Alberta's Industrial Heartland and Beverly Channel Groundwater Quality Baseline Study

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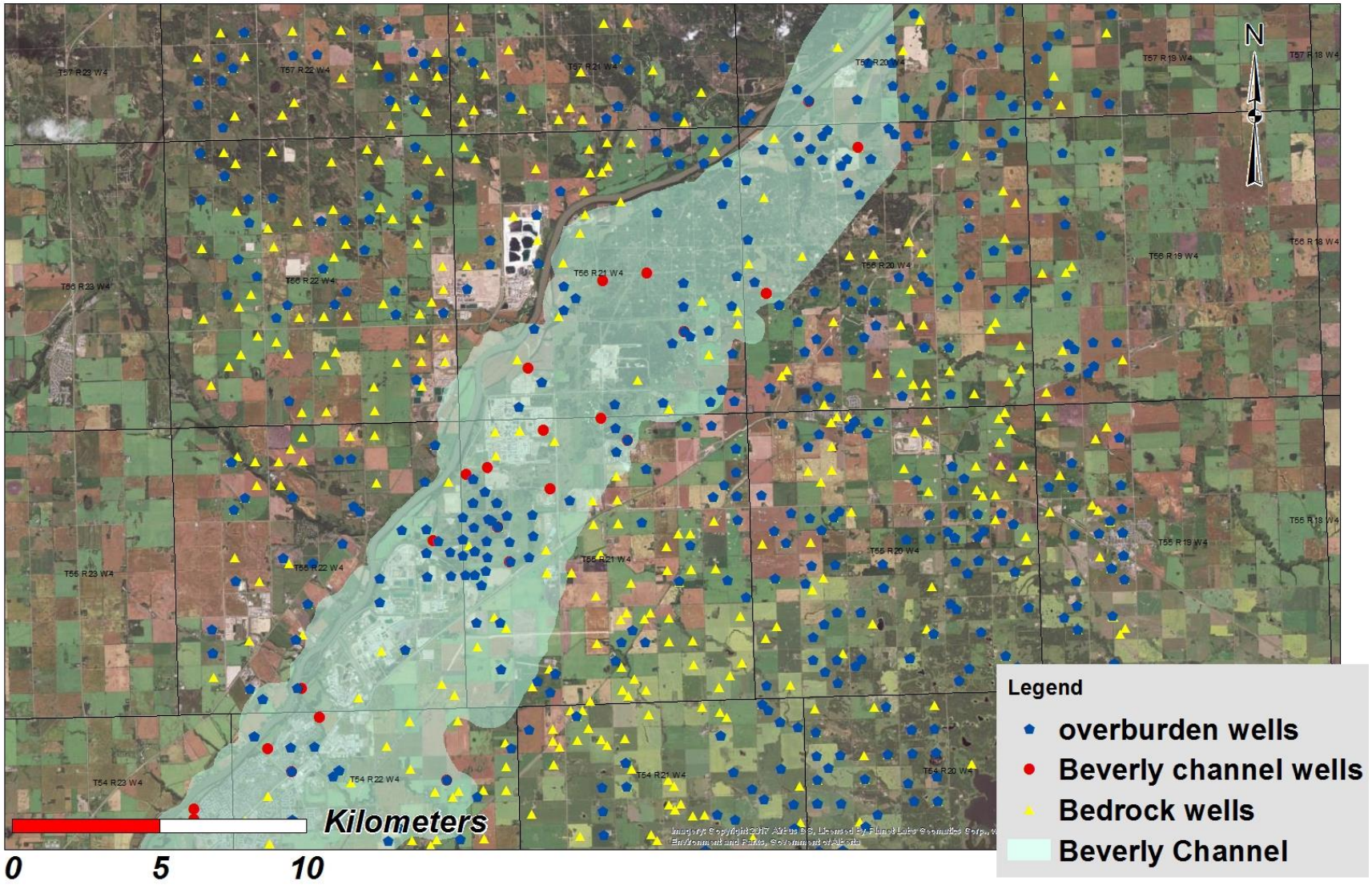
Alberta Environnent and Parks

STUDY AREA

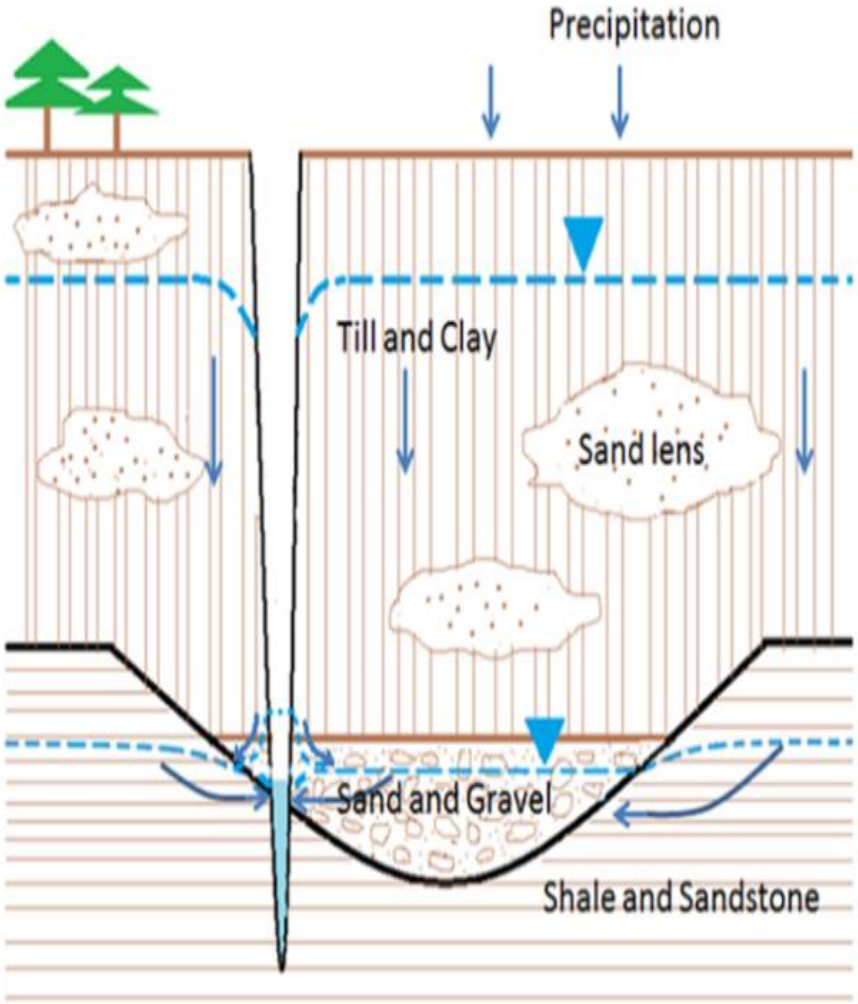

N
Legend
overburden wells
Beverly channel wells
Bedrock wells
Beverly Channel
Kilometers
0
5
10

Data Points

There are 1284 groundwater wells in depths from 6 to 600 feet.

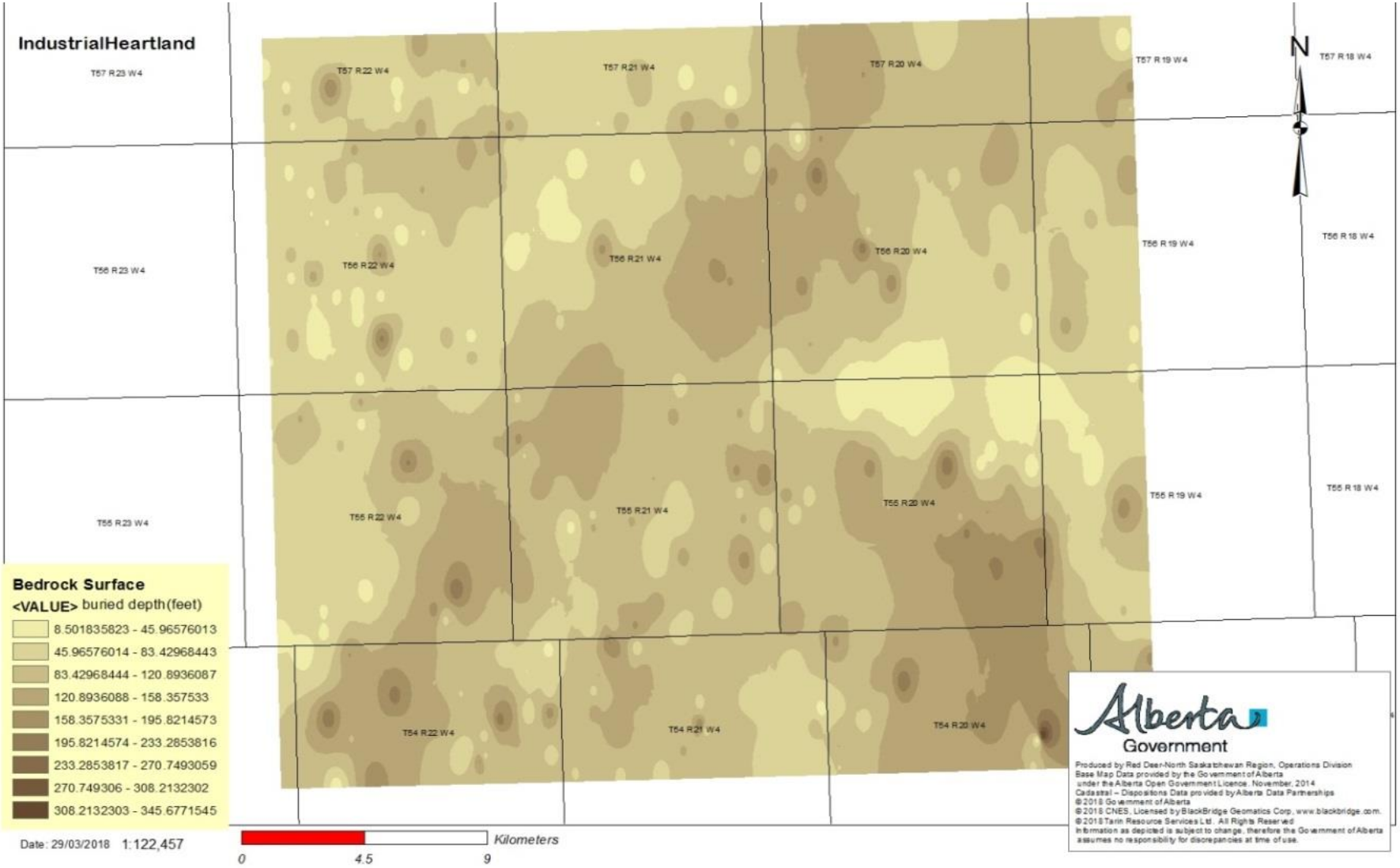
- Overburden: 615 wells
- Beverly Channel: 27 wells
- Bedrock: 642 wells

CONCEPTUAL SITE MODEL



- The overburden: more than 30 meters thick in some areas.
- The channel : about 4 meters thick, unconfined aquifer
- The NS River flows along the Beverly Channel and incised through the Channel and into the Belly River bedrock in the study area.

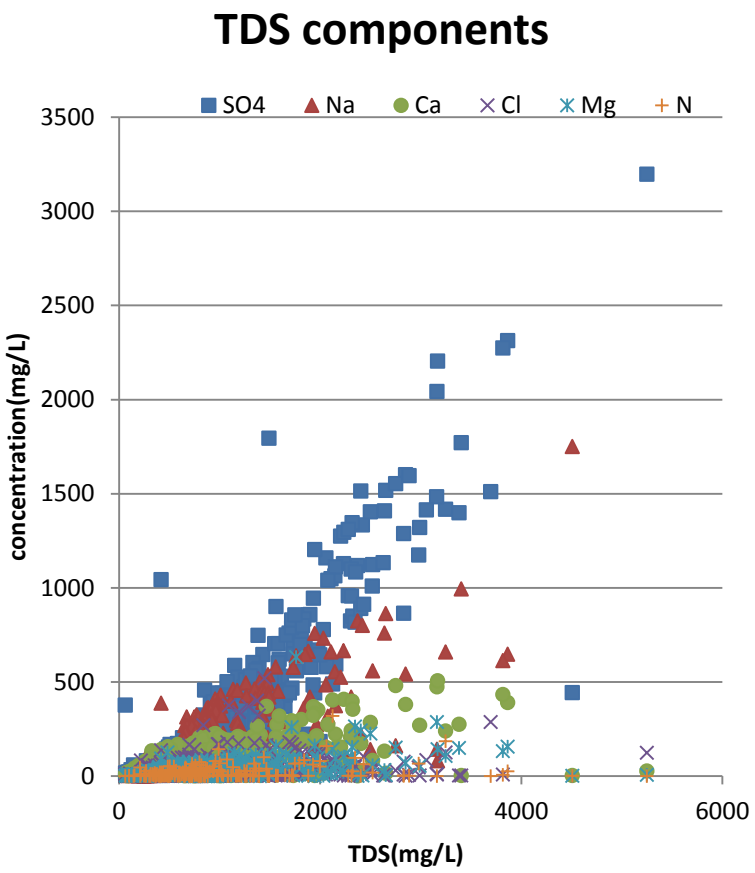
BURIED BEDROCK SURFACE



STUDY OBJECTIVES

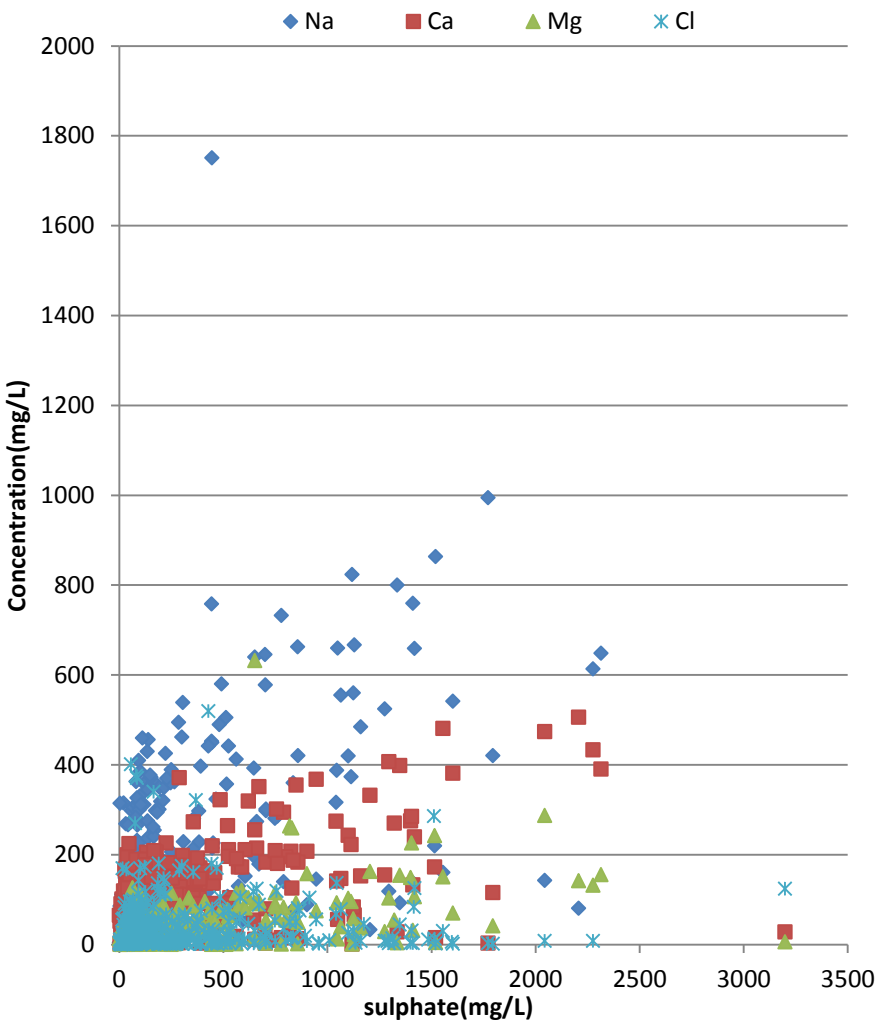
- Overburden groundwater quality
- Bedrock groundwater quality
- Beverly Channel groundwater quality
- groundwater quality relations between different layers

OVERBURDEN GROUNDWATER QUALITY



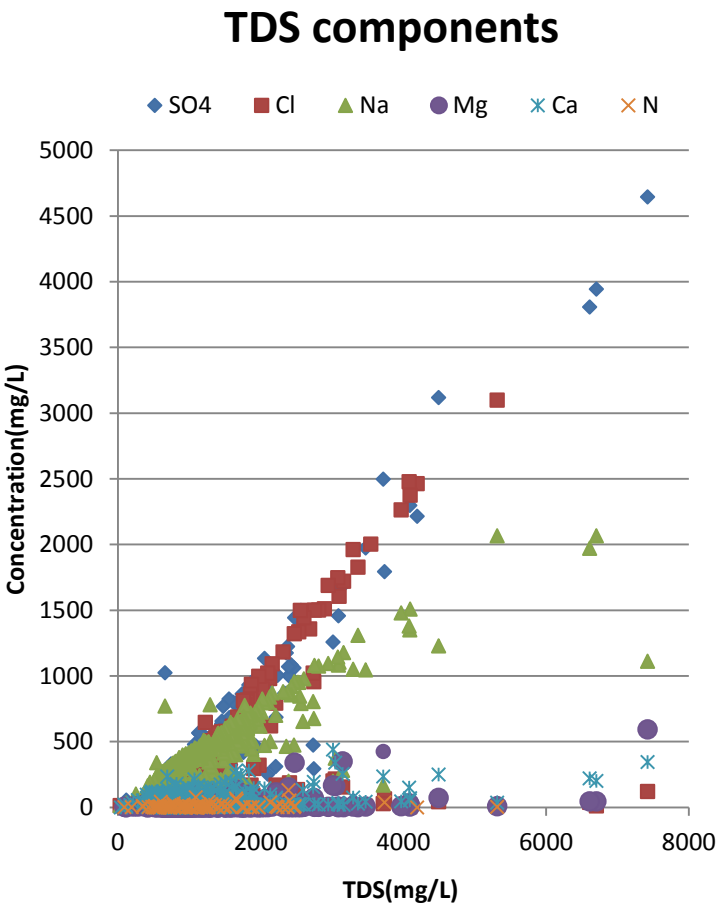
- In order of concentrations: sulphate, sodium, calcium, magnesium, to a lesser extent, chloride and nitrate.

Chemical relationship



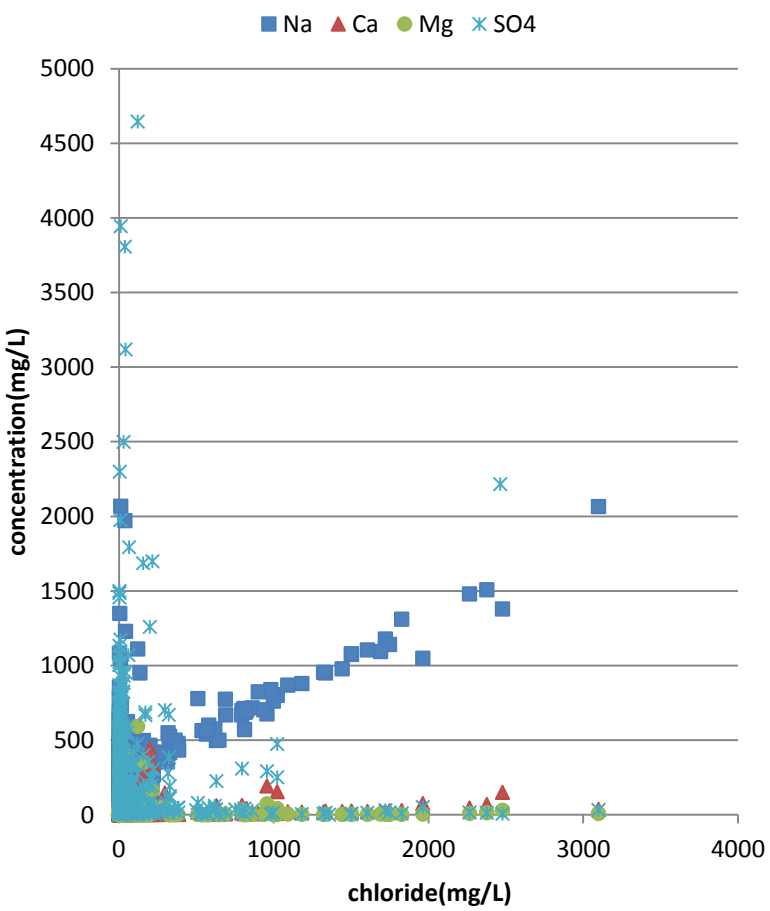
- Major anions: sulphate and chloride
- Major cations : sodium, calcium and magnesium.
- Major dissolved minerals in the overburden soil: Na_2SO_4, $Ca/MgSO_4$
- Minor dissolved minerals: NaCl , $Ca/MgCl_2$.
- The dissolved minerals are mainly from the surrounding soil by soil chemicals process

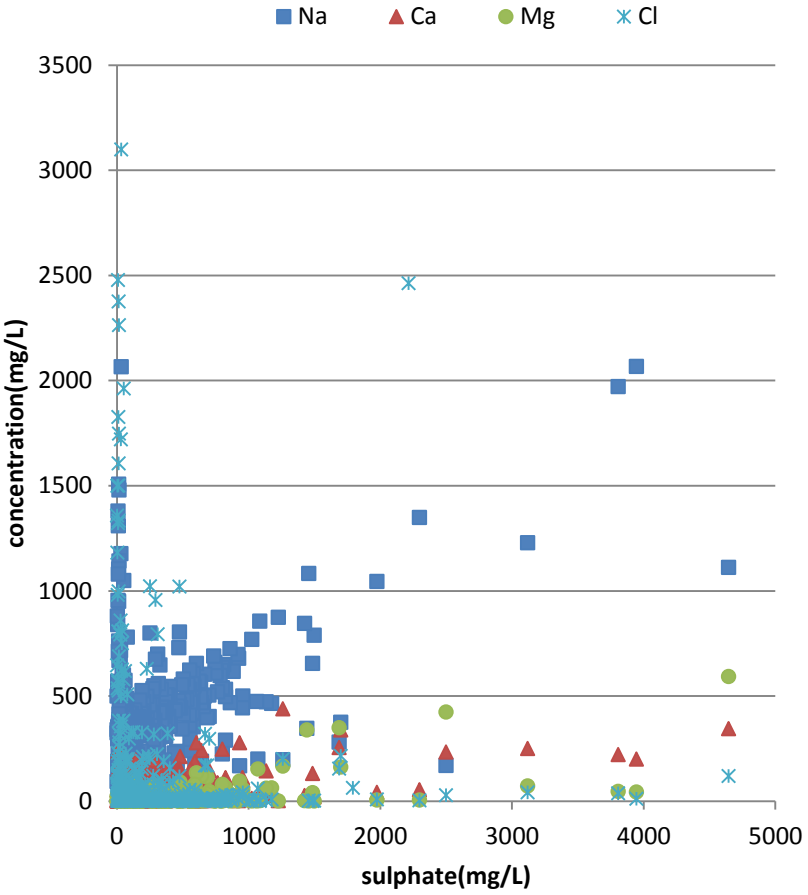
BEDROCK GROUNDWATER QUALITY



- The contributions of the major ions to TDS. In the order of importance are sulphate, chloride, sodium, to a lesser extent, calcium, magnesium, and nitrate.
- Unlike the groundwater in overburden, chloride plays a significant role in TDS components.

Chemical relationship

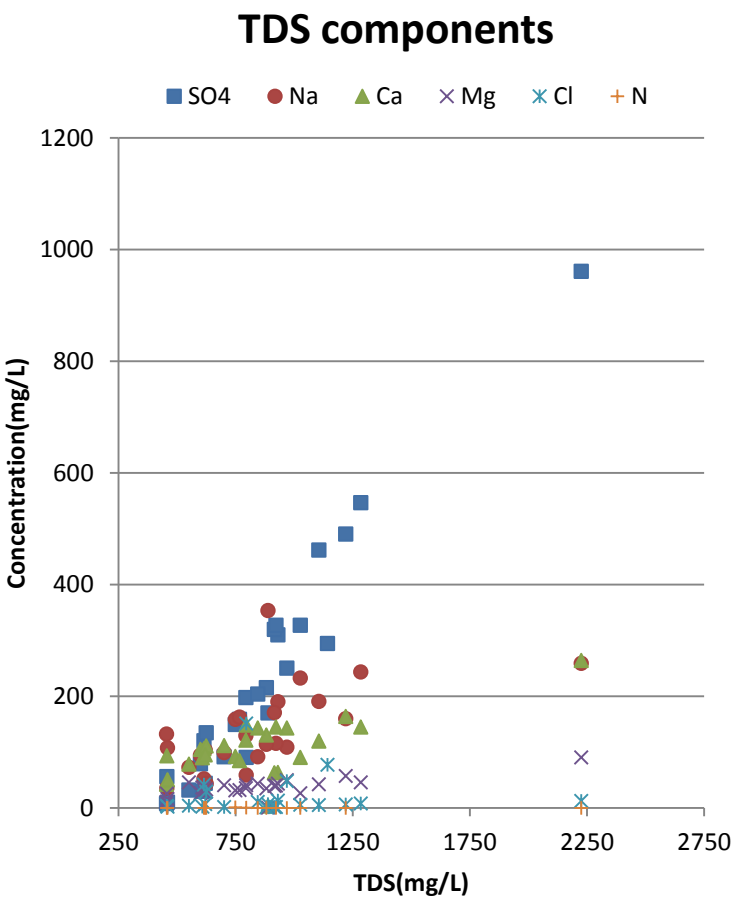




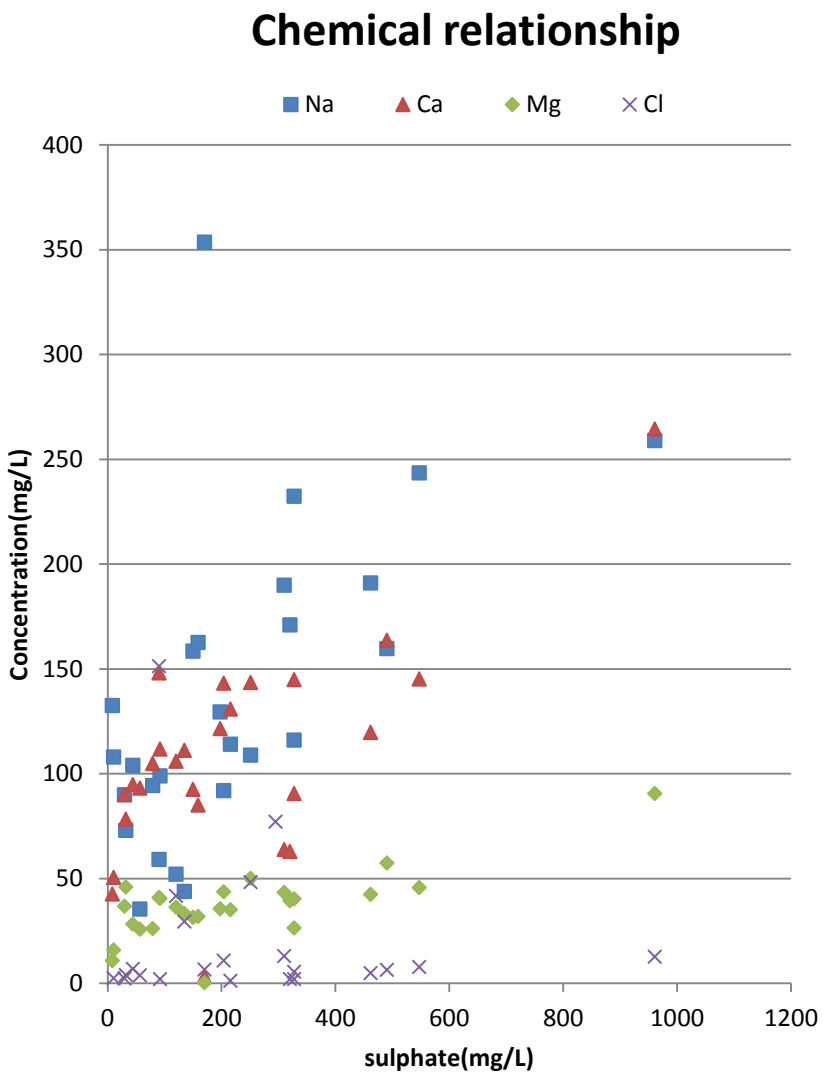
Major minerals dissolved

- Major anions: sulphate and chloride;
- Major cations: sodium, calcium and magnesium.
- Major dissolved minerals in the bedrock: $NaCl$, Na_2SO_4.
- Minor minerals dissolved: $Ca/MgSO_4$, $Ca/MgCl_2$.

BEVERLY CHANNEL GROUNDWATER QUALITY



- In the order of concentrations: sulphate, sodium, calcium, magnesium, to a lesser extent, chloride and nitrate.
- The order sequence of the major ions in the Beverly Channel is similar to the overburden groundwater quality



- Major anions: sulphate and chloride
- Major cations: sodium, calcium and magnesium.
- Major dissolved minerals in the channel :Na_2SO_4, $Ca/MgSO_4$
- Minor minerals dissolved : NaCl, $Ca/MgCl_2$

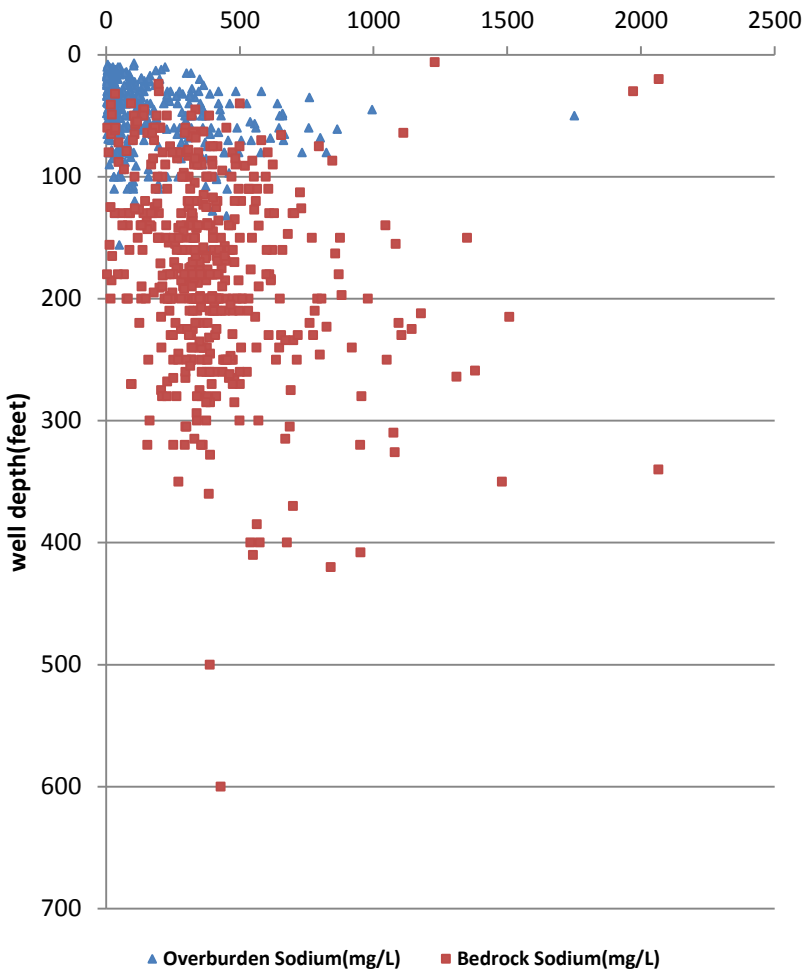
GROUNDWATER QUALITY POSSIBLE INFLUENCE FACTORS

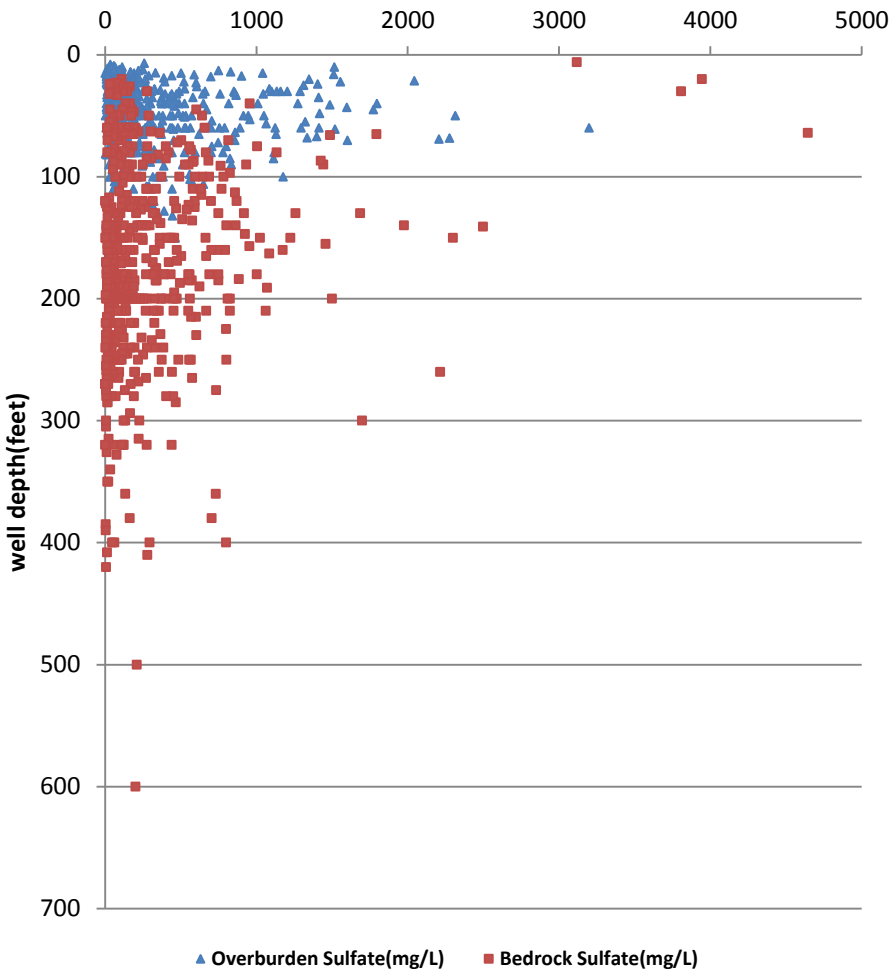
- Soil Chemicals
- Bedrock Sediment Environment
- Surface and Groundwater Interactions
- Human Activities
- Physical, Chemical and Biological Process

Soil Chemicals

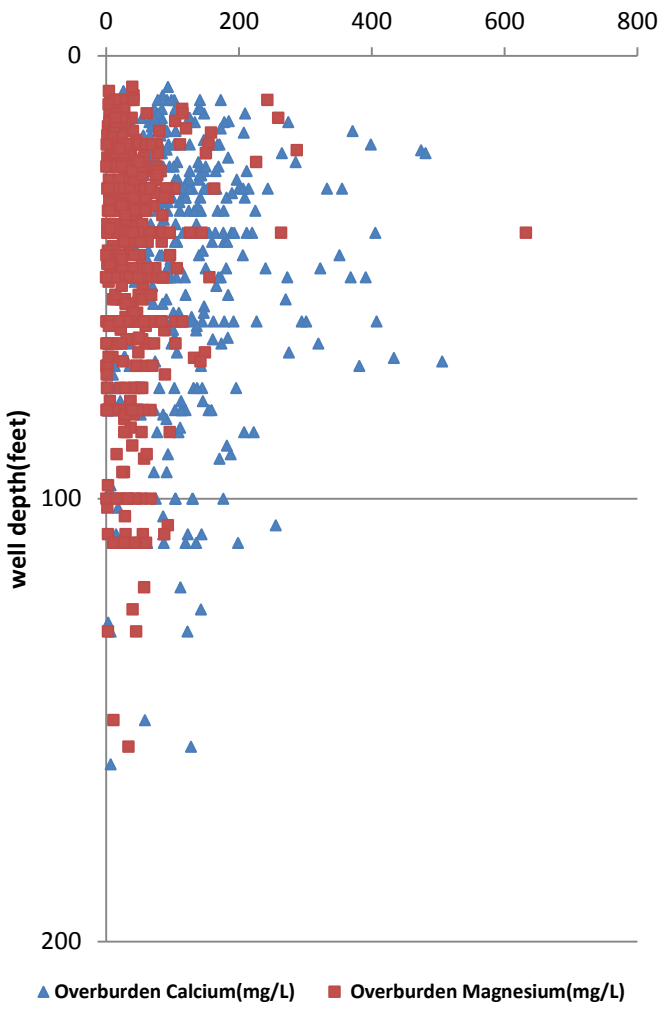
- Overburden soil in this study mainly refers to the unconsolidated soil overlaying on the bedrock.
- Groundwater in overburden soil is mainly recharged by precipitation (rainfall and snow melting), and to a lesser extent, irrigation.
- Some of the overburden area has solonetzic/sodic soil (rich in Na_2SO_4).
- The baseline groundwater quality is mainly composed of naturally dissolving minerals in the overburden soil and some human activities (fertilizer use, road salt and stock feeding).
- Along the groundwater flow path, total dissolved solids (TDS) will increase, (dissolves more minerals from surrounding soil and bedrock with distance).

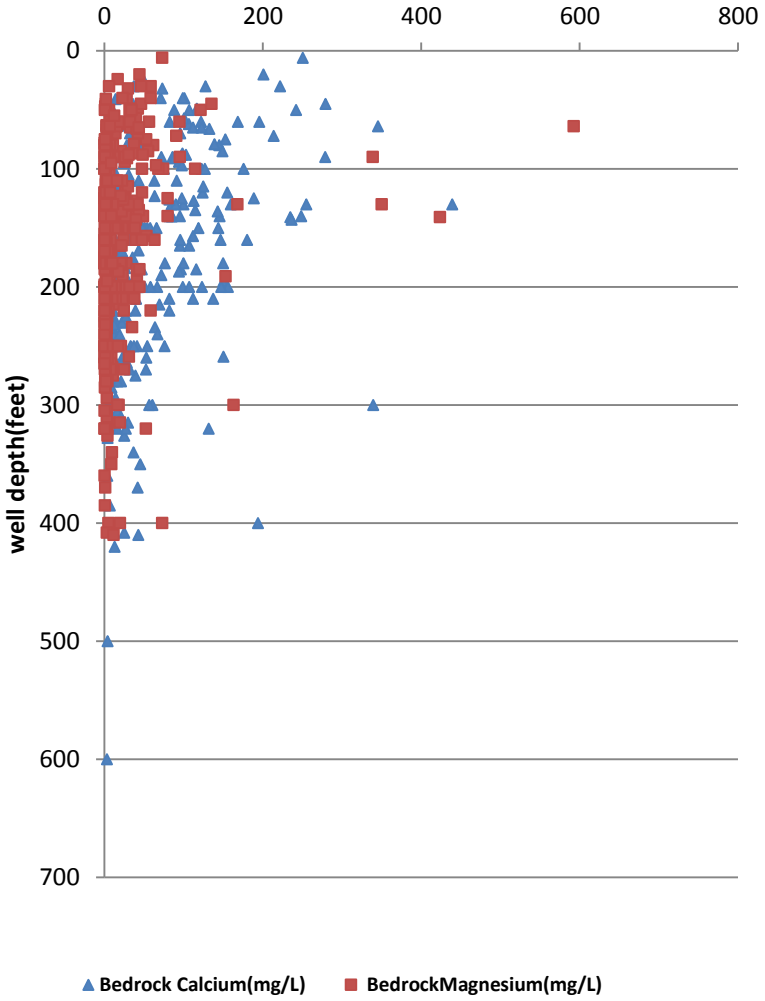
Sodium and sulphate distribution with depth





Calcium and magnesium distribution with depth





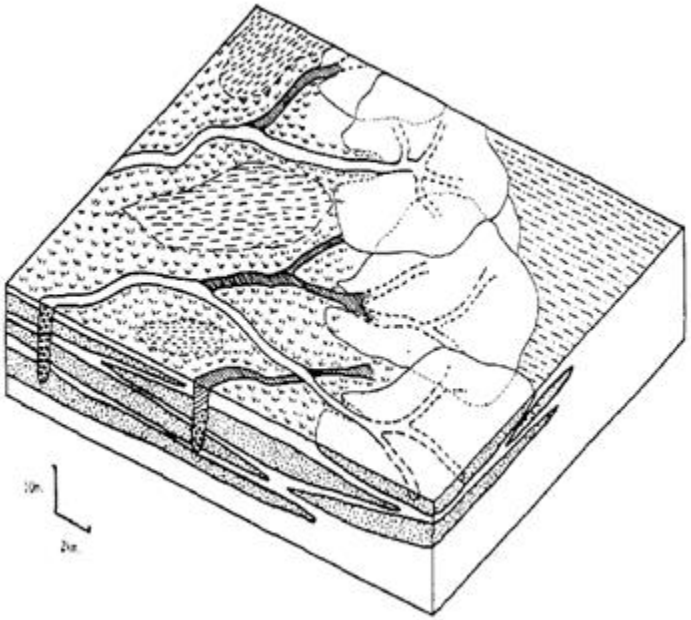
Chemical characteristics with depth

- Sodium shows an increasing trend with well depth. There are only two deeper wells (500-600 feet) with small sodium concentration, due to lack of data, the trend below 400 feet is unclear.

- Sulphate, calcium and magnesium show an increasing trend to a certain depth and then starting a decreasing trend below the depth both in overburden and bedrock.

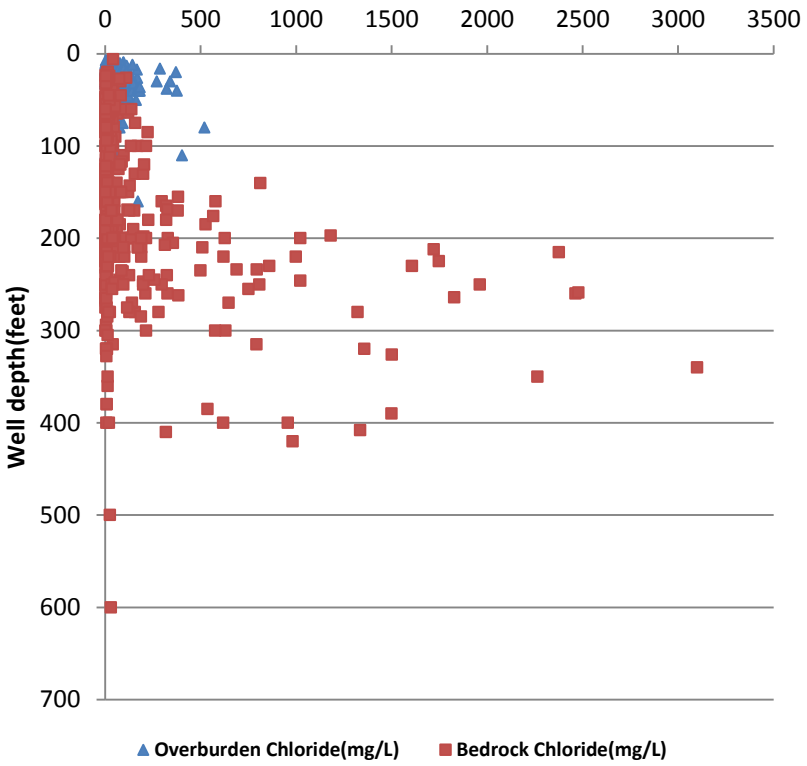
- With high TDS in groundwater, several other processes will start to take effect on the groundwater quality evolution, e.g. ion exchanges, precipitation and biodegradation

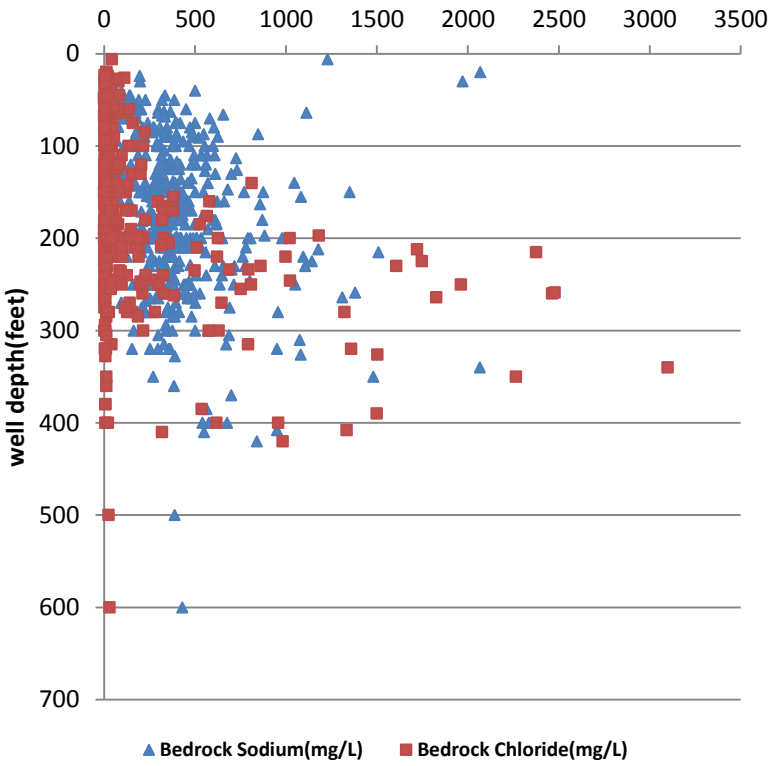
Bedrock Sediment Environment



The Belly River Formation is deposited in a transitional environment along a very shallow basin or low lying coastal plain as shown in Figure (Lerbekmo, 1963; Storey, 1982). The bedrock naturally contains abundance of sodium chloride (NaCl) which was left by the ancient seawater

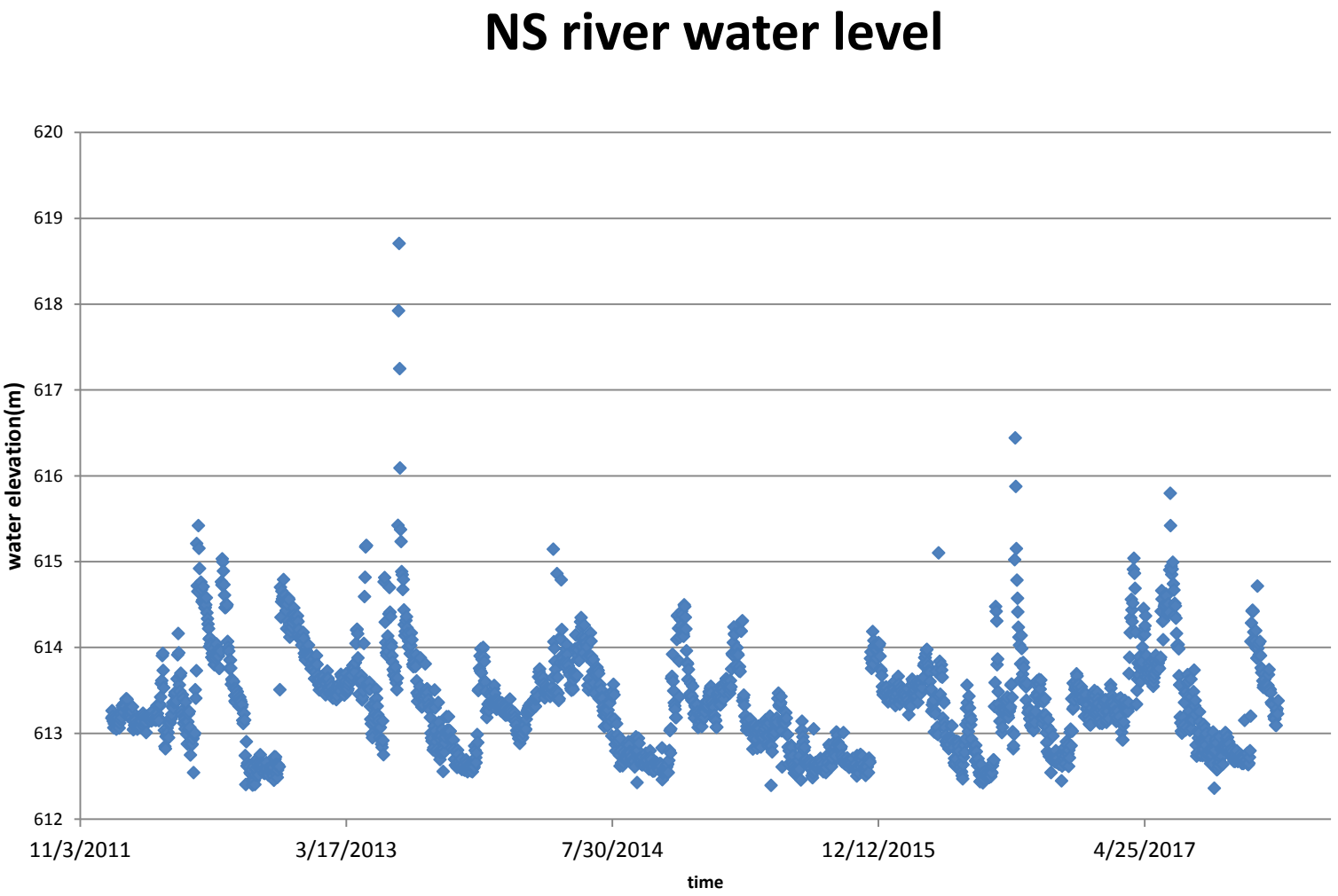
Sodium and chloride distribution with depth



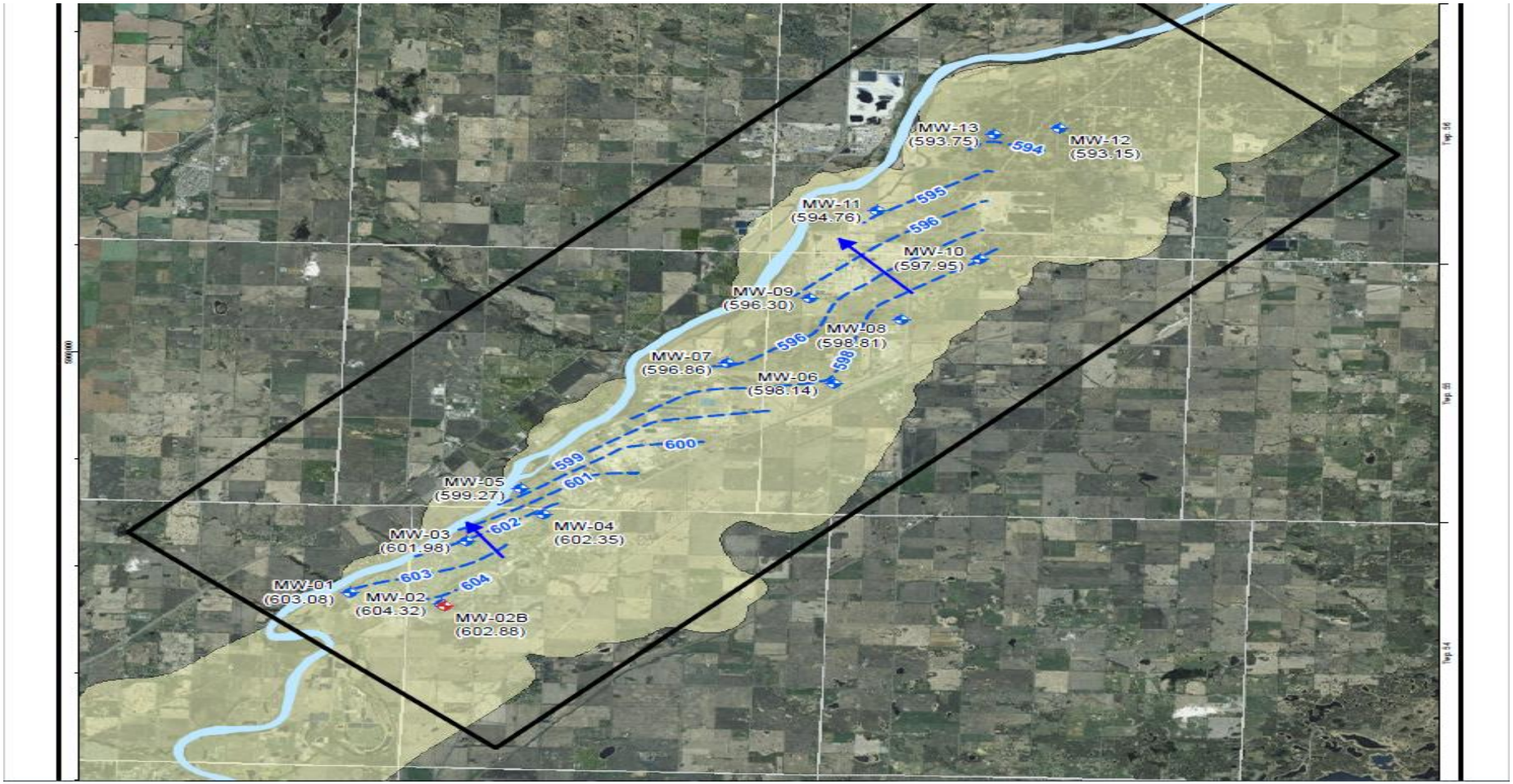


- Bedrock groundwater contain high concentration of chloride and sodium.
- In addition, chloride increases sharply at the depth of 130 feet. It is suspected that level of chloride is related to a buried sea level at this depth.

Surface and Groundwater Interactions



Groundwater flow direction between river and channel

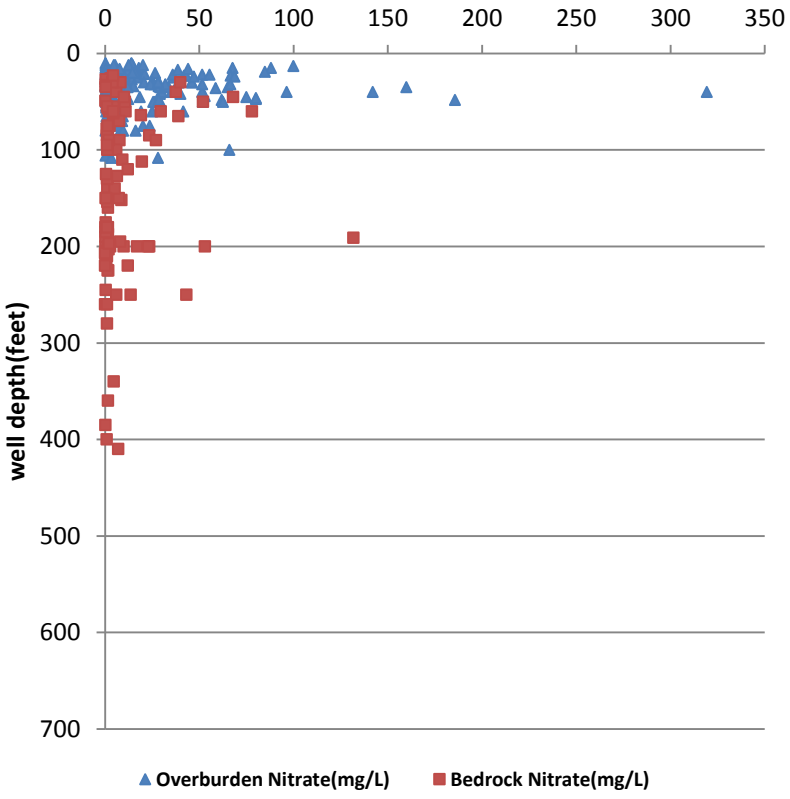


Relationship between NS river and Beverly channel

- The North Saskatchewan River water levels changed seasonally from 2012 to 2017 at the Edmonton observation station
- The lowest elevation is approximately 612.5m, the highest is approximately 619m, with a range of 6-7 m deference.
- Since the Beverly Channel is well connected with the river, this seasonal change in river water elevation may reverse the groundwater flow directions.
- In general, the channel groundwater flows toward the river (with discharge into the river), however in rainy seasons, the river may recharge the channel.
- The TDS in river water is much lower than in the Channel groundwater. This recharge may cause channel water near the river to be relatively fresher than the water away from the river.

Human Activities

Nitrate distribution with depth



- Nitrate in groundwater is impacted by farming activities.
- The nitrate in shallower groundwater has higher concentration
- Other human activities: the road salt and stock feeding (chloride and nitrogen).

Physical, Chemical and Biological Process

With high TDS in groundwater,

- Physical: dissolve, adsorption, ion exchanges
- Chemical: precipitation
- Biological: sulphate, iron, nitrate

LIMITATIONS

- Data in this study were collected from existing available information.
- Well locations are estimated.
- Layer separation is based on a calculated surface.

CONCLUSION

- Overburden: high sodium, high sulphate and high nitrate
- Bedrock: high sodium, high chloride, high sulphate
- Beverly Channel: relatively clean with mixed characteristics