

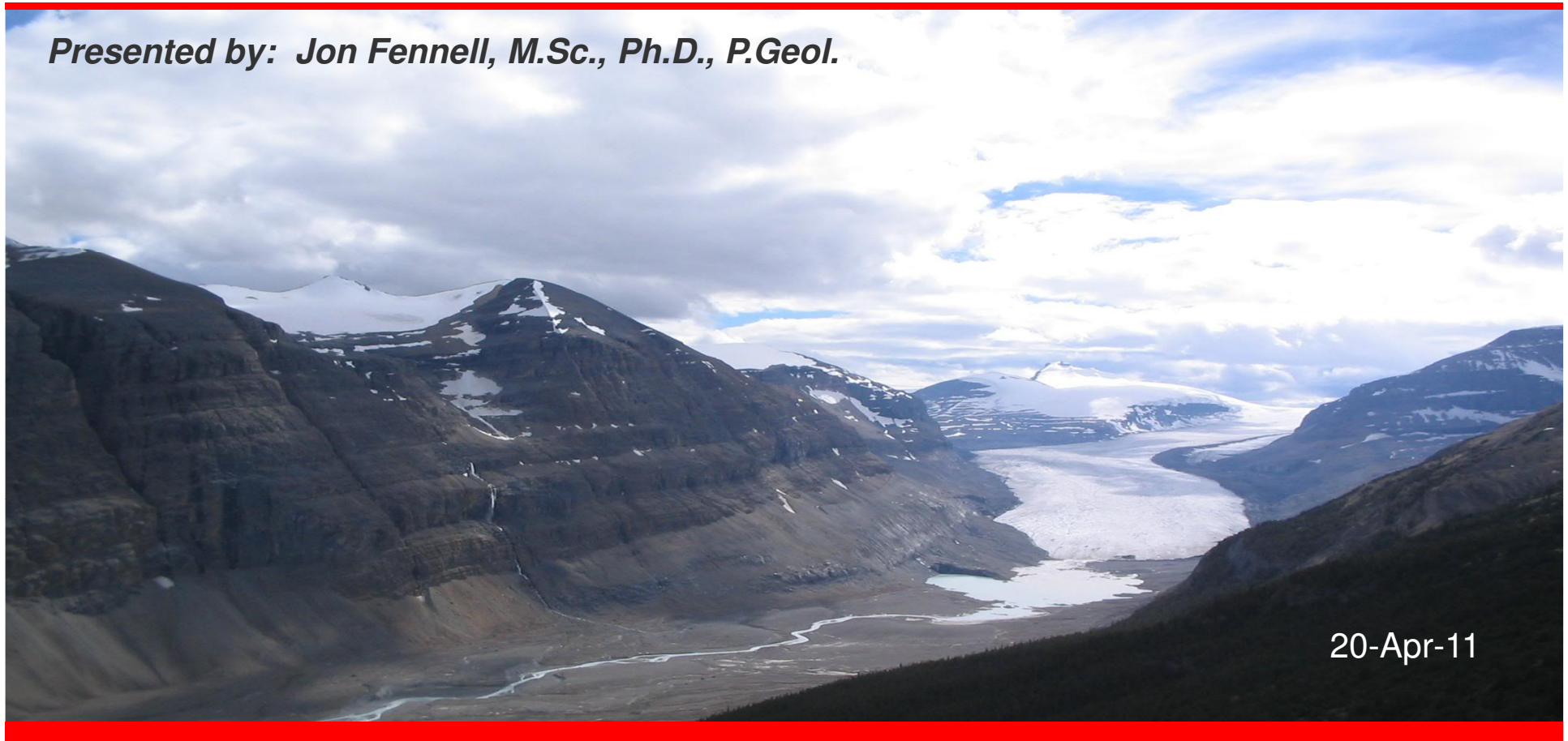


WorleyParsons
consulting practices



Managing what we have: the dynamics of Alberta's water supply

Presented by: Jon Fennell, M.Sc., Ph.D., P.Geol.



20-Apr-11



- Review of water sources and previous balance for Alberta
- Introduction to Blue, Green, Fossil and Virtual water
- Results of provincial water inventory
- Effects of a changing climate
- Virtual water trading





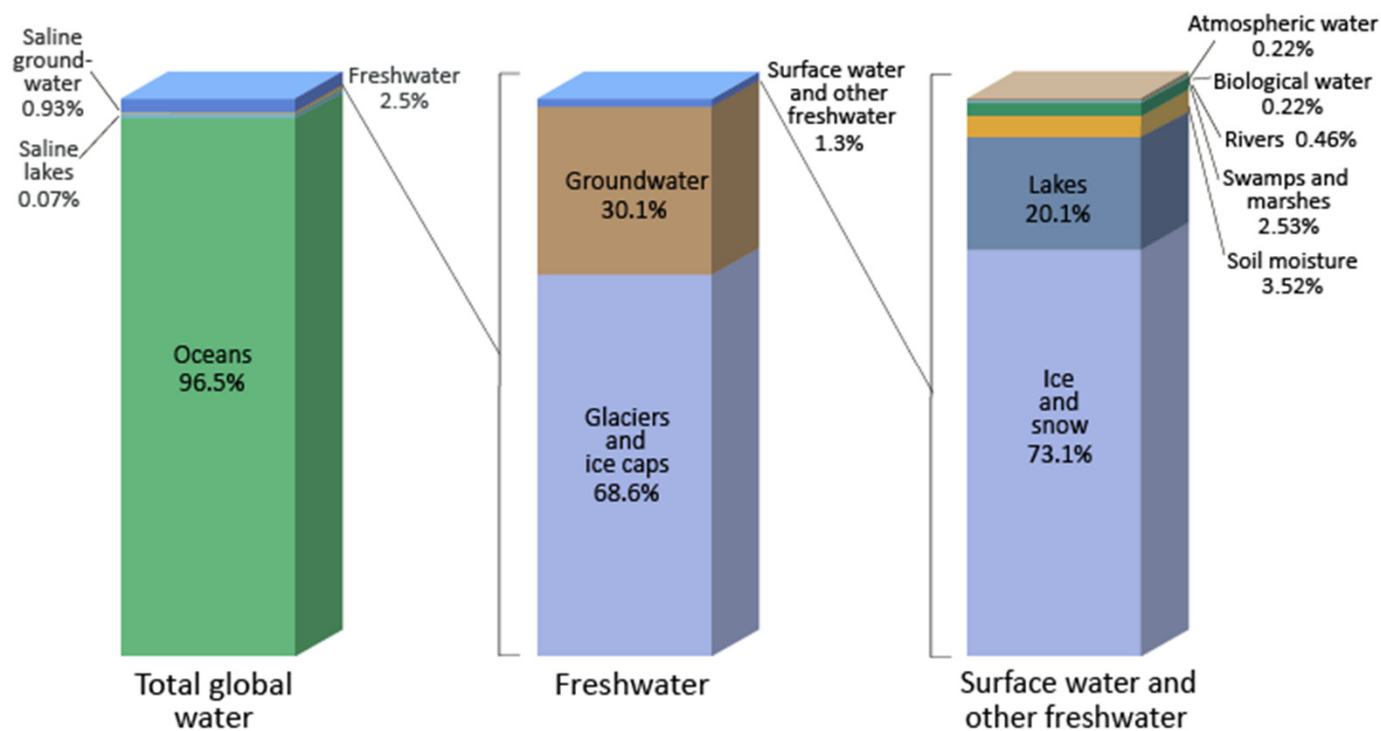
Questions to be answered

- How much water do we have in our province at any given time?
- Where is this water located, above and below ground?
- How is our water being used?
- What is the balance of use vs. replenishment (or recharge)?
- What is the net balance of virtual water in Alberta - export or import?





Earth's water



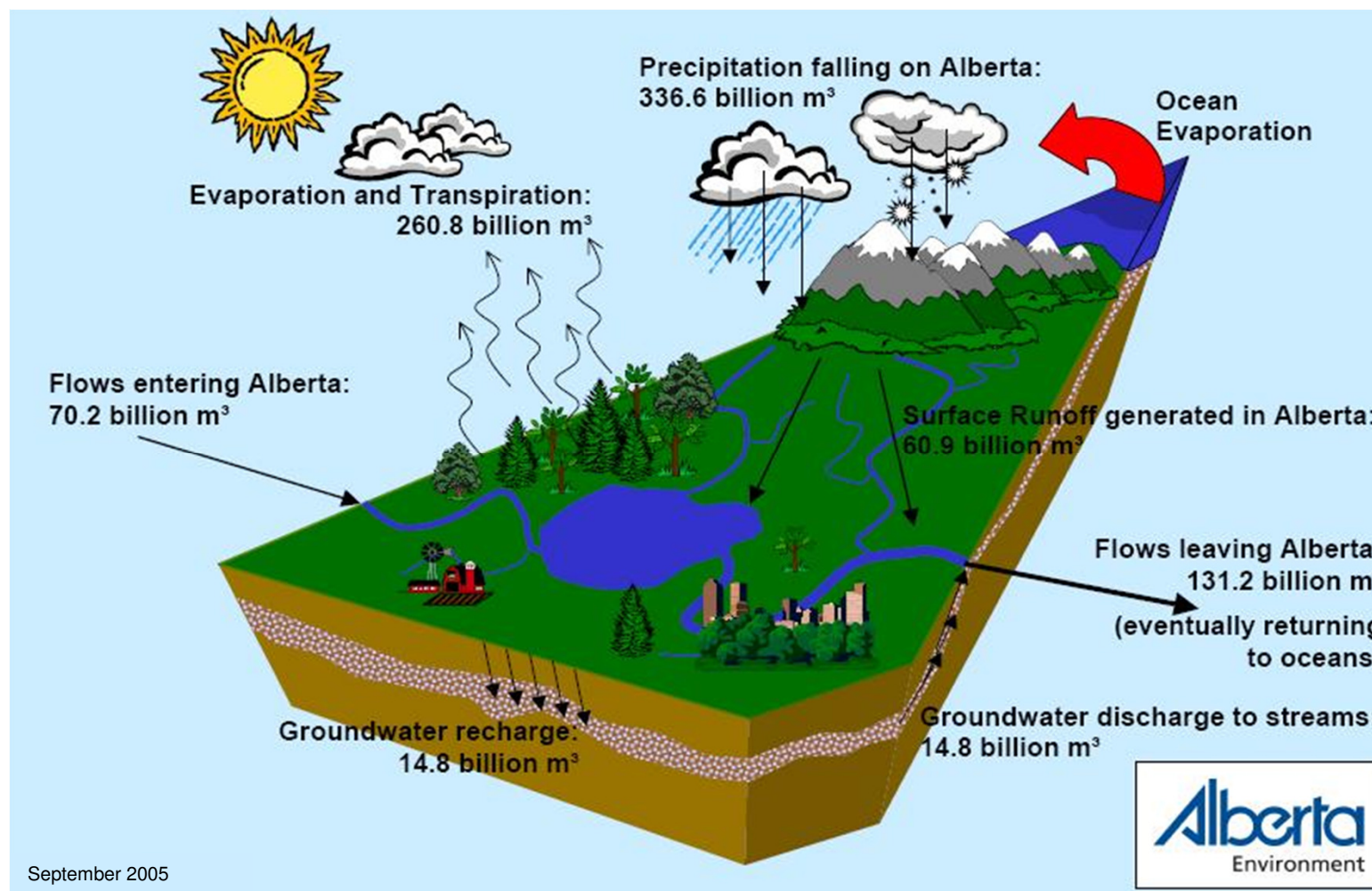
Source: Shiklomanov 1993



WorleyParsons

consulting practices

Previous assessment (2005)





WorleyParsons

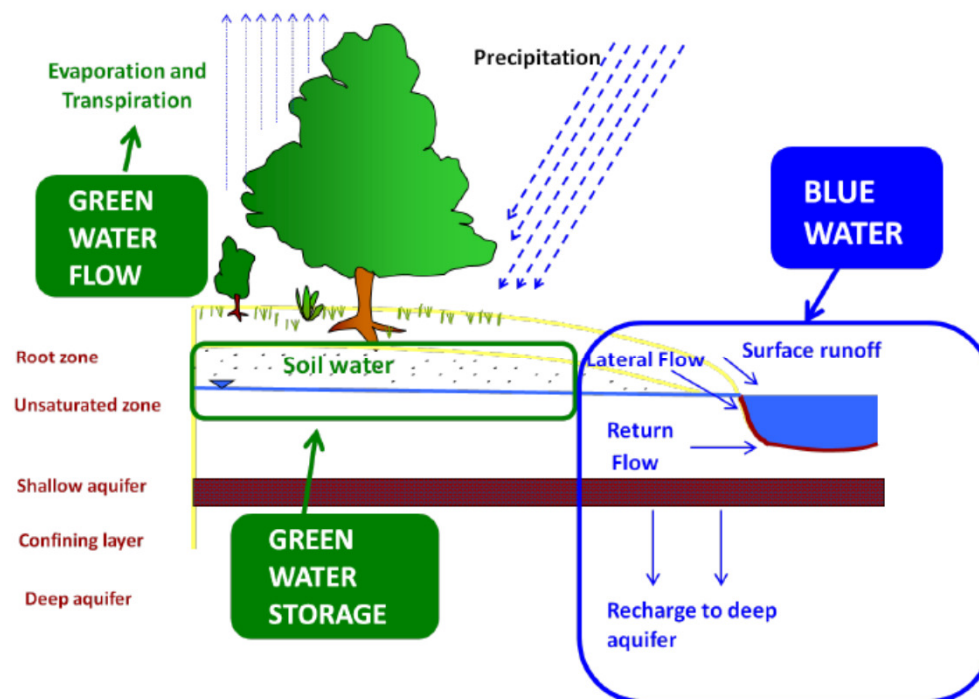
consulting practices

A holistic approach

Blue water: lakes, streams, reservoirs, runoff, groundwater

Green water: soil moisture, evaporation, potential evapotranspiration

Fossil water: deeper aquifers with non-saline and saline water, glacier storage



Virtual water: incorporated or used to produce food & consumer products



WorleyParsons

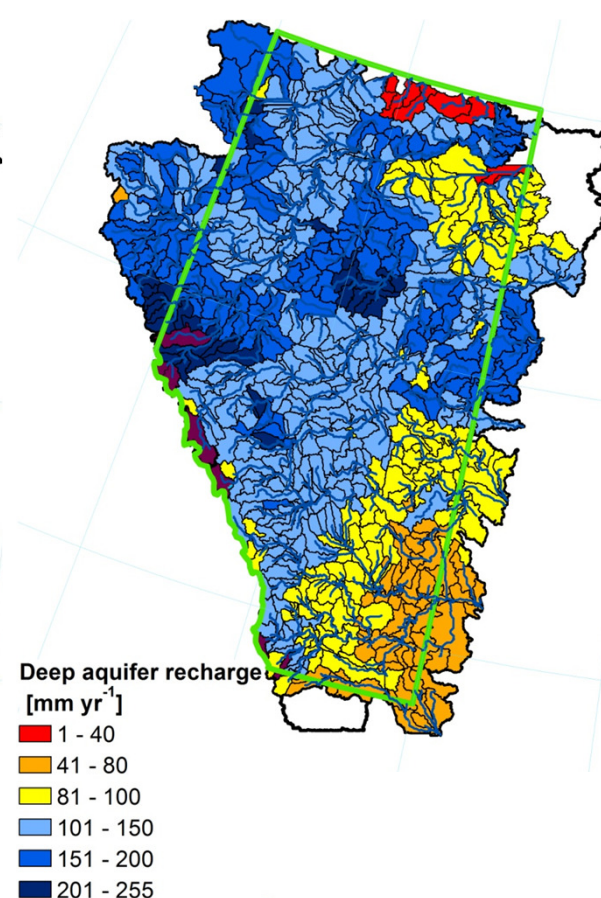
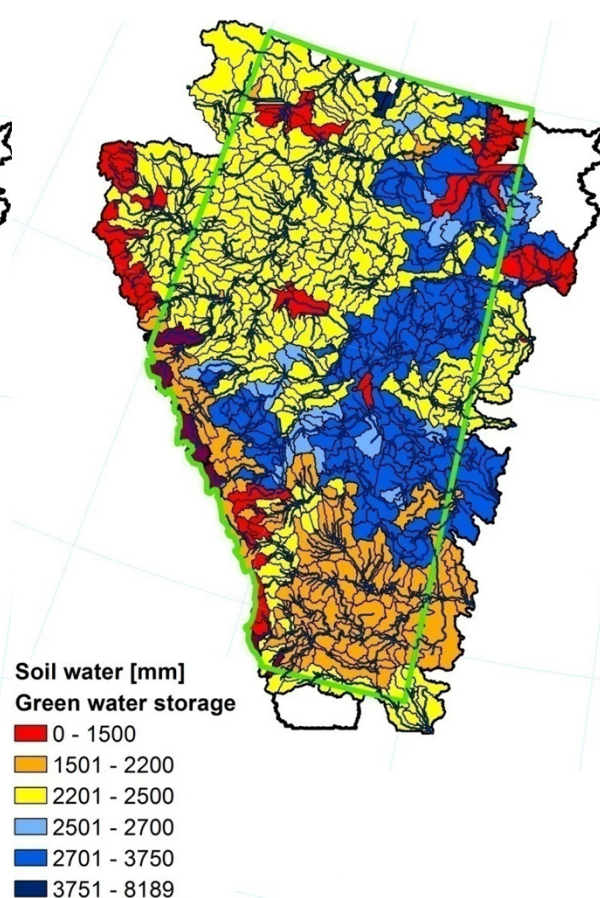
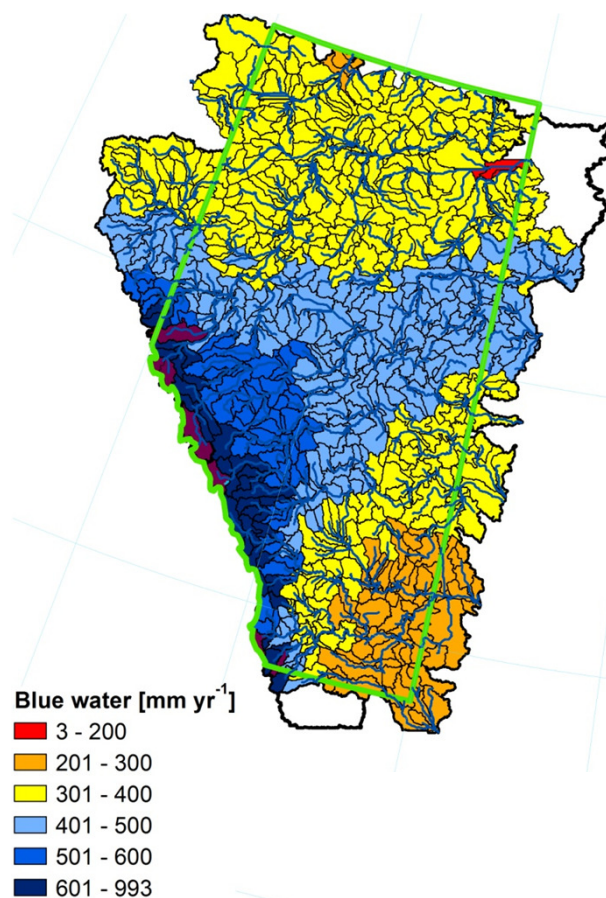
consulting practices

Blue & Green water (SWAT)

174 to 320 billion m³

1,225 to 1,637 billion m³

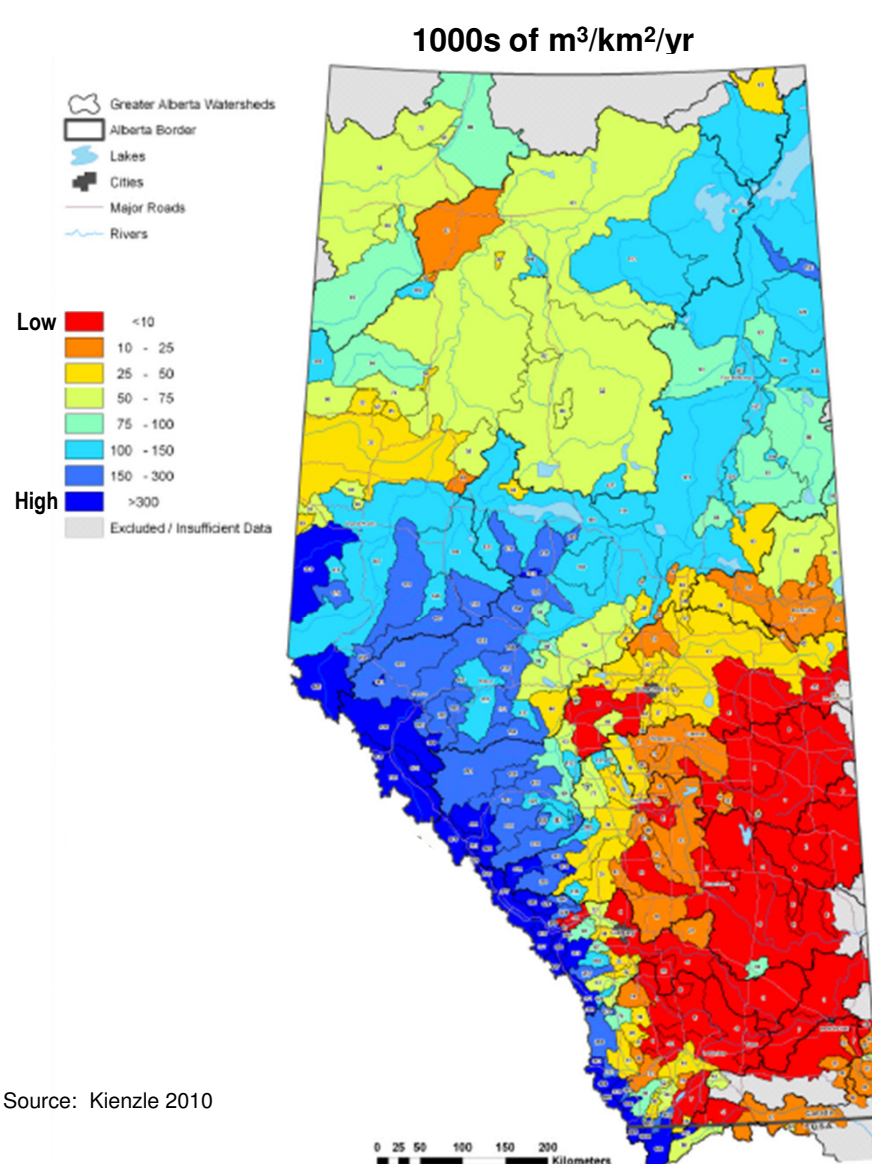
30 to 128 billion m³



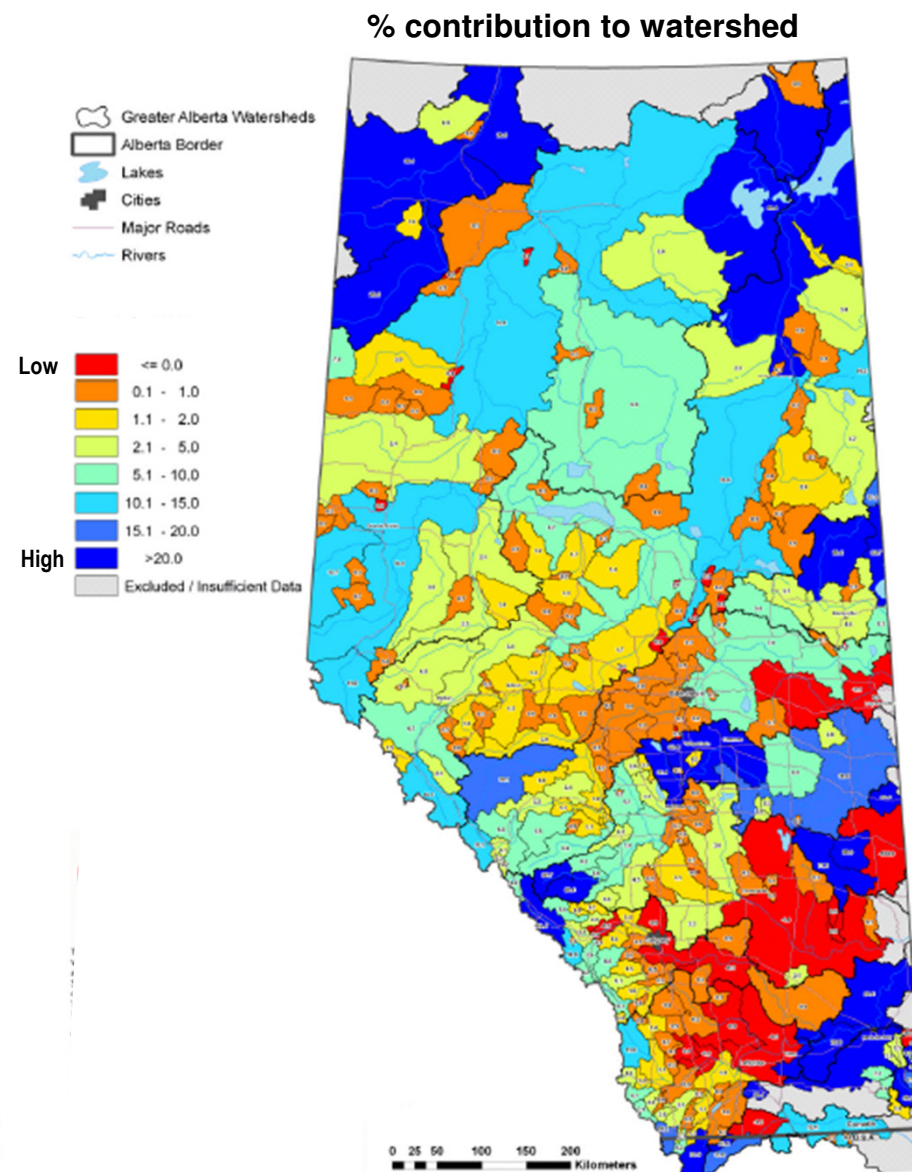
Source: Abbaspour et al. 2010



Basin yields

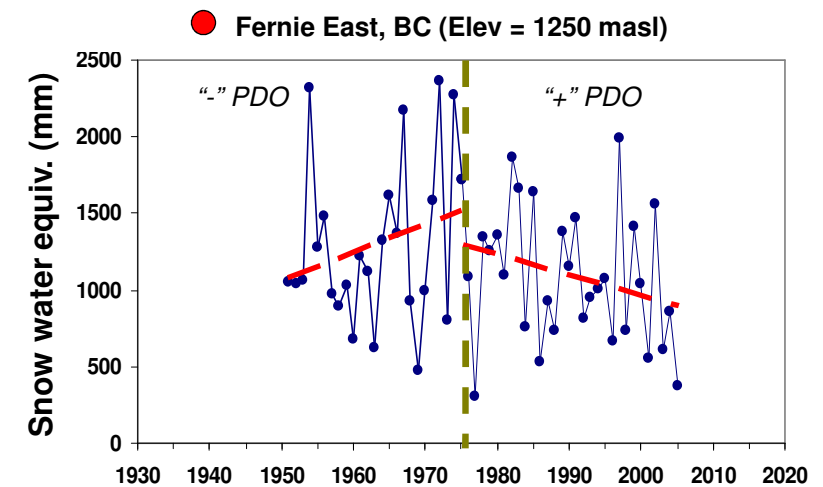
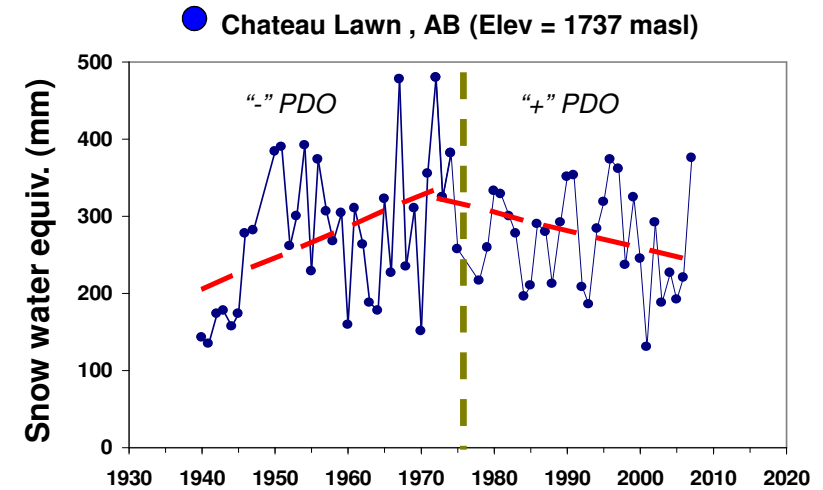
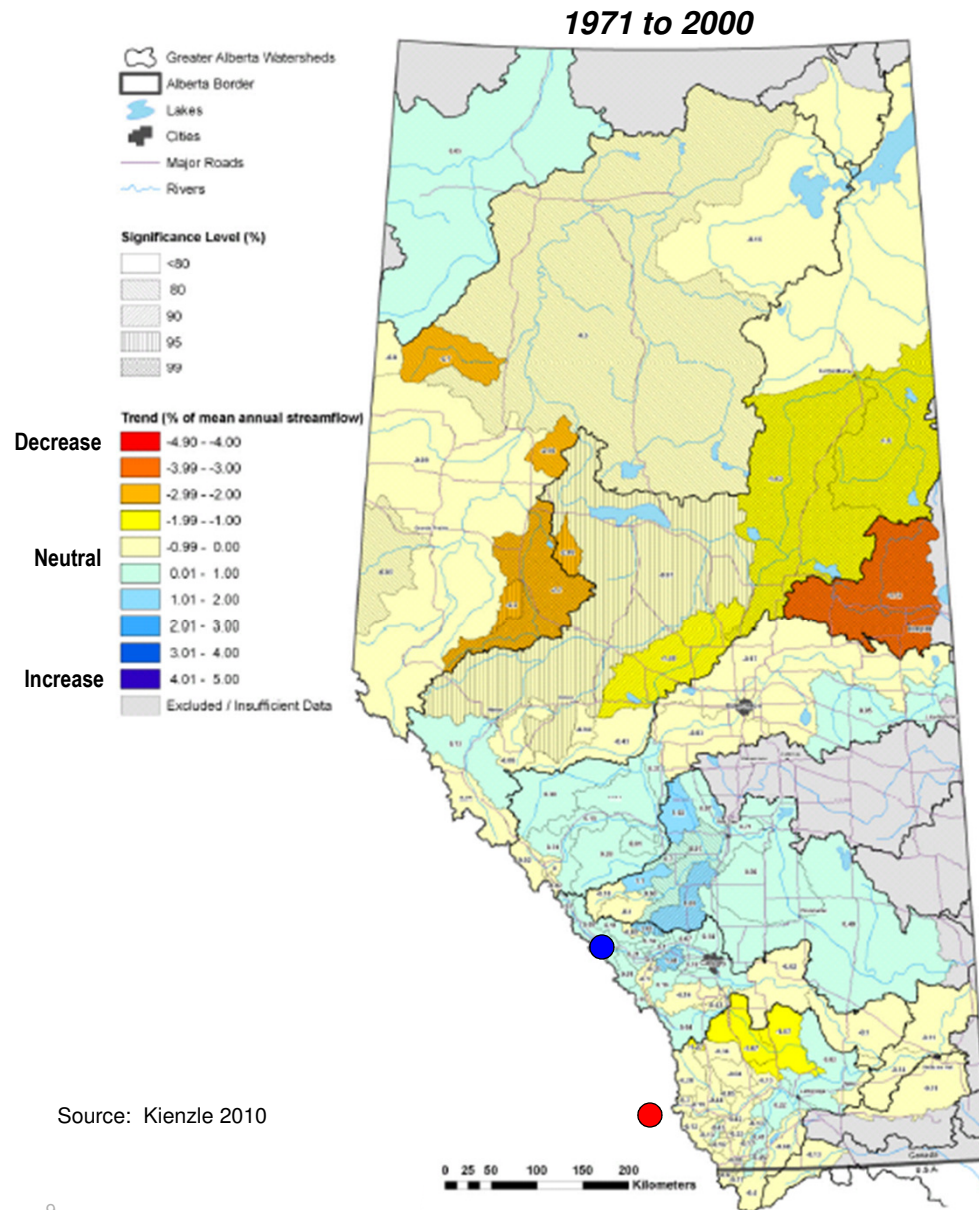


Source: Kienzie 2010





Streamflow and snowpack trends



Source: Alberta Environment



Figure 1 consists of six panels (a-f) showing the time series of the percentage deviation from mean annual flow for different river gauges in Alberta, Canada, from 1900 to 2000. The panels are: (a) North Saskatchewan at Edmonton (green dot), (b) Bow at Banff (blue dot), (c) Oldman near Waldron's (yellow dot), (d) Castle near Beaver Mines (purple dot), (e) Belly near Mountain View (red dot), and (f) St Mary near Babb (magenta dot). Each panel shows the time series with vertical dashed blue lines indicating the transition between negative (-) and positive (+) PDO phases. A map of Alberta shows the locations of the gauges. A bottom panel shows the PDO index from 1900 to 2000, with the '+' phase (warmer, drier) above the zero line and the '-' phase (cooler, wetter) below the zero line.

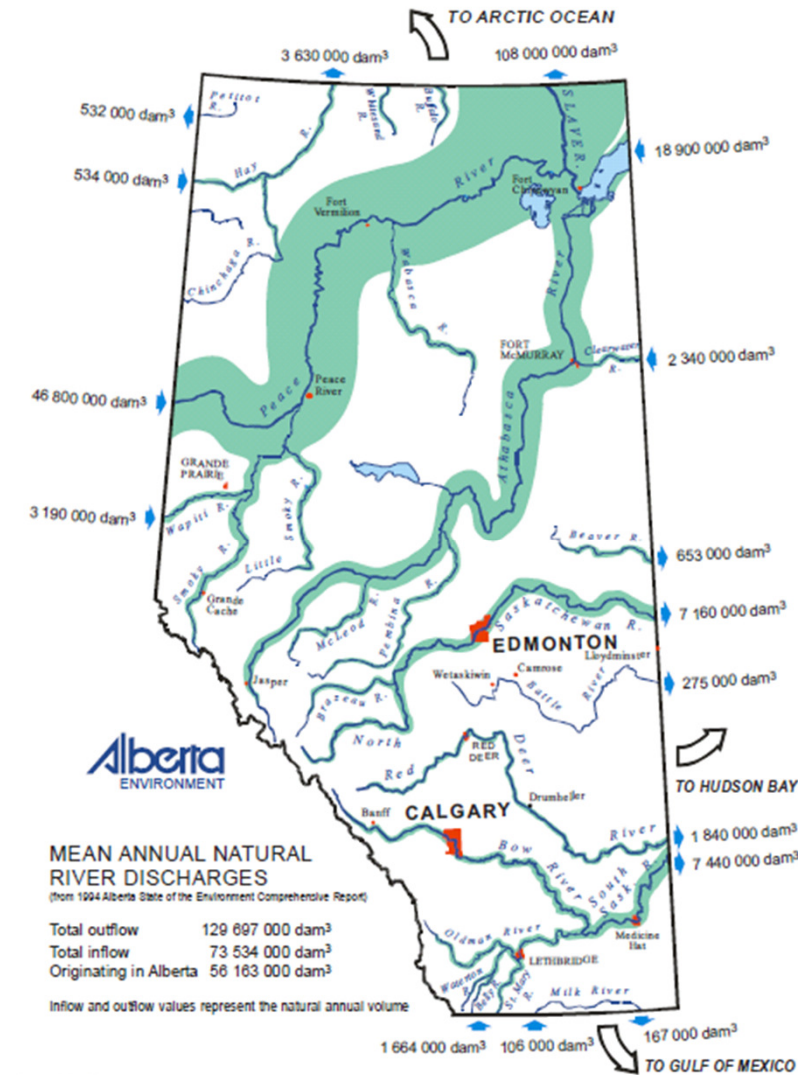




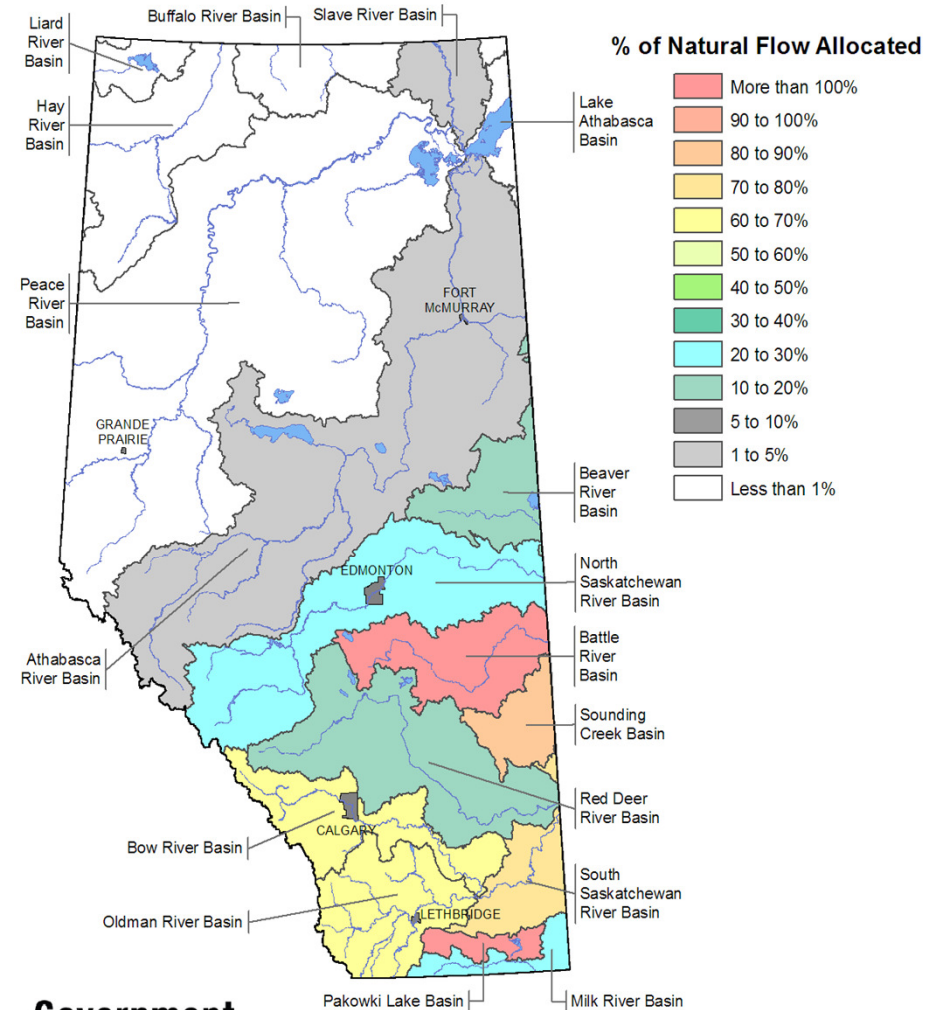

WorleyParsons

consulting practices

Available vs. allocated surface water



M-QSC/NAT-1-CD/figure/mna/2001



Government of Alberta
Environment



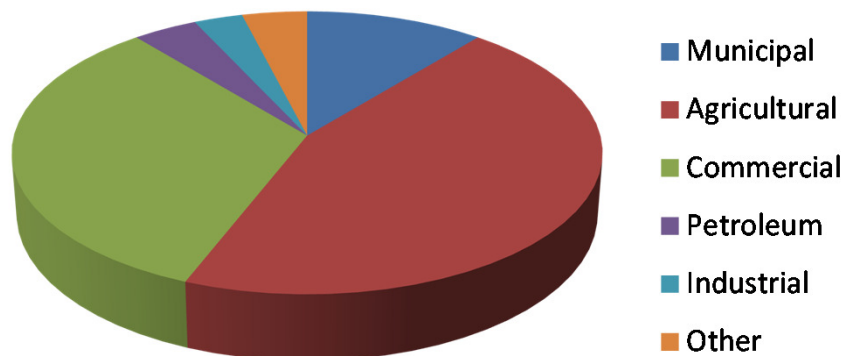


WorleyParsons

consulting practices

How is our water used?

Surface water

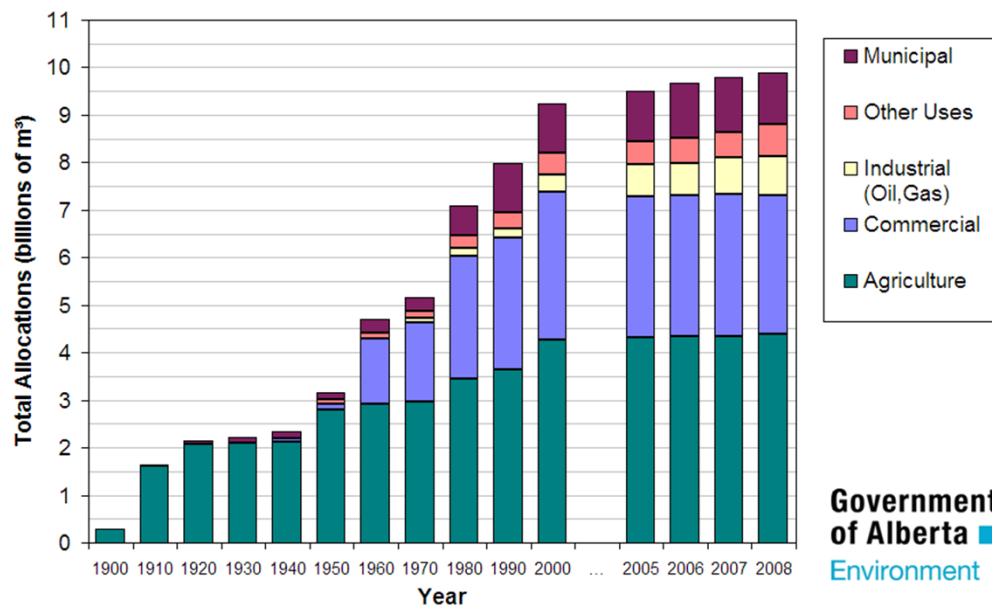


Groundwater



Source: AMEC & AENV 2007

Sectoral Water Allocations Index

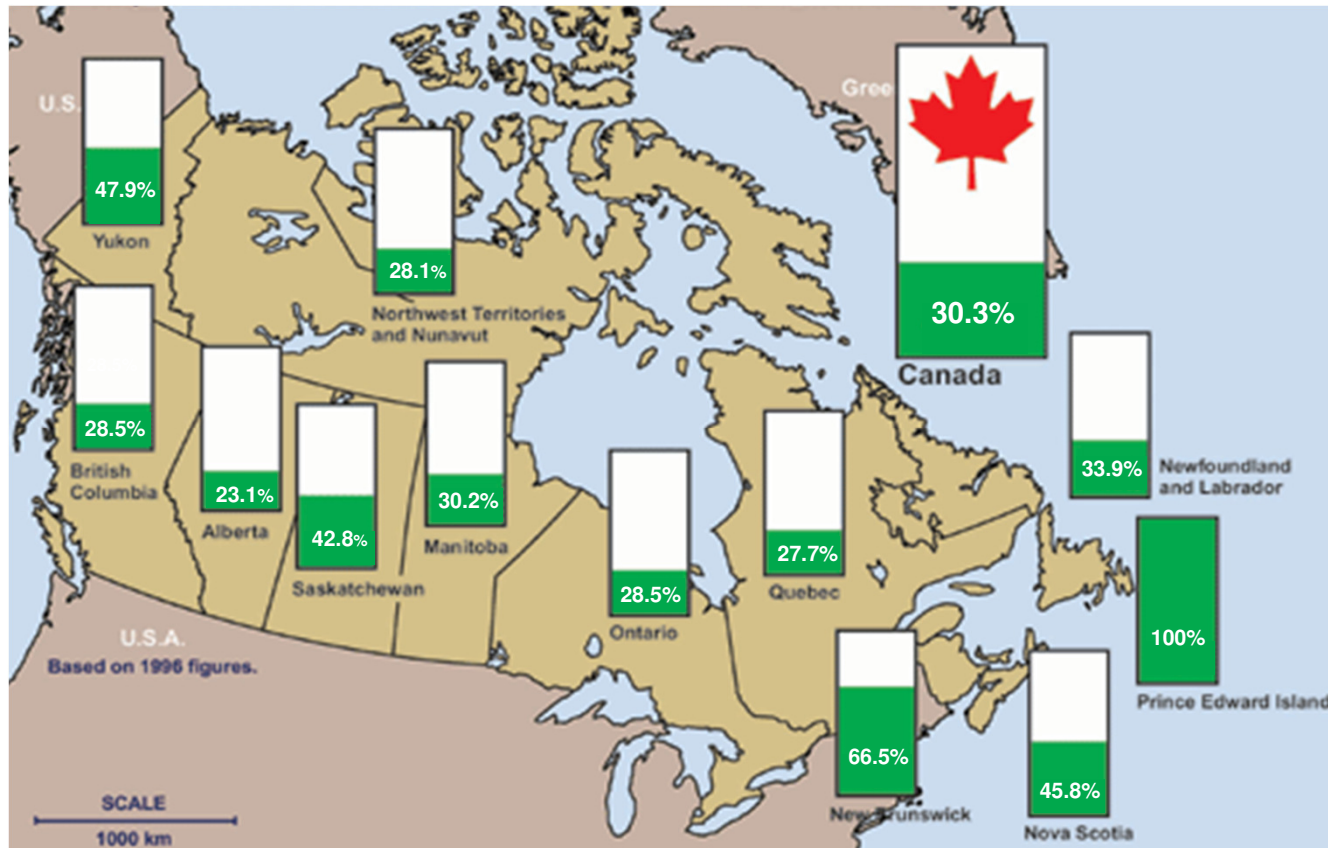


Allocated volumes as of 2009:

Surface water = 9.89 billion m³/year

Groundwater = 0.31 billion m³/year





Source: Environment Canada & Statistics Canada 2010



WorleyParsons

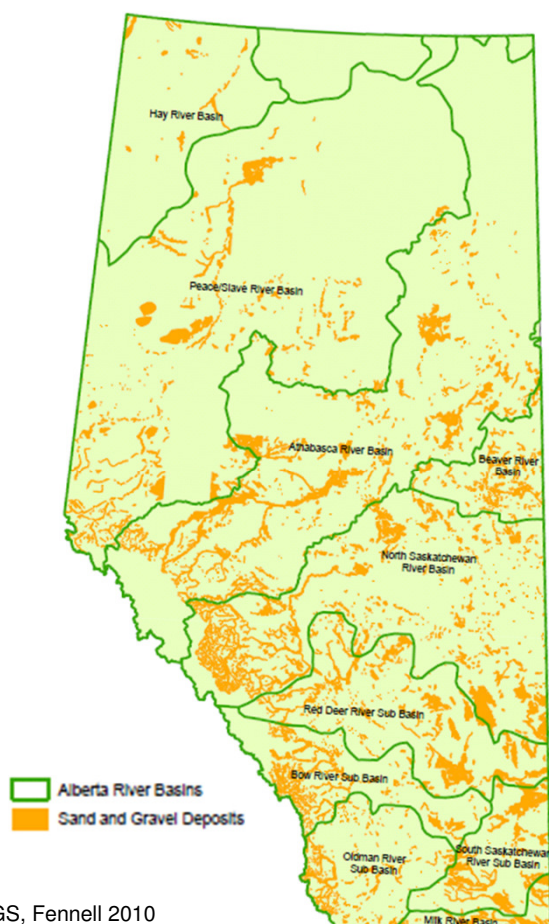
consulting practices

Aquifers types & associated water volumes

Alluvial aquifers

Pore volume: 16 to 55 billion m³

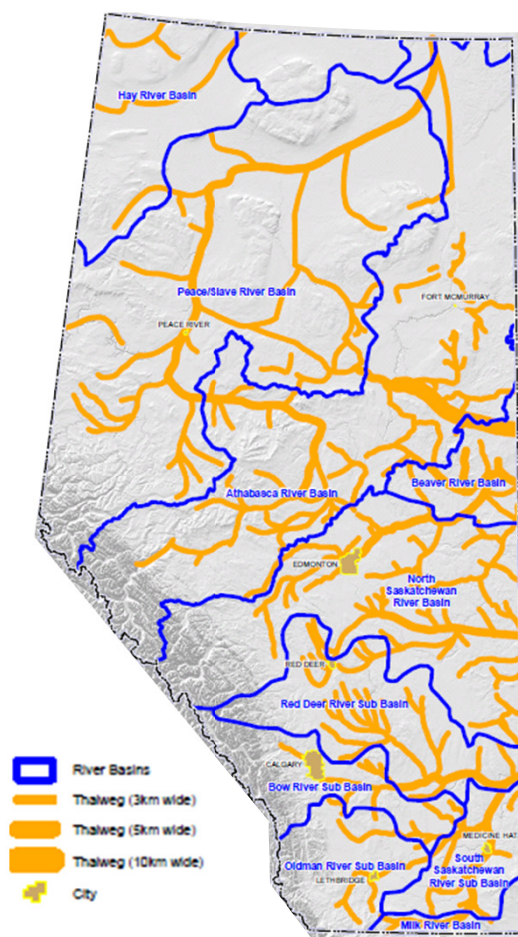
Storage volume: <1 to 2.2 billion m³



Buried channels

45 to 388 billion m³

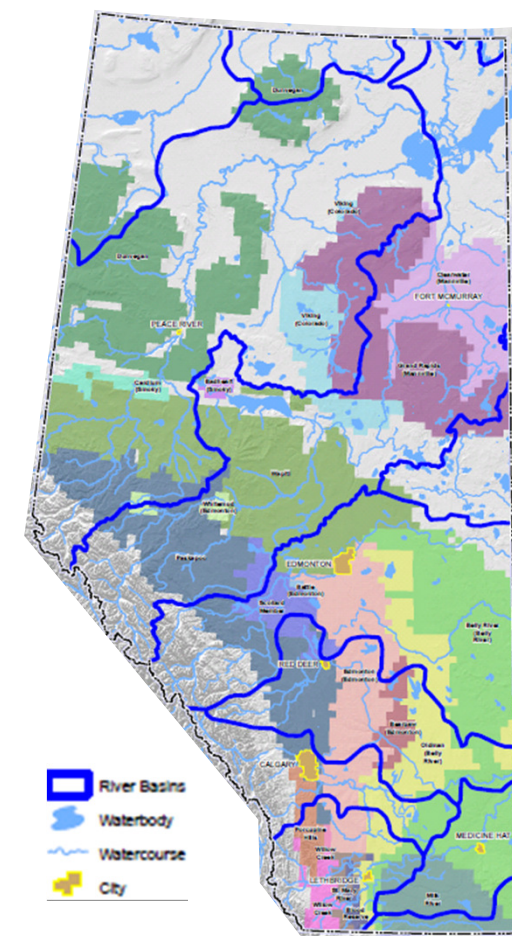
<1 to 4.2 billion m³



Bedrock

165 to 5,620 billion m³

6 to 209 billion m³

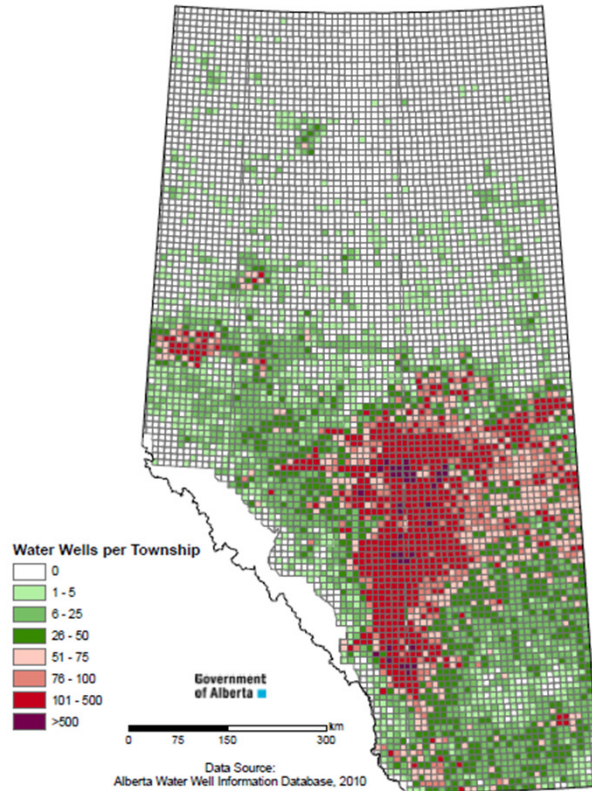


Source: AGS, Fennell 2010



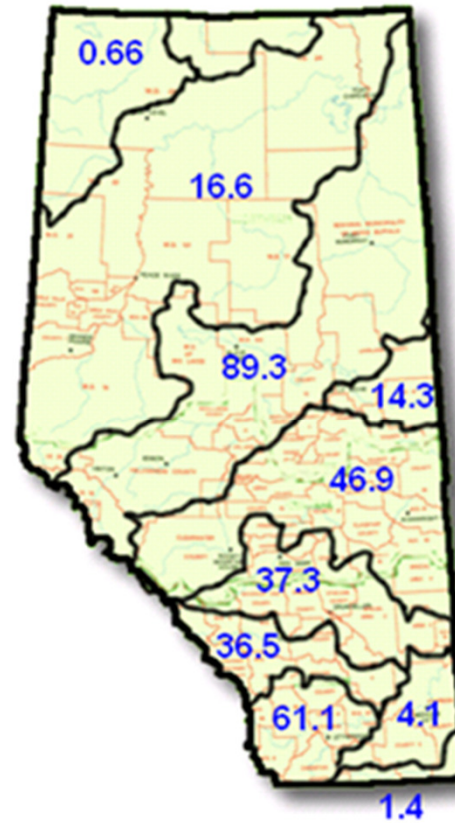
Groundwater use

Water well density



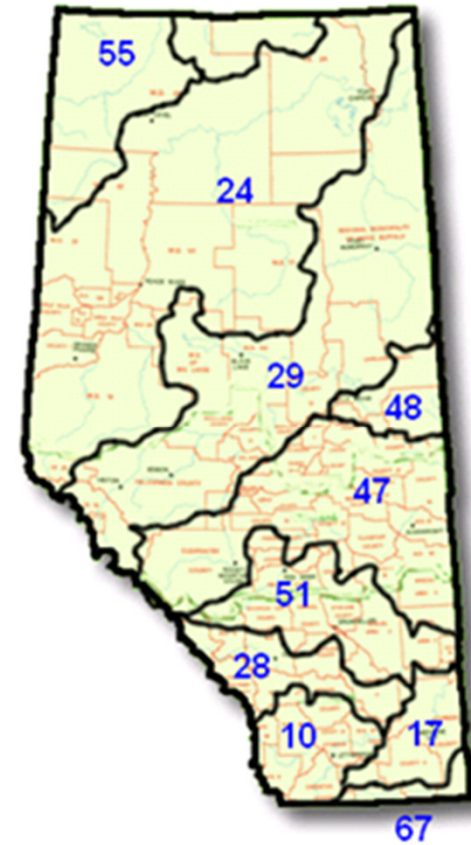
Source: AENV 2010

Millions of m³/yr allocated



Source: AENV 2009

Estimated % used

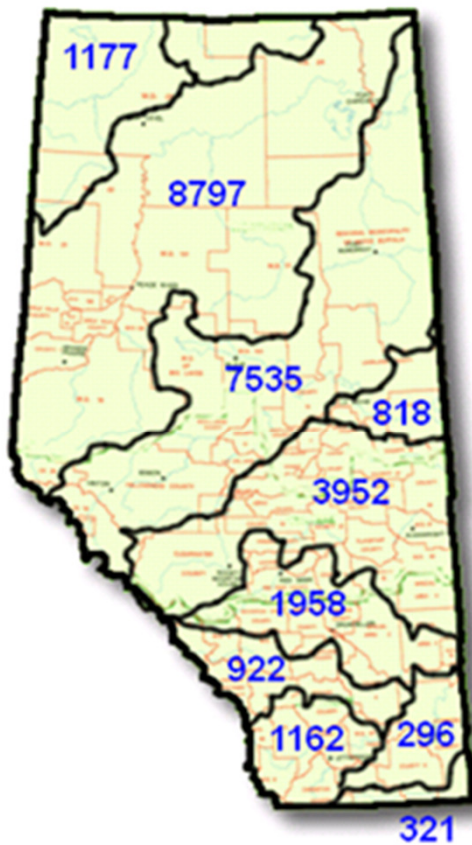


Source: AMEC & AENV 2007



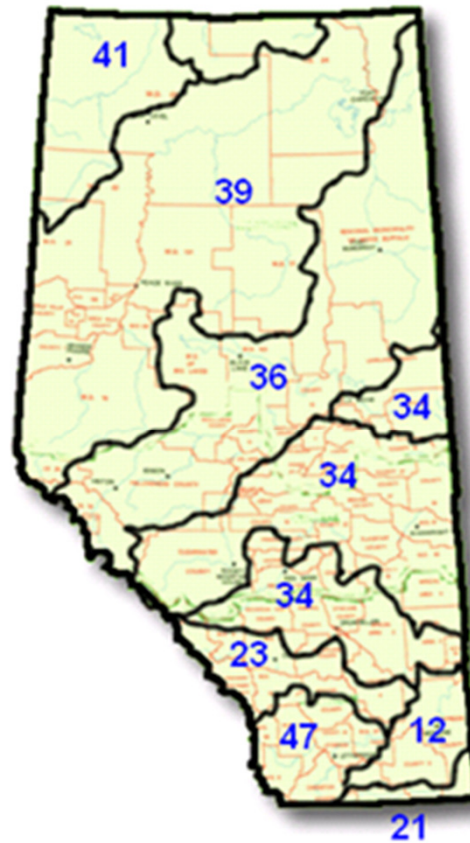
Estimated recharge

Millions of m³/yr (estimated)



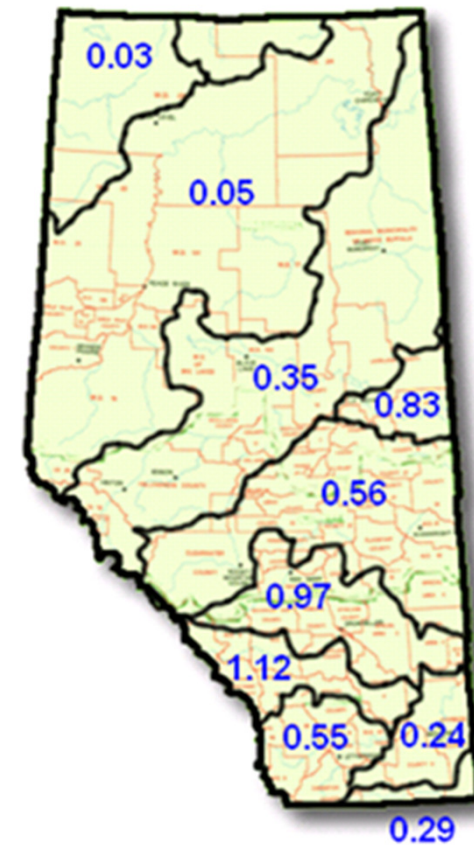
Source: AMEC & AENV 2007

Recharge as % of basin yield



Source: AMEC & AENV 2007

GW use versus recharge (as %)



Source: AMEC & AENV 2007

Recharge: 15 to 30 billion m³/year (possibly as high as 128 billion m³ based on SWAT modelling)

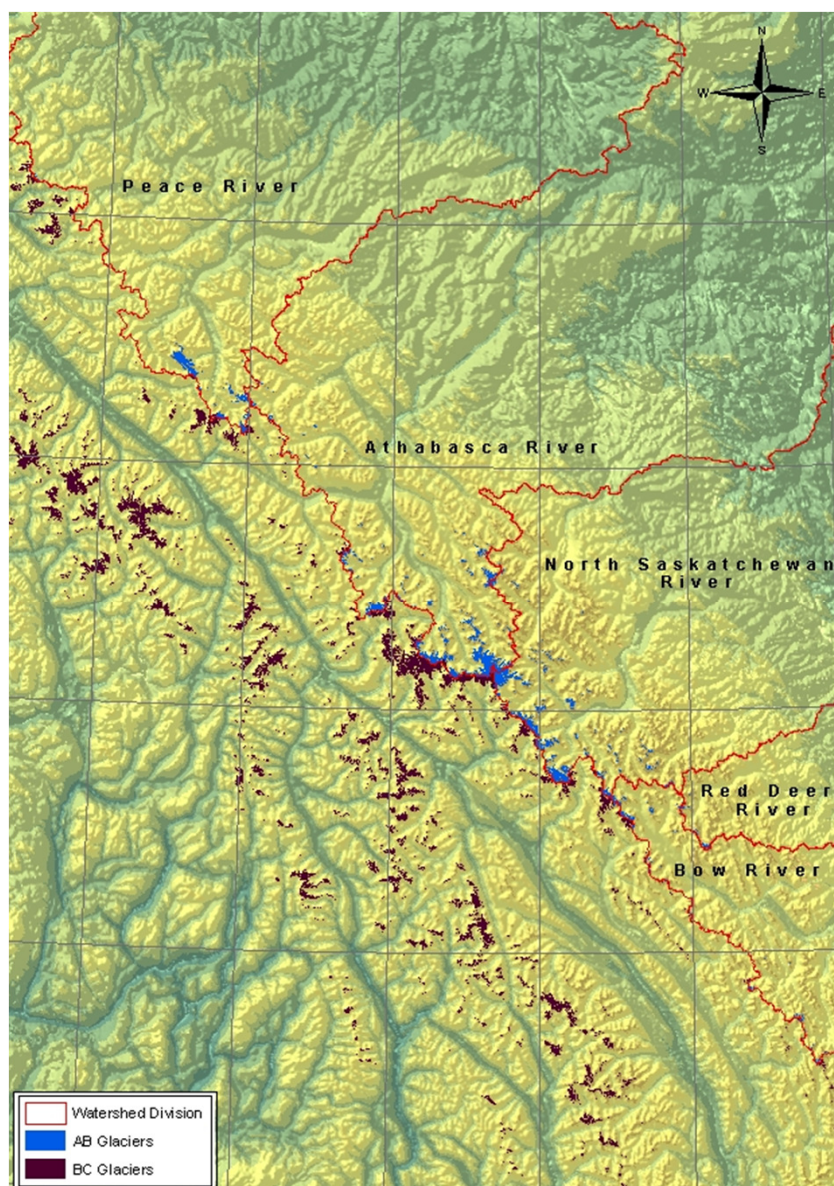
Allocated volume: 0.31 billion m³/year (1 to 2% of estimated annual recharge)



WorleyParsons

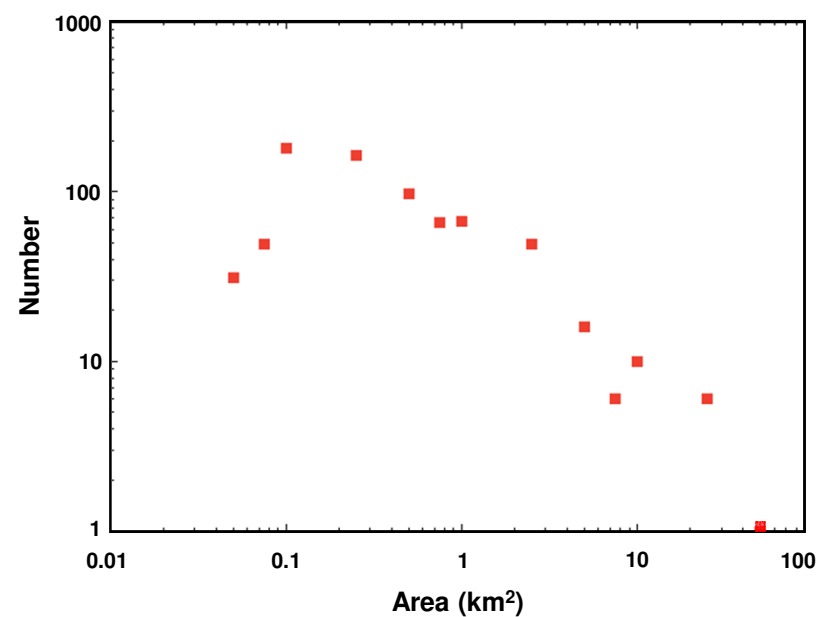
consulting practices

Glacier inventory



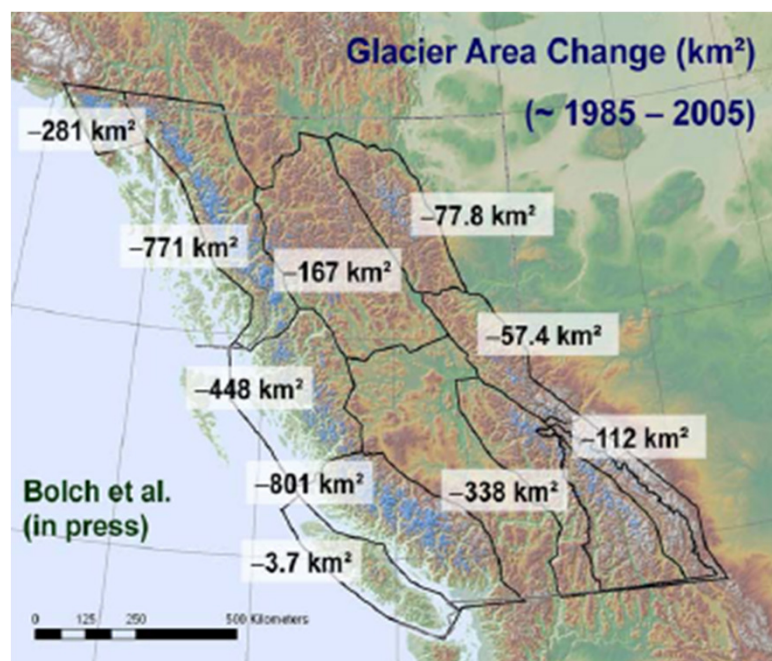
Basin	Count	Area (km ²)	Glacier Volume (km ³)	
			Range	Best estimate
Bow	96	60.1	2.1-3.6	3.0 ± 0.7
Red Deer	22	16.6	0.6-1.0	0.9 ± 0.2
North Saskatchewan	258	286.3	13-19	17.5 ± 4.4
Athabasca	271	320.5	12-18	16.7 ± 4.2
Peace (AB)	94	107.6	6-14	8.8 ± 1.4
Peace (AB and BC)	363	276.7	13-23	16.9 ± 4.2
Alberta	741	791.1	35-55	47 ± 13
Eastern slopes	1010	960.3	43-67	55 ± 15

Source: Marshall and White 2010

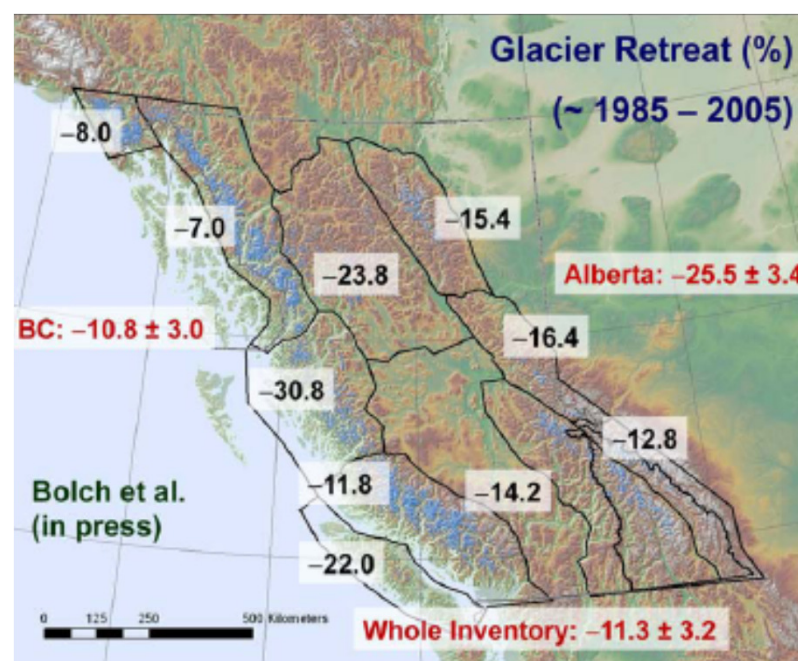




Melt characteristics



Basin	Site	N	f (%)	Average yield (km ³)			% glacial	
				Q_a	Q_{JAS}	Q_g	$\frac{Q_g}{ann}$	JAS
Bow	Calgary	2	45.4	2.6	1.1	0.074	2.8	6.7
Red Deer	Red Deer	3	62.2	1.4	0.5	0.009	0.6	1.8
N. Sask.	Edmonton	5	51.9	5.6	2.8	0.206	3.7	7.4
Athabasca	Ft. McMurray	1	100.0	15.9	6.6	0.134	0.8	2.0
Peace	Peace River	15	74.2	59.7	18.2	0.142	0.2	0.8



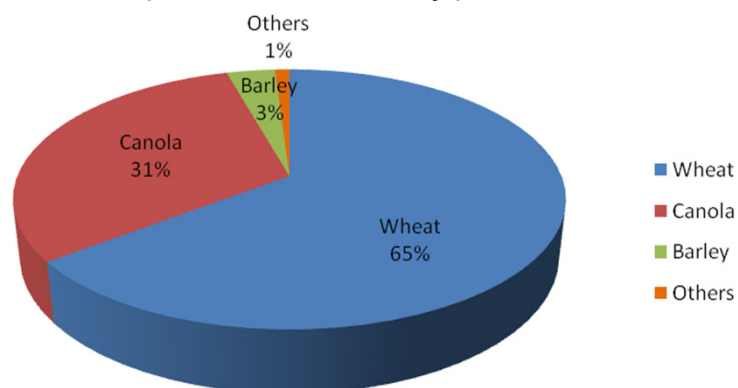
Basin	Ice loss, 2000s (km ³ /yr)	Extrapolated lifetime (yr)
Bow	0.053	53
Red Deer	0.006	132
N. Saskatchewan	0.225	72
Athabasca	0.187	83
Peace	0.091	97

Source: Marshall and White 2010

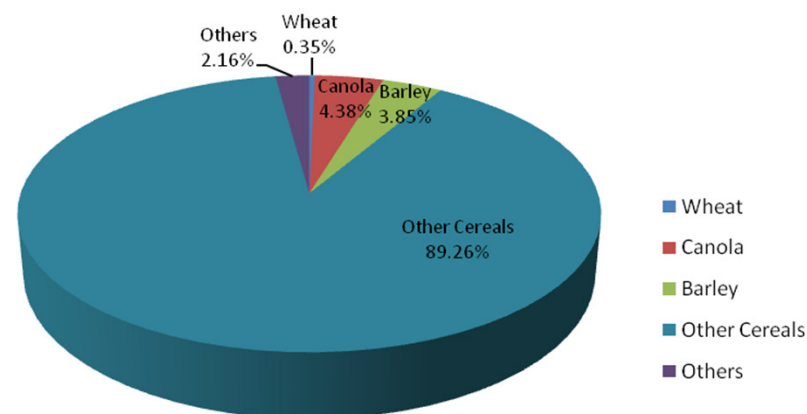


Virtual water trade

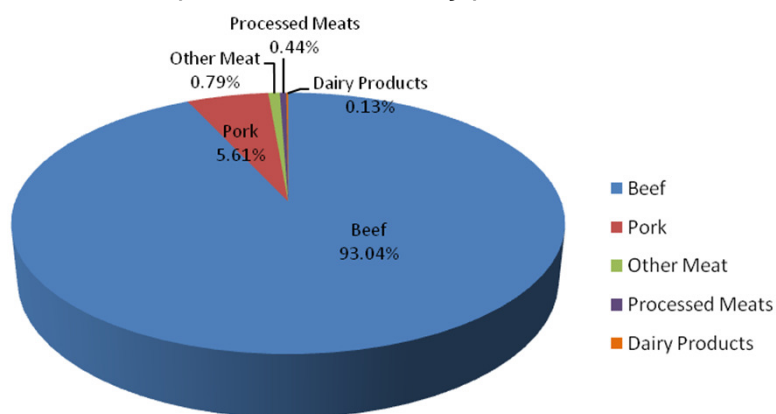
Virtual water export of crop products from Alberta
(Total = 12.1 billion m³/yr)



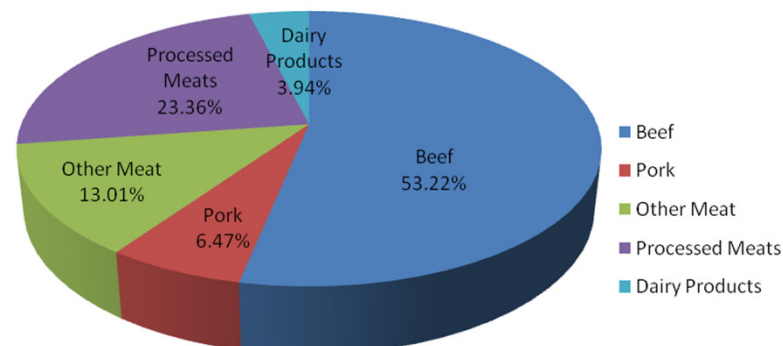
Virtual water import of crop products to Alberta
(Total = 0.73 billion m³/yr)



Virtual water export of livestock products from Alberta
(Total = 4.8 billion m³/yr)



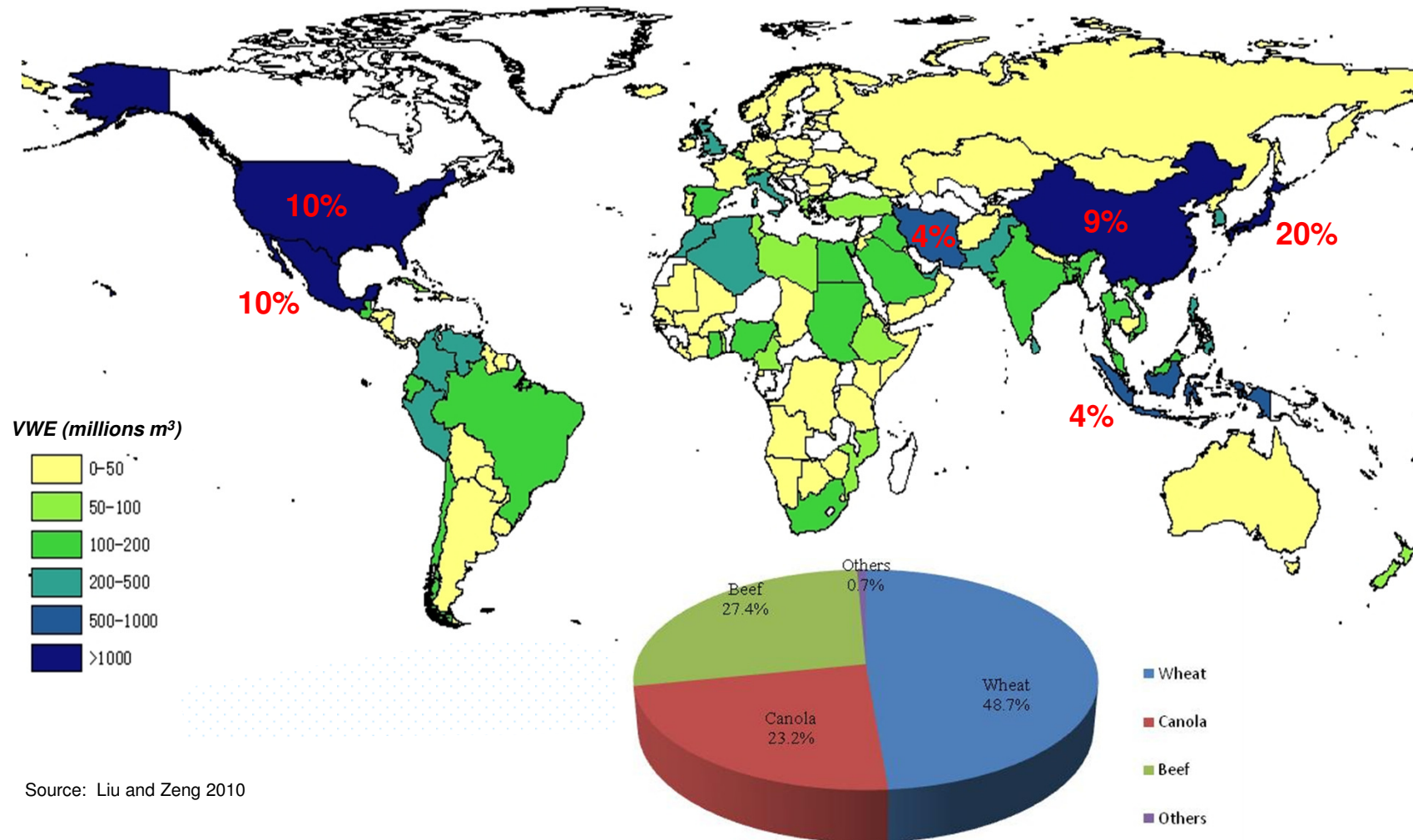
Virtual water import of livestock products to Alberta
(Total = 0.12 billion m³/yr)



Source: Liu and Zeng 2010



Where does it go?



Source: Liu and Zeng 2010



Source of water in Alberta	Estimated volume (km ³)
Basin yields	81 to 253
Blue water (rivers, reservoirs, shallow groundwater)	174 to 320
Green water (soil moisture)	1,225 to 1,637
Groundwater: alluvial aquifers (pore + storage)	18 to 57
buried channel aquifers (pore + storage)	49 to 392
bedrock aquifers (pore + storage)	171 to 5,600
Lakes (only those listed in Atlas of Alberta Lakes)	200
Glaciers	30 to 55
Annual licensed allocation (not all used)	
Surface water	-9.89
Groundwater	-0.31
Annual recharge	
SWAT model	30 to 128
Baseflow separation / % of annual precip. vs. surficial geology	22 to 29
Virtual water	
Export (primarily wheat, canola, beef, pork)	-16.91
Import (primarily cereal grains, beef/pork/processed meats)	0.85

Note: Estimated volumes are based on reasonable assumptions and existing data sources that have been used as reported.



- Alberta is blessed with large quantities of water - not evenly distributed
- Large storage volumes reside in existing lakes, reservoirs, aquifers and remaining glaciers
- Soil moisture and groundwater represent dominant sources of stored water in Alberta
- Water supply risks are evident in certain parts of the province
(due to climate variability & change)
- Opportunities exists to better manage our water supplies to ensure a sustainable future *(e.g., better sub-basin accounting, implementation of conjunctive use strategies)*



WorleyParsons

consulting practices

Project team

Person: Dr. Alexander Zehnder

Affiliation: AWRI

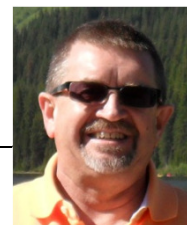
Role: Project Sponsor



Person: David Hill

Affiliation: AWRI

Role: Project Support



Person: Dr. Junguo Liu

Affiliation: Beijing Forest University

Role: Virtual water



Person: Dr. Jon Fennell

Affiliation: WorleyParsons I&E Canada

Role: Groundwater



Person: Dr. Stefan Kienzle

Affiliation: University of Lethbridge

Role: Basin yields & trends



Person: Dr. Karim Abbaspour

Affiliation: Swiss Fed. Institute for Aquatic Sci. & Tech.

Role: Blue & Green water (SWAT modelling)



Person: Dr. Shawn Marshall

Affiliation: University of Calgary, CIRC

Role: Glaciers & melt trends



WorleyParsons

consulting practices



Thank you

jon.fennell@worleyparsons.com

1-800-668-6772 Ext 410