International Conference on Engineering and Ecohydrology for Fish Passage

International Conference on Engineering and Ecohydrology for Fish Passage 2017

Jun 21st, 4:50 PM - 5:30 PM

The Reality of Fish Passage in Concrete Flood Channels

Mike Garello PE
HDR

George Johnson
City of Santa Barbara

Marcin Whitman PE
CDFW

THE REALITY OF FISH PASSAGE IN CONCRETE FLOOD CHANNELS

Presenter, Mike Garello, PE (HDR)

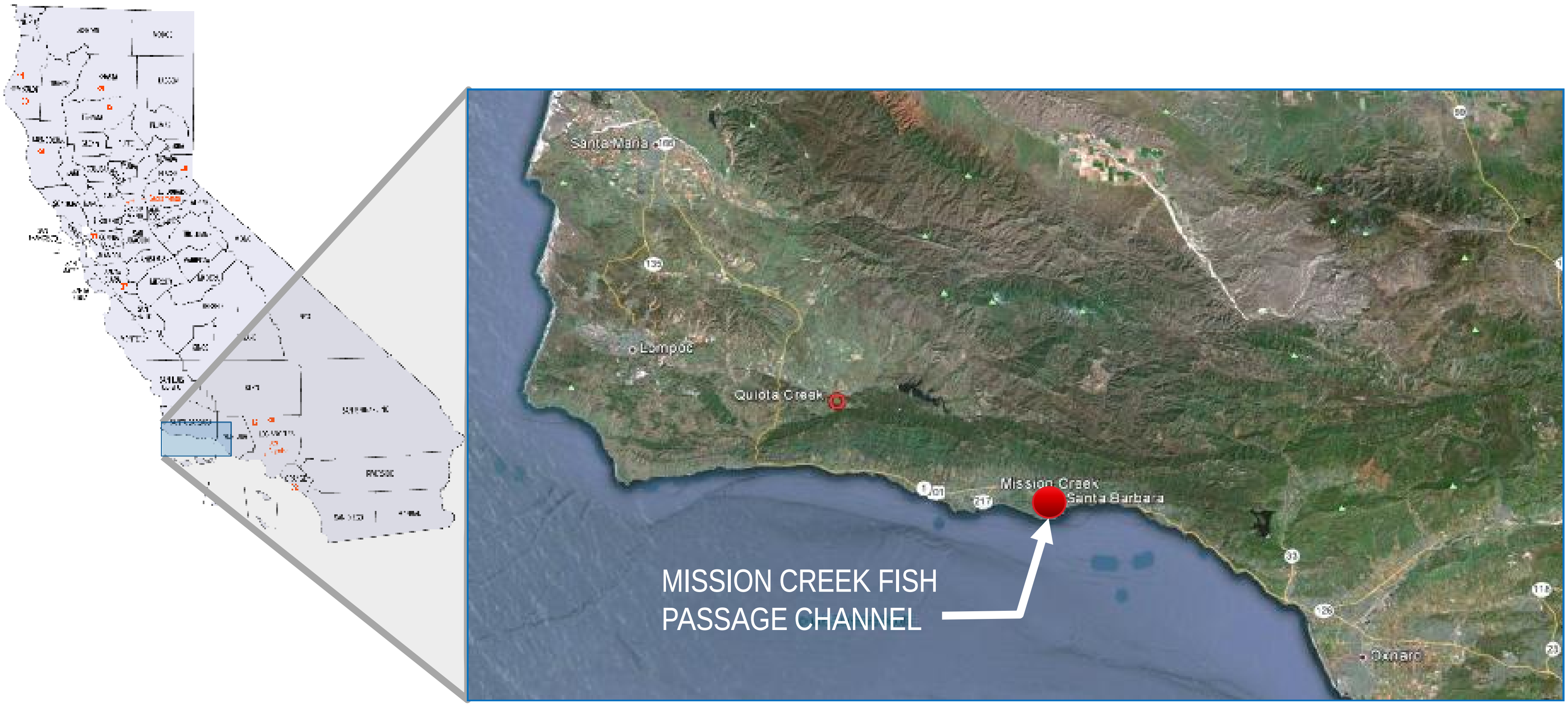
Co-Presenters, George Johnson (City of Santa Barbara) and Marcin Whitman, PE (CDFW)

ACKNOWLEDGEMENTS AND PARTICIPATION

- This unique and challenging project was made possible by a number of contributing organizations:

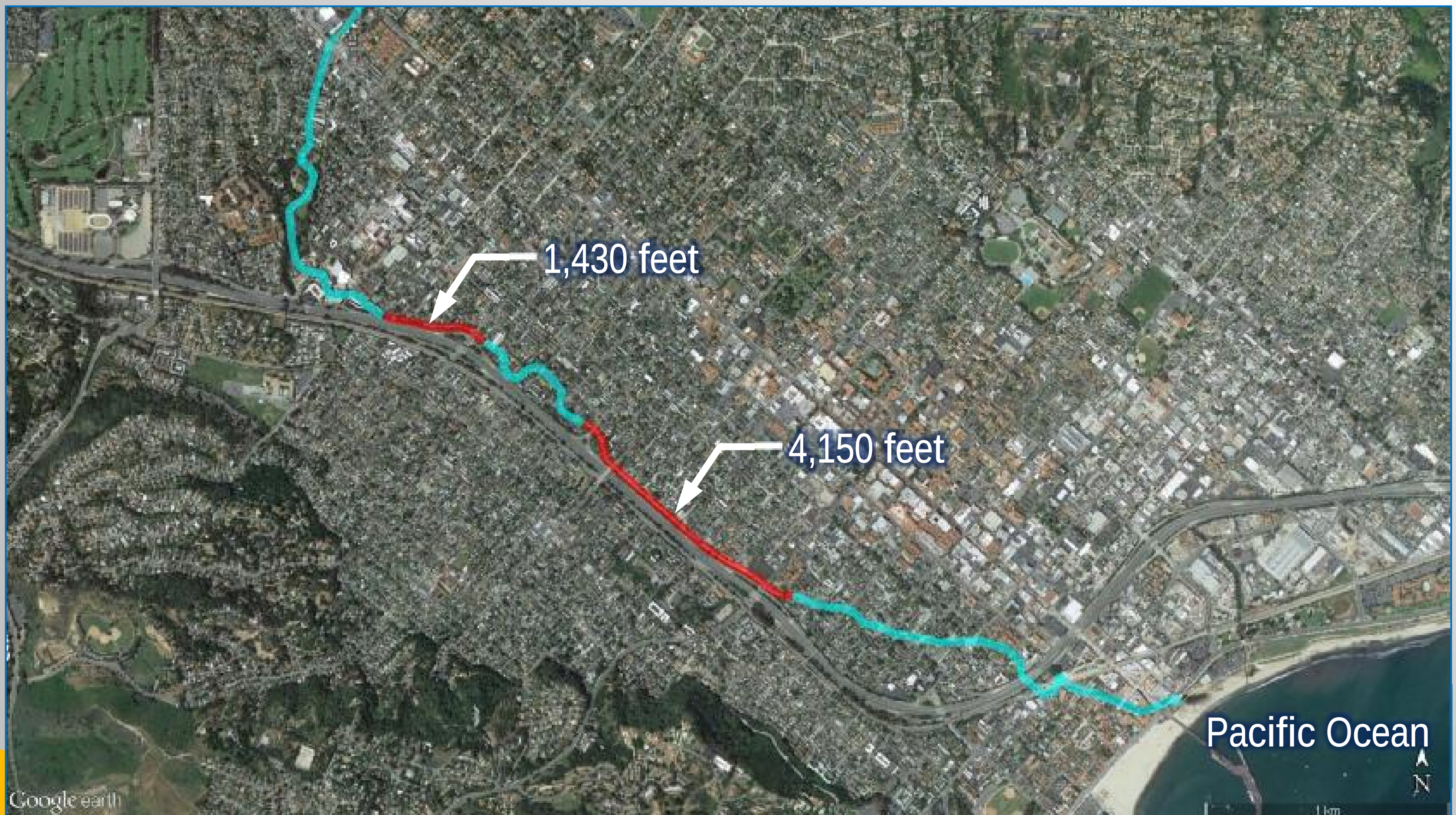
Pacific Hydraulic Engineers and Scientists

PROJECT LOCATION



Santa Barbara, California, USA

MISSION CREEK PRE-PROJECT CONDITIONS



MISSION CREEK PRE-PROJECT CONDITIONS

MISSION CREEK PRE-PROJECT CONDITIONS

SOUTHERN CALIFORNIA STEELHEAD

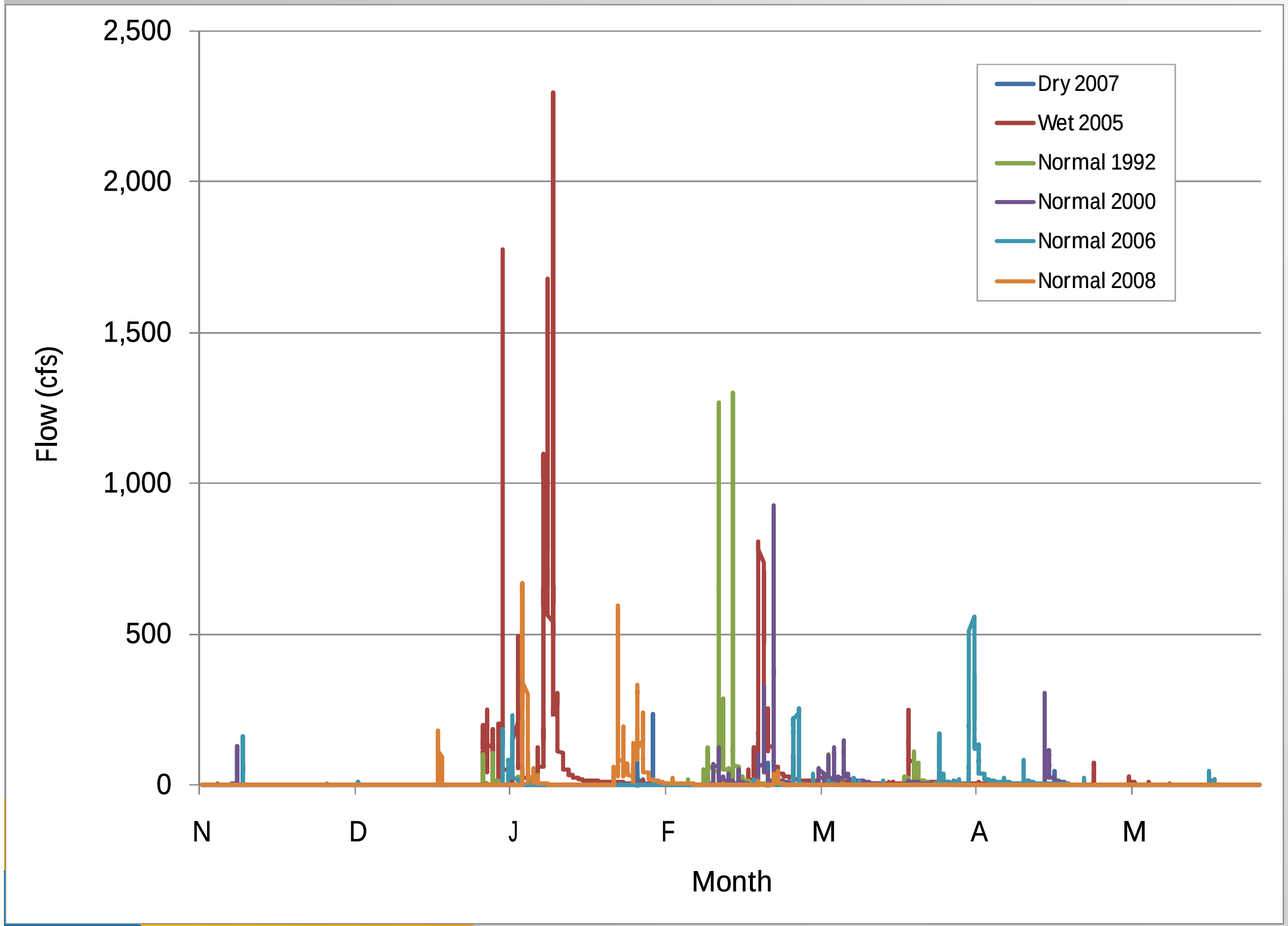
- Southern California Distinct Population Segment (DPS)
- Listed as Endangered by NOAA in 1997
- Critical Habitat Designated in 2000/2004
- Far less than 1% of historic Southern California populations

Photo by COMB

SOUTHERN CALIFORNIA STEELHEAD

- Droughts, floods, and wildfires have a significant impact on resident trout populations
- 81% of the available habitat occurs upstream of the flood control channels
- Multiple impediments to passage exist in addition to the flood control channels
- Flood control channels limit passage due to high velocities and low depths for typical Mission Creek flows
- Development, stormwater return, and low flows all contribute to water quality concerns during the potential migration period

SOUTHERN CALIFORNIA STEELHEAD



The native steelhead population of Sothern California and Mission Creek have adapted to flashy hydrology and uncertain availability of stream flows for migration.

PROJECT GOALS

- Improve fish passage (fisheries)
- No Impact to Flood Conveyance (County)
- Accommodate Sediment Transport (City)
- Limit Additional Maintenance Effort (City)

PROJECT OBJECTIVES
SPECIFIC DESIGN CRITERIA AND CONSTRAINTS

- Target fish passage flows of 10 to 300 cfs
- Maximum jump height and minimum flow depth of 1-foot
- Free draining – no standing water which may lead to vector control issues
- No impact to flood capacity of 3,400 cfs
- Minimize maintenance and bedload removal to the extent possible
- Maintain 12-foot continuous travel lane for maintenance vehicles

PREVIOUS STUDIES AND ALTERNATIVE DEVELOPMENT

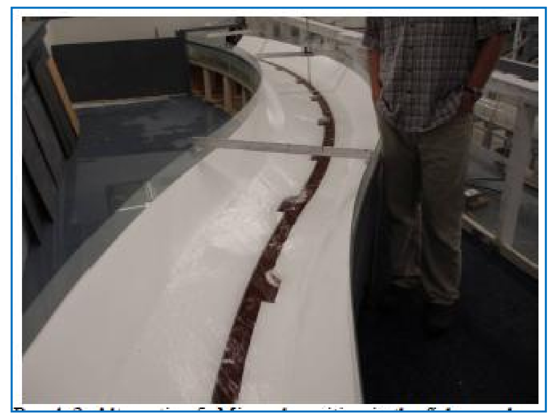
- Numerous efforts began in 2002 to find a solution…

- 2002, County of SB hired Penfield & Smith to perform an assessment of existing conditions.
- 2002, USACE initiated a Section 206 project aimed at Mission Creek Fish Passage issues.
- 2004, USACE published report on hydraulic condition of Mission Creek natural and non-natural channel reaches.
- 2006, the EDC hired Pacific Hydraulic Engineers and Scientists to further develop five potential channel modification alternatives.
- 2008, City of SB hired NHC to perform physical hydraulic modeling of two channel modification alternatives.
- 2010, City of SB hired HDR to perform a performance evaluation, selection, and design of a preferred alternative.

PREVIOUS STUDIES AND ALTERNATIVE DEVELOPMENT

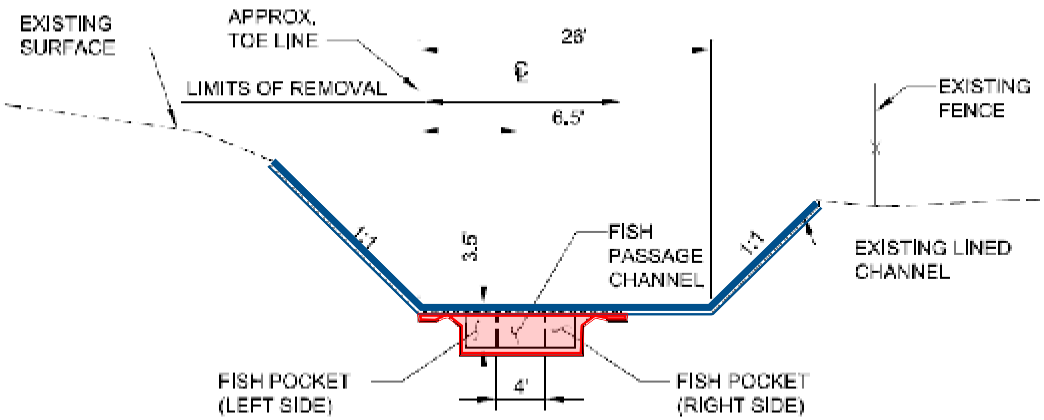
Alternative development, PHES 2006

PREVIOUS STUDIES AND ALTERNATIVE DEVELOPMENT

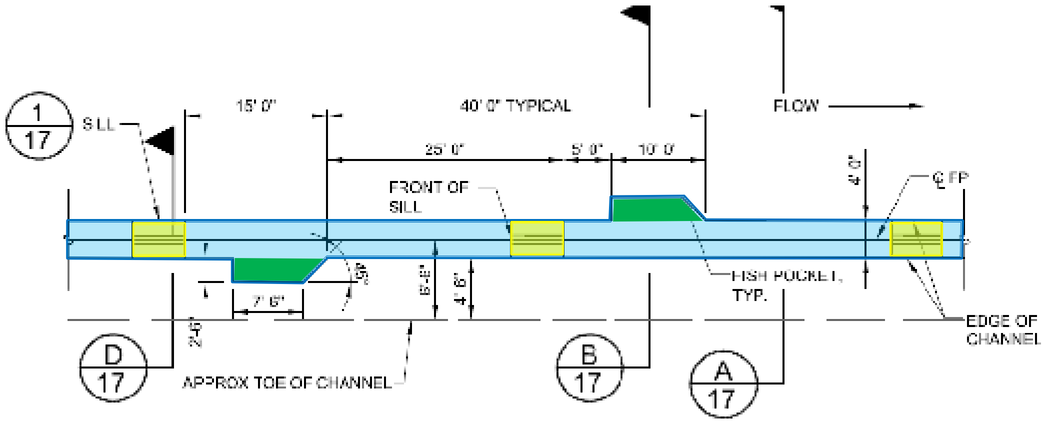


Physical modeling,
NHC 2008

PREVIOUS STUDIES AND ALTERNATIVE DEVELOPMENT



- Saw cut floor of existing channel floor.
- Construct cast-in place concrete fish passage channel.
- Fish resting pockets every 40-ft
- Install sills to maintain minimum hydraulic depth



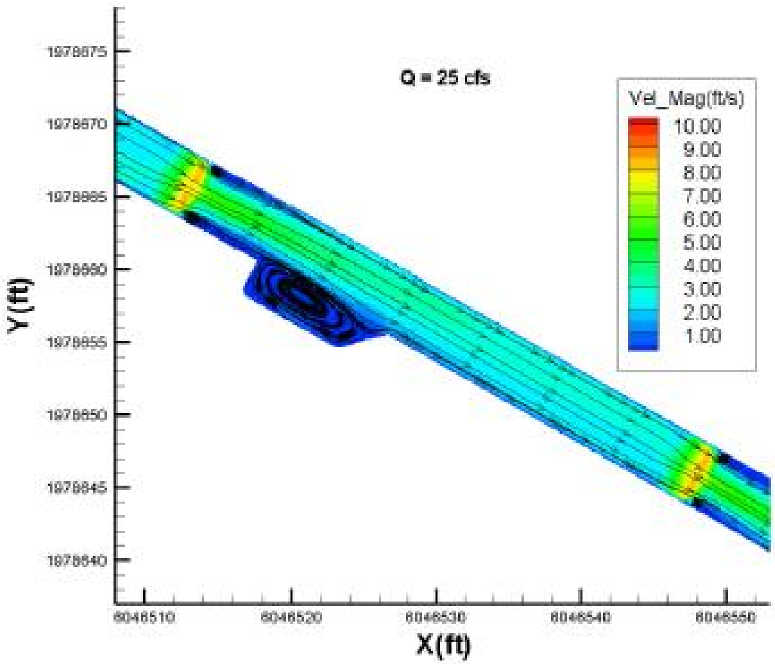
Alternative selection and performance evaluation, HDR, 2010

ALTERNATIVE PERFORMANCE EVALUATION

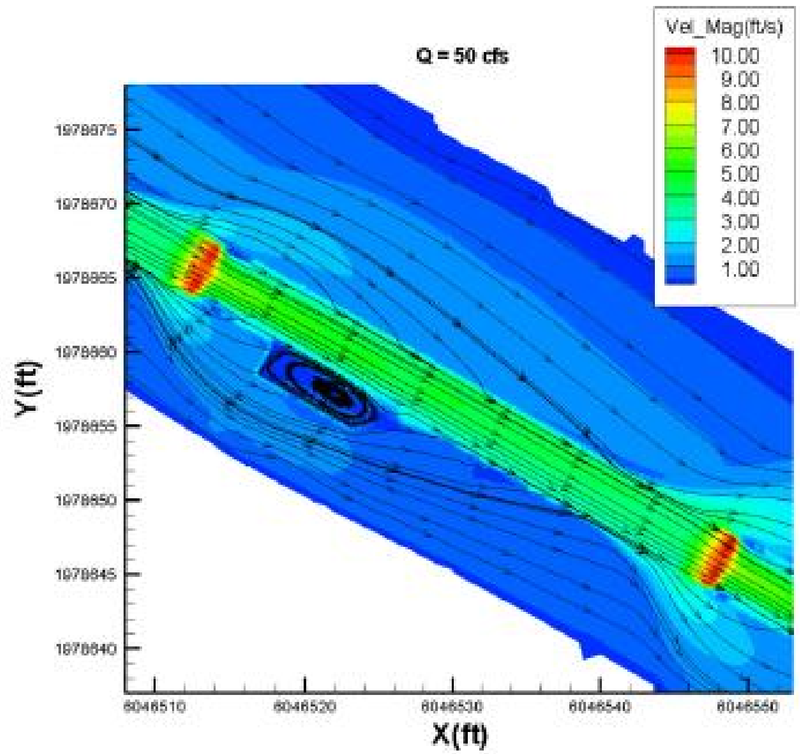
1D, 2D, and 3D CFD hydrodynamic computer modeling used to evaluate hydraulic performance

Fish routing model based on USGS 15-minute flow data, anticipated fish condition, and literature based swimming performance to evaluate fish passage effectiveness

ALTERNATIVE PERFORMANCE EVALUATION

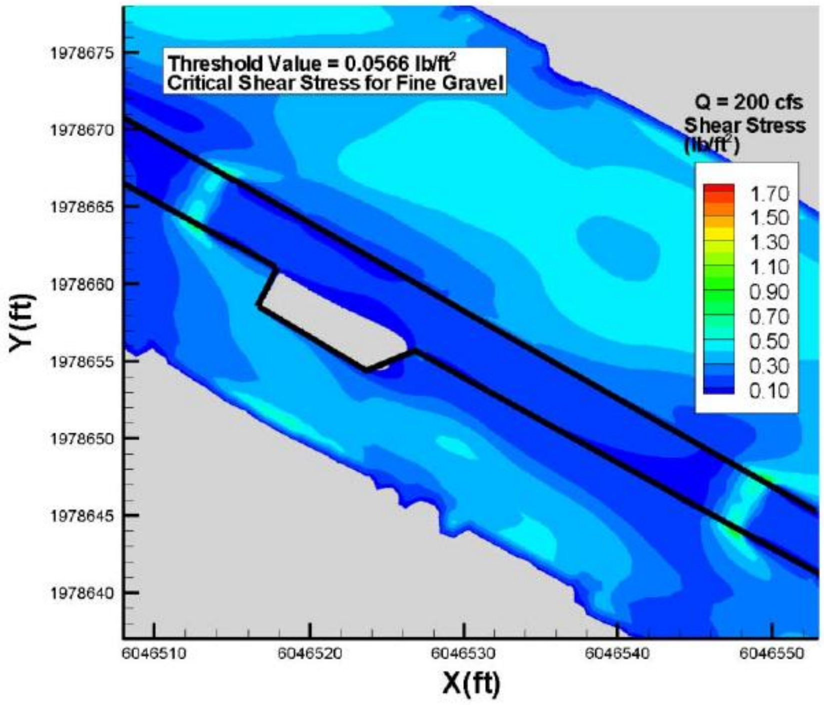


2-Dimensional modeling of recommended alternative



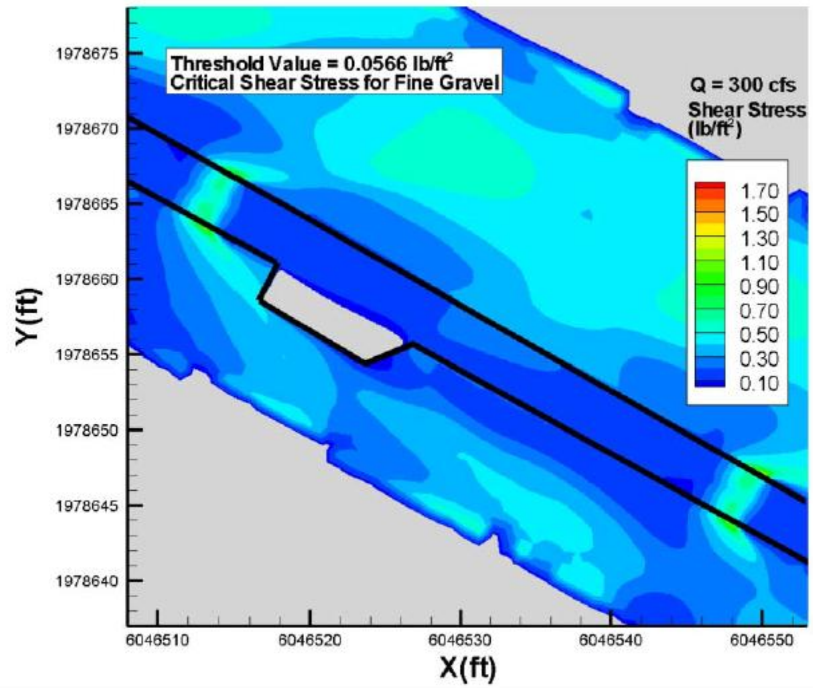
Velocity streamlines at 25 cfs (left) and 50 cfs (right)

ALTERNATIVE PERFORMANCE EVALUATION



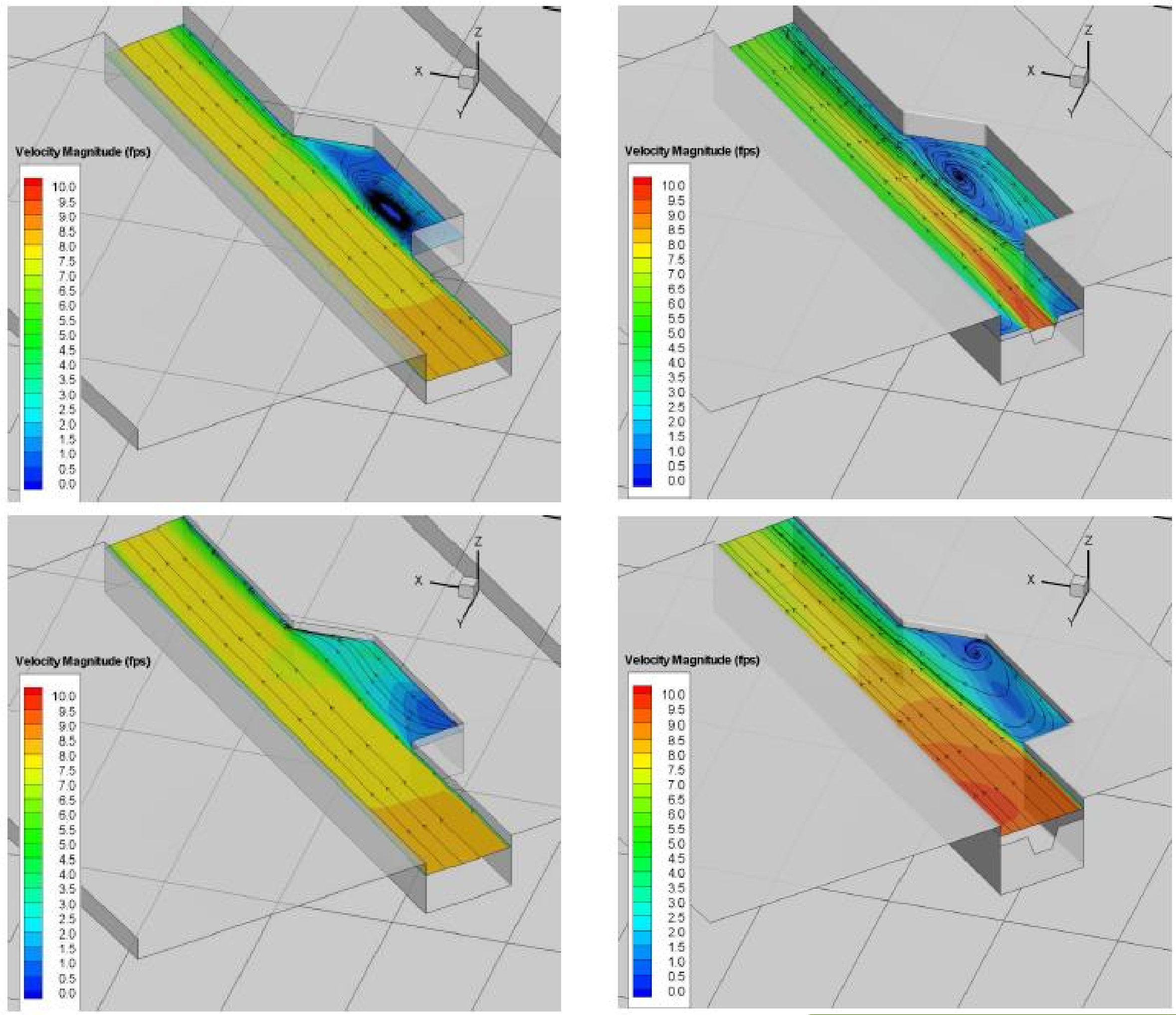
Critical shear exclusion plot for 200 cfs (left) and 300 cfs (right)

2-Dimensional modeling of recommended alternative



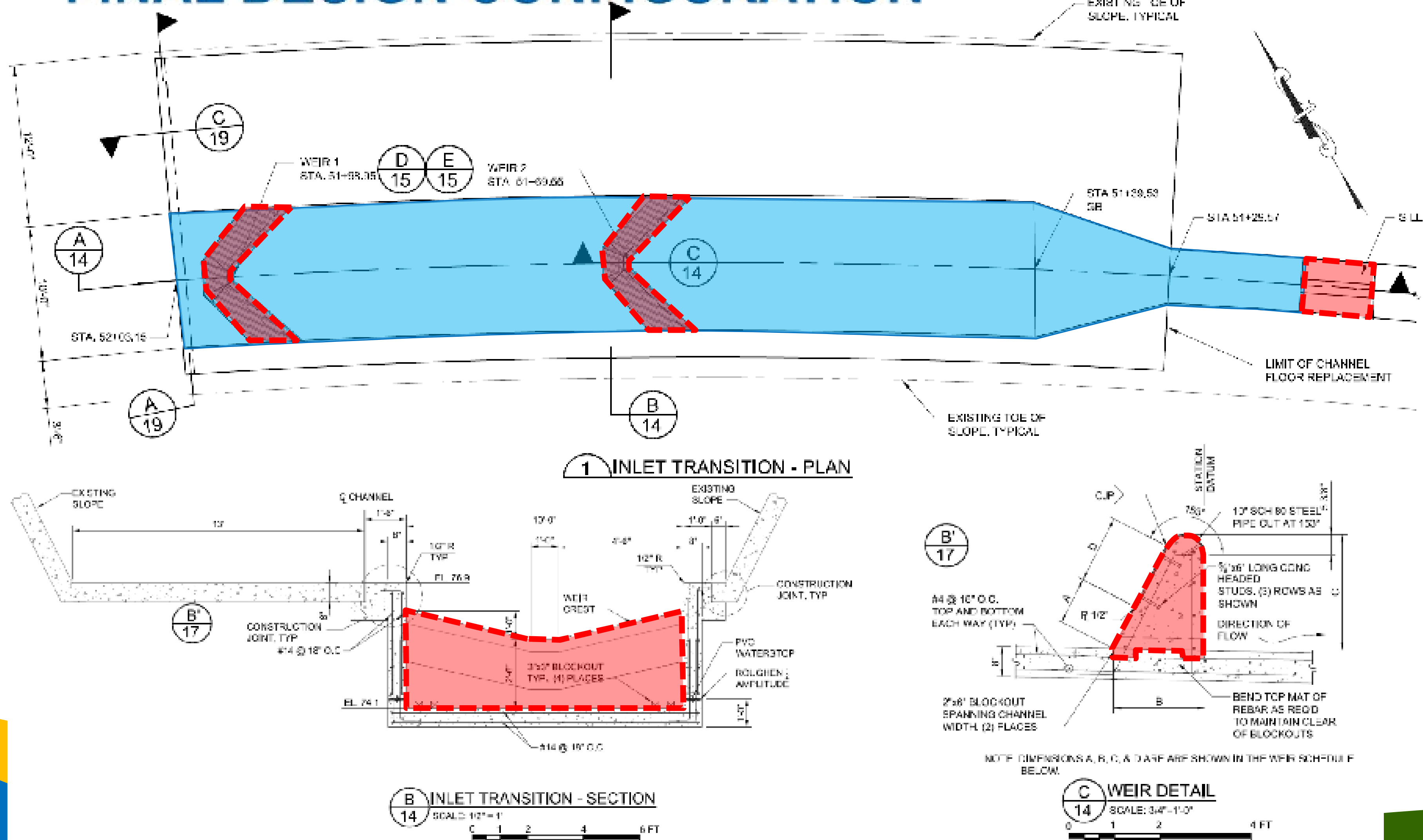
ALTERNATIVE PERFORMANCE EVALUATION

3-Dimensional modeling of recommended alternative.



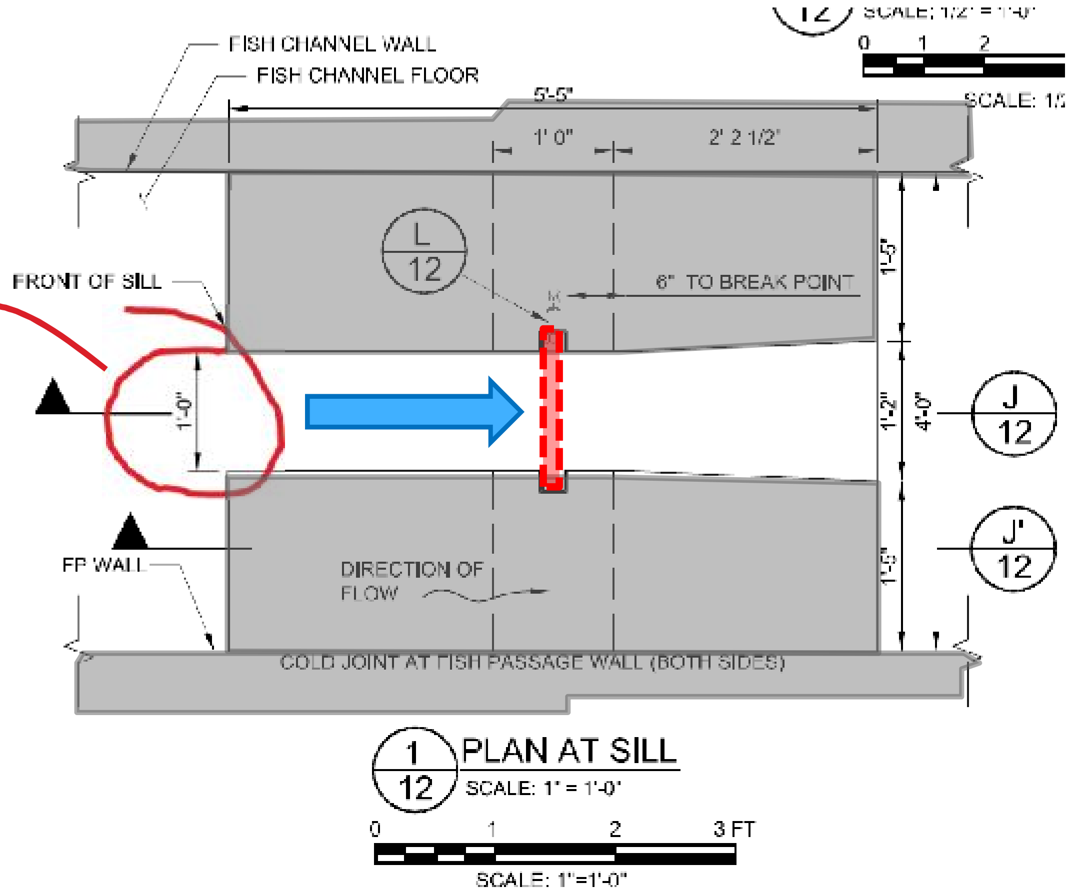
Flow of 100 cfs at four different water column depths.

FINAL DESIGN CONFIGURATION

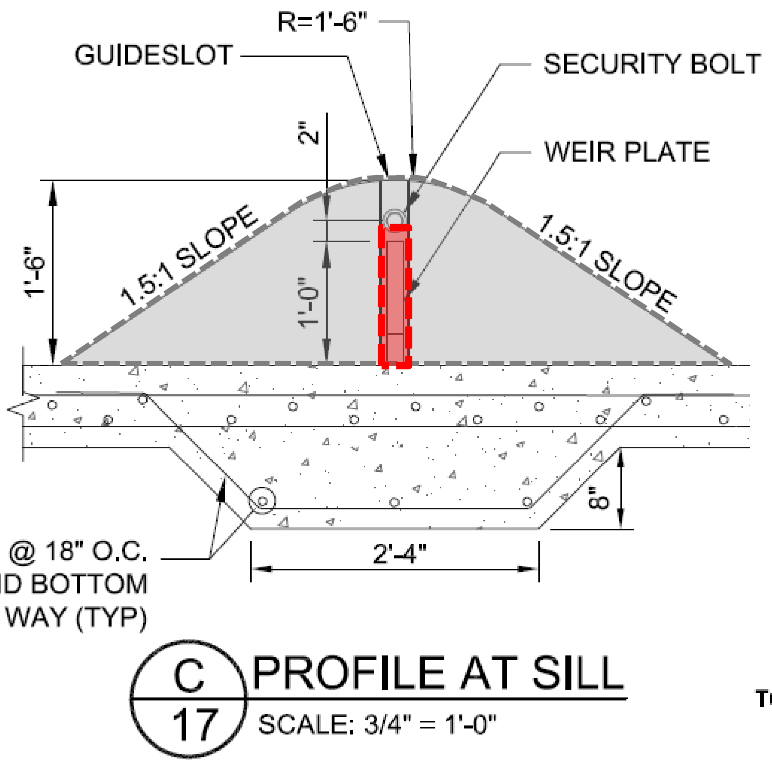


FINAL DESIGN CONFIGURATION

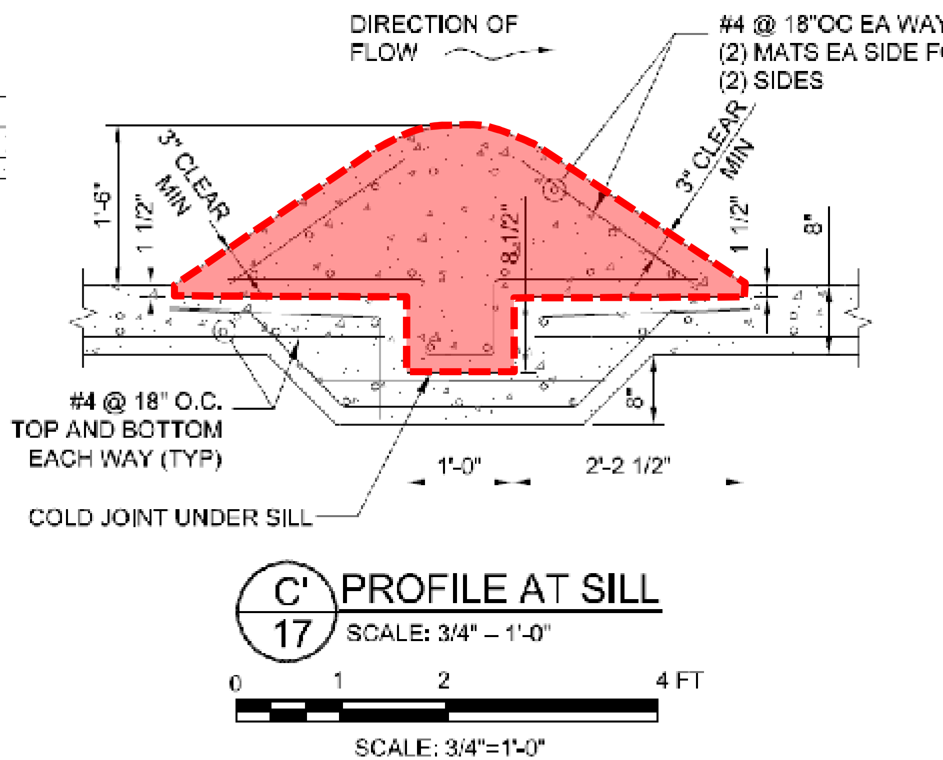
Urban Debris Criteria



FINAL DESIGN CONFIGURATION



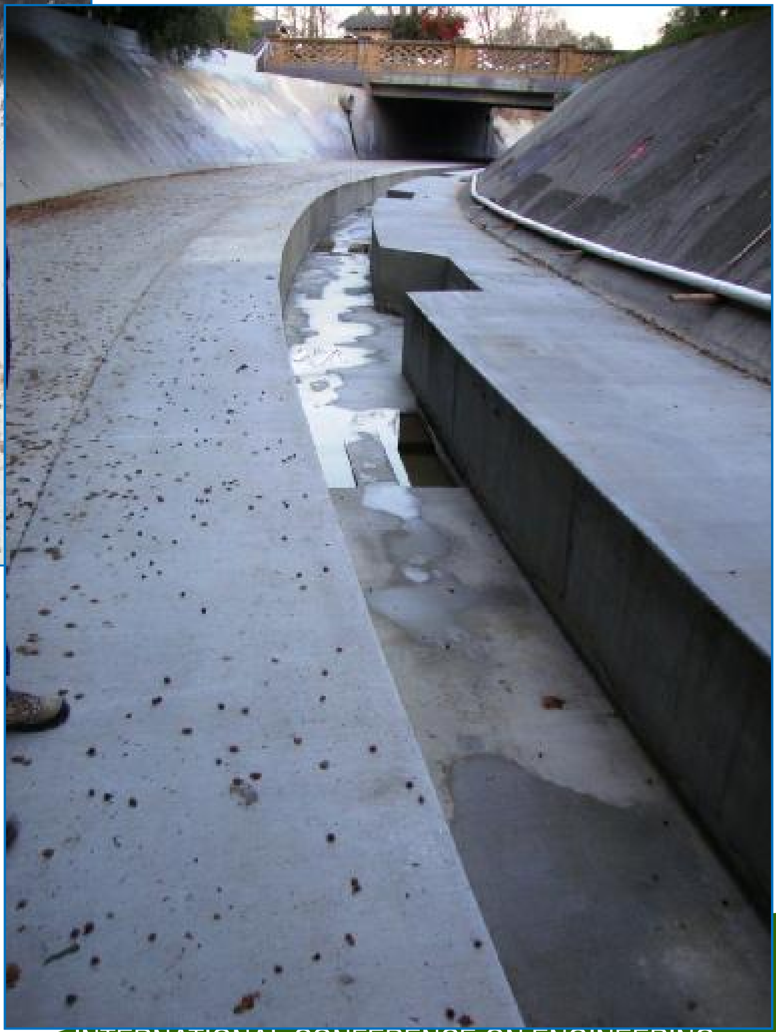
- Semi-removable concrete sills.



CONSTRUCTION

- Phase I (upstream reach)
  - Constructed 2011
  - 1,430 feet (upstream reach)
- Phase II (downstream reach)
  - Constructed 2012
  - 4,150 feet
- Total project length
  - 5,580 feet
- Total construction cost
  - $5M (2013 $US)

CONSTRUCTION



CONSTRUCTION

CONSTRUCTION

CONSTRUCTION

BEFORE

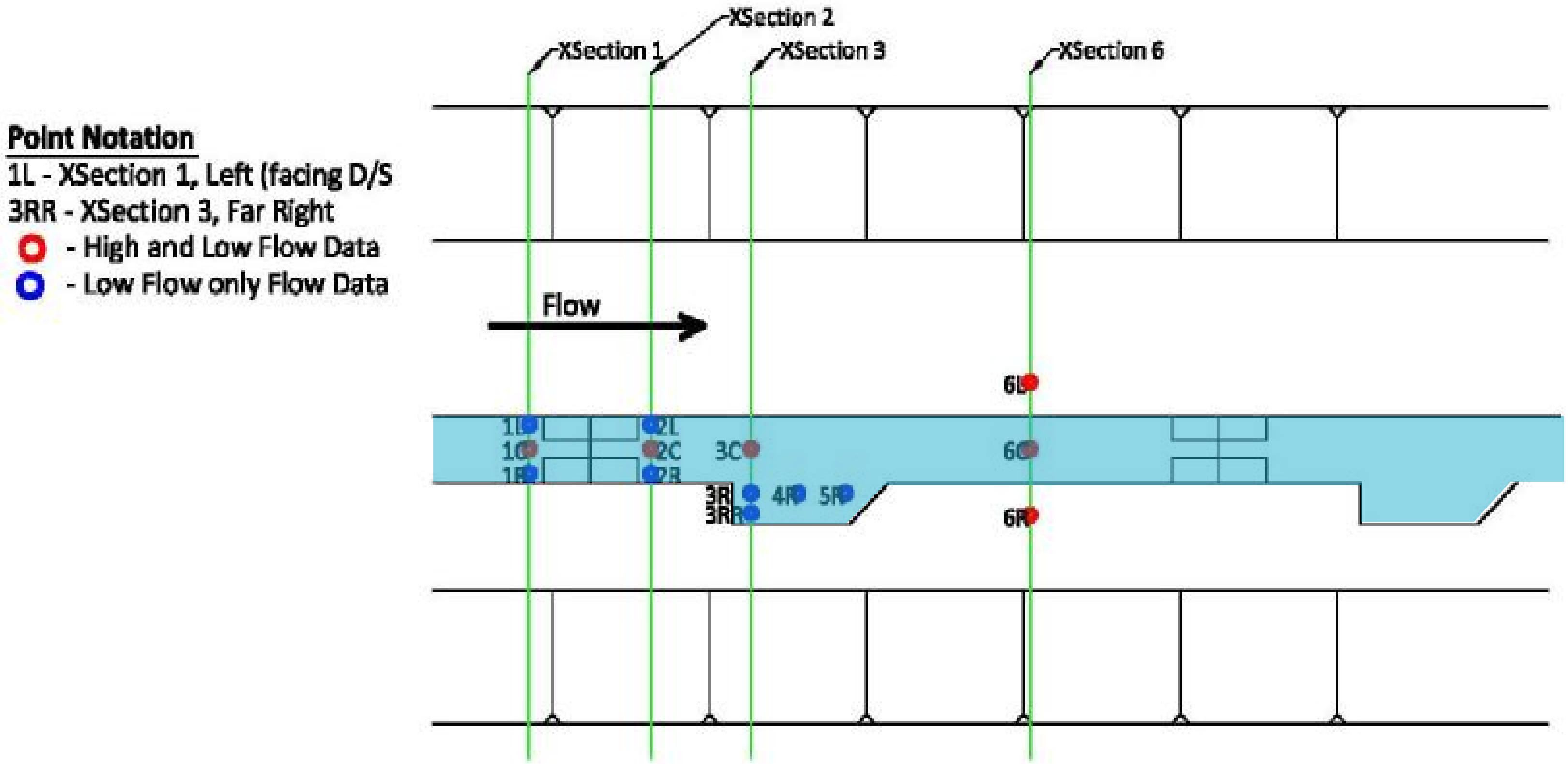
AFTER

2012 - COMPLETED PROJECT

PROJECT MONITORING PROGRAM

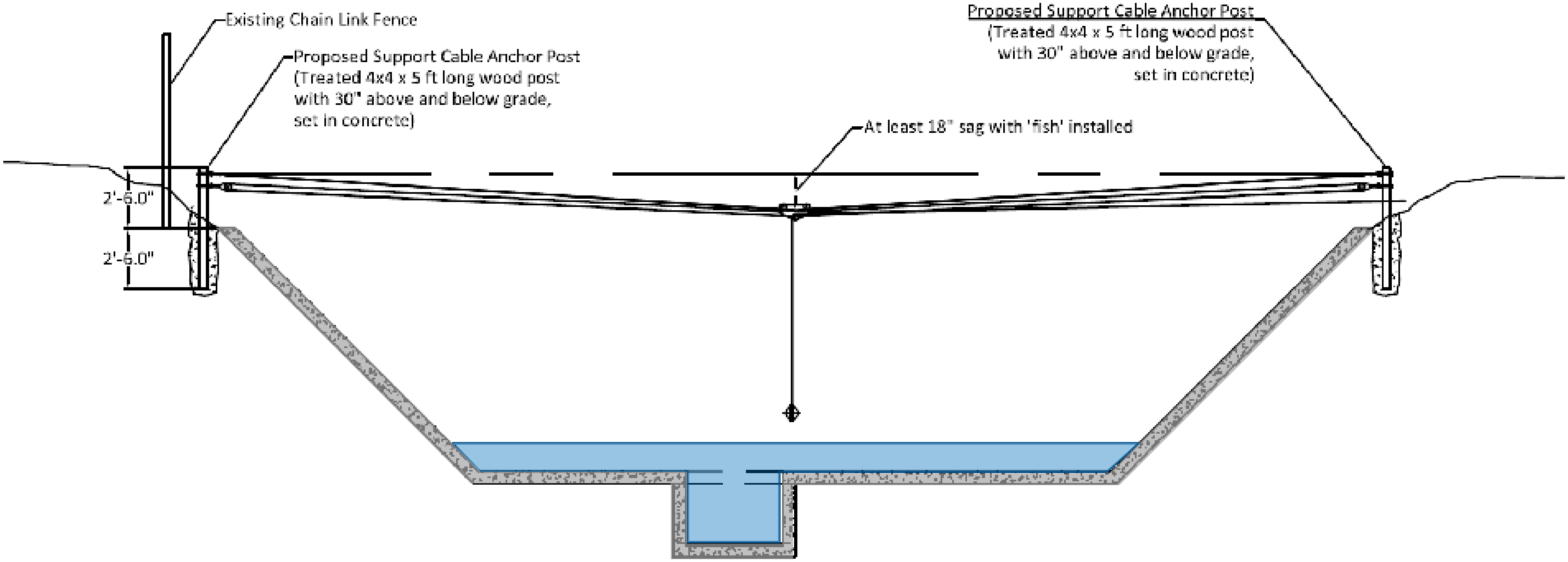
- Storm event based monitoring program
- Observation and photodocumentation
- Flow measurements
  - Low flow events obtained using top-setting rod and velocity meter
  - High flow events obtained using complex system of overhead cables and velocity meter mounted to deployable carriage assembly and weight.

PROJECT MONITORING PROGRAM



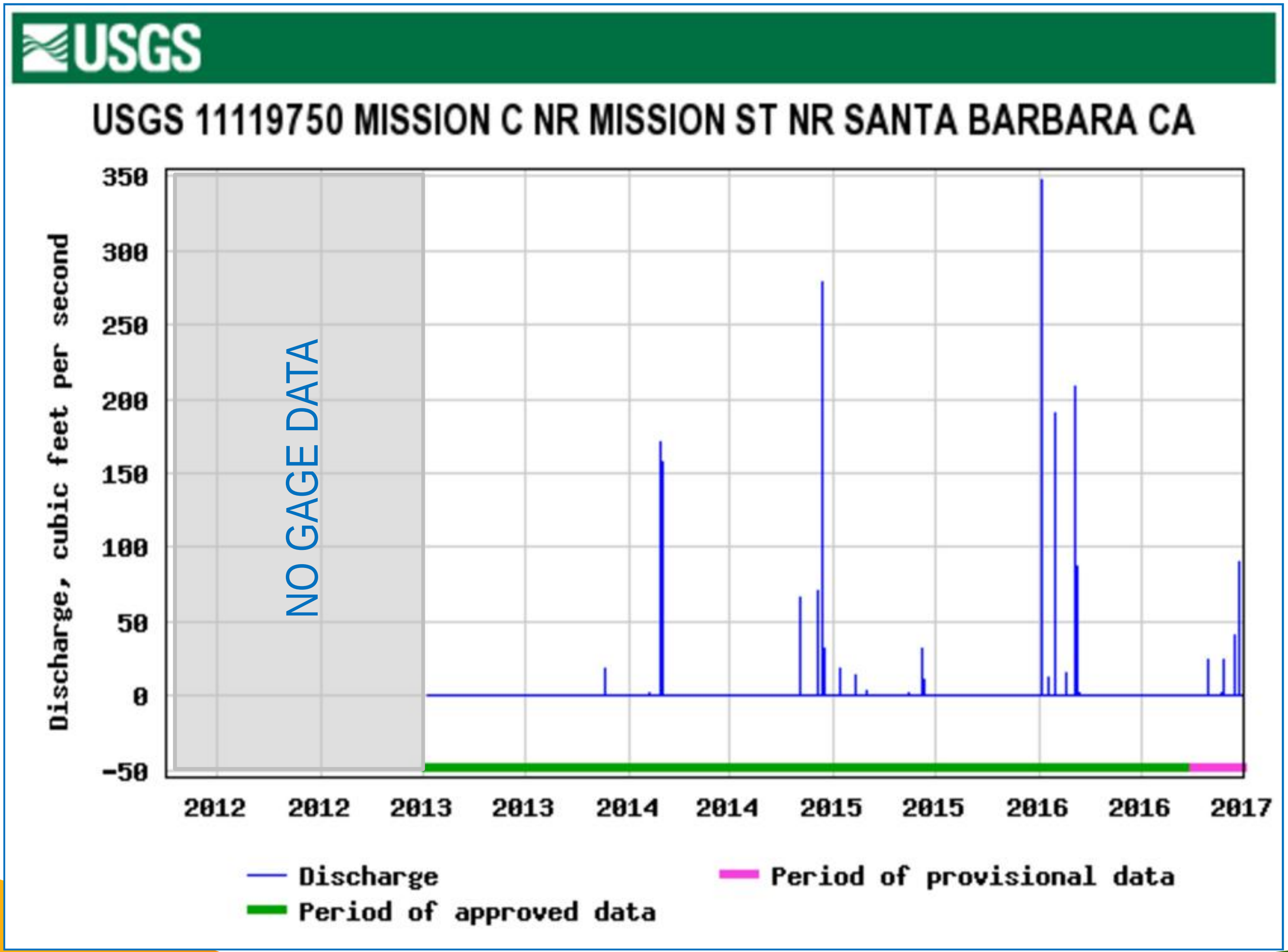
PROJECT MONITORING PROGRAM

- Velocity meter mounted to deployable carriage assembly and weight

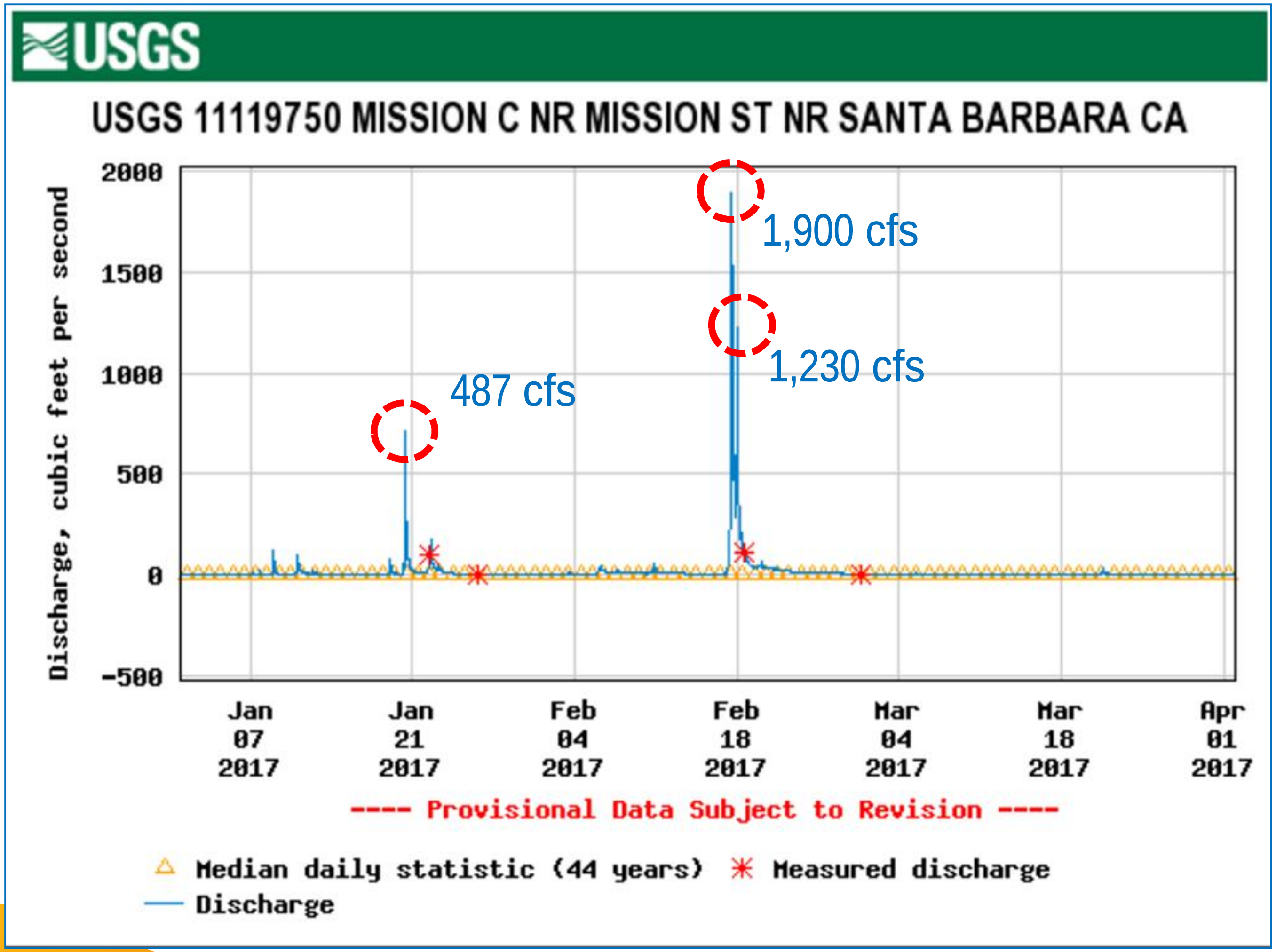


Mission Creek Flood Control Channel

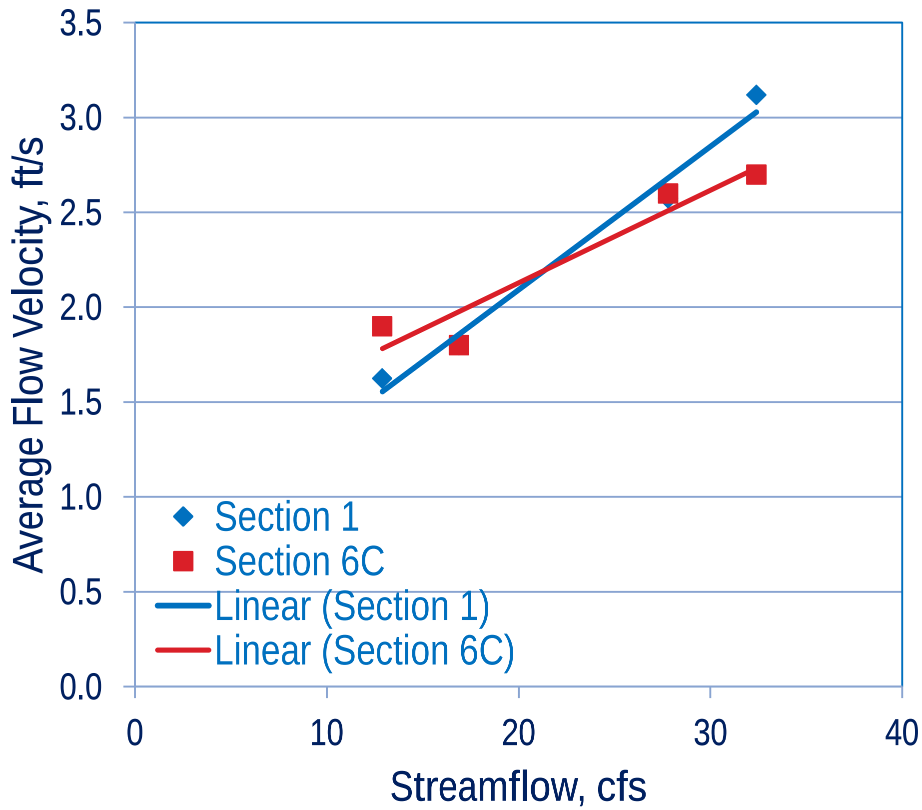
PROJECT MONITORING PROGRAM 2011-2016

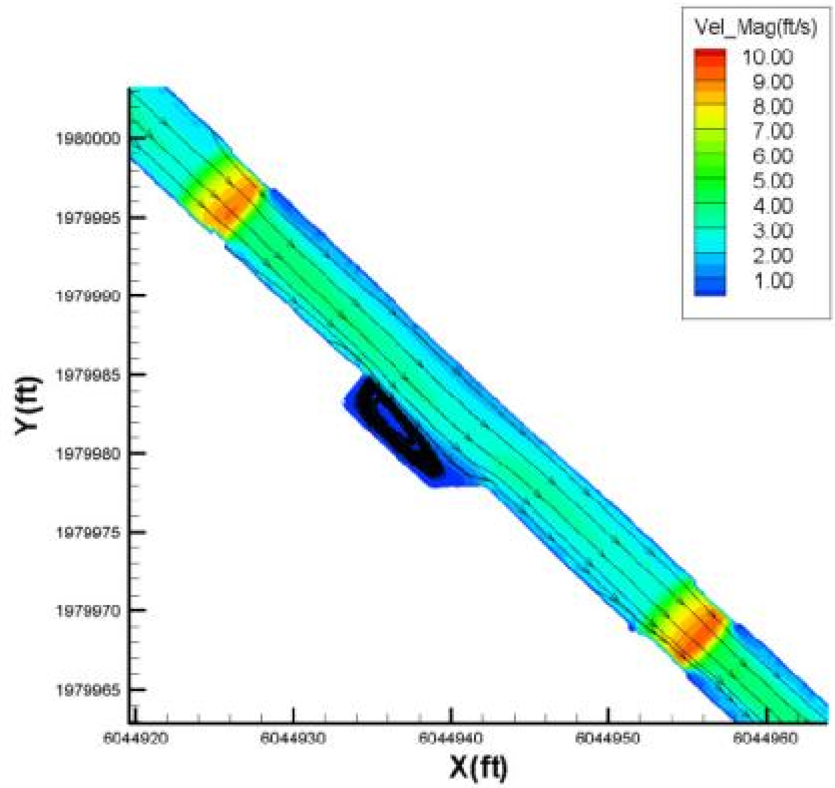


PROJECT MONITORING PROGRAM 2017



MONITORING RESULTS - FLOW

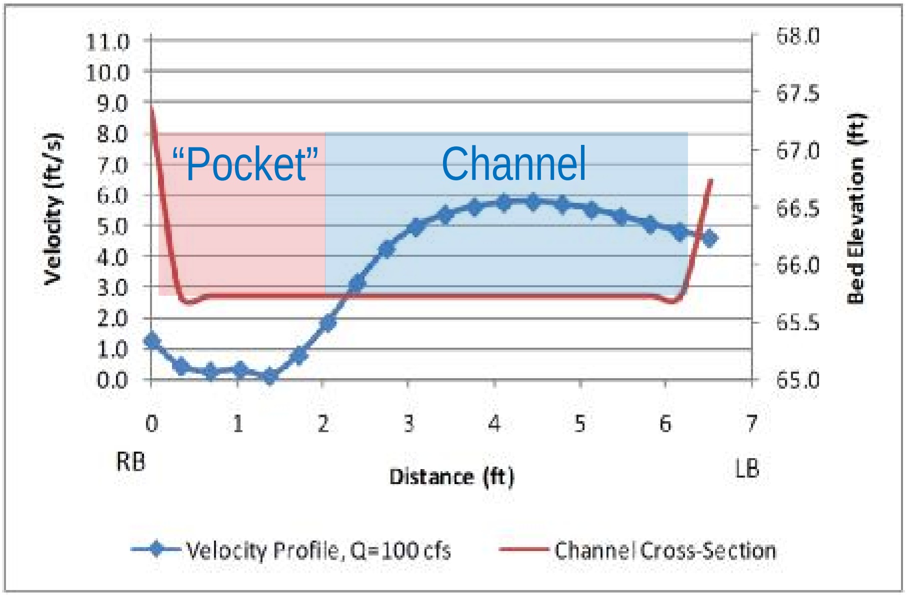




- Measured channel velocities range from 1.6 to 3.1 ft/s at flows ranging from 10 to 35 cfs.

- Anticipated channel velocities range from 2 to 5 ft/s at a flow of 25 cfs.

MONITORING RESULTS - FLOW



Predicted results using 2-D model (HDR, 2010).
Flow 100 cfs
V Channel = 2.0 to 5.9 ft/s
V Pocket = -1 to 1.5 ft/s

Flow Observation 1/20/017
Flow Range 200 - 700 cfs
Time Range 10:00 AM to 12:00 AM
V Channel = 2.7 to 6.7 ft/s
V Pocket = 0.4 to 1.2 ft/s

MONITORING RESULTS - FLOW

2/23/2017, ~12 cfs

3/17/2012, ~35 cfs

MONITORING RESULTS - FLOW

2/17/2017, ~1,000 cfs

2/17/2017, ~600 cfs

MONITORING RESULTS - FLOW

- General observations
  - Velocity in “pockets” ranged from -1.0 ft/s to 1.5 ft/s
  - Velocities in “pockets” appeared to remain low in high flows, however limitations with positioning of measurement device made measurement difficult
  - Concrete channel has greater depth than natural channel, appears more favorable for passage at lower flows.
  - Presence of constructed channel created a low velocity pocket and velocity shear at flows that fully inundated the channel suggesting that passage may be achievable at flows higher than targeted fish passage flows

MONITORING RESULTS - SEDIMENT

- Low-flow observations (Q<100 cfs)
  - Small accumulations of sands and gravels
  - More effort to remove urban debris than sediment

MONITORING RESULTS - SEDIMENT

- Low-flow observations cont.

MONIORING RESULTS – SEDIMENT

- High flow observations (Q>1,500 cfs)
  - No sands and gravels – small particles sizes evacuated from the channel
  - Larger proportion of boulders and large cobbles
  - Accumulation of cobbles and boulders at sills near upstream extent of both Phase I and II reaches – not significant enough to influence passage
  - Additional accumulations appeared at locations were there were apparent additions of flow from stormwater outfalls or changes in cross-sectional geometry

MONITORING RESULTS – SEDIMENT

MONITORING RESULTS - SEDIMENT

MONITORING RESULTS - LIMITATIONS

- Strong currents created difficulty with placing fish in desired location/depth
- Storm peaks generally occur in the early hours of the morning
- Instrumentation was limited to deployment of conventional electromagnetic device on a weighted “fish.” ADCP would likely have been more effective and data rich.

MONITORING RESULTS - LIMITATIONS

CONCLUSIONS - MAINTENANCE

- City anticipated $10,000 per year to accommodate sediment removal after episodic events
- Limited efforts <$10,000 were required during initial years with lower flows
- Maintenance effort after high flows was different in scope, but level of effort was reasonably the same as other low flow years
- Bedload accumulations were left at sills that did not appear to influence fish passage at target low flow rates

CONCLUSIONS – FISH PASSAGE

- Red surveys performed weekly throughout rainy period
- No steelhead were detected upstream of the flood control channels
- For perspective - 5 total fish identified in the conception coast sub-region of the Southern California DPS – the population itself is heavily impacted
- We would like to believe that the absence of evidence is not evidence
- Successful passage TBD through future monitoring

LESSONS LEARNED

- Detailed model development can be used to enumerate potential variability, inform alternative refinement, and decrease uncertainty
- Prototype designs require more rigorous monitoring efforts to verify in the field. Funding and a project steward are a key to success
- Concept may be applicable to other sites, but as with all fish passage projects, there should always be careful consideration of site specific variables

THANK YOU!