consulting engineers
& scientists

Groundwater Quality Results: Is it natural or not?

Frans Hettinga and Brian Tsang

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Groundwater Monitoring Requirements

Often for:

- Alberta EPEA Approvals for industrial facilities, sour gas plants, etc.
- Alberta Code of Practice sites (sweet gas facilities)
- Alberta ERCB Approvals for oilfield waste management facilities
- Saskatchewan Environment and Saskatchewan Energy and Resources for waste management facilities
- BC MOE for waste management facilities
- Miscellaneous risk management plans

Typical Program Design

- Identify potential contaminant sources
- Characterize local hydrogeological system
- Develop and implement monitoring well network and sampling program
- Data interpretation and reporting
- Corrective actions, if necessary

Groundwater Programs

- Monitoring network size ranges from a few wells to dozens
- Frequency from less than once a year to monthly
- May require only one parameter (e.g. chloride), or detailed, tailored analytical suites
- Costs up to tens of thousands $$/year

Groundwater Quality Impact

- Identify trends
- Compare to guidelines (e.g. Alberta Tier 1)
- Compare to background quality

Background Groundwater Quality

Tier 1:

"..is the natural concentration of that substance in a particular groundwater zone in the absence of any input from anthropogenic activities or sources."

Alberta Record of Site Condition Form:

" For all contaminants of potential concern on-site and off-site, no exceedances have been found above any applicable soil and groundwater guidelines in any prior and current assessments"

2010 Standards for Landfills in Alberta

Develop groundwater monitoring program including:

- *background* groundwater quality for each monitoring well;
- existing landfills or landfill cells may establish *background levels* after the start of landfill operations by:

  (i) using historical data; or

  (ii) obtaining groundwater samples from monitoring wells established in nearby areas *not affected* by landfill activity;
- establish groundwater quality control limits for each *naturally occurring* parameter

So…

- What is natural?
- Are some natural compounds contaminants of potential concern?
- What is background?
- How do we avoid “false positives”?
- How do we deal with variable results: temporal, spatial, regional?

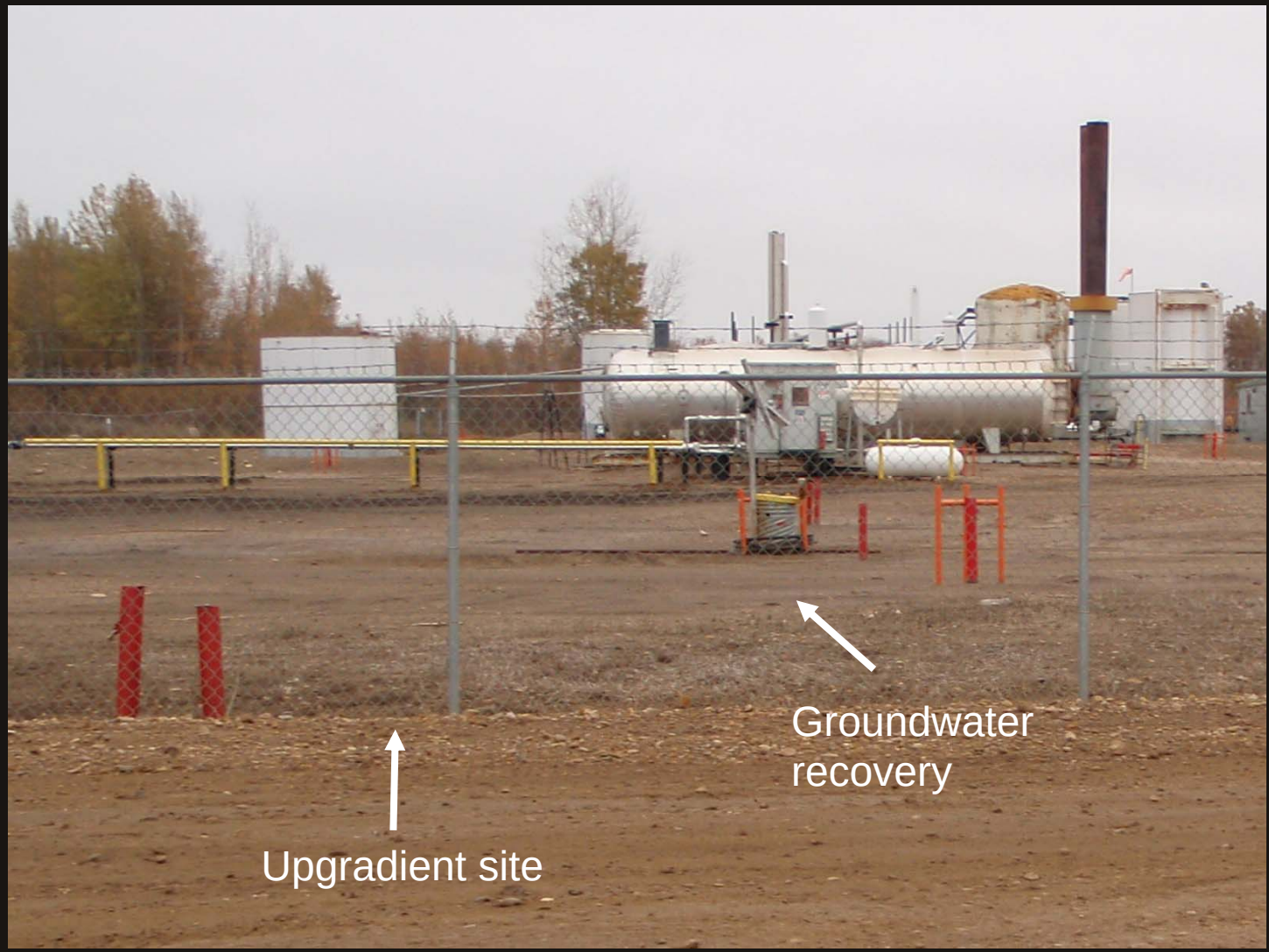
Background Wells – out there

Background Wells – pick a logical spot

Background Wells – material choice and location

Background Wells – no anthropogenic effects

Background Wells – upgradient impact



Analytical Requirements

For instance, Alberta ERCB (amended Directive 58)

- Routine water chemistry
- Dissolved metals
- BTEX, PHCs
- Phenols
- DOC

Others programs may include:

- VOCs
- COD
- DKN/TKN
- Etc.

Example: Chloride

- Often considered a useful parameter to identify groundwater quality impact
- Mobile, conservative, “natural” concentrations in shallow groundwater often low (typical <10 mg/L)

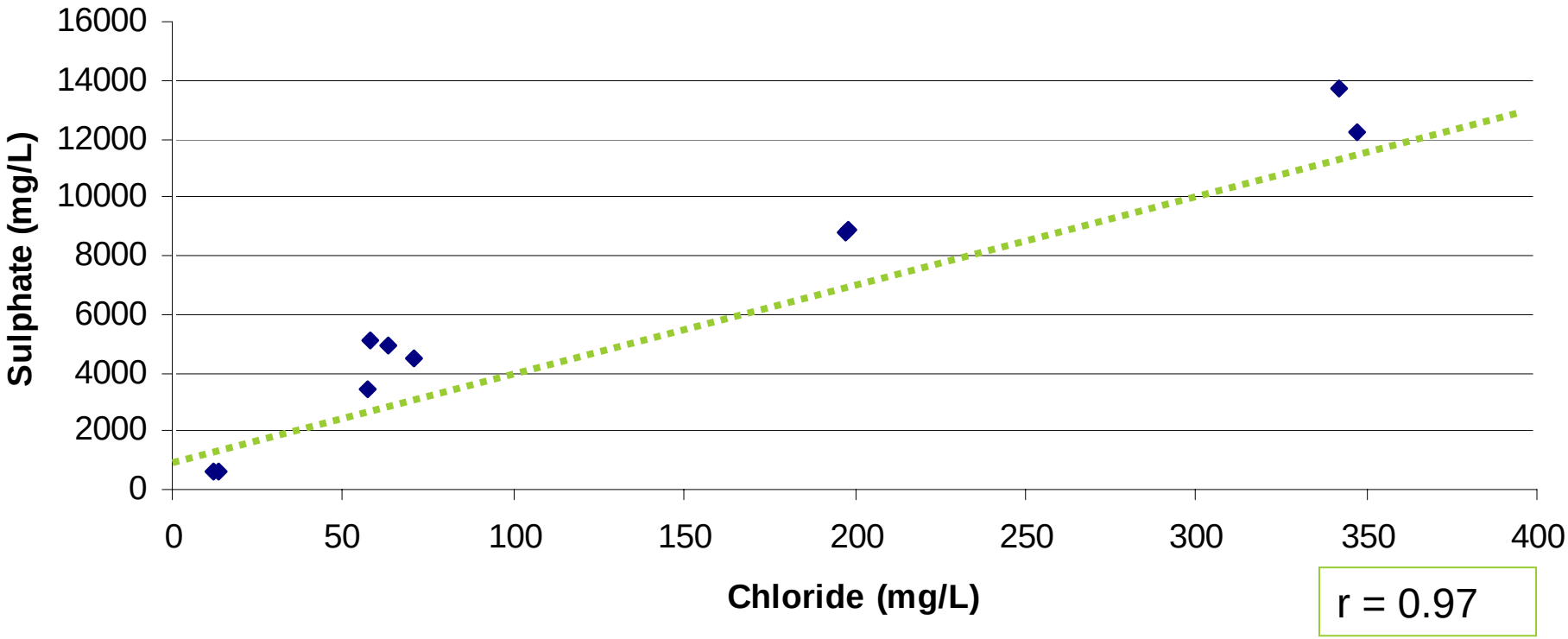
Concern:

- Frequently effects from road salt (e.g. off site)
- Concentrations may be elevated in arid/irrigated land

Example: Chloride

- Recently constructed oilfield facility in southeast Saskatchewan
- Land use prior to 2007 was farmland
- Glacial clay till, naturally saline, water table ~2 m deep
- Six monitoring wells installed in 2007 (< 6 m deep)
- Chloride concentrations up to 350 mg/L
- Clear correlation with sulphate
- Interpreted to be “natural”; but will limit effectiveness of monitoring program

Example: Chloride (6 wells, 2008 & 2009 data)



Example: DOC

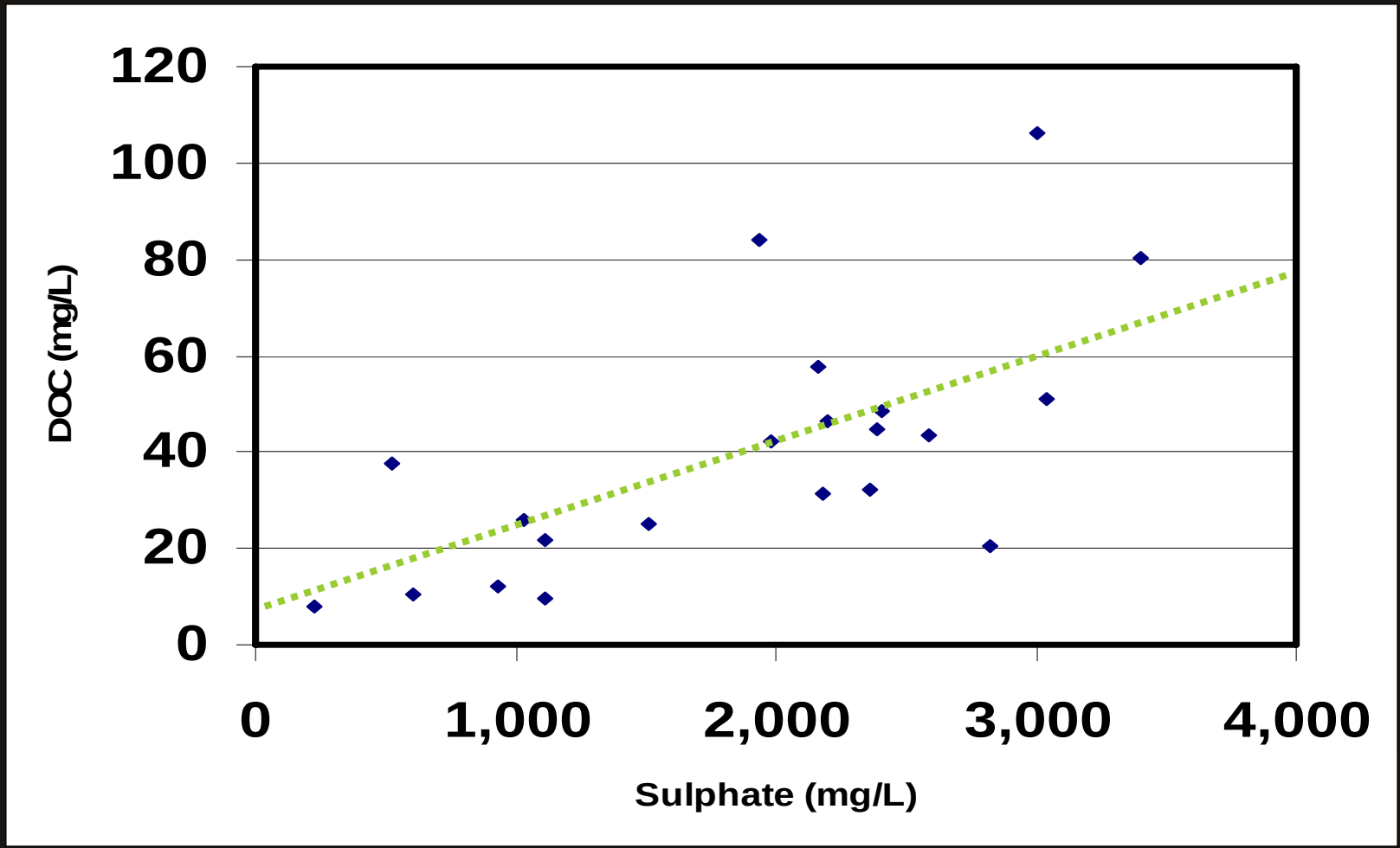
- Dissolved organic carbon
- Considered useful as gross-indicator parameter
- Required in ERCB and many AENV Approvals
- Measures wide variety of compounds; natural and anthropogenic
- “Background” concentrations often < 10 mg/L

DOC – Gas plant in northern Alberta

- Network of approximately 20 wells
- Clay till, shallow groundwater table
- High natural salinity: TDS, sodium, sulphate
- DOC values were considered elevated
- Investigated with HPLC with UV and MS detectors, spectrophotometry, fluorimetry, and infra-red spectroscopy
- Findings: oxygenated, hydroxylated C12 to C21 polar hydrocarbons with a two-to-three ring aromatic structure [e.g., phenols that are hydroxylated derivatives of naphthalene (two fused rings), anthracene, or phenanthrene (three fused rings)]. Believed to be corrosion inhibitors.

Is that true??

Example: Natural (?) DOC



Example: DOC as useful indicator

- Injection well site
- DOC increased at downgradient well

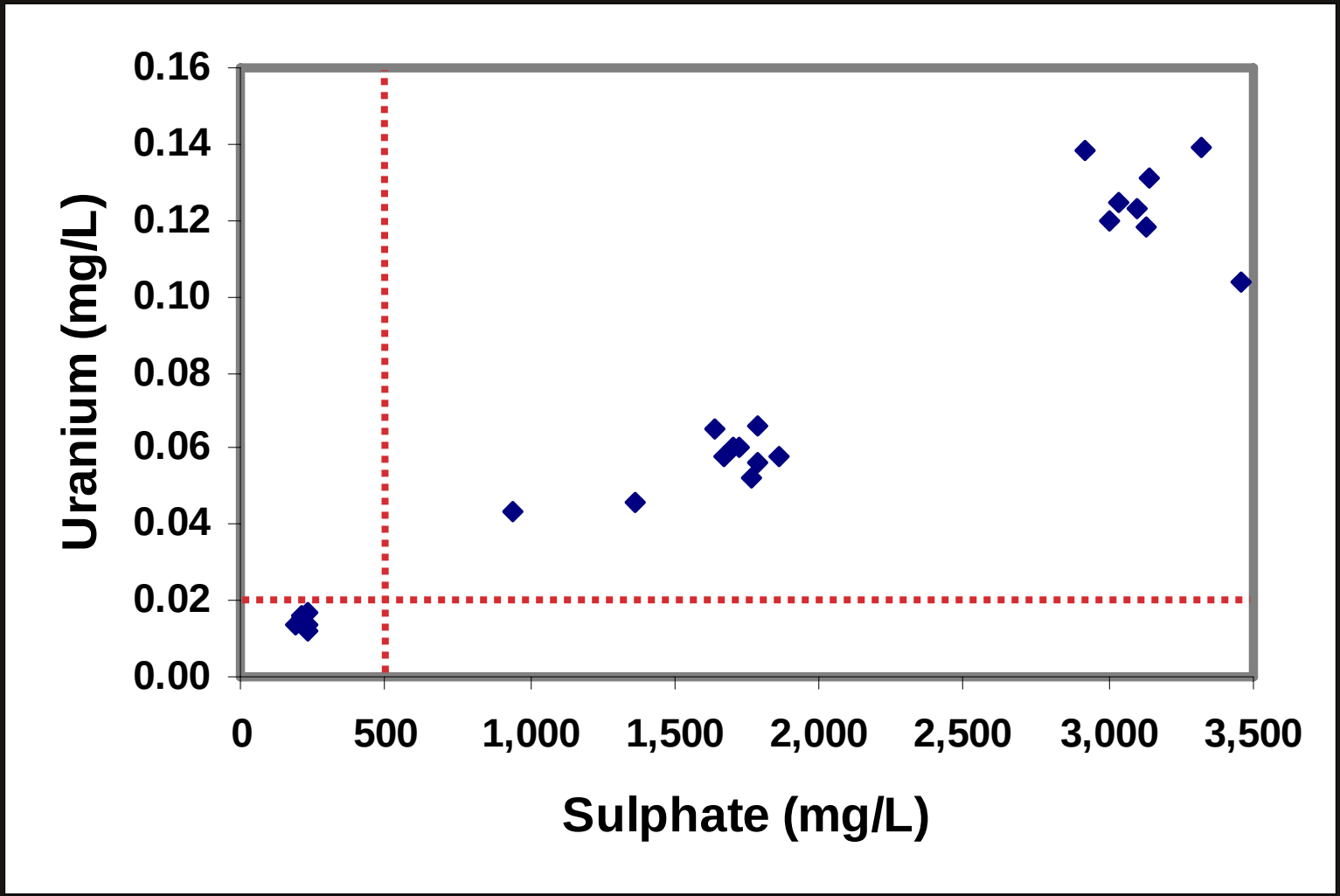
Jun-02	Oct-02	Mar-03	Jun-03	Oct-03
9.2	827	42.6	14.8	1,710

- Analytical program expanded based on DOC trends
- No BTEX, PHC and limited concentrations EPA 8240/8260 VOCs
- Eventually discovered MTBE (230 mg/L in 2004)
- Triggered remedial action

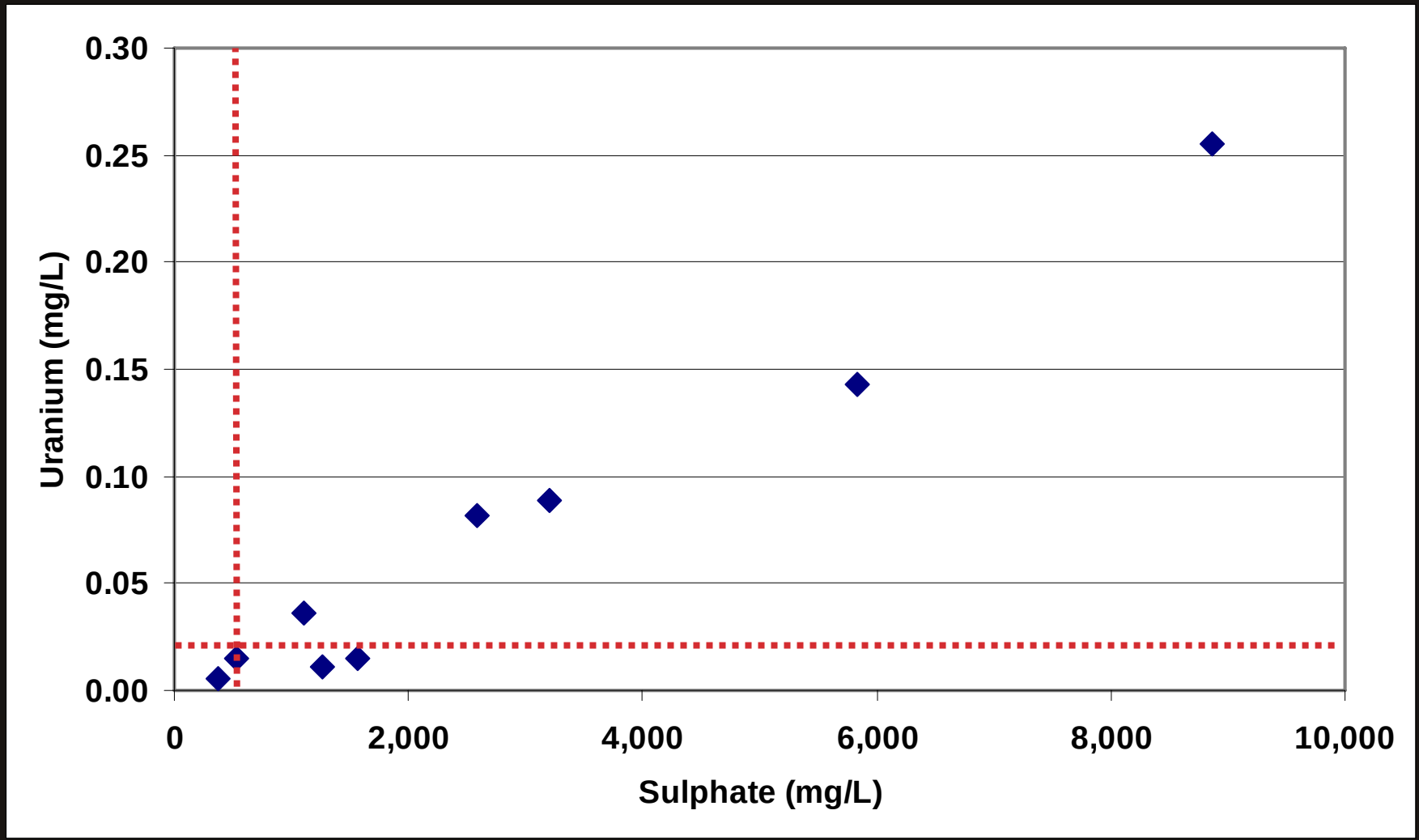
Example: Uranium

- In recent years generally part of ICP metal scan
- Often greater than Tier 1 in saline groundwater and clear correlation with several parameters including TDS, sodium and sulphate
- Distribution in soil and groundwater in prairie provinces not well documented
- Elevated concentrations frequently questioned by regulators

Uranium – Site in Grande Prairie area



Uranium – Site in Calgary



Example: DKN/TKN

- Dissolved (or total) Kjeldahl Nitrogen
- Indicator parameter for nitrogen containing substances
- Waste water parameter, but also useful for amines, ammonium in groundwater

DKN – Site in northern Alberta

- Former land treatment area with AENV Approval
- Requires semi-annual monitoring and sampling
- Extensive analytical program including DKN, but not NH4
- No evidence that amines are a COPC

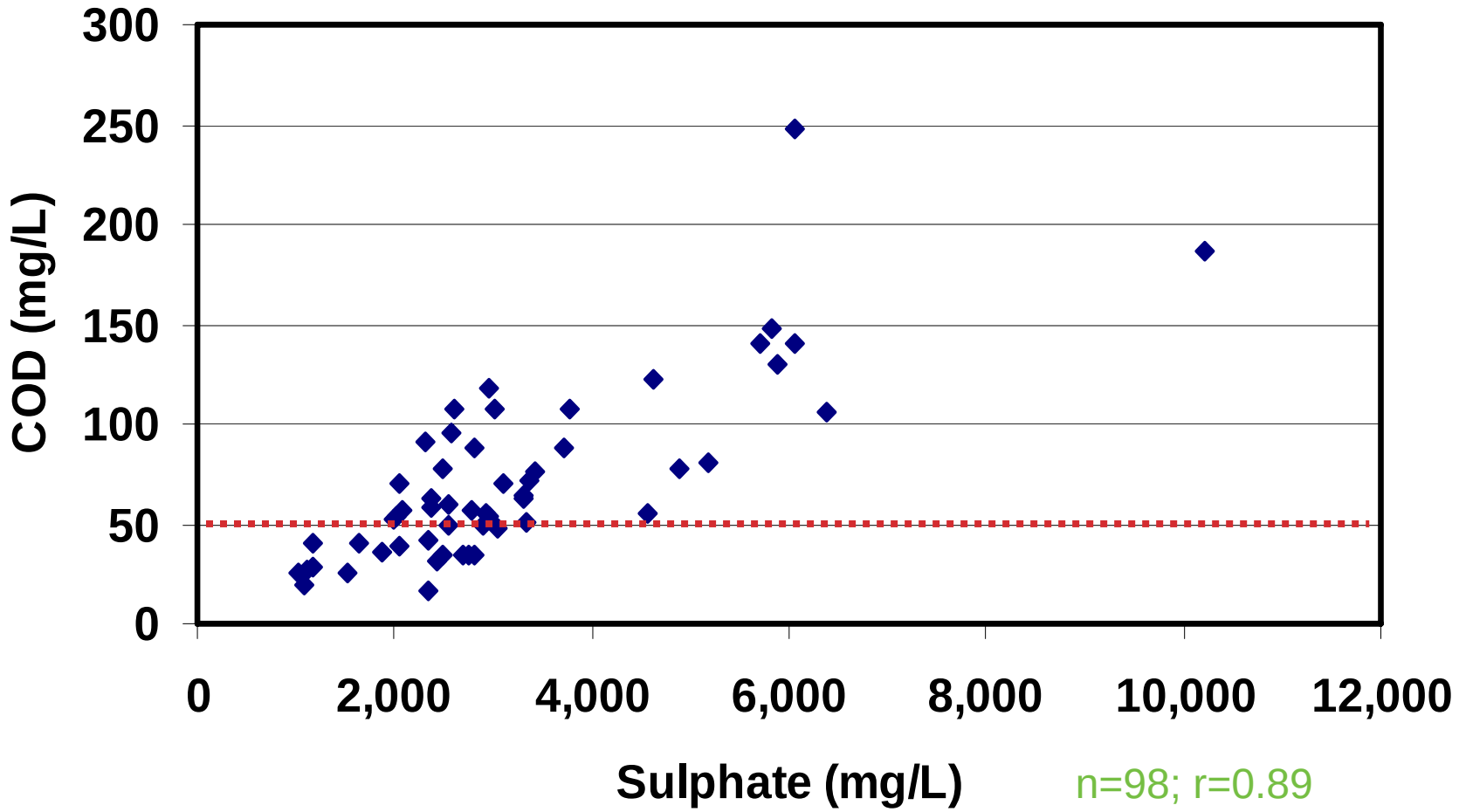
Average Concentration (n=6)	MW-1		MW-2		MW-3	
	Shallow	Deep	Shallow	Deep	Shallow	Deep
DKN (mg/L)	1.4	2.8	1.4	2.6	0.8	2.3
Manganese (mg/L)	<0.05	2.5	0.05	7.2	2.9	10.8

- Interpretation: DKN results in deeper wells higher due to reduced groundwater conditions (e.g. presence of ammonium).

Example: COD

- Chemical Oxygen Demand
- Wastewater parameter
- Still part of many Approval requirements
- Difficult to interpret, often highly variable results
- Likely affected by (naturally) reduced groundwater conditions, organics in soil (e.g. coal in till?)
- No Tier 1 guideline but surface water discharge guideline (50 mg/L) in 2010 Standards for Landfills

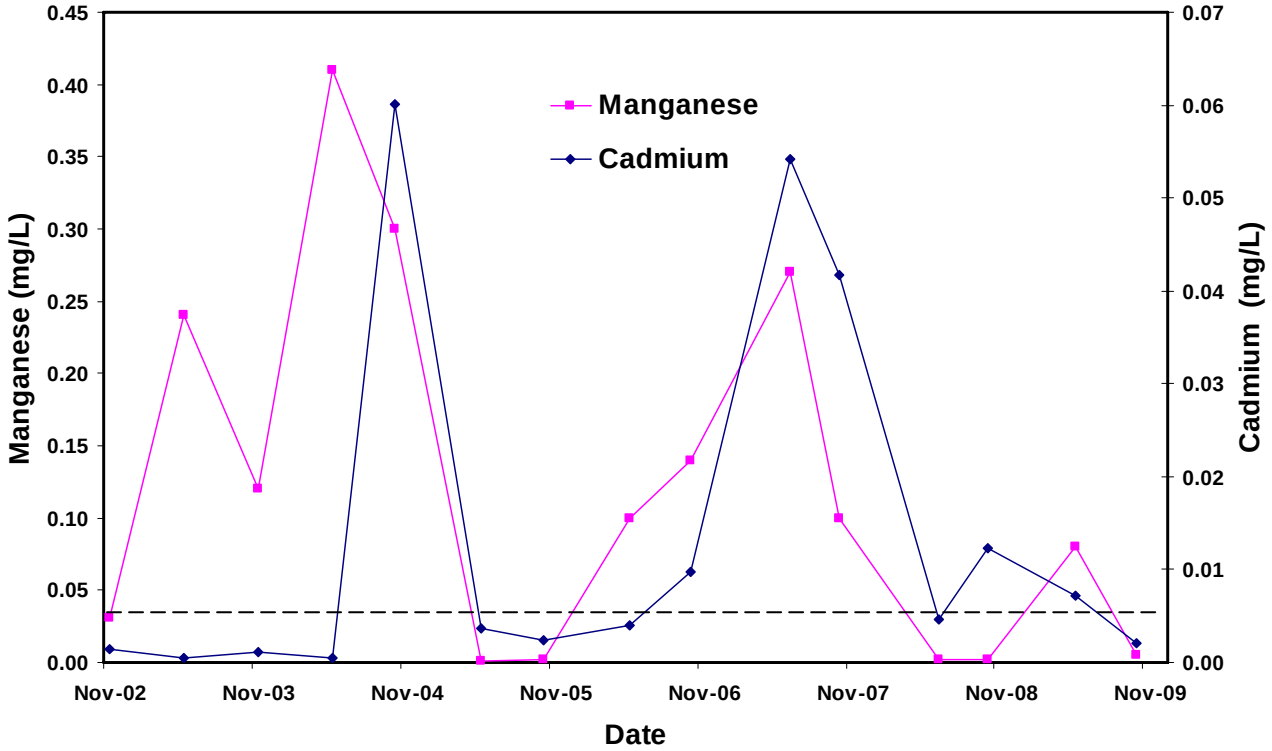
COD – Site in Calgary



Example: Cadmium

- Site in Southern Alberta
- Two sets of monitoring wells; 1997 series and 2002 series. One deep and one shallow background well
- Silty sand, groundwater at ~ 8 m deep
- Since 1997, cadmium typically < detection limit
- Deep background well installed in 2002; cadmium often > guideline for potable water (0.005 mg/L)
- Adjacent land use is agricultural
- Relationship with dissolved manganese?

Groundwater Quality MW 02-08



Solving the Cadmium Mystery

- Literature suggests cadmium mobility affected by manganese
- Not anticipated to be naturally occurring
- Cadmium-bearing stabilizers in PVC plastics?
- Unresolved what caused it in this case

Conclusions

- Establishing background groundwater quality is not always a straightforward process
- Limited information available on background concentrations of several parameters (e.g. DOC, U)
- Some parameters are not always suited to identify impact, especially in naturally saline conditions
- Therefore need to be critical on what we measure and why; keep programs effective
- Possible effect of well materials for low level metals?



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