CASFM 2018 Annual Conference

Watershed Planning Sessions:

Session1: Welcome to The River Mile

Greg Murphy (Calibre Engineering), Chris Kroeger (Muller Engineering), Mike Galuzzi (Merrick & Company)

Session2: Planning for Recreation and Resilience on the Big Thompson River

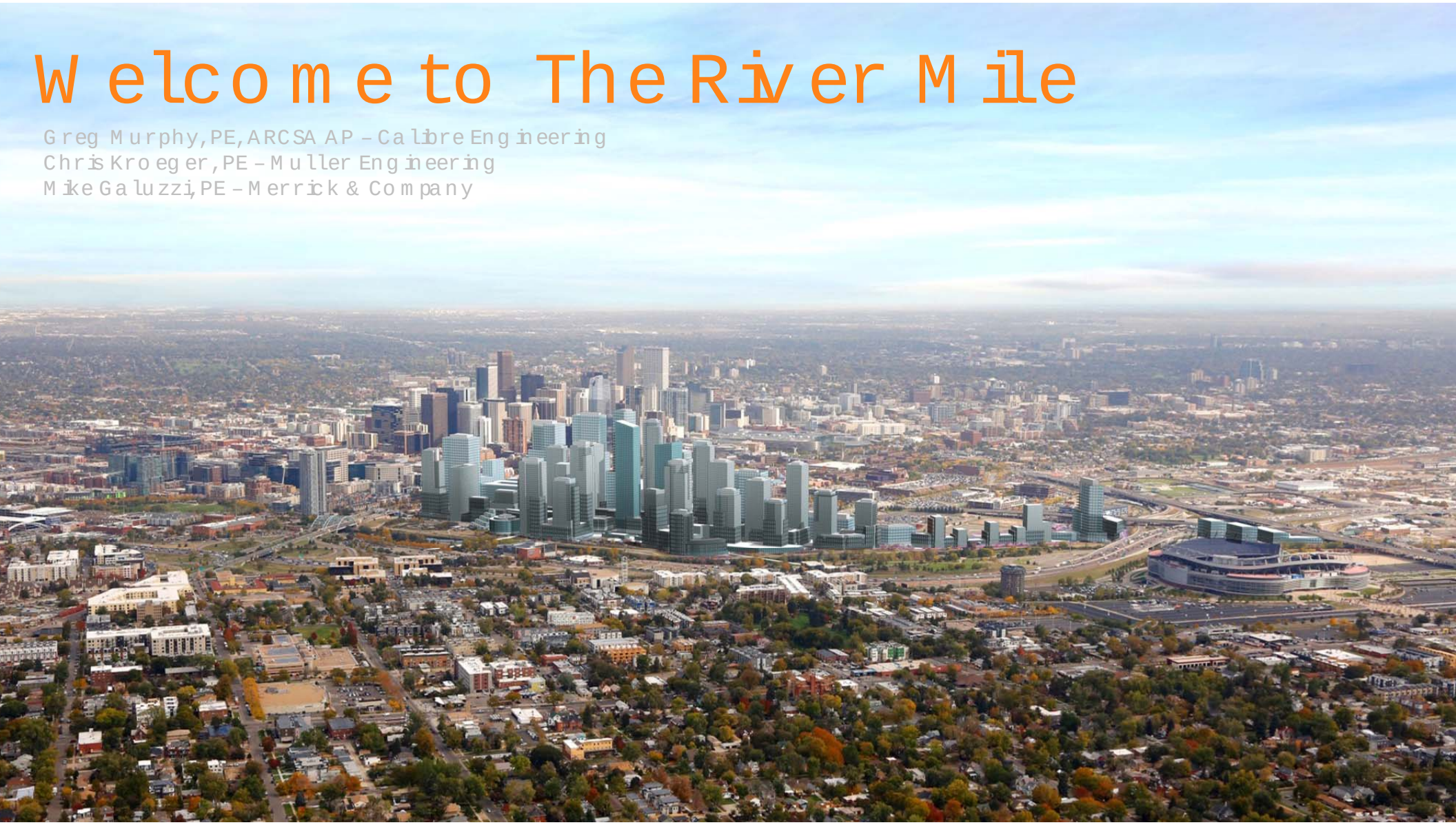
Chris Carlson, Andrew Earles, Kevin Gingery, Kevin Shanks, Brandon Parsons, Shannon Tillack, Julia Traylor, Ellie Garza, & Scott Schreiber (City of Loveland)

Watershed Framework: To Manage Runoff and Create Low Maintenance Stream – Stroh Tributary Case Study

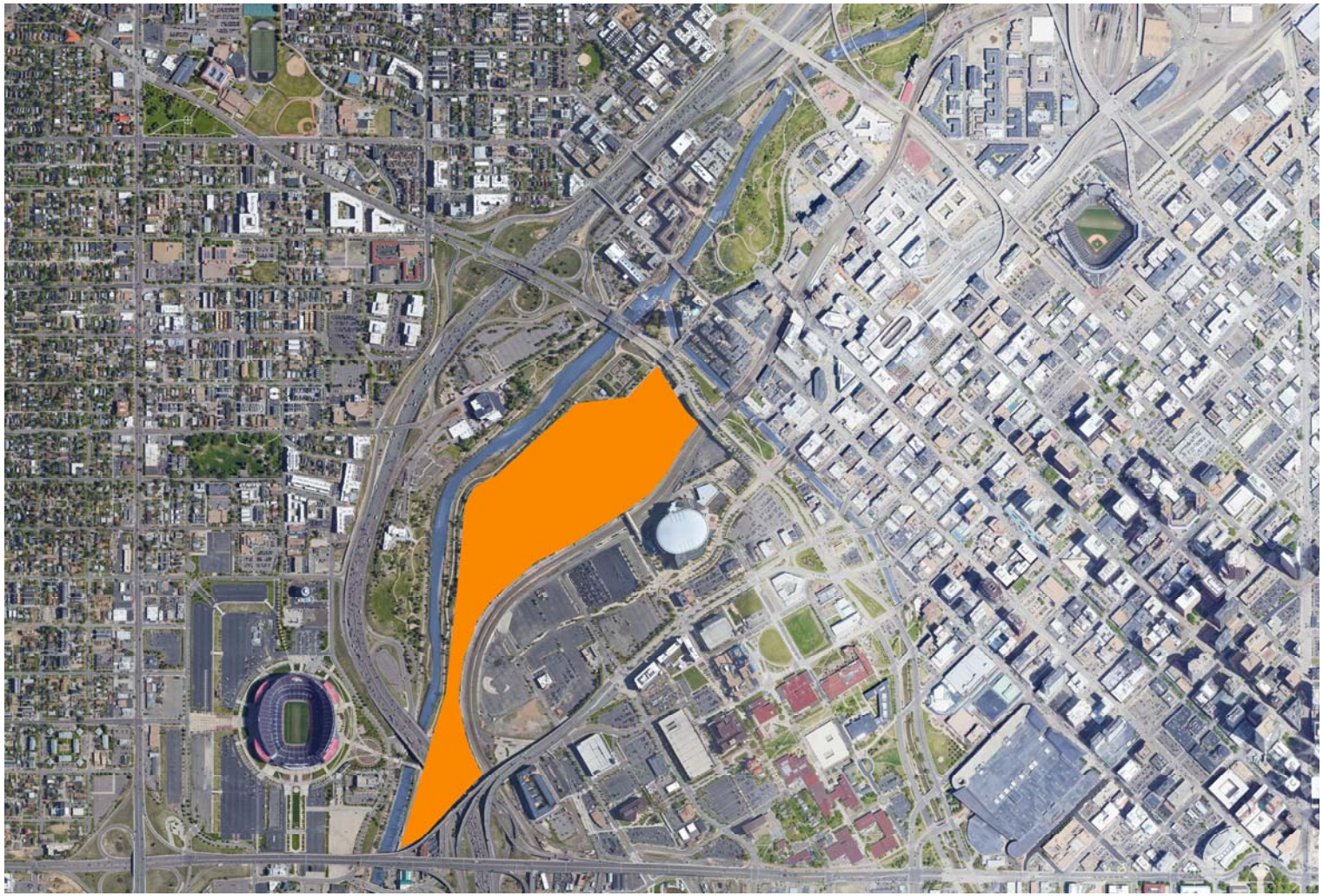
Jacob James (Town of Parker), Barb Chongtoua (UDFCD), Jim Wulliman, Sara Johnson, Katy Shaneyfelt, & Sam Rogers (Muller Engineering Company), Andrew Earles & Brik Zivkovich (Wright Water Engineers)

Welcome to The River Mile

Greg Murphy, PE, ARCSA AP – Calibre Engineering
Chris Kroeger, PE – Muller Engineering
Mike Galuzzi, PE – Merrick & Company

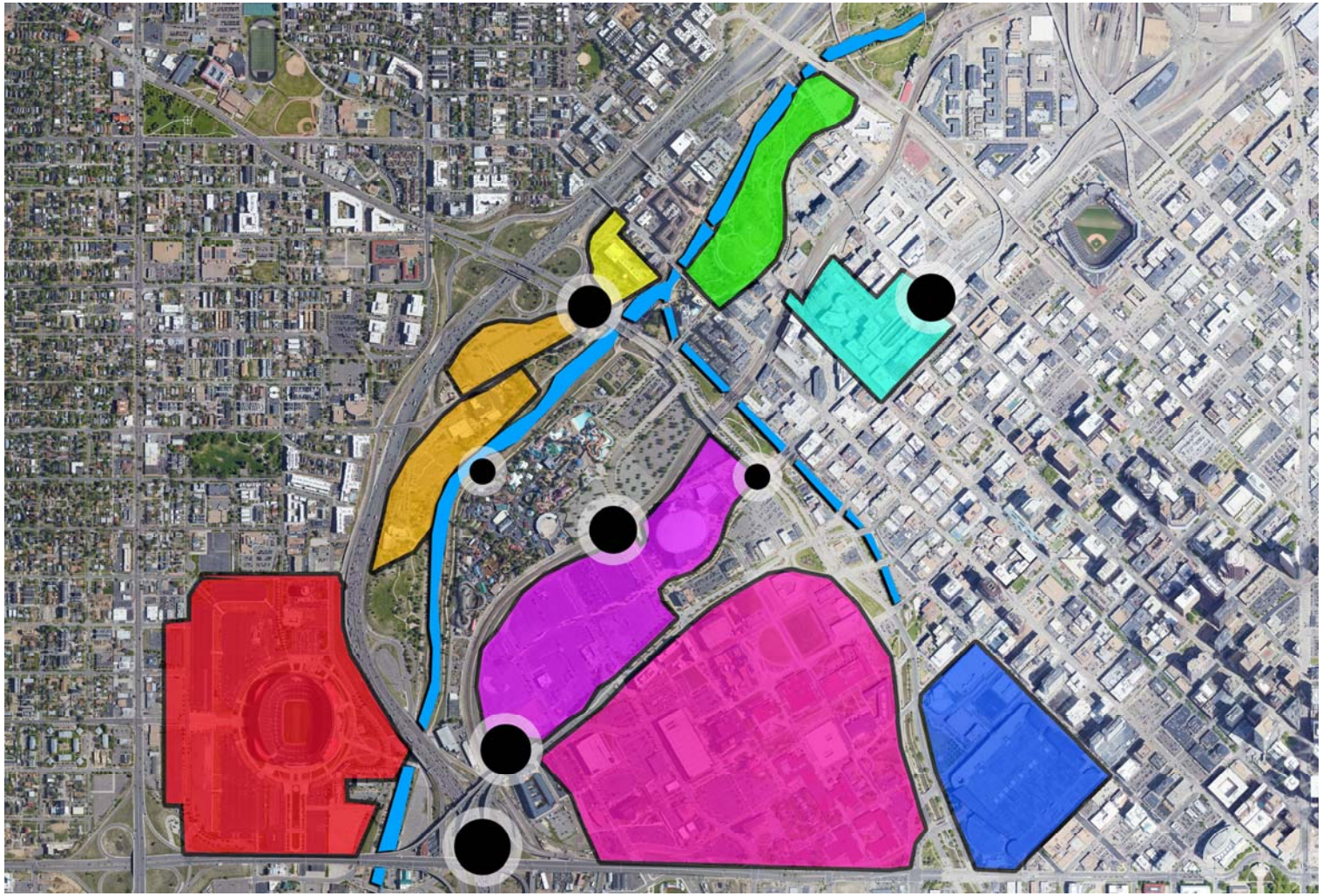


Welcome to The River Mile



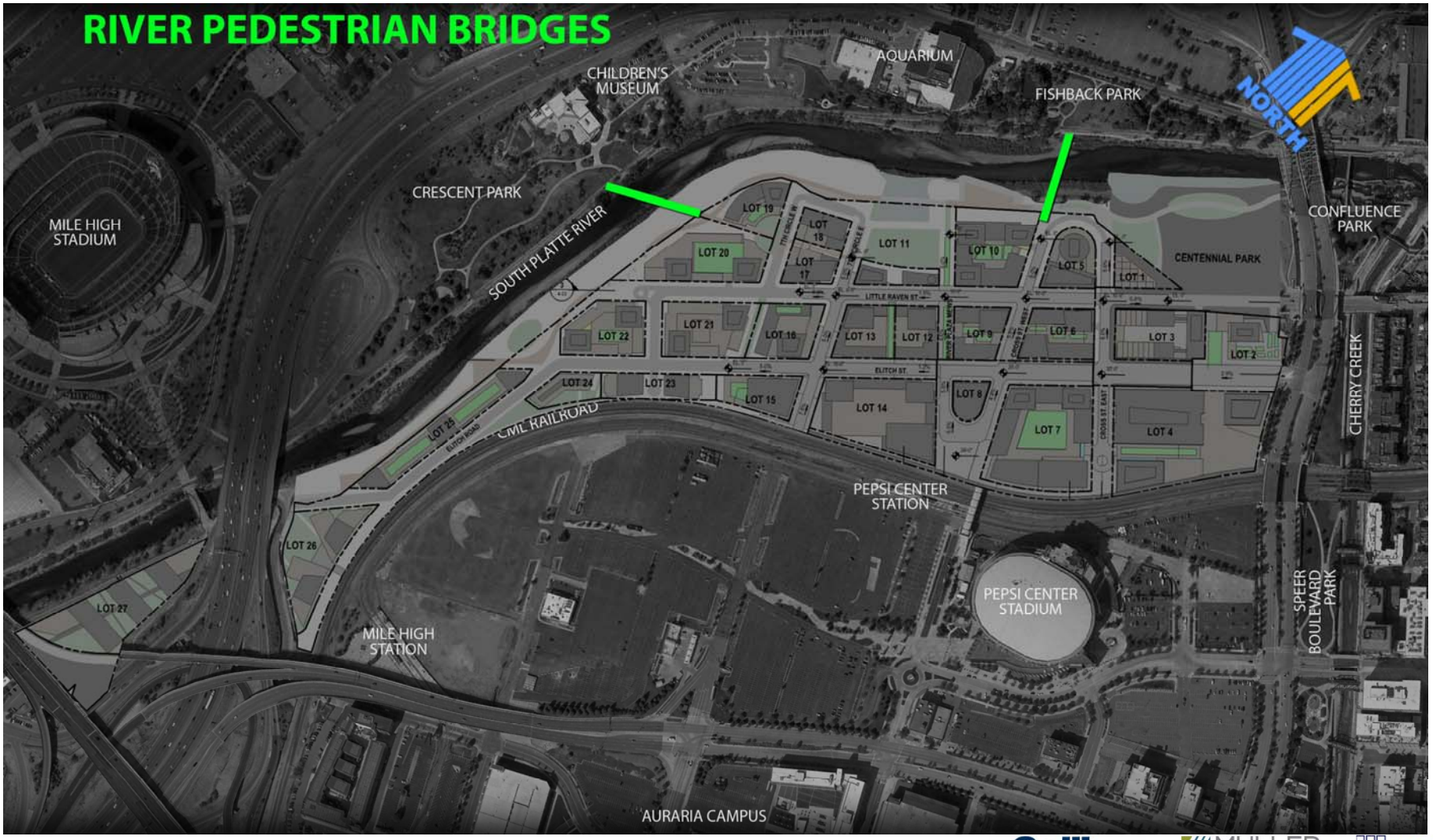
Calibre MULLER ENGINEERING COMPANY MERRICK®

Welcome to The River Mile



Calibre MULLER ENGINEERING COMPANY MERRICK®

Welcome to The River Mile

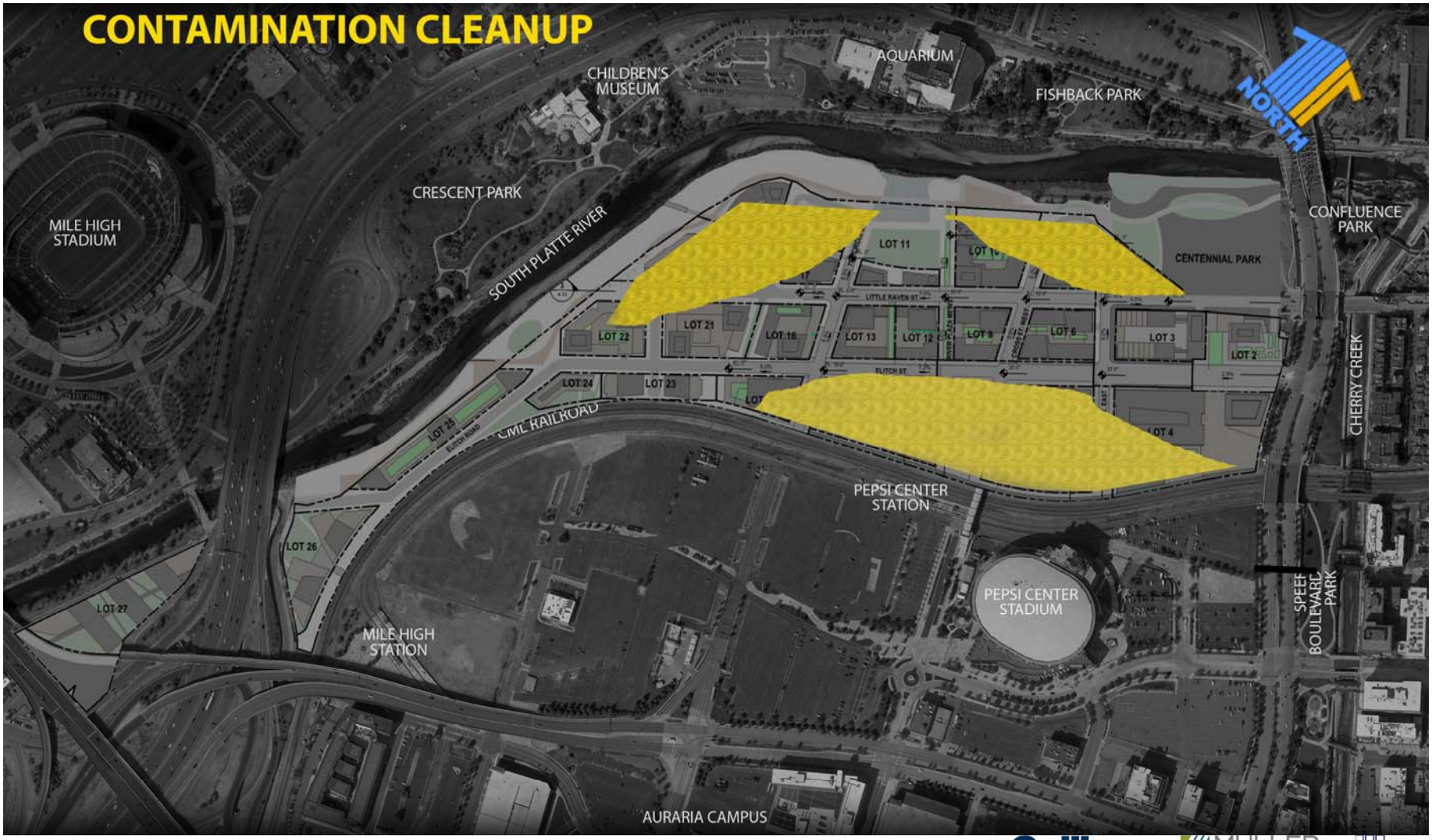


Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

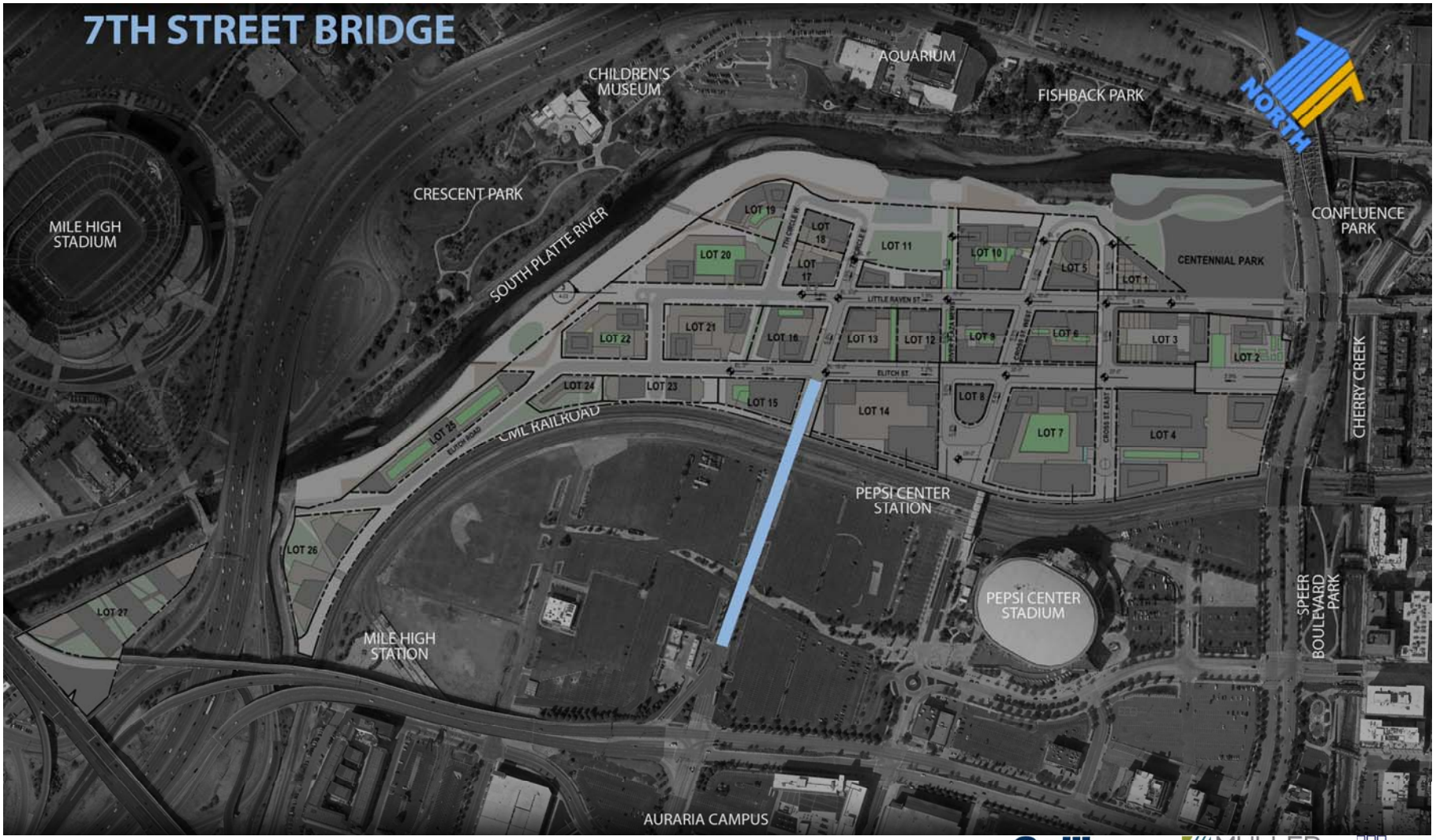
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



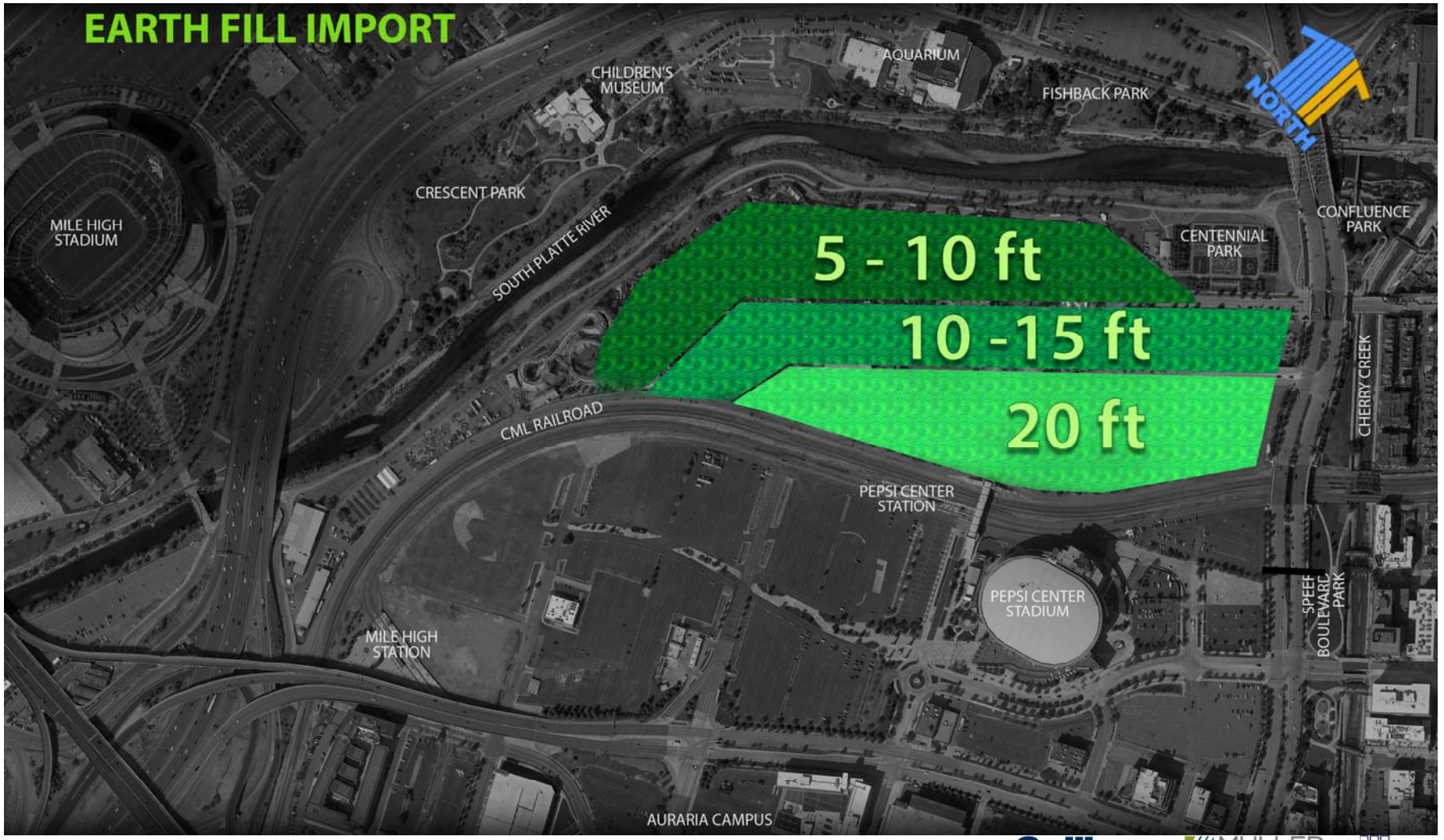
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

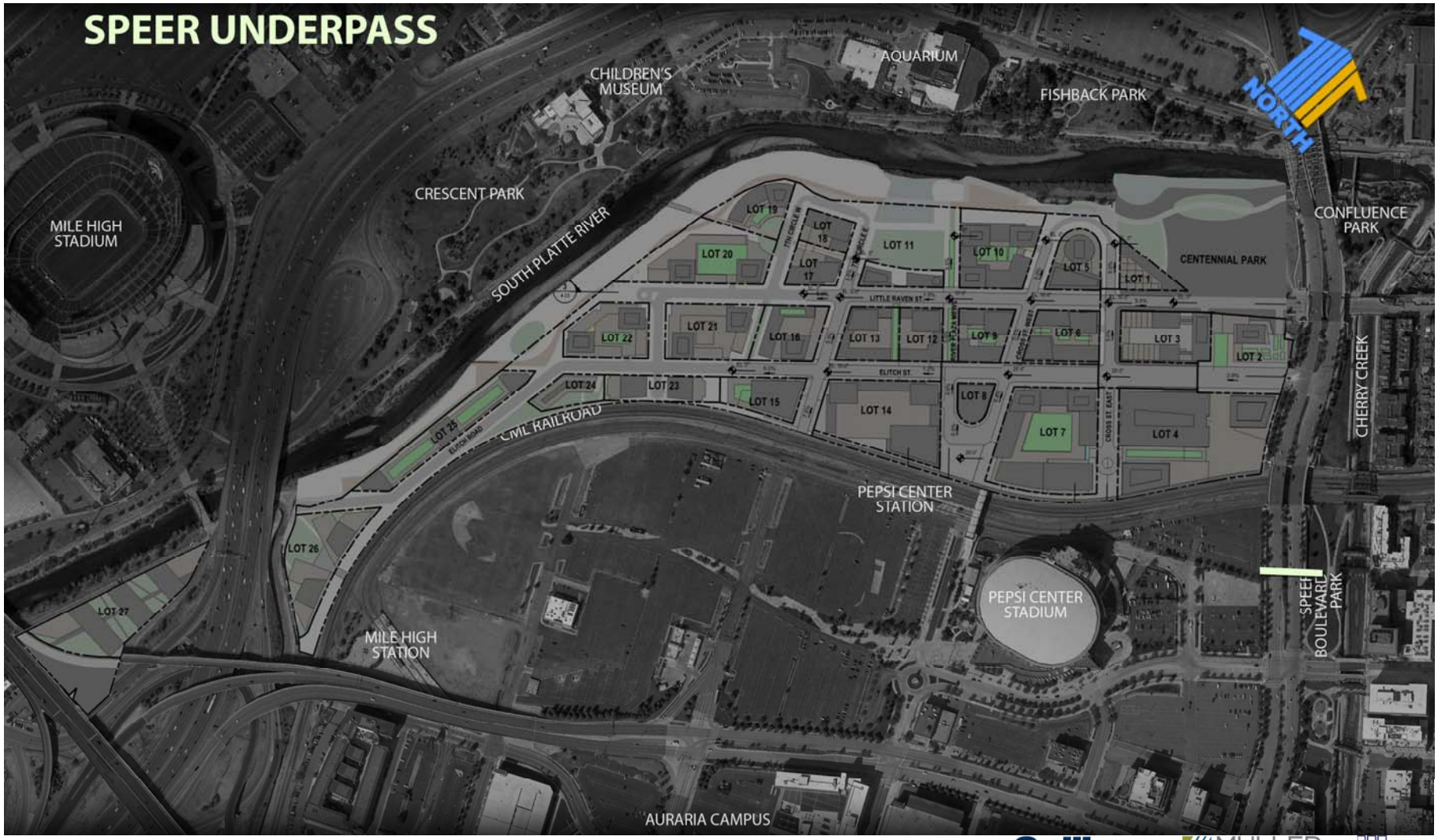


Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

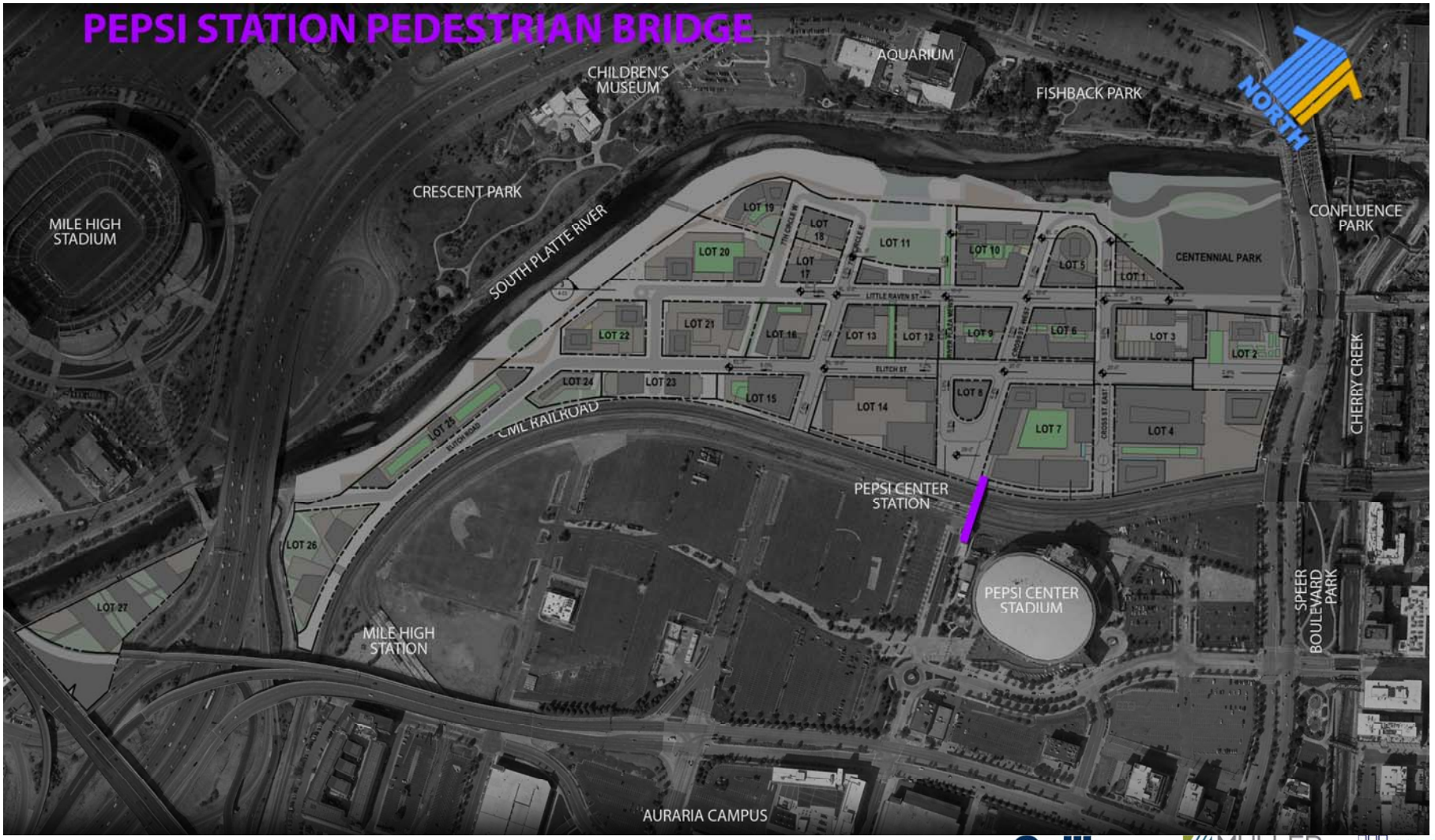
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



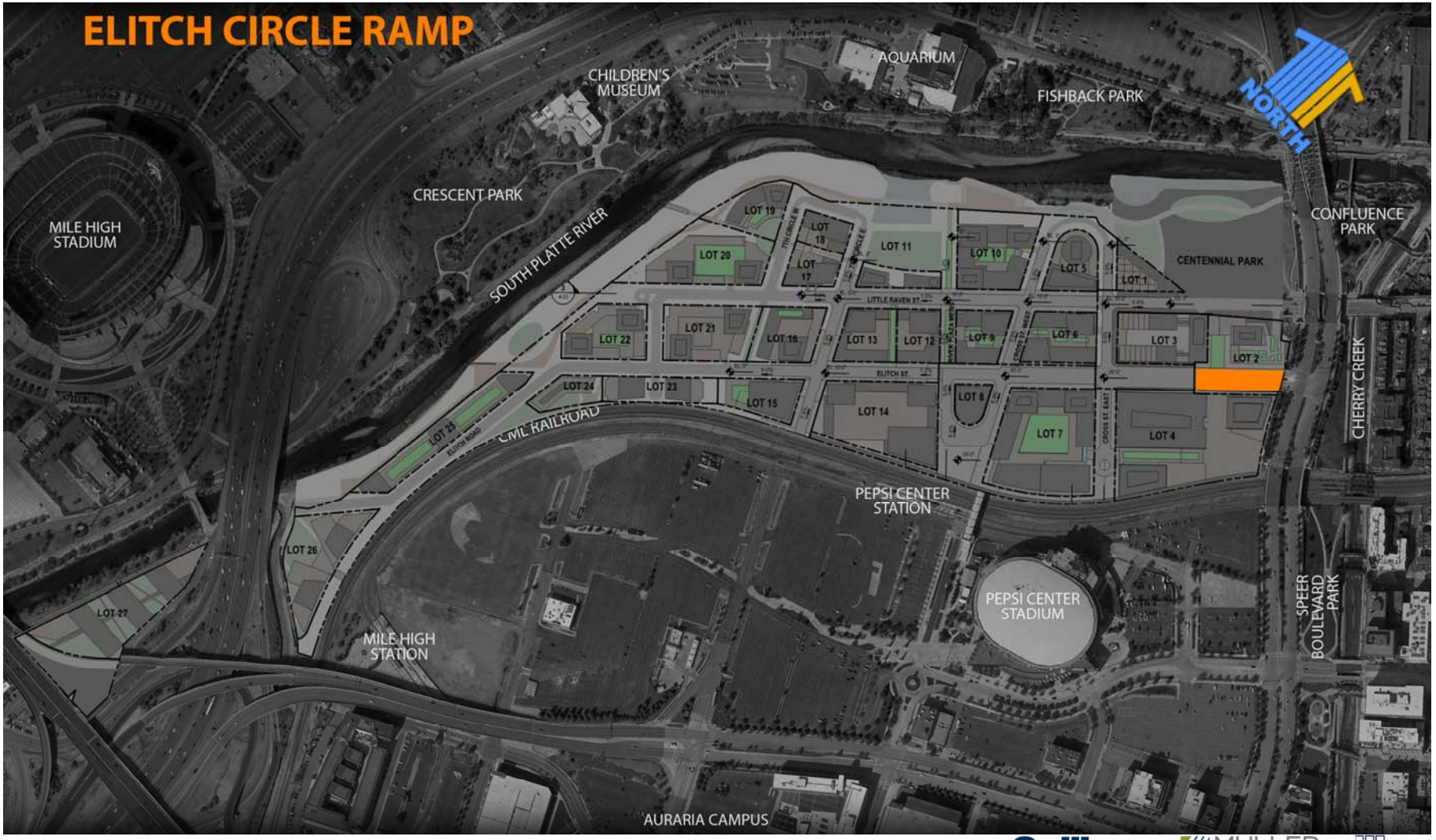
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

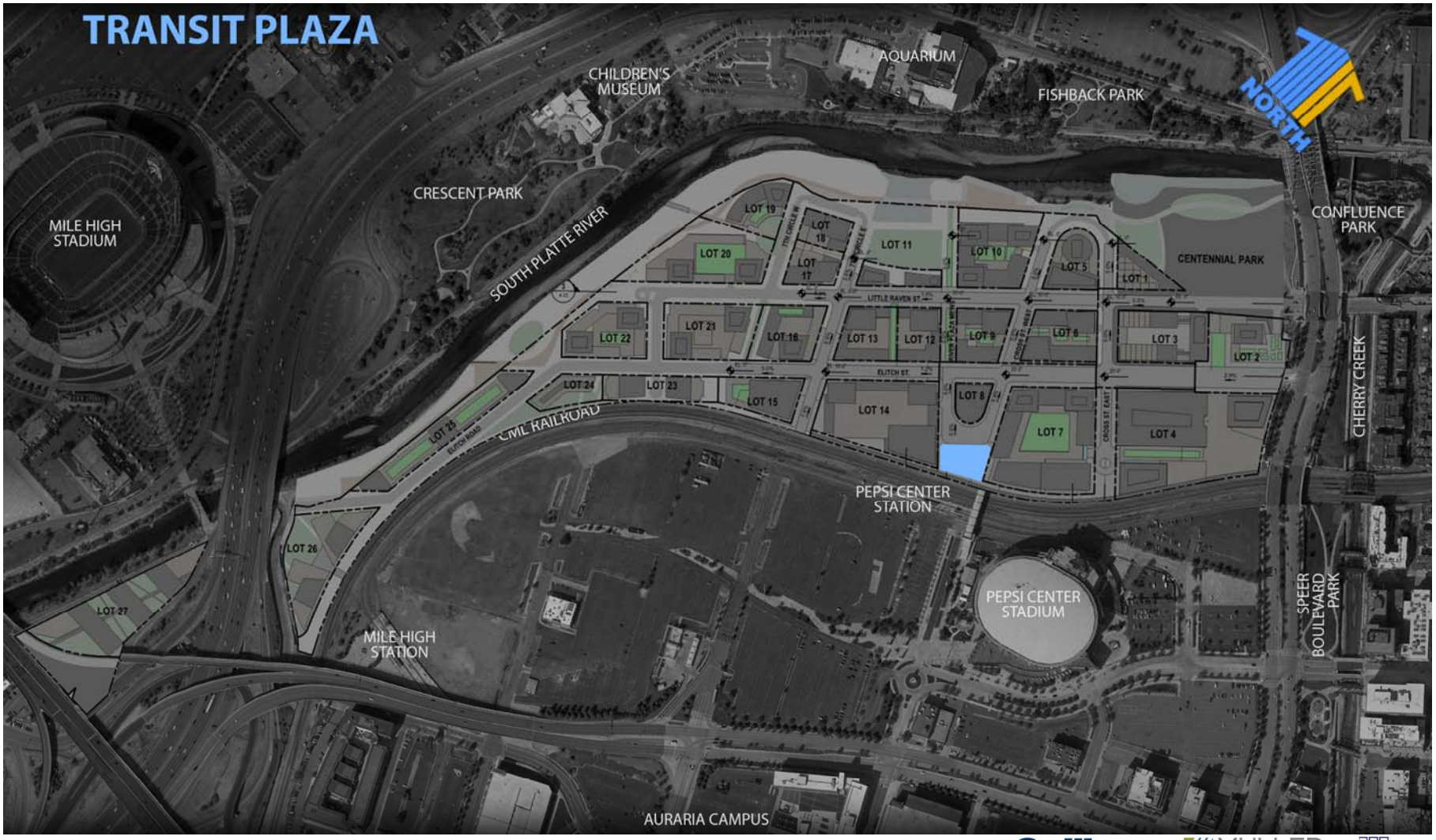


Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

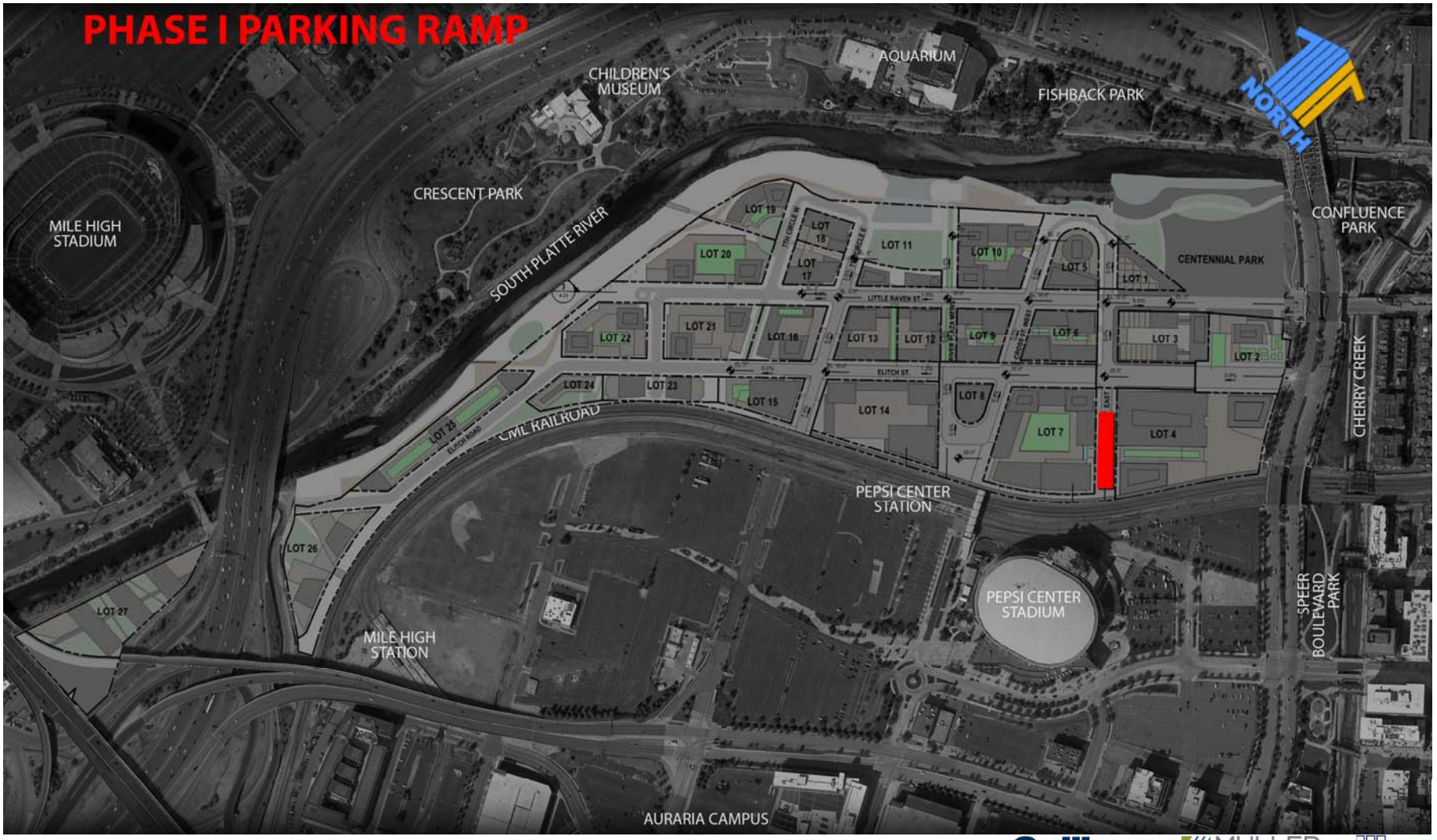
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



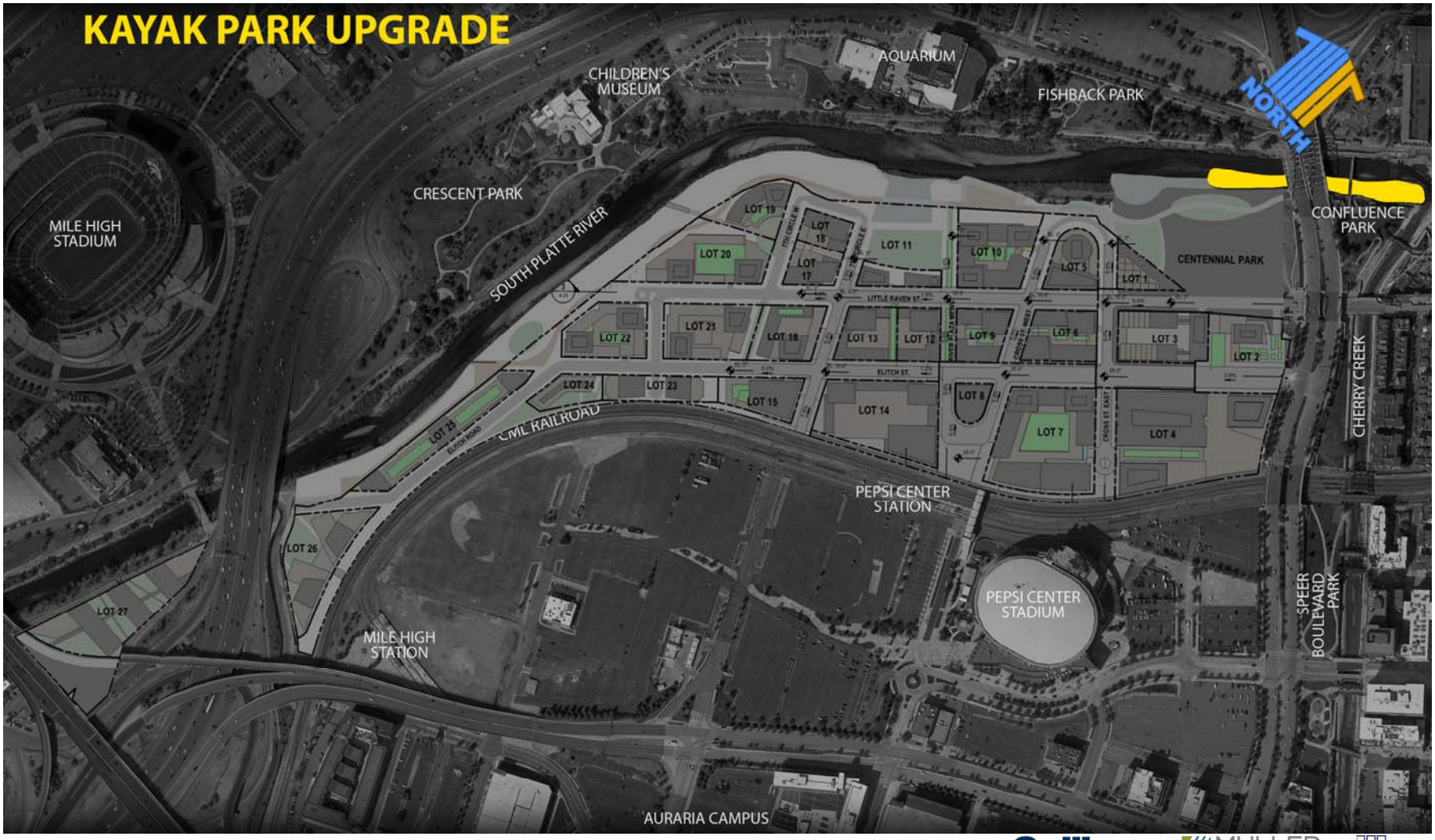
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



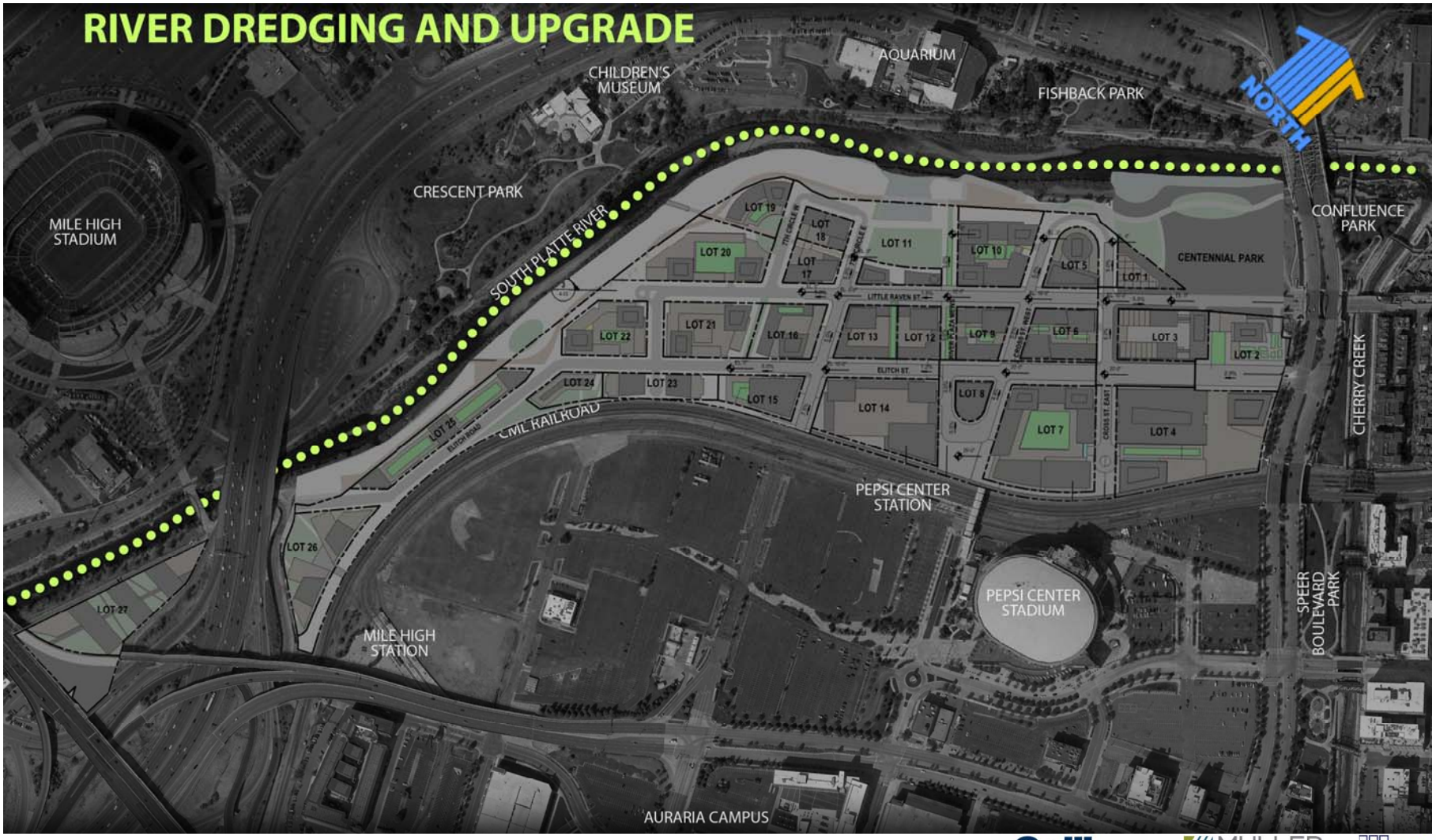
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



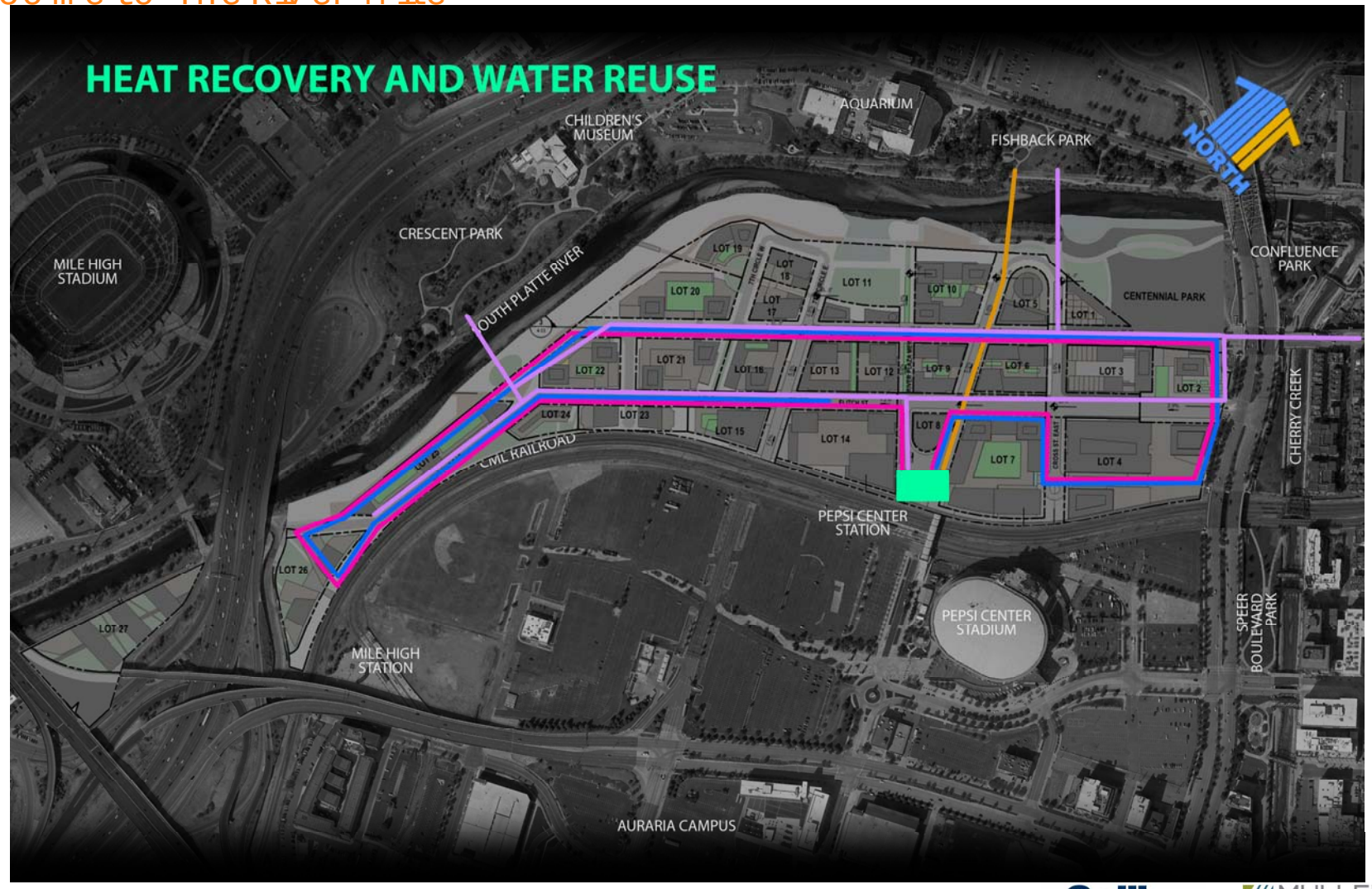
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



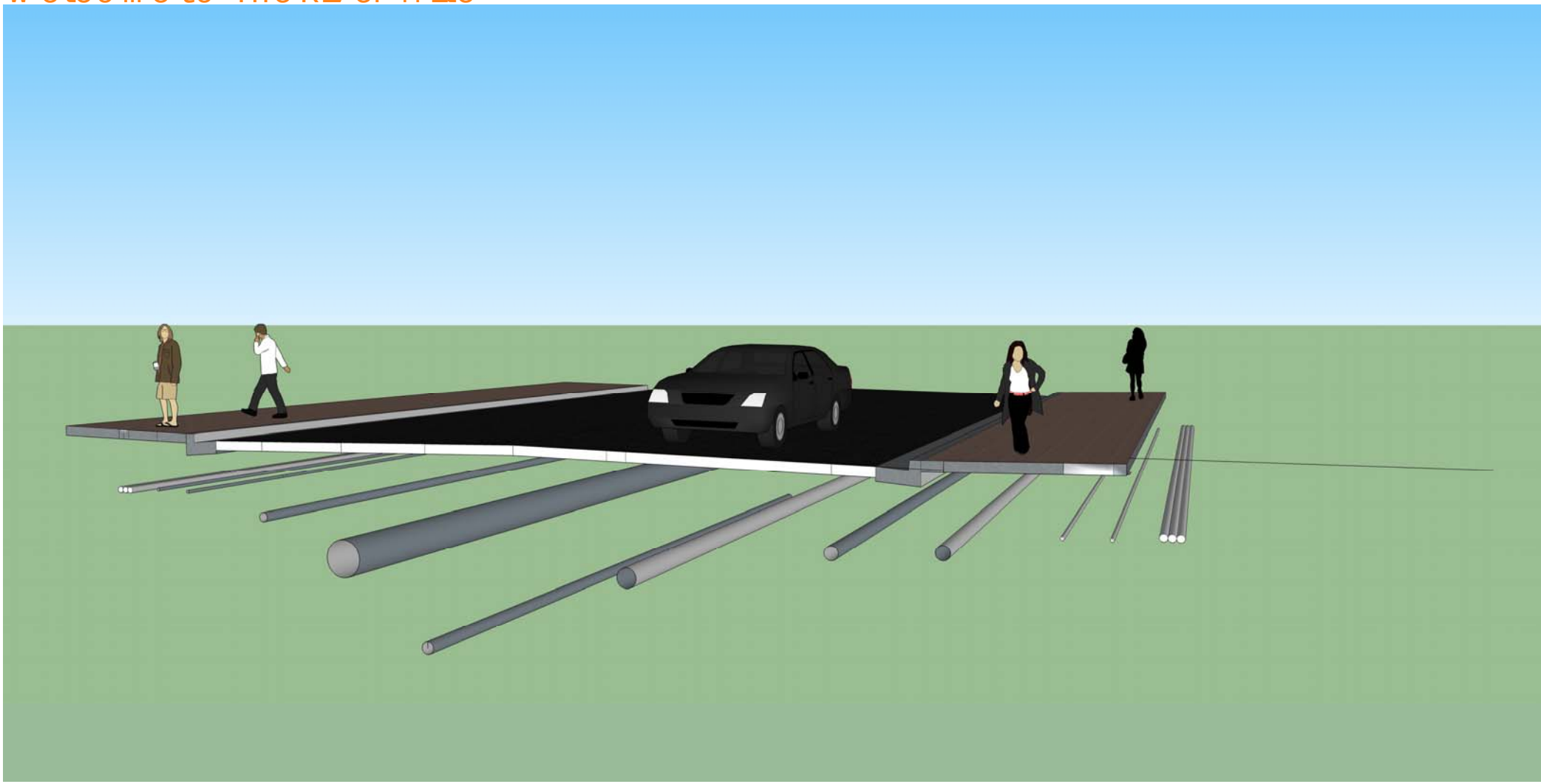
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



Calibre MULLER ENGINEERING COMPANY MERRICK®

Welcome to The River Mile

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

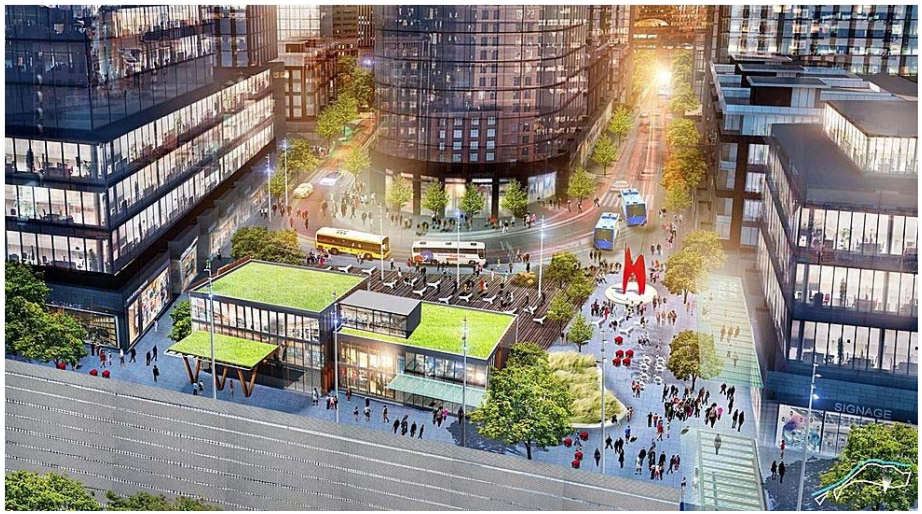
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

The story of this new urban district will be written around the rediscovery and revitalization of the South Platte. And the transformation of this stretch of the river into a mile-long social catalyst. The plan for this new urban district will unlock the waterfront as no other place in Denver does. Homes, restaurants, retail and entertainment offerings will open up to the river.



It will be one of the City's great places –

rivermiledenver.com

Calibre MULLER ENGINEERING COMPANY MERRICK

Resources:

- UDFCD VOL. 3
- City and County of Denver ultra-urban green infrastructure guidelines
- City of Philadelphia green streets design manual
- District-scale green infrastructure scenarios for the Zidell development site, City of Portland

Calibre MULLER ENGINEERING COMPANY MERRICK

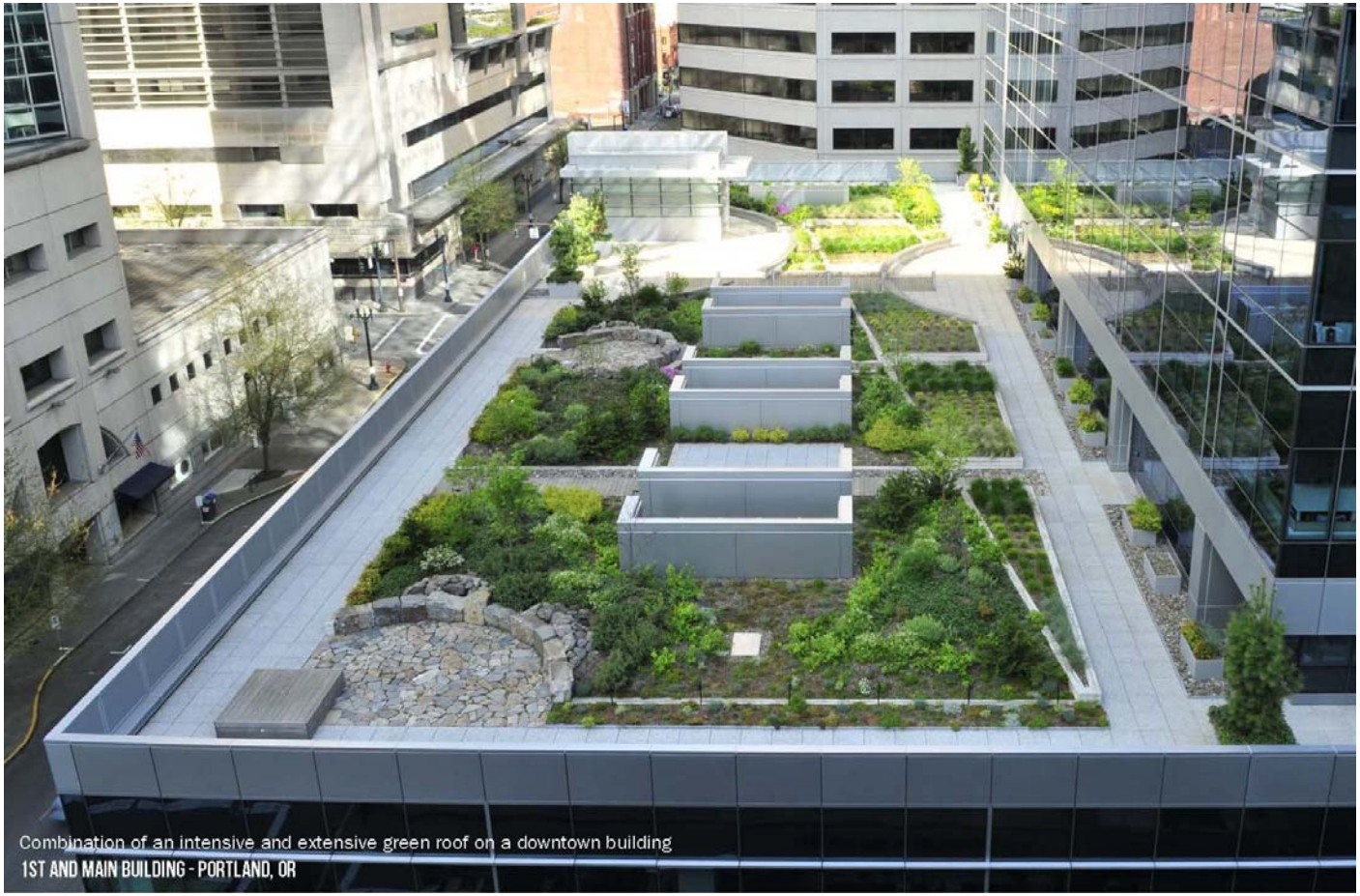
Denver Green Roof Initiative

- Green (includes offsite financial contribution)
- Green + Energy
- Energy
- Certification

Calibre MULLER ENGINEERING COMPANY MERRICK

Green Roofs

Welcome to The River Mile



Beautiful as much as functional

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Social, quality of life, and economic opportunities

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

- image from urban study by United Network Studio

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

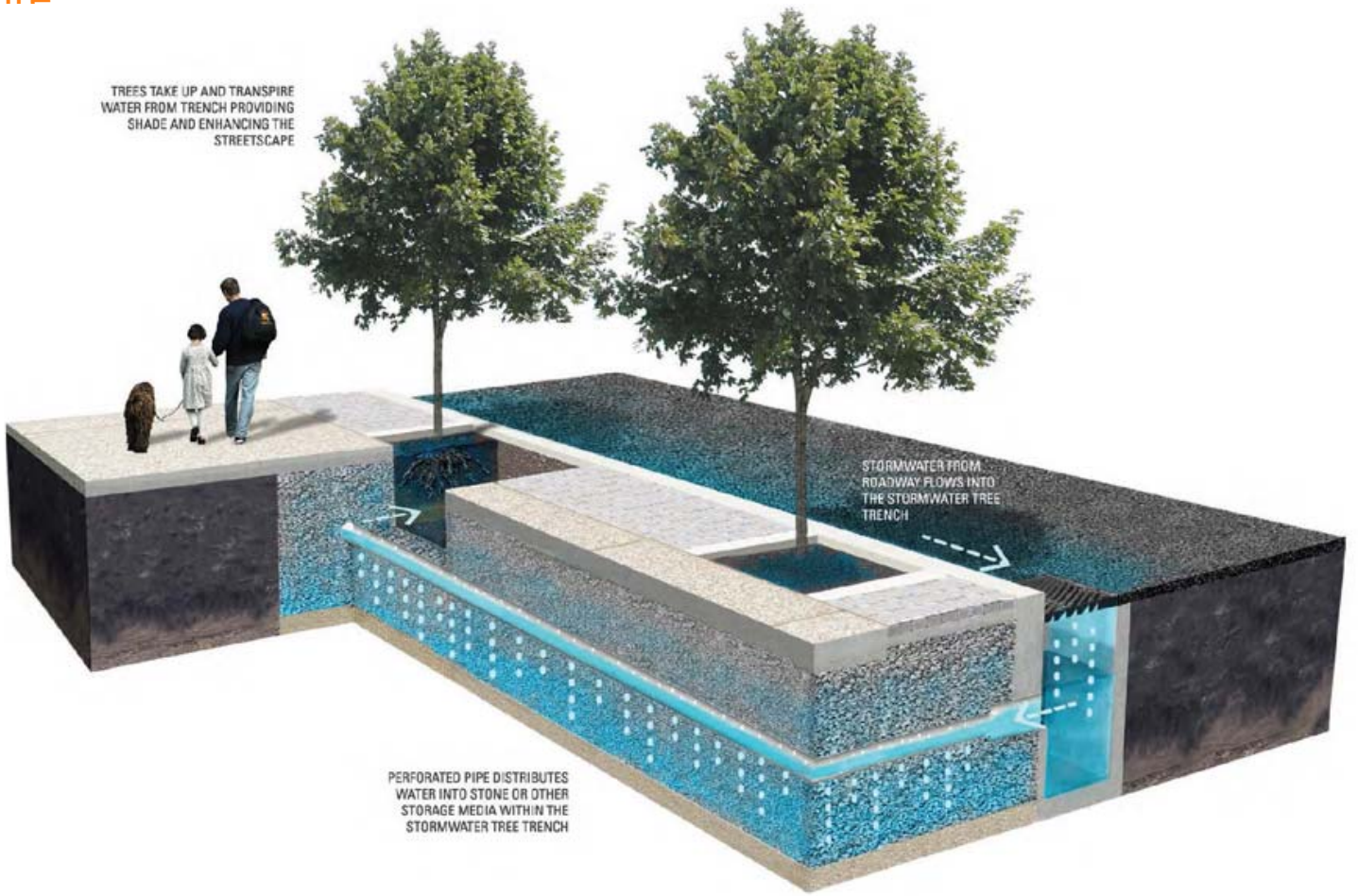
- image from urban study by United Network Studio

Calibre MULLER ENGINEERING COMPANY MERRICK

Back of curb to building face

- Avoid overly dominant components
- Maximize pedestrian space and usability

Welcome to The River Mile

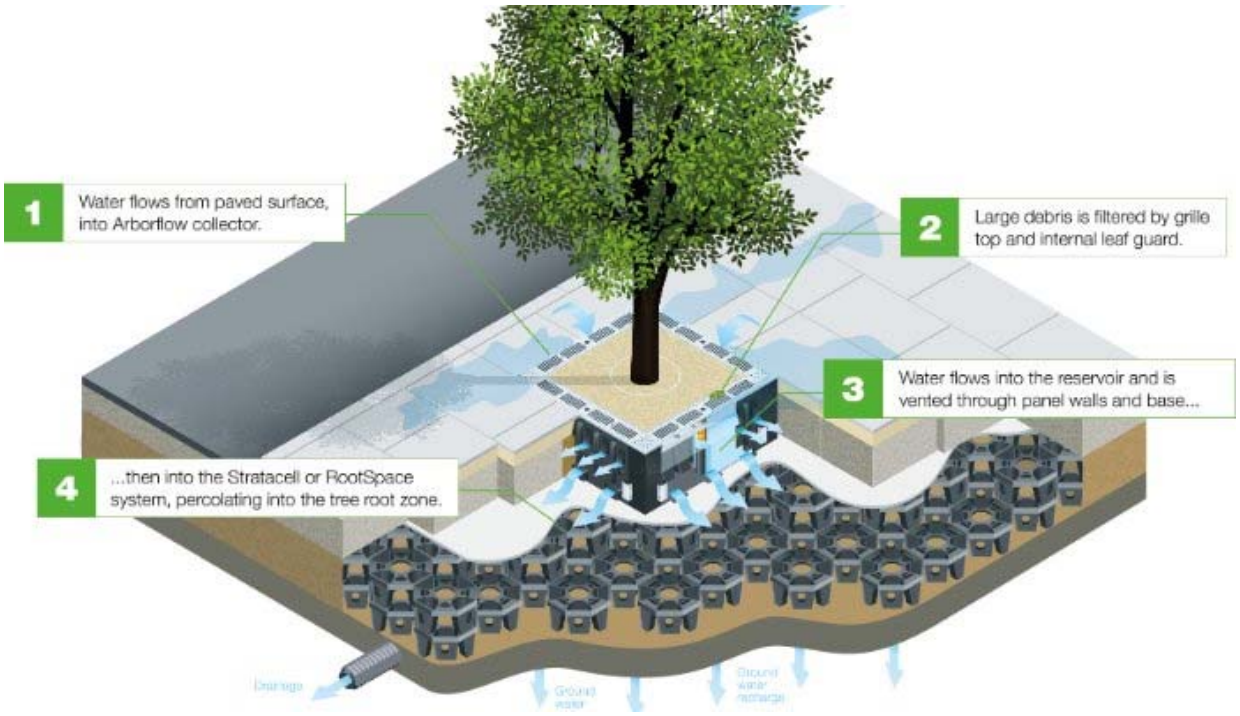


Underground Treatment

Calibre MULLER ENGINEERING COMPANY MERRICK

Underground Treatment

- Better multi-function use of Right of way
- Better for tree health
- Low maintenance
- Promotes infiltration
- Better runoff reduction

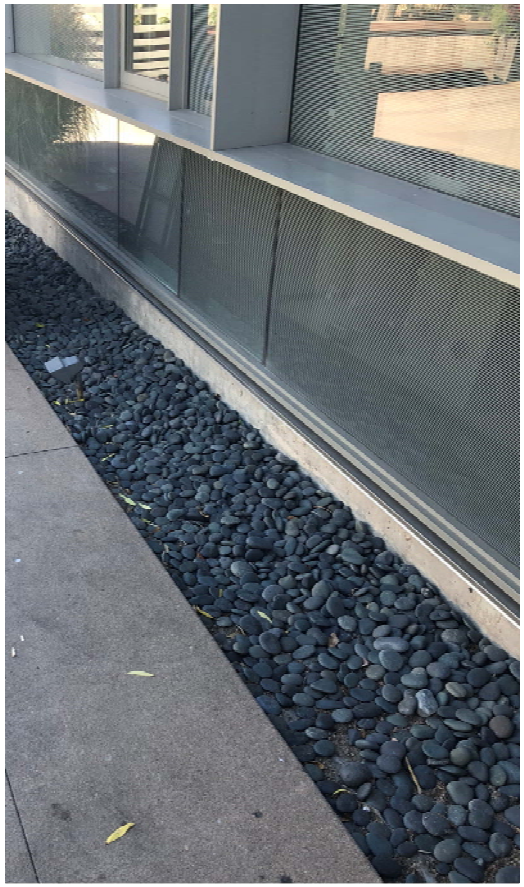


Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Structural Support Systems

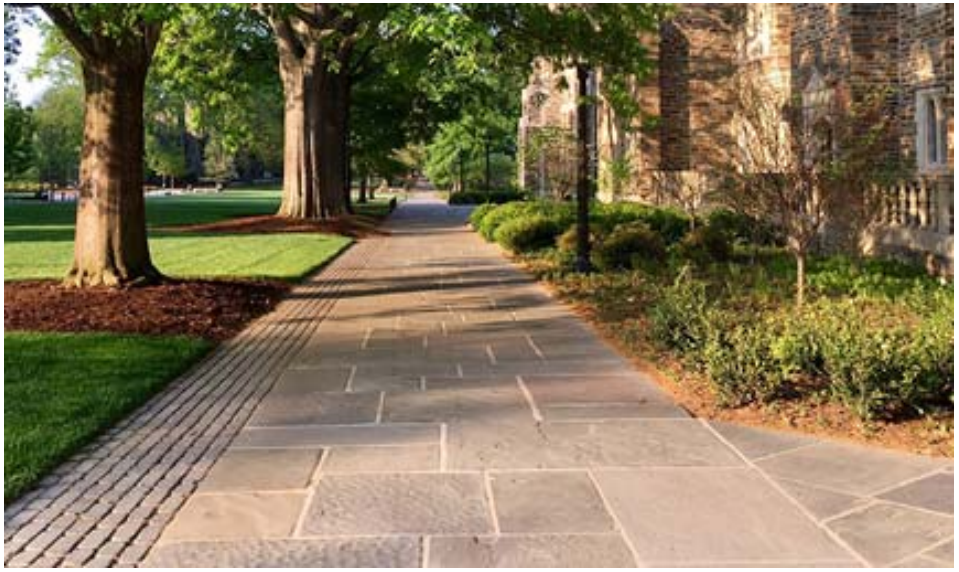
Calibre MULLER ENGINEERING COMPANY MERRICK

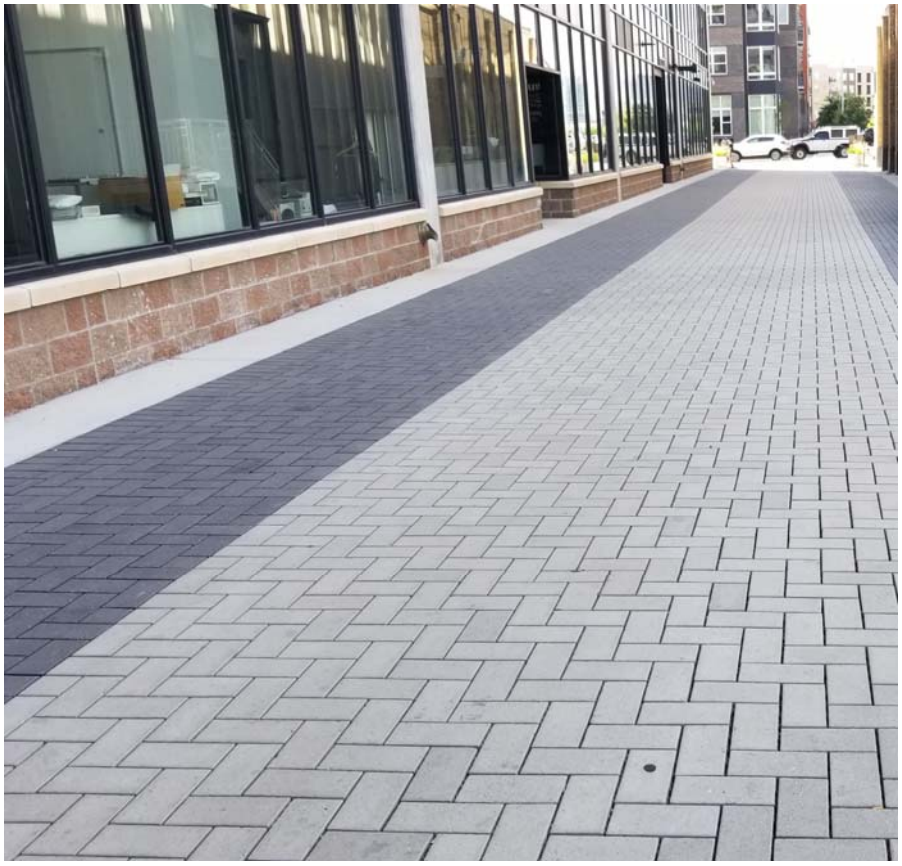


Roof drainage conveyance

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile





Surface treatment options

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

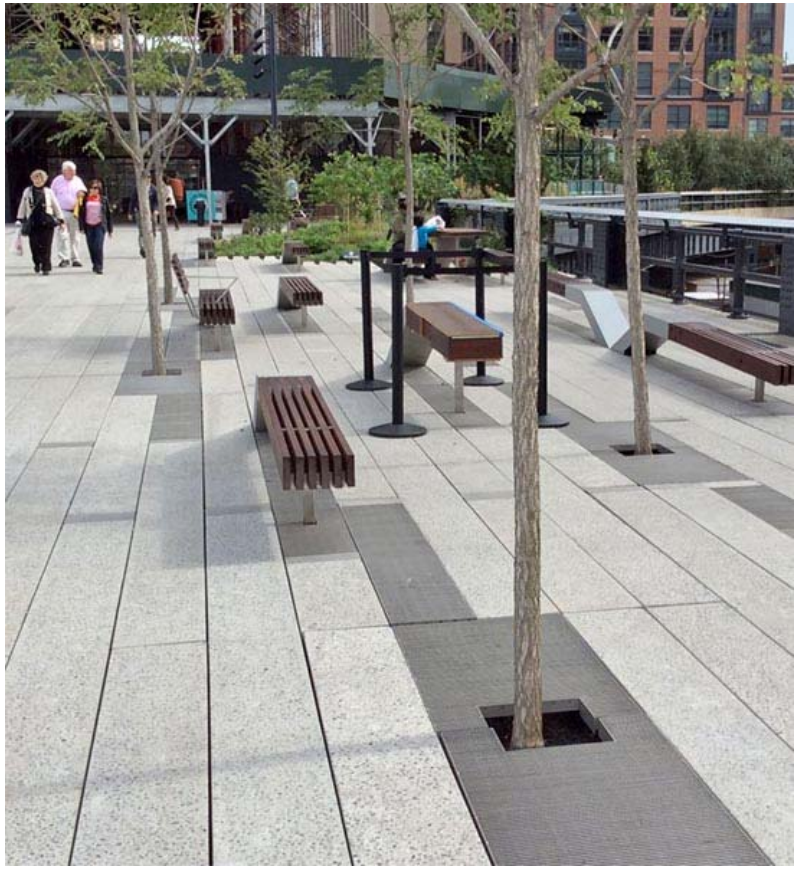
Surface drains to convey stormwater below ground

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Tree Grates

Purposeful, artistic, compatible with mobility goals



Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Are we avoiding planter beds? NO

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Works here.

How about here?

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Provide room for the “Needs”

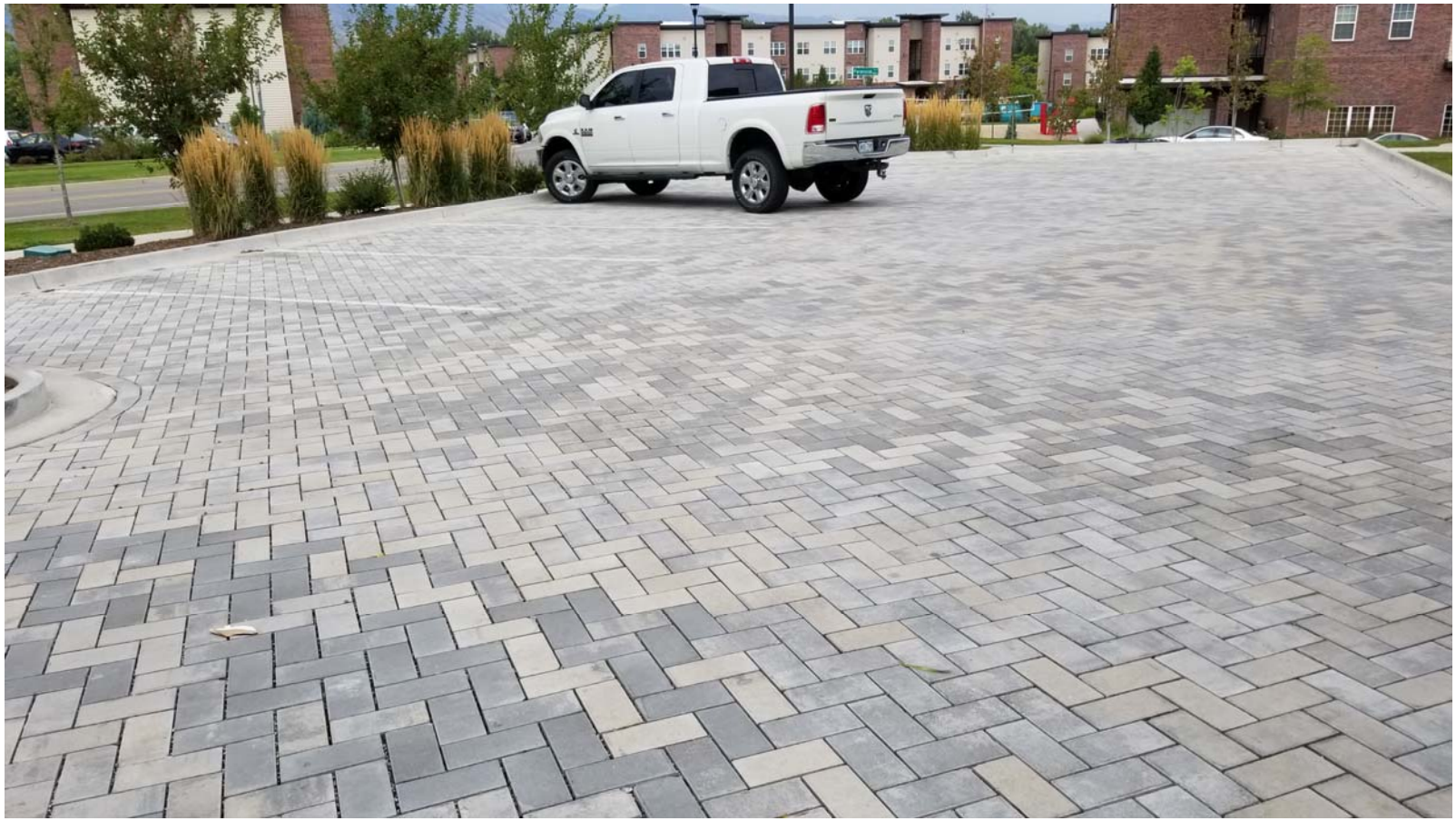
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Can’t forget about the “Wants”

Calibre MULLER ENGINEERING COMPANY MERRICK

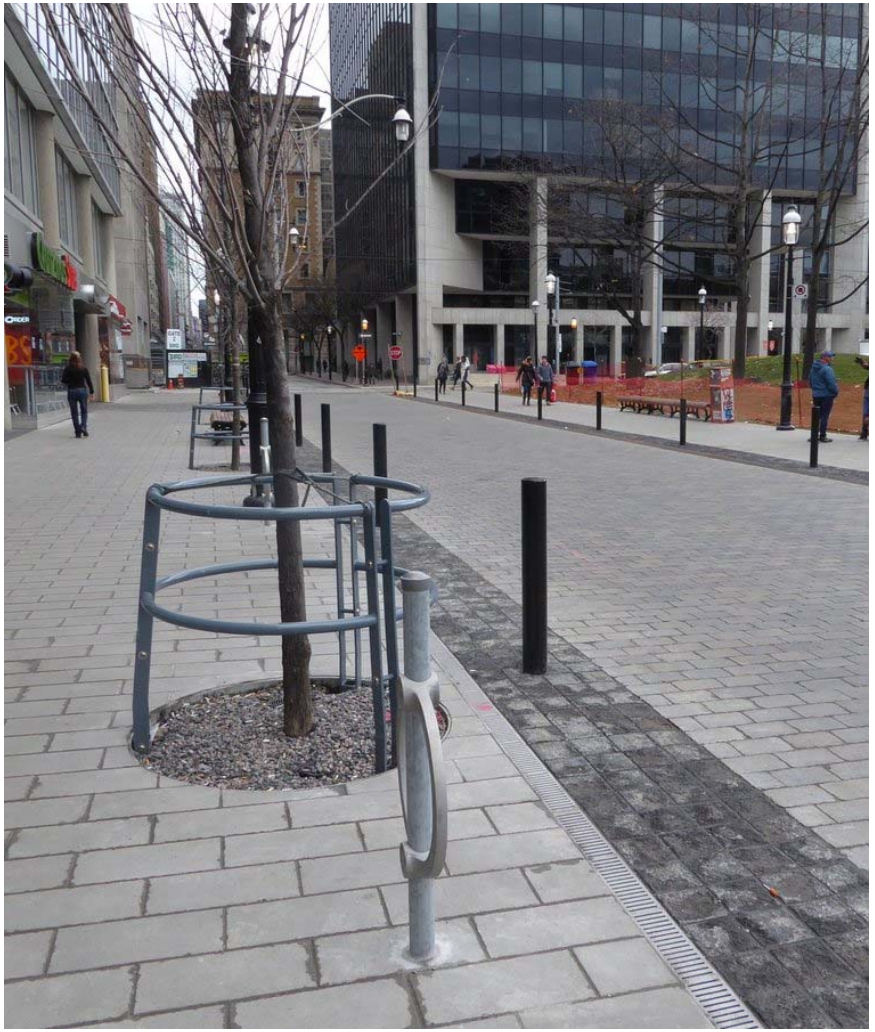
Welcome to The River Mile



Streets

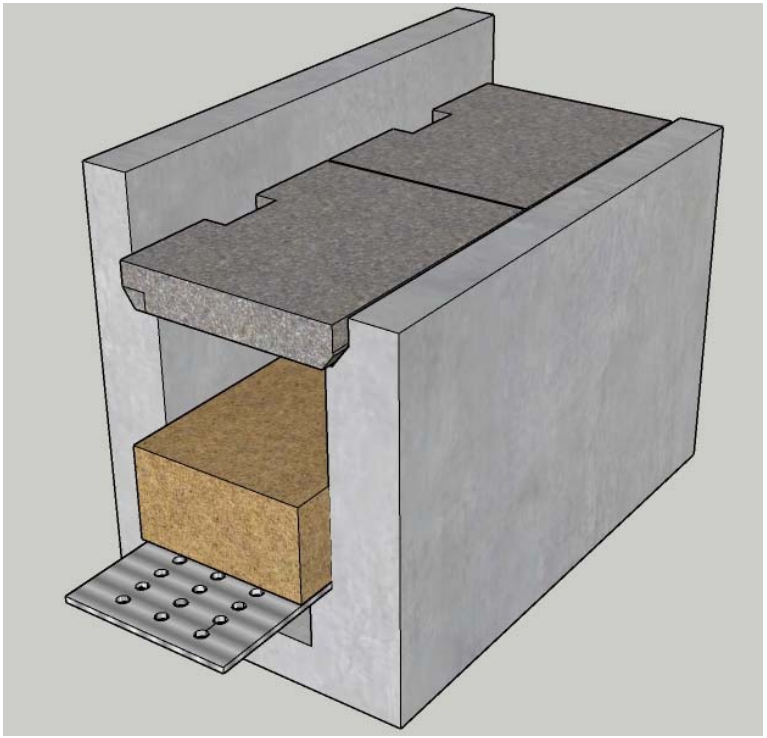
Welcome to The River Mile

Curbless?



Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



Inlet Options

Welcome to The River Mile

Inlet Options

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

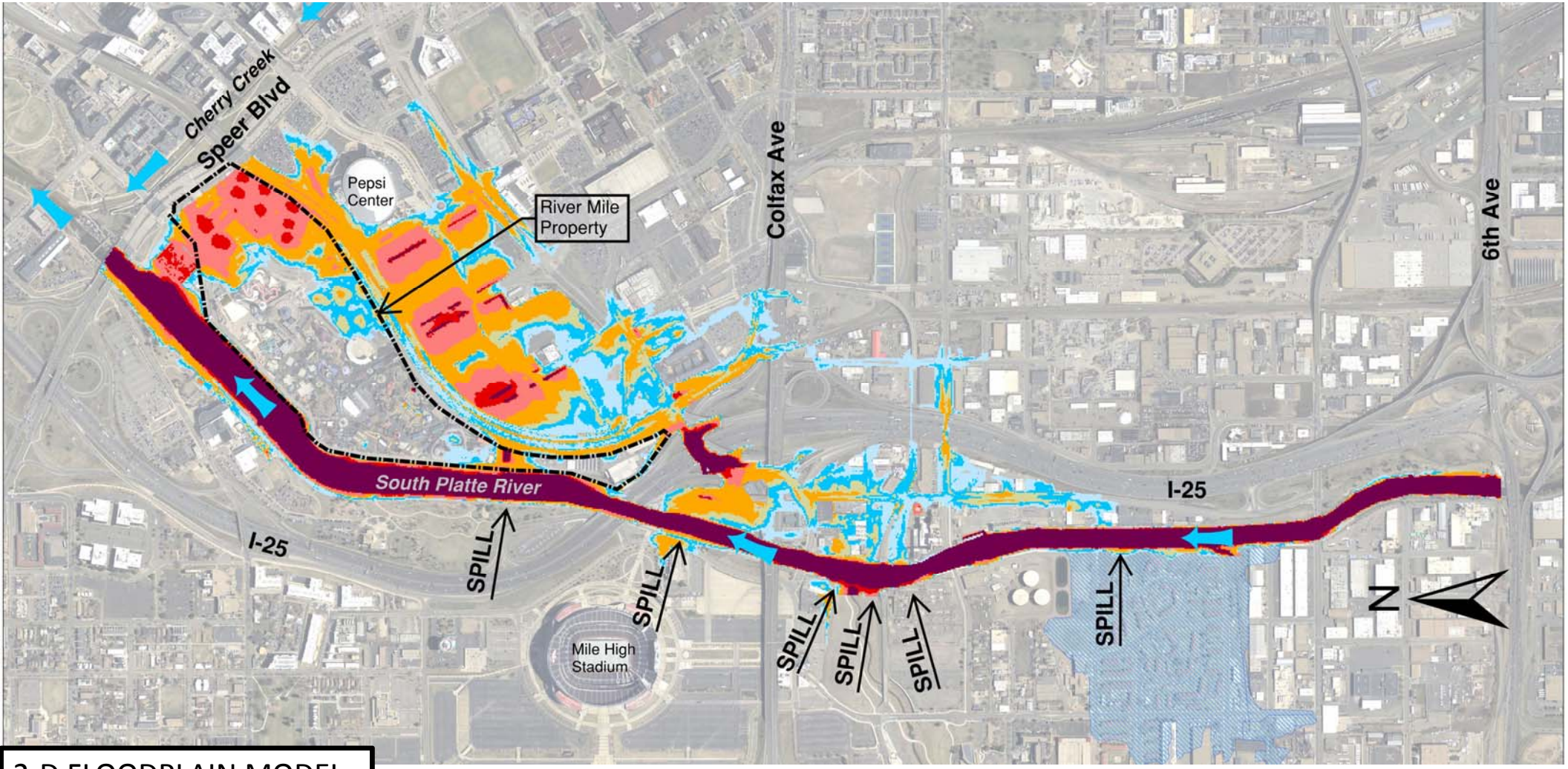
Plazas

Plazas

- Sunken water quality treatment

Calibre MULLER ENGINEERING COMPANY MERRICK

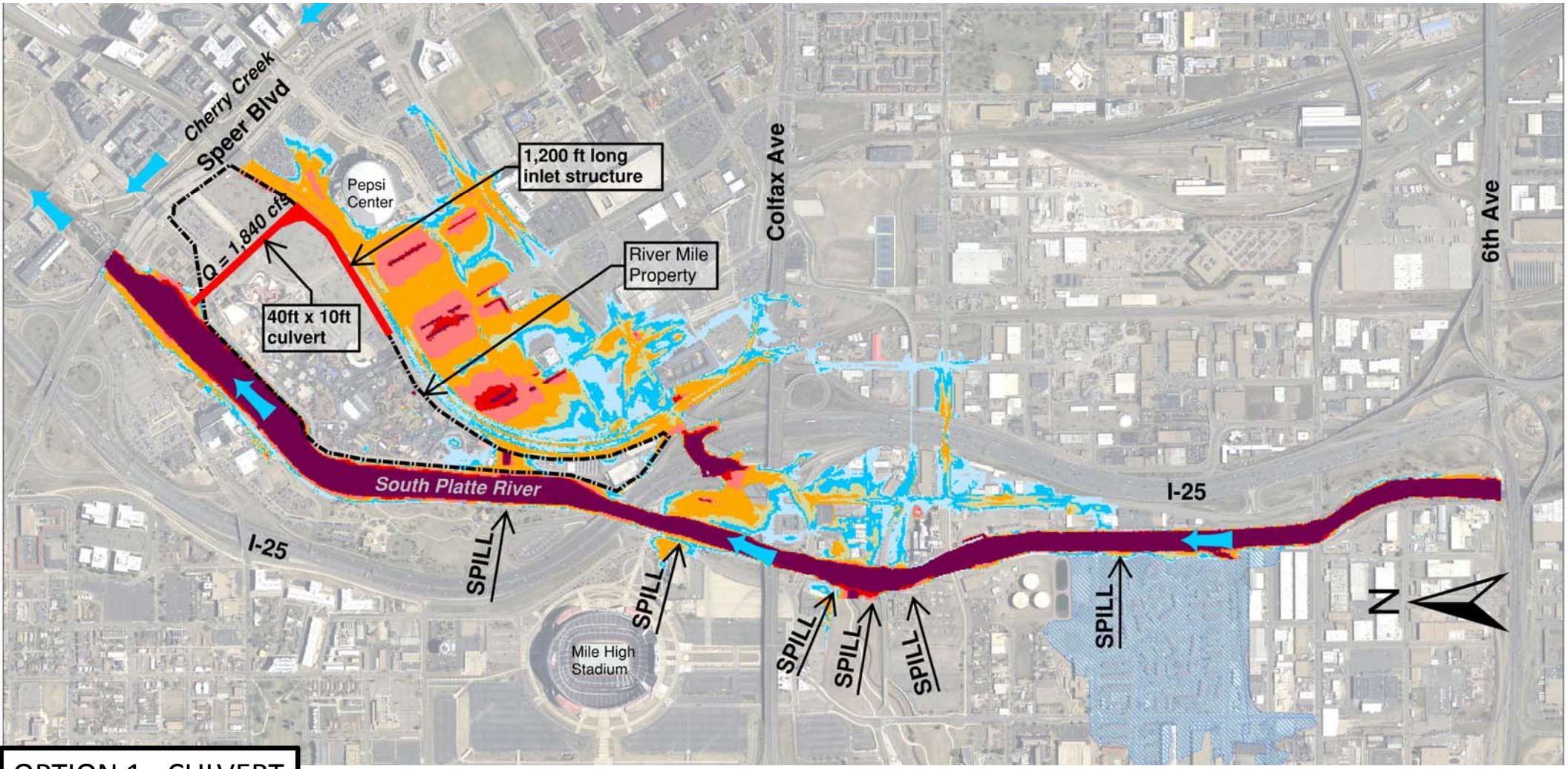
Welcome to The River Mile



2-D FLOODPLAIN MODEL

Calibre MULLER ENGINEERING COMPANY MERRICK

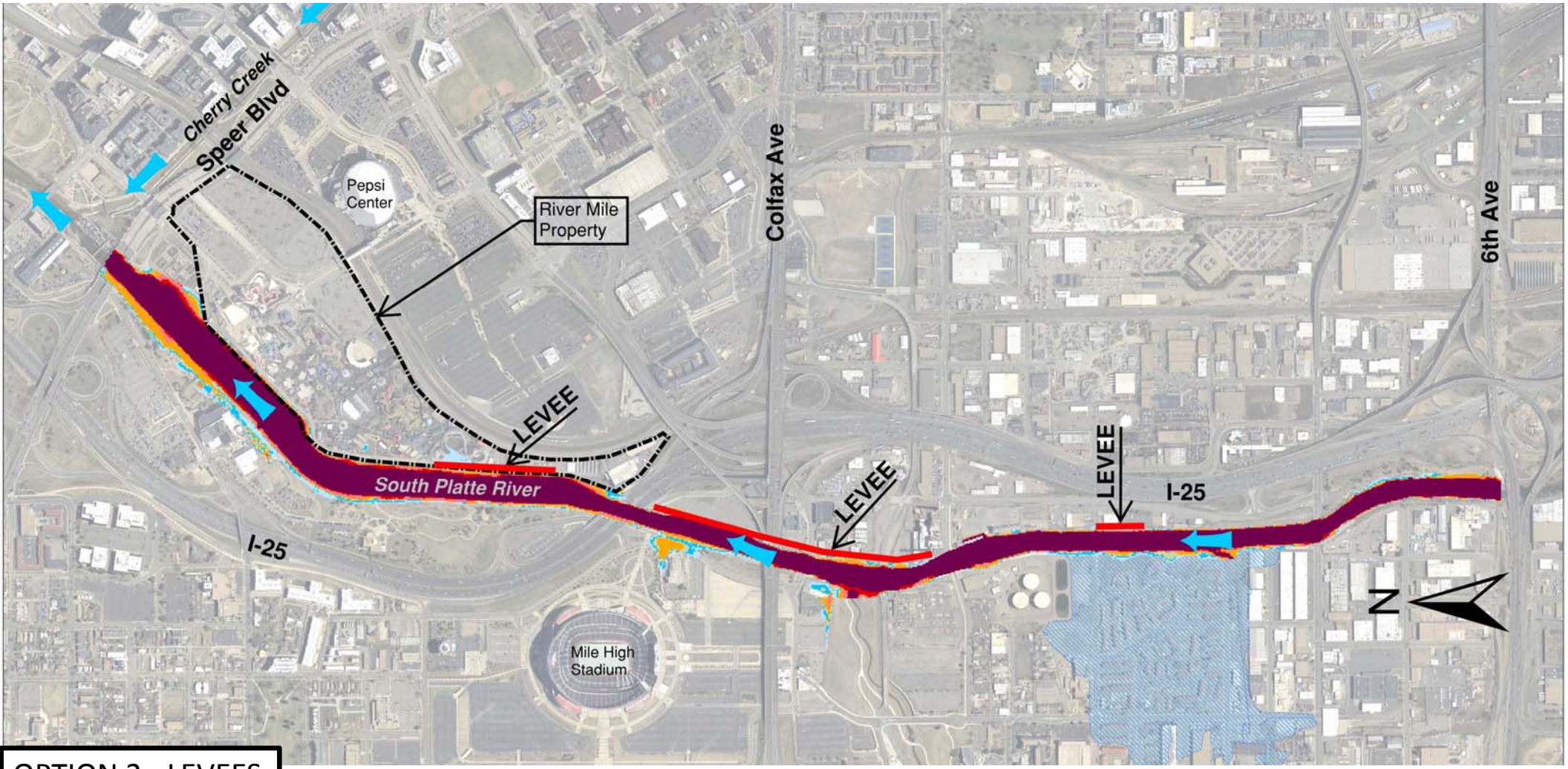
Welcome to The River Mile



OPTION 1 - CULVERT

Calibre MULLER ENGINEERING COMPANY MERRICK

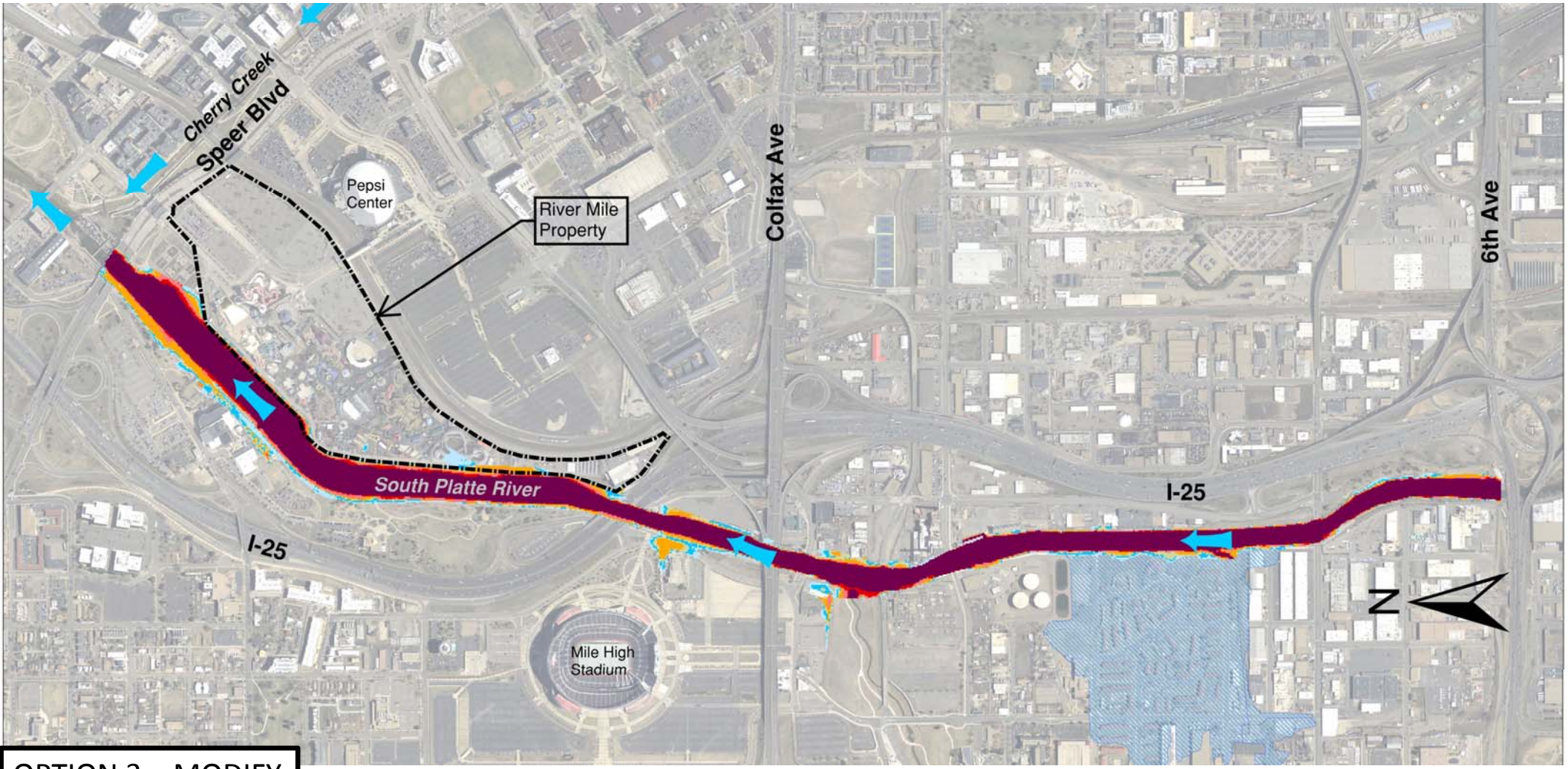
Welcome to The River Mile



OPTION 2 - LEVEES

Calibre MULLER ENGINEERING COMPANY MERRICK

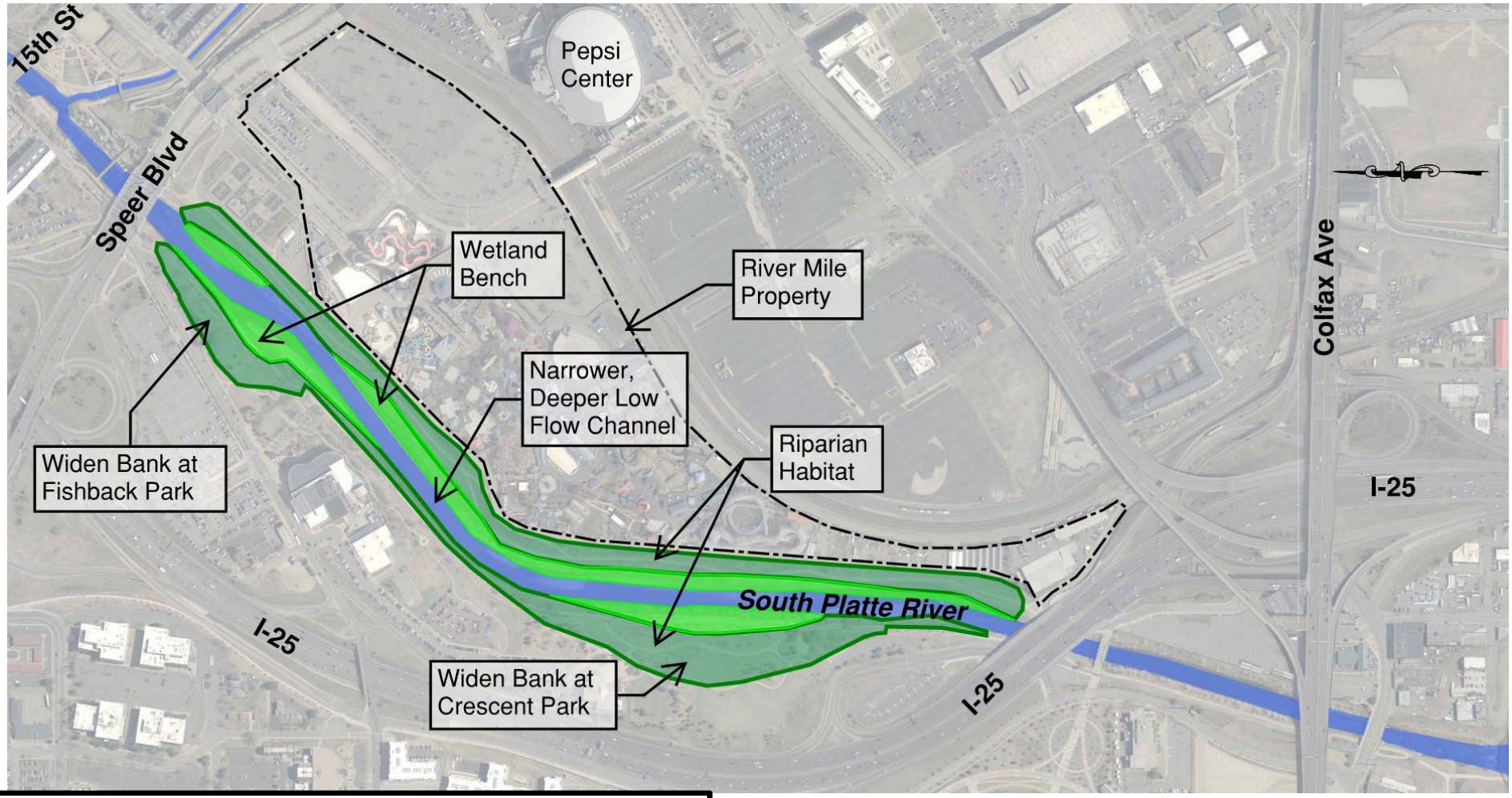
Welcome to The River Mile



OPTION 3 – MODIFY RIVER

Calibre MULLER ENGINEERING COMPANY MERRICK

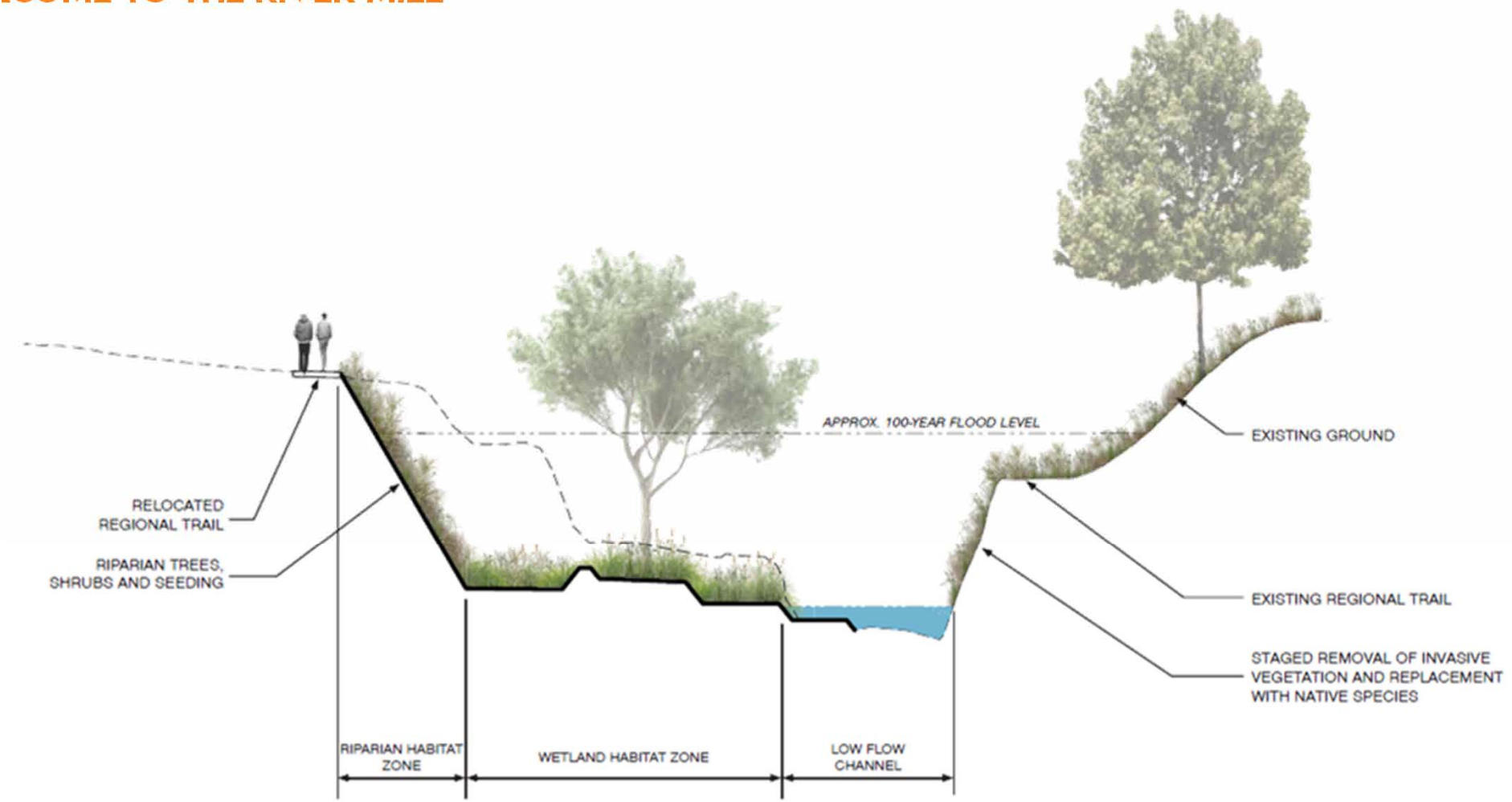
Welcome to The River Mile



DENVER URBAN WATERWAYS RESTORATION STUDY

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile



TYPICAL SECTION

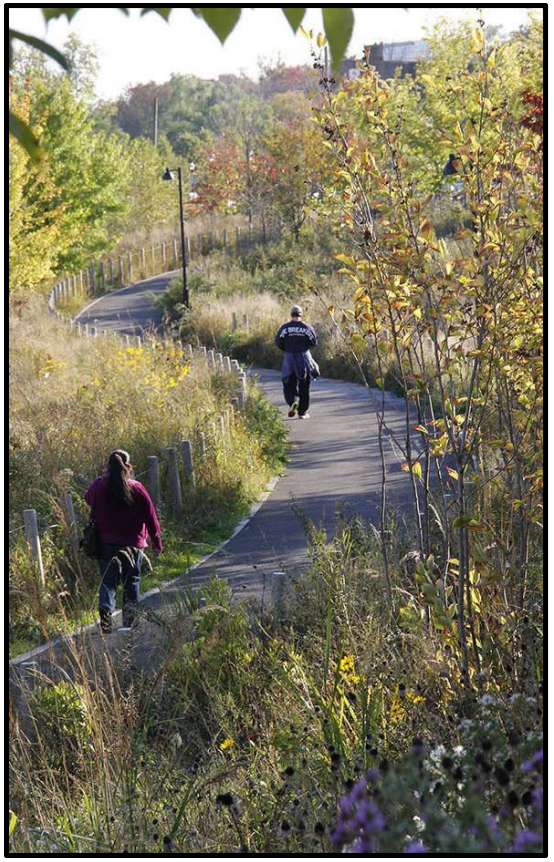
Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Riparian/Wetland Habitat

Aquatic Habitat/Fish

Trails/Paths



MULTIPLE USES

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

River Access

Leisure

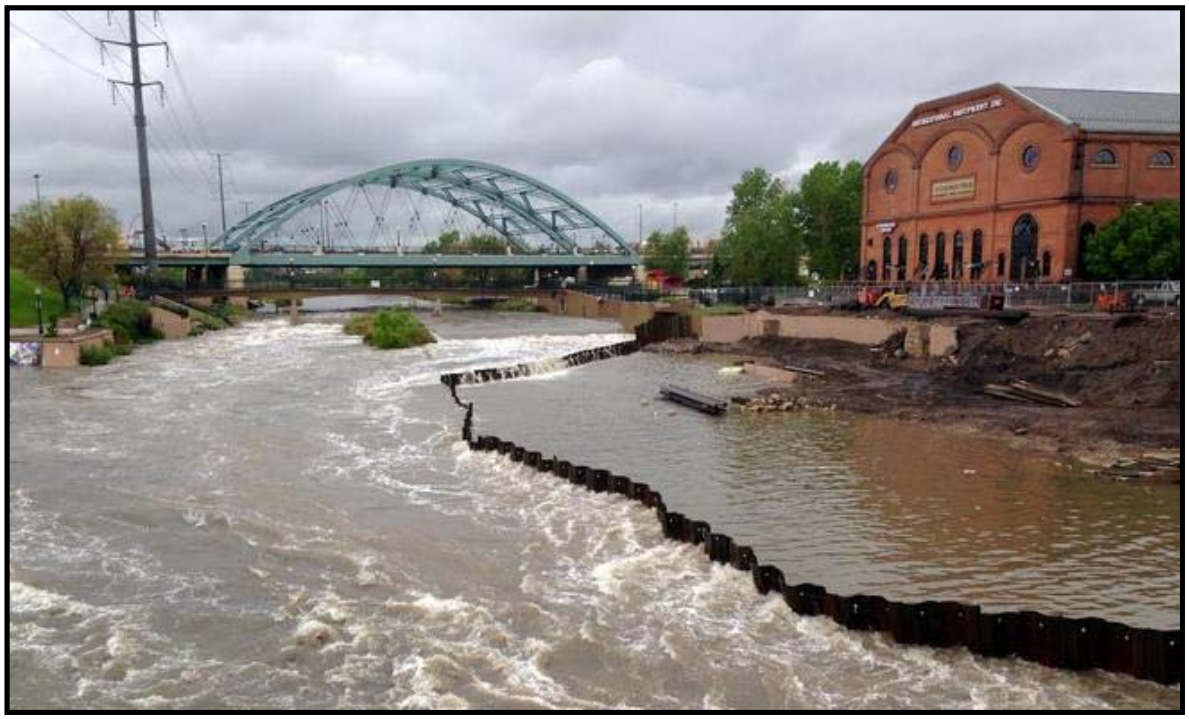
Boating

MULTIPLE USES

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

Flood Control



Swimming/Play

MULTIPLE USES

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

River Surfing

RIVER RUN PARK,
Englewood, Co.

Calibre MULLER ENGINEERING COMPANY MERRICK

Welcome to The River Mile

River Surfing

RIVER RUN PARK,
Englewood, Co.

Calibre MULLER ENGINEERING COMPANY MERRICK

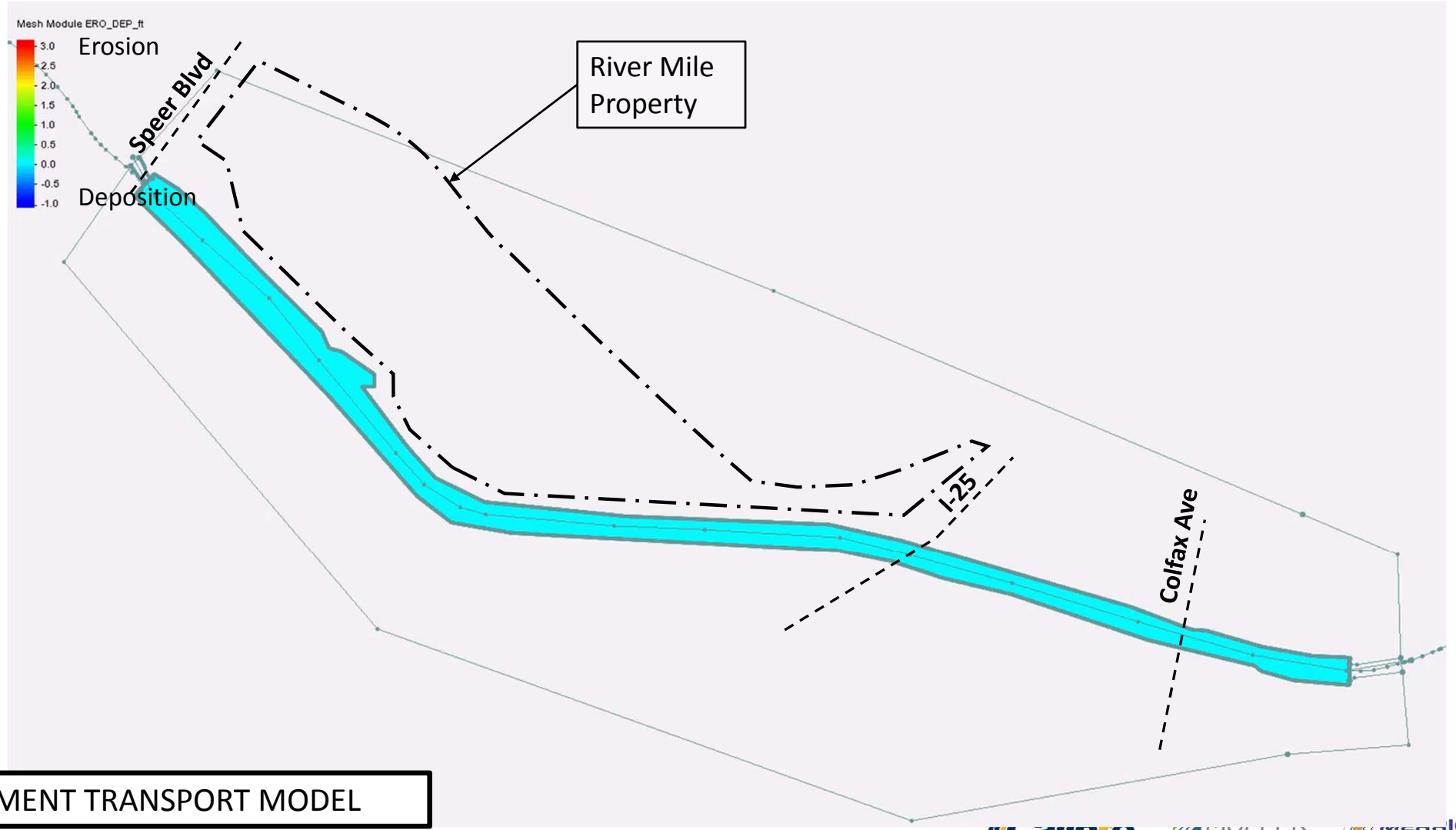
Welcome to The River Mile

CONFLUENCE PARK WHITEWATER COURSE, Denver

Calibre MULLER ENGINEERING COMPANY MERRICK

SEDIMENT TRANSPORT

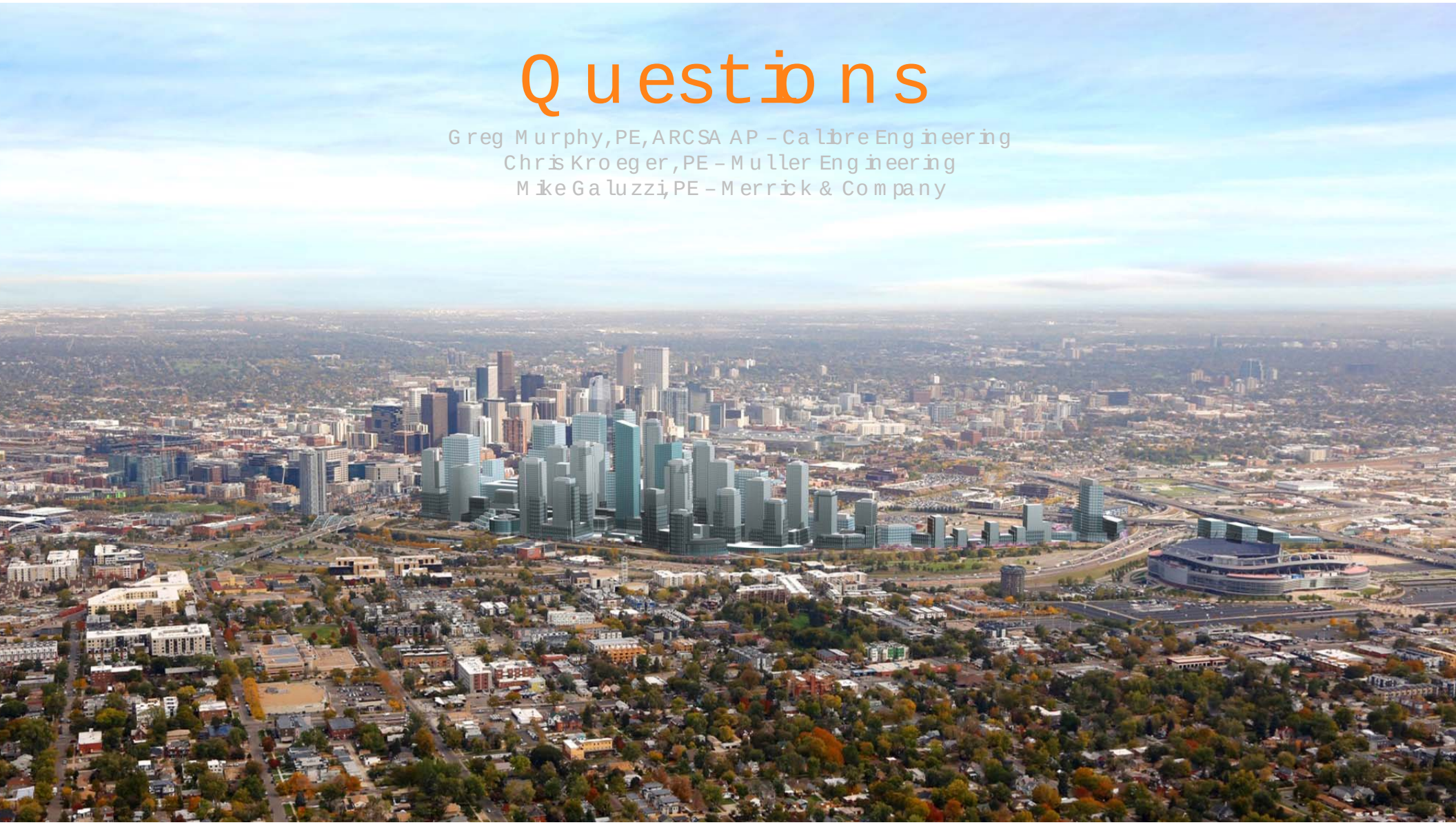
Welcome to The River Mile



SEDIMENT TRANSPORT MODEL

Questions

Greg Murphy, PE, ARCSAAP – Calibre Engineering
Chris Kroeger, PE – Muller Engineering
Mike Galuzzi, PE – Merrick & Company



Planning for Recreation and Resilience on the Big Thompson River

Chris Carlson, P.E., Andrew Earles, Ph.D., P.E., Kevin Gingery, P.E., Kevin Shanks, RLA, Brandon Parsons, Shannon Tillack, P.E., Julia Traylor, Ellie Garza & Scott Schreiber, P.E.

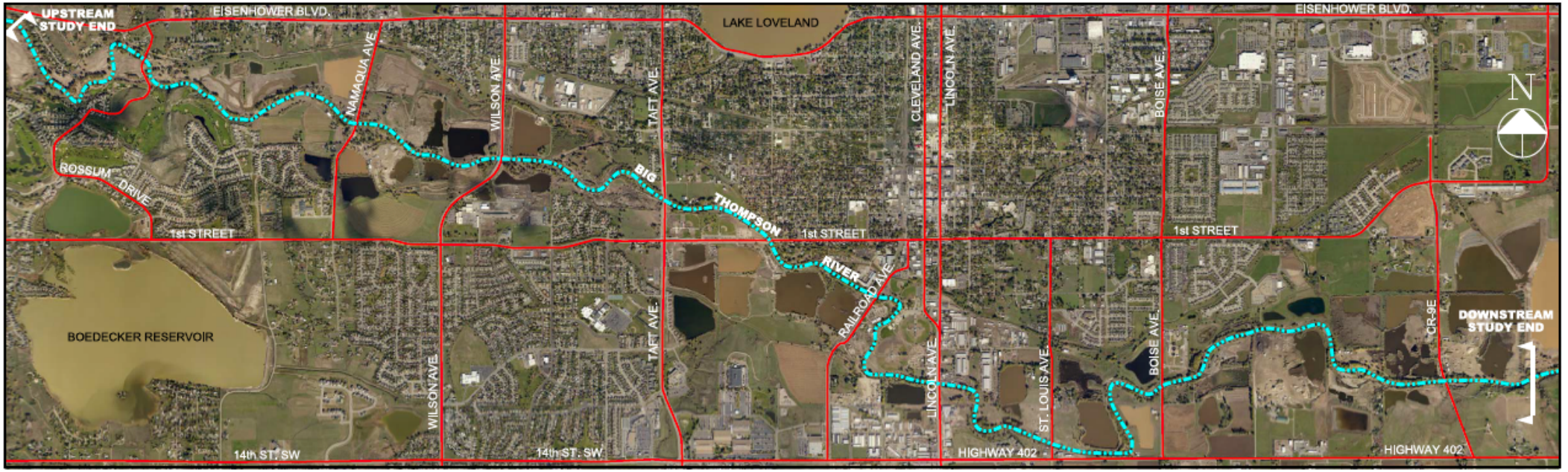
Colorado Association of Stormwater & Floodplain Managers (CASFM) Annual Conference
September 2018, Snowmass Village, Colorado

Overview of Presentation

- Need for Master Plan
- Unique Aspects of Project Approach
- Key Aspects of Master Plan
- Implementation

BIG THOMPSON RIVER CORRIDOR MASTER PLAN

Study Limits Map



Need for Big Thompson River Corridor Master Plan

Master Plan Objectives

- Capture a long term vision for the river corridor
- Recommend projects that mitigate flood hazards, restore the river's ecology, and meet multiple objectives
- Improve resiliency in the corridor
- Restore natural river & floodplain functions
- Recommend how the City can better capitalize on its river – recreation, trails, tourism, redevelopment, etc.
- Improve opportunities for public interaction
- Recommend how to manage & maintain the river corridor

Science Based, Community Driven

- Reach "Fact Sheets"
- Baseline resiliency score cards
- Field investigations
- Gap analysis
- Engineering & planning
  - Hydrology & hydraulics
  - Fish
  - Vegetation
  - Wildlife
  - Water quality
  - Irrigation diversions
  - Parks & recreation

- Trails
- Natural areas
- Bridges and roads
- Utilities
- Buildings
- Private property & infrastructure

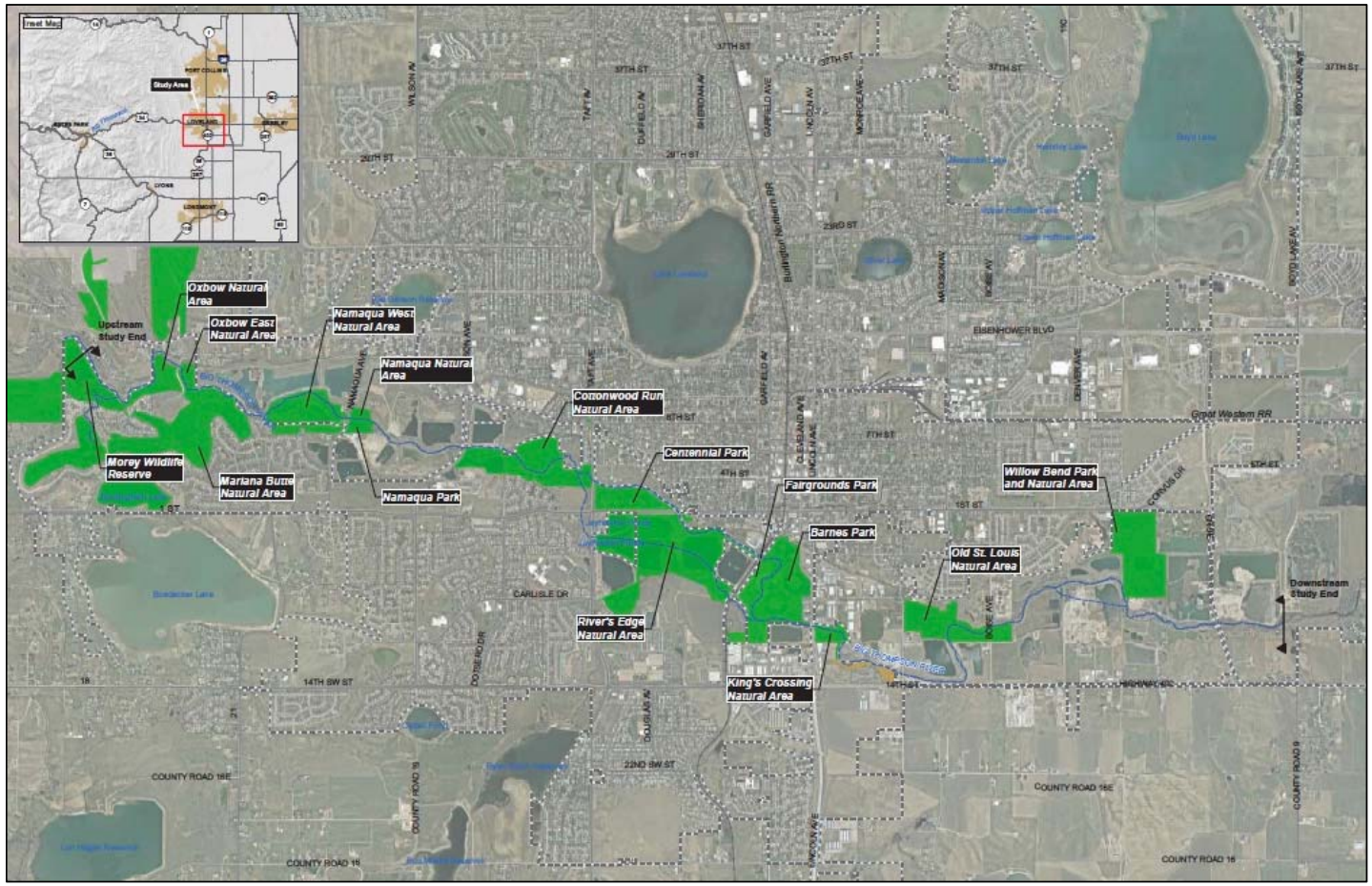
Vision for the Corridor

- A resilient, connected corridor
- Improve flood conveyance / reduce hazards
- Preserve ecological functions
- Urban fishery – improve fishing & access
- Continue open lands acquisition
- Improve river access & water-based recreation
- Regional corridor trail + trail connections
- Open land for wildlife & wildlife viewing

Vision for the Corridor

- Improve water quality
- Downtown access – trail/corridor connection
- Corridor access for future developments
- Redevelopment opportunities on Lincoln Avenue/Hwy. 287
- Comprehensive maintenance and management program
- Growing community involvement – waterway clean-ups, education, nature walks, community events

Open Lands & Natural Areas



Natural Areas

- Wildlife corridor - seating & wildlife viewing areas
- Weed and invasive species control; plant shrubs
- Cattail reduction/diversify wetland species
- River bank erosion protection
- Aquatic restoration & habitat – fishery enhancement
- Protect old gravel pit overtopping
- Water quality

Trails and Recreation

- Water recreation – tubing, fishing, swim/play
- Designated river access points & tubing route
- More trails – including soft surface trails and connections to neighborhoods
- Natural vs. manicured landscaping & appearance
- Trailhead improvements
- Natural play areas
- Bike skills/riding park

Transportation

- Currently 10 roadway crossings of the Big Thompson River within the study boundary
- Current crossing capacity (protection level) 5-50 year event
- Focus on Wilson, Lincoln, Railroad, and the future Boyd Lake Ave.
- Significant issues also at Hwy. 402/St. Louis, Taft & 1st

Resilience

Resilience Assessment Category	Reach 29: Morey-Rossum	Reach 30: Rossum-Namaqua	Reach 31: Namaqua-Wilson	Reach 32: Wilson-Taft	Reach 33: Taft-Railroad
Flood Hazards	18	18	21	17	17
Aquatic Habitat	5	4	5	5	8
Natural Areas/Open Space	11	8	8	11	12
Geomorphology	22	18	12	15	12
Parks and Recreation	5	2	3	5	9
Trails	3	3	3	8	10
Utilities	9	10	12	9	12
Water Quality	20	24	3	11	11
Gravel Pits	24	0	0	0	0
Land Use	13	7	9	11	14
Potential for Flood Damages to Urban Infrastructure/2013 Observations	25	25	30	25	10
Reach Total Score	70	53.9	48.1	53.8	52

Rank (Based on Highest Score)	Baseline Resilience Assessment Score	Reach
1	70	Reach 29: Morey - Rossum
2	67	Reach 38: CR 9E - D/S Limit
3	62	Reach 36: St. Louis - Boise
4	56	Reach 37: Boise - CR 9E
5	53.9	Reach 30: Rossum - Namaqua
6	53.8	Reach 32: Wilson - Taft
7	52	Reach 33: Taft - Railroad
8	48.4	Reach 35: Hwy 287 – St. Louis
9	48.1	Reach 31: Namaqua - Wilson
10	45	Reach 34: Railroad – Hwy 287

Unique Aspects of Project Approach

Balance of Planning & Engineering

Legend:

- Main River Access Point
- Proposed Trail Head
- Existing Restroom
- City of Loveland City Boundary
- Proposed Trail Bridge
- Vegetative Screening
- Big Thompson River
- Major Roadway Connections
- Existing Loveland Recreational Trail
- Proposed Recreational Trail
- Existing Soft Surface Trail
- Proposed Soft Surface Trail
- Sidewalks
- Railroads
- Floodway
- 100-year Floodplain
- Potential Future Development Area
- Ownership - City of Loveland
- The Foundry
- Proposed Gateway

0' 400' 800' Feet

Parks & Recreation		
Fairgrounds Park River Access	$110,000	Mid
Fairgrounds Park Bike Skills Park	$132,000	Mid
Gateway to the Big Thompson River Corridor Railroad Avenue Improvements	$3,500,000	Long
Redevelopment of Old Loveland Wastewater Treatment Plant Site	$875,000	Mid
Fairgrounds Park Trailhead	$175,000	Mid

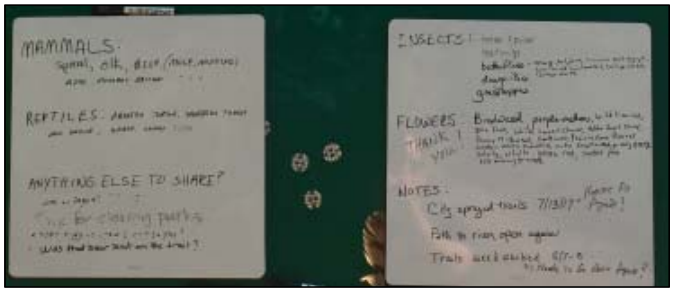
Trails		
Bike Trail Connection from North End of Fairgrounds Park to 1st Street	$158,000	Mid
Realignment of Trail Near Fairgrounds Park River Access	$109,000	Mid

Figure ES-12-Reach 34 Rec Map

Public Outreach

- Farmers Markets
- Summer Concerts
- Summer Festivals
- 2-day Workshop
- Project Website
- Open City Hall

Recreation


MAMMALS.
REPTILES.
ANYTHING ELSE TO SHARE?
INSECTS
FLOWERS
NOTES.

Stakeholders & Partners

Multiple concurrent, ongoing projects

- City of Loveland
  - Public Works
  - Parks & Recreation
  - Water & Power
  - Community& Strategic Planning
- Larimer County
- Big Thompson Watershed Coalition
- Big Thompson Water Quality Forum
- Colorado Department of Local Affairs

Key Aspects of Master Plan

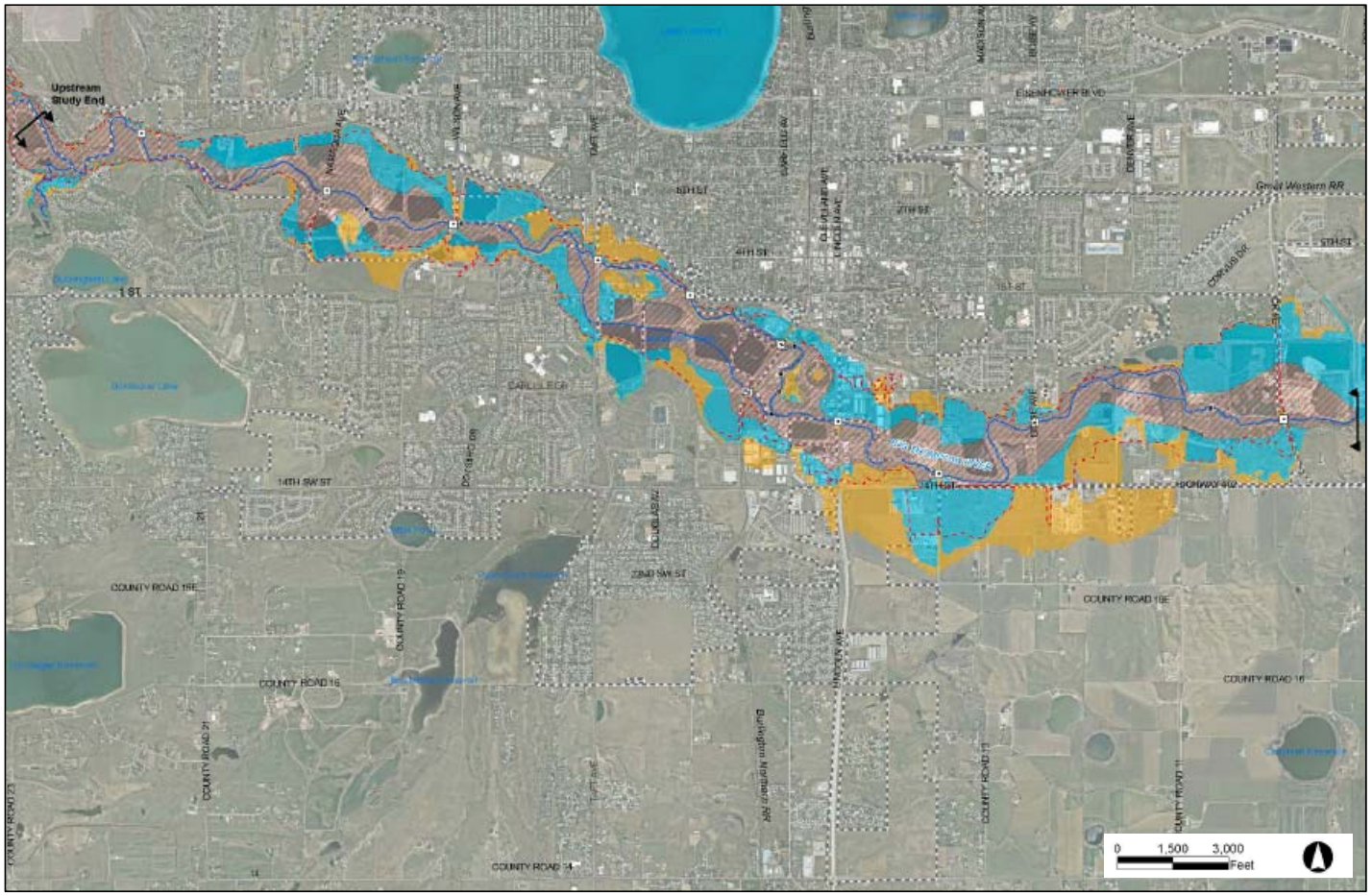
- Flood Hazard Reduction
- Gravel Pit Hazard Reduction
- Geomorphology
- Aquatic Habitat
- City Utilities
- Water Quality
- Natural Areas
- Parks, Recreation, Trails and Land Use
- Community Involvement Opportunities

Resilience

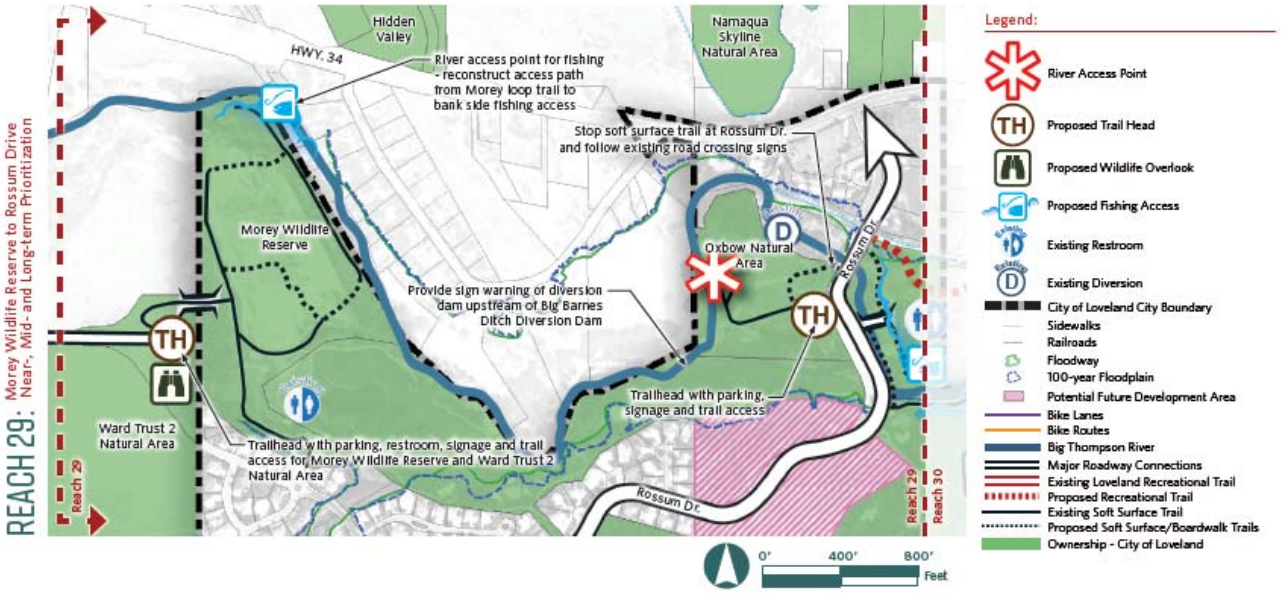
re·sil·ience /rəˈzilyəns/
noun

1. An ability to recover from or adjust easily to misfortune or change.

Floodplain Preservation

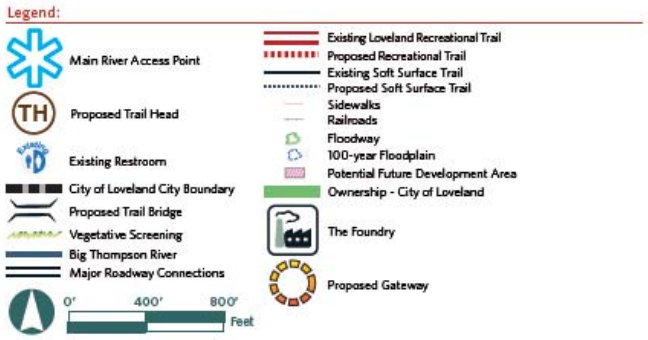


Balance of Recreational Access & Wildlife



Morey Wildlife Reserve – Passive Recreation and a Refuge for Wildlife

Balance of Recreational Access & Wildlife

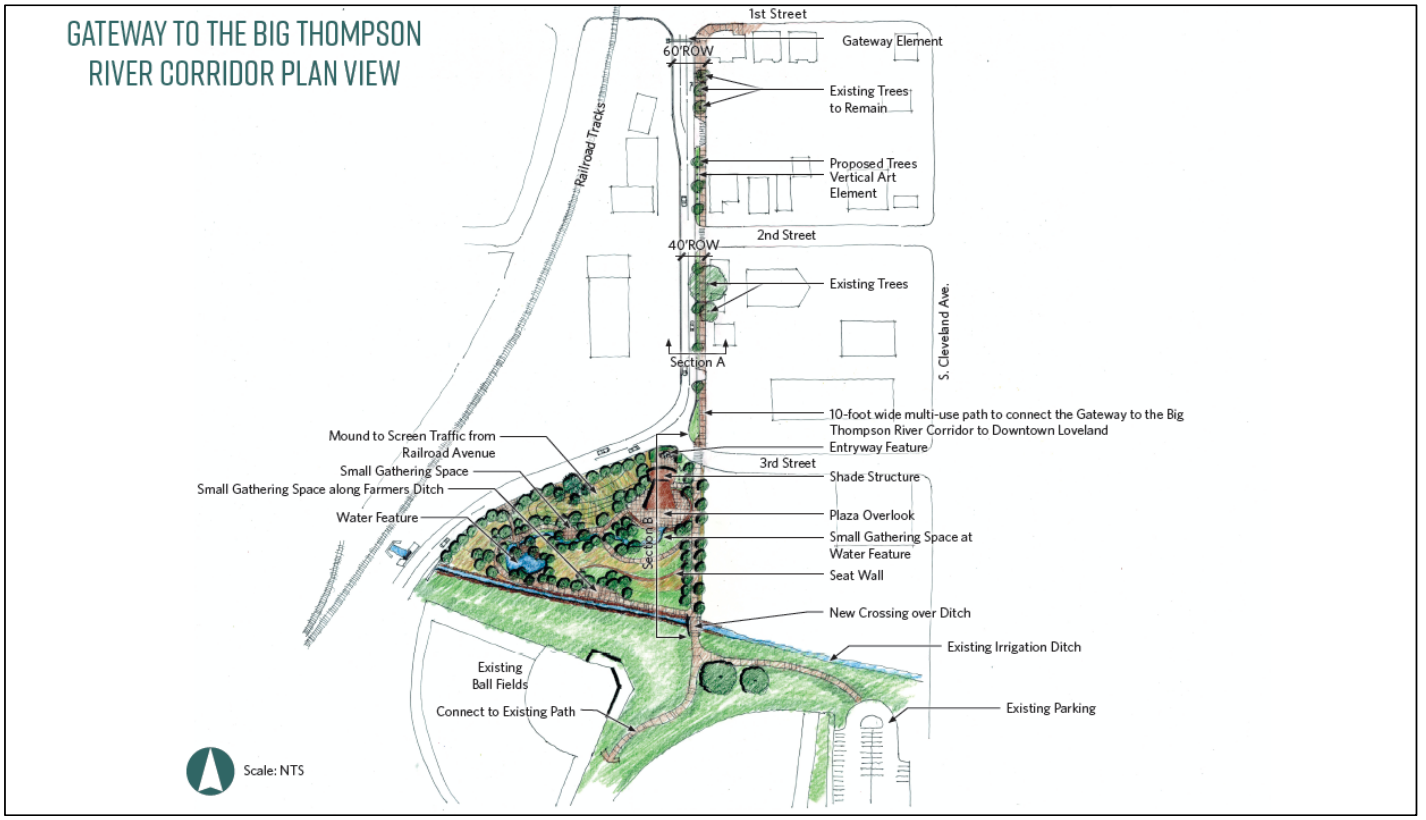


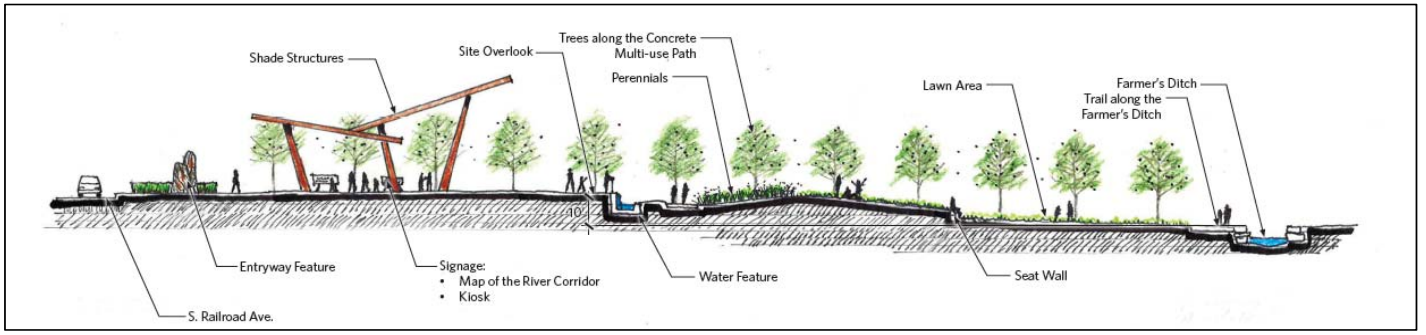
Parks & Recreation		
Fairgrounds Park River Access	$110,000	Mid
Fairgrounds Park Bike Skills Park	$132,000	Mid
Gateway to the Big Thompson River Corridor Railroad Avenue Improvements	$3,500,000	Long
Redevelopment of Old Loveland Wastewater Treatment Plant Site	$875,000	Mid
Fairgrounds Park Trailhead	$175,000	Mid

Trails		
Bike Trail Connection from North End of Fairgrounds Park to 1st Street	$158,000	Mid
Realignment of Trail Near Fairgrounds Park River Access	$109,000	Mid

Fairgrounds Park – Active Recreation and River Access

Connecting the River & Community





Implementation

Category & Cost												
Reach	Flood Hazard Reduction	Gravel Pits[2]	Aquatic Habitat	Geomorphology[2]	Natural Area/ Open Space	Parks & Recreation	Trails	Land Use	Utilities	Water Quality	Maintenance[4]	Total
29	$1,660,000		$1.81M - est. cost of Big Barnes diversion dam retrofit - not included in overall cost estimate since private dam		$100,000	$745,000	$1,083,000				$23,000	$3,590,000
30	$350,000[1]	----[3]	----[3]	----[3]	$100,000	$489,000	$368,000	$174,000			$26,000	$1,483,000
31	----[1]	----[3]	----[3]	----[3]		$43,000	$368,000	$14,000		$300,000	$16,000	$725,000
32				$1,430,000	$161,000	$162,000	$84,000		$111,000		$19,000	$2,473,000
33	----[1]	$2,450,000				$133,000	$123,000		$37,000		$24,000	$2,743,000
34	$16,900,000			$945,000		$4,792,000	$267,000		$74,000		$17,000	$22,970,000
35	$3,230,000	$675,000		$945,000	$24,000	$933,000	$811,000				$14,000	$6,620,000
36		$1,575,000		$790,000	$100,000	$578,000	$734,000				$20,000	$3,800,000
37		$2,625,000		$2,363,000	$136,000	$35,000	$1,493,000			$368,000	$34,000	$6,660,000
38	----[1]	$1,050,000		$473,000			$210,000				$10,000	$2,790,000
Totals	$21,790,000	$8,375,000	----[3]	$6,946,000	$621,000	$7,910,000	$5,541,000	$190,000	$220,000	$670,000	$203,000	$52,824,000

Implementation

Top 5 Priorities

1. Maintenance of River Corridor
2. River Coordinator
3. US 287 - Lincoln Avenue Conveyance Improvements
4. Wilson Avenue – Elevation of Approaches
5. Mariano Exchange Ditch Water Quality Evaluation

Maintenance

River Coordinator

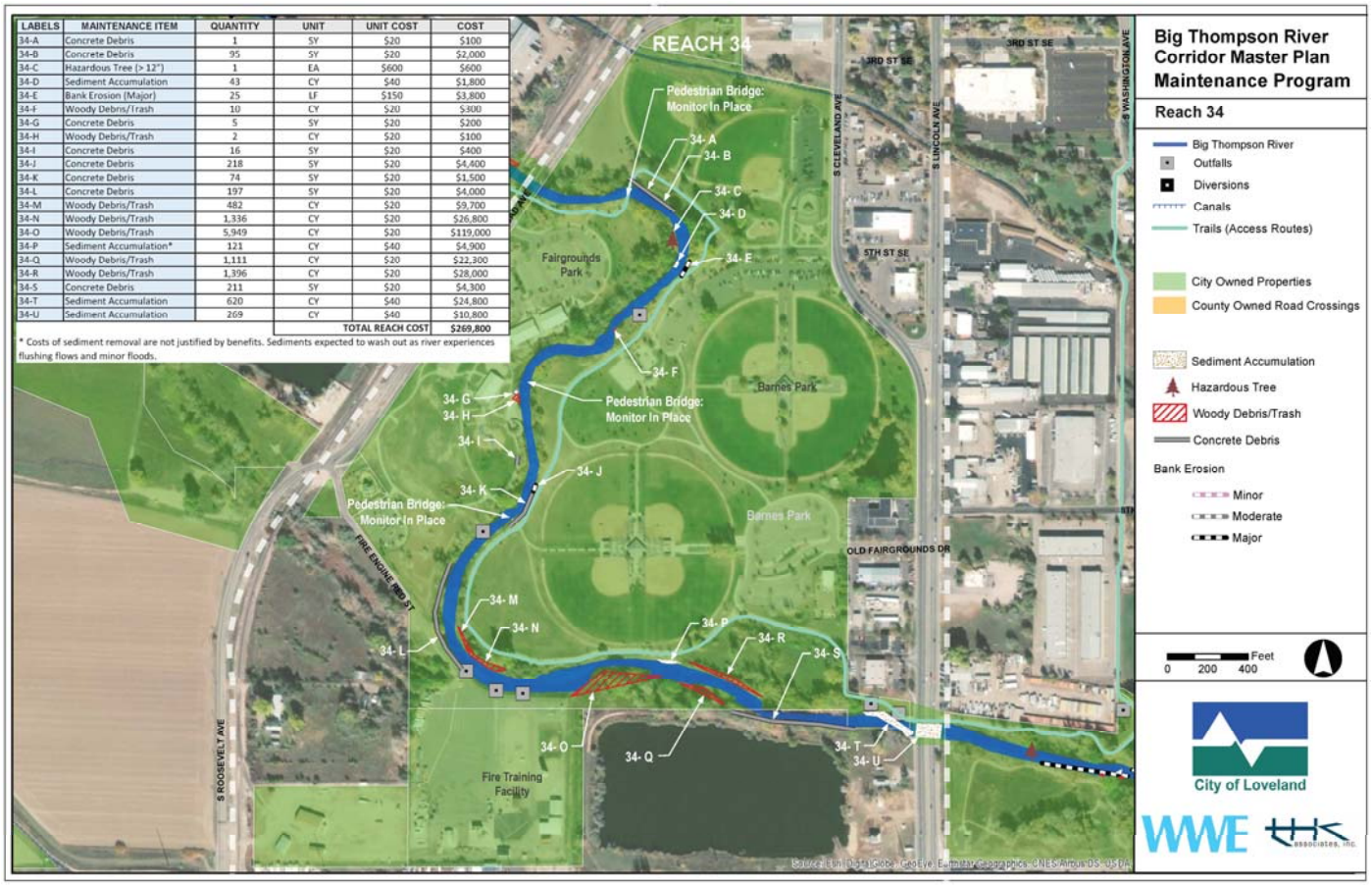
City of Loveland

- Bank Erosion
- Concrete Debris
- Sediment Accumulation
- Tree Removal
- Woody Debris
- Transient Settlements

Maintenance

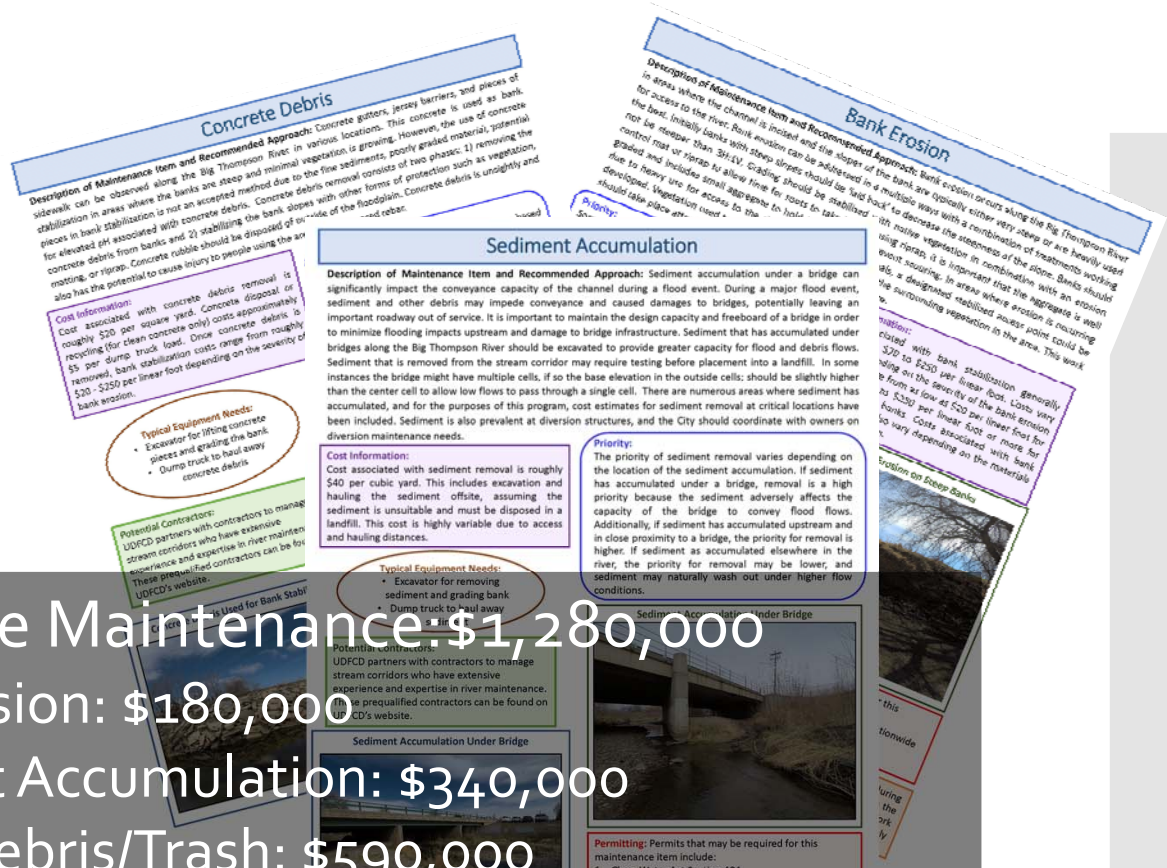
LABELS	MAINTENANCE ITEM	QUANTITY	UNIT	UNIT COST	COST
34-A	Concrete Debris	1	SY	$20	$100
34-B	Concrete Debris	95	SY	$20	$2,000
34-C	Hazardous Tree (> 12")	1	EA	$600	$600
34-D	Sediment Accumulation	43	CY	$40	$1,800
34-E	Bank Erosion (Major)	25	LF	$150	$3,800
34-F	Woody Debris/Trash	10	CY	$20	$300
34-G	Concrete Debris	5	SY	$20	$200
34-H	Woody Debris/Trash	2	CY	$20	$100
34-I	Concrete Debris	16	SY	$20	$400
34-J	Concrete Debris	218	SY	$20	$4,400
34-K	Concrete Debris	74	SY	$20	$1,500
34-L	Concrete Debris	197	SY	$20	$4,000
34-M	Woody Debris/Trash	482	CY	$20	$9,700
34-N	Woody Debris/Trash	1,336	CY	$20	$26,800
34-O	Woody Debris/Trash	5,949	CY	$20	$119,000
34-P	Sediment Accumulation*	121	CY	$40	$4,900
34-Q	Woody Debris/Trash	1,111	CY	$20	$22,300
34-R	Woody Debris/Trash	1,396	CY	$20	$28,000
34-S	Concrete Debris	211	SY	$20	$4,300
34-T	Sediment Accumulation	620	CY	$40	$24,800
34-U	Sediment Accumulation	269	CY	$40	$10,800
				TOTAL REACH COST	$269,800

* Costs of sediment removal are not justified by benefits. Sediments expected to wash out as river experiences flushing flows and minor floods.



Maintenance Types

Maintenance



Restorative Maintenance: $1,280,000

- Bank Erosion: $180,000
- Sediment Accumulation: $340,000
- Woody Debris/Trash: $590,000
- Concrete Debris: $150,000
- Hazardous Tree: $20,000

Questions

Chris Carlson, P.E., CFM
Public Works – Stormwater Engineering
City of Loveland, CO
Chris.Carlson@cityofloveland.org

Andrew Earles, Ph.D., P.E.
& Julia Traylor
Wright Water Engineers, Inc.
Denver, CO
aearles@wrightwater.com
jtraylor@wrightwater.com

Scott Schreiber, P.E.
Wright Water Engineers, Inc.
Glenwood Springs, CO
sschreiber@wrightwater.com

WATERSHED FRAMEWORK: TO MANAGE RUNOFF AND CREATE LOW MAINTENANCE STREAM – STROH TRIBUTARY CASE STUDY

by: Jacob James, P.E., CFM
Town of Parker, Colorado

Barbara Chongtoua, P.E.
Urban Drainage & Flood Control District

Jim Wulliman, P.E., Sara Johnson, P.E., CFM, Katy Shaneyfelt, E.I., and Sam Rogers, P.E., CFM
Muller Engineering Company

Andrew Earles, Ph.D. P.E. and Brik Zivkovich, EI
Wright Water Engineers, Inc.

September 26, 2018

2018 Colorado Association of Stormwater & Floodplain Managers, Snowmass Village, Colorado

Overview

- The Development Process - Seeking a Win-Win Approach
- Reducing Runoff and Laying Out the Land
- Costs of Development
- Modeling
- Lessons Learned and Technical Conclusions

Process of Development

Process of Development

Prior to development

- **Major Drainage Master Planning**
  - Based on assumptions of how watershed will develop
  - Future developed flows guide anticipated stabilization needs
  - Cannot be progressed beyond concept level due to unknowns

Process of Development

Preparation for development

- **Annexation Agreements/Pre-Development Agreements**
  - Identifies development obligations to build infrastructure
  - Based on Master Plans and preliminary engineering reports
  - Timing of improvements
  - Constructed by developer or fee in lieu

Process of Development

Active development stage

- **Subdivision/Site Planning**
  - Sketch 30%
    - Developers submit concept design documents
    - Obligations within annexation/pre-development agreements coordinated with early design documents

Process of Development

Active development stage

- **Subdivision/Site Planning**
  - Preliminary 70%
    - Developers submit preliminary design documents

Process of Development

Active development stage

- **Subdivision/Site Planning**
  - Final Plat
    - Final design documents
    - Cost estimates are finalized for securities and/or fee in lieu obligations
    - Development agreements are finalized codifying obligations and triggers

Process of Development

Active development stage

- **Construction**
  - Inspection of public infrastructure during construction through final acceptance and transfer to municipality

Challenges & Constraints

- Development obligations are determined well before understanding the true impact of development
- Stormwater master plans need to be updated and interpreted
- Development design can occur with limited communication; opportunities and critical information may be missed
- Submittal reviews may produce lengthy comments and design revisions

Seeking a Win-Win

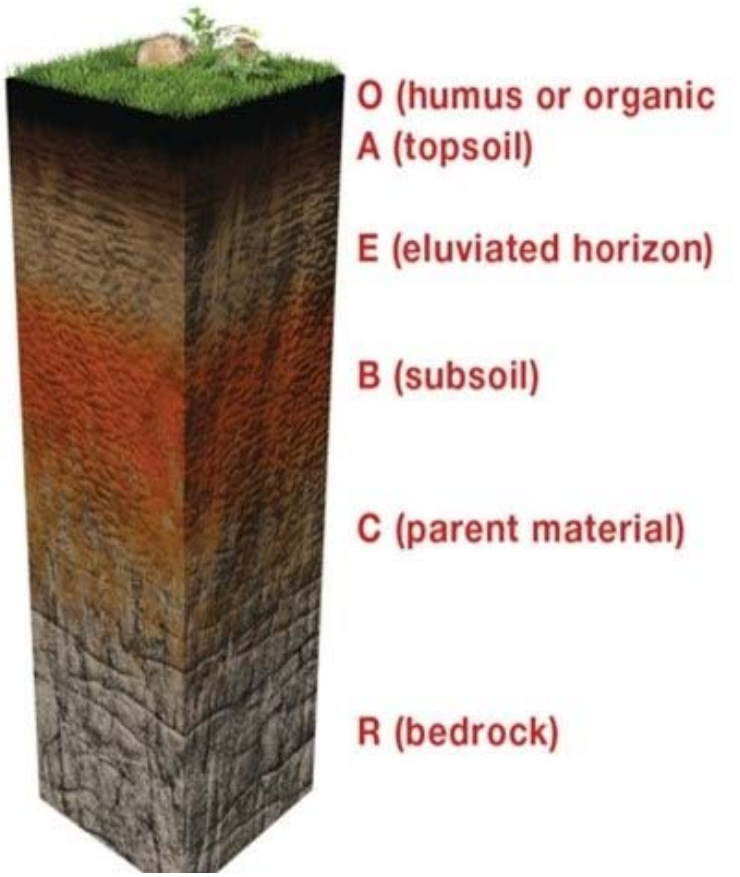
- Dynamic, concurrent stormwater planning
  - Stormwater design is incorporated throughout process
  - Efforts are collaborative
  - Feedback loop is continuous, reducing rework
  - Stormwater informs layout
  - Uses open spaces to reduce runoff and soften streams
  - Infrastructure costs are reduced
  - Long-term maintenance costs are reduced
  - Provides value to community

Seeking a Win-Win

- Dynamic, concurrent stormwater planning
  - Stormwater design is incorporated throughout process
  - Efforts are collaborative
  - Feedback loop is continuous, reducing rework
  - Stormwater informs layout
  - Uses open spaces to reduce runoff and soften streams
  - Infrastructure costs are reduced
  - Long-term maintenance costs are reduced
  - Provides value to community

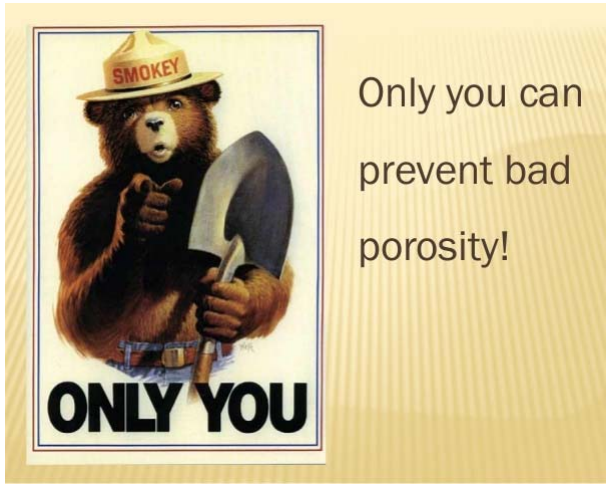
Reducing Runoff, Softening Streams

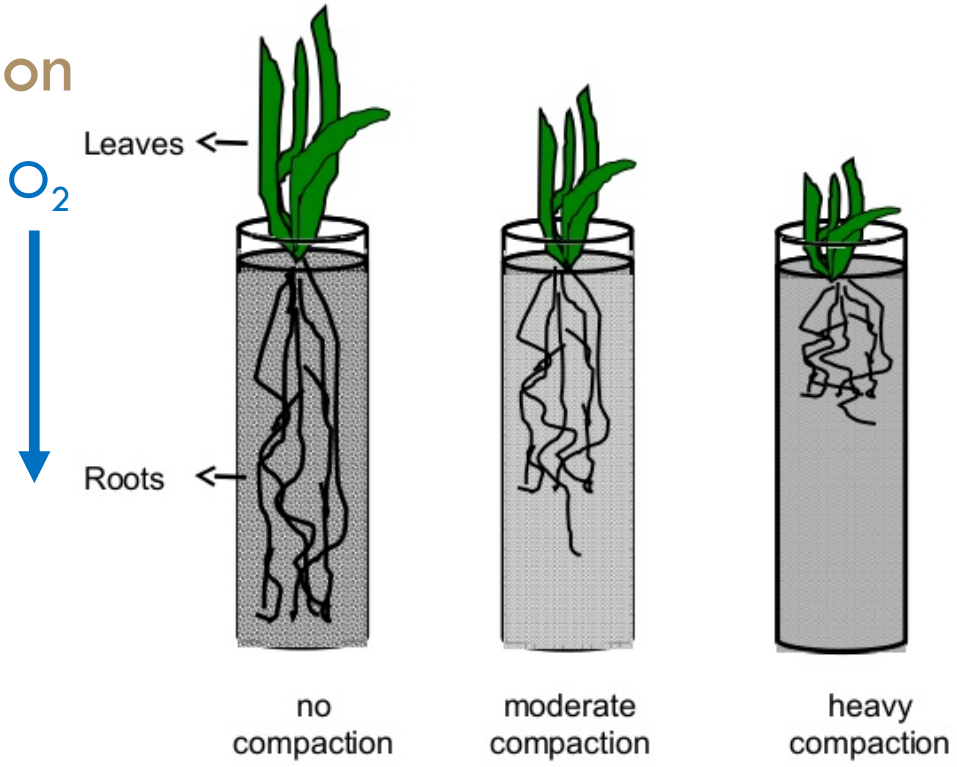
- Soil
  - Loamy texture
  - Organic
  - Low salts



Reducing Runoff, Softening Streams

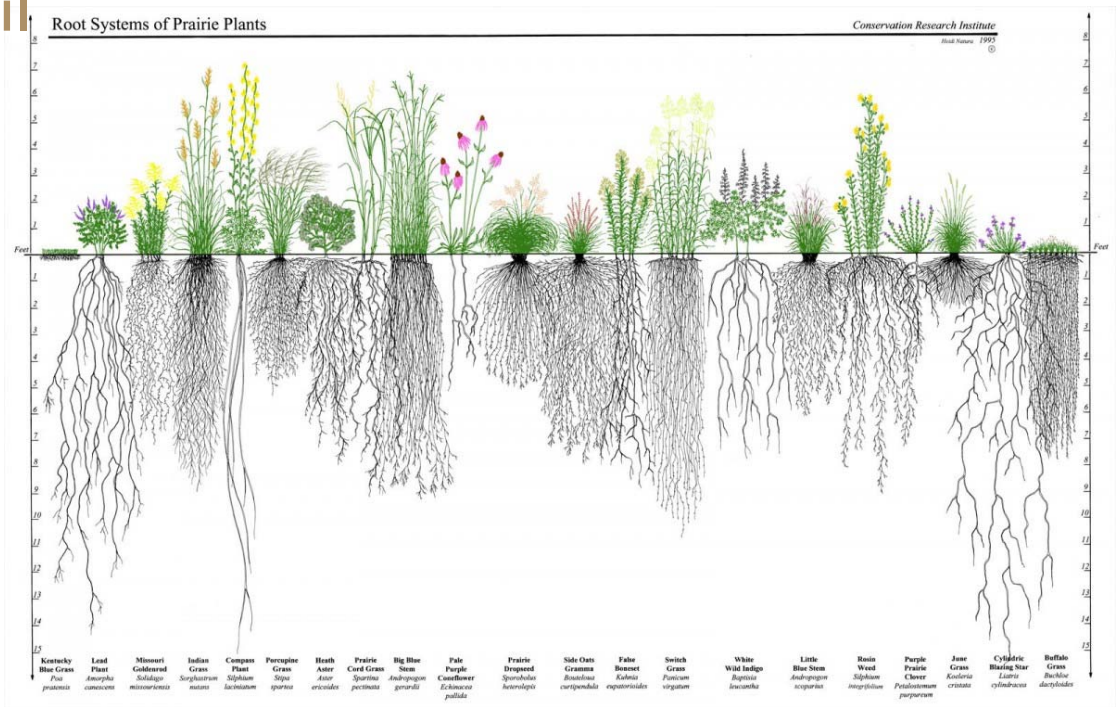
- Air
  - Avoid over-compaction
  - Rip, scarify, disc
  - Encourage root pathways





Reducing Runoff, Softening Streams

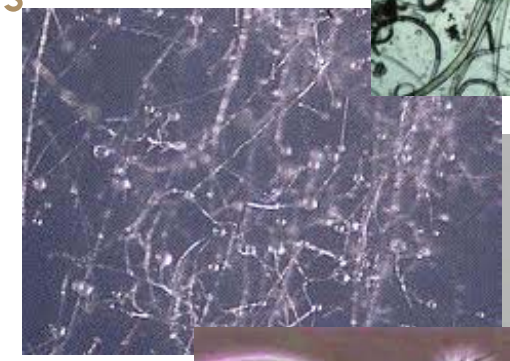
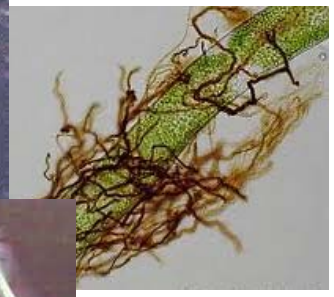
- Vegetation
  - Establish dense turf-forming grass for surface roughness
  - Consider native, deep rooted vegetation for pathways into soil



Reducing Runoff, Softening Streams

- Ecology
  - A cup of topsoil contain
    - 200 billion bacteria
    - 20 million bacteria species
    - 60 miles of fungi
    - 20 million protozoa
    - 100,000 nematodes
    - 50,000 arthropods
    - …and an earthworm




Reducing Runoff, Softening Streams

- Water
  - Distribute runoff over vegetated open spaces
  - Water sustains the life of the soil and vegetation
  - Runoff is reduced via
    - Interception
    - Infiltration
    - Evapotranspiration
    - Deep percolation

Reducing Runoff, Softening Streams

Soil,

Air,

Vegetation,

Ecology,

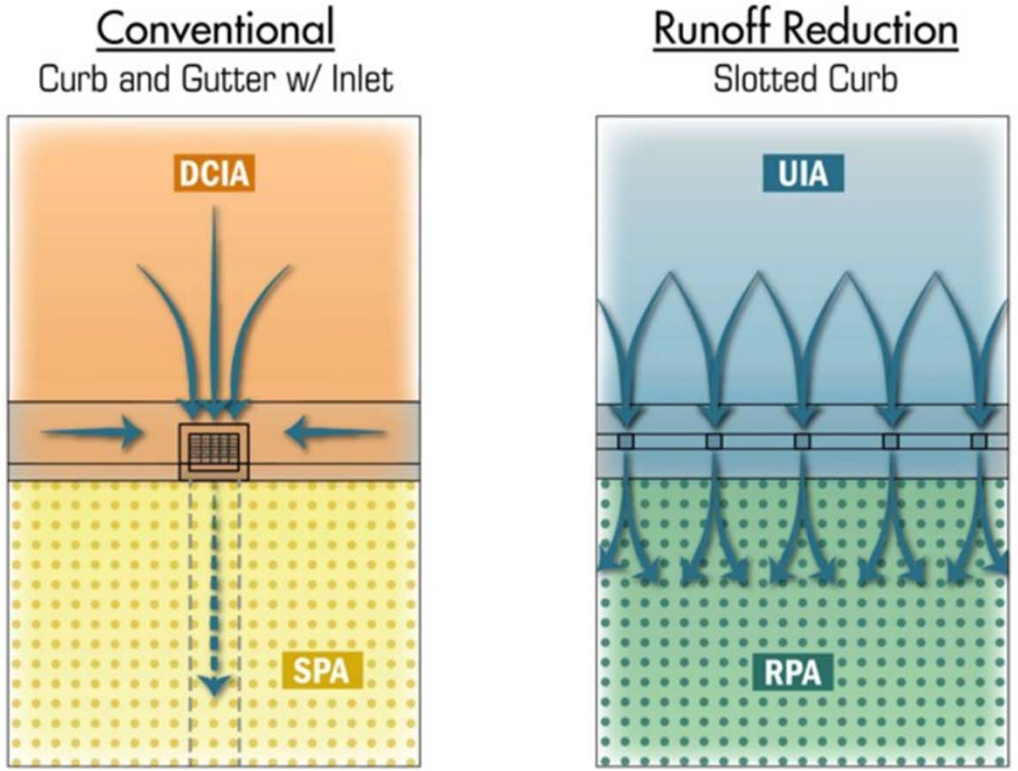
Water

Symbiosis between soil, air, vegetation, ecology, and water:

1. Saves water in the land to support life
2. Saves water courses
3. Saves water quality
4. Saves water supply

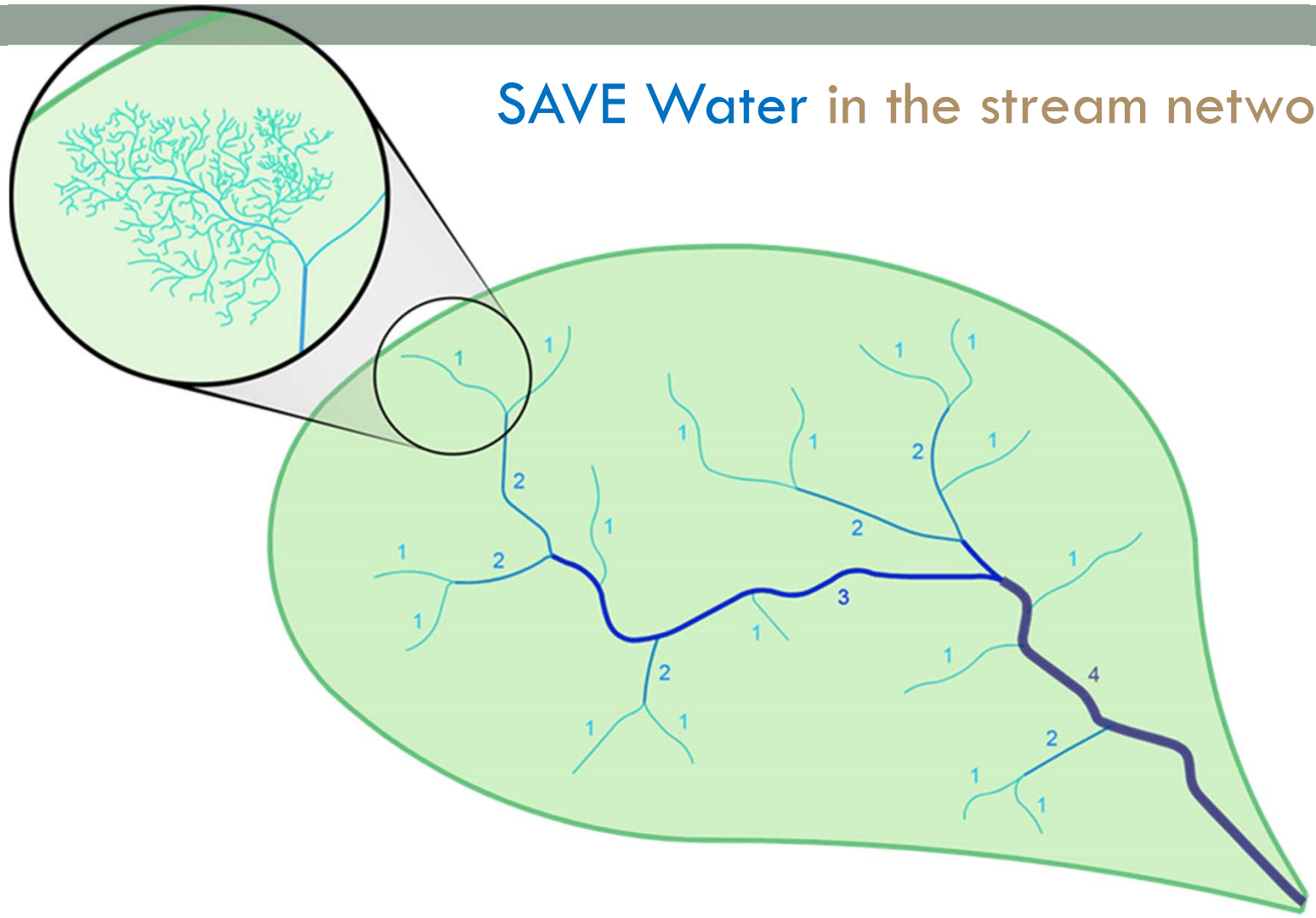
Reducing Runoff, Softening Streams

SAVE Water in landscape areas

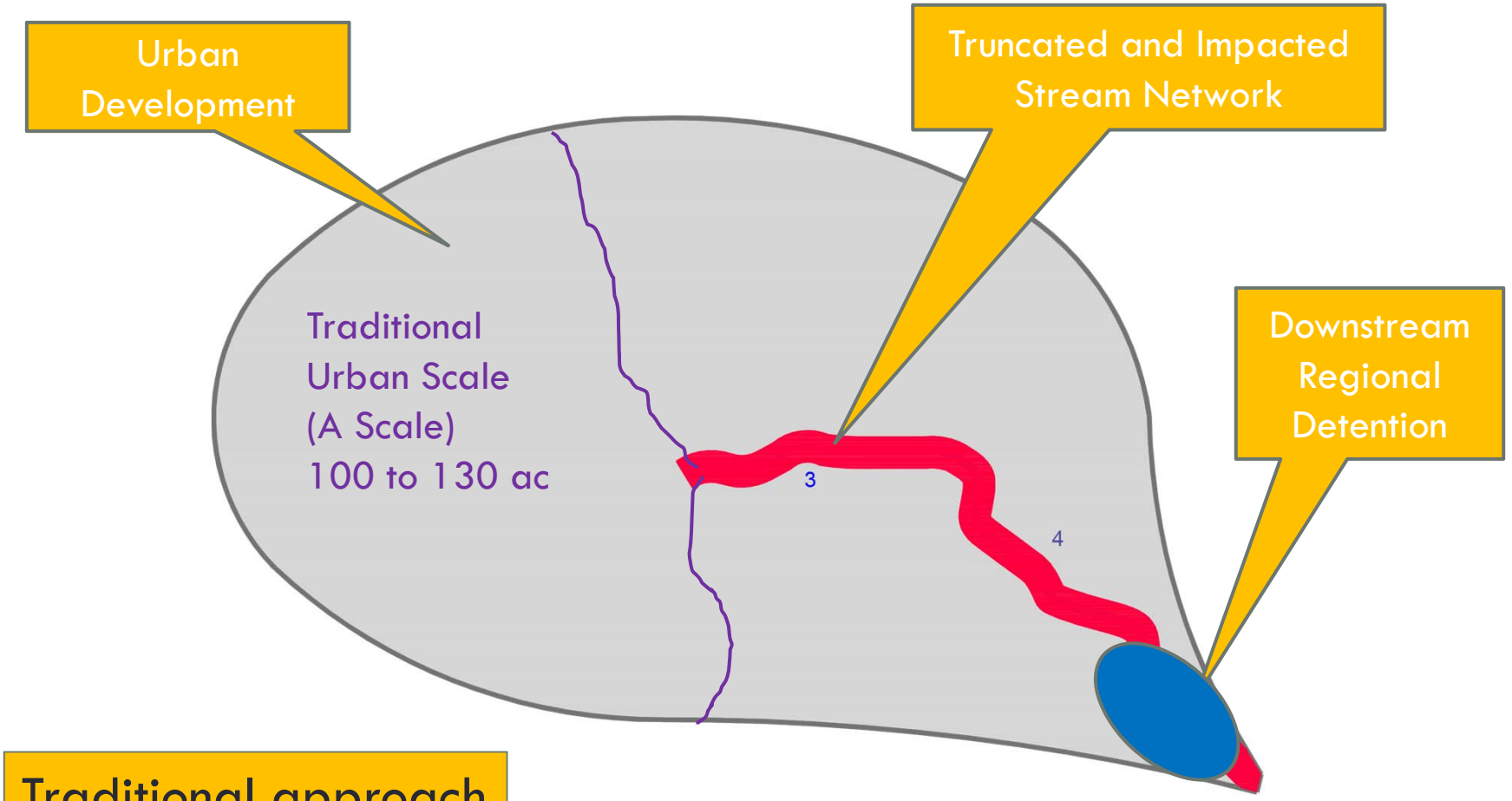


Laying Out the Land

SAVE Water in the stream network

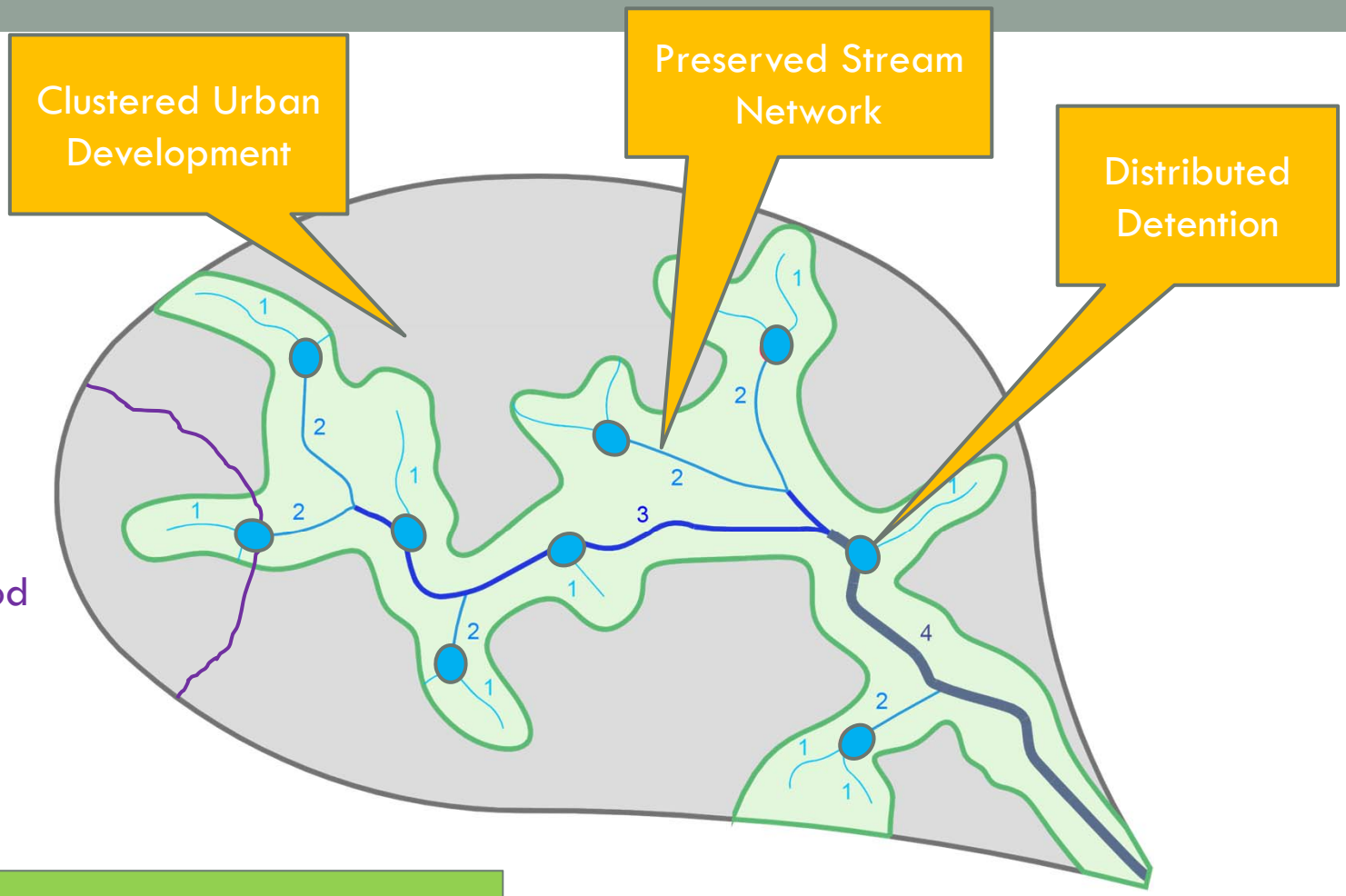


Laying Out the Land



Traditional approach

Laying Out the Land



Neighborhood Scale
(B Scale)
10 to 40 ac

Recommended approach

Laying Out the Land

Curb outfalls rather than inlets and laterals

Laying Out the Land

Grass swales rather than storm sewers

Laying Out the Land

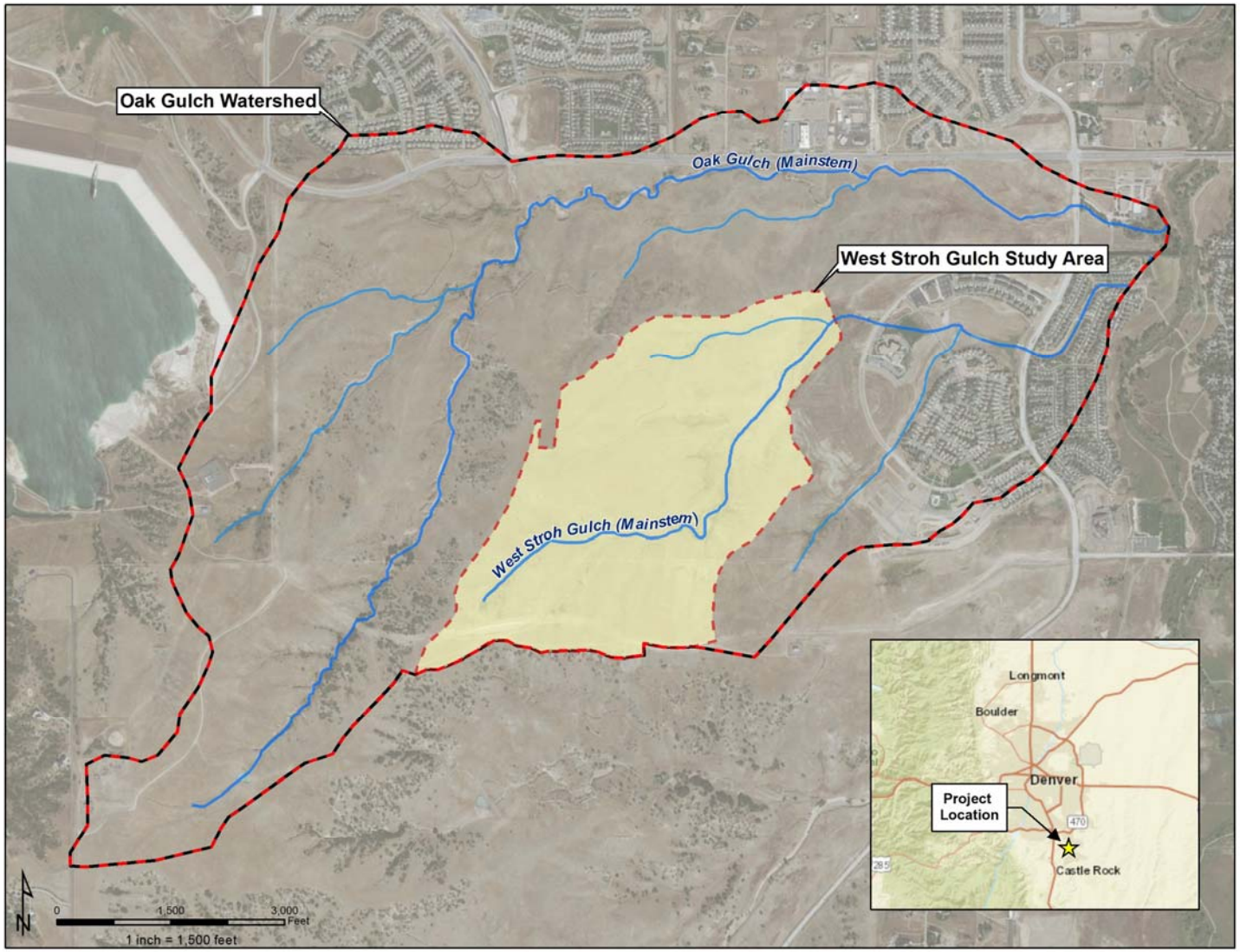
Distributed detention rather than downstream detention

Laying Out the Land

Soft streams rather than structural

Costs of Development

Oak Gulch Watershed



Oak Gulch Planning Timeline

OSP
(2003)
$18,715,963

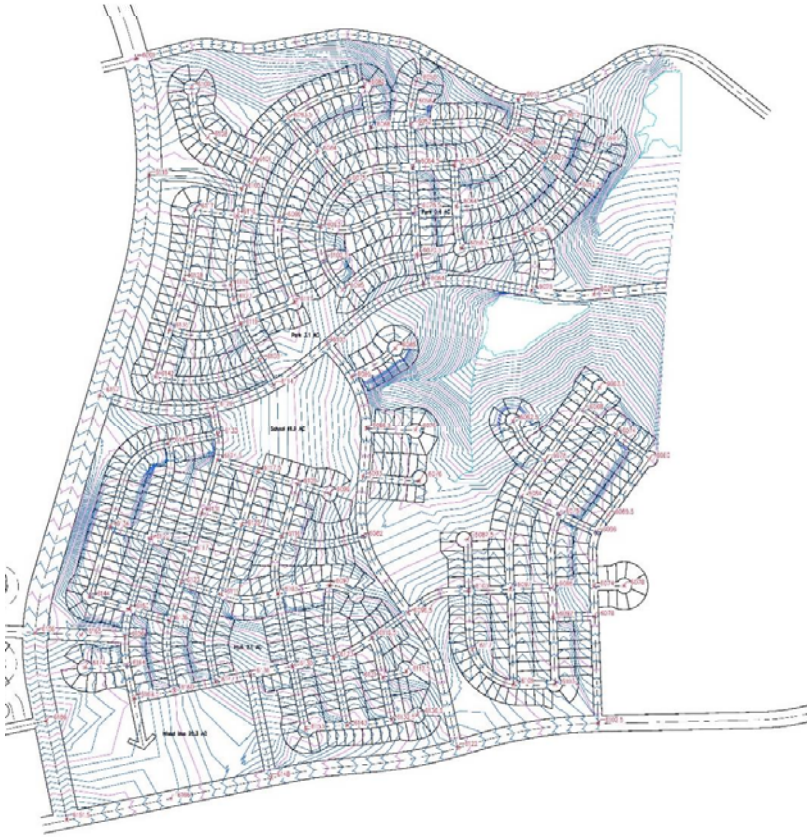
OSP Addendum
(2015)
$22,176,659

Updated Analysis
Checks → Drops
(2016)
$32,604,342

Additional Analysis for West Stroh Tributary
(2018)

Lot Layout

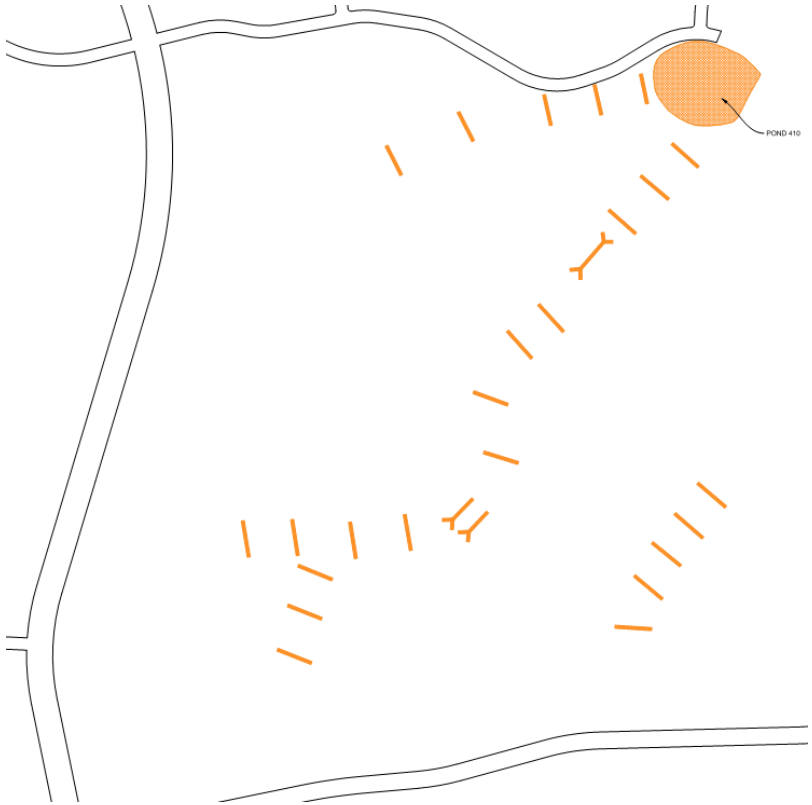
Traditional



Low Maintenance Stream Distributed Detention

Stormwater Layout

Traditional



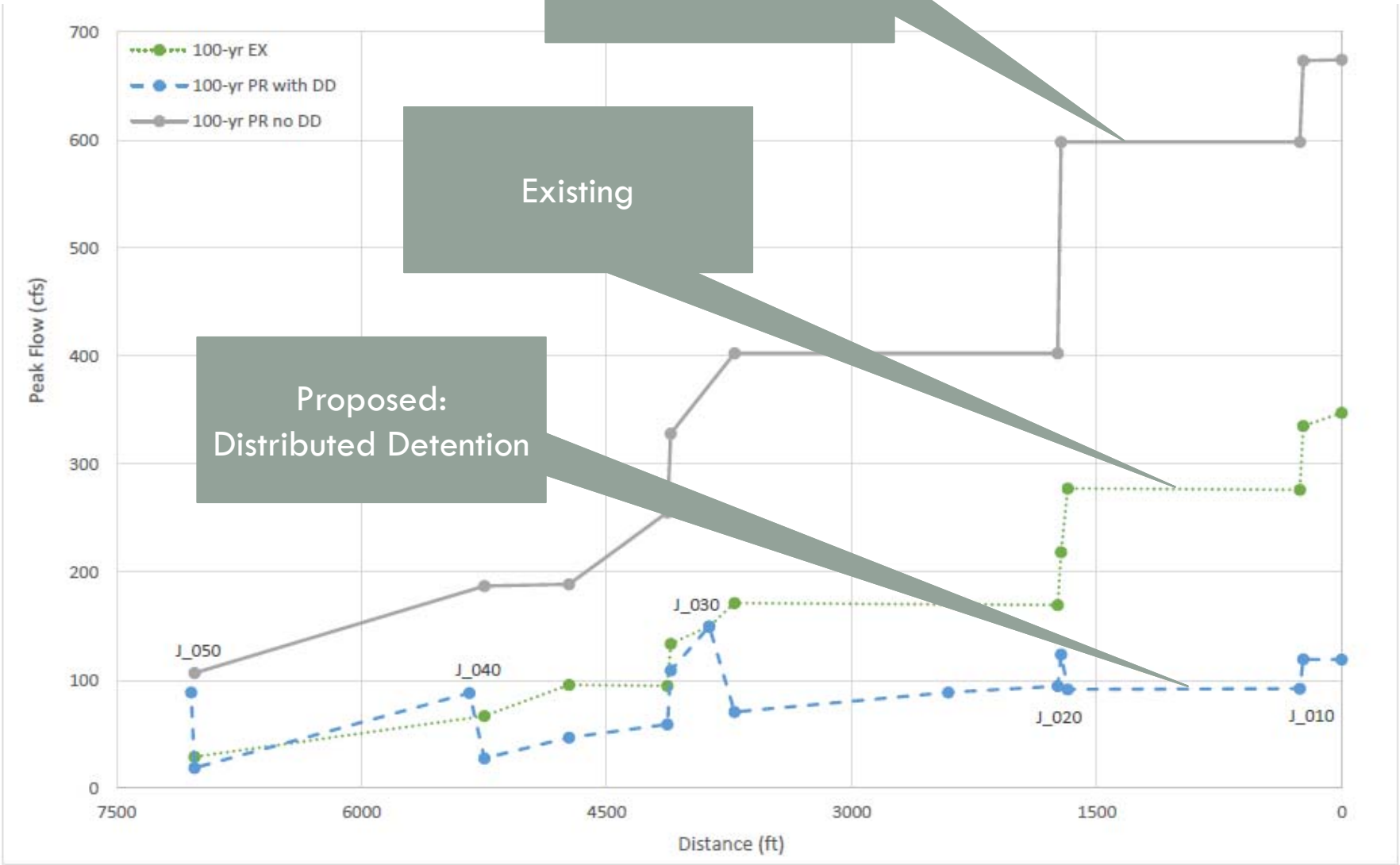
Low Maintenance Stream Distributed Detention

Stormwater Layout

Traditional

Low Maintenance Stream (Distributed Detention)

West Stroh Hydraulic Profile – 100-yr Event

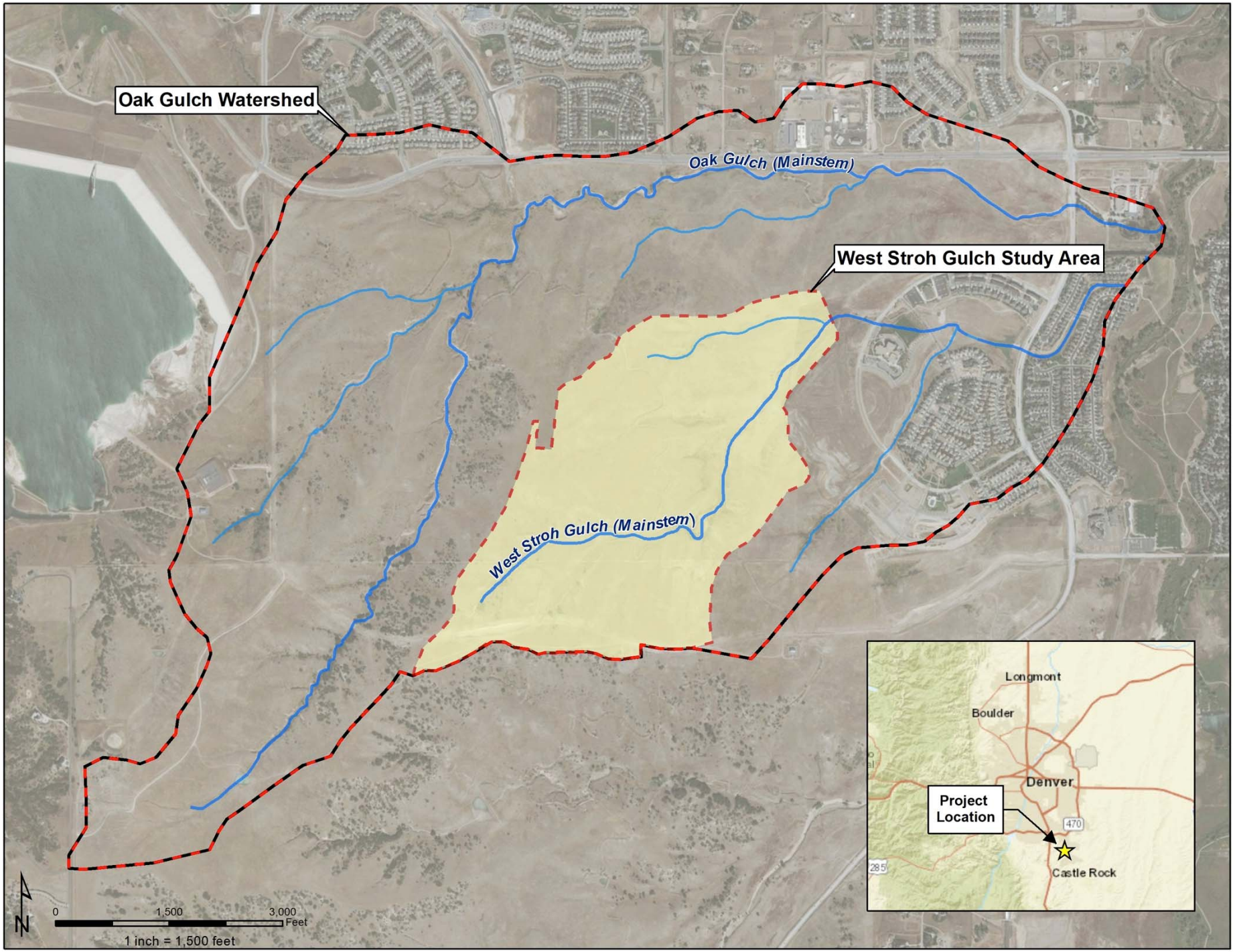


West Stroh Tributary Cost

Watershed Framework Stroh Ranch
Service Plan Cost Comparison

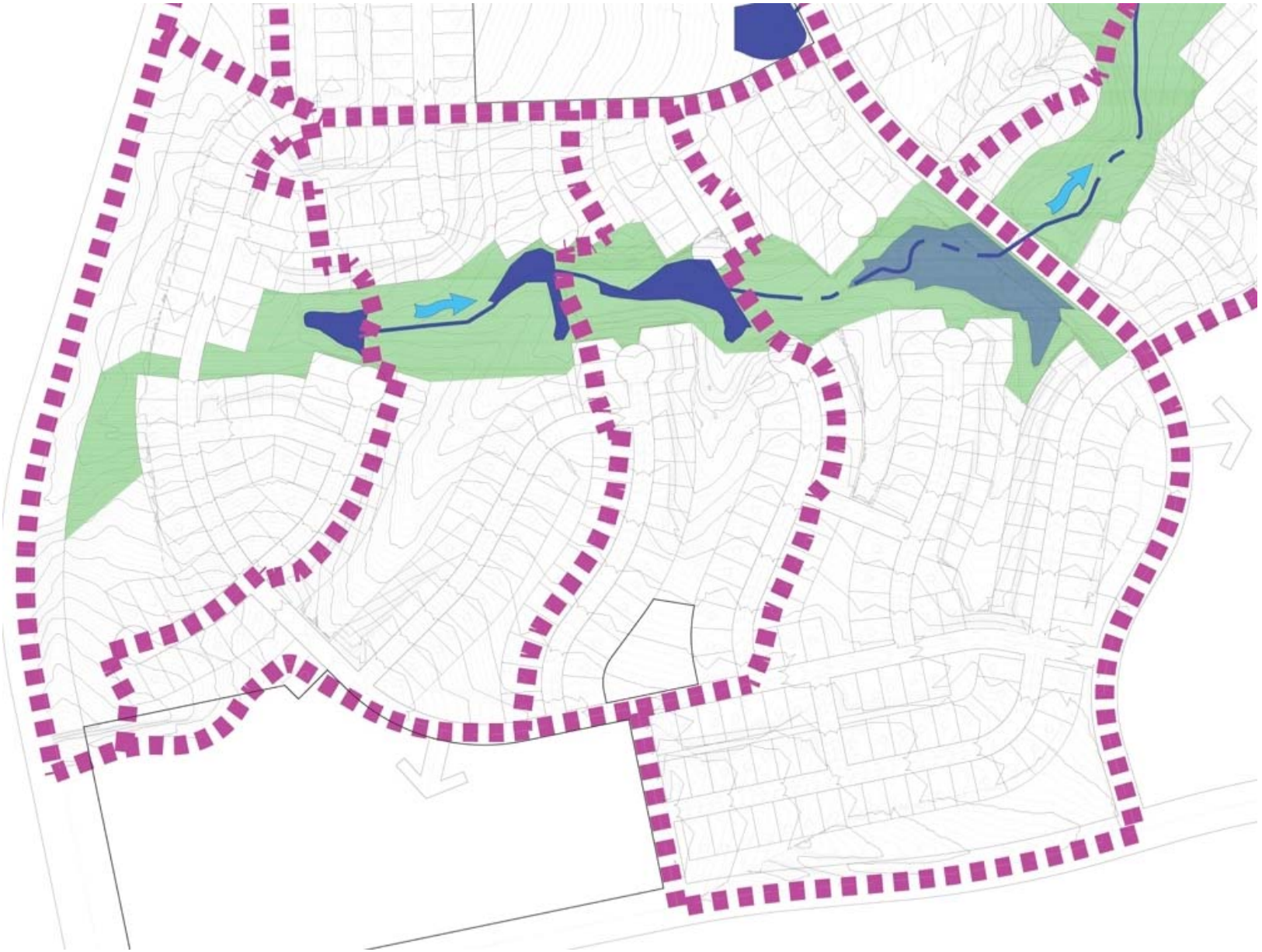
	Estimated Cost	
	Traditional Approach	Low Maintenance Stream Approach
Stream Restoration		
	$9,888,227	$5,778,192

Modeling

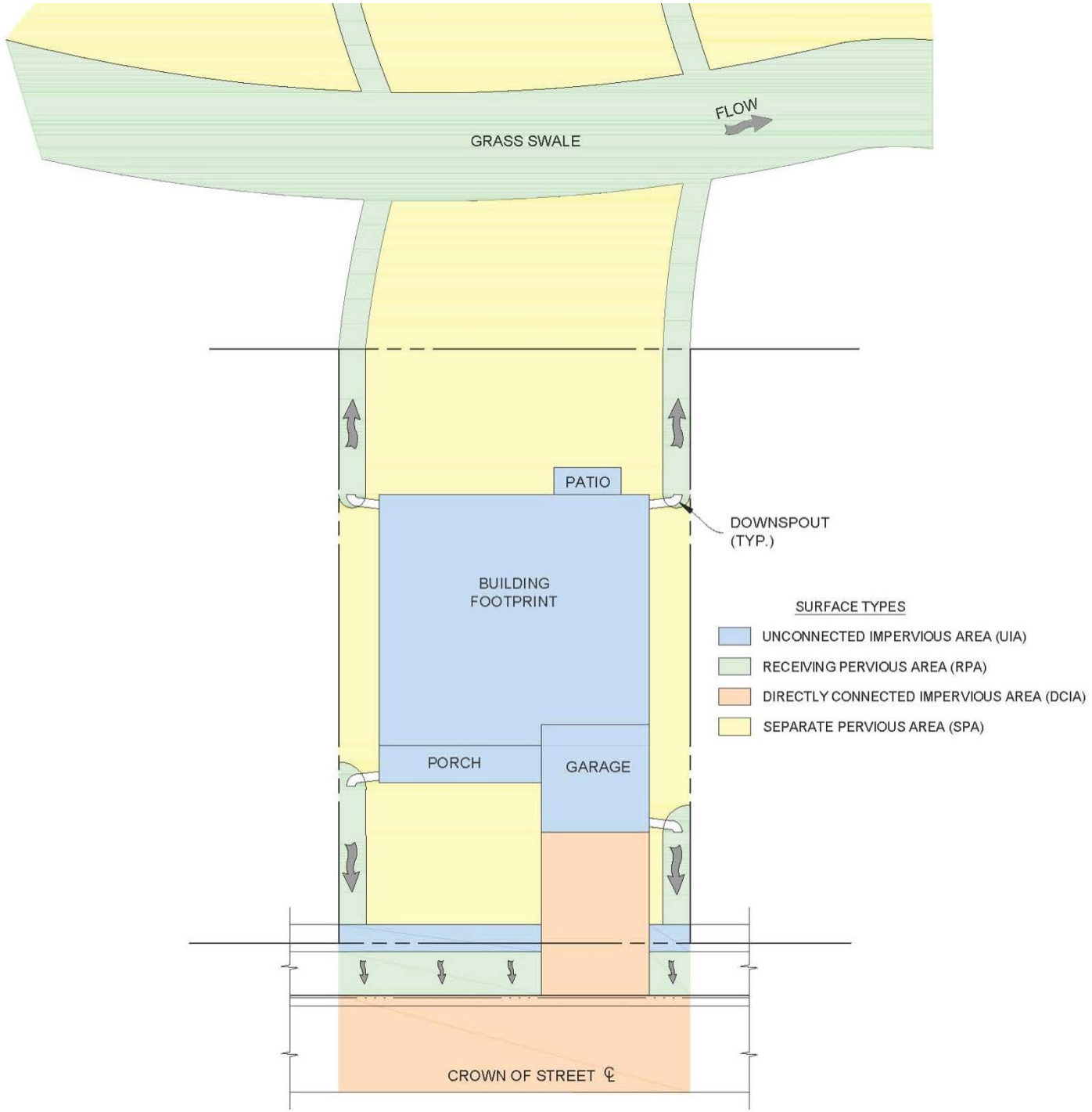

Oak Gulch Watershed
Oak Gulch (Mainstem)
West Stroh Gulch Study Area
West Stroh Gulch (Mainstem)
Longmont
Boulder
Denver
Project Location
470
285
Castle Rock
N
0
1,500
3,000
Feet
1 inch = 1,500 feet

Scenario 1: A-Scale

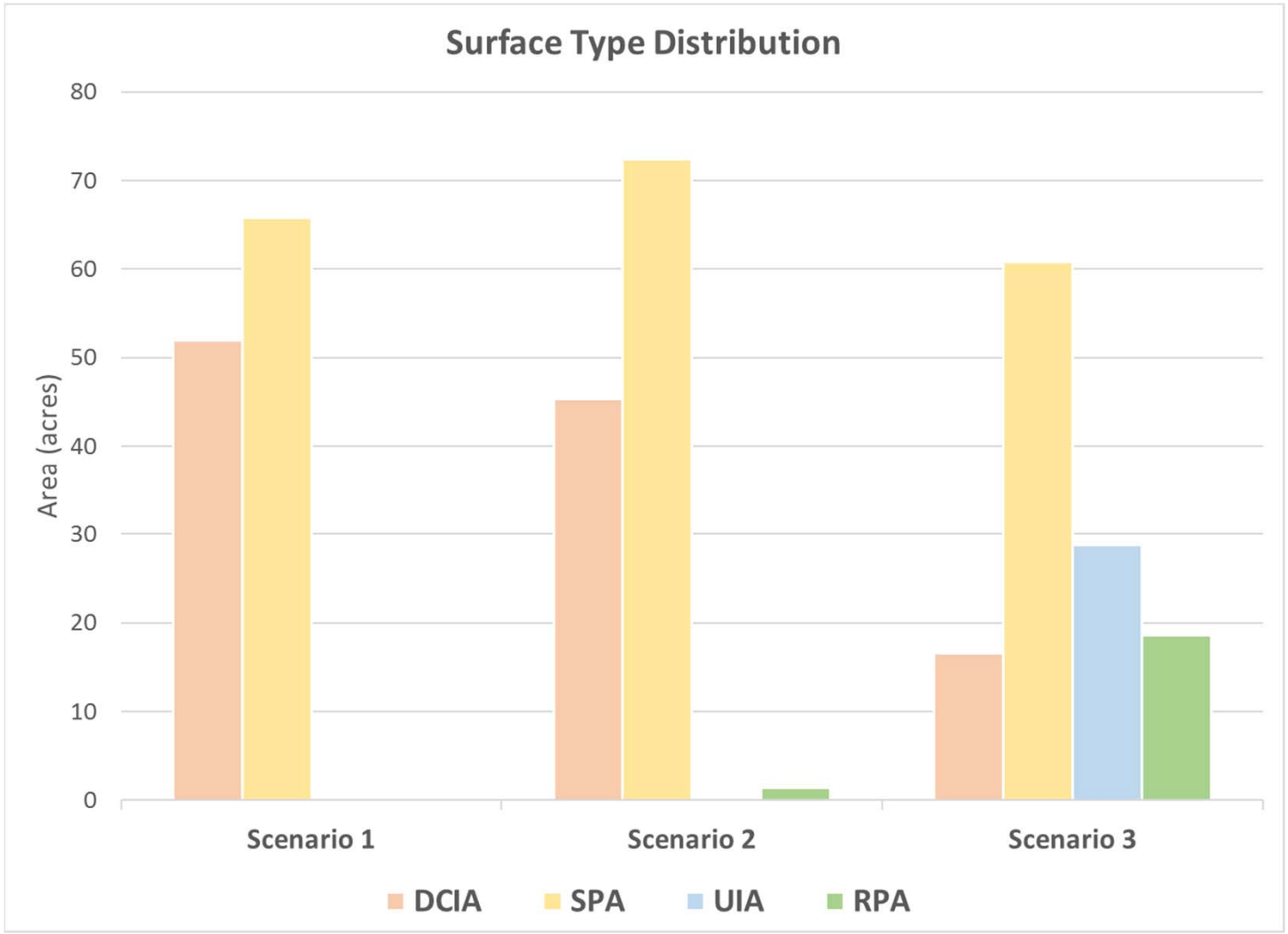
Scenario 2: B-Scale

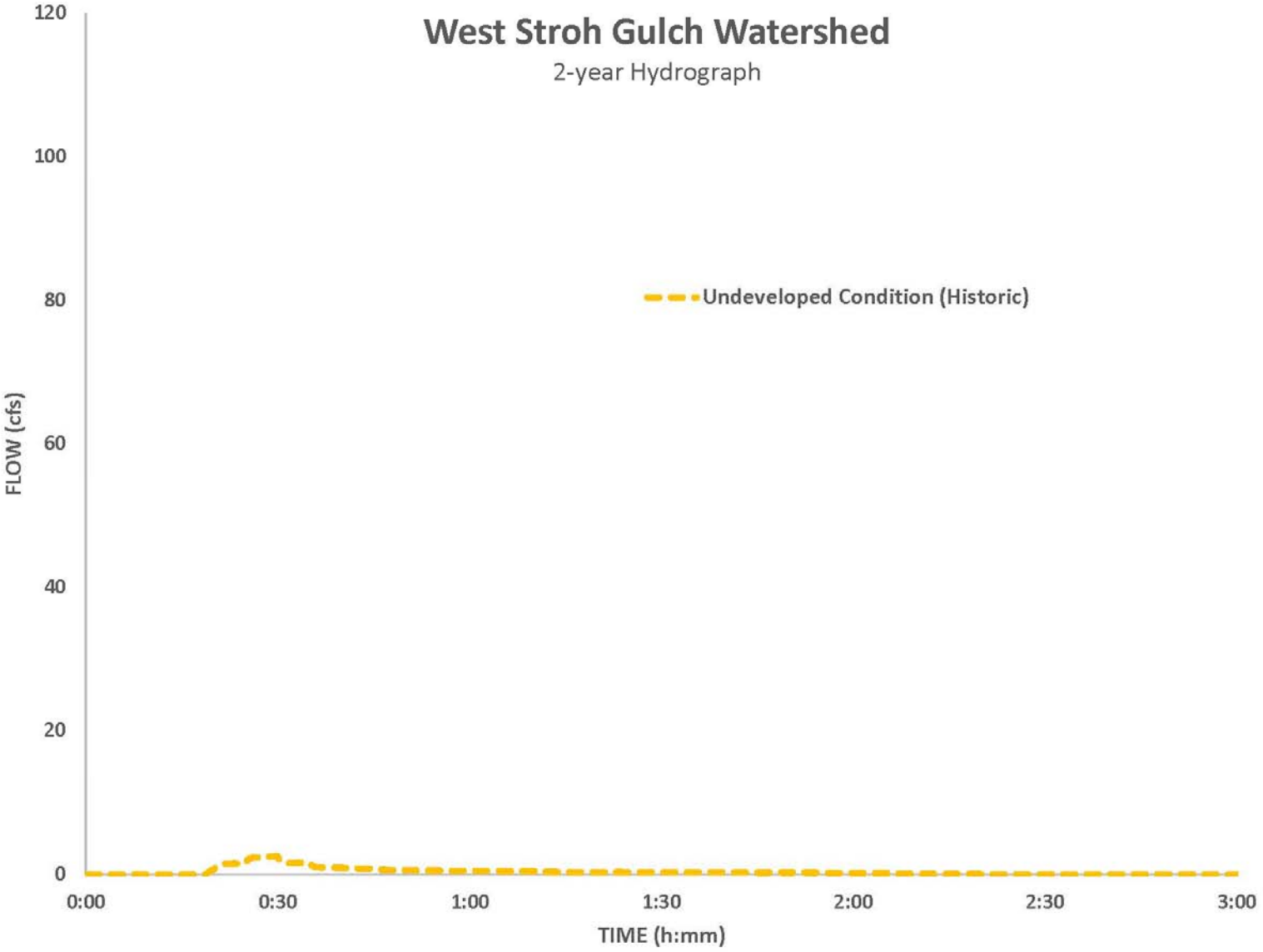


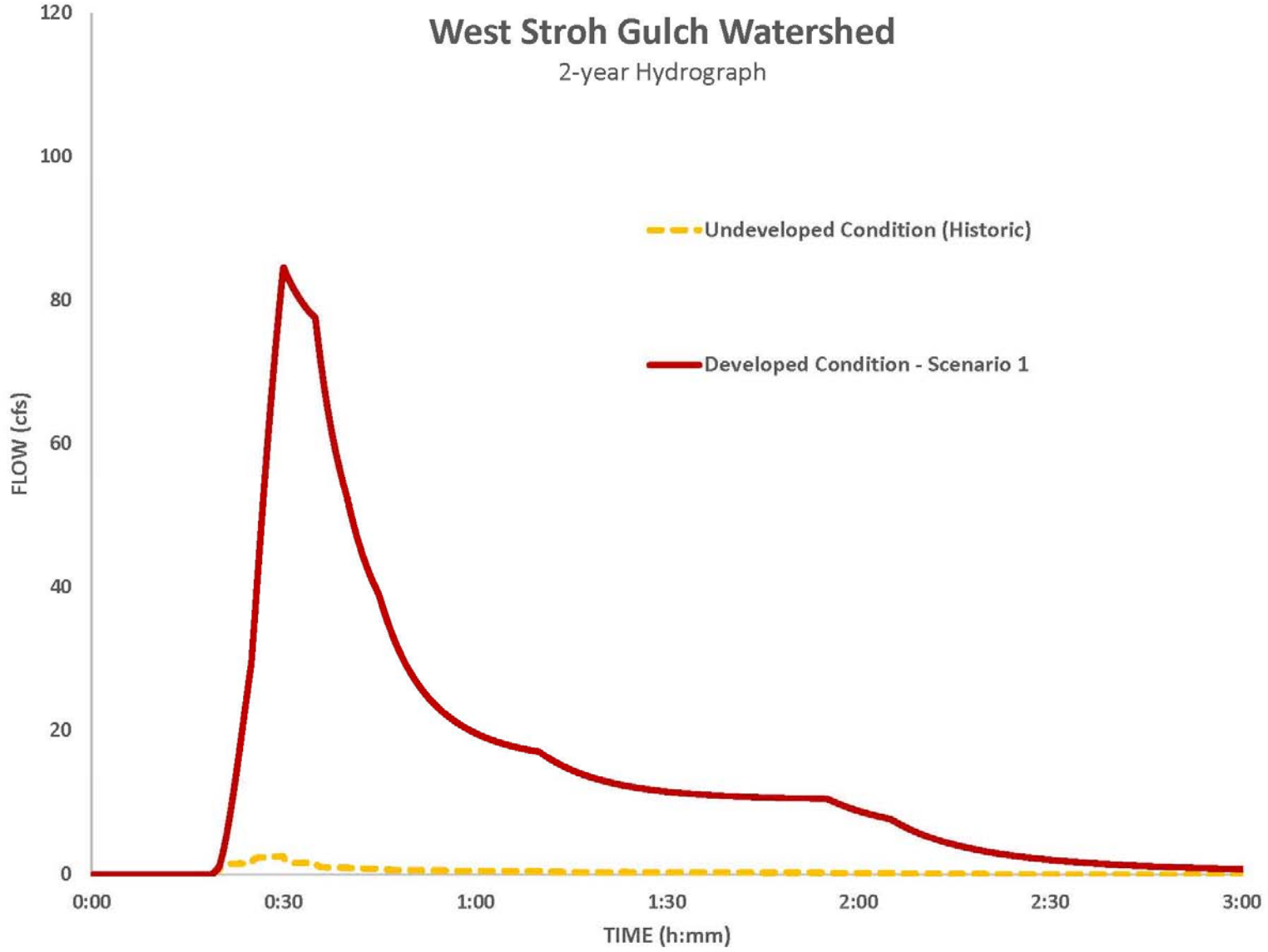
Scenario 3: C-Scale

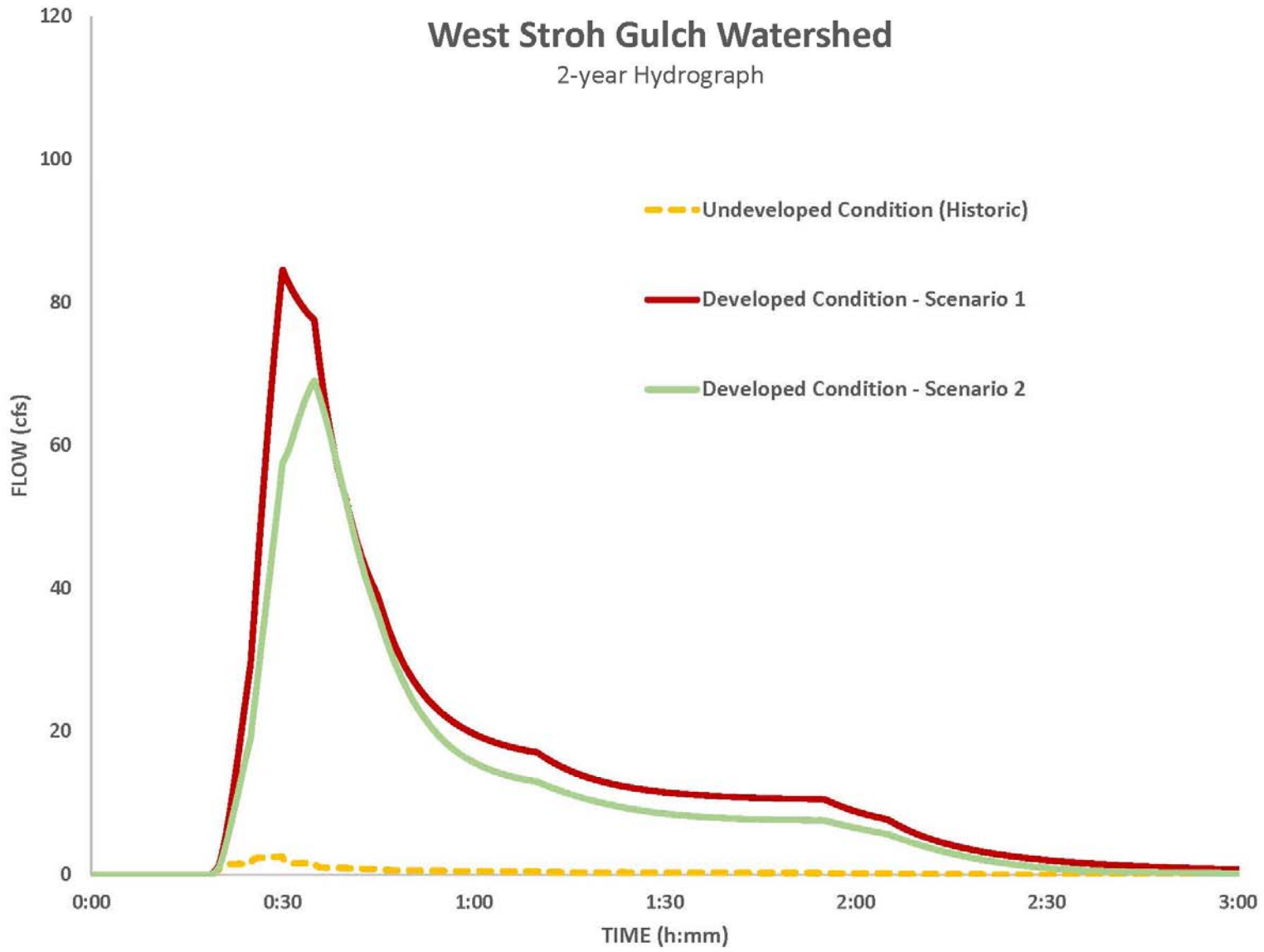

GRASS SWALE
FLOW
PATIO
DOWNSPOUT
(TYP.)
BUILDING
FOOTPRINT
PORCH
GARAGE
CROWN OF STREET ℄
SURFACE TYPES
UNCONNECTED IMPERVIOUS AREA (UIA)
RECEIVING PERVIOUS AREA (RPA)
DIRECTLY CONNECTED IMPERVIOUS AREA (DCIA)
SEPARATE PERVIOUS AREA (SPA)

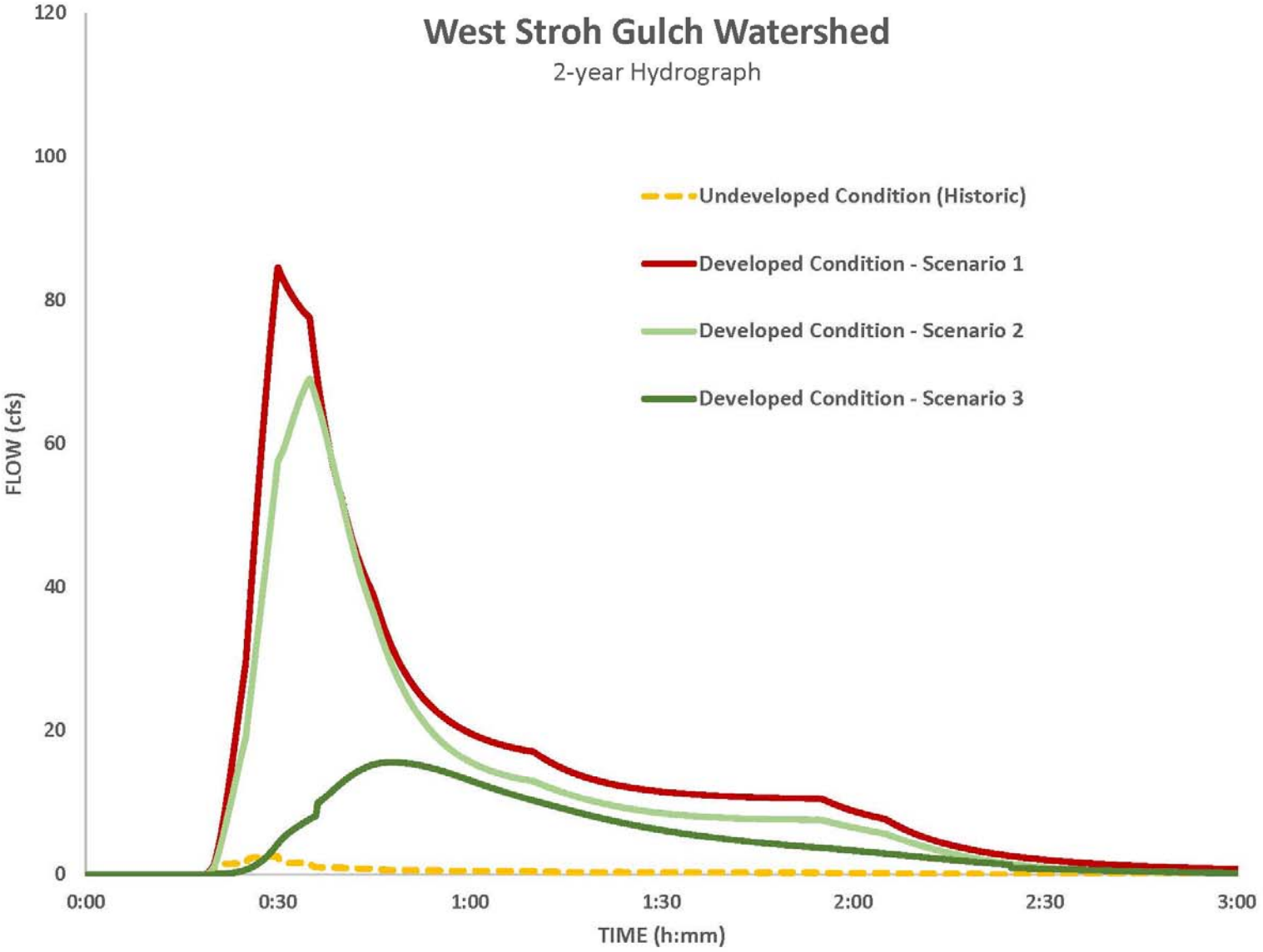
Cover-type Distribution

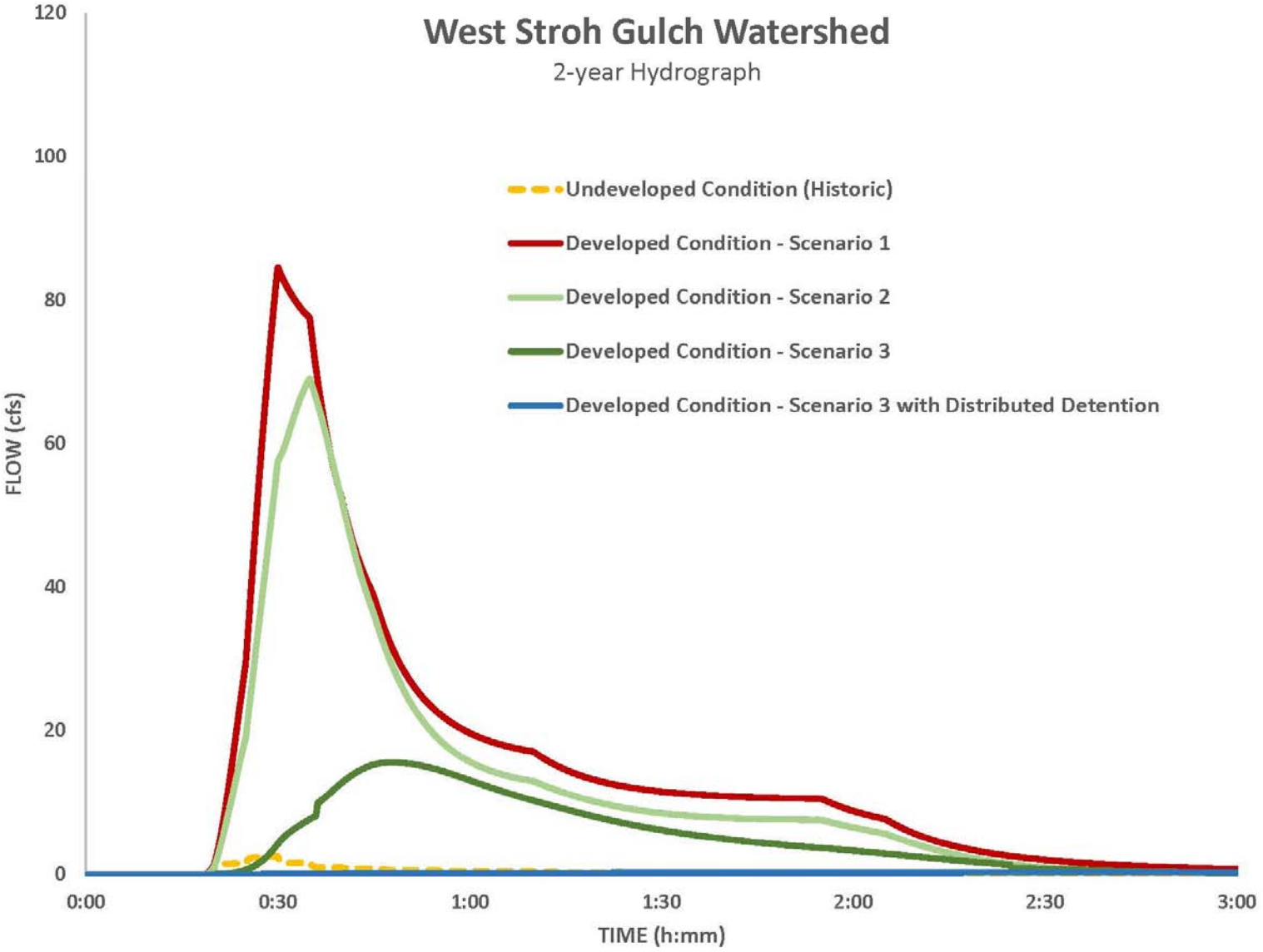



West Stroh Gulch Watershed
2-year Hydrograph
Undeveloped Condition (Historic)
FLOW (cfs)
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
TIME (h:mm)


West Stroh Gulch Watershed
2-year Hydrograph
Undeveloped Condition (Historic)
Developed Condition - Scenario 1
FLOW (cfs)
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
TIME (h:mm)


West Stroh Gulch Watershed
2-year Hydrograph
Undeveloped Condition (Historic)
Developed Condition - Scenario 1
Developed Condition - Scenario 2
FLOW (cfs)
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
TIME (h:mm)

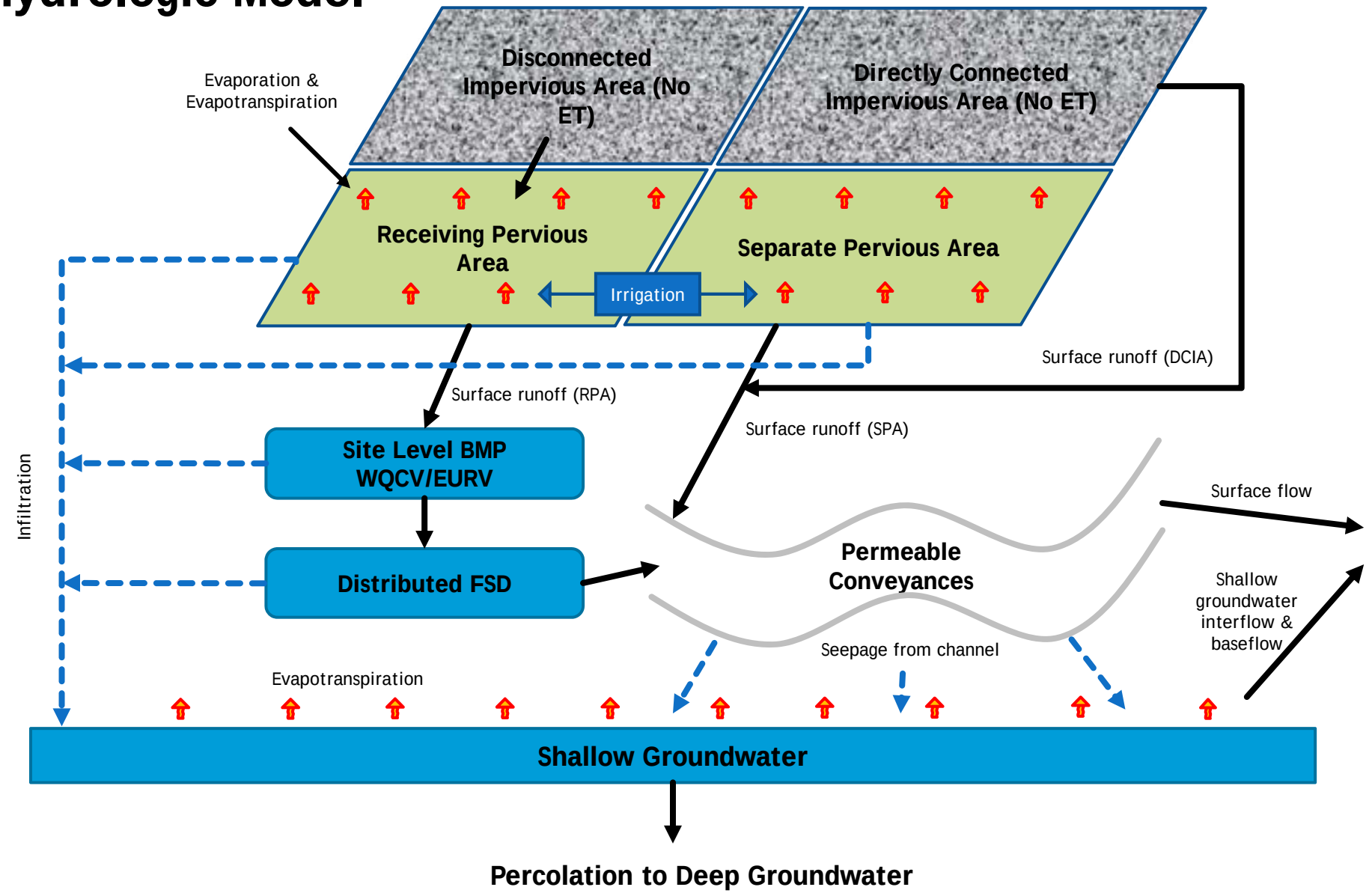

West Stroh Gulch Watershed
2-year Hydrograph
Undeveloped Condition (Historic)
Developed Condition - Scenario 1
Developed Condition - Scenario 2
Developed Condition - Scenario 3
FLOW (cfs)
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
TIME (h:mm)


West Stroh Gulch Watershed
2-year Hydrograph
Undeveloped Condition (Historic)
Developed Condition - Scenario 1
Developed Condition - Scenario 2
Developed Condition - Scenario 3
Developed Condition - Scenario 3 with Distributed Detention
FLOW (cfs)
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
TIME (h:mm)

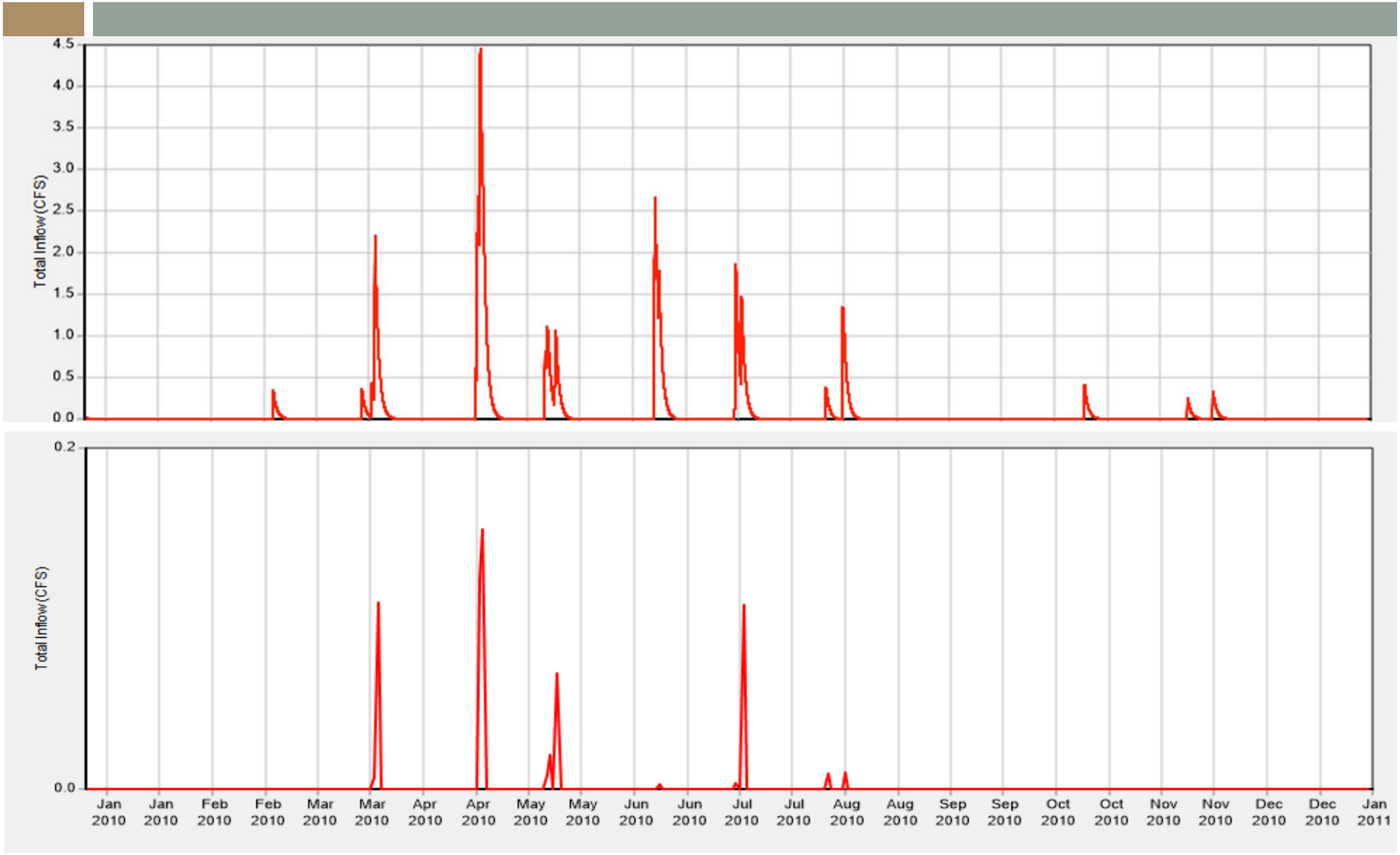
Continuous Simulation

- Water budget analysis
- Rainfall time series
- Evapotranspiration & groundwater
- Accounting for irrigation
- Why do continuous simulation?

Conceptual Hydrologic Model



SWMM Hydrographs – Traditional versus Green



Technical Conclusions

- Traditional modeling practices for stormwater master planning are at a scale that fails to capture many watershed processes that affect infiltration.
- Often, the tributary network upstream of a regional detention facility is sacrificed for development.
- Using a distributed approach protects or recreates the functions of the lower order tributary network.
- Benefits reduce the peak rates and volumes of runoff for design events and help shift the water budget back toward a more natural condition.
- For the study area, the low-maintenance stream approach with distributed FSD results in infrastructure savings of approximately 20%, while providing a more aesthetic and environmentally sensitive approach to managing stormwater runoff.

Lessons Learned

- Early communication of expectations, minimize later costs and frustrations
- Understand which type of developer/landowner you are working with
- Development regulations vary between municipalities
- Incentives based on runoff reduction need to be clearly defined
- Requires close coordination with Planning Department, Developer, H&H modeler
- This pilot needs to culminate in documentation that is easy to understand and follow

Acknowledgements

- EWRI Task Committee - Implementing a Watershed Approach to Manage Stormwater as a Resource for Urban Stream Systems

- Project Collaborators – Harris Kocher Smith, Norris Design, Matrix Design Group, Redland Consulting, DTJ Design, and Stantec

Questions & Answers

Jacob James, P.E., CFM
Town of Parker
Stormwater Manager
jjames@parkeronline.org

Andrew Earles, Ph.D., P.E.
Wright Water Engineers, Inc.
aearles@wrightwater.com

Jim Wulliman, P.E. Sara Johnson, P.E., CFM
Muller Engineering Company
Jwulliman@mullereng.com

Barbara Chongtoua, P.E.
Urban Drainage & Flood Control District
bchongtoua@udfcd.org