Membrane Bioreactor Pilot Plant Operating Experience

Impact of Mixed Liquor Characteristics on Filtration

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Technology Assessment Program

Presentation Objectives

- Share the experience of operating a pilot MBR plant.
- Present water quality and biological process parameters and corresponding filtration performance.

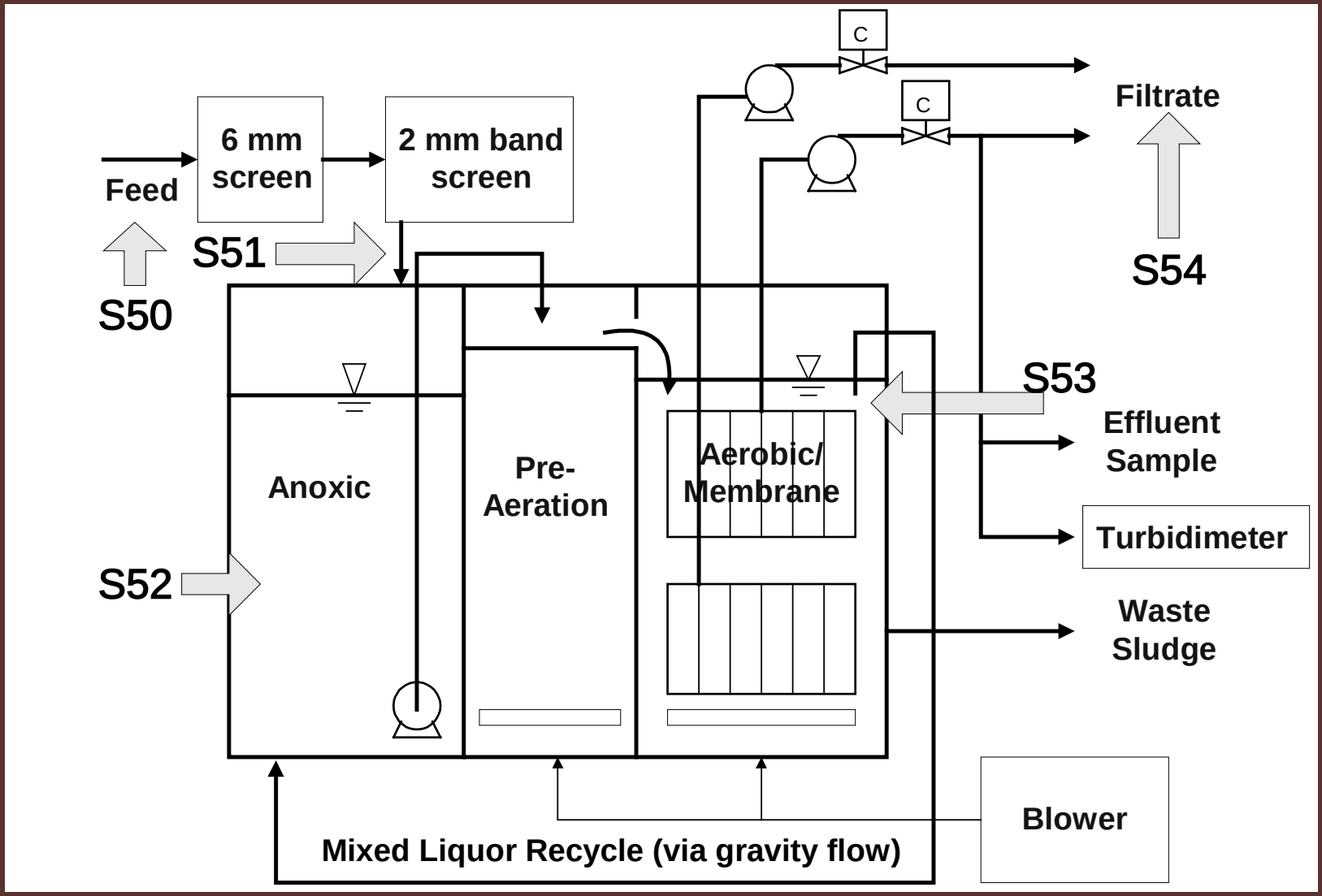
Pilot Information

- Pilot provided by Enviroquip, Inc.
- Pilot equipped with Kubota plate membranes.
- Operated at the West Point Treatment Plant from 2004 – 2006.
- Total process volume of 9,000 gal
- Treatment capacity of 40,000 gal/d

Membrane Specifications

- 200 plates (EW 200)
- Surface area = 13.45 ft^2/plate
- Nominal net flux = 14.7 gfd
- Nominal pore size = 0.4 micron
- Effective pore size = 0.1 micron

Pilot Process Flow Diagram



Pilot Installation

Pilot Operating Conditions

- Nominal net flux = 14.7 gfd
- Relax frequency = 9 min
- Relax duration = 1 min
- Specific air scour = 0.017-0.026 scfm/ft^2
- MLSS = 8,000 – 15,000 mg/L
- ML recycle ratio = 2 – 6
- Feed = primary influent or primary effluent

Testing Phases

- Baseline
- Long term flux increase (125% of nominal flux for 1 month)
- Diurnal flow
- 24-hrs peak event
- 72-hrs peak event
- Polymer addition

Disruptions in Pilot Operation

- Process re-seeding
- Revisions to membrane control logic
- Inspection of membrane cartridges
- Replacement of membrane cartridges
- Replacement of ML recycle pumps
- Replacement of aeration blowers
- Loss of power to West Point pilot facility

Operational Comparison (MBR vs. CAS)

- Both rely on good biological process control
- Physical barrier vs. gravity settling
- Loss of treatment capacity vs. solids carry-over
- MBR parameters:
  - Flux = flow/area (gal/ft^2/d)
  - TMP = trans membrane pressure (psi)
  - Permeability = flux/TMP (gfd/psi)

Membrane Fouling

- Reduction of pore size or effective filtration area
- Additional energy required to pull water through the membrane characterized by:
  - *Increase in trans membrane pressure (TMP)*
  - *Decrease in permeability (flux/TMP)*
- Increases over time
- Response to fouling:
  - *Increase relax frequency*
  - *Increase air scour*
  - *Chemical cleaning*

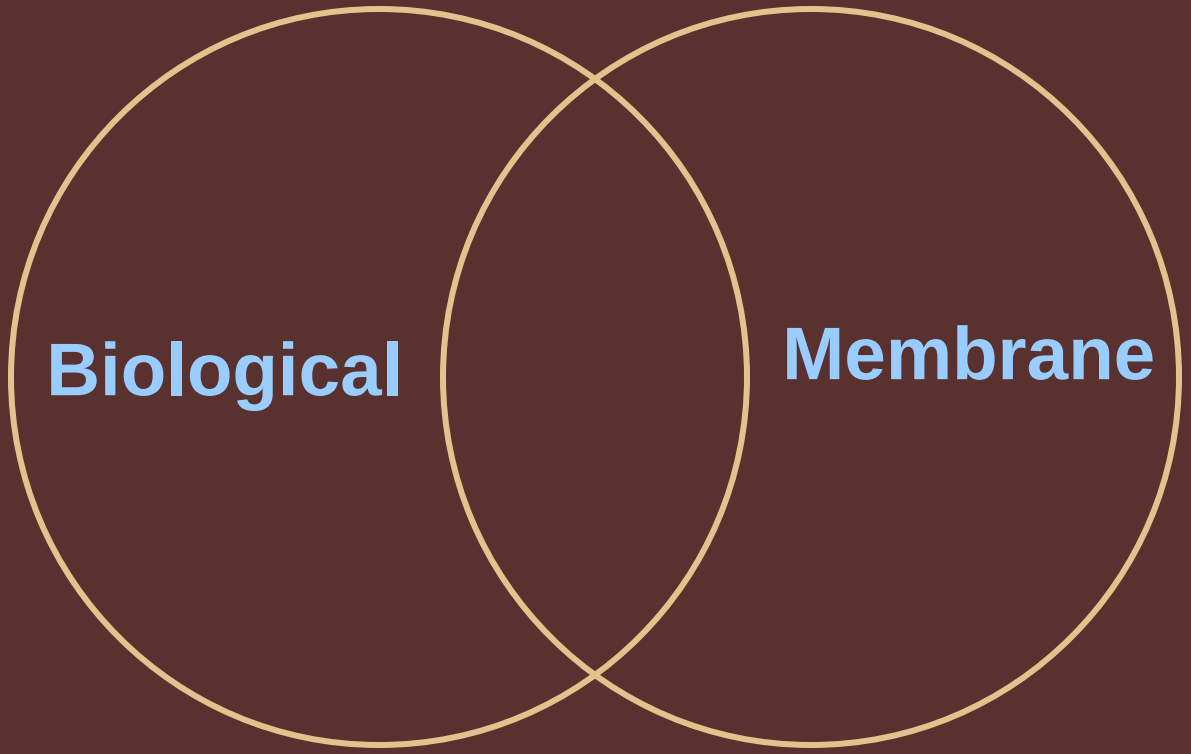
Factors Impacting Characteristics of Biological Process Solids (ML)

- Feed characteristics
- Process Temperature
- DO
- pH
- Hydraulic retention time
- Solids retention time

Biological Parameters Impacting Membrane Fouling Potential

- Mixed liquor concentration
- Viscosity
- Temperature
- Soluble microbial products (SMP)
- Colloidal material

MBR Process Optimization



Pilot Biological Process Monitoring Parameters

- SRT
- MLSS/MLVSS
- sCOD
- Temperature
- pH
- DO
- F/M
- Nitrification
- Filterability
- Specific Oxygen Uptake Rate
- Microscope Inspection

Pilot Membrane Process Monitoring Parameters

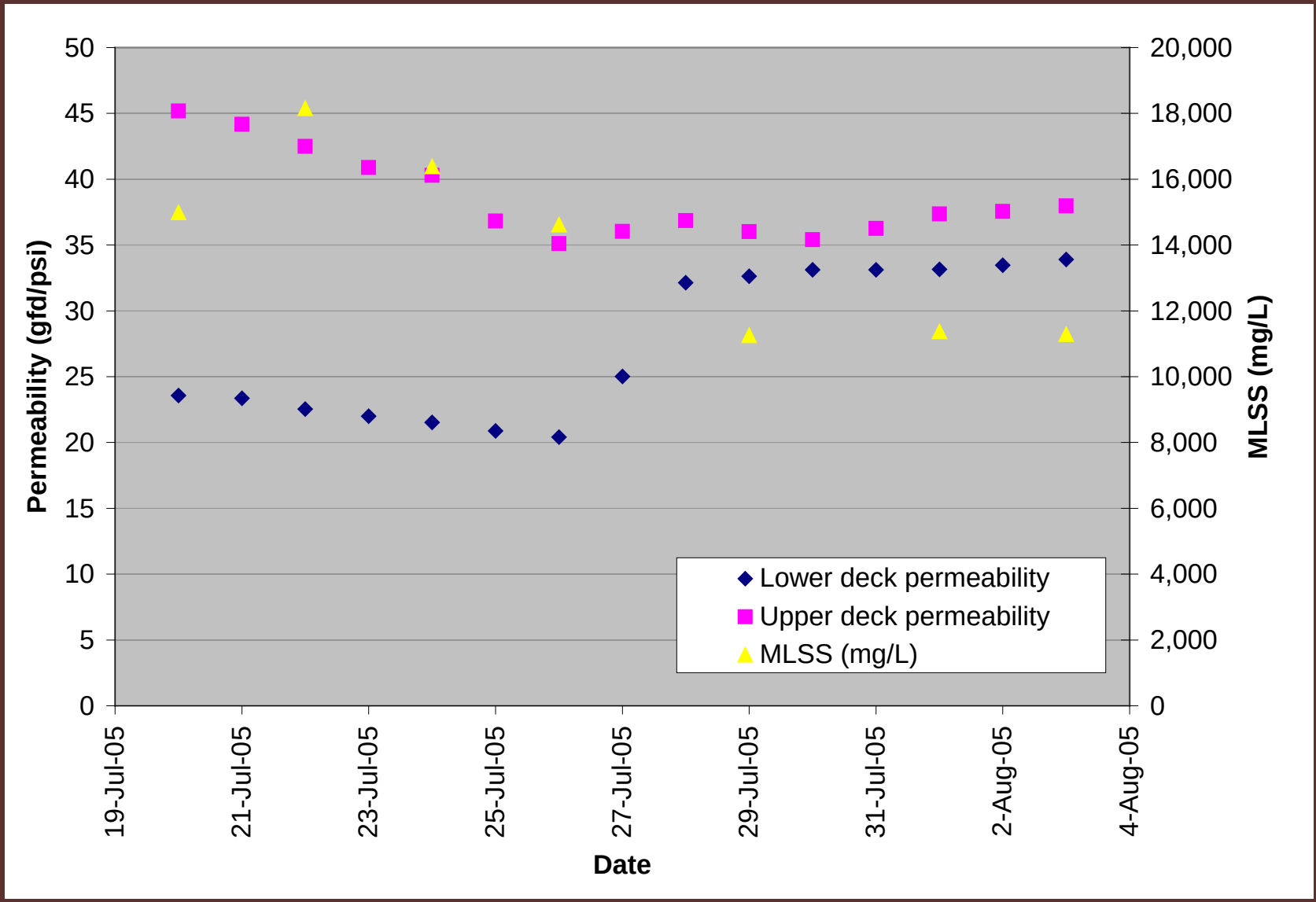
- TMP/Permeability
- Air scour flow
- Effluent turbidity
- Cycle length (permeate/relax)
- Recycle flow
- Permeate flow
- Temperature

Pilot Field Testing

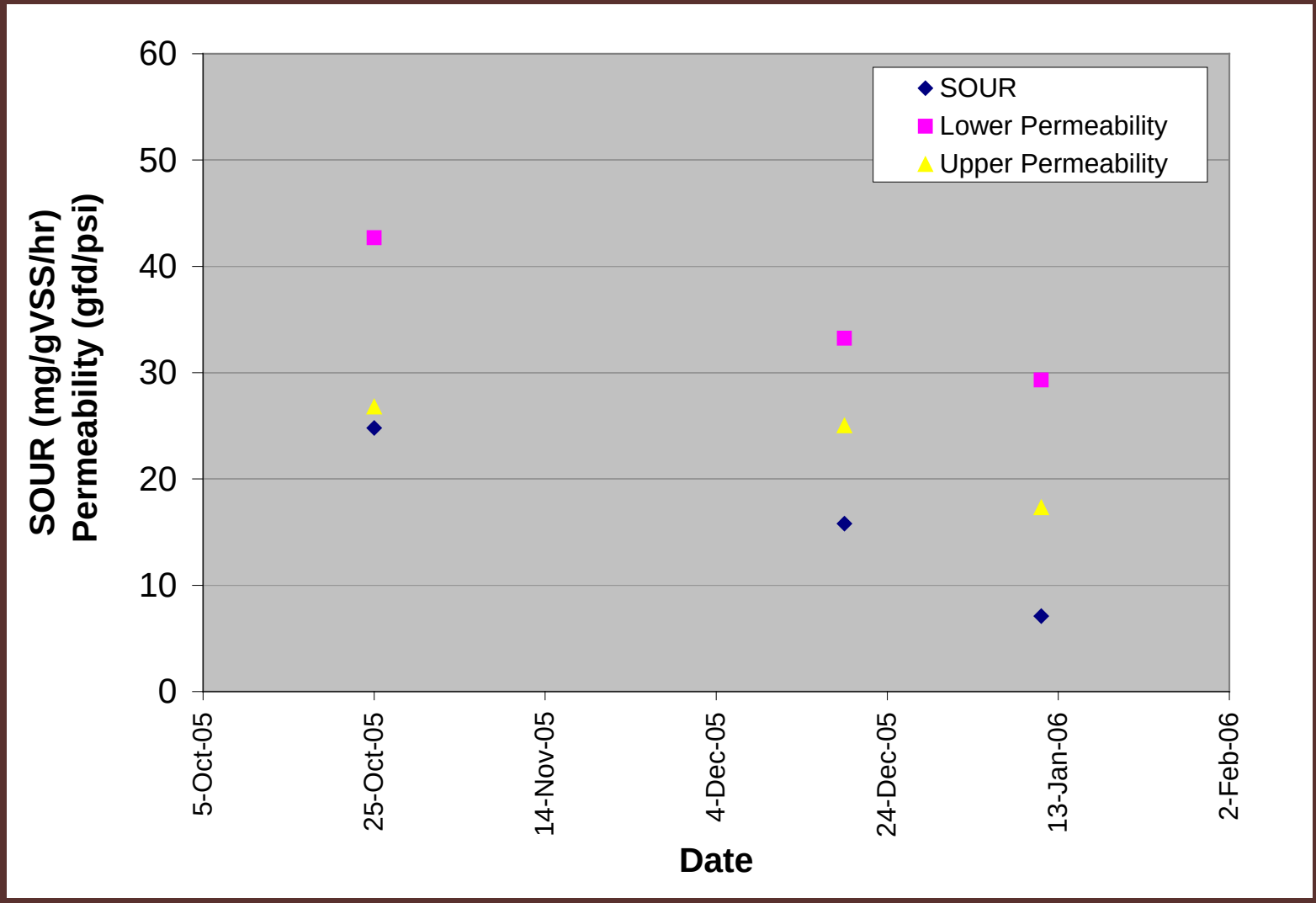
- Filterability (Time to Filter)
- Viscosity
- Capillary Suction Test (CST)
- DO
- Temperature
- pH
- Specific Oxygen Uptake Rate (SOUR)
- Visual inspections (air scour)

MBR Pilot Data Sample

MBR Pilot Data Review (Mixed Liquor Suspended Solids)



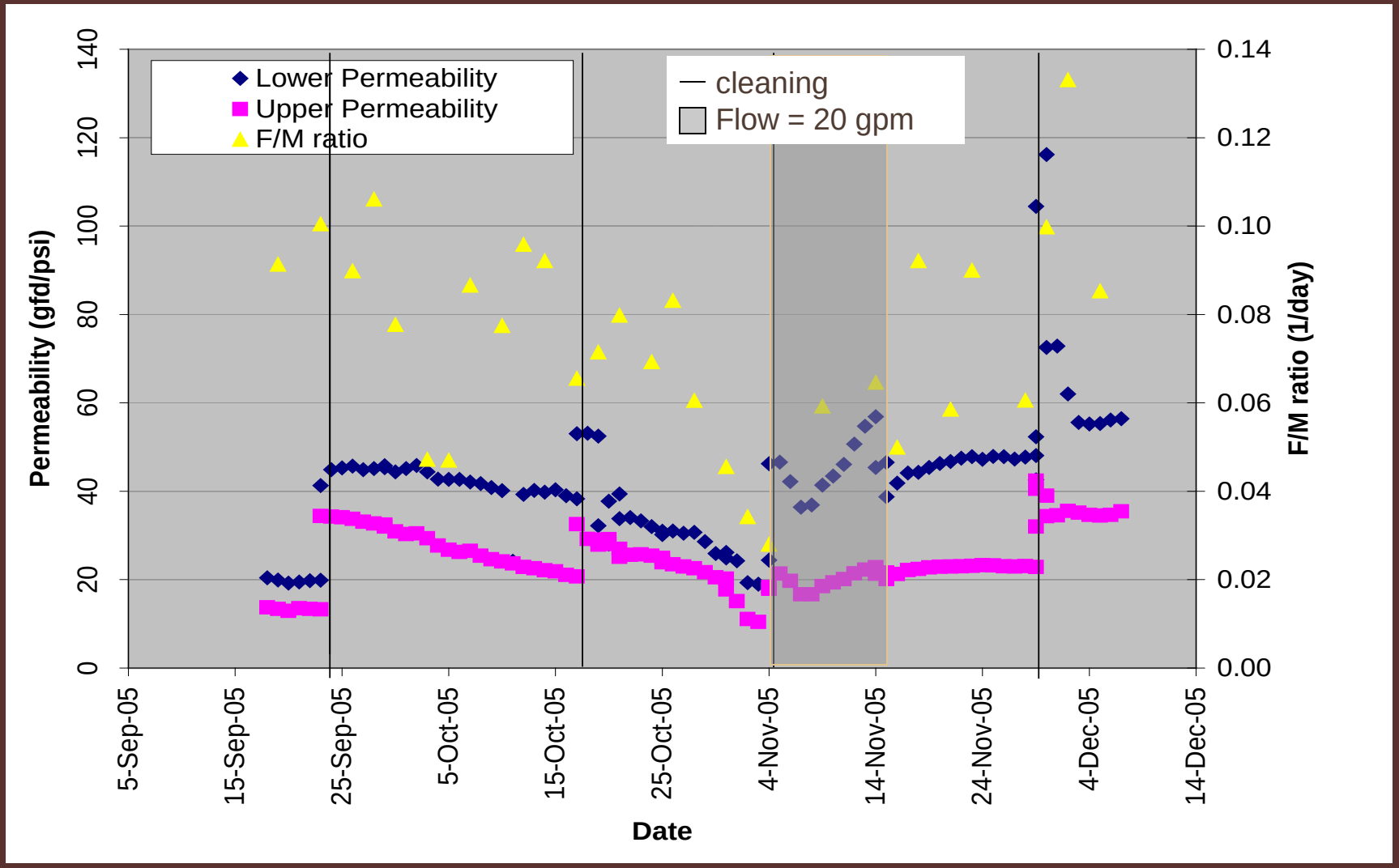
MBR Pilot Data Review (Permeability and SOUR)



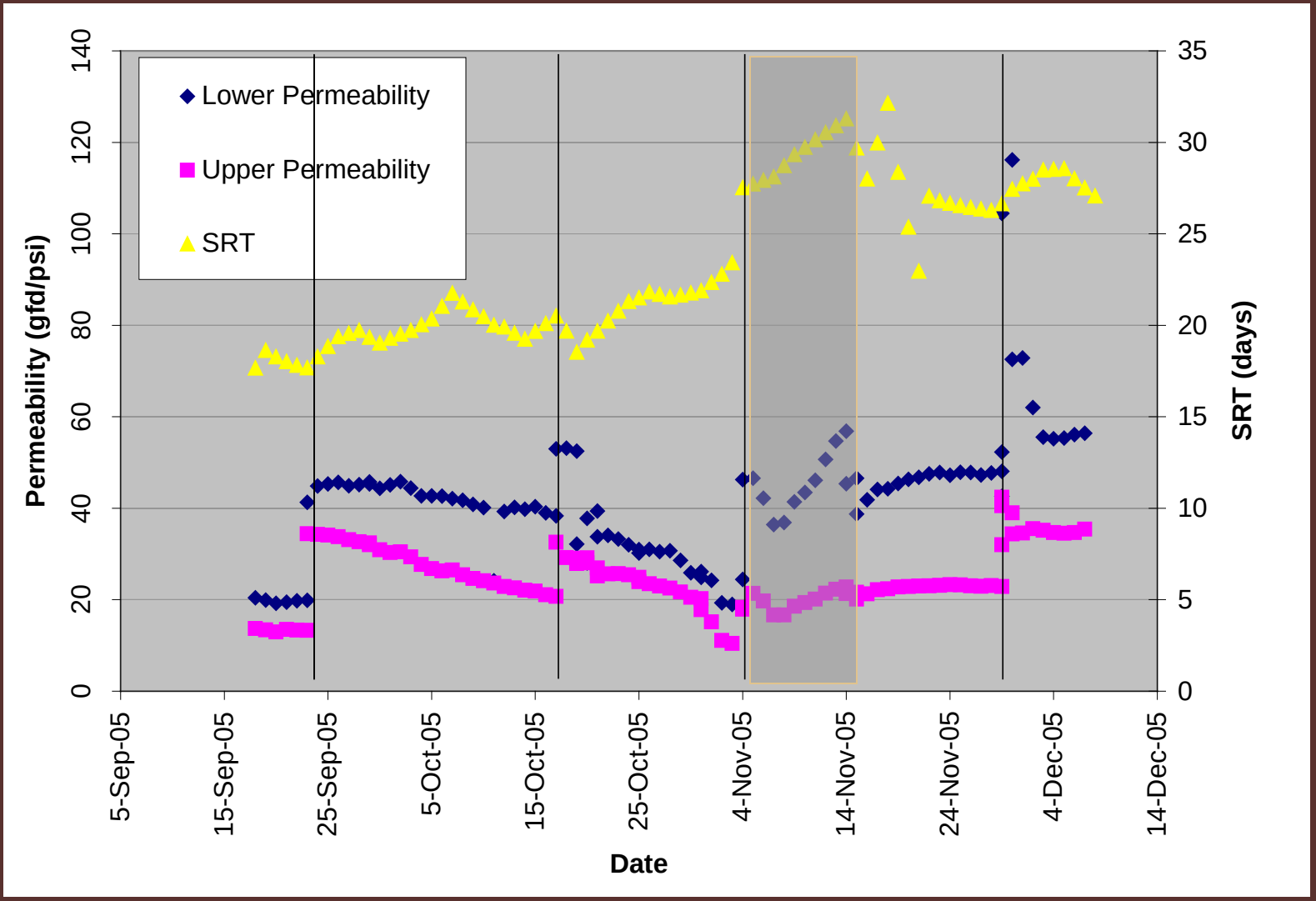
Pilot Operating Conditions for Data Presented in Following Slides

- Sep 18 – Dec 8, 2005
  - Average Temp = 18°C (13-22°C)
  - Average Air Scour = 0.022 scfm/ft^2
  - Average Flow = 28 gpm
  - Average MLSS = 12,000 mg/L

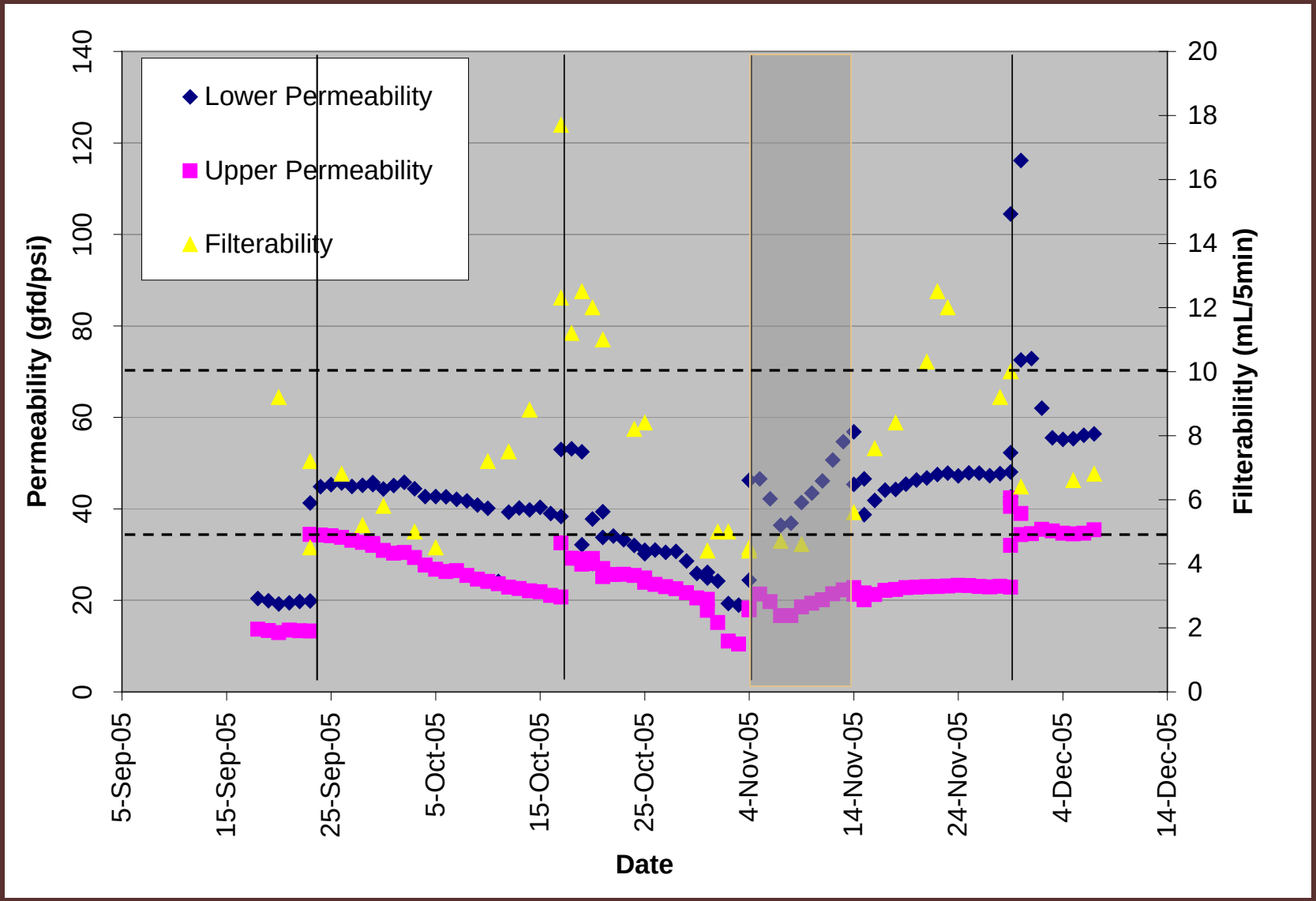
MBR Pilot Data Review (F/M)



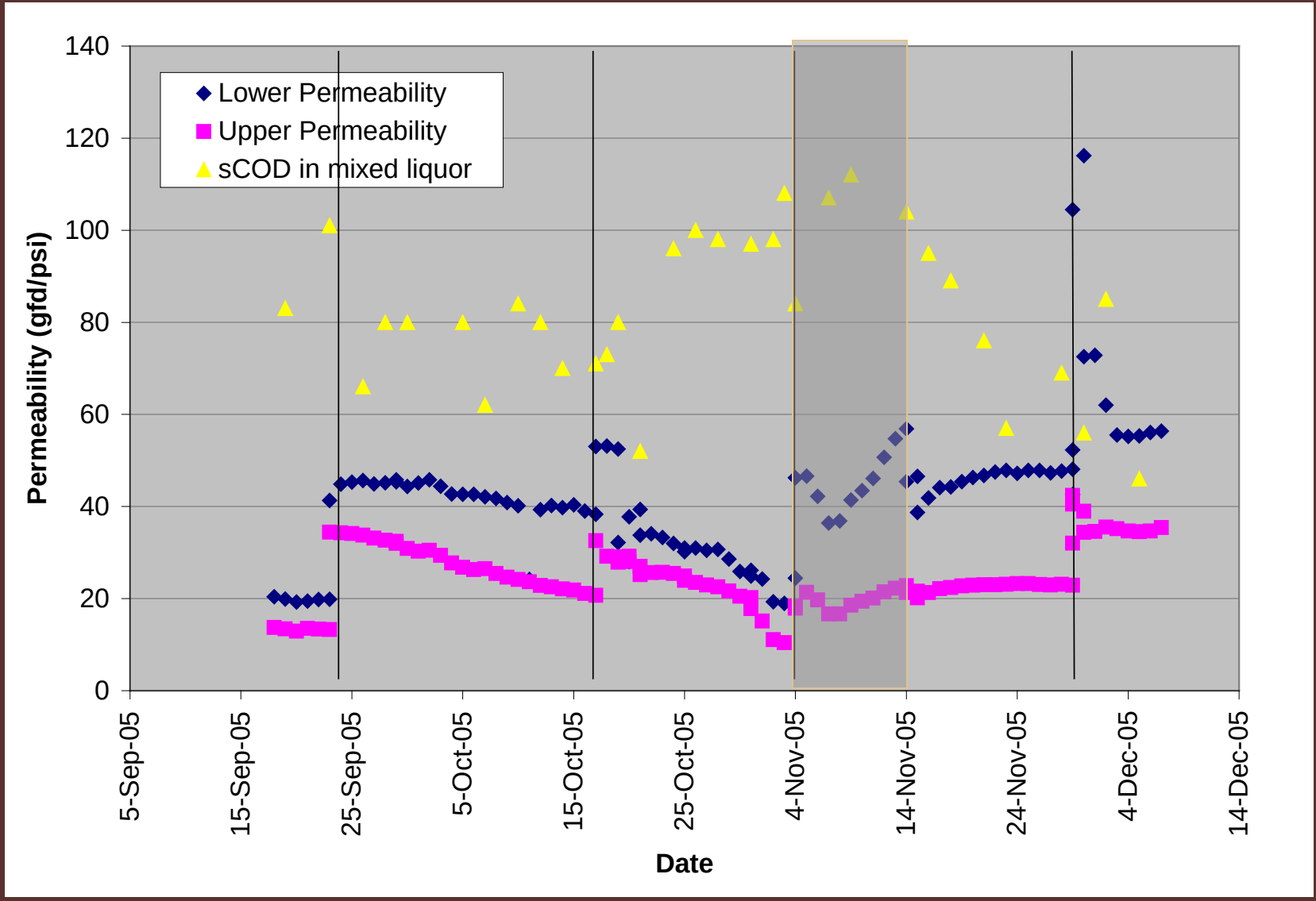
MBR Pilot Data Review (SRT)



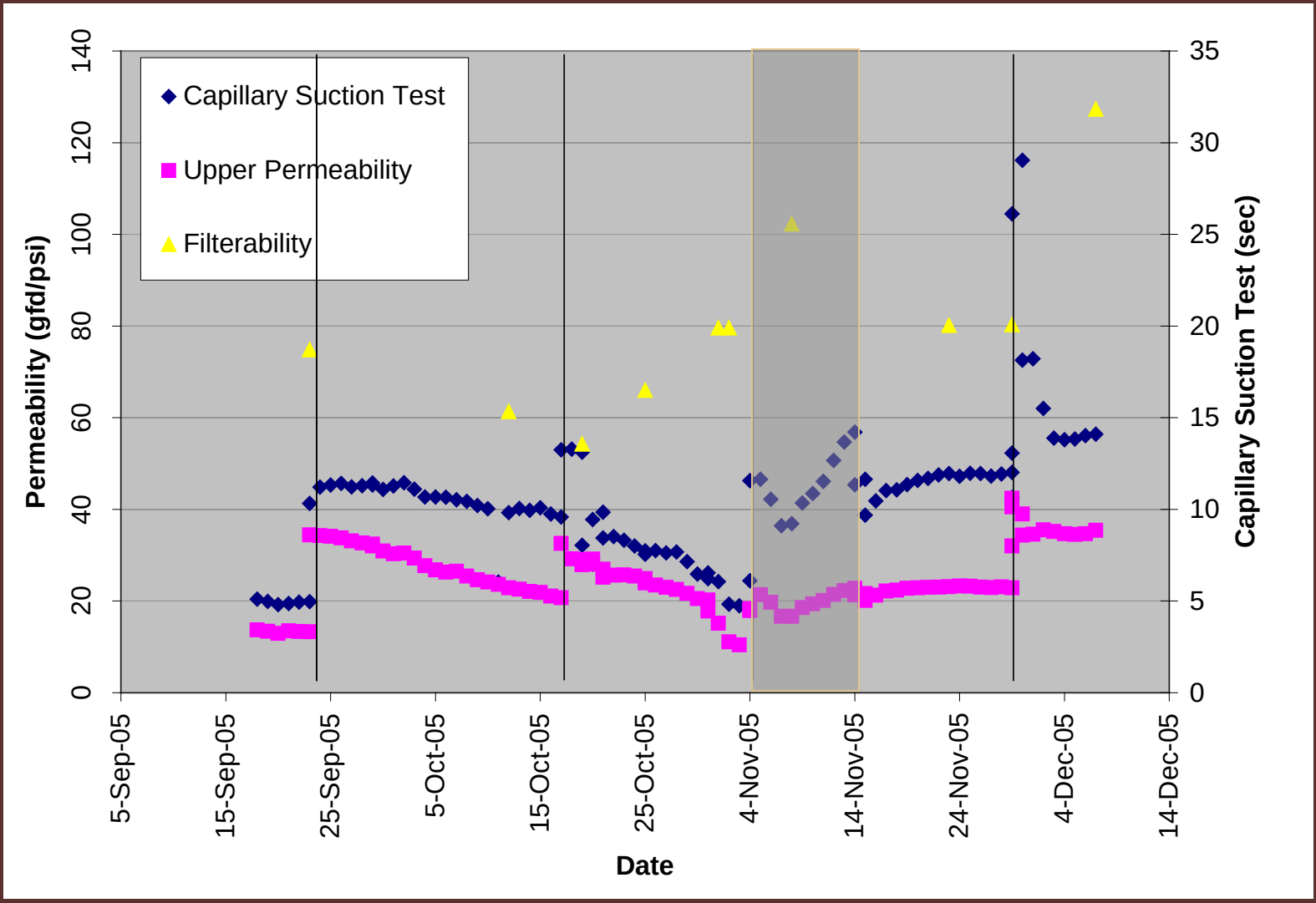
MBR Pilot Data Review (Filterability)



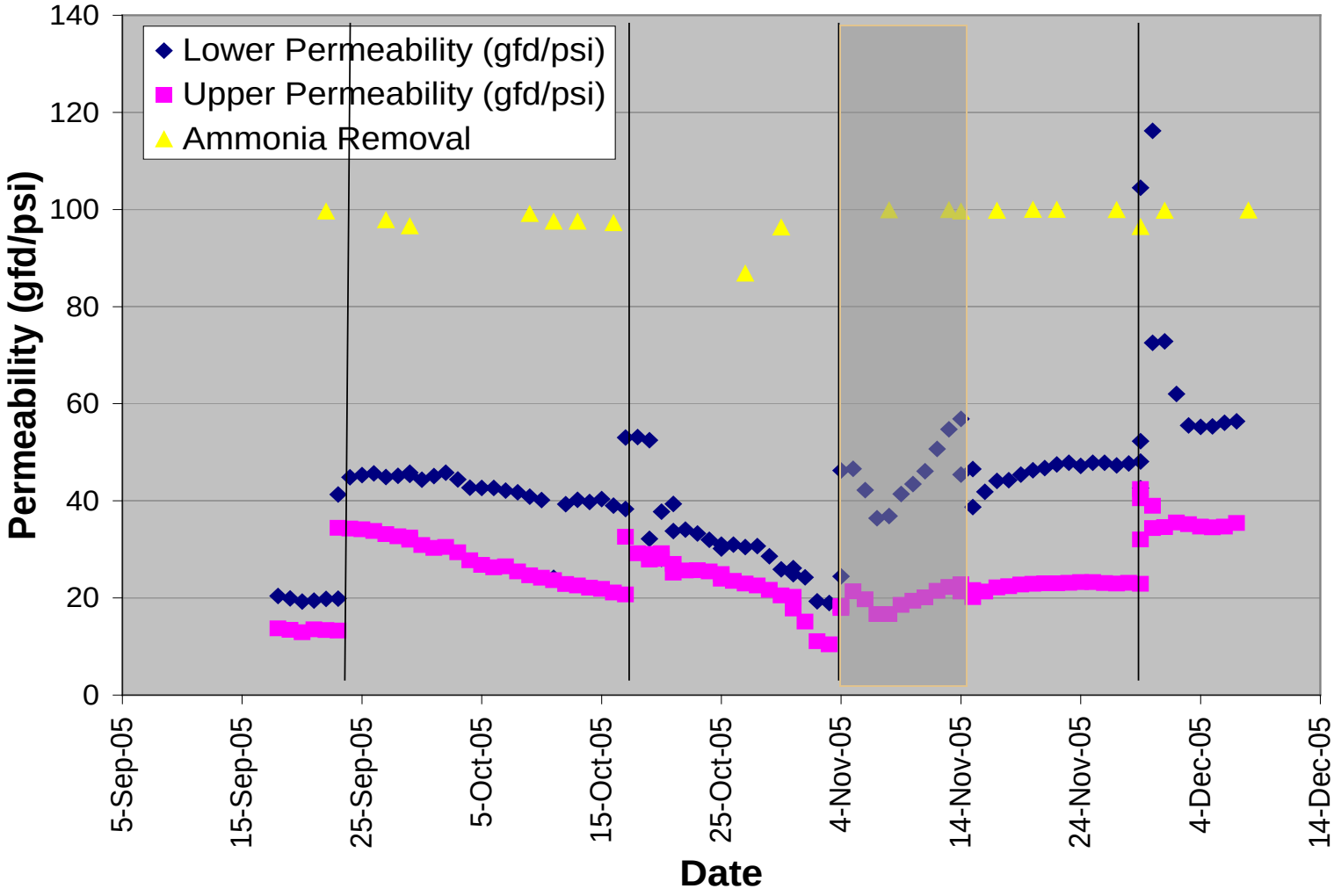
MBR Pilot Data Review (sCOD)



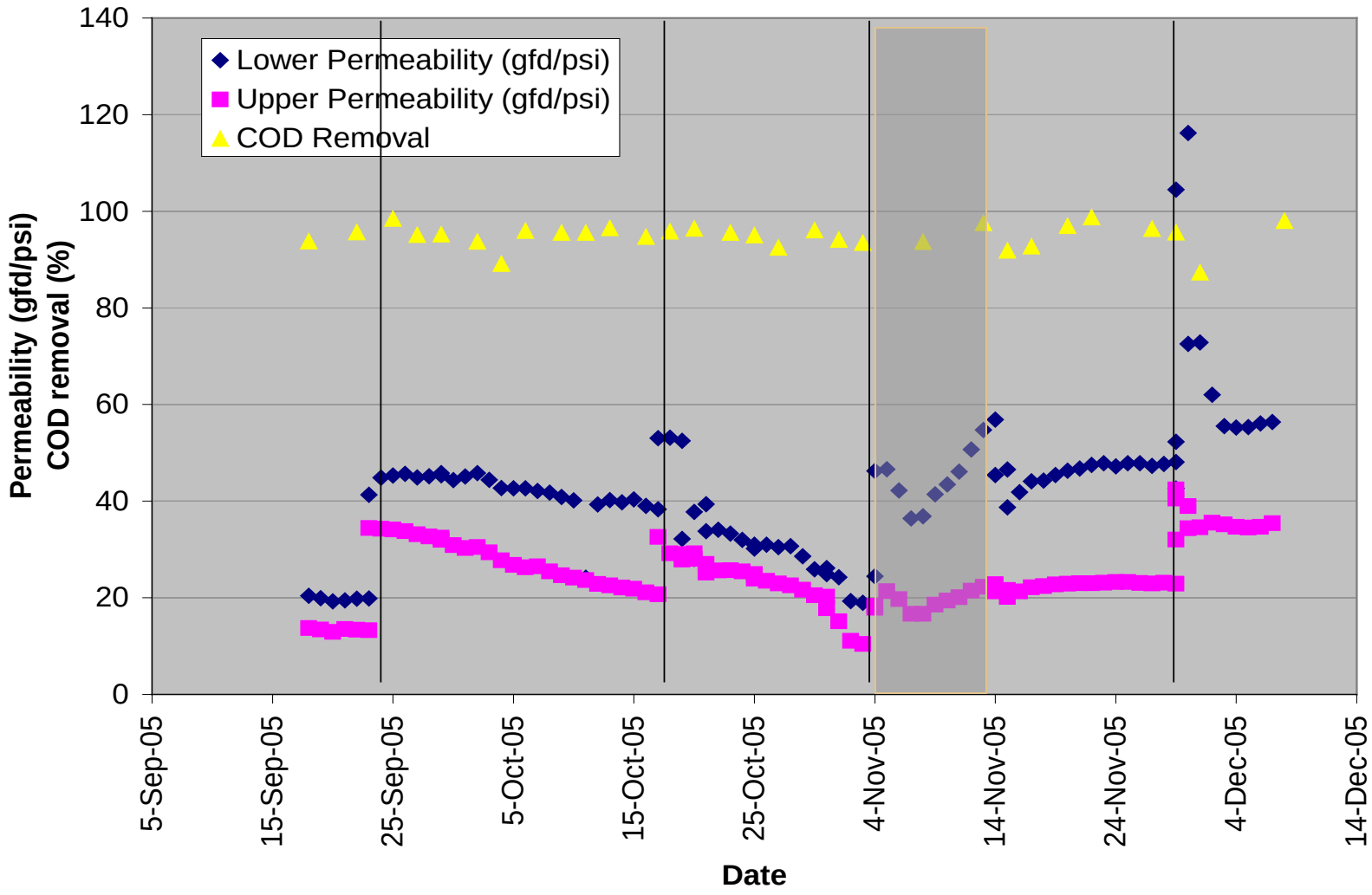
MBR Pilot Data Review (CST)



MBR Pilot Data Review (Nitrification)



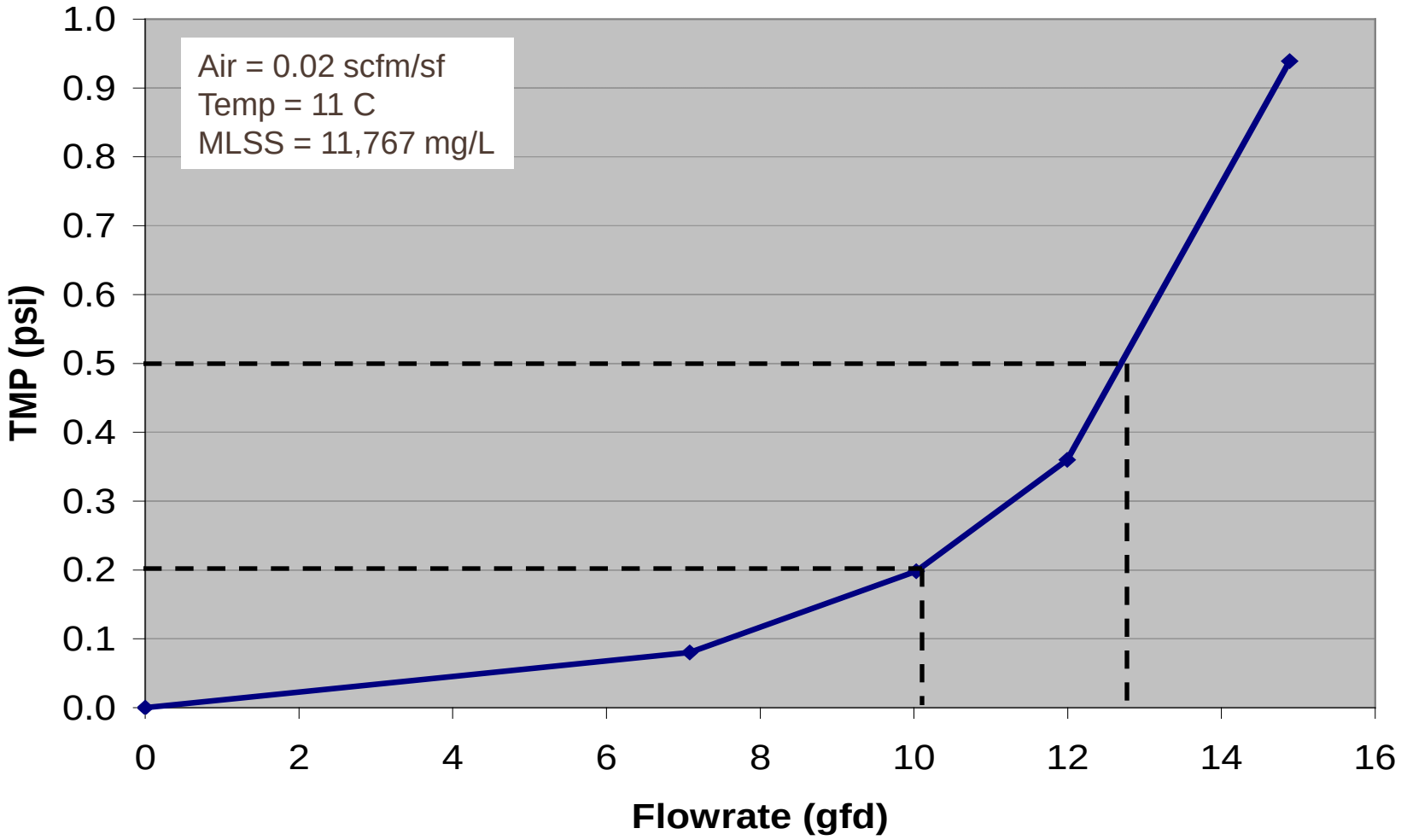
MBR Pilot Data Review (COD Removal)



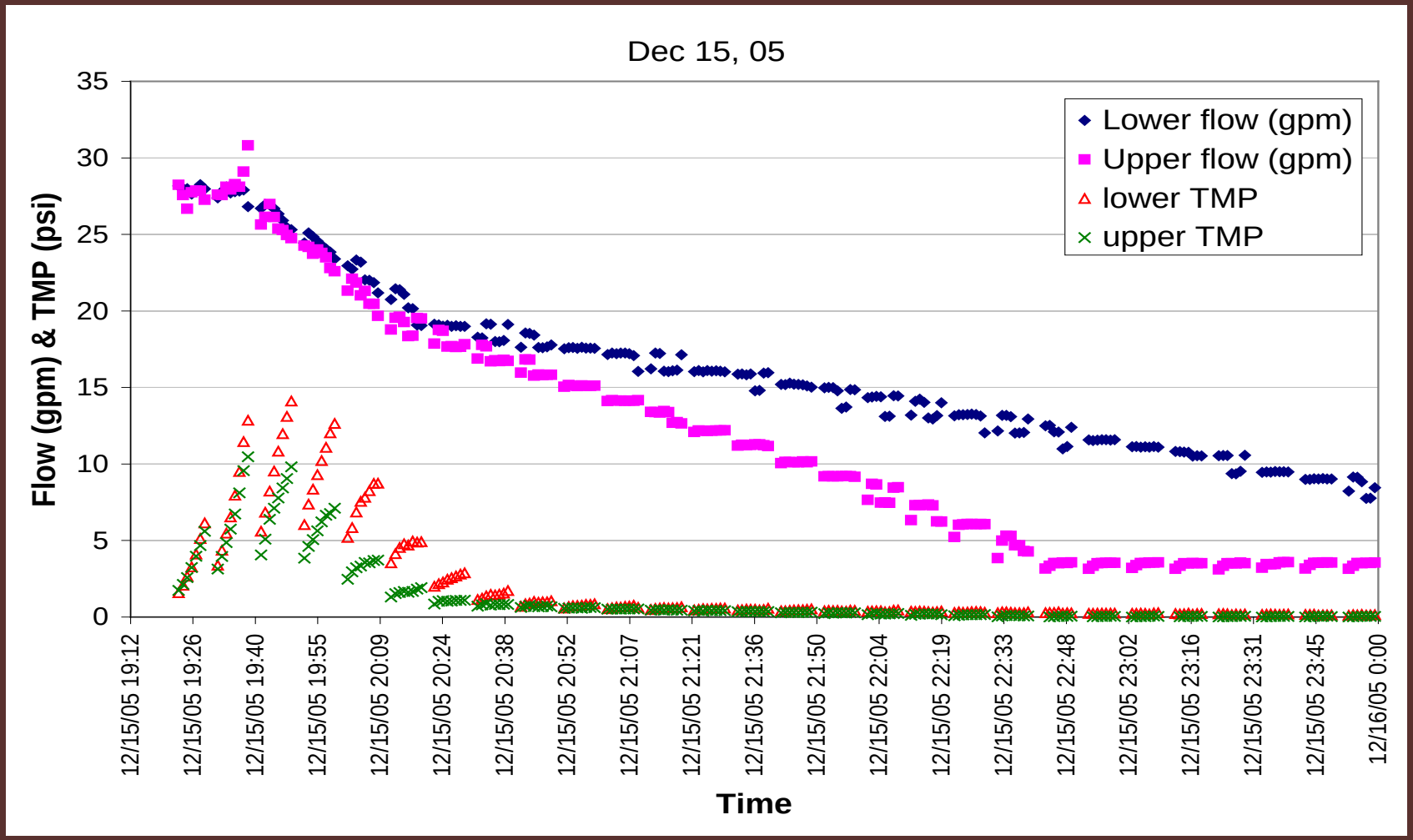
Membrane Fouling Control

- Decrease flux
- Increase specific air scour
- Increase relax frequency
- Increase chemical cleaning frequency
- Polymer addition

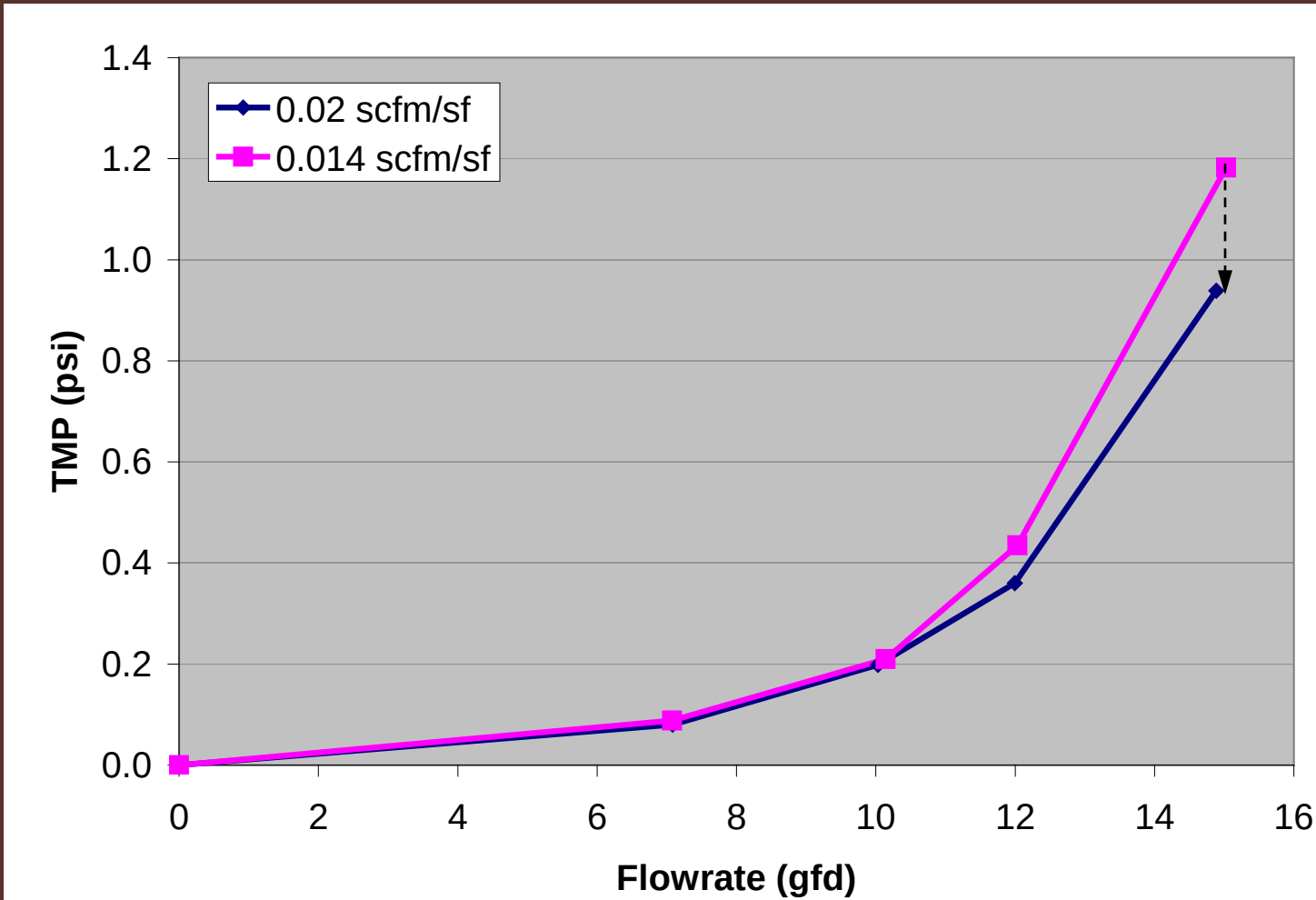
Membrane Fouling Control (Flux Decrease)



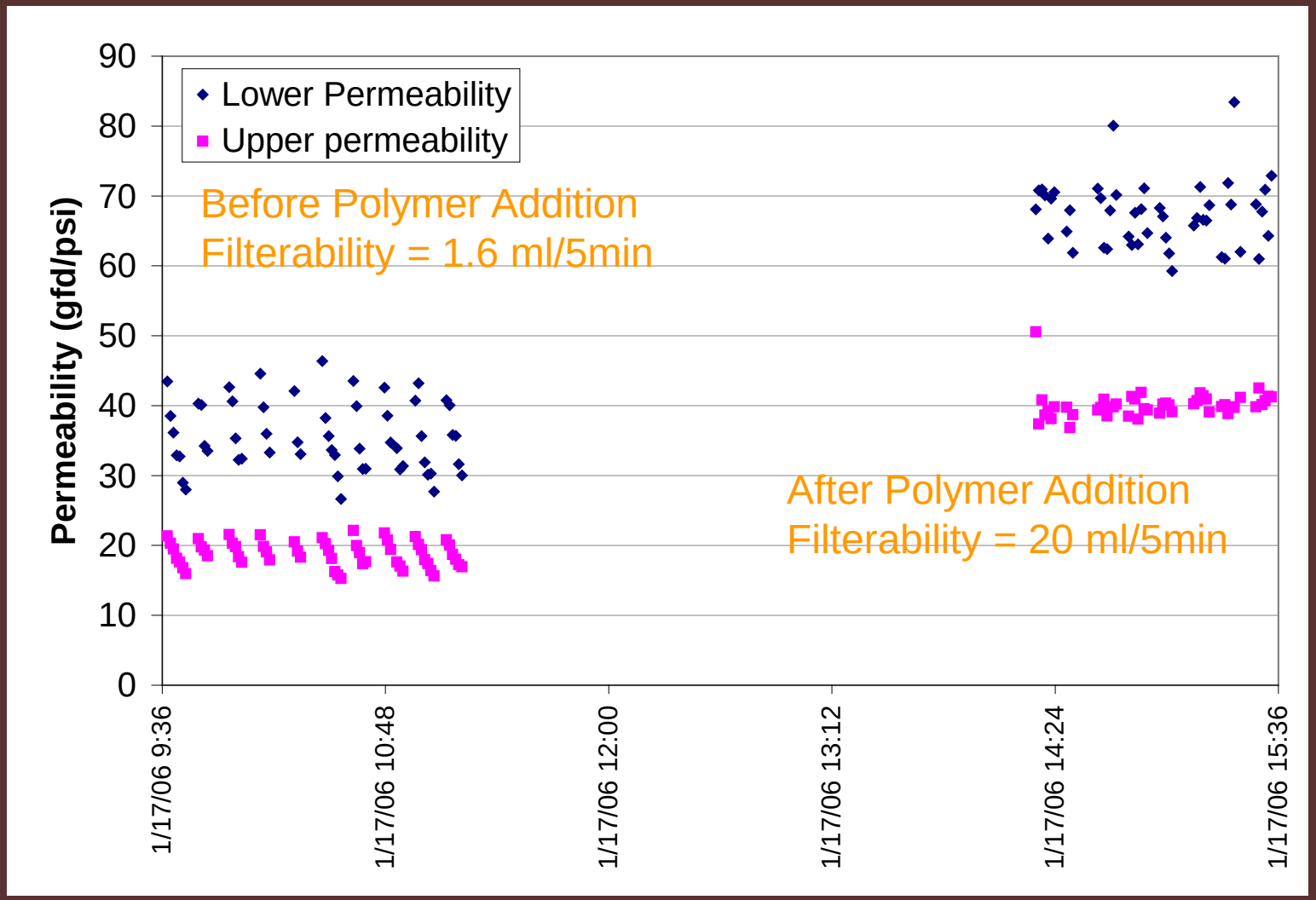
Membrane Fouling Control (Pilot Example – Flux Decrease)



Membrane Fouling Control (Air Scour Rate Increase)



Membrane Fouling Control (Pilot Example -Polymer Addition)



Presentation Summary

- During piloting, several parameters were typically changing at the same time – difficult to establish performance relationships.
- Membrane fouling will occur under all operating conditions.
- Multiple parameters must be monitored simultaneously for troubleshooting and maintenance of filtration process.
- Need to find practical methods for utilizing membrane fouling research data.

Acknowledgements

- Kubota Membrane Corporation
- Enviroquip, Inc.
- West Point Treatment Plant Staff
- King County Environmental Lab Staff

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