Dreissenid Mussel Control for Large Flow, Once-through Systems

Evaluation of Alternatives to Chlorine

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Most often used controls for mussels by facilities on the Great Lakes

- Preventative chlorine application in the form of sodium hypochlorite for piping systems
- Periodic treatment with proprietary chemicals or chlorine for piping systems
- Mechanical cleaning for external structures

Why Consider Alternatives?

- Current chemical treatment methods have environmental risks
- Regulatory requirements for use of chemicals tend to be extensive

Concurrent Evaluations of Promising Technologies by Ontario Power Generation

- Fine Pore Filtration
- UV Light
- Ozone - intermittent
- Ozone - continuous

Evaluation Pre-requisites

- Proven in lab or small scale pilots
- System-sized equipment available
- Evaluate efficacy, constructability, operability

Filter

- Manufacturer – Kinetrics, Ontario
- 790 l/s (12,500 usgpm)
- 40 micron mesh
- automatic backwash
- Start-up November 15th,1999

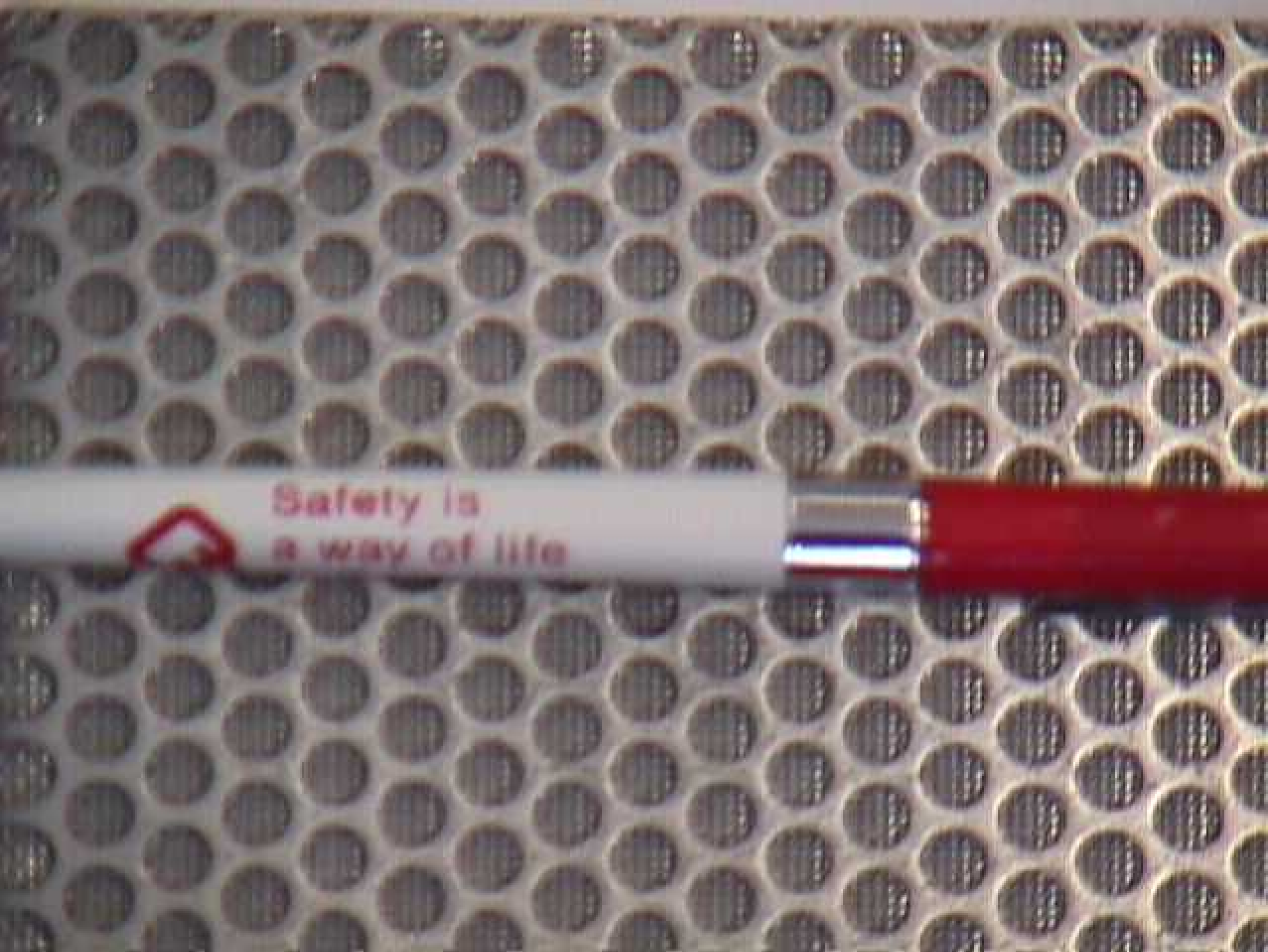
Nanticoke GS on Lake Erie

Site Selection Criteria

- Sufficient room for the large filter in the pumphouse
- Large variation in water quality at the site likely to challenge the filter
- Only 2 of the 3 service water pumps normally required in winter allowing for easier pump outages for installation and testing

The System Arrangement

- Filter size - 6 feet in diameter, 12 feet long
- Filter was installed on a by-pass loop in the pump discharge, downstream of the existing 127 micron service water strainer
- The 127 micron strainer elements were removed at various times during the testing program to challenge the filter


Safety is
a way of life

Monitoring Equipment

- Two sample panels monitored the water on the inlet and outlet of the filter
- Turbidity, pH, conductivity, dissolved oxygen and water temperature were recorded
- Bio-boxes were installed on the inlet and the outlet of the filter


EVER-CLEAR

Operation

- The filter operated in the 315 l/s to 380 l/s range since this was the demand during the test period.

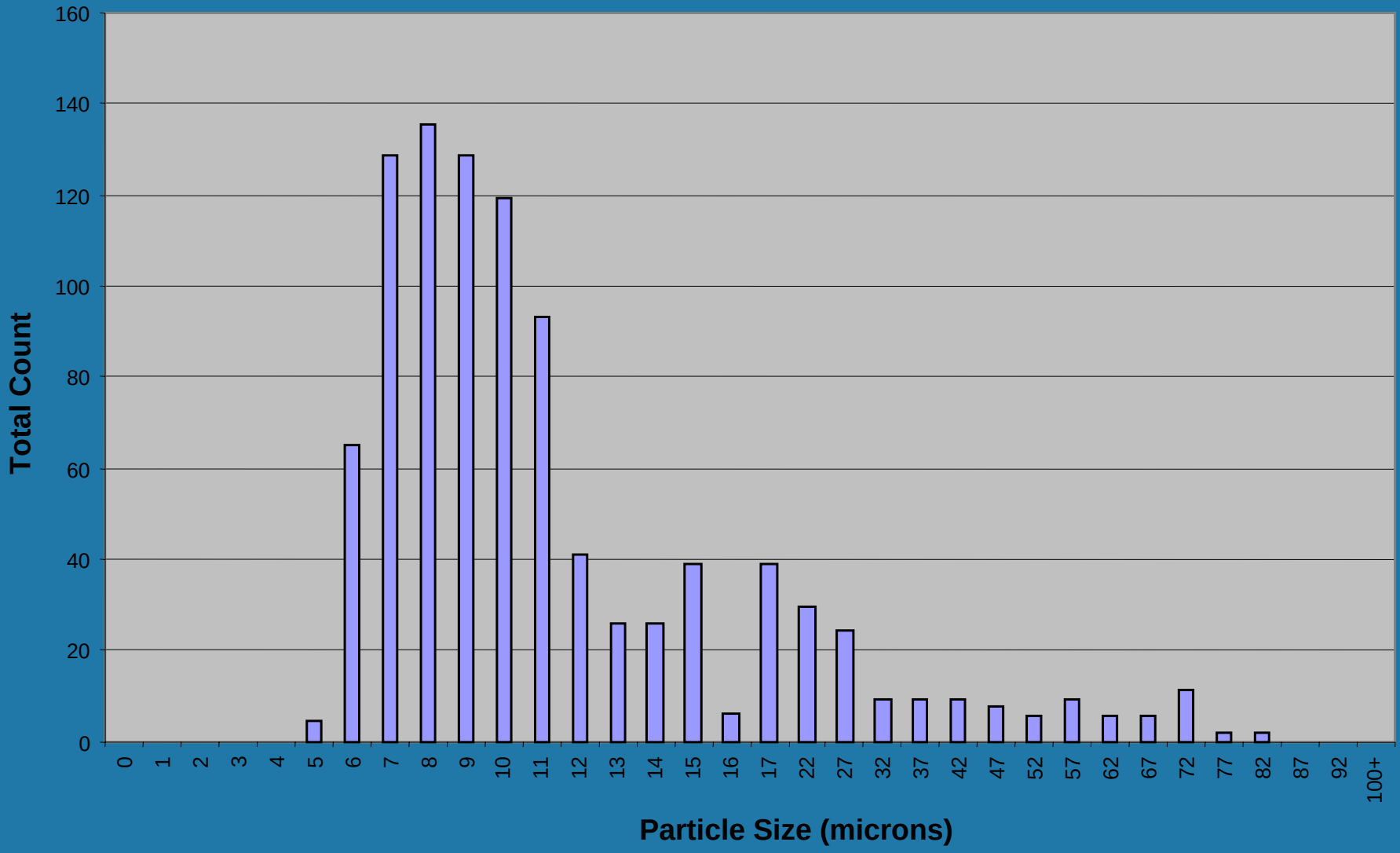
Results

- Filter operated well when inlet water was below 15 PPM TSS
- The backwash system was not effective when inlet water was very high in TSS - 60 PPM
- Veliger removal > 90%
- Veligers passing thru filter all severely traumatized.

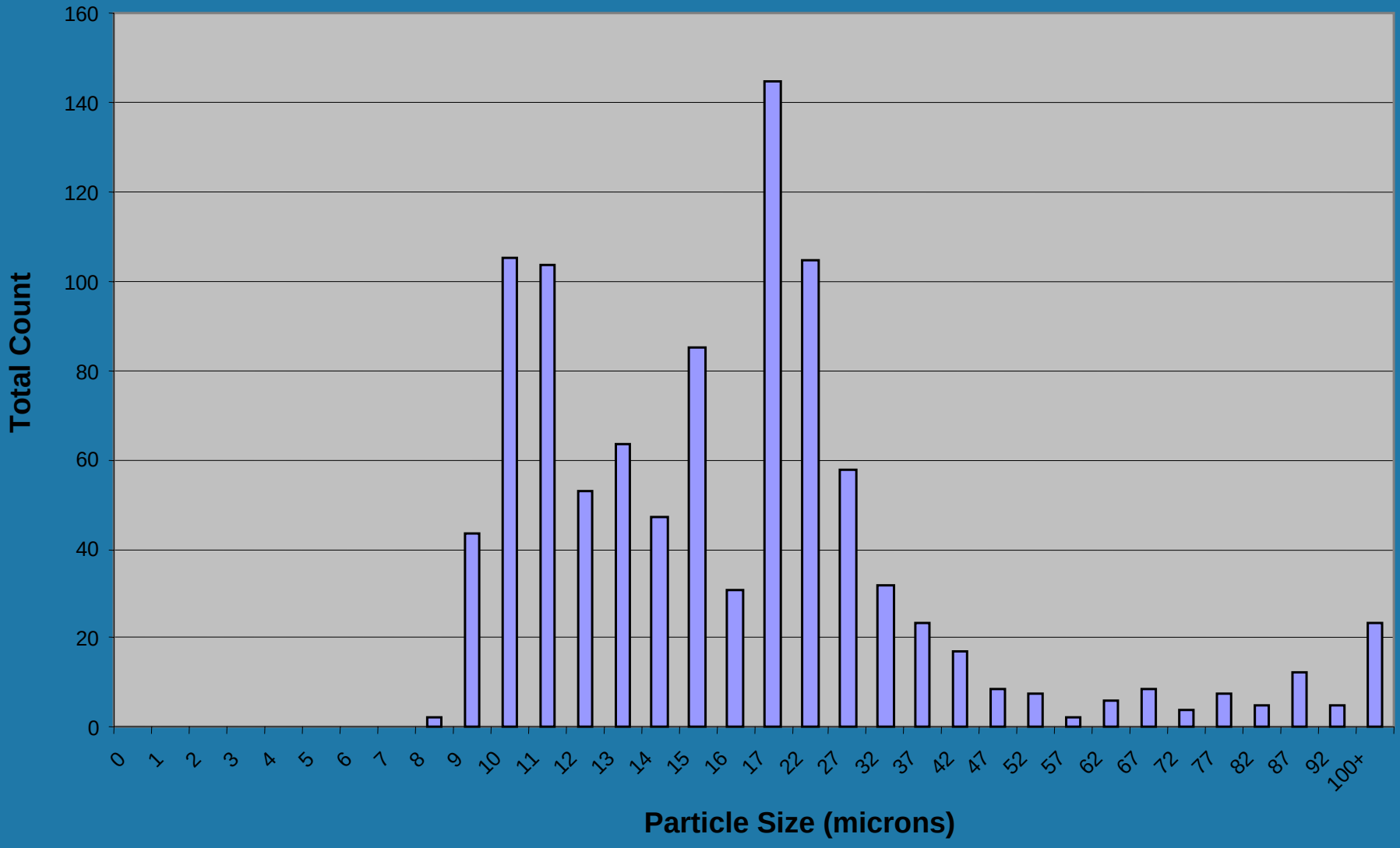
Lessons Learned and Recommendations

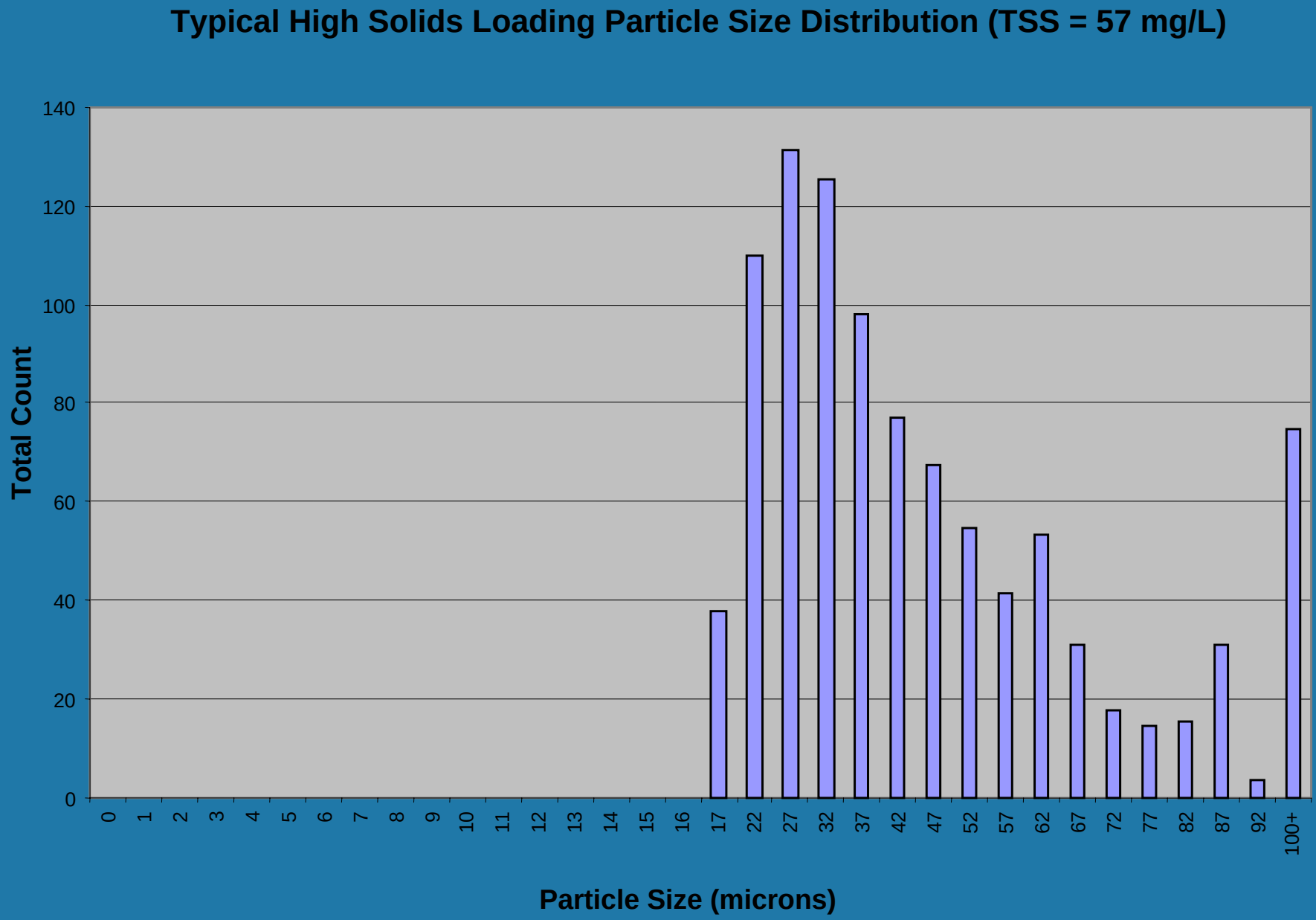
- Requires large space to retrofit.
- Filter may plug requiring manual cleaning during periods of high solids content. – by-pass recommended
- Analyze your silt load and particle size
- Particle size may change with change in TSS

Typical Low Solids Loading Particle Size Distribution (TSS = 4.5 mg/L)



Typical Intermediate Solids Loading Particle Size Distribution (TSS = 13.5 mg/L)




Typical High Solids Loading Particle Size Distribution (TSS = 57 mg/L)
Total Count
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
22
27
32
37
42
47
52
57
62
67
72
77
82
87
92
100+
Particle Size (microns)

Test of Ultra Violet (UV)

Test of Ultra Violet (UV)

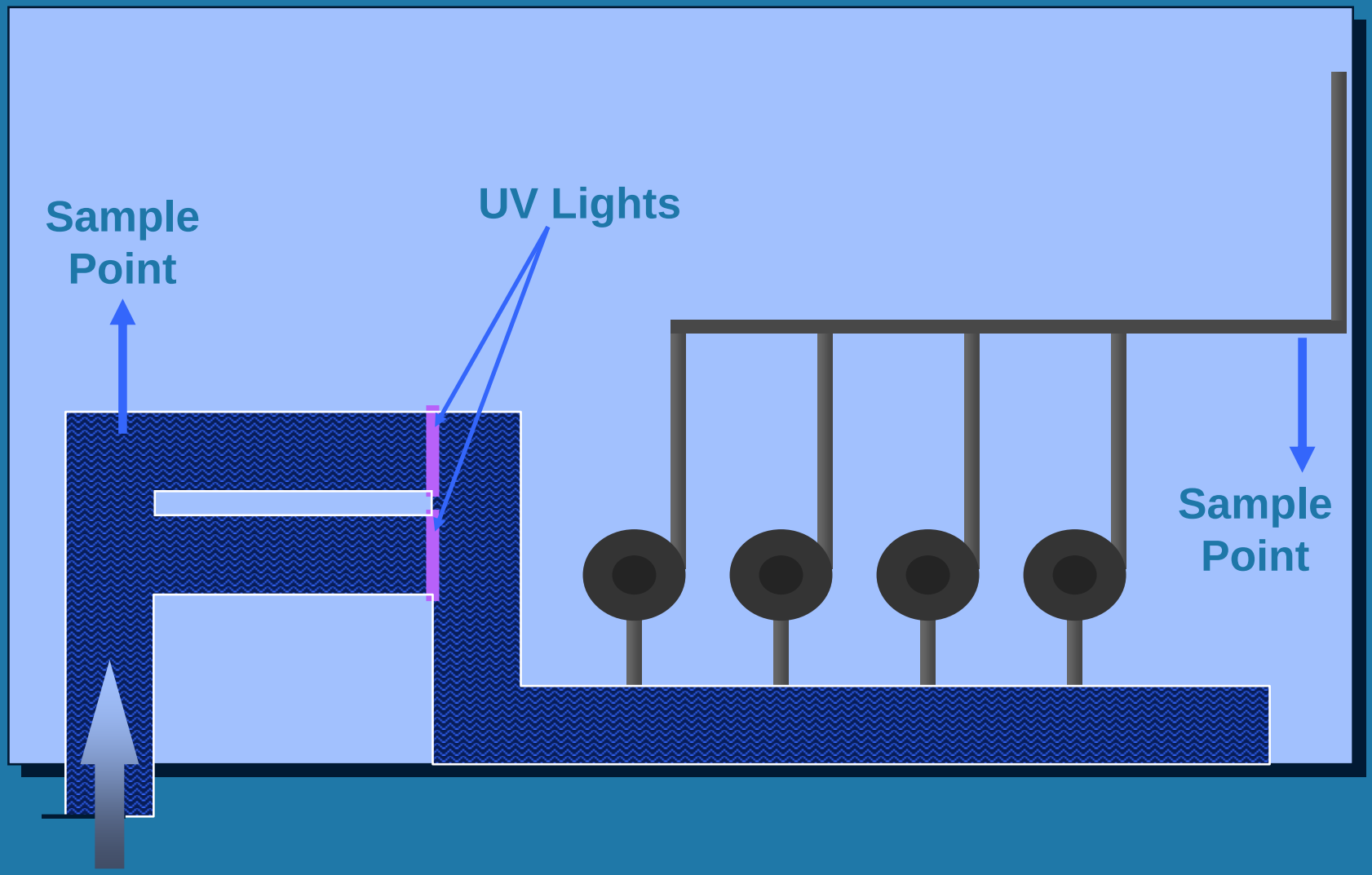
- Installed in Bruce 5-8 CSW
- 760 l/s (12000 usgpm)
- 20 medium pressure lamps
- manufacturer - Elsag-Bailey (now Trojan)
- Start-up: December 6, 1999

UV Light Evaluation

Evaluation Pre-requisites lead to installation on the Common Service Water Sytem:

- Ability to Retrofit
- Maintain Operation - flow
- Accessible for Maintenance
- “System-size”

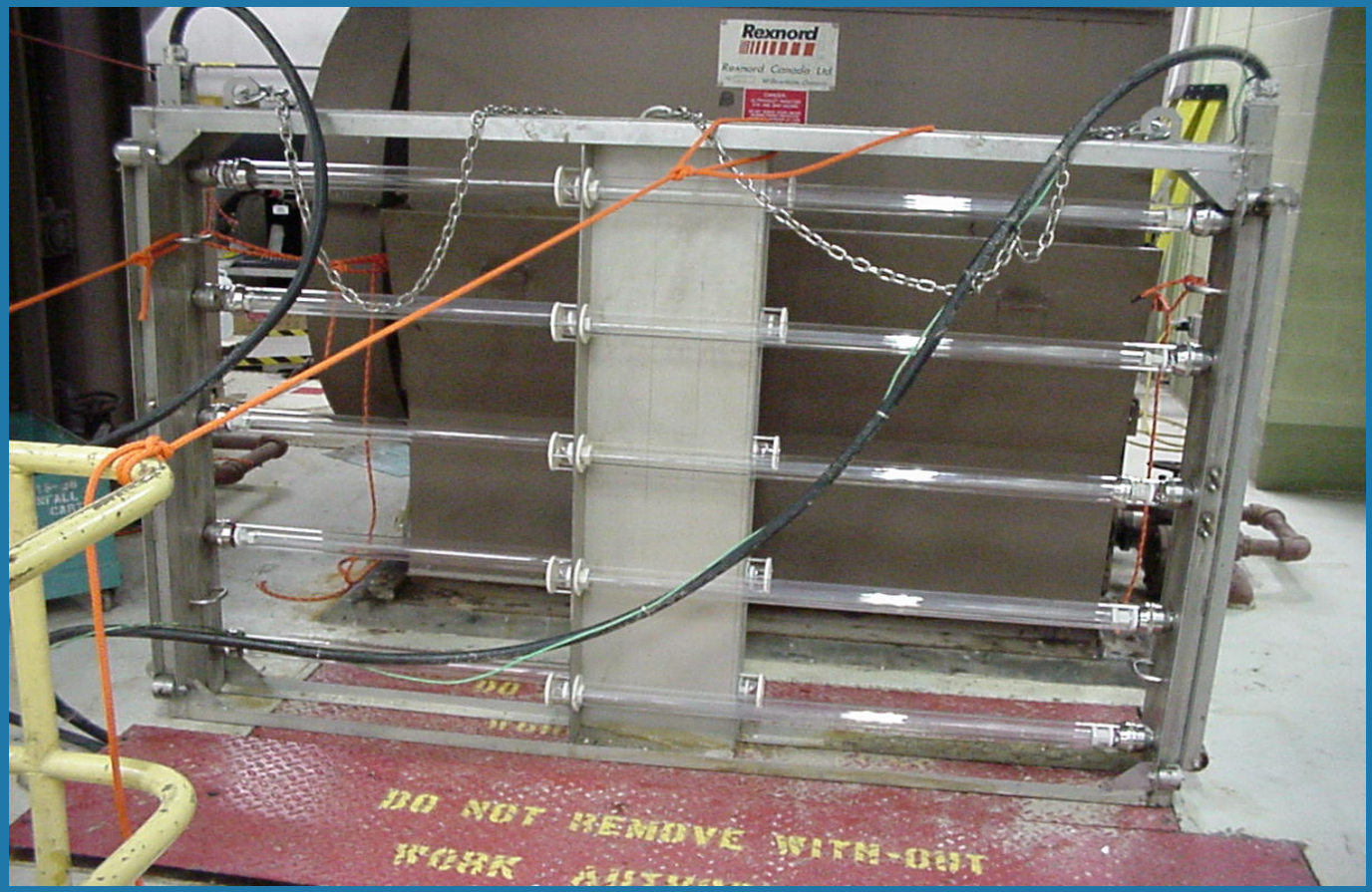
Installation & Commissioning



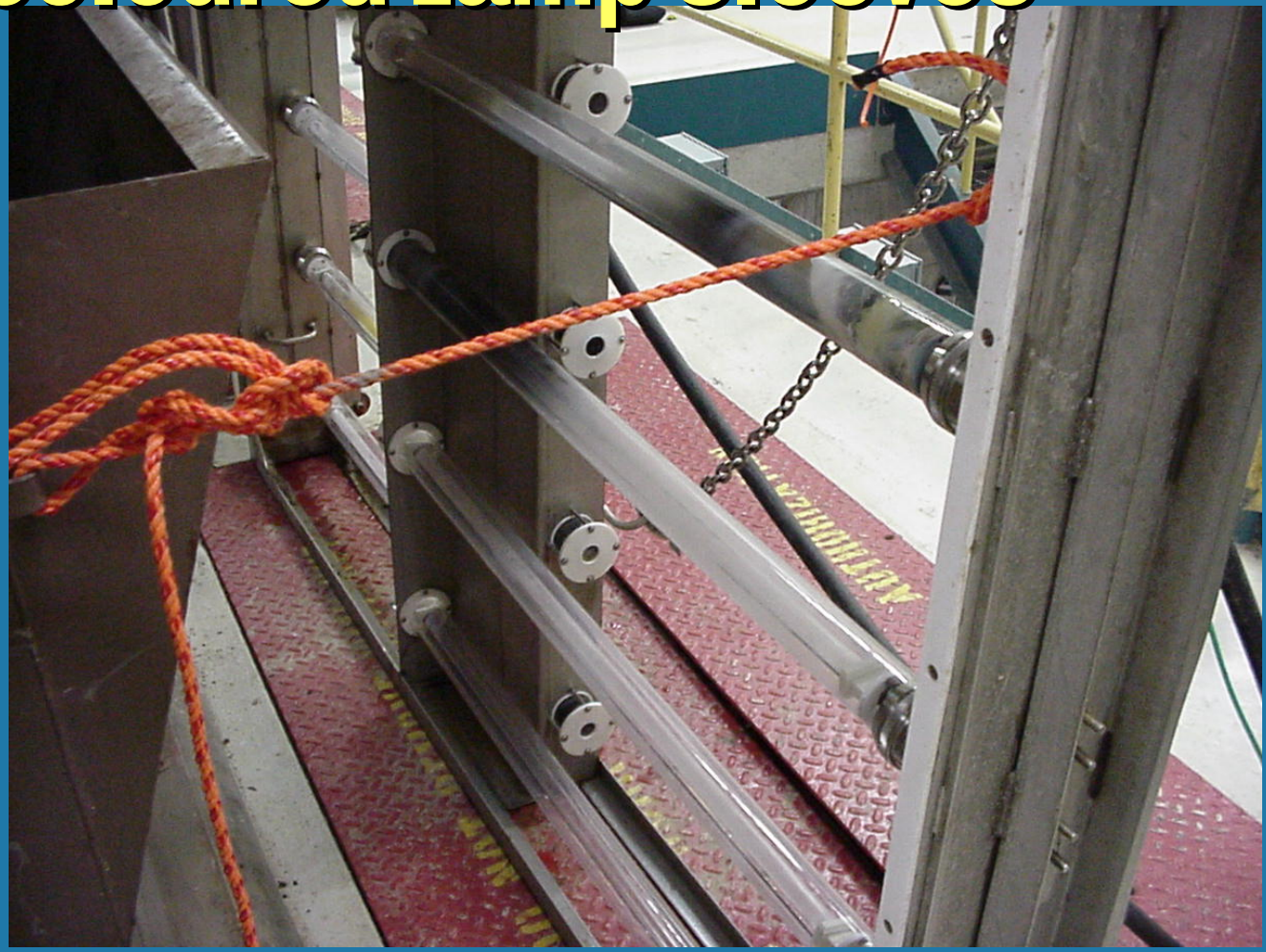
Results

- Equipment
  - operation - lamp trips, leaks
  - maintenance - lamp failure
  - life - tube discoloration
- Biology
  - 85% reduction in settlement

UV Light Bank



Discoloured Lamp Sleeves



Lessons Learned and Recommendations

- OM&A cost of UV is higher relative to chlorine
- At the time it was difficult to get vendors interested. Not a traditional market.
- Efficacy of 85 % may require end of season chemical treatment depending on population size of mussels and system vulnerability

Intermittent Ozone

- Host Site: Bruce A Power Plant on Lake Huron

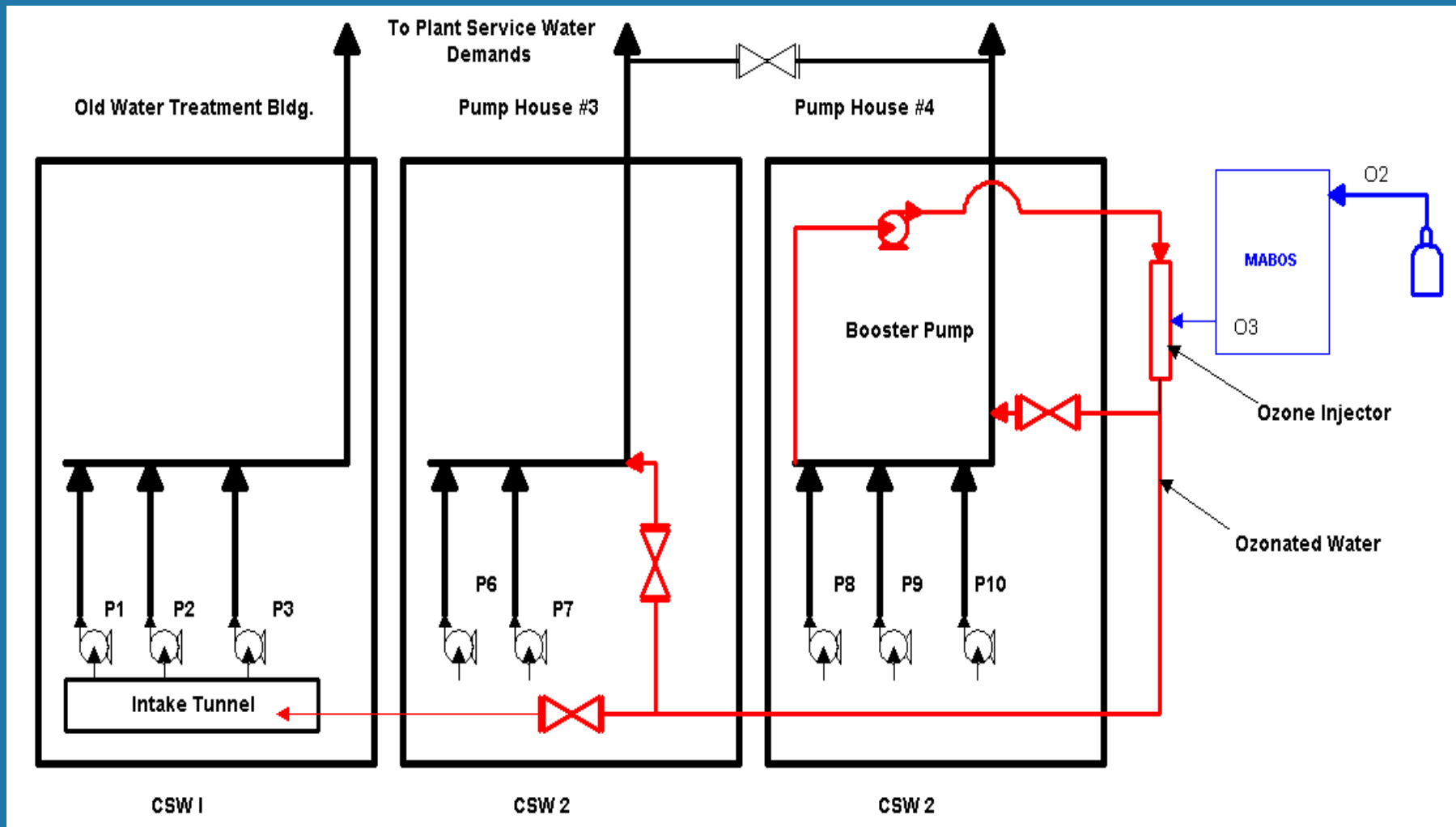
Intermittent Ozone

- manufacturer – Mitsubishi Electric
- 2 kg/day ozone
- 1 kg injected for 5 minutes, 2 times/day
- Design: 630 l/s (10,000 usgpm)
- In service: variable flows as low as 250 l/s but not greater than 630 l/s

MABOS System

- This unique system allows a small ozone generator to continuously produce ozone and store the output in a silicone gel filled tower which is kept at –40C°. Once or twice per day, the entire ozone content of the tower can be released into the service water stream.

Ozone Addition System Layout



Issues Addressed for Ozone use

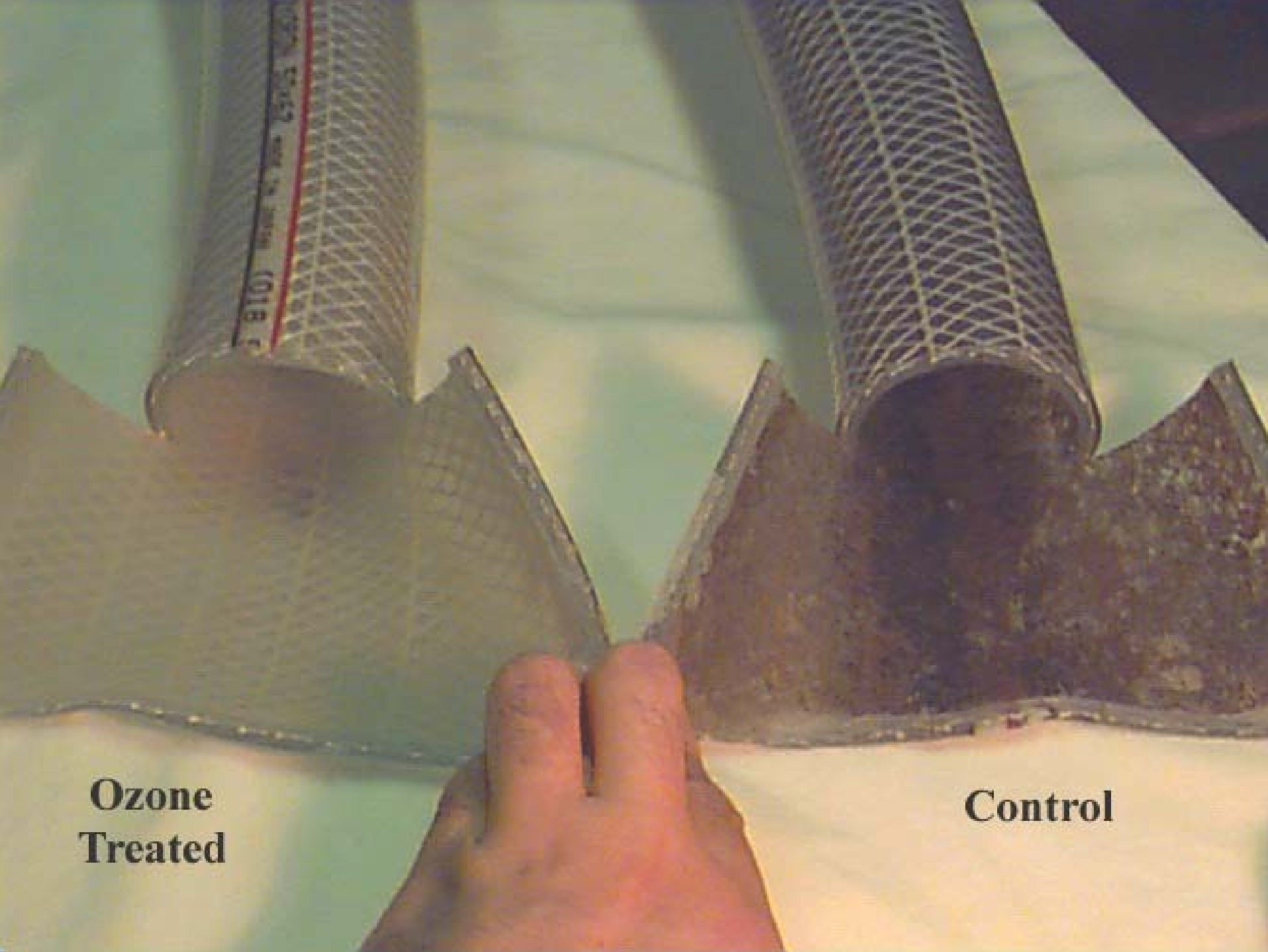
- **Efficacy, Constructability and Operability**

Plus

- Ozone off-gassing
- Compliance with discharge limits
- Corrosion / degradation of materials

Results

- Some veligers were able to settle between ozone additions,
- No veligers survived subsequent exposure to ozone resulting in 100% mortality
- Live juvenile and adult mussels in sidestream samplers became detached


Ozone
Treated
Control

Elastomer Degradation

- Exposure too short to assess effect
- Results from lab tests indicate some reduction in elongation and some loss of tensile strength

Constructibility

- MABOS system was skid mounted – installation was straightforward
- Injection piping was complex so as to cater for multiple injection points

Operability

- Little operator attention required
- Will need flow feedback with injection turn down – due to variable service water flow rates
- Injection into open inlet channels is not practical due to off-gassing.
- Off-gassing at service water drains in main power house is main draw back.

Operating Costs

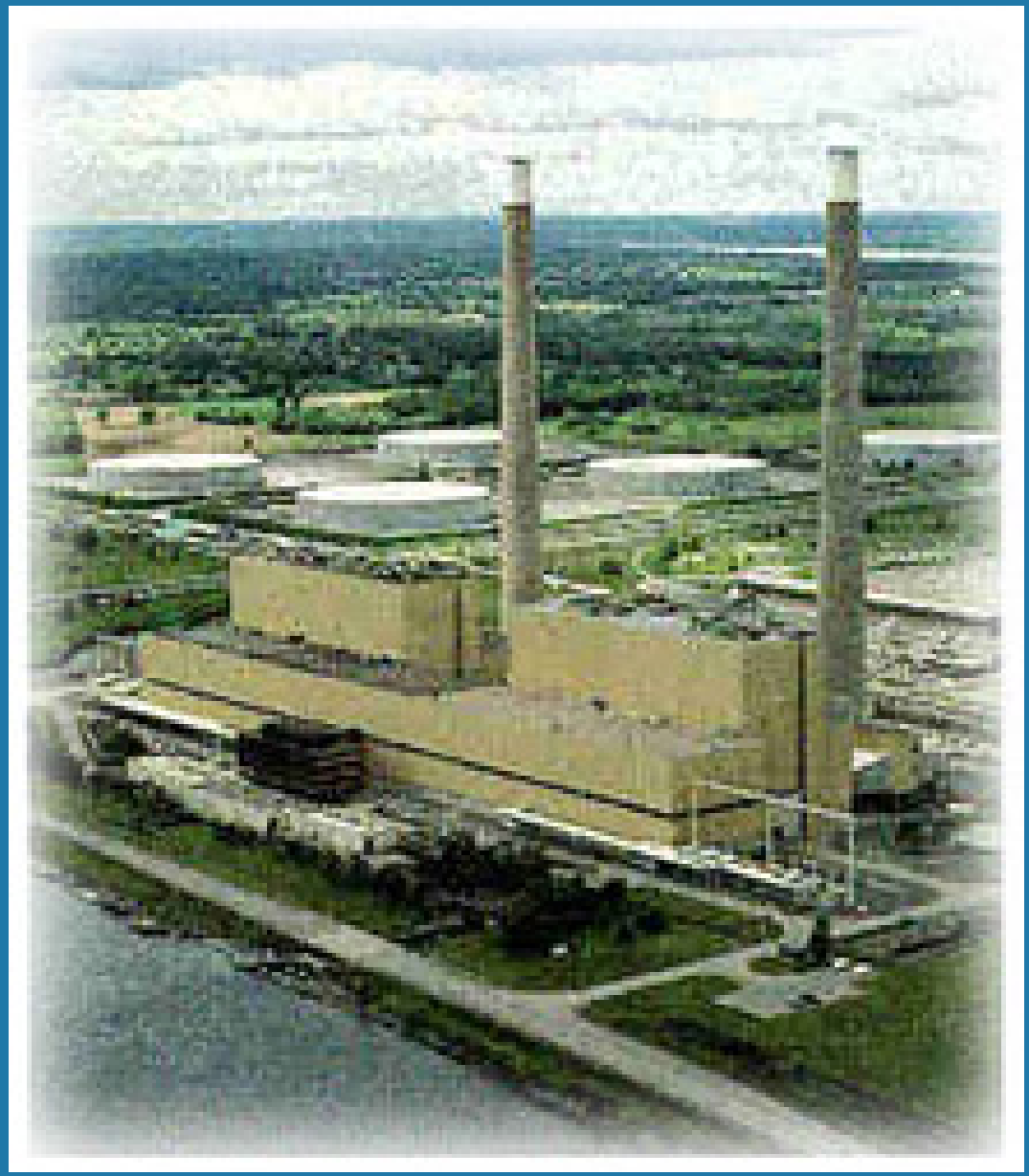
- The initial capital outlay is the largest cost factor to consider.
- Low operating costs - electricity, oxygen and minor repairs were $14k/annum

Intermittent Ozone Conclusion

- System achieved 100% control of zebra mussels

- Injection must be into closed vessels or piping due to off-gassing and high concentrations needed at the injection points.

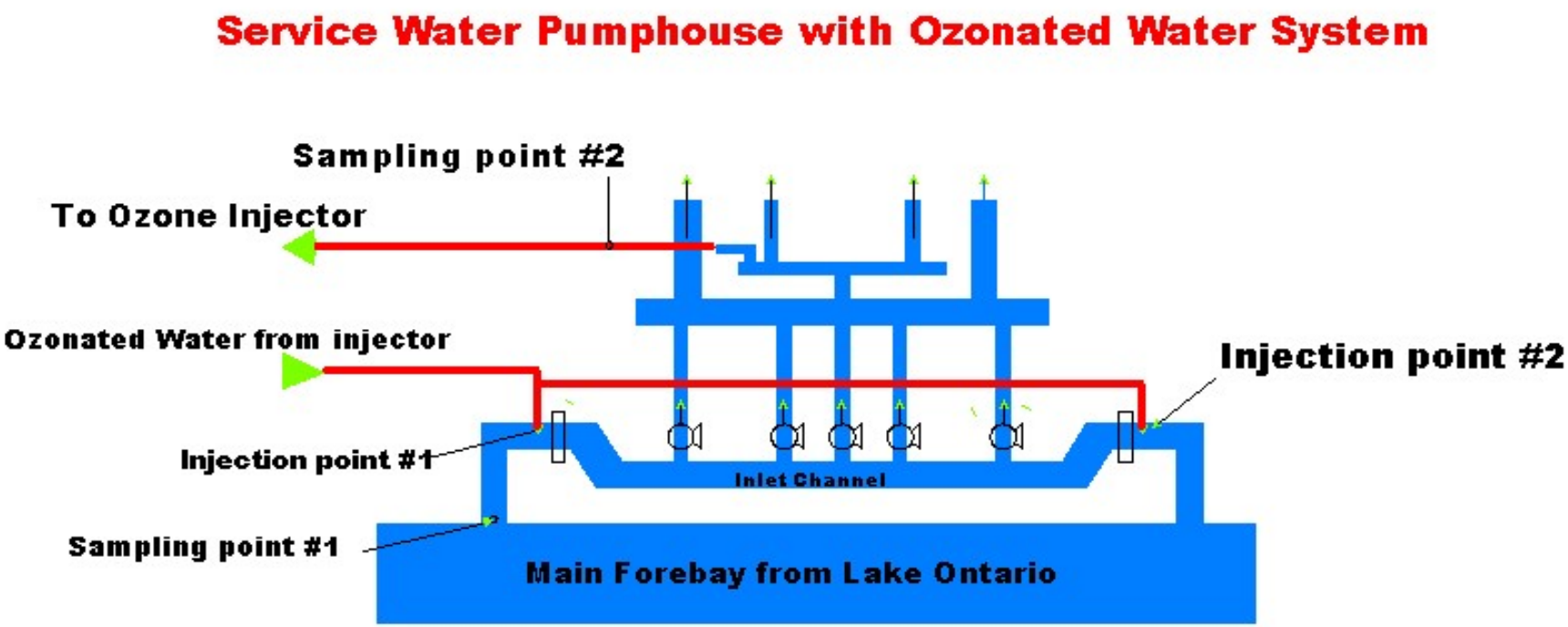
Lennox GS - Continuous Ozone



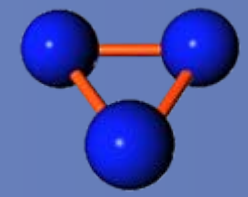
Continuous Ozone

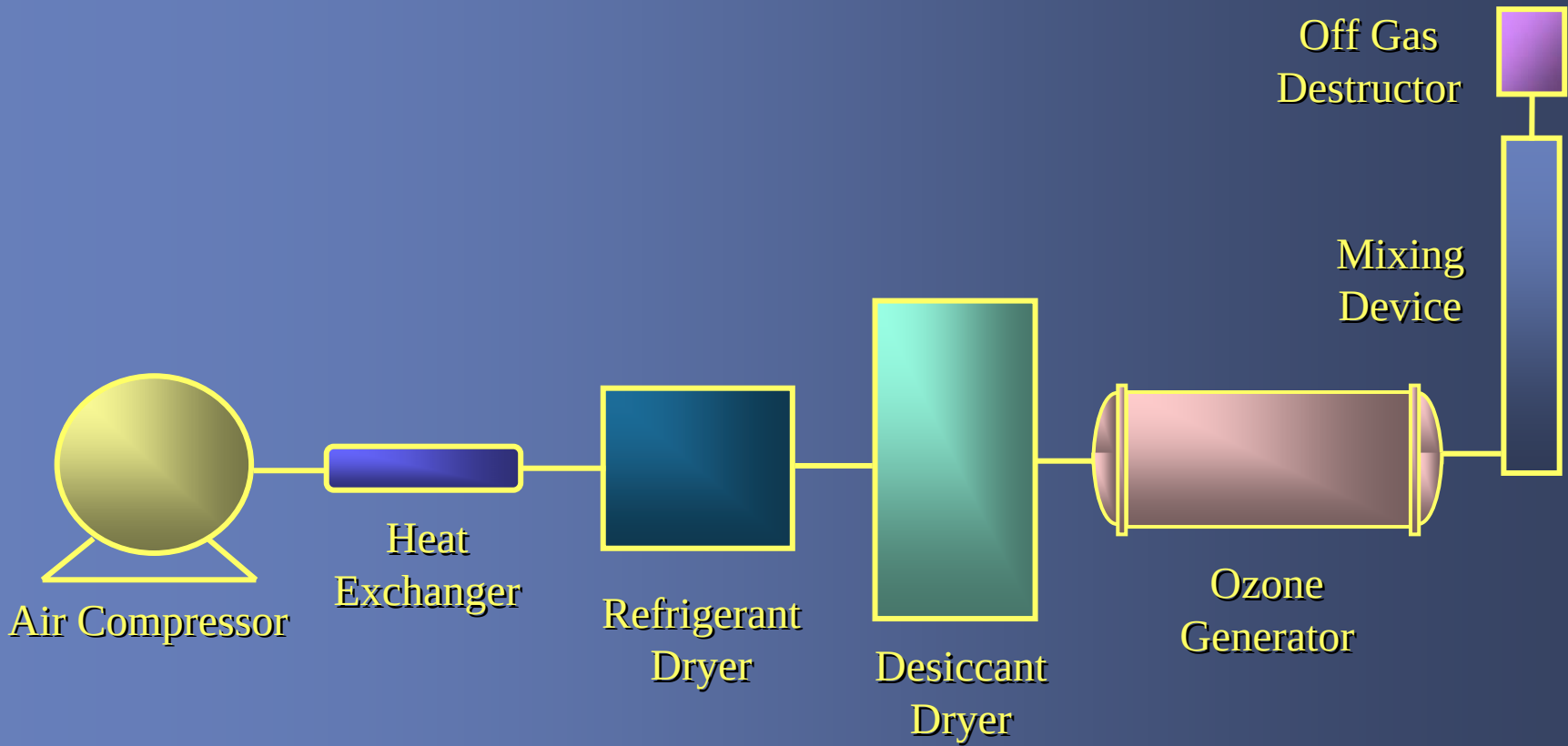
- manufacturer - Hankin Atlas Ozone
- 160 kg/day(350 lb/day) ozone
- Service water flow varies:
  - Design – 2700 l/s (43,000 usgpm)
  - Range during test – 600 l/s to 1300 l/s

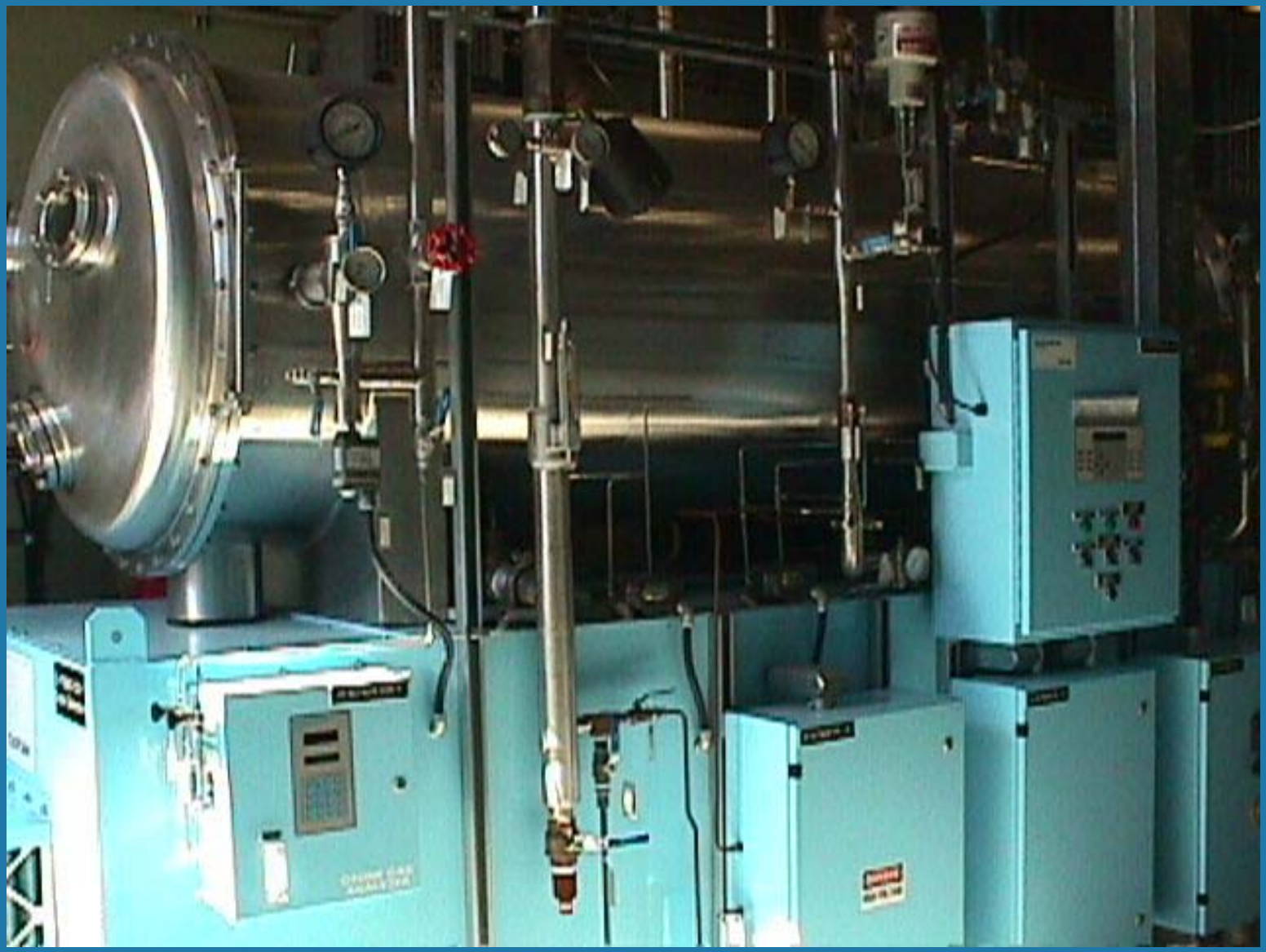
The System Layout

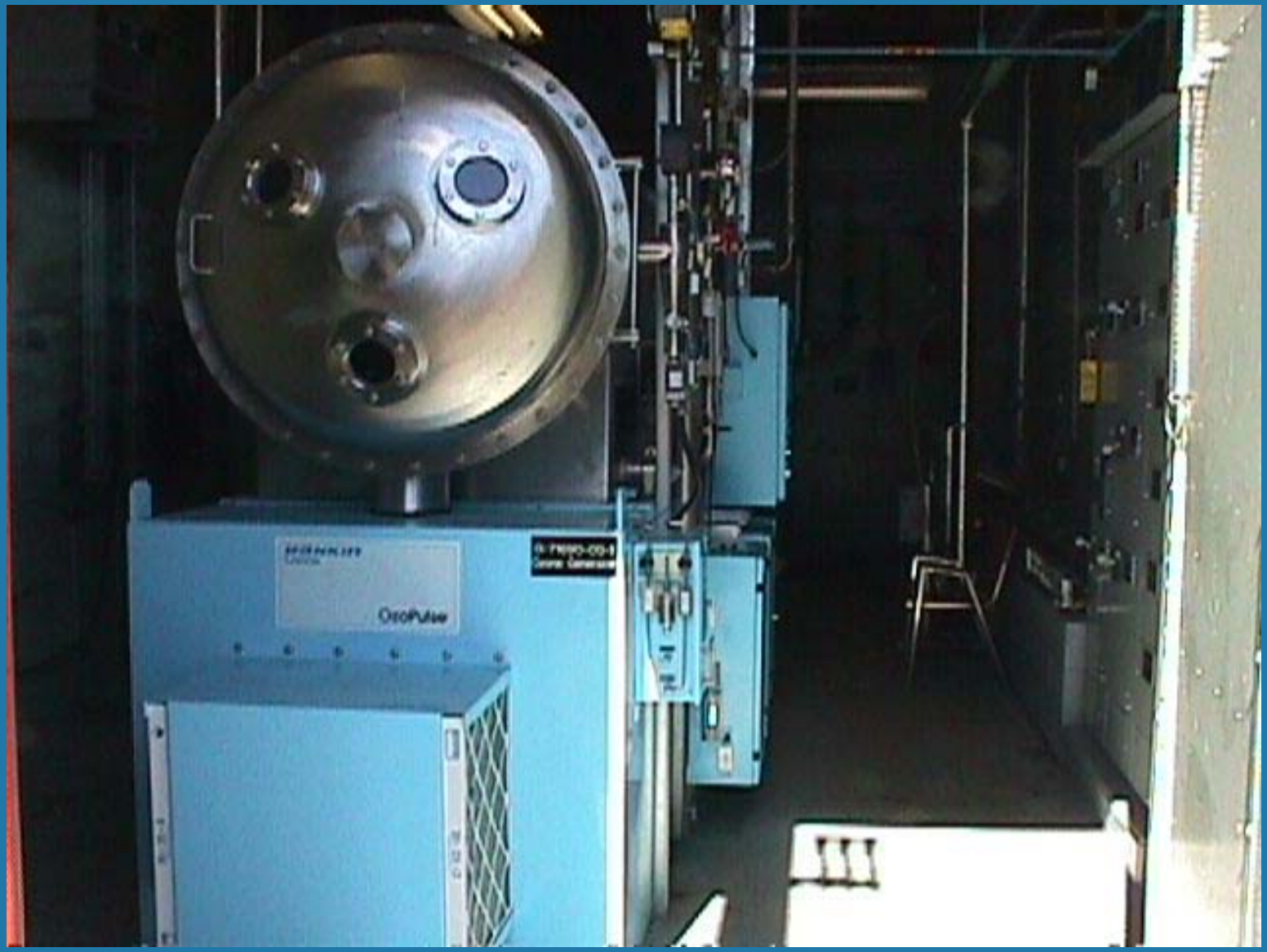


HANKIN Ozone









Diffuser – vertical portion

Diffuser – section at bottom of channel

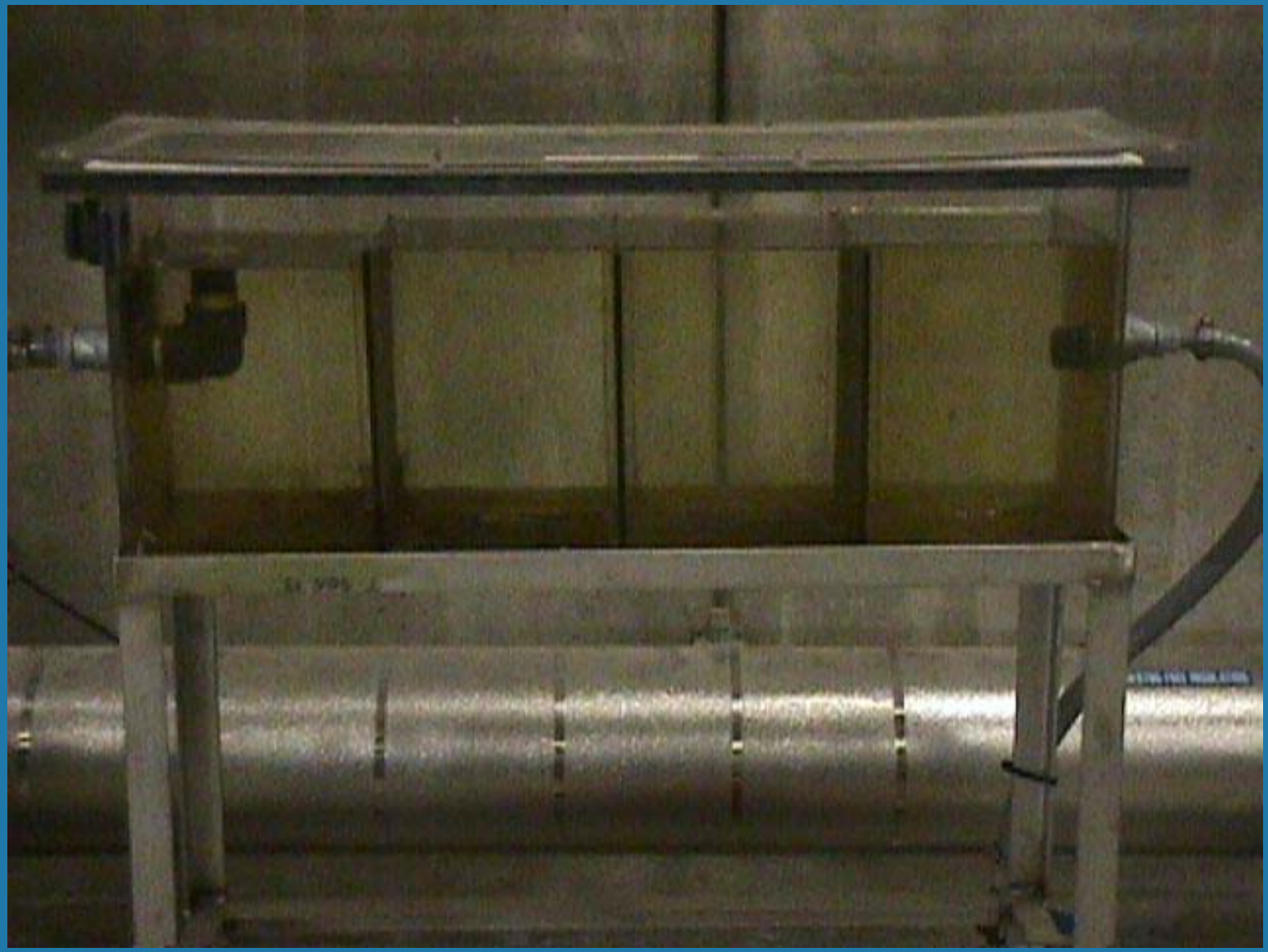
Operation

- Ozone levels immediately after the injection in the inlet channel were 300 ppb
- Ozone levels within the piping system were between 50 – 80 ppb.

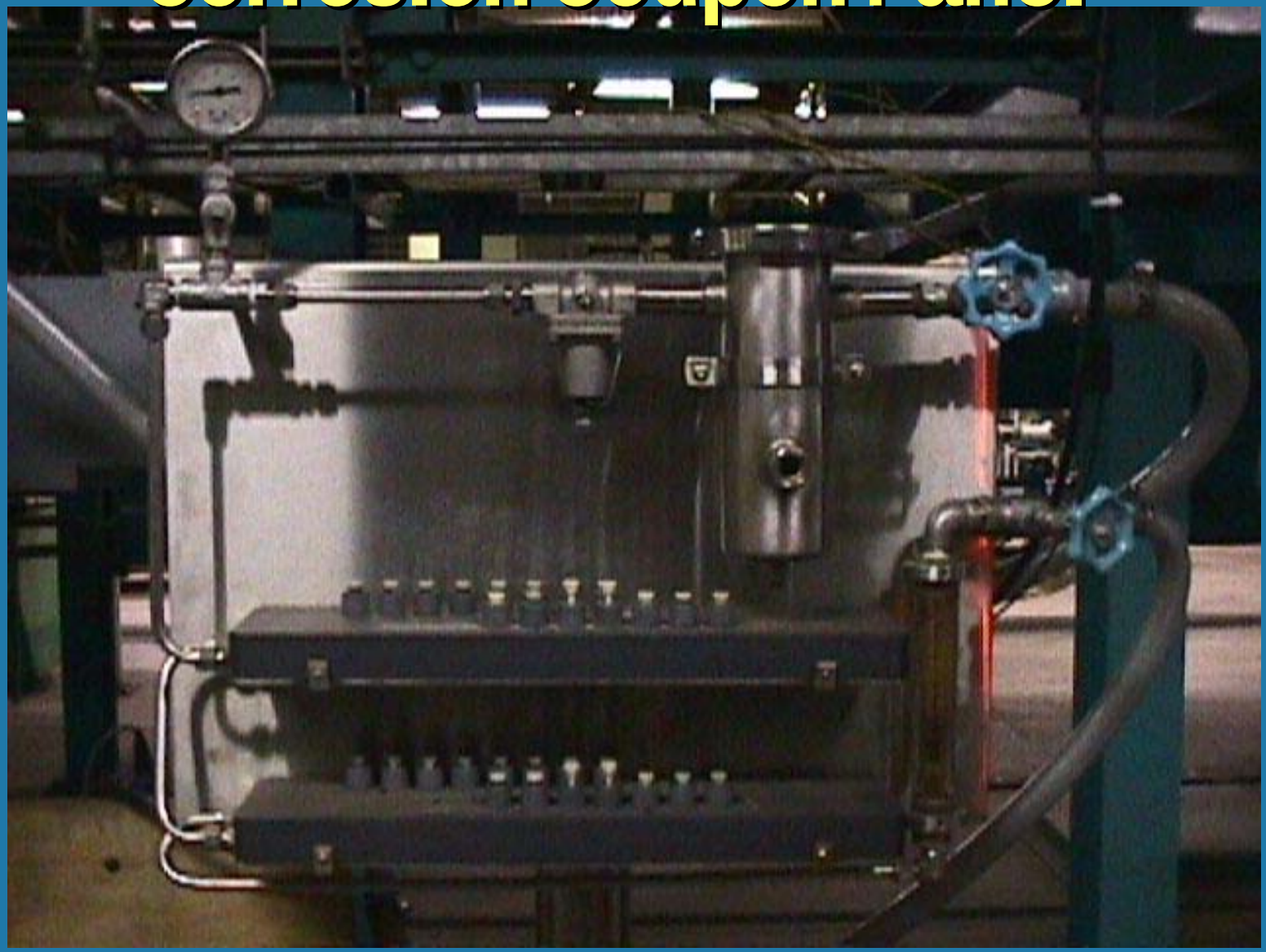
Inlet Channel Results

- Concrete walls of the intake channel remained clean in areas exposed to the 300 ppb levels.
- Greater than 98% reduction in settlement of veligers within the piping system even at the 50 ppb level
- Efficacy =100 %, all settled mussels dead.
- Cooler cleaning has gone down dramatically.

Bio-box



Corrosion Coupon Panel



Constructability & Operability

- Installation of diffusers requires inlet channel to be drained.
- All other components can be installed with no interruption of station power.
- Manual process control is too labor intensive for a station with variable service water flow.

Ozone Off-gassing

- ✓ No difficulties at the injection channel
- ☒ Unacceptable off-gassing at some drains, sumps and tun dishes.
  - ✓ Fixes have been designed

Ozone in Station Outfall

- ✓ Station discharge ozone-in-water levels below detection limit of sampling equipment. < 10ppb
- ✓ Live fish toxicity tests passed

Impact of Ozone on Materials of Construction and Elastomers

- No Corrosion observed on carbon steel coupons
- Little degradation of elastomers

Summary & Conclusions

- An open inlet channel can be protected from mussel settlement at 300 ppb ozone concentration (“Wall of Death”)
- Mussel control in piping systems is generally very good at 50 ppb in the service water pump discharge.
- Plant equipment maintenance is lower.

Summary & Conclusions

- Higher residuals are desirable for greater assurance of control but require more extensive off-gas management solutions.
- Off-gas management is the most significant safety concern for an ozonated water system.
- Compliance with discharge limits demonstrated
- System still in Service!!!