Membrane Bioreactors (MBR)

The Irish Experience

Presentation to Engineers Ireland 17th Sept 2007

Presented By : Patrick Buckley Bsc :BBS
Manager of EPS Bison
Contact : pdbuckley@epsireland.com
bison@epsireland.com
www.epsireland.com

Presentation Overview

- Introduction to EPS Bison
- MBR Technology –History & Development
- MBR The Technology
- MBR Applications
- Case Studies
- EPS Bison Clereflo MBR Plants
- Operation & Maintenance
- Capital & Operating Costs
- Conclusions

EPS Bison

- Strategic Business Unit of EPS Group formed March 2002
- Specific Purpose of Design / Supply / Installation / Commissioning & Servicing of Packaged Treatment Solutions
- Product Range :

  Packaged Treatment Systems
  Packaged Pumping Stations
  Attenuation / Storage / Sprinkler Systems
  Interceptors/Separators / Grease Traps
  Septic Tank Retrofit Systems
  Rain Water Harvesting Systems
  Above Ground Engineered Vessels

EPS Bison

- Full Design & Provision of Turnkey Solutions
- Assistance from initial design stage through planning process to project delivery
- Assistance with all aspects of design for disposal including Assimilative Survey's and Discharge Licence Applications

MBR Technology History & Development

- First commercialised in 70's & 80's

  Small scale applications :

  On board ships

  Landfill leachate

  High strength industrial

MBR Technology History & Development

- Japanese Govt. initiative for initial development
- In Europe First Plant Porlock WWTP 1998 (3800pe)
- Büchel Germany 1999 (1000 pe)
- Rödingen Germany 1999 (3000pe)
- Karst Germany 2004 (80000pe) largest
- In 2005 estimated 10 industrial / 2 municipal in Ireland

MBR Installations By EPS

- As of Sept 2007 EPS Installed / Under construction

Wastewater

- Industrial - 4
- Municipal - 11
- Package - 11

Water

- Municipal – 2 (UF)

Estimated European Installations (1990-2005)

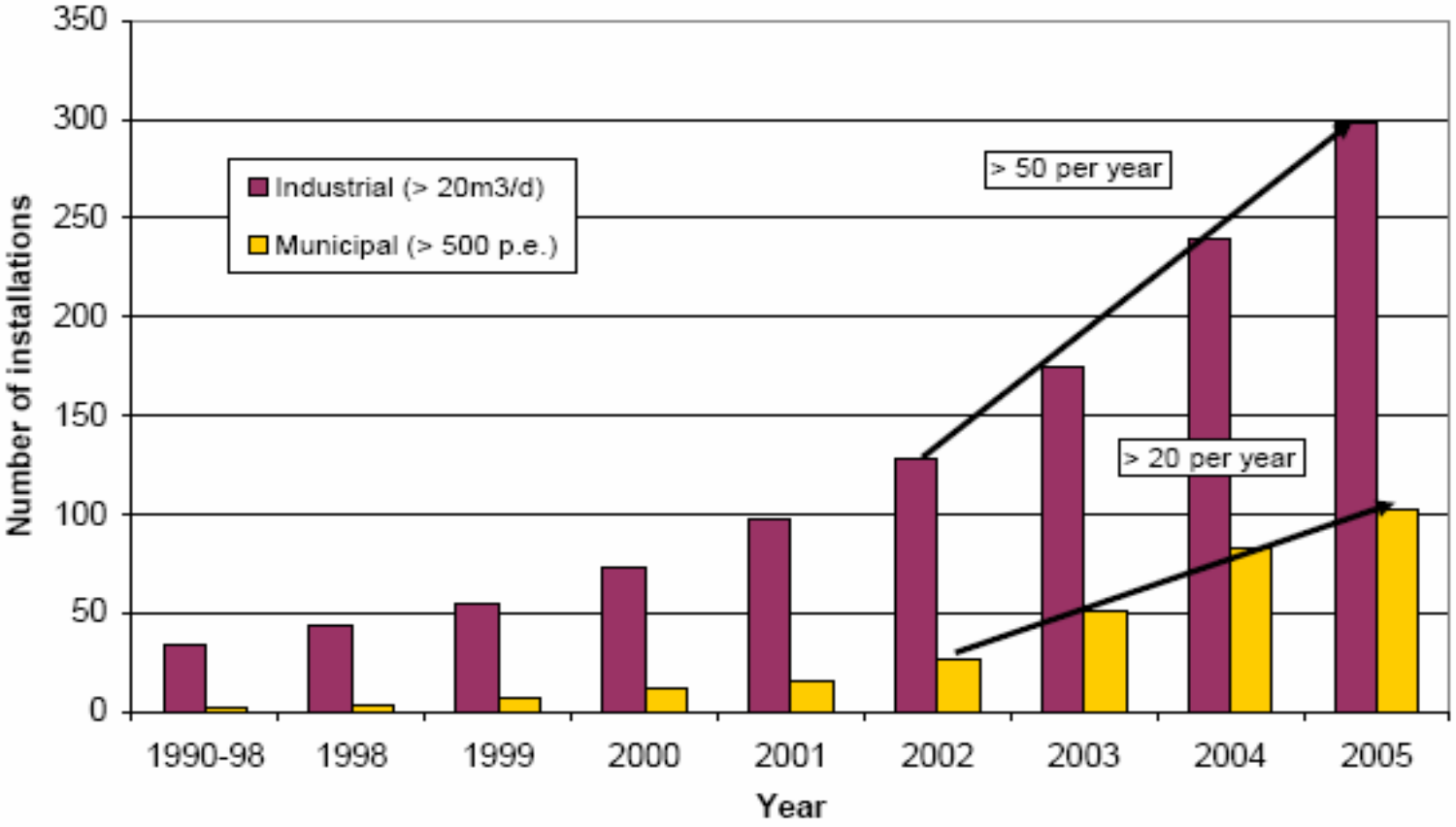


Figure 1. Development of industrial and municipal MBR markets (402 references in graph).

MBR The Technology

Types Of Membrane

- Flat Sheet
- Hollow Fibre
- Tubular Membranes
- Kubota Submerged Flat Sheet
- Others (39 approx)
  Norit x – flow / Berghof / Memos /Zenon
  Toray / Kms – Puron etc

The Product

What is MBR Technology?

Membrane filtration is a liquid separation process in conjunction with the activated sludge process that treats and removes pollution from wastewater producing two outputs:

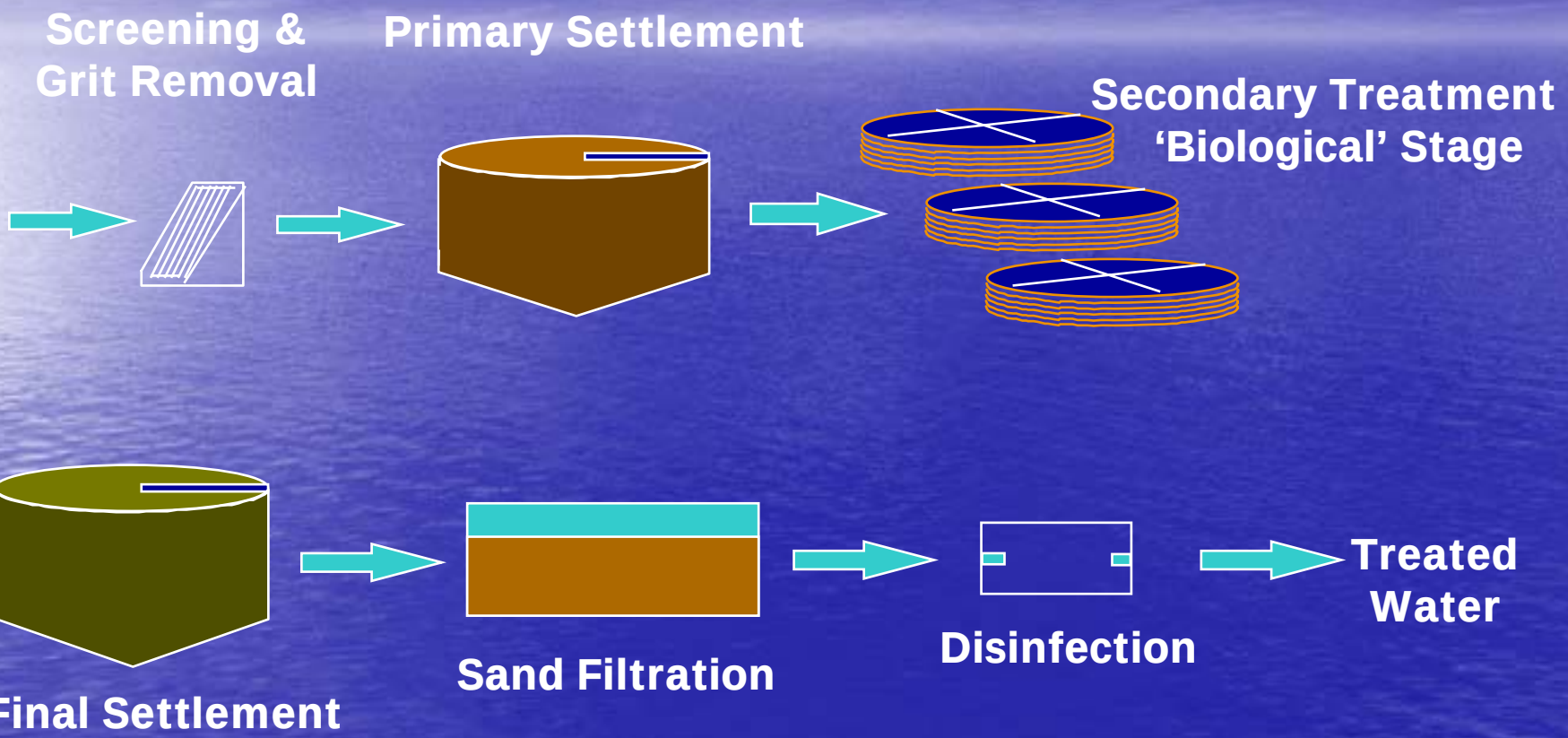
- A highly purified effluent
- A concentrated sludge

Membrane Effluent Treatment

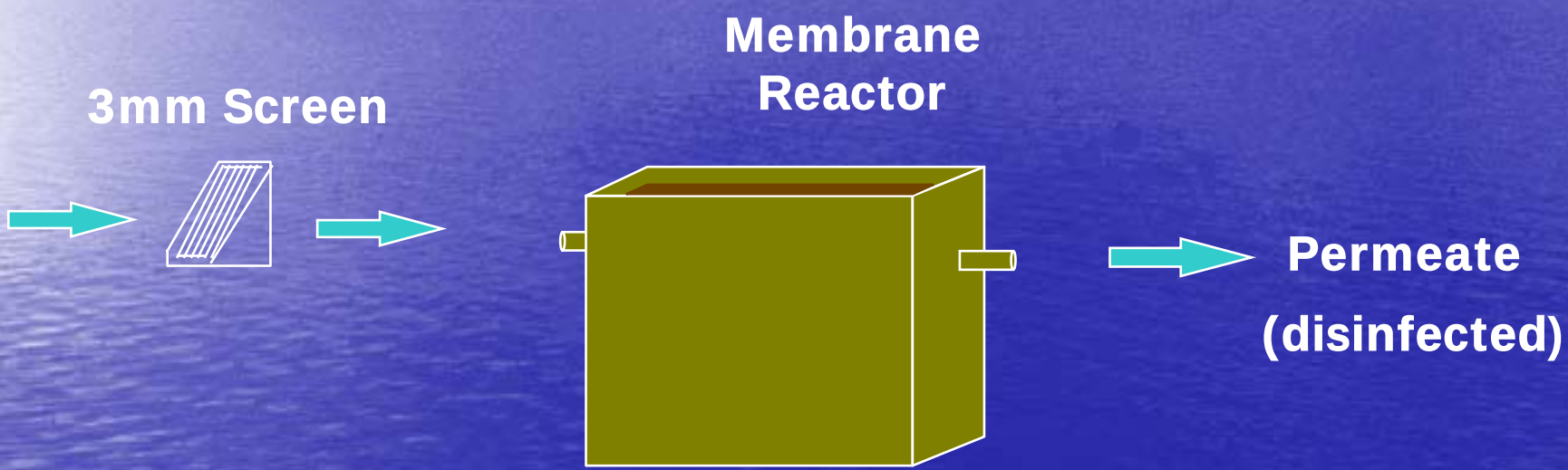
Advantages

- High quality final effluent
- No primary or Secondary Settlement – low land area requirement
- Treatment option for high strength or variable strength effluents
- Lower Sludge production (0.8kg/kgbod)
- Sludge Haulage Costs Reduced
- Retrofittable /Modular

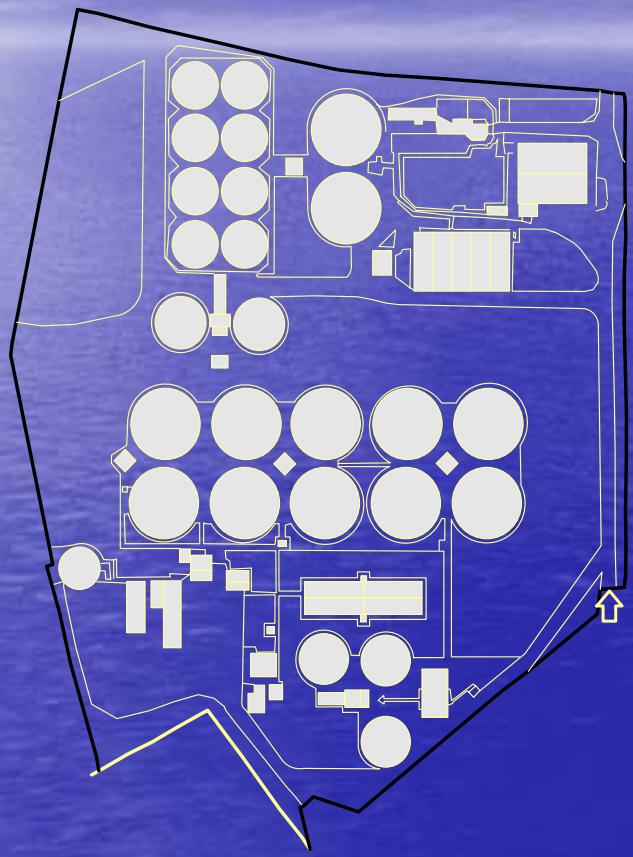
Conventional WwTW

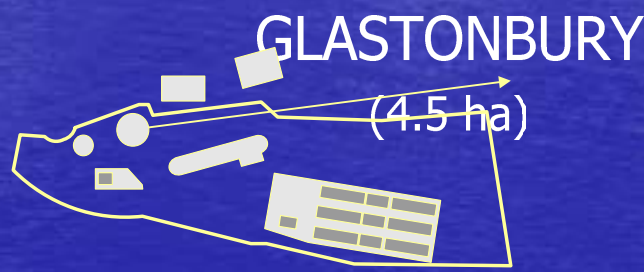


Membrane Bioreactor WwTW

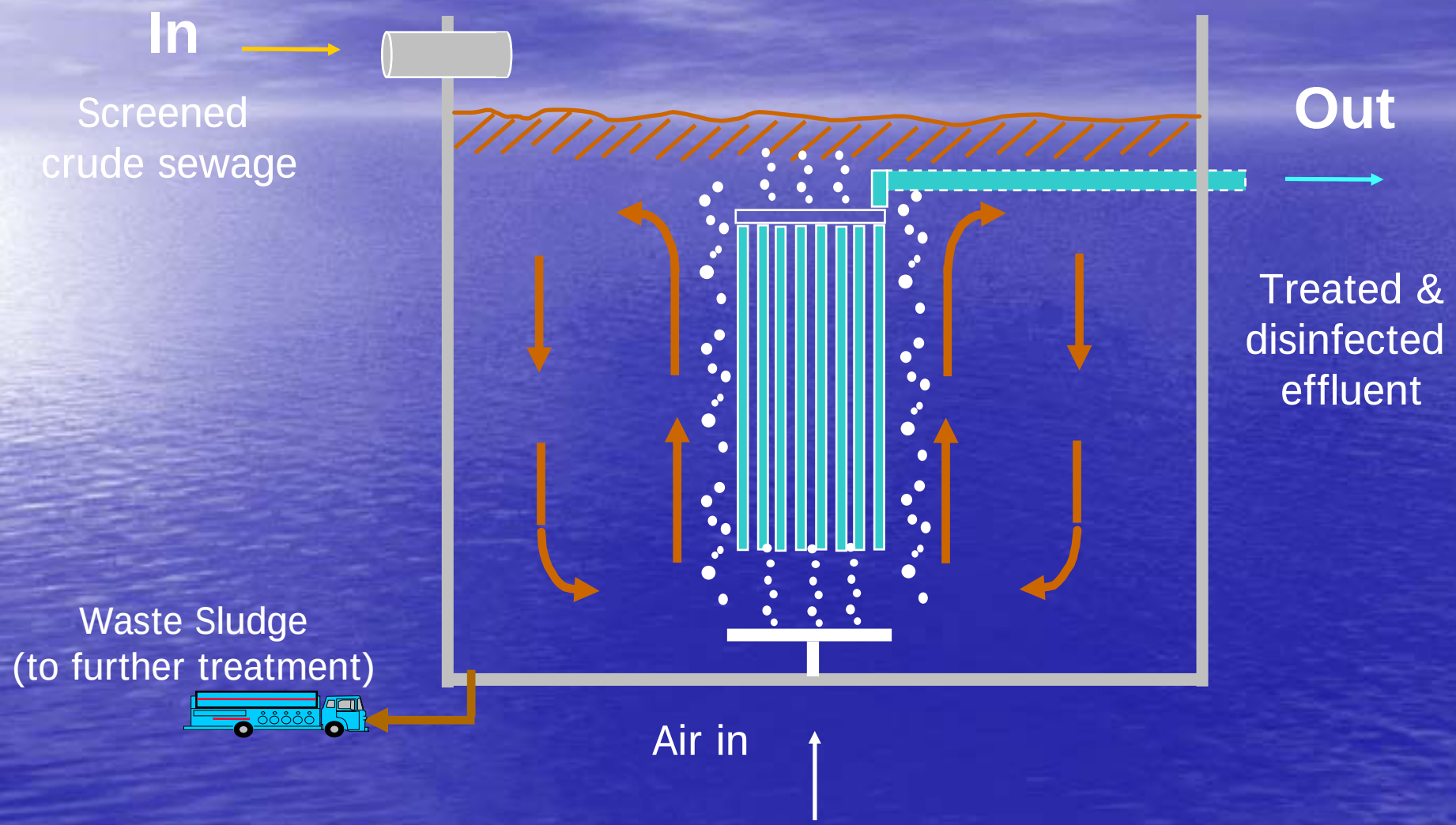


Advantages over conventional plants

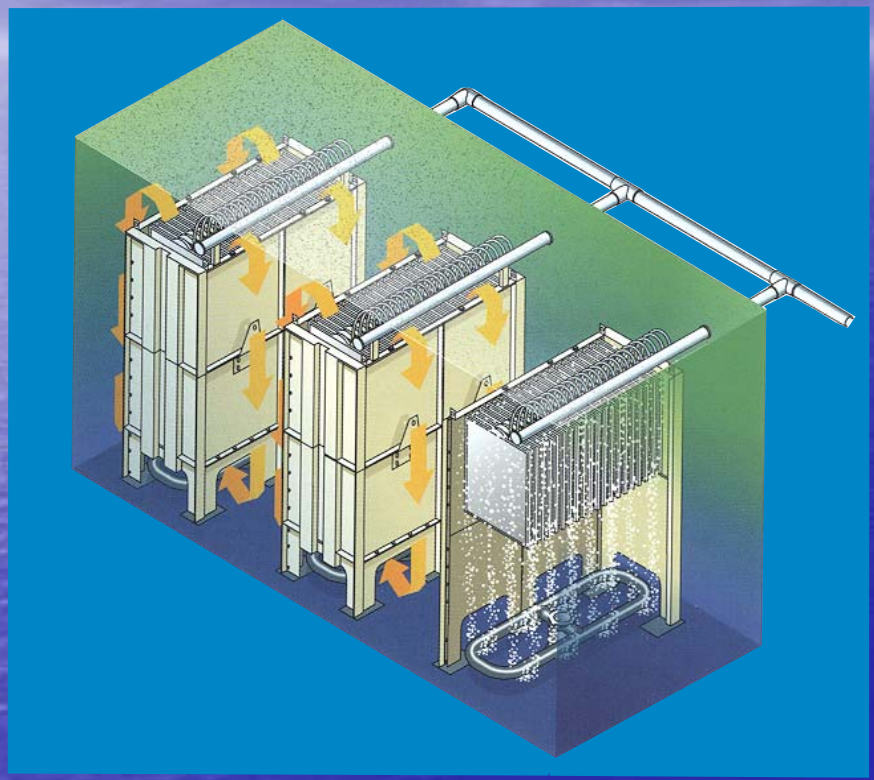




Process Principles



Process Principles



Kubota Membrane Units

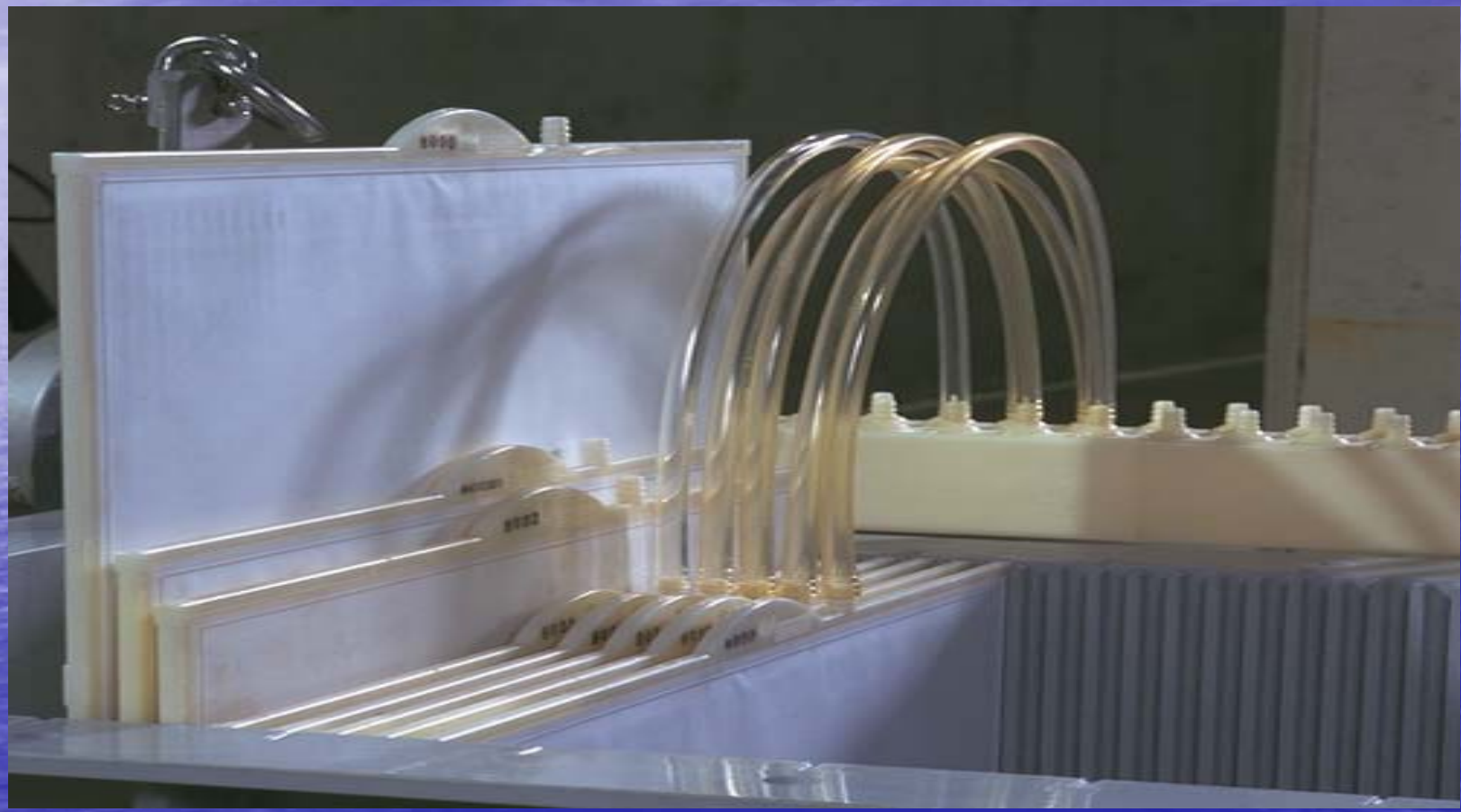
Basic Product Range

- **Includes aeration and filtration sections**
- **Standard Kubota units: 7 - 200 panels**
- **Double Deck design: 300 and 400 panel - reduced plan area**
- **Custom designs to fit application**
- **Gravity or suction operation**

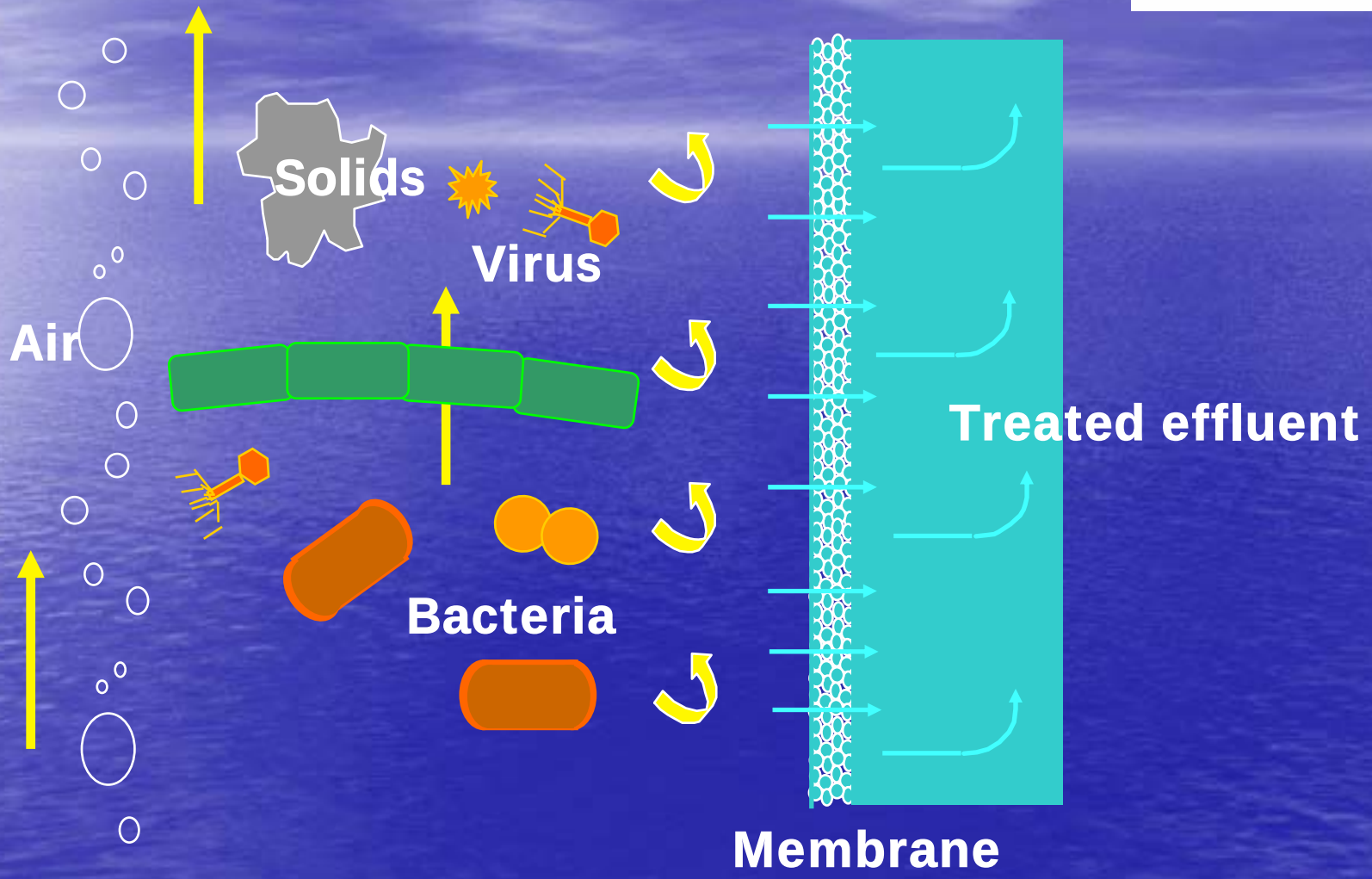
Membrane filtration top section (150 panel)

Diffuser aeration lower section

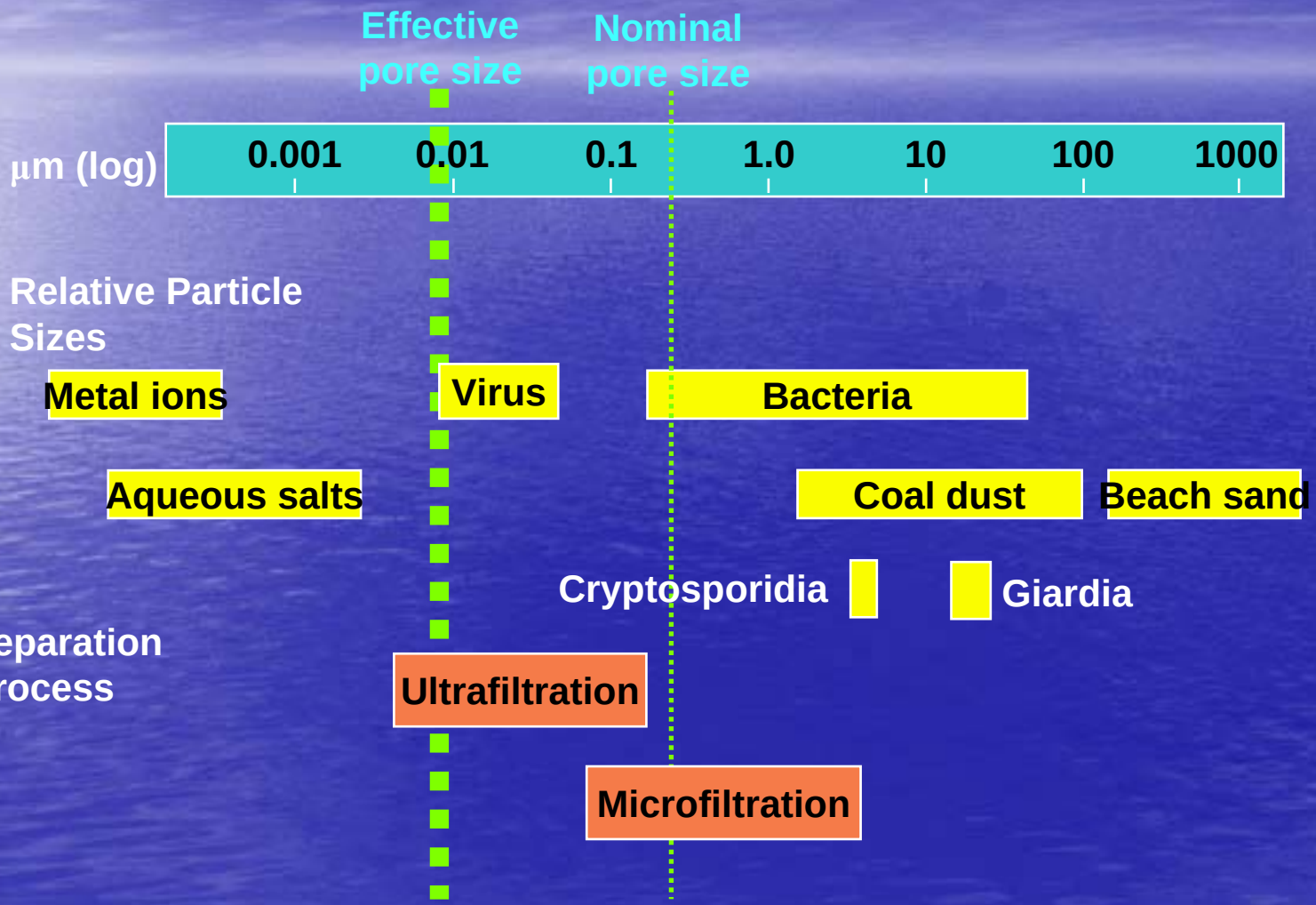
Membrane Panels



Membrane Filtration



Membrane Separation



Membrane Process

Re-use advantages

- Effluent fully disinfected without chemicals
- Near zero pathogen levels (protozoa, bacteria and virus)
  - > log 6 Bacteria
  - > log 4 Virus
- Consistent high quality effluent
  - - SS, BOD, COD
  - - NH_3, $NO_{3,,}$
  - - TP / Ortho P
- Minimal odour

MBR Applications

- Municipal Waste Water
- Domestic/Commercial Waste Water
- Sludge Liquors
- Sludge Thickening
- Industrial Waste Water
- Shipboard Waste Water

MBR Applications

2005 MBR Worldwide Applications

- Household 6%
- Municipal 62%
- Industrial 32%

(COPA MBR)

2005 MBR Installations in Europe

- Industrial 285 units
- Municipal 105 units
- Household 250 units

(B.Lesjean & E. Huisjes : 2007)

EPS References
(installed/under construction)

- Wood Processing 1200M3/d
- Ind. Waste Water 16000pe
- Baileys 200M3/d
- Bweeng 500pe
- Narramore 750pe
- Lismire 500pe
- K Club 500pe
- Cliffs Of Moher 500pe
- Greyabbey 2000pe
- Kircubbin 3000pe
- Drumaness 2000pe
- Aghalee 2000pe
- Aghagallon 2000pe
- Dunloy 2000pe
- Grange 750pe

Case Studies

- Porlock
- Industrial Waste Water

Porlock WwTW

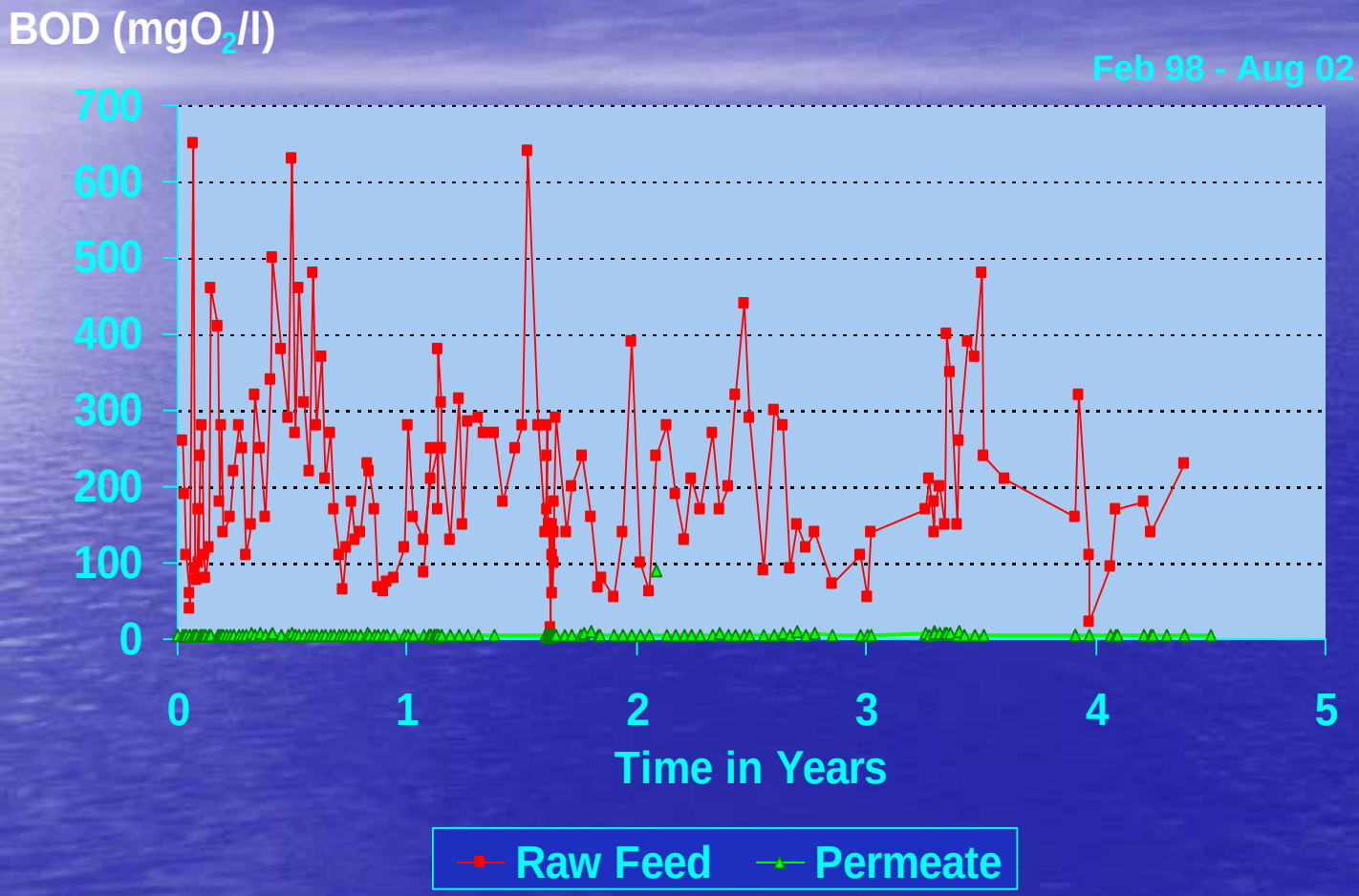
Site data

- Located in Exmoor National Park, with nearby bathing beach
- 3800 population equivalent (summer)
- 1900 m3/d flow to full treatment
- Sewage feed started 12th February 1998

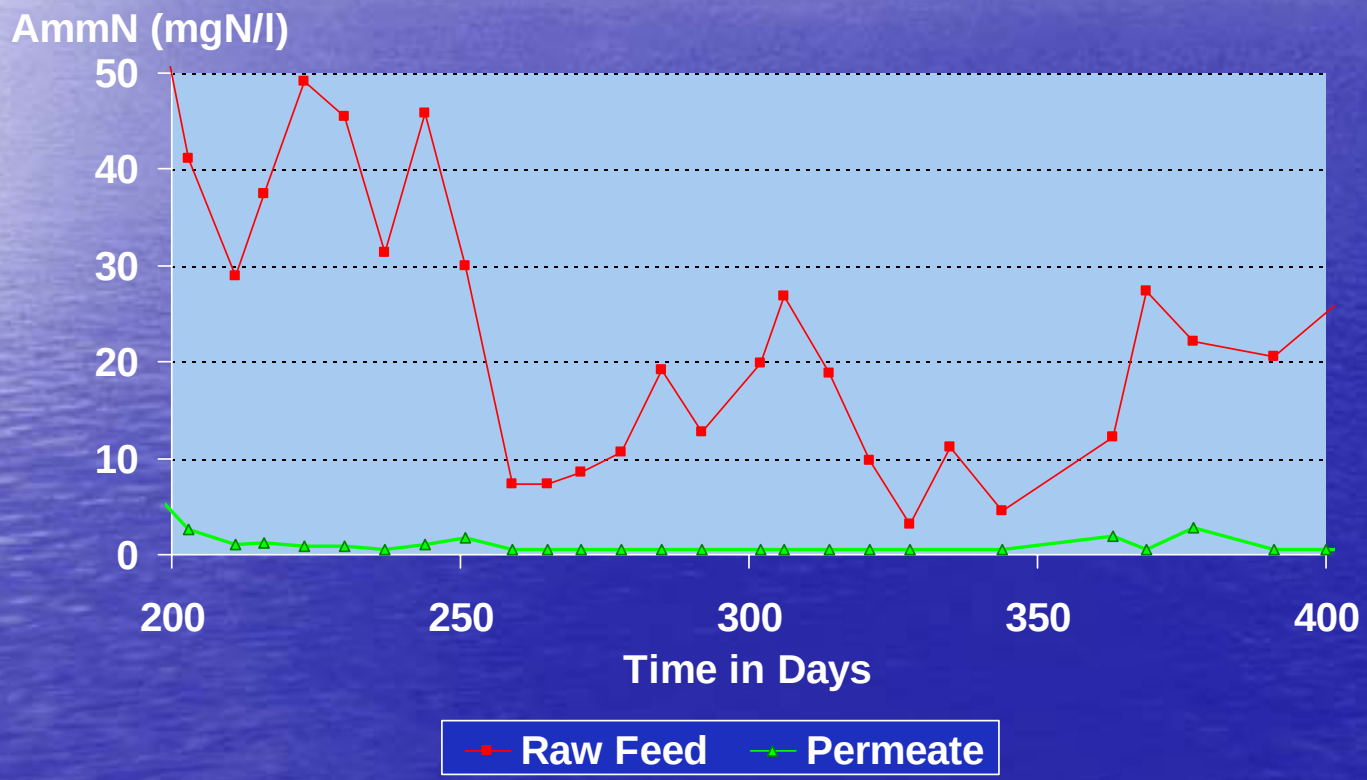
Porlock WwTW

Porlock MBR Building

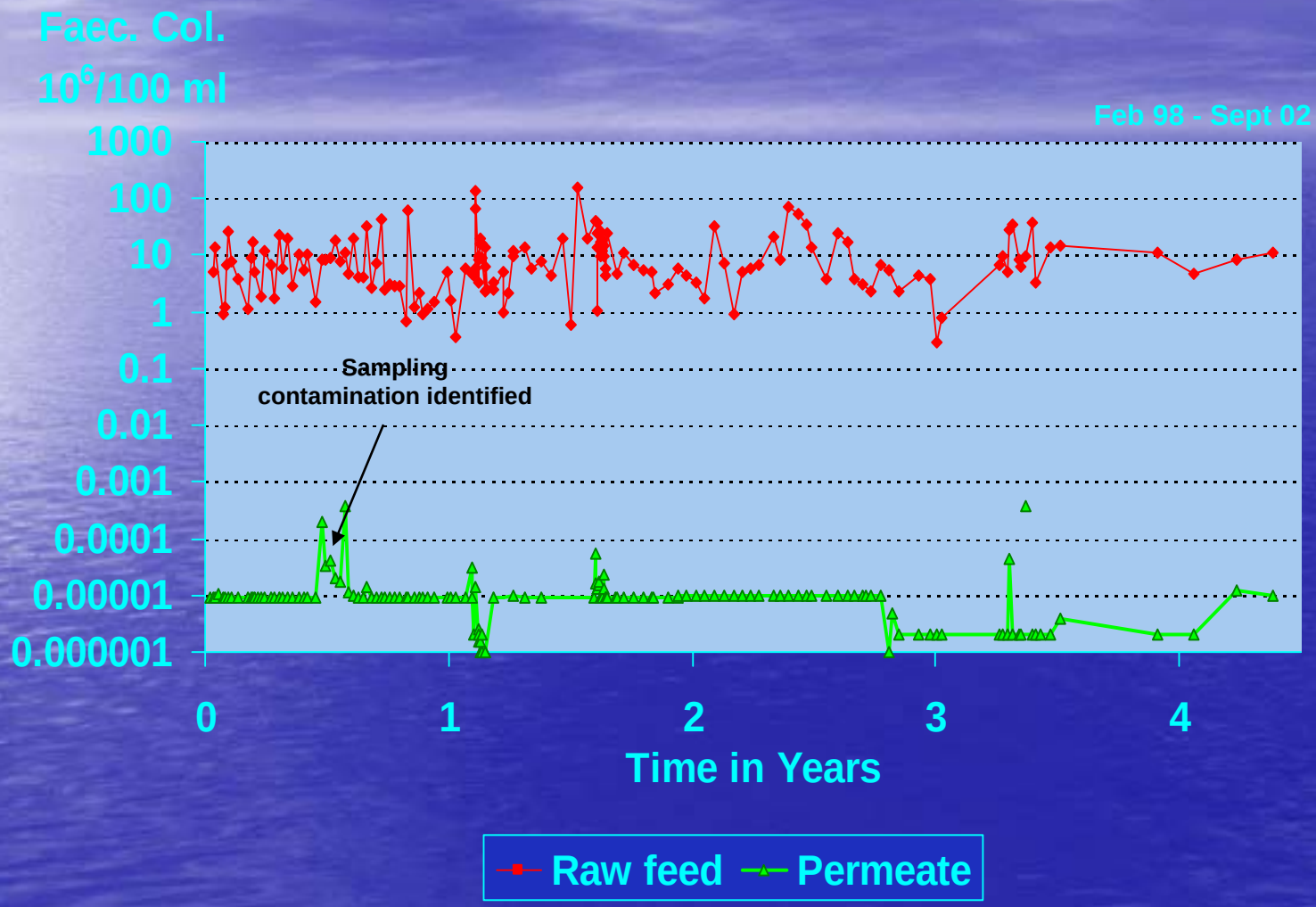
Porlock BOD Removal



Porlock NH3 Removal



Porlock Faecal Coliforms



Porlock STW- Compliance Results

Kubota Submerged Membrane Process

Analyte	No of samples	Crude			Final		
		Min	Max	Average	Min	Max	Average
Total coliforms /100 ml	82	2000000	>3000000000	126000000	2	480	<35
Faecal coliforms /100 ml	83	300000	160000000	14200000	0	378	<15
Faecal streptococcus /100 ml	82	26000	9400000	990000	0	20	<9
Clostridium Perfringens /100 ml	74	100	1800000	125000	0	90	<12
Salmonella /10 litres	74	0	1800	52	0	<1	<0.14
Enterovirus /10 litres	74	200	360000	1840	<1	18	<1.5
F+ coliphage /100 ml	75	1 ?	4350000	154000	0	180	<13
Suspended solids mg/litre	83	20	1030	249	<1	23 ?	<5
Turbidity NTU	32	-	-	-	0.07	1.5	0.23
BOD_5 mgO_2/litre	35	26	640	290	<2	<8	<5

June 1998 – September 2001

Industrial Waste Water

Project Overview

- Enhanced Flow Balancing / Equalisation
- Phosphorus Reduction
- Organic Carbon Reduction (COD/BOD)
- Colour Reduction
- Sludge Treatment
- Blending of Flows
- Process Monitoring
- Control Systems

Industrial Waste Water

- Design Build Project
- Flow rate 600-800 m3/day
- Cod 1200 mg/l
- TP 40mg/l
- Ph 2-12

Industrial Waste Water

Discharge Standard

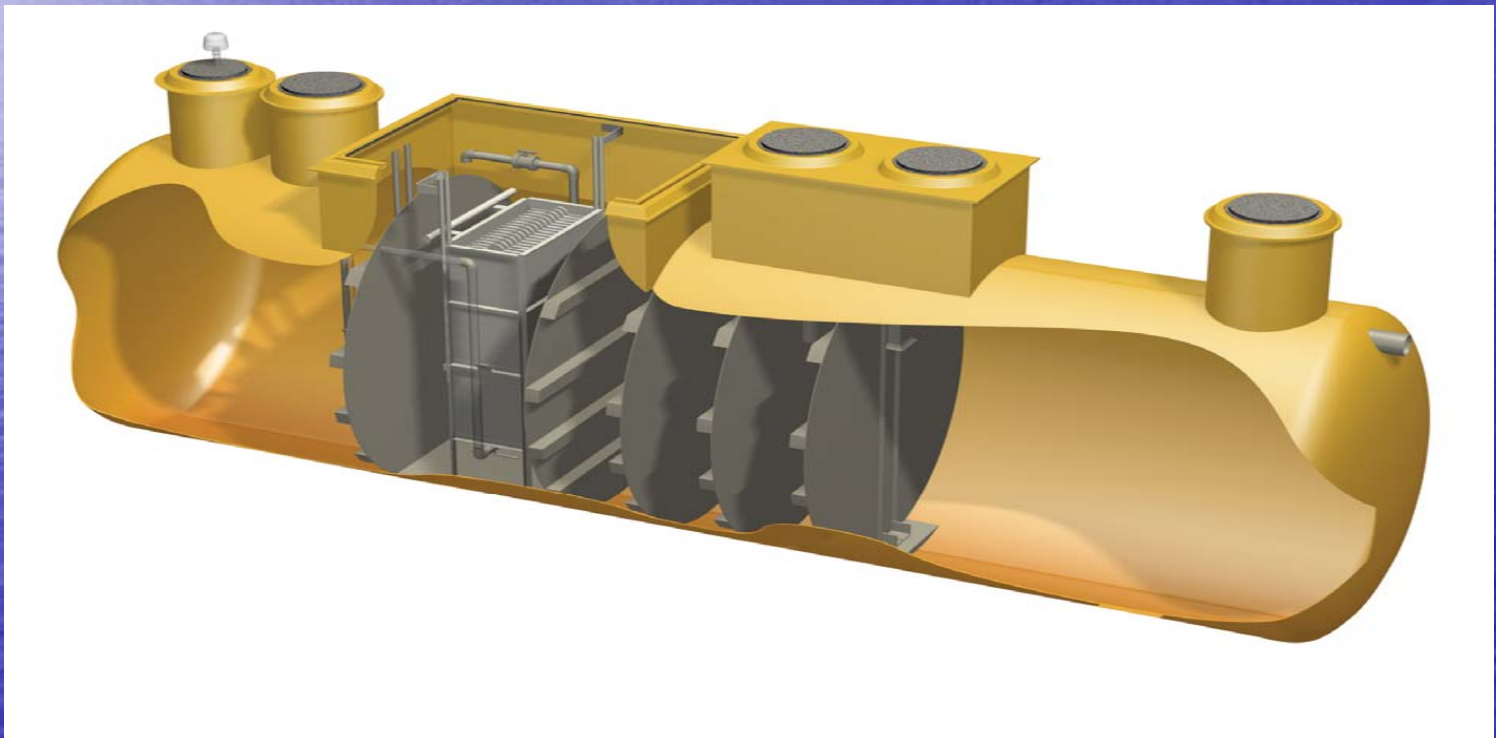
- Cod 75
- TP 16
- Colour 150 ptCo
- BOD 15
- TN 2
- pH 7.5

Industrial Waste Water.

Operational Issues

- Varying Flows/loads
- Varying incoming pH (1.5-13.5)
- Varying incoming temp °C (ambient - 85)
- COD range 2500-3500
- Flow 600-800M3/d

EPS Bison Clereflo MBR.
The Packaged Membrane Solution.



Background

2003 EPS Bison Experiencing

- More Stringent Discharge requirements
- Unique Developments in Sensitive areas
- Enhanced implementation of Phos. Regs
- Enhanced implementation of Nitrate Dir
- Local Authorities increased focus on Discharge Licences
- Need for 5:5:5:1 (BOD:SS:NH3:TP)
- Identified MBR Tech
- Developed For Irish market with Conder Products

Design Philosophy

- To develop a process to satisfy EPS Bison client base (residential, hotels, caravan parks)
- Standardised design
- Off the shelf product range
- Domestic/Commercial wastewater only
- No screen/ solids removed by primary settlement
- Maximum acceptable flux of <0.4 $m^3/m^2/d$
- Quick turnaround
- Low cost design

Design Philosophy

- Standardised plant items
- Only Standby items where essential
- Minimal instrumentation
- Minimal automatic control
- Low specification control panel
- Minimal maintenance requirements

Design Philosophy

- The Clereflo does not have the following as standard but additional requirements can include
- Inlet Screening
- Additional Control requirements
- Monitoring requirements (instrumentation, telemetry)
- Access
- UV Disinfection
- Remote Monitoring
- Anoxic Stage

Design Philosophy

Standardised Plant Items

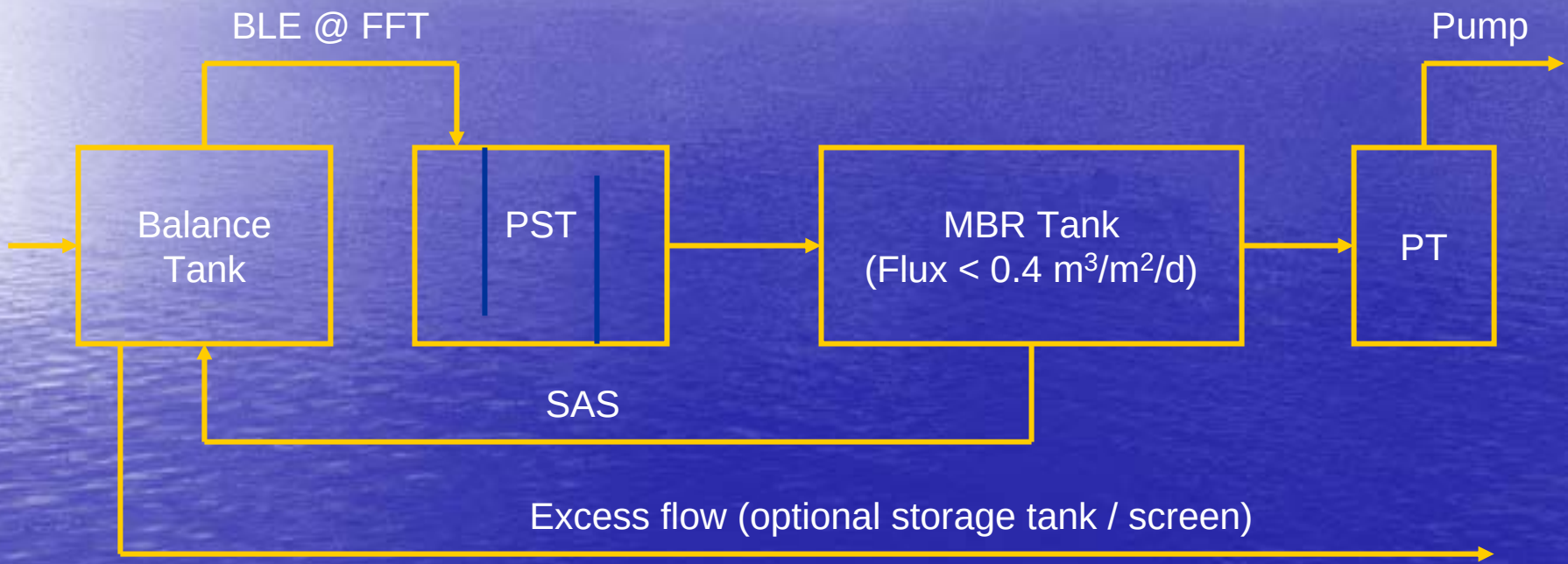
- 75 panel full-height membrane unit
- Standard GRP tank diameters
- One bucket lift elevator (BLE) size across range
- Forward Feed Pumping Option

Design Philosophy

Permeate Quality

- 5 mg/l BOD
- 5 mg/l SS
- 5 mg/l NH3 (Potentially lower)
- Disinfection
- Phosphorus reduction - with chemical addition
- Nitrate & Total Nitrogen Reduction

Process Design



Product Range

- 5:5:5:1: (BOD:SS:NH3:TP)
- 125 pe
- 250pe
- 375 pe
- 500 pe
- 750 pe
- 1000pe

- 2006 - Developed Anoxic Range (5:5:5:1:15:5/BOD:SS:NH3:TP:TN:NO3)
- Sites > 1000pe cast in situ concrete

EPS Bison MBR Projects

- Killerig 250pe
- Stamullen 375pe
- Rolestown 375pe
- Dunboy Castle 375pe phase 1 / 250pe phase 2
- Delphi Adven. Centre 500pe phase 1/500pe 2
- Carlton House 500pe Phase 1 / 250pe Phase 2
- Ballyfin House 250pe
- Inchigeelaga 125pe
- Lispole 375pe
- Knackery <2m3/day * 2 sites

Enquiry Requirements

Preliminary Considerations

- Occupancy/shutdowns
- Anticipated future flows and loads
- Disinfectant and chemical usage
- On-site laundries
- Variable water usage
- Use of waste disposal units
- Grease/Fat trap requirement

WHAT CAN GO WRONG

Failure to achieve flow rate

- Plant too small
- Wrong / incorrect flow rates given / used
- Membrane fouling – operation
- Membrane fouling – nature of effluent

Failure to achieve consent

- Plant too small
- Wrong / incorrect loadings given / used
- Operation – Blower failure, Too high MLSS
- Alkalinity > seven times Ammonia for removal

Case Studies

- Killerig
- Rolestown
- Stamullen

Killerig

- Housing Development (Holiday Homes)
- Commissioned Nov 2005
- 250 pe
- Standard Required (5:5:5:50:2)
  (BOD/SS/NH3/COD/TP)
- Standard Achieved (<1.5:<5:<1.5:17:0.7)
- Running Costs / Year (€)
  ESB 6000 / Chemicals 500 / Desludge 6000 / Operate 5600 / Membrane Replacement (10yr) 1200

Total Cost €19,300

Rolestown

- Hotel Development
- Commissioned Feb 07
- 375pe C/w anoxic and UV
- Standard Required (5:5:5:1:5) (BOD/SS/NH3/TP/NO3)
- Standard Achieved (<2:<5:<.5:0.6:3.5)
- Running Costs /year (€)

  ESB 9500 / Chemicals 500 / Operate 16900

  Desludge 15000 / Membrane Replacement (10yr) 1800

Total Cost €43,700

Stamullen

- Hotel Development
- Commissioned Nov 06
- 375pe C/w Anoxic
- Standard Required (5:5:5:50:1:5) (BOD/SS/NH3/COD/TP/NO3)
- Standard Achieved (<1.7:<5:0.17:22:0.5:<5)
- Running Costs / year (euro)

ESB 8400 / Chemicals 500 / Operate 24000
Desludge 15000 / Membrane Replacement (10yr) 1800

Total Cost €49,700


13 12 2006

Operation and Maintenance

- To Maintain Permeate Quality
- To Maintain Permeate Flow rate

- Planned Maintenance/Servicing

- Planned maintenance will coincide with either chemical clean or desludge

- Desludge – approx 3 months
- Chemical clean – approx 6 months

O&M Overview

Maintaining Permeate Quality

Two Factors influence permeate quality

- **Integrity of membrane panels and permeate pipework**
- **Biological removal of organic and nutrient pollutants**

O&M Overview

Maintaining Permeate Flowrate

Six factors that influence permeate flow rate

- Differential Pressure
- Temperature
- Aeration
- Foulants
- MLSS concentration
- Inter- clogging between membranes

O&M Overview

Typical MBR WwTW Requirements

- Daily automatic sludge-flush of air diffusers (30-60s)
- Daily automatic ‘membrane relaxation’ procedure (30 mins)
- Regular automatic sludge removal
- Site visit once a month
- Two in-situ yearly chemical cleans with either dilute hypo or acid

O&M Overview

Chemical Clean Procedure

- In-situ, semi-automatic procedure
- Requires one operator
- Organic foulants removed with 0.5% NaOCl
- Inorganic precipitants removed with dilute acid
- Spent cleaning solution diluted within the MBR tank

Cost Comparison Conventional A.S vs. MBR

Cost	Conventional 250pe	Conventional 375pe	MBR 250pe	MBR 375 pe
Capital (euro net) Mech/Elec only	160,000	200,000	120,000	220,000
Chemicals	400	500	400	500
Power	5,200	7,200	6,000	8400
Desludge	15,960	24,000	13,500	20,000
Labour	5,600	24,000	5,600	24,000
Replacement costs	n/a	n/a	1200	1800
Total Yr 1	187,160	255,700	146,700	274,700
Total Capital	160,000	200,000	120,000	220,000
Total Operate	27,160	55,700	27,000	54,700
Disinfection (power/replacement)	4000	6000	n/a	n/a
Discharge Standard.	10:10:5:1		5:5:5:1	

Membrane Bioreactor Technology

Membrane costs

(Kubota)

Conclusions

- Consistent high quality disinfected effluent
- Compact, low maintenance, robust
- Membrane replacement costs continue to decrease
- Lower sludge production & concentrated sludge leading to lower transportation costs
- The MBR solution is not the option for all sites

Conclusions

Viable option where :

- **Low peak to average flow ratio**
- **Very tight discharge standards**
- **Space restrictions**
- **Re-Use Requirement**

EU – Wide Standardisation of Membranes

Enhanced Capital Allowance Scheme (25% /yr on a reducing balance for 10yrs/re-use 30% treated effluent)

References

- www.epsireland.com
- www.mbr-network.eu
- Survey of European MBR Market , Trends & Perspectives
- Towards Standardisation of MBR Technology
- COPA MBR Tech
- Conder Environmental

Q & A