Use of Reservoir Aeration for Small System Disinfection By-Products Treatment

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Presentation Outline

- Plant Background & DBP History
- Description of Pilot Efforts
  - Theory
  - Pilot Scale
- Discussion of Pilot Results
- Conclusions

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Spring Point Homeowners

Orcas Island – NW Washington

~40 Residential Connections

All Residential

Package Plant for Surface Water Impoundments

- 20 gpm capacity
- 10 gpm normal operation

Secondary RO Plant for Seawater

- 7 gpm

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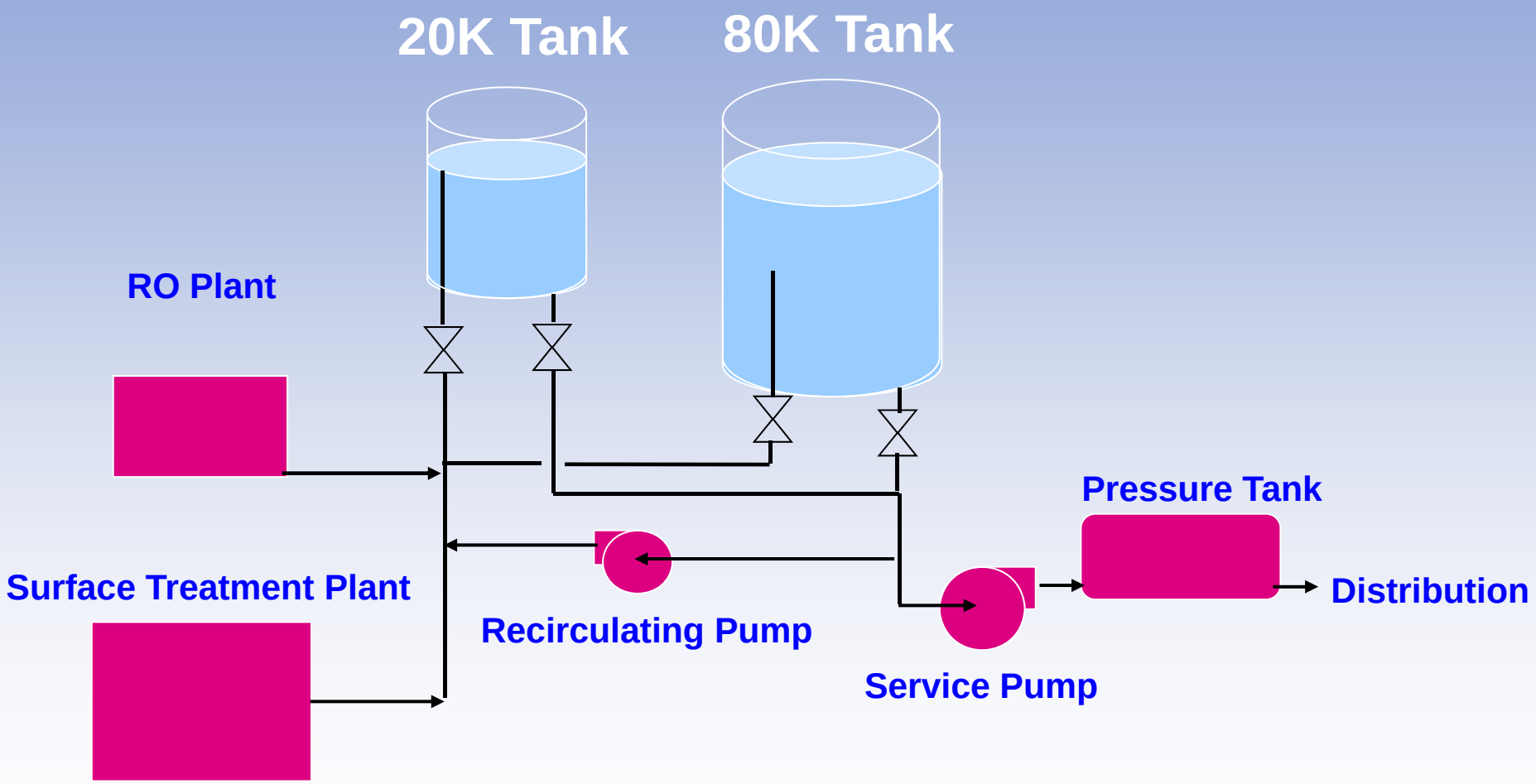
Surface Source Background

- Shallow Surface Impoundments
- Low Turbidity
- High Organics and Color
- High TOC – 6-9 mg/L - Average 7.6 mg/L

System Schematic



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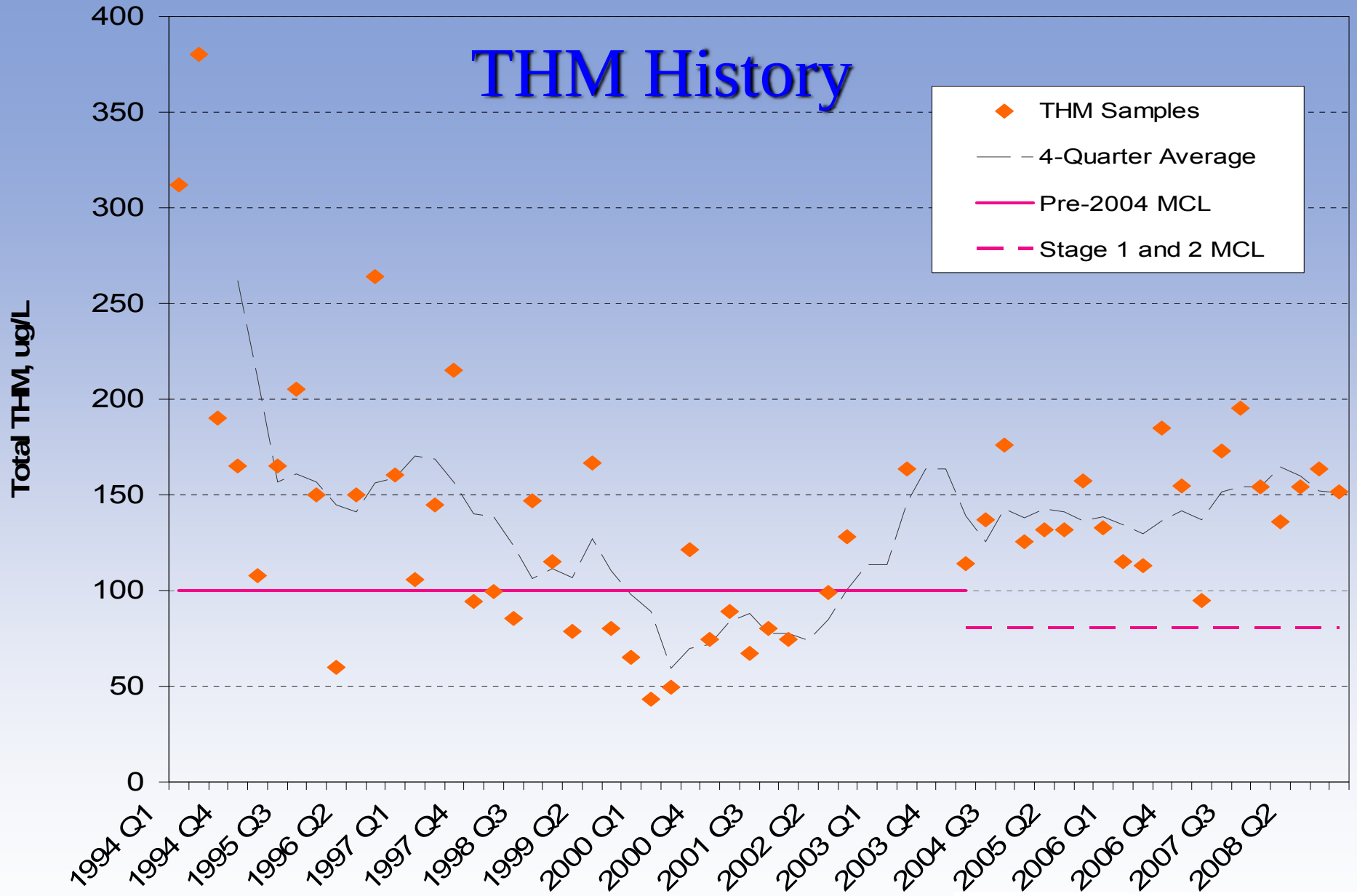
THM History



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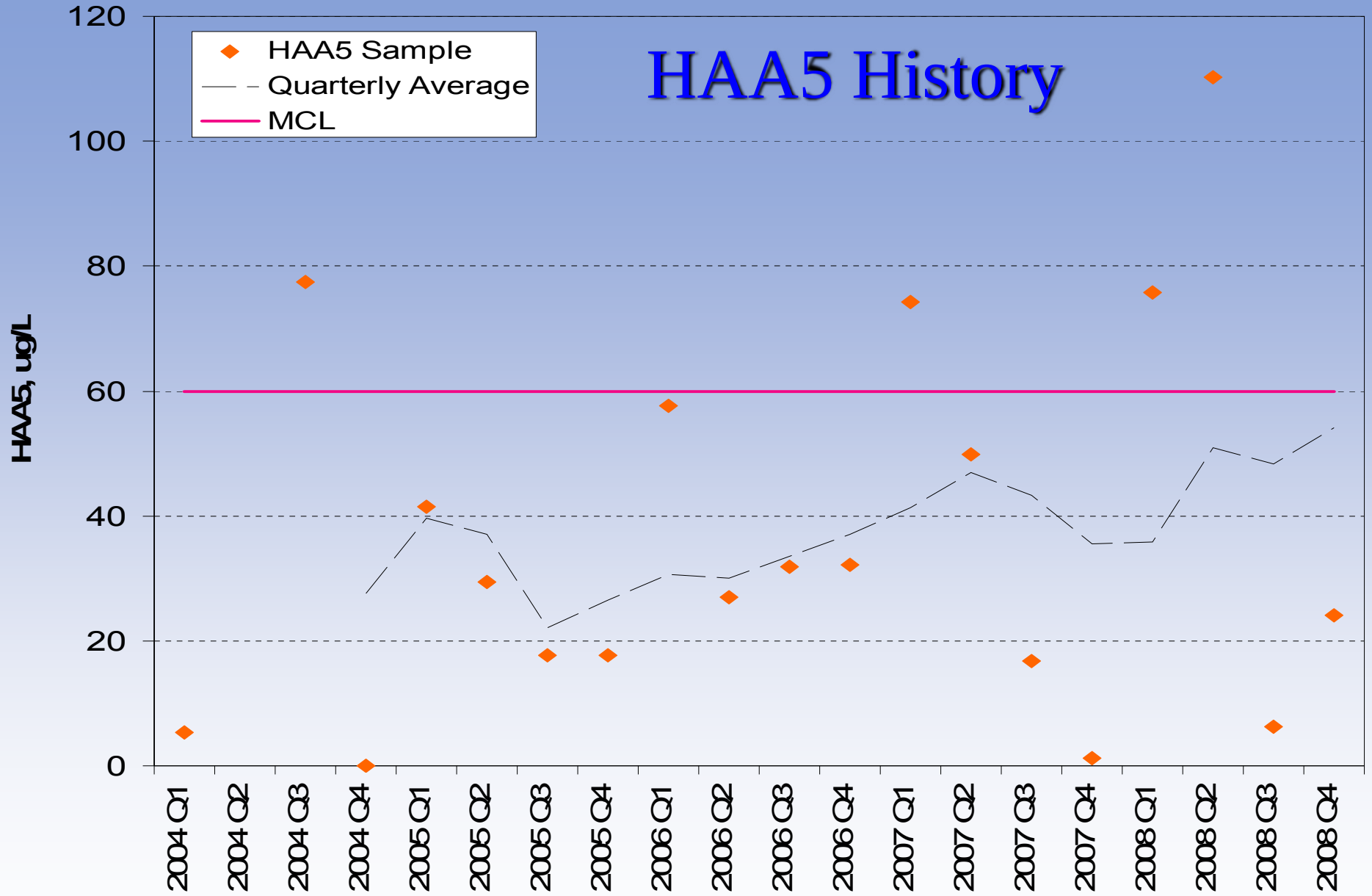
HAA5 History



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TOC Removal History

Raw Water Average TOC – 7.6 mg/L

Filtered Water Average TOC – 5.1 mg/L

~33% Removal of TOC Through Filtration

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Other Considerations

Small System

Part-time Operator

Filter Optimization not a Likely Option

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Purpose of Pilot Study

Investigate aeration as potential post-treatment option to treat DBPs.

Provide design parameters for full scale facility.

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Aeration Theory

Dissolved Gases in Water Governed by Henry's Law Generically Given as:

$$p = Hc$$

Where:

- p = Constituent Pressure in Gas
- H = Henry's Constant
- c = Constituent Concentration in Liquid

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Henry's Law Constants Reflect Volatility of Gasses in Water

DBP	H - atm
Chloroform	200
Dichlorobromomethane	121
Dibromochloromethane	56
Bromoform	35
$CH_2ClCOOH$	0.00051
$CHCl_2COOH$	0.00046
CCl_3COOH	0.00075
$CH_2BrCOOH$	0.00037
$CHBr_2COOH$	0.00024

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Aeration Theory

THMs Less Miscible than HAA5 – Should be Removable by Aeration.

Other Compounds Are Removed by Aeration

Compound	H - atm
Methane	38,000
TCE	550
CO_2	150
Chloroform	200

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Aeration Theory – Types of Aeration

Diffused Bubble Aeration

Air Bubbled Up Through Liquid
Low Air/Water Ratio
Small Air/Water Interface
Good for Gas Transfer into Liquid
Poor for Gas Transfer out of Liquid

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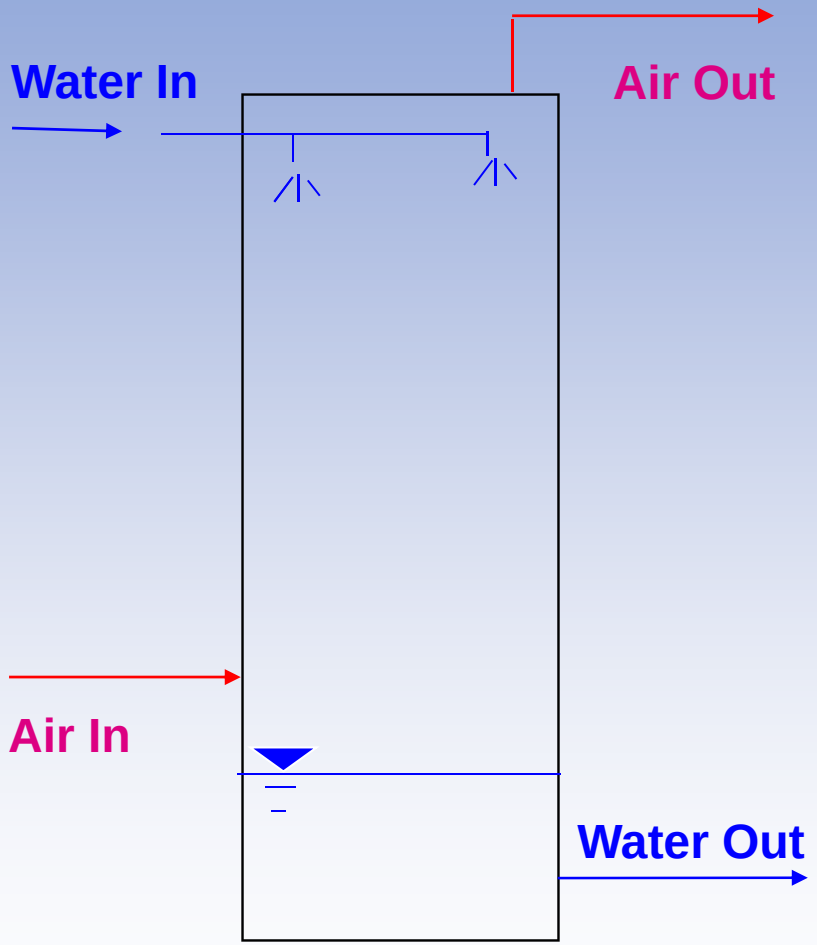
Aeration Theory – Types of Aeration

Spray Tower

Liquid Sprayed Through and Air Stream
High Air to Liquid Ratio
Suitable for Gas Transfer from Liquid



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Aeration Theory – Types of Aeration

Packed Tower

- Liquid Sprayed Through Packed Tower
- Air Stream Generally Countercurrent
- High Air to Liquid Ratio
- Very Suitable for Gas Transfer from Liquid

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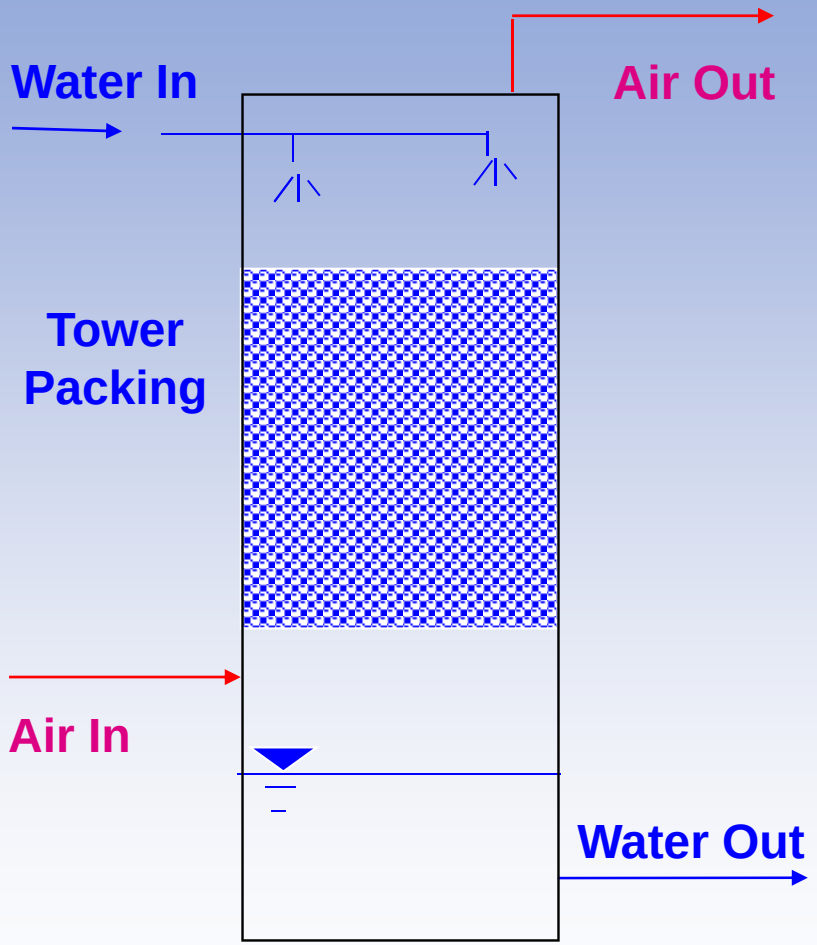

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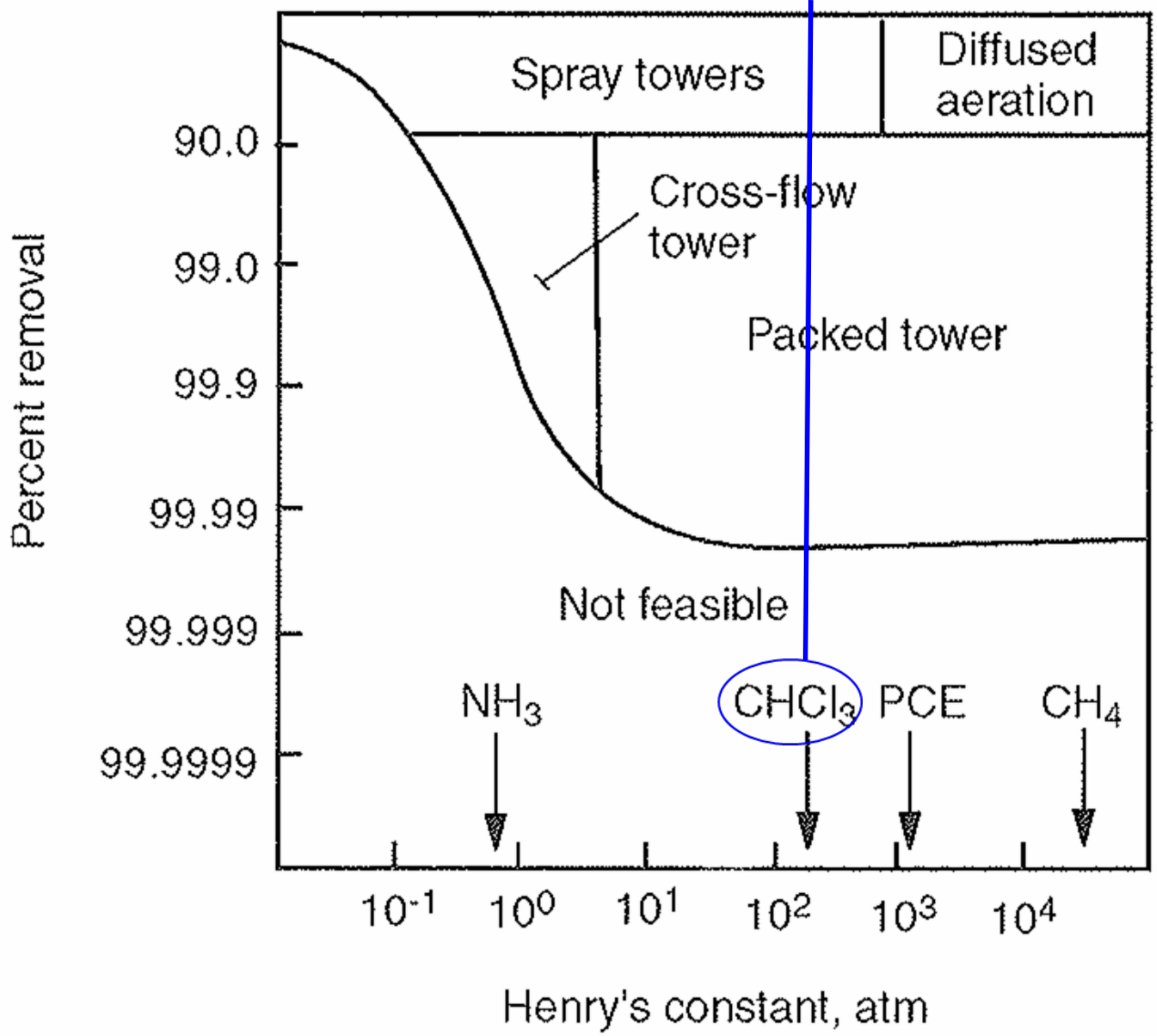
Removal by Aeration Technology



From Water Treatment Principles and Design, MWH, Wiley & Sons, 2005

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Initial Investigation

Investigative Sample Showed THMs Formed Mainly in Reservoir

THM – Outlet of Reservoir = 156.3 µg/L

Distribution Sample = 163.3 µg/L

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Initial Pilot Study

Spray Technology Chosen for Simplicity

Pilot Conducted in 20,000 Gallon Reservoir Only

80,000 Gallons Reservoir Isolated from System

Recirculating Pump Used– 25 gpm

Spray Header Installed in 20,000 Gallon Reservoir

Fan – 1,320 scfm @ 0.03" H_2O

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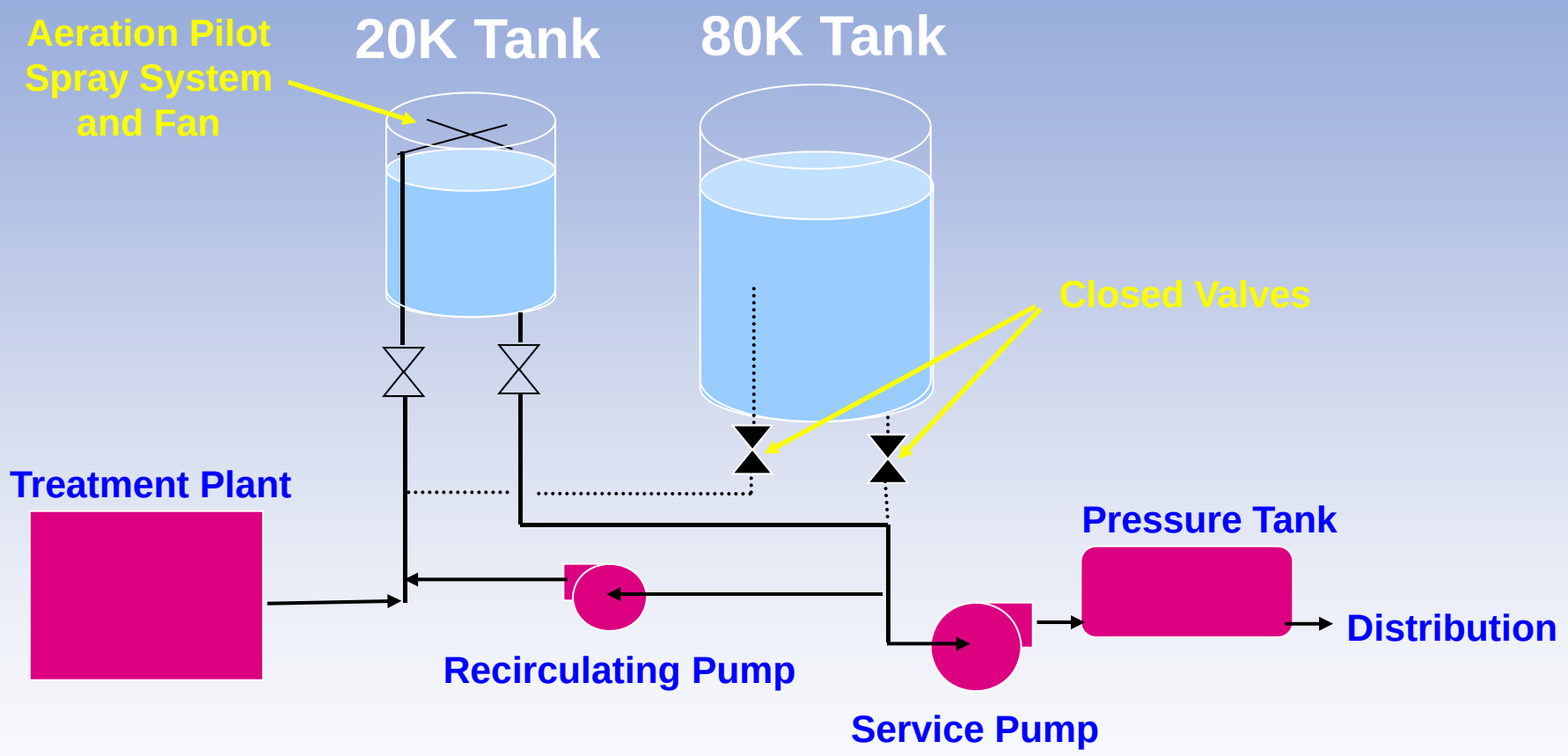
Pilot Operation Schematic



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20,000 Gallon Reservoir

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Header Pipe Installation

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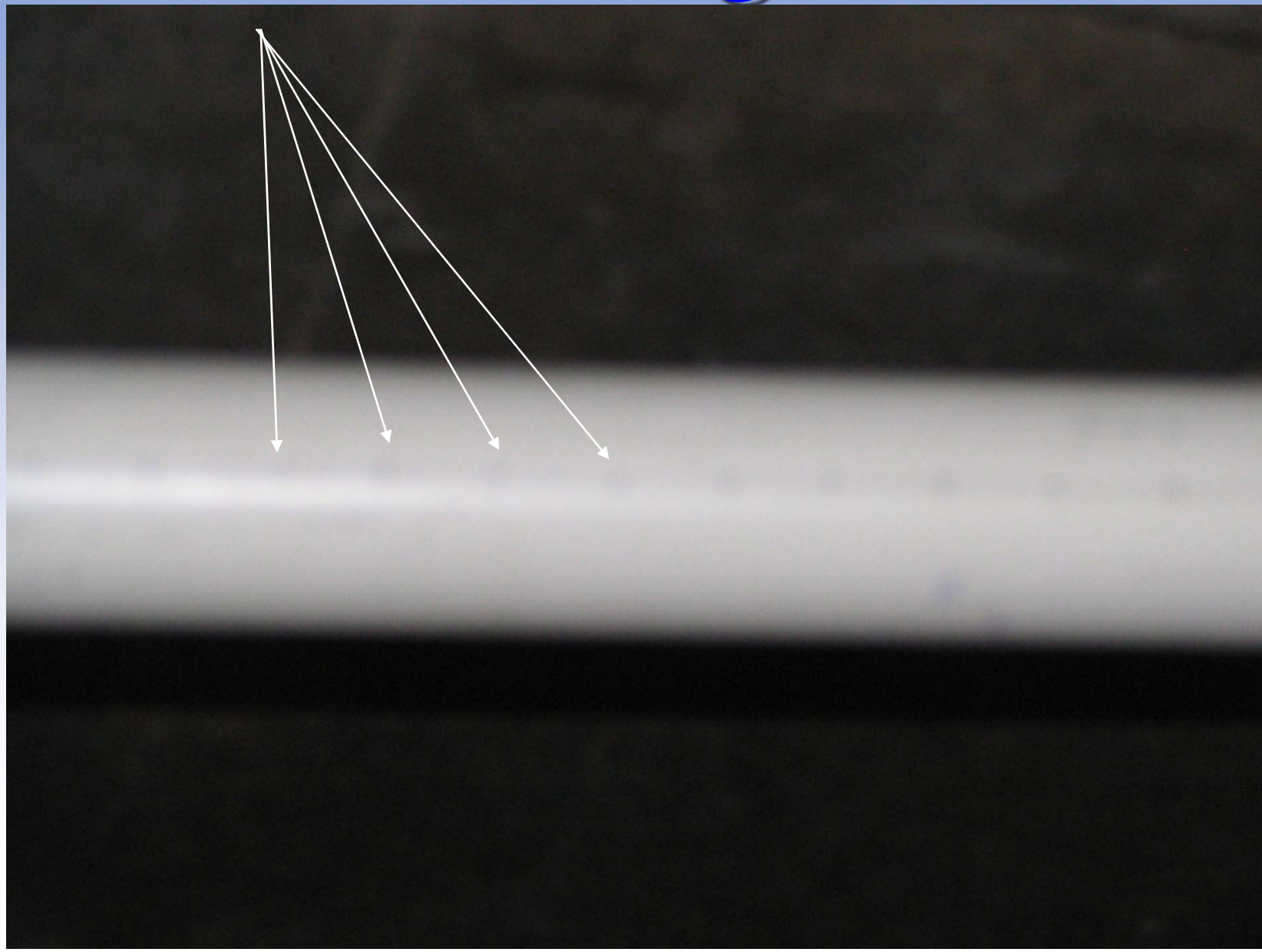
5/16” Holes Drilled @ 1” O.C.



Connection to Reservoir Inlet

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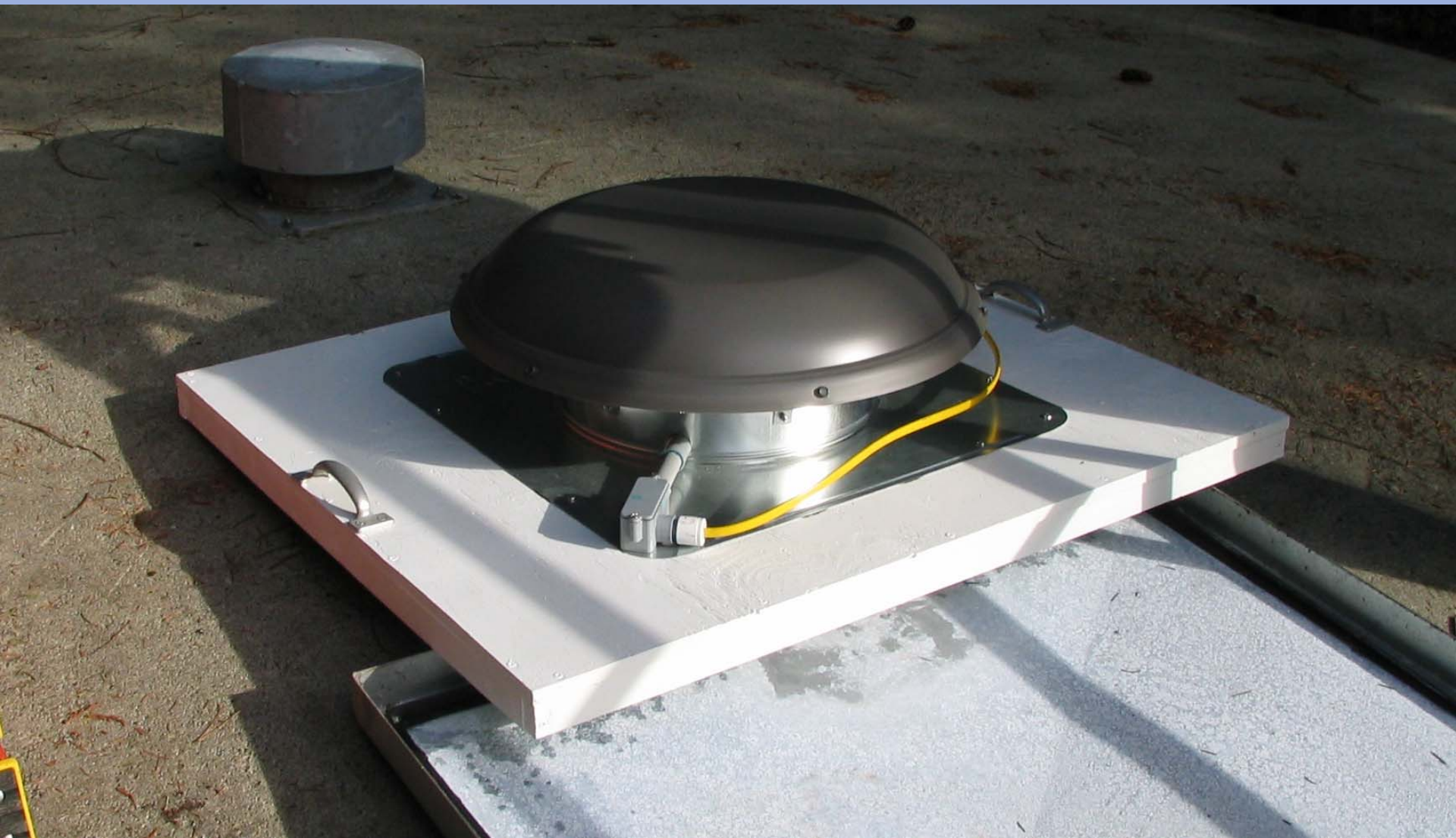
Standard Attic Fan Adapted for Hatch Opening



Interior View of Installed Fan

Spray Pattern

Initial THM Pilot Results – Entry to Distribution System

Date	THM, µg/L	Aeration
February 18, 2010	90.7	No
February 19, 2010	27.4	Yes
February 20, 2010	34.1	Yes

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Full Scale Operation

Initial Results Showed Good Removal with 20K Tank Only.

80K Tank Outlet Valve Opened.

Existing Piping is for Parallel Operation.

Future Piping Modifications Could Allow for Series Operation of Reservoirs.

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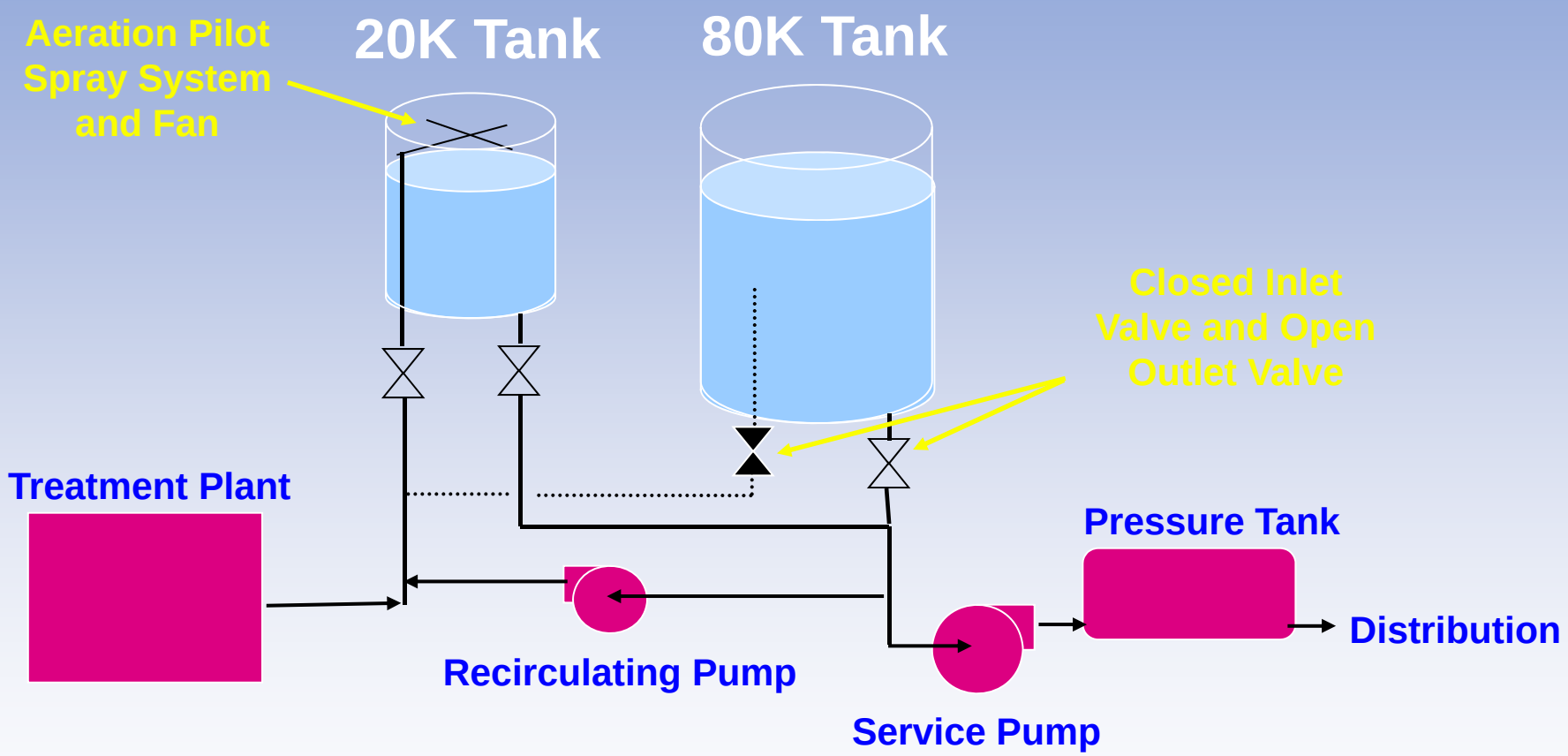
Full Scale Operation Schematic



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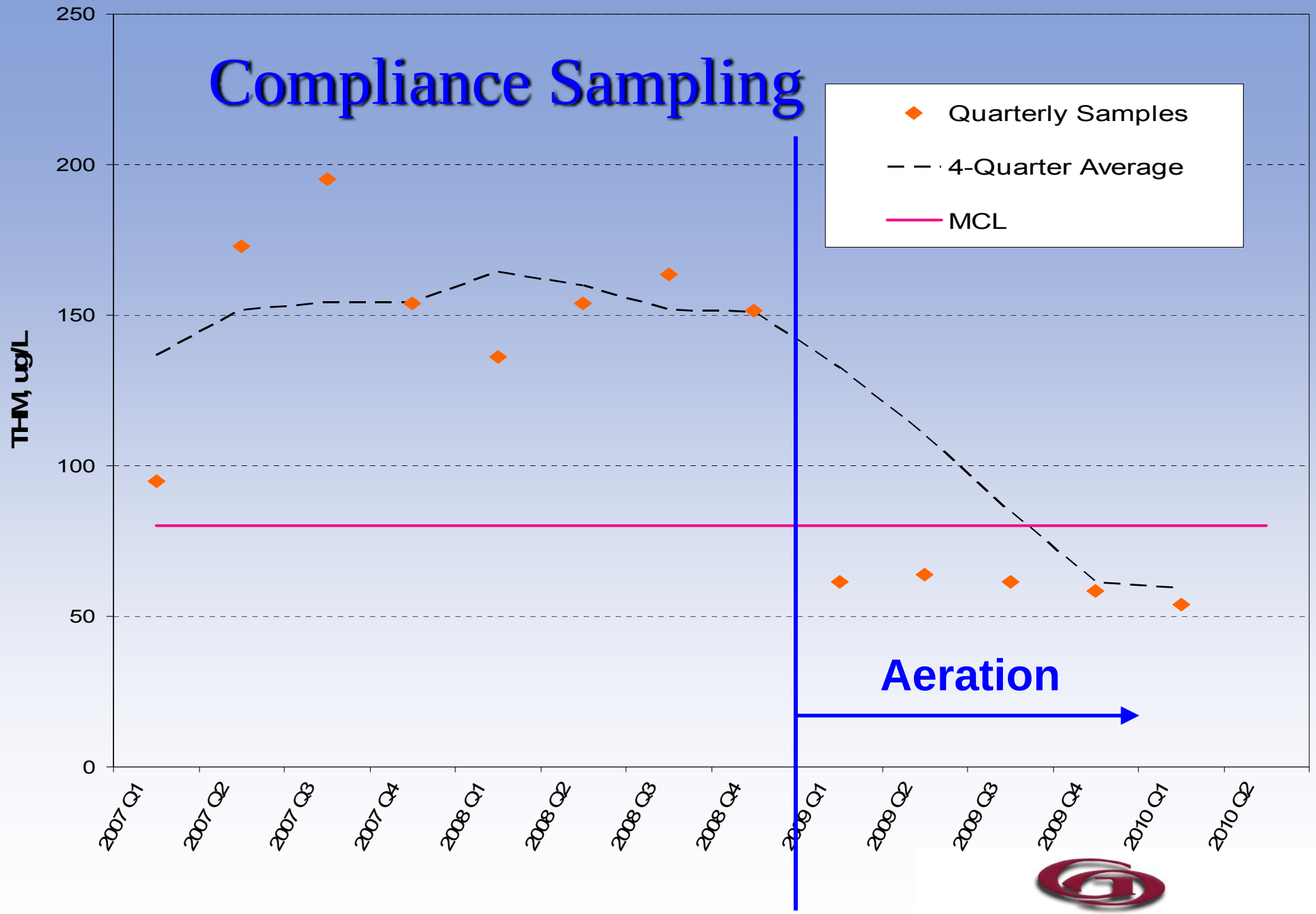
Compliance Sampling



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Regulatory Full Scale Considerations

Washington regulates VOC releases through WAC 173-460.

WAC 173-460 regulates Acceptable Source Impact Limit (ASIL) for toxic compounds.

- ASIL for Chloroform = 0.0435 $\mu g/m^3$

Emitters must stay below ASIL as proven by analysis.

WAC 173-460 sets Small Quantity Emission Rates (SQER) in lieu of analysis.

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Emission Rate Limits for THMs

Compound	SQER, lb/yr
Chloroform	8.35
Bromoform	174
Bromodichloromethane	5.18
Chlorodibromomethane	NA

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Spring Point Compliance

For analysis assume:

- 2 MG Annual Water Use
- 150 µg/L THM
- 100% Removal
- 100% Chloroform

Calculates to 2.5 lb/yr

2.5 lb/yr < SQER of 8.35 lb/yr

Spring Point is in compliance.

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Conclusions

Aeration is Effective at Reducing THMs at Spring Point.

~ 150 µg/L reduced to ~ 60 µg/L

Simple and Cost Effective

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Questions?

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Acknowledgements
Mr. David Dilling
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Spring Point HOA

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