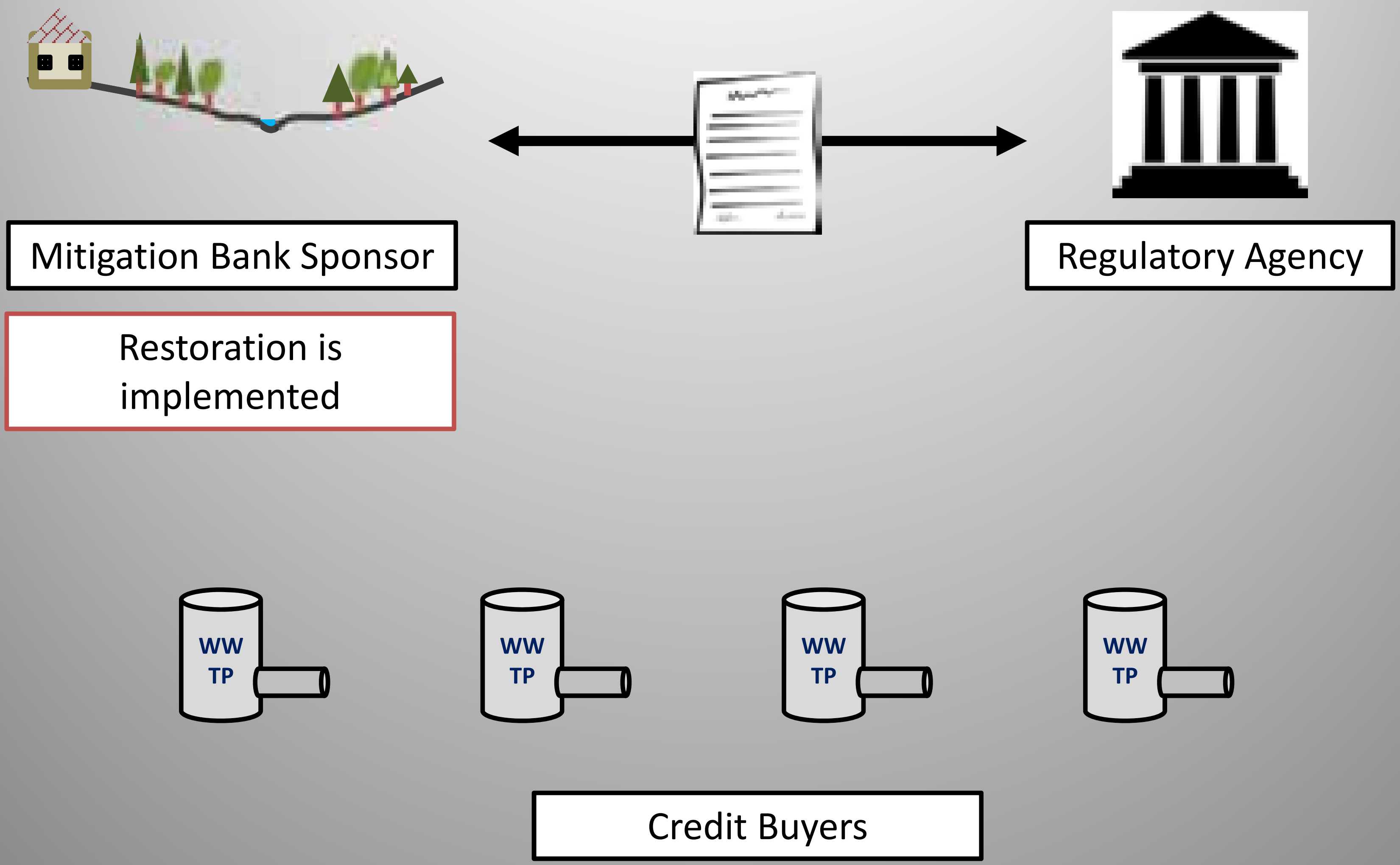
Regulatory Agency

Credit Buyers

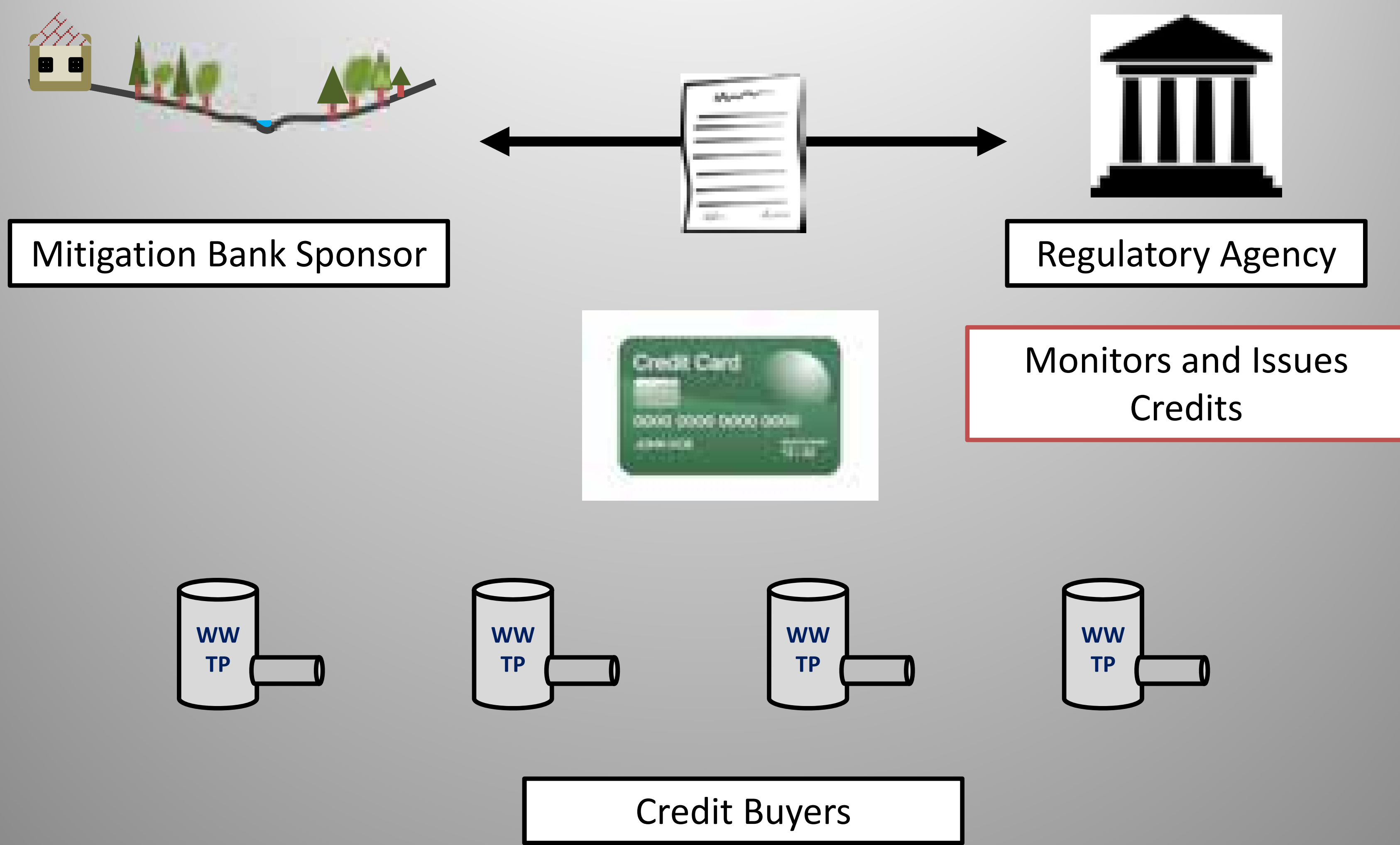
Mitigation Banks

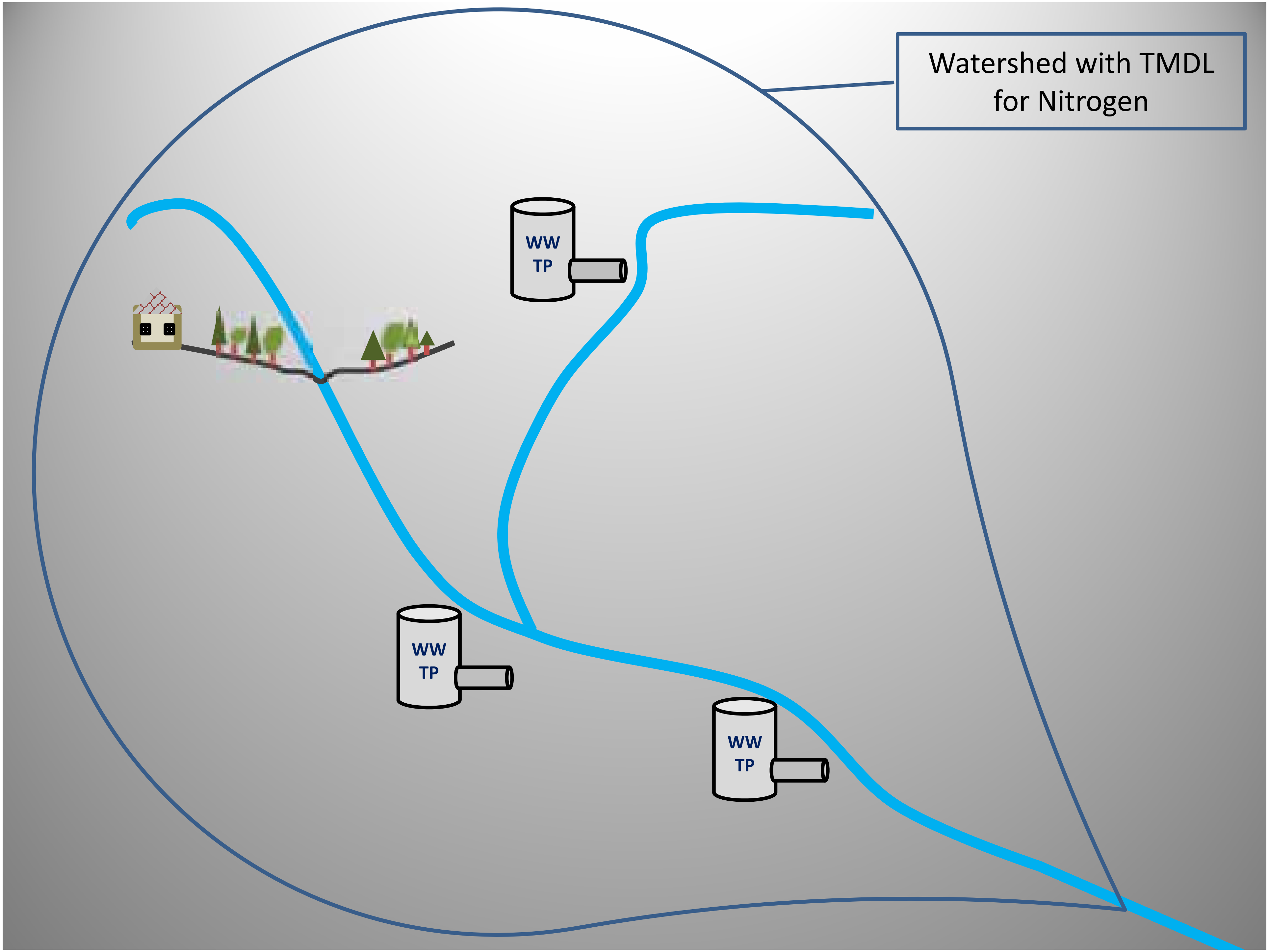


Mitigation Banks



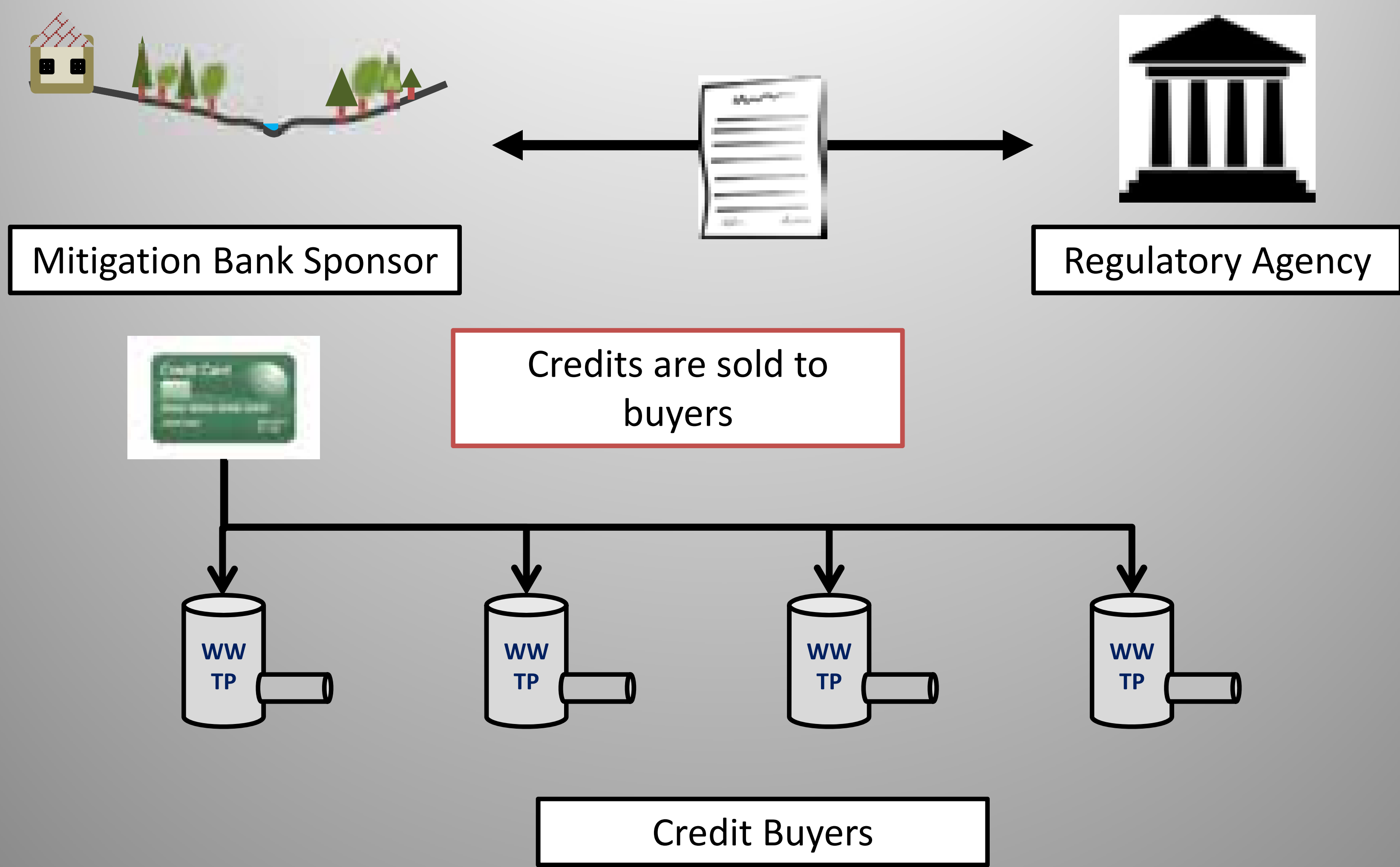
Mitigation Banks

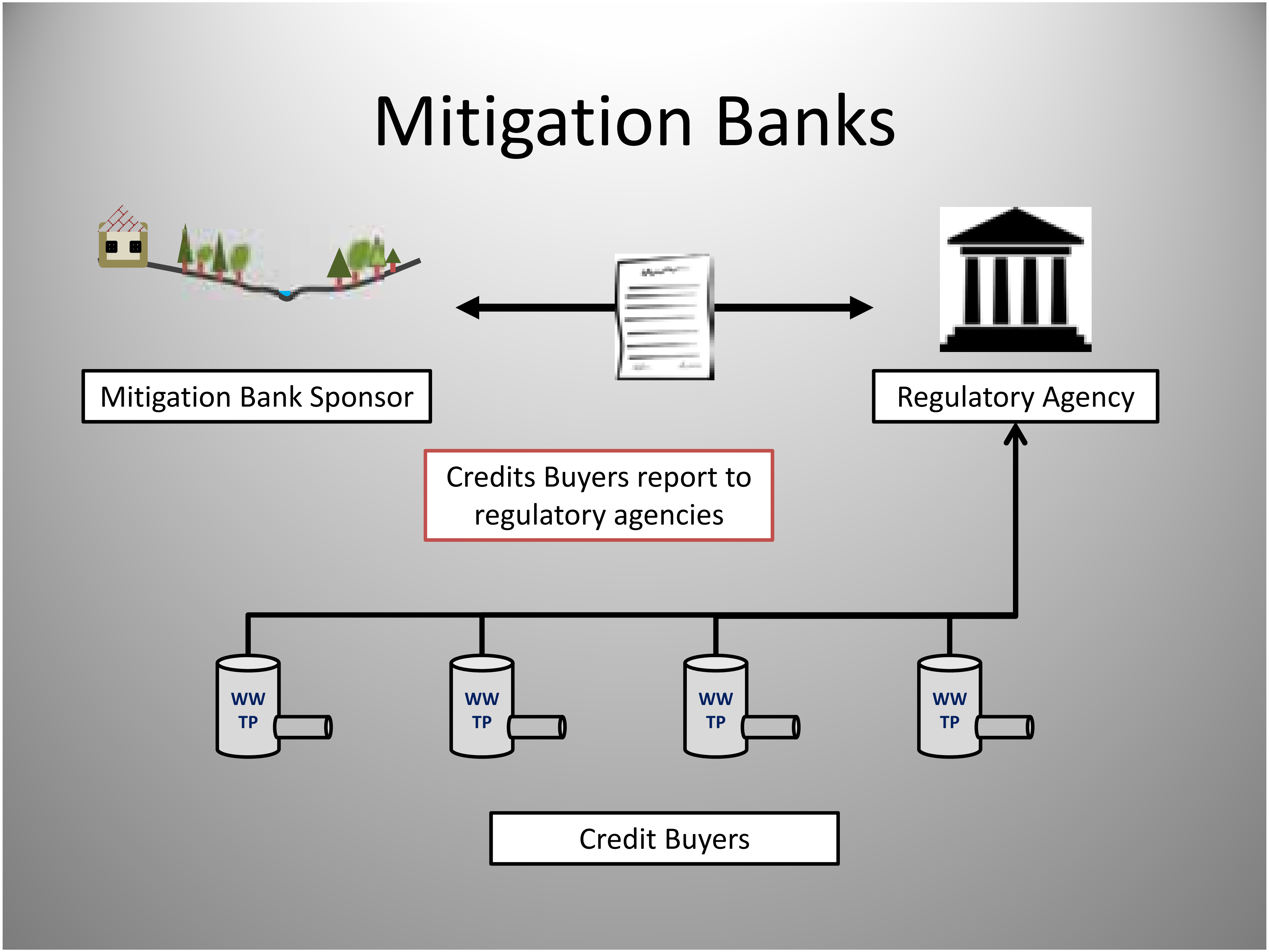




Watershed with TMDL for Nitrogen
WW TP
WW TP
WW TP

Mitigation Banks




Mitigation Banks
Mitigation Bank Sponsor
Regulatory Agency
Credits Buyers report to regulatory agencies
WW TP
WW TP
WW TP
WW TP
Credit Buyers

Advantages

- Time efficient:
  - Credits are available before you need them
  - Aggregation make it easier for agencies to monitor
  - Methodologies for trade are pre-approved
- Lower risk
  - Liability is severed for the credit buyer
  - Bank sponsor needs to provide financial assurances
  - Bank process includes public comment periods

Advantages

- Can be combined with other projects:
  - Other mitigation bank types (wetland, stream, species)
  - Farm and ranches
  - Urban development
  - Subdivisions
- Can be integrated with other programs such as HCPs

Who can be a Mitigation Banker

- Virtually anyone:
  - Private sector players
  - Private sector groups
  - Individual landowner
  - Groups of landowner
  - Cities
  - Public agencies
  - Not-for-profit

THANK YOU!

Noah Greenberg - WWE

NGreenberg@wrightwater.com

(303) 480-1700

Ben Guillon - WRA

guillon@wra-ca.com

(202) 680-8731

Overlooked

Elements of Stream Restoration Projects

Deb Keammerer, M.A.
Restoration Ecologist
The Restoration Group, Inc.
303.503.1783

Janel Servis, M.S.
Environmental Scientist and Engineer
Aqua Terra Compliance, Inc.
303.5878.6782

Construction and Restoration Phasing

- Anticipate completion date at start up
- Target vegetation installation from February through April
    - Better establishment in cool, moist spring conditions
    - Best time to for seeded areas and containerized plants to establish
    - Allows less costly dormant vegetation

Construction and Restoration Phasing

- Incorporate 6 weeks into the construction schedule
- Substantial completion by end of April
- Early installation assures better erosion protection and reduced regulatory liability
- Less summer storm damage
- Fewer warranty period repairs

Hydrology Revisited

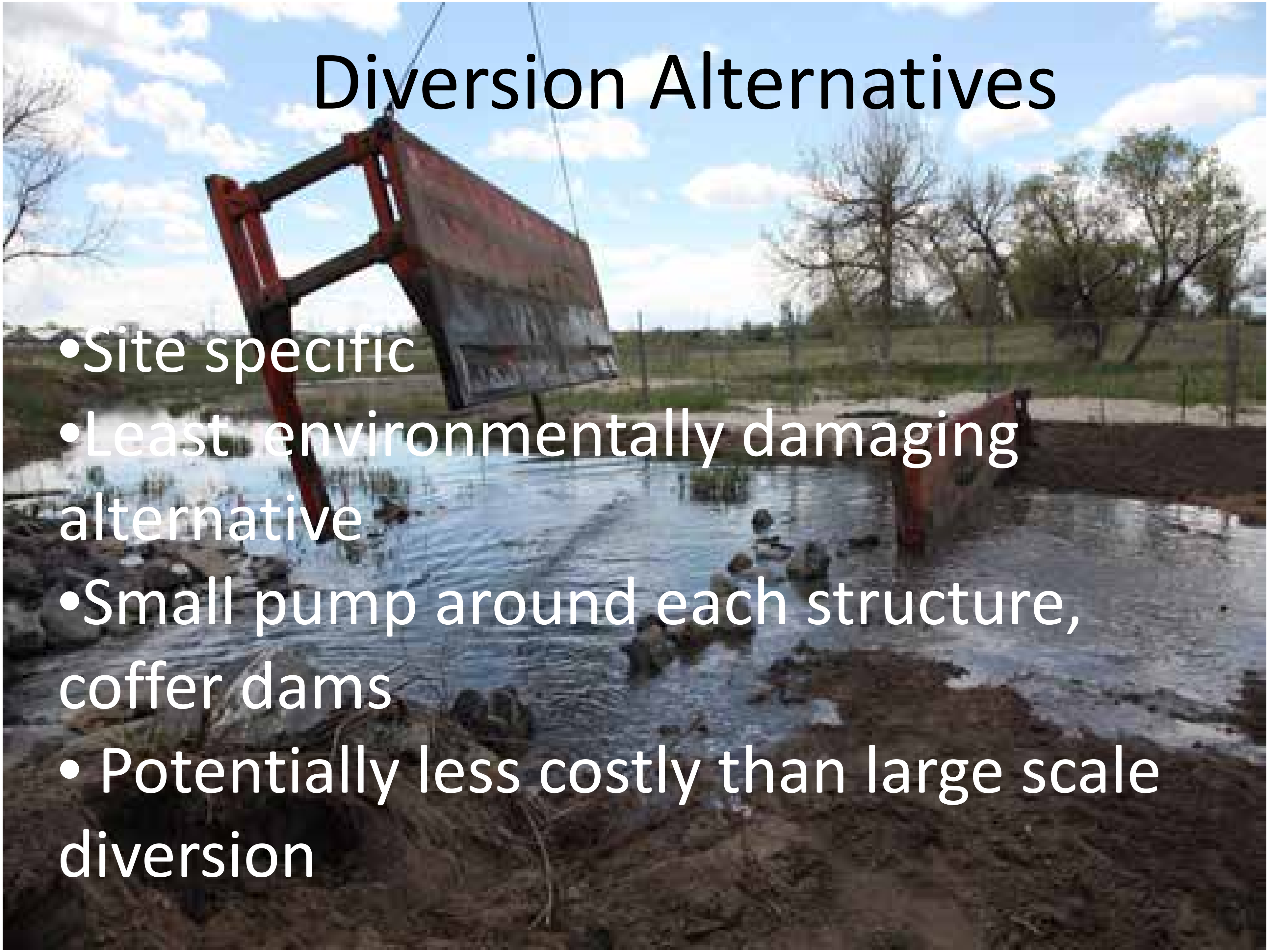
- Natural (Really??)
- Artificial (to varying degrees)
  - Dams
  - Diversions
  - Groundwater wells
  - Inputs to the system

Diversion Problem

- Diversion design, water control and implementation are left to construction contractor as means and methods.

Diversion Trends

- Industry trend toward large fully lined diversions
    - Costly to install and restore
    - Impact large portion of existing riparian and upland vegetation
    - Temporarily eliminate the groundwater recharge



Diversion Alternatives

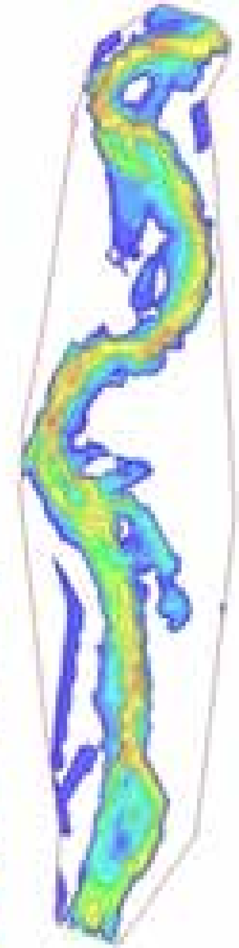
- Site specific
- Least environmentally damaging alternative
- Small pump around each structure, coffer dams
- Potentially less costly than large scale diversion


Conclusion:
We can have better project results
Pay closer attention to seasonal cycles
Understand full hydrologic characteristics
Look for opportunities to improve water quality
Minimize diversion impacts
Plant early!!!!!!


Questions

Phase III

Chuck Lewis Wildlife Area – Yampa River Restoration



Michael Geenen, PE

David Bidelspach, PE

September 11, 2013

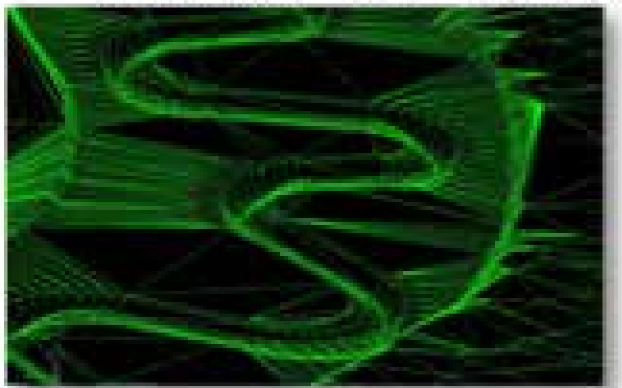
One Team. Infinite Solutions

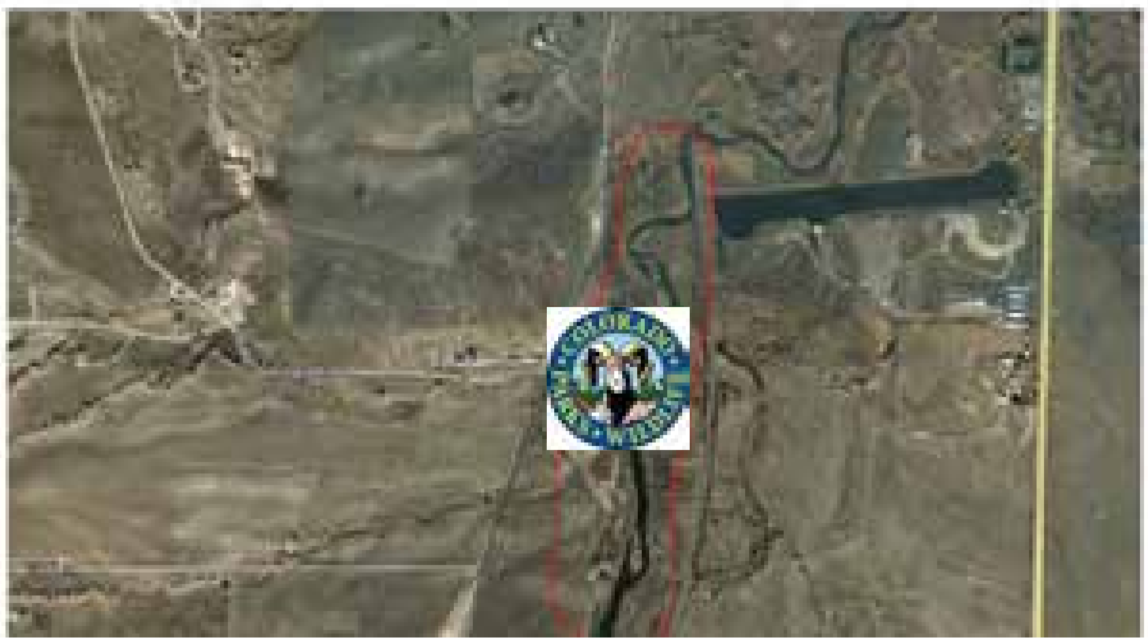
Stantec

North State Environmental

Presentation Outline

- Introduction
- Goals and Objectives
- Design - Components
- Design - Timeline
- Take Home - Lessons
- Design - 3D Optimization




Stantec

- Public Fishing Access on the Yampa River
- Funding Sources
  - Yampa Valley Stream Improvement Charitable Trust (YVSICT)
  - Colorado Department of Parks and Wildlife (CPW)
- **Regional Geomorphic and Fisheries Concerns**
  - Predatory Northern Pike
  - Channel Instability from Anthropogenic Influences
  - Northern Pike Habitat Increased based on Instability

Regional Geomorphic and Fisheries Concerns

Goals and Objectives

- Self Sustaining River System
- Low Potential for CPW Future Maintenance
- Improved Trout Fish Habitat
- Improved Fishery for Anglers
- Improve the Aesthetic Appeal of the River Reach
- *Contribute to the Overall Value of the Chuck Lewis WLA*

Design Components

- **Self Sustaining River System**
  - Design - Alluvial River
  - **Design - Sediment Transport/Transitions (10:1)**
  - Bankfull Dimension and Gage Location (85-90ft)
  - Design - Low Flow Dimension (30-50ft)
  - Design - Flow Regime
  - Design - Remove Habitat Dominated by Northern Pike (River 2-D)
  - Design - Improve Trout Habitat
  - Management – Pike Removal

Design - Sediment Transport/Transitions (10:1)

175ft : 17.5 ft

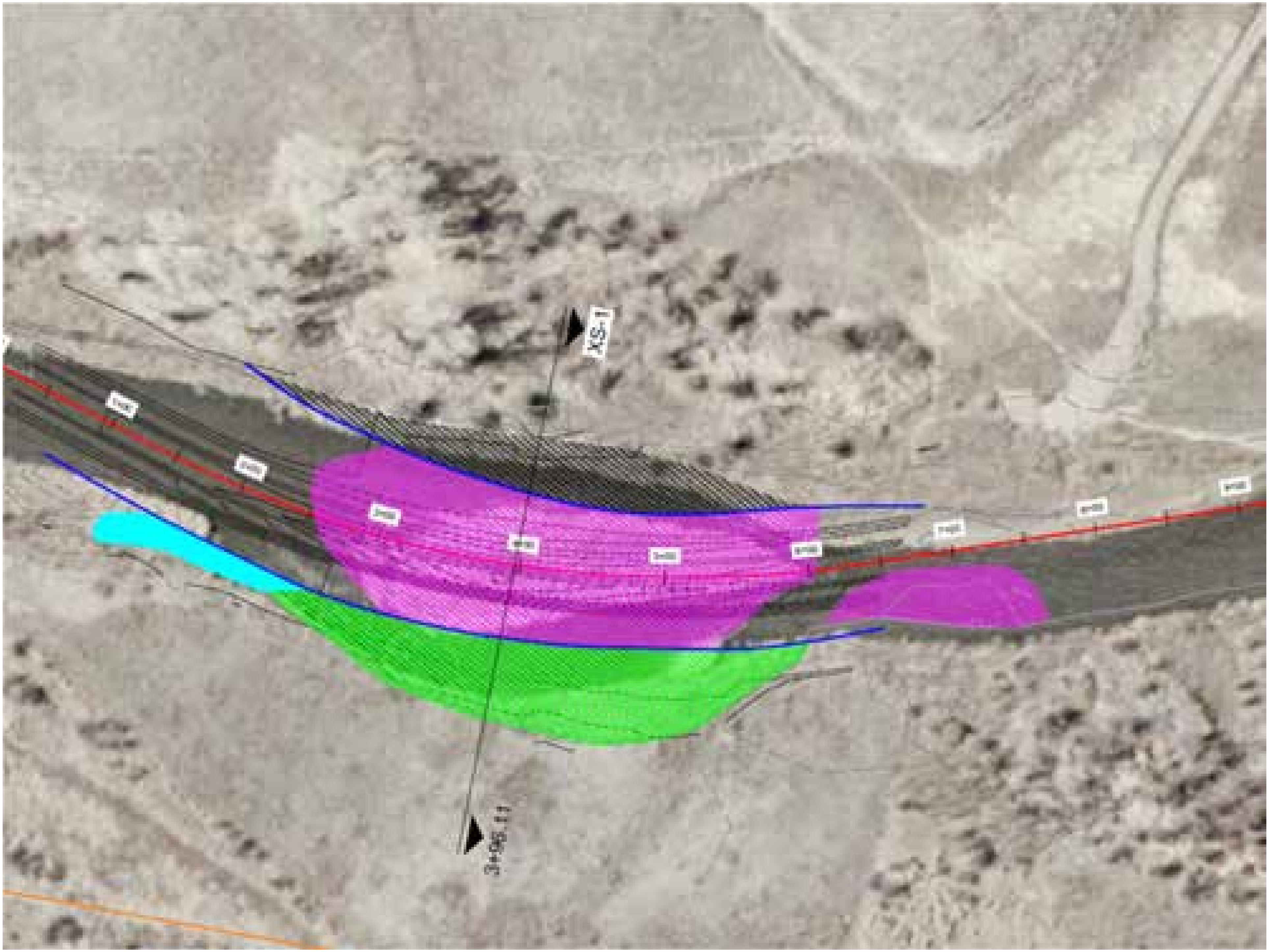
Not 50ft diverging to 145ft

Convergence and Divergence of all Design Flows

Change in velocity and sediment transport competency and capacity due to convergence and divergence of flow could lead to critical flow and a hydraulic jump

(10:1 Horizontal transition)

(100:1 vertical from the channel slope)


XS-1
3+96.11

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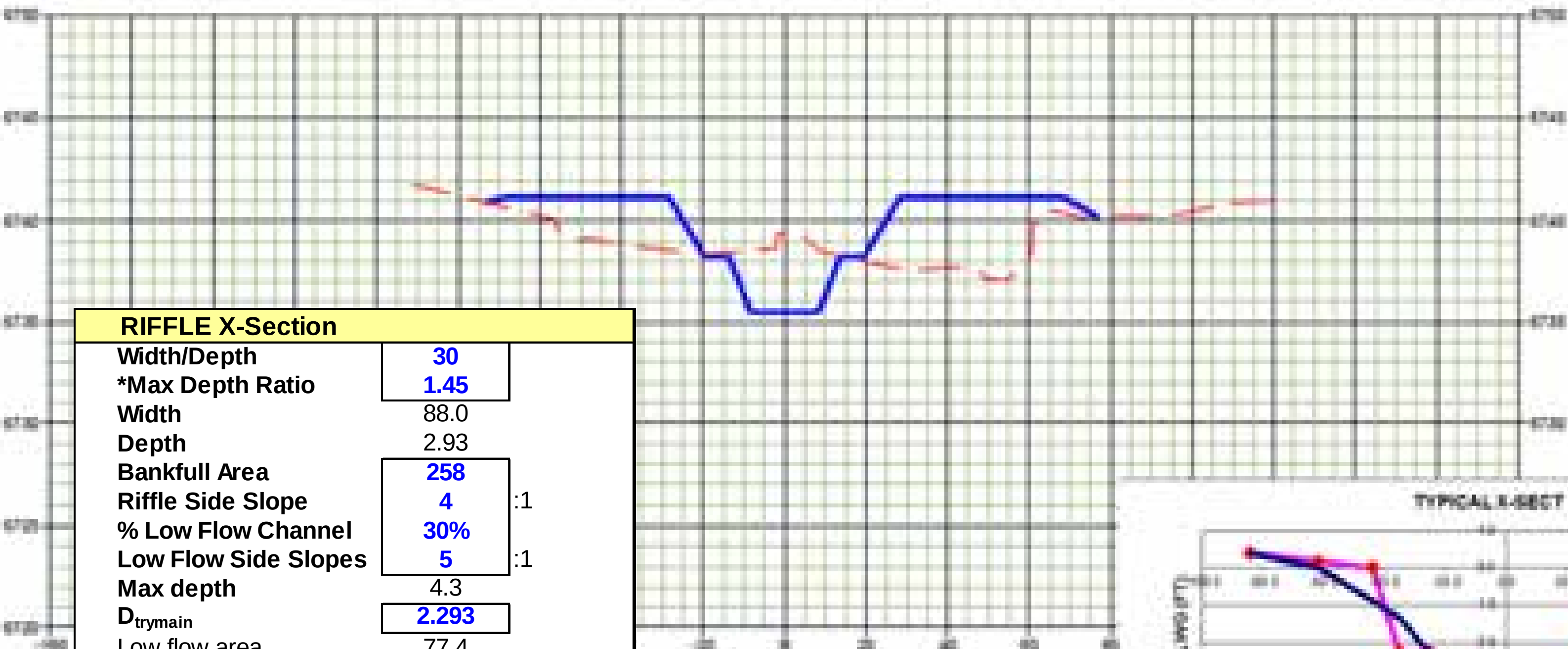
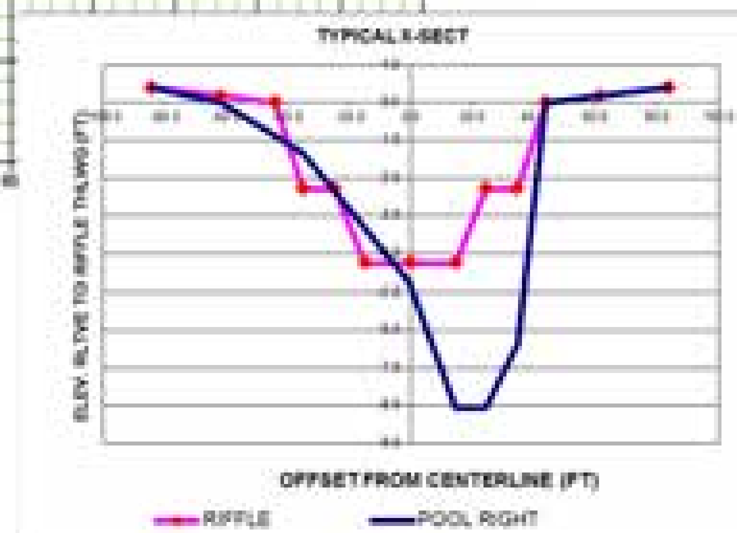


RIFFLE X-Section		
Width/Depth	**30**	
***Max Depth Ratio**	**1.45**	
Width	88.0	
Depth	2.93	
Bankfull Area	**258**	
Riffle Side Slope	**4**	:1
% Low Flow Channel	**30%**	
Low Flow Side Slopes	**5**	:1
Max depth	4.3	
$D_{trymain}$	**2.293**	
Low flow area	77.4	
Area 2 Desired	180.6	
$D_{main\ channel}$	2.292	
W2	69.64	
Average W	78.8	
Area 2 Calculated	180.6	0.0
D_{lfc}	2.0	
W_{lfc}	39.5	
Wtlfc	49.3	
Low Flow Design Q		#REF!
Total Area	**258.0**	**sqft**



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Design - Low Flow Dimension (30-50ft)

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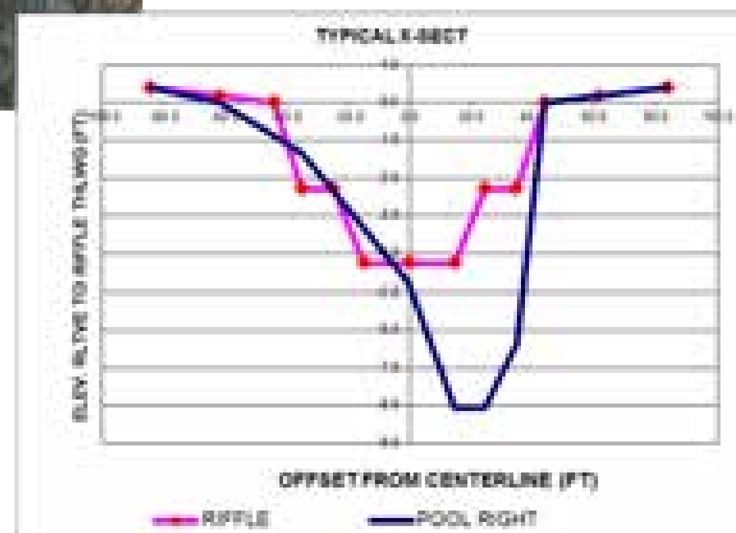

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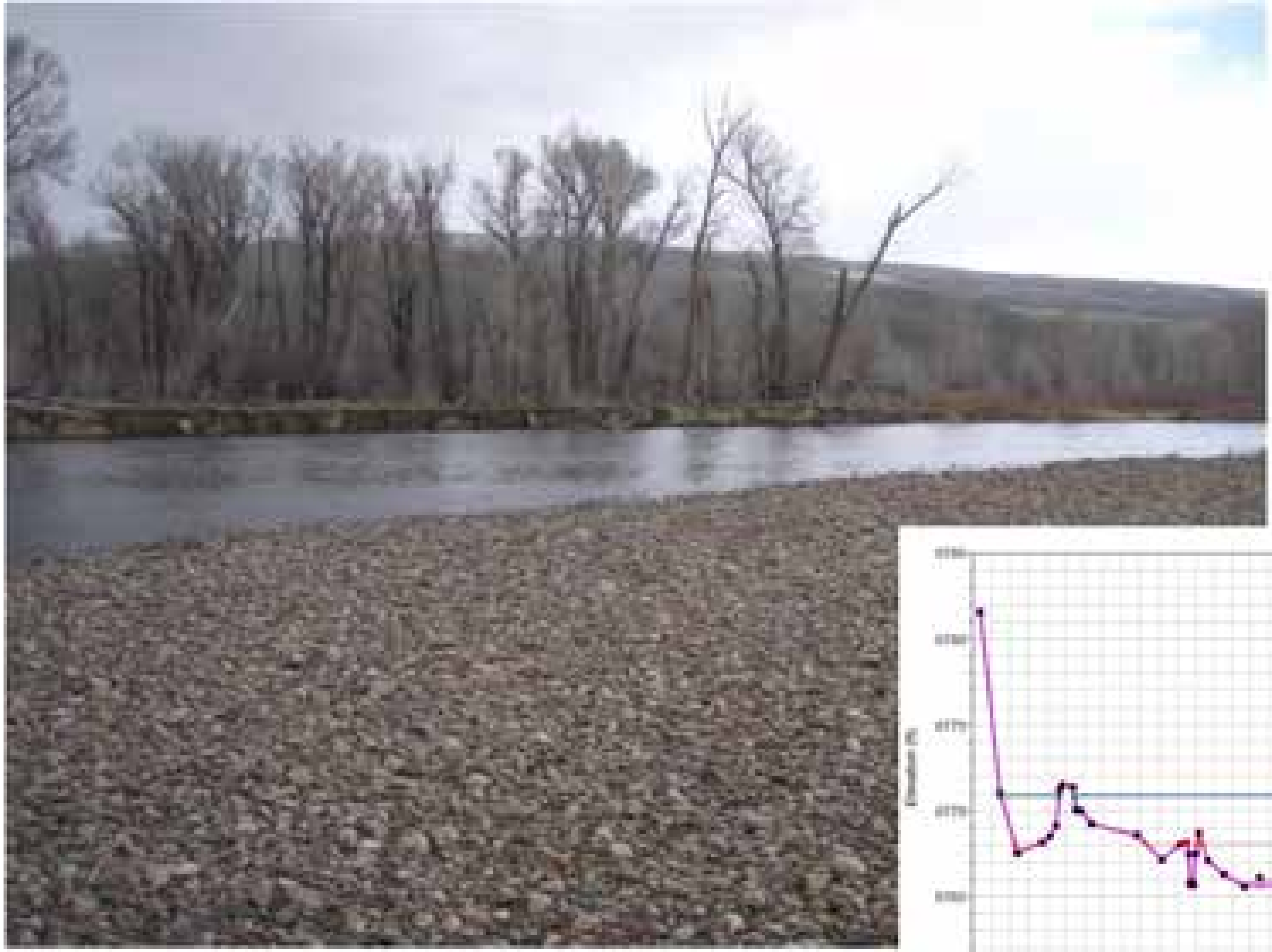
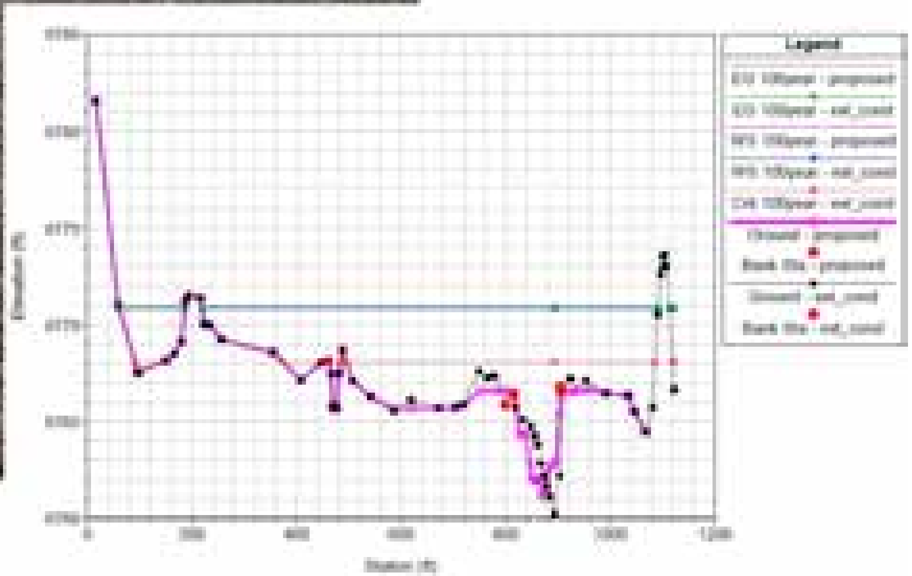
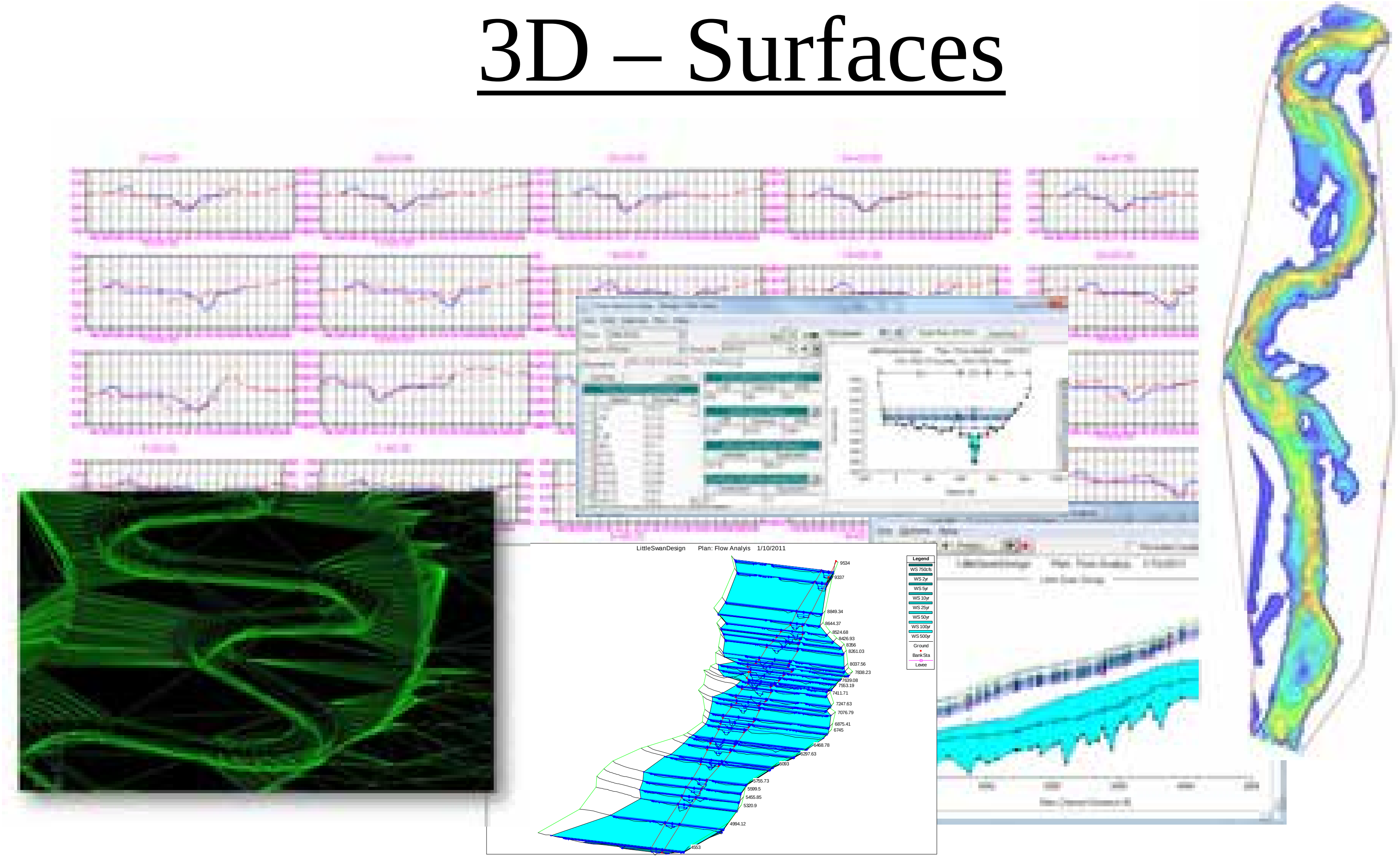
Design - Flow Regime





Design - Flow Regime
<u>3D – Surfaces</u>



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Design - Remove Habitat Dominated by Northern Pike (River 2-D)

Design Components

- **Low Potential for CPW Future Maintenance**
  - Design - Alluvial System C4
  - **Design - Reference Profile Parameters (Energy)**
  - Design - Existing Reach Channel Dimension
  - Design - Reference Reach Pattern
  - Design - Sediment Transport/Transitions (10:1)
  - Design - Natural Substrate (D50 = 45mm)
  - Design - Narrower WDR (120 – 30)
  - Design - Boulder Sizing and Footers
  - Design - Low Profile Large River Structures

Design - Reference Profile Parameters (Energy)

Design Components

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  - **Design - Low Profile Large River Structures**

Design - Low Profile Large River Structures

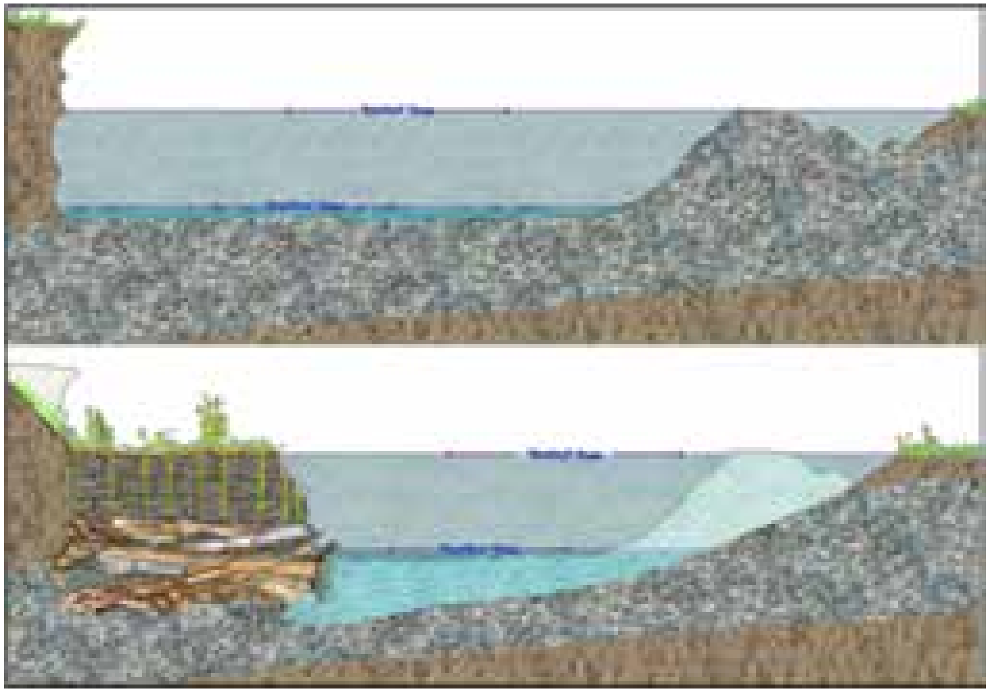
Design - Low Profile Large River Structures

Design - Low Profile Large River Structures

Design Components

- Improved Trout Fish Habitat
  - **Design – Wood Toe Protection**
    - Shade, Cover, Carbon Source, and Feeding Lanes
  - Design – Constructed Riffles with Mini Vanes
    - Low Profile
    - Riffle Pocket Pools
    - Hyporheic Exchange
    - Variable Depths and Slopes in the Riffle
  - Design – Rock J-Hook
    - Deeper Pool Habitat, and Feeding Lanes

Design – Wood Toe Protection




2012/08/02

Design Components

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    - Shade, Cover, Carbon Source, and Feeding Lanes
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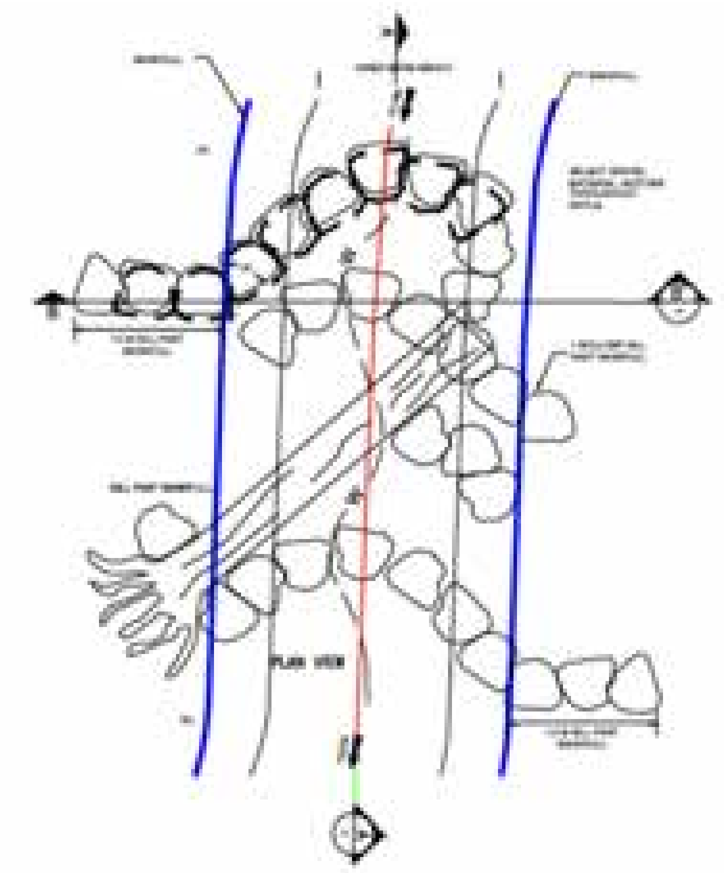
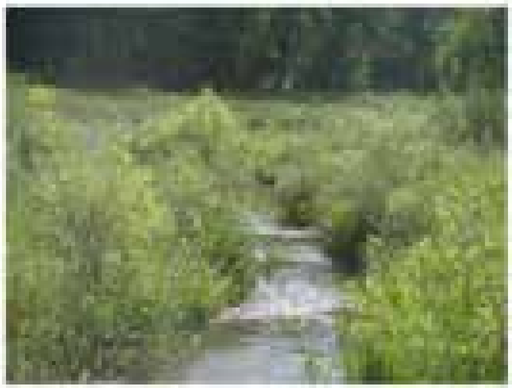
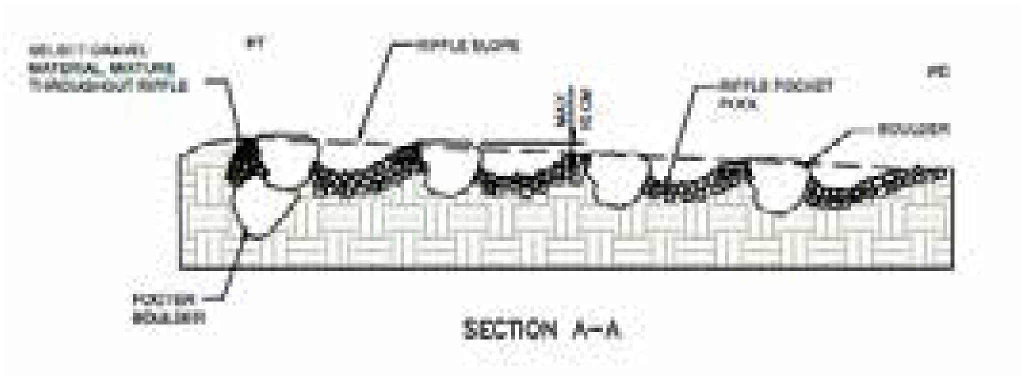






Design Components

- Improved Fishery for Anglers
  - Design – Wood Toe Protection
    - Bank Fishing vs. Wading
  - Design – Constructed Riffles with Mini Vanes
    - Wading/Float
    - Removal of obstructions
    - Deeper Riffle areas
    - Flow Complexity
  - **Design – Rock J-Hook**
    - Access to the River from the bank

Design – Rock J-Hook

- Access to the River from the bank

Design Components

- Improve the Aesthetic Appeal of the River Reach
  – Design - Transplants
  – Design - Re-vegetation
  – Design -Walking trails
  – Design - Narrower WDR
  – Design - Wetland Mitigation
  – Design – Removal of Large Trash and Cars

Goals and Objectives

- Self Sustaining River System
- Low Potential for CPW Future Maintenance
- Improved Trout Fish Habitat
- Improved Fishery for Anglers
- Improve the Aesthetic Appeal of the River Reach
- **Contribute to the Overall Value of the Chuck Lewis WLA**

Design - Timeline

- Review Existing Concept (February 2010)
- Site Visit with Colorado DOW
- Preliminary Concept Design
- Suggest Alternatives
- Define Goals and Objectives (YVSICT and CDOW)
- Grant Applications
- **Design – Build Arrangement with YVSICT**
- Wetland Delineation (2007)

Design - Timeline

- Geomorphic Survey – Survey Grade GPS
- Geomorphic Assessment
- Professional Survey – Control and FEMA
- Gage Analysis – Upstream and Downstream
- Optimization for Grading Quantities
- 30% Concept Design and Quantities
- HEC-RAS model and flood study

Design - Timeline

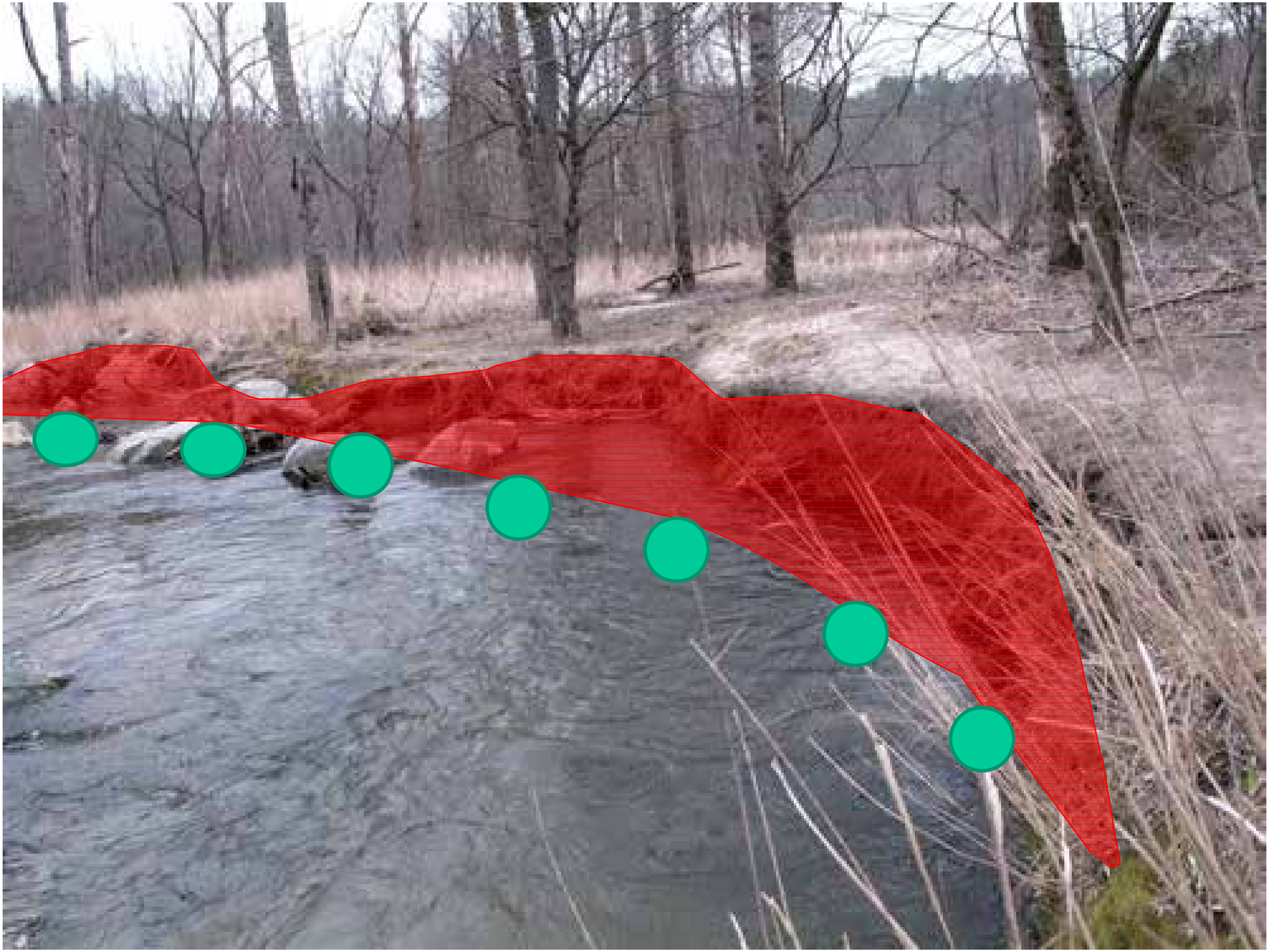
- Re-Design – To achieve “No-Rise”
- Design Optimization
- 60% Design and Quantities
- Apply for USACOE Regional Permit13
- “Final” Design and Quantities
- Apply for Routt County Floodplain Development Permit
- Construction (September 2013)
- Stability and Biological Monitoring (2020?)

Take Home - Lessons

- **Habitat Structures without a stable geomorphology are not sustainable**

- Alluvial Rivers require consideration of sediment transport analysis (Slope and WDR)

- River Horizontal Transitions should be gradual less than 10:1 expansion and contraction in Alluvial Rivers



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- Alluvial Rivers require consideration of sediment transport analysis (Slope and WDR)
- River Horizontal Transitions should be gradual less than 10:1 expansion and contraction in Alluvial Rivers

Take Home - Lessons

- Design Optimization can significantly reduce Costs and Risk in a Design-Build scenario

- Large River Structures should be low-profile and gradual in nature

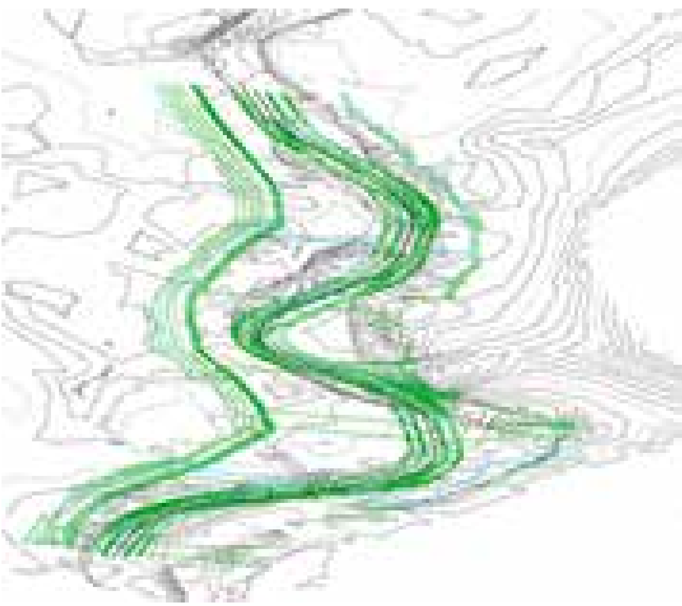
- Reference Conditions should be obtained from the existing reach and a comparable Reference Reach to provide the geomorphic context for a natural channel design

Questions ?

One Team. Infinite Solutions

Stantec

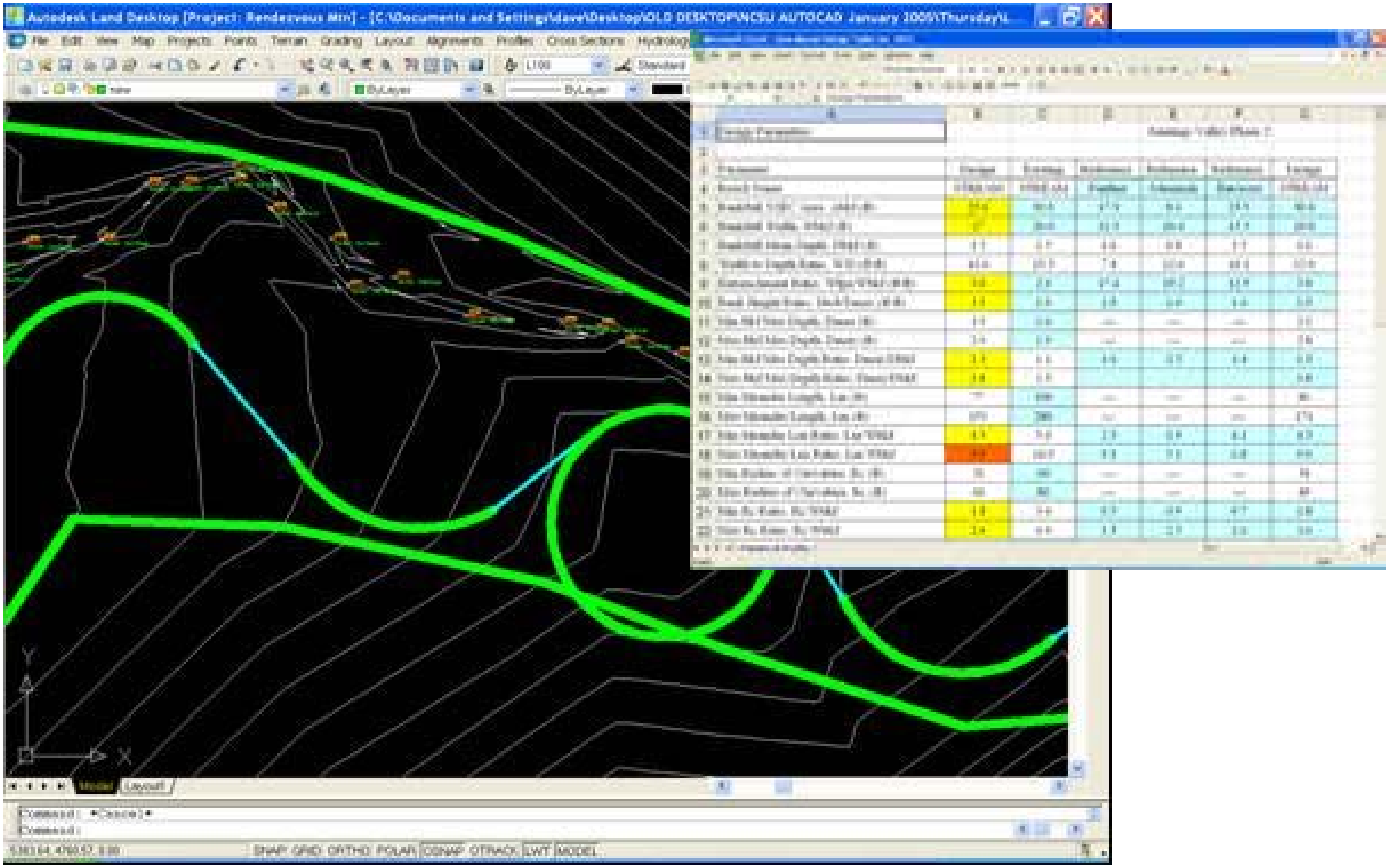
3D- Optimization



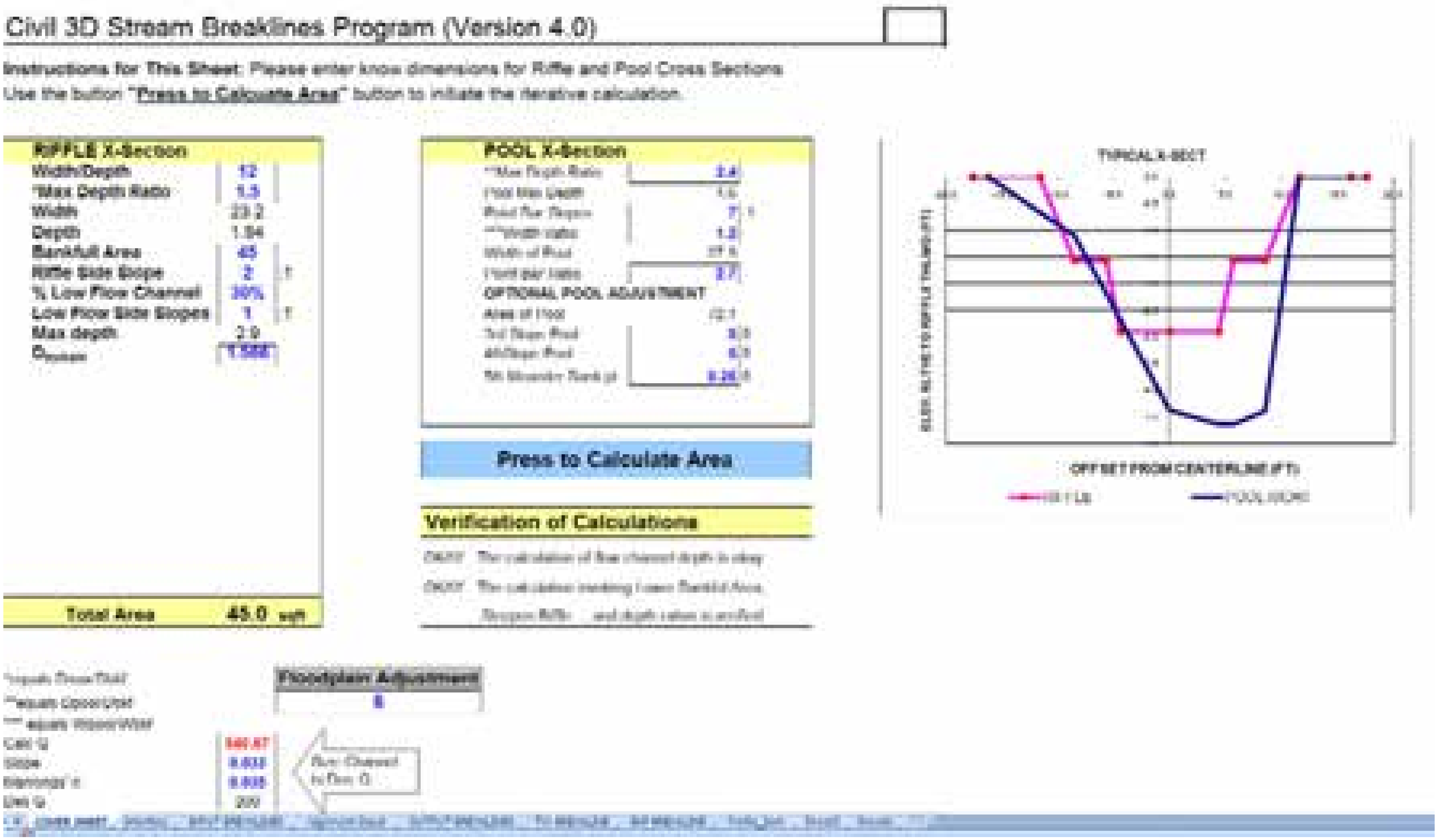
- Hydraulic Modeling is Not Limited
- Easier to Create Design Revisions and Iterations
- Assist in Construction Stakeout
- GPS Guided Construction Equipment

- Good Check for On-site Stupidity During Construction

3-D Design - Layout and Design

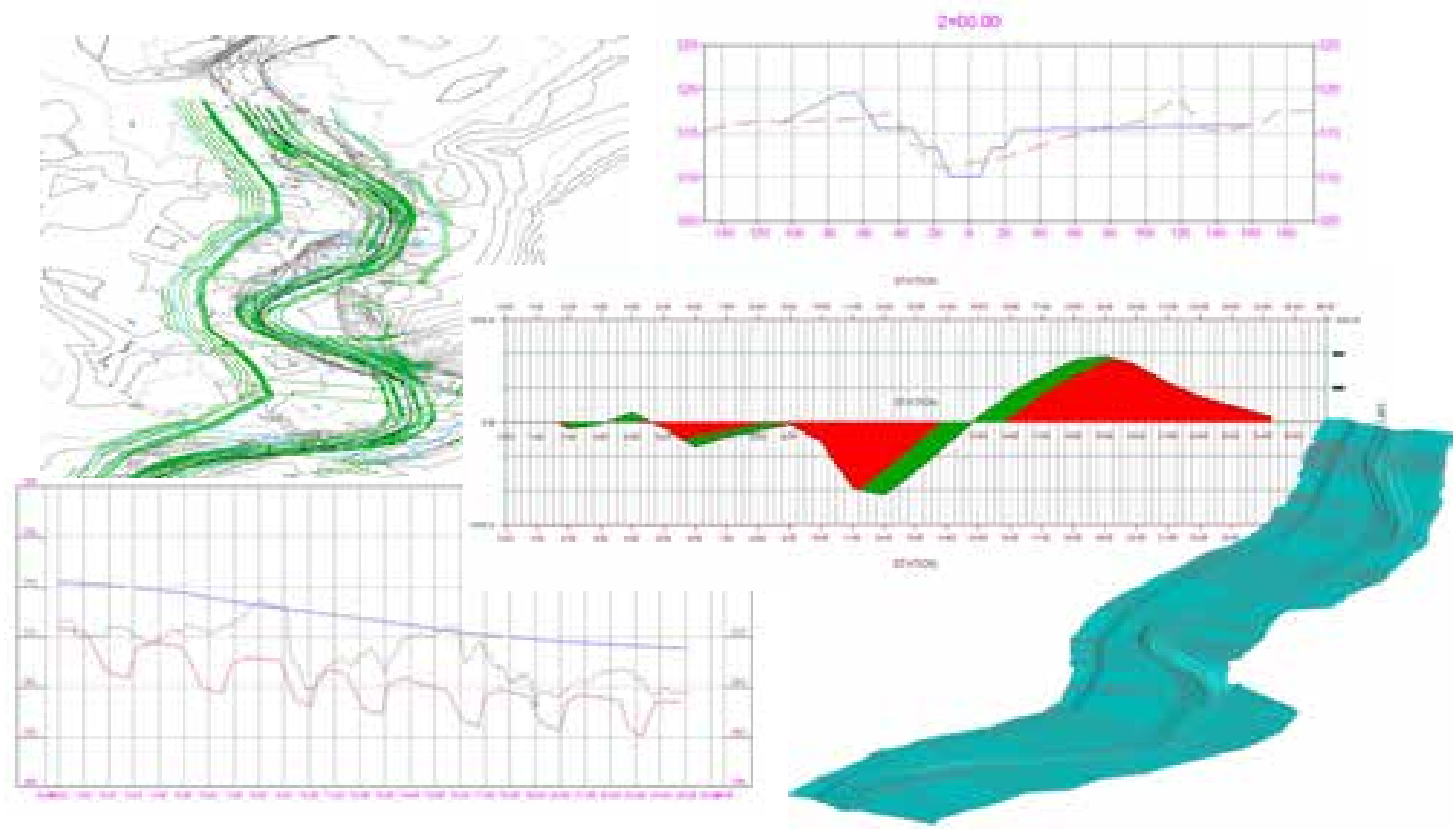


3D – Design and Surface



3D – Design and Surface

3D – Breaklines for Surface

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CAT
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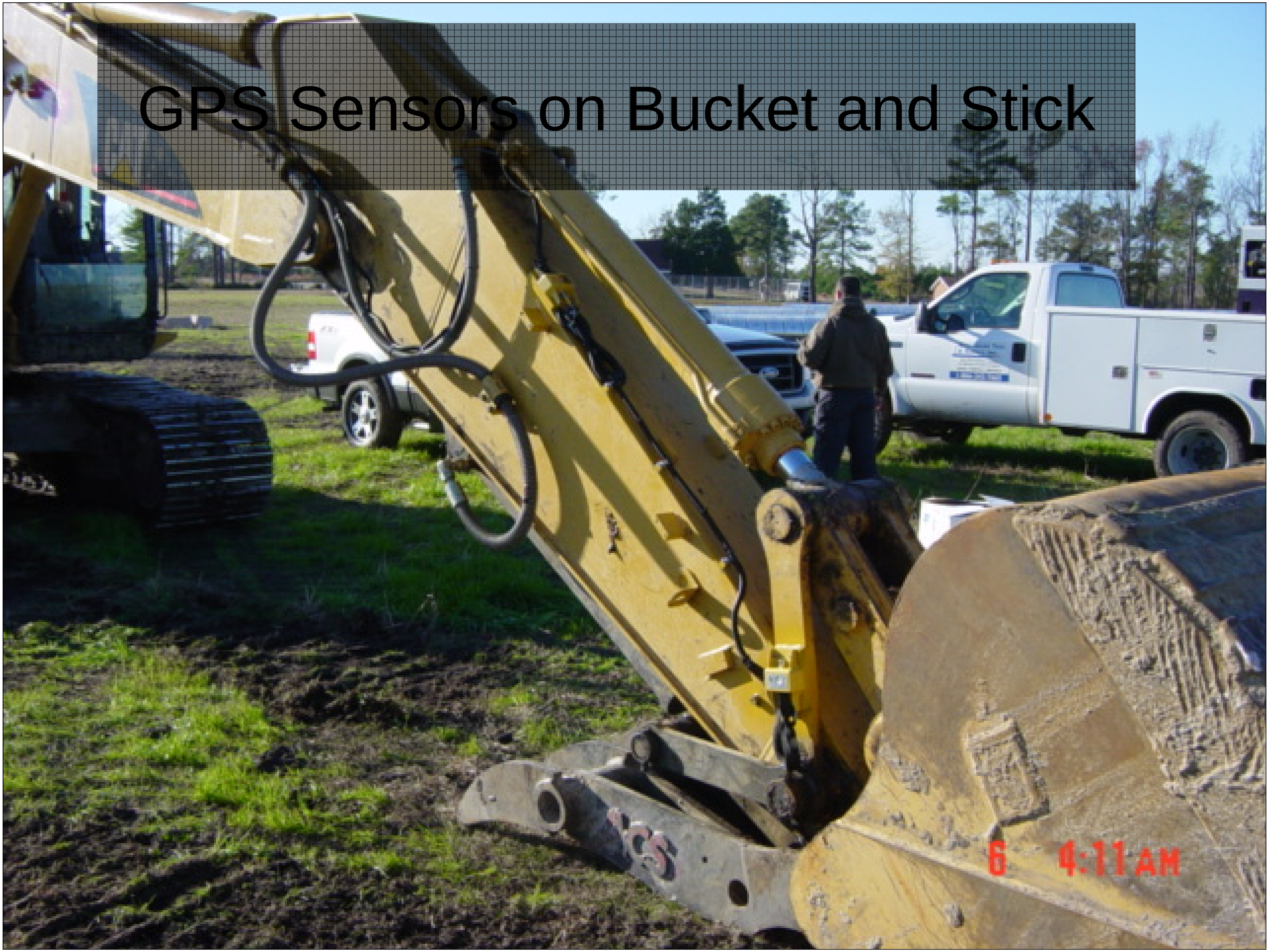
GPS Sensors on Bucket and Stick



GPS Sensors on Boom and Stick


8.50'
8.40'
8.30'
8.20'
8.10'
8.00'
7.90'
7.80'
7.70'
+0.00'
7.74'
GX-60
9 12:58 AM

Increased Variability and Diversity

Questions ?

One Team. Infinite Solutions

Stantec

CASFM 2013

Stream Restoration Using Natural Logs and Sculpted Concrete Logs to Mimic Natural Drop Structures

Presented By:

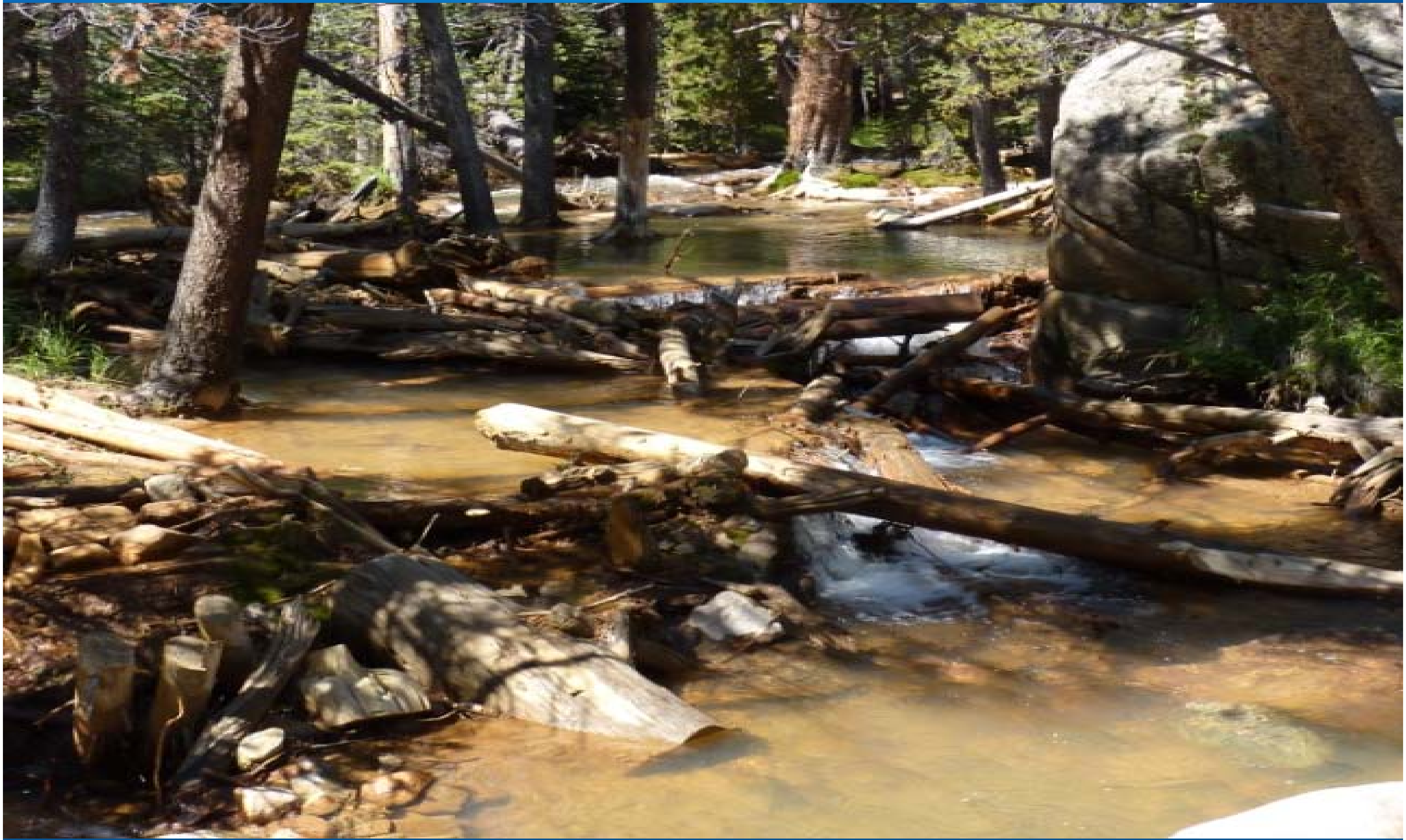
Dave Skuodas, UDFCD
Kyle Hamilton, CH2M HILL

CH2MHILL

Concept Development

- Vision for the Project: Mimic Nature

Guanella Pass



Clear Creek

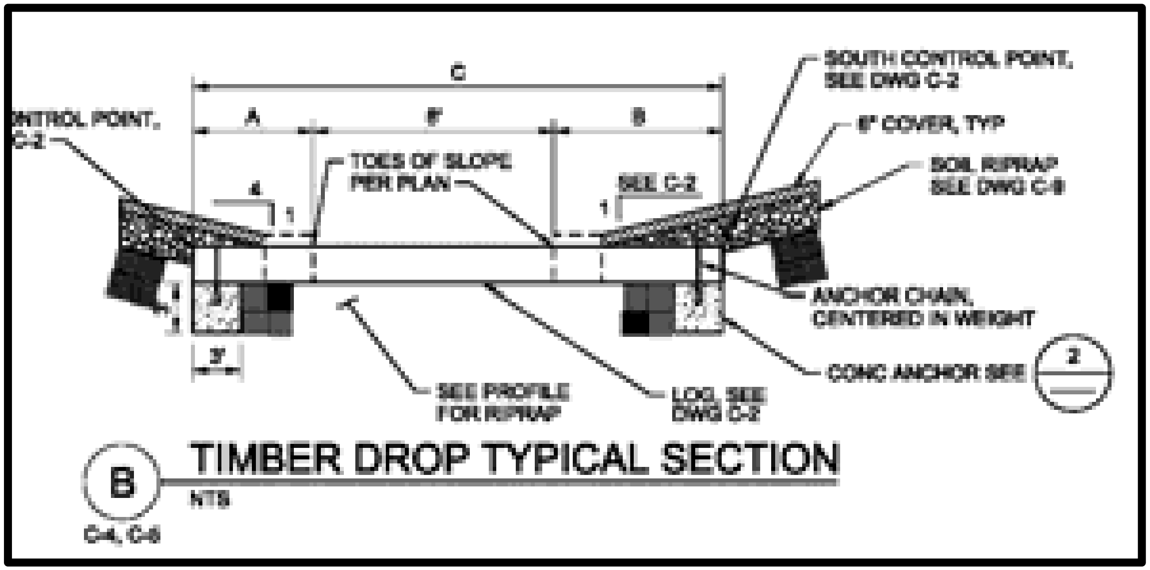
Site Selection

- Timbers Creek
  - Douglas County, CO
  - Ephemeral stream
  - Conifer forest
  - Sand

- Rock Creek
  - Superior, CO
  - Perennial stream
  - Many fallen cottonwood trees
  - Gravel / cobble

Design

- Channel slope
- Hydraulic capacity
- Aesthetics
- Geometry
  - Single logs
  - Stacked logs
  - Sloping face
- Buoyancy
- Constructability
- Longevity
- Upstream and downstream drops incorporate sheet pile cutoffs



Log Parameters

- Wood Type and Decay Resistance
  - Cedar: longevity
  - Pine: readily available
  - Cottonwood: very common along local streams
- Available lengths and diameters
- Density differences
- Bark for aesthetics
- Milled logs allow for tighter specifications

Cedar

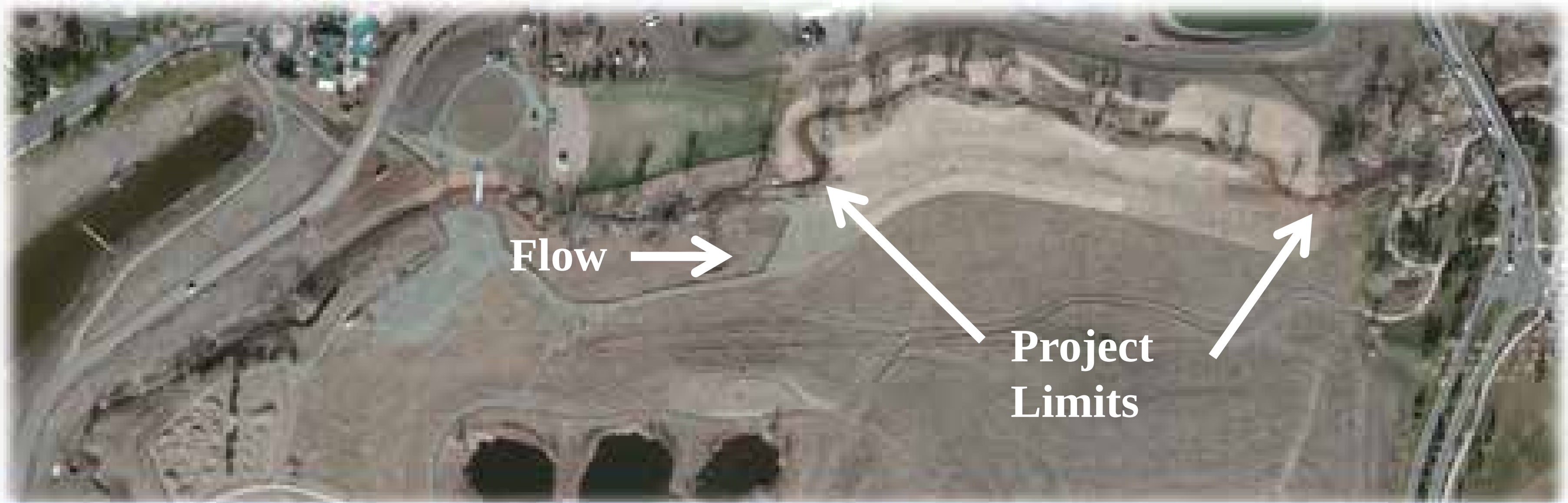
Pine

Cottonwood

Buoyancy Resistance

- Natural log structures are not anchored, but are interlocked and have root structure
- Urban setting demands structural integrity - tax payer dollars being used
- Pilot project included anchoring system analysis
  - Soil and/or boulder cover
  - Cable and duck bill anchors
  - Concrete anchors
- Conservative approach selected for these projects (concrete anchors)

Rock Creek Channel Improvements



Construction

Cedar

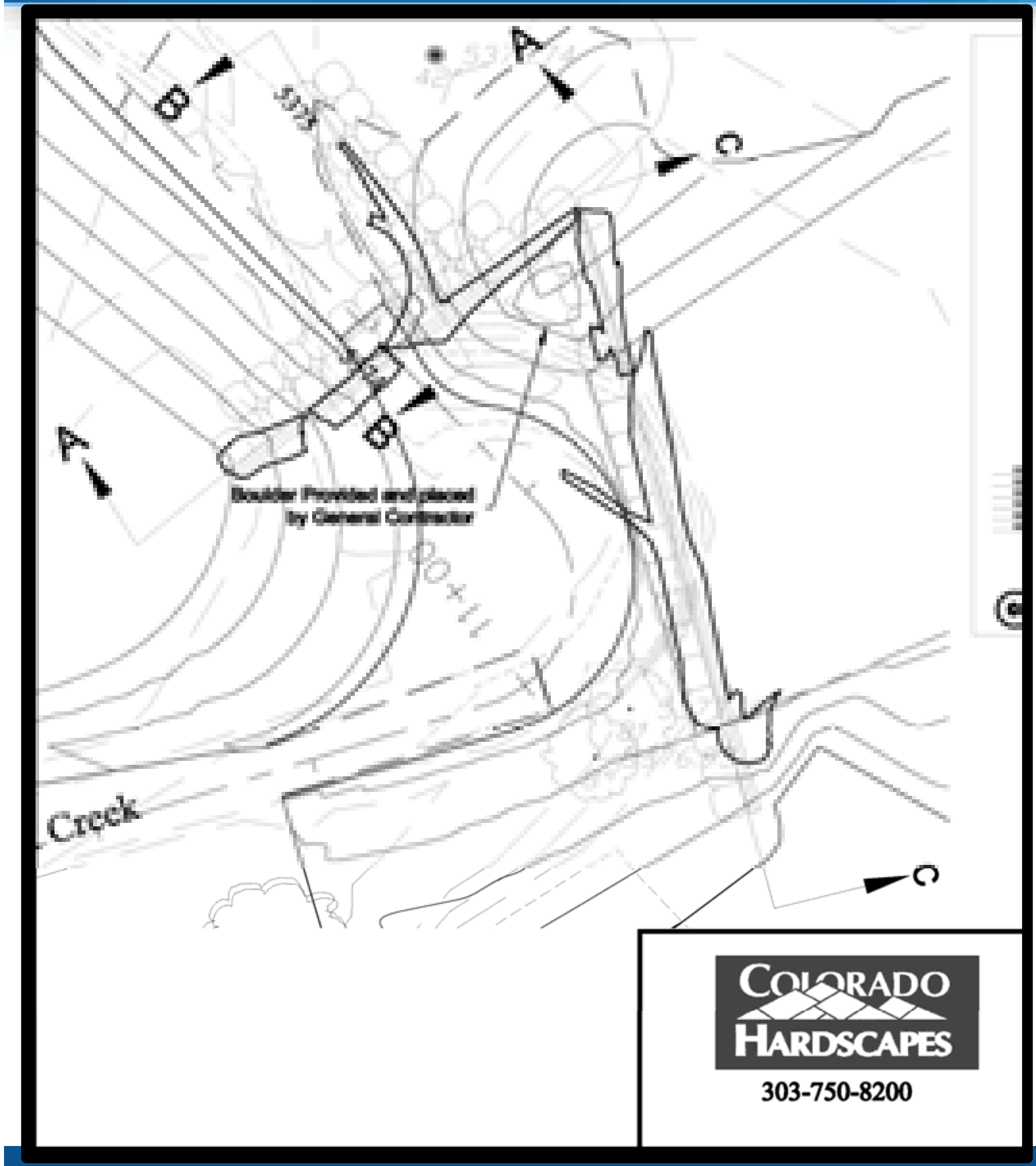
Pine

Fallen Cottonwood

Faux (Concrete) Log Concept Development

- Mimic natural fallen logs
- Use log arrangement as flow splitter for main-channel and overbank storm flows
- Sheet pile cutoff wall
- Shotcrete, sculpting, and staining for aesthetics

Faux Log Flow Splitter




Concrete


Concrete

Observations

- Log diameters will vary along a long log length, trimming may be required
- Cable and duck bill anchors are a likely alternative to the conservative concrete block anchor system
- Undermining potential can be addressed through cutoff systems (sheet pile, geotextile, clay)


Cedar


Cedar


Cedar


Bobcat
Cutoffs


Cedar


Cottonwood
07 28 2011


Cottonwood


Cottonwood


Cottonwood


Cottonwood


Cottonwood


Cottonwood

Monitoring

- Monitoring Goals
  - Log longevity and decay rate
  - Structural stability
  - Differing abrasive forces from sandy soils versus gravel / cobble soils
- Log drops are not an approved UDFCD drop structure method at this time
- Definition of Success?

Conclusions

Logs – Not necessarily cheap or local, but nice option; straighter the better.

Log longevity – So far so good, but submerged is better.

Sculpted logs – look nice, but cost must be justified.

Acknowledgements

- Timbers Creek Project
  - Project Lead: UDFCD
  - Partnering Agency: Douglas County, Colorado
  - Design Engineer: CH2M HILL, Denver, Colorado
  - Contractor: Naranjo Civil Constructors, Greeley, Colorado

- Rock Creek Project
  - Project Lead: UDFCD
  - Partnering Agency: Town of Superior, Colorado
  - Design Engineer: CH2M HILL, Denver, Colorado
  - Contractor: L&M Enterprises, Inc., Denver, Colorado

Thank You

Questions?

Dave Skuodas, UDFCD: DSkuodas@udfcd.org
Kyle Hamilton, CH2M HILL: Kyle.Hamilton@ch2m.com

Resolution of Instabilities in Unsteady State HEC-RAS Models



Context for Model Development

- Project Purpose and Overview
- HEC-RAS Model Development
- Breach Floodplain Mapping



Recent Events Heightened Awareness

- Hurricane Katrina showed:
  - Major urban flooding is tragic and deadly
  - We must be ready for emergency response during severe events
- California's 1997 and 2006 floods showed the system is fragile, deteriorating, and does not provide the protection we need
- Climate change will further increase flood risks if not addressed

Much of California faces **unacceptable flood risks**

- The Central Valley is particularly vulnerable

At last, there is Formal Recognition of the Problem

- In 2005, Governor Schwarzenegger drew attention to California's Flood Crisis, calling for:
  - Improved maintenance
  - System rehabilitation
  - Effective emergency response
  - Sustainable funding

PROPOSITION 84 WATER QUALITY, SAFETY AND SUPPLY. FLOOD CONTROL. NATURAL RESOURCE PROTECTION. PARK IMPROVEMENTS. BONDS. INITIATIVE STATUTE.

OFFICIAL TITLE AND SUMMARY ★★★ Prepared by the Attorney General

PROPOSITION 1E DISASTER PREPAREDNESS AND FLOOD PREVENTION BOND ACT OF 2006.

OFFICIAL TITLE AND SUMMARY ★★★ Prepared by the Attorney General

DISASTER PREPAREDNESS AND FLOOD PREVENTION BOND ACT OF 2006.

- This act rebuilds and repairs California's most vulnerable flood control structures to protect homes and prevent loss of life from flood-related disasters, including levee failures, flash floods, and mudslides.
- Protects California's drinking water supply system by rebuilding delta levees that are vulnerable to earthquakes and storms.
- Authorizes a $4.09 billion dollar bond act.
- Appropriates money from the General Fund to pay off bonds.

Summary of Legislative Analyst's Estimate of Net State and Local Government Fiscal Impact:

- State cost of about $8 billion over 30 years to pay off both the principal ($4.1 billion) and interest ($3.9 billion) costs on the bonds. Payments of about $266 million per year.
- Reduction in local property tax revenues of potentially up to several million dollars annually.
- Additional unknown state and local government costs to operate or maintain properties or projects acquired or developed with these bond funds.

FINAL VOTES CAST BY THE LEGISLATURE ON AB 140 (PROPOSITION 1E)

Senate:	Ayes 36	Noes 1
Assembly:	Ayes 62	Noes 9

ANALYSIS BY THE LEGISLATIVE ANALYST

BACKGROUND

State Role. Multiple agencies at each level of government (state, federal, and local) have some responsibilities for flood management. In addition, private entities own and operate some flood control facilities. The state carries out a number of programs designed to provide flood management. Some of these programs are operated directly by the state, while others provide grants to local agencies for similar purposes.

The state is primarily responsible for flood control in the Central Valley. As shown in Figure 1, the state Central Valley flood control system includes about 1,600 miles of levees, as well as other flood control infrastructure such as overflow weirs and channels. The state directly funds the construction and repair of flood management structures such as levees, typically with a federal and local cost share. For approximately 80 percent of the levees in the Central Valley flood control system, the state has turned over the operations and maintenance to local governments (primarily local flood control districts), although the state retains ultimate responsibility for these levees and the system as a whole.

Outside the Central Valley system, the state's role in flood management generally consists of providing financial assistance to local governments

36 | Title and Summary/Analysis ★★★

The voters and Legislature respond (2006)

floodSAFE
CALIFORNIA

Department of Water Resources

Where bond funding can be spent

$3.275 billion (67%)

Central Valley

Repair and improvements to levees and flood projects in the State and Federal Project system and the Delta

$680 million (14%)

Outside Central Valley

Subventions (federal flood control projects outside of the Central Valley, primarily Bay Area and Southern California)

$935 million (19%)

Statewide

Floodplain mapping, flood corridors, stormwater grants and other flood improvements statewide

floodSAFE
CALIFORNIA

FloodSAFE is a collaborative statewide effort designed to accomplish five broad goals:

- Reduce the Chance of Flooding
- Reduce the Consequences of Flooding
- Sustain Economic Growth
- Protect and Enhance Ecosystems
- Promote Sustainability

FloodSAFE Vision:

A sustainable integrated flood management and emergency response system throughout California that improves public safety, protects and enhances environmental and cultural resources, and supports economic growth by reducing the probability of destructive floods, promoting beneficial floodplain processes, and lowering the damages caused by flooding.

About the System

Complicated System of Channels, Levees and Bypasses

- Upstream reservoirs reduce flows by almost 50%
  - Flows above Sacramento were still almost 400,000 cfs in 1997
    - (as a comparison, the 1965 South Platte River flood was estimated to be 110,000 cfs)
- Levees are intended to confine flow to identified corridors
  - Natural rivers and channels
  - Large flood control bypasses
  - Complex flow regulating structures

California Central Valley Floodplain Evaluation and Delineation Program (CVFED)

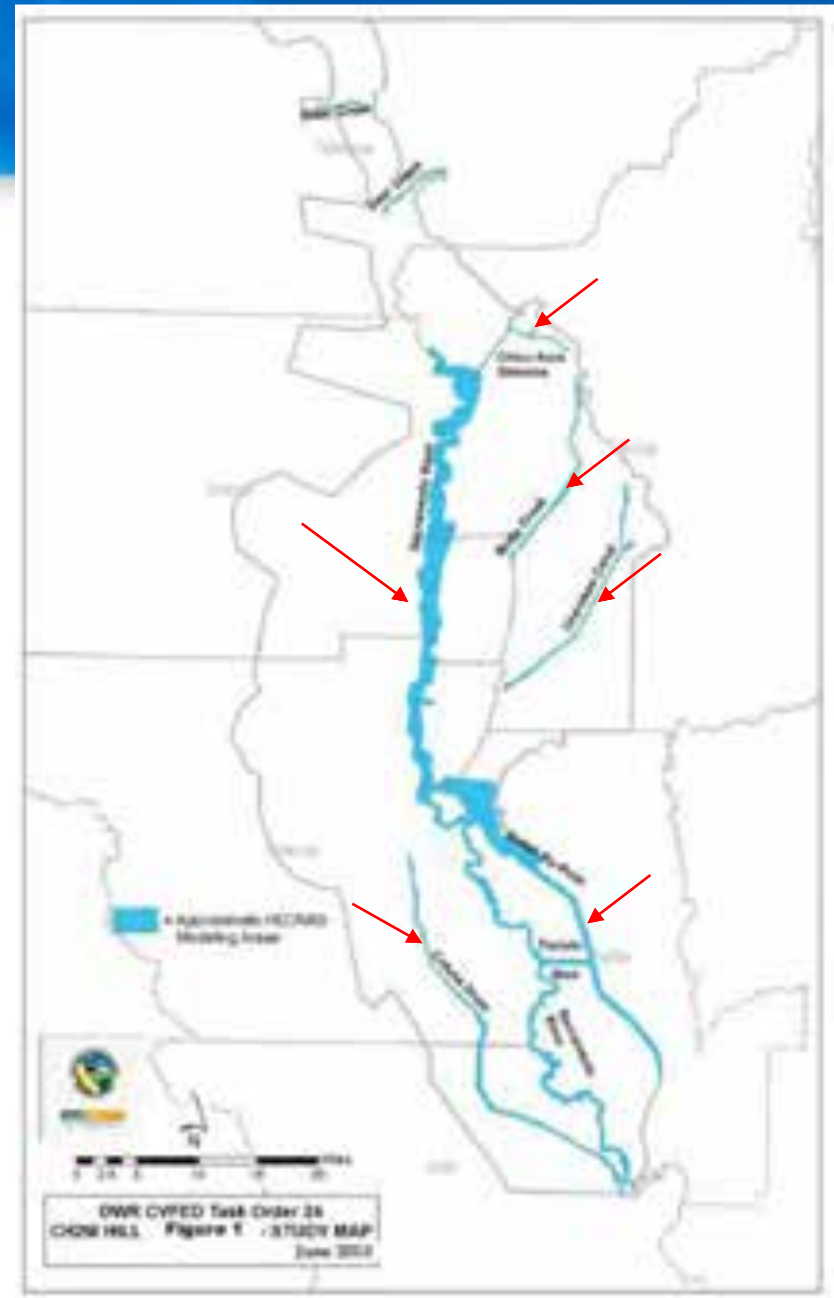
- CVFED is one step in FloodSAFE
  - Central Valley Flood Evaluation and Delineation Program
  - CH2M HILL is one of four contractors and has been assigned the upper Sacramento River System
- Mapping and survey data
- 1D and 2D models of Sacramento and San Joaquin River Systems

California Central Valley Floodplain Evaluation and Delineation Program (CVFED)

- **Develop new physical data, analytical tools, and other work products, including:**
  - Development of highly detailed topographic data using orthophotography, LiDAR, bathymetry and physical surveys within 2,000 square mile study area
  - Construction of 1-D and 2-D hydraulic models for 10-year, 50-year, 100-year, 200-year, and 500-year flood analyses
  - New maps delineating Levee Flood Protection Zones
  - Program will include the development of new maps delineating 100-year, 200-year and 500-year floodplains

HEC-RAS 1-D Model Development

- **Nine Riverine Models encompassing over 260 miles of rivers and bypasses**
  - Chico Area Creeks
  - Butte Creek
  - Cherokee Canal
  - Sacramento River
  - Sutter Bypass
  - Colusa Drain



Overview of Upper Sacramento System

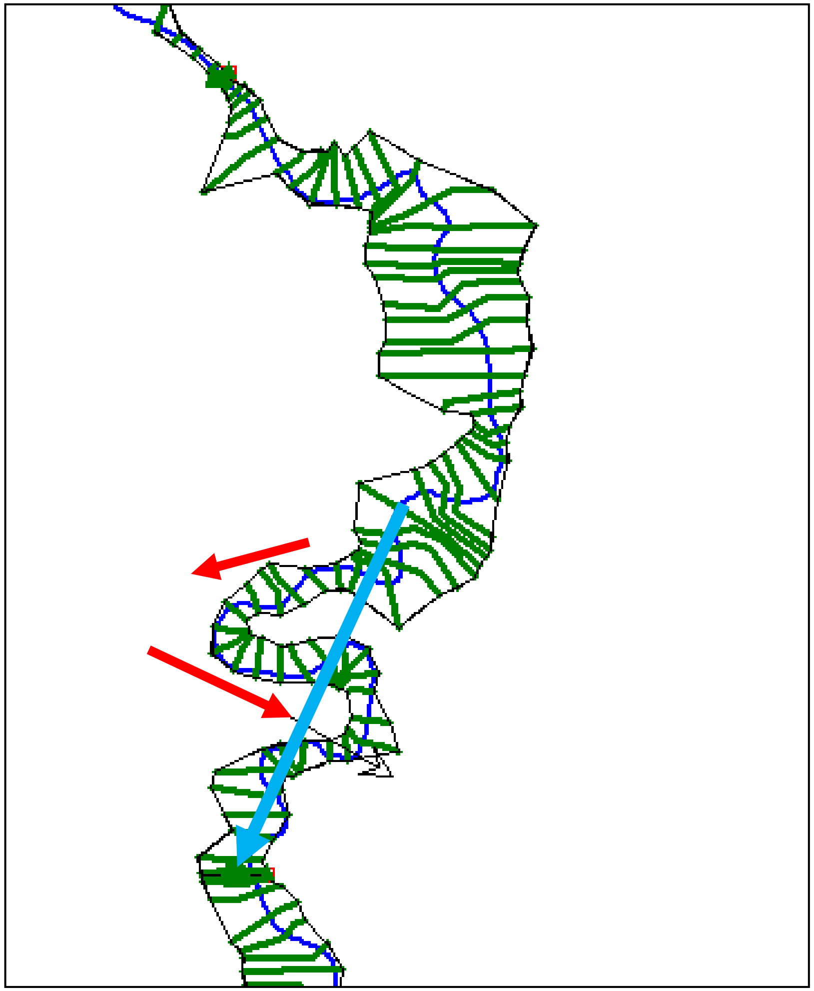
- Total Modeled Length: 301 miles
- 1284 Cross Sections
- Project Levee'd Areas: 375 miles
- Major Structures: Moulton Weir, Colusa Weir, Tisdale Weir
- Major Features: Butte Sink
- Elevation Range on Sacramento River: 120.9' to -2.5' (NAVD88)
- Avg. Slope: 0.02%
- Includes Levees, Lateral Structures, Storage Areas
- Calibrated to 2006 Flood Event

HEC-RAS Modeling Challenges

- Oxbows
- Overbank Area/Parallel Channel Modeling
- Modeling Periods of Low Flow in Channels
- Storage Area Transitions

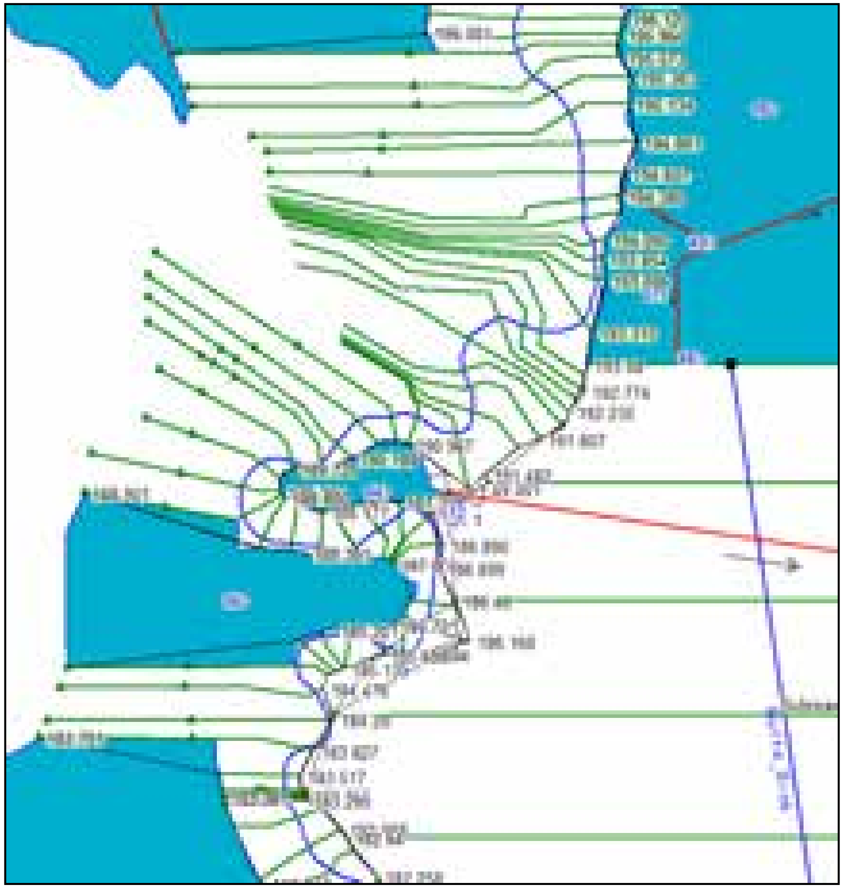
Typical Approach - Oxbows

- Oxbows are typically represented by extending out the cross sections to where the flow is contained
- Performs well when flow remains channelized
- When the water surface increases to where it has flooded the area, water is unable to shortcircuit the channel and flow overland



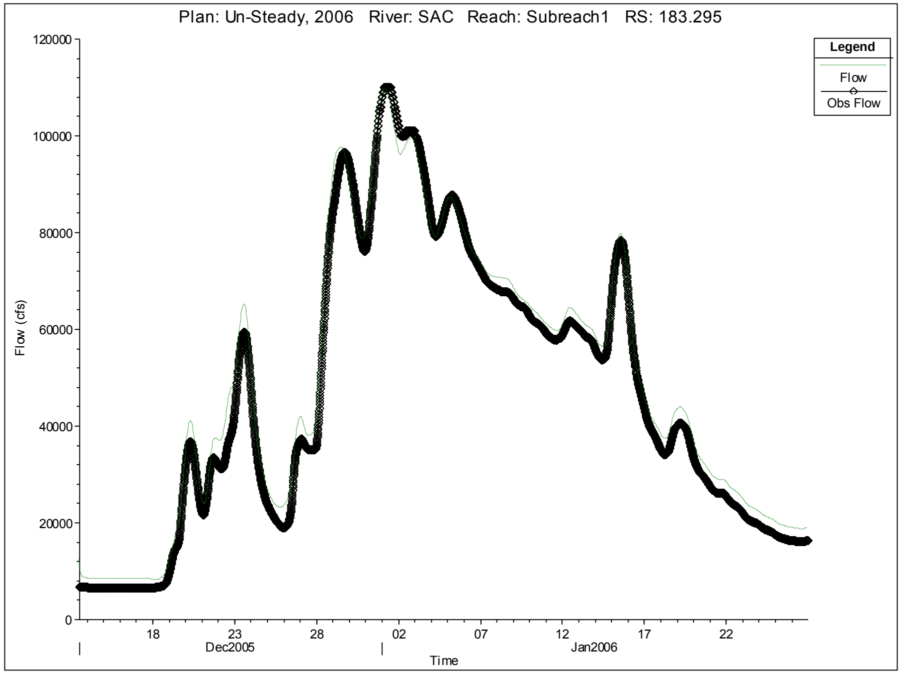
Response to Issue - Oxbows

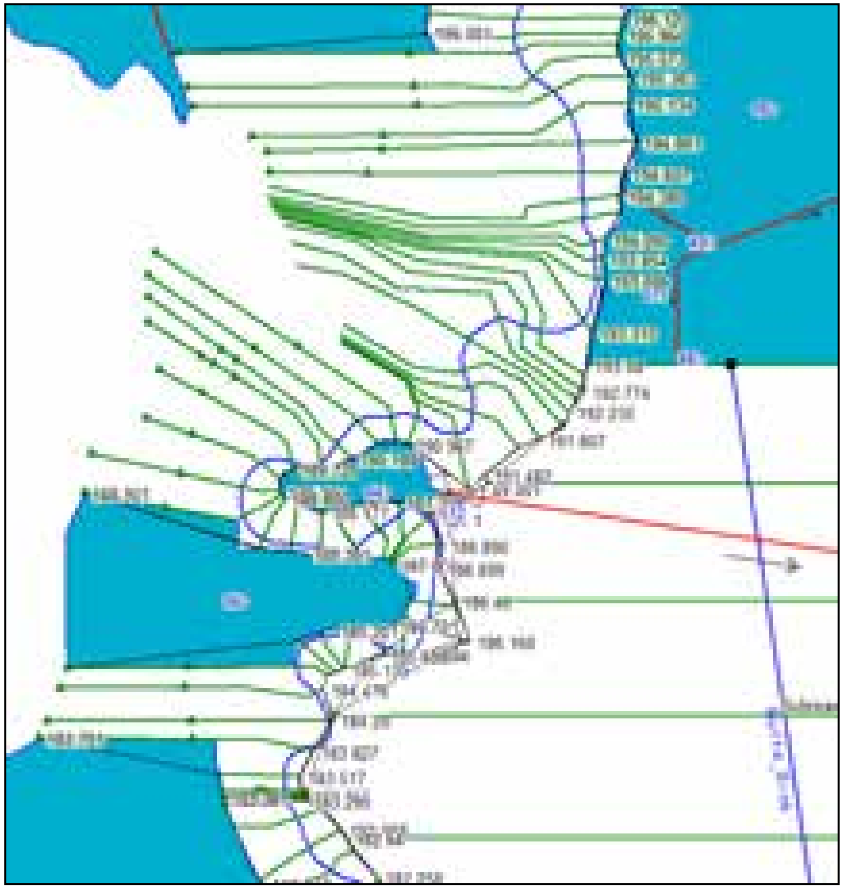
- Utilize cross sections for channelized area
- Model Overland Flow with a Storage Area
- Allows for better representation of hydraulic connectivity



Results of Response - Oxbows

- Model matches timing of peak flows very well
- Both overland flow and channelized flow are modeled



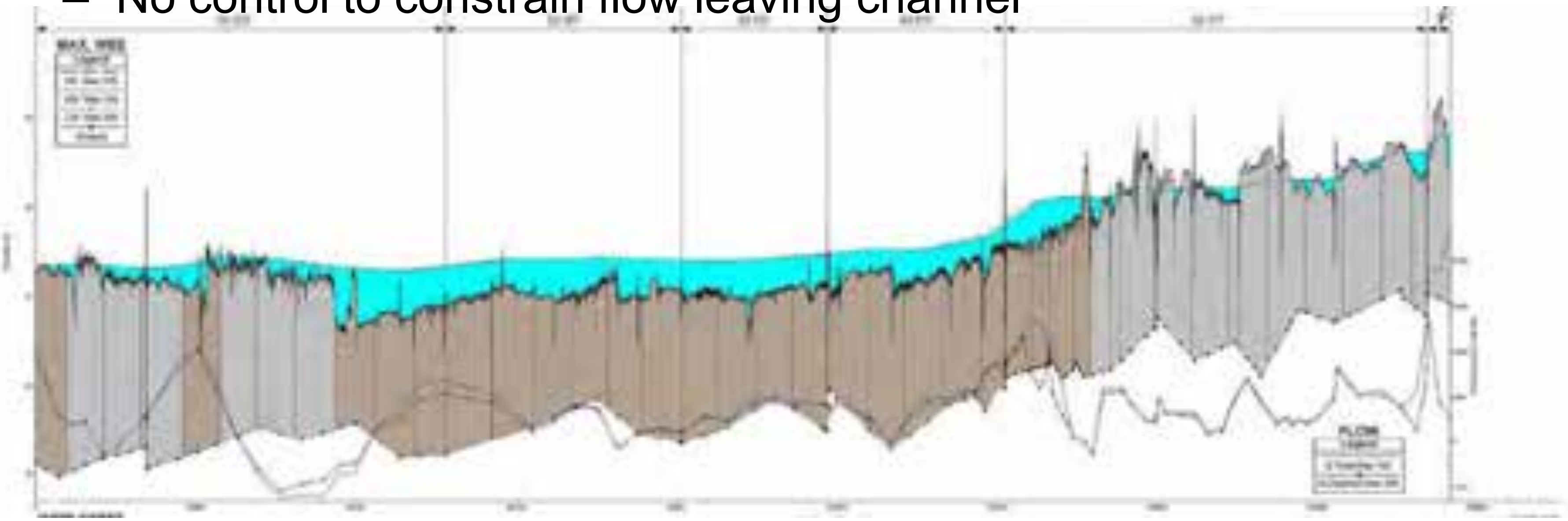


Typical Approach – Overbank Areas

- Typical Approach is to model the overbank with a series of storage areas
  - Allowed flow to enter and exit the overbank through the storage areas.
  - Used in areas with natural overbanks and no levee features.

Issue with Typical Approach – Overbank Areas

- Issue was that flow entered storage area at top end and drained at bottom
  - Change in flow occurred before backwater effects could constrain flow
- Changes in discharge along mainstem up to 15,000 cfs
  - Geometry did not create tailwater
  - No control to constrain flow leaving channel



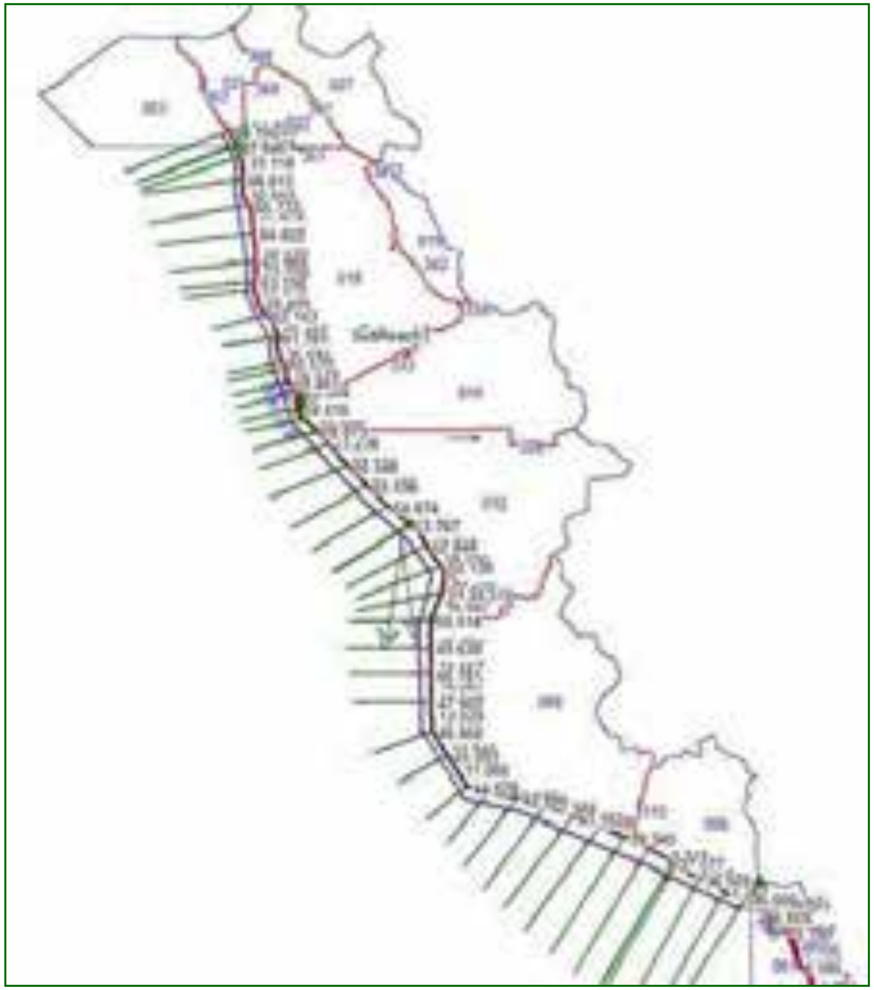
CH2MHILL

Response to Typical Approach – Overbank Area

- Parallel Channel utilized instead of storage areas to model the overbank area
- Usage of Storage Areas was resulting in “looping” flow
- Creates a hydraulic tailwater that balances flow leaving and entering the main channel

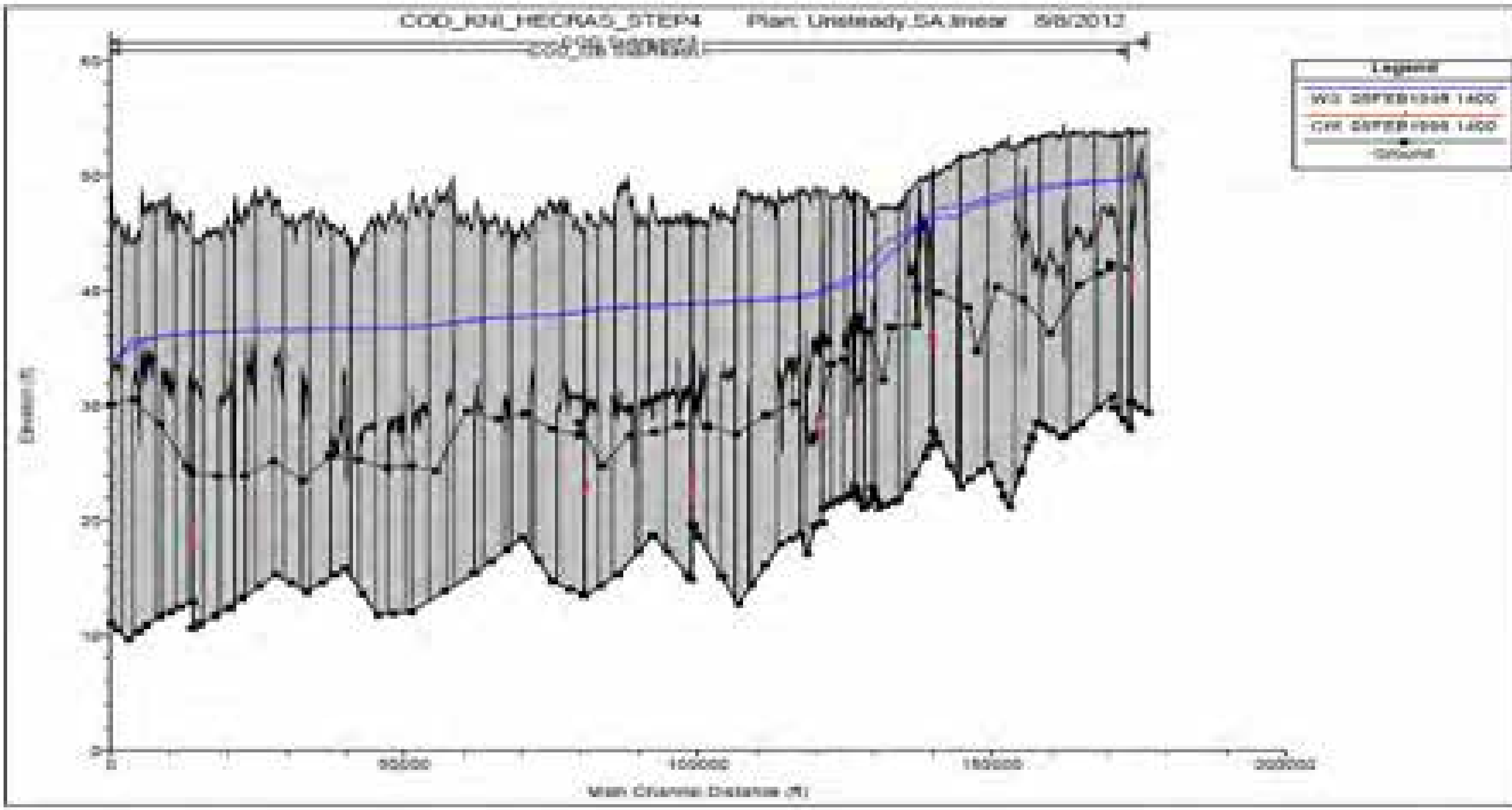
Result of Response – Overbank Area

- Flow can move into/out of main channel and overbank along entire length
- Discharges now relatively constant



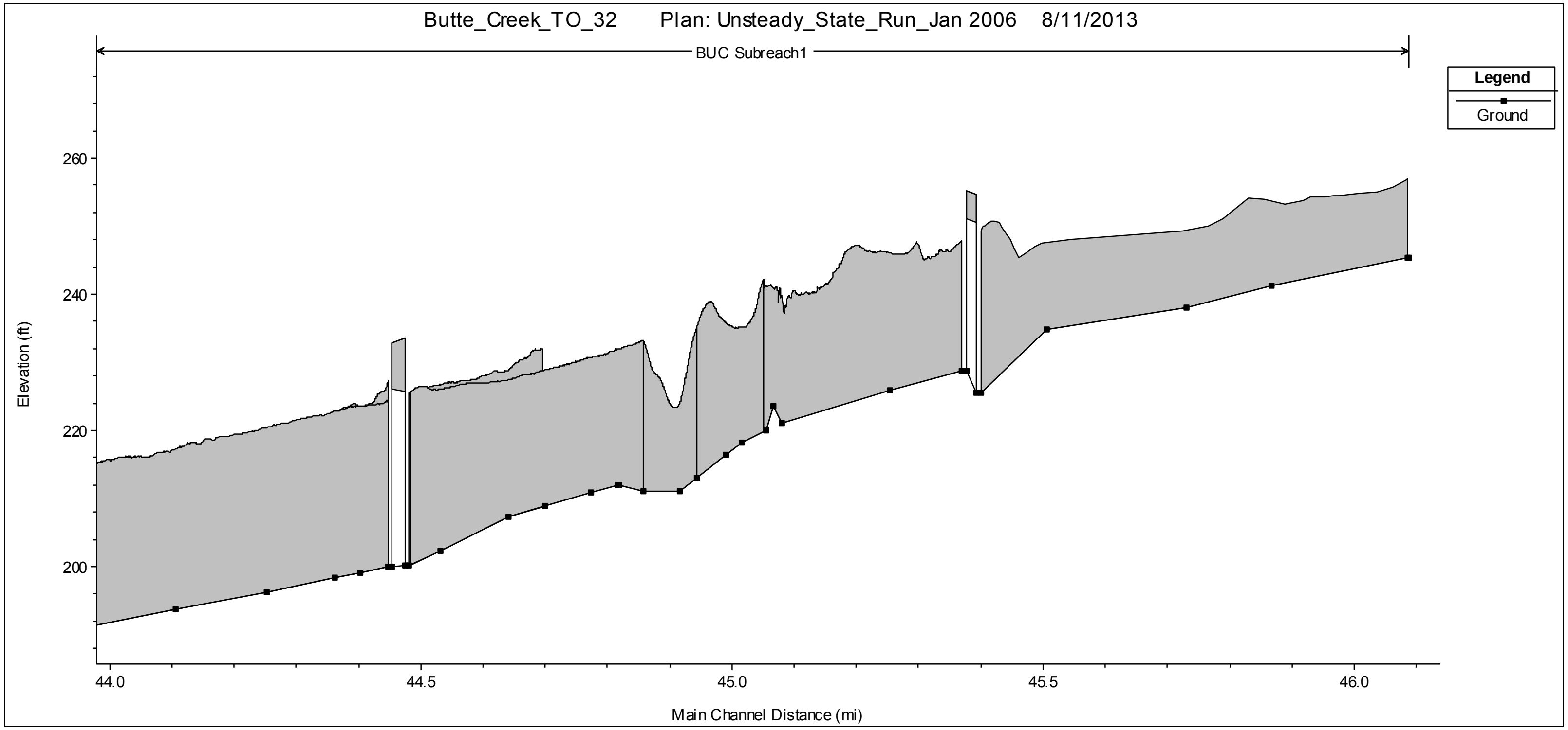
Result of Response – Overbank Area

Flow Profile Similar in Both Conveyances



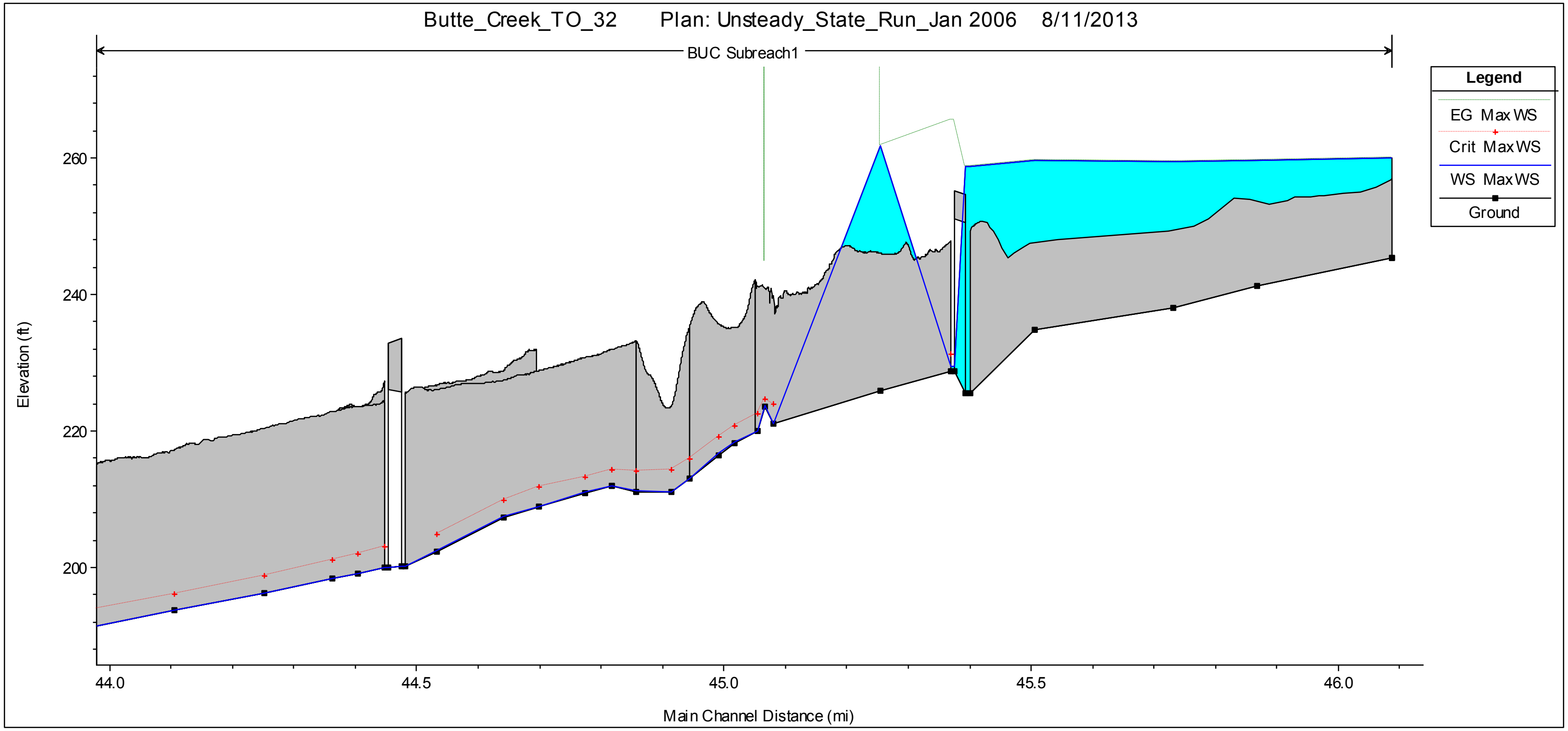
Typical Approach – Low Flow in Channels

- Typical approach is to run the model without modifications to the geometry



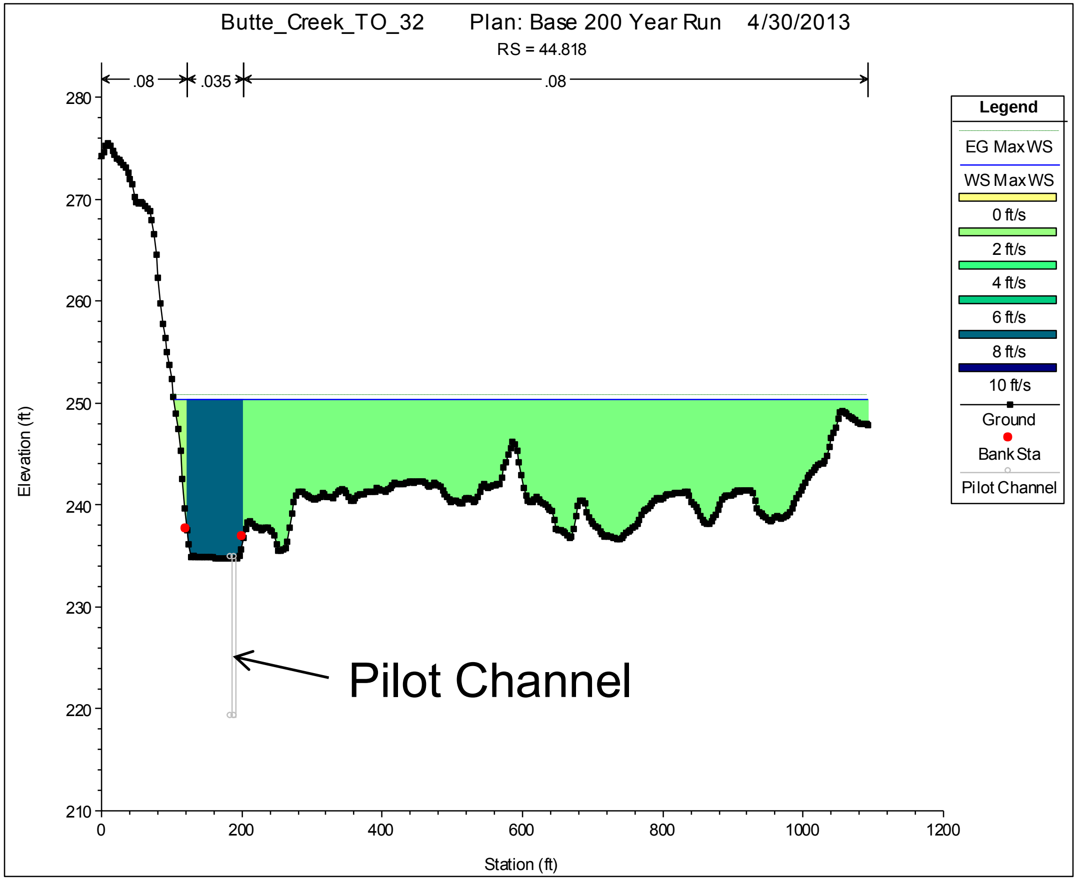
Issue with Typical Approach – Low Flow in Channels

- During Unsteady-State modeling, the channel can run dry due to channel storage
- This results in mathmatical instabilities in the model, typically resulting in failure of the simulation



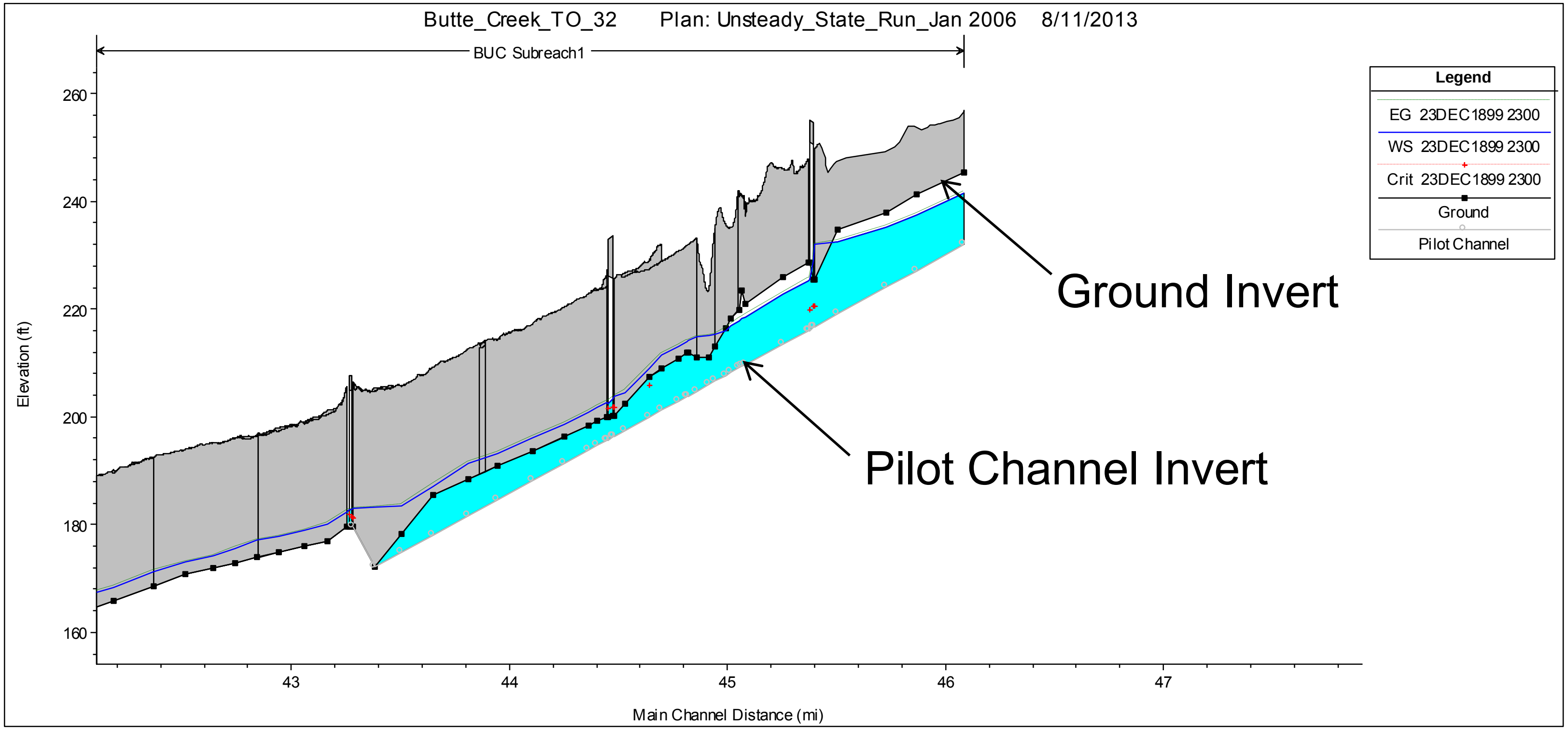
Response to Issue – Low Flow in Channels

- Conveyance of pilot channel is minor in comparison to total conveyance area



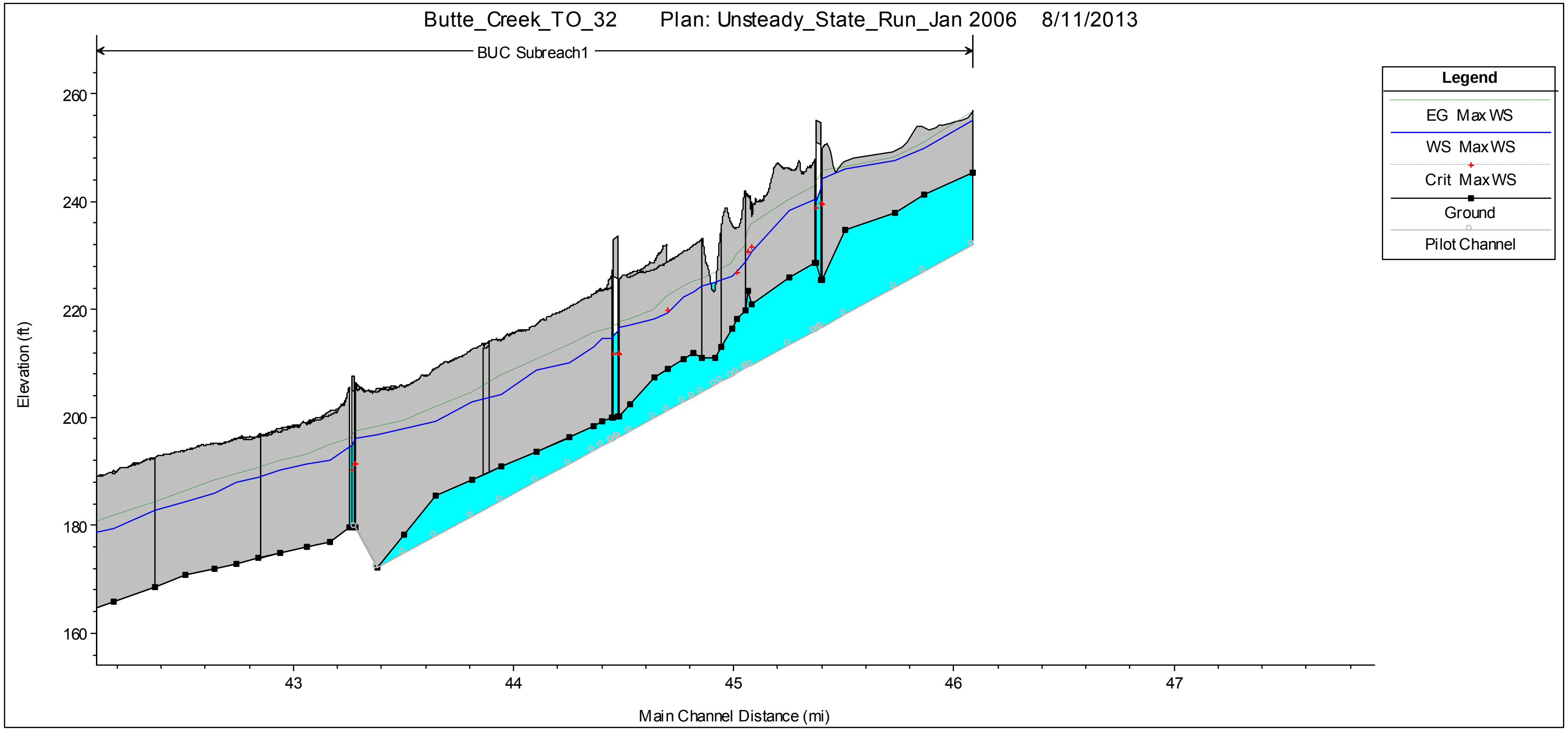
Response to Issue – Low Flow in Channels

- Pilot channel added to maintain water in the channel during low flow periods



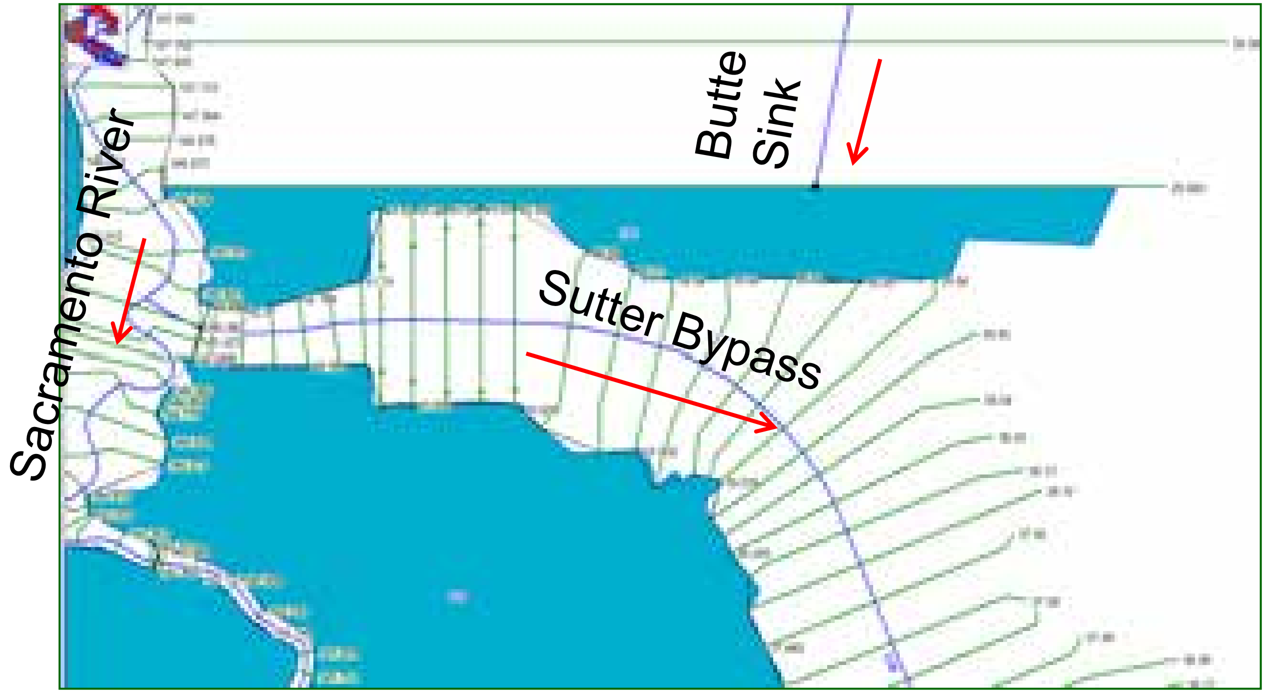
Results of Response – Low Flow in Channels

- Model runs without significant errors



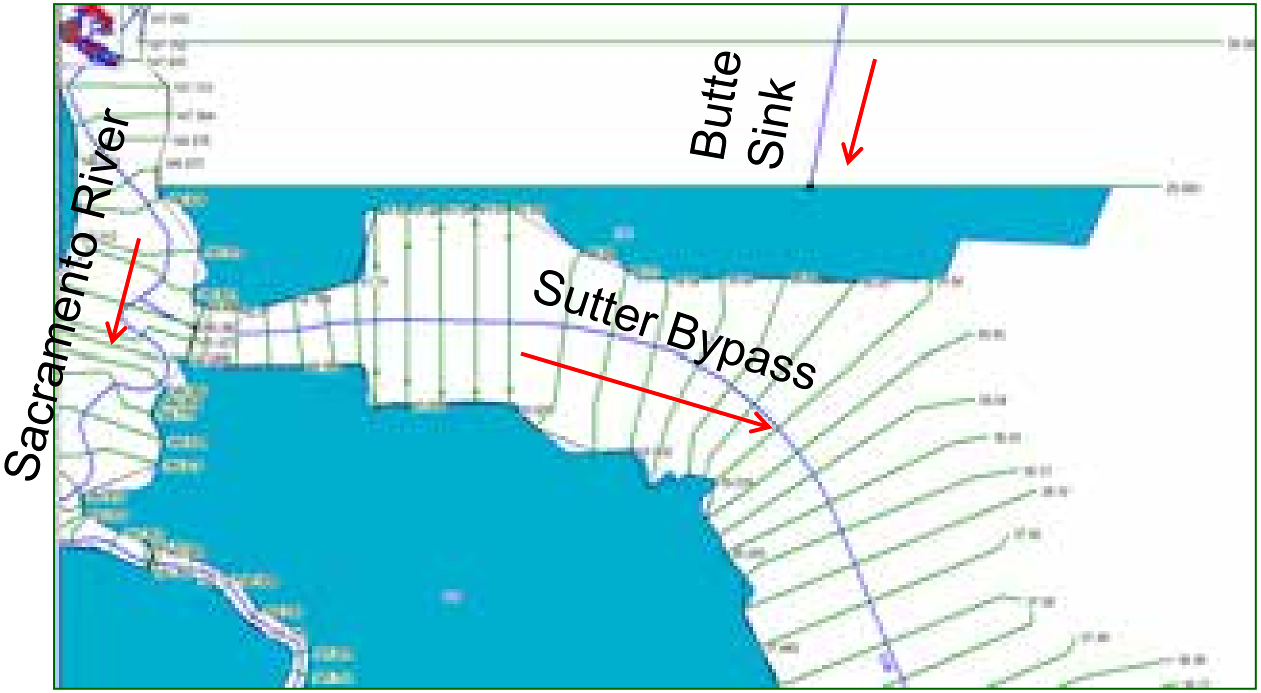
Response – Interface of Large XS into Multiple XS

- Issues With Using a Junction
  - Butte Sink cross section entering junction is much larger than the distance between cross sections in the Sutter Bypass
  - The hydraulic gradient across the Sutter Bypass is not captured



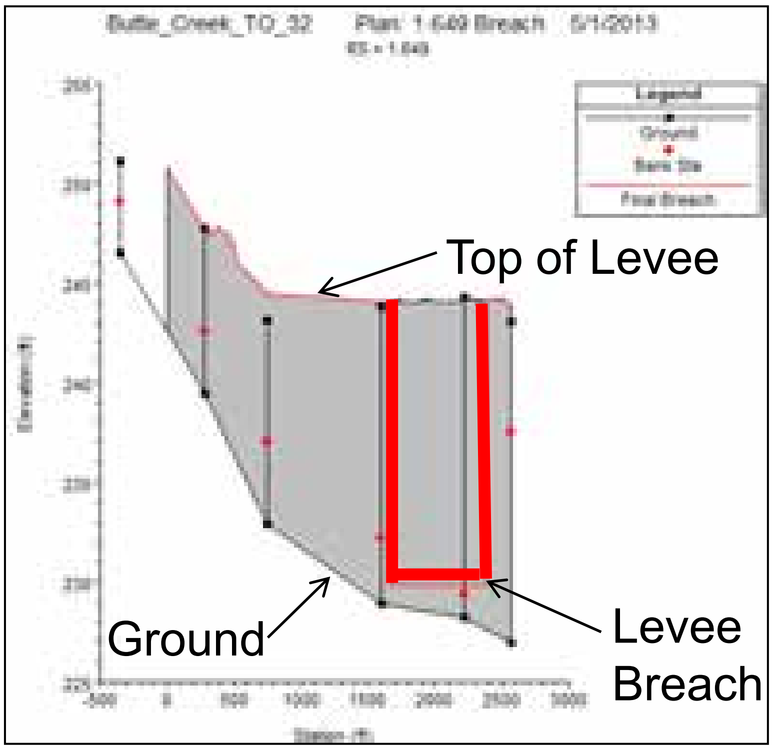
Response – Interface of Large XS into Multiple XS

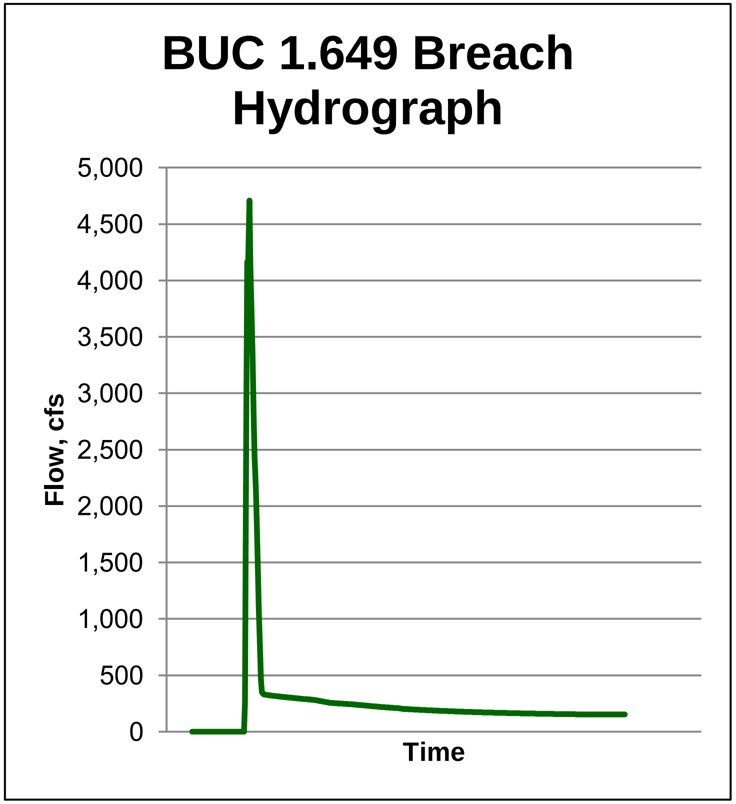
- Storage Area 106 – Added at the interface of Butte Sink and the Sutter Bypass
- Bounded by the Colusa Weir, Sacramento Levees, high ground, the Sutter Bypass, and the Butte Sink



HEC-RAS Breach to FLO-2D

- After developing the model, simulations of breach events were run to develop breach hydrographs



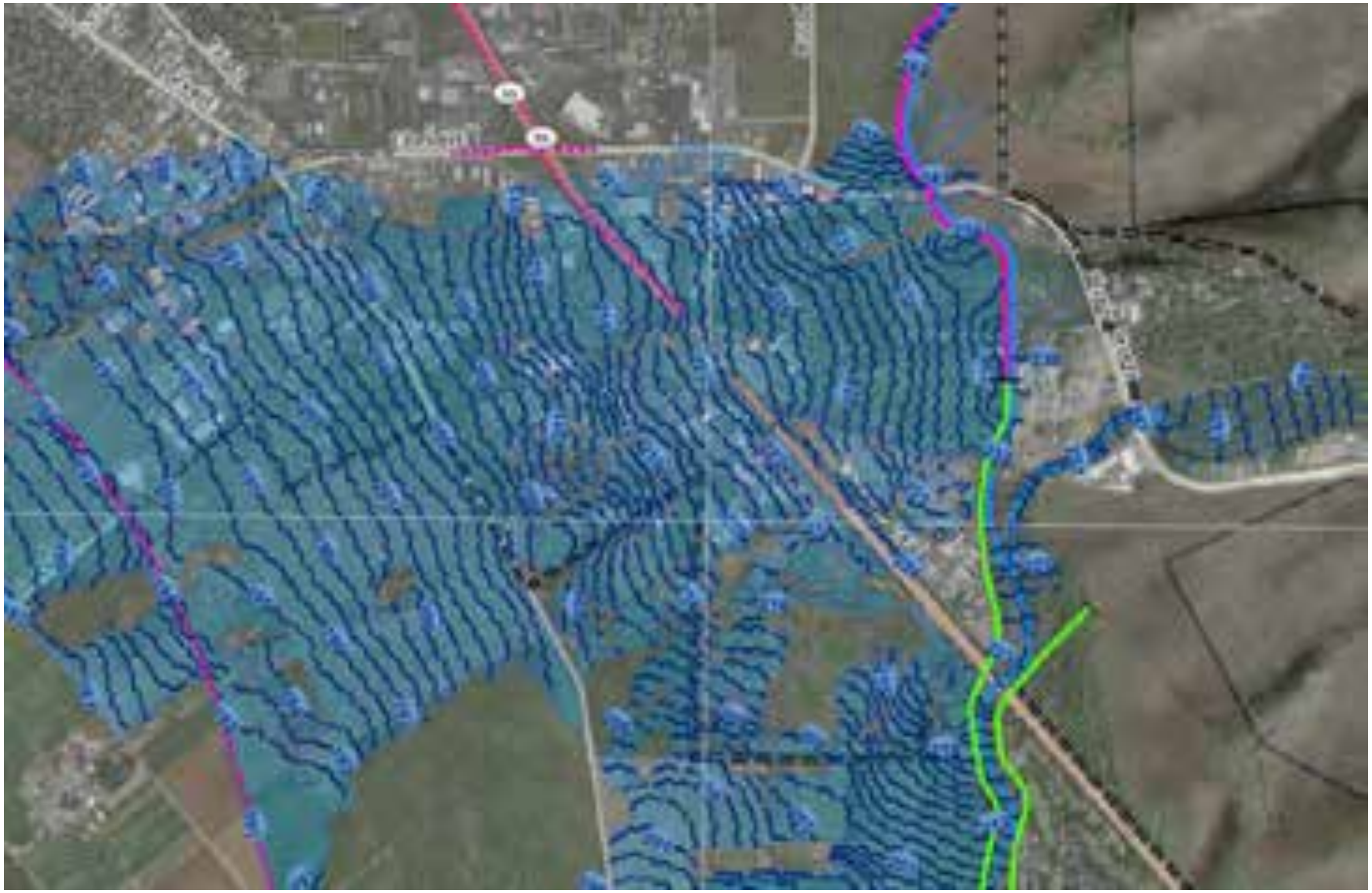


HEC-RAS Breach to FLO-2D

- HEC-RAS Breach Hydrographs were then put into FLO-2D for 2-D floodplain modeling

Floodplain Map Development

- Results of FLO-2D Modeling were used to create flood hazards maps



Questions?

PINEY CREEK MAJOR DRAINAGEWAY PLAN

WATERSHED APPROACH TO UNDERSTANDING SEDIMENT DYNAMICS

2013 CASFM CONFERENCE, STEAMBOAT SPRINGS, SEPTEMBER 10-13, 2013

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

Southeast Metro Stormwater Authority

AURORA

DOUGLAS COUNTY COLORADO

RESPEC CONSULTING & SERVICES

We Heard Stories

Huge floods in the winter

100-ft high vertical channel banks

WE HEARD STORIES

RIVERS THAT APPEAR AND DISAPPEAR

MILES OF SANDY BEACHES

We Heard Stories

Vegetation so thick it would take days to walk through

Reptiles that can swallow small children

TURNS OUT THE STORIES WERE TRUE

BUT NOT AS BAD AS ADVERTISED…

Master Plan Project

Project Sponsors

Urban Drainage and Flood Control District
Southeast Metro Stormwater Authority
City of Aurora
Douglas County

Purpose and Objectives of Study

- Updated watershed hydrology and define 100-year floodplain
- Identify problem areas along Piney Creek and Antelope Creek
- Develop alternative improvements to address problem areas
- Develop a conceptual design plan to address problem areas

Study Completed in February 2012

Study Area Description

STUDY AREA DESCRIPTION

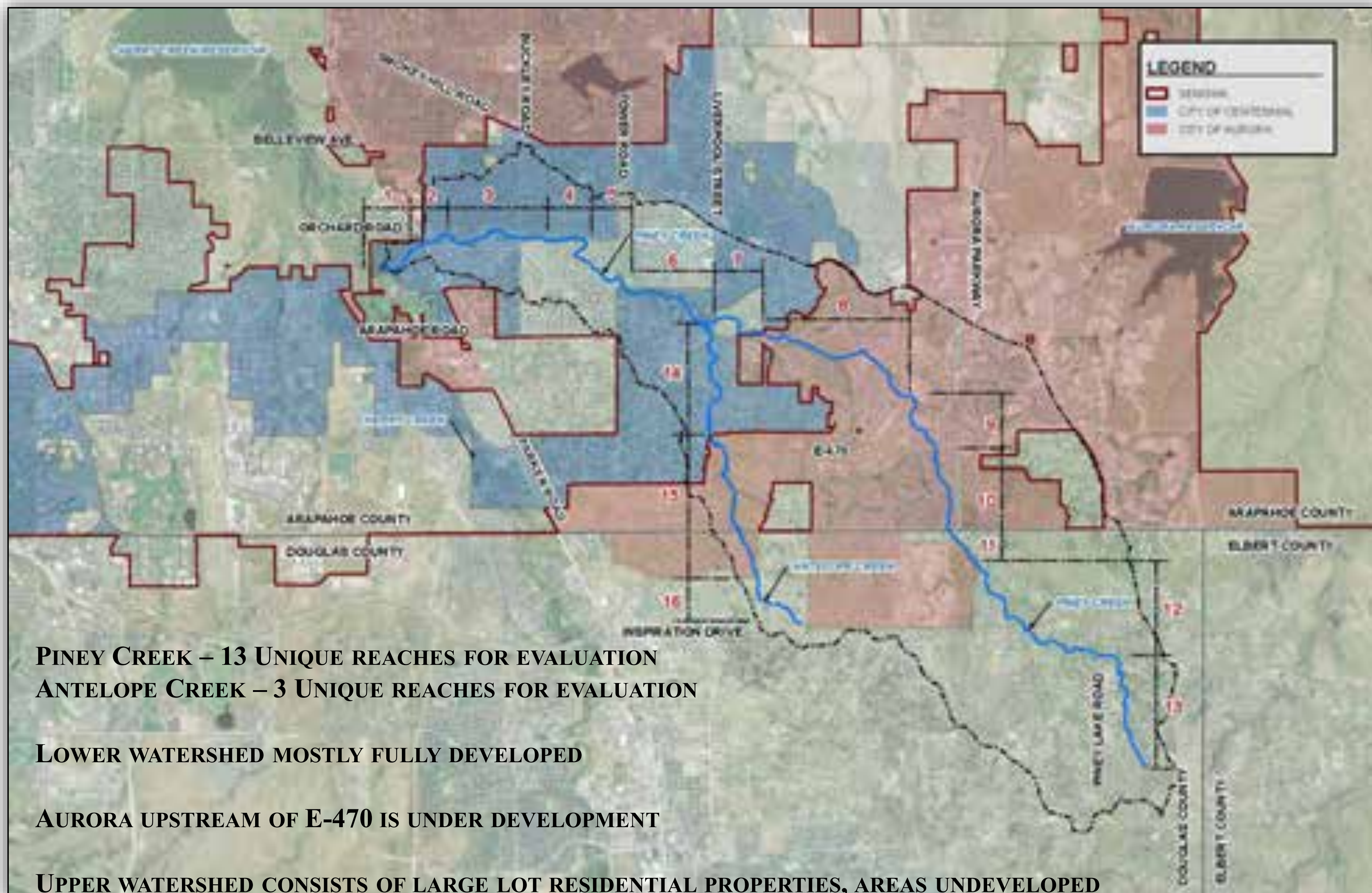
PINEY CREEK WATERSHED – 22 SQUARE MILES

PINEY CREEK DRAINAGEWAY – 13 MILES

ANTELOPE CREEK DRAINAGEWAY – 4 MILES

TRIBUTARY TO CHERRY CREEK, JUST UPSTREAM OF CHERRY CREEK STATE PARK

Study Area Description



Piney Creek – 13 Unique reaches for evaluation
Antelope Creek – 3 Unique reaches for evaluation

Lower watershed mostly fully developed

Aurora upstream of E-470 is under development

Upper watershed consists of large lot residential properties, areas undeveloped

Problem Area Identification

Field Investigation to document existing conditions

Observed problem areas:

- Channel degradation, erosion
- Excessive sediment deposition
- Failed/Inadequate structures
- Undersized roadway crossings
- Flood risk to private property and public infrastructure

Problem Area Identification

- Channel degradation and erosion

Severely Eroded Channel Banks

Severely Eroded Channel Banks

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Problem Area Identification

- Excessive sediment deposition

Sediment Deposition on Public Trails

Excessive Sediment Deposition in Creek

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Problem Area Identification

- Failed/Inadequate structures

Failed Structure at Parker Road

Failed Structure at Piney Lake Road

PROBLEM AREA IDENTIFICATION

- UNDERSIZED ROADWAY STRUCTURES

UNDERSIZED ROADWAY CROSSING

UNDERSIZED ROADWAY CROSSING

Problem Area Identification

- Flood risk to private property and public infrastructure

Flood Risk to Infrastructure

Flood Risk to Infrastructure

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How do we Solve the Problems

We first looked at what has changed within the watershed

- New Development
  - Encroached upon the floodplain
  - Realignment of the channel in areas

- Changes in Hydrology
  - Peak Flows
  - Snowmelt Runoff
  - Base Flow

- Constructed Improvements
  - Channelization
  - Grade control structures

Development along Piney Creek

1954 – 2011 Piney Creek at Parker Road

DEVELOPMENT ALONG PINEY CREEK

1954 – 2011 PINEY CREEK AT TOWER ROAD

CHANGES IN HYDROLOGY

- PEAK FLOW RATES

Changes in Hydrology

- Snowmelt Runoff

Annual average of 33” of snow in 10 events in snowmelt runoff months

Runoff per event = 500 acre-feet

Peak runoff per event = 50 cfs

Estimated to add 5,000 acre-feet of runoff annually, as compared to pre-development conditions

Actual peak flow rates and volumes are highly variable

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Changes in Hydrology

- Base Flow

Increases due to urbanization
(primarily lawn irrigation)

Current urbanized area is approximately 7,000 acres and 40% imperviousness

Surface and subsurface irrigation return flows = 1,000 acre-feet/year

All returns on surface would create about 1.5 cfs of base flow

Irrigation return flows could support about 250 acres of additional wetlands along Piney Creek

However, the return flows are owned by the water supply entity

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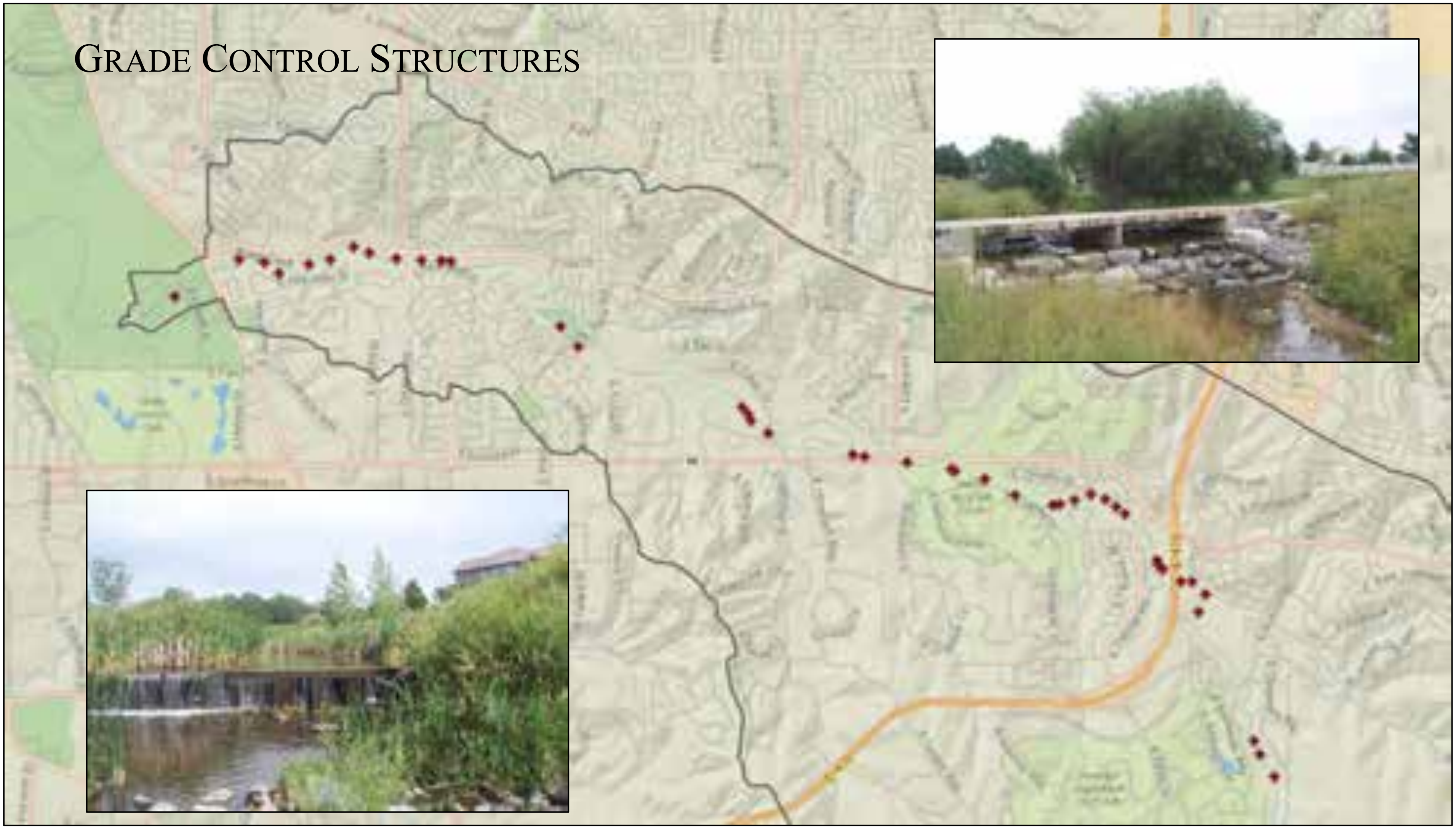
Constructed Improvements



Effects of Change in the Watershed

- Extremely eroded channel banks

EFFECTS OF CHANGE IN THE WATERSHED

- SAND CHOKED FLOODPLAINS AND INCREASED BASE/WINTER FLOWS

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Effects of Change in the Watershed

- Overgrown thick vegetation

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Animal Habitat

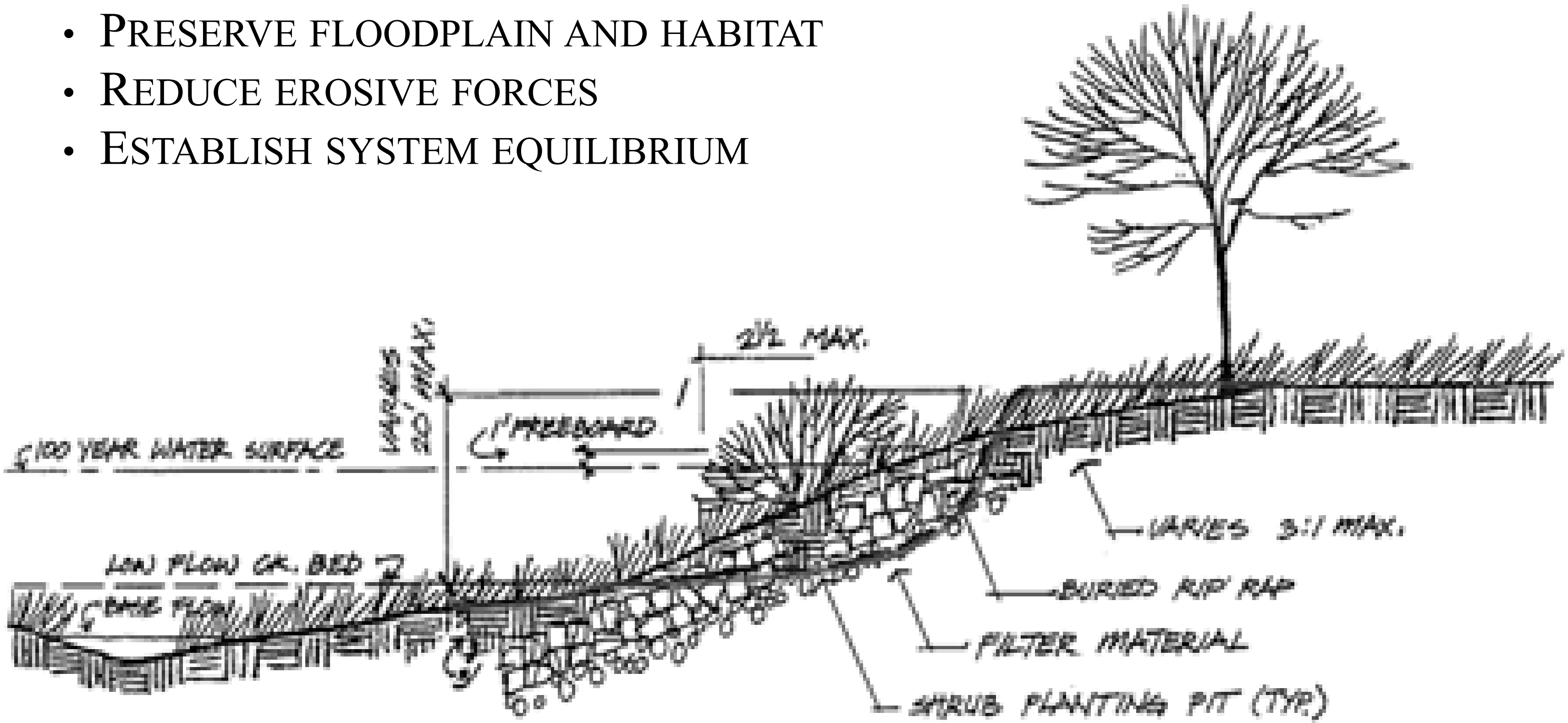
- Through all the change, animal habitat has been preserved

Address the Effects of Change

Cannot restore the creek to historic conditions

Can reclaim the creek to a desirable condition

- Preserve floodplain and habitat
- Reduce erosive forces
- Establish system equilibrium



How Do We Accomplish It

"Obtain a better understanding of sediment erosion and transport within the drainageway"

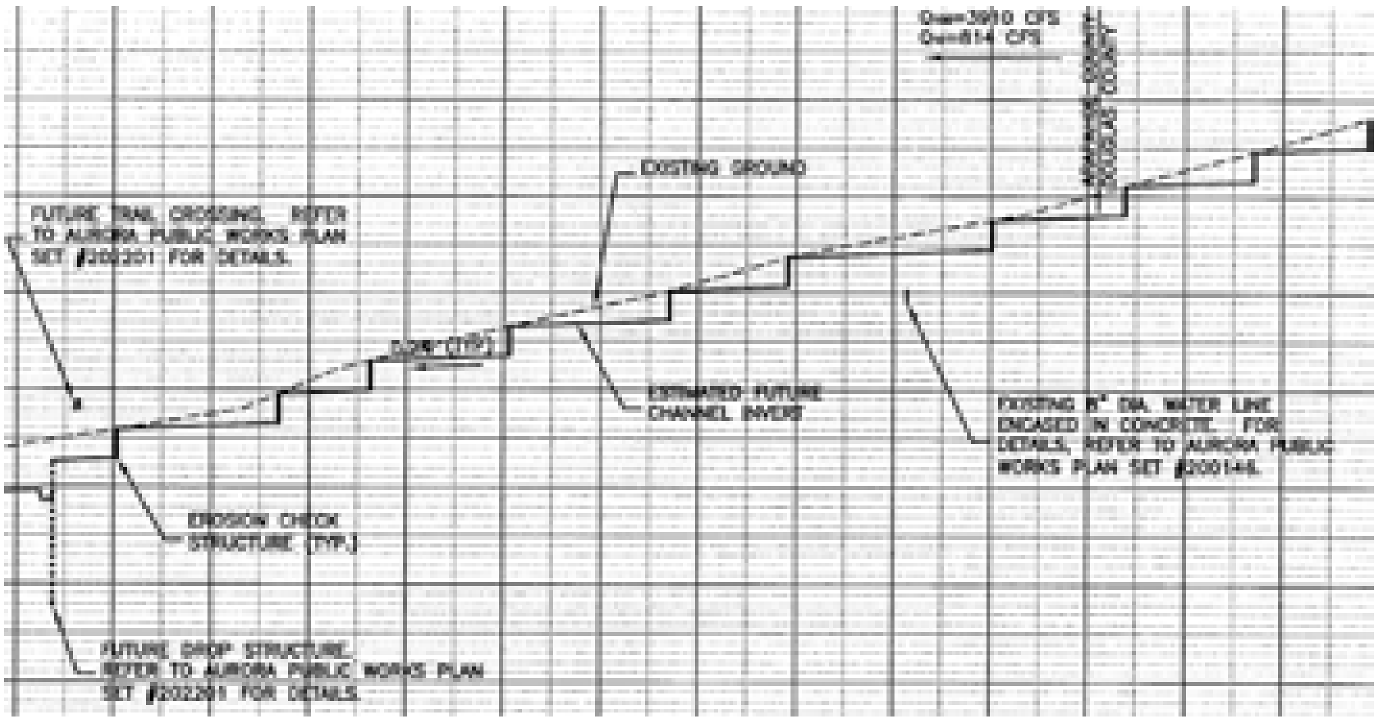
Sediment Erosion and Transport Axioms

- Sediment moves in waves in Piney Creek initiated by storm events
- More frequent events (< mean annual) are primarily depositional - moves "excess" sediment and deposits it short distances downstream
- Less frequent events (> mean annual) typically adds new sediments (by Bank erosion) and moves large masses of sediment
- We will never eliminate all erosion. Therefore, we don't want to stop all sediment transport
- Goal is to maintain system balance (dynamic equilibrium)

START WITH WHAT WE KNOW

PREVIOUS MASTER PLANS (1989 AND 2003)

•USED STANDARD 0.2% AS A STABLE SLOPE FOR ENTIRE REACH OF PINEY CREEK; PROPOSED NUMEROUS (!) EROSION CHECK STRUCTURES



START WITH WHAT WE KNOW

FIELD EVIDENCE OF AREAS OF EXTREME EROSION AND EXTREME SEDIMENTATION

- PINEY CREEK RANCHES DEVELOPMENT CHANNEL BANK AND BED EROSION

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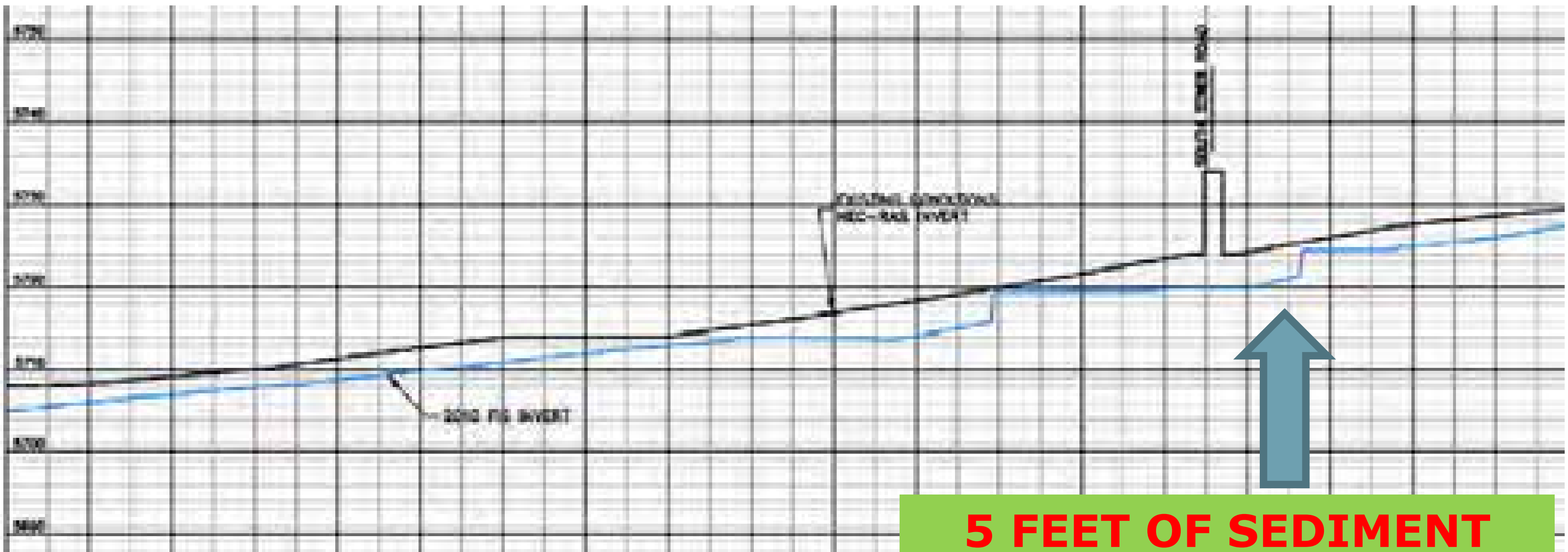
START WITH WHAT WE KNOW

FIELD EVIDENCE OF AREAS OF EXTREME EROSION AND EXTREME SEDIMENTATION

- PINEY CREEK AT SOUTH TOWER ROAD (BURIED DROP STRUCTURES)



5 FEET OF SEDIMENT DEPOSITION IN 8 YEARS!

Start with what we know

Field evidence of areas of extreme erosion and extreme sedimentation

- Piney Creek at South Tower Road (buried drop structures)

5 FEET OF SEDIMENT DEPOSITION IN 8 YEARS!

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Apply analytical tools

Use a watershed approach to sediment transport dynamics

- Limited budget for full blown sediment transport analysis
- HEC-RAS model already in place for floodplain delineation
- Used HEC-RAS sediment transport functions and stream power output
- Limitations:
  - Widely spaced HEC-RAS cross-sections
  - Lack of sediment transport function that truly matches all the physical, hydraulic, and hydrologic conditions of Piney Creek
  - Assumed sediment loaded hydrographs for point stream inflows
  - Single storm snapshots
- Therefore this level of analysis only good for qualitative analysis

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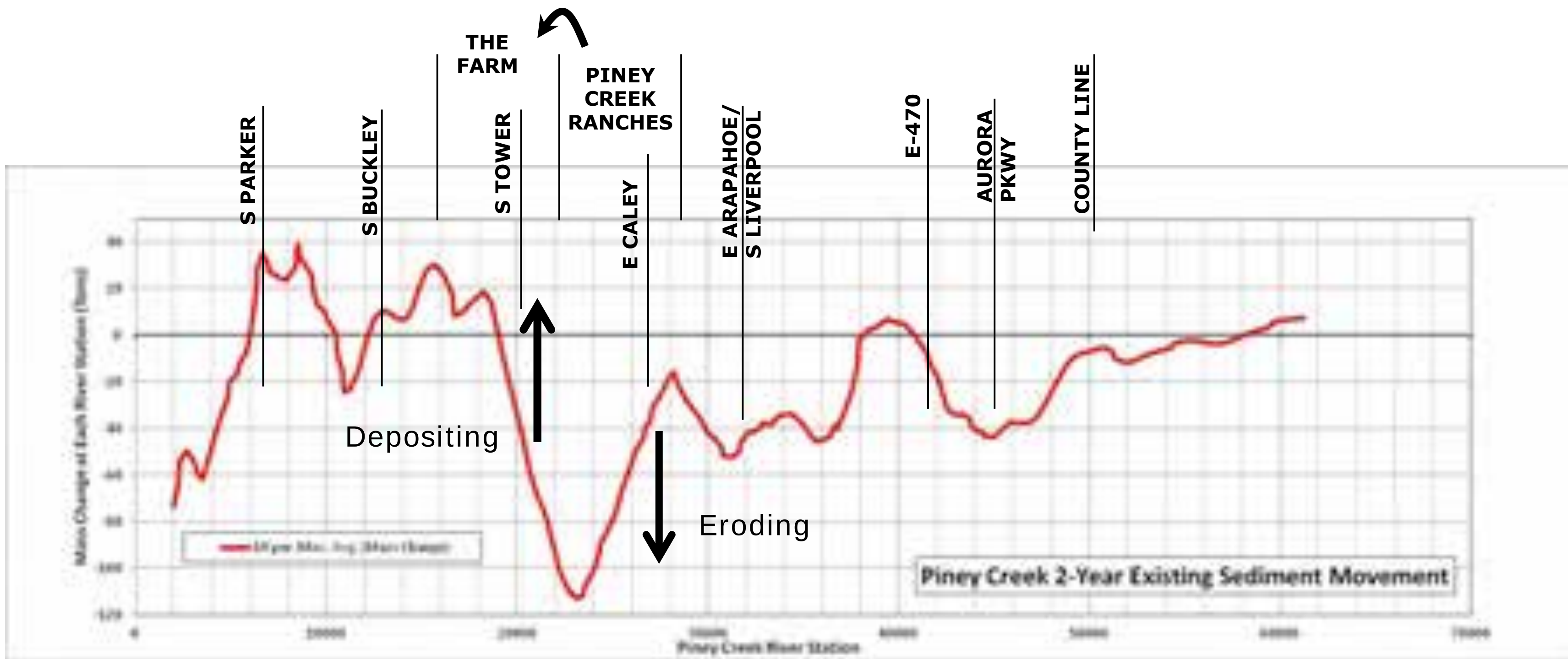
Analyze sediment transport results

Sediment mass movement change



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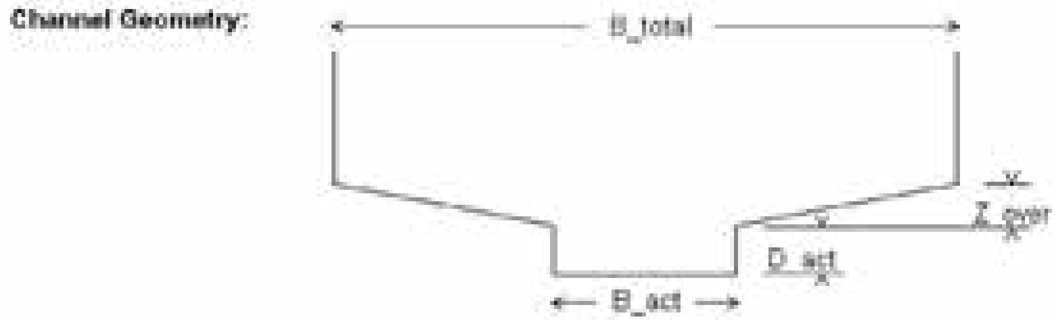
DETERMINE EQUILIBRIUM PARAMETERS

REFERENCE
REACH
APPROACH



Reach	Q_{2yr} (cfs)	So (%)	B_{active} (ft)	B_{total} (ft)	Z_{over} (ft)	D_{active} (ft)	n_{active}	$n_{overbank}$
1	714	0.23	76.4	157	1.74	4.84	0.025	0.060
2	710	0.36	52.7	172	0.39	5.58	0.025	0.060
3	699	0.42	59.3	148	0.54	2.62	0.025	0.060
4	688	0.61	161.0	273	0.41	1.81	0.025	0.060
5	677	0.60	128.7	198	0.21	1.50	0.025	0.060
6	594	0.59	58.0	255	0.21	3.00	0.025	0.060
7	460	0.63	35.4	99	0.58	2.66	0.025	0.060
8	331	0.45	63.9	131	0.65	1.65	0.025	0.060
9	148	0.84	63.3	181	0.37	0.88	0.025	0.060
10	124	1.05	64.0	79	0.93	1.27	0.025	0.060
11	111	1.43	63.0	112	0.51	0.87	0.025	0.060
12	66	1.25	56.0	80	0.65	0.91	0.025	0.060
13	34	1.40	46.0	56	0.65	0.68	0.025	0.060
Prototype	688	0.61	161	273	0.41	1.81	0.03	0.06

Procedure developed by G. K. Cotton Consulting

Determine equilibrium parameters

Compute sediment transport and equilibrium index

Stream Channel Stability - Hydraulic Results and Scaling

Location: Piney Creek future 2-year flows
Calc by: [illegible]
Last Revised: January 4, 2011
Printed: February 8, 2011 12:39

Reach	[illegible] (cfs)	[illegible] (%)	[illegible] (mm)	[illegible]	[illegible] (ft)	[illegible] (ft)	[illegible] (ft)	[illegible] (ft)	[illegible] (cfs)	[illegible] (ft/s)	[illegible] (ft^3/s)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	714	0.230	0.79	2.41	78.4	157	4.0	2.1	714	4.5	17,550	0.32	1.00	1.05	0.38	1.21
2	710	0.300	0.79	2.41	52.7	172	5.6	2.3	710	5.8	44,152	0.82	1.00	1.04	0.59	0.75
3	689	0.420	0.79	2.41	59.3	148	2.6	2.0	689	5.8	59,121	0.88	1.00	1.02	0.69	0.77
4	668	0.610	0.79	2.41	161.0	273	1.9	1.0	668	4.5	53,510	1.00	1.00	1.00	1.00	1.00
5	677	0.600	0.79	2.41	128.7	198	1.5	1.1	677	4.8	58,838	1.10	1.00	0.98	0.98	0.88
6	594	0.590	0.79	2.41	58.0	255	3.0	1.7	594	6.2	73,259	1.37	1.00	0.83	0.97	0.58
7	400	0.650	0.79	2.41	35.4	69	2.7	1.9	400	6.5	67,338	1.26	1.00	0.59	1.05	0.49
8	331	0.450	0.79	2.41	63.9	131	1.8	1.2	331	4.4	18,692	0.32	1.00	0.38	0.74	0.91
9	165	0.340	0.79	2.41	83.3	161	0.9	0.6	165	3.9	12,594	0.24	1.00	0.18	1.38	0.80
10	124	1.050	0.79	2.41	84.0	79	1.3	0.5	124	3.8	13,469	0.25	1.00	0.11	1.72	0.74
11	111	1.420	0.79	2.41	63.0	112	0.9	0.4	111	4.0	18,850	0.35	1.00	0.09	2.34	0.63
12	66	1.250	0.79	2.41	58.0	60	0.9	0.4	66	3.3	8,795	0.53	1.00	0.05	2.05	0.79
13	34	1.400	0.79	2.41	46.0	56	0.7	0.3	34	2.8	3,365	0.06	1.00	0.02	2.44	0.79
14																
15																
16																
17																
18																
19																
20																
Prototype	668	0.610	0.79	2.41	161.0	273.0	1.9	1.0	668	4.5	53,510					

DETERMINE EQUILIBRIUM PARAMETERS

SCALE REACH CROSS-SECTIONS TO EQUILIBRIUM INDEX

Stream Channel Stability - Hydraulic Results and Scaling

Location: Piney Creek future 2-year flows
Calc by: Geo. Strophic, PE
Last Revised: January 4, 2011
Printed: February 9, 2011 12:39

Reach	Q_{2yr} (cfs)	Se (%)	d_{50} (mm)	G	B (ft)	B (ft)	D (ft)	Y (ft)	Q (cfs)	V (ft/s)	Q_s (ft³/hr)	Q_r	d_r	Q_r	S_r	I_r
1	714	0.230	0.79	2.41	50.0	157	3.0	2.7	714	5.2	21,102	0.39	1.00	1.05	0.38	1.00
2	710	0.203	0.79	2.41	37.5	172	3.0	3.4	665	5.4	17,756	0.33	1.00	0.99	0.33	1.00
~~3~~	~~690~~	~~0.430~~	~~0.79~~	~~2.41~~	~~59.3~~	~~148~~	~~1.3~~	~~2.0~~	~~690~~	~~5.8~~	~~53,064~~	~~0.99~~	~~1.00~~	~~1.00~~	~~0.69~~	~~0.70~~
~~4~~	~~686~~	~~0.610~~	~~0.79~~	~~2.41~~	~~161.0~~	~~273~~	~~1.3~~	~~1.0~~	~~686~~	~~4.6~~	~~53,520~~	~~1.00~~	~~1.00~~	~~1.00~~	~~1.00~~	~~1.00~~
5	677	0.410	0.79	2.41	106.0	198	2.0	1.4	677	4.7	35,338	0.66	1.00	0.98	0.67	1.00
6	594	0.260	0.79	2.41	55.0	255	3.0	2.2	580	4.9	18,292	0.34	1.00	0.81	0.43	1.00
7	460	0.296	0.79	2.41	55.0	100	2.0	1.8	460	4.6	15,485	0.29	1.00	0.59	0.49	1.00
~~8~~	~~331~~	~~0.450~~	~~0.79~~	~~2.41~~	~~63.8~~	~~131~~	~~1.8~~	~~1.2~~	~~331~~	~~4.4~~	~~16,892~~	~~0.32~~	~~1.00~~	~~0.38~~	~~0.74~~	~~0.81~~
9	148	0.530	0.79	2.41	55.0	181	1.0	0.8	148	3.5	6,384	0.12	1.00	0.14	0.87	1.00
10	124	0.780	0.79	2.41	75.0	79	0.5	0.5	124	3.3	7,421	0.14	1.00	0.11	1.28	1.00
11	111	0.840	0.79	2.41	75.0	112	0.5	0.5	111	3.2	6,963	0.13	1.00	0.09	1.38	1.00
12	66	1.140	0.79	2.41	75.0	80	0.5	0.3	66	2.9	4,804	0.09	1.00	0.05	1.87	1.00
13	34	1.360	0.79	2.41	60.0	65	0.5	0.2	34	2.5	2,437	0.05	1.00	0.02	2.23	1.00
14																
15																
16																
17																
18																
19																
20																
Prototype	686	0.610	0.790	2.41	161.0	273.0	1.8	1.0	686	4.5	53,519					

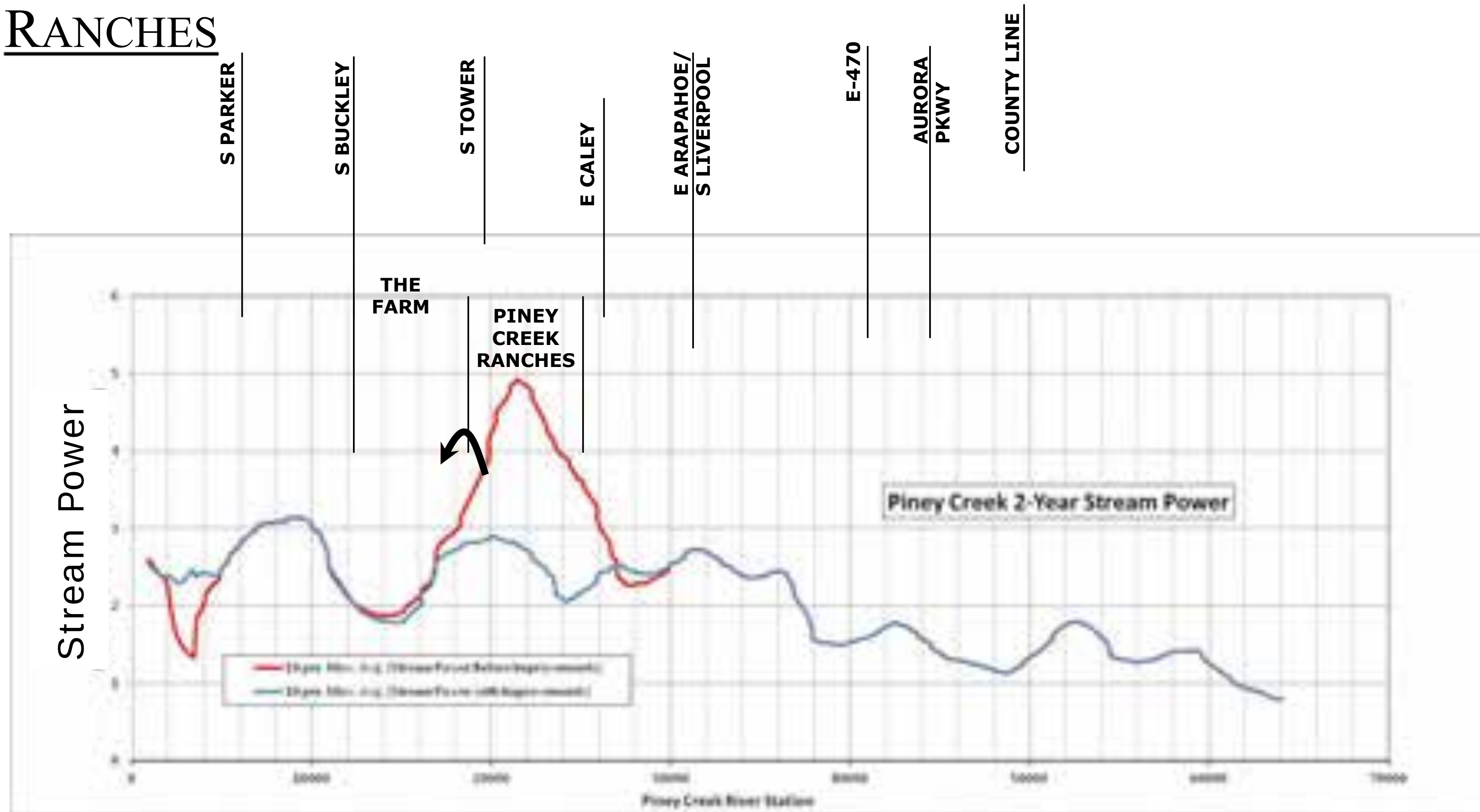
Determine Equilibrium Parameters

Results

Reach	Q_{2yr} (cfs)	So (%)	d_{50} (mm)	G	B_{active} (ft)	B_{total} (ft)	D_{active} (ft)
1	714	0.230	0.79	2.41	50.0	157	3.0
2	710	0.203	0.79	2.41	37.5	172	3.0
~~3~~	~~699~~	~~0.420~~	~~0.79~~	~~2.41~~	~~59.3~~	~~148~~	~~1.7~~
4	~~688~~	~~0.610~~	~~0.79~~	~~2.41~~	~~161.0~~	~~273~~	~~1.7~~
5	677	0.410	0.79	2.41	105.0	198	2.0
6	594	0.260	0.79	2.41	55.0	255	2.0
7	460	0.296	0.79	2.41	55.0	100	2.0
~~8~~	~~331~~	~~0.450~~	~~0.79~~	~~2.41~~	~~63.9~~	~~131~~	~~1.9~~
9	148	0.530	0.79	2.41	55.0	181	1.0
10	124	0.780	0.79	2.41	75.0	79	0.5
11	111	0.840	0.79	2.41	75.0	112	0.5
12	66	1.140	0.79	2.41	75.0	80	0.5
13	34	1.360	0.79	2.41	60.0	65	0.5

APPLICATION OF RESULTS

PROJECTS AT PARKER ROAD, TOWER ROAD, AND PINEY CREEK RANCHES



RESPEC
CONSULTING & SERVICES

DETERMINE EQUILIBRIUM PARAMETERS

CONCLUSIONS

- BASE EQUILIBRIUM ON AN EQUILIBRIUM SECTION WHICH INCLUDES SLOPE, WIDTH, AND DEPTH, NOT JUST SLOPE

- QUALITATIVE ANALYSIS CAN ASSIST IN ASSESSING SOLUTIONS ON A WATERSHED WIDE BASIS

- FOR WATERSHEDS LIKE PINEY CREEK, EQUILIBRIUM CONDITIONS CAN'T BE OBTAINED UNTIL THE EXTREME AREAS OF EROSION ARE ADDRESSED.

Projects to address sediment problems

Piney Creek Sediment Removal Project At tower road

As much as 20,000 cubic yards of sediment removed

Projects to address sediment problems

Piney Creek Improvements Upstream of Tower Road (piney creek ranches) – Currently under design

THANK YOU!

PINEY CREEK MAJOR DRAINAGEWAY PLAN

Varied Topographic Lapsed Snowmelt & GIS Facilitated Runoff Routing in Aspen, Colorado

By
Joseph Machala, EI
Max Shih, PhD, PE, CFM

Acknowledgements
April Long, PE, Stormwater Manager, City of Aspen
Kimberley Pirri, PE, CFM, Project Manager, URS

URS
Denver, Colorado

The City of Aspen

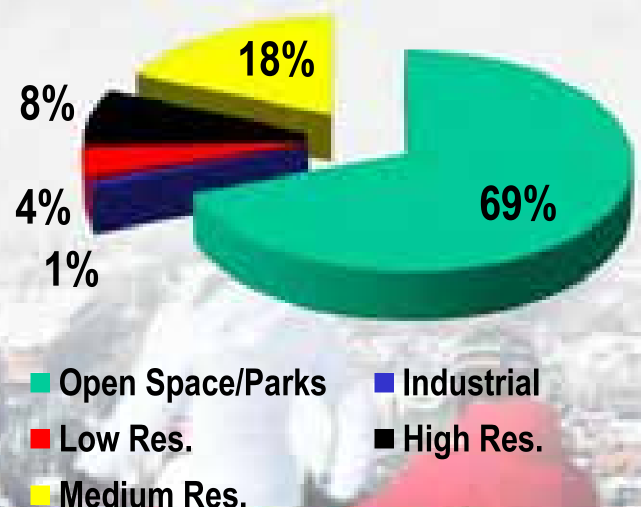
Hunter/Smuggler Surface Drainage Master Plan

- Total study area = 0.5 square mile.
- Six major drainage watersheds, with 82 sub-basins, were analyzed.


Hunter/Smuggler Surface
Drainage Master Plan
Stormwater Runoff Analysis
Mudflow Analysis
Snowmelt Analysis
Alternatives Development
URS

Elevation & Land Covers

- Elevation Ranges from 7,845 ft to 10,545 ft. (Variation = 2,700 ft)
- 70% of study area is a mixture of conifers and aspen forest coverage with shrub/grass understory.

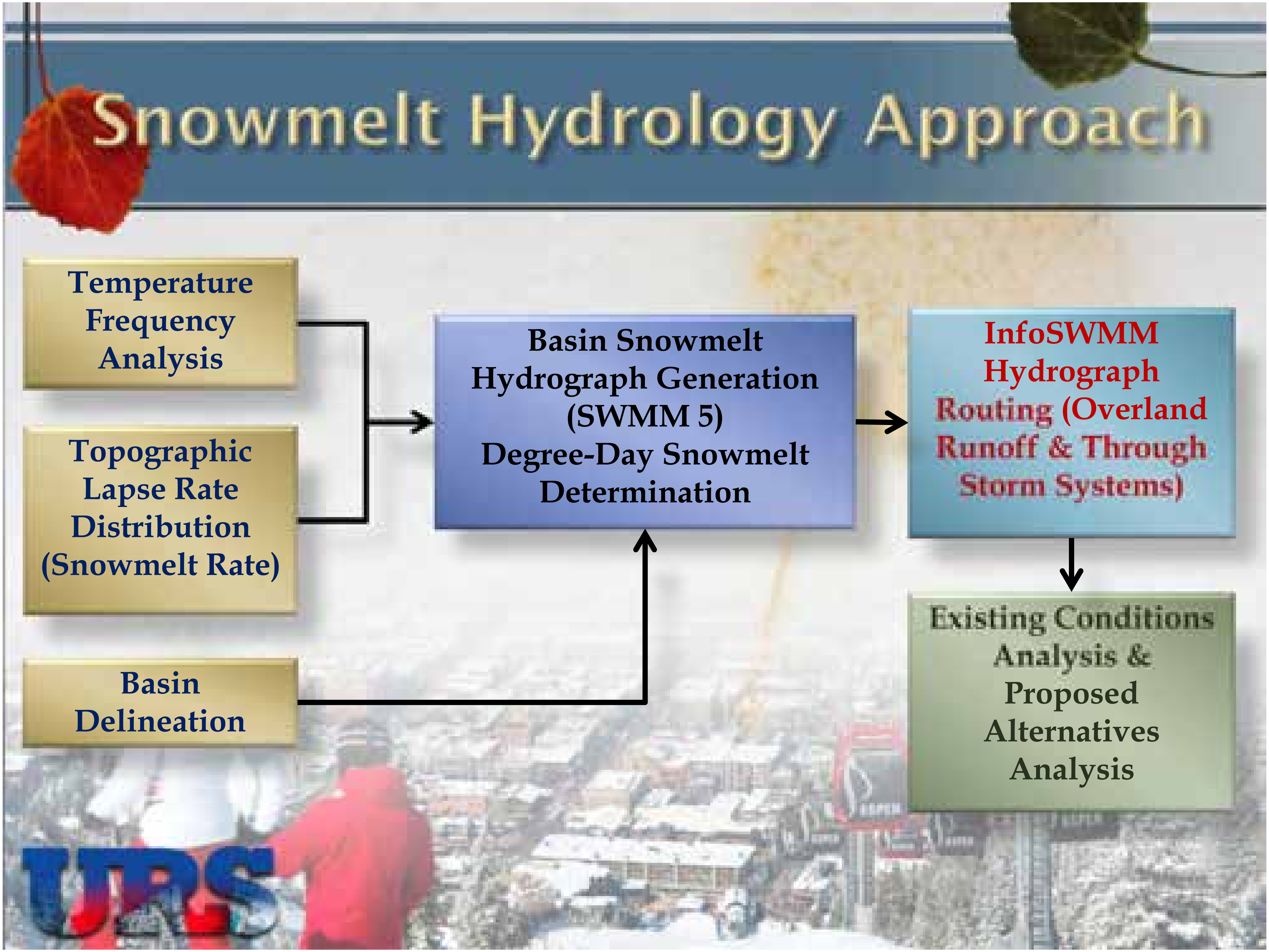


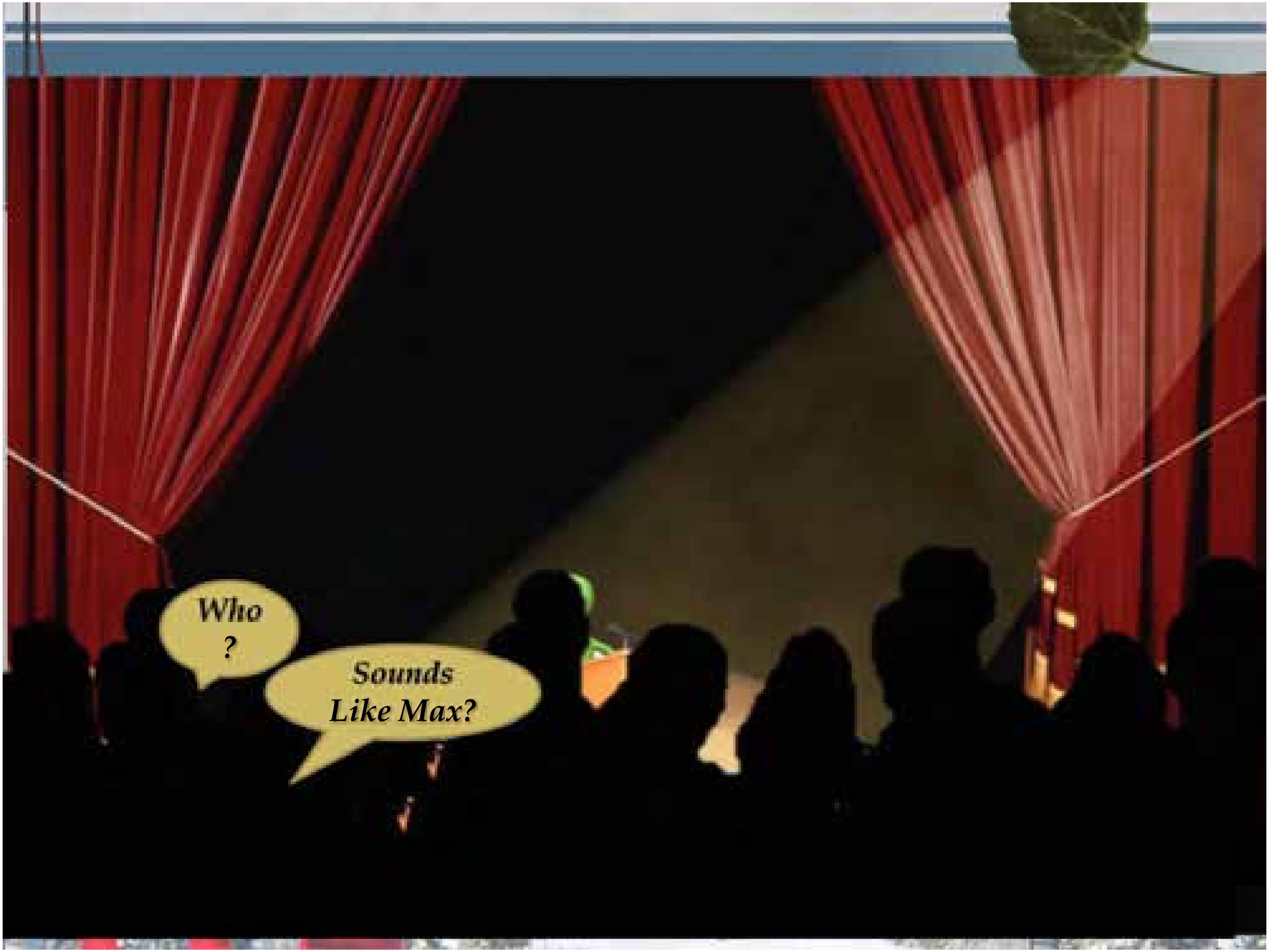
Snowmelt Flooding

King Street Snowmelt Flooding

Parameters of Snowmelt

- Snowmelt during periods of no rain.
- Temperature
  - Elevation
  - Frequency & Duration
- Snowmelt Rate
  - A calibrated snowmelt rate was found to be 0.011 inch/day-°F at the City of Aspen.


Snowmelt Hydrology Approach
Temperature Frequency Analysis
Topographic Lapse Rate Distribution (Snowmelt Rate)
Basin Delineation
Basin Snowmelt Hydrograph Generation (SWMM 5) Degree-Day Snowmelt Determination
InfoSWMM Hydrograph Routing (Overland Runoff & Through Storm Systems)
Existing Conditions Analysis & Proposed Alternatives Analysis
URS


Who
?
Sounds
Like Max?

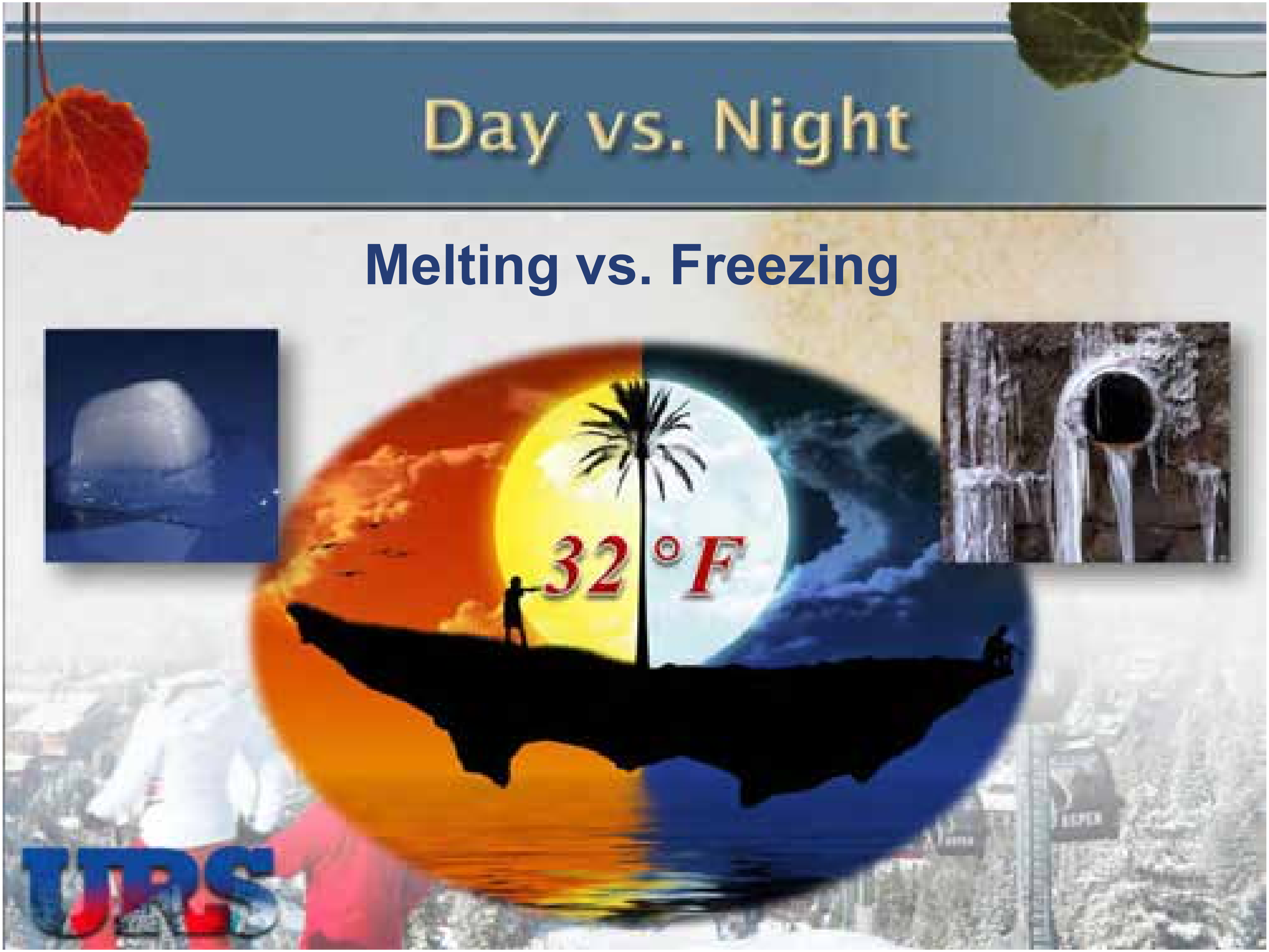
Month for Snowmelt Modeling

- Snow depth is only one inch in May.
- The temperatures in March seldom cause flood events due to snowmelt. (Ave.<32 °F)
- Temperatures were analyzed for April.

Mar	Apr	May
45	52	63
20	26	35
2.7	2.5	2.1
28	20	7.8
27	12	1

	Jan	Feb	Mar	Apr	May	Ju	ov	Dec	Annual
Average Max. Temperature (F)	35	39	45	52	63	7	43	35	55.5
Average Min. Temperature (F)	9.1	12	20	26	35	4	19	9.7	27.7
Average Total Precipitation (in.)	1.7	2.1	2.7	2.5	2.1	1.	.6	1.9	24.37
Average Total Snowfall (in.)	25	27	28	20	7.8		28	25	173.8
Average Snow Depth (in.)	21	28	27	12	1		6	14	

(Source: Station 050372 at Aspen 1 SW, Colorado)


Day vs. Night
Melting vs. Freezing
32 °F

Daily Temperature Distribution

According to the NRCS National Engineering Handbook (NRCS, 2004), a sin curve is suggested to represent the temperature variation within a day.

$$T = T_a + A \cdot \sin[15°(t + C)]$$

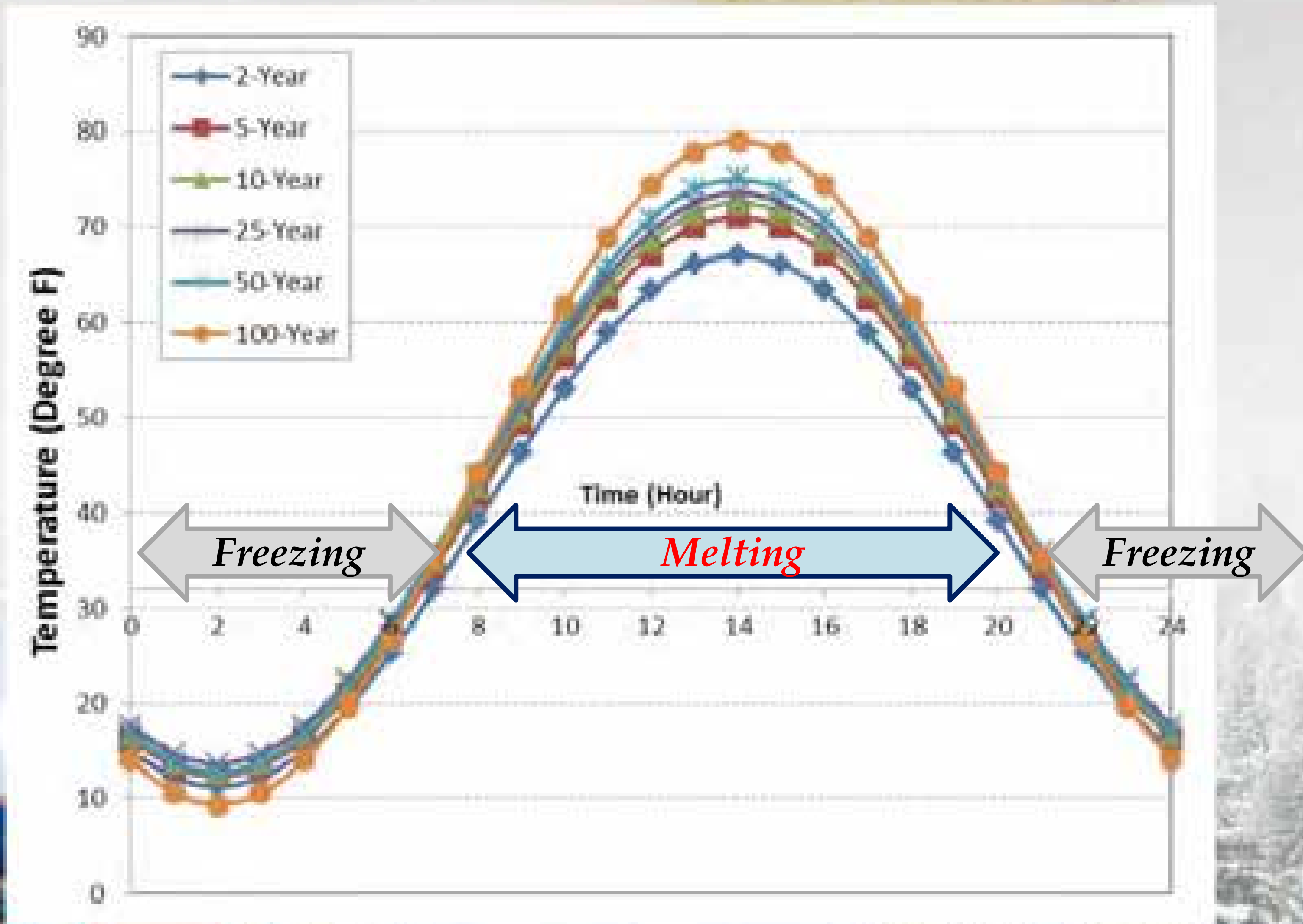
- *t = hour of the day*
- *T = temperature at time t (°F)*
- *T_a = mean temperature for the day (°F)*
- *A = amplitude, $(T_{max}-T_{min})/2$,*
- *C = time shift in hours, assumed to be 16 hours to present the daily peak temperature at 2:00pm.*

Temperature Frequency Analysis

- Western Regional Climate Center Station 050372 at Aspen 1 SW & Station 050370 at Aspen
  - Station 050372 (1914-1980) & Station 050370 (1981-2012)
  - Totaling 80 years
  - Comparison showed Station 050372 was ~ 0.5°F higher than Station 050370 and was adjusted.
- Standard Non-Parametric Frequency Analysis.

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Mean. Daily Temperature (°F)	39.1	41.7	42.6	43.6	43.9	44.2
Max. Daily Temperature (°F)	67.0	71.0	72.5	73.5	75.0	79.0
Min. Daily Temperature (°F)	10.51	4.51	2.51	-2	-3	-10
Temperature Amplitude (°F)	28.2	33.2	35.0	37.8	39.0	44.5

Estimated Daily Temperature Distribution



Snowmelt Computation

Degree-Day Snowmelt Method (EAP SWMM 5)

$$P_s = \frac{K_s}{24} \cdot (T_m - 32°\text{F})$$

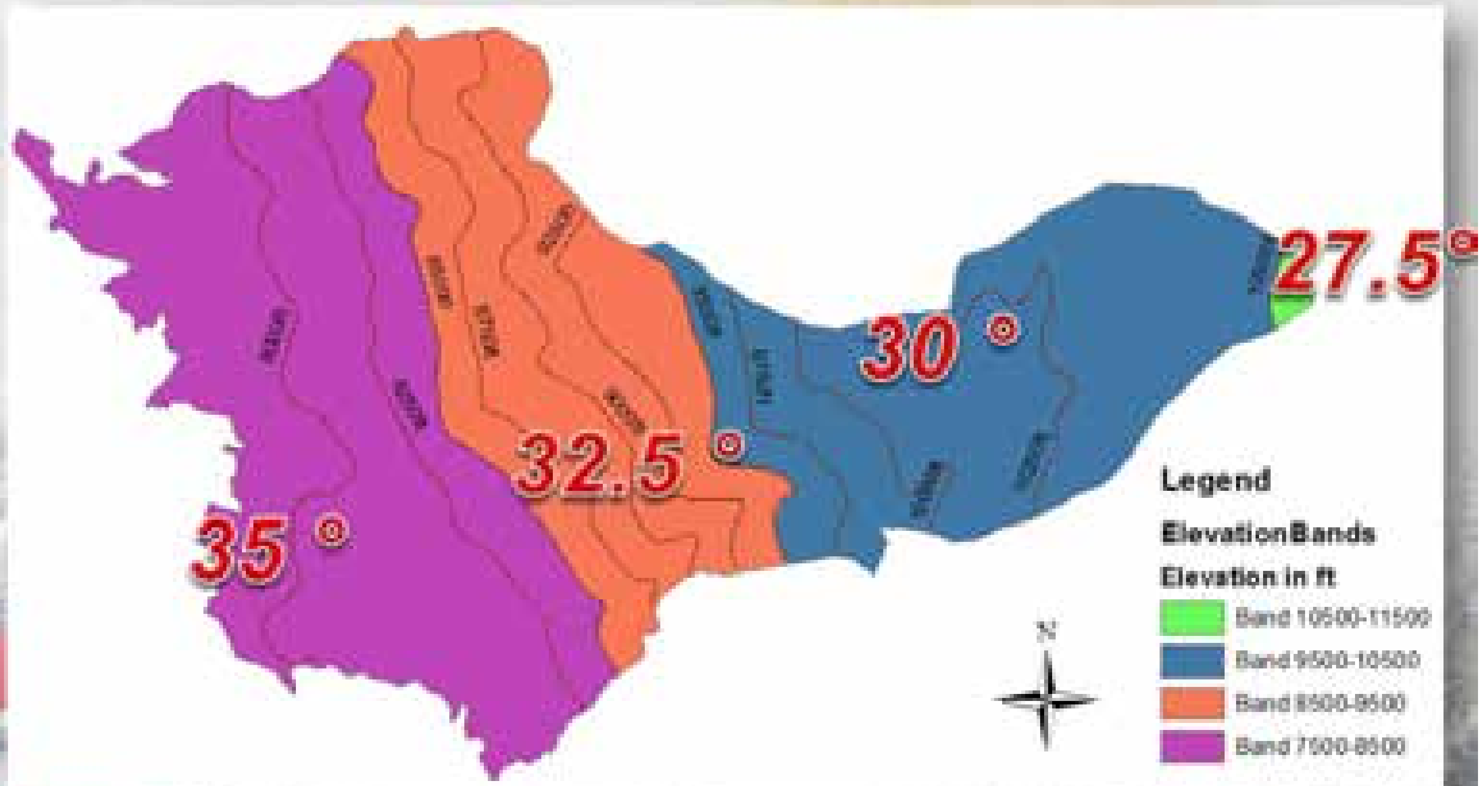
- P_s = snowmelt depth (inch/day),
- K_s = degree-day snowmelt coefficient (inch/day-°F)
- T_m = temperature in °F.
- Antecedent saturated soil and ripe snow conditions

- A calibrated K_s was found to be 0.011 inch/day-°F at the City of Aspen. The station elevation is about 7,930 ft.

URS

Topographic Lapse Rate & Elevation Bands

- Lapse rate of 2.5 °F/1,000 ft in Aspen.
- Air temperature could vary about 6.8 °F.
- The project area was separated into four elevation bands.



Snowmelt Coefficient Elevation Adjustment

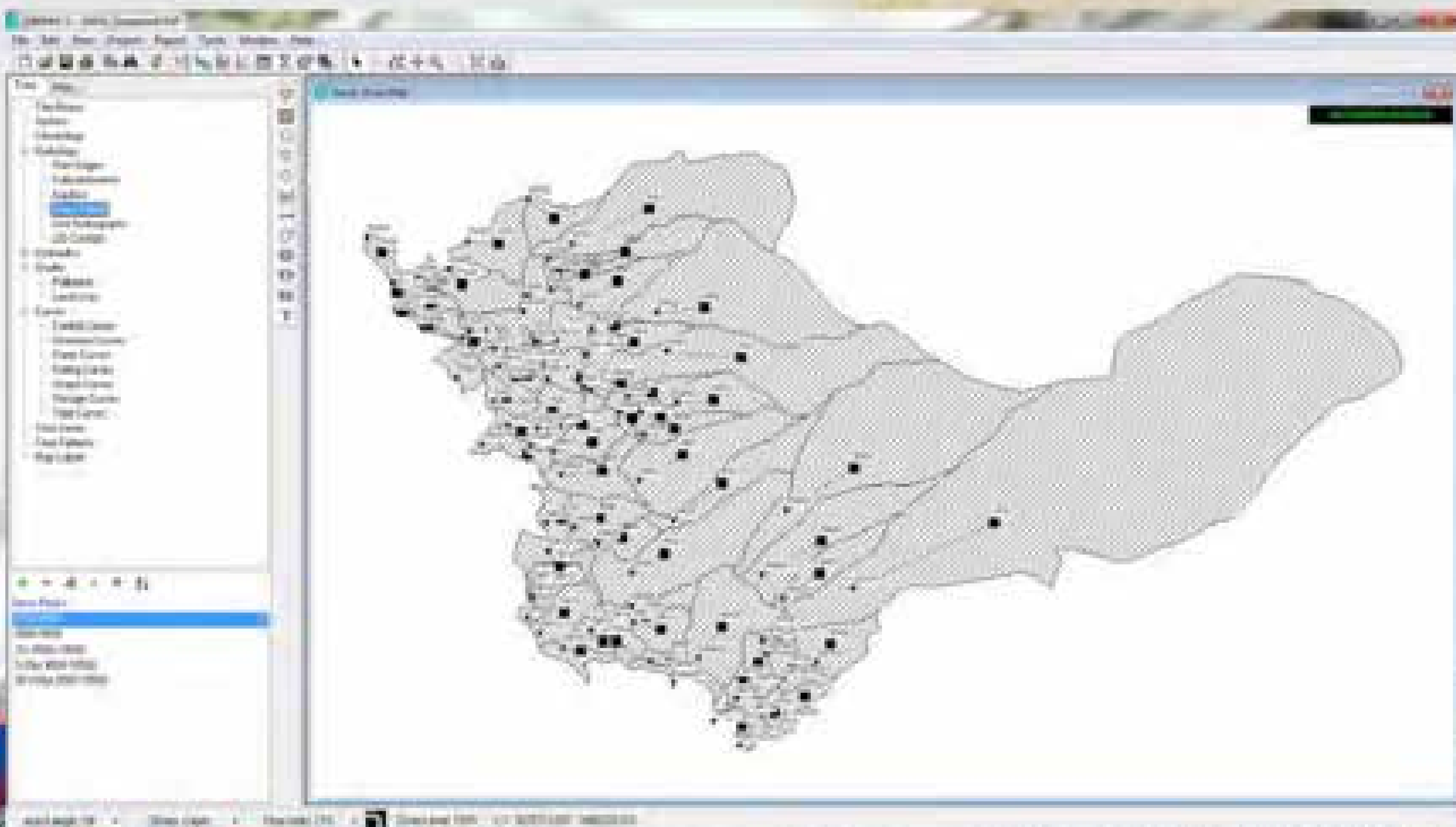
$$P_{s-El} = K_{El-band}\left(T_{Aspen} - 32°\right)$$

- $P_{s\text{-}El}$ = snowmelt depth (inch/hour) in a certain elevation band
- $K_{El\text{-}band}$ = degree-day snowmelt coefficient (inch/hour-°F) belongs to a elevation band
- T_{Aspen} = frequency input temperature time-series in °F

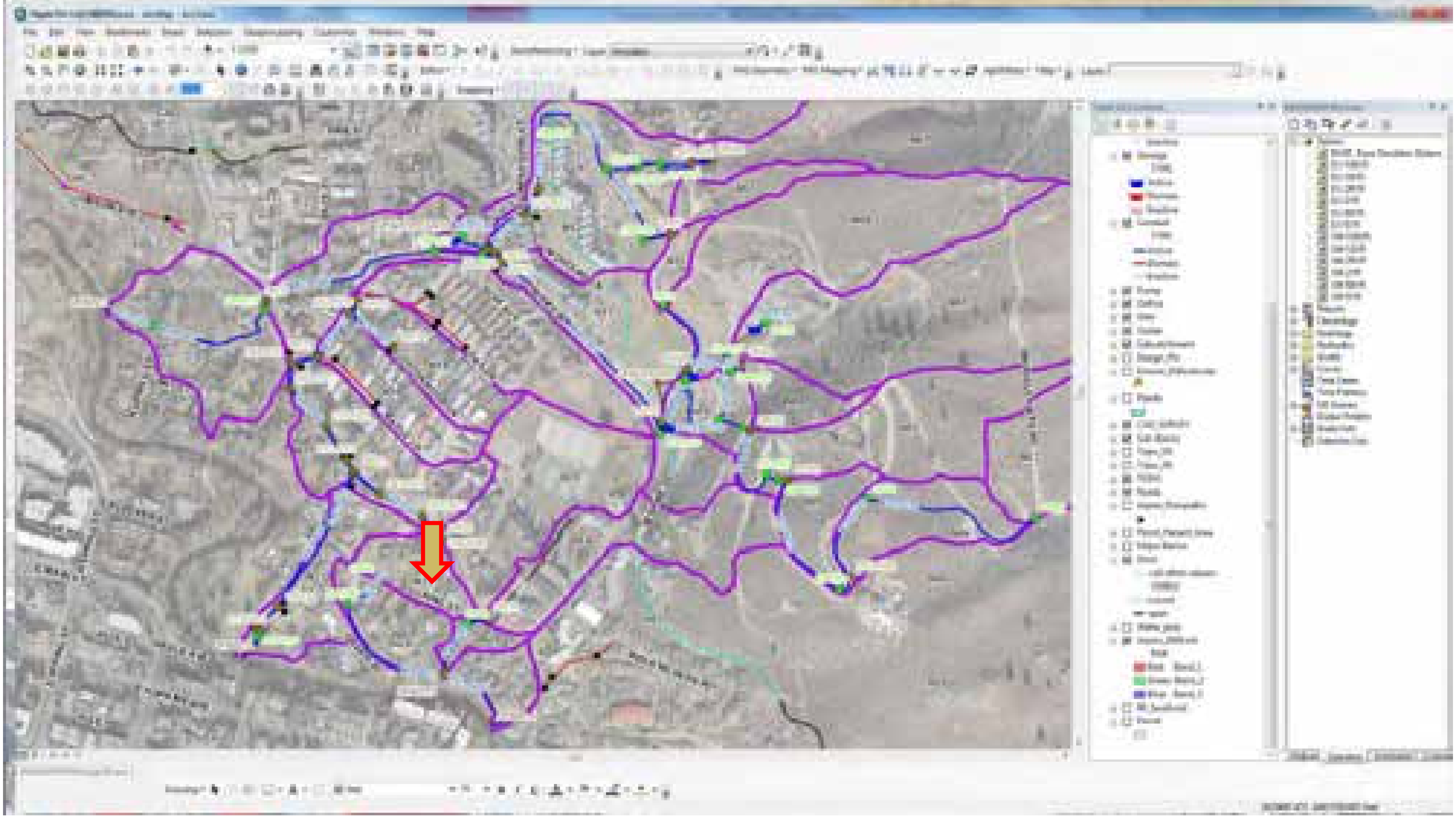
Return Period (Year)	Snowmelt Coefficient (inch/hour-°F)			
	Band (7500-8500)	Band (8500-9500)	Band (9500-10500)	Band (10500-11500)
2	0.00046	0.00043	0.00039	0.00036
5	0.00046	0.00043	0.00040	0.00037
10	0.00046	0.00043	0.00040	0.00037
25	0.00046	0.00043	0.00040	0.00038
50	0.00046	0.00043	0.00041	0.00038
100	0.00046	0.00043	0.00041	0.00039

SWMM 5 Snowmelt Hydrographs

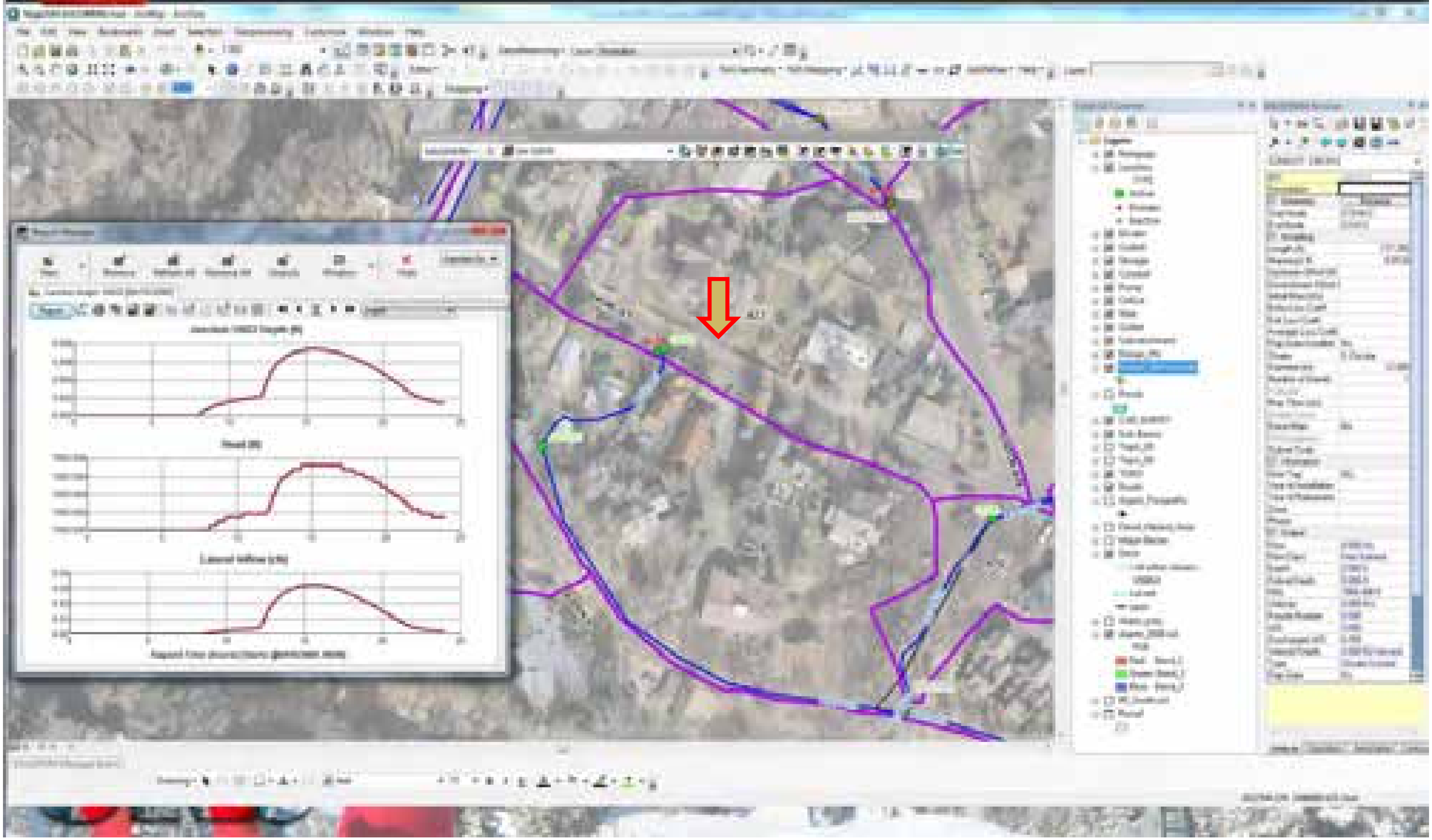
- Generate basin snowmelt outflows using SWMM5.



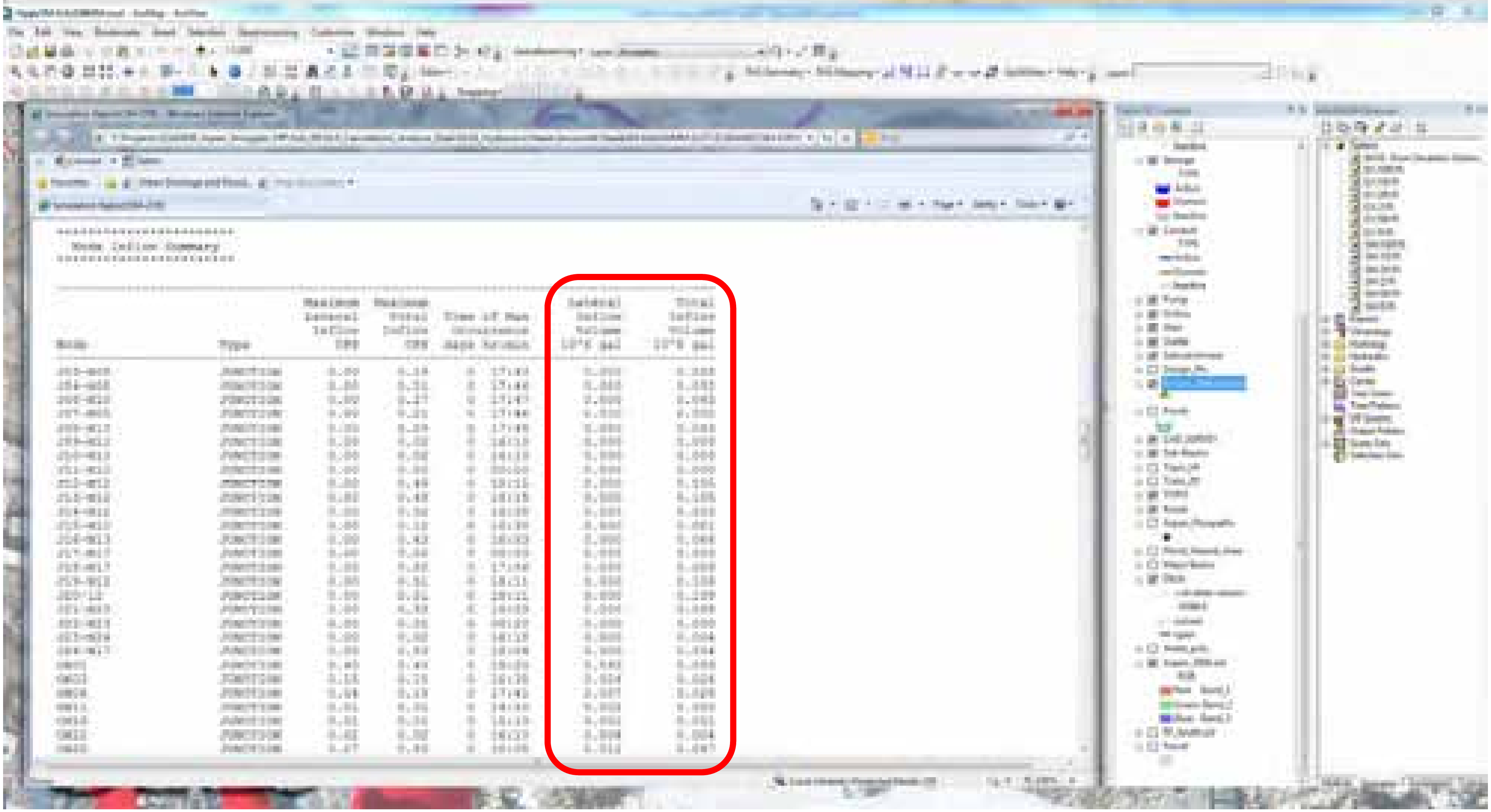
InfoSWMM Hydrograph Routing



InfoSWMM Hydrograph Routing



Estimated Snowmelt Volumes



Estimated Snowmelt Volumes

Design Point Summary Table
Neale Avenue Storm System Snowmelt

Design Point	SWMM Element ID	Conduit ID	Overflow ID	Location	Existing Structure				Conduit Peak Flow (cfs)						Overflow Peak Flow (cfs)						Cumulative Snowmelt Volume (cf)					
					Description	Contributing Area (ac)	Road Classification	Capacity (cfs)	100-year	50-year	25-year	10-year	5-year	2-year	100-year	50-year	25-year	10-year	5-year	2-year	100-year	50-year	25-year	10-year	5-year	2-year
Park Circle Tributary to Oklahoma Flats Outfall																										
N-29	D01-N06	C04-N09	O04-N09	Smuggler Mtn. Rd.	18" CMP	14.9	Local	19	0.3	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	6,684	6,016	5,748	5,347	4,946	3,743
N-28	ON09	C06-N09	O06-N09	Smuggler Mtn. Rd.	12" CMP	16.8	Local	4.2	0.3	0.3	0.3	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	7,754	6,951	6,550	6,149	5,615	4,278
	J07-N05	C10-N05	-	Smuggler Mtn. Rd.	Confluence	16.8	Local	-	0.3	0.3	0.3	0.3	0.2	0.2	-	-	-	-	-	-	7,620	6,818	6,550	6,149	5,615	4,278
N-27	ON05	C09-N10	O09-N10	Smuggler Mtn. Rd.	12" CMP	23.2	Local	7	0.4	0.4	0.4	0.4	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	10,962	9,892	9,358	8,823	8,155	6,016
N-25	P02-N01	OLET03-N10	-	Mine retention pit	Retention	53.8	-	-	0.4	0.2	0.2	0.1	0.1	0.0	-	-	-	-	-	-	25,132	22,592	21,656	20,319	18,849	12,432
N-26	ON08	C15-N08	O15-N08	Smuggler Mtn. Rd.	18" CMP	1.5	Local	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	802	668	668	668	535	401
	J10-N10	C19-N10	-	Smuggler Mtn. Rd.	Confluence	55.3	Local	-	0.4	0.2	0.2	0.1	0.1	0.0	-	-	-	-	-	-	9,625	7,085	6,016	4,679	3,208	401
	J08-N10	C14-N10	-	Smuggler Mtn. Rd.	Confluence	78.5	Local	-	0.6	0.4	0.4	0.4	0.4	0.3	-	-	-	-	-	-	19,651	16,042	14,571	12,566	10,427	5,748
	ON04	C16-N04	O16-N04	Silverlode Dr.	12" CMP	9.1	Local	4	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	5,080	4,545	4,412	4,144	3,877	2,941
N-24	ON11	C25-N04	-	Silverlode Dr.	Road runoff	0.7	Local	-	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	401	267	267	267	267	267
N-23	DW02-N04	OLET-DW02-N04	WEIR01-N04	Silverlode Dr. & Smuggler Mtn. Rd.	Dry Well	9.1	Local	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.1	0.1	5,080	4,545	4,412	4,144	3,877	2,941
N-22	ON10	C12-N10	O12-N10	Park Cir. & Smuggler Mtn Rd. Confluence	12" CMP	90.0	Local	4	0.7	0.6	0.6	0.6	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	25,399	21,255	19,517	17,379	14,839	9,224
	DW01-N10	OLET-DW01-N10	WEIR02-N10	Park Cir. & Smuggler Mtn Rd.	Dry Well	90.0	Local	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.6	0.6	0.5	0.4	25,399	21,255	19,517	17,379	14,839	9,224
N-18	ON13	C29-N13	O29-N13	End of Tributary at Brown Ln.	12" PVC	95.7	Local	2.1	0.8	0.7	0.7	0.6	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	28,340	23,929	22,057	19,651	16,977	10,828
Oklahoma Flats Outfall																										
	ON02	C21-N02	O21-N02	Drainage collector above Silverlode Dr.	36" CMP	59.4	-	165	0.8	0.8	0.7	0.7	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	27,672	24,998	23,795	22,458	20,854	14,037
N-21	D01-N02	C22-N12	O22-N12	Silverlode Dr.	36" CMP	59.4	Local	112	0.8	0.8	0.7	0.7	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	27,672	24,998	23,795	22,458	20,854	14,037
N-20	ON07	C24-N12	O24-N12	Silverlode Dr.	12" CMP	1.5	Local	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	802	668	668	668	535	401
N-19	J20-12	C34-N12	-	Free Silver Ct.	Ditch	60.9	-	-	0.9	0.8	0.7	0.7	0.6	0.5	-	-	-	-	-	-	28,474	25,667	24,464	22,993	21,389	14,571
	J19-N12	C35-N12	-	Free Silver Ct. to Brown Ln.	Road runoff	60.9	Local	-	0.9	0.8	0.7	0.7	0.6	0.5	-	-	-	-	-	-	28,474	25,667	24,464	22,993	21,389	14,438
	D14-N12	C65-N16	O65-N16	Upstream Brown Ln & Nocholas Ln.	12" PVC	60.9	Local	11	0.9	0.8	0.7	0.7	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	28,474	25,667	24,464	22,993	21,389	14,438
	D15-N12	C66-N12	O66-N12	Downstream Brown Ln. & Nicholas Ln.	12" PVC	60.9	Local	10	0.9	0.8	0.7	0.7	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	28,474	25,667	24,464	22,993	21,389	14,438
N-17	ON12	C28-N12	O28-N12	Brown Ln & Park Cir.	12" PVC	156.6	Local	8	0.9	0.8	0.8	0.8	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	31,816	27,004	24,998	22,592	19,651	12,967
N-16	D2-N12	C30-N12	O30-N12	Brown Ln Inlet to Infiltration Tank	24" PVC	163.3	Local	46	1.7	1.5	1.5	1.4	1.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	60,290	52,670	49,462	45,585	41,040	27,405
	J17-N17	C31-N17	-	Brown Ln & Park Cir.	Road runoff	163.3	Local	-	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	0	0	0	0	0	0
	P03-N16	OLET-P03-N16	WEIR03-N16	Centennial Apts. Underground Infiltration Tank	10'x80' Tank	163.9	-	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.2	1.0	0.9	0.8	0.8	0.5	60,557	53,071	49,863	45,852	41,307	27,672
N-15	J18-N17	C36-N17	-	Park Cir.	Road runoff	163.9	Local	-	1.2	1.0	0.9	0.8	0.8	0.5	-	-	-	-	-	-	21,122	14,972	13,234	11,363	9,090	3,476
N-14	ON17	C61-N17	O61-N17	Gibson Ave Inlet	12" CMP	167.5	Local	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.3	0.2	0.1	0.0	0.0	22,993	16,710	14,839	12,967	10,561	4,545
N-01	OFALL-1	-	-	Oklahoma Flats Outfall	Outfall	172.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25,800	19,116	17,245	15,106	12,833	6,283
Neale Avenue Storm System																										
	ON15	C37-N19	O37-N19	Oak Ln. & Cottonwood Ln	24" RCP	5.5	Local	29	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2,807	2,540	2,540	2,406	2,139	1,738
N-12	ON18	C38-N18	O38-N18	Cottonwood Ln.	12" RCP	2.5	Local	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,337	1,203	1,203	1,069	1,069	802
	D03-N19	C39-N19	O39-N19	Cottonwood Ln. Confluence	24" CMP	8.0	Local	13	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	4,144	3,743	3,609	3,476	3,208	2,540
N-10	ON19	C44-N21	O44-N21	Maple Ln. Confluence	24" RCP	10.6	Local	59	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5,481	5,080	4,813	4,545	4,278	3,342
	D08-N21	C45-N21	O45-N21	Gibson Ave. & Maple Ln.	24" RCP	10.6	Local	23	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5,481	5,080	4,813	4,545	4,278	3,342
	D09-N21	C46-N21	O46-N21	Gibson Ave.	24" CMP	10.6	Local	15	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5,481	5,080	4,813	4,545	4,278	3,342
	D10-N21	C47-N21	O47-N21	Gibson Ave	24" CMP	10.6	Local	12	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5,481	5,080	4,813	4,545	4,278	3,342
	D11-N21	C48-N21	O48-N21	East of Gibson Ave & Neale Ave.	36" CMP	10.6	Local	67	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5,481	5,080	4,813	4,545	4,278	3,342
N-09	D04-N20	C41-N21	O41-N21	Gibson Ave. & Matchless Dr.	24" PVC	6.3	Local	35	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3,208	2,941	2,807	2,674	2,540	2,005
	D05-N21	C42-N21	O42-N21	Gibson Ave Tributary	24" RCP	6.3	Local	41	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3,208	2,941	2,807	2,674	2,540	2,005
	D07-N21	C43-N21	O43-N21	Gibson Ave Tributary	24" RCP	6.3	Local	55	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3,208	2,941	2,807	2,674	2,540	2,005
N-08	ON21	C49-N23	O49-N23	Neale Ave & Gibson Ave Confluence	36" CMP	21.8	Local	135	0.4	0.4	0.4	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	11,229	10,293	9,892	9,358	8,689	6,818
	ON23	C50-N23	O50-N23	Neale Ave & Queen St.	36" CMP	24.8	Local	38	0.5	0.4	0.4	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	12,833	11,630	11,229	10,561	9,892	7,754
	D12-N23	C51-N23	O51-N23	Near Neale Ave Bridge; Grate Inlet	36" CMP	24.8	Local	27	0.5	0.4	0.4	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	12,833	11,630	11,229	10,561	9,892	7,754
N-07	D13-N23	C52-N23	O52-N23	Near Neale Ave. Bridge	12" CMP	24.8	Local	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0
N-02	OFALL-2	-	-	Neale Ave. Outfall	Outfall	24.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12,833	11,630	11,229	10,561	9,892	7,754
Smuggler Mine Outfall																										
N-05	ON14	C58-N14	O58-N14	Park Ave. Crossing	18" CMP**	5.0	Local	9	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2,540	2,406	2,273	2,139	2,005	1,471
	D06-N26	C59-N26	O59-N26	Improvised CMP to outfall	18" CMP**	5.6	-	19	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2,941	2,674	2,540	2,406	2,273	1,738
N-03	OFALL-3	-	-	Smuggler Mine Outfall	Outfall	5.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,941	2,674	2,540	2,406	2,273	1,738
Bibbig Exemption Riverside Ditch Outfall																										
N-06	ON22	C55-N24	-	King St. (Flooding)	Low Area; Flooding	1.7	Local	-	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-	-	-	-	936	802	802	668	668	535
N-04	OFALL-4	-	-	Bibbig Exemption Outfall	Outfall	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,540	2,406	2,273	2,139	2,005	1,604

System sufficient if the peak snowmelt flow rate is less than the capacity of the system plus 15%.

Capacity of the existing storm system plus 15% is less than the peak snowmelt flow rate.

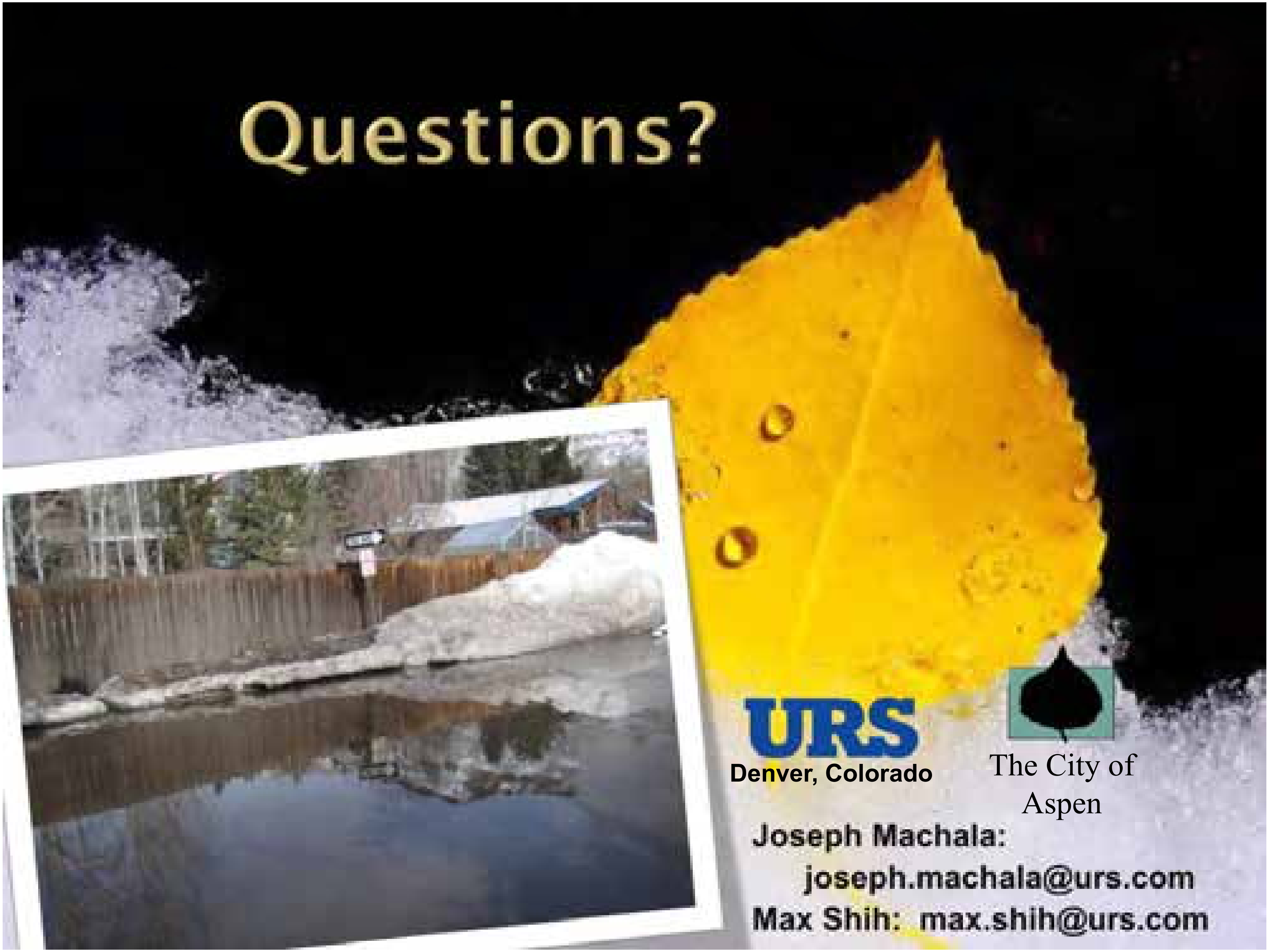
Potential areas of flooding that have no storm system.

Known areas of flooding.

* Approximate values.
**Assumed pipe size.

Conclusions

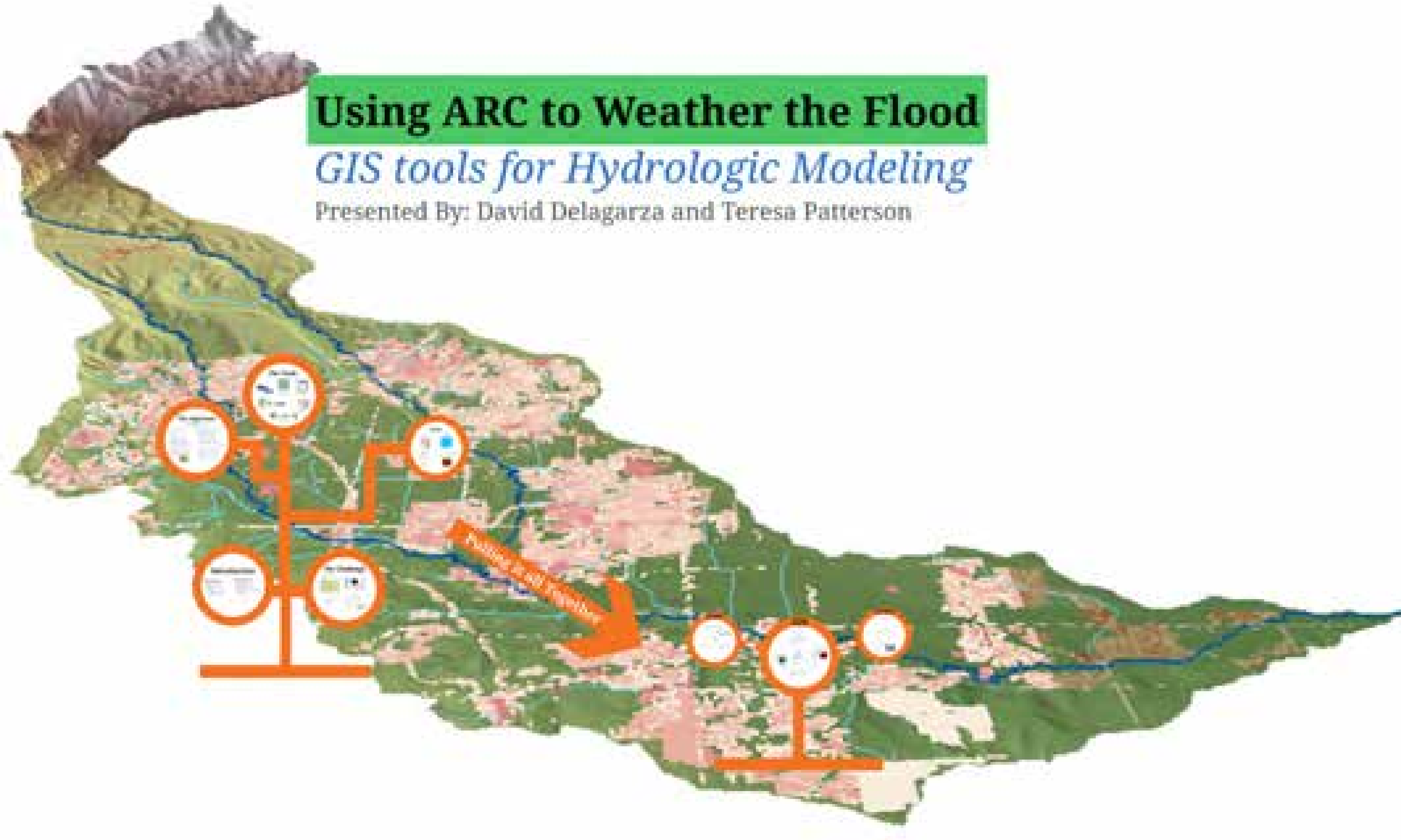
- Snowmelt cumulative volume runoff controls vs snowmelt peak flow
- Snowmelt is not the governing hydrologic process for design in this case. Rainfall peak flow is 2 to 3 magnitudes greater in peak flow for storm system alternative design
- Altering the snow plow maintenance plan could alleviate some snowmelt flooding.
- Lack of storm systems in depressed areas were the main attributing factor to snowmelt flooding.


Questions?
URS
Denver, Colorado
The City of
Aspen
Joseph Machala:
joseph.machala@urs.com
Max Shih: max.shih@urs.com

Using ARC to Weather the Flood

GIS tools for Hydrologic Modeling

Presented By: David Delagarza and Teresa Patterson



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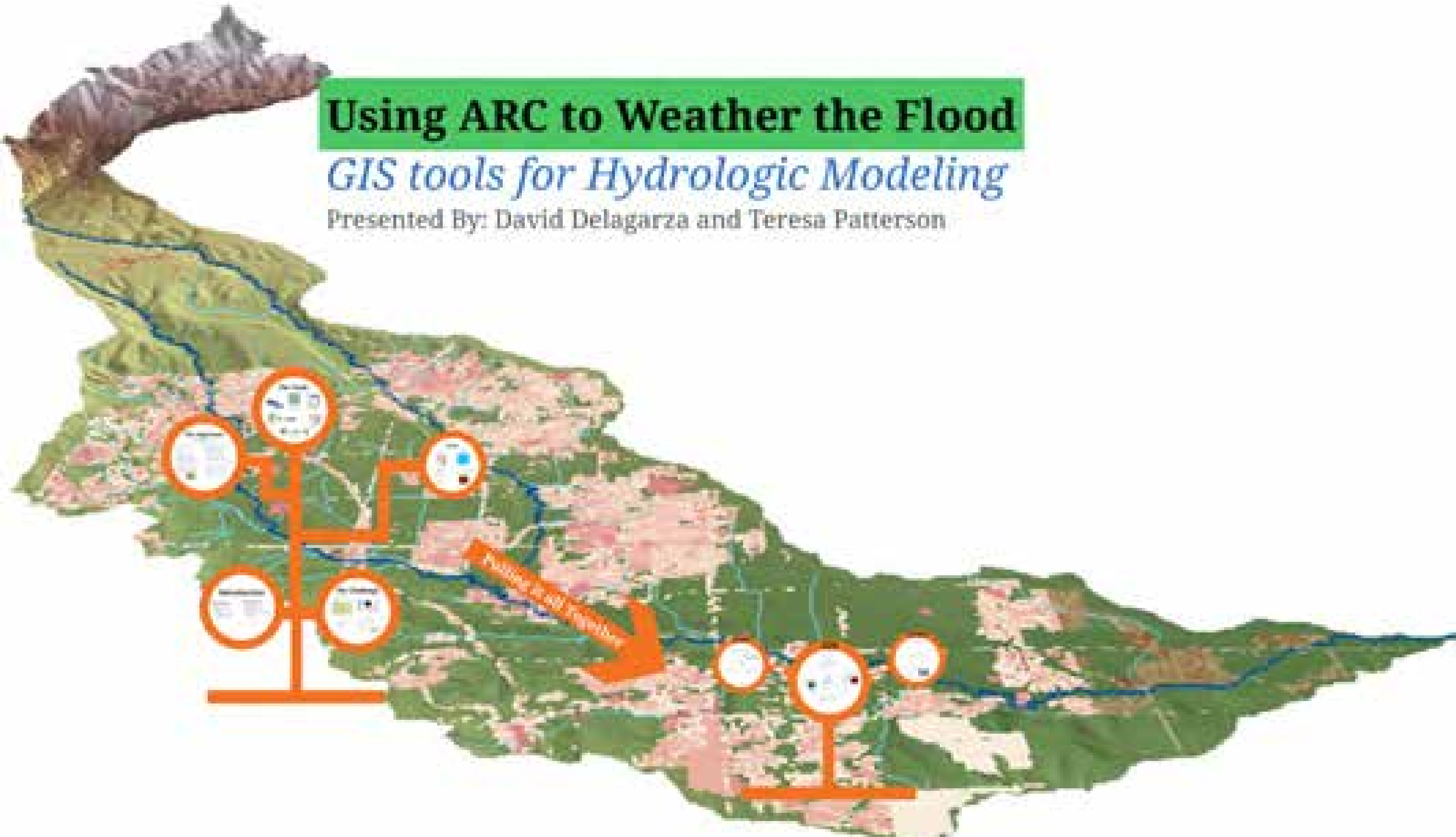

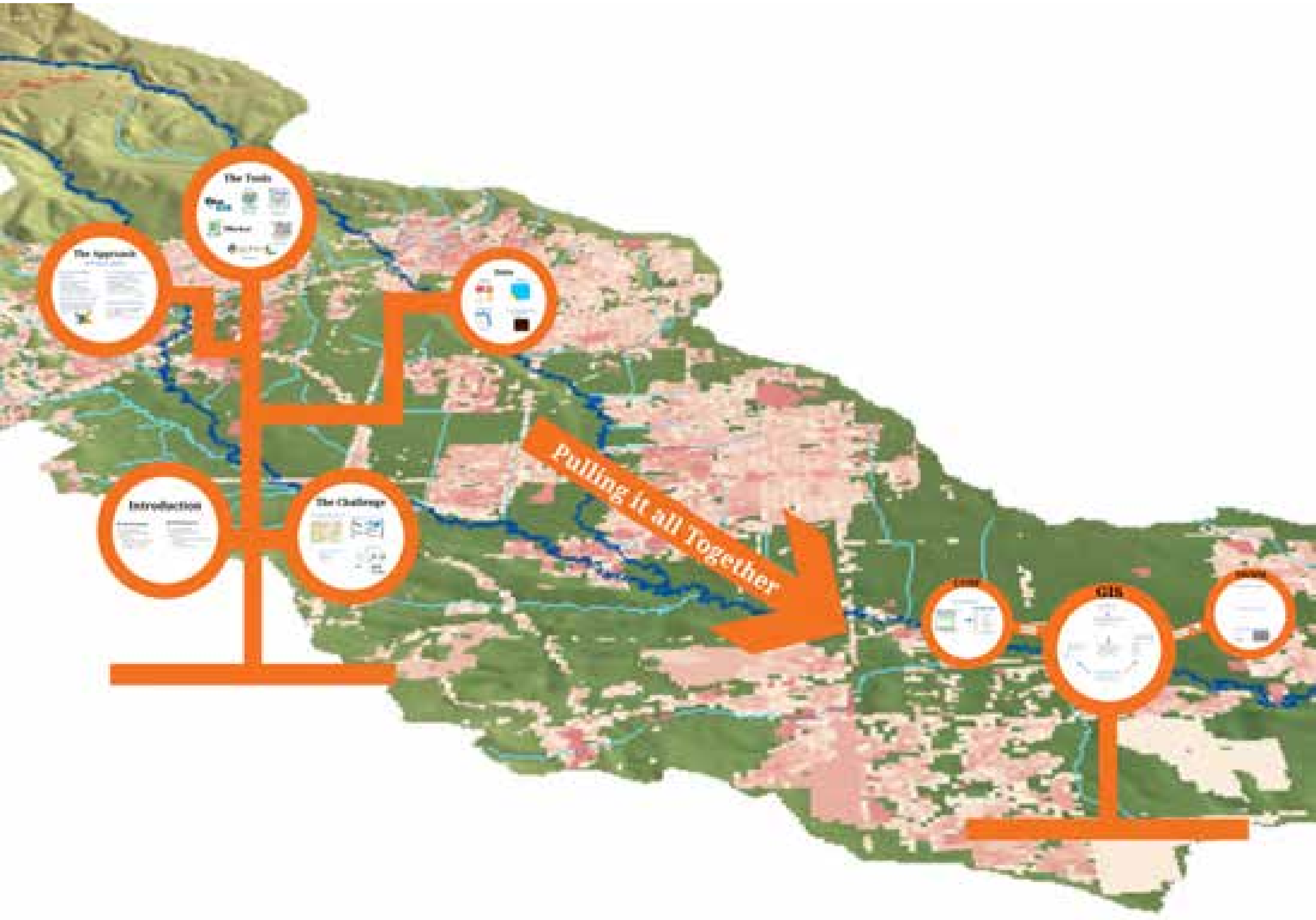
The Tools
The Approach
Introduction
The Challenge
Pulling it all Together
GIS


The Tools
python
The Approach
Data
Introduction
The Challenge
Pulling it all

Introduction

Teresa Patterson

- 14 Years Experience
- 7 UDFCD Planning Studies
- Specializes:
  - Legacy Model Conversion
  - Hydrologic Calibration
  - "Modeling Forensics"

David Delagarza

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The Challenge
Case Study: Coal Creek & Rock Creek
Master Planning Study & FHAD
Many Different Software Packages
Arc GIS
Office Excel
AutoCAD
Many Model Runs Required
Data Duplication

Case Study: Coal Creek & Rock Creek Master Planning Study & FHAD

Many Different Software Packages

Arc
ESRI GIS™

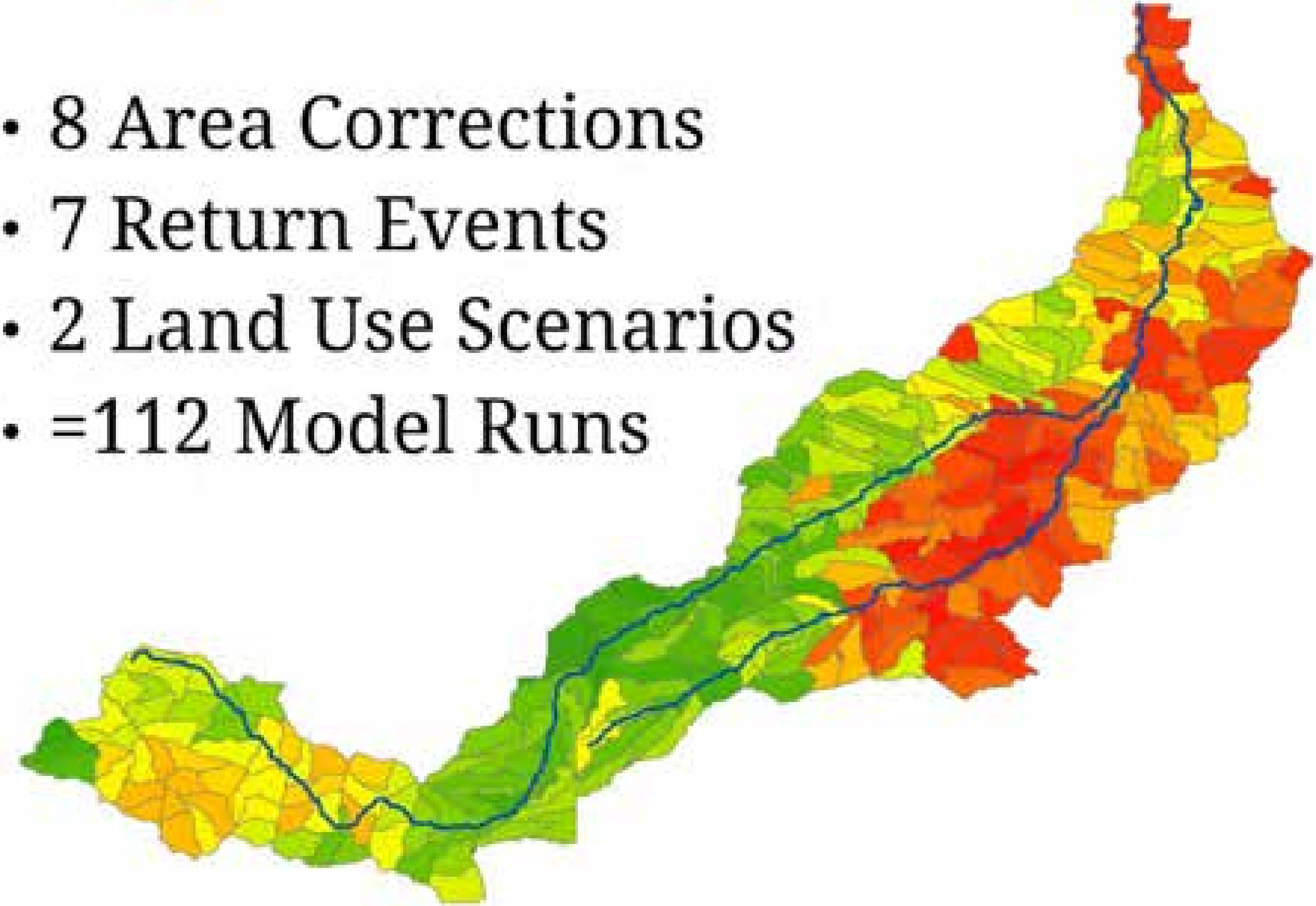
CUHP

Microsoft®
Office Excel

AutoCAD®
Civil 3D®

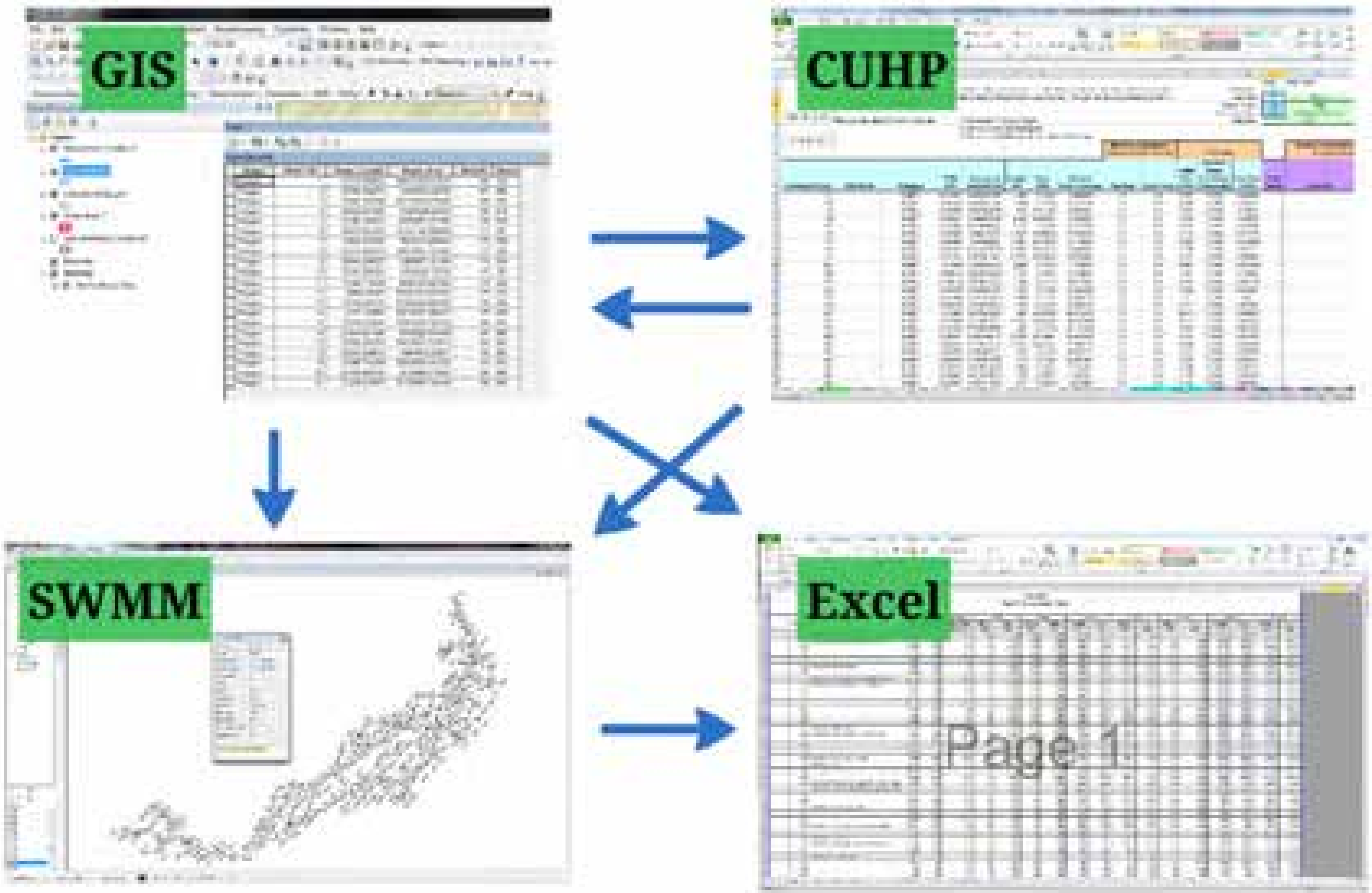
Many Model Runs Required

- 8 Area Corrections
- 7 Return Events
- 2 Land Use Scenarios
- =112 Model Runs



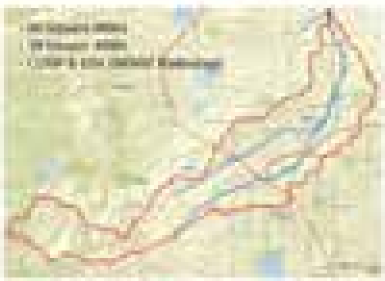
Data Duplication

- Inefficient
- Tedious and Time Consuming
- Error Prone



The Challenge

Case Study: Coal Creek & Rock Creek Master Planning Study & FHAD



Many Different Software Packages

Many Model Runs Required

Data Duplication

The Approach

4 Primary Goals

Use GIS as Primary Database

- GIS is a Database Program
- GIS creates Maps
- Maintain Data in One Place
- Importing to other programs is easy
- Manage late changes easily

Step Away From the GUI

- Manually importing data = errors
- Different programs - different data, tied together with simple scripting

Use GeoProcessing Tools To Simplify Workflows

- ArcHydro tools are adaptable for CUHP & SWMM
- Publicly available Datasets
- Perform actual engineering - not tedious, repetitive tasks

Automate Multiple Runs

- Major time saver - runs in minutes
- Run SWMM from command line!
- Easy Scripting
- Automation in Newest Version of CUHP

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Caveat: Most tasks can now be automated, but NOT ALL...
Engineering Judgement is **important**!

Automate Multiple Runs

ring - not

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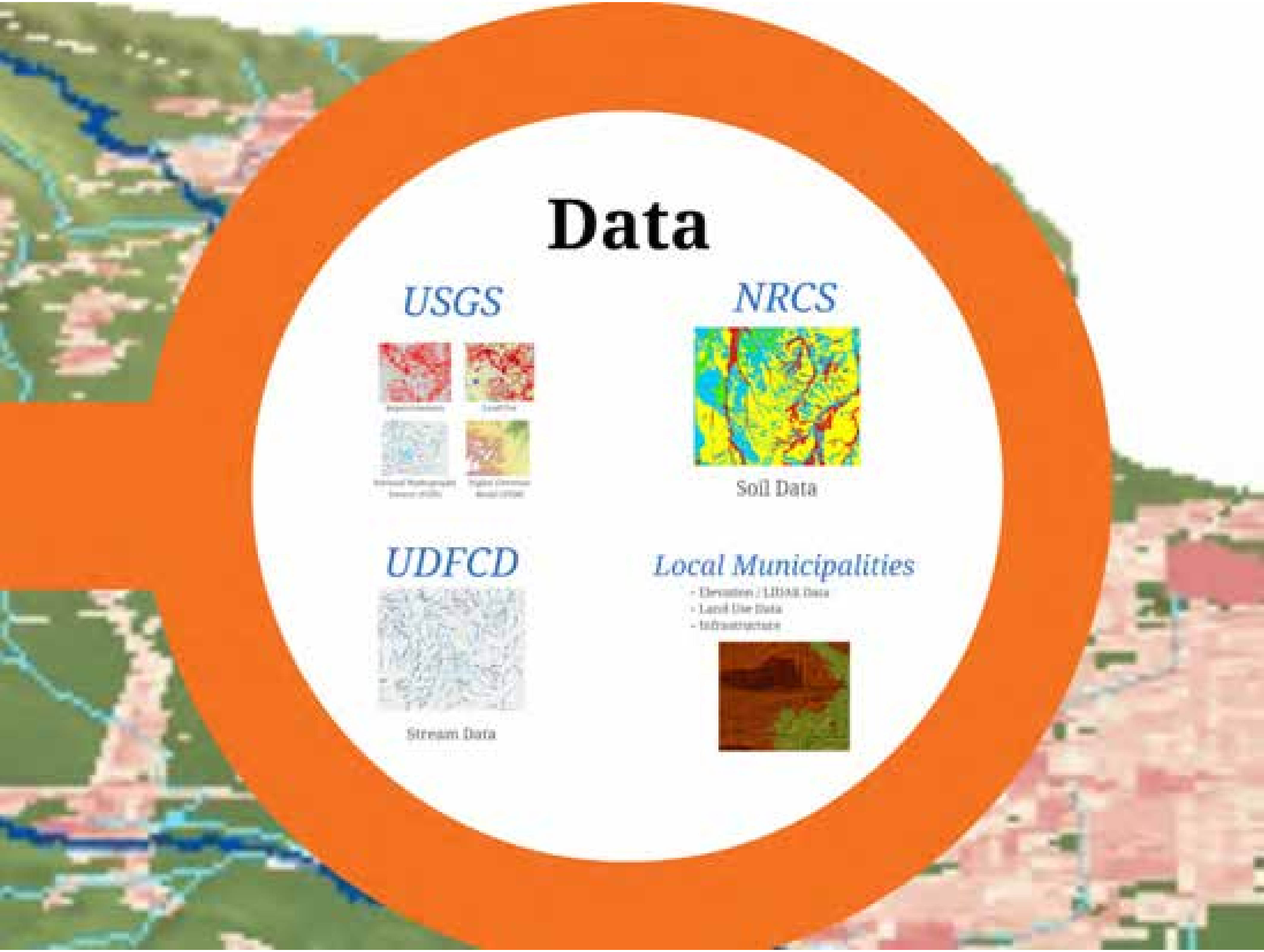
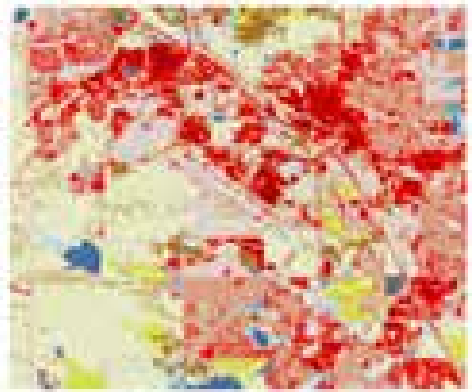
The Tools
Arc
ESRI GIS
CUHP
(Free)
EPA SWMM
(Free)
Microsoft
Office Excel
ArcHydro
(Free)
python
(Free)


Data
USGS
NRCS
Soil Data
UDFCD
Stream Data
Local Municipalities
- Elevation / LIDAR Data
- Land Use Data
- Infrastructure

USGS

Imperviousness

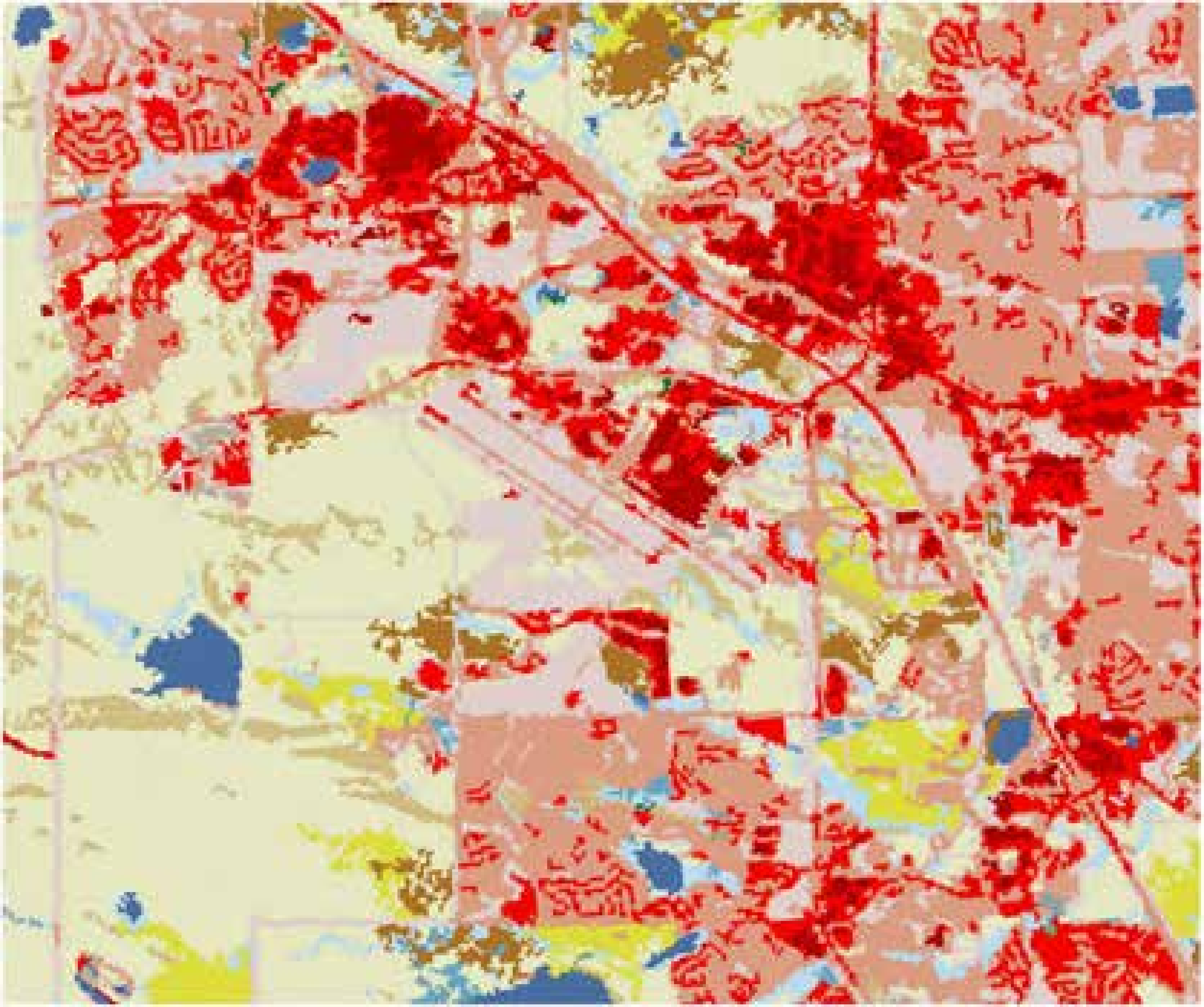


Land Use

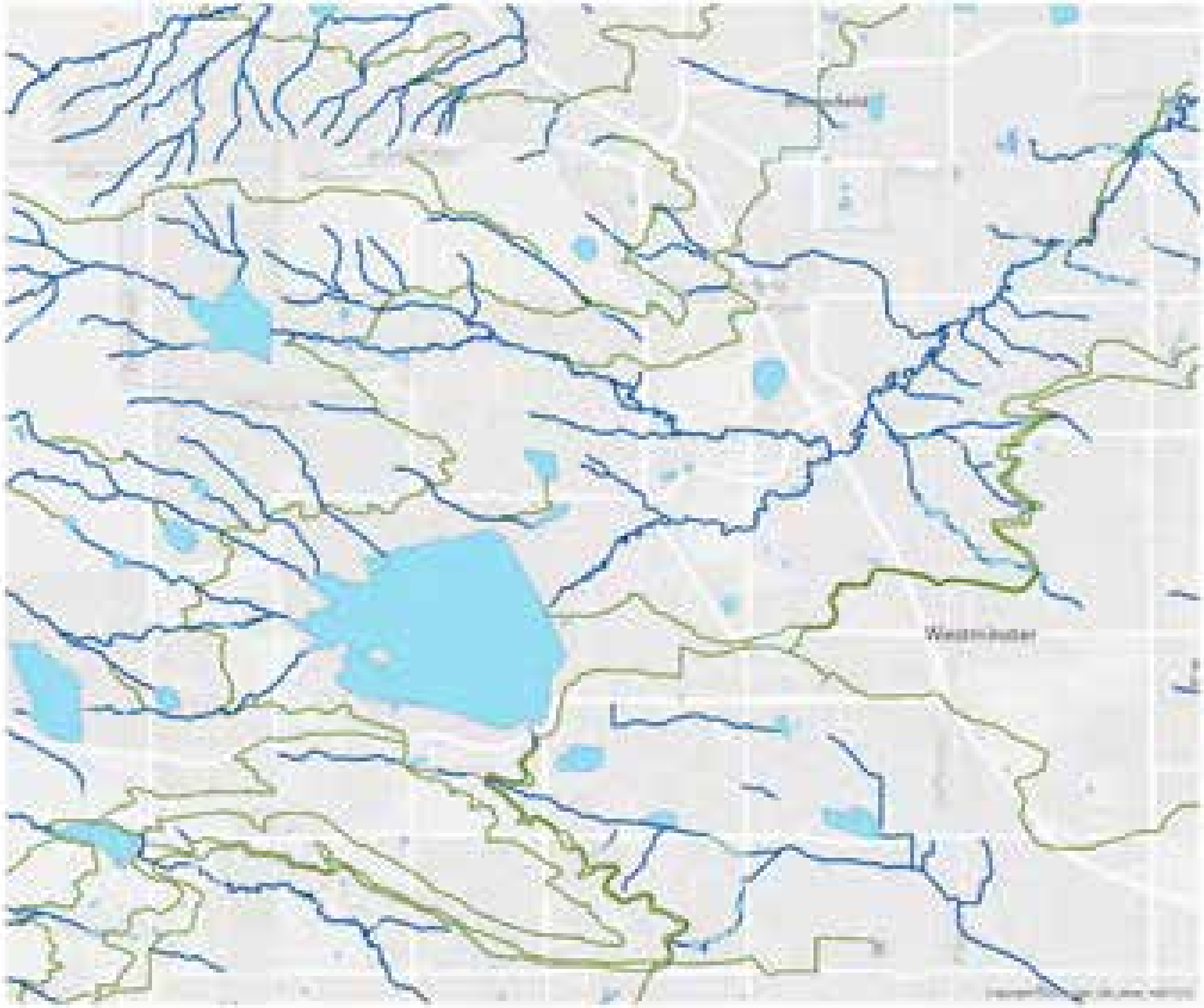
National Hydrography Dataset (NHD)

Digital Elevation Model (DEM)

Imperviousness

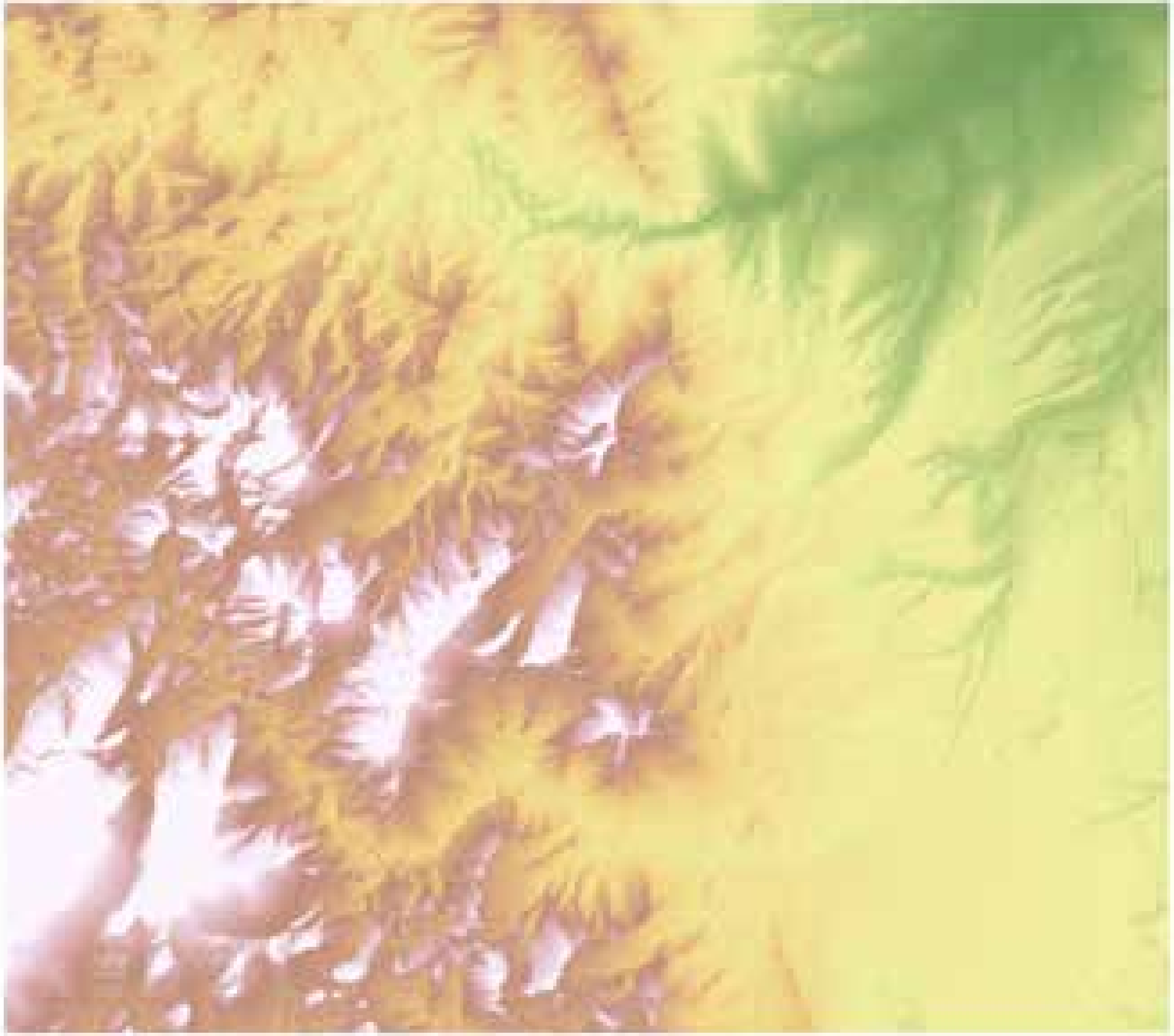


Land Use



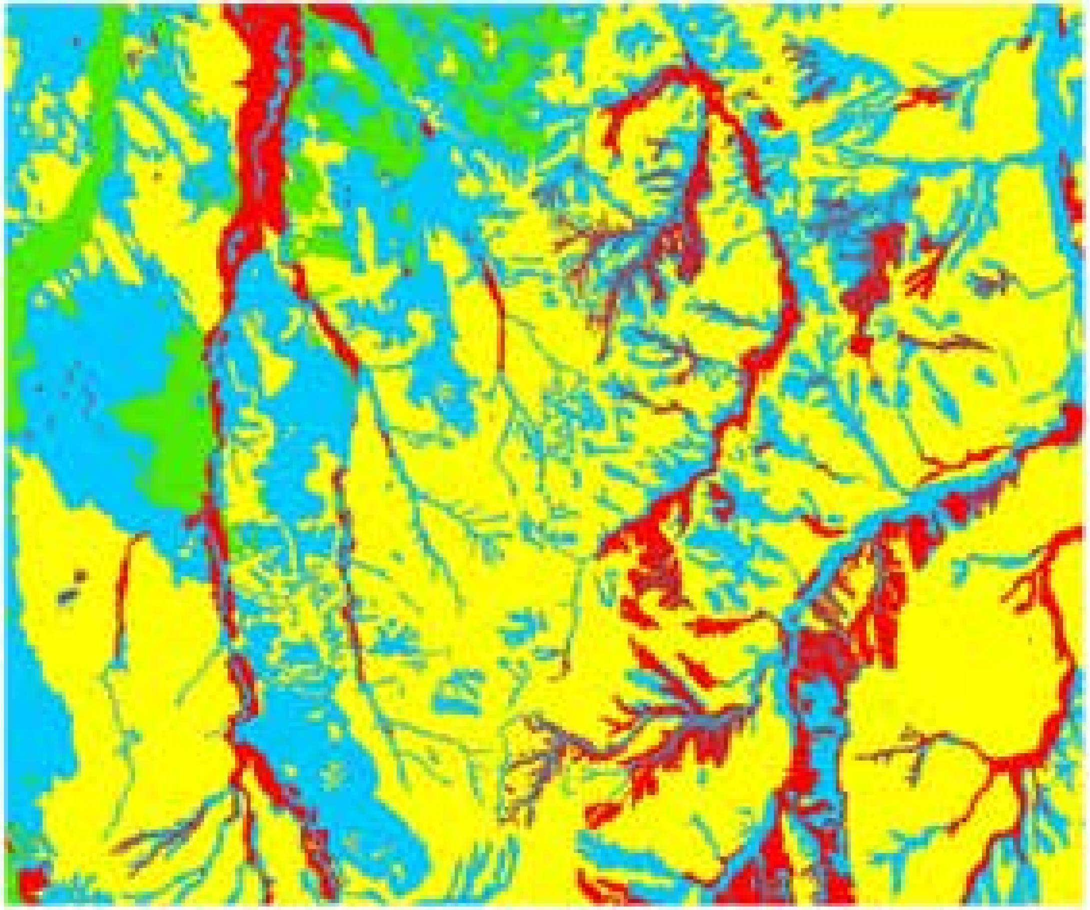
National Hydrography Dataset (NHD)

phy



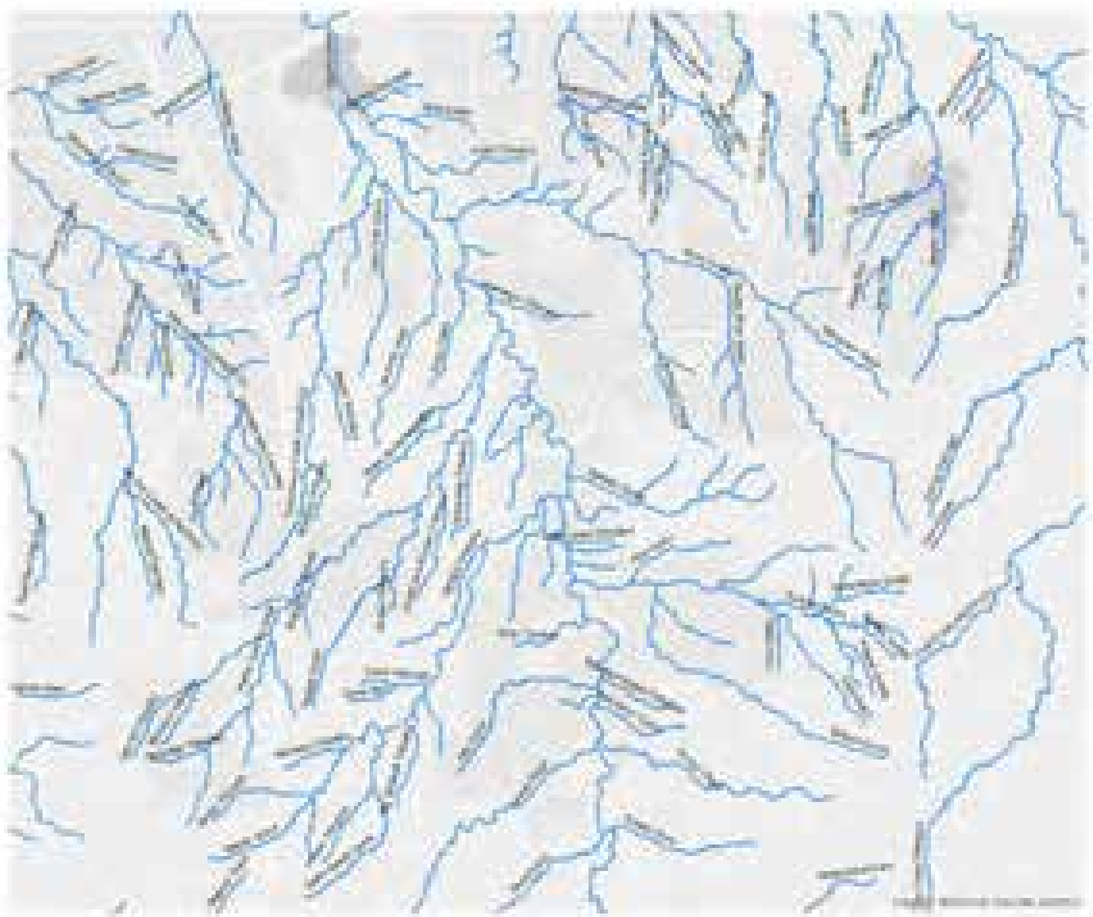
Digital Elevation Model (DEM)

NRCS



Soil Data

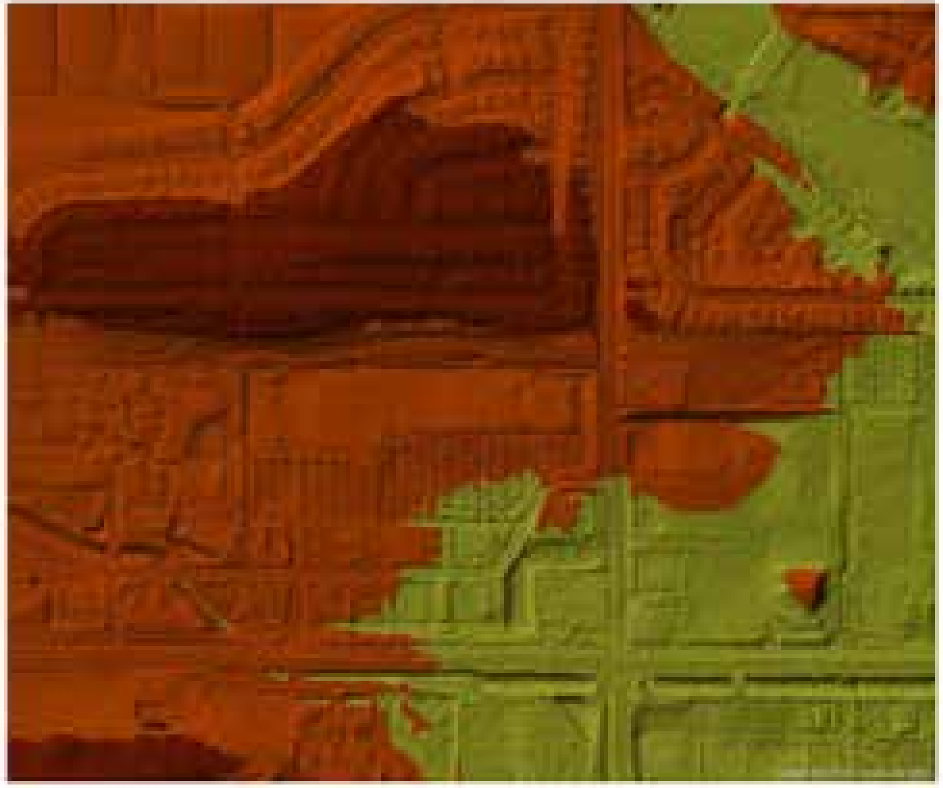
UDFCD

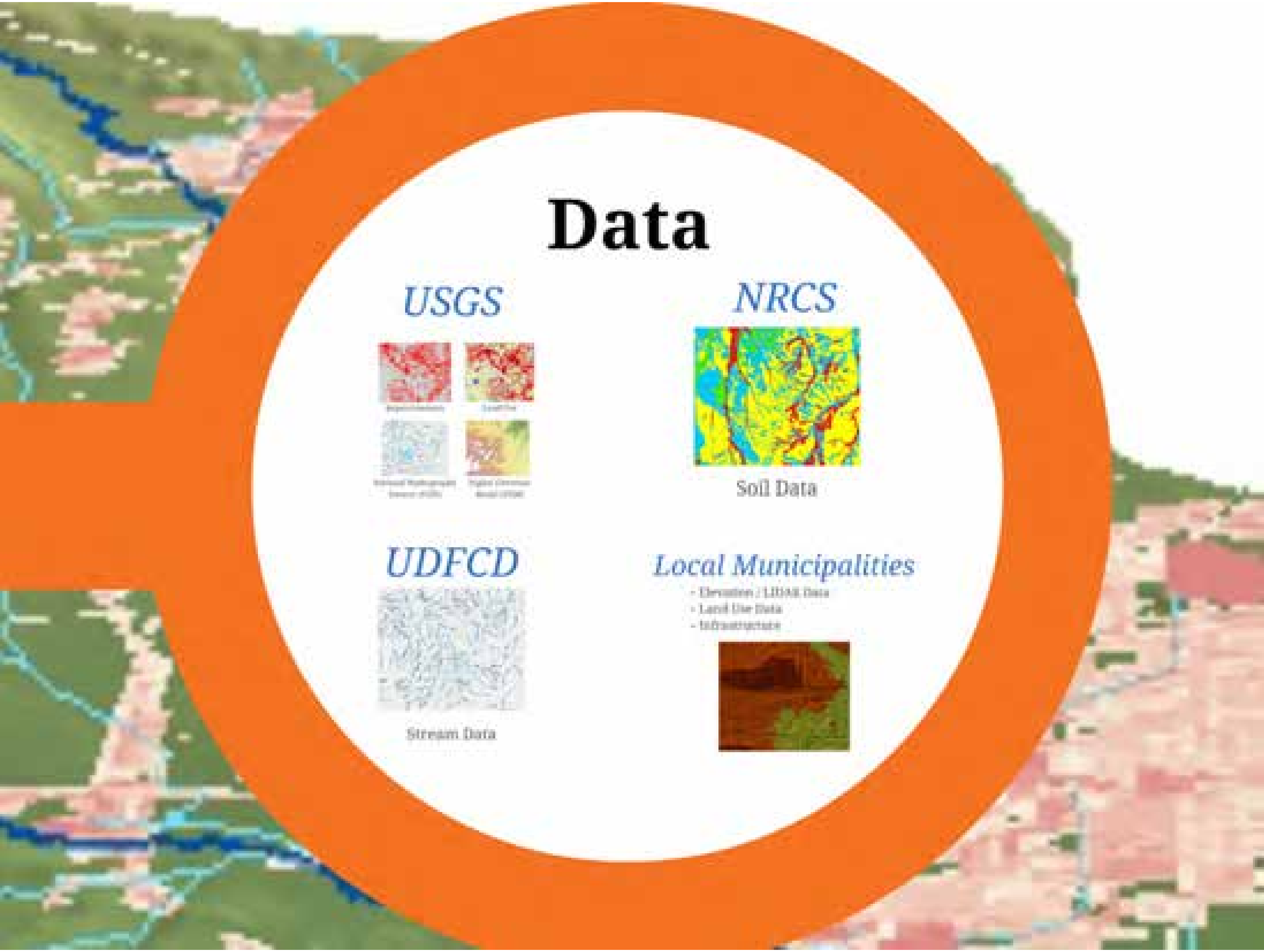


Stream Data

Local Municipalities

- Elevation / LIDAR Data
- Land Use Data
- Infrastructure




Data
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Stream Data
Local Municipalities
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The Tools
Arc GIS
Office Excel
python
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Data
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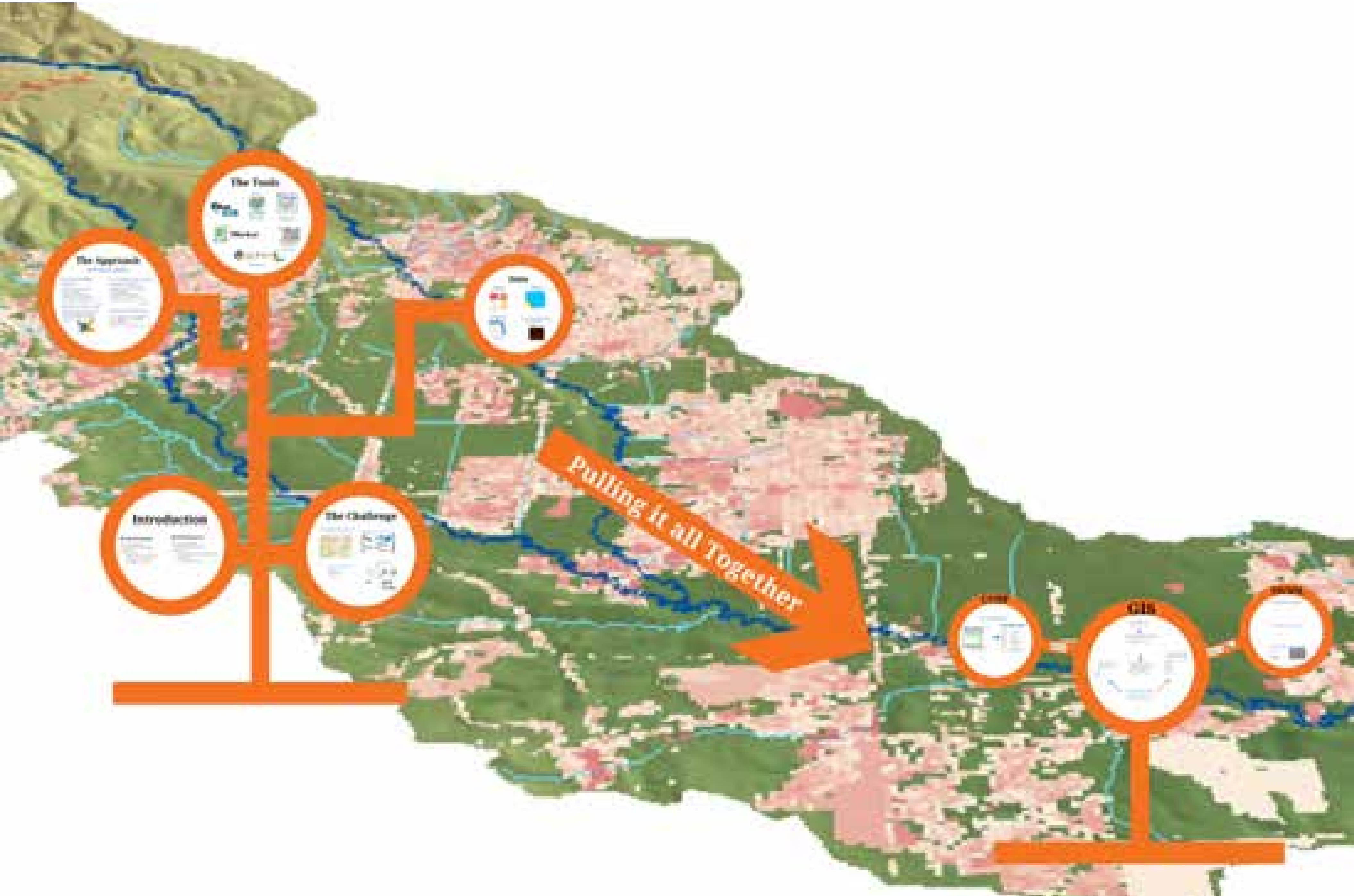
The Challenge
Pulling it all


The Tools
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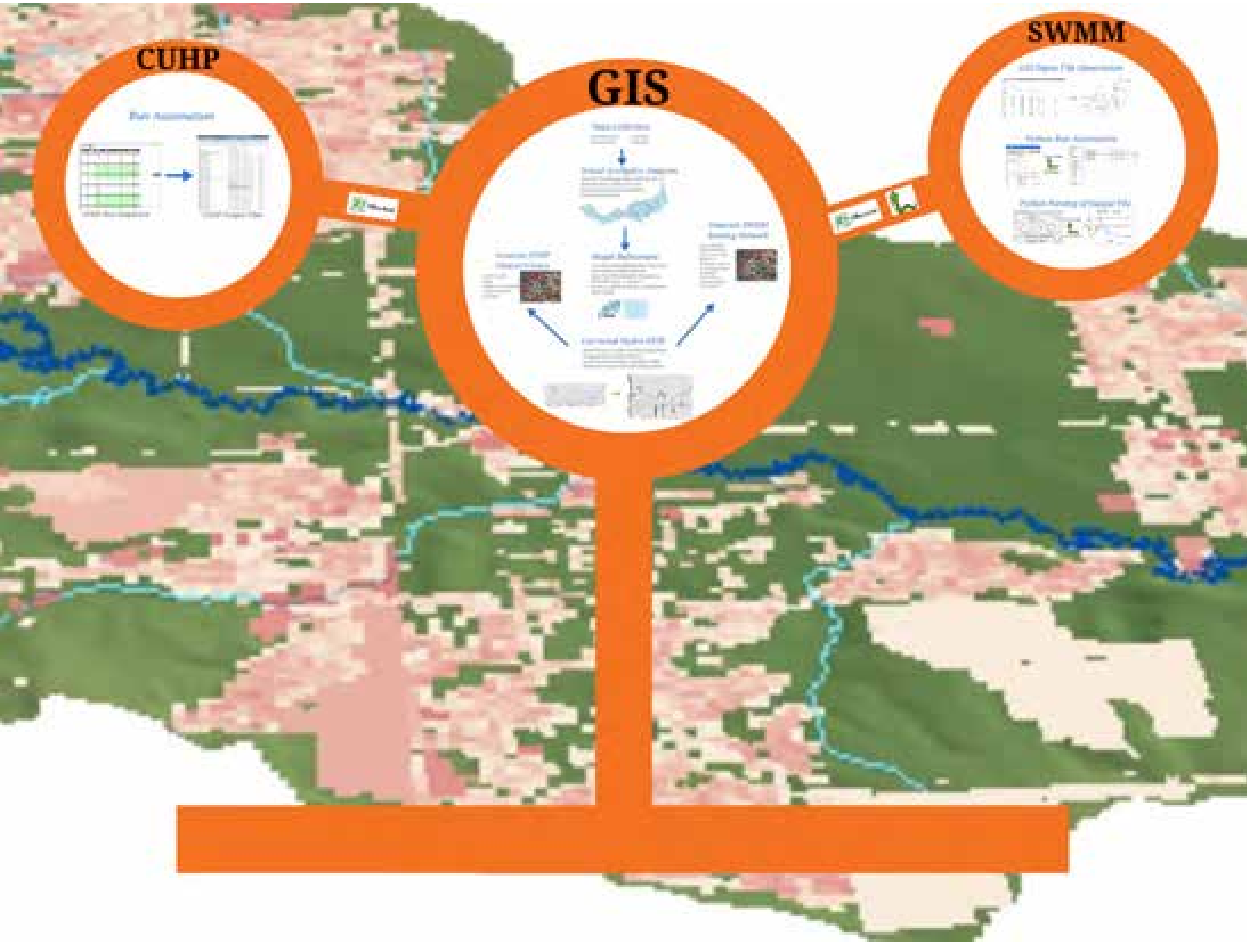
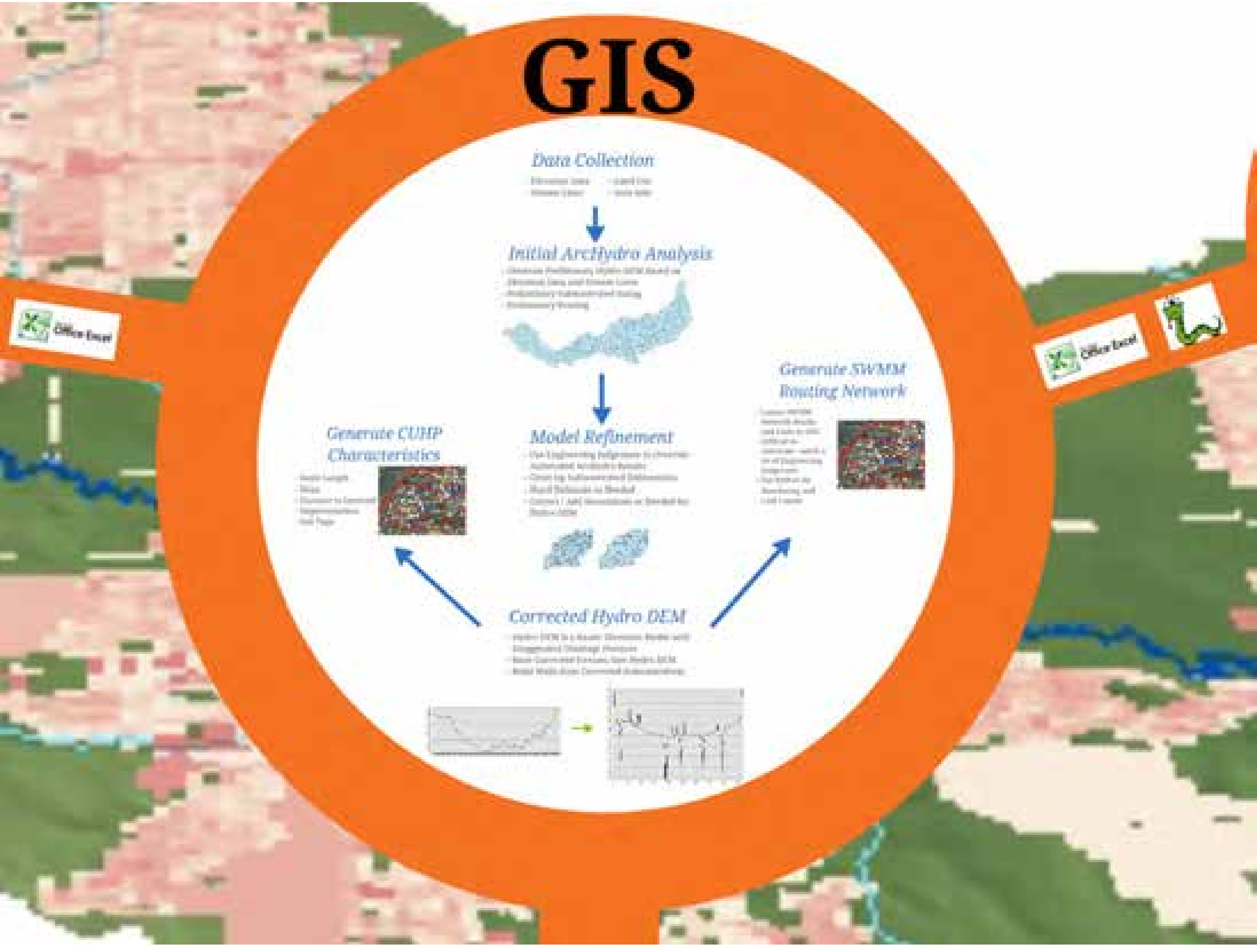
Pulling it all Together
GIS


Pulling it all Together


CUHP
GIS
SWMM

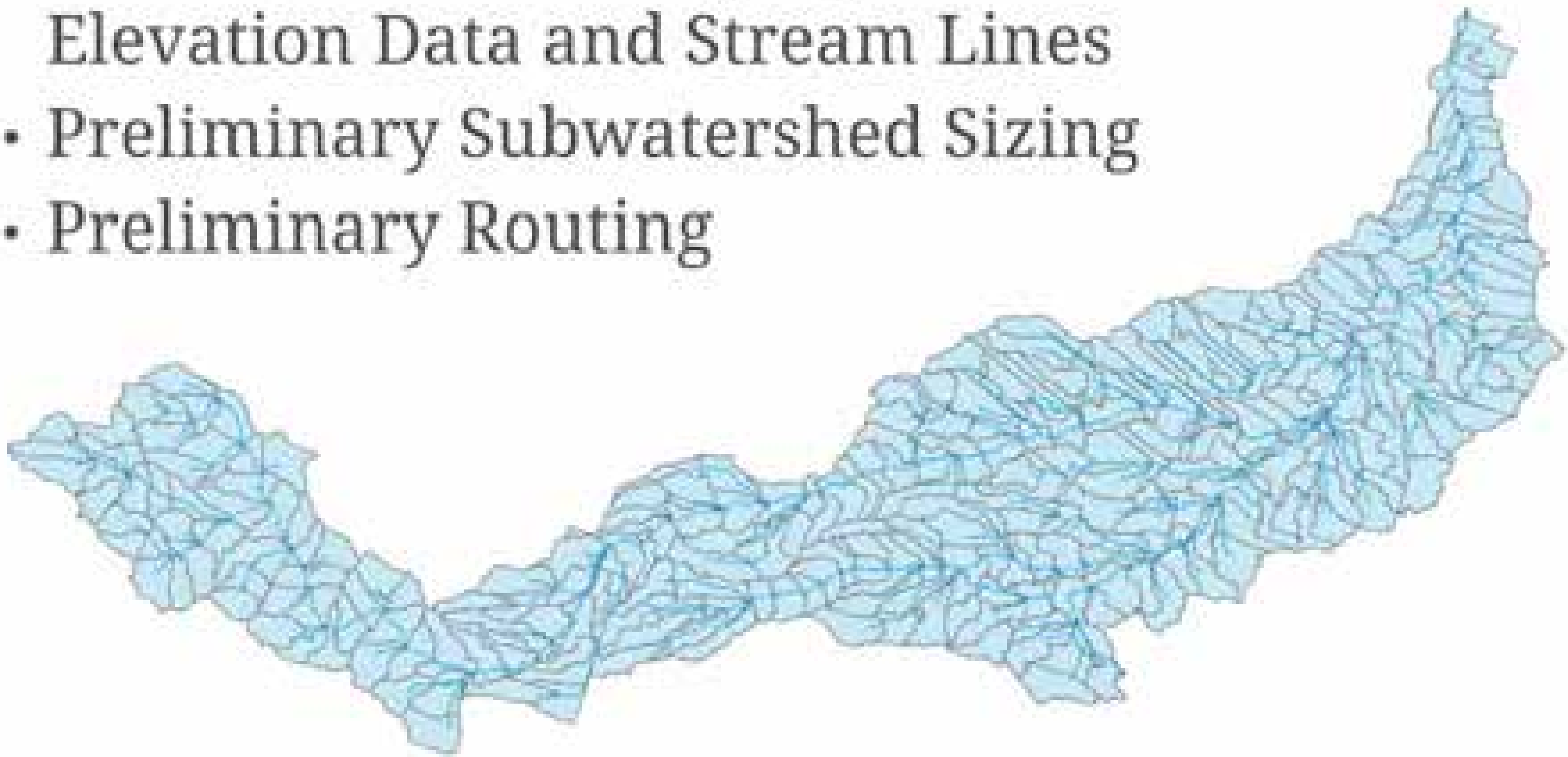

GIS
Data Collection
Initial ArcHydro Analysis
Model Refinement
Generate CUHP Characteristics
Generate SWMM Routing Network
Corrected Hydro DEM
Office Excel
Office Excel

Data Collection

- Elevation Data
- Stream Lines
- Land Use
- Soils Info

Initial ArcHydro Analysis

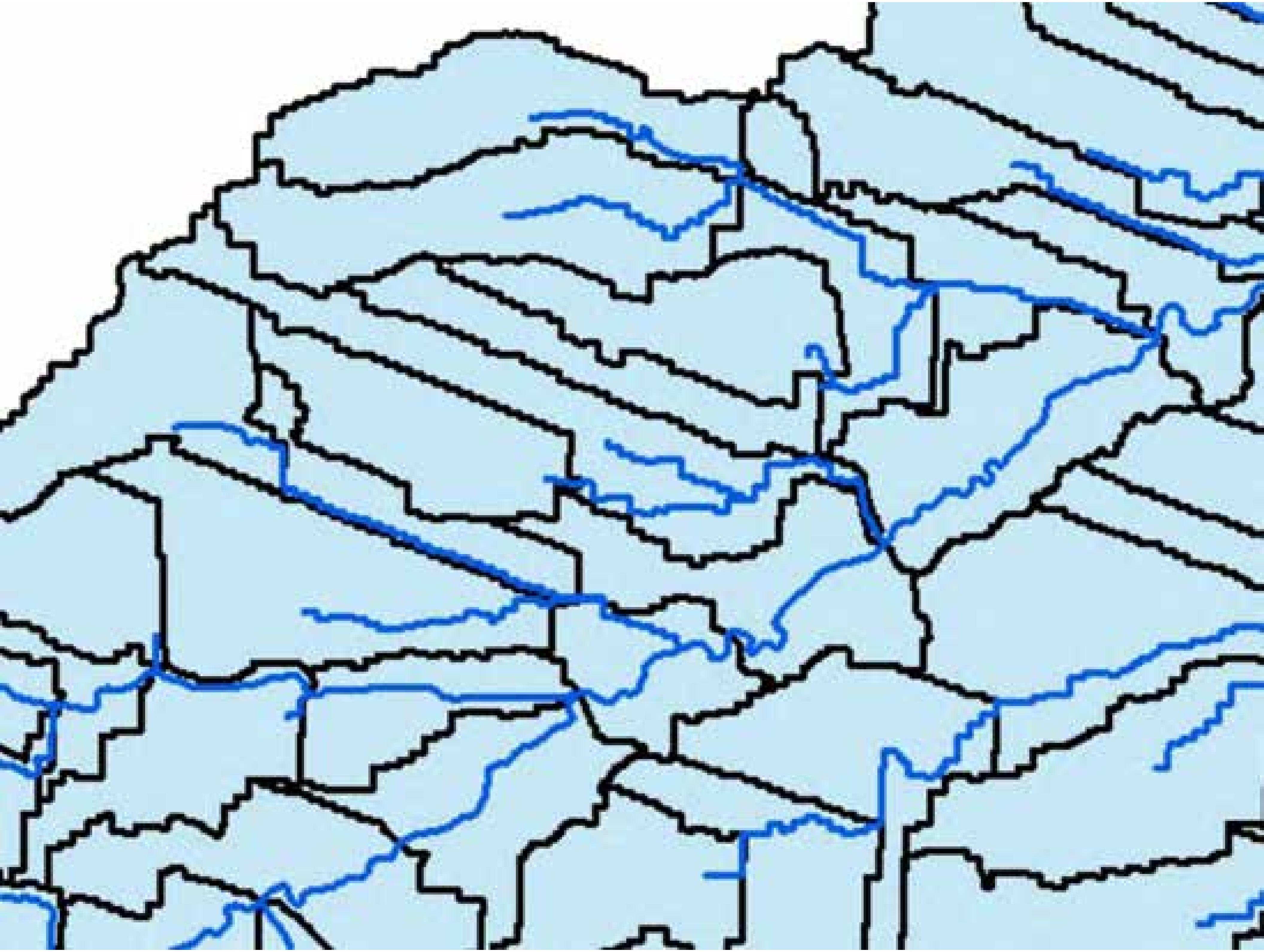
- Generate Preliminary Hydro DEM Based on Elevation Data and Stream Lines
- Preliminary Subwatershed Sizing
- Preliminary Routing

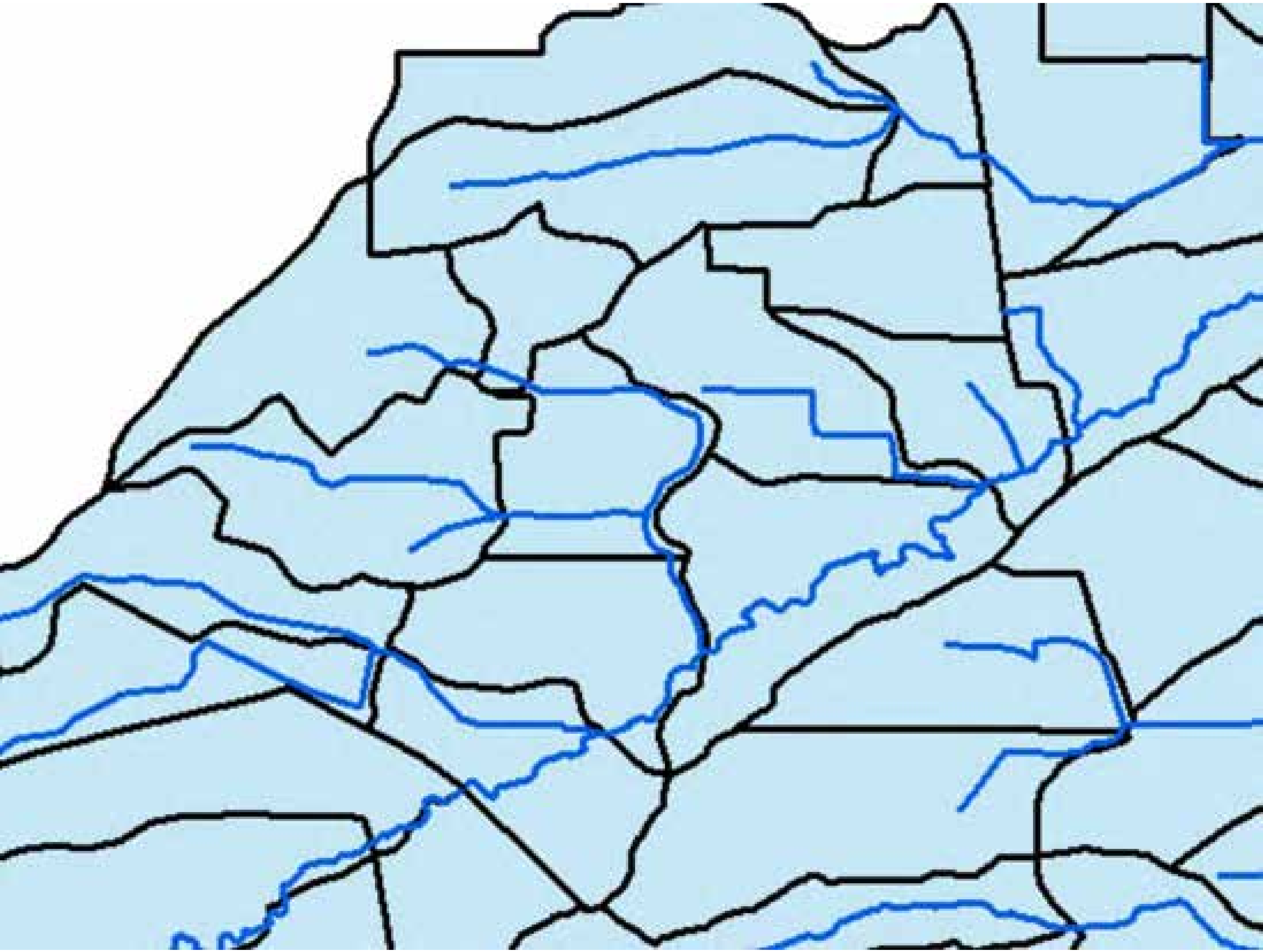


Model Refinement

- Use Engineering Judgement to Override Automated ArcHydro Results
- Clean Up Subwatershed Delineations
- Hand Delineate as Needed
- Correct / Add Streamlines as Needed for Hydro DEM

Correct / Add Streamlines as Needed
Hydro DEM



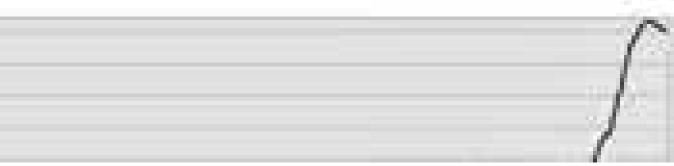


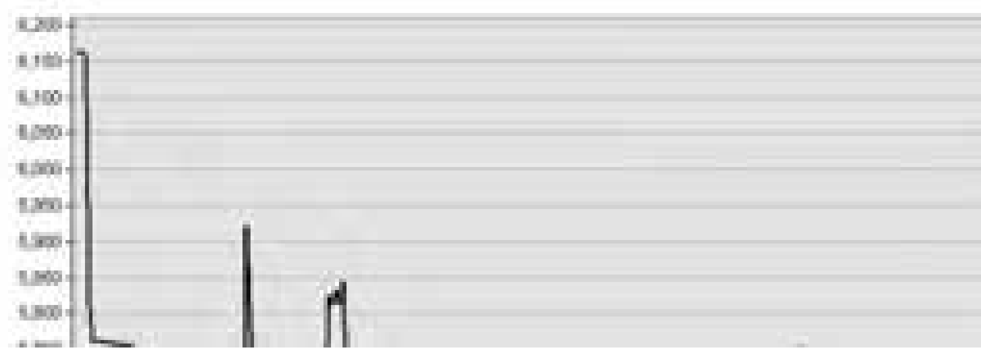
Model Refinement

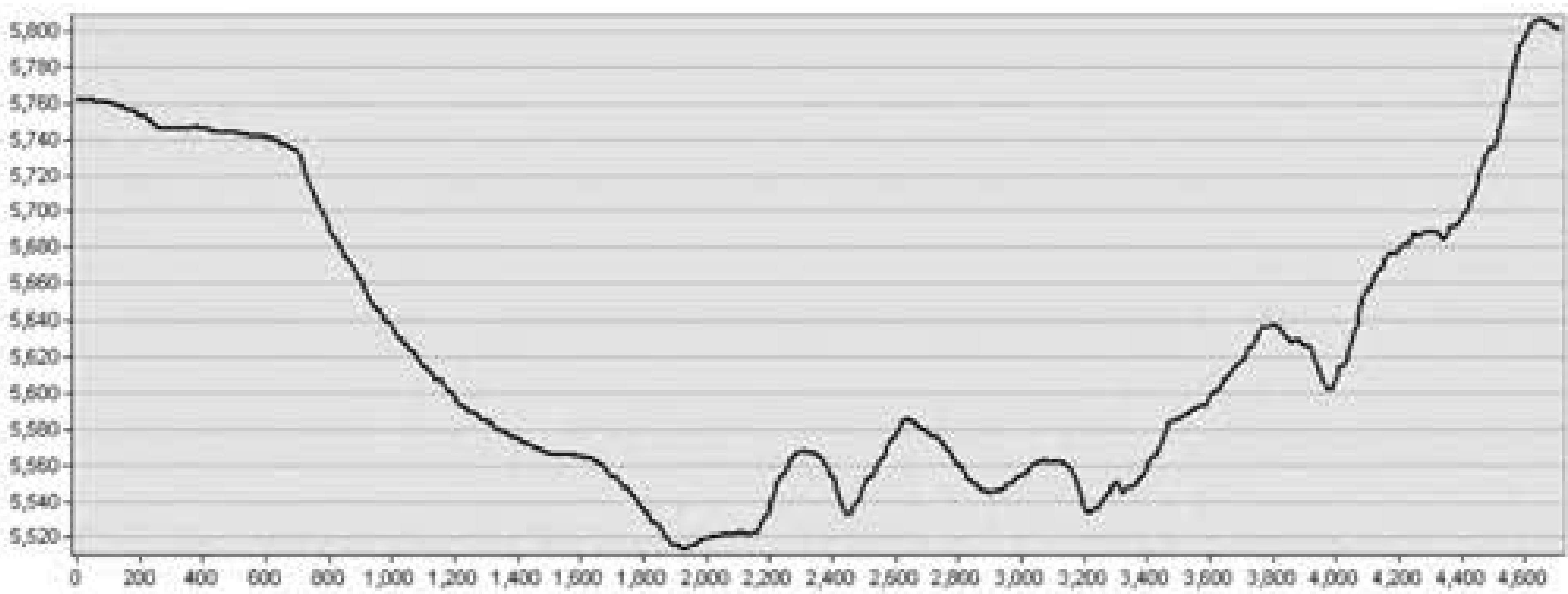
- Use Engineering Judgement to Override Automated ArcHydro Results
- Clean Up Subwatershed Delineations
- Hand Delineate as Needed
- Correct / Add Streamlines as Needed for Hydro DEM

Corrected Hydro DEM

- Hydro DEM is a Raster Elevation Model with Exaggerated Drainage Features
- Burn Corrected Streams Into Hydro DEM
- Build Walls from Corrected Subwatersheds






5,800
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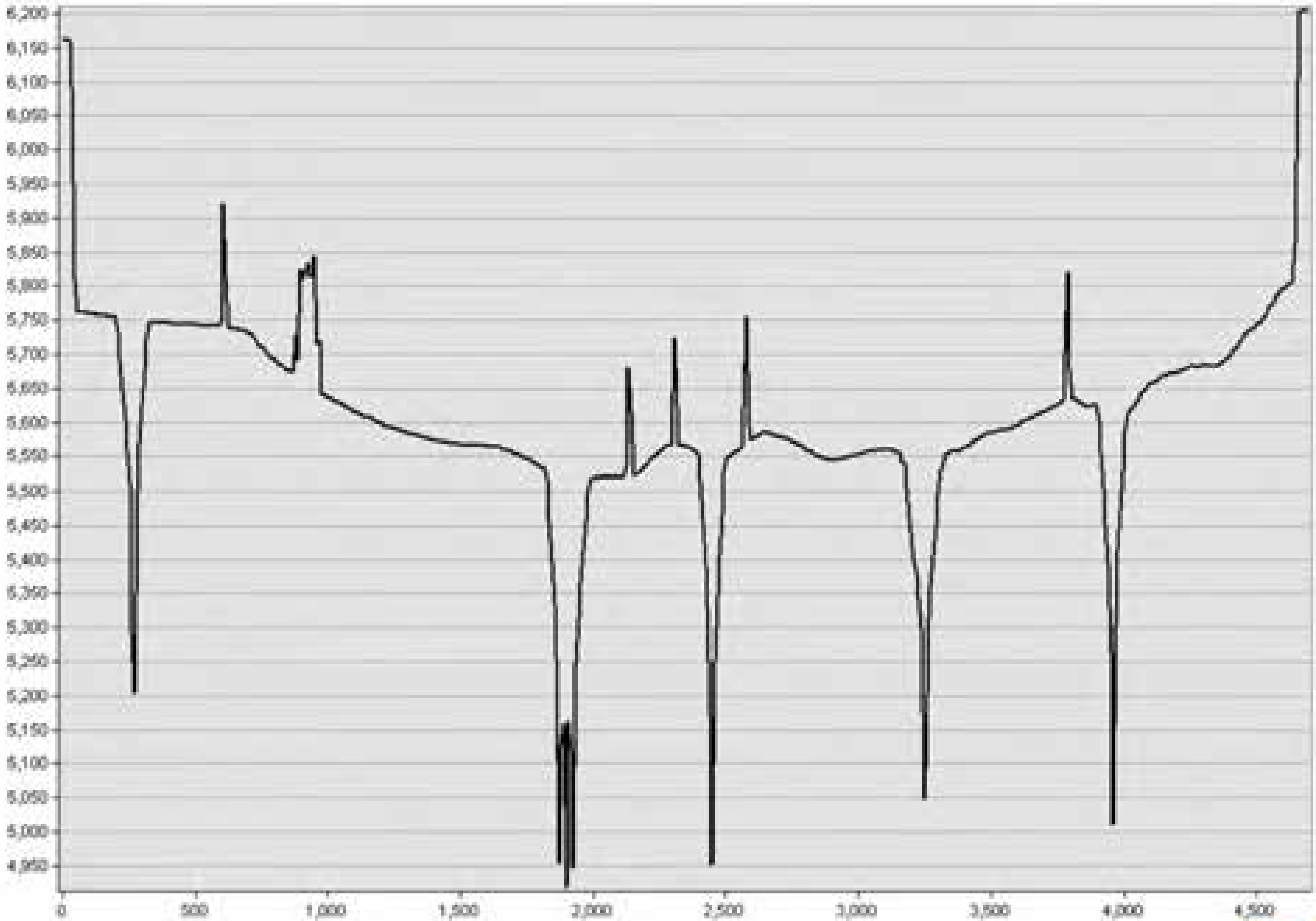
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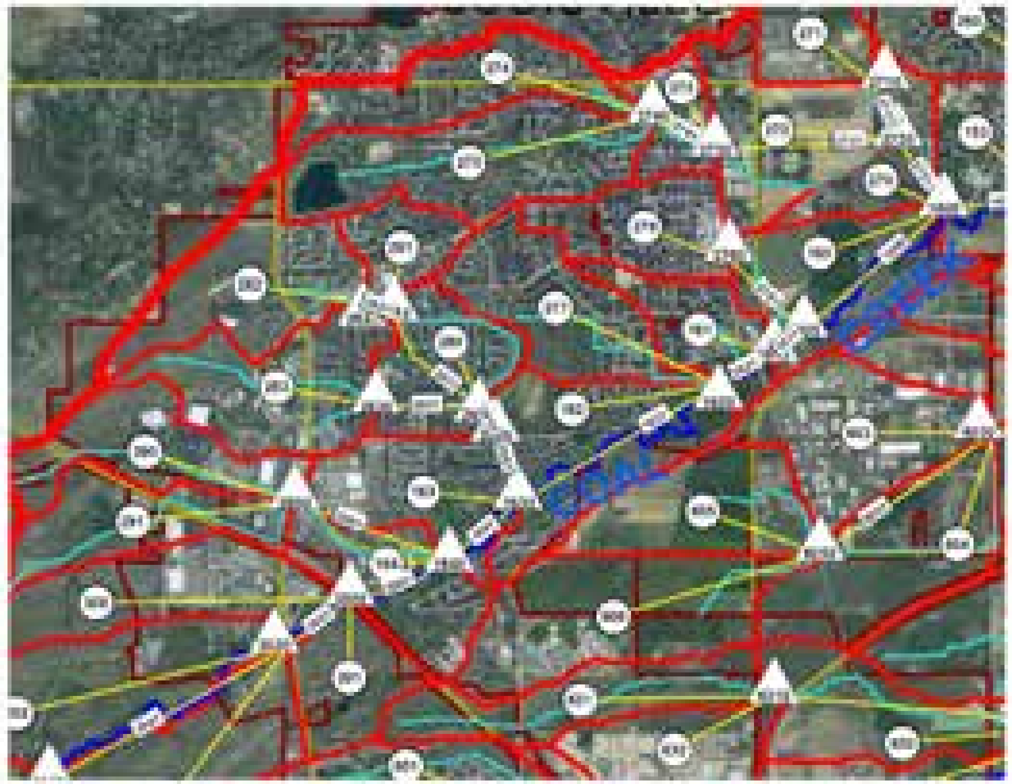
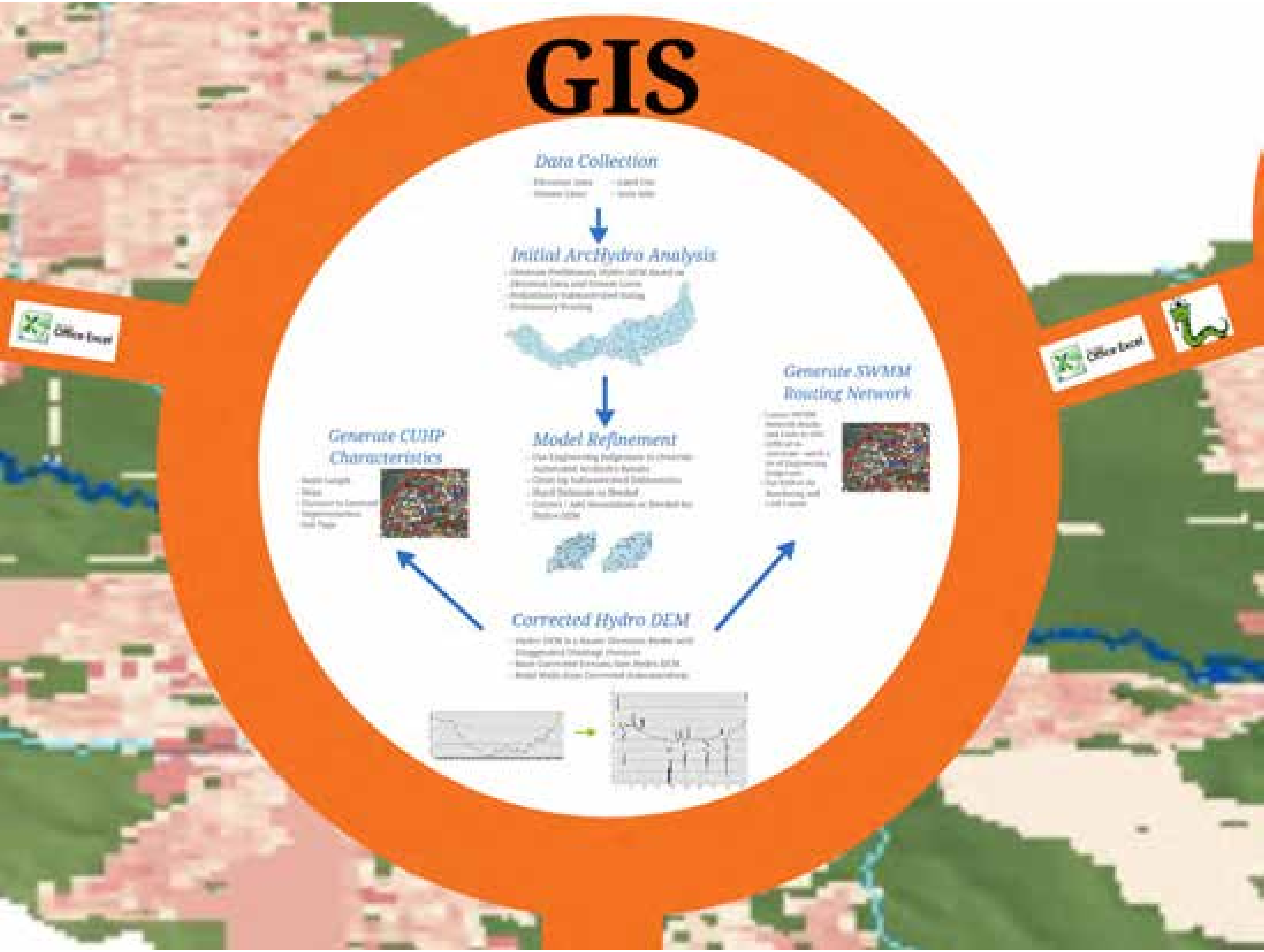
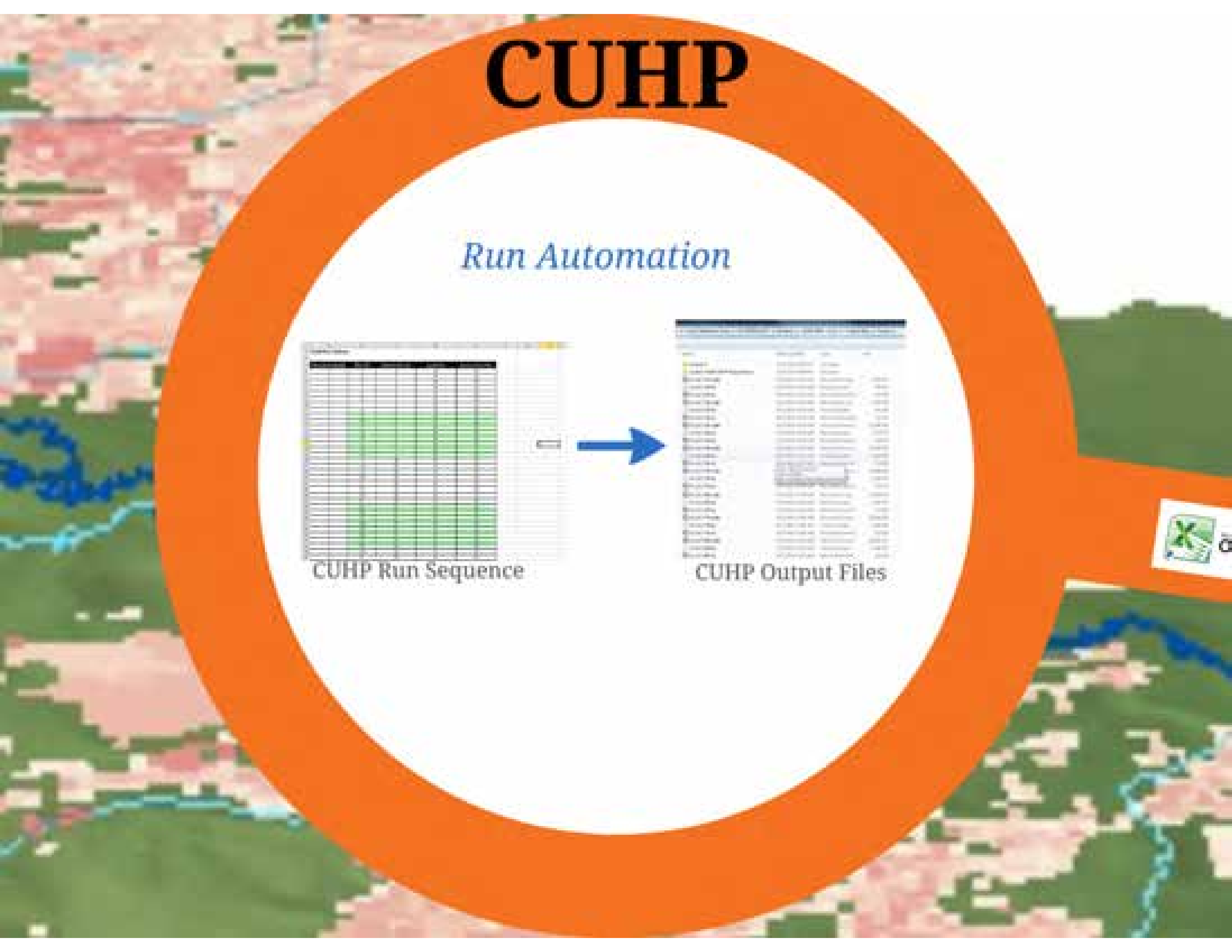
Generate CUHP Characteristics

- Basin Length
- Slope
- Distance to Centroid
- Imperviousness
- Soil Type




GIS
Data Collection
Initial ArcHydro Analysis
Generate SWMM Routing Network
Generate CUHP Characteristics
Model Refinement
Corrected Hydro DEM
Office Excel
Office Excel


Office Excel


CUHP
Run Automation
CUHP Run Sequence
CUHP Output Files

CUHP Run Options

Run (X or blank)	Run ID	Return Period	Land Use	Area Correction
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X	2	2	E	20
X	3	2	E	30
X	4	2	E	40
X	5	2	E	50
X	6	2	E	60
X	7	2	E	70
X	8	2	E	80
X	9	5	E	10
X	10	5	E	20
X	11	5	E	30
X	12	5	E	40
X	13	5	E	50
X	14	5	E	60
X	15	5	E	70
X	16	5	E	80
X	17	10	E	10
X	18	10	E	20
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X	26	25	E	20
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X	28	25	E	40
X	29	25	E	50
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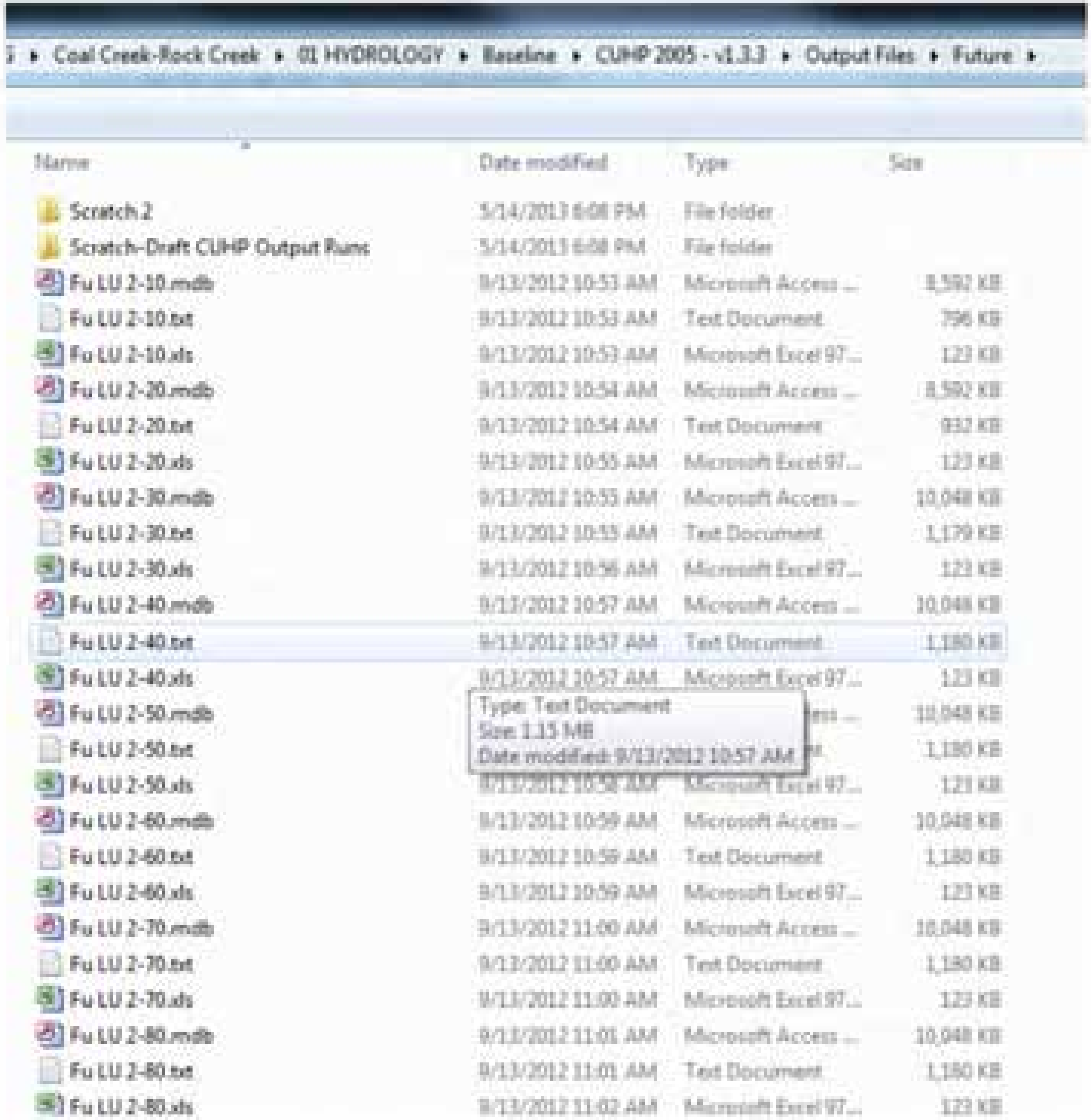
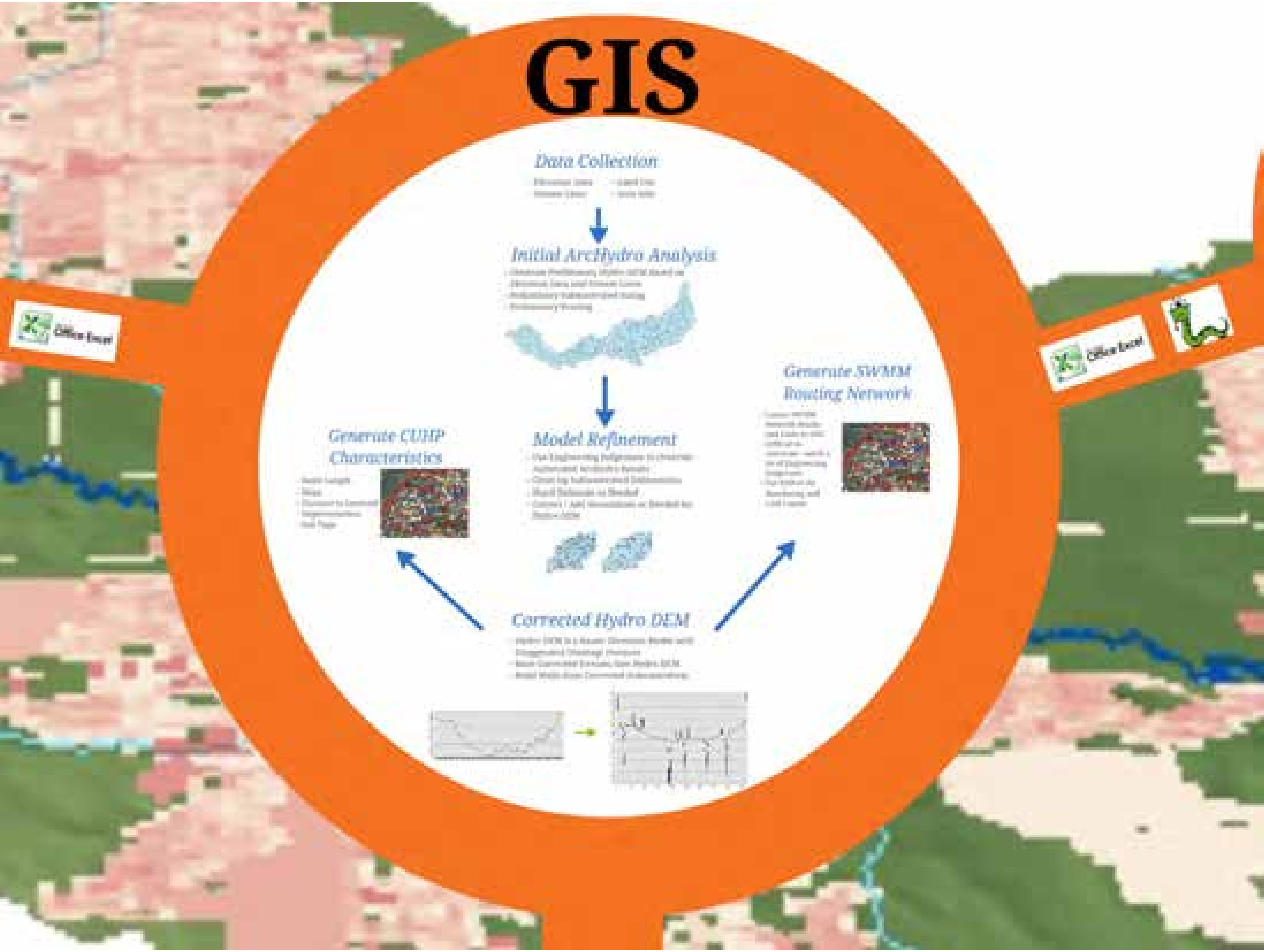
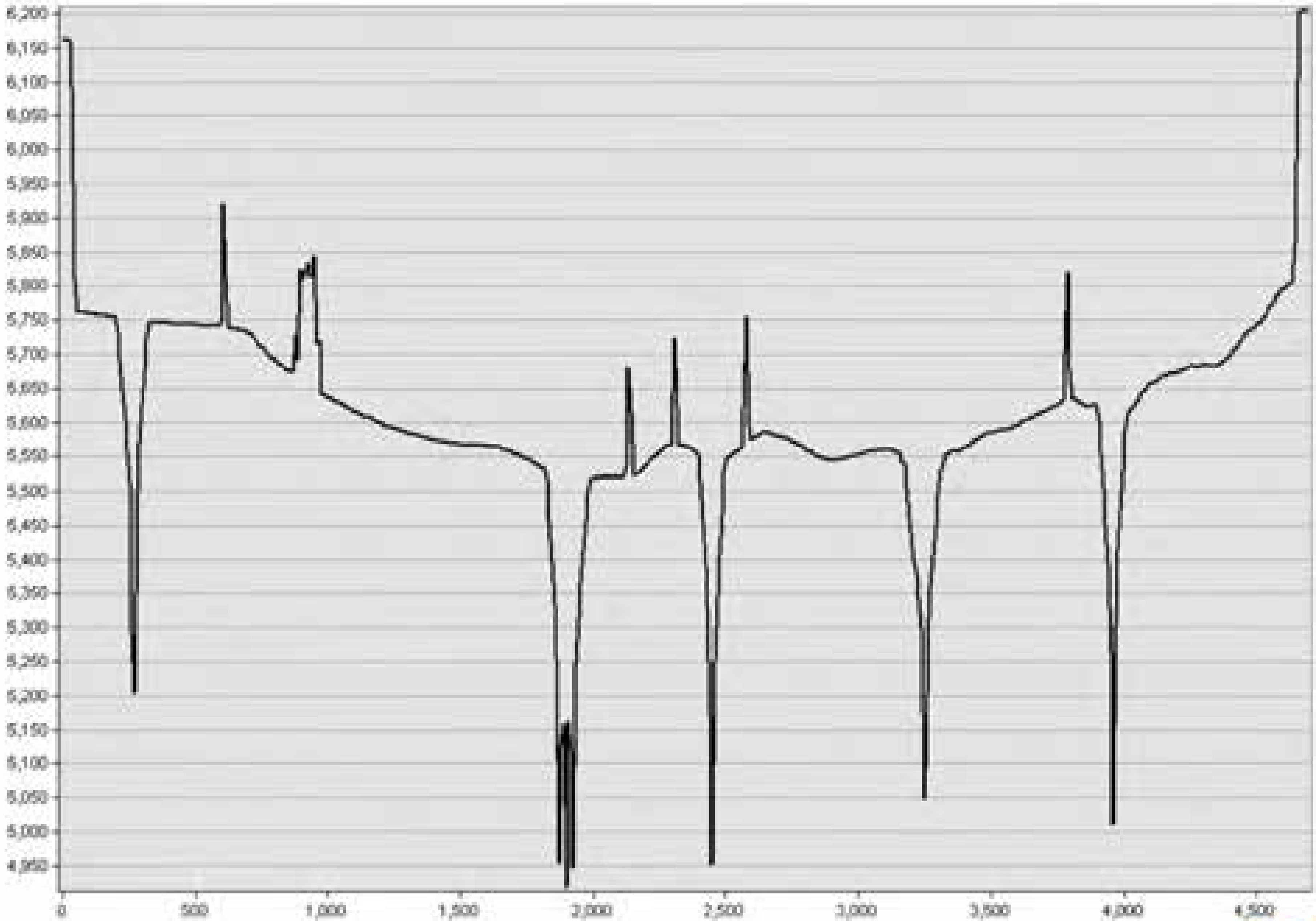
X	31	25	E	70
X	32	25	E	80
X	33	50	E	10
X	34	50	E	20

CUHP Run Sequence



CUHP Output Files


GIS
Data Collection
Initial ArcHydro Analysis
Generate SWMM
Routing Network
Generate CUHP
Characteristics
Model Refinement
Corrected Hydro DEM
Office Excel
Office Excel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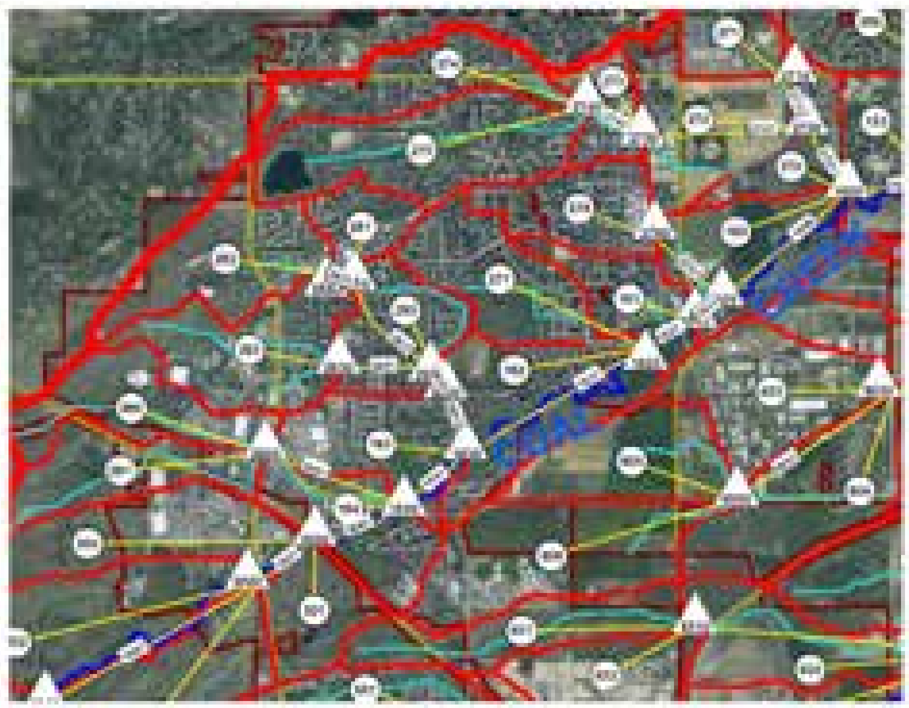
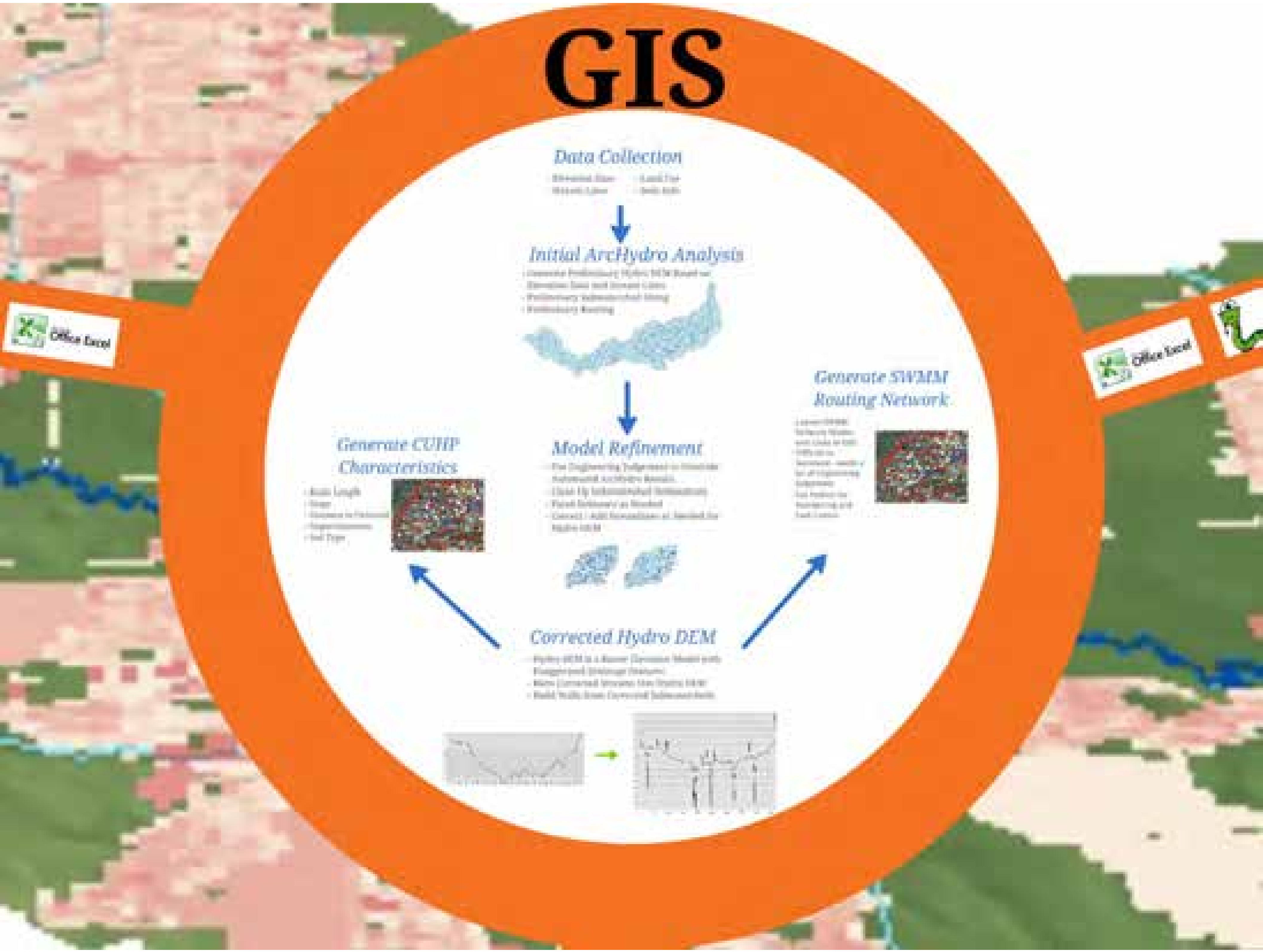
Generate SWMM Routing Network

- Layout SWMM Network (Nodes and Links in GIS)
- Difficult to Automate - needs a lot of Engineering Judgement
- Use Python for Numbering and Link Layout

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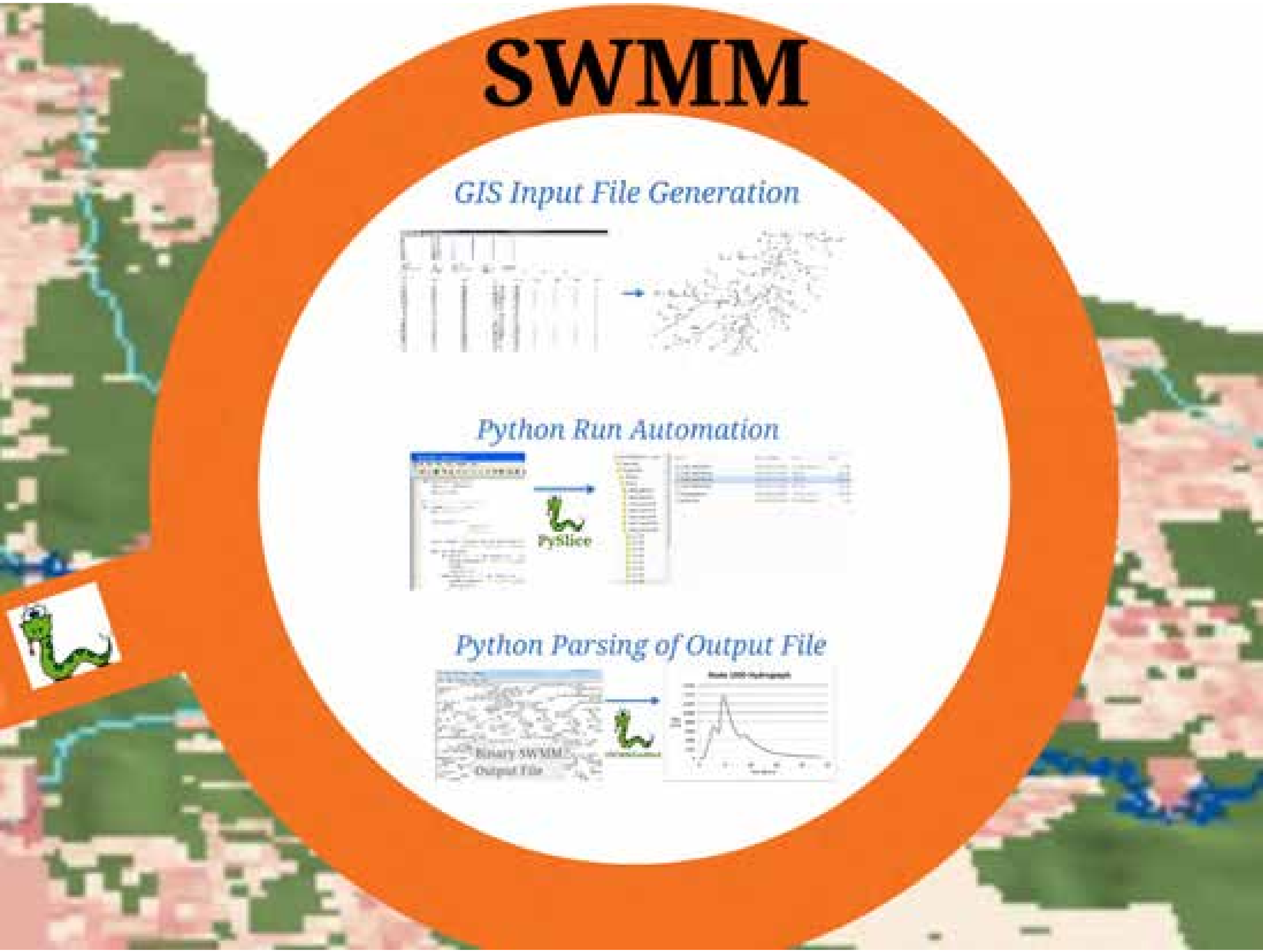
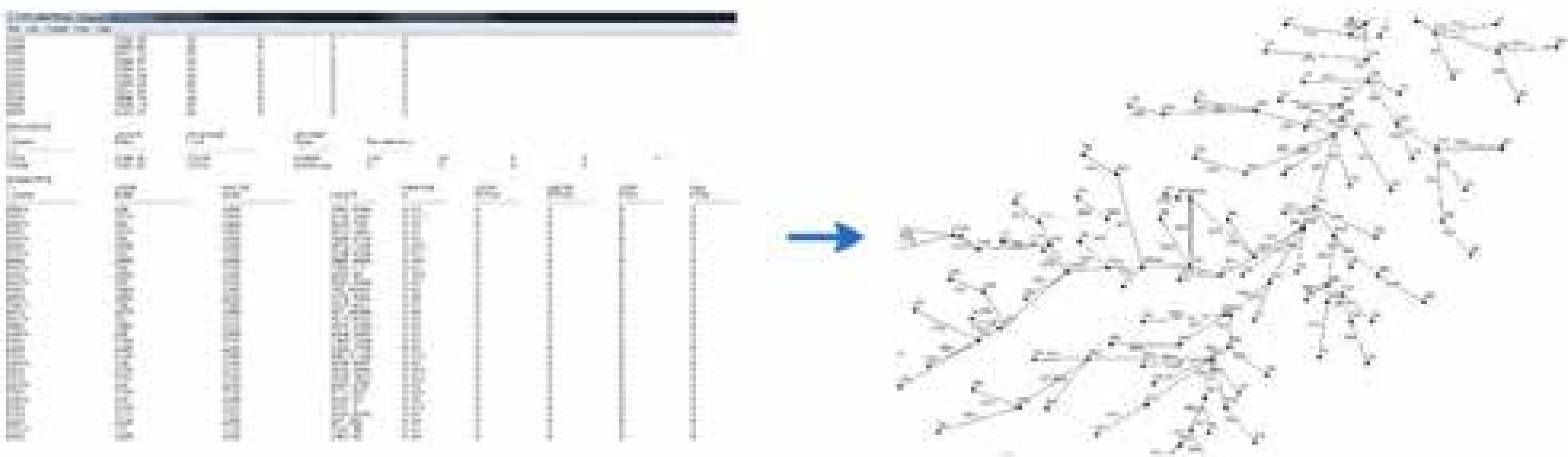
Data Collection
Initial ArcHydro Analysis
Model Refinement
Generate CUHP Characteristics
Generate SWMM Routing Network
Corrected Hydro DEM
Office Excel
Office Excel


Microsoft
Office Excel

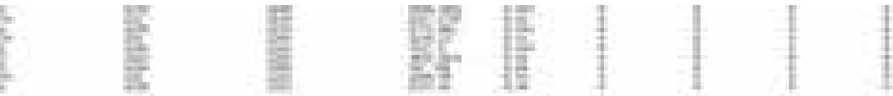

SWMM
GIS Input File Generation
Python Run Automation
PySlice
Python Parsing of Output File
Binary SWMM
Output File

SWMM

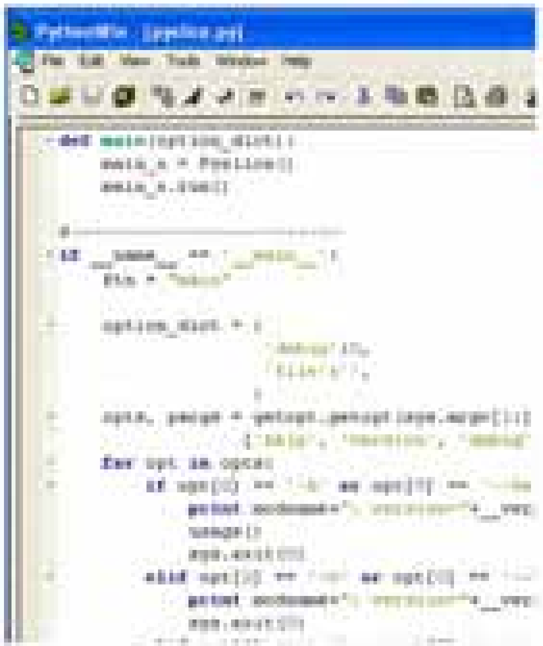
GIS Input File Generation

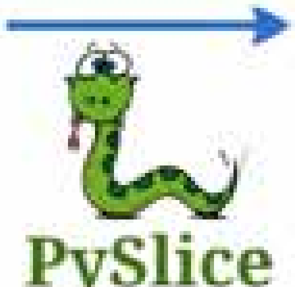


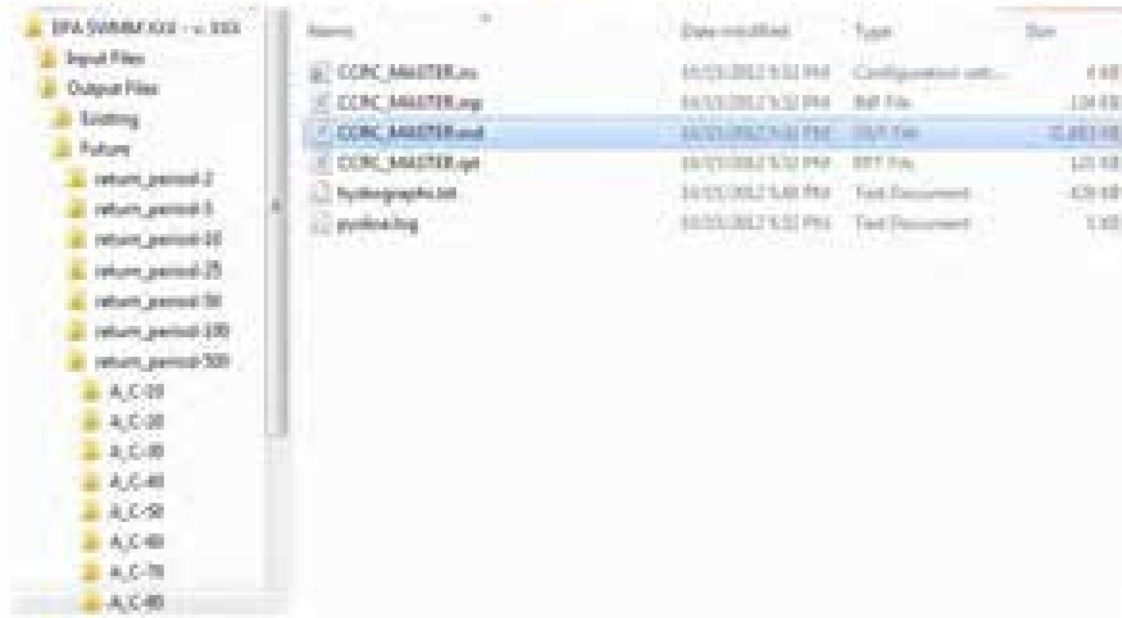
Python Run Automation



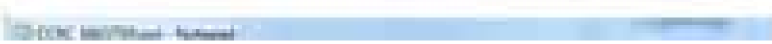
Python Run Automation

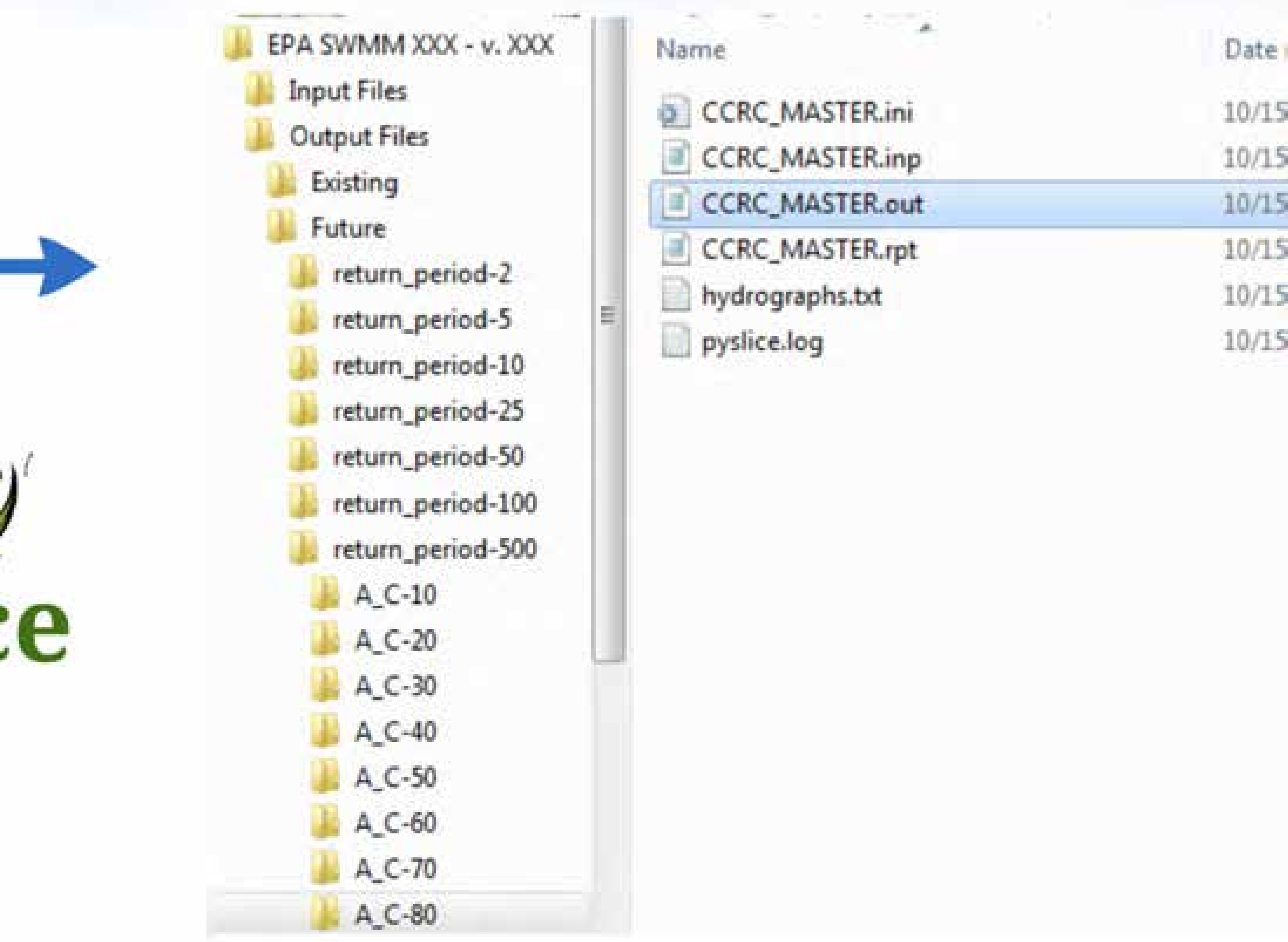






Python Parsing of Output File




EPA SWMM XXX - v. XXX
Input Files
Output Files
Existing
Future
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return_period-5
return_period-10
return_period-25
return_period-50
return_period-100
return_period-500
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A_C-40
A_C-50
A_C-60
A_C-70
A_C-80
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Date
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CCRC_MASTER.out
CCRC_MASTER.rpt
hydrographs.txt
pyslice.log
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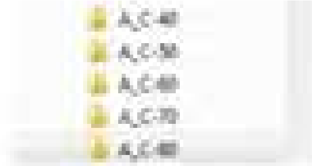
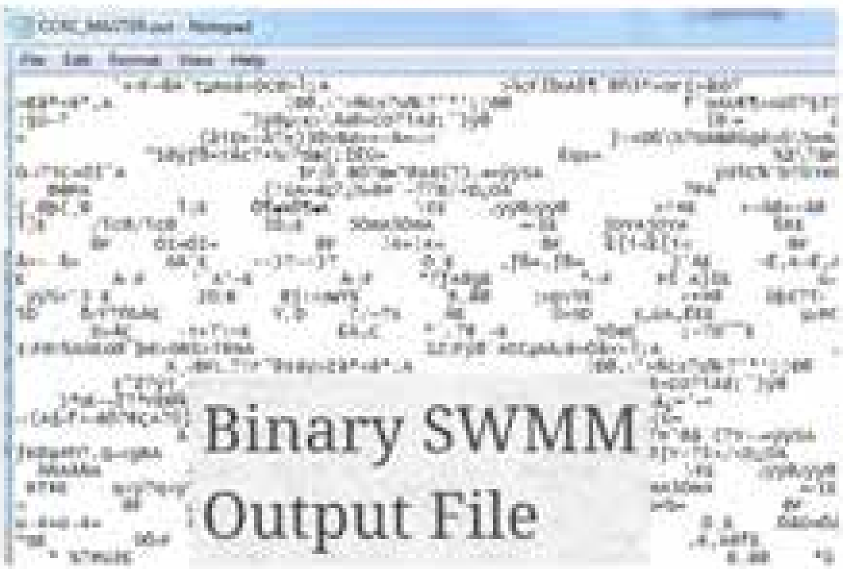
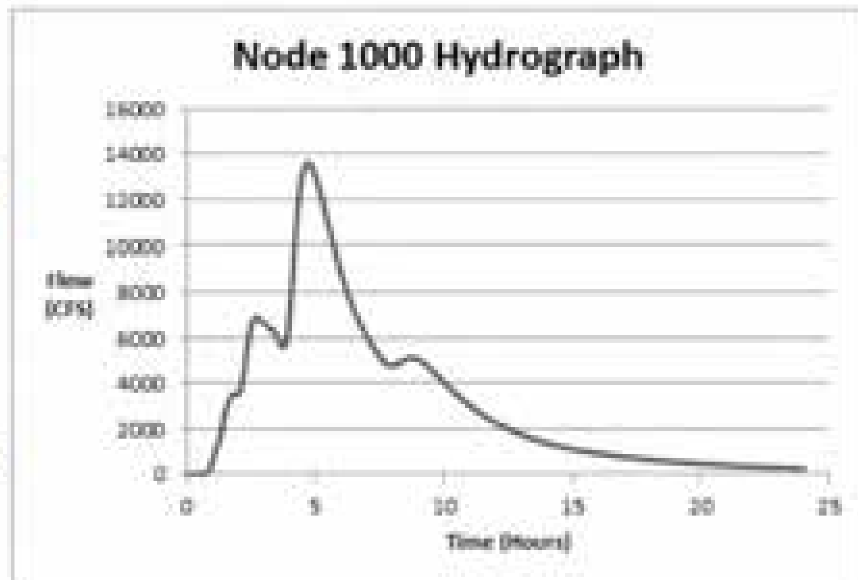
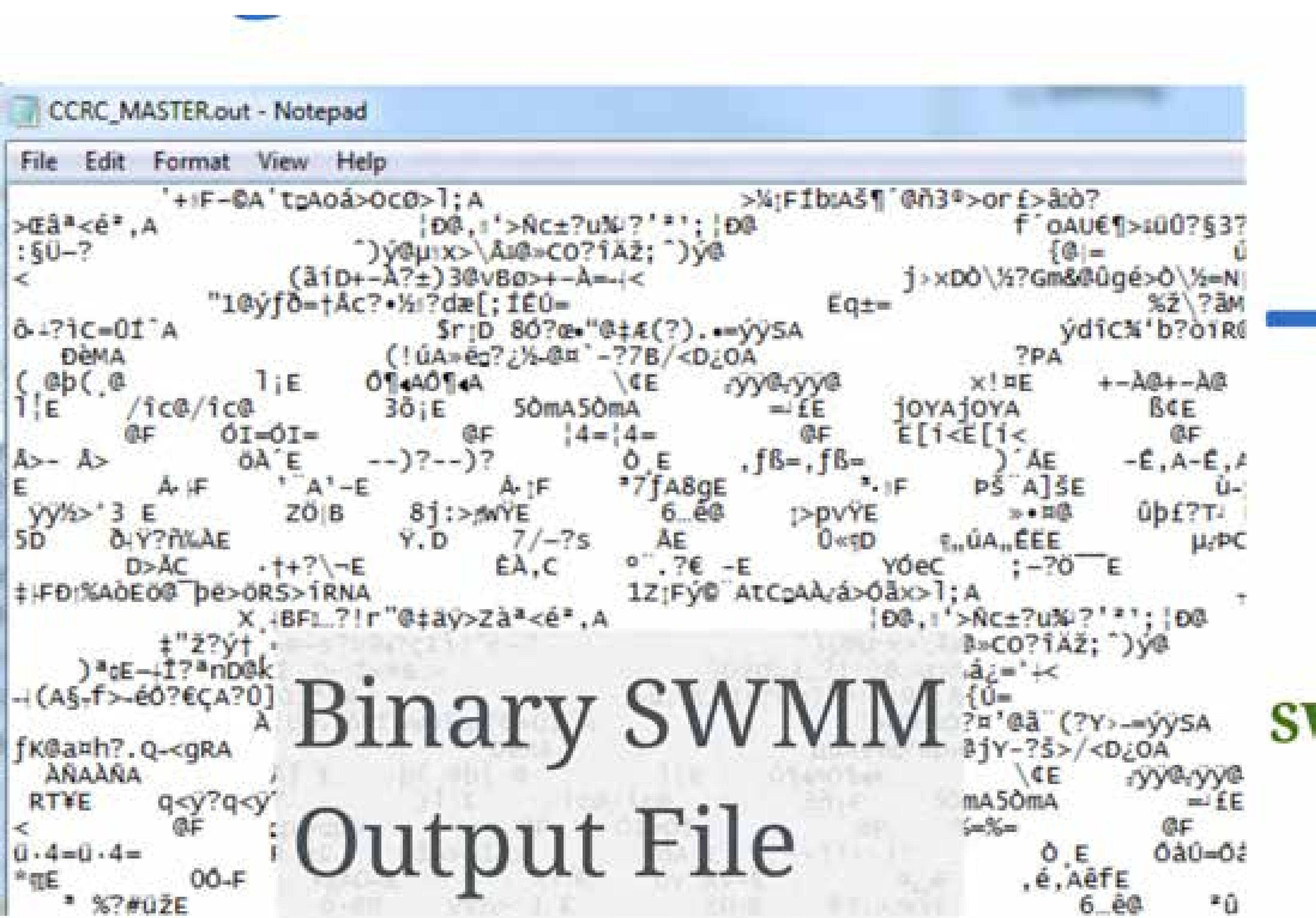
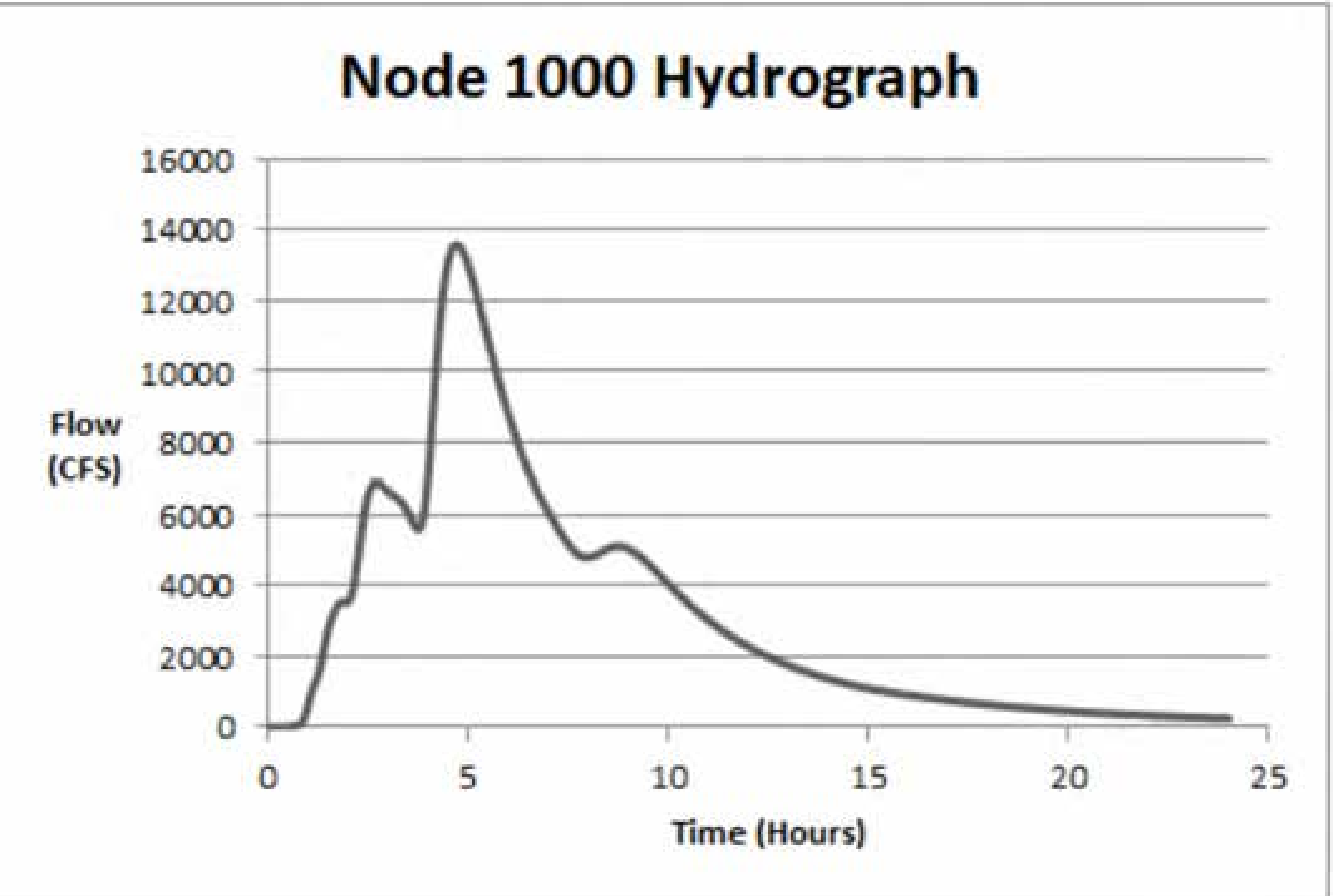


Python Parsing of Output File

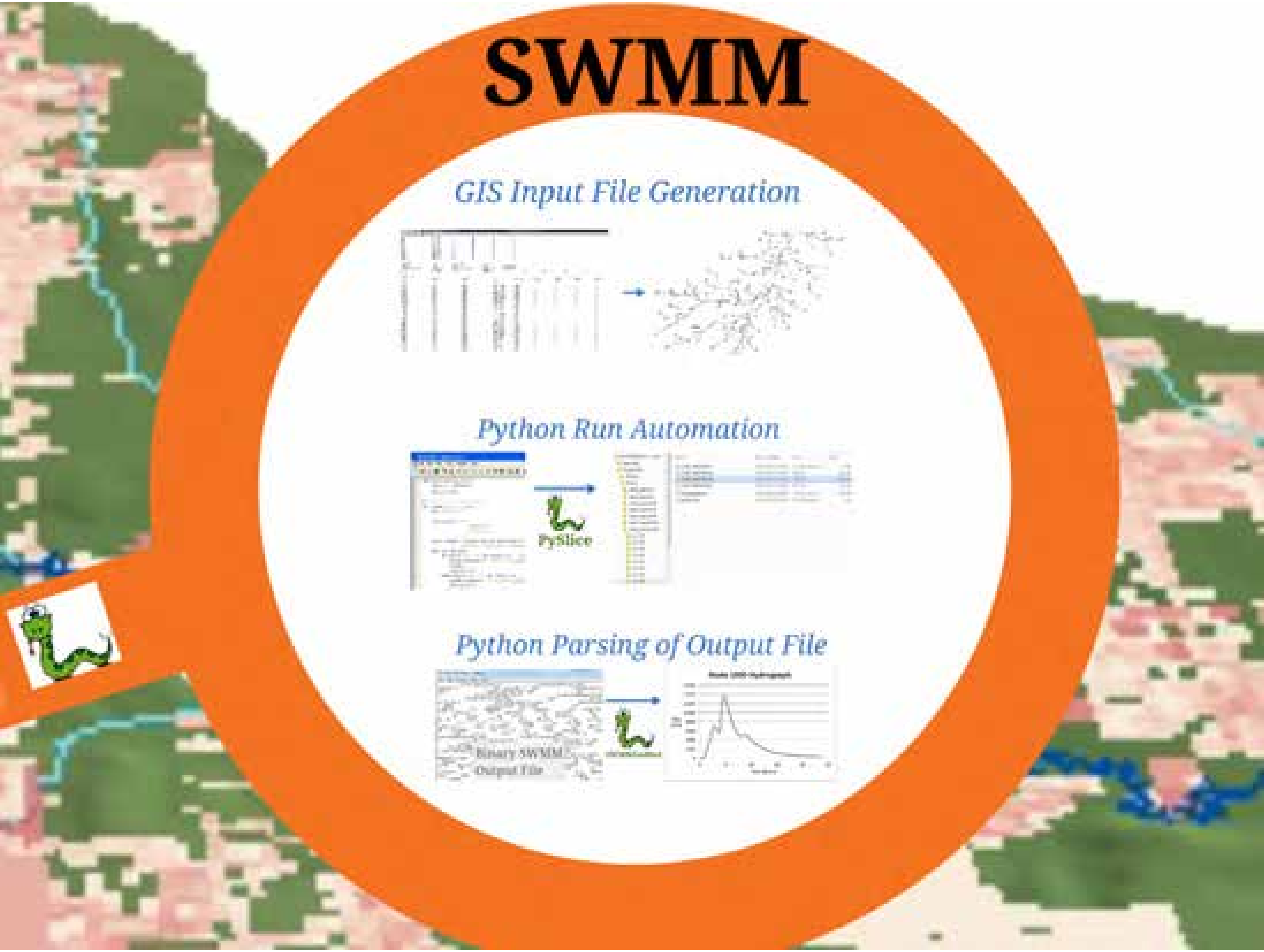





CCRC_MASTER.out - Notepad
File Edit Format View Help
Binary SWMM Output File



Node 1000 Hydrograph
16000
14000
12000
10000
8000
6000
4000
2000
0
Flow (CFS)
0
5
10
15
20
25
Time (Hours)


SWMM
GIS Input File Generation
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PySlice
Python Parsing of Output File
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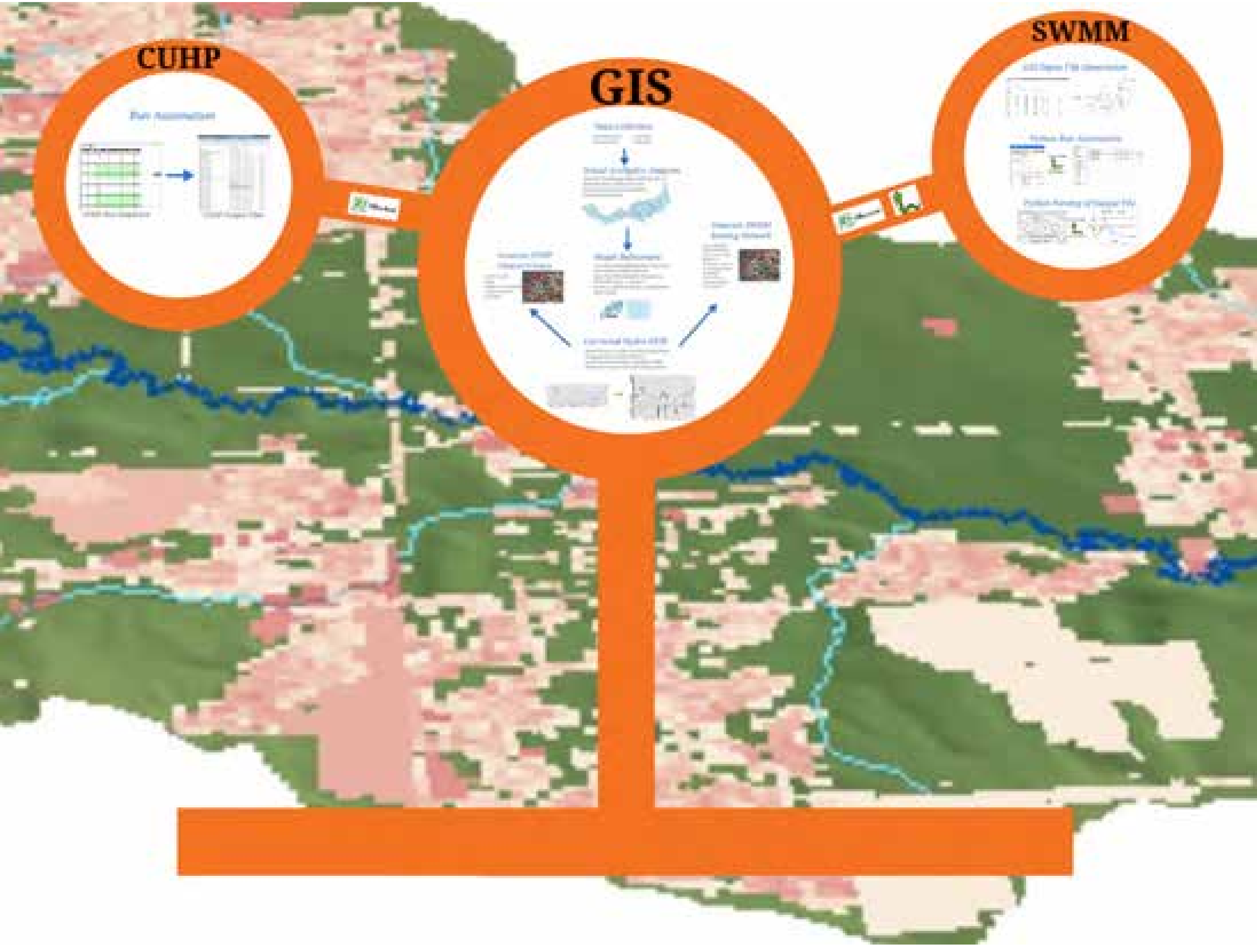
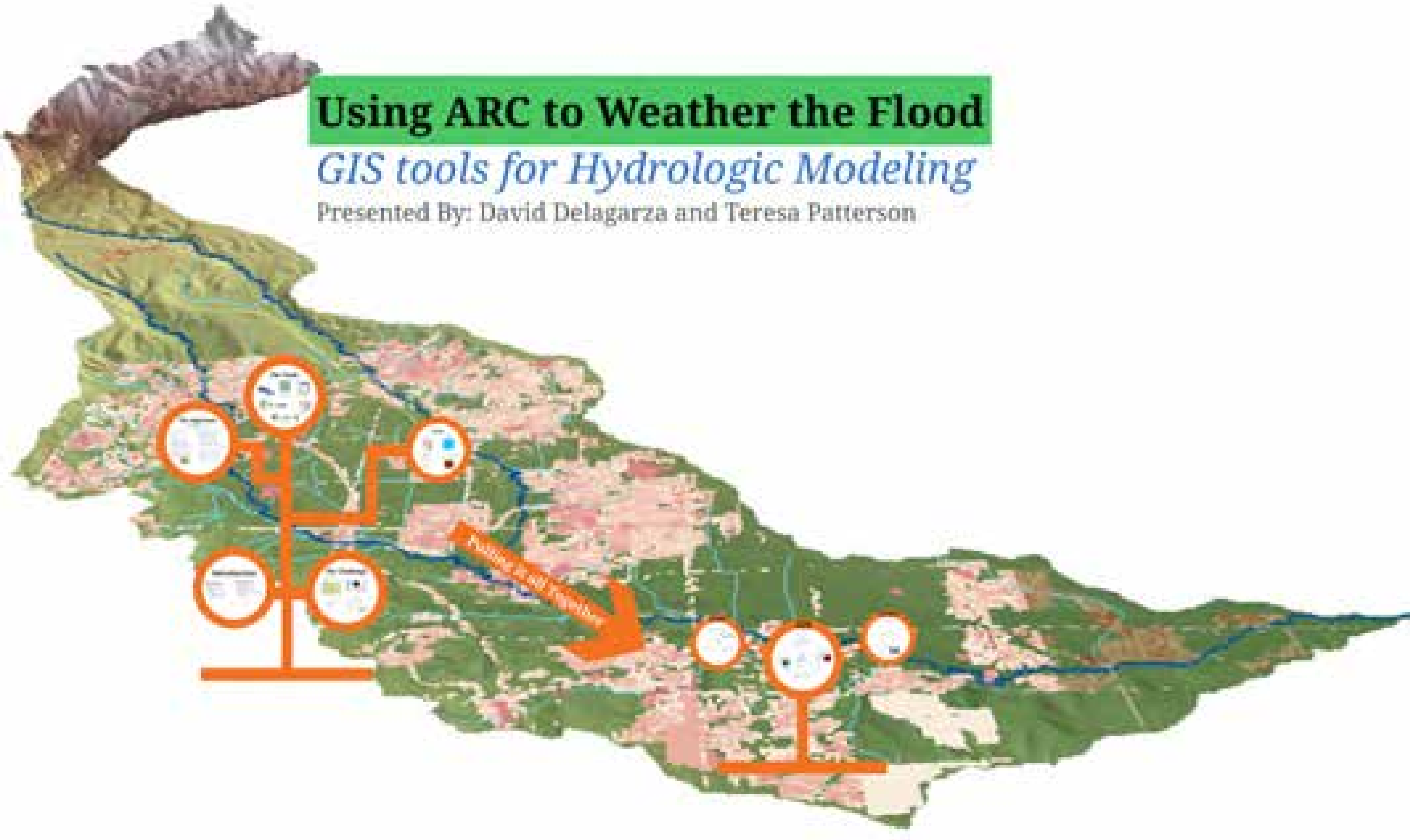
Output File


CUHP
GIS
SWMM

Using ARC to Weather the Flood

GIS tools for Hydrologic Modeling

Presented By: David Delagarza and Teresa Patterson



Comparison of Kinematic and Dynamic Wave Routing for Piped Storm Sewer Systems

Aaron Cook, P.E.
CH2M Hill
Aaron.Cook@ch2m.com

Outline

- Definitions
- Case Studies
- Results
- Recommendations

Kinematic Wave Routing

- Solves the continuity equation and a simplified form of the momentum equation for each conduit
- Continuity Equation: $A_1V_1 = A_2V_2$ or $Q_1 = Q_2$
- Assumes that slope of the water surface equals the slope of the conduit
- Maximum Flow = full normal flow value (no pressure flow)
- Flow in excess of the full normal flow value is either lost to the system, can pond atop the node, or can be diverted

Kinematic Wave Routing

- Allows flows to vary spatially and temporally within a conduit
  - Results in attenuated hydrographs as flow is routed through a conduit
- Does not account for:
  - Backwater effects
  - Entrance/exit losses
  - Flow reversal
  - Pressurized flow
- Typical approach for Master Planning

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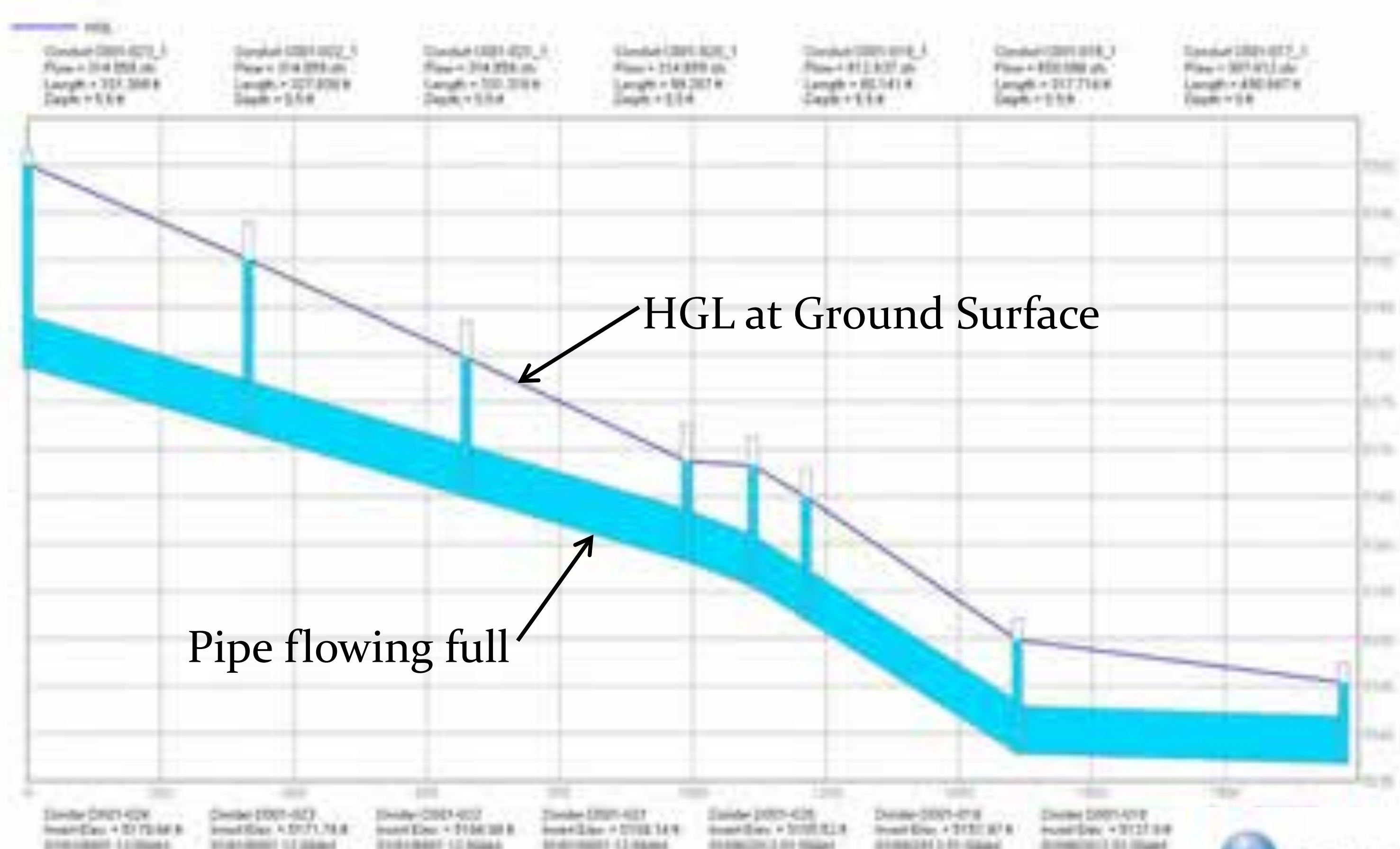
Kinematic Wave Routing



Dynamic Wave Routing

- Solves the complete one-dimensional Saint Venant equations
  - Continuity and momentum equation for each conduit
  - Volume continuity equation for each node
- Theoretically less conservative because of less simplifications

Dynamic Wave Routing

- Allows for pressurized flow such that Maximum Flow is greater than the full normal flow value
- Flooding occurs when the water depth at a node exceeds the maximum available depth
- Can account for:
  - Channel storage
  - Backwater
  - Entrance/exit losses
  - Flow reversal
  - Pressurized flow
- Typical Approach for Design Projects

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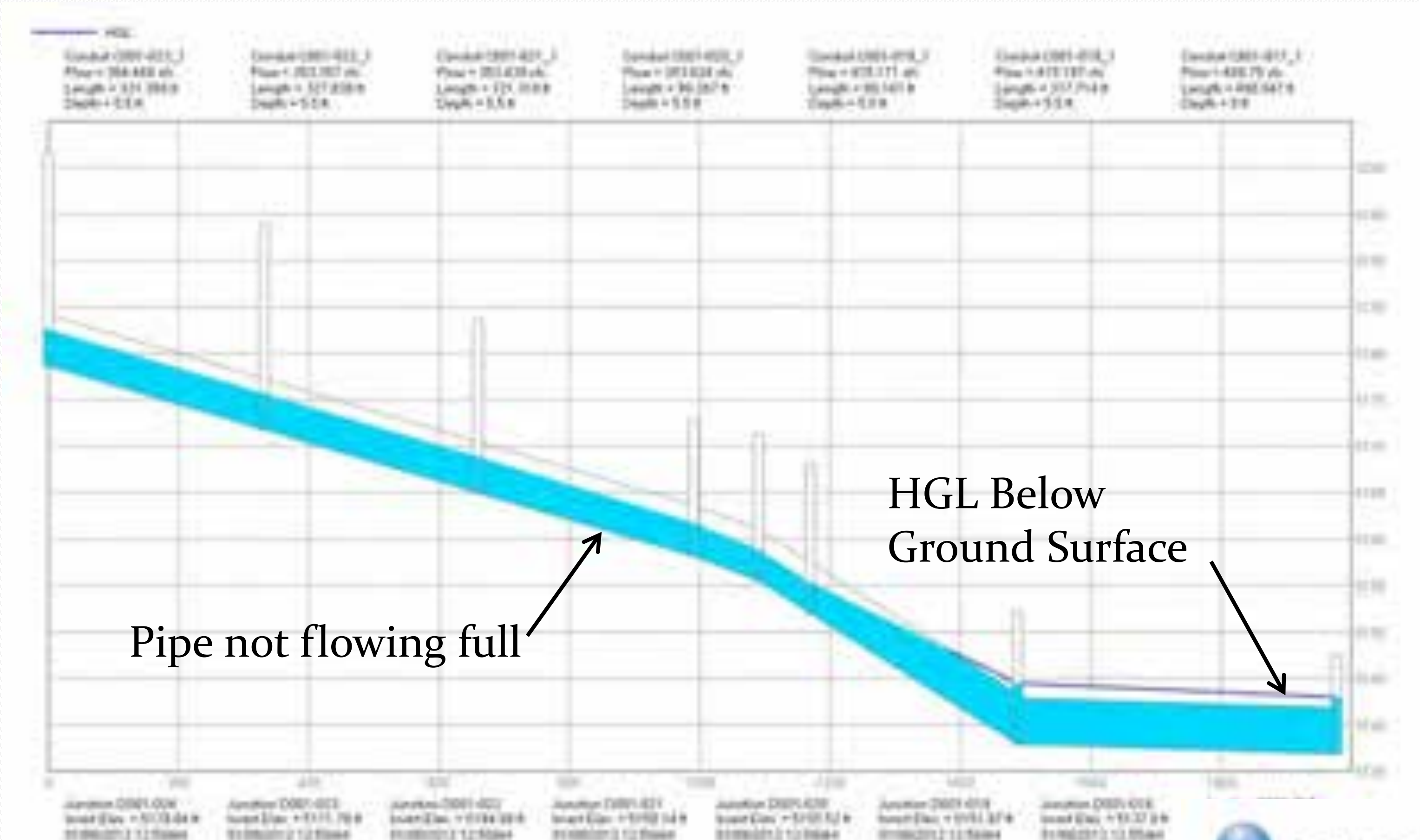
Dynamic Wave Routing



Model Comparison

- Time Step
  - Kinematic – numerical stability with large time steps (5 to 15 minutes)
  - Dynamic – numerical stability with smaller time steps (less than one minute)
- Dynamic Wave Routing can be applied to network layouts with multiple downstream diversions and loops
  - Kinematic wave routing method can only be applied to more simple network layouts
- Kinematic Wave Routing is generally viewed as the conservative approach

Model Differences

- Model: EPA SWMM 5
- Kinematic Model
  - Flow divisions at divider nodes
  - Flow diversion is defined by user, user defines divided link
  - One outfall for multiple conduits
  - Cannot account for tailwater conditions
- Dynamic Model
  - Flow division at junction nodes
  - Flow diversion is determined by model, user does not define divided link
  - One outfall for one conduit
  - Must define tailwater conditions

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Case Studies

- Simple Pipe Network
- Globeville-Utah Junction Outfall Systems Plan

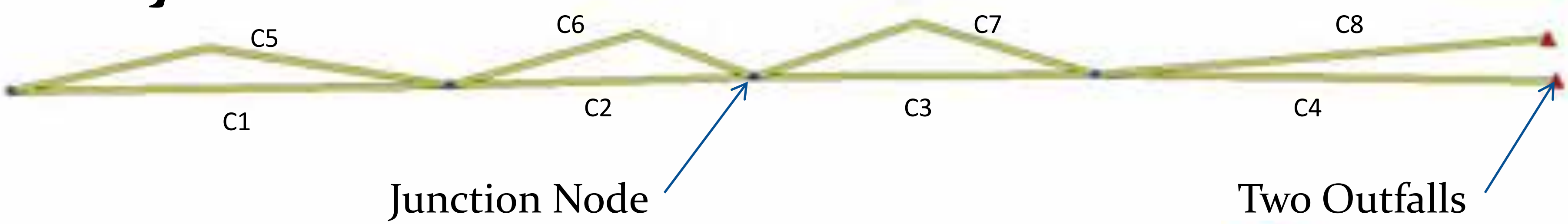
Simple Pipe Network

- Modeled using EPA SWMM 5
- Allows for direct comparison of modeling approaches
- Not impacted by overflows from adjacent pipe systems
- Simple Pipe Network
  - 4 Pipes
  - 4 Overflow Conduits
  - 4 Junctions or Dividers
  - 1 or 2 Outfalls

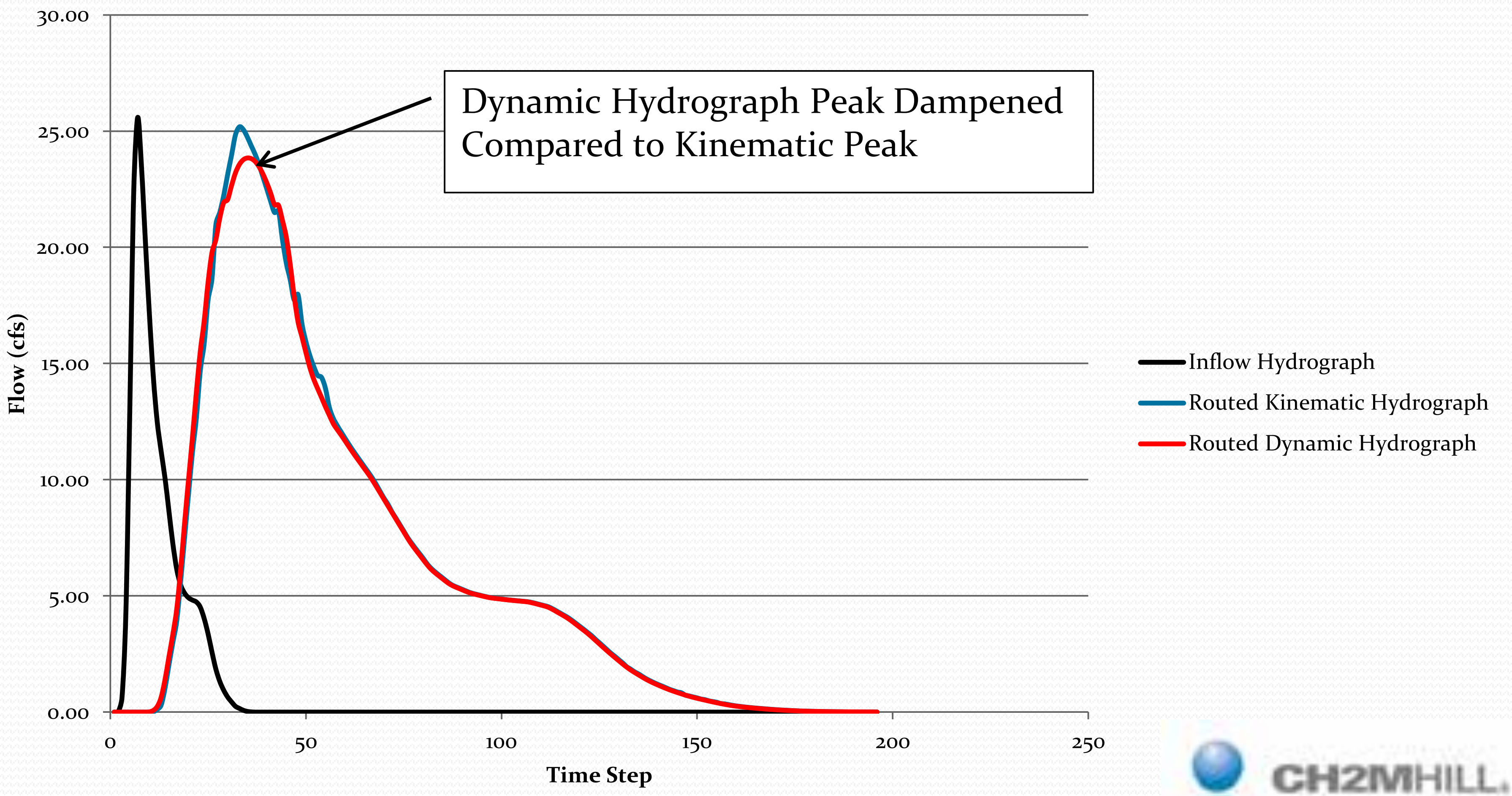
Simple Pipe Network – Plan View Schematic

Kinematic

Dynamic



Simple Pipe Network



Simple Pipe Network Results

				Kinematic		Dynamic	
Conduit	Type	Slope	Length (ft)	Peak Flow (cfs)	Max/Full Flow Ratio	Peak Flow (cfs)	Max/Full Flow Ratio
C1	24" RCP	0.0076	260	21.4	1.0	24.7	1.2
C2	24" RCP	0.0055	182	18.2	1.0	24.0	1.4
C3	24" RCP	0.0147	204	25.2	0.9	23.9	1.0
C4	24" RCP	0.0036	275	14.8	1.0	23.8	1.8
C5	Overflow Channel	-	-	4.2	0.01	0	0
C6	Overflow Channel	-	-	7.2	0.02	0	0
C7	Overflow Channel	-	-	0	0	0	0
C8	Overflow Channel	-	-	10.2	0.01	0	0

Note: Peak Inflow = 25.6 cfs

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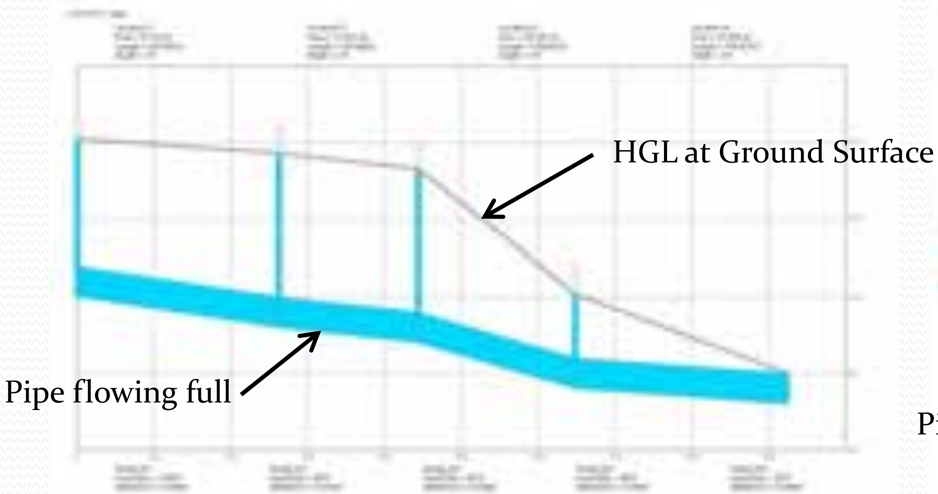
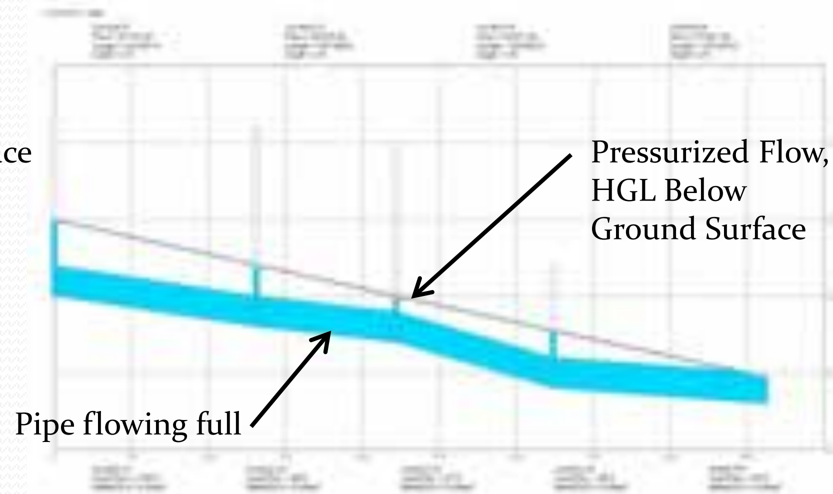
Simple Pipe Network

Kinematic



Dynamic



***Peak Flow Values Shown**

Case Study

- Globeville-Utah Junction Basin
- Outfall Systems Plan (OSP) completed June 2013
- Multiple outfalls to the South Platte River
- Overflows and diversions
- Pipe sizes ranging from small diameter pipes to large box culverts
- Steeper slopes in the upper part of the basin
- Flat slopes near the South Platte River (>0.1%)

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Watershed Map

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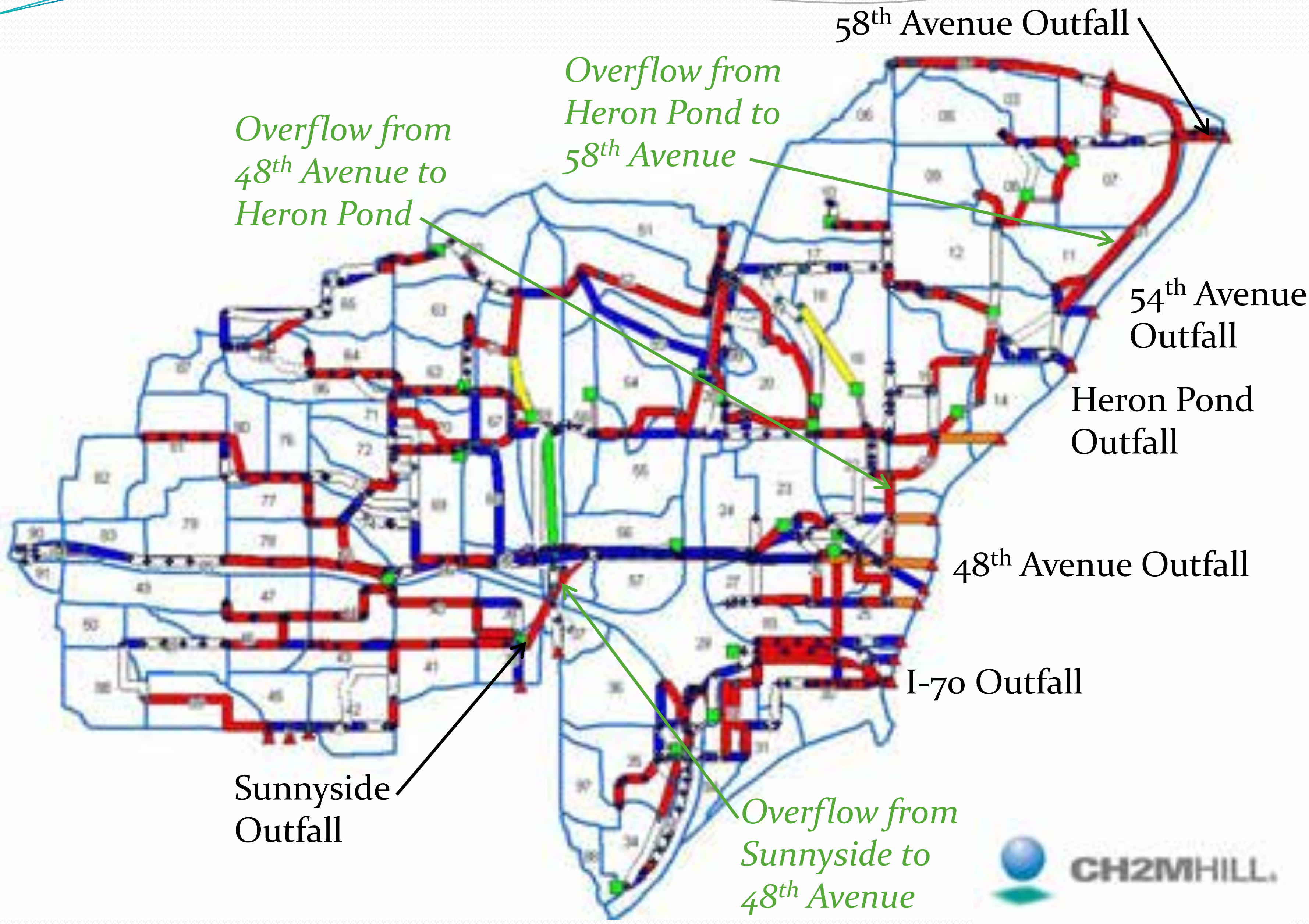
SWMM Model

- 6 Major Outfall Systems
- 60 Miles of Conveyance Elements Modeled
  - 25 Miles of pipe/box culverts
  - 35 miles of open channel/overflow channels
  - 1063 Total Conveyance Elements
- 571 Junction and Divider Nodes
- 18 Outfalls
- 26 Storage Units
- Assumption: Not Inlet Capacity Constrained



58th Avenue Outfall
Overflow from Heron Pond to 58th Avenue
Overflow from 48th Avenue to Heron Pond
54th Avenue Outfall
Heron Pond Outfall
48th Avenue Outfall
I-70 Outfall
Sunnyside Outfall
Overflow from Sunnyside to 48th Avenue

Case Study

- Originally modeled using Kinematic Wave Routing
  - Typical approach for Master Planning projects
- Subsequently modeled using Dynamic Wave Routing
- Why convert the model?
  - Client driven
  - Fully piped system (minor storm system)
  - Goal: Provide same level of service with reduced costs

Case Study

- Two variables selected for comparison
  - Peak Flow (cfs)
  - Maximum to full flow ratio
    - For full flow, maximum to full flow ratio = 1
    - For less than full flow, maximum to full flow ratio < 1
    - For pressurized flow, maximum to full ration > 1

Case Study

- Peak Flow
  - Generally increased by greater than 20% using the dynamic wave method
  - Maximum increase greater than 100%
- Greater increase for flatter pipes
- For those conduits where the water available was limited and the maximum to full flow ratio was substantially less than 1.0, the peak flow generally decreased
  - Due to water storage in the system

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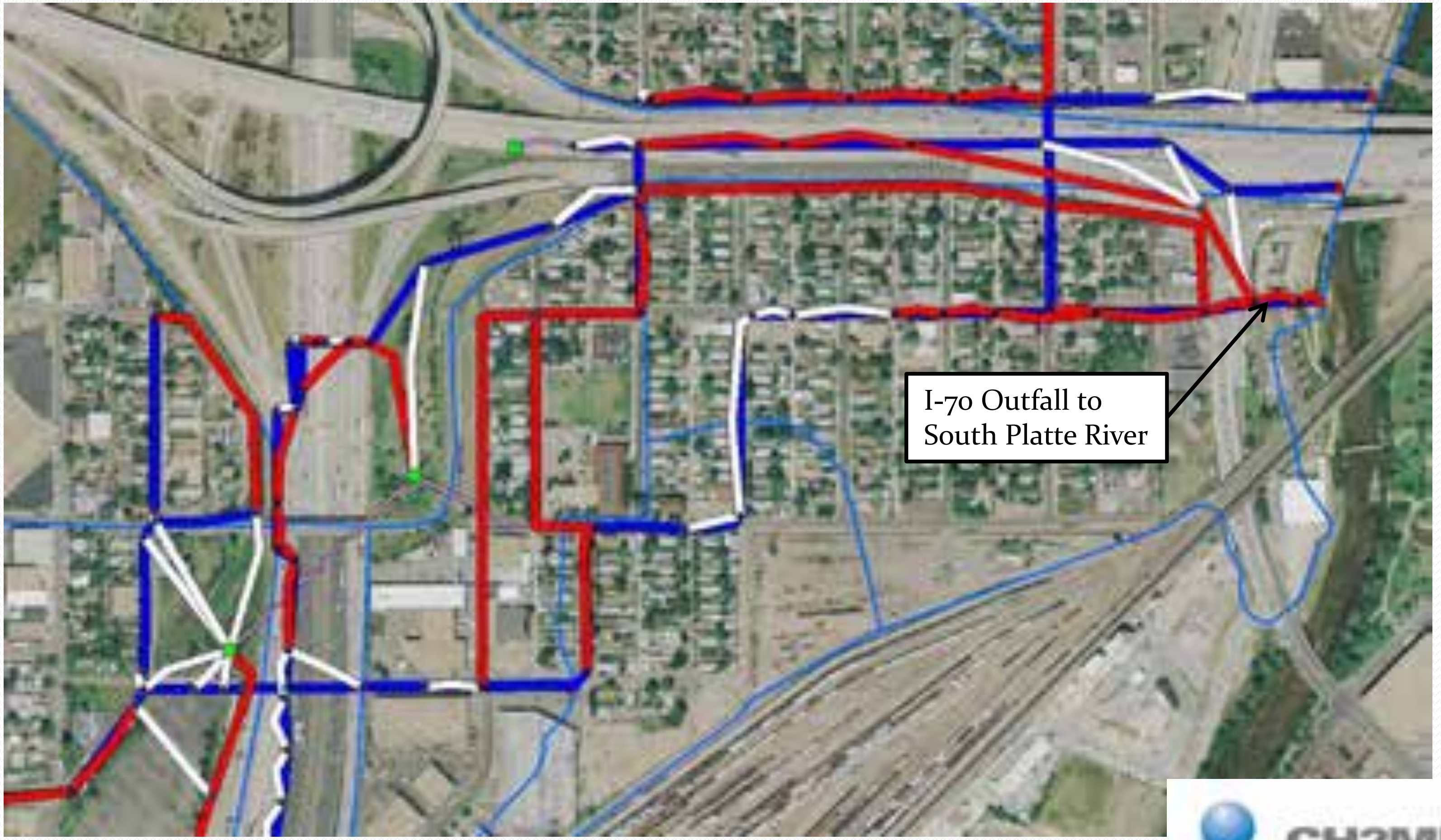
Case Study – I-70 Outfall



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Case Study – I-70 Outfall

- I-70 Outfall
  - Limited overflows from other outfall systems
  - Outfall = 78” RCP
  - Slope = 0.002 ft/ft

	Peak Flow (cfs)	Max/Full Flow Ratio
Kinematic	225	1.0
Dynamic	289	1.4

  - % Increase = 28%
- Increase in peak flow is the result of the dynamic solution

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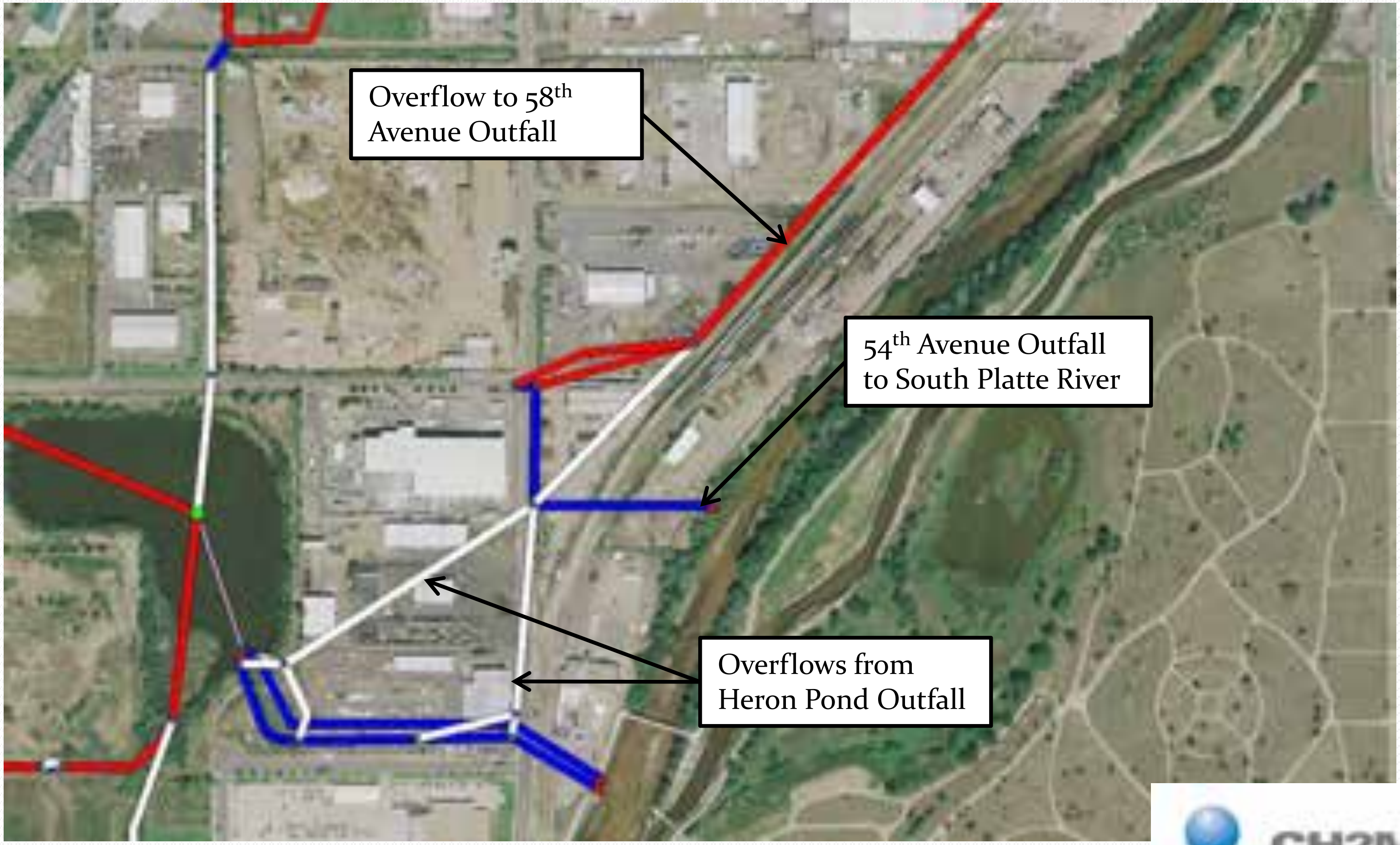
Case Study – 54th Avenue Outfall



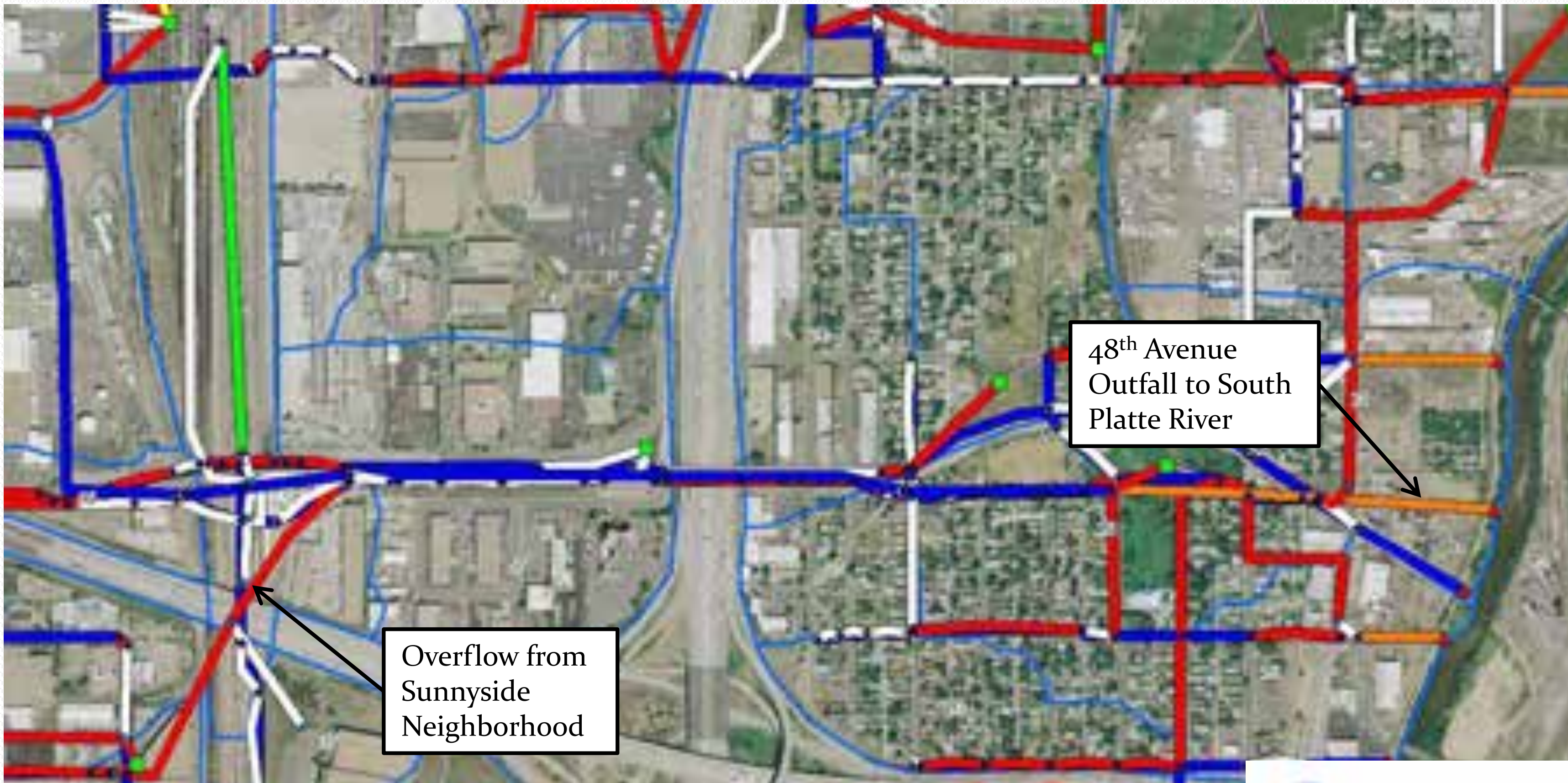
Case Study – 54th Avenue Outfall

- 54th Avenue Outfall to the South Platte River
  - Receives overflows from the Heron Pond outfall and overflows to the 58th Avenue outfall
  - Outfall = 54" RCP
  - Slope = 0.005 ft/ft

	Peak Flow (cfs)	Max/Full Flow Ratio
Kinematic	124	1.0
Dynamic	158	1.4

  - % Increase = 27%
- Increase in peak flow result of the dynamic solution in combination with the overflows

Case Study – 48th Avenue Outfall



Case Study – 48th Avenue Outfall

- 48th Avenue Outfall to the South Platte River
  - Receives overflows from the Sunnyside Neighborhood
  - Outfall = Twin 156” x 72” Box Culvert
  - Slope = 0.0025 ft/ft

	Peak Flow (cfs)	Max/Full Flow Ratio
Kinematic	1374	1.0
Dynamic	1045	0.8

  - % Increase = -24%
- Decrease in peak flow due to eliminating the overflow (421 cfs) from the Sunnyside Neighborhood
- Sunnyside conveys all flow in the dynamic model

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Case Study

- For master planning purposes, using the dynamic wave routing method compared to the kinematic wave routing method resulted in:
  1. Smaller pipes and smaller or fewer detention ponds (with the same level of service, i.e. 10-year storm sewer for both modeling methods)
  2. Smaller pipes, same sized detention ponds, and further reduced pipe sizes downstream of detention ponds (with the same level of service)
  3. Same size pipes and detention ponds (with an increased level of service in the dynamic wave routing method)

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Recommendations and Conclusions

- Kinematic Wave Routing
  - Conservative approach
  - Master Planning
  - Budgets set per Master Plans
  - To be used when planning for risks
  - Steep Slopes
- Dynamic Wave Routing
  - Theoretically less conservative because of less simplifications to the Saint Venant Equations
  - Design
  - Generally reduced pipe sizes and costs when compared to the master plan or increased level of service with the same pipe
  - To be used when determining infrastructure size
    - Pipes with flat slopes

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Recommendations and Conclusions

- Converting from kinematic to dynamic:
  - If the entire model is converted, the pipe size will likely decrease
  - If only a portion of the model is converted, using the kinematic model hydrograph as input into the dynamic model may not be correct
  - Does not account upstream storage, overflows, etc.

Recommendations and Conclusions

- How does this impact floodplain delineation?
  - Surface flooding:
    - Kinematic routing results in greater flows on the surface
    - More conservative floodplain delineation
  - Pipe outfalls:
    - Kinematic routing results in a more peaked hydrograph
    - Dynamic routing can result in higher peak flows

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Questions?

Aaron Cook, P.E.
CH2M Hill
Aaron.Cook@ch2m.com

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GRAVEL PIT BERM FAILURE ANALYSIS

USING NRCS WINDAM B DAM- FAILURE EROSION MODEL

DOUGLAS TRIESTE, P.H.
FLOW TECHNOLOGIES
BRECKENRIDGE, CO

VARRA COMPANIES, INC
FREDERICK, CO

PROJECT OVERVIEW

- NEW GRAVEL PIT MINE PROPOSED ALONG CLPR EAST OF GREELEY BY VARRA COMPANIES, INC IN 100-YR FLOODPLAIN
- MINING OPERATIONS WILL RESULT IN FORMATION OF RIVERSIDE AND LATERAL BERMS
- BERM WIDTH CRITICAL FOR MINING OPERATIONS
  - <u>TOO NARROW</u> – POSSIBLE FAILURE AND CAPTURE OF THE RIVER
  - <u>TOO WIDE</u> – LOSS OF ACCESS TO VALUABLE GRAVEL; LOST REVENUE

VICINITY MAP

LOCATION MAP

STUDY PURPOSE

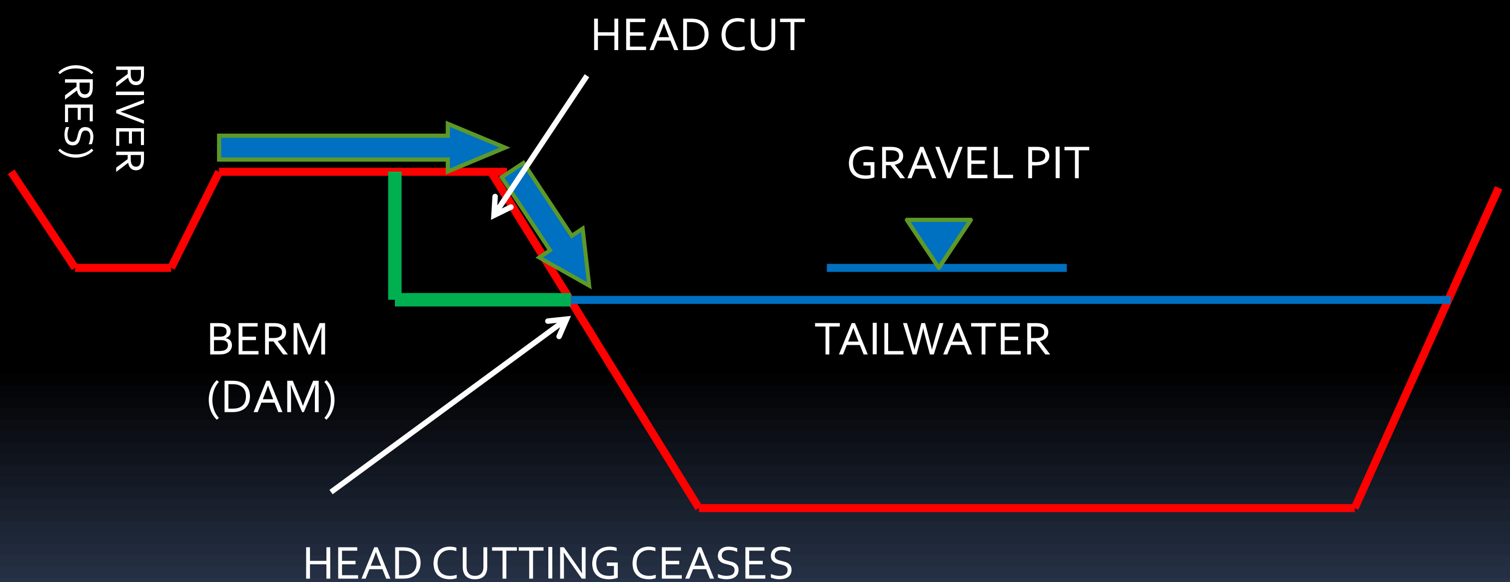
APPLY A DAM-BREACH EROSION MODEL (WINDAM B) TO A GRAVEL PIT BERM TO EVALUATE IMPACTS FROM FLOOD

BERMS AND INFLOW

RIVERSIDE BERM

LATERAL BERM

DAM VS. RIVERSIDE GRAVEL PIT BERM



DAM VS. RIVERSIDE GRAVEL PIT BERM

- BERM PERFORM S AS “EMBANKMENT DAM” BETWEEN RIVER AND PIT
- BERM CREST ELEV = “DAM” CREST ELEV
- BERM CREST WIDTH = “DAM” CREST WIDTH
- PIT D/S FACE = “DAM” D/S FACE
- PIT U/S FACE = “DAM” U/S FACE
- BERM AND DAM MATERIALS BOTH EARTHEN

STUDY APPROACH – 1/4

INFORMATION NEEDED FROM DAM BREACH EROSION MODEL INCLUDES:

- HEAD CUT LENGTH
- HEADCUT DEPTH
- HEADCUT WIDTH
- HEAD CUT TIME PROGRESSION TOWARD RIVER

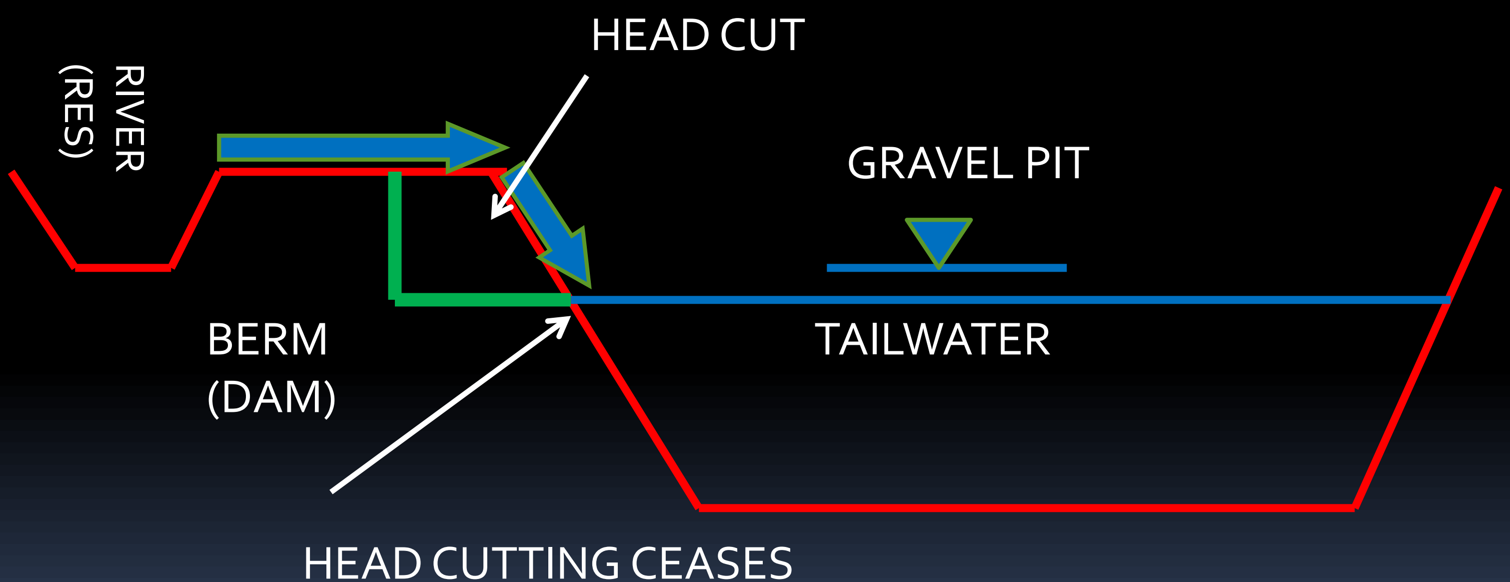
STUDY APPROACH – 2/4

DETERMINE PIT RATE OF FILL & WATER SURFACE ELEVATION DURING FLOOD BASED ON CHANNEL OVERBANK AND FLOODPLAIN INFLOW, AND GROUNDWATER INGRESS

STUDY APPROACH – 3/4

- COMPARE PIT FILL TIME TO BERM HEAD CUT BOTTOM ELEV
- WHEN PIT WATER SURFACE ELEVATION EQUALS THAT OF THE BOTTOM OF HEAD CUTTING ELEVATION, HEAD CUTTING/EROSION WILL CEASE
- HEAD CUT LENGTH IN WINDAM OUTPUT; DETERMINED FROM TIME HEAD CUT CEASES

DAM VS. GRAVEL PIT



STUDY APPROACH – 4/4

AFFECT OF DURHAM PIT (LOCATED IMMEDIATELY UPSTREAM FROM THE SITE IN FP WAS INCLUDED IN THE ANALYSIS BECAUSE RIGHT FP FLOW HAS TO ENTER AND FILL THE PIT BEFORE THAT FLOW CAN BE A COMPONENT OF COULSON FILL TIME

PROCEDURE MAY BE

UNPRECEDENTED

MUCH TO LEARN AND DEVELOP

CRITICAL AREAS

- EXTRACTION PLAN WILL YIELD TWO “GROINS
- RECEIVE CONCENTRATED FLOW ONCE THE RIVER OVERTOPS ITS BANKS
- EVALUATE HEAD CUTTING/EROSION AT GROINS

CRITICAL AREAS

WinDAM B Earthen Embankment Overtopping Analysis Software

Agricutural Research Service

NRCS Natural Resources Conservation Service

Kansas State University

WinDAM B Software
Estimating Erosion of Earthen Embankments and Auxiliary Spillways of Dams
short url for this page: http://go.usa.gov/8Oq

WINDAM B

JOINTLY DEVELOPED BY AGRICULTURAL RESEARCH SERVICE (ARS) AND NATIONAL RESOURCE CONSERVATION SERVICE (NRCS)

WINDAM B

- MODULAR SOFTWARE APPLICATION FOR THE ANALYSIS OF OVERTOPPED EARTHEN EMBANKMENTS (<u>GRAVEL PIT BERMS IN THIS CASE</u>)

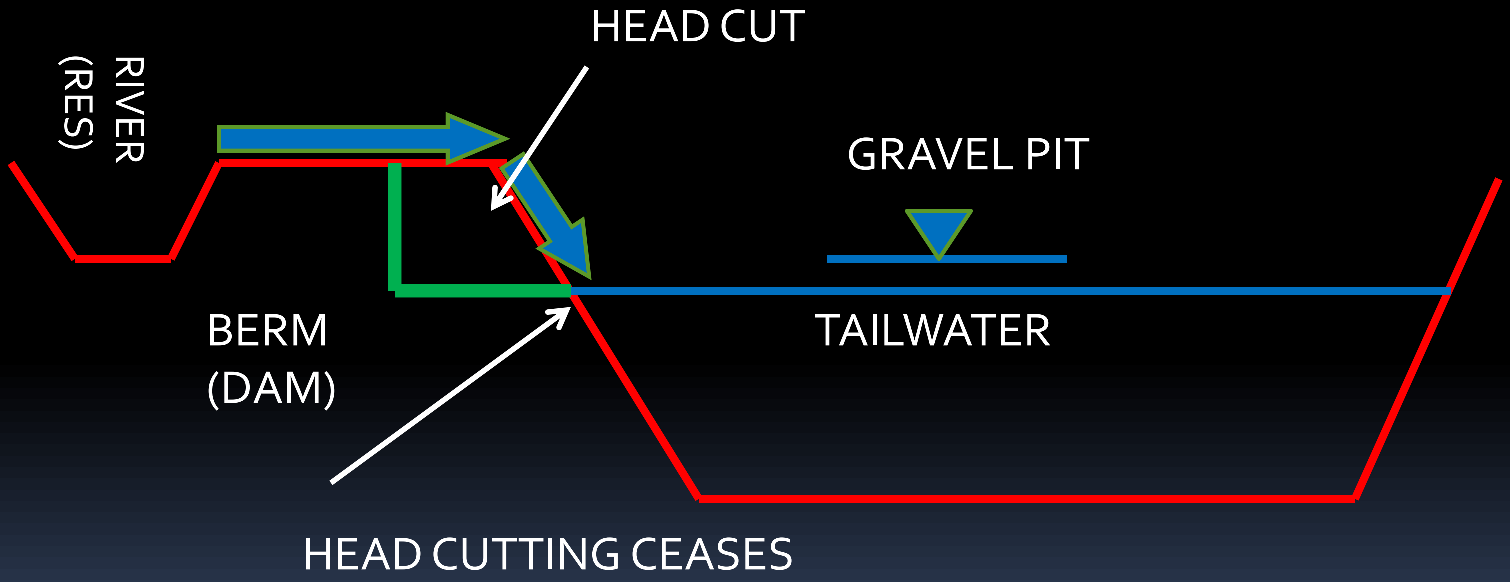
- EVALUATES EROSIONAL FAILURE OF AN EMBANKMENT THROUGH OVERTOPPING

- EVALUATES POTENTIAL FOR VEGETATION OR RIPRAP TO DELAY OR PREVENT FAILURE OF THE EMBANKMENT

APPLICATION OF WINDAM B TO GRAVEL PIT BERMS

- BERM TREATED AS AN EARTHEN DAM
- BERM WIDTH = DAM CREST
- SIDE OF PIT = FACE OF A DAM
- SITE-SPECIFIC SOIL PHYSICAL PARAMETERS
- HISTORIC FLOOD INFLOW HYDROGRAPH (BT, 1976)

DAM VS. GRAVEL PIT



APPLICATION OF WINDAM B TO GRAVEL PIT BERMS

- EVALUATE BERM HEAD CUTTING LENGTH/WIDTH
- “WHAT IF” SCENARIOS
- PLANNING AND DESIGN
- SANITY CHECK FOR BERM FAILURE
- NOT EXACT SCIENCE - BUT, WHAT IS WITH REGARD TO NATURAL PROCESSES?

WinDAM B Capability

- Hydraulics
  - Route 1 hydrograph through 1 dam
- Estimate erosion
  - 1-3 earth or vegetated aux spillways
  - Overtopping erosion of earthen embankment

Overtopping Erosion

- Earthen embankment
- Homogenous fill, not zoned
- Slope protection
  - Bare soil
  - Grass
  - Riprap

BASIC WINDAM B INPUT

- DAM PHYSICAL DIMENSIONS
- DAM GEOTECHNICAL COMPOSITION
- DAM SURFACE DESCRIPTION
- SLOPE PROTECTION
- INFLOW HYDROGRAPH
- RESERVOIR ELEVATION-CAPACITY
- PRIMARY & AUXILIARY SPILLWAY

FOUR-STAGE BREACH EROSION MODEL

FOUR-STAGE BREACH EROSION MODEL

FOUR-STEP PROCESS

1.HEAD CUT FORMATION

2. HEAD CUT ADVANCE THROUGH CREST

3. HEAD CUT ADVANCE THROUGH RESERVOIR (RIVER)

4. BREACH WIDENING

GEOTECHNICAL COMPOSITION

MUST BE CHARACTERIZED

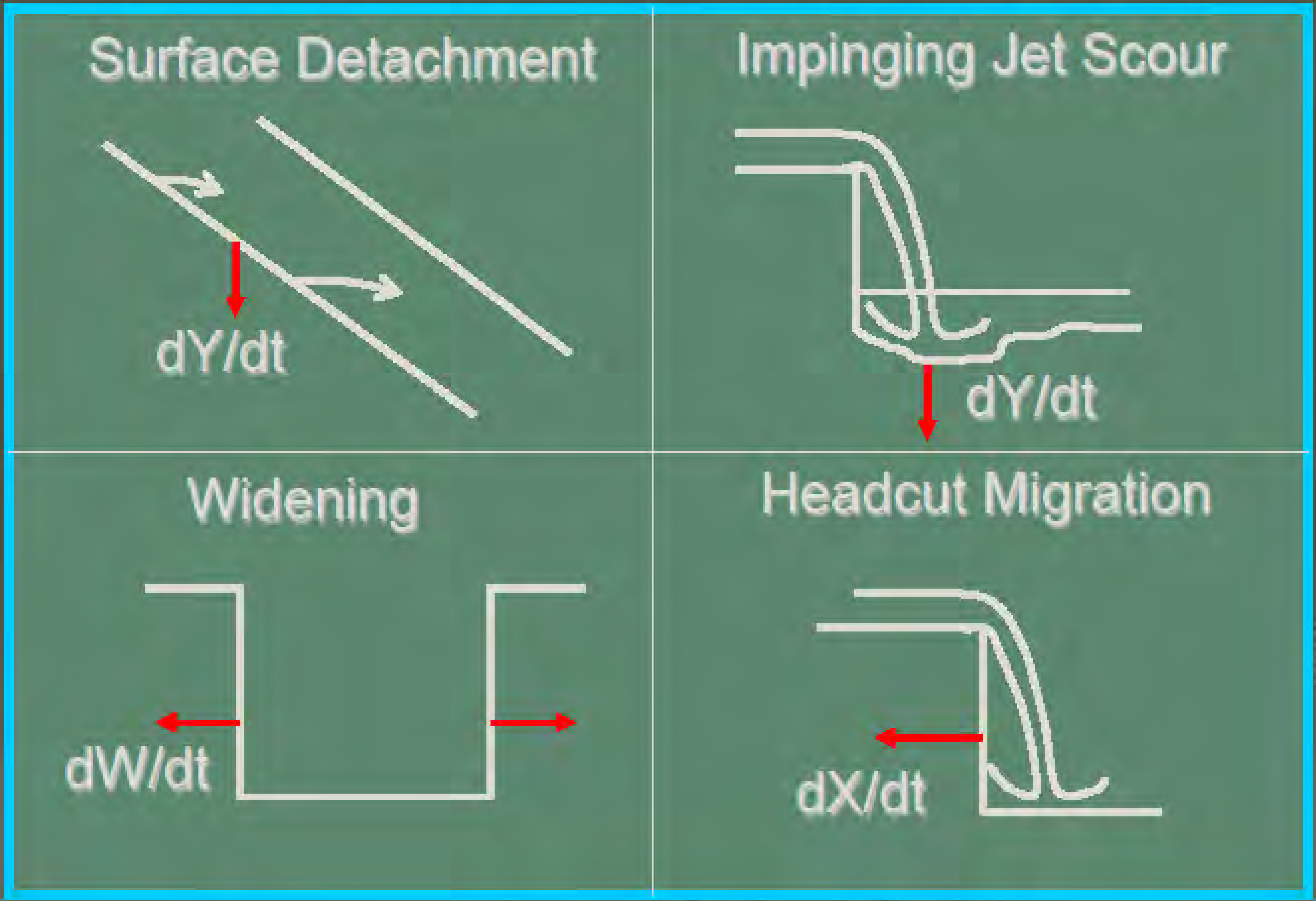
- Erodibility index (Resistance of geologic materials)
- Representative particle size
- Percent clay fraction
- Plasticity index
- Total unit weight
- Undrained shear strength
- Critical shear stress

HEAD CUTTING/EROSION CALCULATIONS

BASED ON EXCESS STRESS

EQUATIONS

Key Embankment Erosion Processes



Embankment Breach
STAGE 1 – Phase 1

Initial Overtopping & Vegetal Failure

Embankment Breach
STAGE 1 – Phase 2

Headcut development

Downcutting

$$\boxed{dY/dt = k_d(\tau - \tau_c)}$$

Widening

$$\boxed{dW/dt = 1.4k_d(\tau - \tau_c)}$$

Transition to Stage 2
When $Y \geq d_c$

Embankment Breach
STAGE 2

Headcut Advance
Through dam crest

Advance

1) $dX/dt = C(A)$
(Energy Based)
or
2) $dX/dt = H k_d(\tau_e - \tau_c)/2E_v$
(Stress Based)

Widening

$dW/dt = dX/dt$

Downcutting

$dY/dt = k_d(\tau_e - \tau_c)$

Embankment Breach
STAGE 3

Headcut advance into reservoir
BREACH DEVELOPMENT

Advance

$$dX/dt = \text{Stage 2 model}$$

or

$$dX/dt = Z(dY/dt)$$

Widening

$$dW/dt = dX/dt$$

$$dW/dt = 1.4 k_d(\tau - \tau_c)$$

Downcutting

$$dY/dt = k_d(\tau - \tau_c)$$

Embankment Breach STAGE 4

Breach Widening

Widening

$$dW/dt = 1.4 k_d (\tau - \tau_c)$$

SENSITIVITY ANALYSIS

- THREE SOIL PARAMETER CASES
  - Weakest (most erosion)
  - Best (mid-way)
  - Strongest (least erosion)

COULSON PIT FILL TIME COMPUTATION

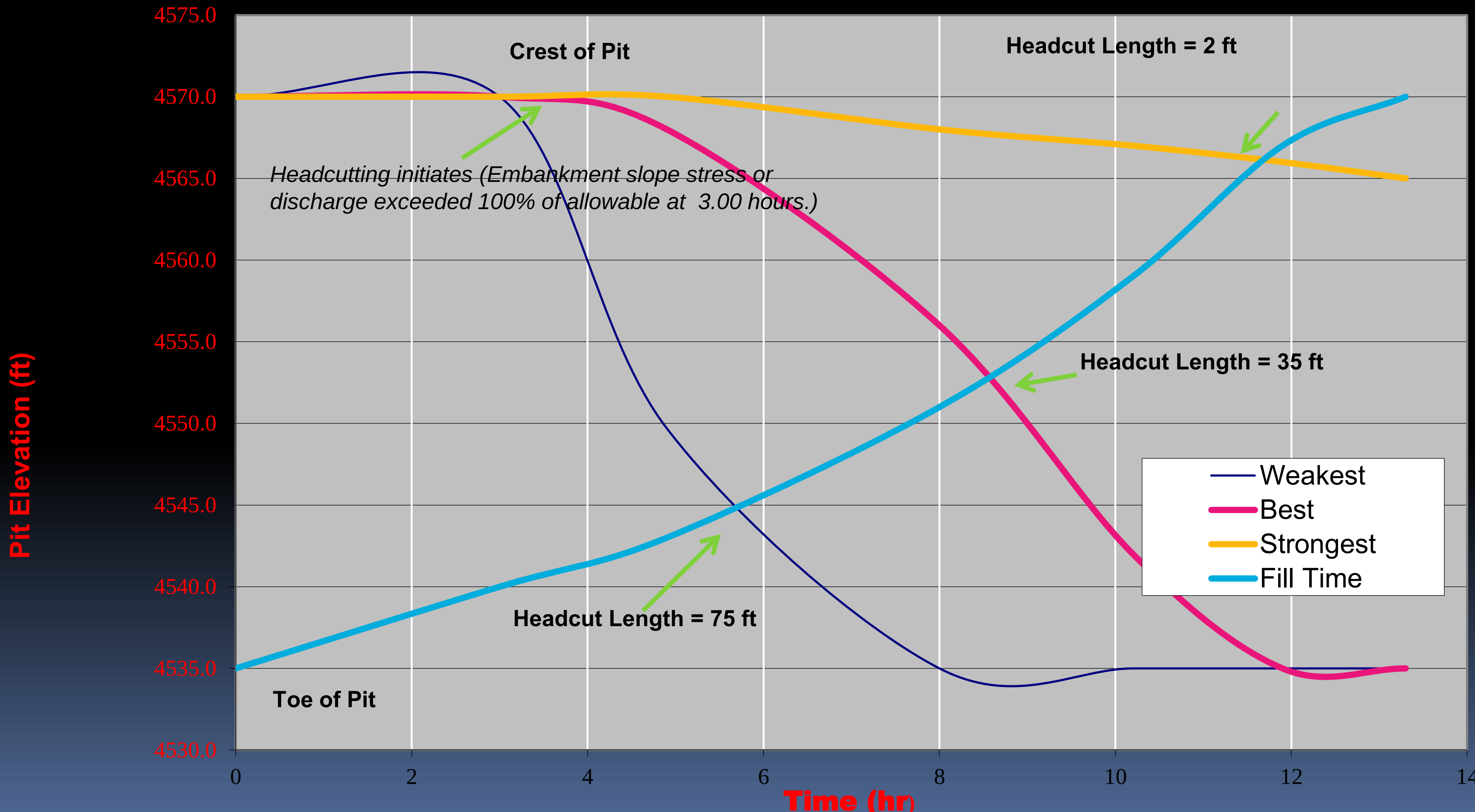
- BOTH DURHAM AND COULSON PITS EMPTY (CONSERVATIVE SCENARIO)
- WITH DURHAM PIT EMPTY, THERE WILL BE MORE TIME FOR HEAD CUTTING/EROSION INTO COULSON PIT ALONG THE RIVERSIDE BERM
- DURHAM PIT FULL WITH COULSON PIT EMPTY (LIBERAL SCENARIO)
- COULSON PIT FILL TIME IS DEPENDENT ON THE VOLUME OF WATER IN DURHAM PIT DUE TO FP INFLOW

DESIGN HYDROGRAPH

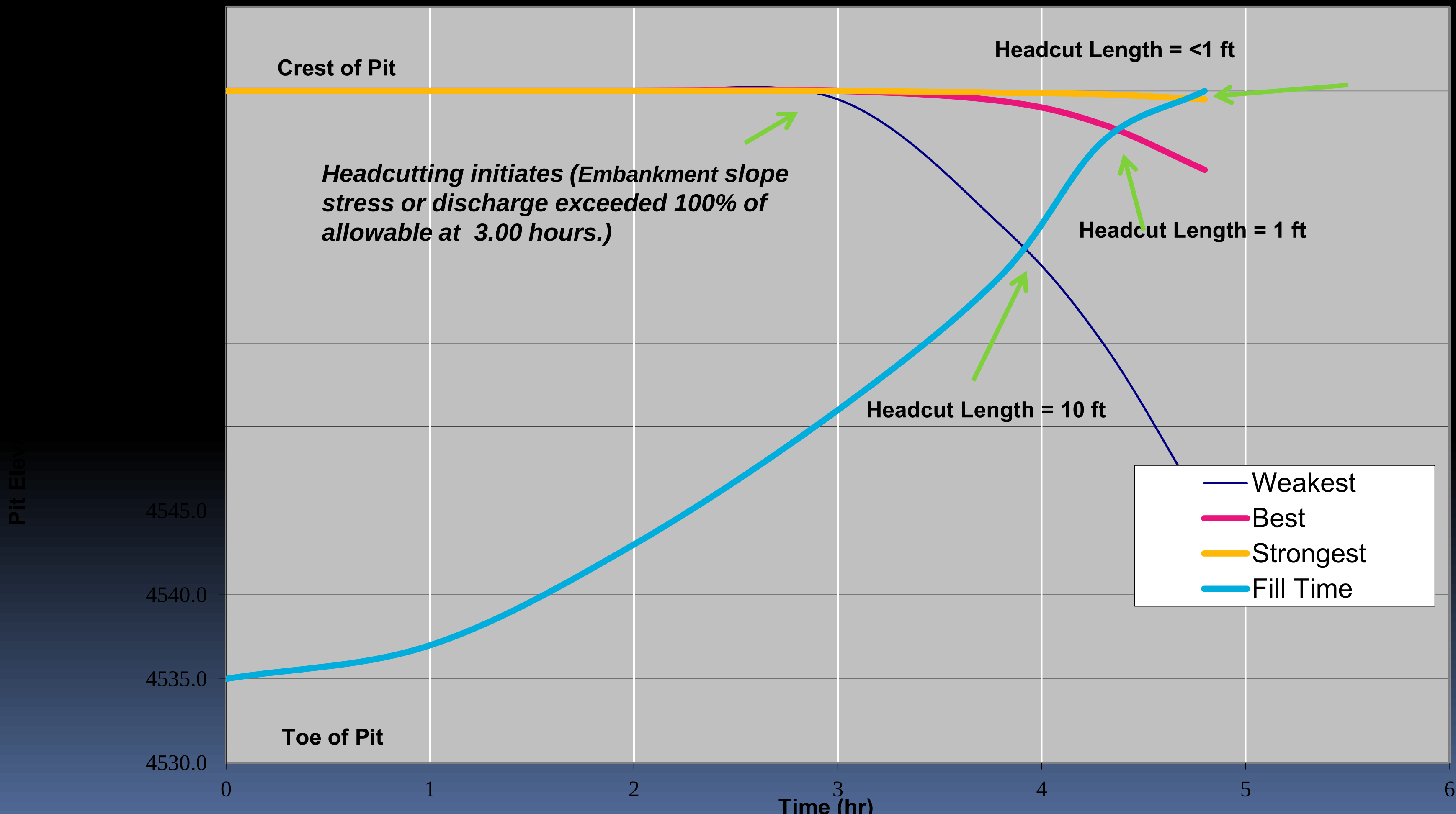
- HYDROGRAPH BASED ON CLPR (CONFLUENCE) JULY 31 1976 FLOOD
- REALISTIC RIVER RESPONSE TO A LARGE, FLASHY FLOOD AT THE SITE
- SAME STORM THAT RESULTED IN THE BIG THOMPSON FLOOD

RESULTS

RIVERSIDE BERM HEAD CUTTING BOTH PITS EMPTY

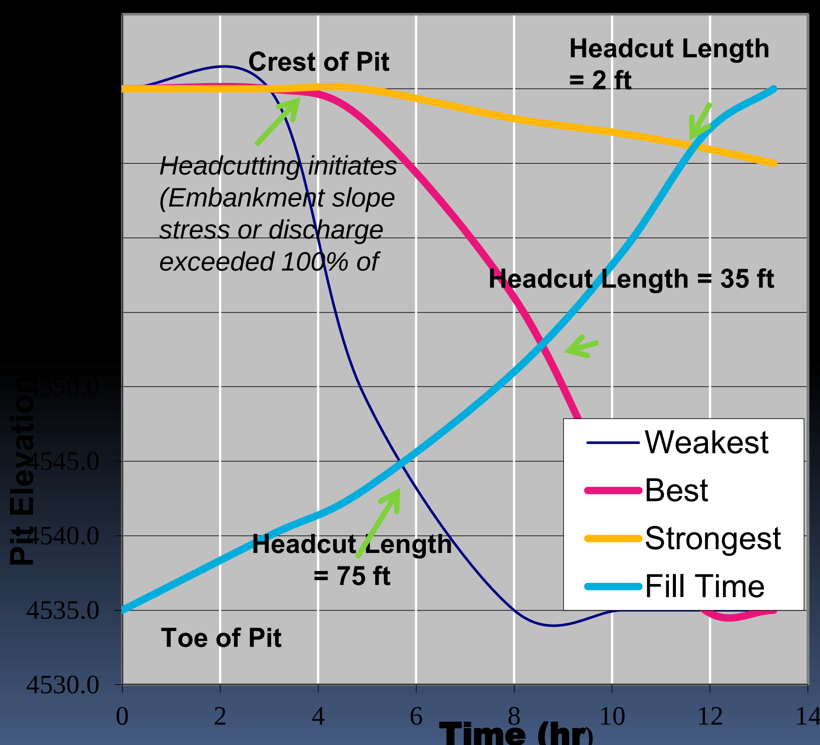


RIVERSIDE BERM HEAD CUTTING DURHAM PIT FULL, COULSON EMPTY

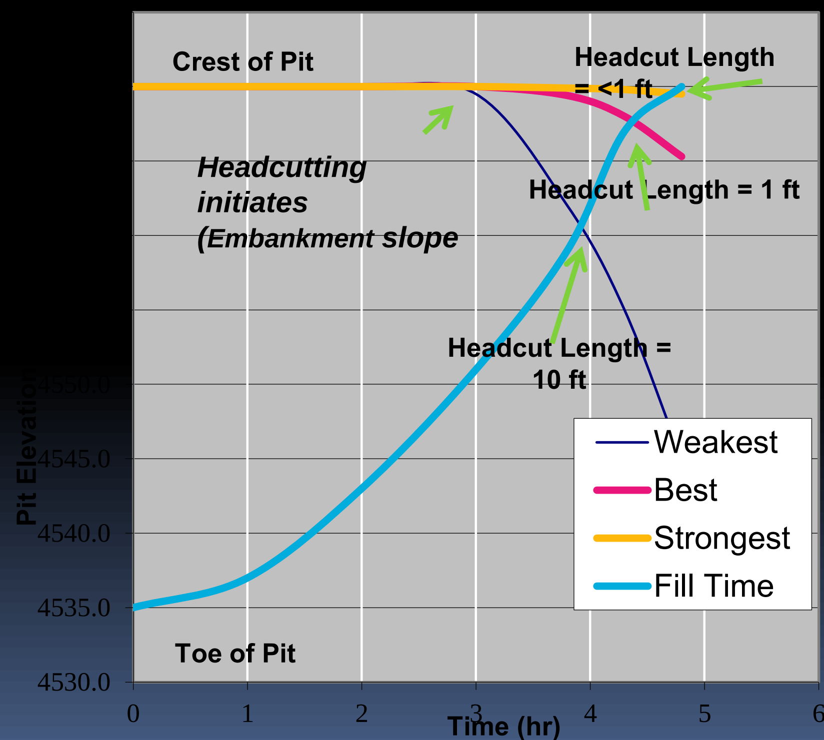


RESULTS COMPARISON

BOTH PITS EMPTY



DURHAM FULL, COULSON EMPTY



CONCLUSIONS

- HEADCUTING LENGTH – 10 FT TO 35 FT (BEST SOIL PARAMETER CASE)
- HEADCUTING LENGTH – 2 FT TO < 1 FT (STRONGEST SOIL PARAMETER CASE)
- HEADCUTING LENGTH – 75 FT TO 10 FT (WORSE SOIL PARAMETER CASE)

CONCLUSIONS

- RESULTS OFFER HIGH LEVEL OF CONFIDENCE THAT A 100-FT RIVERSIDE BERM WIDTH IS SUFFICIENT


WELL, THIS ABOUT SUMS UP EVERYTHING I KNOW

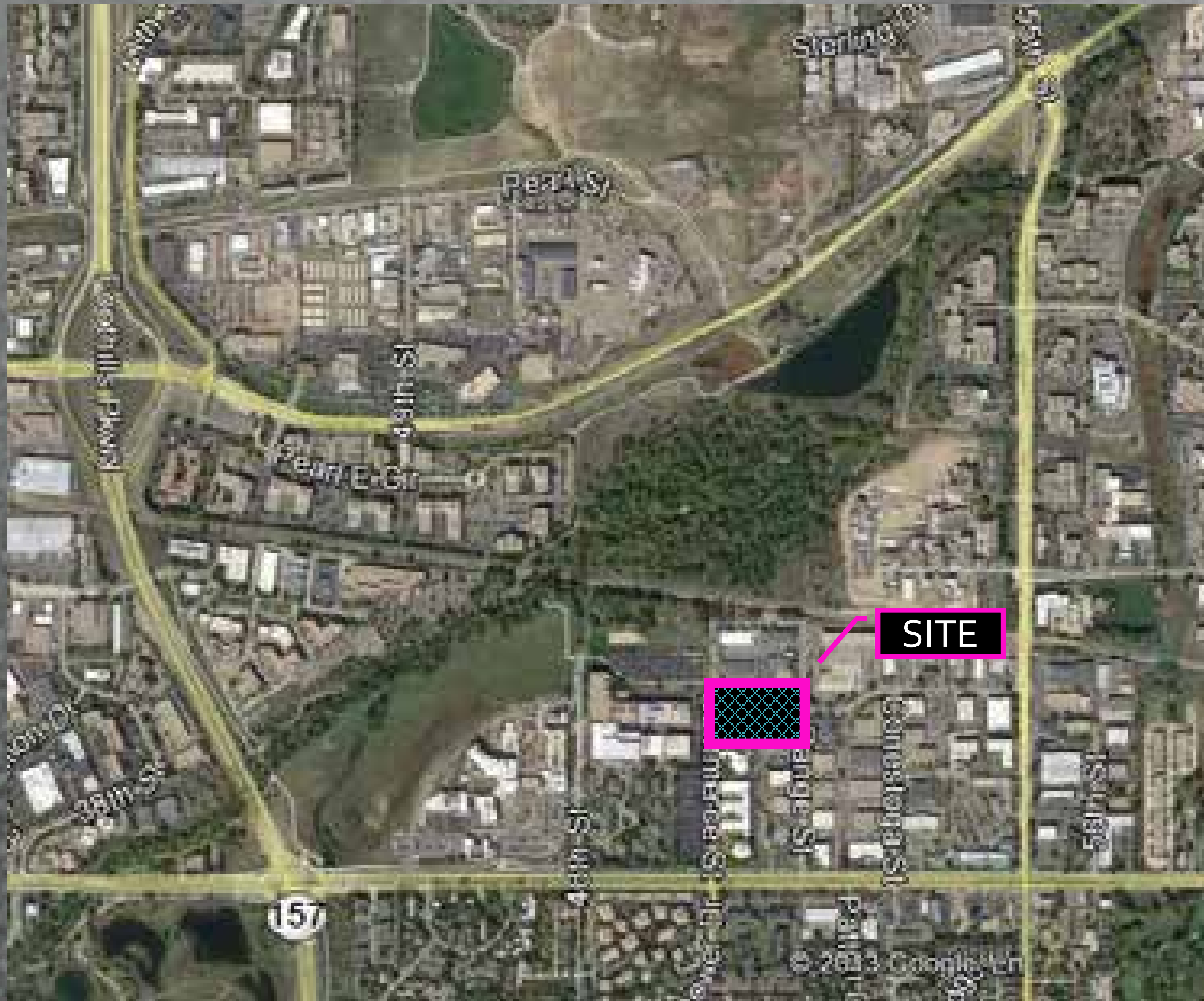
A NEW GENERATION OF PARKING LOT: POROUS ASPHALT AT BALL AEROSPACE

CASFM CONFERENCE 2013

DEBBIE FISHER, P.E., CFM, WRIGHT WATER ENGINEERS

NEW GENERATION OF PARKING LO

- BALL AEROSPACE POROUS PARKING LOT
- BOULDER, COLORADO
- COMPLETED FALL, 2012



ACKNOWLEDGMENTS

- Ball Aerospace – Project owner
- Martin/Martin, Inc. – Engineer of record
- RNL Architects – Land planning and landscape design
- Colorado Asphalt Paving Association (CAPA) – Design and construction services
- National Asphalt Paving Association (NAPA) – Asphalt specifications
- City of Boulder Engineering Staff
- Ground Engineering – Geotechnical testing (percolation)
- GH Phipps- General contractor
- CPI Group – Construction management
- Gilbert Contracting, Inc.. – Construction
- Tom Cahill, P.E., Cahill & Associates – Design guidelines and review

RESEARCH CONDUCTED

- Tom Cahill, P.E. of Cahill & Associates
  - Experience with porous asphalt in Pennsylvania for over 30 year
  - Provided guidance, specifications, details, and review of design
- Site visits and discussions with owners of porous asphalt installations
  - Federal Center
  - Golden Fire Department
- Review of numerous publications
- Discussions with pavement contractors and suppliers
- Design and construction guidance from CAPA and NAPA representatives
- David Hein, P.Eng., Principal Pavement Engineer VP of Transportation, ARA (Applied Research Associates),Chair, ASCE T&DI Permeable Pavement Structu Design Committee
  - •Design assistance and review

PUBLICATIONS USED

ormwater Magazine, *Pervious Pavement New Findings About Their nctionality and Performance in Cold Climates*, September, 2008.

ormwater Magazine, *Porous pavements Q&A*, September, 2009.

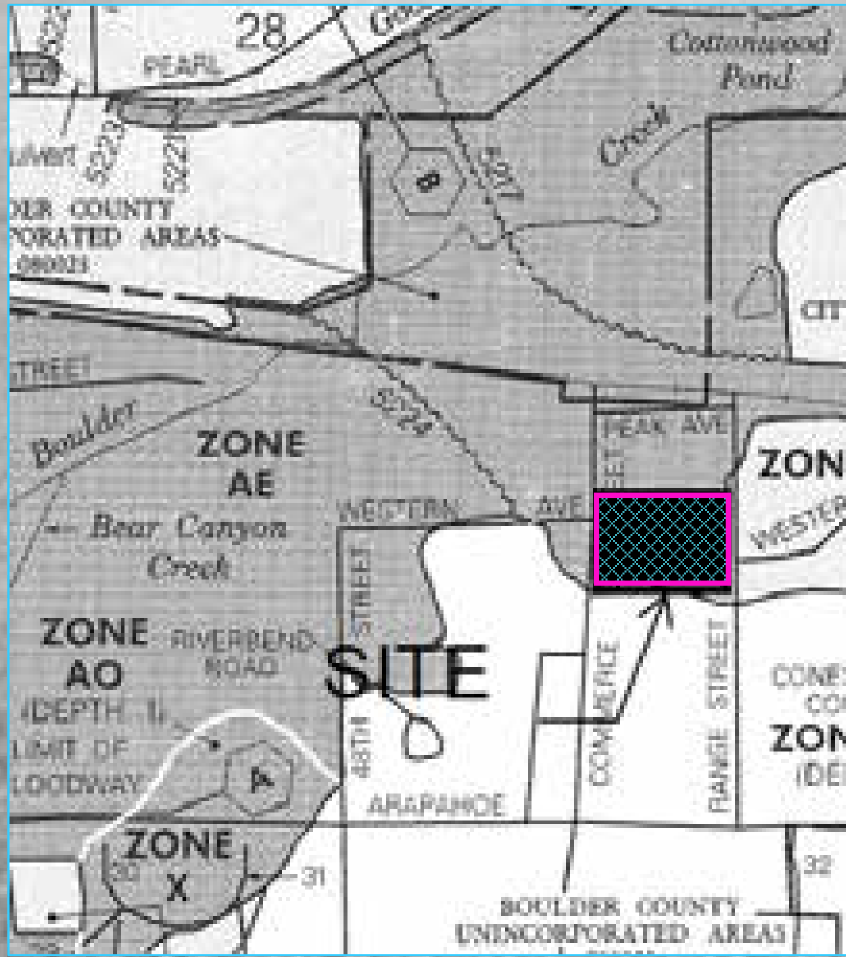
ater Quality and Hydrologic Performance of a Porous Asphalt Pavement a Stormwater Treatment Strategy in a Cold Climate, by Robert M. seen M.ASCE, Thomas P. Ballestero, M.ASCE, James Houle, Joshua F. ggs, Kristopher M. Houle, November 22, 2009.

rous Asphalt Pavements by the national Asphalt Pavement Association.

ormwater Magazine, *Porous Asphalt Pavement with Recharge Beds – Years and Still Working*, by Michelle Adams, May-June, 2003.

SITE CONDITIONS

- Site is in floodplain– Flood elevation up to 3 ft above existing surface
- No detention or water quality existed prior to construction
- Type A hydrologic soil with good permeability



WHY WE CHOSE POROUS ASPHALT

- Solutions to multiple site issues
  - Cost effective
  - Fill required to elevate site
  - Meeting slope and entrance requirements
  - Providing 288 spaces to meet site review requirements
    - using space for detention/water quality would have required structured parking
    - or acquisition of additional land
- Meets UDFCD parameters
  - Expected clogging sources are minimal
  - Traffic volume is low
  - Ball is committed to regular and appropriate maintenance

CONSIDERATIONS

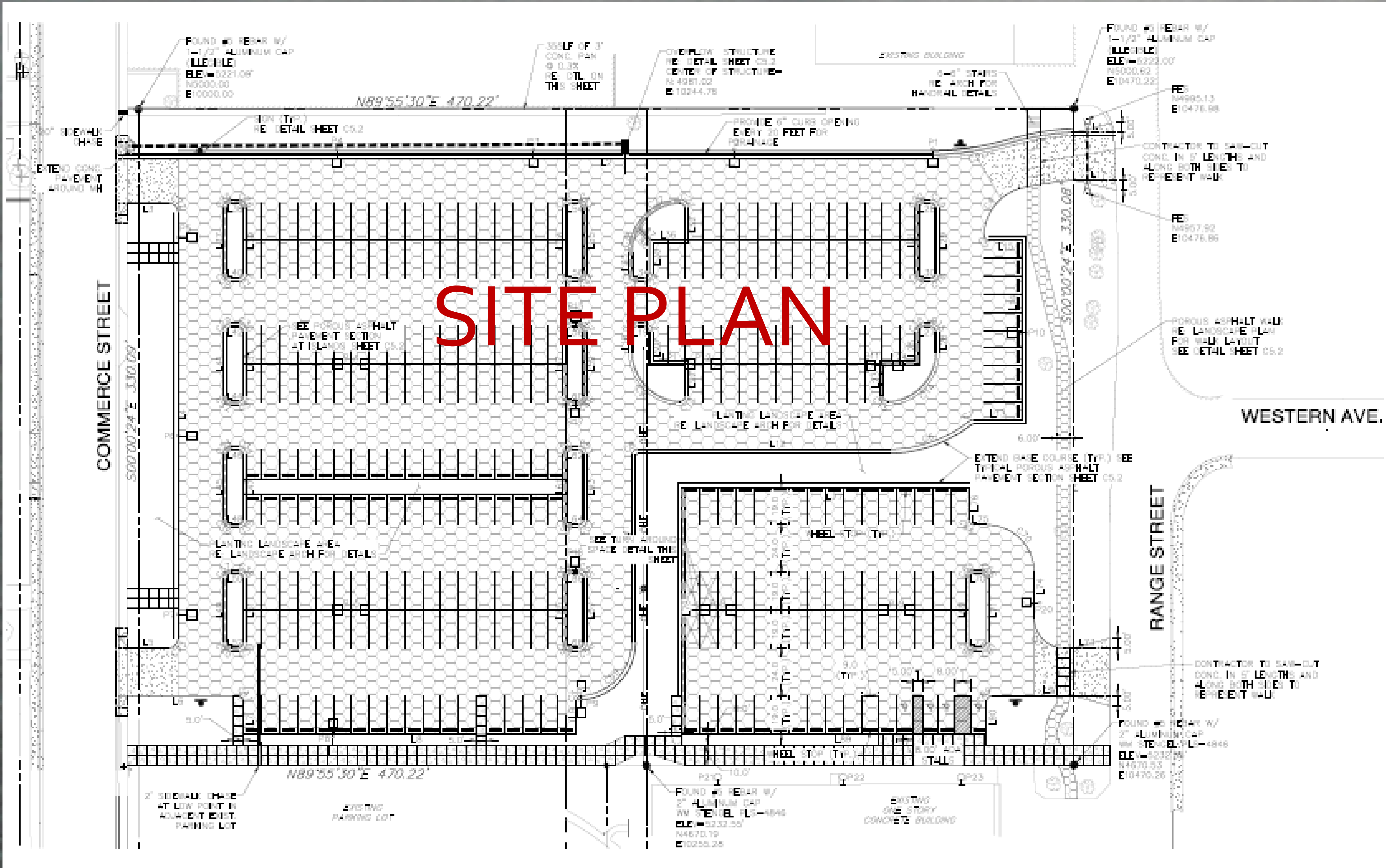
TRADITIONAL ASPHALT

- 69% Impervious overall
- 0.1 AC FT of WQCV
- Difficult to get adequate WQCV or detention depth due to groundwater
- Storm sewer and concrete pans
- Area required for WQCV and/or detention not readily available
- 3 Ponds and release structures
- Possible detention
- Loss of up to 40 parking spaces, requiring structure or more land

POROUS ASPHALT

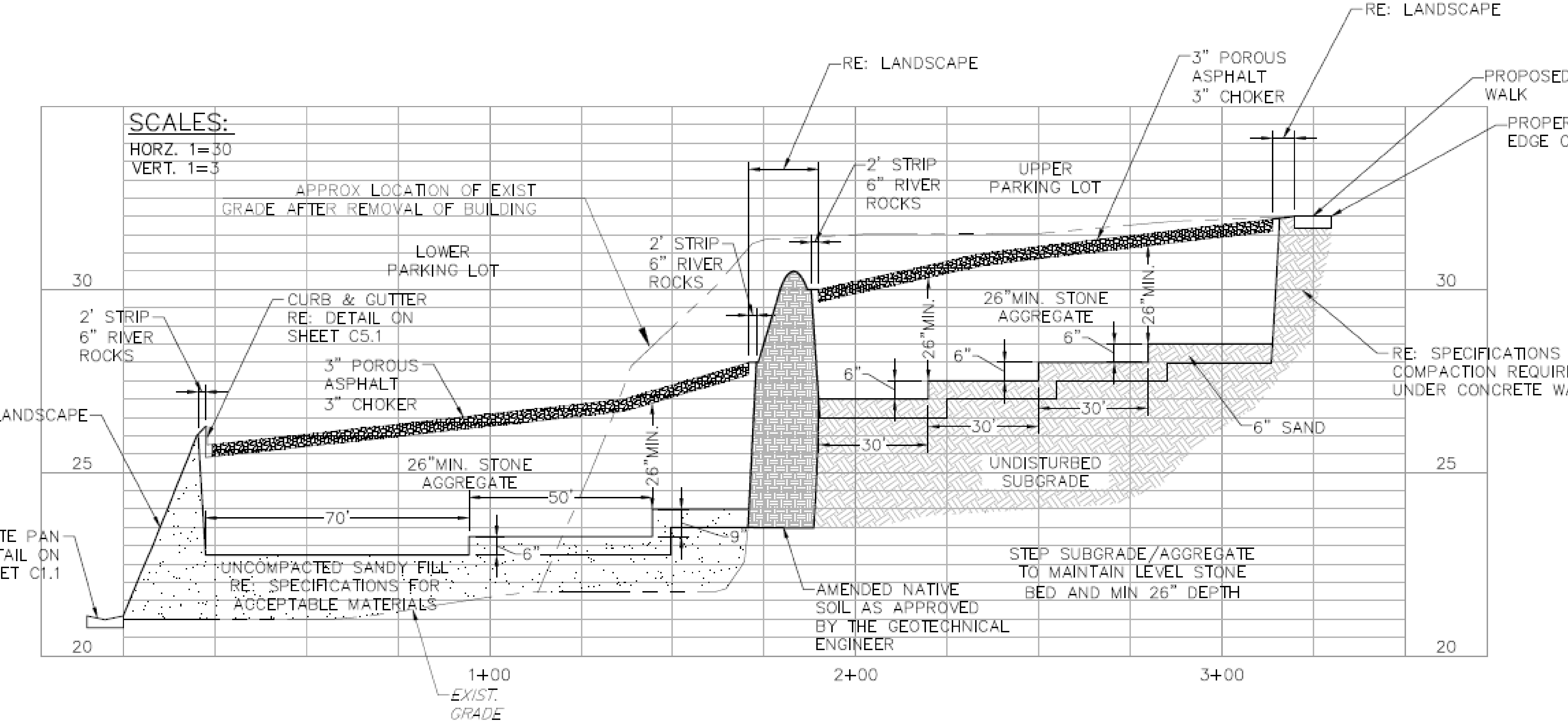
- **22% Impervious overall**
- **.04 AC FT of WQCV**
- **Grading can be much flatter (used 1% for added insurance)**
- **No storm sewer required**
- **No ponds required**
- **One simple release/overflow structu**
- **No loss of parking or need for structure or more land**
- **No ponding**

SITE PLAN

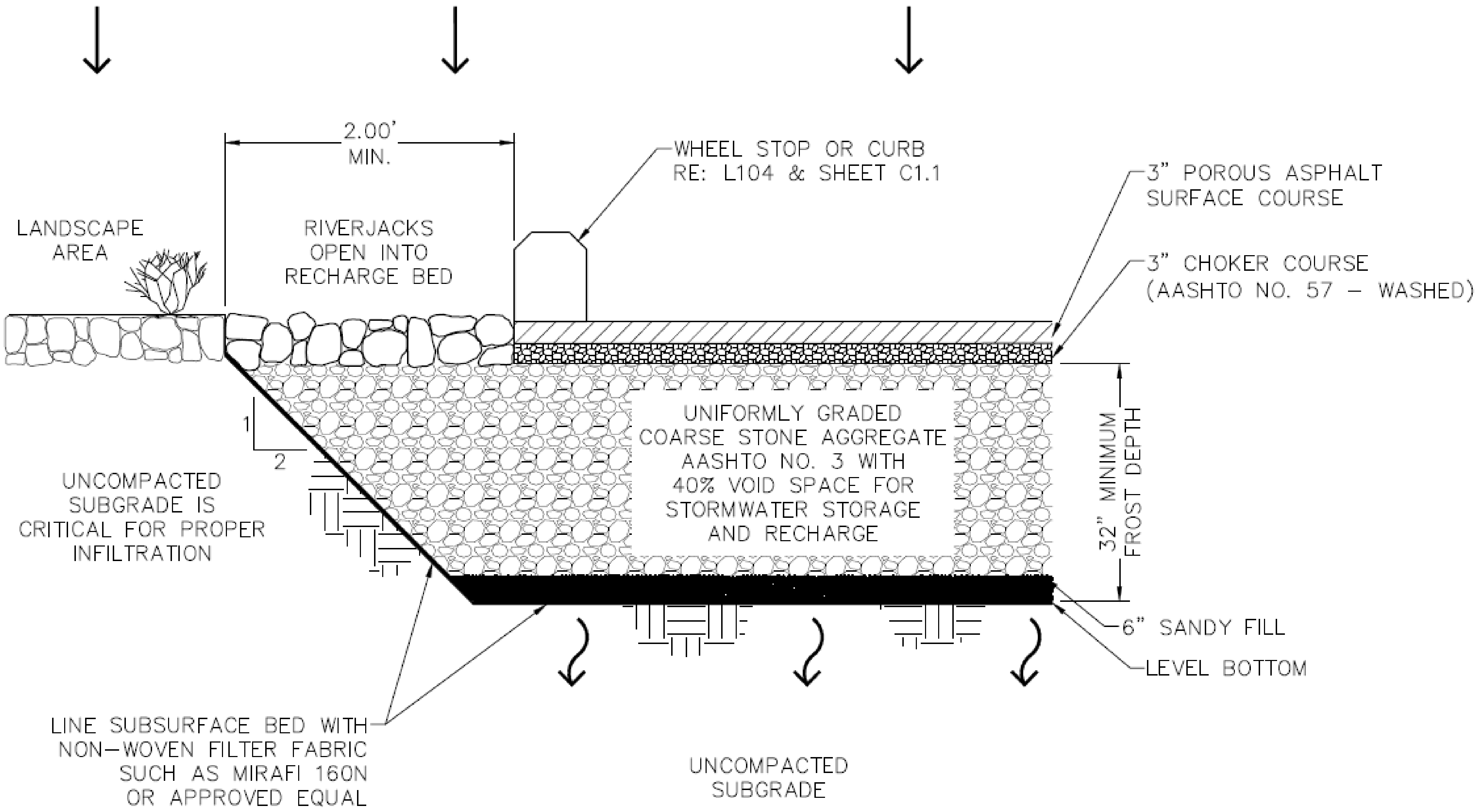


COMMERCE STREET
WESTERN AVE.
RANGE STREET
N89°55'30"E 470.22'
S00°00'24"E 330.09'
S00°00'24"E 330.08'
EXISTING BUILDING
EXISTING PARKING LOT
EXISTING ONE STORY CONCRETE BUILDING

CROSS-SECTION



SUBGRADE/AGGREGATE
CROSS–SECTION A–A
NTS



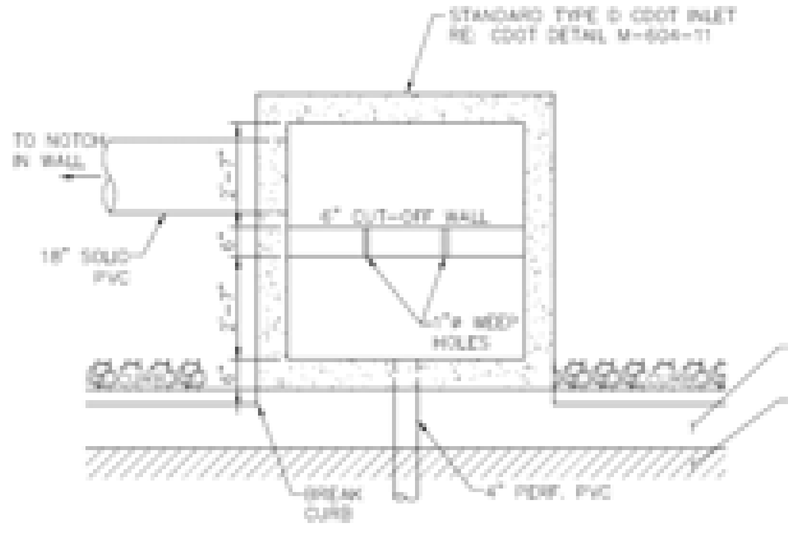
TYPICAL POROUS ASPHALT PAVEMENT SECTION

N.T.S.

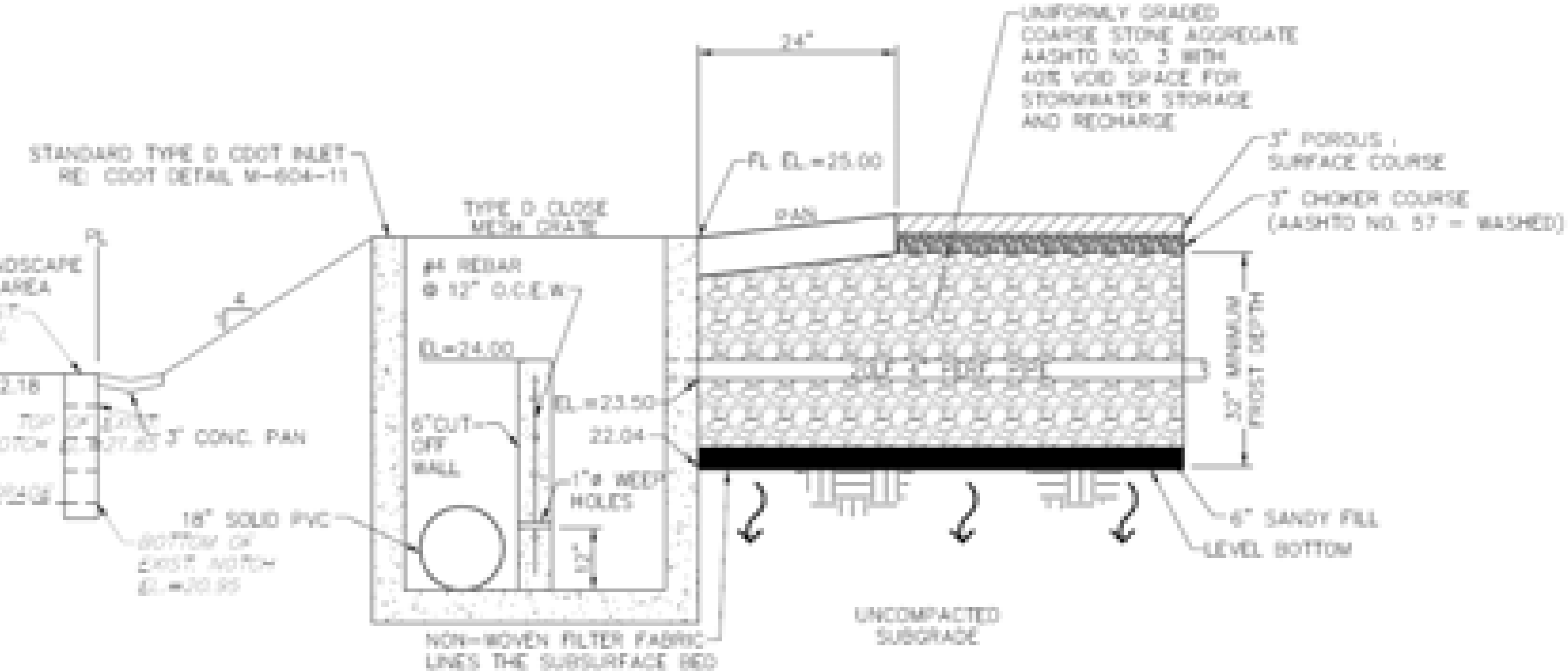
MATERIALS

- Uncompacted subgrade
- Mirafi 160N filter fabric
- Sand – CDOT Class C filter material
- Rock base: 2-3” fractured-face
- Choker course – AASHTO #57, washed
- Asphalt mix targeted 24% air voids
- Binder PG 64-22

OVERFLOW STRUCTURE



MODIFIED CDOT TYPE D
OVERFLOW STRUCTURE
PLAN VIEW
N.T.S.



MODIFIED CDOT TYPE D
OVERFLOW STRUCTURE
SECTION C-C
N.T.S.

KEY COMPONENTS DURING CONSTRUCTION

- EXPERIENCED CREW THAT UNDERSTANDS POROUS ASPHALT
- GOOD OVERSIGHT
- IMPORTANCE OF SEQUENCING
- MINIMAL COMPACTION
- LANDSCAPING BEFORE PAVING
- PROPER ASPHALT MIX
- GOOD GRADE CONTROL
- MINIMAL ROLLING

1 - OVERLOT GRADING

2 – ISLANDS AND UTILITIES

3 - RELEASE STRUCTURE

4 -PERMEABLE SOIL BARRIER, SAND

ROCK BED

CHOKER COURSE

POROUS ASPHALT TOPPING

MINIMIZE ROLLING

COMPLETED PHOTOS

COSTS AND SAVINGS

- $1500 Per parking space to construct
- Eliminated storm sewer pipe, inlets, pans (saved approx. $200/space)
- Eliminated water quality and detention structures (saved approx. $200/space)
- No loss of land, structure, or additional land purchase required
- Saved $570 per space on stormwater plant investment fee(sq. ft. fee applied to impervious surfaces)
- Annual savings of approx. $6000 on stormwater fee (sq. ft. fee applied to impervious surfaces – approx. $400-$500 per space over 20 years)
- Maintenance – Vacuuming vs. crack-sealing, seal-coating, rotomil and overlay
- Deicing chemicals

UMMER/RAIN - SHORTLY AFTER RAIN STOR

OROUS LOT

- O PUDDLES
- OT SLICK
- AVEMENT DRY UNDER VEHICLES
- RIES QUICKLY IN UNCOVERED REAS

REGULAR ASPHALT

- MANY PUDDLES
- SOME PLACES SLICK
- WET UNDER VEHICLES

WINTER/SNOW

QUICK MELTING

NO MELTING AND
ICING ACROSS LOT

POST-CONSTRUCTION OBSERVATIONS

POST-
CONSTRUCTION
LANDSCAPING
EQUIPMENT IS
DAMAGING THE
PAVEMENT

OSION FROM LACK OF
NDSCAPING AT SOUTH
GE OF LOT

LESSONS LEARNED

uality control at all stages

ggregate can be moved by heavy equipment (asphalt trucks) after initial lacement

Vatch for gradation of the sand and rock filter layers and adherence to specs

ir temperature is not a factor. It was in the 30’s to 40’s when the asphalt was laced

he asphalt finishing technique is very important, i.e., timing of the rolling (no ibration) and the temperature of the mix

he contractor must have experience with porous asphalt placement

nsure landscape operations are complete prior to asphalt placement to prevent logging of the pores.

Jnconfined edges are subject to raveling when exposed to vehicle traffic

BALL SATISFACTION

- Employees appreciate lack of any ice ponding, eliminating slip and fall accidents
- Environmentally friendly
- No need for harsh ice-melt chemicals
- No runoff yet into Boulder Creek
- Filtered through sand under entire area
- Recharges ground water
- Huge savings on stormwater and plant investment fees

FOR MORE INFORMATION

- Guy Fromme, Ball Aerospace Corp.
  - gfromme@ball.com
- Tom Clayton, Colorado Asphalt paving Association
  - tomclayton@co-asphalt.com
  - www.co-asphalt.com
- Debbie Fisher, Wright Water Engineers
  - dfisher@wrightwater.com
  - www.wrightwater.com
- Duane Jansen, Andre' Schlappe, Martin/Martin, Inc.
  - djansen@martinmartin.com
  - aschlappe@martinmartin.com

QUESTIONS???

DESIGN OF A RETROFIT WATER QUALITY CONTROL STRUCTURE TO MAXIMIZE POLLUTANT REMOVAL EFFICIENCY FOR AN EXISTING STORMWATER WETLAND

Laurie Trifone and Chris Olson, Colorado State University
Basil Hamdan, City of Fort Collins

Table of Content

- Background
  - BMP design
  - Stormwater Quality Management
  - Pollutant removal
- Howes Street Basin, Fort Collins, CO
  - Project Objectives
  - Methods
  - Results
  - Conclusions

BMP Design

- Quantity and quality control
  - Pollutant prevention
  - Outlet Structure

Background: SW Management

- Retrofit
- New Development

2012 Aerial of Fort Collins

2012 Google maps: Fort Collins

WQCV Calculation

- Urban Drainage and Flood Control District

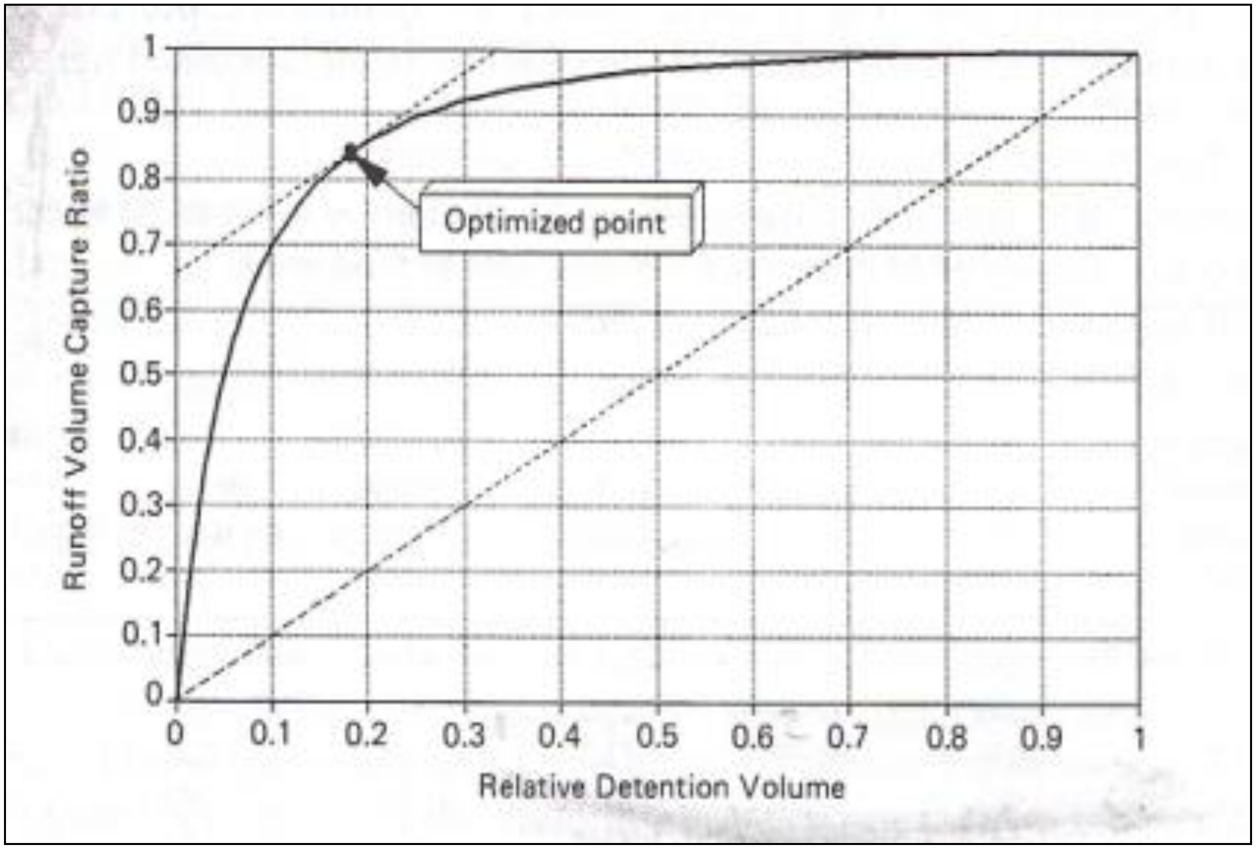
$$WQCV = a(0.91i - 1.19i^2 + 0.78i)$$

Drain Time (hrs)	Coefficient, a
12	0.8
24	0.9
40	1.0

i= watersheds percent impervious

a= regression constant

WQCV Calculation
Optimized Capture Volume Curve



Normalized to the 99.9% runoff event (largest storm event in area)

Optimizing the Capture volume (Urbonas and Stahre 1993)

BMP Performance Estimation

- Removal efficiency analysis
  - Influent concentrations
  - Effluent concentrations
- Mass of total

pollutant load removed

Howes Street Basin (HSB) WQCS Design Fort Collins, CO

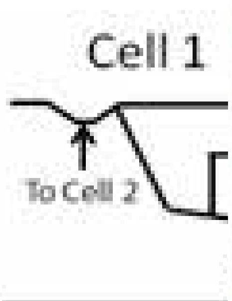
- Project beginning
  - 2009-2011 field study
- Measurable pollutant removal
- WQCV Design

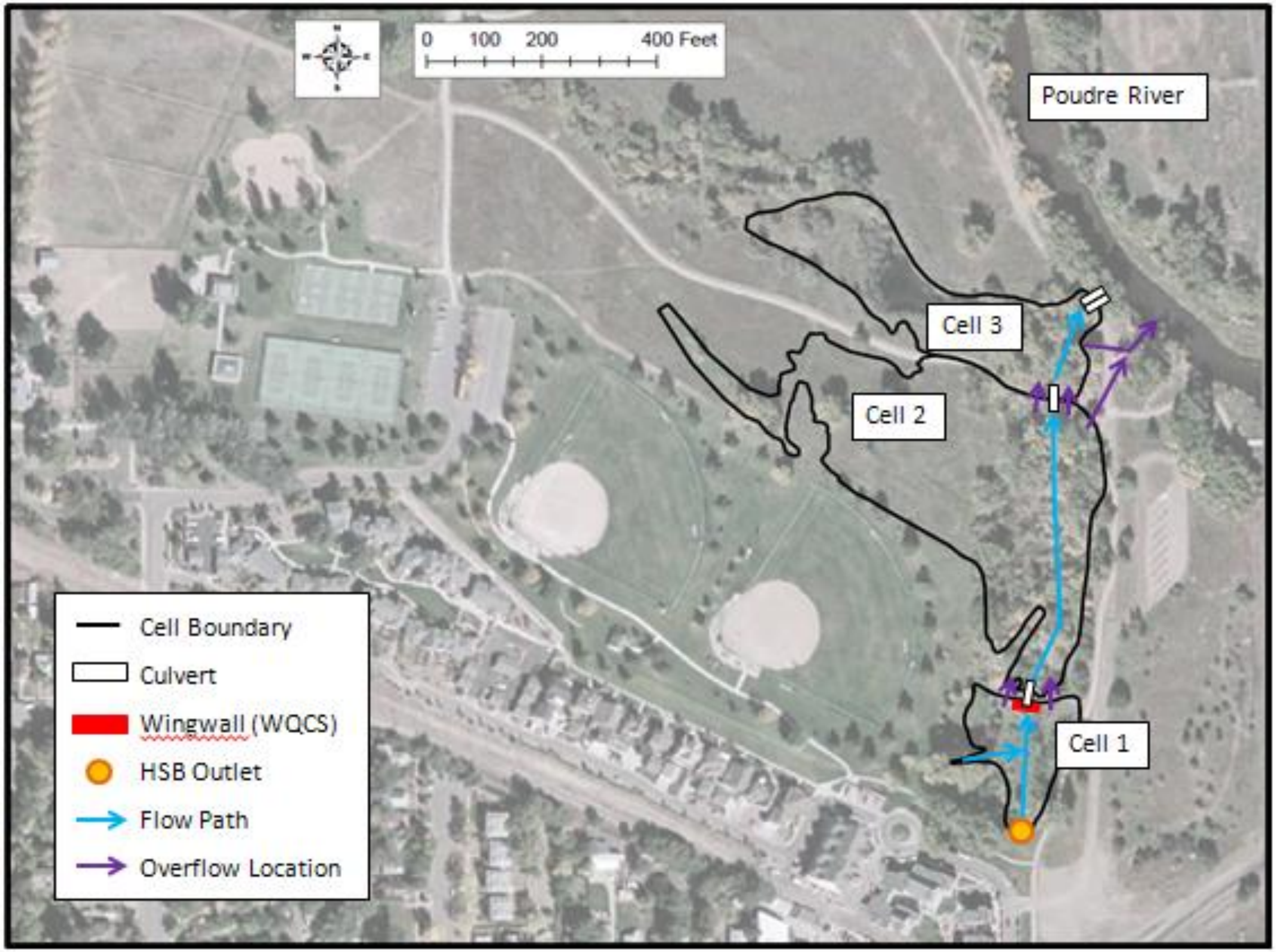
- Develop method for design of water quality control structure in a retrofit BMP
  - Efficiency
  - Pollutant removal
  - Limitations

HSB and Wetland

- 505 acre watershed
- Mixed land use
- Storm sewer system
- 7 acre wetland
- Restrictions

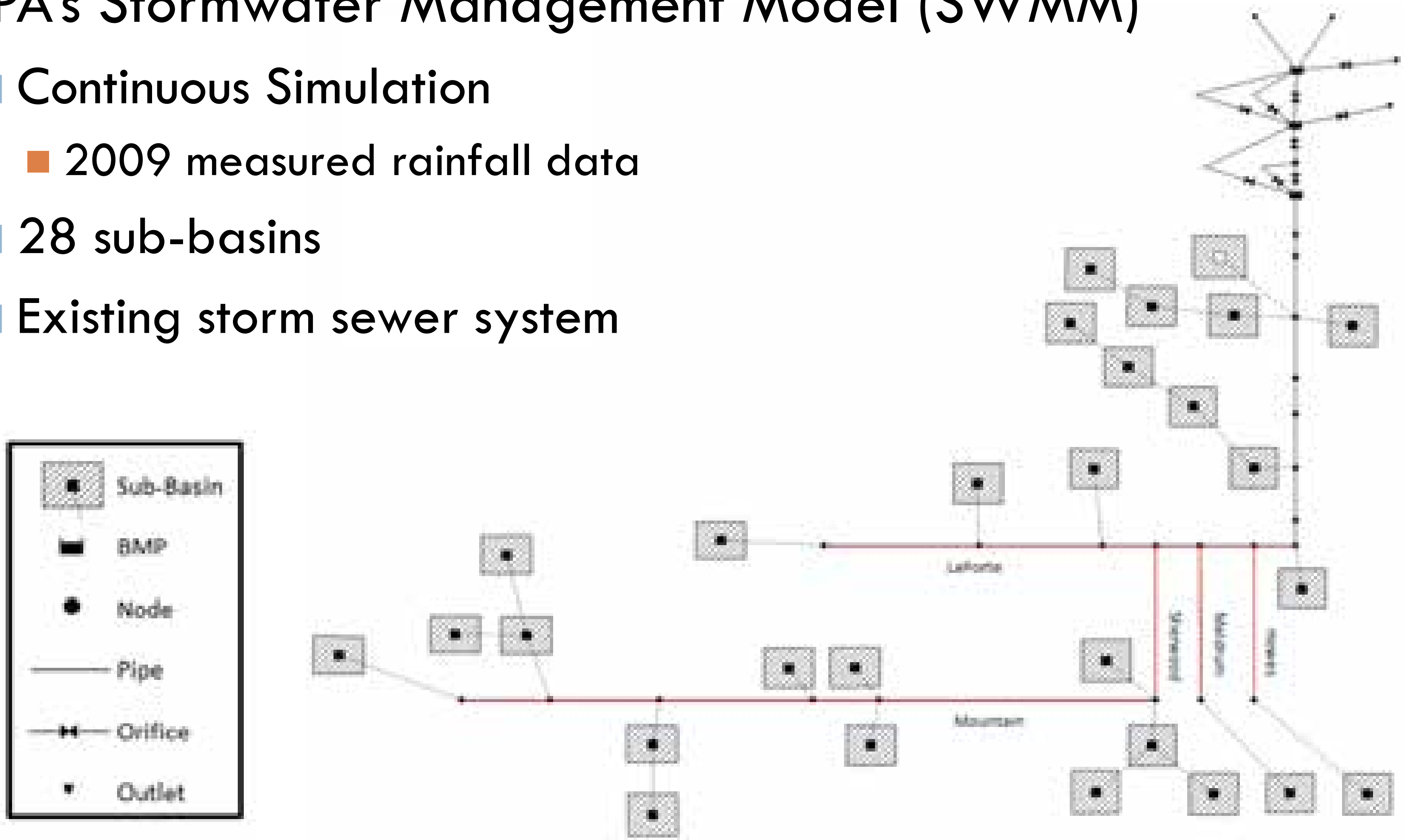
Wetland Existing Conditions



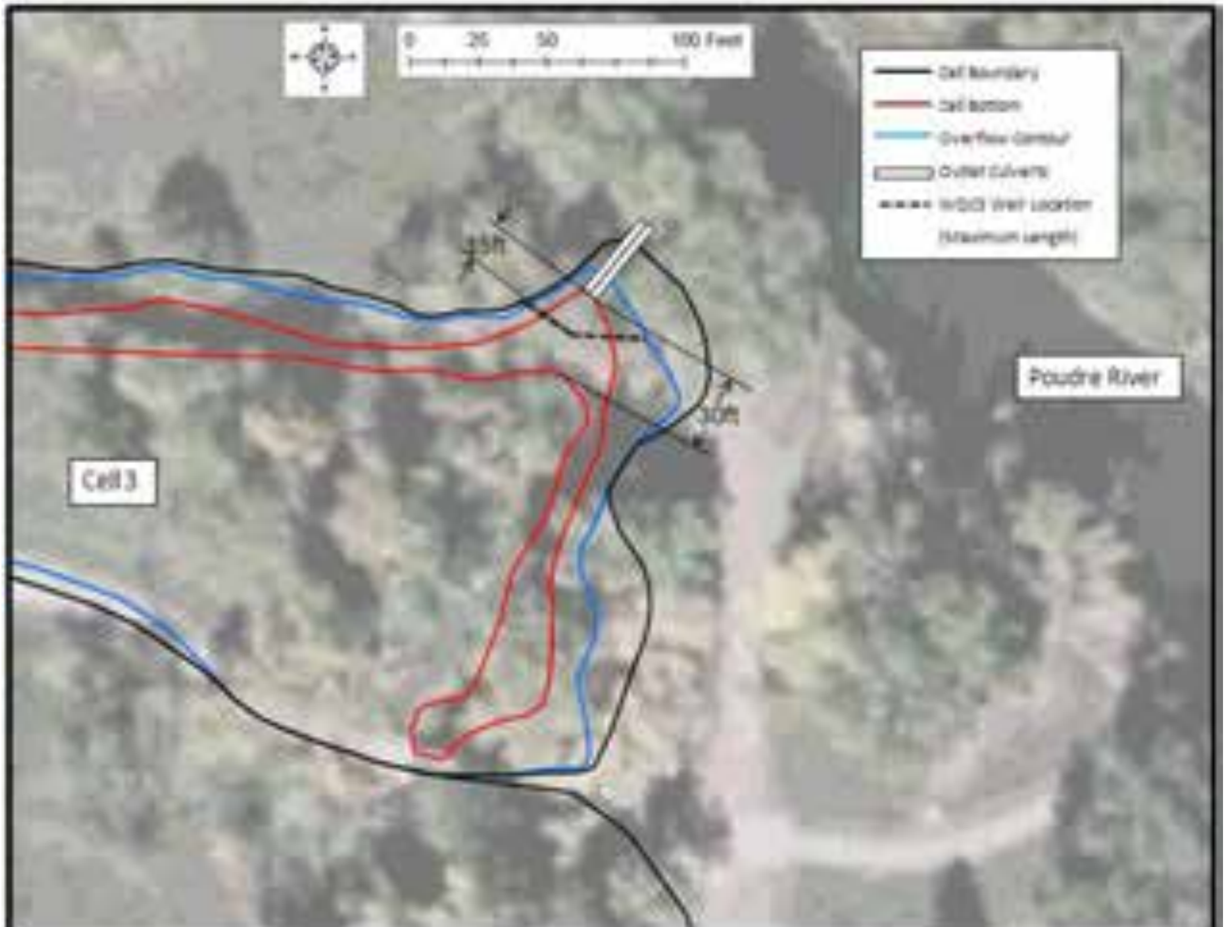


Stormwater Modeling

- EPA's Stormwater Management Model (SWMM)
  - Continuous Simulation
    - 2009 measured rainfall data
  - 28 sub-basins
  - Existing storm sewer system



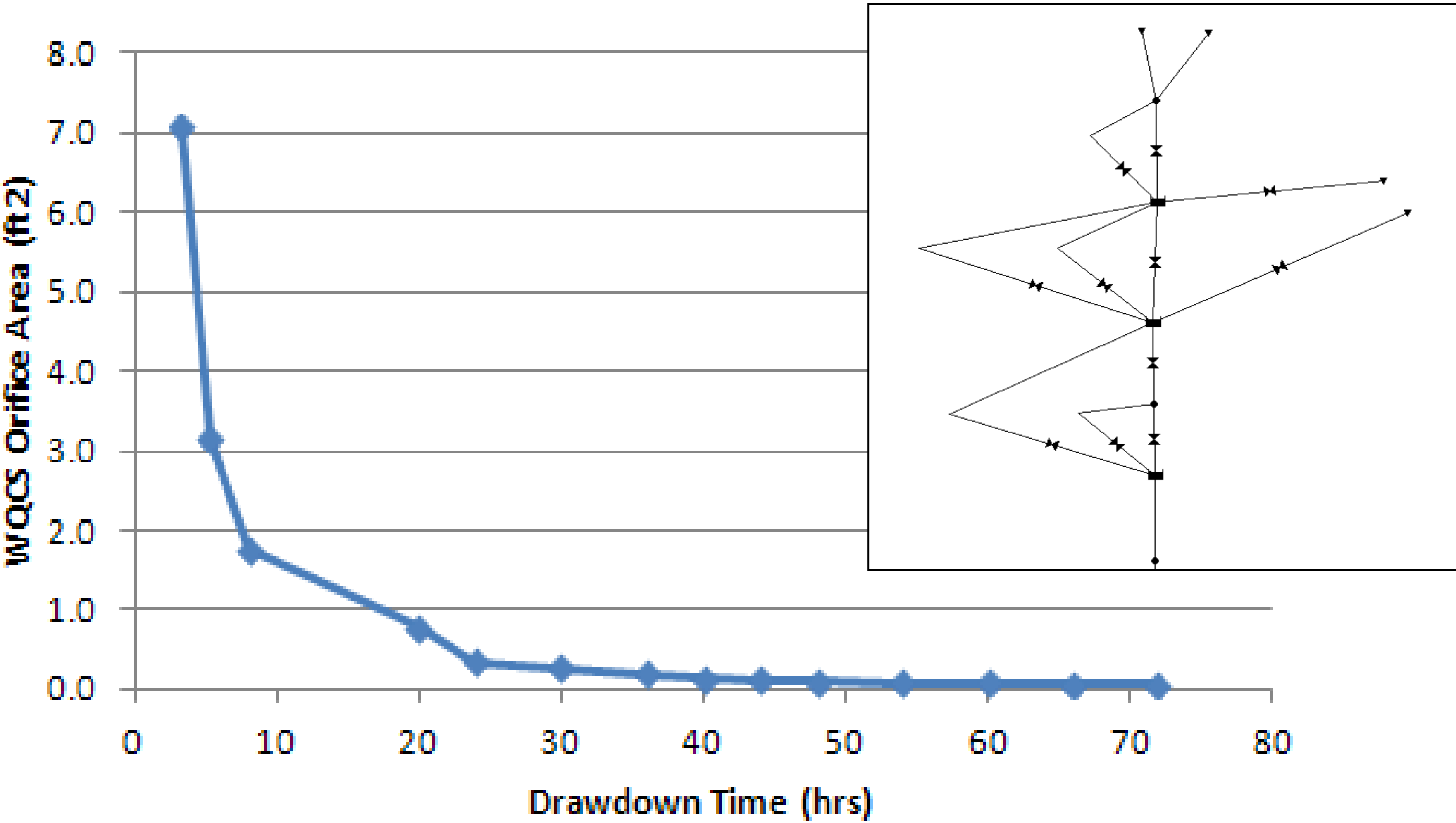
Proposed WQCS



Transverse Weir Flow Equation

$$L = \frac{3.33 * h^{3/2}}{Q}$$

WQCS Orifice



k-C* Model: BMP Performance

- k-C* model

$$C_0 = e^{(-k/HLR)} * (C_i - C^*) + C^*$$

C_i=261 mg/L

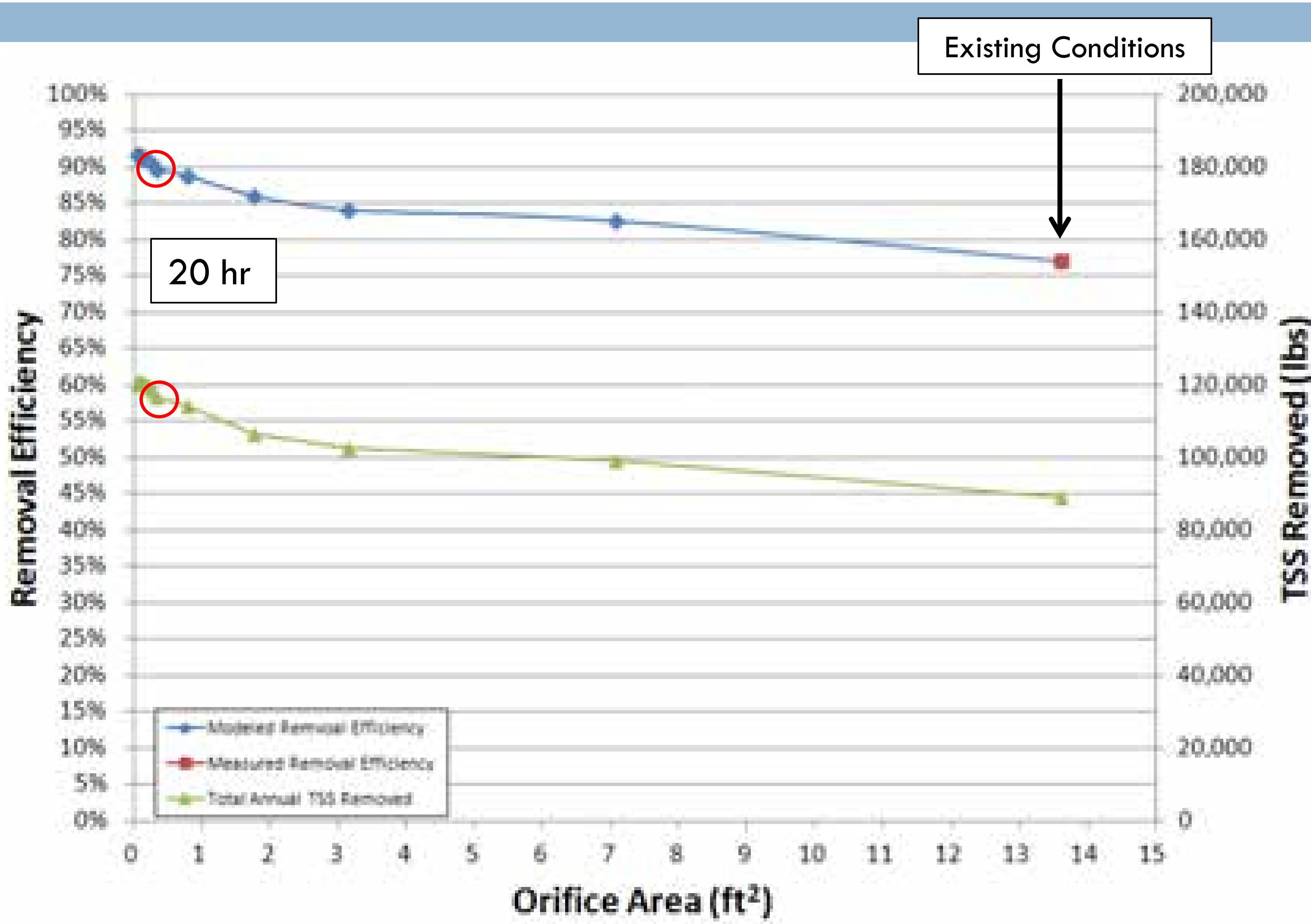
C^*=14 mg/L

k=2670 m/yr

HLR=Calculated from SWMM output, m/yr

$$\text{Removal Efficiency} = 1 - \frac{C_0}{C_i}$$

Results/Conclusions



Conclusions

- Results of the proposed method shows that by maximizing the drawdown time the removal efficiency and mass of TSS removed is also maximized
  - Irreducible pollutant concentration
- Design considerations
- Apply to additional retrofit BMPs to confirm results

Questions?

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Media Filter Drains - Water Quality Option for Linear Projects
presented by Justin Wendel (CDOT) and
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CDOT and Water Quality
Why is it so cumbersome?
Challenges
Typical CDOT BMP = WQ Basin
Media Filter Drain


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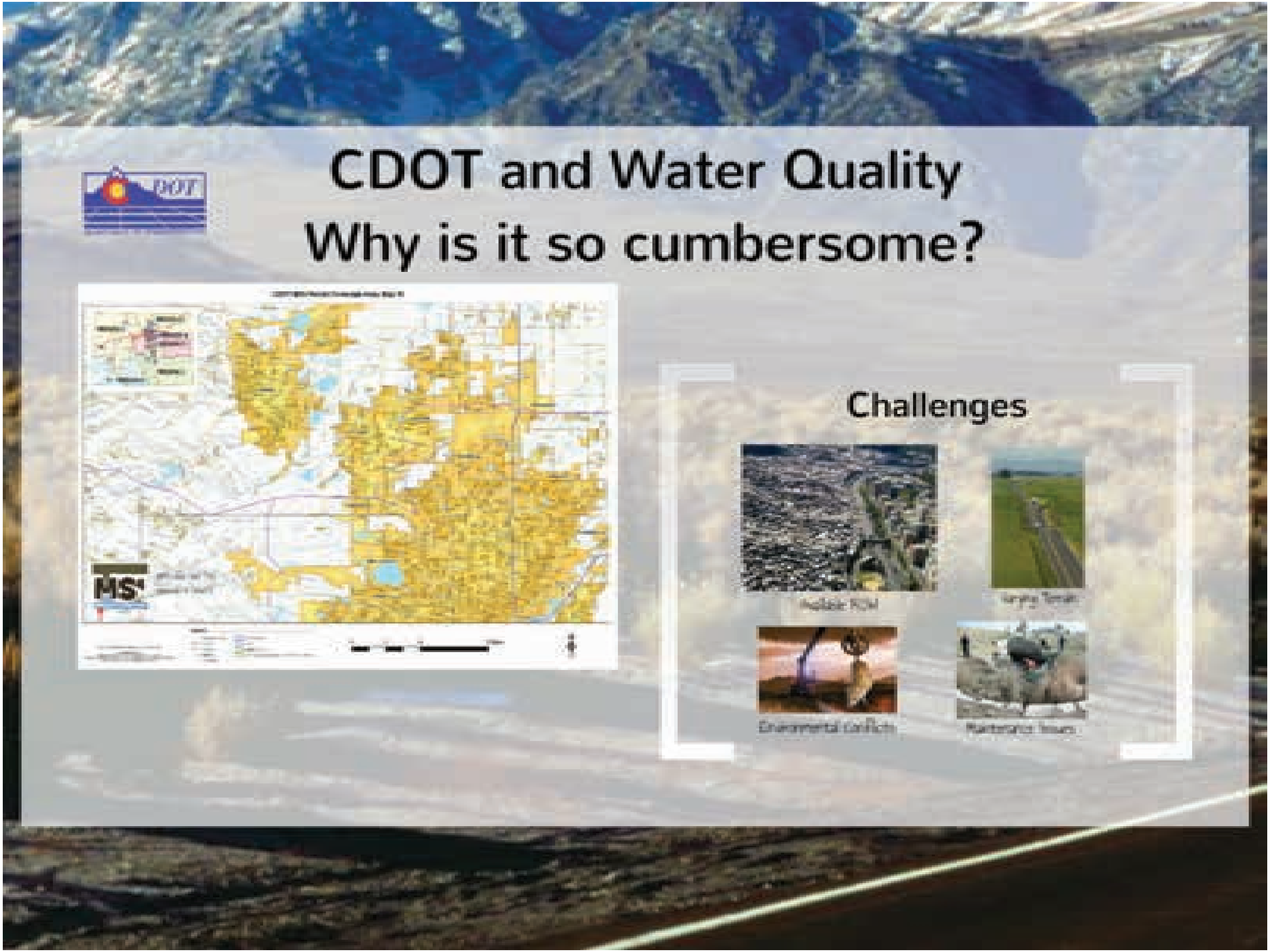
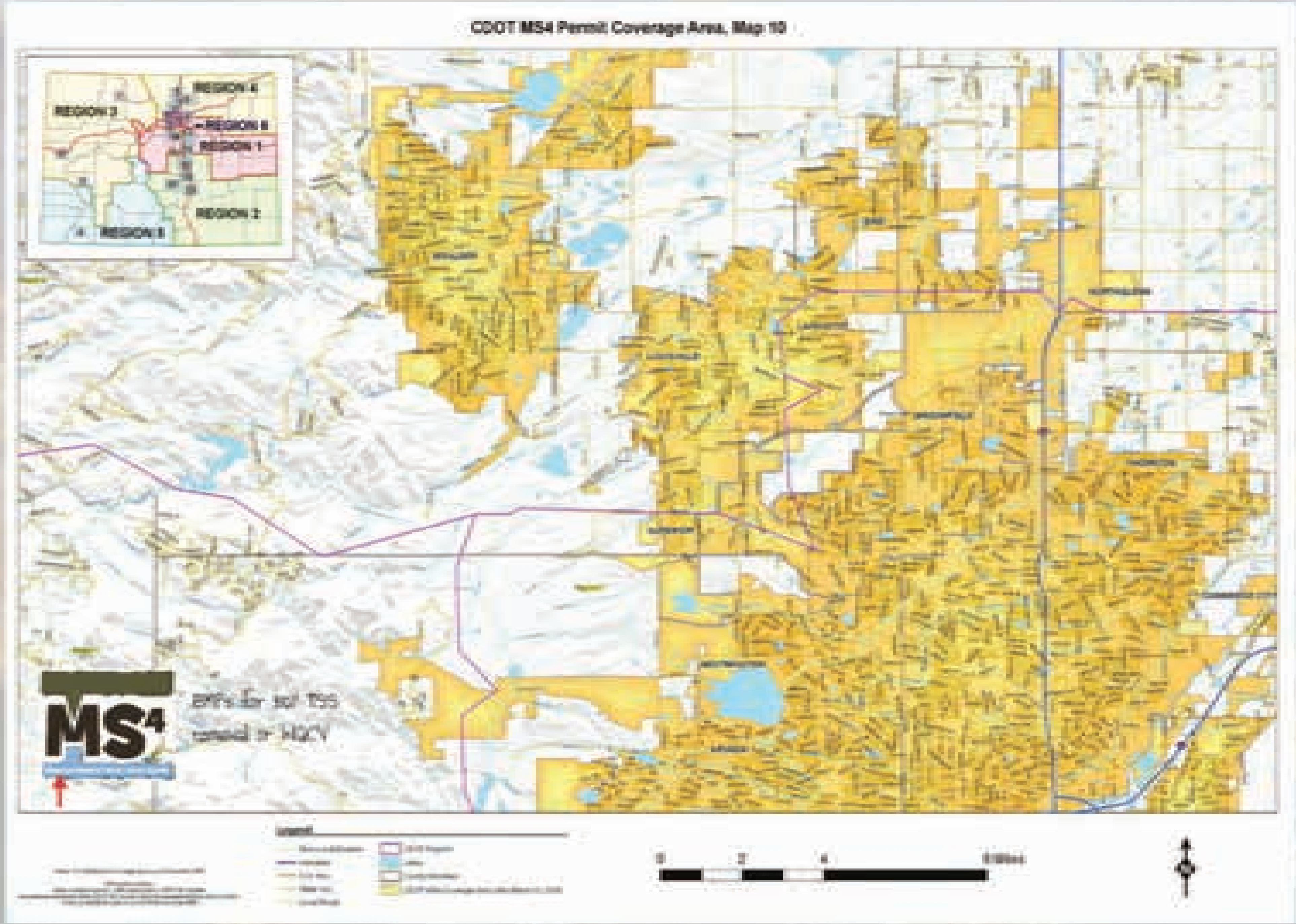
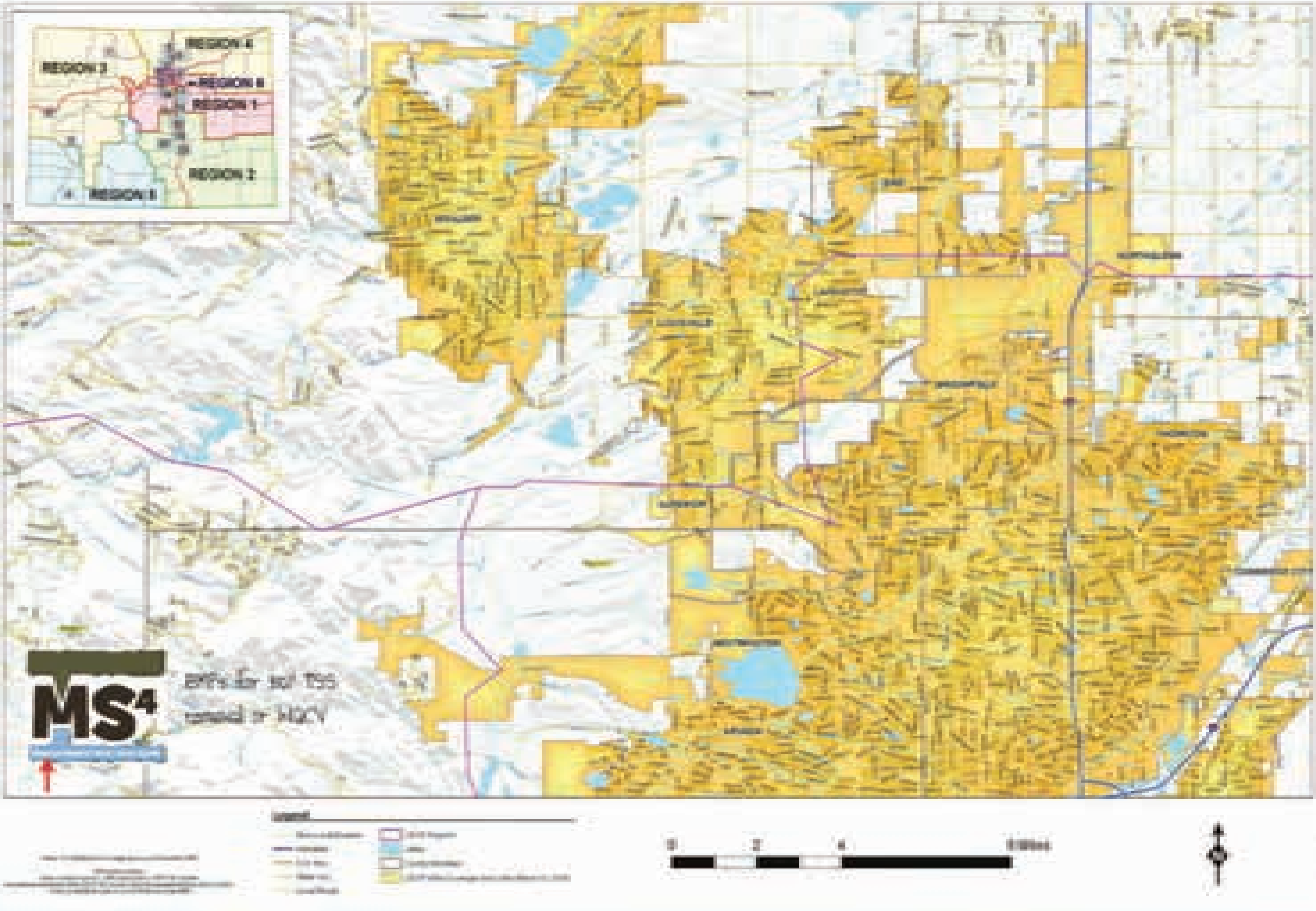

CDOT and Water Quality
Why is it so cumbersome?
Challenges
Available ROW
Varying Terrain
Environmental conflicts
Maintenance Issues


CDOT MS4 Permit Coverage Area, Map 10
REGION 4
REGION 3
REGION 6
REGION 1
REGION 2
REGION 5
MS4
Legend
0
2
4
8 Miles

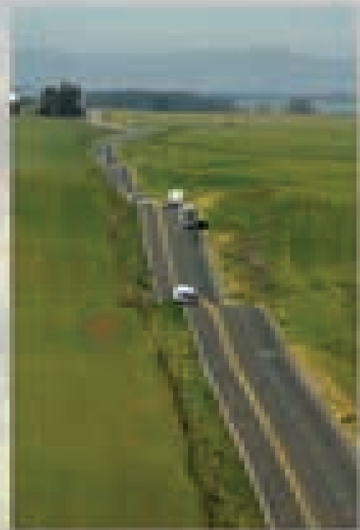
Region 1
MS4
Municipal Separate Storm Sewer System
BMPs for 80% TSS
removal or WQCV
Legend
Rivers and Stream

CDOT MS4 Permit Coverage Area, Map 10



Challenges

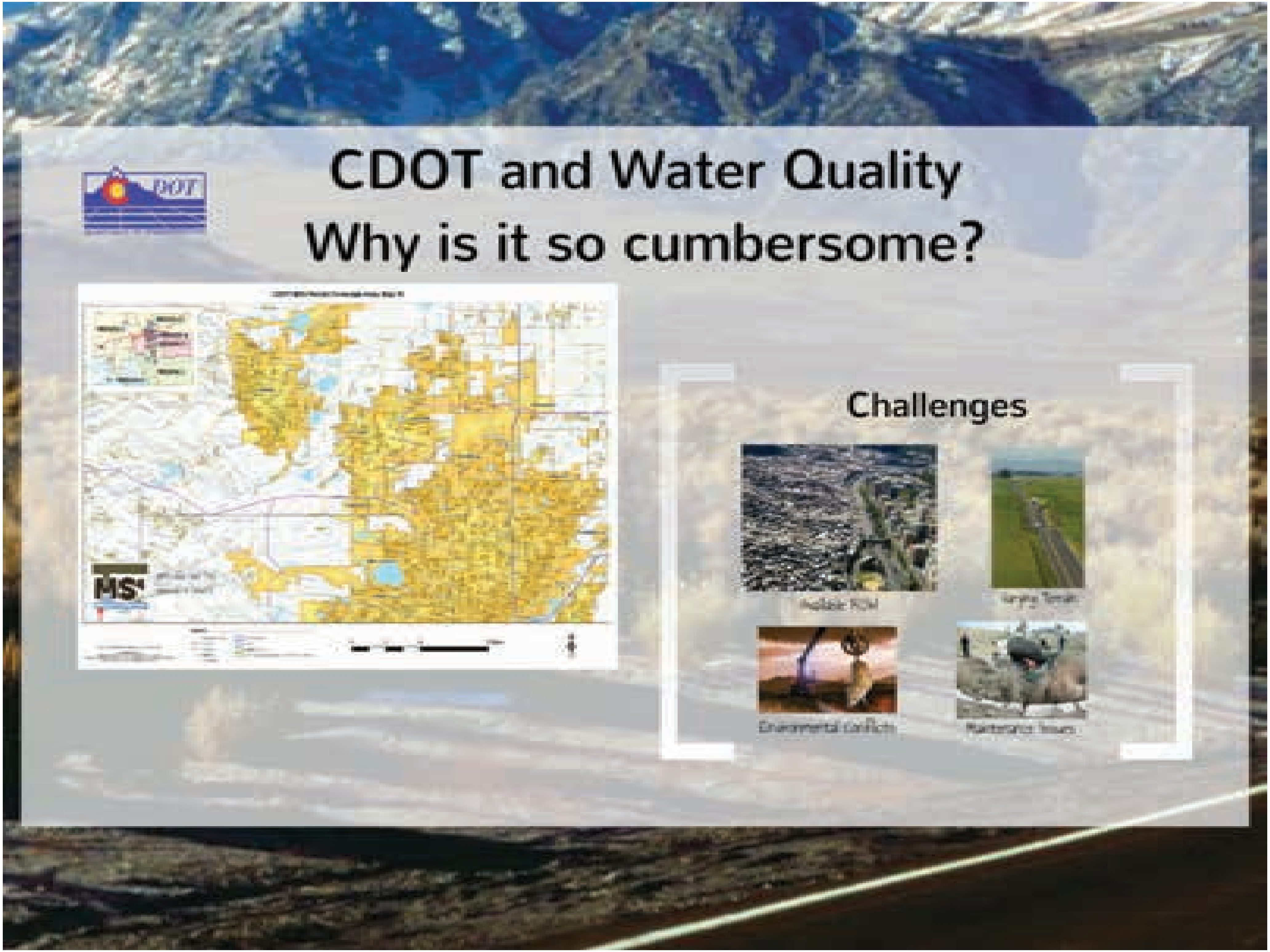
Available ROW



Varying Terrain

Environmental Conflicts

Maintenance Issues


CDOT and Water Quality
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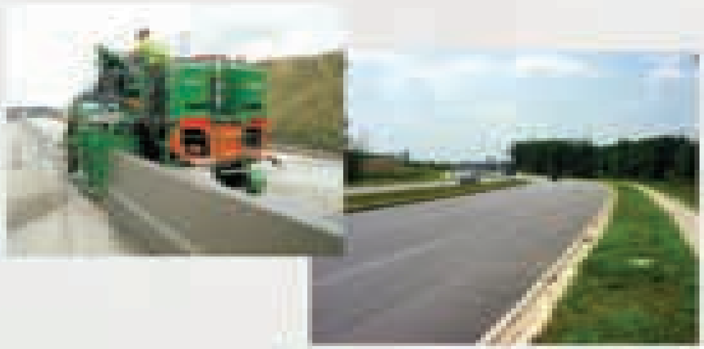
Maintenance Issues

Typical CDOT BMP = WQ Basin

3 Key Components

1) Treatment Facility

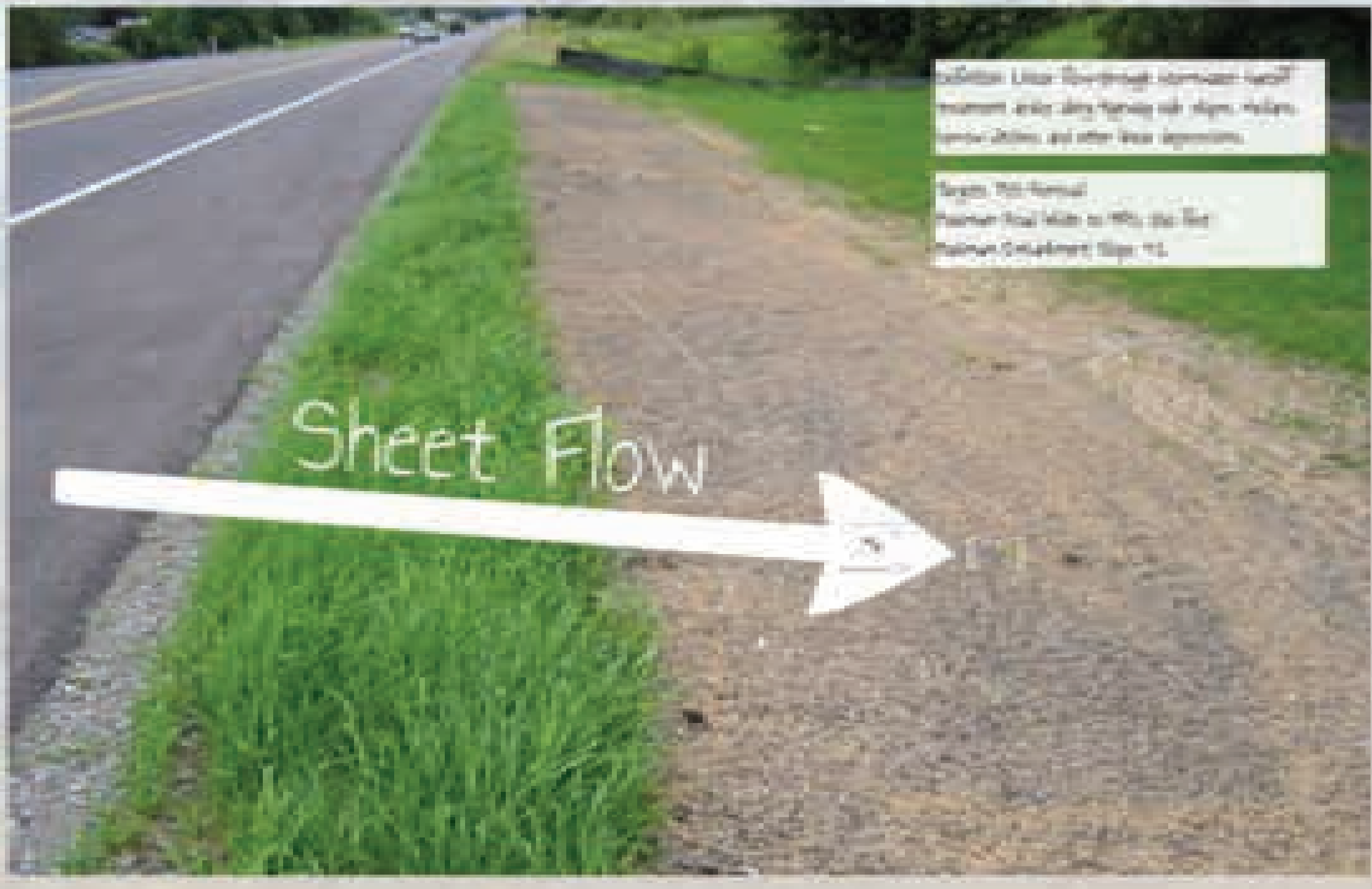
2) Interception

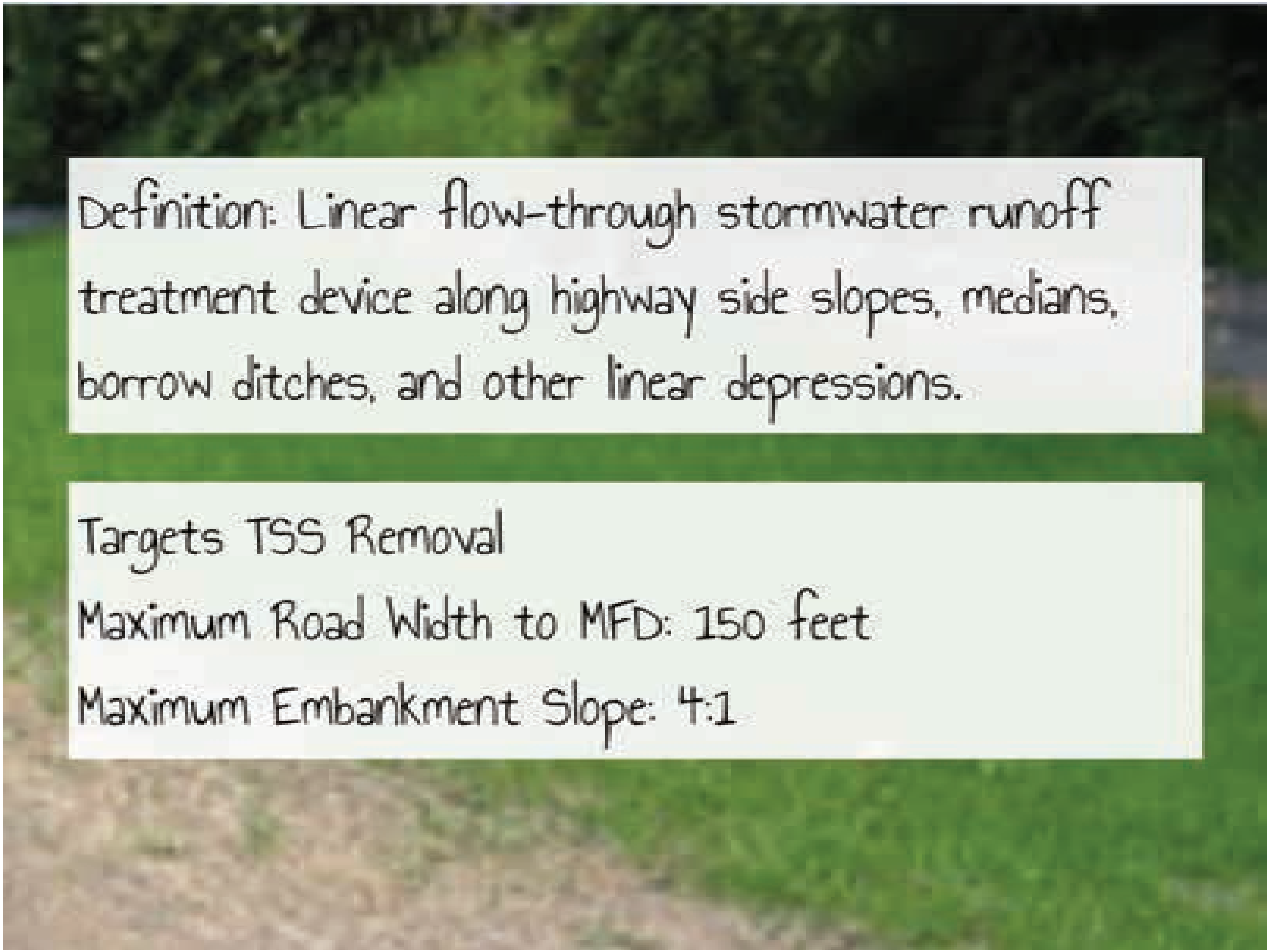


3) Conveyance

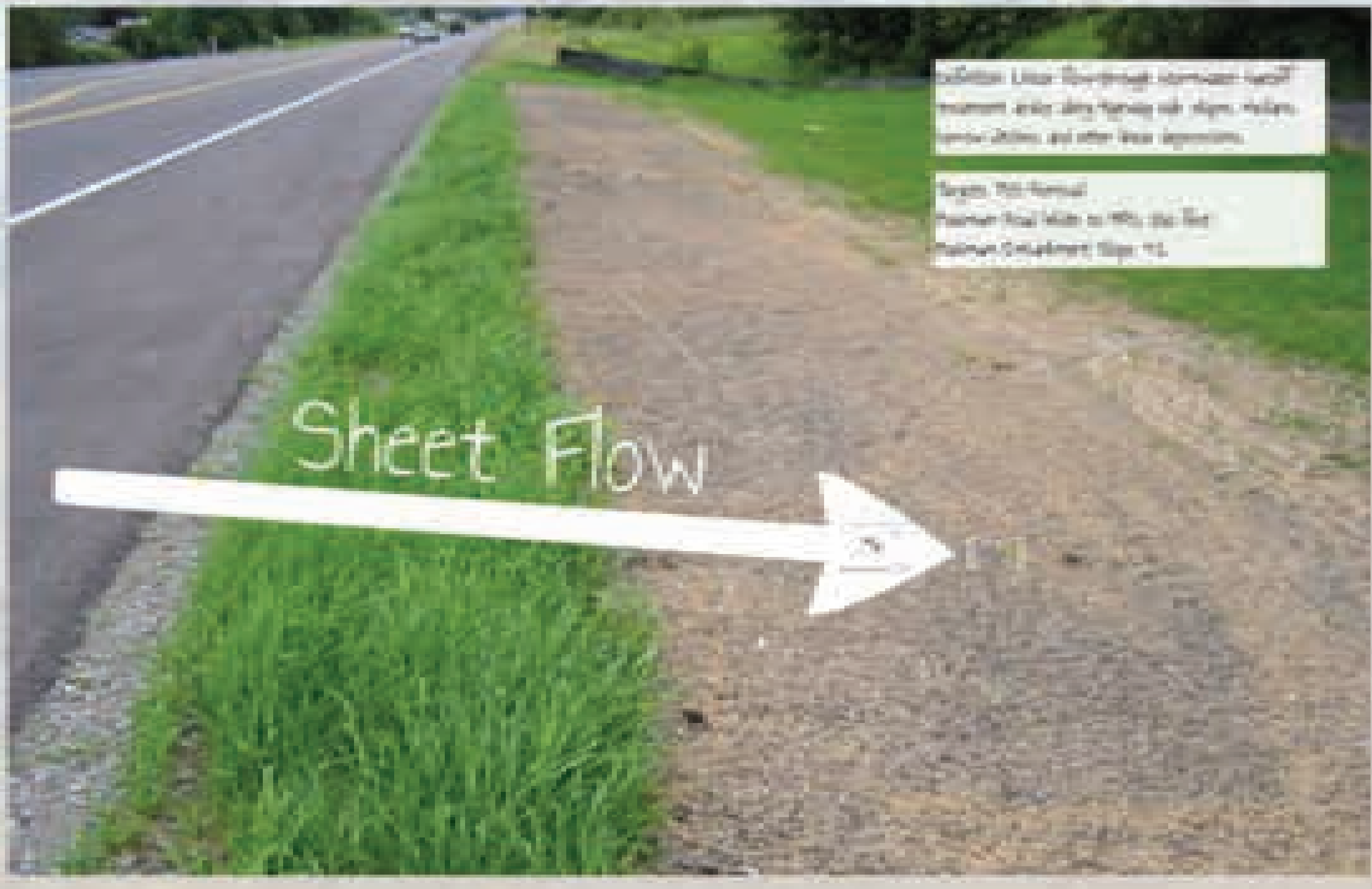
Typical CDOT BMP = WQ Basin

Media Filter Drain

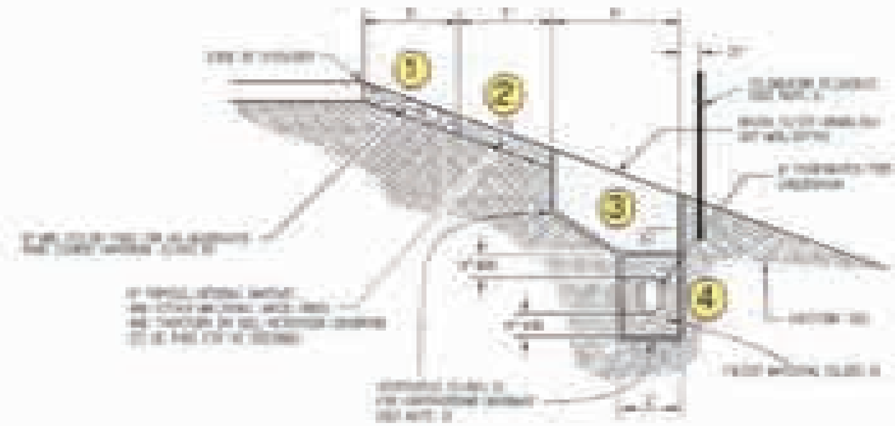



Definition: Linear flow-through stormwater runoff treatment device along highway side slopes, medians, borrow ditches, and other linear depressions.
Targets TSS Removal
Maximum Road Width to MFD: 150 feet
Maximum Embankment Slope: 4:1

Media Filter Drain

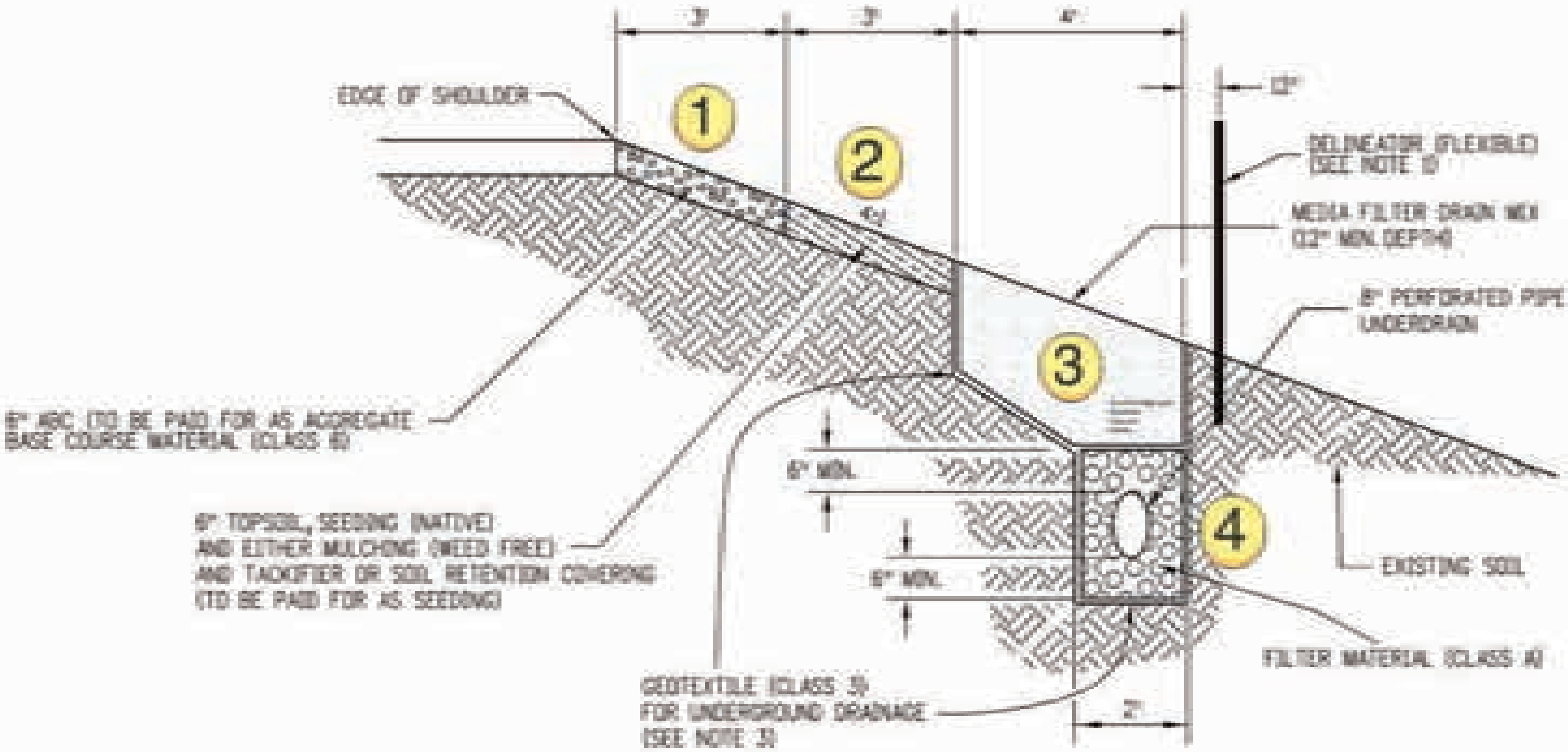


GENERAL NOTES



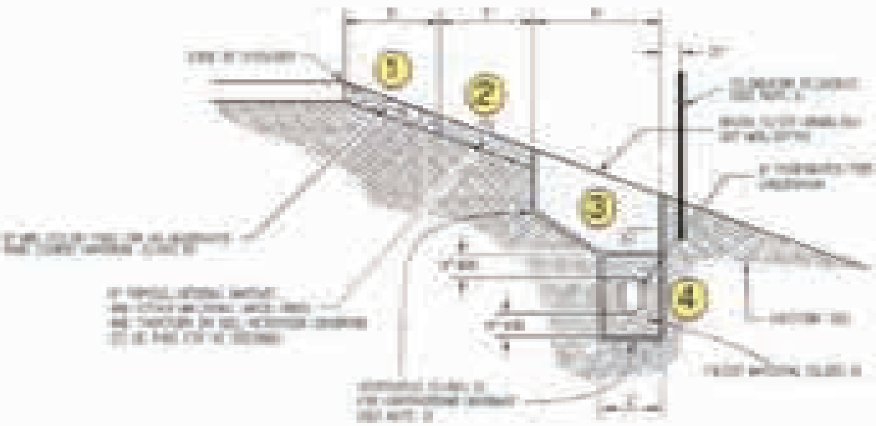
MEDIA FILTER DRAIN

Computer File Information	00000	Sheet Revisions	Colorado Department of Transportation	As Constructed	MEDIA FILTER DRAIN	Project No./Code
			Region Number or Staff			



MEDIA FILTER DRAIN

- Crushed Aggregate
- Dolomite
- Gypsum
- Perlite



MEDIA FILTER DRAIN

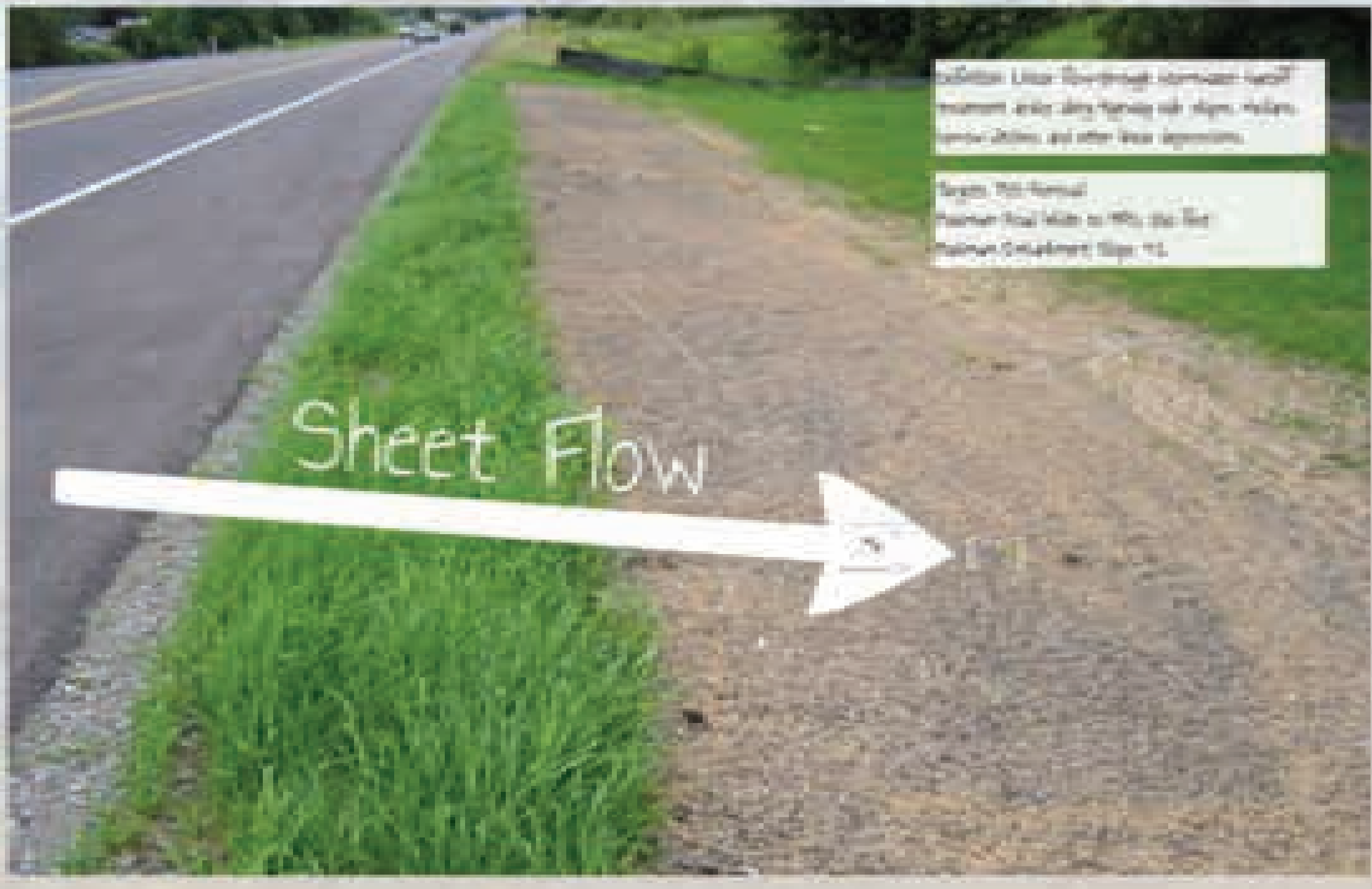
GENERAL NOTES

Computer File Information	00000	Sheet Revisions	Colorado Department of Transportation	As Constructed	MEDIA FILTER DRAIN	Project No./Code
			Region Number or Staff			

Design Considerations

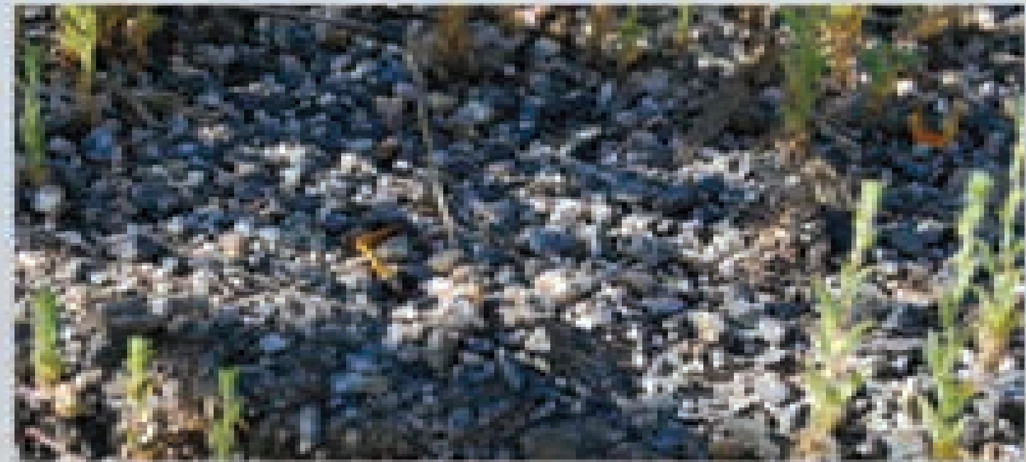
- Sheet Flow
- Gravel Shoulders
- Follows roadway slope (<5%)
- Fooprint: 10' strip along road
- Doesn't require plant nutrient uptake
- Uncomplicated

Media Filter Drain



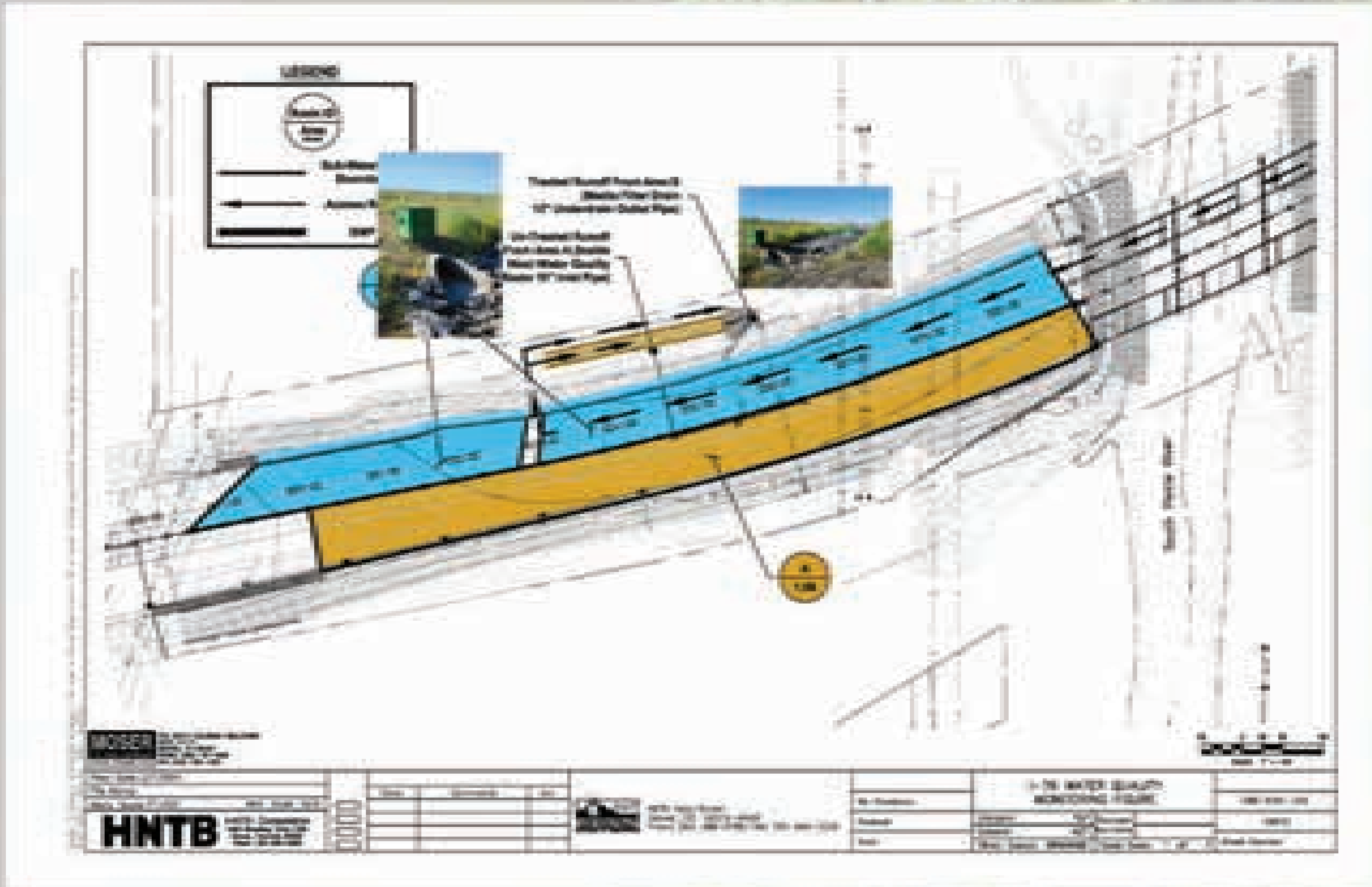
I-76 Over South Platte River

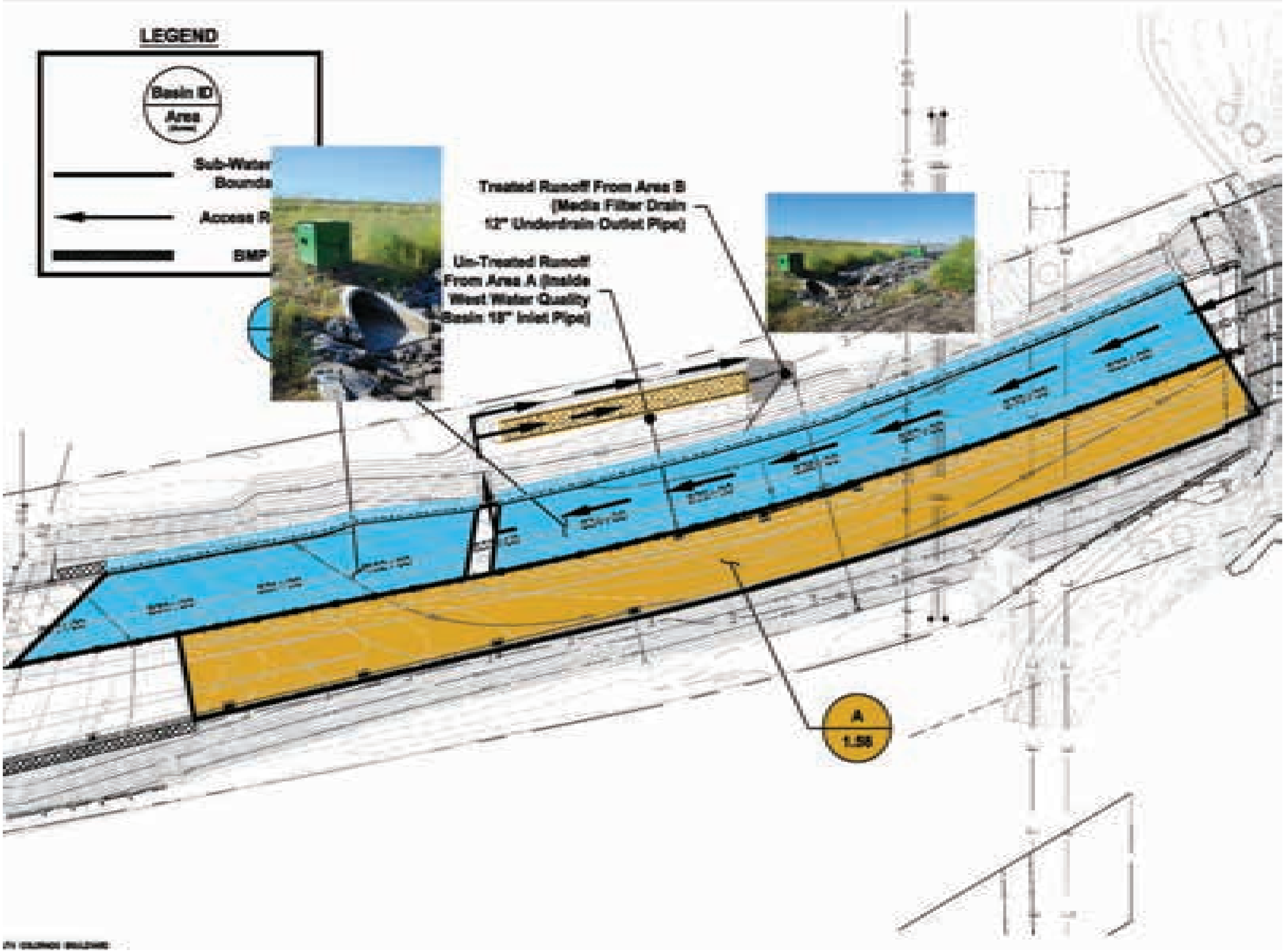
Installed 2,300 LF of MFD



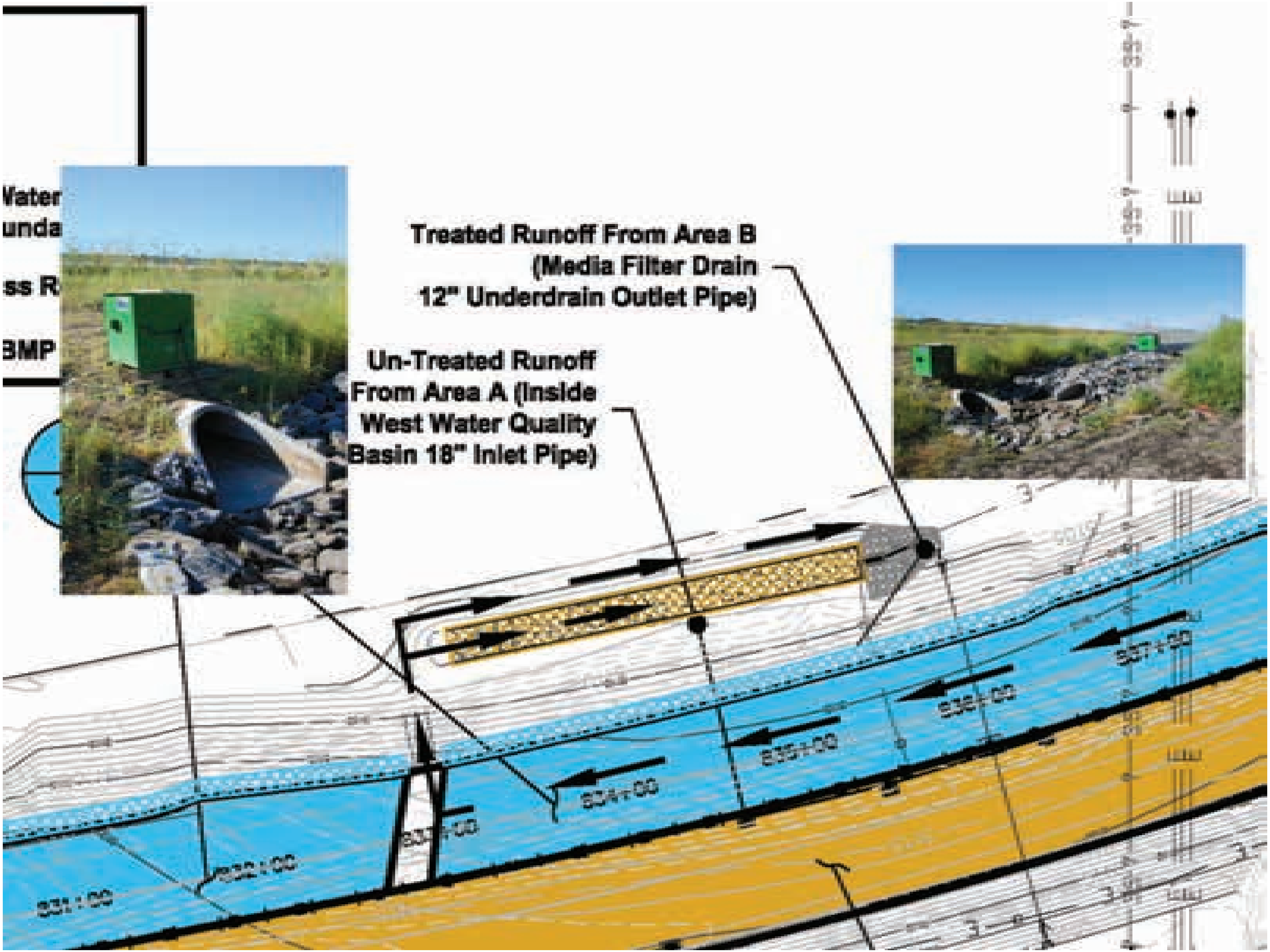
Installed 2 WQ EDBs

Monitoring Program





LEGEND
Basin ID
Area
Sub-Water
Bounda
Access R
BMP
Treated Runoff From Area B
(Media Filter Drain
12" Underdrain Outlet Pipe)
Un-Treated Runoff
From Area A (Inside
West Water Quality
Basin 18" Inlet Pipe)
A
1.58


Treated Runoff From Area B (Media Filter Drain 12" Underdrain Outlet Pipe)
Un-Treated Runoff From Area A (Inside West Water Quality Basin 18" Inlet Pipe)
831+00
832+00
833+00
834+00
835+00
836+00
837+00

I-76 Over South Platte River

EDB vs MFD


Phase 1
Broomfield
Broomfield
Northglenn
Federal He
Westmins
sville
Wadsworth Pkwy
36
128
287
95
121
25
44
42
5


Google earth

Fun Facts

- 10 Miles
- 18 EDB (3.3 acres to 30.8 acres)
- 16.5 Miles of Pipe, 525 Inlets, 160 Manholes
- 8 Irrigation Crossings
- 3 Major Drainage Crossings

EDB Considerations

- Interception, Conveyance & Treatment Design
- 75-Year Life Span
- Frequent Maintenance
- Maintenance Access Issues
- EDB cost = $160/lf + land


Phase 1
Broomfield
Broomfield
Northglenn
Federal He
Westmins
sville
36
128
287
95
121
25
44
42
5


Phase 2
Louisville
42
Superior
Arapahoe Rd
157
S Broadway St
Marshall Dr
170


Google earth

MFD Considerations

- Sheet Flow – Eliminate Interception & Conveyance
- Up to 20-Year Life Span
- Maintenance – Scarify surface
- Easily accessible
- MFD cost = $15/lf

EDB vs MFD

MFD - Is it for me?

- Sheet flow
- Shoulders
- Limited Space
- Limited $$$
- Uncomplicated Design

Resources

WSDOT Media Filter Drain Design Guide

http://www.wsdot.wa.gov/publications/manuals/fulltext/m31-16/Chapter5.pdf

CDOT Project Detial for MFD

http://www.coloradodot.info/business/designsupport/standard-plans/2012-m-standards-plans/2012-project-special-details/media-filter-drain

CDOT Project Specification

http://www.coloradodot.info/business/designsupport/construction-specifications/2005-construction-specs/2005psp/sections-300-500-revisons%20mfd.docx/at_download/file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Why is it so cumbersome?
Typical CDOT BMP = WQ Basin

Estimating Nutrient Loads in Urban Runoff under Colorado's Regulation 85

Project Sponsors:

Urban Drainage and Flood Control District

Colorado Stormwater Council

Consultant Team:

Jane Clary and Andrew Earles, P.E., Ph.D., Wright Water Engineers, Inc.

Scott Struck, Ph.D., Geosyntec Consultants

Robert Pitt, P.E., Ph.D., University of Alabama

Larry Roesner, P.E., Ph.D., Colorado State University

Overview

- Background: Colorado's Nutrient Regulations 85 and 31
- MS4 Requirement: "Data Gap Analysis"
- Project Approach
  - Colorado Data
  - National Data—National Stormwater Quality Database (NSQD—Pitt)
- Findings
- Conclusions—what do we know about nutrients in urban runoff in Colorado?

Colorado's Nutrient Regulations

- Regulation 31—relates to instream standards
  - Adds criteria for total phosphorus, total nitrogen, chlorophyll-a
  - Interim criteria—10-year window for most streams
- Regulation 85—relates to discharge permits
  - Requirements for municipal WWTP and certain industrial discharges:
    - Numeric effluent limits (TIN & TP)
    - Instream monitoring
  - Requirements for MS4s:
    - Public education and outreach
    - Pollution prevention/good housekeeping for municipal operations
    - "Data gap analysis" for MS4 stormwater discharges
  - Also discusses non-point sources

Discharge Permit Limits for WWTPs (Reg. 85)
(not applicable to MS4 discharges)

Table 1. Numeric Effluent Limits for Existing and New Domestic Wastewater Treatment Works (Regulation 85)

	Numeric Effluent Limits[4] Existing Facilities [New Facilities]	
Parameter	**Annual Median[1]**	**95th Percentile[2]**
Total Phosphorus	1.0 mg/L [0.7 mg/L]	2.5 mg/L [1.75 mg/L]
Total Inorganic Nitrogen as N[3] (TIN)	15 mg/L [7 mg/L]	20 mg/L [14 mg/L]

[1]Running Annual Median: The median of all samples taken in the most recent 12 calendar months.
[2]The 95th percentile of all samples taken in the most recent 12 calendar months.
[3]Determined as the sum of nitrate as N, nitrite as N, and ammonia as N.
[4]See Regulation 85 for additional detail on types of domestic wastewater facilities subject to these standards and applicable dates for new and existing facilities.

Instream Interim Criteria (Reg. 31)

(not applicable to MS4 discharges)

Table 2. Interim Total Phosphorus Values (Regulation 31)

Waterbody Type	Total Phosphorus Criteria
Lakes and Reservoirs, cold, >25 acres	0.025 mg/L[1]
Lakes and Reservoirs, warm > 25 acres	0.083 mg/L[1]
Lakes and Reservoirs, <=25 acres	RESERVED
Rivers and Streams – cold	0.110 mg/L[2]
Rivers and Streams - warm	0.170 mg/L[2]

[1]Summer (July 1-September 30) average total phosphorus (mg/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance frequency 1-in-5 years.
[2]Annual median total phosphorus (mg/L), allowable exceedance frequency 1-in-5 years.

Table 3. Interim Total Nitrogen Values (Regulation 31)
(Not Effective Prior to May 31, 2017)

Waterbody Type	Total Nitrogen Criteria
Lakes and Reservoirs, cold, >25 acres	0.426 mg/L[1]
Lakes and Reservoirs, warm, > 25 acres	0.910 mg/L[1]
Lakes and Reservoirs, <=25 acres	RESERVED
Rivers and Streams – cold	1.250 mg/L[2]
Rivers and Streams - warm	2.010 mg/L[2]

[1]Summer (July 1–September 30) average total nitrogen (mg/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance frequency 1-in-5 years.
[2]Annual median total nitrogen (mg/L), allowable exceedance frequency 1-in-5 years.

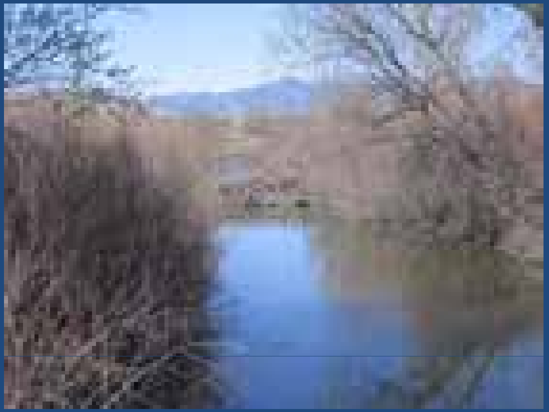
“Discharge Assessment Data Report”

(Due to Division by October 31, 2014)

- “Identify information that exists and the need for additional monitoring to be conducted in the future to determine the approximate nitrogen and phosphorus contribution to state waters due to discharges from MS4.”
- “Document the availability of existing data, and [provide] a “Gap Analysis” that identifies the need for additional information (e.g., monitoring data or studies), in accordance with the requirements of [the regulation].”

Reg. 85 Load Estimation Approaches Allowed in Data Gap Report

- Monitoring data from the MS4 discharge or downstream waters
- Monitoring data from other entities
- Land-use based models
- Land-use based data from literature



Before we get started…

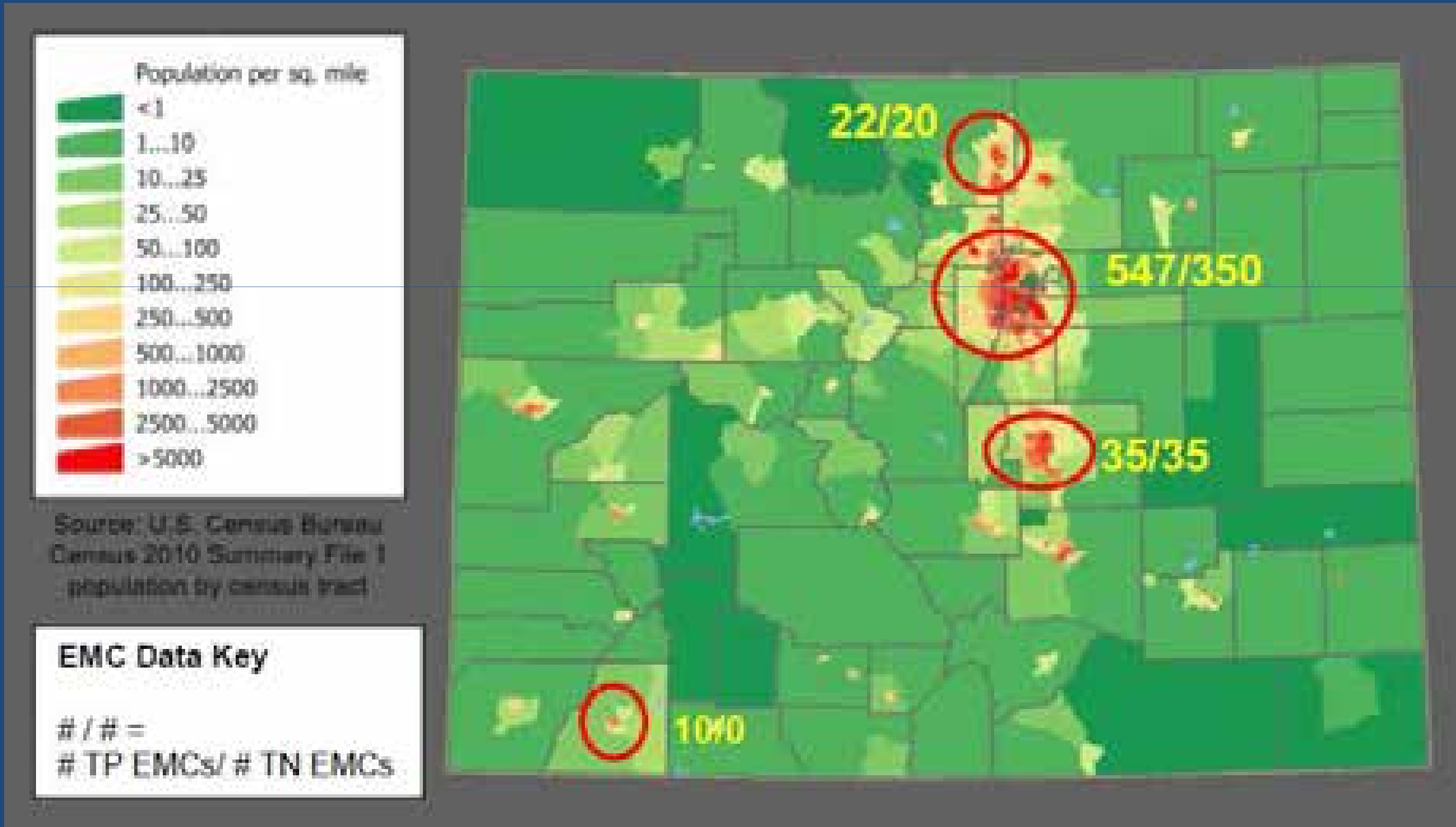
The Big Picture is Nutrient Loads

- Nutrient Concentration x Flow Volume = Load
- The data gap question focuses on the concentration component of load estimation.
- However, hydrology is the big difference by land uses and for different parts of the state.
- Methods for runoff volume calculations are well-documented by UDFCD and others.

Approach Selected for Data Gap Report

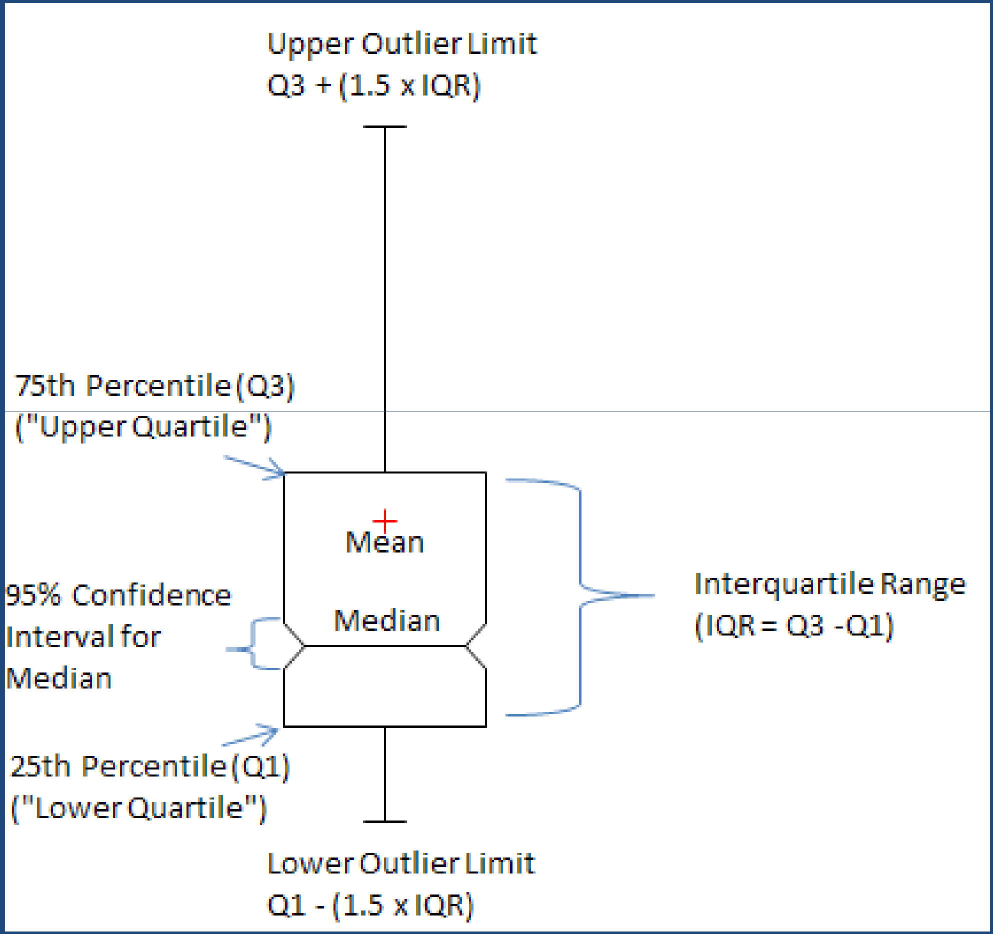
- Colorado EMC data for urban stormwater runoff
- Primary Data Sources
  - DRURP (1980's)
  - Phase 1 permit monitoring (1990's)
  - UDFCD BMP monitoring (inflow data)
  - Other BMP monitoring (ACWWA, Grant Ranch)
  - CSU/City of Fort Collins
  - CDOT Permit-required monitoring
- Supplementary Data
  - City and County of Denver outfall monitoring (grabs)

General Distribution of Nutrient Monitoring EMCs in Colorado Relative to Population



Statistical Methods

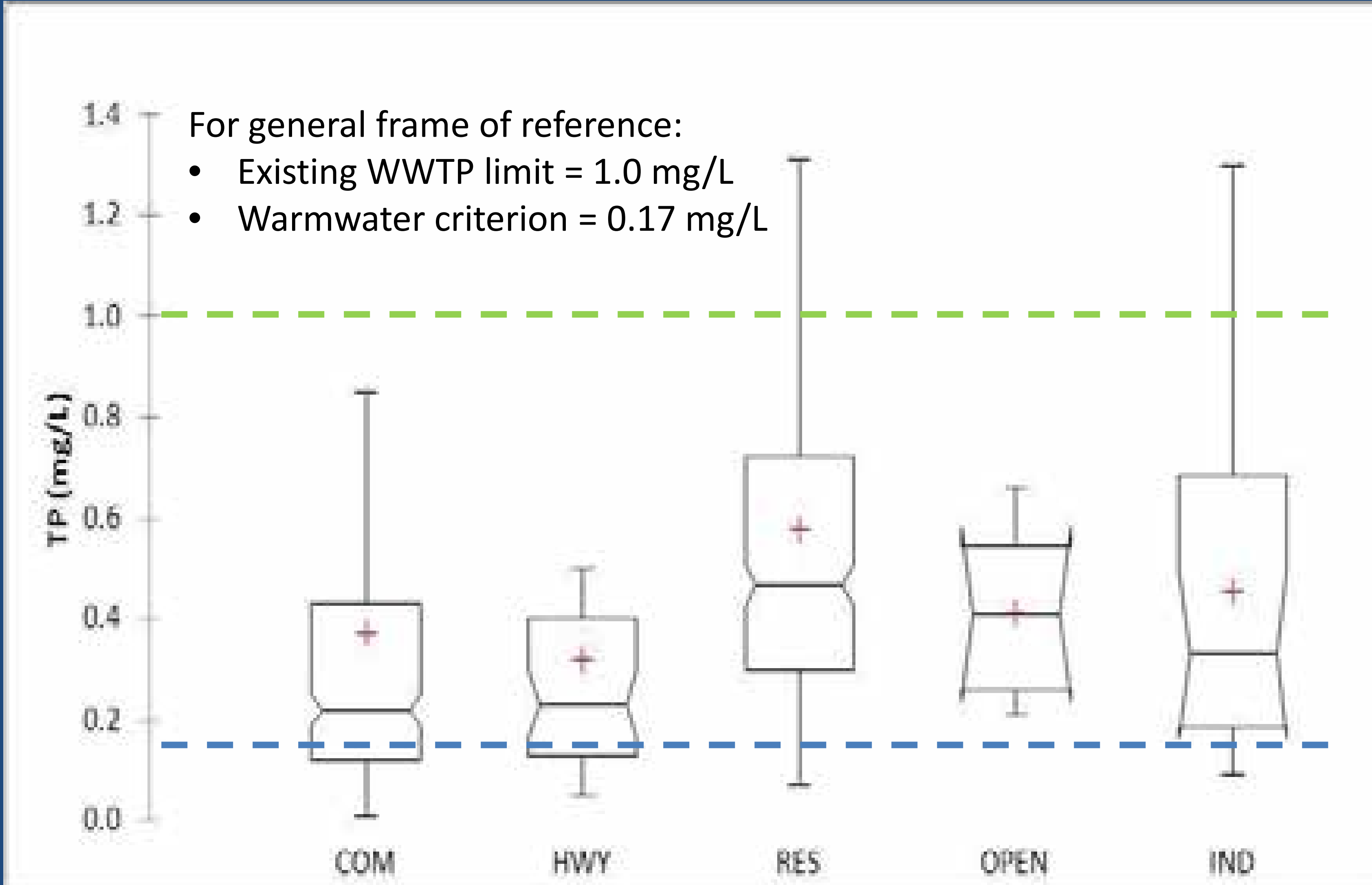
- Basic descriptive statistics
- Boxplots
- Time-series plots
- Cumulative frequency distribution
- Normal probability plots
- Hypothesis testing
  - Kruskal-Wallis
  - Mann-Whitney
  - Dunn’s Procedure
- Spearman correlation analysis & scatter plot matrices



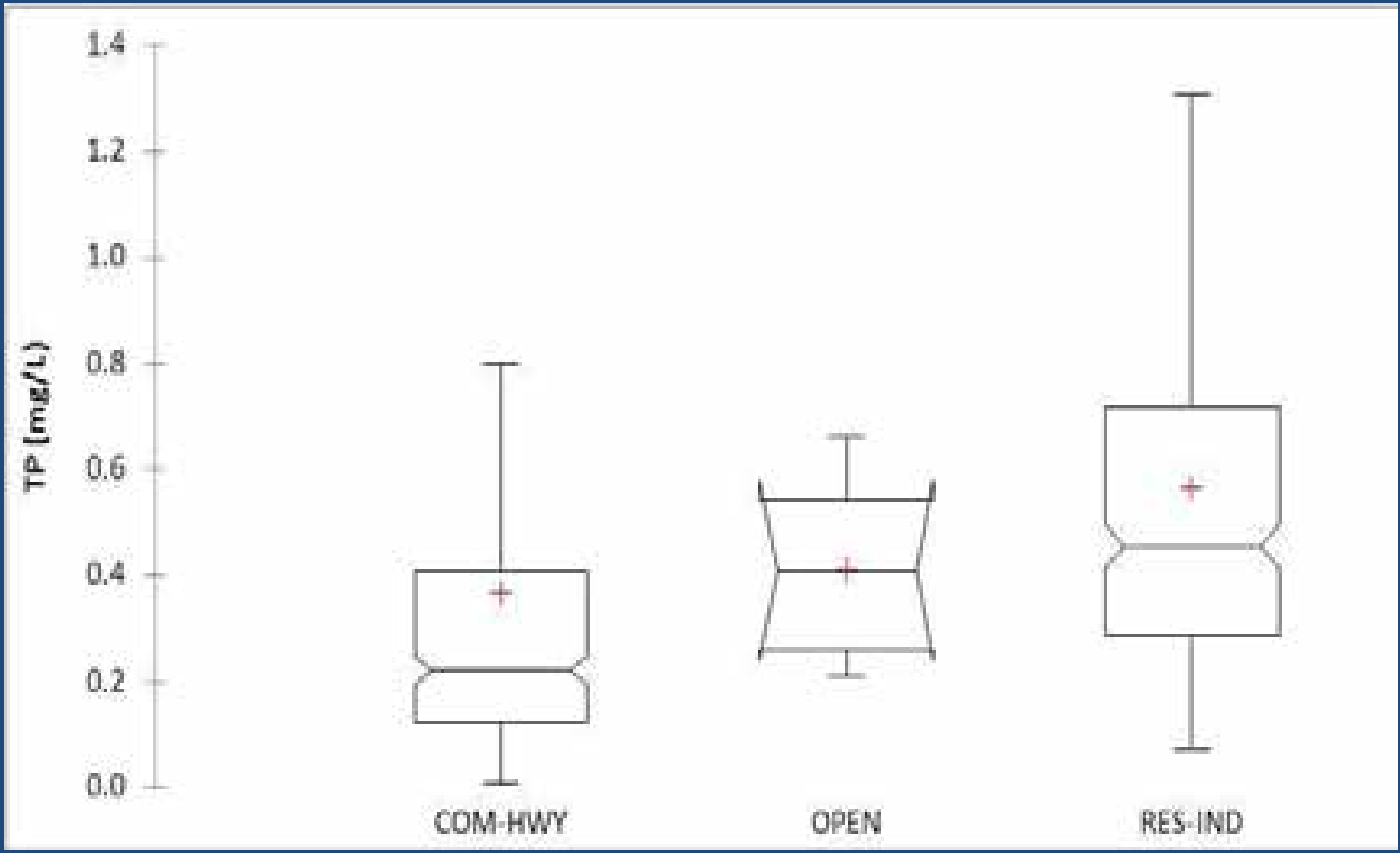
Colorado Total Phosphorus (mg/L)in Runoff

Land Use	# Events	Min	Max	25th %	Median (Upper & Lower 95% CI)	75th %	Mean (Upper & Lower 95% CI)	COV
Individual Land Use Categories								
COM	282	0.01	6.30	0.12	**0.22** (0.18-0.27)	0.43	0.37 (0.31-0.44)	1.5
HWY	41	0.05	2.60	0.13	**0.23** (0.16-0.31)	0.40	0.32 (0.19 -0.45)	1.3
IND	23	0.09	1.30	0.19	**0.33** (0.17-0.66)	0.69	0.45 (0.31-0.59)	0.7
OPEN	7	0.21	0.66	0.26	**0.41** (0.21-0.53)	0.54	0.41 (0.25 -0.58)	0.4
RES	261	0.07	2.71	0.30	**0.47** (0.41-0.51)	0.72	0.58 (0.53 -0.63)	0.7
Combined Land Use Categories								
COM-HWY	323	0.01	6.30	0.12	**0.22**	0.41	0.37 (0.31-0.42)	1.5
RES-IND	284	0.07	2.71	0.29	**0.46**	0.72	0.57 (0.52-0.61)	0.7

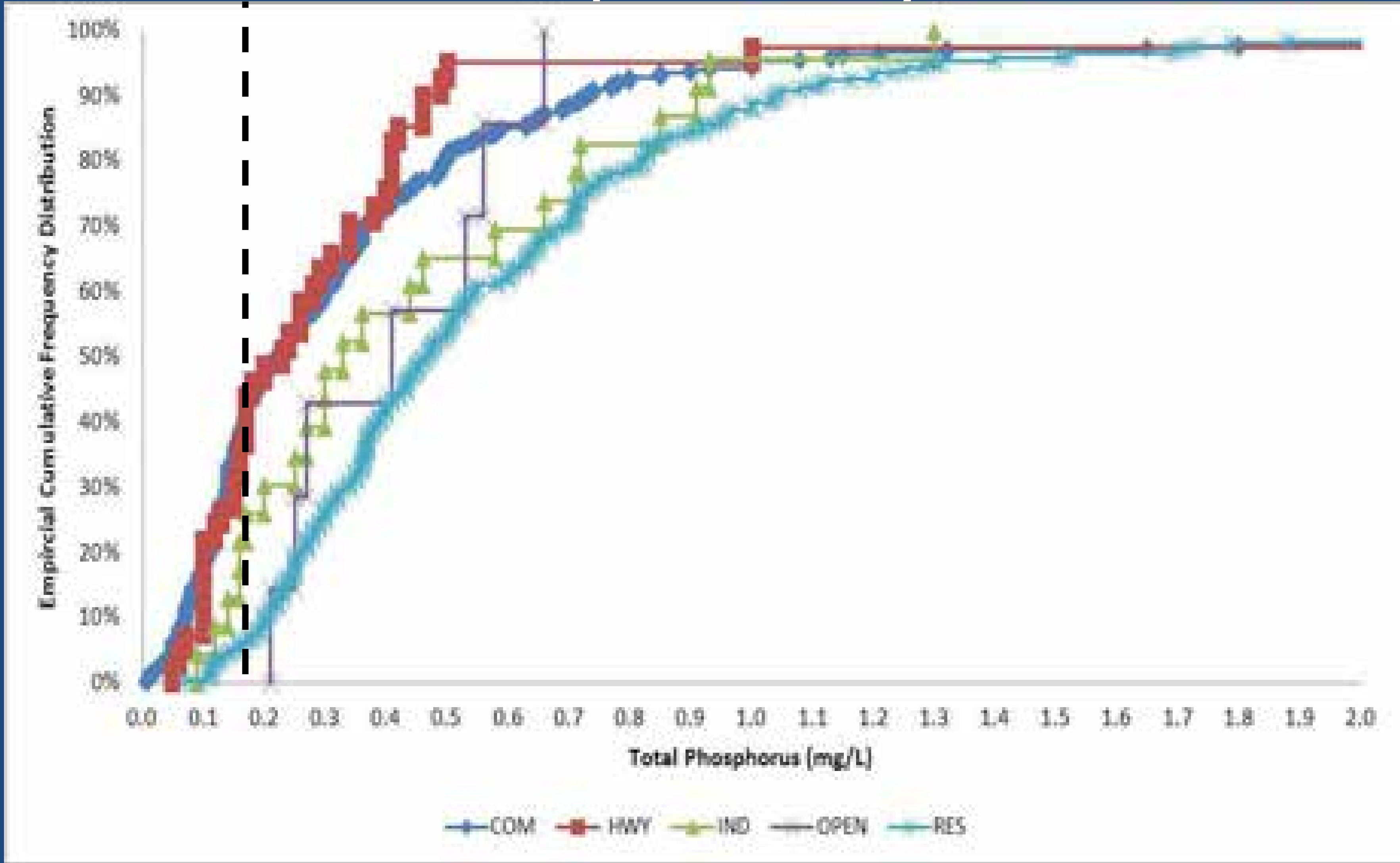
Colorado TP Boxplots by Land Use



Colorado TP Boxplots by Combined Land Use



Cumulative Frequency Distribution for CO Total Phosphorus by Land Use



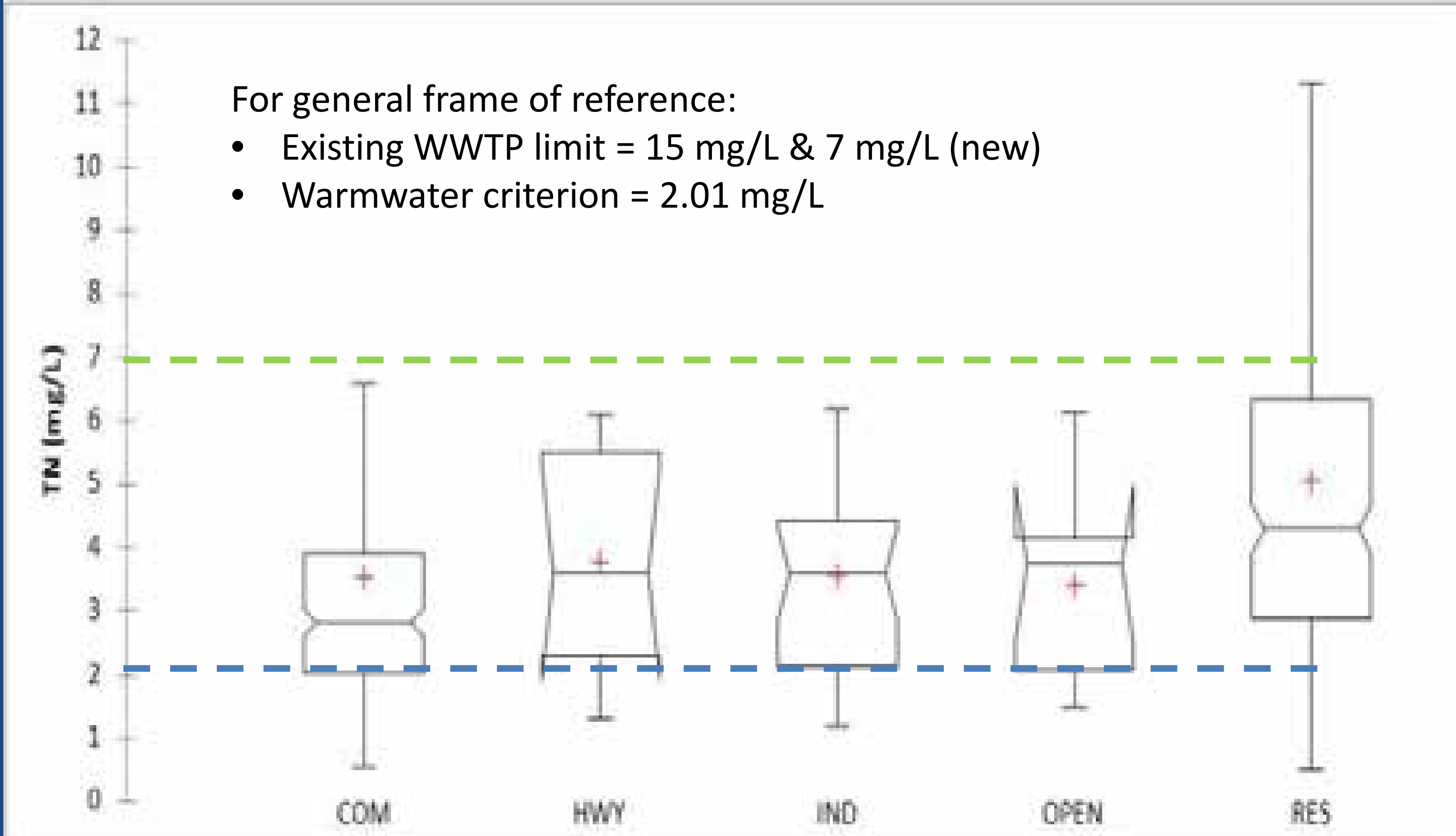
Colorado Total Nitrogen (mg/L) in Runoff

Land Use	#	Min	Max	25%	Median (Upper & Lower 95% CI)	75%	Mean (Upper & Lower 95% CI)	COV
Individual Land Use Categories								
COM	171	0.54	16.63	2.03	**2.83** (2.55-3.10)	3.90	3.54 (3.15 -3.94)	0.74
HWY	9	1.30	6.10	2.30	**3.60** (1.30-5.50)	5.50	3.78 (2.39-5.17)	0.45
IND	23	1.20	8.70	2.15	**3.60** (2.00-4.37)	4.44	3.56 (2.78-4.34)	0.49
OPEN	7	1.49	6.12	2.08	**3.76** (1.49-4.11)	4.14	3.40 (1.90-4.90)	0.44
RES	195	0.51	22.77	2.87	**4.30** (3.71-4.82)	6.34	5.06 (4.61-5.51)	0.63
Combined Land Use Categories								
COM-IND	194	0.54	16.63	2.02	**2.9** (2.6-3.2)	3.97	3.55 (3.19-3.90)	0.71

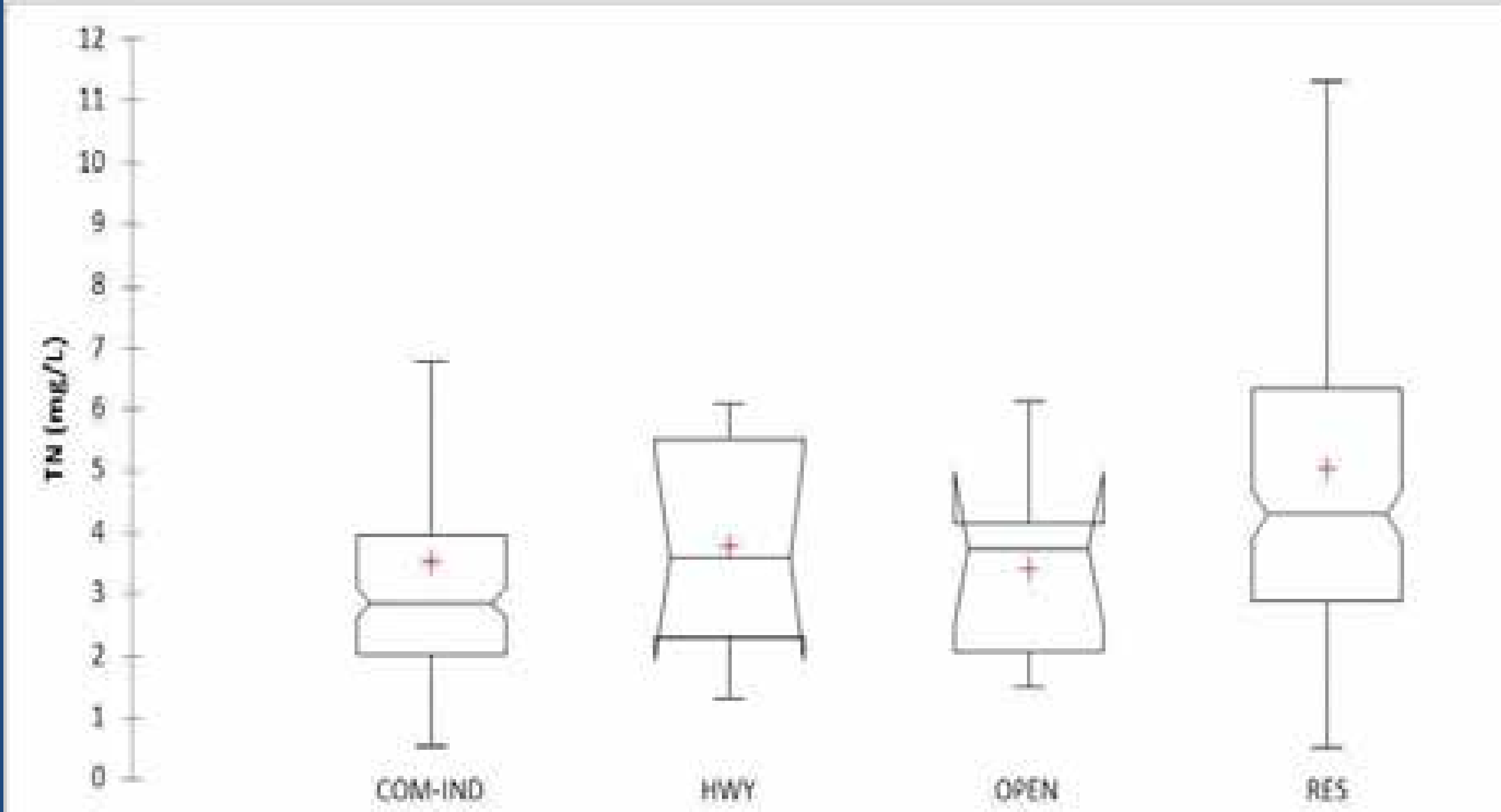
Colorado TN Boxplots

For general frame of reference:

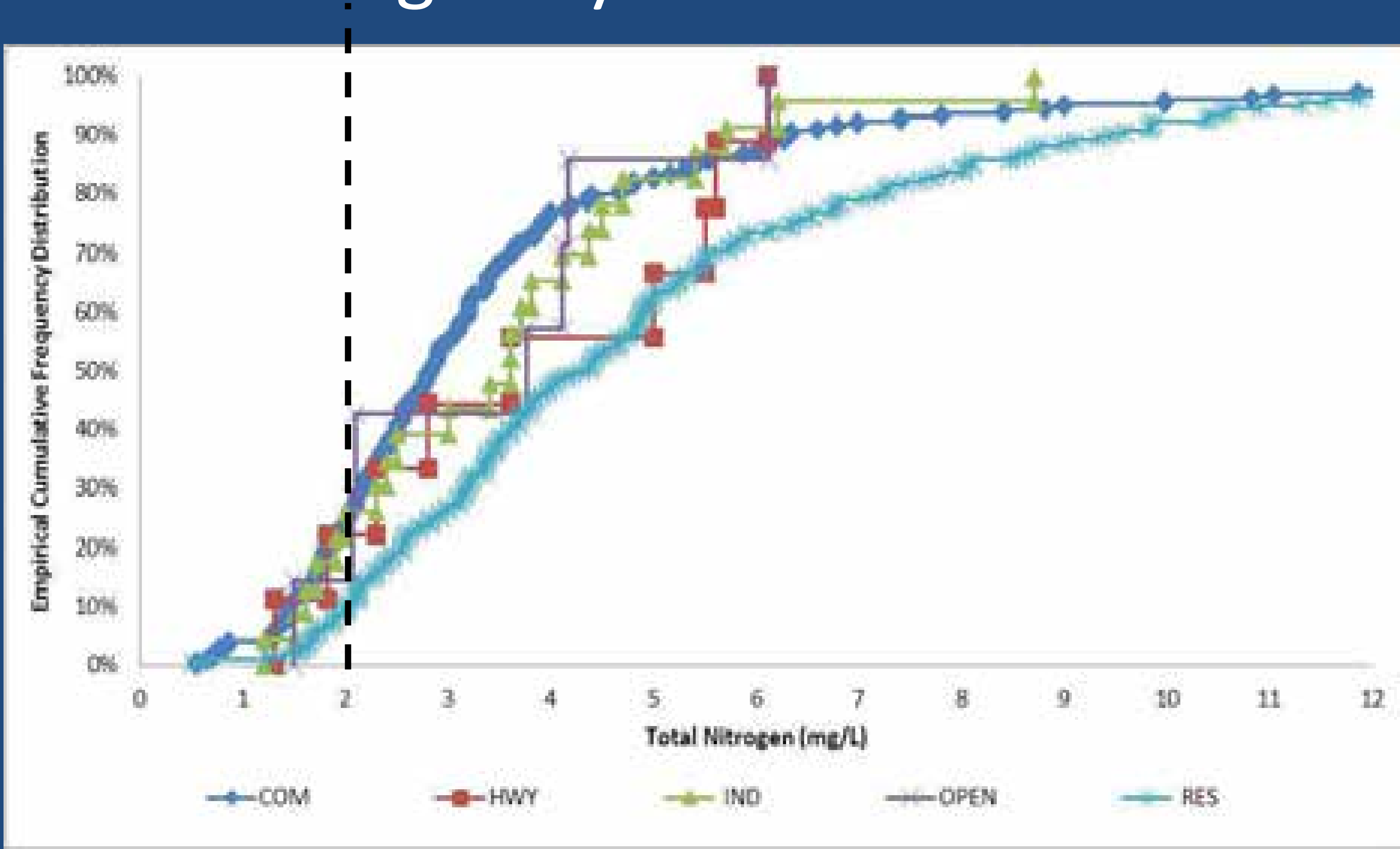
- Existing WWTP limit = 15 mg/L & 7 mg/L (new)
- Warmwater criterion = 2.01 mg/L



Colorado TN Boxplots by Combined Land Uses



Cumulative Frequency Distribution for Total Nitrogen by Land Use in Colorado

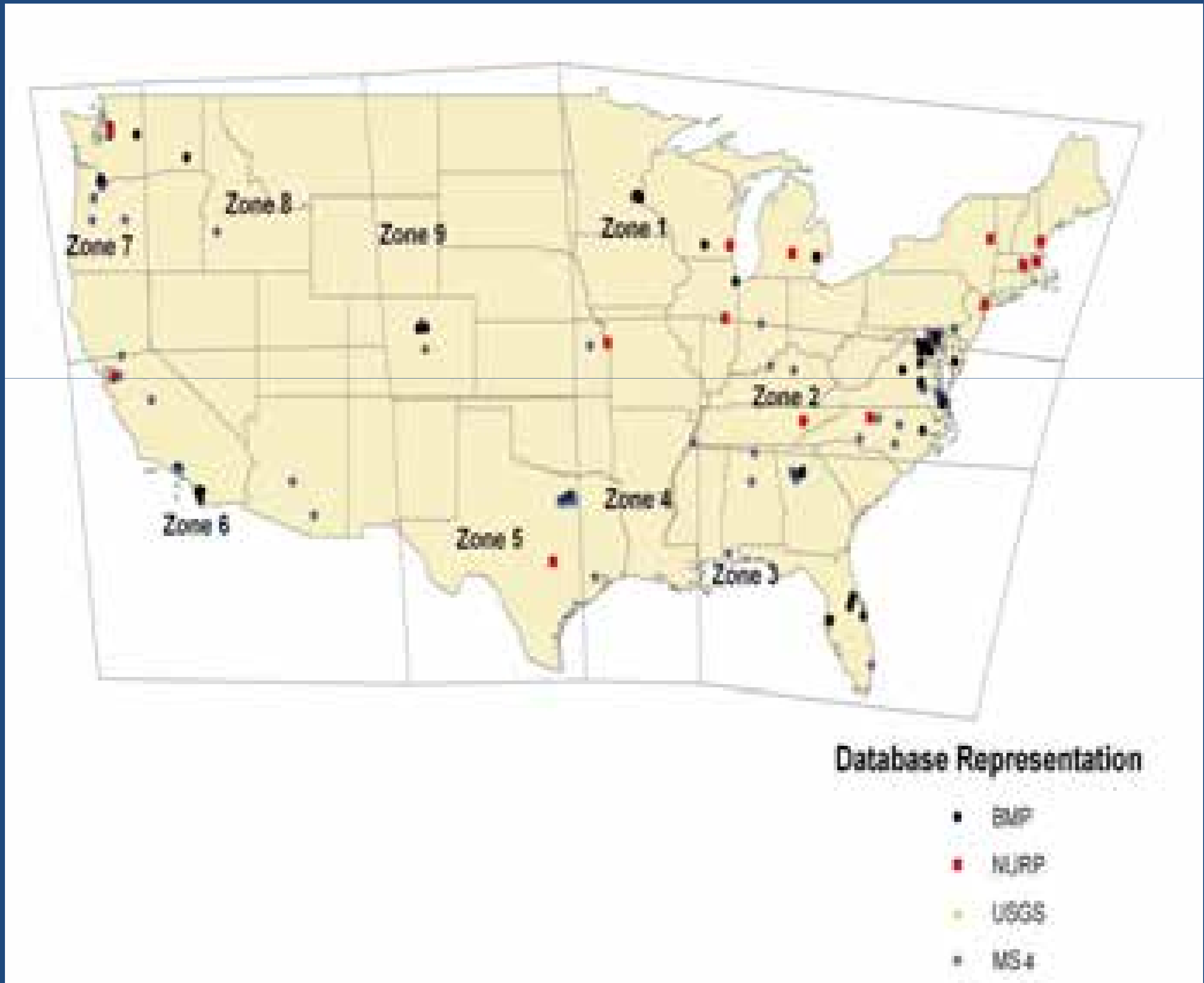


Spearman Correlation Coefficients for TP, TN, TSS by Land Use

- Open space (natural areas):
  - TP & TSS strongly correlated .
  - No other statistically significant correlations.
- Commercial and residential areas:
  - Positive correlations among TSS, TN & TP
  - TSS & TN correlation not as strong as TSS & TP correlation or TP & TN correlation
- Industrial areas:
  - TP & TN strongly correlated.
  - No significant correlations with TSS.
- Highway-related areas:
  - TP & TN not significantly correlated.
  - TSS not evaluated.

		COM		
COM		TN	TP	TSS
	TN	1.00	0.57	0.39
	TP	0.57	1.00	0.74
	TSS	0.39	0.74	1.00
		HWY		
HWY		TN	TP	TSS
	TN	1.00	-0.25	NA
	TP	-0.25	1.00	NA
		IND		
IND		TN	TP	TSS
	TN	1.00	0.78	-0.08
	TP	0.78	1.00	0.20
	TSS	-0.08	0.20	1.00
		OPEN		
OPEN		TN	TP	TSS
	TN	1.00	0.68	0.46
	TP	0.68	1.00	0.93
	TSS	0.46	0.93	1.00
		RES		
RES		TN	TP	TSS
	TN	1.00	0.58	0.45
	TP	0.58	1.00	0.58
	TSS	0.45	0.58	1.00

NSQD v.3 Runoff Characterization Data by U.S. EPA Rain Zone



Comparison CO TP to EPA Rain Zones

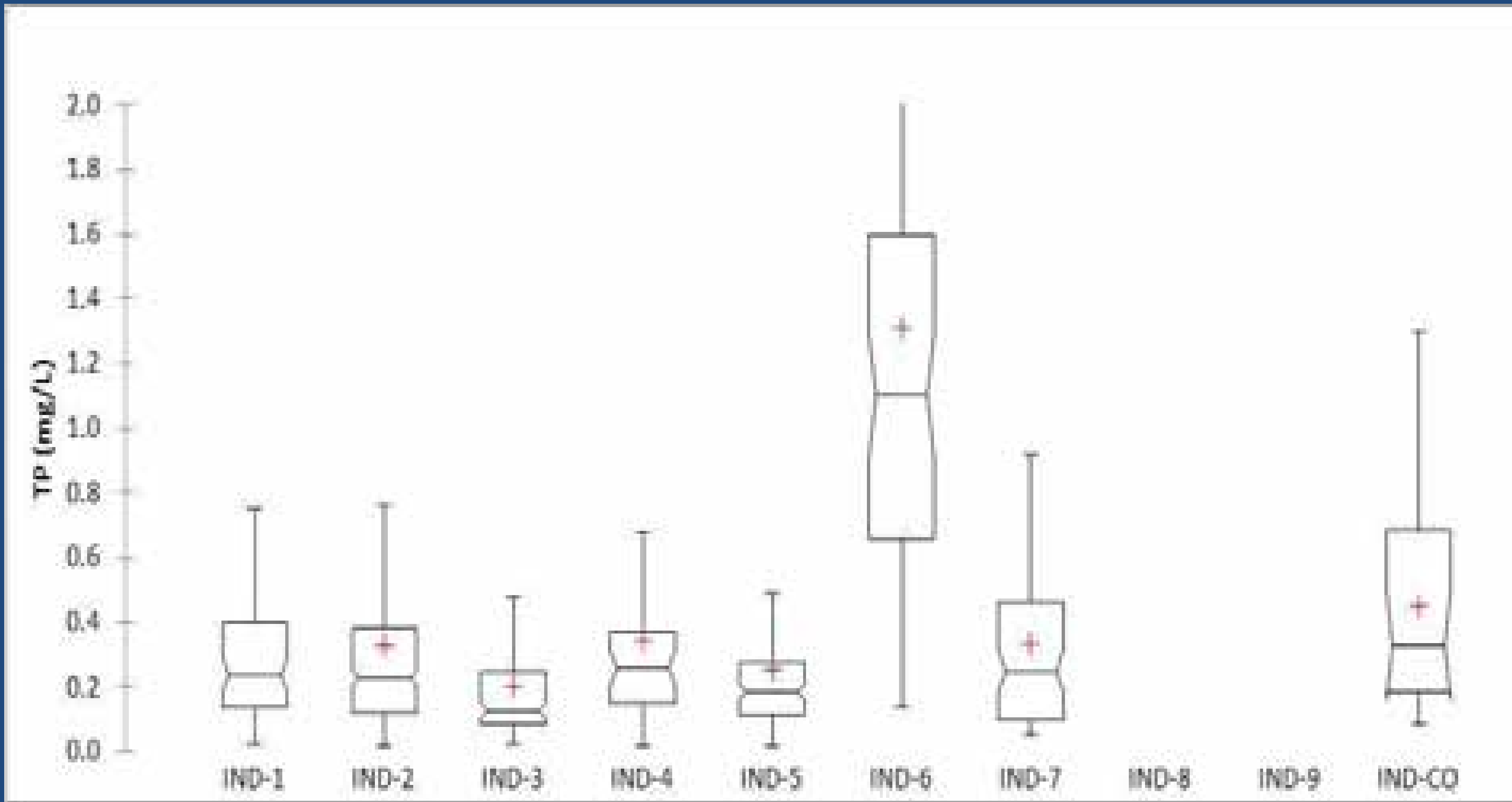
(Kruskal-Wallis/Dunn's Procedure)

Rain Zone		Colorado Land Use				
Rain Zone	Description	COM (282)	HWY (41)	IND (23)	OPEN (7)	RES (261)
1	Great Lakes/ Northeast	Higher (263)	NSD (3)	NSD (74)	Higher (139)	Higher (498)
2	Mid-Atlantic	NSD (621)	Lower (177)	Higher (360)	NSD (106)	Higher (1923)
3	Southeast	NSD (141)	Higher (14)	Higher (108)	--	Higher (410)
4	Lower Miss. Valley	NSD (50)	--	NSD (49)	NSD (18)	NSD (91)
5	Texas	Higher (112)	NSD (246)	Higher (108)	NSD (67)	Higher (206)
6	Southwest	Lower (35)	NSD (135)	Lower (61)	NSD (2)	NSD (67)
7	Northwest	NSD (84)	NSD (24)	Higher (76)	--	Higher (331)
8	Rocky Mtns.	*Lower* (7)	--	NSD (1)	--	NSD (15)

Higher/Lower/NSD = indicates whether Colorado's TP results are higher, lower or not significantly different statistically from another other rain zone;

(#) = number of samples in data set

Colorado TP Data vs. NSQD Data for EPA Rain Zones: Industrial Land Uses



Comparison CO TN to EPA Rain Zones

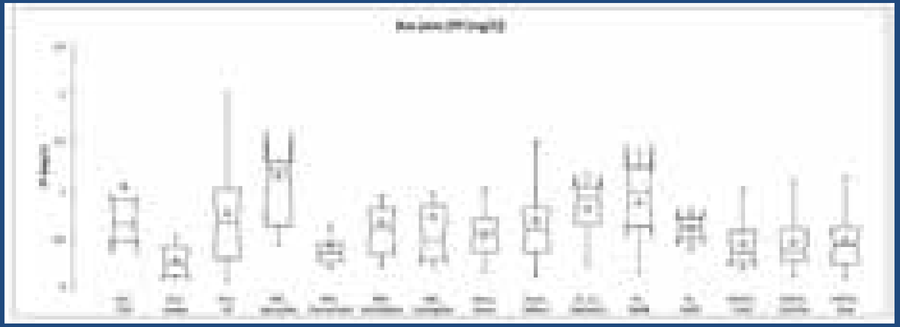
(Kruskal-Wallis/Dunn's Procedure)

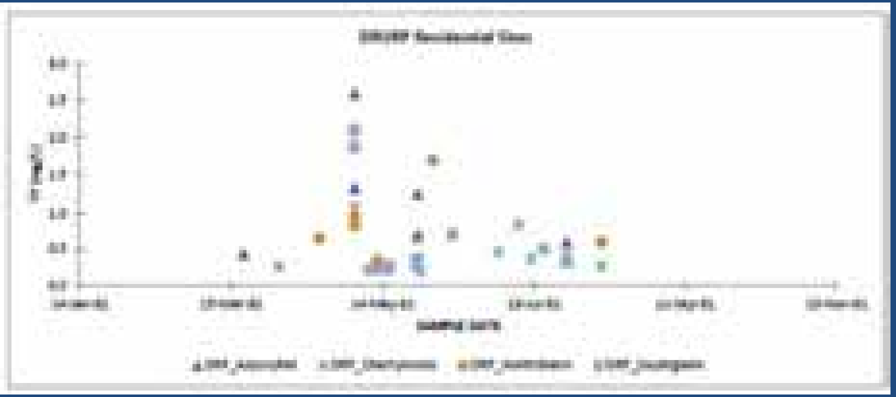
		Colorado Land Uses (#) = number of samples in data set				
Rain Zone	Description	COM (171)	HWY (9)	IND (23)	OPEN (7)	RES (195)
1	Great Lakes/Northeast	Higher (12)	--	NSD (6)	Higher (5)	Higher (30)
2	Mid-atlantic	Higher (76)	--	NSD (87)	Higher (57)	Higher (111)
3	Southeast	Higher (37)	NSD (14)	NSD (28)		Higher (49)
4	Lower Miss. Valley	Higher (26)	--	NSD (29)	NSD (12)	Higher (56)
5	Texas	--	--	--	--	--
6	Southwest	NA (2)	--	NSD (10)	--	NA (3)
7	Northwest	--	--	--	--	--
8	Rocky Mtns.	--	--	--	--	--

Higher/Lower/NSD = indicates whether Colorado's TP results are higher, lower or not significantly different statistically from another other rain zone;
(#) = number of samples in data set

Other Topics Explored

- Statistics for individual sites
- Old vs. new data
- Fraction of NO3/NO2 in TN (≈25% for COM, IND, RES)
- Snowmelt vs. runoff
- Concentration vs. imperviousness





Nutrient Load Estimation

$$Load\left[\frac{lb}{ac}\right] = 0.226 \times EMC\left[\frac{mg}{L}\right] \times Runoff\,[in]$$

- To estimate nutrient loads from urban land uses:
  - ✓ precipitation data
  - ✓ runoff volume calculations
  - ✓ nutrient EMC data
- For runoff volume calculations:
  - – drainage area
  - – land use
  - – imperviousness
  - – soil type
- Water Quality Capture Optimization and Statistics Model (WQ-COSM) (UWRI 2011)

Example Spreadsheet Approach Based on WQ-COSM

Site Name: CSC Template
Drainage Area: 10.00 acres

- From WQ-COSM
- From USDCM Storage Chapter for Land Use
- Run for A, B and C/D for each Land Use
- EMCs from Data Analysis for Land Use

Percentile Distribution of Runoff-Producing Precipitation Events		Landuse Imperviousness	Hydrologic Soil Group	Runoff	Runoff Event Mean Concentration (EMC) for Land Use	Runoff Pollutant Load	Estimated Event Load
Percentile	Precipitation Depth (in)*	Single Family Residential	A, B or C/D	Runoff (in)	Landuse TP (mg/L)	TP (lb/acre)	TP (lb)
1%	0.080	40%	C/D	0.032	0.47	0.003	0.03
5%	0.090	40%	C/D	0.036	0.47	0.004	0.04
10%	0.100	40%	C/D	0.040	0.47	0.004	0.04
15%	0.100	40%	C/D	0.040	0.47	0.004	0.04
20%	0.100	40%	C/D	0.040	0.47	0.004	0.04
25%	0.100	40%	C/D	0.040	0.47	0.004	0.04
30%	0.100	40%	C/D	0.040	0.47	0.004	0.04
35%	0.120	40%	C/D	0.048	0.47	0.005	0.05
40%	0.140	40%	C/D	0.056	0.47	0.006	0.06
45%	0.170	40%	C/D	0.068	0.47	0.007	0.07
50%	0.200	40%	C/D	0.080	0.47	0.008	0.08
55%	0.202	40%	C/D	0.081	0.47	0.009	0.09
60%	0.240	40%	C/D	0.096	0.47	0.010	0.10
65%	0.280	40%	C/D	0.112	0.47	0.012	0.12
70%	0.310	40%	C/D	0.124	0.47	0.013	0.13
75%	0.380	40%	C/D	0.152	0.47	0.016	0.16
80%	0.450	40%	C/D	0.180	0.47	0.019	0.19
85%	0.570	40%	C/D	0.228	0.47	0.024	0.24
90%	0.770	40%	C/D	0.308	0.47	0.033	0.33
95%	1.100	40%	C/D	0.463	0.47	0.049	0.49
99.5%	2.517	40%	C/D	1.184	0.47	0.126	1.26
100%	4.820	40%	C/D	2.975	0.47	0.316	3.16

* Events < 0.08 in excluded to account for impervious depression storage.

Overall Conclusion

- A significant EMC-based urban runoff data set is available to characterize nutrient loads in urban runoff in Colorado.
- Data Report provides statistical characterization of TP & TN concentrations by land use for this purpose.
- Additional monitoring for purposes of general characterization of nutrients in urban runoff in Colorado is likely not necessary to meet requirements of Regulation 85.
- However, in watersheds where nutrient impairments have been identified and urban stormwater runoff is a likely contributor, then targeted monitoring to identify watershed-specific nutrient sources may be beneficial to help prioritize selection and placement of BMPs.

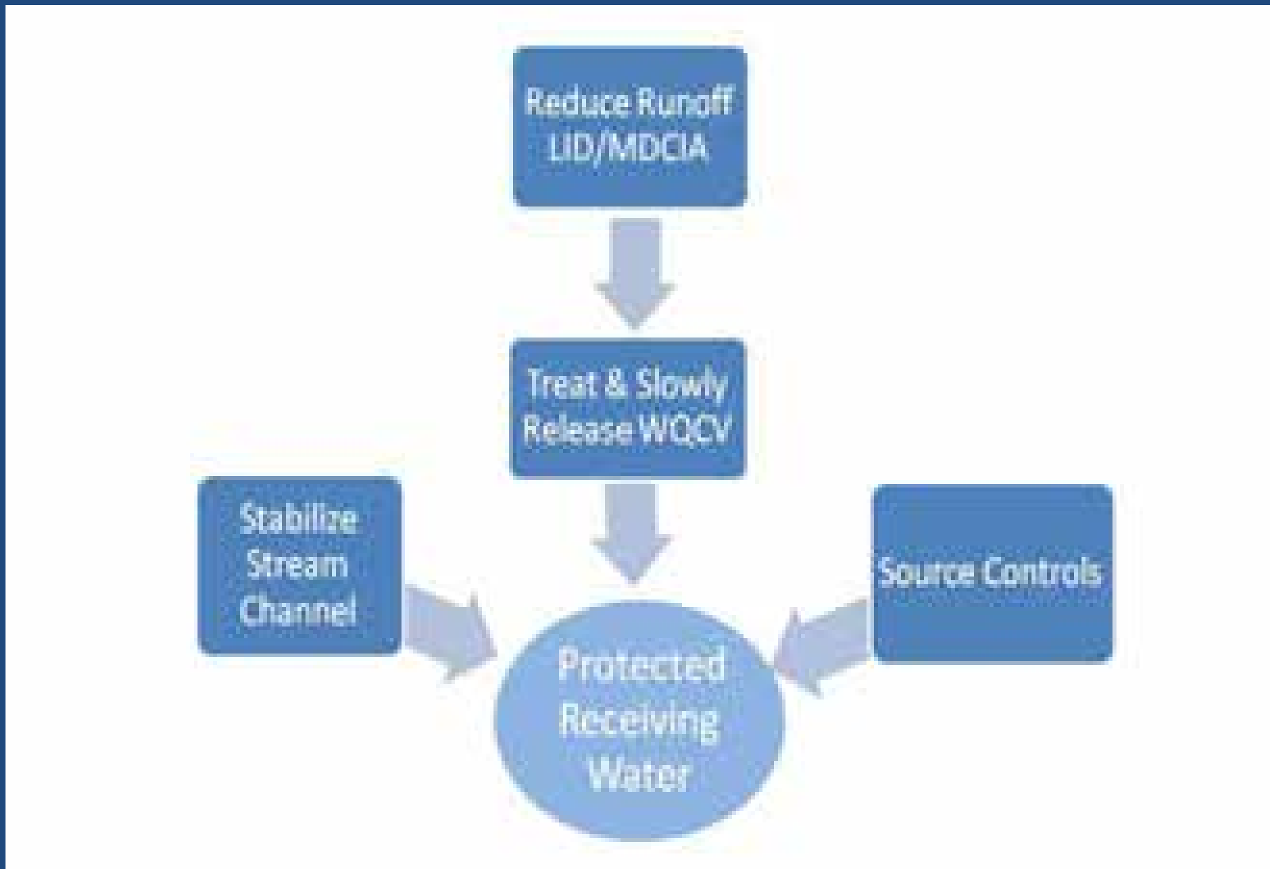
Other Specific Findings

- Colorado nutrient EMC data set:
  - TP (n = 614) & TN (n = 405)
  - Represents most urban land uses
  - Residential and commercial are particularly strong
- Median TP for EMCs by land use in Colorado ranges from 0.22 to 0.47 mg/L, with statistically significant differences among some land uses.
- TP in residential runoff is statistically higher than commercial and highway-related land uses.
- Median TN for EMCs by land use in Colorado ranges from 2.83 to 4.30 mg/L, with statistically significant differences among some land uses.
- TN in residential runoff is statistically higher than commercial and industrial land uses.

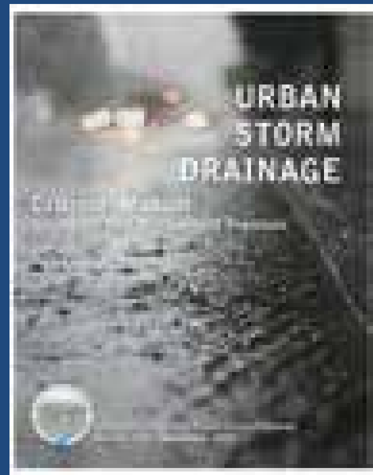
Findings (cont.)

- Median untreated TN & TP by land use are all higher than interim instream water quality standards—including runoff from natural areas.
- Median untreated TN & TP by land use are all lower than the Reg. 85 WWTP discharge limits.
- Colorado TP is within ranges observed in other EPA Rain Zones.
- Colorado TN tends to be higher than ranges observed in other EPA Rain Zones.
- Rain Zone 6 (Southwest) may be useful for supplementing western Colorado data set.

Not part of the study… but tools for addressing nutrients in urban areas



UDFCD's Four Step Process (USDCM Vol. 3, 2010)



Questions?

Jane Clary, Wright Water Engineers
clary@wrightwater.com

Scott Struck, Ph.D., Geosyntec Consultants
sstruck@geosyntec.com

Holly Piza, P.E., Urban Drainage and Flood Control District
hpiza@udfcd.org

Jill Piatt-Kemper, P.E., Colorado Stormwater Council
jpiatt@auroragov.org

Rio Grande Stormwater Improvements

Flow-Based Versus Volume-Based Water Quality Measures

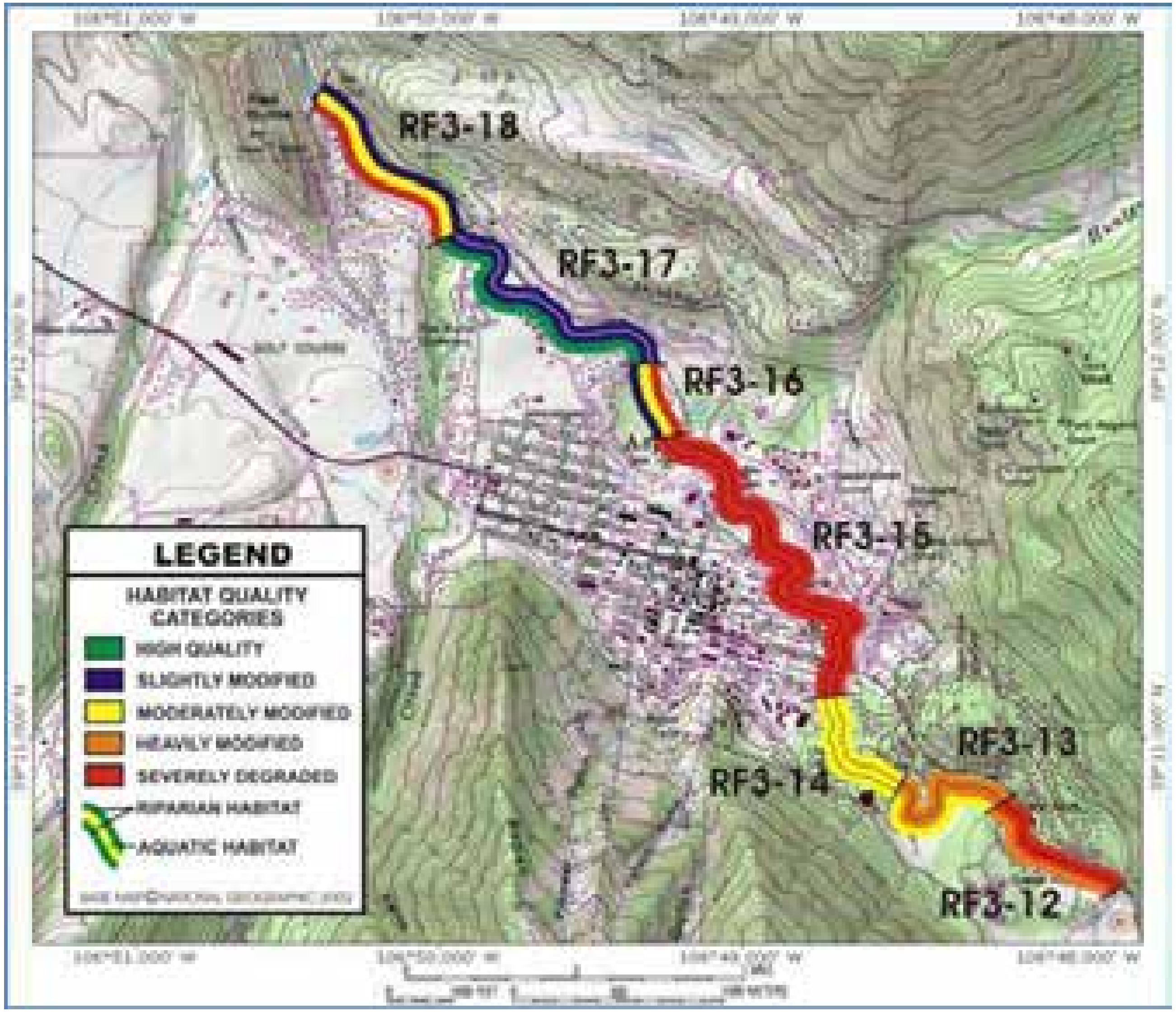
RESPEC

Water Quality in Aspen

RESPEC

The City of Aspen

Water Quality in Aspen



RESPEC

The City of Aspen

Aspen's Drainage System

- Springs Street system
  - 725 acres
  - 16% imperviousness
- Mill Street system
  - 140 acres
  - 35% imperviousness

General Park Layout & Constraints

RESPEC

Project Goals, Concerns, & Concepts

- Meet the URMP requirements for water quality treatment.
- Incorporate that treatment into a park setting with a natural aesthetic.
- The park's aesthetic is critical due to its proximity to John Denver Sanctuary, Theater Aspen, & the Rio Grande Trail.
- Pass a base flow to recharge permanent storage within the ponds and provide visual interest to park visitors.

RESPEC

The City of Aspen

Water Quality Capture Volume

URMP WQCV (acre-feet)

	MDCIA=0	MDCIA=1.5
Spring Street System	2.42	1.88
Mill Street System	0.79	0.66

- Available surface area = 0.80 acres
- Shouldn’t be a problem! About 3 feet deep! Perfect!
- I bet the Parks Department will be thrilled!

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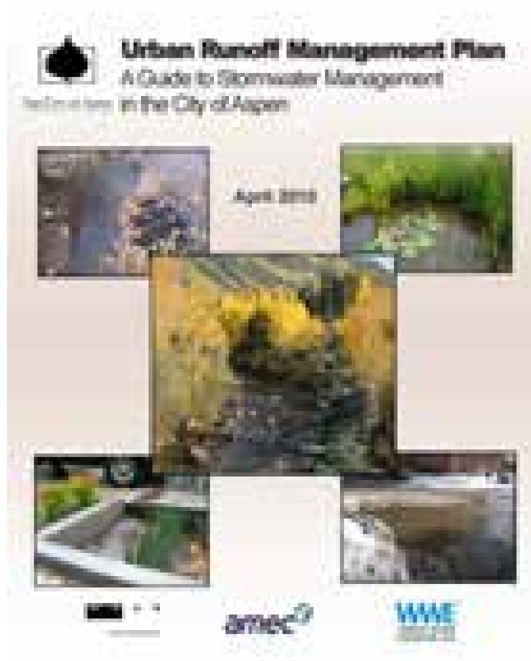
The Parks Dept. had their Own Plan…

RESPEC

The City of Aspen

What does the URMP actually say?

- The standard criteria: "…80th percentile treatment and > 90 percent removal of particles 60 microns & larger."
- The standard solution: "…emptying time for the WQCV shall be a minimum of 12 hours…" This… "should provide a very high level of removal (greater than 90%) for this size of particles (USEPA 1986)
- Could there be an alternate solution?
- What is this USEPA 1986 reference?



Flow-Based Methodology

- *Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality,* USEPA **1986**
- Nothing new here
- Removal under dynamic (flow through) conditions

$$R = 1 - \left[1 + \frac{1}{n} \cdot \frac{v_s}{Q/A}\right]^{-n}$$

R = fraction of initial solids removed (R * 100 = % Removal)

v_s = settling velocity of particles

Q/A = rate of applied flow divided by surface area of basin (an "overflow velocity," often designated the overflow rate)

n = a parameter which provides a measure of the degree of turbulence or short-circuiting, which tends to reduce removal efficiency

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Now what?

- We varied P_1 in CUHP/SWMM until the total storm volume equaled the WQCV required by the URMP to arrive at some kind of flow-based equivalent to the WQCV.
- We used the resultant peak flow rate as the desired water quality flow rate for the system.
- The magic P_1 was 0.44”, more than the 6-month value of 0.36” and less than the 1-year value of 0.53”.
- Peak flow rates, including a 2-cfs base flow assumed for each system were **19 cfs** for Spring Street and **17 cfs** for Mill Street.

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Park Concept and Schematic

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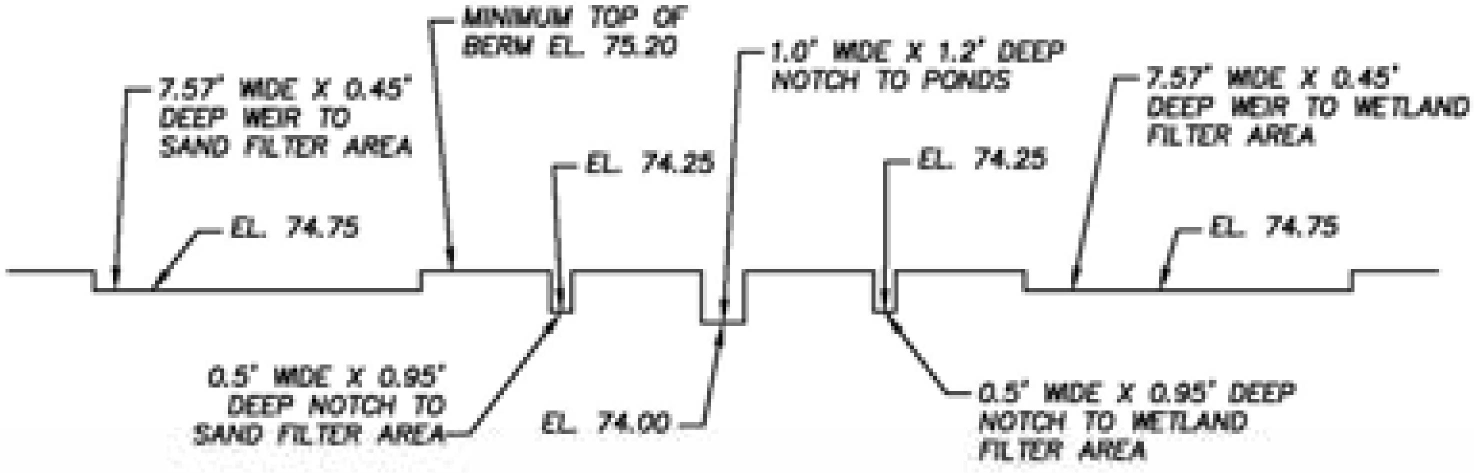
How water moves through the park



Structure& Flow Destination	Base Flow	Storm Event
Notch to Central Watercourse & Ponds	1.8	4.0
Notch to Sand Filter	0.5	1.4
Notch to Wetland	0.5	1.4
Weir to Sand Filter	0	6.1
Weir to Wetland	0	6.1
Total	2.8	19.0

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When it's all said and done

- During peak water quality flow in the Spring Street system (**19 cfs**), we get **98%** removal of the 60-micron particle. Surface area total is 0.45 acres.
- During peak water quality flow in the Mill Street system (**9 cfs**), we get **90%** removal of the 60-micron particle. Surface area total is 0.12 acres.
  - This does not include benefit accrued by cascading drops along Mill Street.
  - Equation underestimates true sediment vault removal rate.

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Does the sediment vault really work?

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Final Product

South of Pond 3, looking north toward Theatre Aspen

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Final Product

Looking east across Pond 3 at overflows from Pond 2

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Final Product

Looking west across Pond 2 toward Pond 3 & foot bridge

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Final Product

Walking paths integrated into the system

Final Product

Pond 4 adjacent to and south of Theatre Aspen

How does this work again?

- Settling Velocity = Submerged Weight – Drag

$$V_s = \frac{1}{18}\left[\frac{gd^2}{v}(SG-1)\right]$$

SG = specific gravity

ν = viscosity, ft^2/s

d = diameter of particle in question, mm

g = gravity

- $$Fraction\ Removed = \frac{Settling\ Velocity, V_s}{Critical\ Settling\ Velocity, V_c}$$

- $$V_c = \frac{Depth, D}{Detention\ Time, T} = \frac{D*V}{L} = \frac{W*D*V}{W*L} = \frac{Q}{A}$$

- $$Fraction\ Removed = \frac{Settling\ Velocity, V_s}{Q/_A}$$

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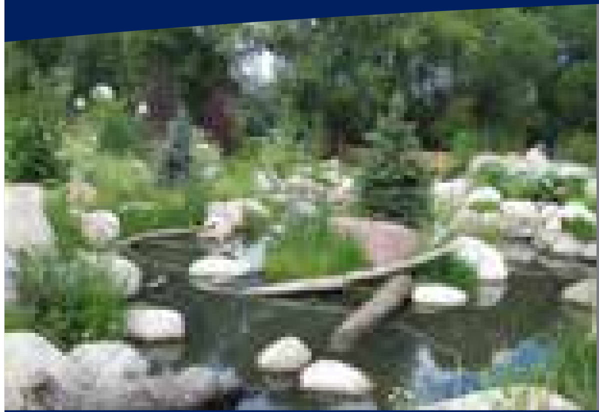
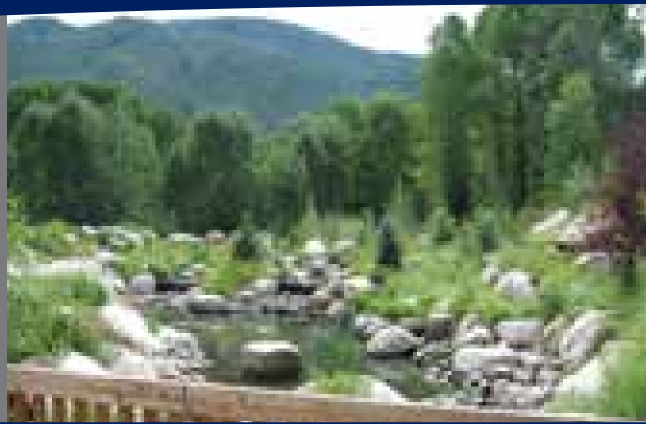




Questions?

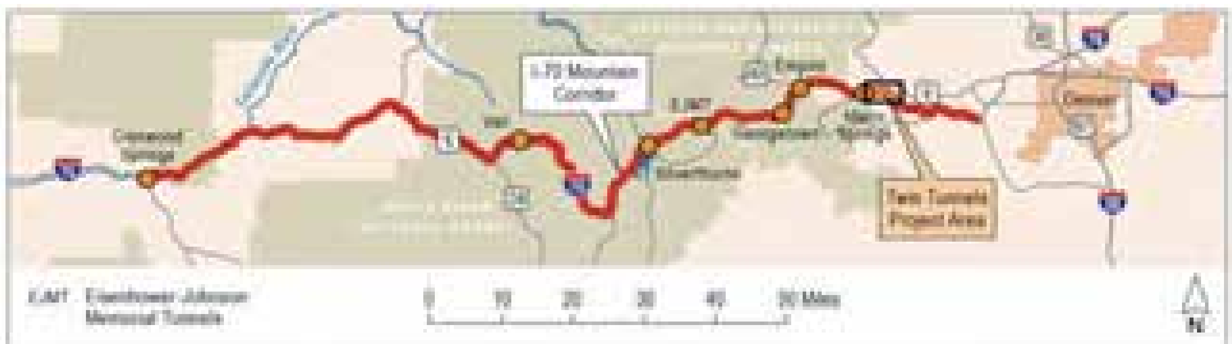
I-70 Twin Tunnels
Water Quality Mitigation

Holly Huyck
CDOT

Josh Hollon
Atkins

I-70 Mountain Corridor:
Denver to Glenwood Springs

I-70 Mountain Corridor with Twin Tunnels Project Location



Project Background

- Programmatic EIS and ROD signed in 2011
- Twin Tunnels is part of the minimal improvements listed in the ROD.
- Twin Tunnels EA and FONSI signed in 2012
- Includes Context Sensitive Solutions Approach and
- Clear Creek Sediment Control Action Plan (SCAP)

Clear Creek—The Receiving Water

ATKINS

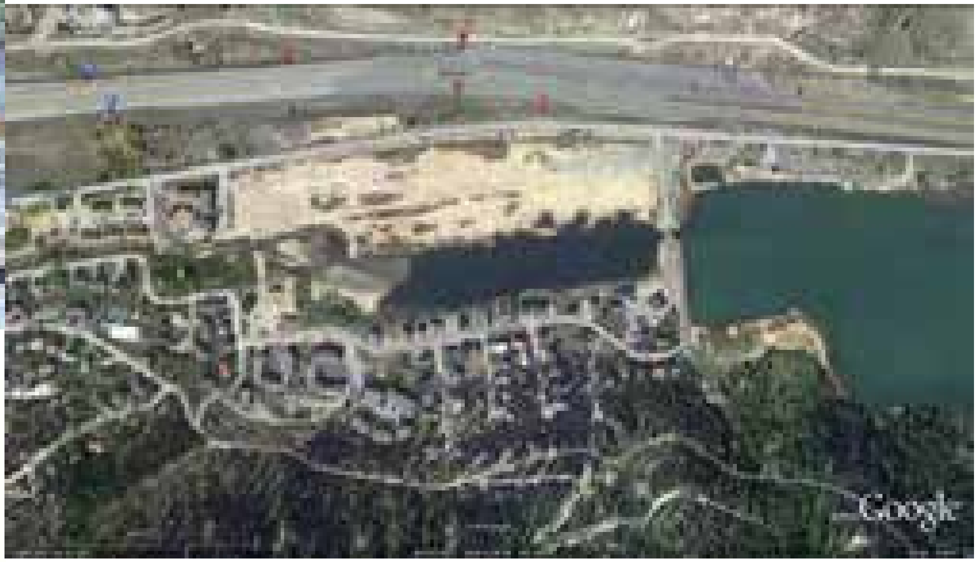
- ❖ Drinking water for 300,000 CO residents and Coors
- ❖ Historic mining made this watershed a Superfund Area. (listed in early 1980s).
- ❖ Argo Plant to treat mine drainage in Idaho Springs removes 700 lbs./DAY of metals
- ❖ Fish recovering; stream remains impaired for metals
- ❖ Black Hawk water intake downstream
- ❖ Fishing and rafting are major businesses

Potential Pollution Sources

ATKINS

- Erosion from cut and fill slopes
- Historic mine drainage and runoff (stream impaired for cadmium in Twin Tunnels area)
- Highway runoff (e.g. metals from vehicle parts)
- CDOT winter maintenance (traction sand or deicers)
- Spills from vehicles

Pollution Sources



Existing Water Quality Mitigation

- A few sediment basins in Clear Creek Watershed—some are informal and others are more formal
- All existing basins capture sediment, not spills
- Constantly improving the designs
- CDOT maintenance of BMPs is critical
- Sweeping after snow storms or in spring
- Used sand NOT reused—has to go somewhere!

← Basin near Dumont

Berthoud Pass →

Water Quality Maintenance

I-70 Widening

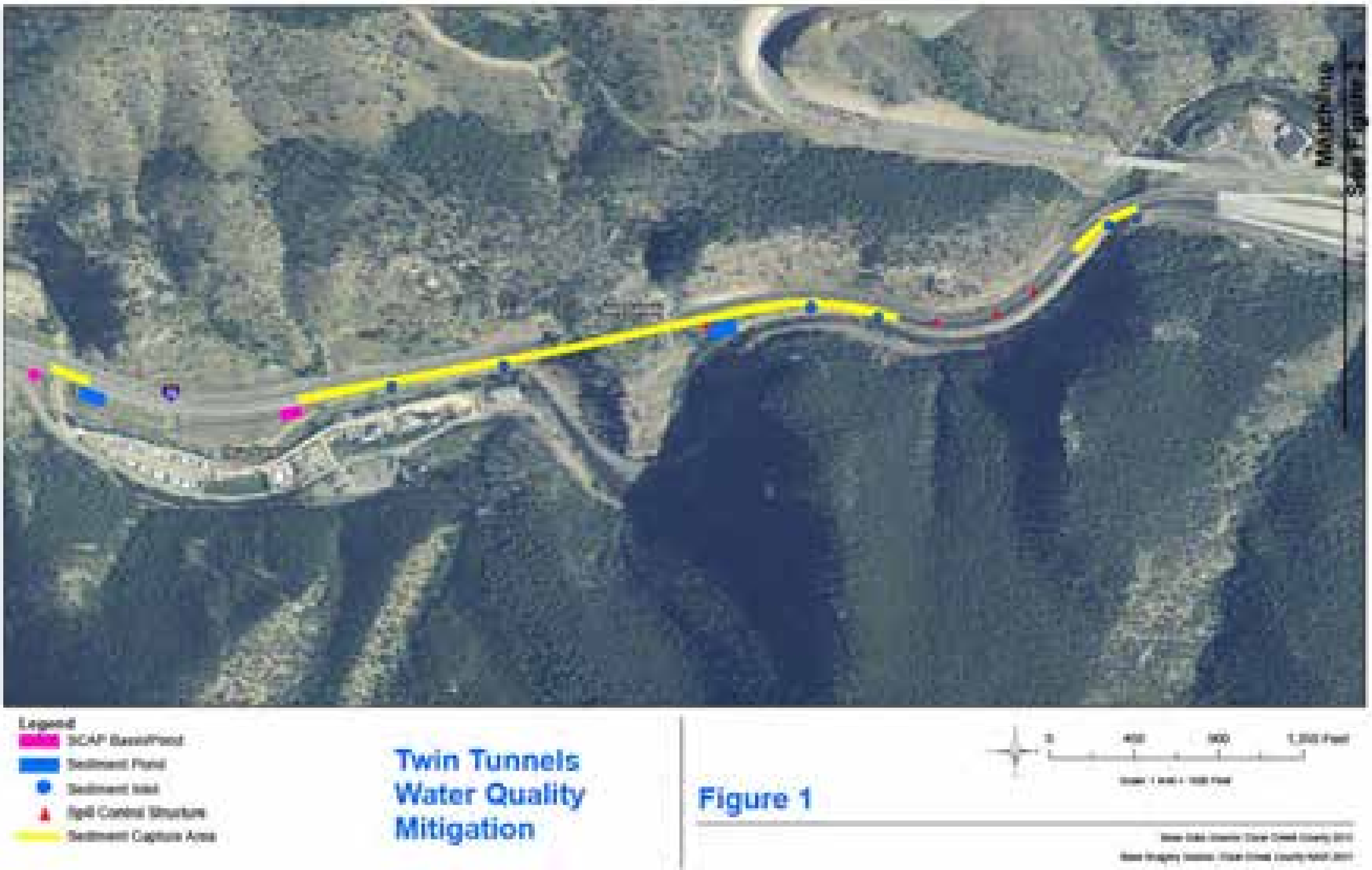
Twin Tunnels Water Quality

Tunnel Widening

I-70 Curve Flattening

Twin Tunnels Water Quality

Water Quality Improvements



Water Quality Improvements

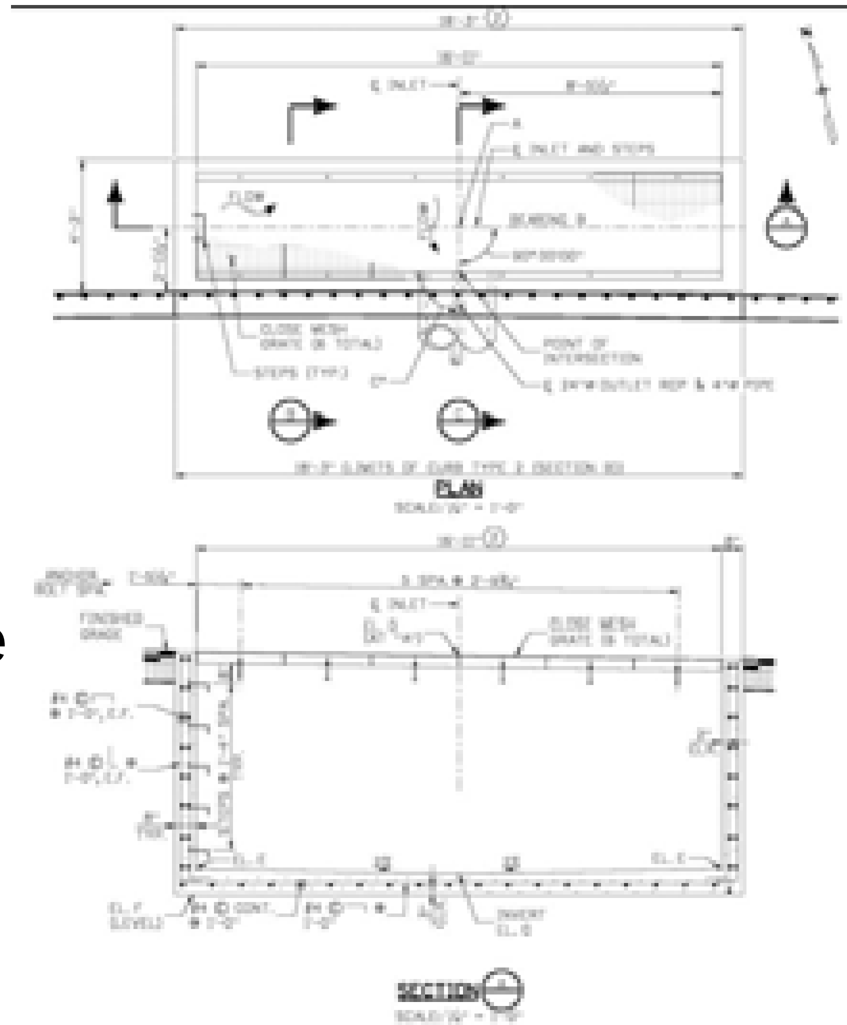
Elimination of Direct Runoff

Twin Tunnels Water Quality

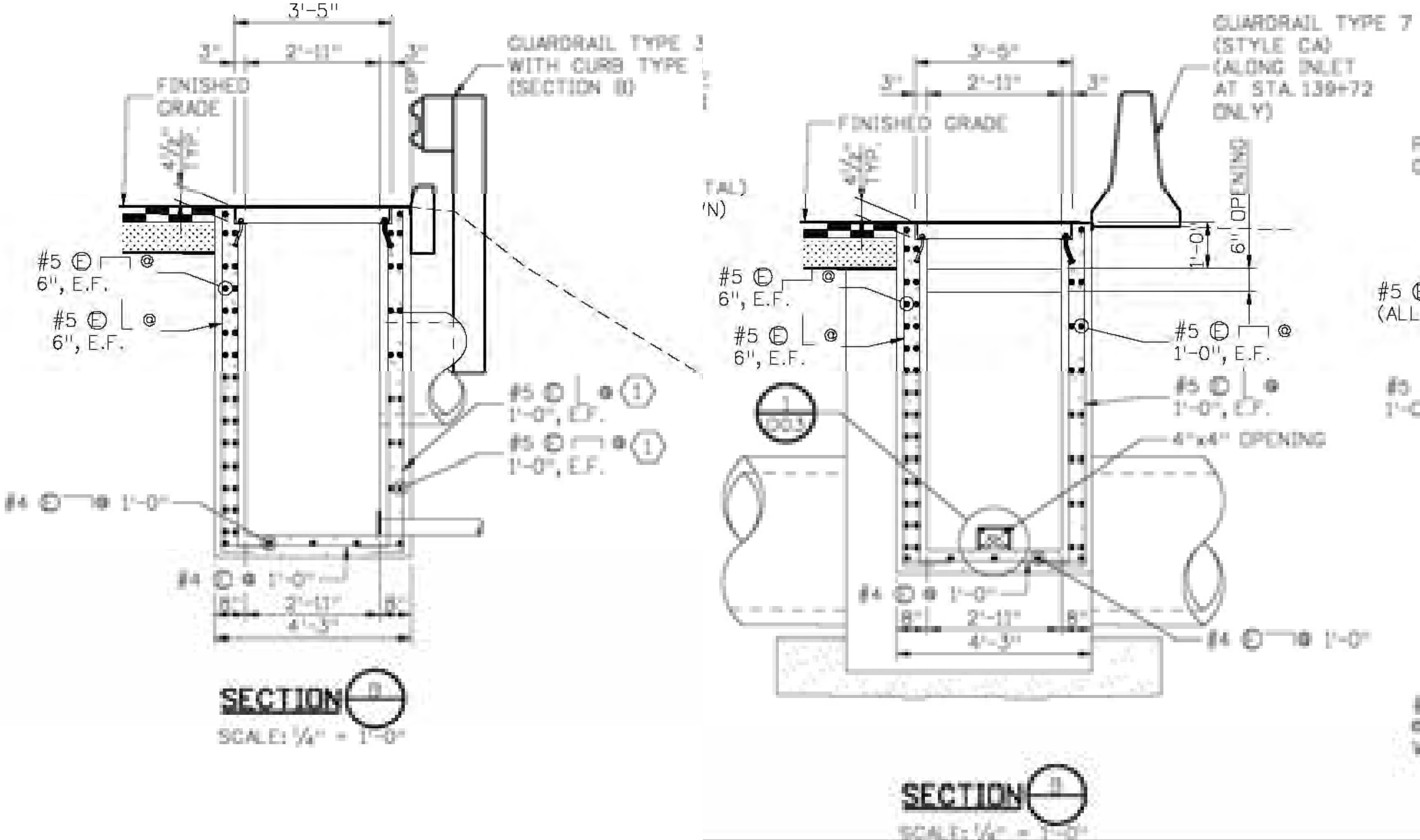
Sediment Inlets

Sediment Inlets

- ❖ Depth < 7 ft
- ❖ Length < 20 ft
- ❖ 1 year maintenance cycle
- ❖ Close mesh grate
- ❖ Access steps



Sediment Inlets

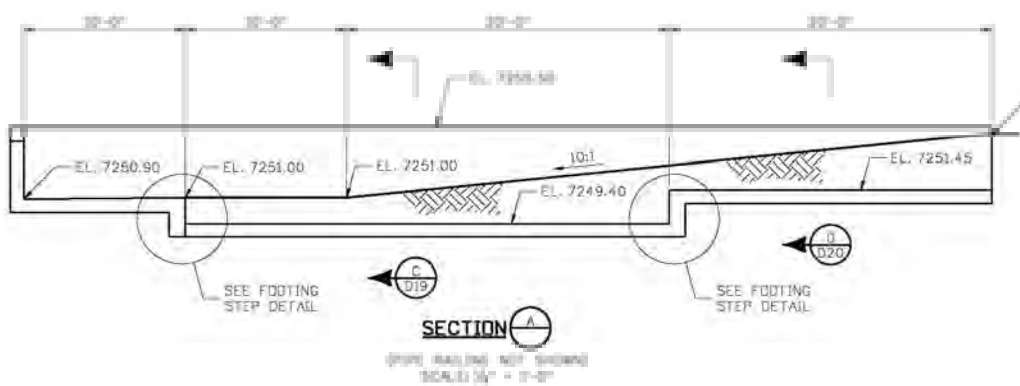


Twin Tunnels Water Quality

Sediment Ponds

Sediment Ponds

- ❖ Width > 12 ft
- ❖ Push wall
- ❖ Slab bottom
- ❖ 5 year maintenance cycle
- ❖ Delineators
- ❖ Access



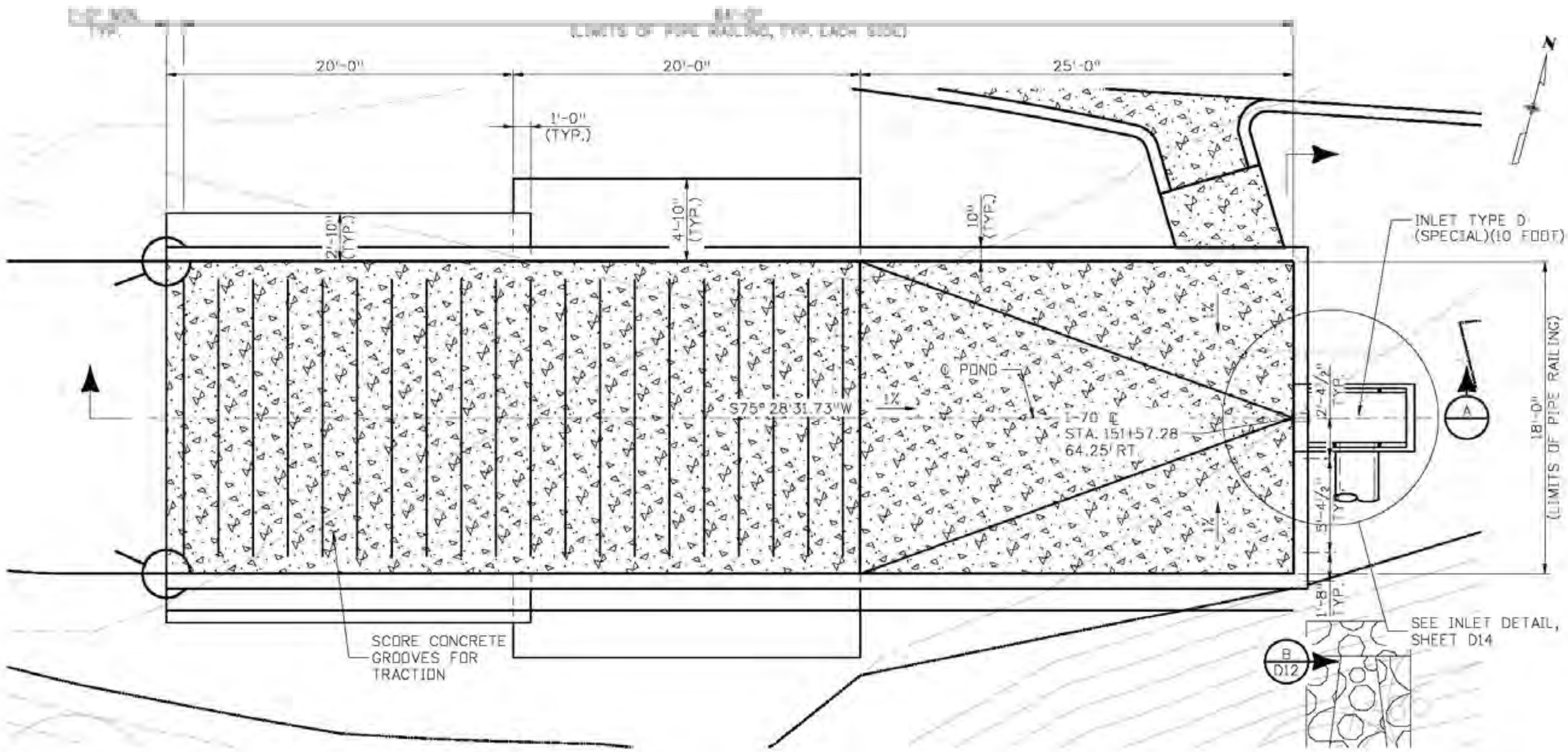
Sediment Ponds

Sediment Ponds

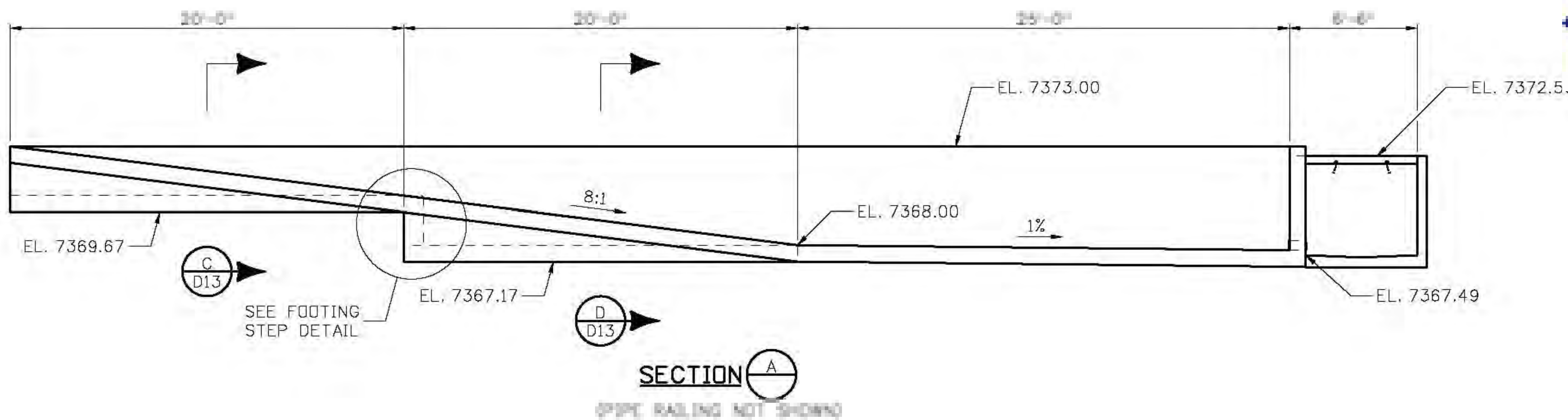
Sediment Ponds

Spill Control

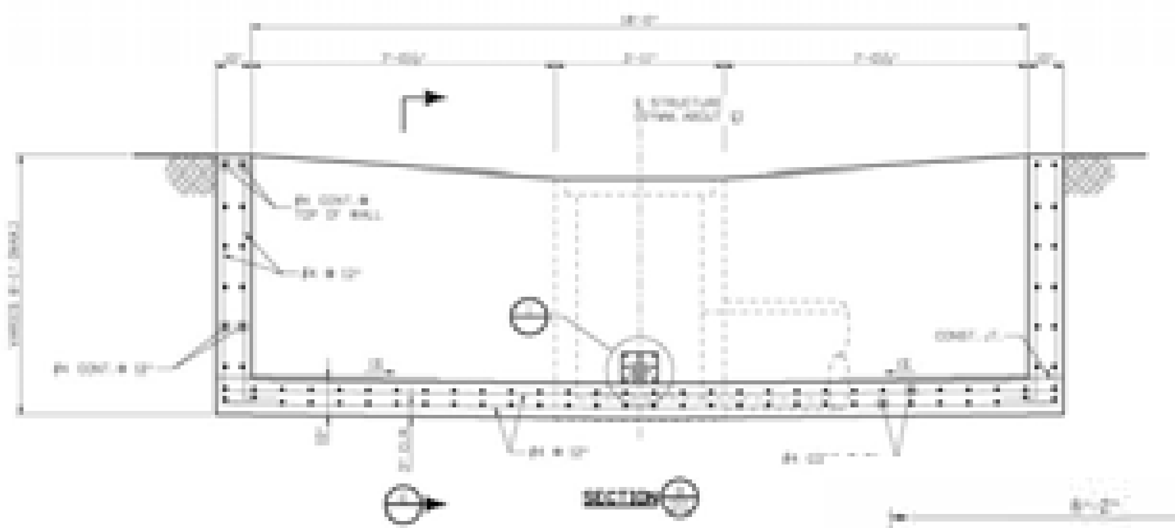
Spill Control

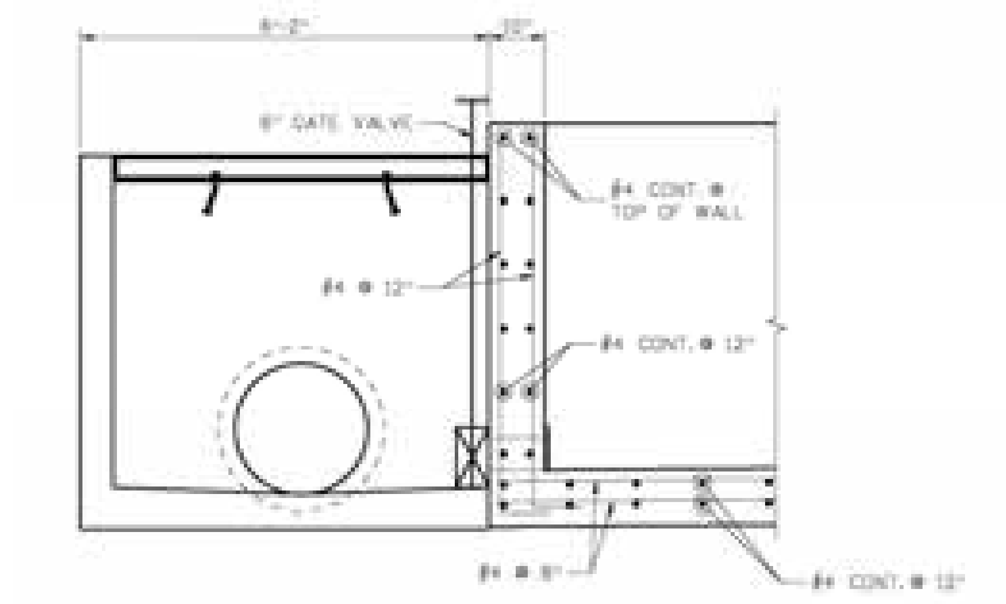


Spill Control

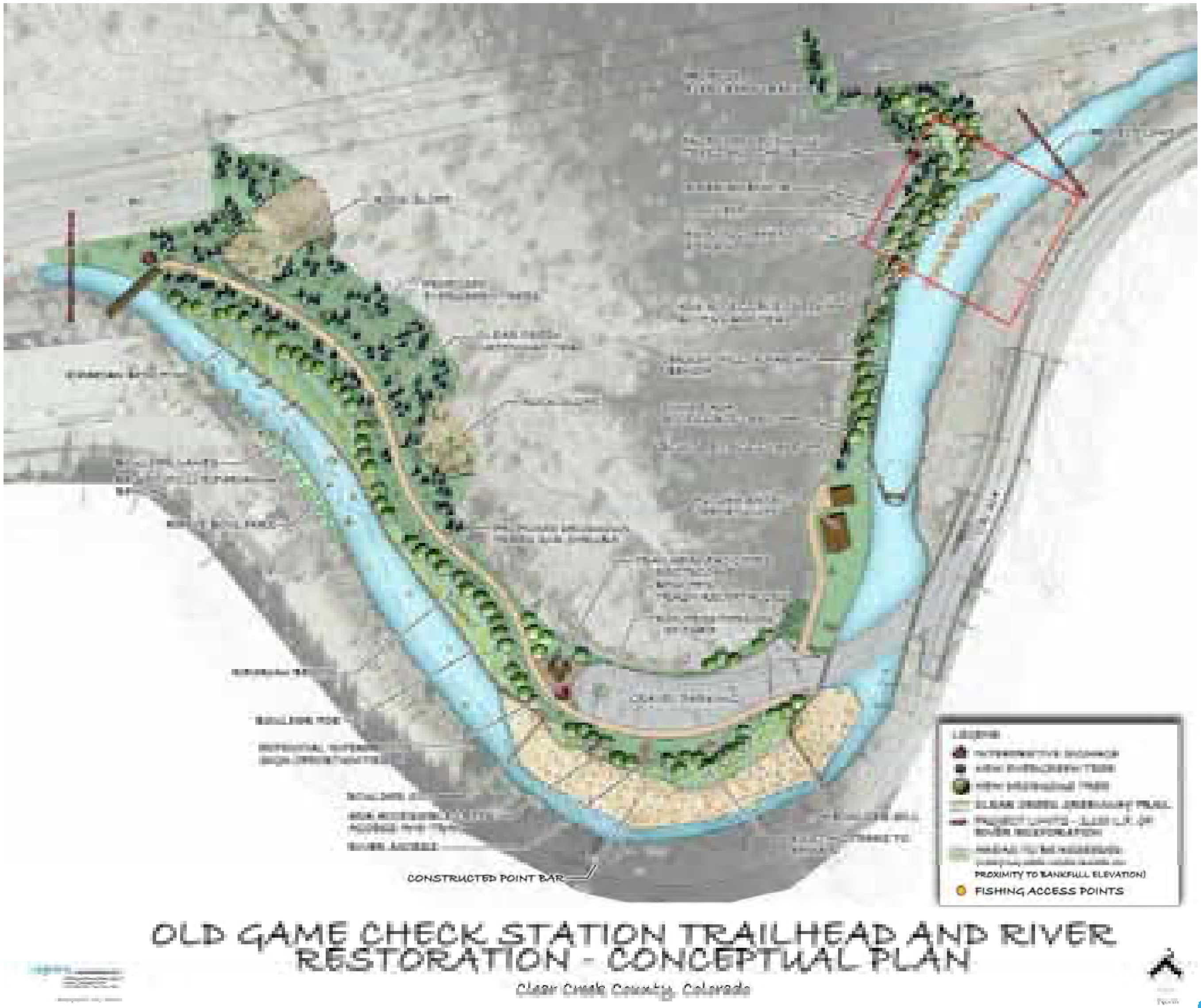


Spill Control





Clear Creek Restoration



I-70 Twin Tunnels
Water Quality Mitigation

Holly Huyck, Ph.D.
Senior Water Quality Specialist
CDOT-Region 1
720-497-6934
Holly.Huyck@state.co.us

Josh Hollon
Water Resources Manager
Atkins
720-475-7051
Joshua.Hollon@atkinsglobal.com

Brantner Gulch at Holly Street

Brantner Gulch at Holly Street

Project History – Mr. Jim Kaiser, PE

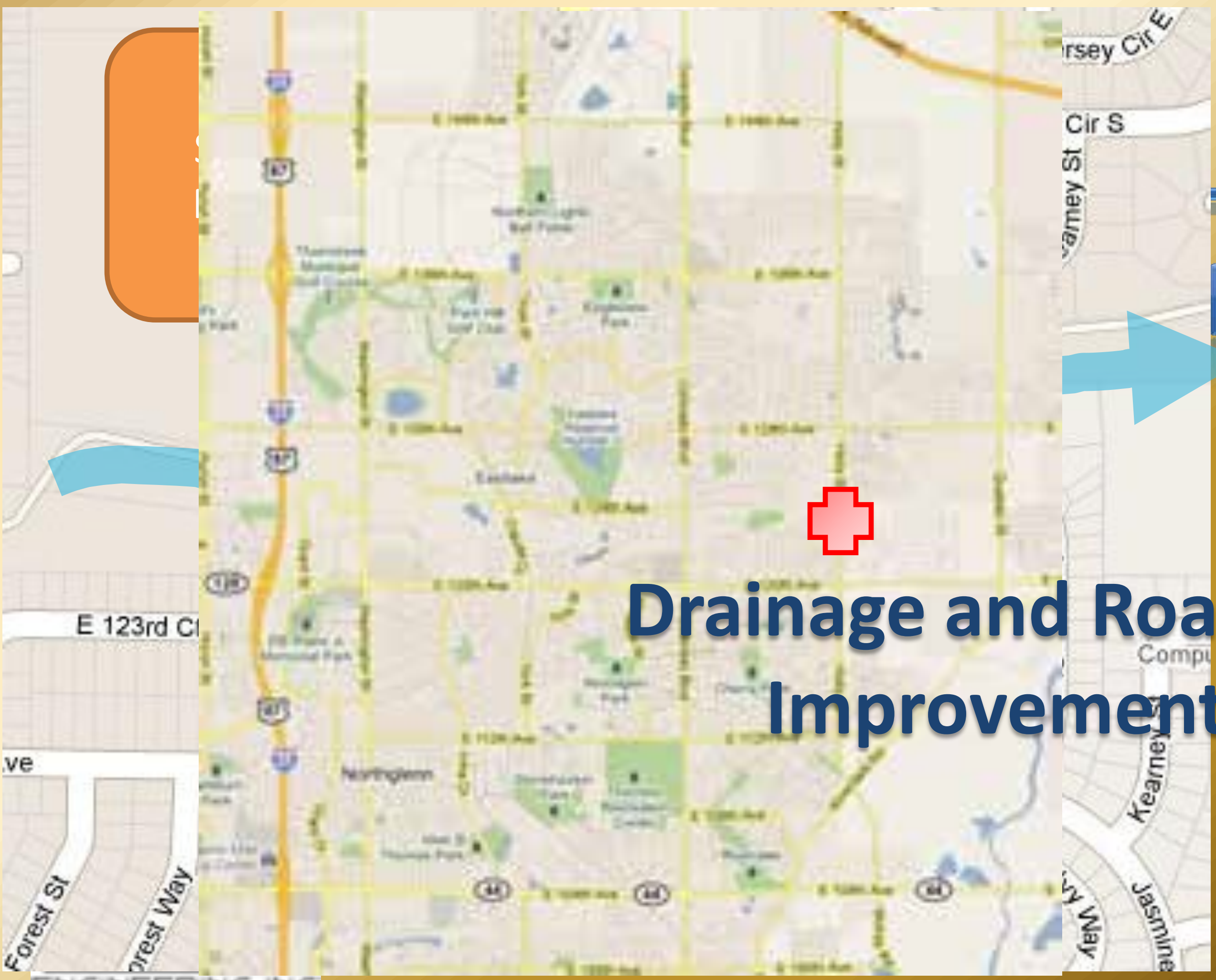
City of Thornton

Project Development – Mr. Penn Gildersleeve, PE

ICON ENGINEERING, INC.

Construction and Results – Mr. Dave Skuodas, PE

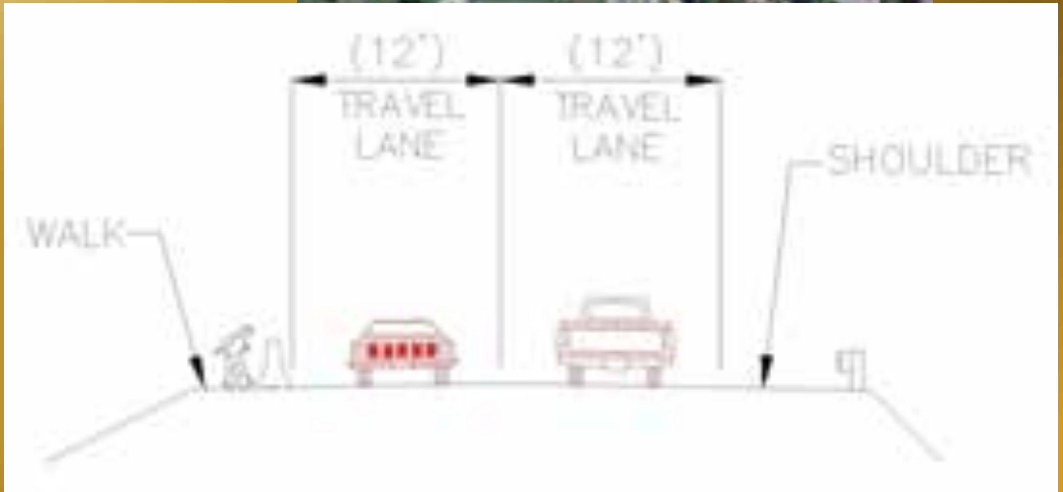
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT



Drainage and Roadway Improvements

PROJECT OVERVIEW

1. Existing Conditions
   - Roadway
     - 2 lanes
     - Guardrail
     - Concrete barricades
     - Single Trail (west side)
   - Drainage
     - 2-48” CMP



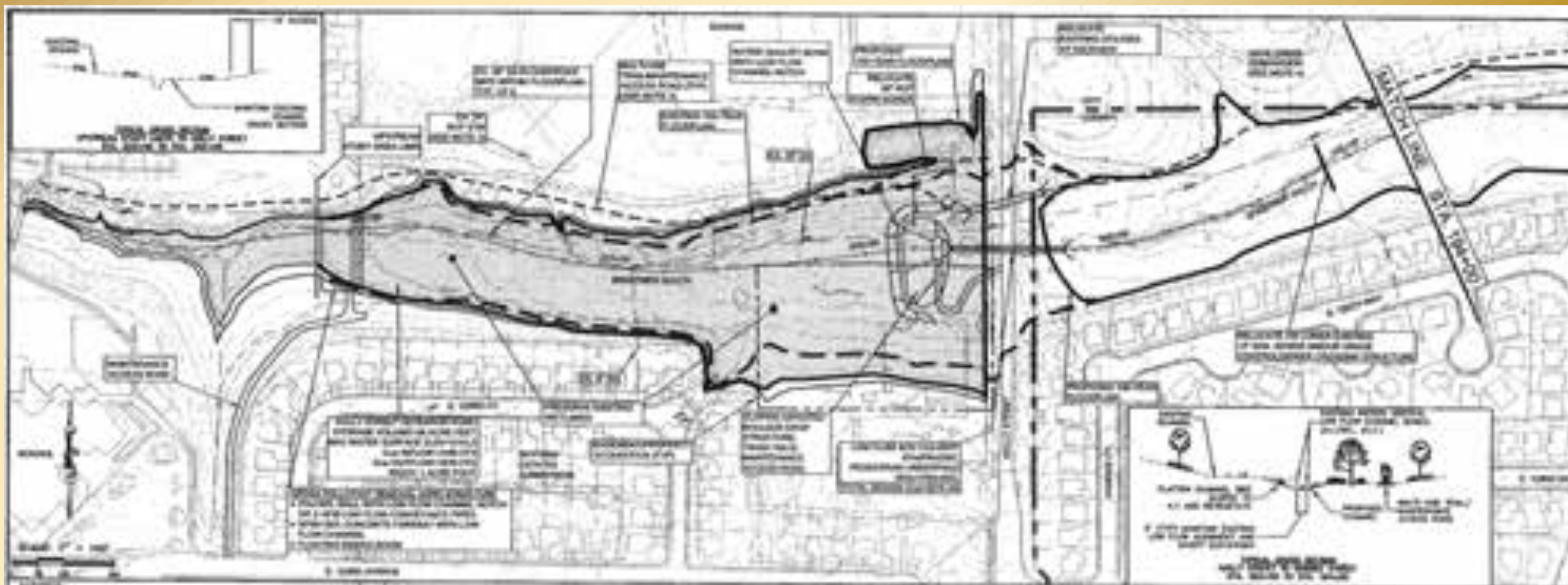
EXISTING FEMA 100-YR FLOODPLAIN

BRANTNER GULCH

OVERTOPPING HOLLY STREET

Brantner Gulch at Holly Street

Original Concept



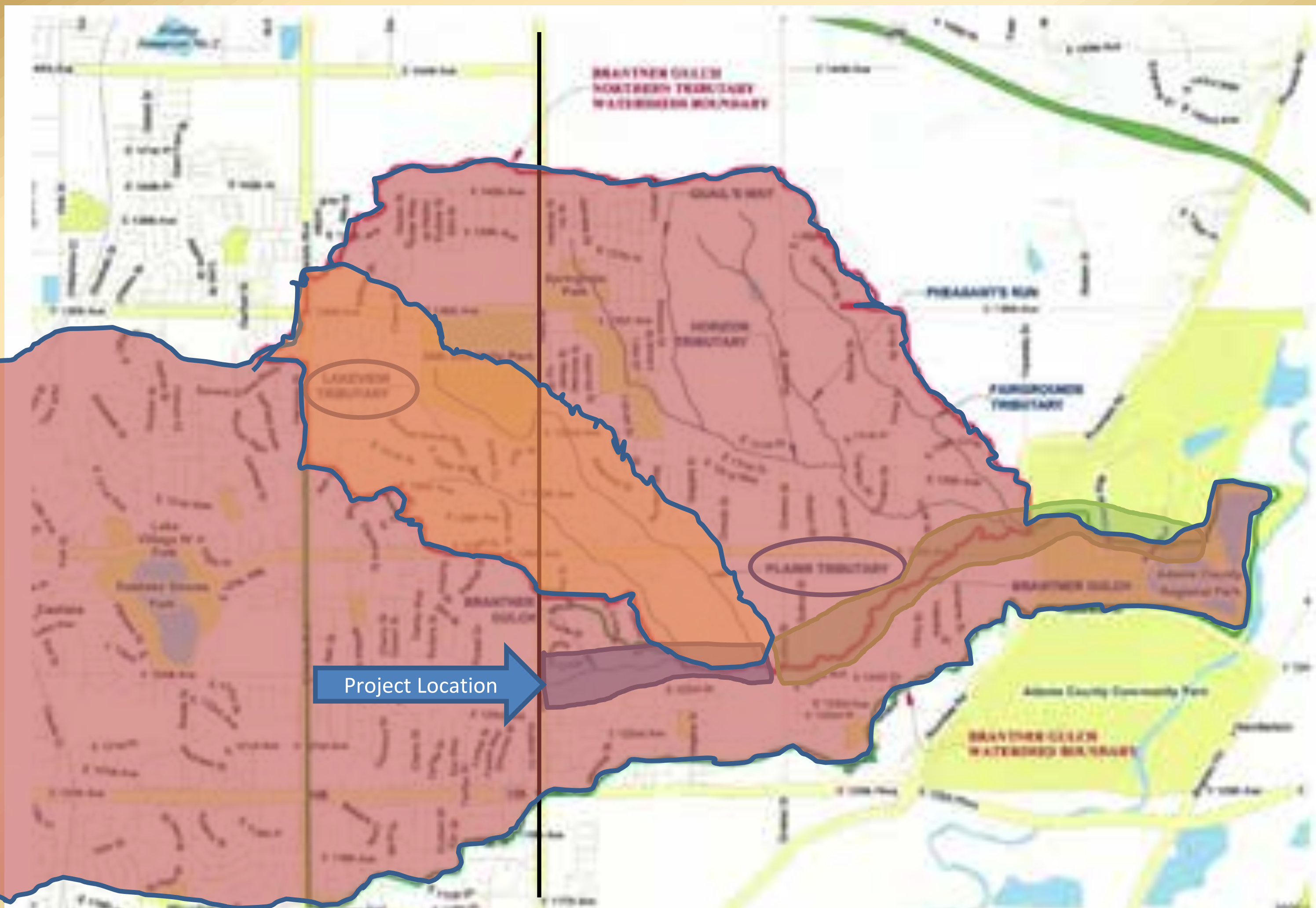
- Raise Existing Road 8-ft
- Separate Trail and Low Flow Storm Water Crossings
- 56 ac-ft Online Detention Pond
- Raise Existing Floodplain 3-ft
- Reduce Peak Discharge from 3160-cfs to 2510-cfs

Brantner Gulch at Holly Street

Brantner Gulch at Holly Street

Brantner Gulch at Holly Street

Opportunity

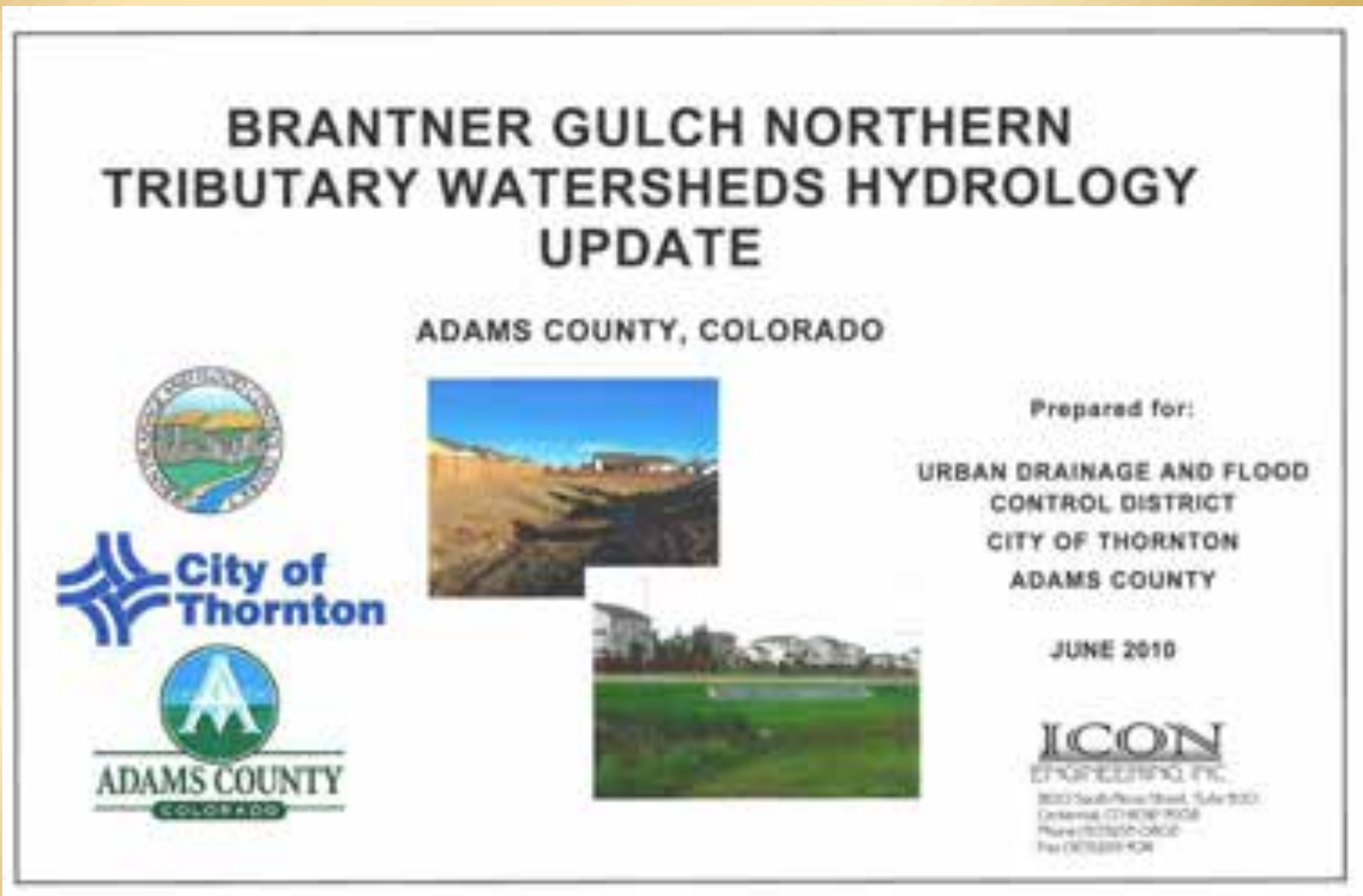


Existing detention ponds on <u>downstream</u> tributaries met ownership and maintenance criteria.

Could we reduce the need for regional detention at Holly Street?

Brantner Gulch at Holly Street

Solution


BRANTNER GULCH NORTHERN TRIBUTARY WATERSHEDS HYDROLOGY UPDATE

ADAMS COUNTY, COLORADO

City of Thornton

ADAMS COUNTY COLORADO

Prepared for:

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

CITY OF THORNTON

ADAMS COUNTY

JUNE 2010

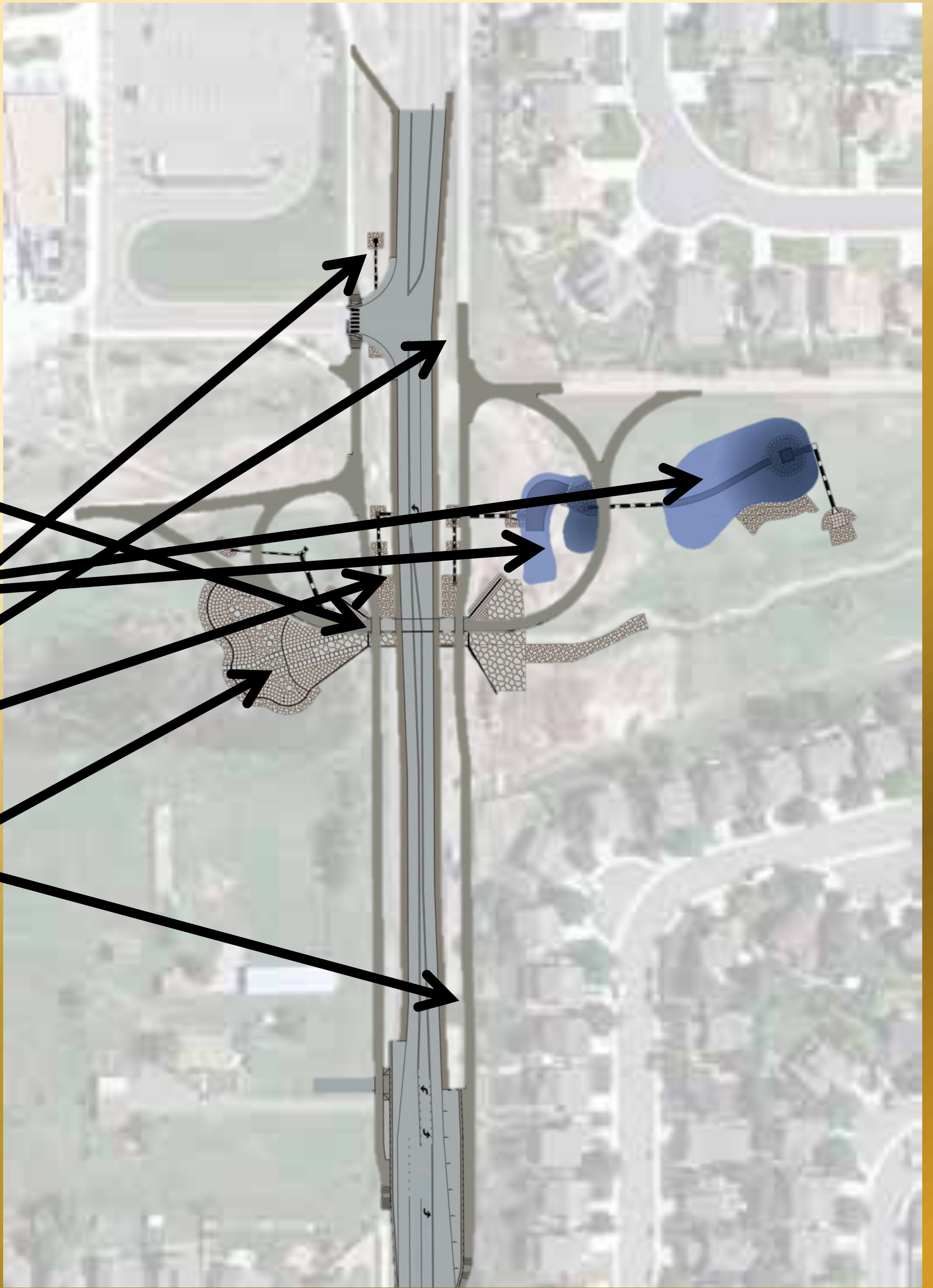
ICON ENGINEERING, INC.

Update Hydrology to Include New Ponds

SOLUTION

FINAL DRAINAGE INTERIM ROAD

- Combined Pedestrian/ Drainage Culvert (No Detention)
- Water Quality Pond (With Forebay And Micropool)
- Roadside Ditches and Inlets
- Tiered Drop Structure



Brantner Gulch at Holly Street

Design Project Team

ICON Engineering

- Benesch - Structural Design
- ERO Resources - Wetlands Permitting
- Ground Engineering Consultants - Geotechnical
- Corey Electrical - Lighting

SOLUTION Combined Pedestrian/ Drainage Culvert (no detention)

24’ x 11’ Contech Conspan Arch

Brantner Gulch at Holly Street

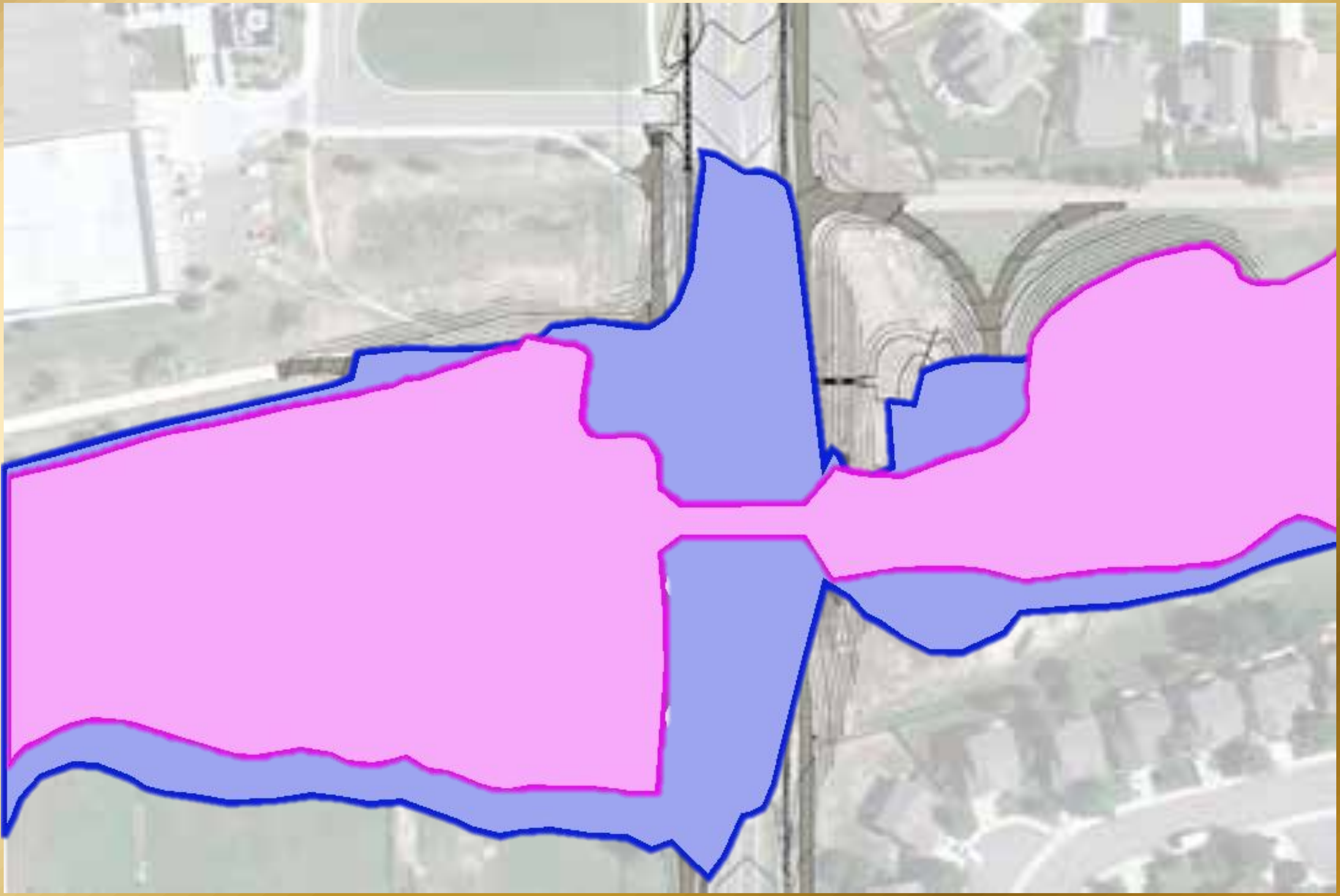
Solution

Brantner Gulch at Holly Street

Wetlands Habitat

Preserved and Enhanced

100-YR FEMA FLOODPLAIN
(BEFORE VS. AFTER)



Brantner Gulch at Holly Street

Solution

- Minimize Holly St. Detention Pond
- Provide Single Trail and Storm Water Crossing
- Raise Existing Road 3.5-ft
- Lower Existing Floodplain 3-ft
- Match Master Plan Peak Discharge In
  Critical Downstream Reach

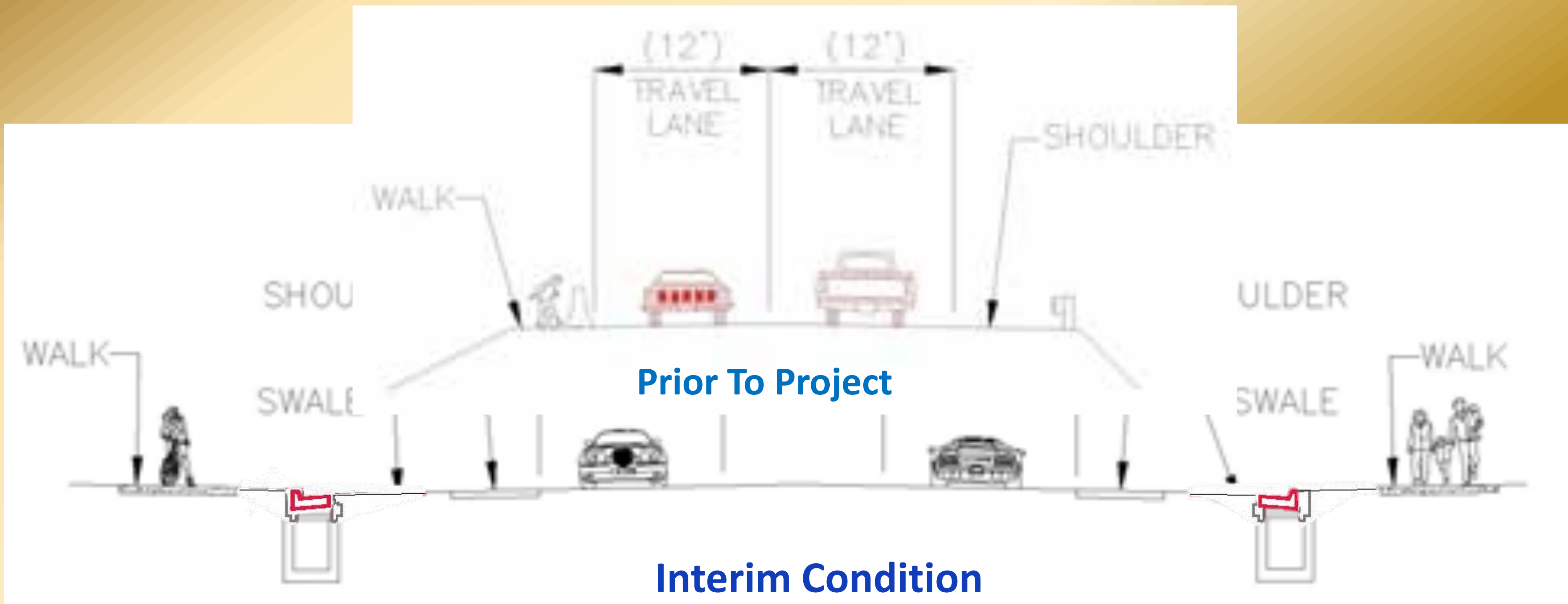
Brantner Gulch at Holly Street

Forebay and Micropool

SOLUTION
ROADWAY AND TRAIL INTERIM CONDITION

- Plan
- Section
- Lighting
- Low point on the roadway raised 3.5-ft

HOLLY STREET SECTIONS

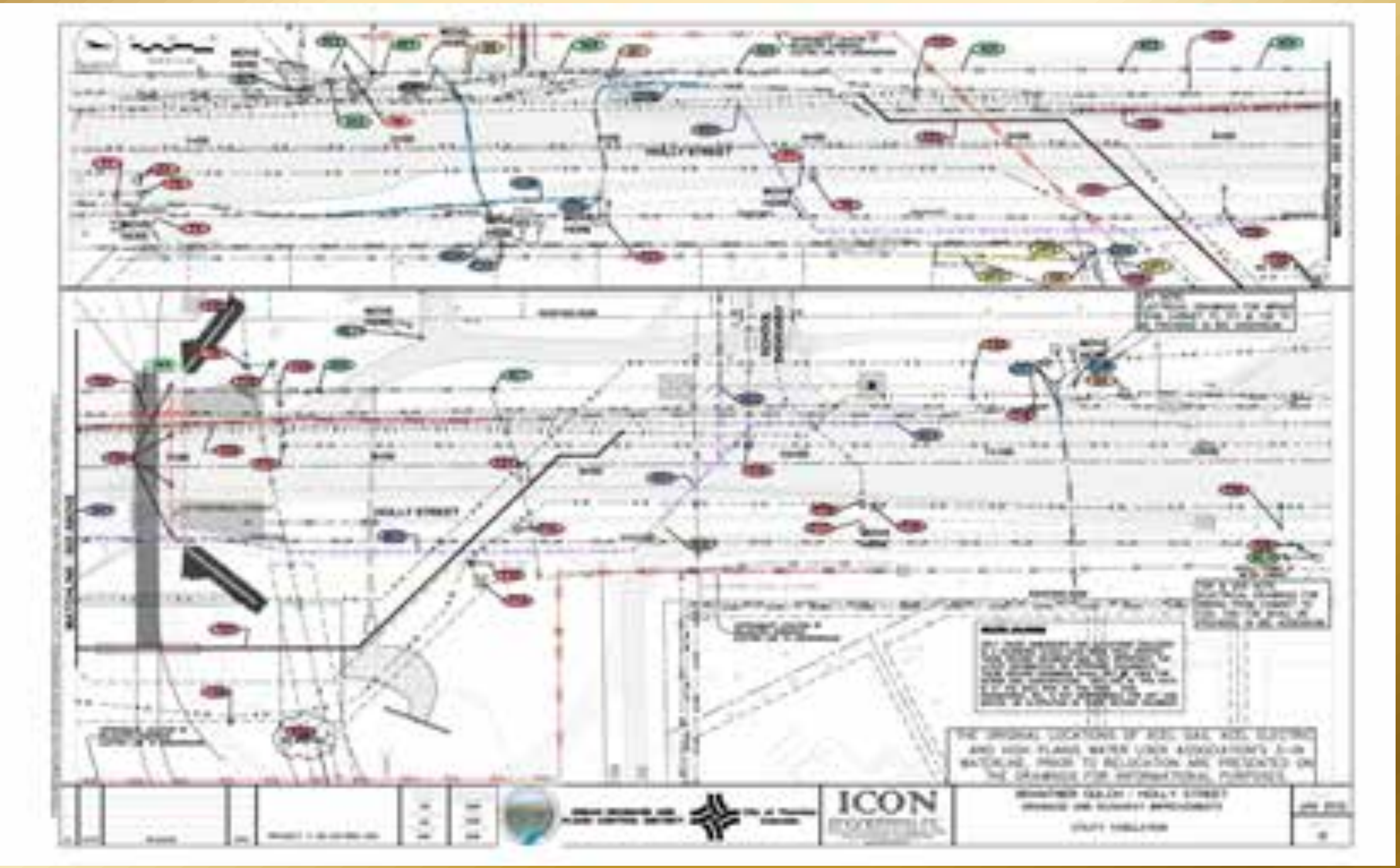


Brantner Gulch at Holly Street

Trail Solution

Brantner Gulch at Holly Street

Utilities Solution

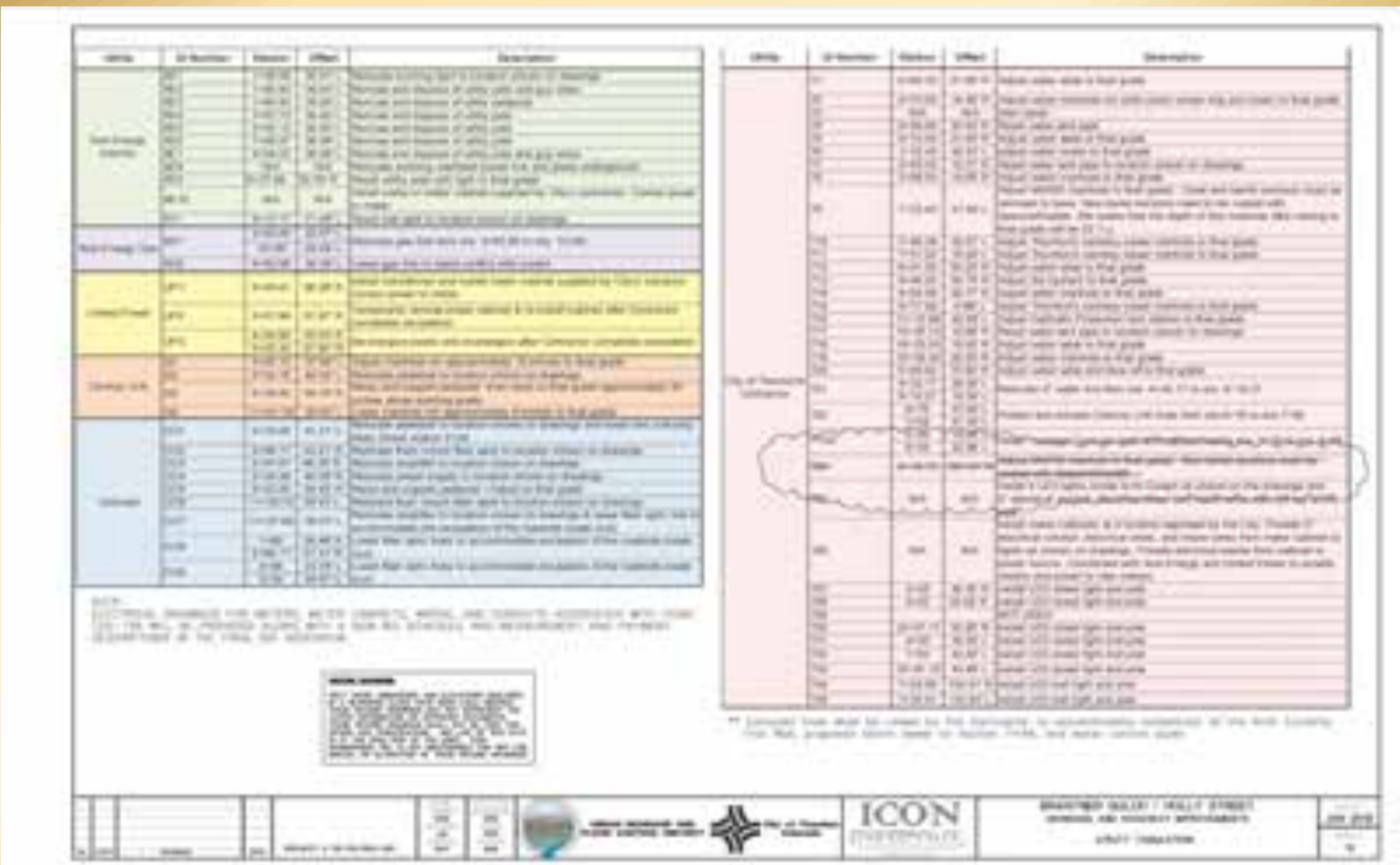


10 Utility Owners

42” Water
30” Water
30” Sanitary
Metro SS
HP Gas

Brantner Gulch at Holly Street

Solution

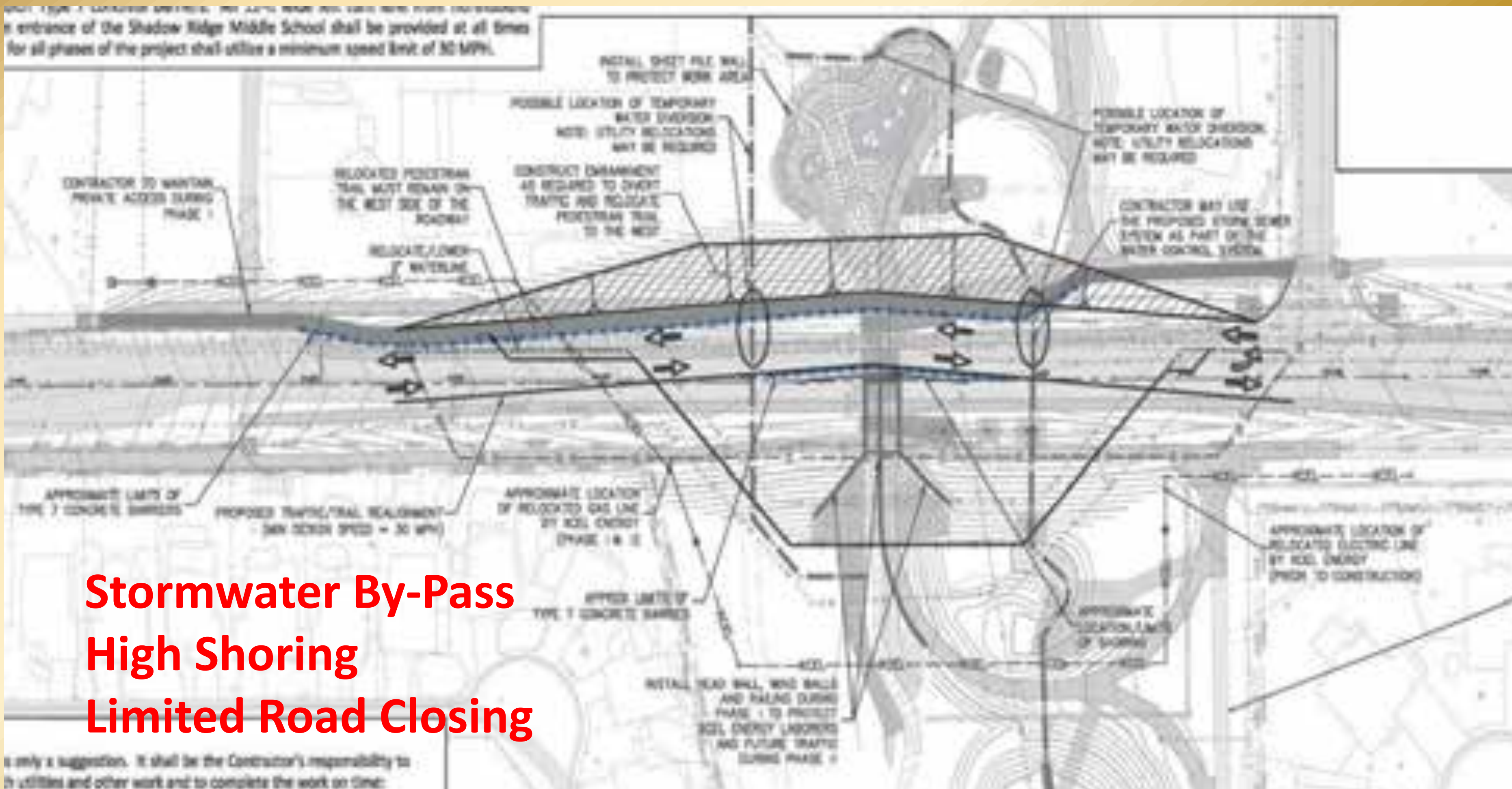


Detailed drawings and specifications identified the costs and responsibilities of the Owners, Contractor, and Utility Companies

Brantner Gulch at Holly Street

Schedule

Phased Planning For Success



Stormwater By-Pass

High Shoring

Limited Road Closing

Brantner Gulch at Holly Street

Schedule

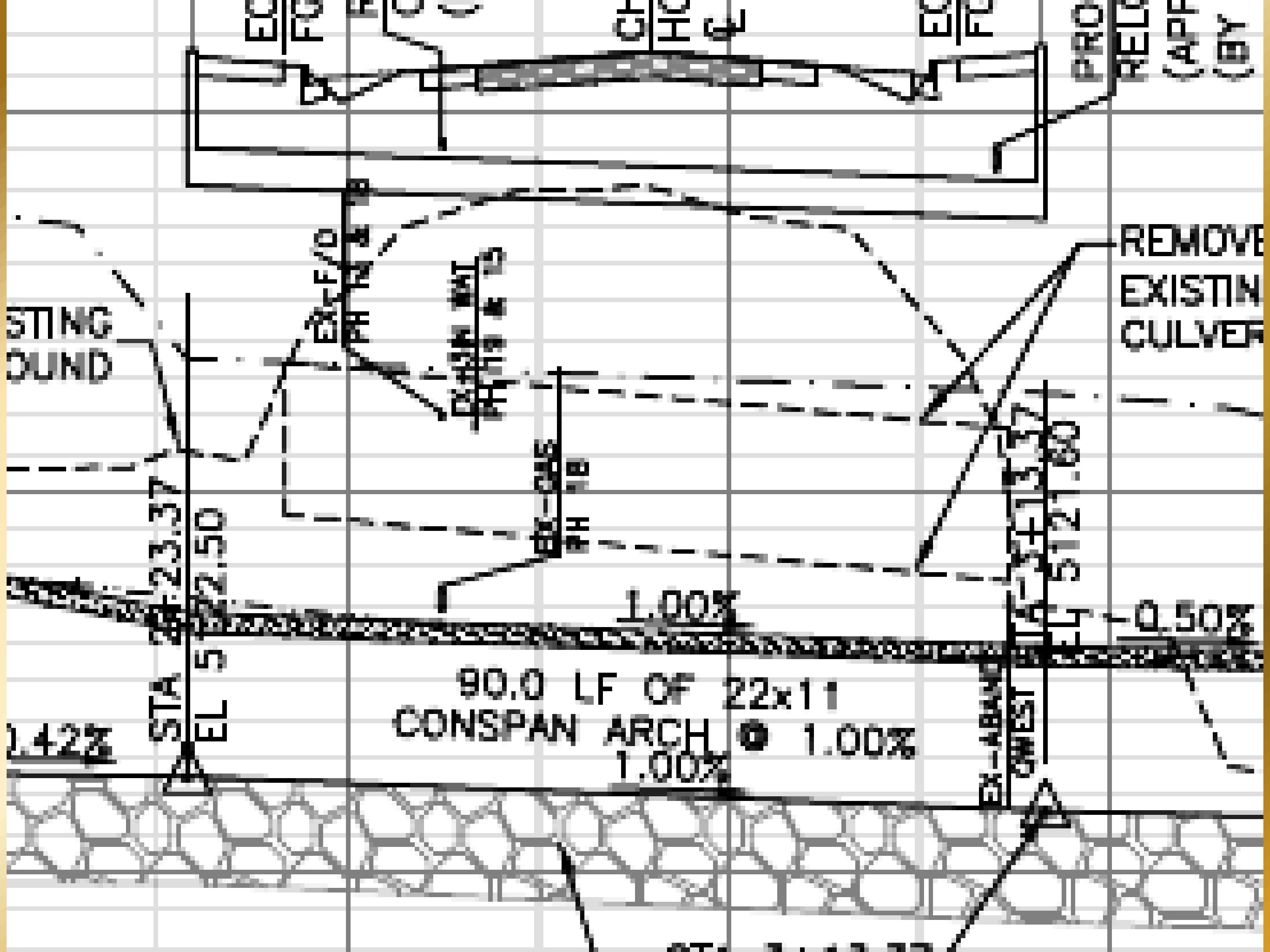
8/6/08	2008 Flood
3/13/09	City and UDFCD select Engineer
1/18/11	Preliminary Design Complete
1/17/12	Final Design Complete
3/26/12	Construction Starts
5/26/12	School Closes for Summer
5/27/12	Holly Street Closed
8/9/12	Holly Street Open
8/10/12	School Starts
11/6/12	Construction Complete

Brantner Gulch at Holly Street

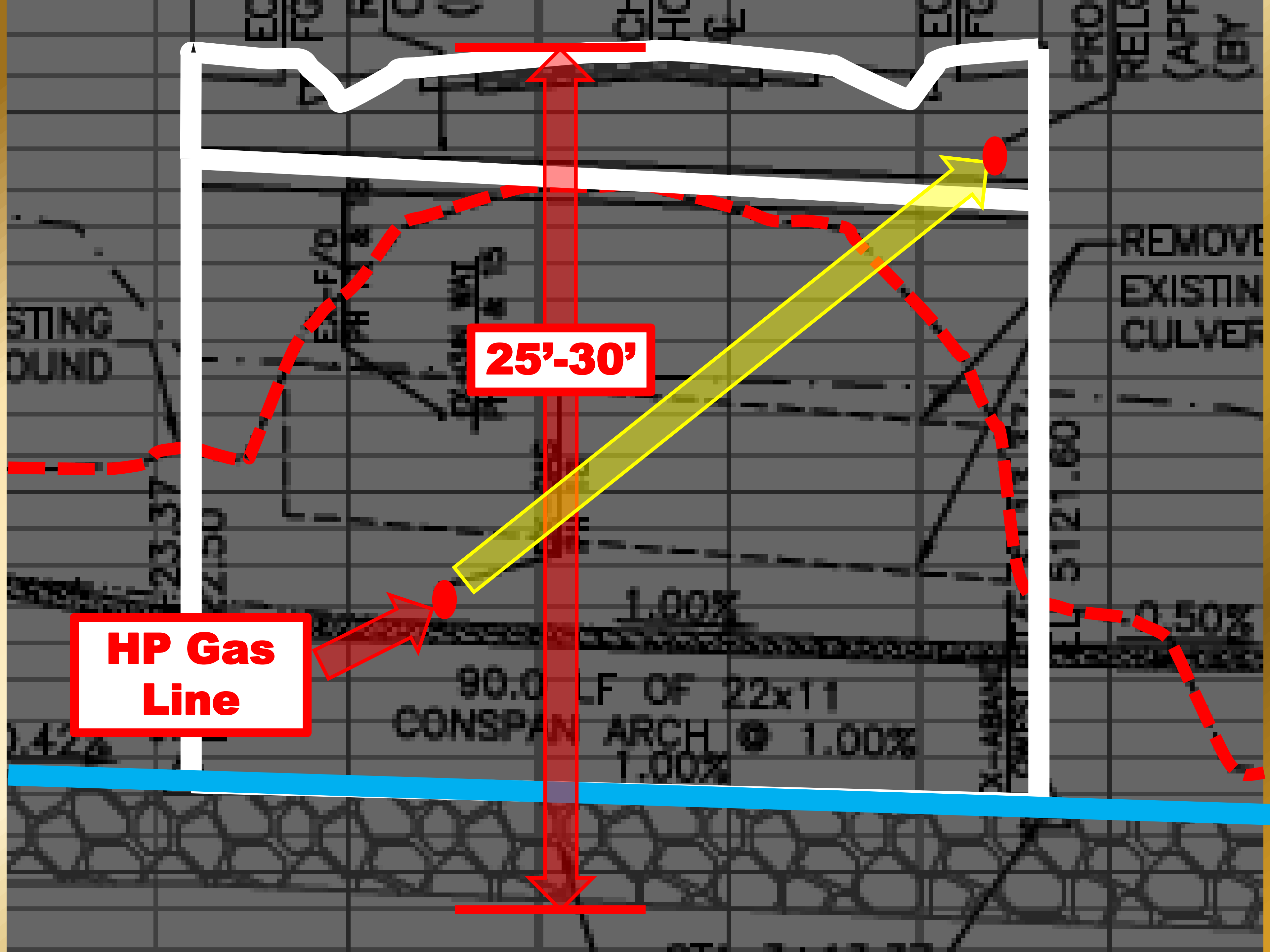
Budget

Engineer's Estimate	$2,637,403.00
Average Bid	$2,605,714.00
Low Bidder	$2,354,714.80
Final Construction Cost	$2,389,402.58

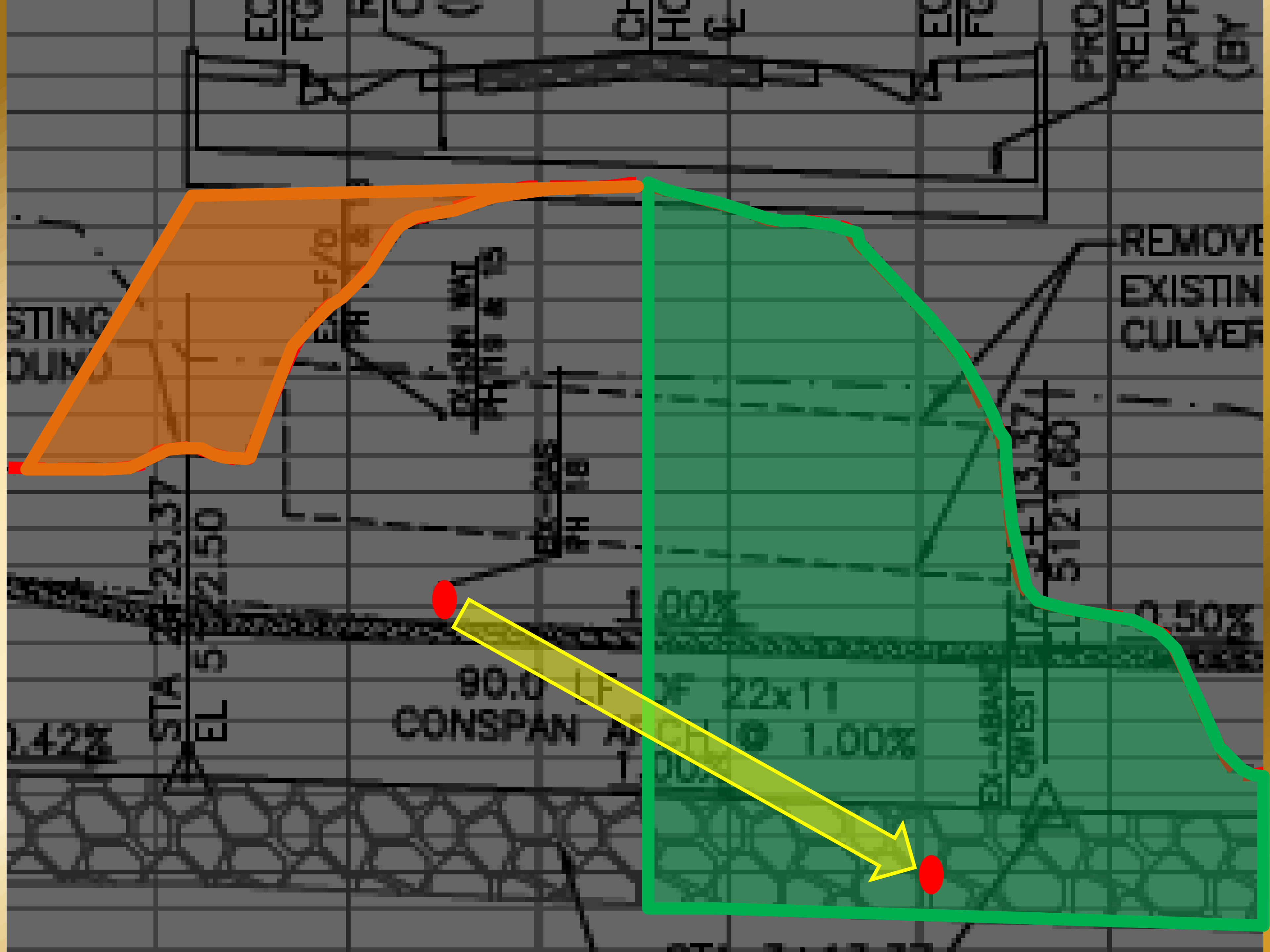
- Total Of 7 Bids Received
- T. Lowell Construction Awarded Contract
- Increase By Change Order Of Less Than 1.5%

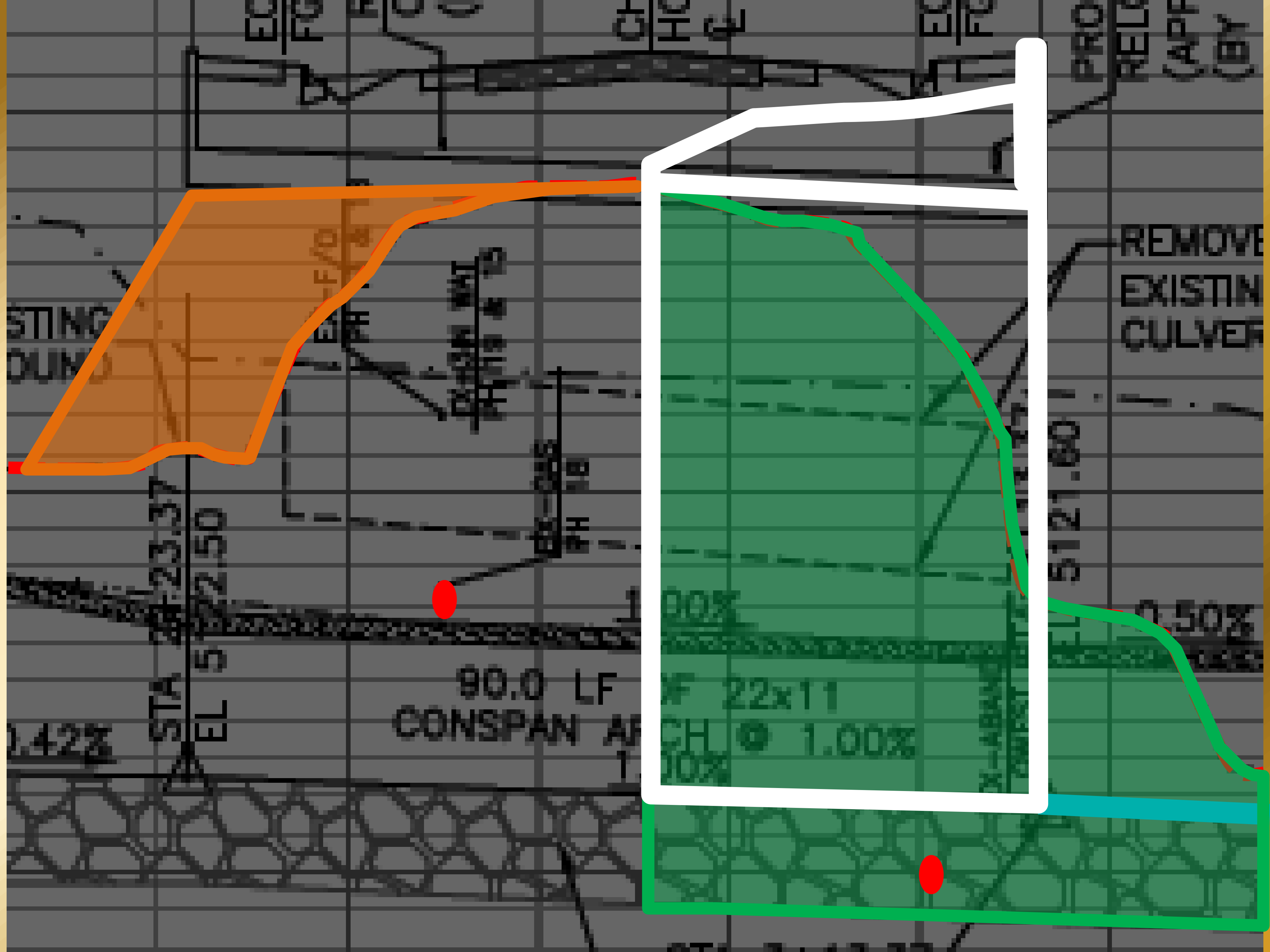


REMOVE
EXISTIN
CULVER
STING
OUND
1.00%
-0.50%
90.0 LF OF 22x11
CONSPAN ARCH @ 1.00%
1.00%
0.42%



25'-30'
HP Gas Line
REMOVE EXISTIN CULVER
STING OUND
1.00%
0.50%
90.0 LF OF 22x11 CONSPAN ARCH @ 1.00%
1.00%
0.42%
5121.60


REMOVE
1.00%
0.50%
90.0 LF OF 22x11
CONSPAN ARCH @ 1.00%



REMOVE
EXISTIN
CULVER
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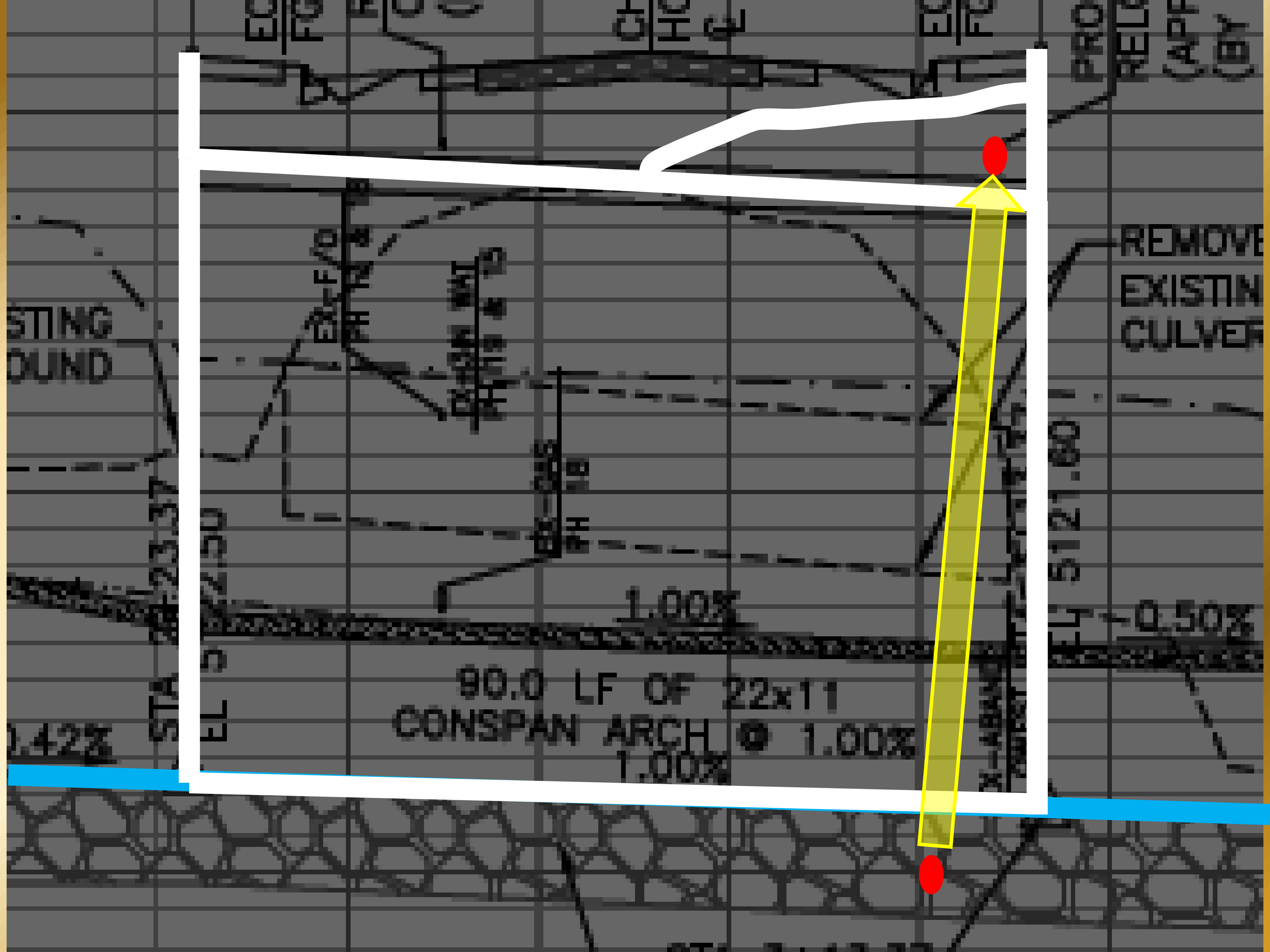
0.50%
90.0 LF
22x11
CONSPAN AR CH @ 1.00%
5121.60



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CONSPAN ARCH @ 1.00%
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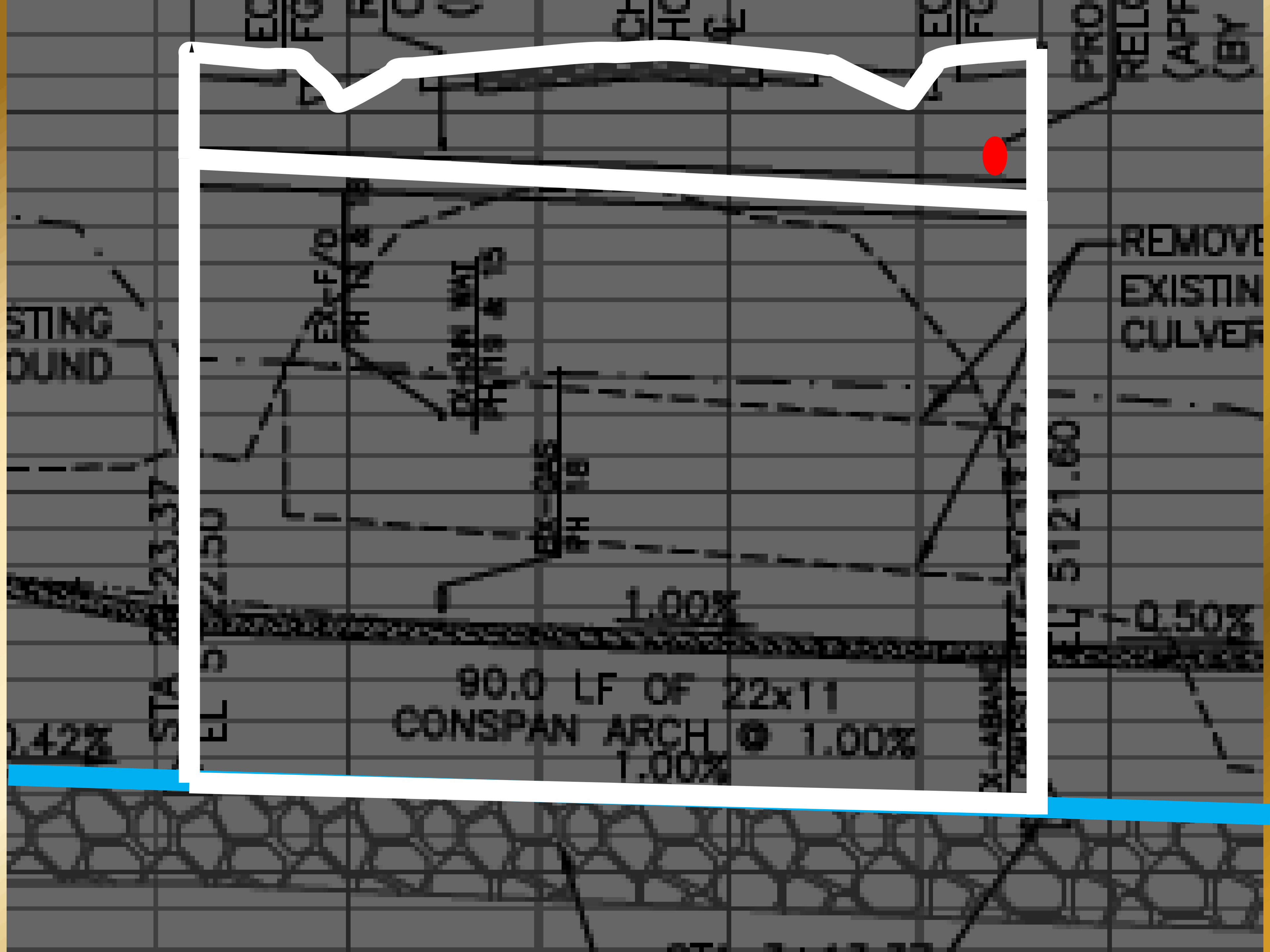
REMOVE
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CULVER
STING
OUND
1.00%
0.50%
90.0 LF OF 22x11
CONSPAN ARCH @ 1.00%
1.00%
0.42%
5121.60


HITACHI


DEERE


EXISTING
CULVERT
DEERE
DEERE


EXISTING
CULVERT


GAS LINE
BYPASS


22'


DAVE BENNETTS
SHEA THOMAS
EXISTING
CULVERT


22’


Google earth


HITACHI

Brantner Gulch at Holly Street

Alternate Path to School

Brantner Gulch at Holly Street

Discussions with Shadow Ridge Middle School Principal - Susie Wickham




THE CHERRY CREEK STREAM RECLAMATION AT PARKER JORDAN CENTENNIAL OPEN SPACE

presented

September 12, 2013

presented to

presented by

THE CHERRY CREEK STREAM RECLAMATION AT PARKER JORDAN CENTENNIAL OPEN SPACE

presented

September 12, 2013

presented to

CASFM

presented by

Engineering Consultants

introduction

overview/background
innovative design elements
collaboration
construction
project successes

project complexity

floodplain

FEMA regulated

100 year flow

structures

impacts

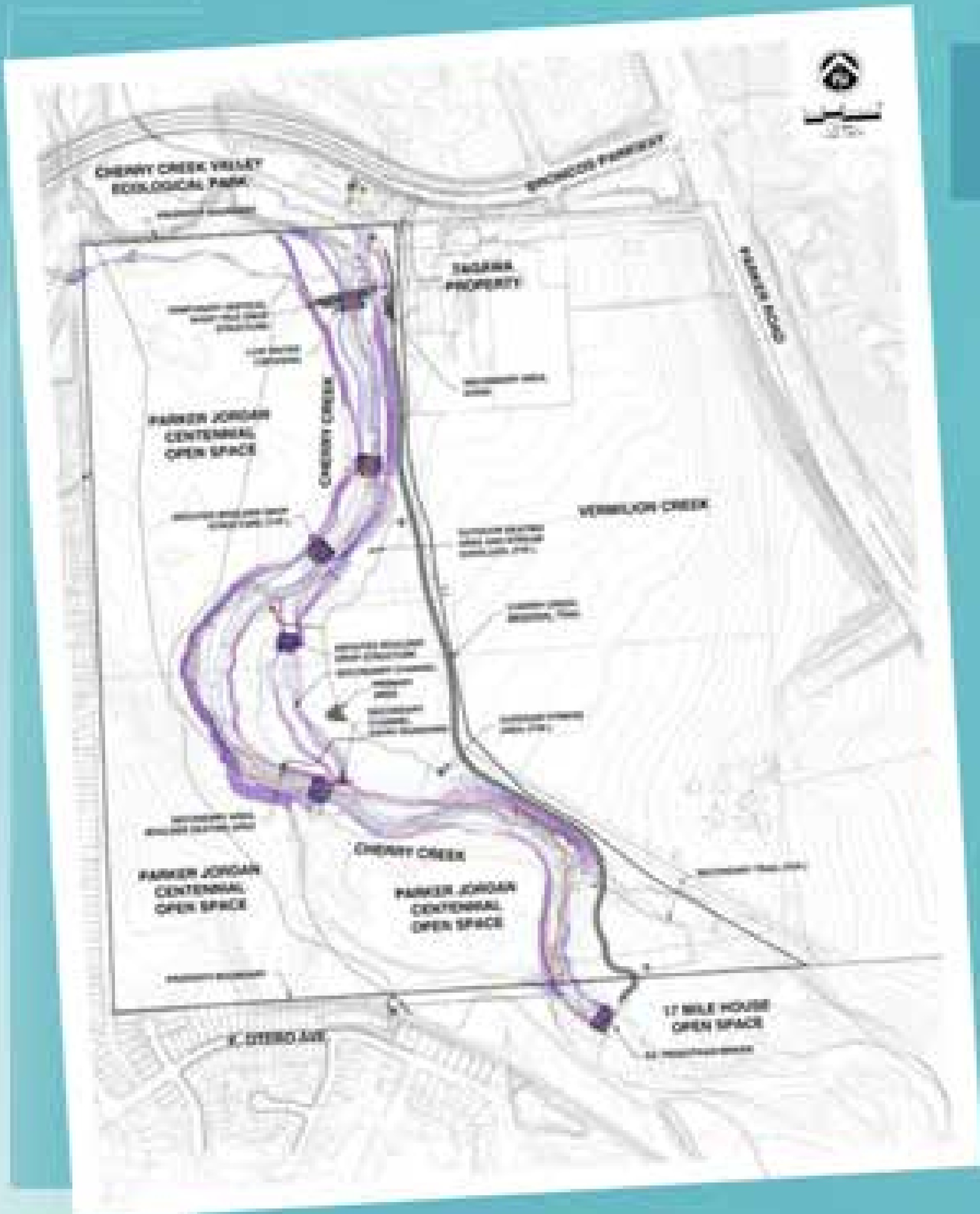
location

miscellaneous

partnership

of the channel

concurrent reclamation project



location

cherry creek

107 acres located within an urban area

a mile of existing stream corridor

history of this site had considerable "baggage"

public open space

floodplain

FEMA regulated

100 year flow:
46,000 cfs ±

insurable structures

no adverse impacts

miscellaneous

public-private partnership

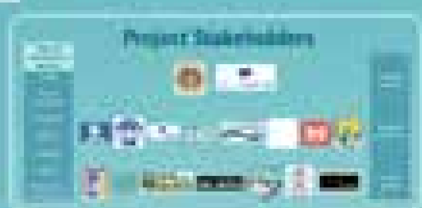
existing state of the channel

concurrent reclamation project downstream

collaboration

"Alone we can
do so little;
together we can
do so much"

Helen Keller



Project Stakeholders

financial contributors & partners

- PJMD
- City of Centennial
- SEMSWA
- UDFCD
- CCBWQA
- GOCO
- Cherry Creek Working Group

2 property owners

8 reviewing jurisdictions

7 vested parties

Systems Thinking

design team

J3 Engineering
Valerian
The Restoration Group
ERO Resources Corporation
Ground Engineering
Performance Engineering
Hutchison Papesh Engineering
United Development Companies


the
existing conditions
the
most degraded,
unstable reach
along Cherry
Creek

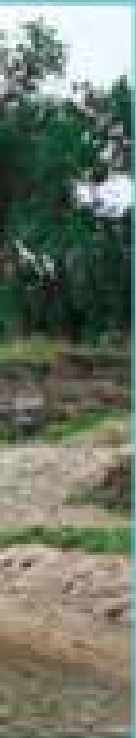
Loss of Wetlands & Upland Vegetation

0.14 acres of designated wetlands along a mile of stream corridor

Rapidly Incising Stream with Extensive Bed Erosion

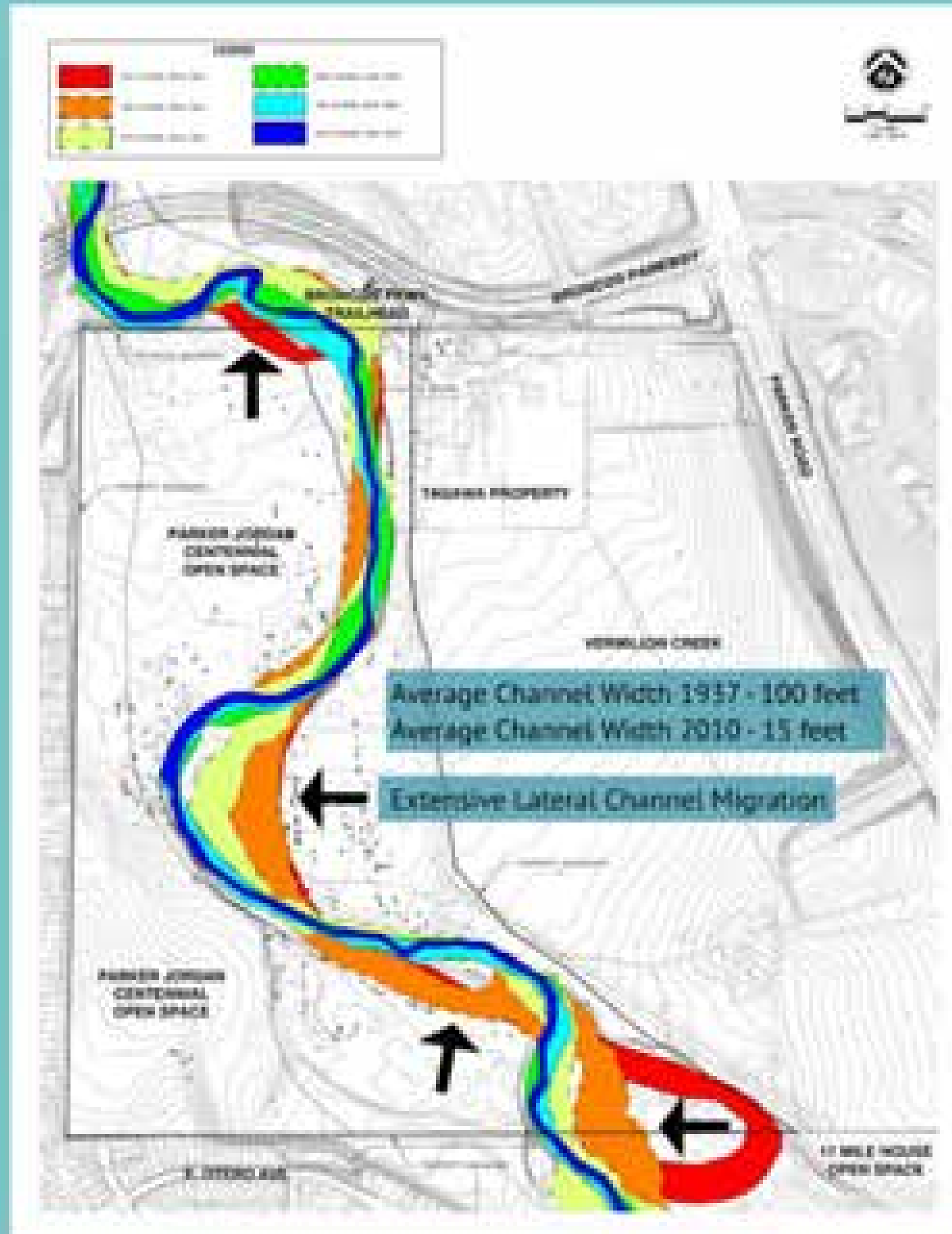
From 2005 - incising at a rate of 1' foot per year
Equates to approximately 3,000 cubic yards of pollutants and material from the site conveyed to Cherry Creek Reservoir annually

on

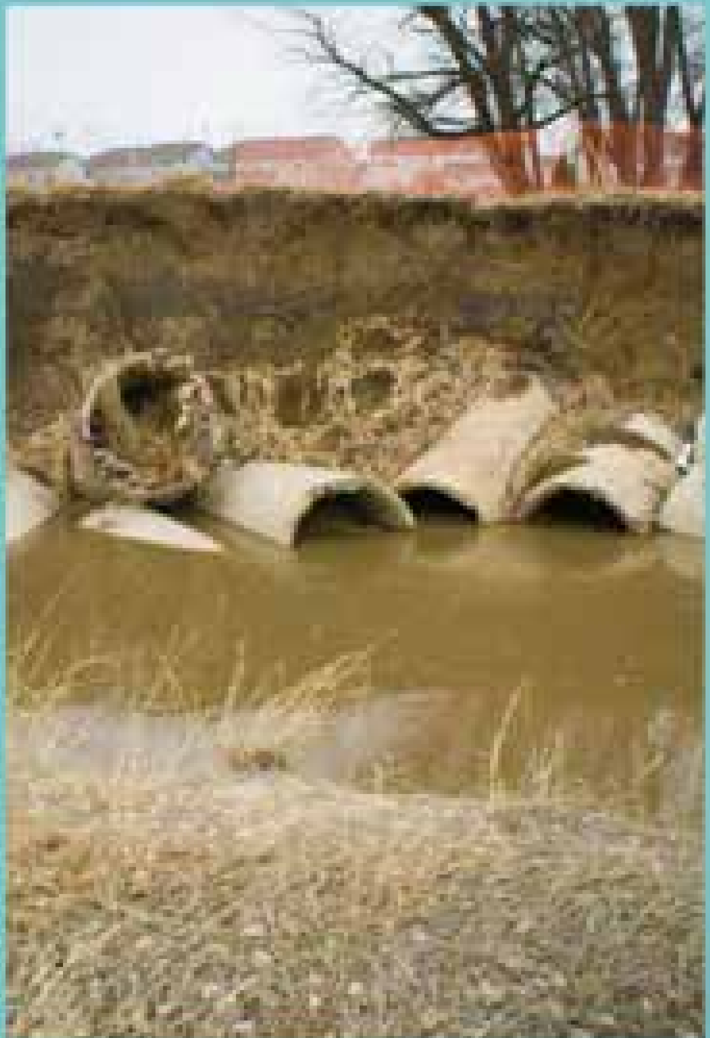


year
s of
ed to

Confined Main Stream Corridor



Bank Instability, Erosion and Material Sloughing



Severely Degraded Riparian Corridor

Severe Damage From Recreational Uses

Causes

Increased runoff
Grazing pressures
Off-road, recreational uses
Noxious weed encroachment
Lowering water table

the most degraded, unstable reach along Cherry Creek

"The channel was in an extremely unstable state that resulted in erosion rates that were over 140-times rates that were considered 'typical' for Cherry Creek"

William Ruzzo, P.E.

excerpt from CCBWQA Project Summary Memorandum of PJCOS

primary project goals

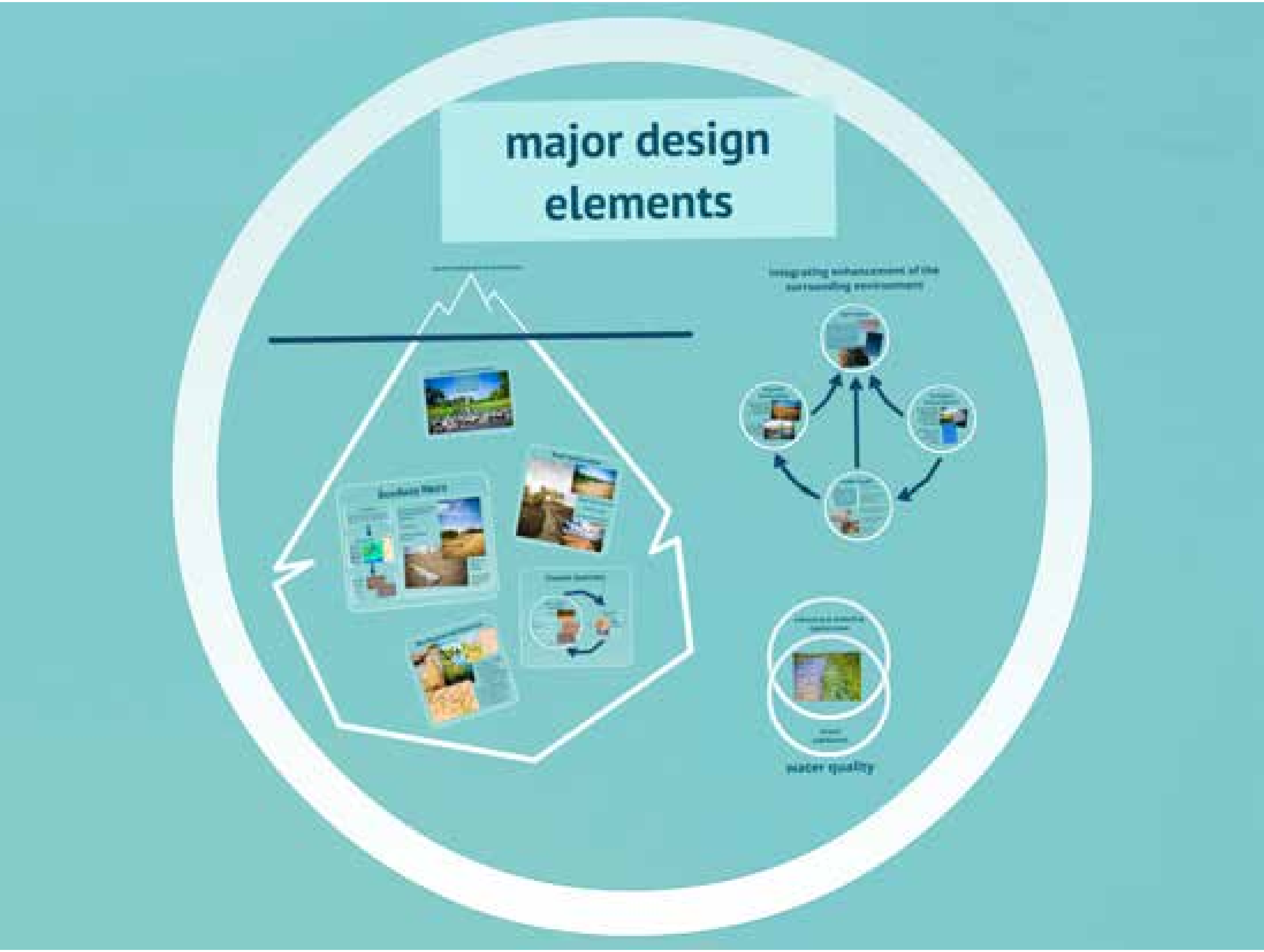

Stream Stabilization
implement stream stabilization measures to reduce the flow velocities and mitigate erosion and sediment transport


Open Space &
Recreational Enhancement
create a sustainable open space experience that treats the riparian and stream corridor as a resource


Water Quality Enhancement
reduce sediment conveyance, which is the primary transport mechanism for phosphorus, through stream stabilization measures and bio-engineered solutions and increase filtration, plant uptake and infiltration of pollutants via attenuating overbank stream flows during high flow events.

Floodplain Preservation

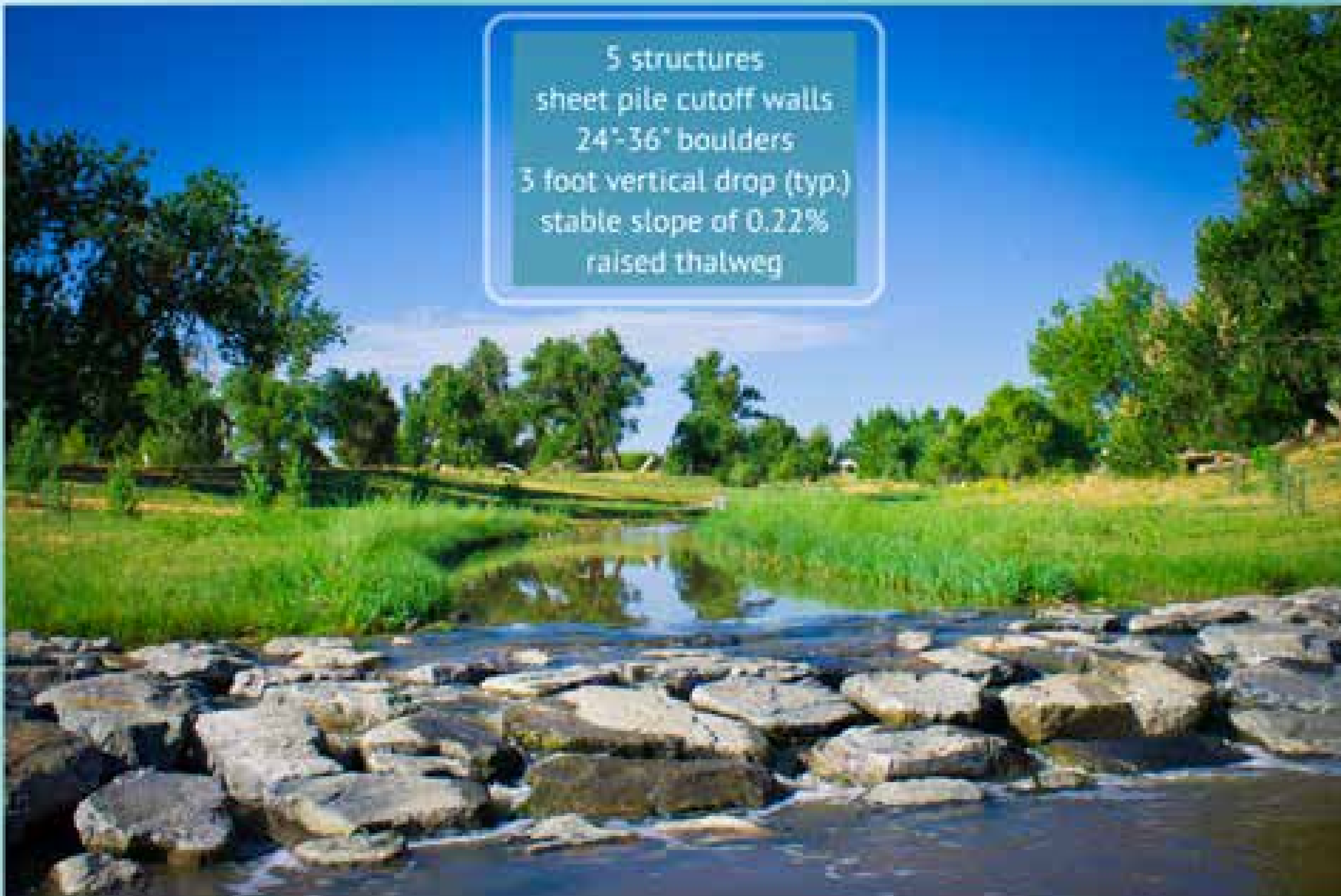
protect the vital floodplain corridor for its benefit to public health and safety, wildlife and the environment, and aquifer recharge value


major design elements
integrating enhancement of the surrounding environment
water quality

Stream Stabilization & Flood Safety


Bendway Weirs
Bank Stabilization
Channel Geometry
Bio Engineered Solutions
Regional Connectivity

Grouted Boulder Drop Structures



Bank Stabilization

Grouted boulder edge walls

Soil filled riprap

Bio-engineered solutions

Bendway Weirs

Description

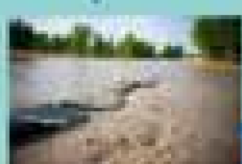
Submerged or non-submerged linear [illegible] permeable or impermeable, usually positioned in series near the thalweg of river [illegible]

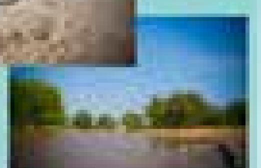
How they work

[illegible]

Benefits

[illegible]





placed along the two most erosive bends within the project site

36" boulders

soil filled riprap toe protection

oriented 40 degrees upstream

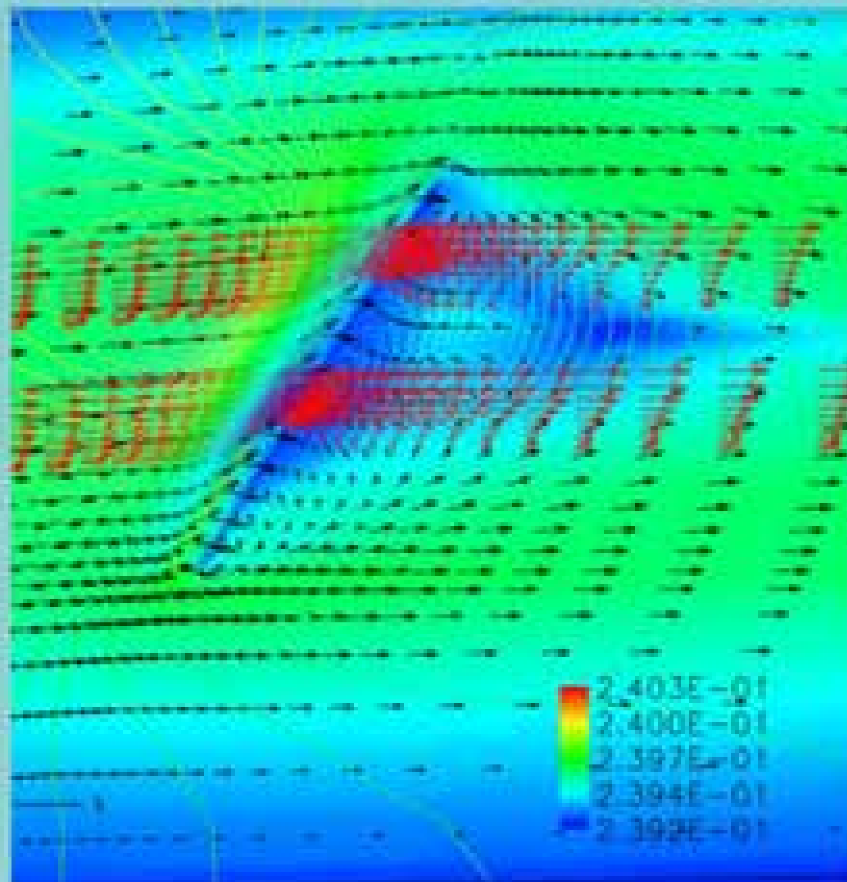
placed in series for increased benefit

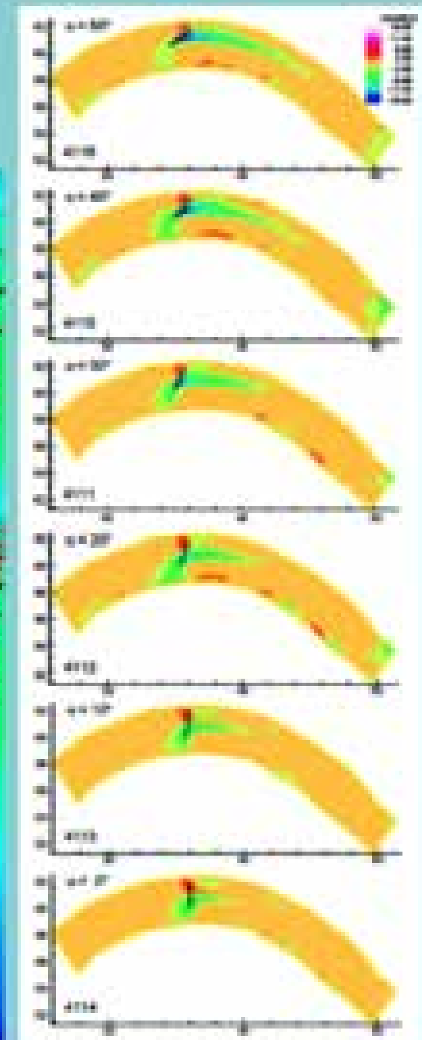
Description

Submerged or non-submerged linear rock structures, permeable or impermeable, usually positioned in series near the thalweg of river bends

How they work

Resistance of the weir establishes a high-pressure zone in front of the weir near the center of the weir, while a low-pressure zone develops behind the weir, near the tip. These zones redirect the high-energy flow away from the concave bank while creating a low-velocity recirculation zone, or eddy pool.





Benefits

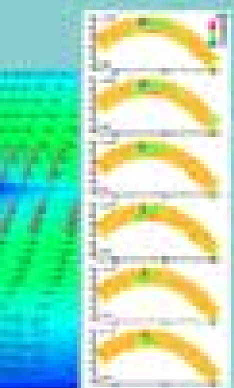
Reduce the magnitude of secondary flows in channel bends

Alleviates bend migration

Bank erosion reduced

n

linear
meable, usually
alweg of river



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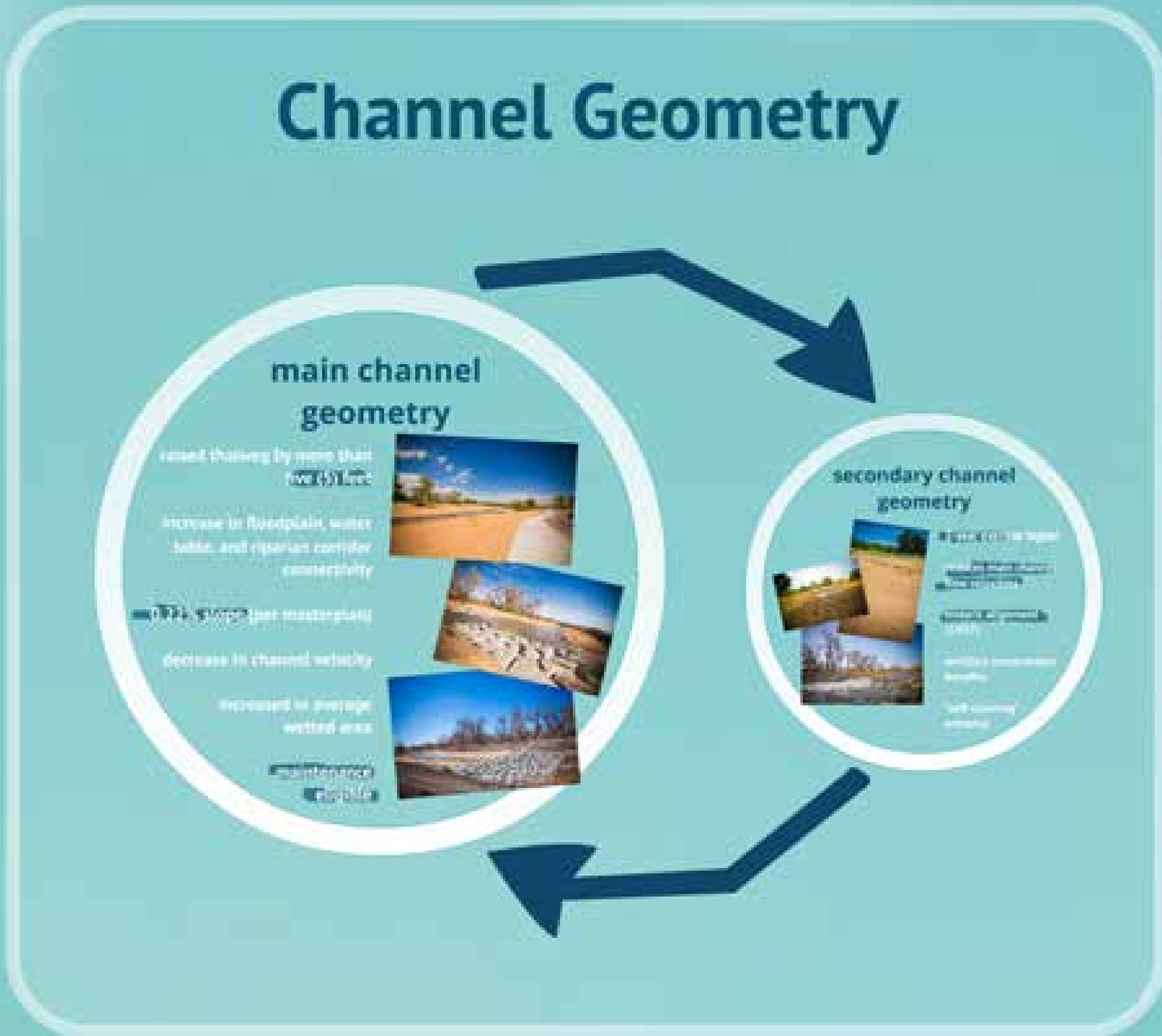

Channel Geometry
main channel geometry
raised thalweg by more than
increase in floodplain, water table, and riparian corridor connectivity
decrease in channel velocity
increased in average wetted area
secondary channel geometry

main channel geometry

raised thalweg by more than five (5) feet

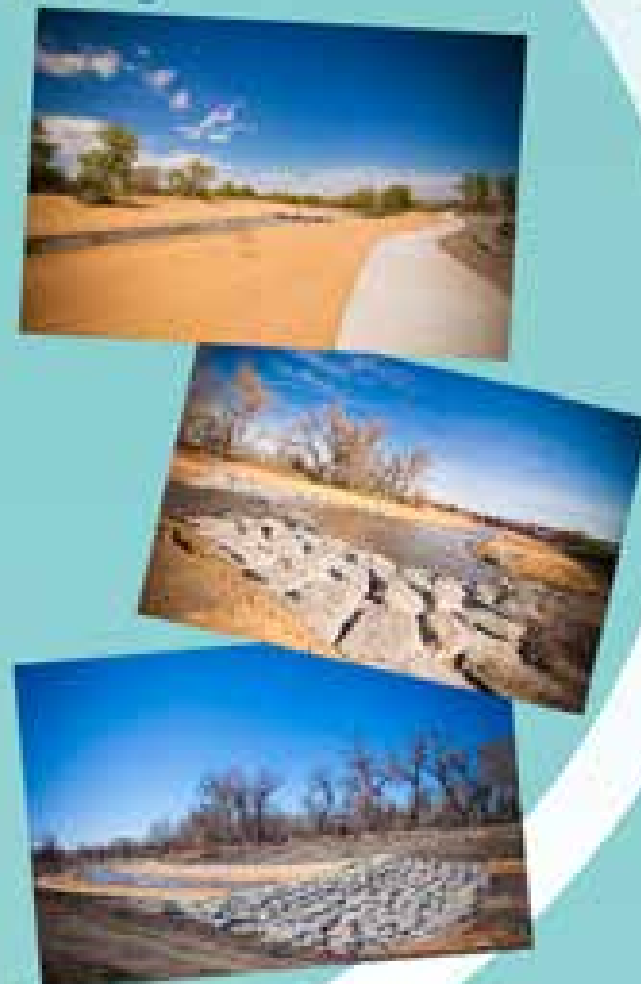
increase in floodplain, water table, and riparian corridor connectivity

0.22% slope (per masterplan)

decrease in channel velocity

increased in average wetted area

maintenance eligible



secondary channel geometry

2-year event or higher

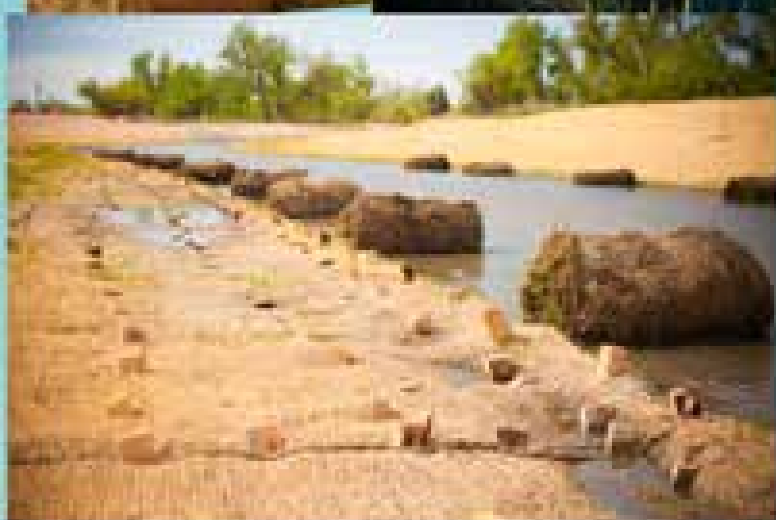
reduces main channel flow velocities

historic alignment (1937)

ancillary construction benefits

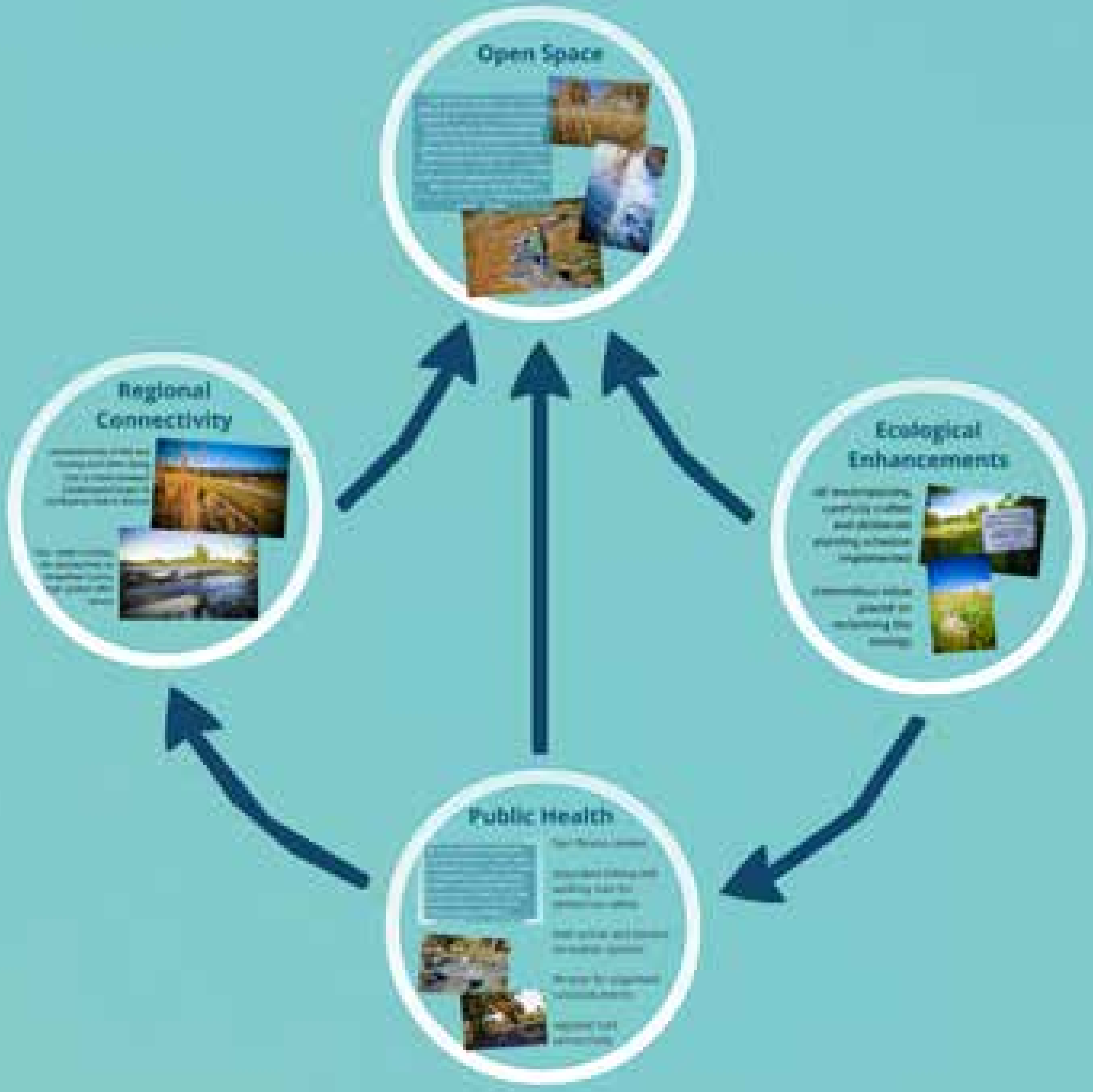
"self-cleaning" entrance

Bio-Engineered Solutions



26,500 sq. ft. - Wetland Sod
110,500 - Willow live stakes
10,200 lineal feet - Biolog
8 acres - Wetland seed
10 acres - Upland seed
69 - Golden currant (5 gallon)
184 - Wild Plum (5 gallon)
76 - Chokecherry (5 gallon)
89 - Peachleaf Willow (5 gallon)
65 - Western snowberry (5 gallon)
48 - Plains Cottonwood (2.5" cal.)
72 - Plains Cottonwood (1.5" cal.)
45 - Plains Cottonwood (1" cal.)
45 - Plains Cottonwood (poles)
24 - Common Hackberry (2.5" cal.)

integrating enhancement of the surrounding environment



Ecological Enhancements

all-encompassing, carefully crafted and deliberate planting schedule implemented

tremendous value placed on reclaiming the ecology

Public Health

"Americans will be more likely to change their behavior if they have a meaningful reward... The real reward is invigorating, energizing, joyous health. It is a level of health that allows people to embrace each day and live their lives to the fullest without disease or disability."

four fitness centers

separated biking and walking trail for pedestrian safety

both active and passive recreation options'

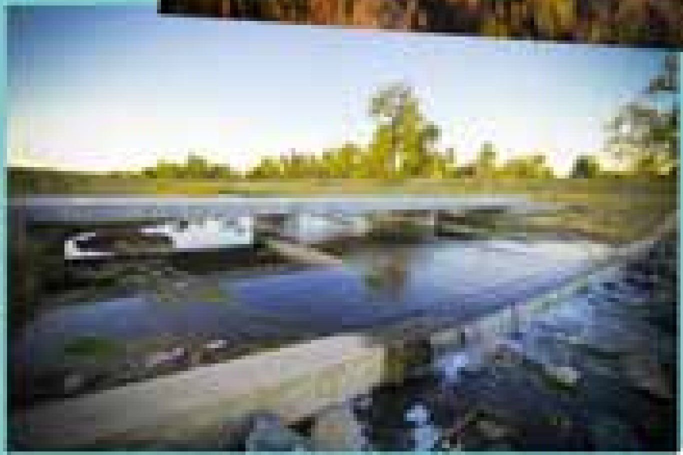
5k loop for organized run/walk events

regional trail connectivity

Regional Connectivity

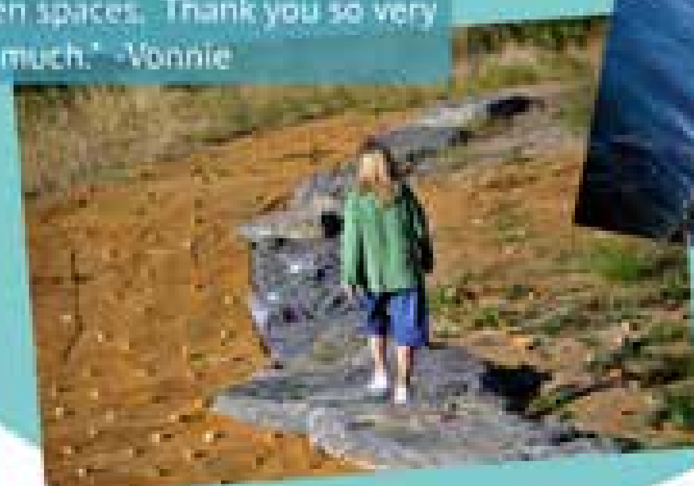
completed one of the last missing trail links along Cherry Creek between Castlewood Canyon & Confluence Park in Denver

low water crossing for connectivity to Arapahoe County trail system (404 nexus)



Open Space

"I just love the way you respected the natural beauty of that area and provided places of rest and solace in magnificent wood and stone. There is wonderful variety with the paved paths and soft paths and places to cross the creek and places to just sit quietly and marvel at nature and catch up with our souls. What a gift you have designed for all of us to be able to access the beauty of these treasured open spaces. Thank you so very much." -Vonnie

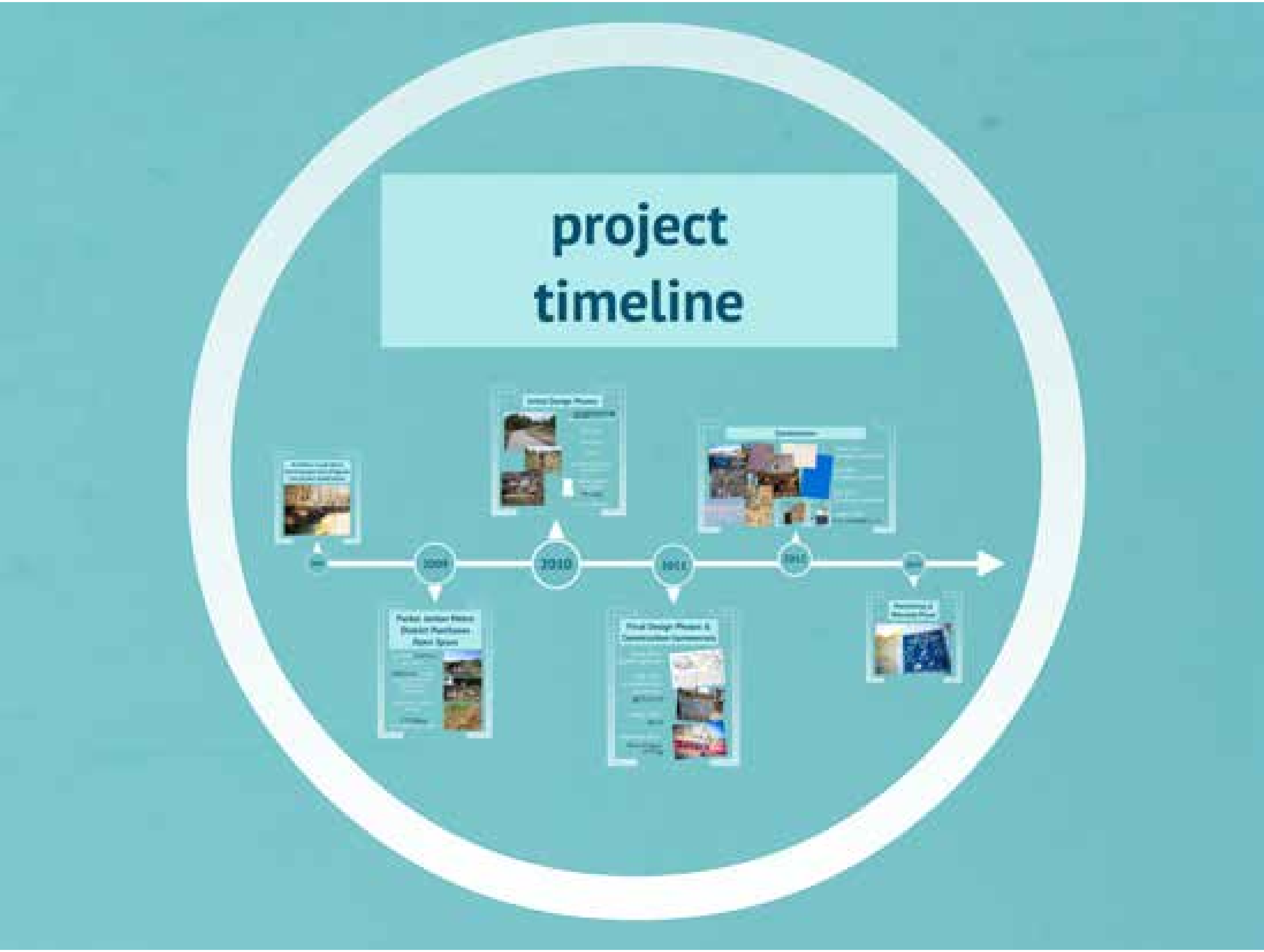


enhancing & protecting
riparian areas

stream
stabilization

water quality


1:1 wetland mitigation
acres of enhanced riparian areas
reduction in phosphorus by approximately 87 pounds per year - equates to an annual benefit of $310,938 in protecting water quality
sustainable plant diversity
reduced sediment transport and less erosive velocities


project
timeline
2010

Vermillion Creek Metro District begins Due Diligence into Stream Stabilization

2007

2007

2009

2010

Parker Jordan Metro District Purchases Open Space

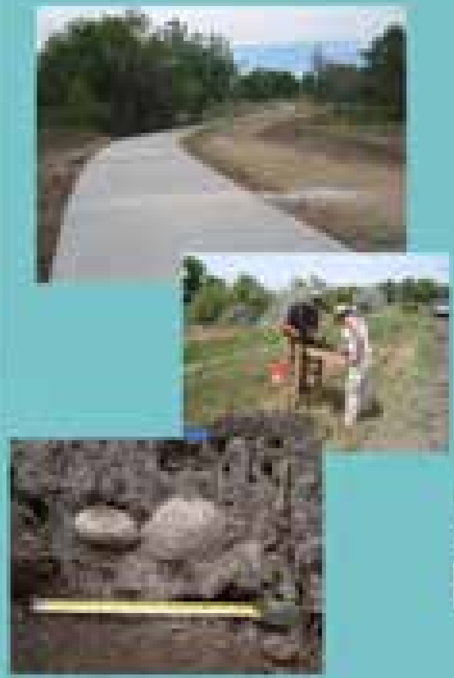
April 2009 - 80 acres purchased

due diligence for open space and channel improvements commences

Sept 2009 - notice to proceed

regional trail construction documents

Initial Design Phases



10-foot regional trail designed and constructed

30% design

90% design

CLOMR

comprehensive design assessment

cultural resource survey finds artifacts

design modification

2009

2010

2011

assessment

cultural resource survey finds

artifacts

design modification

2010

2011

2012

Final Design Phases & Construction Commences

march 2011
CLOMR approved

july 2011
all construction documents approved

august 2011
bid

september 2011
construction began

Construction

march 2012
1st phase completed

may 2012
2nd phase completed

july 2012
3rd phase completed

august 2012
construction ended

2012

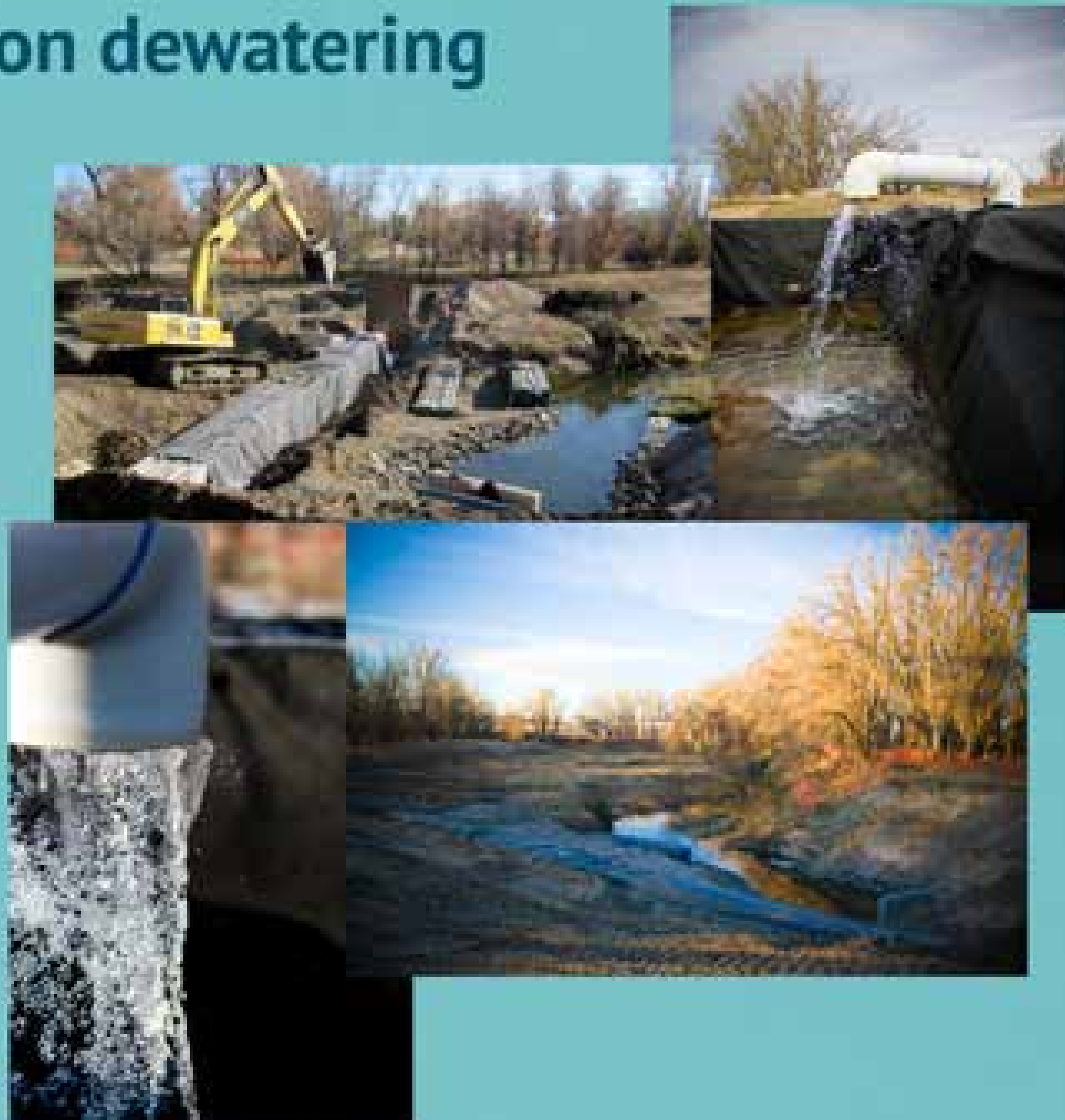
construction dewatering

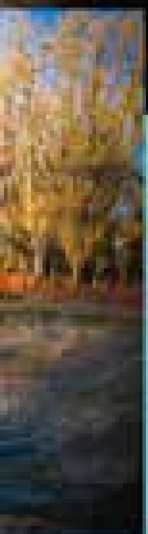
two major components
- dewatering
- diversion

complex
- phasing
- jurisdictional requirements

substitute water supply plan (SWSP)

state dewatering well NOI





flood event

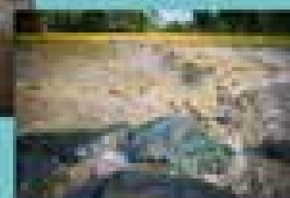
june 6th & 7th, 2012

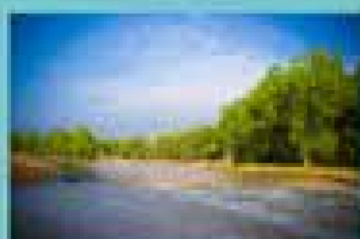
1,700 cfs (2-year event)
- flow witnessed within secondary channel

completion
- Phase 1 - 100%
- Phase 2 - 80%
- Phase 3 - 25%

minimal vegetation establishment

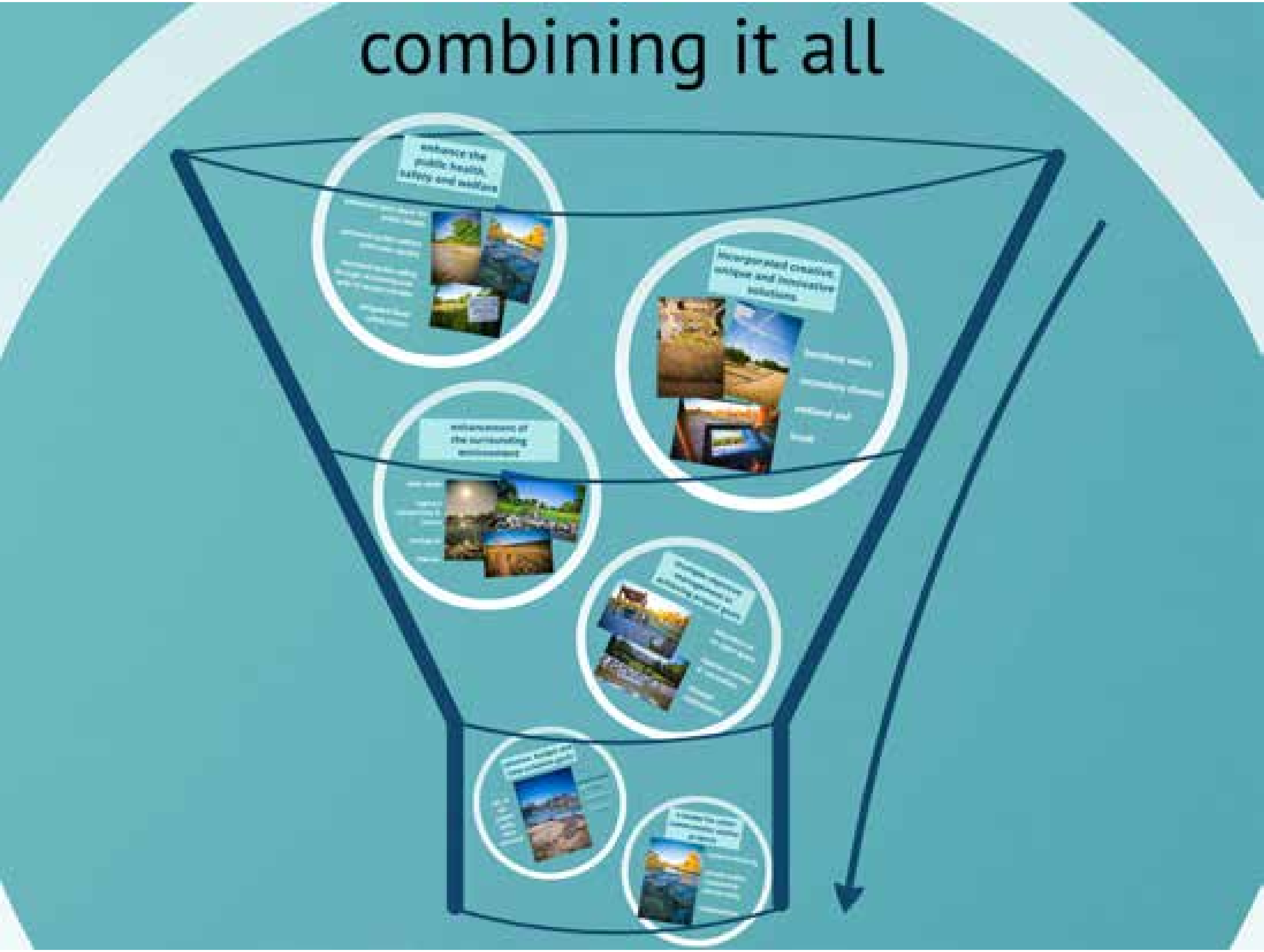
site performed exceptionally well





2013

Monitoring & Warranty Phase


combining it all
enhance the public health, safety and welfare
incorporated creative, unique and innovative solutions
enhancement of the surrounding environment

enhance the public health, safety and welfare

enhanced open space for public health

enhanced public welfare with water quality

increased public safety through reclaiming one-mile of stream corridor

mitigated flood safety issues

incorporated creative, unique and innovative solutions

bendway weirs

secondary channel

wetland sod

kiosk

enhancement of the surrounding environment

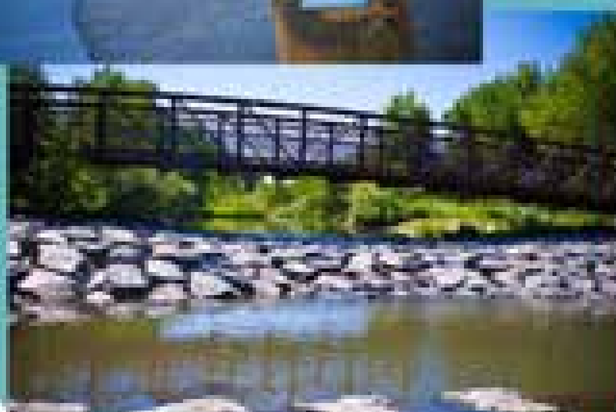
open space

regional connectivity & access

ecological

channel

multiple-objective management in achieving project goals



education in an open space

riparian corridor & recreation

channel stabilization

solution, budget and time schedule goals

ALL of the project goals were achieved

project budget

engineers cost estimate
$3,544,082

contractor bid price
$3,355,559

final project cost
$3,478,650

ALL of
the
roject
goals
were
chieved

project bu
engineers cost es
$3,544,082

contractor bid p
$3,355,559

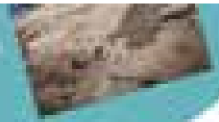
final project c
$3,478,650

a model for other communities and/or projects

systems thinking

private-public relationship success story

collaboration



a mile of severely degraded Cherry Creek now stabilized, protected, healthy and thriving through a holistic collaboration and design


combining it all
a mile of severely degraded Cherry Creek now stabilized, protected, healthy and thriving through a holistic collaboration and design


thank you
J3 Engineering Consultants
CONTACT INFORMATION
Ken Cecil, P.E. CFM
303.368.5601
Josh Duncan, P.E., CFM
303.261.6886
Susan Brown
303.347.1200

Lefthand Creek Flood Control Project

CASFM Conference 2013

Project Team

w e n k

ERO

ERO Resources Corp.

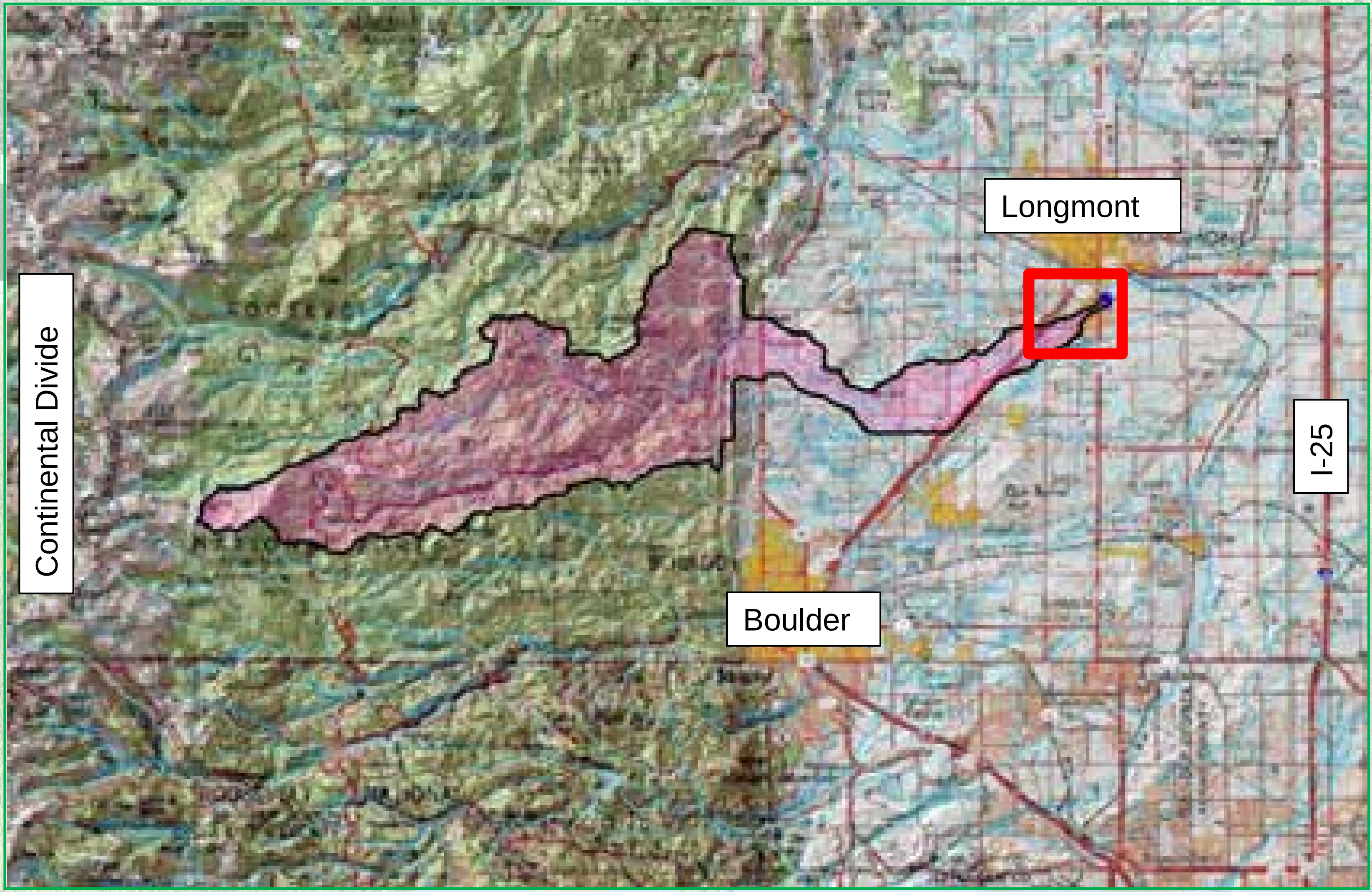
CITY OF LONGMONT COLORADO

DEFALCO CONSTRUCTION

MULLER

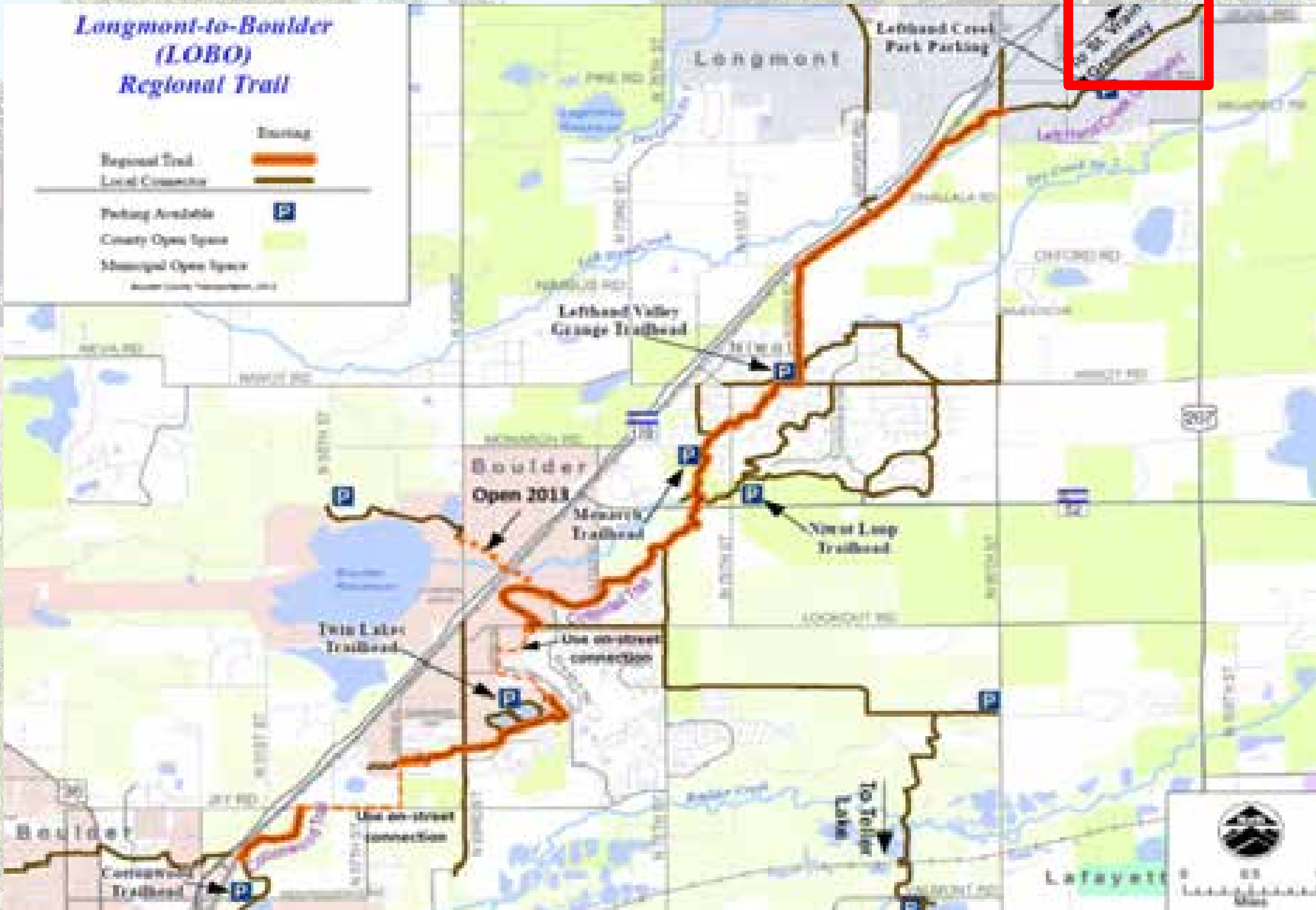
NARANJO CIVIL CONSTRUCTORS

Project Location



Drainage basin area = 72 sq mi - 100-year flow rate = 5,000 cfs

LOBO Trail



Longmont-to-Boulder (LOBO) Regional Trail
Existing
Regional Trail
Local Connector
Parking Available
County Open Space
Municipal Open Space
Longmont
Lefthand Creek Park Parking
Lefthand Valley Grange Trailhead
Boulder
Open 2011
Monarch Trailhead
Niwot Loop Trailhead
Twin Lakes Trailhead
Use on-street connection
Use on-street connection
Boulder
Cottonwood Trailhead
To Teller Lake
Lafayette

Vicinity Map

Development

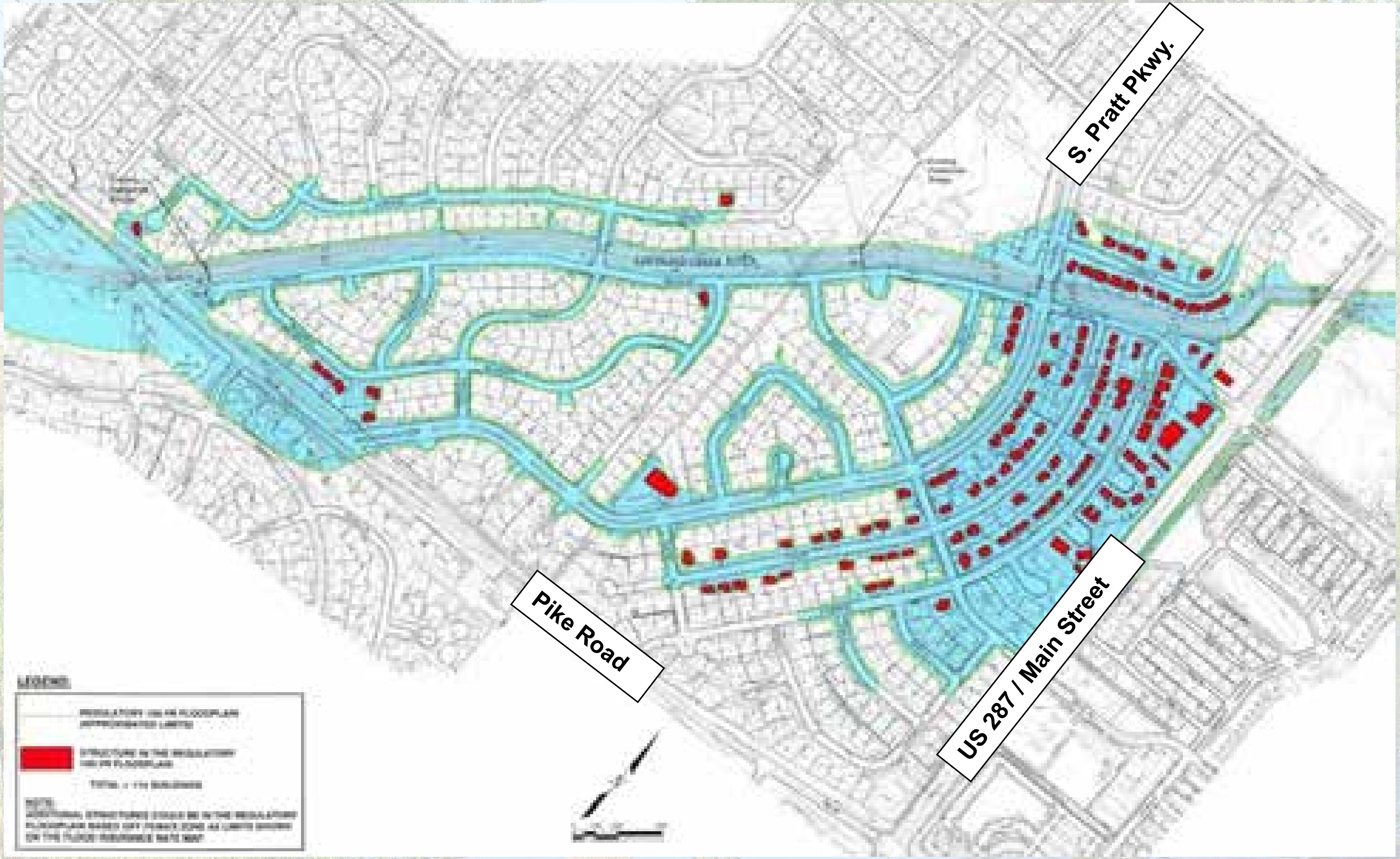
1963

2013

1969 Flooding

1995 Flooding

Regulatory Floodplain

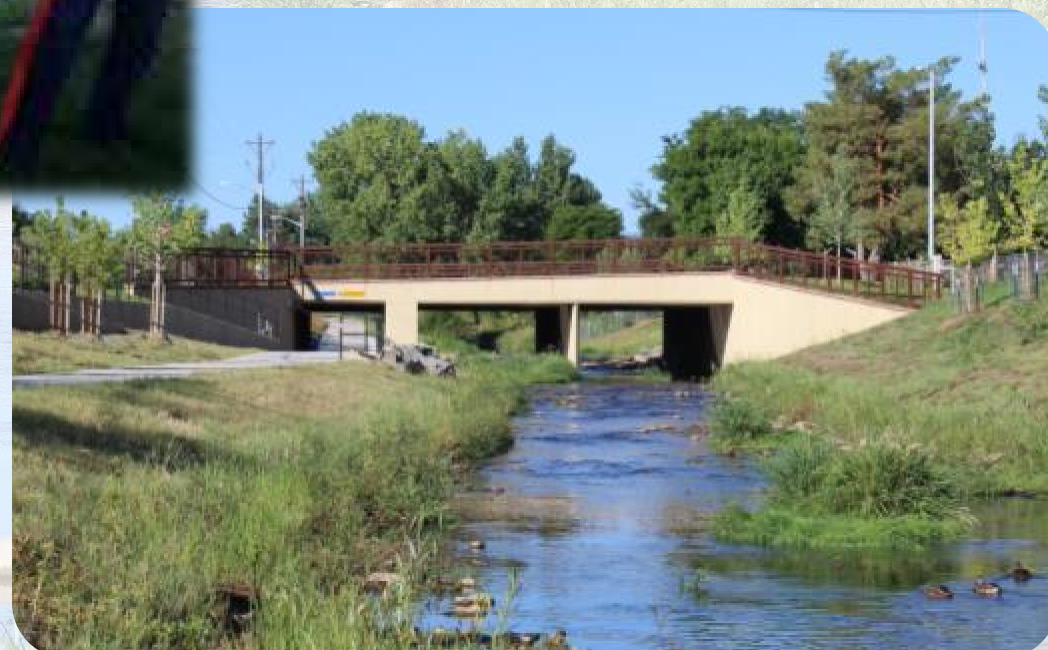


2007 Storm Drainage Bond

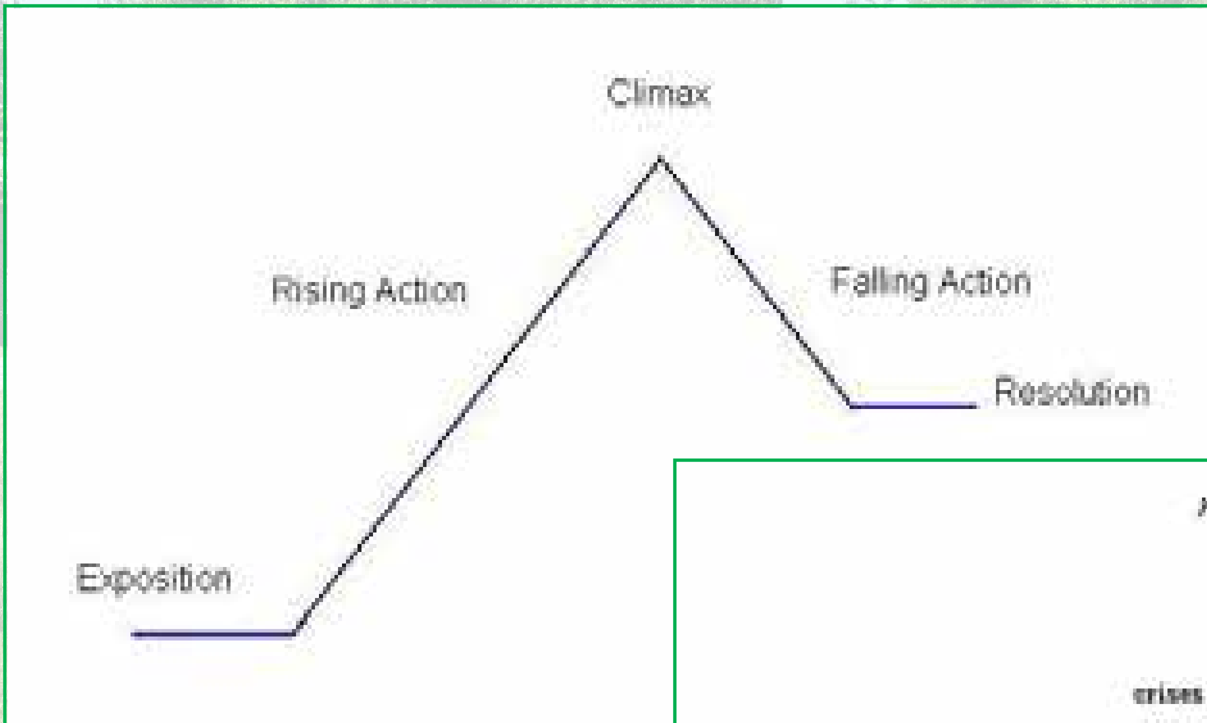
- **Ballot Issue 2B**

  - **Improve City Storm Drainage System**
  - **Reduce risk of serious flooding**
  - **Lefthand Creek identified as a priority project**

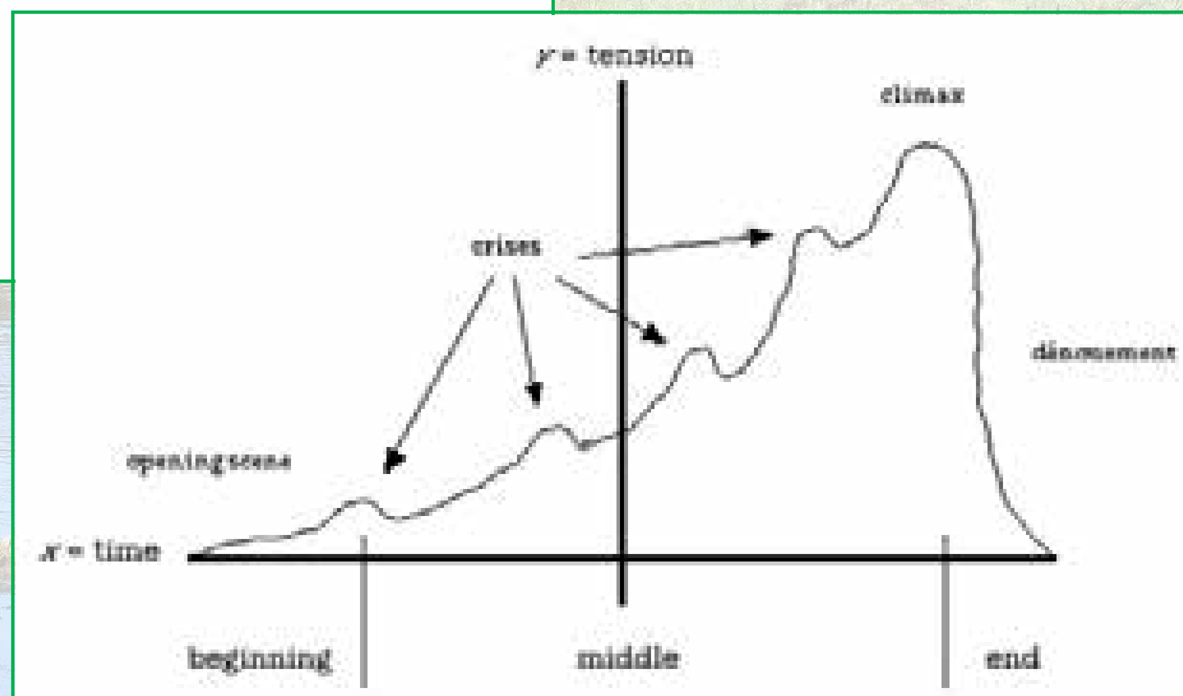
Process vs. Product



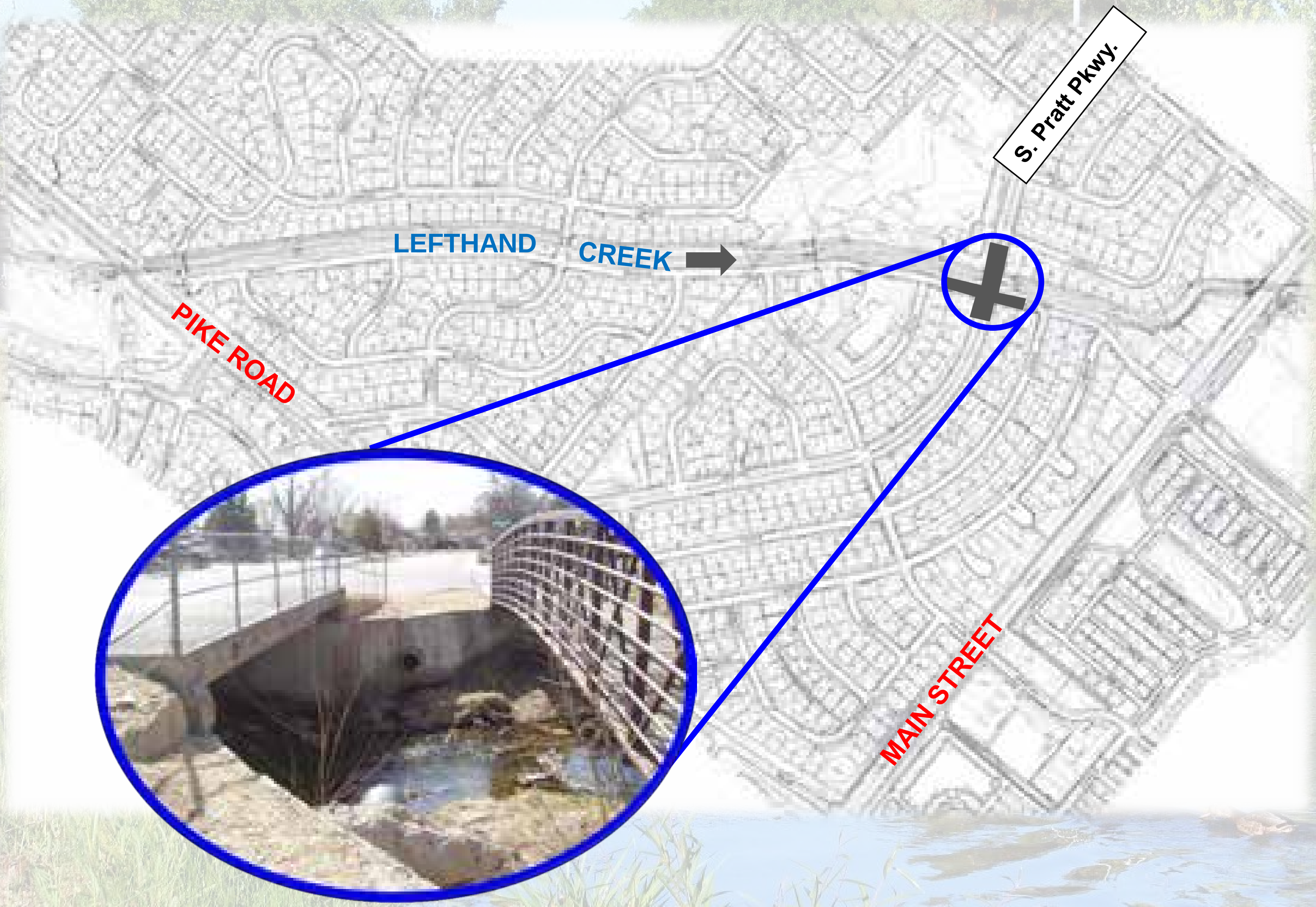
Great Story



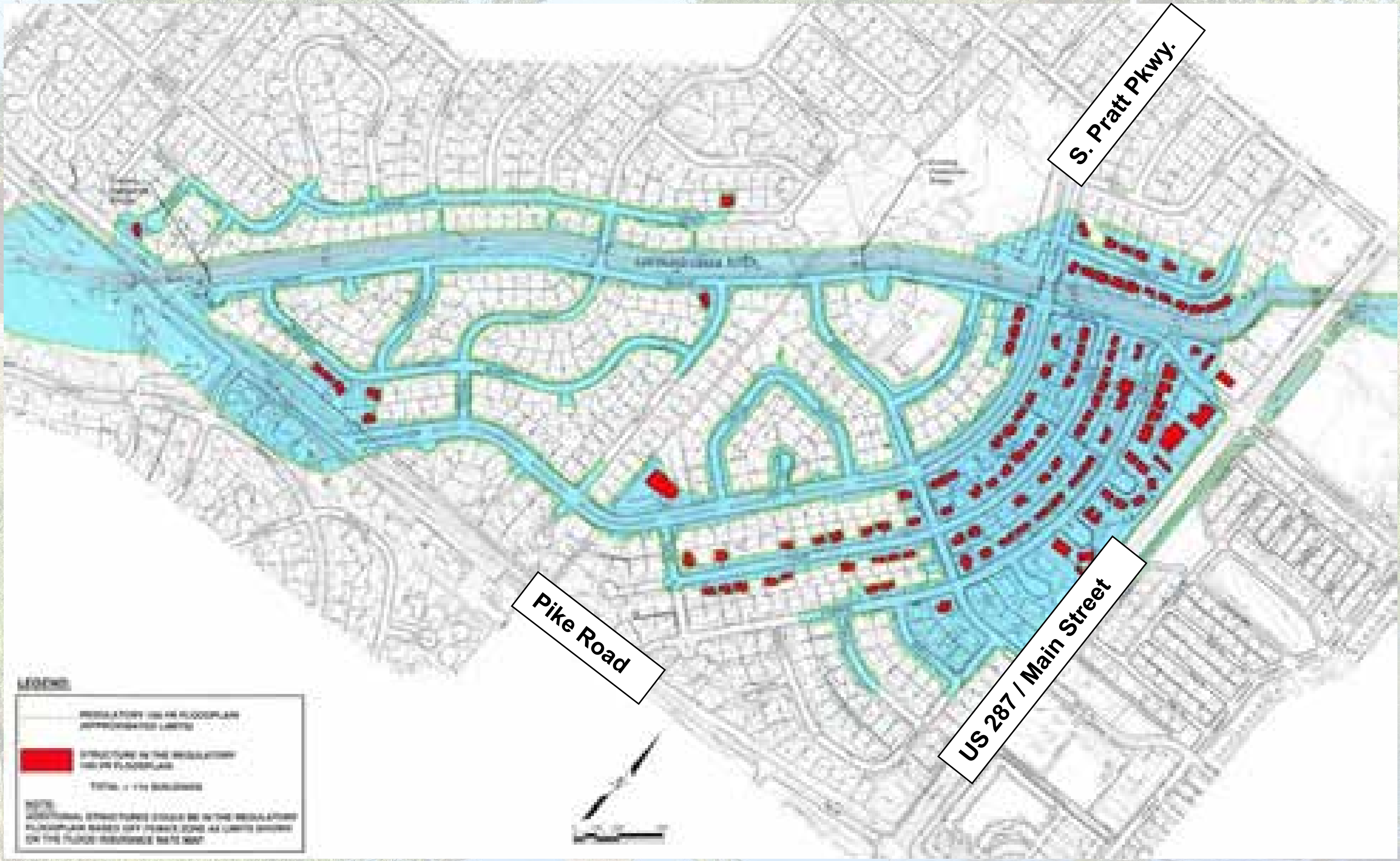
Story Structure



Rising Action

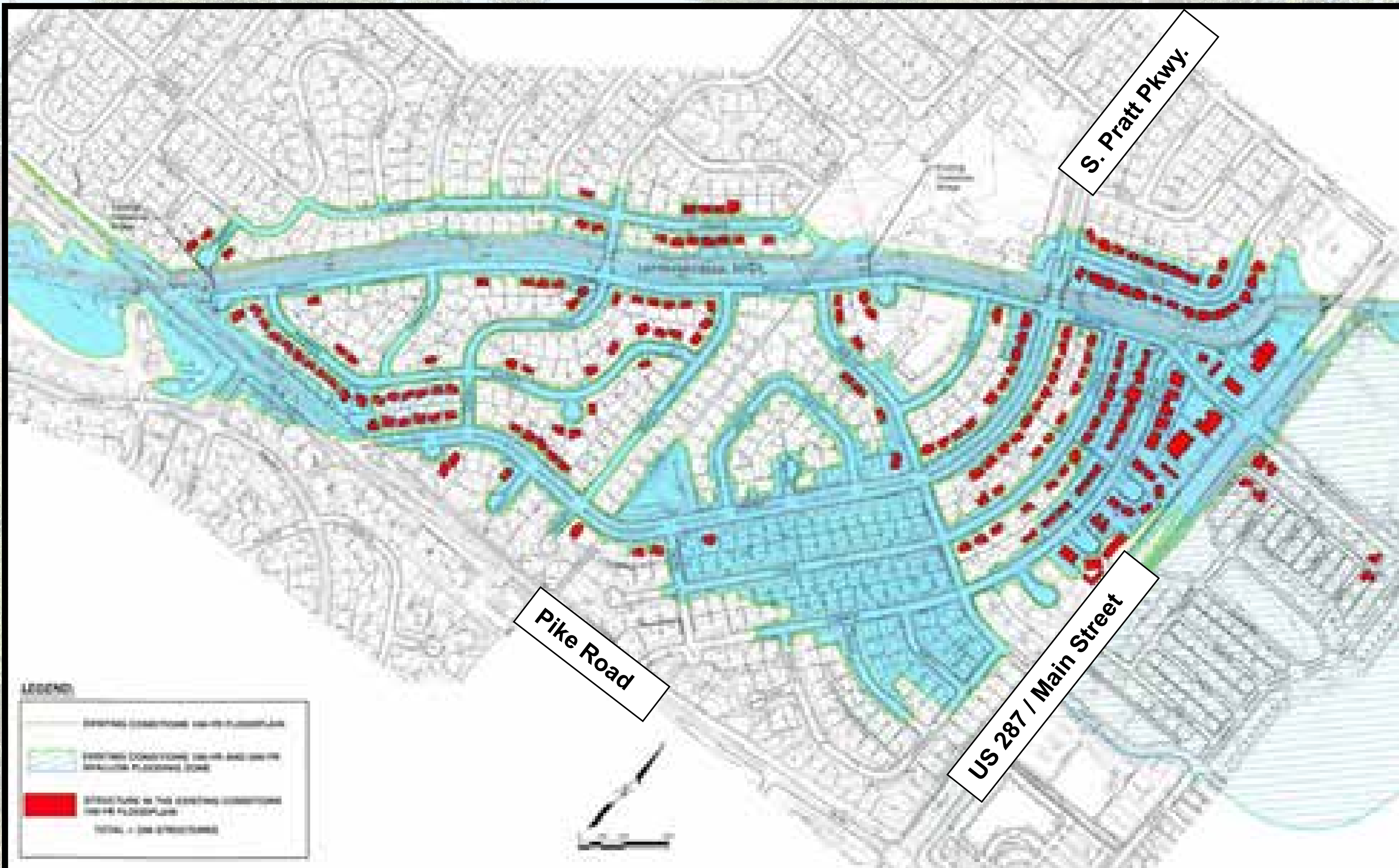


Rising Action

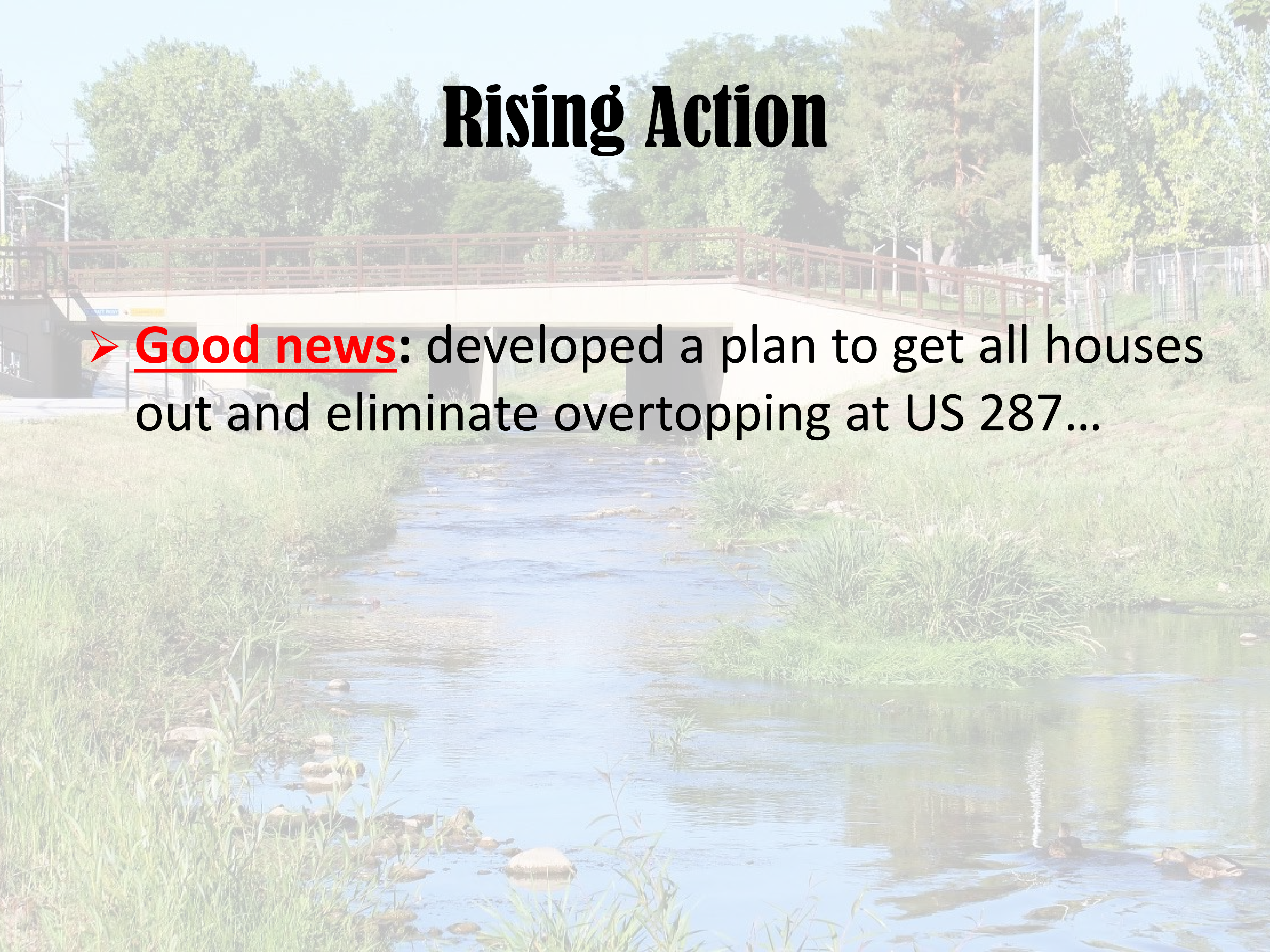


Regulatory floodplain

Rising Action



Existing floodplain analysis brings about more concerns



Rising Action

- **Good news**: developed a plan to get all houses out and eliminate overtopping at US 287…

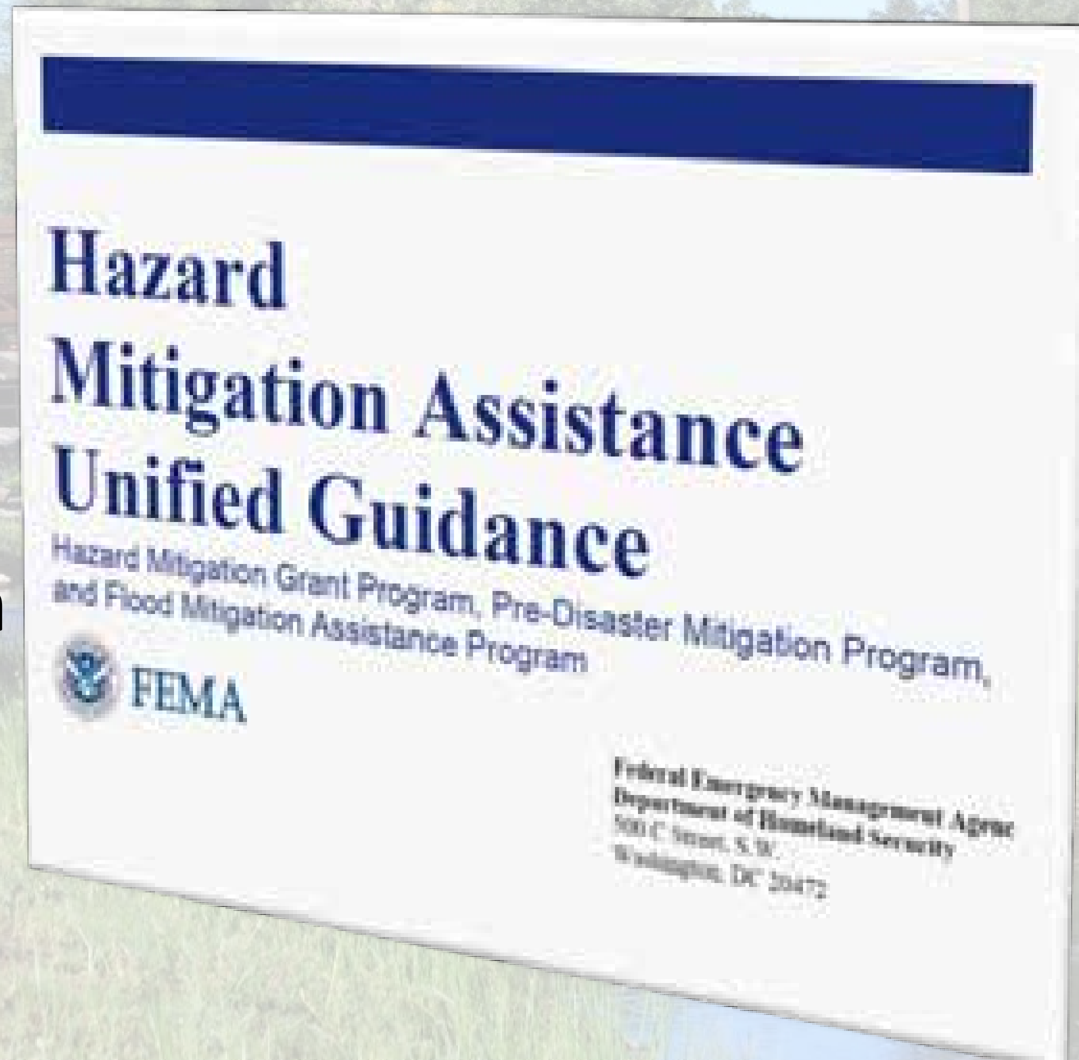
Rising Action

- **Good news**: developed a plan to get all houses out and eliminate US 287 overtopping…

- **Bad news**: plan costs over $11 million (well above original $2 million project budget)

Rising Action

- Reorganize City Funds
- Apply for FEMA Hazard Mitigation Grant



Hazard Mitigation Assistance Unified Guidance

Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program

FEMA

Federal Emergency Management Agenc
Department of Homeland Security
500 C Street, S.W.
Washington, DC 20472

Rising Action

New Budget:

- Original Budget = $2 million
- Additional Funding from City = $2 million
- FEMA Grant = $3 million
- Total Budget = $7 million

New Plan:

- Eliminate Overtopping of US 287
- Maximize flood mitigation for houses

Proposed Improvements

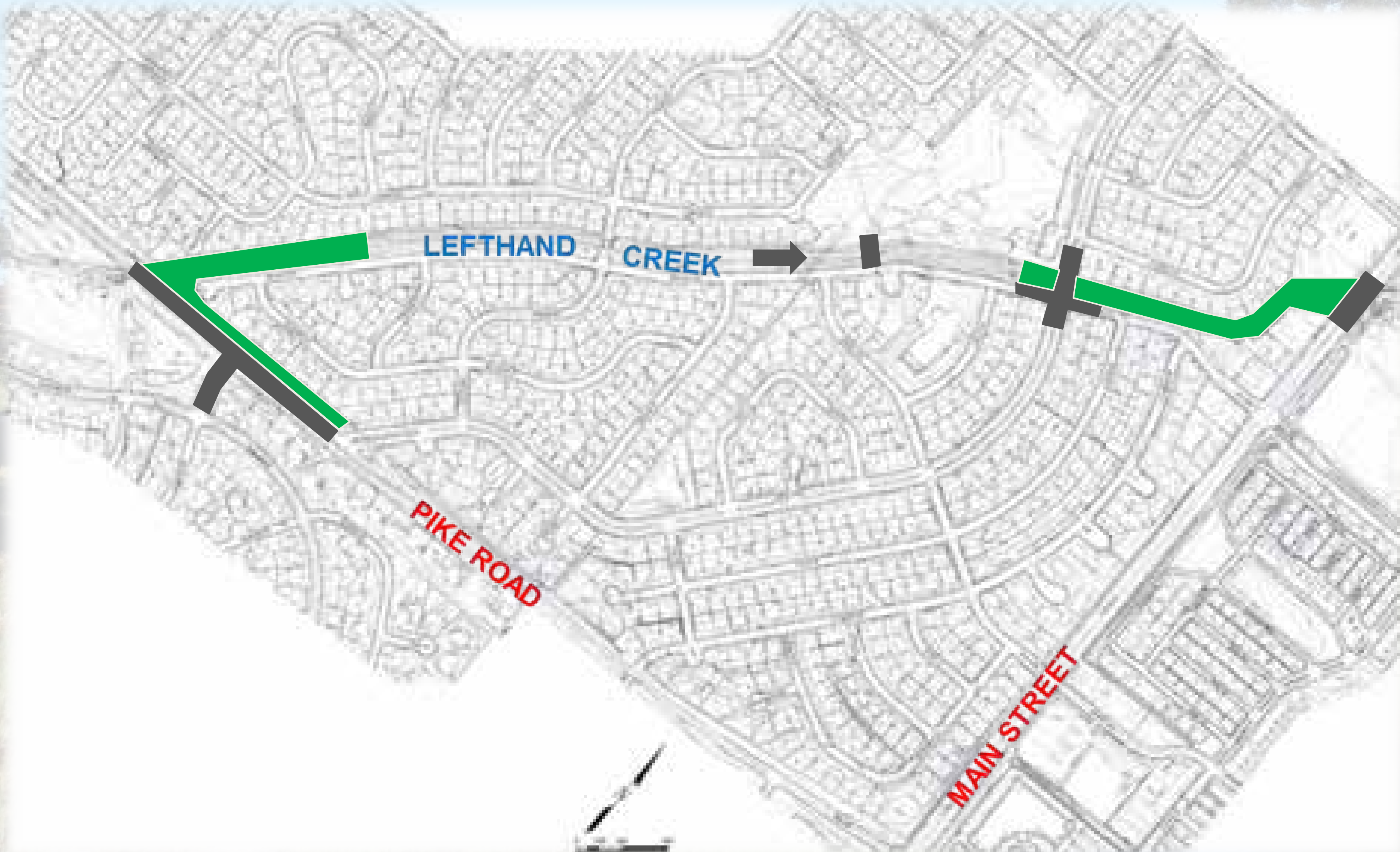
Proposed Improvements

Proposed Improvements

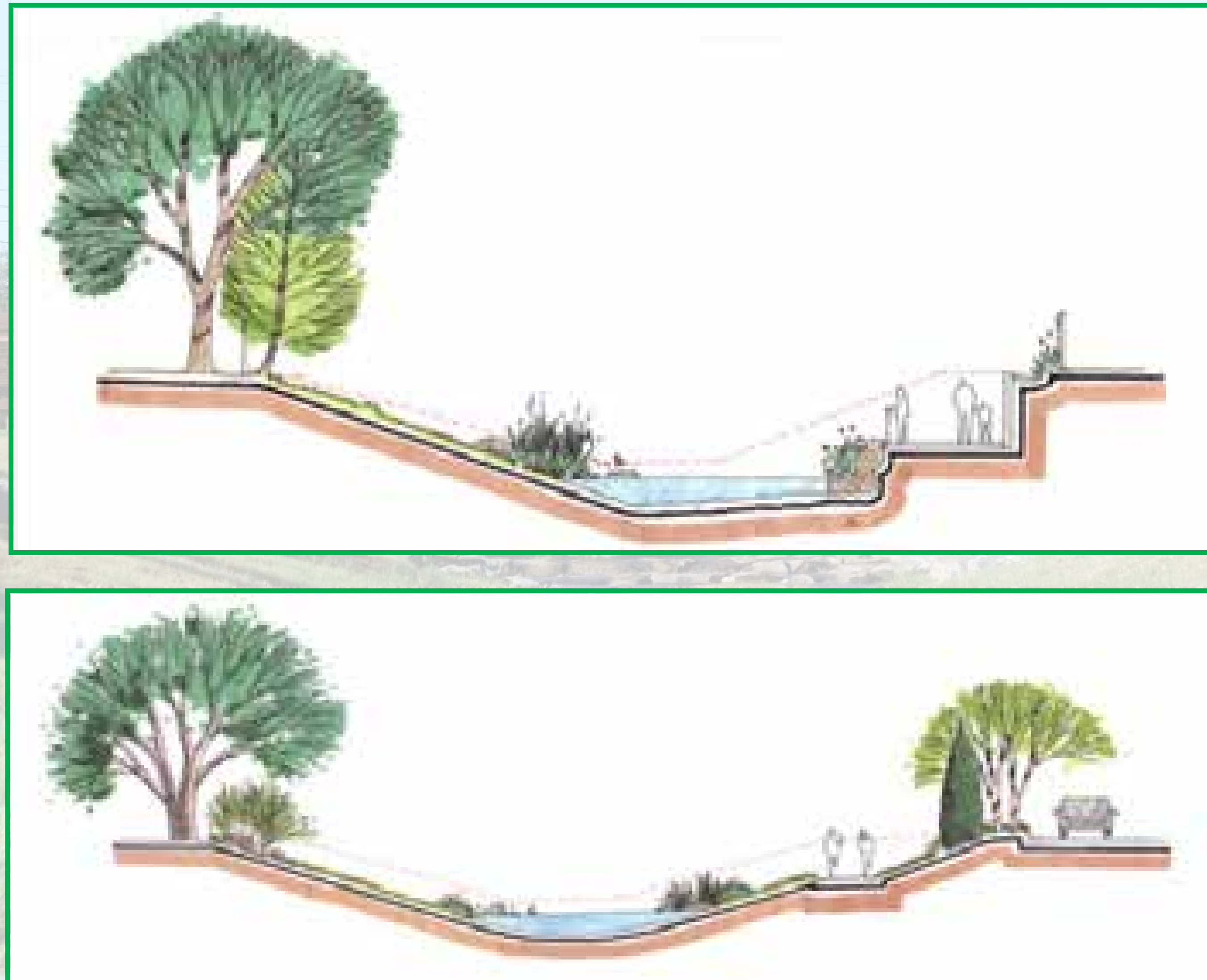
Proposed Improvements

Proposed Improvements

Proposed Improvements

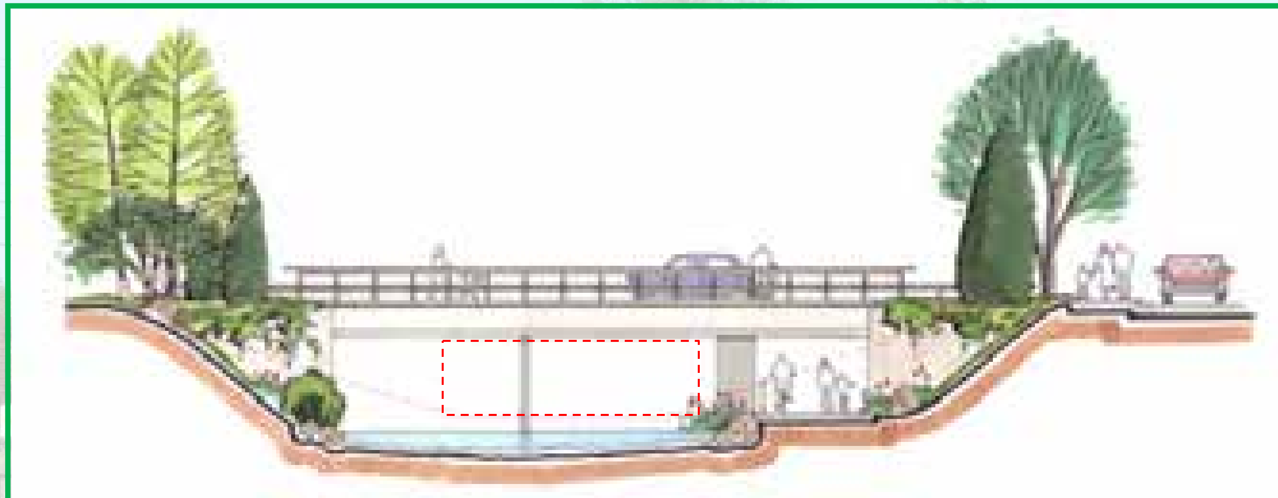


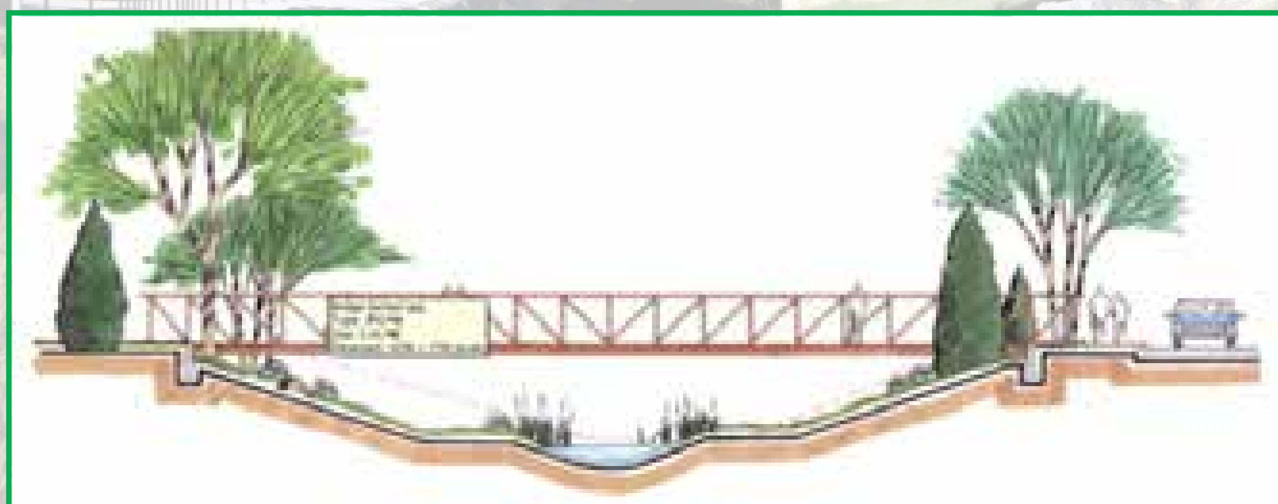
Proposed Improvements



Typical Sections

Proposed Improvements





Typical Sections

Rising Action

Existing Floodplain

Rising Action

Proposed Floodplain

Rising Action

Existing Floodplain

Rising Action

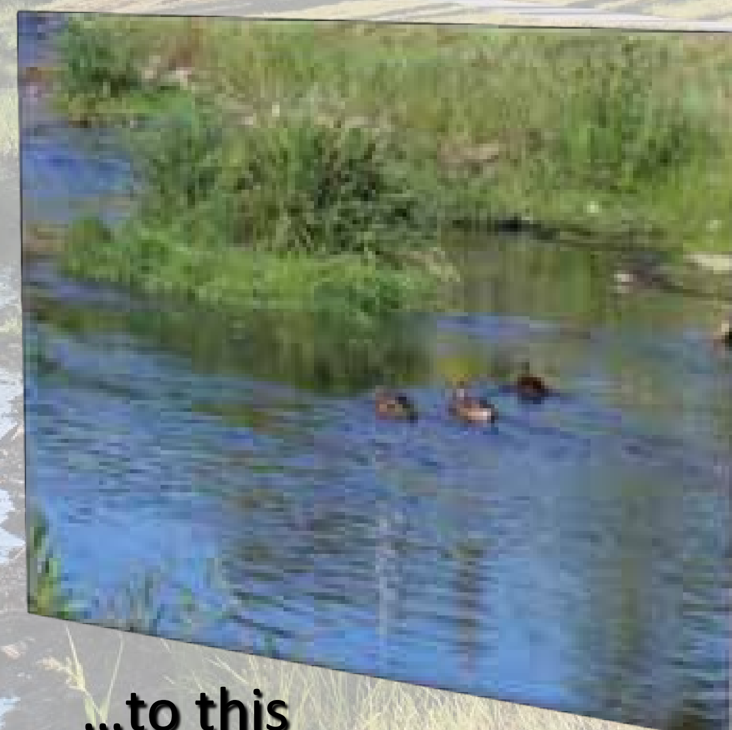
Proposed Floodplain

Rising Action

Environmental challenges

- Get project team and regulatory agencies on same page
- Mitigate major tree removal
- Minimize capacity obstructing vegetation
- Maintain characteristics/functions below OHWM

From this…

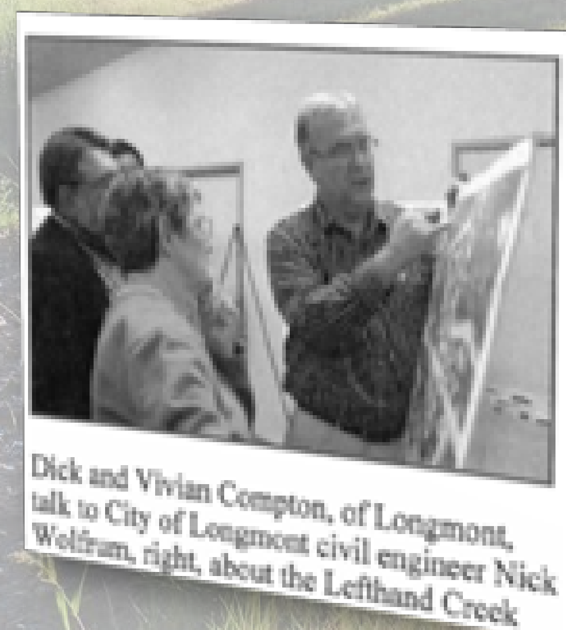


…to this

Rising Action

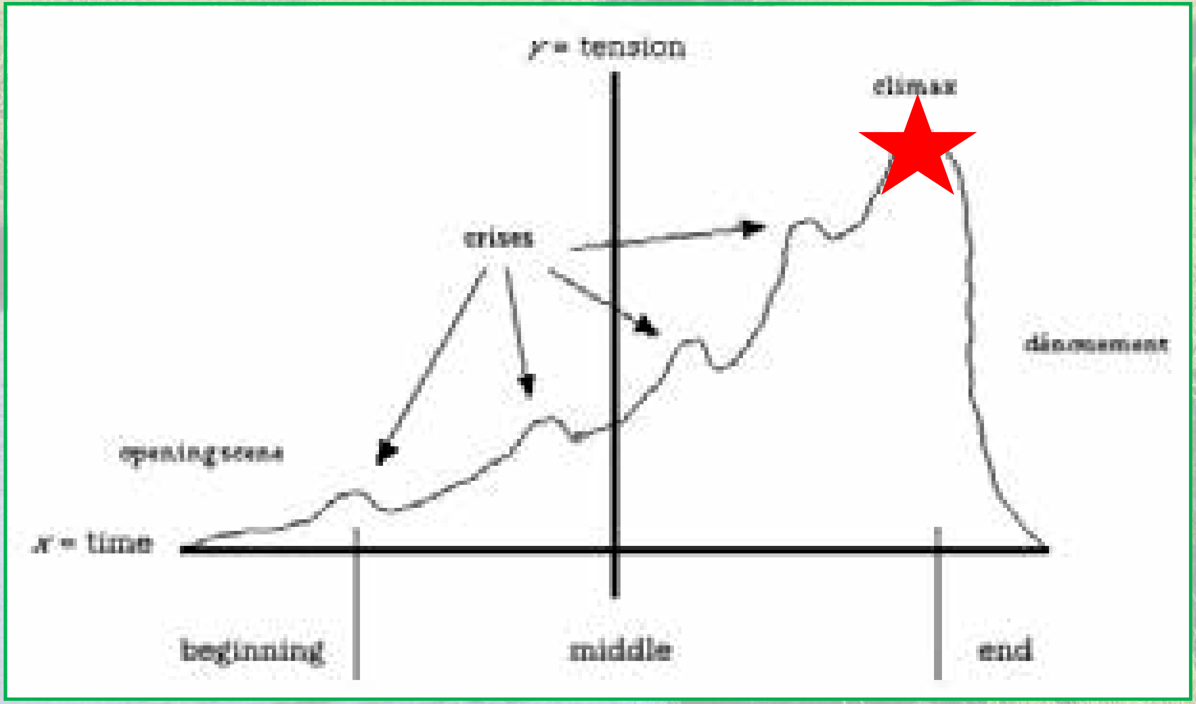
Public Outreach Challenges

- Make residents part of the team
- Educate residents on floodplain process/benefits
- Incorporate desired design features (new ped. bridge)
- Address concerns related to construction disruption



Climax

- FEMA Grant awarded!
- CLOMR application approved!
- Environmental clearances/permits issued!
- Public outreach concerns addressed!



Resolution

Time to deliver the project…

- Added 20’x10’ box culvert and 12’x8’ ped cell to US 287 crossing
- Replaced 28’x8’ S. Pratt Pkwy bridge with double 20’x10’ box and 12’x8’ ped cell
- 550 LF of 10’ concrete retaining wall
- 190 LF of 8’ concrete retaining wall
- 500 LF of 2.5’ boulder retaining wall
- 1,100 LF of 3.5’ boulder retaining wall
- 3,100 LF of bioengineered bank protection
- 2 grouted boulder drop structures (1.5’ and 2.5’ high)
- Raised 500 LF of Pike Road and 200 LF of Ridgeview Street
- Reconfigured 300 LF of South Pratt Parkway and 200 LF of Missouri Avenue
- Exported 30,000 CY of soil
- Replaced 2 pedestrian bridges (90’ and 100’ long)
- 4,000 LF of recreational trail
- 9 storm sewer renovations
- Relocated 450 LF of waterline and 100 LF of sanitary sewer
- Relocated 470 LF of irrigation ditch
- Planting of 170 trees, 1,700 shrubs, 8,900 wetland plugs, and 6.5 acres of seed

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Resolution

BEFORE

AFTER

Resolution

BEFORE

AFTER

Resolution

BEFORE

AFTER

Resolution

AFTER

BEFORE

Resolution

BEFORE

AFTER

Resolution

BEFORE

AFTER

Resolution

BEFORE

AFTER

Resolution

BEFORE

AFTER

Resolution

BEFORE

AFTER

Resolution

New Road

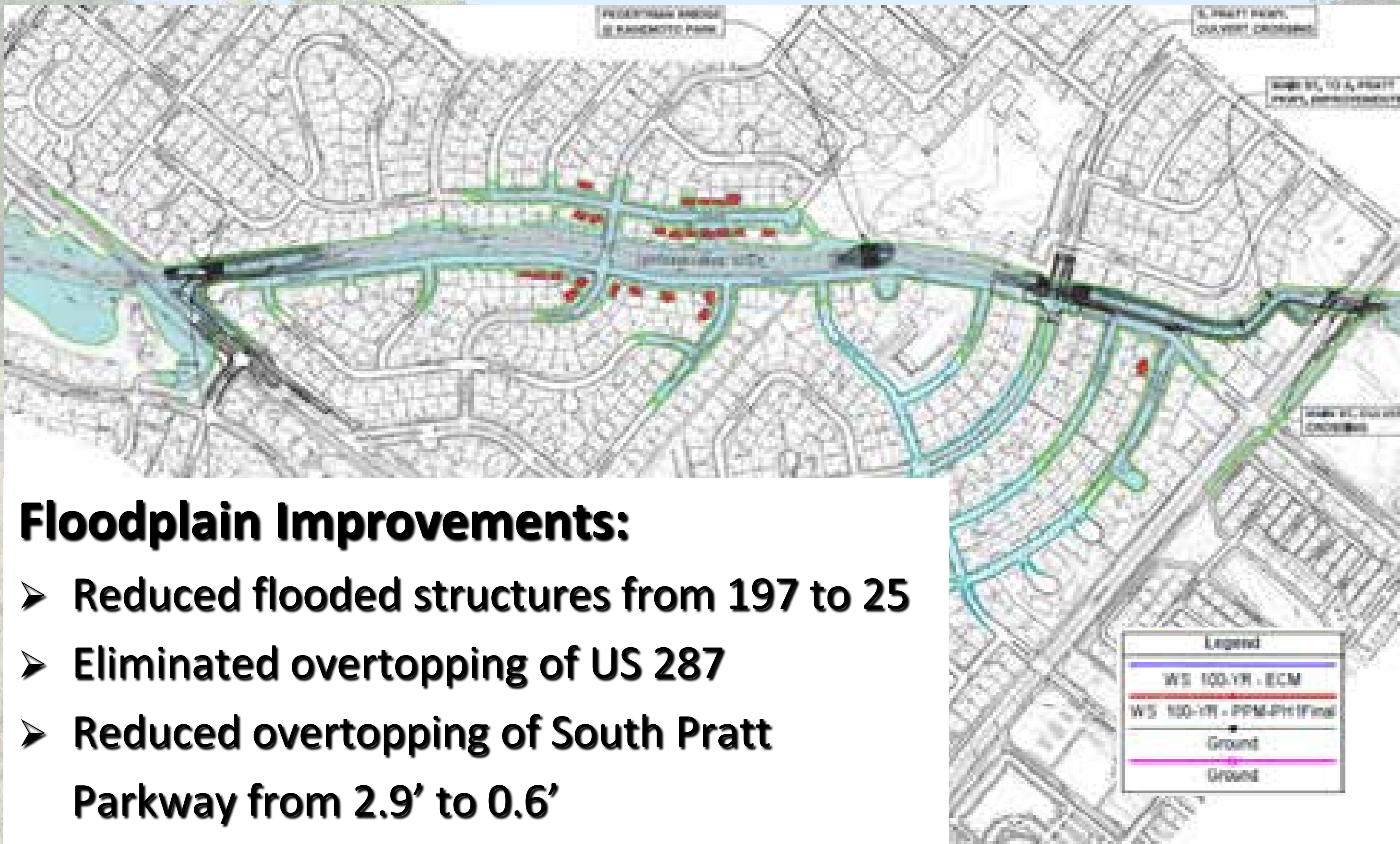
New Swale

Best Seller… …or not?

- Judging Criteria

Best Seller… …or not?

Enhancement of Public Health, Safety and Welfare



Floodplain Improvements:

- Reduced flooded structures from 197 to 25
- Eliminated overtopping of US 287
- Reduced overtopping of South Pratt Parkway from 2.9’ to 0.6’

Best Seller... ...or not?

Enhancement of Public Health, Safety and Welfare

Trail Improvements:

- Eliminated at-grade trail crossing at South Pratt Parkway
- Increased capacity prior to trail overtopping at US 287
- Replaced 2 dilapidated pedestrian bridges

Best Seller… …or not?

Enhancement of Surrounding Environment

- **Maintained natural characteristics below the OHWM**
- **Incorporated step-pool sequences into drop structures**
- **Planted 170 trees, 1,700 shrubs, and 8,900 wetland plugs**
- **Water quality features incorporated to treat runoff**

Best Seller… …or not?

Creative, Unique, Innovative Solutions

- Complex hydraulic modeling
- Increased flood capacity without increased space
- Strategic selection and placement of plant materials
  - wetland grasses, not willows
  - trees with narrow trunks placed higher up on banks
- Alternate funding source through FEMA grant

Best Seller... ...or not?

Multiple Objective Management

- Provide a safe drainage corridor
- Protect existing infrastructure
- Provide facilities to enhance recreational value
- Establish a wildlife friendly environment
- Improve water quality
- Improve roadway/traffic facilities
- Make efficient use of dollars

Best Seller...   …or not?

Problem Solutions, Budget Goals, and Time Schedule

Construction Costs:

- City of Longmont = $4,000,000
- FEMA = $3,000,000

Schedule:

- Floodplain Study: 5/2008 – 5/2009
- Final Design/CLOMR: 5/2009 – 11/2010
- FEMA Grant Process: 11/2010 – 8/2011
- Construction: 9/2011 – 12/2012
- LOMR: 12/2012 - Present

Best Seller… …or not?

A Model for Other Communities and Projects

- Proactive in identifying and funding flood mitigation projects
- Working through Pre-NFIP constraints:
  -high flooding potential with little room for expansion-
- Balancing public safety, environment, and recreation
- Persistence in working through obstacles to achieve project goals

Sequel…

- 2nd Phase defined to eliminate flooding of remaining houses.
- On City's Future Projects List for $4 million

Questions?