In-situ Biotreatment of Airport De-icing Fluid

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From Science to Solutions™

Ottawa

Background

- 2001 relocated central deicing facility (CDF)
- Cause for elevated concentrations investigated
  - Likely cause: Dripping off taxiing aircraft
- Not a concern before
- When pad location changed, glycol dripping off aircraft impacted the storm water that flows into the Rideau River
- Result – orders from both EC and MOE


YOW
Rideau River
New CDF
X
Old CDF/ New Terminal
X

Assessments

- Hydrogeological Study (Robinson Consultants)
  - To determine ground water flow direction and velocity
- Treatability Study (SAIC Canada)
  - To determine if natural attenuation would work

Hydrogeological Assessment

- OMCIAA selected the most suitable location (no future development potential)
- Confirmed:
  - GW flow to the north
  - GW flow speed 4.0 x 10^{-2} cm/s or 4 yrs to the property boundary
  - Soil consists mainly of sand
- GW has been monitored for past two years: 2 X 10^{-2} cm/s

Relative Locations

Solution

- Not attract wildlife (birds)
- Economical
- Little or no personnel resources

In-Situ Bio

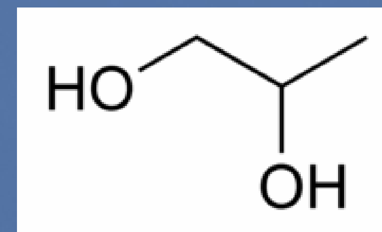
- Will it work at this site?
  - Indigenous bacteria
  - Proper soil conditions
    - Nutrient level
  - Hydrogeology

Glycol

Ethylene Glycol

- Sweet, odourless, colourless liquid
- Toxic
- Easier to break down in the Environment

Propylene Glycol



- Tasteless, odourless, colourless liquid
- Non-toxic
- Remains in the Environment longer

Approach

- Bench scale (laboratory)
- Pilot scale
- Full scale implementation

Laboratory Experiments

- Soil nutrient level
- Capacity of indigenous bacteria to degrade glycol
- Aerobic or Anaerobic
- Time frame

Aerobic vs Anaerobic

- Traditional lagoons are aerobic
- In general: aerobic faster than anaerobic
- Different breakdown products

Simple Flask Test

- Actual soil at proposed site for infiltration bed was used as biodegradation medium and source of microorganisms
- Spiked glycol at an initial concentration of approx. 50 mg/l
- Both aerobic and anaerobic tests
- No nutrients added

Flask Test

Results

After 28 days

Initial	Flask A (Aerobic)	Flask B (Aerobic)	Flask C (Anaerobic)	Flask D (Anaerobic)
52 mg/L	53 mg/L	53 mg/L	53 mg/L	22 mg/L

Soil at selected site not likely to support sustained biological degradation of glycol if glycol impacted water is released into the infiltration bed as is.

Bioreactor Test

- Microbes from airport storm water sump
  - Exposure to glycol from de-icing pad
  - Sludge from storm sewer
- Nutrients (Mineral salts)
- Custom-made bioreactor –
  - aerobic and anaerobic operation
  - process parameter control
  - larger reactor volume.

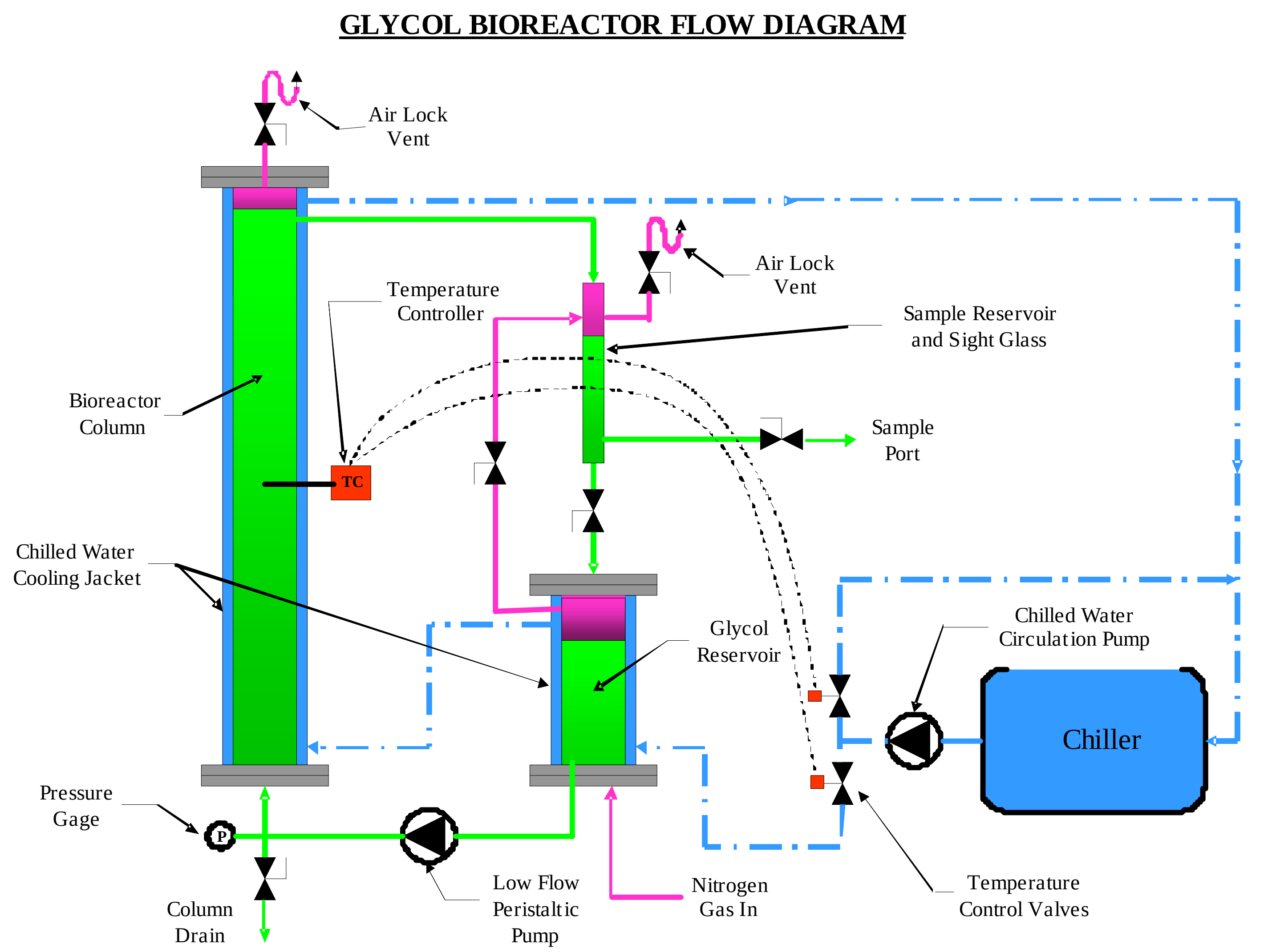
Bioreactor Test results:

- Reactor is anaerobic after 5 days.
- Glycol concentration dropped below detection limit between 7 to 14 days.
- Visible active bacteria culture growth.
- Shows lag phase before glycol degrading anaerobic microbes become active.

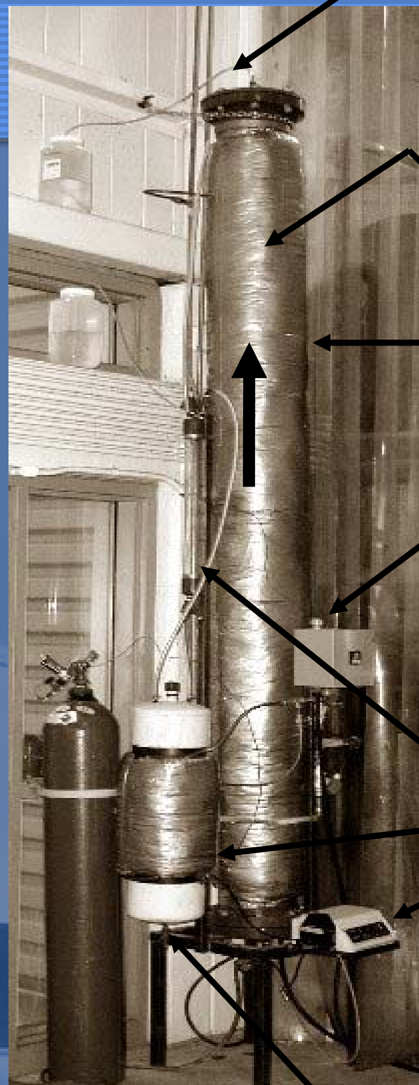
Pilot-scale Test

- Mimic field groundwater flow and conditions
- Flow velocity: 15 mm / minute
- Temperature: between 8 and 12 C
- Air tight system with special sampling reservoir
- Nitrogen purge
- Actual sand from proposed infiltration bed site

Column Schematic



Pilot-scale
Column Test System



Pilot-scale Column Test Results

- 4 weeks system conditioning
- Injection of nutrients and microbes
- Between 10-21 days, glycol concentration dropped to below detection limit

In-situ Glycol Bioremediation

Bench-Scale Results

Day	Glycol mg/L
0	39
7	32
14	<5

Column Results

Day	Glycol (mg/L)
0	182
10	163
21	<5

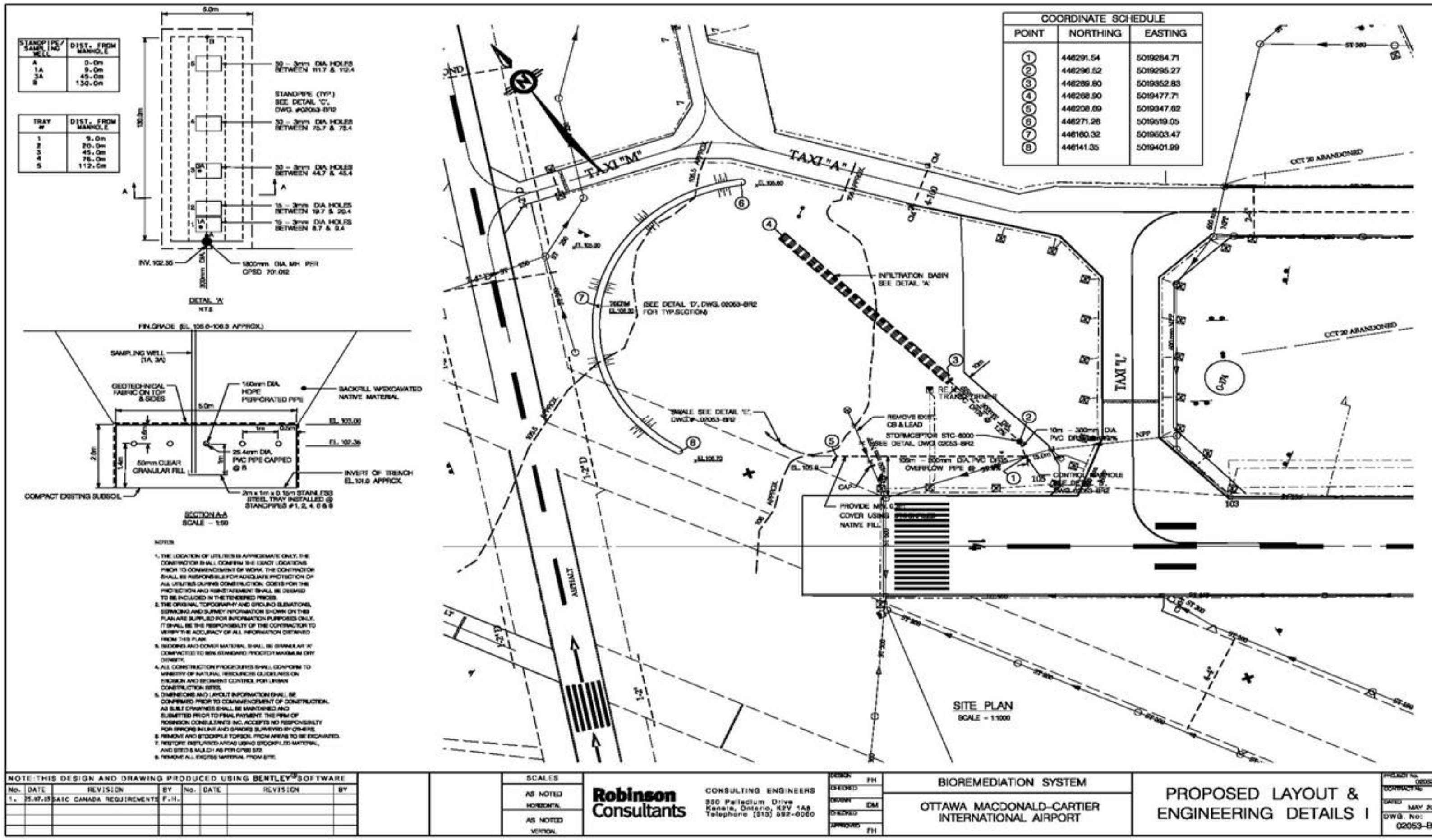
Conclusion

- Able to biodegrade glycol in an anaerobic environment using indigenous microbes
- Soil at selected site not likely to sustain biological degradation of glycol if glycol is released into the infiltration bed
- Infiltration bed system should include nutrient and bacteria injection

Bioremediation System Design

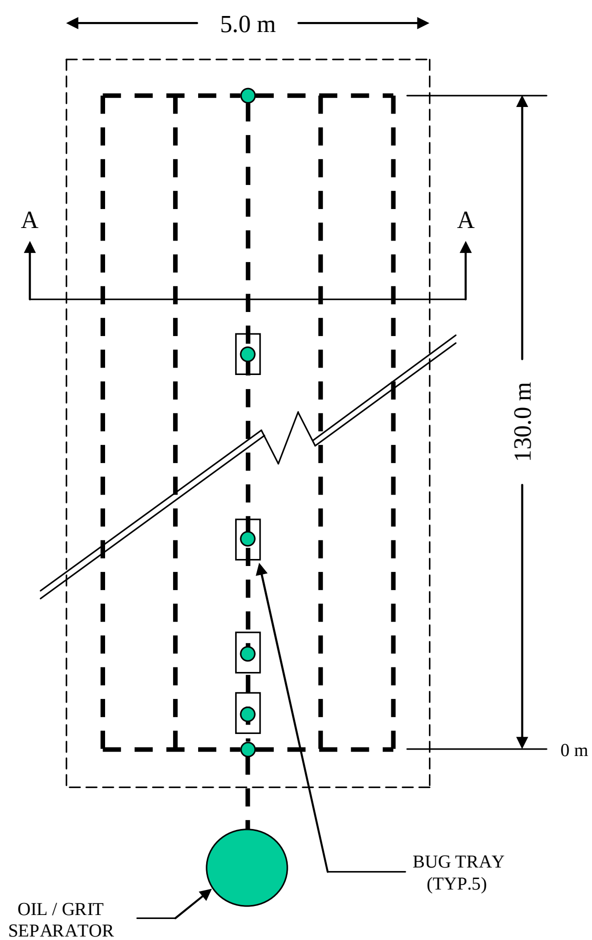
- Septic field 130m X 5 m
- Flow diversion valve
- Stormceptor™ to collect oil and grit
- Capacity of 340 L/s
- Overflow to ground surface
- Containment berm

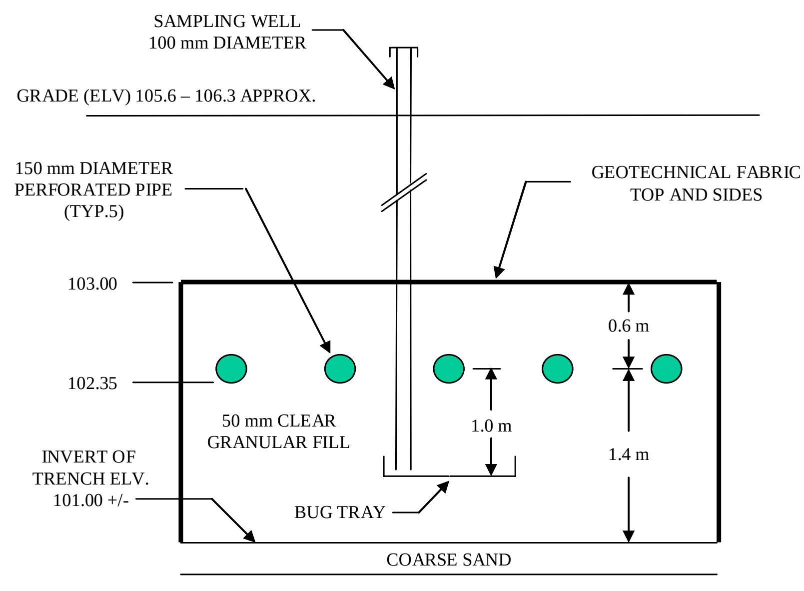
System design



Schematic

OTTAWA INTERNATIONAL AIRPORT GLYCOL BIOTREATMENT SYSTEM SCHEMATIC





SECTION A - A

NOTES :

- BUG TRAYS TO BE 1m x 2m x 0.15m x 1.5mm THK. STAINLESS STEEL. QTY.5.

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- BUG TRAYS ARE TO BE LOCATED BENEATH STAND PIPES 2, 3, 5, 7 & 9.
- PROVIDE SAMPLING WELL FOR BUG TRAYS LOCATED BENEATH STAND PIPES 2 AND 5..

Concentric Injection Pipe

System Specifics

- Five bacterial trays for inoculation
  - Monitoring ports for bacteria (pre-winter sampling)
- Injection piping for nutrients (salts) (weekly – winter)
  - Monopotassium phosphate
  - Ammonium chloride
  - Calcium chloride and
  - Magnesium chloride
- Monitoring wells (degradation of glycol and by-products)

Installation of ‘Bug’ Tray

Manifold Installation

Inoculation

- Initial Idea:
  - Collect bacteria from existing storm sewer
  - Add nutrients and ethylene glycol
  - Let acclimate
  - Re-inject acclimated bacteria into treatment system

Canadian Environmental Protection Act

- CEPA
  - New Substances Division
- NO!
  - Cannot re-inject any bacterial solution that has been modified *ex-situ* unless:
    - The exact bacterial consortium has been determined **and:**
    - The consortium is on the DSL **or:**
    - The new consortium has been *proven* to be benign

Plan ‘B’

- Collect bacteria from existing storm sewer
- Dilute in 200 litres of nutrient solution
- Re-inject into system
- Add glycol (dilute) to acclimate the bacteria
  - This was done a few weeks before to overcome the lag phase

Collection of sludge

Inoculation of Tray

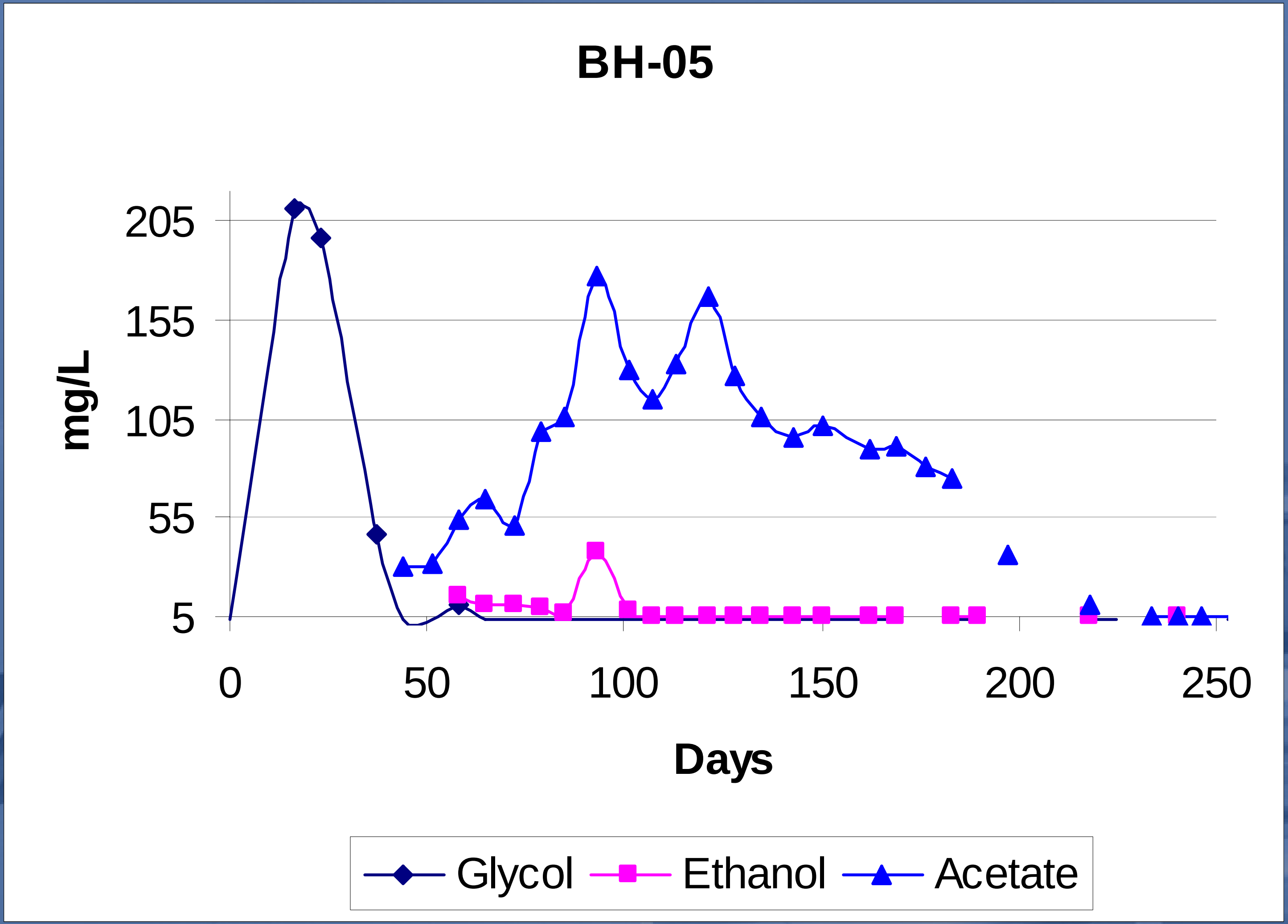
Performance Monitoring

- Initially 5 monitoring wells (2003-2004)
  - To confirm GW flow and glycol degredation
- Now 11 monitoring wells (2004-2005)
  - To achieve a confidence level
- Monitoring for glycols, nitrate, sulphate, phosphate, ethanol, acetate, temperature and dissolved oxygen
- Monitoring done weekly

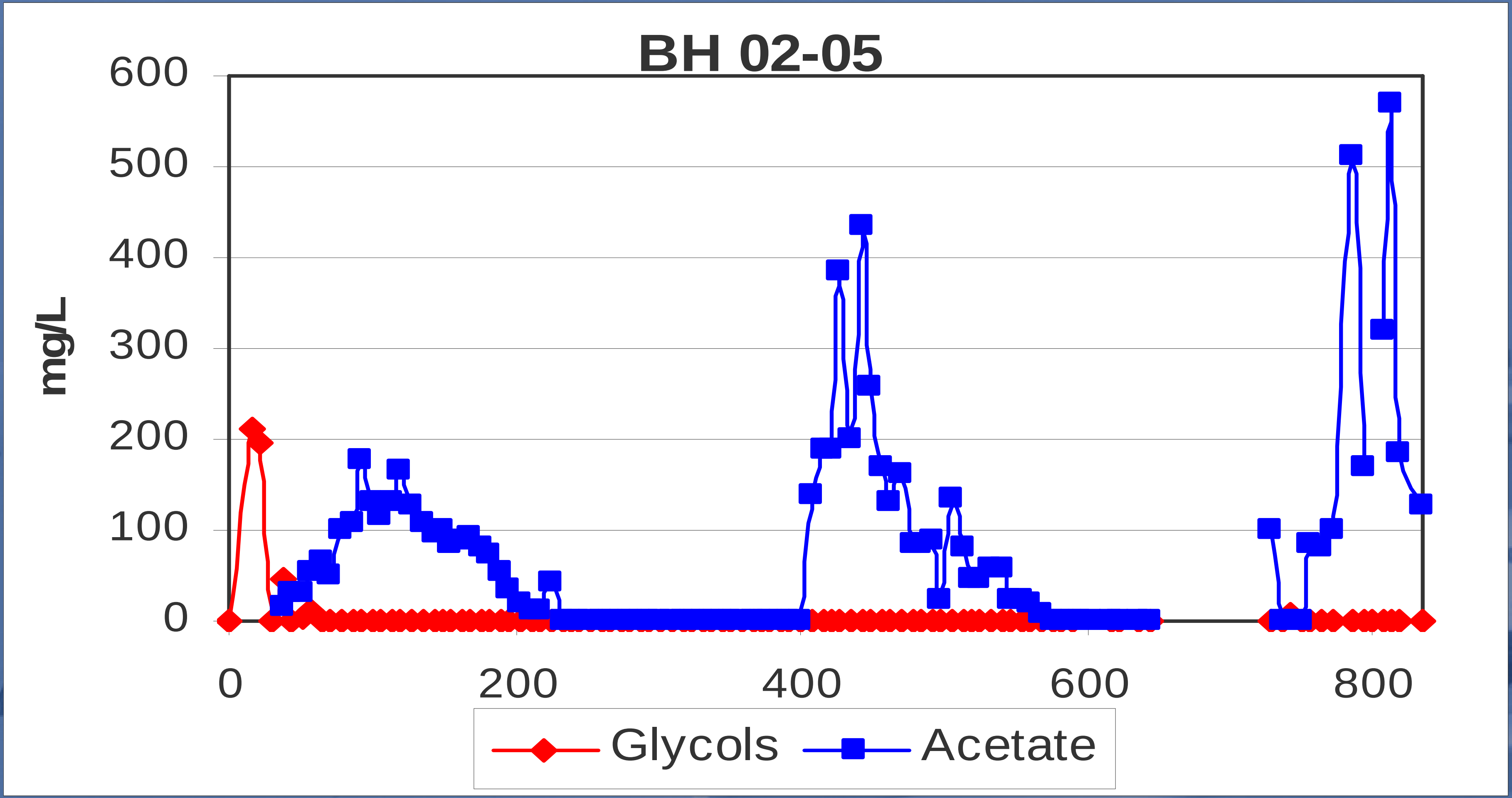
Monitoring Results

- Glycol degrades within a week
- By-products are ethanol, acetate, methane
- Ethanol degrades very rapidly
- Methane not-encountered
- Acetate degrades within 6 months (low concentrations)

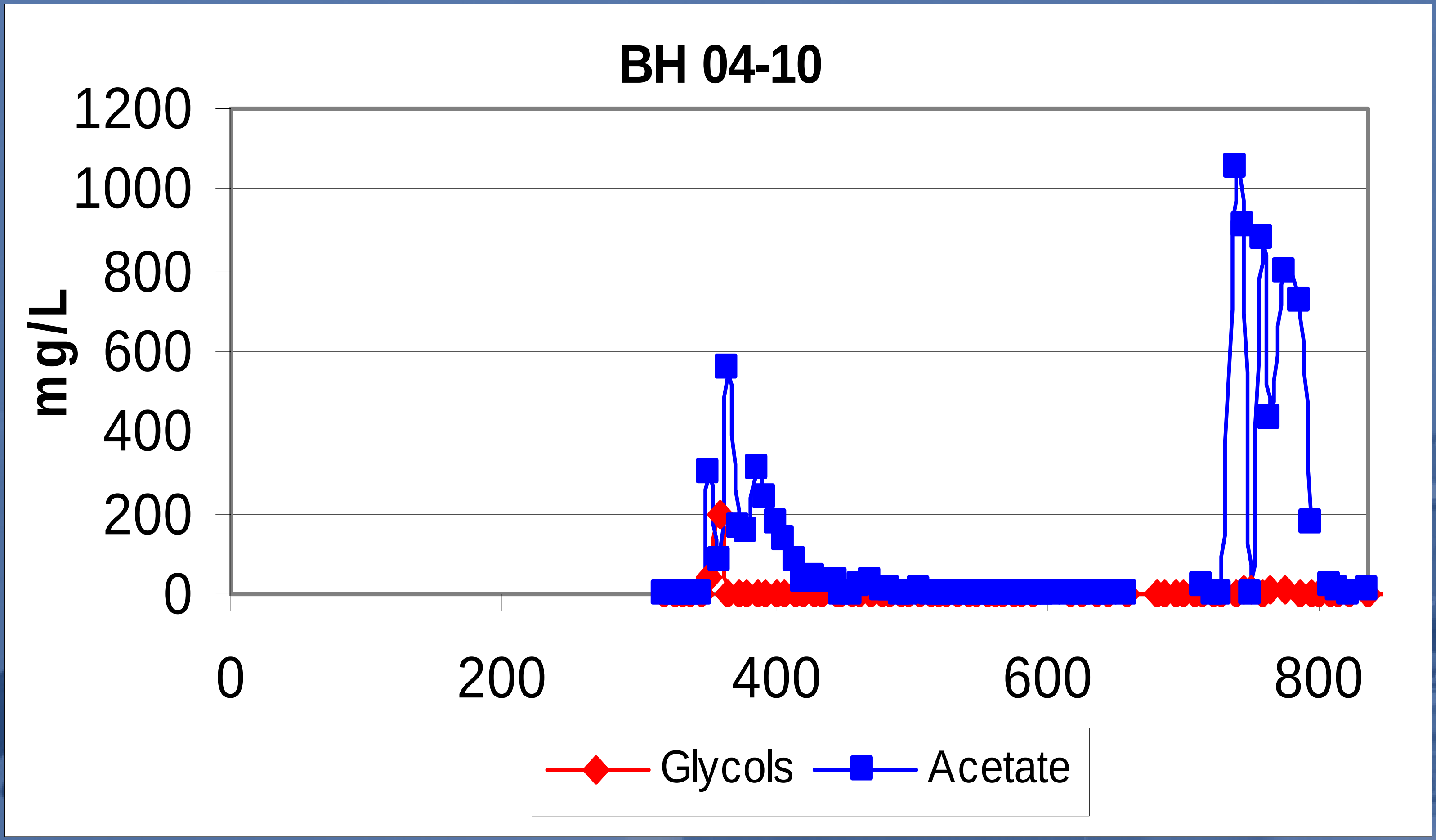
1st Year Results



Results over 3 years at 40m from infiltration bed



Results after 3 years 6m from infiltration bed



Conclusions

- System appears to have become more efficient in second year of operation
- Glycol degrades readily when the system is enhanced with local bacteria
- Regulators are very satisfied with the system
- System cost $400,000
- Operational cost $50,000/year to date

Conclusions

- Bench testing valuable
  - Initial approach for an aerobic system too energy intensive
  - Defined minimum operating parameters
- Be Flexible /Adaptable
  - Inoculation technique had to be modified to meet regulations
- Bioremediation best when simple
  - Original design utilized a series of injection points and pumps – new system single point, gravity feed

Injection

Next Steps and Goals

- As knowledge gained, reduce monitoring and injection events
- Ultimate Goals
  - Self sustaining system
  - Monitoring quarterly only

System Photo