HYDROGEOLOGICAL MODELLING APPLIED TO MINERAL EXPLORATION

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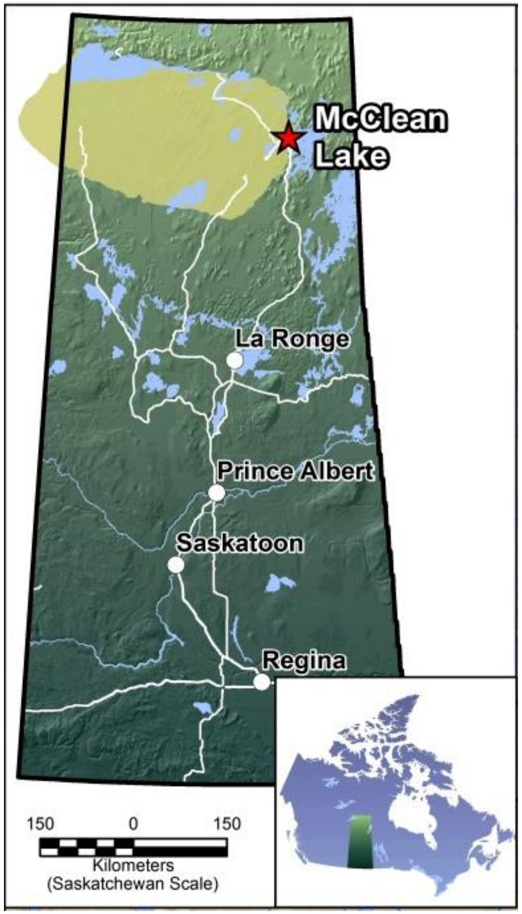
ATHABASCA BASIN (CANADA)



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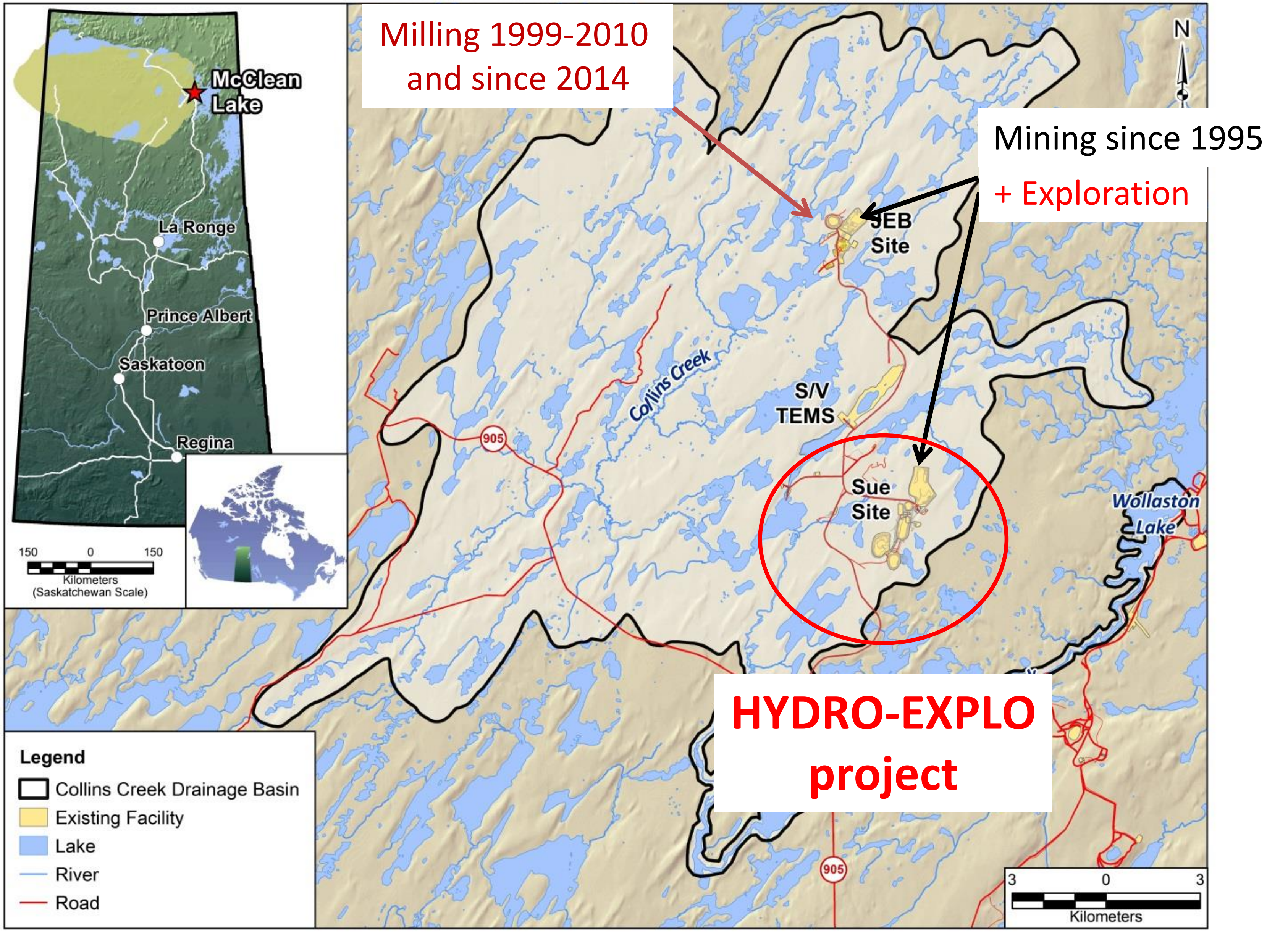
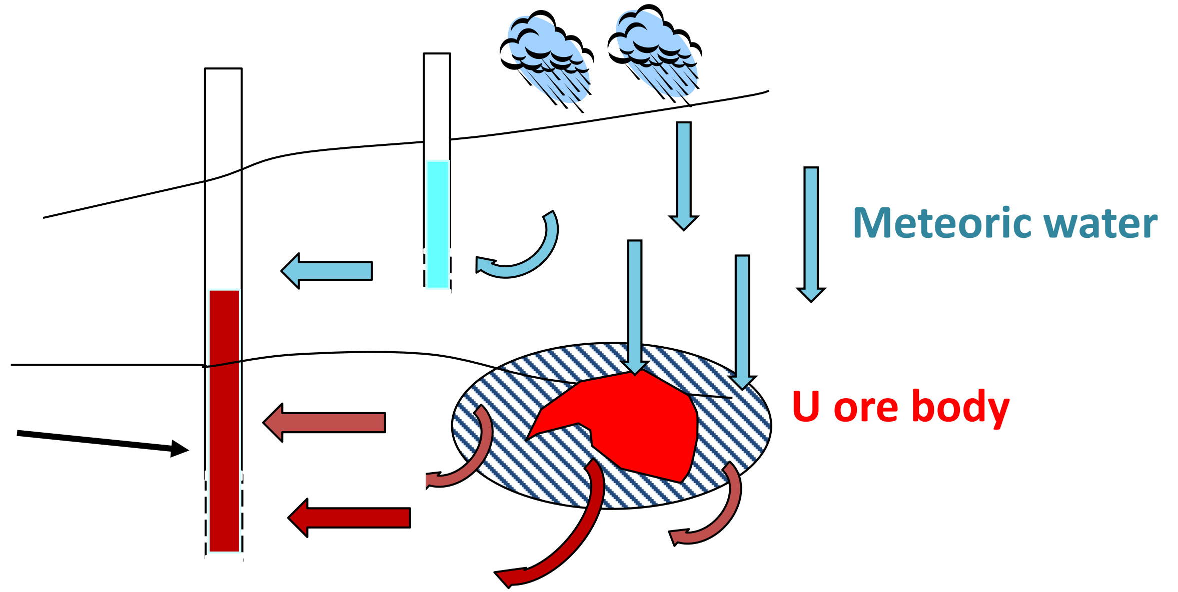
Location

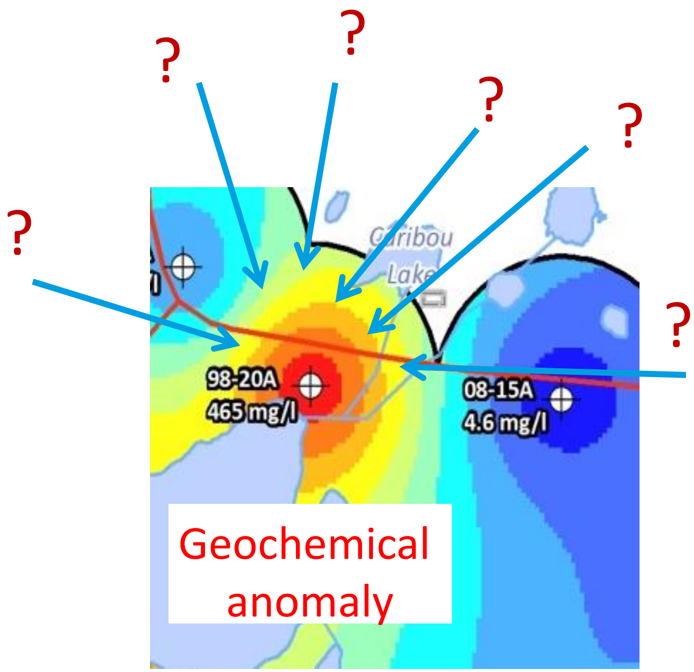


Milling 1999-2010
and since 2014
Mining since 1995
+ Exploration
HYDRO-EXPLO
project
McClean
Lake
La Ronge
Prince Albert
Saskatoon
Regina
150 0 150
Kilometers
(Saskatchewan Scale)
JEB
Site
S/V
TEMS
Sue
Site
Collins Creek
905
Wollaston
Lake
N
3 0 3
Kilometers
Legend
Collins Creek Drainage Basin
Existing Facility
Lake
River
Road

Question

How to find the source of a GW geochemical anomaly found downstream of an orebody?





Method = Hydrogeochemical Exploration

We tested the feasibility of a multi-disciplinary approach combining :

- A geological model
- A hydrogeochemical survey of GW
- A 3D GW flow model.

Goal

Help exploration to extend known deposits and find new ones

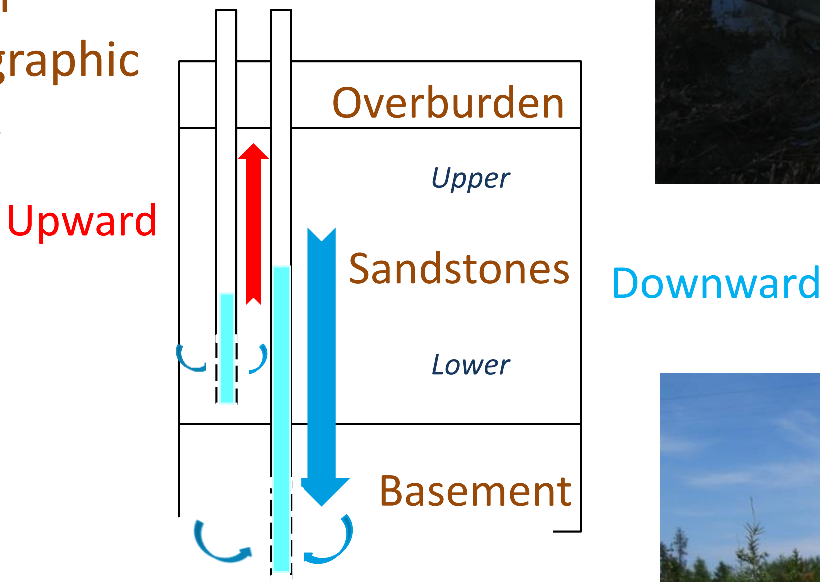
Field acquisition

August- October 2016

Water level measurements on 60 wells
+ GW sampling on 31 wells

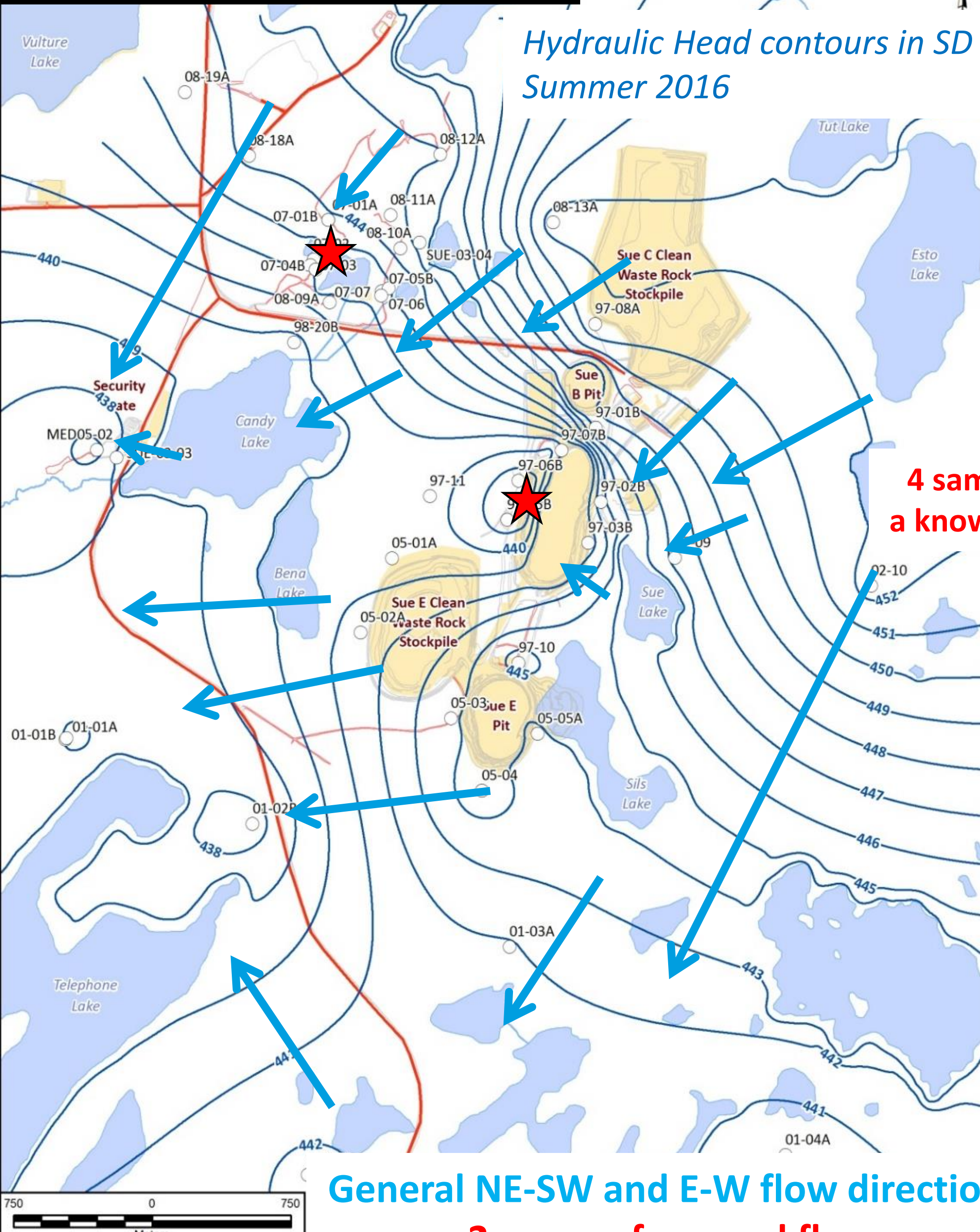
- ✓ 11 screened in the Basement
- ✓ 19 screened in the Sandstones

3 main hydrostratigraphic units



4 nested wells to check the vertical drainance

Groundwater Flows

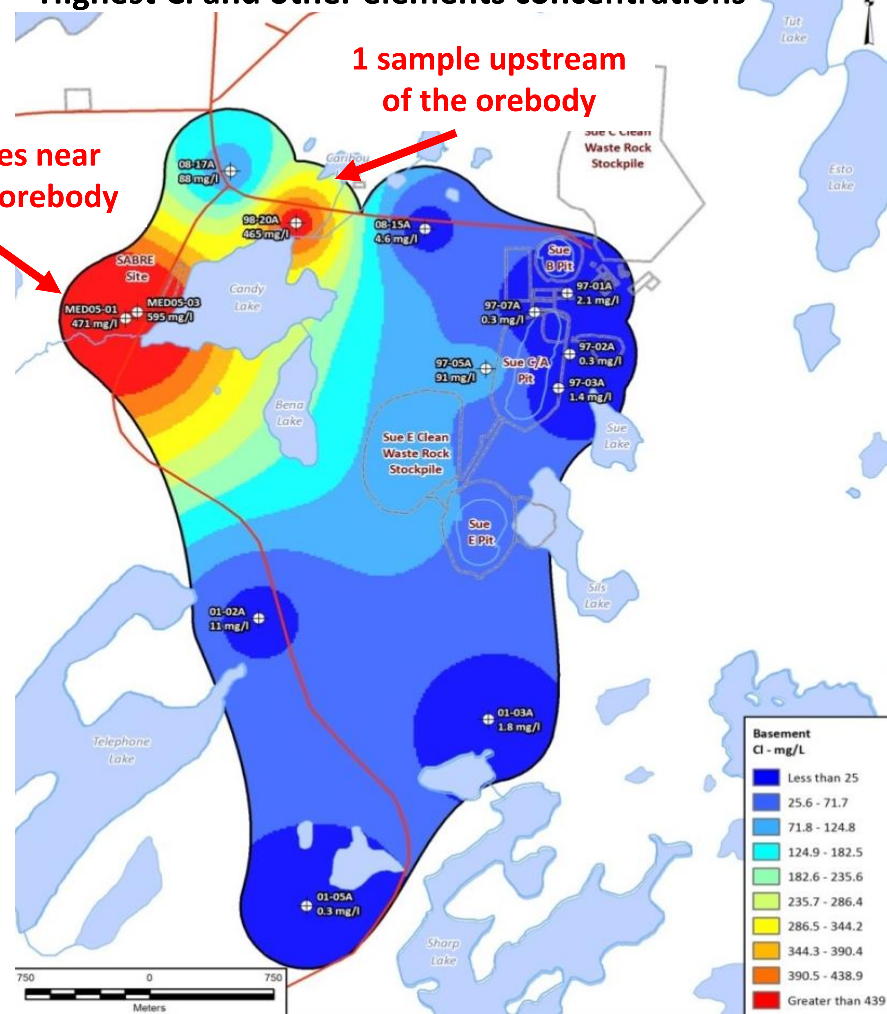


General NE-SW and E-W flow direction,

2 zones of upward flow

Hydrogeochemical results

- **Very low U concentration for all samples** < 0.1 µg/L for 20 samples
- **Strong reducing conditions,** Eh ~ -100mV
- **Saturation Indexes > 0 for Uraninite and Coffinite**
- **5 samples with very high TDS** (400-900 mg/L), **Highest Cl and other elements concentrations**



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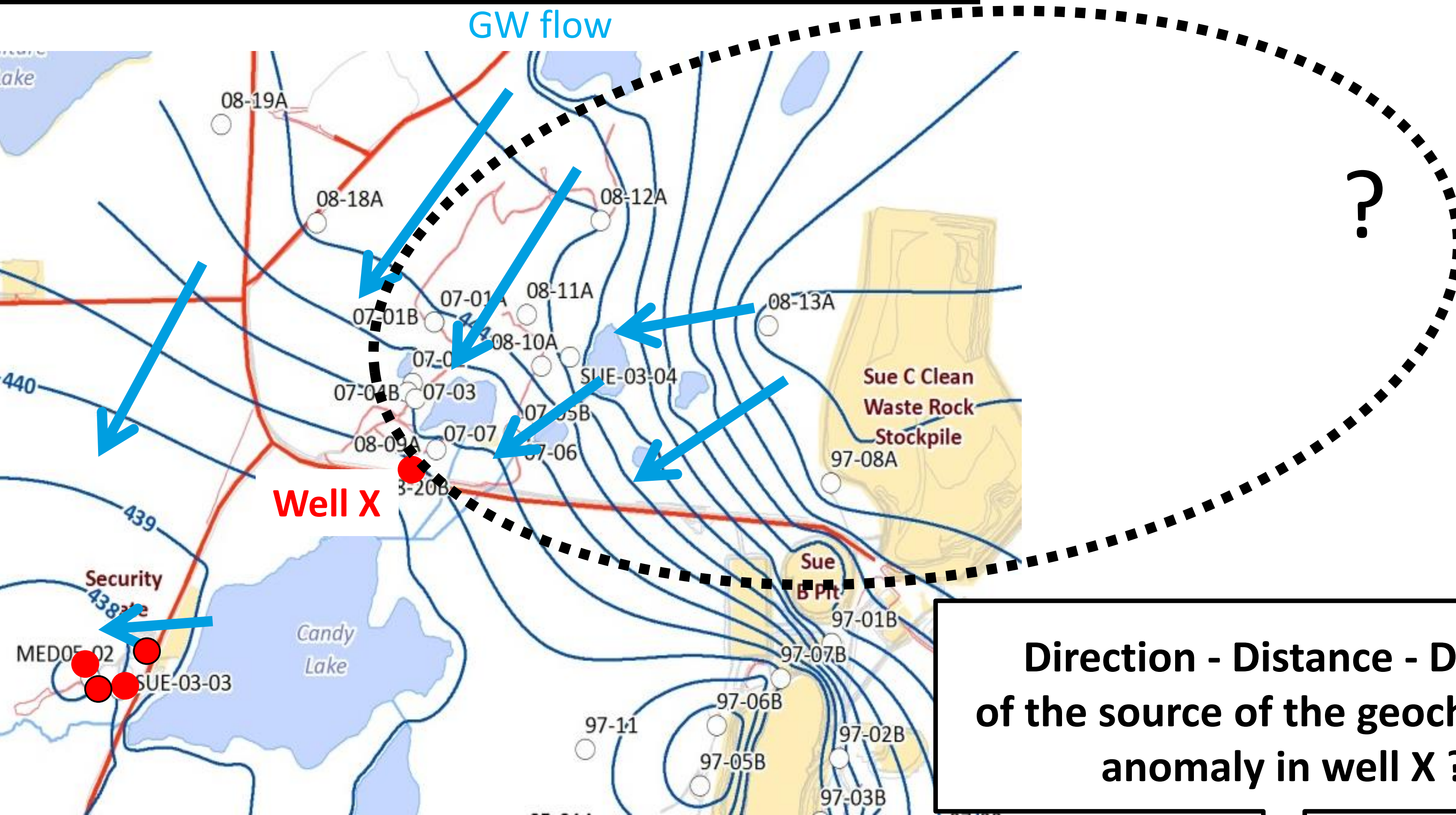
Zoom upstream of the anomalous well



McClean A
U deposit

Direction - Distance - Depth of the source of the geochemical anomaly in well X ?

Development of a 3D GW model

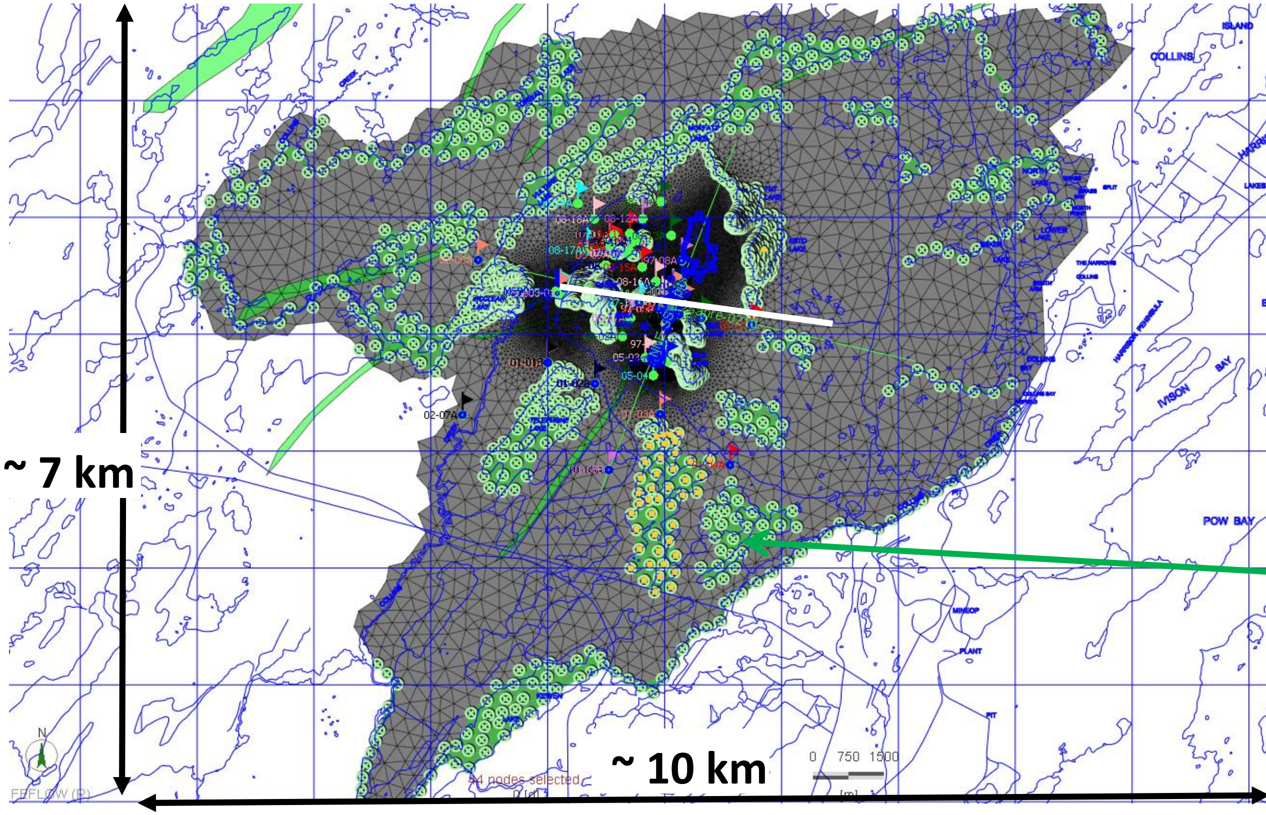
Groundwater model

FeFlow

Thickness ~ 300 m, 19 layers

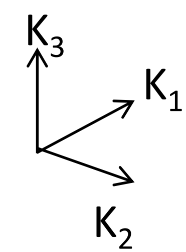
Triangular meshes 32 250 nodes

Net Recharge = 55 mm/yr

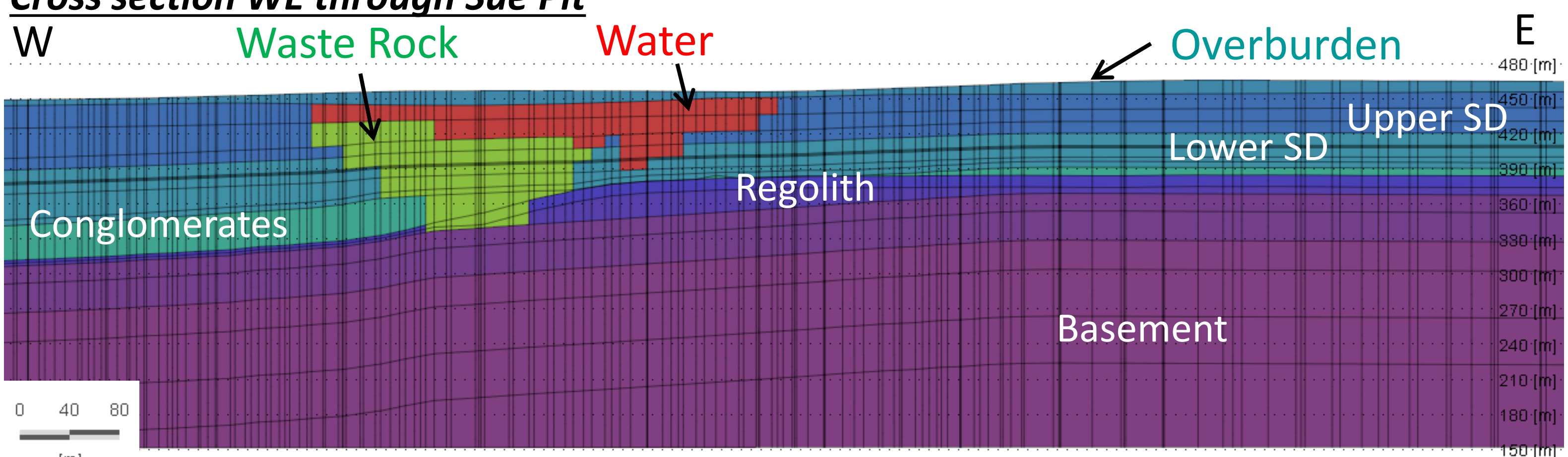


Constant Head Boundary conditions for lakes and pits

Hydraulic Conductivity



Cross section WE through Sue Pit



$K = 8e^{-7}$ m/s

$K = 8e^{-6}$ m/s

$K = 6e^{-7}$ m/s

$K_{1,2} = 5e^{-8}$ m/s

$K_3 = 5e^{-9}$ m/s

Calibrated K

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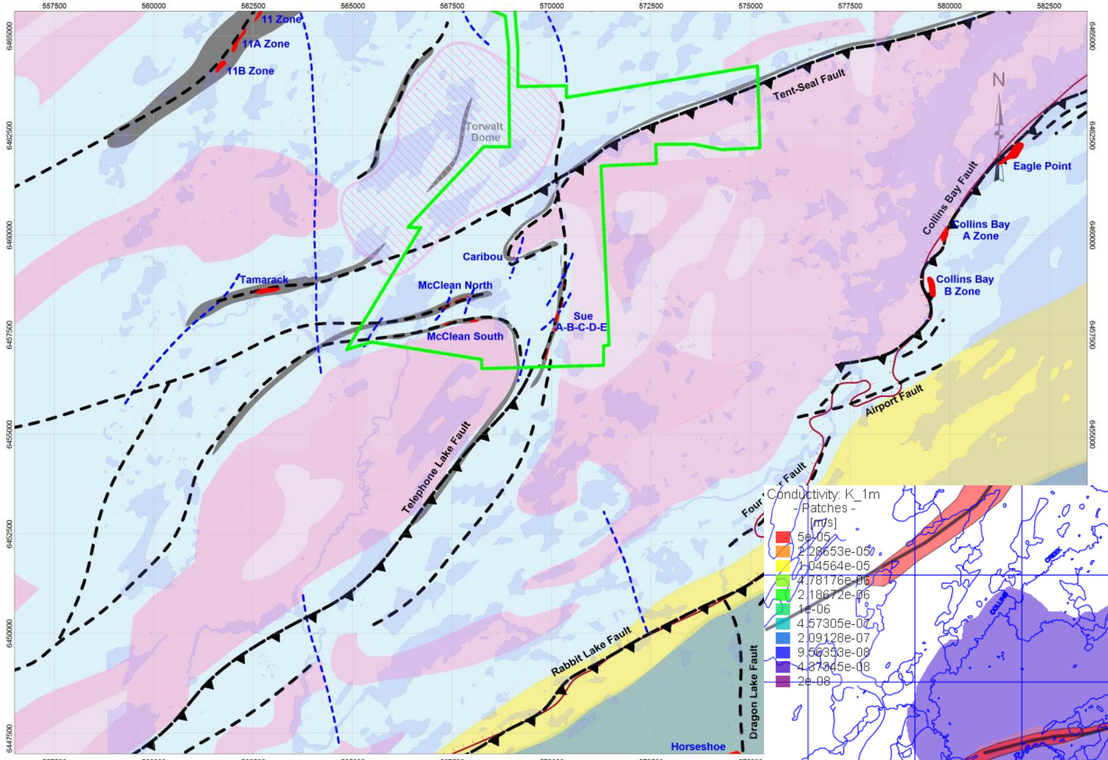
GW model structure

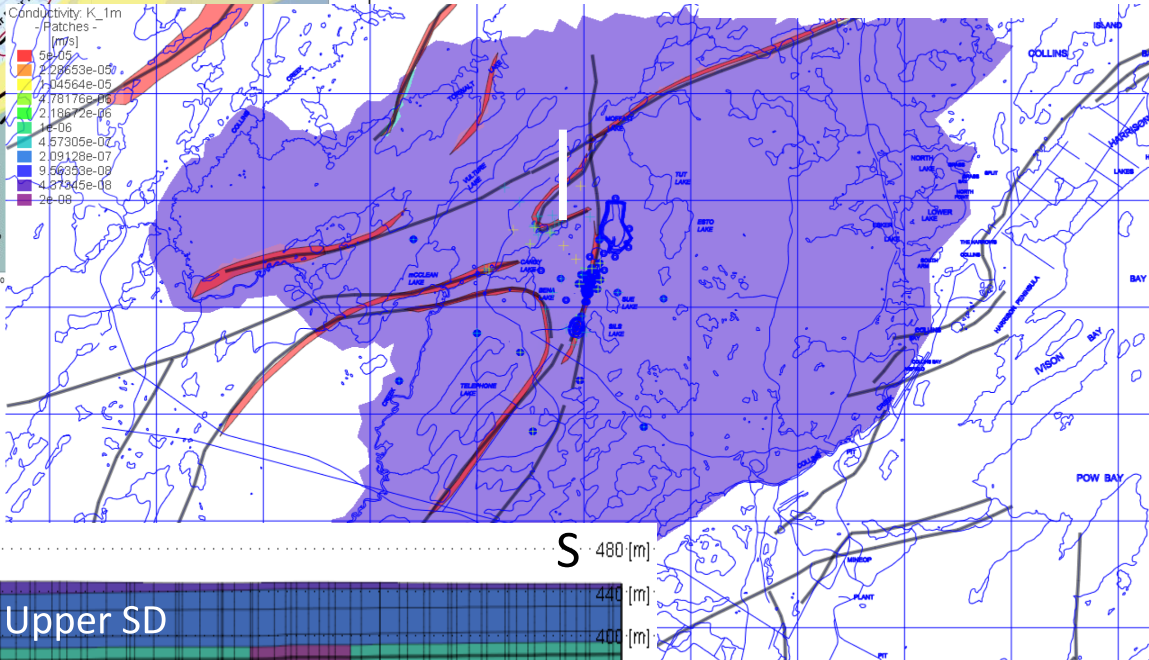


Map of the basement structures (G. Gudmundson, 2017)

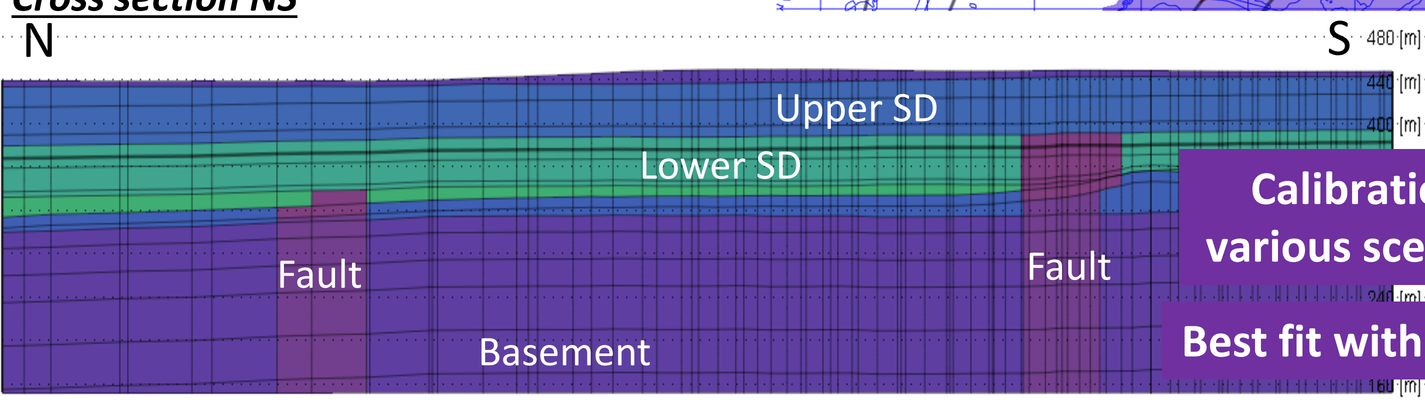
Simplification of the geological structure to represent the possible GW pathways

Addition of faulted zones in the basement as vertical structures

20-150m of thickness



Cross section NS

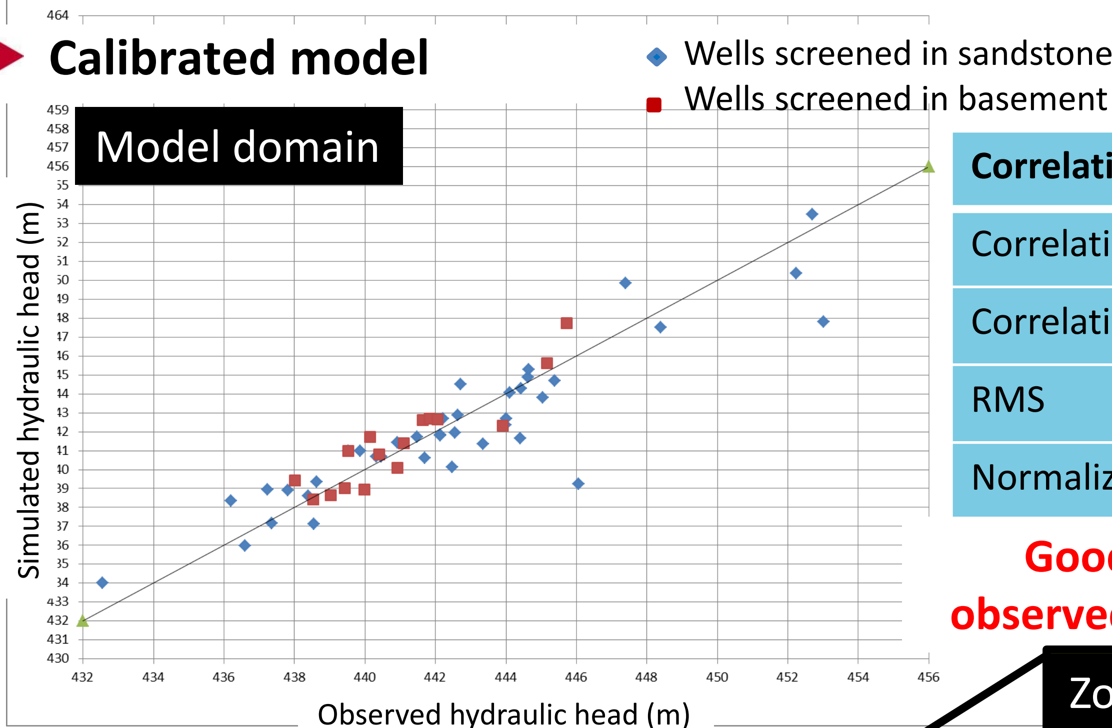


Calibration of the model with various scenarii of K in fault zones

Best fit with Kv fault > Kv basement

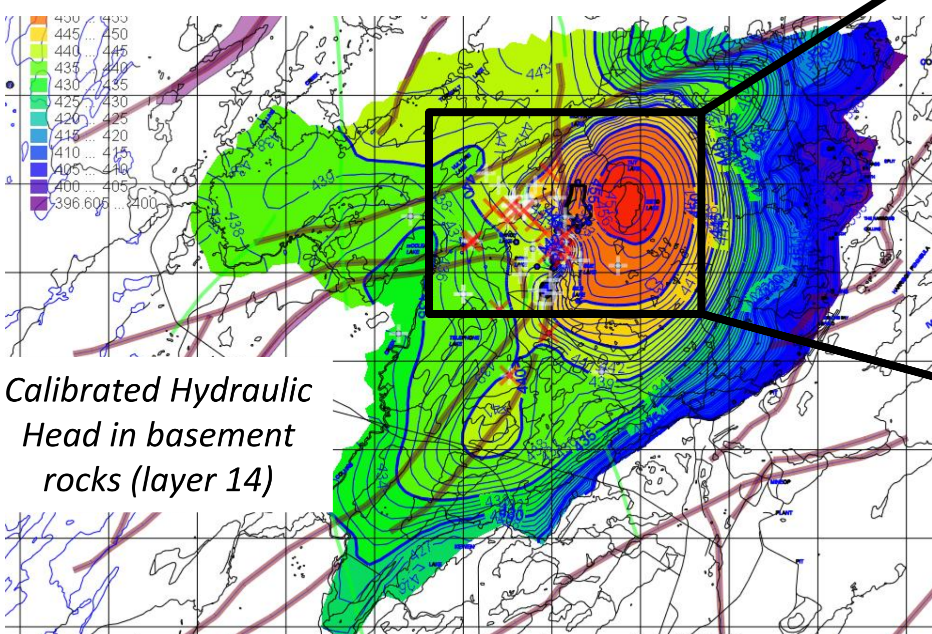
GW model results

Calibrated model

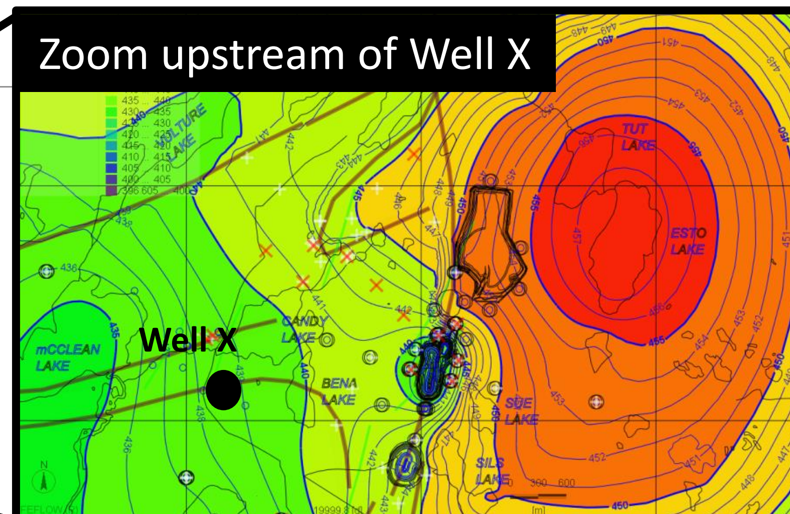


Correlation Coef (56 wells)	0.91
Correlation Coef Basement wells	0.92
Correlation Coef Sandstones wells	0.91
RMS	0.98 m
Normalized RMS	0.04%

Good matching between simulated and observed hydraulic heads in the model domain



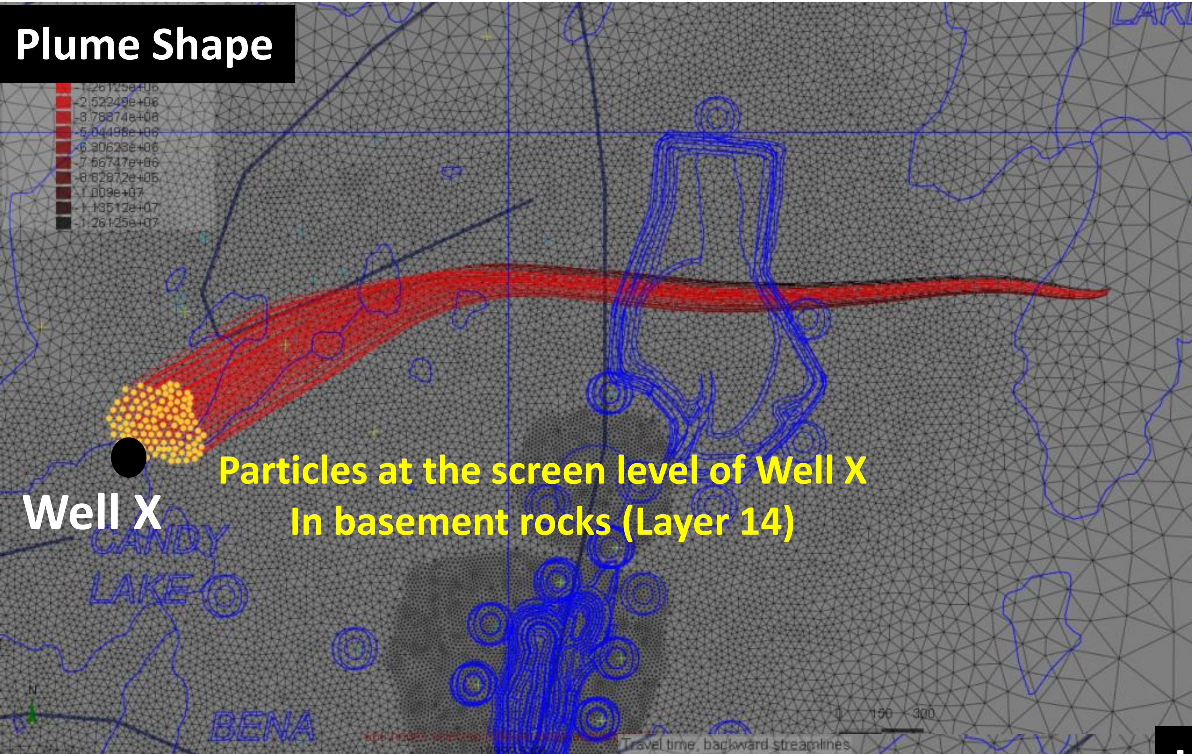
Calibrated Hydraulic Head in basement rocks (layer 14)



Correlation Coef on the 24 wells located upstream of Well X	0.88

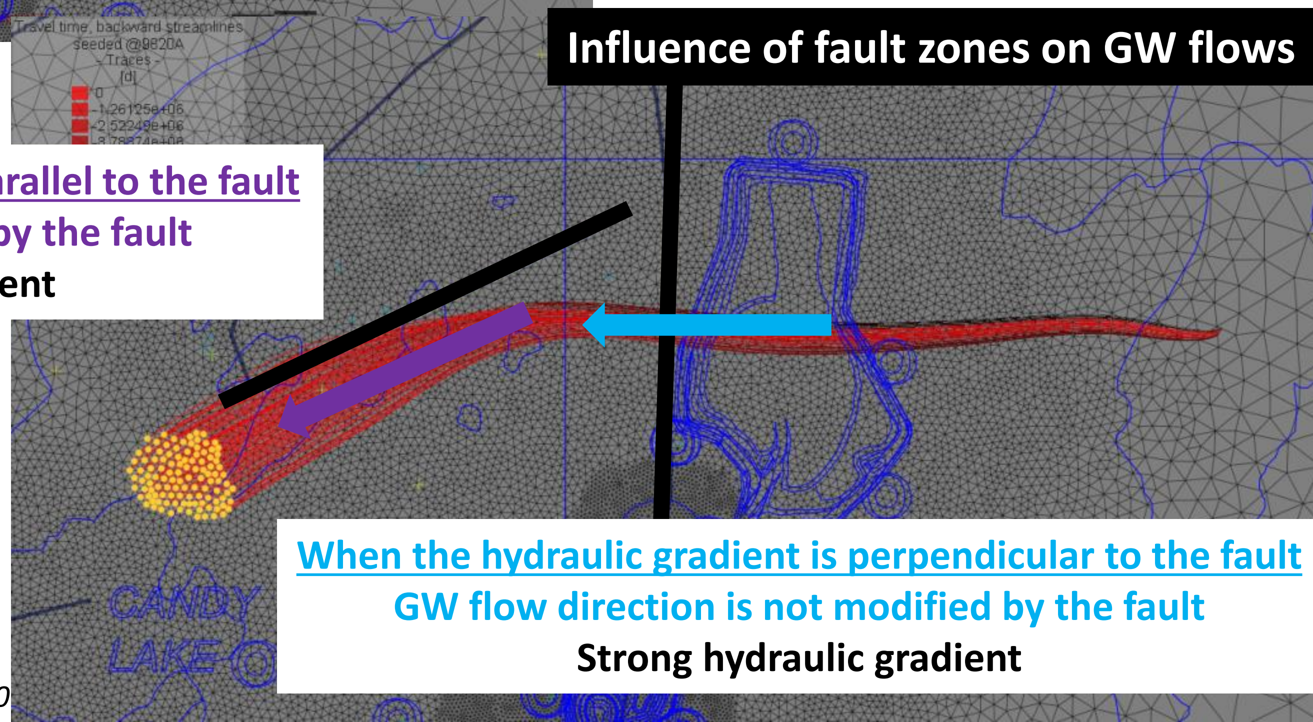
Model allows displaying the water pathlines, backward from our anomaly

Backward GW pathlines



Plume upstream of Well X is :

- narrow (max 300m wide)
- about 3600 m long



When the hydraulic gradient is parallel to the fault
GW direction is controlled by the fault
Low hydraulic gradient

When the hydraulic gradient is perpendicular to the fault
GW flow direction is not modified by the fault
Strong hydraulic gradient

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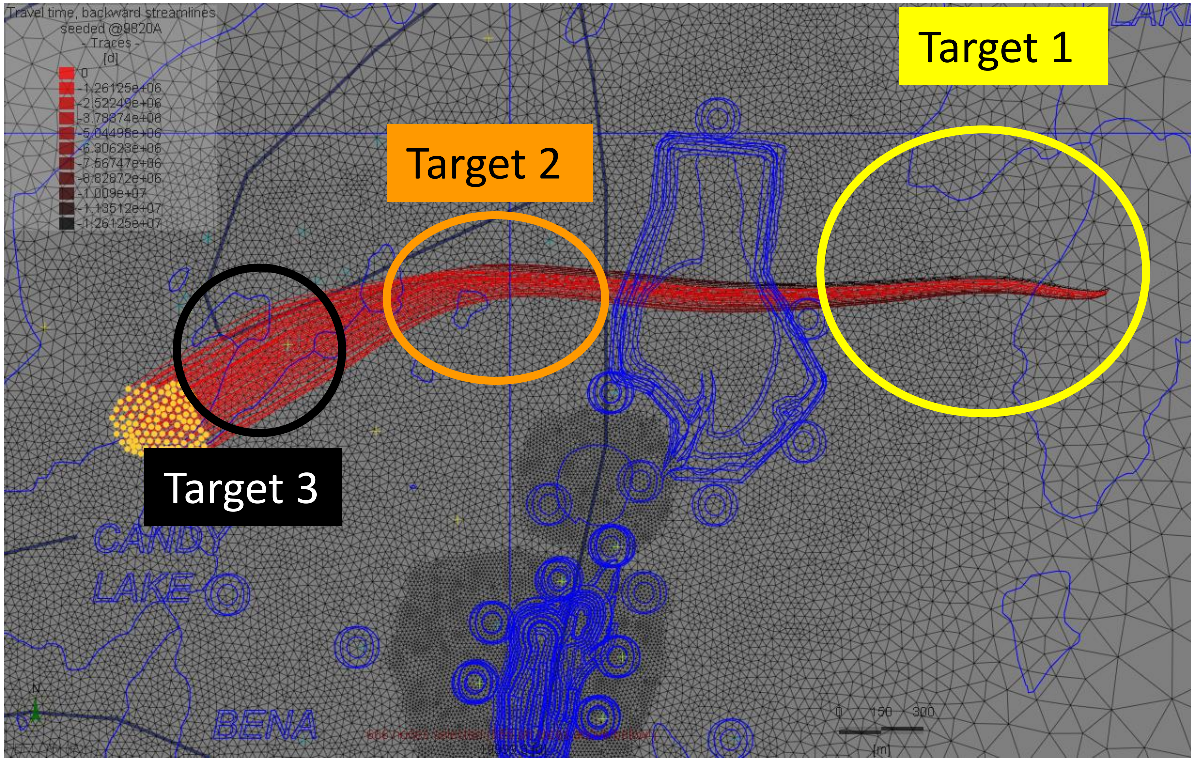
Conclusion

- Significant geochemical anomaly in Cl, Na, Mg, K…
  in the 4 wells close to a known orebody + well X
  Strong relationship between these elements indicating a common source

- Type of anomaly already found in GW at Cigar Lake mine
  attributed to the dissolution of such elements present within the alteration halo surrounding the ore body

- A 3D groundwater model was developed to interpret the source of the anomaly. It allows :
  - evaluating the role of the geological structures in the GW flow
  - displaying backward water pathlines and plume shape upstream of the anomaly
  - calculating travel time
  - Identifying 3 new targets for future exploration



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