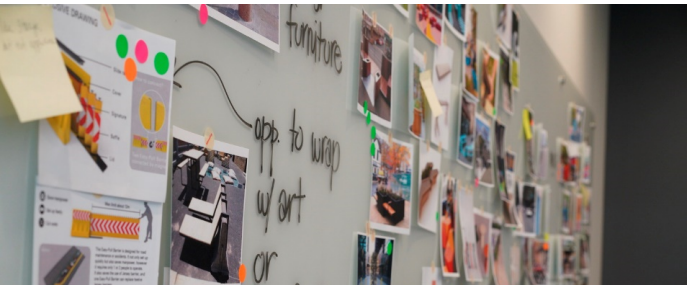

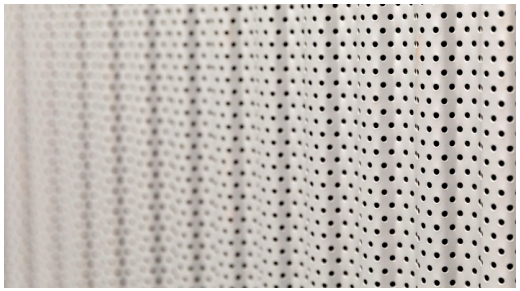

TRANSPORTATION:
"Navigating Floodplain & Drainage Challenges for Transportation Projects"

August 22, 2024

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Hank Amen, PE, CFM
CLIENT MANAGER – WATER

Andrew Schimenti, PE, CFM, ENV SP
SENIOR ENGINEER – WATER

Bryan Cabrera, PE
PROJECT ENGINEER - MESQUITE

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ABOUT US

Founded in 1956 on the very mindset that drives us today, we're here to improve communities by making them more sustainable, better connected, and more efficient. Simply put, we work to leave the world better than we found it.

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Since 2018, we ranked in the **Top 100** on *Engineering News-Record's* national list of Top 500 Design Firms.

1 BRIDGE/CULVERT DESIGN

- Data Collection
- Culvert vs. Bridge
- Hydrologic and Hydraulic Analysis Methods
- 2D Case Study – SH71 and Halfway Creek
- Design Criteria

2 STREAMBANK STABILIZATION

- Scour Analysis
- Channel Evolution Model
- Common Causes of Failure
- Geotechnical and Geomorphological investigation
- Stabilization techniques and applications

3 CITY PROJECT MANAGEMENT

- Overview
- Lessons Learned
- Case Studies

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Bridge & Culvert Design

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CULVERT

Advantages

- Lower cost with easier construction
- Better hydraulic control; IE Brokeback
- Less structural design
- No deep foundation required

Disadvantages

- Limited capacity
- Not feasible for large waterways
- Limited fill heights
- Greater floodplain impacts

BRIDGE

Advantages

- Can span larger waterways
- Less environmental or hydraulic impacts
- Greater capacity and conveyance
- Less prone to debris and siltation
- Reduced ROW footprint

Disadvantages

- Typically, more costly
- Less hydraulic control
- Require monitoring and inspections

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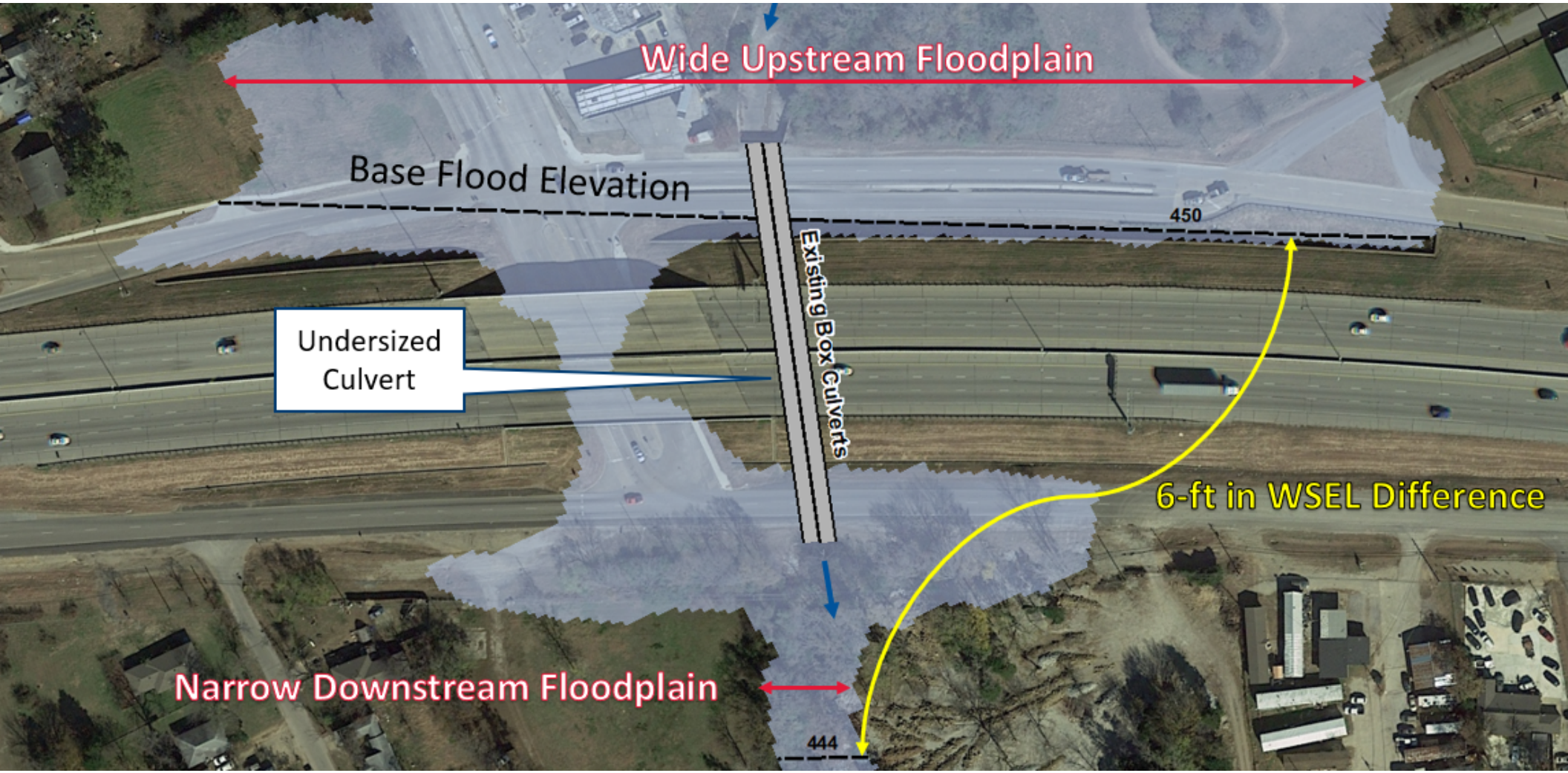

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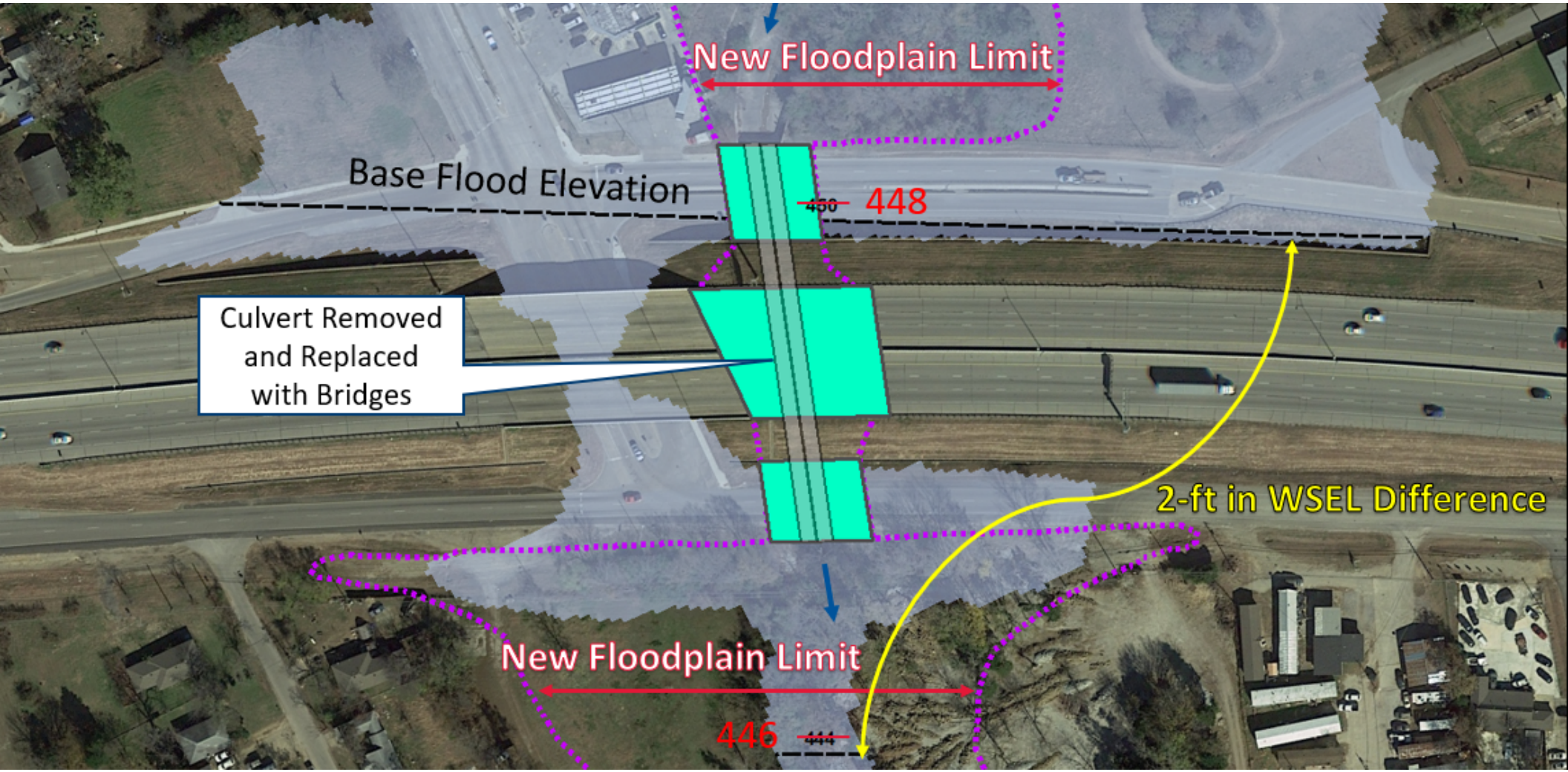

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FEMA Flood Insurance Studies (FIS)

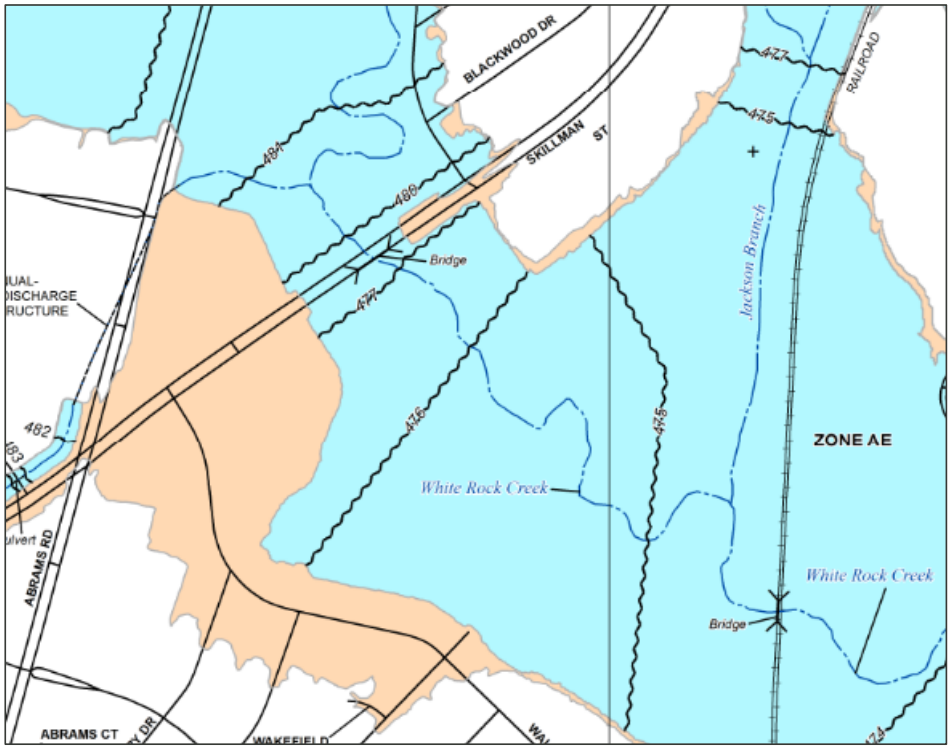

Table 4 – Summary Of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mile)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.20% Annual Chance
New Detailed Study Streams					
WHITE ROCK CREEK (CONTINUED)					
At White Rock Lake Spillway	99.10	23,600	36,600	42,800	56,000
Below confluences of Rush Creek and Williamson Branch	99.10	29,800	45,100	52,600	69,600
Below Dixon Branch	92.49	27,900	43,200	49,500	65,100
3,450 feet below Mockingbird Lane	83.80	26,800	41,200	47,100	61,400
Above Mockingbird Lane	83.26	26,700	41,100	47,100	61,200
Above DART Railroad	80.82	29,300	47,000	54,100	68,900
Above Skillman Road	72.40	27,500	43,600	50,300	64,000
Above Abrams Road	70.32	27,200	43,000	49,700	63,100
Above Fair Oaks Boulevard	69.24	31,100	47,400	53,900	65,100
Below confluence of Richardson Branch	66.68	33,200	49,500	55,600	65,000
Above Greenville Avenue	65.81	32,900	49,300	55,400	64,300
Below confluence of Unnamed Tributary 1,200 feet above Greenville Avenue	65.81	32,900	49,300	55,500	64,300
Below confluence of Unnamed Tributary 650 feet below Royal Lane	64.97	32,800	49,300	55,300	63,900

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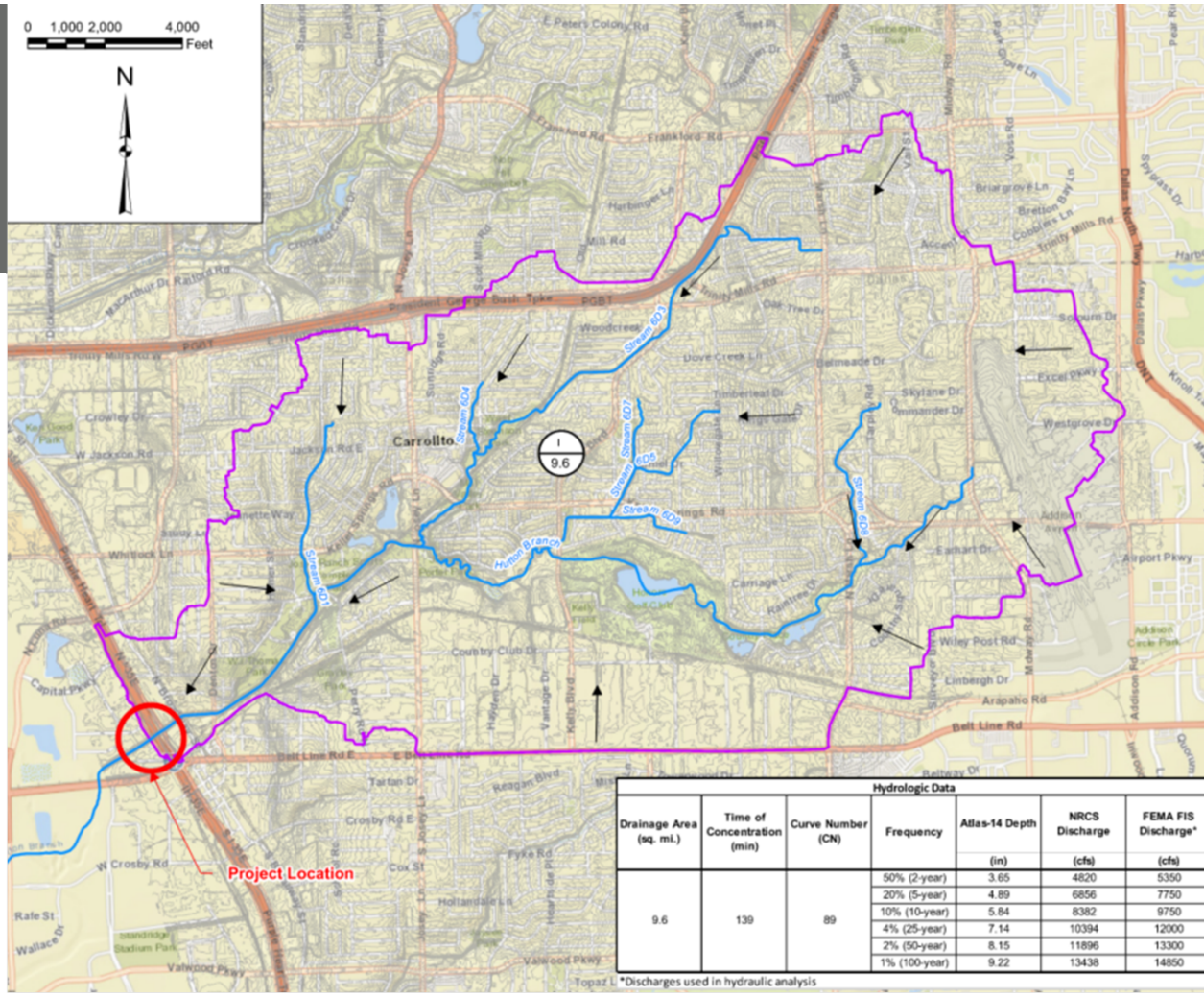
Hydrologic Analysis Methods

- Previous Studies/FEMA FIS Reports
- Rational Method <200ac
- Unit Hydrograph Method (HEC-HMS)
  - Drainage Area between 100-ac and 10 sq. mi.
  - Rainfall Source – NOAA Atlas-14
  - Storage, Losses and Timing
  - Rain - on - Grid
- USGS Gage Analysis (HEC-SSP, Peak FQ)
- Regional Regression Equations
  - DA > 10 sq. mi, not used for urban watershed with reservoirs



Hydrologic Data

Drainage Area (sq. mi.)	Time of Concentration (min)	Curve Number (CN)	Frequency	Atlas-14 Depth (in)	NRCS Discharge (cfs)	FEMA FIS Discharge* (cfs)
9.6	139	89	50% (2-year)	3.65	4820	5350
			20% (5-year)	4.89	6856	7750
			10% (10-year)	5.84	8382	9750
			4% (25-year)	7.14	10394	12000
			2% (50-year)	8.15	11896	13300
			1% (100-year)	9.22	13438	14850

*Discharges used in hydraulic analysis

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Hydraulic Analysis Method

- USACE HEC-RAS Modeling Software
- Typical Four Cross-Section Placement
- Bridge Elements Incorporated:
  - Roadway Profile
  - Roadway Width
  - Low Chord
  - Pier Type and Placement
  - Abutment Type

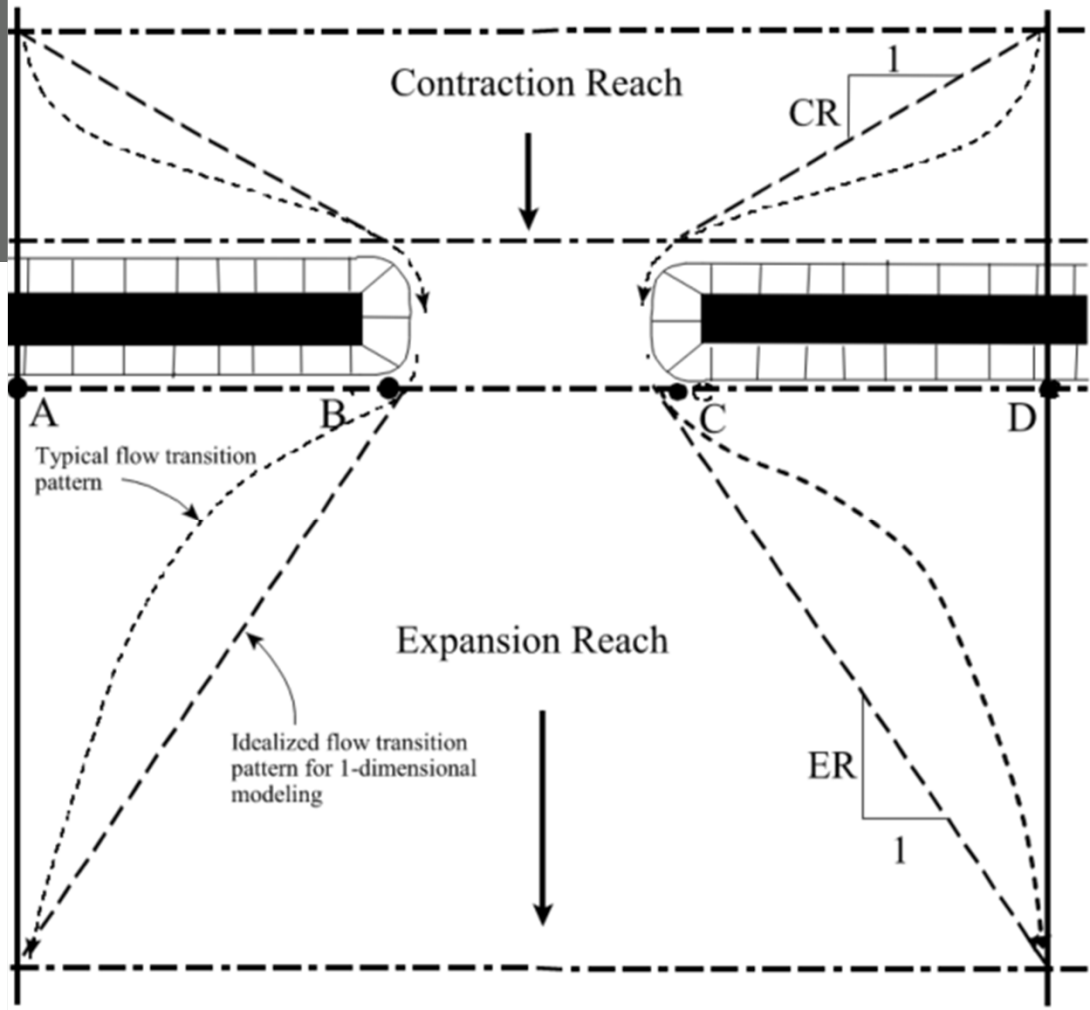

Figure 6-11 Cross Section Locations at a Bridge or Culvert

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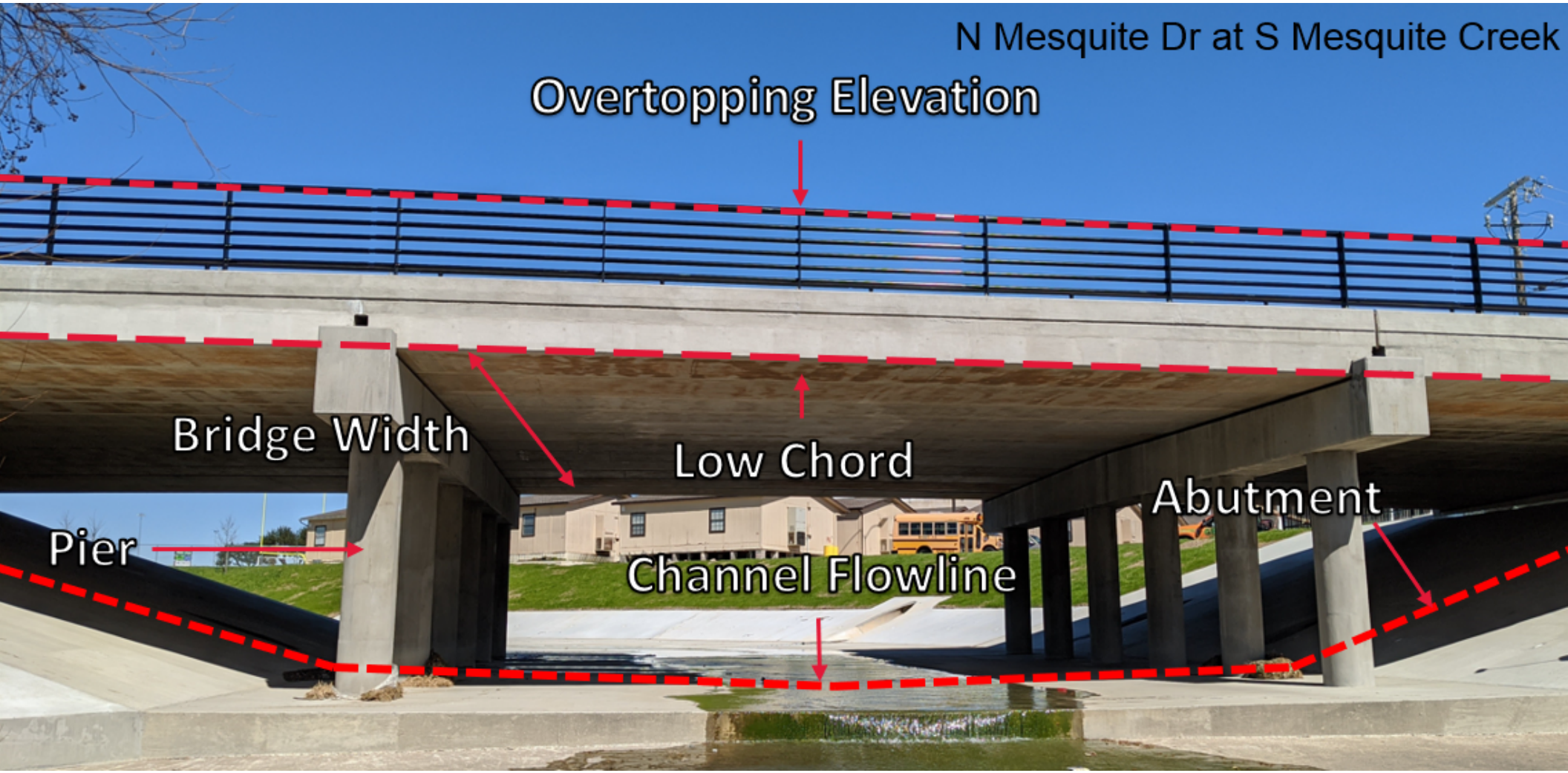

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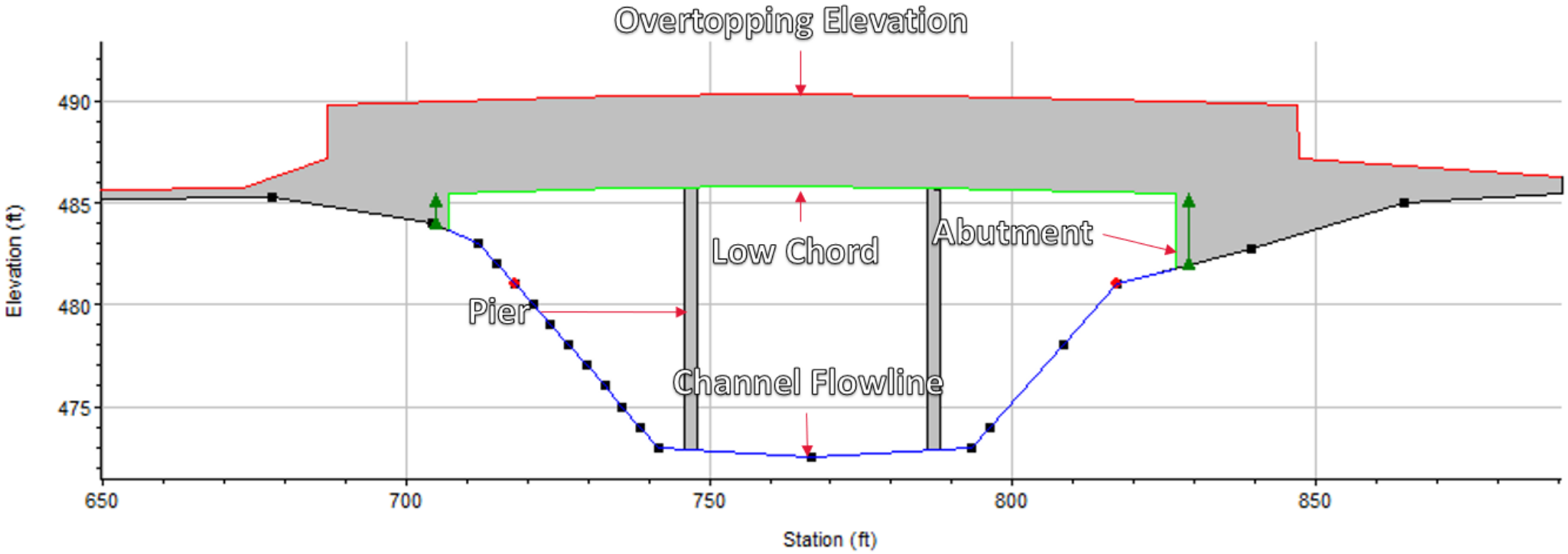
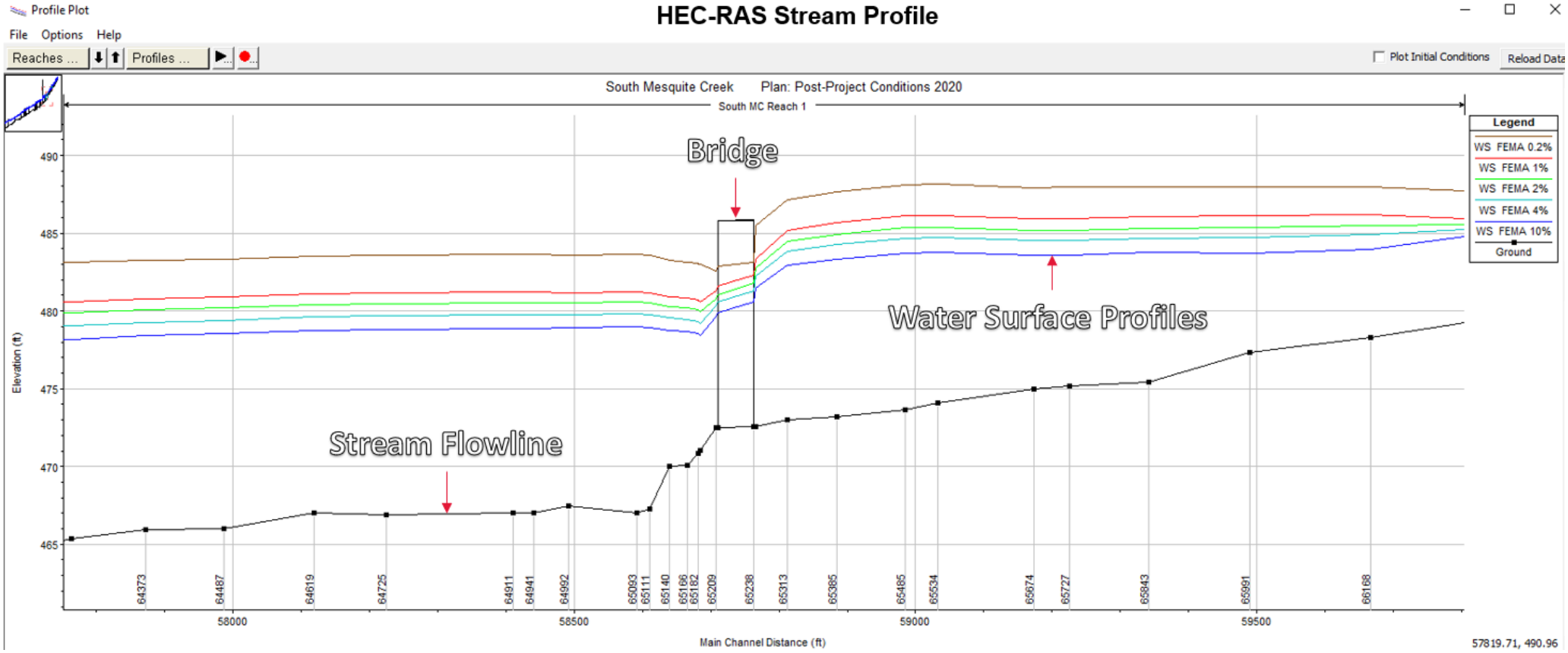

Overtopping Elevation
Low Chord
Abutment
Pier
Channel Flowline
Elevation (ft)
490
485
480
475
650
700
750
800
850
Station (ft)

HEC-RAS Stream Profile



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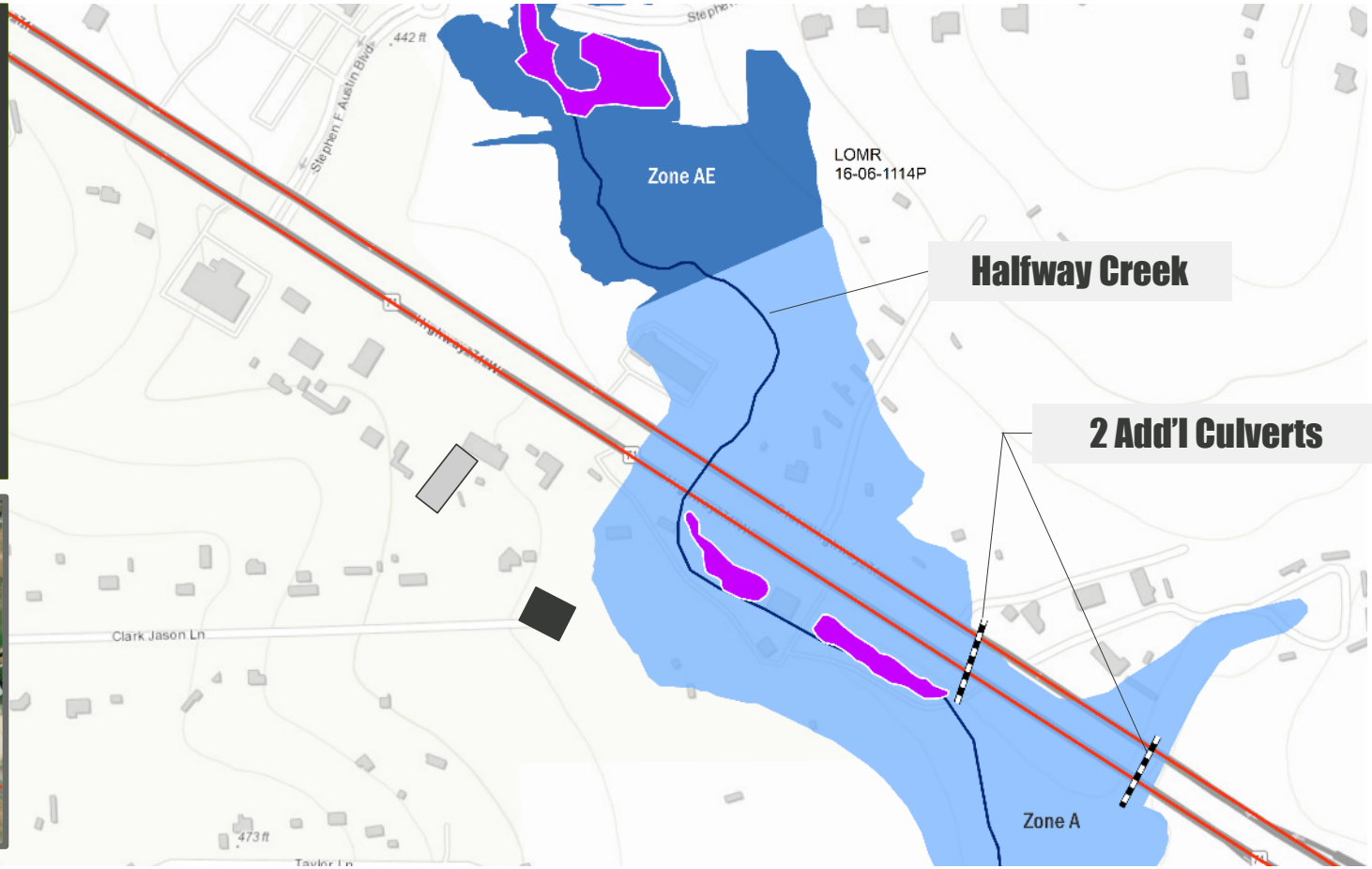
SH 71 at Halfway Creek | *Bastrop, Tx*

2D CASE STUDY



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Model Review Findings
(Schematic)

- Hydrology – Update sub basins with storage/routing, move to HMS
- Flow Increase Downstream, storage loss upstream of bridge
- Hold current Base Flood Elevation within ROW, no rise 1% WSEL
- Complex - split flow, multiple tributaries, hydrology/timing
- Eliminate road overtopping of SH71 (flooding initiates at 10% AEP)
- Flooding Complaints on both sides of SH71 – Hargis Memo
- Existing Structure straddling creek banks – 5 culverts & weir

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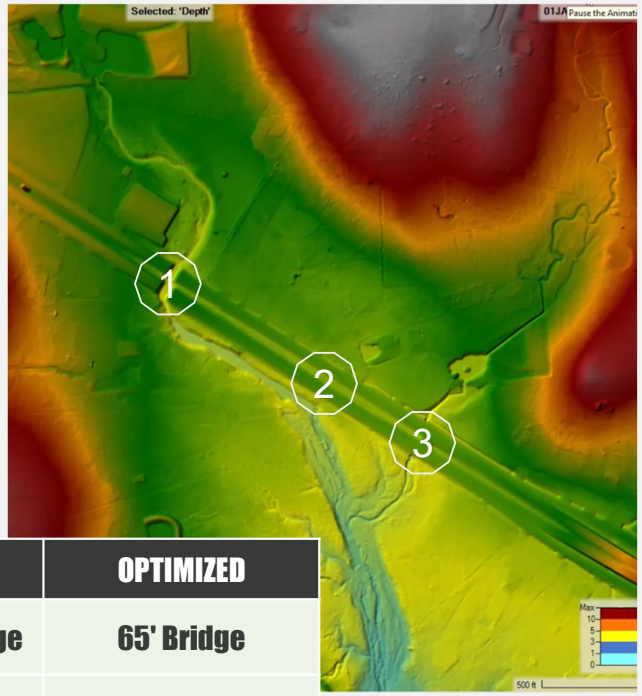
SH 71 at Halfway Creek | *Bastrop, Tx*

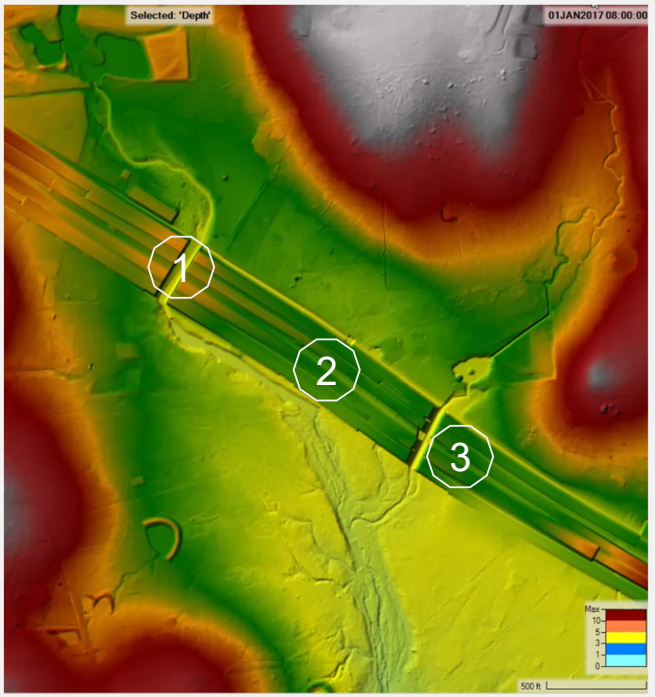
Utilized 2D modeling to:

- Solve a complex flooding issue of a Major Collector while still adding new Frontage and ML
- Optimized Bridge span lengths, Culvert size
- Minimize roadway embankment and retaining wall height.

2D Existing Results



2D Proposed Results



LOCATION	STRUCTURE	SCHEMATIC	OPTIMIZED
1	Halfway Creek Bridge	35'-70'-35' Bridge	65' Bridge
2	Commercial Culvert 6	Extend exist 36"RCP	(5) 10x5 MBC
3	Unnamed Tributary	(3) 9x5 MBC	70' Bridge

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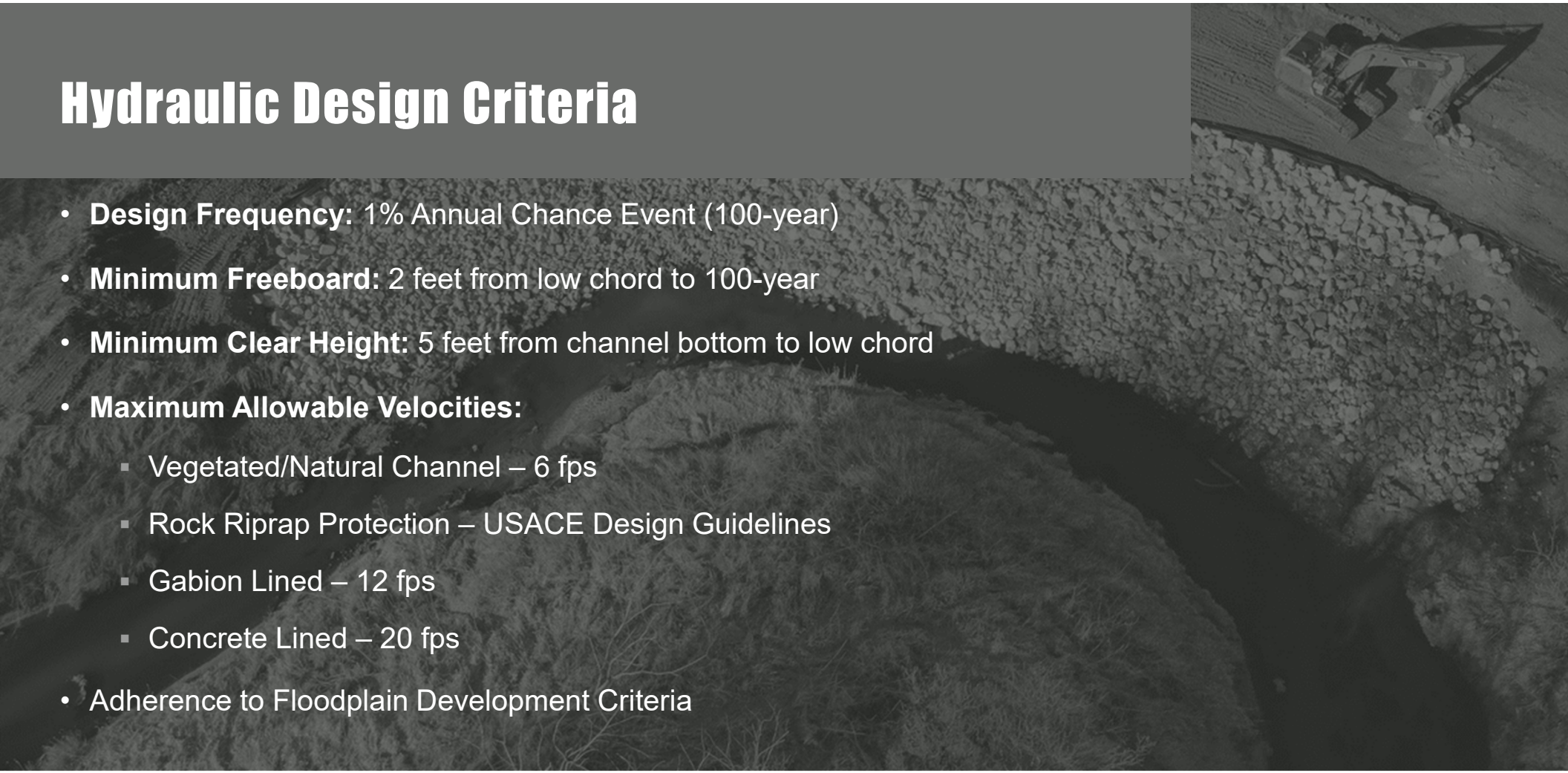
Hydraulic Design Criteria



- **Design Frequency:** 1% Annual Chance Event (100-year)
- **Minimum Freeboard:** 2 feet from low chord to 100-year
- **Minimum Clear Height:** 5 feet from channel bottom to low chord
- **Maximum Allowable Velocities:**
  - Vegetated/Natural Channel – 6 fps
  - Rock Riprap Protection – USACE Design Guidelines
  - Gabion Lined – 12 fps
  - Concrete Lined – 20 fps
- Adherence to Floodplain Development Criteria

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Scour & Streambank Stabilization

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Scour at Bridges

What is the most common cause of failure of bridges?

Scouring of material from bridge foundations

Scour Definition:

Scour is the result of erosive action of running water, excavating and carrying away materials from the bed and banks of streams

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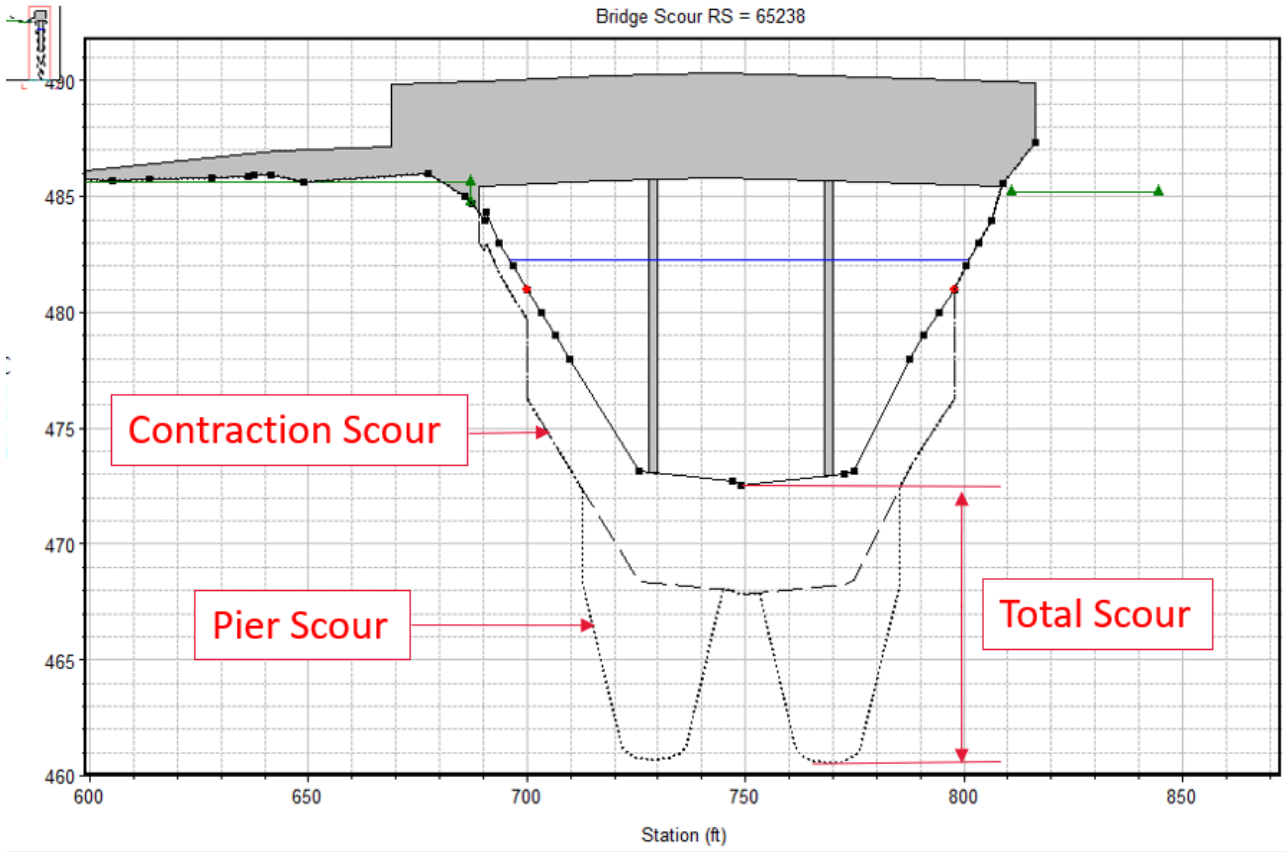

Scour Analysis

- Three components of Total Scour:
  - Long Term aggradation/degradation
  - Contraction Scour
  - Pier/Abutment Scour
- Scour Countermeasures
  - Rock Rip rap
  - Gabion Mattress
  - Concrete Lining

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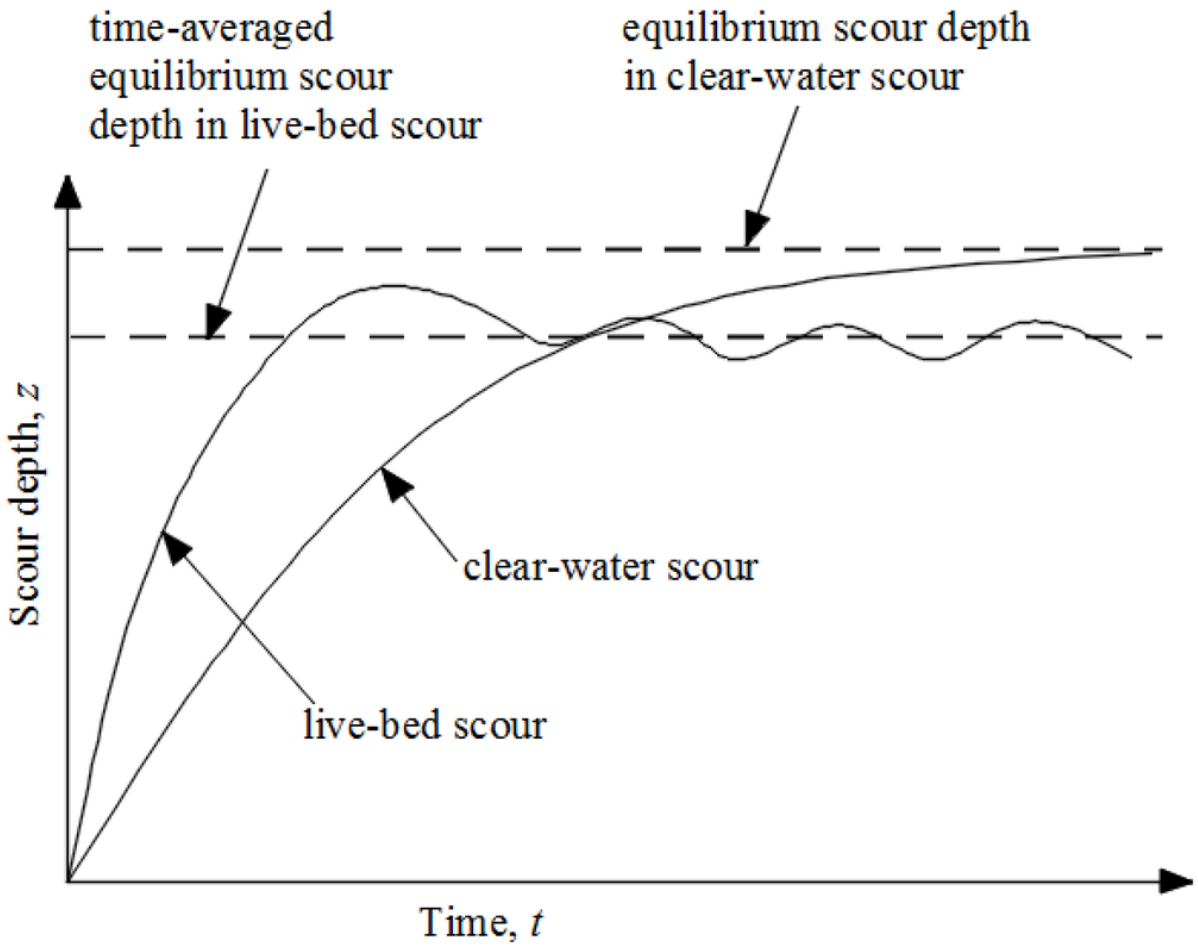

Contraction Scour Conditions

- Live-bed Scour
- Clear-water Scour

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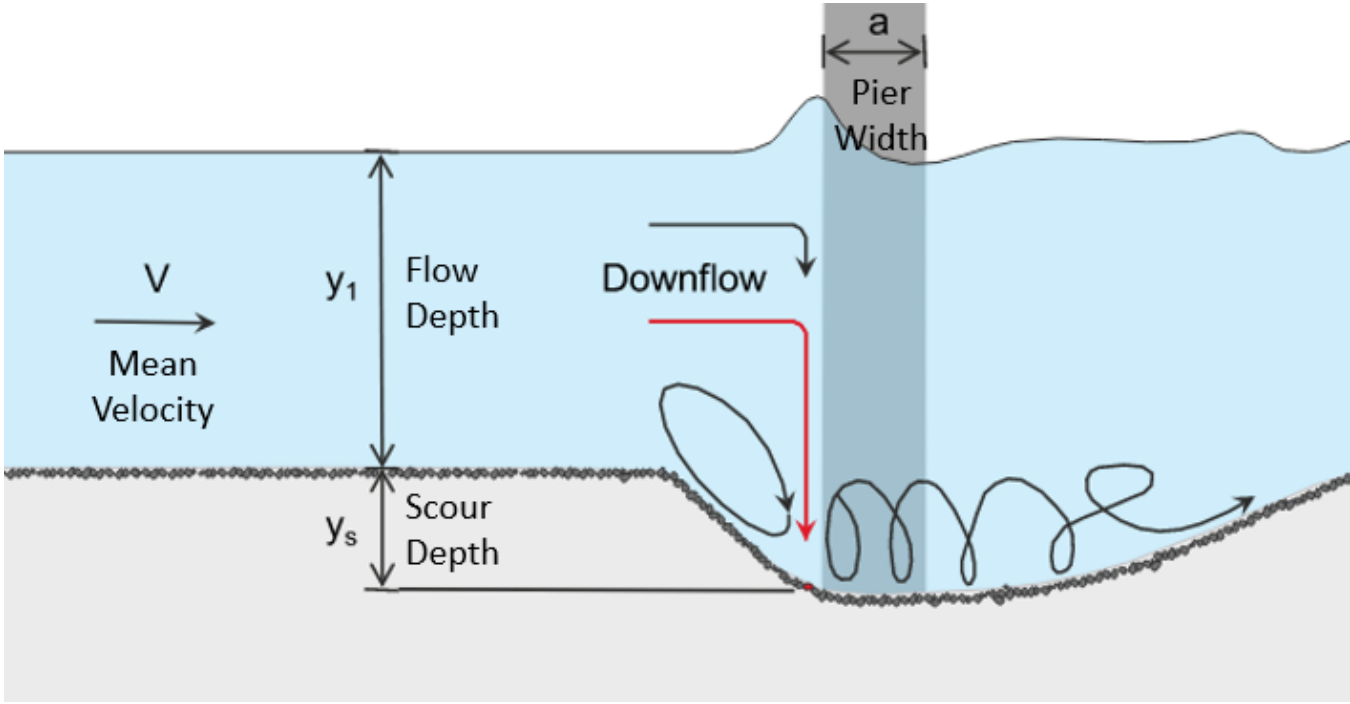
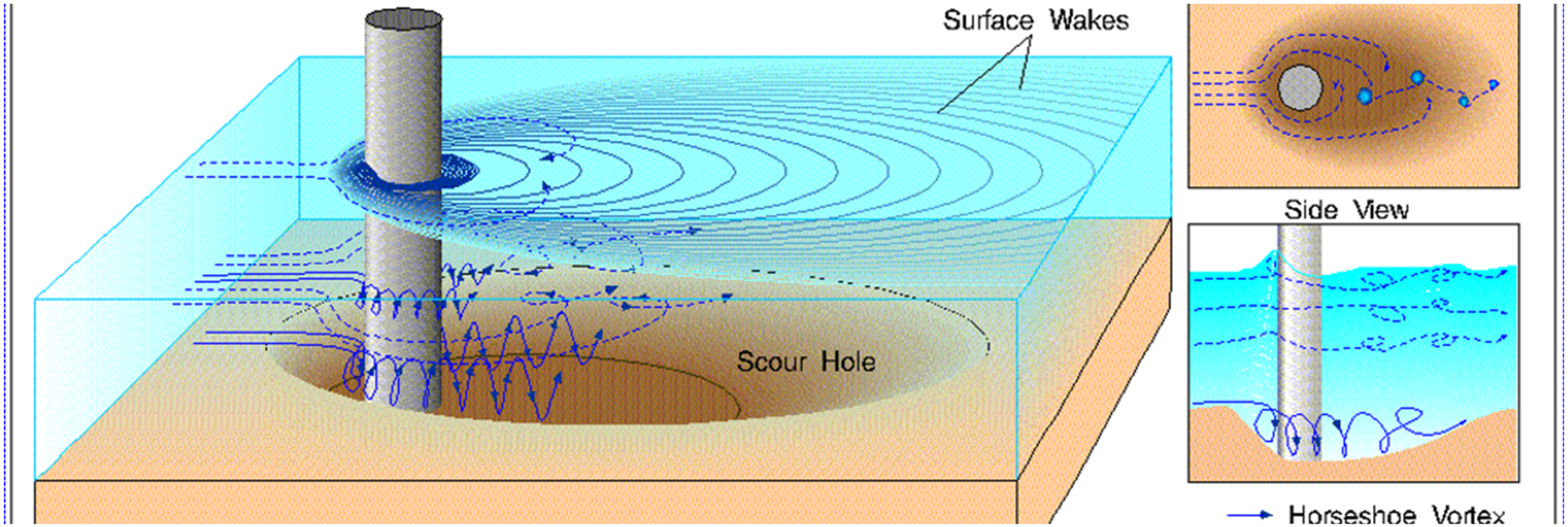
Pier Scour Conditions

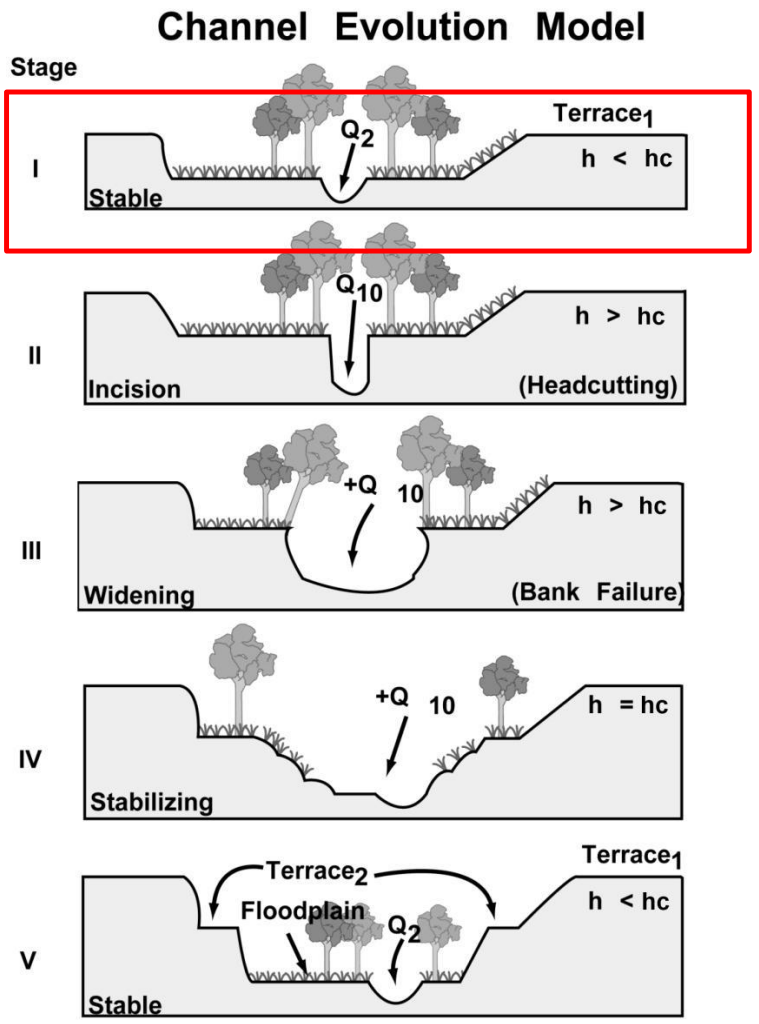
- Function of:
  - Bed Material Characteristics
  - Bed Configuration
  - Flow Characteristics
  - Fluid Properties
  - Pier/foot Geometry



Local Scour - Pier



East Fork Trinity River, Seagoville



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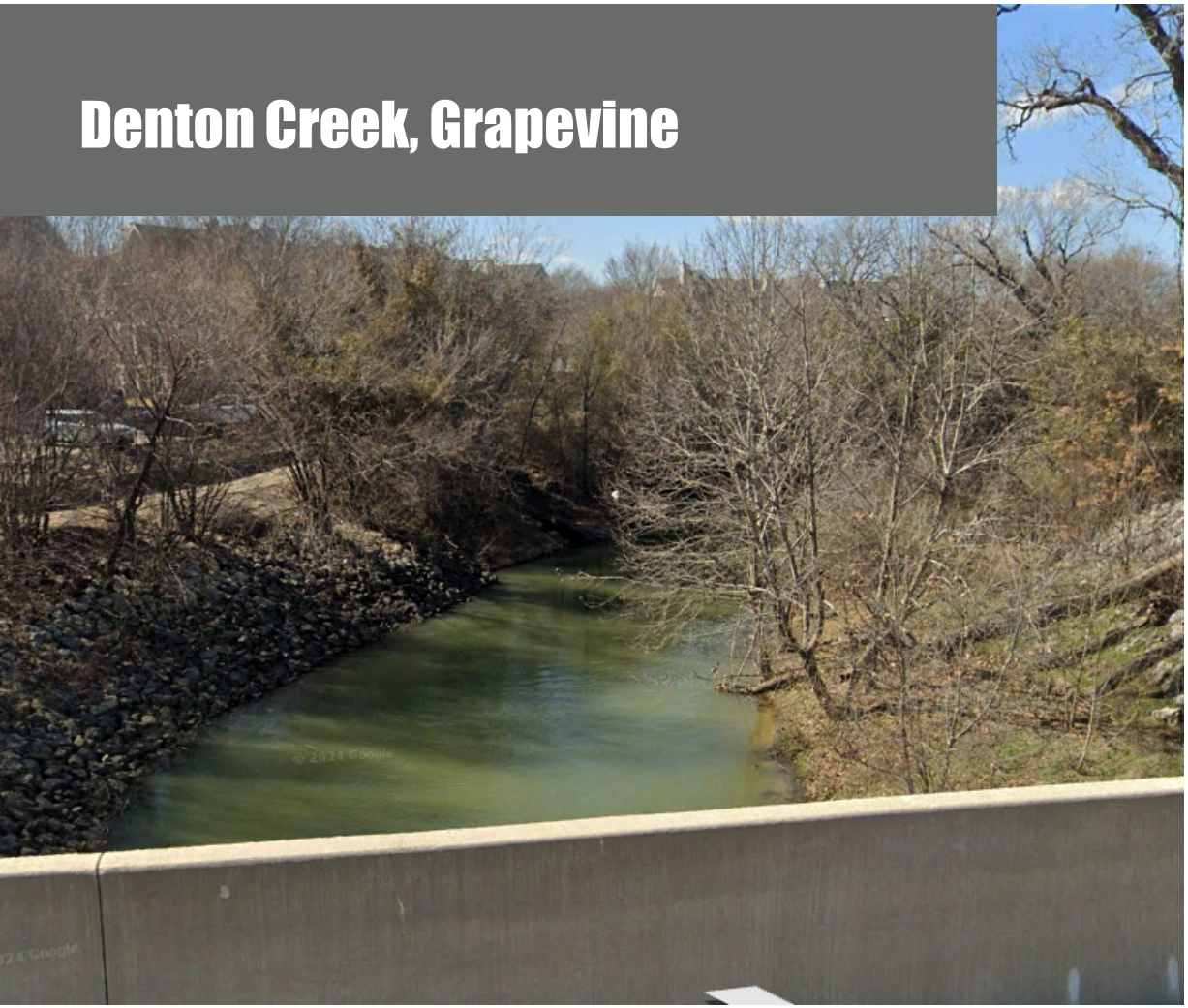
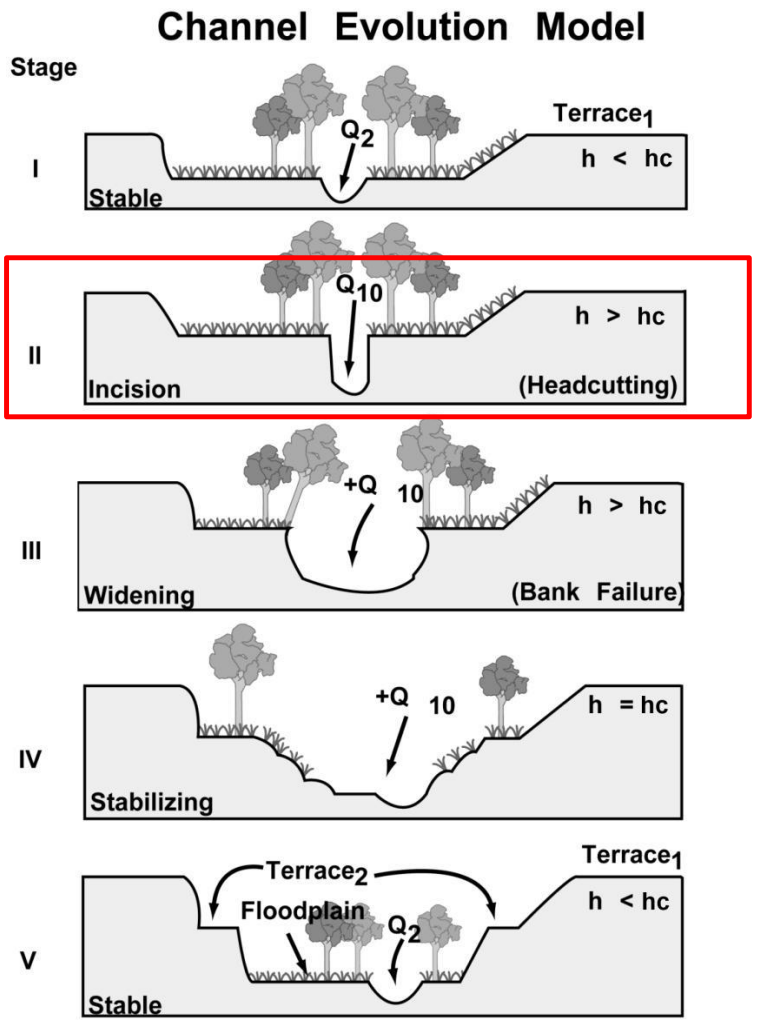
Denton Creek, Grapevine





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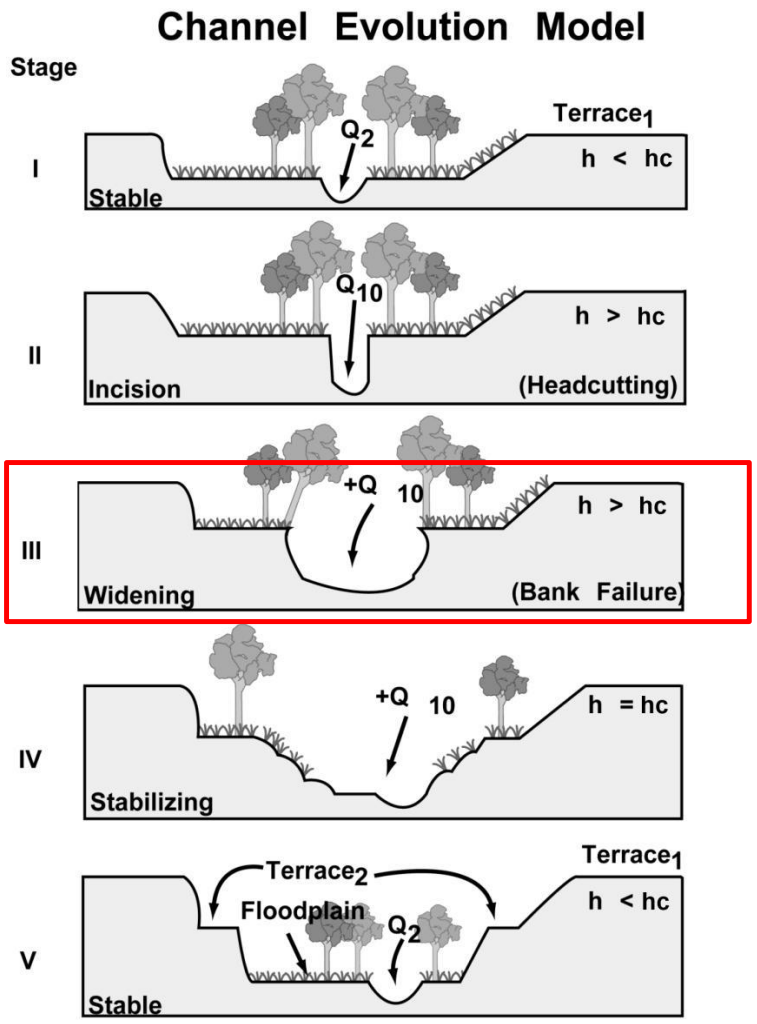
Denton Creek, Coppell



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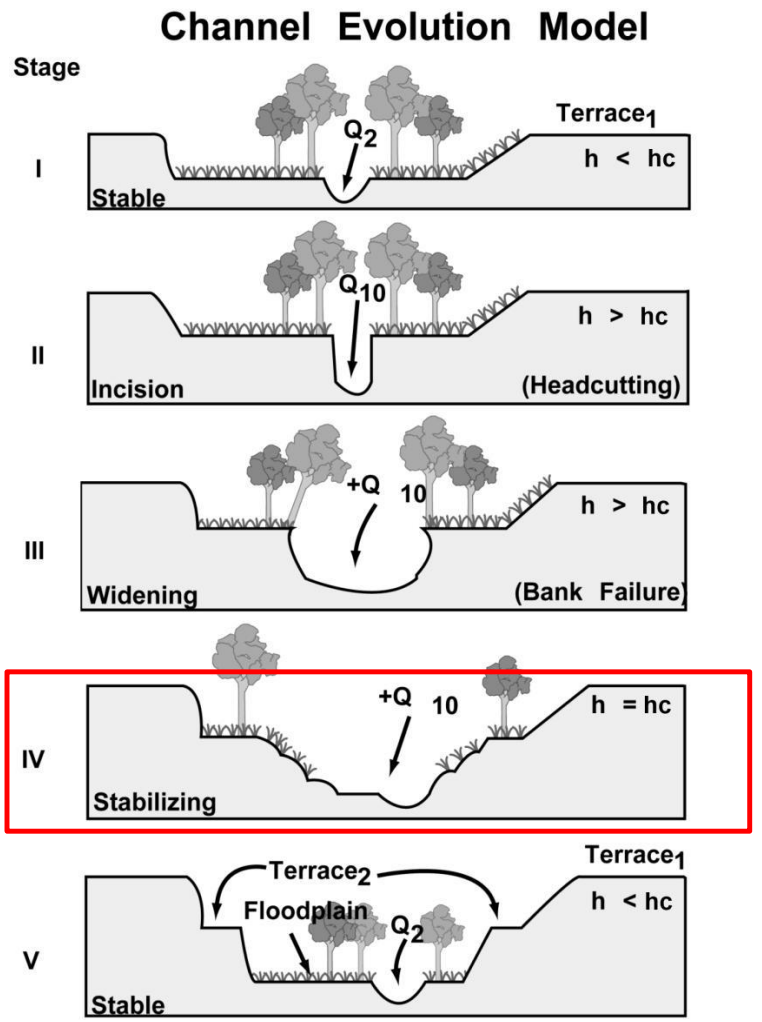
Hickory Creek, Balch Springs



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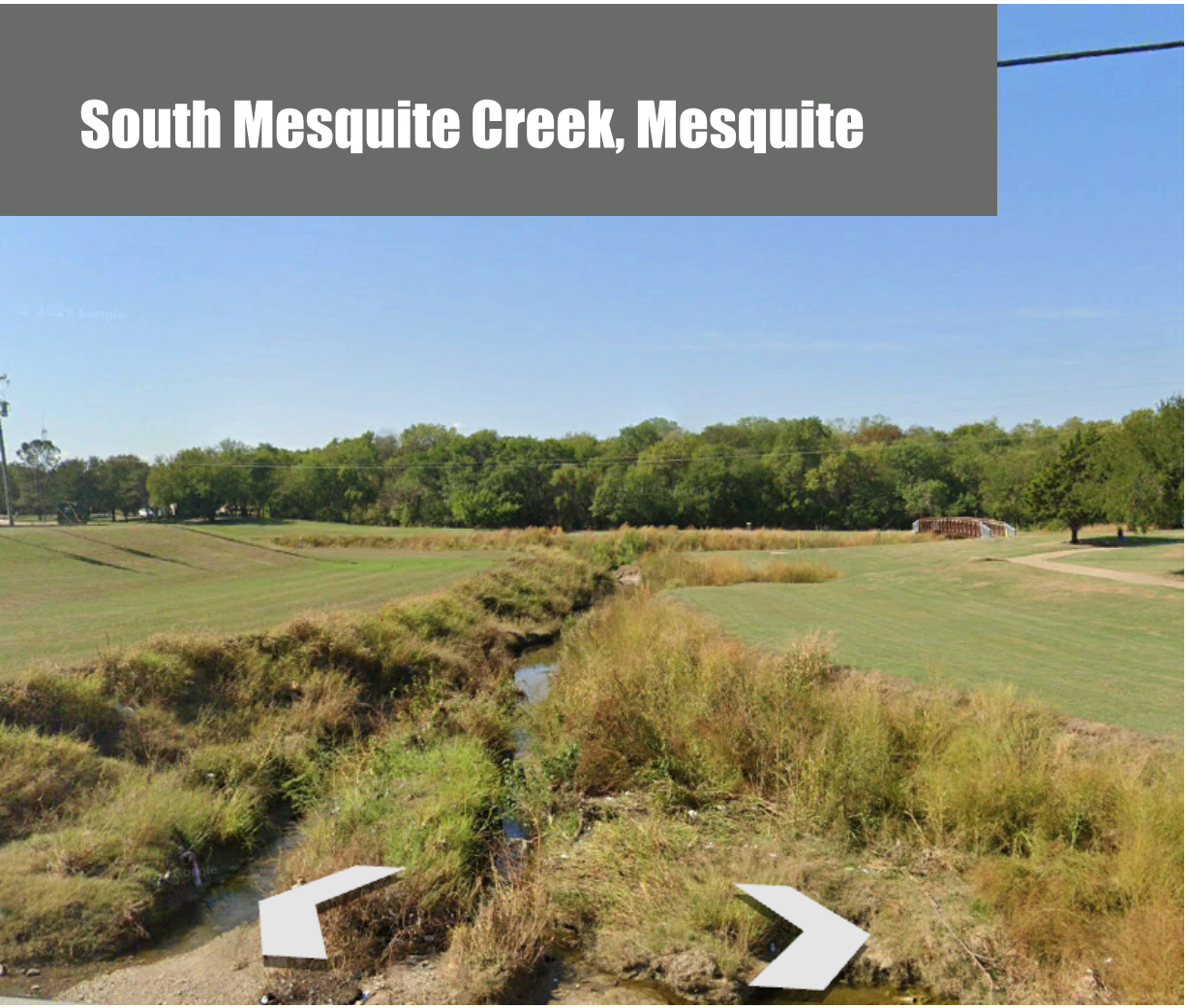
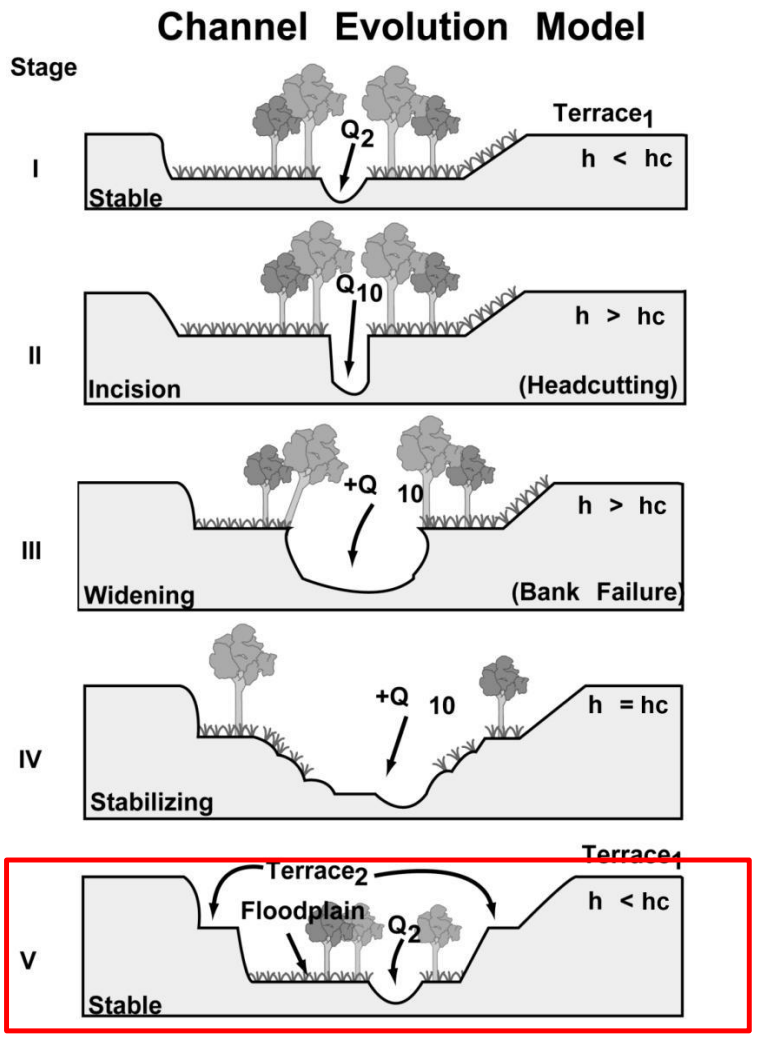
South Mesquite Creek, Mesquite





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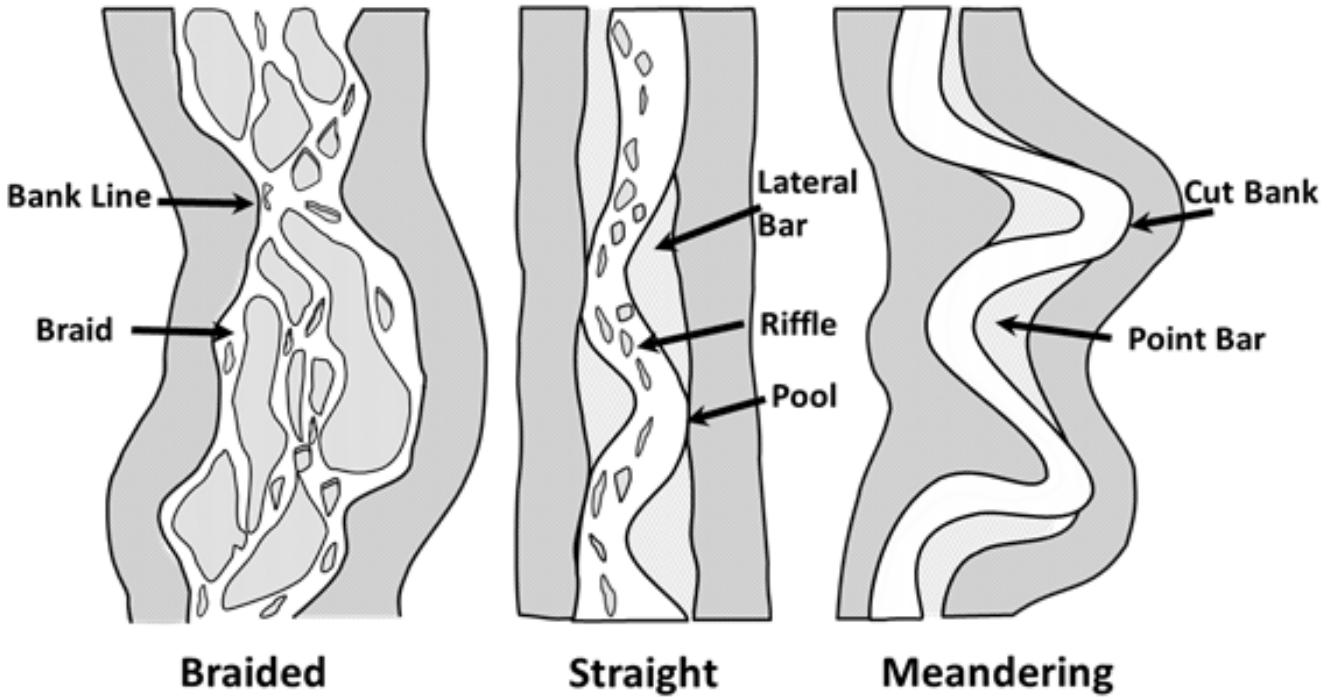
Instability and Stream Planform

Stream planform is:

- the shape of a stream when viewed from above
- useful in understanding stream morphology and potential stream response to change



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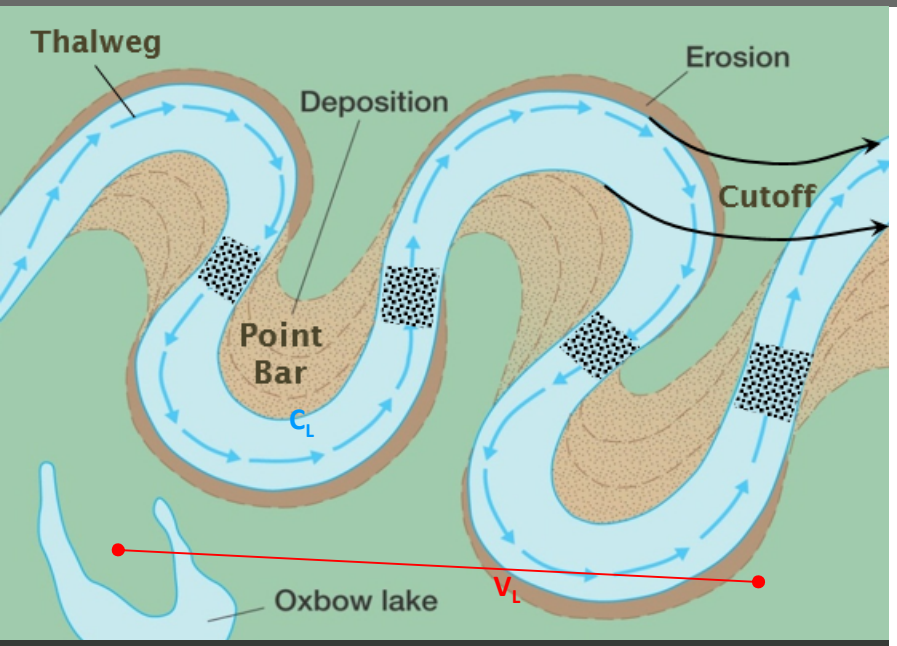
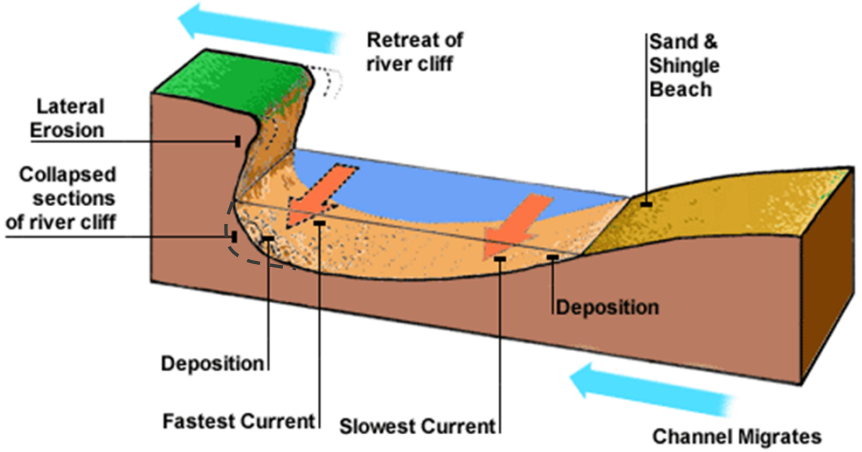
Meandering Streams





Features

- Thalweg
- Sinuosity (CL/VL)
- Point bar
- Cutoffs and oxbows

Flow Patterns

- Shear Stress
- Velocity
- Helicoidal Flow

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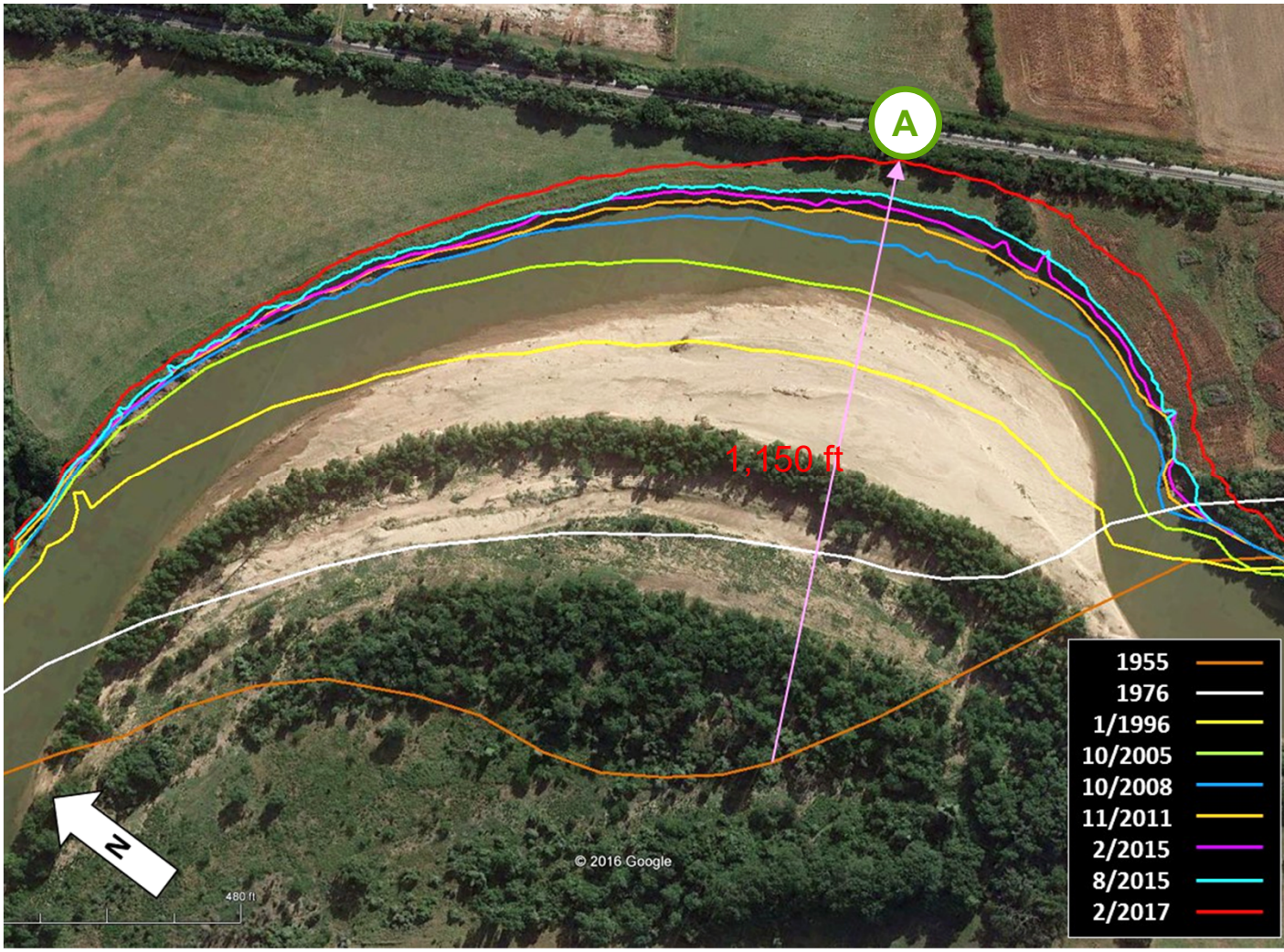
Brazos River near Highbank, TX



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Brazos River near Highbank, TX

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Straight Streams

- Considered a transitional stage
- Many straight streams/reaches are man-made/modified
- Even in straight channels, the thalweg will meander

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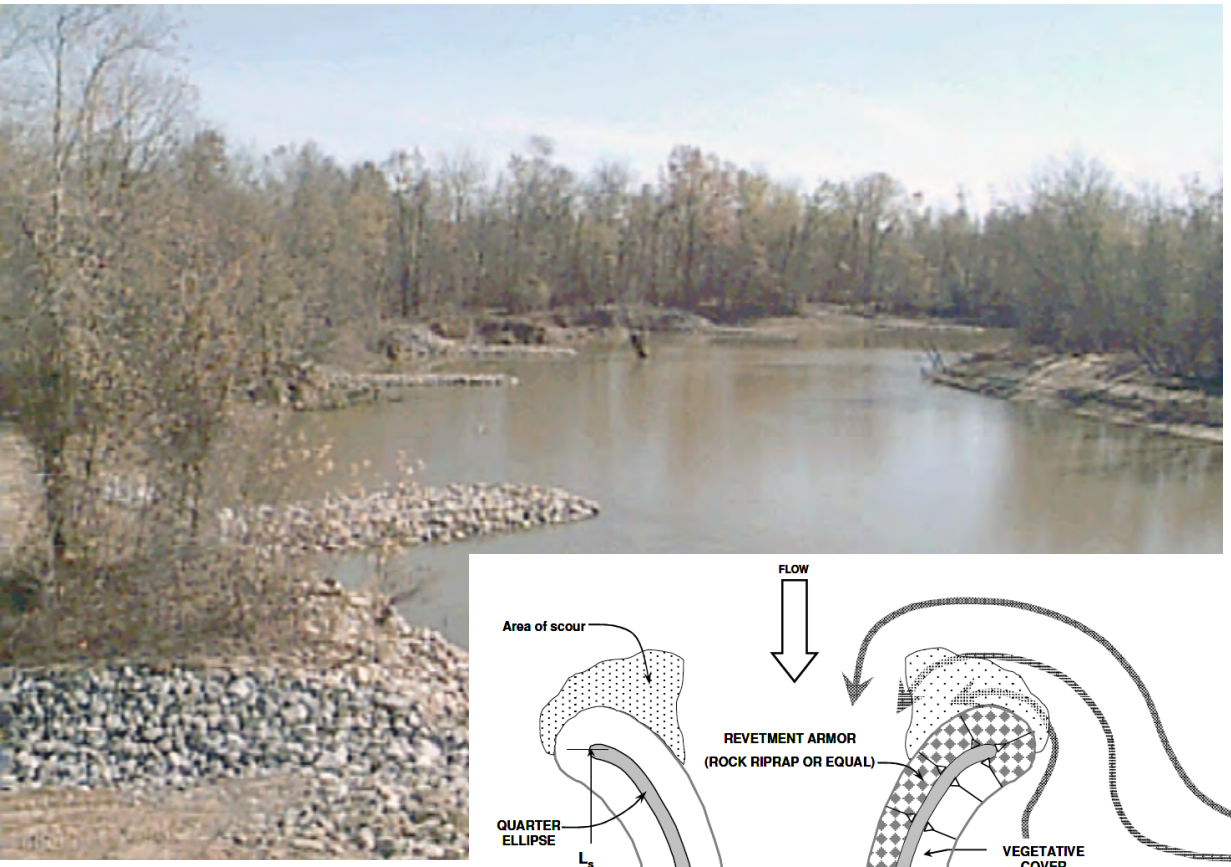

HYDRAULIC COUNTERMEASURES:
RIVER TRAINING STRUCTURES

TRANSVERSE STRUCTURES
Impermeable spurs (jetties, groins, wing dams)
Permeable spurs (fences, netting)
Transverse dikes
Bendway weirs/Stream barbs[1]
Hardpoints
Drop structures (check dams, grade control)
Embankment Spurs
LONGITUDINAL STRUCTURES
Longitudinal dikes (crib/rock toe/embankments)
Retards
Bulkheads
Guide banks
AREAL STRUCTURES/TREATMENTS
Jacks/tetrahedron jetty fields
Vanes
Channelization
Flow relief (overflow, relief bridge)
Sediment detention basin

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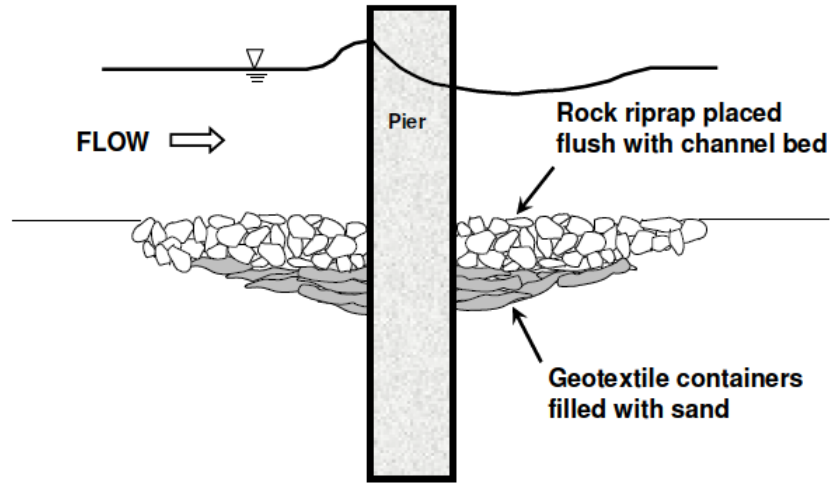
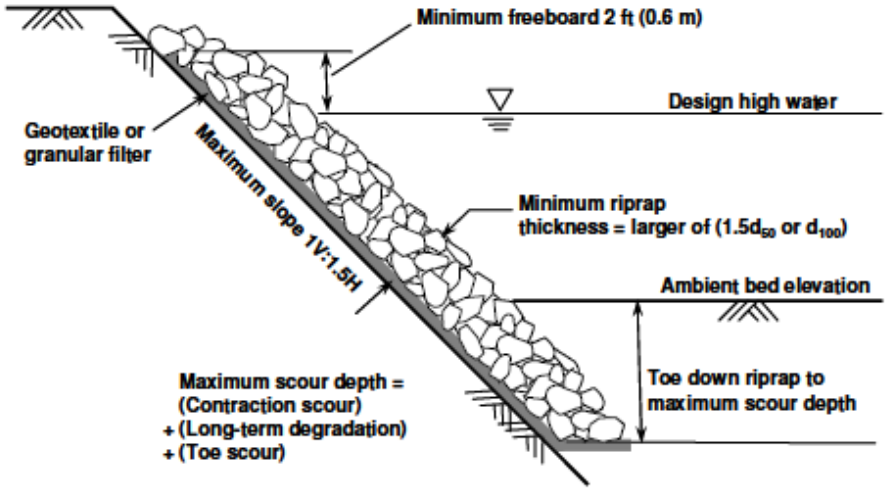
HYDRAULIC COUNTERMEASURES:
Armoring

REVETMENTS AND BED ARMOR
Rigid
Soil cement
Roller compacted concrete
Concrete pavement
Rigid grout filled mattress/concrete fabric mat
Fully grouted riprap
Flexible/articulating
Riprap
Self launching riprap (windrow)
Riprap fill-trench
Gabions/gabion mattress[2]
Wire enclosed riprap mattress (rail bank/sausage)
Articulated blocks (interlocking and/or cable tied)
Concrete/grout mattress (fabric-formed)
Partially grouted riprap
LOCAL SCOUR ARMORING
Riprap (fill/apron)
Fully grouted riprap
Concrete armor units (Toskanes, tetrapods, etc.)[3]
Grout filled bags/sand cement bags
Gabions/gabion mattress[2]
Articulated blocks (interlocking and/or cable tied)
Sheet pile/cofferdam
Partially grouted riprap





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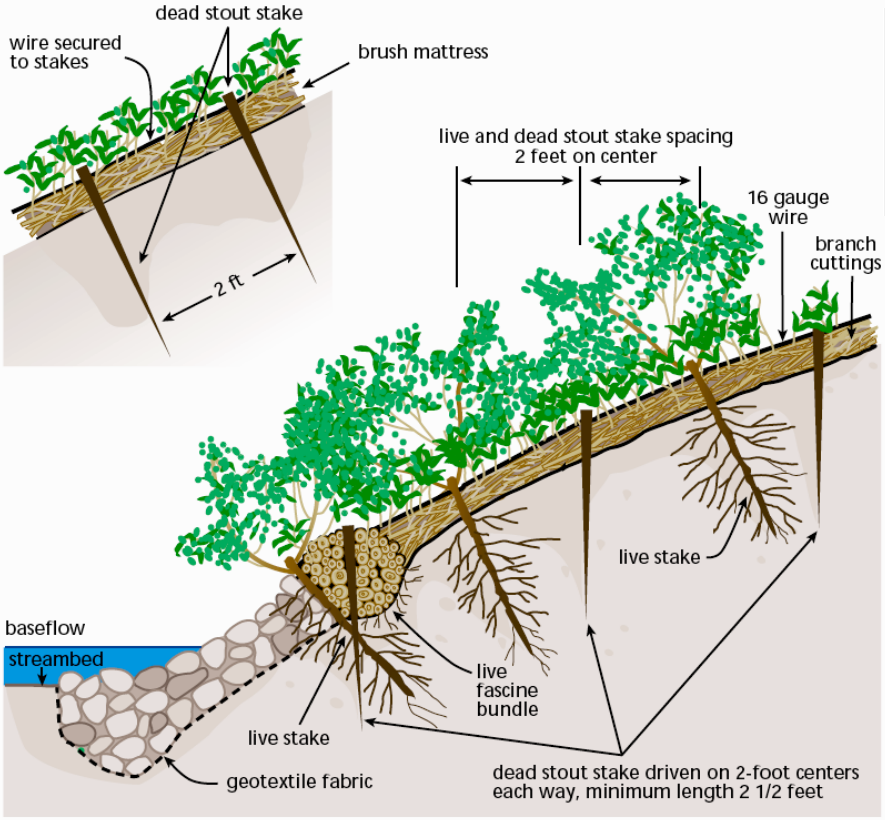
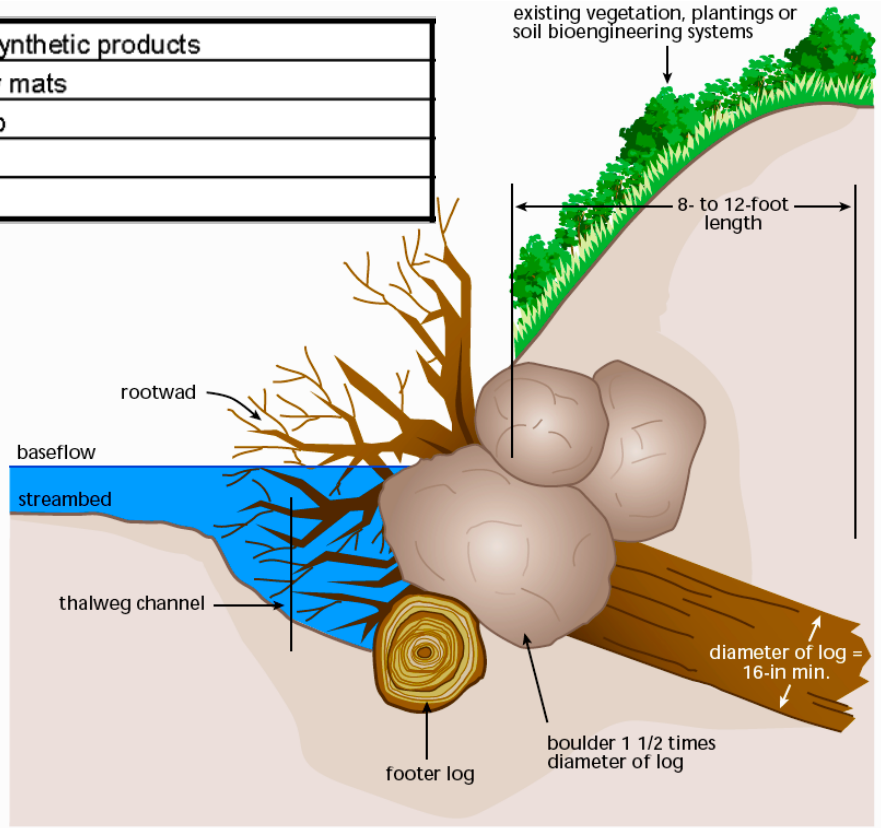
BIOTECHNICAL COUNTERMEASURES



Vegetated geosynthetic products
Fascines/woody mats
Vegetated riprap
Root wads
Live staking



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CITY PROJECT MANAGEMENT: OVERVIEW

TRANSPORTATION PROJECTS INVOLVING FLOODPLAIN CAN INCLUDE THE FOLLOWING CHALLENGES:

- Thoroughfares crossing major creeks can include multiple jurisdictional boundaries
- Floodplain impacts to project drainage system
- Project impacts to floodplain
- Bridge structure scour and channel erosion protection
- Environmental, agency coordination, permitting
- Utility Coordination
- Impacts to adjacent property
- More frequent and larger flood events in recent years

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CITY PROJECT MANAGEMENT: LESSONS LEARNED

- **TWO- PHASE DESIGN OPTION-**
  Preliminary Design (30%+/-): initial H&H, horizontal and vertical alignment, ROW/permitting requirements, Final Design scope, stakeholder meeting
  Final Design- complete design, ROW, permitting, utility relocations
- **ROW ACQUISITION, UTILITY COORDINATION, PERMITTING-**
  Initiate in 30%-60% Design to keep off critical path
- **CONSTRUCTIBILITY REVIEWS-**
  Field review of existing conditions and design
- **CHANNEL ALIGNMENT/STABILZATION-**
  Evaluate need for protection of slopes, abutments, and bridge structure due to channel alignment, erosion, etc.
- **COMMON FLOODPLAIN PROJECT ELEMENTS-**
  Electric Transmission Lines, parks and trails, property access, continuously changing channel conditions due to scour and erosion

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CITY PROJECT MANAGEMENT: LESSONS LEARNED

UTILITY IDENTIFICATION AND COORDINATION

Electric transmission lines- check for clearance, impacts to construction activity

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CITY PROJECT MANAGEMENT: LESSONS LEARNED

CHANGING CONDITIONS DUE TO SCOUR AND EROSION
Channel erosion in park at creek bend approaching bridge structure

CHANNEL STABILIZATION
Additional gabion blocks added to protect bridge abutment from scour

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CITY PROJECT MANAGEMENT: LESSONS LEARNED

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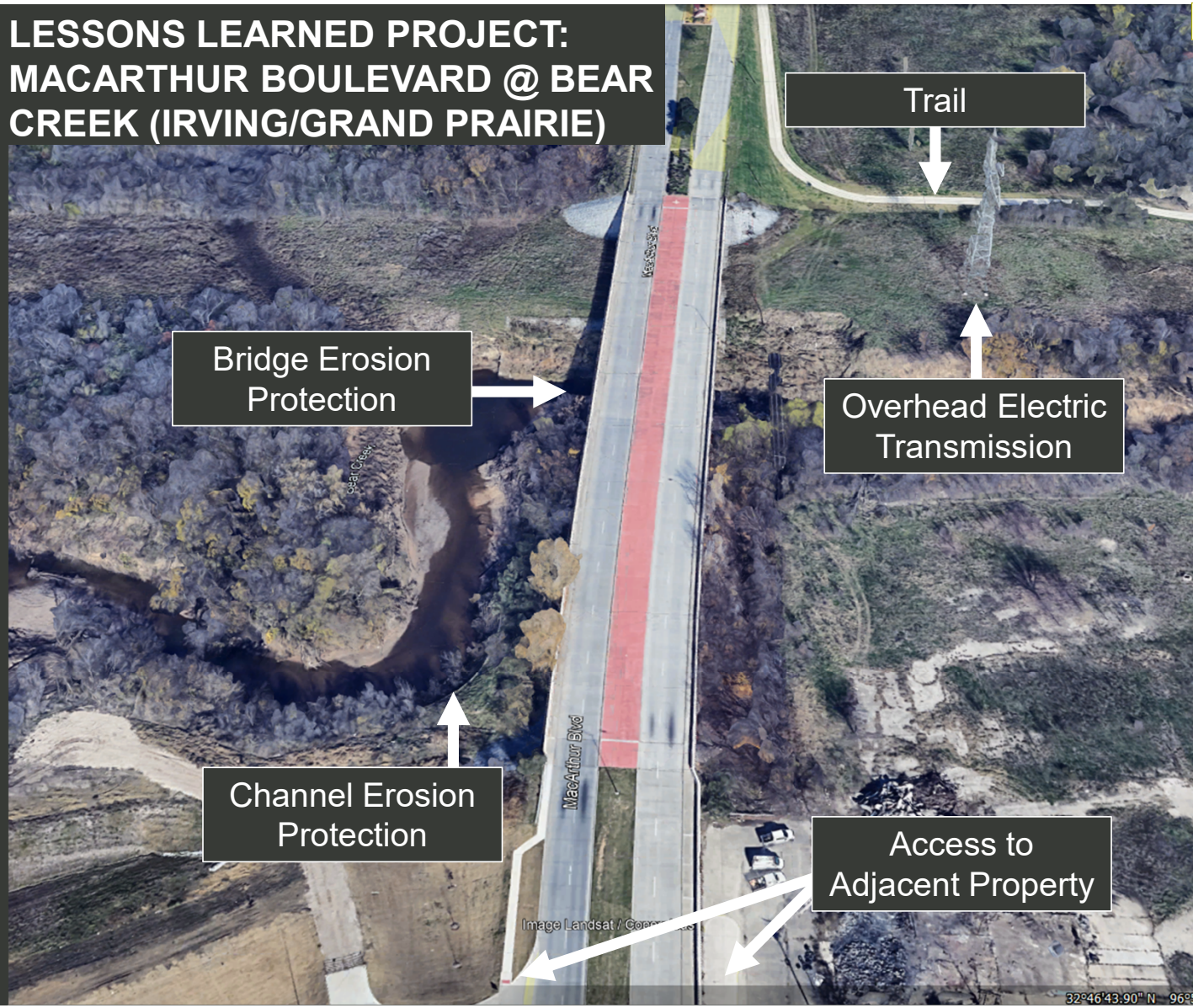
CITY PROJECT MANAGEMENT: LESSONS LEARNED

LESSONS LEARNED PROJECT: MACARTHUR BOULEVARD @ BEAR CREEK (IRVING/GRAND PRAIRIE)



Slide 45

HA0 Need to get a new slide from Mesquite that has the callouts shown better that are hard to see

Hank Amen, 2024-08-06T16:37:55.922

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CITY PROJECT MANAGEMENT: LESSONS LEARNED

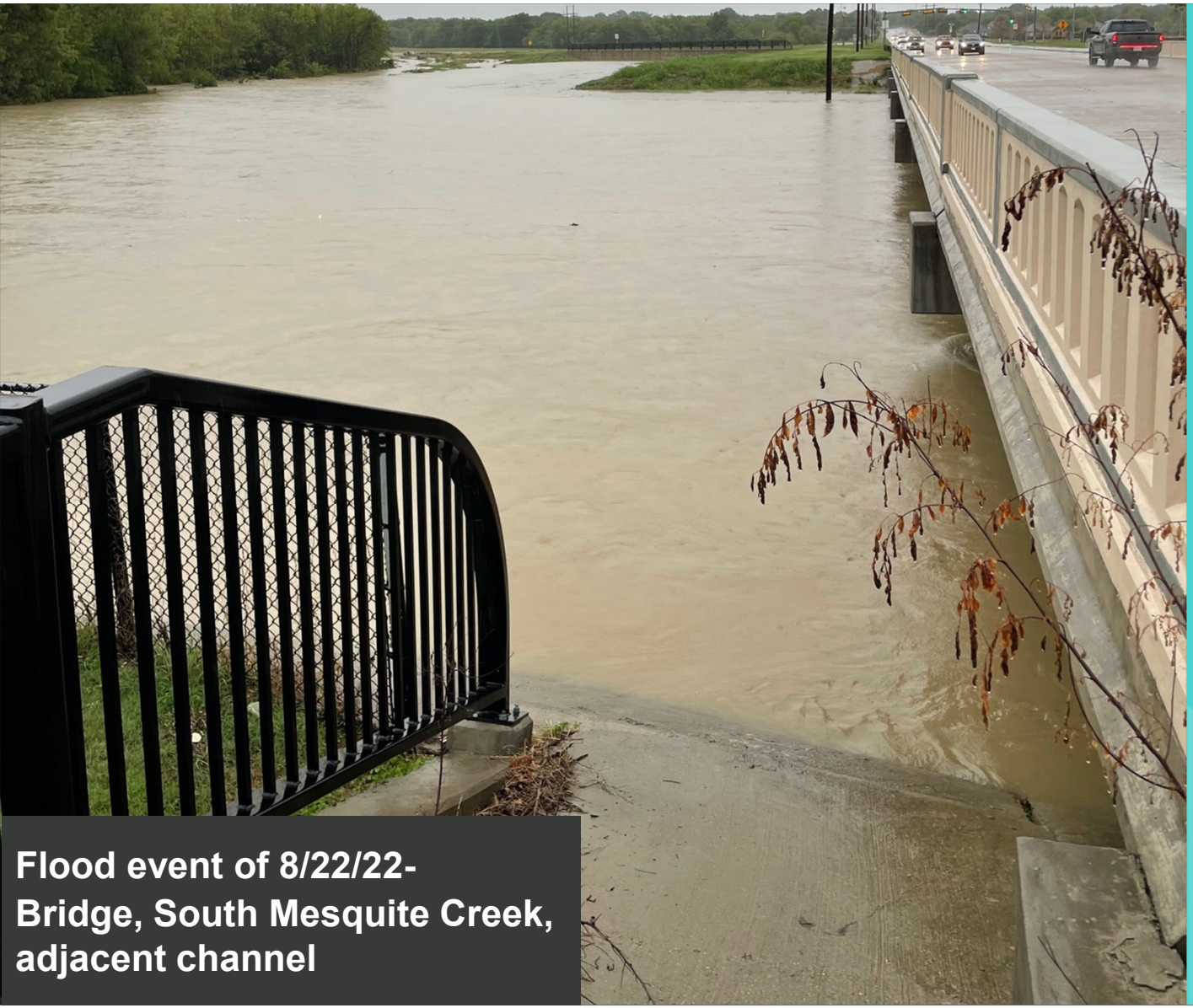
LESSONS LEARNED PROJECT: MACARTHUR BOULEVARD @ BEAR CREEK

- **Dallas County Bond Program Project**
- **Multi-jurisdictional: Cities of Irving and Grand Prairie**
- **Oncor Transmission Lines adjusted for clearance (project cost), de-energized for bridge beam installation**
- ROW acquisition from property at bridge on east side involving claim of damages, reconstructed driveway access
- **Individual 404 Permit, Wetlands Mitigation**
- **Meandering stream movement from initial survey resulted in bridge alignment revision and addition channel erosion protection**
- Channel slope protection at bridge
- Trail constructed after project
- New development and driveway access on west side after project

Slide 46

HA0 Not a Mesquite Project - Or focusing on the Floodplain or bridge crossing, consider removing

Hank Amen, 2024-08-06T16:23:41.821



Flood event of 8/22/22- Bridge, South Mesquite Creek, adjacent channel

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MESQUITE PROJECT: PIONEER ROAD

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MESQUITE PROJECT: PIONEER ROAD

(BELT LINE ROAD TO E. CARTWRIGHT ROAD) COMPLETED 2015

- **Two-Phase Design**, **constructed by Dallas County** as part of Major Capital Improvements Program (MCIP)
- **Stakeholder Meeting** (Charrette)- Preliminary Design determined four-lane divided thoroughfare was not practical to construct with narrow existing ROW in residential area, Public Meeting prior to construction
- Four-lane undivided concrete thoroughfare including bridge, large culverts, and parallel drainage channel
- **Minimal environmental impact**, CLOMR/LOMR, **Nationwide 404 Permit**
- New thoroughfare higher than some existing residential lots and adjacent City Lake Park created **challenges with access, drainage, fences, screening, retaining walls**
- Construction **accommodated wood electric transmission poles without relocation**
- **Flood event of 8/22/22-** 14 inches of rain upstream and 12 inches locally, main channels and bridge structure functioned properly, one intersection closed due to high water

Existing Westbound Bridge and Proposed Eastbound Bridge.

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MESQUITE PROJECT: F. P. LUCAS BOULEVARD

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MESQUITE PROJECT: F. P. LUCAS BOULEVARD

MCKENZIE ROAD TO E. CARTWRIGHT ROAD UNDER CONSTRUCTION

- **Two-Phase Design, constructed by City** as part of Dallas County MCIP
- **Stakeholder Meeting** (Charrette)- changed typical section and construction phasing, switched project delivery from County led to City led
- Westbound bridge previously constructed
- Previous slope protection project in South Mesquite Creek
- Four-lane divided concrete thoroughfare including eastbound bridge and large culverts
- **Minimal environmental impact**, CLOMR/LOMR, **Nationwide 404 Permit**
- Significant fencing coordination with adjacent property owner
- Fiber subcontractor bored through City sanitary sewer outfall line during relocations
- **No conflict with crossing electrical transmission lines but will have to be de-energized for bridge construction, other overhead line relocations required**
- **Project includes pedestrian trail and trail connection**

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