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WATER TECHNOLOGIES

High Efficiency Cross-Flow Microsand Filtration as Pretreatment in Desalination Applications

Apr 2022

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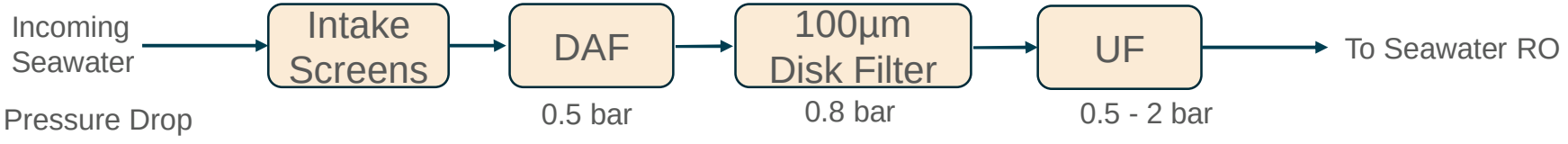
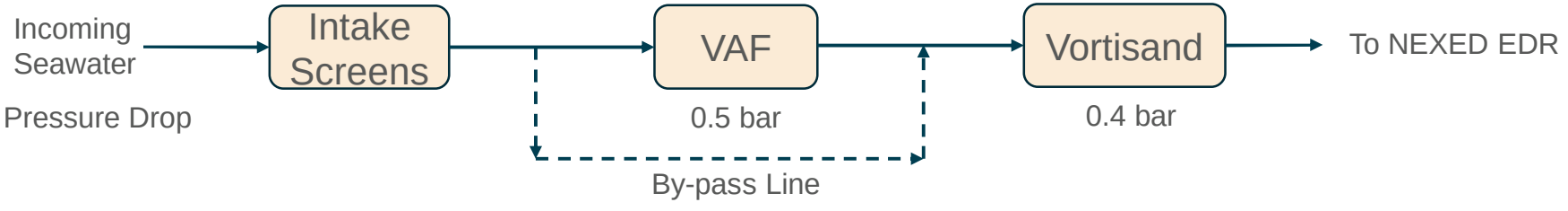
Background

- There has been much effort in energy reduction of main desalting step in seawater desalination.
- This study proposes to use a high efficiency cross-flow microsand filtration in the pre-treatment step.
- Current Seawater Desalination Pretreatment Process:



- Seawater Pretreatment with VAF and Vortisand:



- A typical traditional pre-treatment system would require 0.3-0.4kwh/m3, while a fine filtration system only requires about 1-2 bar pressure drop, which is equivalent to around 0.1-0.2kwh/m3

Process design: Feed water key characteristics

- Feed water:
  - Coarse screen filtered seawater from Tuas South Desalination Plant
  - TDS - 31 – 34,000 ppm
  - Temperature - 30 – 33’C,
  - pH - 7.8 – 8.4
  - TSS - 5 – 20mg/L
  - Turbidity - 3 – 15 NTU

Process design: Feed water key characteristics

- Laser particle size distribution results show that the majority of the particles are submicron in size.
- High efficiency sand filters are able to filter up to sub-micron level, simple to operate and require simple cleaning steps, thus is the technology chosen to be tested for seawater pre-treatment.

7th Apr 2021

Seawater sample

Particle Size (μm)	Differential Result							
	Unit : counts/mL				Unit : % counts			
	Data 1	Data 2	Data 3	Average	Data 1	Data 2	Data 3	Average
0.5	504060	503310	505040	504137	92	92	92	92
1	43810	44030	43950	43930	8	8	8	8
10	690	680	780	717	<1	<1	<1	<1
20	70	20	10	33	<1	<1	<1	<1
25	10	10	10	10	<1	<1	<1	<1
30	10	30	10	17	<1	<1	<1	<1
50	<1	<1	<1	<1	<1	<1	<1	<1
80	<1	<1	<1	<1	<1	<1	<1	<1

Vortisand® High Efficiency Cross-Flow Microsand Filtration

- Cross-flow microsand filtration enables much higher performance than traditional multimedia filters.
- MMF uses different layers of media for filtration.
  - Utilises depth filtration (300-700µm), 5-10 gpm/ft².
  - Requires higher backwash flowrate to achieve fluidisation of sand & anthracite. Roughly **twice the filtration flowrate**.
  - Only able to achieve **10 to 25-micron filtration**.

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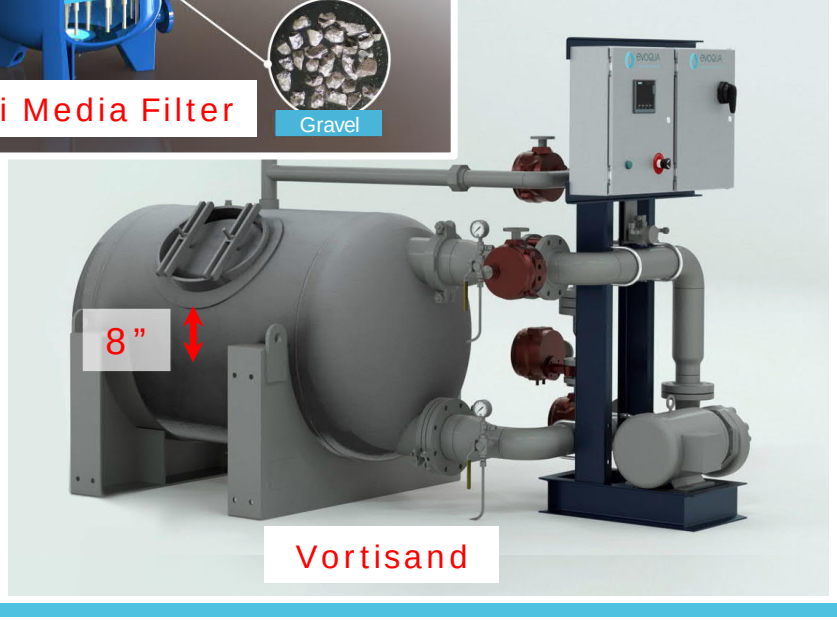
  - Only able to achieve **10 to 25-micron filtration**.
- Vortisand® HE cross-flow microsand(150µm) filtration.
  - Combines suspension & depth filtration, **20 gpm/ft² (4X)**
  - Requires much lower backwash flowrate **40% of filtration flowrate**.
  - Able to achieve **submicron filtration, SDI <5**.



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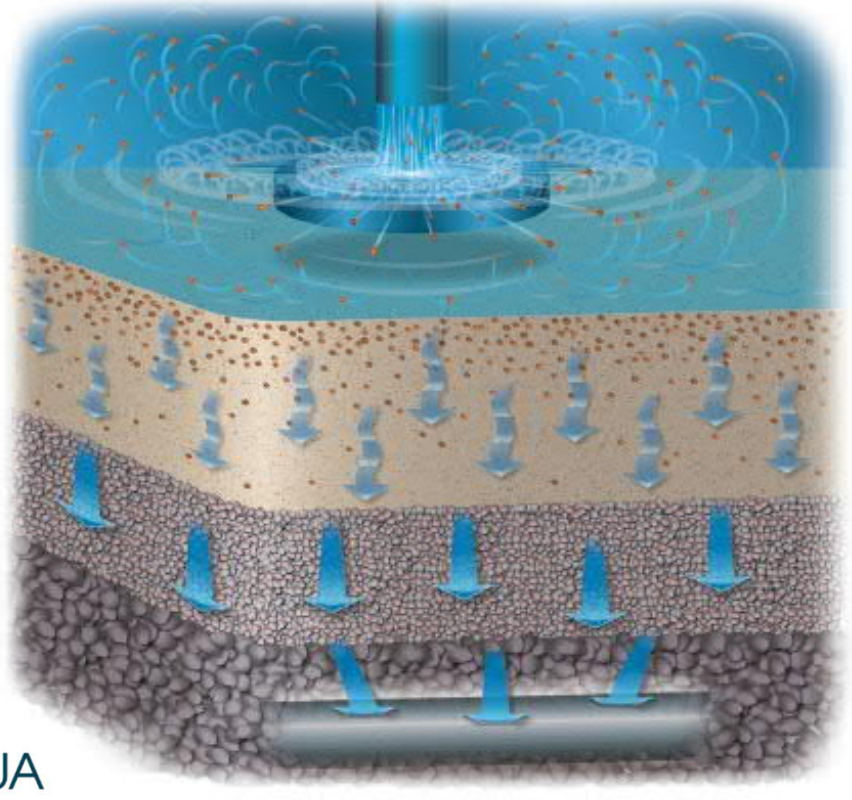
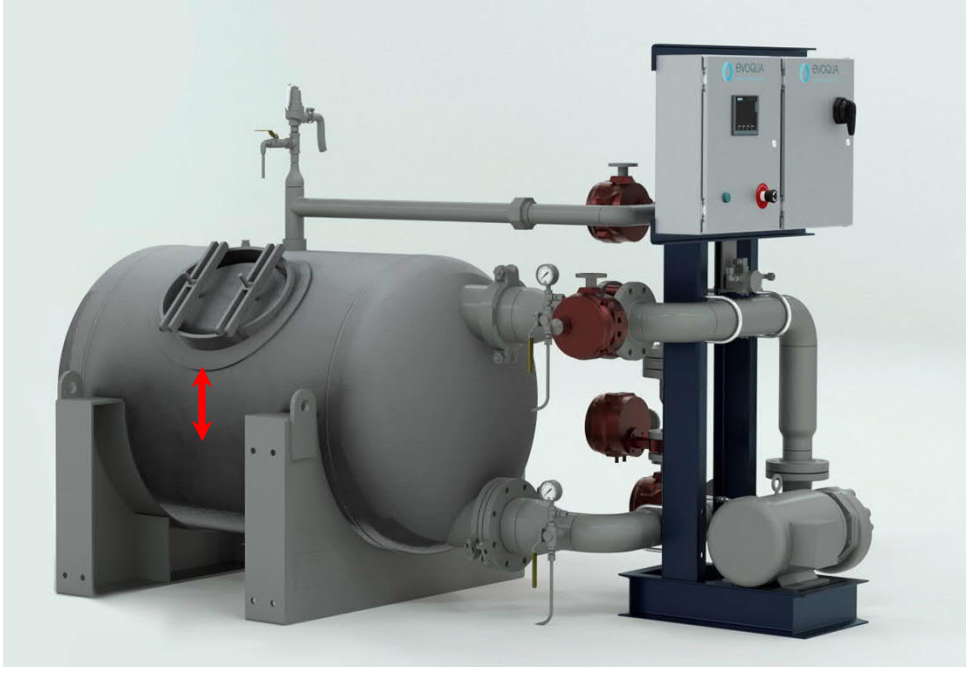
Vortisand® High Efficiency Cross-Flow Microsand Filtration

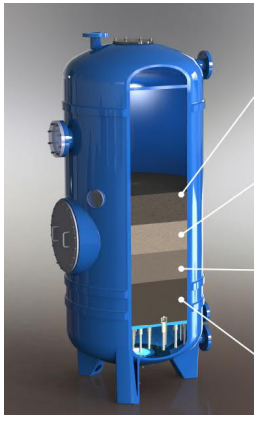
- Cross-flow device keeps solids continuously in suspension instead of pushing it into the sand and quickly plugging the media.





Vortisand® High Efficiency Cross-Flow Microsand Filtration

- Possibility to stack vessels for halving already compact footprint.



Particle count results, selection of guard-filter

- Raw seawater feed is from 2mm travelling screen filter, so a prefilter for the Vortisand® is needed.
- Two stages of V-series™ self-cleaning screen filters with 25 and 10-micron screen sizes were installed for flexibility in testing different running options.

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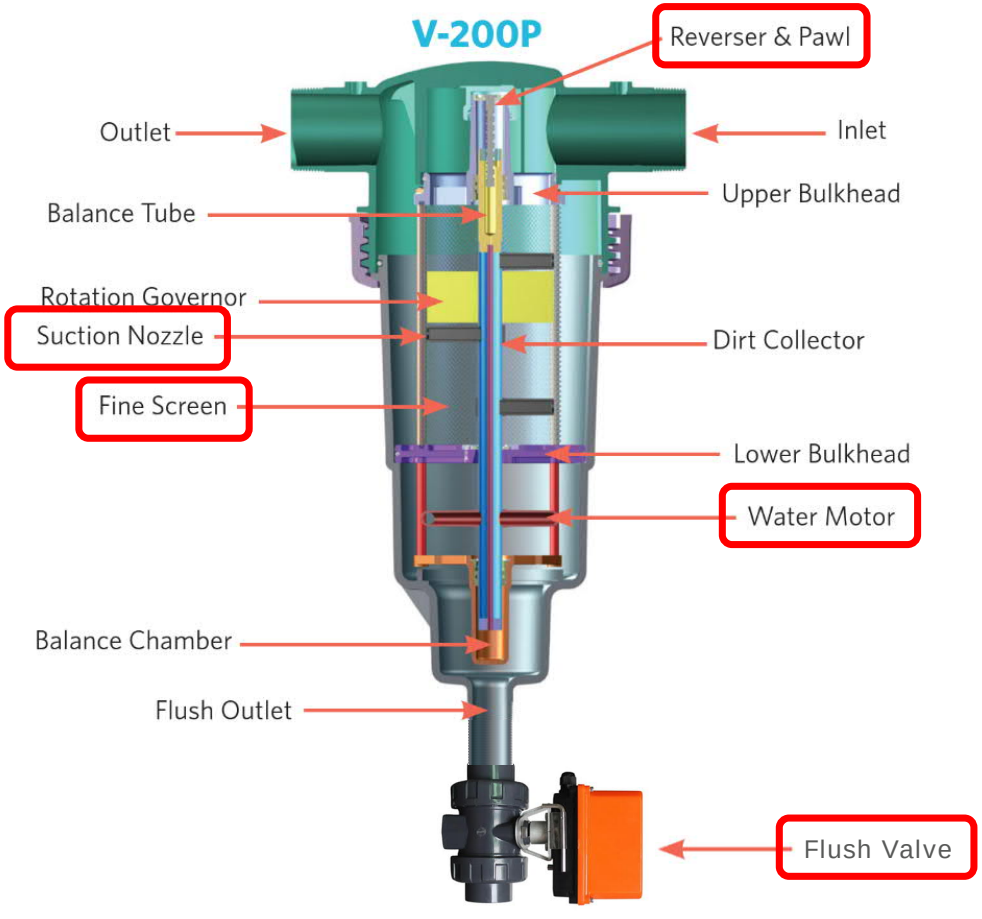
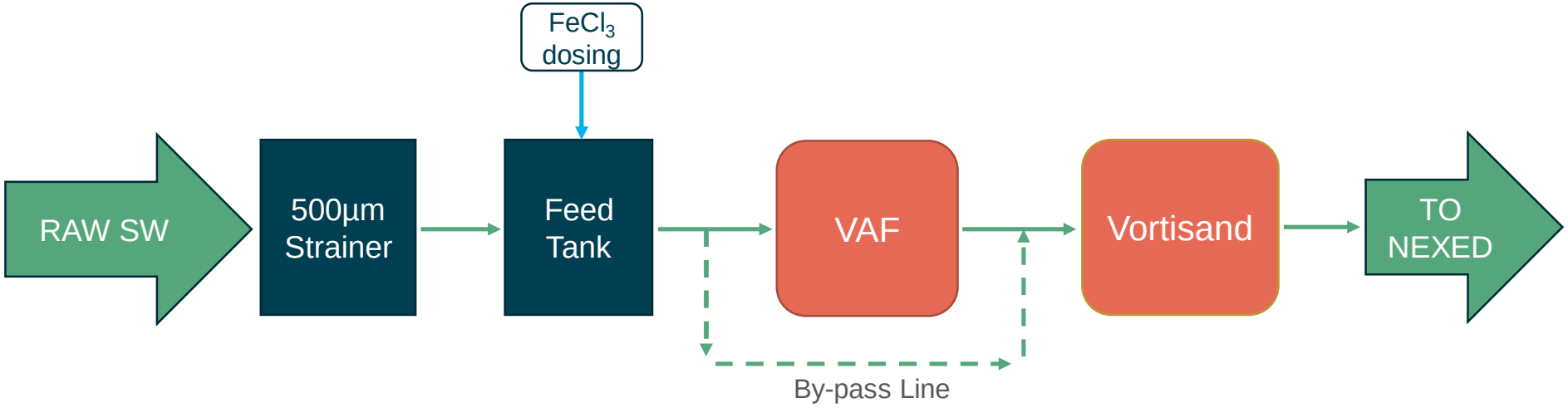
Evoqua’s V-series™ self-cleaning screen filter

- Most self-cleaning filters on the market uses piston or motor type mechanism.
- V-series™ filters utilises a reverser & pawl design to generate an efficient cleaning path of the suction nozzles.
- The self-cleaning function is activated by just opening a flush valve and the system pressure provides the motive force for the whole mechanism.
- Only instrumentation is a flush valve & DP switch.

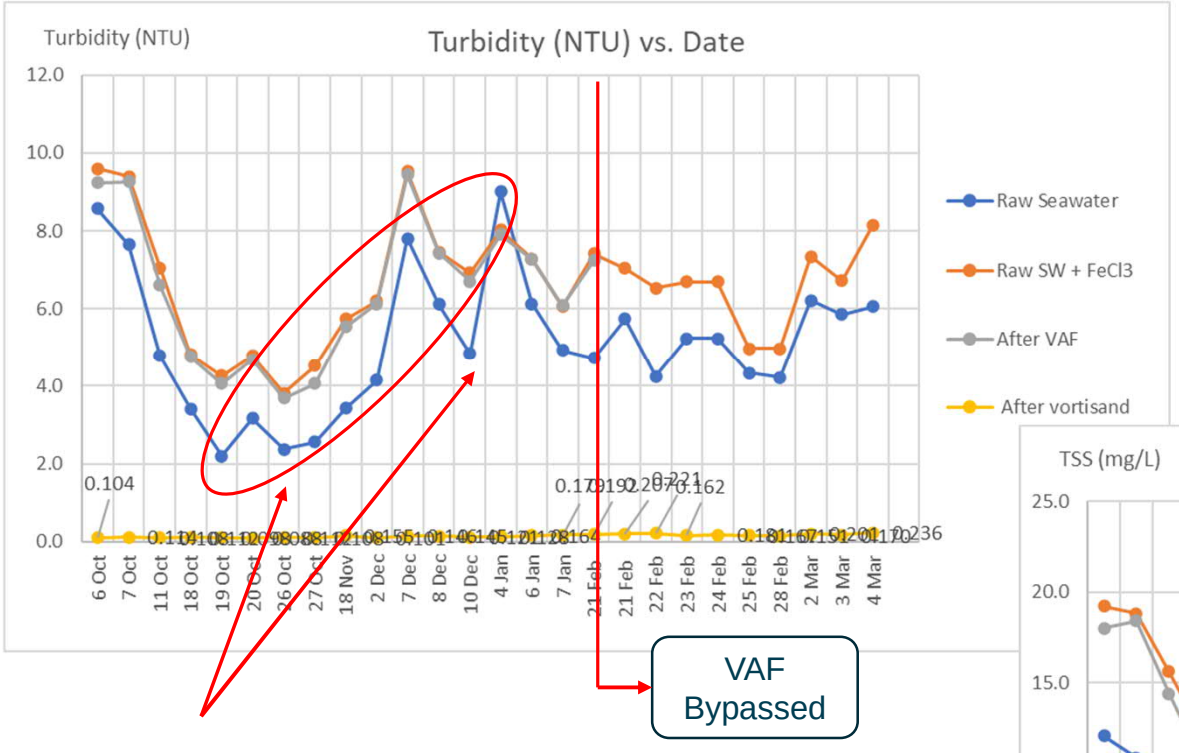


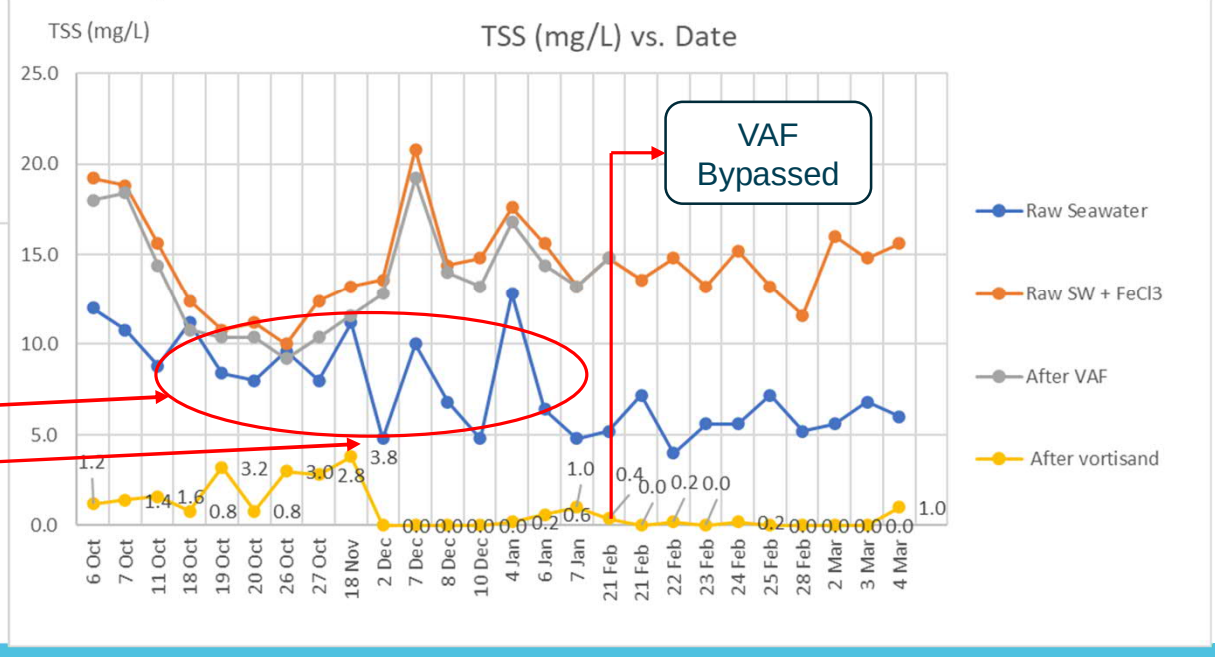
Process Design – Final Design

- Jar testing was performed to choose a suitable coagulant, $FeCl_3$.



Test Results – Lab readings





Low turbidity at same TSS level*, causing less than optimum $FeCl_3$ dosing calculated, affecting Vortisand® product TSS.

** (Turbidity <=> TSS correlation deviation)*

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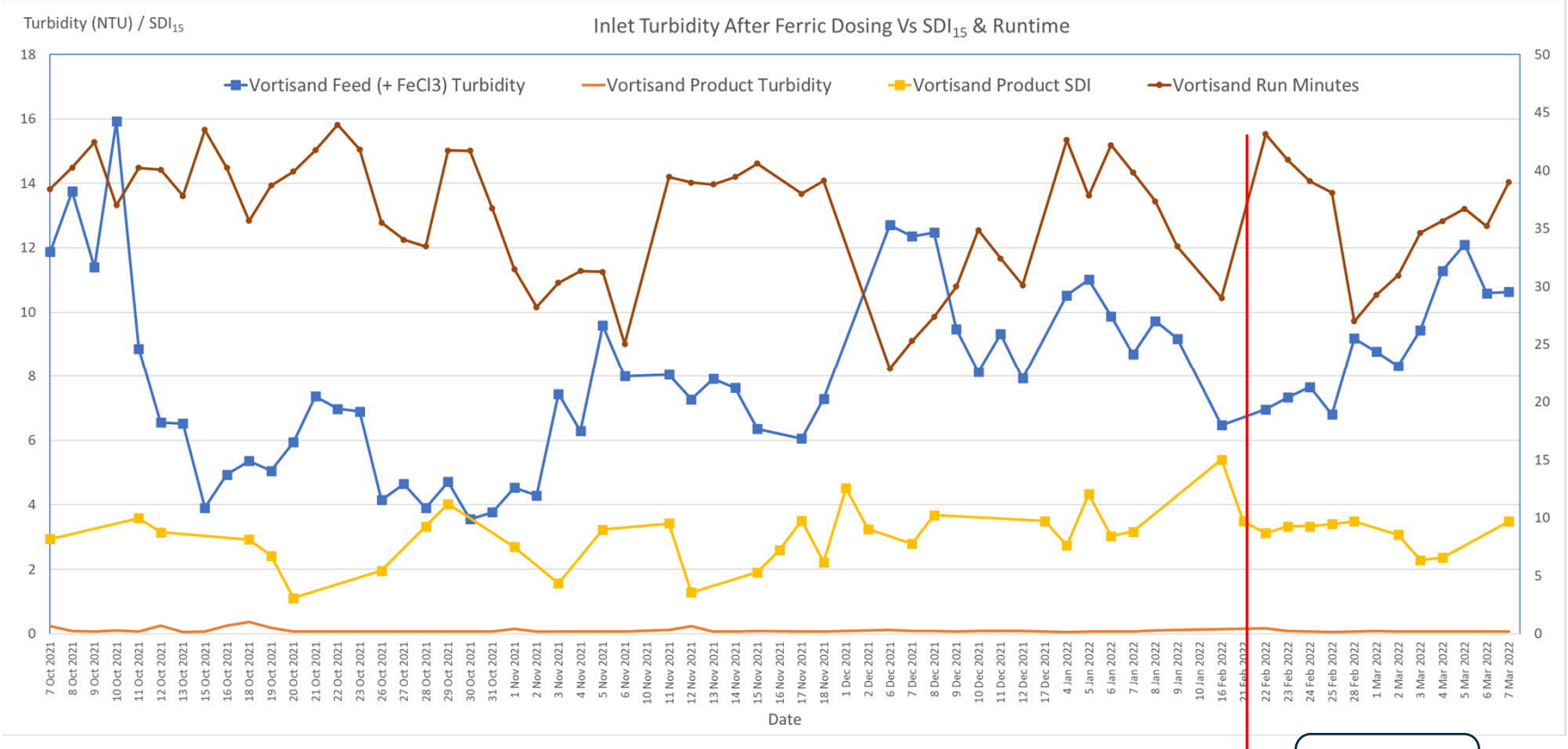
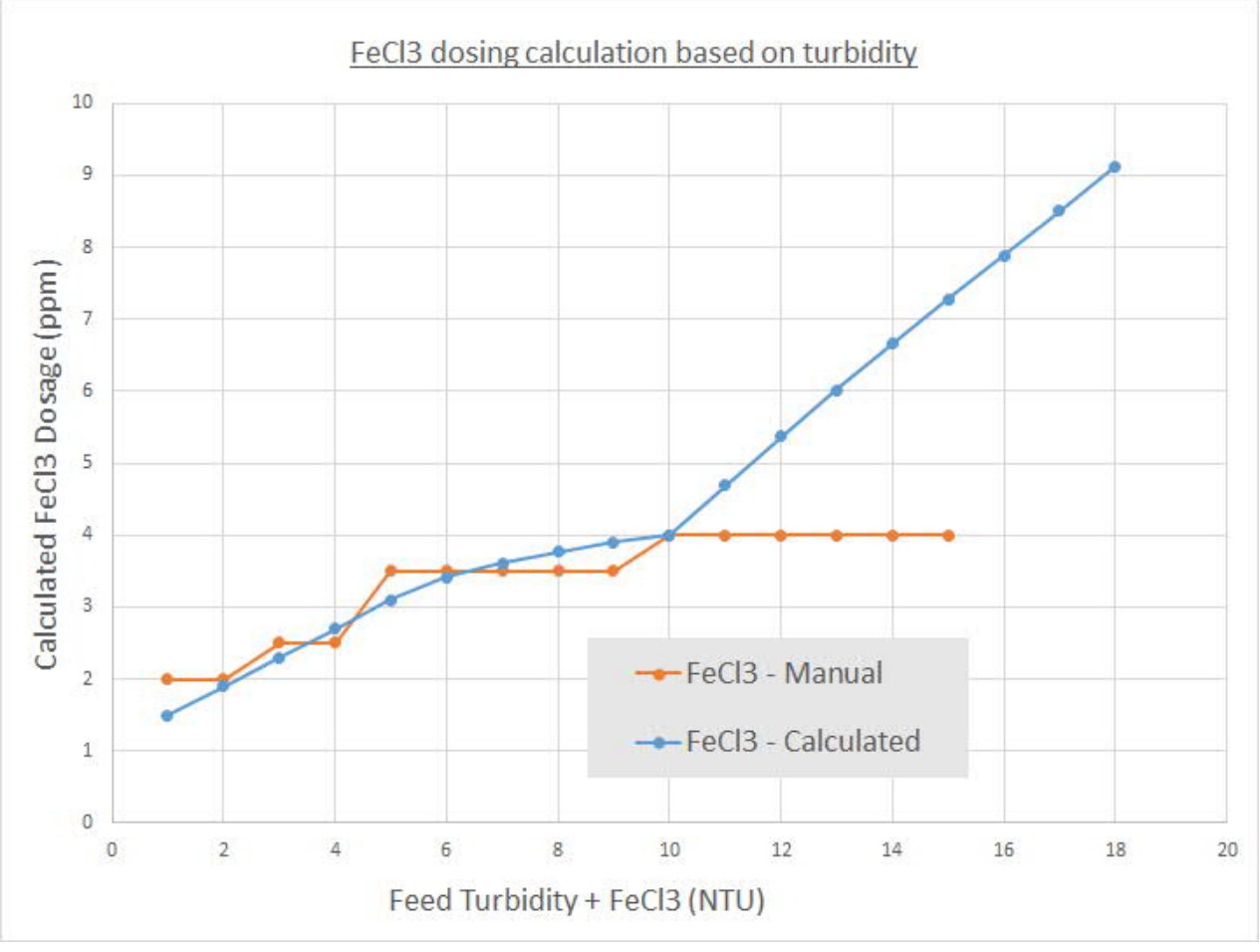
Test Results – Onsite readings



Vortisand product seems unaffected or even more stable than with VAF

Process Improvement: $FeCl_3$ & Backwash duration auto-calculation

- Initially the $FeCl_3$ dosage and backwash duration was manually controlled.
- After collection of several data points, $FeCl_3$ auto dosing and backwash duration calculation vs. feed turbidity was implemented and continually fine-tuned.



Vortisand® maintenance regime

- Operation: ~30 to 40 minutes runtime
- Cleaning with sodium hypochlorite once a week @ ~185ppm free chlorine “in the vessel” (with no free chlorine dosing upstream).
- Once a month HCl cleaning @ pH <3, 1hr soak

Challenges encountered

- If an incoming high turbidity/algae bloom incident occurs, damages to sand unrecoverable.
  - Implemented incoming turbidity limit trip @ 18NTU.
  - Preferably require DAF before Vortisand®, which also can't take oil & grease in the event of oil-spill incidents in Singapore waters.

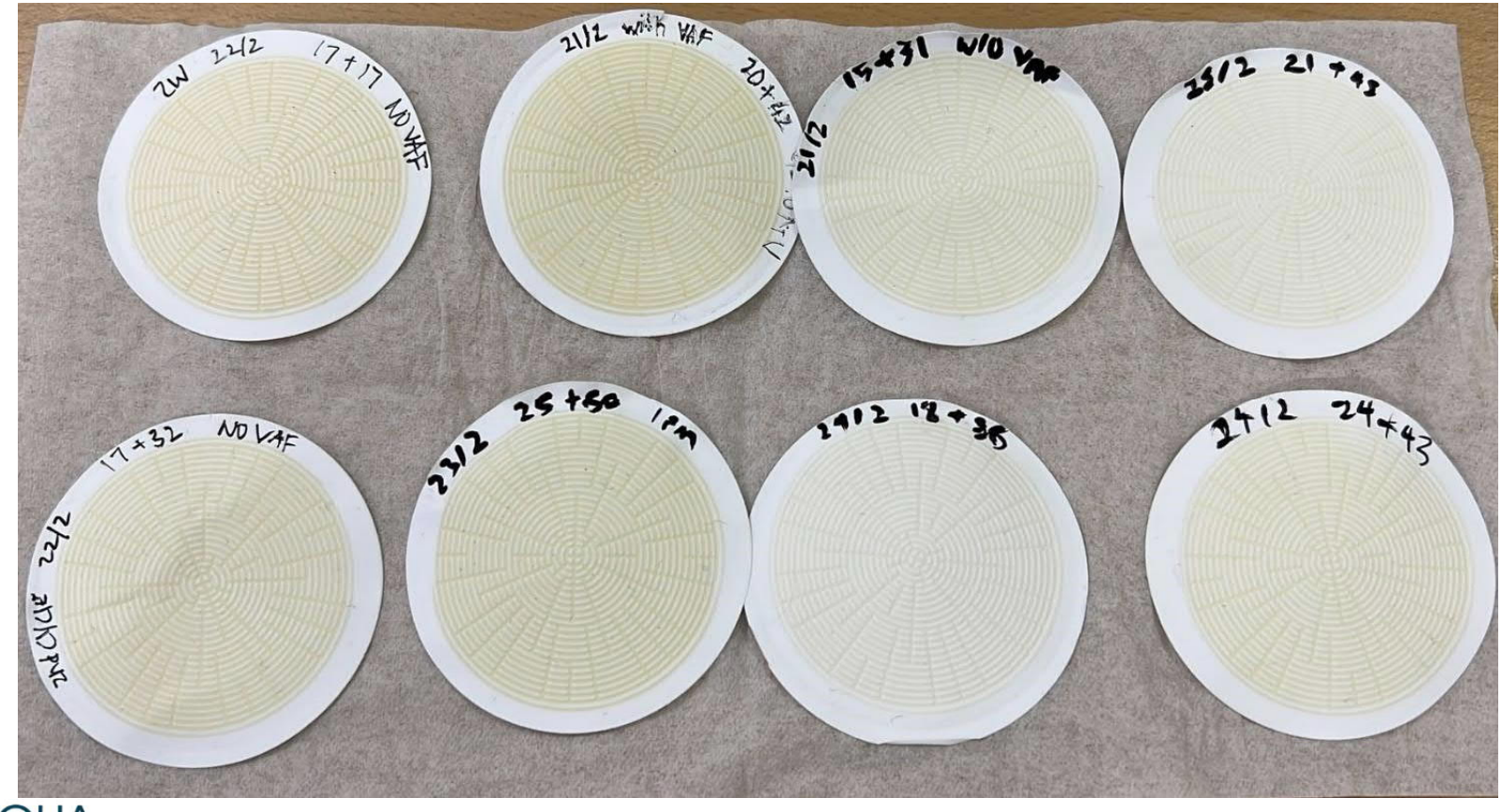
- Sampling solenoid turbidity valves cause erratic reading
  - Implemented turbidity analyser back-pressure control.

Comparison of Vortisand® and UF

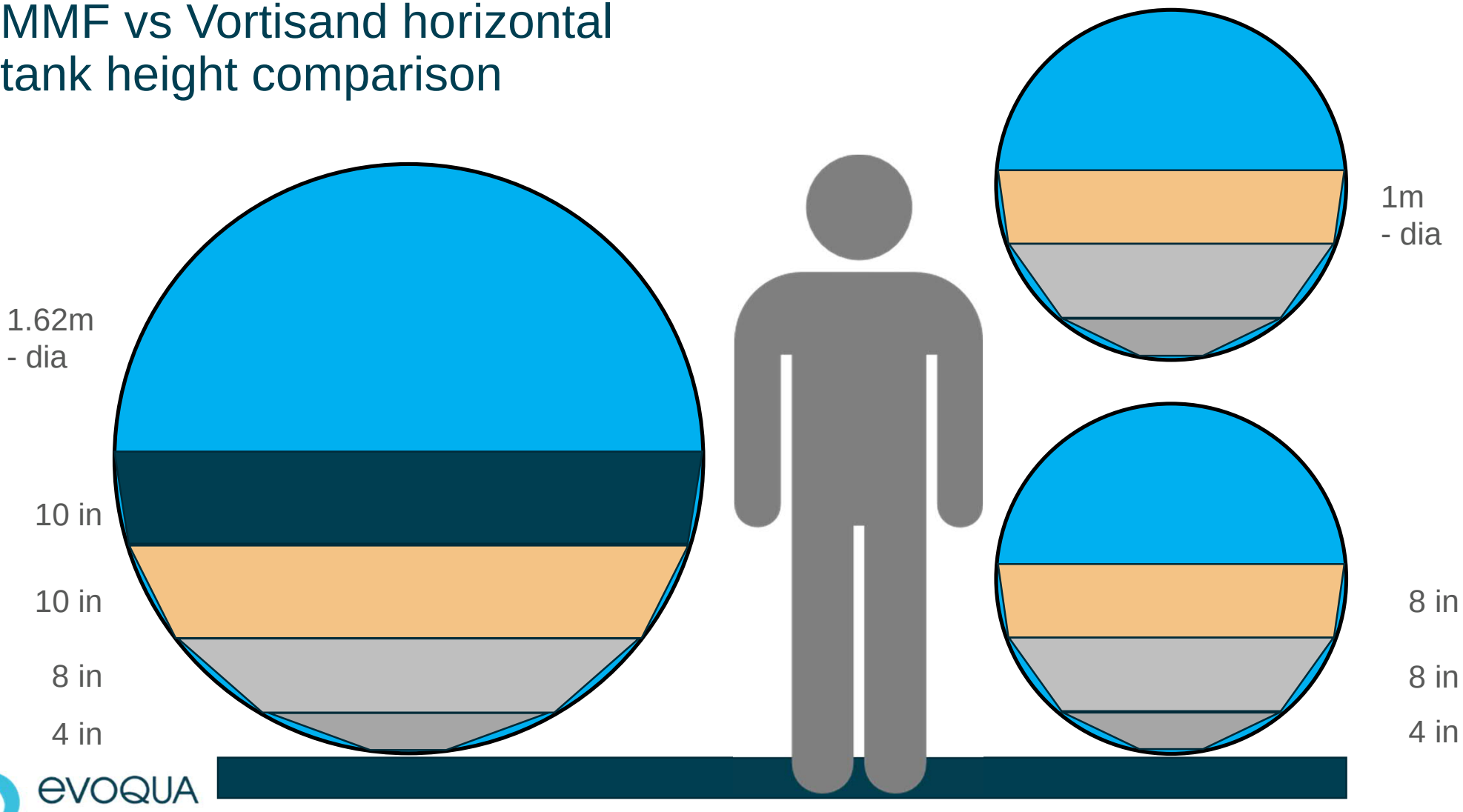
Description	Vortisand®	UF
Design Flow rate	8-10 m^3/h	10 m^3/h
Filtrate Turbidity	<0.2 NTU	<0.1 NTU
Filtrate SDI	< 5, average 3	<3
Energy Consumption	0.04 kWh/m3	0.13 kWh/m3
Chemical Cleaning	Only to control bacterial growth when no disinfectant dosed upstream	Acid/Caustic/Disinfectant: - Chemical Enhanced Backwash ~ Daily/Weekly - Cleaning In Place (with soak) ~ Weekly/Monthly
Cleaning chemicals	Biocide may be used during backwash if no continuous Sodium Hypochlorite dosing, acid cleaning may be used every 2-3 months if FeCl3 as coagulant	Chloric Acid (Or Sulfuric Acid), Sodium Hypochlorite, Citric Acid, Sodium Hydroxide
Wastewater need neutralization?	Not required	Yes
Media shelf life or membrane life	5 years (recommended)	3-5 years (typical)
Recovery rate	~80% (When scale up, it could be up to 95%)	~90% (with air scouring) (Note: w/o air scouring, recovery can be lower)

Backup Slides

SDI filter papers



MMF vs Vortisand horizontal tank height comparison



THANK YOU