Achieving Zero Effluent Phosphorus

The Membrane Treatment Solution

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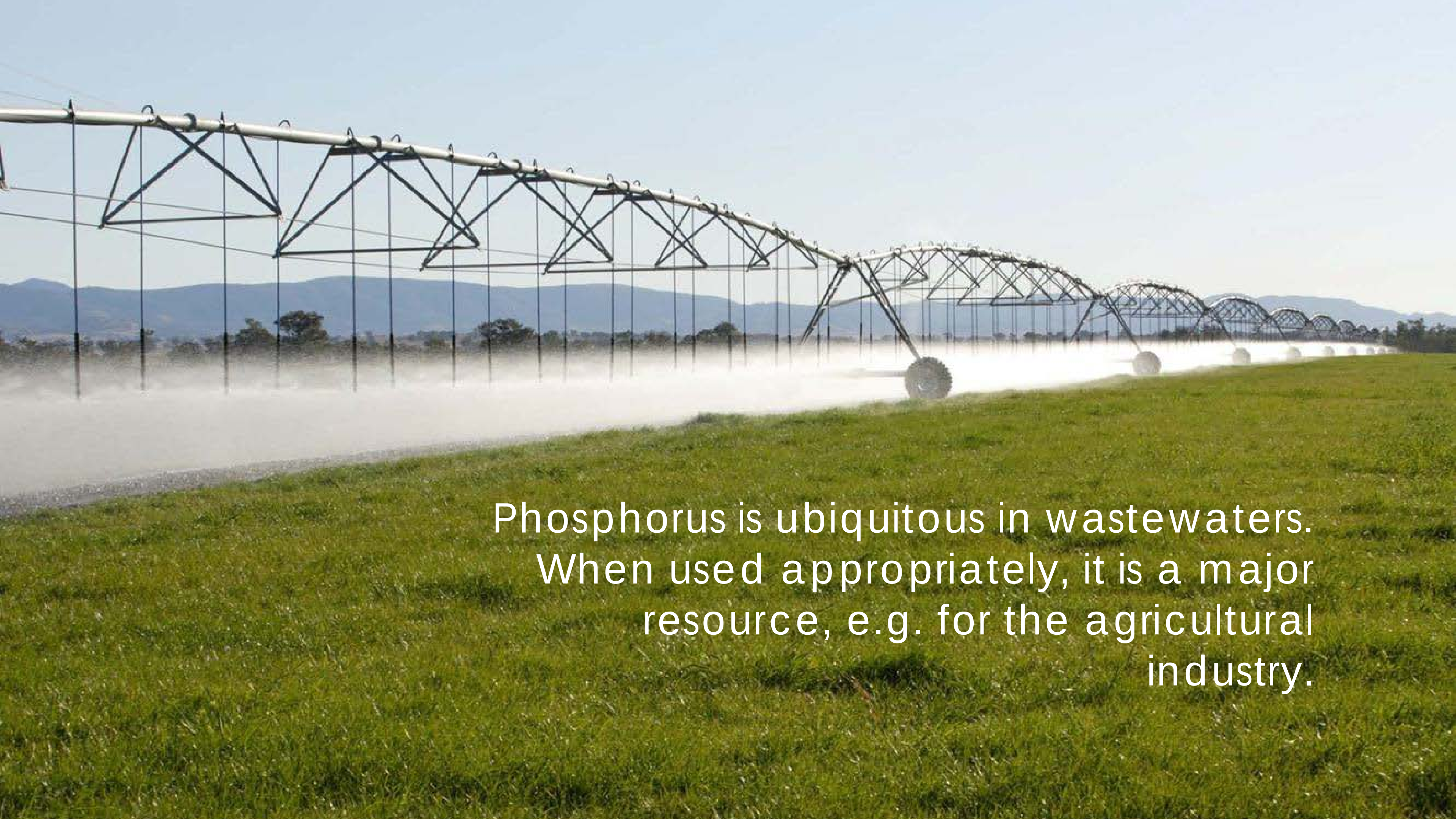
MWH now part of Stantec


Phosphorus is ubiquitous in wastewaters.
When used appropriately, it is a major
resource, e.g. for the agricultural
industry.


Uncontrolled release of phosphorus, however, could lead to eutrophication, which significantly affects the river eco-system.

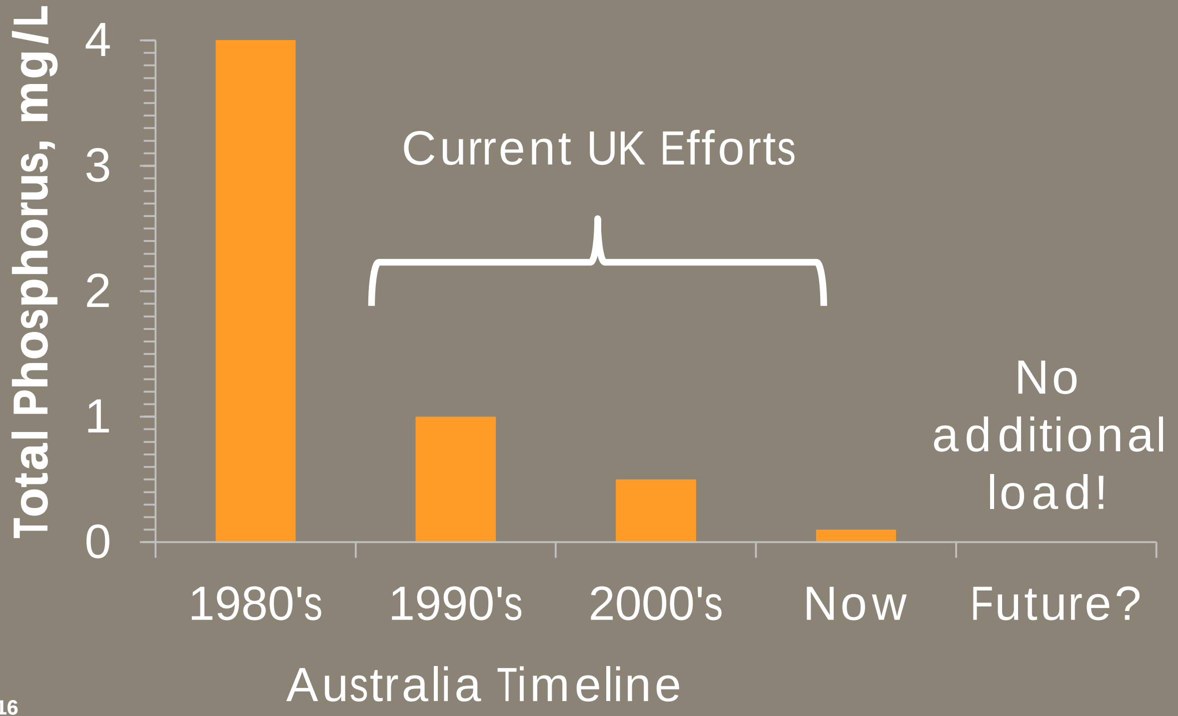
Outline of Presentation

1. **The phosphorous limits and typical removal technologies**

2. **The Googong Project - Phosphorous removal using membranes**

3. **Questions**

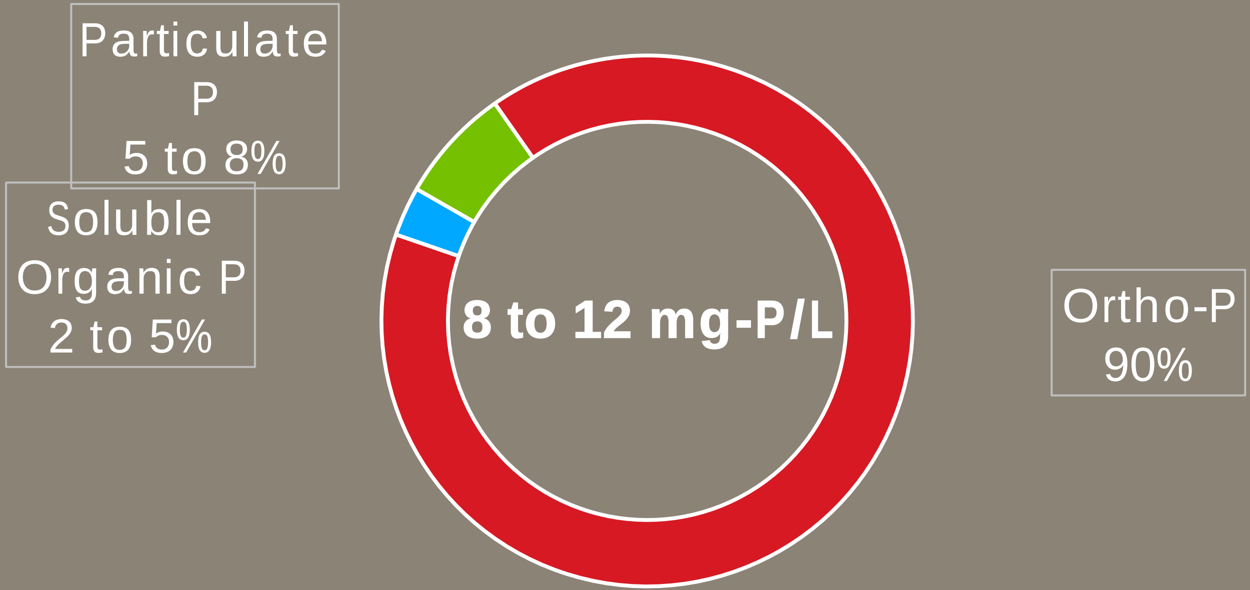
Effluent P limit is going down....



Source: European Commission 2016

Phosphorus Load

Phosphorus – Typical Domestic Wastewater



Phosphorous Removal

Phosphorous has to leave the system as particulate-bound compounds

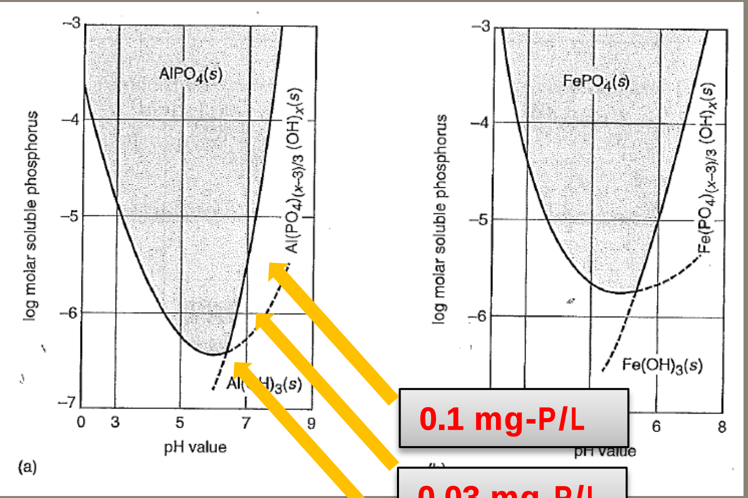
Two main removal mechanisms:

1. **Chemical precipitation**
   - Co precipitation (1-2 mg/L)
   - Multipoint / tertiary (0.1 – 0.5 mg/L)
2. **Enhanced (excess) biological phosphorous removal**

Choice of Coagulants

Ferric or ferrous (as chloride or sulphate)

Alum (sulphate), or ACH



0.1 mg-P/L

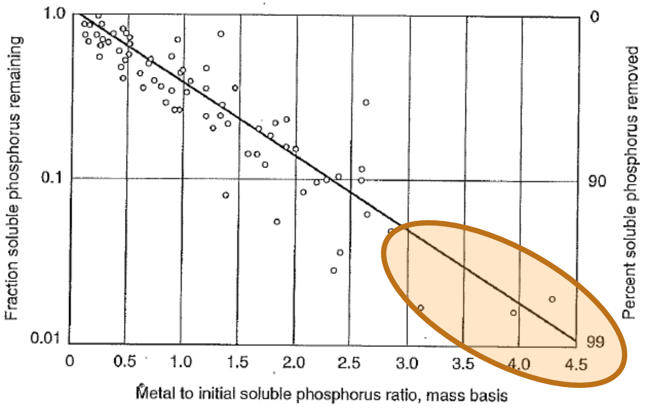
0.03 mg-P/L

0.014 mg-P/L

Source: Metcalf & Eddy (2004)

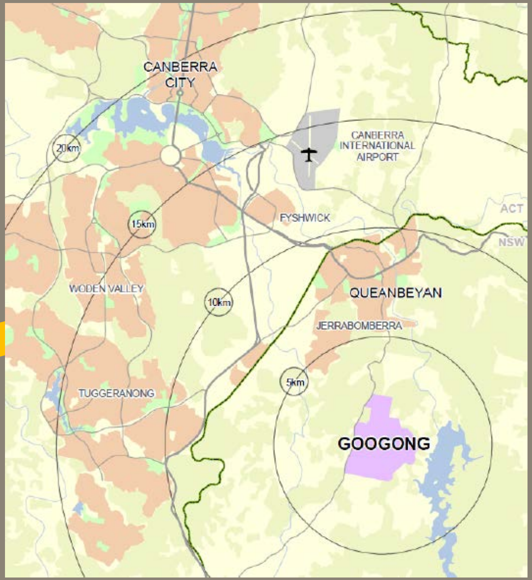
Phosphorus reduction, %	Mole ratio, Al:P Range	Mole ratio, Al:P Typical
75	1.25:1–1.5:1	1.4:1
85	1.6:1–1.9:1	1.7:1
95	2.1:1–2.6:1	2.3:1

[a] Developed in part from U.S. EPA (1976).



The Googong Story

In early 2000's, a new town was being planned for development near Canberra.



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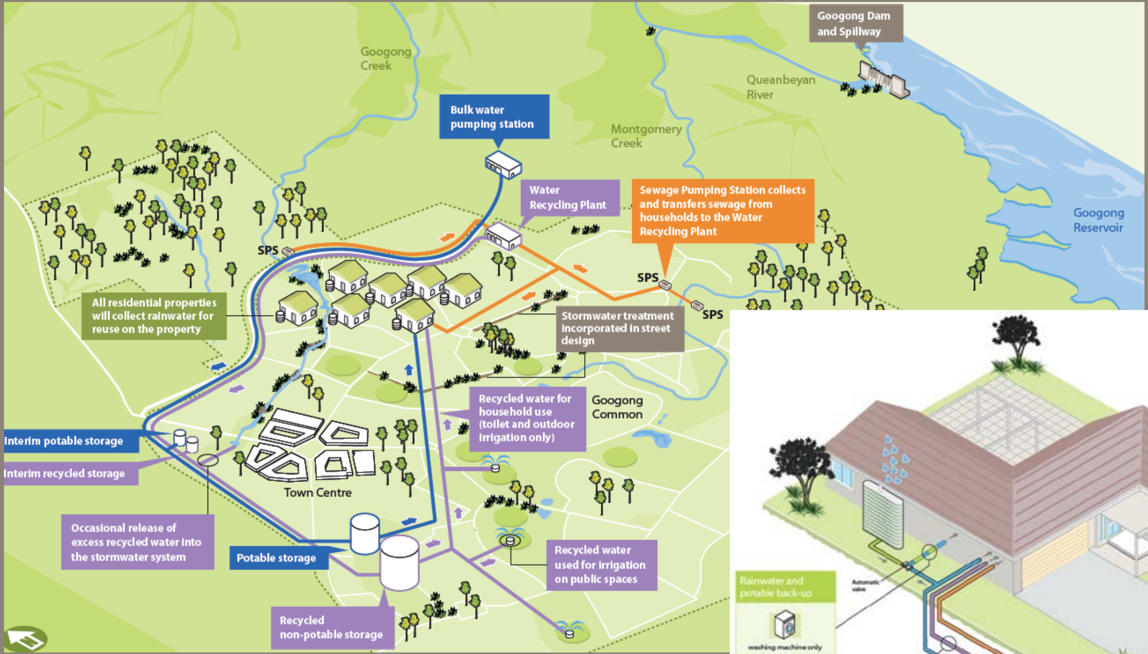
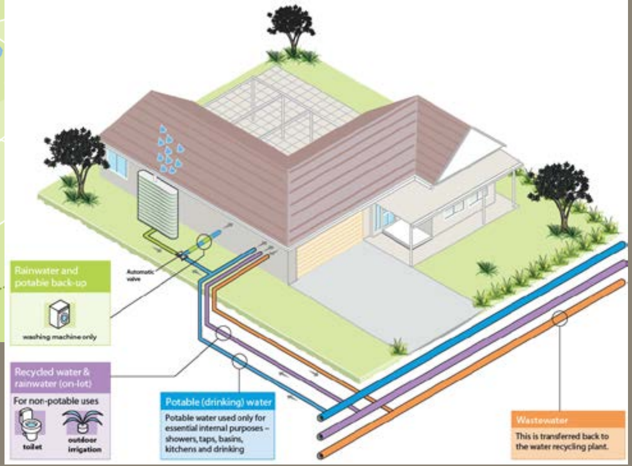




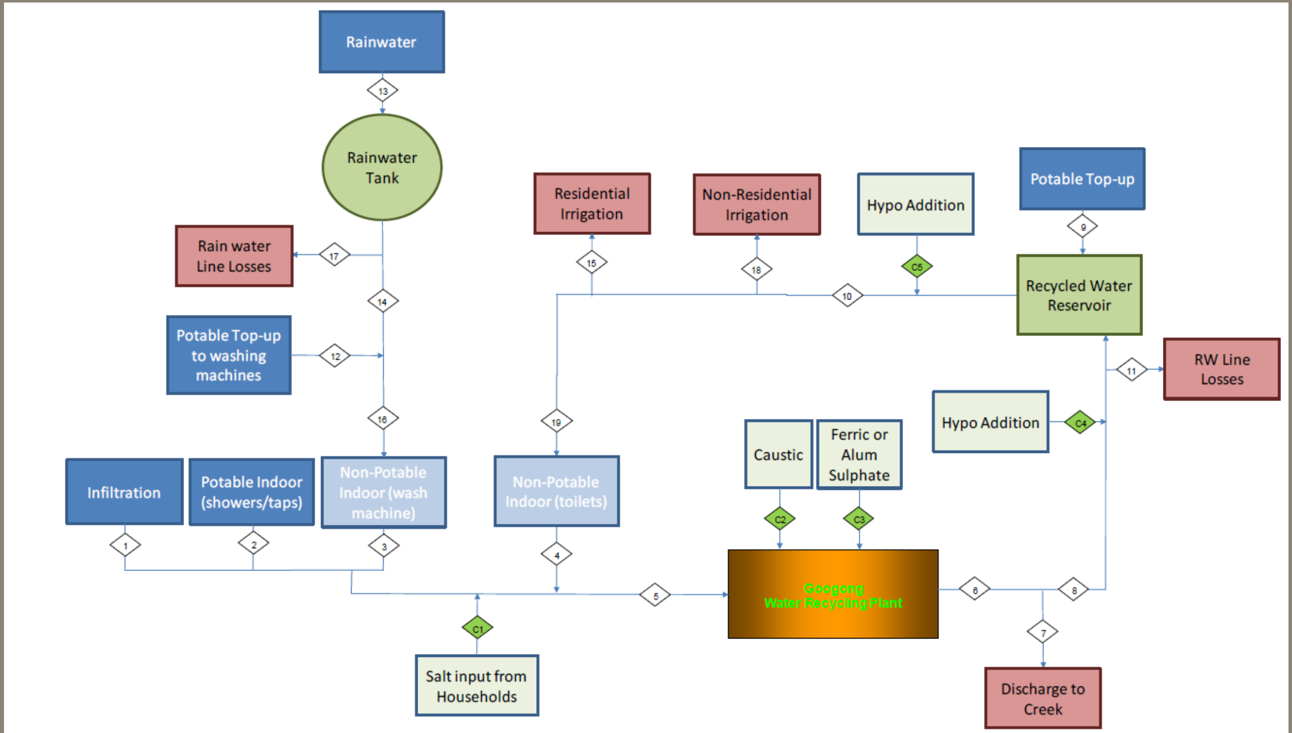
The Phosphorous & TDS Challenges!

- **Target 0.3 mg/L 50% P – discharge to Molonglo River**
- **Water Recycling - semi-closed water loop → TDS accumulation**
- Important to consider both phosphorous and TDS at the same time.

- **Additional project challenges:**

1. Need for membrane filtration
2. Land is premium!

Water & TDS Modelling



TDS Balance Key Outcomes

Phosphorous precipitating chemicals (alum and/or ferric) are the <u>second highest</u> contributor to TDS in water cycle.

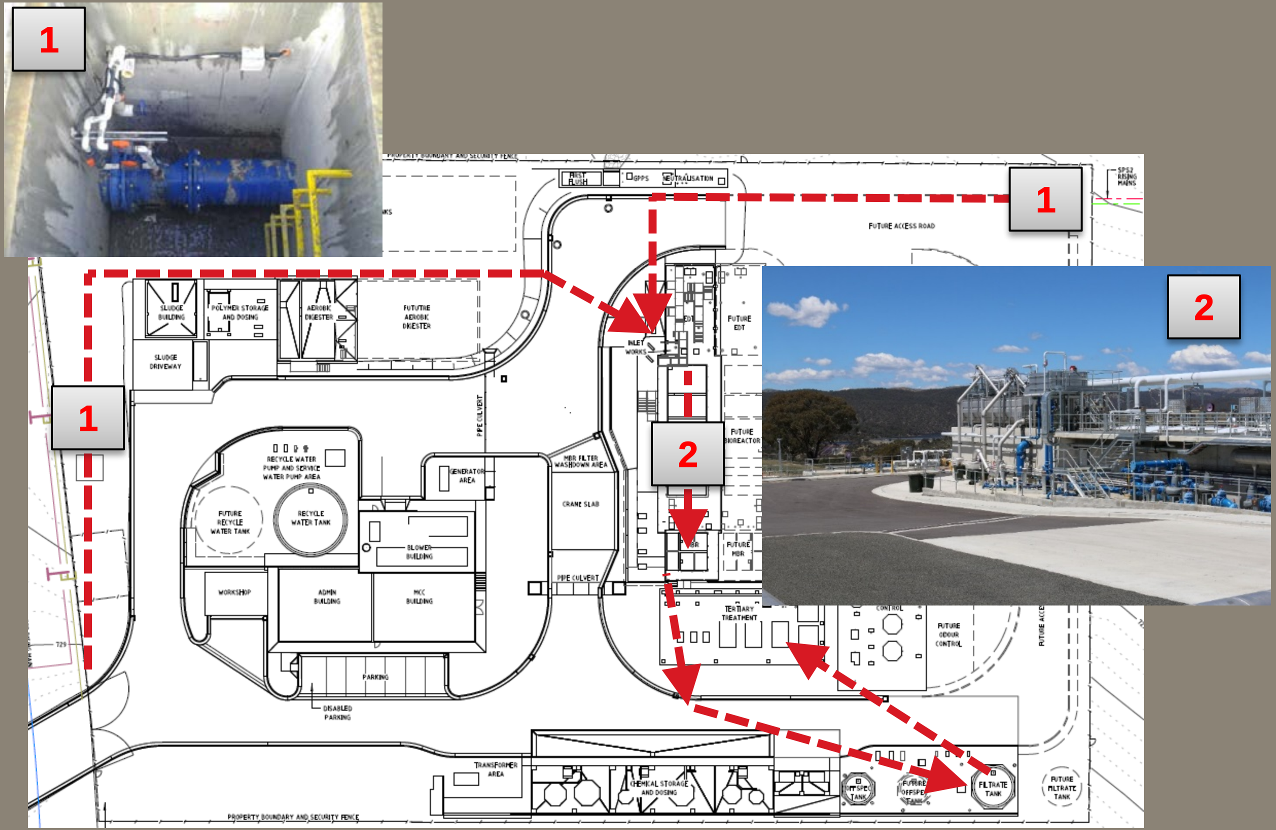
- It is important to minimize chemical dose
- Overdose will lead to depressed pH, meaning more caustic dose, which also increases TDS

- Biological phosphorous removal could improve efficiency of chemical uses

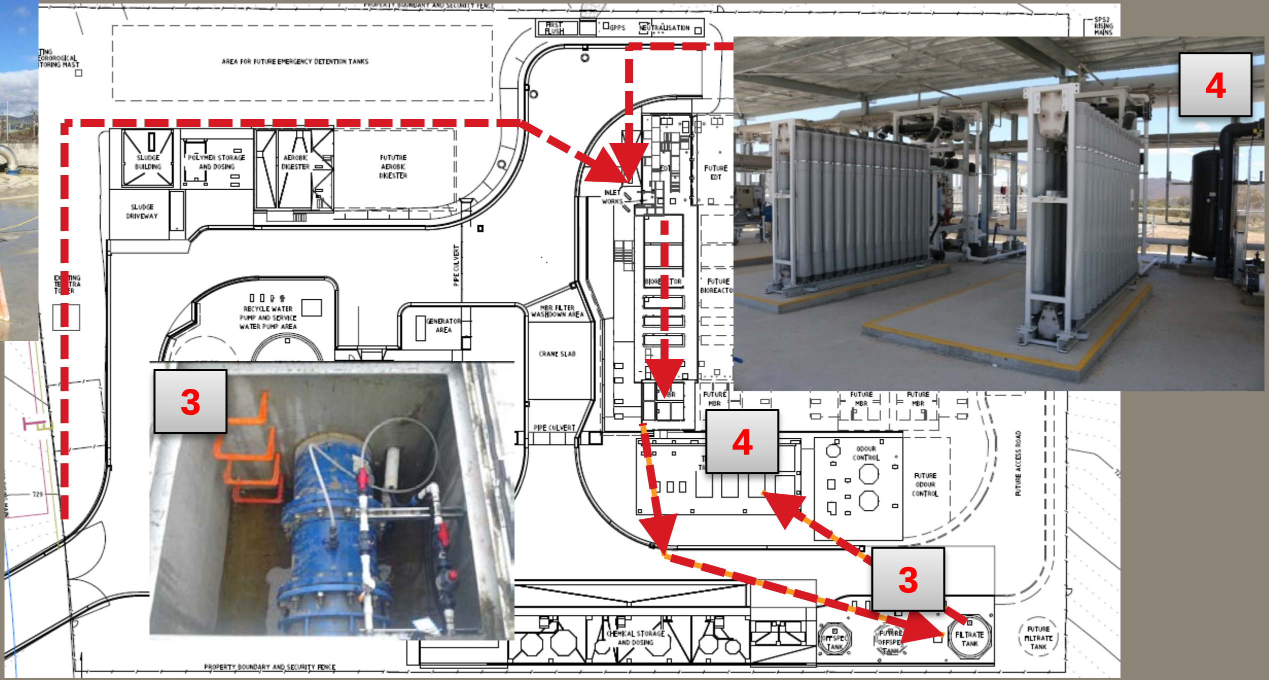
P Removal Process Design

1. Multi-point dosing + separation to minimize chemical dosage (MBR followed by pressure UF)
2. Recycle tertiary precipitates to bioreactor to maximize chemical efficiency
3. Managing sludge return liquor
4. Ability to operate bioreactor in enhanced biological phosphorous removal mode

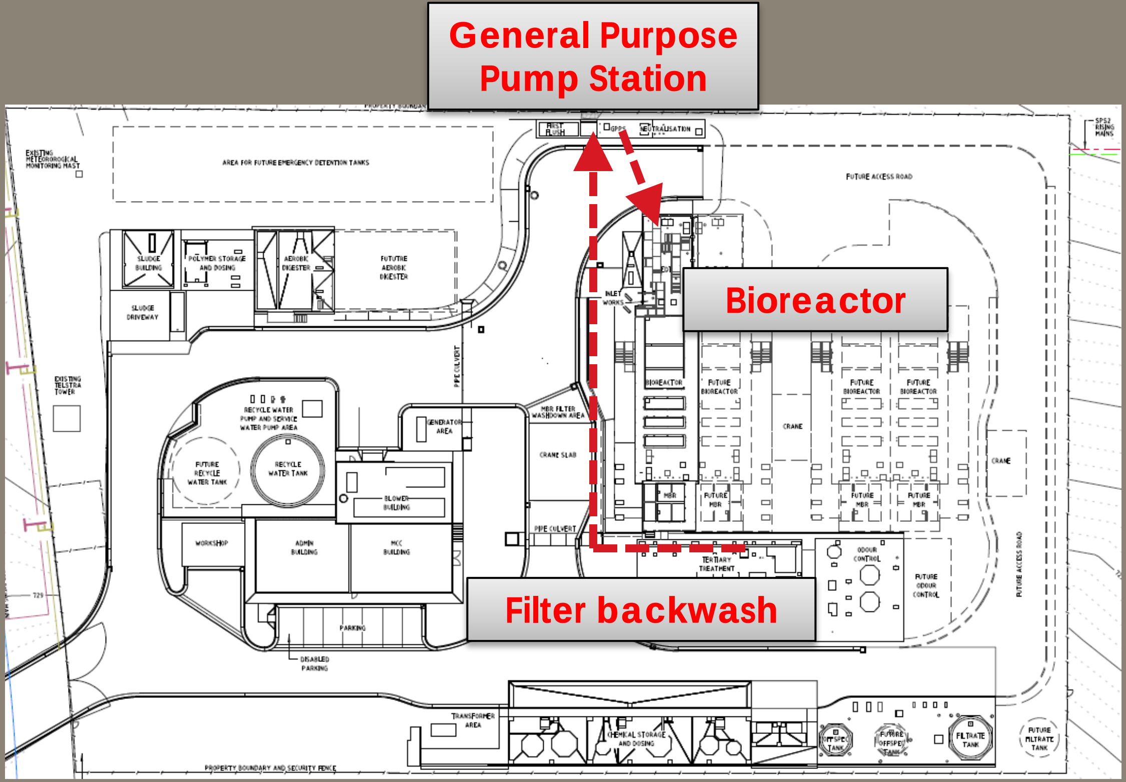
Process Flow & Ferric Dosing



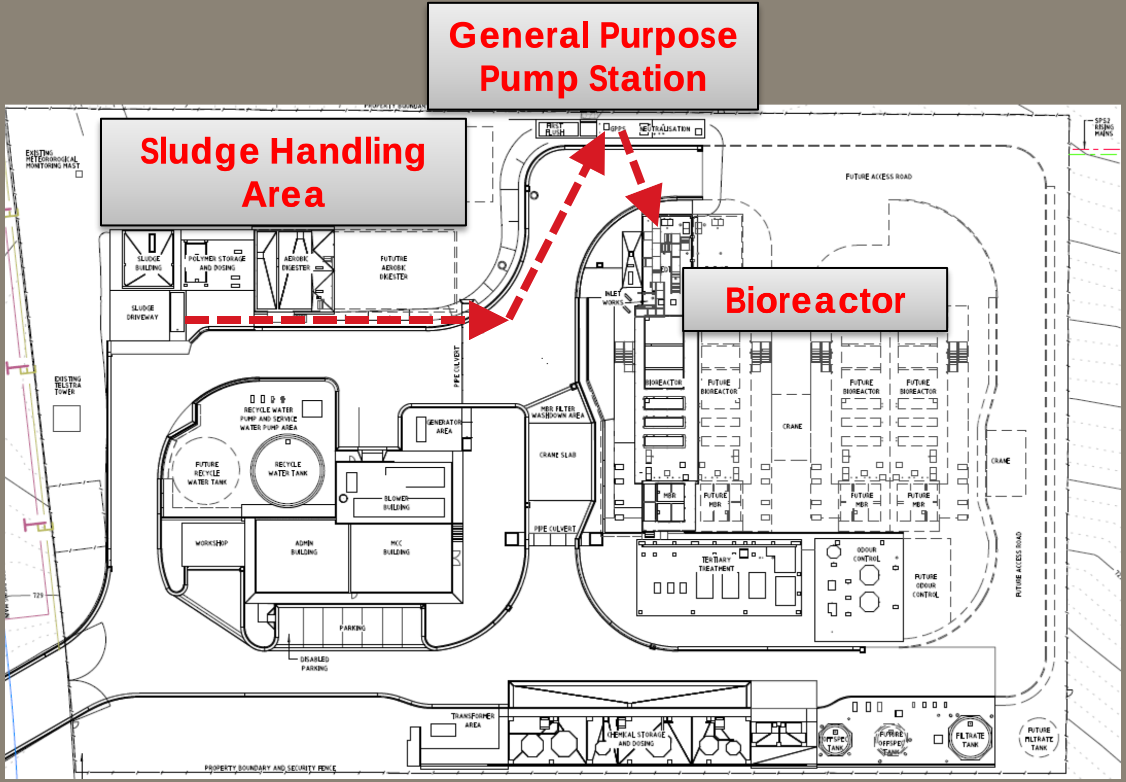
Tertiary Phosphorus Removal



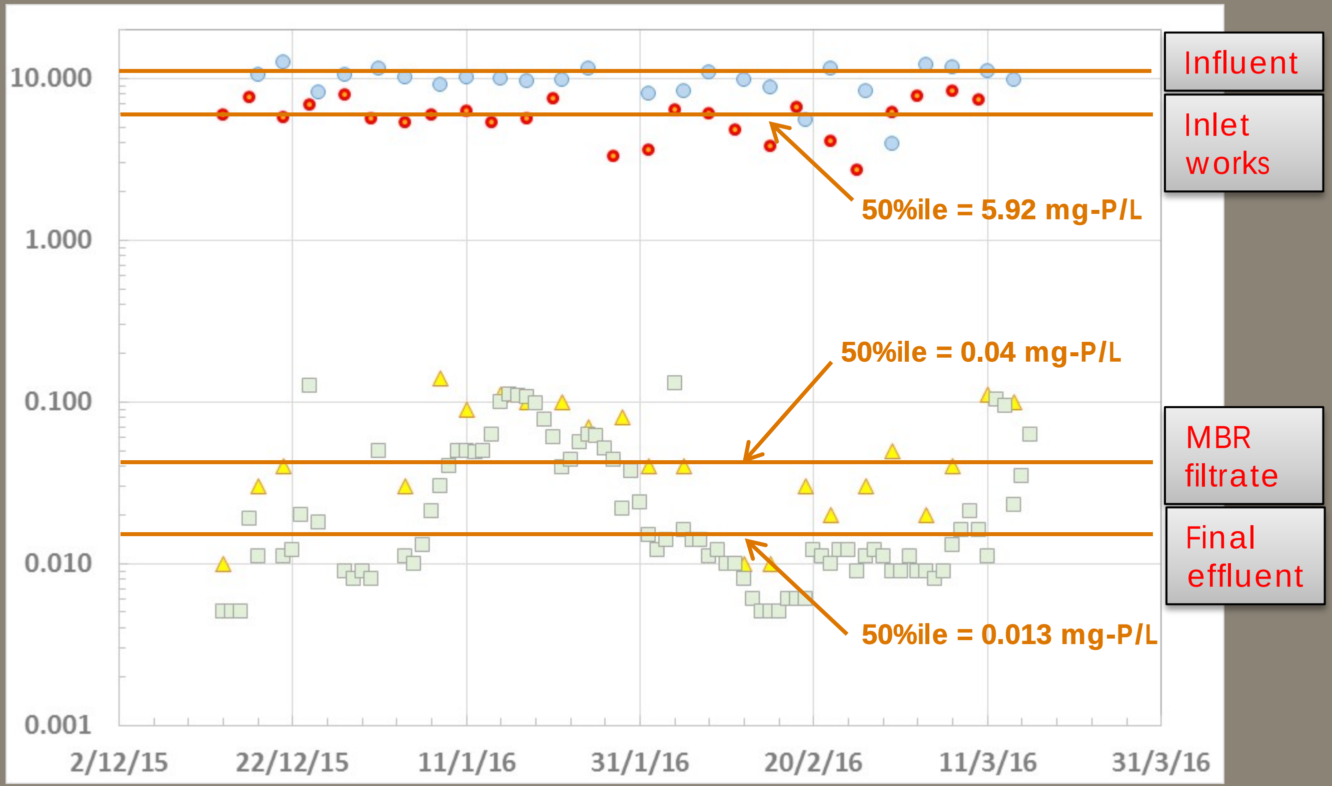
Reuse of Residual Alum Precipitate



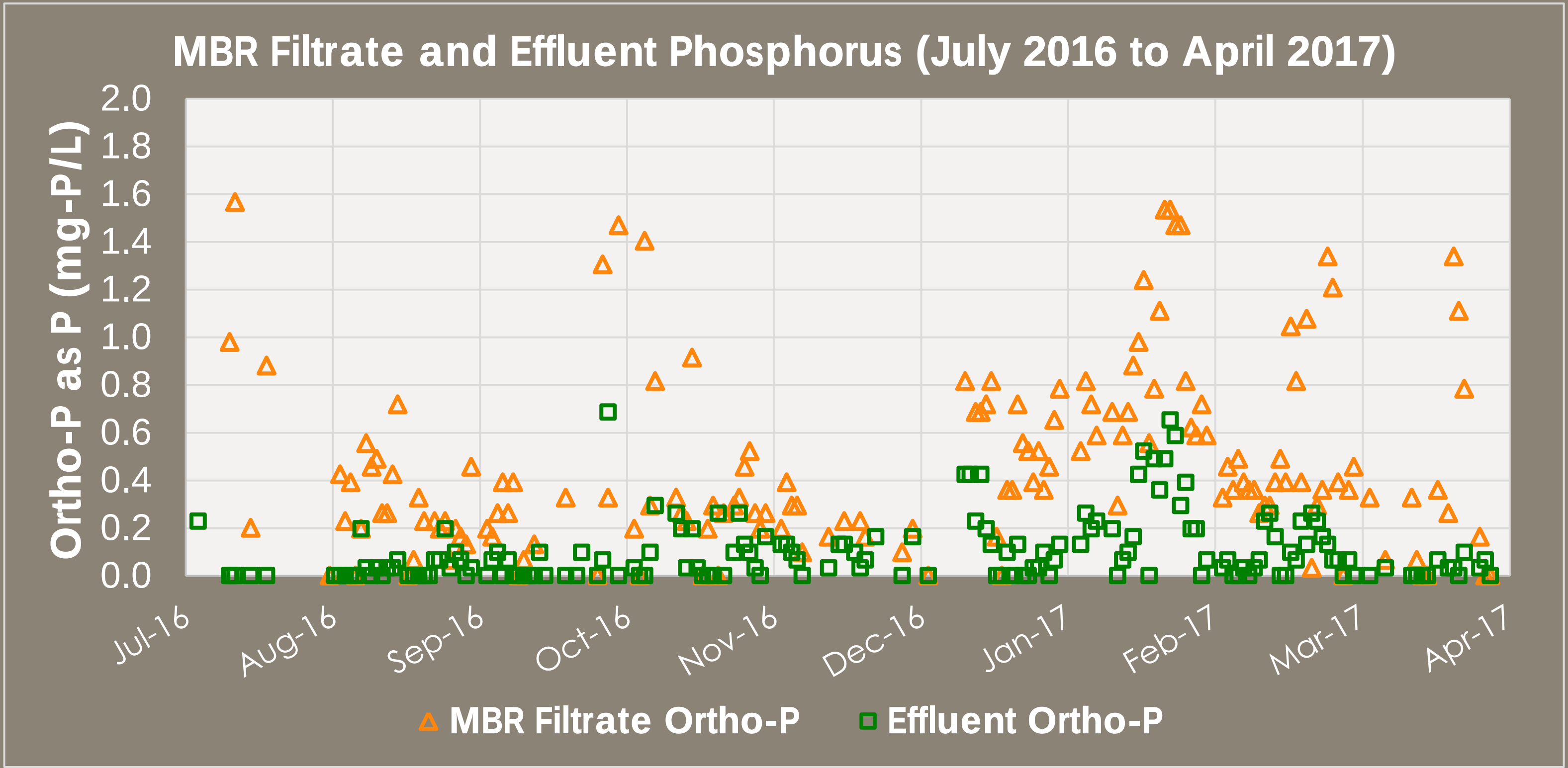
Sludge Liquor Management



Commissioning Outcomes



Operating Outcomes - Phosphorus



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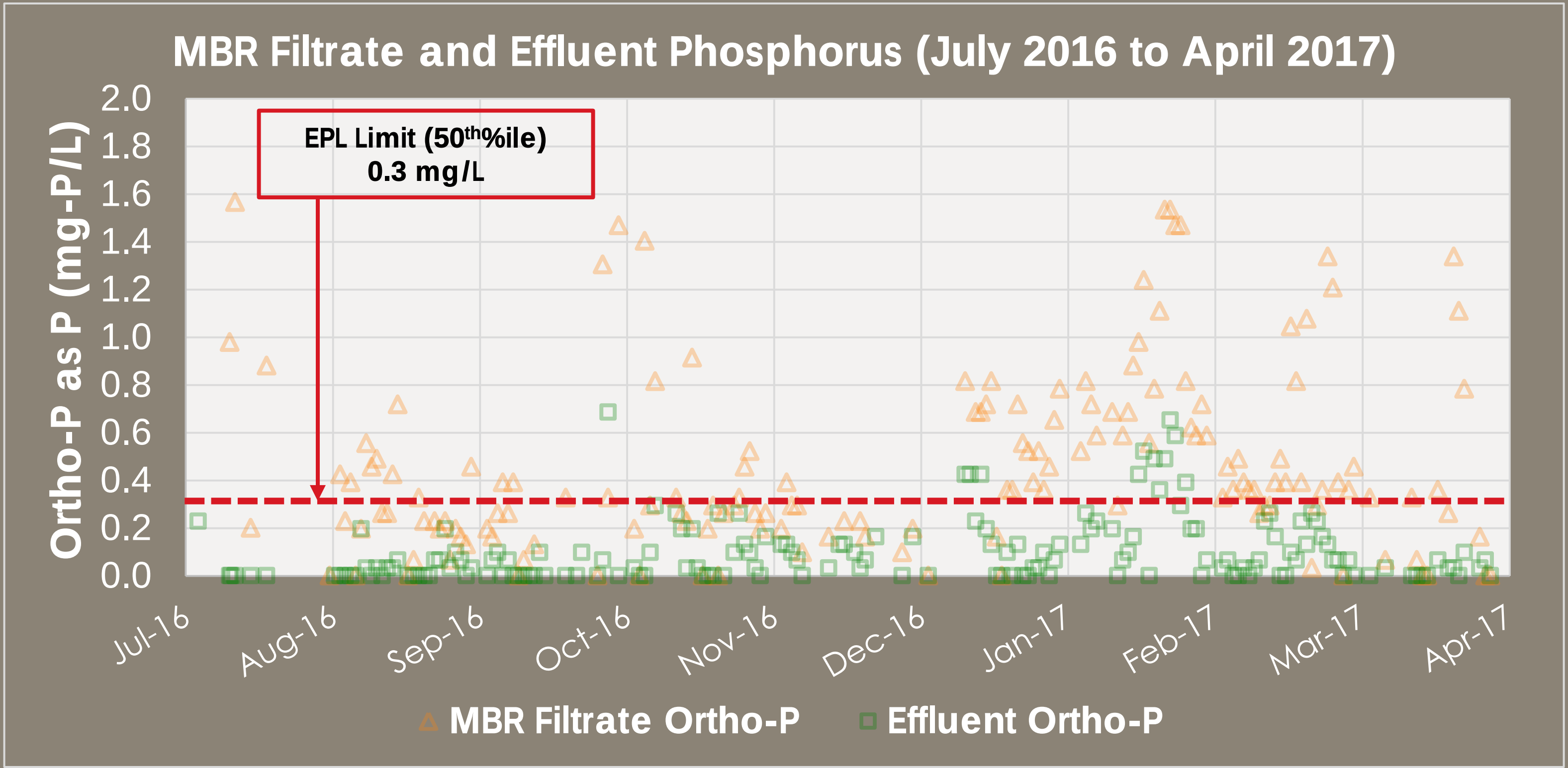

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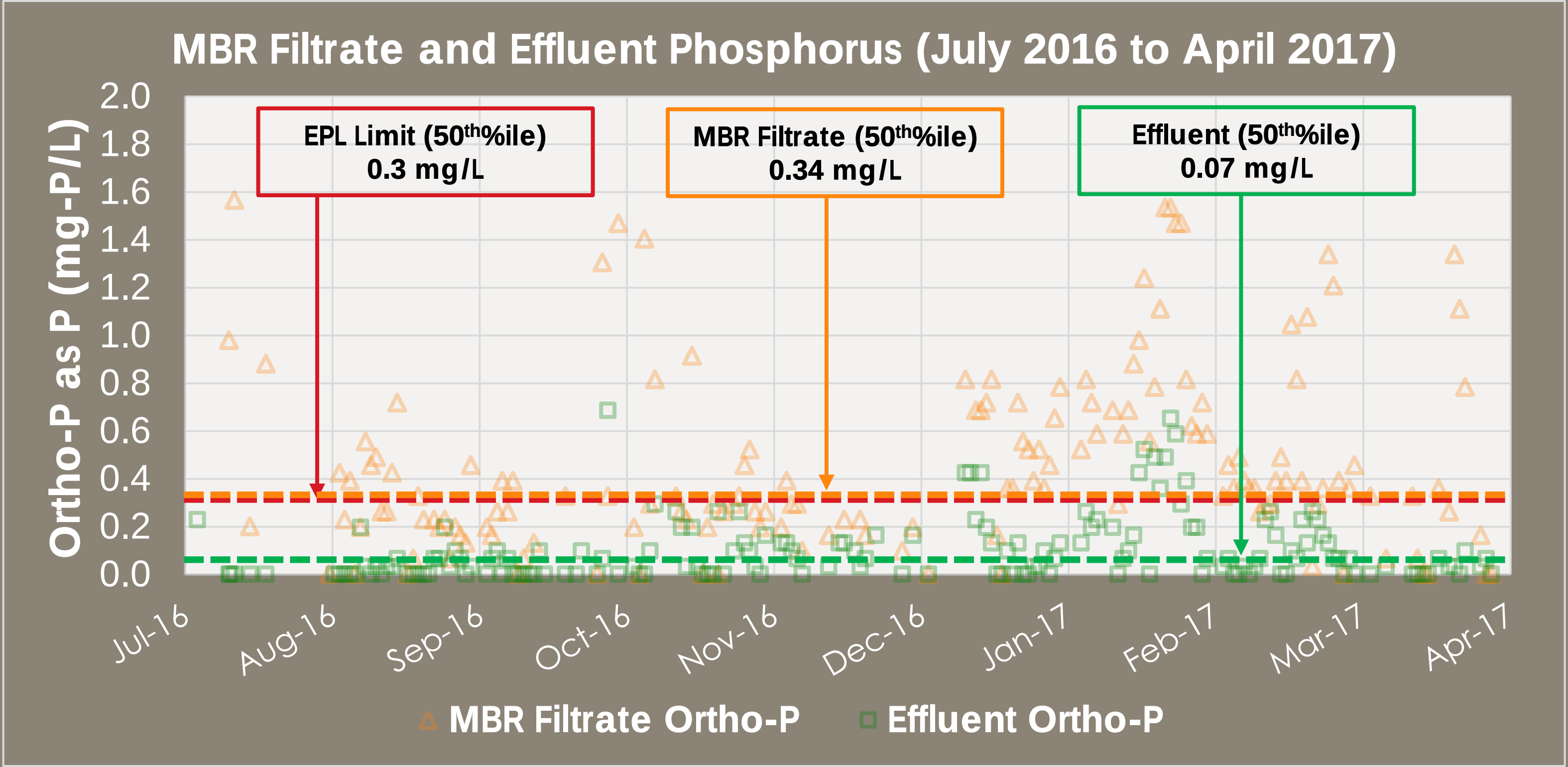
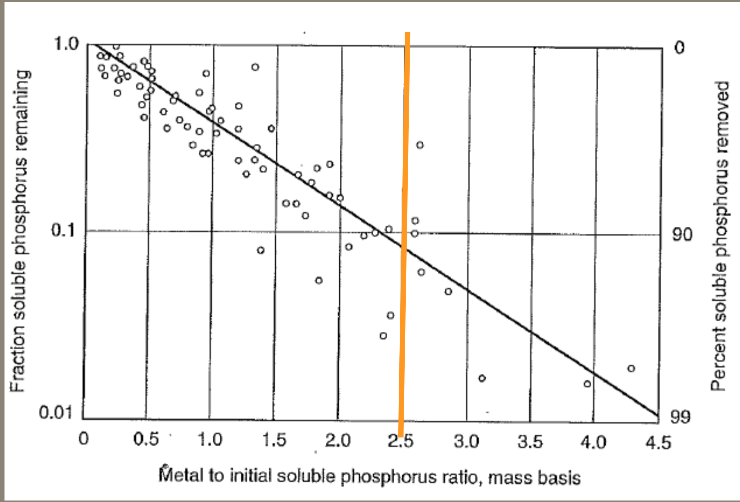


What about Chemical Consumption?

Ferric usage

- First dose (sewer main):
  - 3.1 mg-P/L removed @ 1.5 Fe : P molar ratio
  - Ferric also suppresses H_2S gas
- Second dose (bioreactor):
  - 6.6 mg-P/L removed
  - Fe : P molar ratio = 2.1 or 3.1 (allowing for effect of alum dose return)



Overall Fe+Al : P molar ratio = 2.5, with 99.4% removal

What about TDS?

TDS impacts ~ 106 mg/L SO_4 attributable to P precipitating chemicals

Process	Influent (mg/L)	Effluent (mg/L)	Difference (mg/L)
P removal	31 (PO4)	106 (SO4)	**+75**
N removal	64 (NH3)	4 (NO3)	**-60**
Disinfection & membrane cleaning		17 (Na) 12 (Cl)	**+29**
Bicarbonate	311 (alkalinity)	63 (alkalinity)	**-151**
Others (Mg, Ca)	26	28	**+2**
		Total:	**-105**

Summary & Lessons Learnt

Globally, phosphorous limit is trending down

Technology is now available to achieve near-zero P

Lessons learned from the Googong project:

- Multi-point dosing (with ferric & alum) is key to achieving chemical efficiency. It also increases process robustness,
  - Process / equipment breakdown
  - Supply of chemicals
- Managing shock loads well gives consistent performance
- Membrane removes fine or colloidal phosphorous, allowing very low limit to be achieved

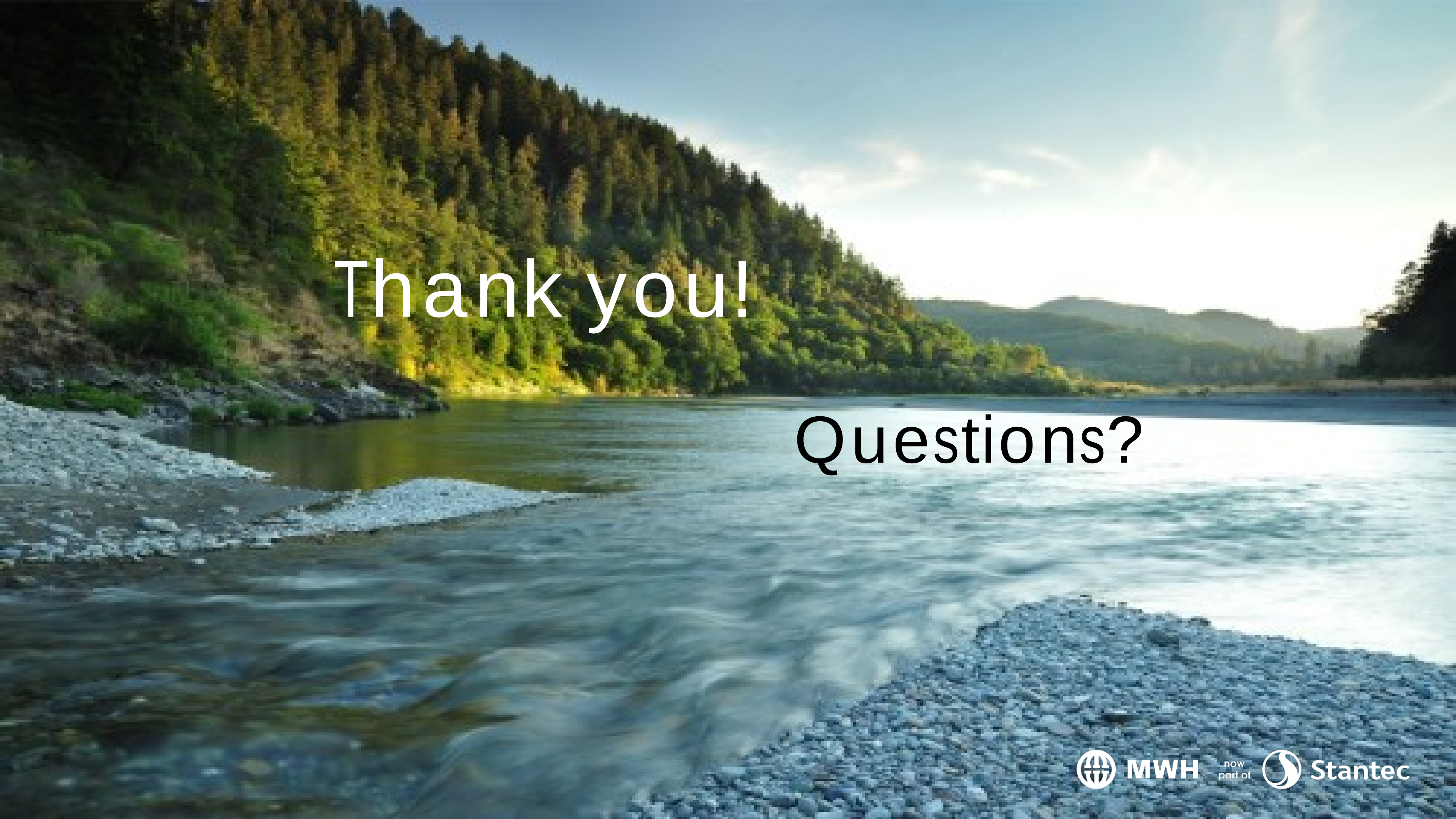
Ongoing & Future Works

Flow monitoring works

- Understand amount of water recycled in the loop to clarify TDS modelling works

Optimize chemical additions

- Further reduce ferric and alum doses
- Using citric acid (instead of sulphuric acid) for membrane cleaning


Thank you!
Questions?
MWH now part of Stantec