MemJet
Membrane Bioreactor
Technology

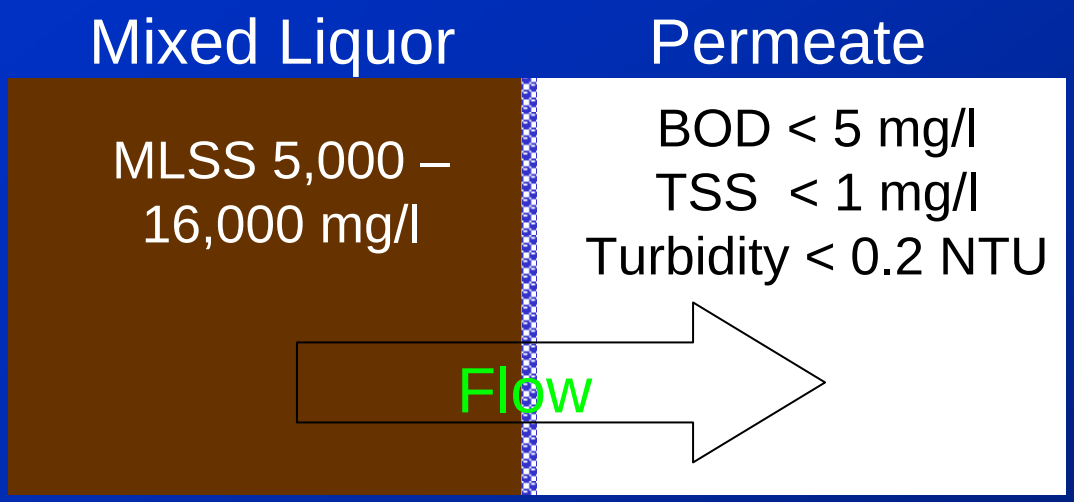
USFilter, Jet Tech Products

Presentation Outline

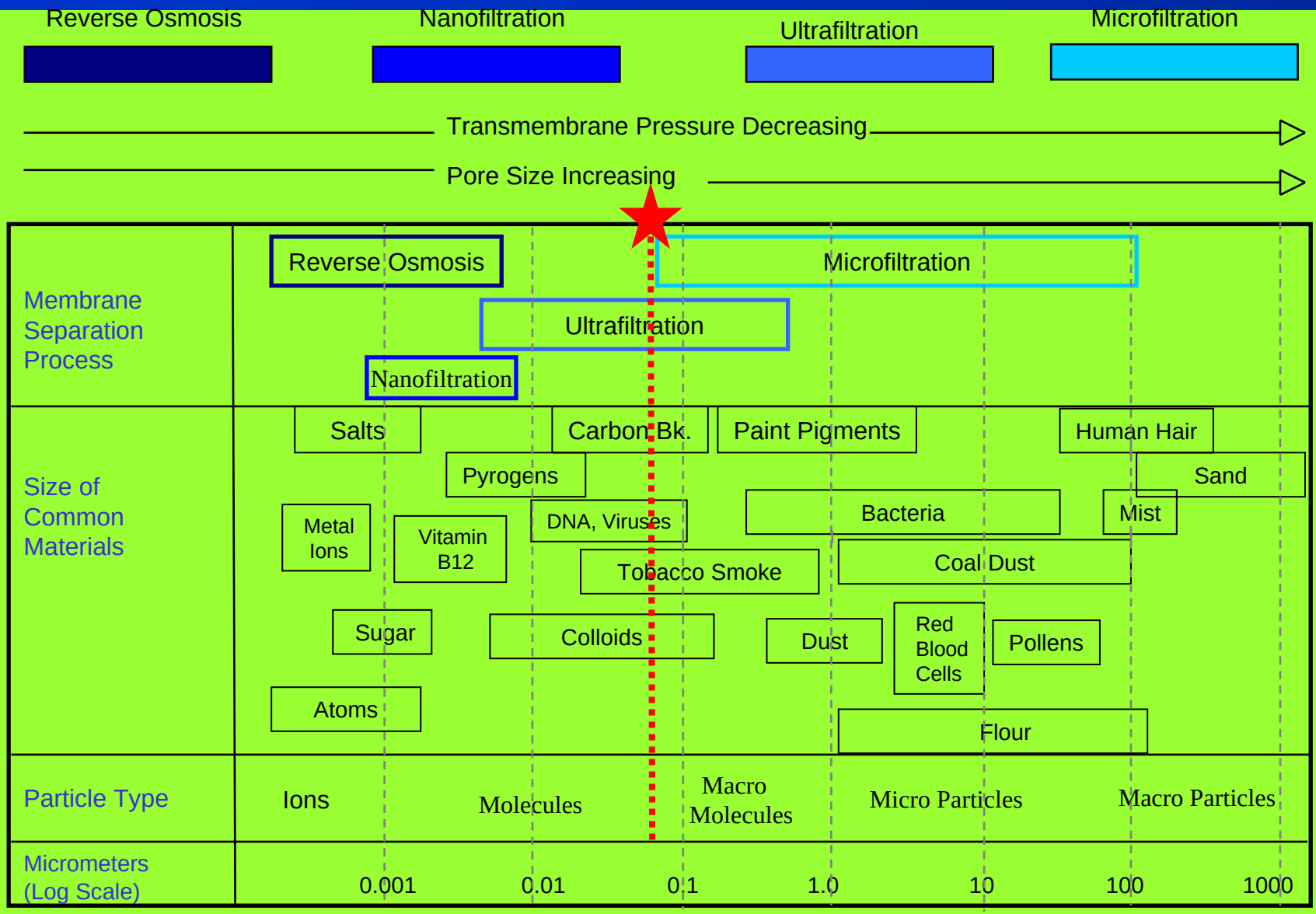
- Membrane Filtration Basics
- MBR Evolution
- Value of MBR Technology
- USFilter MBR design
- Pilot Capabilities
- Demonstration Plant

Membrane Filtration Basics

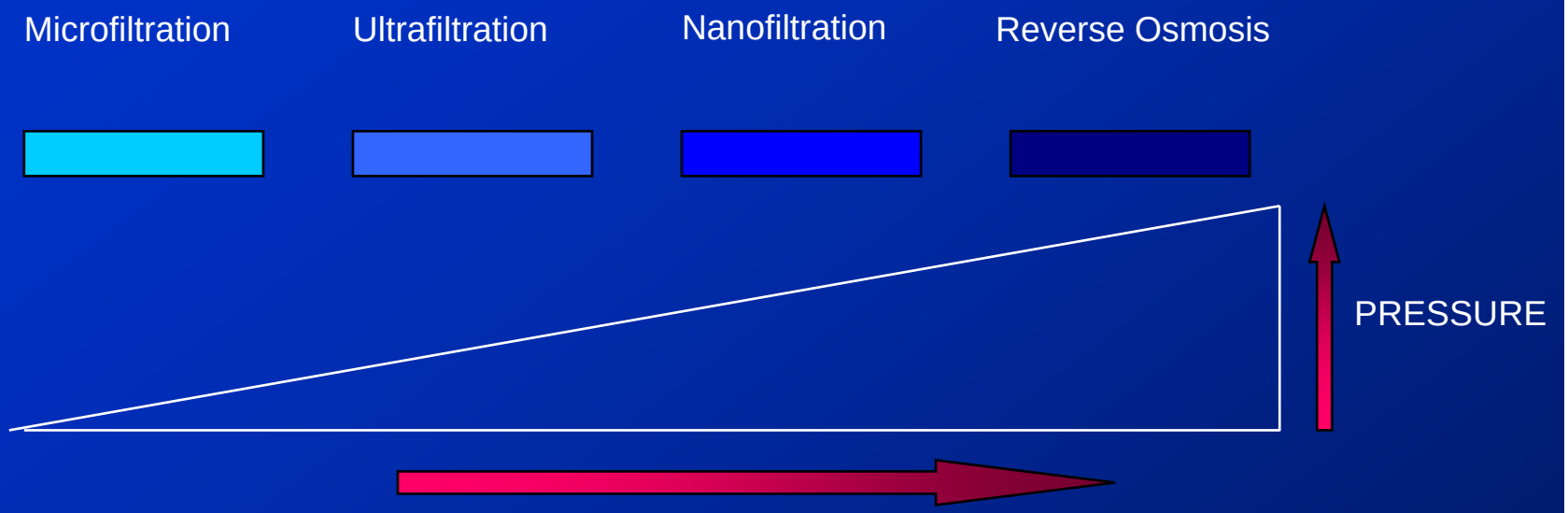
Low-Pressure Polymeric Membrane



Membrane Filtration Spectrum



Membrane Spectrum



Filtration in the 0.1 micron range is the most widely used membrane type in wastewater treatment applications.

Definitions

- **Immersed membrane:** Membrane submerged directly in process, outside to inside flow under vacuum
- **Flux:** Loading rate of flow per membrane surface area in GPD/Ft^2 ("GFD")
- **TMP:** Pressure across membrane surface in PSI
- **Permeability:** Flux divided by the pressure GFD/PSI
- **Packing Density:** Area of fibers divided by module area
- **Lumen:** Open center of the fiber
- **Backpulse:** Reverse flow with change from vacuum to pressure on membrane
- **Maintenance Clean:** Short term, in-process cleaning procedure
- **CIP:** Clean-In-Place chemical clean process

Four-Module Pilot

Membrane Configurations

- **Polymer Monolith**
  - Single material (homogeneous)
  - Self-supporting
  - Single manufacturing process
  - Hollow fiber configuration only
- **Laminate**
  - Multiple materials (non-homogeneous)
  - Multiple manufacturing processes
  - Supported
  - Hollow fiber or flat-sheet configuration

Polymer Monolith

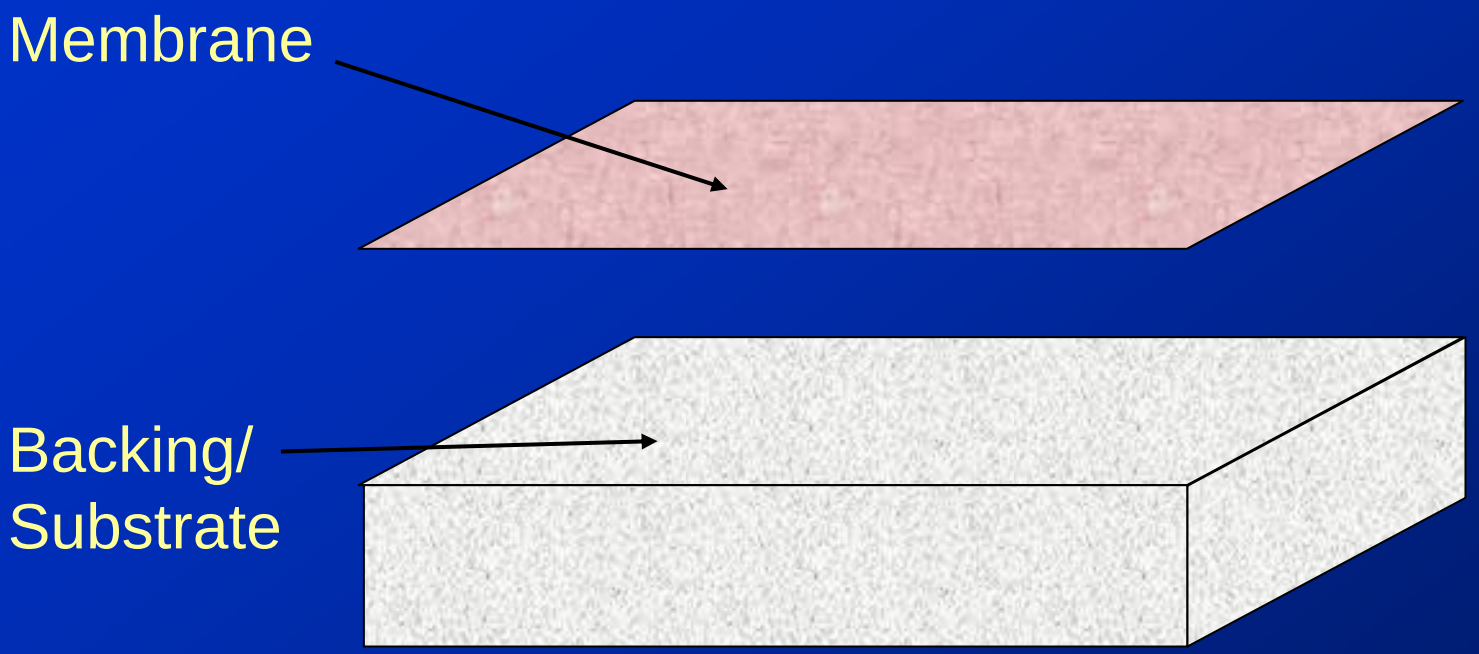
- **Symmetrical**
  - Pore structure similar through membrane depth
  - Microfiltration only

- **Asymmetrical (used in MBR)**
  - Also called “skin” membranes
  - Very thin, tight membrane layer at surface with macroporous substructure
    - Microfiltration
    - Ultrafiltration

Laminated Membrane

Membrane

Laminated Membrane



- Membrane is applied to a substrate or backing for support
- Mechanical bond is critical

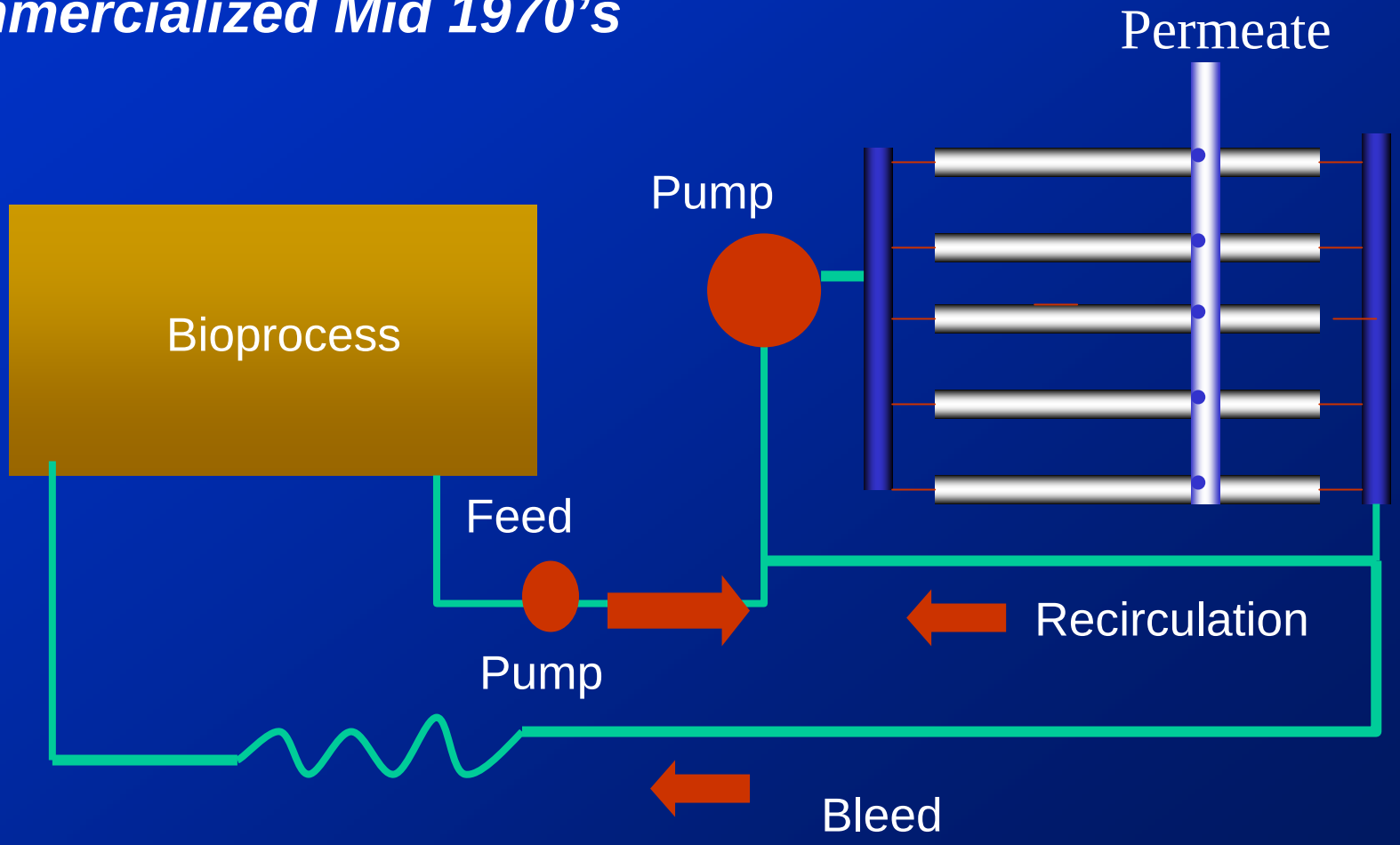
Membrane Comparison

Characteristic	Polymer Monolith	Laminate
Materials	1 (Homogeneous)	2 or more
Tensile Strength	Low	High
Radial Strength	High	Low
Delamination Potential	None	Yes
USFilter Configuration	Yes	No

Membrane Bioreactor Evolution

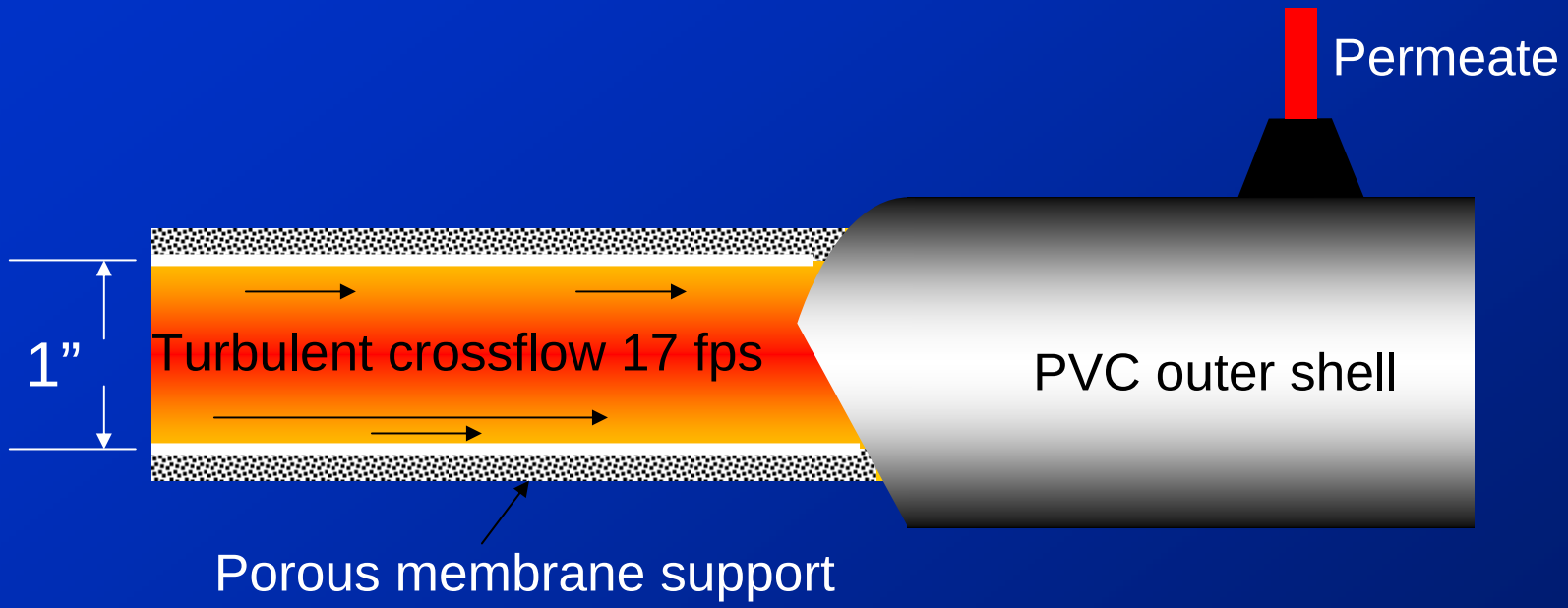
Tubular Membrane Feed & Bleed MBR's

Commercialized Mid 1970's



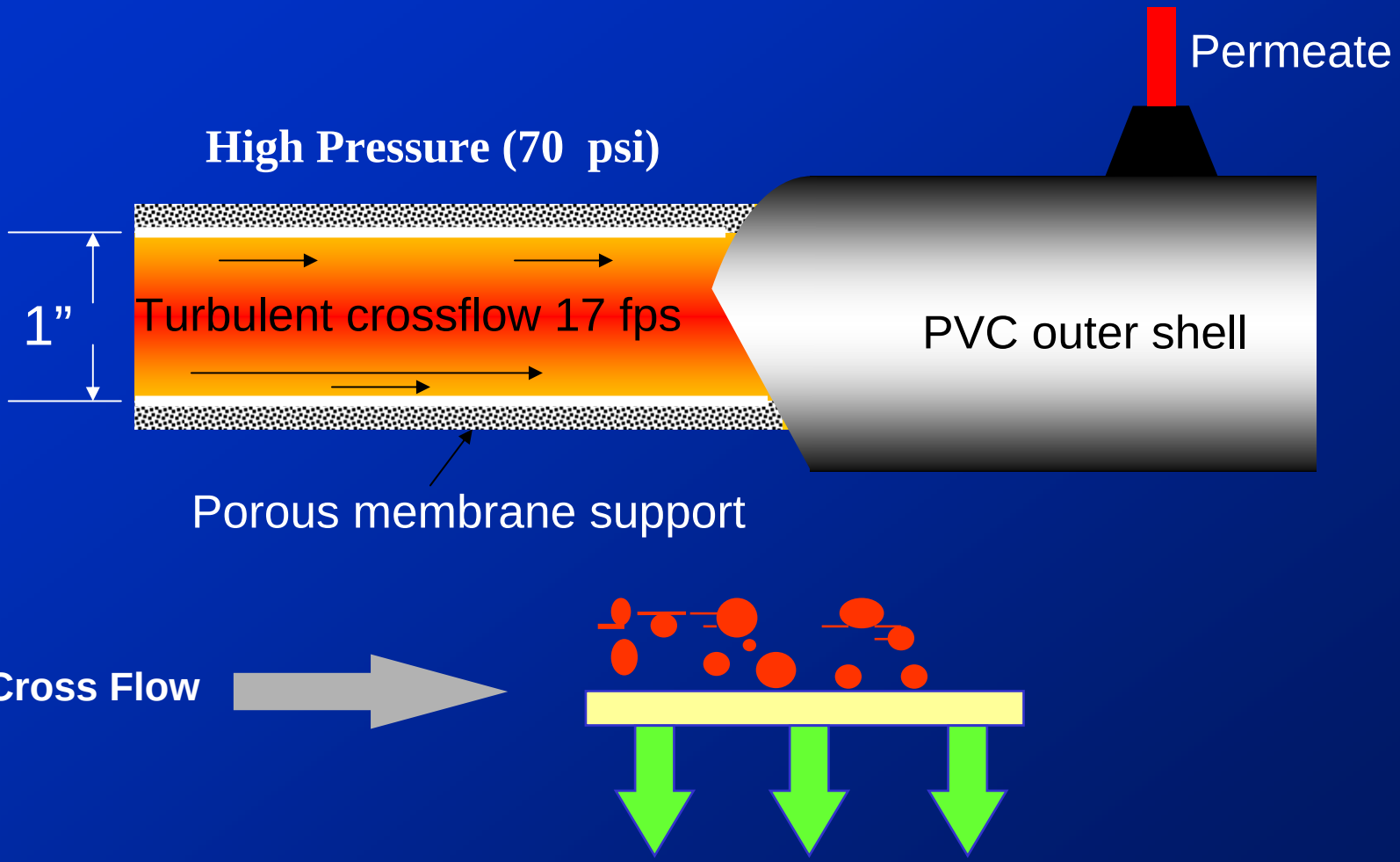
Cross Flow Tubular

Low surface area - high energy consumption



Cross Flow Tubular

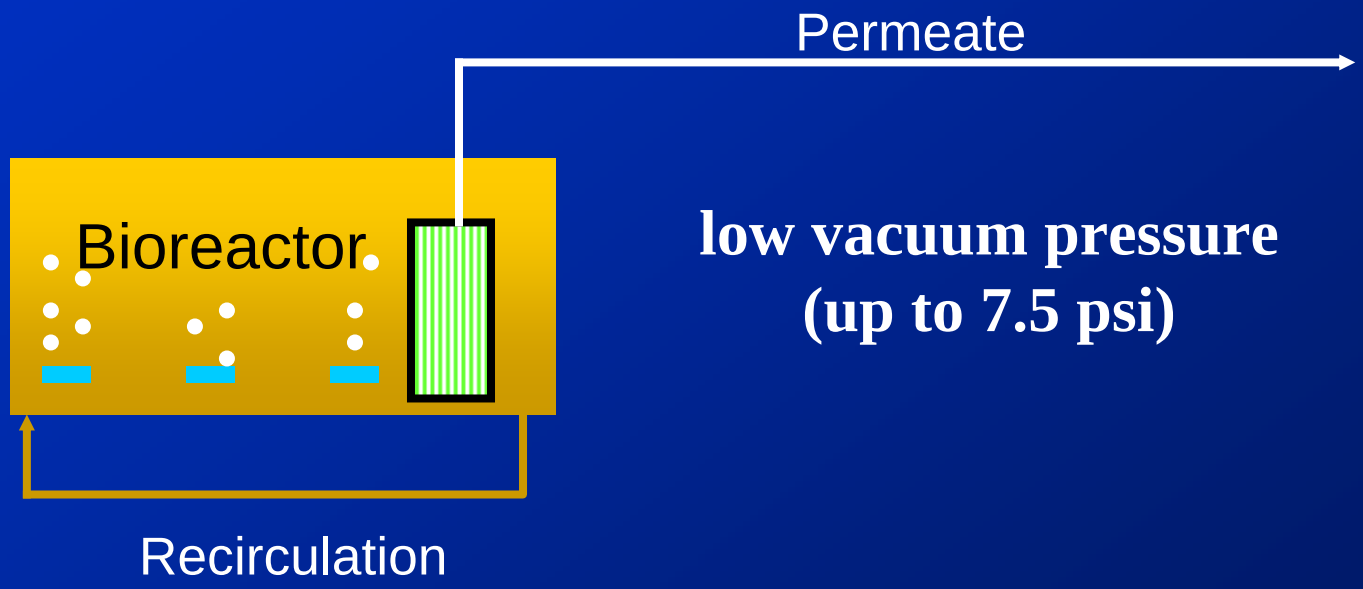
Low surface area - high energy consumption



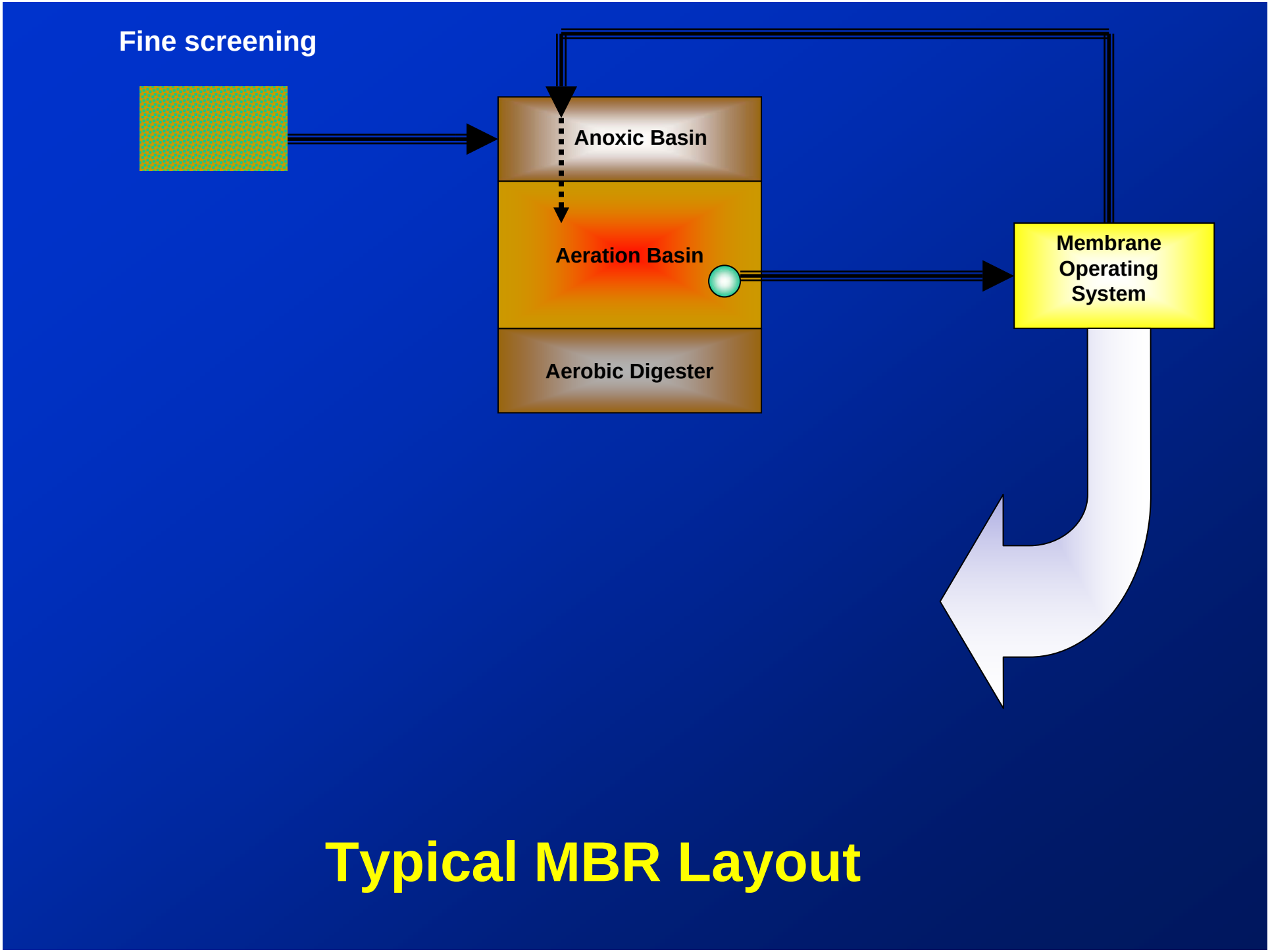
Immersed Membrane MBR

High surface area – reduced energy consumption

Commercialized 1990's

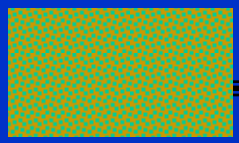


low vacuum pressure
(up to 7.5 psi)



Typical MBR Layout

Fine screening



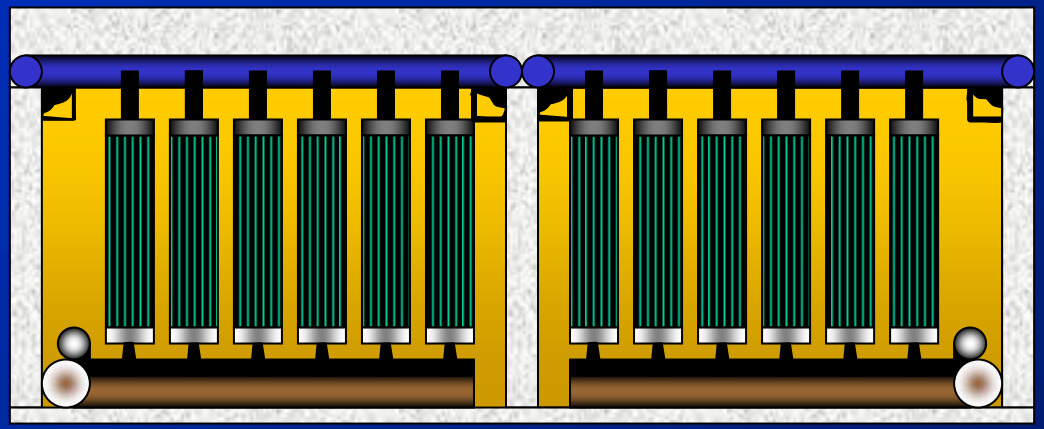
Anoxic Basin

Aeration Basin

Aerobic Digester

Membrane Operating System

Membrane Operating System



Typical MBR Layout

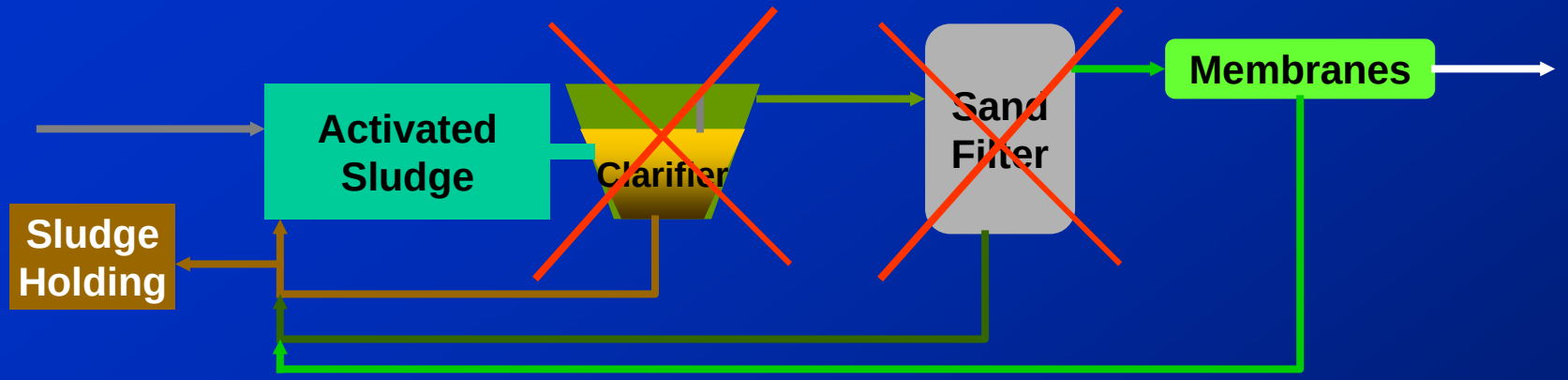
Benefits of Immersed MBR Technology

Value of MBR technology over conventional processes

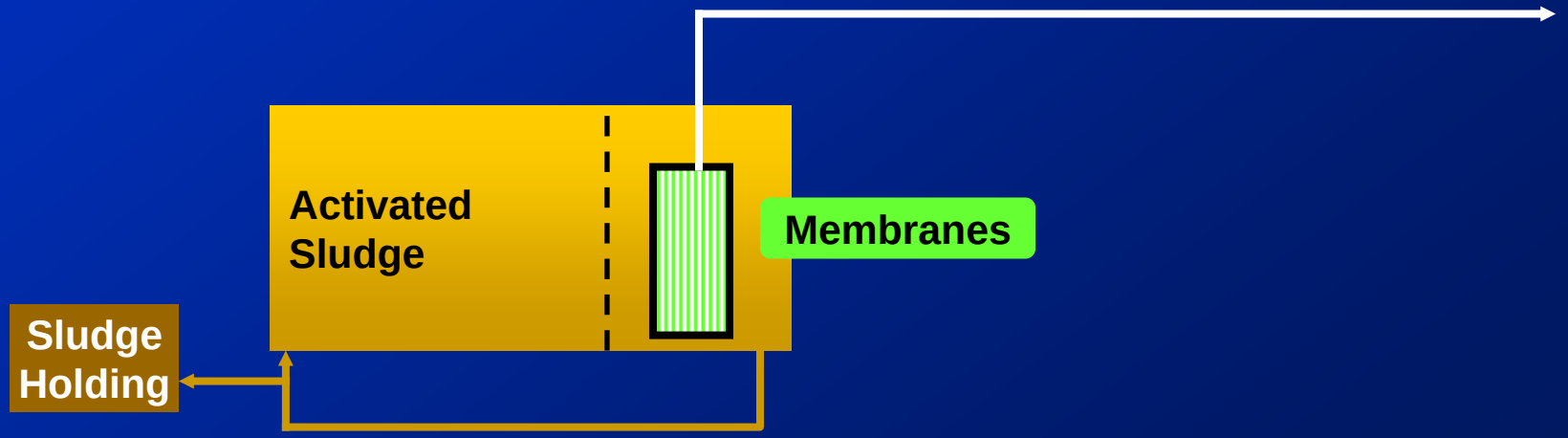
- Fewer process steps to achieve comparable effluent quality
- Eliminates sludge settleability problems
- Small Footprint
- Modular expansion capability
- Reduced sludge yield
- High quality effluent
  - Low effluent turbidity
  - Excellent nutrient removal capability
  - High rejection efficiency of organic constituents, solids and micro-organisms
  - Uncompromised effluent in upset conditions

“Less is More”

Conventional Process Using Low Pressure Membranes



Integrated Membrane Bioreactor



Integrated Membrane Bioreactor Process

HIGH MLSS

Conventional

2,000 - 4,000 mg/l

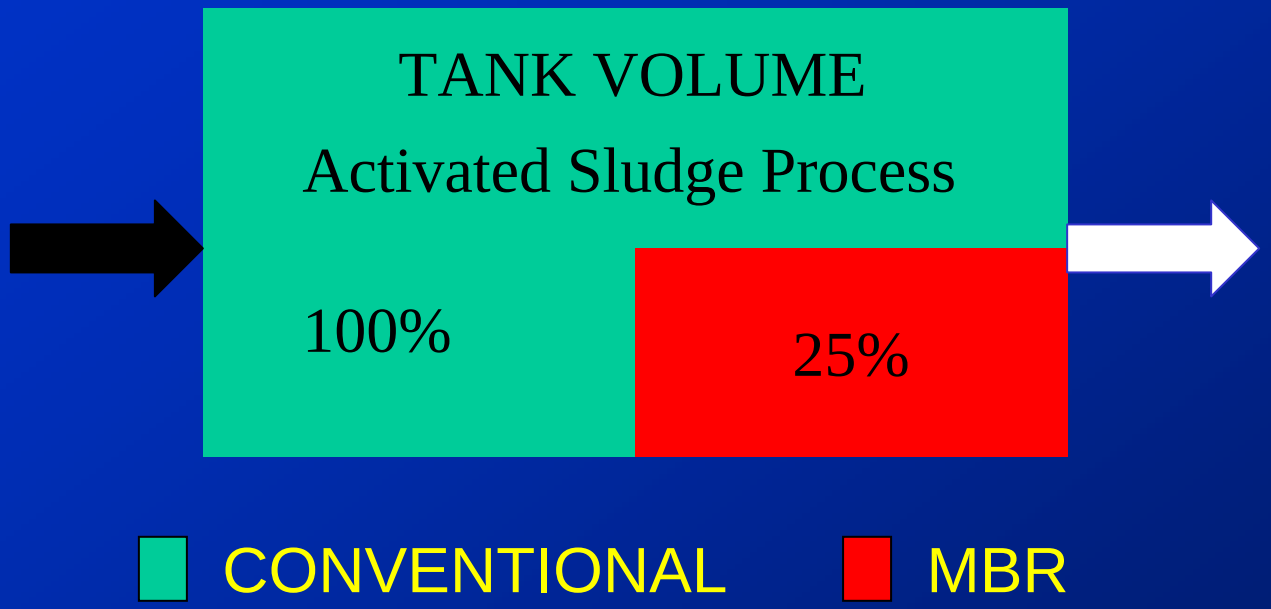
Integrated Membrane Bioreactor

8,000 - 16,000 mg/l

$$\frac{F}{M} = \frac{\text{BOD Loading}}{\text{MLSS} \times \text{Aeration Vol.}}$$

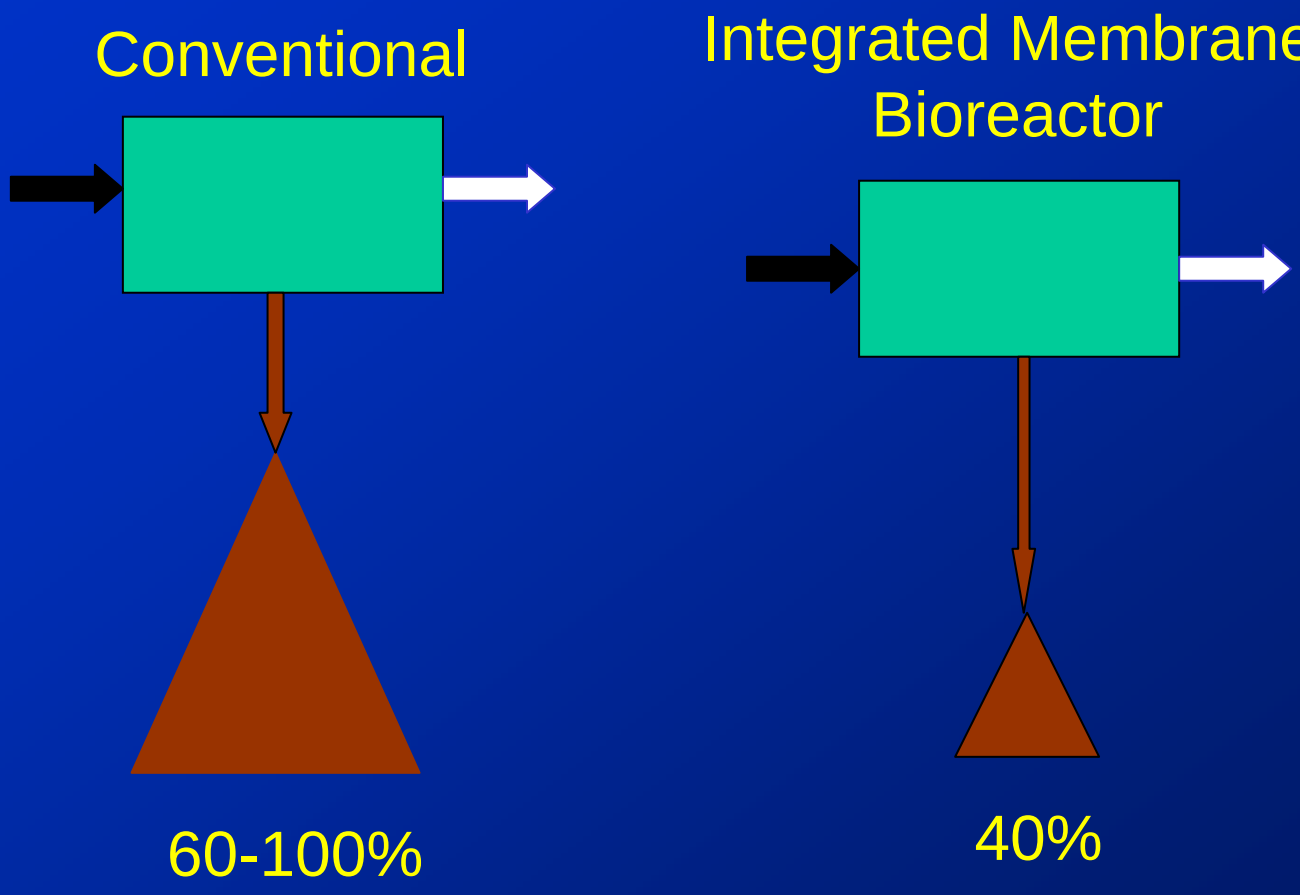
BOD X Daily Flow

Integrated Membrane Bioreactor Process



Small Footprint

Integrated Membrane Bioreactor Process



Low Sludge Yield

Where do MBR's fit?

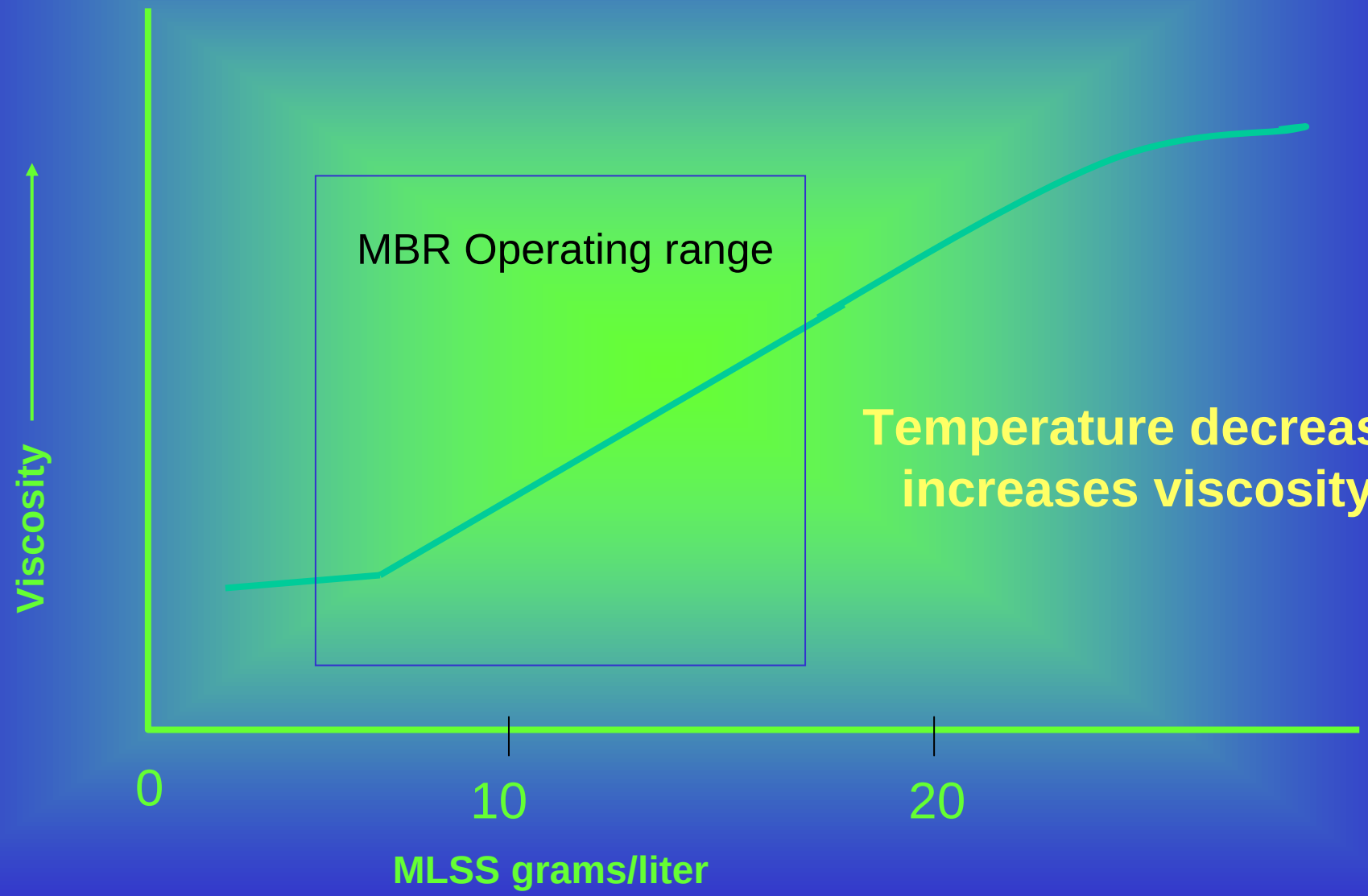
- Advanced phosphorus and nitrogen removal
- Effluent reuse and recharge
- Limited footprint
- Upgrade of existing plants
  - Increased flow in existing tankage
  - Restricted effluent requirements
  - Nutrient reduction
  - Add-on to existing biological process

USFilter

MemJet

MBR Technology

Viscosity vs. Mixed Liquor Solids Concentration



Managing the Membrane Environment

Keys to success:

- Fine screening
- Controlling fluid transfer

Failure results in:

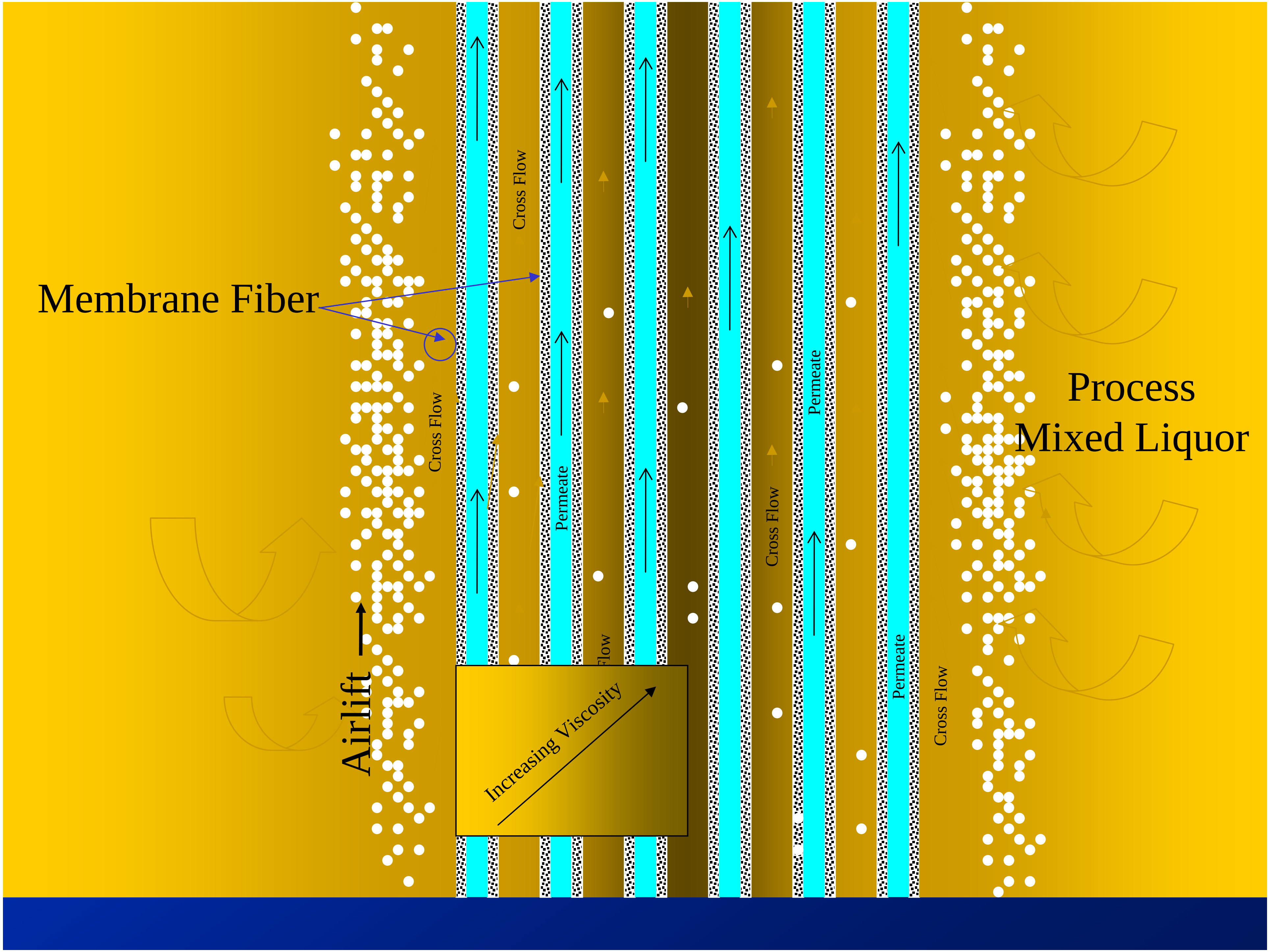
- Solids packing around fibers
- High Fluid Viscosity around fibers
- Loss of Permeability (Fouling)
- High Maintenance

USFilter MBR Design

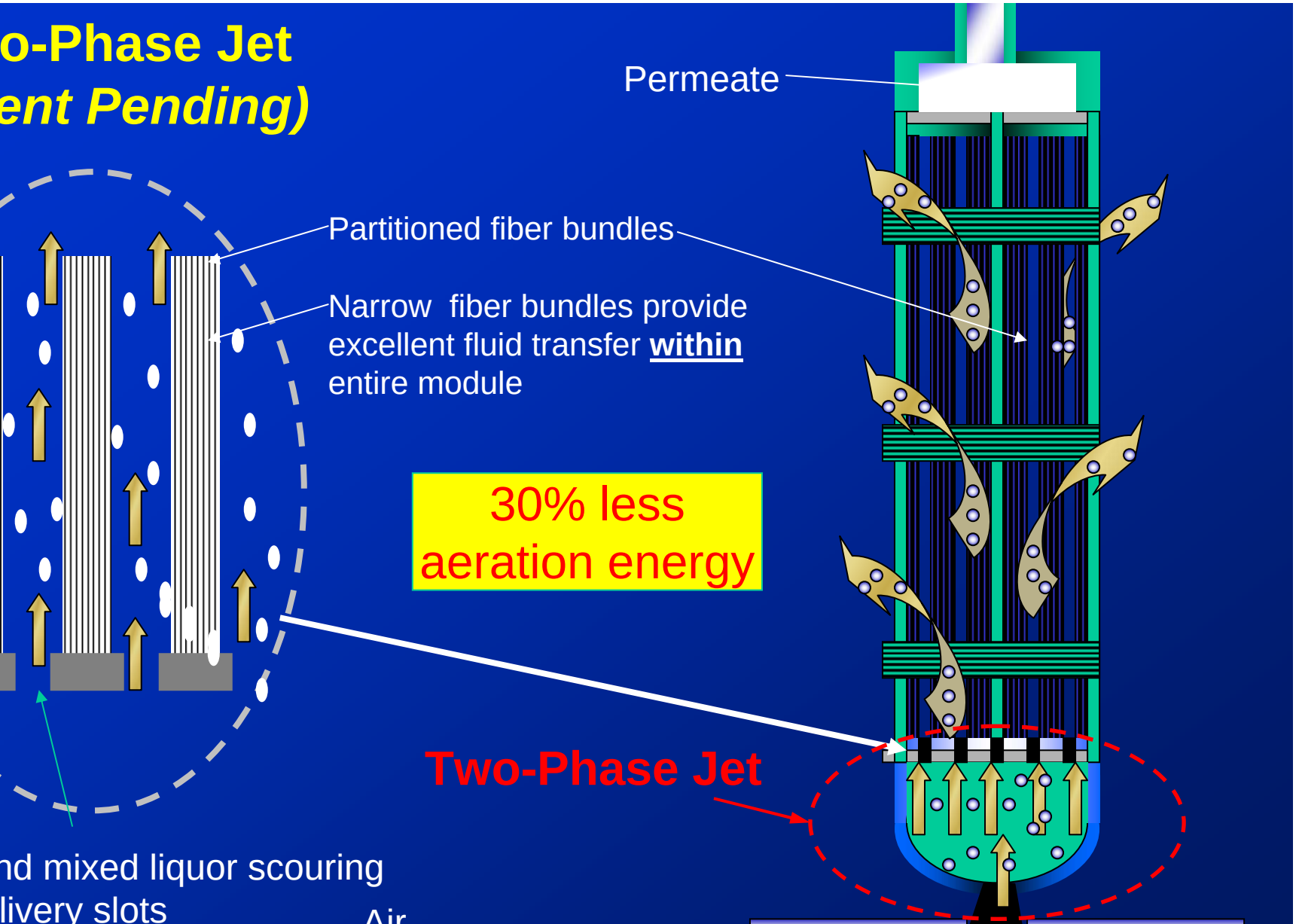
- **Managing the Membrane Environment**
  - **Fluid Renewal System (Two-Phase Jet)**
  - **Separated Membrane Process**
- **Maintenance Procedures**
  - **Backpulse**
  - **Maintenance Clean**
  - **CIP**
- **Integrity Test Capability**
  - **Ability to predict turbidity breakthrough, identify source, and repair**

Features & Benefits of USFilter MBR

- Controlled environment around membrane system
- Positive fluid transfer into fiber bundles
- Uniform distribution of flow and solids
- Cross-flow dynamics minimize energy consumption
- Automated, in-place, membrane cleaning process (membrane removal unnecessary)
- Safe environment for plant operators
- Flexibility in biological process selection

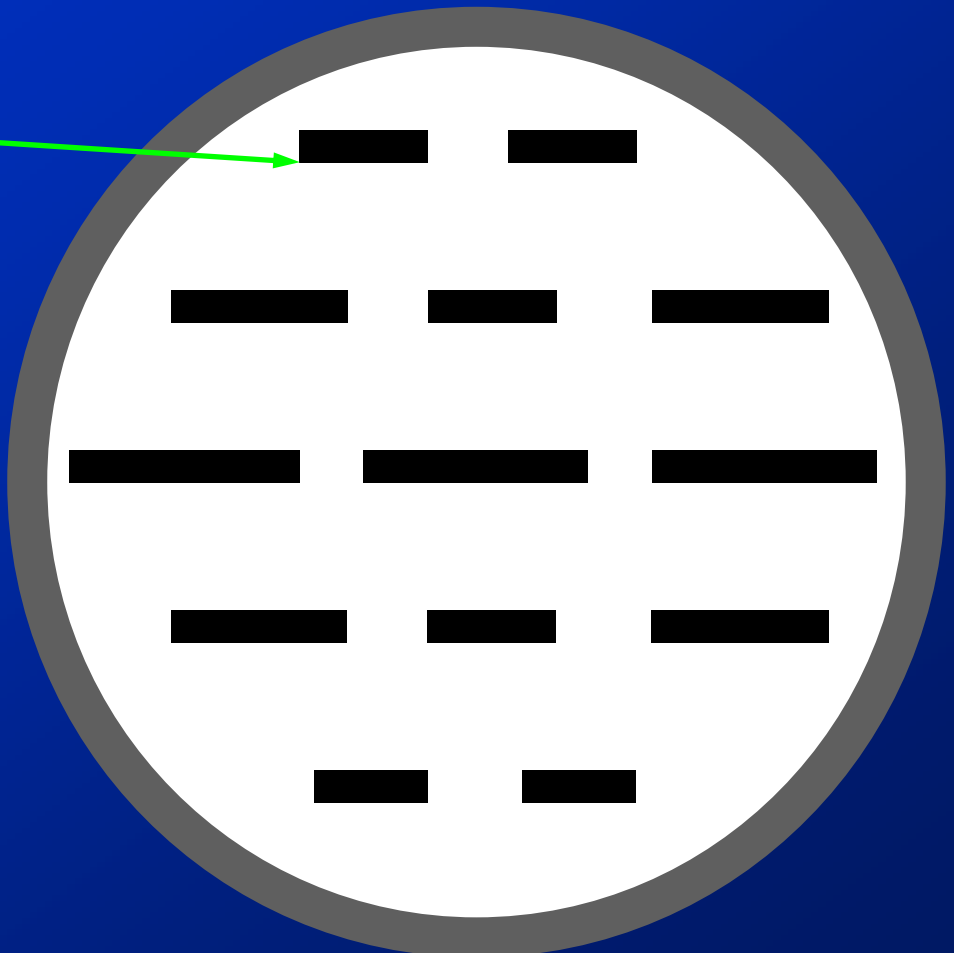


Membrane Fiber
Process
Mixed Liquor
Airlift
Cross Flow
Permeate
Increasing Viscosity


o-Phase Jet
ent Pending)
Permeate
Partitioned fiber bundles
Narrow fiber bundles provide excellent fluid transfer **within** entire module
30% less aeration energy
Two-Phase Jet
nd mixed liquor scouring
livery slots
Air

Bottom of Module

Air & Mixed
Liquor “Ports”

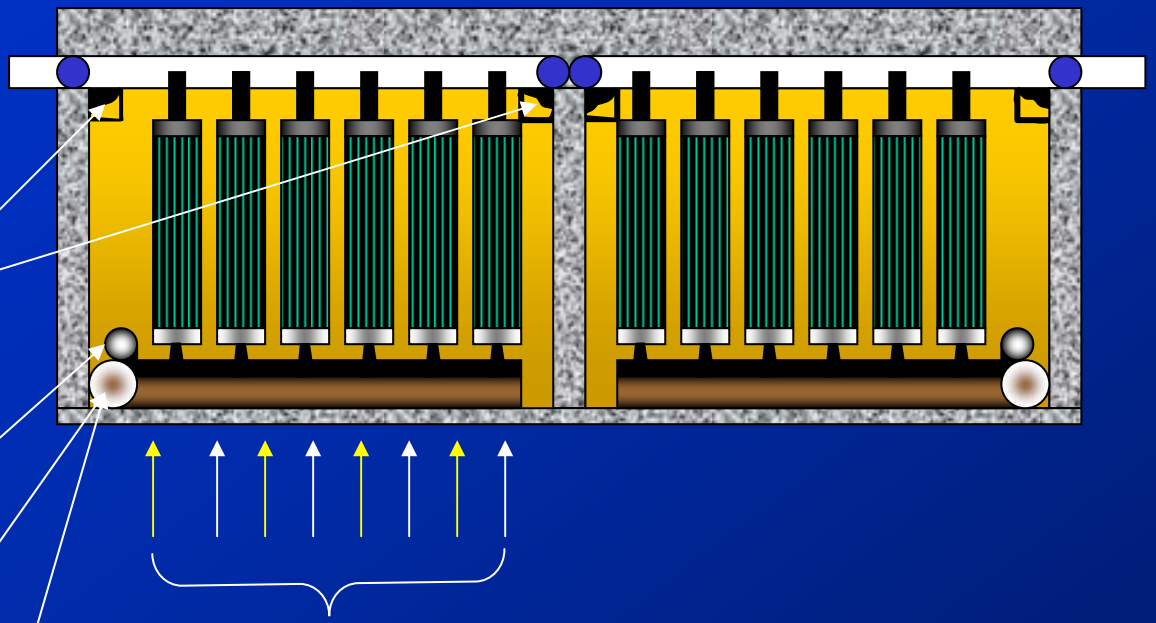


vides even distribution
r & mixed liquor within
ule

-divides module into
ller partitioned bundles

nembrane fibers are
ured with air and mixed

Membrane Operating System



ed liquor
rflow &
ase
noval

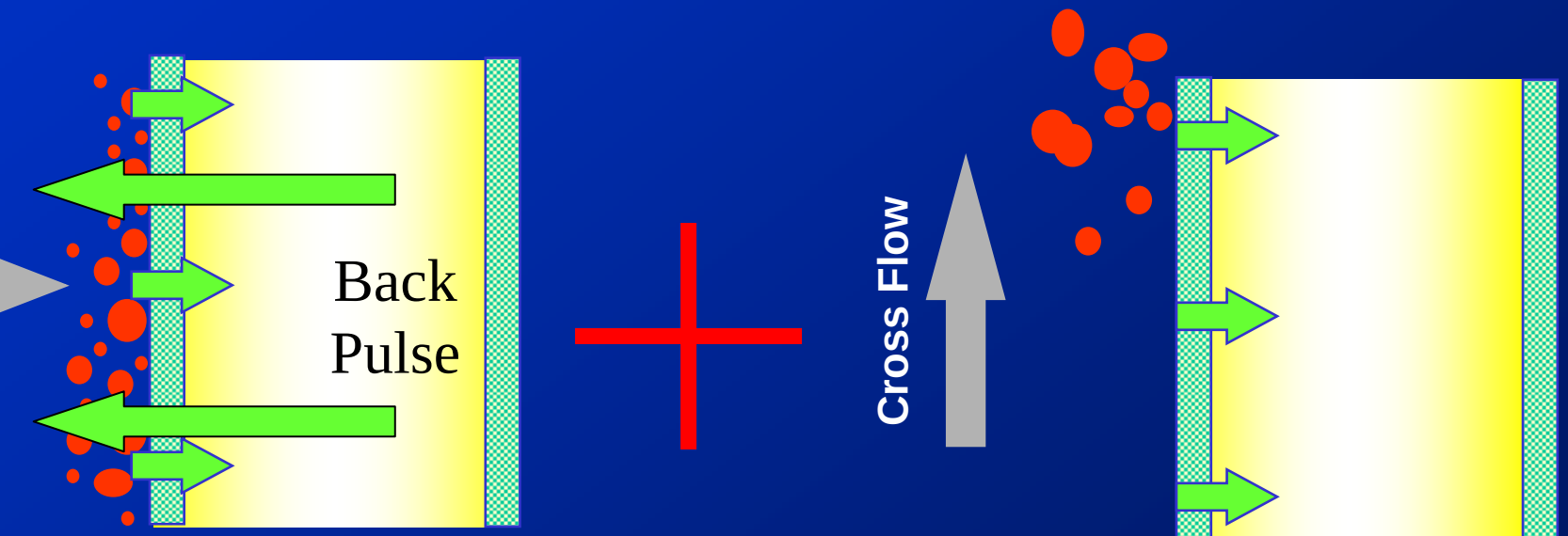
membranes

d liquor
embranes

liquor & air operated
endently

Uniform air/mixed liquor
distribution across membranes

Combination of
Cross-Flow Dynamics
and
Dead-End Filtration



Factors impacting cleaning interval

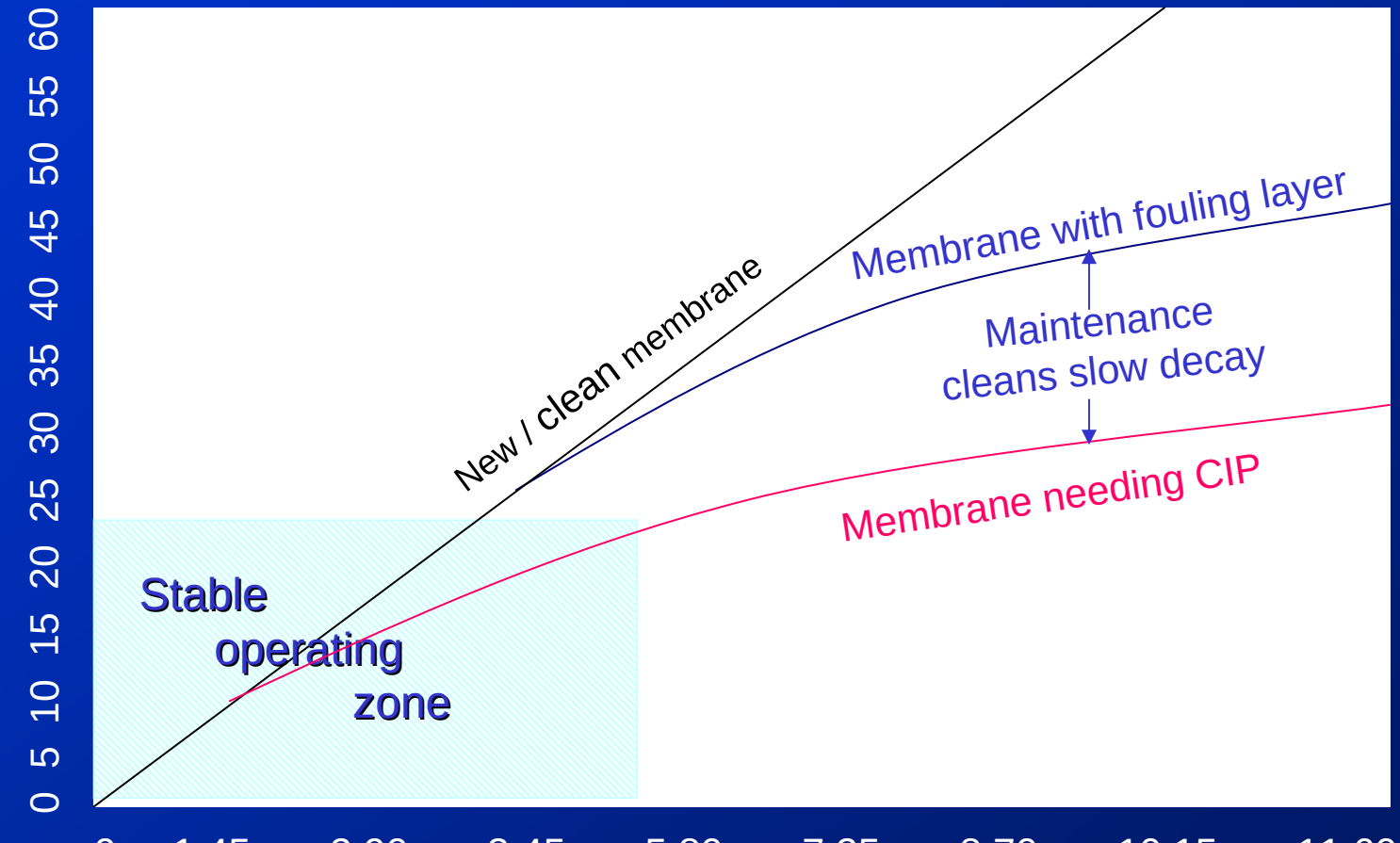
Prescreen: Poor prescreen will cause fibers and debris to be trapped in fiber bundles restricting movement

Free oils and greases: These can coat the membranes and decrease flux. Standard municipal wastewater not a problem.

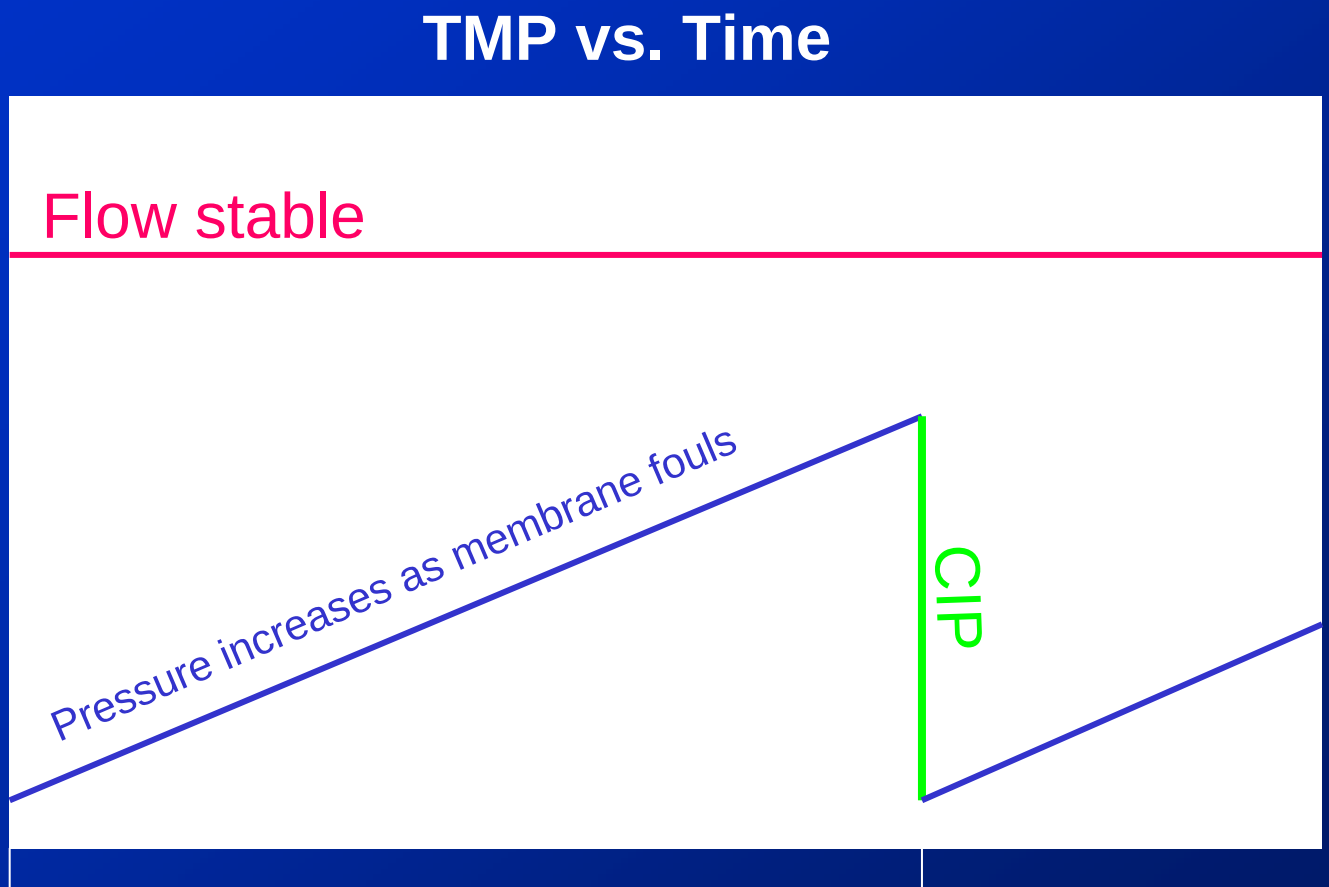
Polymers: High concentration of polymers can coat membranes and decrease flux.

ermeability Curve - Flux vs. TMP

pact of fouling layer on permeability



ow Control Operation



Membrane Maintenance

- Backpulse
- Maintenance Clean
- Relaxation
- Clean-In-Place (CIP)

ckpulse

- Completely Automated
- Every 12-20 minutes
- 15 second duration
- Reverse flow utilizing filtrate pumps
- Jet with mixed liquor and air remains in operation

axation

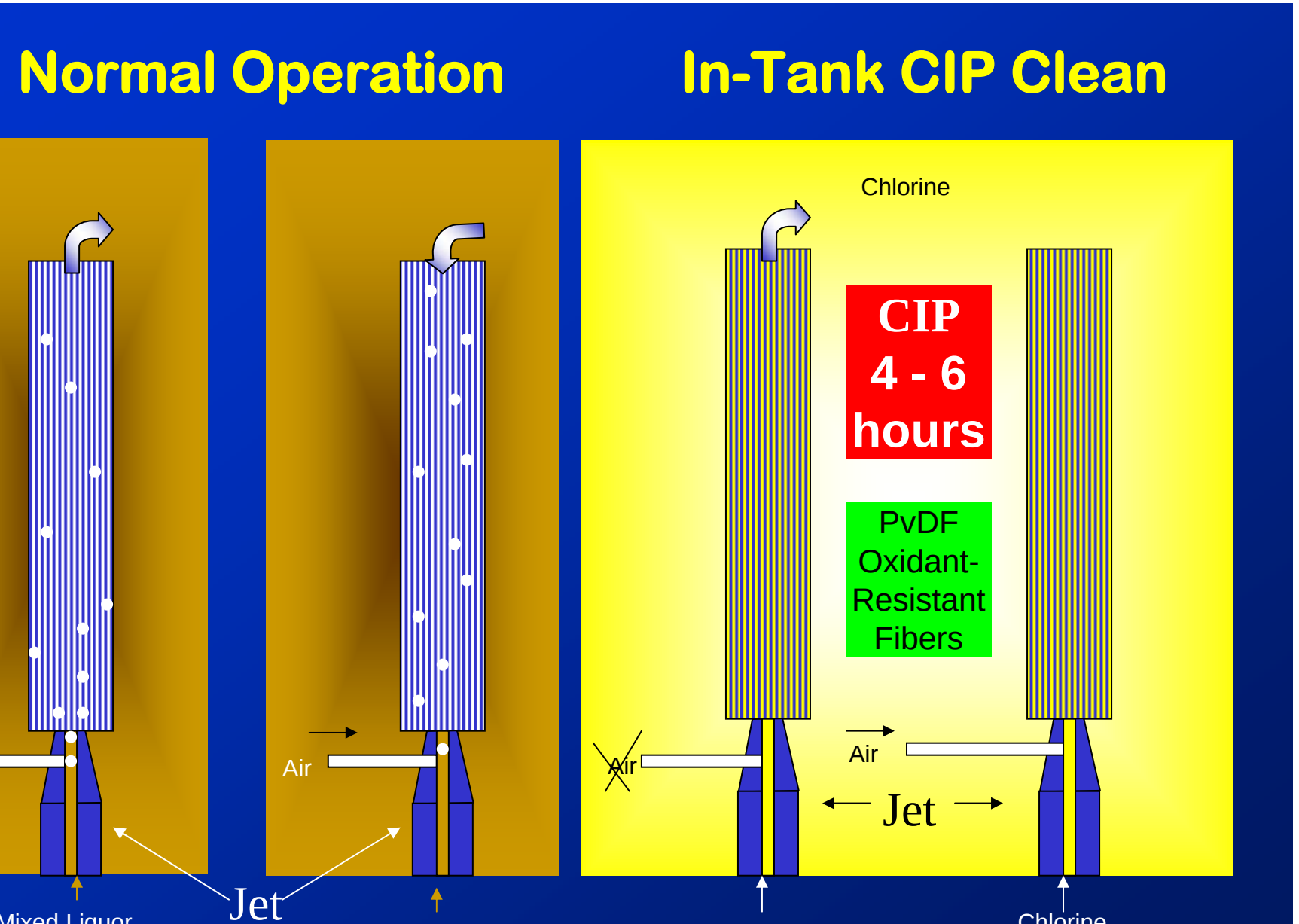
- Completely Automated
- Using periodically to reduce solids buildup on membrane surface
- Relieves solids tension on membrane surface so they are scoured away
- Filtrate pumps are stopped
- Jet with mixed liquor and air remains in operation

ntenance Clean

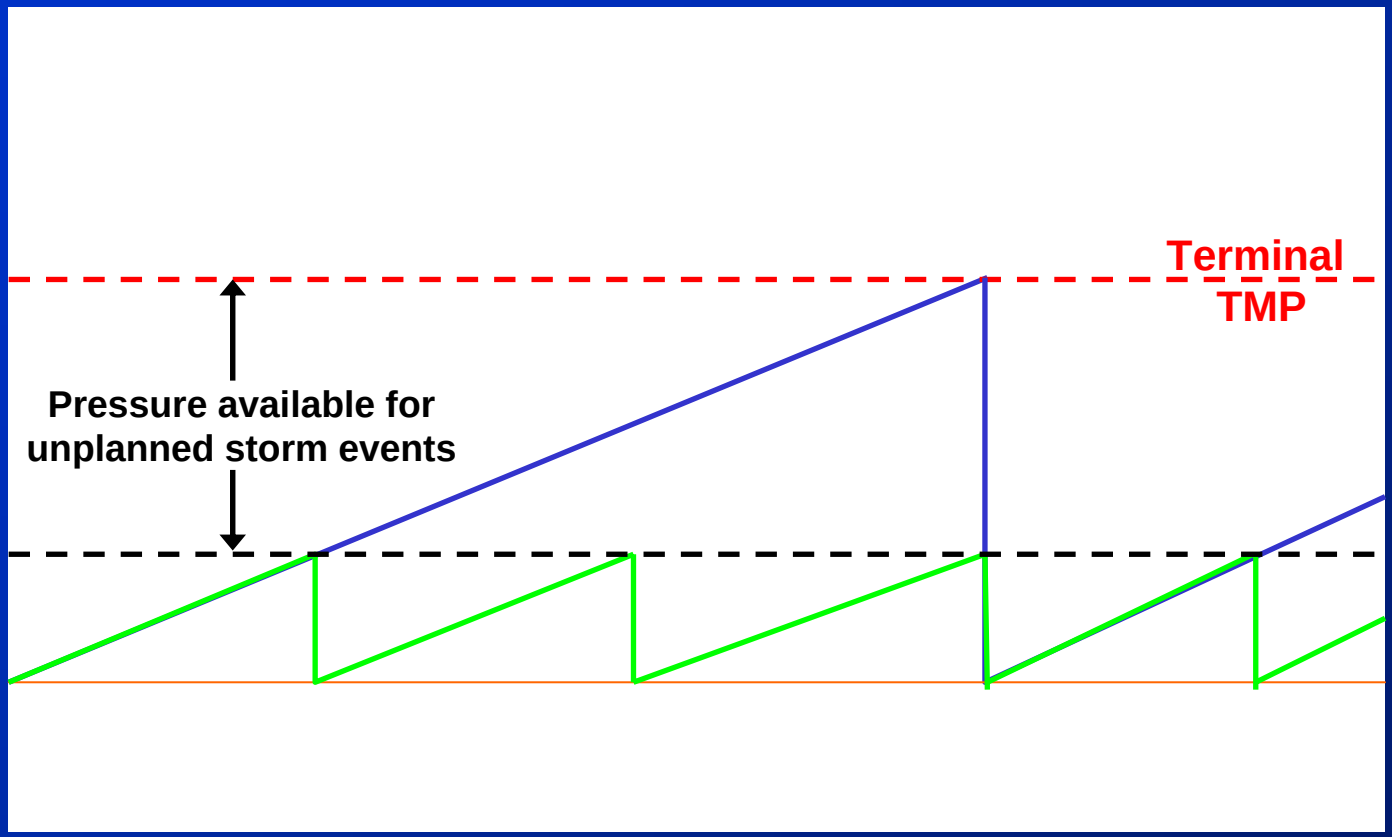
- Completely Automated
- Every 1-2 weeks on larger plants
- 30-40 minutes duration
- Inject chlorinated filtrate (200 mg/l) into membrane
- Inhibits biological surface fouling
- Mixed liquor remains in tank

an-In-Place (CIP)

- Automated – no membrane removal
- Every 2-6 Months
- 4-6 hours per membrane cell
- Mixed liquor sent back to biological tanks
- Utilizes chlorine @ approximately 1,000 mg/l
- Occasional acid cleans for inorganic fouling


Normal Operation
In-Tank CIP Clean
Air
Jet
Mixed Liquor
Chlorine
CIP
4 - 6
hours
PvDF
Oxidant-
Resistant
Fibers
Air
Air
Jet
Chlorine

ffect of CIP Frequency



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cations Piloting

5,760 GPD MBR Pilot


Membrane Operating System
MOS
USFilter
USFilter
TIU 786

omplete “Rack” Assembly

MBR Demonstration Plant

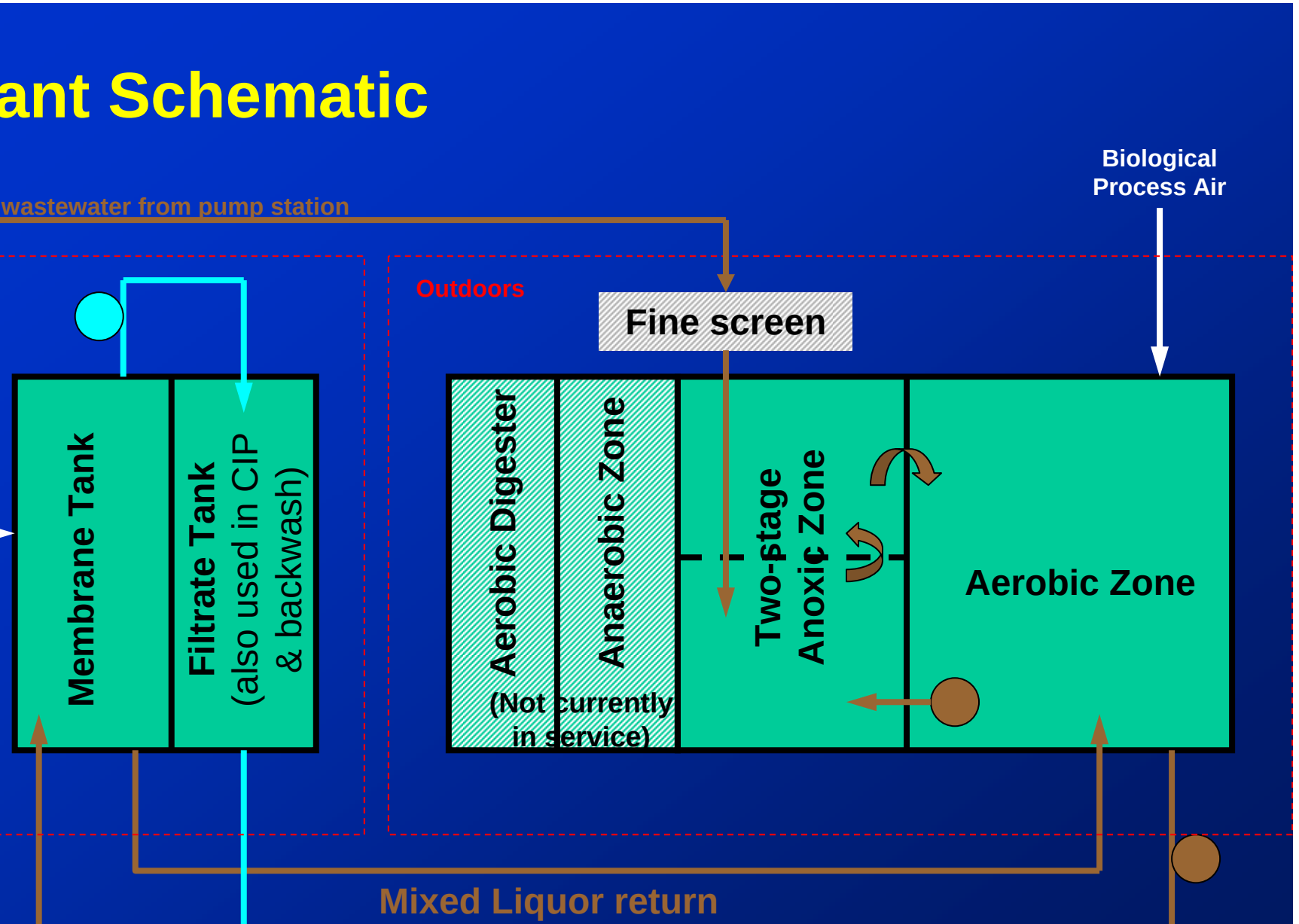
Kansas City, Kansas MUD

ant Design

Design capacity 50,000 GPD

Complete plant includes

- **Fine Screen**
- **Anaerobic Reactor**
- **Two-stage Anoxic Reactor**
- **Aerobic Reactor**
- **Membrane Operating System (MOS)**
- **Aerobic Digester**


ant Schematic
Biological
Process Air
wastewater from pump station
Outdoors
Fine screen
Membrane Tank
Filtrate Tank
(also used in CIP
& backwash)
Aerobic Digester
(Not currently
in service)
Anaerobic Zone
Two-stage
Anoxic Zone
Aerobic Zone
Mixed Liquor return

Biological Process Tanks


mbrane Tank

or questions:

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Thank you for your

CONCERN