



International
Desalination
Association

Water Arabia 2009

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“Desalination: The Vision of Today and the Future”

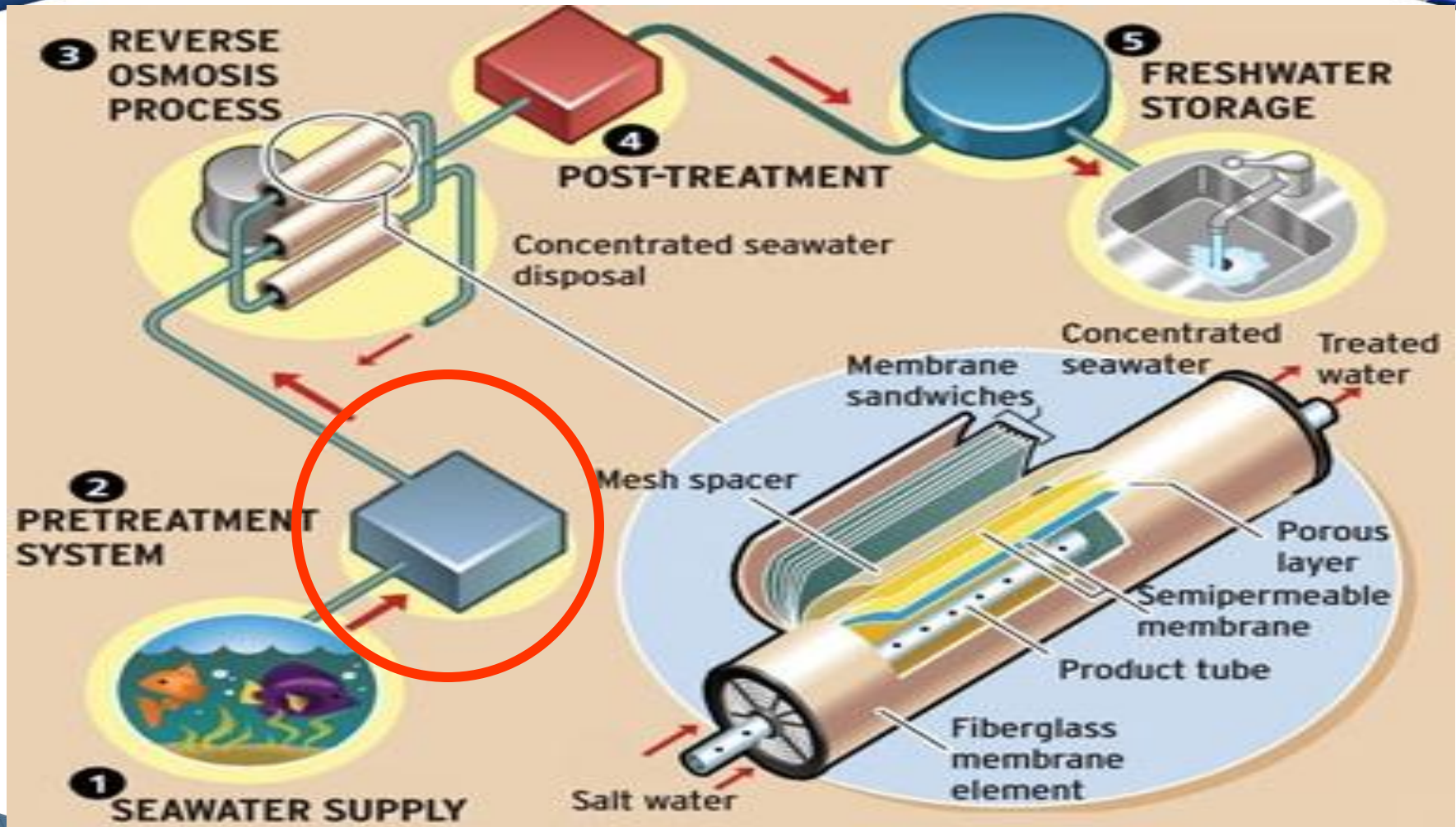
Comparative Seawater RO Pretreatment Evaluation Using Existing Plant and Pilot Plant

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Solutions & Technologies

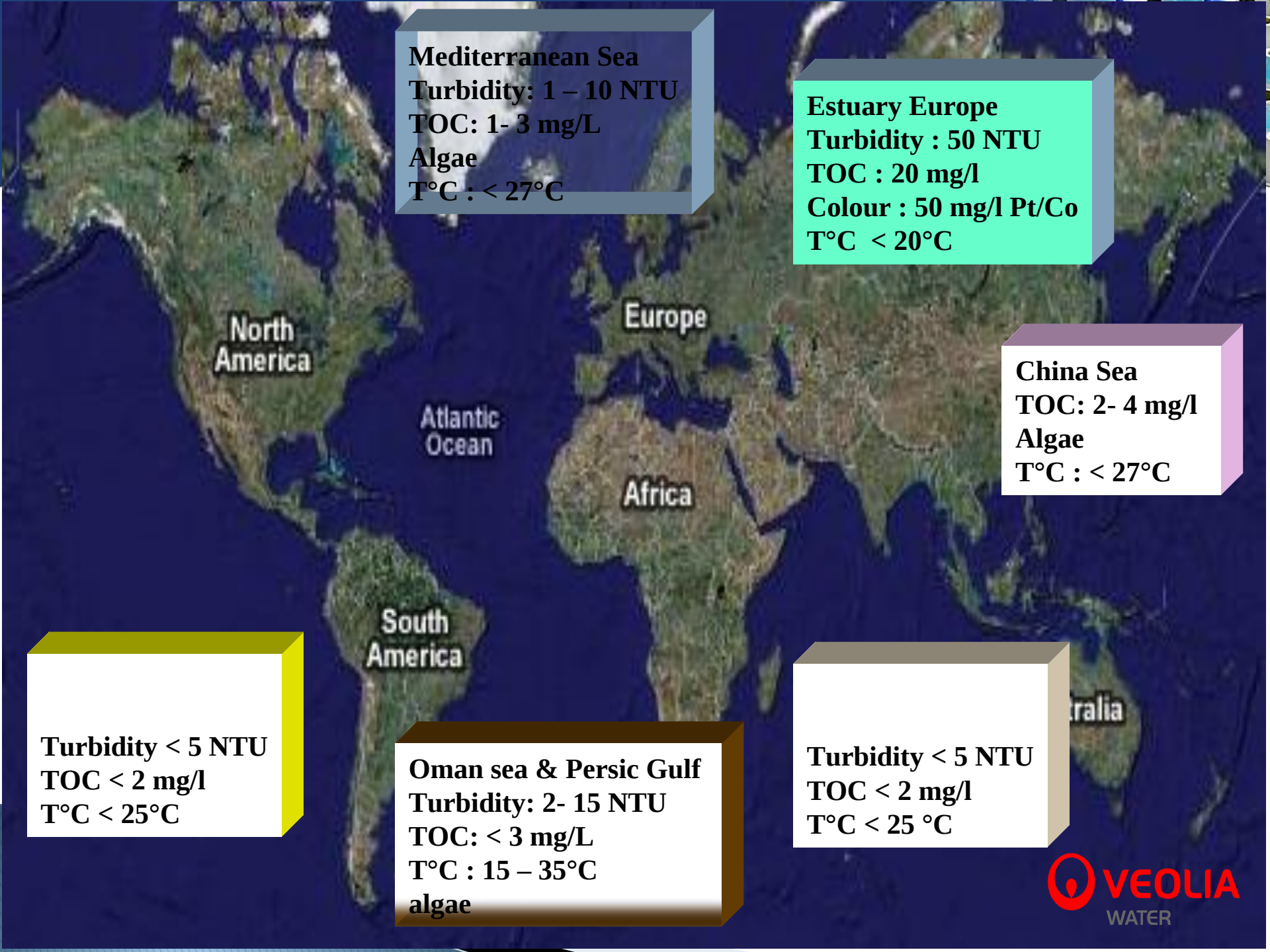
Keith Craig, Technical Manager Veolia Water Australia

The pre treatment : The key of the success



Objectives of the Pre treatment

- Turbidity < 0,5 NTU
- SDI < 4
- No oxidant
- Low residual metal (Fe, Al)
- Low organic carbon content
- No algae cells
- Low particles counts



Mediterranean Sea
Turbidity: 1 – 10 NTU
TOC: 1- 3 mg/L
Algae
T°C : < 27°C

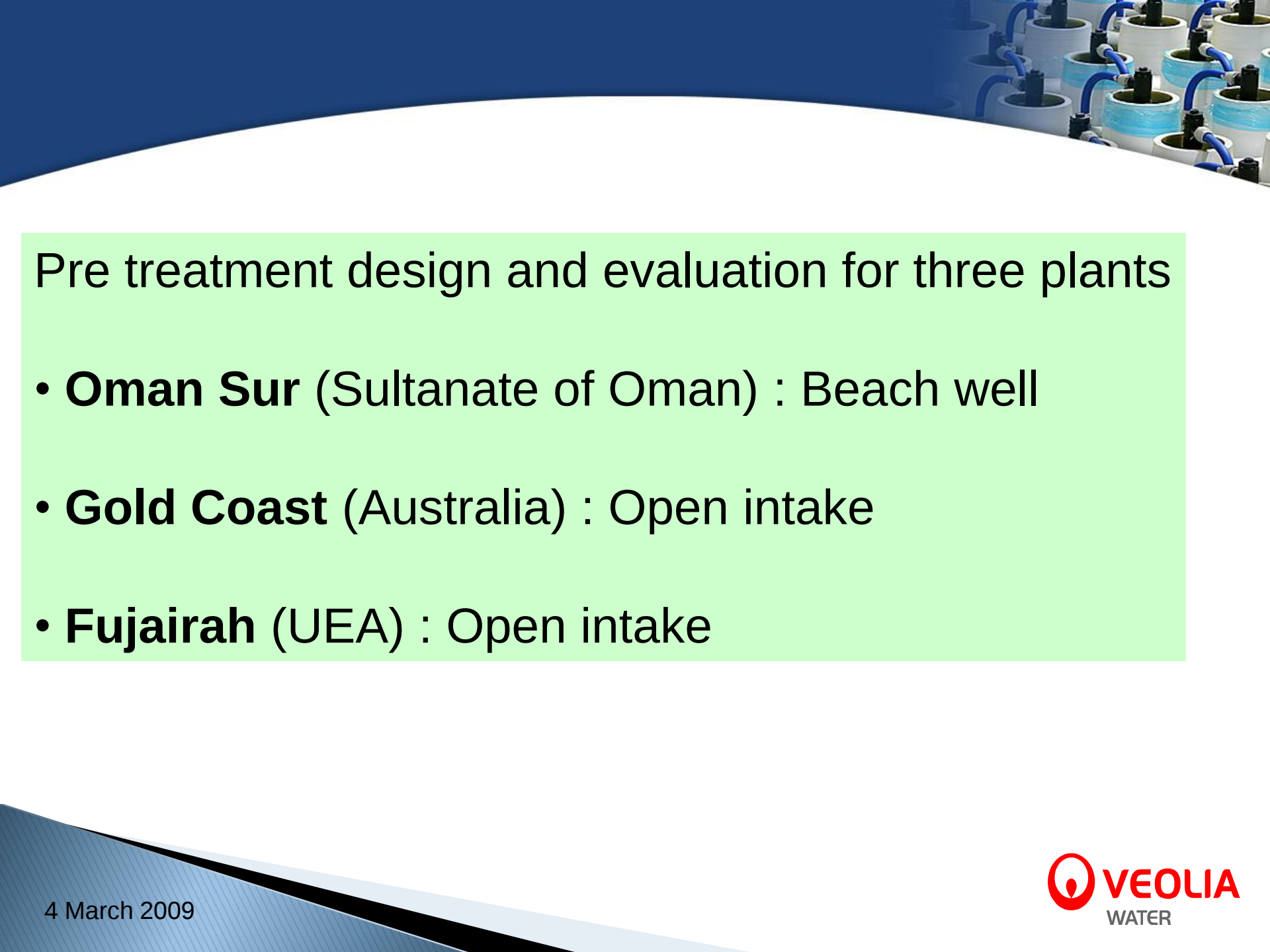
Estuary Europe
Turbidity : 50 NTU
TOC : 20 mg/l
Colour : 50 mg/l Pt/Co
T°C < 20°C

China Sea
TOC: 2- 4 mg/l
Algae
T°C : < 27°C

Turbidity < 5 NTU
TOC < 2 mg/l
T°C < 25°C

Oman sea & Persic Gulf
Turbidity: 2- 15 NTU
TOC: < 3 mg/L
T°C : 15 – 35°C
algae

Turbidity < 5 NTU
TOC < 2 mg/l
T°C < 25 °C



Pre treatment design and evaluation for three plants

- **Oman Sur** (Sultanate of Oman) : Beach well
- **Gold Coast** (Australia) : Open intake
- **Fujairah** (UEA) : Open intake

1. Case of Oman Sur



1. Case of Oman Sur Plant

The plant nominal capacity shall be **80 200 m³/d**

BW Flow rate pumped

m³/d

187 617



33 beach wells split up into 3 areas corresponding to 3 main underground water incomes

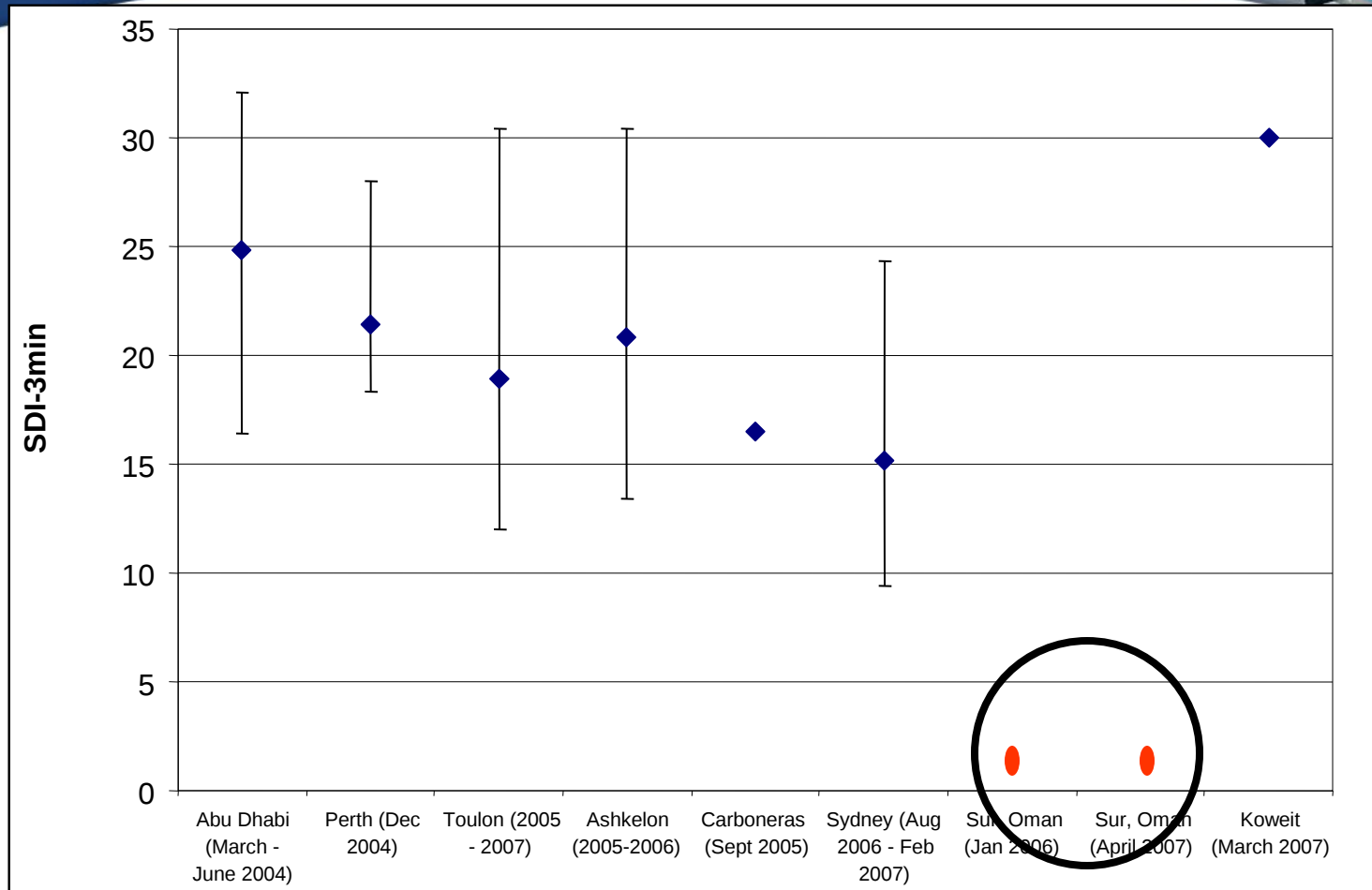
Piping network length of ~4000m

Wells yield 70 & 100 l/s result of :
best optimization
(OPEX/CAPEX)
limitation of equipments type
number

1. Case of Oman Sur : Raw water quality

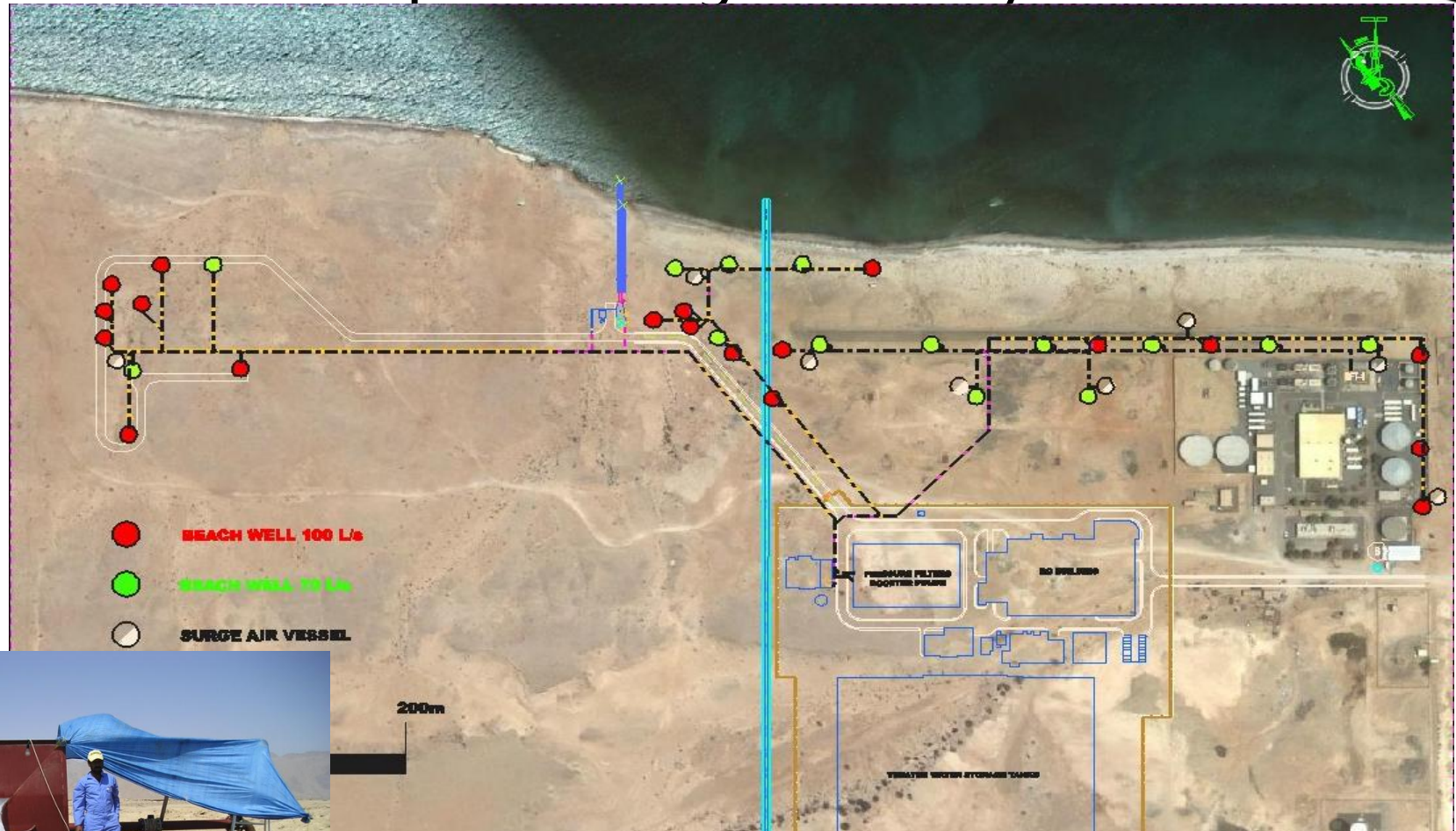
Water quality parameter	New BW-6	BW-1	FW-1	BW-2	FW-2	BW-3	FW-3
SDI-15min (Millipore HAWP membrane)	0.8	1.3	0.5 – 0.6	0.8	0.9	0 -0.6	-
pH	7.4	7.4	7.4	7.3	7.3	7.3	7.3
TOC (mg/L)	0.67	< 0.5	0.5	0.79	0.5	< 0.5	0.81
Total Nitrogen (mg/L)	0.21	0.15	0.12	0.30	0.26	0.27	0.25
Total UV ₂₅₄ (/m)	0.83	0.74	0.72	0.86	0.78	0.65	0.81
Total Hydrocarbons (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

1. Case of Oman Sur : Comparative SDI



1. Case of Oman Sur: Beach wells implementation

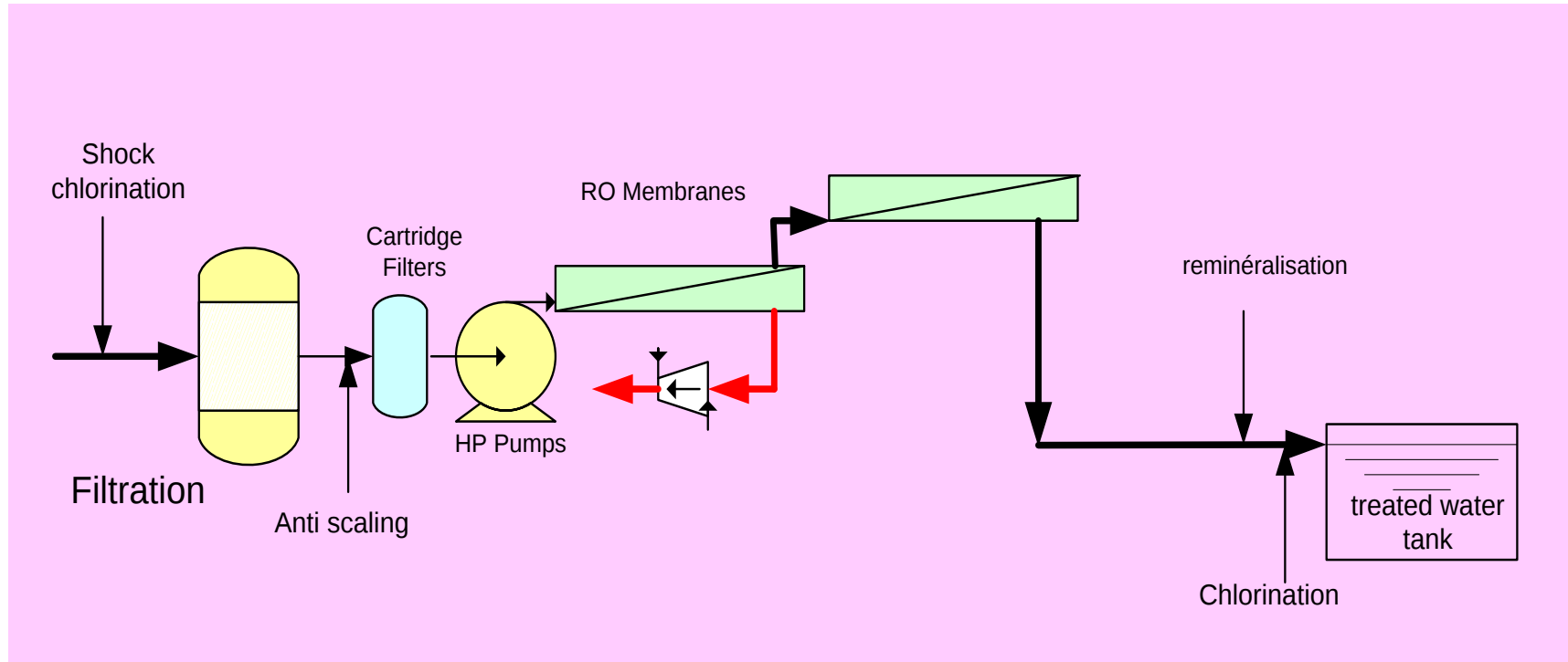
► Optimized general layout



1. Case of Oman Sur : Beach wells pumping



Simple Filtration mono or dual media



- No Coagulant
- No acid
- No sludge treatment

3 existing plants working on the same site does not use chemicals for the pre treatment

Cas of Oman Sur : Chlorination of the inlet

- Shock chlorination
- Chlorine injection upstream of the seawater pumps is done in order to control sea shell growth and sea flora.
- The chlorine is injected as chlorine solution which is prepared by means of NaOCl.

Prechlorination type		Shock treatment
Dose	mg/l	2
Frequency		1 h / day
NaOCl solution concentration	%	12.5

Case of Oman Sur : Filtration

1st stage filter criteria

Feed Filter Flow rate	m ³ /d	61,675
Number of Filters Horizontal pressure filters		6
Dual Media Filtration	pumice media - Sand	600 mm 600 mm
Diameter of the filter	m	3.50
Surface of a filter	m ²	42
Filter Cycle	h	48
Filter velocity	m/h	10.2

II nd stage filter criteria

Feed Filter Flow rate	m ³ /d	125,942
Number of Filters Horizontal pressure filters		8
Filter velocity	m/h	15.6
MonoMedia Filtration	Sand	600 mm

Case of Oman Sur : Filtration

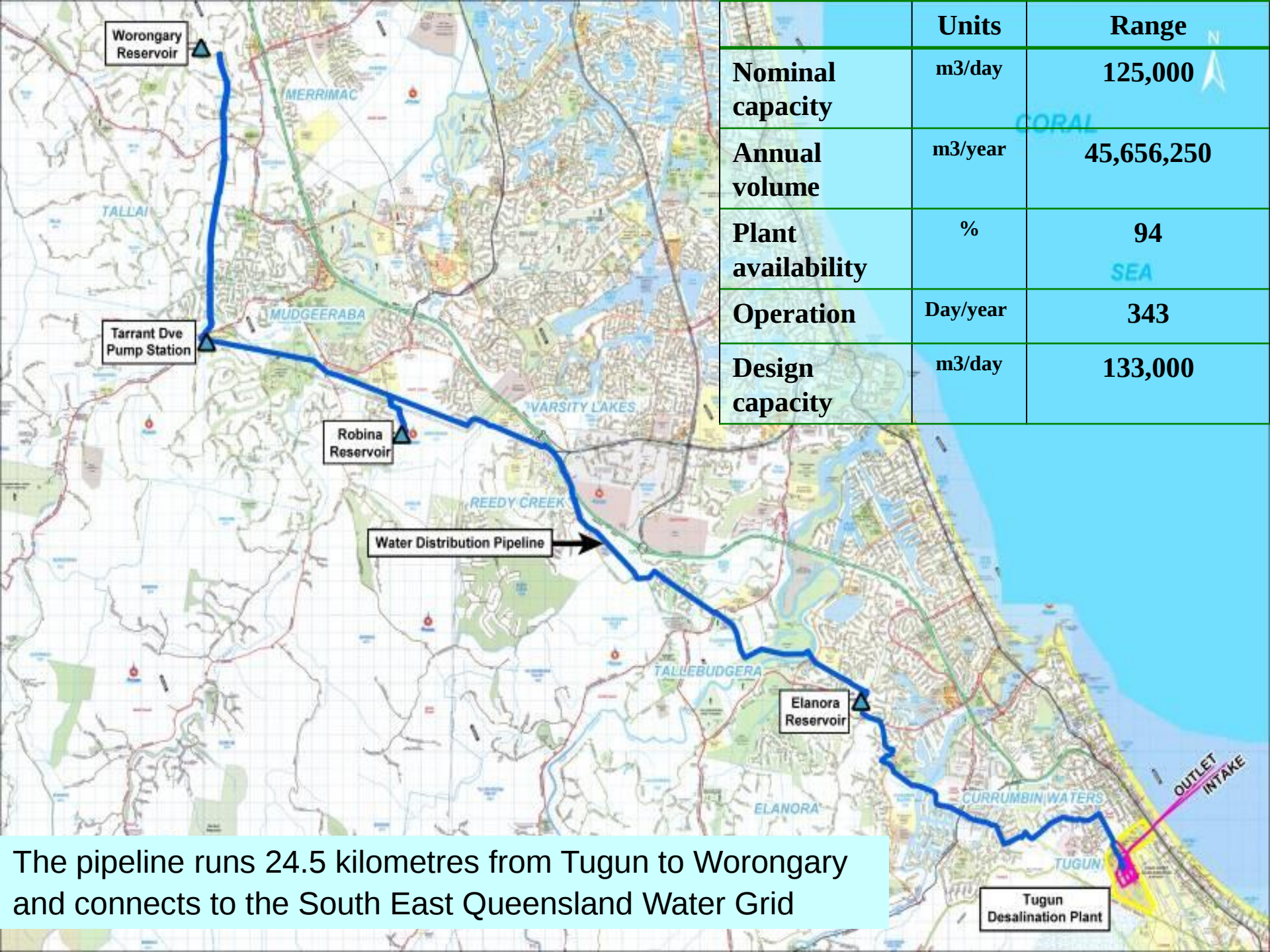


Case of Oman Sur : view of the pre treatment



2. Case of Gold Coast Desal Plant

- ❑ The Gold Coast Desalination plant has been constructed as a part of the Queensland State Government's \$9 Billion South East Queensland Water Grid Strategy. This Strategy has been developed in response to a growing population and unprecedented drought, which has seen the region's water storages fall to below 20% of capacity.
- ❑ The project is a **Design, Build and Operate** contract with a **fifteen year** operations and maintenance period.
- ❑ The Alliance style project includes the delivery of a **125 ML/day** Seawater Reverse Osmosis plant, and the construction of two tunnels 2.0 and 2.2 kilometers long. **24.5 kilometers** of delivery pipework has also been constructed to connect the desalination plant to the SEQ Water Grid.



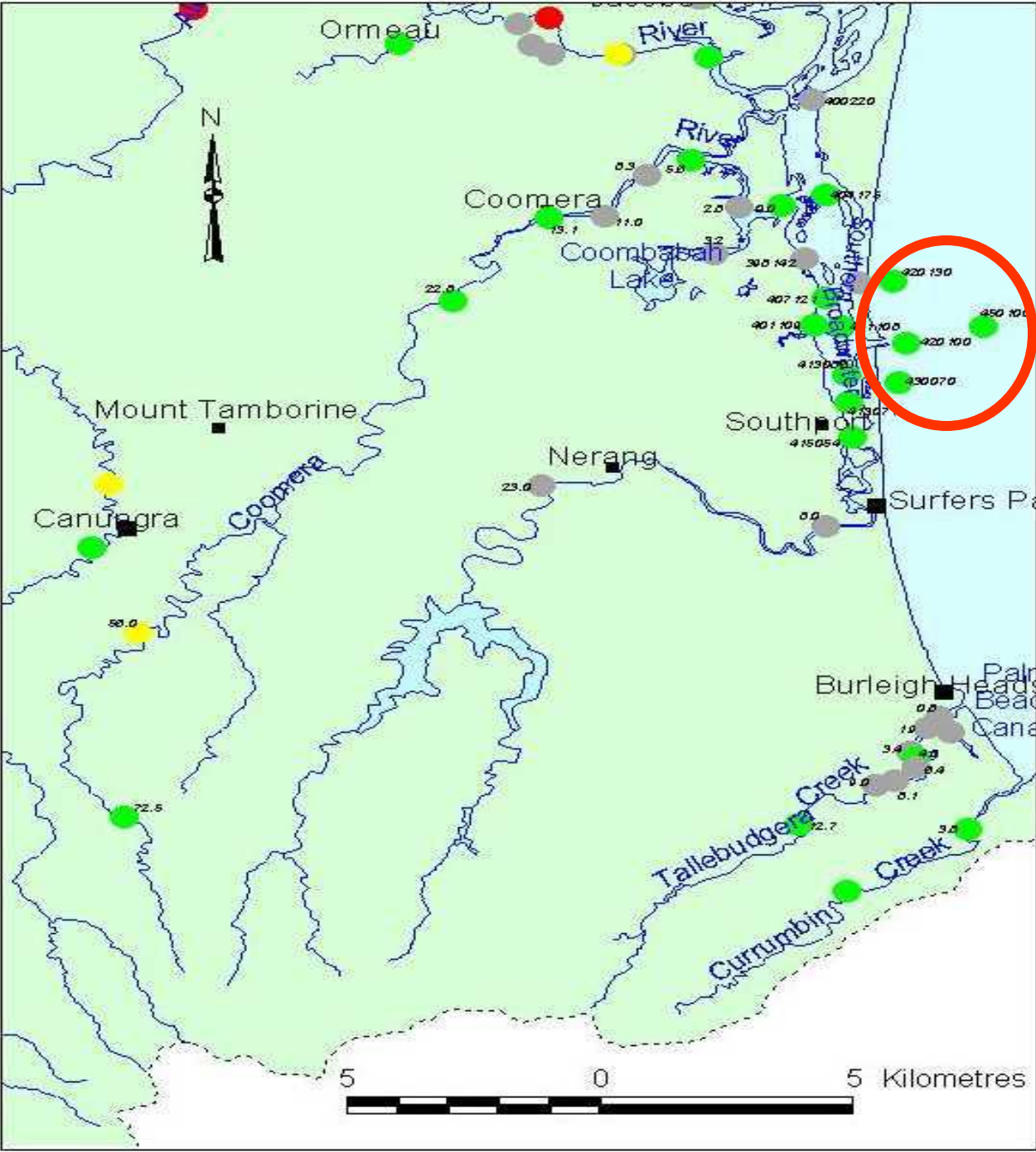
	Units	Range
Nominal capacity	m3/day	125,000
Annual volume	m3/year	45,656,250
Plant availability	%	94
Operation	Day/year	343
Design capacity	m3/day	133,000

The pipeline runs 24.5 kilometres from Tugun to Worongary and connects to the South East Queensland Water Grid

Parameters (Gold Coast Desal Plant)	Units	Range / Max value
Seawater design temperature	Deg C	17 – 28
Seawater total dissolved solids design values	mg/L	34,000 – 38,000
pH		7.6 – 8.3
Total suspended solids	mg/L	10
Turbidity	NTU	7
Bicarbonate as HCO ₃	mg/L	160
Carbonate as CO ₃	mg/L	30
Chloride as Cl	mg/L	21,000
Sulphate as SO ₄	mg/L	3,000
Fluoride as F	mg/L	1.8
Bromides	mg/L	76
Dissolved hydrocarbons	mg/L	0.10
Total organic carbon	mg/L	4
Calcium	mg/L	450
Magnesium	mg/L	1,450
Sodium	mg/L	11,700
Boron	mg/L	5

Red tide in Gold Coast





Map of EPA sampling locations.

- 
- The pre-treatment pilot plant was constructed and installed at Kropp Park at Tugun Beach.
 - The pilot plant is a granular media filtration system that can operate in contact or direct filtration mode.
 - The seawater intake is located 1.5 km offshore from Kropp Park in 24 m of water.
 - The pre-treatment pilot plant and intake was commissioned the week of the 4 September and runs commenced week of 12 September 2006.

2. Case of Gold Coast DP : Pilot Plant



- Confirm the pre-treatment process selected.
- Finalise design parameters.
- Confirm pre-treated filter water quality.
- Establish most economical and robust design.
- Minimise risk of pre-treatment process issues or failure.

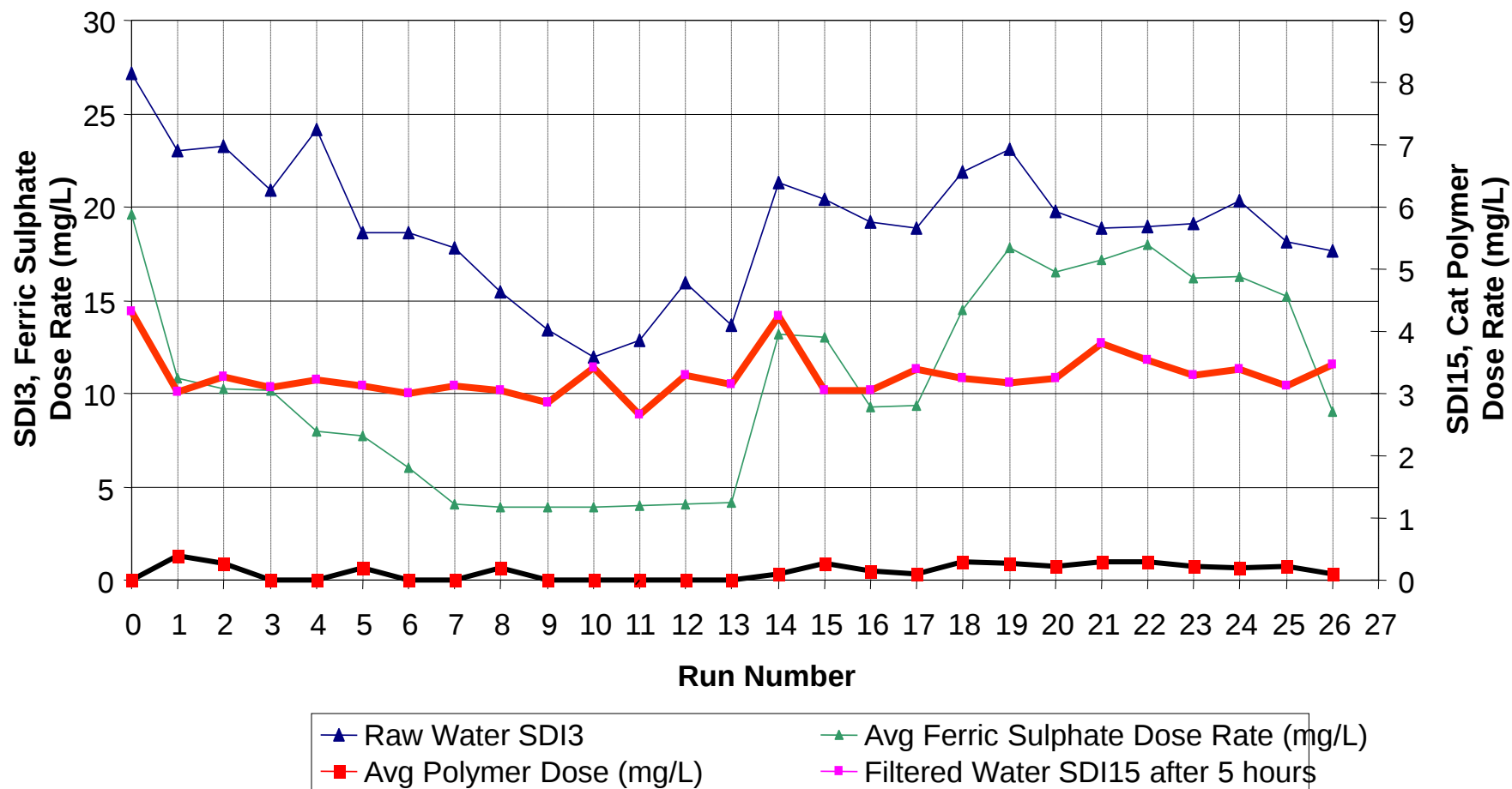


2. Case of Gold Coast : Pilot plant design

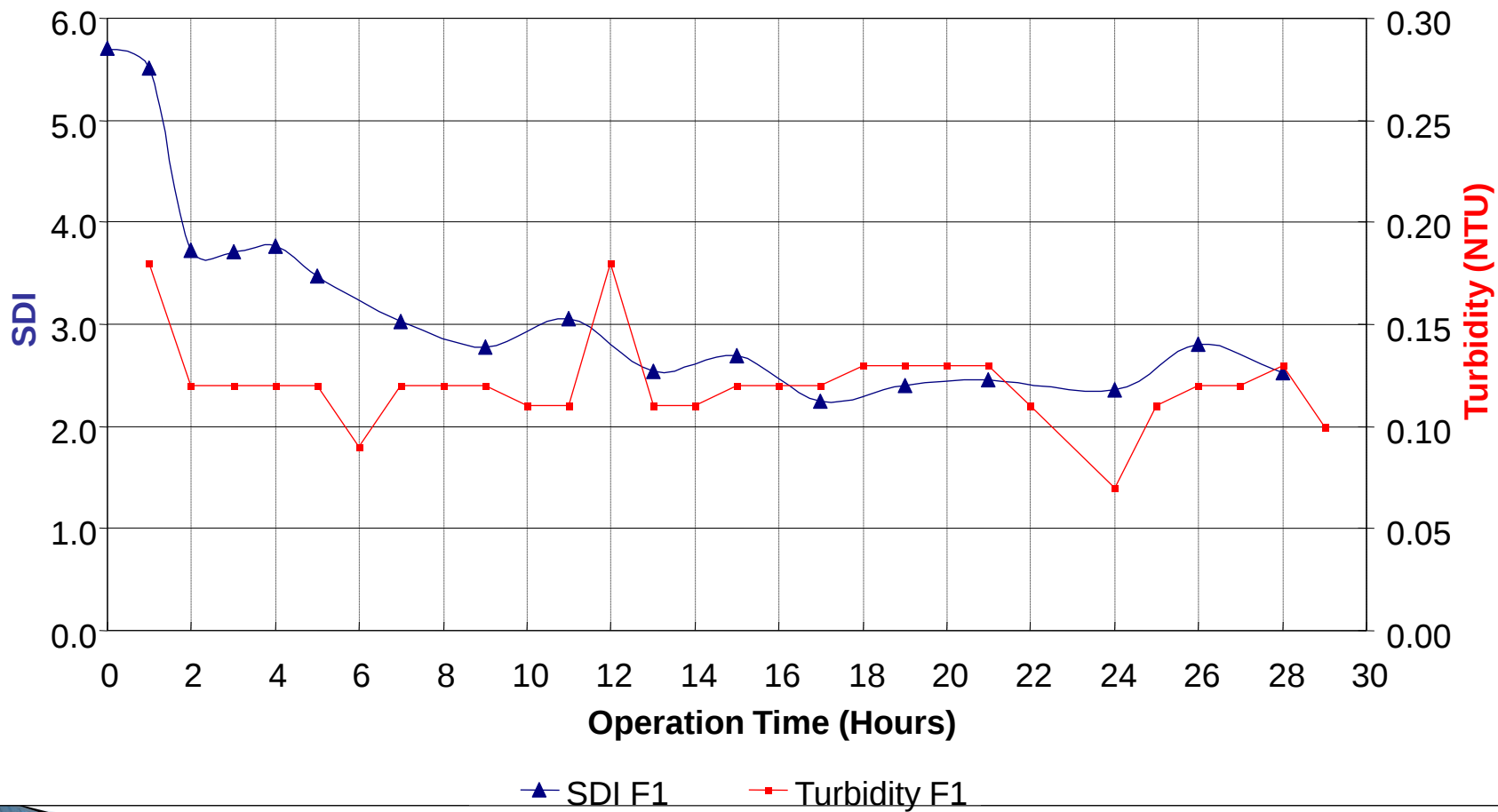
Parameter	Value
Flocculation time	20 mins
Flocculation G value	75 sec ⁻¹ ,
Filtration rate	6.7 m/hr
Filtration time	29 hrs/31 hrs
Ferric Sulphate Dose Rate	6 - 18 mg/L
Cationic Polymer (LT 425)	0 – 0.21 mg/L
Coagulation pH	6.7
Filter Media Sand / Australian filter coal	0.7 mm E.S. - depth 900 mm 1.5 mm E.S. - depth 800 mm

GCDA Pilot Plant

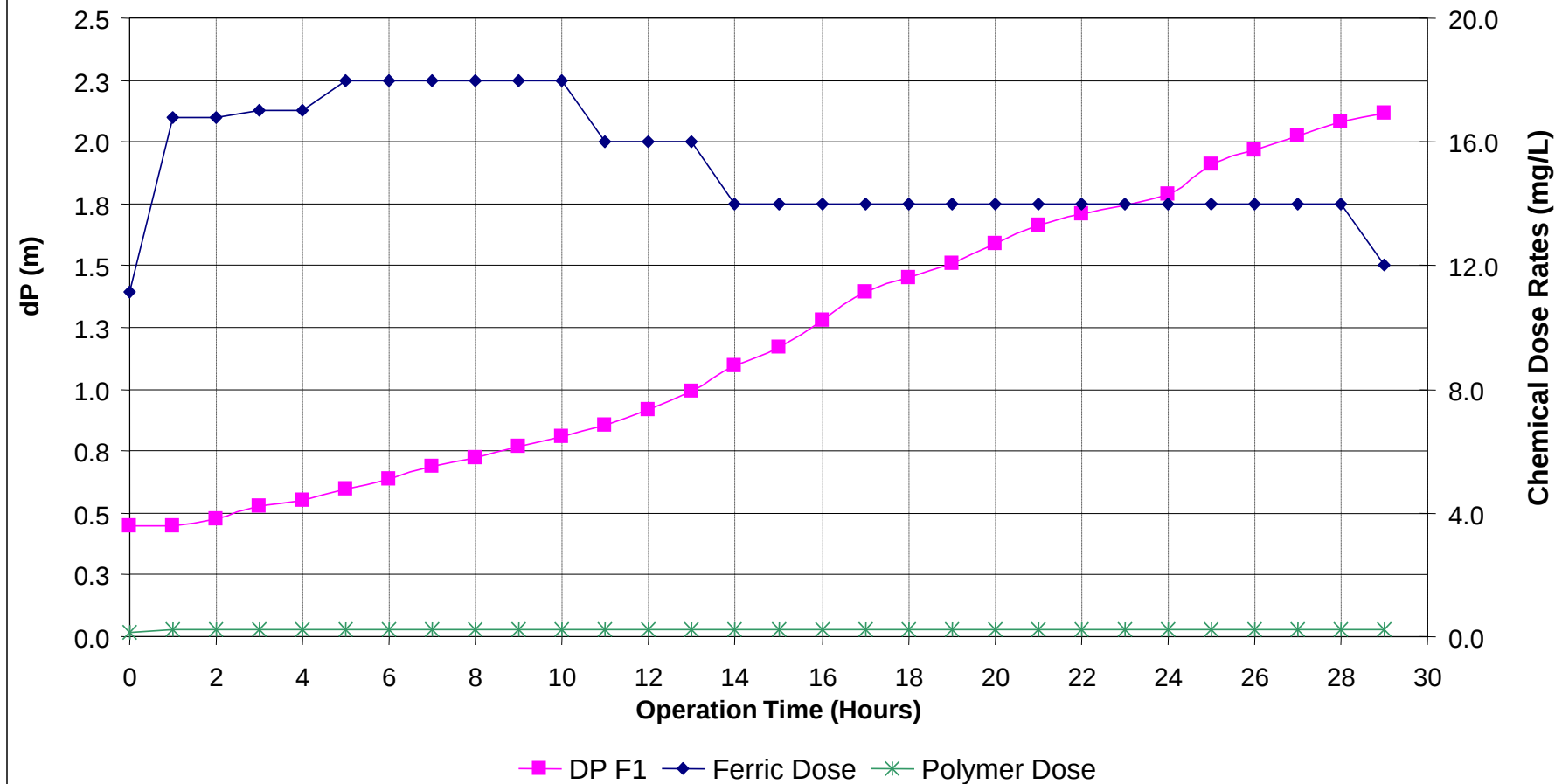
Raw Water SDI3, Filtered Water SDI15 after 5 hours, Chemical Dose Rates



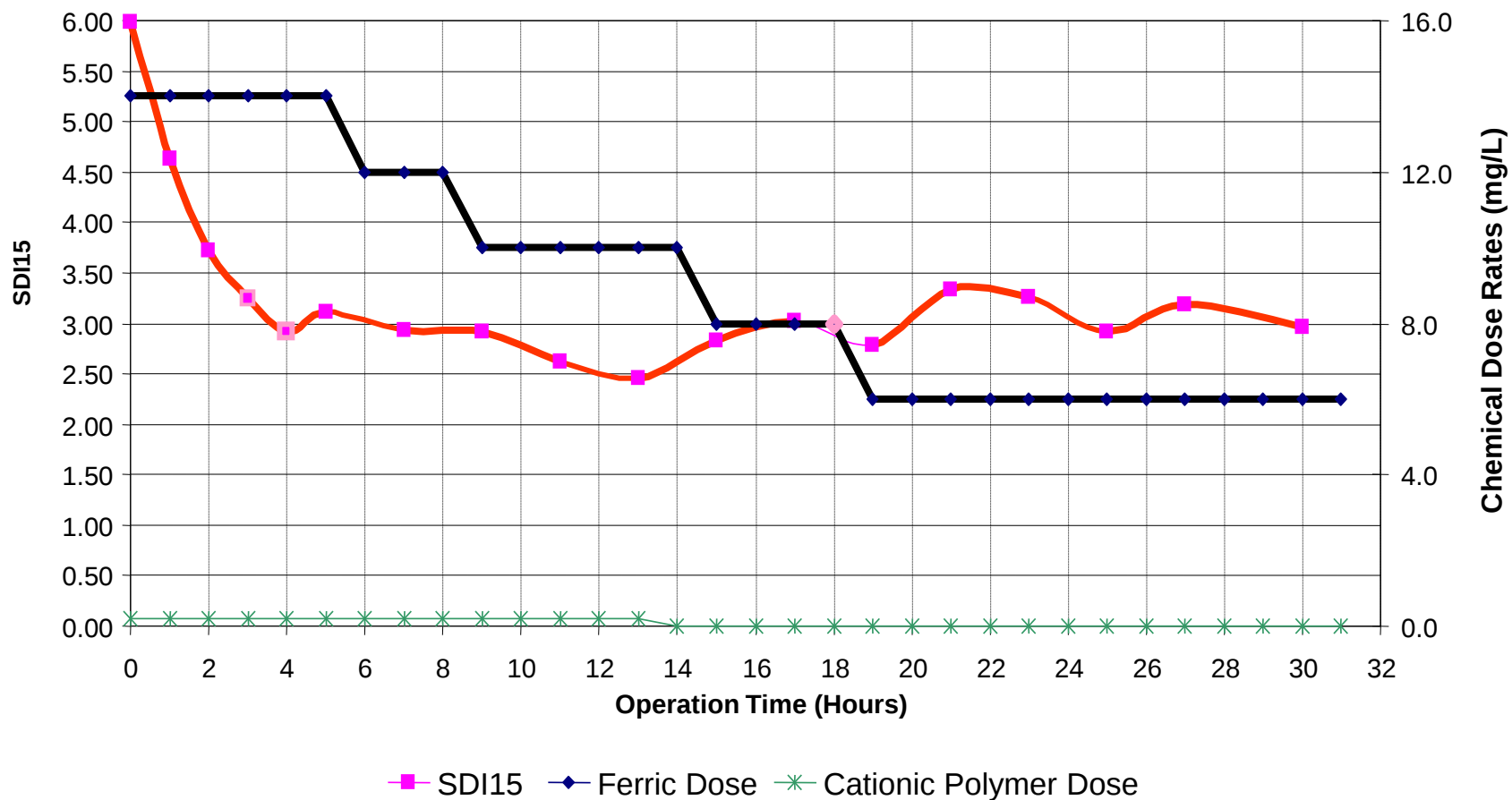
**Fe₂(SO₄)₃ =12-18 mg/L; pH =6.7 ; Filter Rate =6.7 m/hr; Cat Poly = 0.2 mg/L;
Floc Time = 20 mins**



**Fe₂(SO₄)₃ =12-18 mg/L; pH =6.7 ; Filter Rate =6.7 m/hr; Cat Poly = 0.2 mg/L;
Floc Time = 20 mins, Direct Filtration**



**Fe₂(SO₄)₃ = 6-14 mg/L; pH =6.7 ; Filter Rate =6.7 m/hr; Cat Poly = 0 - 0.2 mg/L;
Floc Time = 20 mins, Direct Filtration**



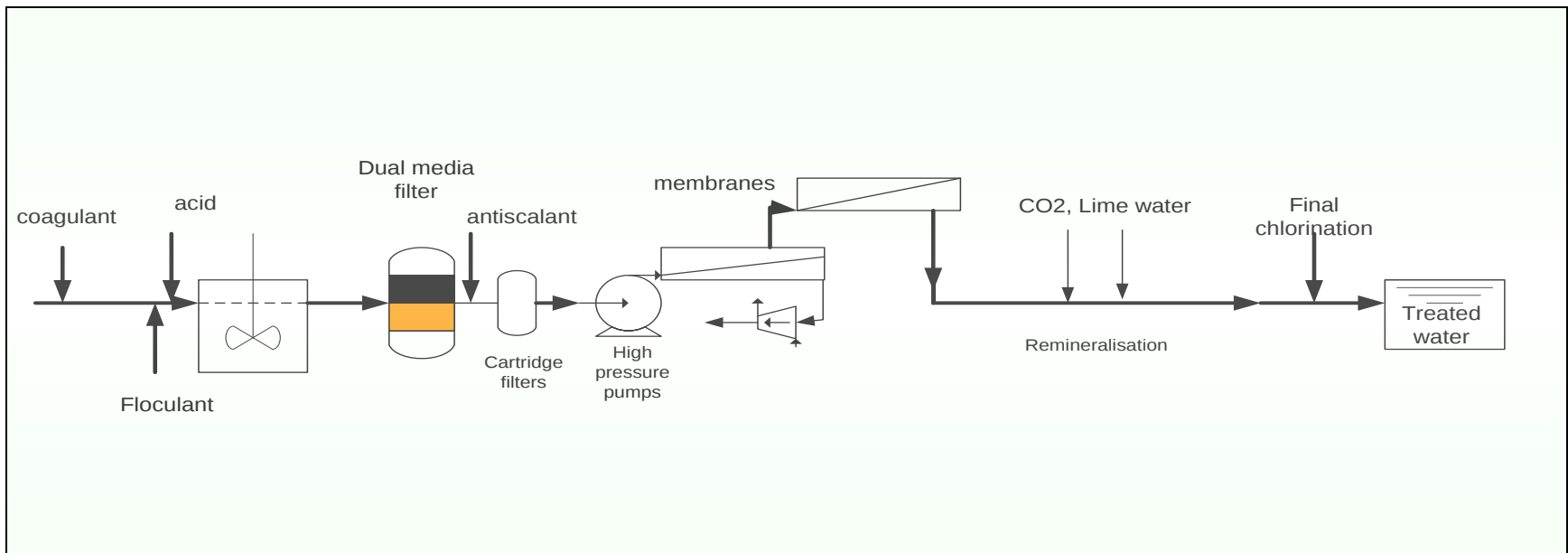


After 11 weeks testing the seawater SDI3 values have varied from 11.5 to 25.2.

After the filter run is allowed to mature to filtered water SDI15 values around 3.0 through high doses of chemical coagulants, the filter bed appears to reach a stabilisation which allows chemical dose rates to then be decrease.

The direct filtration process at a filtration rate 6.7 m/hr has proved effective with filter run times >40 hours. Results to date indicate direct filtration at a filter rate of 6.7 m/hr with a flocculation time of 20 minutes achieved suitable SDI15 values and filter run times.

Gold Coast Desalination water Treatment



2. Case of Gold Coast :Flocculation tank sizing

Flocculation		
Filter feed water	m3/d	345,394
Number of unit	u	4
Number of tanks in series per unit	u	3
Volume per unit	m3	1,178
Residence time 4 units	min	19.9

2. Case of Gold Coast :Filtration design

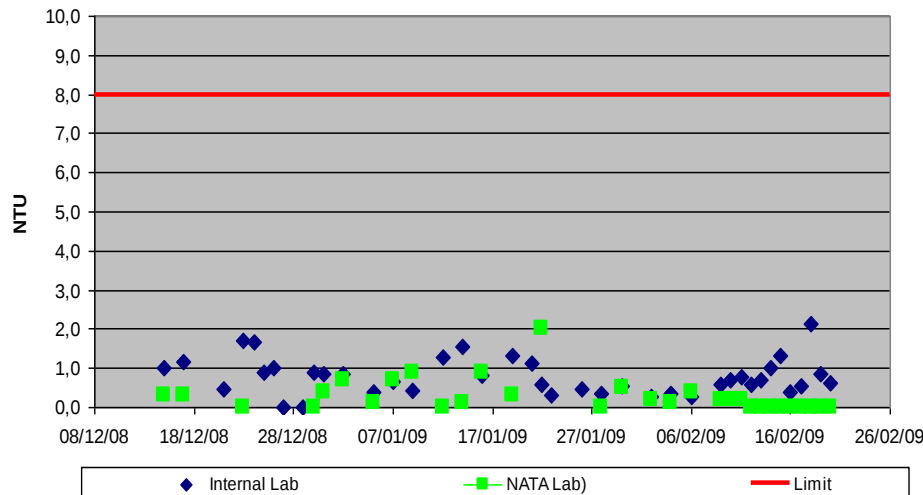
Number of filter	u	18
Filter type Dual media gravity filter		Sand + Anthracite
Filter area	m²	119.3
Total Height of media layer	mm	1600
Filtration rate - 18 filters (N)	m/h	6.6

NaOCl Liquid		H ₂ SO ₄ Liquid	
Concentration	13% (130 g/L of active chlorine)	Concentration	98%
Dosing rate mg/L	0 to 10 as active chlorine	Dosing rate mg/L	35 maxi
Frequency	1h/day	Frequency	Continuous
Injection point	Inlet of the intake pipe, pumping or Discharge pipe of the intake pumps	Injection point	Static mixer prior pre treatment

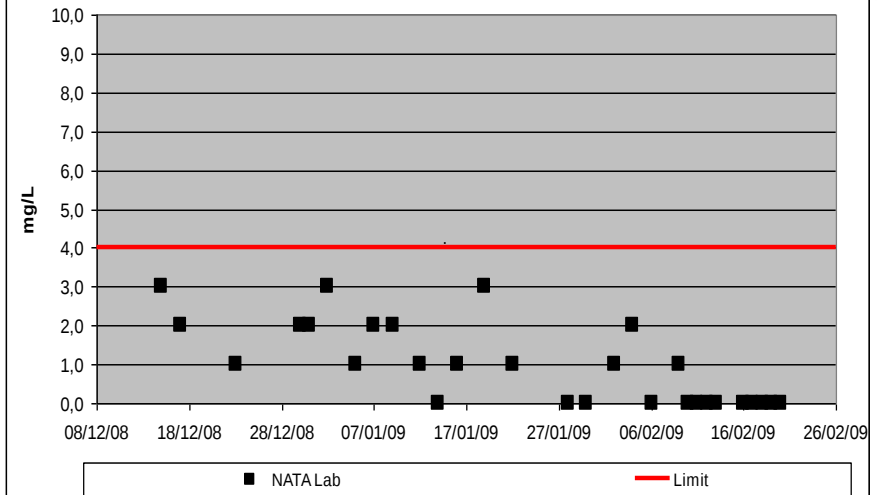
Fe ₂ (SO ₄) ₃ Liquid		Polyelectrolyte Liq or Powder	
Concentration	40 %	Concentration	100 %
Dosing rate mg/L	4 maxi (Fe)	Dosing rate mg/L	0.2 maxi
Frequency	Continuous	Frequency	continuous
Injection point	Static mixer prior to pre treatment	Injection point	Static mixer prior to flocculation

2.Case of Gold Coast : SDI, TOC & Turbidity inlet water

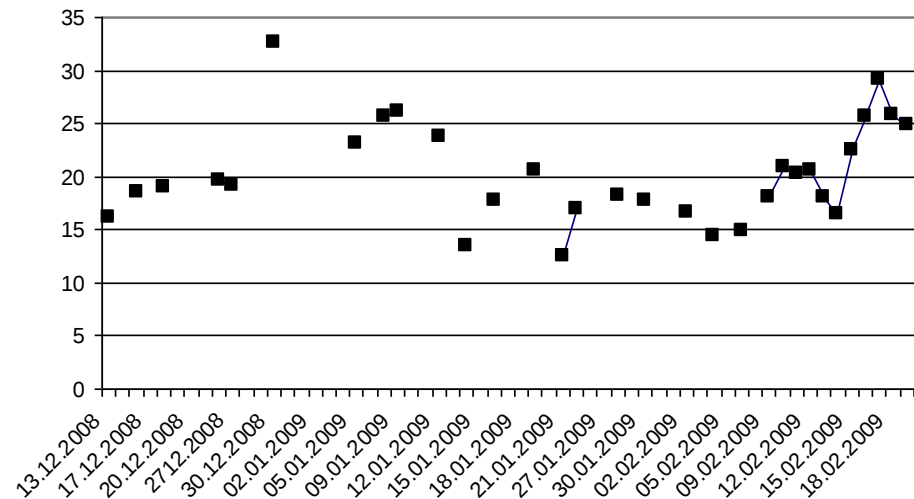
TURBIDITY



TOTAL ORGANIC CARBON

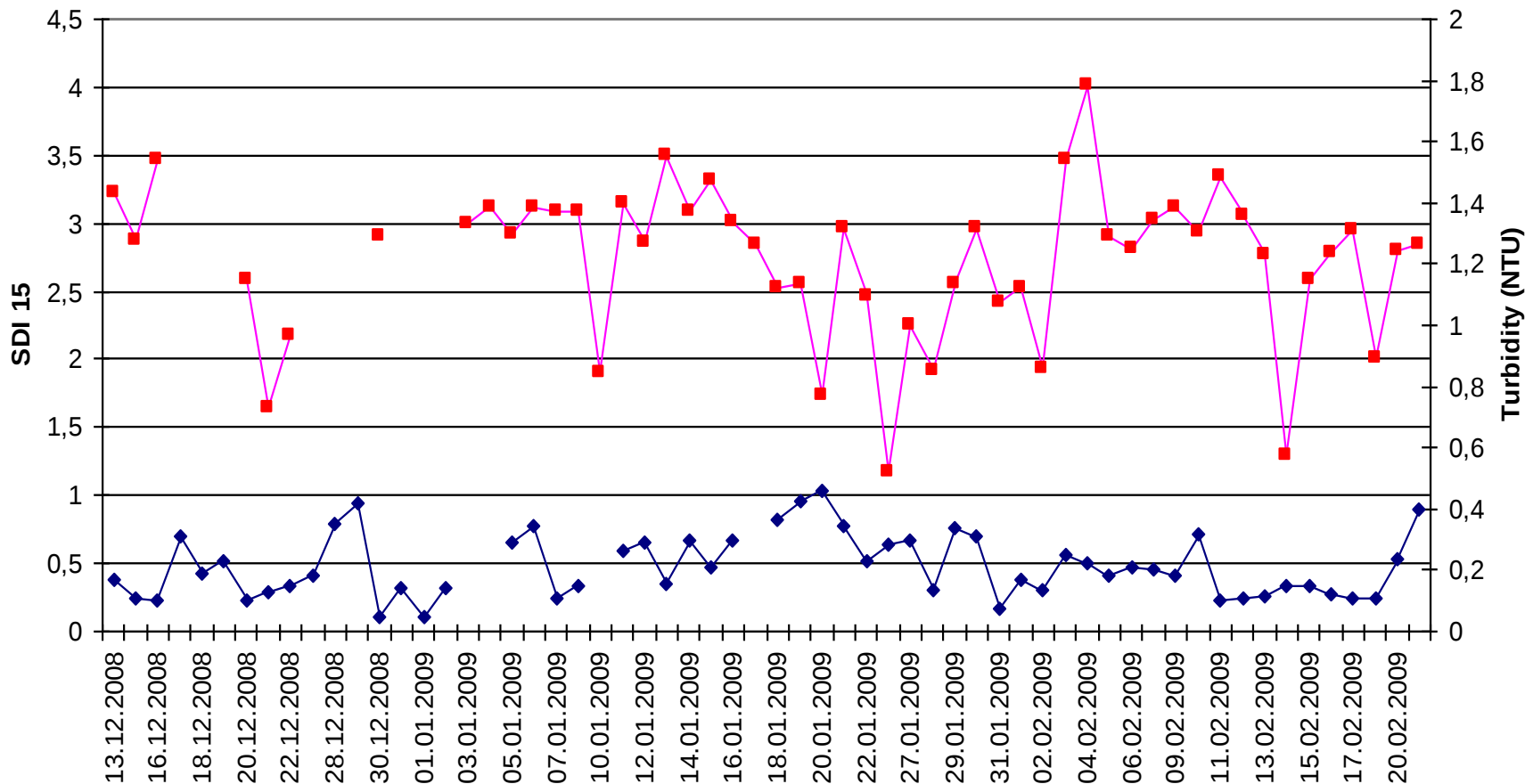


SDI 3 raw water



2. Case of Gold Coast : SDI & Turbidity

SDI 15 & Turbidity on the filtered water



2. Case of Gold Coast : six months of operation

- ❑ The sea water SDI_3 has been around similar values as during the pilot plant work from 16 to around 28.
- ❑ The pre-treatment filters have been operating for 6 months and are achieving SDI_{15} values of around 2.8 to 3.5 typically just over 3.0 with filter run times in excess of 40 hours.
- ❑ The initial acceptance testing at 33 and 66% have been complete and now they are moving onto 100% testing.

Gold Coast Desalination Plant

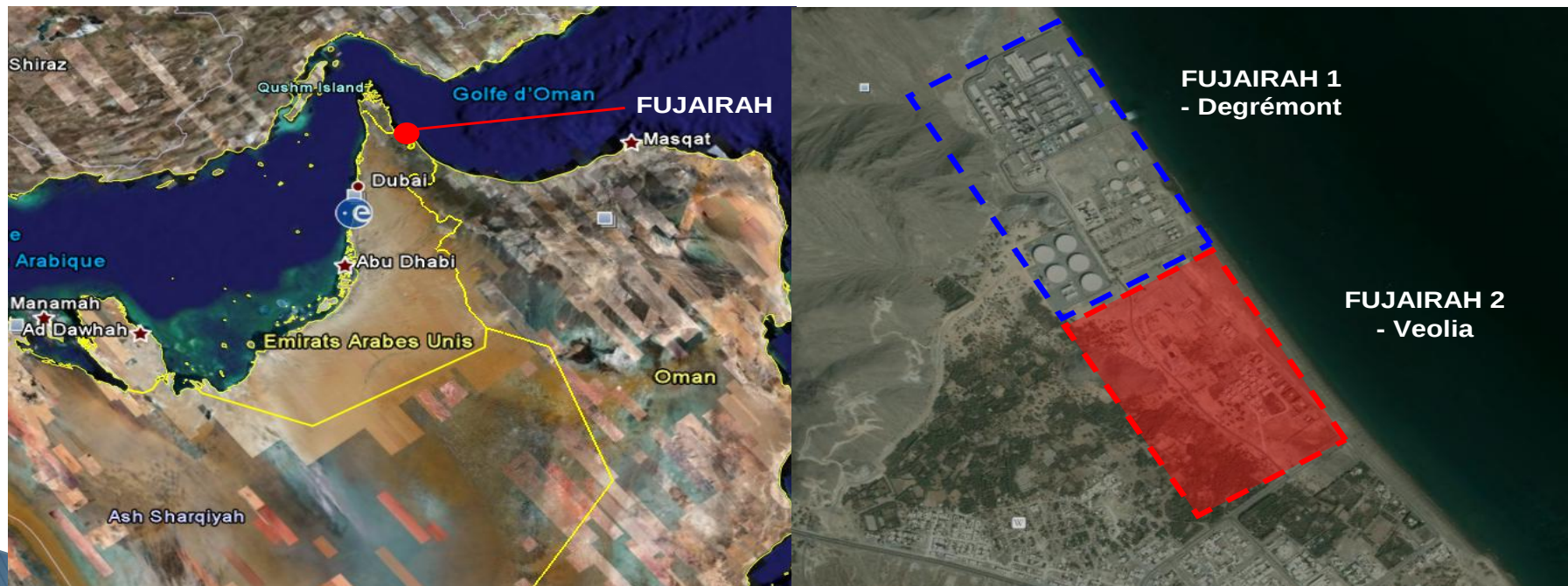


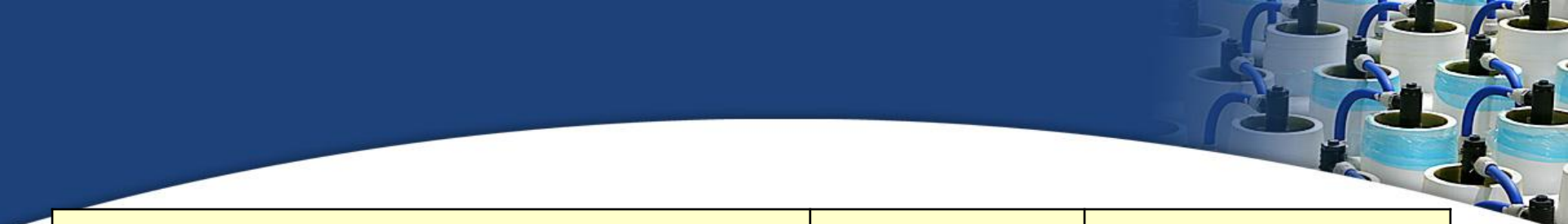
Gold Coast Desalination Plant



3. Case of Fujairah (UEA)

Fujairah power and desalination plant (F1 and now there is F2) is a hybrid plant at Qidfa', Fujairah in the United Arab Emirates. It is located next to the Qidfa Power Station 5 kilometres (3.1 mi) south of Khor Fakkan and 20 kilometres (12 mi) north of the city of Fujairah. The Fujairah plant is the first hybrid plant in the Middle East, and the largest desalination hybrid plant in the world.



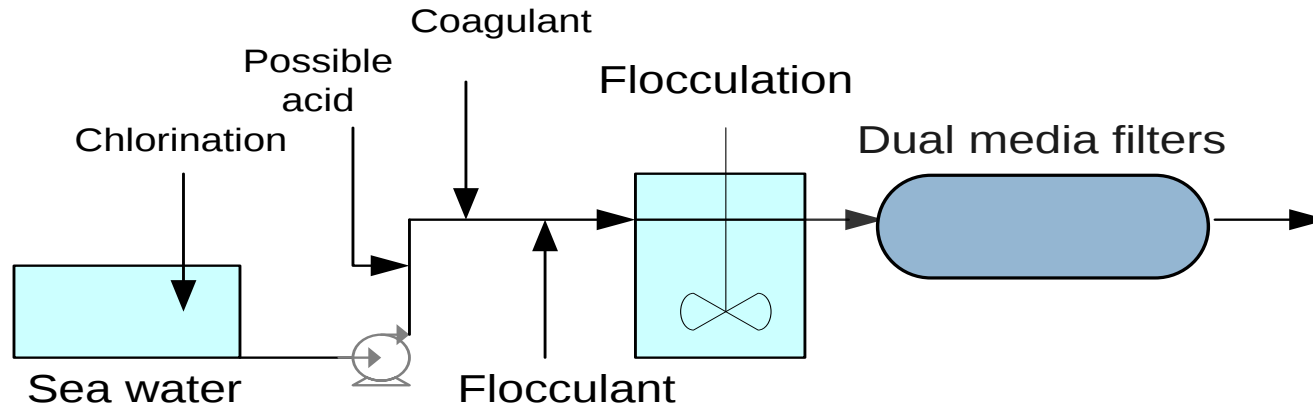


Water flow rate base solution	m3/day	365 882
Hourly flow base sol	m3/h	15 245
Produced Flow	m3/day	136 800

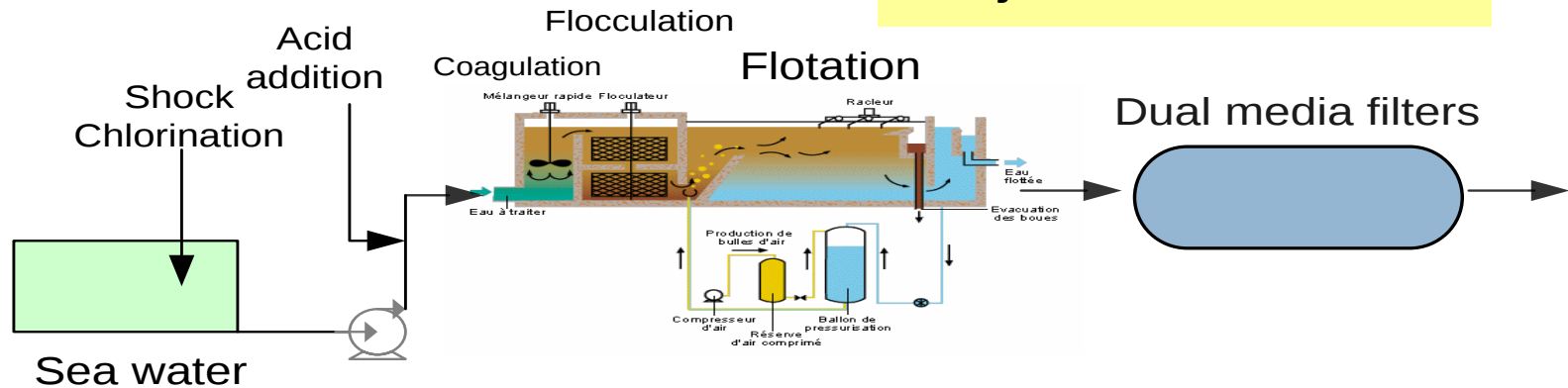
Parameter	Units	Design analysis parameters
Temperature	°C	22-33
pH		8.05
Turbidity	NTU	3.33 (max)
TDS (Total Dissolved Solid)	ppm	40,500
SDI (Silt Density Index)	%/min	14.4 -28
Total Petroleum Hydrocarbon Content	ppm	< 0.1

3. Case of Fujairah (UEA)

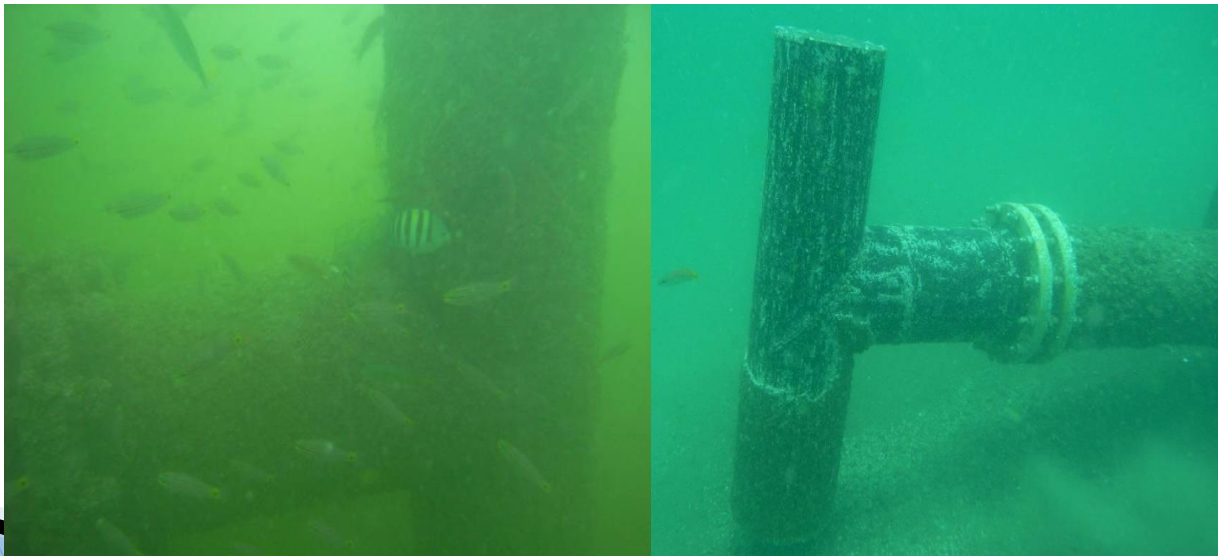
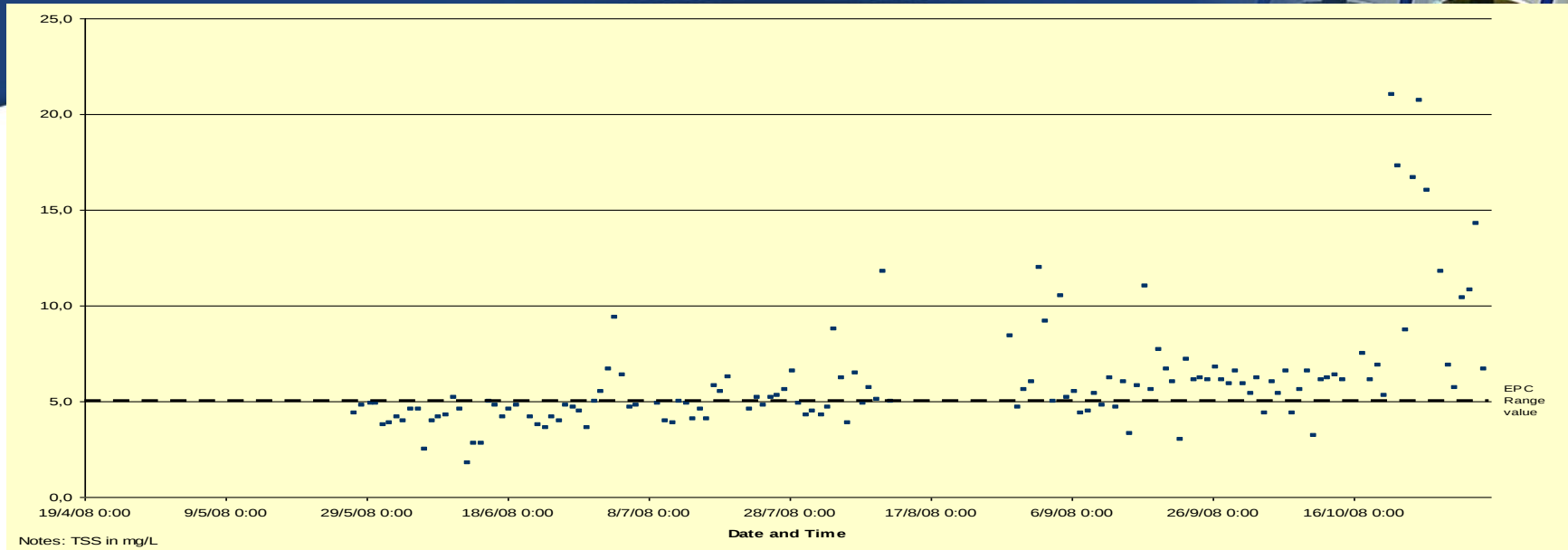
Fujairah 1 : existing Plant



Fujairah 2 : new Plant



3. Case of Fujairah - Seawater TSS monitoring



Exceptional bloom algae

- ▶ “The 'red tide' happens every year but, for a number of reasons, this year it has been the worst for years. The size and spread of the occurrence has adversely affected fishing and tourism industries.”
- ▶ Saif Mohammad Al Shara, Director of the East Region Office for the Ministry of Environment and Water
- ▶ Gulf News, 18/11/08

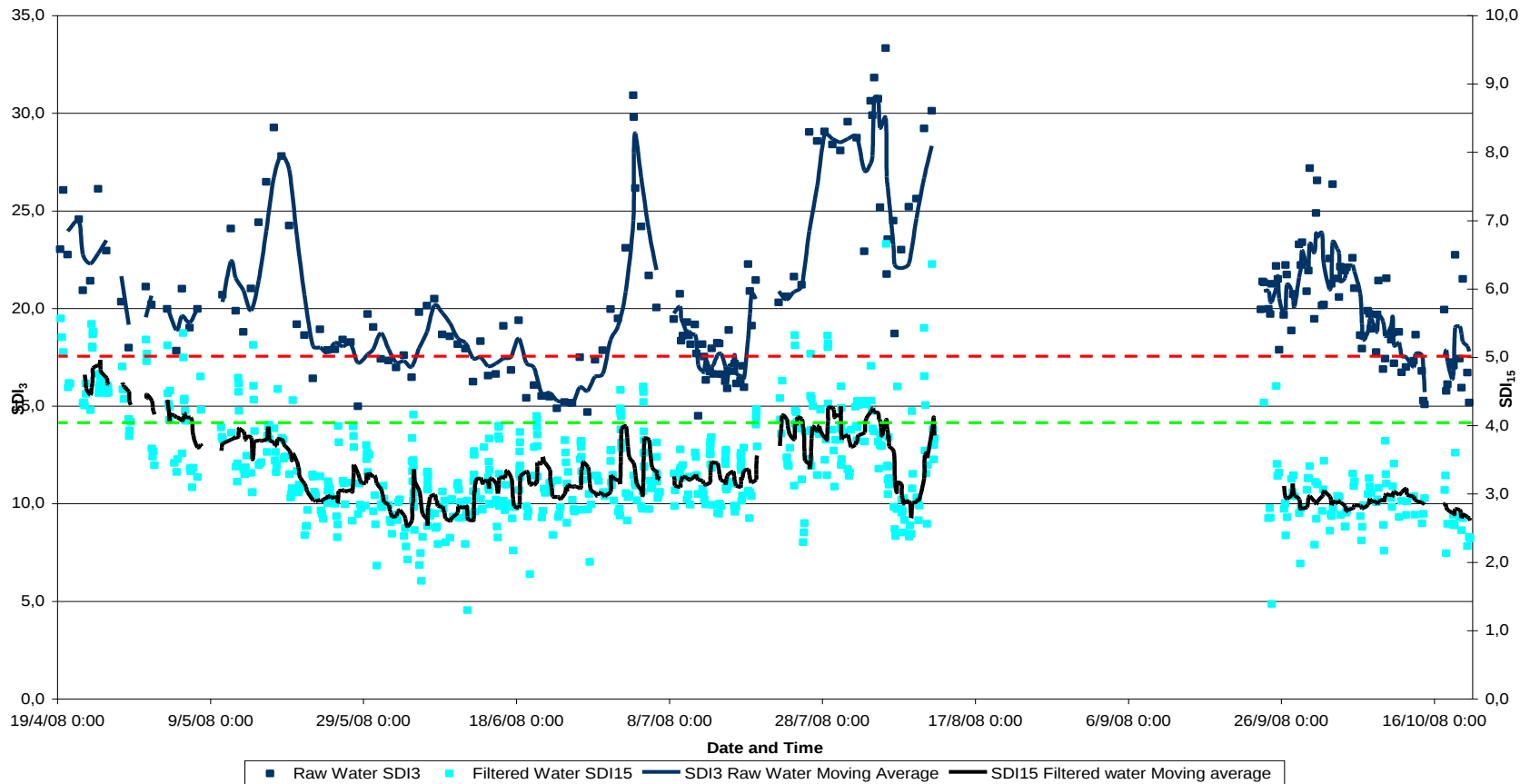




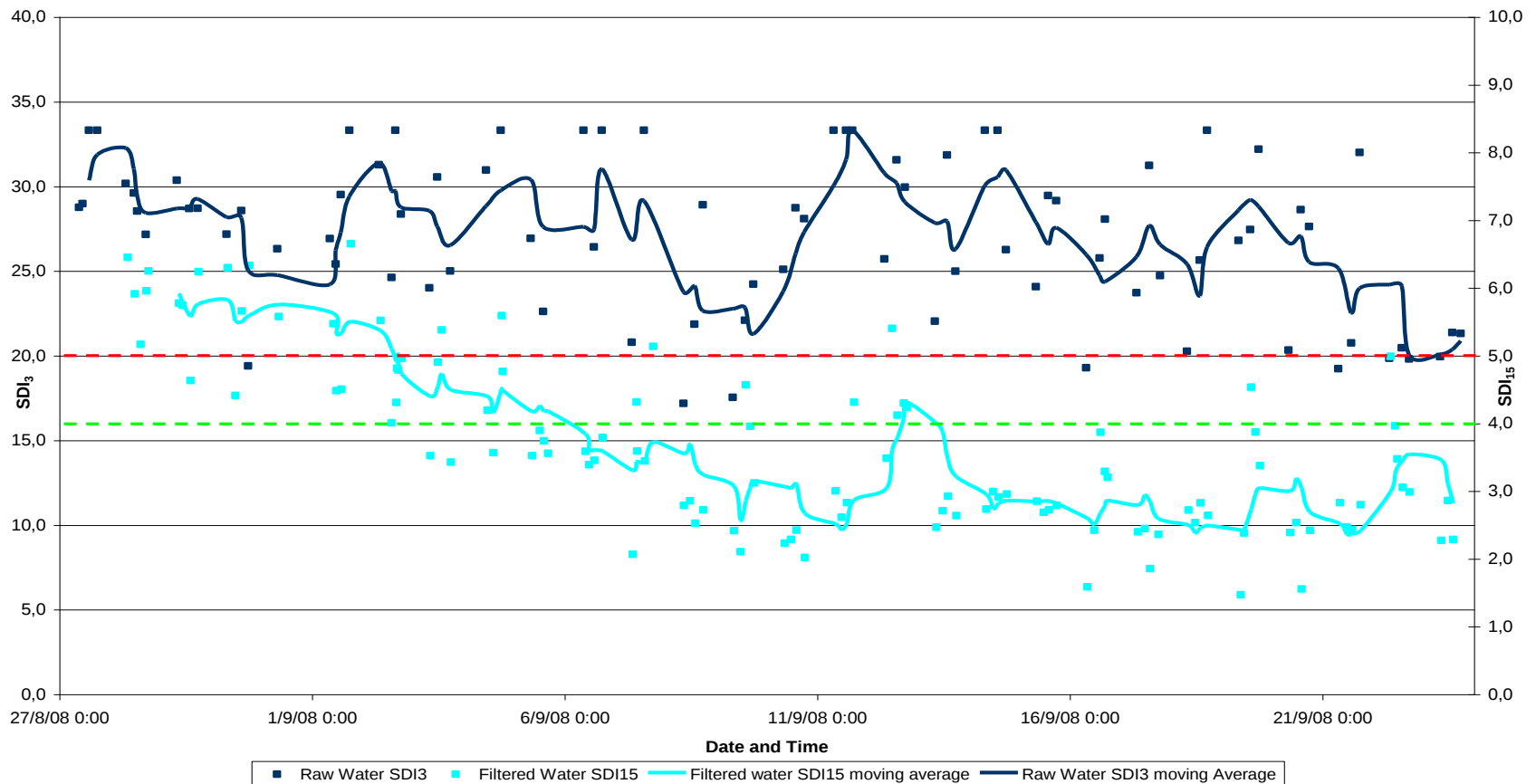


SDI during the complete two normal periods

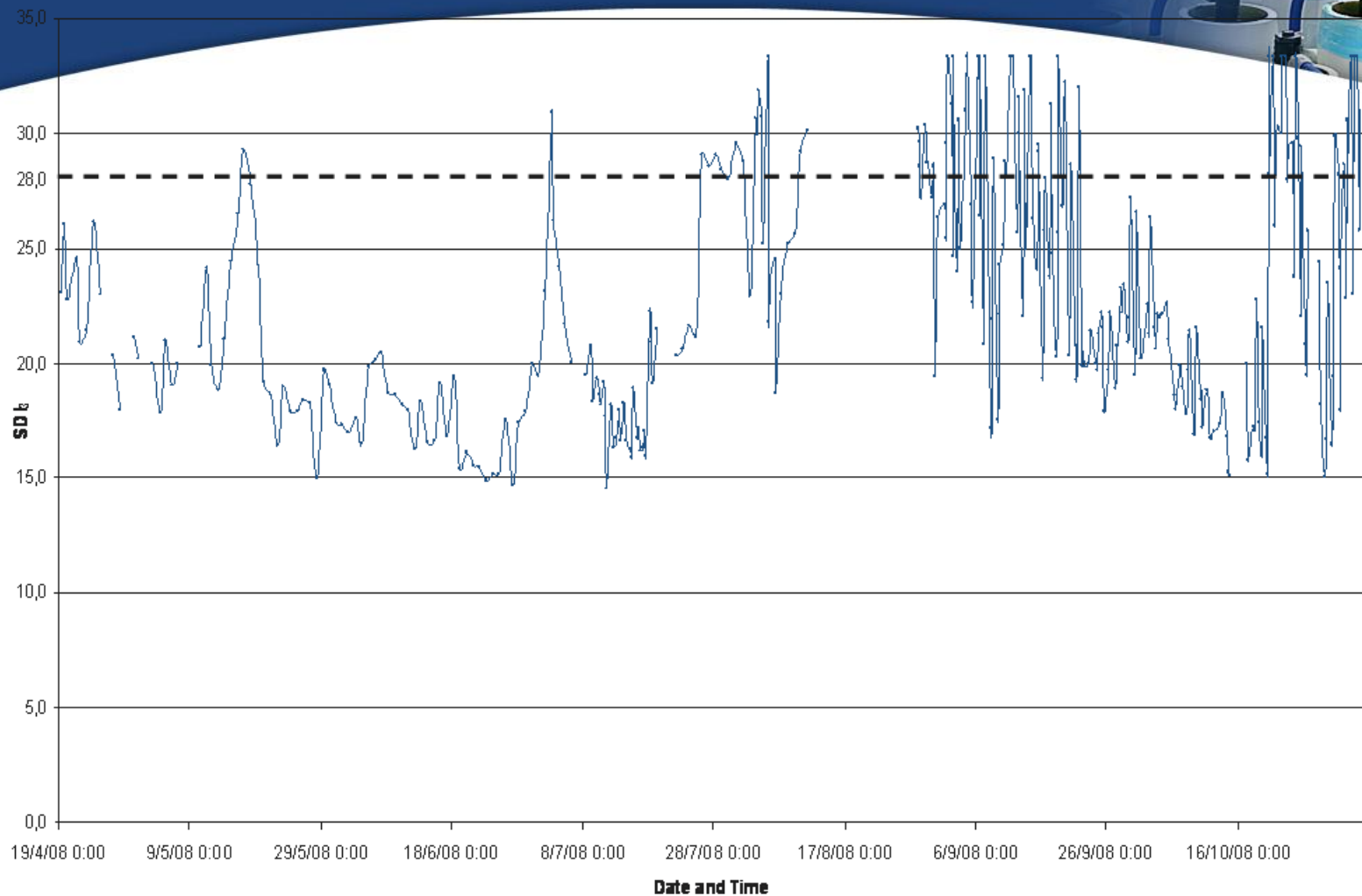
SDI



SDI

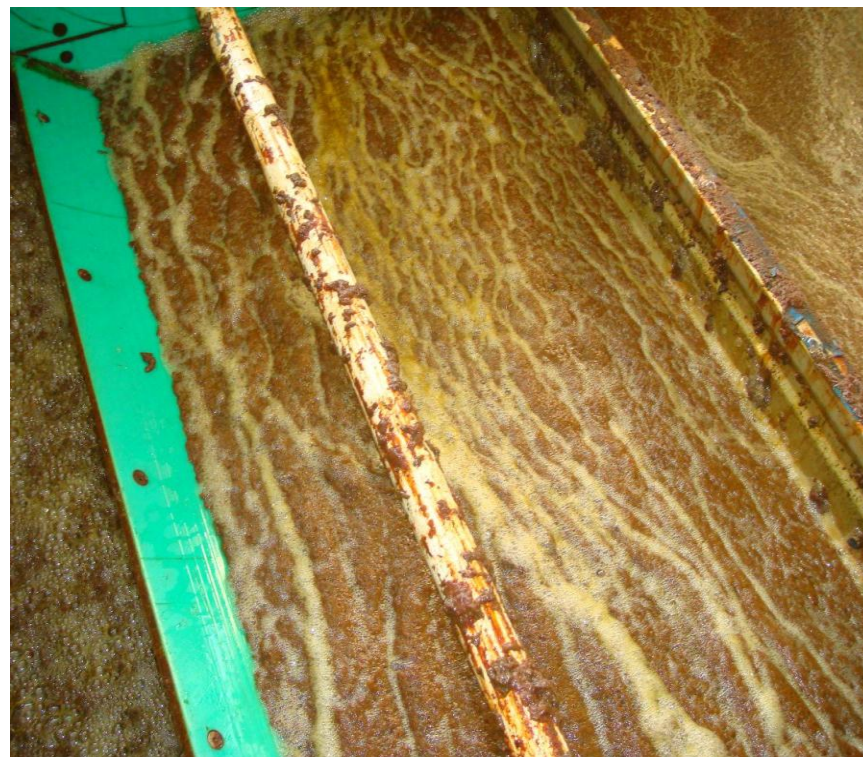


Seawater SDI3



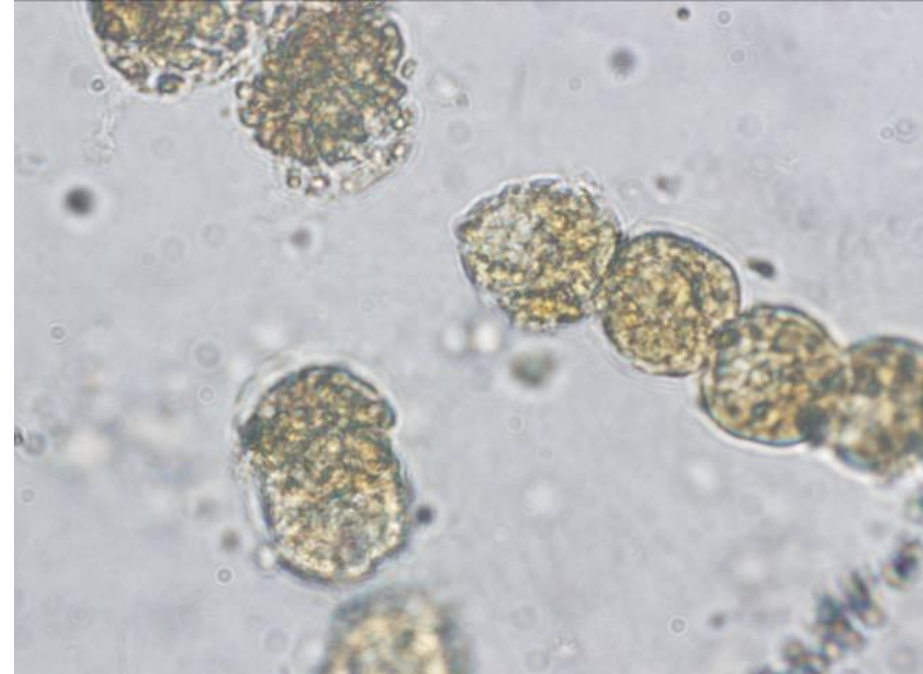


**Surface of the floatation tank
during normal operation**



**Surface of the same floatation tank
during a red tide event**

Seawater Quality



- ▶ “Red tide” aka “Harmful Algal Bloom”, caused by the phytoplankton specie *Heterosigma sp.* (class Raphidophyceae).

Courtesy of Elise Marquis, Research Associate at the United Nation University, Dubai. Used with permission.



3. Case of Fujairah : objectives of Pilot plant in conformity

Objectives:

❑ Chemicals dosing:

H_2SO_4 : < 25 mg/L as pure product

FeCl_3 : < 7 mg/L as Fe in the first coagulation step

FeCl_3 : 0 to 0.5 mg/L as Fe in the second coagulation step

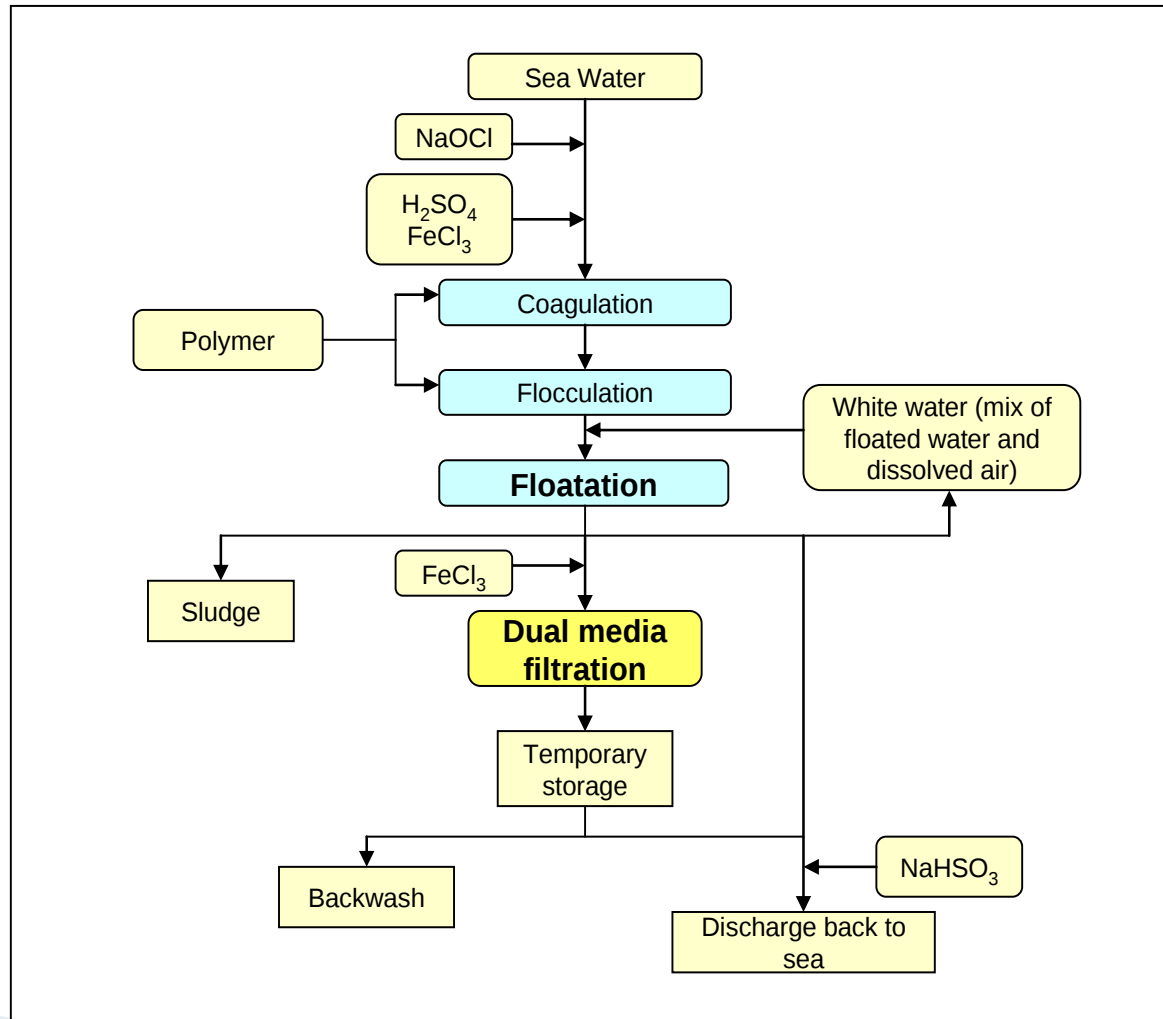
❑ Filtered water quality:

SDI(15 min) less than 5 at all time

SDI(15 min) less than 4 more than 90% of the time

❑ Filtration cycle longer than 40 hours

Fujairah : ▶ Pretreatment diagram



Conclusion

- ❑ A proper pre treatment is therefore considered to be the key to successful RO plant operation
- ❑ The choice of the pre treatment depends of the raw water quality and its evolution during the year.
- ❑ All the parameters have to be considered (red tide & bloom algae, hydrocarbons, TOC, T°C) and not only Turbidity and SDI.
- ❑ Pilot plant is recommended whenever it is possible.
- ❑ The data collected by Veolia over the past 10 years allows us a good understanding of the phenomena that occur in seawater, and helps us offer the best solution