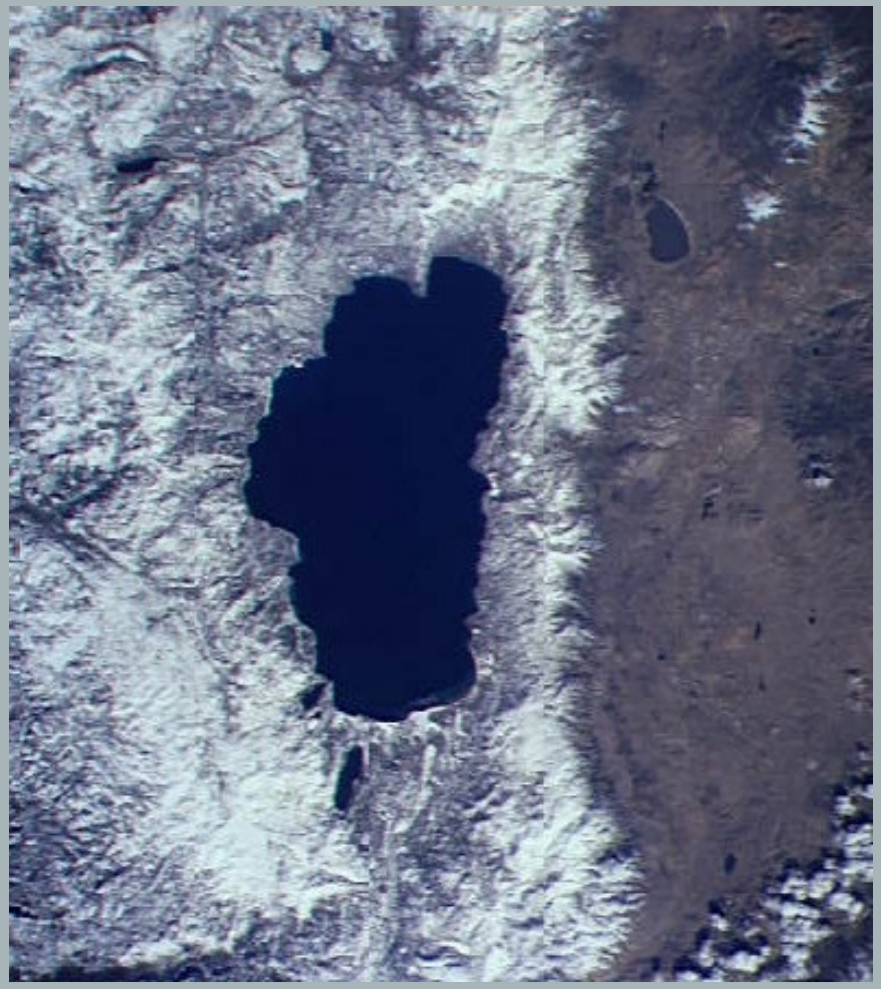
Availability of Phosphorus for Algal Growth in Sediment and Stream Water Inputs to Lake Tahoe



Joseph W. Ferguson,

Robert G. Qualls

University of Nevada, Reno

John Reuter

University of California, Davis

Rationale

- *Phosphorus is limiting biological growth*
- *Not all P loaded into the lake is available for algal and microbial growth*
- *Relative importance of sources may differ*
- *Need more relevant input for Lake Tahoe Clarity Model*
- *This may provide better information for TMDL limits*

Annual Phosphorus Loading to Lake Tahoe

- *Source – (Total-P, Soluble-P)*
- *Atmospheric Deposition – 12.4, 5.6*
- **Stream Loading – 13.3, 2.4*
- *Direct Runoff – 12.3, 2.4*
- *Groundwater – 4, 4*
- *Shoreline Erosion – 1.6, N/A*

(units in 10^3 kg/year)

(Reuter, et al. 2001)

Historical Work / Literature

- *Suspended sediments collected from 5 tributaries to the lower great lakes: 21.8 percent of the total particulate P was bioavailable. (De Pinto, et al. 1981)*
- *Suspended sediments collected from the Flathead River-Lake ecosystem in Montana: 4-6 % of the total particulate P was bioavailable. (Ellis and Standford, 1988)*

Outline

- ***Materials and Methods***

1) *Algal Bioassay*
2) *Chemical Fractionation*

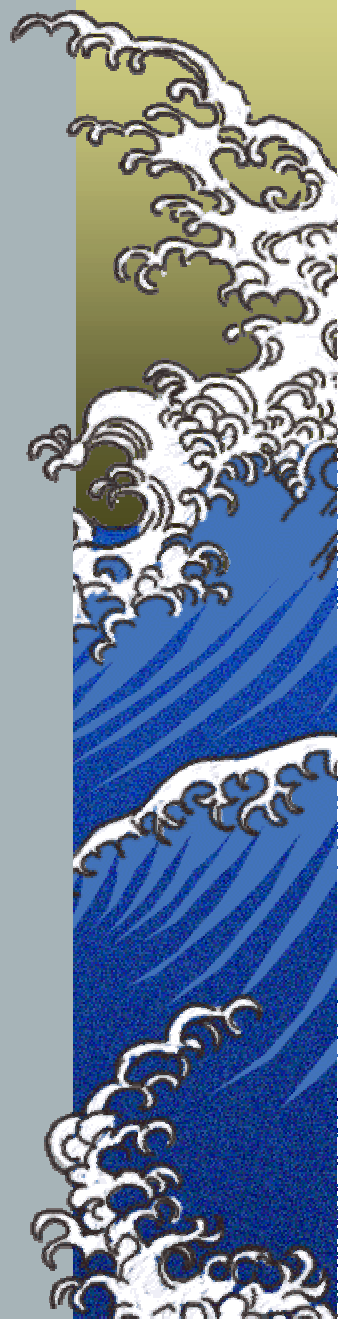
- ***Results***

1) *What percentage of Total P is bioavailable?*
2) *How do the different sources rank?*
3) *Is there a chemical extraction that serves as a surrogate for an algal bioassay?*

- ***Conclusions***
- ***Future Work***

Materials and Methods

- *Algal Bioassay (DePinto et al. 1981)*
- *Chemical Extraction (Hedley et al. 1982)*



Materials Sampled

- *Suspended sediments from:*

1) 5 Major tributary streams

- EC, GC, IC, UT, and WC.

2) 5 Direct urban runoff areas

- RB, SY, OS, SQ, and TC.

- *Dissolved organic P from:*

3) 2 major tributary streams

- EC, UT

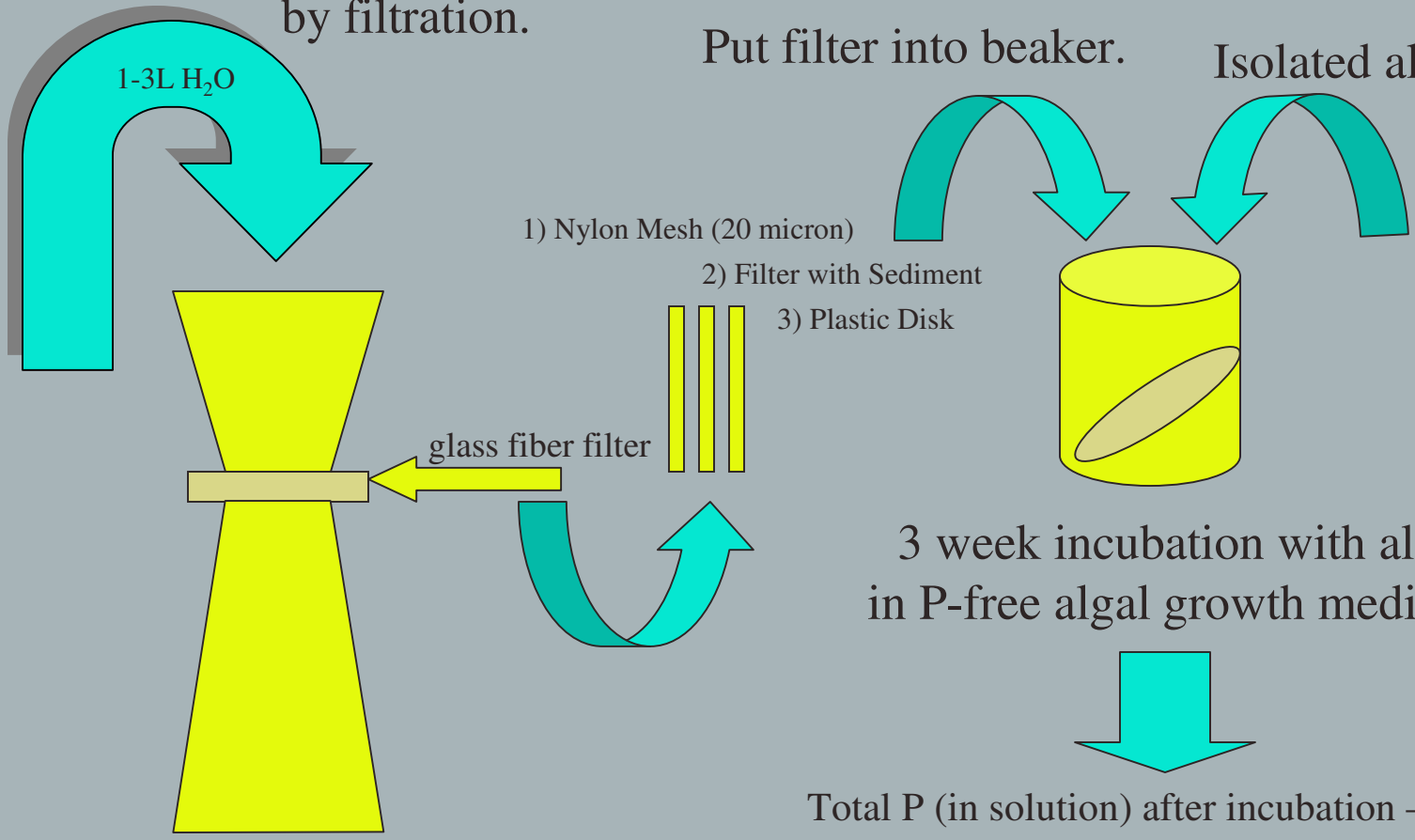
- *Erodable Streambank Sediments from:*

4) All LTIMP erodable stream banks

- IC, GC, WC, UT, EC, ThC, GbC, TrC, and BC

Methods - Bioassay Procedure

Isolate suspended sediments by filtration.



Put filter into beaker.

Isolated algae

3 week incubation with algae in P-free algal growth medium.

Total P (in solution) after incubation –

Total P (in solution) before incubation =

Total P uptake by algae from sediments

Algal Bioassay Incubation

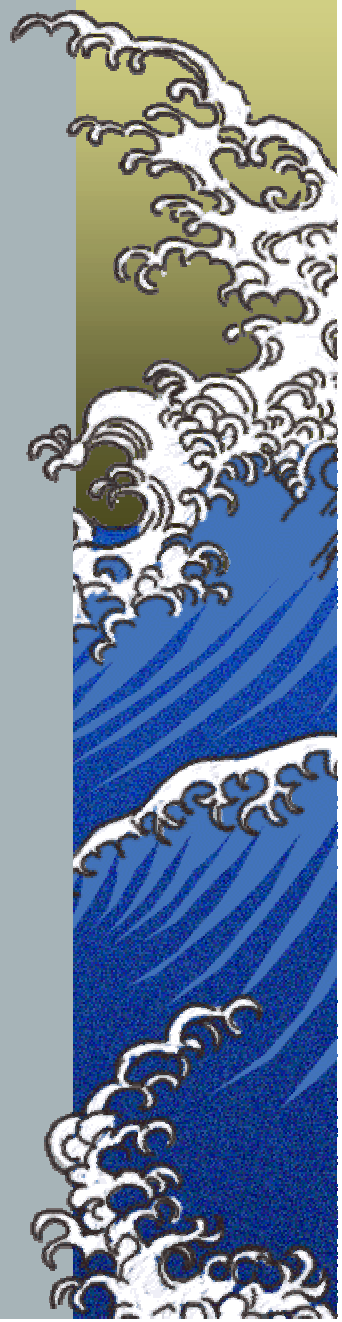
Algal Bioassay Incubation, *Selenastrum Capricornutum*

Algal Bioassay Incubation (21 days)

Algal Bioassay

- *Total P that appears in solution after incubation is due to 2 mechanisms:*

1) *Direct uptake of exchangeable PO_4*
2) *Uptake of organic P that is mineralized by phosphatase enzymes.*



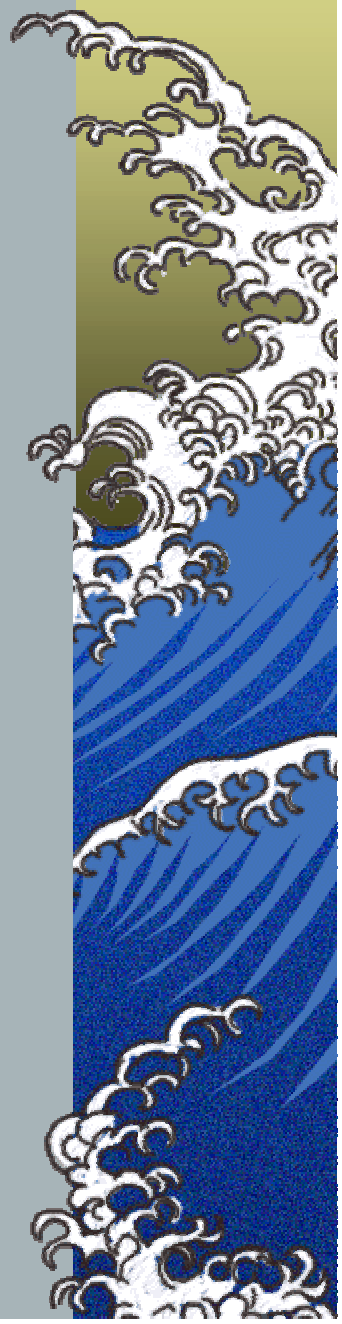
Methods - Chemical Fractionation Procedure

- *Anion Exchange Membrane extract**
- *$NaHCO_3$ extractable inorganic, microbial biomass*, and organic P*
- *NaOH extractable inorganic and organic P*
- *HCl extractable Total P*

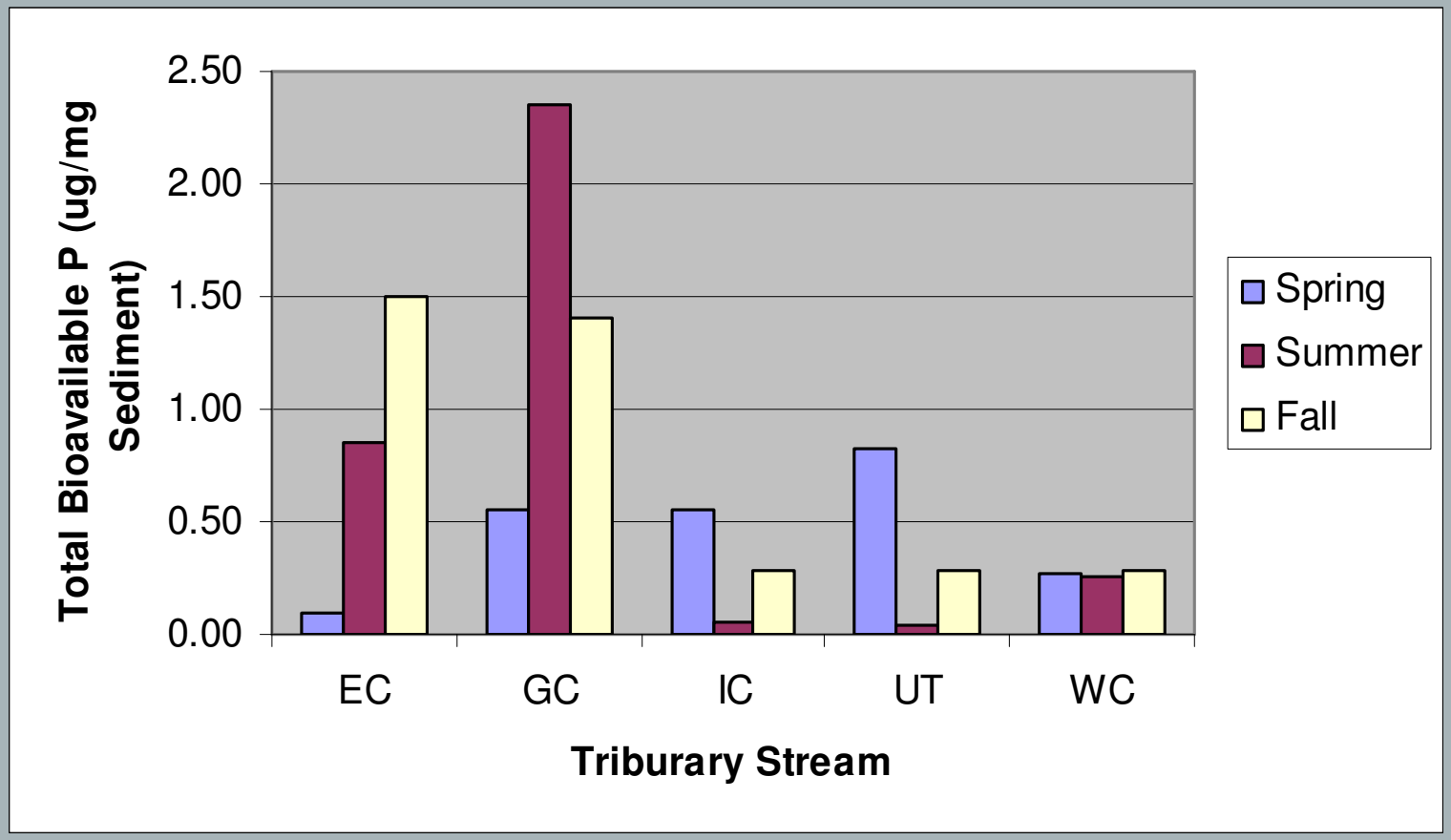
**not tested for suspended sediments*

Results

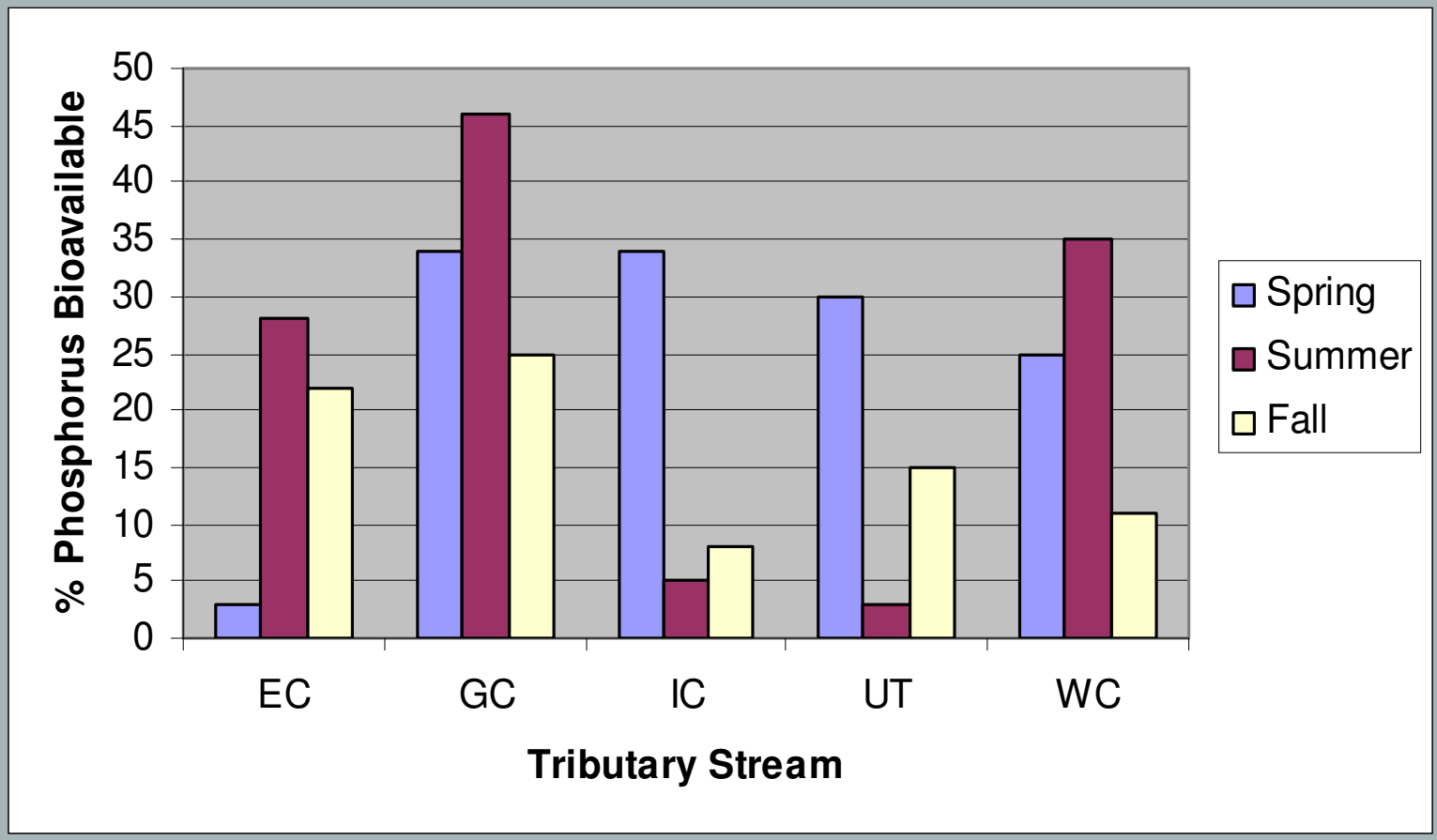
- *Total P bioavailable from different sources (ug P/mg sed.)*
- *Percentage of total P that is bioavailable*
- *Relative rank of sources in ug P/mg sed., and % of TP that is bioavailable.*
- *Correlation between a chemical extract and bioavailability.*
- *High molecular weight dissolved organic P not found to be highly bioavailable*



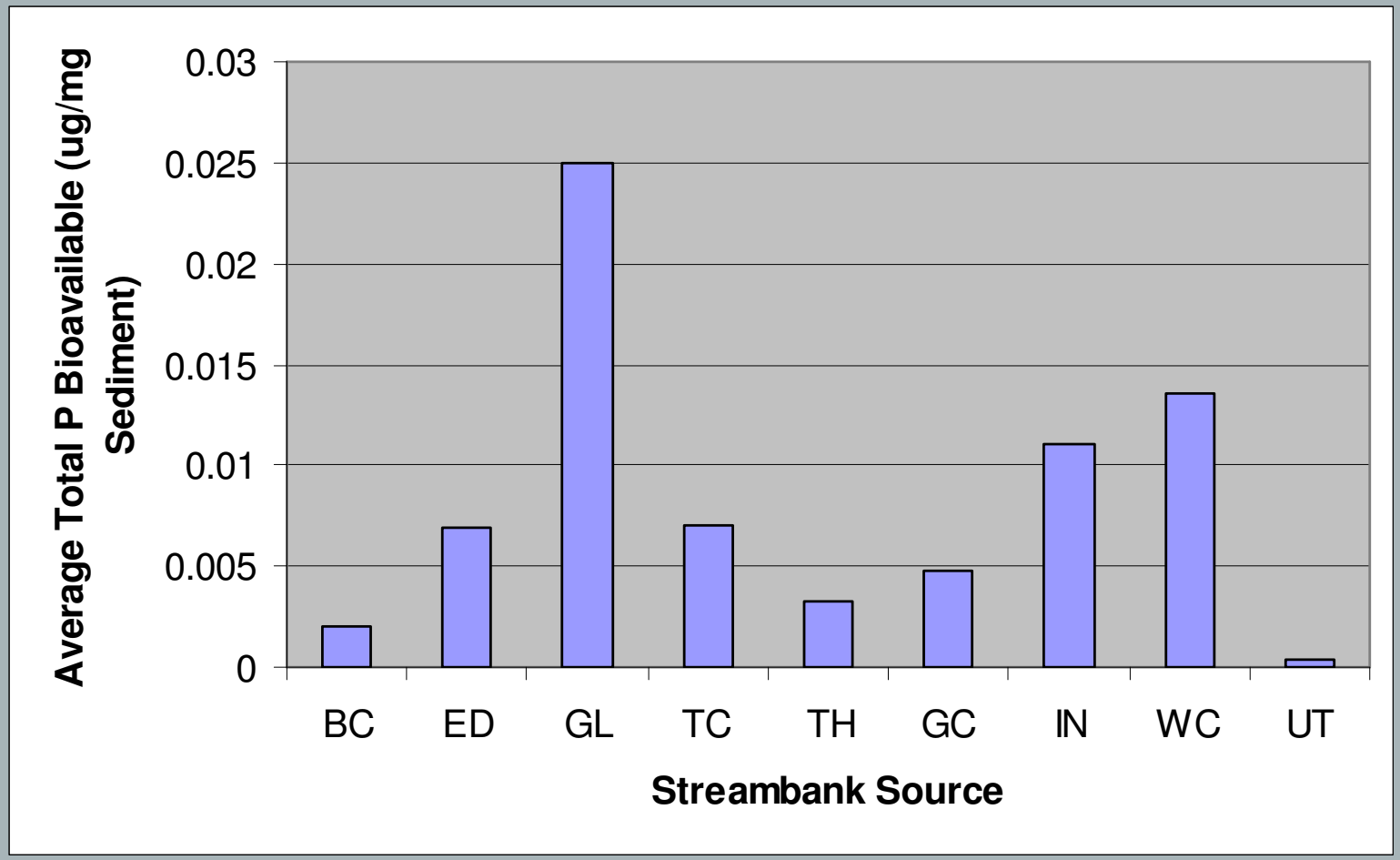
Total Bioavailable P (ug/mg sediment) in the Stream Sediments of 5 Tributaries of Lake Tahoe in Spring, Summer, and Fall 2003



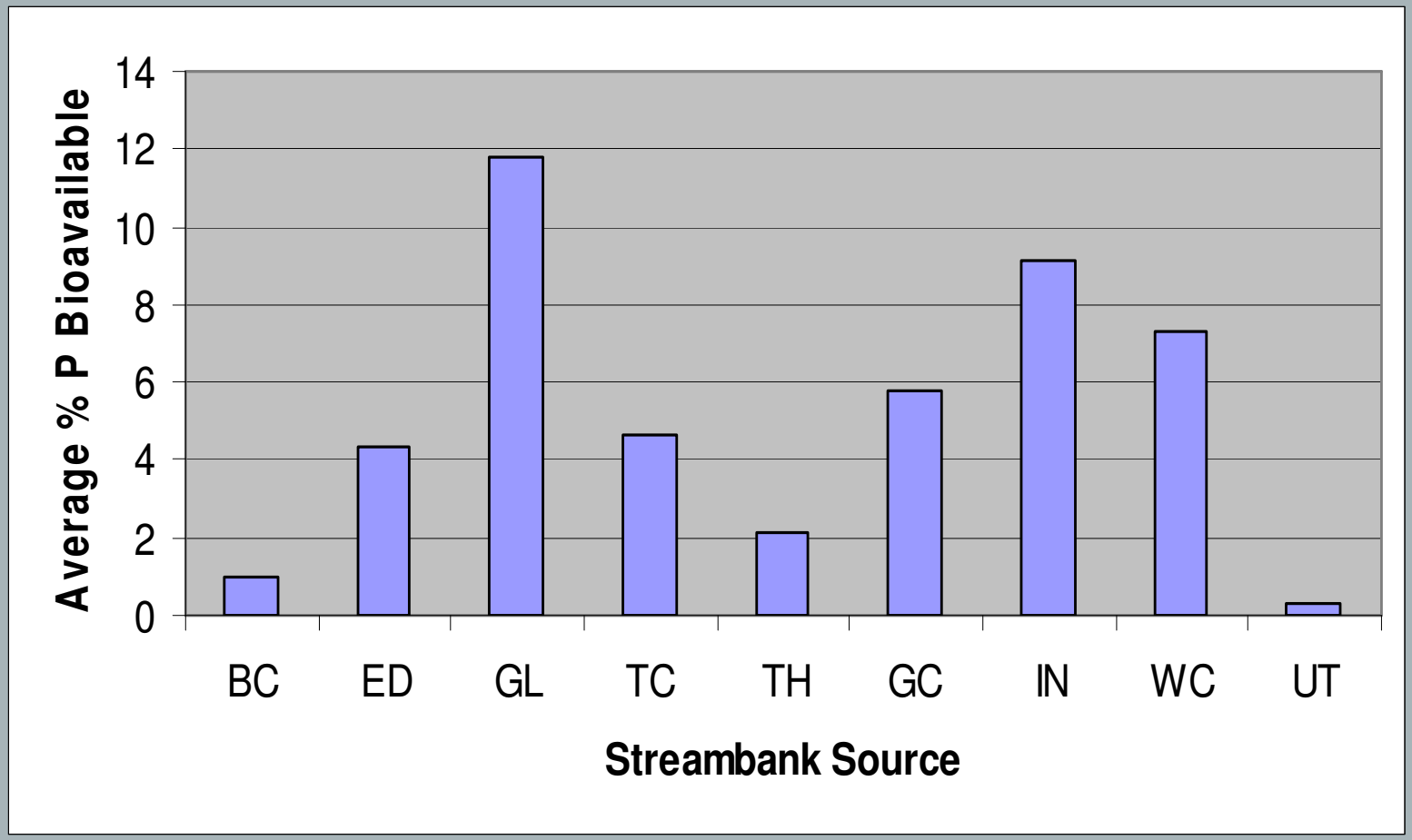
Percent Phosphorus Bioavailable in the Stream Sediments of 5 Tributaries of Lake Tahoe in Spring, Summer, and Fall 2003



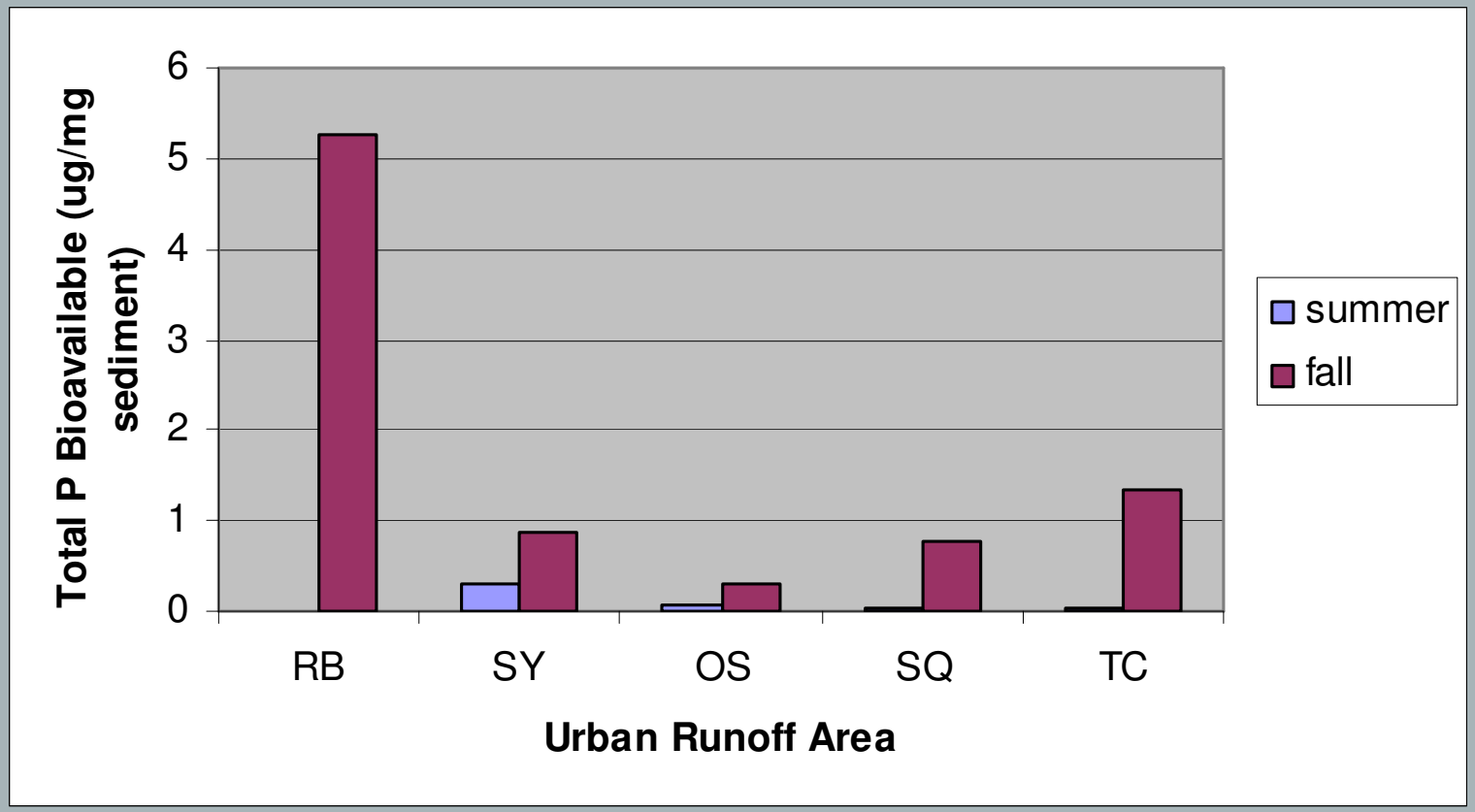
Total Bioavailable P (ug/mg sediment) in the Stream Bank Sediments of 9 TTIMP Sites of Lake Tahoe



Percent Phosphorus Bioavailable in the Stream Bank Sediments of 9 Tributaries of Lake Tahoe



Total Bioavailable P (ug/mg sediment) in the Runoff Samples of 5 Urban Areas of the Lake Tahoe Basin in Summer and Fall 2003



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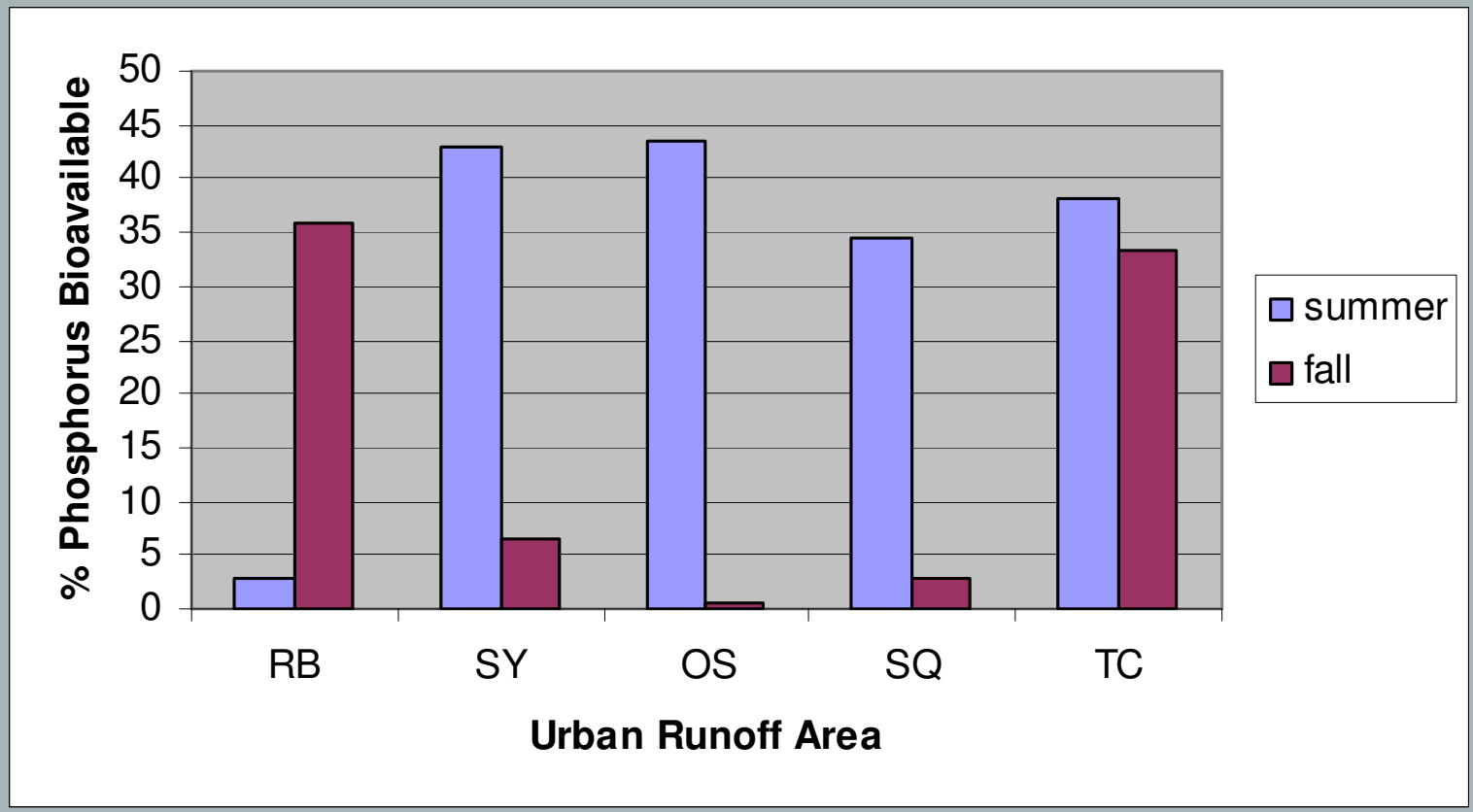
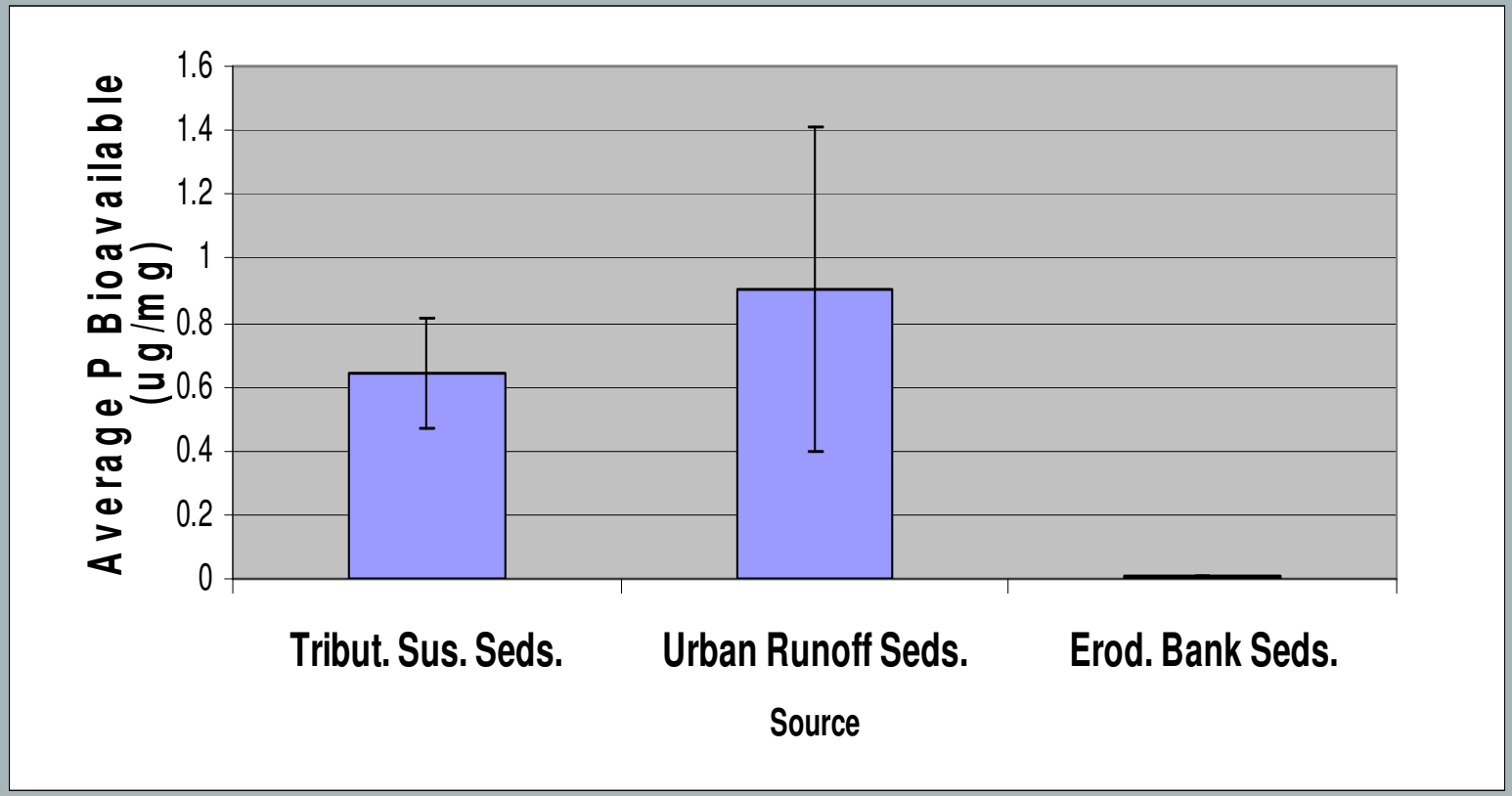


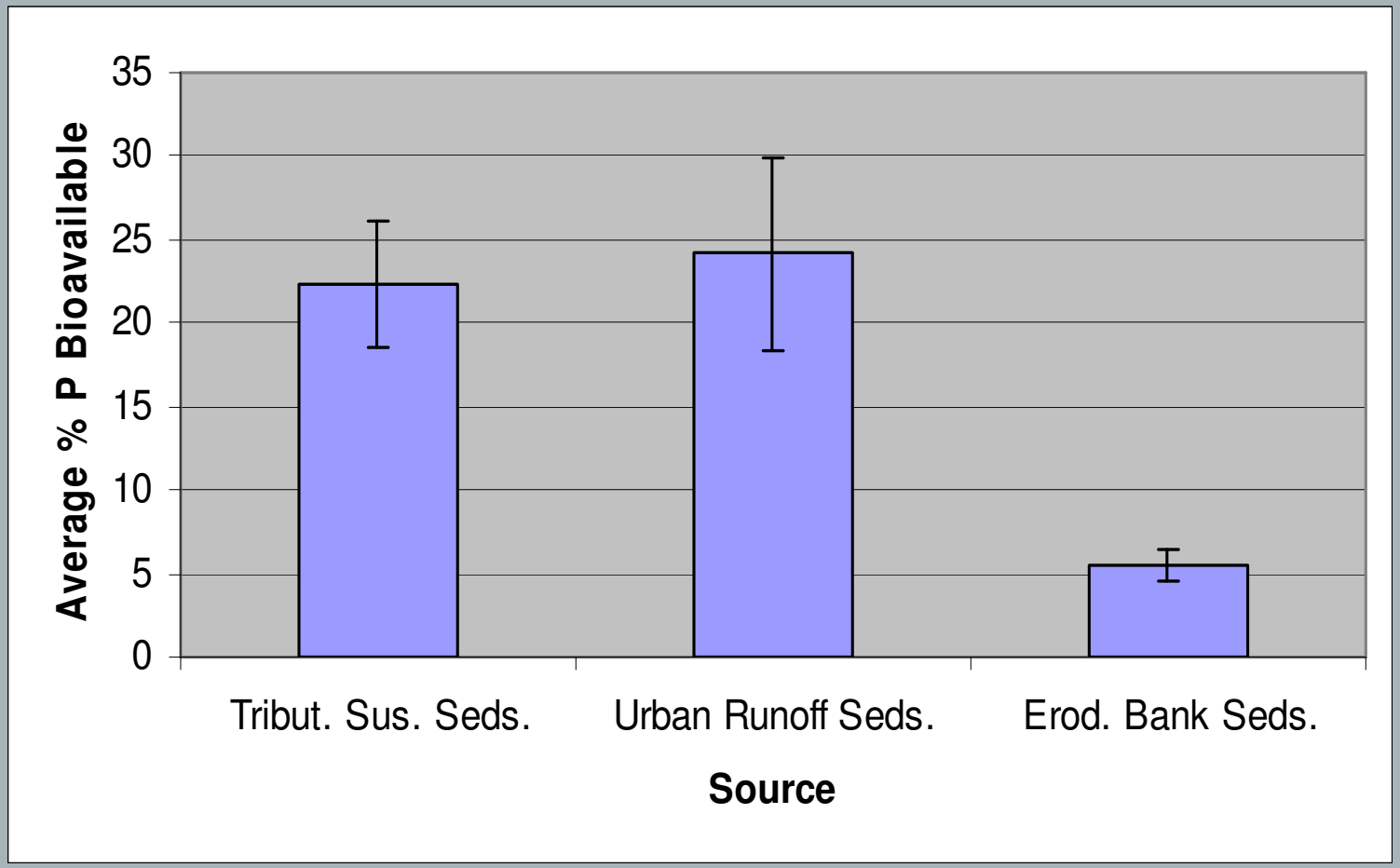
Relative Rank of Sources

(ug/mg sediment)

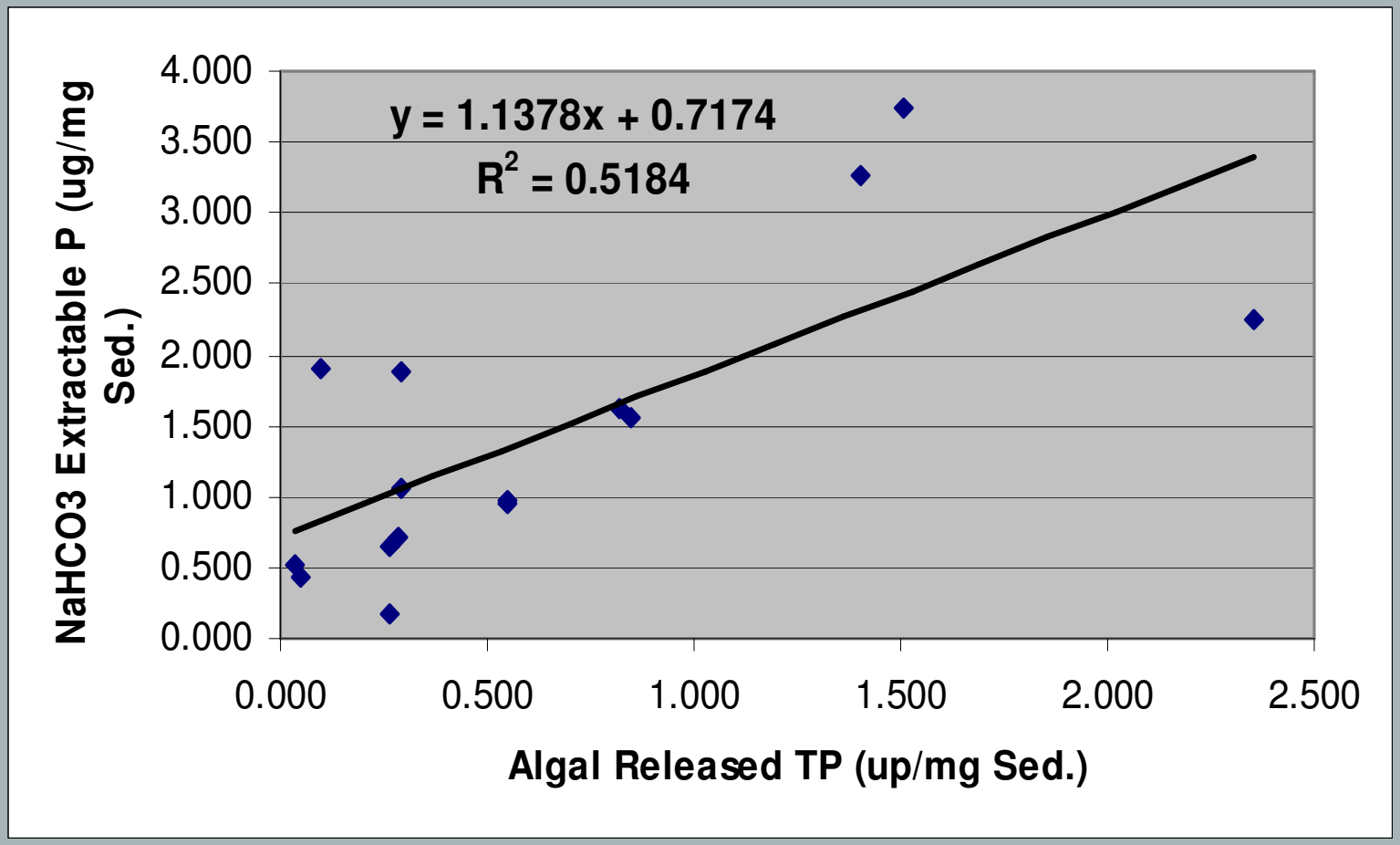


Relative Rank of Sources

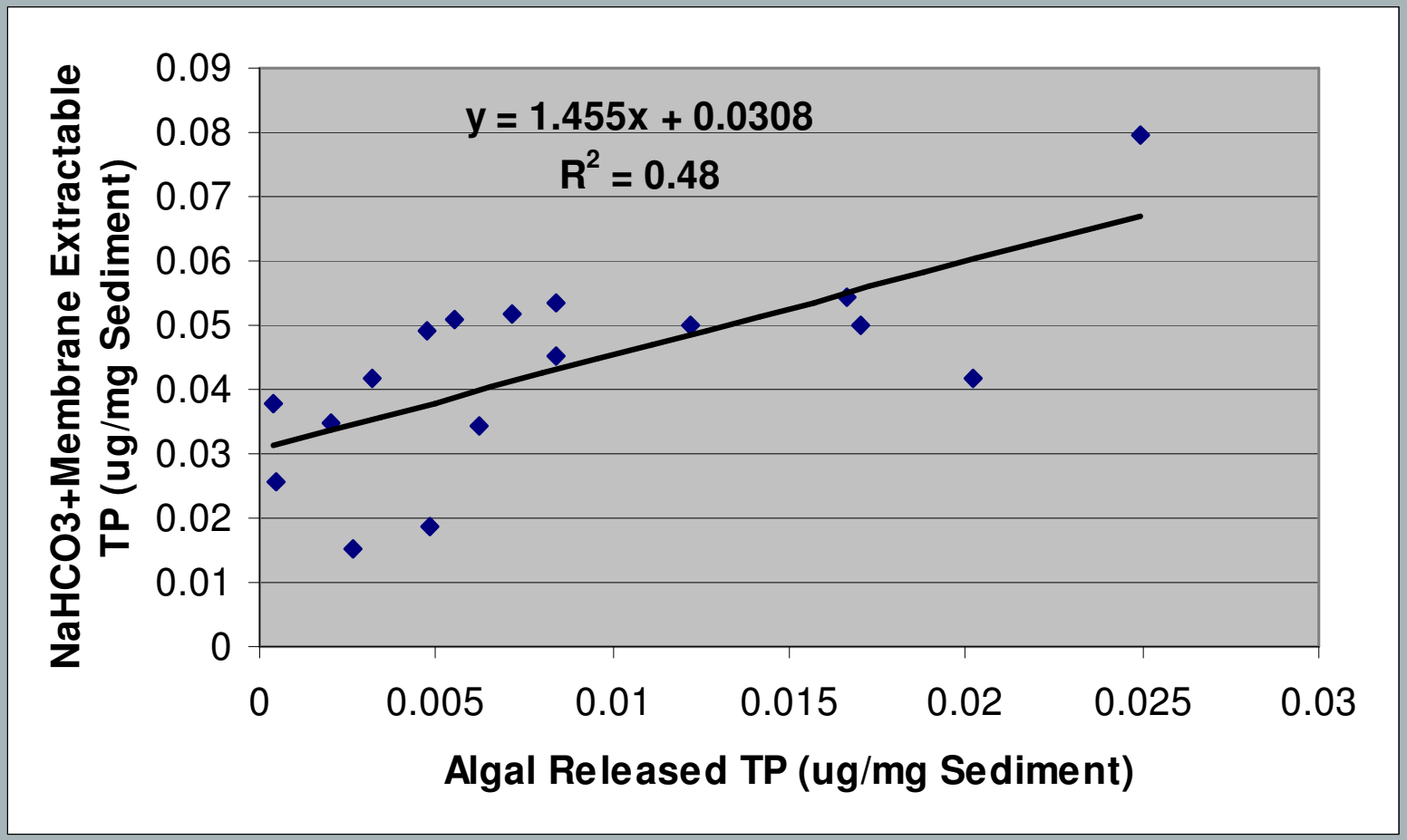
(% P Bioavailable)



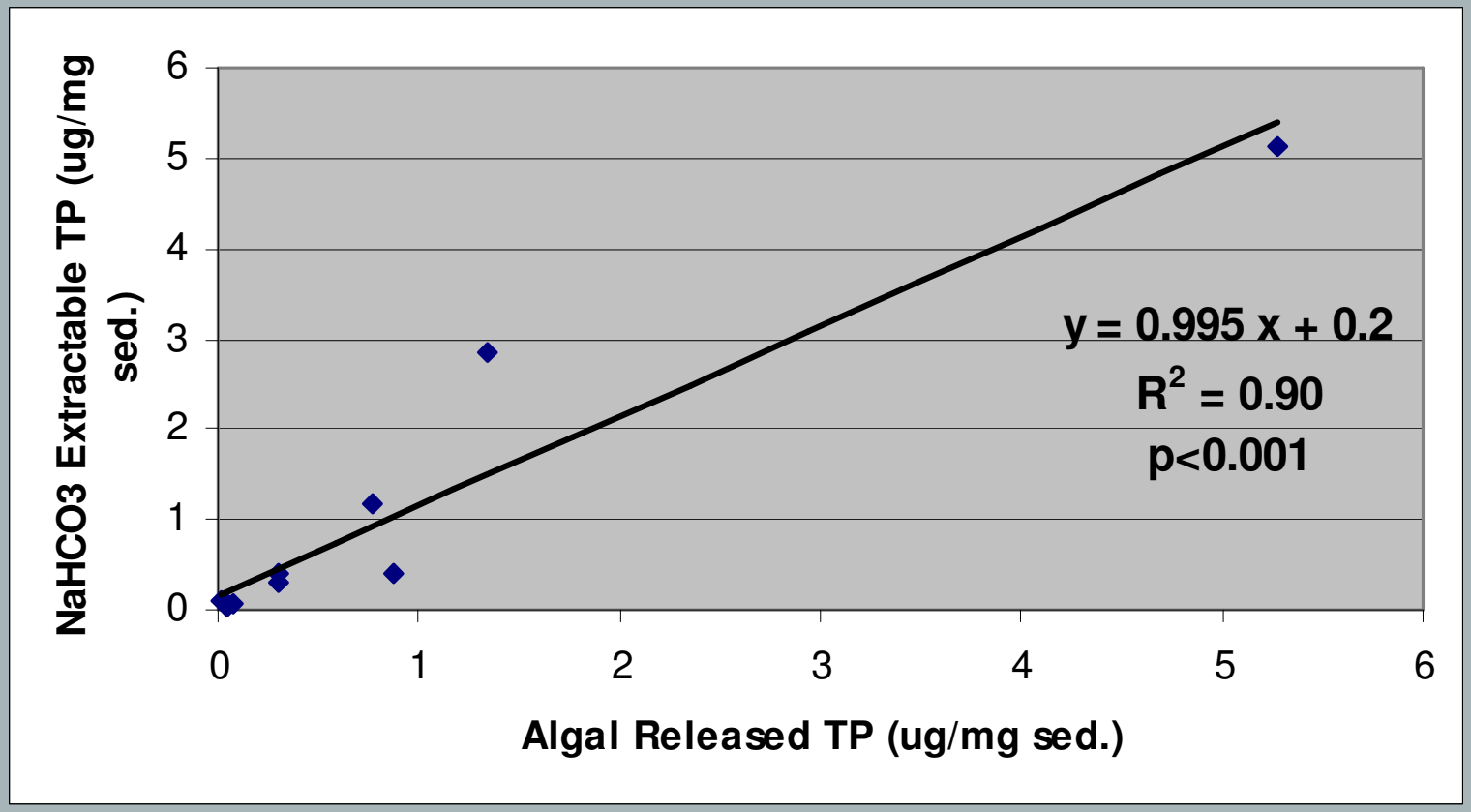
Bioavailable P vs. $NaHCO_3$ Extractable P for Suspended Stream Sediments



Bioavailable P vs. Membrane + $NaHCO_3$ Extractable P for All Stream Bank Sediments



Bioavailable P vs. $NaHCO_3$ Extractable P for Urban Runoff Sediments



DOP Mineralization and Algal Uptake from UT and EC

UT Average	Initial (ug/L)	Final (ug/L)
PO4	8	10
DOP	15	16
PP	20	14
TP	44	40

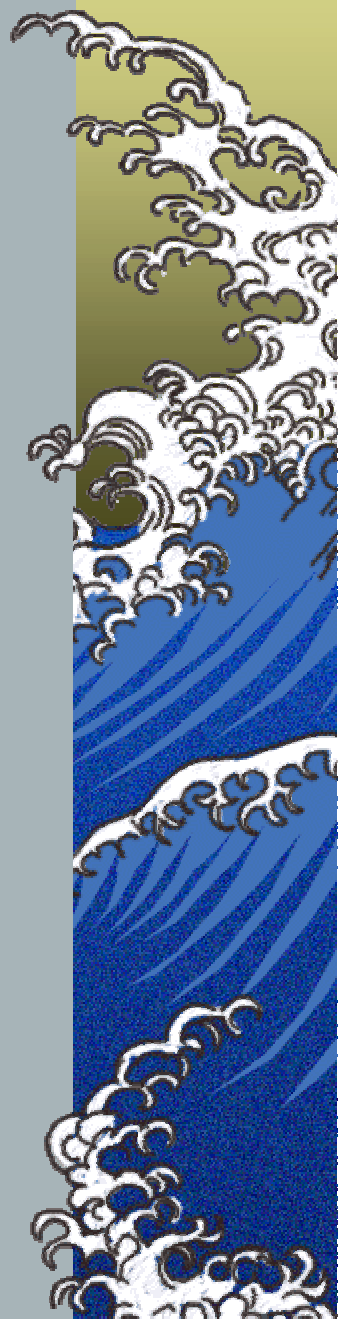
EC Average	Initial (ug/L)	Final (ug/L)
PO4	11	6
DOP	10	8
PP	15	32
TP	37	45

Conclusions

- *Less than 50% of suspended sediment P is bioavailable from all sources (average is 22.33%)*
- *% of sediment P bioavailable is highly variable between sources and season*

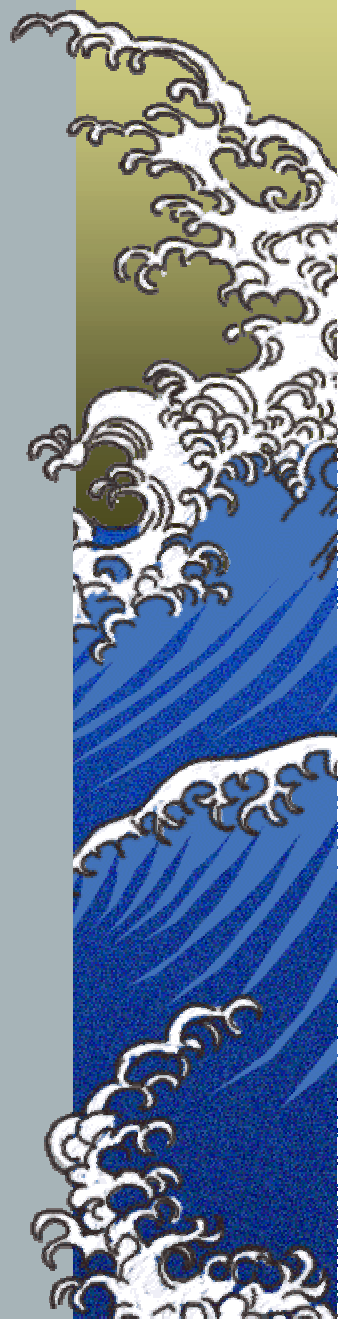
1) *Suspended stream seds. (2 – 47%)*
2) *Streambank seds. (<1 - 16%)*
3) *Urban runoff seds. (1 – 44%)*

- *$NaHCO_3$ extractable total P is a fairly good indicator of bioavailable P.*
- *DOP inputs from 2 Tributary Streams not likely highly bioavailable.*



Future Work

- *More work on the mineralization rate of DOP in the lake*
- *Particulate P settling in the lake*
- *Atmospheric deposition inputs*



Acknowledgments

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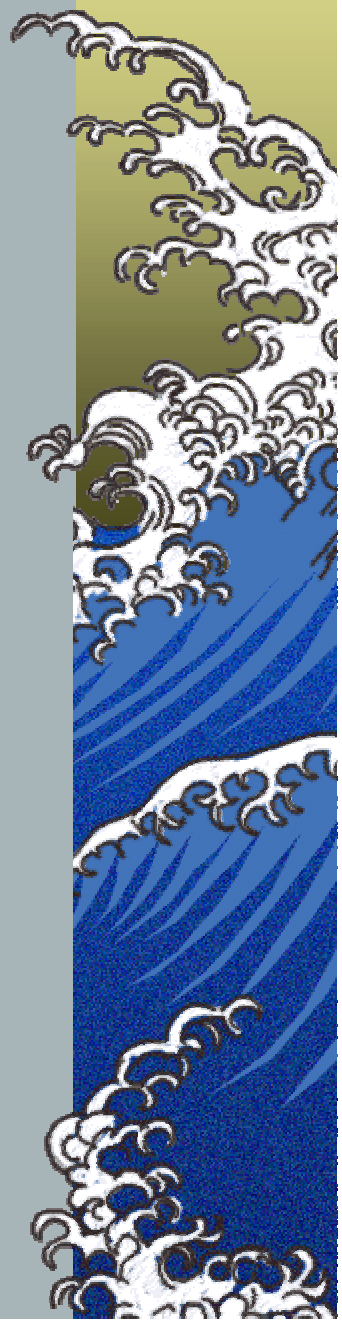
- *Funded by the California Regional Water Quality Control Board, Lahontan Region*



Questions