

Groundwater Overview for Lakeland Industry and Community Association (LICA)

Alberta Environment and Parks

November 14, 2019

Context for Presentation

- Stakeholder interests in groundwater
 - Groundwater Availability (e.g. for domestic use)
 - Groundwater Quality (e.g. aesthetic concerns, arsenic)
 - Groundwater – Surface Water Interactions (e.g. lake levels, flooding)

Outline of Presentation

1. Overview of Groundwater Policy
2. Introduction to Groundwater Science
3. Groundwater Setting in Cold Lake – Beaver River Area
4. Publically accessible Sources of Groundwater Information

Selected Provincial Groundwater Policy

Overview of Provincial Groundwater Policy

- Water Act
 - Legislation that supports and promotes the conservation and management of water in Alberta
 - Regulate disturbances and diversions of groundwater
 - Alberta Environment and Parks and Alberta Energy Regulator share responsibility for regulating groundwater use
 - Guide to Groundwater Authorization is good resource for applicants wanting to make use of groundwater

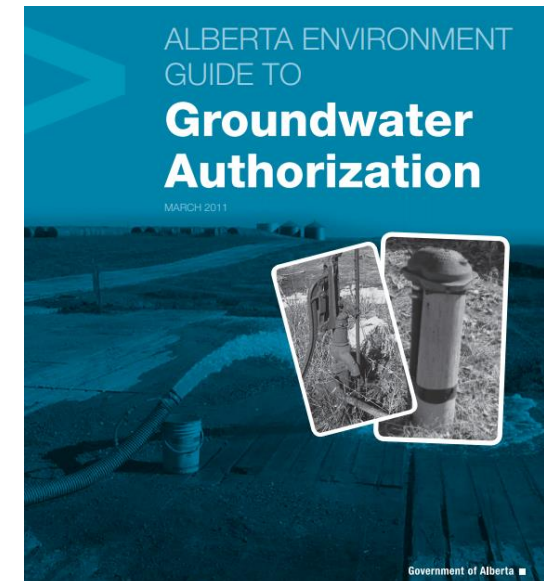


Province of Alberta

WATER ACT

Revised Statutes of Alberta 2000
Chapter W-3

Current as of December 17, 2014

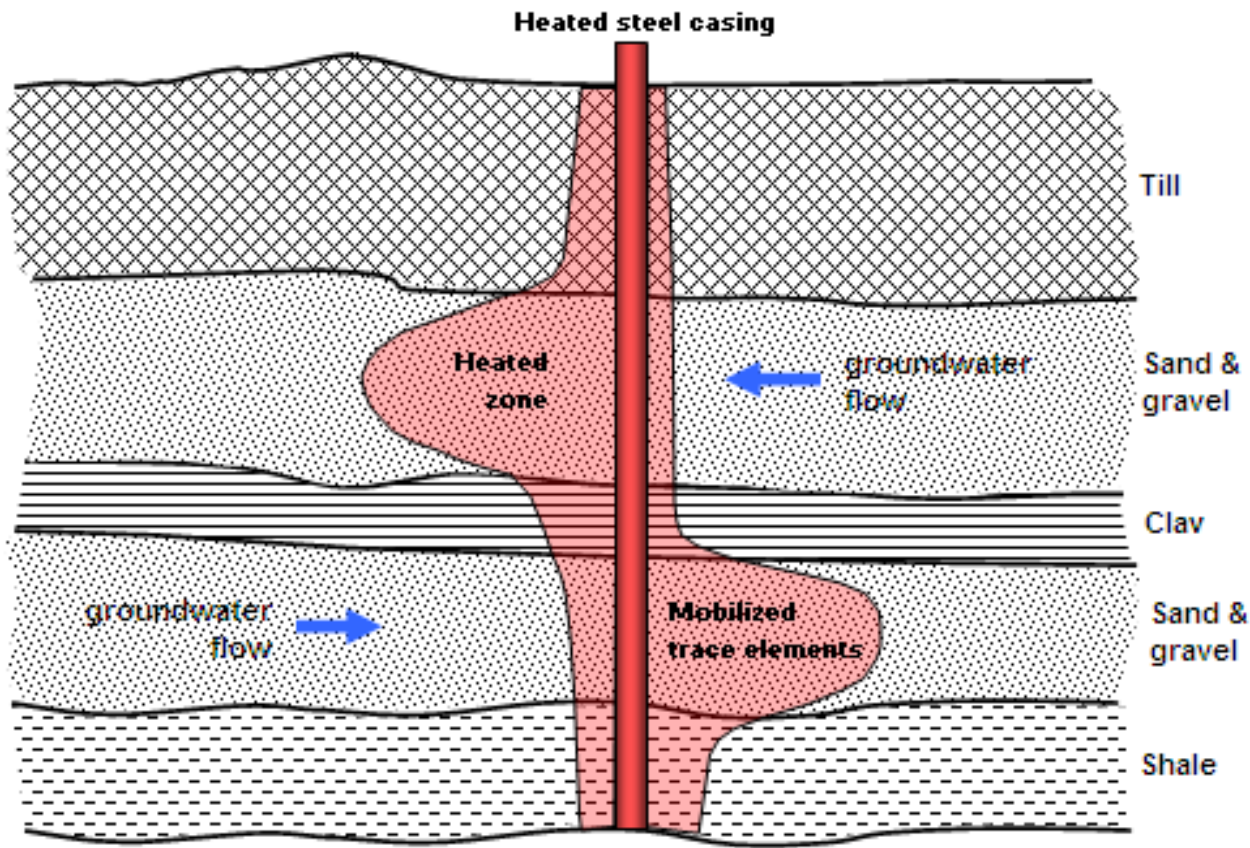


Overview of Provincial Groundwater Policy

- Environmental Protection and Enhancement Act
 - Primary Act through which regulatory requirements for air, water, land, and biodiversity are managed. The Act designates activities for which an approval or registration is required
- Sections 107 – 112 of Act are main parts of the act dealing with Contaminated Sites
 - Prohibited releases (Sec 108 & 109)
 - Release reporting (Sec 110 & 111)
 - Duty to take remedial measures (Sec 112)

Overview of Provincial Groundwater Policy

Directive for the Assessment of Thermally-Mobilized Constituents in Groundwater for Thermal In Situ Operations



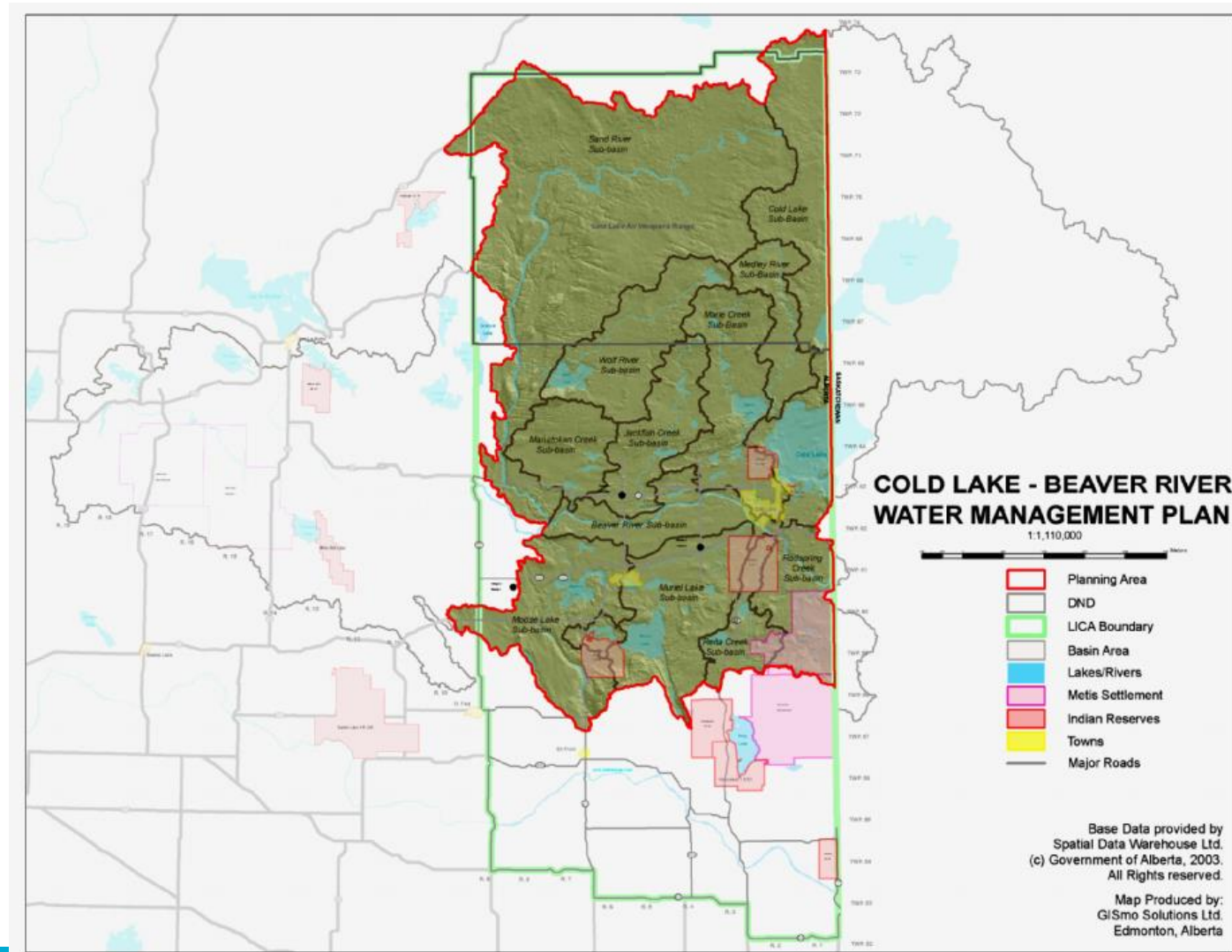
Title:	Assessment of Thermally-Mobilized Constituents in Groundwater for Thermal In Situ Operations
Number:	AEP, Water Quality, 2018, No. 1
Program Name:	Groundwater Policy
Effective Date:	June 1, 2018
This document was updated on:	

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Overview of Provincial Groundwater Policy

Cold Lake – Beaver River Water Management Plan



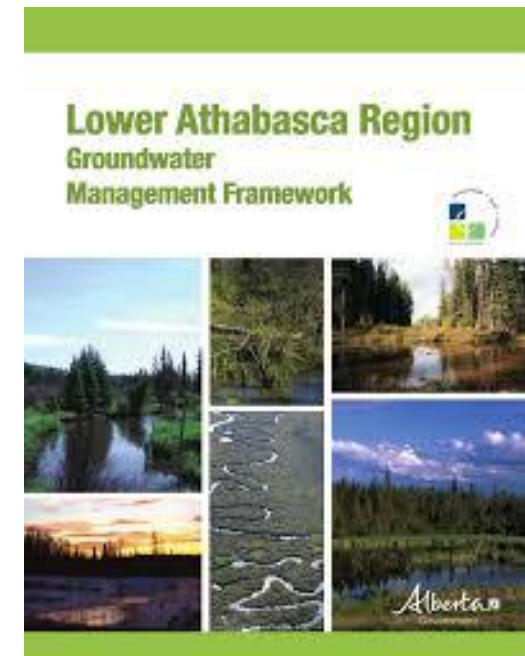
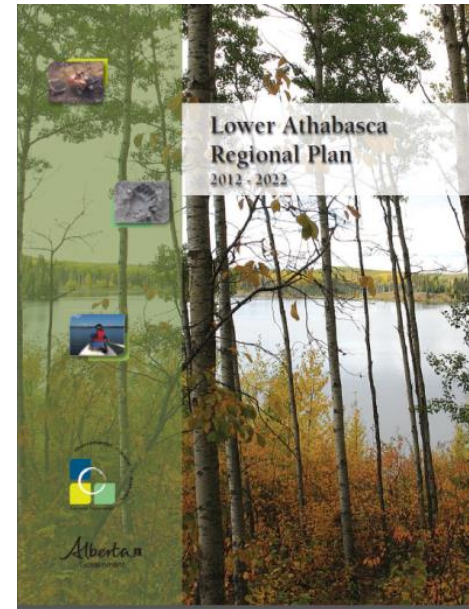
Regional Plans and Environmental Management Frameworks

Lower Athabasca Regional Plan (LARP)

- First regional plan developed under LUF and ALSA
- Includes Environmental Management Frameworks for Air Quality, Surface Water Quality, Surface Water Quantity, and *Groundwater*

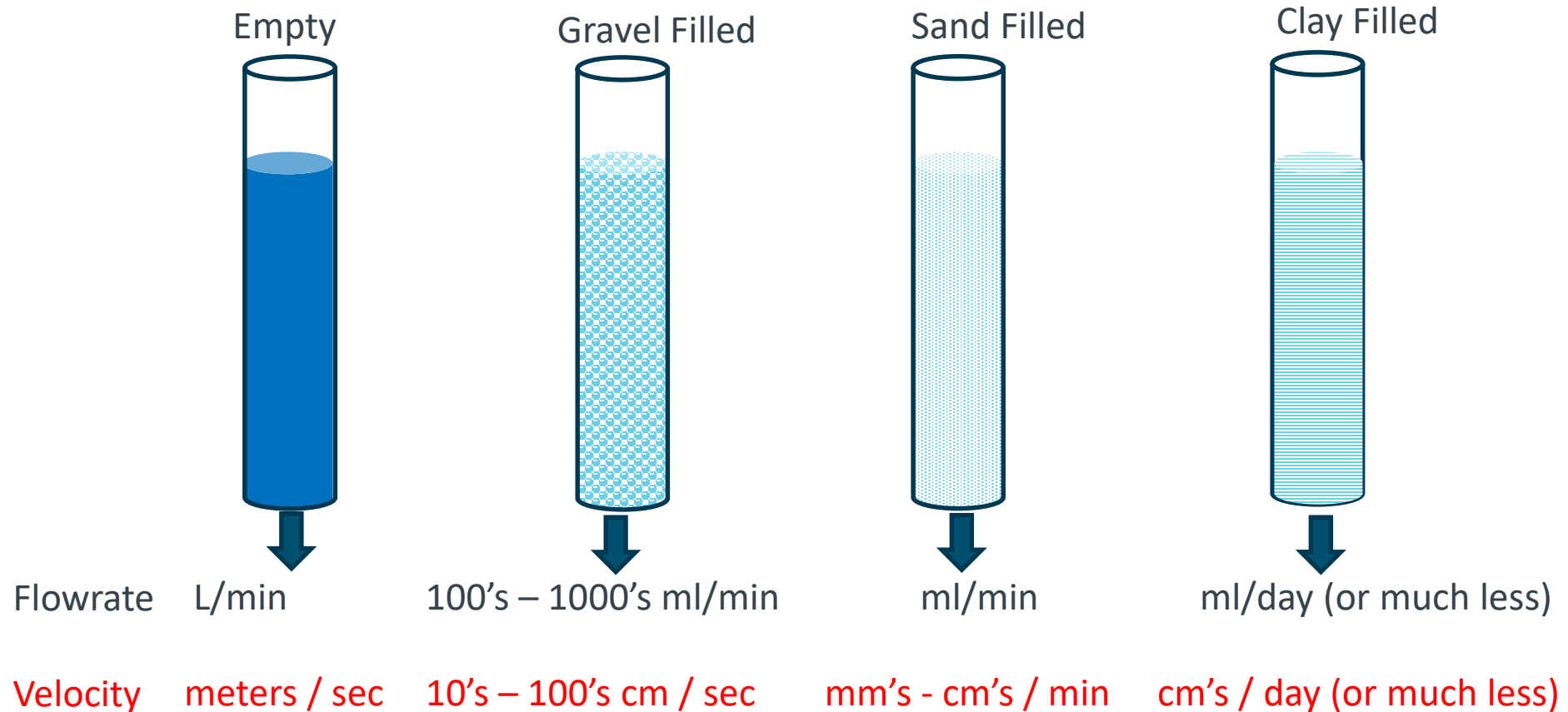
Lower Athabasca Groundwater Management Framework

- Management of regional scale cumulative effects
- Enhancement to current/proposed system of air, water and biodiversity management



Groundwater 101

Groundwater 101 - Visualization of Groundwater Flow Rates (Gravity Drainage of a 2" Pipe)

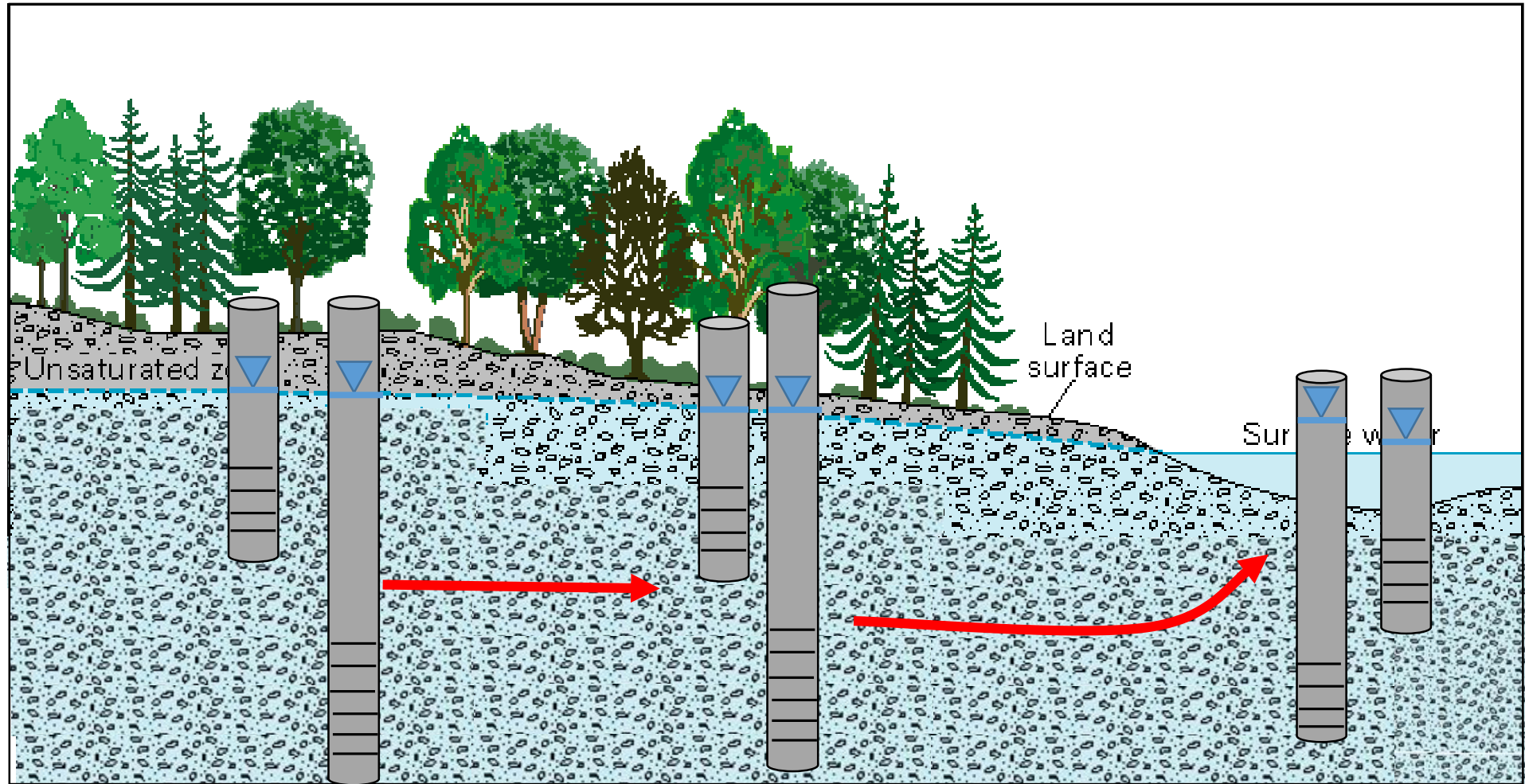


Typical Aquifers

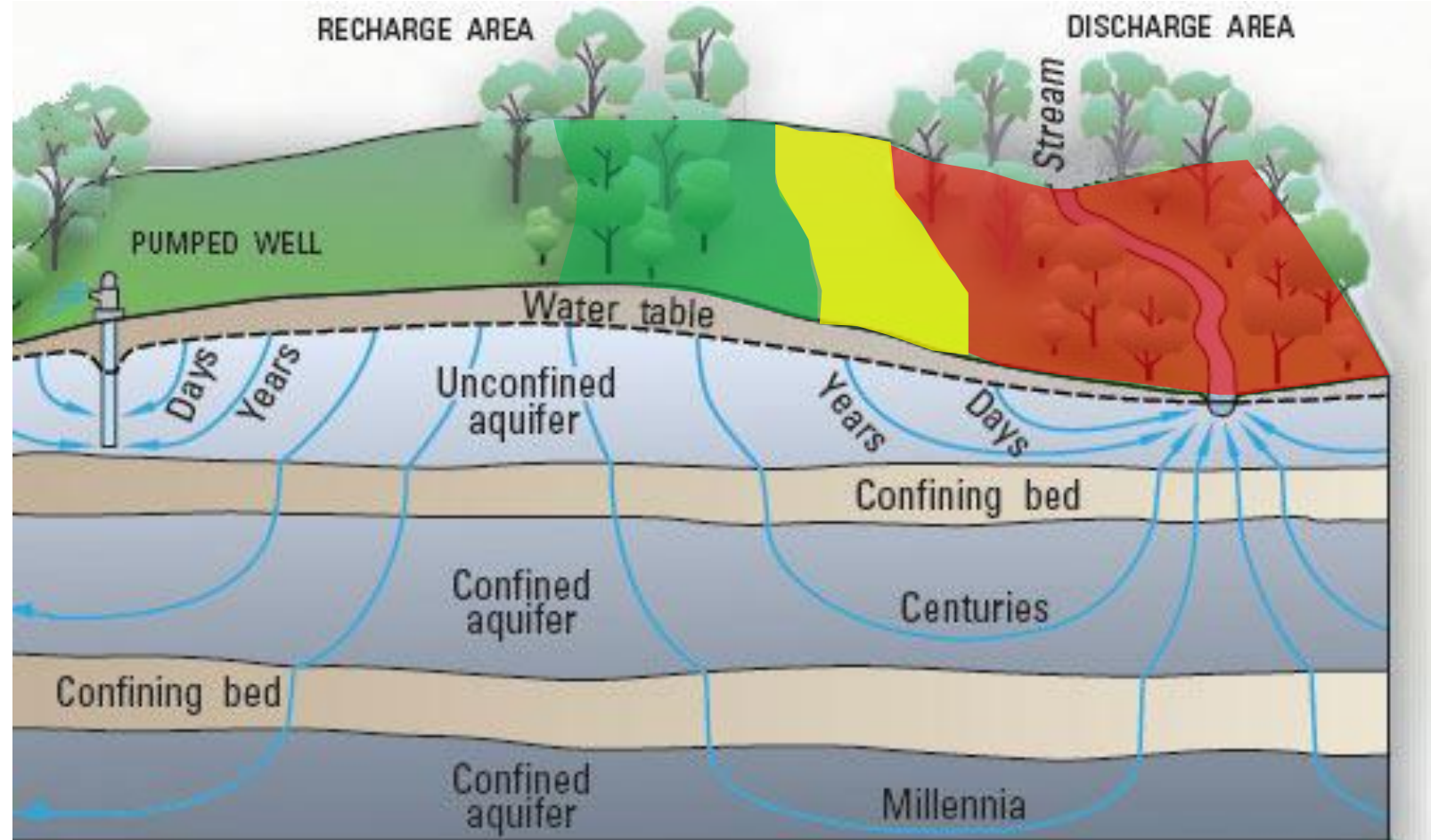
Typical Aquitards



Groundwater 101 - Determining Groundwater Flow Directions



Groundwater 101 - Groundwater Surface Water Interactions



Groundwater 101 - Relationship between Geology and Groundwater Flow

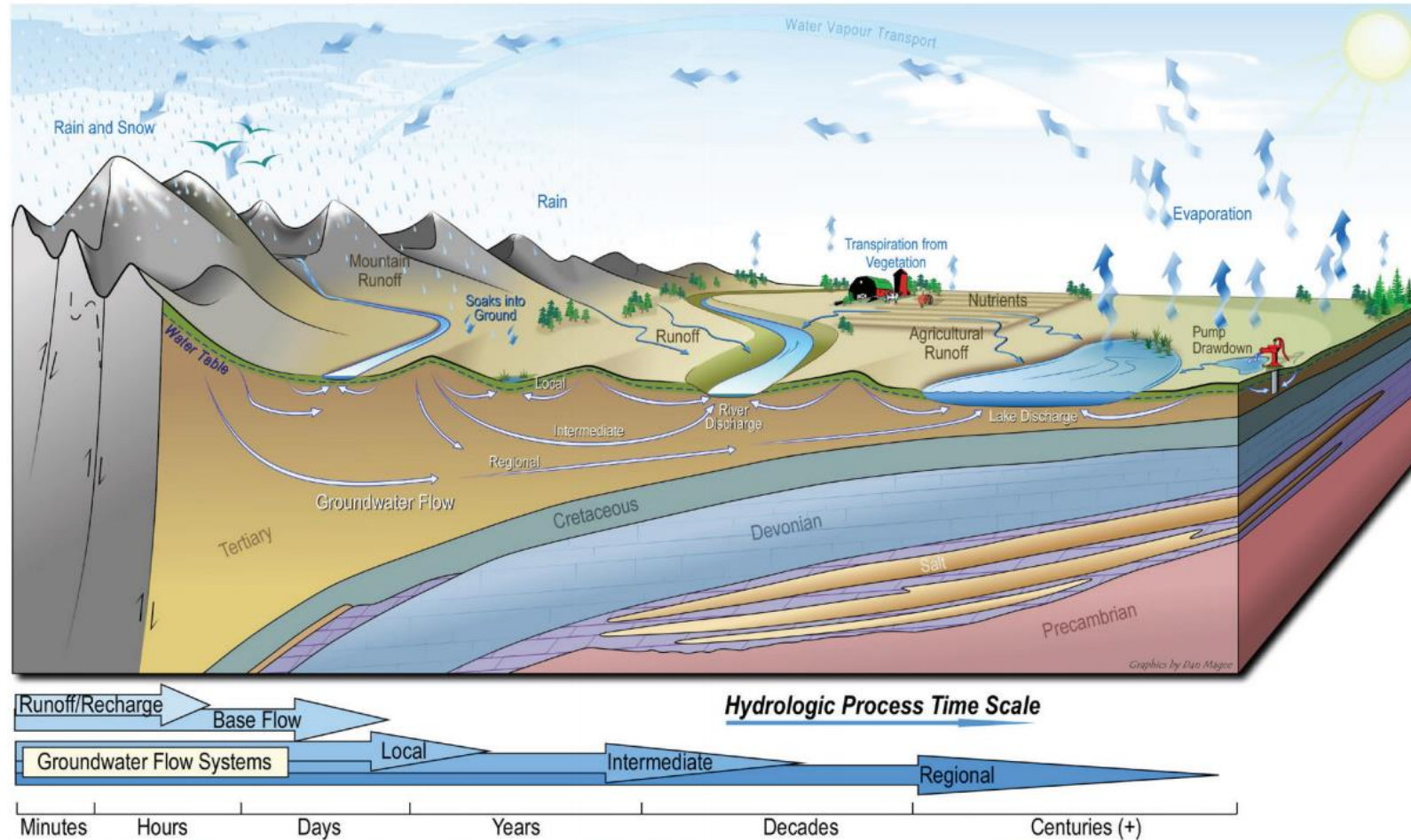
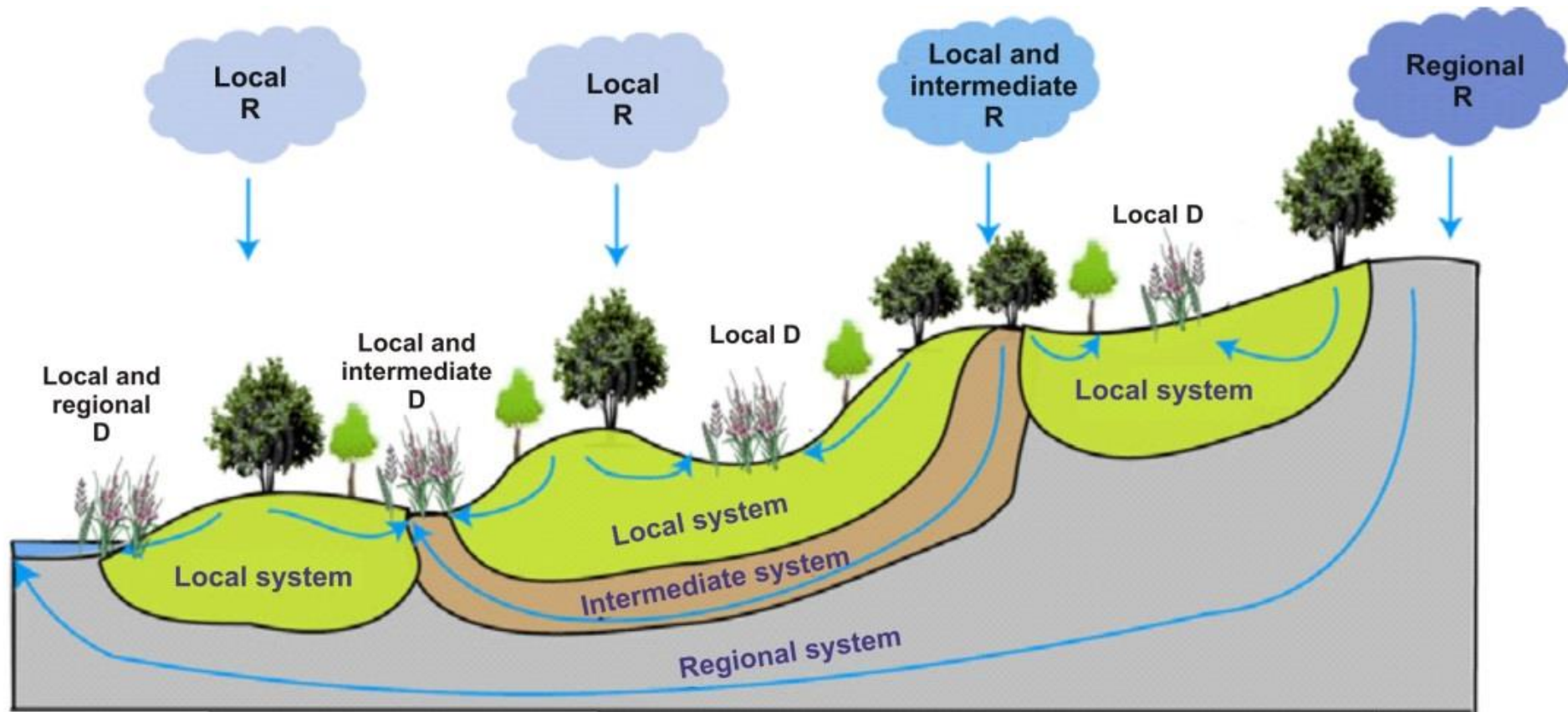


Figure 2. Idealized hydrological cycle of the Edmonton–Calgary Corridor.

Groundwater 101 - Regional vs. Local GW Flow



Groundwater 101 – Surface Water Interactions

Gaining Lake

- gains water from groundwater system



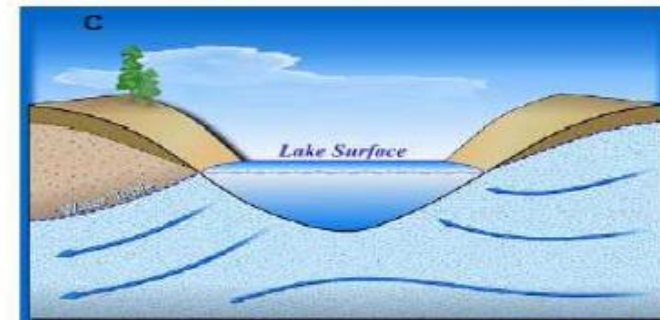
Losing Lake

- Loses water to groundwater system



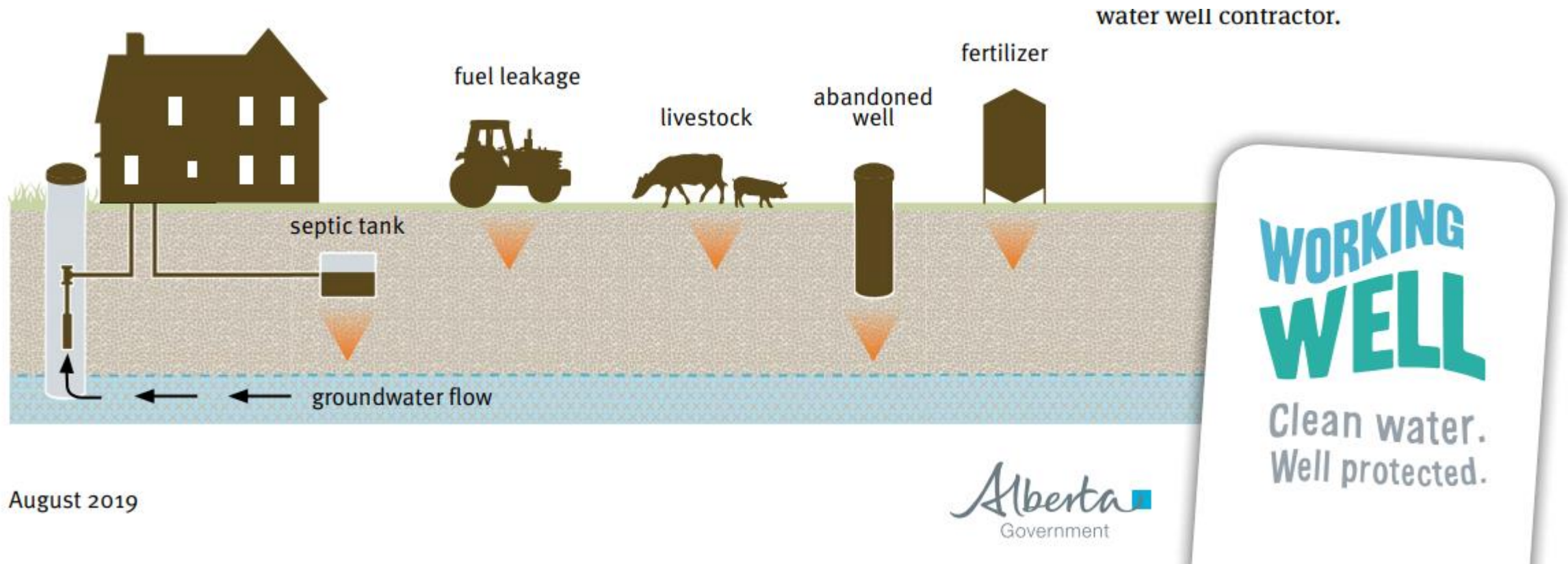
Flow-through

- Groundwater In \approx Groundwater Out



Source: AENV, 2006. Groundwater Quantity and Brackish Water State of the Basin Report

Groundwater 101 – Potential Contamination Sources

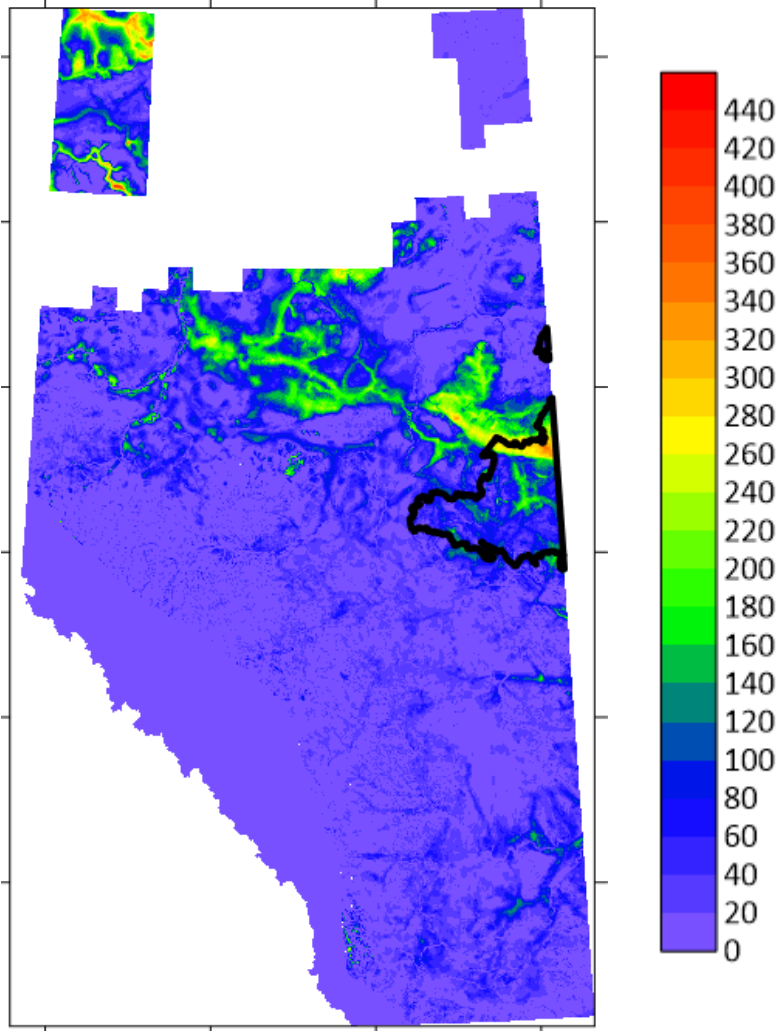


August 2019

<https://open.alberta.ca/publications/working-well-clean-water-well-protected-2019>

Groundwater Setting of the Cold Lake Beaver River Basin

Provincial Context for Geological Setting

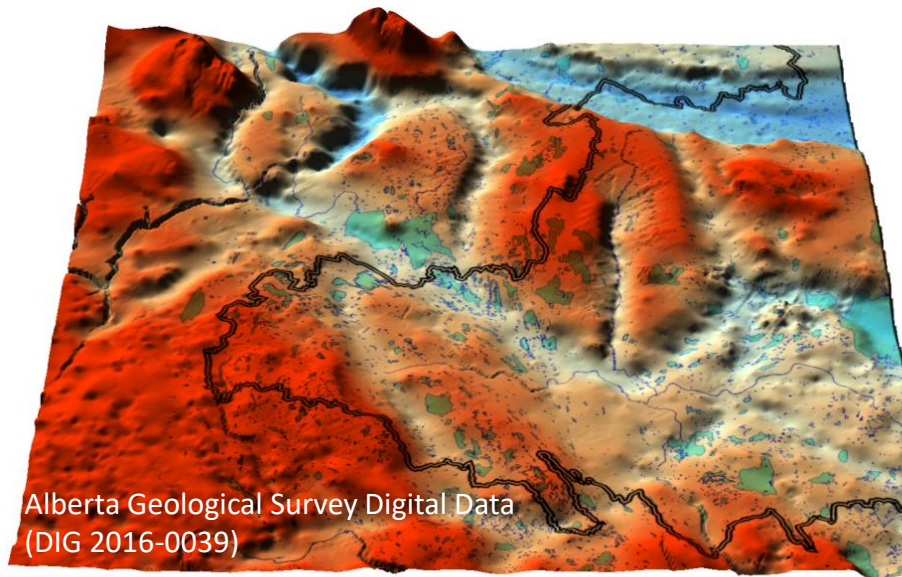


www.RiverValley.ab.ca

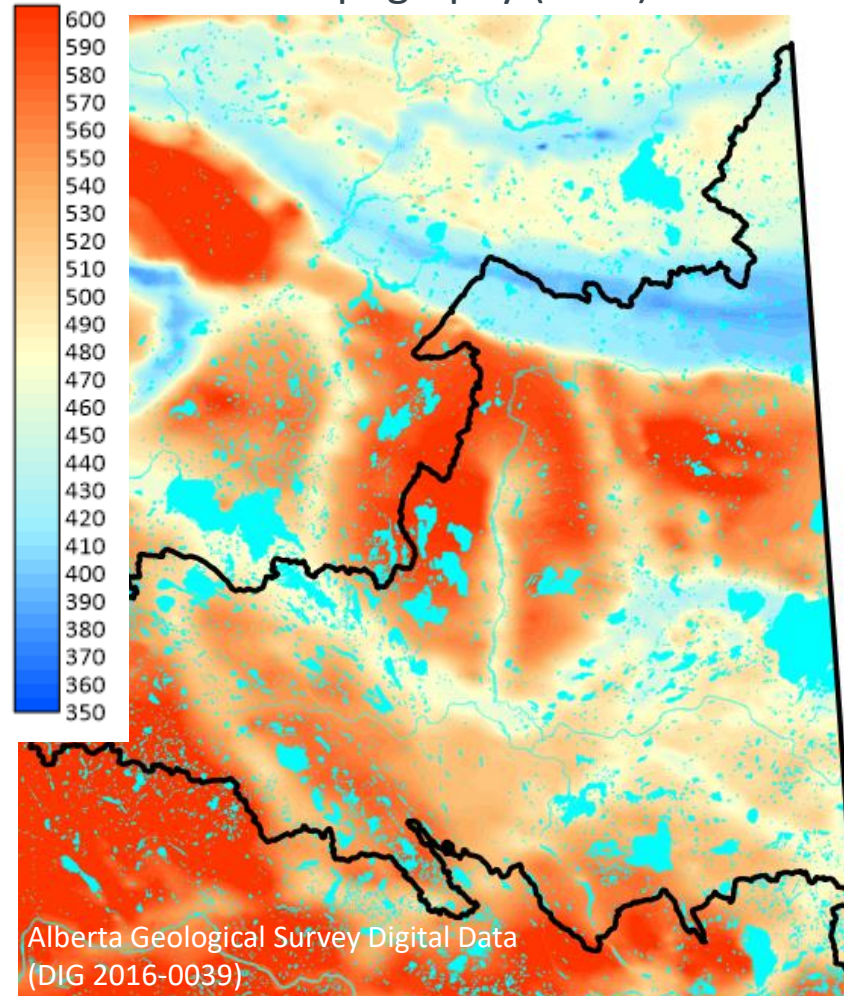


Overburden Thickness in Cold Lake – Beaver River Area

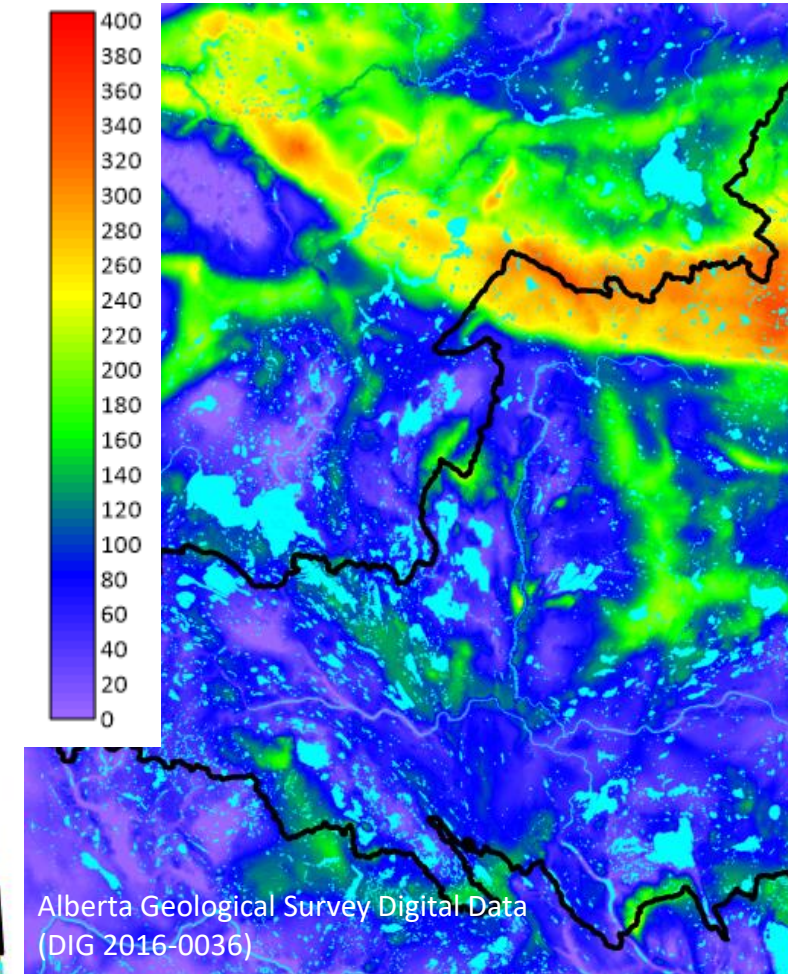
Bedrock Topography (masl)



Bedrock Topography (masl)



Sediment Thickness (m)

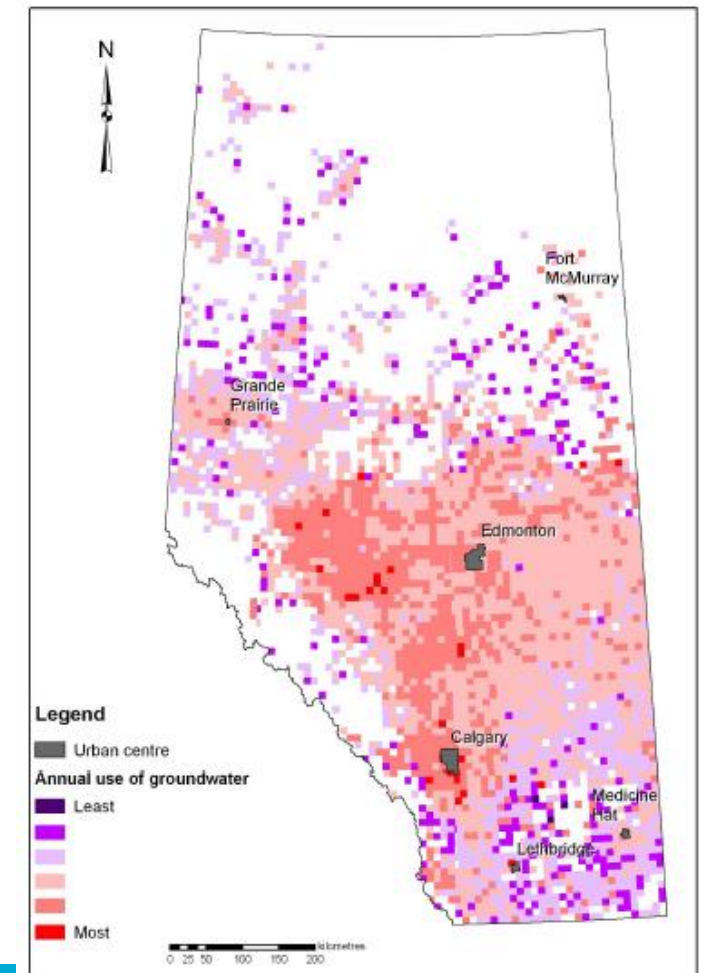
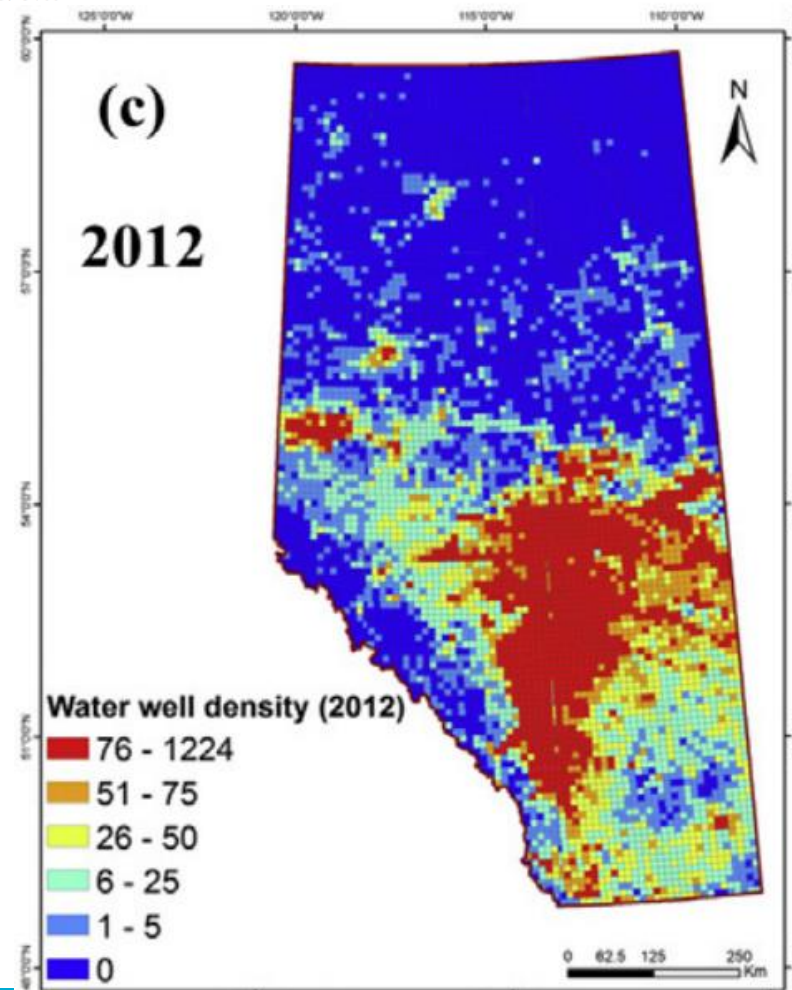
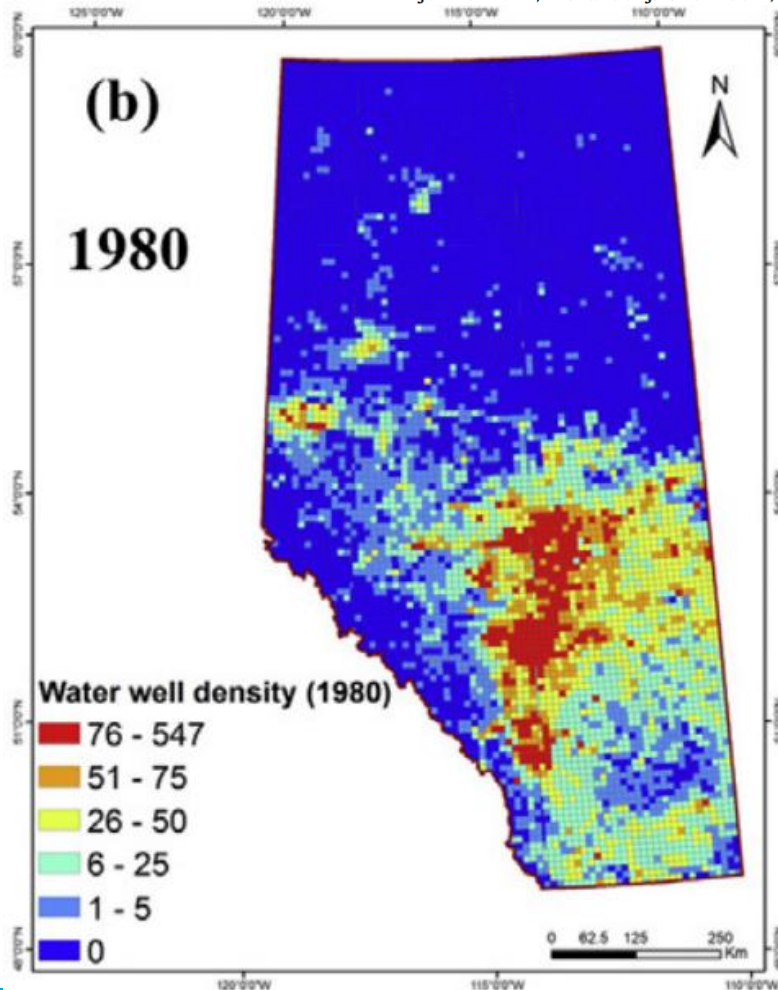


Provincial Context – Groundwater Use

Uncertainty based assessment of dynamic freshwater scarcity
in semi-arid watersheds of Alberta, Canada

Monireh Faramarzi^{a,*}, Karim C. Abbaspour^b, W.L. (Vic) Adamowicz^c, Wei Lu^c,
Jon Fennell^d, Alexander J.B. Zehnder^e, Greg G. Goss^f

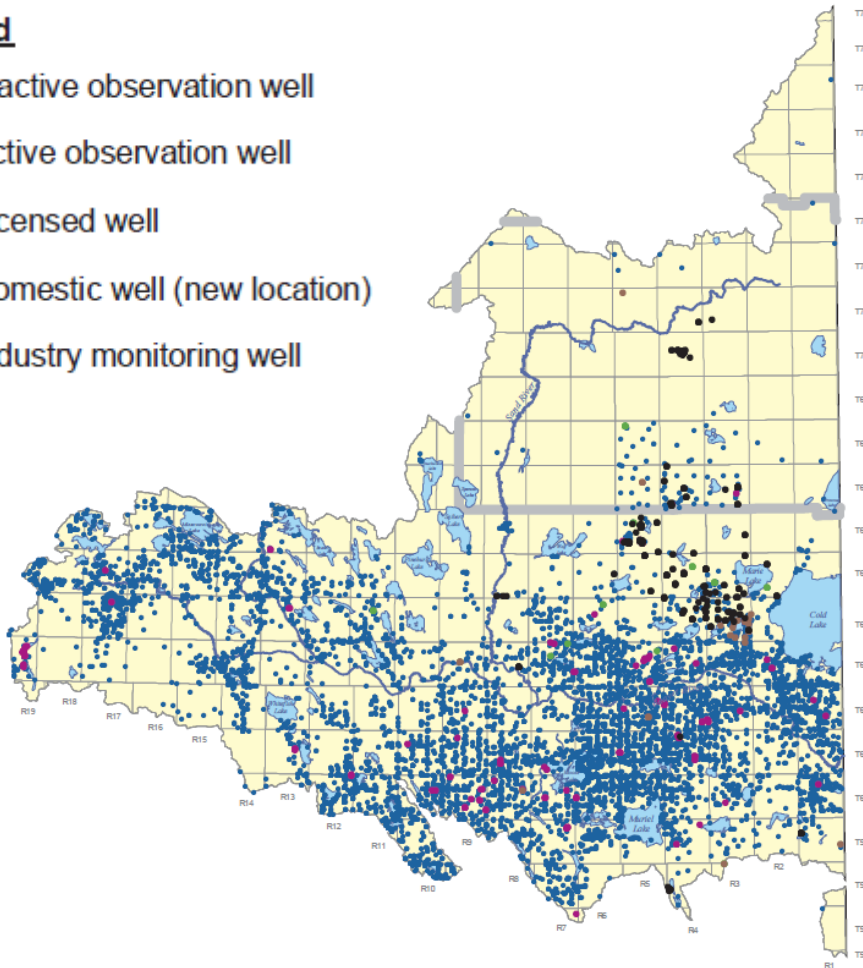
Alberta Geological Survey
Open File Report 2009-02



Water Wells in Cold Lake – Beaver River Area

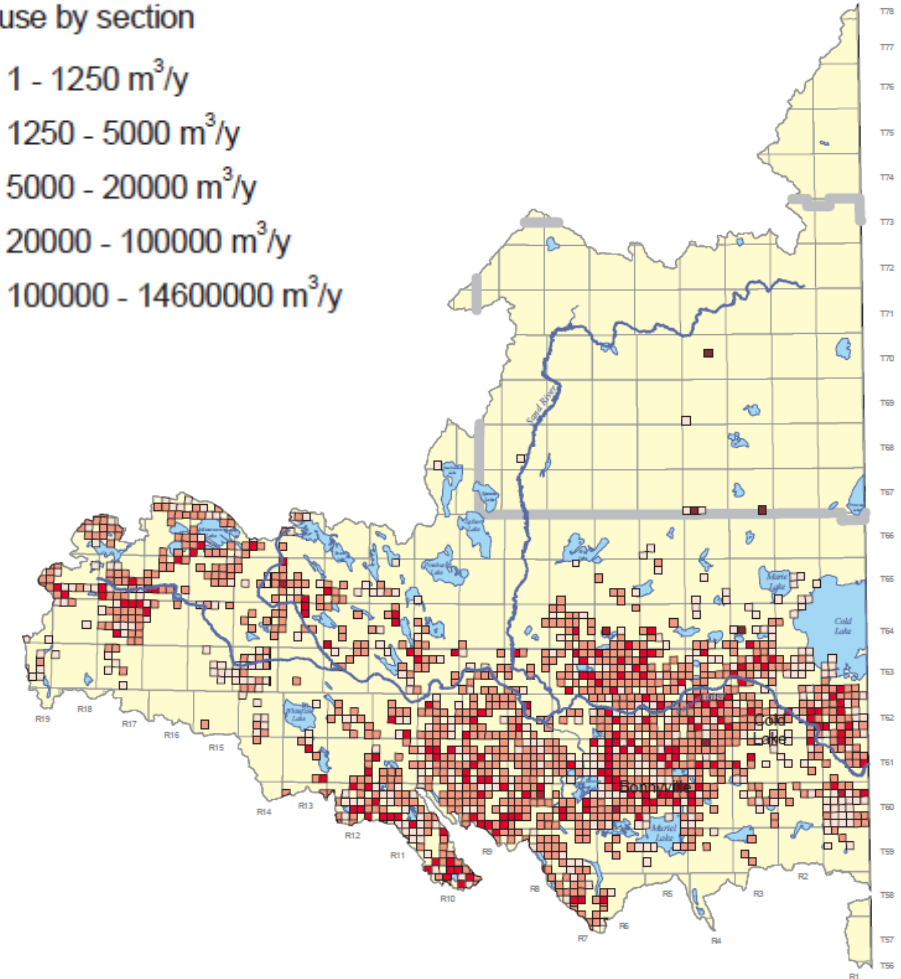
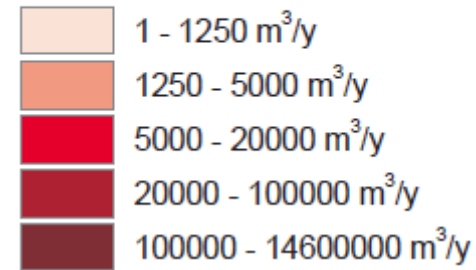
Legend

- Inactive observation well
- Active observation well
- Licensed well
- Domestic well (new location)
- Industry monitoring well

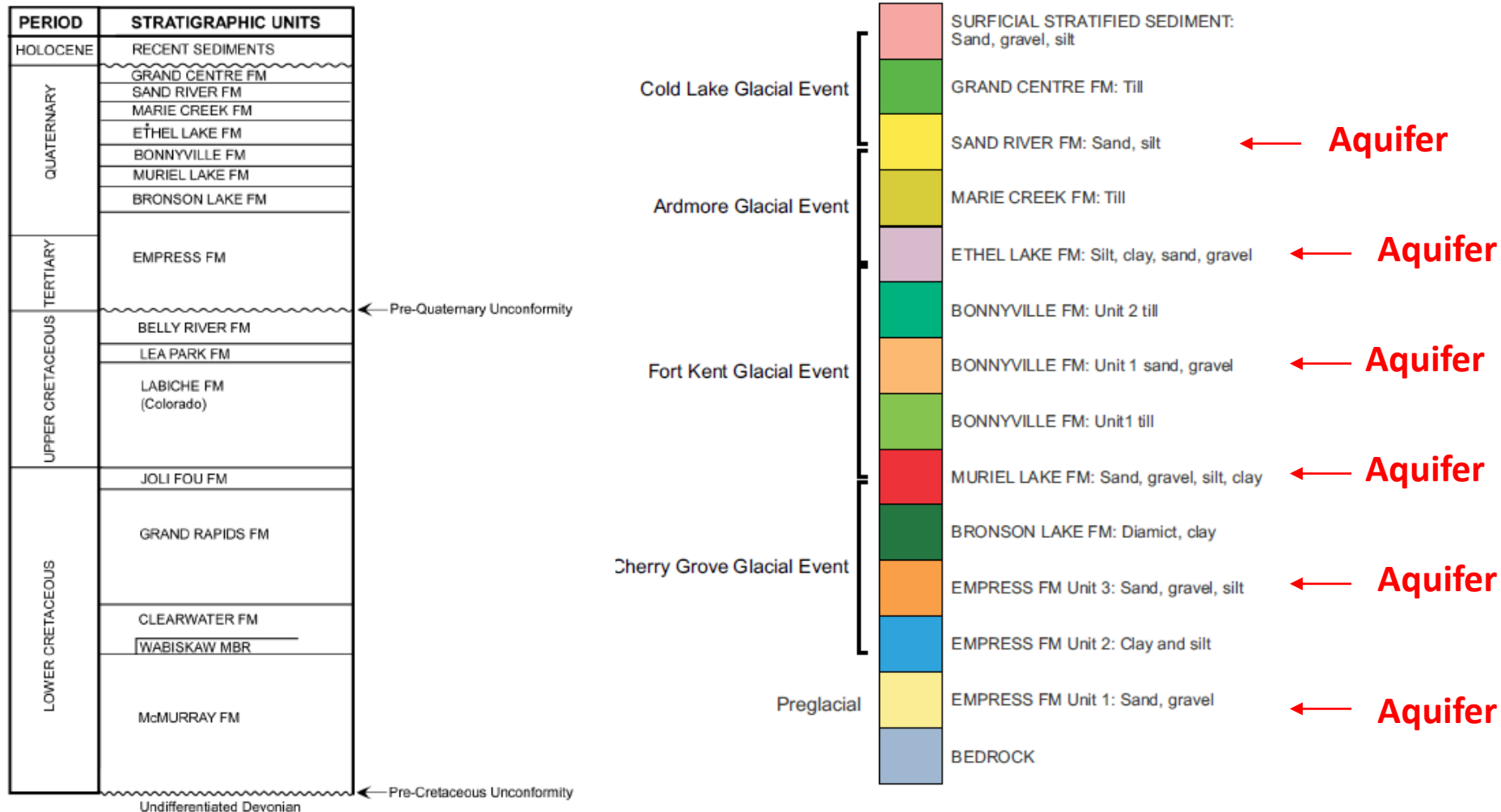


Legend

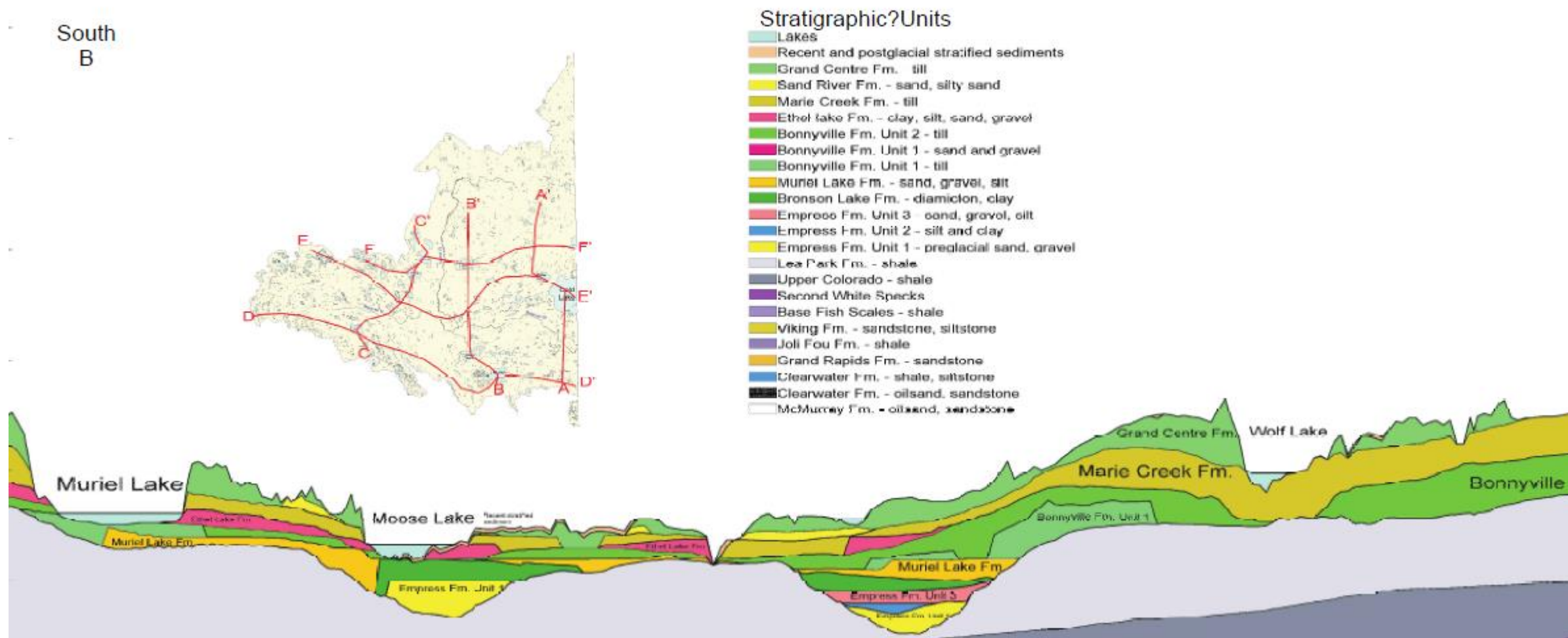
Annual use by section



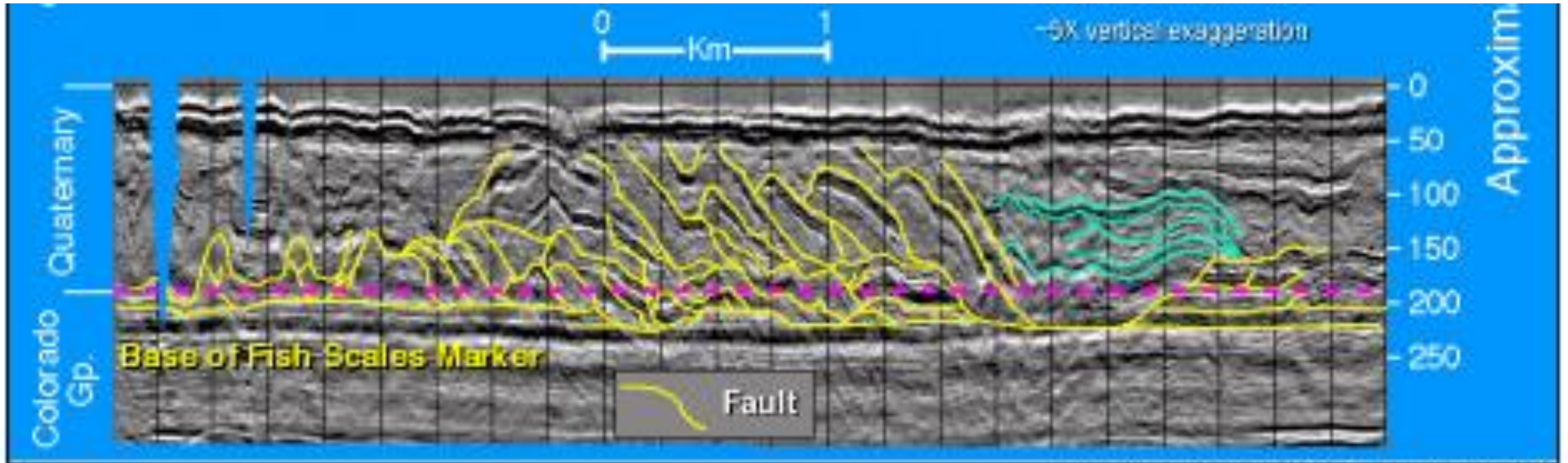
Geological Formations in the Cold Lake Beaver River Area



Overburden Stratigraphy in Cold Lake – Beaver River Area



Glaciotectonism in Cold Lake Beaver River Area

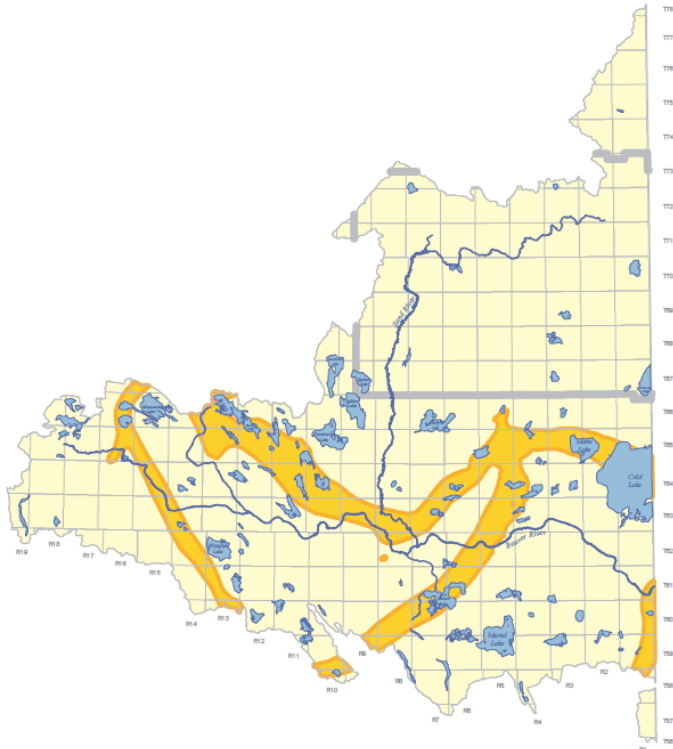


(modified from Andriashek et al, 1999)

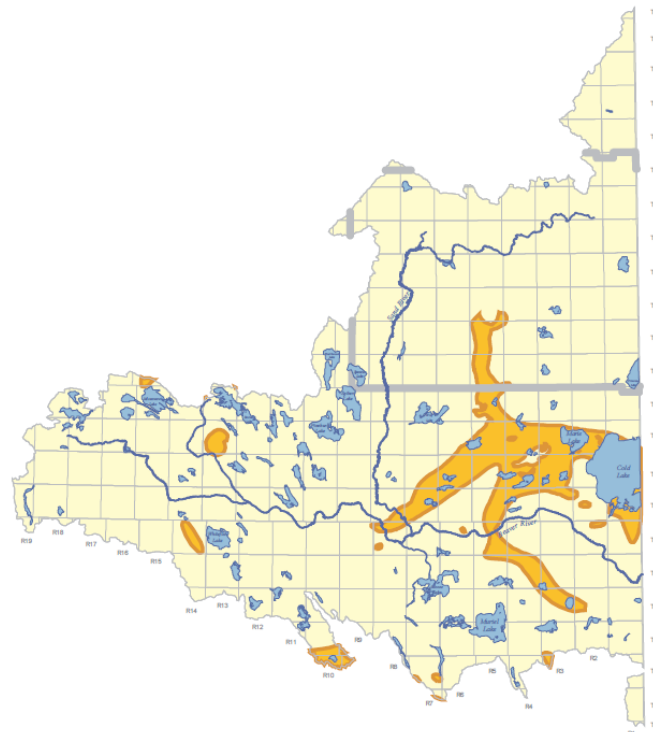
Figure 34. Glaciotectonic features of the Helina Channel, west of Marie Lake in the Cold Lake area, showing imbricate and folded beds of glacially thrust Quaternary sediment.

Distribution of Key Aquifers in Cold Lake - Beaver River Area

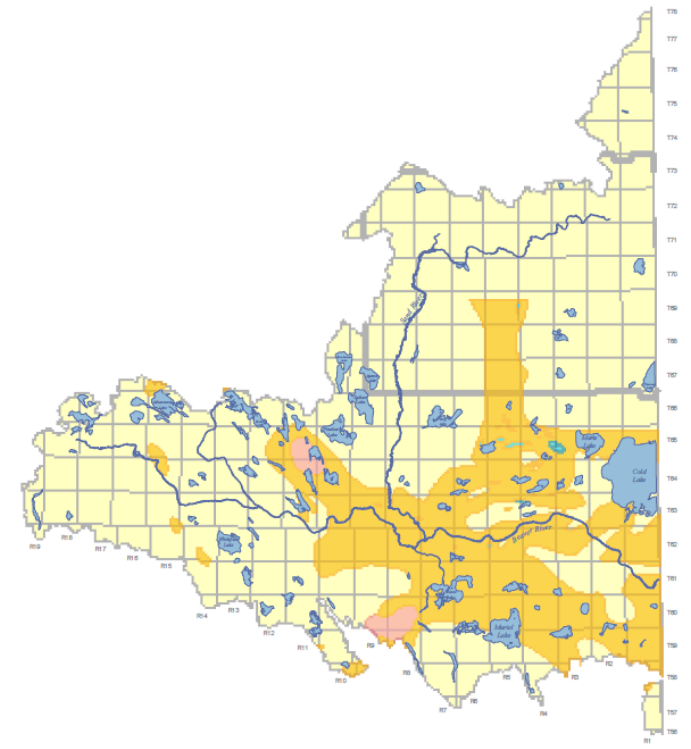
Empress 1 Formation



Empress 3 Formation

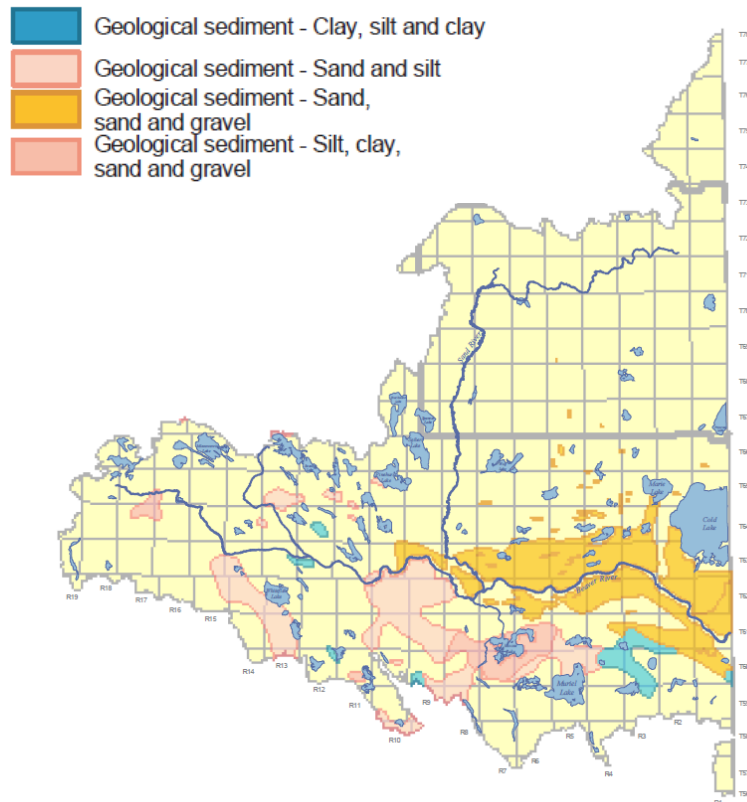


Muriel Lake Formation

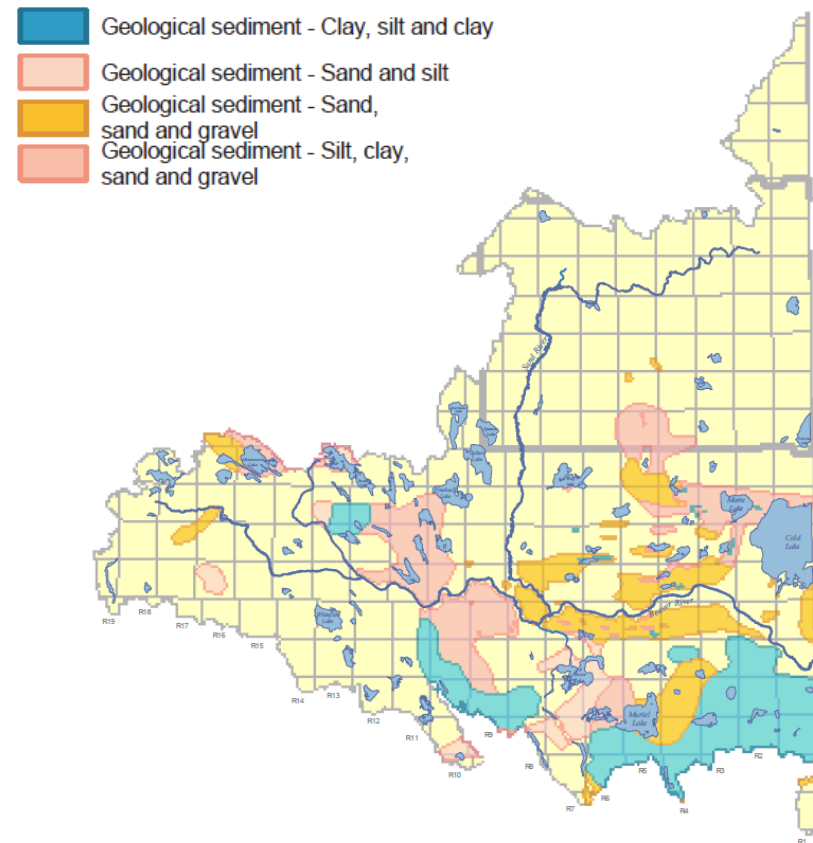


Distribution of Key Aquifers in Cold Lake - Beaver River Area

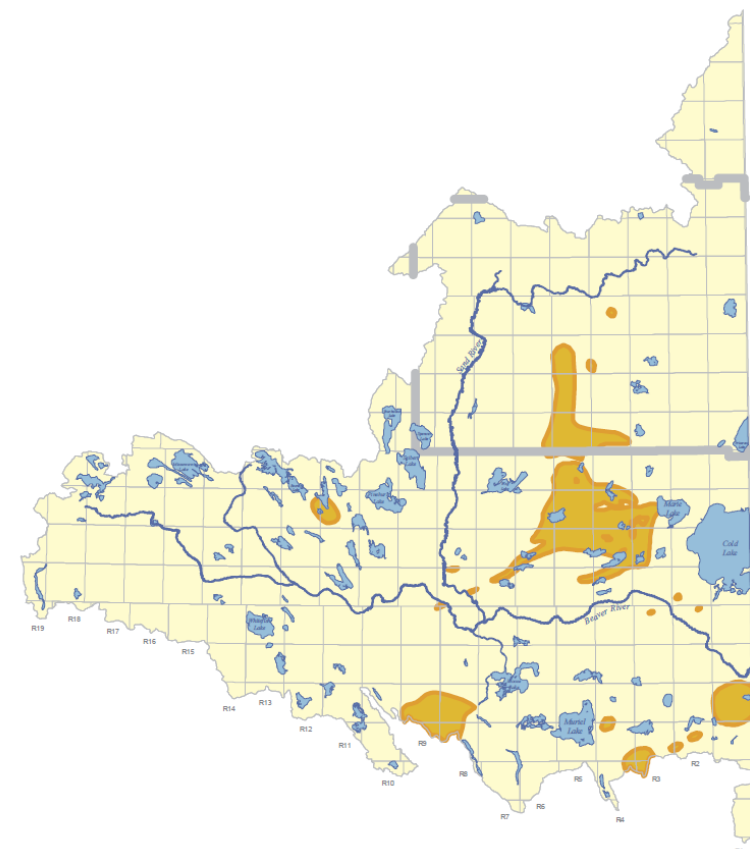
Sand River Formation



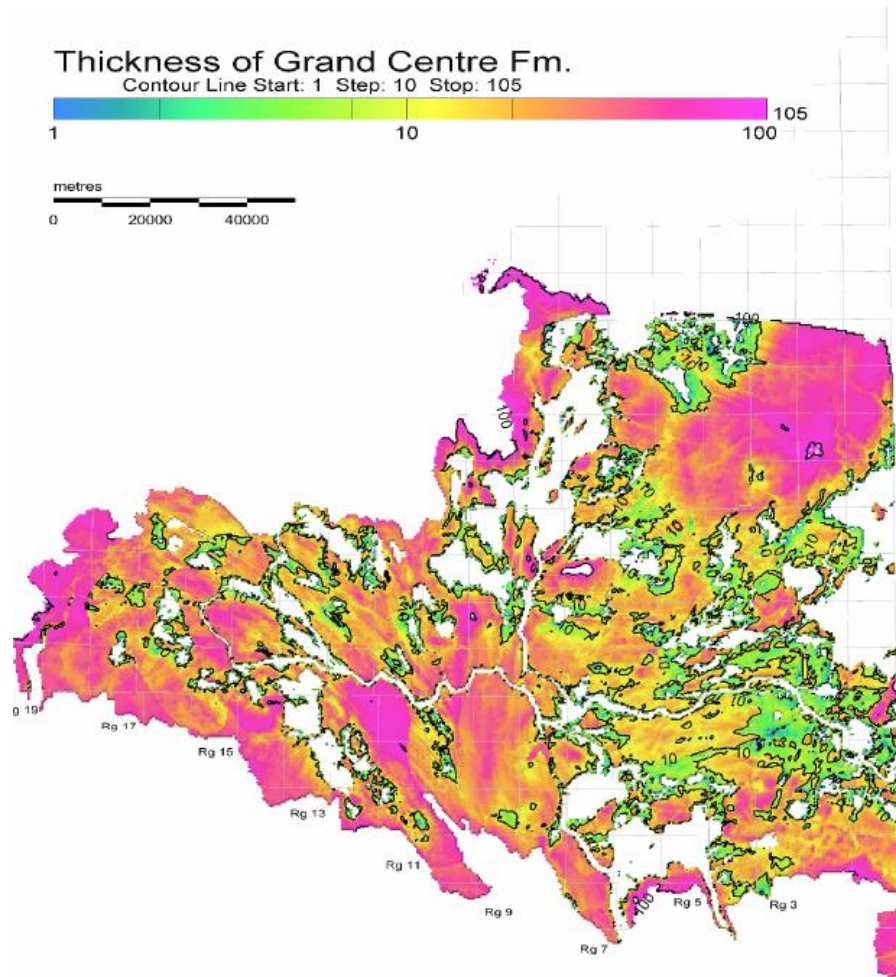
Ethel Lake Formation



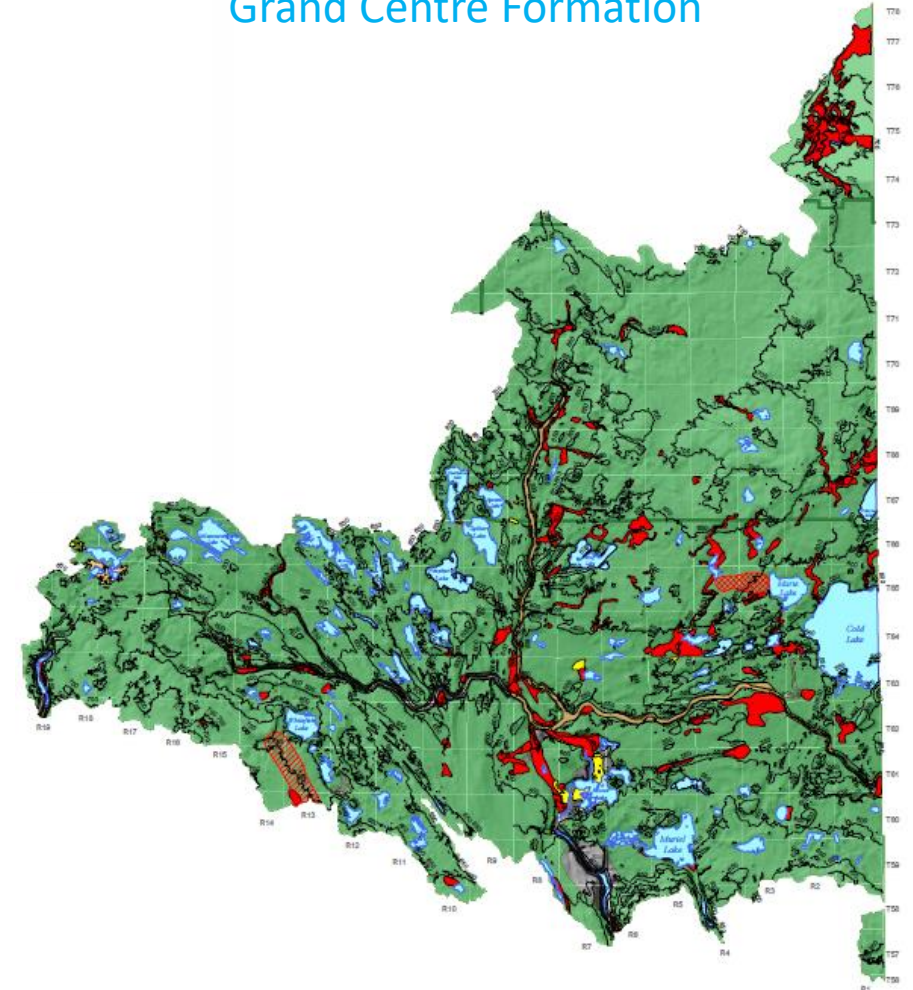
Bonnyville 1 Formation



Distribution of Key Aquifers in Cold Lake - Beaver River Area



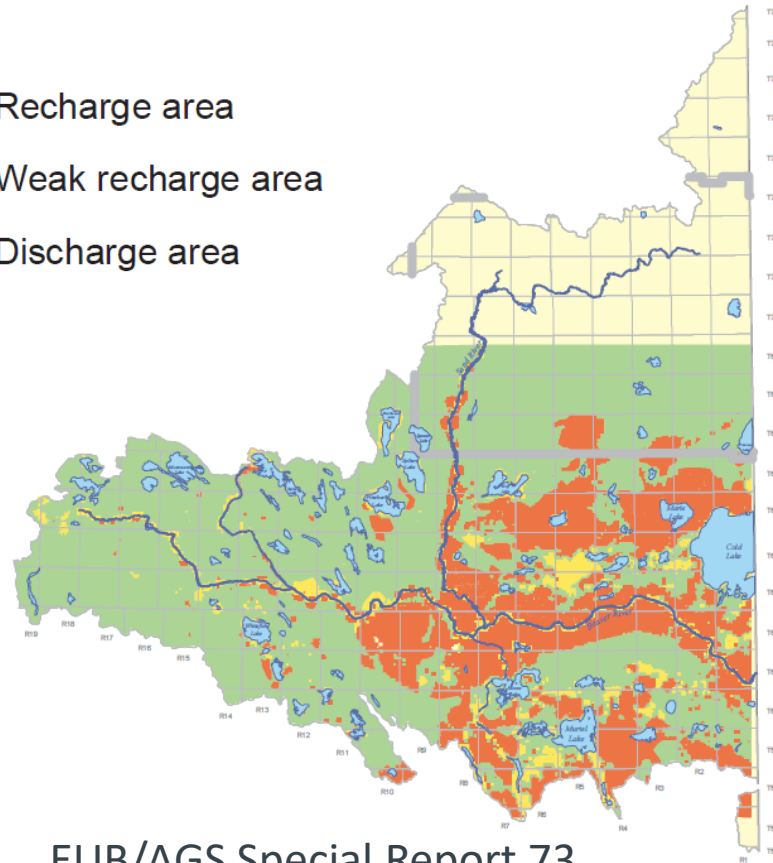
Grand Centre Formation



Groundwater Flow Directions in Cold Lake – Beaver River Area

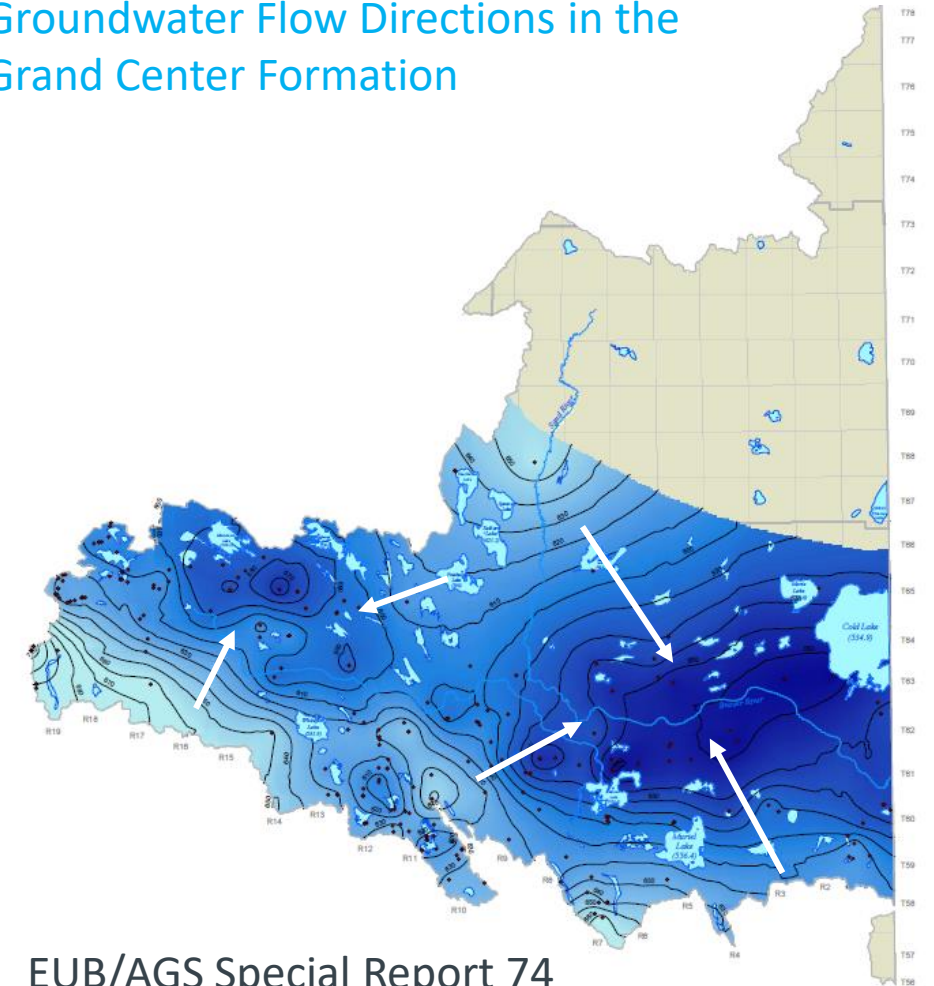
Distribution of Recharge and Discharge Areas

- Recharge area
- Weak recharge area
- Discharge area



EUB/AGS Special Report 73

Groundwater Flow Directions in the Grand Center Formation



EUB/AGS Special Report 74

Groundwater 101 - Groundwater Susceptibility (to Contamination)

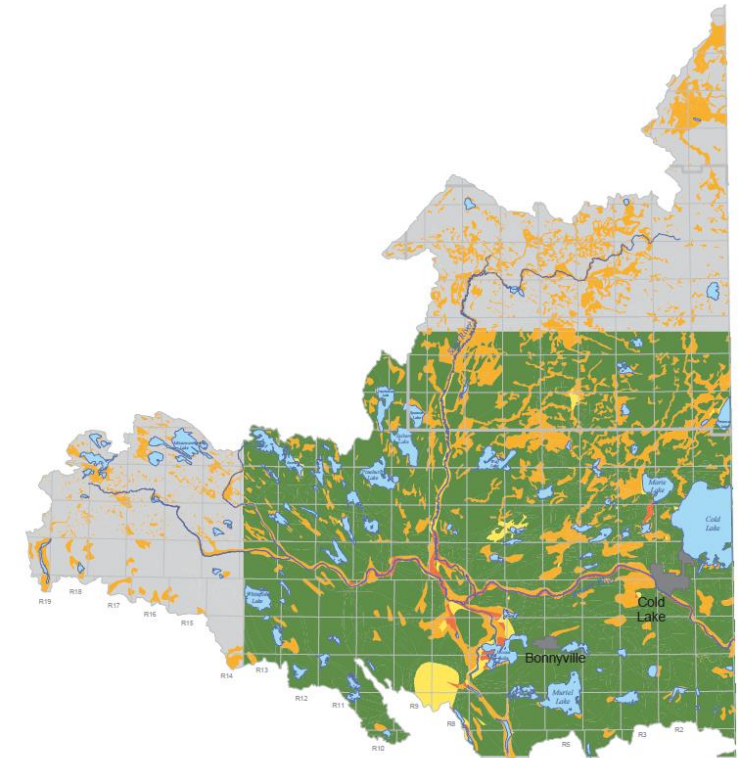
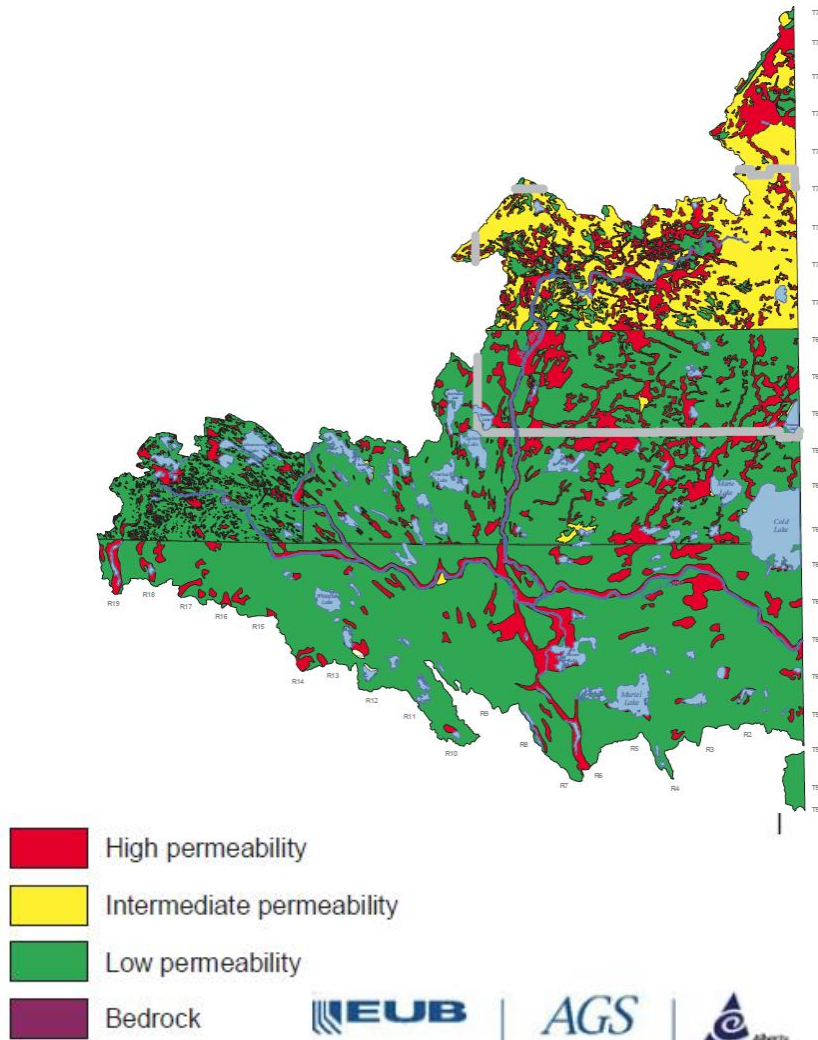
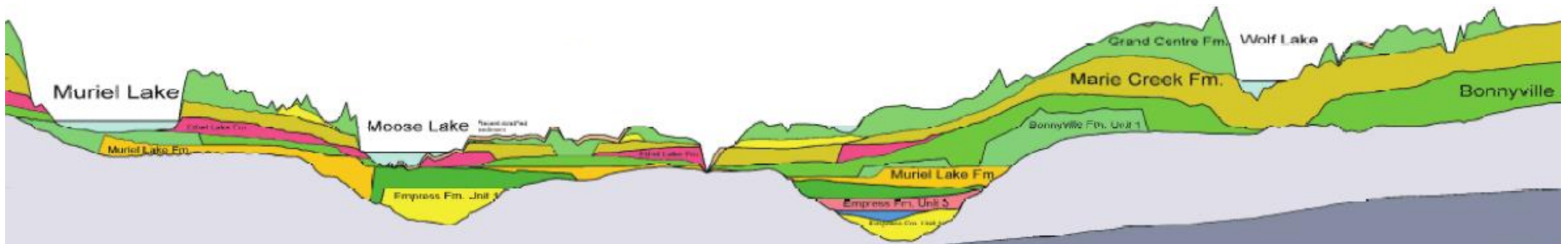


Figure 6.2. Aquifer sensitivity to contamination.

Groundwater Residence Times in Overburden Deposits

Formation			Tritium
	$^{14}\text{C}_{\text{DIC}}$ pMC	Corr. age (years B.P.)	(T.U.)
Grand Centre	78.6	Recent	10.2
Sand River	–	–	–
Marie Creek	50.9–99	1700–recent	<0.8–14.4
Ethel Lake	31.5–61.2	6200–1200	<0.8
Bonnyville	54.6	3700	<0.8
Muriel Lake	18.1–59.6	14,000–800	<0.8
Bronson Lake	–	–	–
Empress Unit 3	9.9–28.5	18,000–6700	<0.8
Empress Unit 1	5.5–42.4	25,000–3000	<0.8

Source: Moncur et al. 2015



Groundwater – Surface Water Interactions

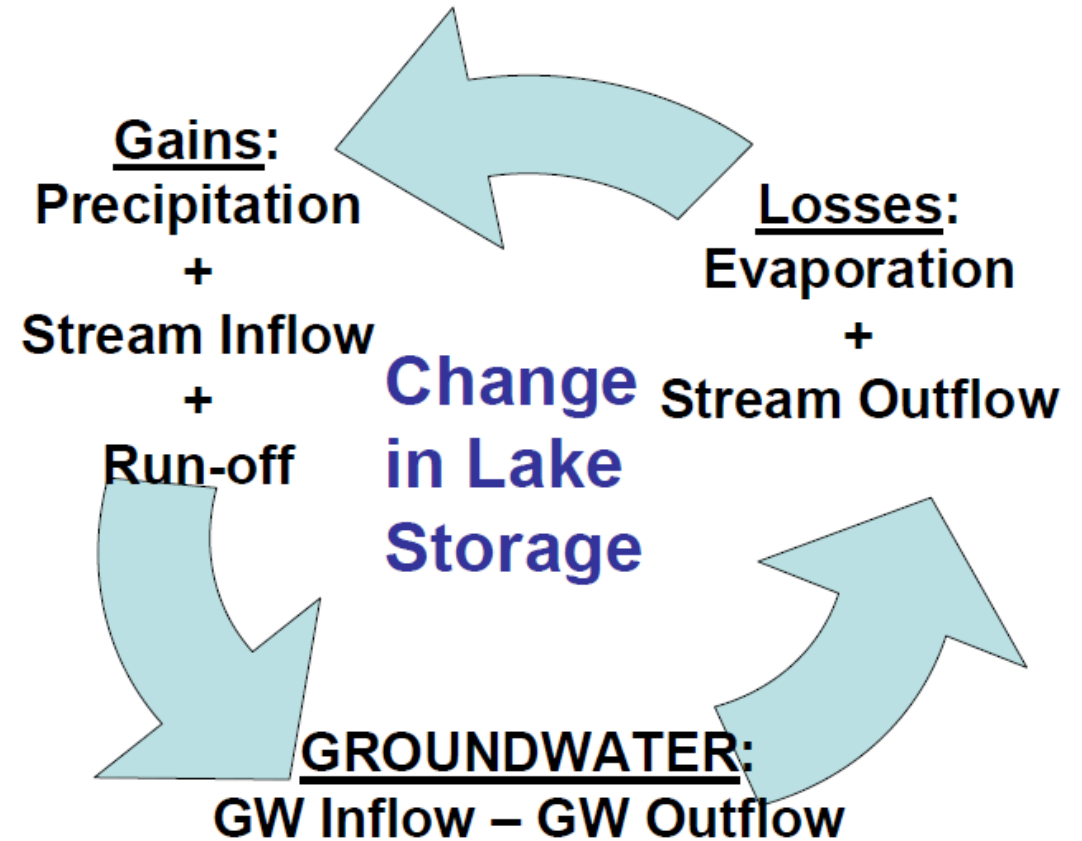
Alberta
Freedom To Create. Spirit To Achieve.

**Cold Lake-Beaver River Basin
Winter Lake Level Project:
A Groundwater-Surface Water
Interaction Study**

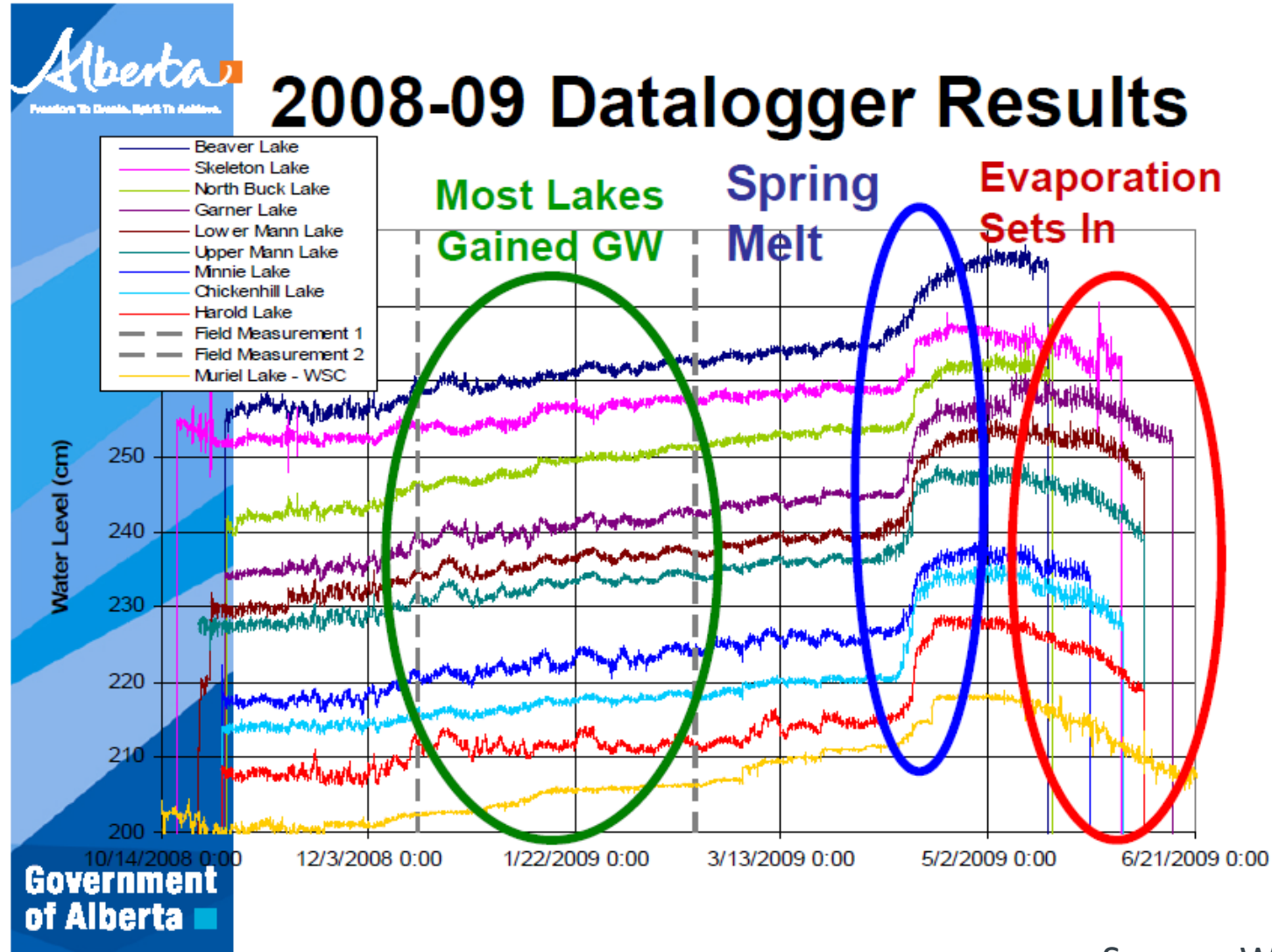
Presented to
Skeleton Lake Stewardship Association
at Twin Atria Bldg., Edmonton, Alberta
May 6, 2010

Brent Welsh, EIT
Regional Hydrogeologist
Alberta Environment, Northern Region

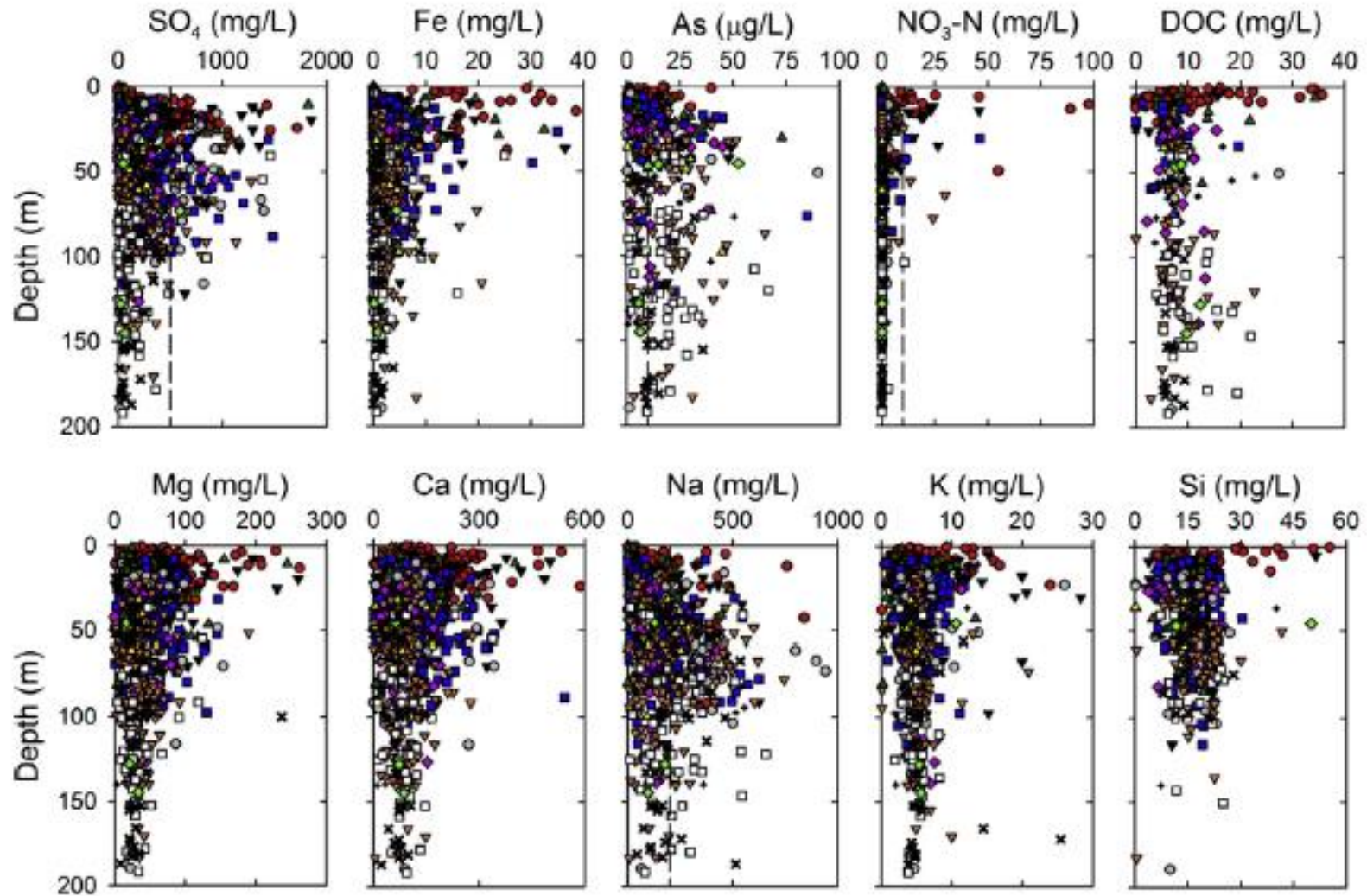
**Government
of Alberta**



Groundwater – Surface Water Interactions



Groundwater Quality in Cold Lake – Beaver River Area

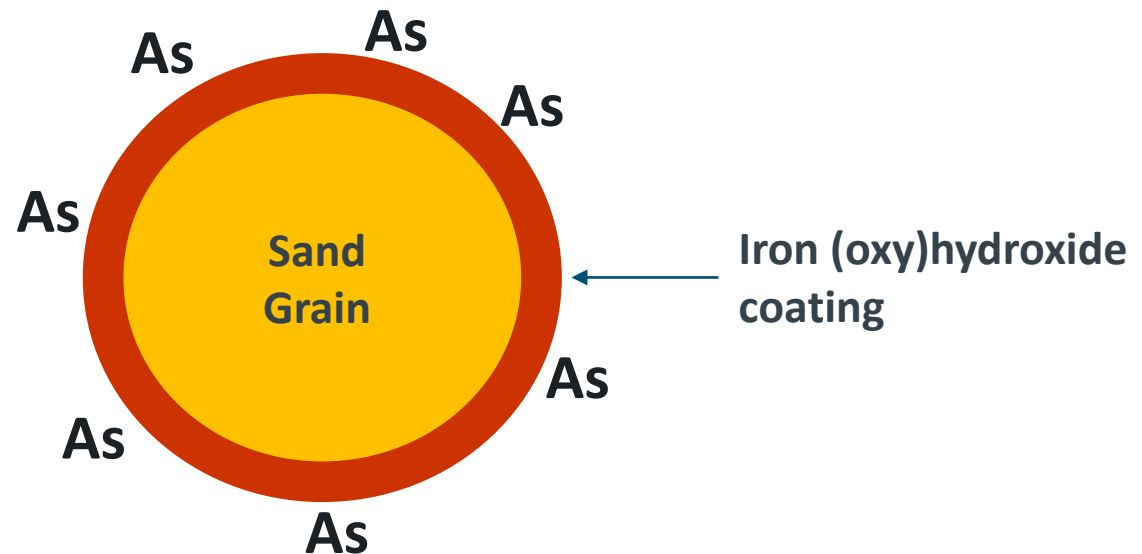


Natural Sources of Arsenic (As)

- Pyrite / Arsenopyrite



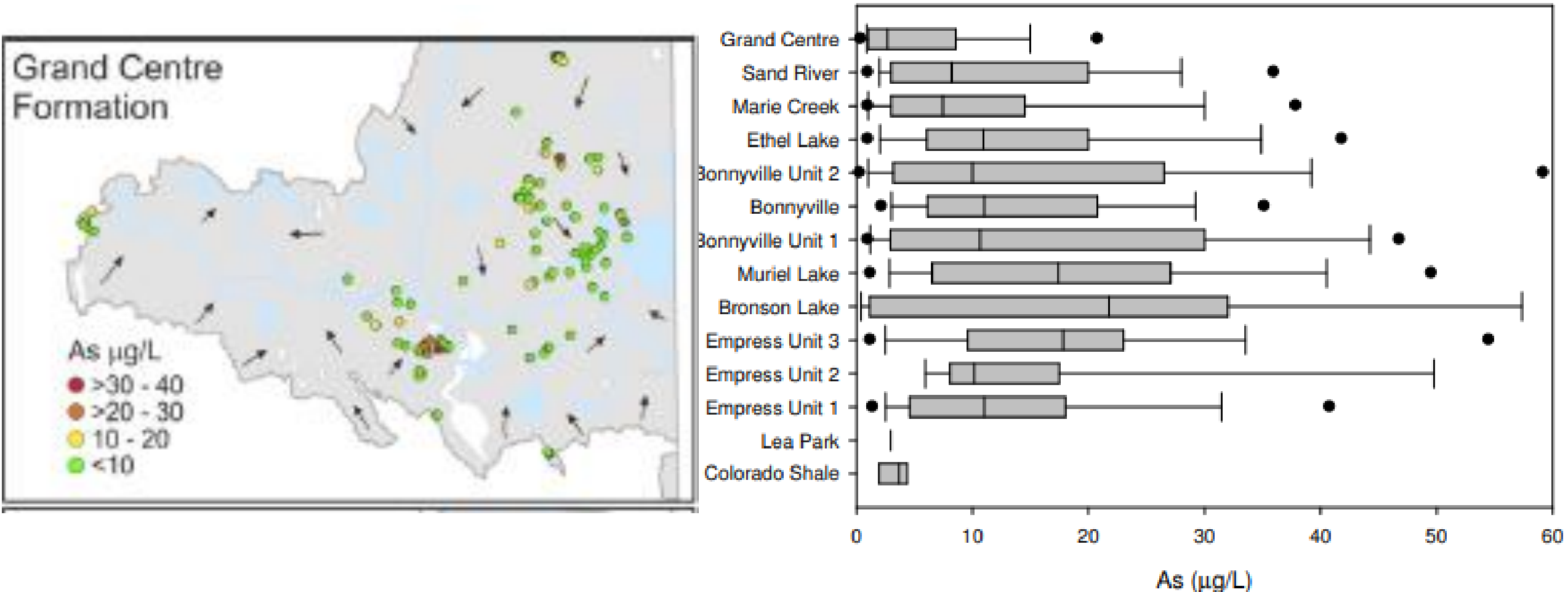
- Iron (Oxy)Hydroxides



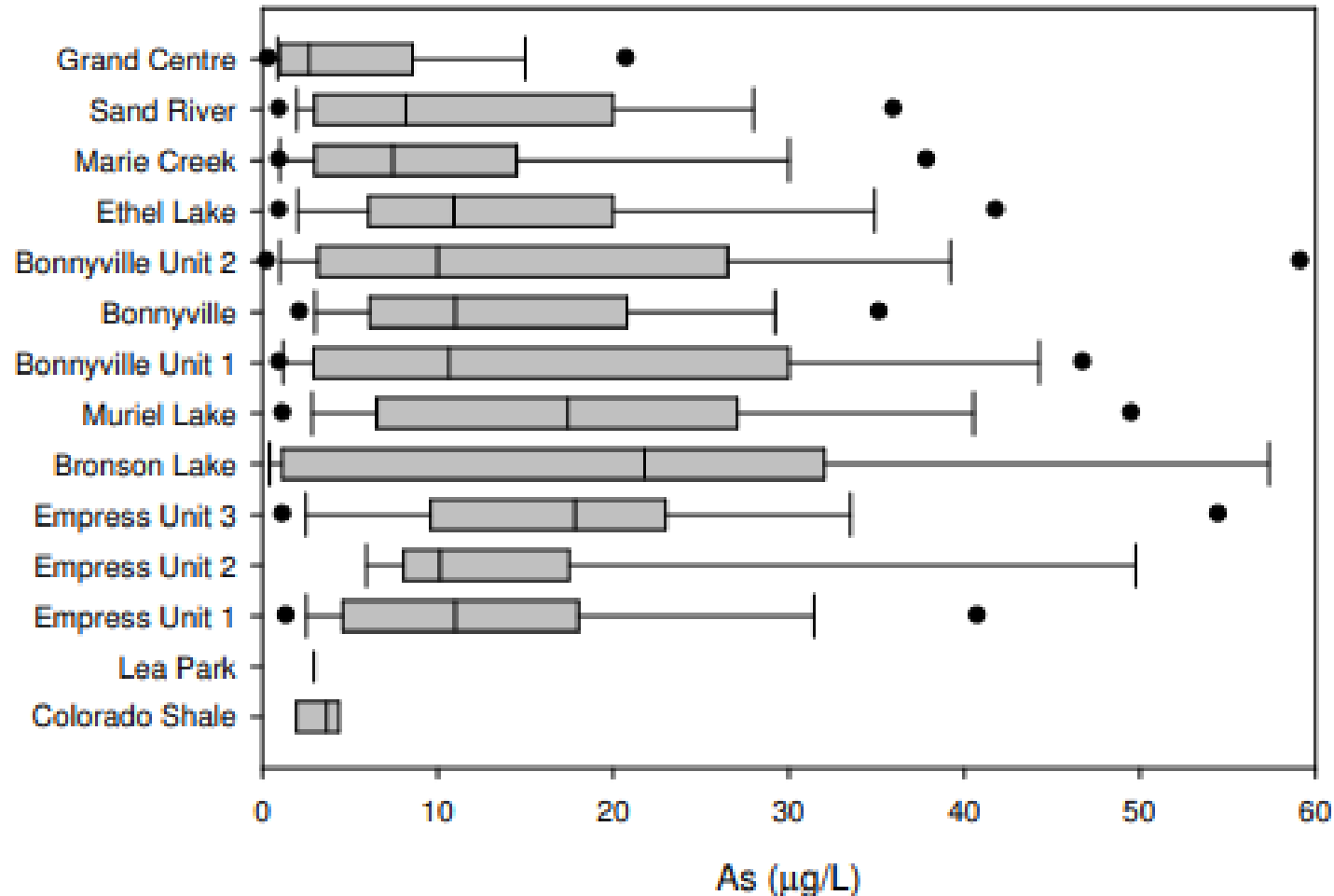
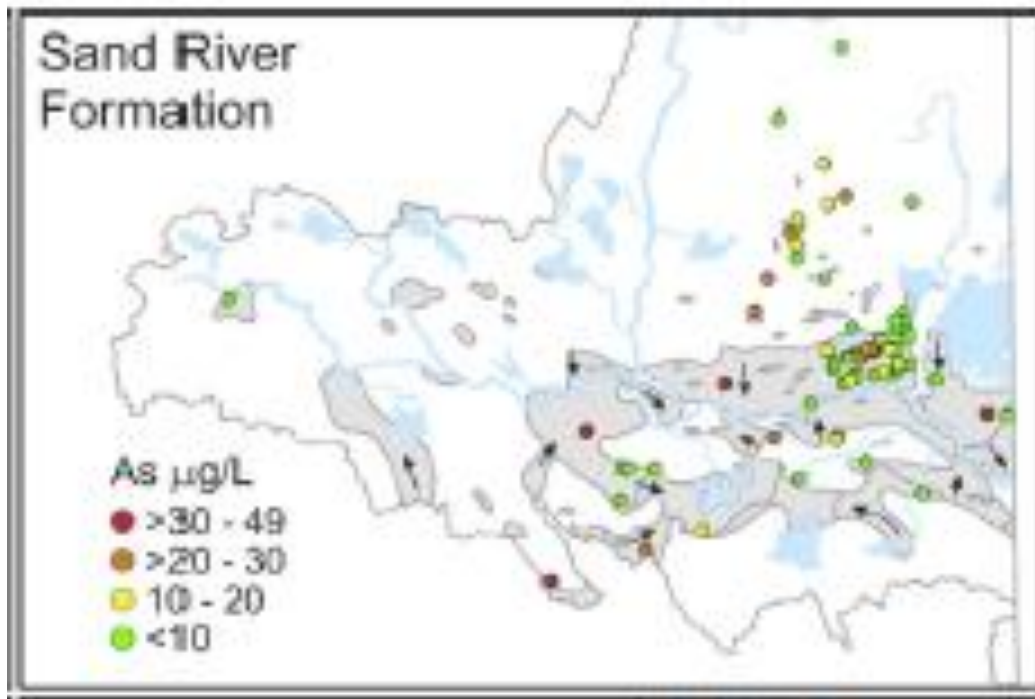
Arsenic in Groundwater

- Compared to most metals, arsenic is more mobile in natural waters
 - Arsenite (As^{3+})
 - In water has the form: H_3AsO_3
 - Arsenate (As^{5+})
 - In water has the form: H_2AsO_4^- and HAsO_4^{2-}

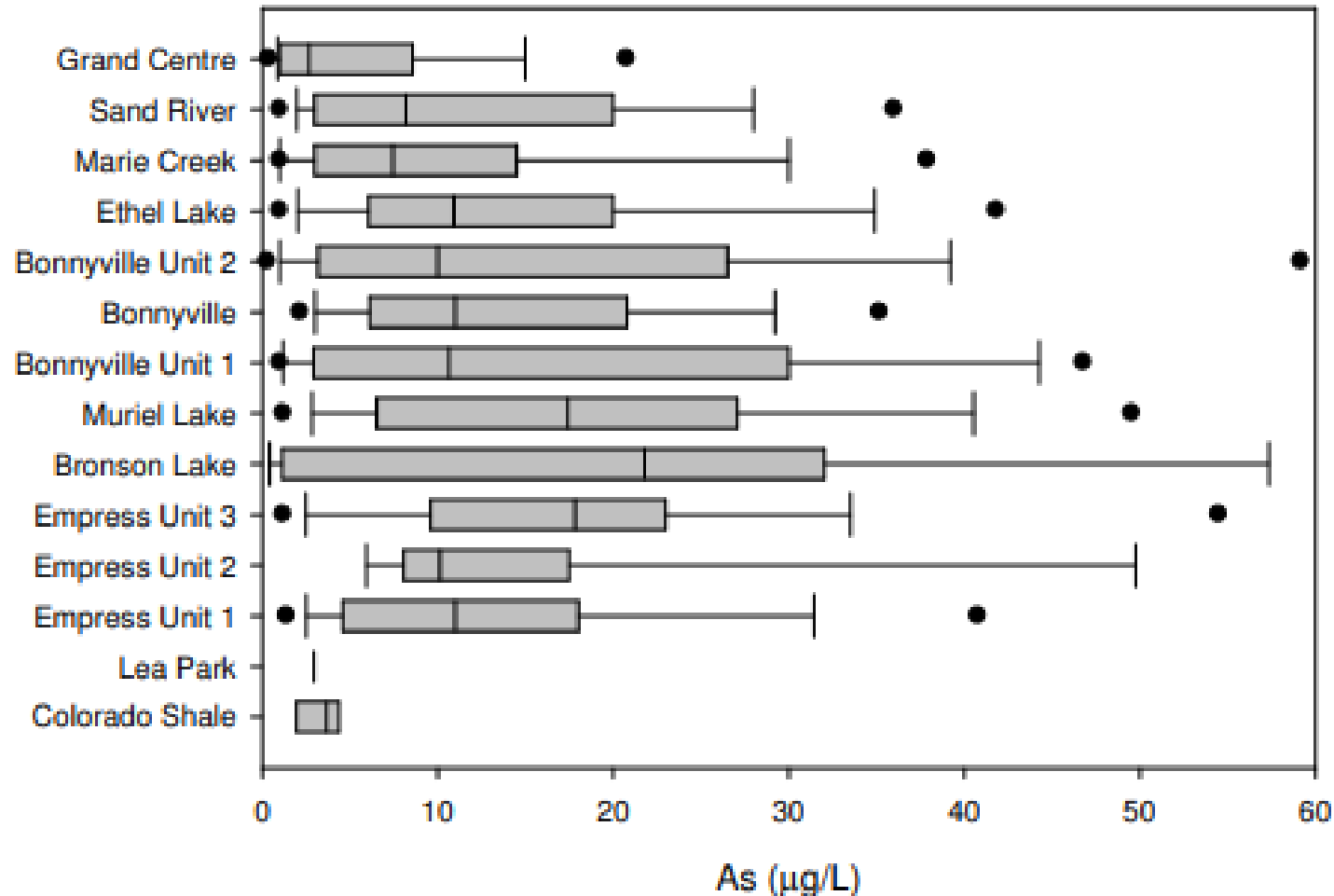
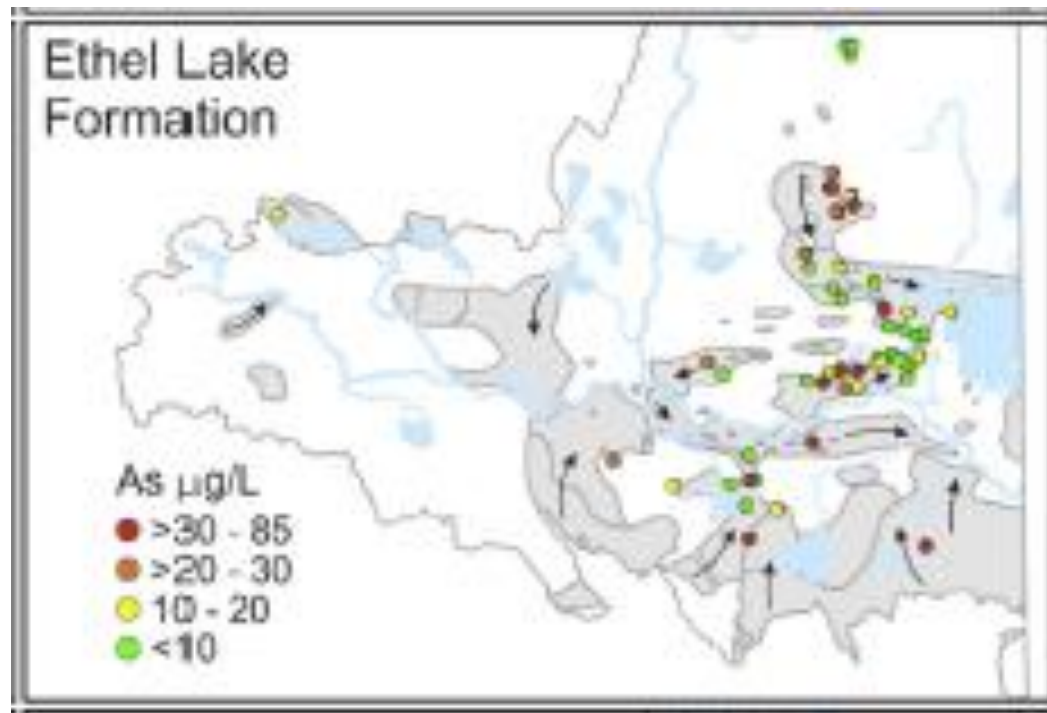
Arsenic Distribution in Groundwater in the Cold Lake – Beaver River Area



Arsenic Distribution in Groundwater in the Cold Lake – Beaver River Area



Arsenic Distribution in Groundwater in the Cold Lake – Beaver River Area



Publically Available Data Sources

Publically Available Sources of Information (1/2)

- Provincial Groundwater Observation Well Network:
 - <https://www.alberta.ca/groundwater-observation-well-network.aspx>
- Alberta Geological Survey Website:
 - <https://ags.aer.ca/>
- Alberta Water Well Information Database:
 - <https://www.alberta.ca/alberta-water-well-information-database-overview.aspx>

Publically Available Sources of Information (2/2)

- Environmental Site Assessment Repository:
 - <https://www.alberta.ca/environmental-site-assessment-repository.aspx>
- Oil Sands Information Portal:
 - <http://osip.alberta.ca/map/>
- Working Well Program:
 - <https://www.alberta.ca/working-well.aspx>
- Alberta Environmental Public Health Information Network (AEPHIN) – Domestic Well Water Quality in Alberta
 - <http://aephin.alberta.ca/index.html>

Groundwater Studies in Cold Lake – Beaver River Region (not exhaustive)

1. AESRD (Alberta Environment and Sustainable Resource Development). 2013. Lower Athabasca Region Groundwater Management Framework: Supporting Document for the Cold Lake – Beaver River (CLBR) area. ISBN: 978-1-4601- 1117-8.
2. AHW (Alberta Health and Wellness). 2000. Arsenic in Groundwater from Domestic Wells in Three Areas of Northern Alberta. Health Surveillance Report. ISBN: 0-7785-0708-4.
3. AHW (Alberta Health and Wellness). 2014. Domestic Well Water Quality in the Beaver River Basin 2009, Drinking Water Quality and Human Health Assessment. Alberta Domestic Well Water Quality and Assessment Program. ISBN: 978-0-7785-8281-6.
4. Andriashek, L.D. and Fenton, M.M. 1983. Surficial Geology of the Sand River Area, NTS 73L, 1:250,000, Alberta Research Council, Edmonton, AB, Canada.
5. Andriashek, L.D. and Fenton, M.M. 1989. Quaternary Stratigraphy and Surficial Geology of the Sand River Area, NTS 73L, Bulletin 57, Alberta Research Council, Edmonton, AB, Canada.
6. Andriashek, L.D. 2000. Geochemistry of selected glacial and bedrock geologic units, Cold Lake Area, Alberta. Alberta Geological Survey Earth Sciences Report 2000-10.
7. Andriashek, L.D. 2003. Quaternary geological setting of the Athabasca Oil Sands (InSitu) Area, Northeast Alberta. Alberta Geological Survey Earth Sciences Report 2002-03.
8. Fennell, J.W. 2008. Effects of Aquifer Heating on Groundwater Chemistry with a Review of Arsenic and its Mobility. Ph.D. Thesis, University of Calgary, Calgary, AB, pp. 330.
9. Lemay, T.G. 2003. Arsenic concentrations in Quaternary drift and Quaternary–Tertiary buried channel aquifers in the Athabasca Oil Sands (in situ) Area, Alberta. Alberta Energy and Utilities Board, Alberta Geological Survey, Geo-Note 2002-04.
10. Lemay, T., Parks, K., Andriashek, L.D., Michael, K., Jean, G., Kempin, E. Stewart, S. 2005. Regional Groundwater Quality Appraisal, Cold Lake-Beaver River Drainage Basin, Alberta. Alberta Geological Survey Special Report 73.
11. Moncur, M.C. 2010. Uranium Anomalies in Shallow Groundwater near Bonnyville, Alberta. Water for Life: Knowledge and Research Series. ISBN: 978-0-7785-9952-4.
12. Parks, K. and Andriashek, L.D. 2002. Baseline Investigations into the Groundwater Resources of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta; Alberta Geological Survey, EUB Special Report 98, 480 p.
13. Parks, K., Andriashek, L.D., Michael, K., Lemay, T., Stewart, S., Jean, G., Kempin, E. 2005. Regional Groundwater Resource Appraisal, Cold Lake-Beaver River Drainage Basin, Alberta. Alberta Geological Survey Special Report 74.
14. Stein, R., Dudas, M., Klebek, M. 2000. Occurrence of arsenic in groundwater near Cold Lake, Alberta, Alberta Environment, Edmonton, AB, Canada.
15. Welsh, B., Kerkhoven, E., van der Kamp, G. 2012. A winter water balance approach to quantifying lake-groundwater interactions in the Beaver River Basin, Alberta. International Association of Hydrogeologists Congress 2012. Niagara Fall, Canada.

Take-Away Messages

- Groundwater for domestic use is derived from a complex network of unconsolidated sediments above bedrock.
- Groundwater moves slowly (generally 10's of metres per year). Groundwater age increases with depth.
- Arsenic is naturally present in the sediments of the region, and arsenic is naturally elevated in groundwater of the region.

Questions?

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