Anticipating the Unexpected in the Context of Dam Removal

2019 Compensatory Mitigation Webinar Series, Webinar 7

Shawn M. Chartrand
Geophysical Scientist
Balance Hydrologics
Vanderbilt University

Webinar Topics

Part 1: General Overview of Routine Maintenance, Adaptive Management and Remediation

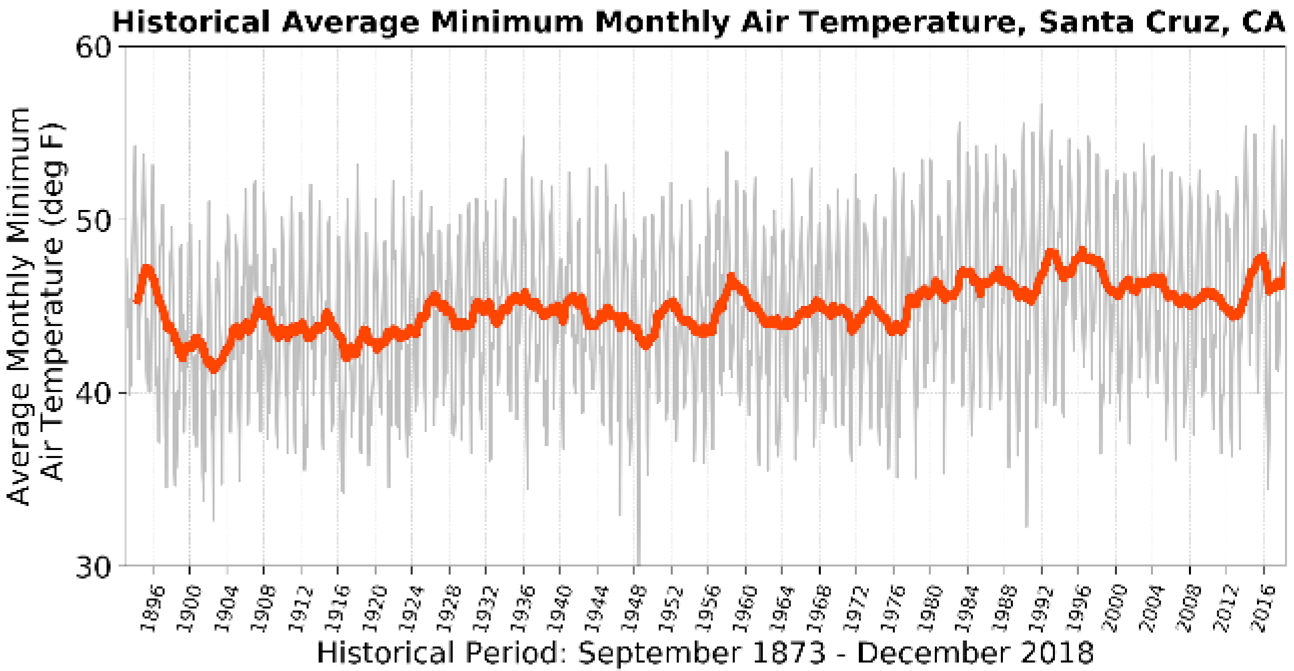
Part 2: Dam Removal Case Study

Anticipating the Unexpected
The Big Picture

1. It is IMPOSSIBLE to anticipate all future conditions.
   - **Climate** - hotter, wetter, drier, more extreme?
   - **Vegetation** - species transition, pace of transition?
   - **Wildlife** - extinction, dominance of new species?
   - **Political/Legal** - water rights modifications, new laws?
   - **Land-use** - change of regional or local planning trajectory?

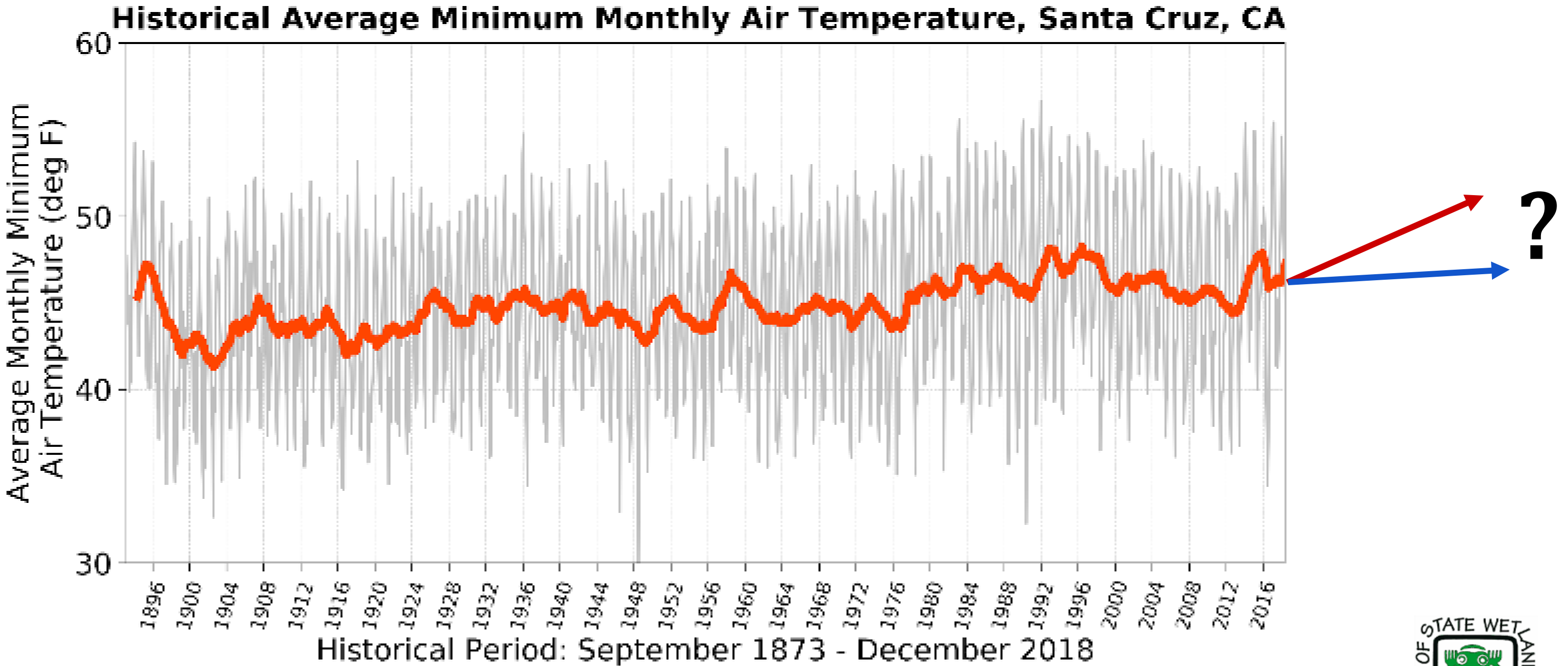
Anticipating the Unexpected
The Big Picture

1. It is <u>IMPOSSIBLE</u> to anticipate all future conditions.



Anticipating the Unexpected
The Big Picture

1. It is IMPOSSIBLE to anticipate all future conditions.



Anticipating the Unexpected
The Big Picture

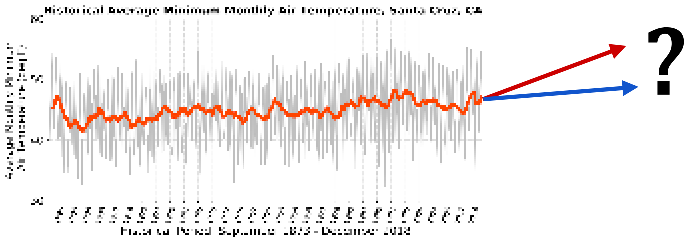
1. It is IMPOSSIBLE to anticipate all future conditions.
2. Identify the risks [uncertainties] and examine whether the proposed design approach addresses the risks as best as possible.

Transparent Design Process

CFAAR

Chartrand and Hassan, 2017, https://eartharxiv.org/eus6c/

Identify Key Design Risks



Anticipating the Unexpected
The Big Picture

1. It is IMPOSSIBLE to anticipate all future conditions.
2. Identify the risks [uncertainties] and examine whether the proposed design approach addresses the risks as best as possible.
3. Encourage practitioners to build an overall strategy to address risk through potential post construction direct actions:
   - **Routine maintenance**
   - **Adaptive management**
   - **Remediation***

ASSOCIATION OF STATE WETLAND MANAGERS

Anticipating the Unexpected
The Big Picture

1. It is IMPOSSIBLE to anticipate all future conditions.
2. Identify the risks [uncertainties] and examine whether the proposed design approach addresses the risks as best as possible.
3. Encourage practitioners to build an overall strategy to address risk through potential post construction direct actions:
   - **Routine maintenance**
   - **Adaptive management**
   - **Remediation***

→ Help achieve the design intent, goals and objectives

Anticipating the Unexpected
The Big Picture

Routine Maintenance

Actions typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase.

Anticipating the Unexpected
The Big Picture

Routine Maintenance

Actions typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase.

Routine maintenance involves direct actions that are consistent with the expectations of post construction site evolution and maturity.

Chartrand and Hassan, 2017, https://eartharxiv.org/eus6c/

Anticipating the Unexpected
The Big Picture

Routine Maintenance

Actions typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase.

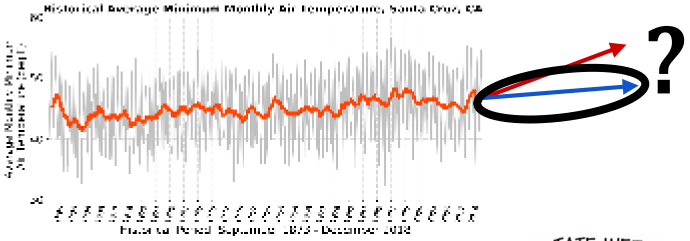
Routine maintenance involves direct actions that are consistent with the expectations of post construction site evolution and maturity.

Transparent Design Process

CFAAR

Chartrand and Hassan, 2017, https://eartharxiv.org/eus6c/

Identify Key Design Risks



Anticipating the Unexpected
The Big Picture

Adaptive Management

Actions are the result of adjusting the constructed site condition to adapt to on the ground changes that diverge from expectation, which is detailed within the design documentation.

Anticipating the Unexpected
The Big Picture

Adaptive Management

Actions are the result of adjusting the constructed site condition to adapt to on the ground changes that diverge from expectation, which is detailed within the design documentation.

Actions are not typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase. But actions could be discussed as possibilities.

Anticipating the Unexpected
The Big Picture

Adaptive Management

Actions are the result of adjusting the constructed site condition to adapt to on the ground changes that diverge from expectation, which is detailed within the design documentation.

Actions are not typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase. But actions could be discussed as possibilities.

On the ground changes are not, however, radically different from expectation.

Anticipating the Unexpected
The Big Picture

Adaptive Management

Actions are the result of adjusting the constructed site condition to adapt to on the ground changes that diverge from expectation, which is detailed within the design documentation.

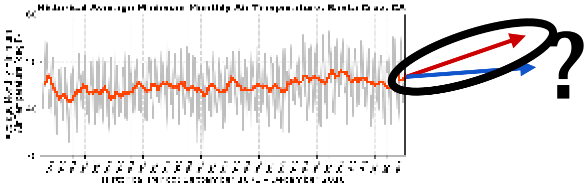
Actions are not typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase. But actions could be discussed as possibilities.

On the ground changes are not, however, radically different from expectation.

Transparent Design Process

CFAAR

Identify Key Design Risks



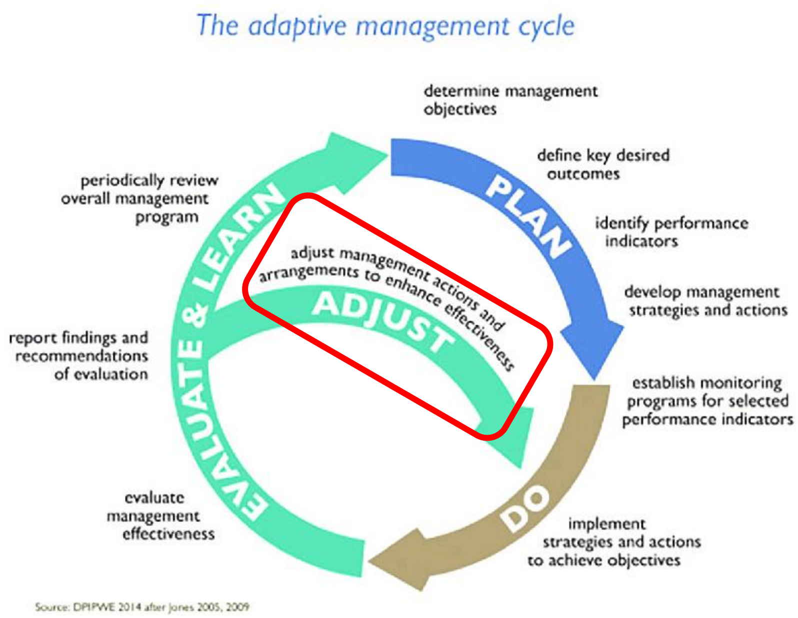
Anticipating the Unexpected
The Big Picture

Adaptive Management

Actions are the result of adjusting the constructed site condition to adapt to on the ground changes that diverge from expectation, which is detailed within the design documentation.

Actions are not typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase. But actions could be discussed as possibilities.

On the ground changes are not, however, radically different from expectation.



Source:https://www.researchgate.net/publication/320934215_Meaning_and_Action_in_Sustainability_Science_Interpretive_approaches_for_social-ecological_systems_research/figures?lo=1

Anticipating the Unexpected
The Big Picture

Adaptive Management

Actions are the result of adjusting the constructed site condition to adapt to on the ground changes that diverge from expectation, which is detailed within the design documentation.

Actions are not typically covered by an Operations and Maintenance Manual (OMM) developed within the design and permitting phase. But actions could be discussed as possibilities.

On the ground changes are not, however, radically different from expectation.

Proactive Strategies

Provide as much detail as possible within design documentation to facilitate awareness and general support for possible actions - i.e. plan ahead with the regulatory permitting staff.

Agree to an expedited permitting process for adaptive management actions.

Encourage project owners to line item budget allocations for adaptive management actions over a 2-5 year post-construction period.

Pre-qualify contractors for work.

Anticipating the Unexpected
The Big Picture

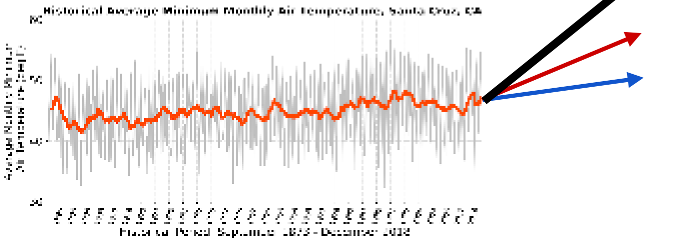
Remediation

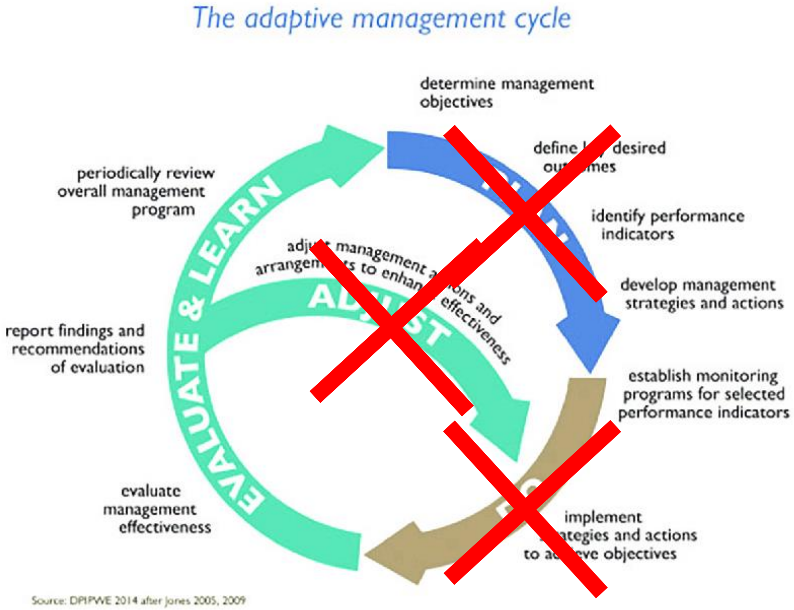
Actions [or Inaction] are the result of evolving site conditions that were not anticipated or expected by the design documentation or the regulatory permits. Could be due to weather or natural landscape events at the limit of historical events, or inadequate planning [understanding site context], design development, design analysis and review, and/or inadequate construction.

Anticipating the Unexpected
The Big Picture

Remediation

Actions [or Inaction] are the result of evolving site conditions that were not anticipated or expected by the design documentation or the regulatory permits. Could be due to weather or natural landscape events at the limit of historical events, or inadequate planning [understanding site context], design development, design analysis and review, and/or inadequate construction.





Source:https://www.researchgate.net/publication/320934215_Meaning_and_Action_in_Sustainability_Science_Interpretive_approaches_for_social-ecological_systems_research/figures?lo=1

Anticipating the Unexpected
The Big Picture

Routine Maintenance

Anticipated and planned post-construction work

Adaptive Management

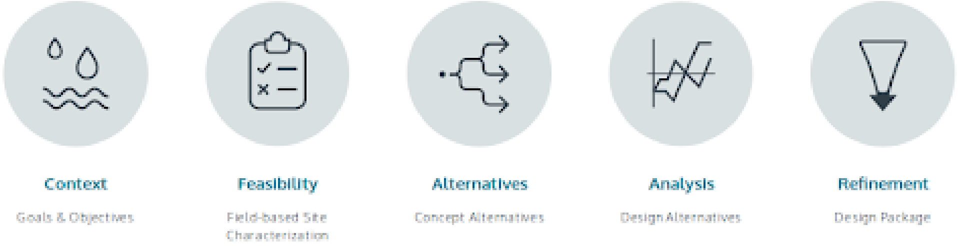
Anticipated but not planned post-construction work

Remediation

Not anticipated and not planned post-construction work

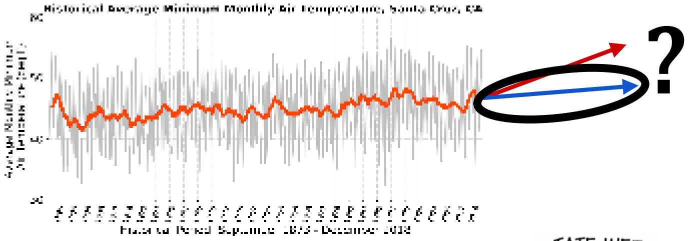
Transparent Design Process

CFAAR



Chartrand and Hassan, 2017, https://eartharxiv.org/eus6c/

Identify Key Design Risks



Webinar Topics

Part 1: General Overview of Routine Maintenance, Adaptive Management and Remediation

Part 2: Dam Removal Case Study

Basic Problem Statement

How does one take down this dam and:

1. Provide immediate fish passage conditions?
2. Provide immediate resting and holding conditions?
3. Minimize release of reservoir sediments to downstream reaches?
4. Meet specific channel stability design criteria?

Former San Clemente Dam, Carmel River, California

Project Location and Geography

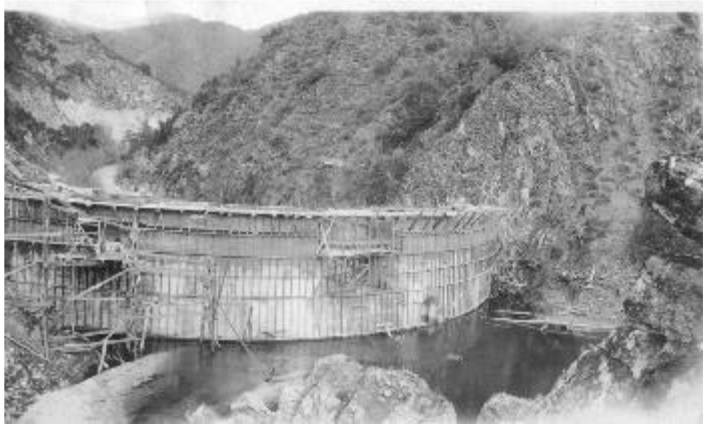
- 30 km upstream of mouth at Carmel
- Warm, dry summers and cool, wet winters
- Wildfires occur roughly every 10 years
- Drainage area of 75 square kilometers
- Hydrology affected by ENSO
- Supports runs of Steelhead*

Factors Leading to Dam Removal

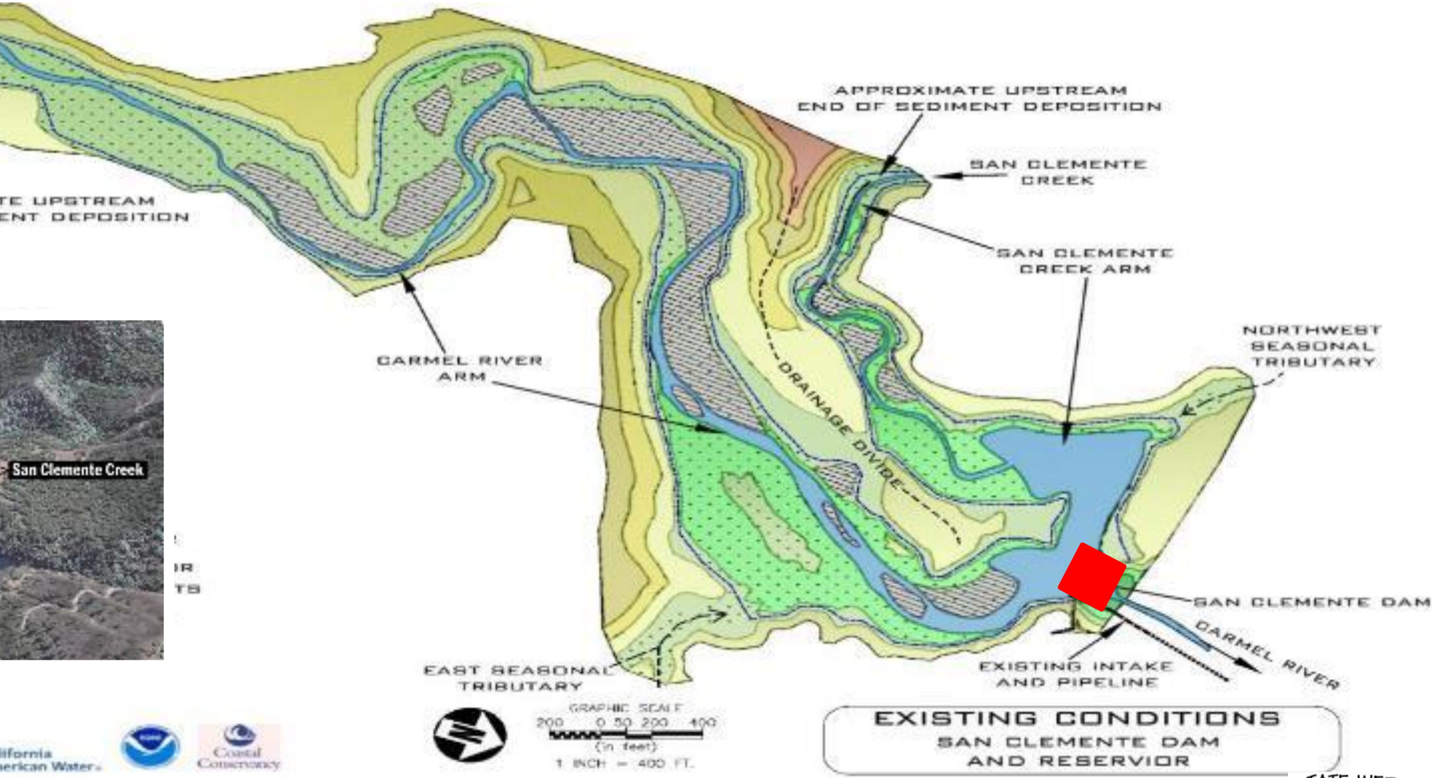
- Dam safety order issued early 1990's
- 25+ km of steelhead habitat upstream
- Re-build/ buttress cost was high for water supply benefits
- Sediment release risk deemed to high for downstream flooding impacts
- Water storage reduced to 70 acre-feet
- Sediment removal failed environmental review

Dam and Reservoir Historical Details

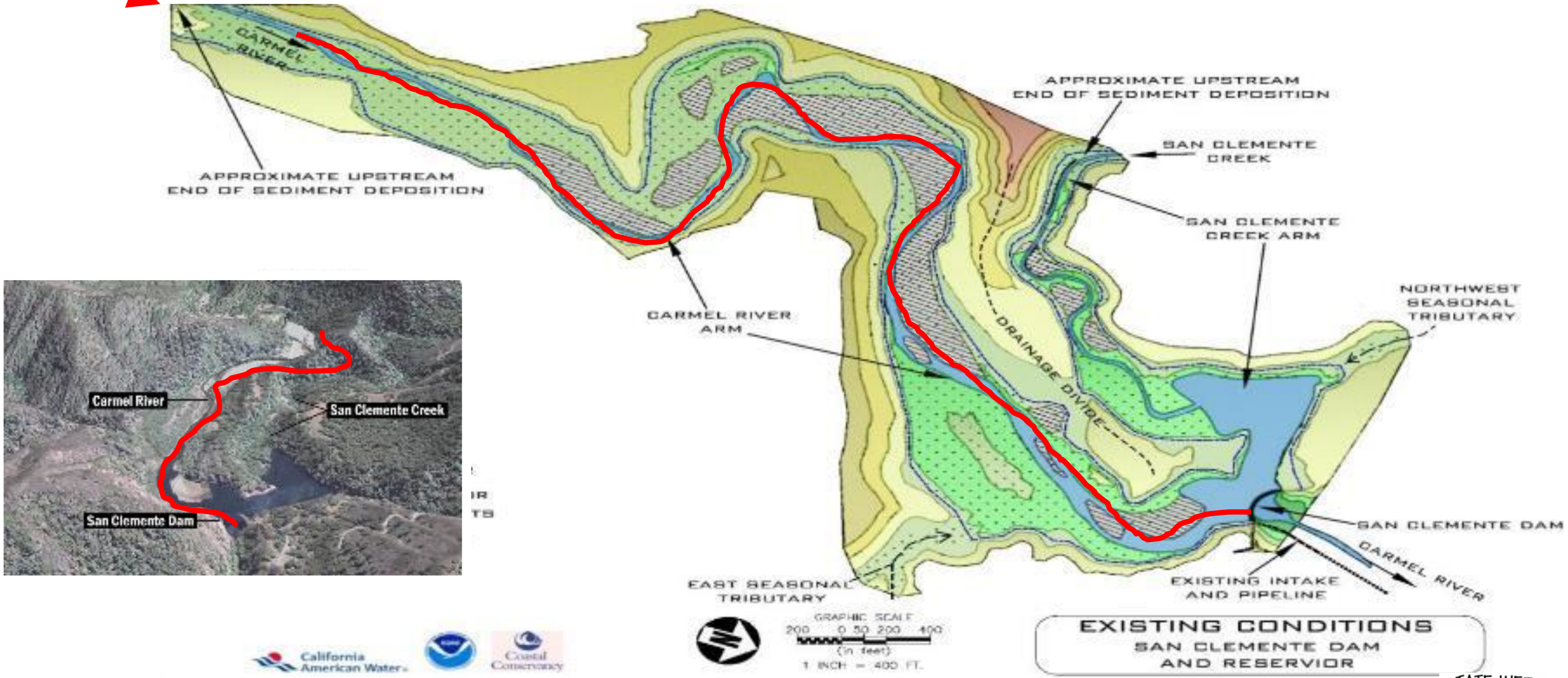
- Dam constructed in 1921
- Concrete arch dam – 32 meters
- Supply water to Carmel Valley
- Large supply pulses due to fire and granitics
- Reach-average slope of 2.6%
- Local grain size distribution: 0.1–1000+ mm
- System exhibits recurrent corridor resetting events



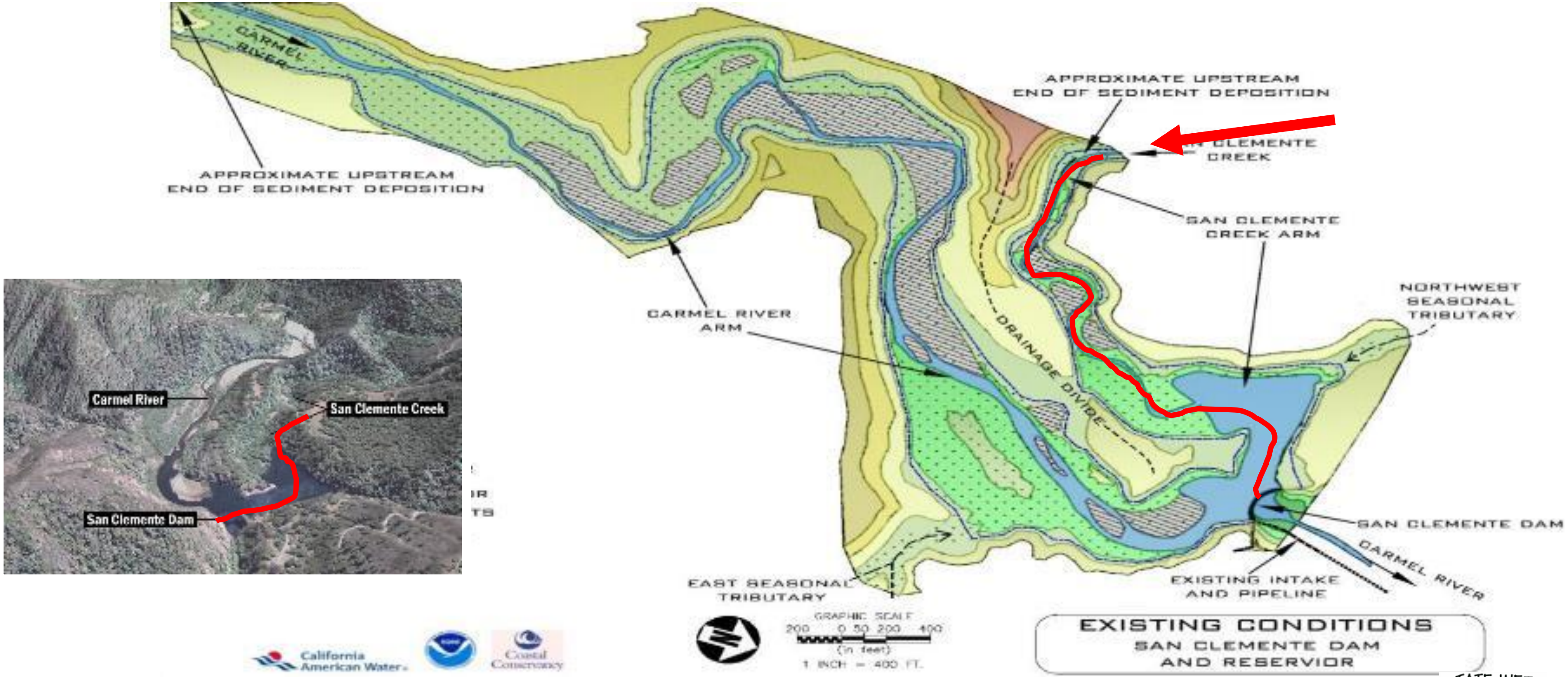
Dam and Reservoir Historical Details



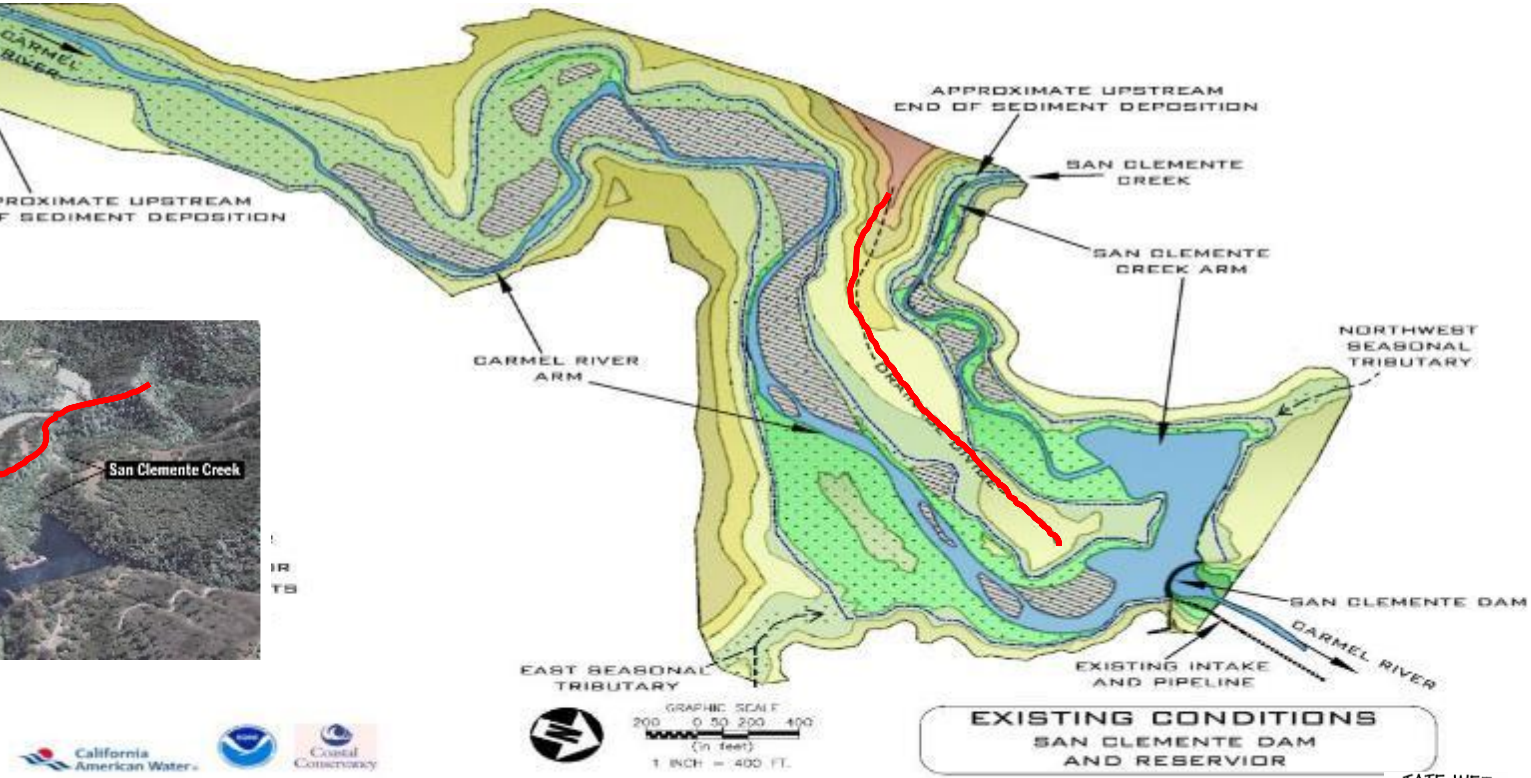
Dam and Reservoir Historical Details



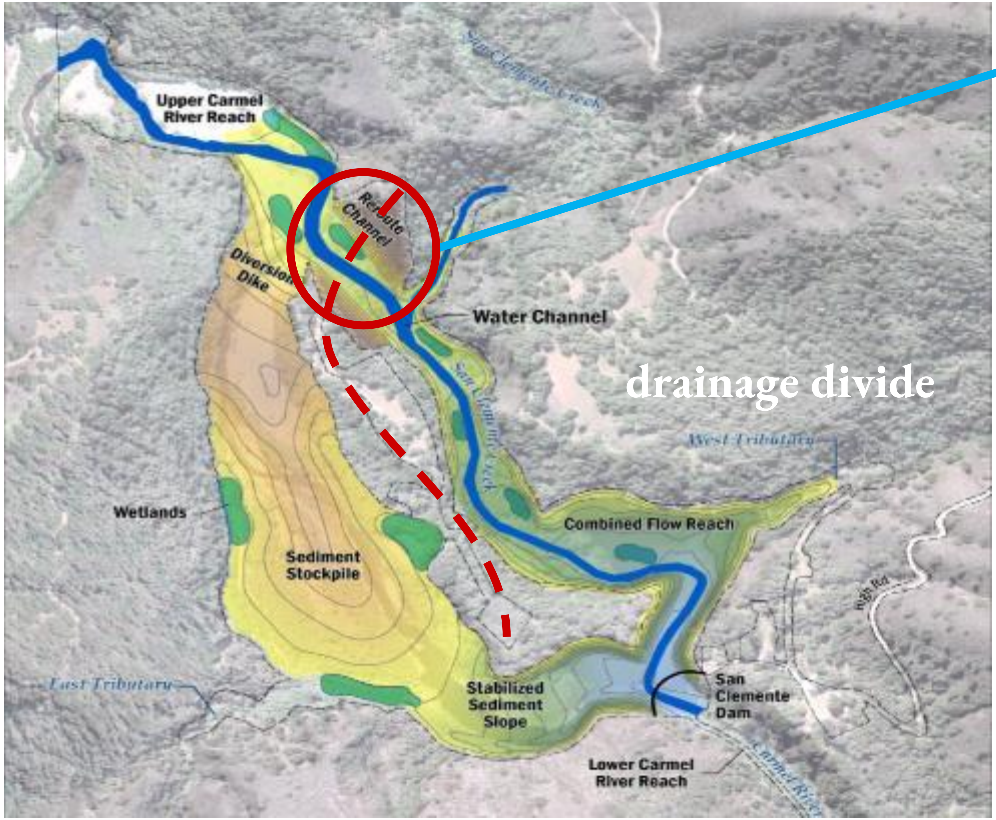
Dam and Reservoir Historical Details



Dam and Reservoir Historical Details



Design Overview



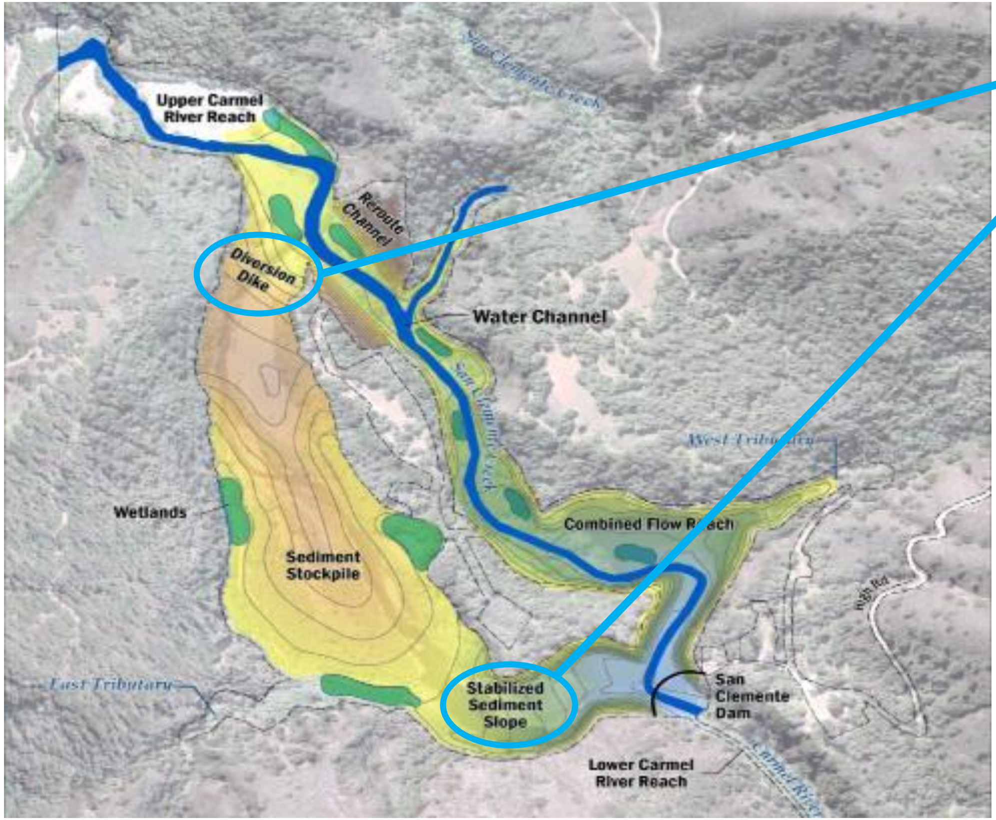
Relocate the mainstem Carmel to the adjacent valley

Bedrock cut to move the river

Applicable Design Criteria

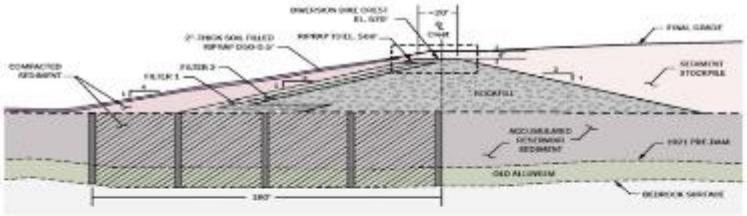
- Maximum credible earthquake: 7.1M

Design Overview



Retain all reservoir sediment on site

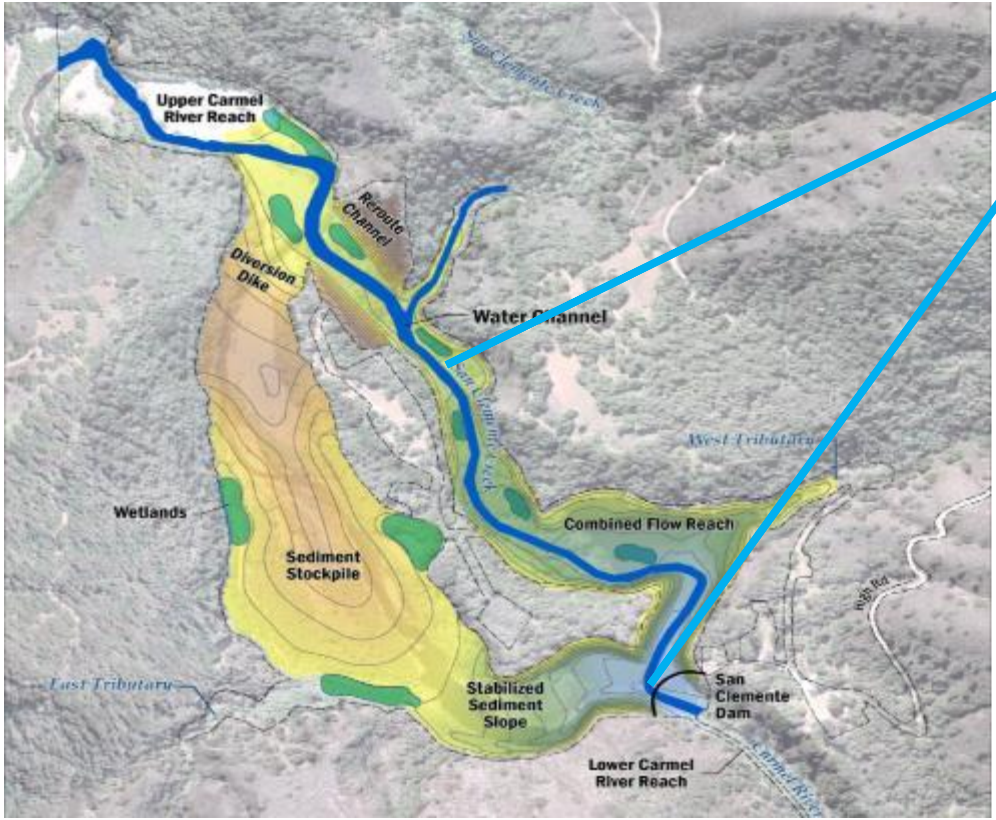
Diversion Dike



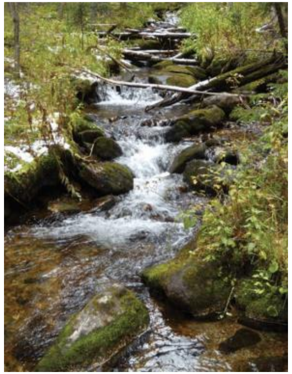
Applicable Design Criteria

- 500-year flood
- Maximum credible earthquake: 7.1 magnitude

Design Overview



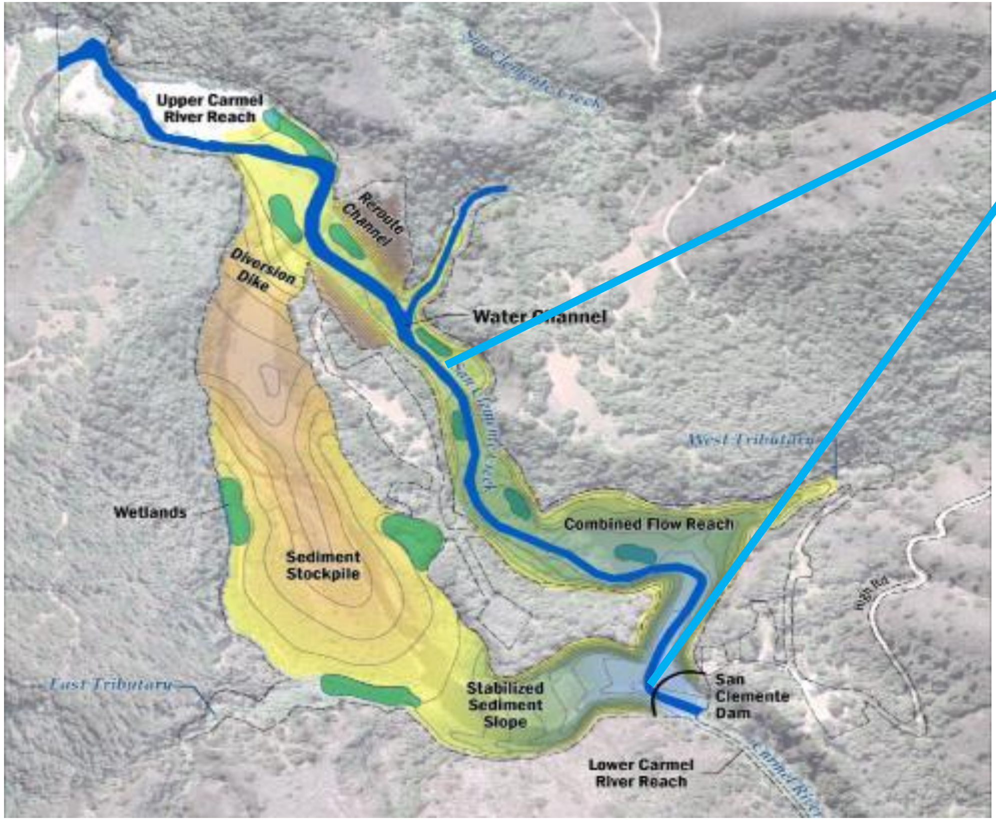
Construct new channel with step-pools



Source: Yocham et al., 2014 U.S. Forest Service T.R.: RMRS-GTR RMRS-GTR-323

Resting pools every 60 meters

Design Overview

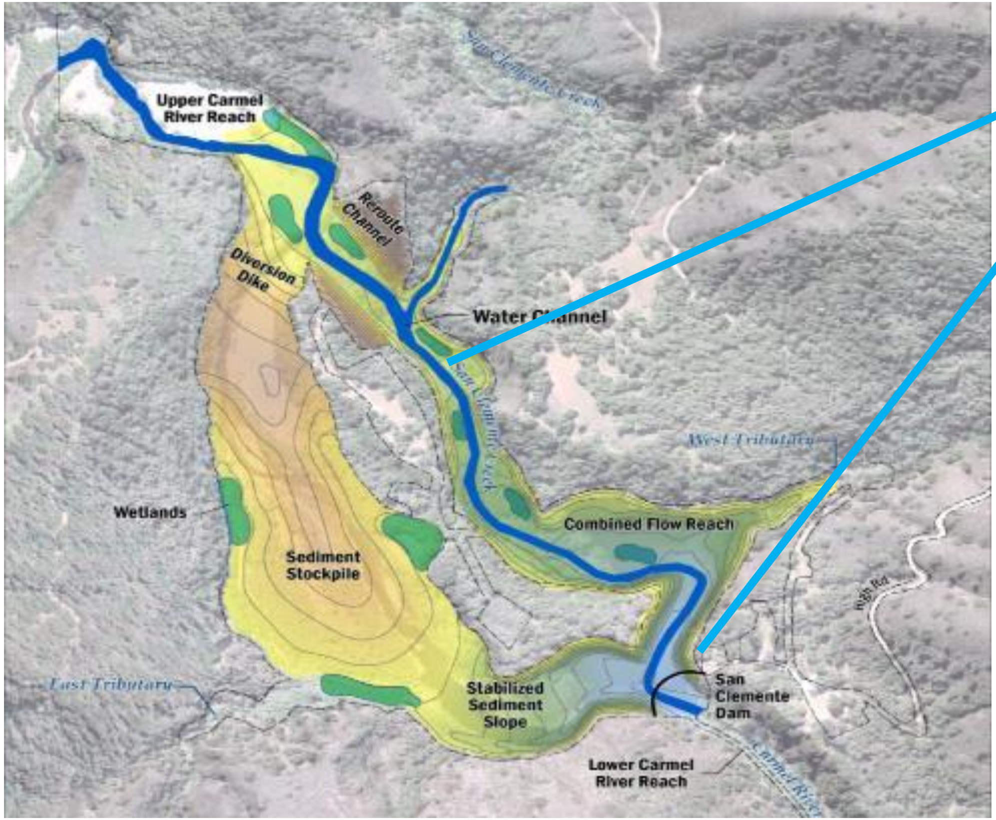


Construct new channel
with step-pools

[Applicable Design Criteria]

- Step crest boulders *stable* up to 50-year flood
- Maximize adult steelhead passage potential up to the 1.5-year flood
- Maximum slope of 5%
- Diversify step-pool geometry
  - ✓ Width: 8-12 meters
  - ✓ Spacing: 6-10 meters

Design Overview



Provide boulder and cobble source piles

Boulder source pile

Applicable Design Criteria

- Maximize volume of boulder count within overbank staged substrate piles

Constructed Condition

And Then Water Year 2017 Hit…

- 10-year flood in January 2017
- 45-year flood in February 2017
- Large wildfire in contributing basin

And Then Water Year 2017 Hit…

And Then Water Year 2017 Hit…

ASSOCIATION OF STATE WETLAND MANAGERS

And Then Water Year 2017 Hit…

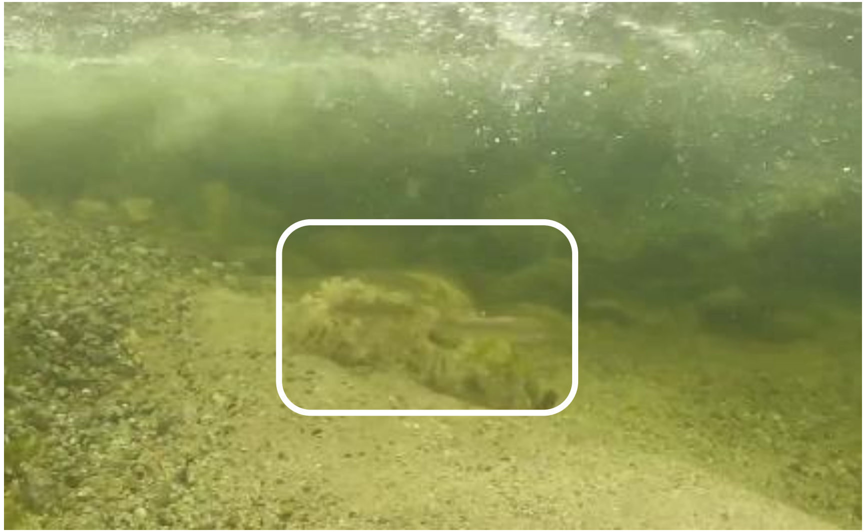
So What Happened Next?

- **Routine maintenance**
- **Adaptive management**
- **Remediation***

Actions [or Inaction] are the result of evolving site conditions that were not anticipated or expected by the design documentation or the regulatory permits. **Could be due to weather or natural landscape events at the limit of historical events**, or inadequate planning [understanding site context], design development, design analysis and review, and/or inadequate construction.

So What Happened Next?

Was the Constructed Reach Functional?



- **Routine maintenance**
- **Adaptive management**
- **Remediation***

Actions [or Inaction] are the result of evolving site conditions that were not anticipated or expected by the design documentation or the regulatory permits. **Could be due to weather or natural landscape events at the limit of historical events**, or inadequate planning [understanding site context], design development, design analysis and review, and/or inadequate construction.

Closing Thoughts

- Providing the proper ingredients is more important the getting the recipe correct. [**CFAAR**].
- Prepare the public, stakeholders and clients for the unexpected at any time in the post construction period [**SET EXPECTATIONS**]
- Work early and cooperatively between project owners and regulatory staff [**BUILD TRUST**].
- Remediation does not always mean new direct actions - unanticipated change can offer a path to achieve project goals and objectives [**P.C. CHANGE ≠ FAILURE**].

Thanks for Your Time!

Shawn M. Chartrand
Geophysical Scientist
Balance Hydrologics
Vanderbilt University

Balance Hydrologics

2019 Compensatory Mitigation Webinar Series, Webinar 7

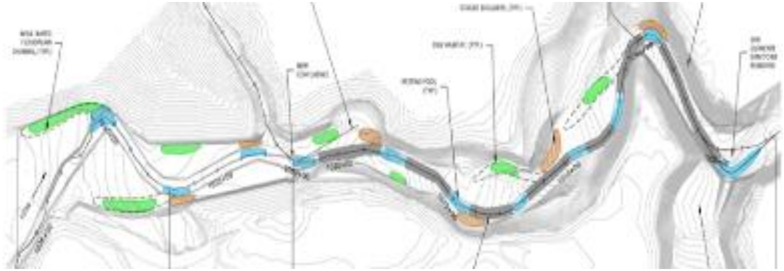
ASSOCIATION OF STATE WETLAND MANAGERS

Dam Removal Primary Objectives

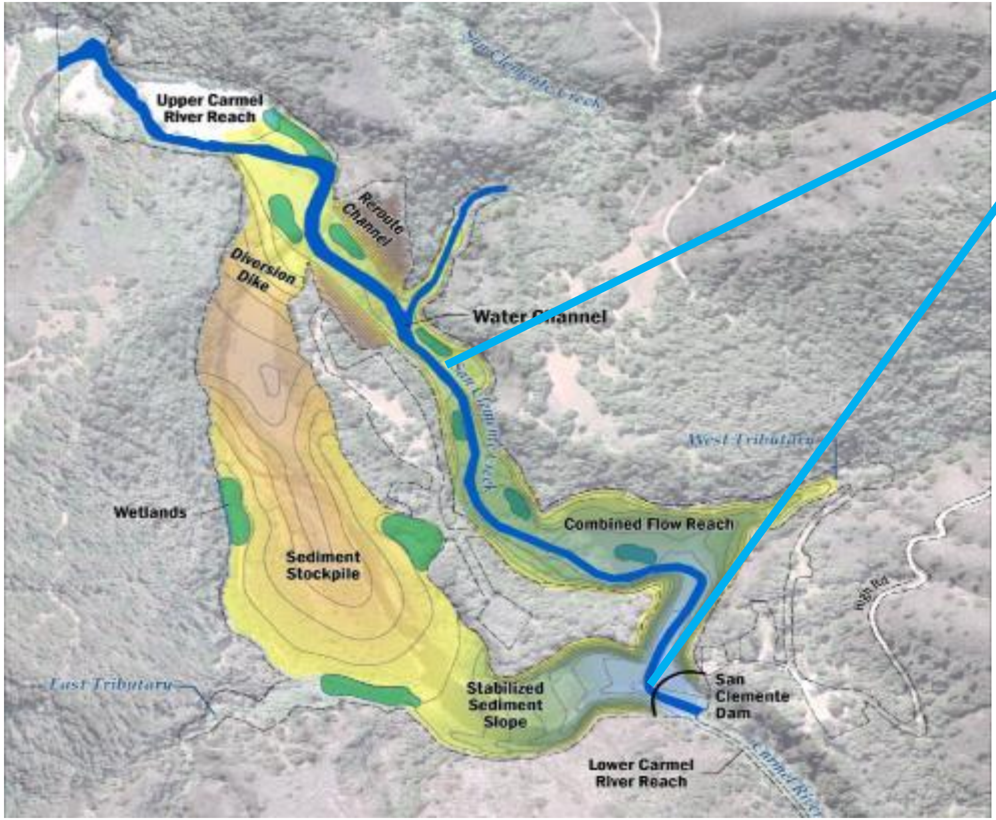
1. Minimize downstream flooding impacts
2. Provide immediate fish passage
3. Meet specific channel stability criteria
4. Provide ingredients to promote natural river evolution
5. Provide riparian and upland habitat

Project Overview

- Project studies began in 1992
- Draft EIR/EIS released in 2006; certified in 2007
- Project design began in 2008 (independent review panel)
- Design-build contractor selected in 2013
- Largest dam removal in California history [through 2019]
- Primarily a geotechnical design and construction effort
- Project design and construction = ~82 million USD



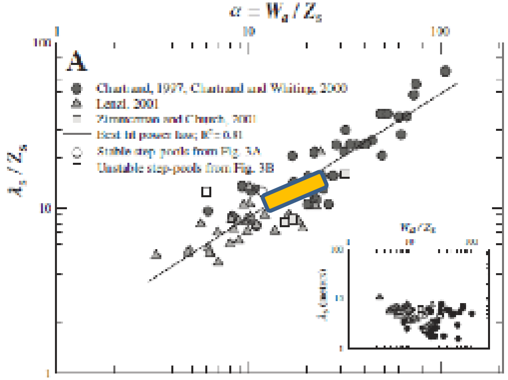
Design Overview



Construct new channel with step-pools

Applicable Design Criteria

- Design consistent with:
  - ✓ Whittaker and Jaeggi, 1982;
  - ✓ Thomas et al., 2003; and
  - ✓ Chartrand et al., 2011



Chartrand et al., 2011, Geomorphology 129