Submerged Membrane Bioreactors : Recent Applications in the Gulf Region

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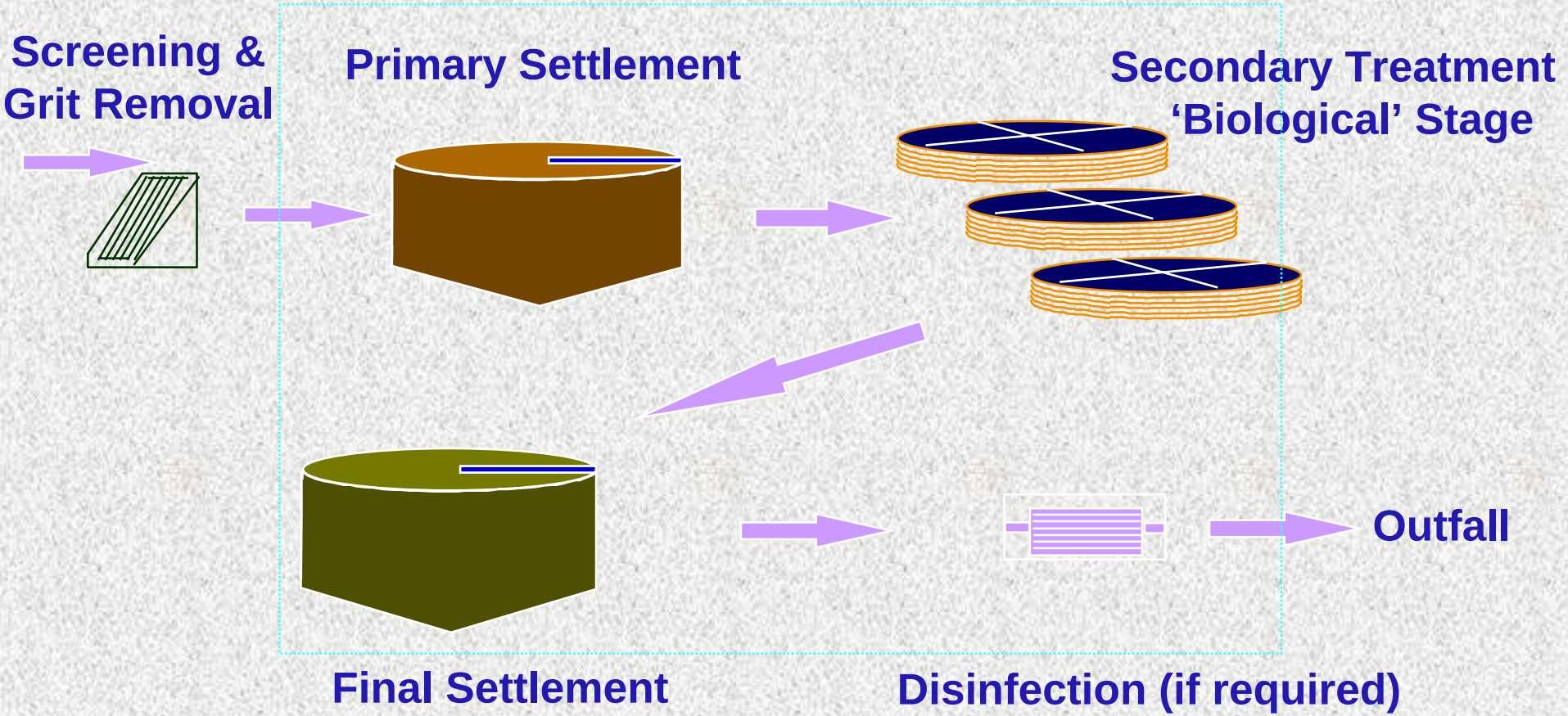
Overview

- An Introduction to Submerged Membrane Technology
- Middle East Installations, including Al Ansab
- Conclusion

An Introduction to Submerged Membrane Technology

- Pilot plant and testing from 1989
- First commercial plant commissioned August 1991
- First MBR Technology treatment plant 1995
- Over 1000 plants are operational or under construction (Kubota)

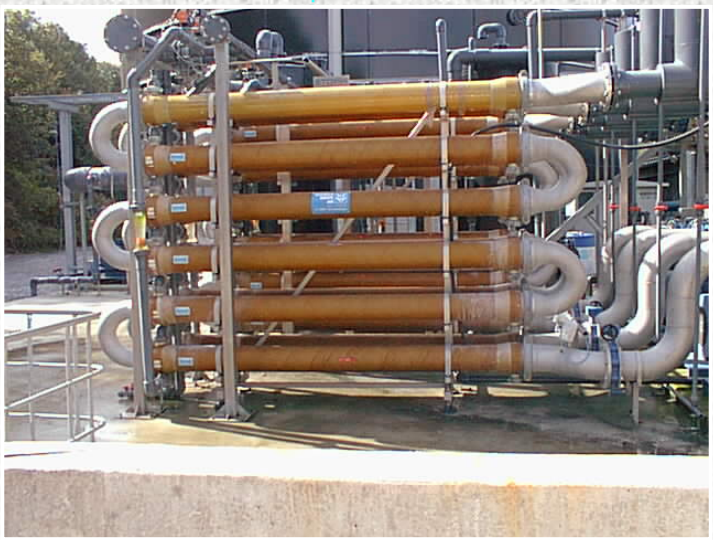
SMBR : Overcoming inherent weakness in conventional design



SMBR : 1st Generation MBR

Screening &
Grit Removal

Secondary Treatment
'Biological' Stage



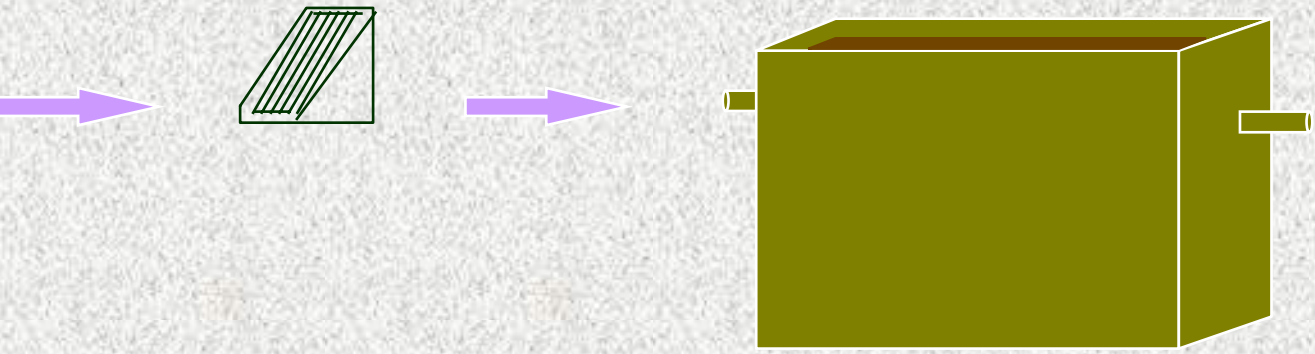
Reuse

'Rack and tube' membranes

SMBR : 2nd Generation - One step Submerged Membrane Technology

Screening & Grit Removal

Combined Treatment Stage

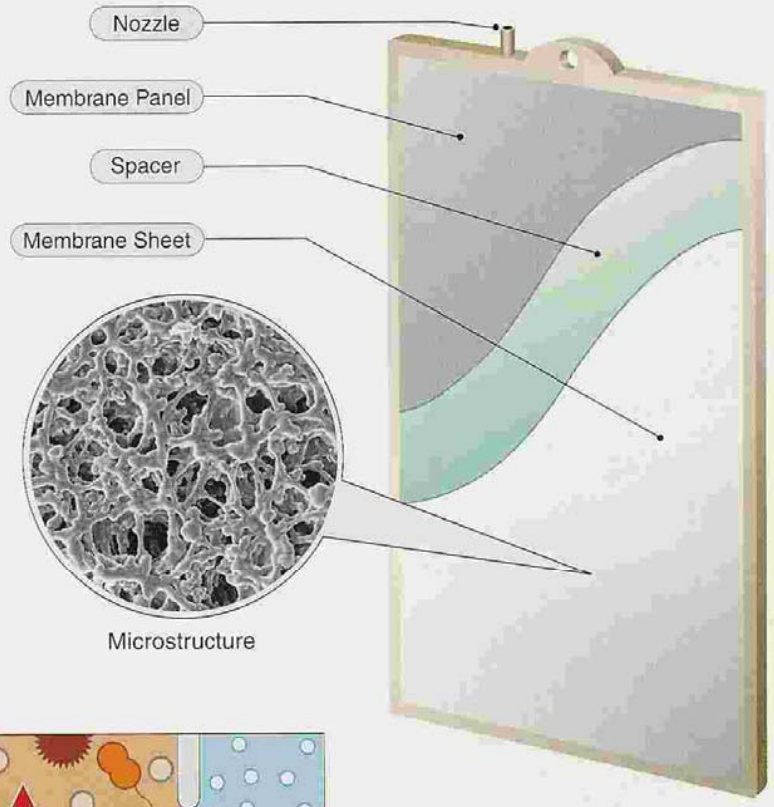


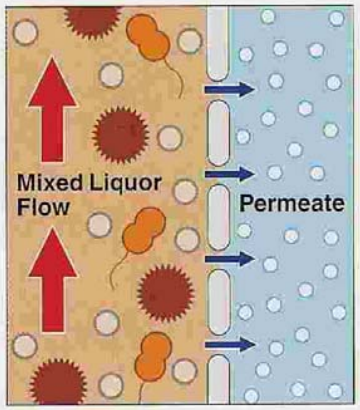
Reuse

(disinfected effluent)

SMBR Intro

- The Membrane...
  - > 1000 installations
  - Operating since 1990
  - Title 22 approved
  - Membrane Life > 10 years



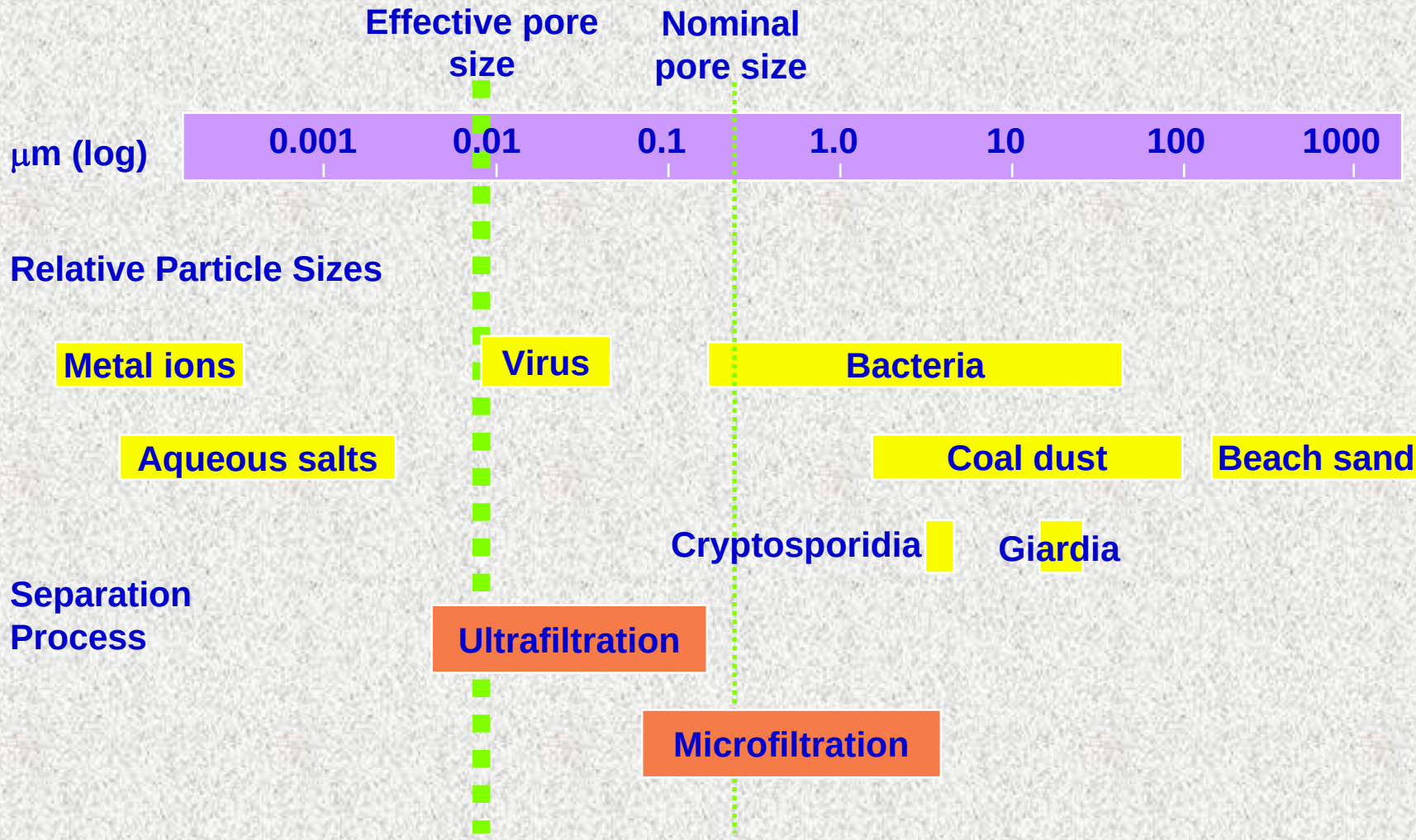


Cross Flow Filtration

Mixed liquor flows parallel to the membrane surface, while water permeates through the membrane.

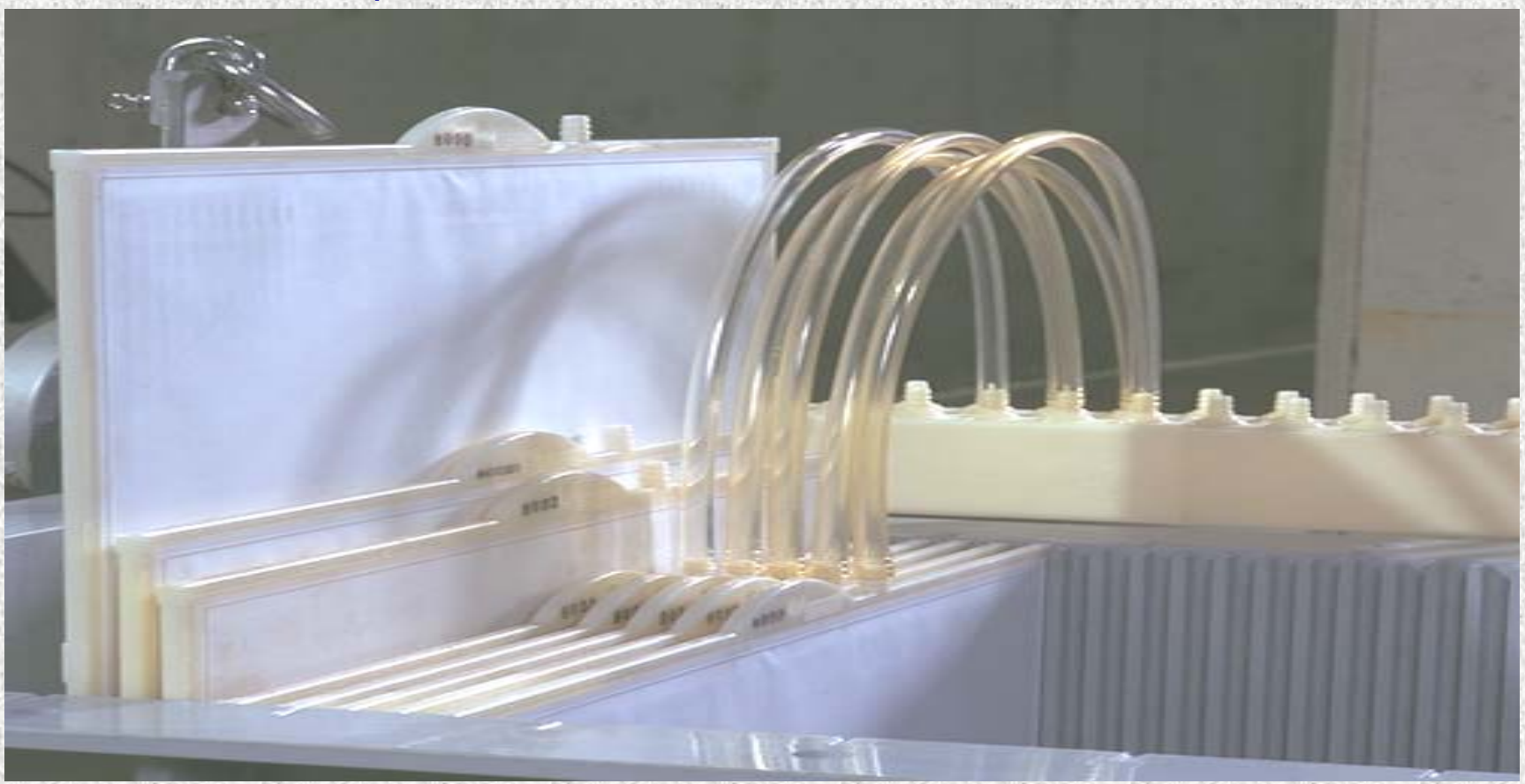
Cross flow prevents the membrane surface from fouling.

SMBR Intro : Title 22



SMBR Intro : The membrane panel

Membrane unit and panels

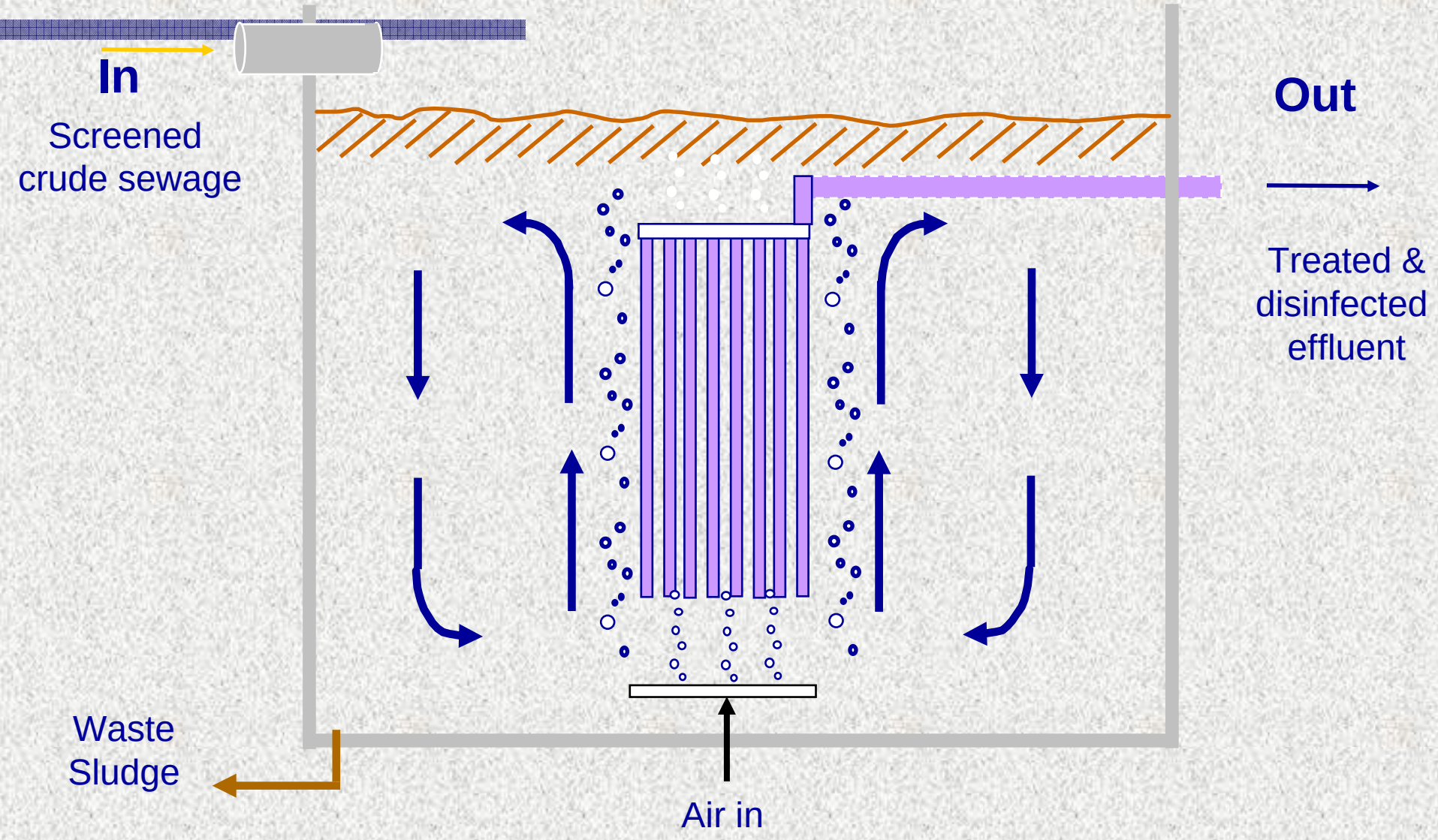


SMBR Intro

Membrane filtration top section

Diffuser aeration lower section

SMBR Intro : Principle of Operation



SMBR Intro : Principle Advantages

- **High Effluent Quality**
  - < 3 mg/L BOD
  - < 1 mg/L Total Suspended Solids
  - < 1 mg/L Ammonia-N
  - < 2.2c/100mL Total Coliforms (Title 22 approved)
  - < 1/L parasite
  - < 0.1 mg/L Total Phosphorus*
  - < 3 mg/L Total Nitrogen*
  - < 0.2 NTU Turbidity

SMBR Intro : Principle Advantages

- **Plant footprint**
  - High MLSS operation (not gravity dependent)
    - No clarifiers, smaller volume aeration
    - No separate sludge digestion
  - Much reduced sludge production
  - Sludge produced is stabilised and mineralised
  - System able to handle shock loadings

Priniciple Advantages of MBR

- **Simple Operation**
  - One step process
    - Gravity system – no suction pumps
    - no daily chemical requirements
    - No daily maintenance requirements
    - Plants designed to be operated remotely
- **Retrofittable**
    - Enhance existing assets

SMBR Intro: Why MBR is popular...

- **Proven Performance**
  - > 10 Years operation
  - > 1000 plants operating (Kubota)
- **Proof of extended membrane life**
  - > 10 years continuous operation
- **Dramatically reduced cost**
  - 60% reduction in membrane cost in last 2 years

Aquator in The Middle East

- SMBR has arrived to The Middle East
  - Proven performance at plants operating in similar conditions, like BAT (Turkey), QVC (Qatar)
  - Continuing decrease in costs
  - Growing acceptance of technology
  - Growing number of reference sites
    - Demand for high quality effluent
    - Easy to operate/maintain
    - Low footprint

Middle East Installations

- Tubli Bay Pilot Trial (Bahrain)
- BAT Combined Industrial Plant (Turkey)
- QVC Industrial Plant (Qatar)
- Abu Dhabi Containerised Plant (UAE)
- Almarai Dairy ETP (Saudi Arabia)
- Almarai STP (Saudi Arabia)
- Al Ansab Water Recycling Facility (Oman)

Tubli Bay Pilot Trial, Bahrain

- 12 months operation to October 2002
- Demonstrate effective operation > 40degC
- Demonstrate removal of parasites
- Demonstrate longevity of membranes in high temps
- Result
  - Approval by Bahrain ministry

Tubli Bay Trial

- 10 panel unit
- 5m^3/d flow
- Sidestream from Tubli Bay WWTP
- Cylindrical stainless steel vessel

Tubli Bay Trial – Summary of Results

			Average Result	S.D.
Influent	**Total Suspended Solids**	**mg/L**	**3660**	**888**
	pH		**7**	**0.2**
	Conductivity	**uS/cm**	**4700**	**307**
	Total Suspended Solids		**5.6**	**4**
	COD	**mg/L**	**25**	**10**
Permeate	**BOD_5**	**mg/L**	**0.8**	**1**
	Ammonia-N	**mg/L**	**0.45**	**2**
	Parasites	**no/L**	**0**	**0**
	Coliforms	**no/500mL**	**0**	**65**
	Coliforms - errors removed	**no/500mL**	**0**	**1**

Notes

1. Total Suspended Solids results impacted upon by high salt levels, true reading ~ 1-2 mg/L

2. A total of 50 samples from 22 May to 21 July, were taken to provide the above results.

BAT Industrial Plant

- Combined Cigarette/Domestic Waste
- 680m^3/d Daily Flow
- COD ~ 2000 mg/L
- TSS ~ 550 mg/L
- Client : British American Tobacco
- Location : Izmir, Turkey
- Status: Operational since October 2002

BAT Turkey

- 800 no membrane panels
- Additional fine bubble aeration to cater for industrial load
- Full reuse on site

BAT Industrial Plant, Turkey

Qatar Vinyl Industrial ETP

- Existing plant – poor settling sludge
- MBR Retrofit to retain biomass and increase effluent quality
- Design Flow : 320m^3/day
- Client : Technip (Rome)
- COD ~ 2,000mg/L
- Cl^- ~ 10,000mg/L
- Location: QVC, Messaid Industrial City, Qatar
- Status: Operational since November 2003

QVC

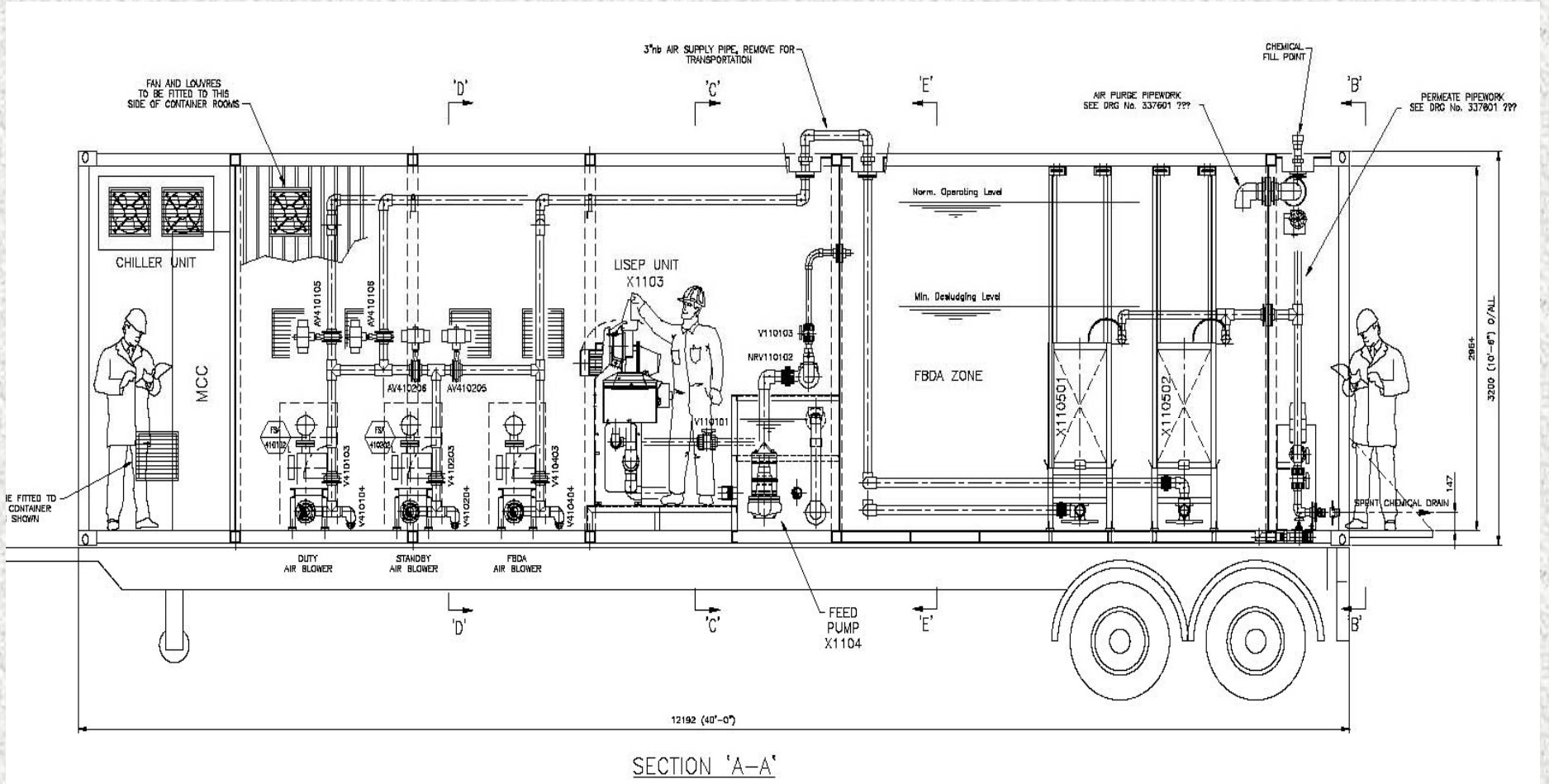
- 40’ ISO shipping container plant
- Preassembled in Dubai prior to shipment to Qatar
- Connection with minimal disruption to existing

Qatar Vinyl Industrial ETP

Abu Dhabi Containerised Plant

- 150m^3/d domestic waste, constant flow
  - Approx 600 persons
- 40’ ISO shipping container equivalent
  - Ease of transport / construction
- Fully enclosed screenings area, including screenings washing/compaction for non-odourous operation
- Status: Under construction, commissioning Mar 2004

Abu Dhabi Containerised Plant, UAE



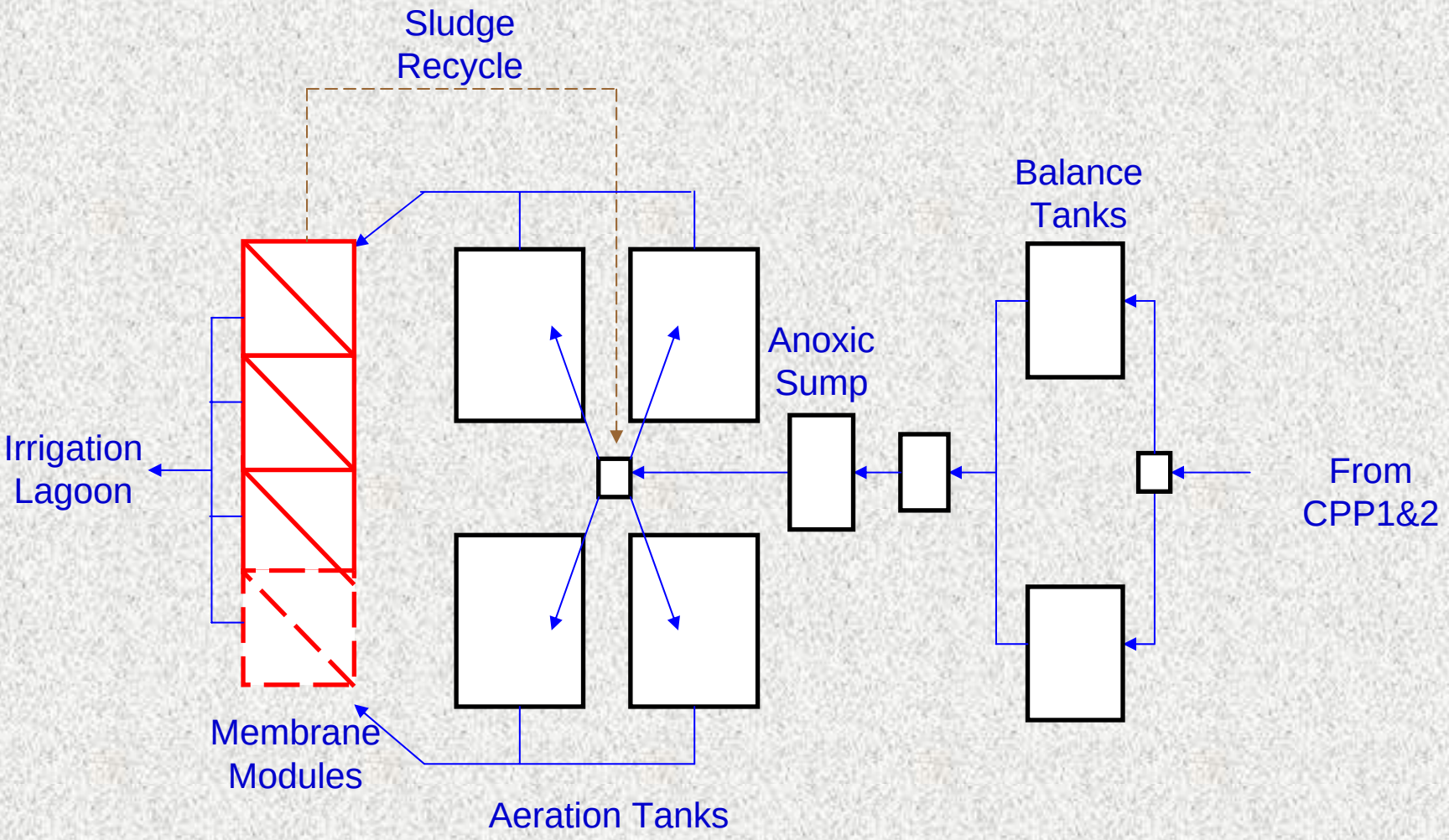
SECTION 'A–A'

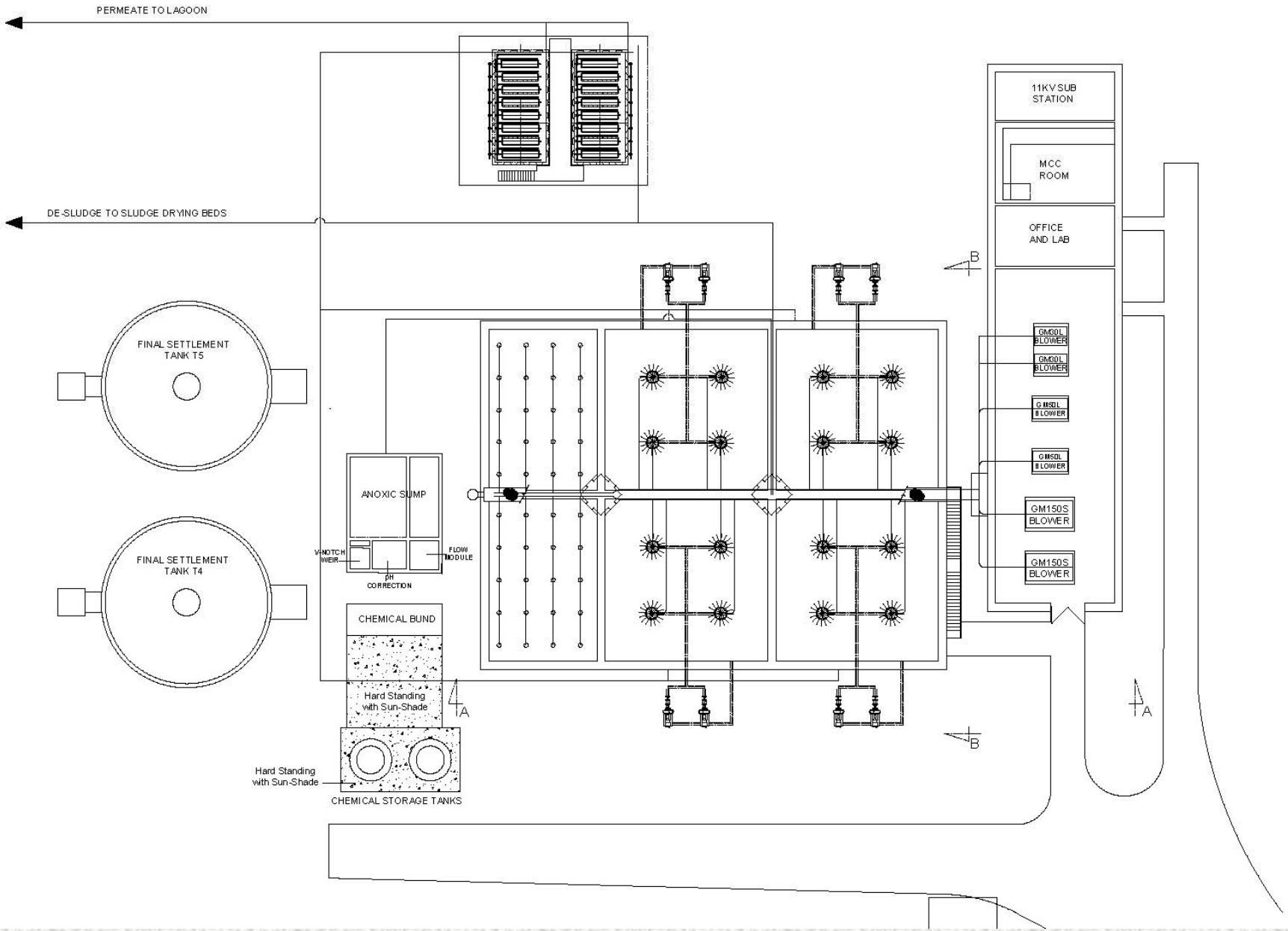
Abu Dhabi Containerised Plant, UAE

Almarai Industrial Plant, KSA

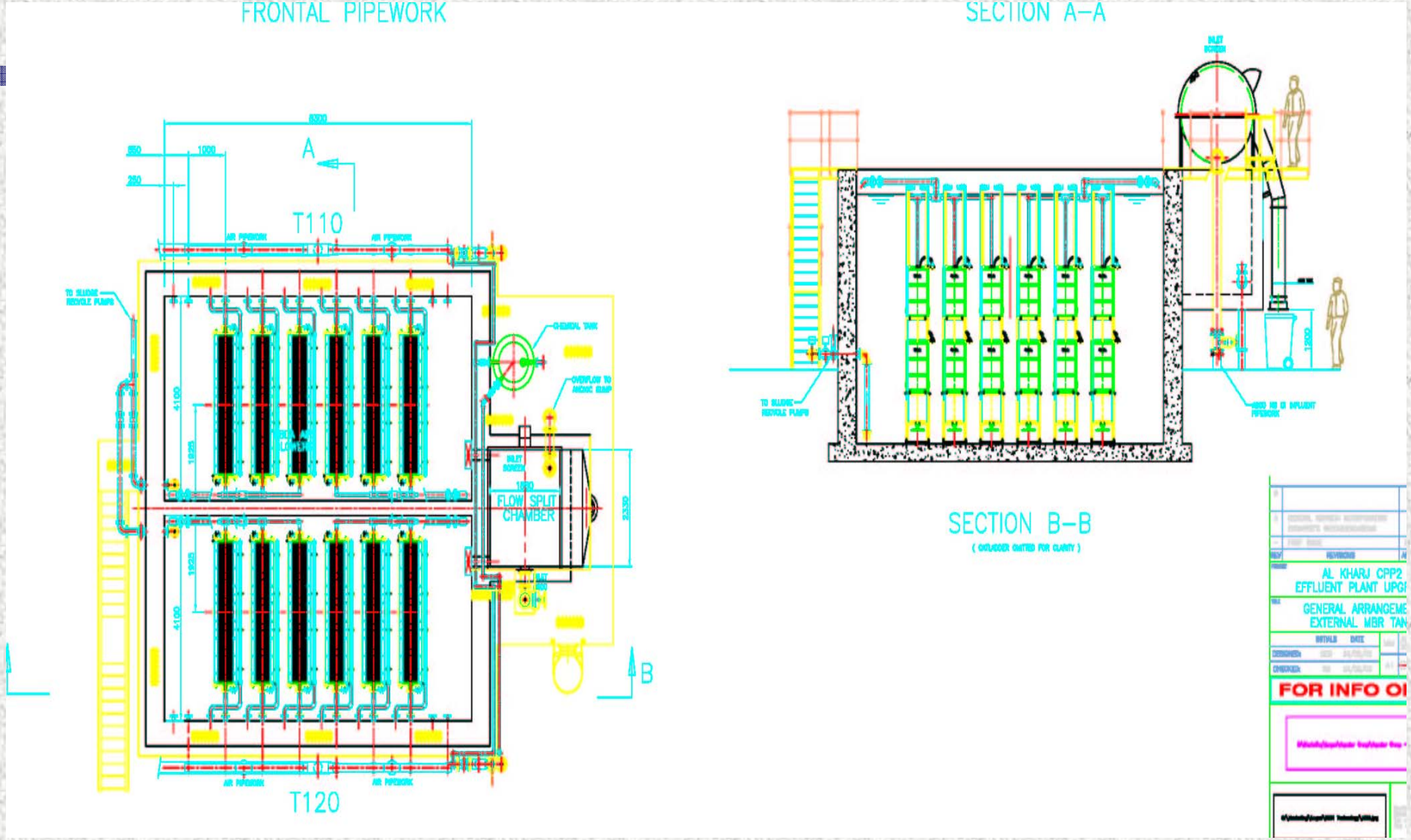
- Waste from dairy operations, Al Kharj
- Full flow 4000m^3/d
- 12 no. EK400 membrane units (up to 16)
- COD ~ 2000mg/L
- Retrofit of existing conventional plant
- Client : Saudi Berkefeld – Wetico
- End User : Almarai Corporation
- Status: Under construction, to commission Oct 2004

Almarai : Process Flow




PERMEATE TO LAGOON
DE-SLUDGE TO SLUDGE DRYING BEDS
11KV SUB STATION
MCC ROOM
OFFICE AND LAB
FINAL SETTLEMENT TANK T5
FINAL SETTLEMENT TANK T4
ANOXIC SUMP
V-NOTCH WEIR
FLOW MODULE
pH CORRECTION
CHEMICAL BUND
Hard Standing with Sun-Shade
Hard Standing with Sun-Shade
CHEMICAL STORAGE TANKS
GM30L BLOWER
GM30L BLOWER
GM50L BLOWER
GM50L BLOWER
GM150S BLOWER
GM150S BLOWER
A
A
B
B

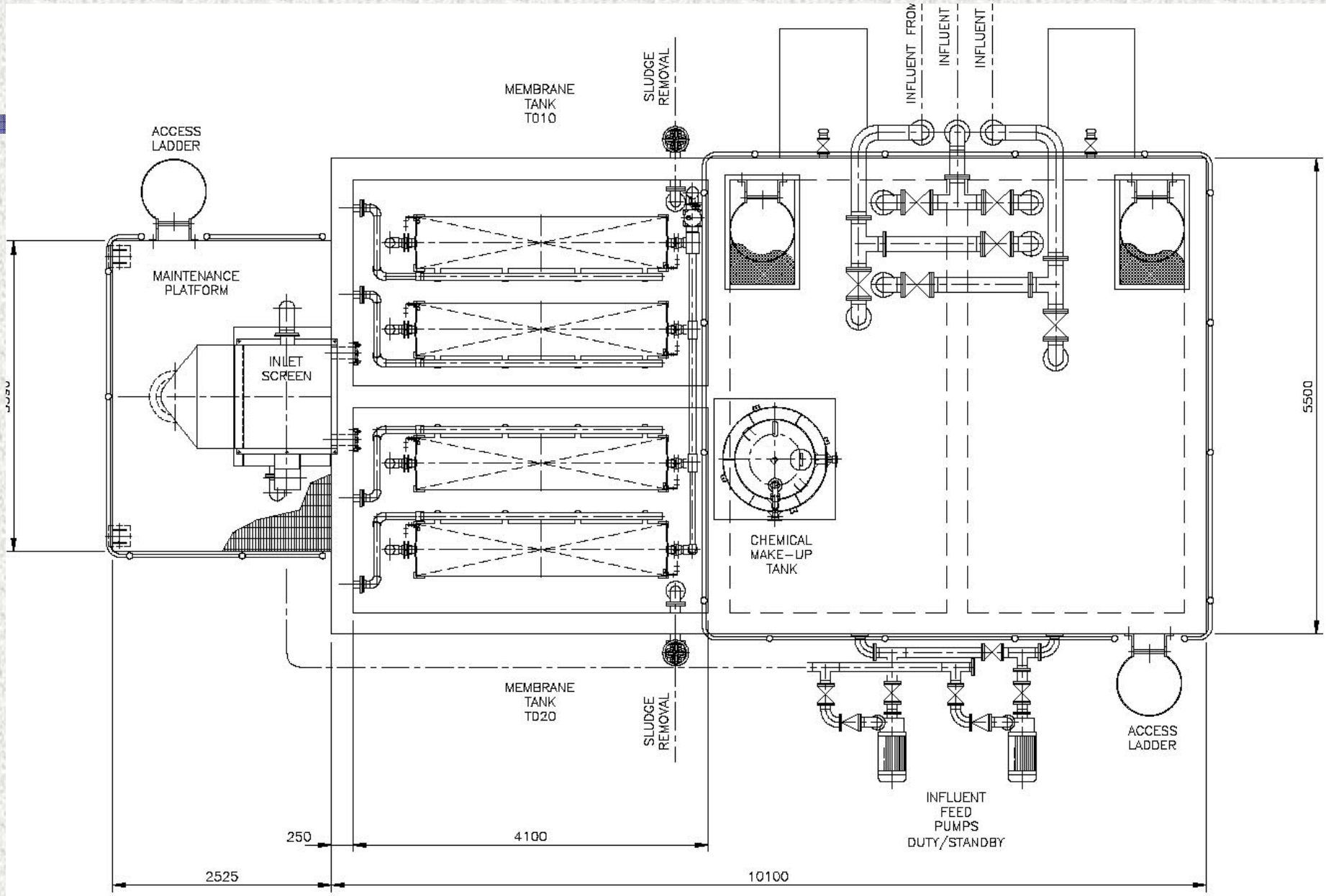
Almarai Industrial Plant, KSA



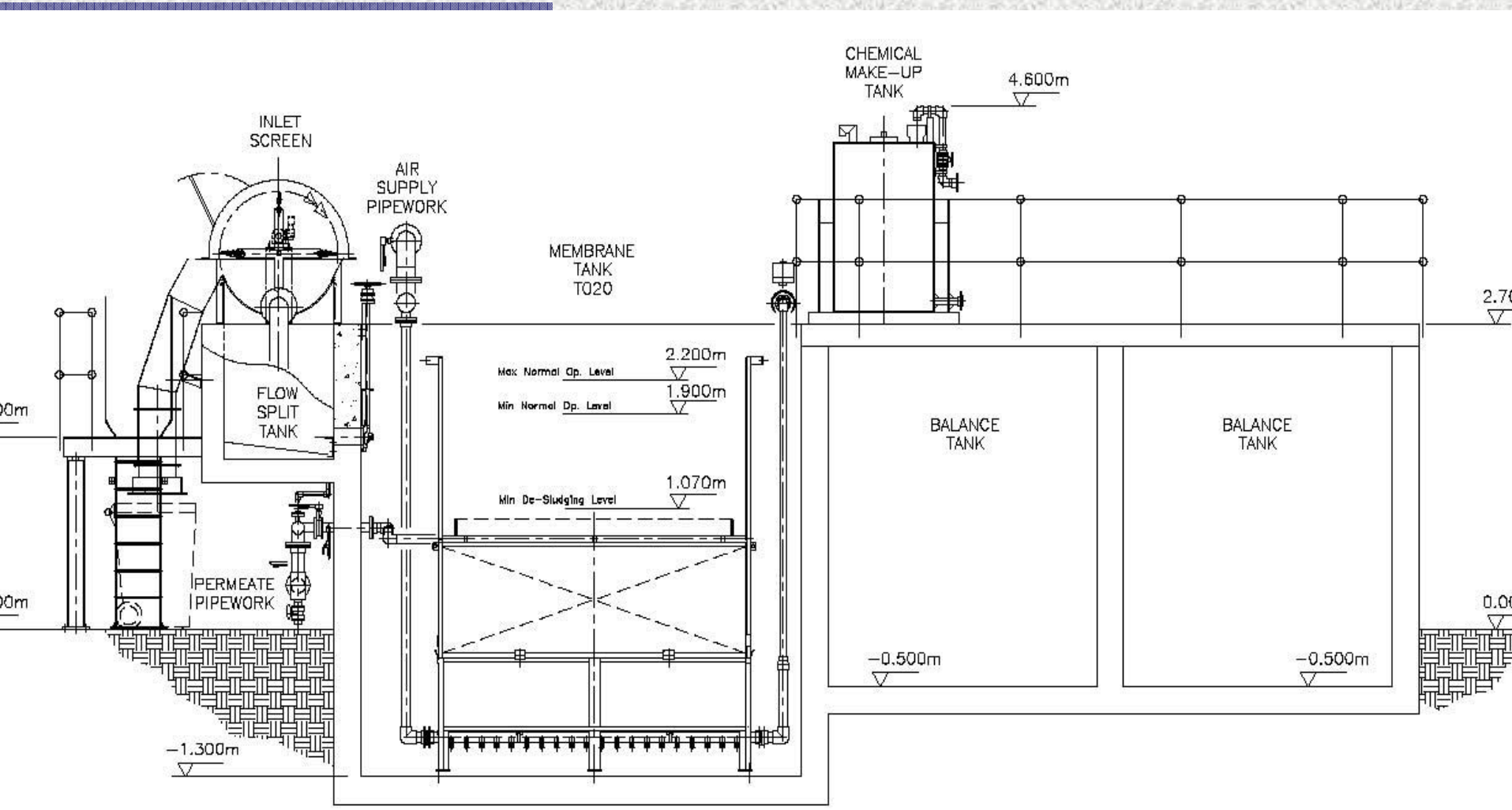
Almarai Domestic Plant, KSA

- Sewage waste from workers, Al Kharj
- Full flow 750m^3/d
- 4/6 no. ES200 membrane units
- Client : Saudi-Berkefeld WETICO
- End-User: Almarai Company Ltd
- Status: Under construction, to commission Oct 2004

Almarai Domestic Plant, KSA



Almarai Domestic Plant, KSA



Al Ansab Water Recycling Facility, Oman

- The worlds largest submerged membrane plant, to treat a daily flow of up to 75,000m^3/day
- Competitively tendered in Sept 2003
- Contract award December 2003
- Collaborative design between Metcalf & Eddy and Aquator
- Part of the ‘Muscat Water Plan’

Al Ansab : High effluent quality

- BOD < 10mg/L
- TSS < 10mg/L
- NH_3-N < 1mg/L
- NO_3-N < 8mg/L
- F.Coliforms < 2.2c/100mL
- Viable helminth ova < 1/L
- Turbidity < 2 NTU
- All at 95%ile limits

Al Ansab : Membrane Selection

- Membrane selection
  - EK400 units
- Operating mode selection
  - Gravity
- Number of units
  - 304 installed
- Number of panels
  - 121,600

Al Ansab : Membrane Design

- Principles
  - ‘Sub-critical’ operation
    - Ie No more than 2 no. chemical cleans per year
    - Ie minimise air usage
- Flux selection : 1.0m/d (41.5L/h.m^2) Instantaneous Peak
- Flux selection : 0.8m/d (33L/h.m^2) Peak Day
- Flux selection : 0.6m/d Average
- FFT treatable with 1 tank offline

Al Ansab Design : Membrane Control

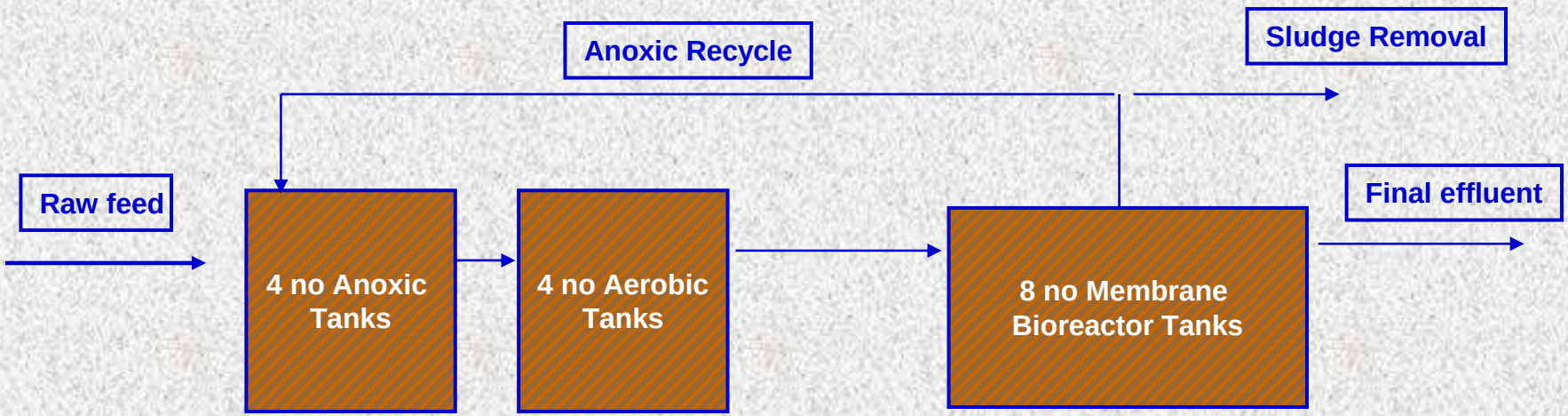
- Principles
  - -> Minimise change in MLSS
  - -> Minimise change in flux
- ‘Fixed’ level operation
  - ‘Look up table’
    - Water Level – Flux – Flow
  - Water level @ 4.6 – 4.8m

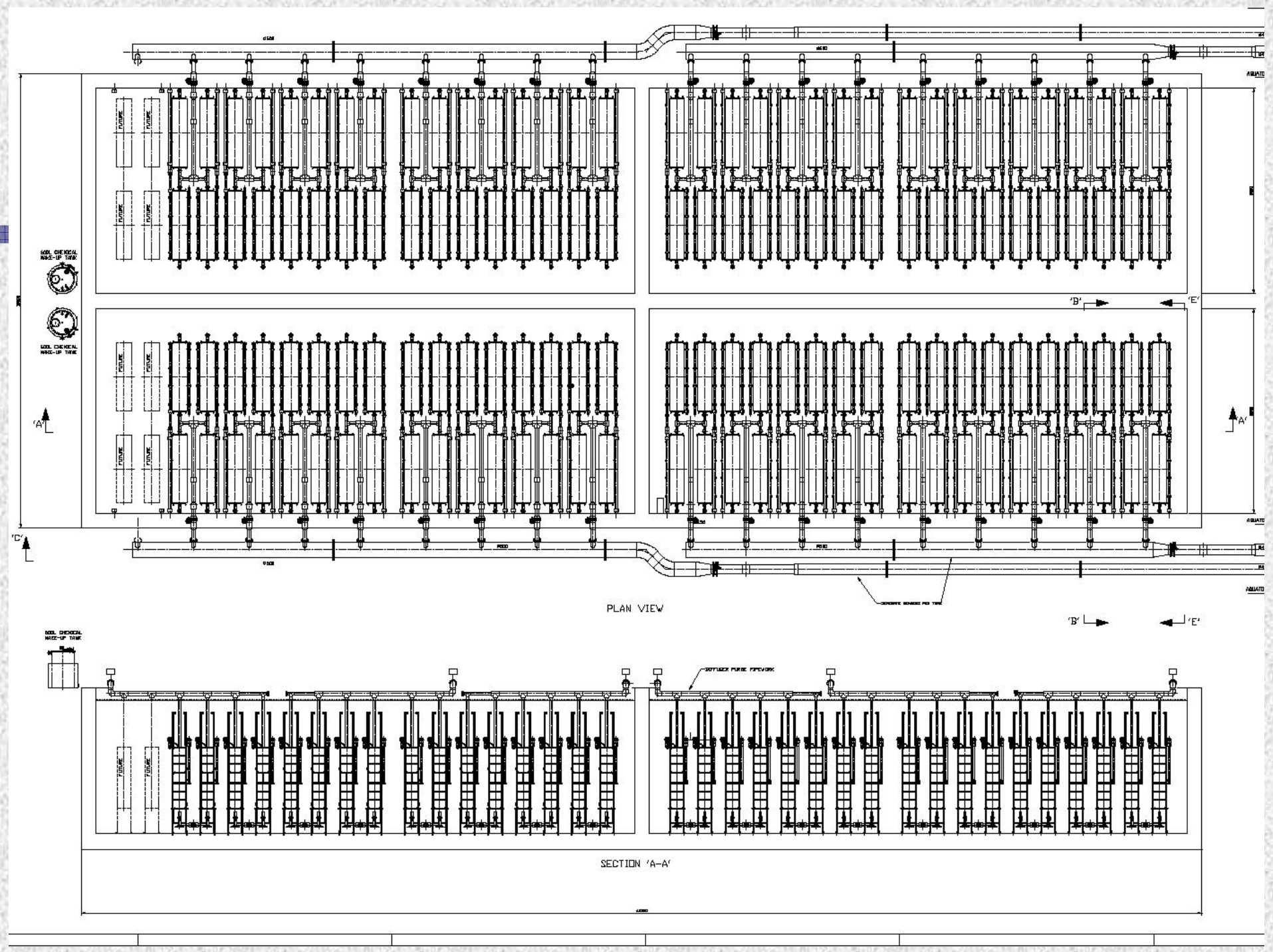
Al Ansab : Membrane Design

- Eight (8) tanks, each with 38 no membrane units, in 2 rows of 19 (capacity 22)
- Membrane units coupled into group of 4 for permeate withdrawal and air delivery
- Completely automatic chemical cleaning system
  - 2 * makeup tanks per 4 no membrane tanks
  - Automated valve delivery to permeate collection header
- Remote monitoring
- 5/10 Year Comprehensive Membrane Life Warranty

Al Ansab : Design Considerations

- BNR Design for Denitrification




'A'
'B'
'C'
'D'
'E'
FUTURE
PLAN VIEW
SECTION 'A-A'

Al Ansab : Design Output

- Overall tank footprint, including Anoxic, Aerobic and Membrane Zones is 150m * 50m – for a 300,000 person plant
- Plant commissioning expected Dec 2005
- Landmark project for the Middle East and MBR in general

Conclusions

- MBR is a well suited technology to the Middle East
- MBR has proven successful in the Middle East
- Due to Al Ansab, the Middle East is now leading the way in MBR application