

# From East to West: Learning from experiences of MBRs from Texas to Singapore.

Andrew Shaw, Joshua Berryhill,  
Jordan Hibbs, Ignacio Cadena,  
Laura Stratton, Nash Reddy,  
Dylan Christenson

Black & Veatch and Enprotec/Hibbs & Todd



Texas Water™ 2021 - Virtual  
March 29 - April 1, 2021



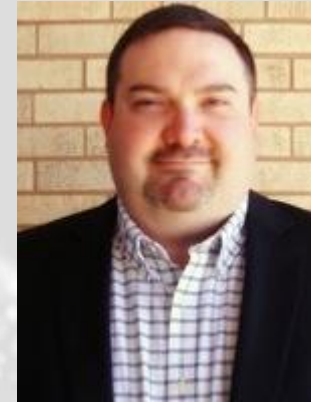
# Outline

- Introductions
- A Tale from **West Texas**
- A Singapore Story
- Common Themes

# Today's Presenters



**ANDY SHAW**  
Global Practice & Technology  
Leader,  
Black & Veatch



**JOSH BERRYHILL**  
Technical Director,  
Enprotec / Hibbs &  
Todd

# A Tale From West Texas

- ▶ Hamby Water Reclamation Facility
- ▶ Abilene, TX



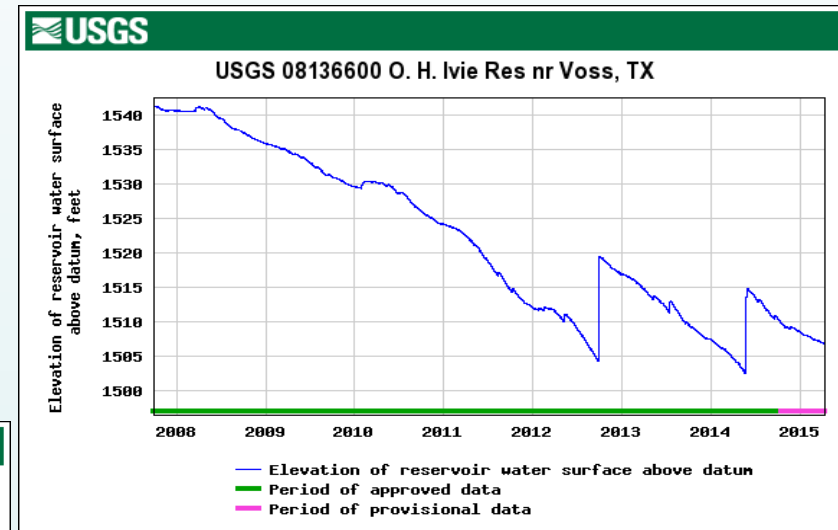
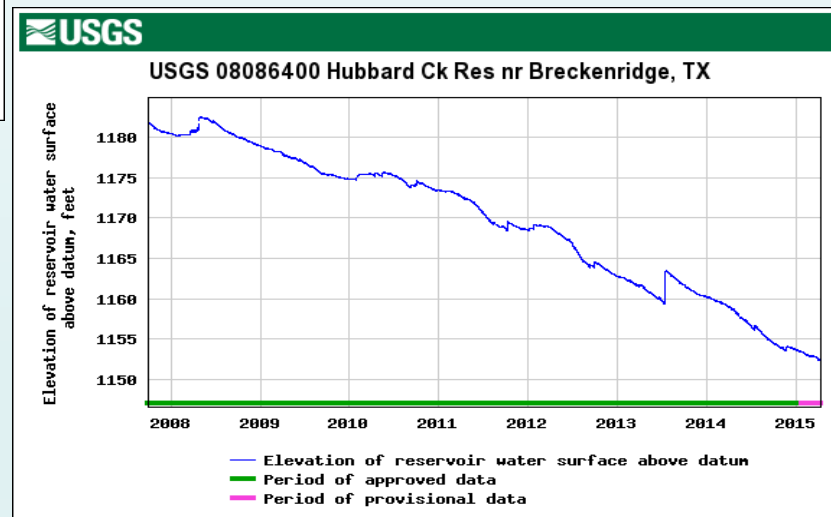
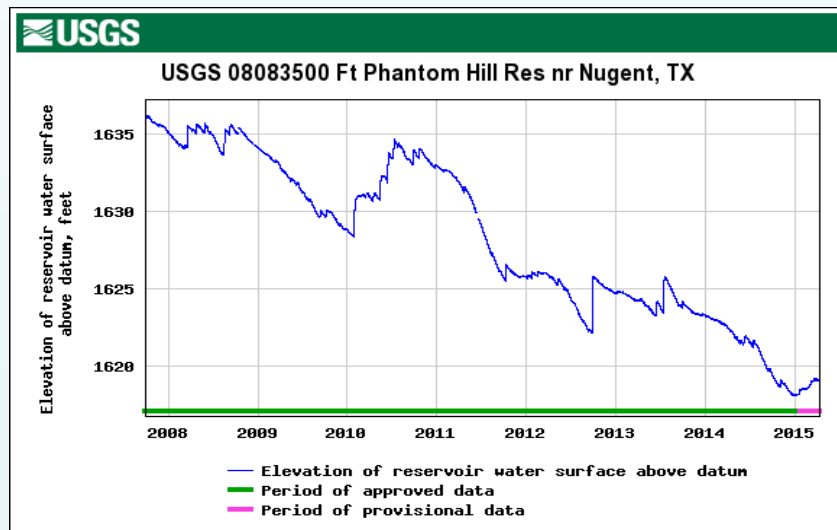


# Abilene's Water Sources

**Hubbard Creek Lake**  
Full pool: 1,183.0 ft msl  
2015: - 30.73 ft

**Lake Fort Phantom Hill**  
Full pool: 1,635.9 ft msl  
2015: - 16.85 ft

**Lake O.H. Ivie**  
Full pool: 1,1551.5 ft msl  
2015: - 44.81 ft



# Abilene's Water Sources in 2013

- The recent historic drought severely affected Abilene's raw water sources.



# City of Abilene

## Water Production and Wastewater Reuse Schematic (**Before/After Upgrades**)

Hubbard Creek Reservoir



Northeast WTP



Grimes WTP

Hargesheimer WTP



Hamby WRF



Outfall 003  
Lake Fort  
Phantom Hill



Outfall 001  
Freewater  
Creek



Outfall 002  
Kirby Lake



Reuse  
Customers

Lake O.H.  
Ivie



# Indirect Potable Reuse **Quality Drivers**

- Constituents of concern in the Hamby WRF effluent, were it to be used for indirect potable reuse included:
  - **CBOD<sub>5</sub>, TSS, ammonia, pH, DO, phosphorus**
  - Nitrogen/Phosphorus-algae growth leads to taste and odor
  - Salinity levels and other secondary parameters
  - DBPs - TTHMs, HAA5, Bromate, others?
  - Contaminants of Emerging Concern (CECs)



# Anticipated TPDES Permit Limits and Reuse Quality Standards

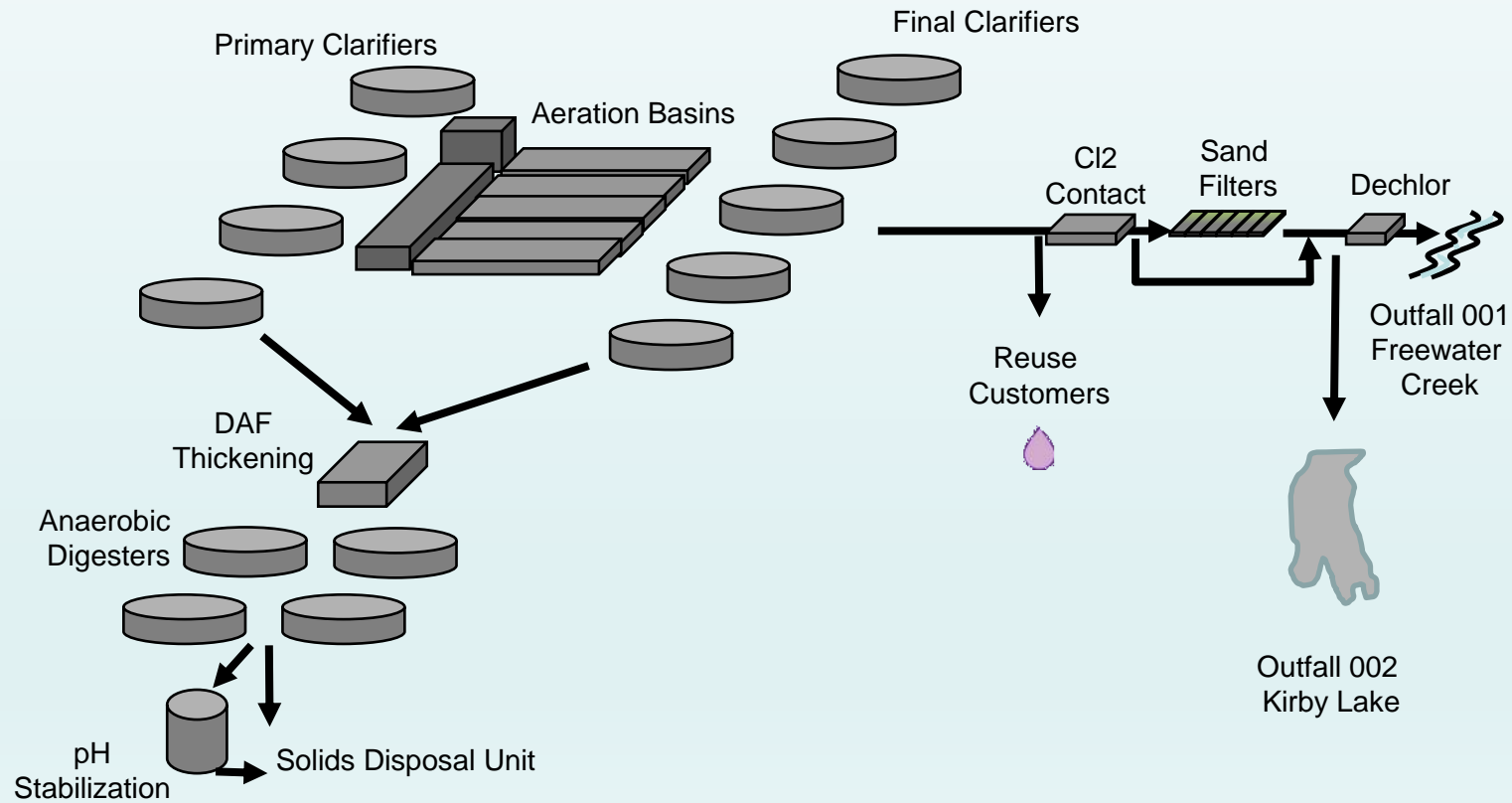
Parameter	Anticipated Outfall No. 001/002 TPDES Permit Limits	Anticipated Outfall 003 TPDES Permit Limits	Current Type I Reuse Quality Standards per Reclaimed Water Rules
5-day Carbonaceous Biochemical Oxygen Demand (CBOD <sub>5</sub> ), milligrams per liter (mg/L)	April-Sept.: 7 Oct.-March: 10	5	5
Total Suspended Solids (TSS), mg/L	15	15	None
Ammonia-Nitrogen, (NH <sub>3</sub> -N), mg/L	April-Sept.: 2 Oct.-March: 3	2	None
Total Phosphorus (TP), mg/L	0.5	0.5	None
<i>Escherichia coli</i> ( <i>E. coli</i> ) or Fecal Coliform (Fecal) Colony Forming Units per 100 milliliters (CFU/100 mL)	<i>E. coli</i> : 126	<i>E. coli</i> : 126	Fecal: 20 (30-day geometric mean) 75 (single grab max)
Turbidity, Nephelometric Turbidity Units (NTU)	None	None	3

# Hamby Water Reclamation Facility (Prior to Upgrades)



# Hamby WRF

## Plant Process Schematic (Prior to Upgrades)





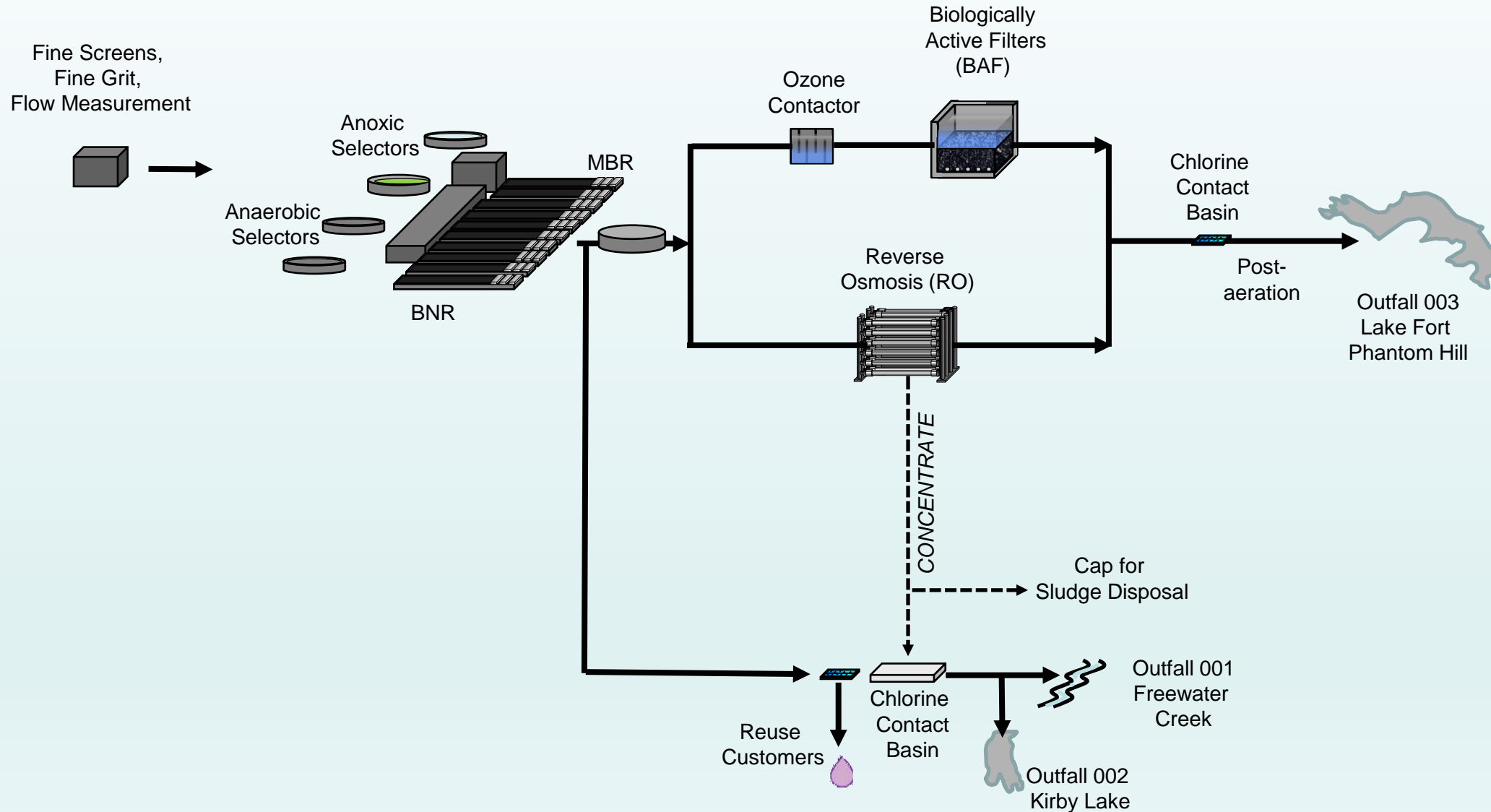
# Hamby Water Reclamation Facility (During Construction)



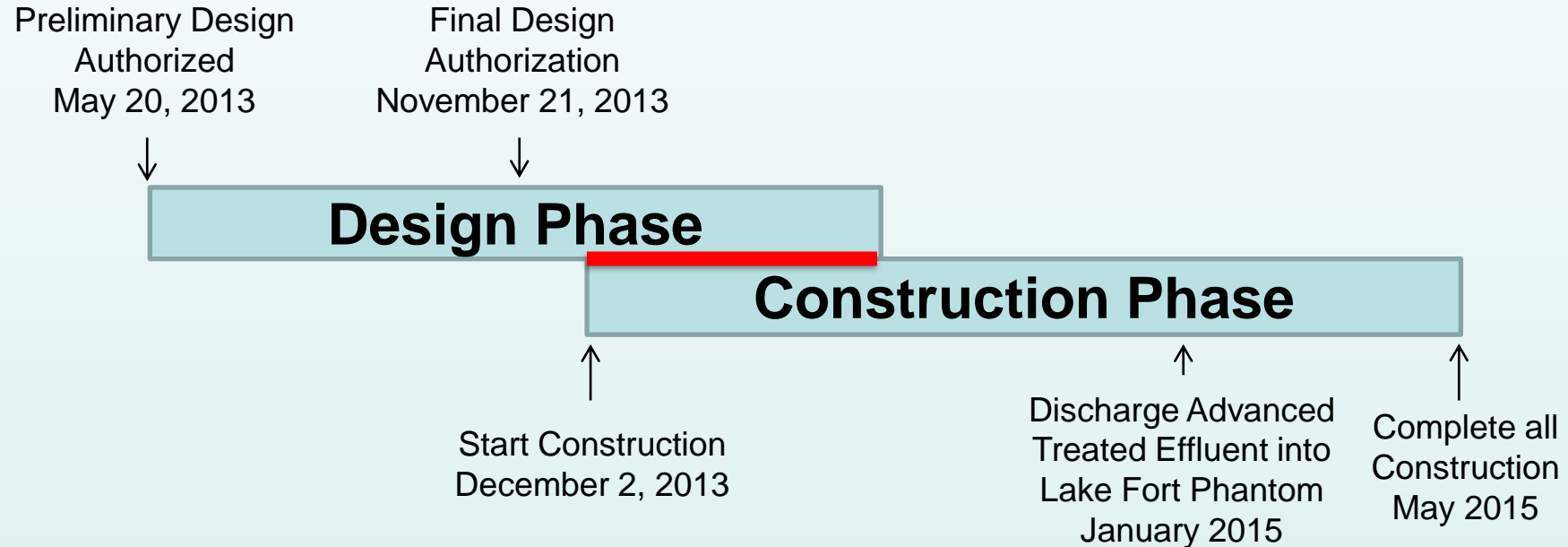


# Hamby WRF Improvements

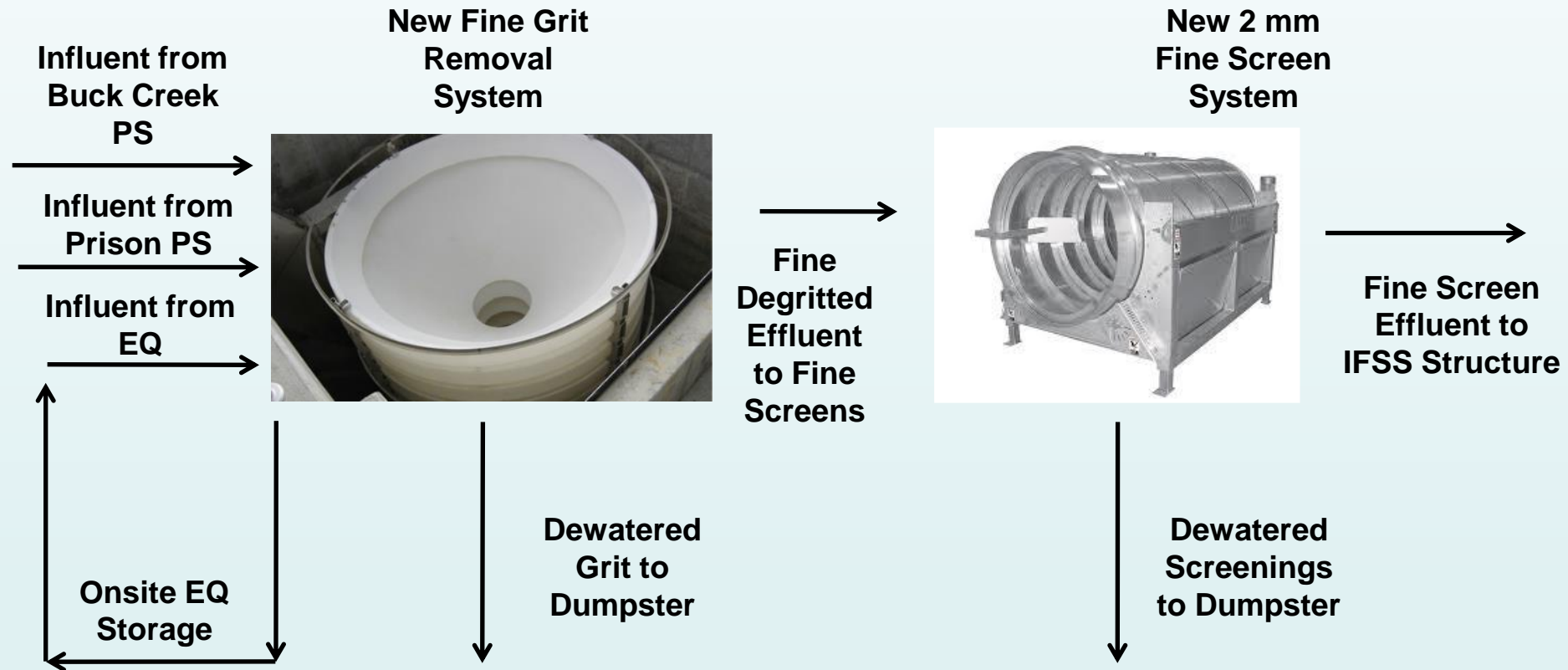
## Process Schematic (After Upgrades)



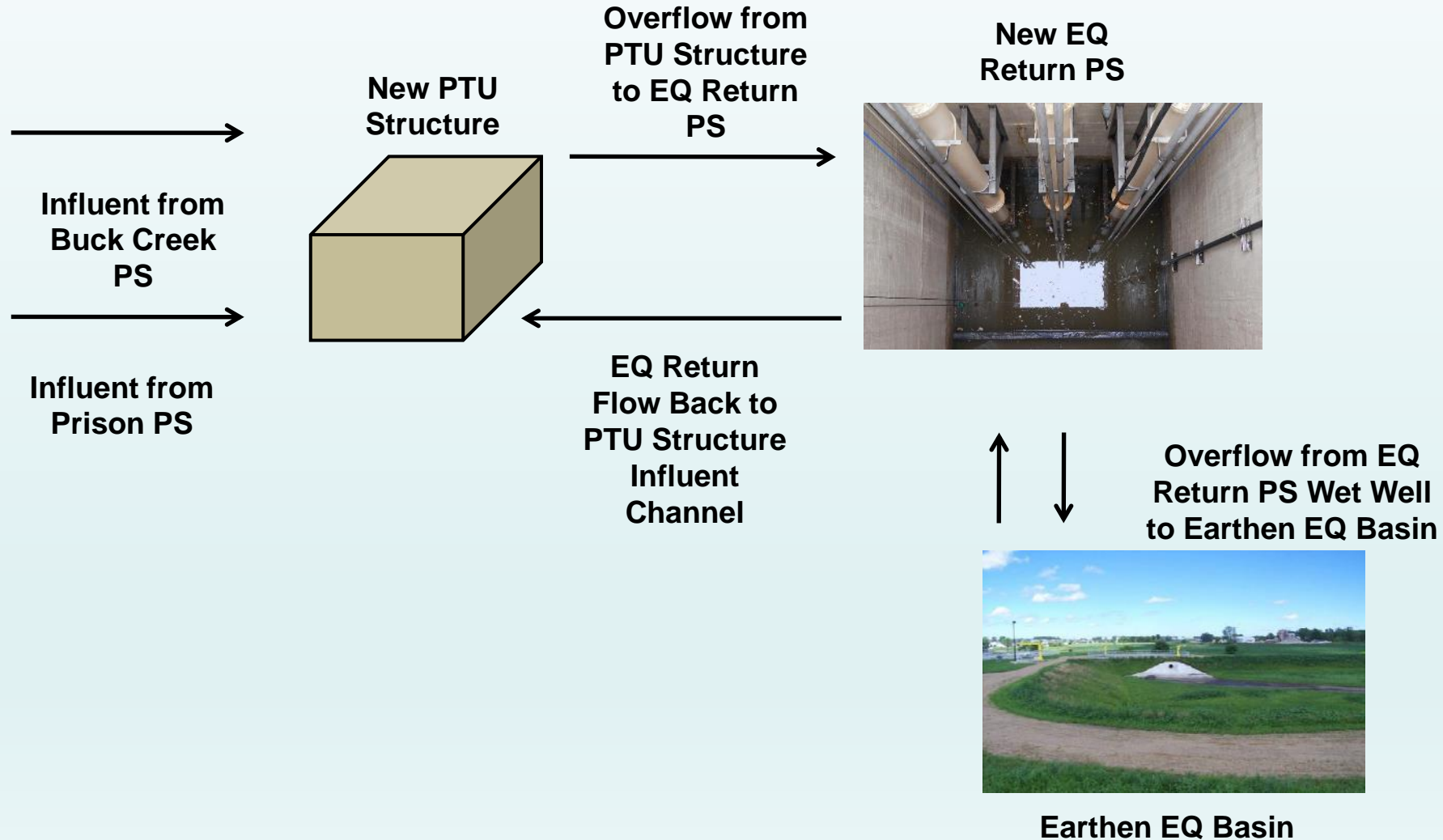
# Hamby WRF Project Timeline



# Pretreatment System

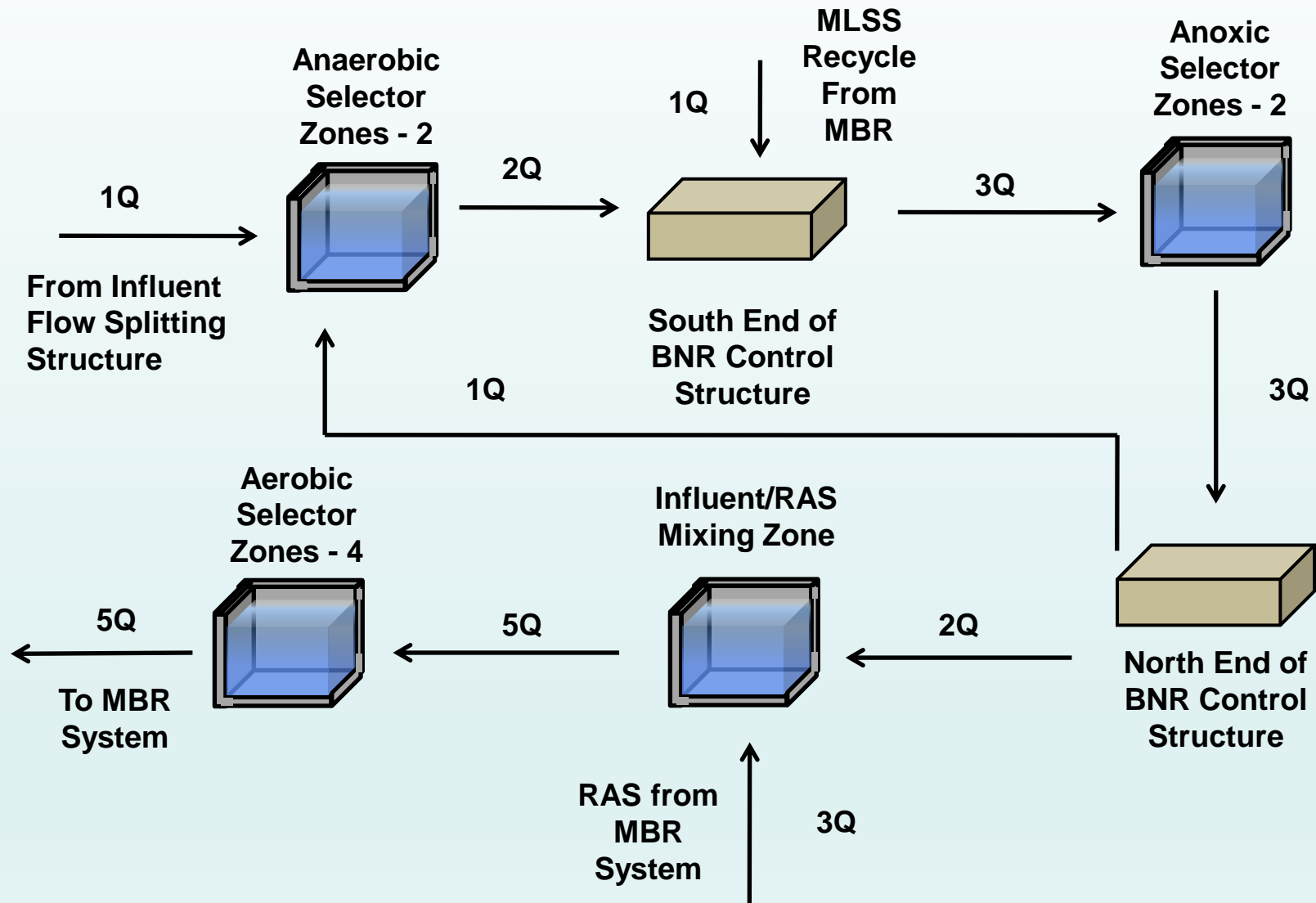


# Flow Equalization System

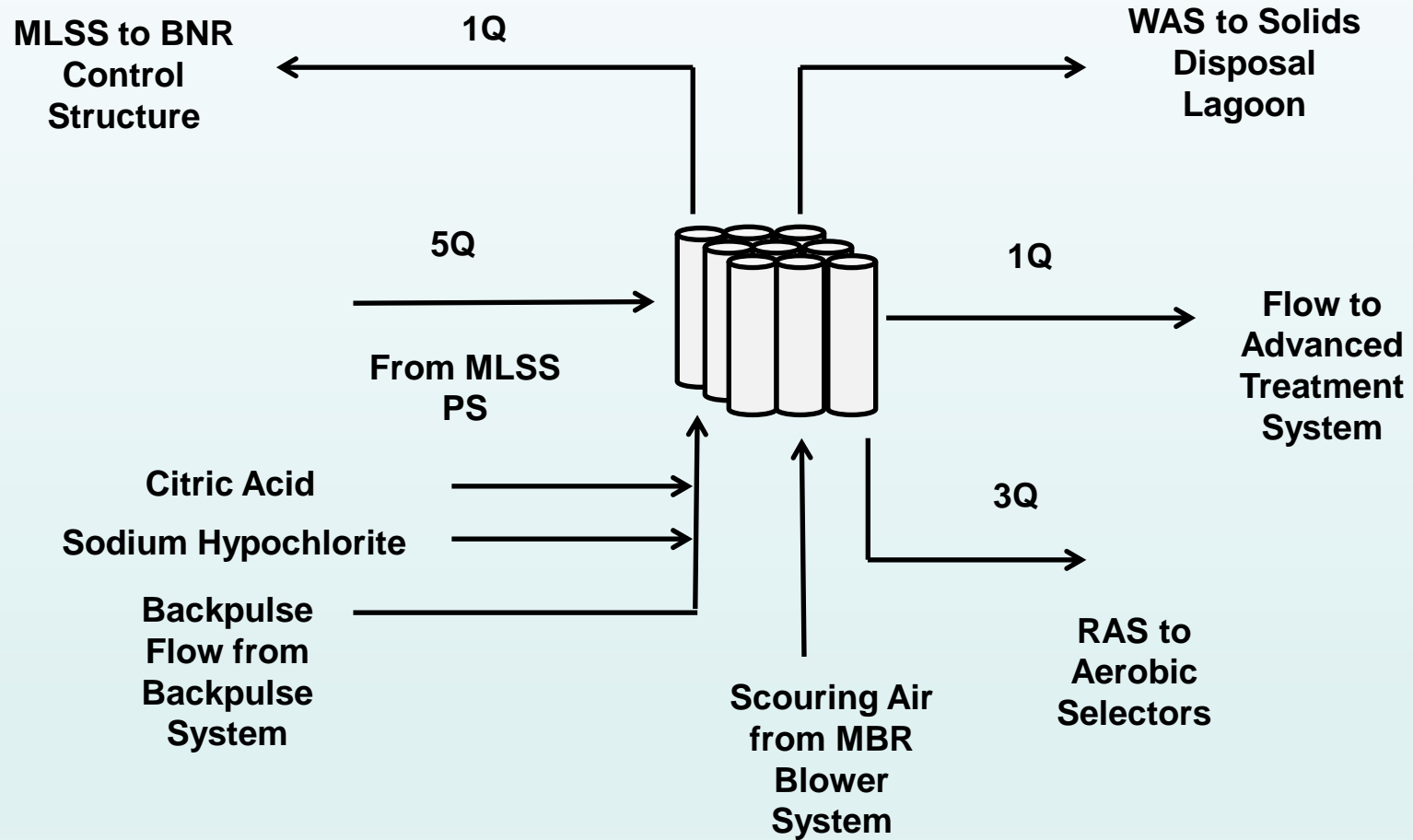




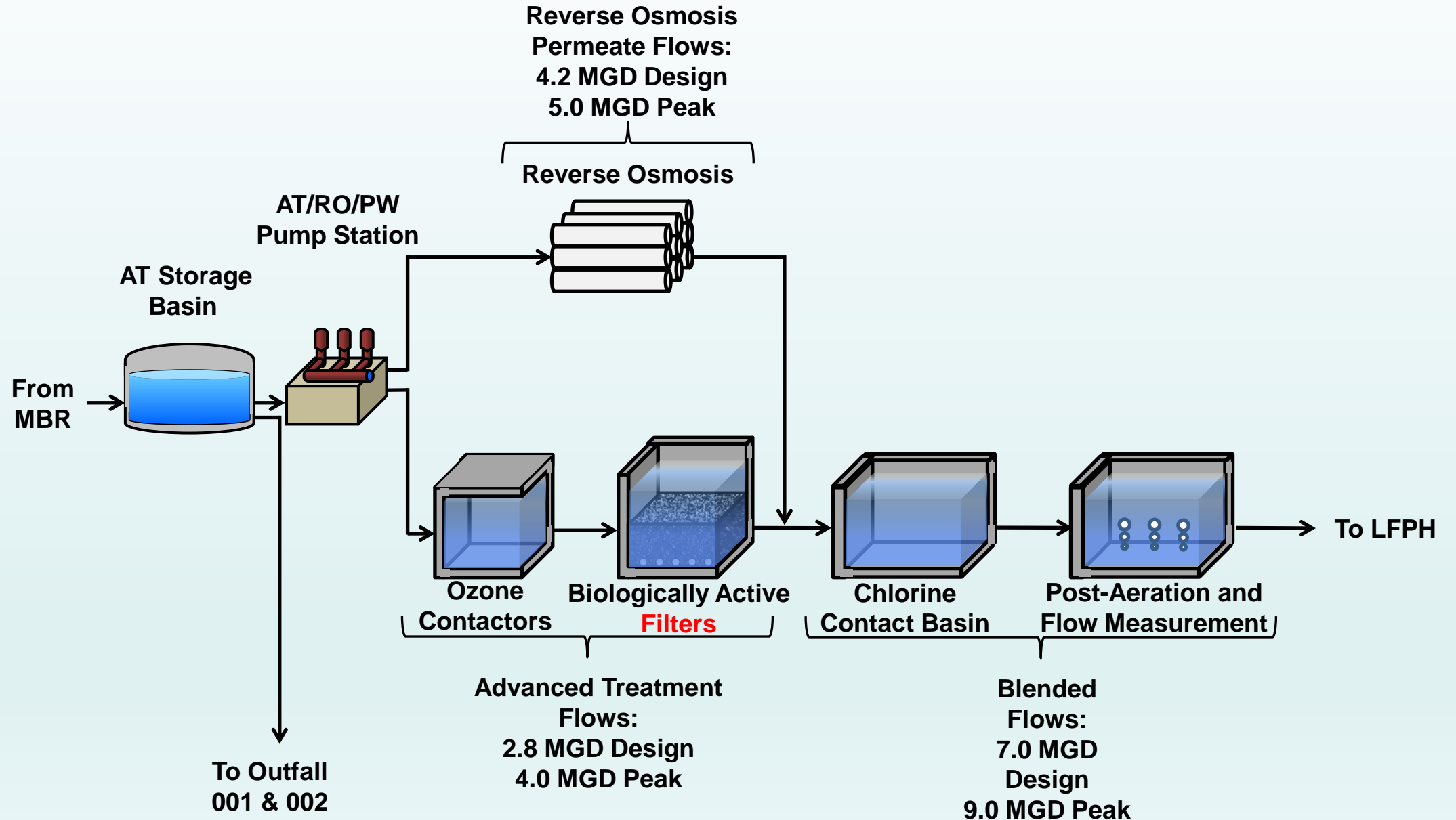
# Biological Nutrient Removal System



# Membrane Bioreactor System



# Advanced Treatment System



# Comparison of Advanced Treated Effluent Treatment Goals and Actual Performance

Parameter	Goal	Actual Performance
Annual Average Flow Rate to Lake Fort Phantom Hill	7 MGD	6-7 MGD
Total Phosphorus	0.5 mg/L	0.03 mg/L
TDS	375 mg/L	325 mg/L
Chloride (as Cl <sup>-</sup> )	100 mg/L	80 mg/L
Sulfate (as SO <sub>4</sub> <sup>2-</sup> )	95 mg/L	70 mg/L
Pathogen Removal/Inactivation <sup>b</sup>		
<i>Cryptosporidium parvum</i>	4-log	4-log+
<i>Giardia lamblia</i>	4-log	4-log+
Viruses	0.5-log	0.5-log+
Contaminants of Emerging Concern (CECs)	50 - 90% Reduction	80% Reduction



The Tuas Water  
Reclamation Plant

# A Singapore Story



# SINGAPORE AND NEIGHBORS



# SINGAPORE's 4 National Taps

**Local Catchment Water**  
2/3 S'pore's land area as  
catchments

**Water from  
Johor**

**NEWater**

30% of current water needs  
(55% by 2060)

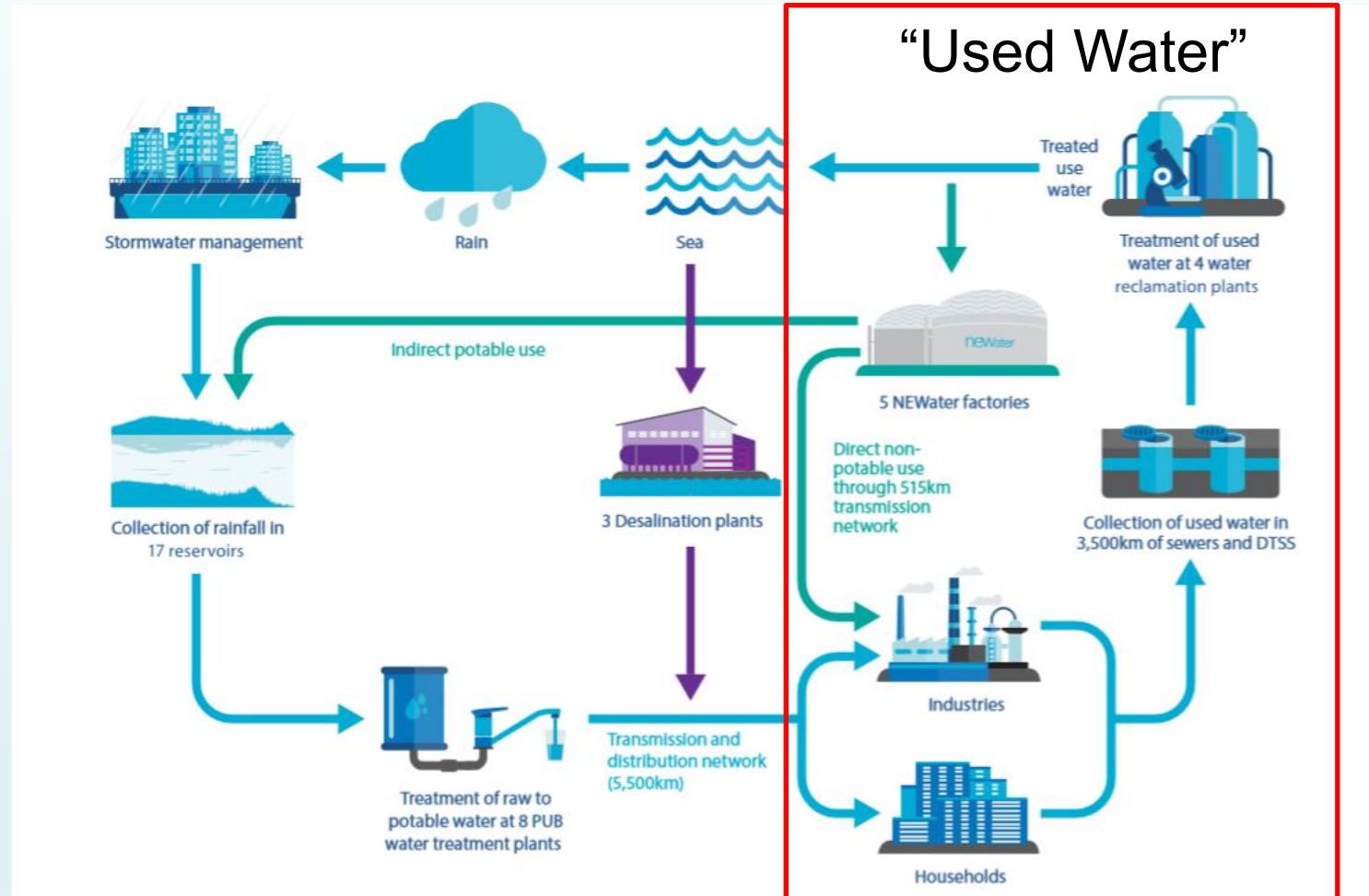
**Desalinated Water**

100 mgd or 120 mgd (US gal),  
25% of demand





# Singapore Water Loop

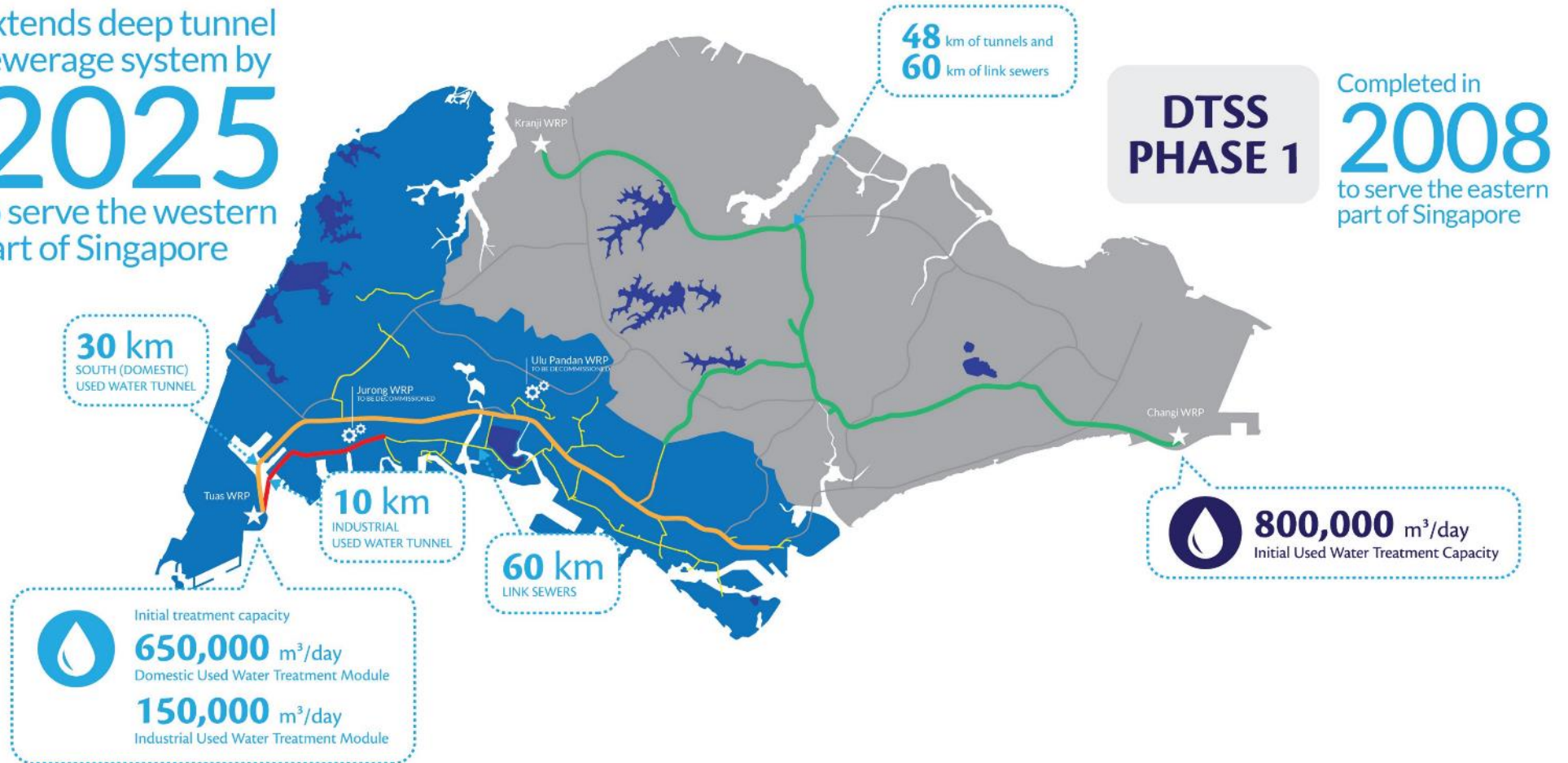




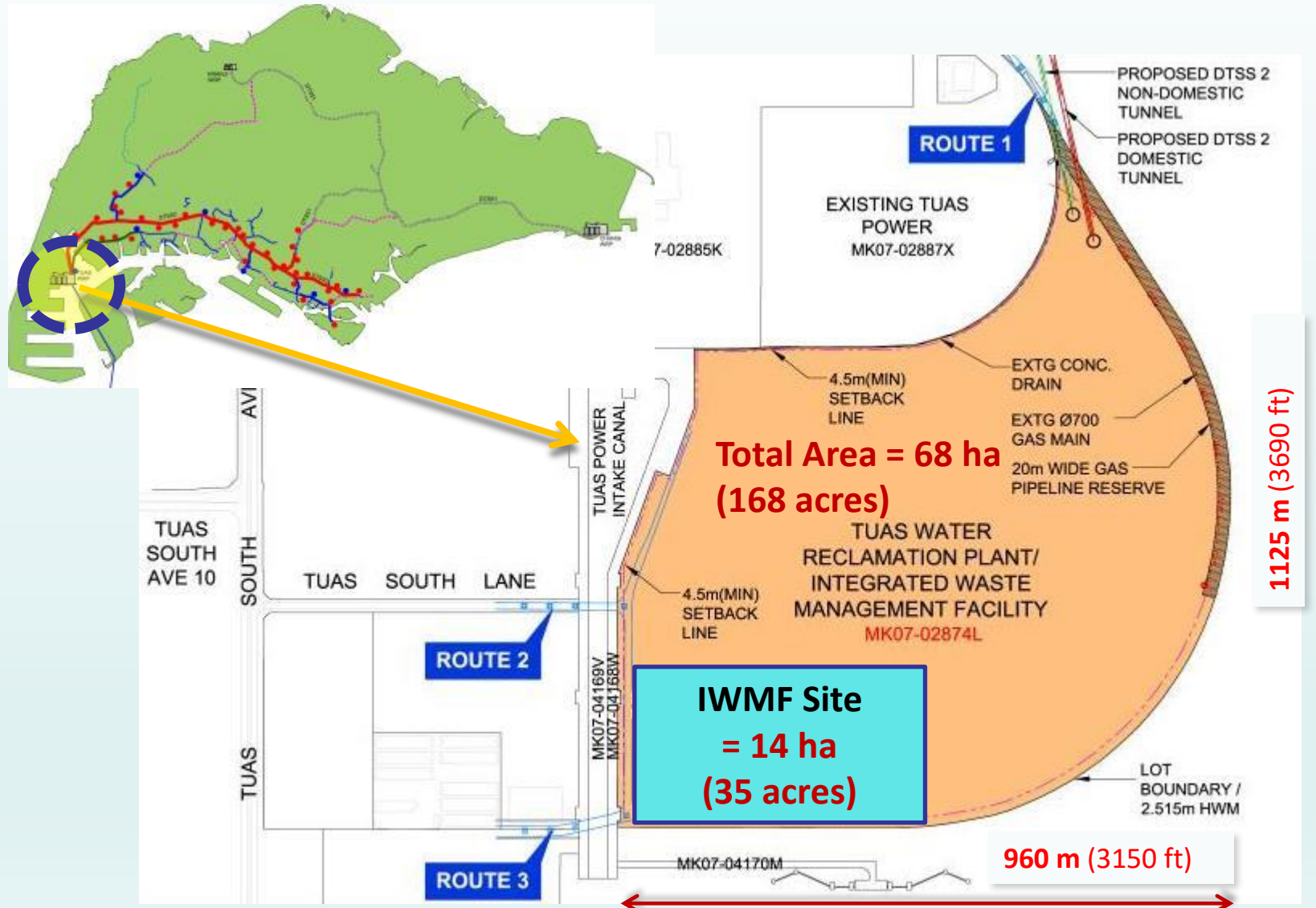
# Deep Tunnel Sewerage System (DTSS)

## DTSS PHASE 2

Extends deep tunnel  
sewerage system by  
**2025**  
to serve the western  
part of Singapore



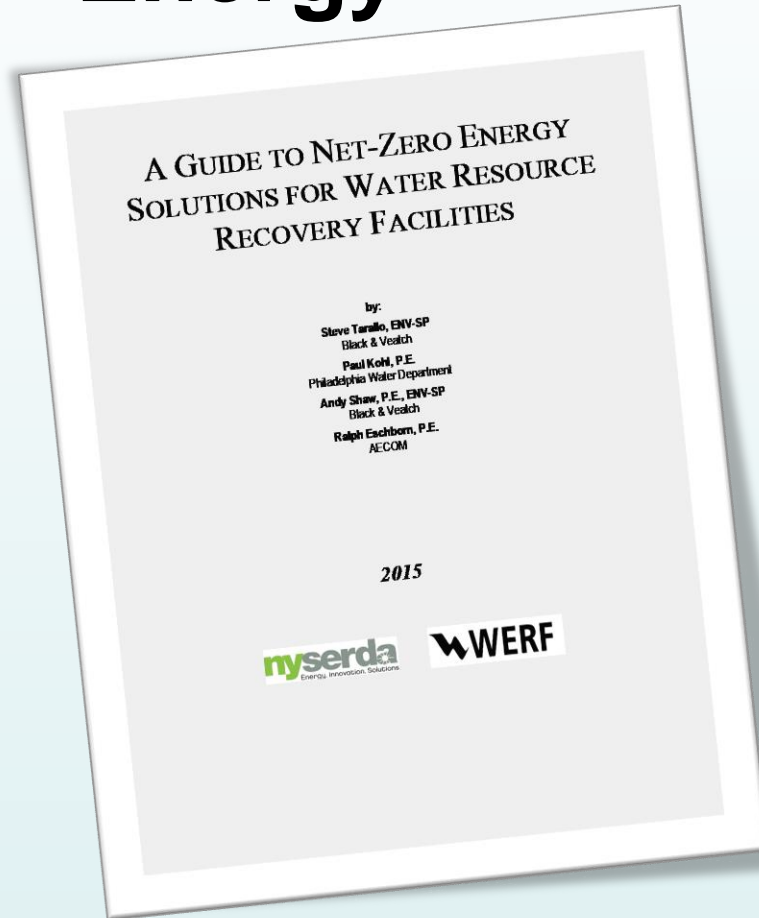
# Tuas Water Reclamation Plant Site Layout





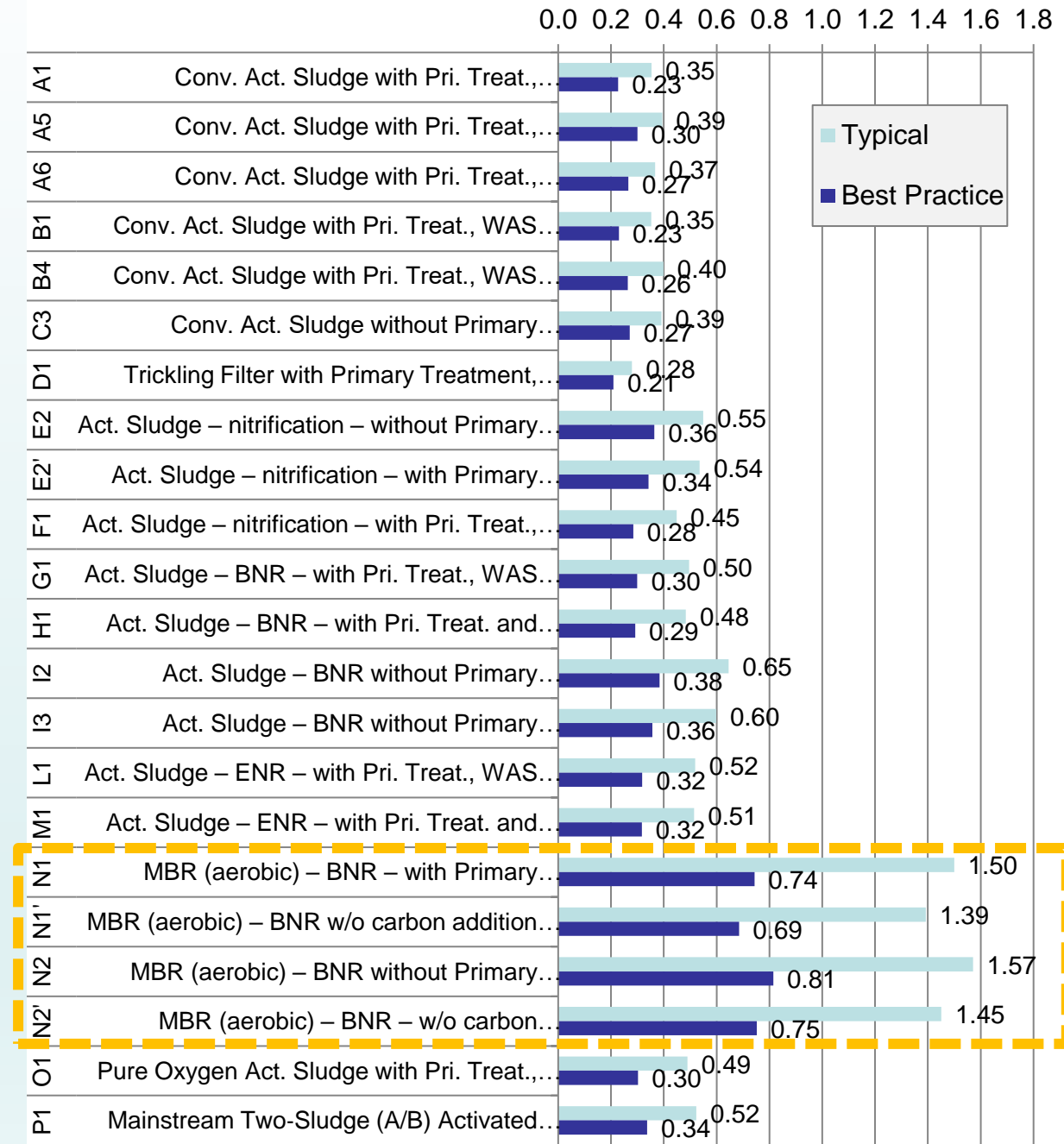


# Energy



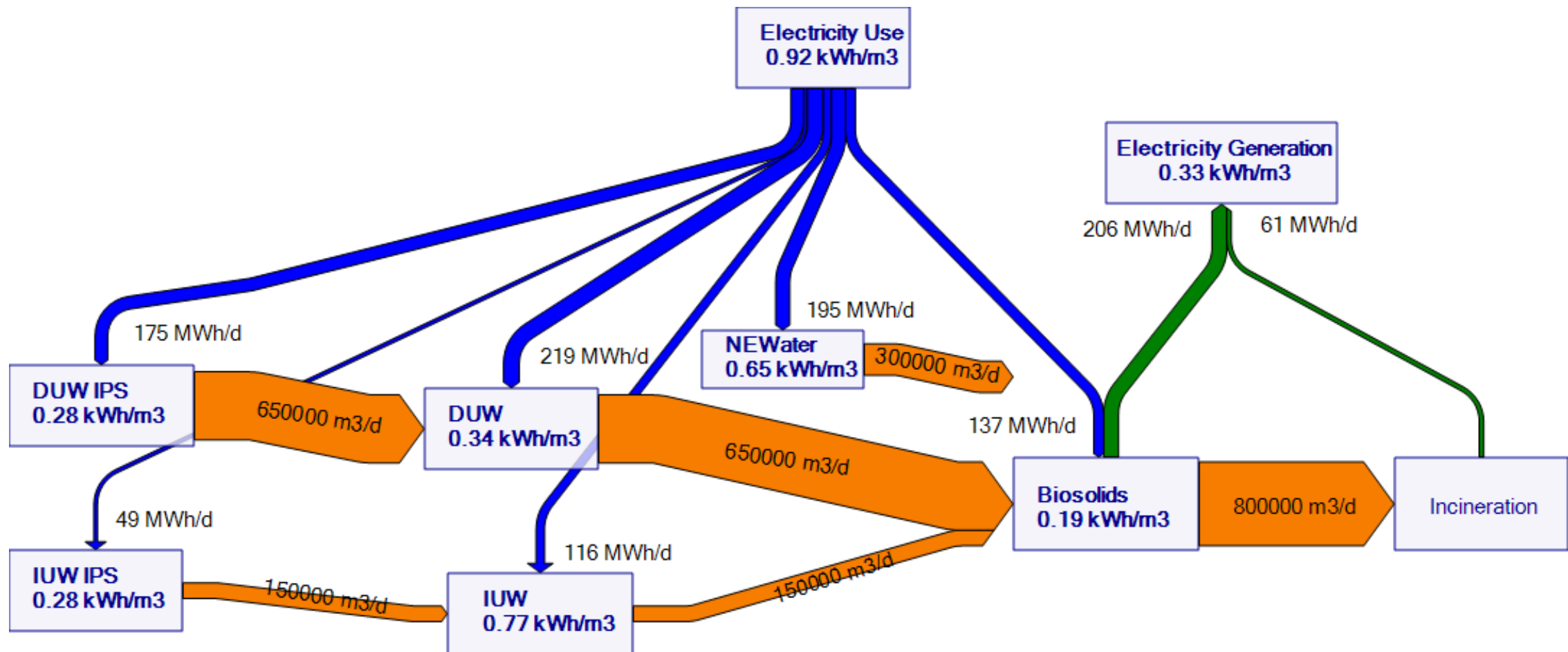
**Expect MBR in  
0.7 – 1.6 kWh/m<sup>3</sup>**

**Total Plant Electricity Usage (kWh/m<sup>3</sup>)**





# Treatment Energy Intensity

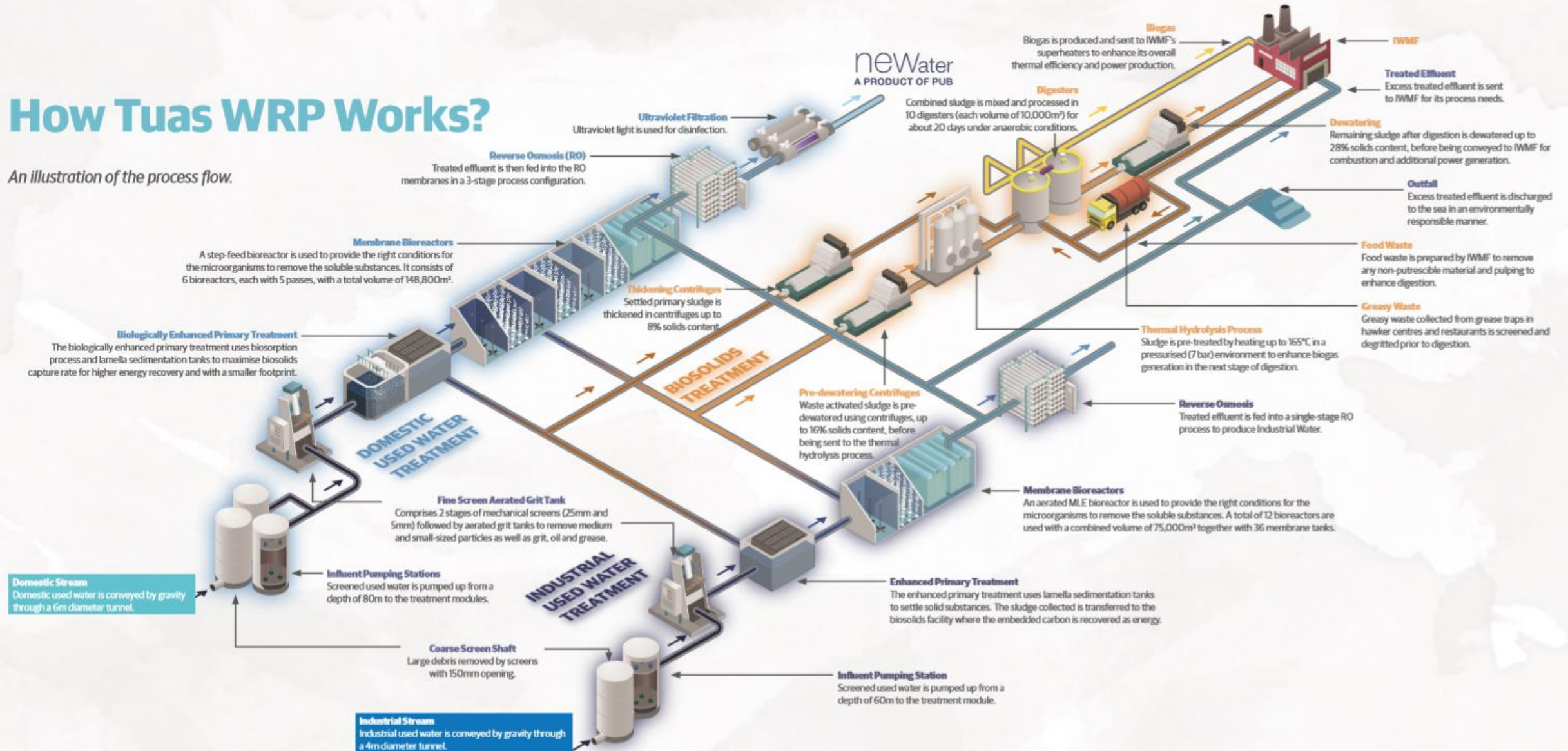




# TWRP Process Trains

## How Tuas WRP Works?

An illustration of the process flow.



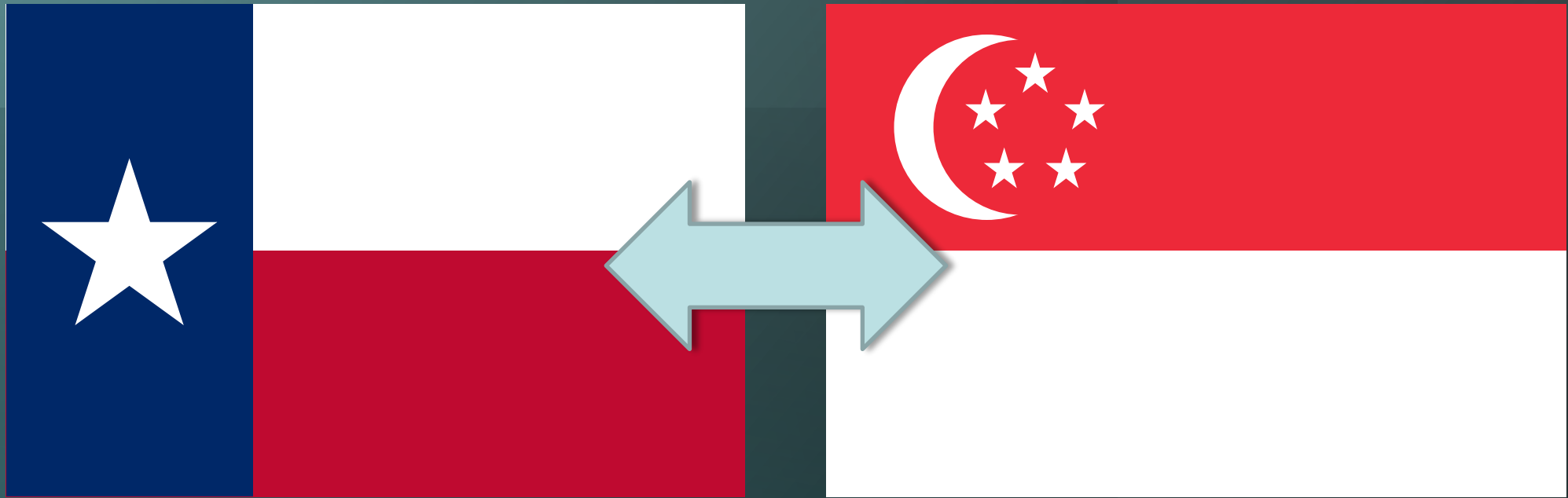
# DTSS Timeline



Image © 2021 Maxar Technologies  
© 2021 Google

Google Earth

# Common Themes



# Common Themes from East to West...



- Water Stress Driving More Reuse
  - Non-potable
  - Potable
- MBR Becoming the “Workhorse” for Reuse
- Energy/Operating Costs Coming Down
- MBR + RO for IPR






## Dr. Andrew Shaw

+1 913-980-6318  
ShawAR@bv.com

 @AndyRShaw2000  
 AndyRShaw

## Joshua Berryhill

+1 325-698-5560  
joshua.berryhill@e-ht.com

 JoshuaLBerryhill