360 ENERGY LIABILITY MANAGEMENT

KEEP IT SIMPLE, SCIENTISTS:
THE BENEFITS OF APPLYING RISK PRINCIPALS TO SIMPLE SITES AND THE DATA THAT GETS YOU THERE

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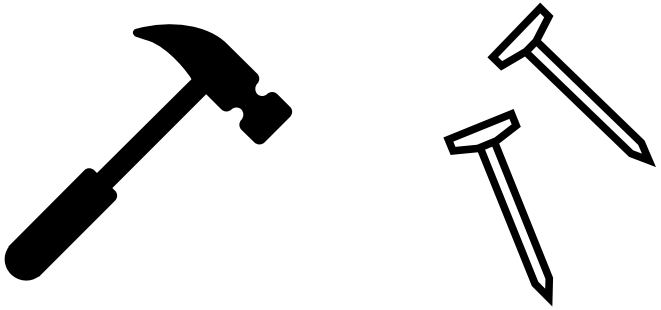
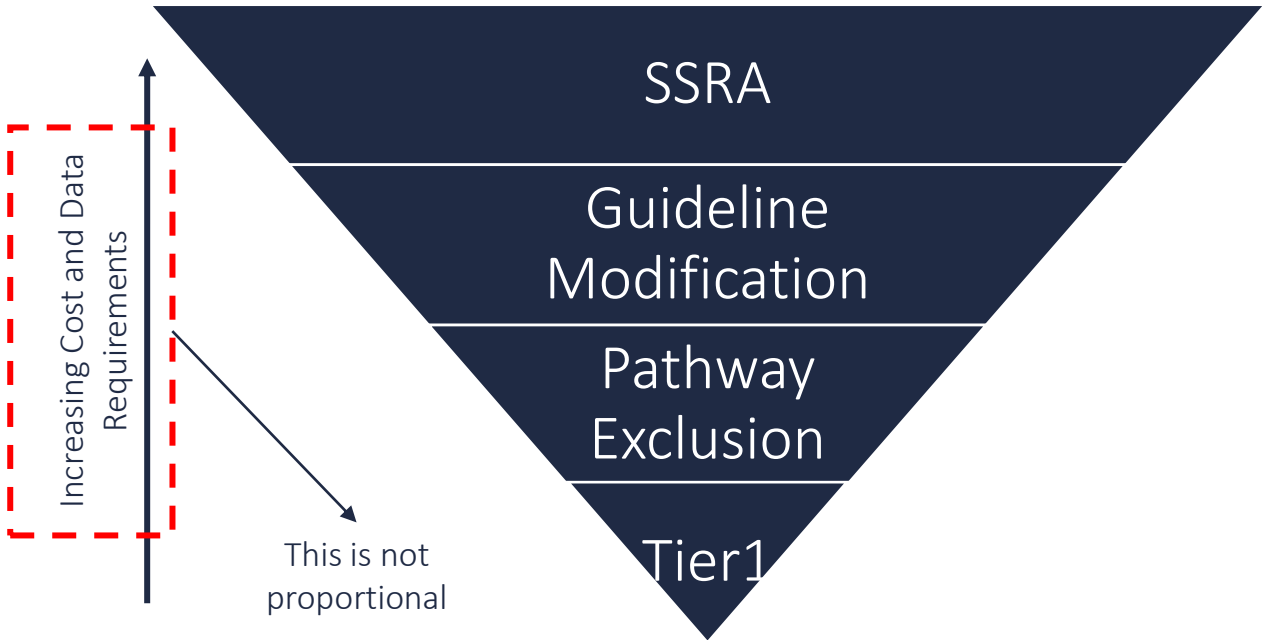
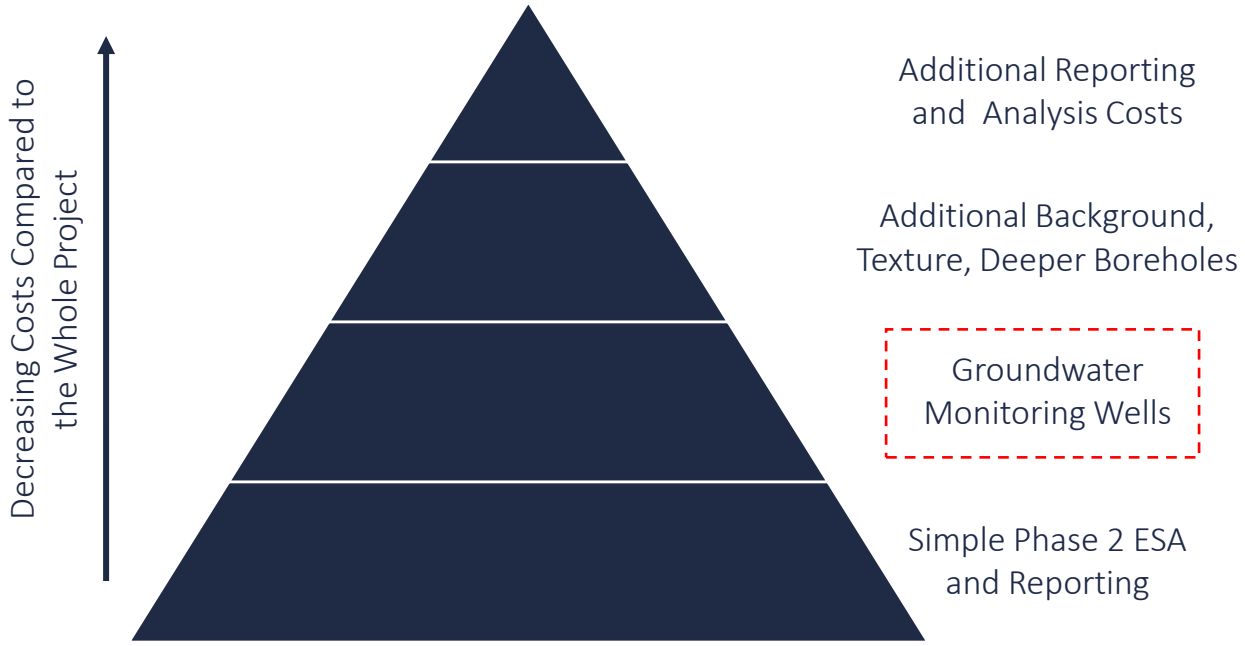
OCTOBER 2023

Keeping it Simple




SSRA
Guideline Modification
Pathway Exclusion
Tier1
Increasing Cost and Data Requirements
This is not proportional

Keeping it Simple



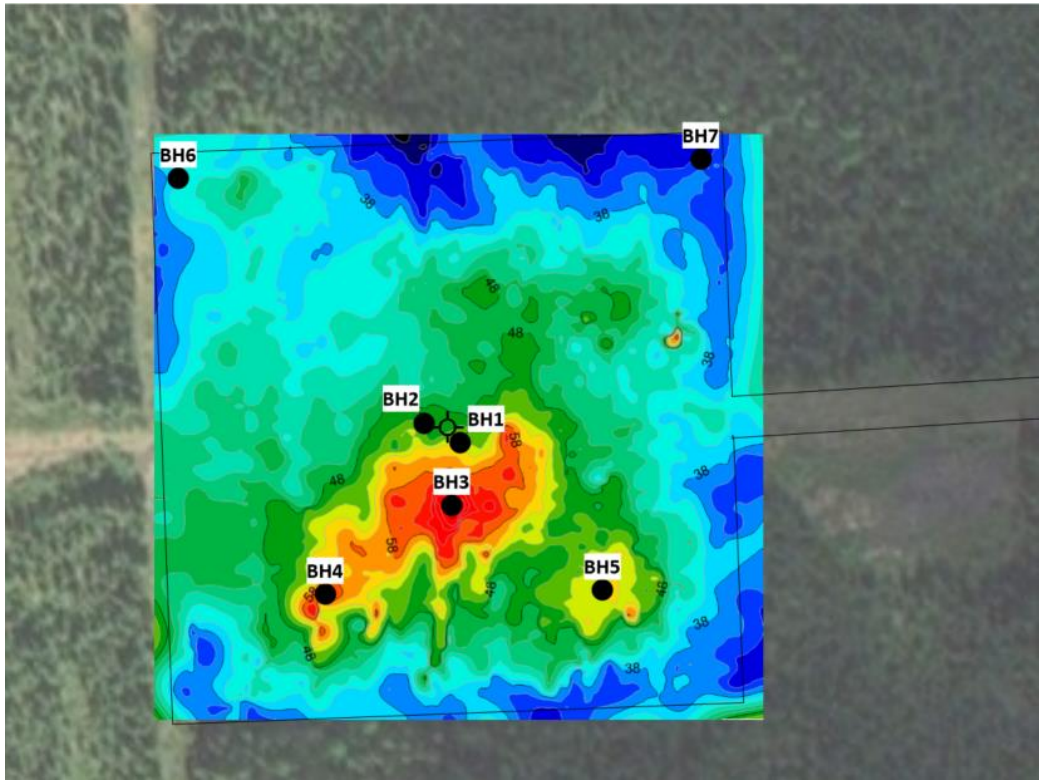
Assessment and Remediation Guidelines

- Tier 1 - generic guidelines designed using relatively conservative assumptions
- Non-alcoholic example, as it is Friday morning!!!

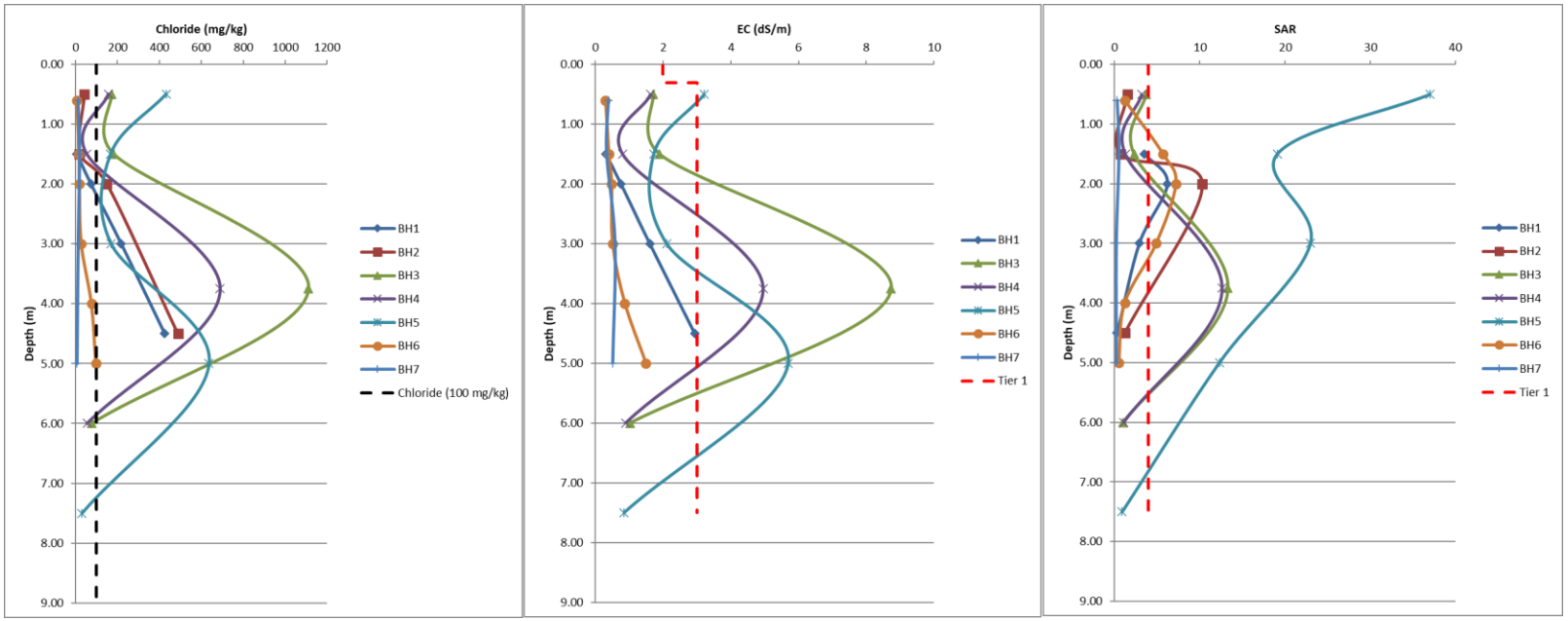
Tier 1

Tier 2

A Tale Of “One Simple Site”: Approached Two Different Ways

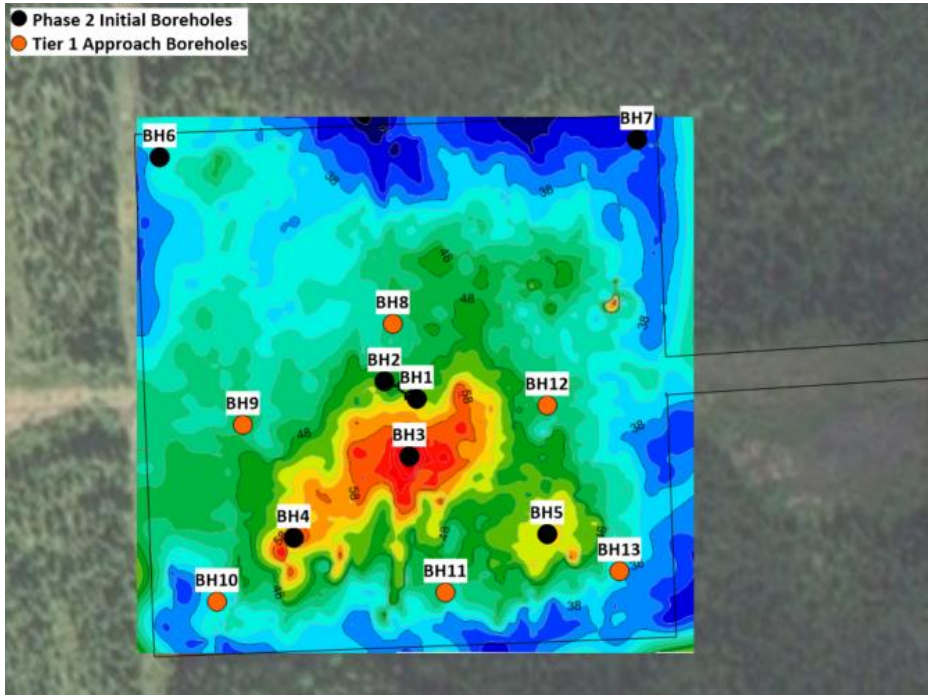


“One Simple Site”: Approached Two Different Ways



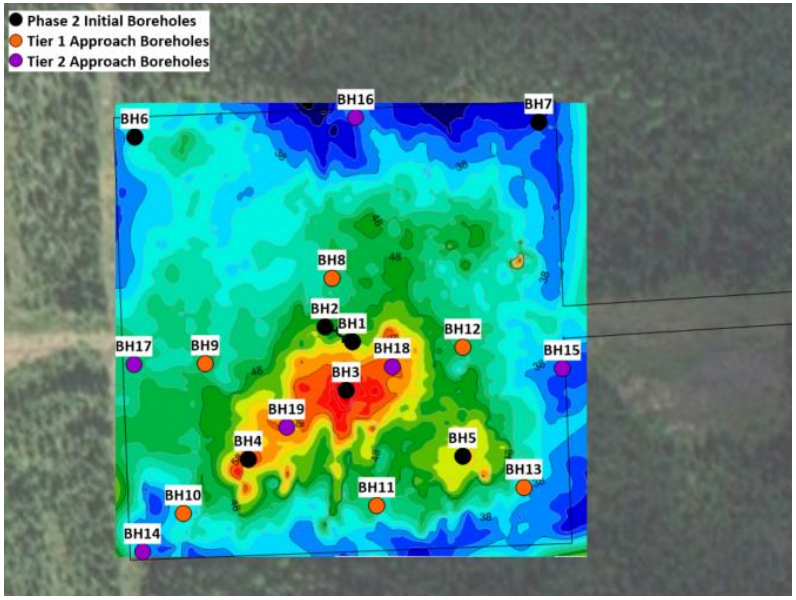
“One Simple Site”: Approach Method 1

- Approach as a Regular Tier 1 Site
  - Assuming groundwater is not impacted
  - Characterize and delineate APECs to Tier 1
  - Two background boreholes
  - Vertical and lateral closure for chloride
  - Cost is approximately $8,000 to $12,000



“One Simple Site”: Approach Method 2

- Approach With a Risk Perspective
  - Delineate APECs
  - Six background boreholes, higher sample intensity, more texture by sieve and hydrometer
  - Vertical and lateral closure for chloride
  - Minimum four boreholes per APEC
  - One deeper borehole for DUA buffer
  - Shelby tubes
  - Cost is approximately $17,000 to $20,000



"One Simple Site": Approached Two Different Ways

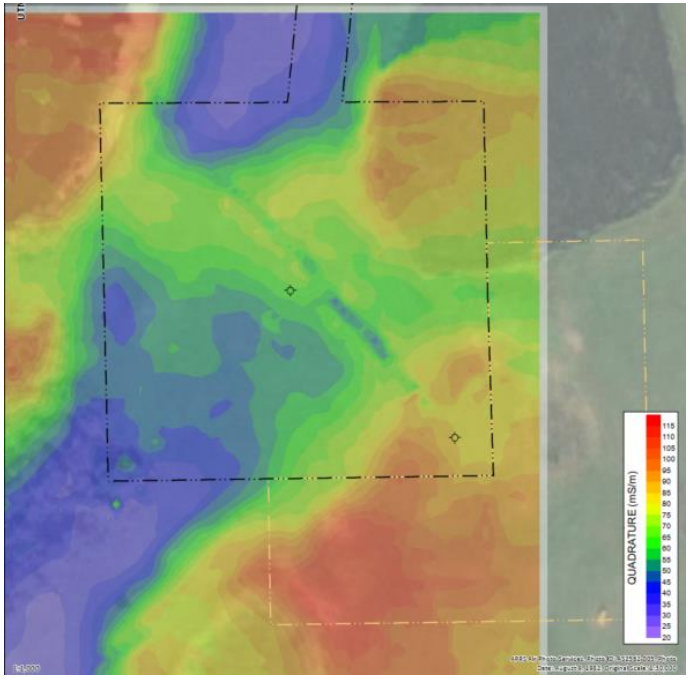
- Cost Breakdown of Investigation and Reporting (approximate)
  - Tier 1 – $8,000 to $12,000
  - Tier 2 – $17,000 to $20,000

- Volumes / Cost Breakdown for Remediation

Guidelines Applied	Area (m^2)	Depth (m)	Volume (m^3)	Estimated cost ($125/$m^3$)
Tier 1	750	6	4500	$ 562,500.00
Tier 2	750	1.5	1125	$ 140,625.00
Additional Costs for Tier 2 Investigation				$ 10,000.00
Tier 2 Actual Cost				$ 150,625.00
Cost Savings				$ 411,875.00

Preplanning

- Background Borehole Locations
- Groundwater Receptors
  - Freshwater Aquatic Life
  - Livestock and Irrigation (depth to GW < 6 m)
  - Drinking Water - Water Well Drilling Reports



Water Well Drilling Reports:

ESA1 identifies water wells within 300 m of the site. Review in detail during ESA2 planning.

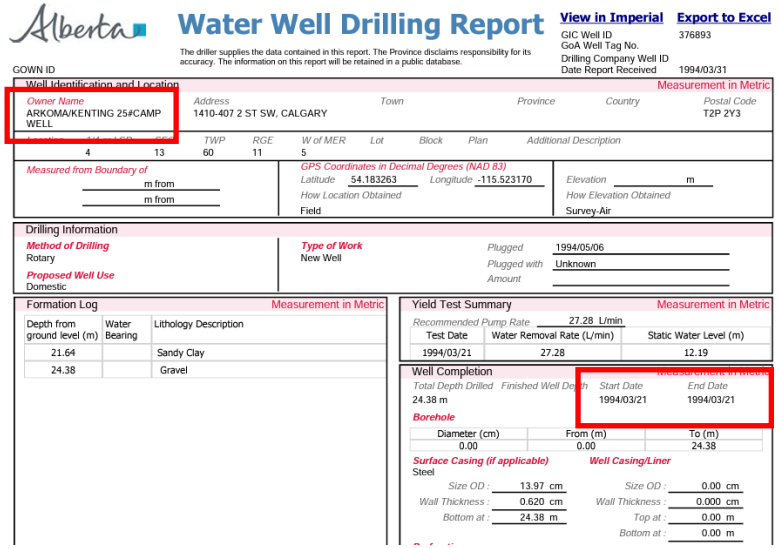
Oil Well Spud Date:
March 24, 1994

Oil Well Drilling Contractor:
Arkoma Drilling Rig #25

Water Well Drilling Date:
March 21, 1994

Water Well Owner:
Arkoma/Kenting 25#Camp Well

Lithology:
21 m Sandy Clay



Alberta

Water Well Drilling Report

View in Imperial | Export to Excel

The driller supplies the data contained in this report. The Province disclaims responsibility for its accuracy. The information on this report will be retained in a public database.

GIC Well ID 376893
GoA Well Tag No.
Drilling Company Well ID
Date Report Received 1994/03/31

GOWN ID

Well Identification and Location — Measurement in Metric

Owner Name: ARKOMA/KENTING 25#CAMP WELL
Address: 1410-407 2 ST SW, CALGARY
Town | Province | Country | Postal Code: T2P 2Y3

TWP	RGE	W of MER	Lot	Block	Plan	Additional Description
4	13	60	11	5		

Measured from Boundary of
m from
m from

GPS Coordinates in Decimal Degrees (NAD 83)
Latitude 54.183263 Longitude -115.523170
How Location Obtained: Field

Elevation m
How Elevation Obtained: Survey-Air

Drilling Information

Method of Drilling: Rotary
Proposed Well Use: Domestic
Type of Work: New Well
Plugged 1994/05/06
Plugged with Unknown
Amount

Formation Log — Measurement in Metric

Depth from ground level (m)	Water Bearing	Lithology Description
21.64		Sandy Clay
24.38		Gravel

Yield Test Summary — Measurement in Metric

Recommended Pump Rate 27.28 L/min

Test Date	Water Removal Rate (L/min)	Static Water Level (m)
1994/03/21	27.28	12.19

Well Completion

Total Depth Drilled 24.38 m | Finished Well Depth | Start Date 1994/03/21 | End Date 1994/03/21

Borehole

Diameter (cm)	From (m)	To (m)
0.00	0.00	24.38

Surface Casing (if applicable): Steel
Size OD : 13.97 cm
Wall Thickness : 0.620 cm
Bottom at : 24.38 m

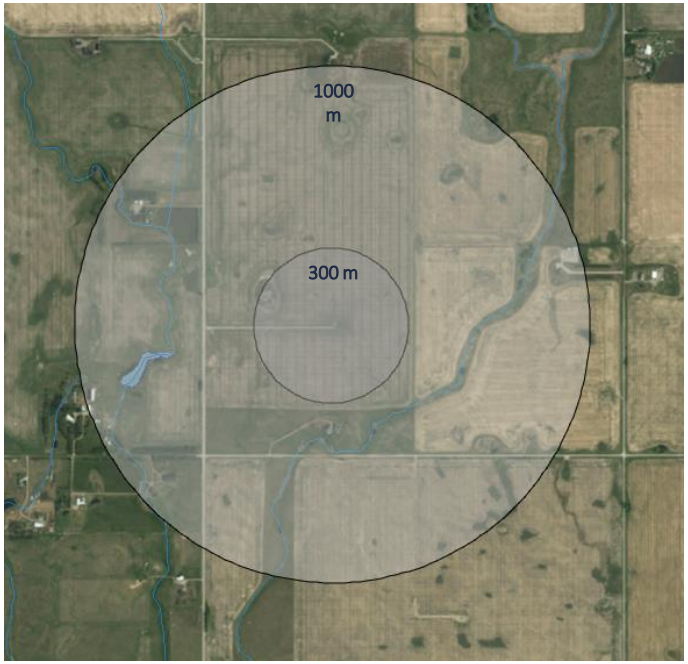
Well Casing/Liner
Size OD : 0.00 cm
Wall Thickness : 0.000 cm
Top at : 0.00 m
Bottom at : 0.00 m

On Lease Water Well -Support for Potential DUA Receptor Exclusion

Keeping it Simple

Freshwater Aquatic Life

- Tier 1 assumes FAL 10 m from impacts
- Identify all waterbodies that can support an aquatic ecosystem 1000 m from
- Potential Exclusion of Pathway for BTEX (groundwater flow direction and parameter specific)
- Can not be excluded for salts but the farther away the better
- Depending on the contaminants of concern, a recalculation under Tier 2 using the actual distance to the closest aquatic ecosystem, can substantially relax guidelines.



Chlorides:

The swear word heard in oil/gas company offices in Western Canada, but the most challenging and fun part of the work for environmental consultants.

The Tier 1 requirement to delineate chlorides in soil to meet the lowest applicable guideline is often either overlooked or misunderstood in basic Phase 2 assessments. This can lead to regulatory rejection of the ESA 2 at the time of reclamation, or over excavation of salt impacted soils.

- Natural versus anthropogenic sources
- Shallow impacts and deep groundwater

Phase 2: Sampling with Tier 2 in Mind

- Texture requirements
  - Texture by sieve and hydrometer (sand % / silt % / clay %) from 0 to 1.0 m, 1.0 to 1.5 m and subsoil (>1.5 m)
  - Three samples from each depth interval / unique lithology observed
- One deeper borehole (not in the impacted area)
  - Potentially to exclude the DUA for BTEX and relax SST guidelines
  - Need 5 m of “isolating geologic unit” with a hydraulic conductivity less than 1×10^{-7} m/s
  - Shelby tubes are relatively inexpensive to obtain and very valuable, if required
- Minimum four boreholes within each impacted area
- Lateral and vertical delineation

Other Tools and Considerations

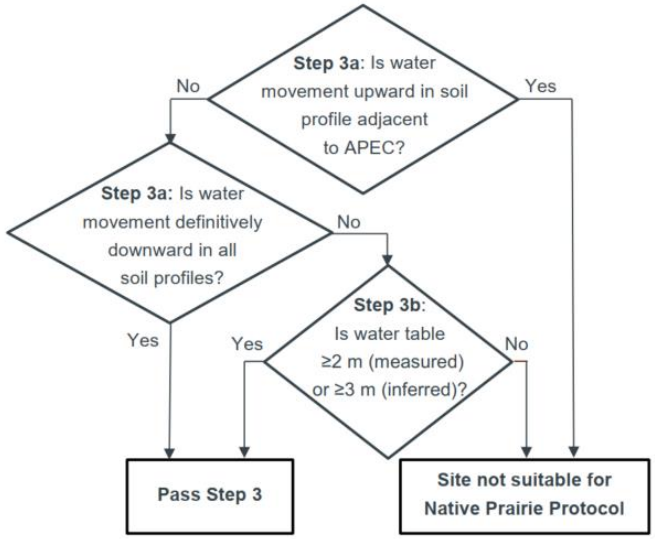
Native Prairie Protocol (NPP)

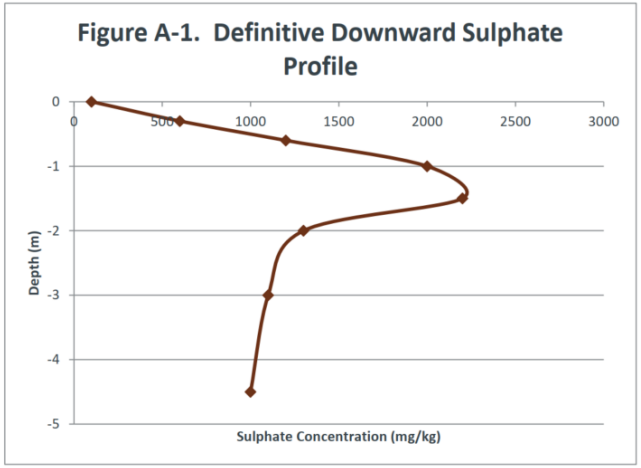
- Soil salinity > Tier 1 guidelines
- Meets SST guidelines for all pathways except root zone
- No adverse effects to the plant community
- Demonstrate no likely future adverse effects
    - Groundwater deeper than 2 m
    - Min one soil profile near each salt impacted area
    - Minimum of three soil profiles in background
    - Total of eight samples should be collected from each borehole between surface and 4.5 m in depth with closer sample spacing at shallow depths and wider spacing with increasing depth
    - Potential to change RZ drainage rate in SST regardless of vegetation

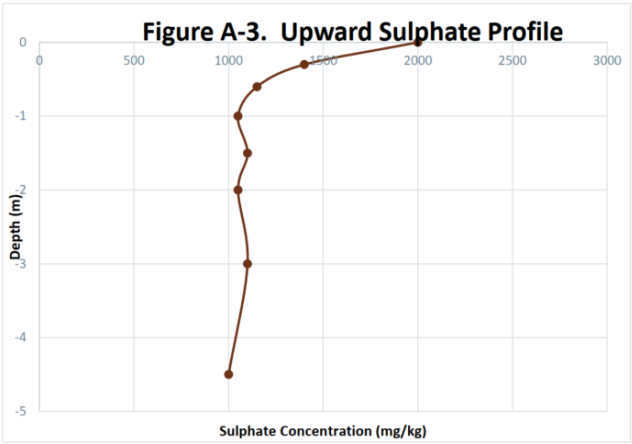
- Plan to collect required data during initial/supplemental ESA2.
- Complete a native grasslands DSA in conjunction with obtaining data to support SST/NPP.

Other Tools and Considerations

Native Prairie Protocol (NPP)







Phase 2: Sampling with Tier 2 in Mind

- Do you really need monitoring wells?
  - FAL is constraining; need at least 3 shallow
  - DUA is constraining; 3 deep may help but not if lithology indicates groundwater is slow
  - Nested pairs can help with rooting zone and DUA guidelines
- But…
  - Can use borehole logs for depth to GW, per the SST
  - Determine background TDS by sulphate concentrations in soil
  - Look for coarse intervals in Sat% data

Complicated, Simplified

- Detailed review of available background information
- Look at information from other local area sites
- Data, Data, Data – characterize and delineate
- Employ expertise early
- Client Perception – Tier 1 is too conservative, but Tier 2 is too costly. Potential major savings on remediation

Questions?