

New Jersey Water Environment Association – Annual Conference

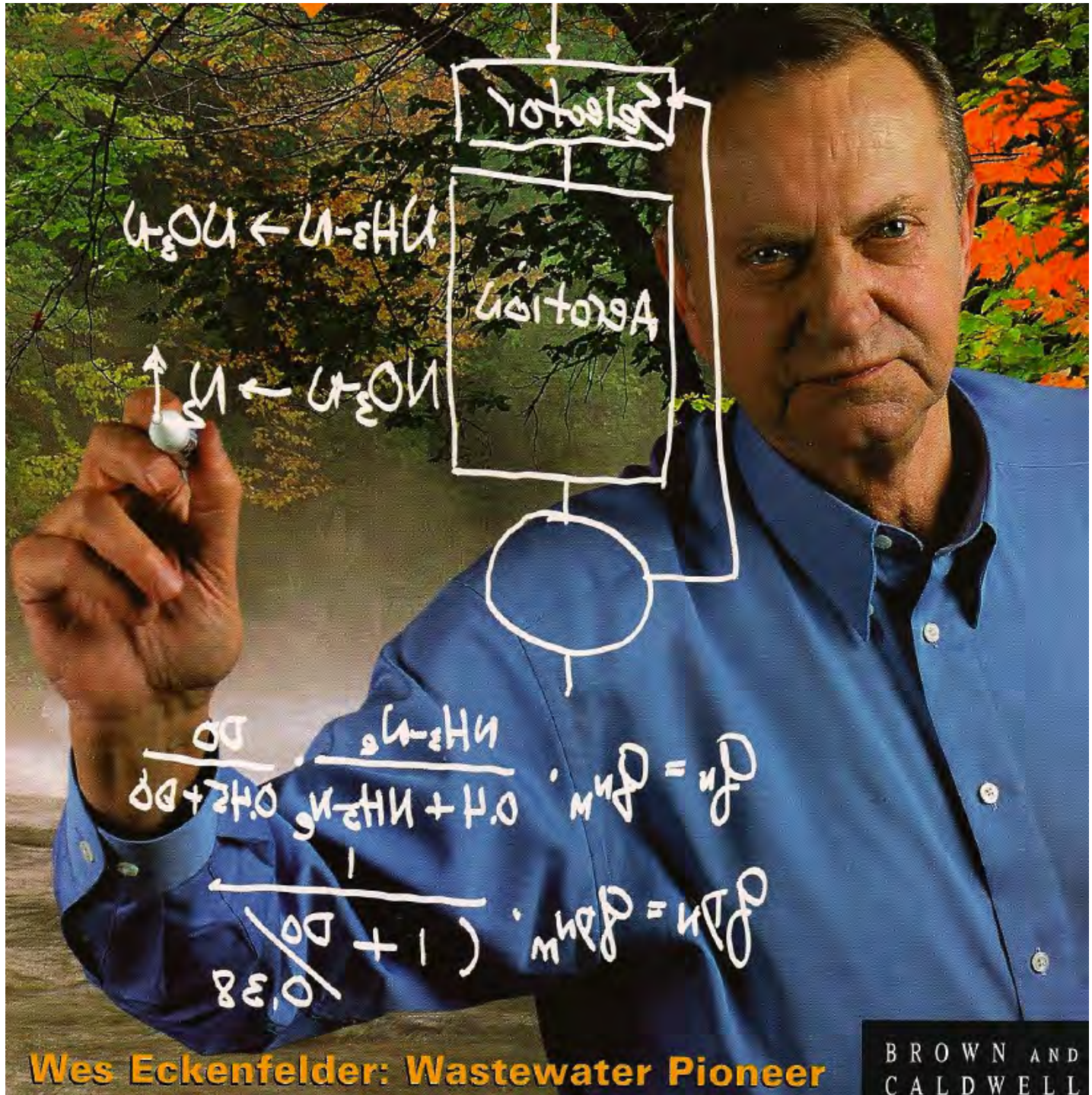
May 17, 2016



W. Wesley Eckenfelder Memorial Lecture

Phosphorus Recovery

**James L. Barnard, Ph.D. WEF Fellow
Global Practice & Technology Leader
Black & Veatch Kansas City MO**



Wes Eckenfelder: Wastewater Pioneer

BROWN AND CALDWELL

A student of Wes



Braunschweig Germany



Contents



- ⌘ Background to nutrient recovery
- ⌘ Early days
- ⌘ Eternal phosphorus cycle
- ⌘ Recovery needs concentration of P
- ⌘ Latest on BPR
- ⌘ Phosphorus recovery
- ⌘ Ultimate nutrient recycling

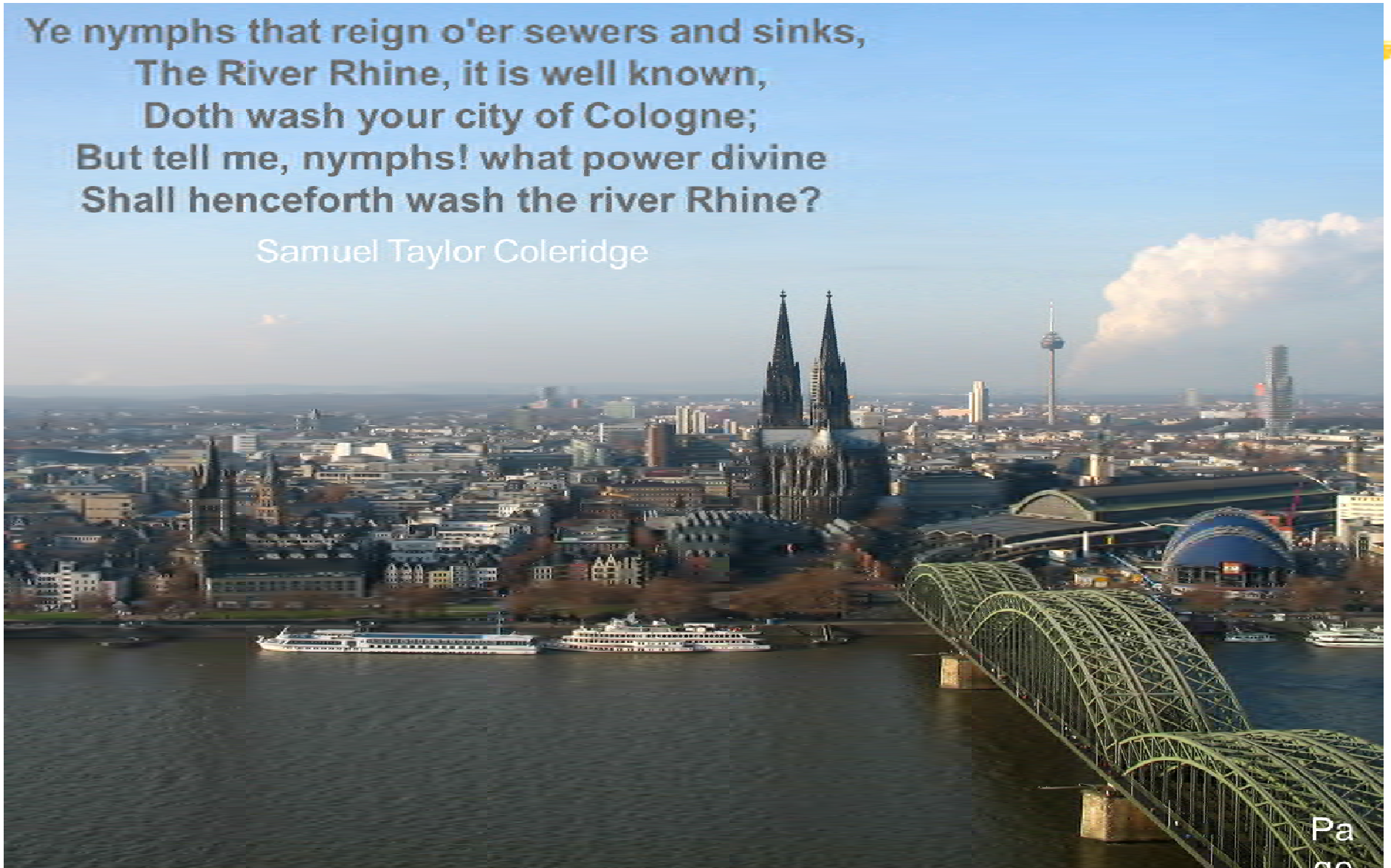
We must protect our little planet



The Culture of Flushing

Ye nymphs that reign o'er sewers and sinks,
The River Rhine, it is well known,
Doth wash your city of Cologne;
But tell me, nymphs! what power divine
Shall henceforth wash the river Rhine?

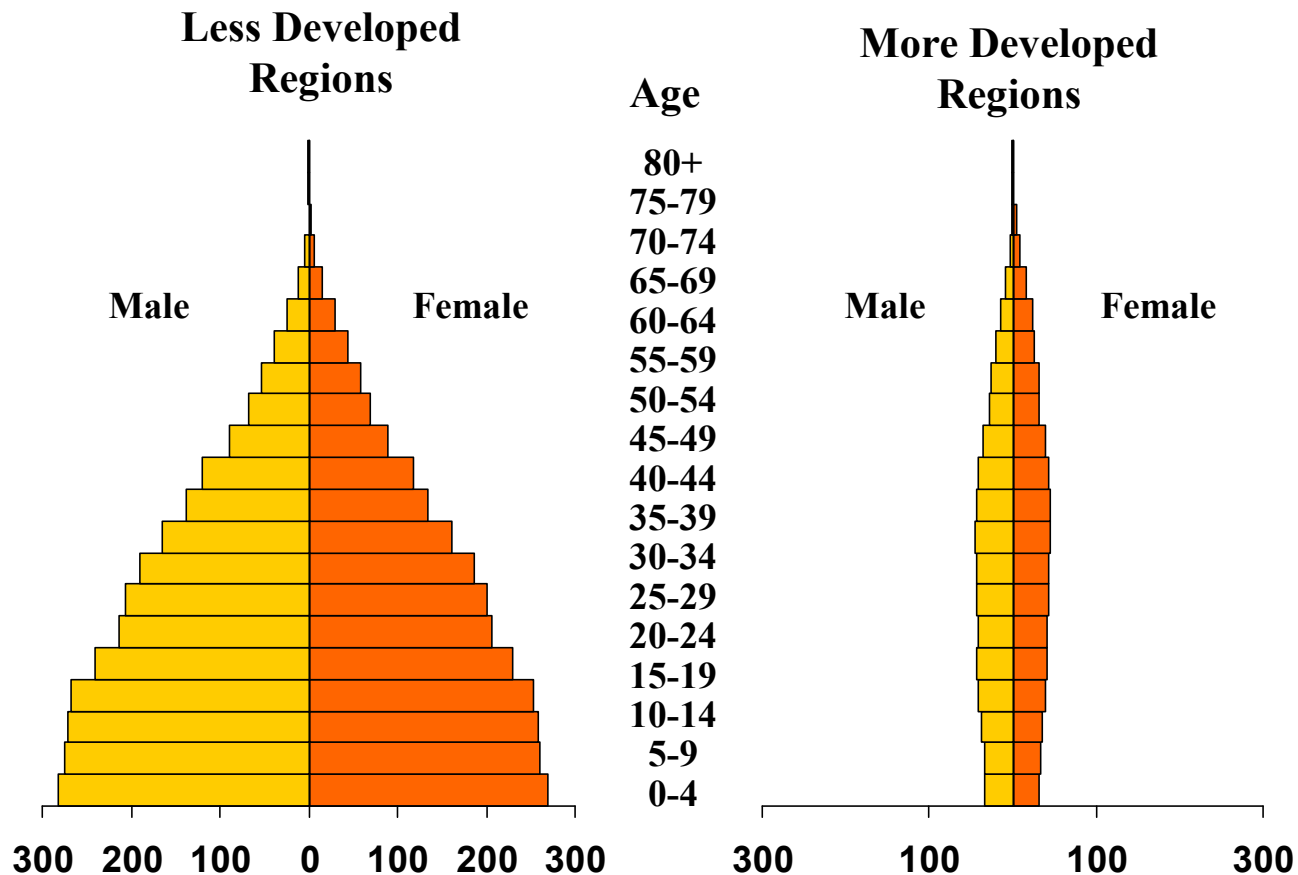
Samuel Taylor Coleridge



Age Distribution of the World's Population

Population Structures by Age and Sex, 2005

Millions



Source: United Nations, *World Population Prospects: The 2004 Revision*, 2005.

VICTOR HUGO – LES MISÉRABLES



"A great city is the most powerful of stercoraries. To employ the city to enrich the plain would be a sure success. If our gold is filth, then our filth is gold....these fetid streams of subterranean slime which the pavement hides from you, do you know what all this is? It is the flowering meadow, it is the green grass, it is marjoram and thyme and sage, it is game, it is cattle, it is the satisfied low of huge oxen at evening, it is perfumed hay, it is golden corn, it is bread on your table, it is warm blood in your veins, it is health, it is joy, it is life."

Before activated sludge



October 10, 1900

Day 10

Activated sludge 1914

Ardern



Lockett

*Thanks for support of
Worshipful Company
of Grocers*



Some main points from A&L papers and discussions



- ⌘ Full nitrification was considered as producing a stable effluent
- ⌘ Nitrification needed longer aeration time
- ⌘ Nitrifiers growth decline with lower temperature
- ⌘ Nitrifiers growth decline with pH
- ⌘ The disappearance of nitrogen was a mystery
- ⌘ The surplus sludge was unusually rich in phosphorus
- ⌘ Granular sludge was formed in the batch reactors

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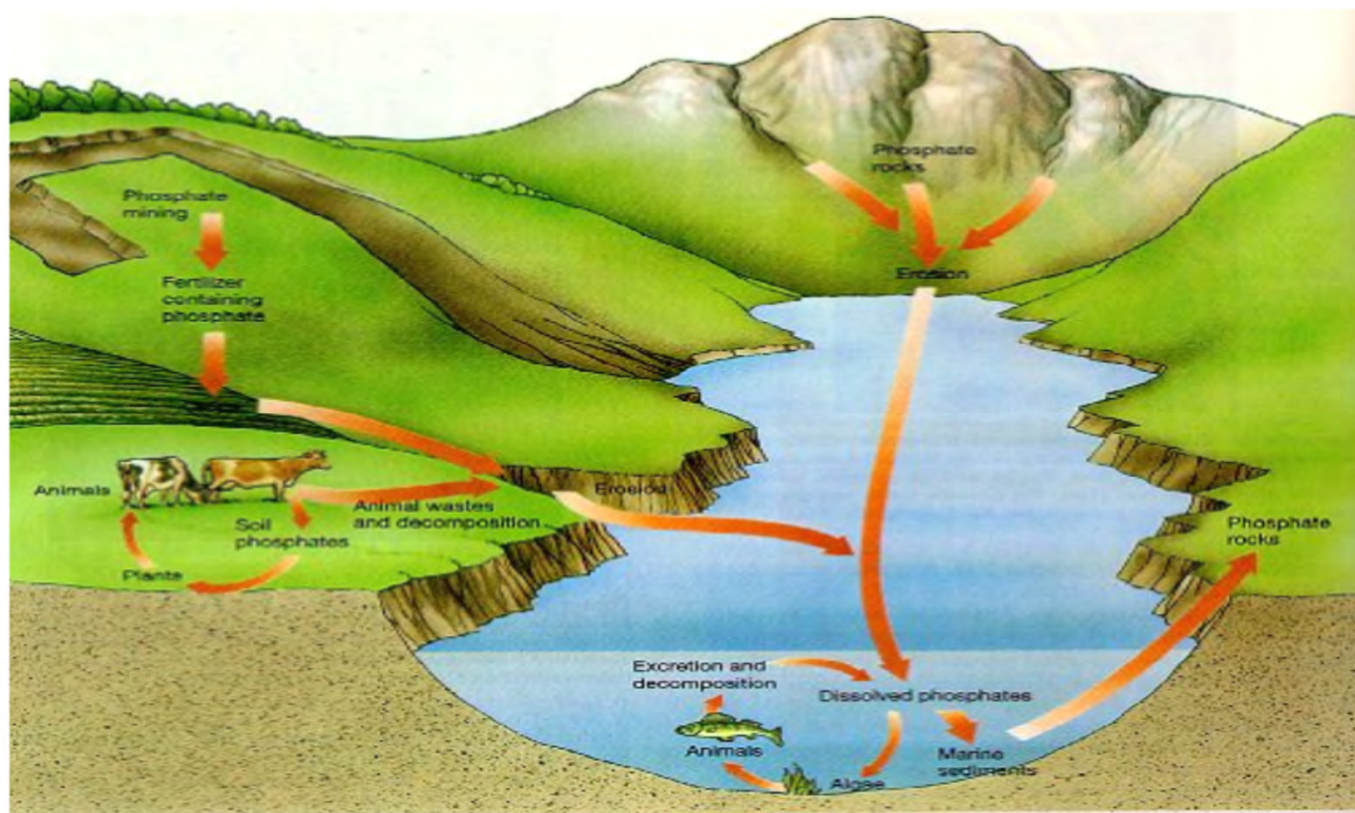
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The Eternal Phosphorus Cycle



The phosphorus cycle in terrestrial and aquatic environments. Recycling of phosphorus is slow because no important form of phosphorus exists in gaseous form. Phosphorus that becomes part of the marine sediments may take millions of years to solidify into rock, uplift as mountains then erode away to become available to living things.

Point to Ponder

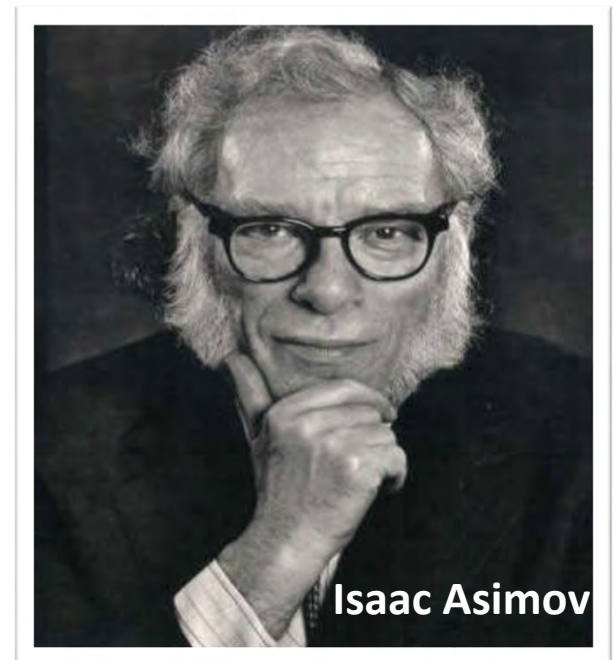


It is surprising that so much global attention has been paid to “peak oil” that we have missed noticing the threat of “peak phosphorus” - it is time to turn that trend around, as we will have to wait tens of millions of years for geological processes to restore the concentrated P that we have disseminated in two centuries.

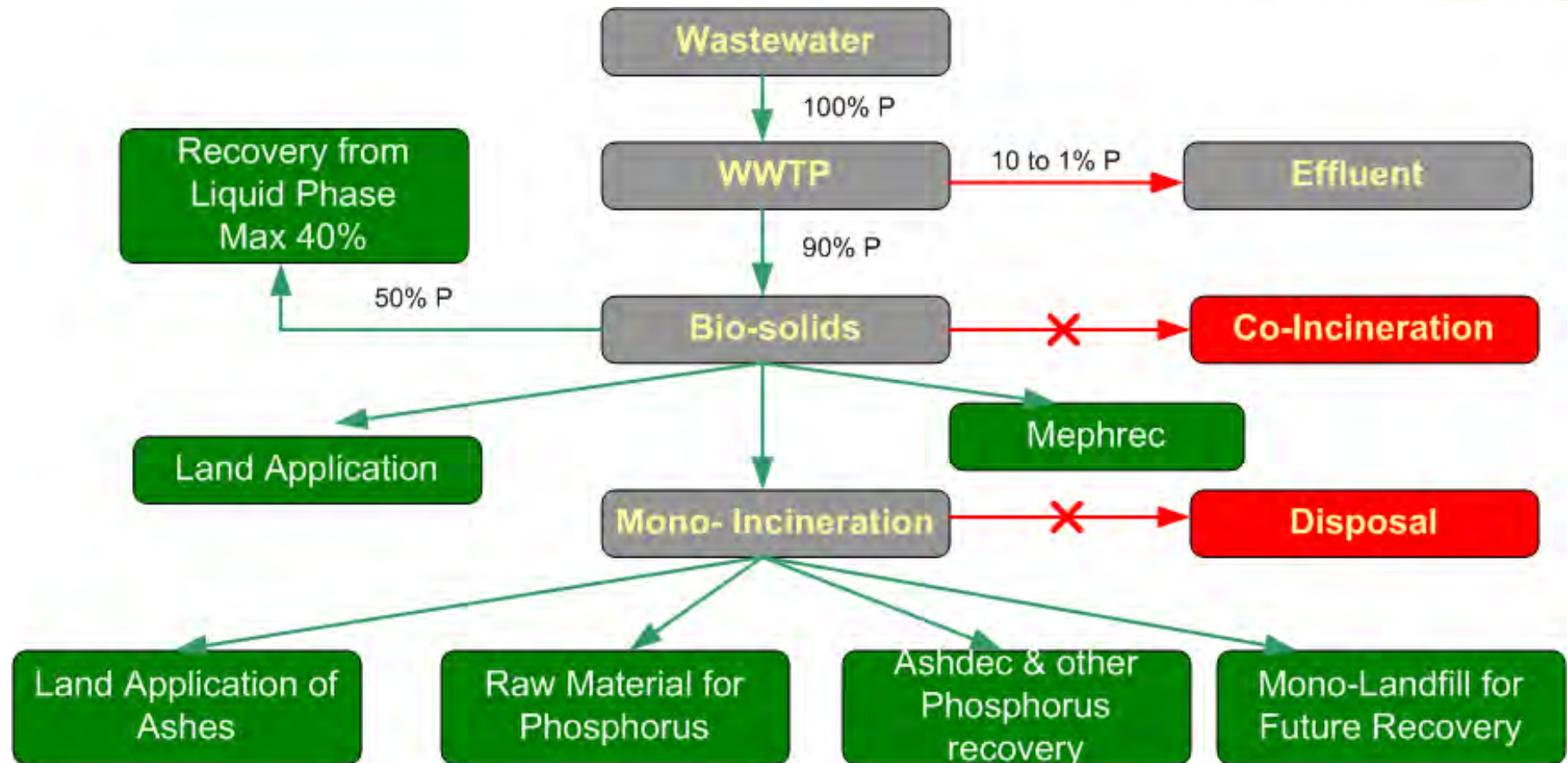
Asimov on Chemistry

About Phosphorus

“We may be able to substitute nuclear power for coal power, and plastics for wood, and yeast for meat, and friendliness for isolation, but for phosphorus there is neither substitute nor replacement.”



Concept of Complete Phosphorus Recovery



■ No P recovery

Adapted from Petzet & Cornel 2011



**BIOLOGICAL
PHOSPHORUS REMOVAL**

Is Biological phosphorus removal reliable?



Biological phosphorus removal is something you design for, hope for, then add chemicals if it doesn't work

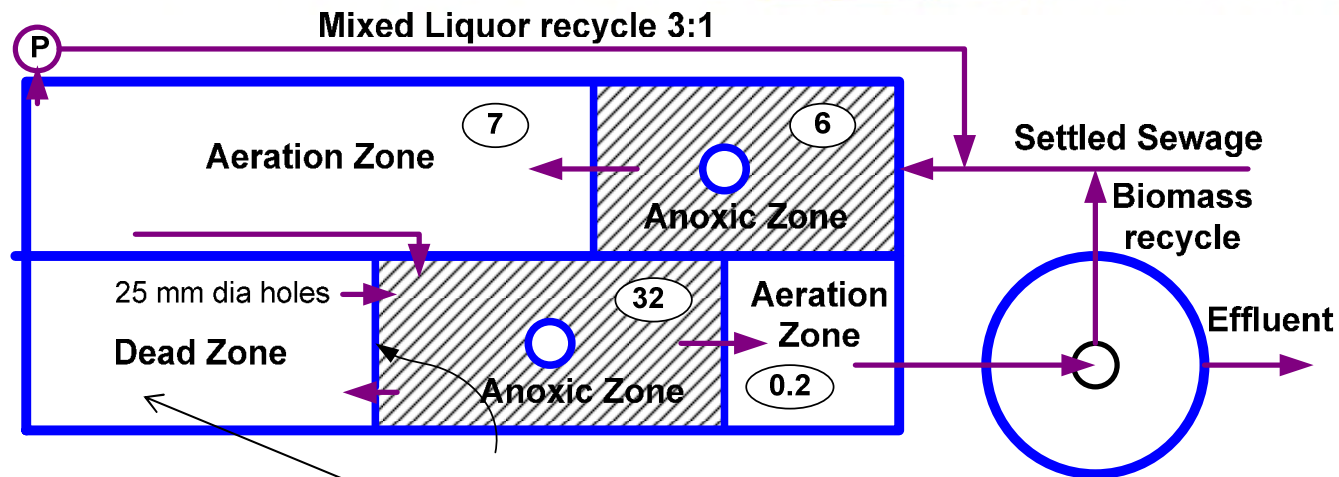
- Paul Harremoes 1998

Biological phosphorus removal is notoriously unreliable

- More recent Paper at Beijing IWA Conference

Fear of the Unknown?

Bardenpho Pilot Plant 1972



100 m³/d

The purpose of the dead zone was to allow relative adjustments to the other zones



Typical Flow sheets

When using SND much simpler process flow sheets are possible

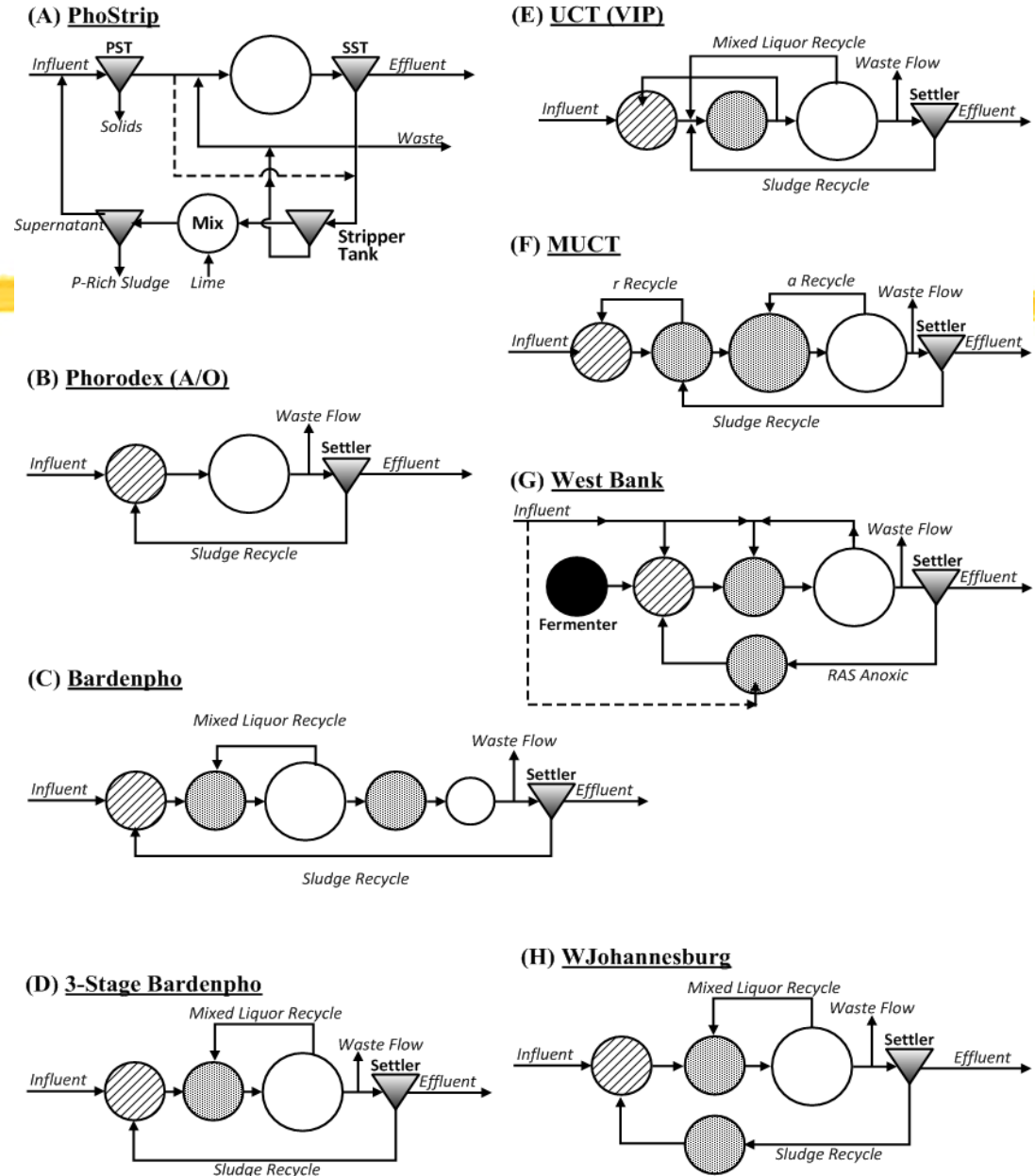
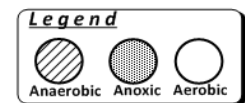
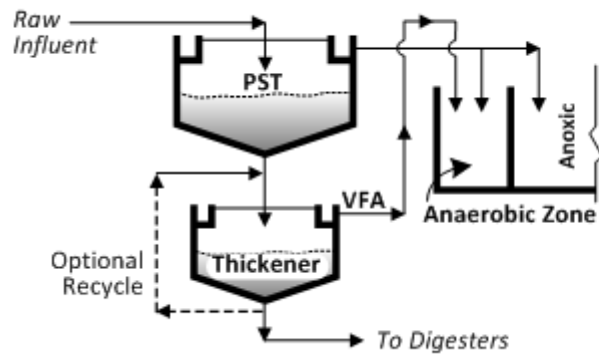


Figure 3 Various traditional flow sheets for biological phosphorus removal. In many of them the aeration basin may consist of oxidation ditches

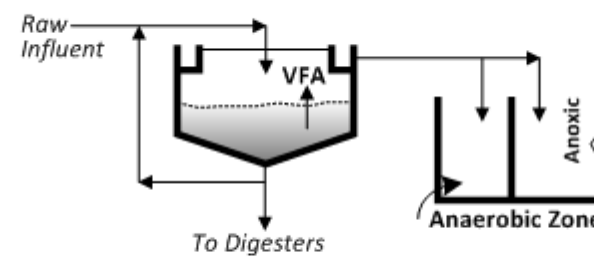


VFA from Fermenters

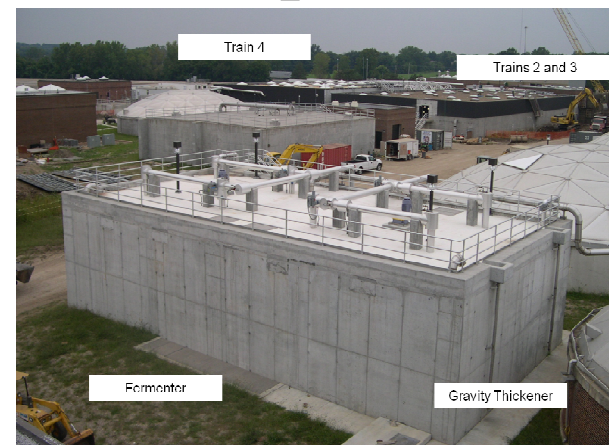
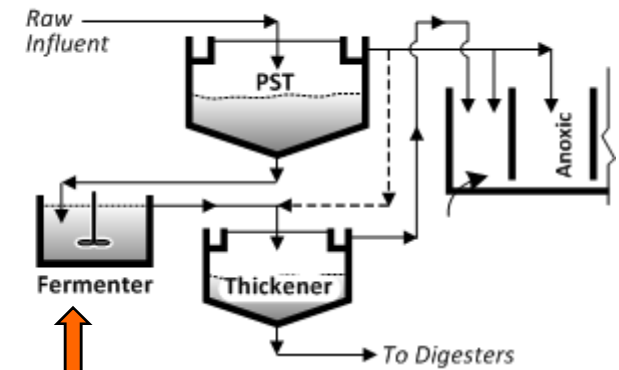
A. STATIC FERMENTER



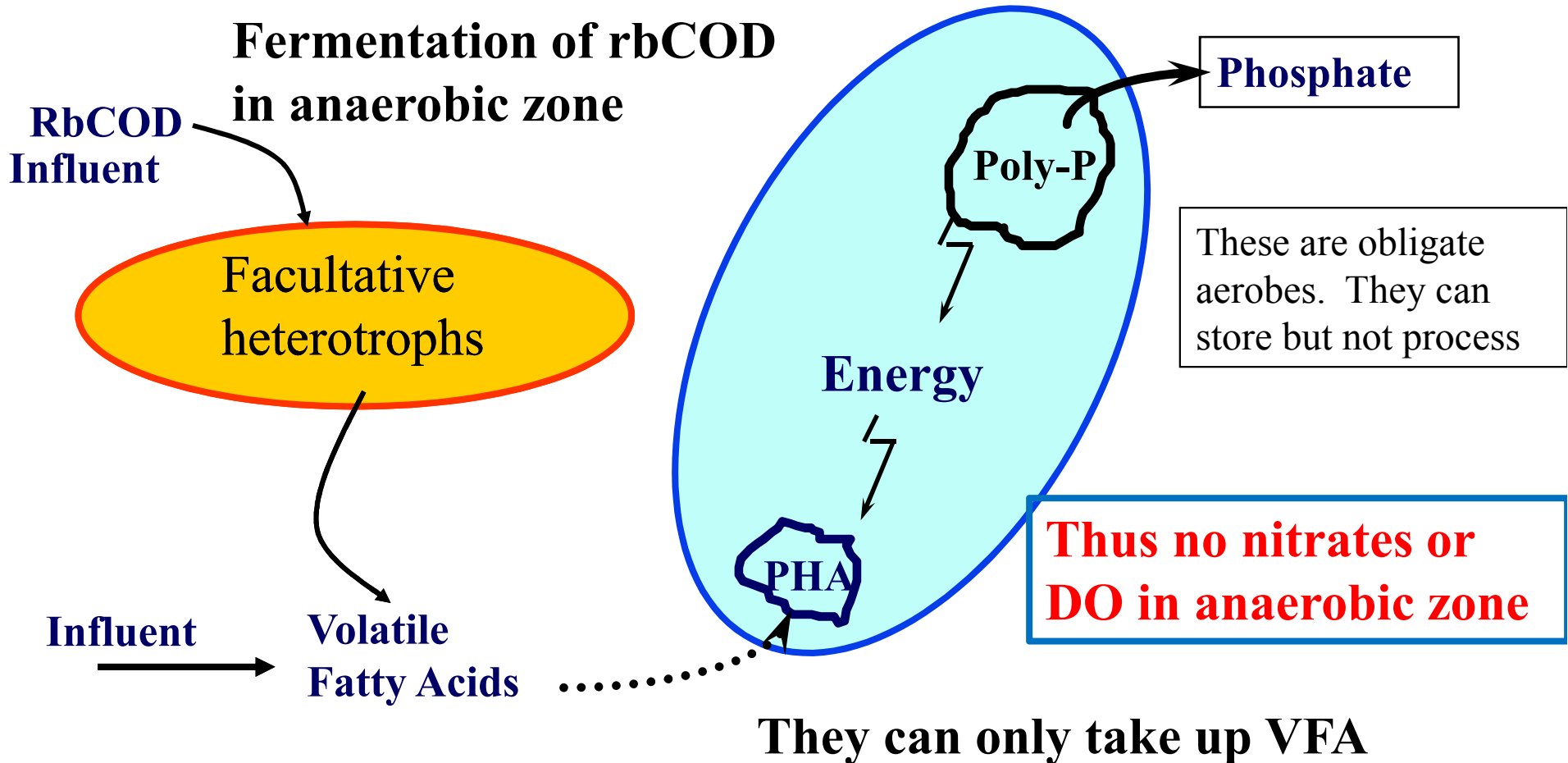
B. ACTIVATED PRIMARY



C. FERMENTER THICKENER

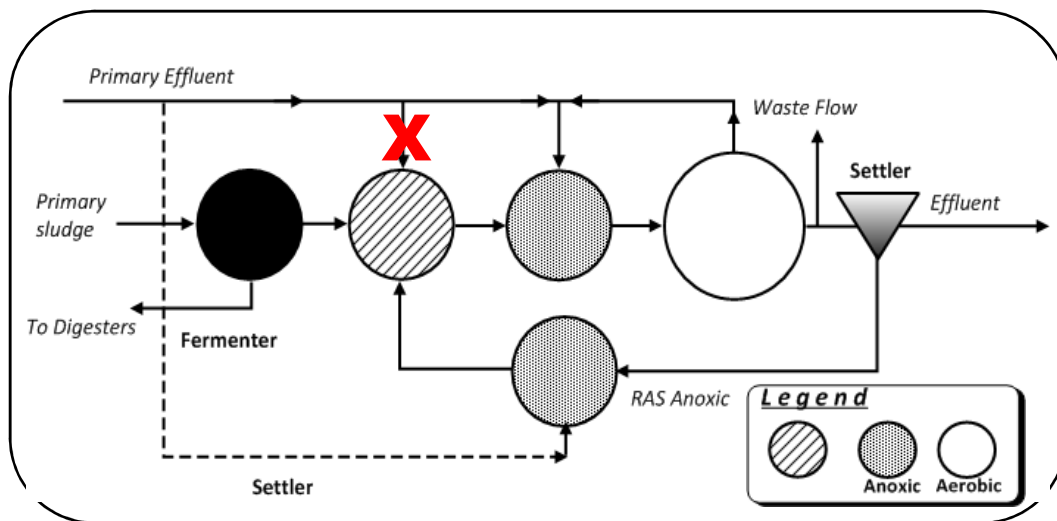


Bio-P Organisms Store PHA and Release P in the **Anaerobic Zone**



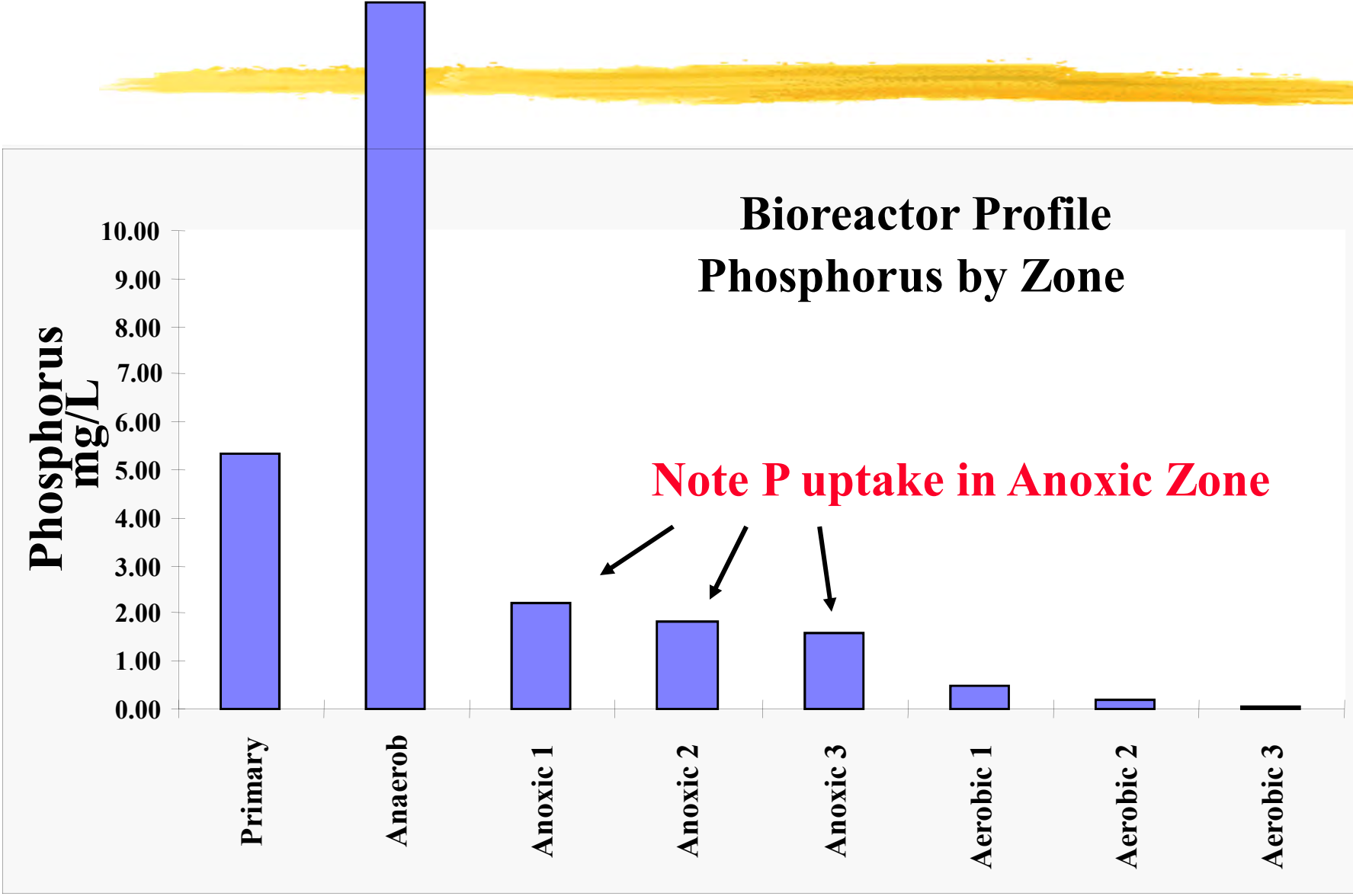


Westside Kelowna BC (Westbank)



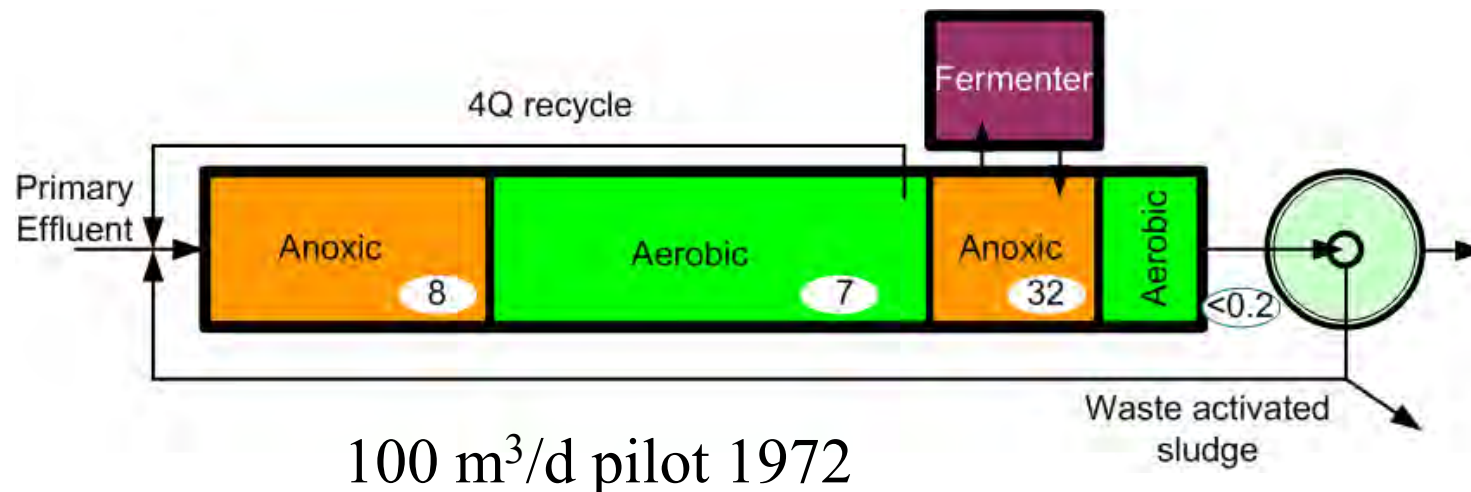
TN < 6 mg/ℓ
 BOD < 5 mg/ℓ
 TSS < 2 mg/ℓ
 TP < 0.15 mg/ℓ

Westbank WWTP

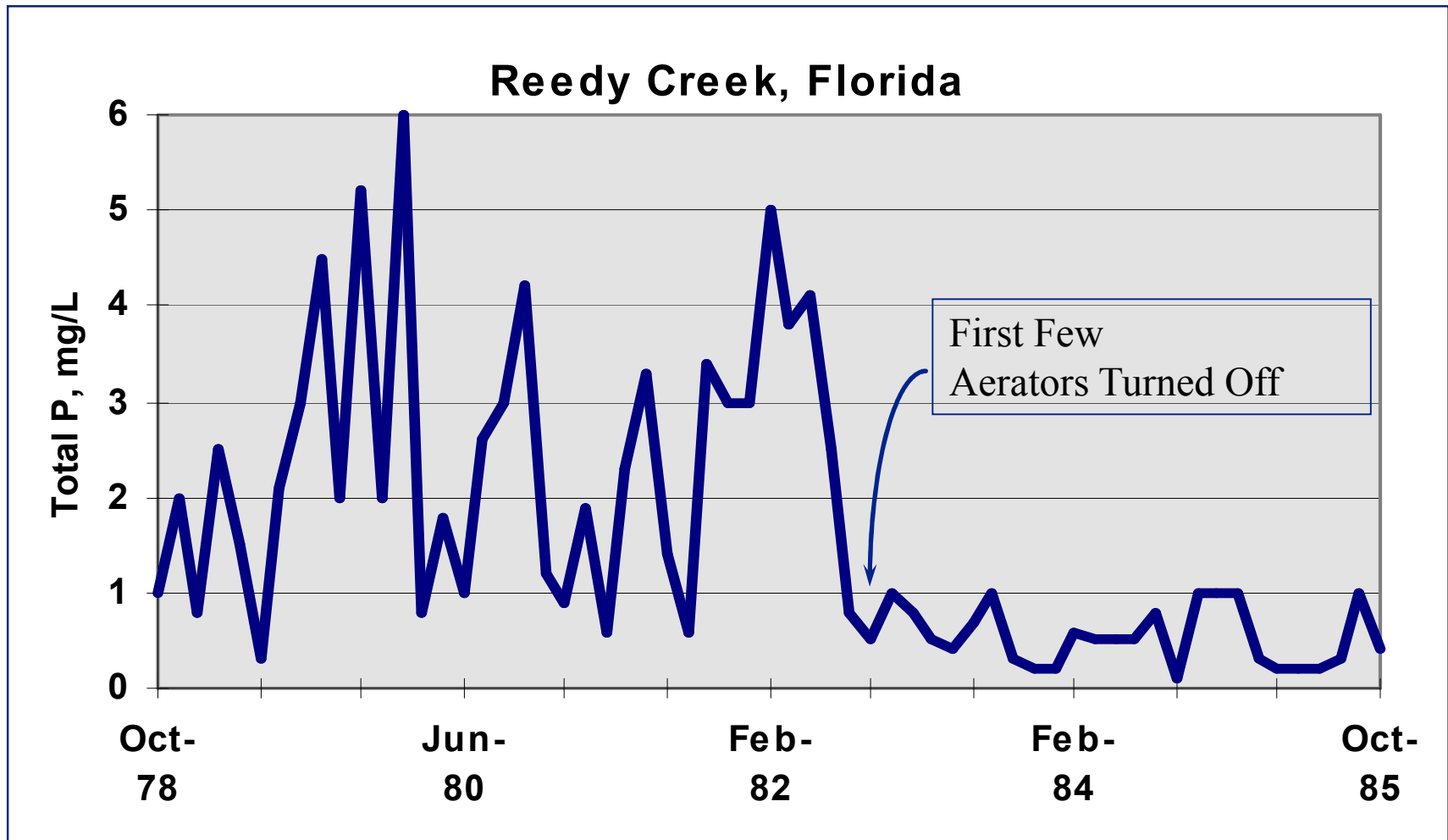


Mixed Liquor Fermenter (MLF)

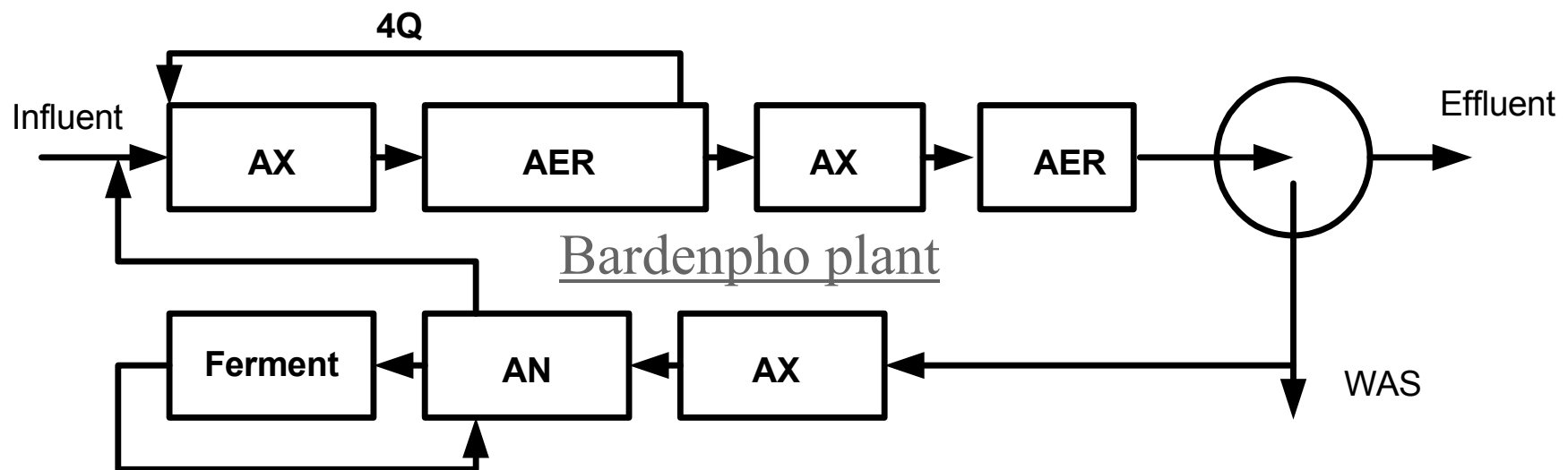
- ⌘ From experience at a number of plants fermentation of some of the mixed liquor was successful in achieving BioP and reducing nitrates
- ⌘ Mostly influent wastewater has very low VFA and even low rbCOD that could be fermented in the anaerobic zone
- ⌘ Solution — ferment some of the mixed liquor as happened in original pilot plant



Switching off Aerators - Disneyworld



South Cary NC

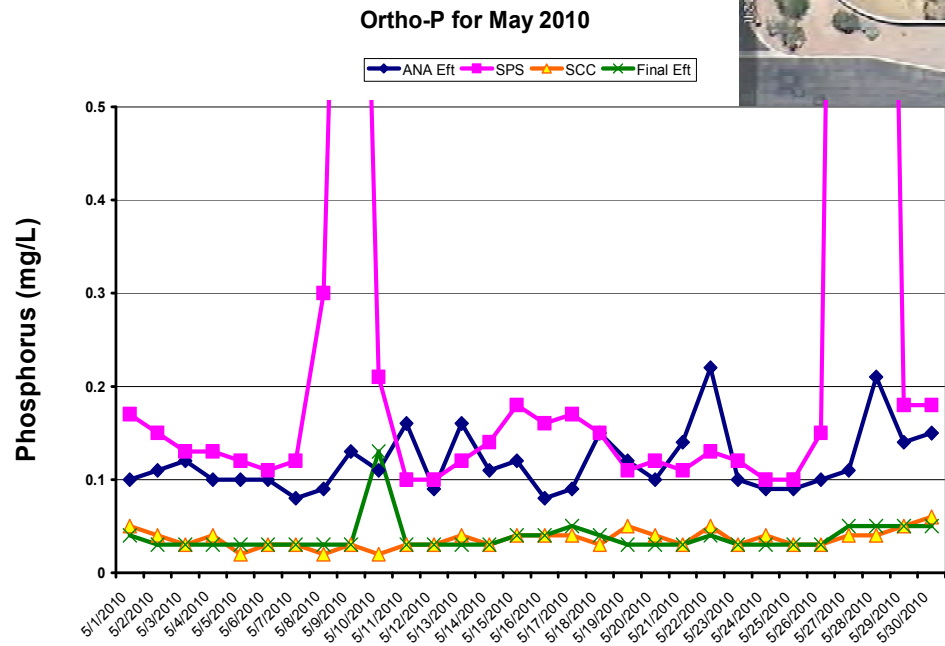
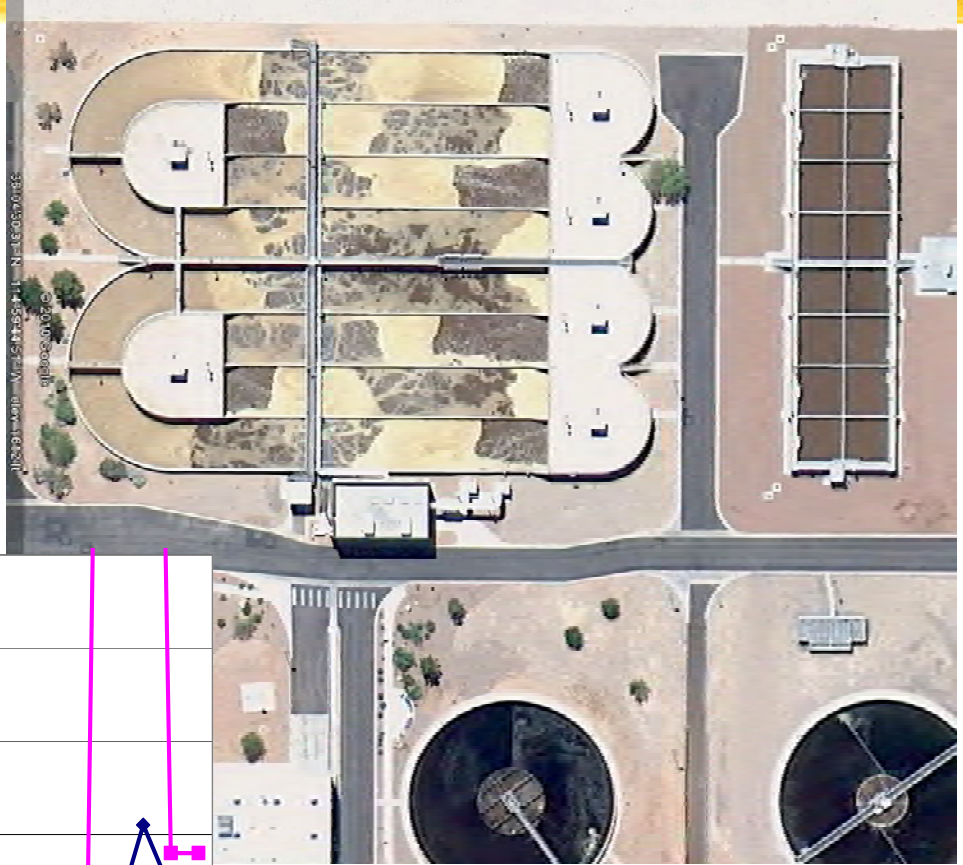


RAS Fermentation

Stroud, R and Martin, C. (2001) South Cary Water Reclamation Facility's Nutrient Removal Modifications and Reduction Success, Town of Cary, NC, *Proceedings of WEFTEC2001*

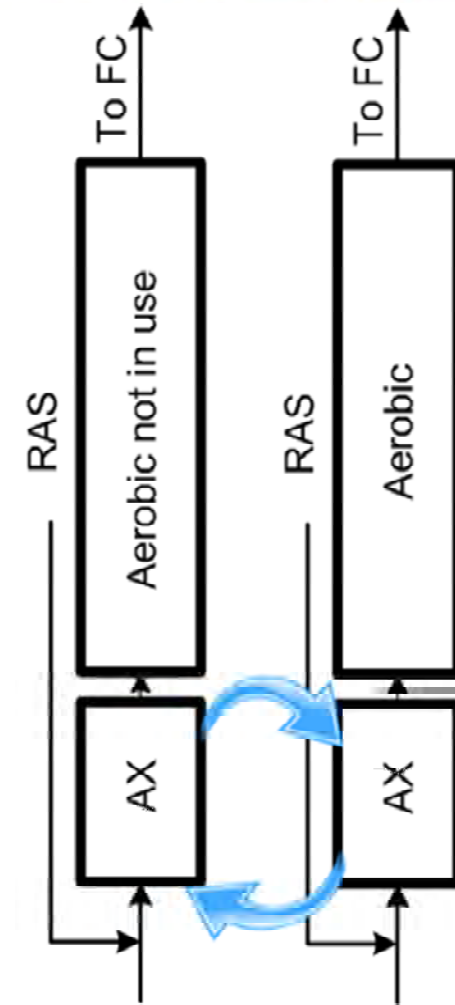
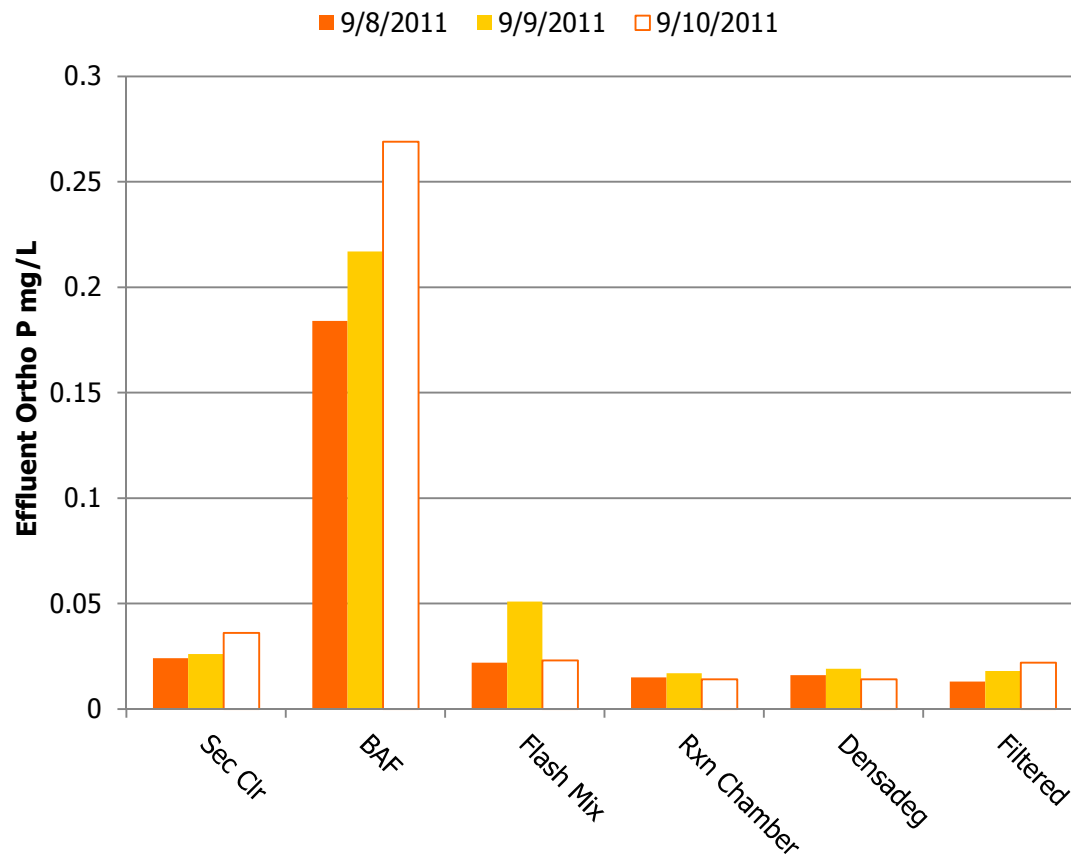
Carousel Plant Henderson NV 60 ML/d – Upgraded to BNR

Switching off a mixer in the anaerobic zone resulted in In-plant Fermentation

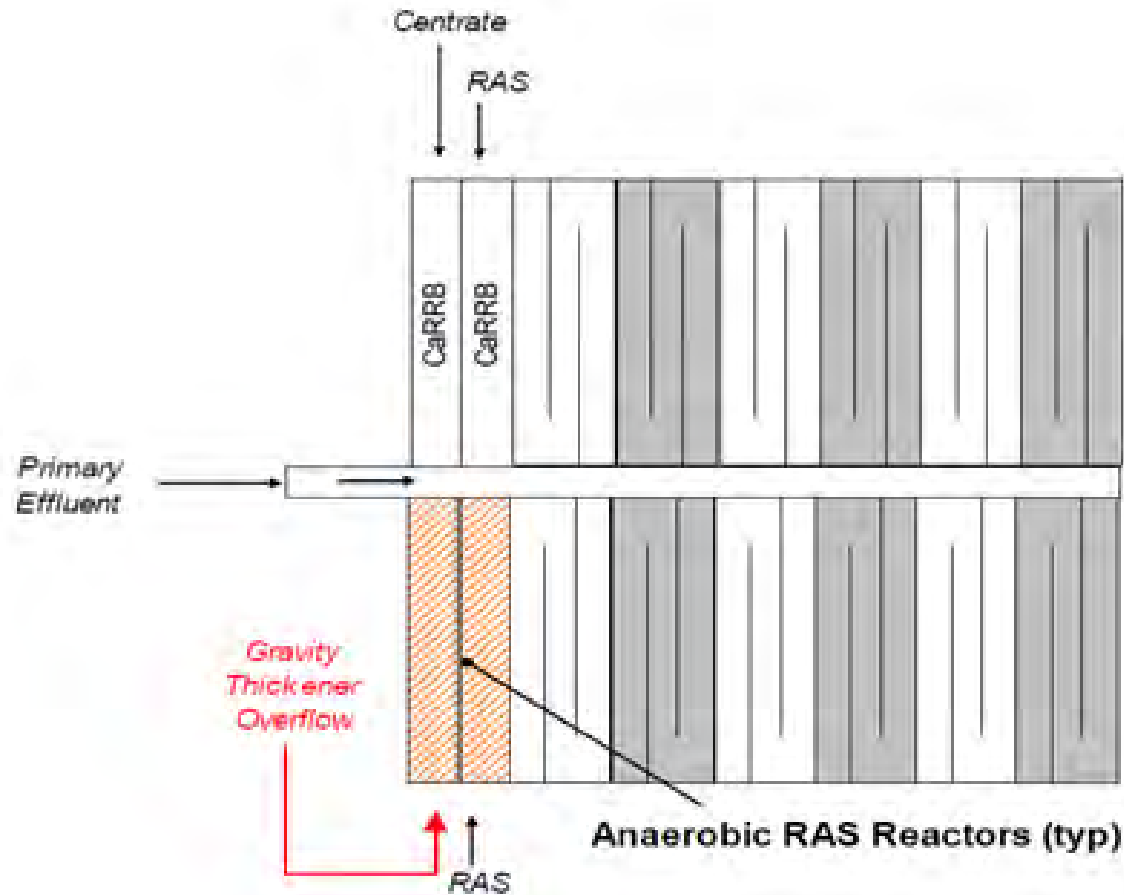


Phosphorus removal with Side-stream fermentation

Iowa Hill CO plant — From Chris Maher

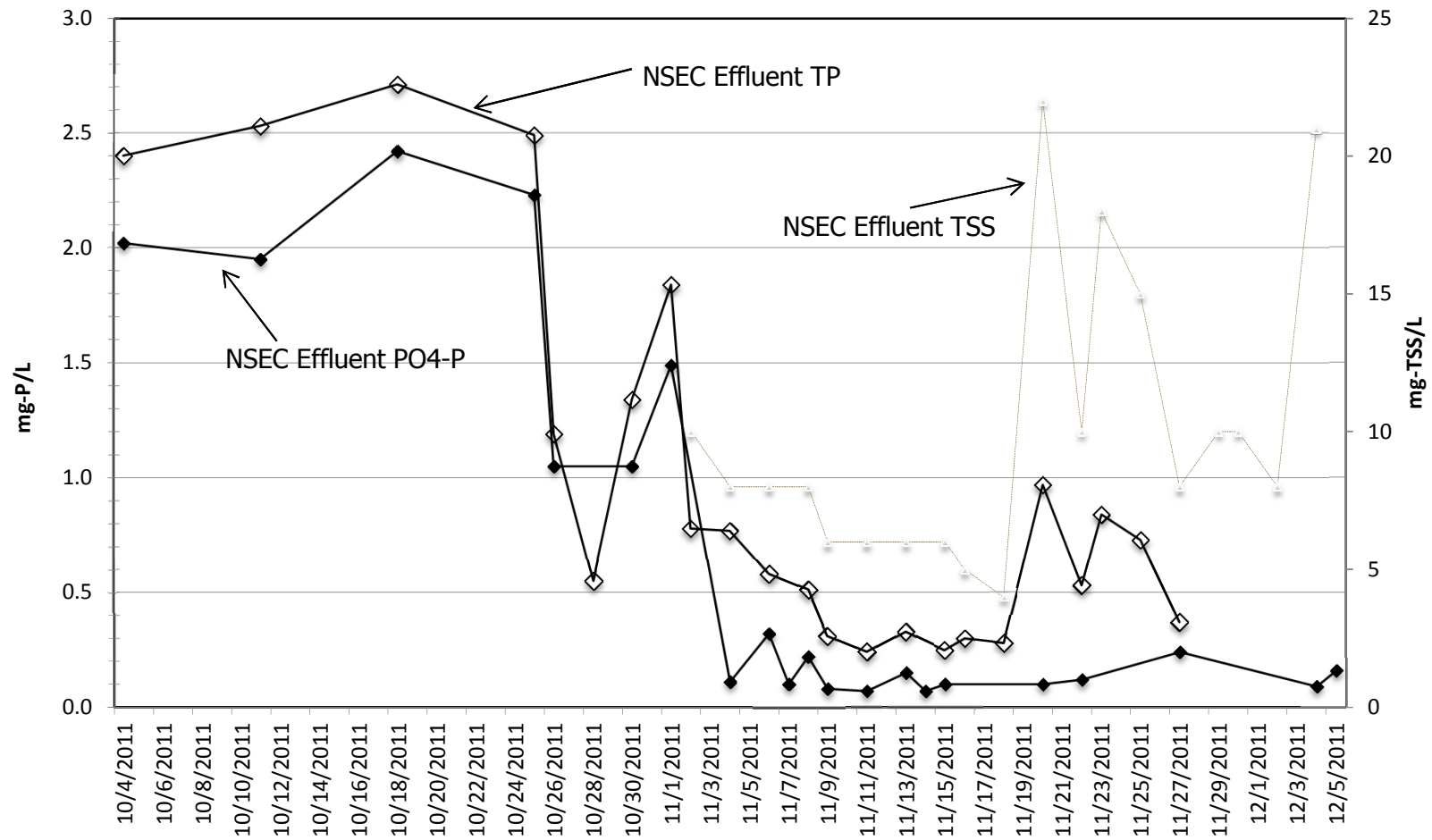


Experiment at Denver Metro



Cavanaugh, L., Carson, K., Lynch, C., Phillips, H., Barnard, J. and McQuarrie, J. (2012) A Small Footprint Approach for Enhanced Biological Phosphorus Removal: Results from a 106 mgd Full-Scale Demonstration. *Proceedings of the 85th Annual Water Environment Federation Technical Exhibition and Conference*, New Orleans, LA, October 2012.

Phosphorus Removal by RAS Fermentation - Denver Metro





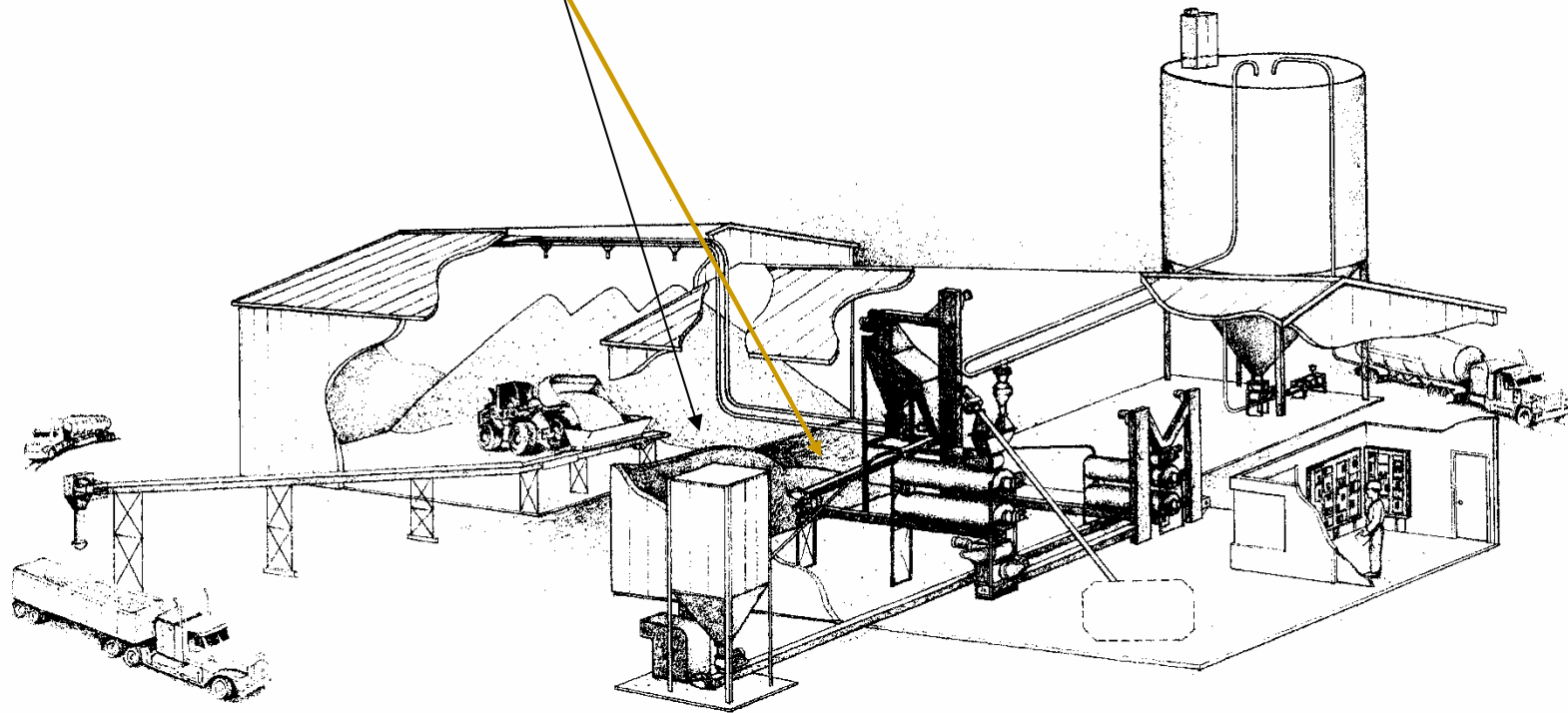
Phosphorus recovery

Composting Banff, AB Canada



Lime treated raw biosolids with ammonia capture

High pH drives off ammonia which is captured as ammonia nitrate



STRUVITE PRECIPITATION TECHNOLOGY ALTERNATIVES

Ostara Pearl®



Multiform Harvest

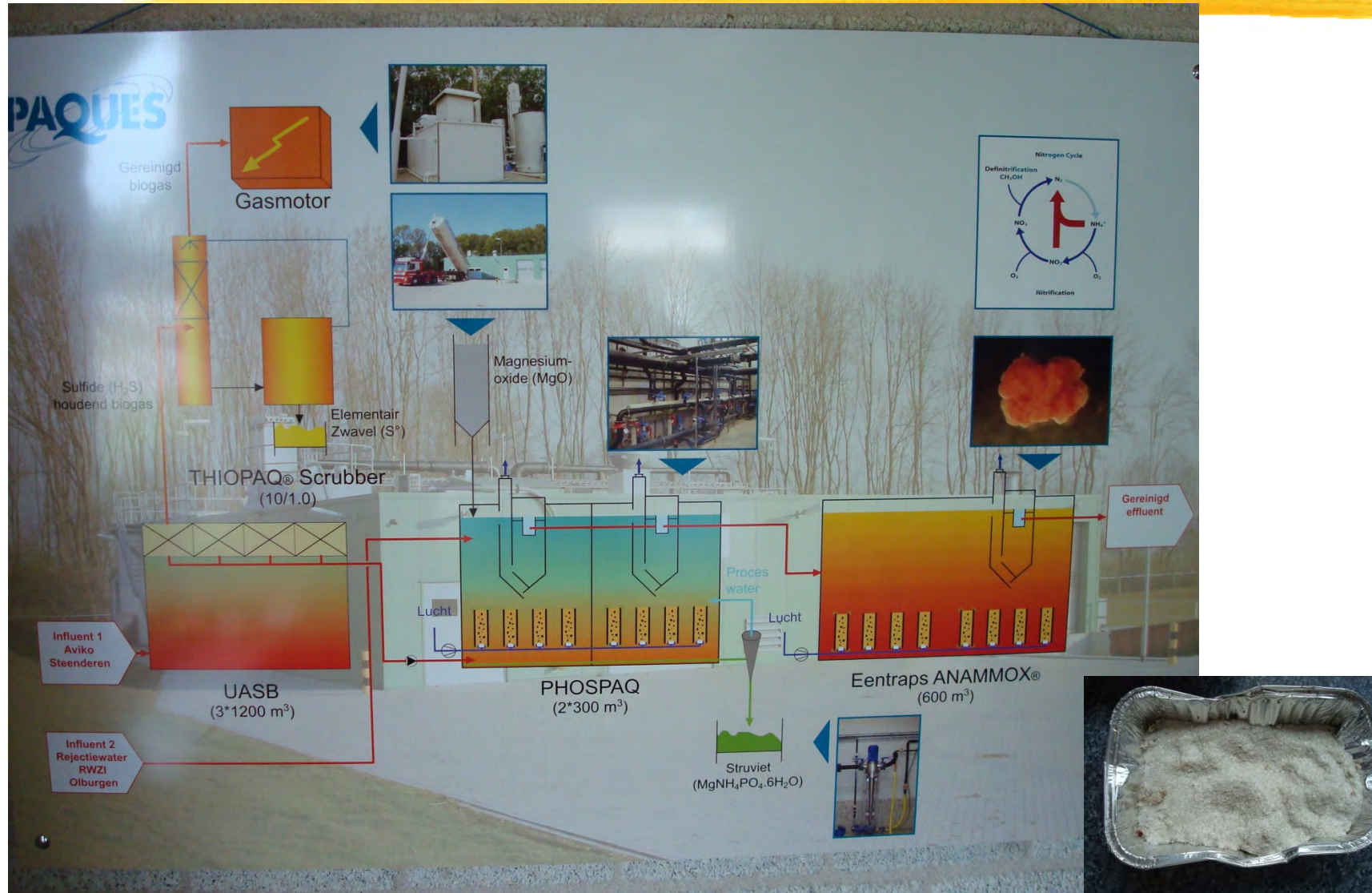


**Kansas Environmental
Management
Associates (KEMA)
Phred™**

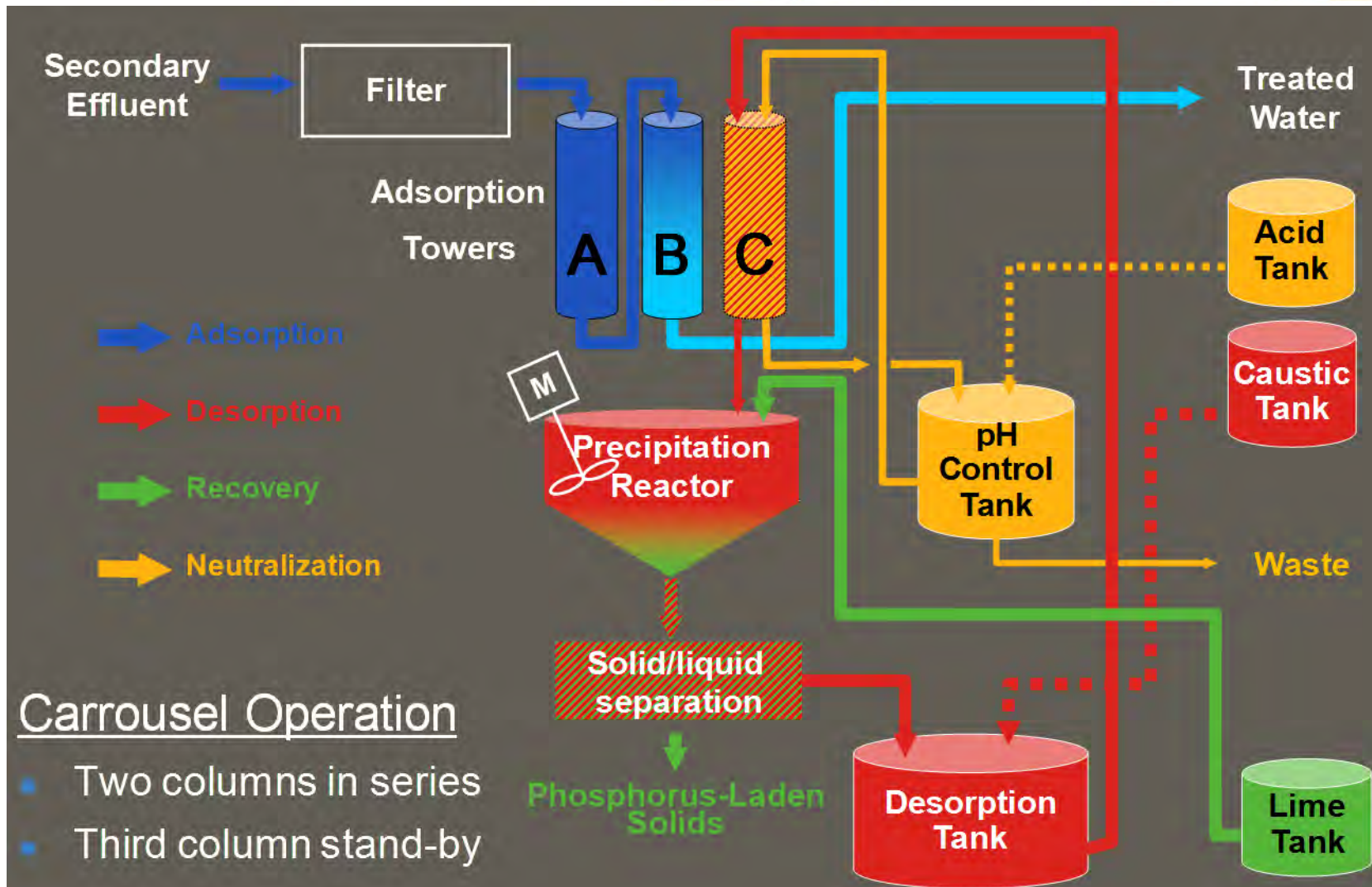


January 29, 2013

Paques Plant - Waterstromen

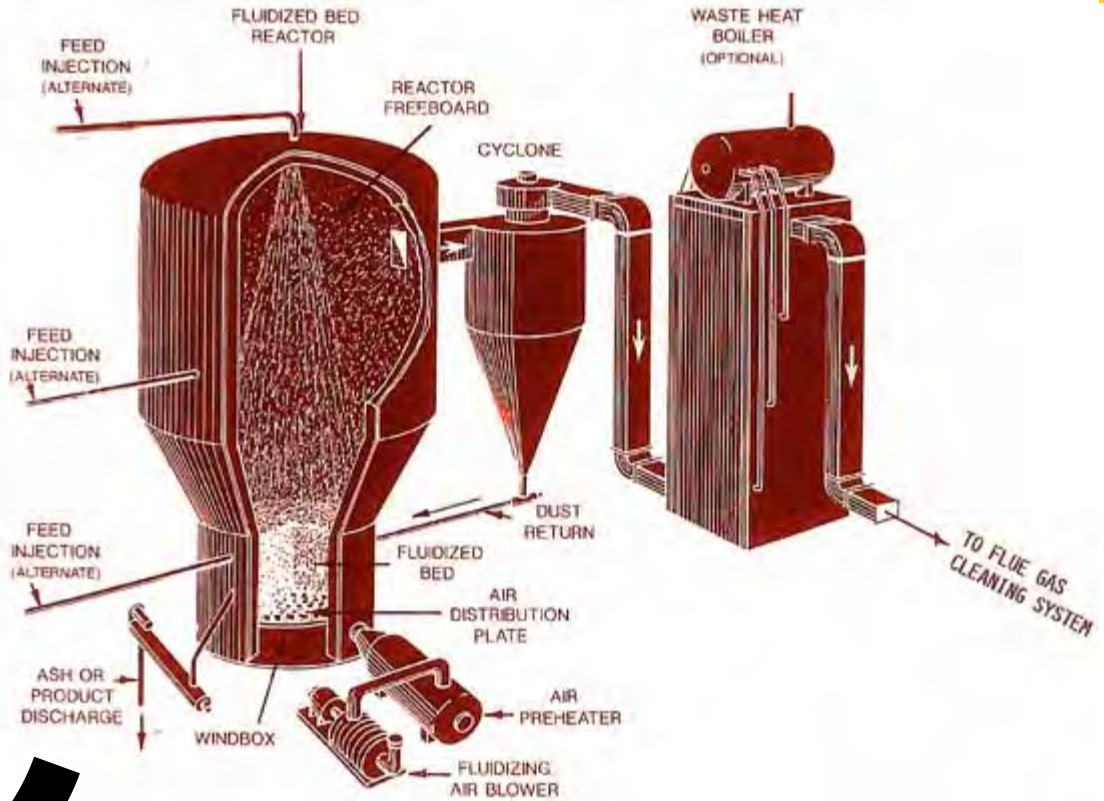
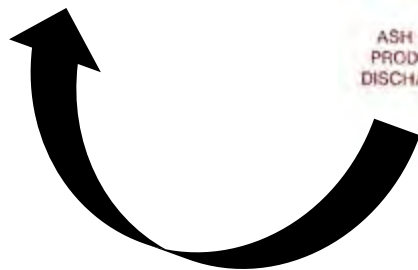


CAROUSEL OPERATION IS ONE KEY TO COMPLETE PHOSPHORUS CAPTURE



Incinerator Ash

Deposit in dedicated site for future recovery



Using corn for bio-fuel production



An estimated 1.7 m tons of phosphorus being used for making bio-fuels

With 40% of the grain crop going to bio-fuels for no gain in energy and enormous subsidies

Rock Creek OR –Ostara plant



**Recovering 4 tons of
struvite per day**

Me and RFK Jr



When I first said I could get biological phosphorus removal I was called a snake oil salesman



I want a picture with this snake oil salesman

Now all smile

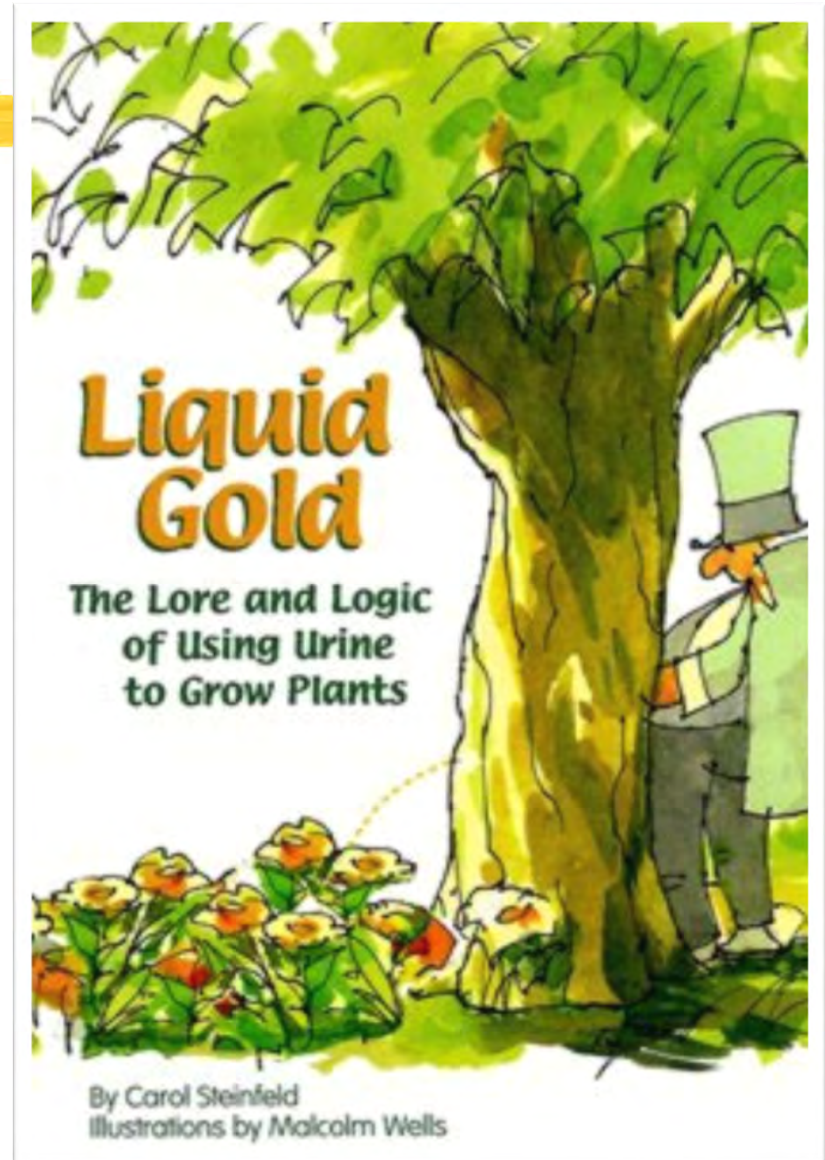




The Ultimate Nutrient Recycle

Urine recovery

- Urine contains 70% to 80% of the Nitrogen and Phosphorus in domestic wastewater
- When urine is separated and stored ammonia is hydrolyzed and the pH goes up
- Within a few weeks the urine is totally free of pathogens
- Research underway to recover struvite
- Excess ammonia recovered with stripping and production of ammonia sulphate



Dual flush toilet



**This is not what you think
it is!!!!**



Big Problem Getting the men to sit

Backyard garden Kampala Uganda



Apartments in Hong Kong – Ideal for urine recovery



November 12-13, 2014

Do-it-yourself Fertilizer

urine → fertilizer

DIY KIT



By Choice or by Need



Working in the garden is also a shared experience for the family, and instills in children an understanding of the natural cycles of growth which provide lessons of lifelong value

Future vegetable gardens?



MOTTO OF THE DAY

What doesn't kill you makes you stronger !!!!!!!





And thank you all for coming