

# **CLEAN AND SAFE DRINKING WATER WORKSHOP**

## **GANDER**

### **22ND SEPTEMBER 2004**

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# **SAFE WATER FOR CONNE RIVER**

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# The Problem

Use of peaty lake and river waters for water supply in small communities.

The brown color from natural organics in these surface waters reacts with chlorine, used for disinfection, and produces high levels of carcinogenic

**THM's & HAAs**

Bacteria and viruses and chlorine resistant pathogens in these surface waters can make the water unsafe for drinking e.g. Beaver Fever and other dangerous stomach disorders

These surface waters often have high levels of Iron, Manganese and Aluminum in them requiring removal to meet standards



Current drinking water standards:

Canadian: 100  $\mu\text{g}/\text{l}$  THMs, no regs for HAAs

USA: 80  $\mu\text{g}/\text{l}$  THMs, 60  $\mu\text{g}/\text{l}$  HAAs

Future: further tightening?

# Conne River

Source: A dammed stream off the Southwest Pond

Prior Treatment: chlorination only

THMs: average of 66 samples was 189  $\mu\text{g}/\text{l}$  (according to latest figures on Dept. of Environment website)

# Initial Study

Early in 2001 DMG (of Gander) & 3D-N Engineering Services (of Markham Ontario) were asked to look at treatment options

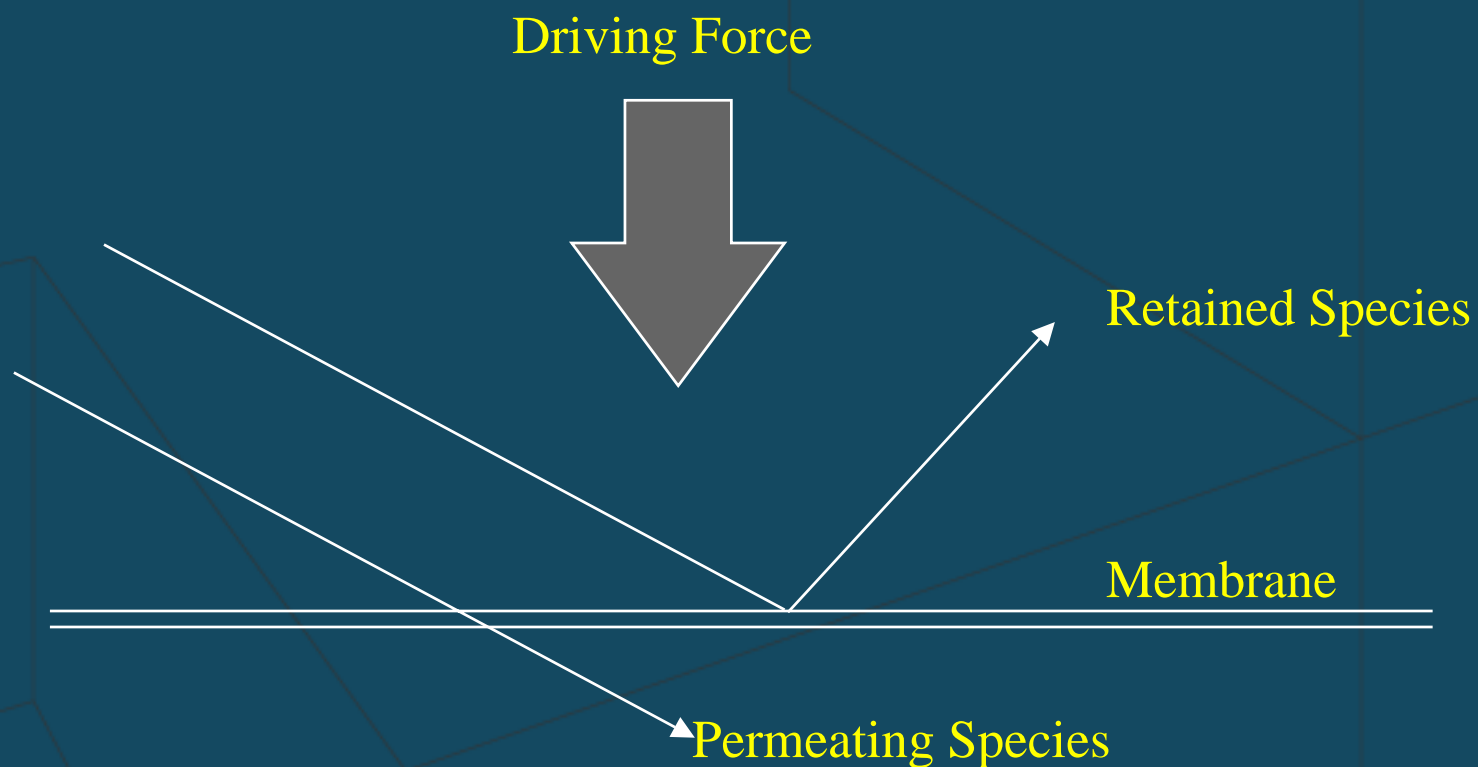
Different technologies considered:  
various types of filtration (rapid, direct, slow sand, etc.), adsorption technologies, micro-sand filters, membrane technology



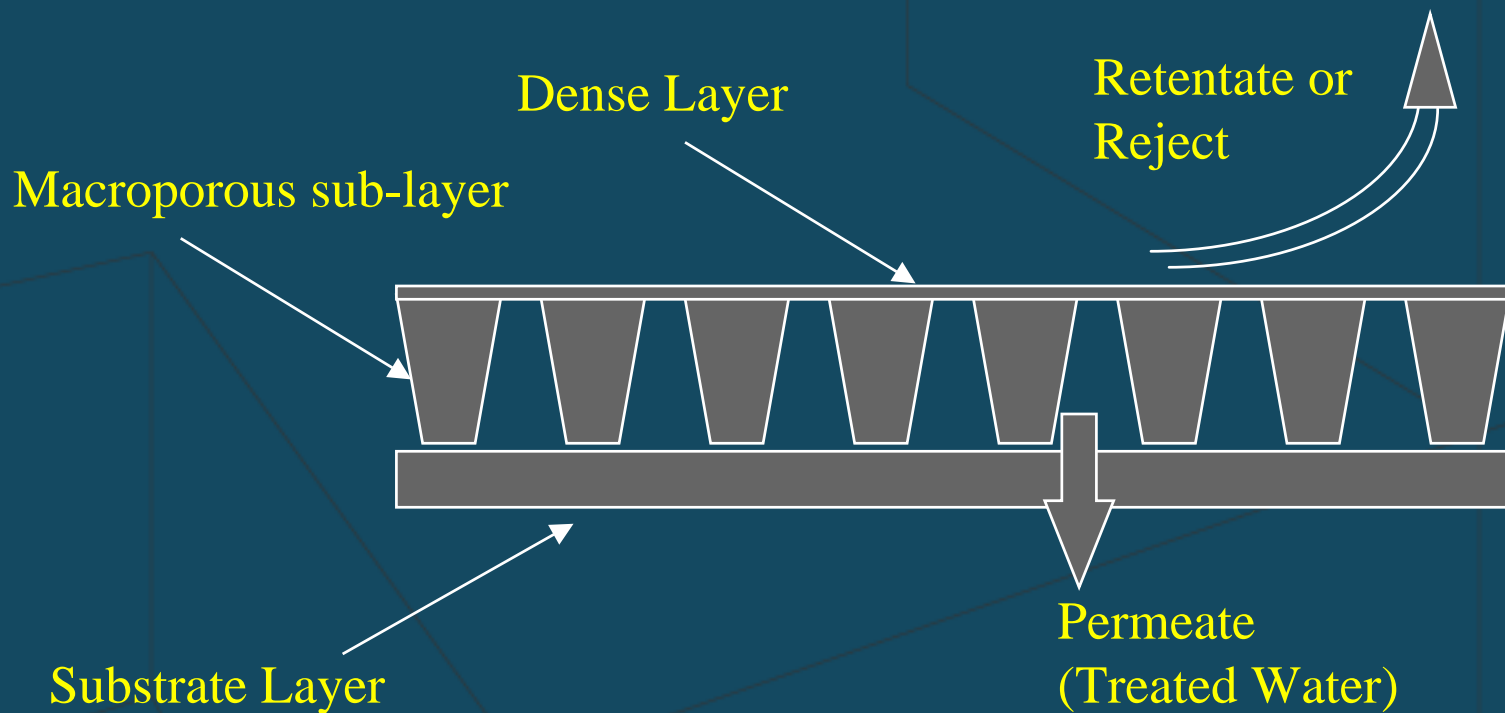
# Questions asked:

- **Would the colour requirements be met?**
- **Was the technology capable of 4 log removal of giardia cysts?**
- **Was the technology proven?**
- **Additional requirements (i.e. chemical precipitation)?**
- **Other considerations included serviceability, ease of operation & community benefit**
- **Decision: To pilot adsorption & membrane technologies**

# What is a membrane? A Basic View



# Membrane Structure



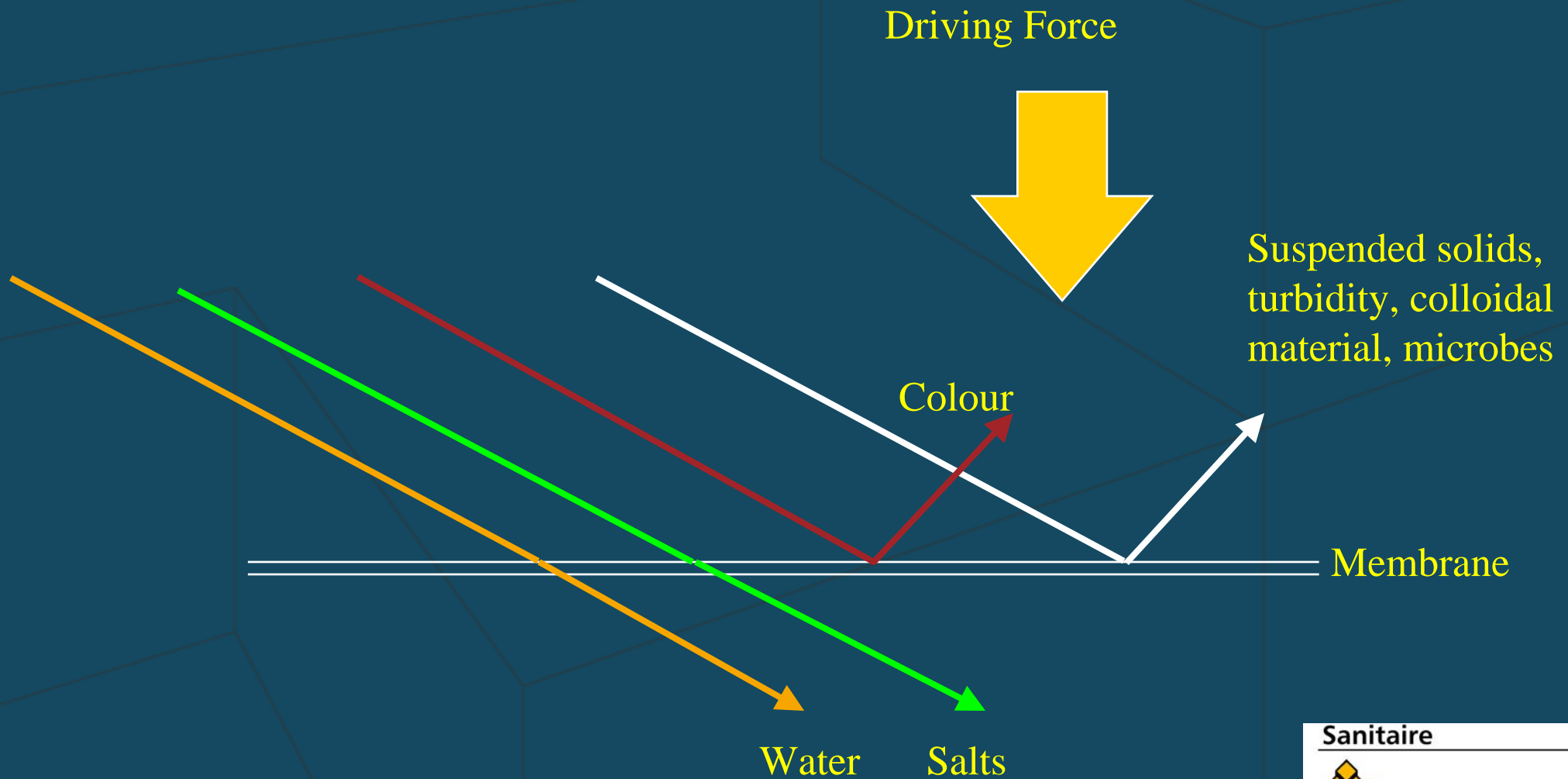
# Membrane Technologies

Reverse Osmosis	Nanofiltration	Ultrafiltration	Microfiltration
RO	NF	UF	MF
Susp Solids Bugs + Organics Salinity	Susp Solids Bugs + Organics	Susp Solids Bugs +	Susp Solids Bugs
Desalination NO3 removal	Colour removal	Crypto/virus removal	Crypto removal
99% NaCl retention	500 MWCO	0.03 $\mu$	0.2 $\mu$

tighter separation

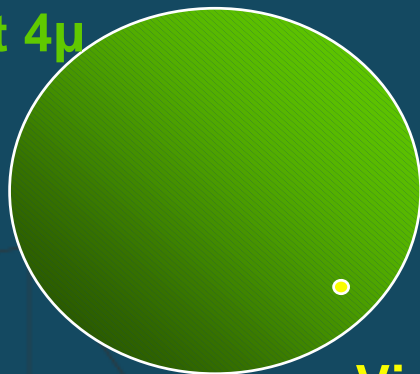
# Membrane Separations

## A Basic View NF



# Relative sizes

Crypto cyst 4 $\mu$



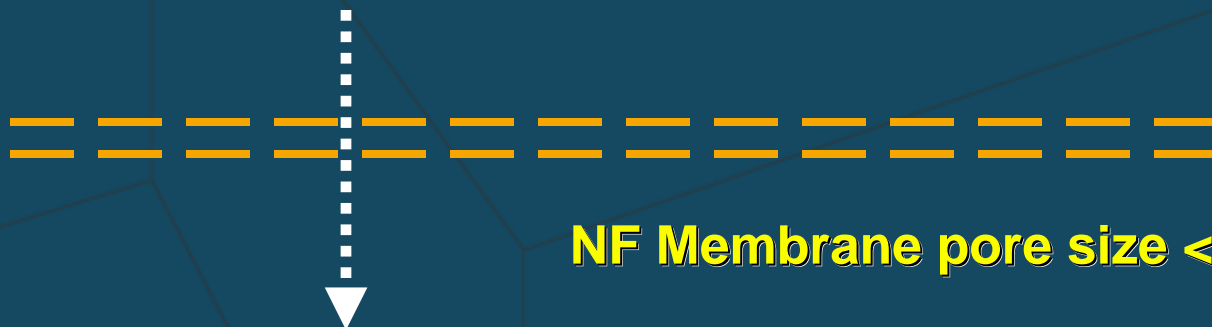
E.Coli 0.5 x  
2.5 $\mu$



Bacillus Spore  
0.8 x 1.5 $\mu$



Virus 0.03-0.05 $\mu$



NF Membrane pore size < 0.005 $\mu$

# Design Parameters: Flux & Recovery of Water

Raw Water



The diagram illustrates the water recovery process. A large blue arrow labeled 'Raw Water' enters from the left. It splits into two paths: one continues to the right as 'Reject / Surplus Water' (15% to 40%), and another turns downwards as 'Treated Water or Permeate' (60% to 85% Recovery). A horizontal dashed yellow line is positioned below the main flow path.

15% to 40%  
Reject /  
Surplus  
Water

Flux is the volume of water or permeate produced per unit area in a certain time i.e. liters per m<sup>2</sup> per hour (lmh)

60% to 85% Recovery of Treated Water or Permeate

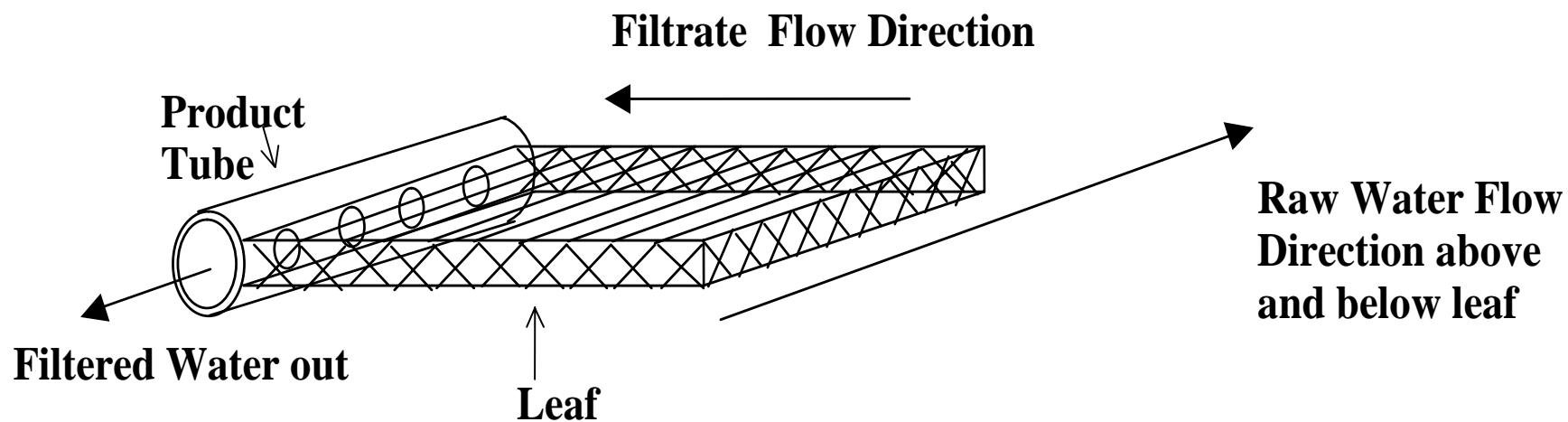
# Membrane selection for piloting:

- **Nanofiltration: for removal of colour and dissolved organics**
- **Spiral wound configuration:**
  - **capacity > 0.5 MLD therefore most economic configuration**
  - **high membrane surface area per unit volume - compact**



# Spiral membrane configuration:

Two layers of membranes separated by a spacer -  
glued around three edges



Multiple leaves connected to product tube  
and wrapped around tube to form an  
element

# Spiral Membrane Elements



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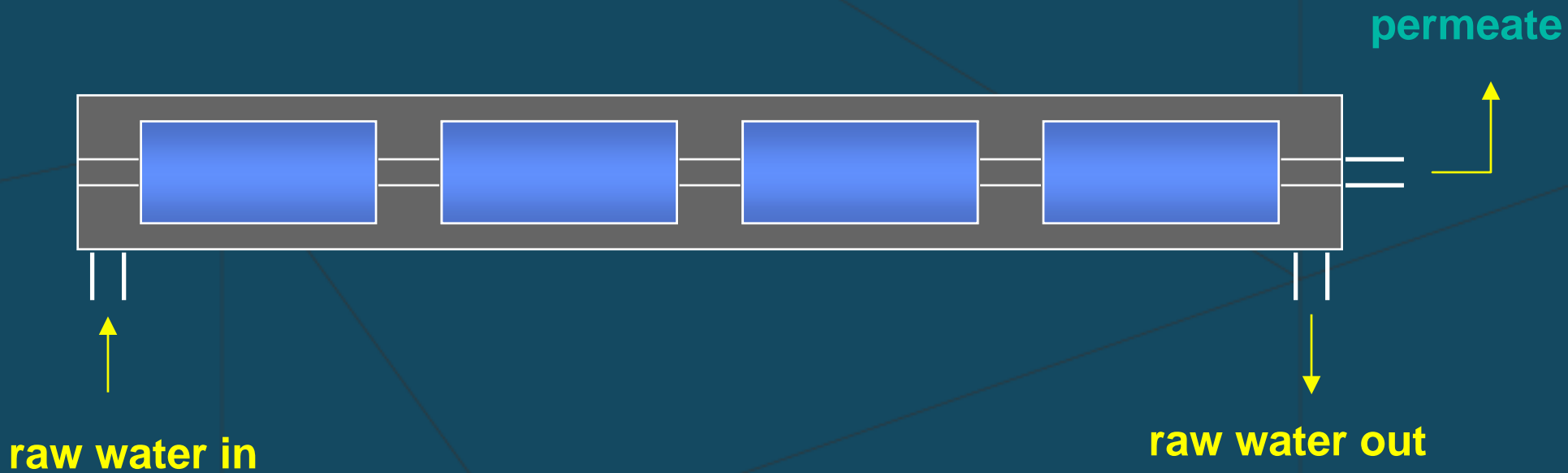


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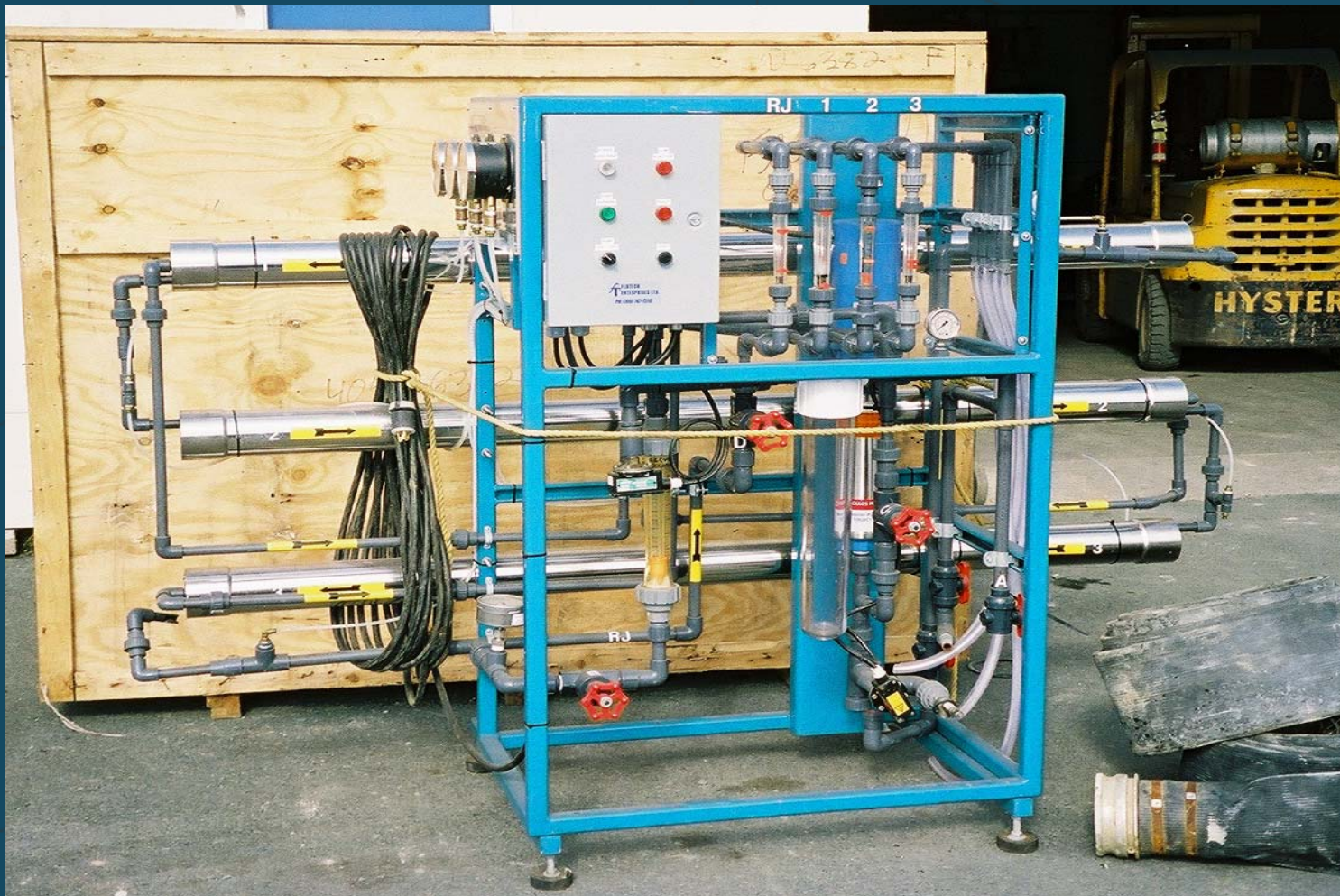
# Spiral Membrane Pressure Vessel



# Membrane Pressure Vessel

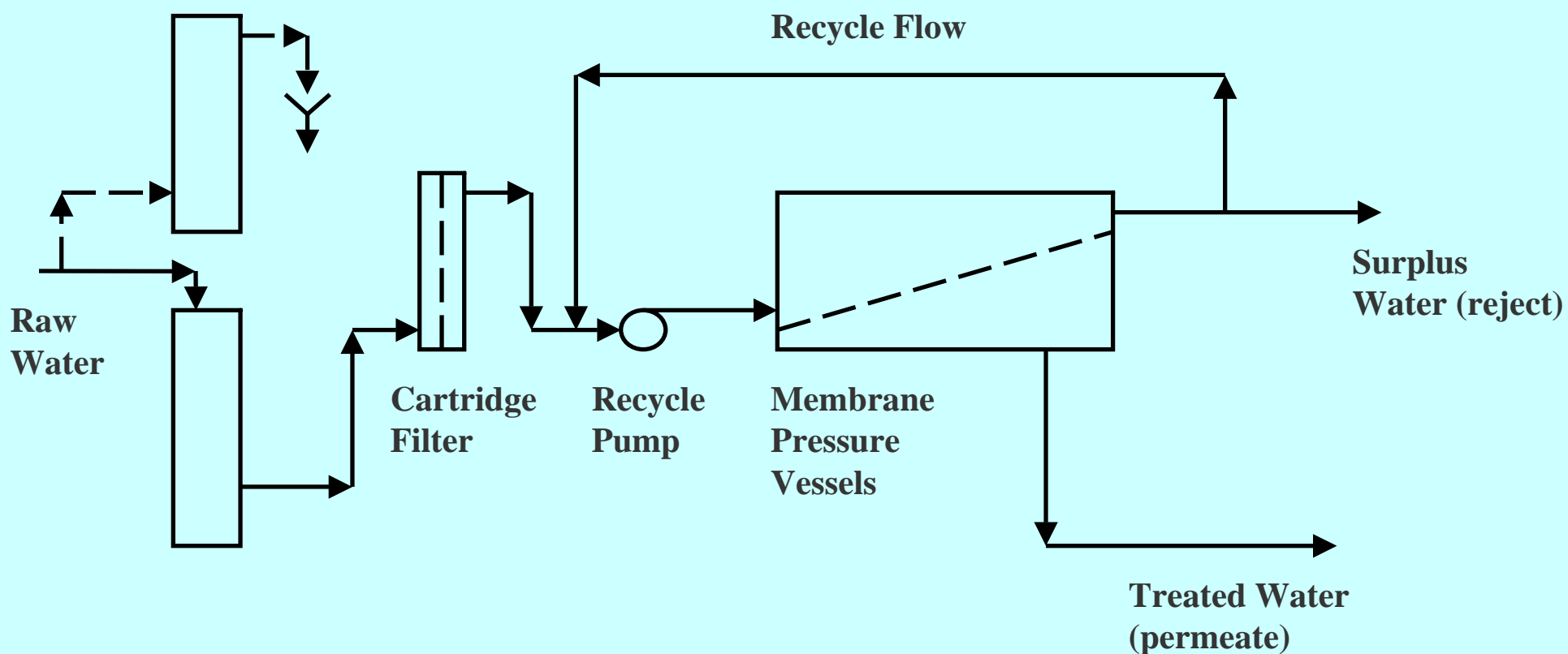


# Spiral Membrane Pilot Plant

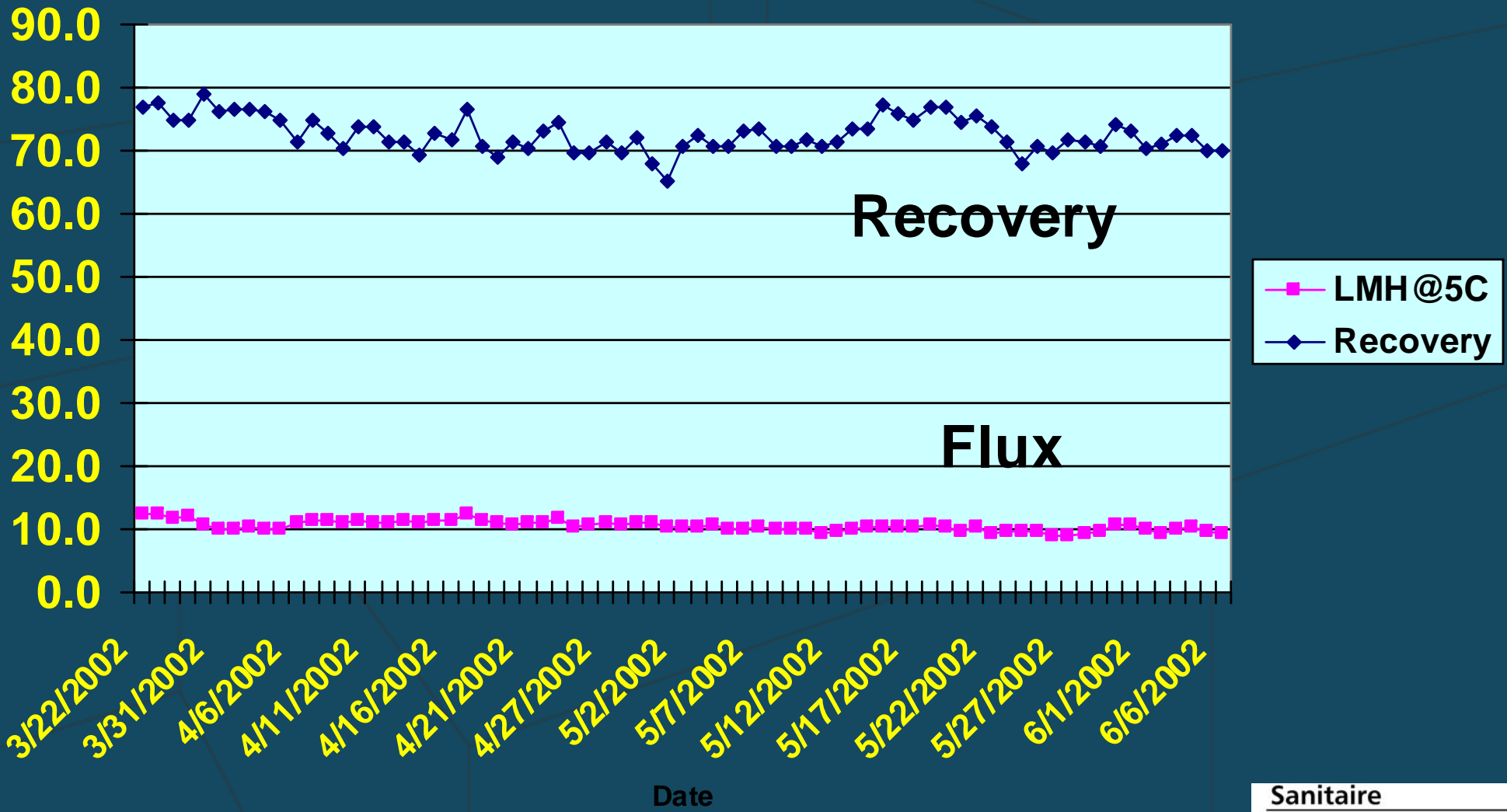


# Membrane pilot plant flow diagram

Dual media filters:  
1 duty, 1 in backwash or  
on standby



# Conne River Pilot Data



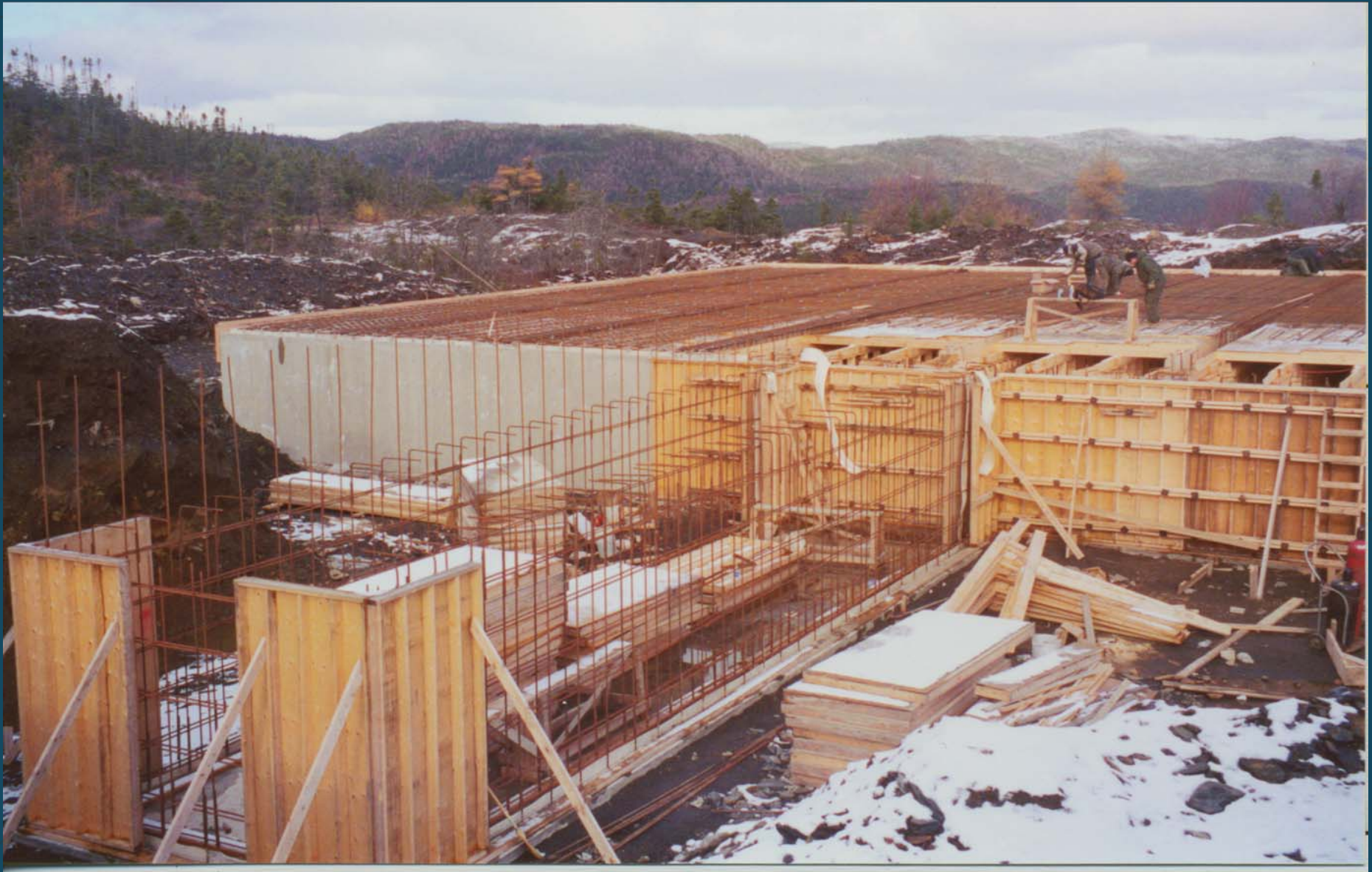
# Membrane Pilot Plant Results

- **Pilot ran for 110 days**
- **Simple operation**
- **Minimal fouling**
- **Minor adjustments required once or twice a week to maintain flux & recovery**
- **Chemical cleaning every 2½ weeks**
- **Reduction of colour (100%), TOC (70%), & metals including aluminum (70%)**



# Reasons for Selecting Membranes

- **High quality water to meet current guidelines and upcoming regulations**
- **Reliable in its simplicity**
- **No chemicals used as part of the treatment process**
- **Low labour cost**
- **Low maintenance cost**
- **Low life cycle cost**
- **Easily expanded/shrunk to meet rising/falling demand**



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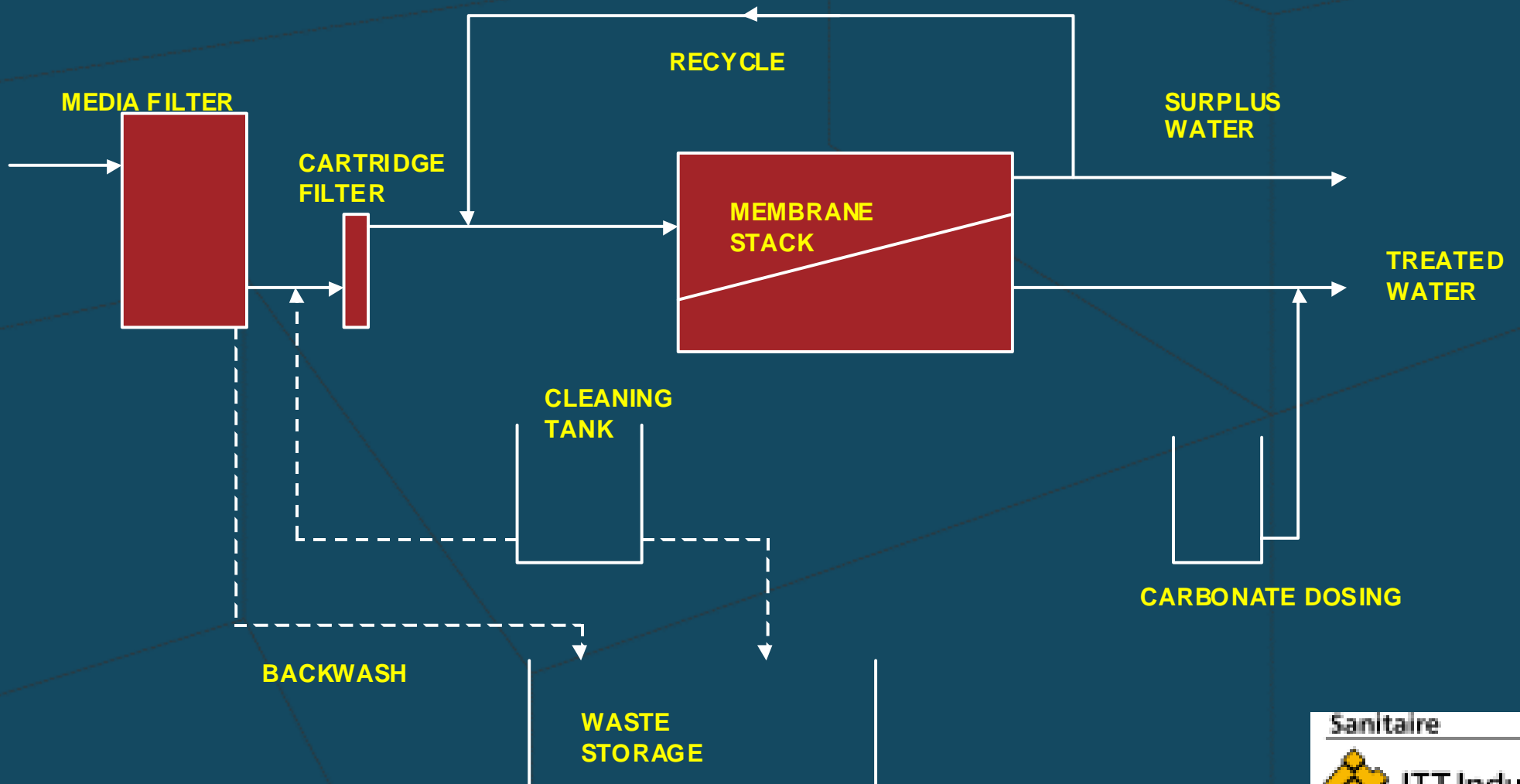


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# Raw Water Spec for Conne River

- Colour up to 80 Colour Units
- DOC 5 to 10 mg/l
- Iron up to 0.25 mg/l
- Aluminum up to 0.13 mg/l
- pH 5.3 to 6.0
- Turbidity Up to 10 NTU
- Temperature 3 to 20 deg C

# Simplified Flow Diagram



# Membrane System Equipment

- Media filters: 6 pressure vessels -  
backwash on time or  $\Delta P$
- Cartridge filters: 10 micron nominal
- Membrane plant: 29 eight inch pressure vessels
- Membrane area: 5,684 m<sup>2</sup>
- Cleaning tank: 2,000 gallons
- Post-treatment: sodium carbonate dosing (pH  
7) & chlorination

# Membrane System Equipment (Cont.)

- Installed power: 52.5 kW for feed & recycle pumps (production); 4.7 kW for mixers & 30 kW cleaning tank heater (intermittent use)
- Waste tank: 90 m<sup>3</sup> - holds sand filter backwash & spent cleaning solutions



# Membrane System Equipment (Cont.)

- Instrumentation:
  - pressure sensors
  - differential pressure sensors
  - raw and treated water turbidity
  - temperature sensors
  - final water pH
  - flow meters (recycle, surplus water & treated water)



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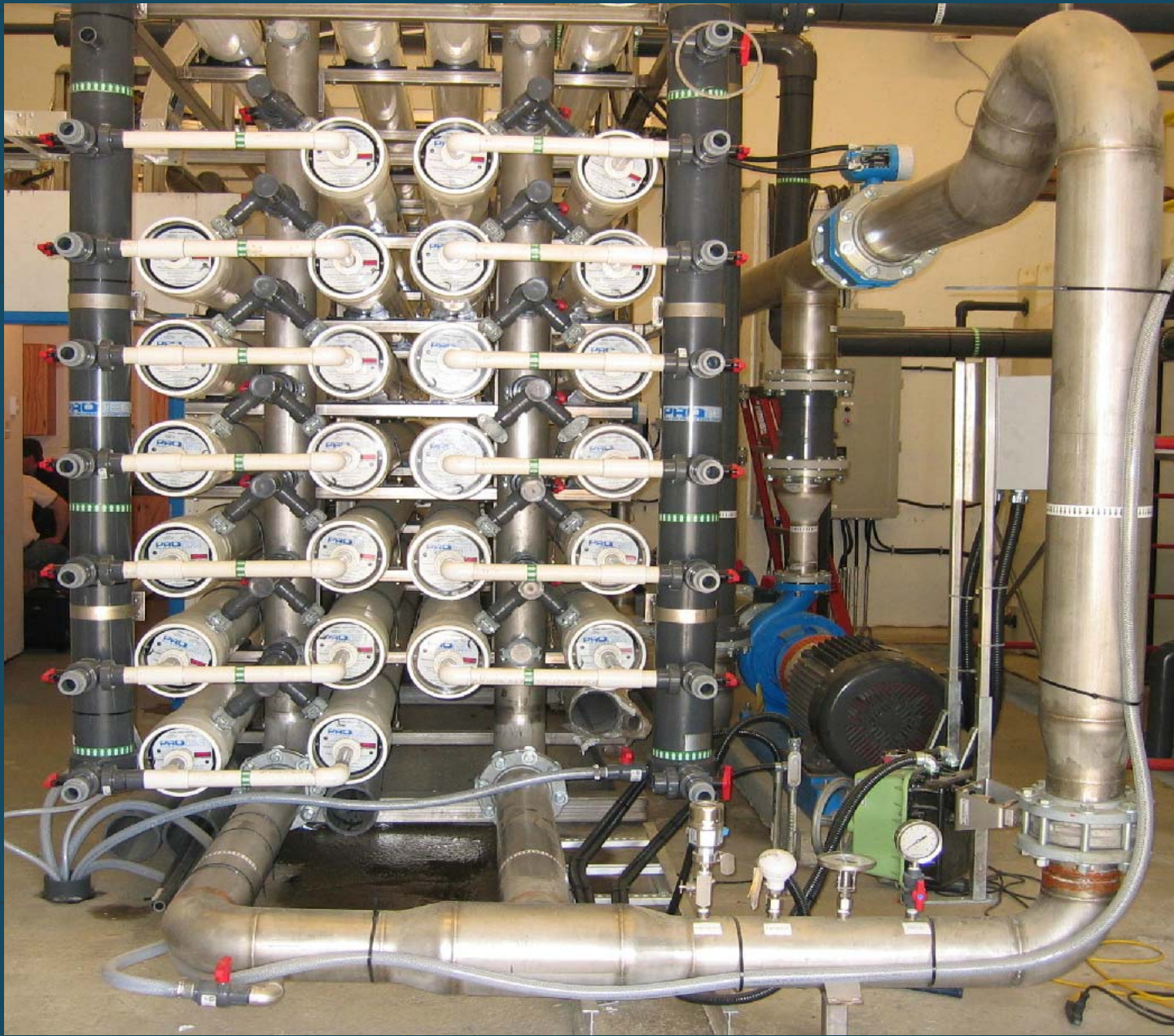
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# Operation

- **Start up on June 1st**
- **System runs in auto according to demand (level in reservoir)**
- **Top up chlorine tank weekly**
- **Top up sodium carbonate tank every 3 weeks**
- **to date chemical clean (mild citric acid) on membranes completed every 2-3 weeks; chlorine flush once every 2-3 weeks**



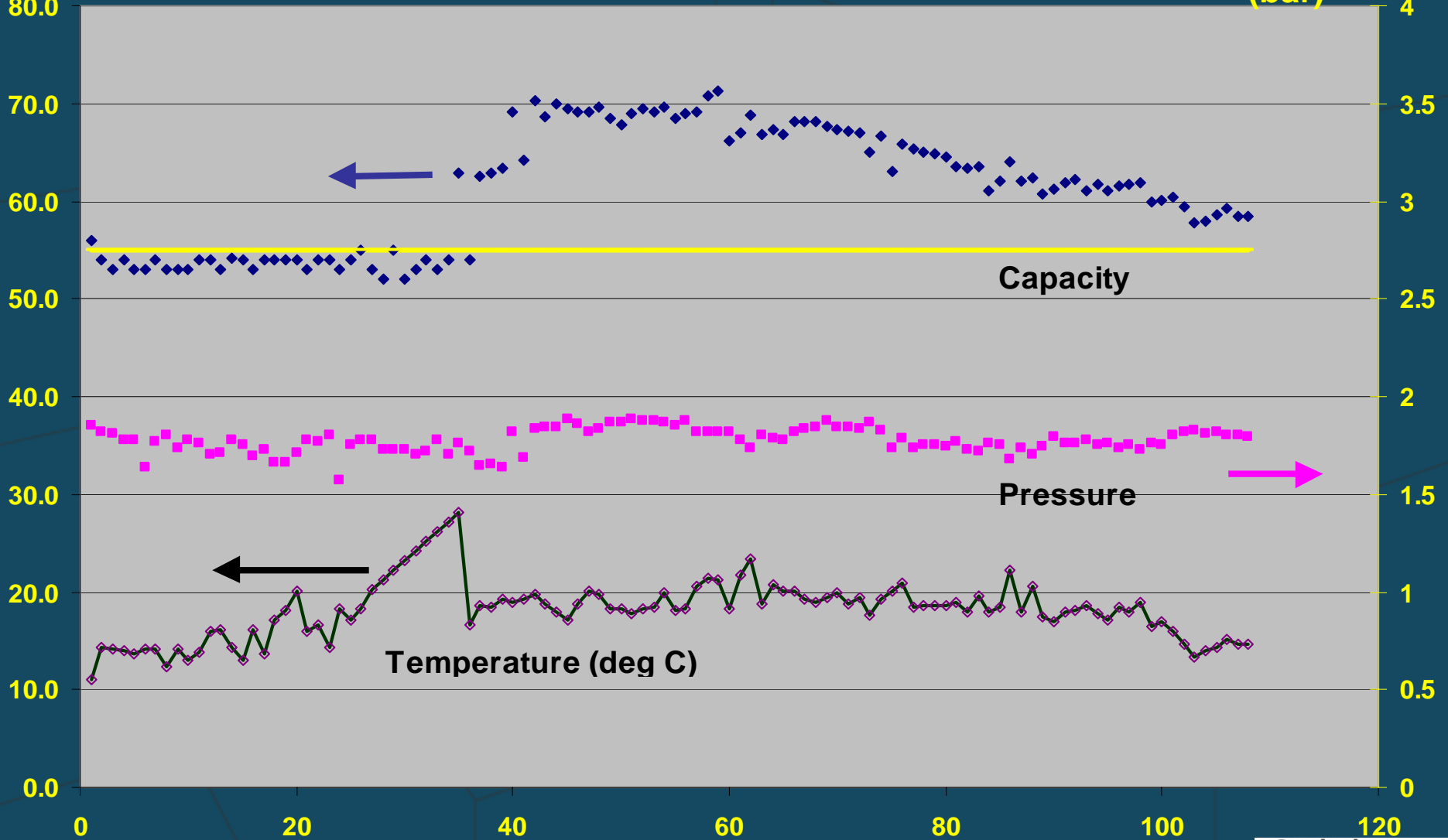
# Water Quality

- **Turbidity (on-line):** 0.02-0.03 NTU
- **Chlorine demand:** dropped by approx. 55%
- **Colour:** <3 TCU
- **TOC:** 1.0\*
- **THM:** 30-35 microg/l\*
- **Iron:** 0.01 mg/l\*

# Membrane System Performance

Capacity  
(m<sup>3</sup>/hr)

Average  
Pressure  
(bar)



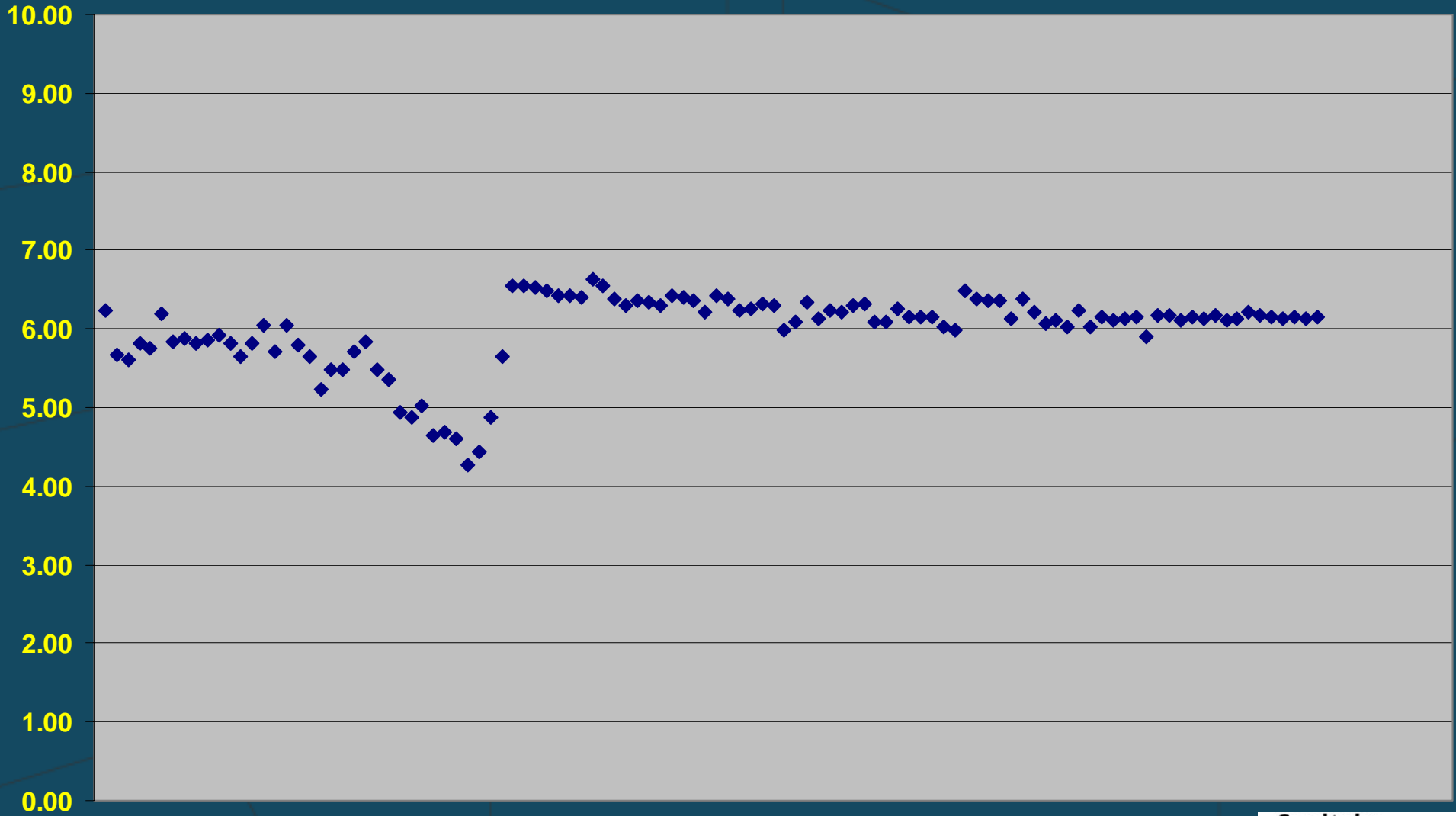
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# Temperature Corrected Capacity

m<sup>3</sup>/hr/bar



# Capital & Operating Costs

- **Capital equipment \$1.2m**
- **Projected operating costs:**
  - **approx. \$50,000 a year**
  - **\$0.10 per m<sup>3</sup> of treated water**
  - **\$0.027 per 1000 usgallons of treated water**

# Environmental Impact

- **No wastewater treatment needed**
- **10 to 25% of extracted water returned unused to source with no chemicals added**
- **Membrane washwater and sand filter backwash - low volume, non toxic, meets surface water discharge standards in Newfoundland when bled out with unused water**

# The Fyne Process

- **Barrier to pathogens and viruses**
- **Disinfection By Products (THMs & HAAs) removed to well below recommended safe levels**
- **No Chemical Hazards**