The Final Phase of San Clemente Dam – Removal and Stream Restoration

Godwin, W. , Waeber, J. , Wade, D, and McGowan, W

Annual Meeting, Association of Environmental & Engineering Geologists– Kona, Hawaii

September 21, 2016 Technical Session #1

Presented By:

William Godwin, P.G., C.E.G.

KLEINFELDER
Bright People. Right Solutions.

Outline

- Project Location and History
- Project Overview
- Geology
- Final Design Elements
- Final Construction Phases
- Dam Removal(s)
- Instrumentation and Monitoring
- Questions

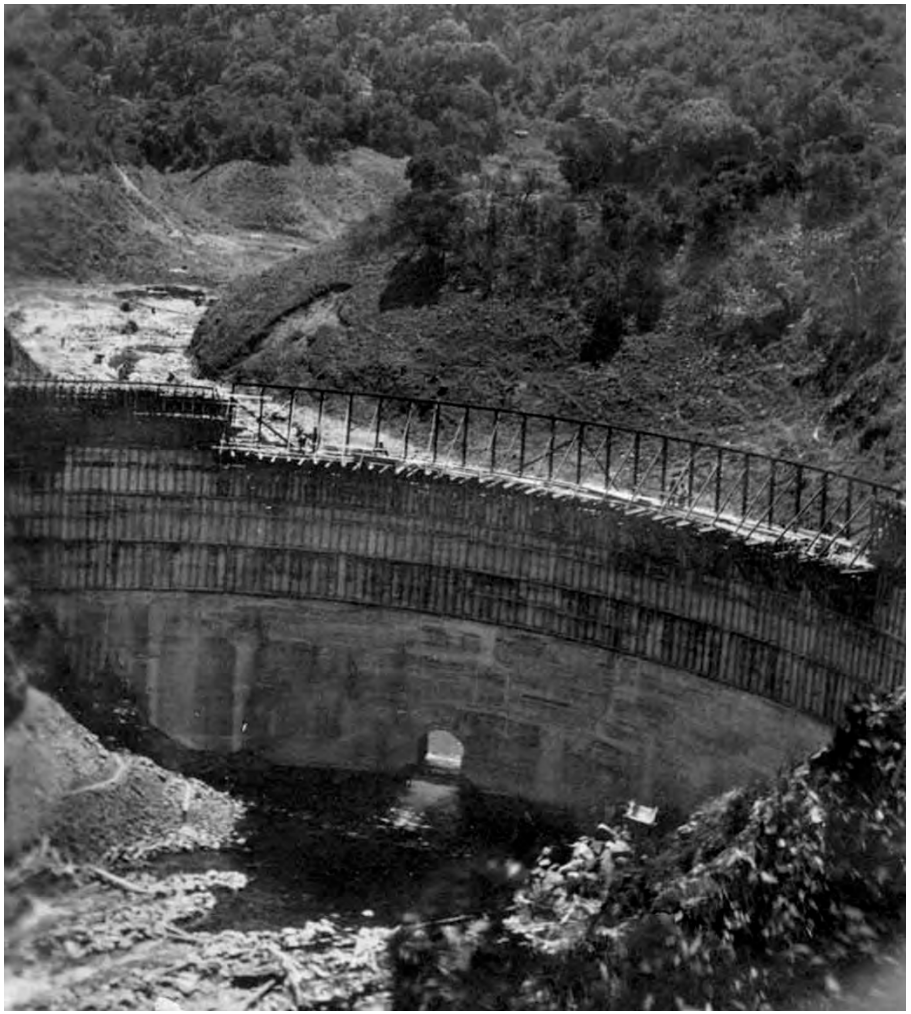
Project Location

History of San Clemente Dam

- Constructed between 1920 & 1921 by PIC
- Owned and operated by California American Water
- Built for drinking water storage for Monterey Peninsula
- Fish ladder added later

History of San Clemente Dam

- Built in V-notch canyon below confluence of San Clemente Creek and Carmel River
- Concrete arch dam
  - 106 feet high
  - 300 foot width
  - 1425 acre-feet – now 70 acre-feet
  - Over 2.5 million cubic yards of sediment

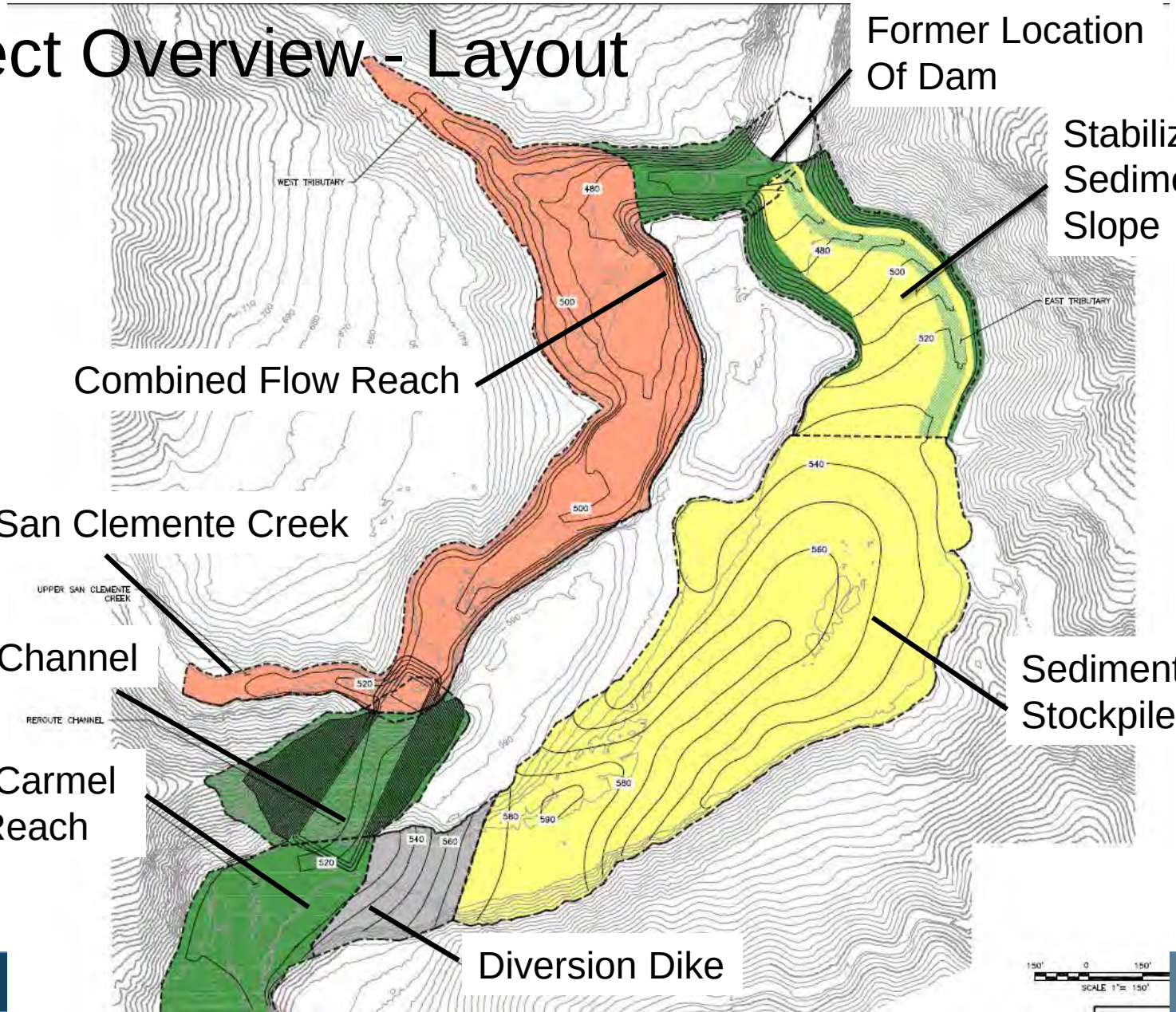


Project Overview

Project Overview

- 1990's CDWR – DSOD issued safety order
- Potential failure during MCE (7.0M Tularcitos fault) or PMF
- 2006 released a draft EIS
- EIR Alternatives:
  - Dam Strengthening ($50M)
  - Dam Removal
- 2008 CAW – preferred removal of the dam. Benefits: fish access, sediment replenishment, removal of hazard
- Previous investigations by URS, MWH, Woodward-Clyde and Kleinfelder
  - URS provided an indicative design

Project Overview - Layout



Project Overview – Key Stakeholders

- $83M cost
- Funding: California American Water
- California Department of Fish & Wildlife
- California Natural Resources Agency
- California Wildlife Conservation Board
- California State Coastal Conservancy
- National Marine Fisheries Service – NOAA
- Resources Legacy Fund
- The Nature Conservancy
- United States Fish & Wildlife Service

Project Overview – Project Team/Schedule

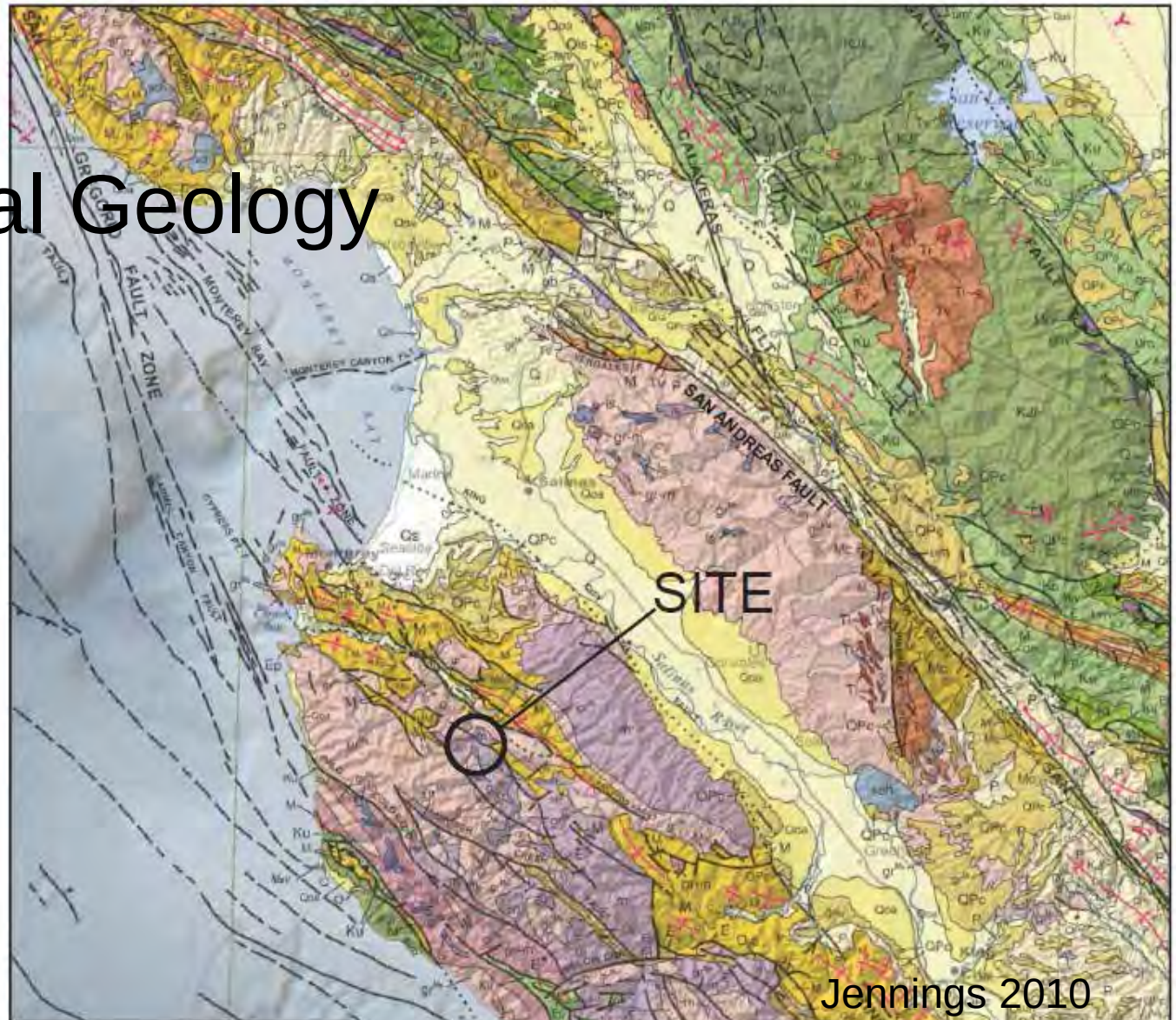
- Granite Construction – General Contractor
- Kleinfelder – Engineer of Record (EOR) and lead Civil/Geotechnical designer
- Tetra Tech – H/H modeler, Channel Restoration design
- Rana Creek, Habitat Restoration

Oversight

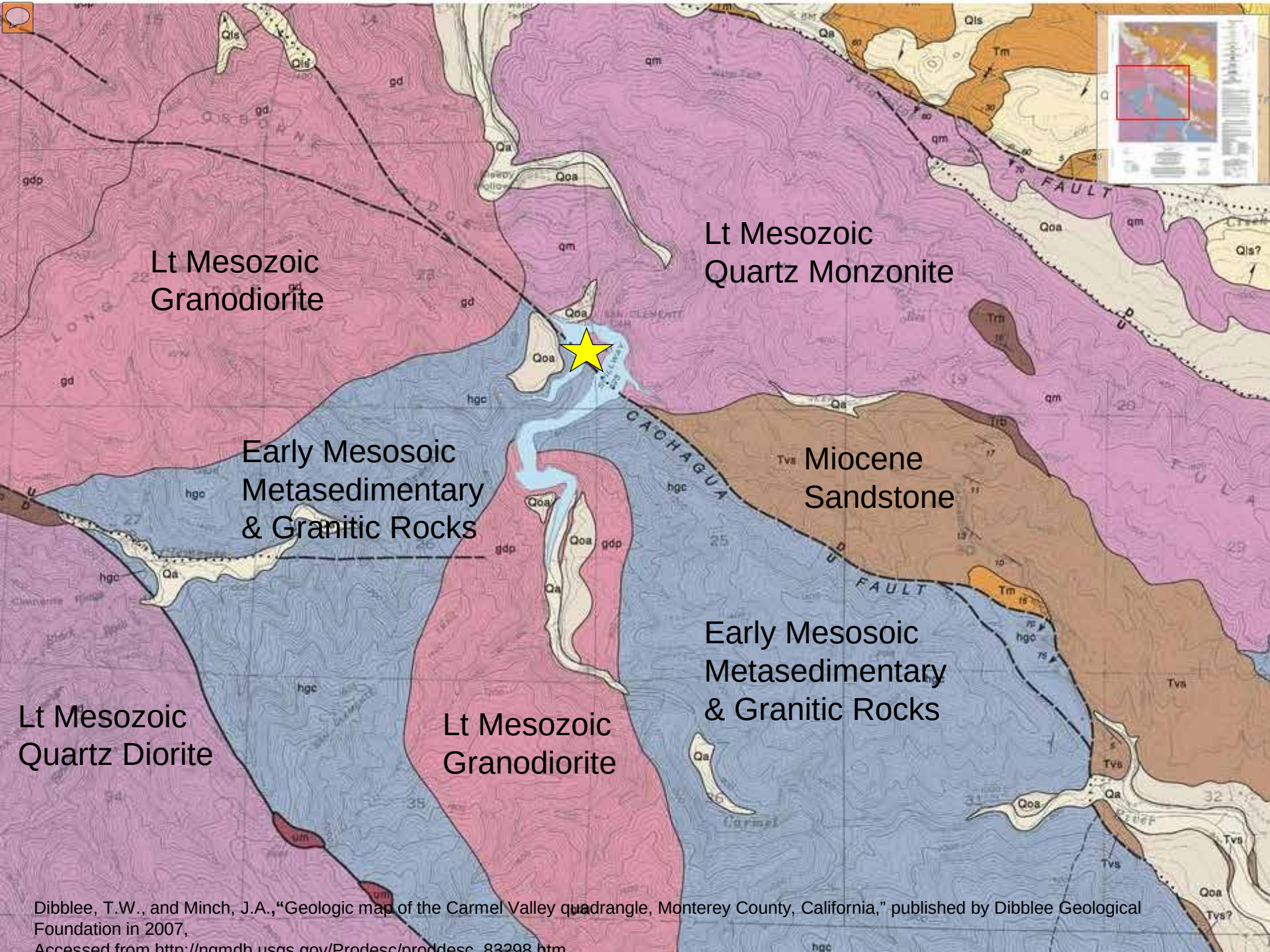
- AECOM – Owners Engineer
- WSC – Construction Mgr.

- **2013 Season:** Geotechnical Investigation, initial diversion structures, overall design
- **2014 Season:** Reroute Cut, Diversion Dike, Sediment Stockpile, design/construct
- **2015 Season:** Stabilized Sediment Slope, dam removal, CFR channel design/construct

Regional Geology

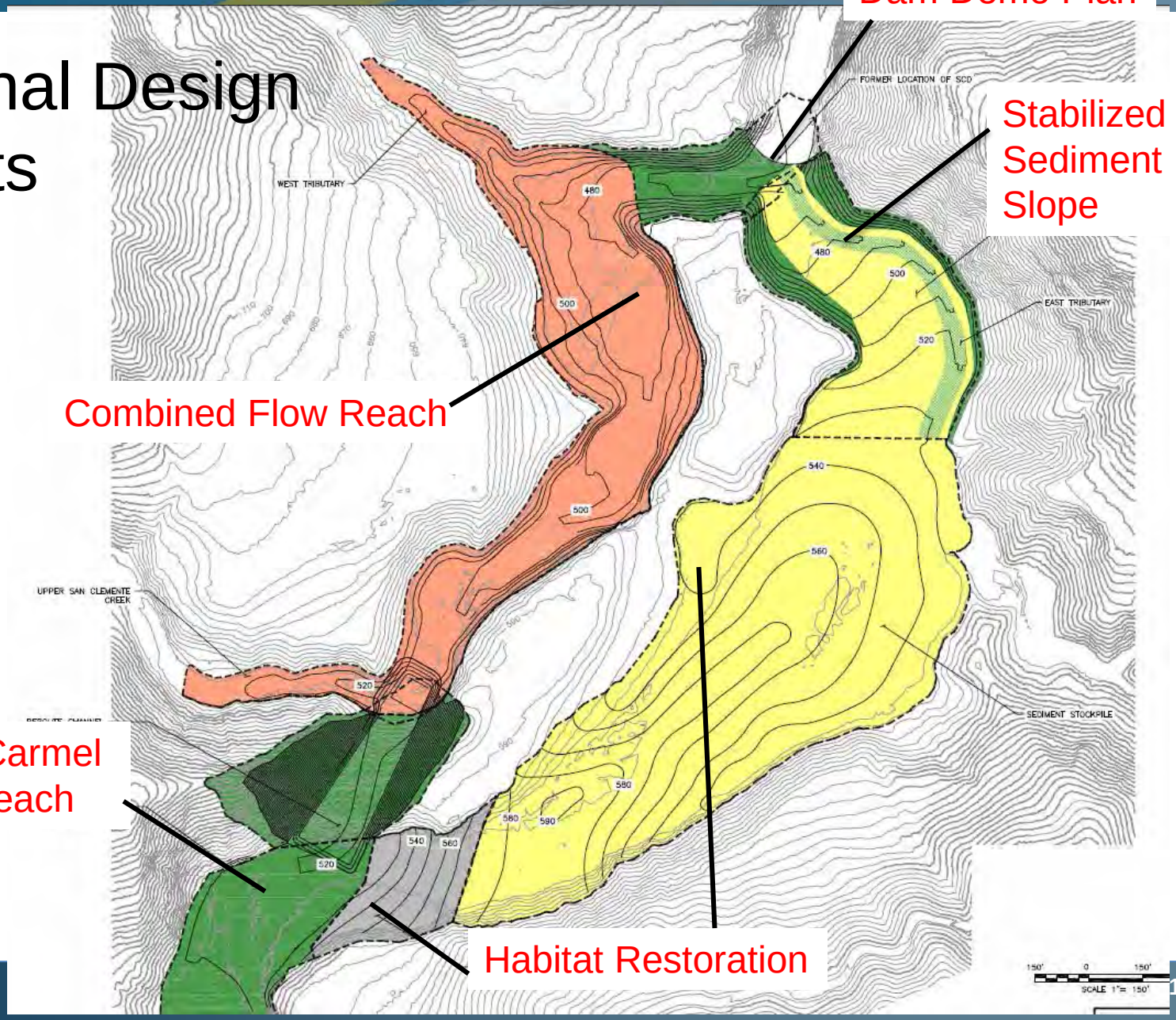


Jennings 2010

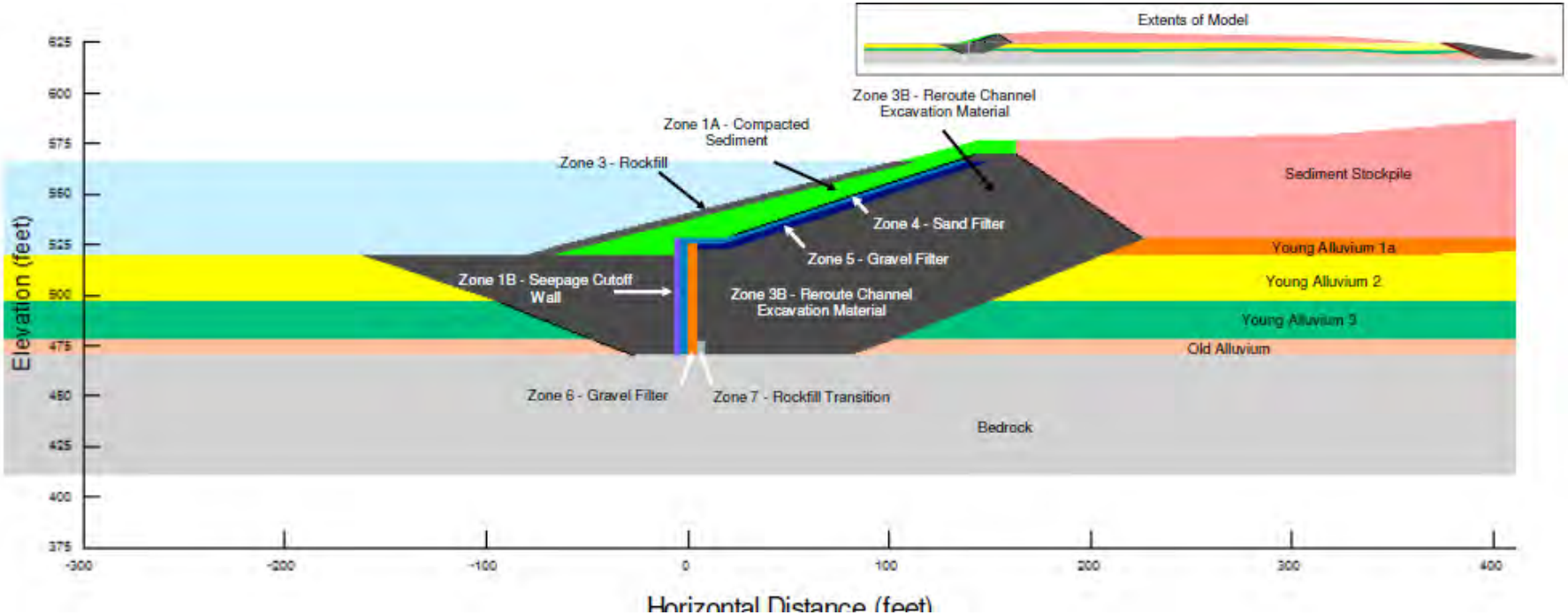


Dibblee, T.W., and Minch, J.A.,"Geologic map of the Carmel Valley quadrangle, Monterey County, California," published by Dibblee Geological Foundation in 2007,
Accessed from http://ngmdb.usgs.gov/Prodesc/proddesc_83298.htm

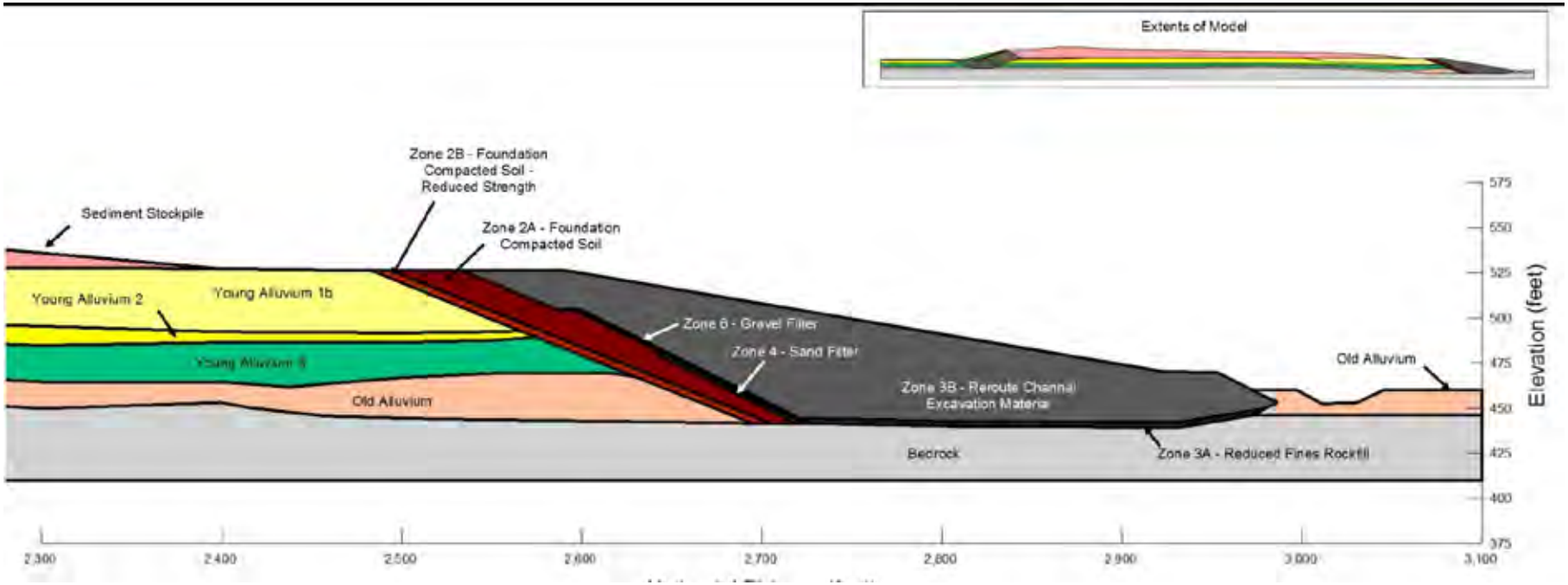
2015 Final Design Elements



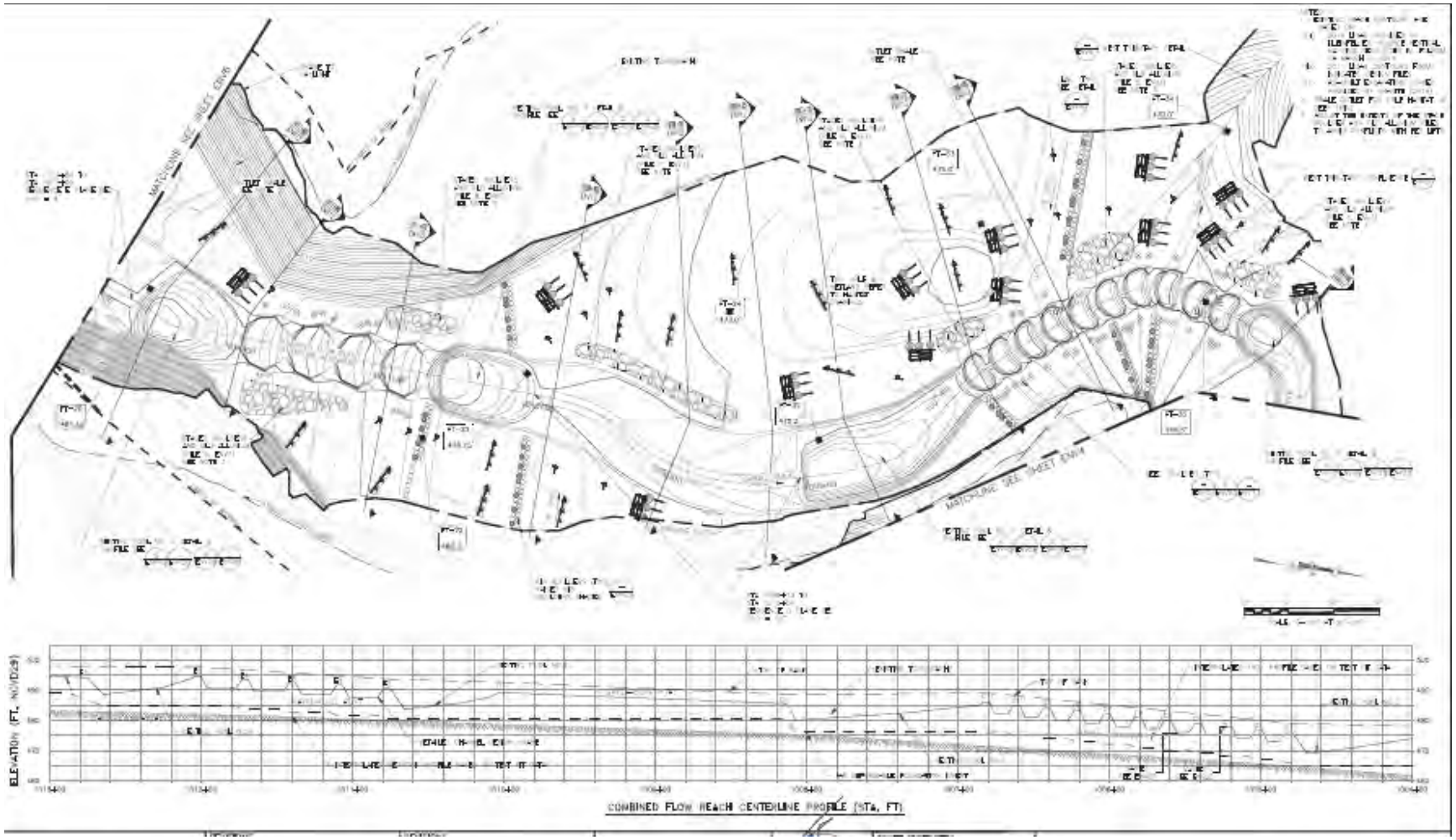
Diversion Dike (DD) Design



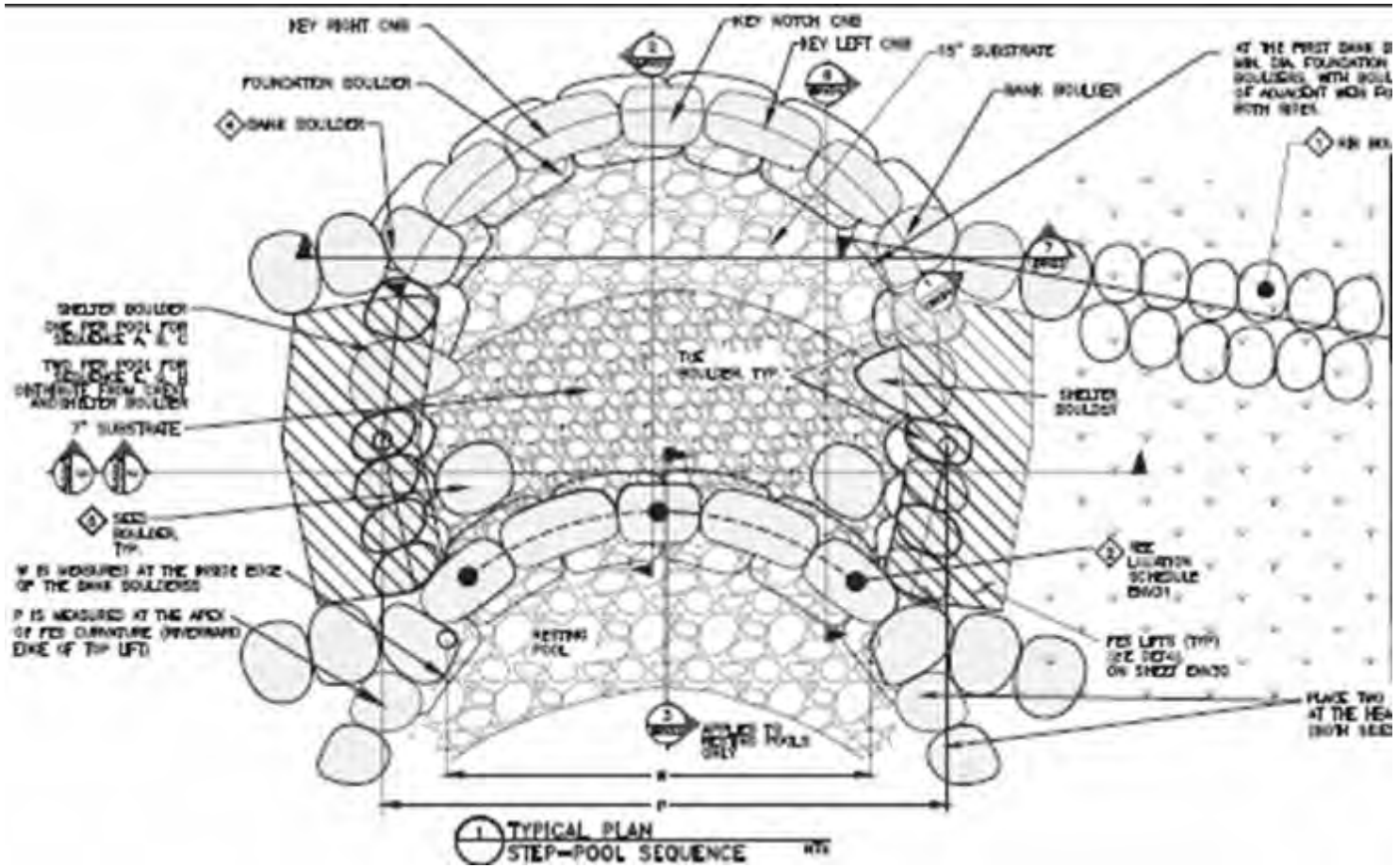
Stabilized Sediment Slope (SSS) Design



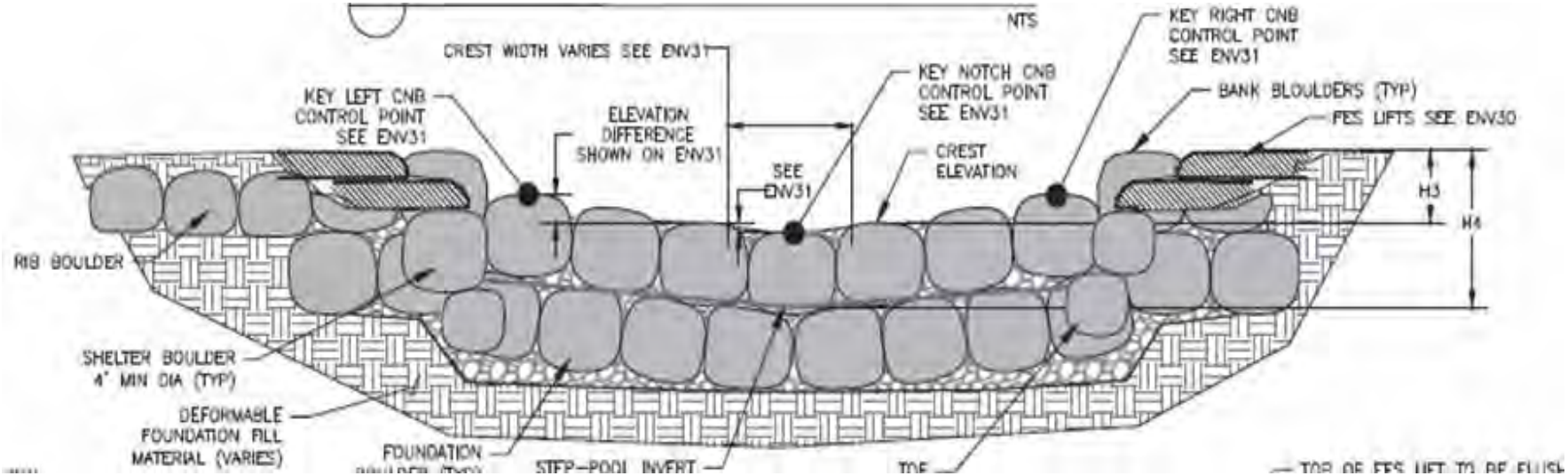
Combined Flow Reach (CFR) Design



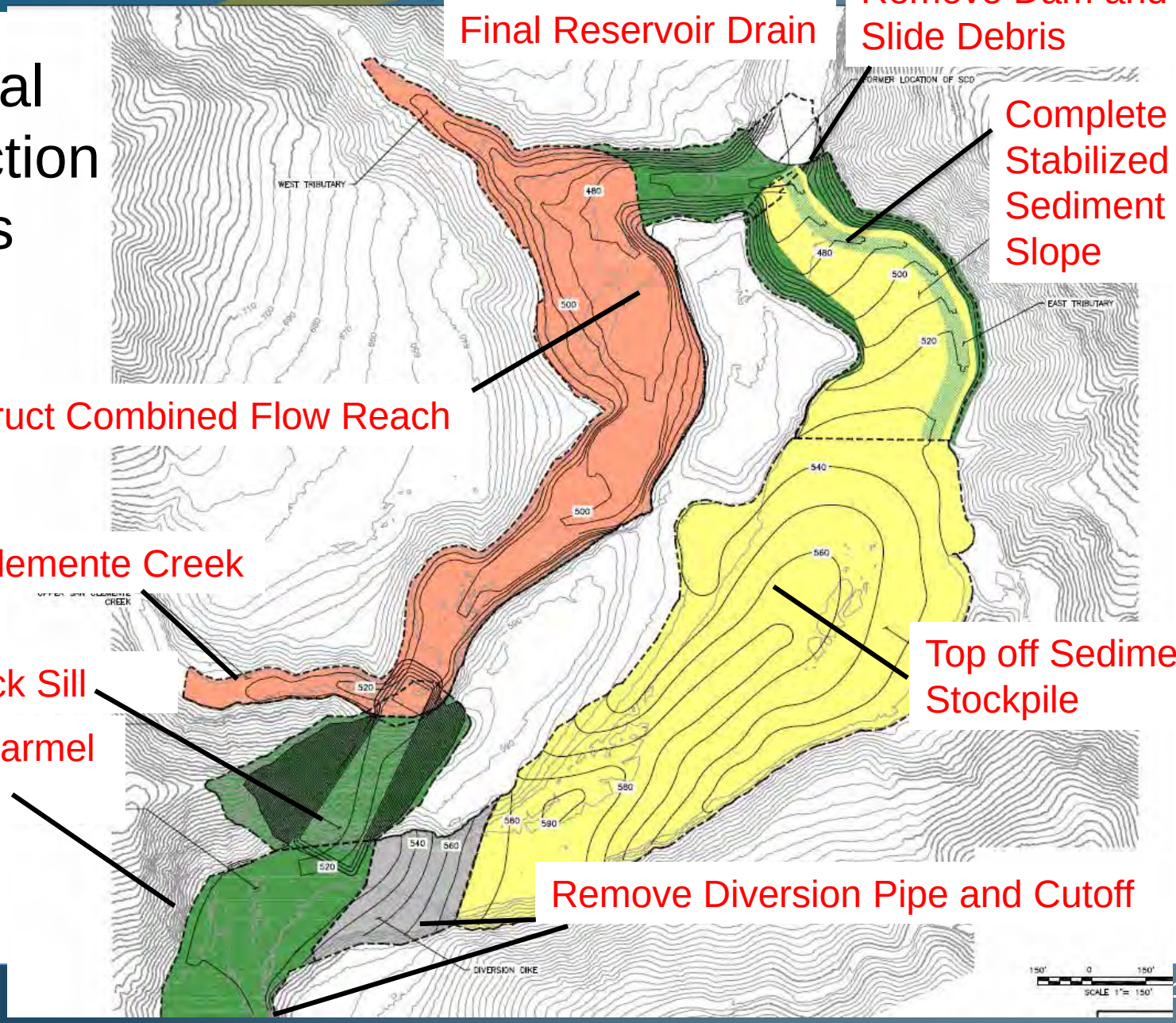
CFR Design – Step Pool Plan



CFR Design - Step Pool Elevation



2015 Final Construction Elements



Construction – Christmas Slide/pipe repair

Dec. 2014 landslide; Mar. 2015 debris removal and pipe repair

June 2015 right abutment and diversion pipe

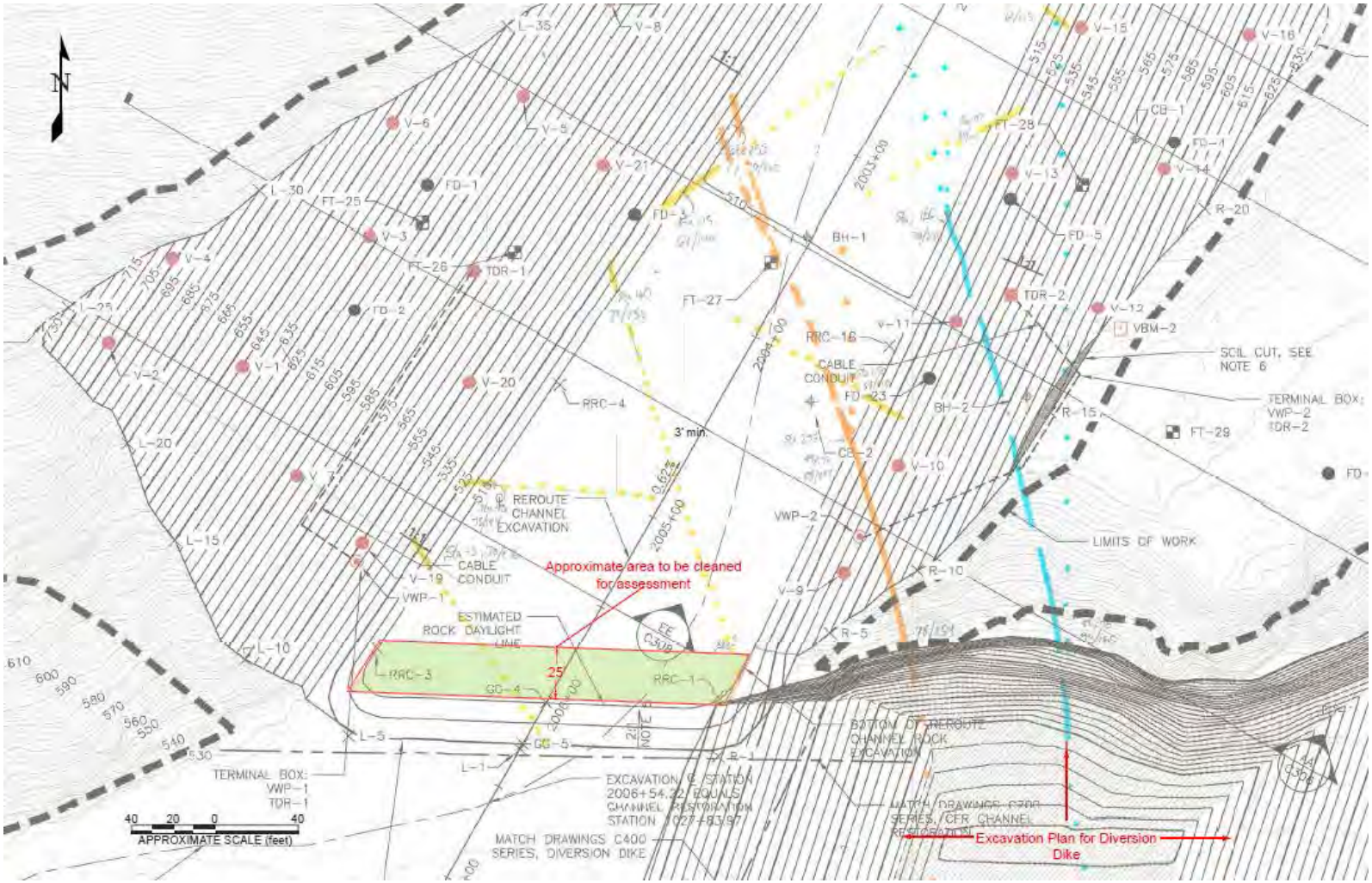
Construction – Reservoir Dewatering

Construction - Diversion Dike (DD)

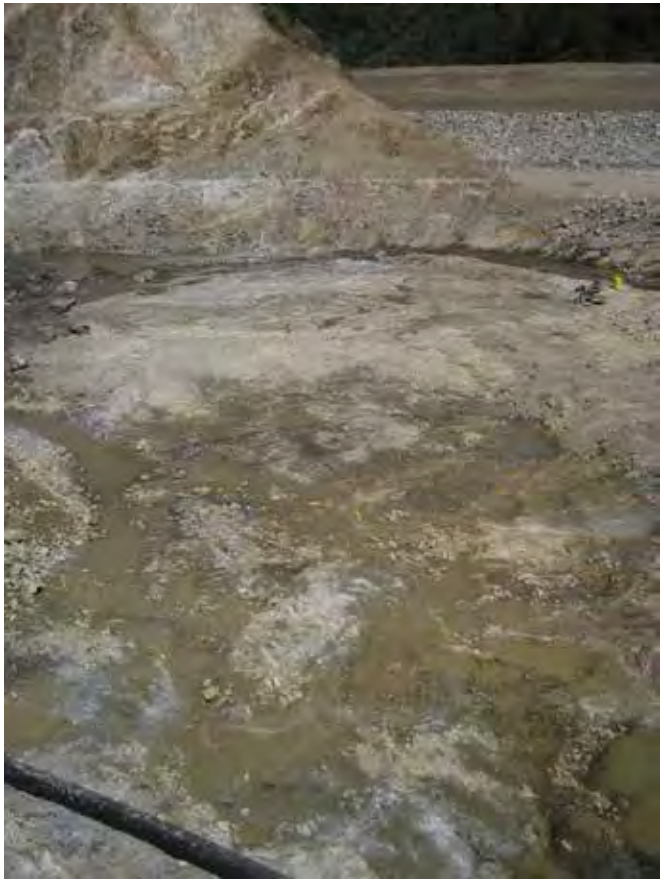
October 2014 view NE

October 2015 view SW

Construction – Reroute Channel Rock Sill



Construction – Reroute Channel Rock Sill



Construction – SSS foundation mapping

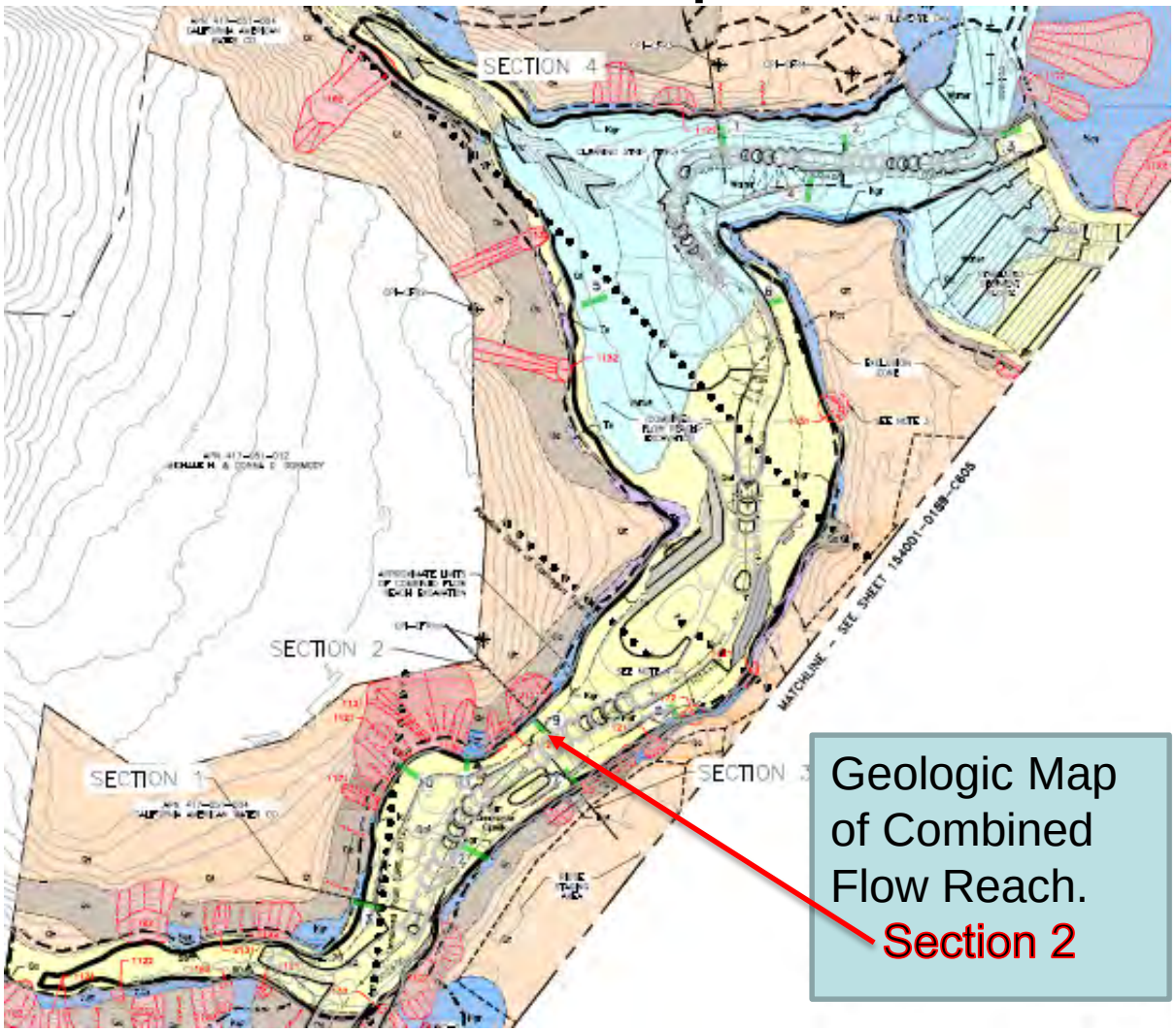
Toe of SSS

Transition beneath SSS

Construction – Geologic Strip Mapping

Potential for catastrophic landsliding and stream blockage

Evaluation – Catastrophic Landslide Risk



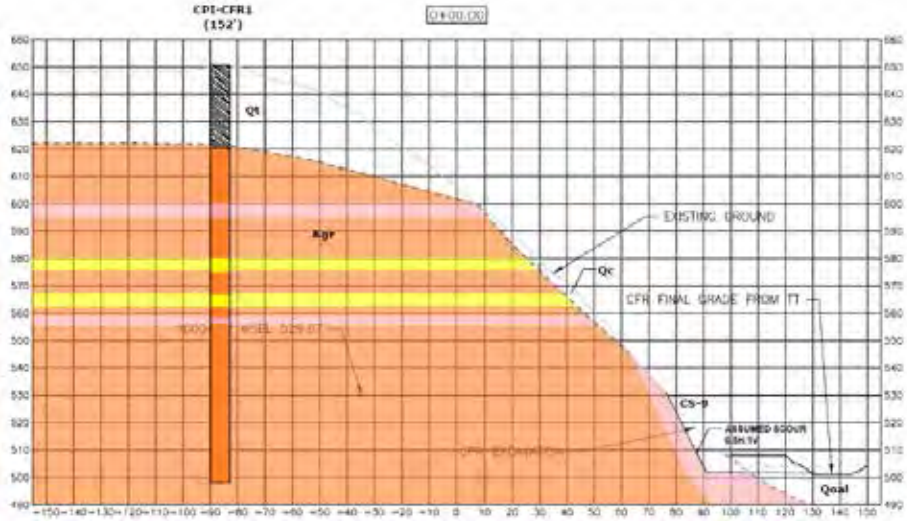
Geologic Map of Combined Flow Reach.
Section 2

Evaluation – Catastrophic Landslide Risk

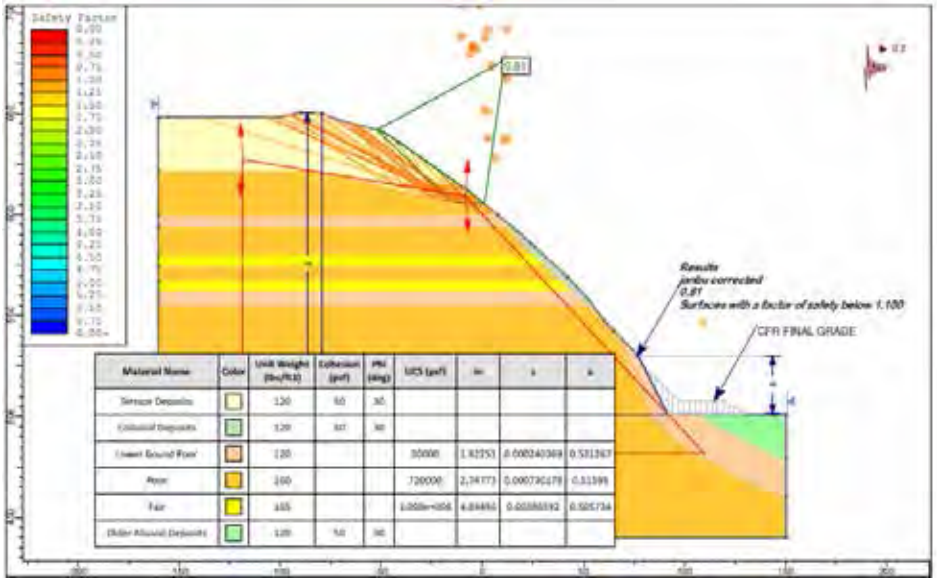
- Failure of CFR valley ways leading to stream blockage due to runout.
- Evaluation Methodology:
  - Inputs:
    - Geologic data (borehole, strip mapping, GSI, RMR)
    - Scour Analysis (1000 flood event WSE, Erodibility Index K)
    - Slope Stability (K_h = 0.2 (1/2 of pga)
  - Analysis: Scour by Annandale (1995) of Required Stream Power vs K; Rock Mass Erodibility Index; Limit Equilibrium method for Slope Stability

Evaluation – Catastrophic Landslide Risk

Geomechanical Model, Section 2



Pseudostatic Analysis, Section 2



(De) construction – dam removal

Upstream Ramp and use Pneumatic hammer

Recycle rebar, bury concrete in SSS

Sigh…..No Explosives

(De) construction – DSOD Concerns

Left Abutment Rockfall

Right Abutment Stability

Boulders for CFR Pools - Material Testing

"Drop Test" at various quarries to measure durability.

Eventually used mostly concretions from two quarries in Livermore valley

Construction – CFR pool construction

Step Pool sequence

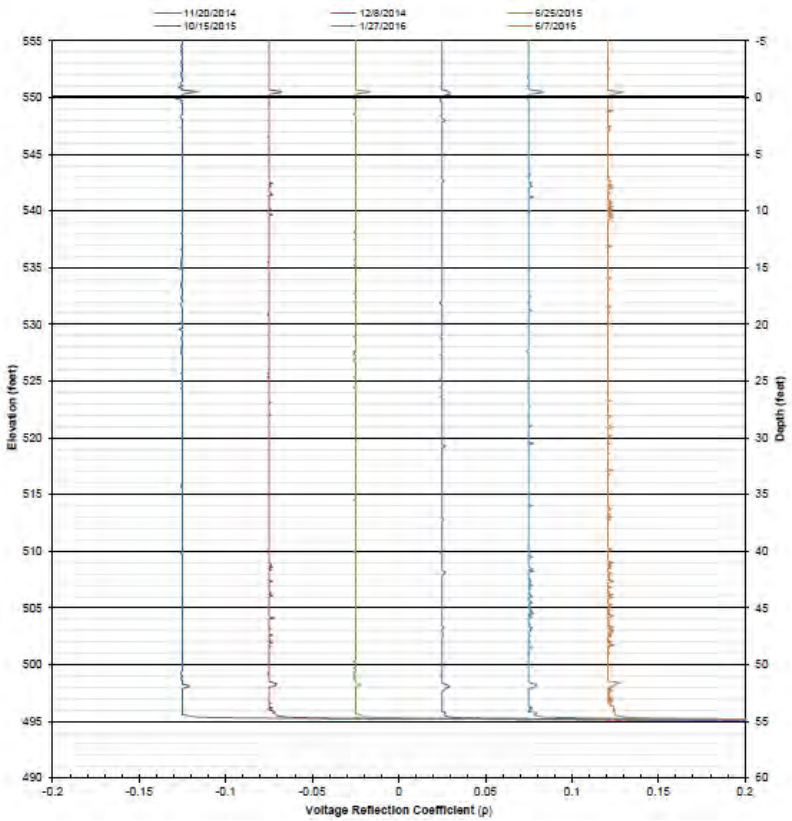
Field Supervision

Instrumentation installation and monitoring

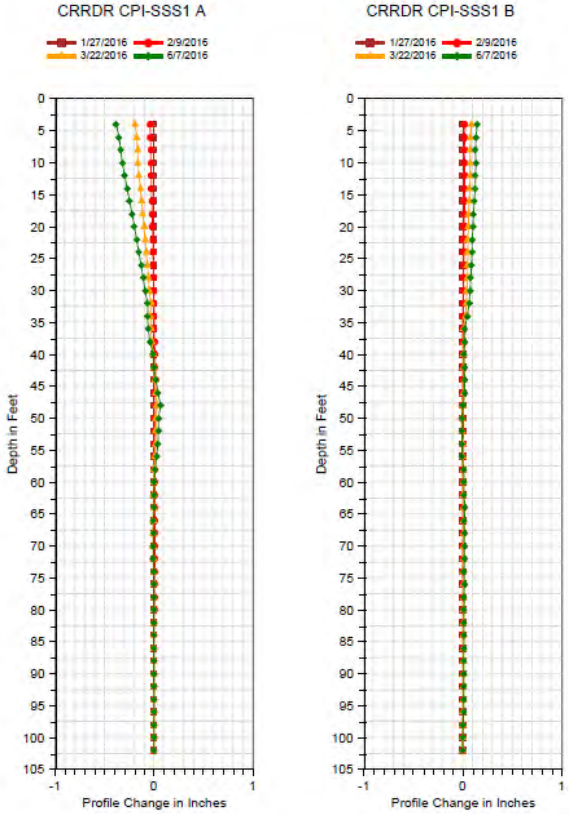
- Slope inclinometers (SI) along former reservoir rim and top of engineered embankments
- Time Domain Reflectometers (TDR):
  - Deformation at depth
  - No magnitude
- Reflective Survey Monuments:
  - All over slope
  - Measured biannually
- Vibrating Wire Piezometers
- Instrumentation data collection

Instrumentation installation and monitoring

TDR for Reroute, Left Slope



Slope Inclinometer for SSS



Removal of 1883 Old Carmel River Dam

Sleepy Hollow Ford Bridge Construction

Path Forward – 5 year monitoring period

- Slope stability and erosion reconnaissance
- Instrumentation measurements (Slope Inclinometer, VWP, TDR and surface settlement markers)
- Additional monitoring via Triggering Events
  - 4.0M EQ w/in 50 miles
  - 10yr flood event (>3,600 cfs)
- Habitat die-off/ replacement
- Win-win for everyone
  - Dam removal for safety
  - Restore ecological balance
- Turnover to BLM

- Acknowledgements
  - Aman Gonzalez - California American Water
  - Brian Hussar – Granite Construction Company
  - Craig Hall, GE – GEI
  - Morley Beckman, PE – Kleinfelder
  - Jeff Richmond, CEG – Kleinfelder
  - Kami Deputy, PE – Shannon & Wilson
  - Merideth Beswick, PE, GIT - Kleinfelder

QUESTIONS?