HDR

Introductions

Dan Pfeifer – Transportation Hydraulics Manager

15 years working in Hydrology & Hydraulics

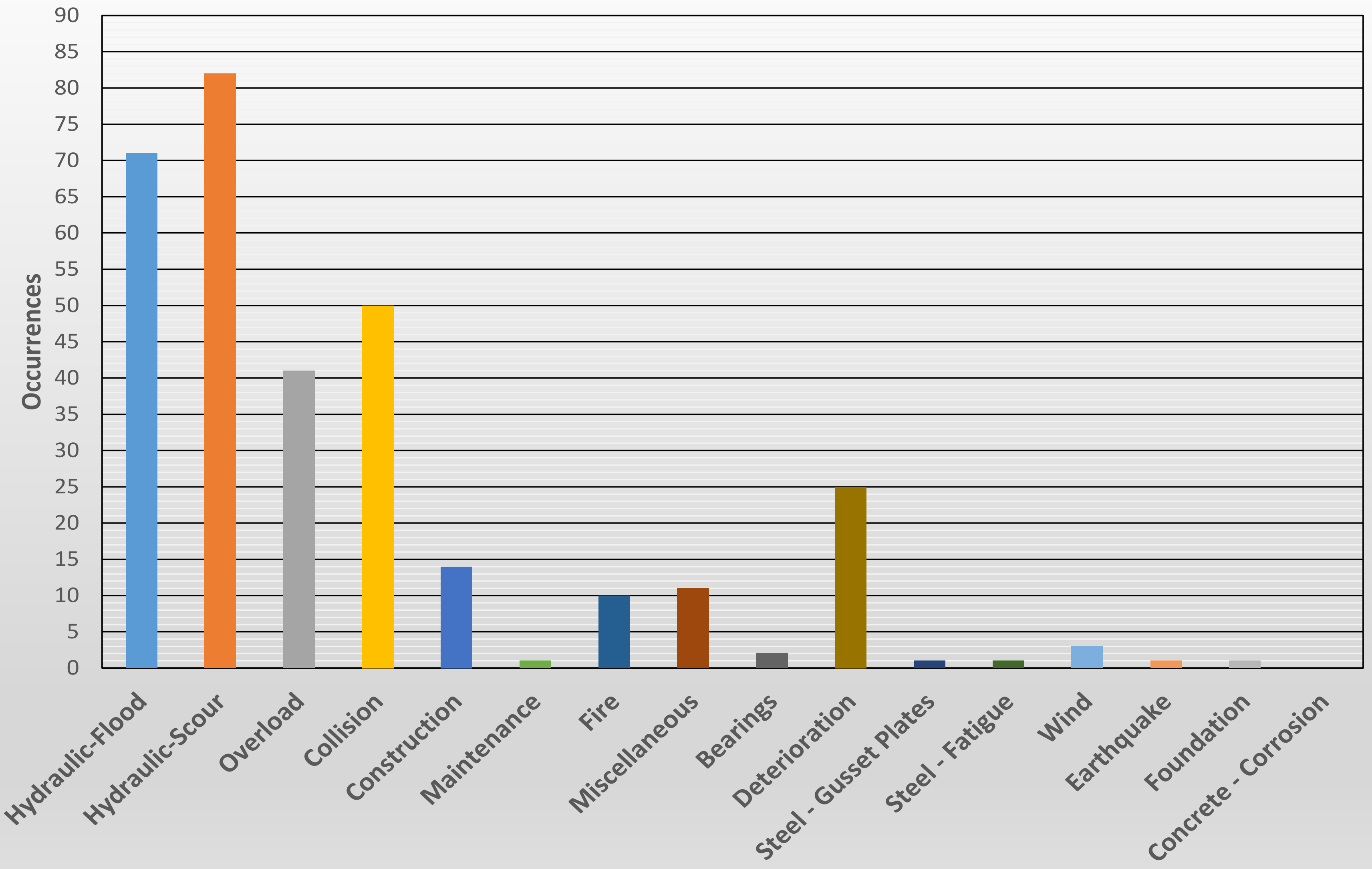
Water Resources and Transportation Hydraulics

Study and Final design
Stormdrain Design
Bridge Hydraulics
Scour and Scour Mitigation
Sediment Transport
Stormwater Pump Stations
Large Scale Drainage Infrastructure
Multi-Dimensional Hydraulics
Field Assessment

PRINCIPAL BRIDGE FAILURE CAUSES

- Flooding – changing climate and extreme weather events are causing more flood-related damages to bridges
- Scour – gradually wearing away streambed material (soils) around and underneath the bridge piers and abutments
- Deterioration – bridges in US earn C+ rating for maintenance and safety. One out of every nine bridges is considered structurally deficient
- Design & Manufacturing Defects – weak structural elements, insufficient redundancy, poor quality steel/concrete, improper welding techniques
- Other – overload, earthquake, collision, fire

STATISTICS OF BRIDGE FAILURE



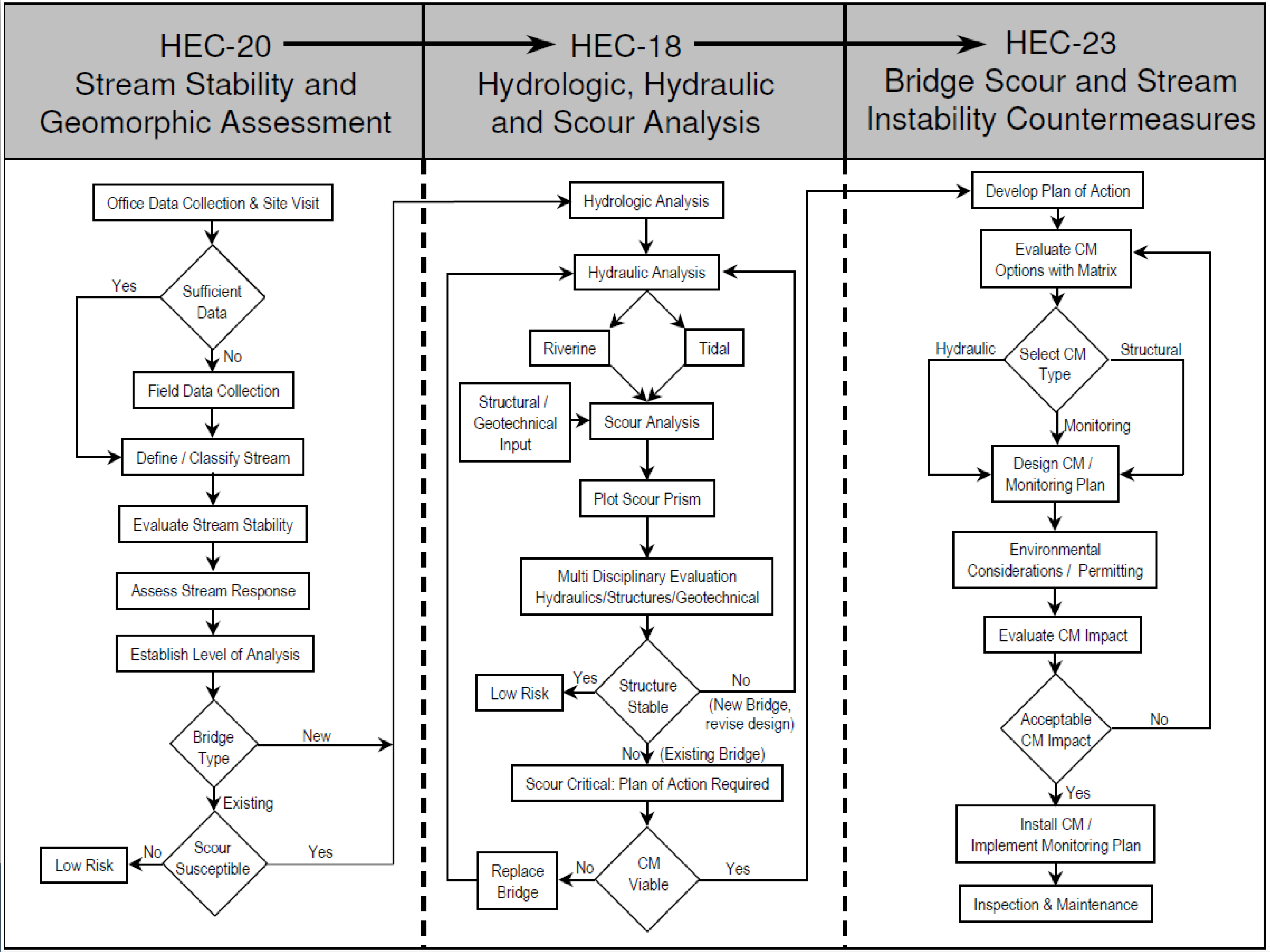
Source: Michael Taricska (2014)
Master Thesis, Ohio State University

Cause of Bridge Failure in US (2000-2012)

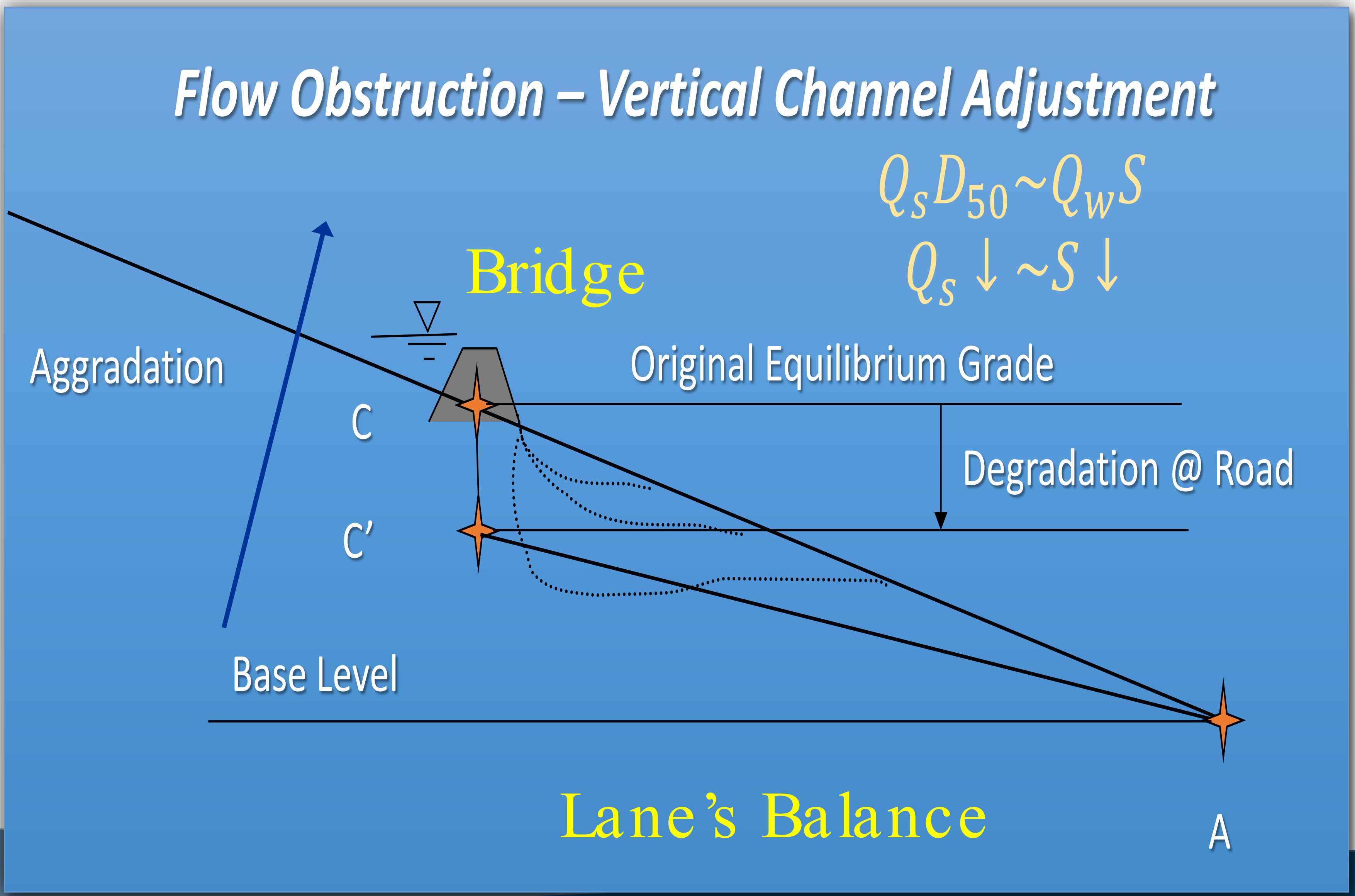
TYPES OF BRIDGE SCOUR

- Contraction Scour – results from a contraction of flow area at bridge which causes an increase in velocity and shear stress on streambed
- Bend Scour – sediment eroded by a transverse roller of flow on the outside bank caused by helical (secondary) flow in a bend
- Bedform Scour – occurs as part of the formation and movement of dunes & antidunes in alluvial rivers, mostly in upper regime flow
- Pier & Abutment Scour – gradually wearing away streambed material around and underneath the bridge piers and abutments due to vortex formation (turbulence) near flow obstruction
- Long-Term Degradation (Headcut) – gradual lowering of the streambed due to a deficit in sediment supply or increased sediment transport capacity
- Lateral Erosion – commonly caused by realignment of a stream and erosion of its banks near abutments of the bridge

FHWA BRIDGE SCOUR EVALUATION



GEOMORPHIC ASSESSMENT



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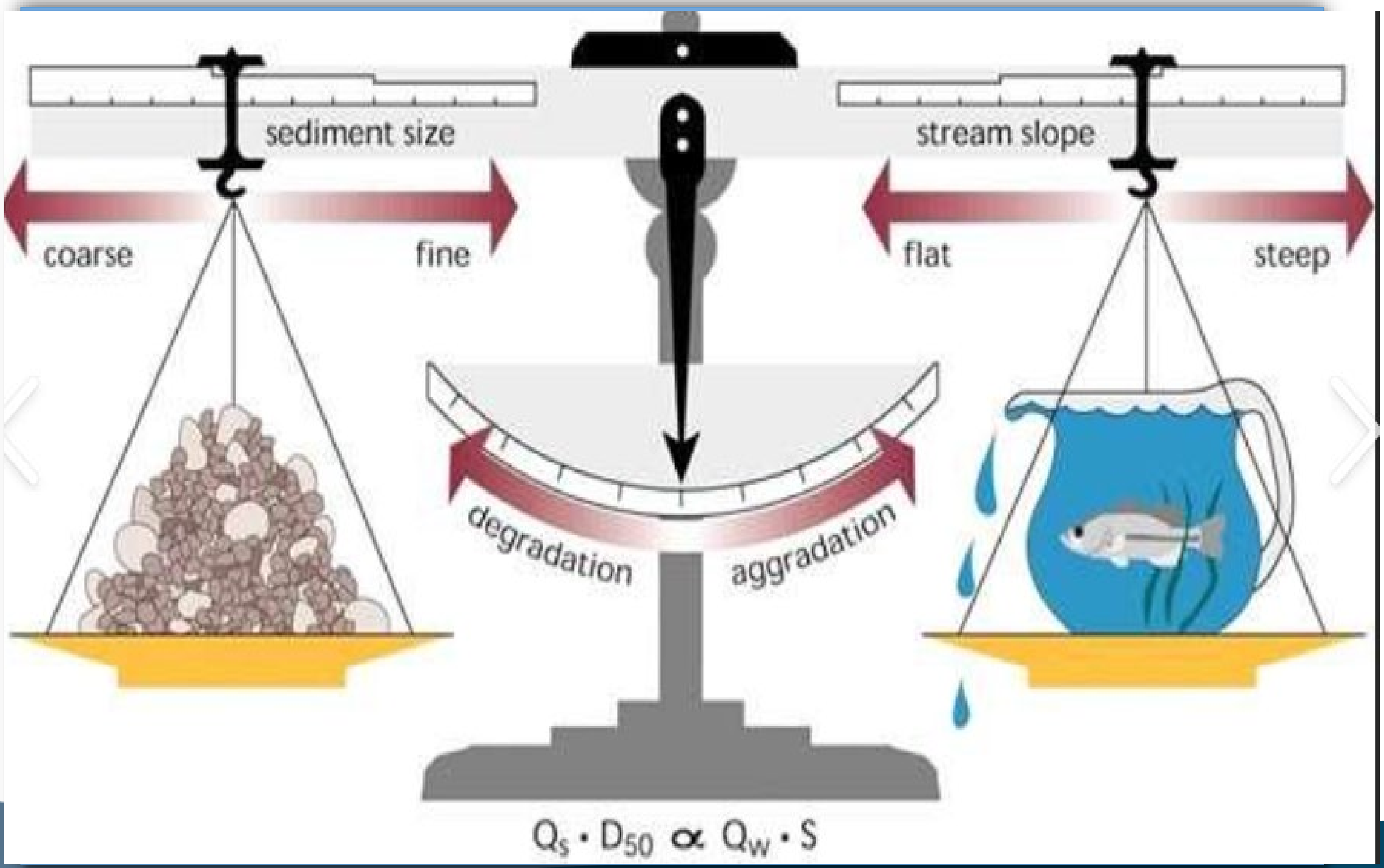
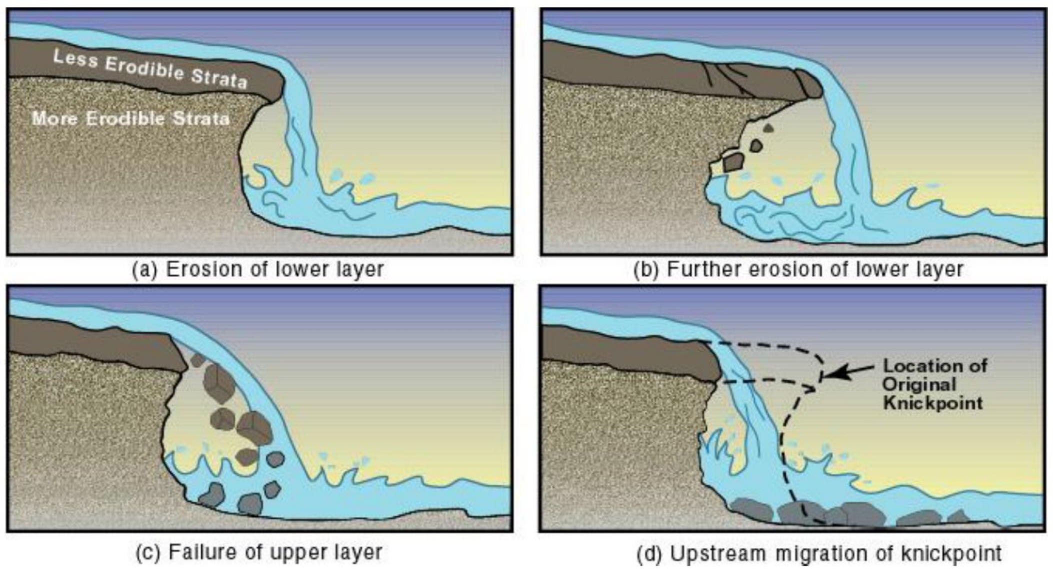
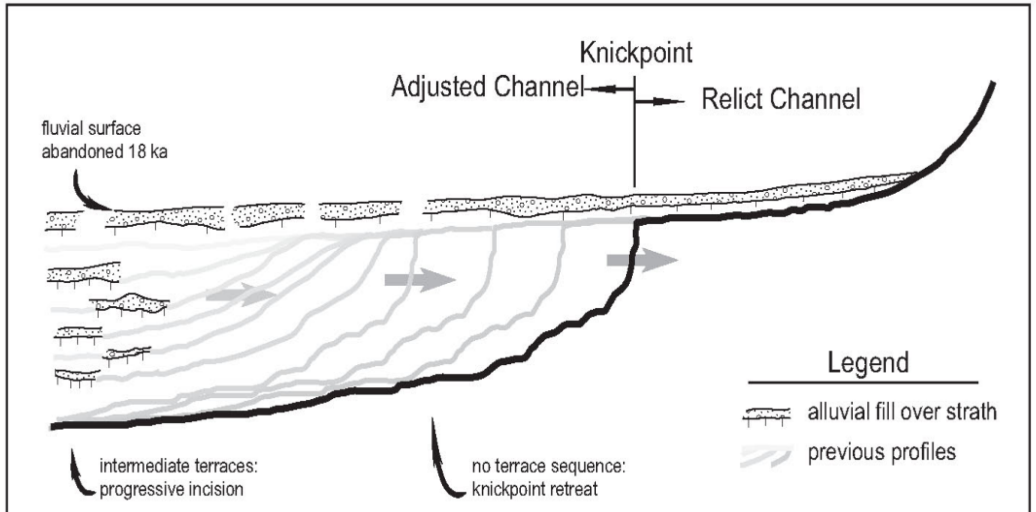
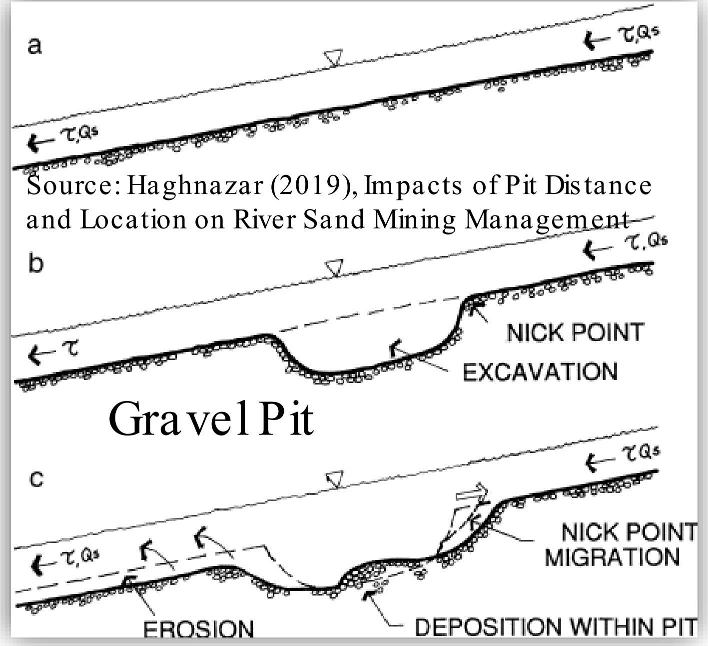


HEADCUTTING





Source: https://serc.carleton.edu/details/images/12592.html

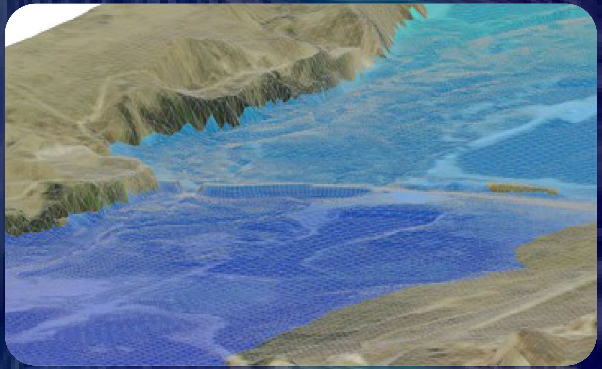


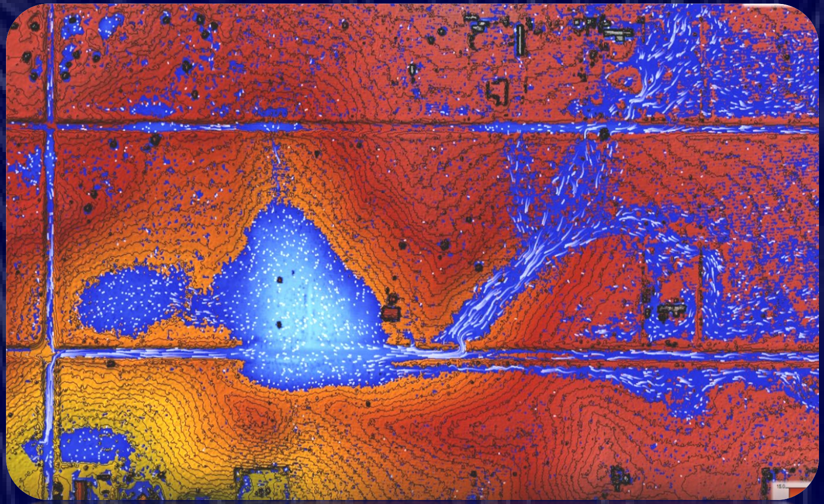
Source: Haghnazar (2019), Impacts of Pit Distance and Location on River Sand Mining Management

Gravel Pit

Source: http://www.er-contech.com/Flexible-Concrete-Revetment

Structures in the Multiverse





Modeling Mother Nature and Structures

Mesh – LiDAR, Point Cloud

Conceptual Design

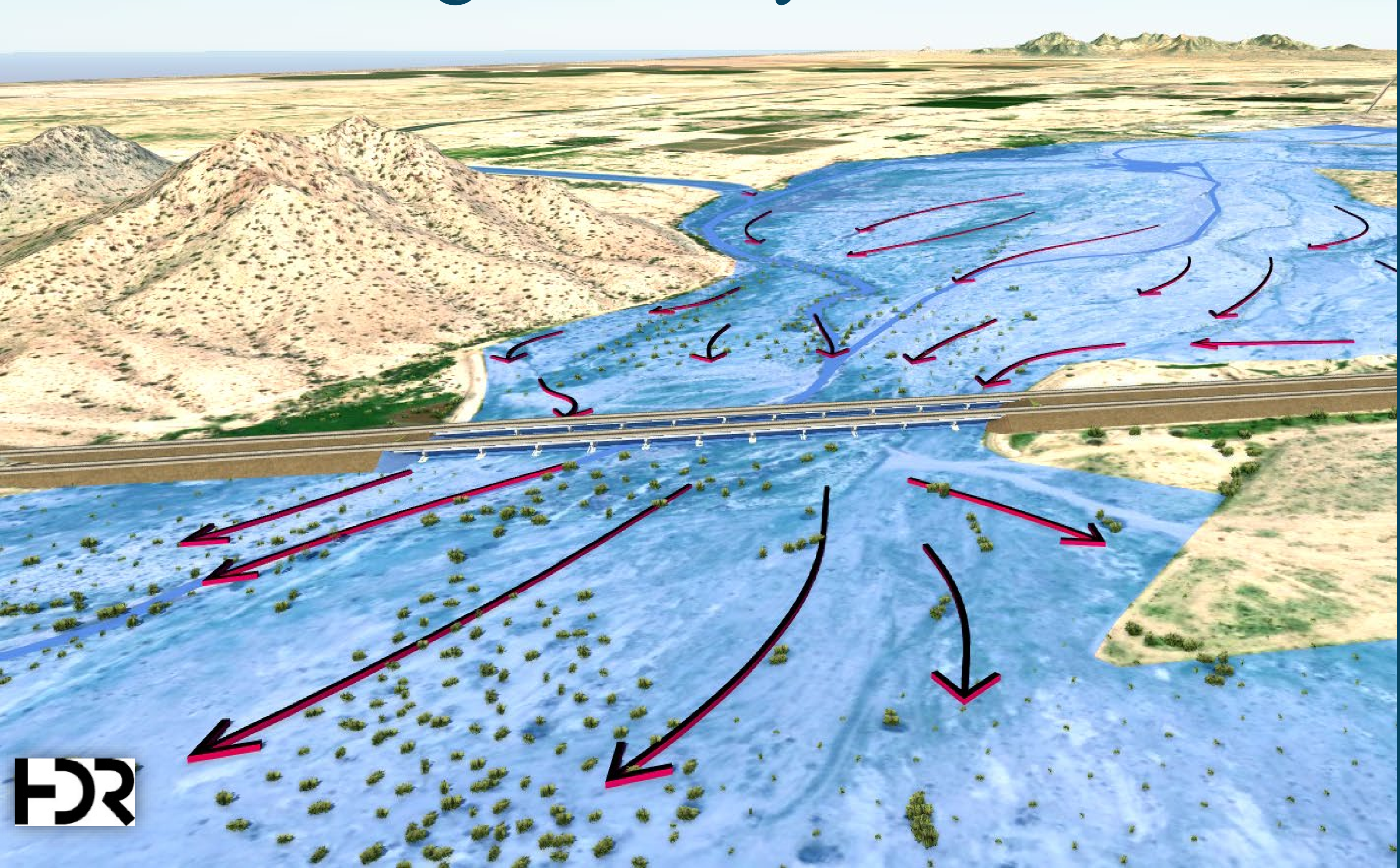
Global Warming

Informed Decisions

Infrastructure

FDR

ADOT I-10 Widening Gila River Bridge Study



GOALS

Assess Existing Capacity & Performance

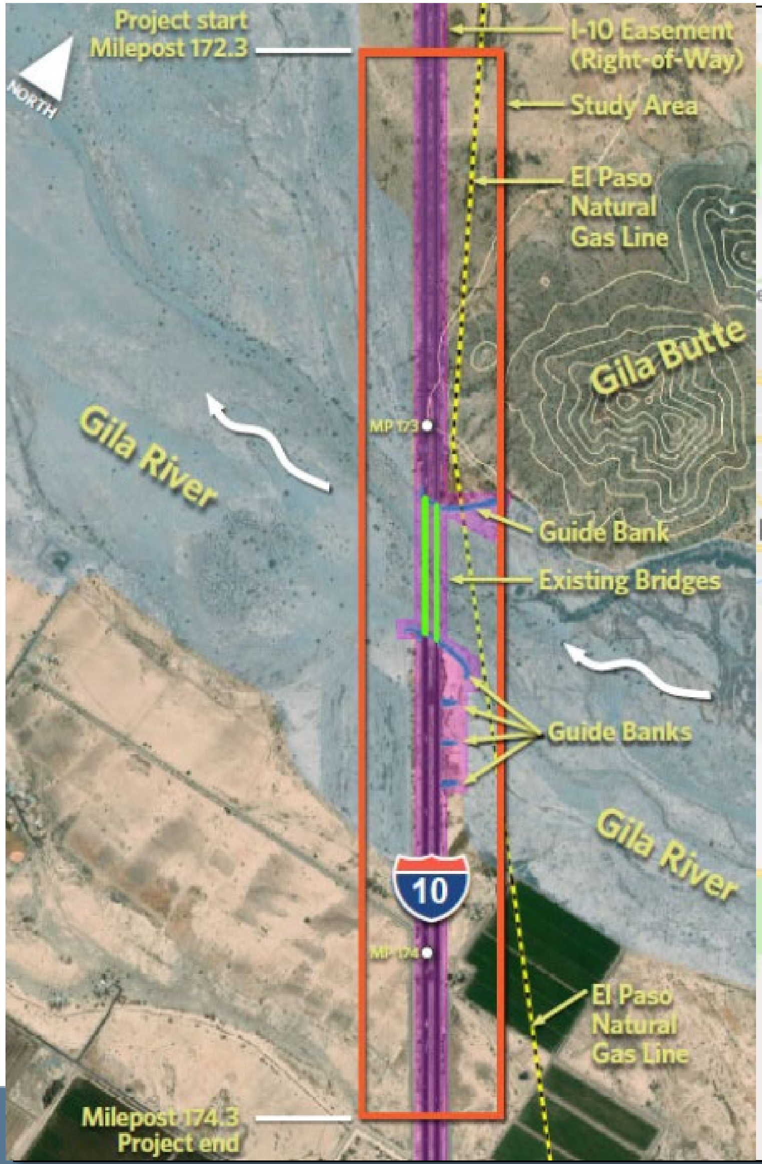
2D Modeling Initiative

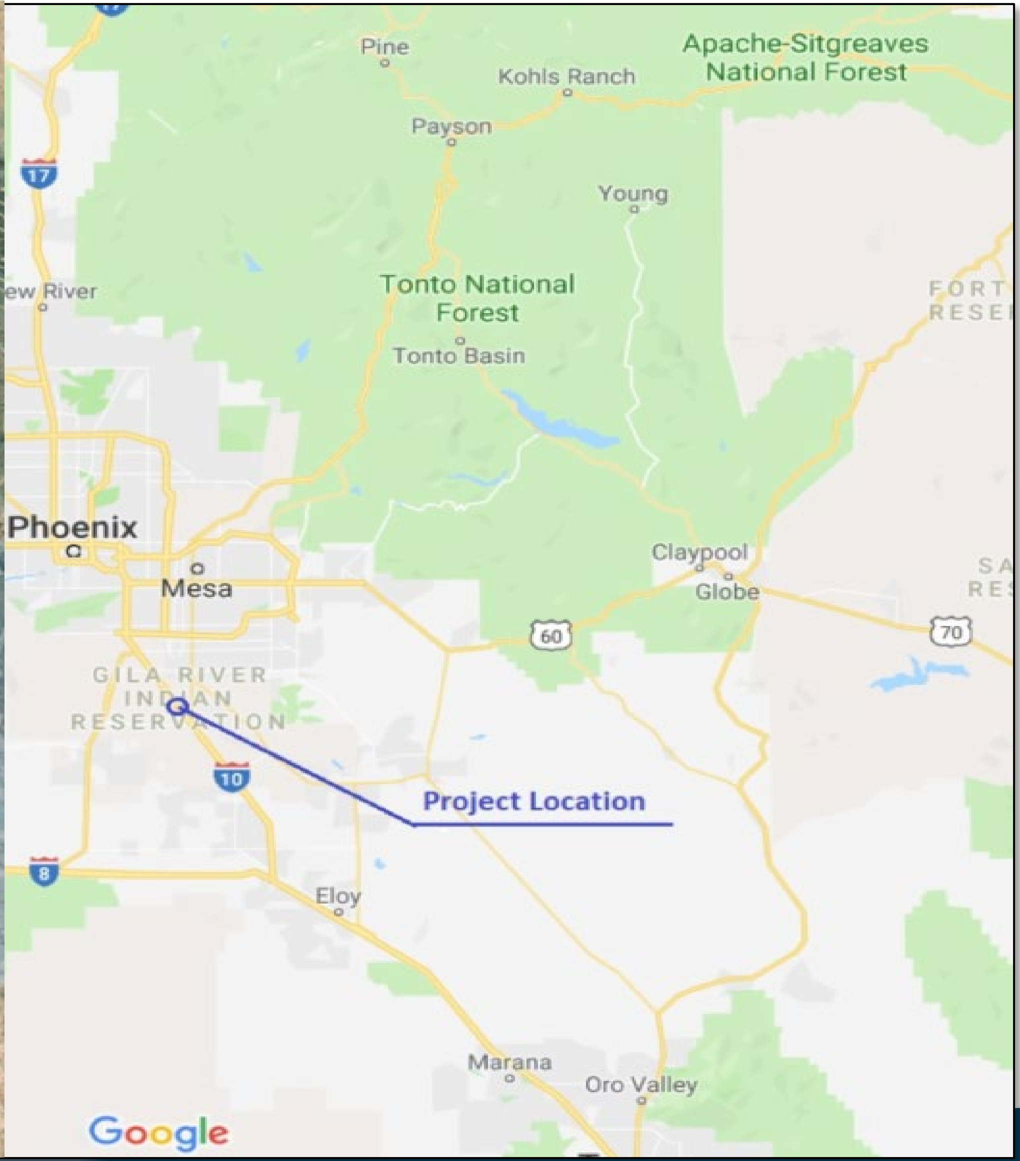
Recommendations

Global Warming

Support Final Design Decision

I-10 BRIDGE LOCATION, AZ





I-10 HYDROLOGY

- 19,520 Sq Mi
- Regulated Flows - Dams
- Gage Data 1912 - 2021
- Multiple 100,000cfs+ Events
- Multiple River Systems
- Stretches Into Both New and Old Mexico

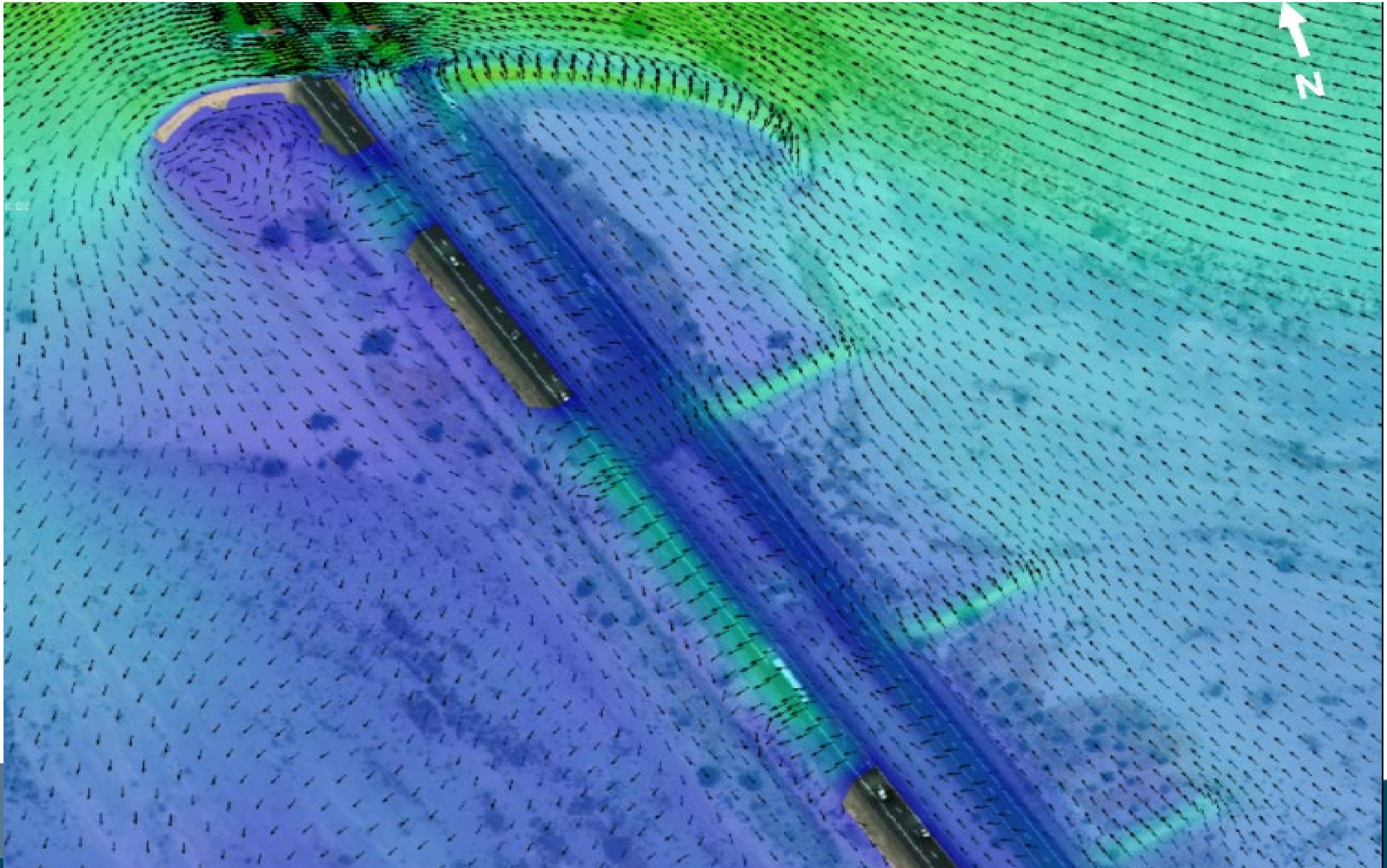
I-10 FIELD VISIT

- 17 Span Concrete Girder
- L = 1,337ft
- Complex Pier w/ Pie Walls
- Expansive Floodplain

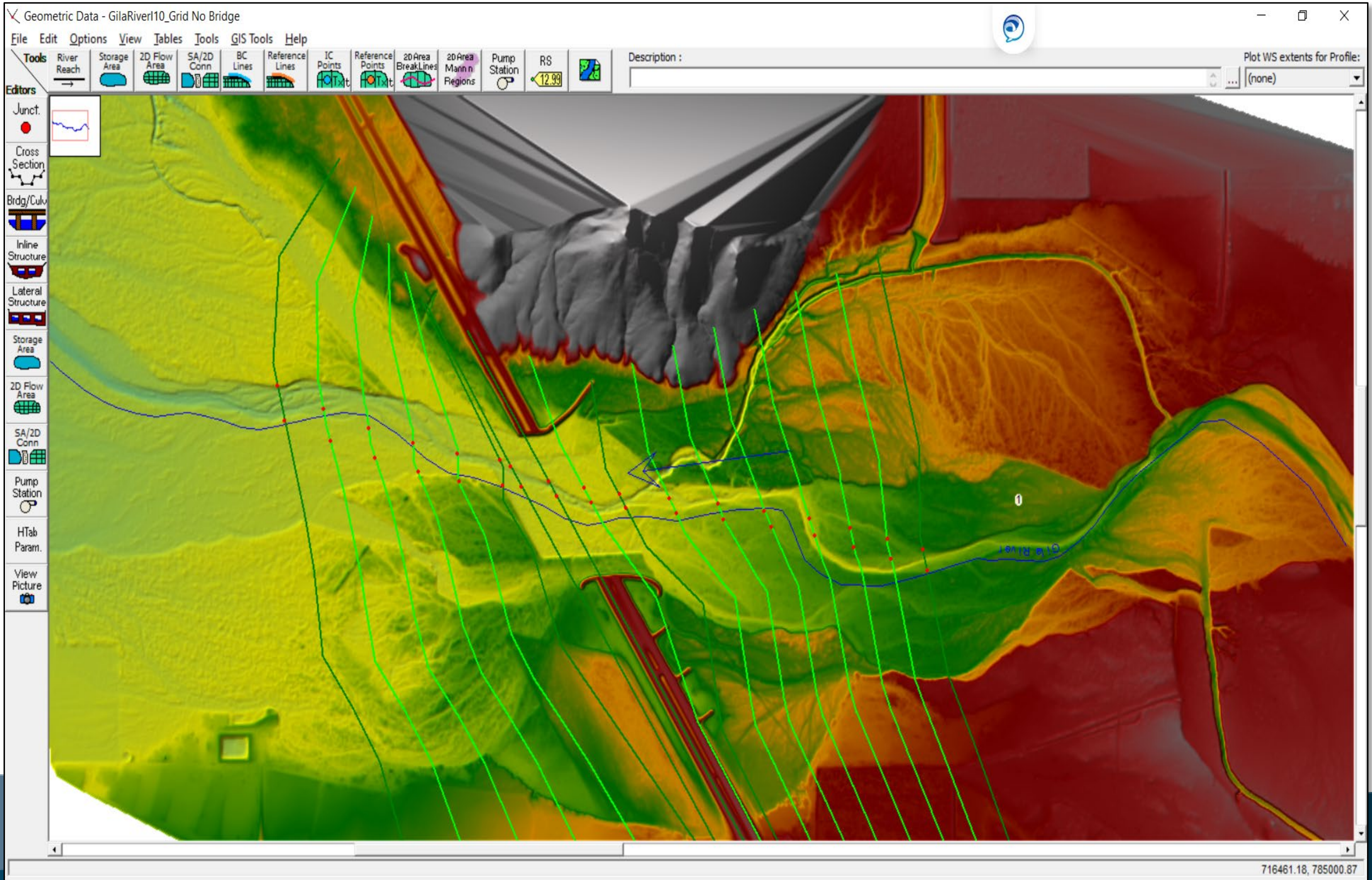
I-10 FIELD VISIT

I-10 FIELD VISIT

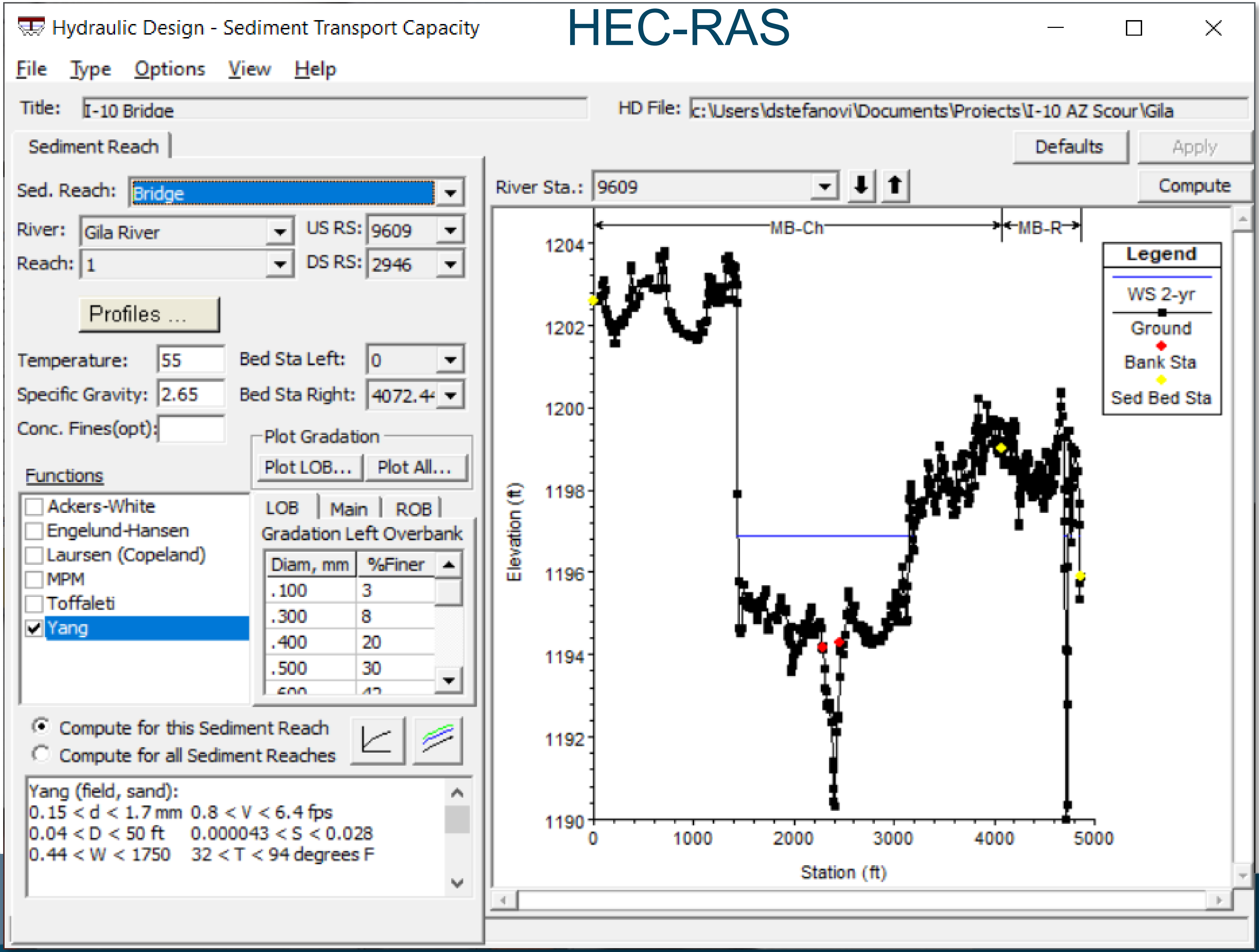
I-10 BRIDGE HYDRAULICS ASSESMENT



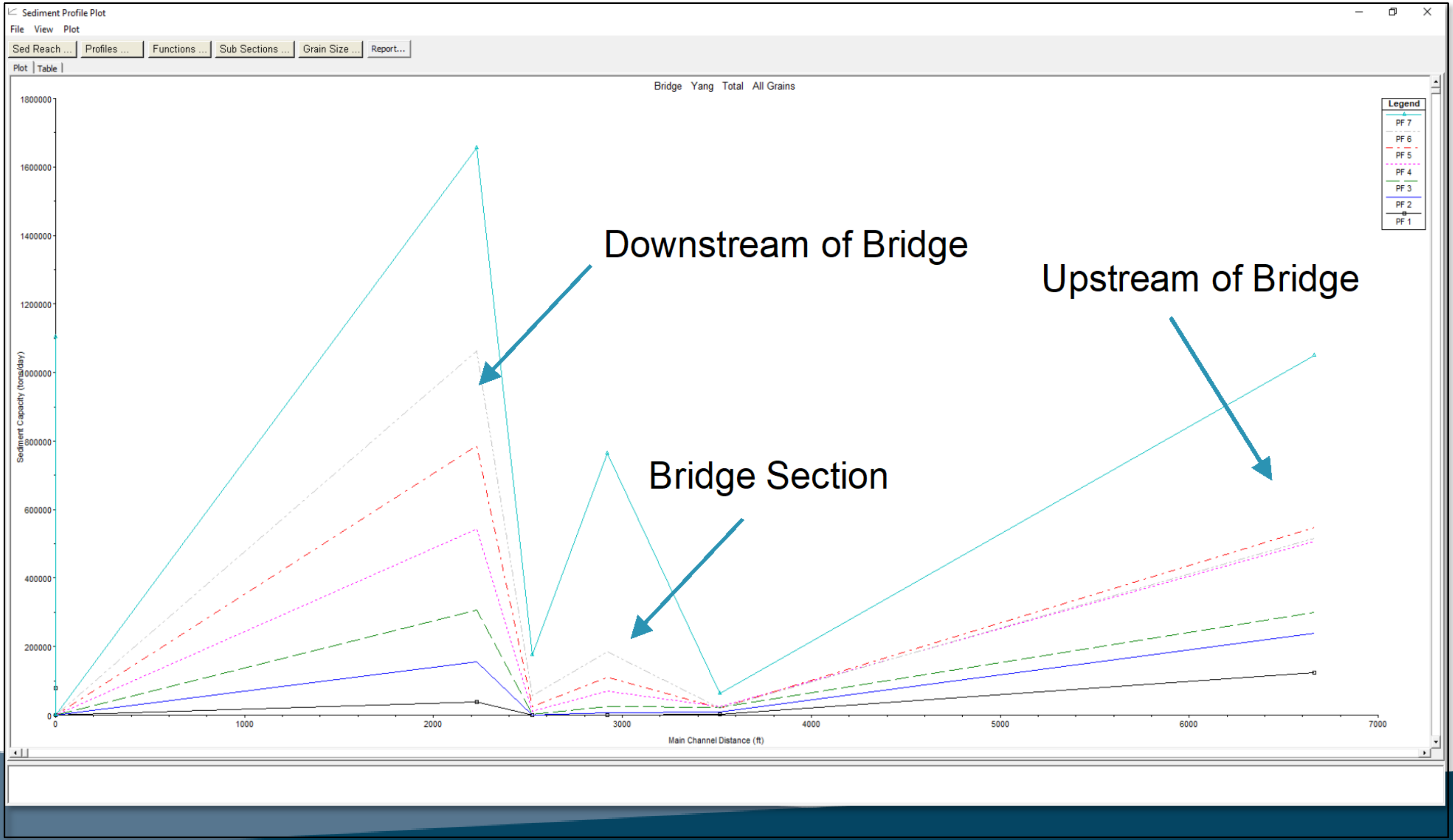
I-10 BRIDGE HEC-RAS MODEL



HEC-RAS

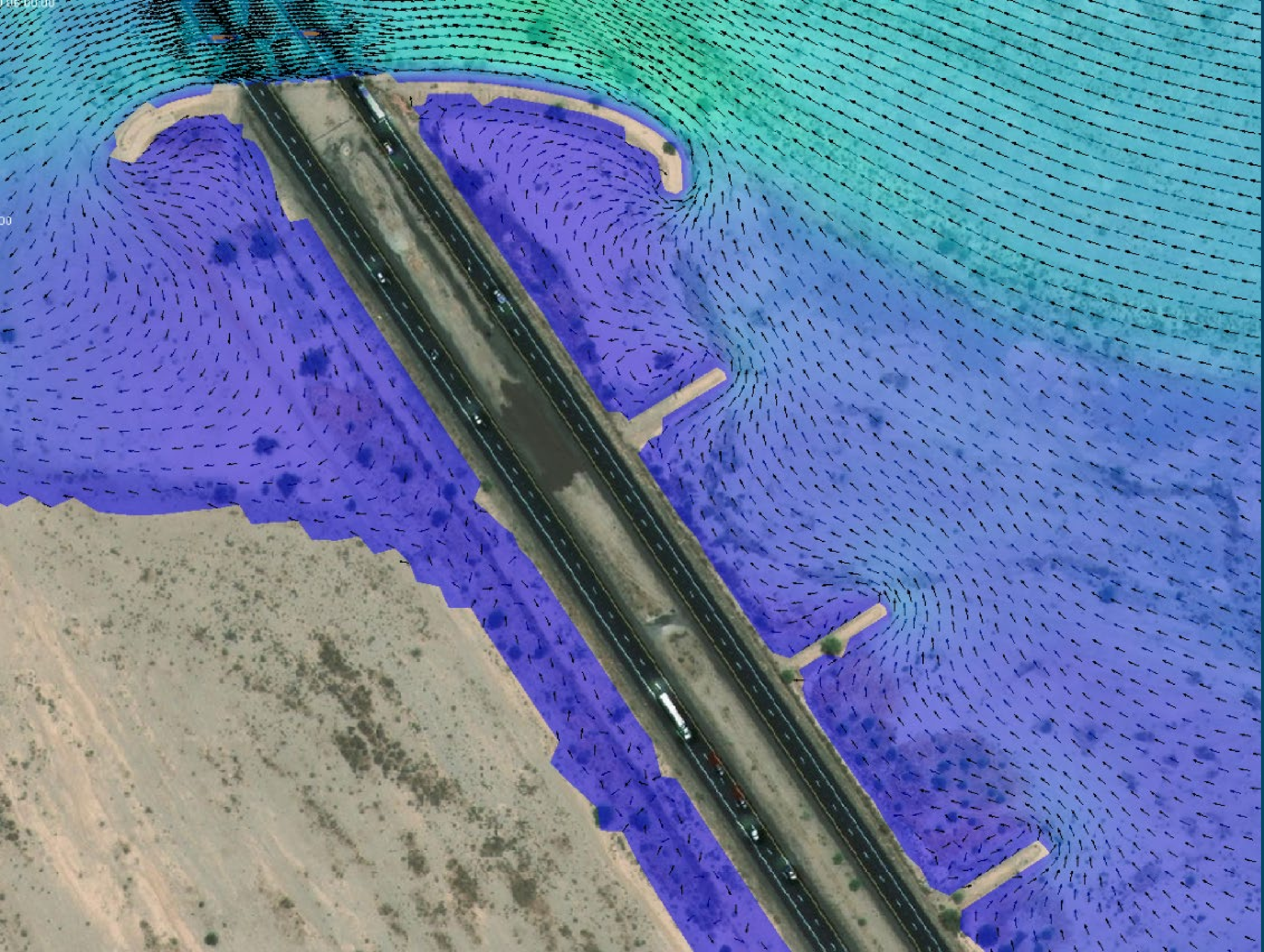

Hydraulic Design - Sediment Transport Capacity
File Type Options View Help
Title: I-10 Bridge
HD File: c:\Users\dstefanovi\Documents\Projects\I-10 AZ Scour\Gila
Sediment Reach
Defaults
Apply
Sed. Reach: Bridge
River Sta.: 9609
Compute
River: Gila River
US RS: 9609
Reach: 1
DS RS: 2946
Profiles ...
Temperature: 55
Bed Sta Left: 0
Specific Gravity: 2.65
Bed Sta Right: 4072.4
Conc. Fines(opt):
Plot Gradation
Plot LOB...
Plot All...
Functions
Ackers-White
Engelund-Hansen
Laursen (Copeland)
MPM
Toffaleti
Yang
LOB
Main
ROB
Gradation Left Overbank
Diam, mm
%Finer
.100
3
.300
8
.400
20
.500
30
Compute for this Sediment Reach
Compute for all Sediment Reaches
Yang (field, sand):
0.15 < d < 1.7 mm 0.8 < V < 6.4 fps
0.04 < D < 50 ft 0.000043 < S < 0.028
0.44 < W < 1750 32 < T < 94 degrees F
MB-Ch
MB-R
Legend
WS 2-yr
Ground
Bank Sta
Sed Bed Sta
Elevation (ft)
1204
1202
1200
1198
1196
1194
1192
1190
0
1000
2000
3000
4000
5000
Station (ft)

SEDIMENT TRANSPORT CAPACITY AT I-10 BRIDGE



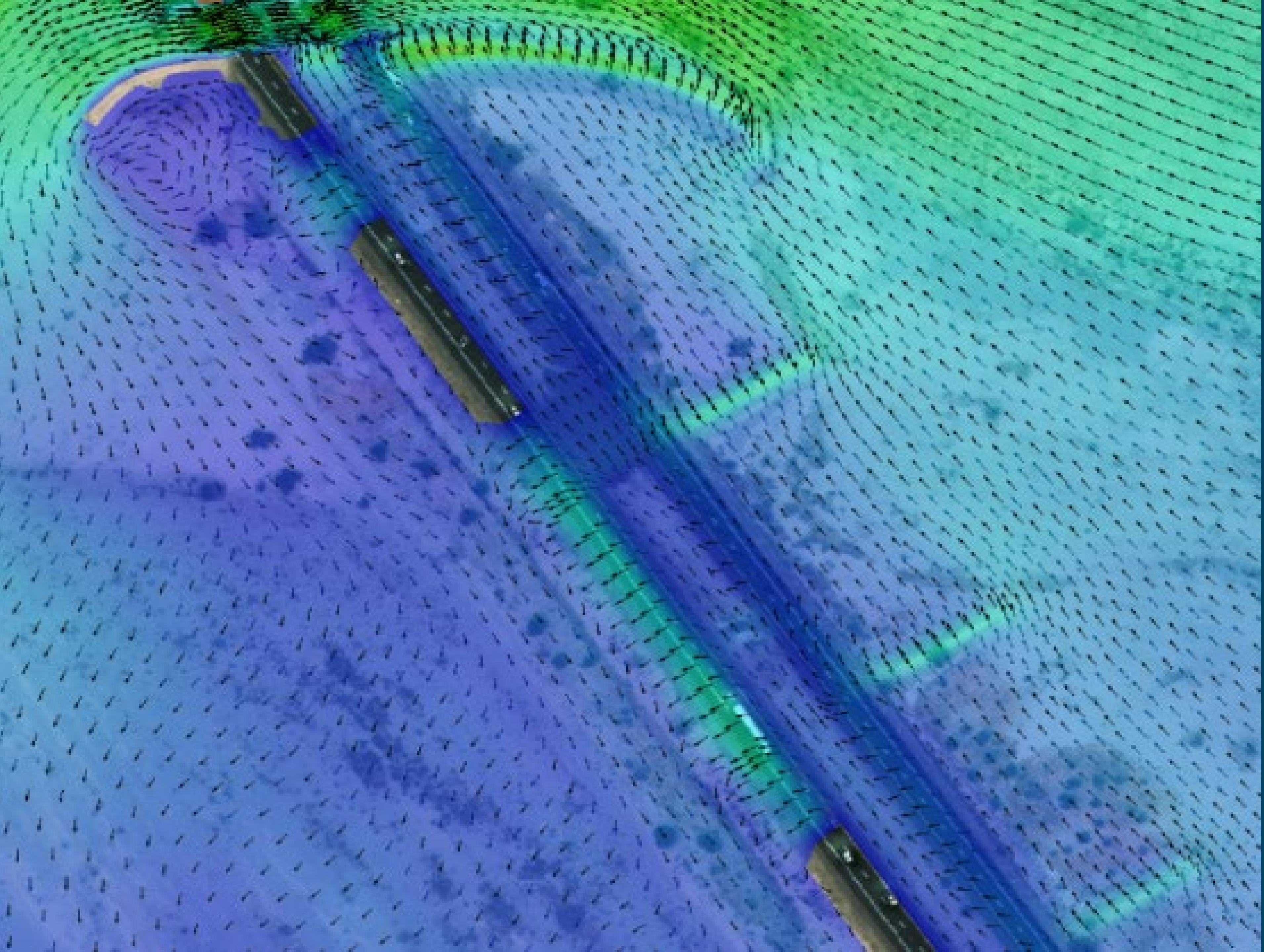
CONCLUSIONS

- Average annual sediment transport capacity upstream of I-10 bridge is 111,000 tons/day
- Average annual sediment transport capacity at I-10 bridge is only 17,000 tons/day
- Average annual sediment transport capacity downstream of I-10 bridge increases to 110,000 tons/day
- *Significant decrease in sediment transport capacity through I-10 bridge crossing will cause long-term sediment deposition (~4 ft in 50 years) on channel bed, unless routine removal of sediment occurs*
- *Abrupt increase in sediment transport capacity downstream of I-10 bridge crossing will produce geomorphic headcut (channel incision) with tendency to propagate upstream if not mitigated*



MODELING BENEFITS

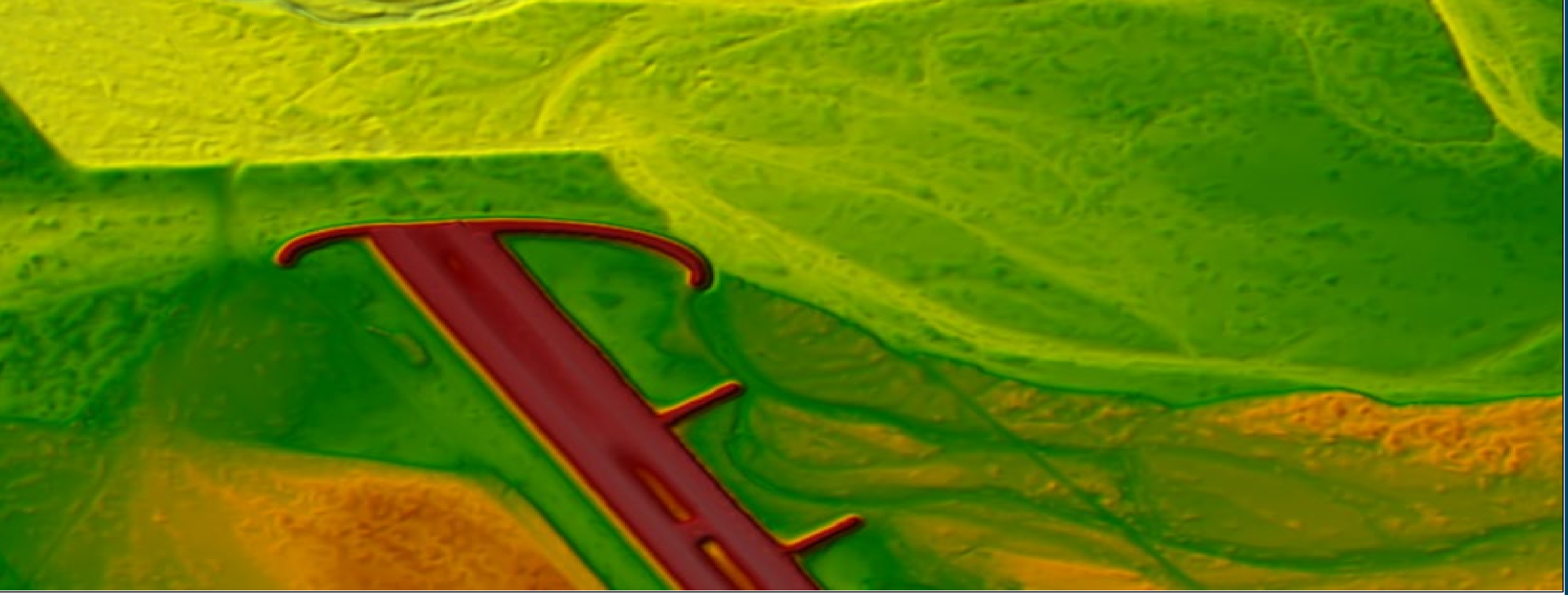
Refined Understanding

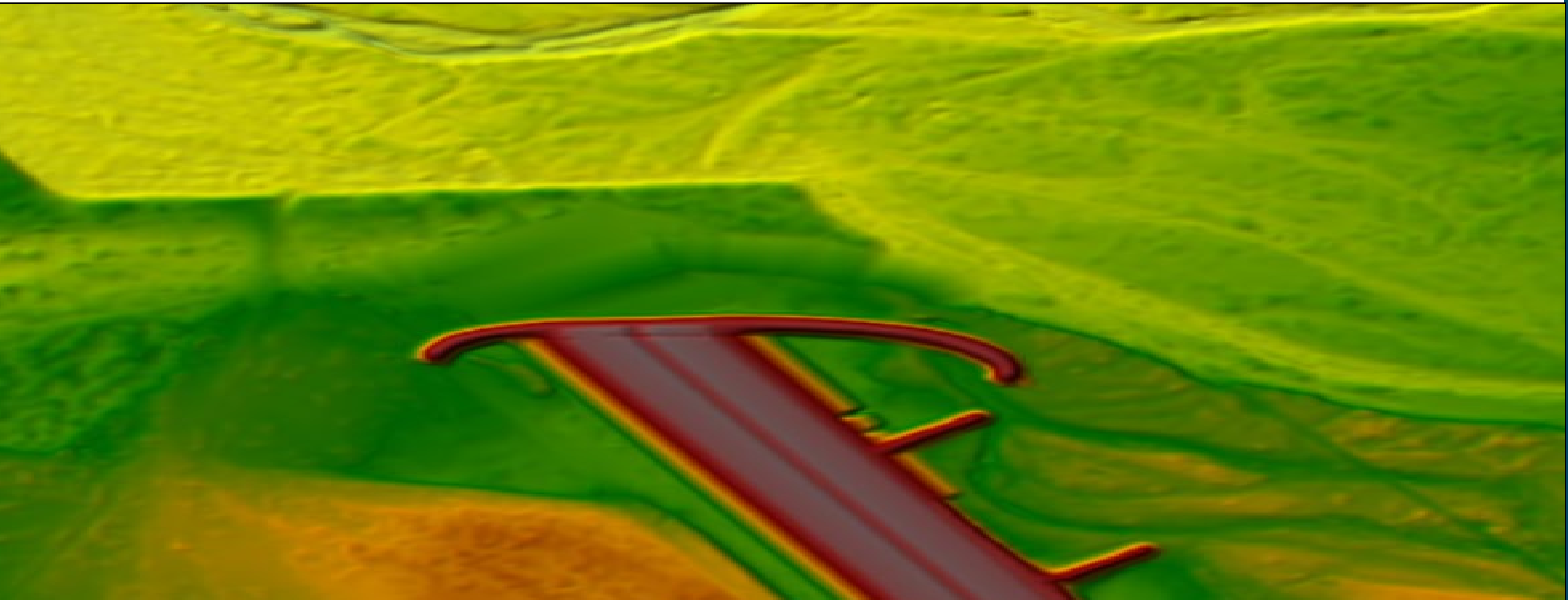


MODELING BENEFITS

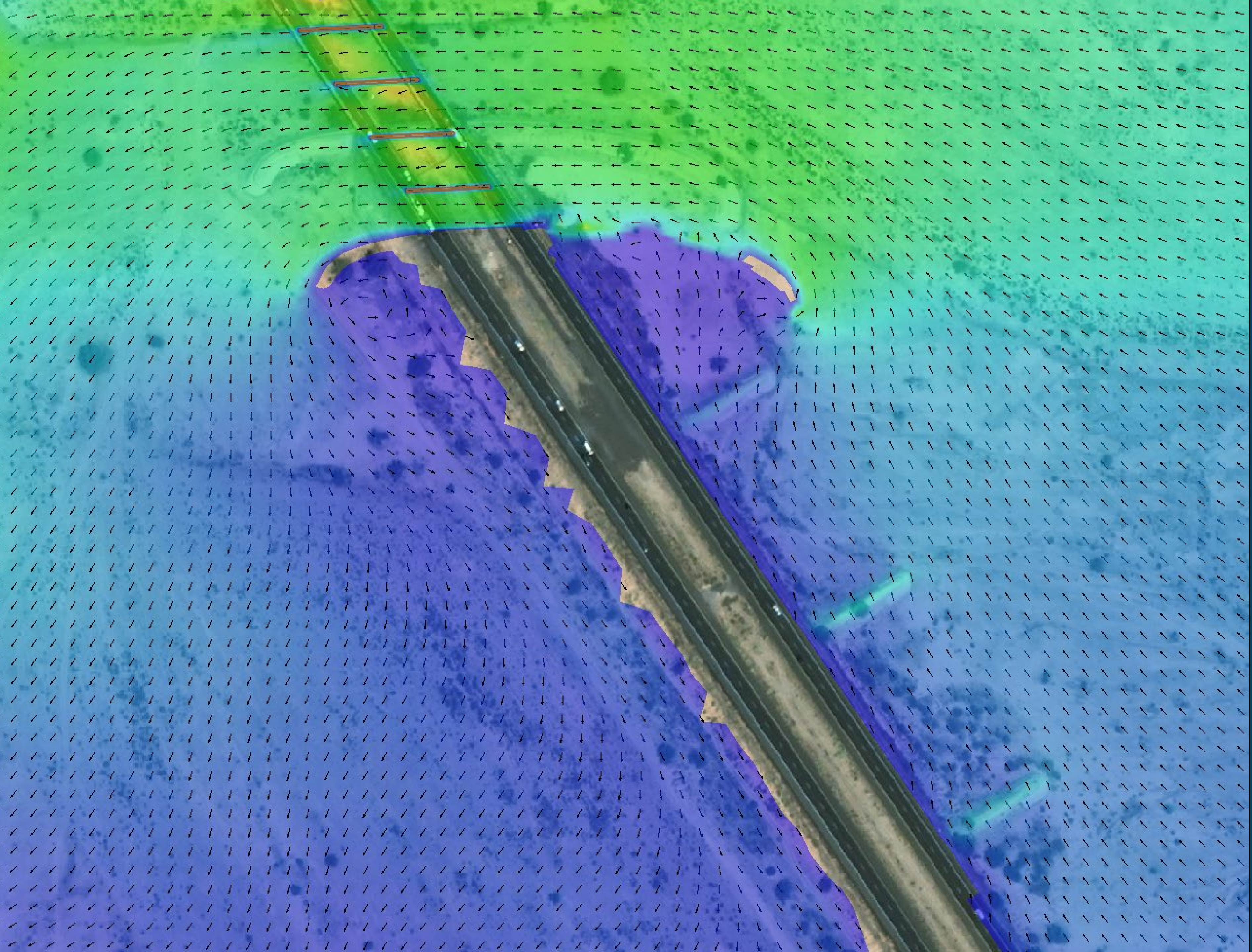
Avoid Cost/Impacts

MODELING BENEFITS



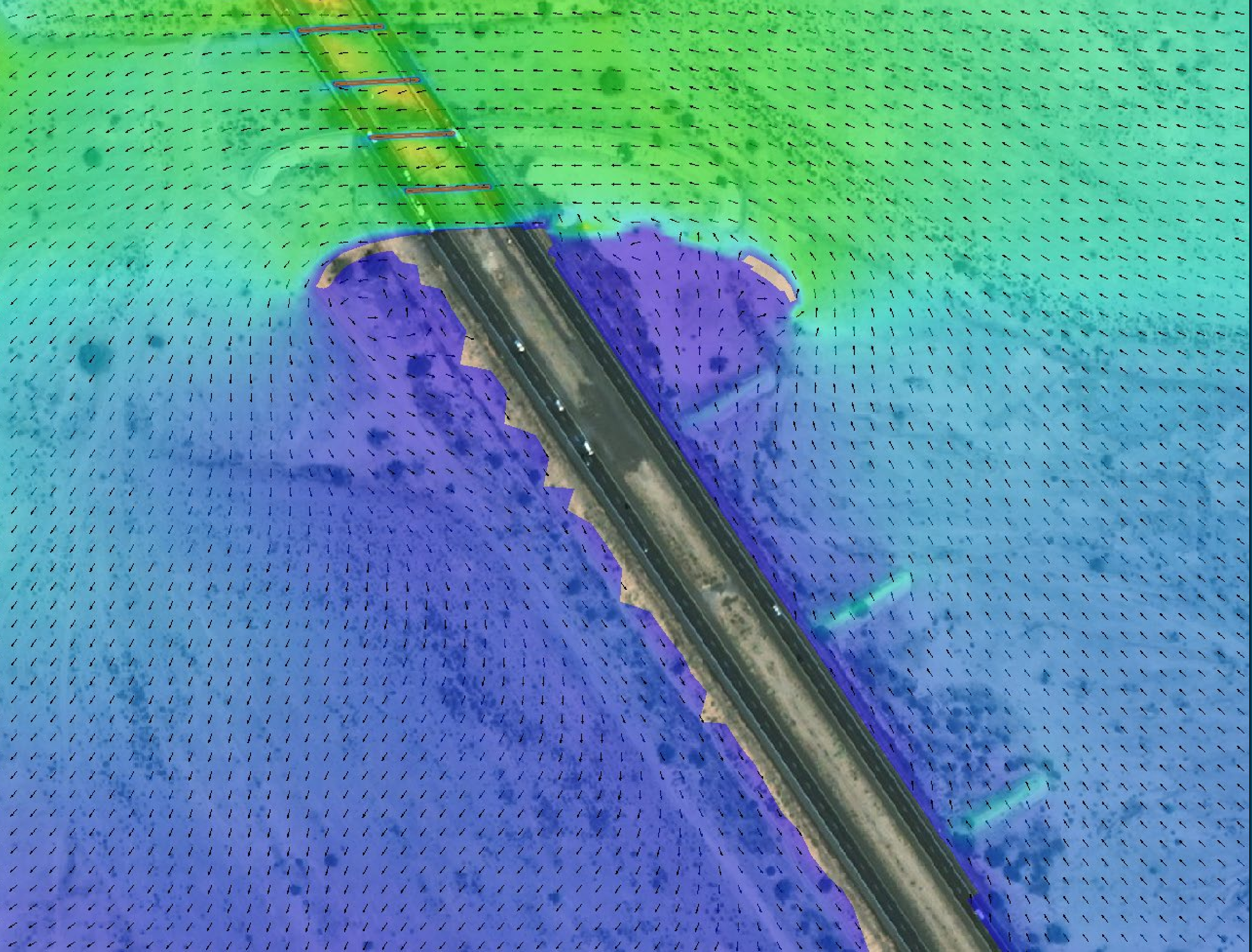


Assesset Management



MODELING BENEFITS

Improvement Recommendations



MODELING BENEFITS

Cost Savings

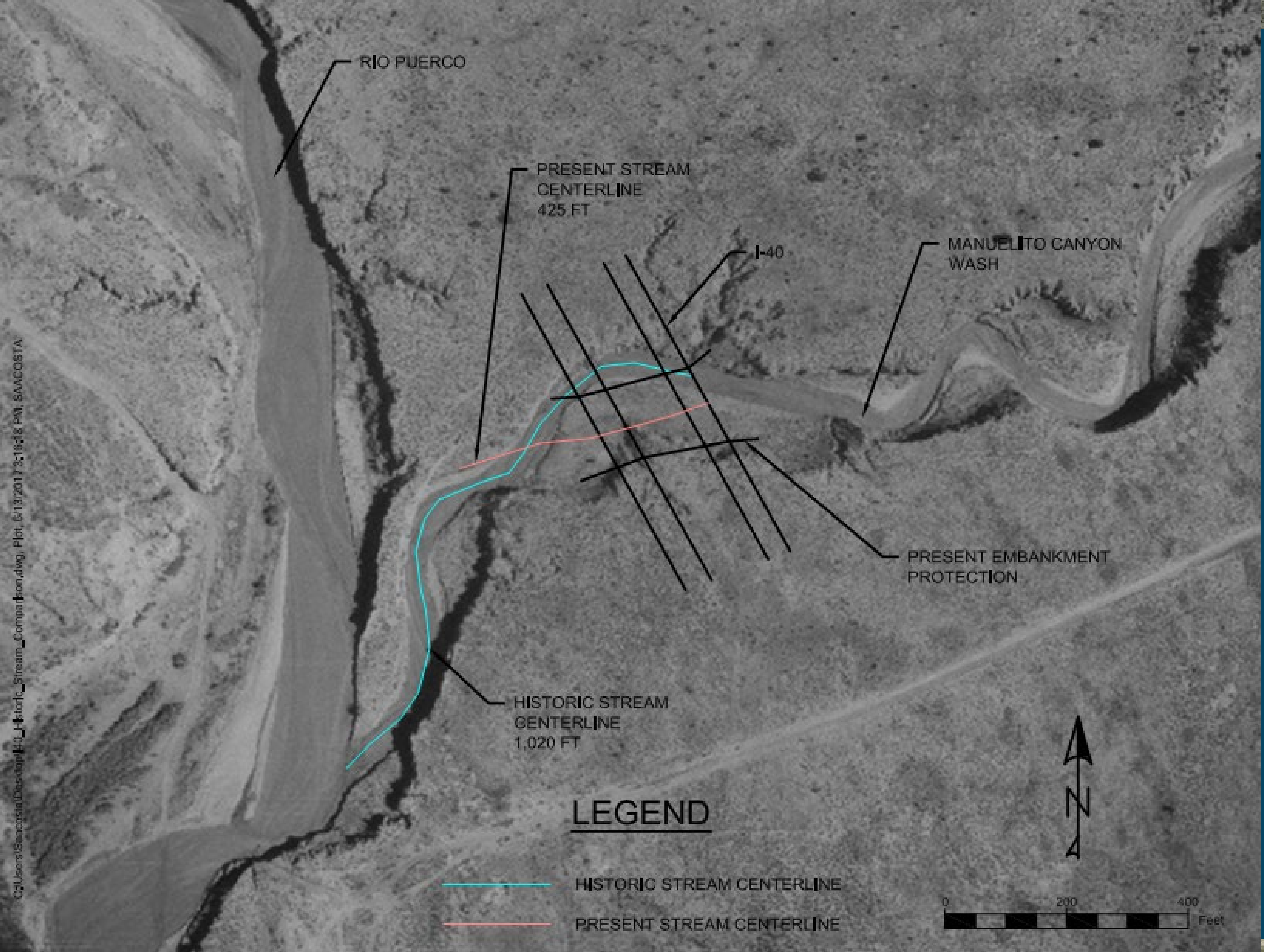
GOALS

Restore Wash

Improve Bridge Geometry

Mitigate Scour/Erosion

Improve Safety to Motorists



Historic Design

Minimize Bridge

Fill in Wash

Apply Scour Protection

Shorten Natural River Flowpath

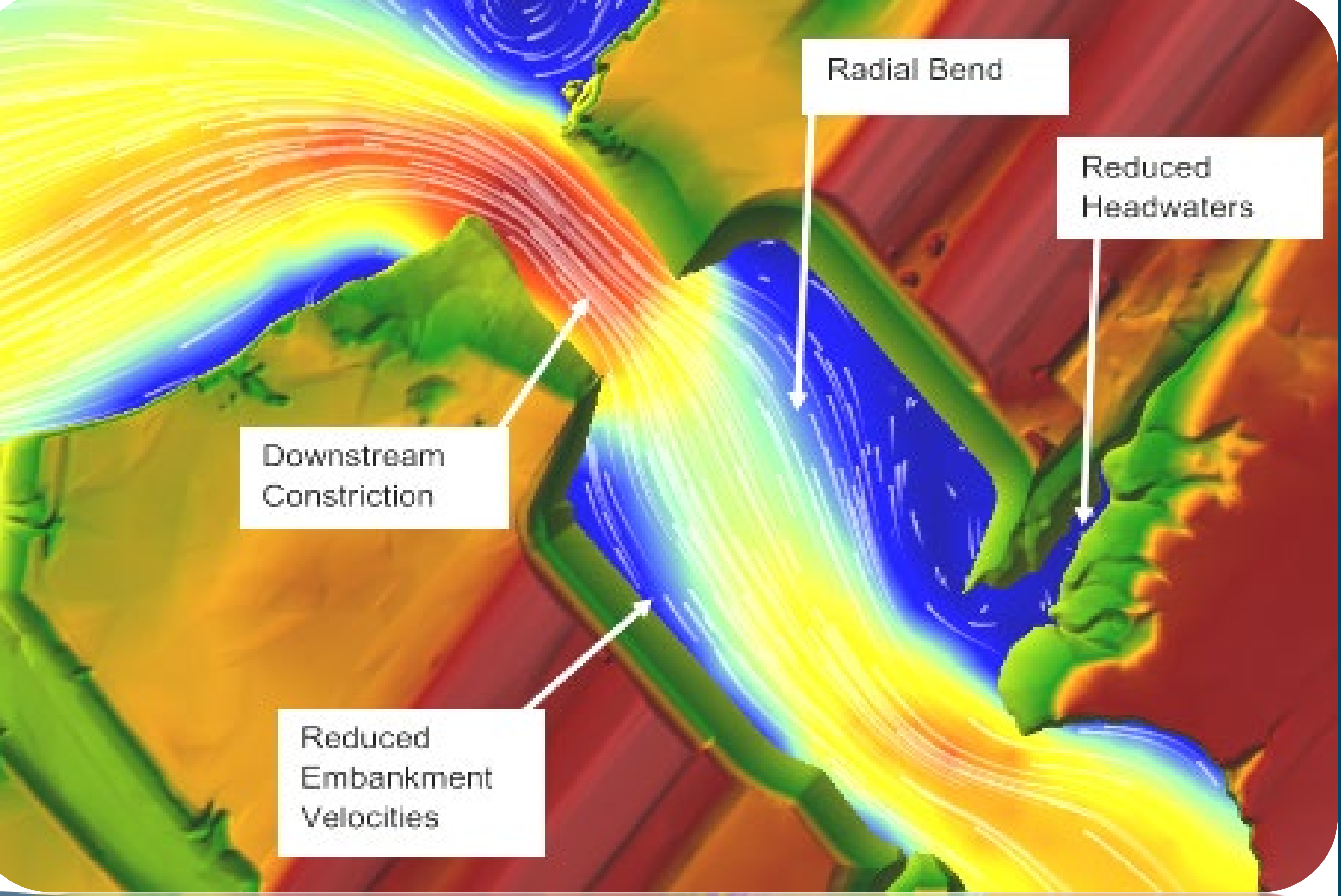
Results

Wash Locked Between Bridges

River Slope

Lateral Migration

Lanes Balance in Action



DESIGN GOALS

Stable Outfall

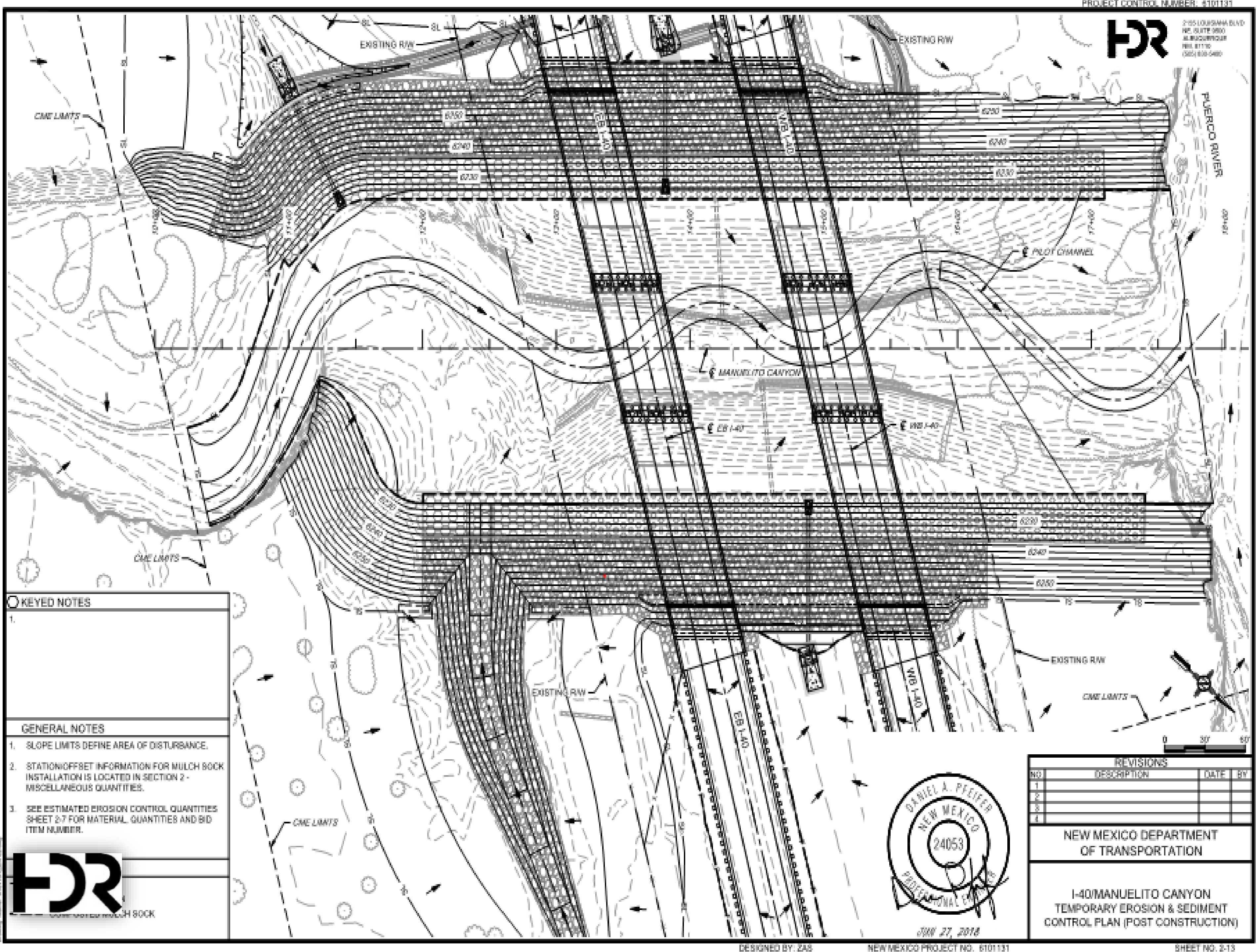
Steady Profiles

Restore Wash

Stable Hydraulics

Stable Bedslope

Optimize Cost



DESIGN GOALS

Stable Outfall

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Optimize Cost

Questions?

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