SNC·LAVALIN

Fate of Industrial Nitrogen in an Alluvial Aquifer

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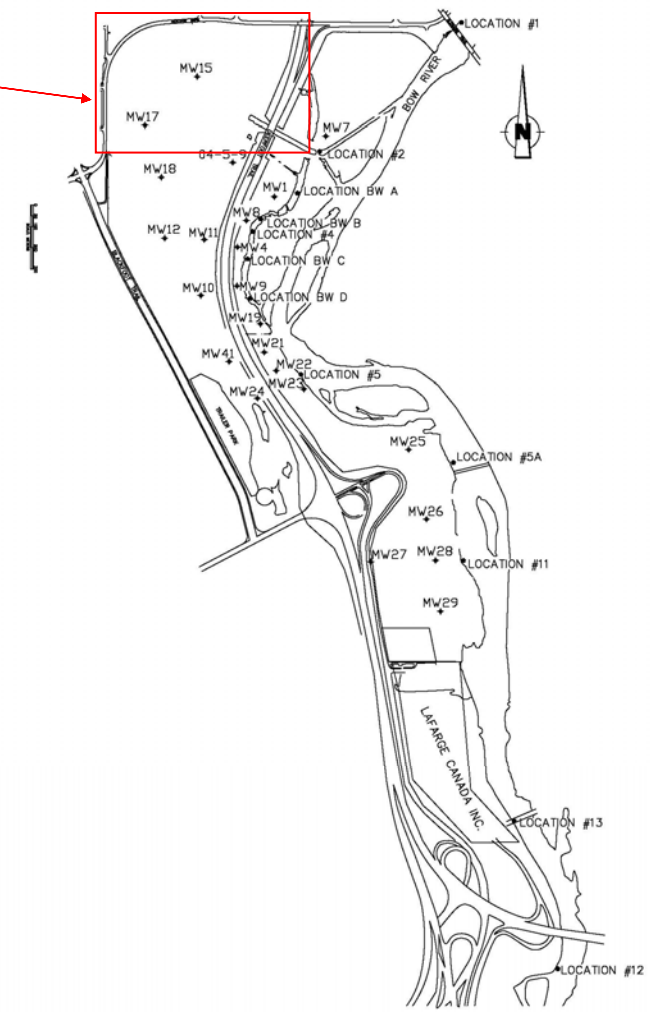
PRESENTATION OUTLINE

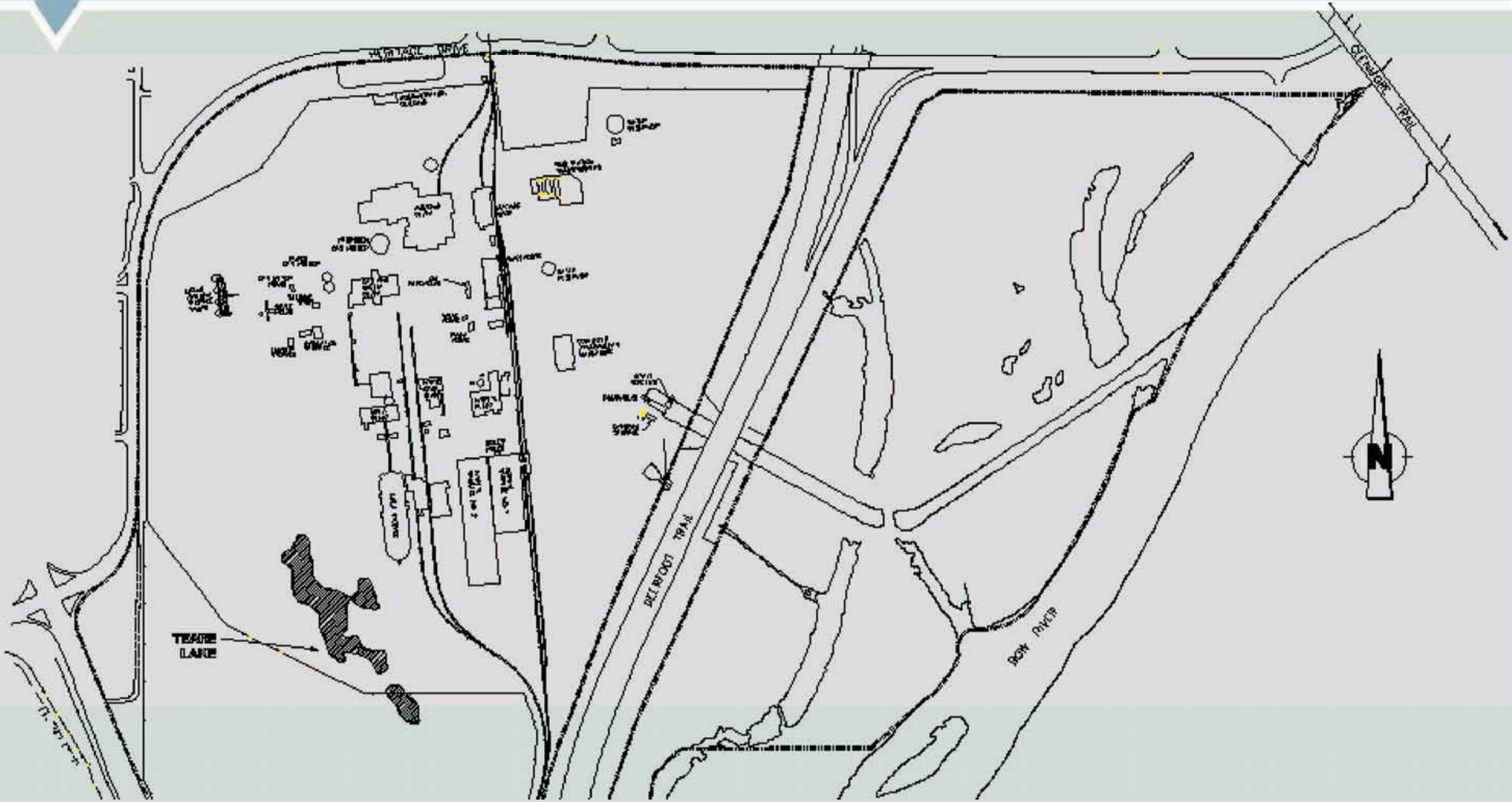
- Site History
- Study Purpose
- Results
- Conclusions
- Recommendations

STUDY SITE

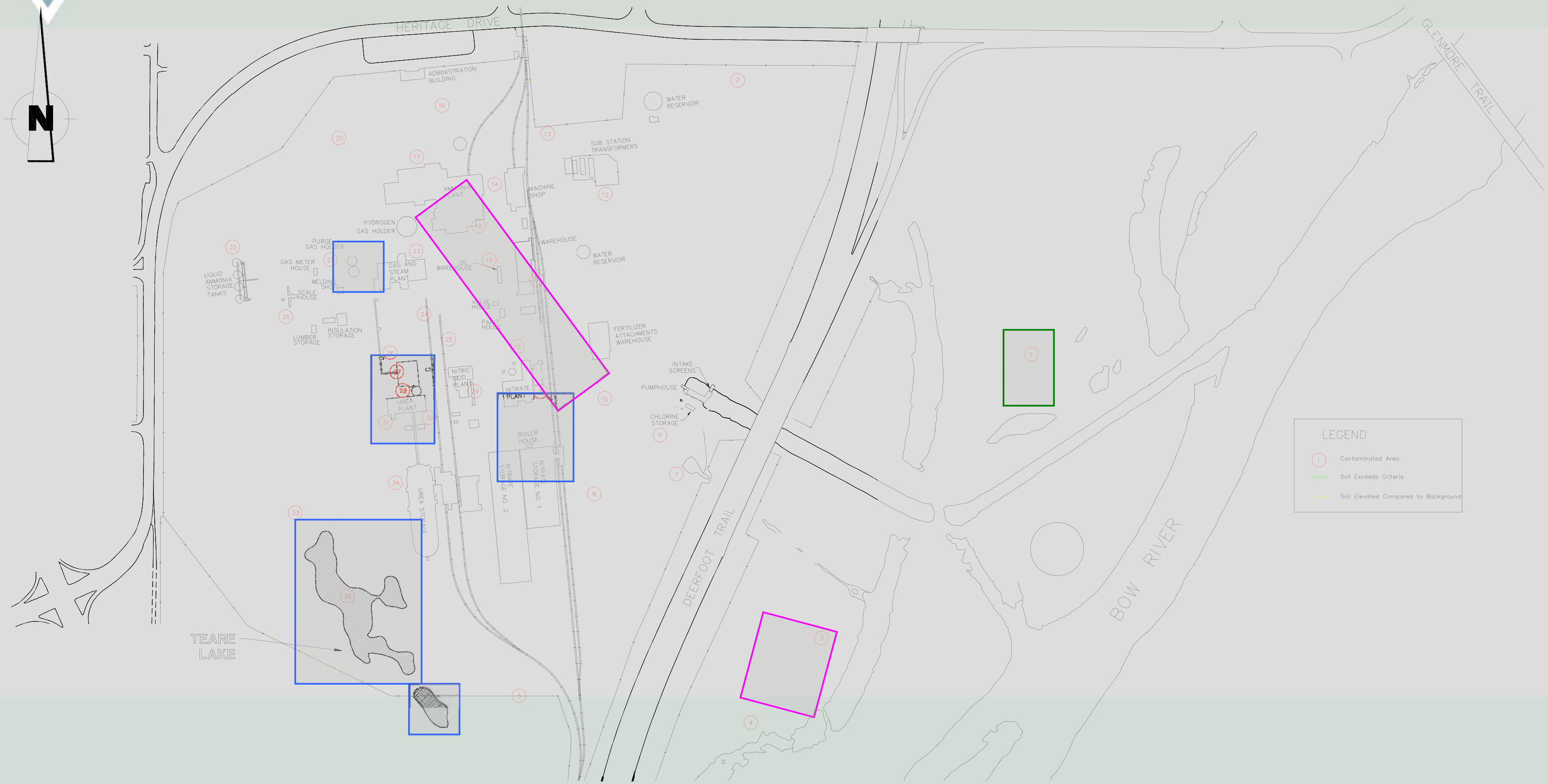
Plant Location



HISTORIC SITE PLAN



RESIDUAL CONTAMINATION



Blue Squares = residual N Pink Squares = residual metals Green Square = residual N and metals

SITE DEVELOPMENT

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STUDY PURPOSE

- Investigate groundwater contamination and geochemistry in an alluvial aquifer
- Evaluate monitored natural attenuation (MNA)
  - Demonstrate that natural processes are removing contaminants from groundwater
  - Demonstrate it is taking place at a rate that is protective of human health and environment
- Direct assessment of Bow River impacts by the contaminated groundwater

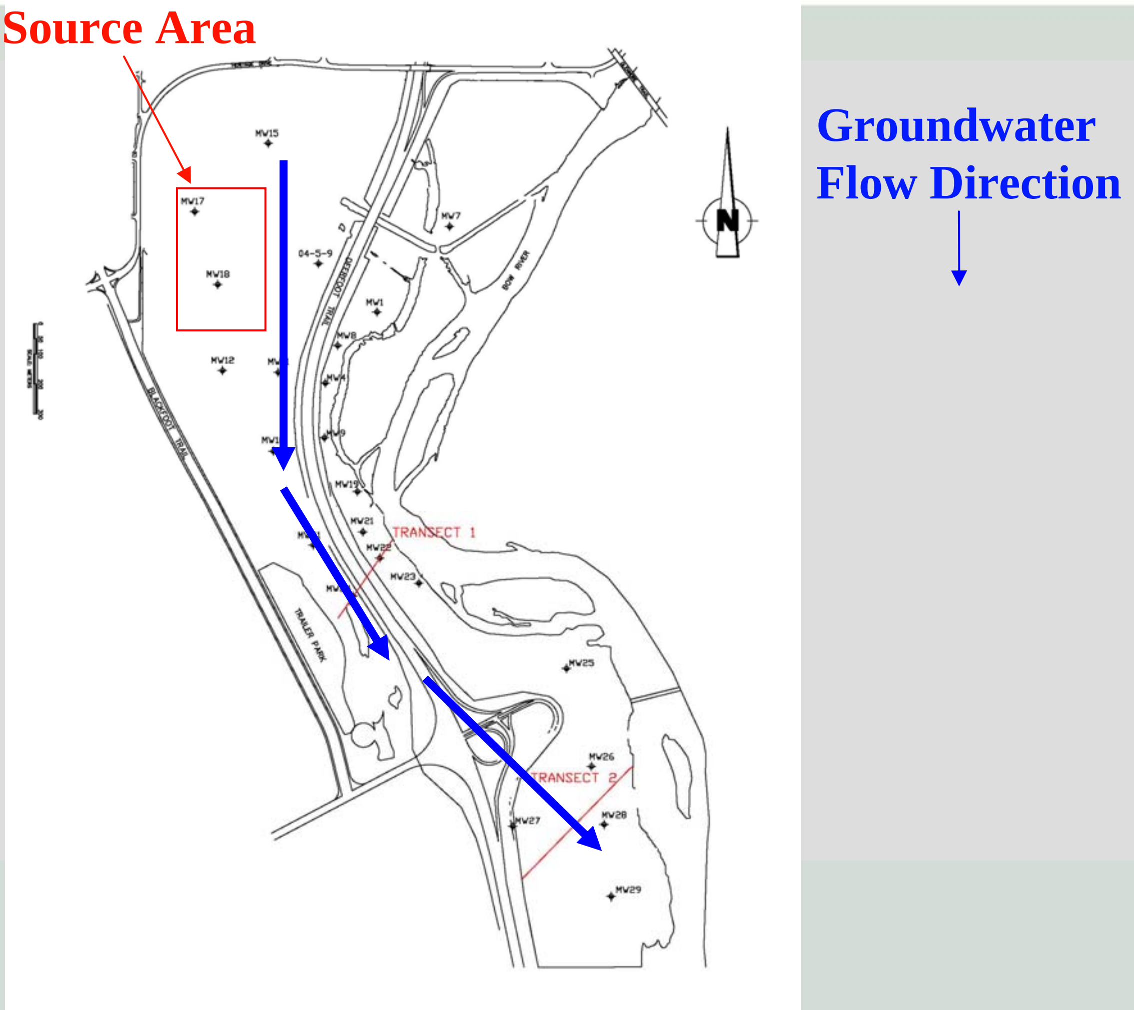
METHODS

- Historical data review
- Water sampling (flood period)
- River and groundwater N mass flux estimates
- Hyporheic zone sampling

GEOLOGY AND HYDROGEOLOGY

- **Silt overlying fluvial sands and gravels overlying bedrock (Paskapoo Formation)**
  - Bedrock depth varies from 4 to 14 m bgs
- **Groundwater hydraulically connected with surface water as evident in:**
  - Piper plots
  - Water table fluctuations associated with river stage
- **Water depth varies from 1.5 to 5.5 m bgs**
- **Hydraulic Conductivity on order of 10^{-3} m/s**

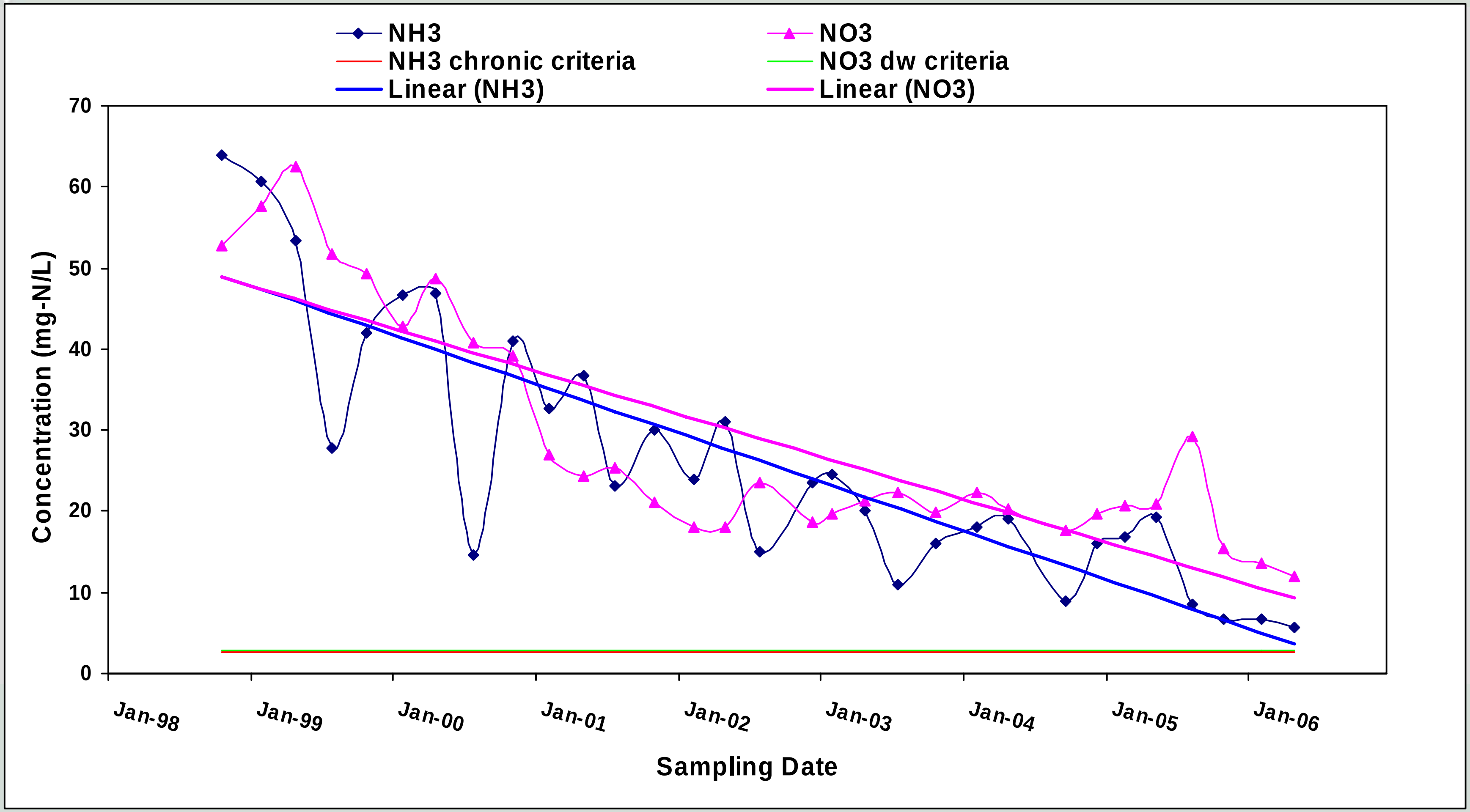
STUDY SITE


Source Area
Groundwater
Flow Direction
N
MW15
MW17
MW18
MW7
04-5-9
MW1
MW8
MW12
MW25
MW26
MW27
MW28
MW29
MW21
MW23
TRANSECT 1
TRANSECT 2
BOW RIVER
TRAILER PARK

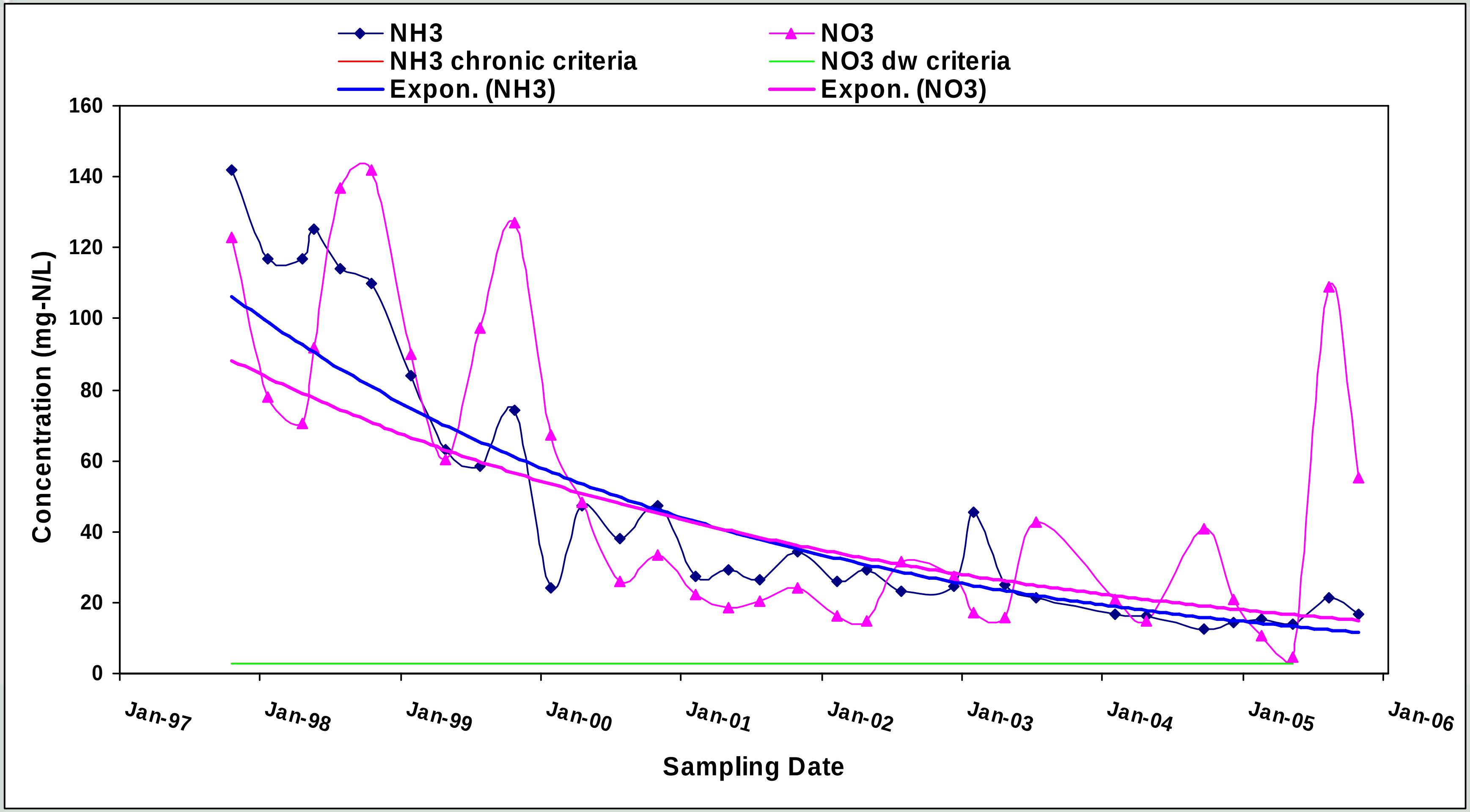
RESULTS

- NH_3 & NO_3^- concentration & mass decreasing over time
- 11 of 22 wells above NH_3 chronic FAL criteria and 17 of 22 wells above NO_3^- FAL criteria (April 2006)
- Maximum estimated time to reach criteria is 24 years for NH_3 and 16 years for NO_3^- (in MW29)

CONCENTRATION DECREASE - MW25



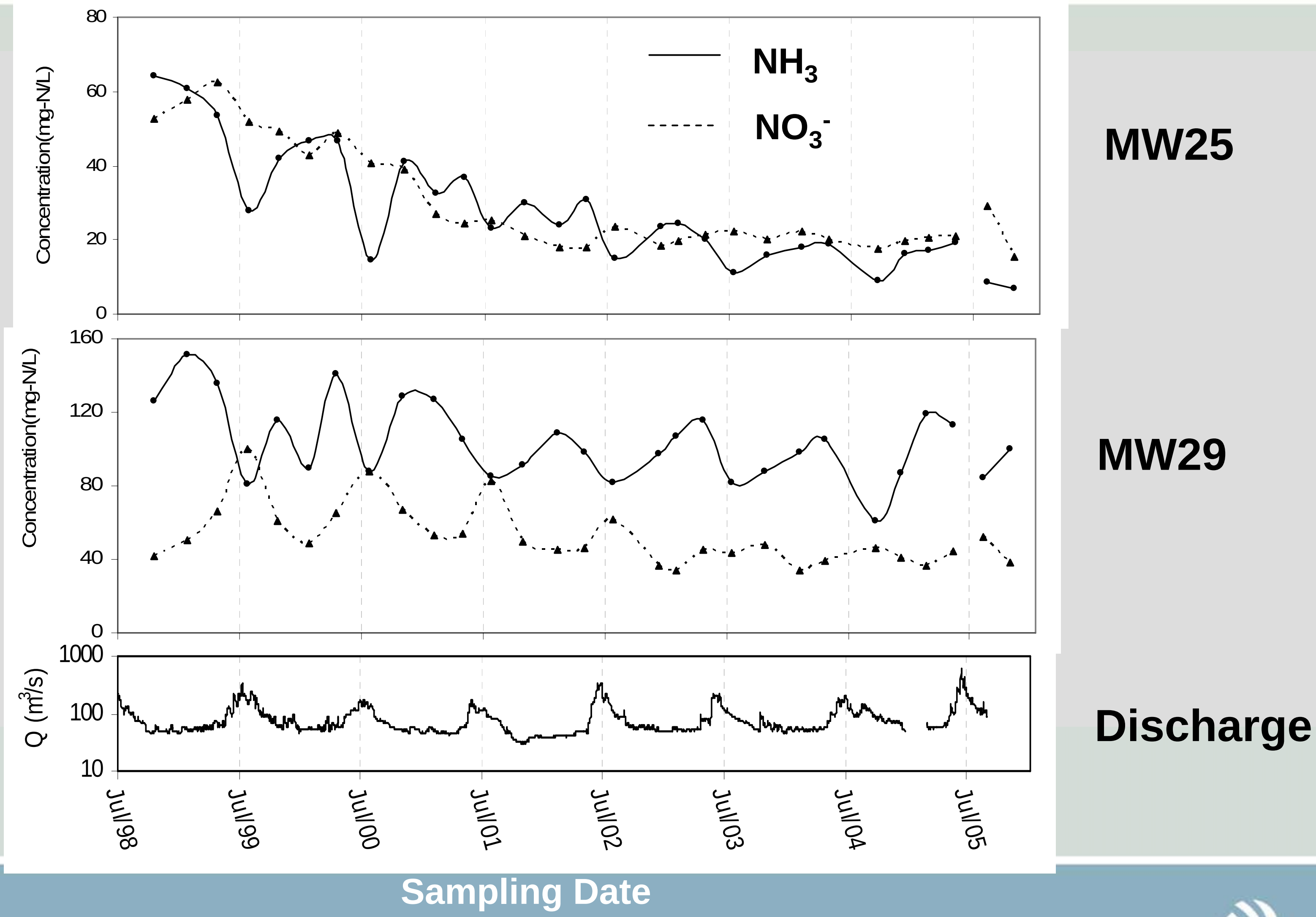
CONCENTRATION DECREASE – MW11



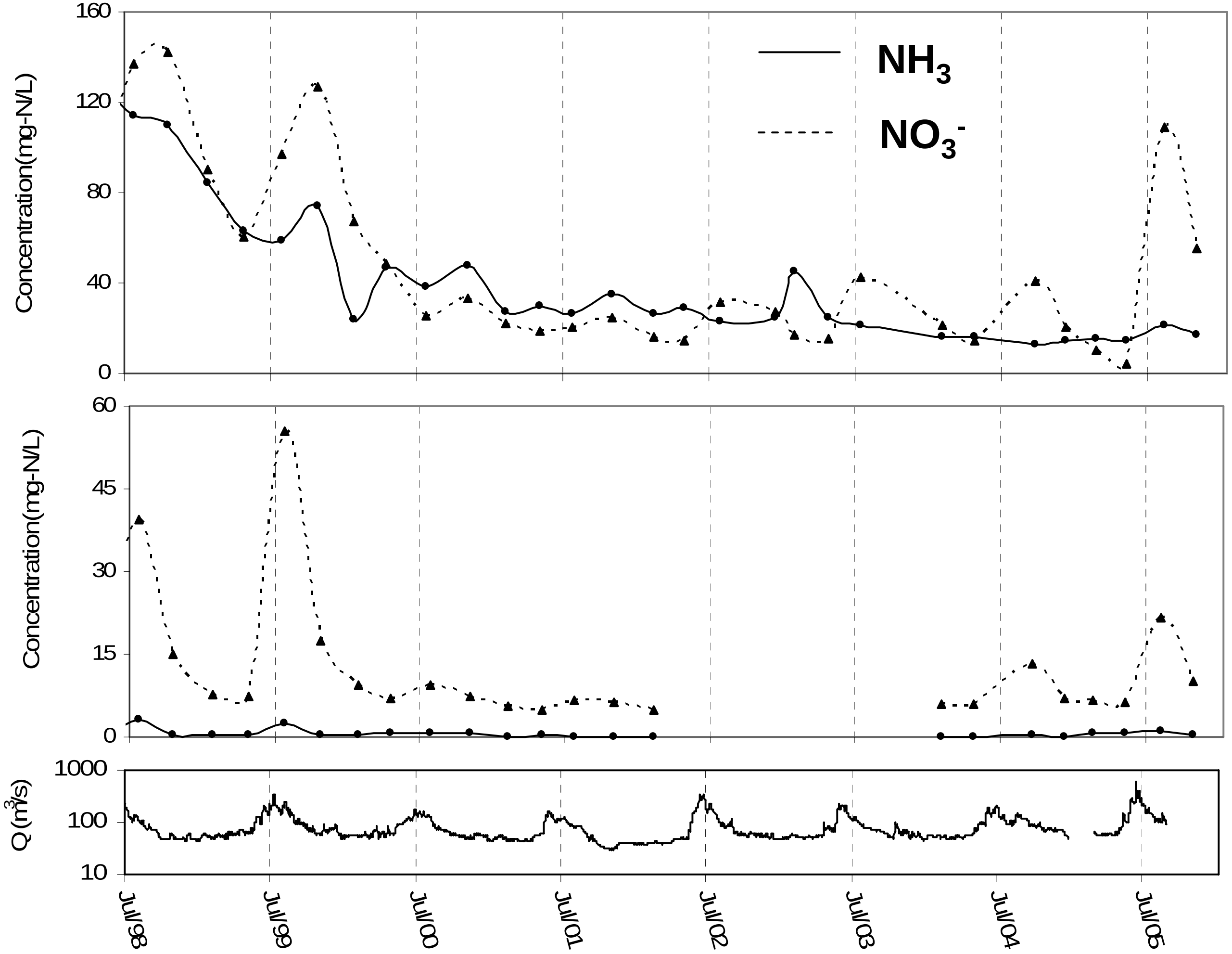
2005 FLOOD INSIGHTS

- **Spring flooding causes periods of high river discharge and high water table in wells**
  - Initiates nitrification (MW25, MW26, MW28 & MW29)
    - → Nitrification is biological oxidation of ammonia to nitrate
    - → Aerobic reaction
  - Source area continuing to release residual nitrogen (MW7, MW8, MW9, MW11, MW17 & 5-9)

NITRIFICATION



SOURCE AREA



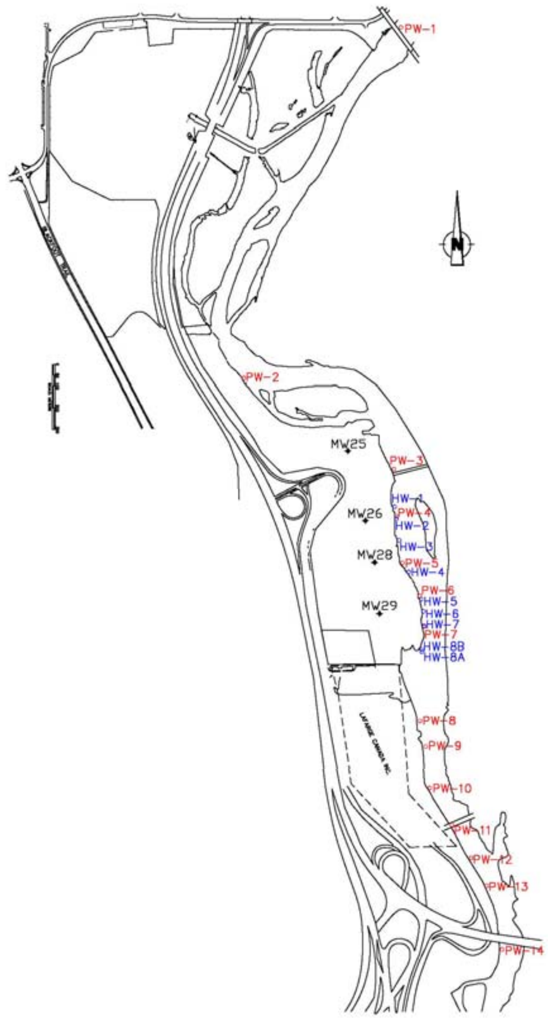
MW11

04-5-9

Discharge

Sampling Date

HYPORHEIC SAMPLING LOCATIONS

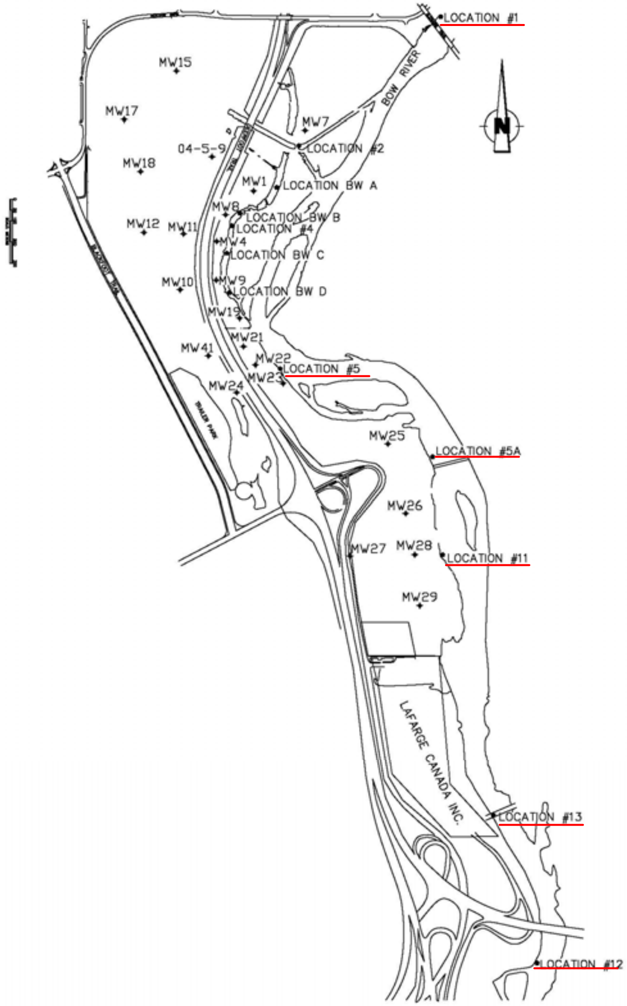


GROUNDWATER IMPACTS ON RIVER

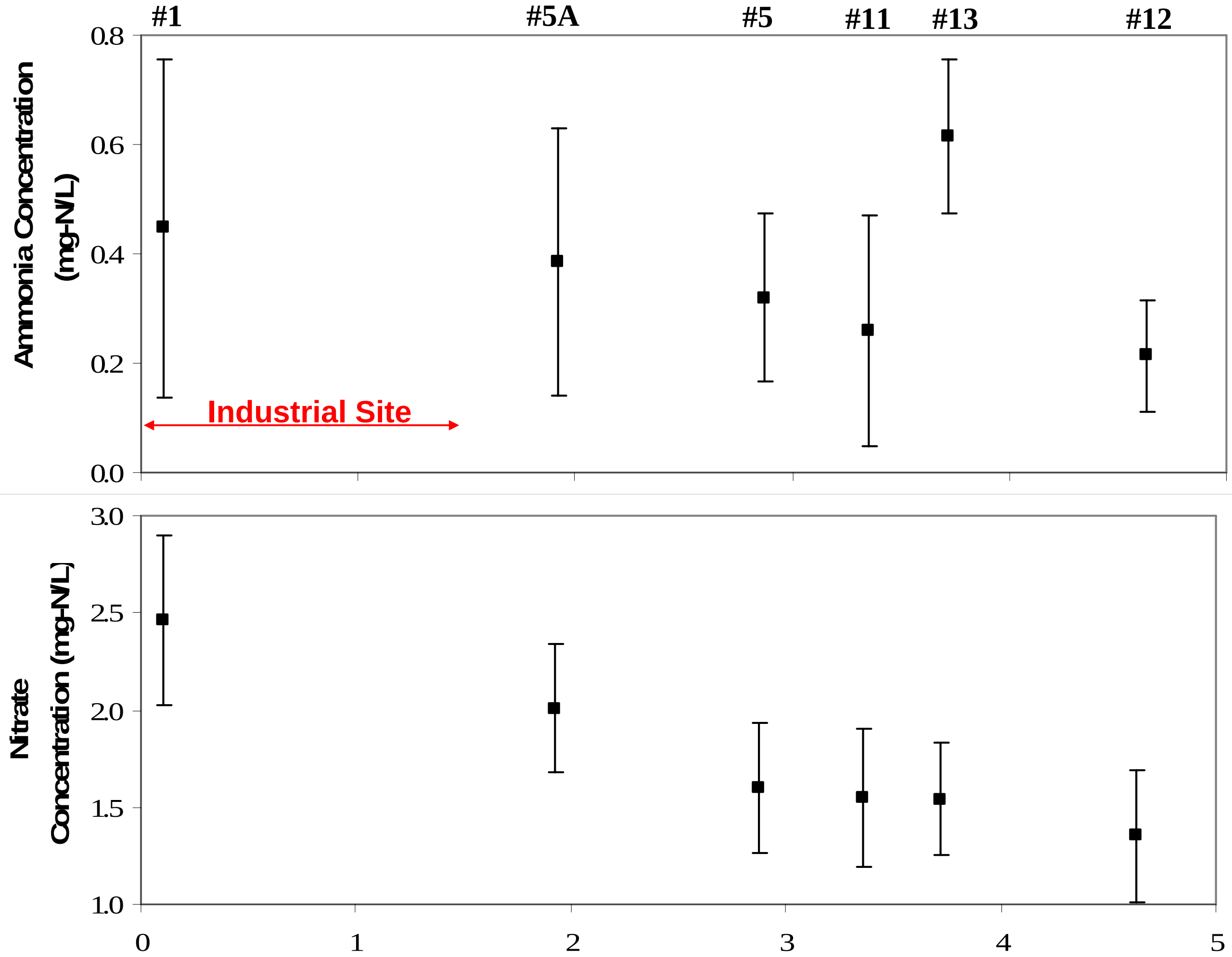
- **Elevated NH_3 & NO_3^- concentrations in hyporheic groundwater**
  - up to 21 and 45 mg-N/L, respectively,
  - spatially variable
  - evidence of paleochannels

- **NH_3 & NO_3^- concentrations in Bow River consistently below criteria**
  - During hyporheic sampling
  - Long term monthly sampling program

BOW RIVER SAMPLING LOCATIONS



BOW RIVER SAMPLES



Distance from Glenmore Bridge (0 km)

RIVER TRANSECT LOCATIONS

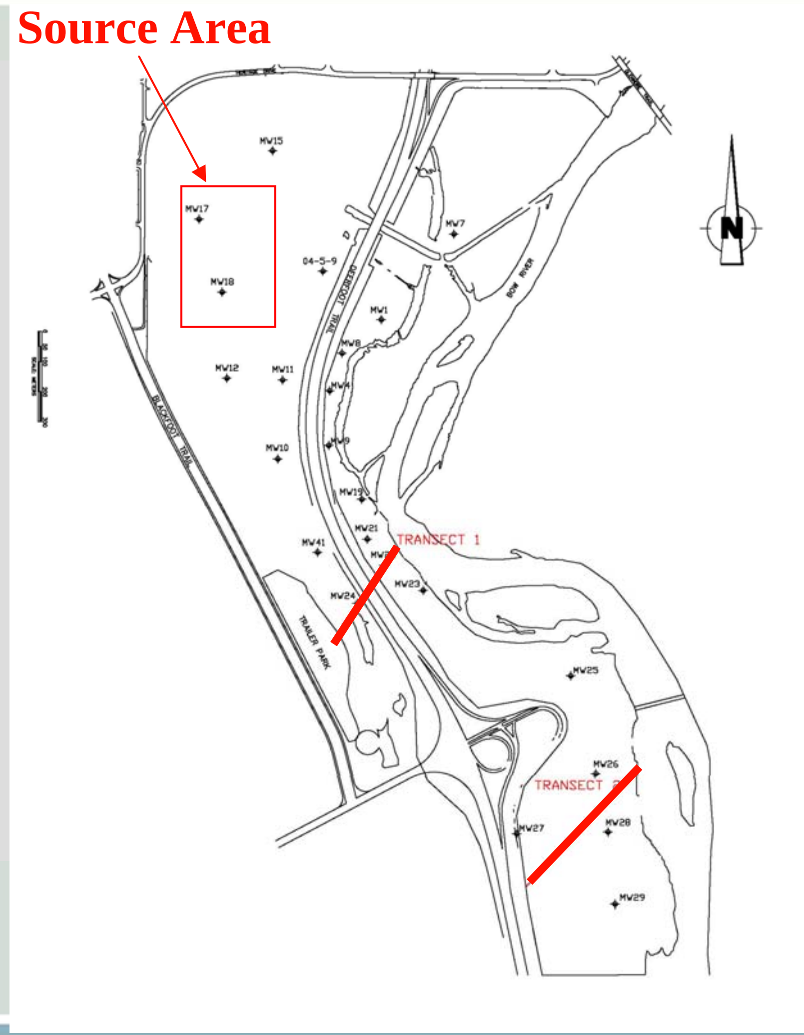
RIVER MASS FLUX ESTIMATES

- **Significant increase in mass fluxes of Cl^-, NH_3 and NO_3^- from background to WWTP**

- **Not significant difference observed from the site**
  - suggests discharge of nitrogen-rich groundwater does not have as measurable an effect as wastewater effluent

			River Mass Flux (Mg/d)		
Bridge	Km from WWTP outfall	Q	NH_3	$N0_3^-$	Cl^-
Odgen	-1.0	122 - 145	0.039 - 0.043	1.5 - 1.8	36 - 43
Glenmore	2.6	137 - 162	0.74 - 0.88	6.5 - 7.6	64 - 75
Southland	5.3	130 - 154	0.51 - 0.60	7.4 - 8.7	70 - 82
Douglasdale	8.9	116 - 138	0.34 - 0.39	4.3 - 5.1	53 - 61

GROUNDWATER TRANSECT LOCATIONS



GROUNDWATER MASS FLUX ESTIMATES

Ammonia			Nitrate			Chloride		
1998 (kg/d)	2005 (kg/d)	Δ(%)	1998 (kg/d)	2005 (kg/d)	Δ(%)	1998 (kg/d)	2005 (kg/d)	Δ(%)
Transect 1								
13.3	2.5	81	2.9	1.5	48	11.8	8.8	25
Transect 2								
41.8	26.1	38	15.6	9.5	39	74.0	77.7	-5

- **<1% of WWTP effluent nitrogen (~4,000 and 8,160 kg/d) in the Bow River**

CONCLUSIONS

- **MNA could be an acceptable alternative for GW remediation**
  - Decreasing mass and concentration due to non-destructive (i.e. dilution) and destructive processes (i.e. nitrification)
  - Demonstrated little effect on main receptor (Bow River) as compared to WWTP effluent

RECOMMENDATIONS

- **Allow natural attenuation to remediate site**

- **Continued research**
  - Improve river mass flux estimations
    - → add Deerfoot bridge
    - → improve velocity-area methodology
    - → integrate diurnal fluctuations in river concentrations
  - Evaluate nitrification and potentially denitrification via weekly/monthly sampling of multi-level piezometers

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