# Implementing a Watershed Approach for Stormwater: A User's Manual

2017 UDFCD Annual Seminar

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Project Manager

Stream Services Program

# User's Manual

How to

- **Develop** the watershed with **a win-win mental model**
- **Convey rainfall** through the watershed **to reduce runoff**
- **Convey runoff** through streams **to reduce risk and costs**

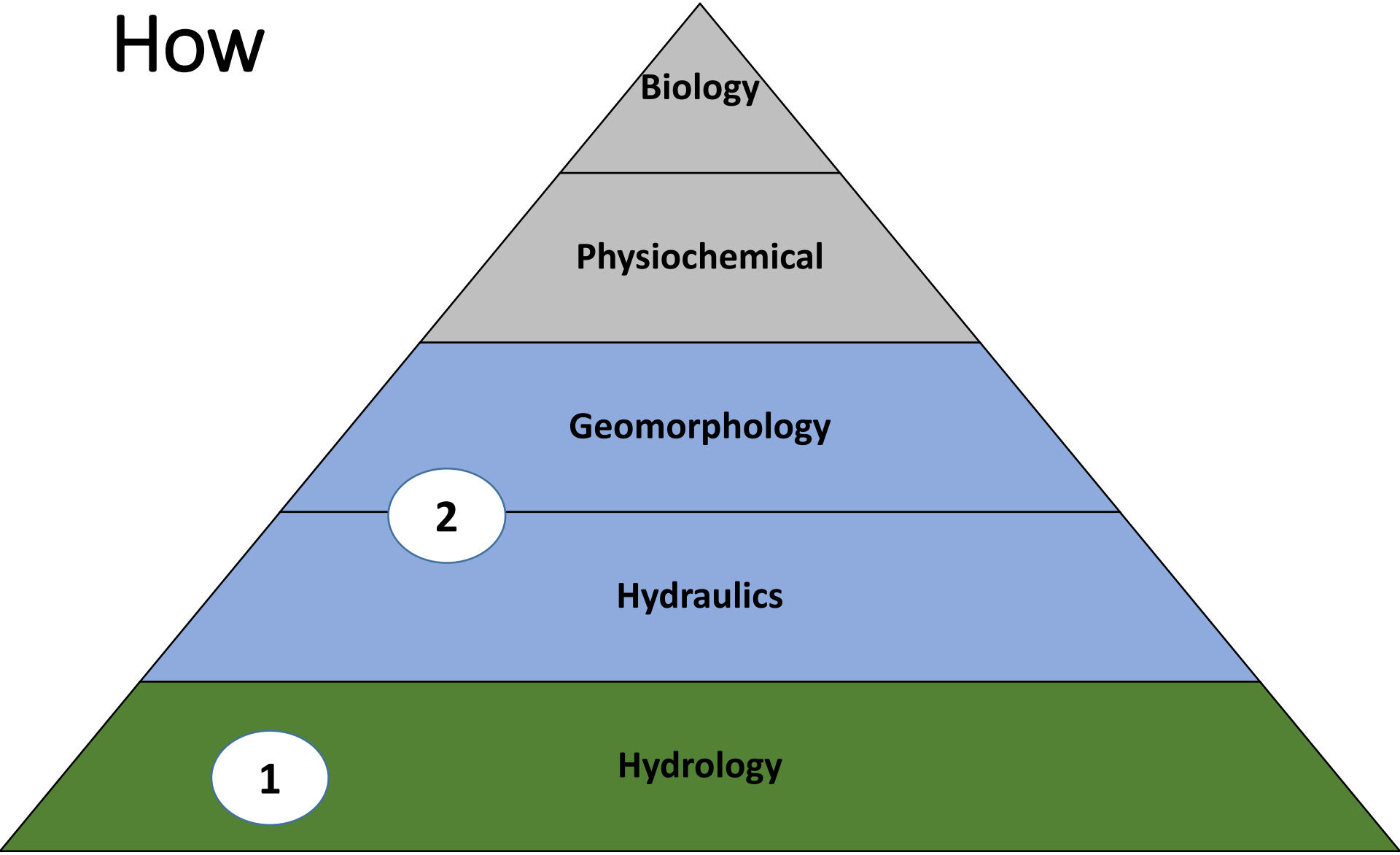
# Why

**Get more benefits from what we build**

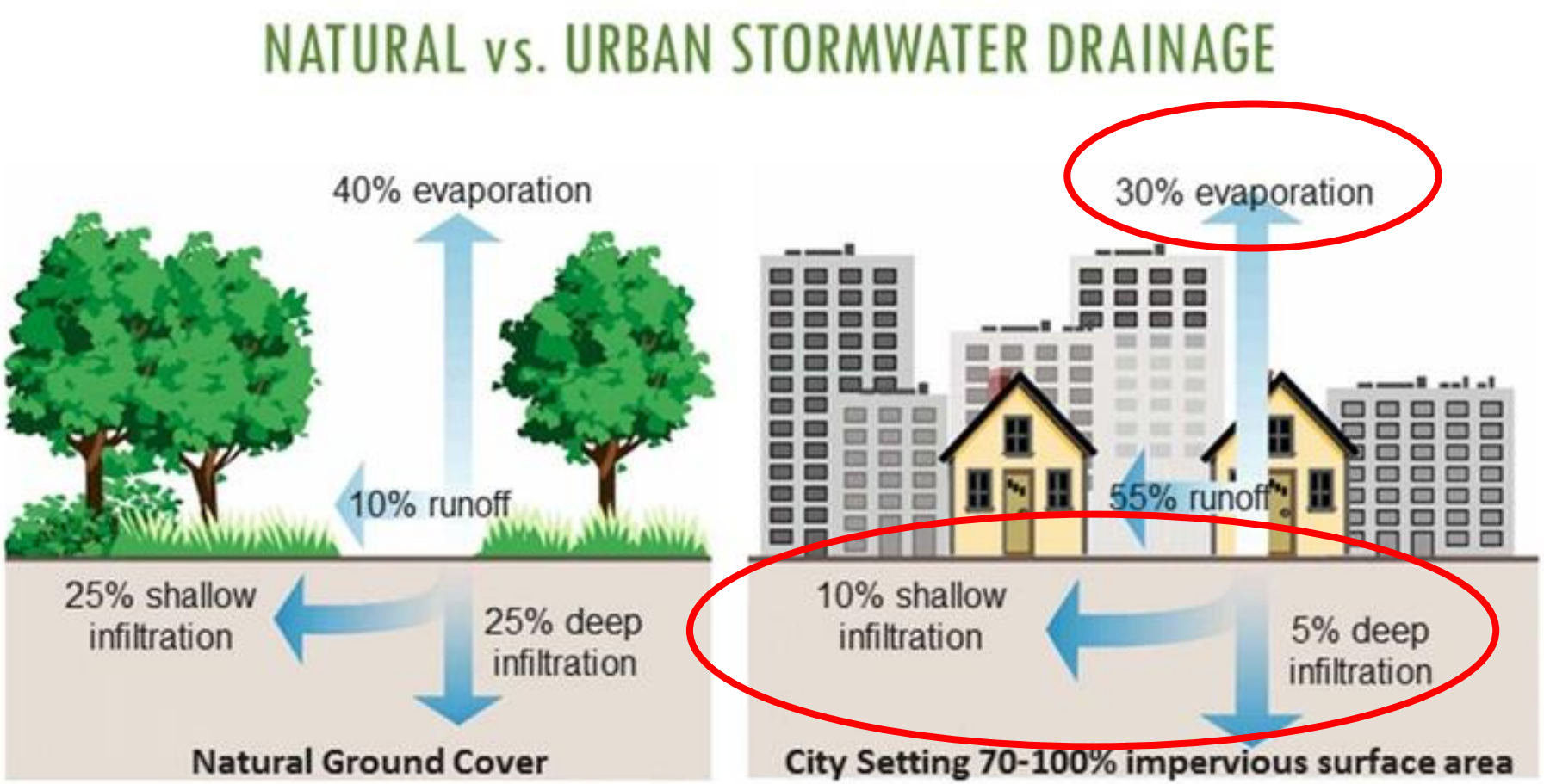
**and**

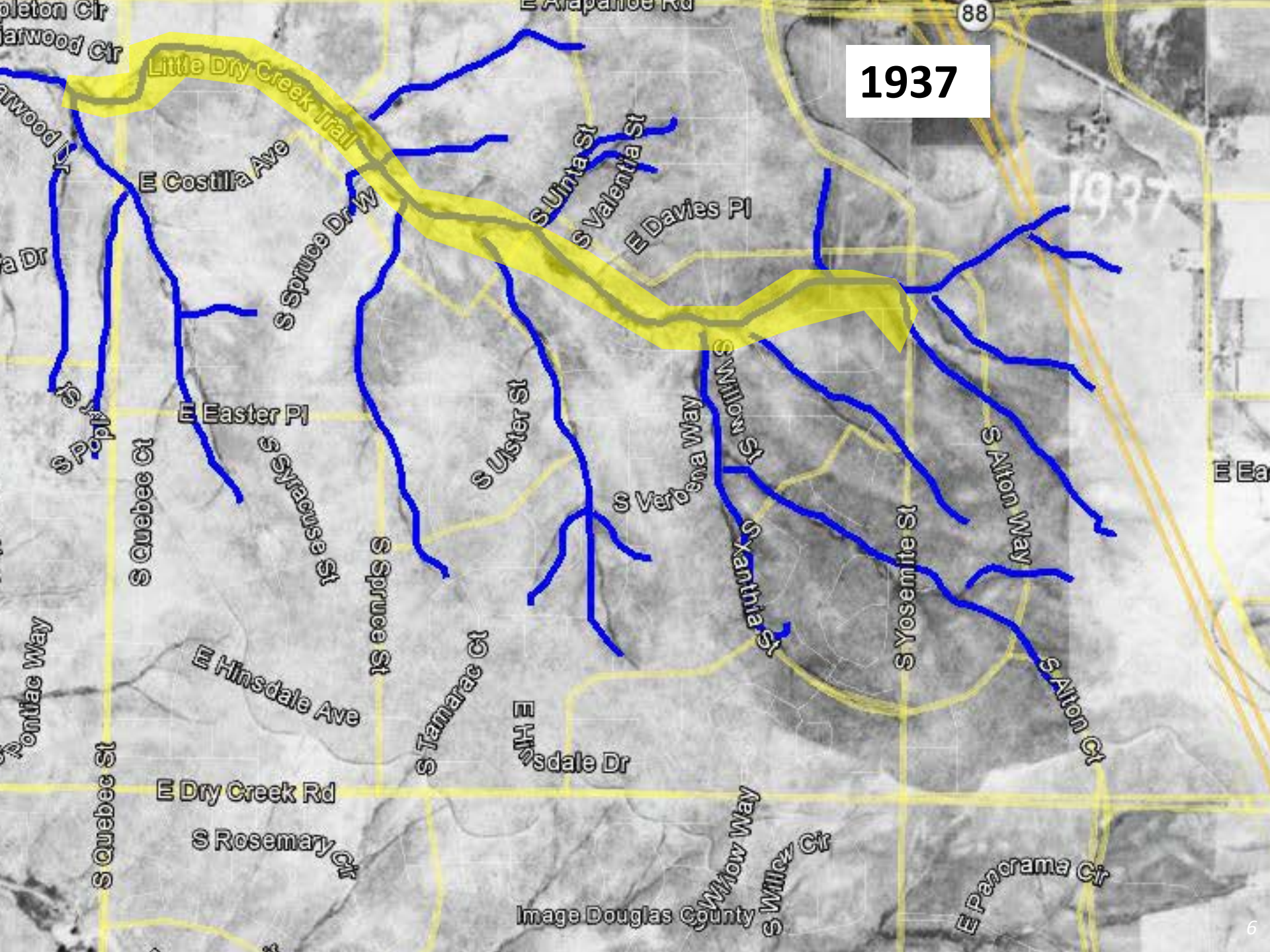
**Spend less building**

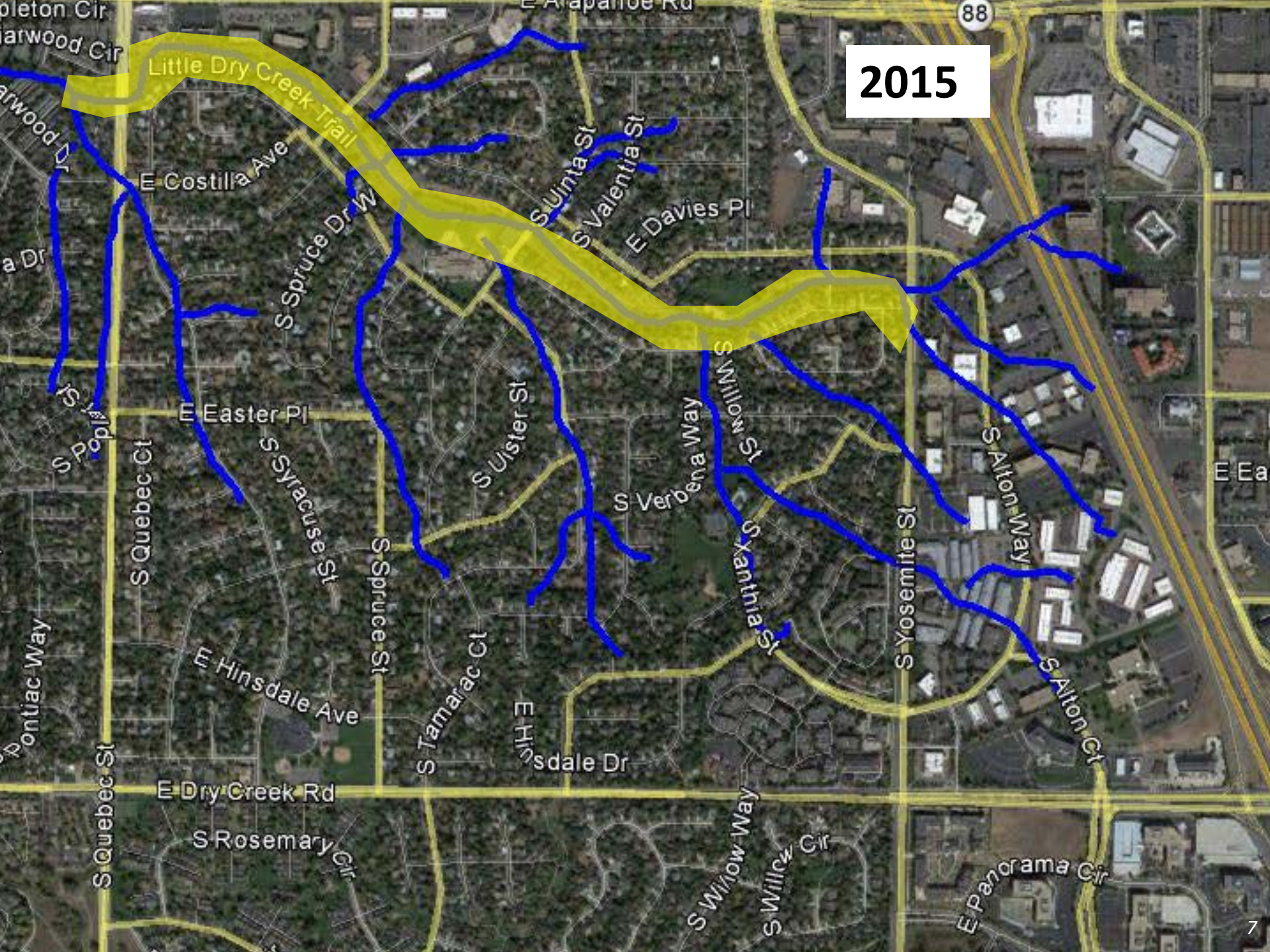
# How


Biology
Physiochemical
Geomorphology
2
Hydraulics
1
Hydrology

# Hydrology


NATURAL vs. URBAN STORMWATER DRAINAGE
40% evaporation
10% runoff
25% shallow infiltration
25% deep infiltration
Natural Ground Cover
30% evaporation
55% runoff
10% shallow infiltration
5% deep infiltration
City Setting 70-100% impervious surface area


1937
Little Dry Creek Trail
E Costilla Ave
S Spruce Dr W
S Uinta St
S Valentia St
E Davies Pl
S Willow St
S Verbena Way
S Xanthia St
S Alton Way
S Yosemite St
S Alton Ct
E Easter Pl
S Quebec Ct
S Syracuse St
S Ulster St
S Spruce St
S Tamarac Ct
E Hinsdale Ave
E Hinsdale Dr
S Pontiac Way
S Quebec St
E Dry Creek Rd
S Rosemary Cir
S Willow Way
S Willow Cir
E Panorama Cir
Image Douglas County
88


2015
Little Dry Creek Trail
E Costilla Ave
S Spruce Dr W
S Uinta St
S Valentia St
E Davies Pl
E Easter Pl
S Poplar St
S Quebec Ct
S Syracuse St
S Uster St
S Spruce St
S Verbena Way
S Willow St
S Xanthia St
S Yosemite St
S Alton Way
S Alton Ct
E Hinsdale Ave
S Tamarac Ct
E Hinsdale Dr
E Dry Creek Rd
S Quebec St
S Rosemary Cir
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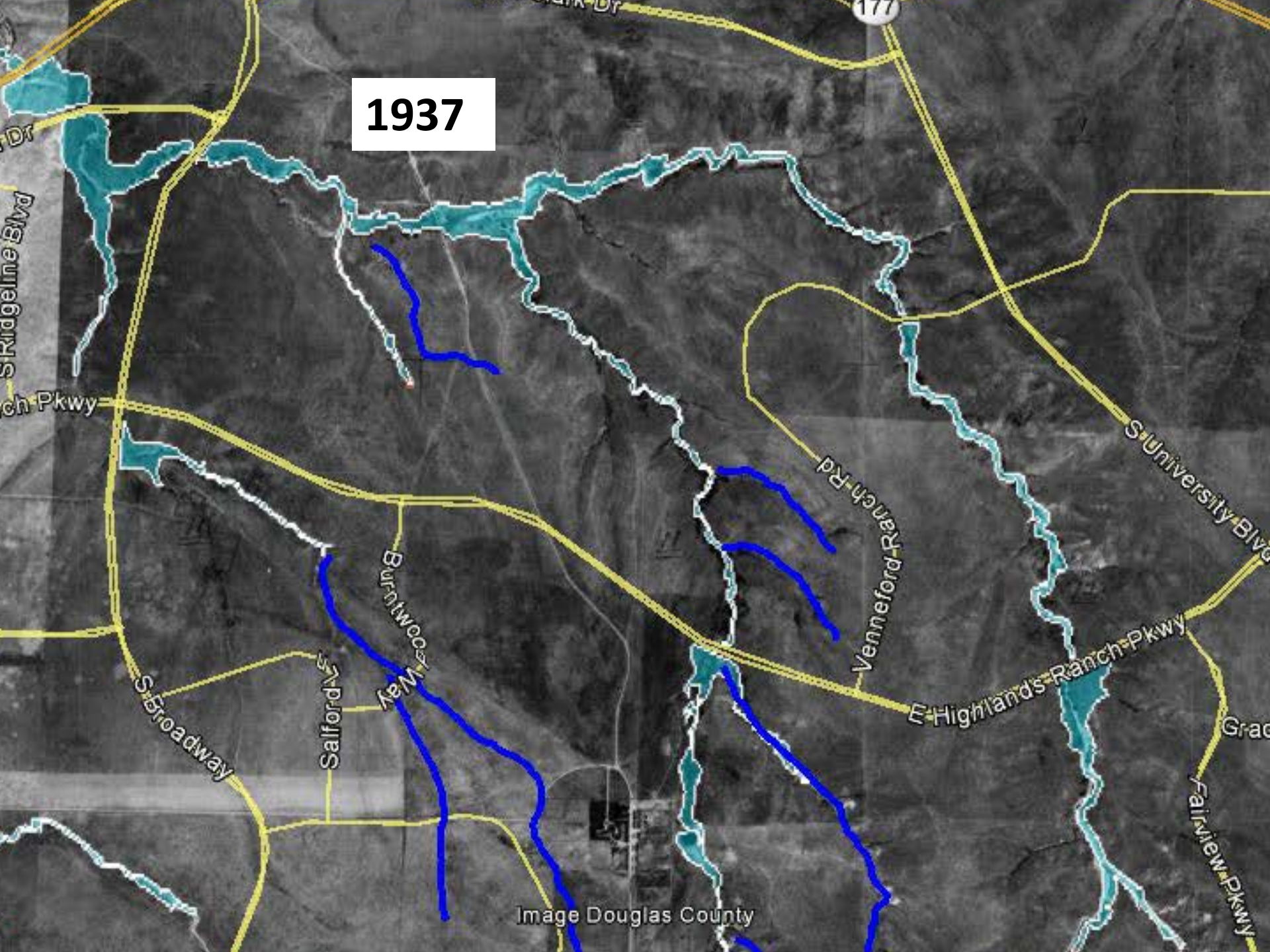
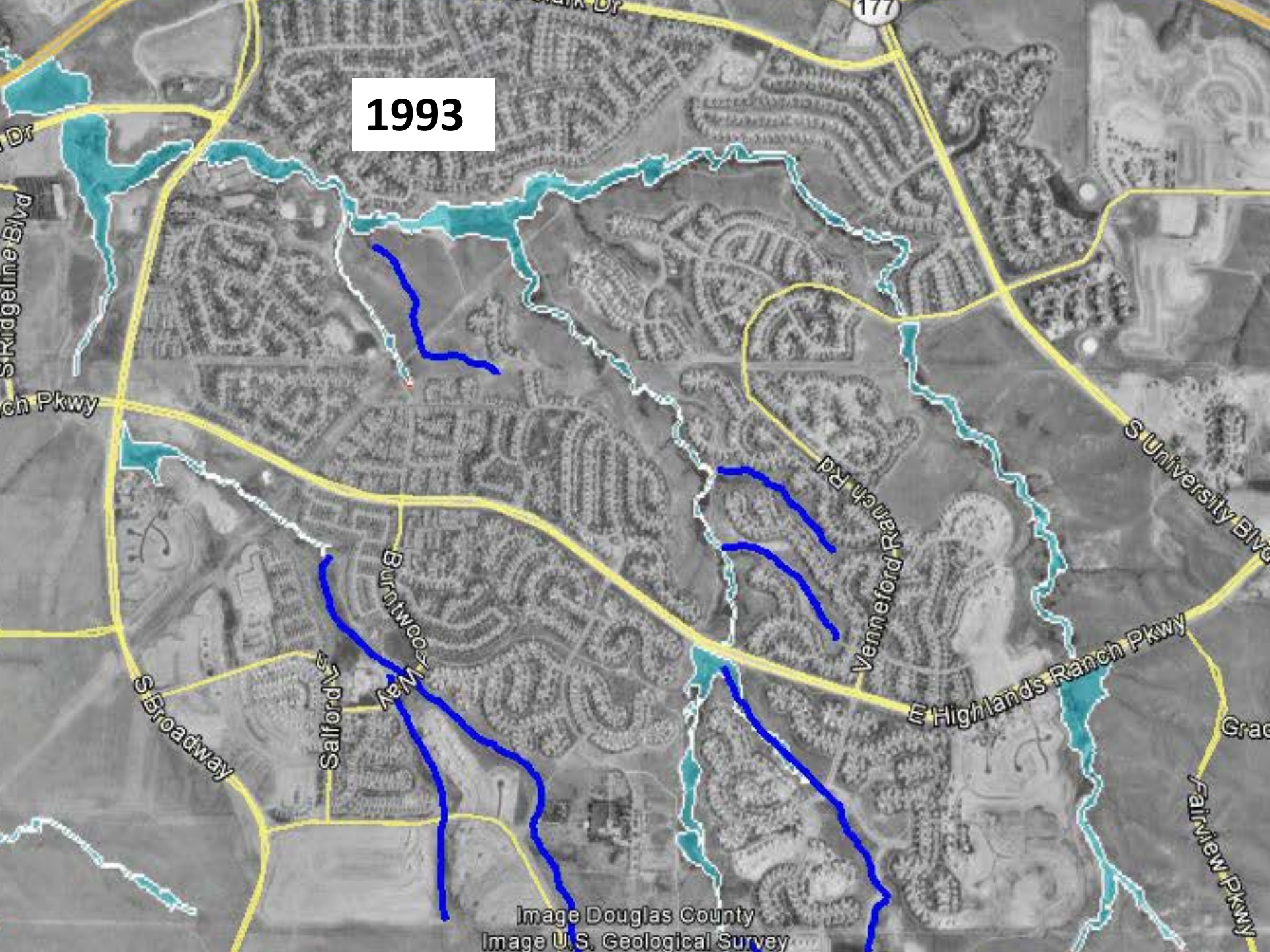
E Panorama Cir
88


1937
S Ridgeline Blvd
ch Pkwy
S Broadway
Salford Way
Burntwood Way
Venneford Ranch Rd
S University Blvd
E Highlands Ranch Pkwy
Fairview Pkwy
Image Douglas County


1993
177
S Ridgeline Blvd
ch Pkwy
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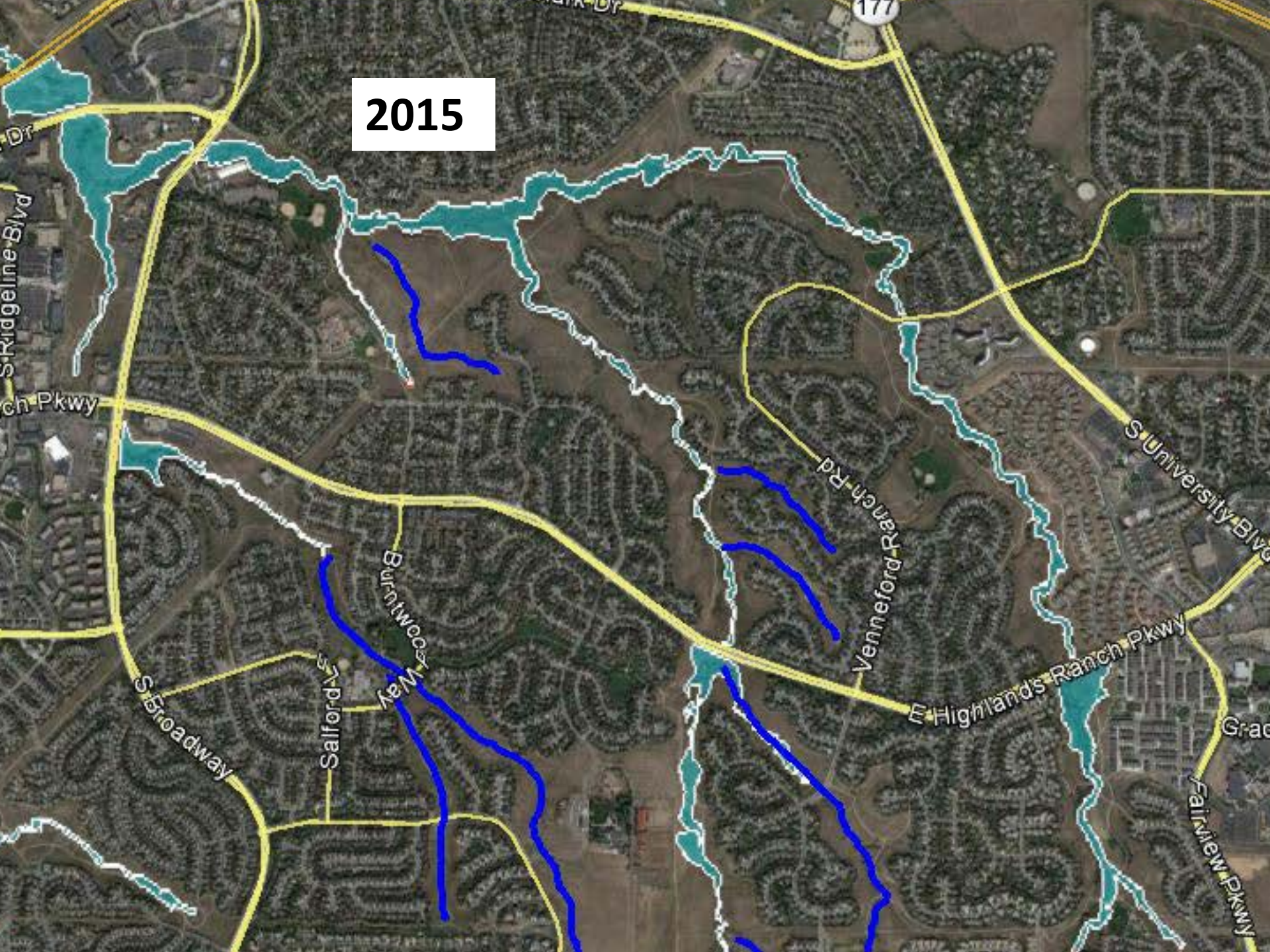
Salford Ln
Burntwood Way
Venneford Ranch Rd
E Highlands Ranch Pkwy
S University Blvd
Fairview Pkwy
Image Douglas County
Image U.S. Geological Survey


2015
S Ridgeline Blvd
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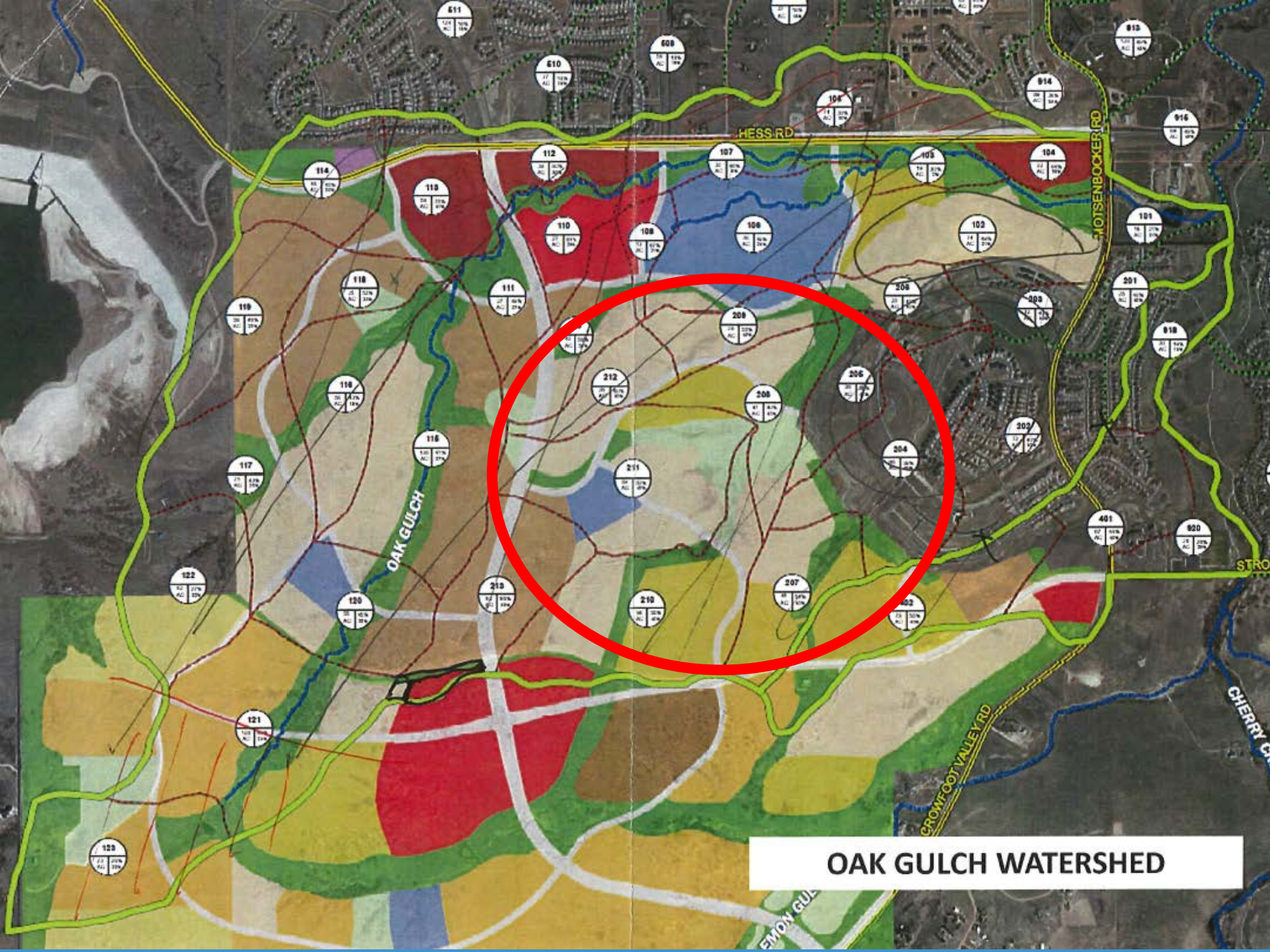
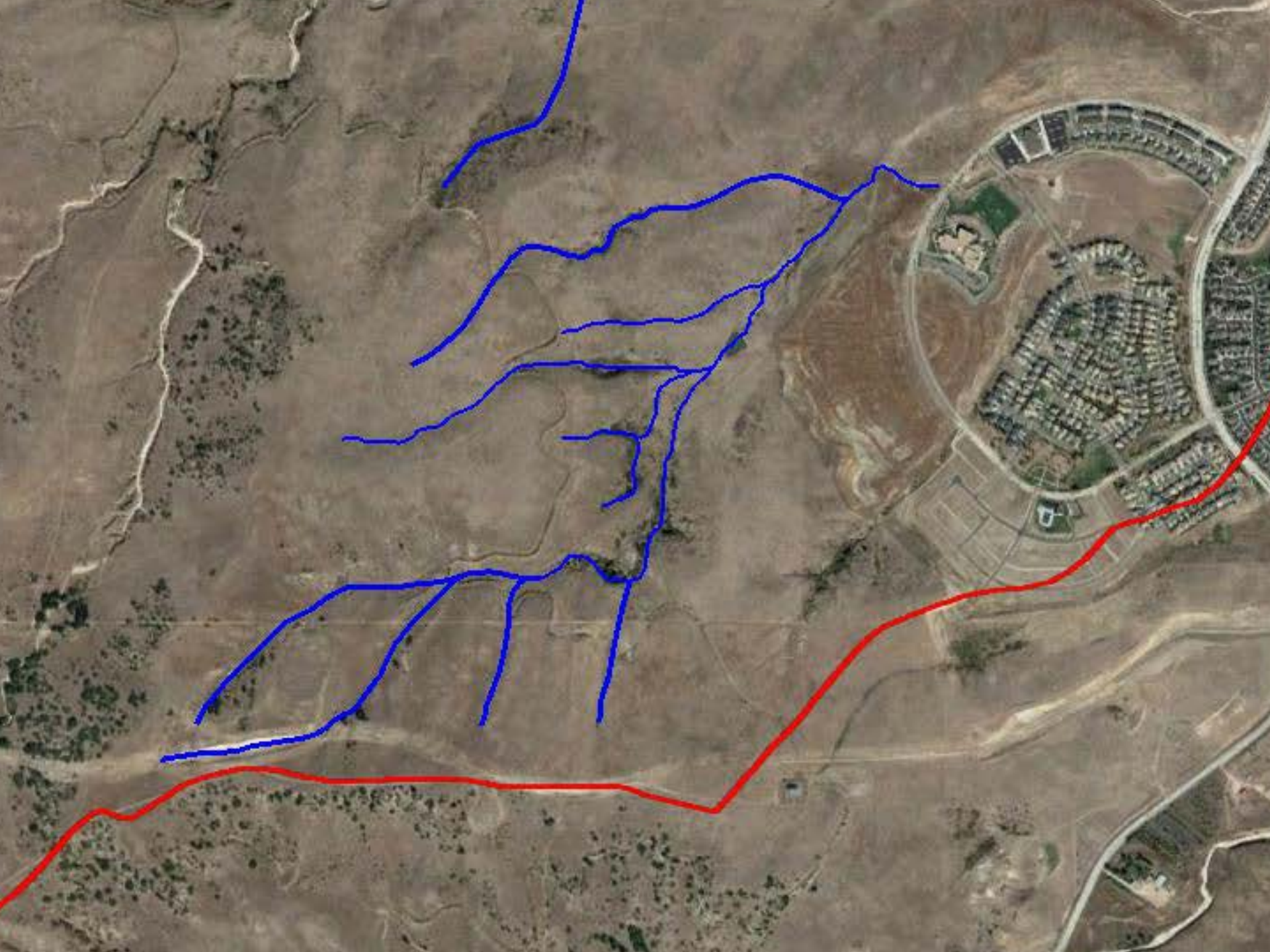
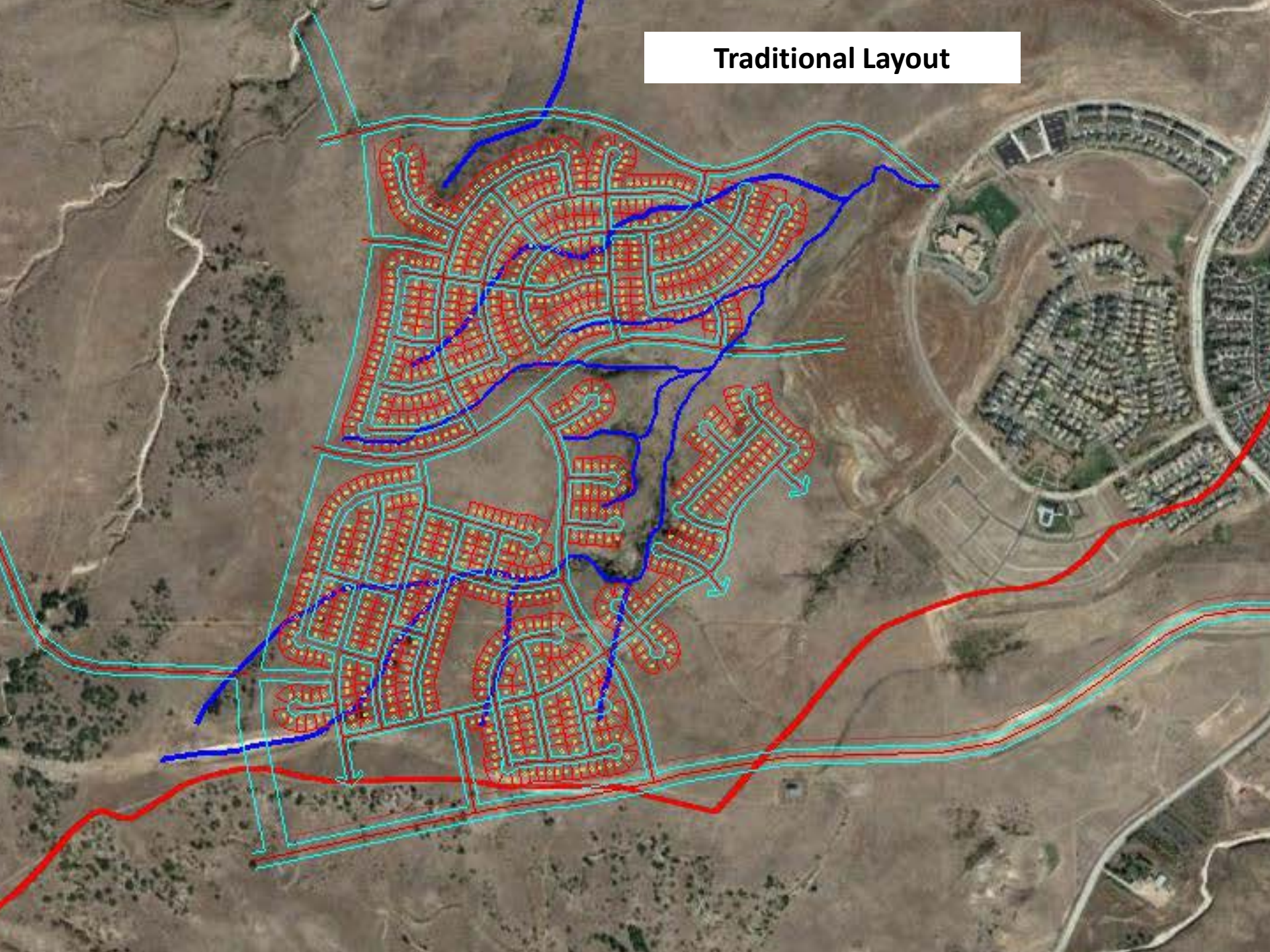
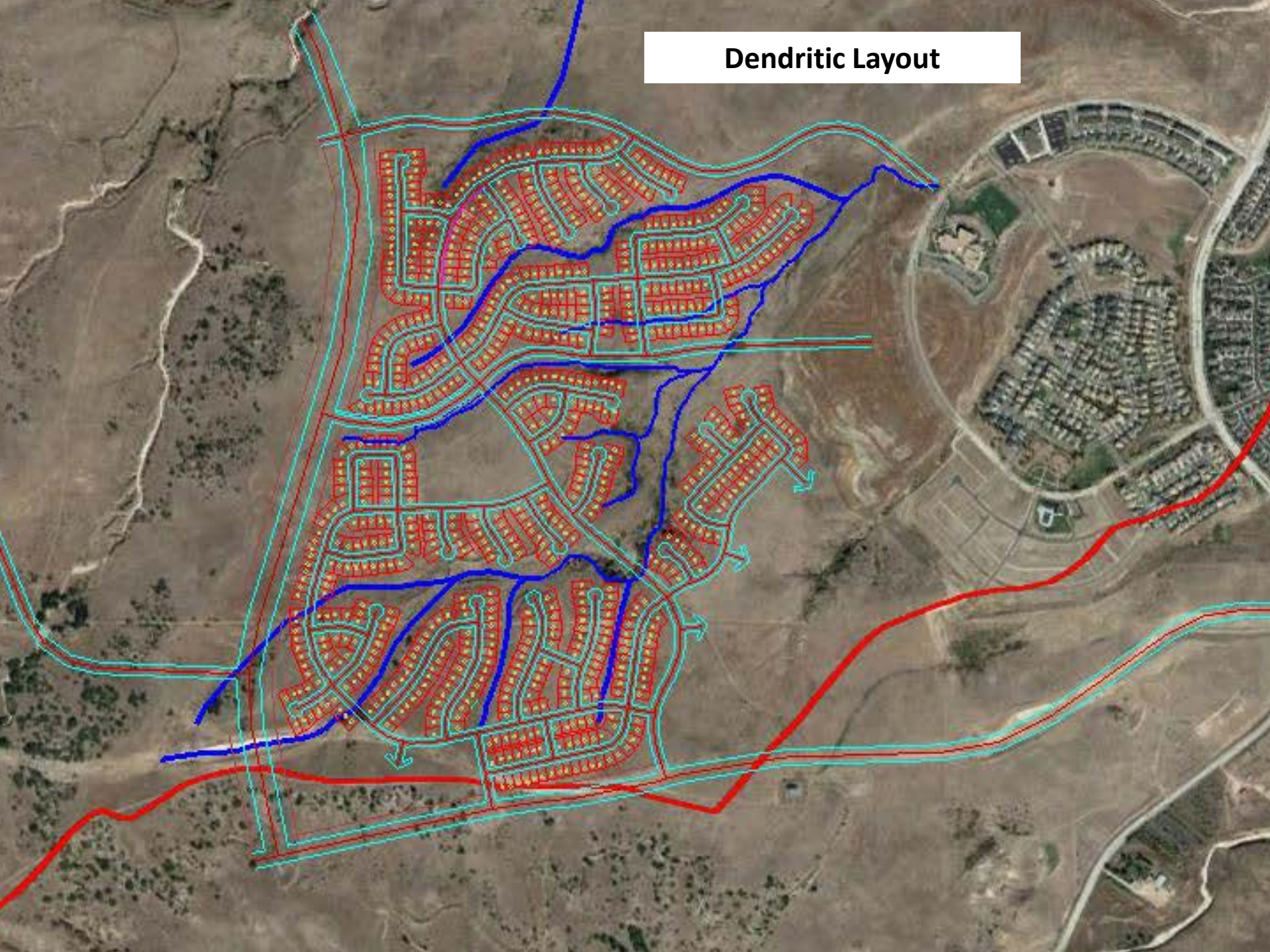
Fairview Pkwy


HESS RD
HOTSENBOOKER RD
OAK GULCH
CROWFOOT VALLEY RD
OAK GULCH WATERSHED




Traditional Layout

# Dendritic Layout

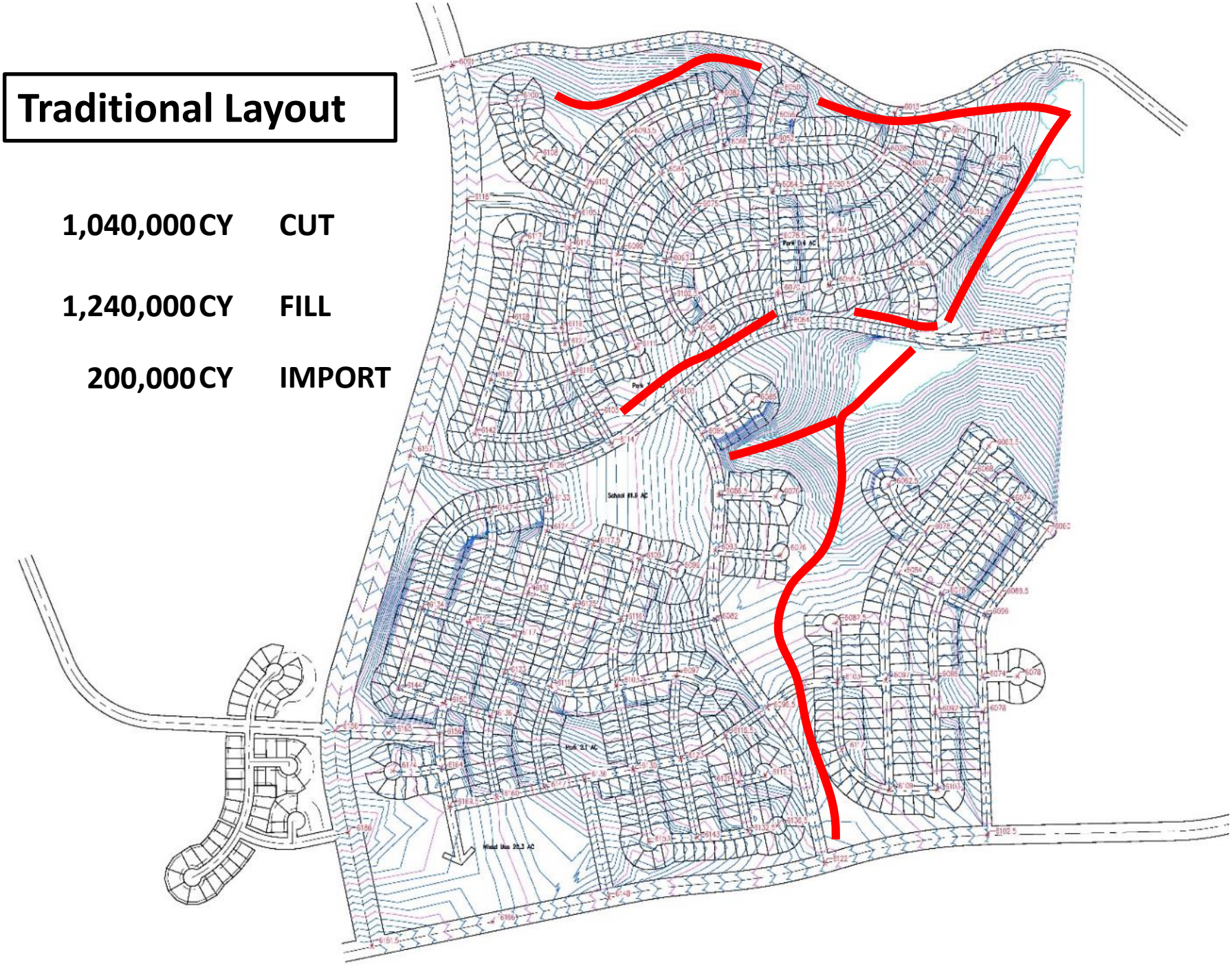


# Traditional Layout

**1,040,000 CY CUT**

**1,240,000 CY FILL**

**200,000 CY IMPORT**

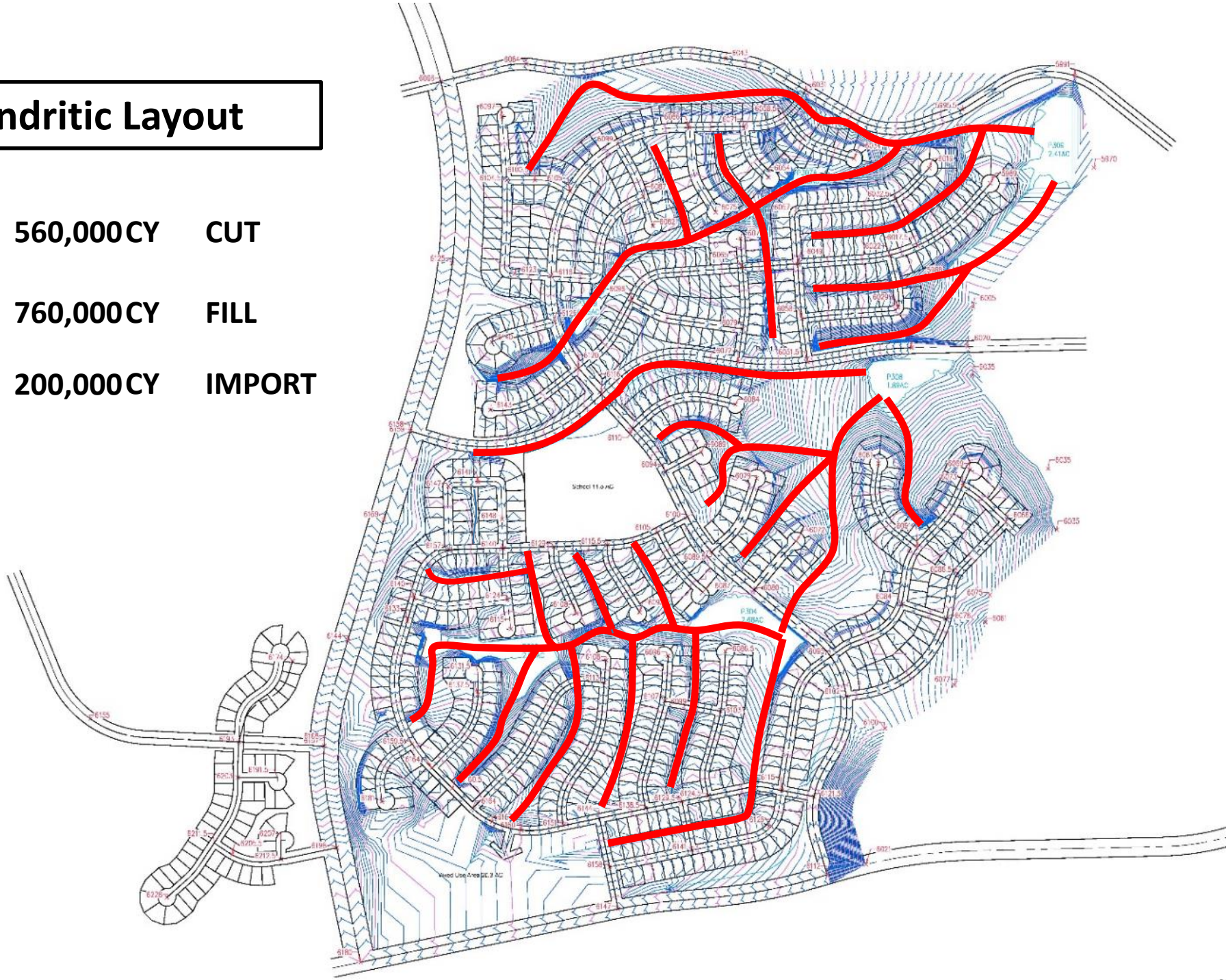


# Dendritic Layout

560,000 CY CUT

760,000 CY FILL

200,000 CY IMPORT



# Summary of Development Metrics

| Traditional Layout | | Dendritic Layout | |
|---|---|---|---|
| 878 | Lots | 797 | Lots |
| 320 | (AC) Total Boundary | 320 | (AC) Total Boundary |
| 5.6 | (AC) Park | 5.6 | (AC) Park |
| 11.9 | (AC) School | 11.9 | (AC) School |
| 20.3 | (AC) Mixed Use | 20.4 | (AC) Mixed Use |
| 2.7 | Gross Density (Units/Acre) | 2.5 | Gross Density (Units/Acre) |

# Mental Models

TRADITIONAL LAYOUT

ENGINEERS OPINION OF CONSTRUCTION COSTS

| | | |
|---|---|---|
| EARTHWORK / EROSION CONTROL | $ | **13,228,725** |
| PUBLIC ROADWAY IMPROVEMENTS | $ | **23,141,006** |
| PARKS, TRAILS, AND RECREATION | $ | 1,271,334 |
| SIGNAGE & STRIPING | $ | 512,039 |
| DRAINAGE AND STORMWATER | $ | 1,011,200 |
| SANITARY IMPROVEMENTS | $ | 3,092,015 |
| WATER SYSTEM IMPROVEMENTS | $ | 9,381,008 |
| Public Improvements Total | $ | **67,128,524** |
| Cost Per Lot | $ | **76,456** |

DENDRITIC LAYOUT

ENGINEERS OPINION OF CONSTRUCTION COSTS

| | | |
|---|---|---|
| EARTHWORK / EROSION CONTROL | $ | **8,237,200** |
| PUBLIC ROADWAY IMPROVEMENTS | $ | **21,556,033** |
| PARKS, TRAILS, AND RECREATION | $ | 1,271,334 |
| SIGNAGE & STRIPING | $ | 503,706 |
| DRAINAGE AND STORMWATER IMPROVEMENTS | $ | 1,005,200 |
| SANITARY IMPROVEMENTS | $ | 3,779,383 |
| WATER SYSTEM IMPROVEMENTS | $ | 8,325,552 |
| Public Improvements Total | $ | **58,081,931** |
| Cost Per Lot | $ | **72,876** |

# Mental Models

TRADITIONAL LAYOUT

ENGINEERS OPINION OF COI

| | |
|---|---|
| EARTHWORK / EROSION CONTROL | |
| PUBLIC ROADWAY IMPROVEMENTS | |
| PARKS, TRAILS, AND RECREATION | |
| SIGNAGE & STRIPING | |
| DRAINAGE AND STORMWATER | |
| SANITARY IMPROVEMENTS | |
| WATER SYSTEM IMPROVEMENTS | |
| Public Improvements | |
| Cost Per Lot | $ 76,456 |

DENDRITIC LAYOUT

ION OF CONSTRUCTION COSTS

| | | |
|---|---|---|
| ITROL | $ | 8,237,200 |
| MENTS | $ | 21,556,033 |
| ION | $ | 1,271,334 |
| | $ | 503,706 |
| ER IMPROVEMENTS | $ | 1,005,200 |
| | $ | 3,779,383 |
| NTS | $ | 8,325,552 |
| mprovements Total | $ | 80,081,931 |
| Cost Per Lot | $ | 72,876 |

## TRADITIONAL LAYOUT

| Lot Type | Number of Lots | Lot Premium | Total |
|---|---|---|---|
| Standard | 837 | $ - | $ - |
| Walk Out | 23 | $ 8,000 | $ 184,000 |
| Garden | 18 | $ 3,000 | $ 54,000 |
| Total | 878 | | |
| | | | **$ 238,000** |

## DENDRITIC LAYOUT

| Lot Type | Number of Lots | Lot Premium | Total | |
|---|---|---|---|---|
| Standard | 649 | $ - | $ - | |
| Walk Out | 112 | $ 8,000 | $ 896,000 | |
| Garden | 36 | $ 3,000 | $ 108,000 | |
| Total | 797 | | | Potential |
| | | | **$ 1,004,000** | 76% Increase |
| | | | | Revenue |

## TRADITIONAL LAYOUT

| Lot Type | Number of Lots | Lot Premium | Total |
|---|---|---|---|
| Standard | 837 | $ - | $ - |
| Walk Out | 23 | $ 8,000 | $ 184,000 |
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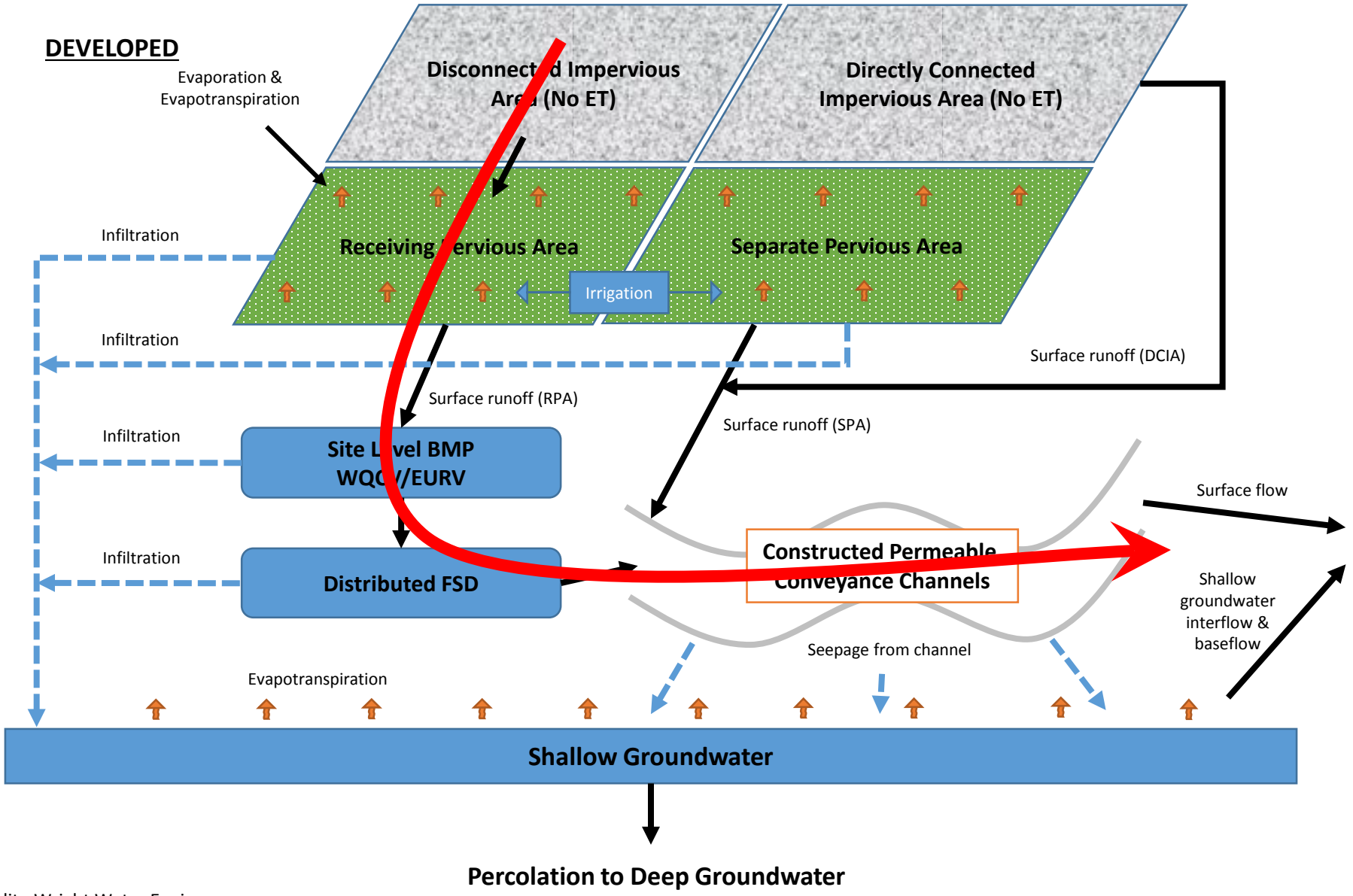
| Total | 878 | | |

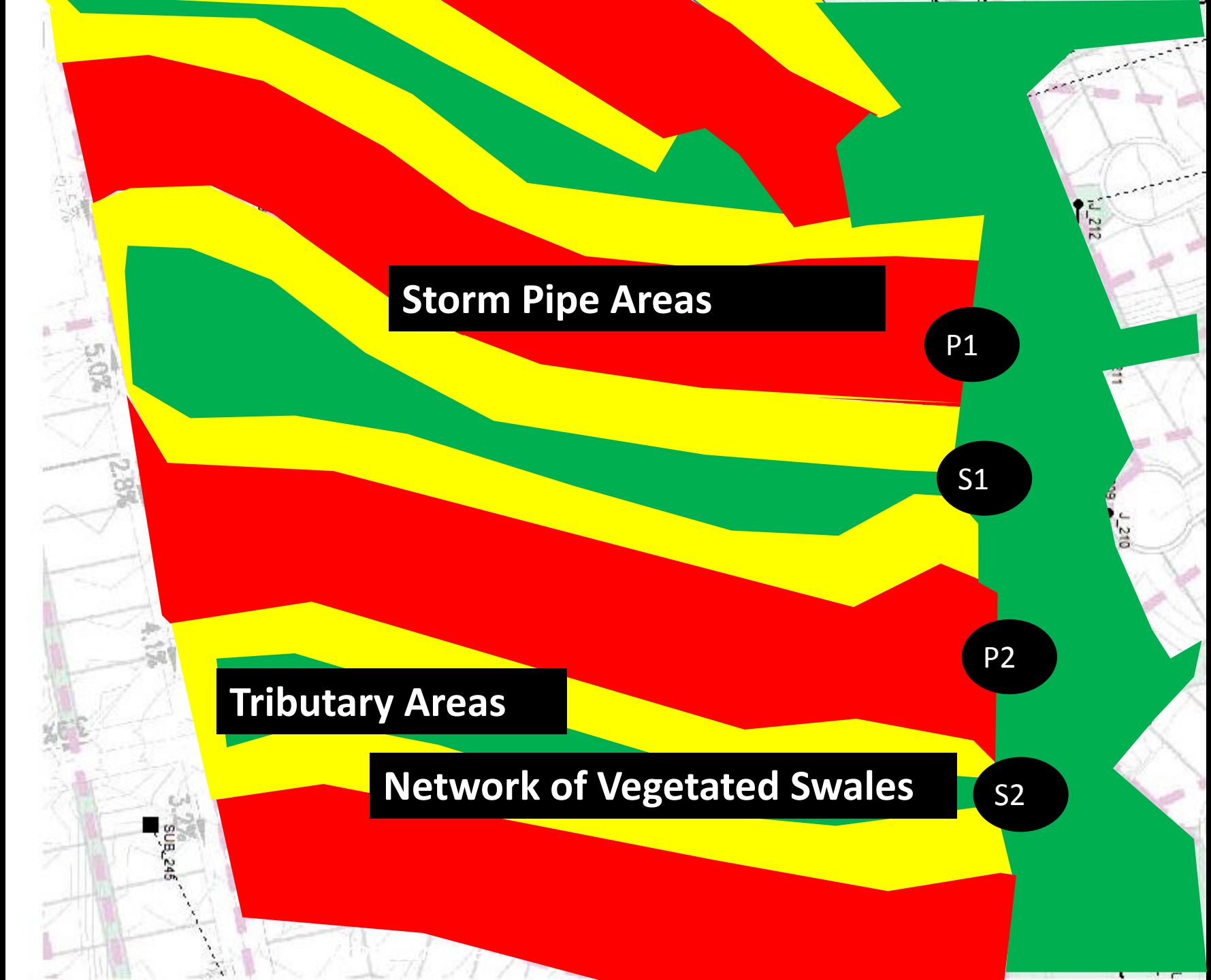
# Premium Lots Increase by 70%

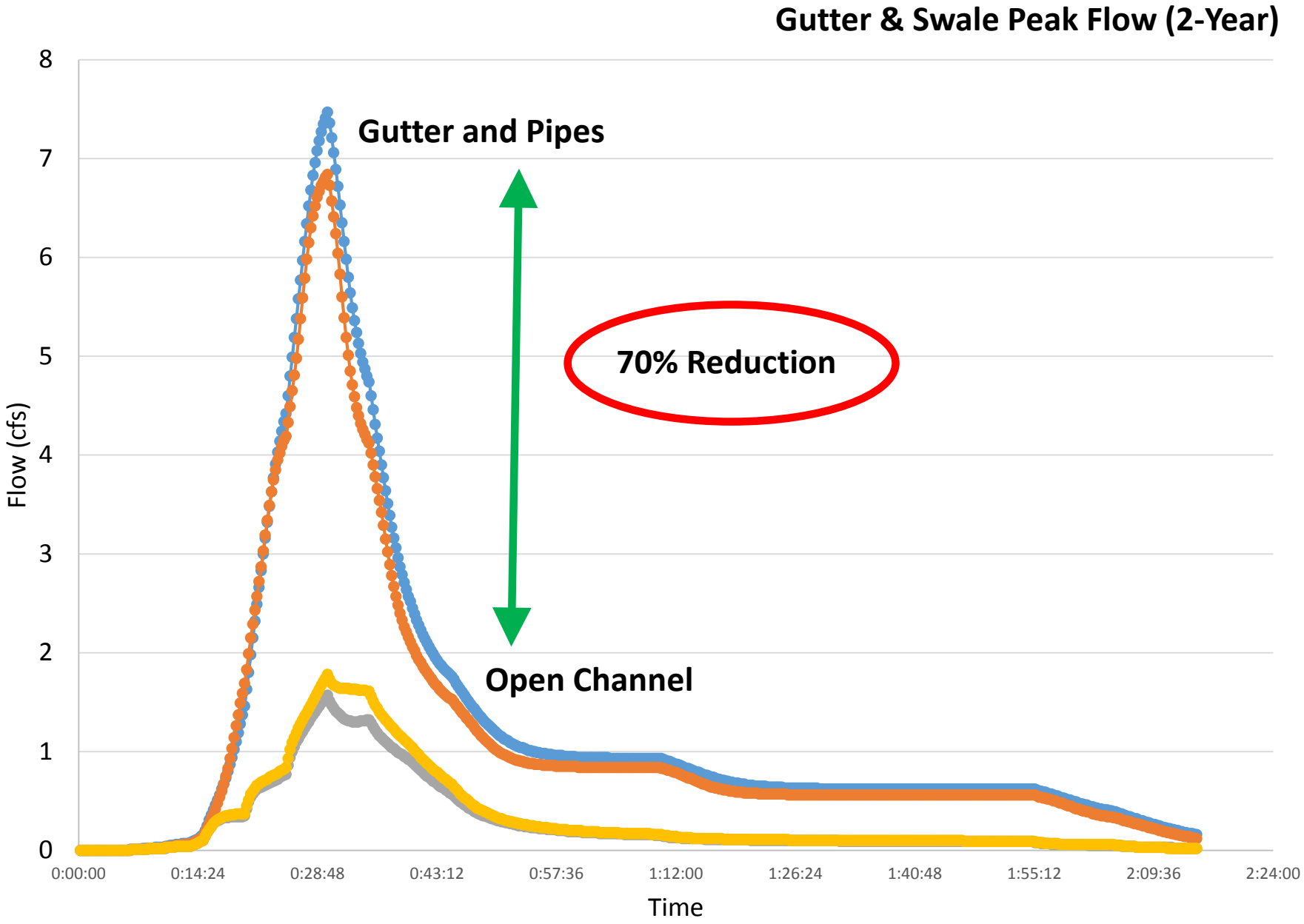
| Lot Type | Number of Lots | Lot Premium | Total | |
|---|---|---|---|---|
| Standard | 649 | $ - | $ - | |
| Walk Out | 112 | $ 8,000 | $ 896,000 | |
| Garden | 36 | $ 3,000 | $ 108,000 | |
| Total | 797 | | | Potential |
| | | | **$ 1,004,000** | 76% Increase |
| | | | | Revenue |

# Continuous and Design Rainfall Modeling

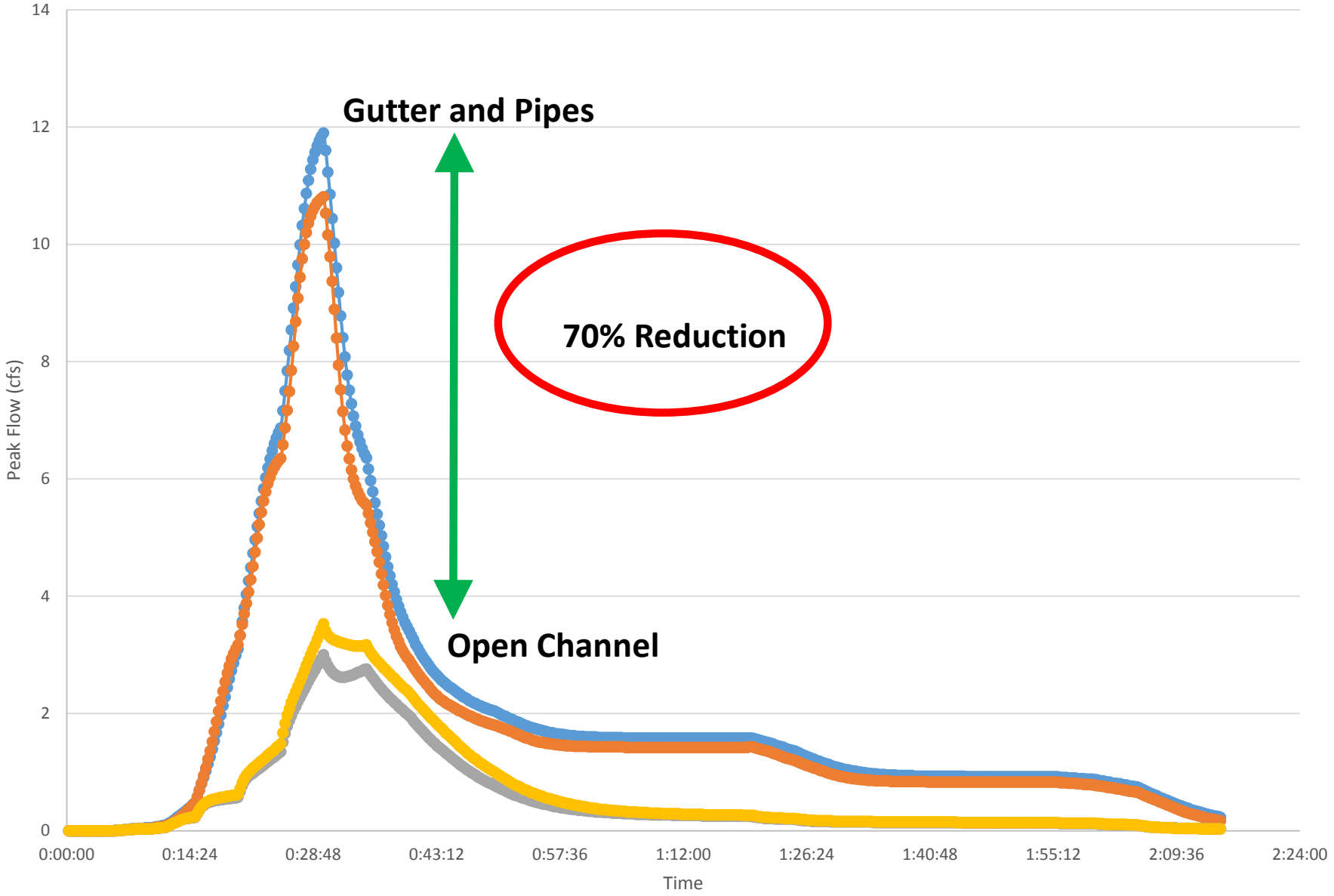


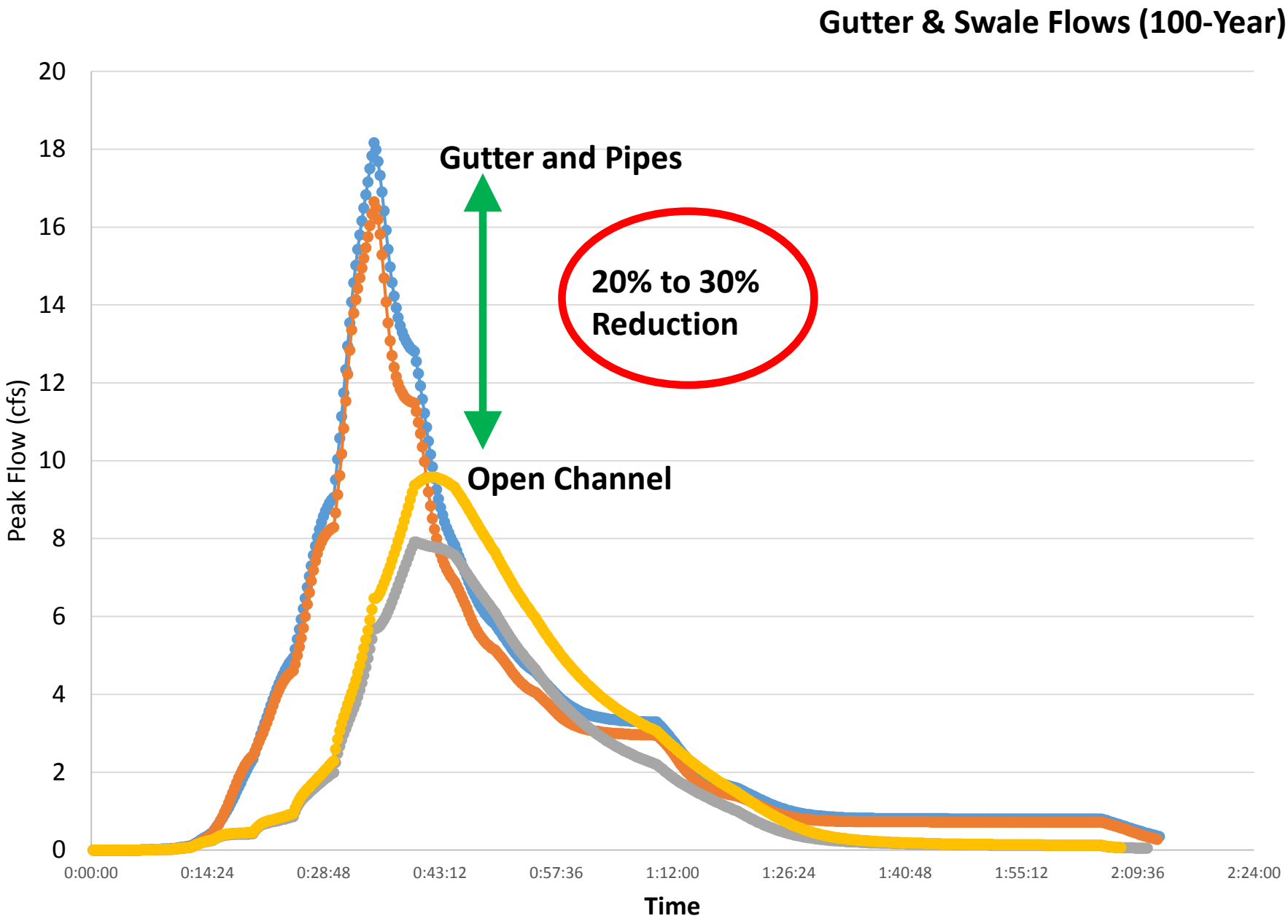

Credit: Wright Water Engineers


Storm Pipe Areas
P1
S1
P2
Tributary Areas
Network of Vegetated Swales
S2
J_212
J_210
SUB_245
5.0%
2.8%
4.1%
3.2%

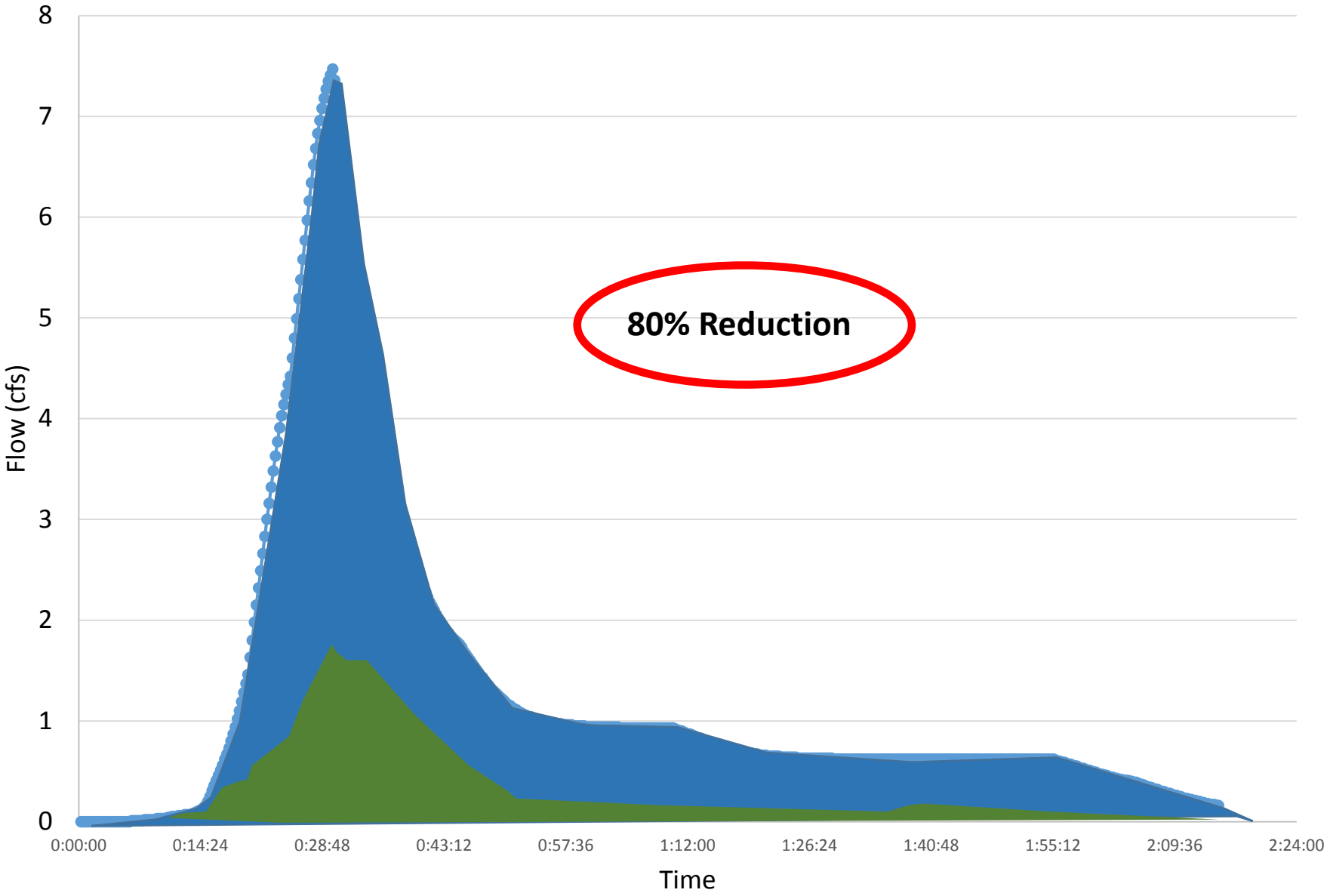

Gutter & Swale Peak Flow (2-Year)
Gutter and Pipes
70% Reduction
Open Channel
Flow (cfs)
Time
0
1
2
3
4
5
6
7
8
0:00:00
0:14:24
0:28:48
0:43:12
0:57:36
1:12:00
1:26:24
1:40:48
1:55:12
2:09:36
2:24:00

# Gutter & Swale Flows (10-Year)



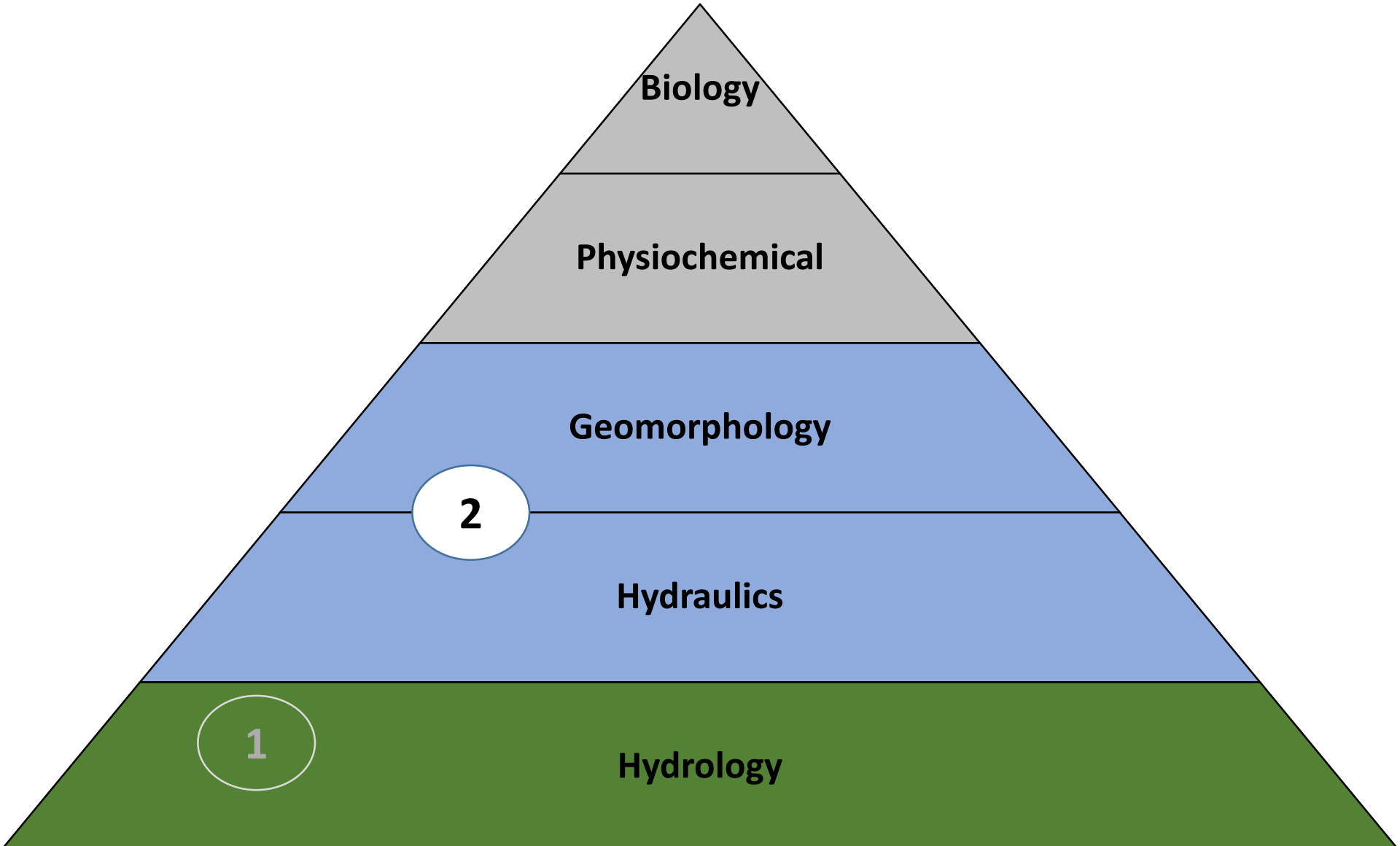

Gutter & Swale Flows (100-Year)
Gutter and Pipes
20% to 30%
Reduction
Open Channel
Peak Flow (cfs)
Time
20
18
16
14
12
10
8
6
4
2
0
0:00:00
0:14:24
0:28:48
0:43:12
0:57:36
1:12:00
1:26:24
1:40:48
1:55:12
2:09:36
2:24:00

## Gutter & Swale Volumes (2-Year)



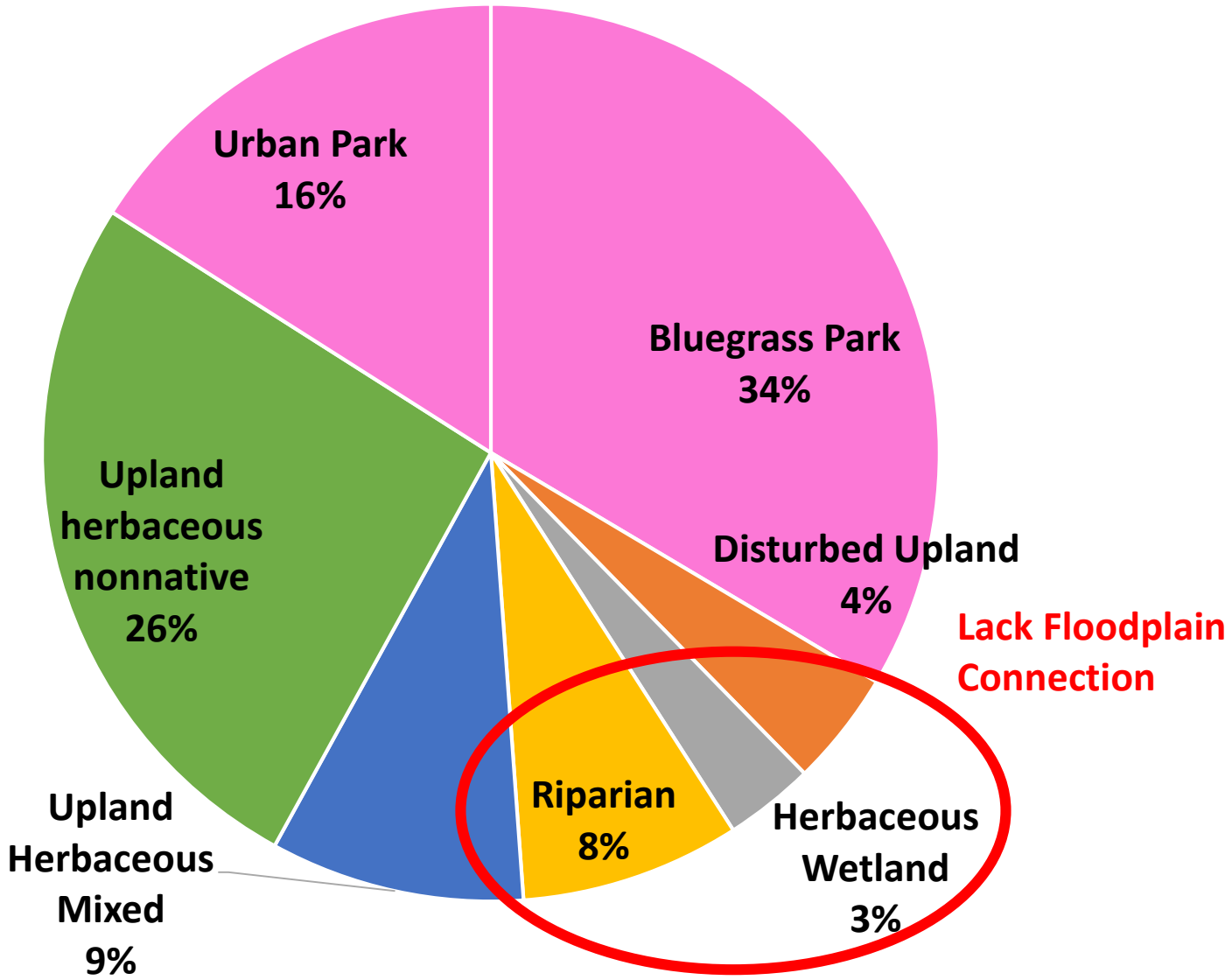
# Maintain a dendritic open channel system

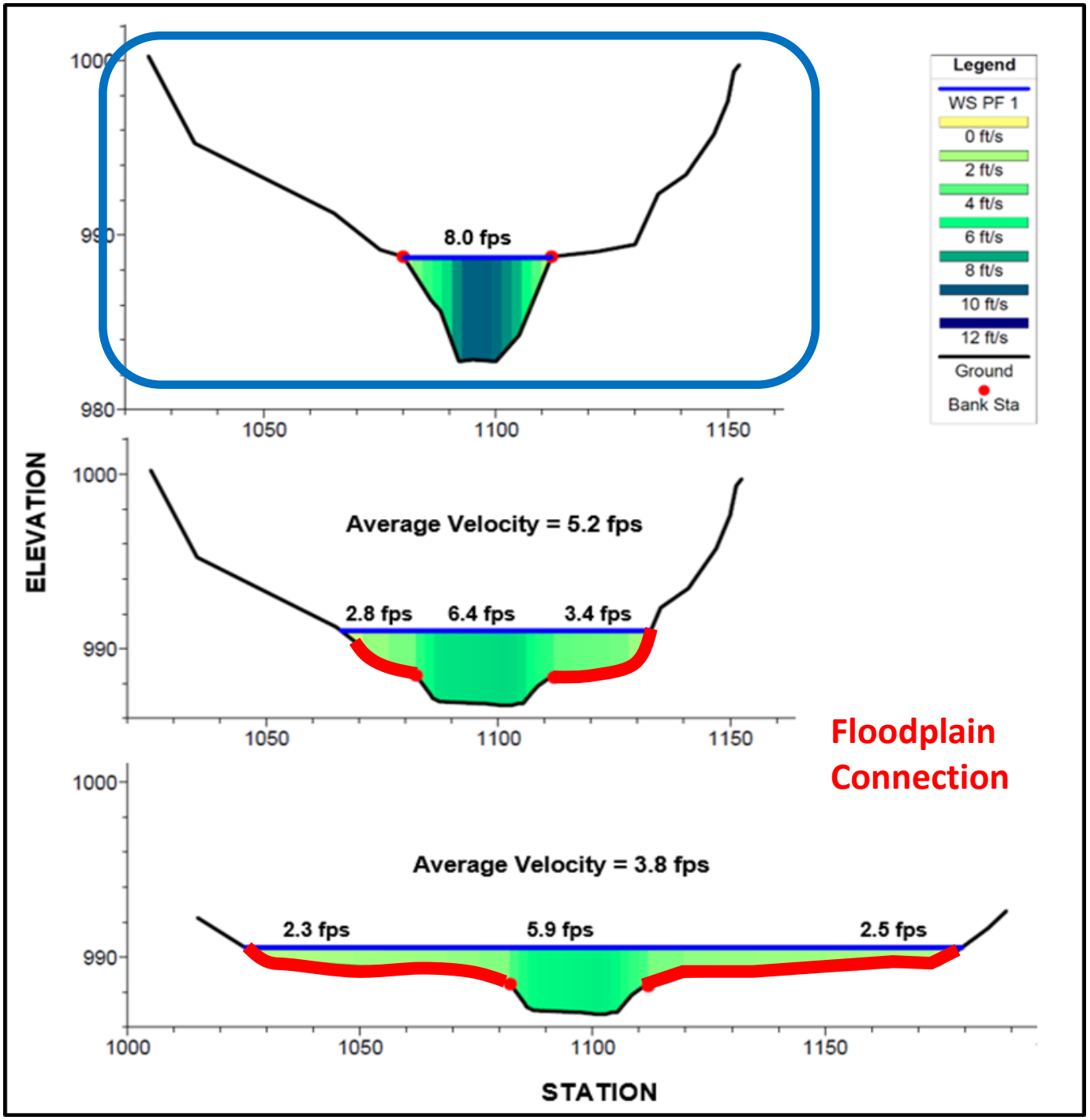
# Stream Works



Lakewood Gulch at Tennyson Street, July 2013

# Vegetation Communities, All Streams in Denver






**Floodplain Connection**

# Are we reducing risk?

ACER TECHNICAL MEMORANDUM NO. 11
ASSISTANT COMMISSIONER - ENGINEERING AND RESEARCH
DENVER, COLORADO

## DOWNSTREAM HAZARD CLASSIFICATION GUIDELINES

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
1988

# Are we reducing risk?

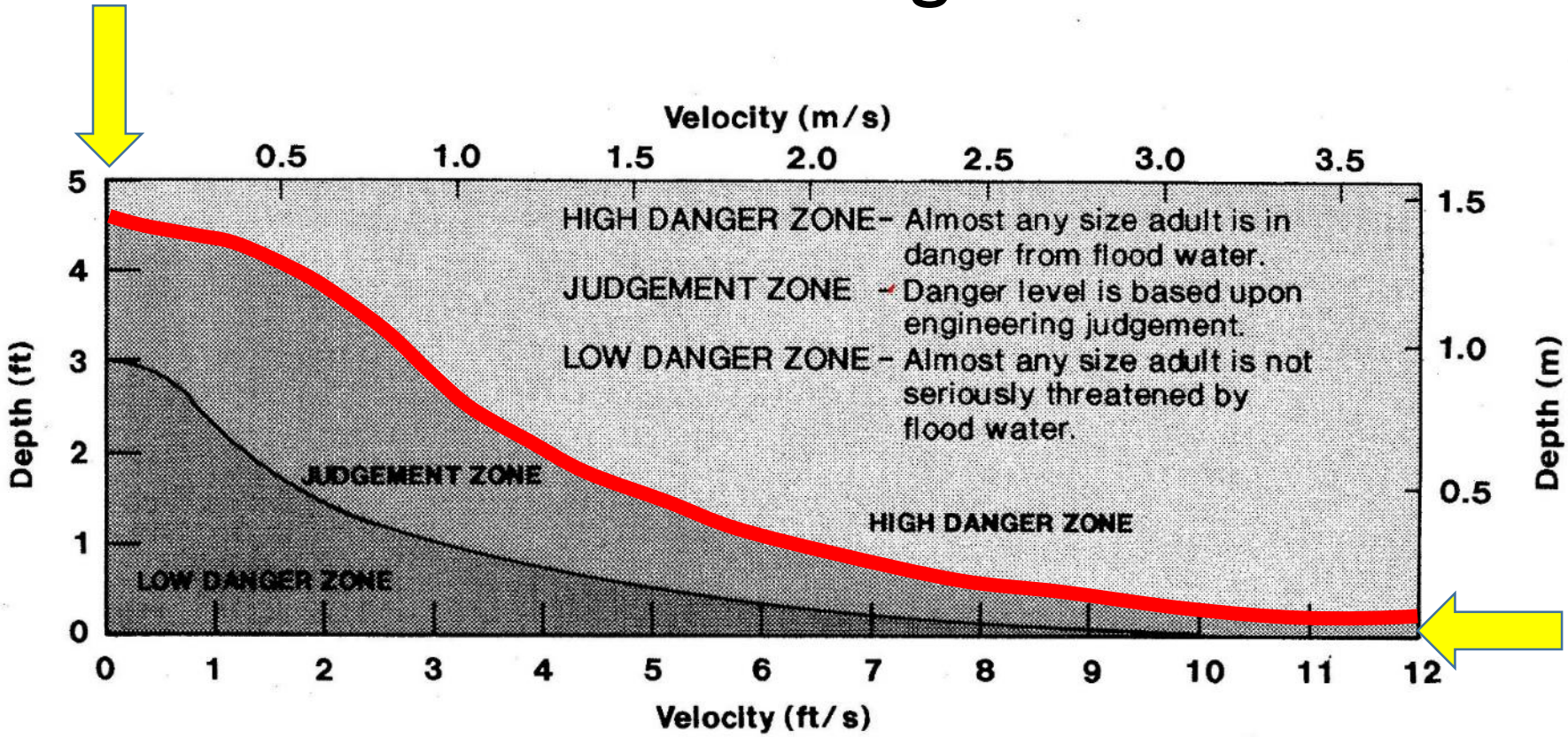
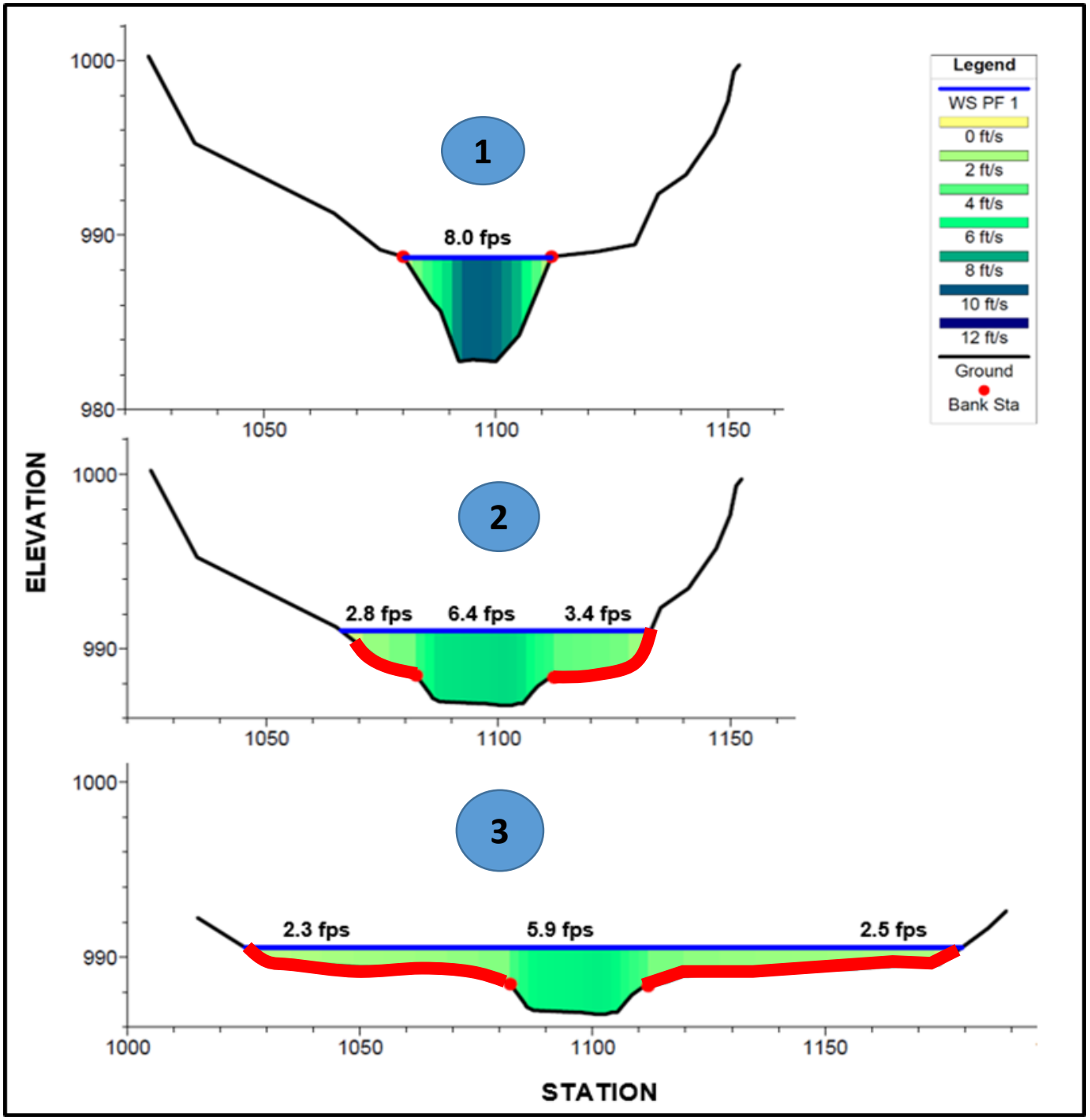



**Figure 5. – Depth–velocity flood danger level relationship for adults.**


1000
990
980
1
8.0 fps
1050
1100
1150
Legend
WS PF 1
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
ELEVATION
2
2.8 fps
6.4 fps
3.4 fps
3
2.3 fps
5.9 fps
2.5 fps
STATION

# Are we reducing risk?

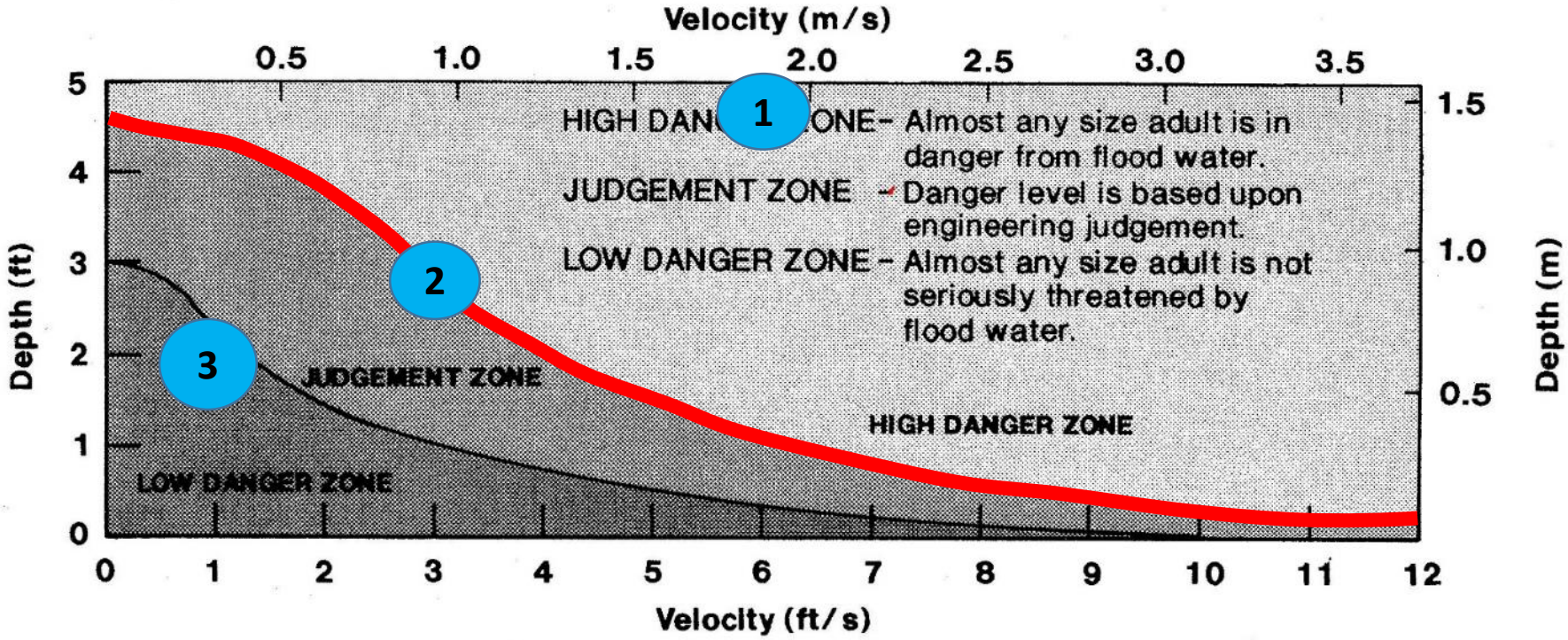
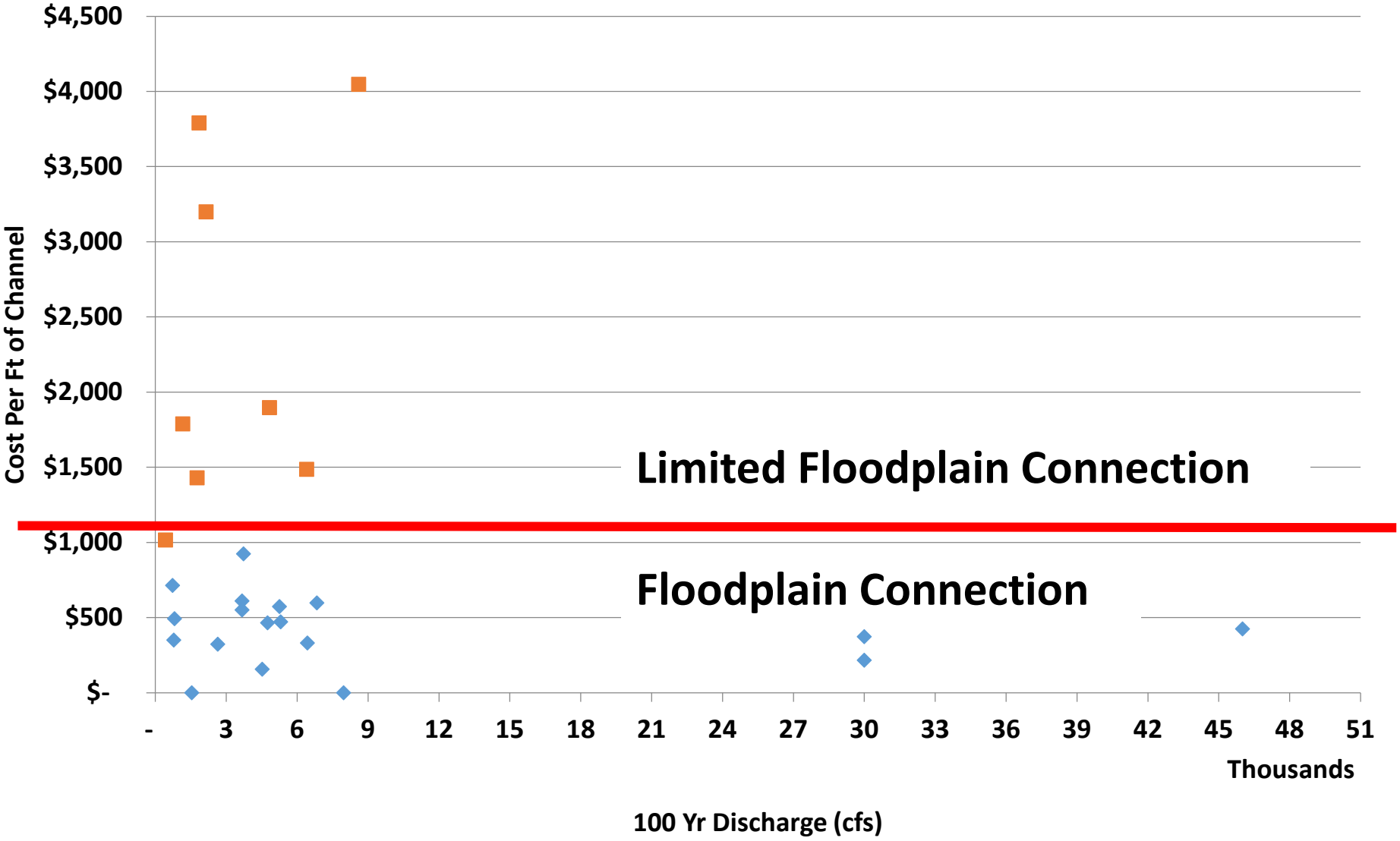
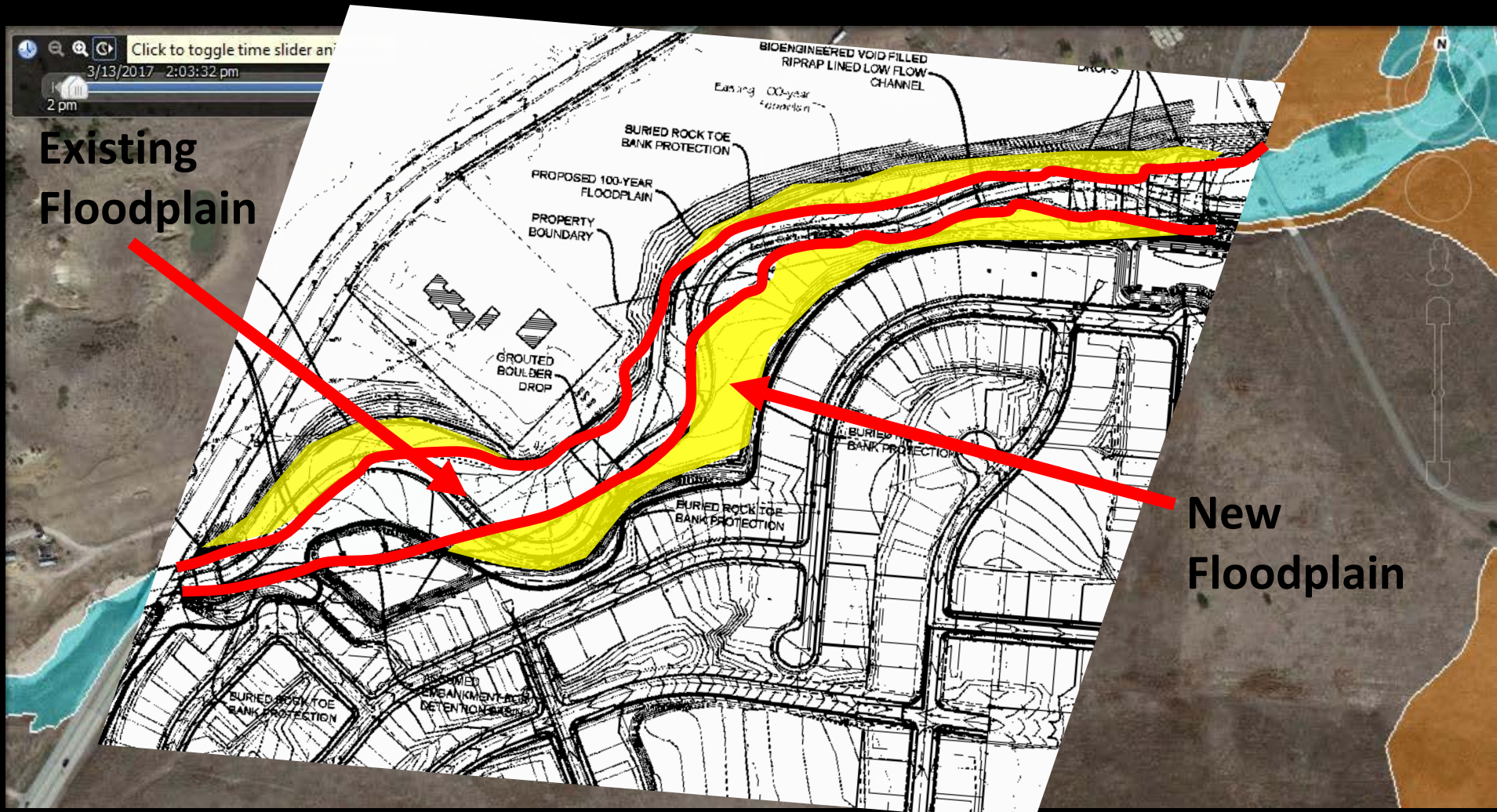



**Figure 5. – Depth–velocity flood danger level relationship for adults.**

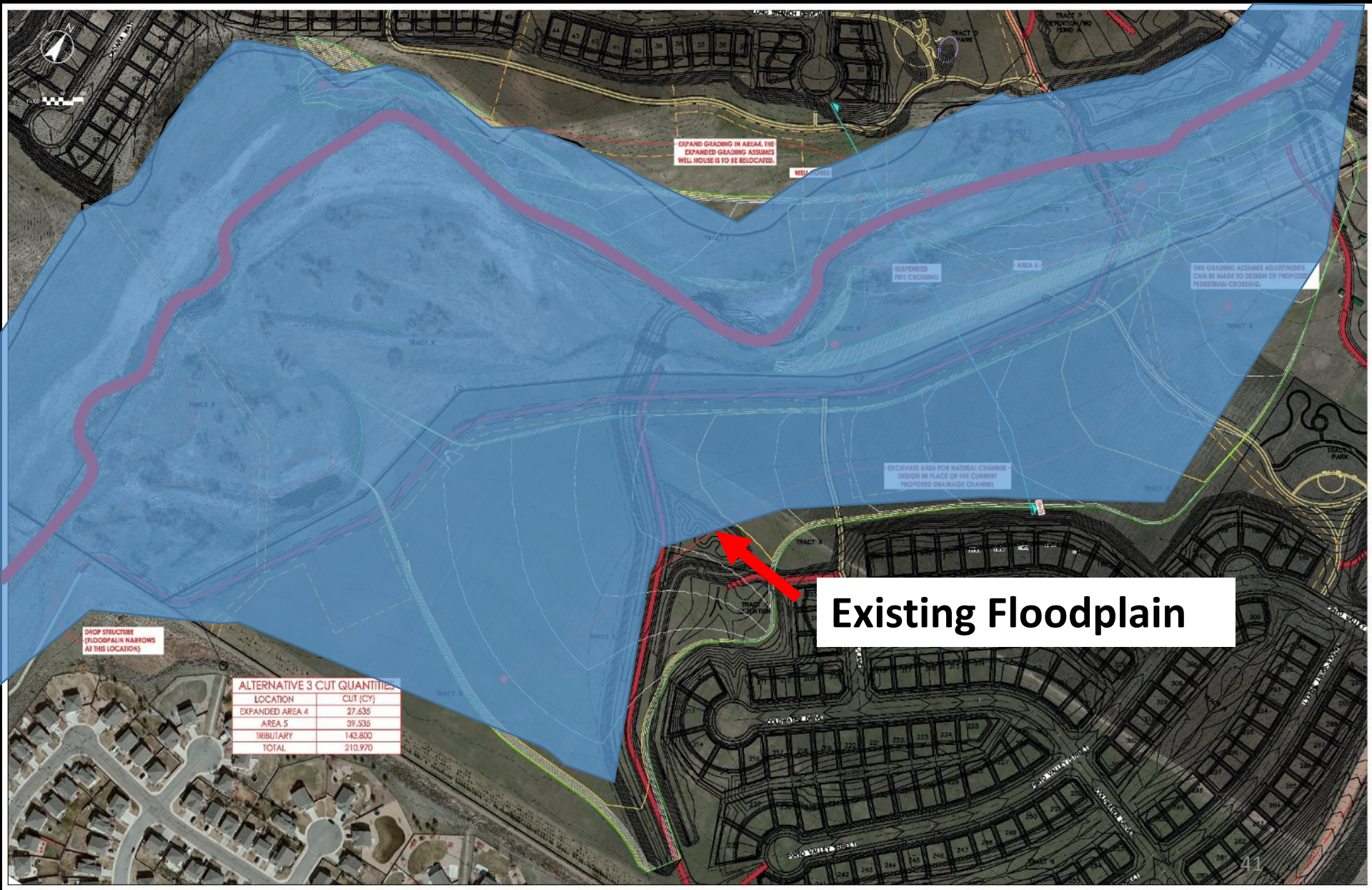
# Are we reducing costs?



# Flirt with the *Floodplain*



# Reconnect with an old *Floodplain*



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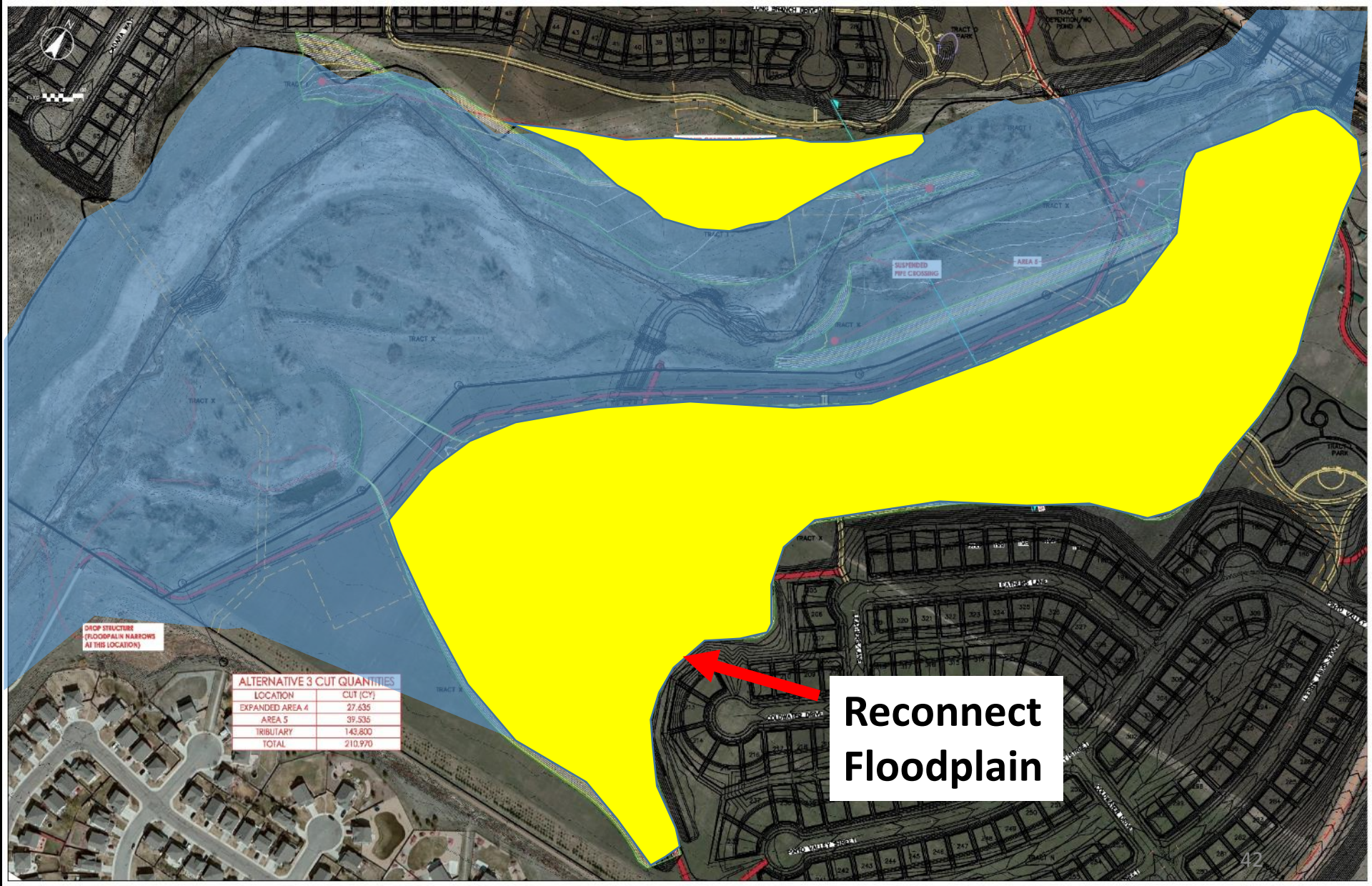
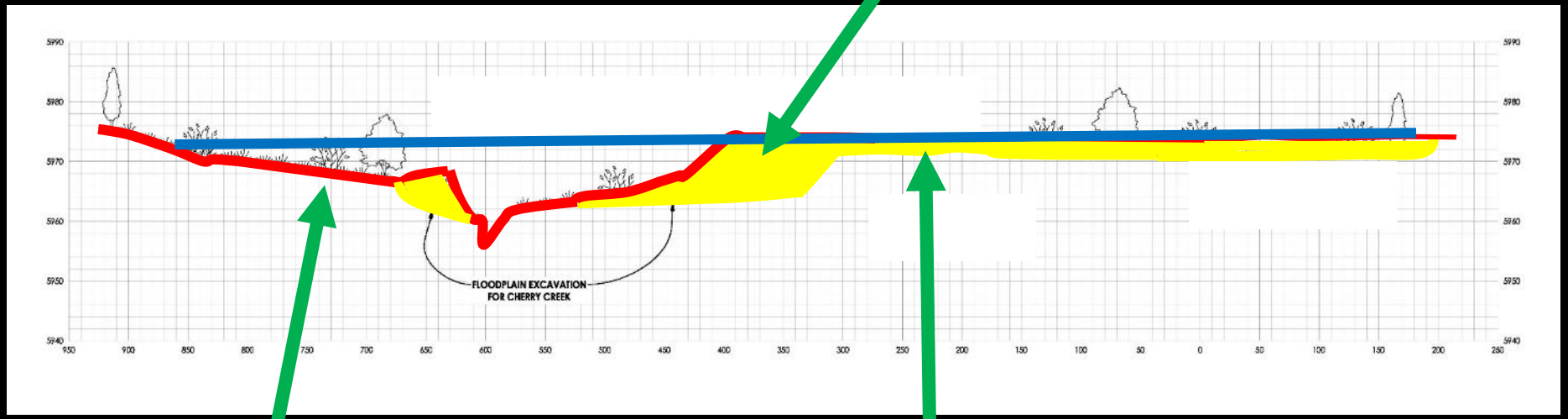
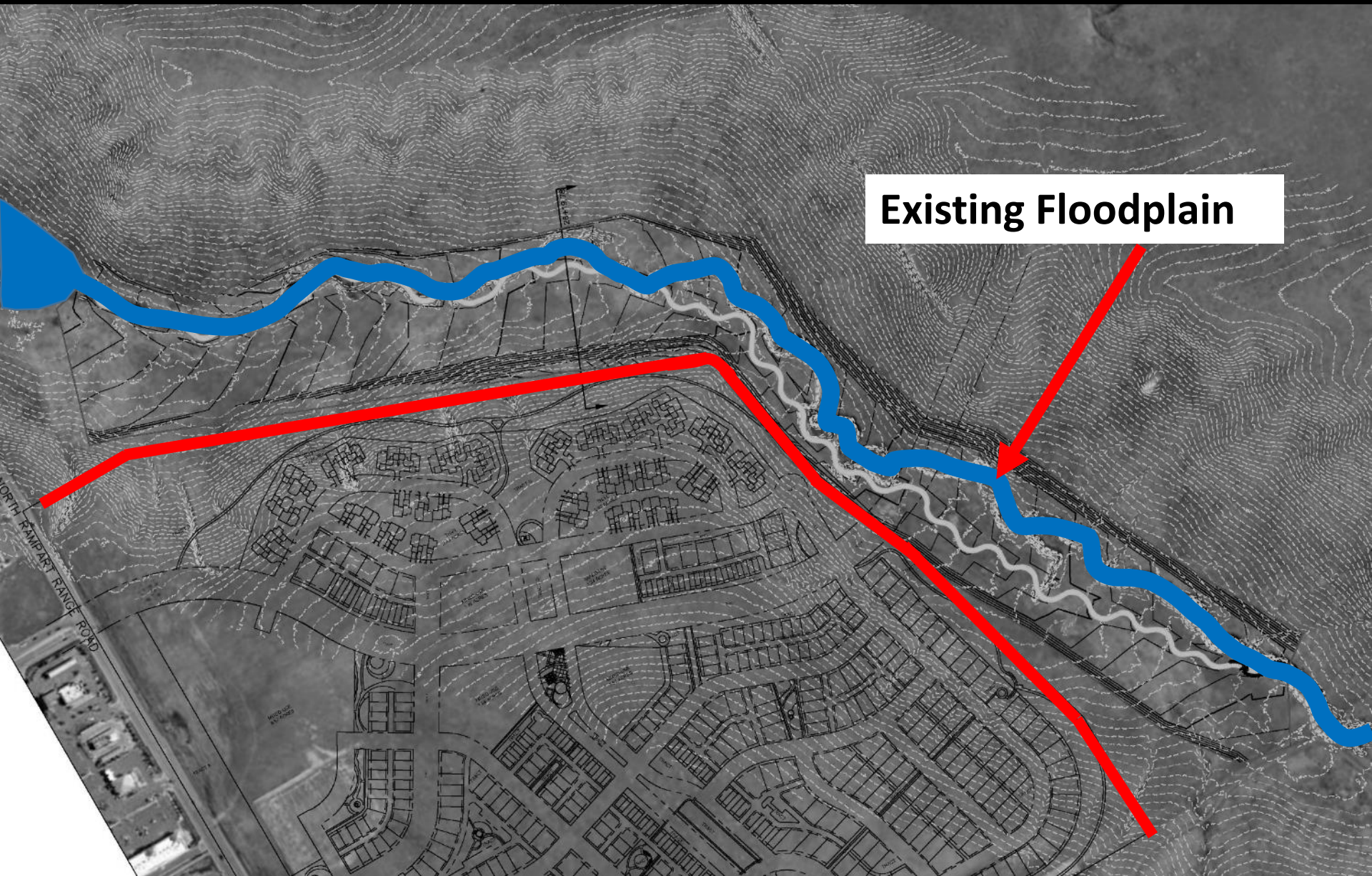
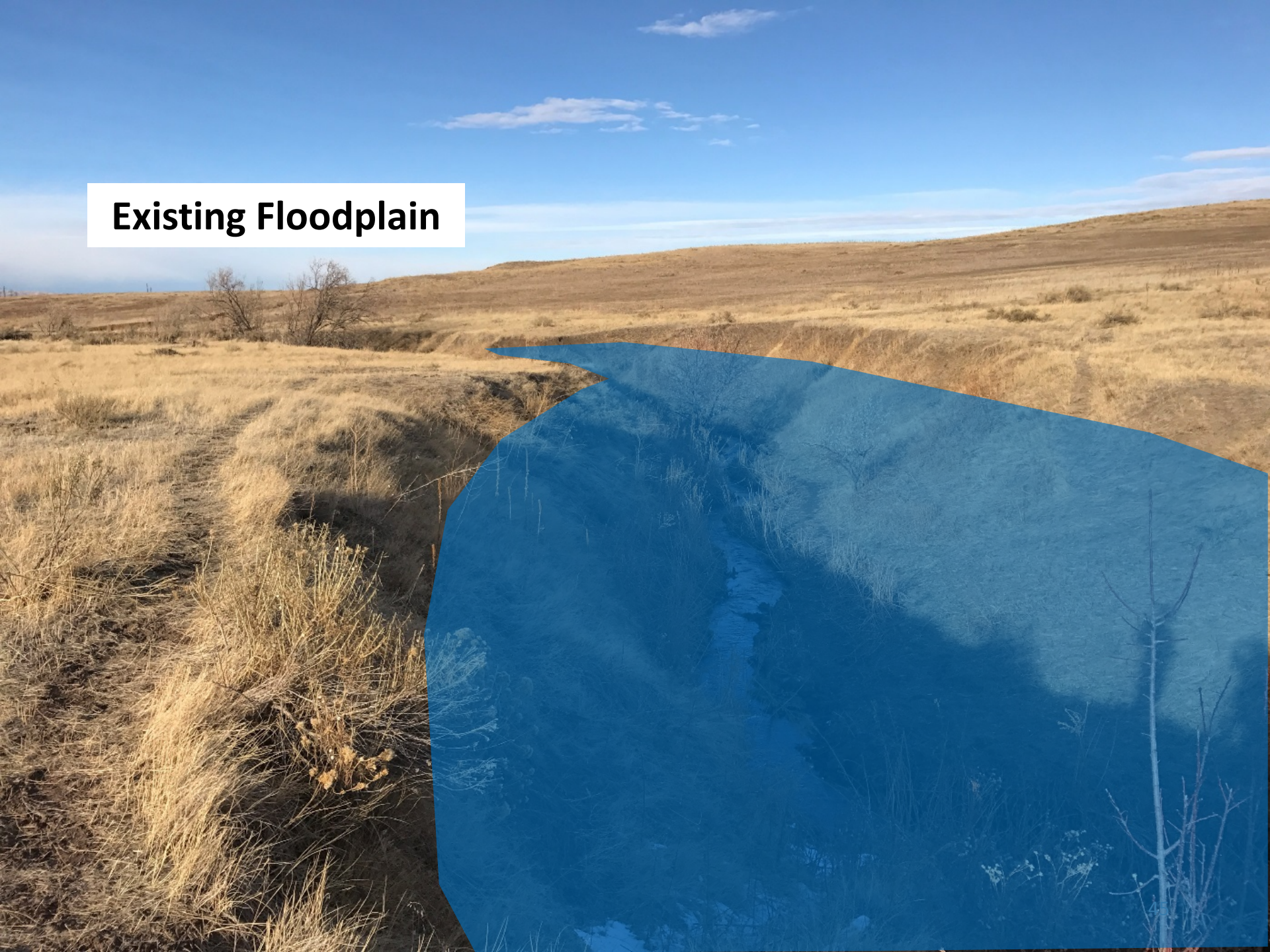


# Reconnect with an old *Floodplain*

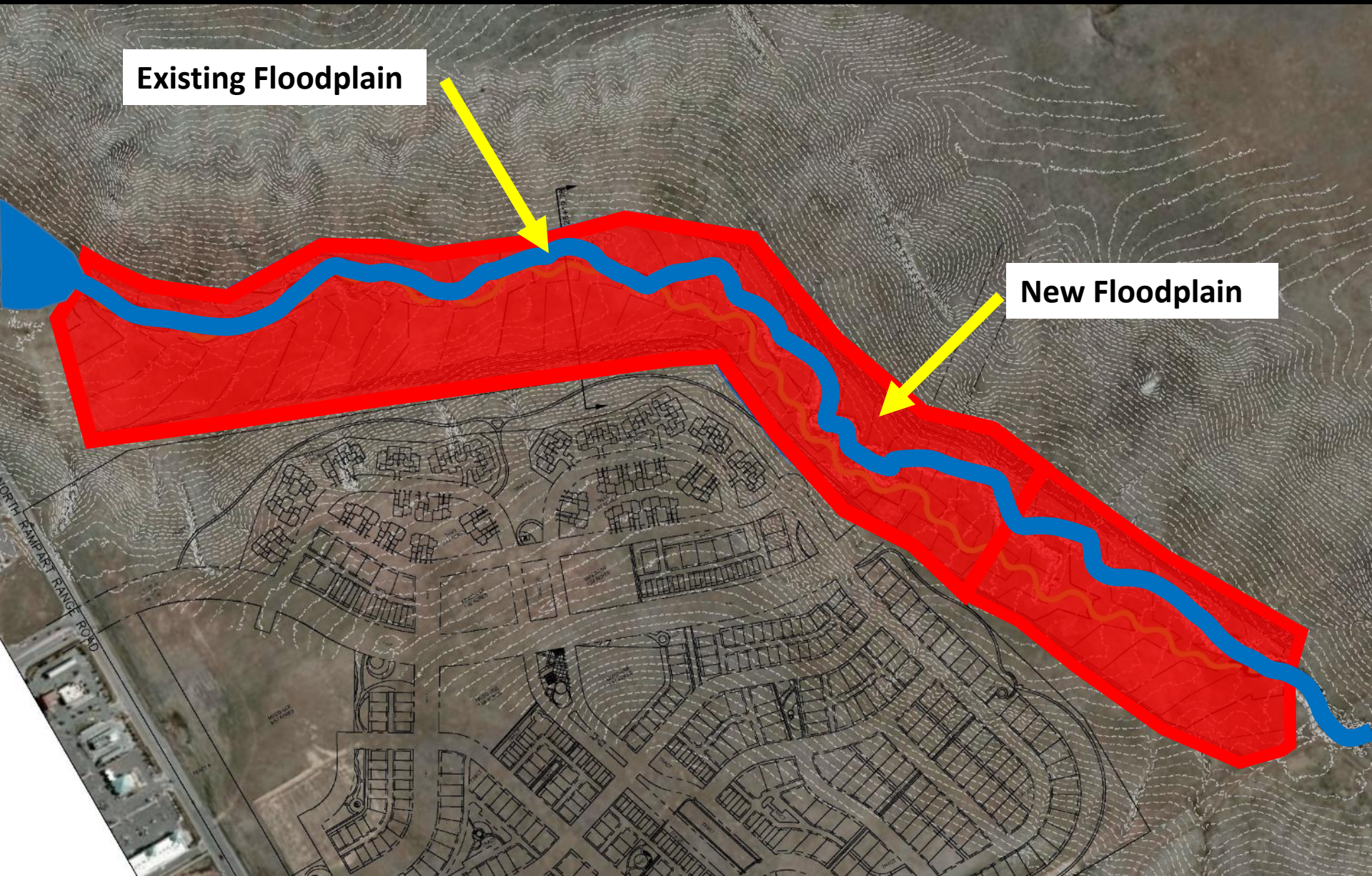


# Engage a New Floodplain

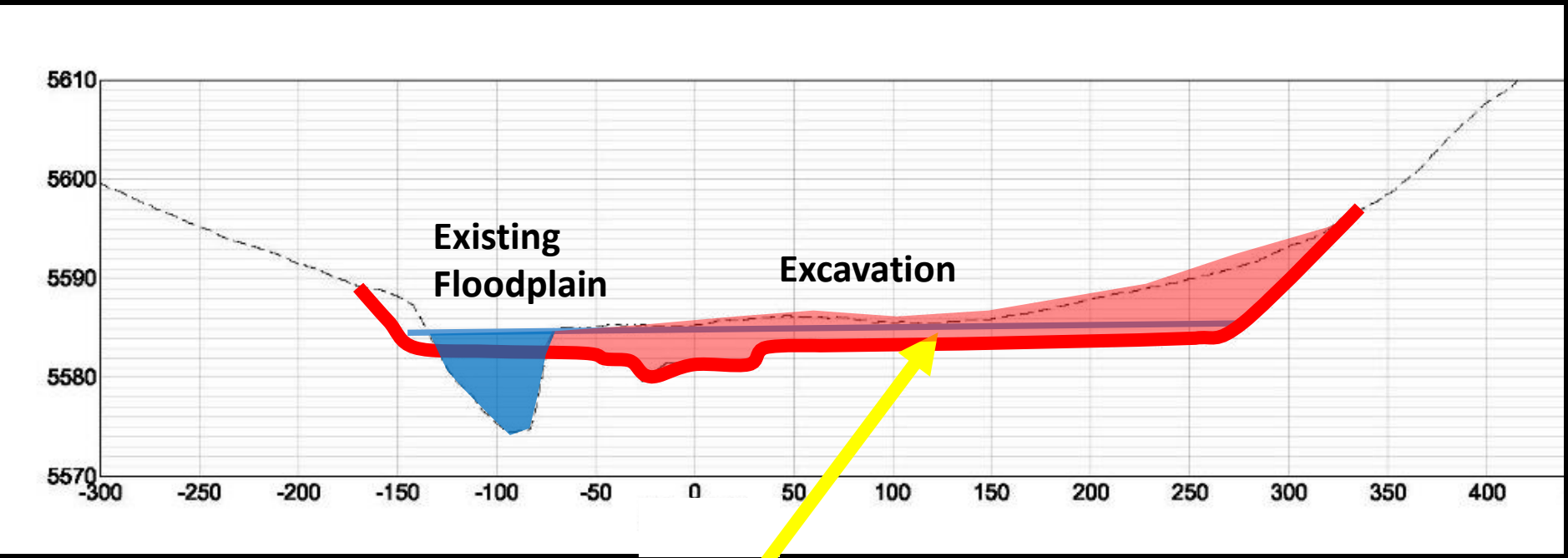



Existing Floodplain

# Engage the floodplain



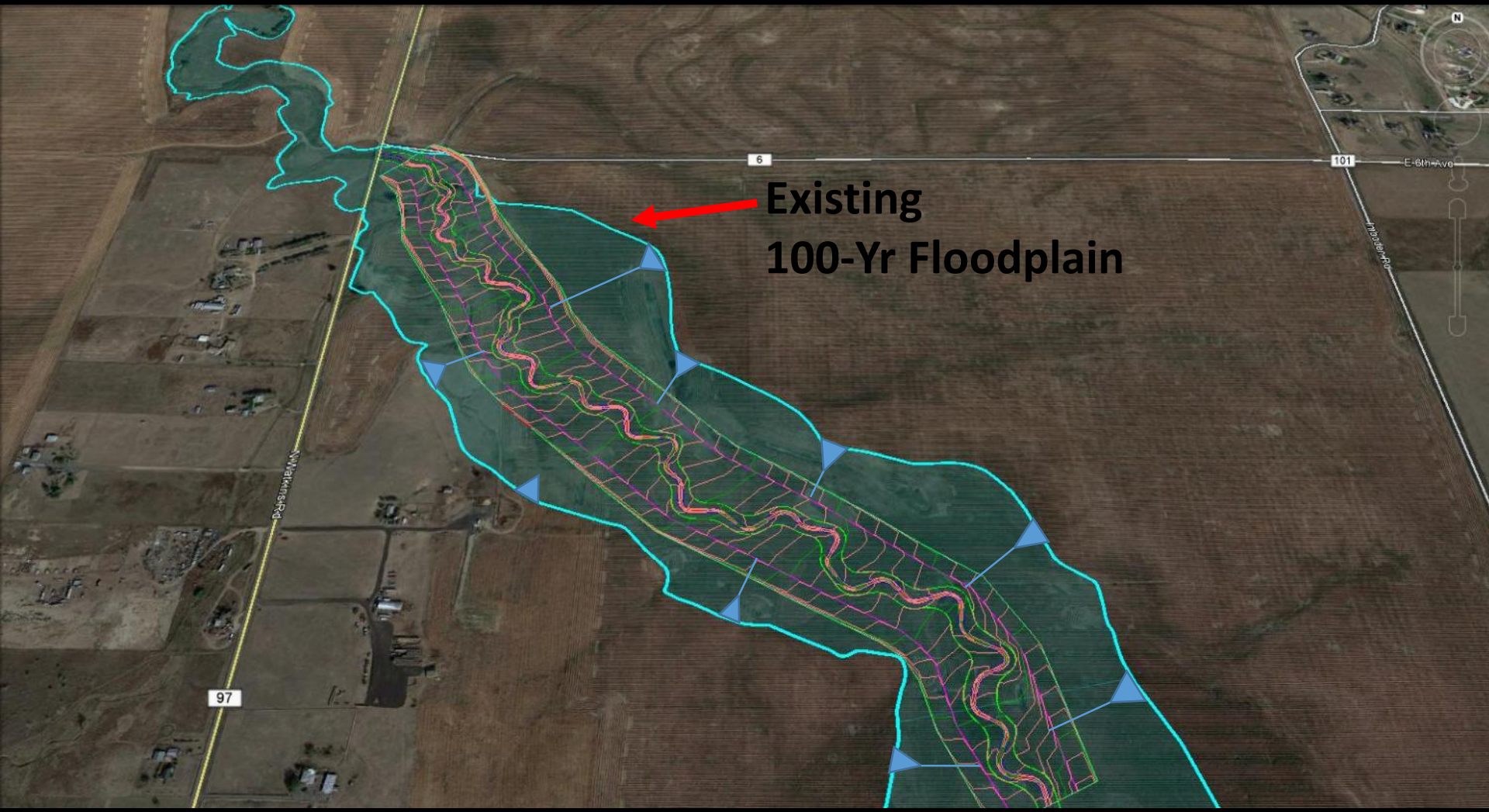
# Engage the floodplain



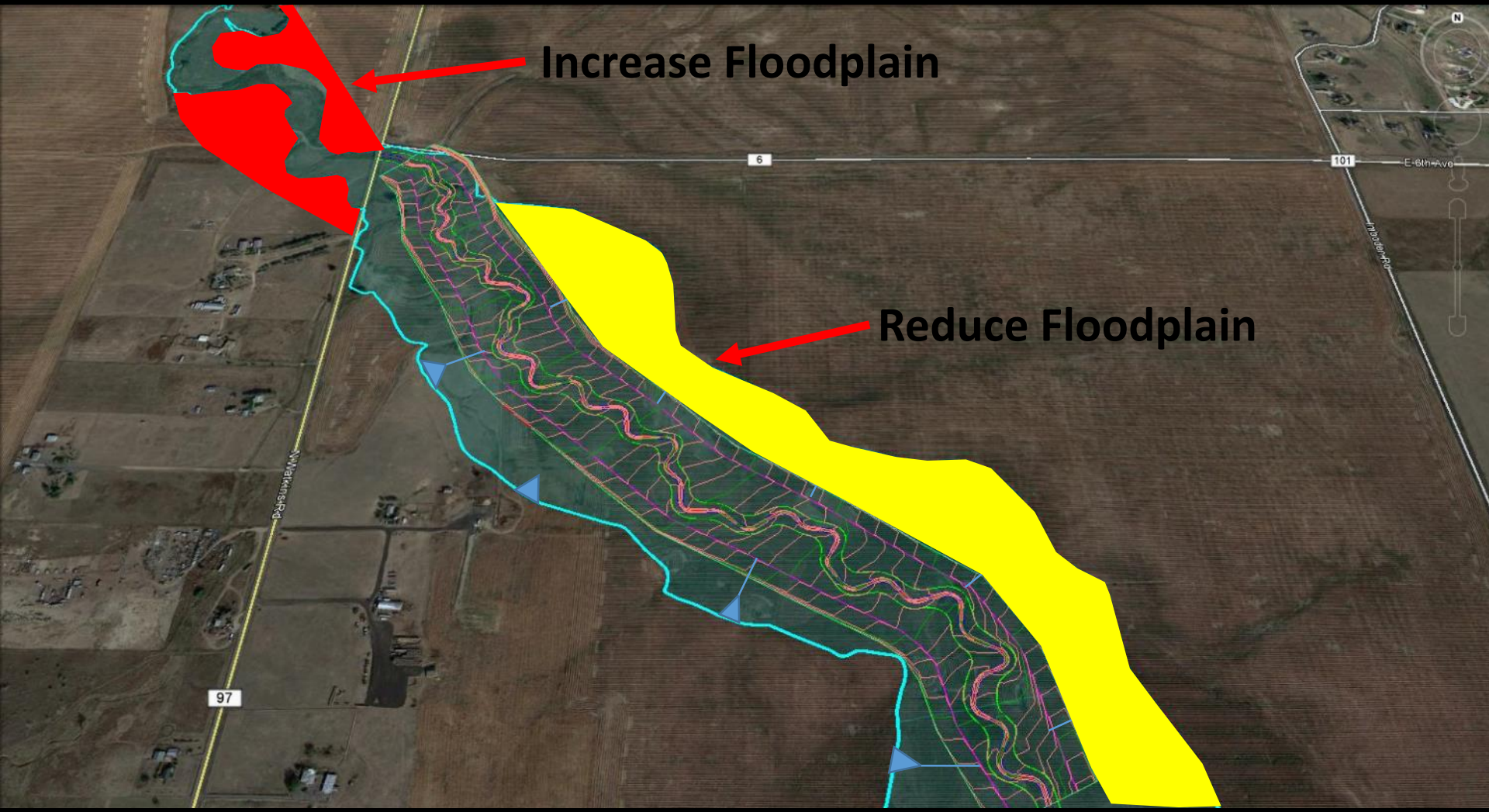

Depth in Floodplain = 3 feet

Shear Stress < 1 lbs/ $ft^2$ , vegetation for armoring sufficient

# Floodplain Banking



# Floodplain Banking



# Take Aways

- **Partner with Development** with a win-win mental model
- Maintain a **network of open channels**
- **Engage the floodplain using a three stage channel**

# How will this be useful to YOU

- Criteria
- Masterplan
- Maintenance Eligibility
- Stream Management
- On-Line Community Resource Center