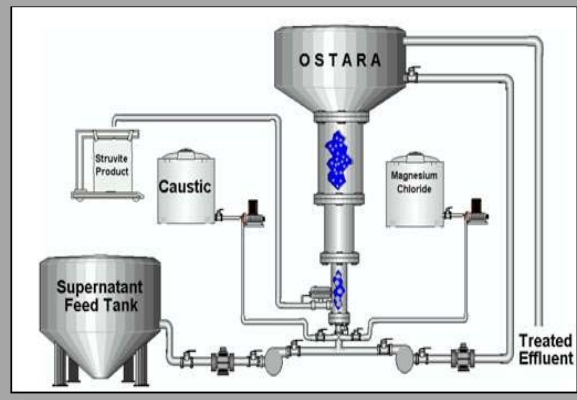
The Other Phosphorus Predicament



Sam Jeyanayagam, PhD, PE, BCEE
Senior Associate
Malcolm Pirnie
(614) 430-2611

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Solutions for Life™

OWEA Conference
16 June 2010

Presentation Outline

- Importance of Phosphorus
- Phosphorus Source
- Current Use Profile
- Phosphorus Cycle
- Phosphorus Recovery from Wastewater
- Take Home Messages

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The Importance of Phosphorus

- Essential element of all life forms:
  - Genetic material, ATP , Bones
- A primary nutrient required for plant growth
- Detergents, crop protection, pharmaceuticals, flame retardant, etc.

An average human body contains 650 g of Phosphorus.

Phosphorus is a Precious Element

- *Essential* – no substitutes, natural or synthetic
- *Non-Renewable*

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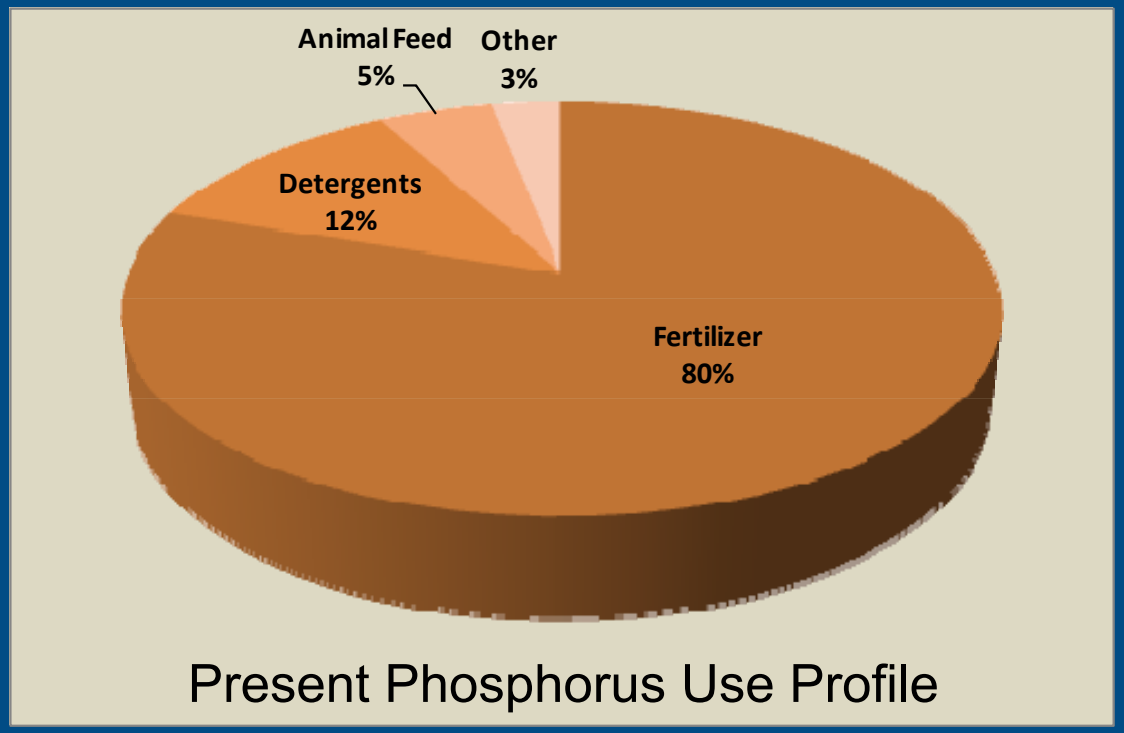
Phosphorus By the Numbers

- Occurs as phosphate rock (various forms of calcium phosphate)
- Worldwide reserves: 163 Billion metric tonnes
  - Most of this is not economically recoverable
- Annual production: 40 million metric tonnes
- Geographic distribution:
  - China
  - Morocco
  - USA
  - South Africa

>80% of world's reserves
>66% world's production

Current Phosphorus Use Profile

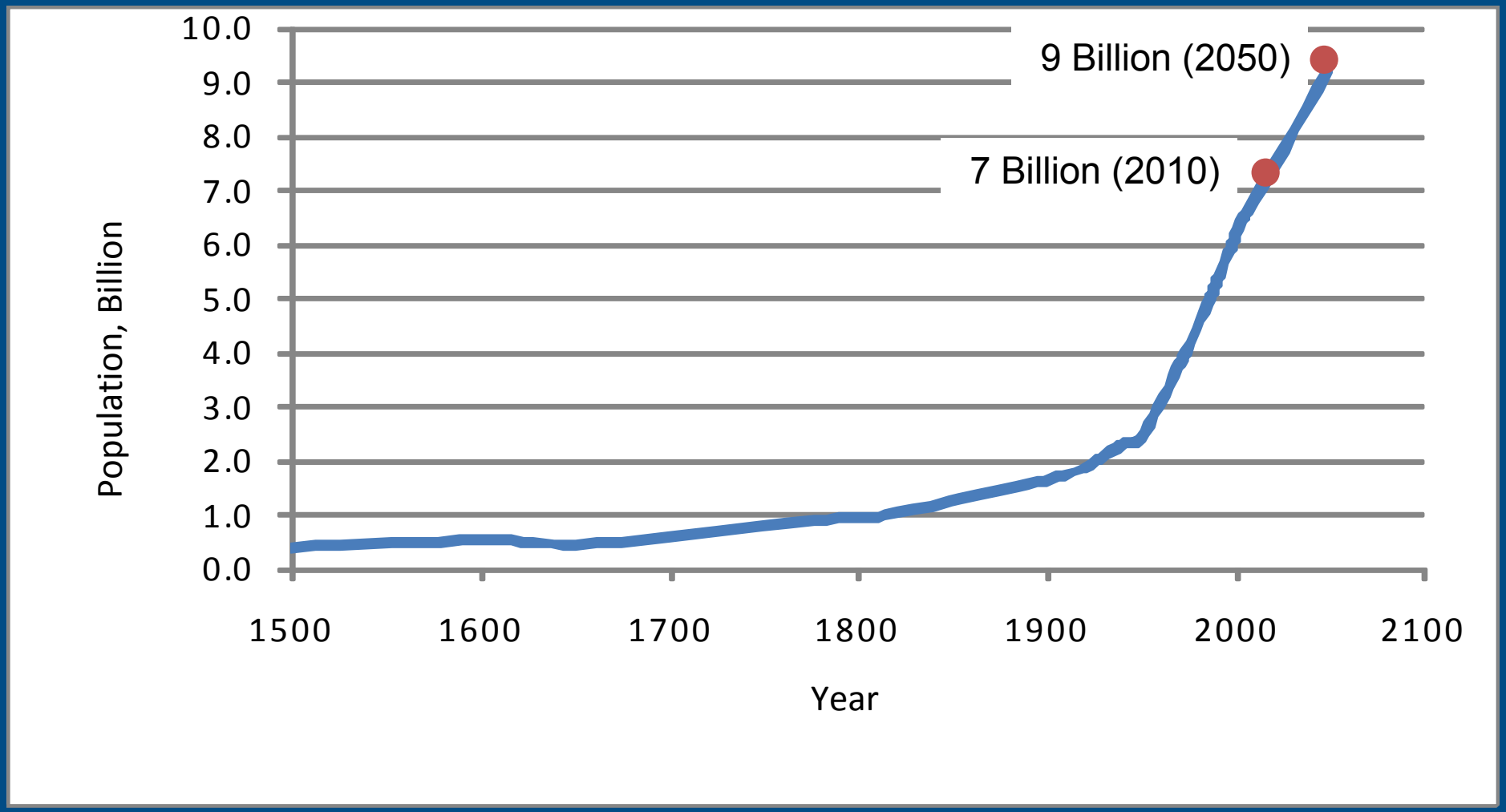


Present Phosphorus Use Profile

Fertilizer use expected to increase due to

- Rapid population growth
- Increased intensive agriculture

Population Explosion



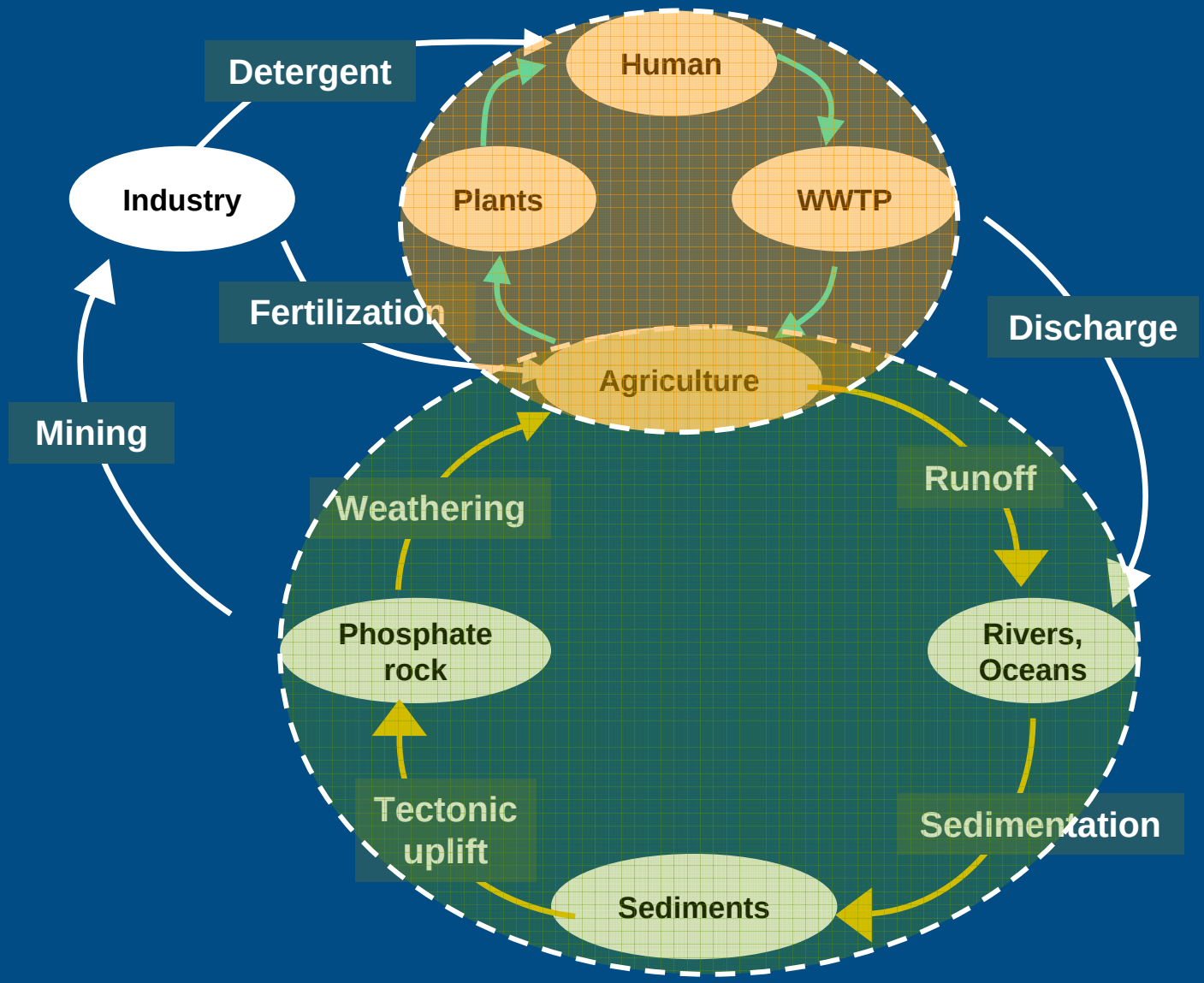
The Phosphorus Crisis

- Phosphorus resources are declining both in quality & accessibility

Availability of high quality P:
- 100 years globally
- 40 year in the US

- Poor quality sources have increasing amounts of contaminants (Cd, U, Ni, Cr, Cu, Zn)
  - Higher cost of recovery
- Global response:
  - Sweden : 60% of P recycled from wastewater by 2015
  - China: 135% export tariff
  - Use of special urine separation toilets (Japan & Europe)

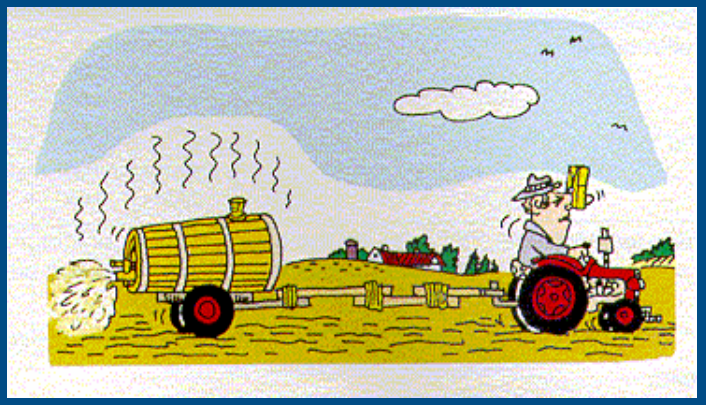
Is there Really a Loss of Phosphorus?



Cornel *et al* (2009)

Status of Land Application

- Land application is a cost effective way to recycle phosphorus
- However, this is not a viable long-term strategy for many utilities
  - Suitable land is becoming more distant
  - Public perception
  - Regulatory uncertainty
  - European trend



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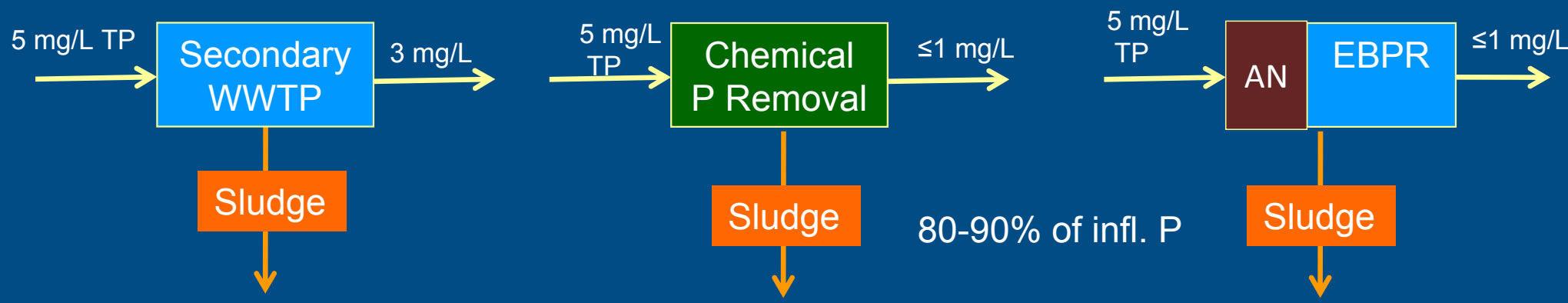
Can we Recover P from Wastewater?

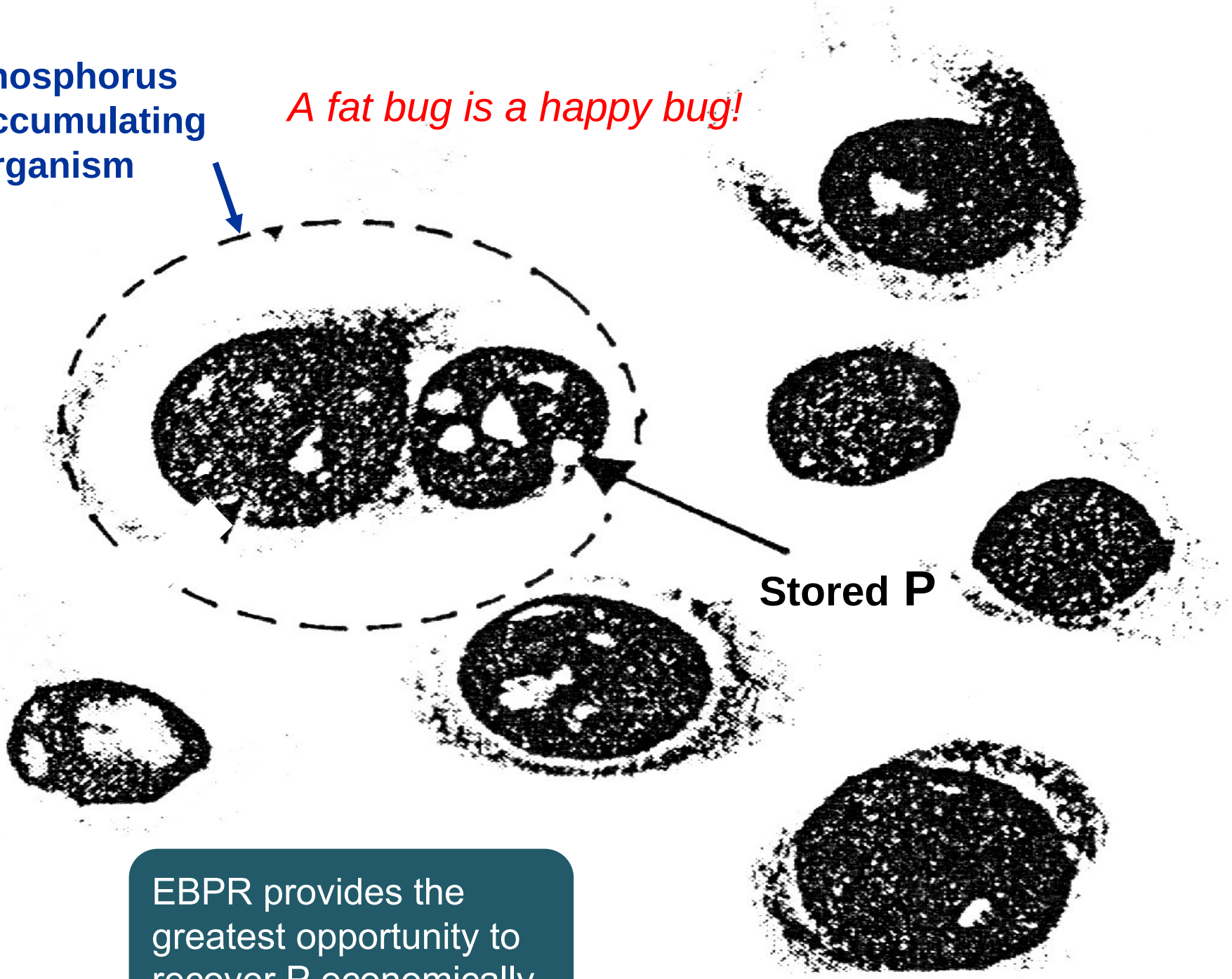
- Human waste
  - 400,000 tons/year of phosphorus in US sewage
- Phosphorus removed by WWTPs ends up in the sludge



Mechanism	• Synthesis	• Synthesis • Chemical precipitation	• Synthesis • Enhanced P uptake
Sludge P Content	1 – 2%	5 – 10 %	5 – 10%

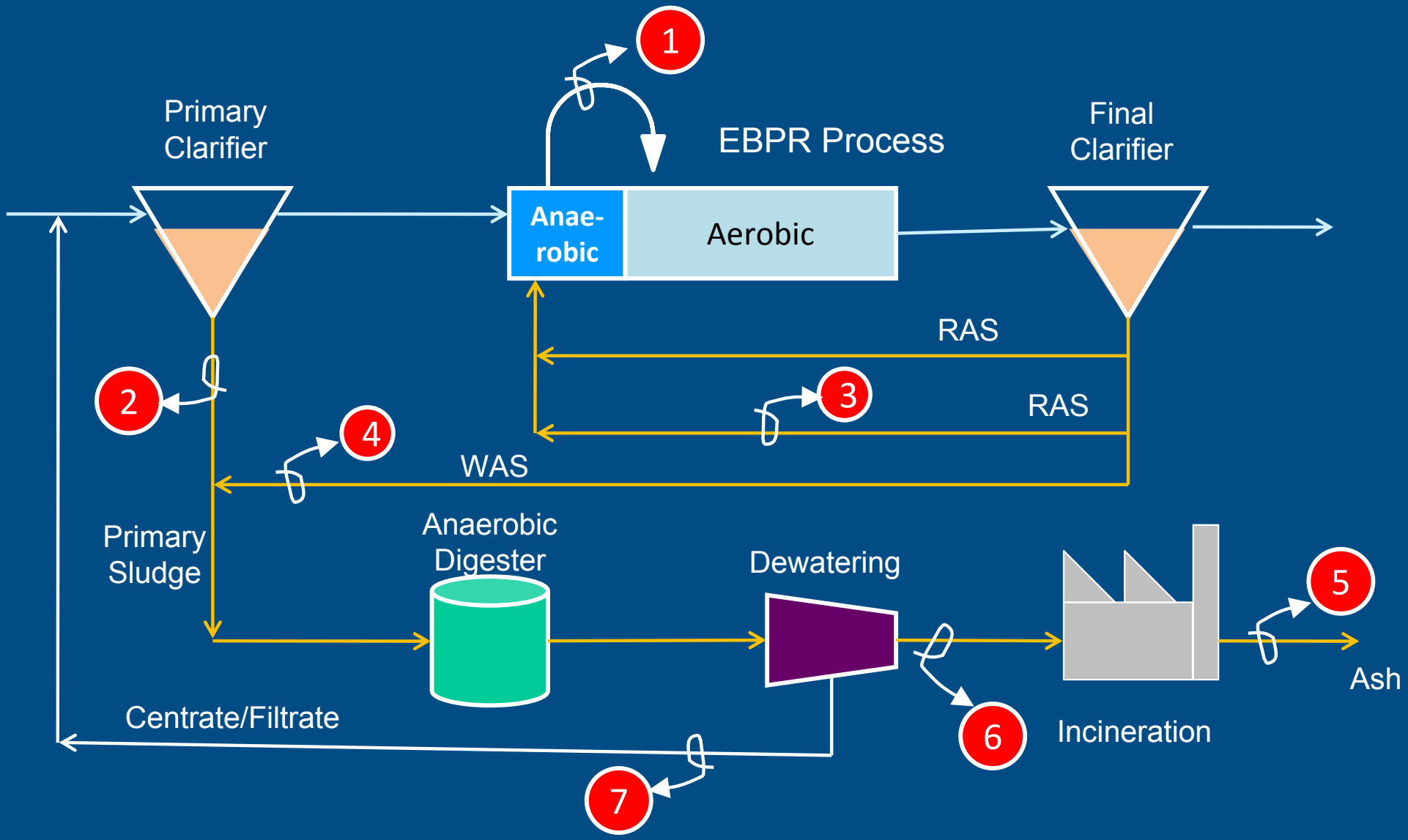
Phosphorus Accumulating Organism

A fat bug is a happy bug!



EBPR provides the greatest opportunity to recover P economically

Potential Locations for P Recovery



Phosphorus Recovery Technologies

- Proven technologies
- Emerging technologies

Proven P Recovery Technologies

Technology	Feed Stream	Product	External Inputs
Crystalactor	RAS	$CaPO_4$	Lime, sand
PhoStrip	RAS	$CaPO_4$	Lime
Ostara	**Centrate, filtrate**	**Struvite**	**MgCl, NaOH**

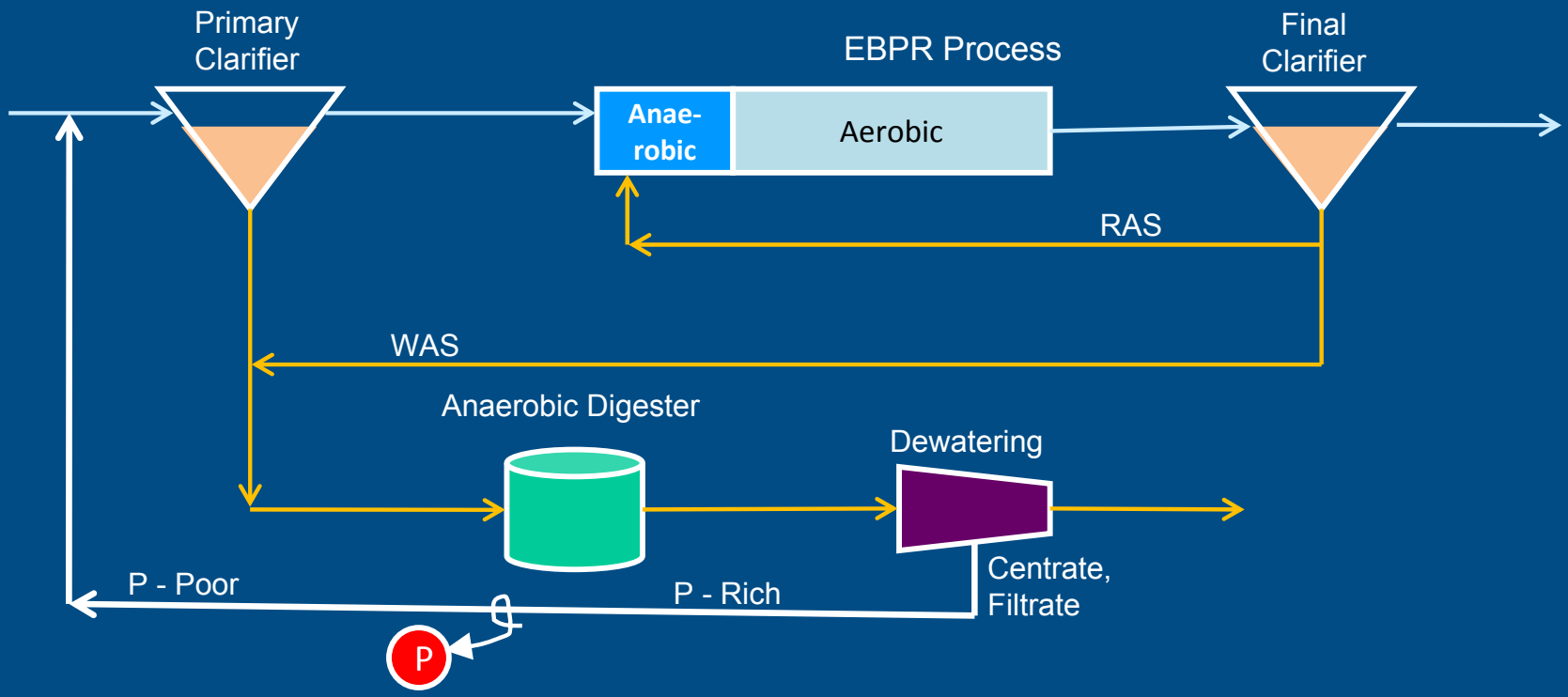
Struvite – Friend or Foe?

- Struvite is Magnesium Ammonium Phosphate ($MgNH_4PO_4$)
  - Kidney stones
- Forms readily when:
  - Molecular ratio of Mg:N:P is 1:1:1
  - pH around 9.0.
- Often an O&M nightmare at EBPR facilities:
  - Anaerobic digestion releases P, Mg, & ammonia
  - Turbulence drives out CO_2 resulting in pH rise & struvite scaling

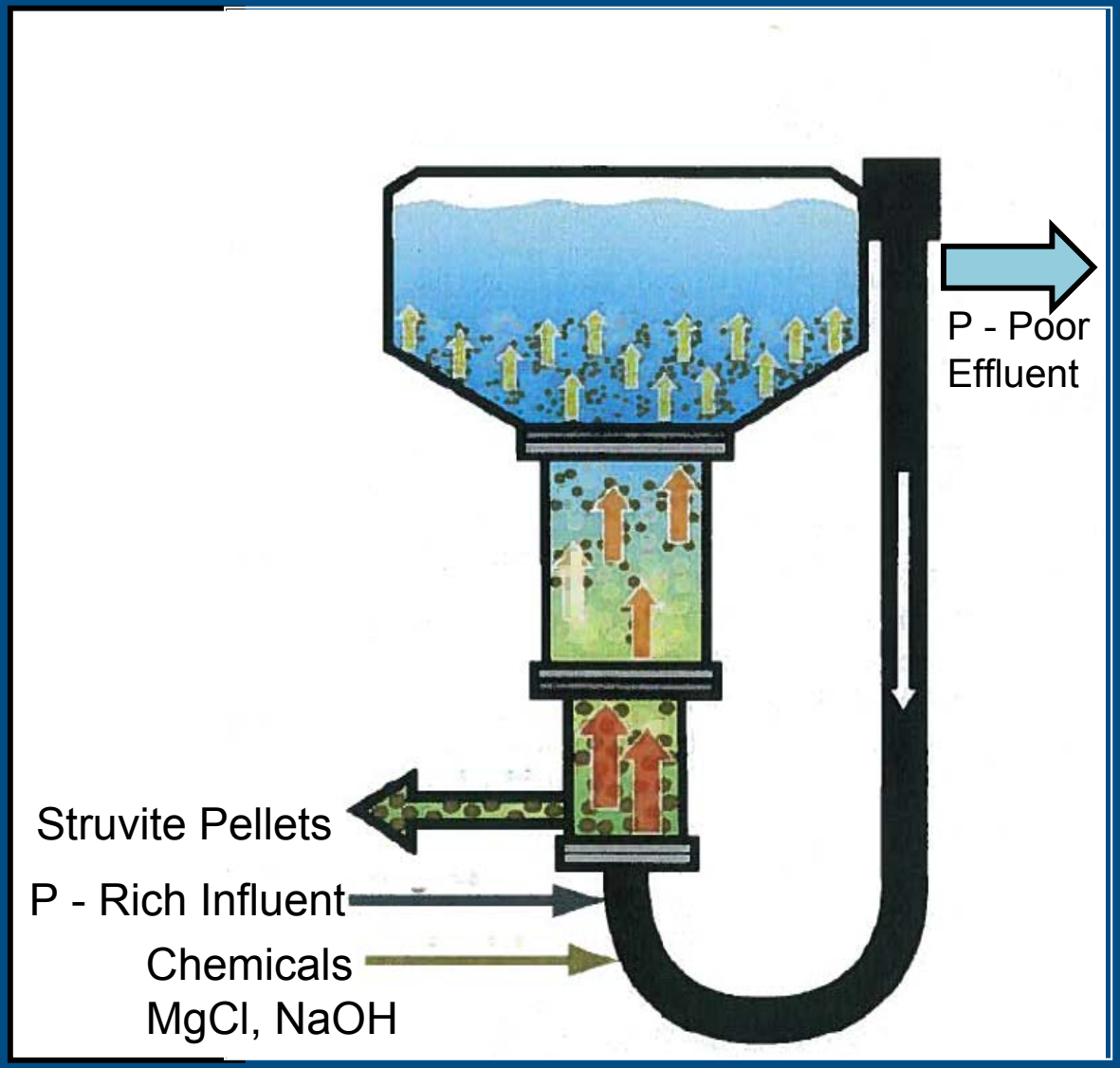
When Fate Hands a Lemon..

- Controlled Struvite formation & collection
- Source of slow release fertilizer – highly marketable
  - 5% N; 28% P; 0% K

Other benefits:
- Recycle treatment
- No struvite scaling



Ostara P Removal Process

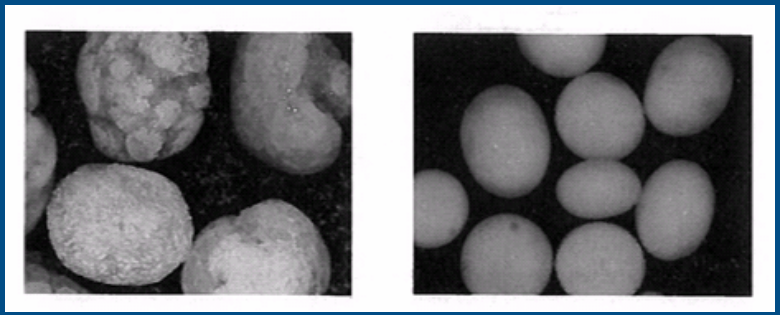


Requirements:

- PO4–P > 75 mg/L
- TSS < 1000 mg/L
- 140 lbs/day/module
- Plant size >5 MGD

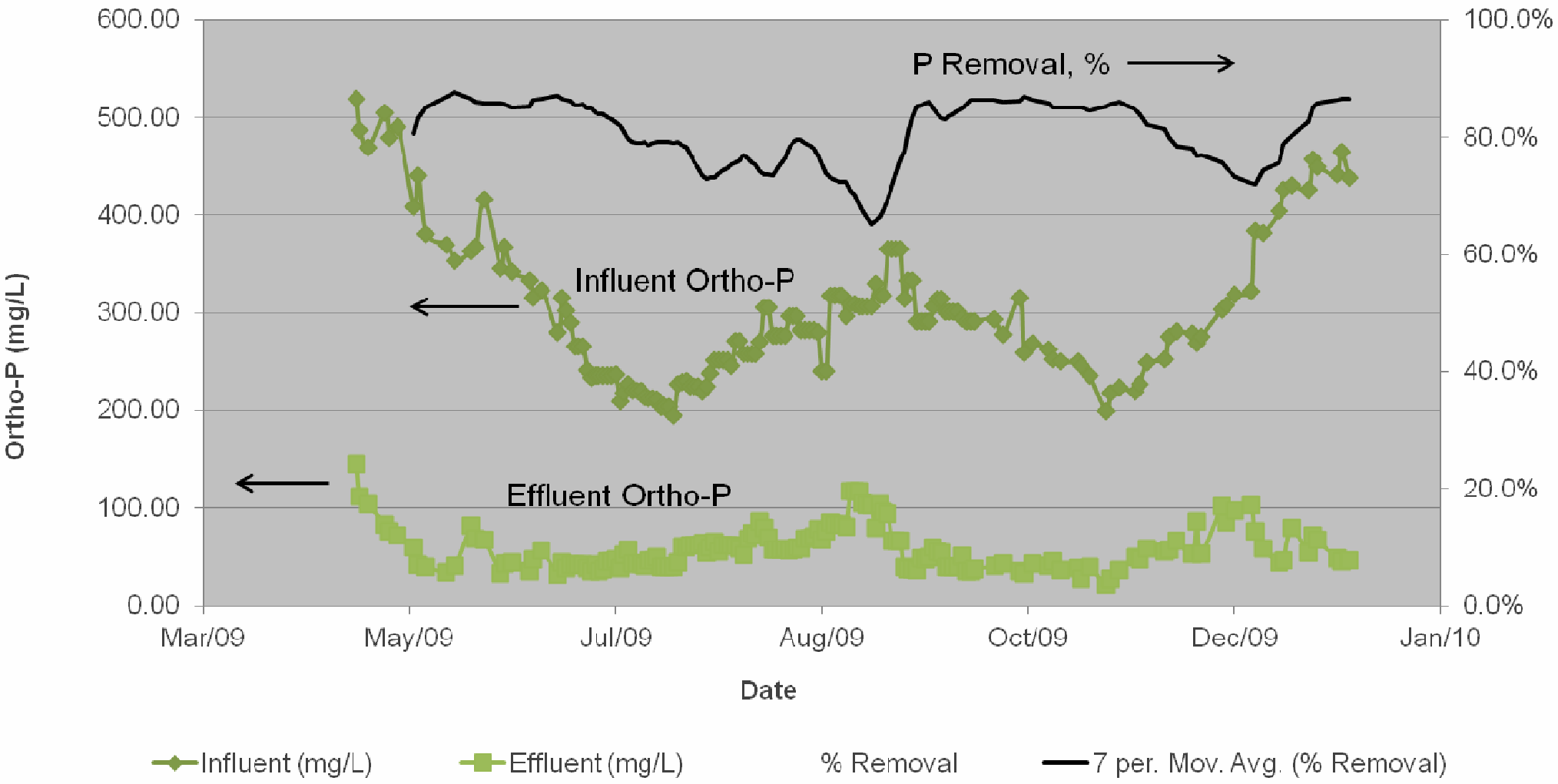
Ostara Installations

- Durham WWTF, Portland, OR (20 MGD)
  - June 2009
- Gold Bar WWTP, Edmonton, Alberta (82 MGD)
  - May 2007
- Nansemond Treatment Plant, HRSD, VA (30 MGD)
  - 2010
- York WWTP, York, PA (26 MGD)
  - 2010



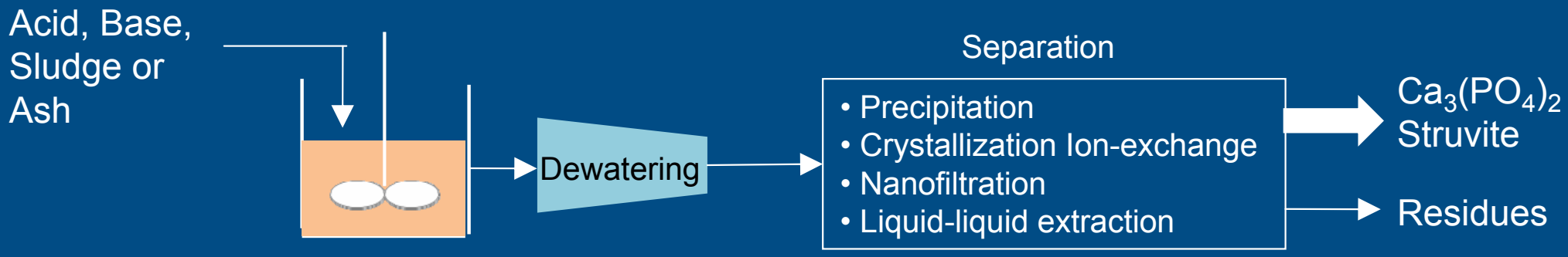
Durham WWTF
Portland, OR

Ostara Performance - Durham WWTP



Emerging **P Recovery Technologies**

Technology	Origin	Feed Stream	Product	External Inputs
KREPO	Sweden	Primary sludge	Ferric Phosphate	Heat, pressure, H_2SO_4, NaOH
Seaborne	Germany	Digested sludge	Struvite	Heat, H_2SO_4, NaOH, $Mg(OH)_2$
Kemicond	Sweden	Primary sludge	Ferric Phosphate	H_2SO_4, H_2O_2, polymer
BioCon	Denmark	Incinerator ash	H_3PO_4	H_2SO_4, ion-exchange
SEPHOS	Germany	Incinerator ash	$AlPO_4$, $Ca_3(PO_4)_2$	H_2SO_4, NaOH, Ca^{2+}



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Take Home Messages

- Phosphorus is vital to life; there is no substitute for it
- Phosphate rock quality & accessibility are declining due to:
  - Rapidly growing population and intensified agriculture
- Experts predict high quality phosphorus would be exhausted in about 100 years.
- Land application is a cost effective way to recycle P. However, this is not a viable long term option for many utilities.

Take Home Messages

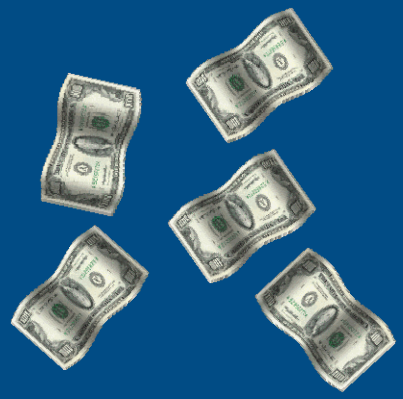
- P discharged in the effluent is essentially lost
- EBPR offers the greatest opportunity for cost effective P recovery
- Struvite recovery from sidestreams also provides the benefit of sidestream treatment (P and ammonia removal) at BNR facilities.
- Struvite is a highly marketable end-product

Take Home Messages

The decision to incorporate P recovery should be based on a Triple Bottom Line 'Plus" analysis:

- Environmental factors – Is it low impact?
- Economic factors – Is it affordable?
- Social factors – Is it socially acceptable?
- Technical factors – Is it practical, does it work?

It behooves you to hold on to your kidney stones!

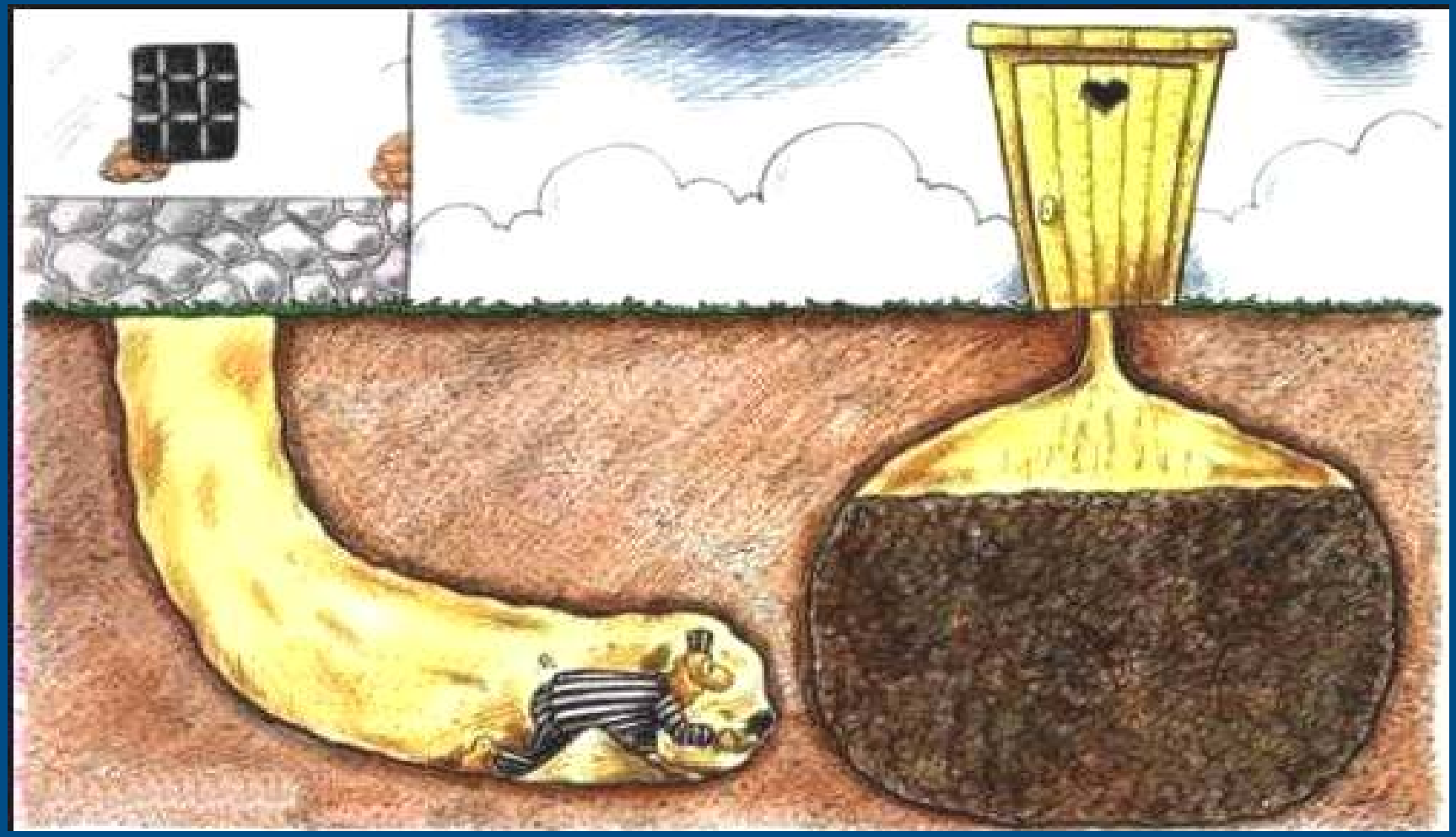


A President Understood the Looming Phosphorus Crisis Over 70 years Ago

“I cannot overemphasize the importance of phosphorus not only to agriculture but also the physical health and economic security of the people of the nation.”

Franklin D. Roosevelt, 1938

Questions



Planning Always Avoids Problems!

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