

Monitored Natural Attenuation (MNA)

Consortium for Research on Natural
Attenuation (CORONA)

Brent Moore, Devon Canada Ltd.



Overview

- **Project Introduction**
- **Research Overview**
- **Update**
 - ◆ *site characterization*
 - ◆ *temperature effects*
 - ◆ *sampling effects*
- **Next Steps**



Researchers

■ University of Alberta

- ◆ *Dr. Kevin Biggar, Principal Investigator*
- ◆ *Dr. Selma Guigard*
- ◆ *Dr. Carl Mendoza*
- ◆ *Dr. Clayton Deutsch*
- ◆ *Dr. Julia Foght*

■ Active Graduate Students, U of A

- ◆ *James Armstrong*
- ◆ *Dean Morin*
- ◆ *Tesfaalem Haile*



Technical Steering Committee

- Mr. Brent Moore Devon, Chairman
- Dr. Kevin Biggar U of A
- Mr. James Armstrong U of A (Komex)
- Mr. Scott Hillier Conoco
- Mr. Tony Epp AENV
- Dr. Ted Nason AENV
- Dr. Cathy Lareshen COURSE
- Mr Saviz Mortazavi Env. Canada
- Dr. Ryan Dupont Utah State Univ.
(external reviewer)



Monitored Natural Attenuation (MNA)

Knowledge-based approach

**Conceptual model of transport and
attenuation processes**

**Monitor containment/reduction of
contaminants to ensure receptors
remain protected.**

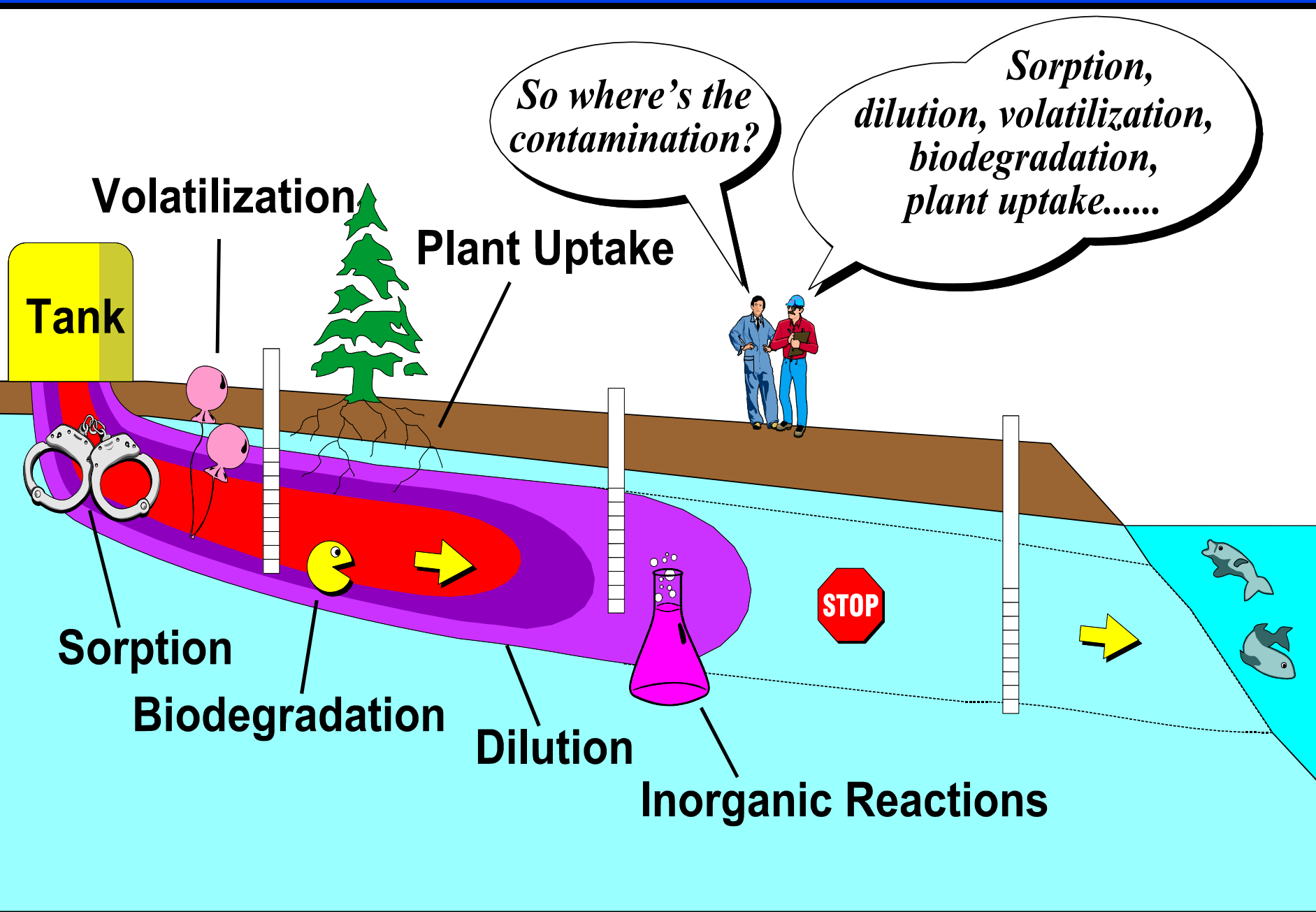


Current Regulatory Status

- **MNA widely accepted approach**
 - ◆ *Not a default option*
 - ◆ *Must address source removal*
 - ◆ *Must prevent receptor exposure*
- **Alberta: recognize MNA, but no specific guidelines established**



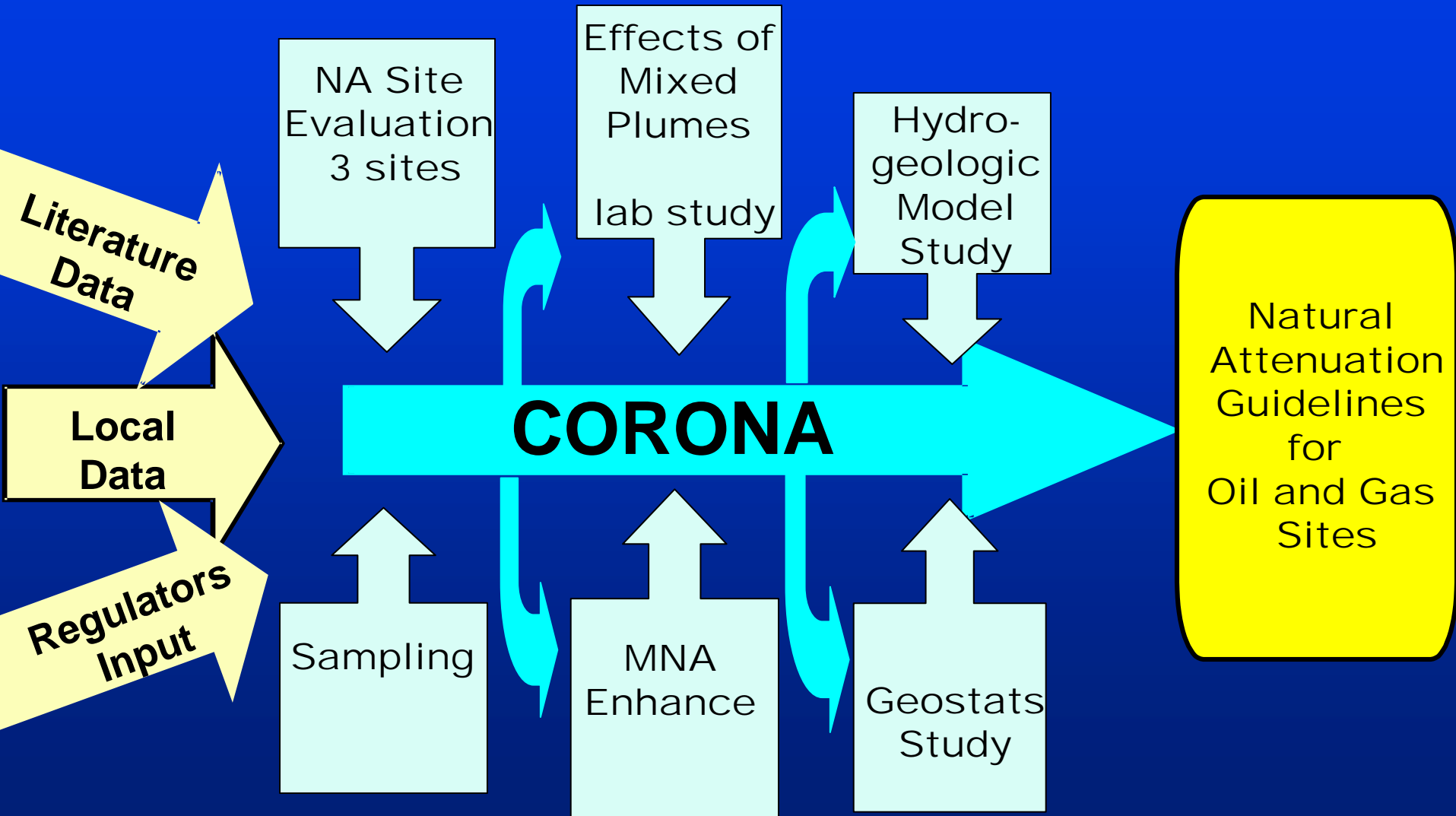




Inputs

Activities

Outcome



Input

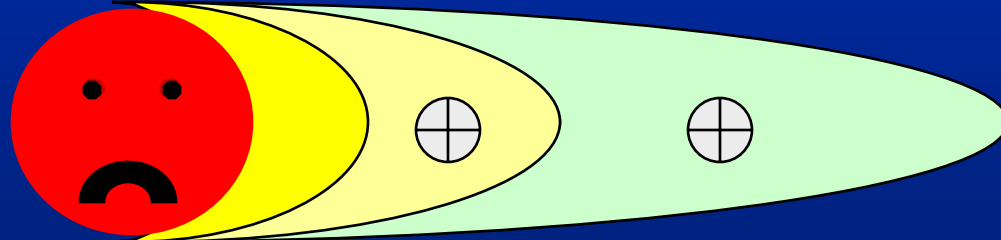
- Do monitoring data support MNA?
 - ◆ *decreasing hydrocarbon concentrations*
 - ◆ *characteristic geochemical patterns*

Background

Well



Source

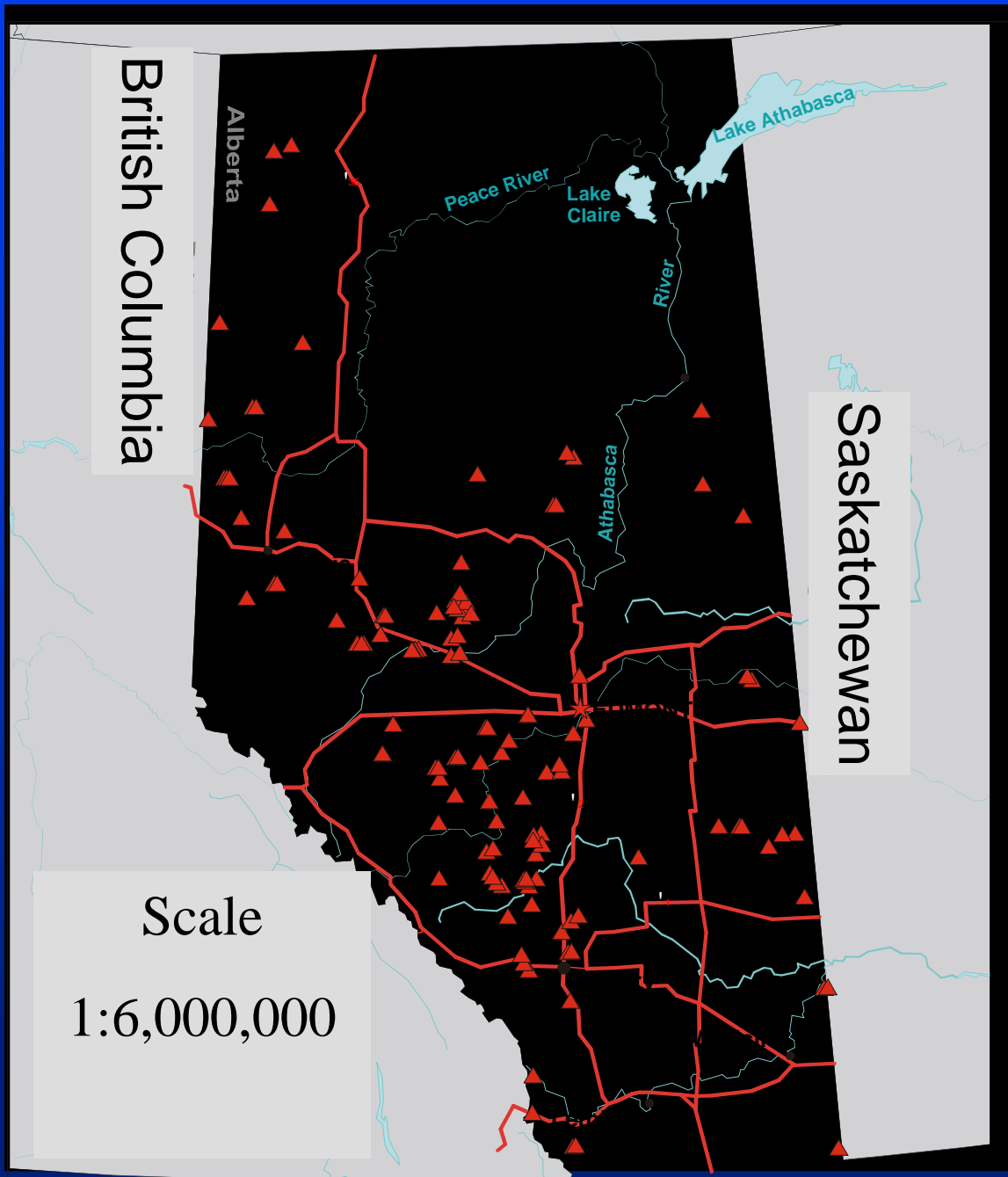


Plume

Wells

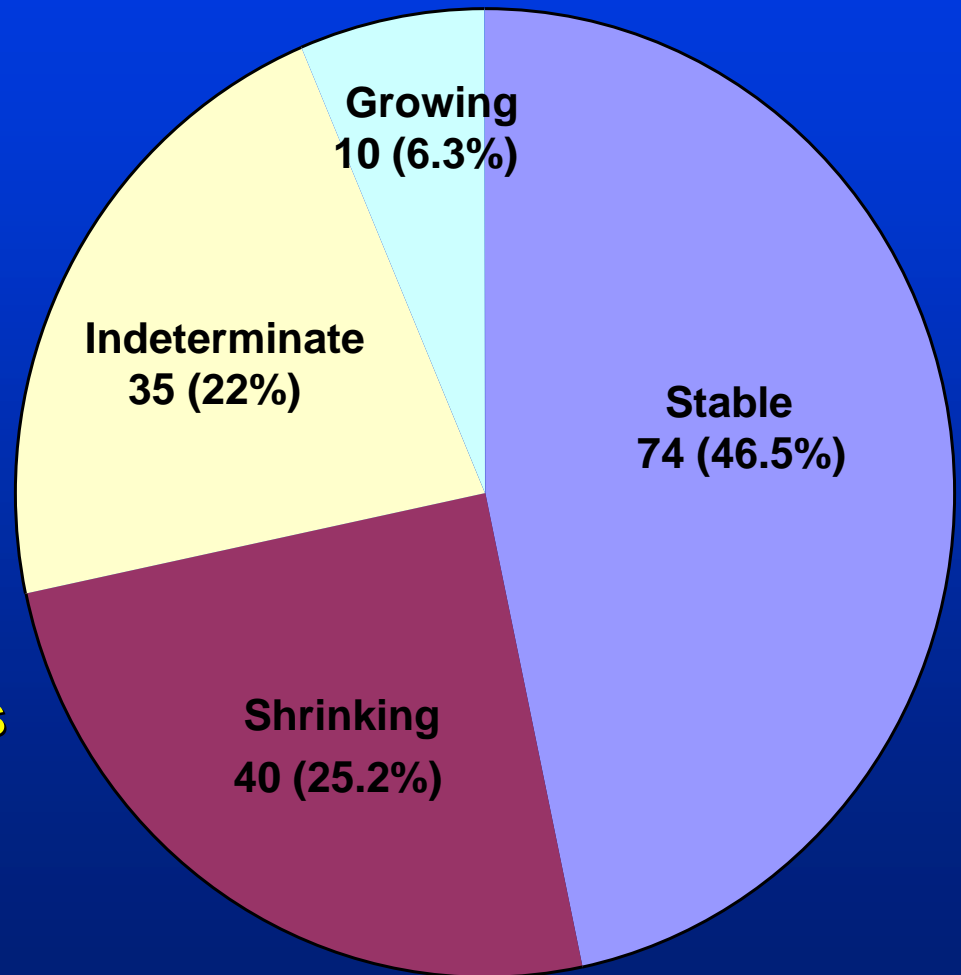
Lower oxygen, nitrate, sulphate
higher iron, manganese, methane





PHC Plume Trends

- 71% of PHC plumes are shrinking or stable
- Growing plumes associated with increases in co-contaminants
- Other studies had higher numbers of shrinking plumes



Projected Program (2001 Summary)

- **Started** detailed MNA site characterization
- **Conducted** MNA sampling study with AENV
- **Started** lab studies
- **Initiated** sulphate reduction with NWRI



Site Characterization

- **Source Delineation**

- ◆ *CPT-UVIF for delineating free hydrocarbon*

- **Monitoring**

- ◆ *Sampling method influence*

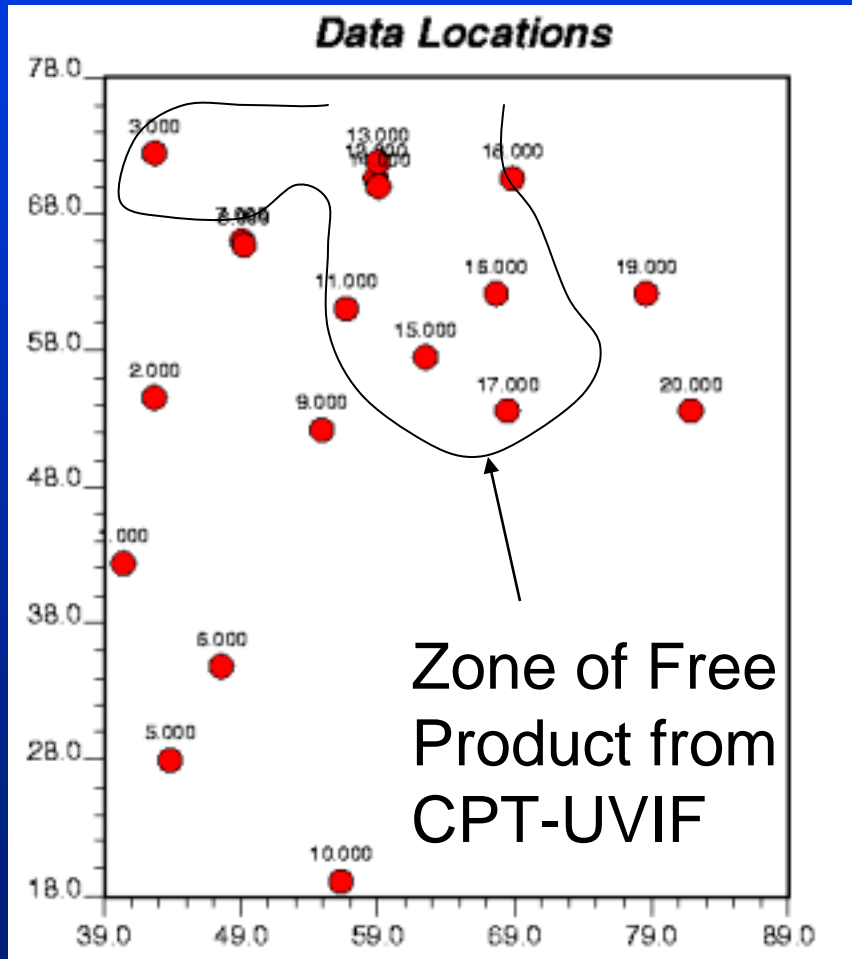
- ◆ *Purging influence on analyses for MNA*

- ◆ *Seasonal influences*

- **How much data needed**

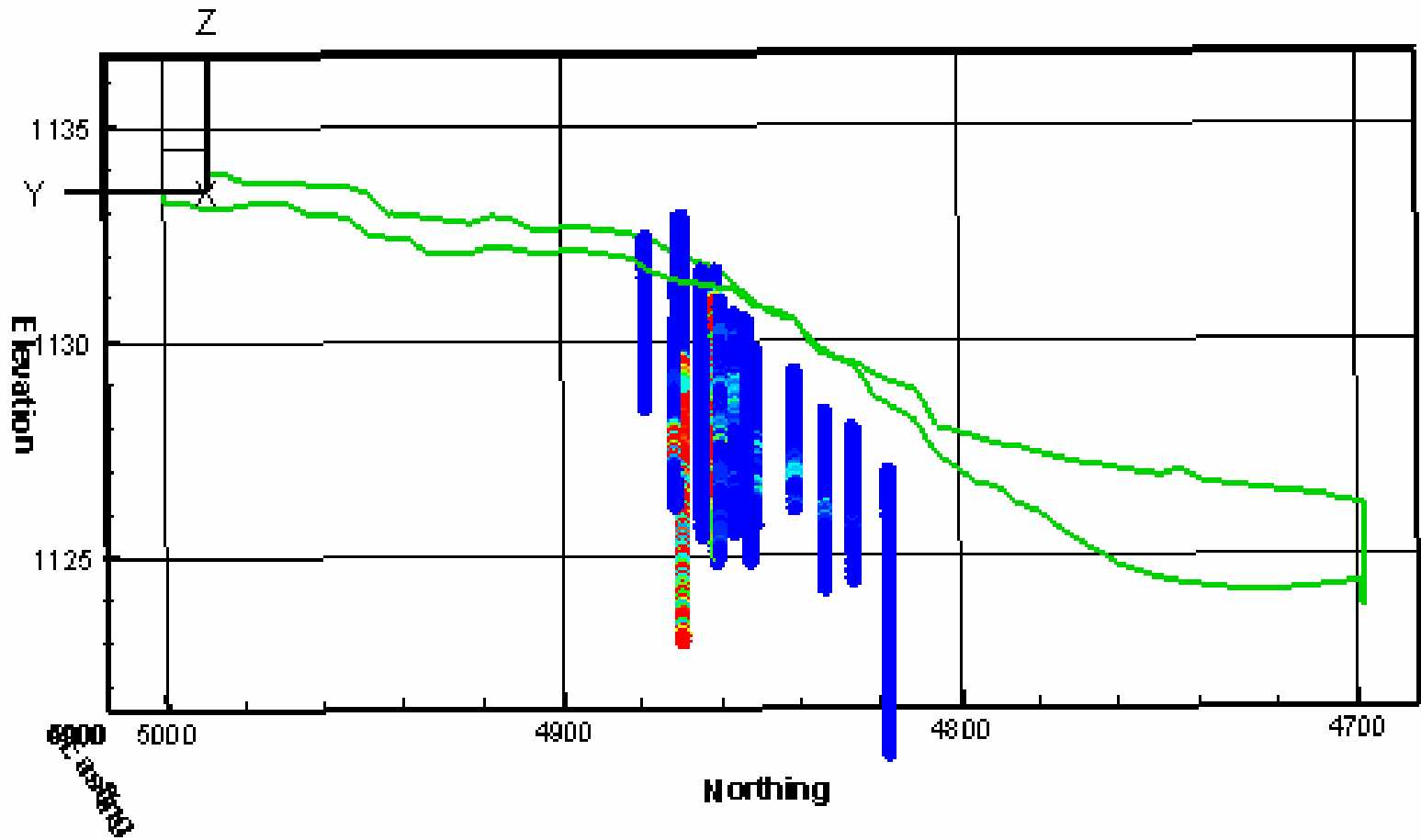


Source Delineation Using CPT-UVIF

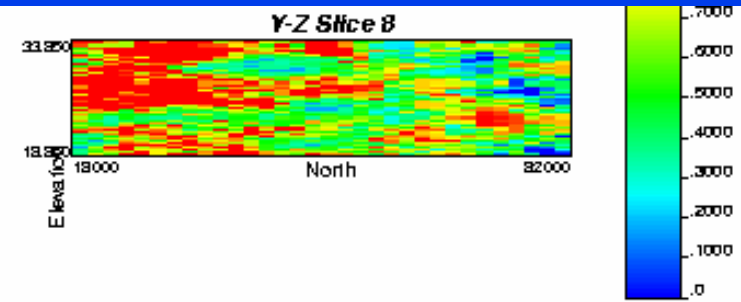
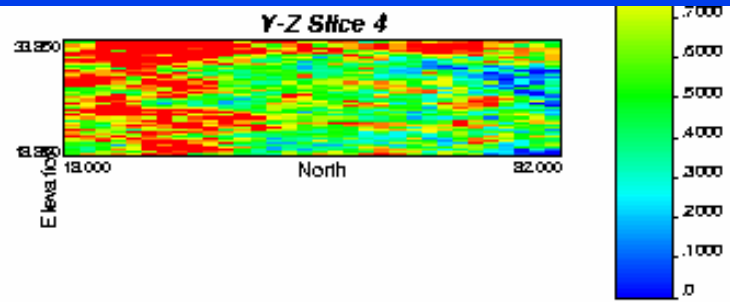


- Worked great for former flare pit
- Inconsistent response for a light condensate



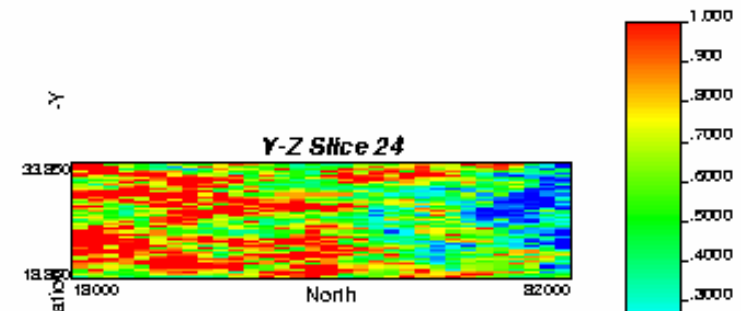
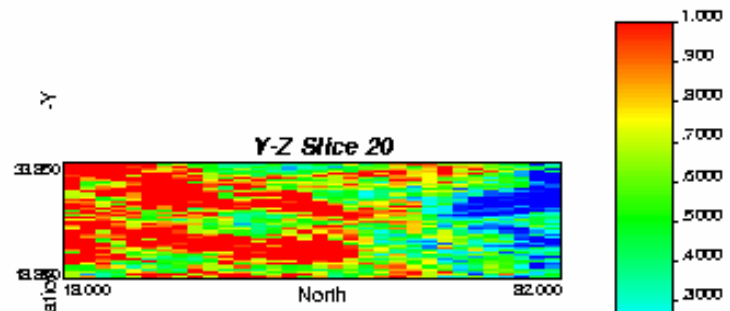
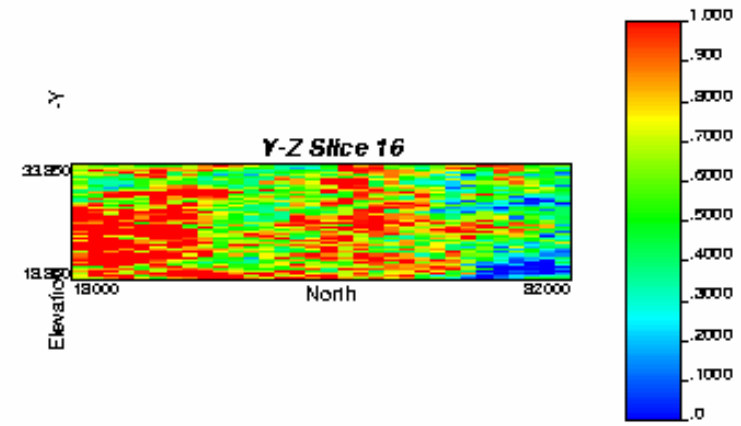
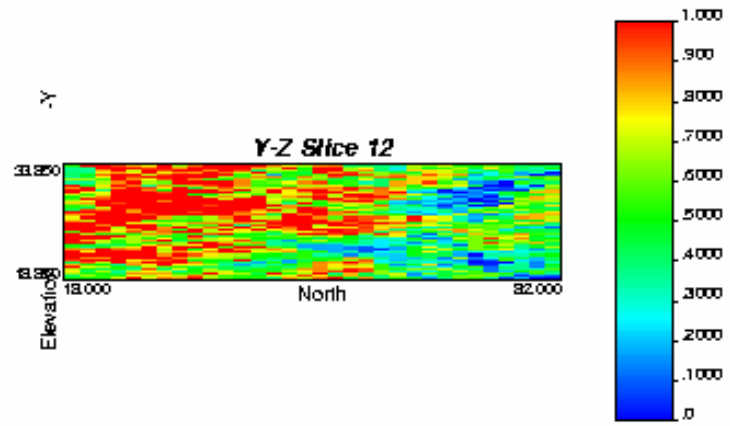


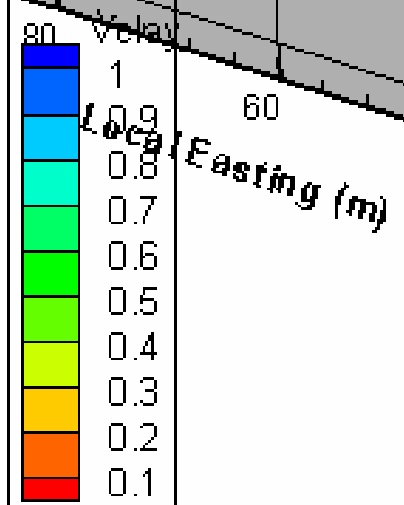
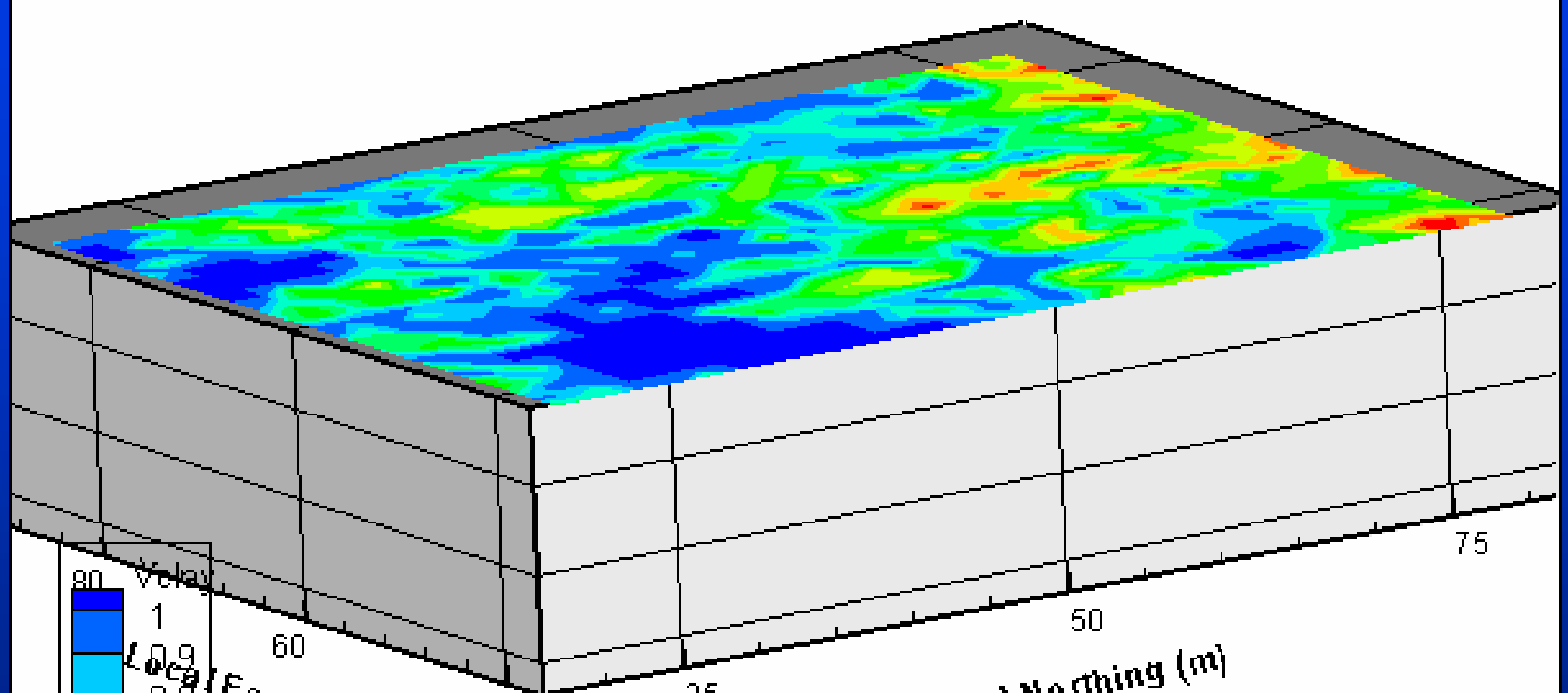
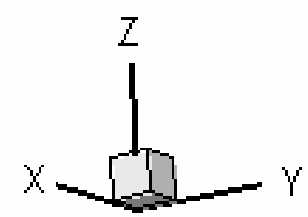
UVIF Response (hot colour means more oil)



Red = clay
Blue = sand

Flow direction ← Source





50

75

60

40

25

Local Northing (m)

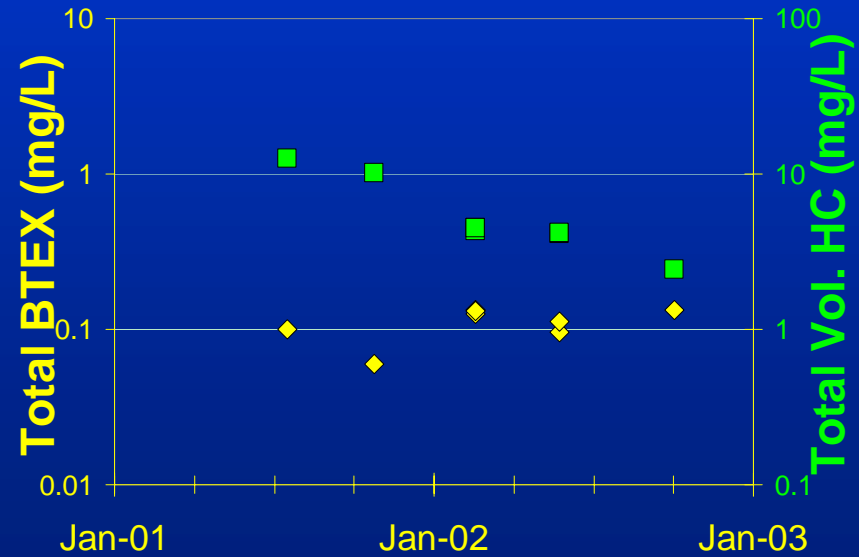
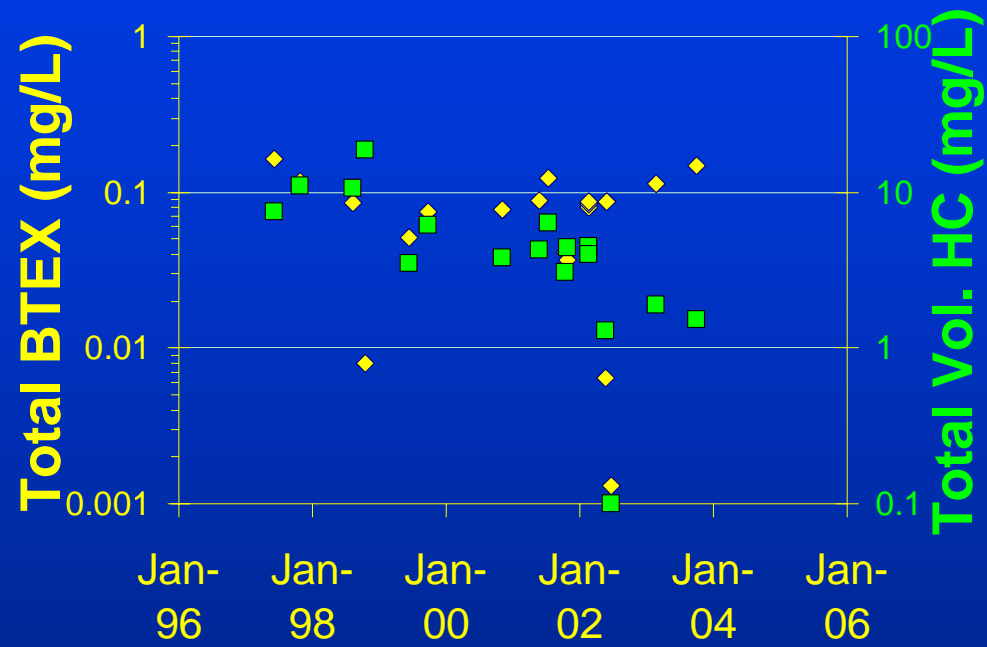
Local Easting (m)

General Overview

- **Stable or downward trend in hydrocarbon**
- **Biodegradation evidence:**
 - ◆ *enriched iron, depleted sulphate*
- **Possible winter inhibition**
- **Possible purging influences**



Time Trend

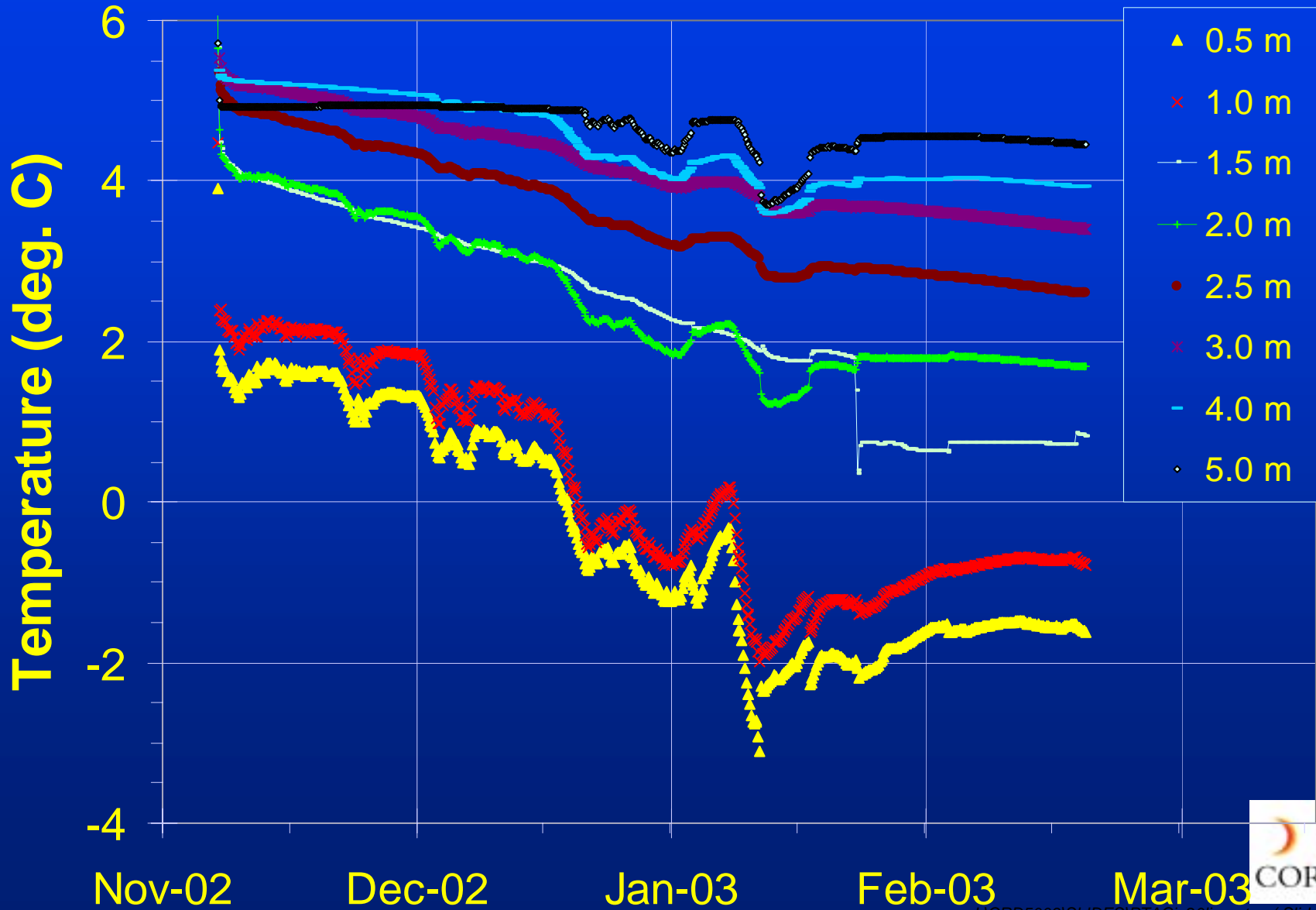


Seasonal Effects

- Slower or absent biodegradation in winter?
- Seasonal change in microbial processes.



Temperature Change

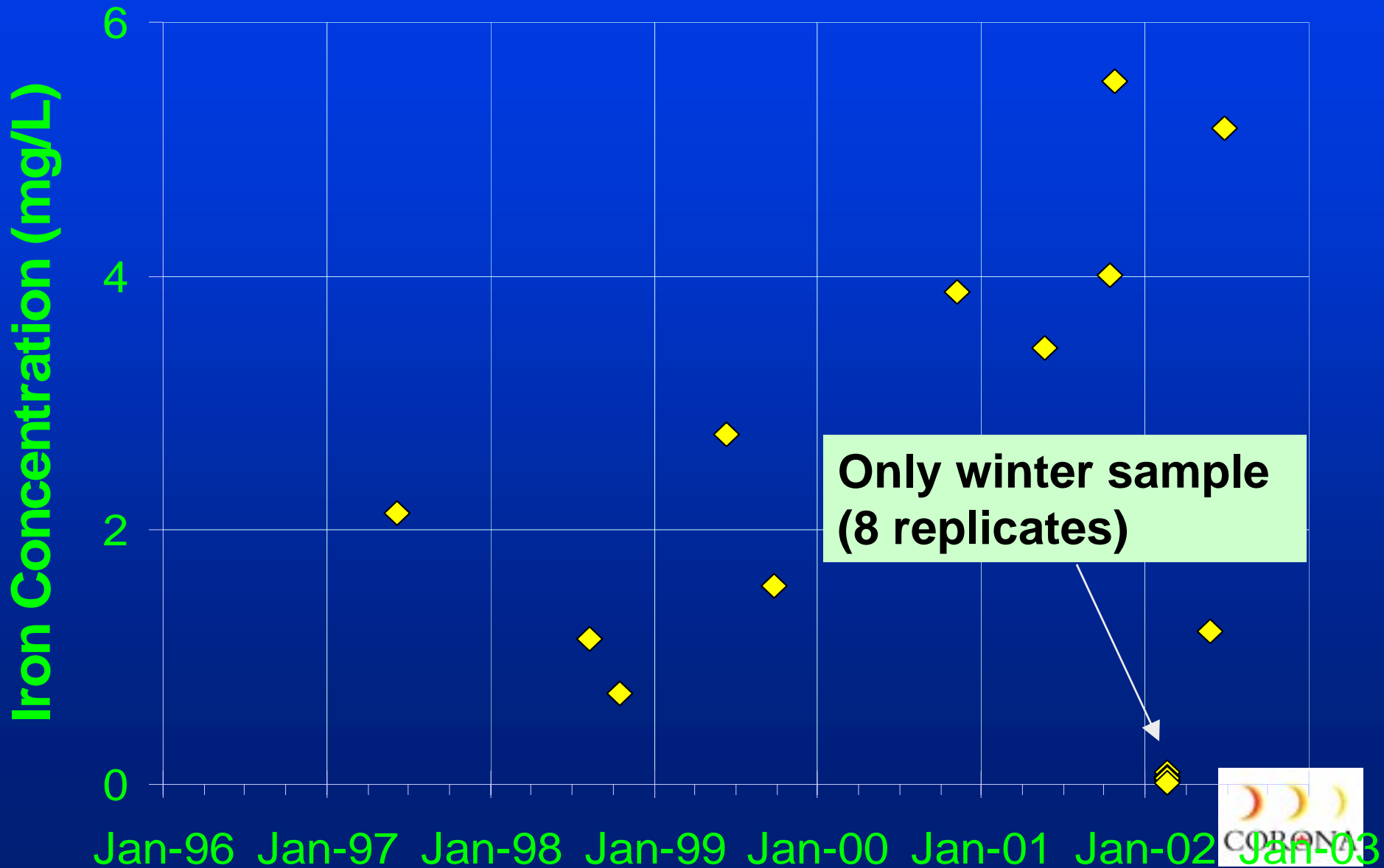


Temperature Effects

- **Dissolved iron decreased in winter**
 - ◆ *Possible decrease in bioactivity*
 - ◆ *Possible change in microbial process*
- **No effect on other indicators**



Temperature Effect Diss. Iron

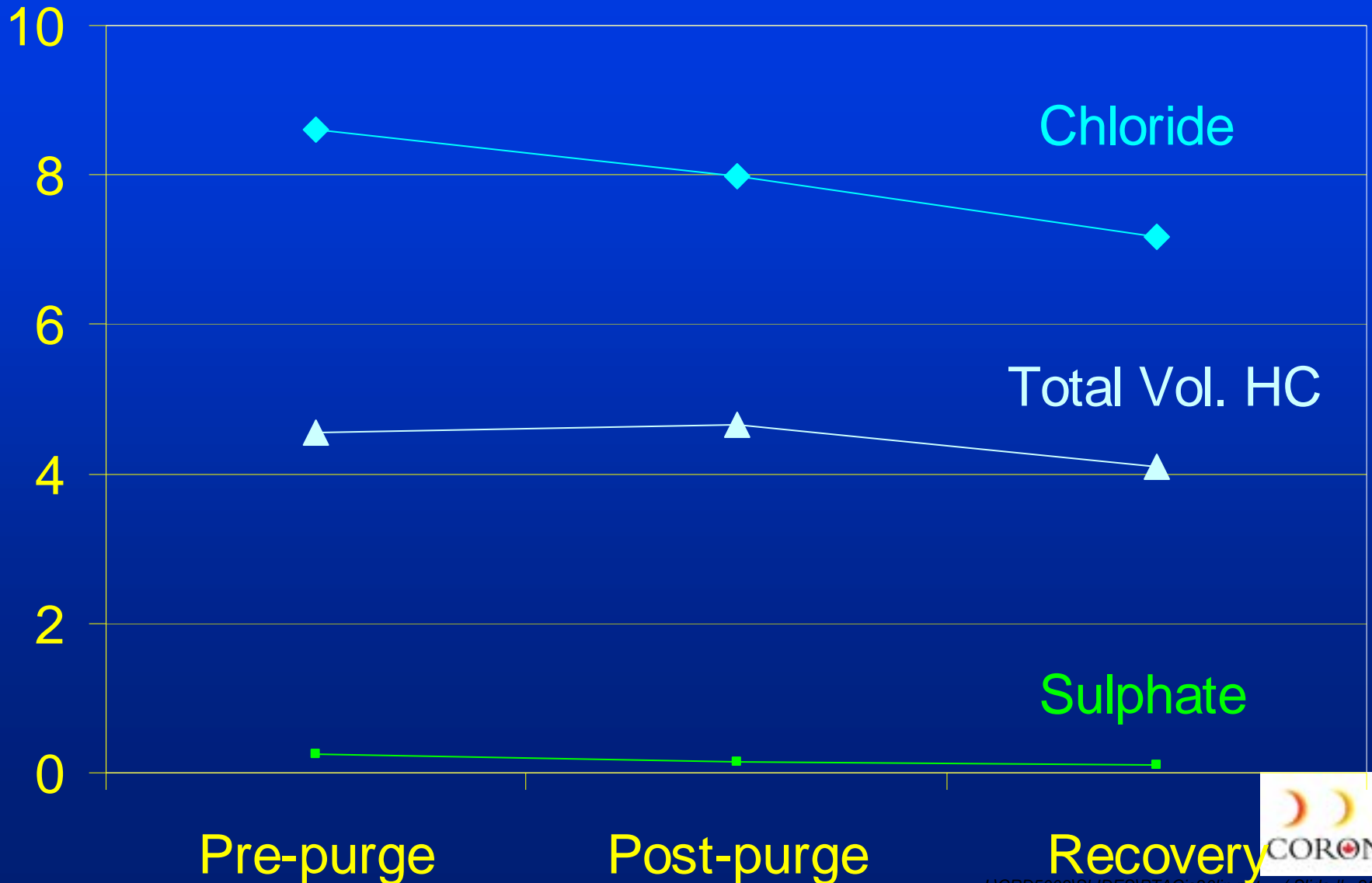


Purging Effect

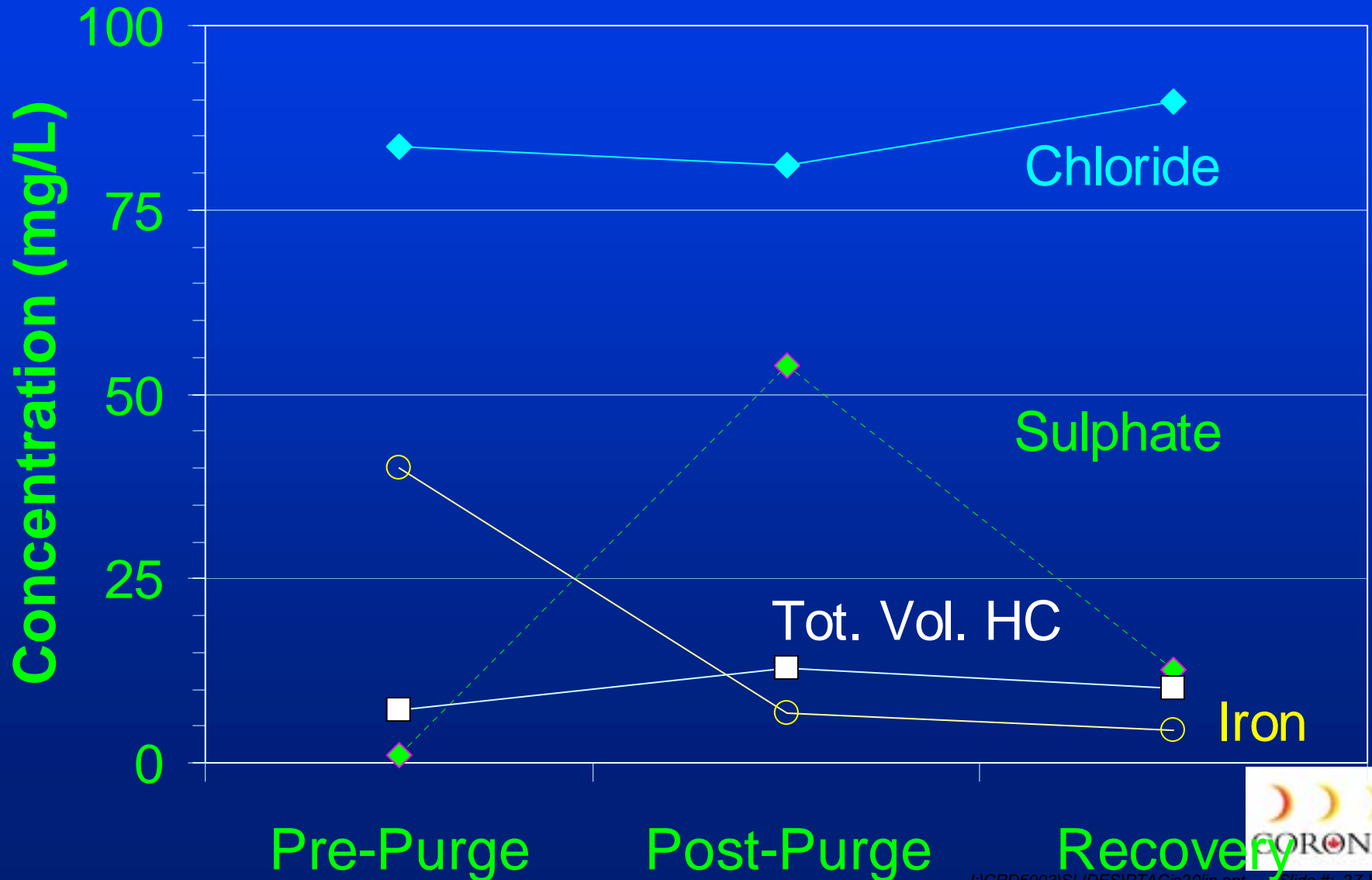
- **Current protocol: purge 3 borehole volumes or until dry:**
- **This approach may cause:**
 - ◆ *oxidation of water*
 - ◆ *mixing of multiple zones*
 - ◆ *volatile hydrocarbon loss*
- **How to interpret MNA indicators?**



Site 1: No Purging Effect



Site 2: Strong Effect



Geochemical Zones

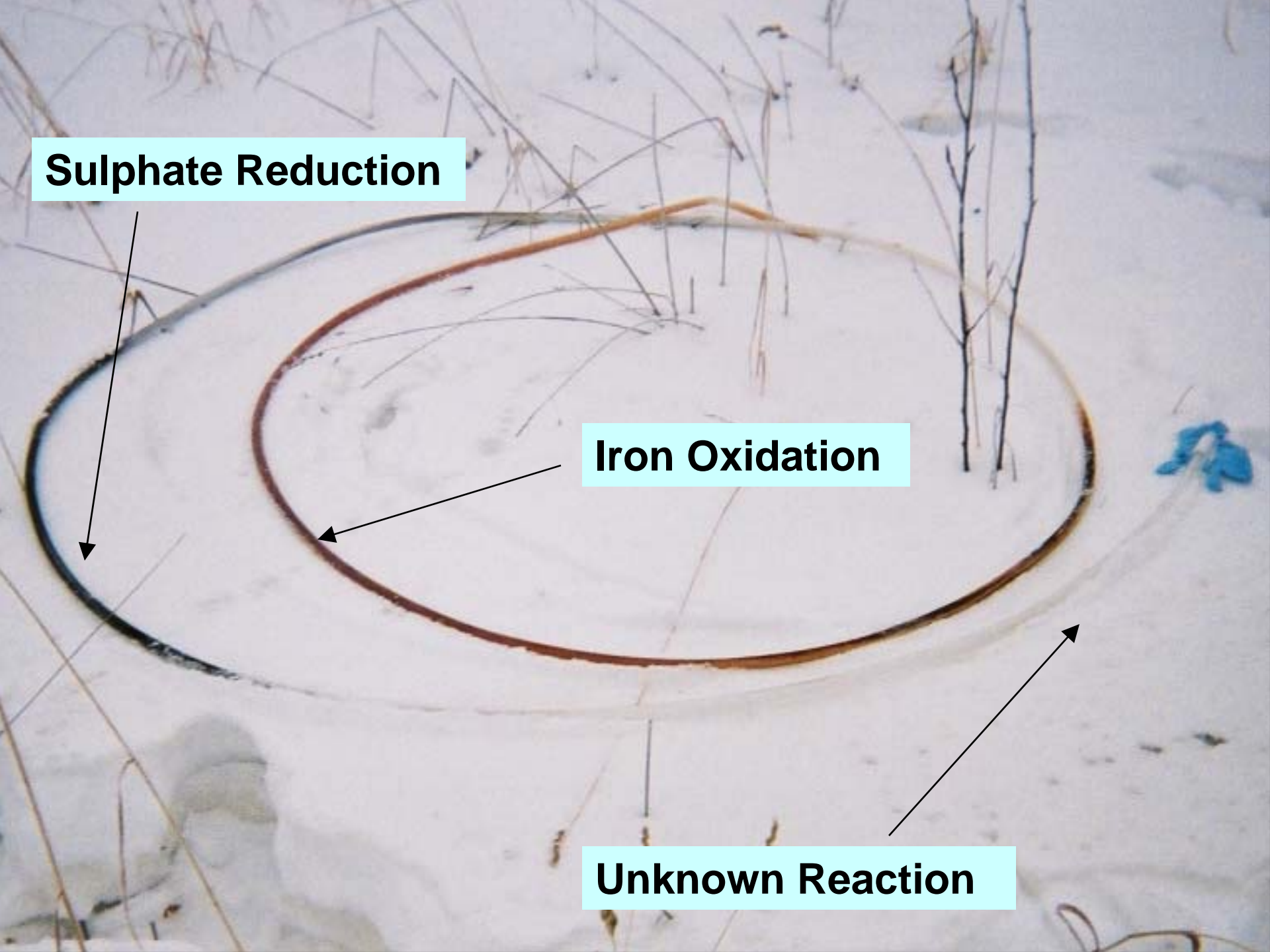
- Vertical changes in geochemistry
- Sample depends on depth and mixing
- Well construction influence



Sulphate Reduction

Iron Oxidation

Unknown Reaction



Next Steps

- **Continue site characterization**
- **Assess sampling influences**
 - ◆ *method*
 - ◆ *purging effect*
- **Initiate laboratory experiments**
- **Initiate modelling studies**



Cooperative Programs

- **Biodegradation enhancement**
 - ◆ *Sulfate injection with bromide tracer*
- **Field study conducted with NWRI**
 - ◆ *Project Lead: Dr. Dale Van Stempvoort*
- **First phase showed:**
 - ◆ *loss of injected sulfate*
 - ◆ *isotopes indicate biodegradation*



Cooperative Programs

- Dissolved gas monitoring method
- Field study through U of C
 - ◆ *Project Lead: Drs. Cathy Ryan, Angus Chu*
- Initial data showed:
 - ◆ *U of C method is better than current test*
 - ◆ *indicated methanogenesis at CORONA sites*



Summary

- **Site characterization is critical**
- **Standard sampling protocol is suspect**
- **Bacteria may stop in winter (1 site checked)**
- **Sulfate enhancement is promising**
- **U of C dissolved gas method promising**

