



Collaboration in Remediation Practices using Geophysics and Soil Sampling



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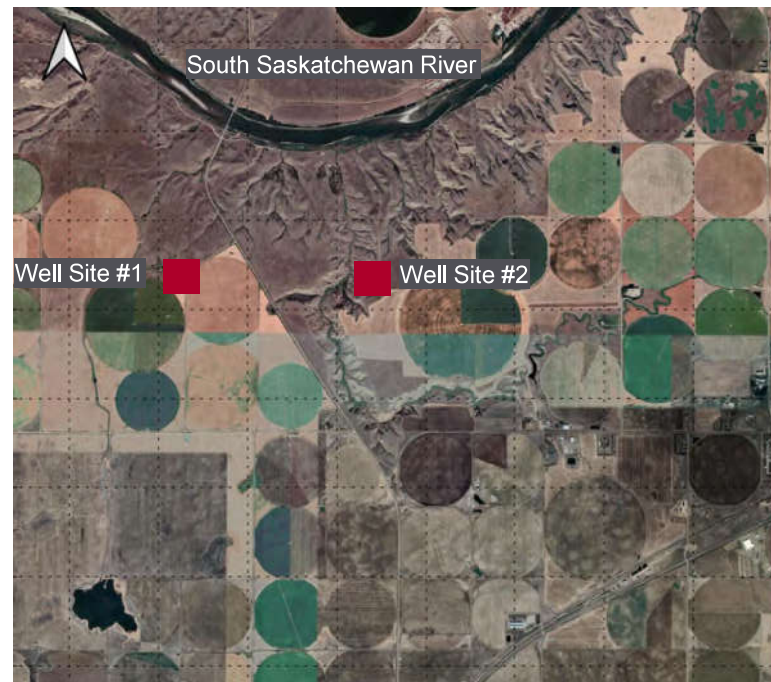
5/25/2022 Calgary, AB



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Overview

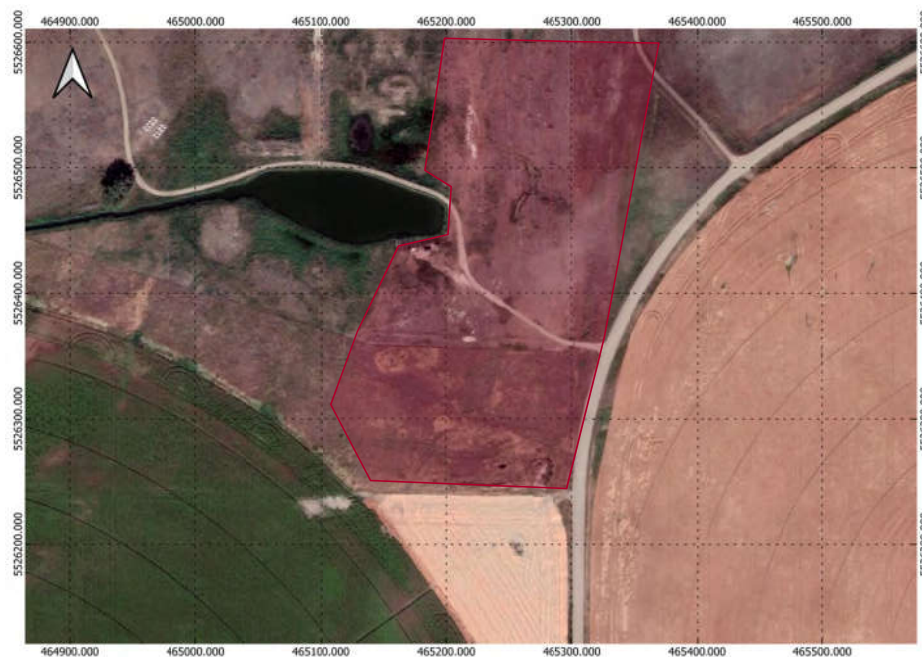
- **Two Decommissioned Oil and Gas Sites in Southern Alberta**
 - Historical Overview and Decommissioning
 - Environmental Significance and Land Use
 - Site Assessment – Environmental and Geophysical
 - Planned Closure Strategy and End Land-Use



HISTORICAL OVERVIEW

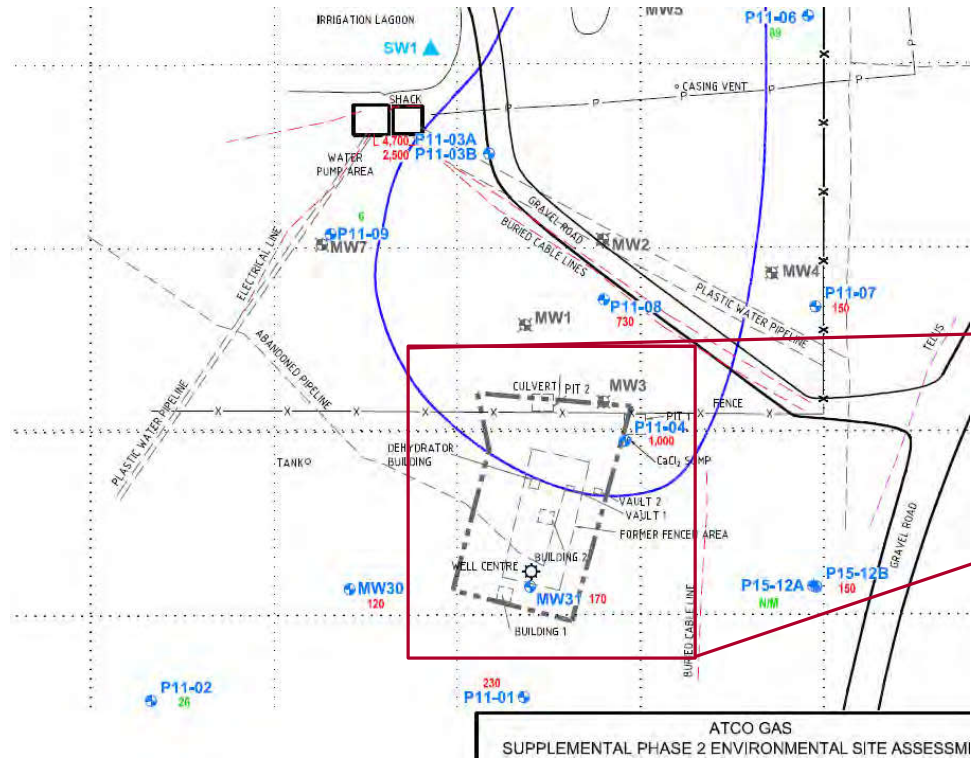
Well Site #1

- Original well was spudded on March 22, 1912 and put into production on Aug. 7th, 1912
- Well site converted to liquid petroleum gas storage in May, 1968, and suspended in 1987
- Site was abandoned in November, 1996
- Infrastructure included wellhead, two buildings, above-ground and buried piping, a dehydrator, calcium chloride sump, and two vaults
- Phase 1 ESA (2006) identified two pits during aerial photo review



HISTORICAL OVERVIEW

Well Site #1



HISTORICAL OVERVIEW

Well Site #1



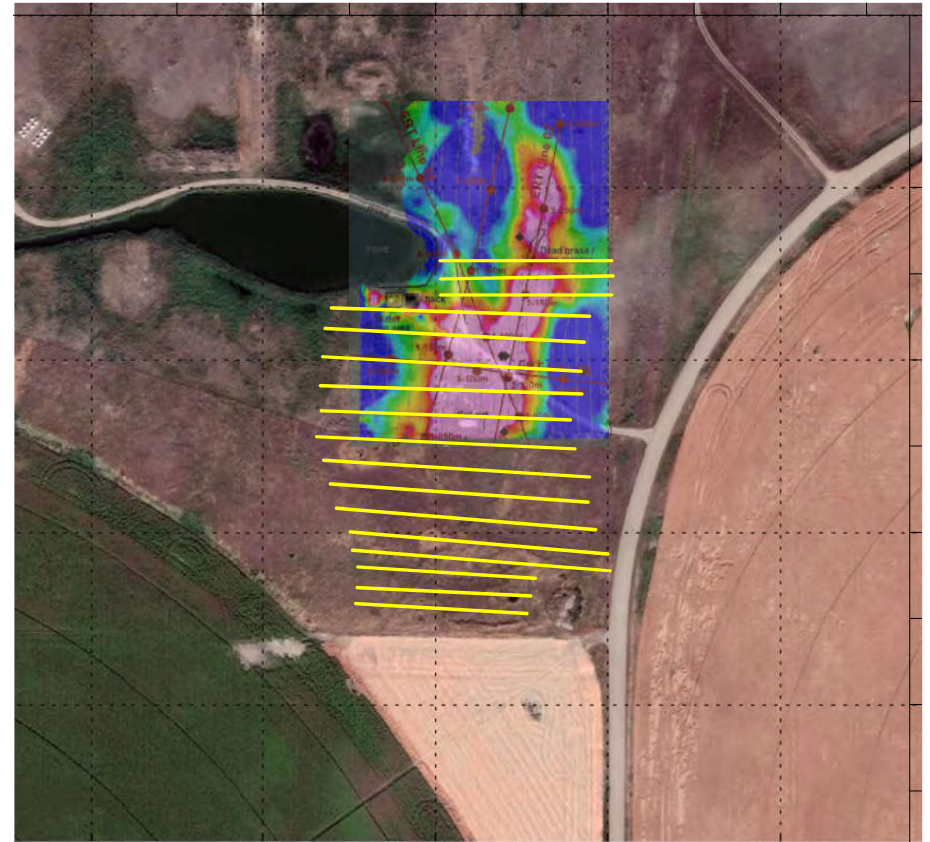
Historical Environmental Site Assessments:

- 1977 – site inspection of leaking surface casing
- 1980 – internal company memo addressed to Canadian Western Natural Gas (CWNG) indicated elevated chloride in casing vent overflow
- 1991 – Lore & Associates prepared a report for CWNG detailing an environmental assessment and development plan
- 1994 – Komex International Ltd. conducted an environmental audit where areas void of vegetation and elevated pH, EC, and SAR values were reported
- 1996 – Land Resources Network Ltd. completed an environmental audit. Seven locations were sampled and elevated soluble chloride concentrations were noted near the CaCl₂ sump. No recommendation to conserve the native top soil was made.
- 1999 – ATCO Pipelines sent a letter to Alberta Environmental Protection indicating their intent to reclaim 17 well sites in the region, including this well site. Stantec Ltd. conducted an environmental evaluation of the site to develop and implement a remediation/reclamation plan, including geophysics, soil sampling, borehole drilling, lab analysis, and monitoring well installation. Unsuitable EC and SAR levels were found, along with elevated TDS throughout the Site. Surface reclamation was proposed but not executed.
- 2000 - 2002 – Stantec completed a supplemental environmental investigation to evaluate and delineate impacts previously identified. Two main environmental risks were identified: chloride impacts to the nearby irrigation lagoon and the migration of chloride impacted groundwater to down-gradient receptors.
- 2006 – WorleyParsons Komex conducted a Phase 1 ESA to identify actual or potential evidence of impact. A Phase 2 ESA was recommended.
- 2010 – WorleyParsons conducted geophysical investigations (EM31/EM38 and ERT). Elevated terrain conductivities exceeding 100 mS/m covered an area of ~ 7,200 m² encompassing historical facilities. ERT lines measured conductivities exceeding 140 mS/m at depths below the EM31, interpreted to indicate groundwater impacts.
- 2011 – WorleyParsons extended their ERT lines, followed by a Phase 2 ESA. Impacts were interpreted down-gradient of the CaCl₂ sump, down to at least 11.5 mbgs but not exceeding 16.0 mbgs. Soluble chloride was used as an indicator of facility-related impacts.
- 2017 – A Supplemental Phase 2 ESA was performed by Advisian WorleyParsons Group, which delineated historical soil impacts across the Site. 18 boreholes were advanced to 13.1 mbgs and two sets of nested monitoring wells. Chloride was used to indicate soil impact, with concentrations up to 100 mg/kg considered as background.
- 2021 – DMT Geosciences Ltd was contracted by Stantec to perform a RCV survey to acquire a pseudo-3D volume of terrain conductivity to assess site impacts. Results were reported to Stantec, which was then taken on by Envirosearch Ltd. for additional soil sampling and borehole analysis using the results of the RCV survey.

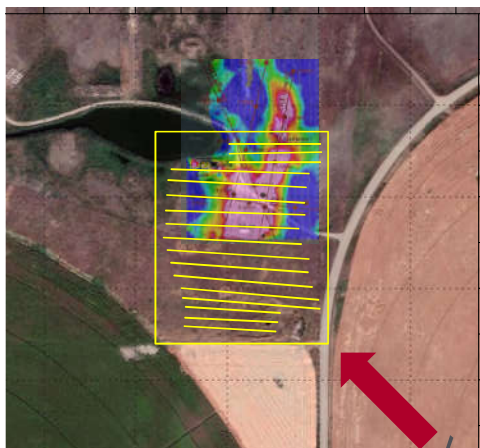
Well Site #1



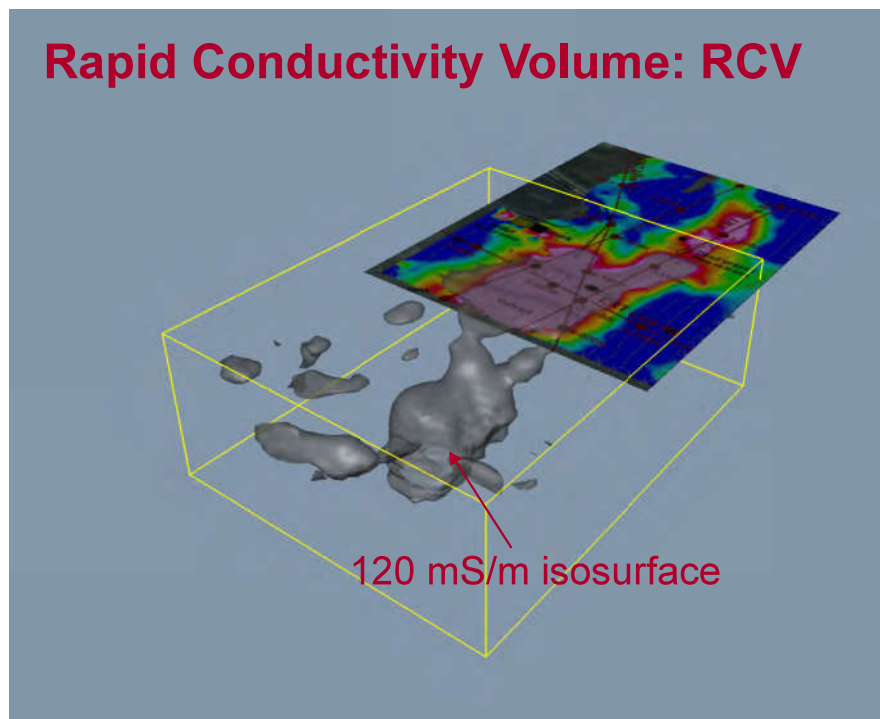
- Previous EM31 results shows lateral delineation
 - No vertical delineation...
- Rapid Conductivity Volume (RCV) survey to cover lease area and delineate down to approx. 20 mbgs



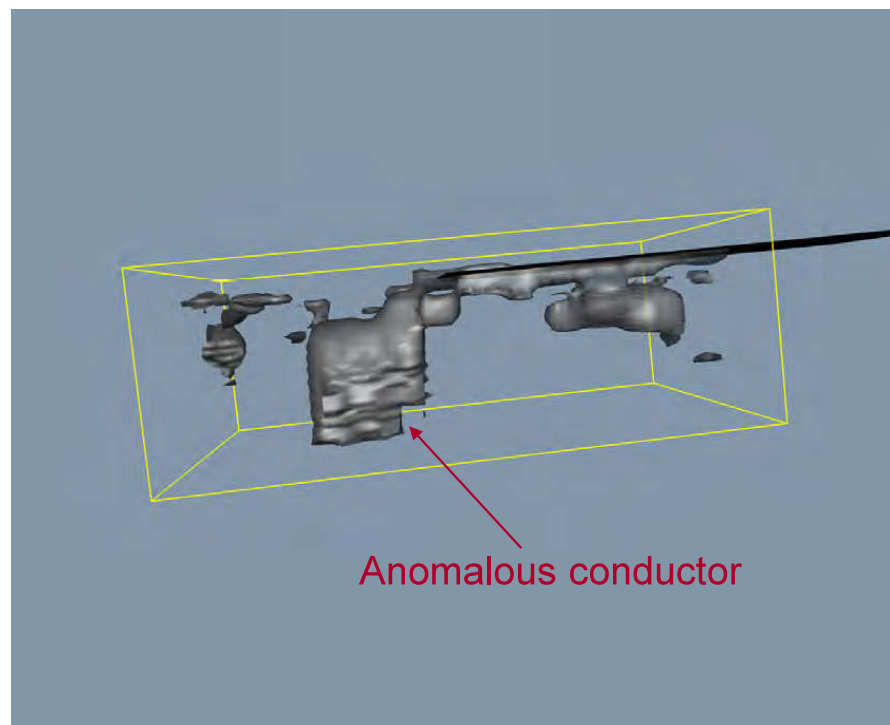
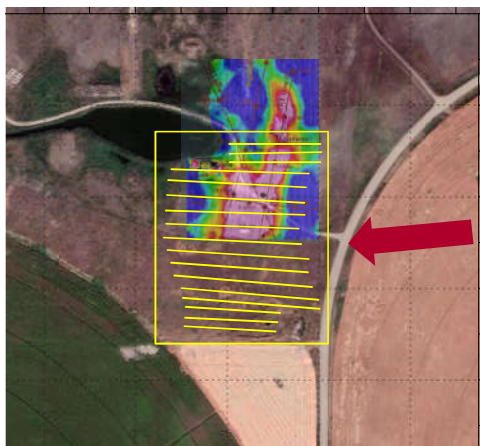
Well Site #1



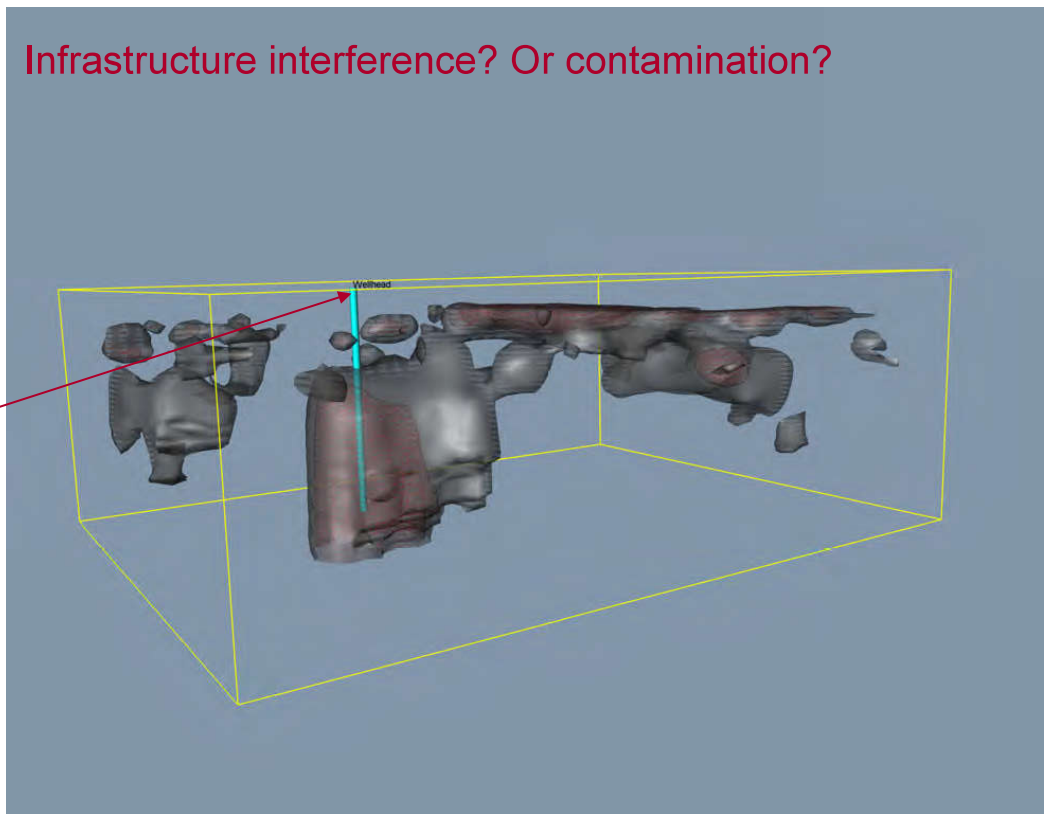
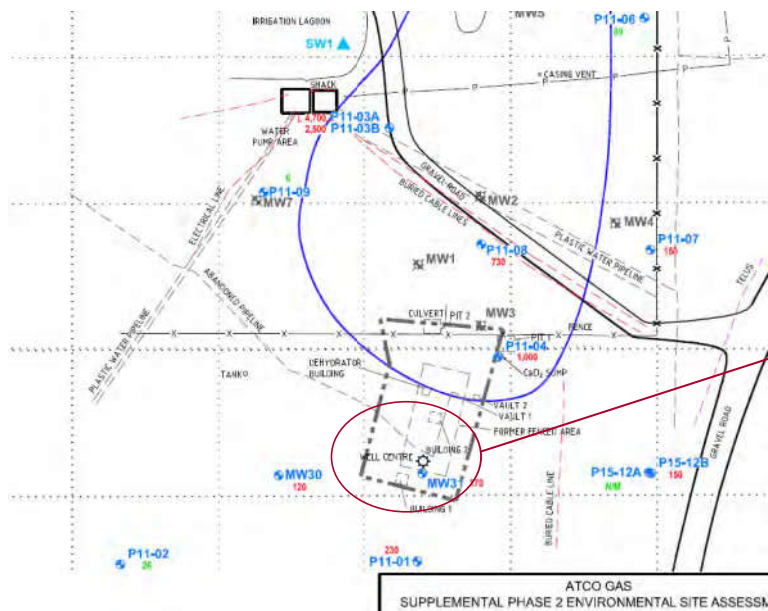
View perspective



Well Site #1



Well Site #1



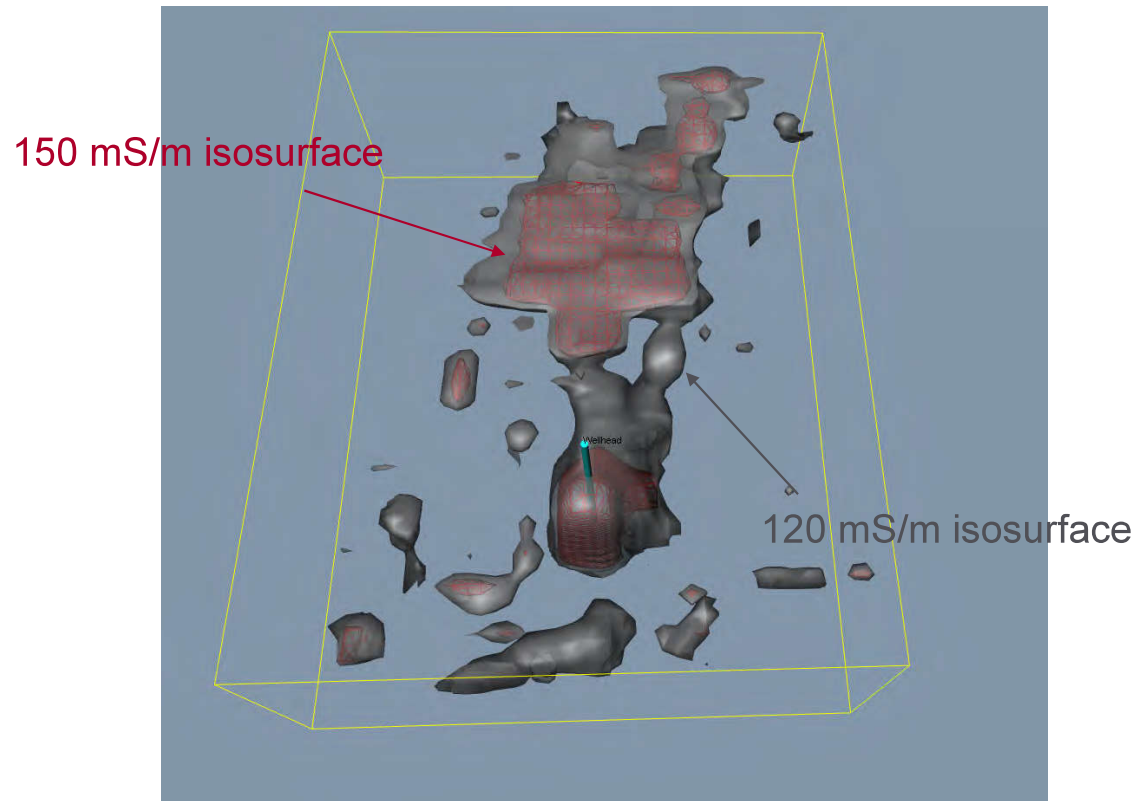
Well Site #1



- **Boreholes shown:**
 - Pre-2021 sampling highlighting chloride concentrations ≥ 100 mg/kg
 - Borehole size scaled to chloride concentration: wider = higher [Cl]



Well Site #1



Well Site #1

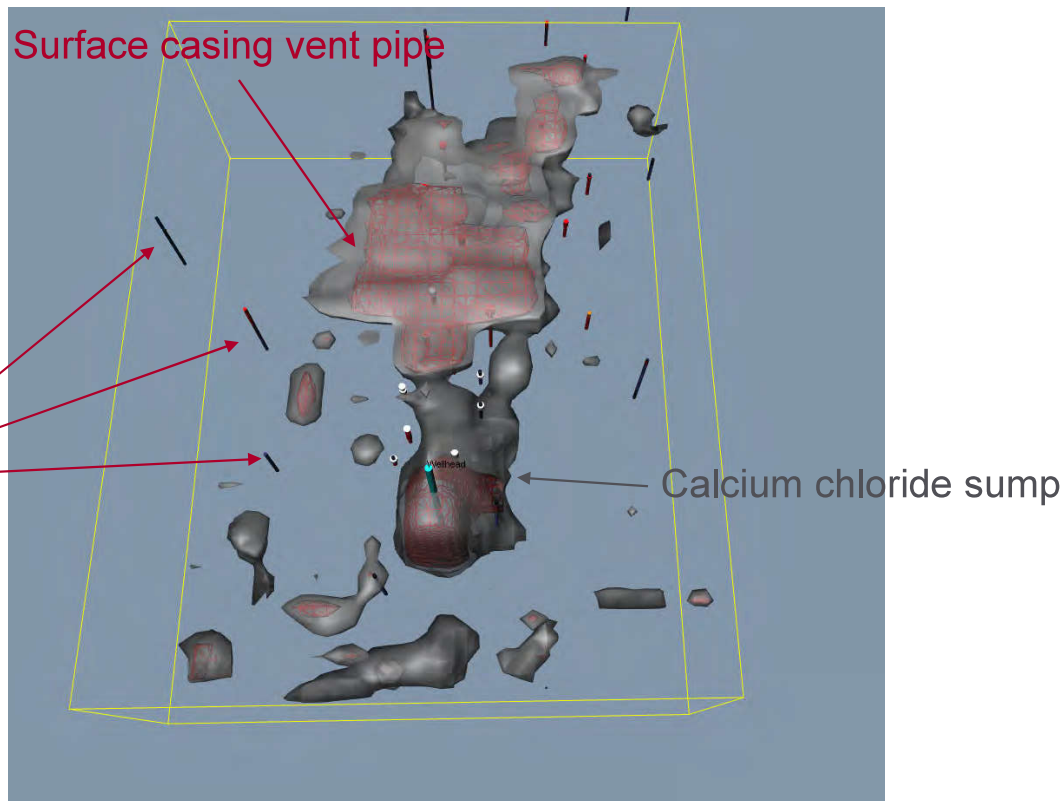


- **Two different contaminant sources identified:**

- Well center and Calcium Chloride Sump (deep)
- Surface casing vent pipe (shallow)

- **Boreholes shown:**

- 2021 sampling Program to target geophysical anomalies



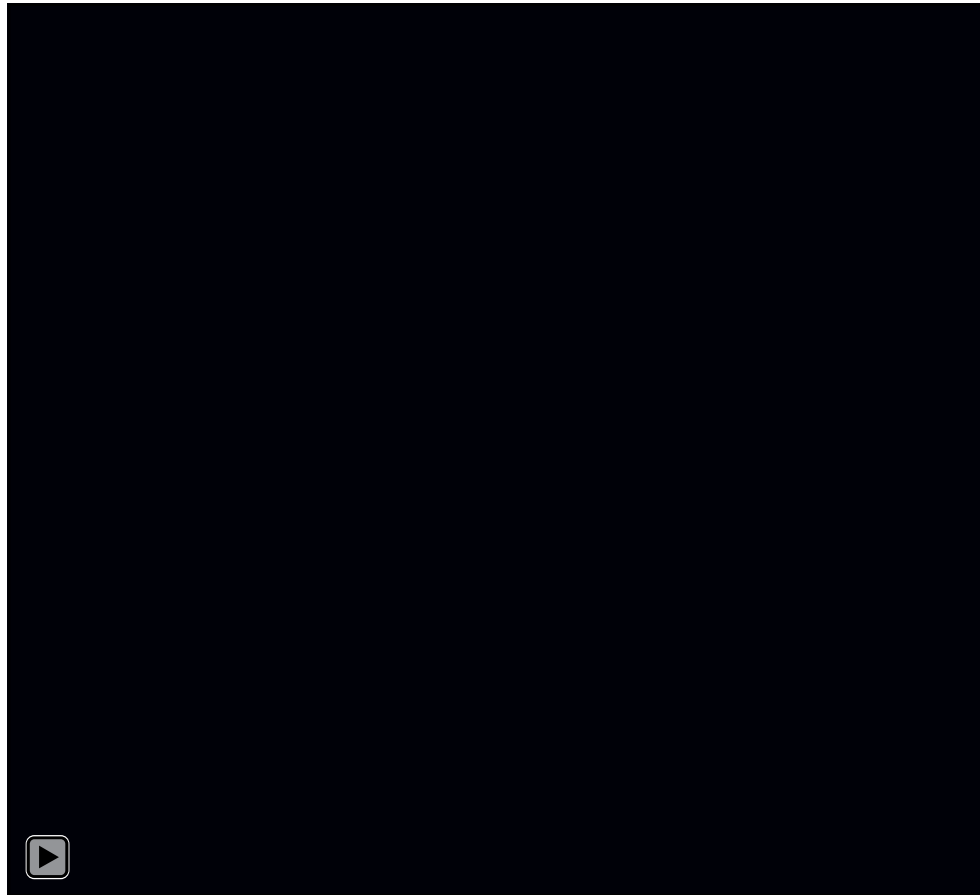
2021 GEOPHYSICAL PROGRAM

Well Site #1

- 2021 Borehole Sampling Program to target geophysical anomalies



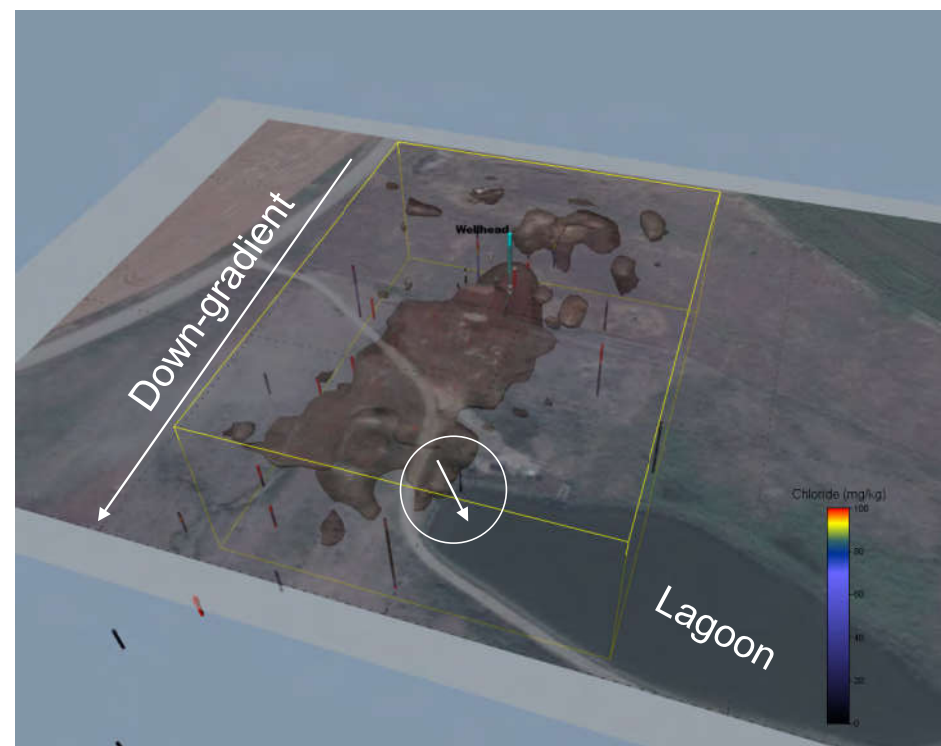
2021 GEOPHYSICAL PROGRAM
Well Site #1



Well Site #1 – Summary and Current Conditions



- **2021 Sampling program showed good correlation with the RCV survey – geophysics can be used for salt impact delineation and volume estimation (with care)**
- **Two main sources identified:**
 - Well center and calcium chloride sump → deeper impact
 - Surface casing vent → shallower impact
- **Concerns for closure:**
 - Deep impacts have possible implications for domestic water well use and river
 - Shallow impacts have possible implications for ecological receptors (i.e. plant-rooting zone and irrigation lagoon)

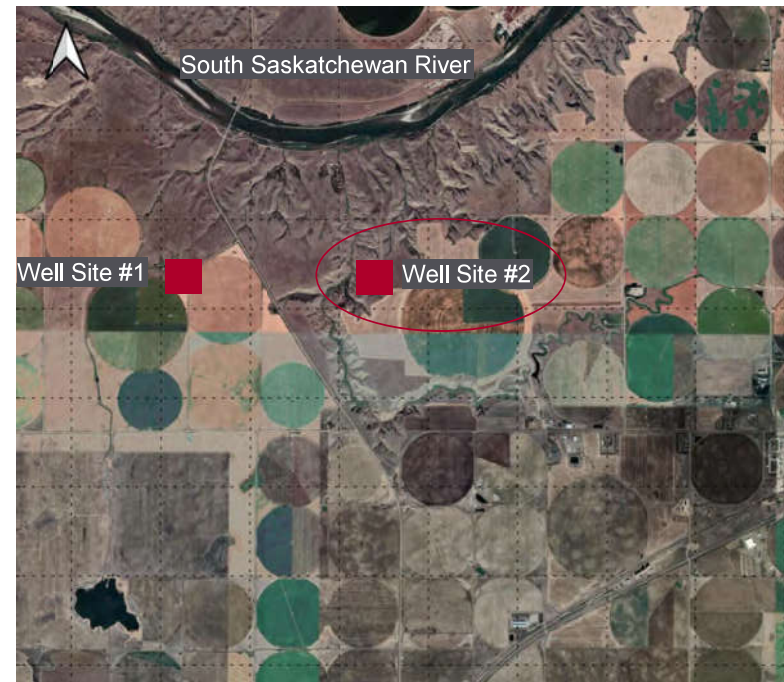


SITE #2 OVERVIEW
Well Site #2



▪ **Location conditions:**

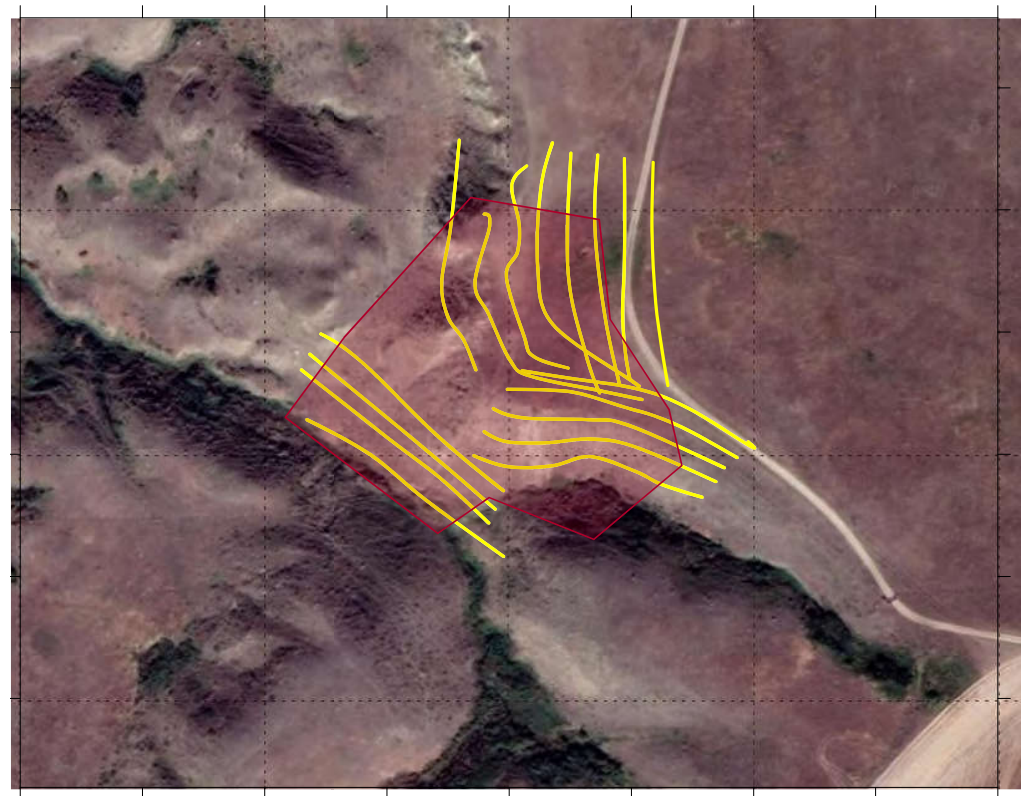
- Very sensitive land; pre-contact stone circles, native prairie landscape, sensitive wildlife
- Surrounded by steep, gully terrain



Well Site #2



- Adjacent to a steeply sloped ravine situated 290 metres west of the lease site
- Produced natural gas from 1912 to 1968
- Converted to gas storage in 1968, suspended in 1995
- Site was abandoned in 1996
- Infrastructure included wellhead, a dehydrator, calcium chloride sump, vault, and surface casing vent pipe
- Various ESA's and geophysical surveys performed since 1996



HISTORICAL OVERVIEW

Well Site #2

- Steep!
- Complicated terrain

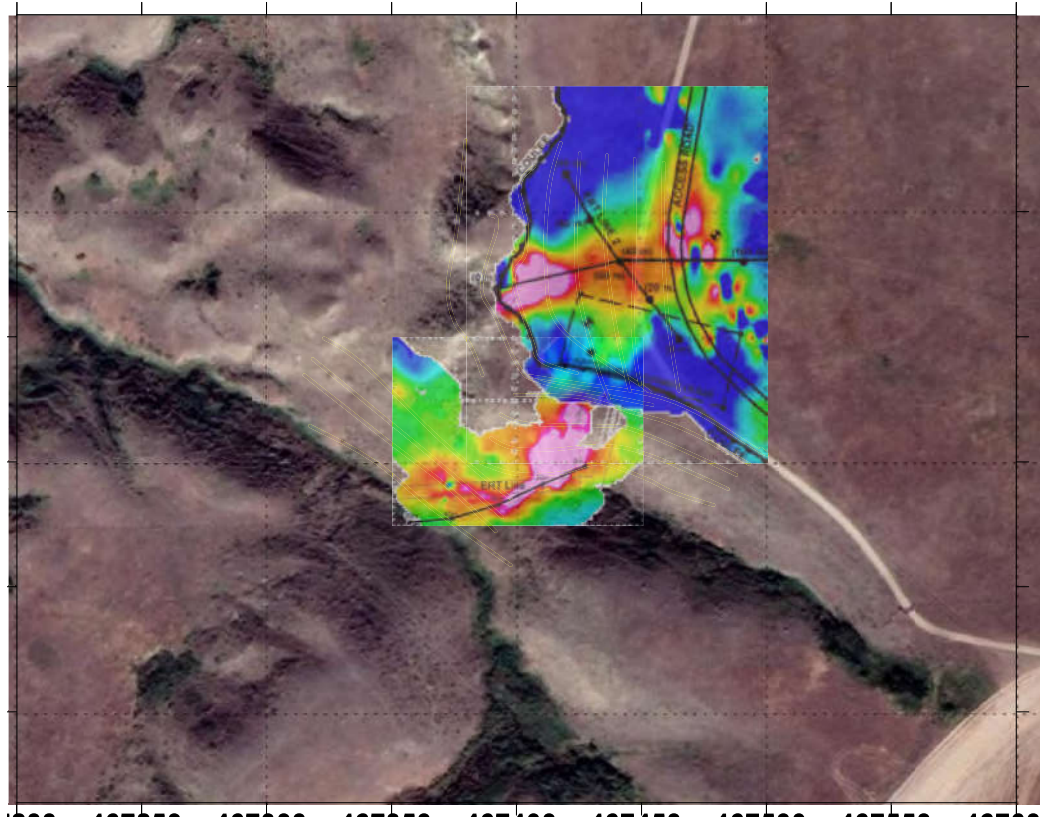


HISTORICAL OVERVIEW

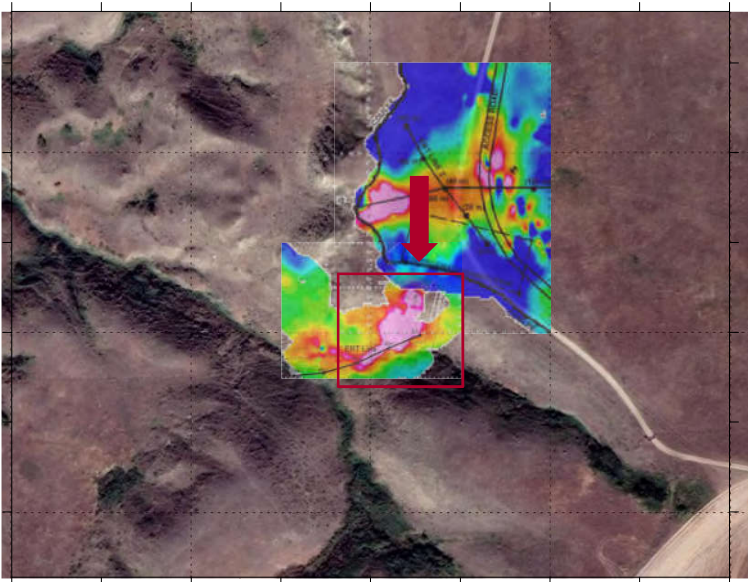
Well Site #2



- EM31 surveys show impacts near the surface



HISTORICAL OVERVIEW
Well Site #2



Well Site #2



Well Site #2



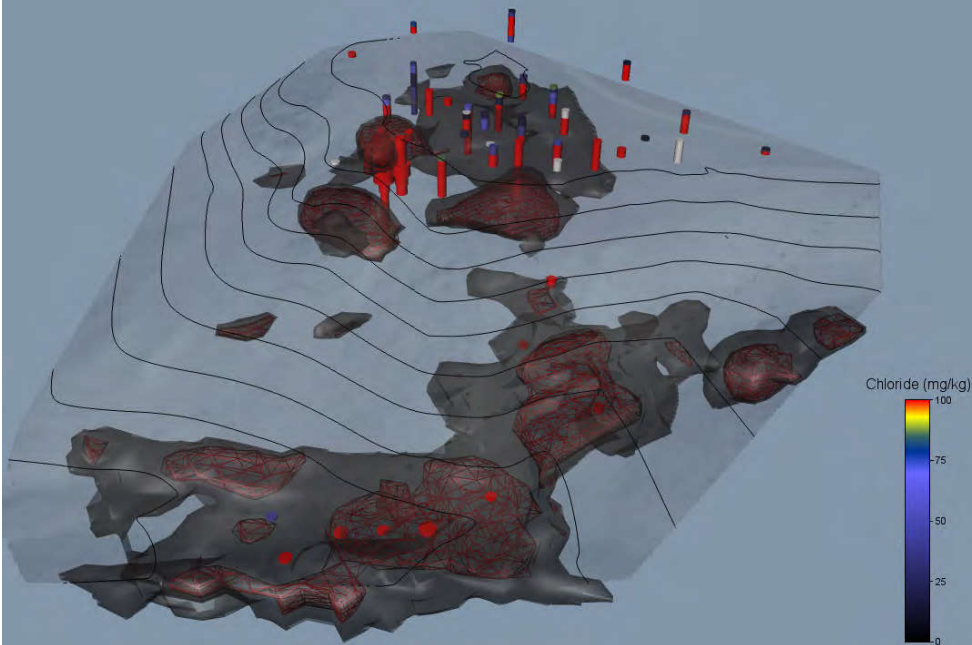
- **Two different sources mapped:**
 - Calcium chloride sump
 - Surface casing vent pipe



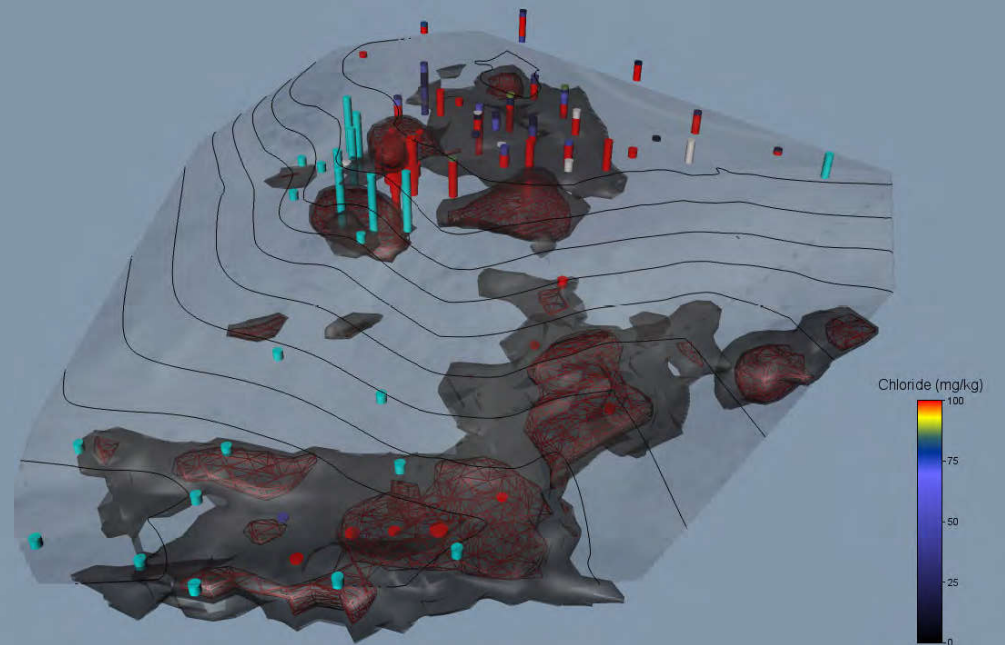
2021 GEOPHYSICAL PROGRAM
Well Site #2



Pre-2021 borehole sampling



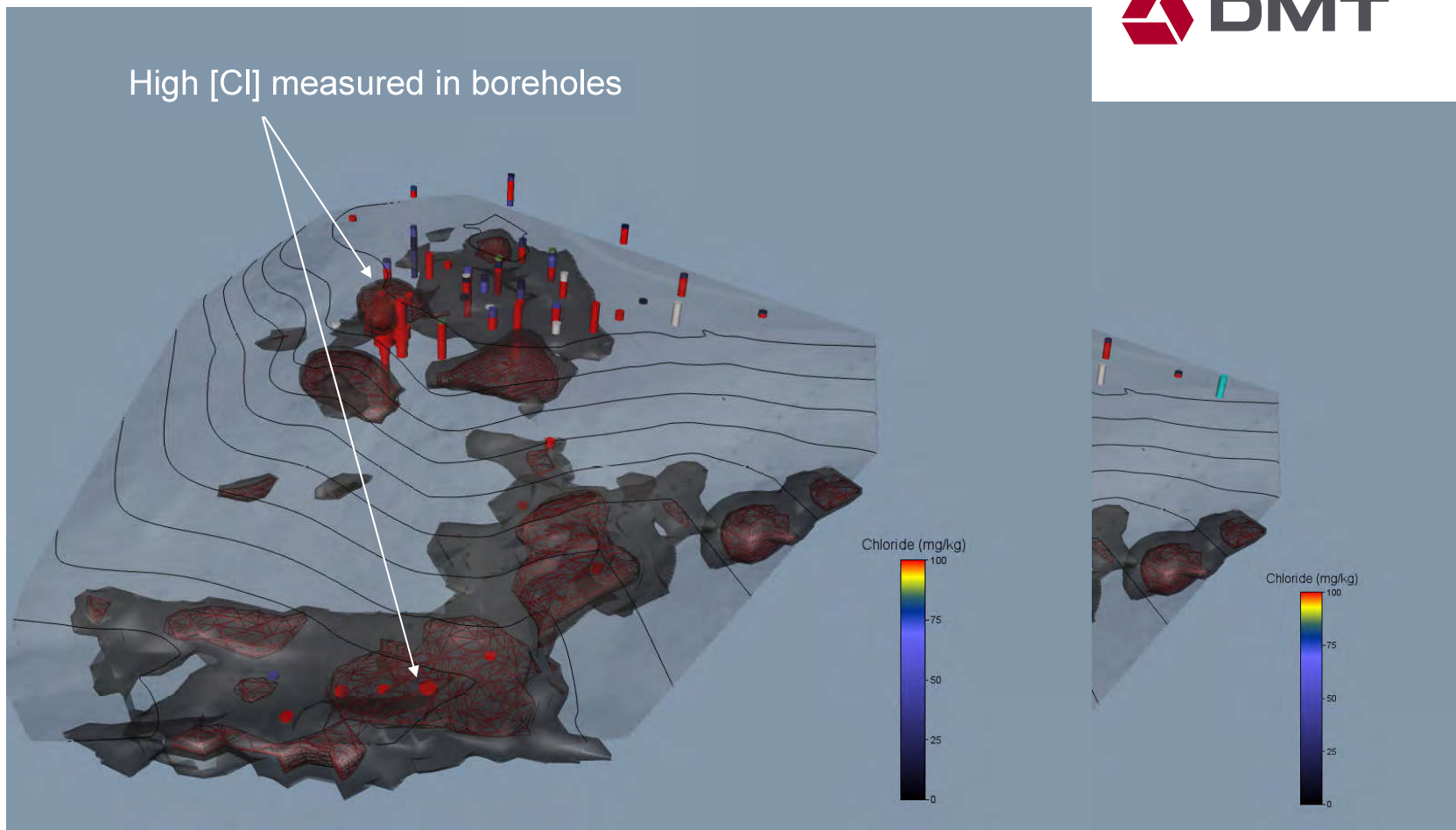
Planned borehole sampling



Well Site #2



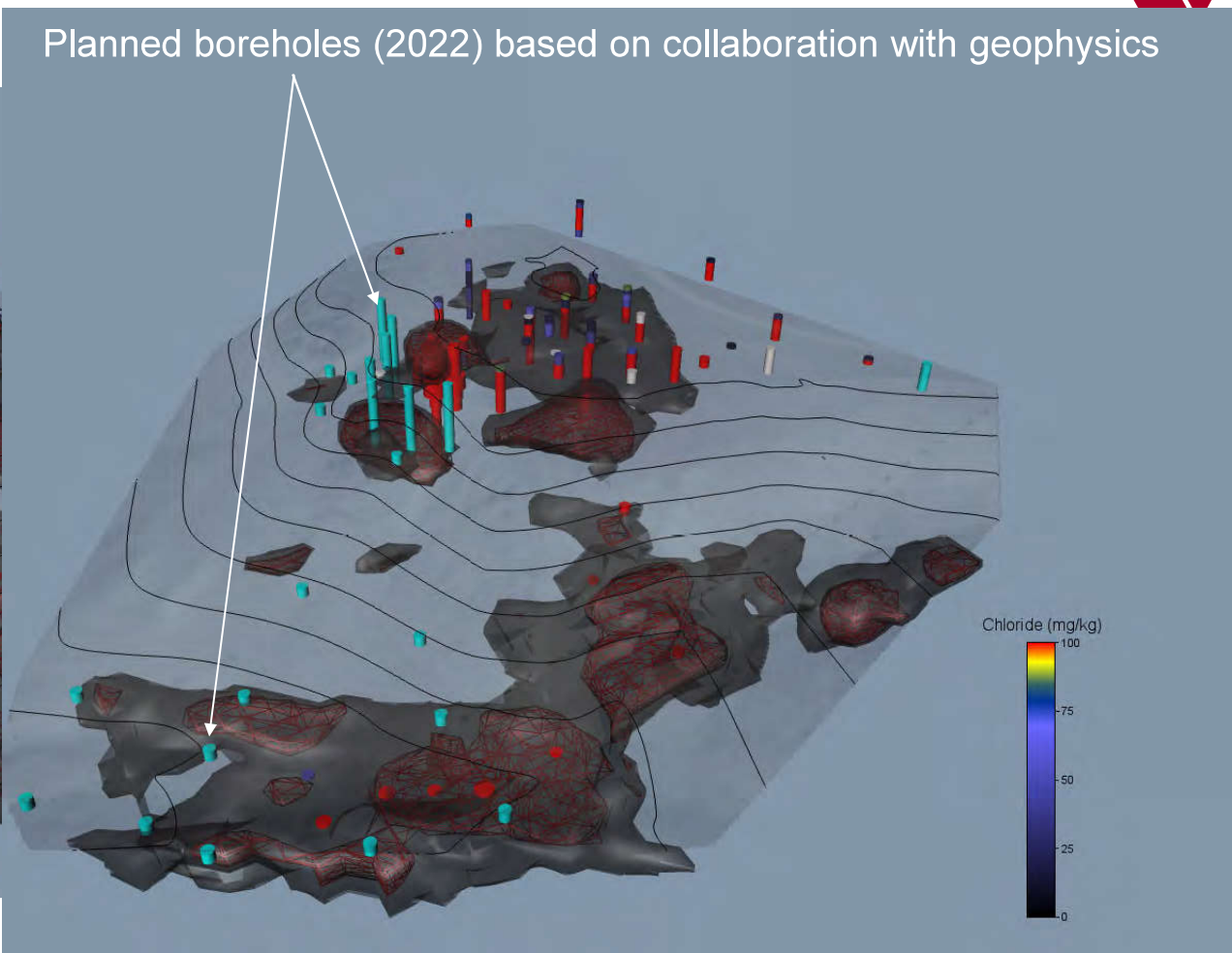
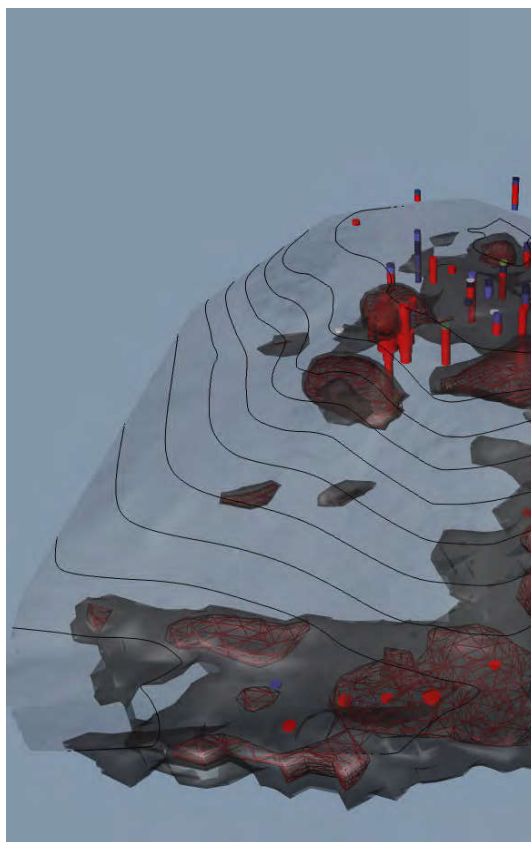
High [Cl] measured in boreholes



Well Site #2



Planned boreholes (2022) based on collaboration with geophysics

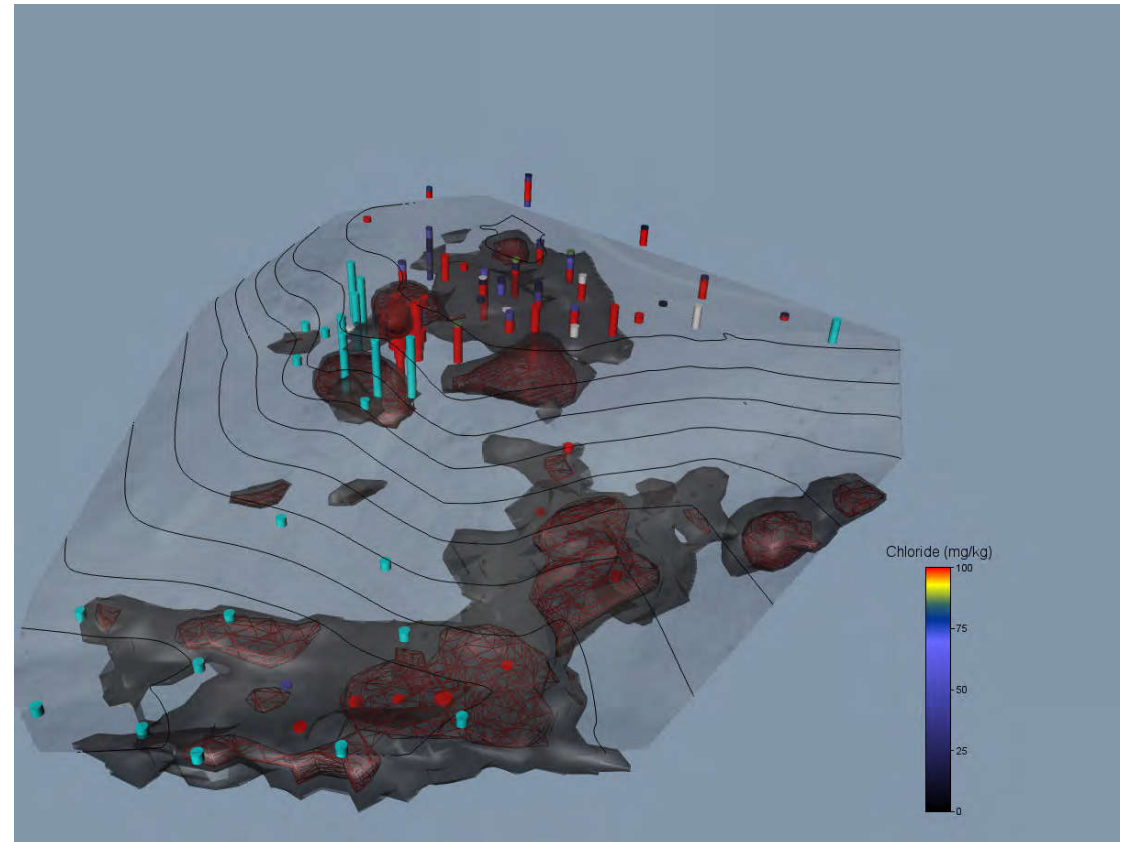


SUMMARY

Well Site #2 – Summary and Current Status



- Pre-2021 sampling showed good correlation with the most recent geophysical program → geophysics relied on heavily for impact delineation
- Planned borehole samples (shown in cyan) are targeted based on the pseudo-3D model, improving efficiency and cost effectiveness of the sampling strategy
- Geophysics aids with complicating factors:
 - Sensitive vegetation and wildlife – sweeps required every survey
 - Pre-contact stone circles limit the sampling area
 - Steep topography limits the ability to sample deeper (i.e drill rig)



Conclusions

- Geophysical surveys provide valuable site assessment tools that limit the cost and “guess work” attributed to borehole sampling – sharing all the information improves the effectiveness of these surveys
- Geophysics can provide valuable information/delineation in complex or rugged terrain, where traditional ground sampling is difficult / impossible
- Combined efforts between consulting companies with different expertise allows for the optimal strategy to be put forward towards the ultimate goal of remediation and reclamation





Thank You



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