Water Supply Reliability

Fishery Restoration

Science & Engineering

Stakeholder Participation

Power Generation

POTTER VALLEY PROJECT TECHNICAL STUDIES

Lake Pillsbury Sediment Management Discussion

Lisa K. Stromme, PE – Senior Water Resources Engineer

Dr. Yantao Cui, PE – Senior Hydraulic Engineer

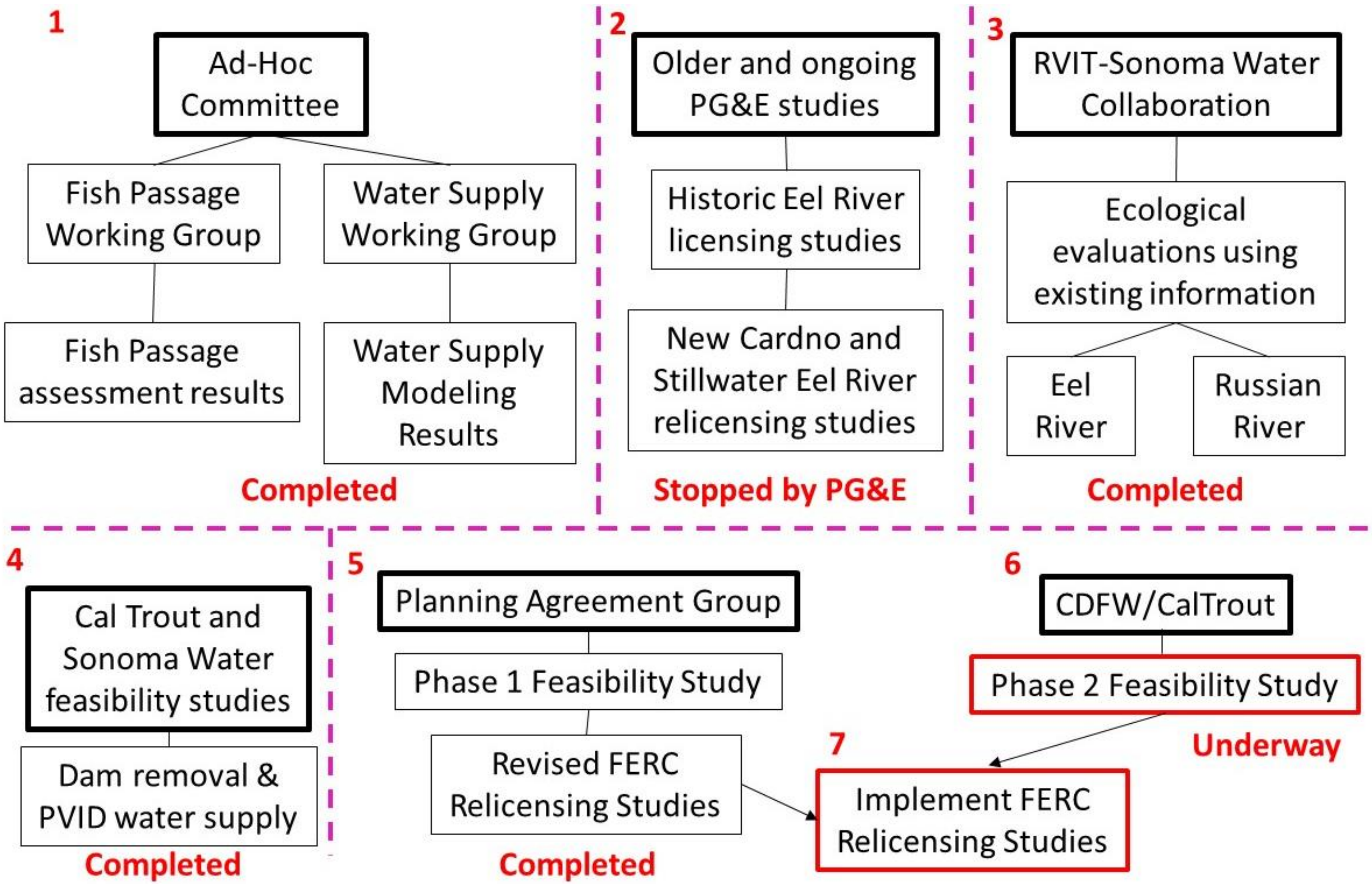
Fred Meyer – Stream Restoration Designer

Scott McBain – Fluvial Geomorphologist

Laura Wildman, PE – Civil Engineer

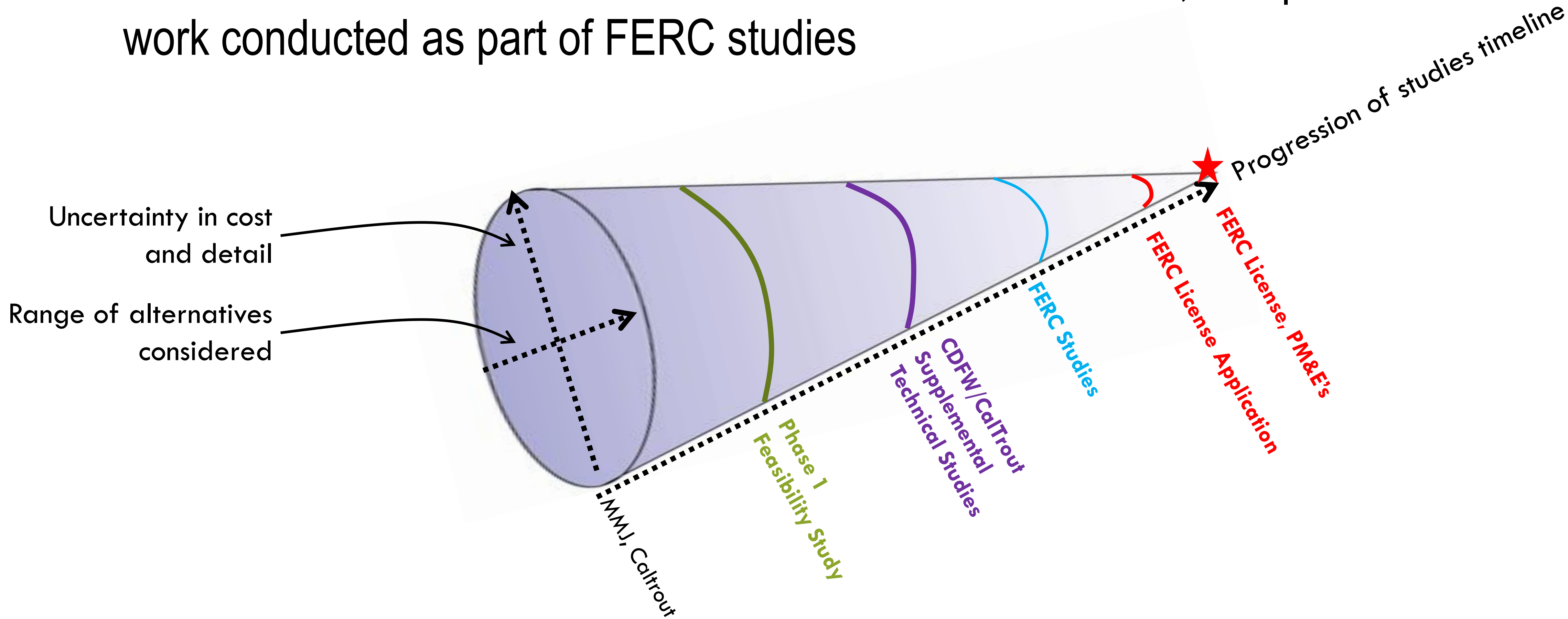
California Trout 50 — For 50 Years. Forever. | Stillwater Sciences | McBain Associates Applied River Sciences | McMillen Jacobs Associates

Overview of where we are



Meeting Objectives

- Provide an overview of work conducted to date on Feasibility Studies
- Facilitate a technical discussion of work conducted to date, and potential work conducted as part of FERC studies



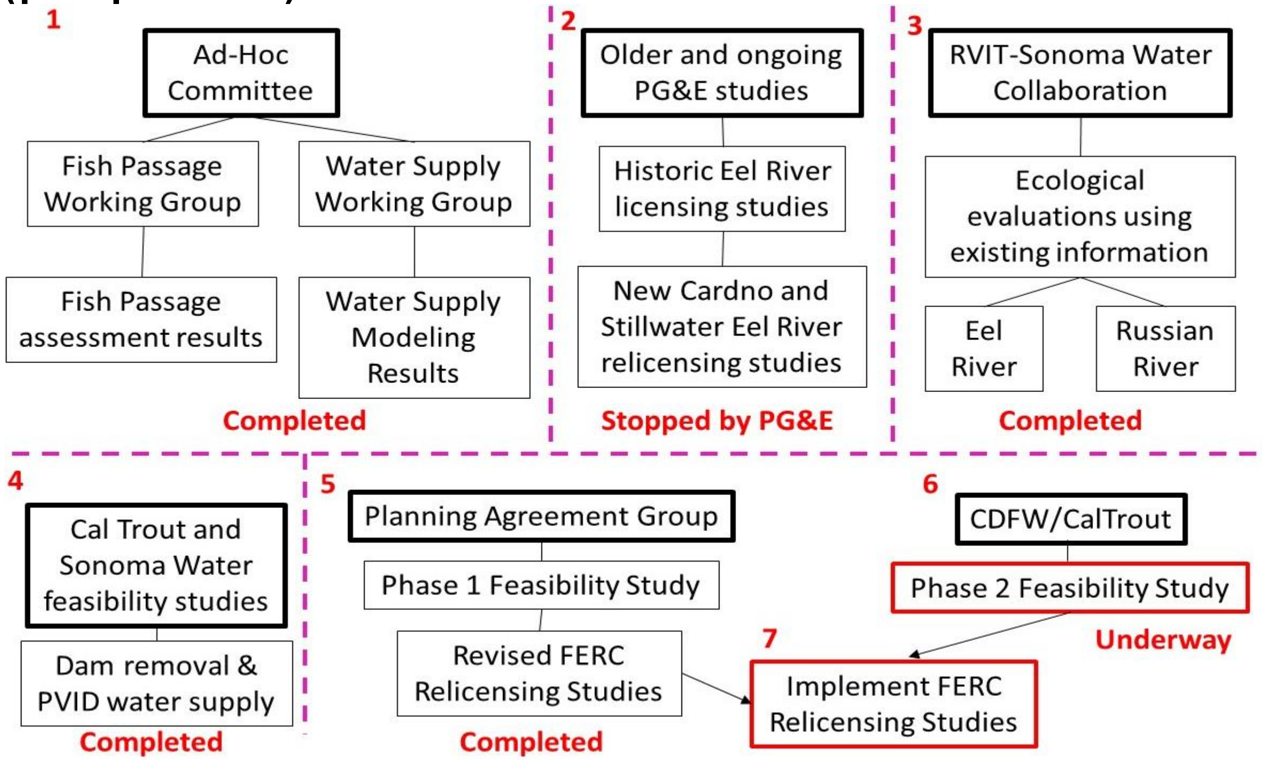
Components of Presentation

- Part 1: Overview of work completed to date
- Part 2: Overview of Lake Pillsbury Sediment Storage Calculations
- Part 3: Overview of Lake Pillsbury “mobile sediment” Calculations
- Part 4: Overview of Potential Sediment Management Options with different Scott Dam Decommissioning Options
- Part 5: Suspended Sediment Concentration Analysis for different Scott Dam Decommissioning Options
- Part 6: Study AQ12 overview and discussion

Part 1: Overview of work completed to date

Part 1: Overview of Work Completed to Date

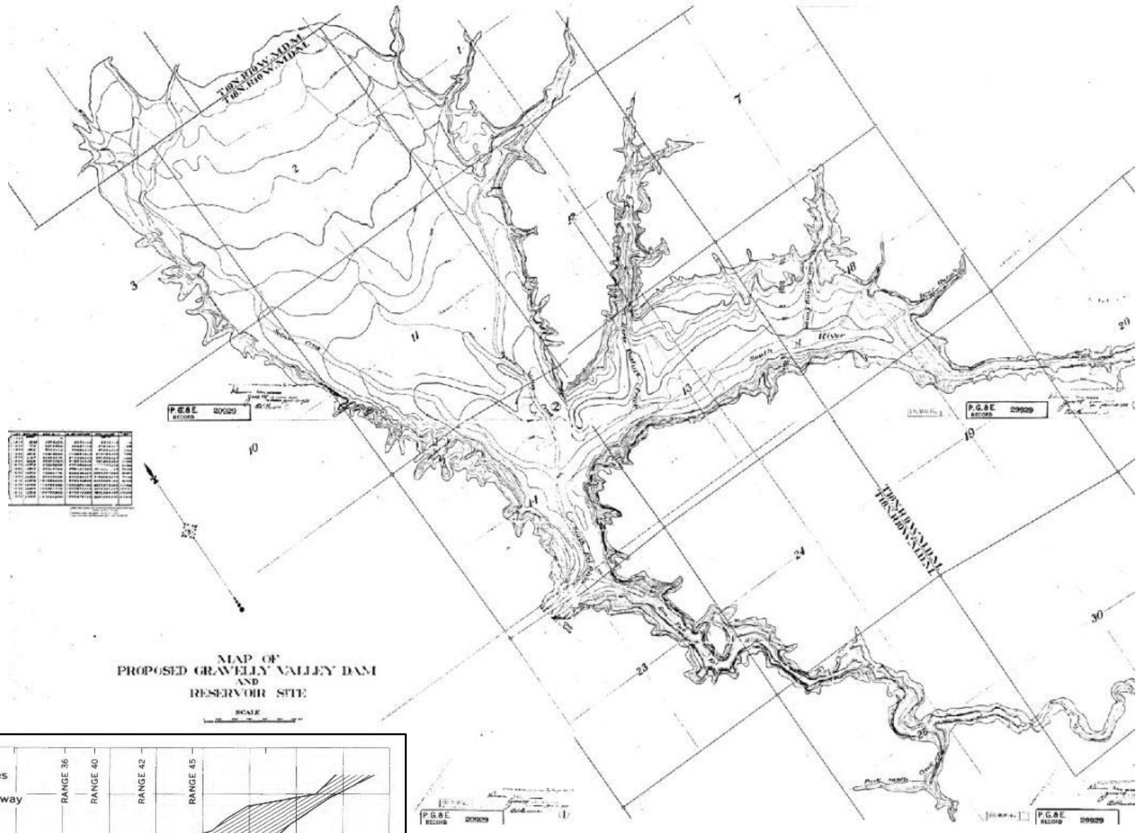
- CalTrout and Sonoma Water Initial Feasibility Studies (2018-2019)
- NOI Parties Feasibility Study Phase 1 (2020)
- Subsequent Internal Review as part of PVP Technical Studies (now)
- FERC Relicensing Study AQ4 and AQ12 (proposed)

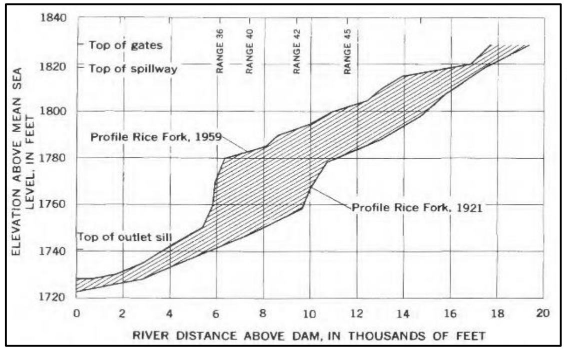


Part 2: Overview of Lake Pillsbury Sediment Storage Calculations

Data Sources: 1921-22 and 2015-16

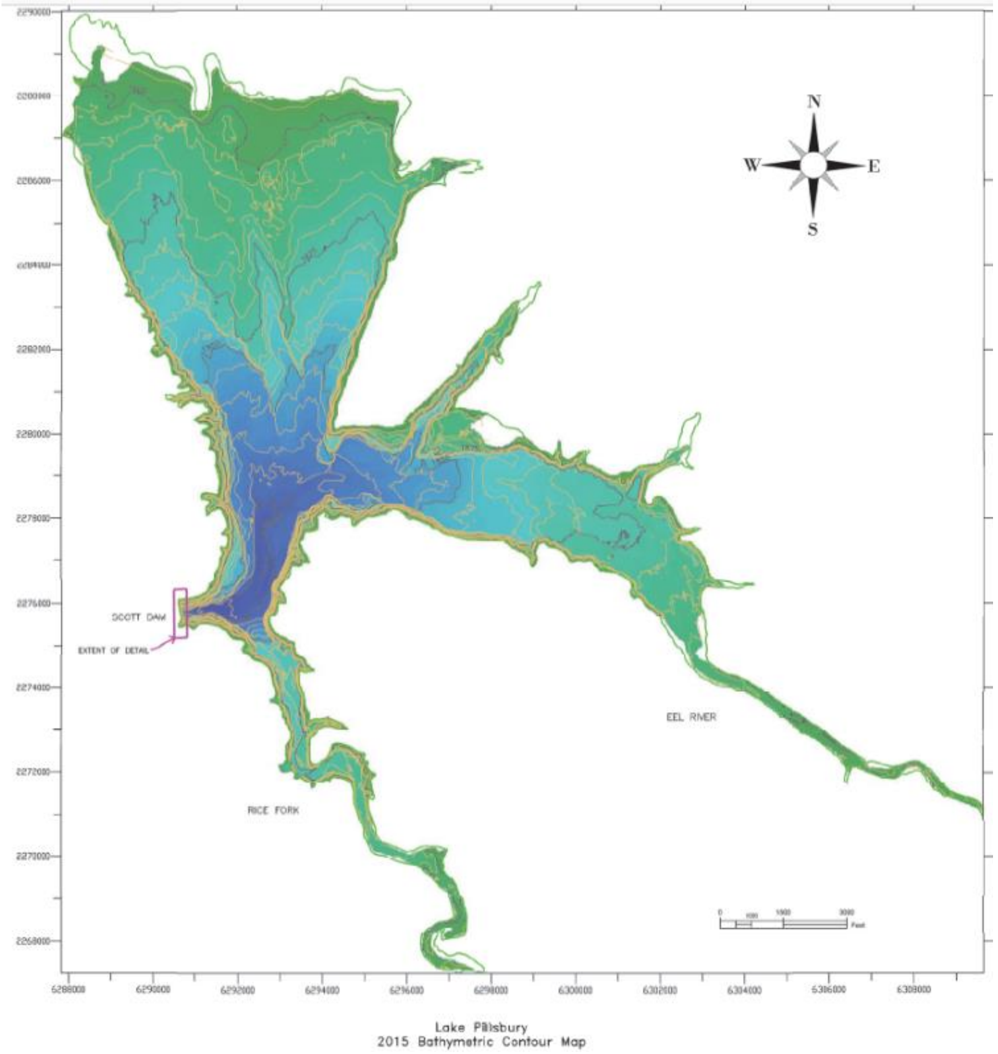
1922 Topography (USGS)



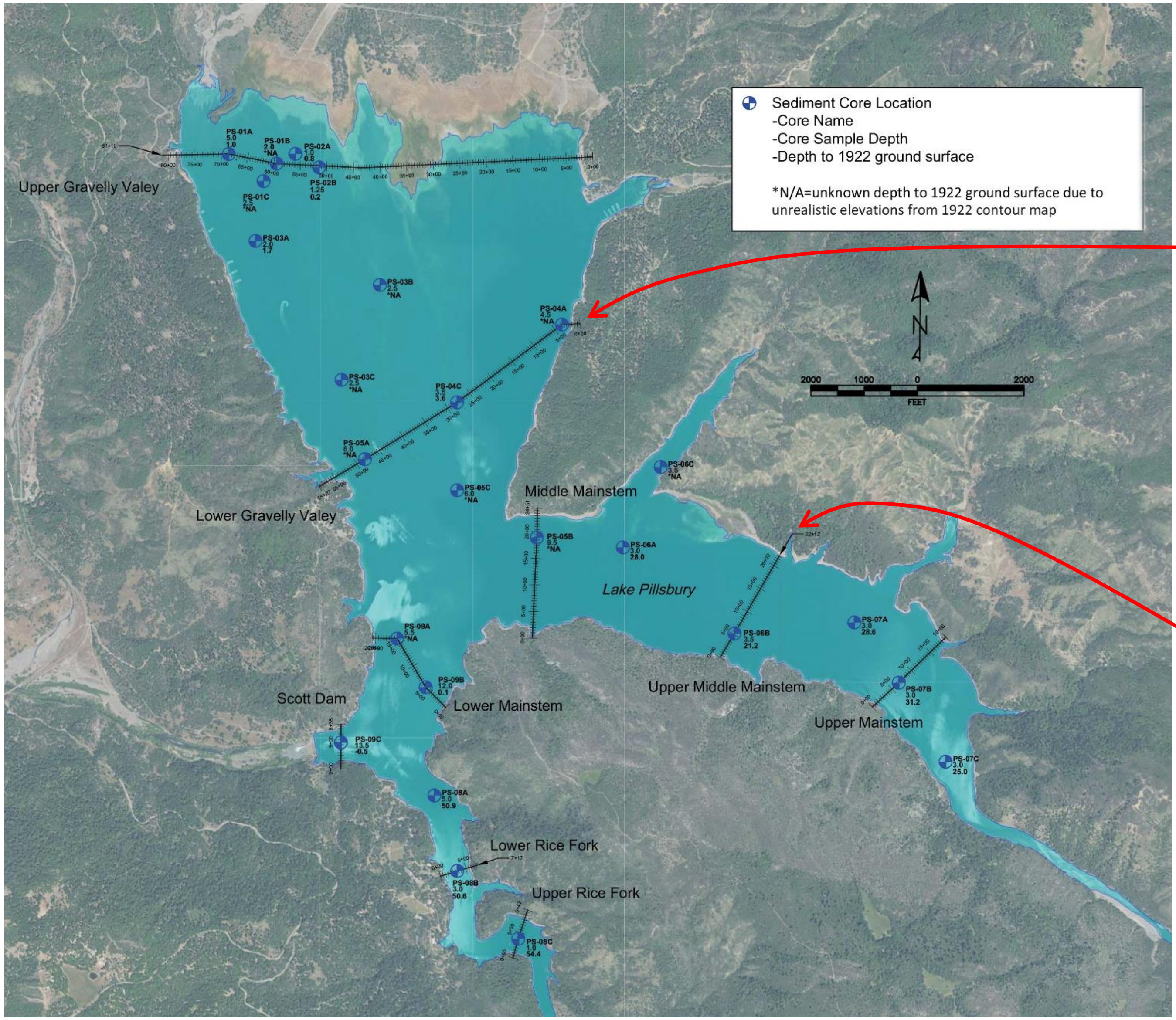


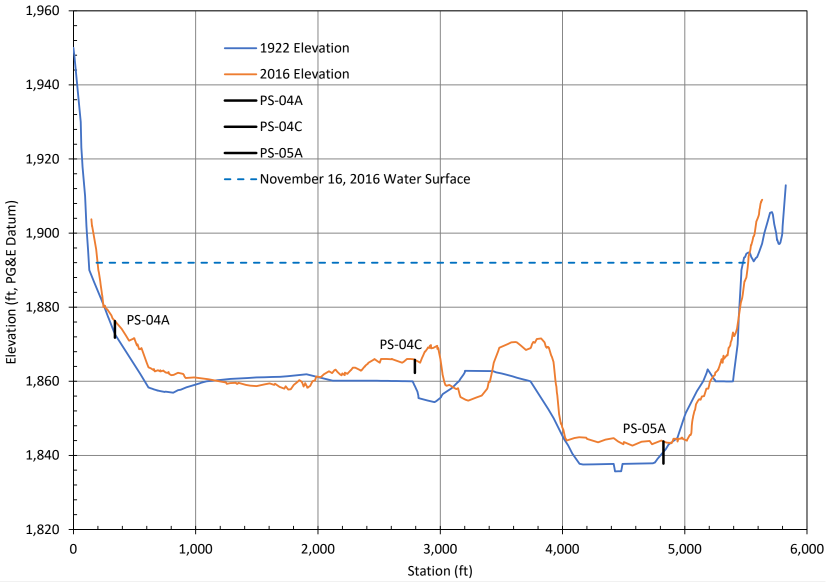
1921 Rice Fork Channel Profile (USGS)

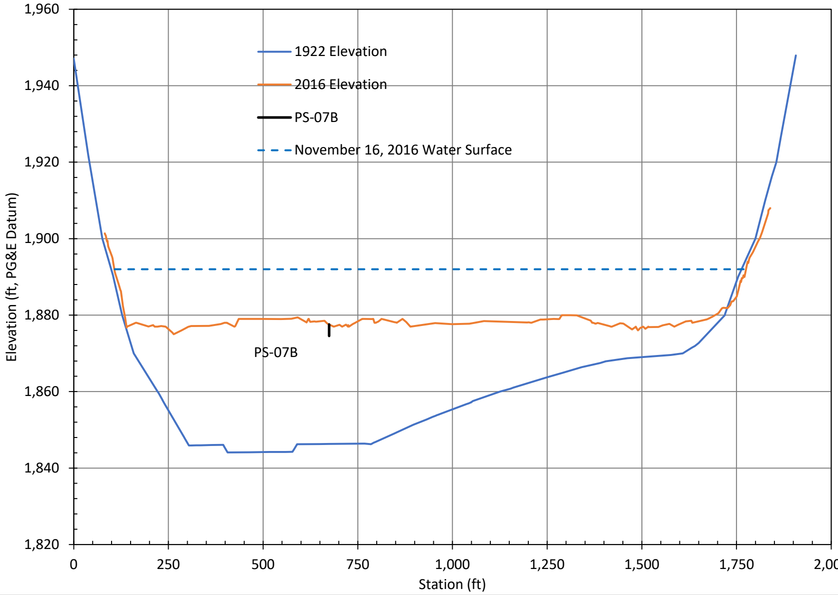
2015-16 Bathymetry (PG&E)



1922-2015 Comparison







Part 2: Overview of Lake Pillsbury Sediment Storage Calculations

Two methods were used to estimate total sediment volume within Lake Pillsbury:

1. Digitized 1922 surface was subtracted from the 2015 DTM and bounded by the 2015 reservoir slope toe. Result: 22,000,000 cu yds.
2. Each surface – 1922 digitized surface and the 2015 DTM were subtracted from a surface plane with the assigned maximum reservoir height of 1910 ft. The two results were subtracted. Result: 20,500,000 cu yds.
3. Used 21,000,000 cy yds for the Feasibility Study.

QUESTIONS?

Part 3: Overview of Lake Pillsbury "Mobile Sediment" Calculations

How Do We Expect Lake Pillsbury Sediment to be Eroded, and How Much?

We have learned a lot about sediment mobility post-dam removal through recently completed dam removal projects.

Example #1:
Wide impoundments with deep sediment depths (>> bankfull channel depth) = Transport a significant percentage of the impounded sediment.
We can equate this scenario to Eel River within Lake Pillsbury.

Example #2:
Wide impoundments w/ shallow sediment depths (< or = bankfull channel depth) = Transport only a small percentage of the impounded sediment.
We can equate this scenario to Salmon Creek within Lake Pillsbury.

Example #3:
Narrowly confined impoundments regardless of sediment depth = Often transport 100% of impounded sediment.
We can equate this scenario to the Rice Fork within Lake Pillsbury.

Note: other scenarios exist, but we are focusing on those that apply to the removal of Scott Dam.

Example #1 – Lake Mills: Glines Canyon Dam Removal

Wide Impoundment, Deep Sediment: Lake Mills draining post Glines Canyon Dam Removal on the Elwha River.

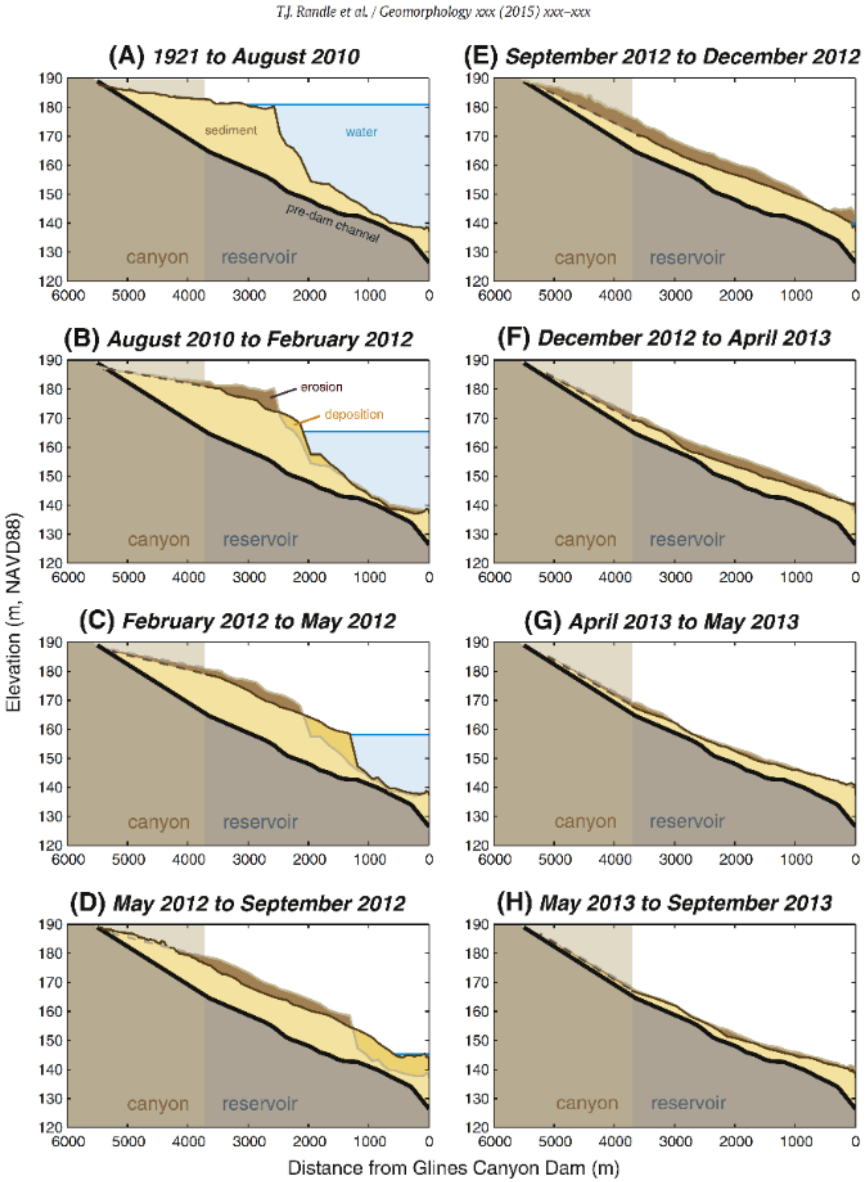
As the channel first down cuts into the impounded sediment, it creates a wide braided channel with a much flatter slope. The channel actively moves within the braided channel width transporting a significant amount of sediment and developing highly erosive terraces as it continues to down cut. This process continues until the slopes start to steepen and eventually the pre-dam riverbed and floodplain elevations are reached.

Example #1 – Lake Mills: Glines Canyon Dam Removal

Lake Mills Draining & Sediment Mobilizing Post-Glines Canyon Dam Removal.

Example #1 – Lake Mills: Glines Canyon Dam Removal

Lake Mills Draining & Mobilizing Sediment Post Dam Removal.



Similar to Eel River Arm Upstream of Scott Dam

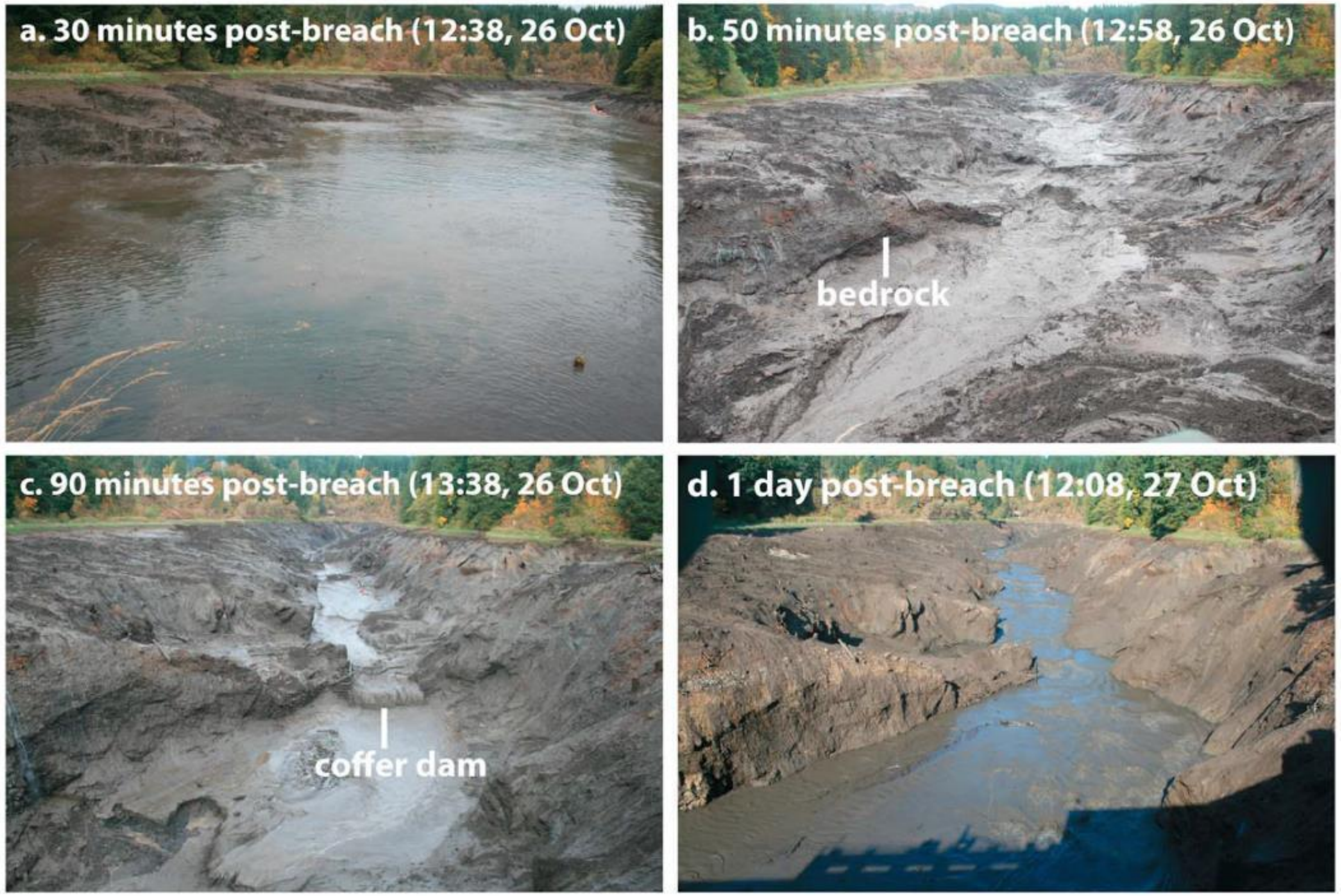
Example #2 – Tannery Brook Dam Removal

Wide impoundment, shallow sediment:
Tannery Brook Dam removal and pond draining post dam removal.

Similar to Gravelly Valley Tributaries

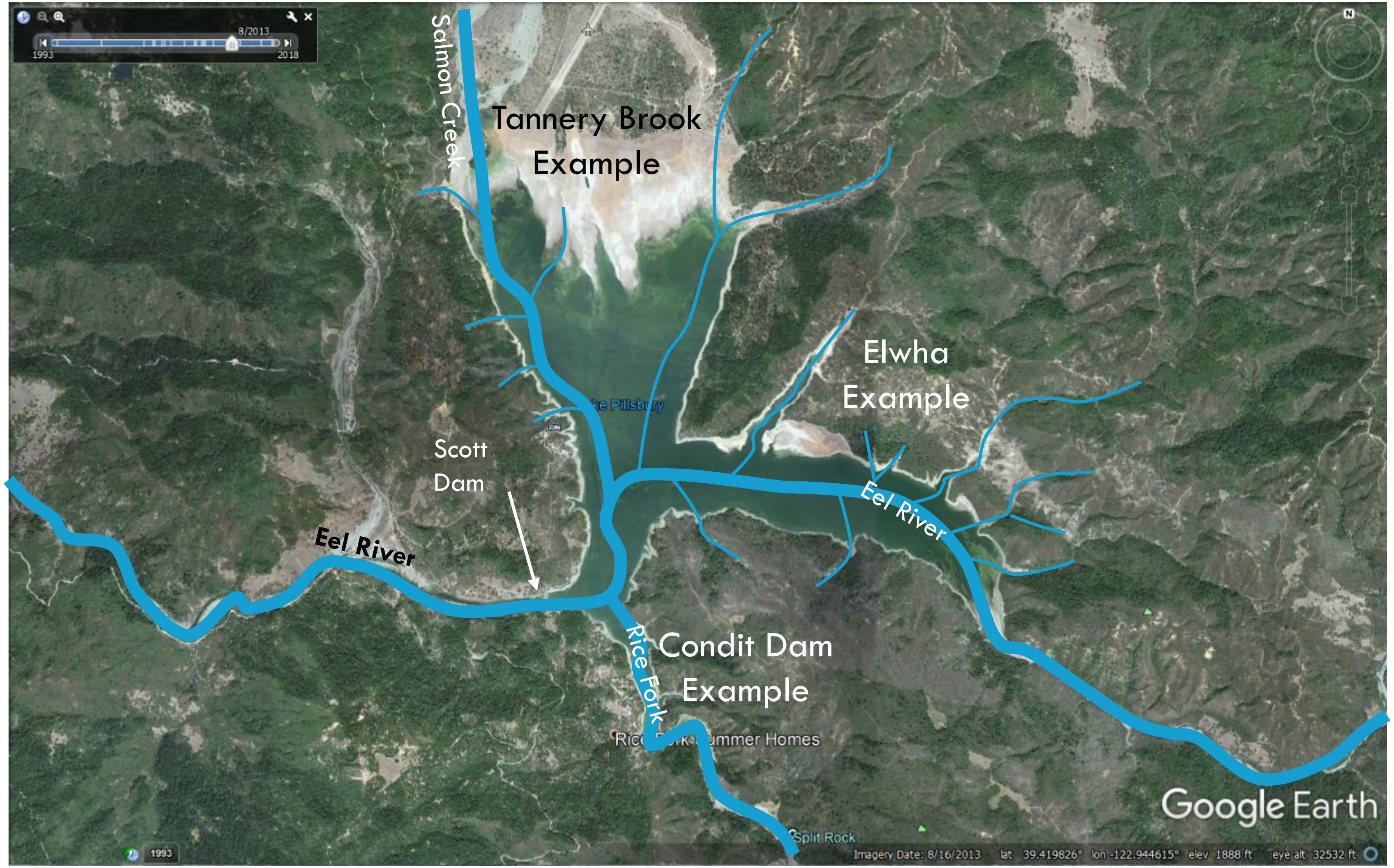
Example #3 – Condit Dam Removal

Condit Dam Removal: Narrowly Confined Valley = All Impounded Sediment Mobilizes



Similar to Rice Fork Tributary

Application to the Eel River: Planform



Needs:

1) Vertical incision process and depth
2) Lateral migration process and width
3) Side-slope assumptions

4) Volume Calculations

Observations from Lake Pillsbury during 2013-14 drought (9,000 ac-ft)

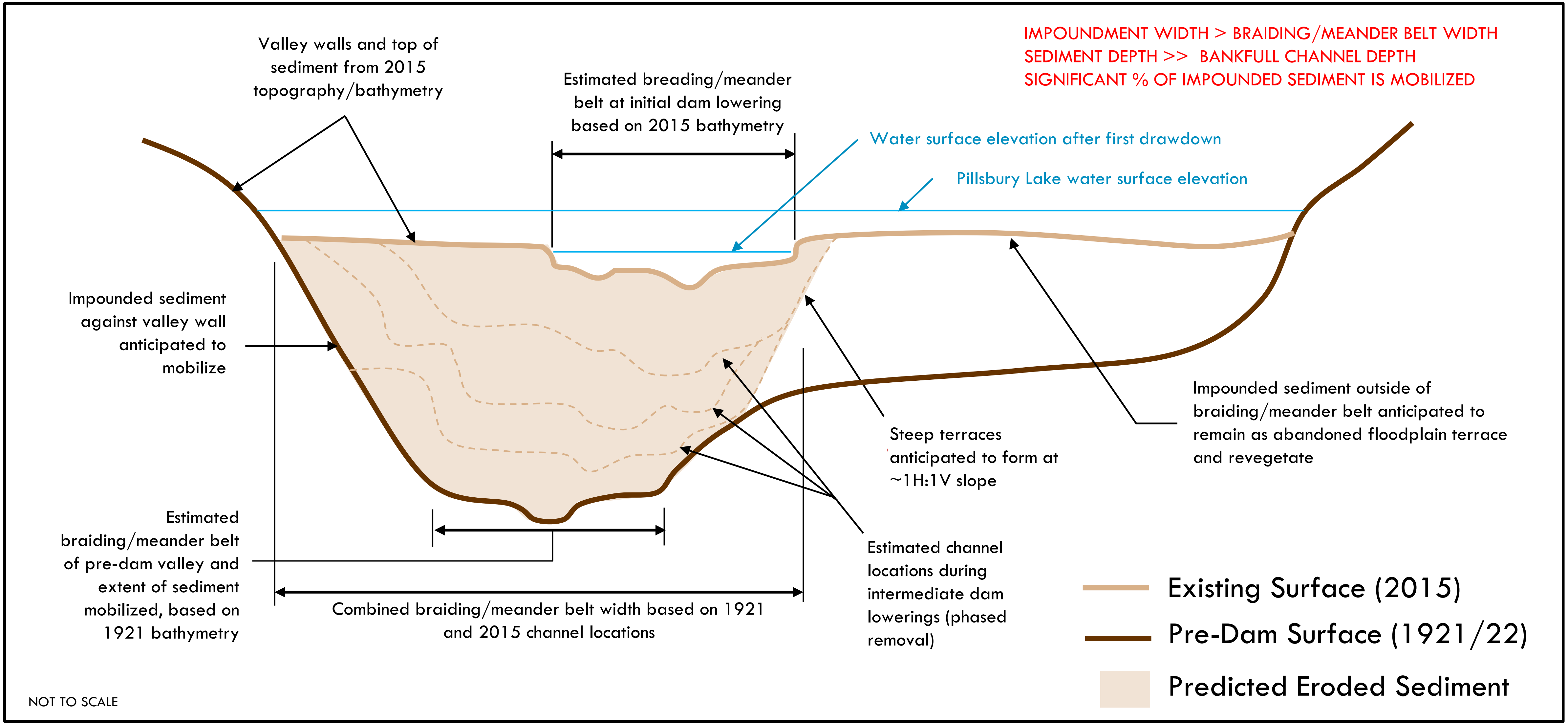
Mobile Sediment Volume Analysis Methods

- Mobile sediment boundaries were digitized in AutoCAD for the Rice Fork, Salmon Creek, Squaw Valley Creek, & main-stem Eel River.
- Recent bathymetry digitized in AutoCAD from PG&E 2015 bathymetric map. Historic valley bottoms and channel alignments were digitized in AutoCAD using USGS 1921 Survey data.
- Bankfull widths for Rice Fork, Eel River, and Salmon Creek calculated from regional hydraulic geometry relationship (Bieger et al. 2015) with watershed size calculated from USGS StreamStats. Braiding/meander belt widths were approximated based on bankfull width (Williams 1986).
- **Rice Fork**: Braiding/meander belt width = valley bottom width, so all impounded sediment has the potential to mobilize. Volume = difference between 2015 bathymetry and 1921 survey data.
- **Salmon Creek & Squaw Valley Creek**: Braiding/meander belt width < valley bottom width, so less sediment has potential to mobilize. Volume = difference between 2015 bathymetry and 1921 survey data, within braiding/meander belt width, with 1H:1V side slopes.
- **Eel River**: Braiding/meander belt width < valley bottom width, but initial braiding/meander belt is offset from final channel alignment; so combined braiding/meander belt is wider, and more sediment has potential to mobilize. Volume = difference between 2015 bathymetry and 1921 survey data, within the outer edges of both braiding/meander belt widths, with 1H:1V side slopes.

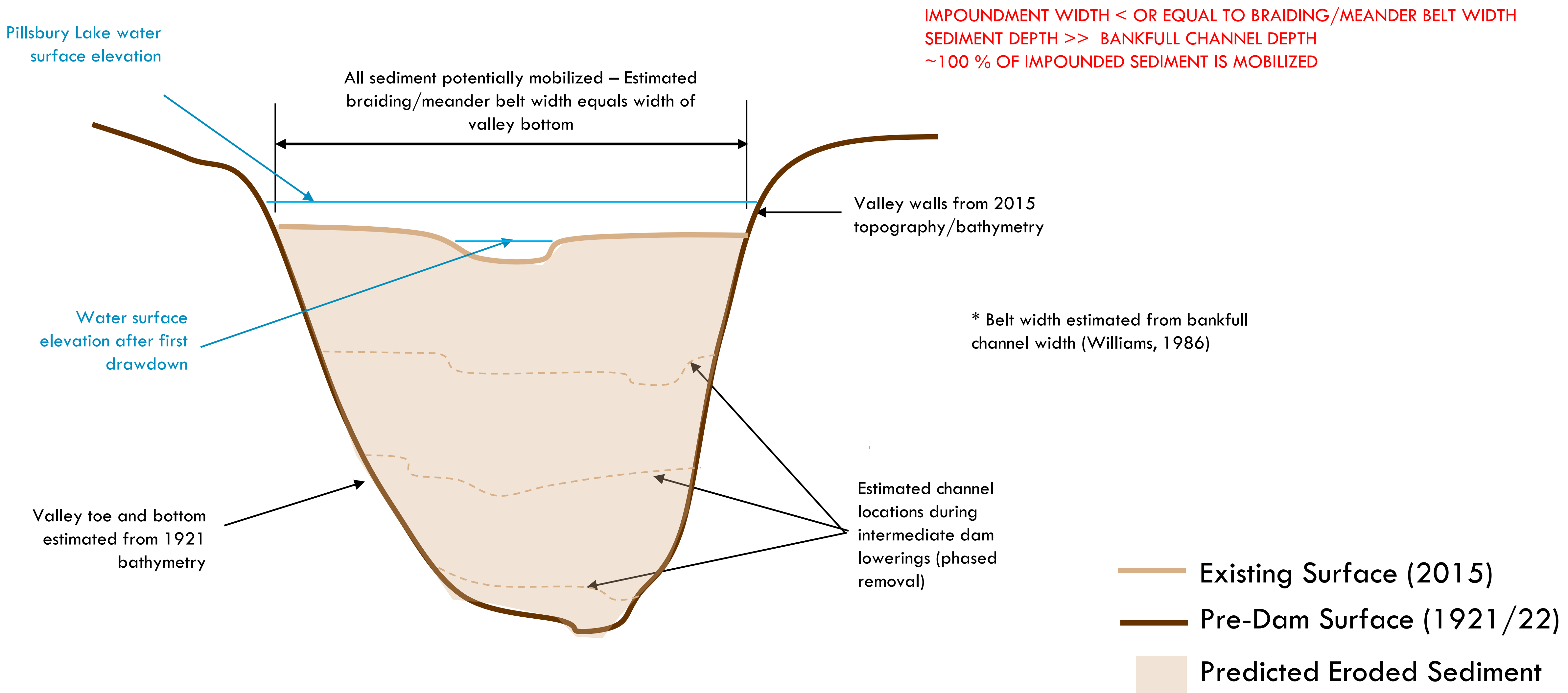
Mobile Sediment Volume Analysis Assumptions

- Analysis assumes that all sediment outside the mobile boundary will be stabilized in place through natural revegetation and/or planting of riparian vegetation.
- Analysis assumes that the river channel width after decommissioning will eventually return to historic channel width and location.
- Assumes a river bank side-slope of 1:1.
- Does not account for sediment accumulation that has occurred after the 2015 bathymetric survey.
- Does not provide an estimate for the area and extent of riparian vegetation/topsoil that may be needed for stabilizing old lakebed and riparian forest recovery.

Conceptual Sediment Erosion: Eel River

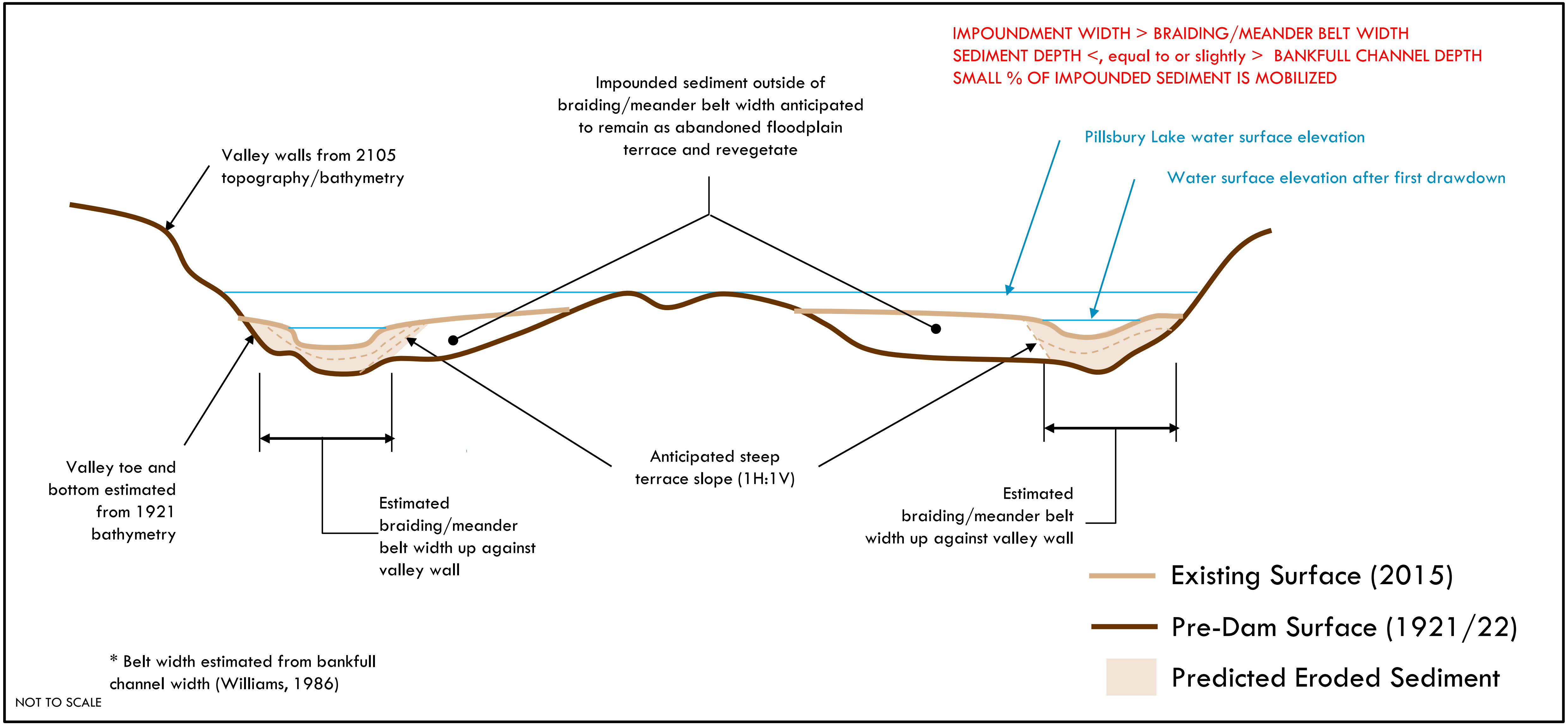


Conceptual Sediment Erosion: Rice Fork

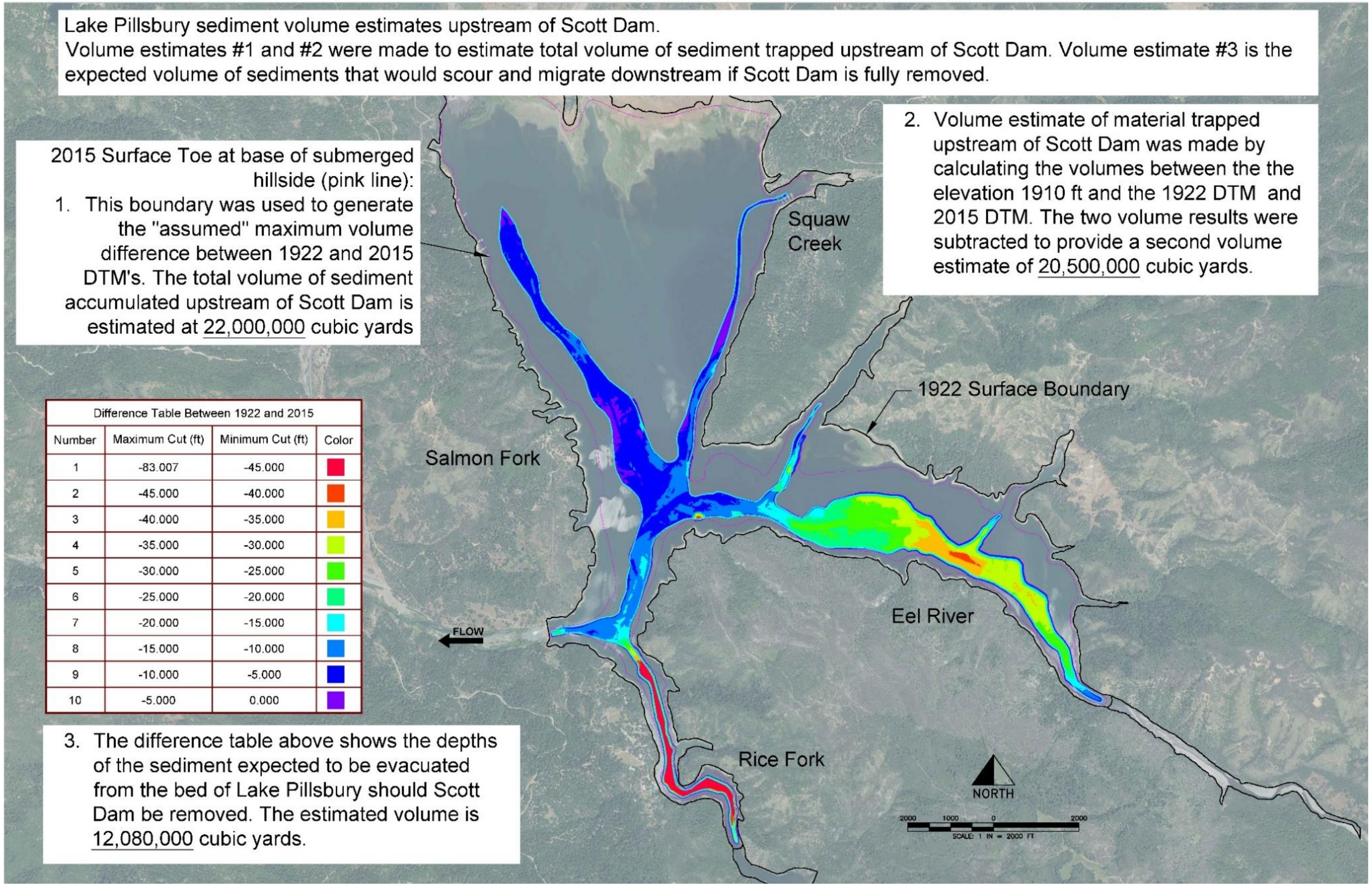


NOT TO SCALE

Conceptual Sediment Erosion: Gravelly Valley Tributaries



Results



- Varying meander belt widths based on three examples
- Depth based on 1921/22 bathymetry and profile surveys
- **Best estimate is approximately 12,000,000 cu yds of "erodible sediment"**

QUESTIONS?

Part 4: Overview of Potential Sediment Management Options with different Scott Dam Decommissioning Options

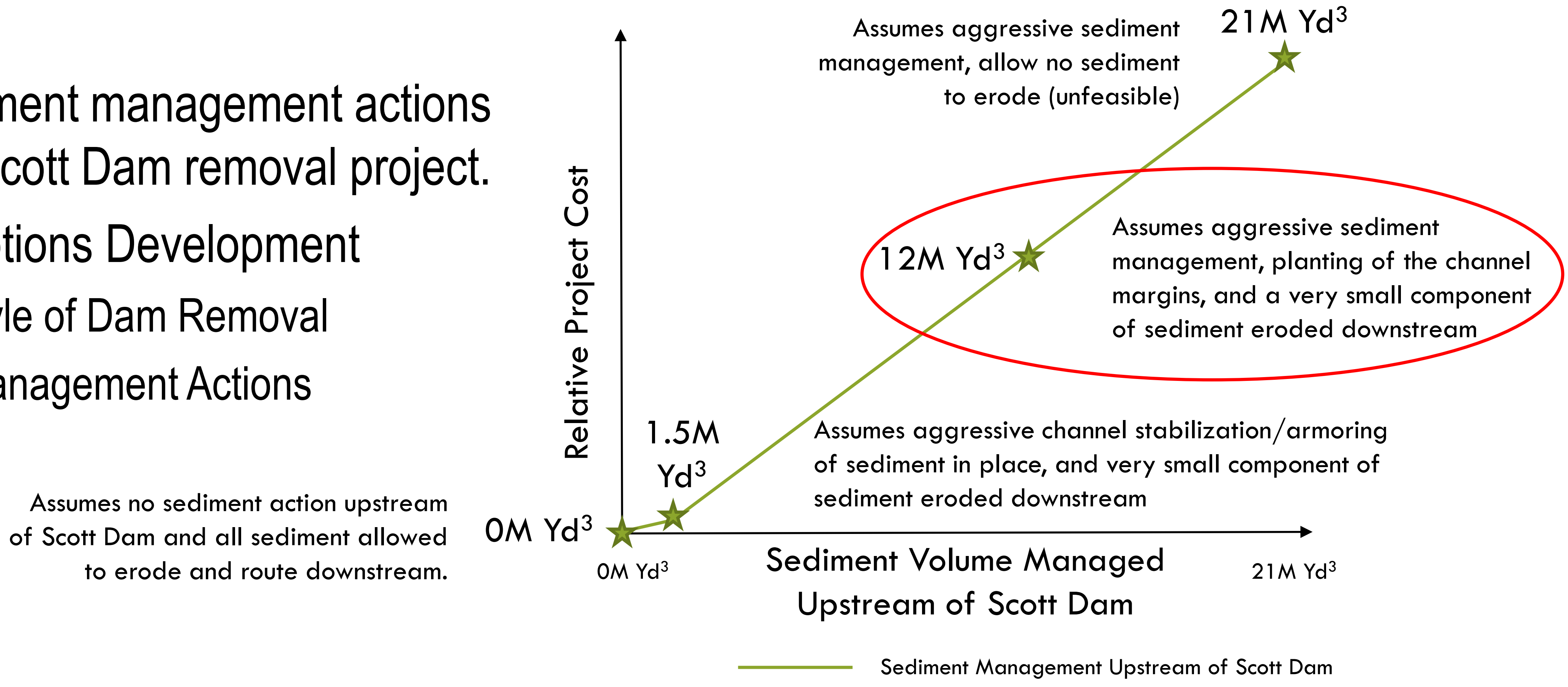
Part 4: Sediment Management Options

Sediment Management Planning Goal:

Identify the sediment management actions needed for the Scott Dam removal project.

Management Options Development

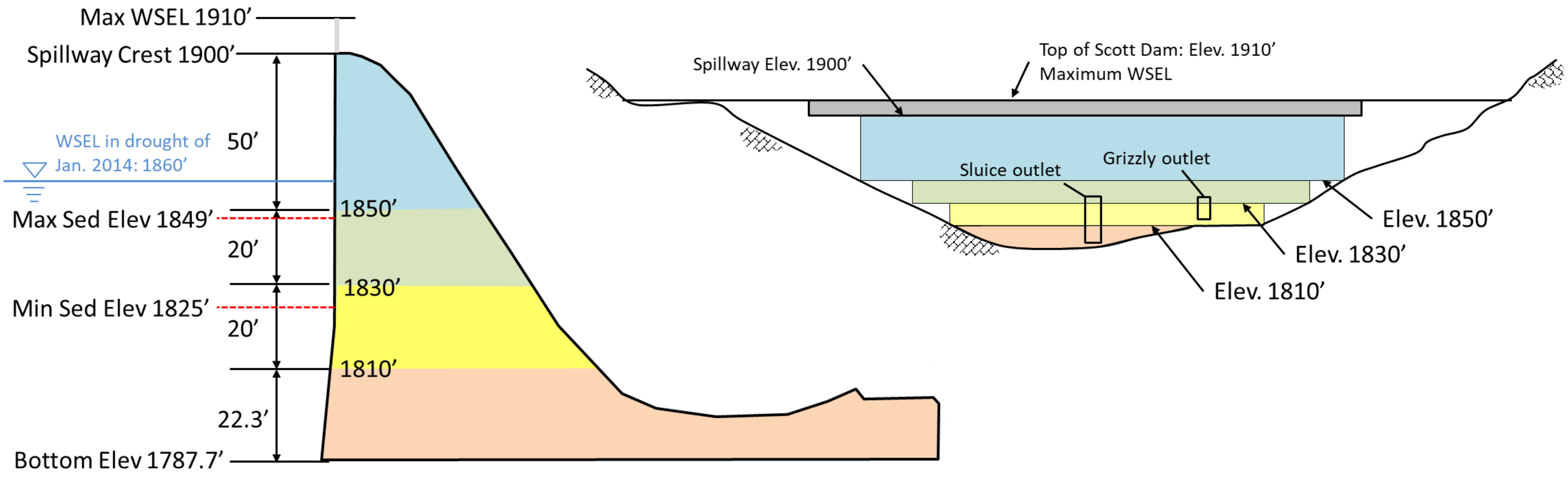
- Rate and Style of Dam Removal
- Sediment Management Actions



Rate and Style of Dam Removal

Rapid Dam Removal – One Year Duration

Phased Dam Removal – Four Year Duration



Elevations are in PG&E Datum

Scott Dam is a cyclopean concrete, ogee gravity dam ~130 ft in height with a total length of 805 ft

Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

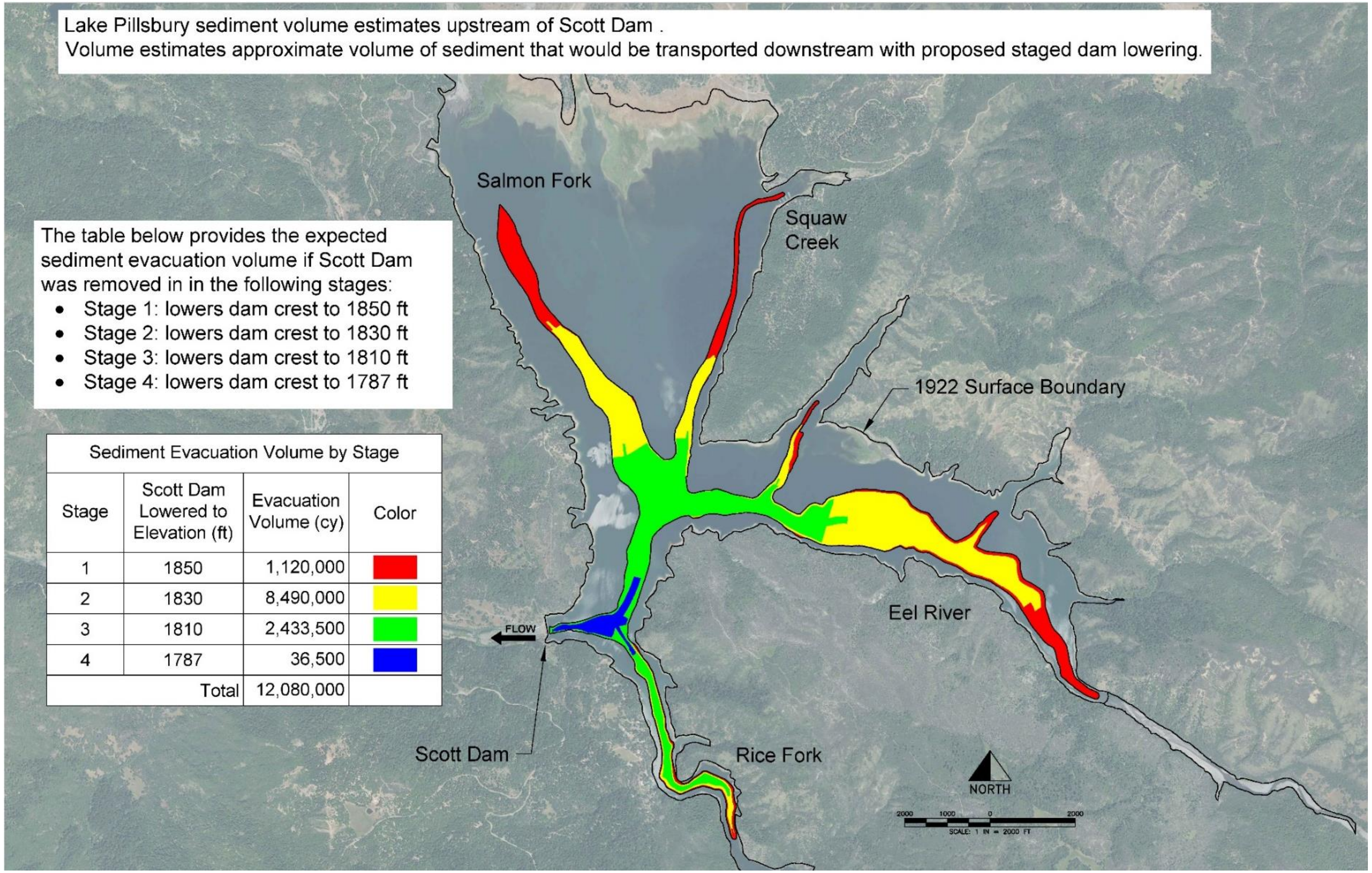
Sediment Management Actions

Sediment Retention

- Surface Stabilization
- Sediment Relocation

Sediment Release

- Rapid Dam Removal
- Phased Dam Removal

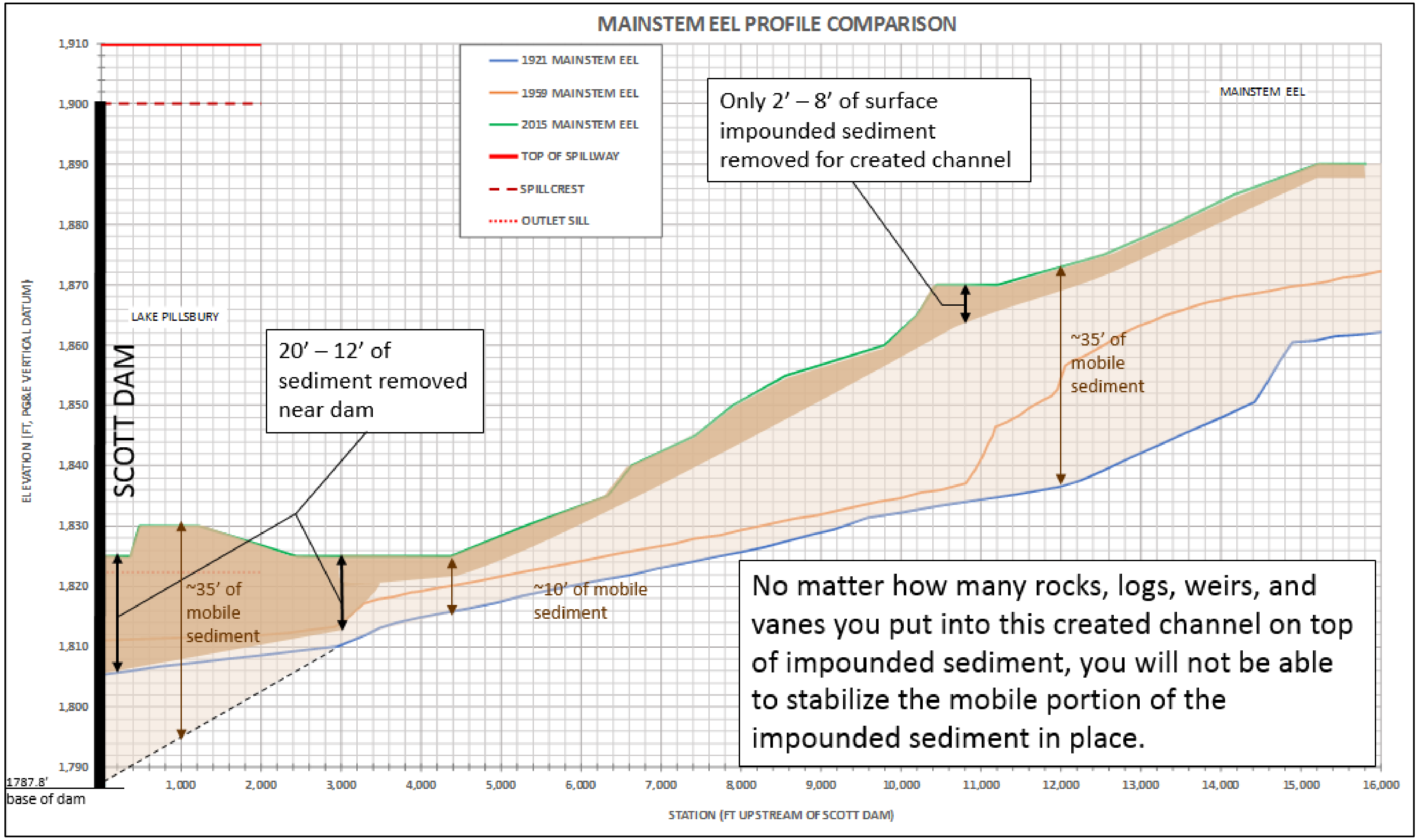


Sediment Evacuation Volume by Stage

Stage	Scott Dam Lowered to Elevation (ft)	Evacuation Volume (cy)	Color
1	1850	1,120,000	red
2	1830	8,490,000	yellow
3	1810	2,433,500	green
4	1787	36,500	blue
	Total	12,080,000	

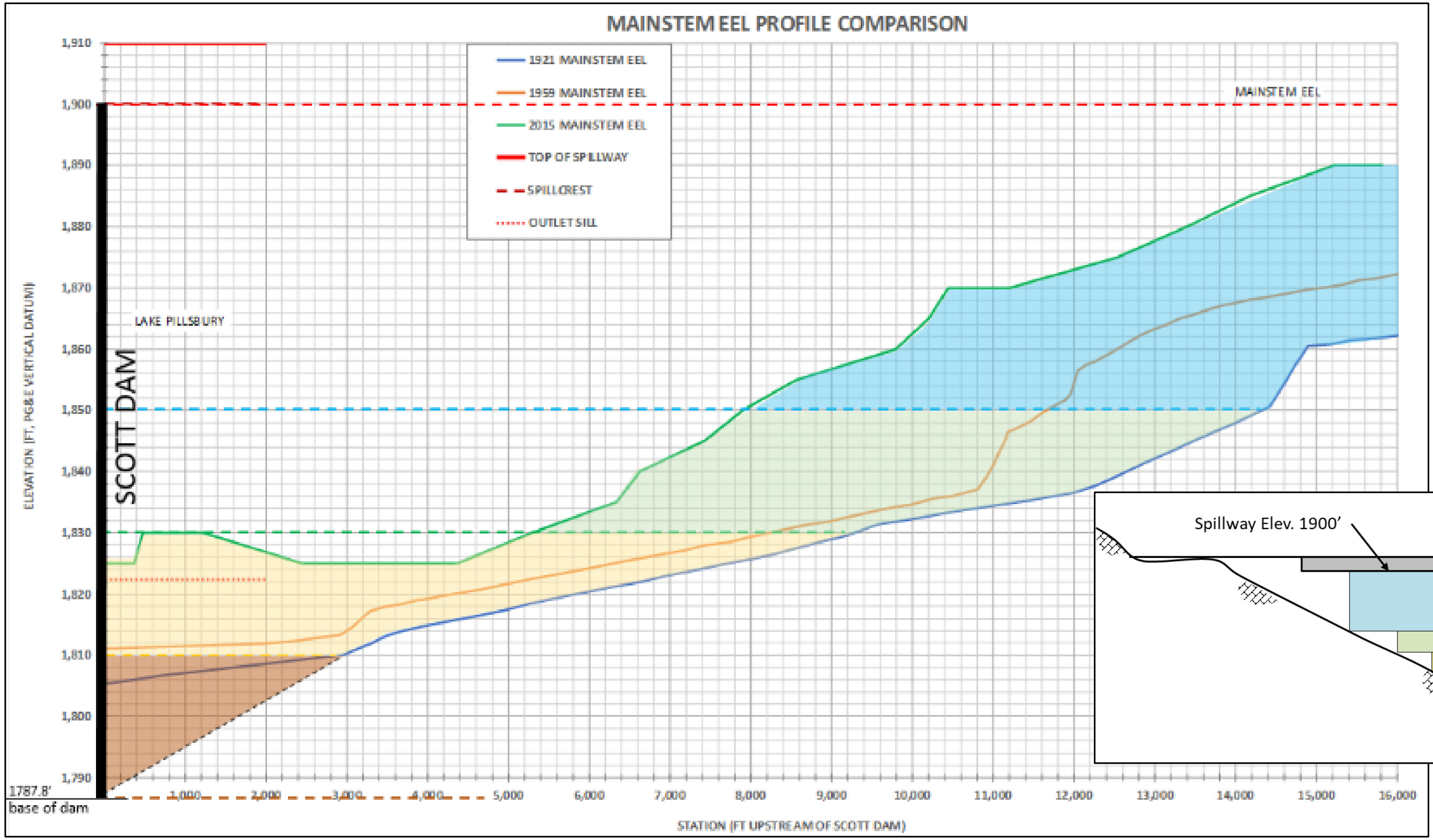
Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

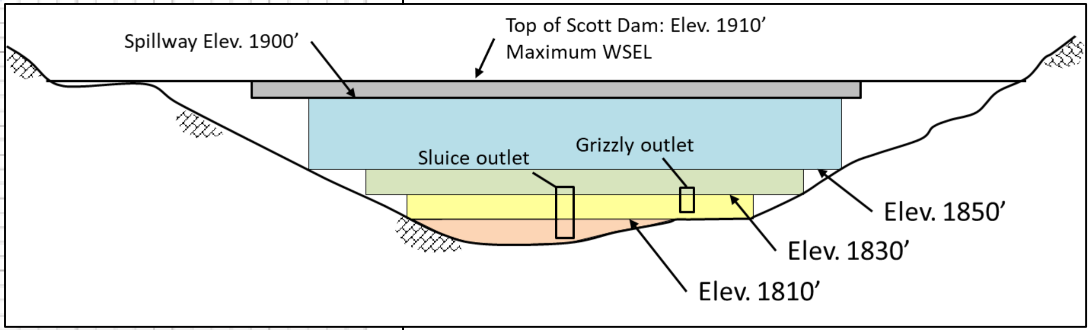
Surface Stabilization – Mainstem Eel River



Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

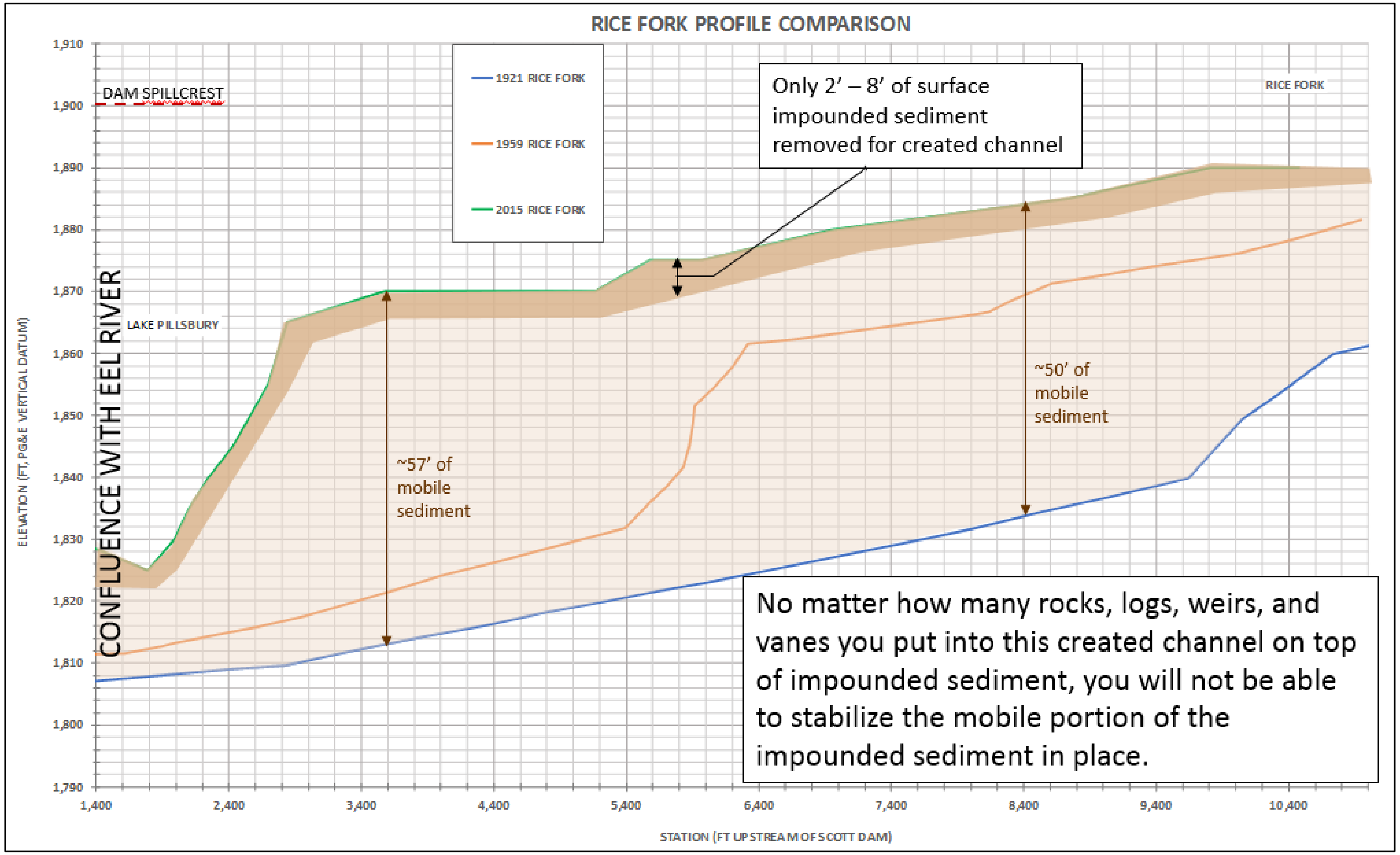
Sediment Relocation – Mainstem Eel River





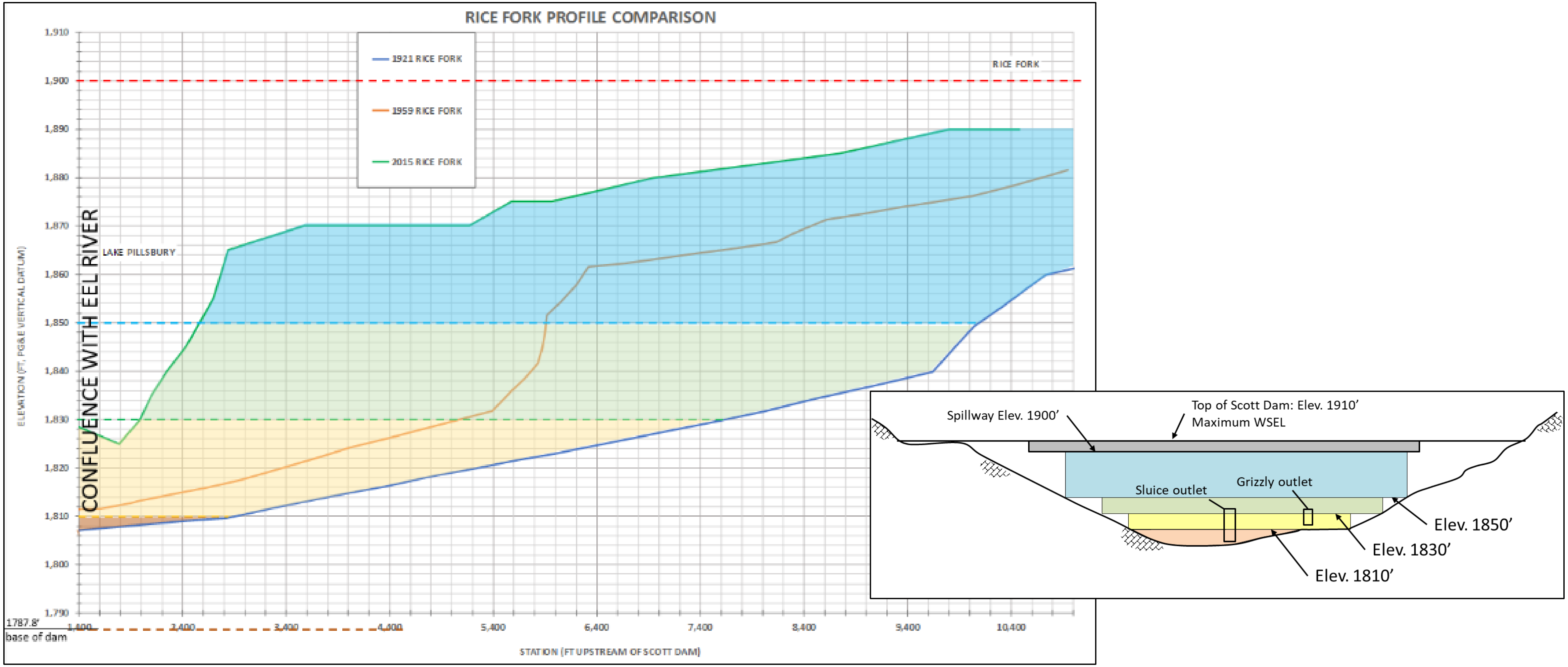
Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

Surface Stabilization – Rice Fork



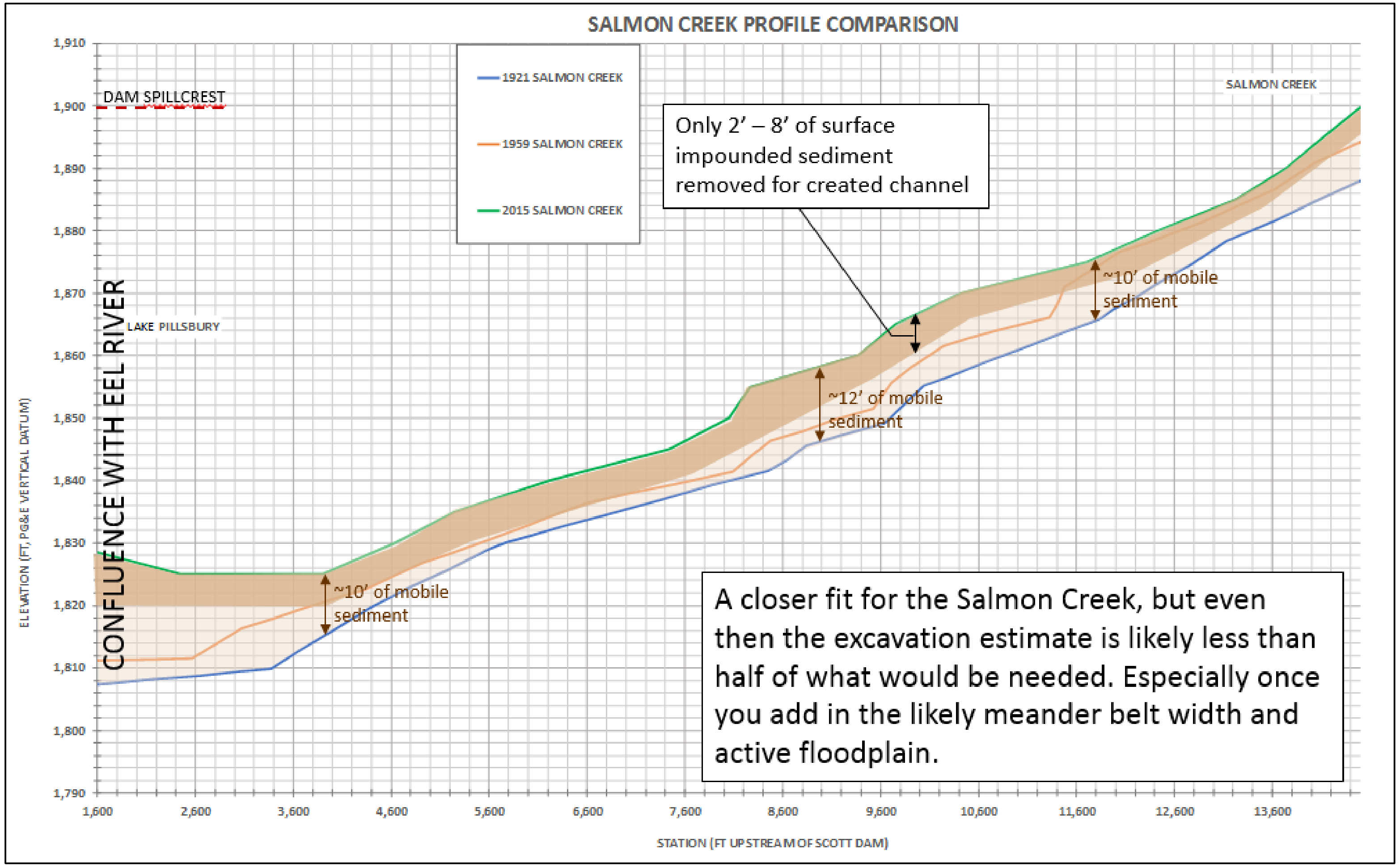
Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

Sediment Relocation – Rice Fork



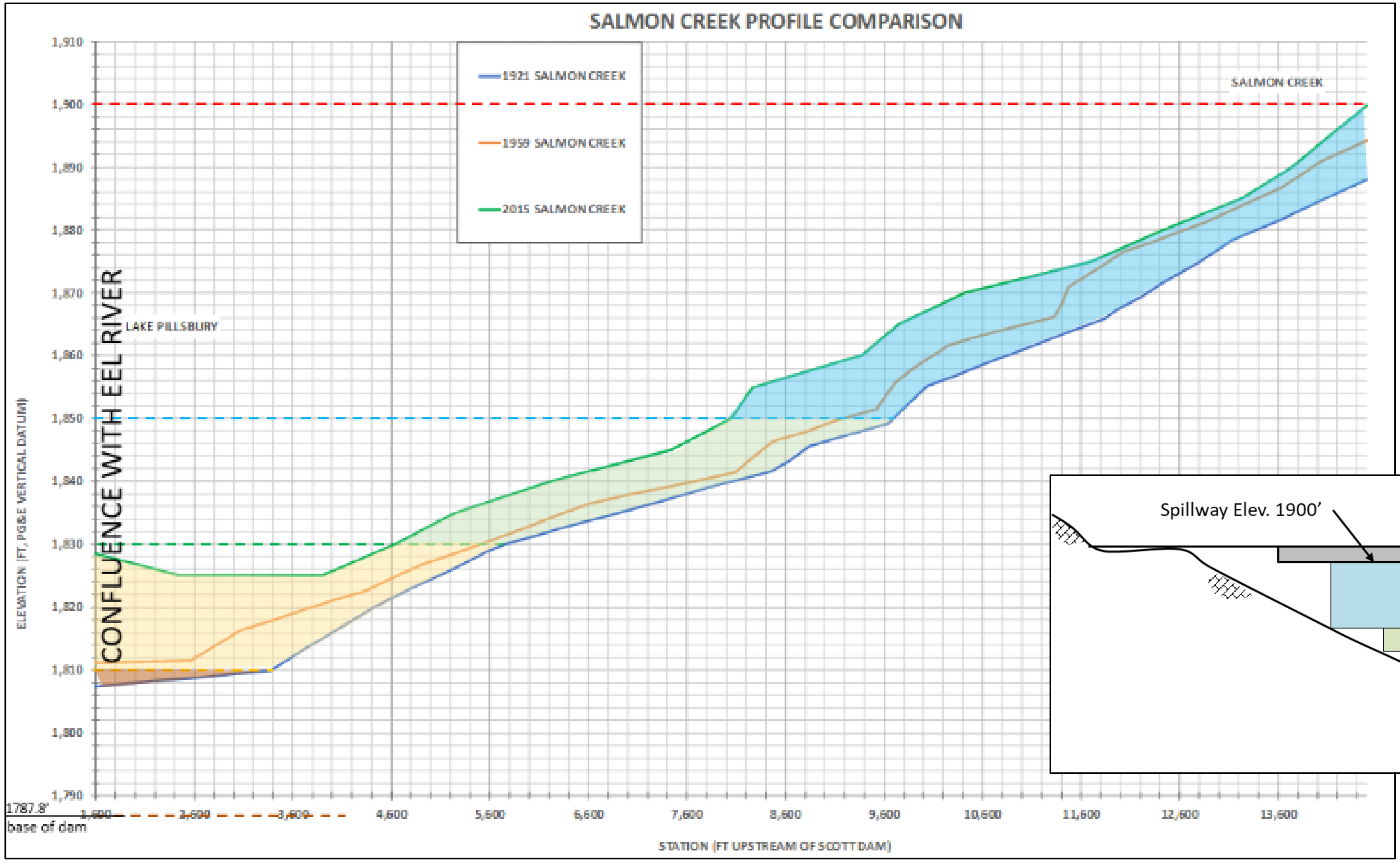
Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

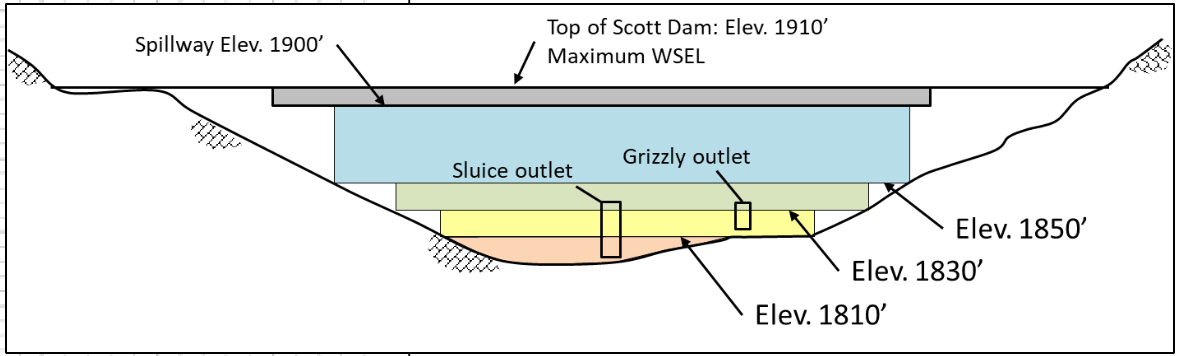
Surface Stabilization – Salmon Creek



Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

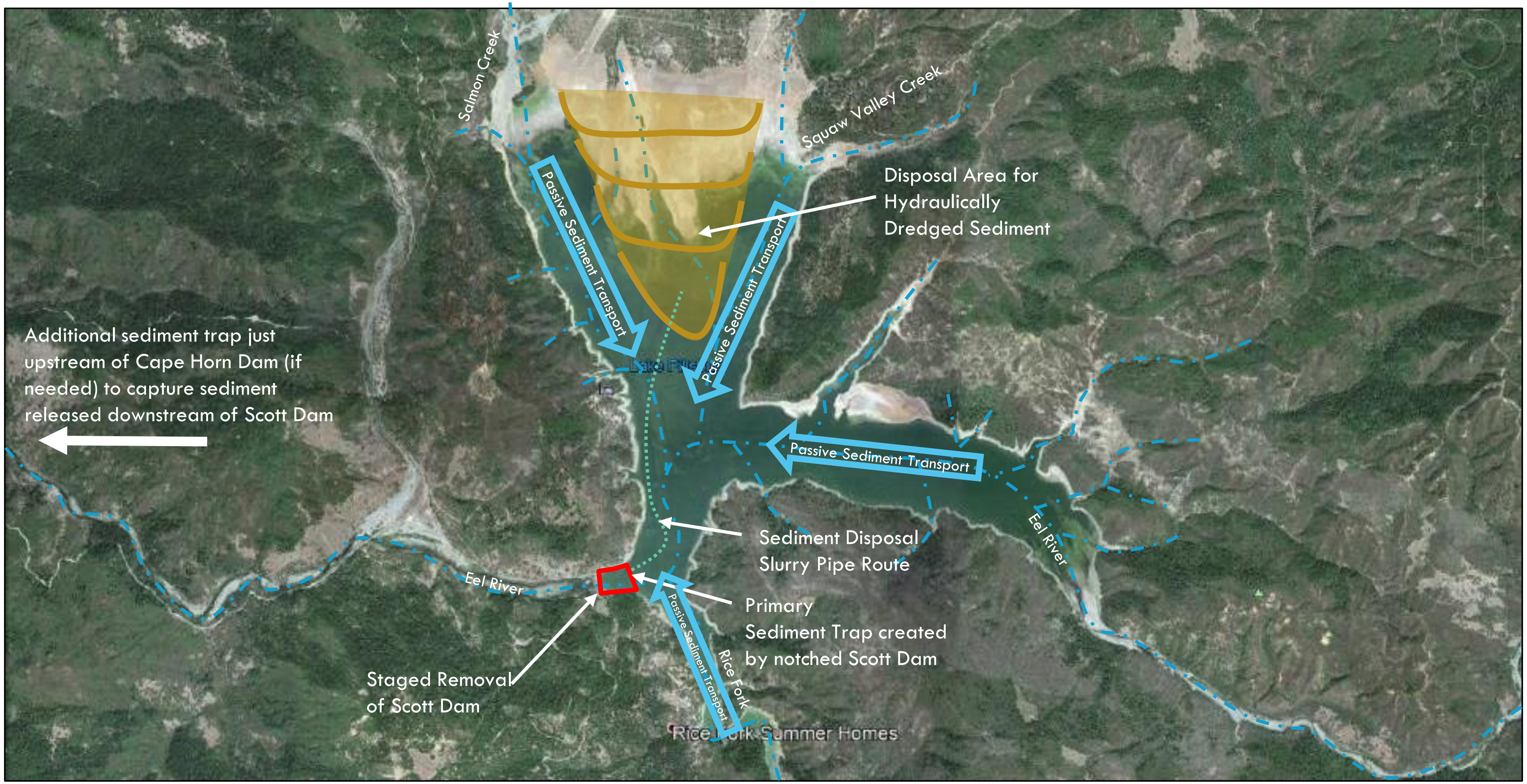
Sediment Relocation – Salmon Creek





Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

Phased Removal with Mobile Sediment Relocation



Sediment Relocation

Sediment Removal from Lake Pillsbury

- Hydraulic Dredging/Sluicing
- Mechanical Excavation

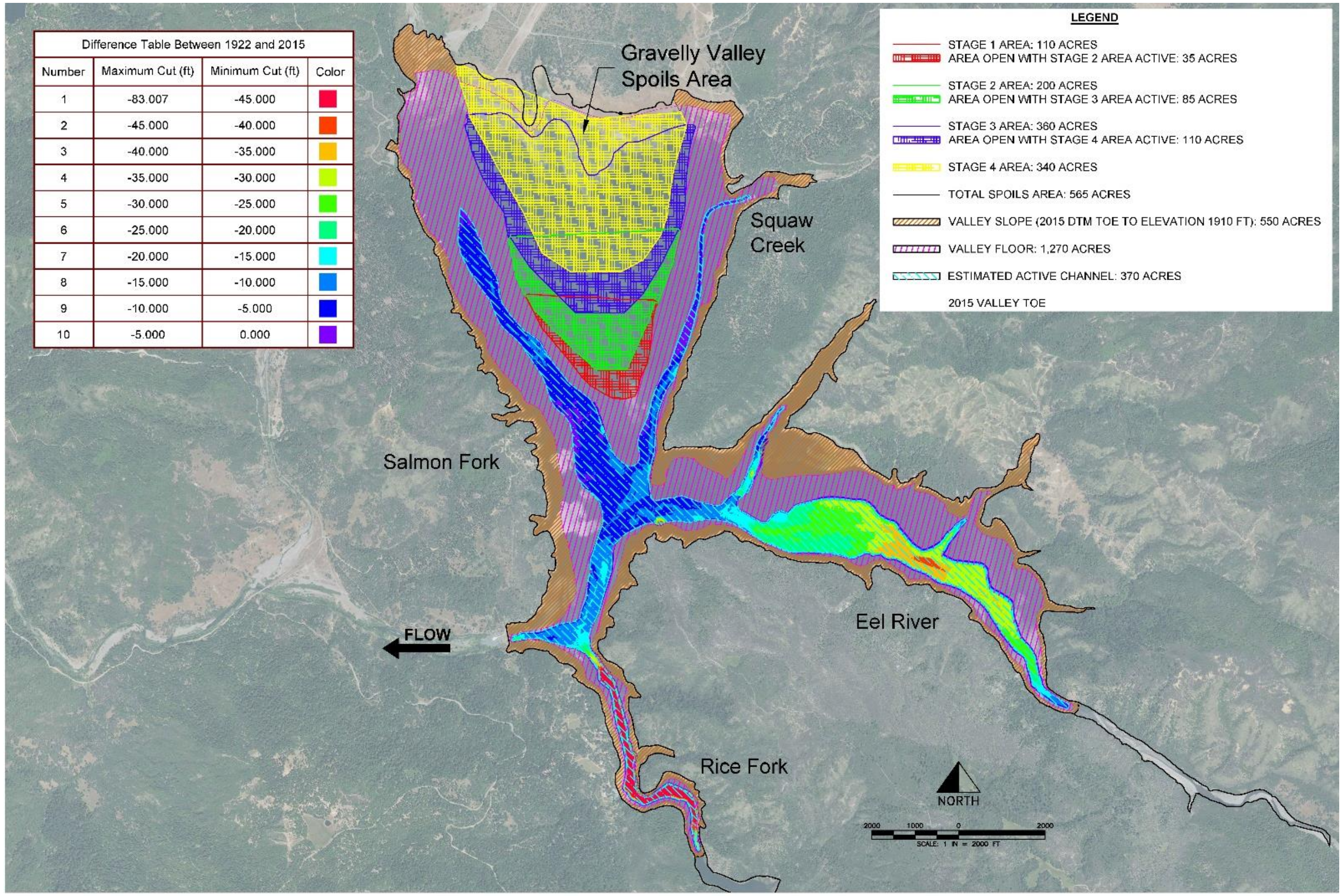
Sediment Transport to Disposal Area

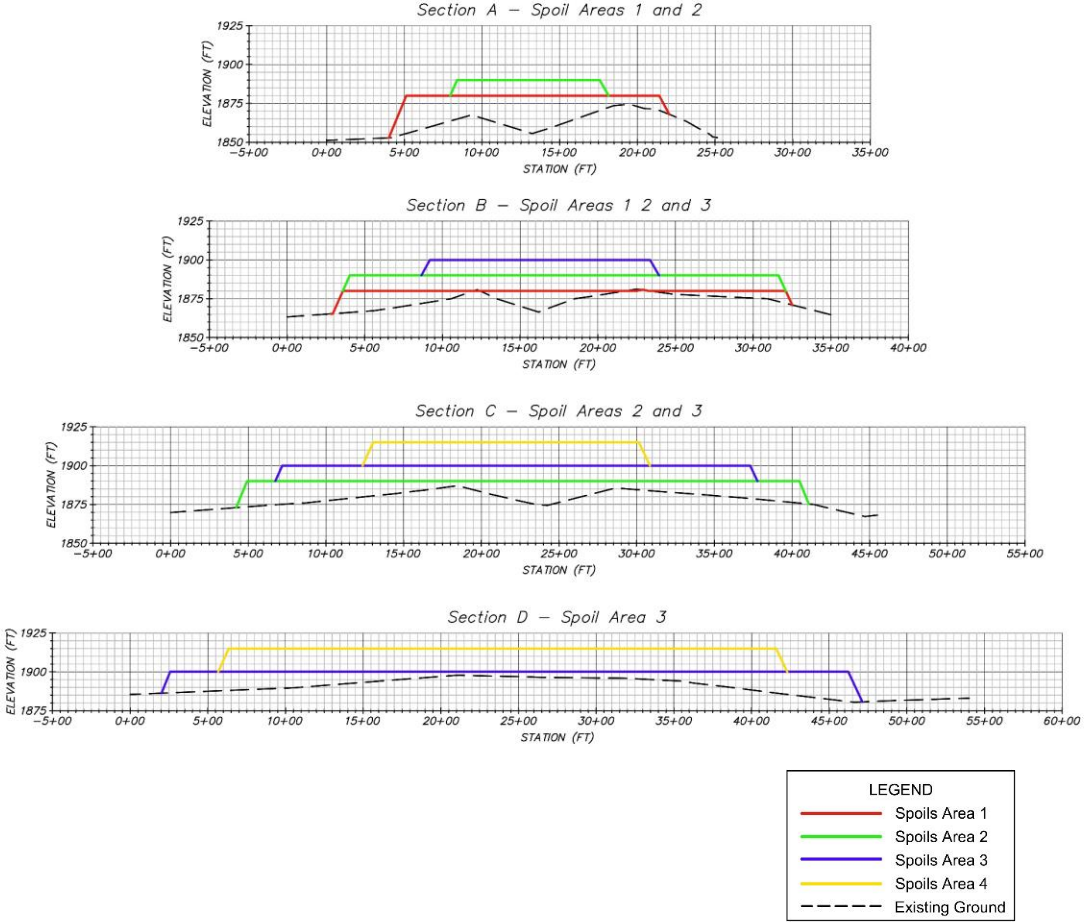
- Transport via Pipeline
- Transport via Off-Highway Hauling

Sediment Disposal

- Gravelly Valley Disposal Area

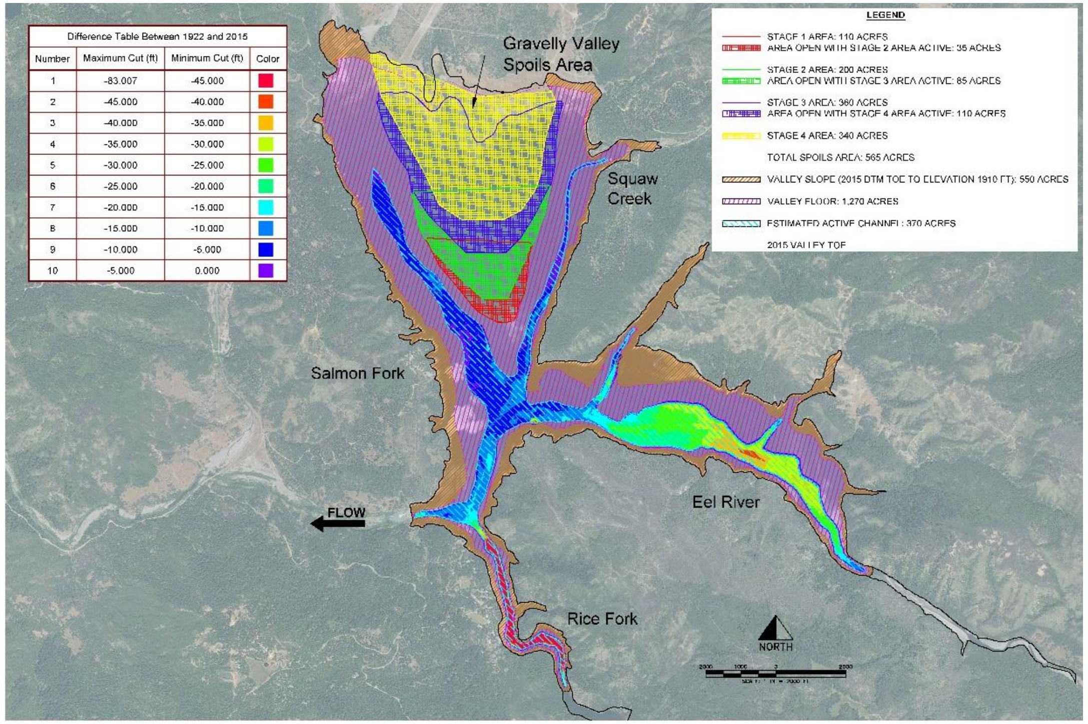
Gravelly Valley Disposal Area – Staged Placement





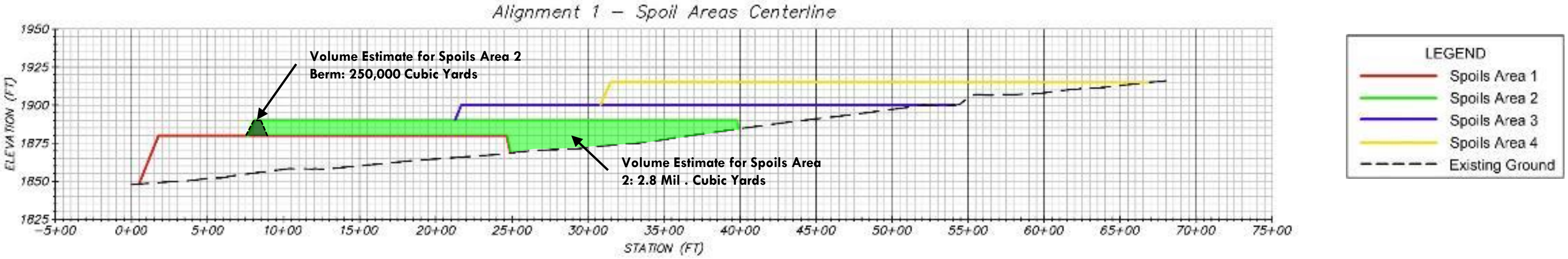
Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

Gravelly Valley Disposal Area – Storage Capacity



Number	Maximum Cut (ft)	Minimum Cut (ft)	Color
1	-83.007	-45.000	
2	-45.000	-40.000	
3	-40.000	-35.000	
4	-35.000	-30.000	
5	-30.000	-25.000	
6	-25.000	-20.000	
7	-20.000	-15.000	
8	-15.000	-10.000	
9	-10.000	-5.000	
10	-5.000	0.000	

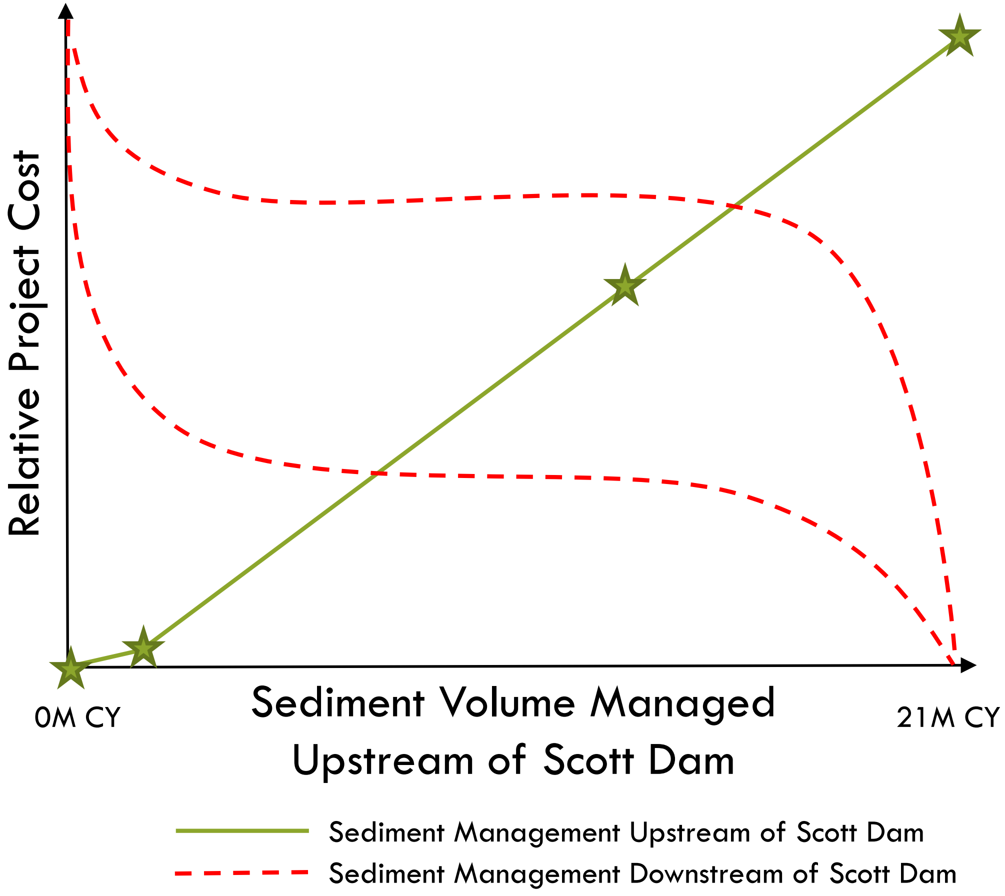
CONCLUSION: There is sufficient space to spoil 16 million CY of sediments at Gravelly Valley spoils area



Elevations are in PGE vertical datum: Subtract 81.5 ft to get to NGVD29

Sediment Management Assessment

Sediment Management Downstream of Scott Dam



Downstream Considerations

- Amount of Sediment Released
- Timing of Sediment Released
- Characteristics of Sediment Released
- Possible Contaminants Released
- Potential Duration of Sediment Release
- Potential Location(s) of Sediment Impacts
- Potential Timing of Sediment Impacts

Part 5: Suspended Sediment Concentration Analysis for different Scott Dam Decommissioning Options

Objective and Scenarios

Provide an "order of magnitude" analysis for the natural erosion of fine sediment expected from Lake Pillsbury from Scott Dam removal

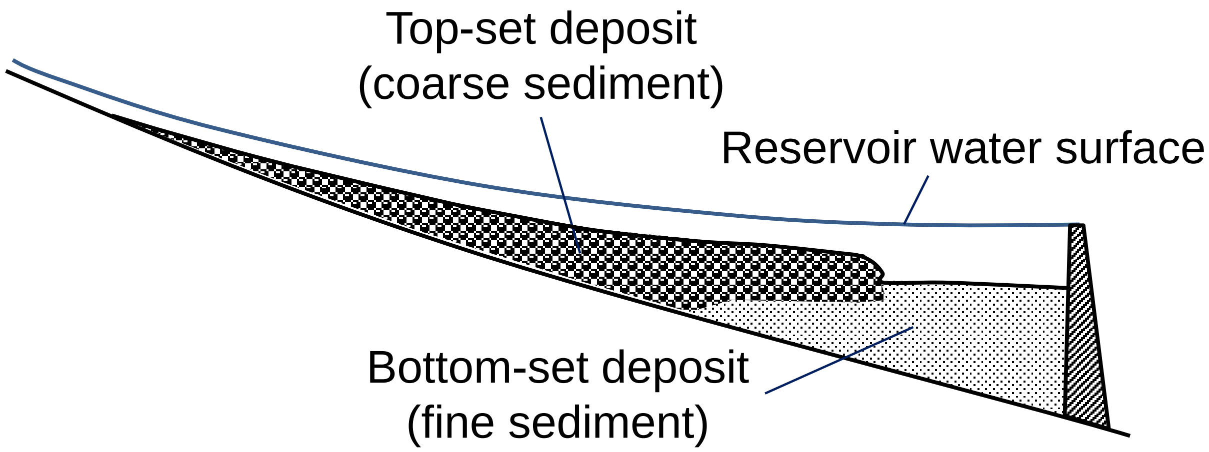
Initial Scenarios

Scenario #1: Rapid removal of Scott Dam (1 year), rapid erosion of Lake Pillsbury sediment

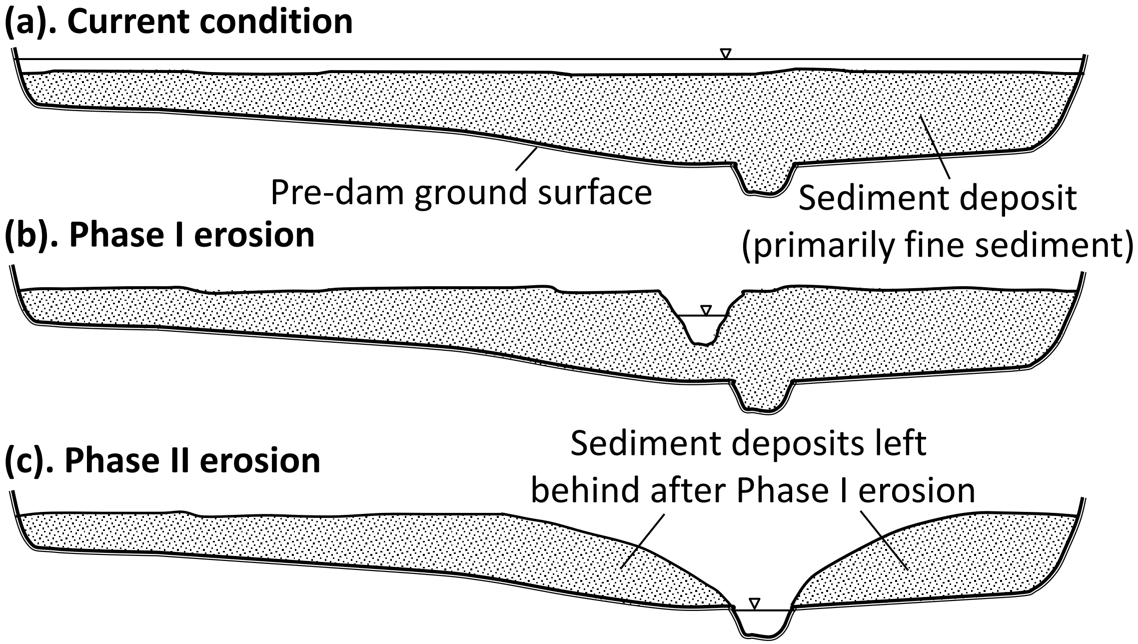
Scenario #2: Phased removal of Scott Dam (4 years), extended erosion of Lake Pillsbury sediment

Conceptual Models: Reservoir stratigraphy and incision process

Stratigraphy



Incision Process

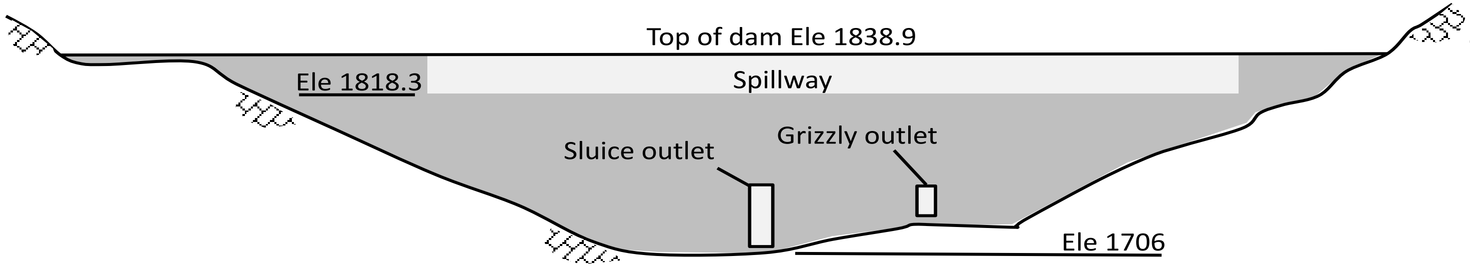


Conceptual model

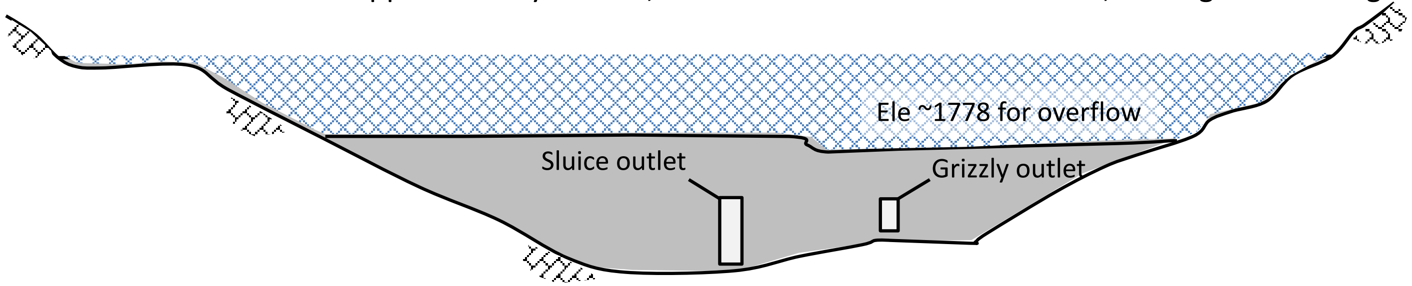
- Rapid removal via Vertical Notching:
  - Rapid erosion of all erodible reservoir sediments (n=1)
  - Erosion would occur during first winter storms
  - Extremely high suspended sediment concentration
  - Shorter duration of high suspended sediment concentration
- Phased removal:
  - Repeated rapid erosion of reservoir sediments with each notching event (n=4)
  - Erosion would occur over multiple years and seasons
  - High suspended sediment concentration
  - Longer duration of high suspended sediment concentration

Potential Scott Dam Vertical Notching Process

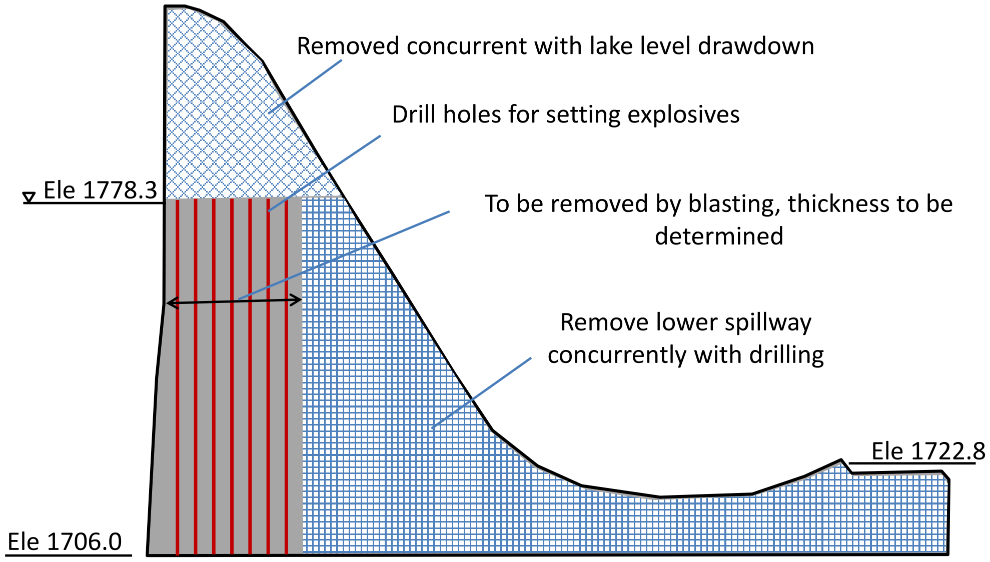
a. Current condition



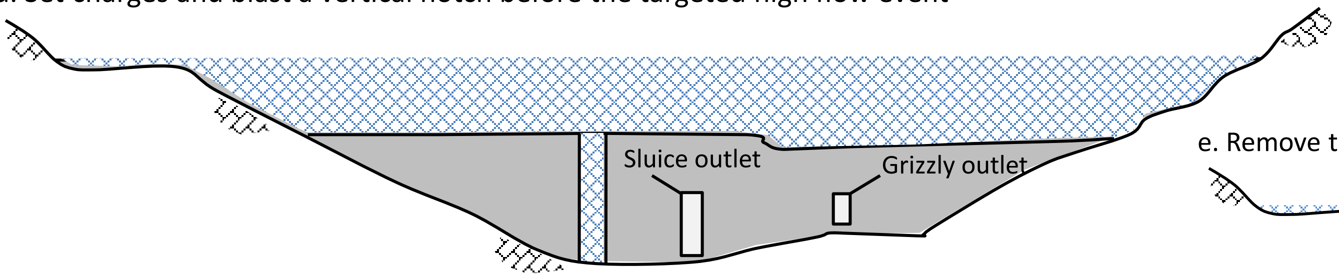
b. Draw lake level down to approximately 1778 ft, remove the dam above lake level, leaving one side higher



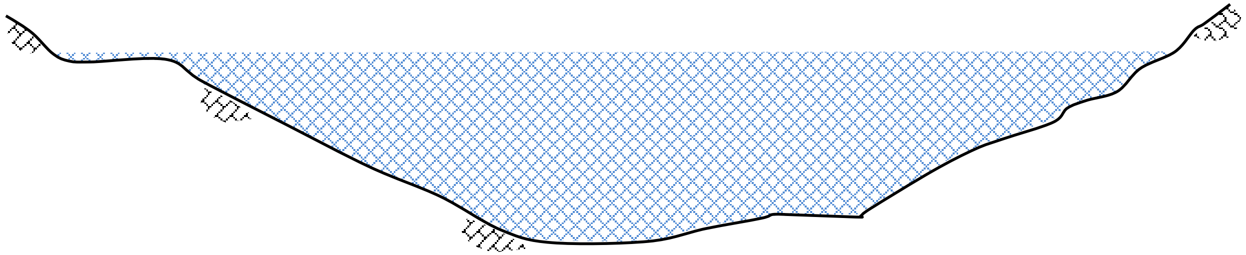
c. Drilling holes for setting explosives and remove lower spillway in the notching section



d. Set charges and blast a vertical notch before the targeted high flow event



e. Remove the rest of the dam



Elevations are in NGVD29 datum: Add 81.5 ft to get to PGE vertical datum

Governing Equations

$$C = \begin{cases} 50\left(\frac{V^3}{gHv_s}\right)^{1.55}, & \frac{V^3}{gHv_s} \le 10 \\ 135\left[ln\left(\frac{V^3}{gHv_s}\right)\right]^{3.1}, & 10 < \frac{V^3}{gHv_s} \le 100 \\ 620\left(\frac{V^3}{gHv_s}\right)^{0.7}, & \frac{V^3}{gHv_s} > 100 \end{cases}$$

Computing suspended sediment concentration based on velocity, depth, and settling velocity of particle based on grain size of sediments in reservoir

$$Q_w = \frac{1.48}{n} B H^{5/3} S^{1/2}$$

Mannings equation to compute velocity based on slope, assumed channel width, and water depth

Compute Suspended Sediment Concentration

Compute Phase 1 erosion duration

$$Q_s = CQ_w/\rho_d$$

Computes suspended sediment transport rate based on concentration, flow, and sediment density

$$t_0 = M_1/Q_s$$

Computes Phase 1 erosion time based on volume of fine sediment in reservoir and suspended sediment transport rate

Assumptions

	Rapid Vertical Notching	Phased Removal
Years for removal and erosion	1	4
Flow for erosion	1,000 cfs to 3,000 cfs	133 cfs
Channel Width	300 ft	300 ft
Channel Gradient	0.01 (1%)	0.01 (1%)
Median grain size	0.11 mm	0.11 mm
Settling velocity	0.000358 ft/sec	0.000358 ft/sec
Sediment dry density	1,590 lb/cu yd	1,590 lb/cu yd
Volume of sediment to be eroded	12,000,000 cu yd	12,000,000 cu yd
Manning's n	0.025	0.025

Results: Rapid removal via Vertical Notching

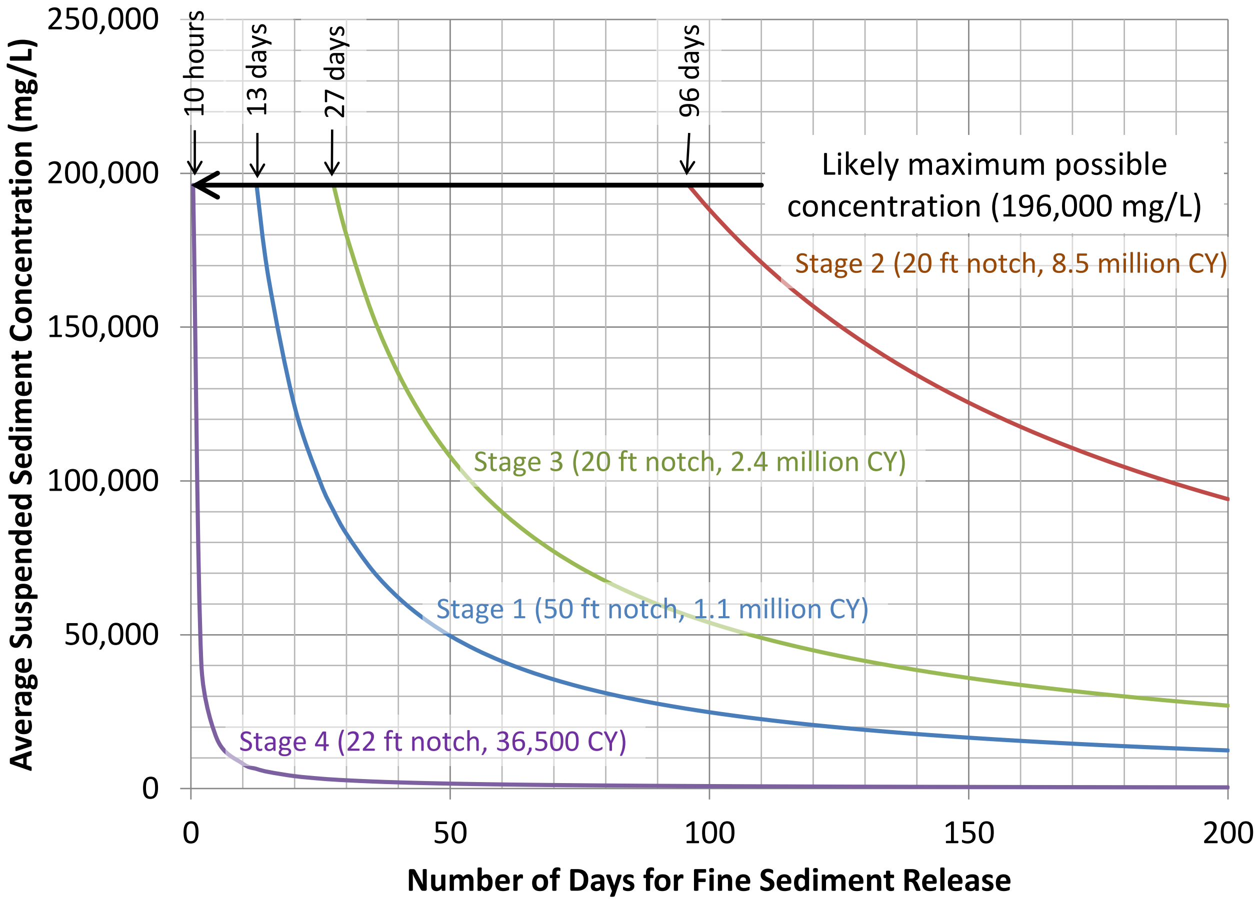
Water discharge	1,000 cfs	2,000 cfs	5,000 cfs
Suspended sediment concentration (mg/L)	457,800	612,500	900,000
Duration of Phase 1 erosion (days)	7.7	2.9	0.8

Conservative Assumptions:

- Phase 1 erosion duration is likely over-estimated
- Channel width may be wider than actual
- Channel gradient assumption may be steeper than actual
- Assumes all 12 million cu yd is fine sediment

Results: 4-Stage Phased Removal

- Maximum computed suspended sediment concentration of 196,000 mg/L
- Duration of maximum suspended sediment concentration varies due to differential volumes in each dam notching phase.
- Longest duration = 96 days for first notching phase, only 10 days for final notching phase
- Total duration ~ 136 days with concentrations = 196,000 mg/L
- Duration of suspended sediment over 50,000 mg/l is hundreds of days, particularly during the first notching phase



Summary

- As found at other dam removal sites, there is a tradeoff between the two dam removal strategies
- Rapid Removal: concentrations > 400,000 mg/L depending on flow during erosional event, but duration is much shorter than Phased Removal (8 days compared to hundreds of days of elevated concentrations)
- Phased Removal: lower concentrations (~200,000 mg/L), but much longer duration (>100 days)
- Next Step: conduct initial biological assessment of these results (February)

QUESTIONS?

Part 6: Study AQ12 Overview and Discussion

Overview of Study AQ12 components

- **Sediment Transport Modeling downstream of Scott Dam**
- **Suspended Sediment Concentrations downstream of Scott Dam**
- Multi-dimensional Hydraulic Modeling at key downstream locations
- **Lake Pillsbury Sediment Management Assessment**
- Lake Pillsbury Vegetation Management Assessment
- Surface Water Diversion and Groundwater Supply Review

Sediment Transport Modeling downstream of Scott Dam

- Supplemental bathymetric surveys to refine topography
- Additional reservoir sediment sampling to better assess grain size and stratigraphy
- 1-D coarse sediment transport modeling from Scott Dam to Middle Fork Eel
  - Different dam decommissioning scenarios
  - Different hydrologic scenarios
  - Focus at key infrastructure (Diversion, fish ladder, bridges)
  - May transition to multi-dimensional modeling depending on 1-D results
- Comparison of sediment yield changes at downstream locations

Suspended Sediment Concentrations downstream of Scott Dam

- Refinement of computations shown today based on improved sediment stratigraphy/composition
- Comparison of sediment release to downstream suspended sediment concentrations
- Biological evaluation of computed suspended sediment concentrations compared to background concentrations
- Evaluate different dam decommissioning alternatives

Lake Pillsbury Sediment Management Assessment

- Refine sediment management volumes based on:
  - Refined results of predicted sediment evaluation from Lake Pillsbury
  - Assessment of potential geomorphic and biological changes downstream
  - Assessment of potential changes in water supply reliability at downstream diversions
  - Refinement in Scott Dam decommissioning strategy
  - Refinements in sediment management approaches and resulting cost
- Final Sediment Management Plan would be part of Protection, Mitigation, and Enhancement (PM&E) measures

Wrap up and Next Steps

- Lake Pillsbury Revegetation Considerations: tomorrow
- Additional Technical Workgroup meetings for this and other topics
  - CDFW/Caltrout Supplemental Feasibility Study: Now→May 2021
  - NOI Parties FERC Study Plan: TBD, sometime in 2021
- Completion of CDFW/CalTrout Supplemental Feasibility Study: June 2021