# Spokane Regional Wastewater Phosphorus Bio-availability Study

# Final Report

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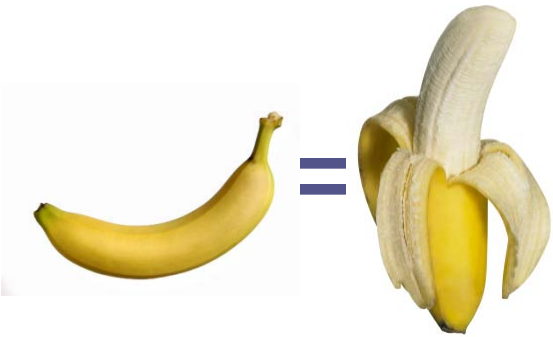
# Phosphorus Speciation

- Phosphate ($PO_4^{-3}$)

## Recalcitrant Phosphorus

| Inorganic P | Organic P |
|---|---|
| • Apatite | • Polyphosphate |
| • ( $Ca_3(PO_4)_2$ ) | • Inositol hexakisphophate |
| • $AlPO_4$ | • L-α-phosphatidyl choline |
| • $FePO_4$ | • phosphoenol pyruvate |
| | • glycerophosphate |



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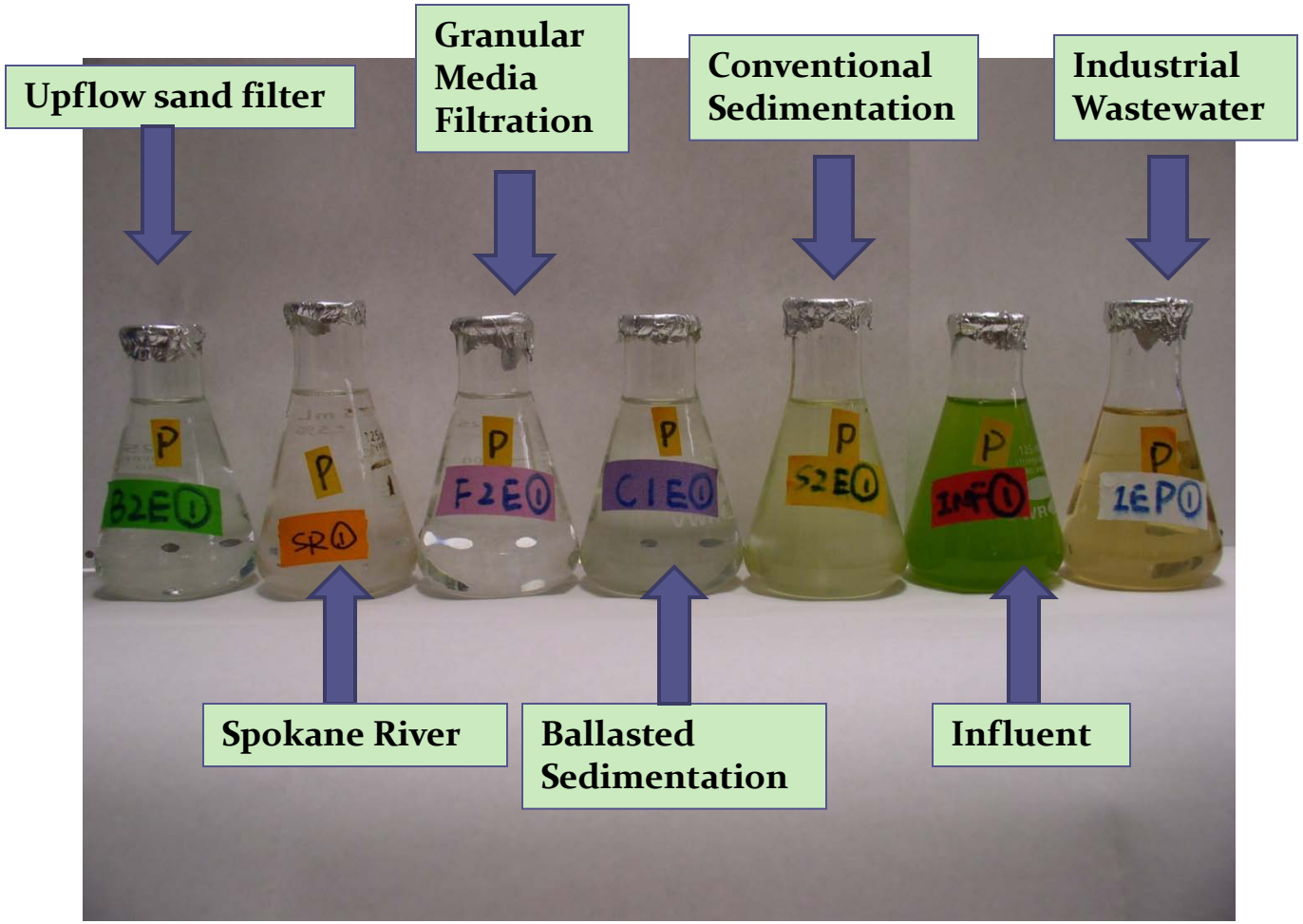
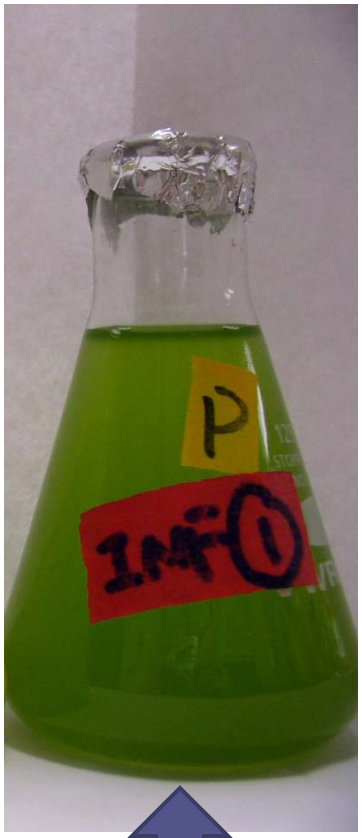
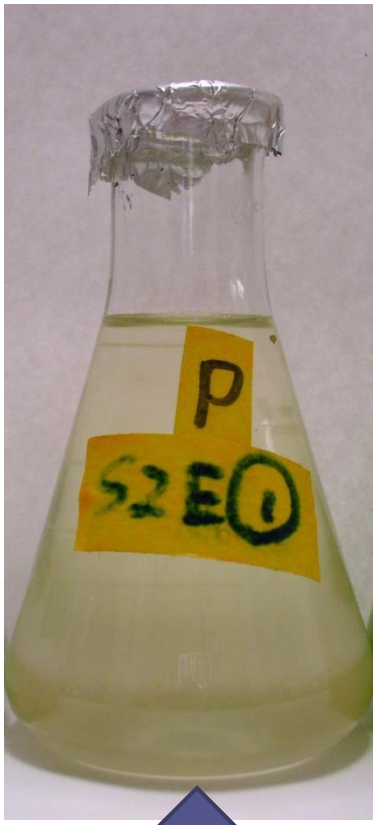
# Results


Upflow sand filter
Granular Media Filtration
Conventional Sedimentation
Industrial Wastewater
Spokane River
Ballasted Sedimentation
Influent



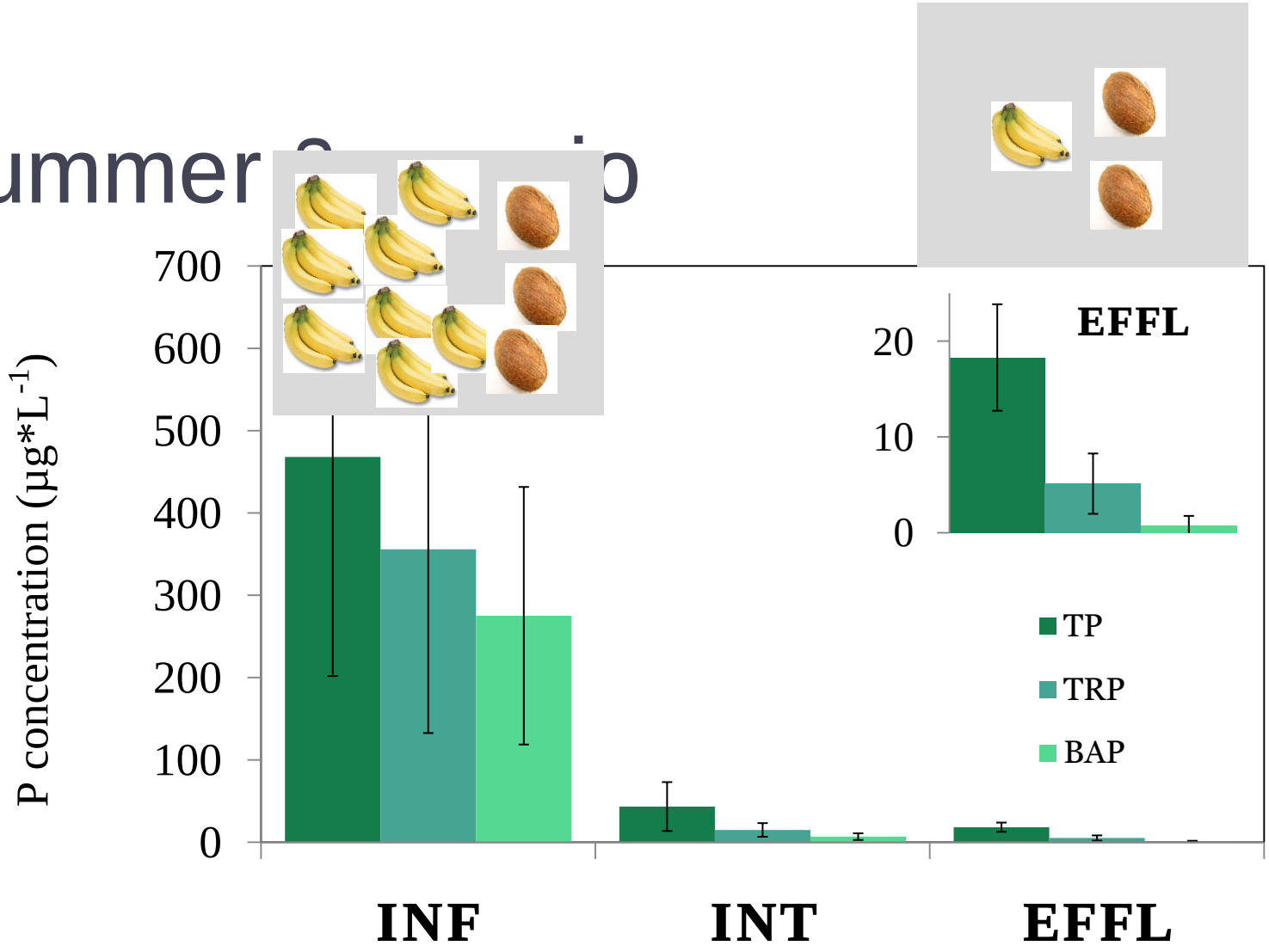

Influent




Intermediate

Effluent

# Summer Sampling

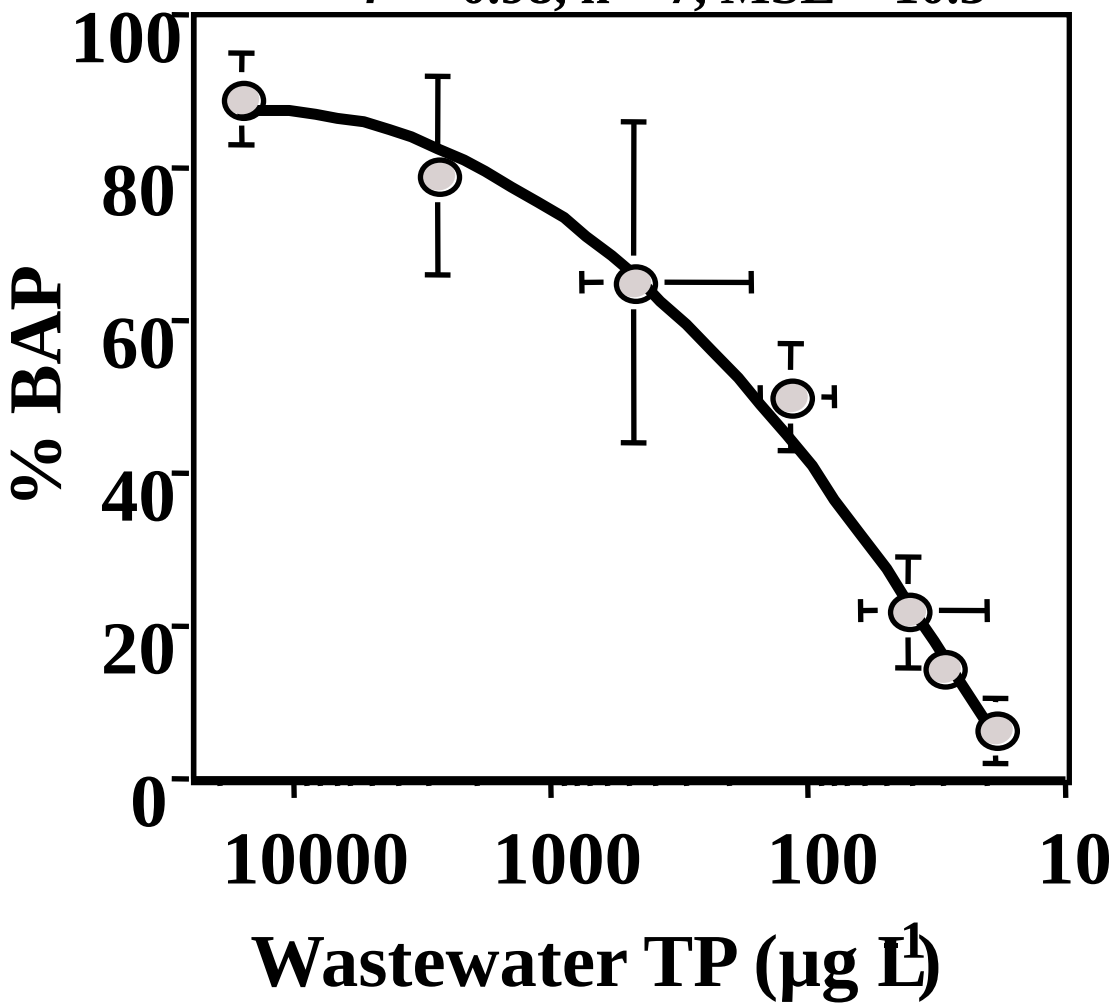



INF-Inffluent INT-Intermediate EFFL-Effluent

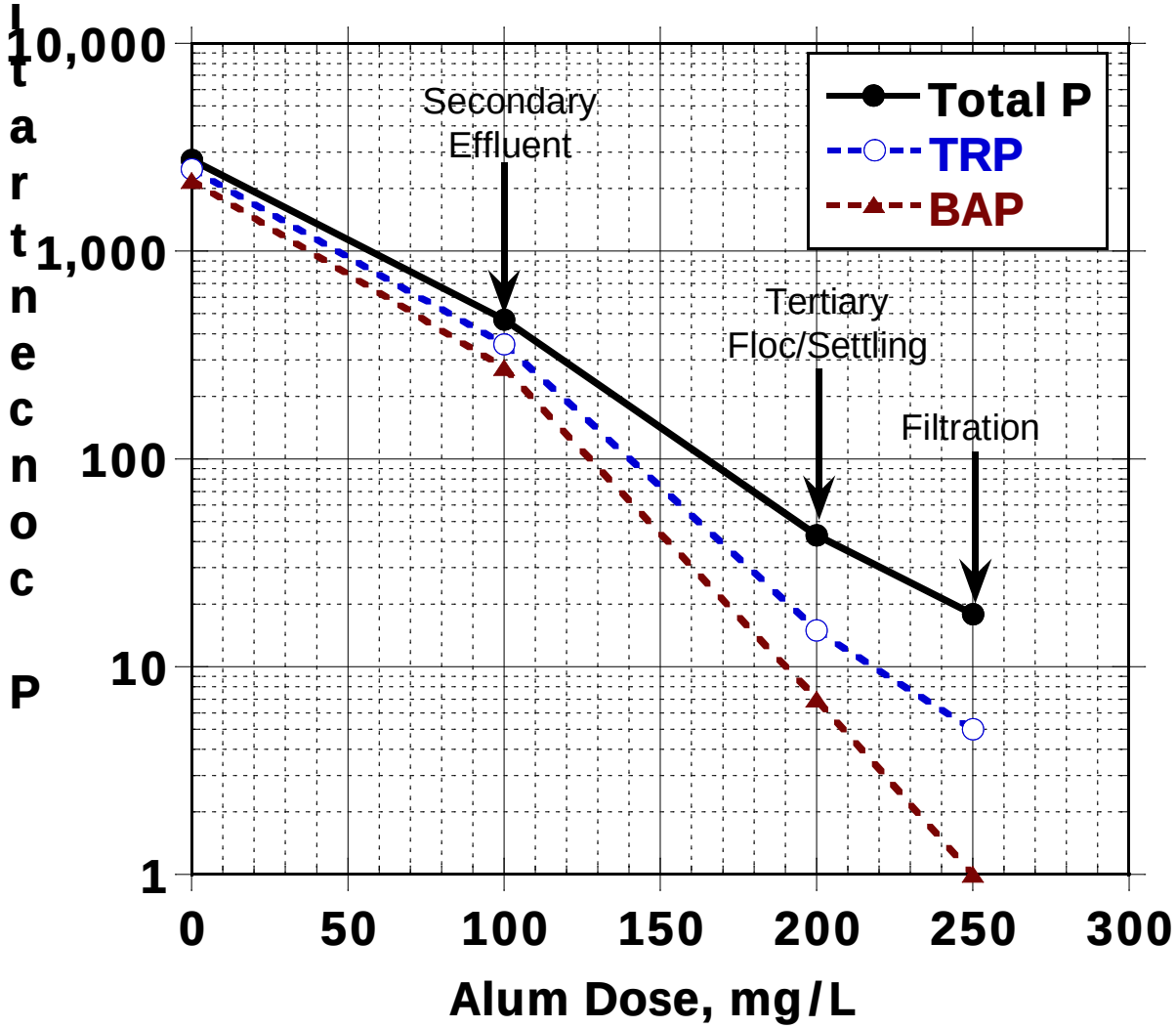
# BAP% vs. TP in alum treatment process

**%BAP = -12.19*log (TP)$^2$ + 92.03*log(TP) + 94.17;**

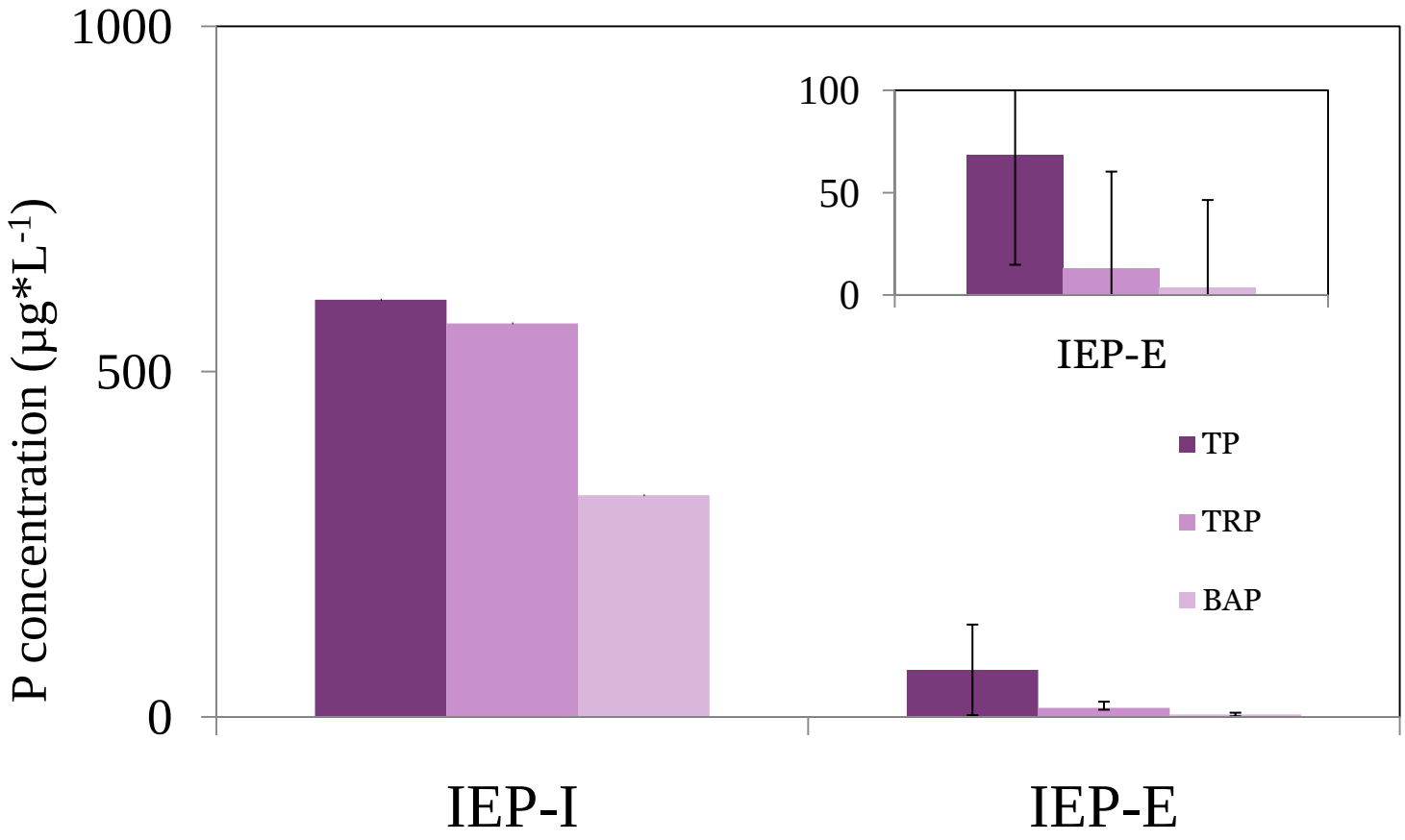
**$r^2$ = 0.98, n = 7, MSE = 10.3**



# Effect of Chemical Dose and Tertiary Treatment on Effluent P Species

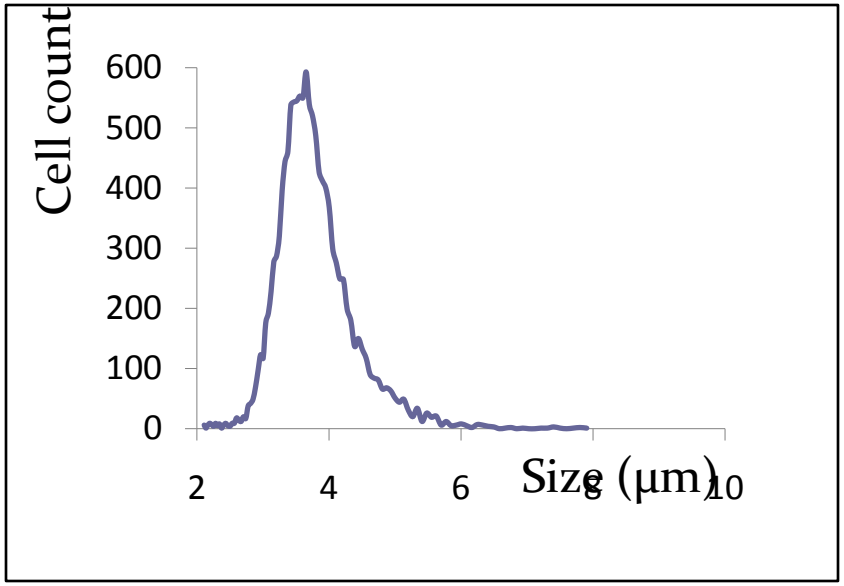


# Inland Empire Paper

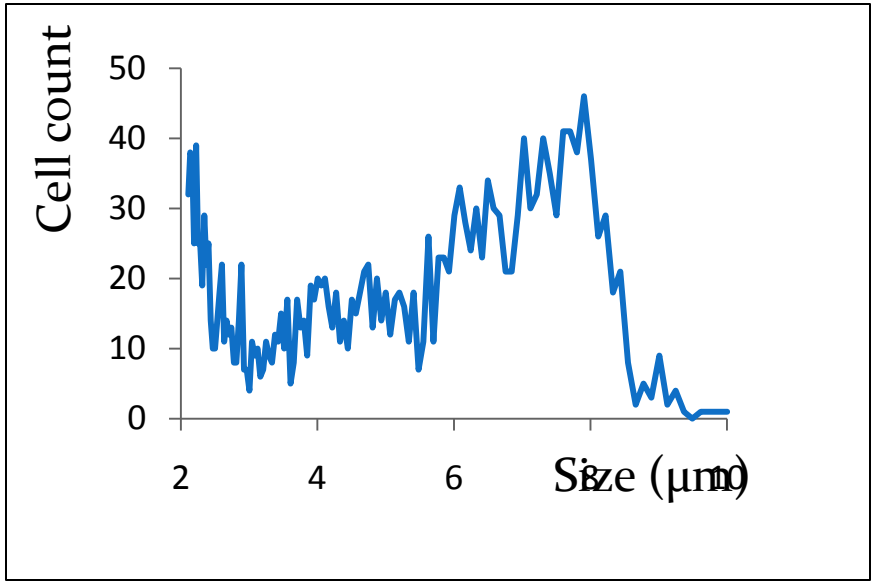


# Inland Empire Paper

Expected

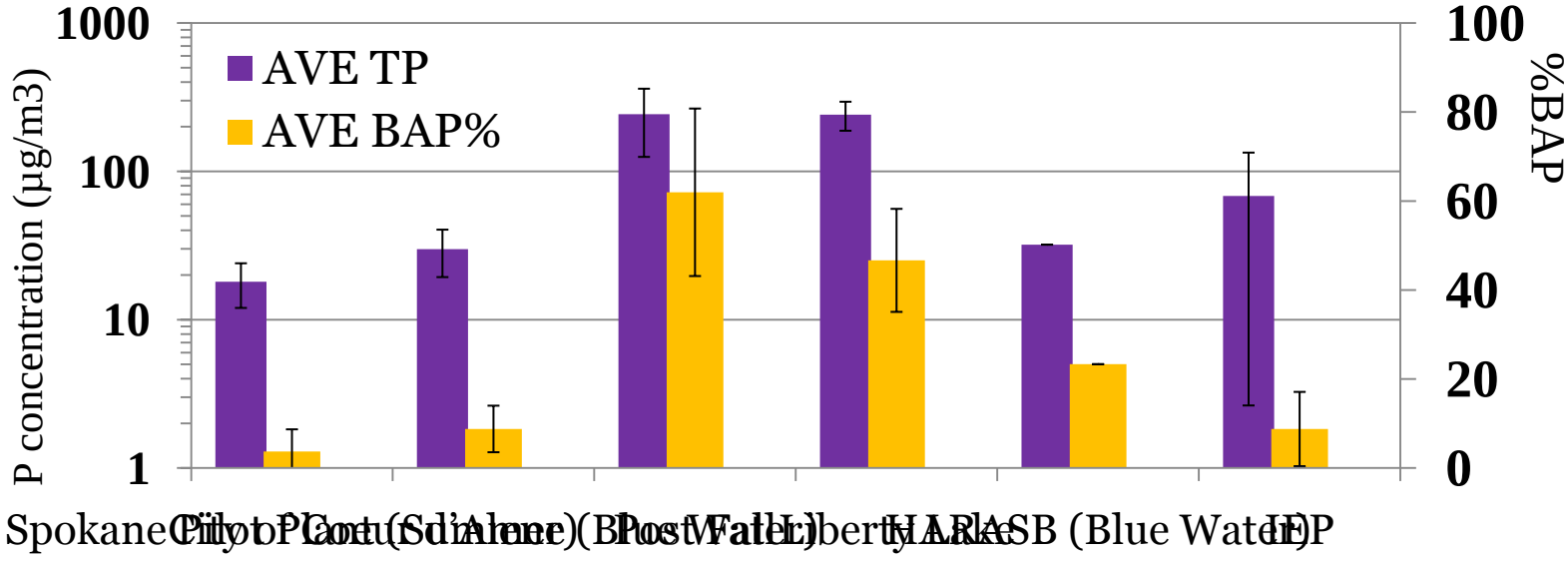


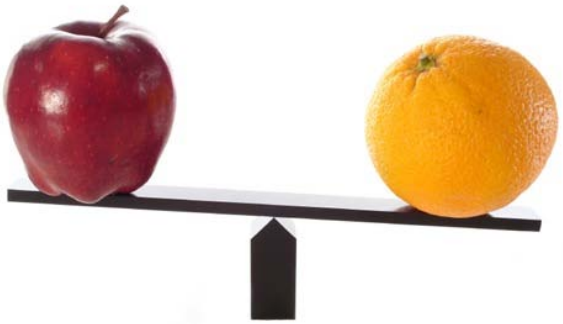

Industrial Wastewater




| IEP | Sep. 10 | Dec.3rd |
|---|---|---|
| Chl-*a* *(µg/L)* | 1.06 | 1.6 |

# Comparison of %BAP and TP

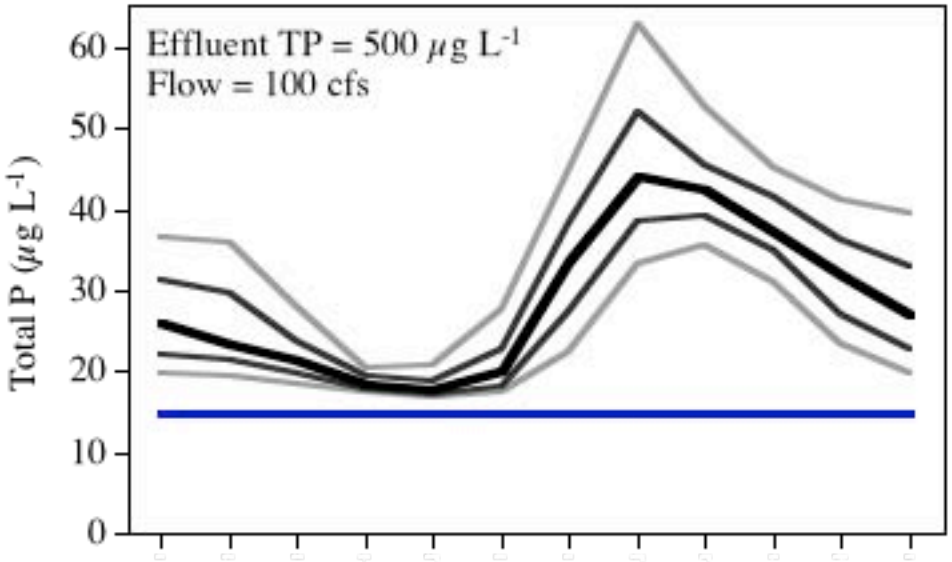


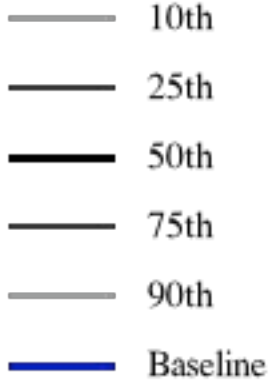



# Future Studies

- Add concentrated P-free growth media to pure effluent to test for colimitation
- Add concentrated P-containing growth media to pure effluent to test for toxicity
- More samples ($n \approx 10$) for other plants
- Assess long-term BAP for selected effluent
- Analyze Chl for IEP experiments

# Mass Balance:



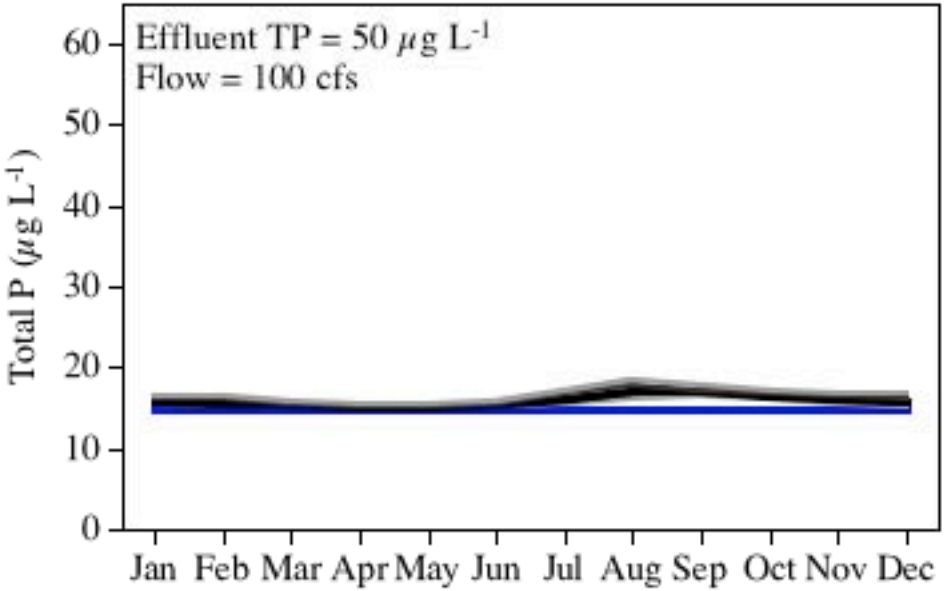

Overall increase
7.8 ± 2.8 μg $L^{-1}$

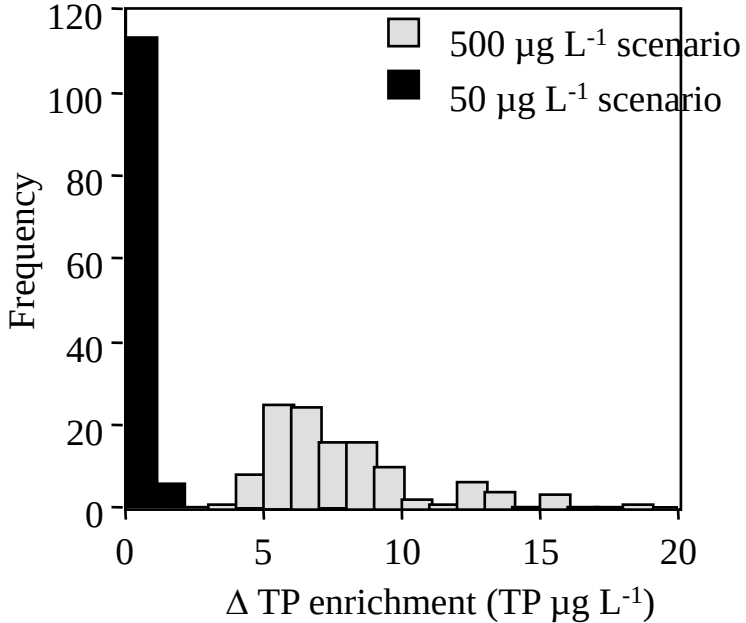
0.6 ± 0.2 μg $L^{-1}$

Low flow period (July-Oct)
22.9 ± 6.7 μg $L^{-1}$

1.7 ± 0.5 μg $L^{-1}$

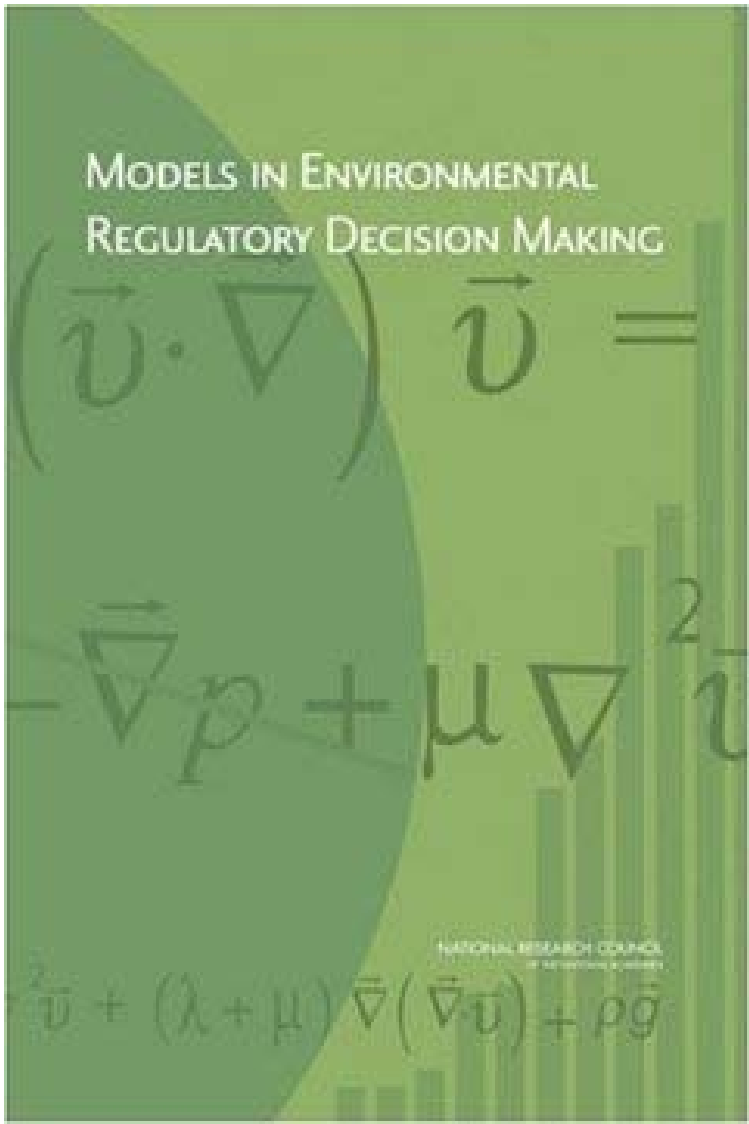
Either way, Δ TP is reduced by > 90%



*"Models will always be constrained by computational limitations, assumptions and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all aspects for a particular regulatory application. These characteristics…suggest that model evaluation be viewed as an integral and ongoing part of the life cycle of a model, from problem formulation and model conceptualization to the development and application of a computational tool."*

— NRC Committee on Models in the Regulatory Decision Process (NRC 2007)



# Guidance on the Development, Evaluation, and Application of Environmental Models

Page 19: "*The natural complexity of environmental systems makes it difficult to mathematically describe all relevant processes, . . . The challenge facing model developers and users is determining when a model, despite its uncertainties, can be appropriately used to inform a decision*."

EPA/100/K-09/003 | March 2009
www.epa.gov/crem

United States Environmental Protection Agency

1. Model evaluation addresses the soundness of the underlying science,

2. the quality and quantity of available data,

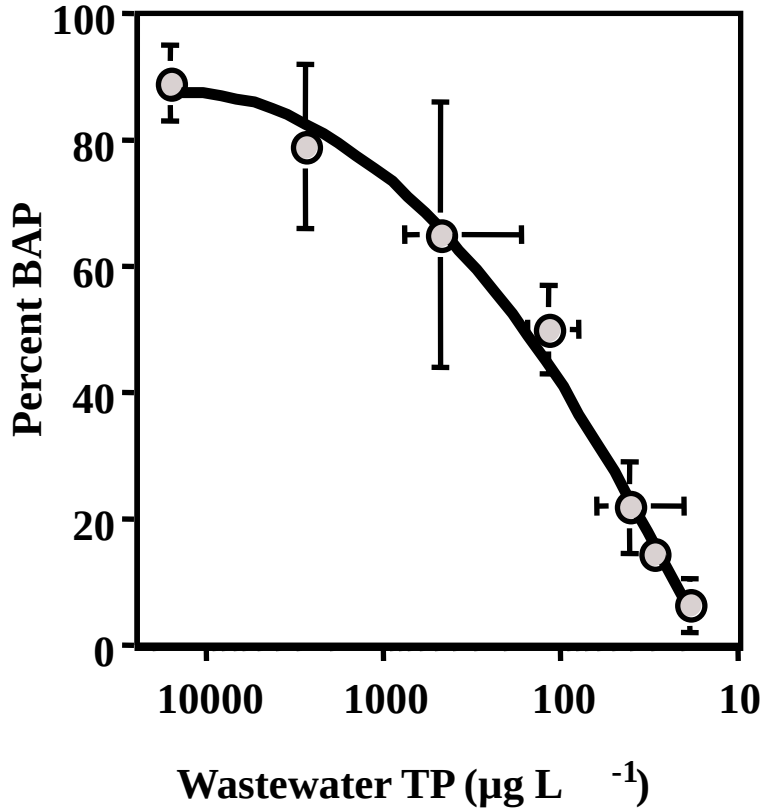
3. the degree of correspondence with observed conditions,

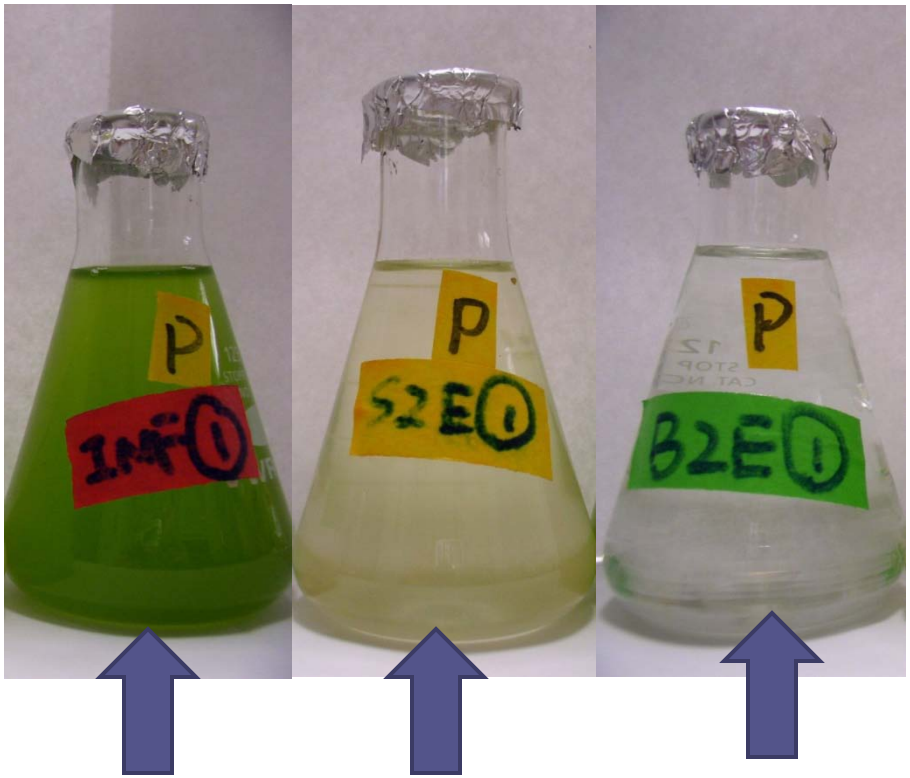
4. Recommended evaluation process includes:
   a) peer review
   b) QA project planning,
   c) model corroboration
   d) sensitivity analyses and
   e) uncertainty analyses.

# Conclusions

1) Our study suggests the effluents from several of the facilities discharging to Spokane River have considerably lower %BAP than conventional effluents.
2) Considering %BAP is very important because for example conventional WWTP effluents generally have much higher bioavailability than natural P sources
3) If we could start all over again, we would make several adjustments to our experimental protocol that would better account for potential confounding influences due to toxicity, nutrient colimitation, and even floc formation in our BAP bioassays
4) Field experiments examining %BAP in situ (i.e., Long Lake) would be very interesting
5) If the dischargers are able to get to lower discharge concentrations, i.e. ≈ 50 μg $L^{-1}$, and these effluents have much lower %BAP, there will be a dramatic reduction in BAP loading to the Spokane River & Long Lake
6) To adequately represent the likely impact of these much reduced discharges of bioavailable P a more carefully developed model than is currently available will be needed
7) The NRC and US EPA have recently provided very detailed guidance on how such a model should be developed
8) The definitive measure of the eutrophication potential of the new effluents will be the response of Long Lake itself during the next decade

# Questions?




Influent Intermediate Effluent