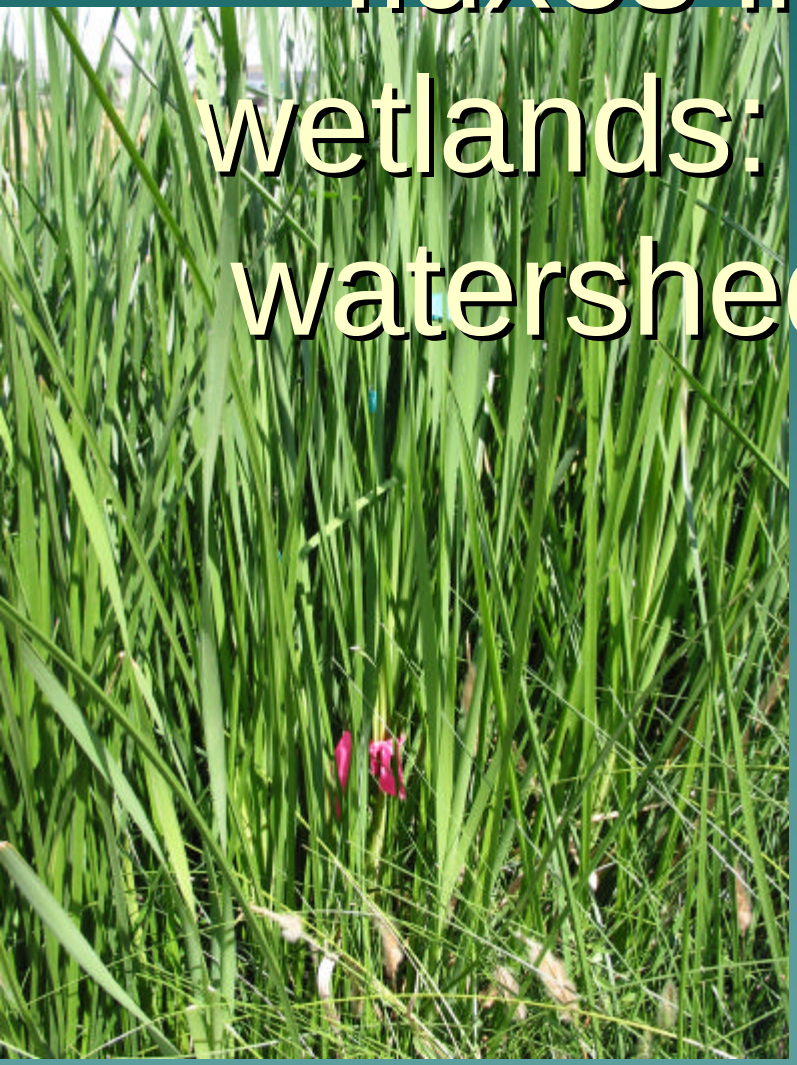
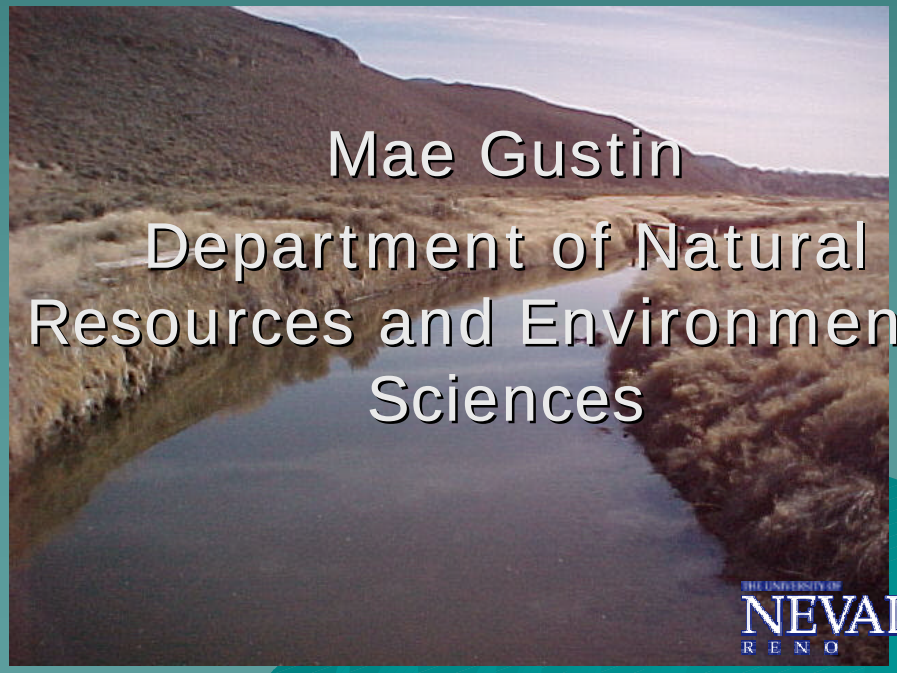
Total and methyl mercury fluxes in constructed wetlands: Implications for watershed management





Mae Gustin

Department of Natural Resources and Environmental Sciences

THE UNIVERSITY OF NEVADA RENO

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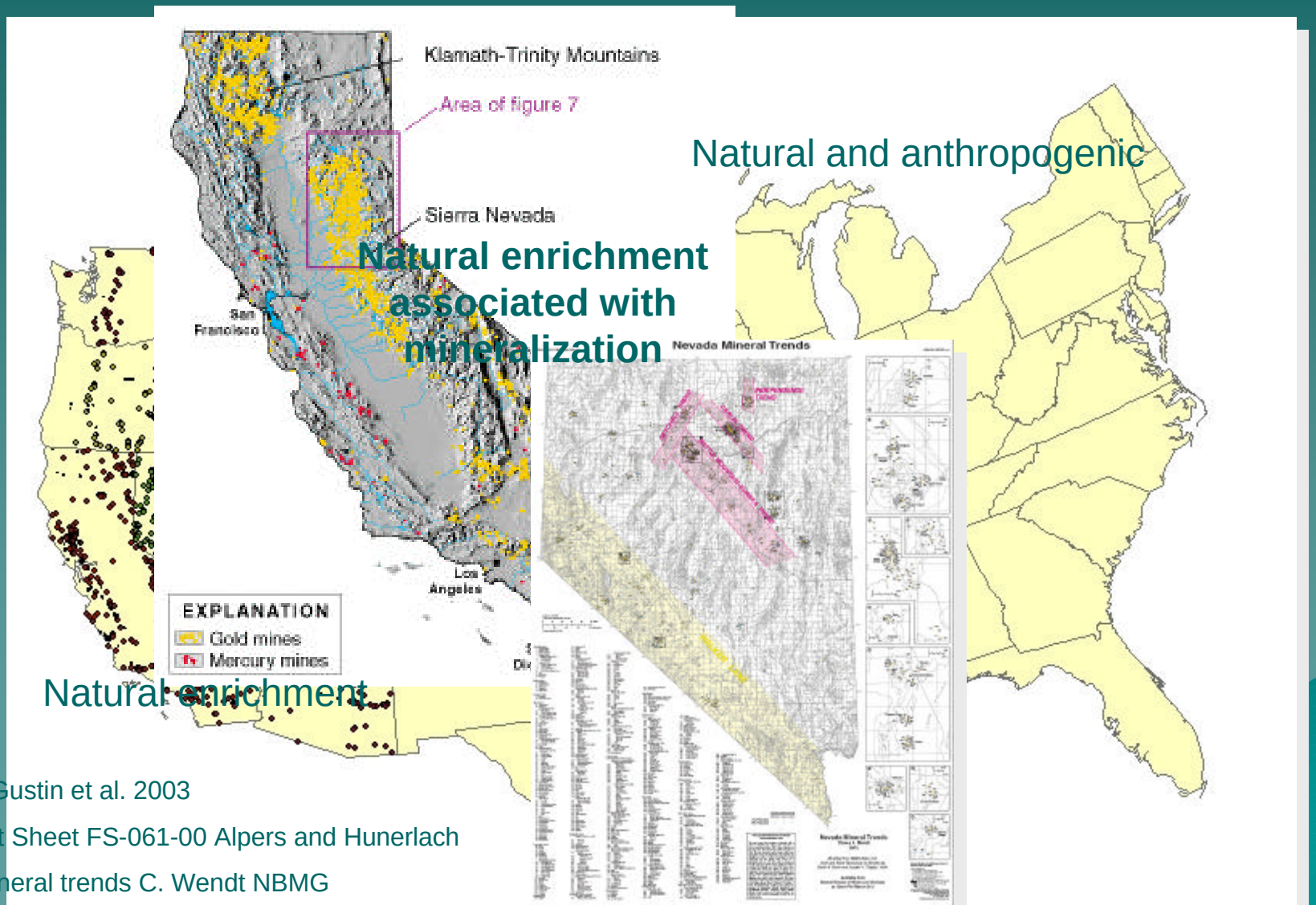
  - Cities of Reno and Sparks, NV
  - Nevada Division of Environmental Protection
  - Truckee Meadows Water Reclamation Facility
  - Washoe County Regional Water Planning Commission

Mercury in western systems



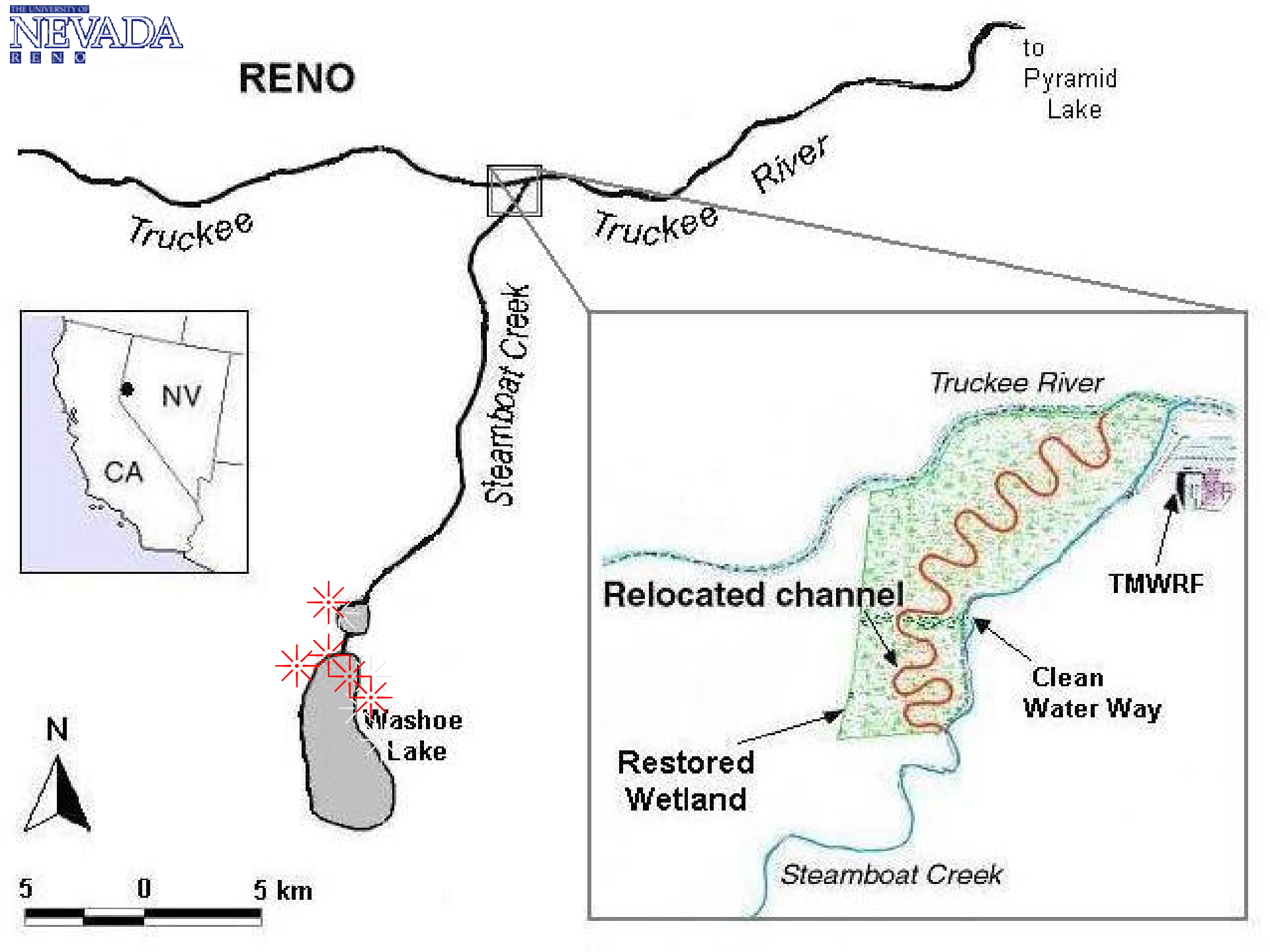
J. Rytuba/Gustin et al. 2003

USGS Fact Sheet FS-061-00 Alpers and Hunerlach

Nevada Mineral trends C. Wendt NBMG

Major objectives of research

- Investigate the influence of wetlands on methyl Hg production in western systems where
  - Water sources may fluctuate
  - Water availability may change
  - Chemistry may be influenced by geologic setting and water use


THE UNIVERSITY OF NEVADA RENO
RENO
to Pyramid Lake
Truckee
Truckee River
Steamboat Creek
NV
CA
Washoe Lake
N
5 0 5 km
Truckee River
Relocated channel
TMWRF
Clean Water Way
Restored Wetland
Steamboat Creek

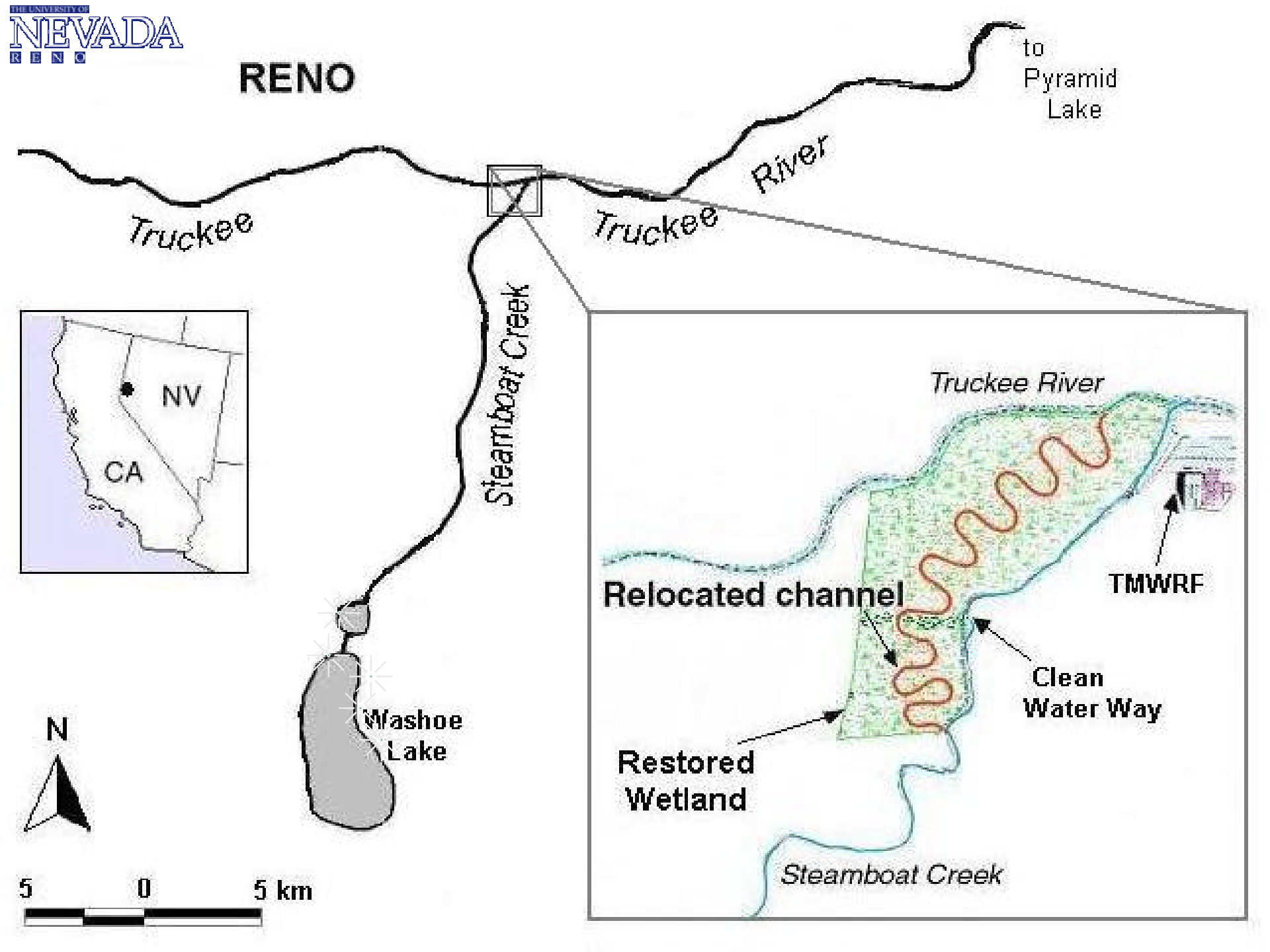
Introduction

- Steamboat Creek annually contributes 70 tons of nitrogen, 15 tons of phosphorus, and 900 tons of suspended solids to Truckee River

- High Hg content in creek water (24 to 800 ng/L) and sediments (0.2 to 10.2 μg Hg /g (dw)

- Hg mostly derived from ore processing waste

- Truckee River terminus is Pyramid Lake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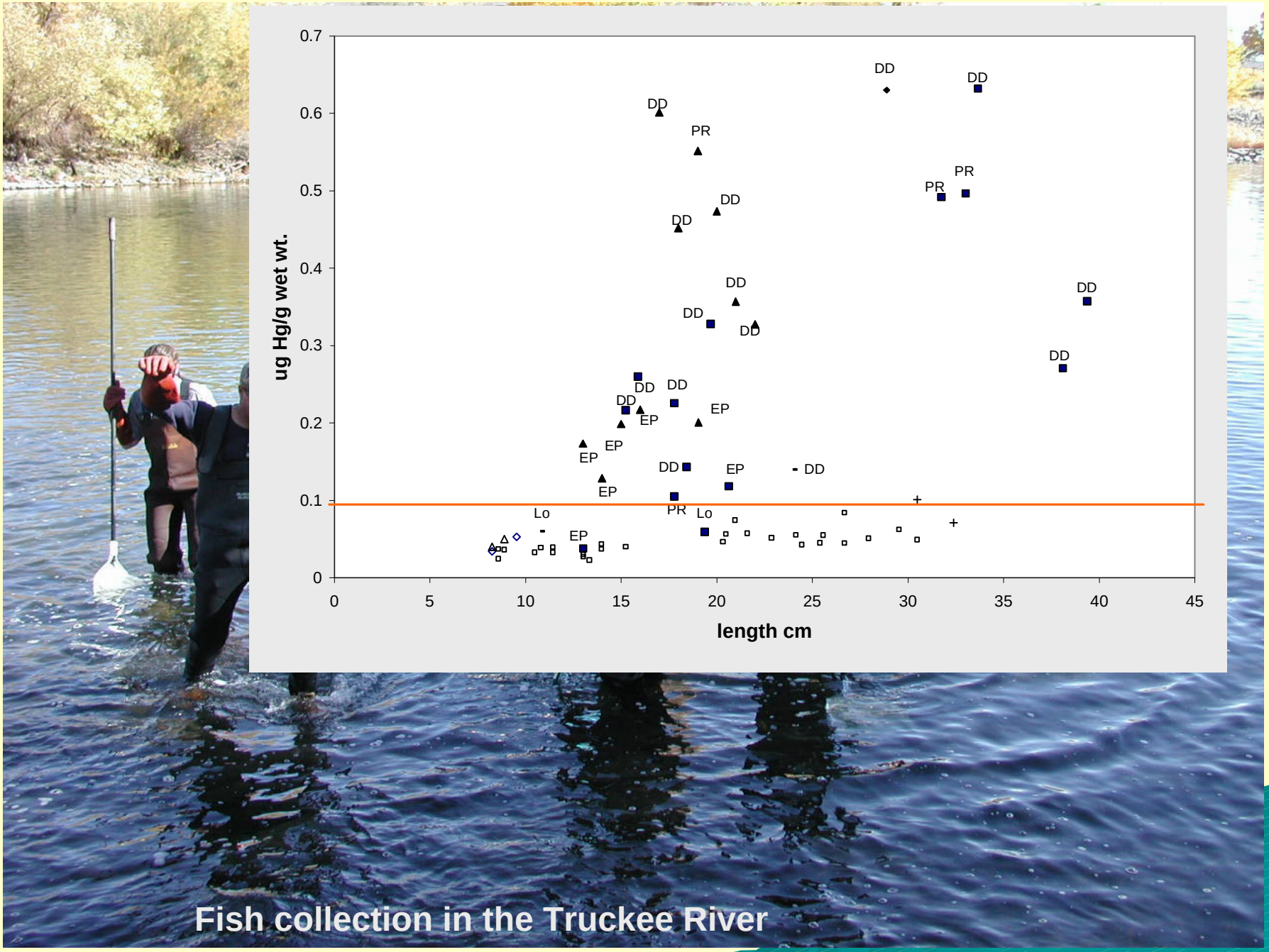
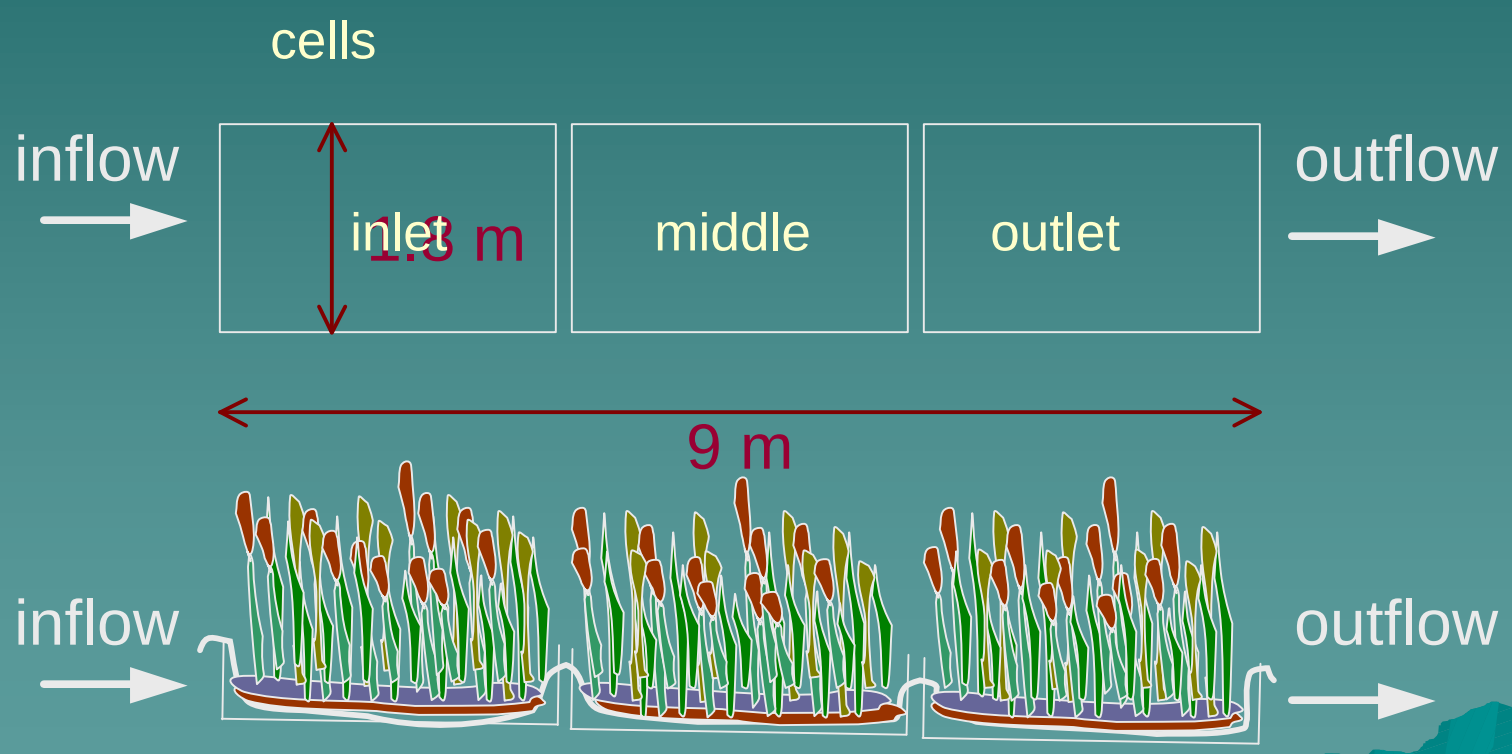


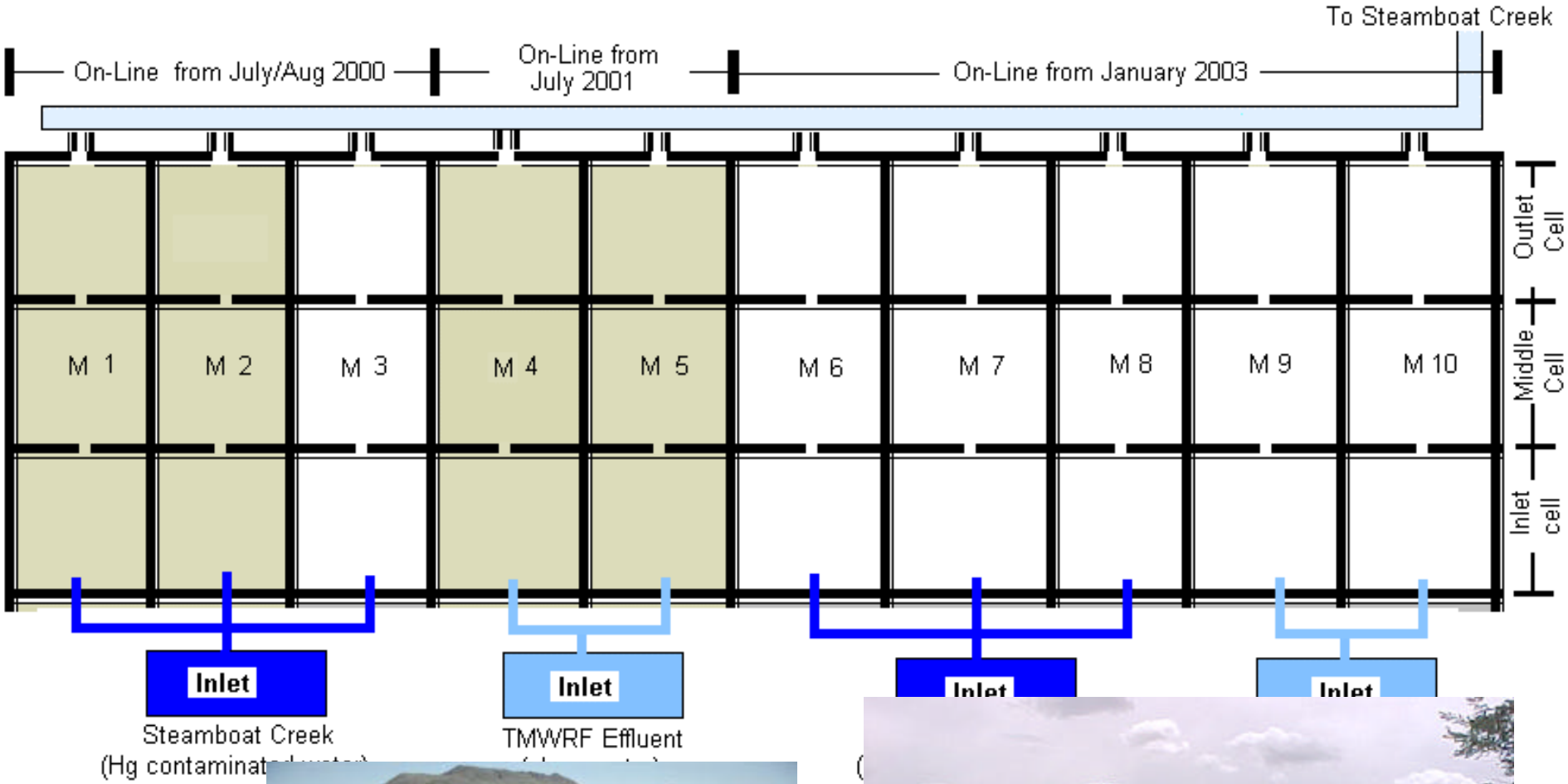
Fish collection in the Truckee River

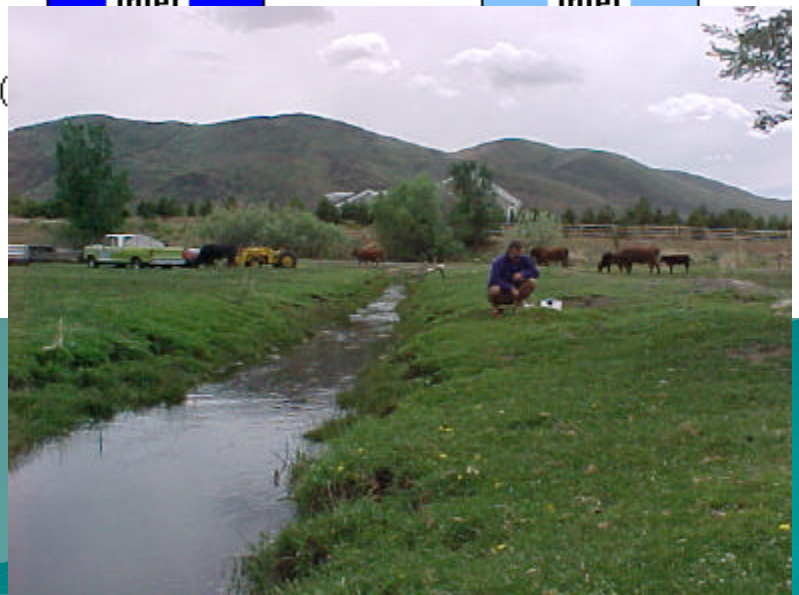
Wetlands

Experimental Setting

Small surface-flow wetlands consisted of 10 parallel trains, each having:




To Steamboat Creek
On-Line from July/Aug 2000
On-Line from July 2001
On-Line from January 2003
M 1
M 2
M 3
M 4
M 5
M 6
M 7
M 8
M 9
M 10
Outlet Cell
Middle Cell
Inlet cell
Inlet
Inlet
Inlet
Inlet
Steamboat Creek
TMWRF Effluent
Mesocosms (M)

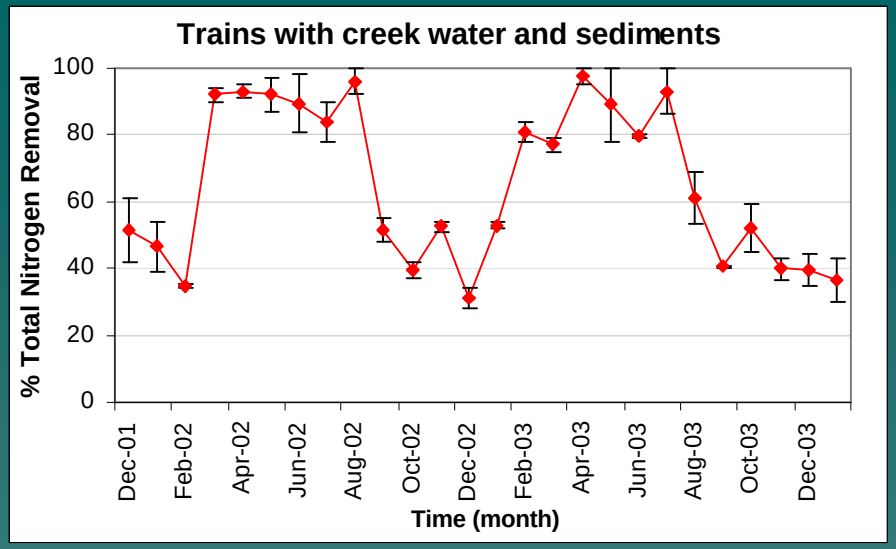


Important differences in quality of water sources

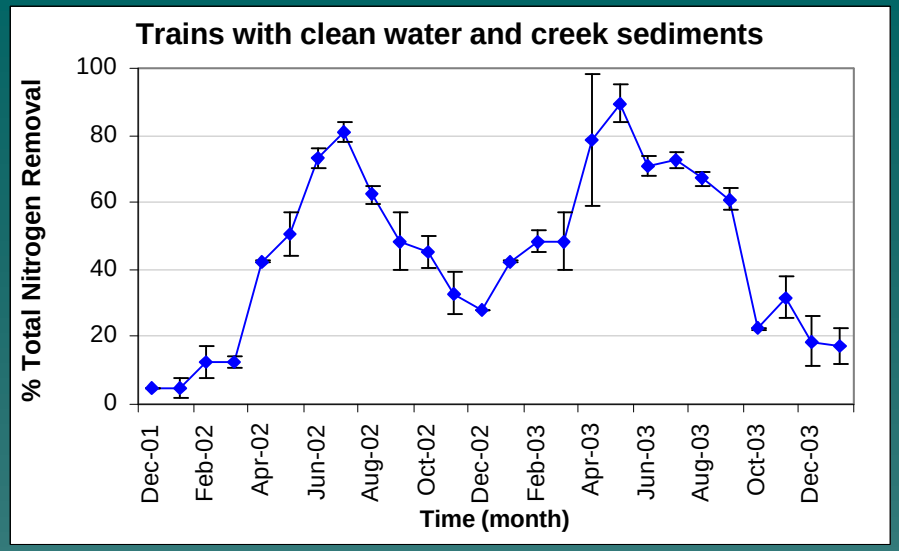
In general ***treatment plant effluent …….than creek water***

- Temperature warmer and more constant
- Higher sulfate concentrations 100 ± 15 mg/L versus 80 ± 15 mg/L
- Lower total and methyl mercury concentrations
- pH lower
- Nitrate/Nitrite lower
- Orthophosphate lower
- TSS lower
- TOC higher

	THg*	MeHg*	pH	DO*	$NO_3^-+NO_2^-$*	TKN*	TP	OP*	TSS*	TOC*
Creek water	172 ± 147	4.25 ± 4.21	8.2 ± 0.4	8.5 ± 2.9	0.5 ± 0.2	1.0 ± 0.4	0.5 ± 0.5	0.2 ± 0.06	32 ± 18	4.5 ± 1.9
Plant effluent	10 ± 6	0.61 ± 0.59	7.6 ± 0.5	4.5 ± 1.9	0.1 ± 0.1	1.7 ± 0.6	0.2 ± 0.1	0.05 ± 0.04	8 ± 5	9.4 ± 4.1

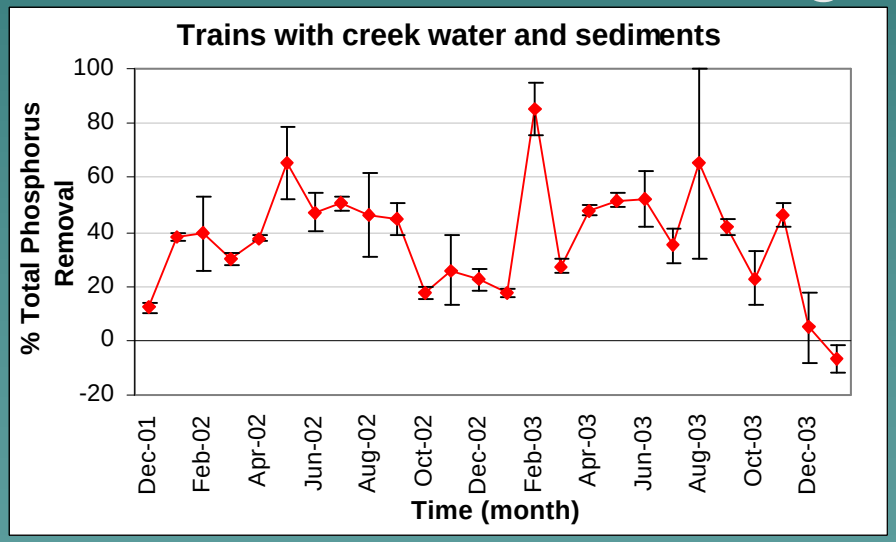


Creek water

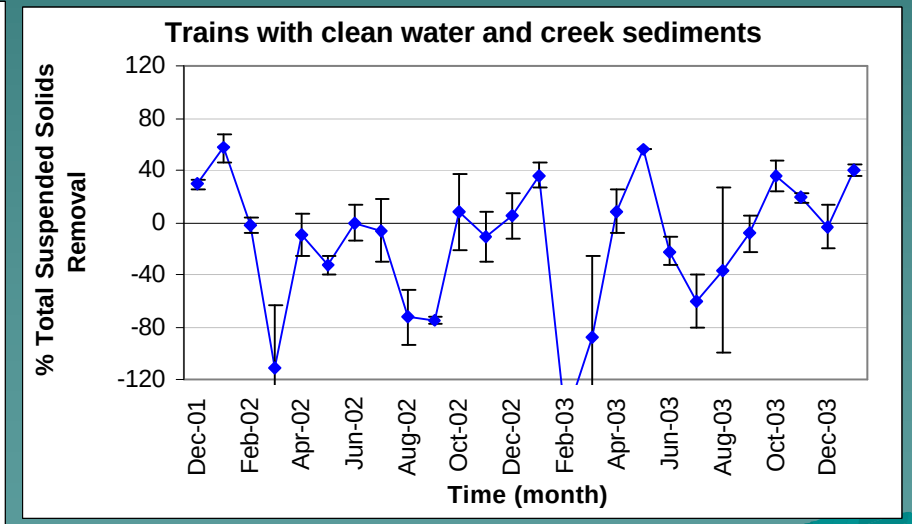


Plant effluent

Nitrogen removal



Creek water

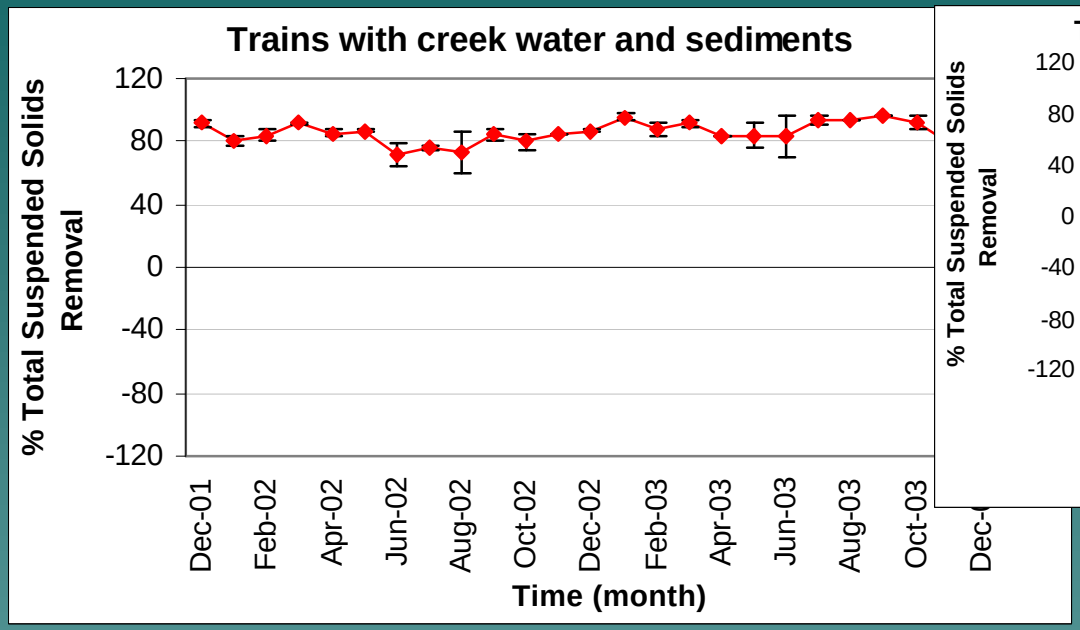


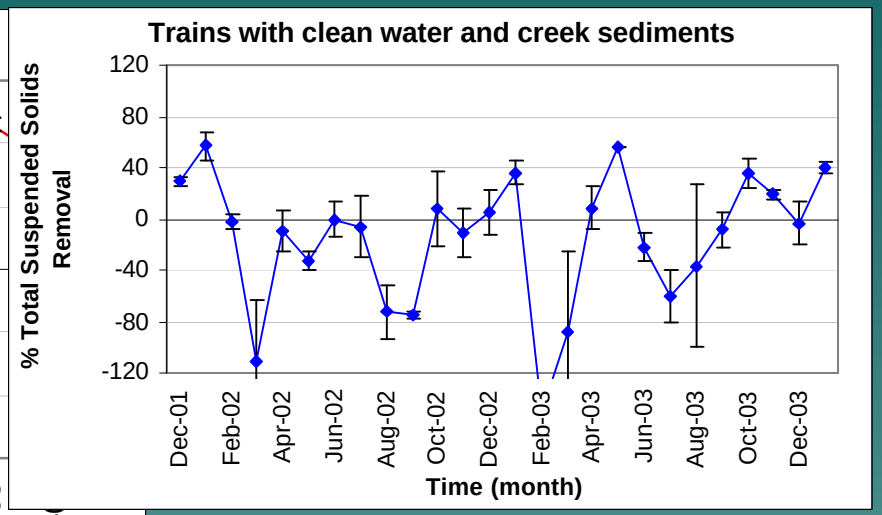
Plant effluent

Phosphorus removal

NEVADA RENO

Total Suspended Solids (TSS):





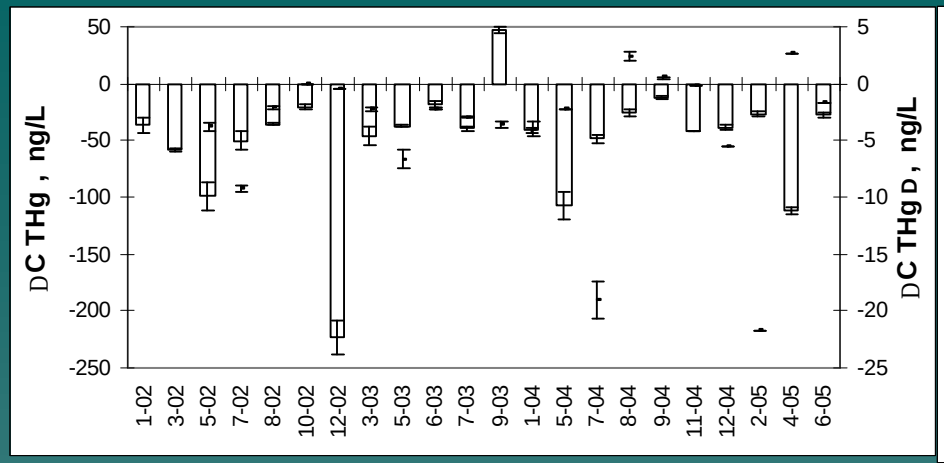
Plant effluent

Creek water

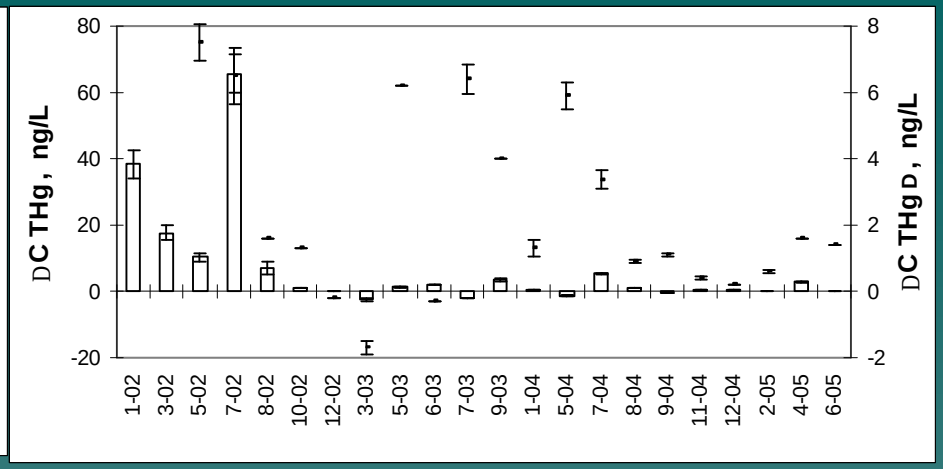
> 75% Mercury in Creek water is particulate bound

Total mercury and TSS correlated

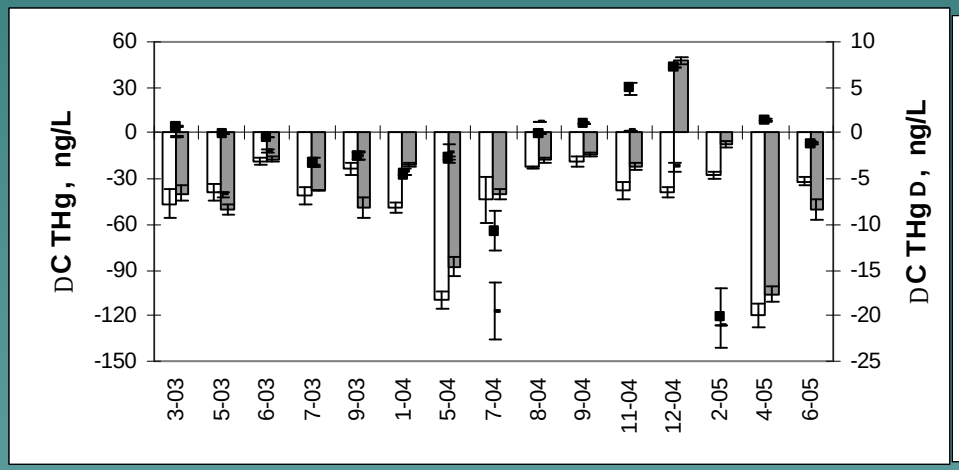
Both correlated with flow



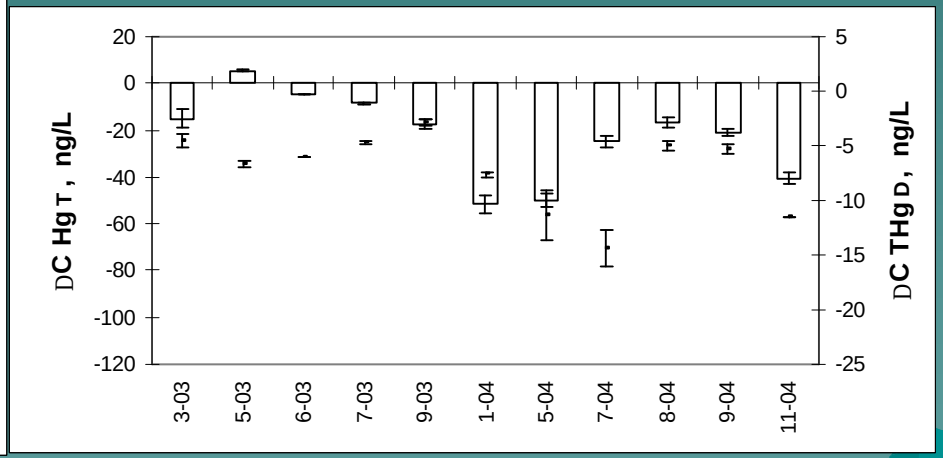
Creek water –Creek sediments



Plant effluent – Creek sediments

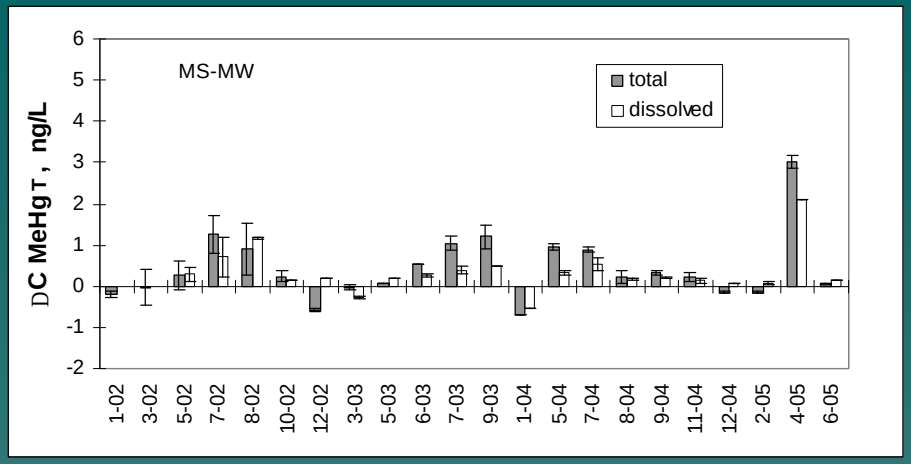


Creek water -Clean sediments

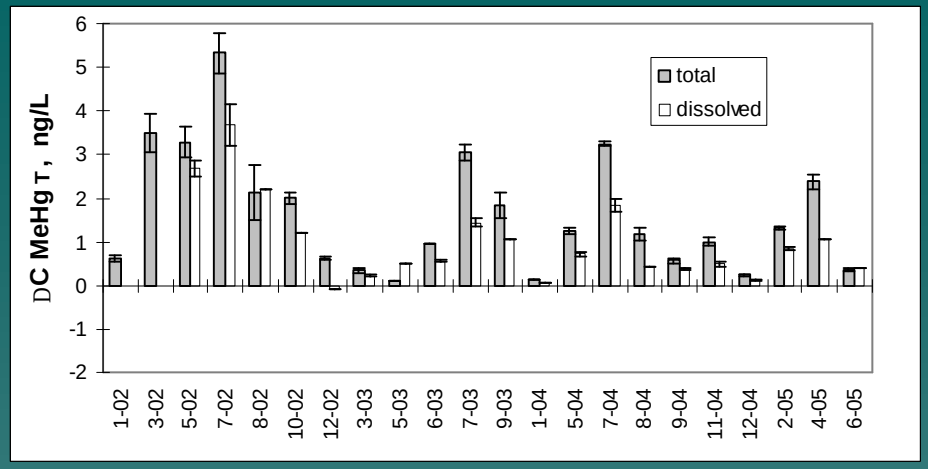


Plant effluent – Clean sediments

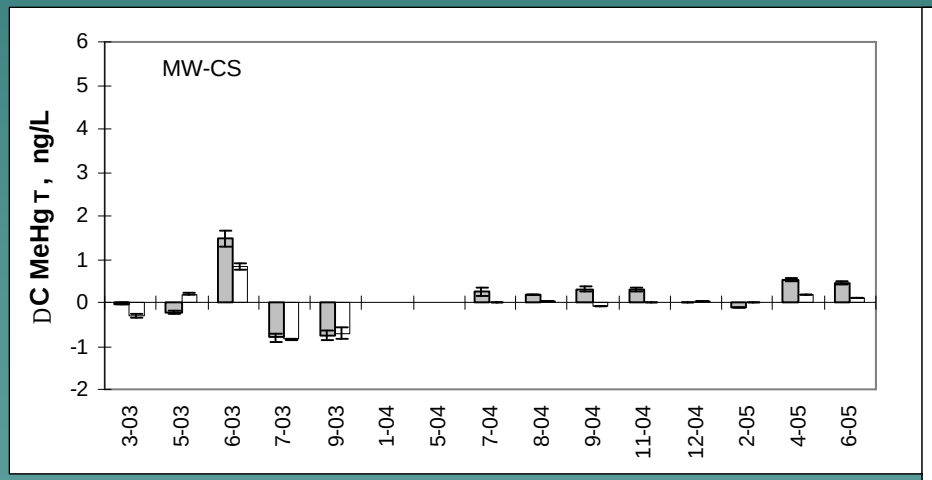
?C of total Hg in water of the outlet - inlet



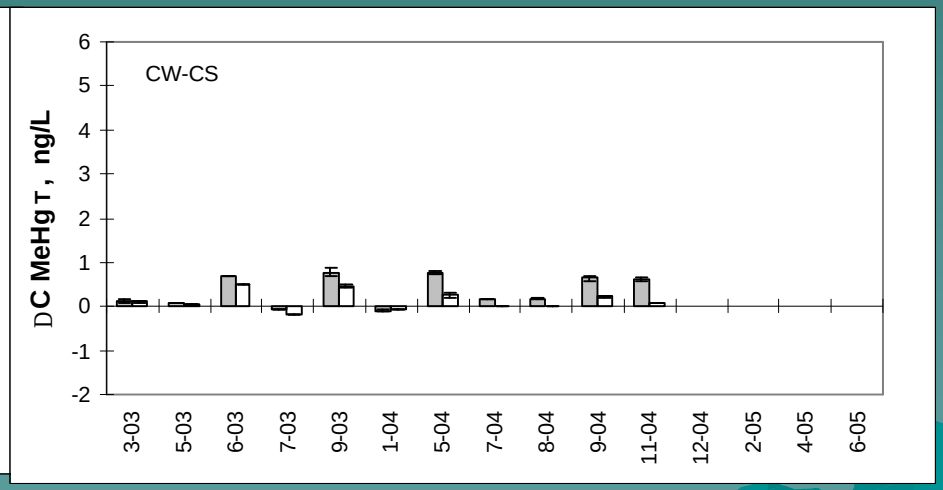
Creek water- Creek sediments



Plant effluent- Creek sediments



Creek water- Clean sediments

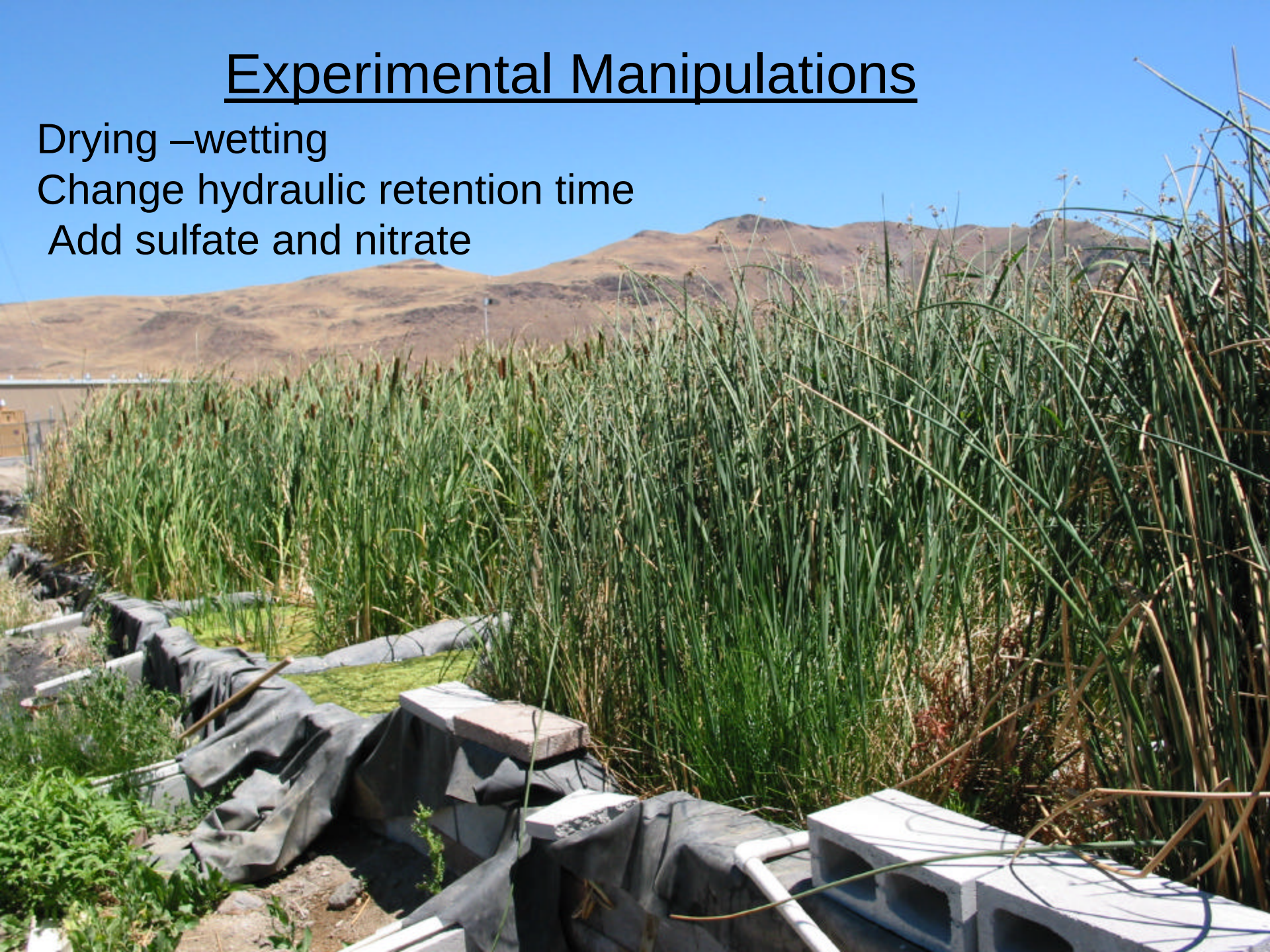


Plant effluent- Clean sediments

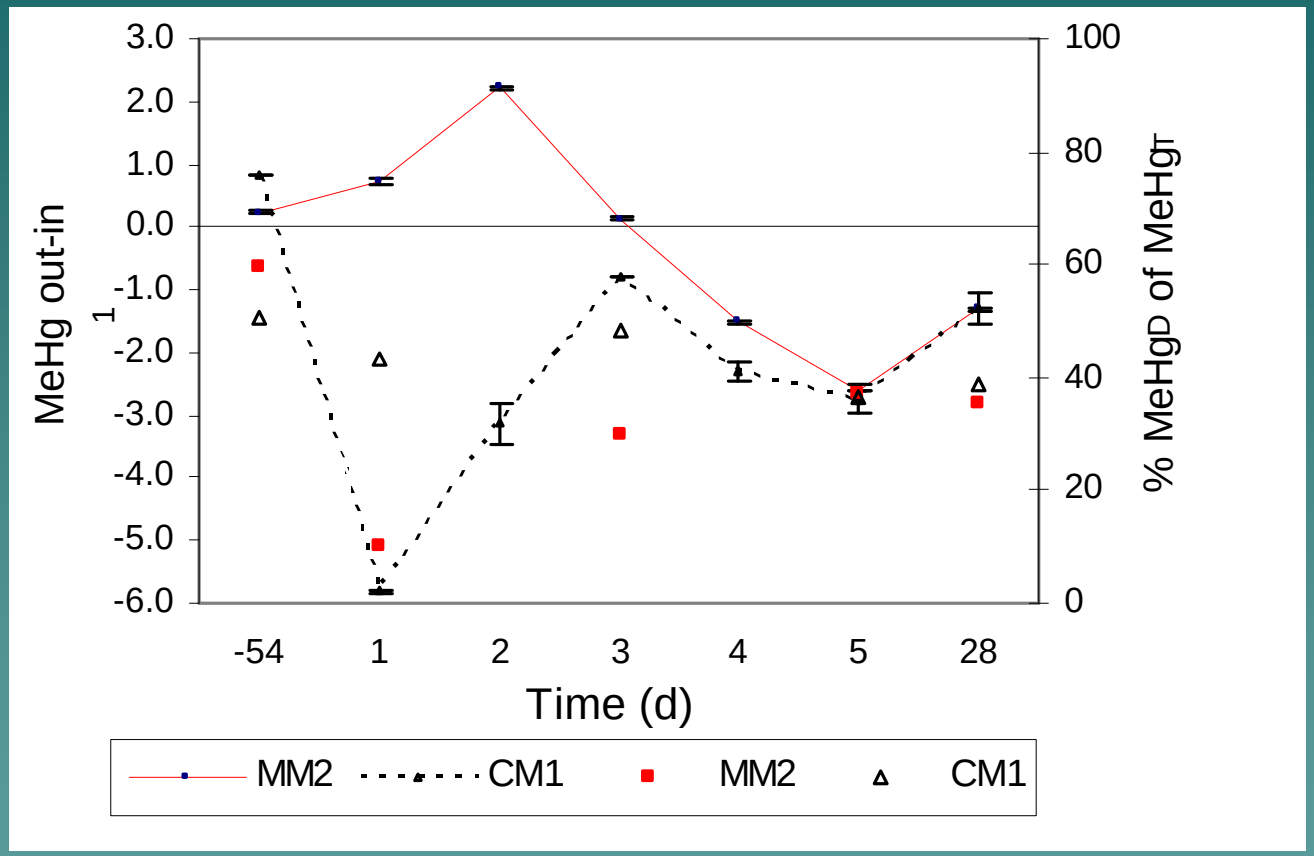
?C of Methyl Hg in water of the outlet- inlet

Experimental Manipulations

Drying –wetting
Change hydraulic retention time
Add sulfate and nitrate

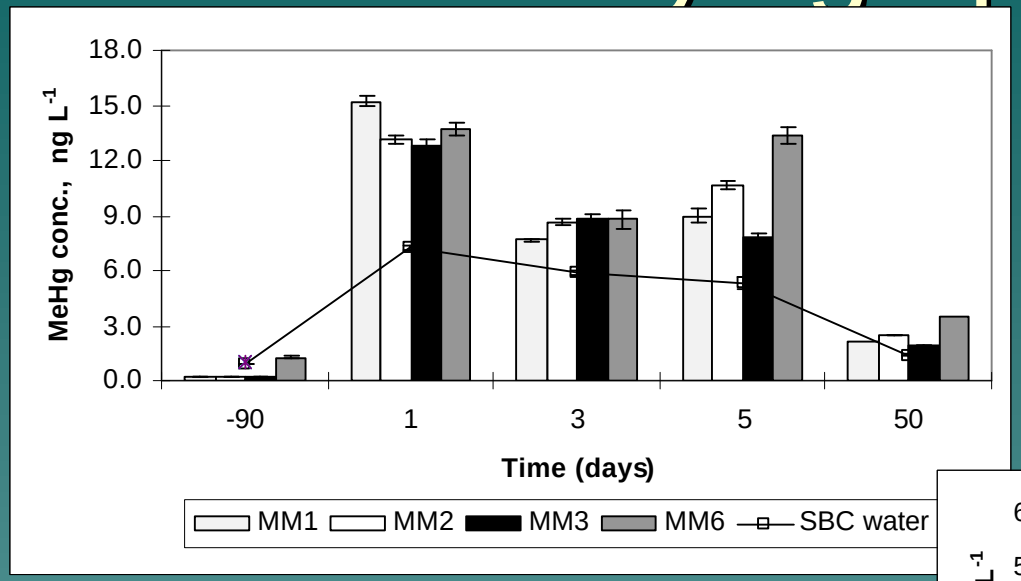


Drying and Wetting
Mesocosms with creek sediments

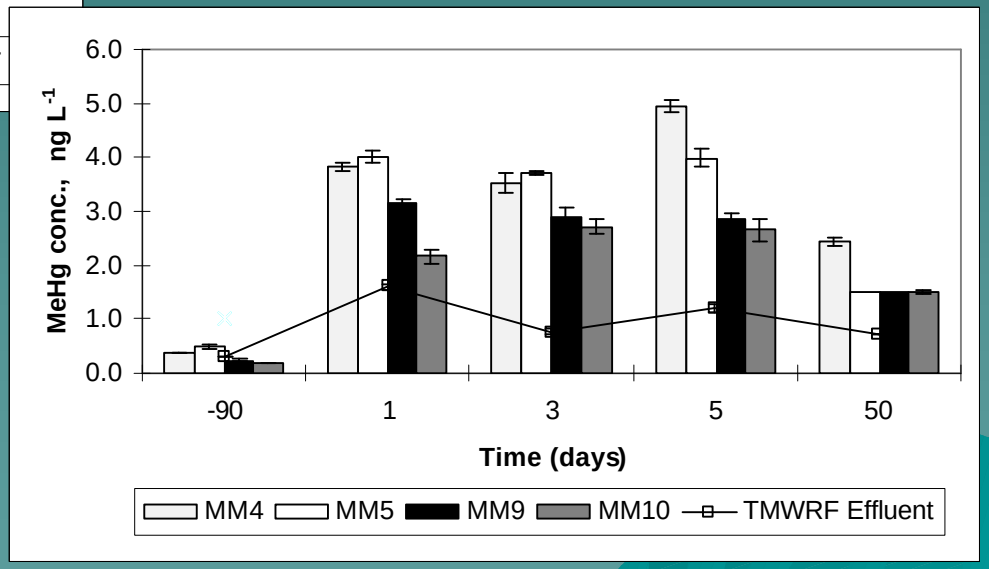


Creek water-creek sediments

Winter drying-spring rewetting



Creek water



Plant effluent

No significant change with

increase in water retention time (from 4 hours to 8 hours)

decrease in retention time (from 4 hours to 30 min)

Chemical manipulations using Plant effluent

- Sulfate added
  - Increased from 100 to 250 mg/L

    Slight increase in methyl mercury output

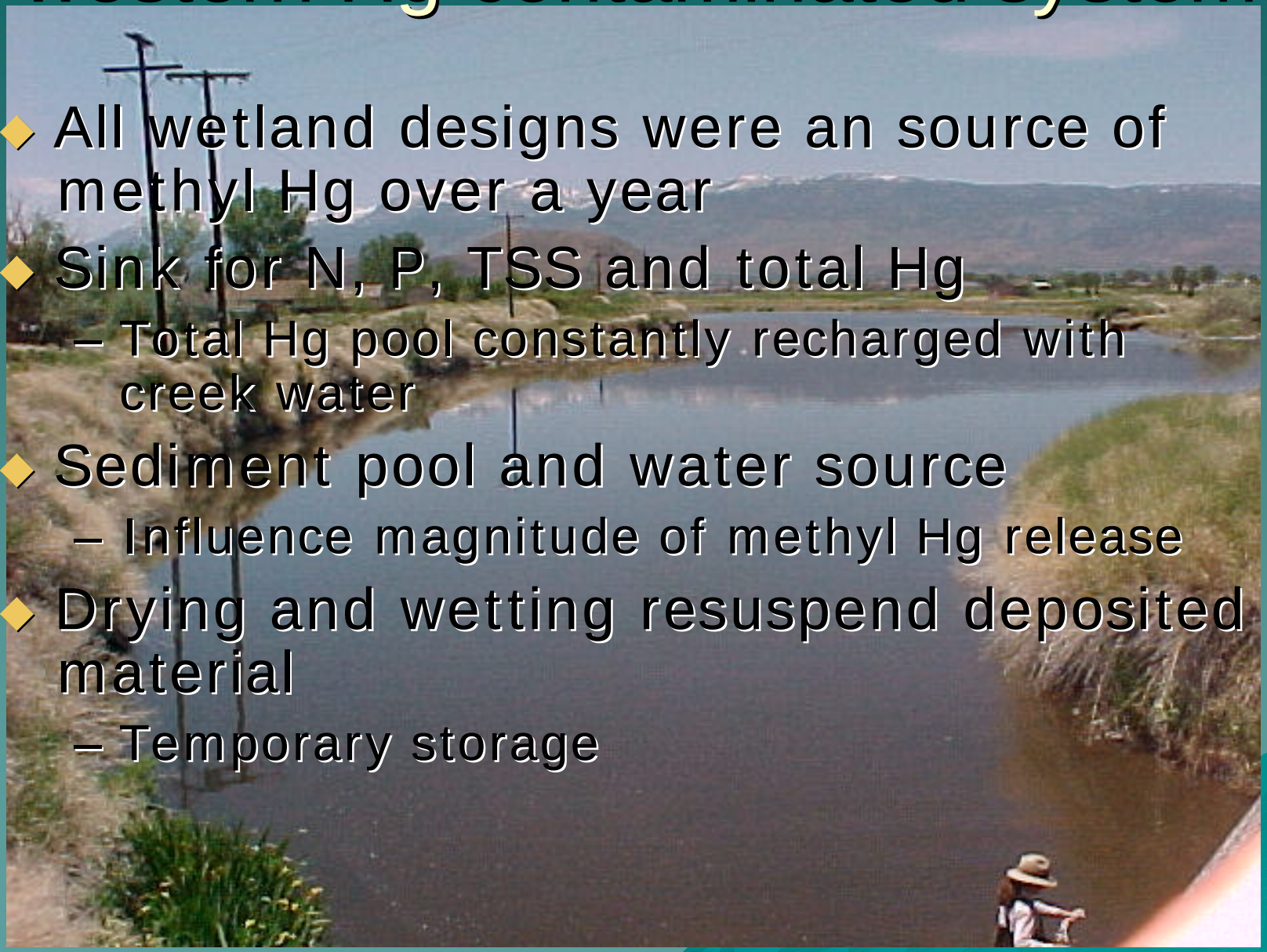
    No significant effect because above optimum concentration
- Nitrate added
  - Increased Plant effluent from 0.1 to 10 mg/L

    No effect concentrations are less than those where reduced methylation reported

Overall

- Net removal of sulfate from inlet to outlet of all mesocosms
- ? C sulfate between inlet and outlet and temperature best correlated (negative) with ? C methyl mercury concentrations in water
- Nitrate addition of 10 mg/l did not influence
- Sulfate increase did not influence but sulfate loss clearly correlated with methyl mercury release
- Waste water exacerbated methyl Hg production
  - Important for implications of use of wastewater to maintain flows in wetlands in arid systems

Considerations for wetlands western Hg contaminated systems



- All wetland designs were an source of methyl Hg over a year
- Sink for N, P, TSS and total Hg
  - Total Hg pool constantly recharged with creek water
- Sediment pool and water source
  - Influence magnitude of methyl Hg release
- Drying and wetting resuspend deposited material
  - Temporary storage

Considerations for wetlands western Hg contaminated systems

- Benefits of nutrient removal and TSS and total Hg load reductions versus methyl mercury production

Questions?