In-Situ Groundwater Nitrification and De-Nitrification Remediation Processes

CREATING AND DELIVERING BETTER SOLUTIONS

Presented by Steve Mailath,
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Problems with Ammonia and Nitrate

- Over fertilization (eutrophication) of surface waters with N
- Ammonia toxic to animal species
  - fish and invertebrates
- Nitrate contamination of drinking water
  - blue baby syndrome – methemoglobinemia
- Discounted value of brown-field development

Environmental and Regulatory Issues

- Environmental regulations are becoming more stringent with time
  - Environmental enforcement orders
- Growing public concern of environmental management
- Restricted land use

Where is the Problem – Who is responsible

- Fertilizer manufacturing and storage facilities
  - Brown-field developer
- Sewage treatment facilities
  - City of Calgary
- Agricultural areas
  - Farmers
- Airports
  - Calgary airport authority

Problems with Existing Solutions

- Expense
  - Treatment facilities
  - Piping
  - Operating
- Large footprint, need to close site

In-Situ Groundwater Nitrification and De-Nitrification Remediation Processes

In-situ nitrification:

- Extracting groundwater
- Adding oxygen and nutrients
- Injection of amended groundwater

In-situ de-nitrification

- Extracting groundwater
- Adding carbon and nutrients
- Injection of amended groundwater

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Advantages

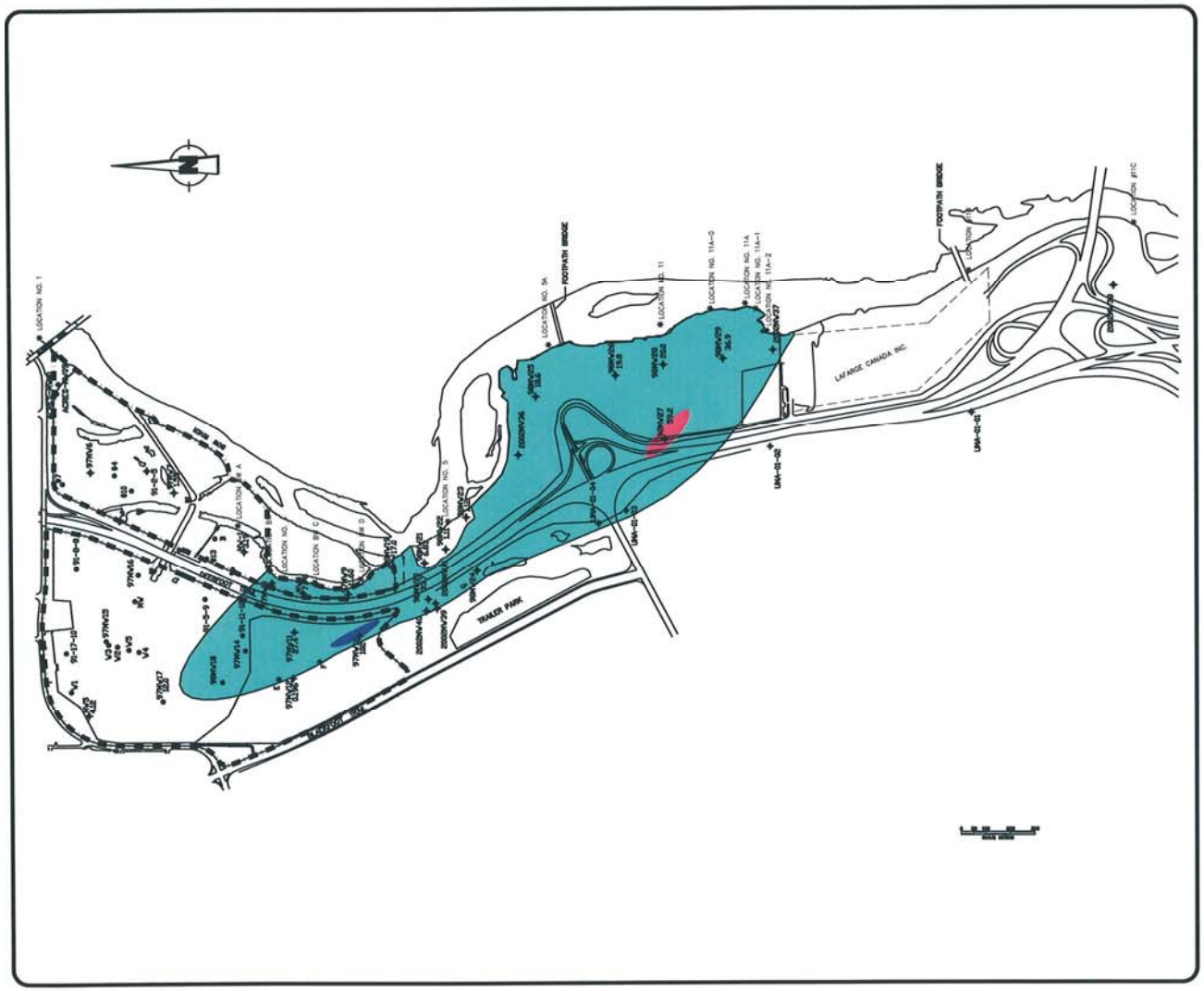
- Performs as well as best in class solutions at less than half the cost
- Full mass removal - nitrates reduced to N gas
- Small footprint and less intrusive than most solutions
- Requires fewer wells and piping
- Year round treatment
- Free bio-reactor (in situ)

Options

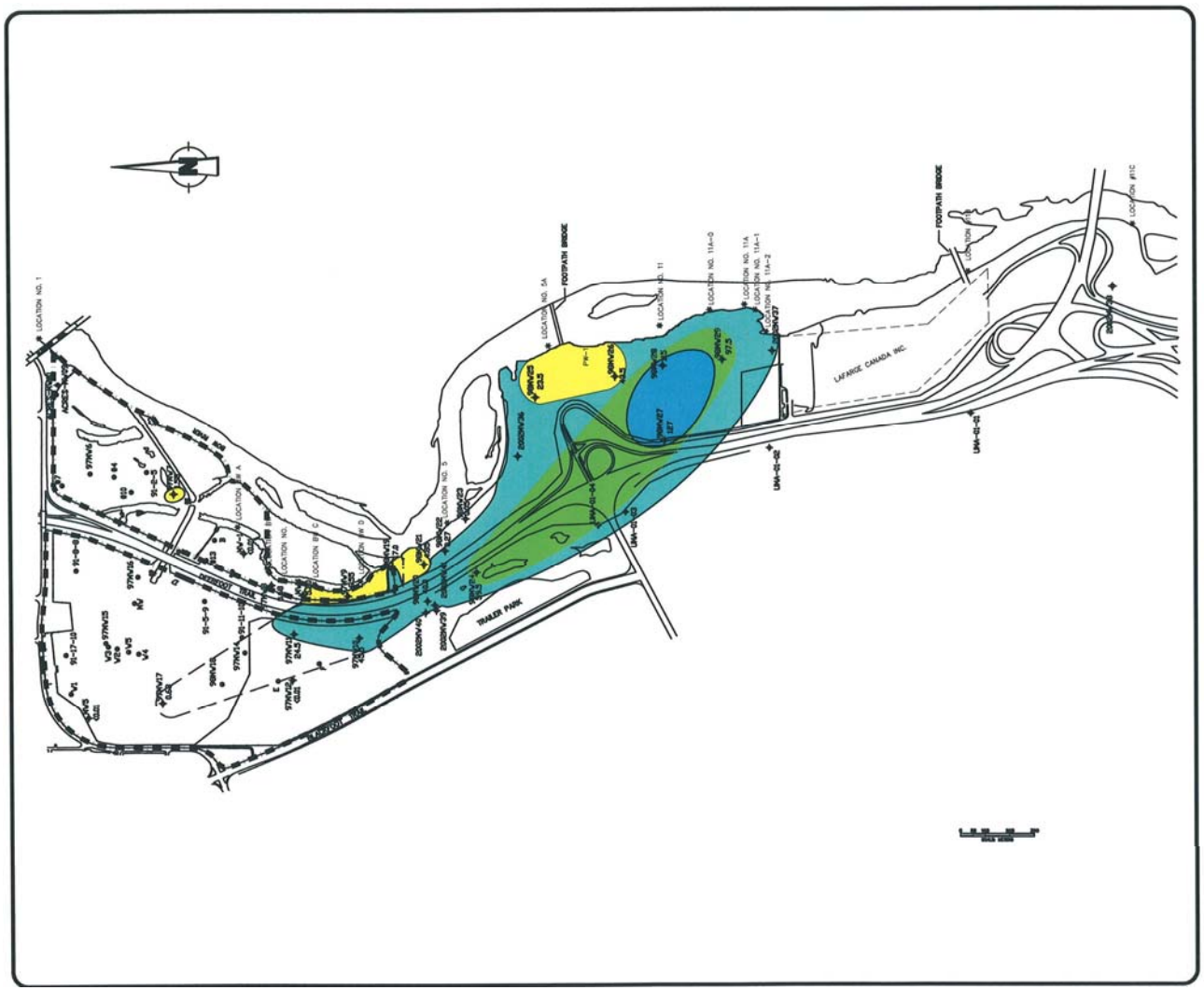
Options	Main Limitations	Capital ($ Million)	Operating ($/year)	Present Value Cost[1] ($ million)
1. Groundwater Extraction and Irrigation	Summer treatment	$0.85	$57,000	$1.4
2. Groundwater Extraction and Discharge to City Sanitary Sewer	Removal of ammonia only	$0.69	$50,000	$1.2
3. Groundwater Extraction and Electrochemical Treatment	High cost	$3.1	$155,000	$4.7
4. Groundwater Extraction and Biological Treatment (Nitrification)	High cost	$1.6	$100,000	$2.6
5. Groundwater Extraction and Wetlands Disposal	Summer treatment, low N	$0.64	$51,000	$1.2
6. In-Situ Electrochemical Treatment	Low perm soils	$2.8	>$35,000	>$3.0
7. On-Site Ex-Situ Biological Treatment	High cost	$5.0 to $7.0	>$35,000	>$5.0
8. In-Situ Nitrification and De-Nitrification	High perm soils	$0.2 $0.1	$30,000 $25,600	$0.5 $0.4

[1] Present value based upon 15 year life and 5% rate of return.

Nitrate Plume

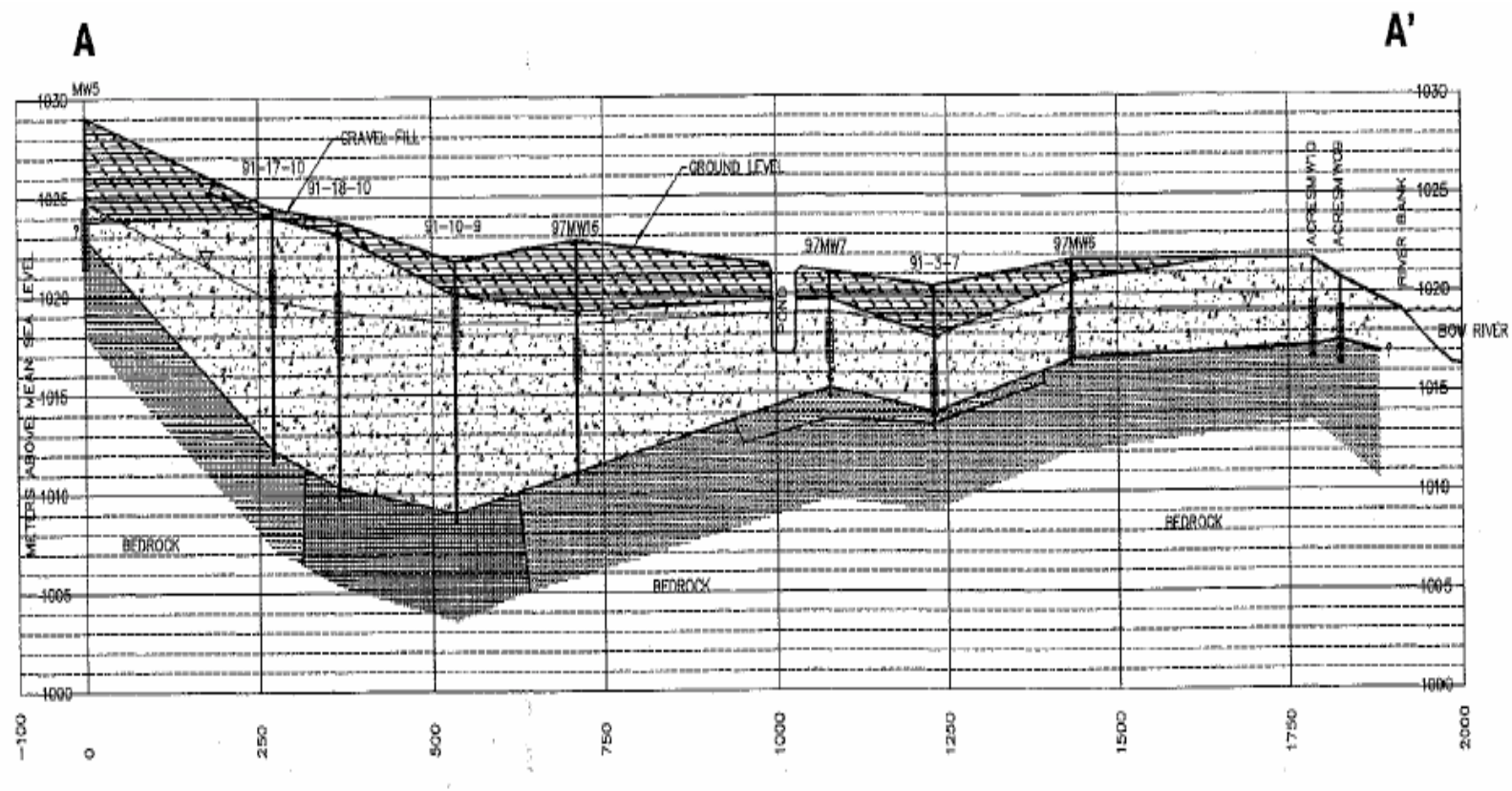


Ammonia Plume

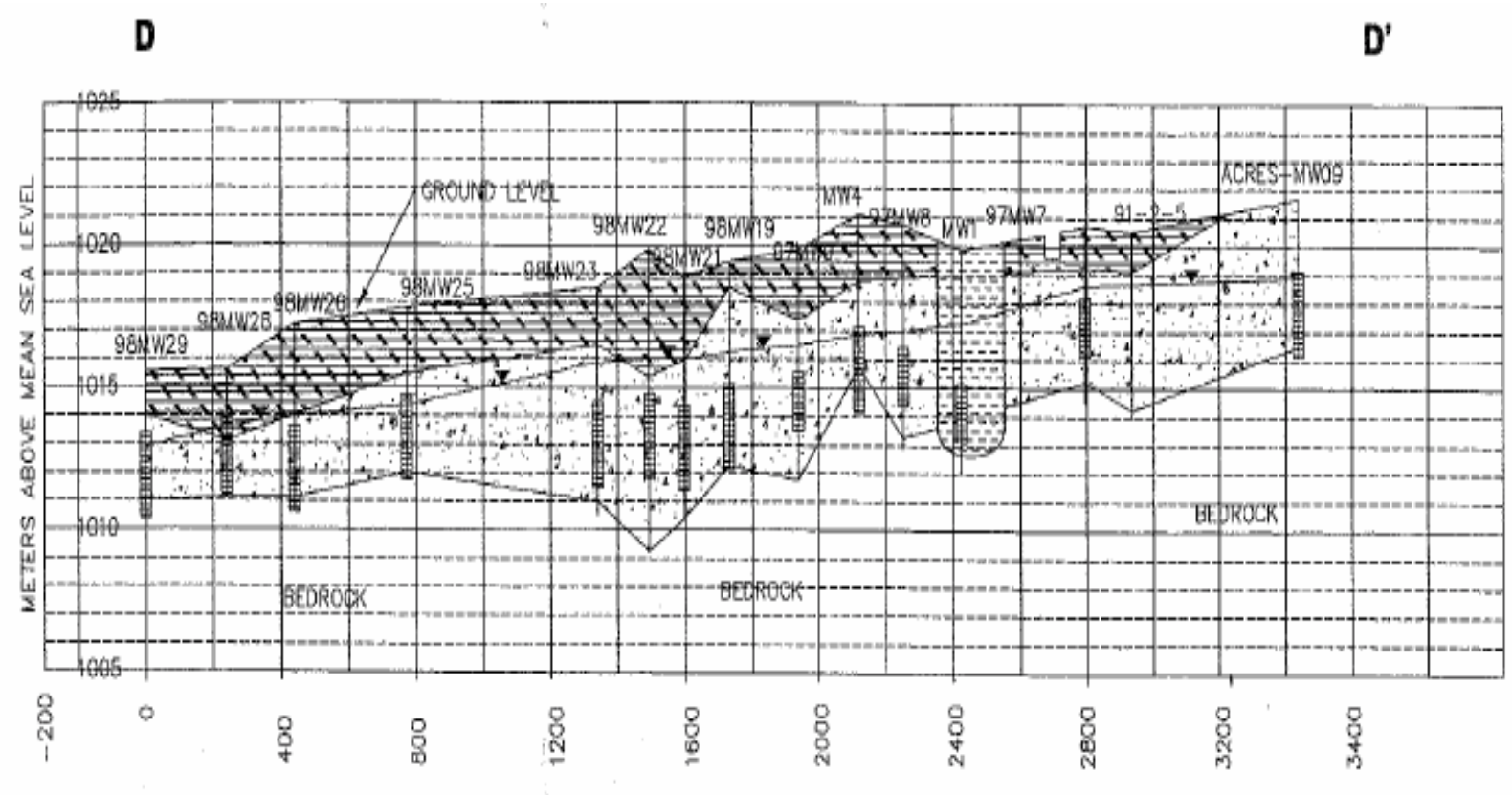


Site Plot Plan

Cross-Section A-A’



Cross-Section D-D’

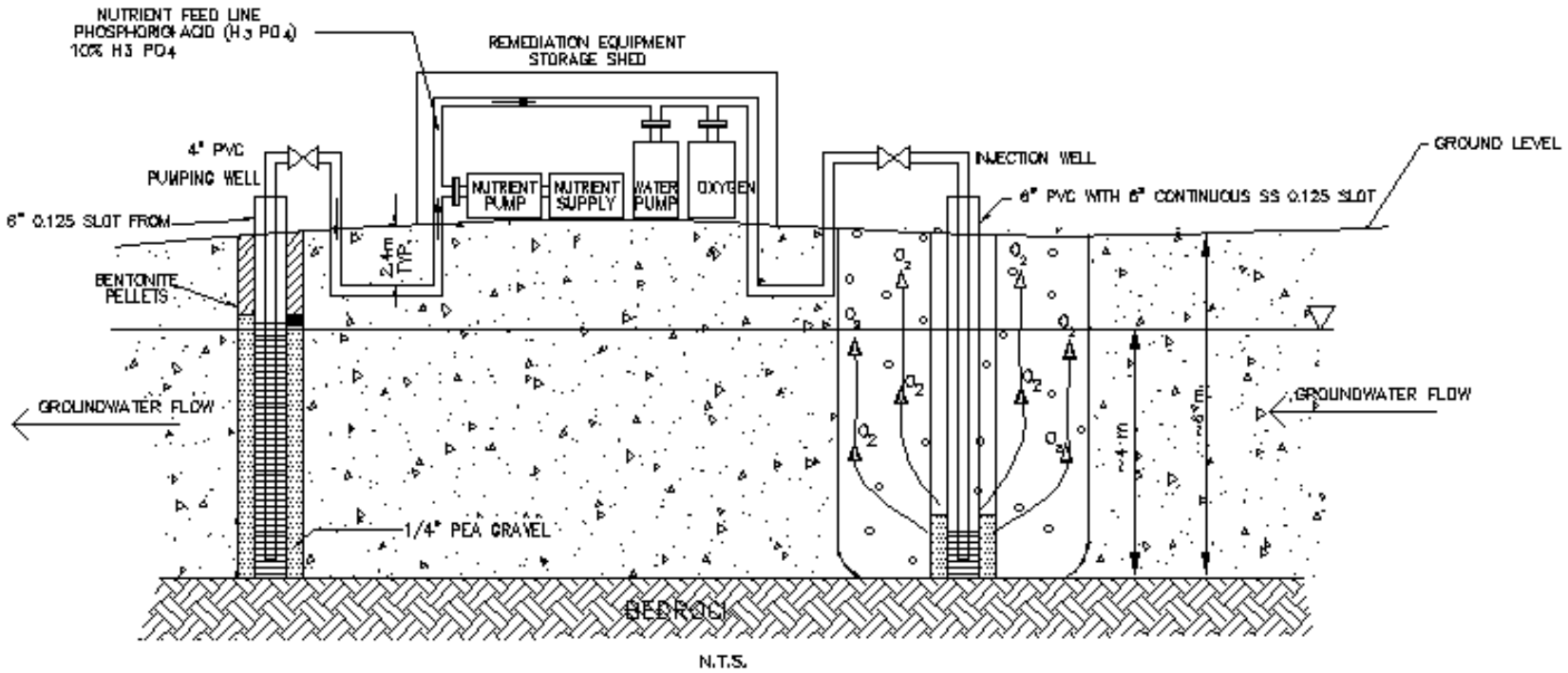


Typical Gravel

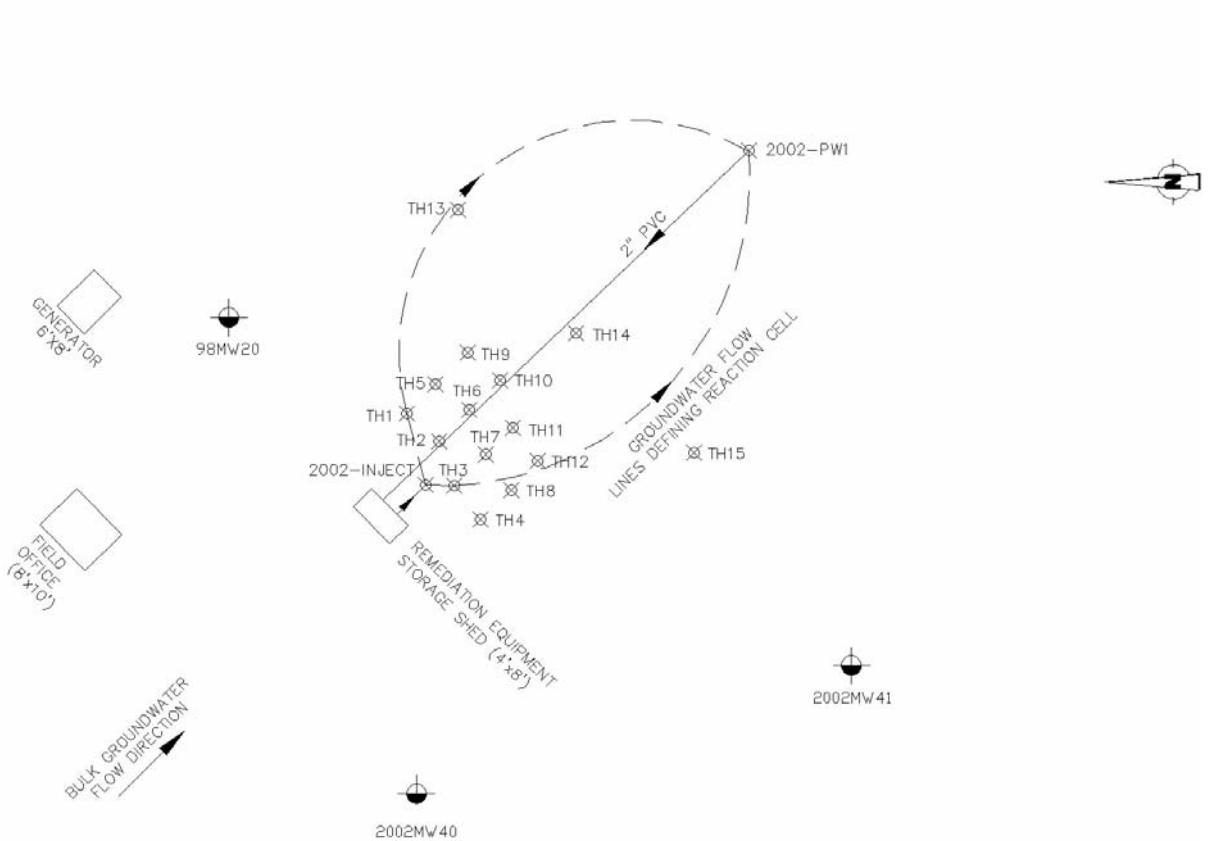
Hydraulic Parameters

• Section length	425 m (perpendicular to flow
• Section thickness	3.0 m
• Hydraulic conductivity	49 m/day
• Hydraulic gradient	0.0023
• Groundwater velocity	0.3 – 0.5 m/day
• Groundwater flux	144 m^3/day (22 igpm)
• Ammonia concentration	63.2 mg-N/L
• Nitrate concentration	94 mg-N/L (i.e., 31 mg-N/L in-situ plus 63 mg-N/L generated by nitrification)

In-Situ Nitrification

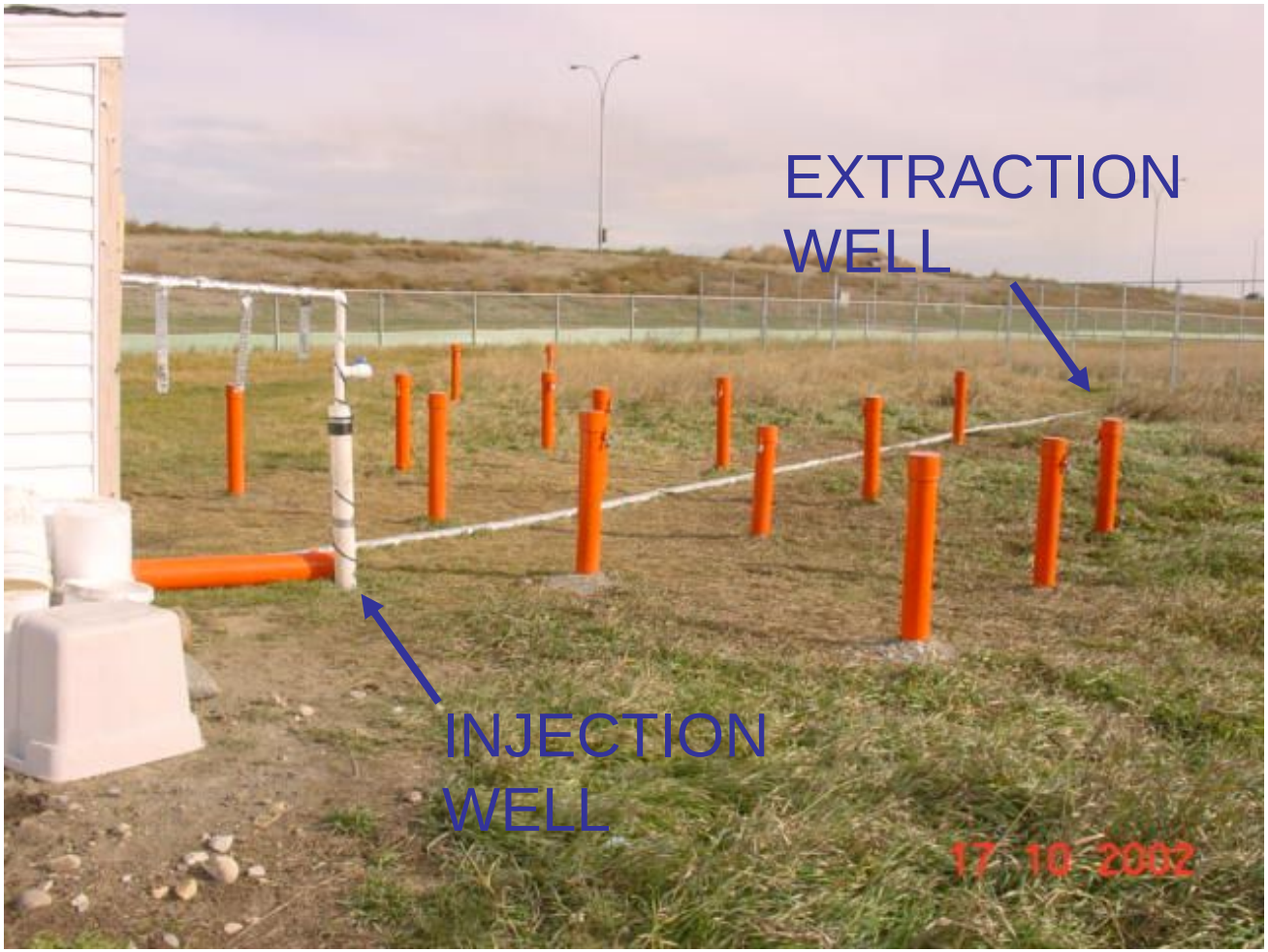


Pilot Test Site



Test Site

Test Site



Installing Monitoring Wells

Test Site

Nitrification

TREATMENT SHED

Oxygen Addition

Amendment Addition

GAS LIQUID REACTOR

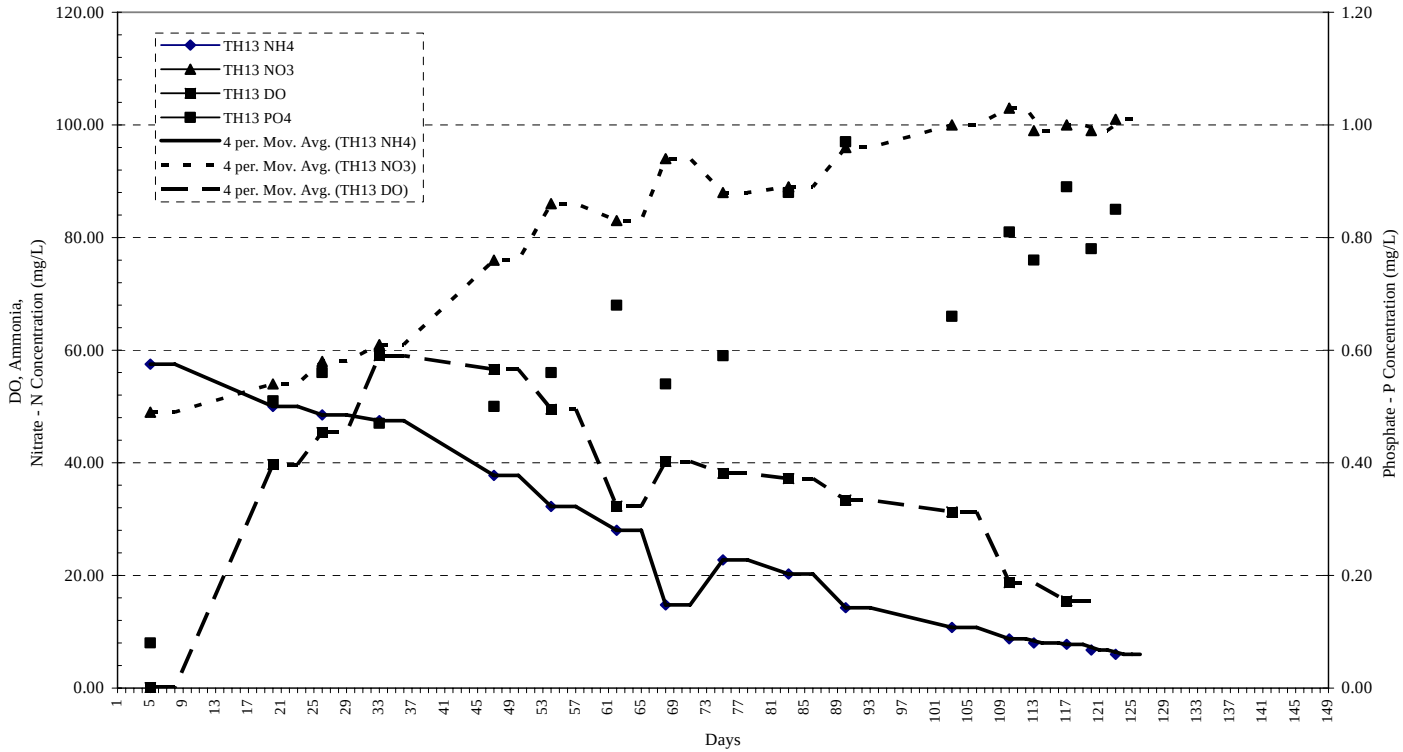
OXYGEN DELIVERY

NUTRIENT DELIVERY

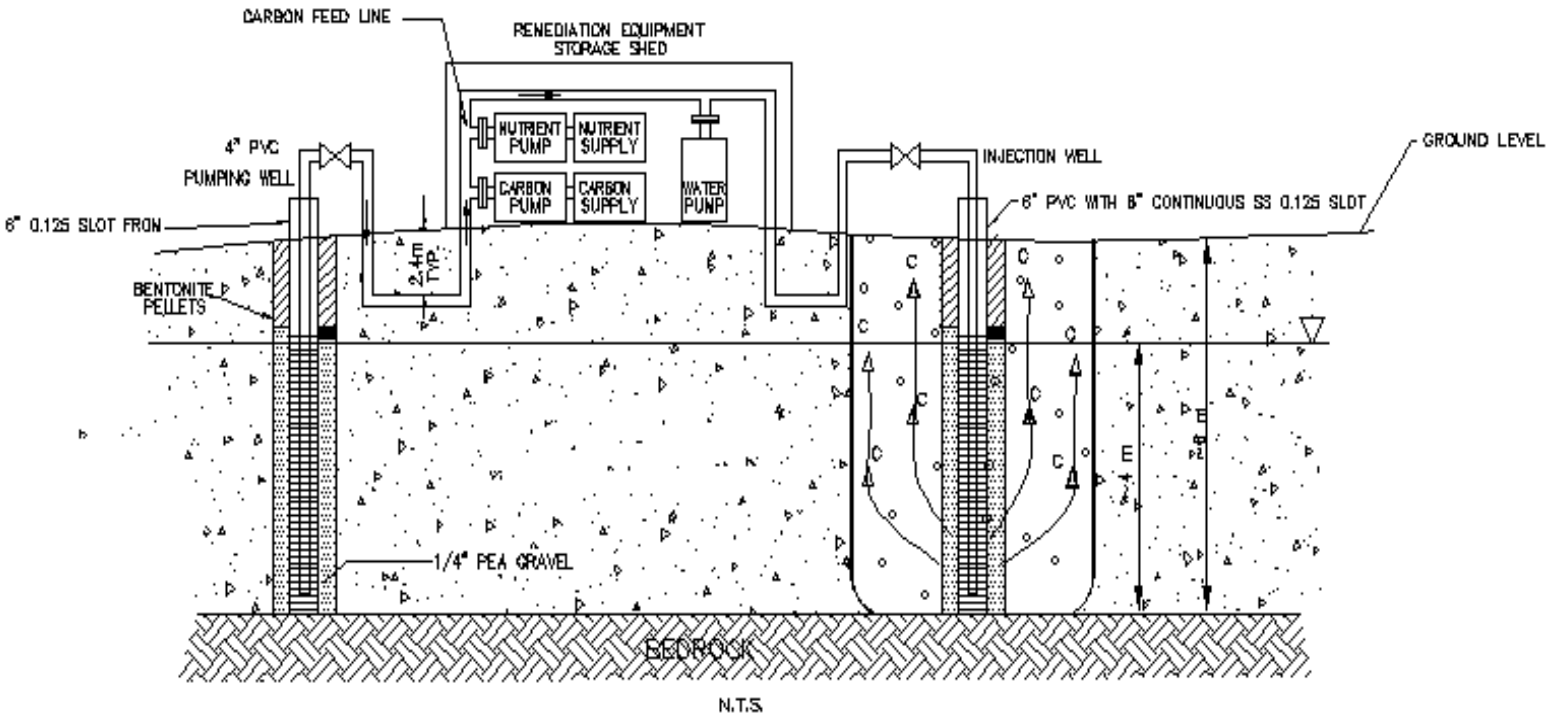
Amendment Addition

Nitrification Results

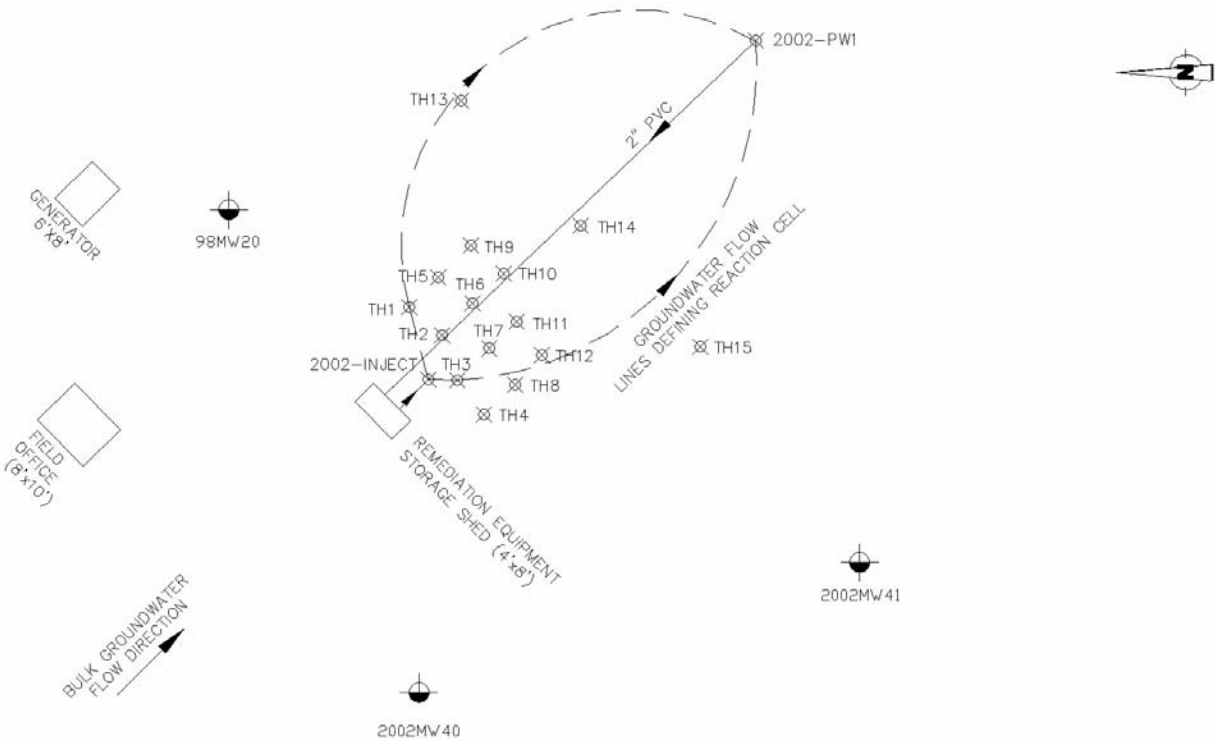
66 – 89 % AMMONIA REDUCTION



In-Situ De-Nitrification



Pilot Test Site



Amendment Addition

NO OXYGEN DELIVERY

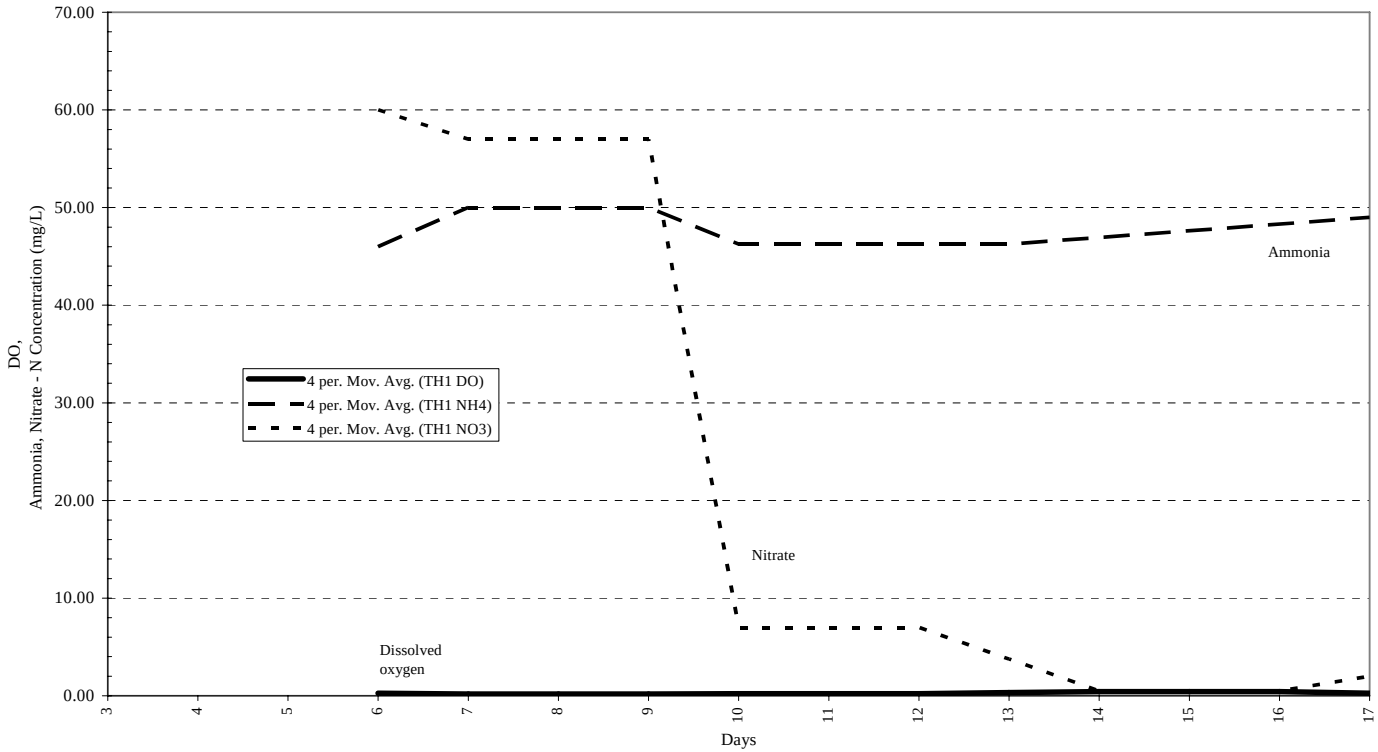
NUTRIENT DELIVERY

De-Nitrification

Field Lab

De-Nitrification Results

78 – 99 % NITRATE REDUCTION



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Questions

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QUESTIONS

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