Mechanical Mercury Extraction Process Test Results at Combie Reservoir, Grass Valley, CA

EPA Region 9 State of the Science Workshop on Mercury Remediation in Aquatic Environments

September 26, 2013

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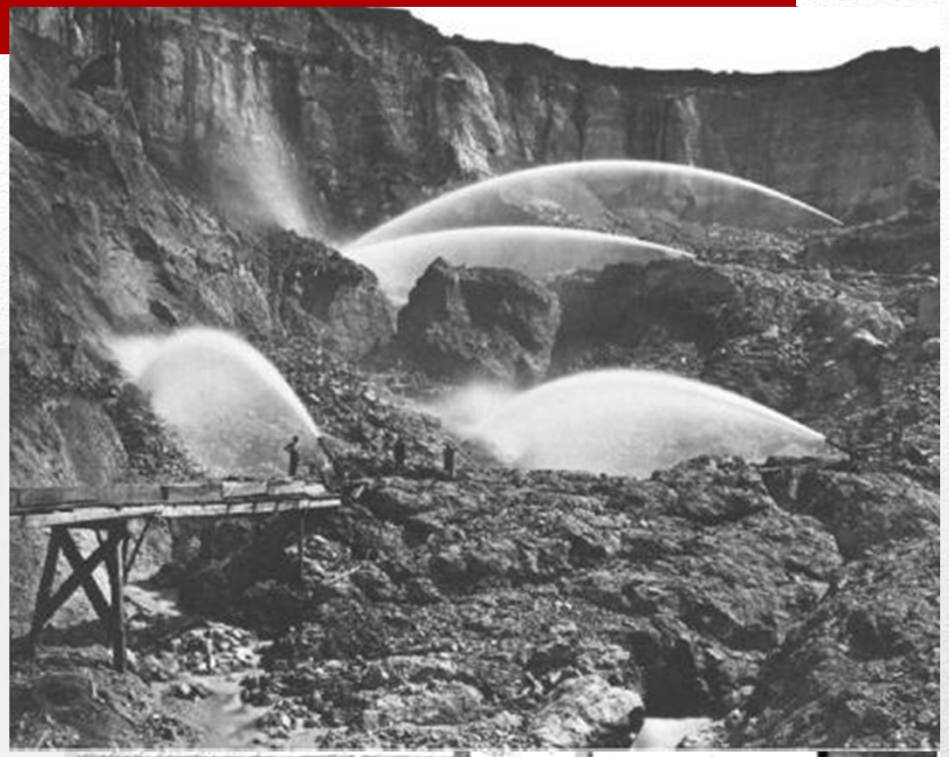
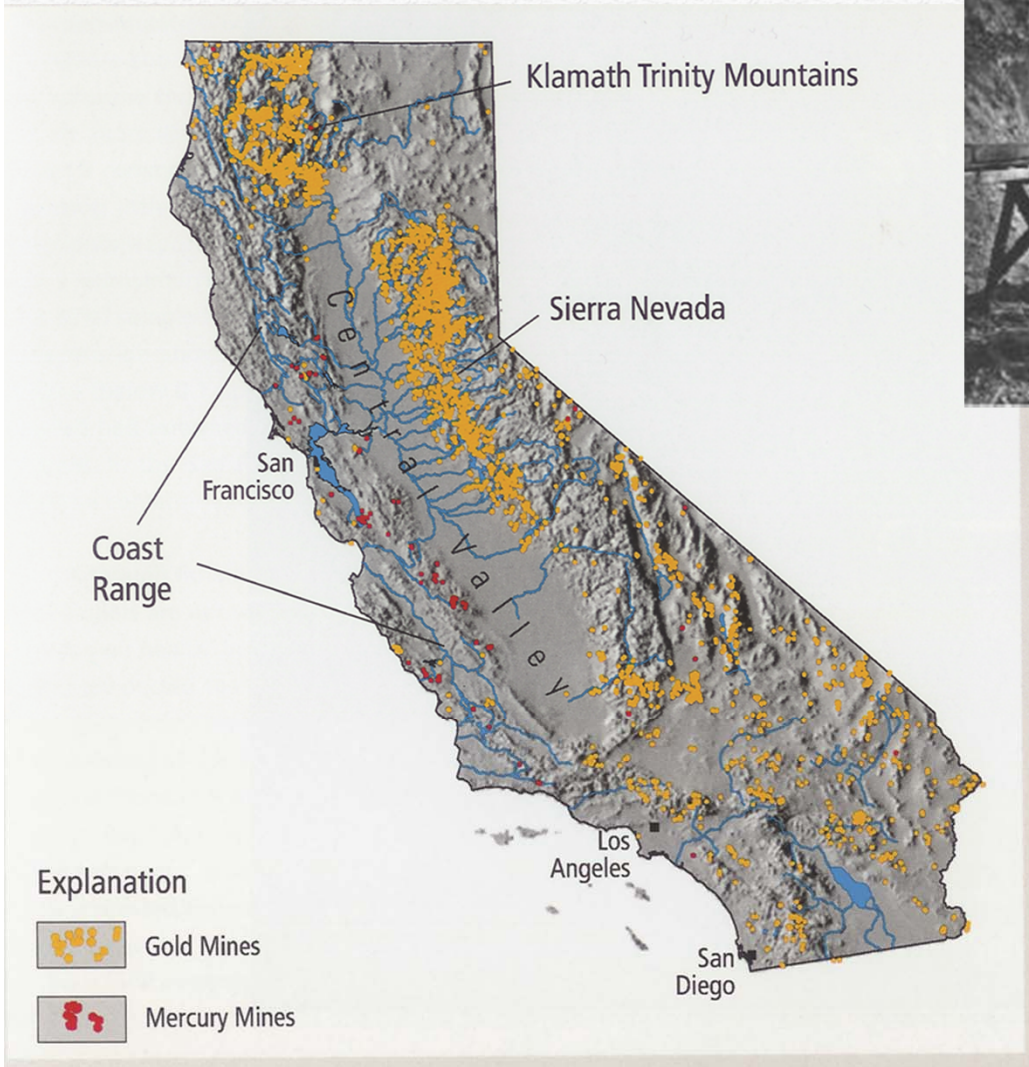
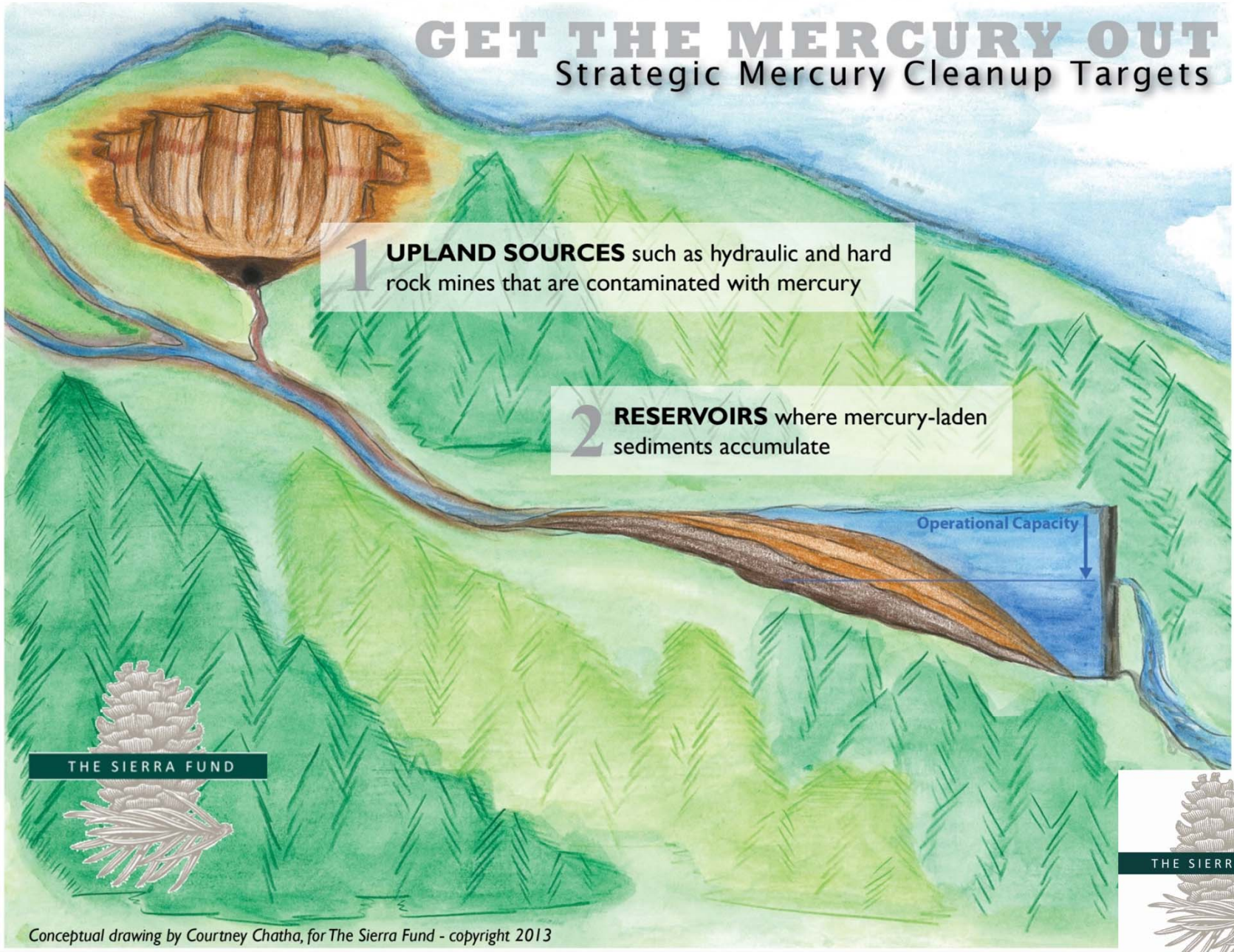
Mercury and the Gold Rush







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Humbug Creek Watershed Assessment and Management Plan

Upland Sources: Malakoff Diggins

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Upland Sources: Malakoff Diggins

Unstable Landscape

- One mile long pit (7,000ft), half mile wide (3,000 ft)
- Surrounded by cliffs 200-500 ft high

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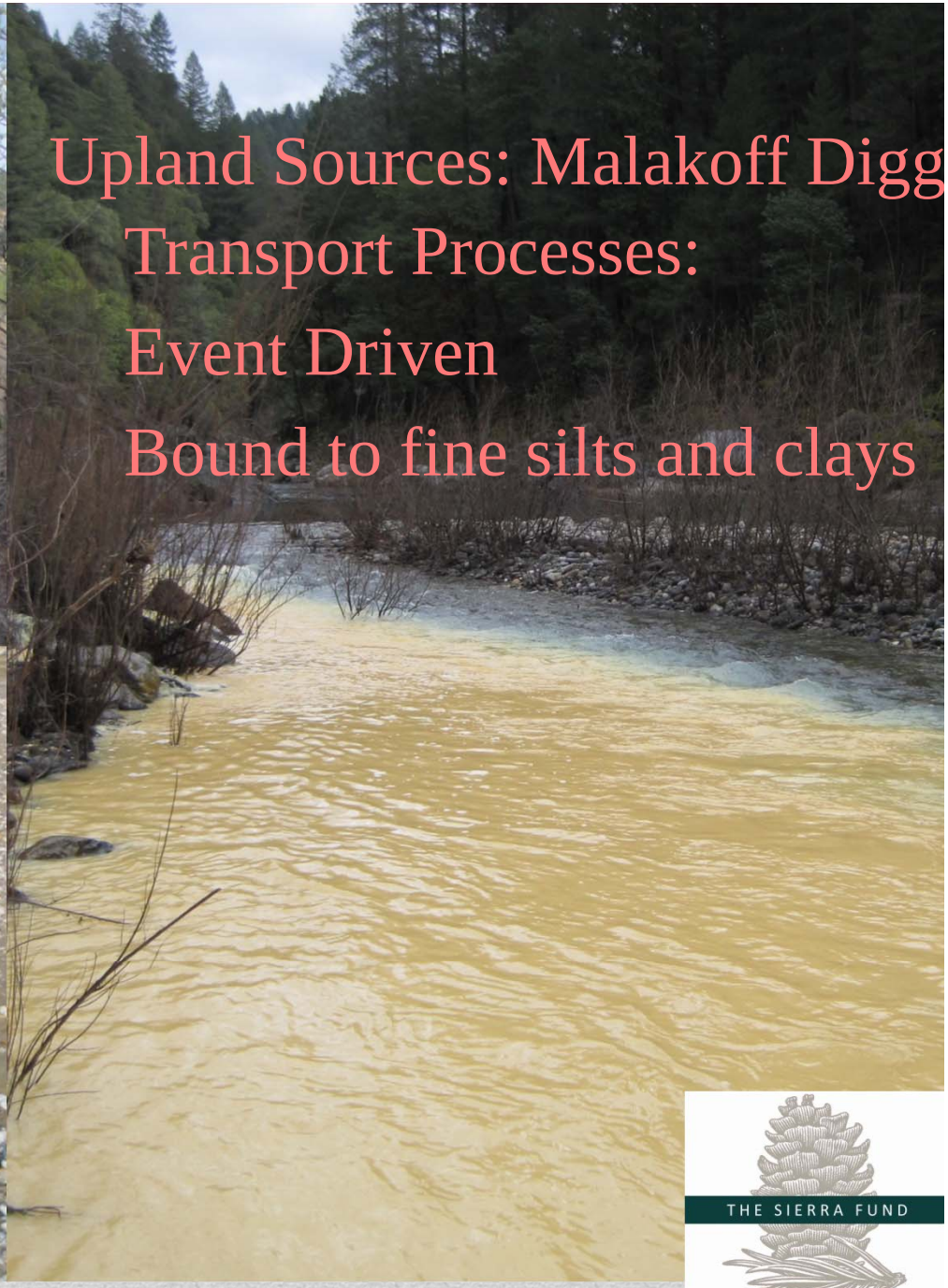

Upland Sources: Malakoff Digg

Transport Processes:

Event Driven

Bound to fine silts and clays

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Deer Creek 1909

Greenhorn Creek 2010

Mercury used during hard rock and hydraulic mining is still entrained in the river gravels.

CA Gold Rush and Hg

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Fish Consumption and Hg

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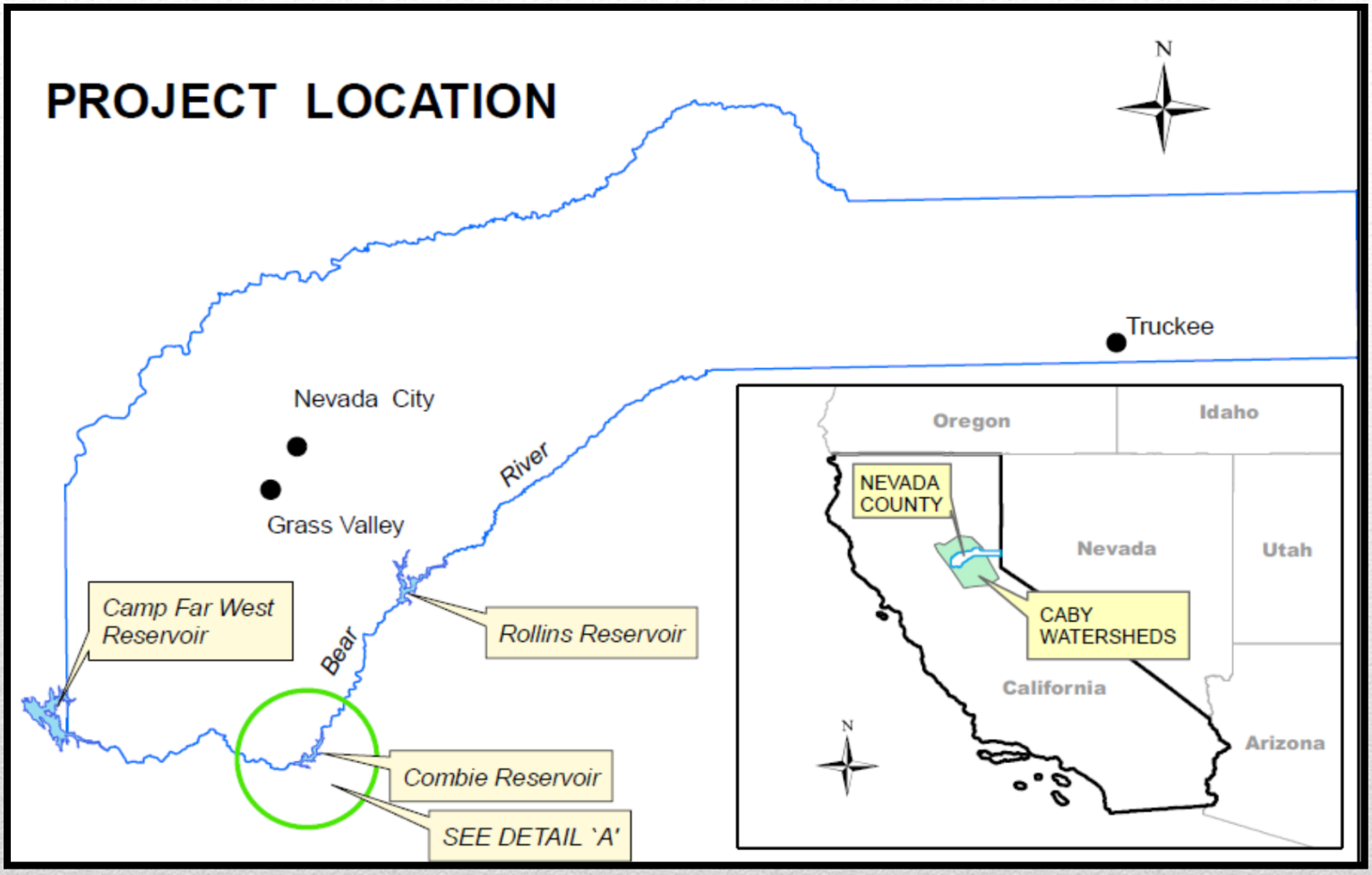

Bear River, Nevada Co. CA

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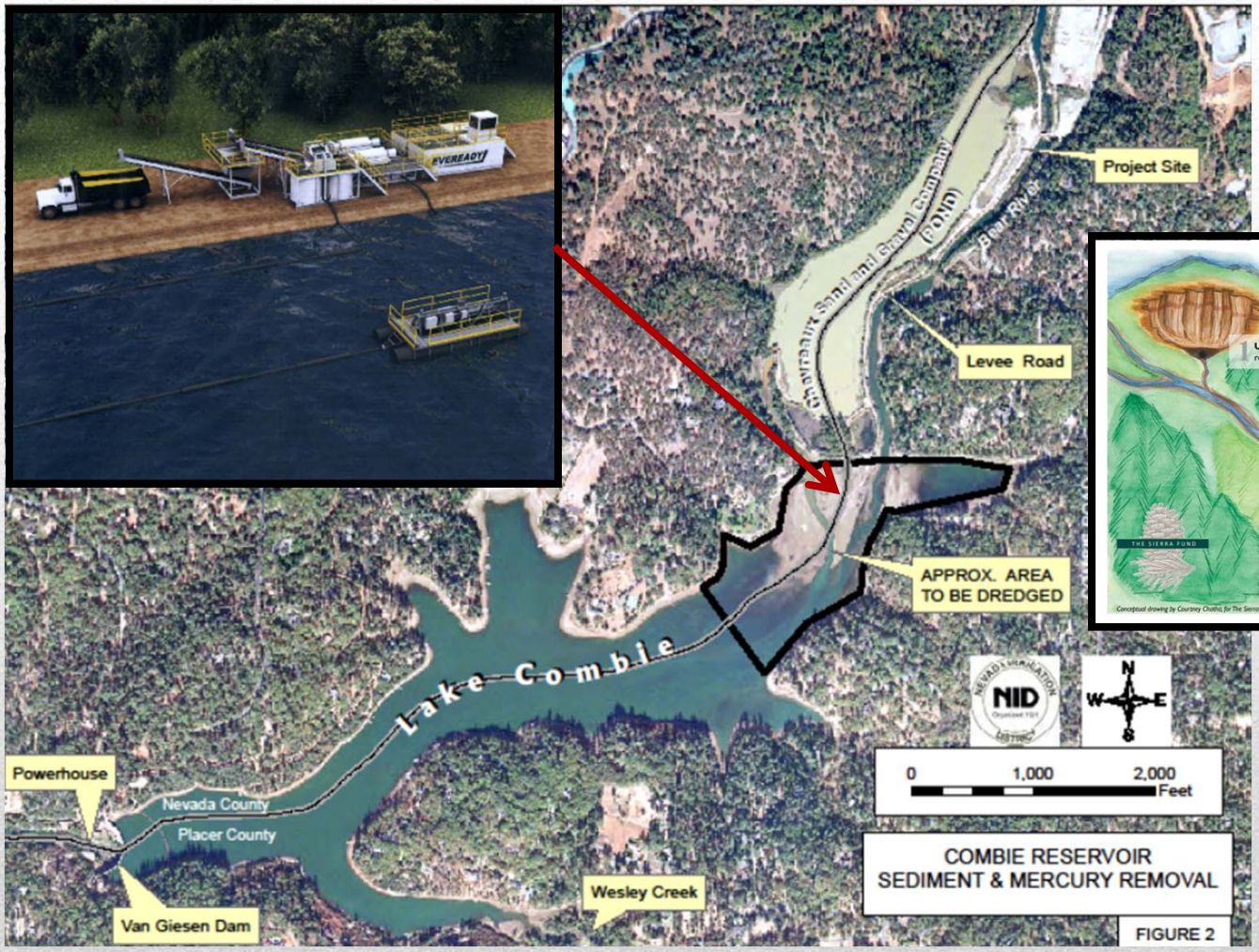

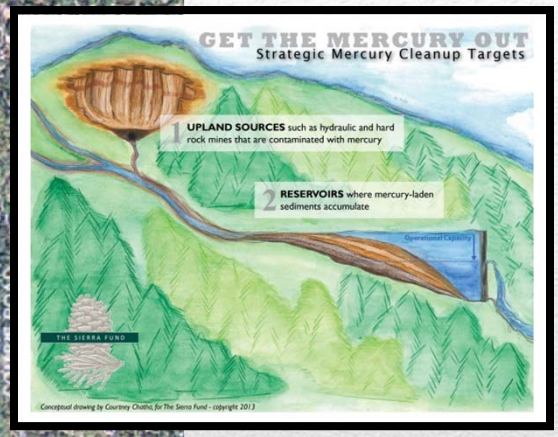

Aggregate Mining & 303 (d)

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- Production Unit 16-32 L/sec
- 60-80 G's
- Mobile platform with other equipment

- 3-5 year project
- Dredge 60,000-120,000 yd^3
- 20-70 kg of Hg removed
- Water storage space
- Gold

Equipment Design

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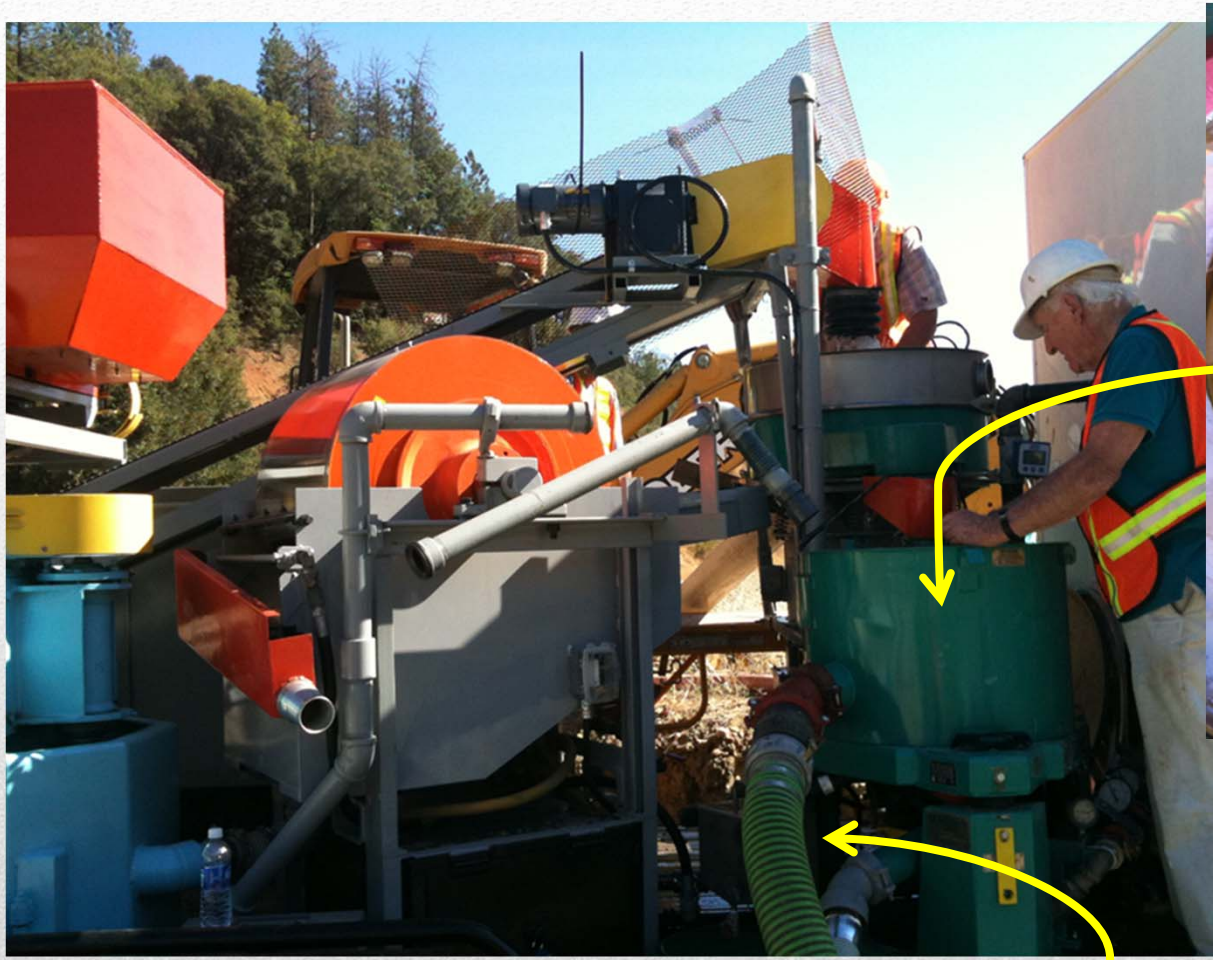

Equipment Design

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Equipment Video

Equipment Tests

- 4 tests done in Sept/Oct 2009
  - Silt/clay from the drying beds (1)
  - Material from reservoir (3)
- Closed system tests
  - Water and sediment budget
  - Mercury budget
- Three head and three tail samples
- Reactive, methyl, and total mercury
- Calculated percent removal of mercury

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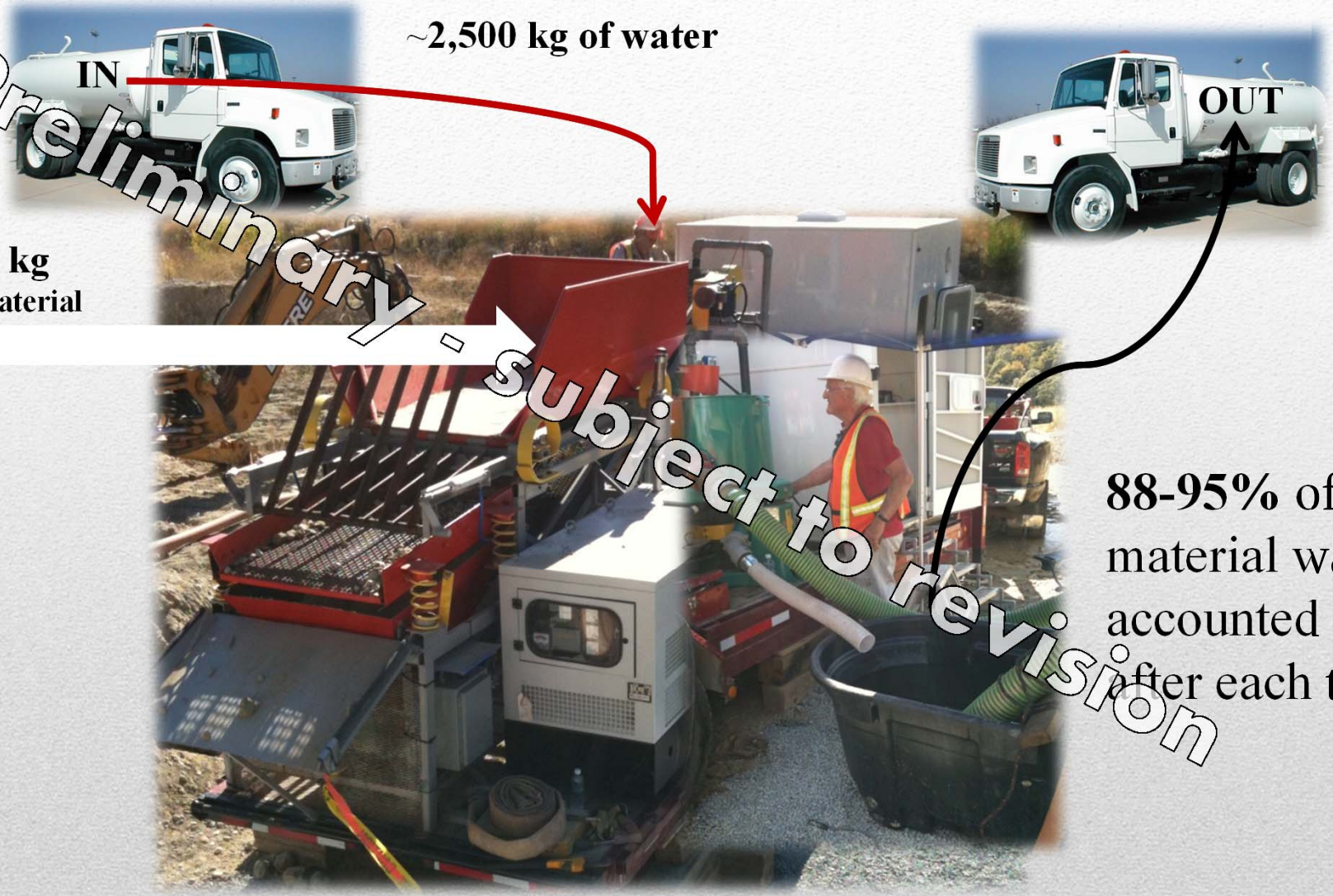

88-95% of the material was accounted for after each test

Sediment and Water Mass Balance

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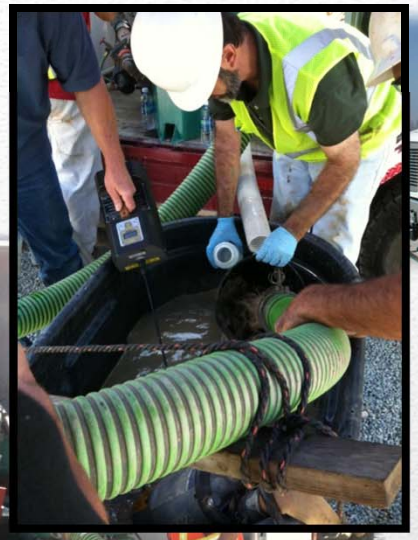
		Test 1	Test 2	Test 3	Test 4
Length of Test	min	20	20	23	31
IN	kg	3745	2749	4140	4208
OUT	kg	3428	2623	3633	3700
IN -OUT= Error	kg	317	126	506	509
% accounted for	%	92%	95%	88%	88%

Mass Balance-QAQC



~100 kg
dry material
0.20 ppm
THg

0.23 ppm
THg

Preliminary - subject to revision

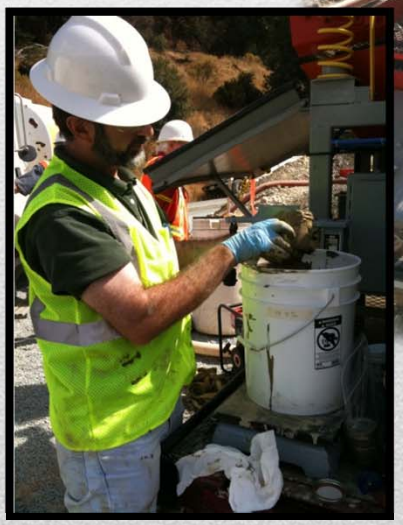
Mass Balance for Mercury ?

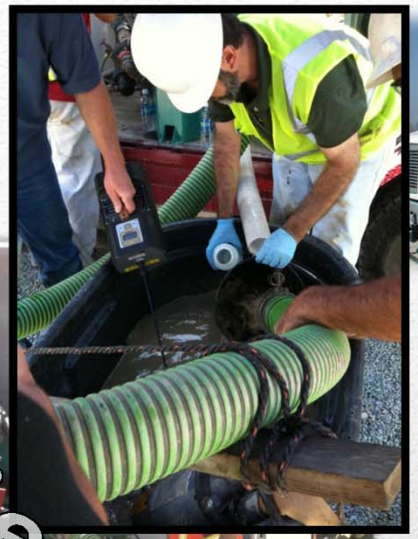
Mass Balance for Mercury ?

Preliminary - subject to revision

~100 kg
dry material

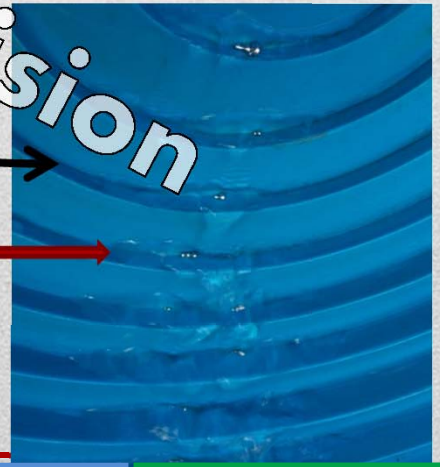
0.20 ppm
THg





0.23 ppm
THg

~300 mg Hg



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Test 1

9/28/09 - Drying Bed Material

- Material processed (dry): ~108 kg
- Total mercury (USGS data):
  - Head samples: 0.20 ± 0.04 ppm (86% fines)
  - Tail samples: 0.23 ± 0.02 ppm (100% fines)
- Mercury Extracted: ~330 mg

Mercury extracted per dry weight of material 3.06ppm (mg/kg)

Preliminary - subject to revision

Problems:

Grain size difference between heads and tails

Sampling technique of heads problems with "nugget effect"

Assumption:

- Hg in **sand** is 0.01 ppm

Englebright Lake (Alpers et al., 2006)
Daguerre Point Dam (Hunerlach et al., 2004)

Correct for grain-size difference **(finer tails)**

→ Hg in **fines** of heads = Hg in **fines** of tails

Material measured by USGS represents Hg associated with fine particles (silt-clay)

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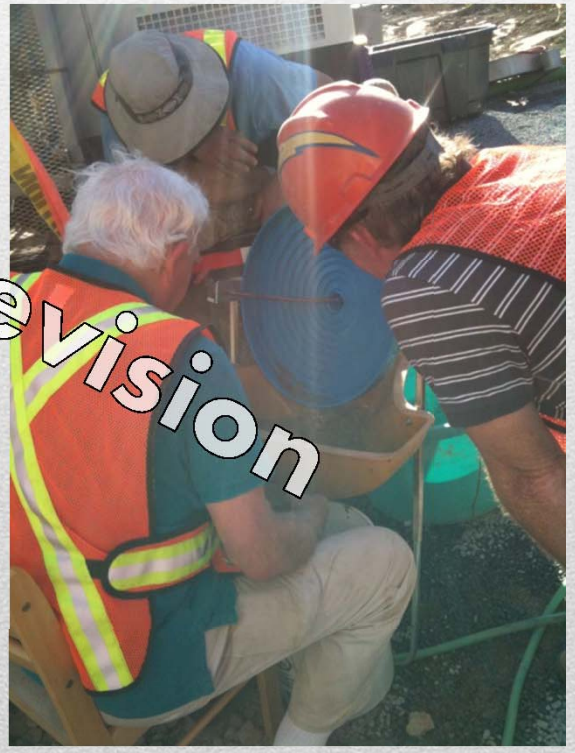
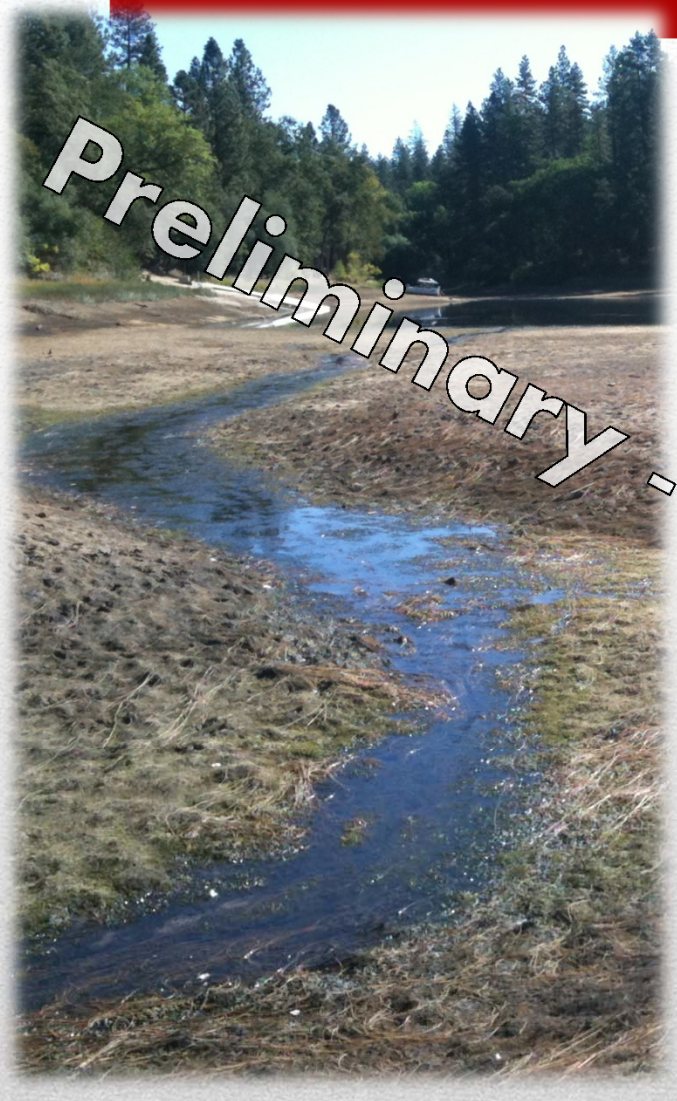
Assumption:

- All free elemental Hg removed

→ Hg recovered added to head composition

Recalculate mercury in head material by adding the mercury recovered per dry weight of the material to the head composition

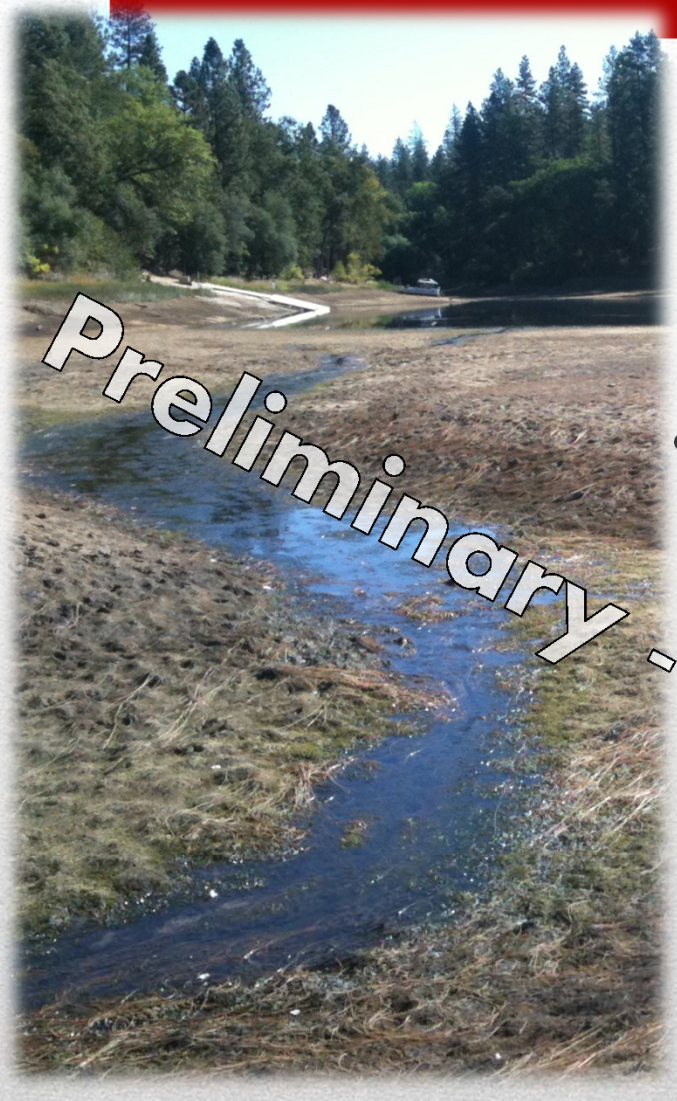




Head material : 0.2ppm

Tail material: 0.23ppm Hg

% Mercury Removal



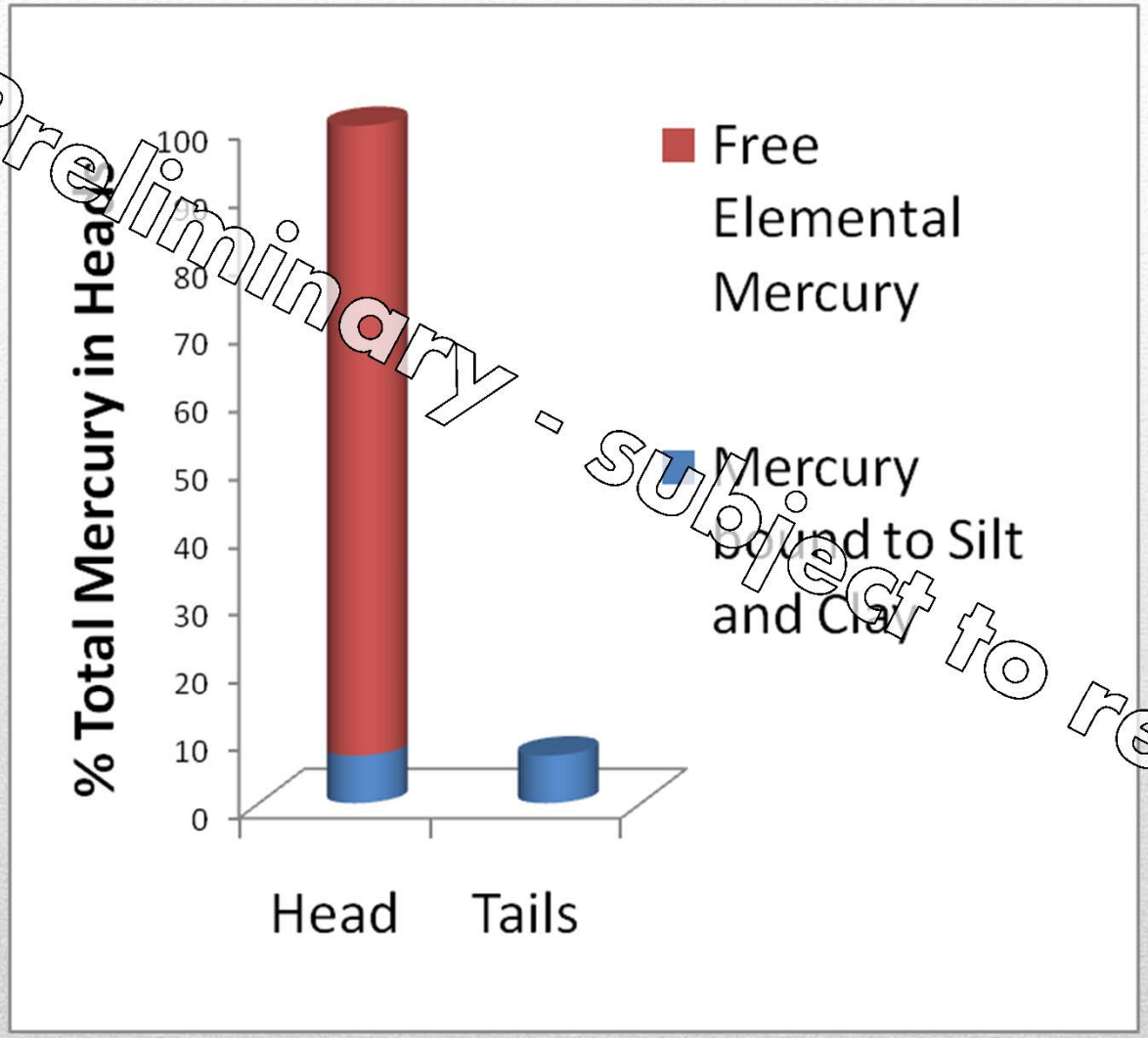
Head material : 0.20ppm + 3.06ppm = 3.26ppm Hg

Tail material: 0.23ppm Hg

Recovered: 3.06mg Hg

% Recovery = Recovered/head = 3.06/3.26 = **94.0%**

% Mercury Removal



Conceptual Model of Mercury Removal

1) Closed system tests in the field using water trucks was successful, 88-95% of the material was accounted for.

2) The samples taken of the head material were not an accurate representation of the head material, due to the "nugget effect."

3) Mercury attached to the fine-grained (< 0.63mm) material was not removed by the equipment.

4) Methylmercury and reactive mercury did not change as a result of the processing.

5) **The free Hg(0) in the sand size fraction (> 0.63 mm) that was removed by the extraction process represents approximately 93% of the calculated THg in the head material.**

Conclusions

Lessons Learned

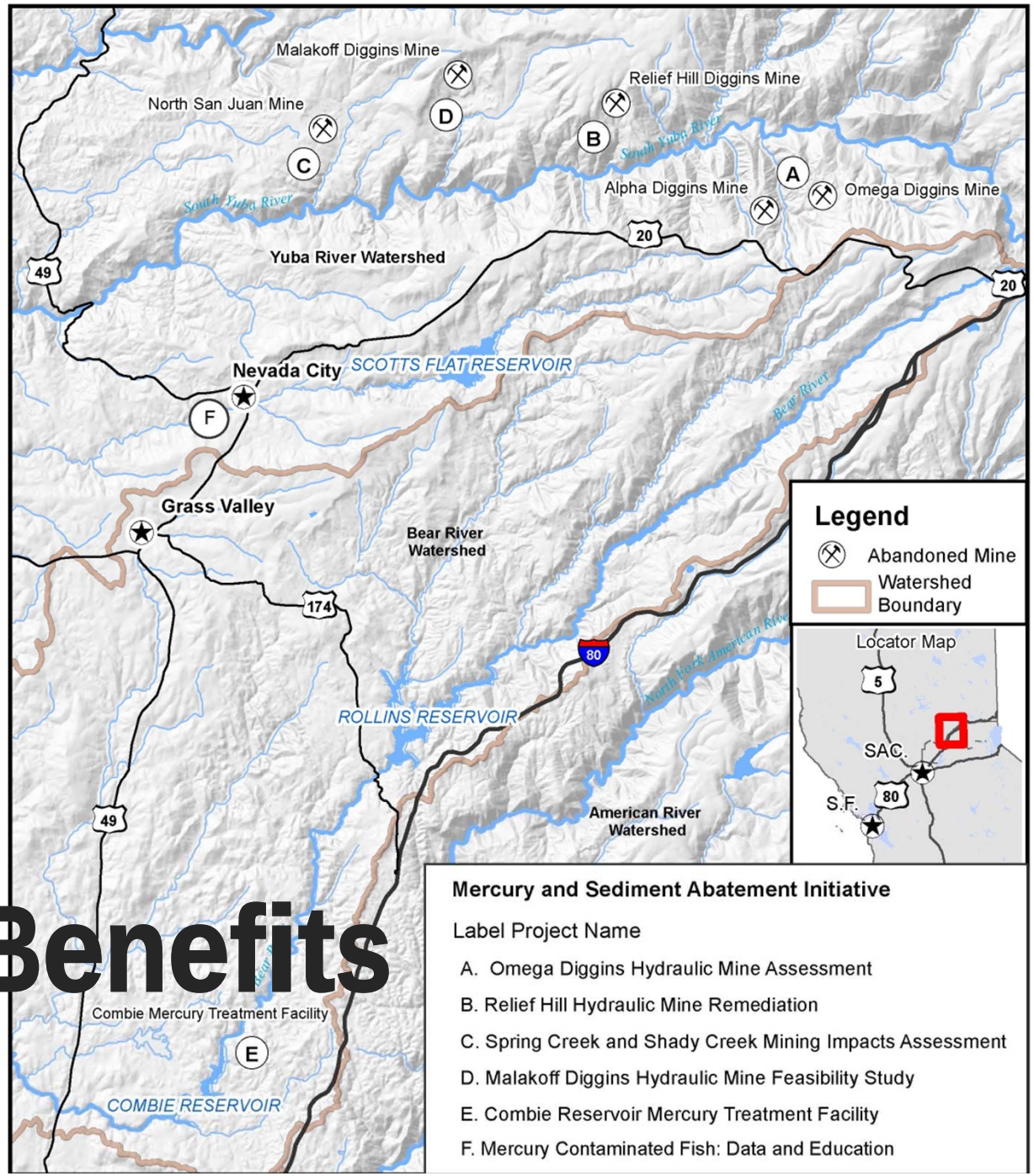
- Sampling Mercury – Nugget Effect
  - Total mercury
    - Mercury bound to fine silts and clays
    - Free elemental mercury – Not evenly mixed throughout
- Turbidity treatment is key to reducing mercury in the environment

Next Steps

- Additional equipment tests with spiked material
- Publish results in peer-reviewed journal
- Pre-project sampling of water, sediment, and biota- to measure project benefits and fill critical data gaps in mercury fate and transport
  - Hg – fish
  - Pollution Credit program
- Secure project funding

Multiple Benefits

- Water storage space
- Removal of an environmental toxin
- Methylation potential in upper reservoir – deeper/colder
- Downstream benefits
- Habitat and wildlife benefits
- Cumulative Benefits – strategic approach



- Sierra Nevada reservoirs and mercury-impacted rivers
  - Rollins Reservoir, NID owned facilities and beyond
- Products with environmental benefits – gold
- Statewide TMDL process
  - BMP for Mercury Control Program
    - Reservoir operation and maintenance
    - Ship channel maintenance in Bay Delta

Applicability

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- CABY IRWMP
- Sierra Nevada Conservancy
- Regional Water Quality Control Board
- State Water Resources Control Board
- Ryan Jones

Thank You

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