M & T Pump Station Intake Second Physical Model

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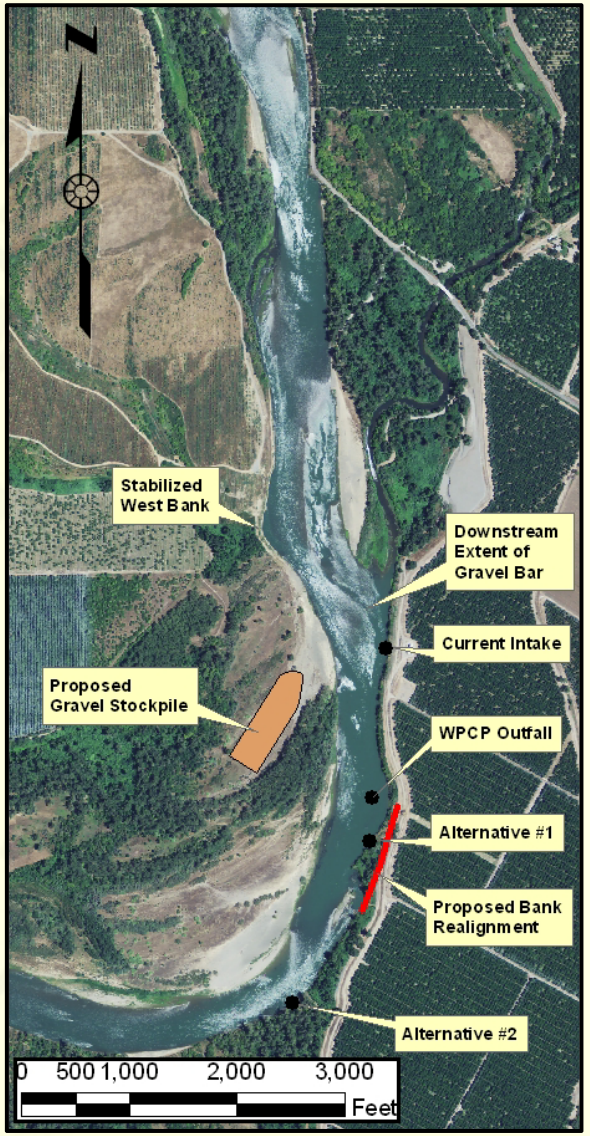
Introduction

- Since prior 2007 testing, bar migration and sedimentation at the current pump intake has continued
- TetraTech, Inc., working in coordination with Ducks Unlimited, Inc., funded a second physical model study in 2010
- Evaluate hydraulic, morphologic, and sedimentation patterns near the following sites:
    1. Current pump intake location
    2. Proposed Alternative 1 site, ~2,200 ft downstream of the current pump-intake location
    3. Proposed Alternative 2 site, ~3,500 ft downstream of the current pump-intake location
- Three channel configurations:
    1. Current field conditions (Baseline)
    2. Gravel-stockpile on the west floodplain
    3. Realigned section of the east bank with revetment for Proposed Alternative 2 site



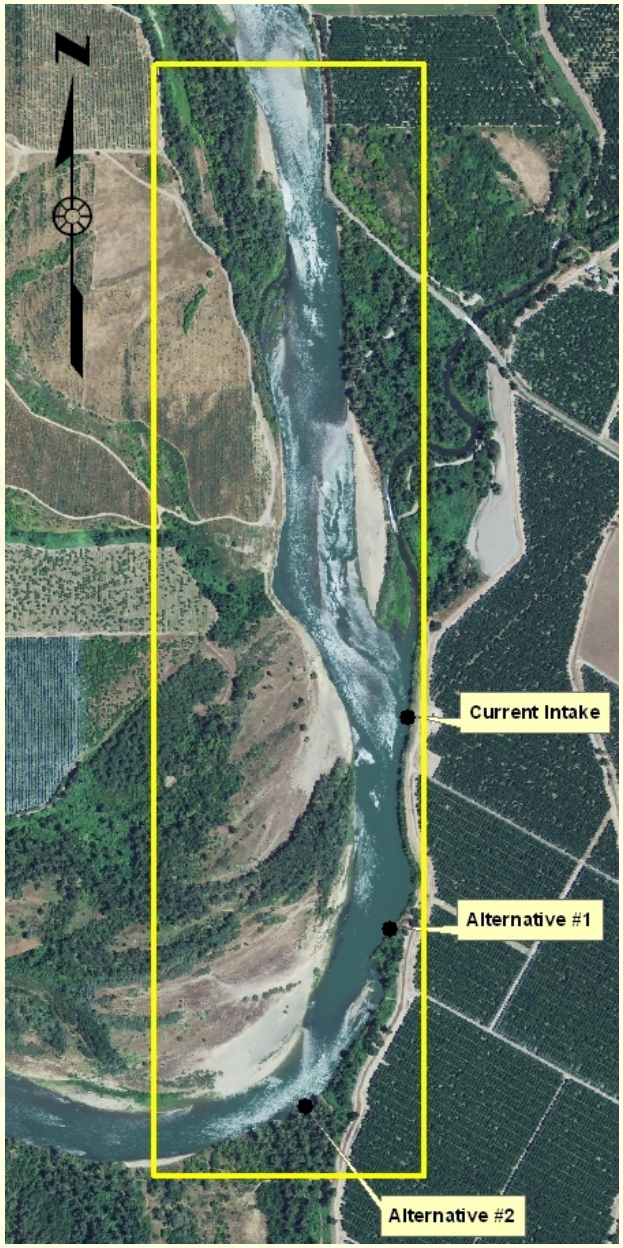
Locus map illustrating the study reach

Physical Model

- 10,300-ft reach of the Sacramento River
- 1:100 Undistorted Froude-scale
- Sediment Scaling
  - Ratio of Shields parameter to critical Shields parameter
  - Ratio of flow velocity to critical flow velocity
  - Rouse number
- Scaled sediment sizing for mobile material within the channel
  - Model bed material d_{50} = 0.15 mm
  - Prototype bed material d_{50} = 40 mm
- 3 scaled discharges evaluated:
  - 145,000-cfs (10-yr recurrence interval flow)
  - 90,000-cfs (bankfull discharge)
  - 10,000-cfs (50% exceedance flow)

Variable	Symbol	Dimension	Similitude Relationship
Length	L	L	$L_p = 100 \cdot L_m$
Time	T	T	$T_p = 10 \cdot T_m$
Velocity	V	L/T	$V_p = 10 \cdot V_m$
Shear Stress	τ	M/LT^2	$\tau_p = 100 \cdot \tau_m$
Discharge	Q	L^3/T	$Q_p = 100{,}000 \cdot Q_m$
Unit Discharge	q	L^2/T	$L_p = 1{,}000 \cdot L_m$
Note: Subscripts m and p denote model and prototype, respectively			

Froude-scale conversions



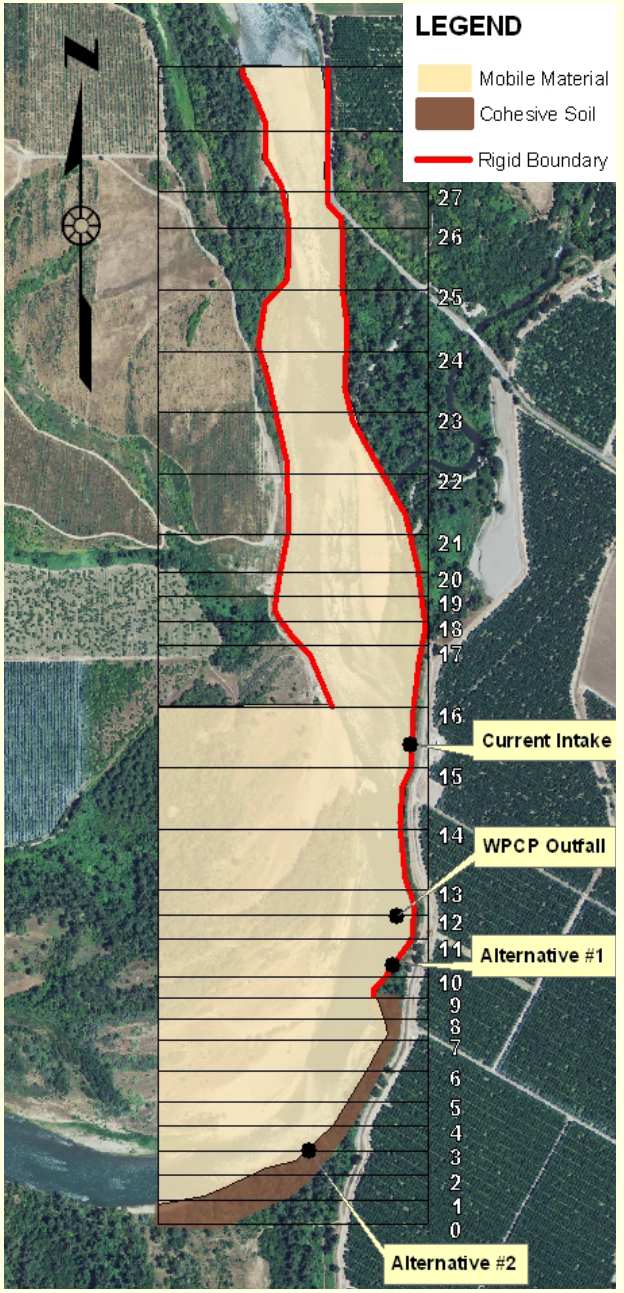
Model extents identified on aerial photograph of the Sacramento River

Physical Model

Model construction started in the summer of 2010:

- 30 E-W soil-cement cross sections
- 1 N-S cross-section defining the downstream boundary
- Very fine sand material to model bed and floodplain sediment
- Cohesive soil to model cohesive stream banks along downstream east bank
- Mesh baffle to provide uniform flow entrance conditions
- Downstream gate to control backwater
- Sediment feed upstream of the test reach
- Installation of artificial trees and canopy

Summary of Variables		
Variable	**Prototype**	**Model**
Hydraulic		
Elevation, Length	110 ft	1.10 ft
Flow Depth	25.0 ft	0.25 ft
Discharge	145,000 cfs	1.45 cfs
Flow Velocity	6.0 ft/s	0.6 ft/s
Shear Stress	2.0 psf	0.02 psf
Sediment		
Sediment d_{50}	40 mm	0.15 mm
Time	22.9 hr	1 hr



Identified Sediment Locations

Test Matrix

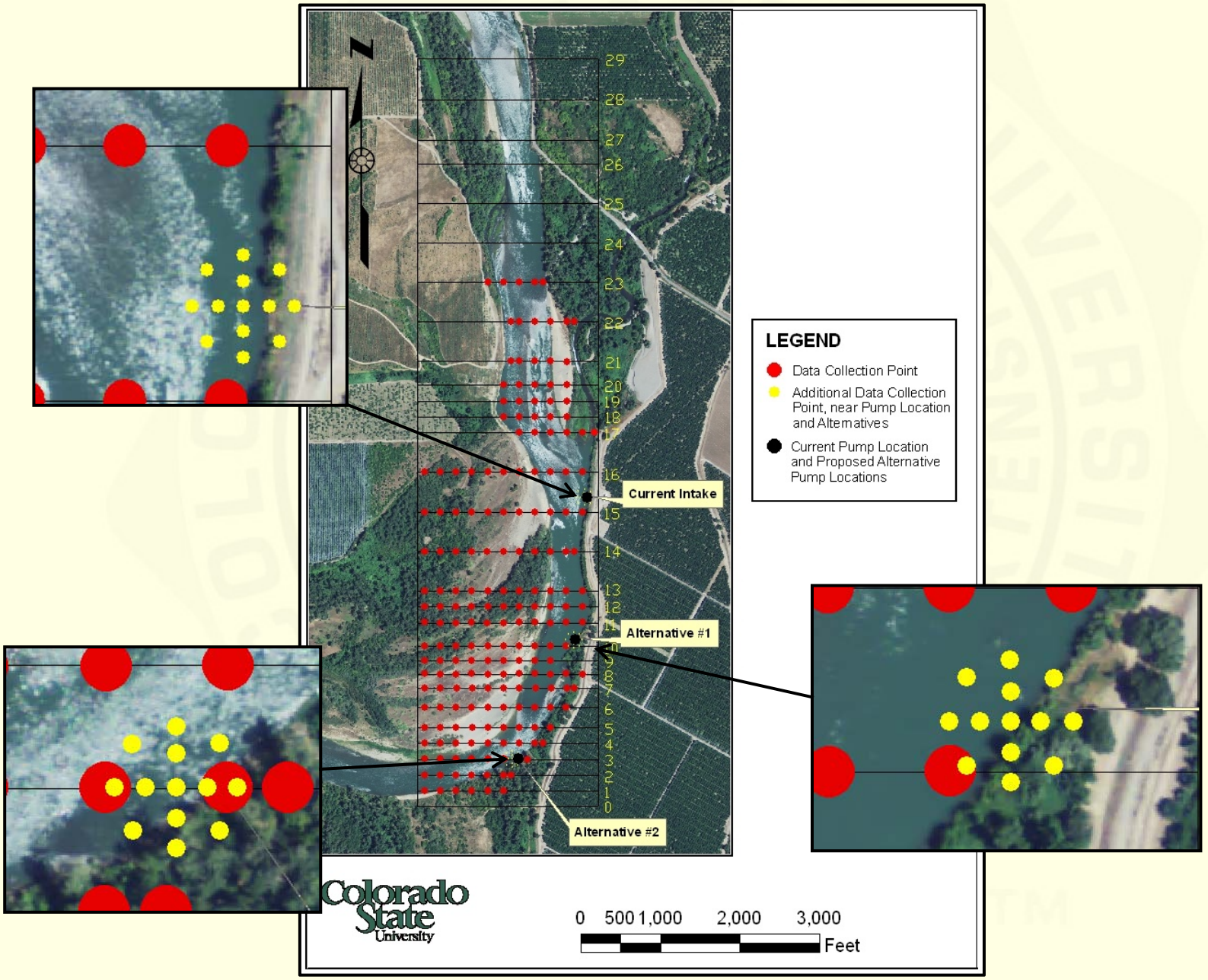
- Baseline
  - 10,000 cfs (8.5 hrs)
  - 90,000 cfs (143 hrs)
  - 145,000 cfs (7.5 hrs)
- Gravel Stockpile
  - 145,000 cfs (7.5 hrs)
- Realigned Bank
  - 10,000 cfs (4 hrs)
  - 90,000 cfs (148 hrs)
  - 145,000 cfs Test 1 (8 hrs)
  - 145,000 cfs Test 2 (8 hrs)
    - bed reset to original realigned-bank elevations between Test 1 and Test 2
  - 145,000 cfs Test 3 (8 hrs)
    - Bed elevations not reset between Test 2 and Test 3 resulting in 16 total hours of 145,000-cfs testing

Typical Testing Program

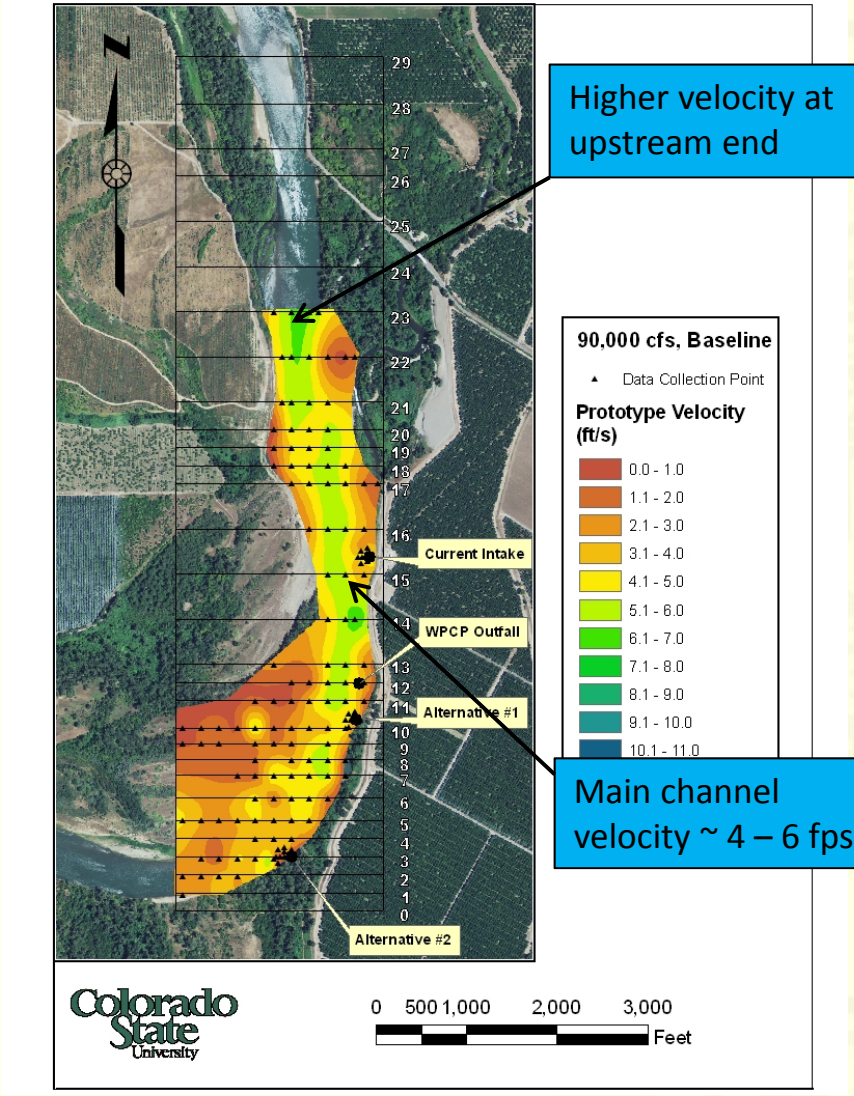
- Testing program:
  - Measure bed elevation before testing
  - Establish model discharge and backwater
  - “Begin” testing
    - Measure flow velocities
    - 10,000-cfs testing for ~8-hours
    - 90,000-cfs testing for ~140-hours
    - 145,000-cfs testing for ~8-hours
  - Slowly decrease the discharge and drain the model
  - Measure bed elevation after testing

10,000-cfs Baseline Testing

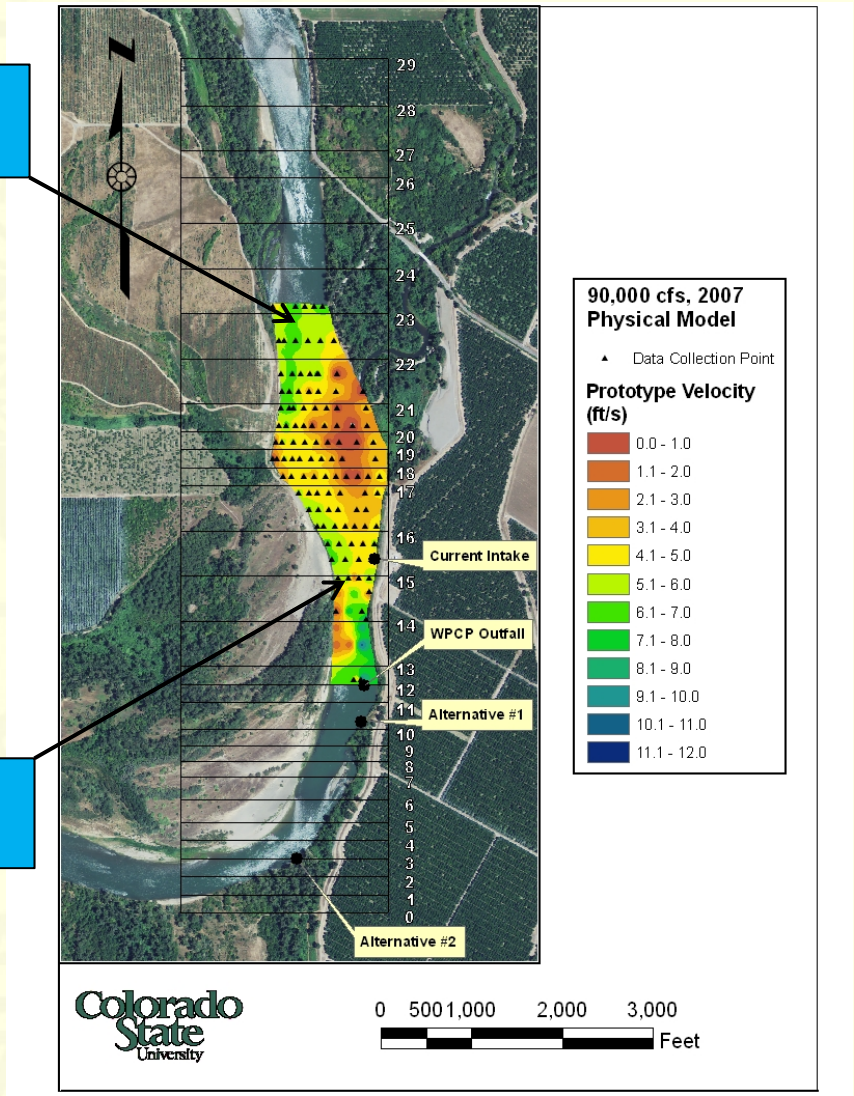
Data Collection Locations



Comparison of Second Physical Model with the 2007 Model

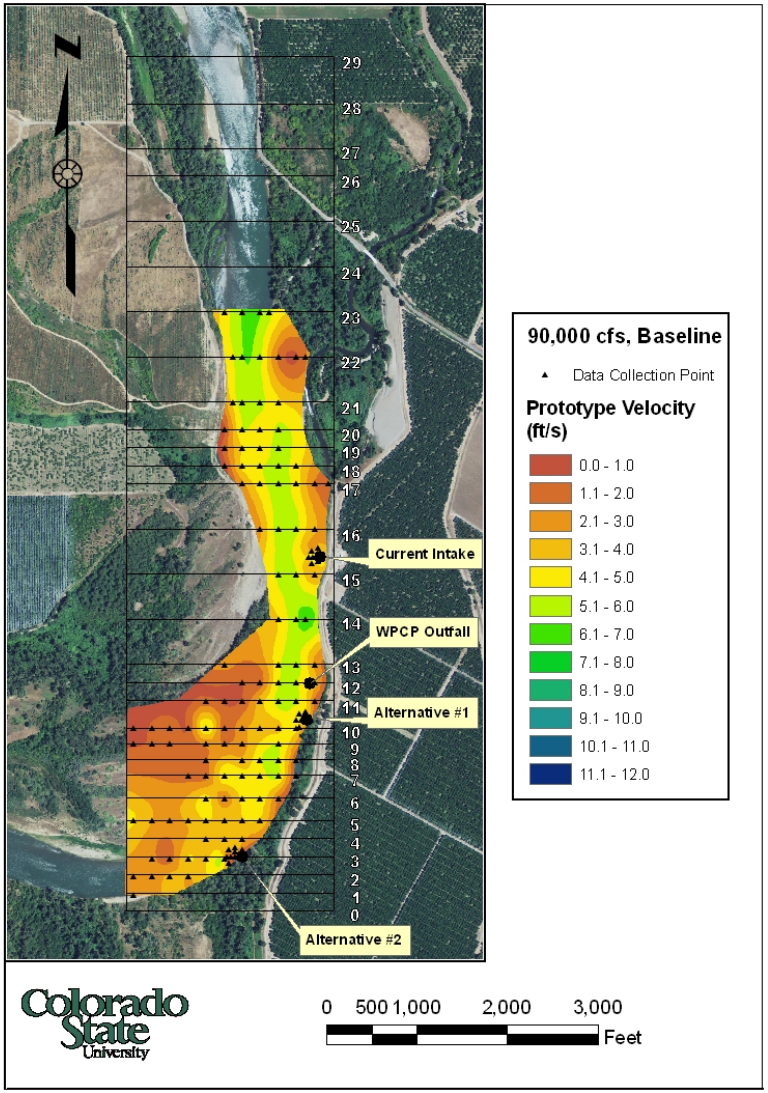


Baseline Velocity Distribution of 2010 Model: 90,000-cfs Testing

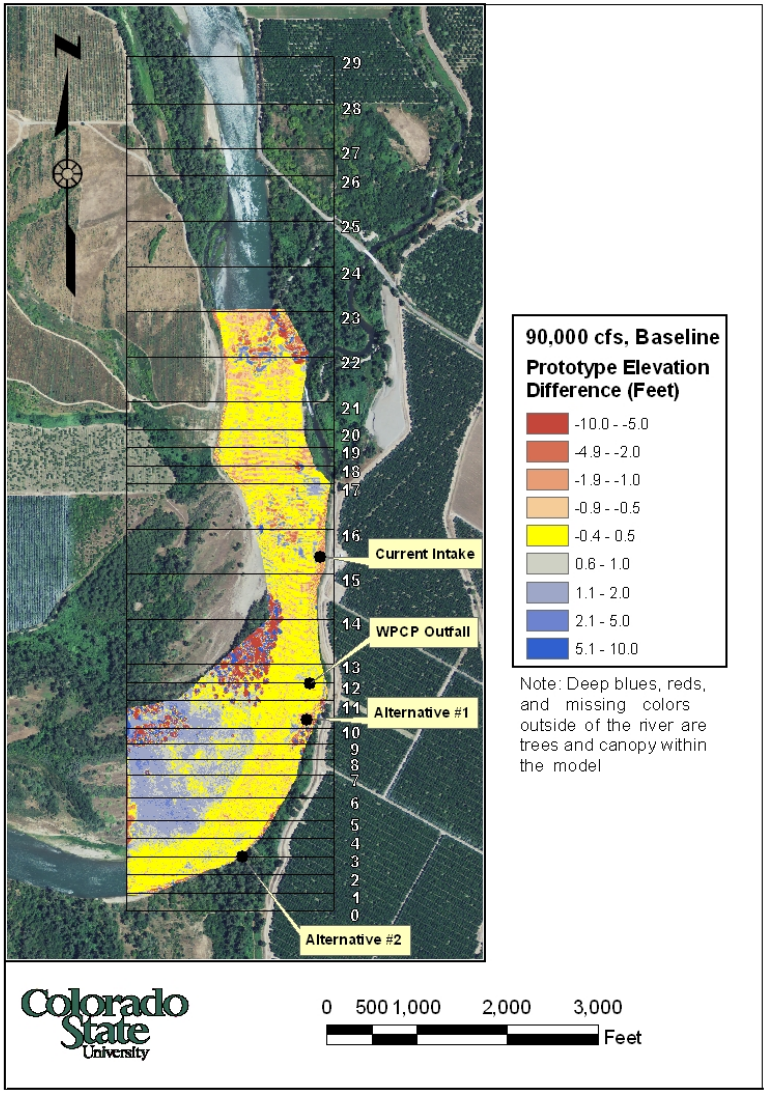


Baseline Velocity Distribution of 2007 Model: 90,000-cfs Testing

Baseline Testing: 90,000-cfs

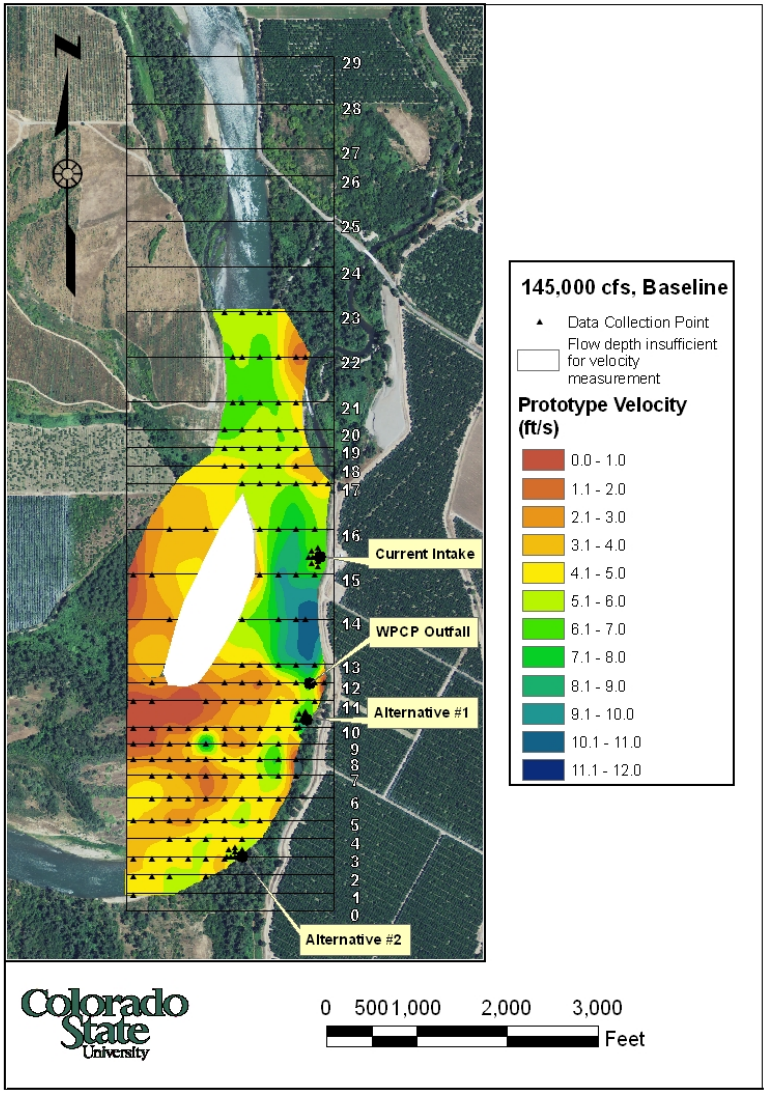


90,000-cfs Baseline Flow Velocity Distribution

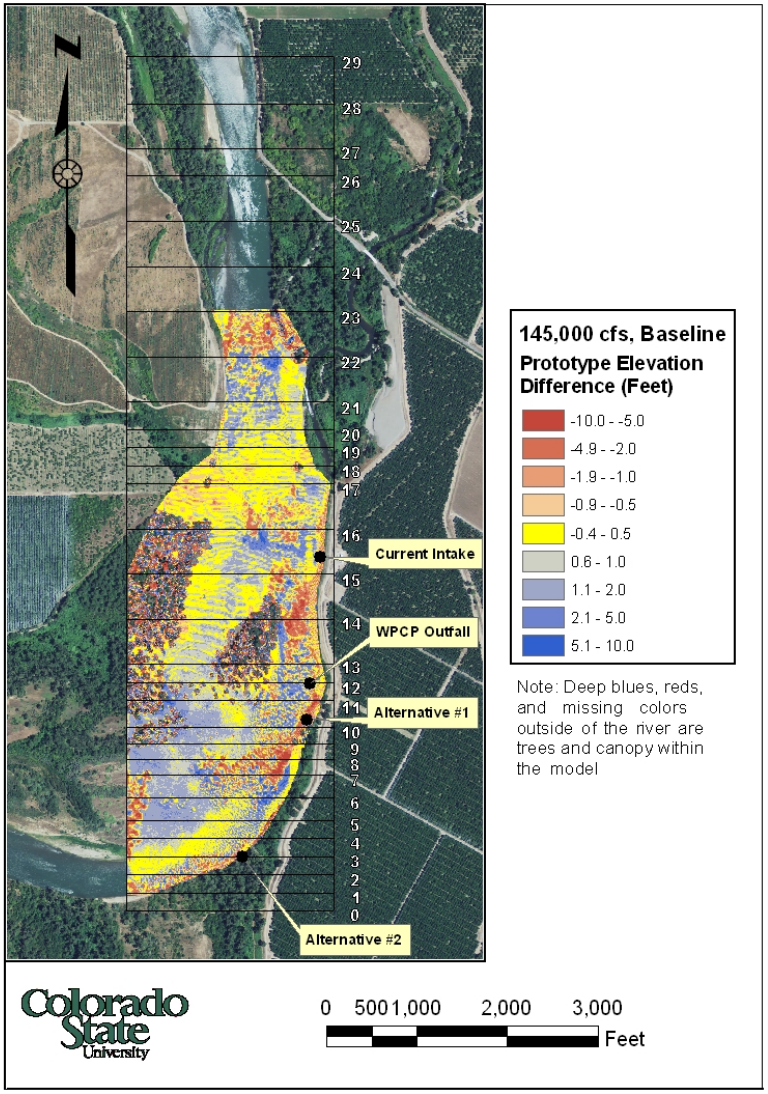


Elevation Difference between Post-90,000-cfs Baseline Testing and Pre-10,000 cfs

Baseline Testing: 145,000-cfs



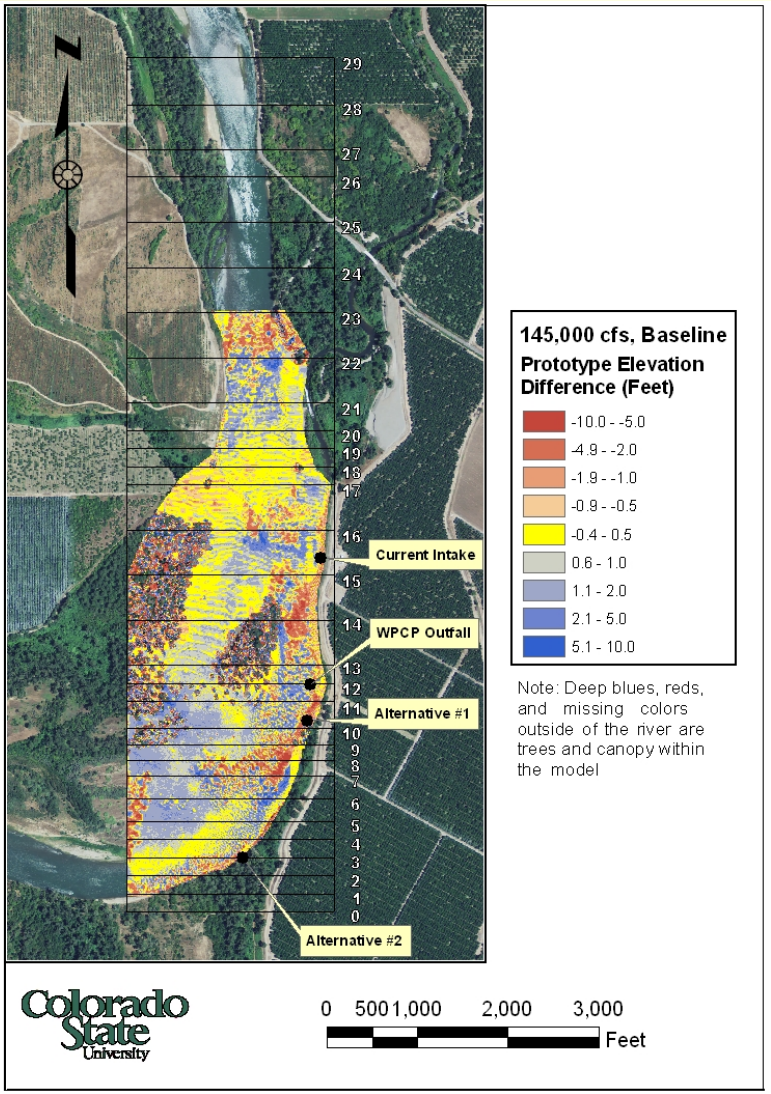
145,000-cfs Baseline Flow Velocity Distribution



Elevation Difference between Post-145,000-cfs Baseline Testing and Pre-10,000 cfs

Baseline Testing Summary

- Current Pump Location
  - Continued trends of sedimentation near the pump
  - Agg. up to 5 ft (from 145,000-cfs test)
  - Lower flow velocities compared to the main channel promoting sedimentation
- Proposed Alternative 1 Site
  - Agg. up to 5 ft in the main channel (from 145,000-cfs test)
  - 2 to 5-ft strip of deg. along the bank (from 145,000-cfs test)
- Proposed Alternative 2 Site
  - Negligible agg. and deg. (from 145,000-cfs test)
- WPCP Outfall
  - Negligible agg. and deg. (from 145,000-cfs test)



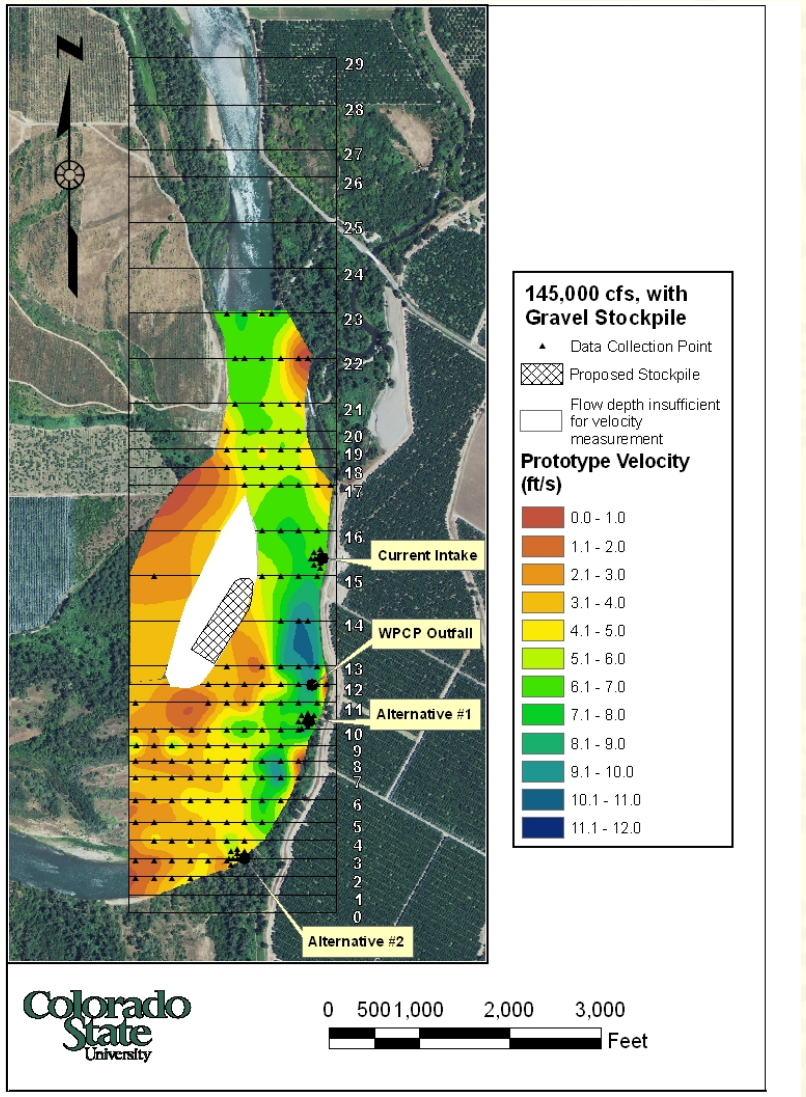
Elevation Difference between Post-145,000-cfs Baseline Testing and Pre-10,000 cfs

Hydraulic Modeling – Gravel Stockpile

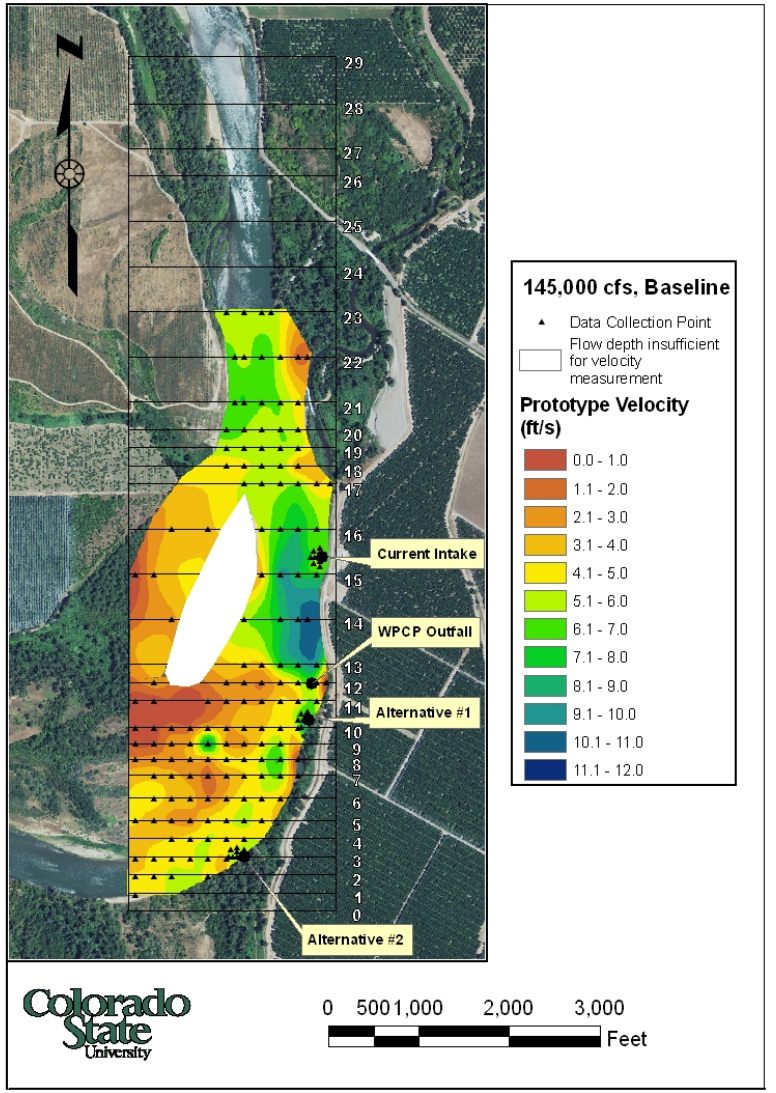
- Prototype Gravel Stockpile:
  - 1000’ Long x 300’ Wide x 10’ High
  - 1.5H:1V Side Slopes
  - To be constructed of dredged channel material from maintenance of current pump station
- Model Gravel Stockpile:
  - Scaled down prototype dimensions
  - Superimposed on baseline configuration topography
  - Used mobile sediment to construct
  - Significantly inundated only at model 145,000-cfs flow

Constructed model Gravel Stockpile

Gravel Stockpile: Comparison

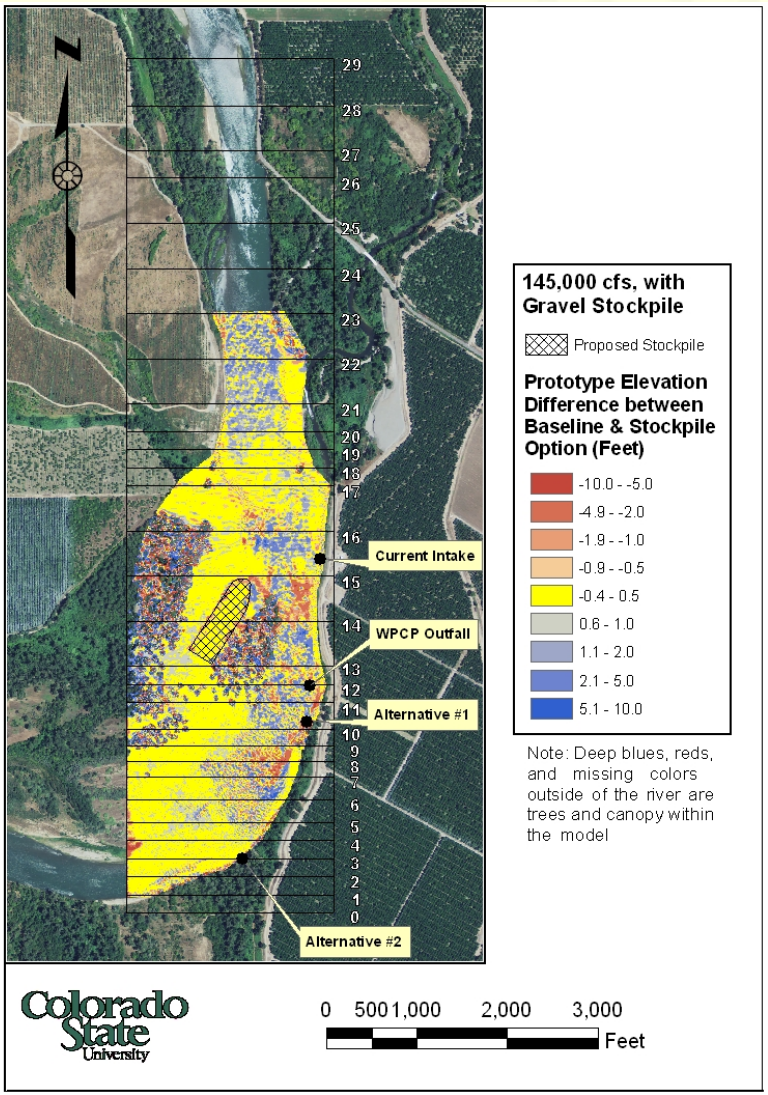


145,000-cfs with Stockpile
Flow Velocity Distribution

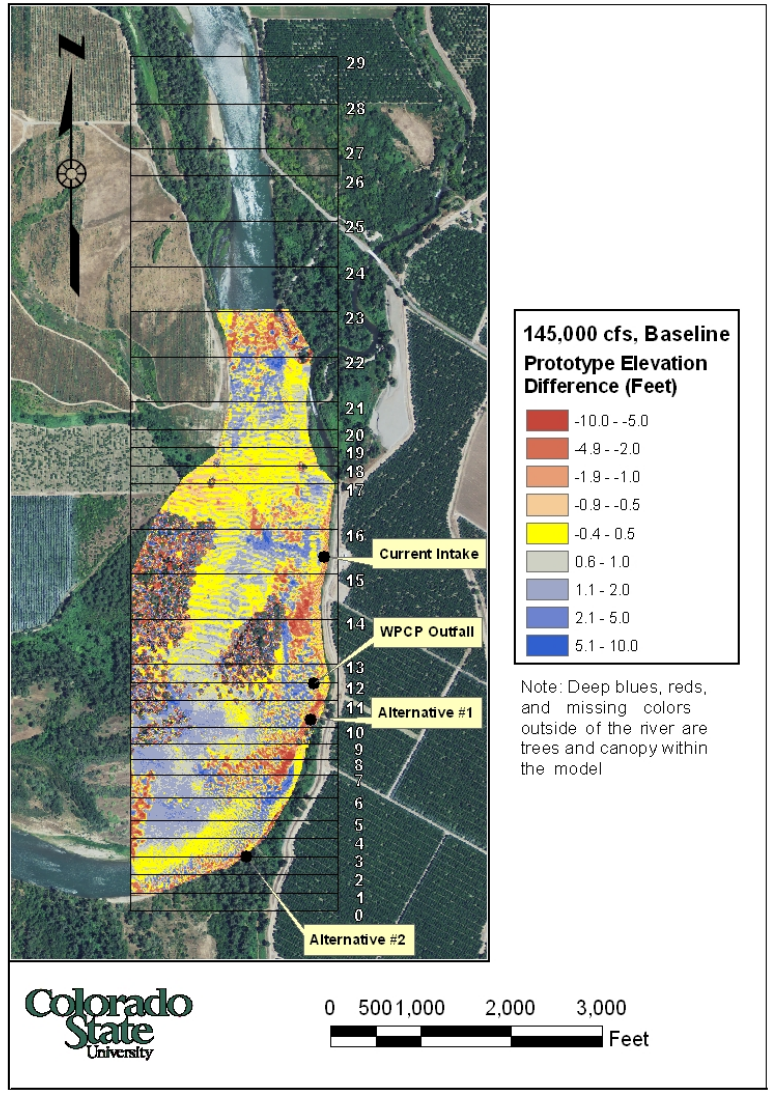


145,000-cfs Baseline
Flow Velocity Distribution

Gravel Stockpile: Comparison



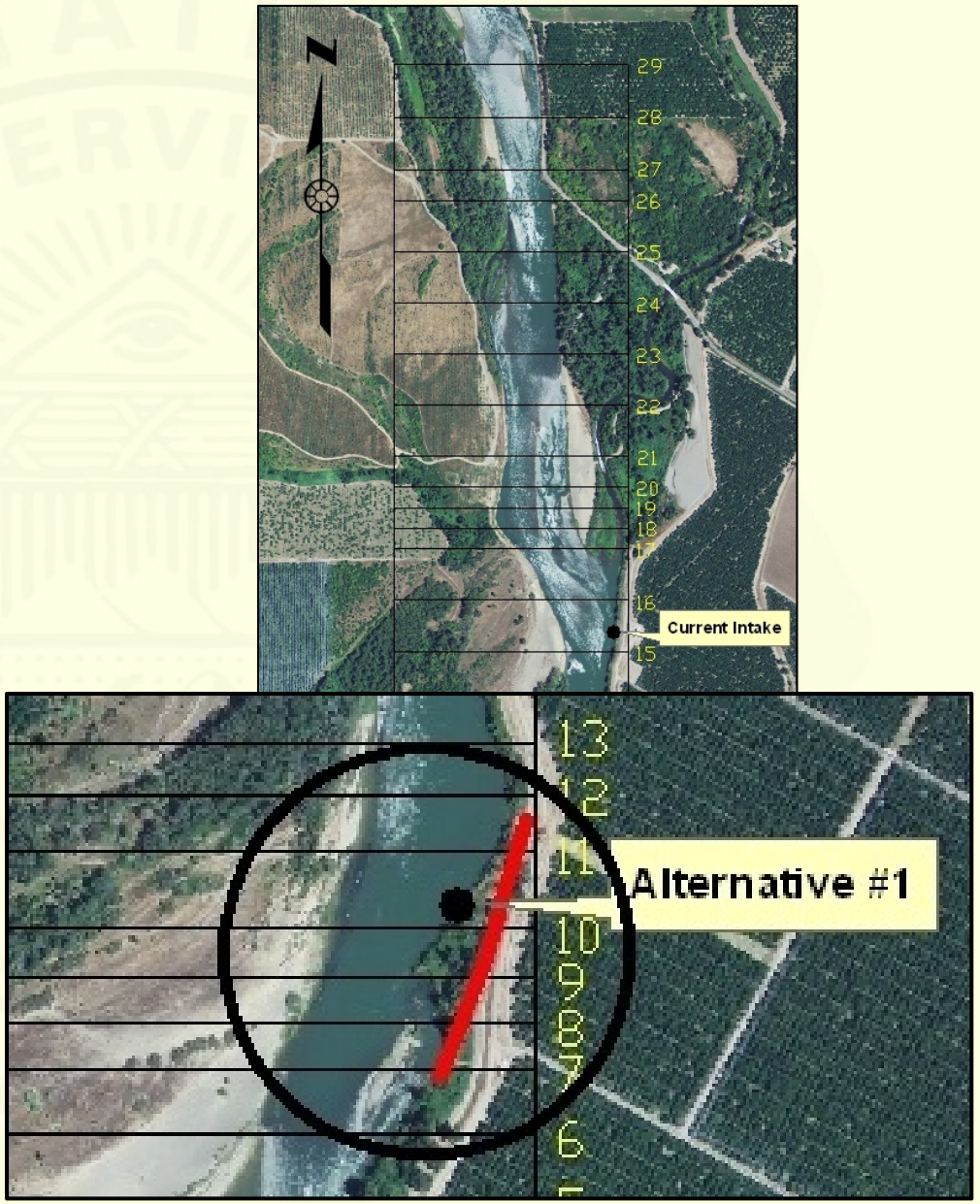
Post-145,000-cfs Gravel-stockpile Testing Elevation Difference from Initial Gravel-stockpile Elevations



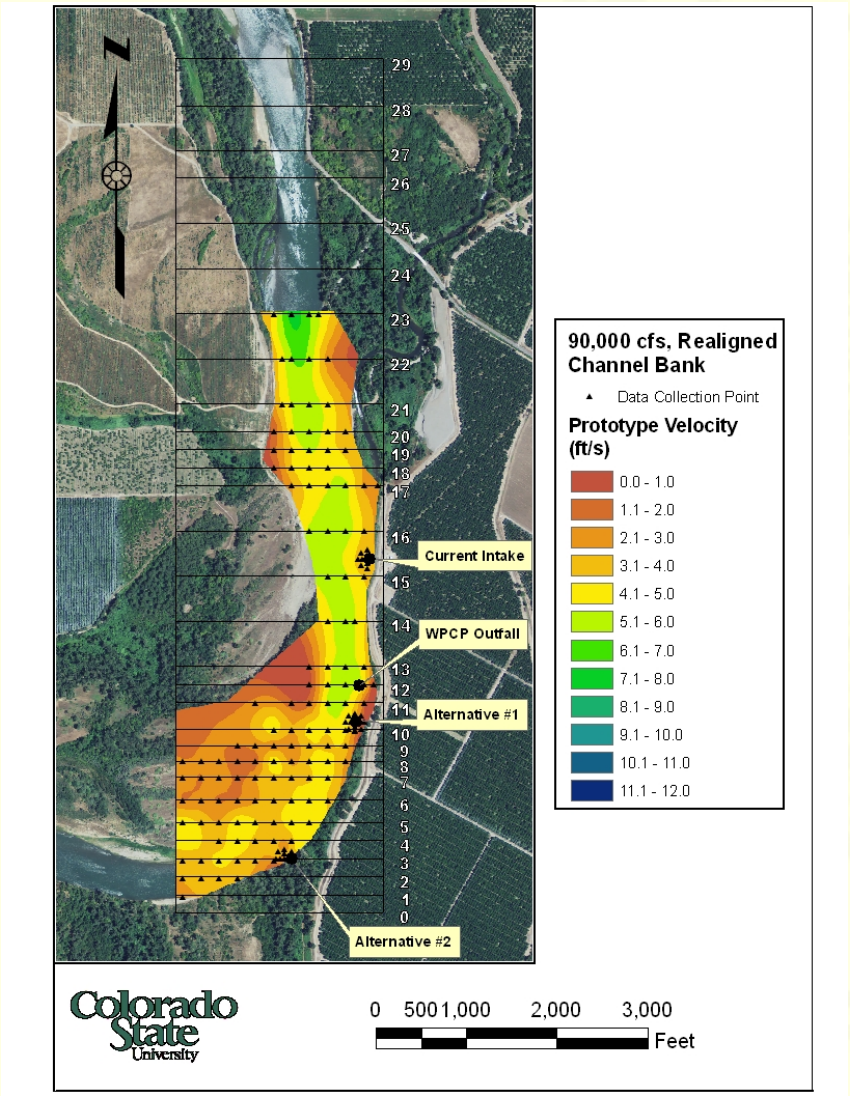
Post-145,000-cfs Baseline Testing Elevation Difference from Post-10,000-cfs Baseline

Hydraulic Modeling – Realigned Bank

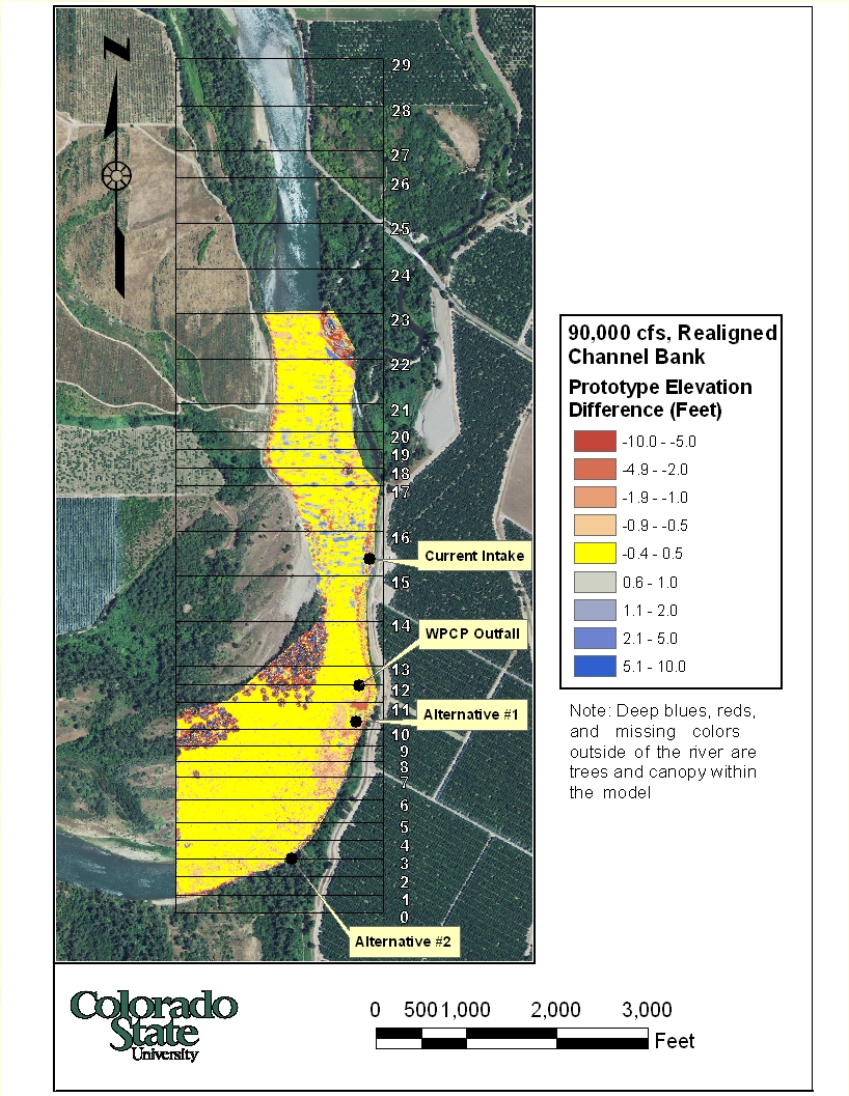
- Prototype Bank realignment
  - Straightening of East bank near Proposed Alternative 1 Site
  - Riprap along east bank from current pump intake to downstream of Proposed Alternative 1 Site
  - Pea-gravel used to model riprap
- Proposed Alternative 1 Site is no longer a potential relocation site with the bank realignment



Bank Realignment Testing: 90,000-cfs

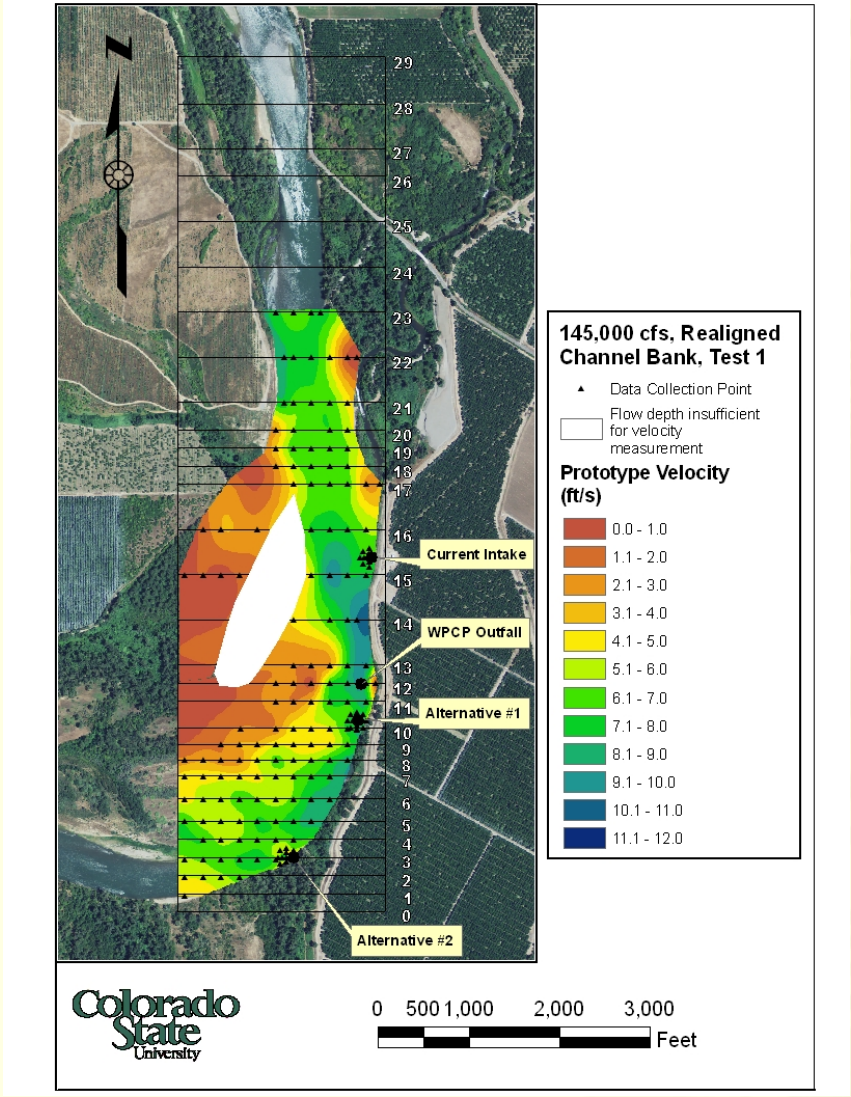


Realigned Bank 90,000-cfs Flow Velocity Distribution

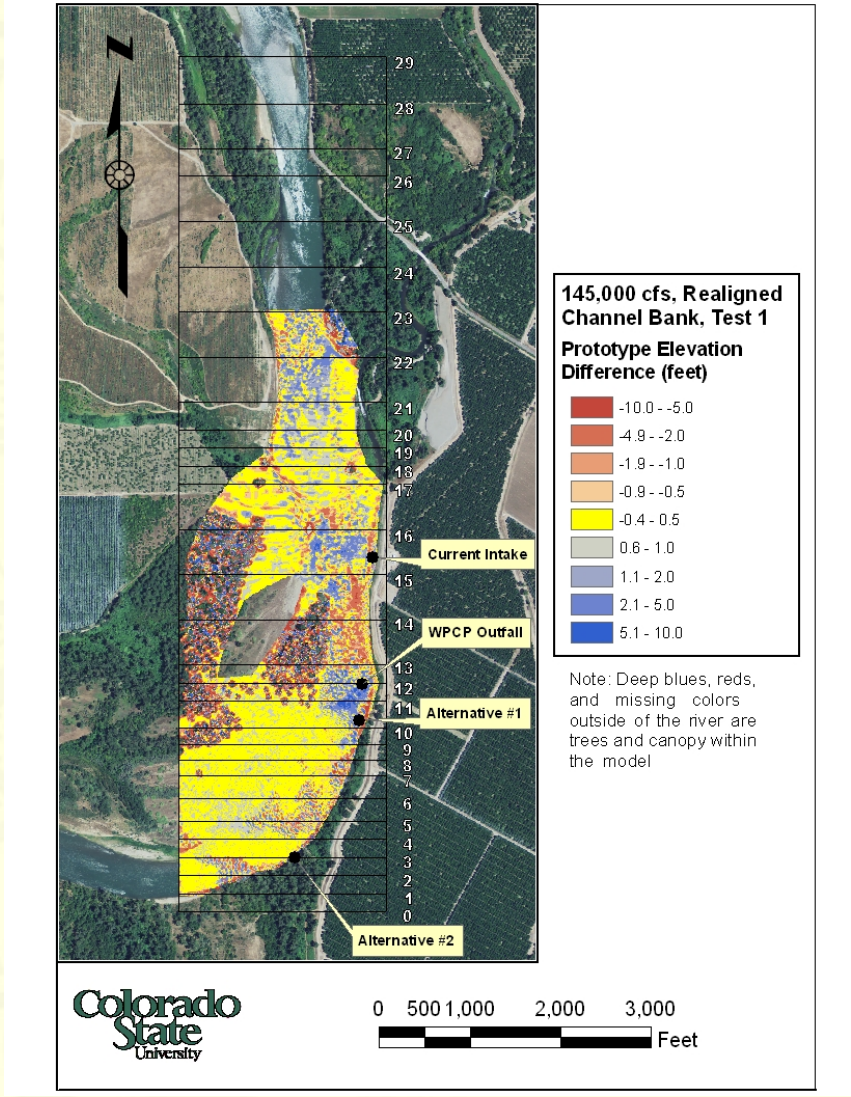


Elevation Difference between Post-90,000-cfs Realignment Testing and Pre-10,000 cfs

Bank Realignment Testing: 145,000-cfs

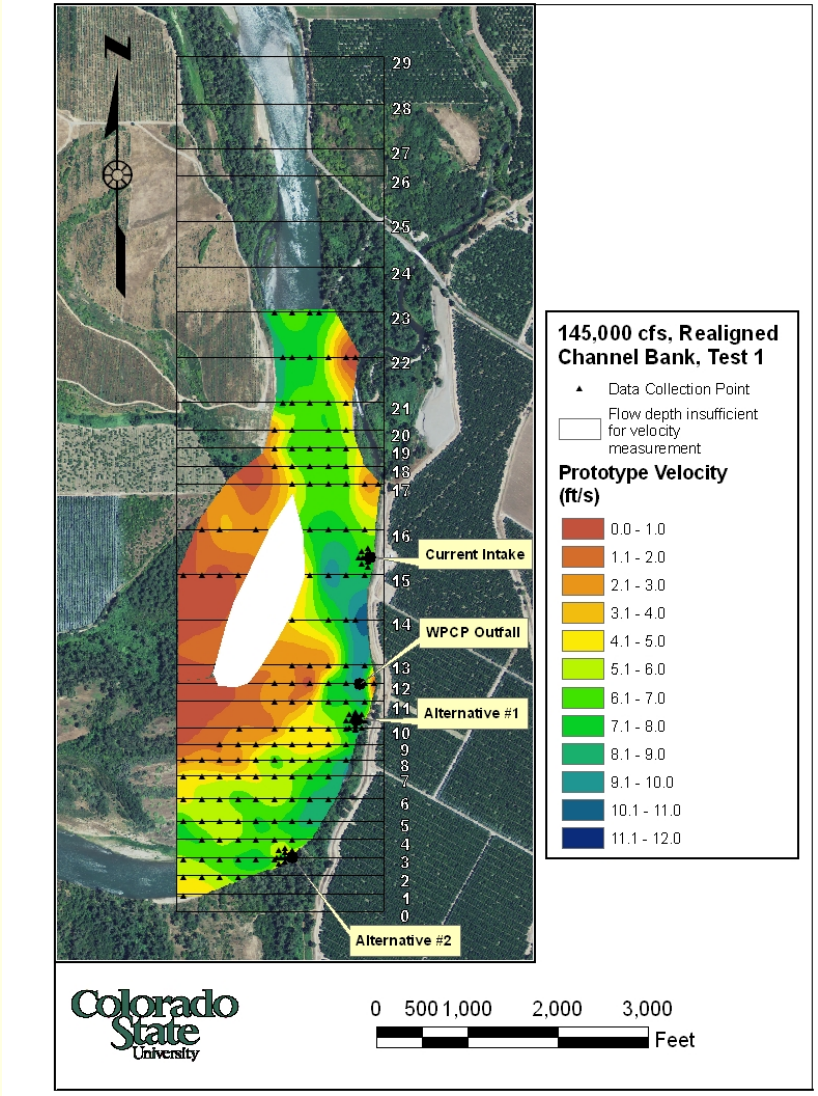


Realigned Bank 145,000-cfs Flow Velocity Distribution

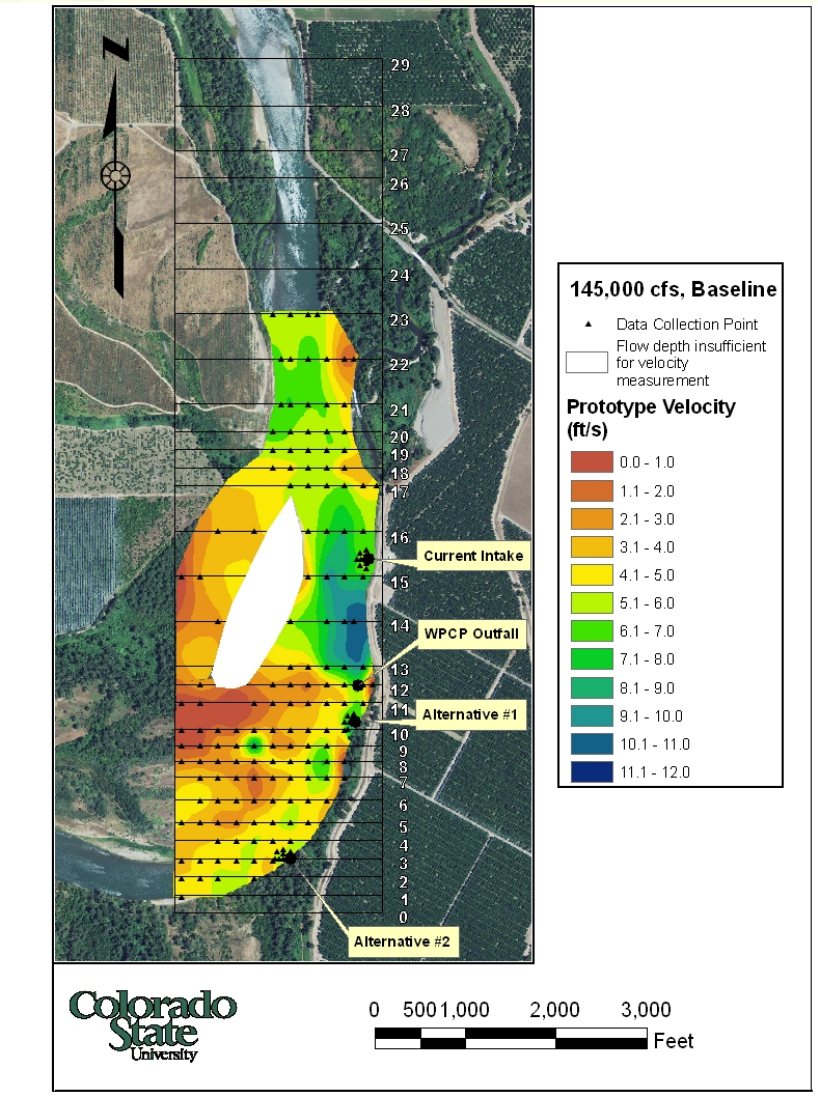


Elevation Difference between Post-145,000-cfs Realignment Testing and Pre-10,000 cfs

Bank Realignment: Comparison

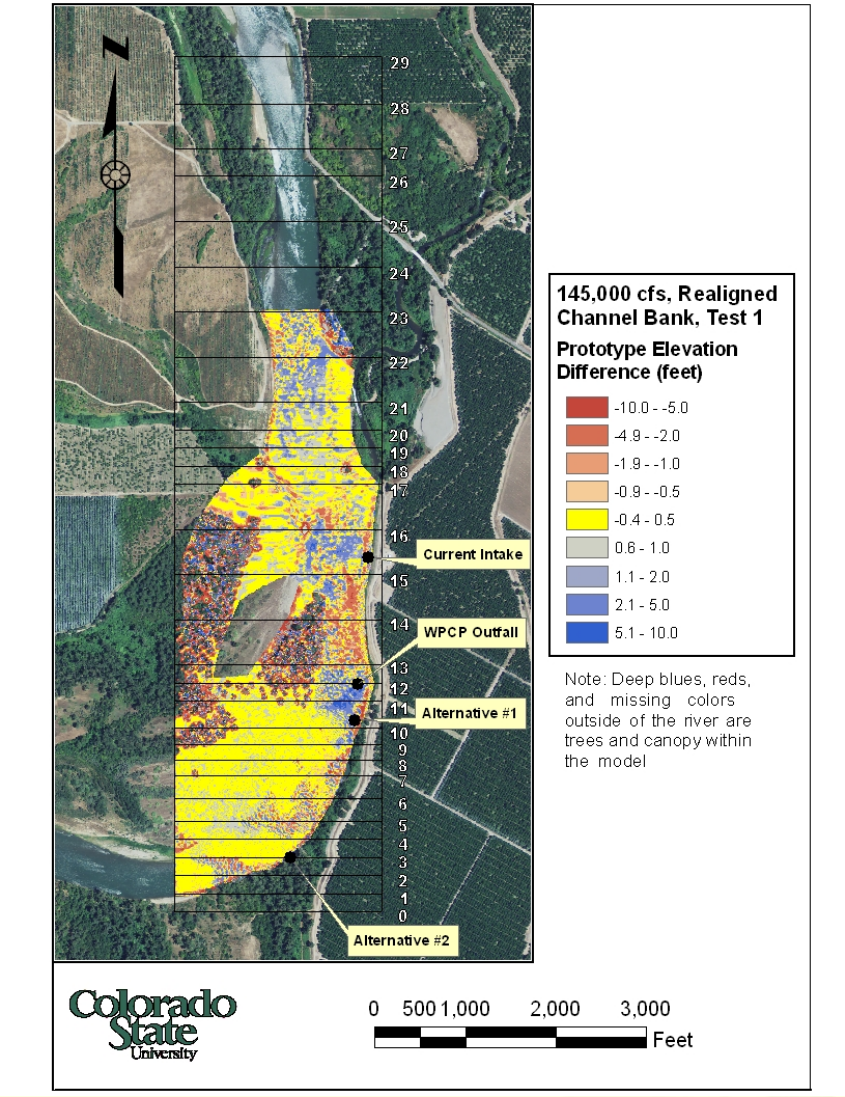


Realigned Bank 145,000-cfs Flow Velocity Distribution

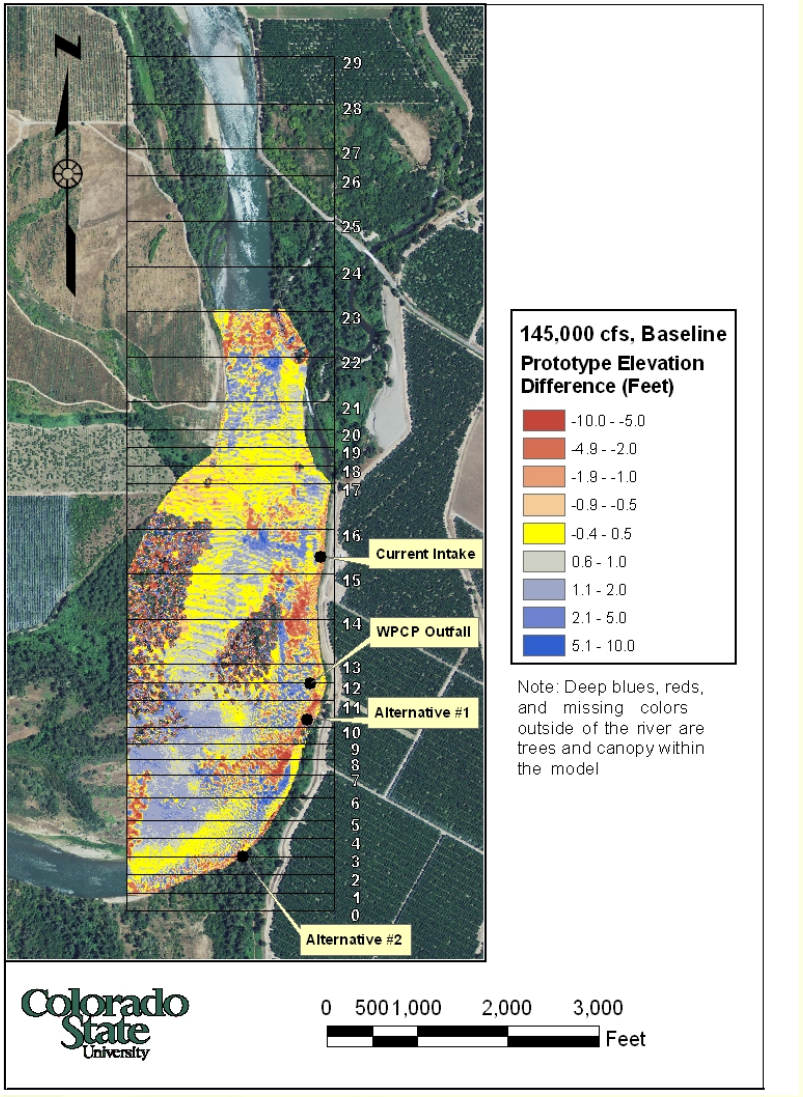


Baseline 145,000-cfs Flow Velocity Distribution

Bank Realignment: Comparison

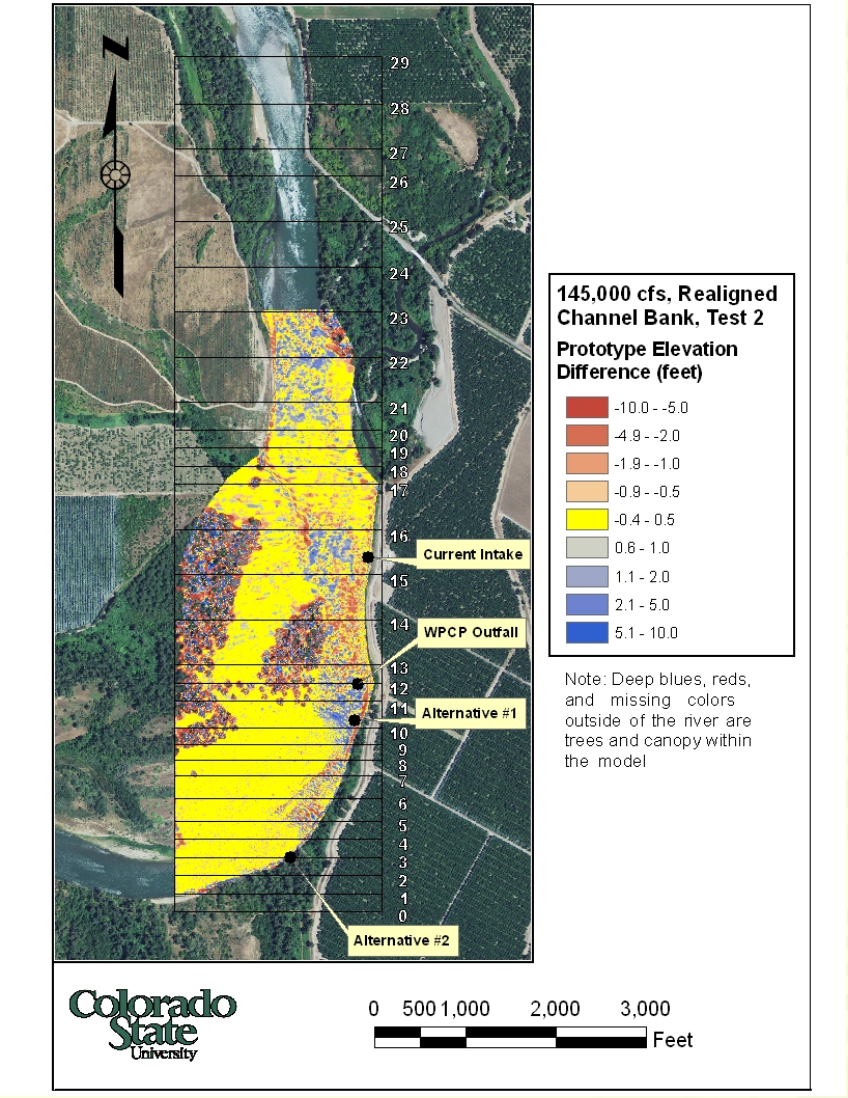


Post-145,000-cfs Realigned-bank Test 1 Elevation Difference from Pre-10,000-cfs Test

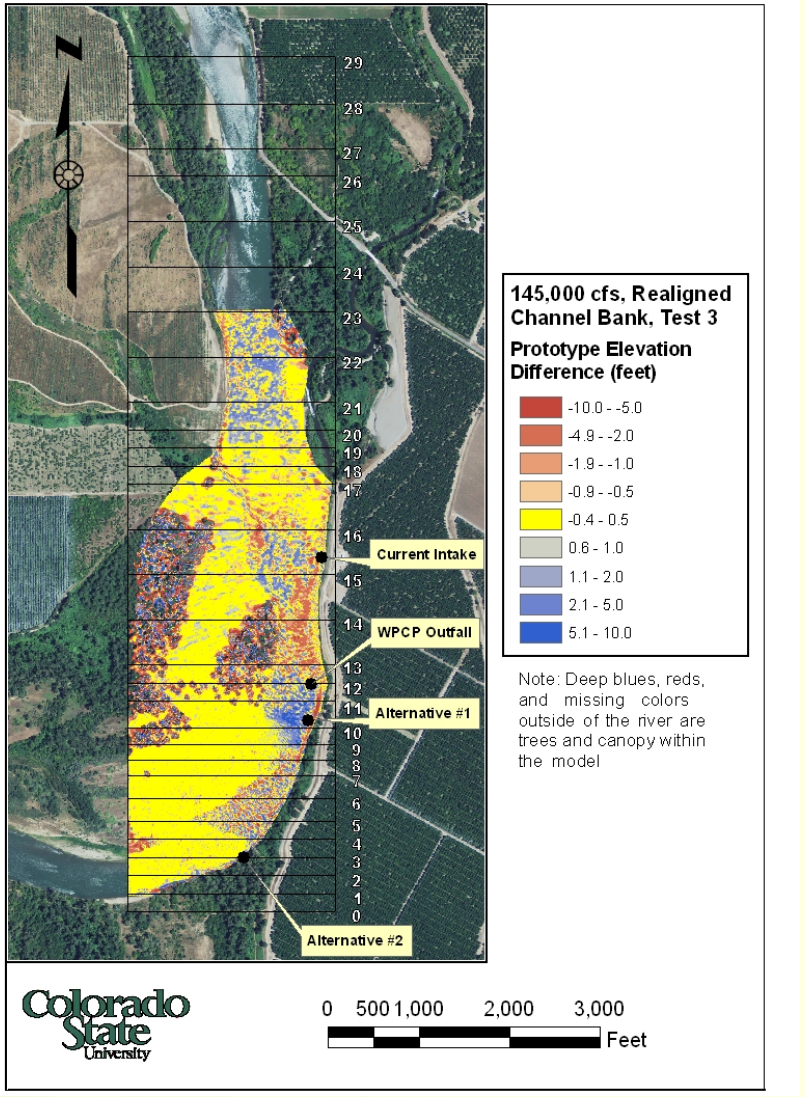


Post-145,000-cfs Baseline Testing Elevation Difference from Post-10,000-cfs Baseline

Bank Realignment: Comparison

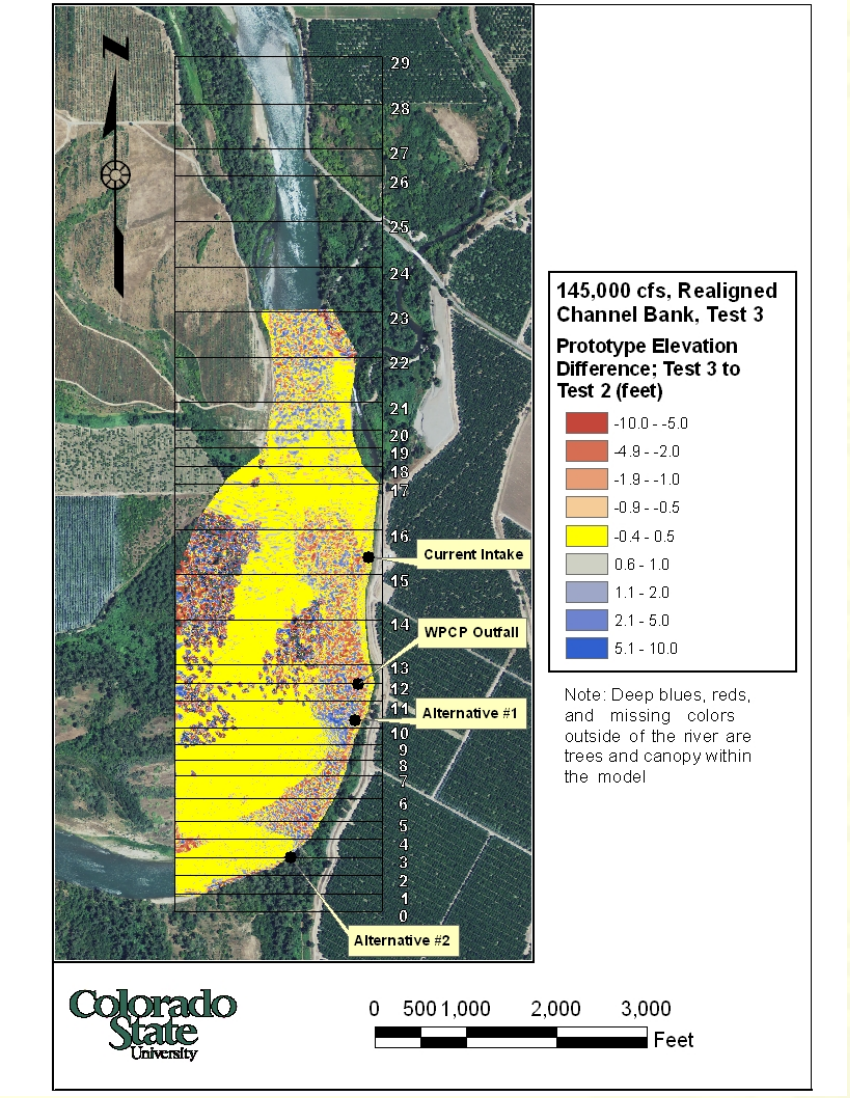


Realigned Bank 145,000-cfs Post-Test 2
Bed Elevation Difference from Pre-Test 2 (8 hrs)

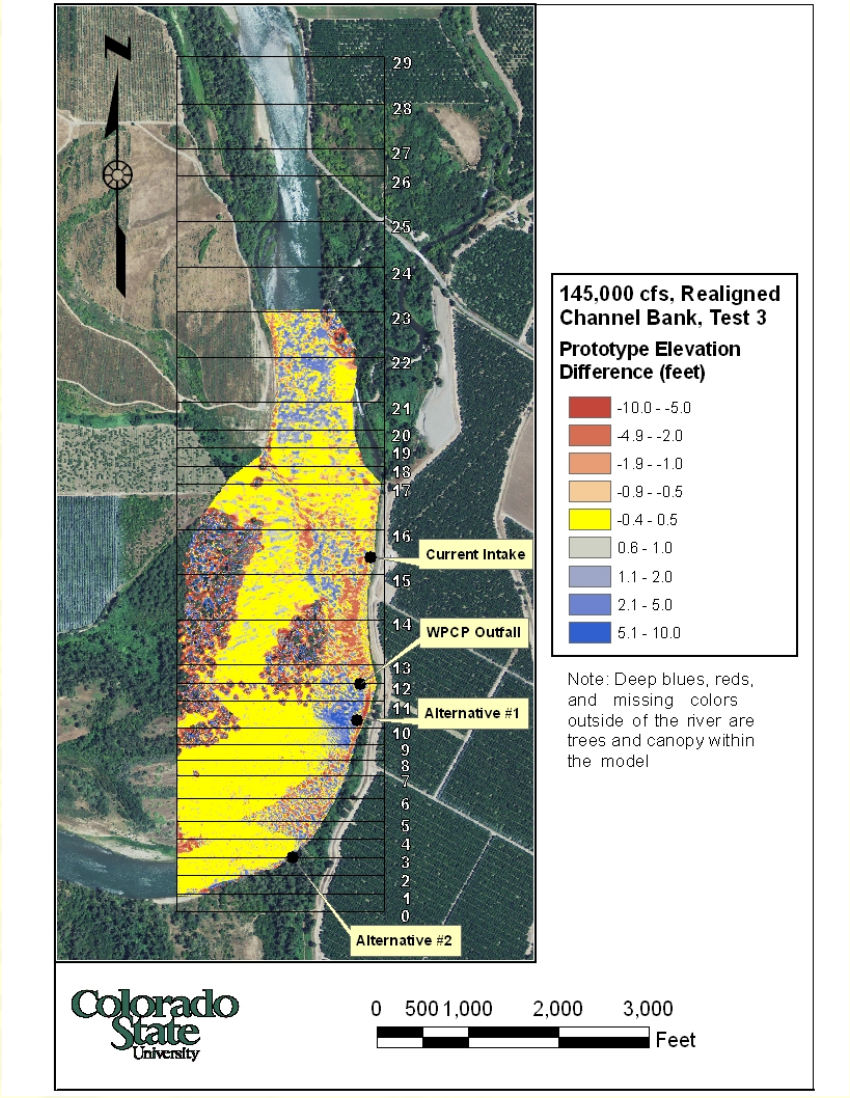


Realigned Bank 145,000-cfs Post-Test 3
Bed Elevation Difference from Pre-Test 2 (16 hrs)

Bank Realignment: Comparison



Realigned Bank 145,000-cfs Post-Test 3
Bed Elevation Difference from Pre-Test 3 (8 hrs)

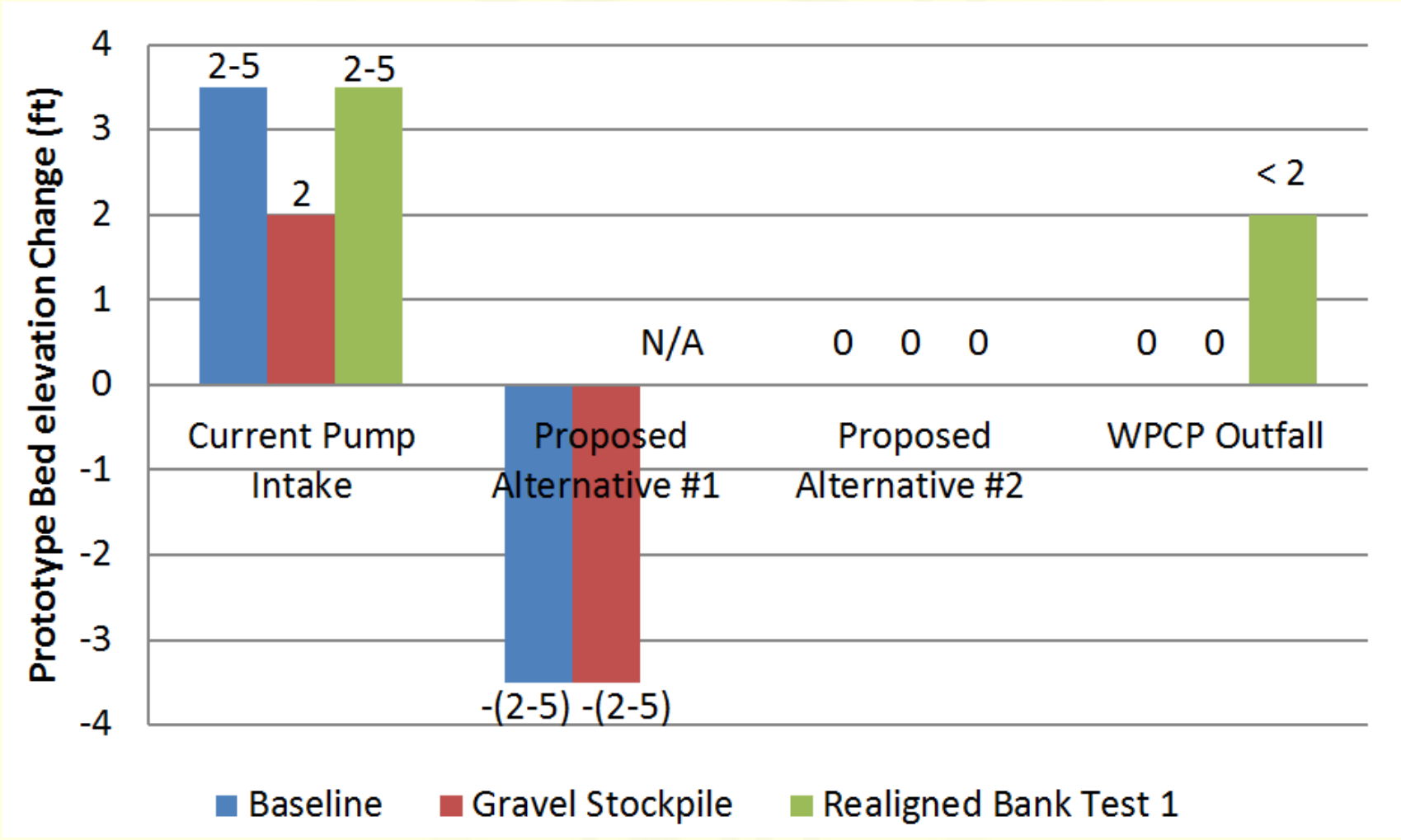


Realigned Bank 145,000-cfs Post-Test 3
Bed Elevation Difference from Pre-Test 2 (16 hrs)

Bank Realignment Testing Summary

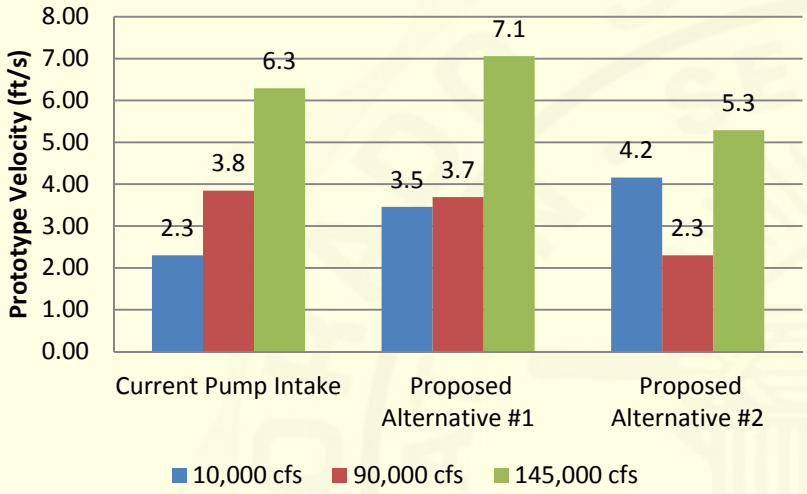
- Hydraulic and sedimentation trends varied from Baseline and Gravel-stockpile trends
- Higher main-channel flow velocities compared to Baseline Testing
- Current pump location
  - Agg. up to 5 ft just northwest of current pump-intake (from 145,000-cfs test)
  - Negligible velocity difference compared to Baseline conditions
- Proposed Pump Alternative Location #1
  - Deg. up to 2 ft at 10,000 cfs and 90,000 cfs
  - Agg. up to 5 ft immediately upstream (from 145,000-cfs test)
  - Increased flow velocities compared to baseline conditions at 145,000 cfs
- Proposed Pump Alternative Location #2
  - Negligible agg. and deg. (from 145,000-cfs test)
  - Increase in velocity of main channel compared to Baseline
- WCPC Outfall
  - Agg. immediately upstream
  - Deg. immediately downstream
  - Measured upstream agg. suggests that a maximum of 2 ft of aggradation could be expected at the WPCP outfall

Summary Chart

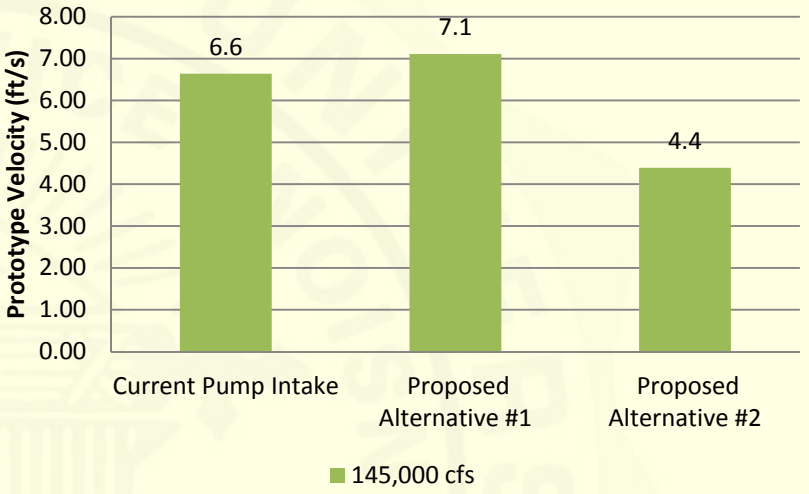


Summary Charts

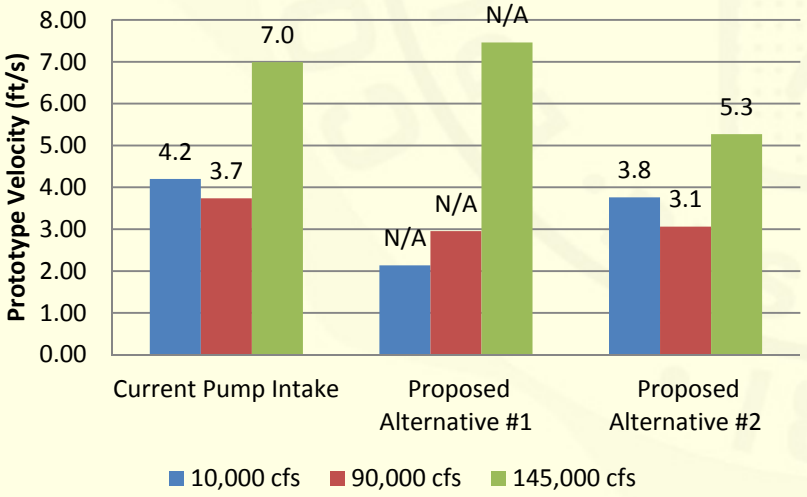
Baseline Testing



Gravel Stockpile Testing



Realigned Bank Testing



Conclusions from Hydraulic Model

- Continued sedimentation up to 5 ft is expected with existing field conditions near the current pump-intake location
- Construction of the gravel stockpile on the west floodplain would have an insignificant effect on the hydraulics and erosion and sedimentation trends within the study reach
- The Proposed Alternative 1 site may be suitable for pump-intake relocation because the model predicted degradation up to 5 ft near the Proposed Alternative 1 site for both the existing field conditions and with the construction of the gravel stockpile
- The Proposed Alternative 2 site may be suitable for pump-intake relocation because
    - The model indicated minimal aggradation and degradation near the Proposed Alternative 2 site
    - The site experienced the most consistent bed elevations with minimal aggradation and degradation in the surrounding areas compared to the other evaluated pump location sites
- The model indicated aggradation immediately upstream of the WPCP outfall and degradation immediately downstream of the WPCP outfall with the bank realignment for the Proposed Alternative 2 site
    - The measured upstream aggradation suggests that a maximum of 2 ft of aggradation could be expected at the WPCP outfall.