Hydrogeological characterisation of the Calgary-Lethbridge Corridor to inform land use planning

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WaterTech 2016 - 7 April 2016

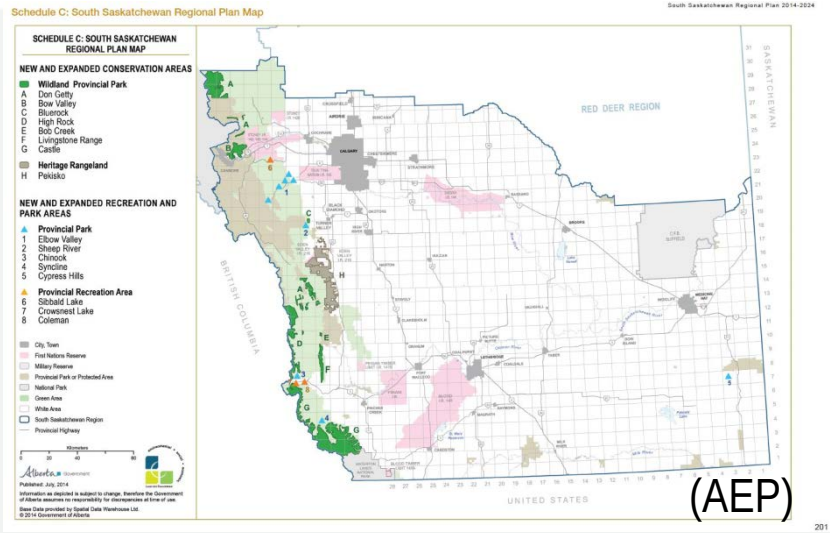
South Saskatchewan Region

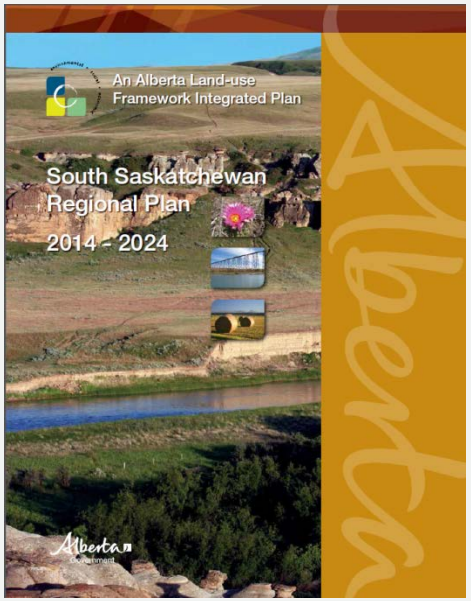
Land Use Planning Framework

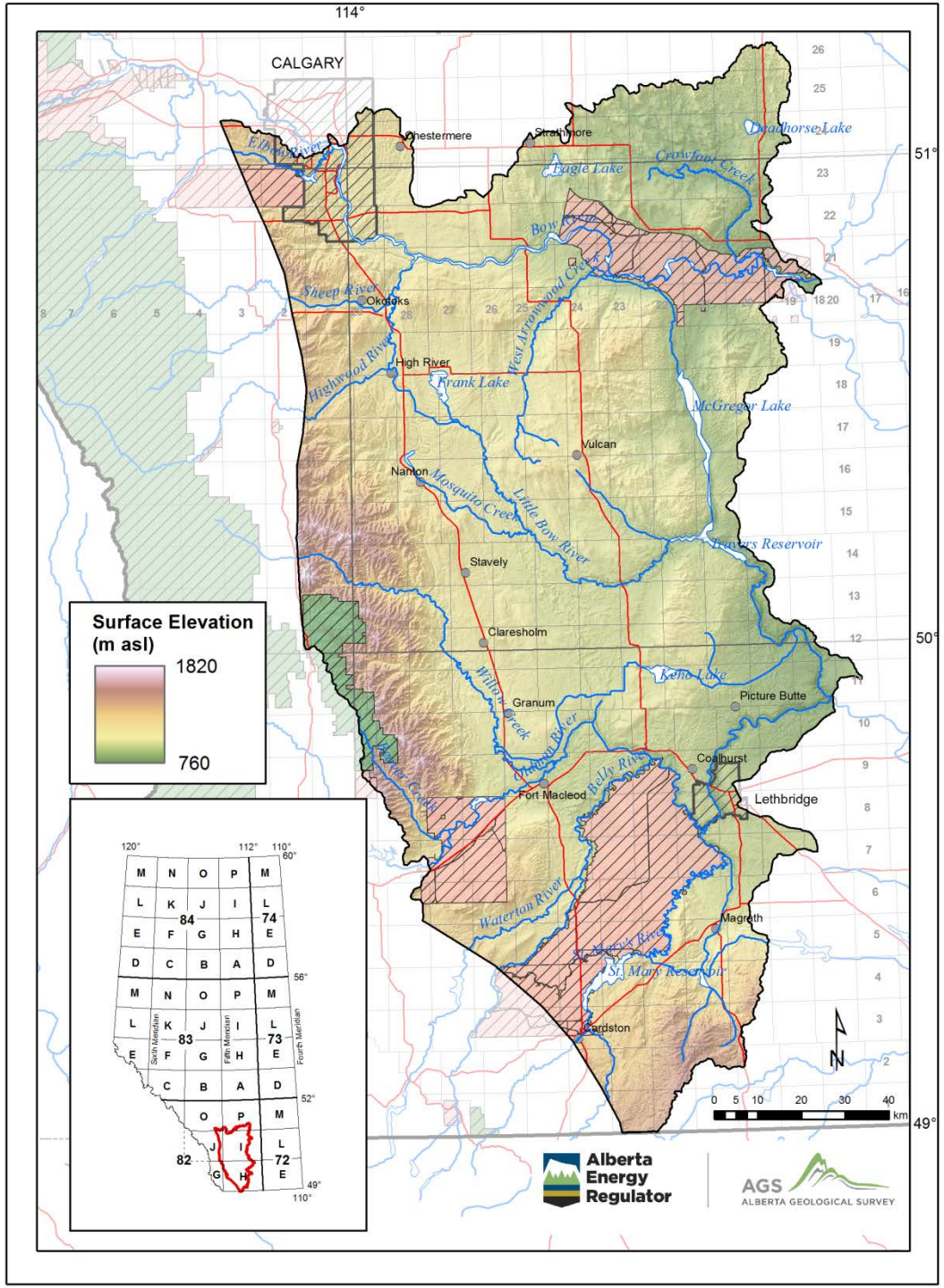
South Saskatchewan Regional Plan

Groundwater Management Framework

Enhanced GW Monitoring Network

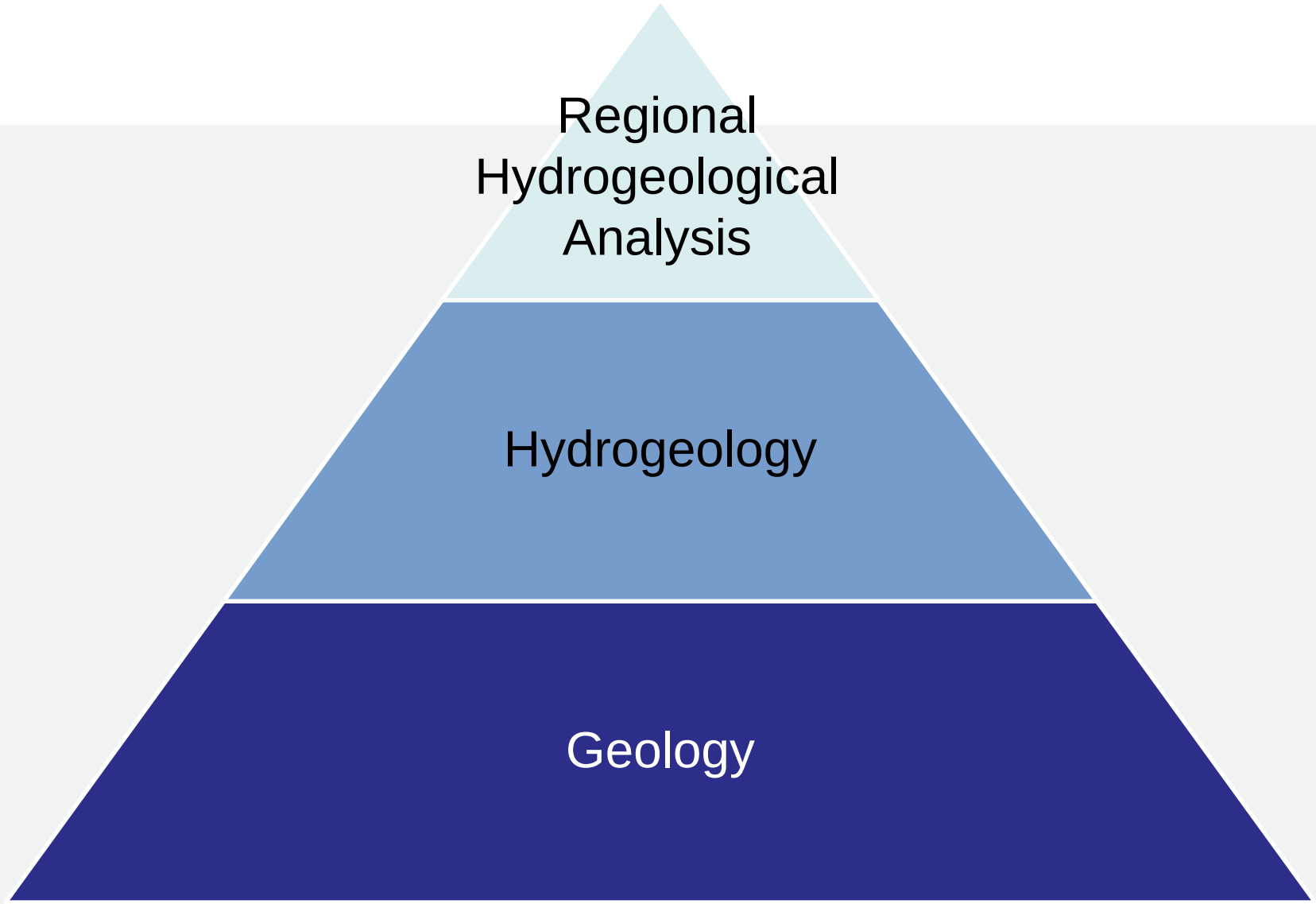






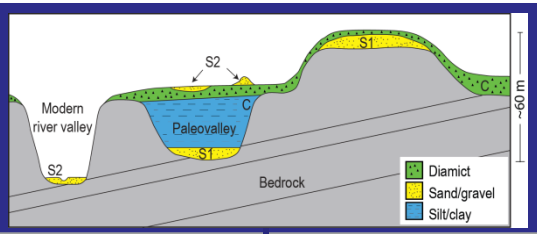
Calgary-Lethbridge Corridor

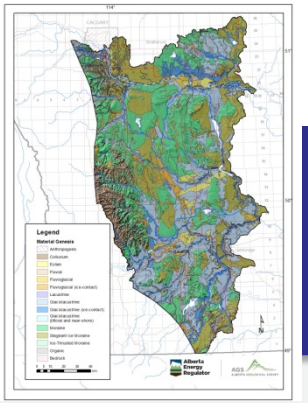
- 21 159 km^2
- Shape defined by 8 sub-basins limited by the deformation belt to the west


Regional
Hydrogeological
Analysis
Hydrogeology
Geology

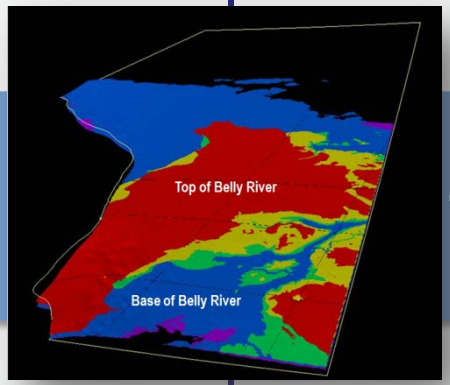
Geology

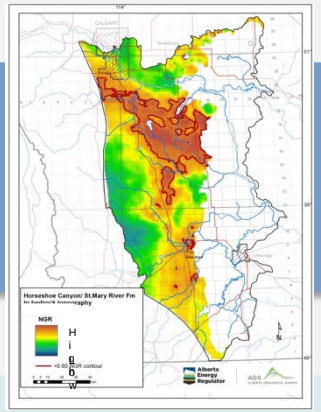
Surficial



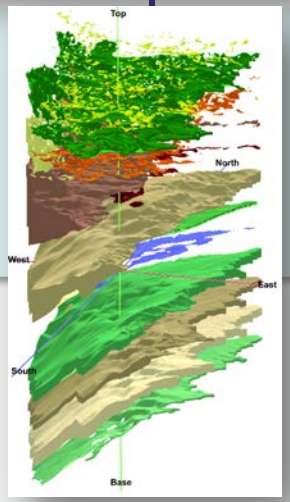


Bedrock

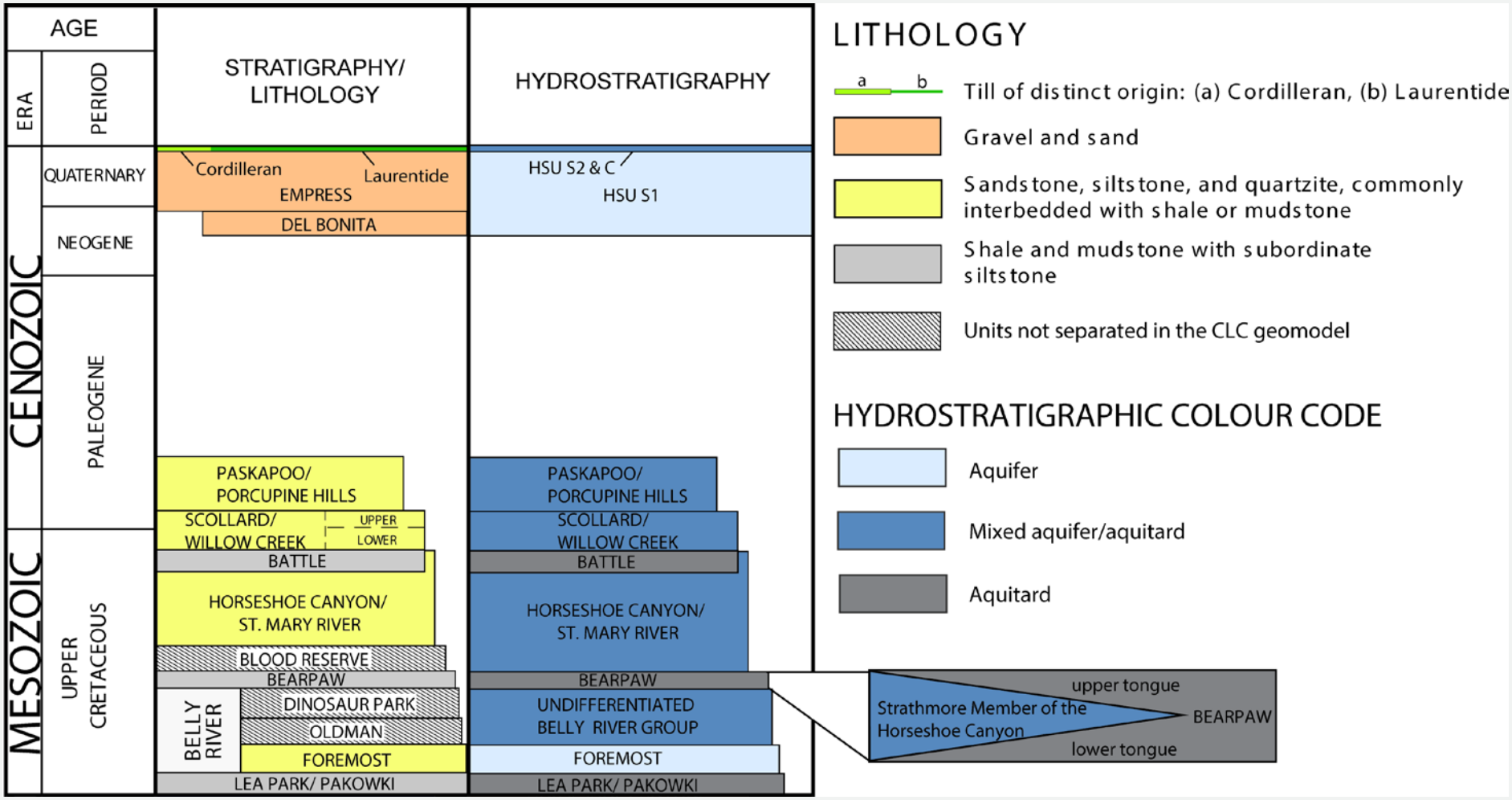




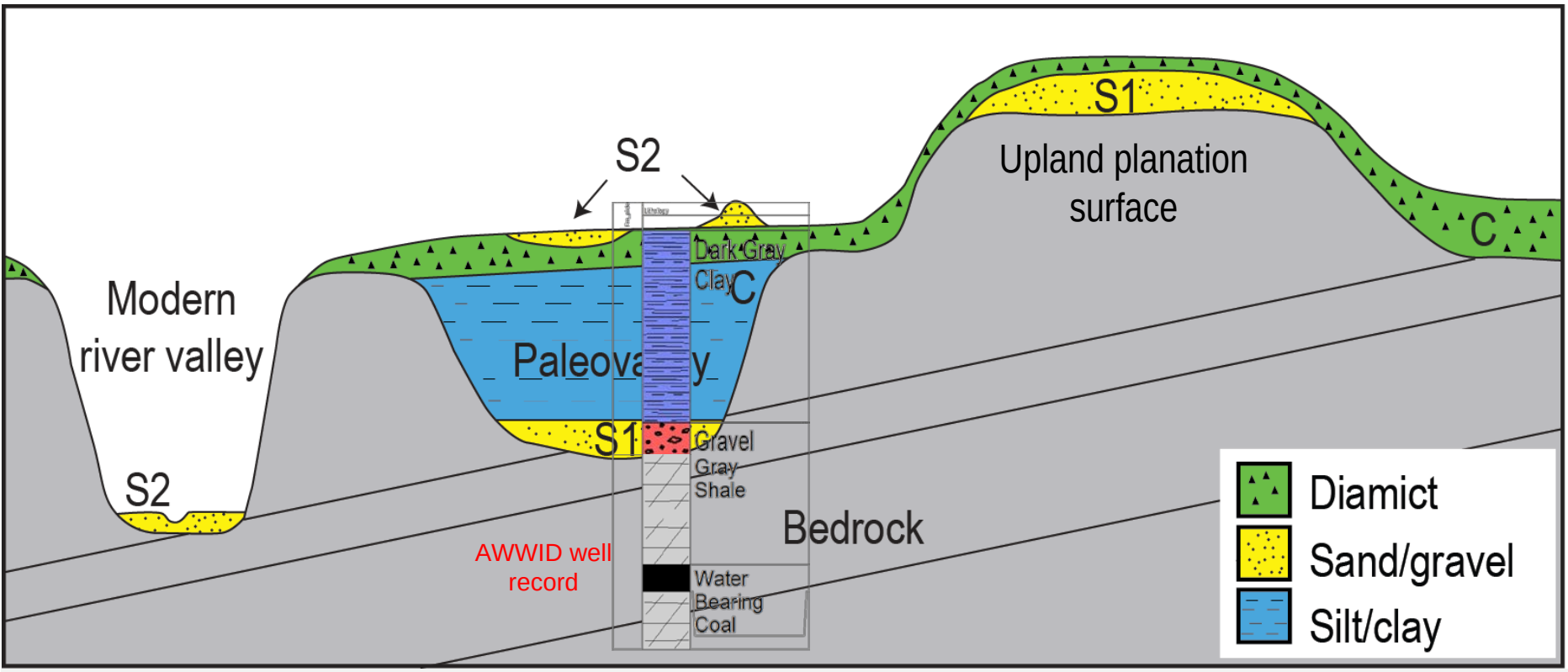
Regional Hydrostratigraphy



Hydrostratigraphy of the CLC

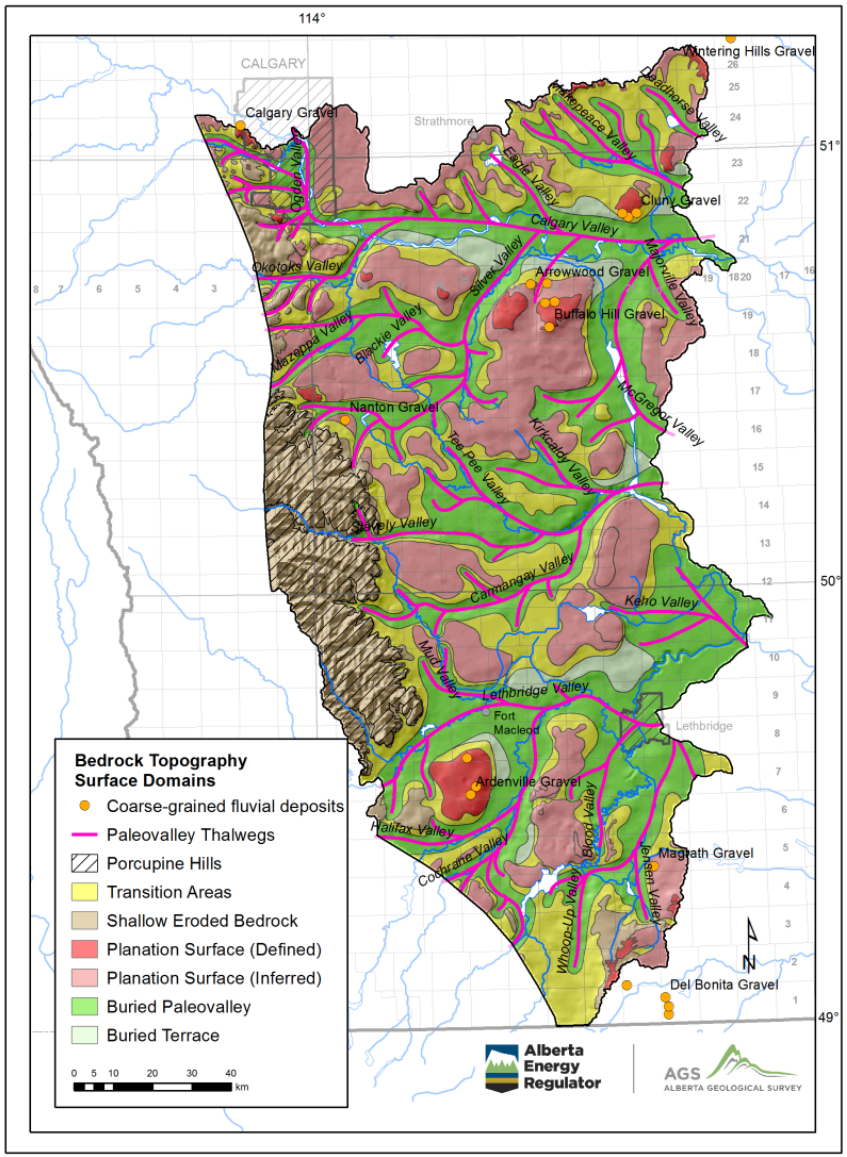


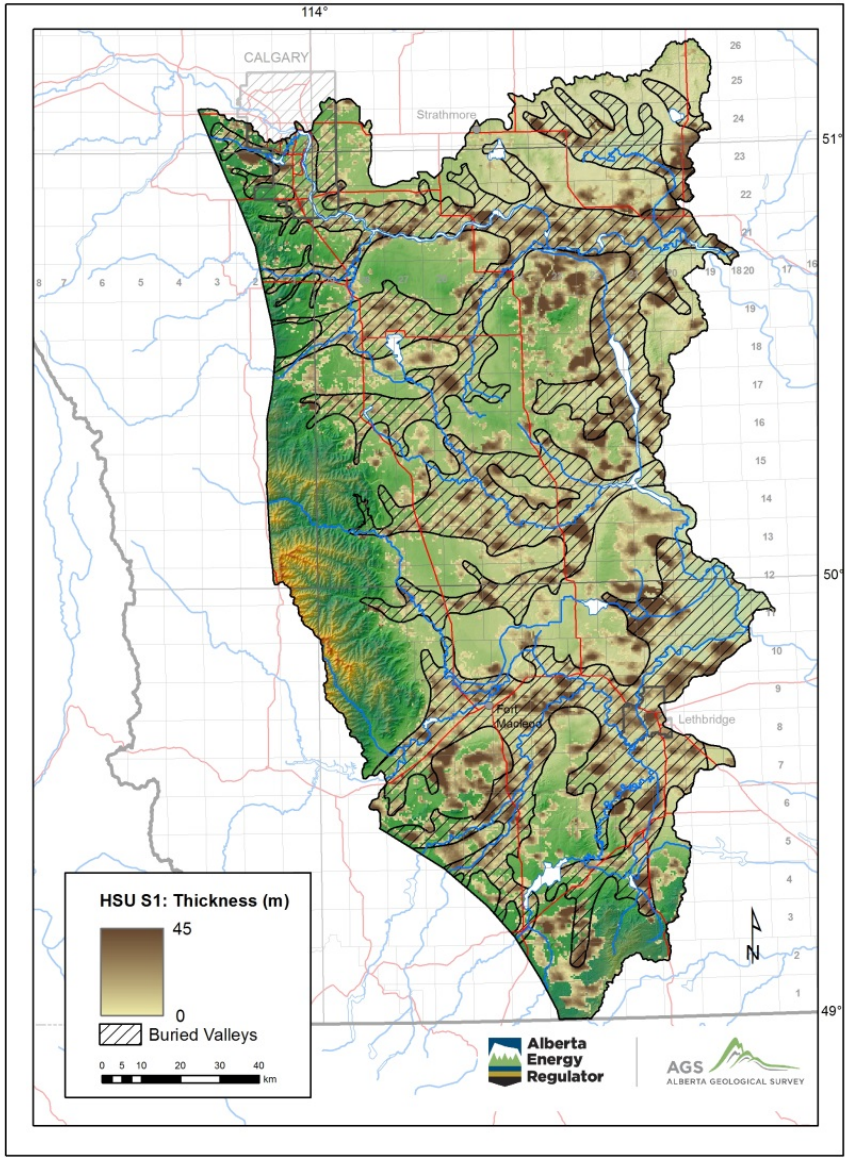
Unconsolidated HSUs



- Simplifications of the Neogene-Quaternary succession were made to establish the vertical sequence of three hydrostratigraphic units (HSUs) above bedrock

Unconsolidated HSUs





Unconsolidated HSUs

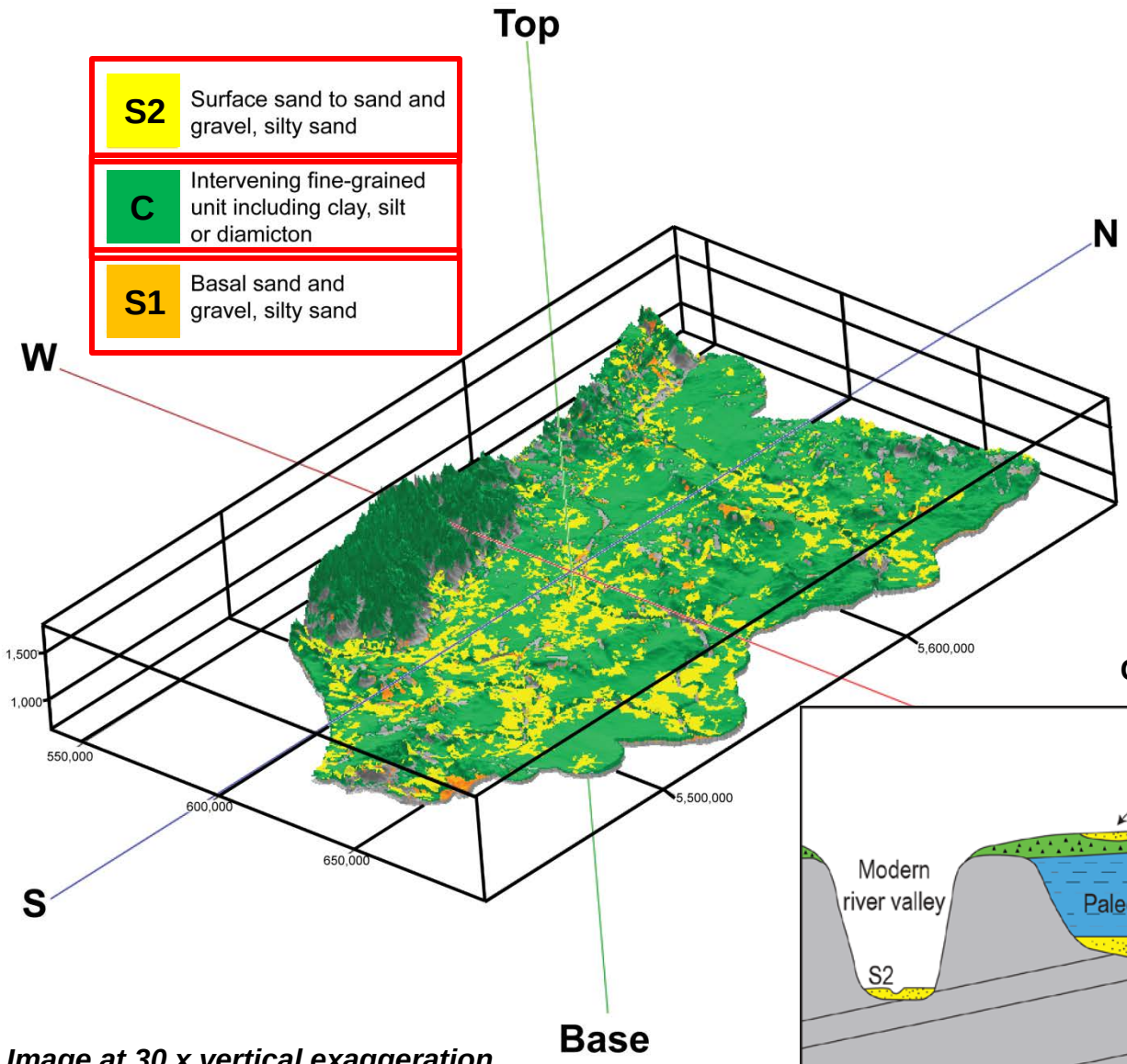
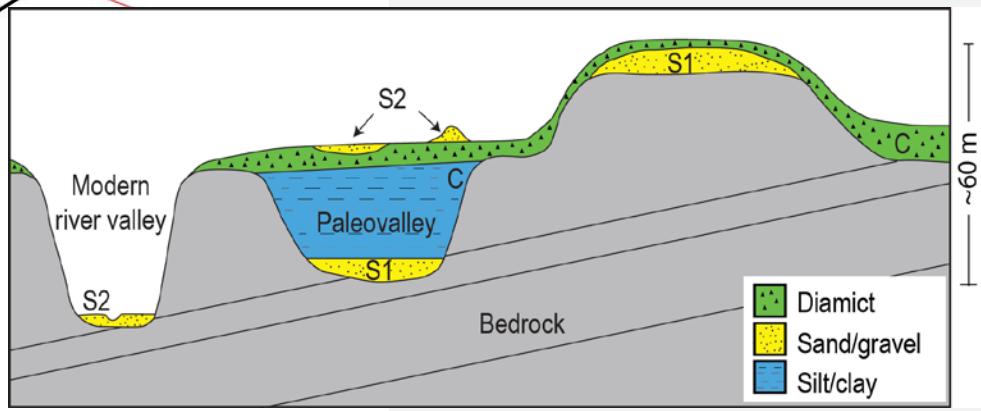


Image at 30 x vertical exaggeration

Conceptual Model



3D Geological Framework of Alberta

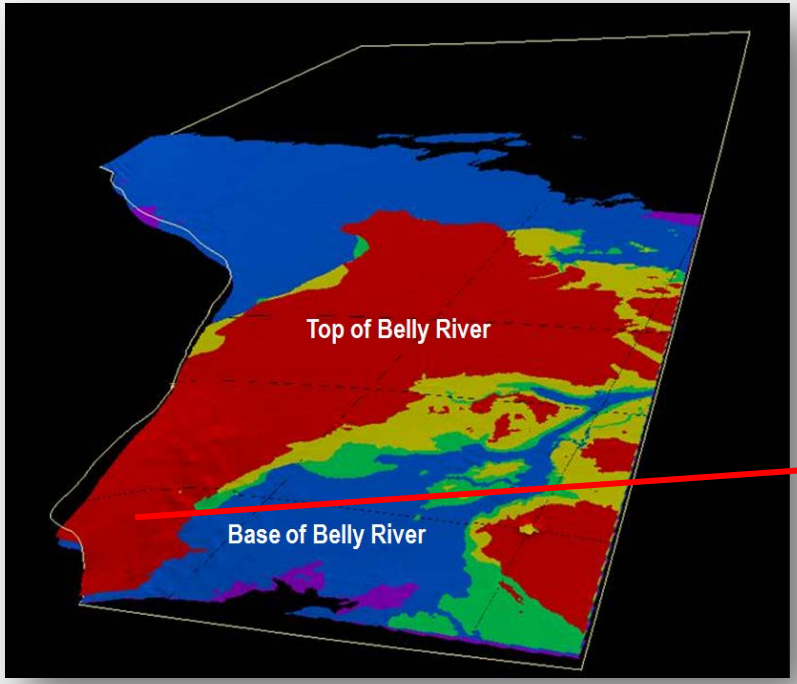
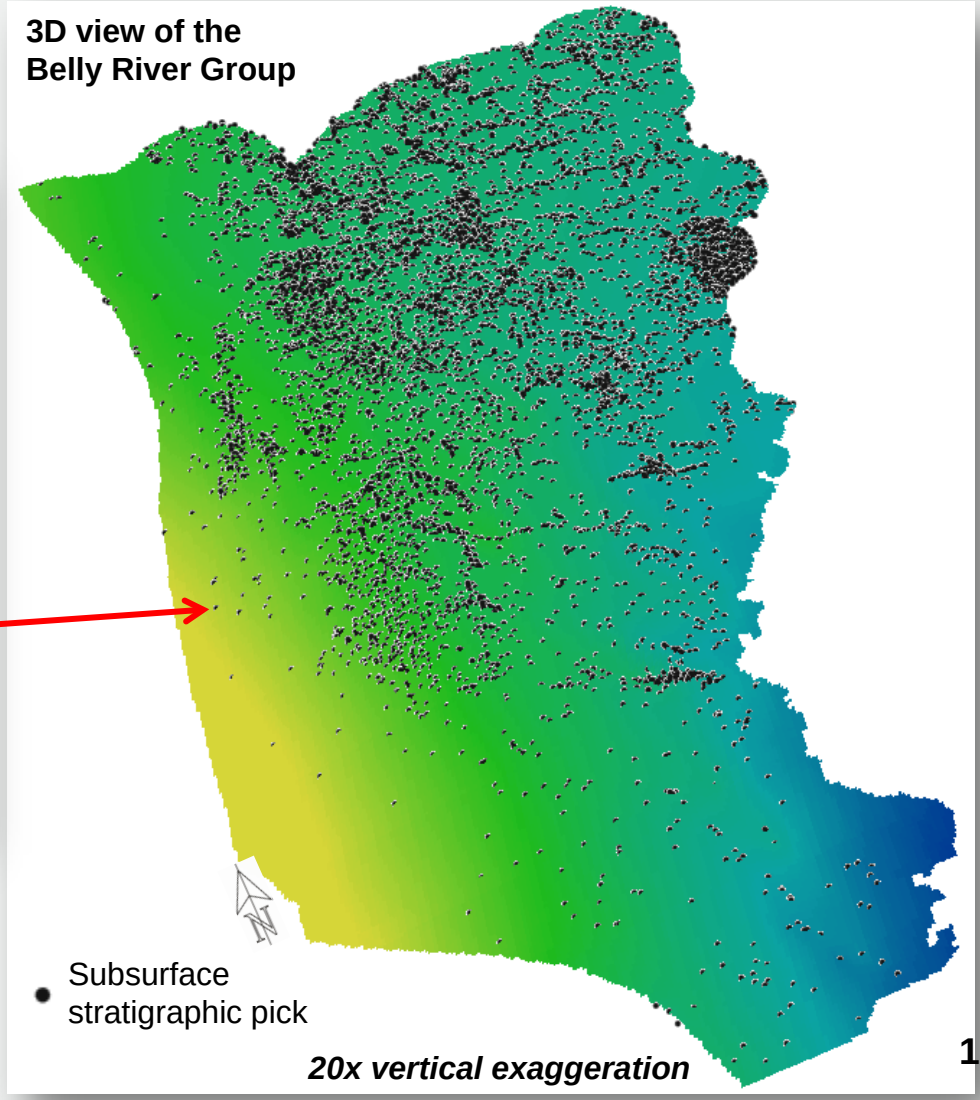
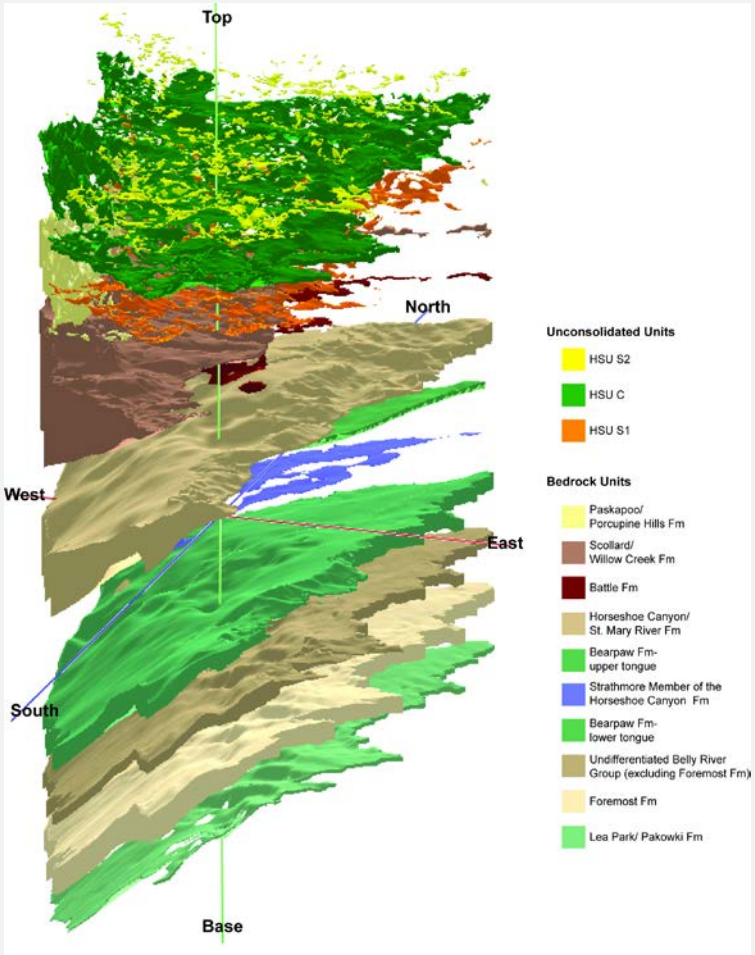


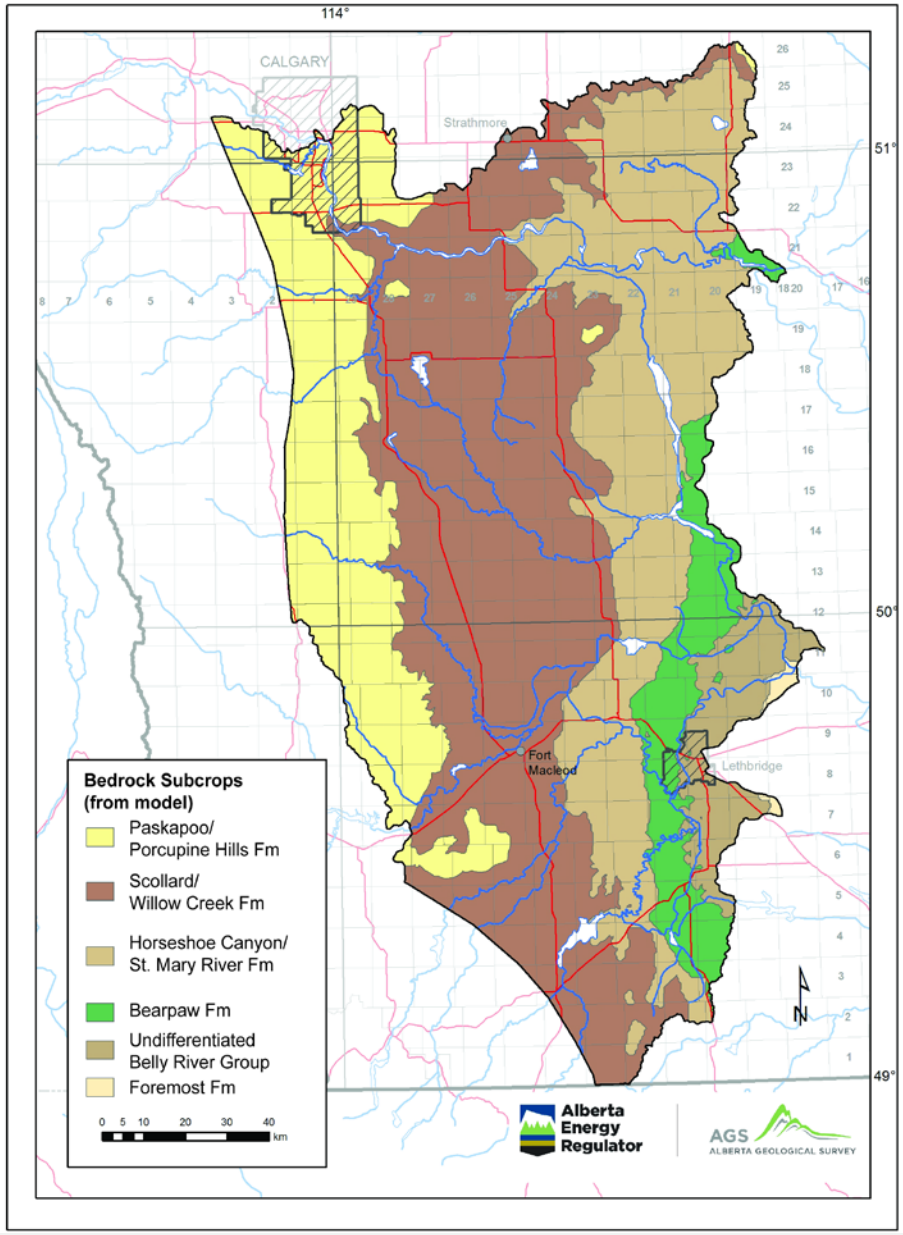
Image taken from the 3D Geological Framework of Alberta

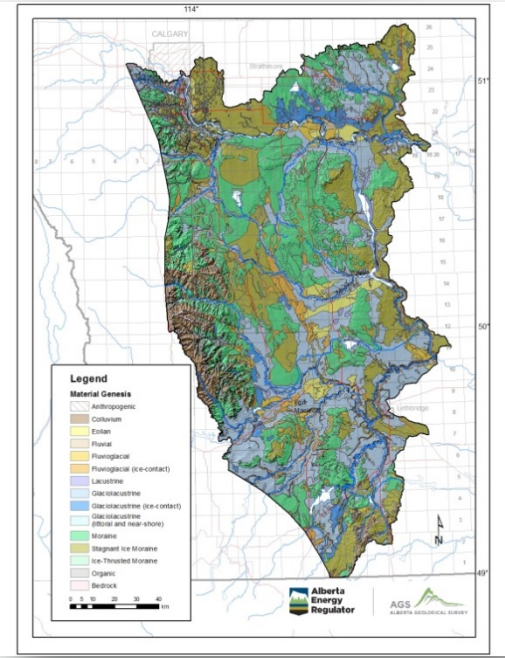


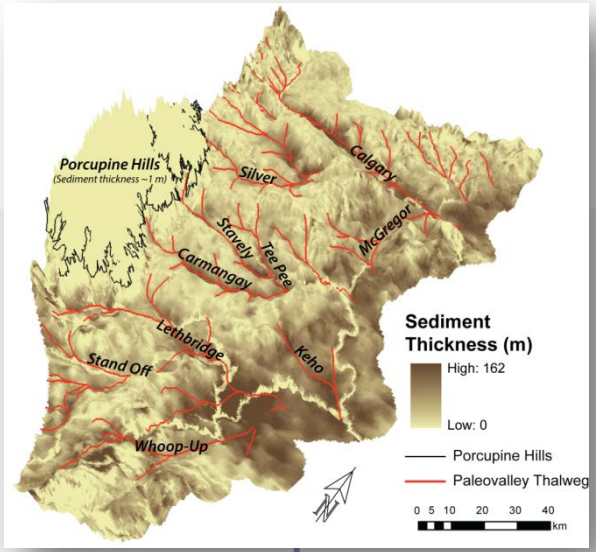
AGS

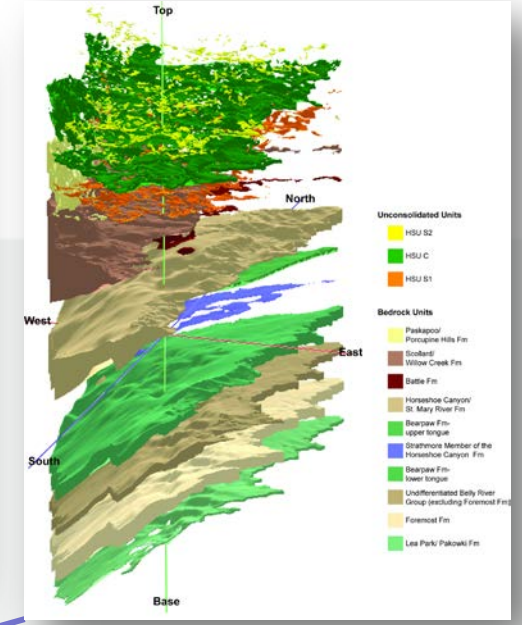
Hydrostratigraphic Model



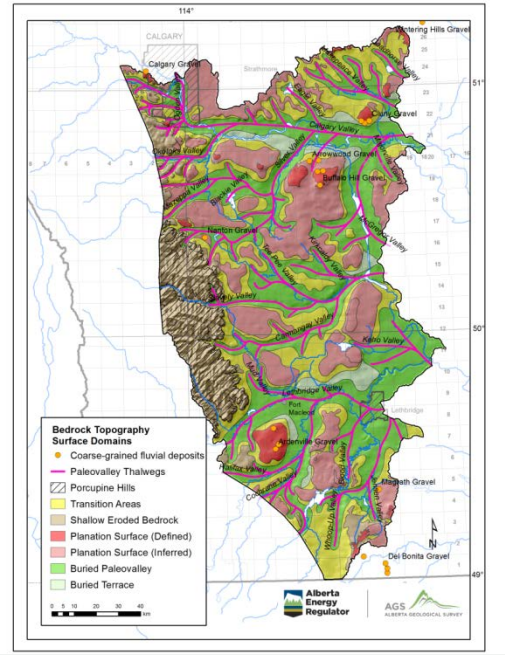


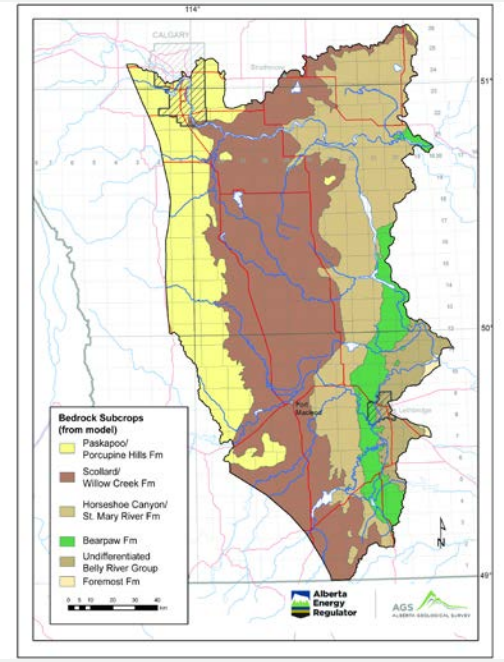

Legend
Material Genesis
Anthropogenic
Colluvium
Eolian
Fluvial
Fluvioglacial
Fluvioglacial (ice-contact)
Lacustrine
Glaciolacustrine
Glaciolacustrine (ice-contact)
Glaciolacustrine (littoral and near-shore)
Moraine
Stagnant Ice Moraine
Ice-Thrusted Moraine
Organic
Bedrock
Alberta Energy Regulator
AGS

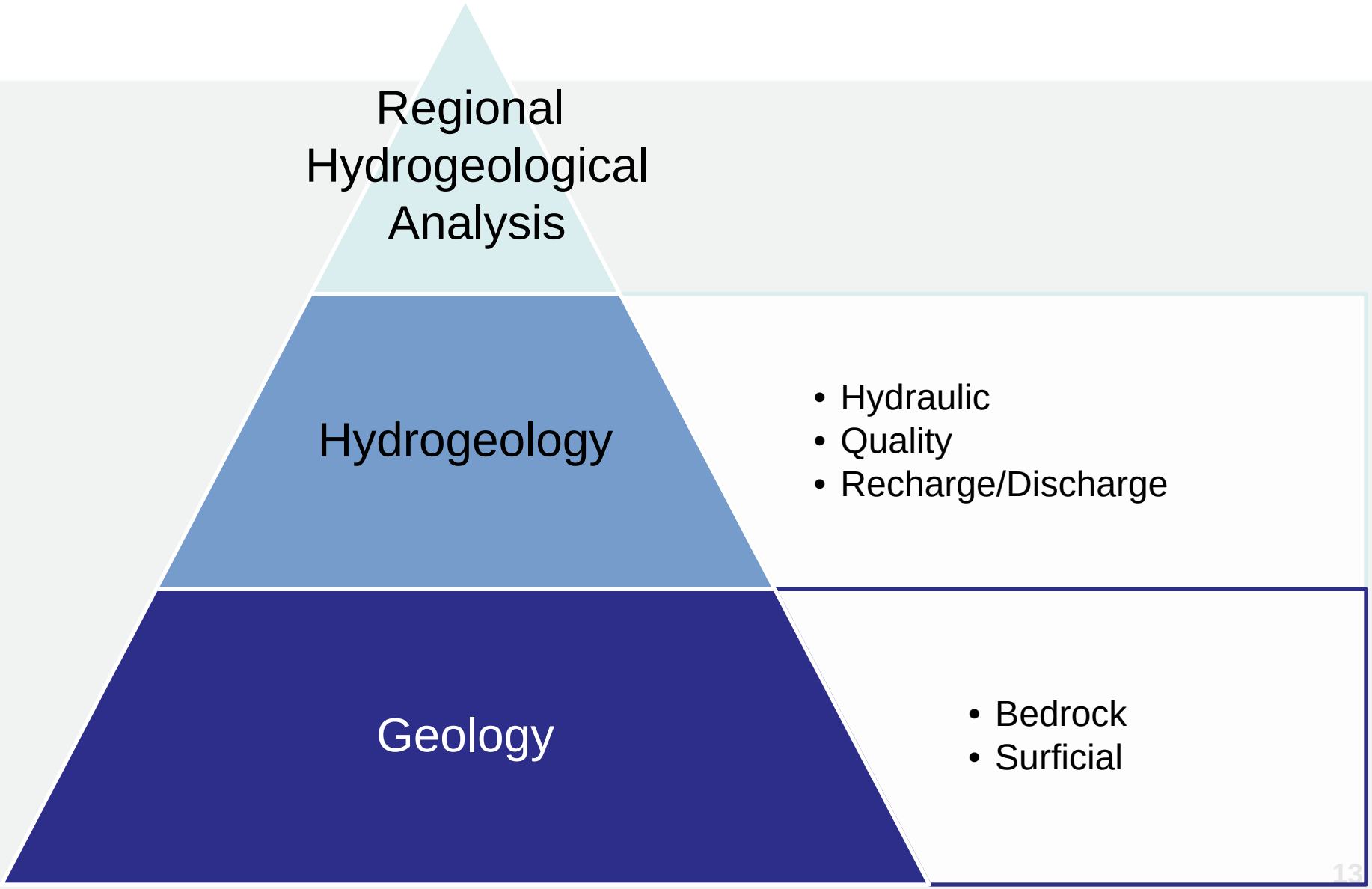

Porcupine Hills
(Sediment thickness ~1 m)
Silver
Calgary
Stavely
McGregor
Tee Pee
Carmangay
Lethbridge
Keho
Stand Off
Whoop-Up
Sediment Thickness (m)
High: 162
Low: 0
Porcupine Hills
Paleovalley Thalweg
0 5 10 20 30 40
km


Top
North
West
East
South
Base
Unconsolidated Units
HSU S2
HSU C
HSU S1
Bedrock Units
Paskapoo/ Porcupine Hills Fm
Scollard/ Willow Creek Fm
Battle Fm
Horseshoe Canyon/ St. Mary River Fm
Bearpaw Fm- upper tongue
Strathmore Member of the Horseshoe Canyon Fm
Bearpaw Fm- lower tongue
Undifferentiated Belly River Group (excluding Foremost Fm)
Foremost Fm
Lea Park/ Pakowki Fm

Geology

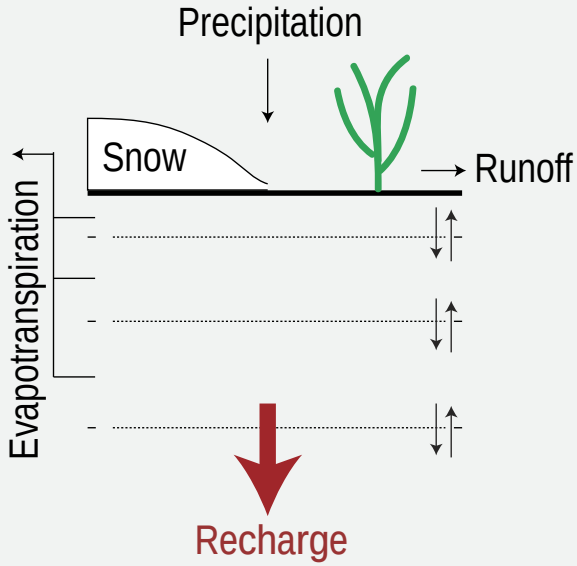

Bedrock Topography
Surface Domains
Coarse-grained fluvial deposits
Paleovalley Thalwegs
Porcupine Hills
Transition Areas
Shallow Eroded Bedrock
Planation Surface (Defined)
Planation Surface (Inferred)
Buried Paleovalley
Buried Terrace
Alberta Energy Regulator
AGS


Bedrock Subcrops
(from model)
Paskapoo/ Porcupine Hills Fm
Scollard/ Willow Creek Fm
Horseshoe Canyon/ St. Mary River Fm
Bearpaw Fm
Undifferentiated Belly River Group
Foremost Fm
Alberta Energy Regulator
AGS


Regional Hydrogeological Analysis
Hydrogeology
• Hydraulic
• Quality
• Recharge/Discharge
Geology
• Bedrock
• Surficial

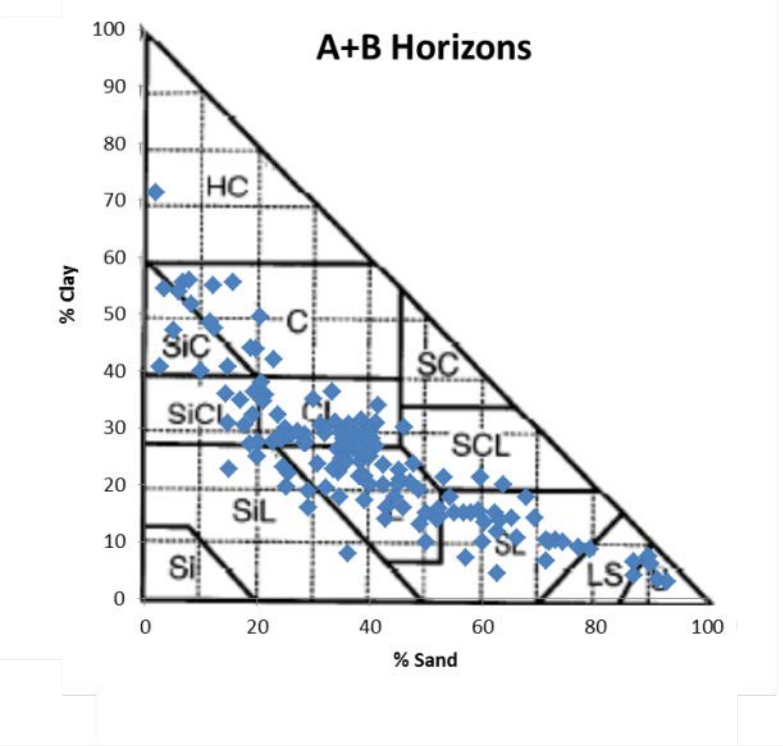
Versatile Soil Moisture Budget Model (VSMB)

- 1D
- Used in Canadian Prairies by ARD/ACIS and UofC



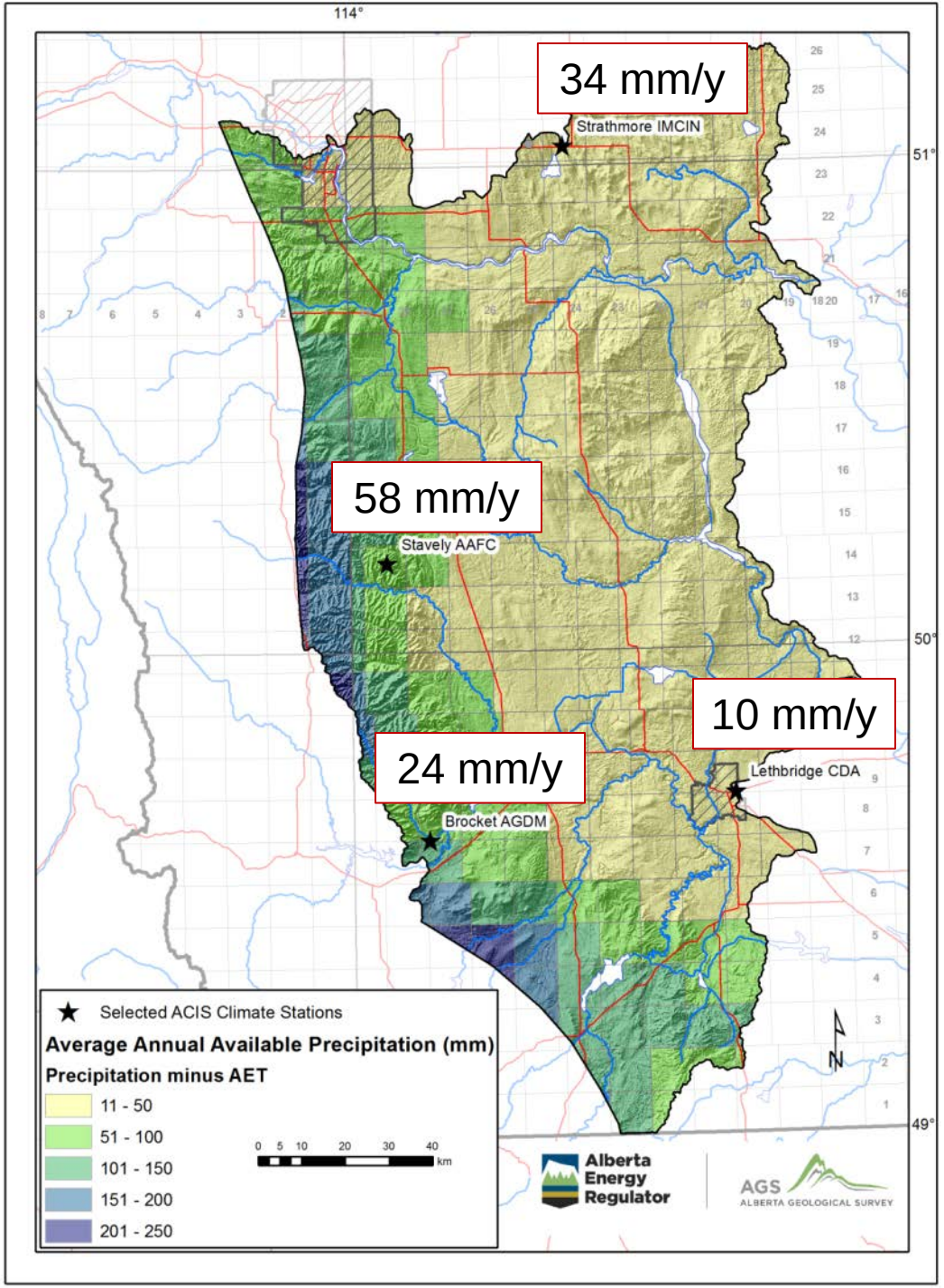
VSMB Modelling

- Different simulations for different conditions
  - 2 soils (sandy loam/silty clay)
  - 2 vegetation (grass/wheat)
  - 3 ET routines
  - 4 weather stations



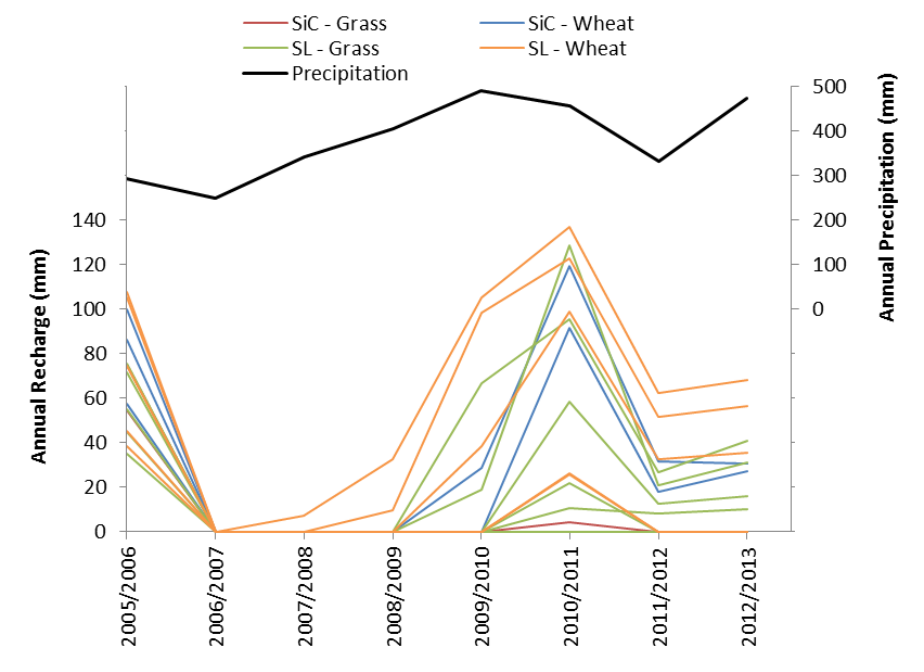
Recharge

- 70 of 144 simulations had recharge
- Previous estimates for south AB range ~ 5 – 40 mm/yr



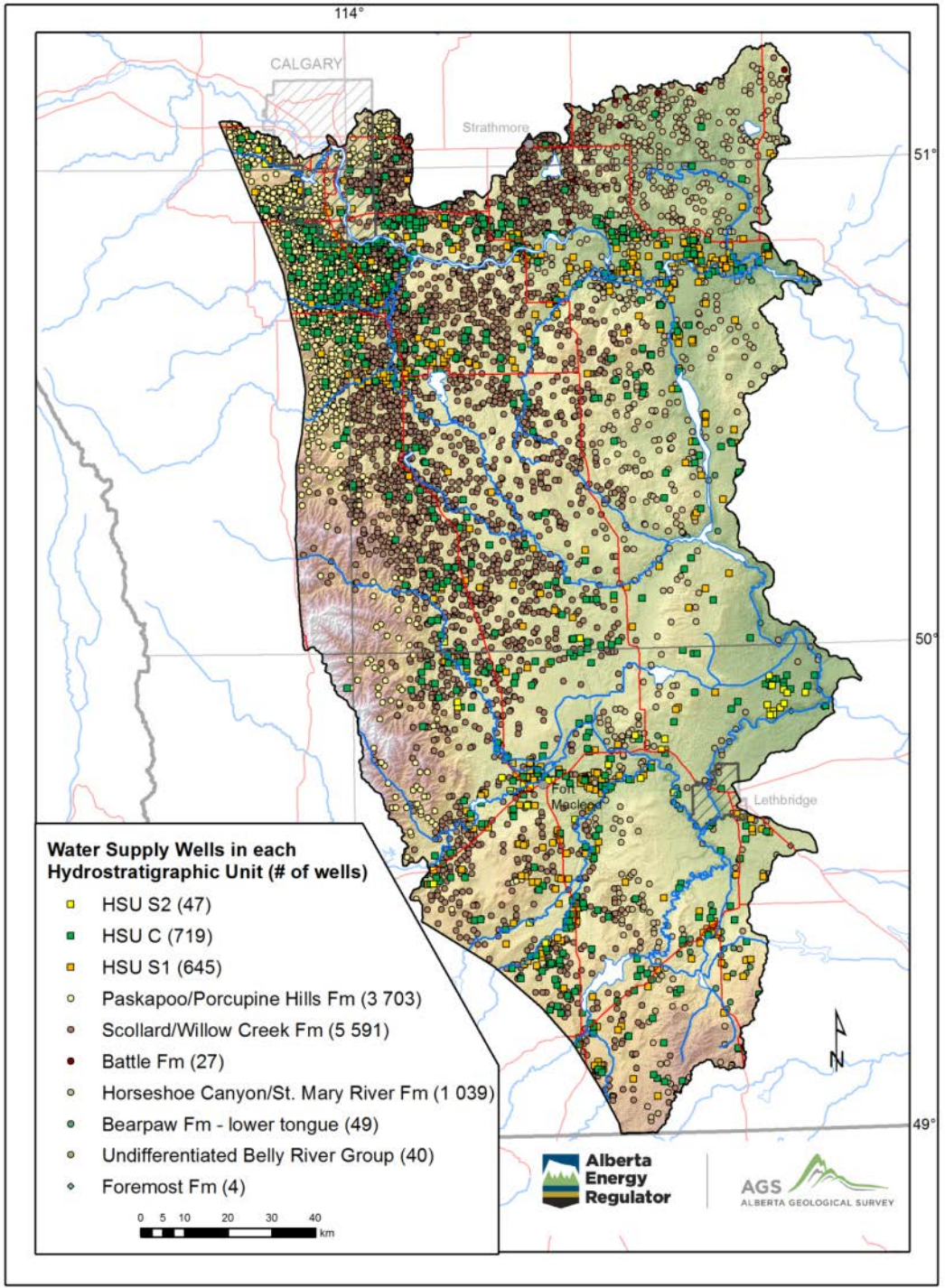
Recharge

- Highly variable year to year (0-100+ mm range) and seasonally
- Depression focused recharge important (UofC)

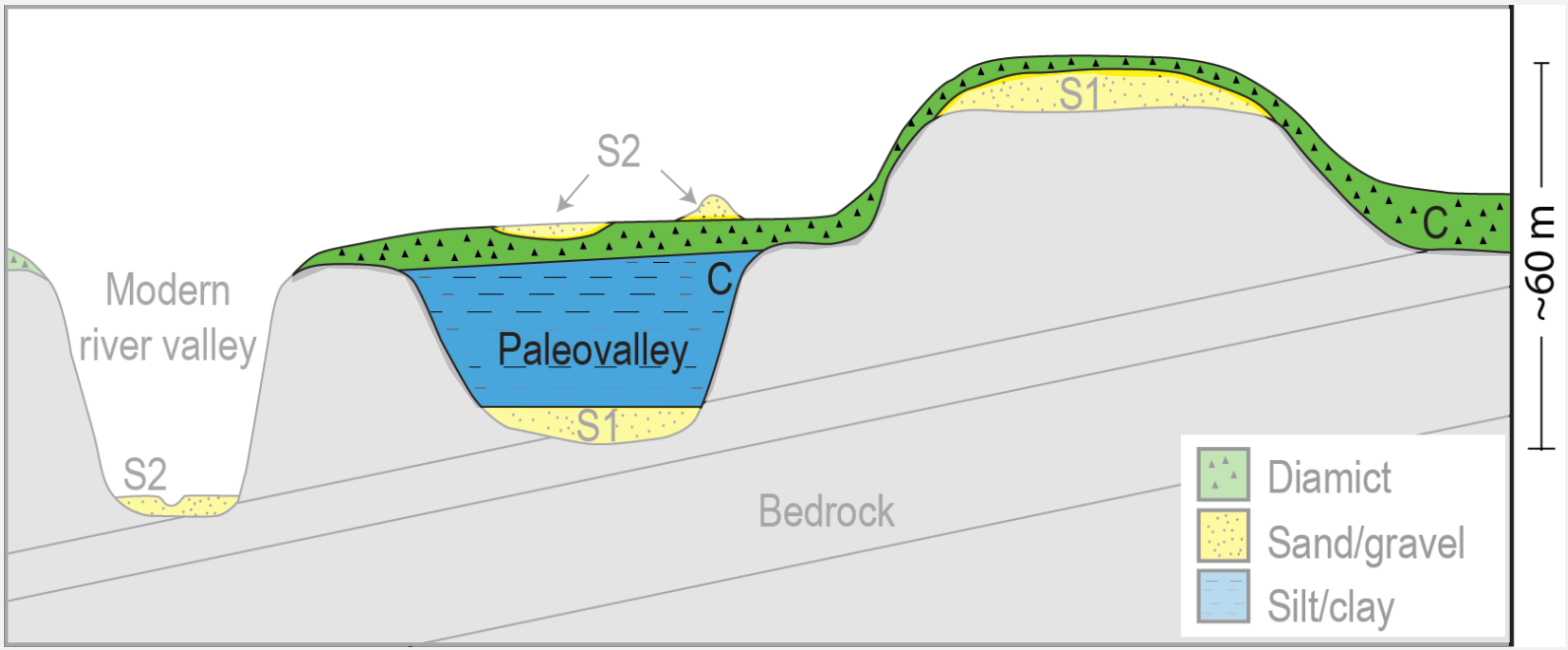


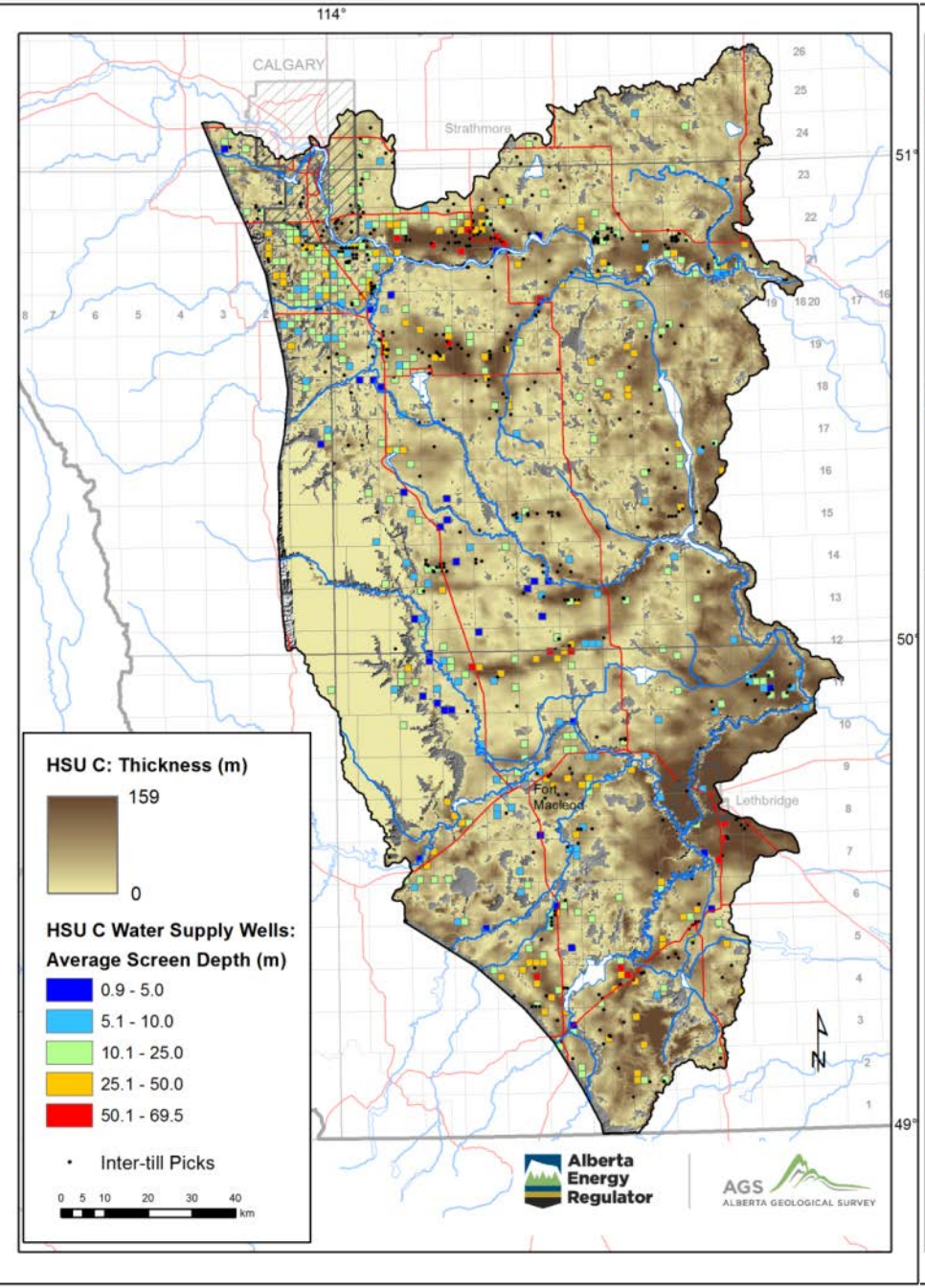
Water Supply Wells

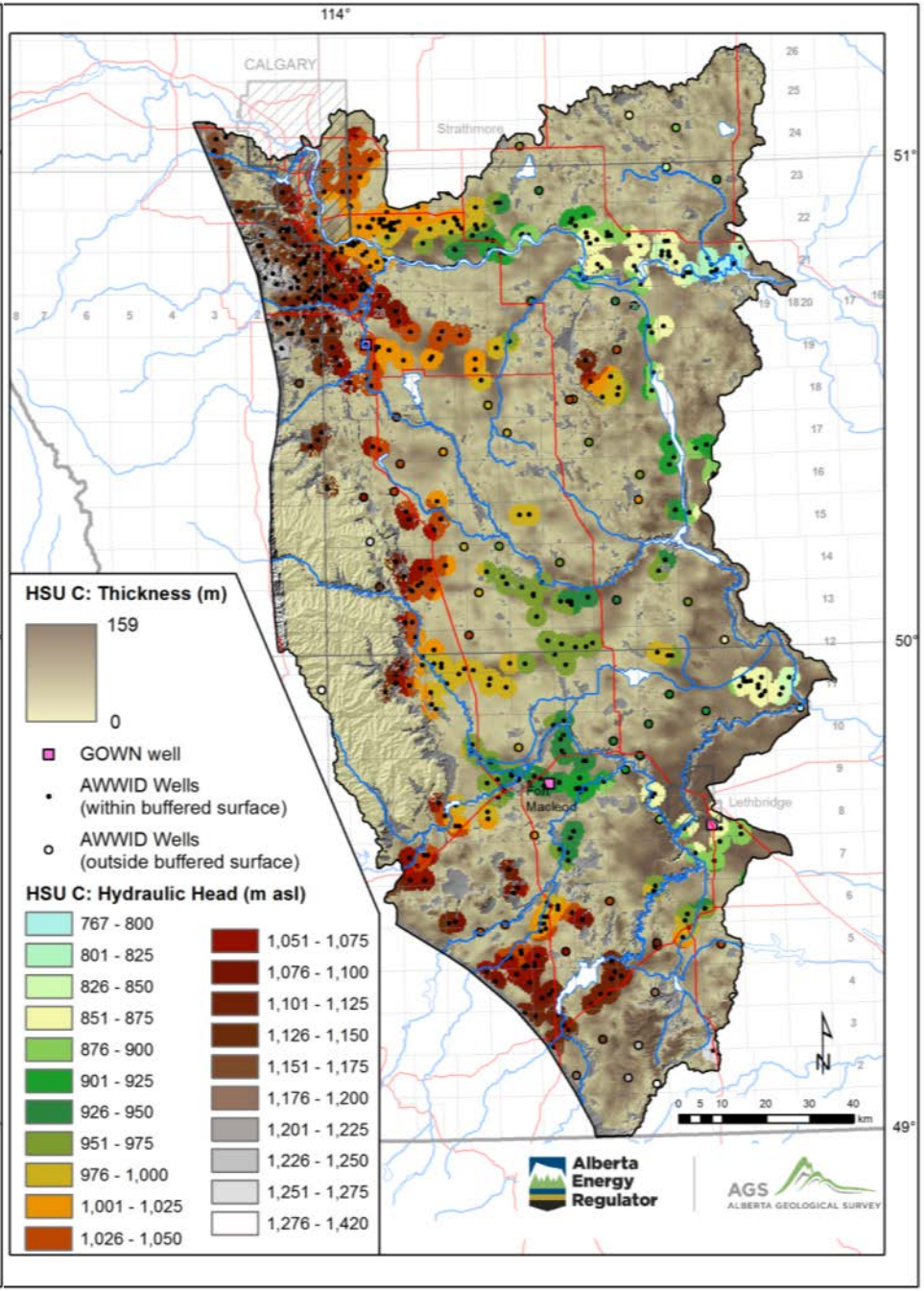
- E.g. Domestic, stock, municipal, etc.
- NOT observation, test holes, dewatering, etc.
- Allocation based on middle of screen



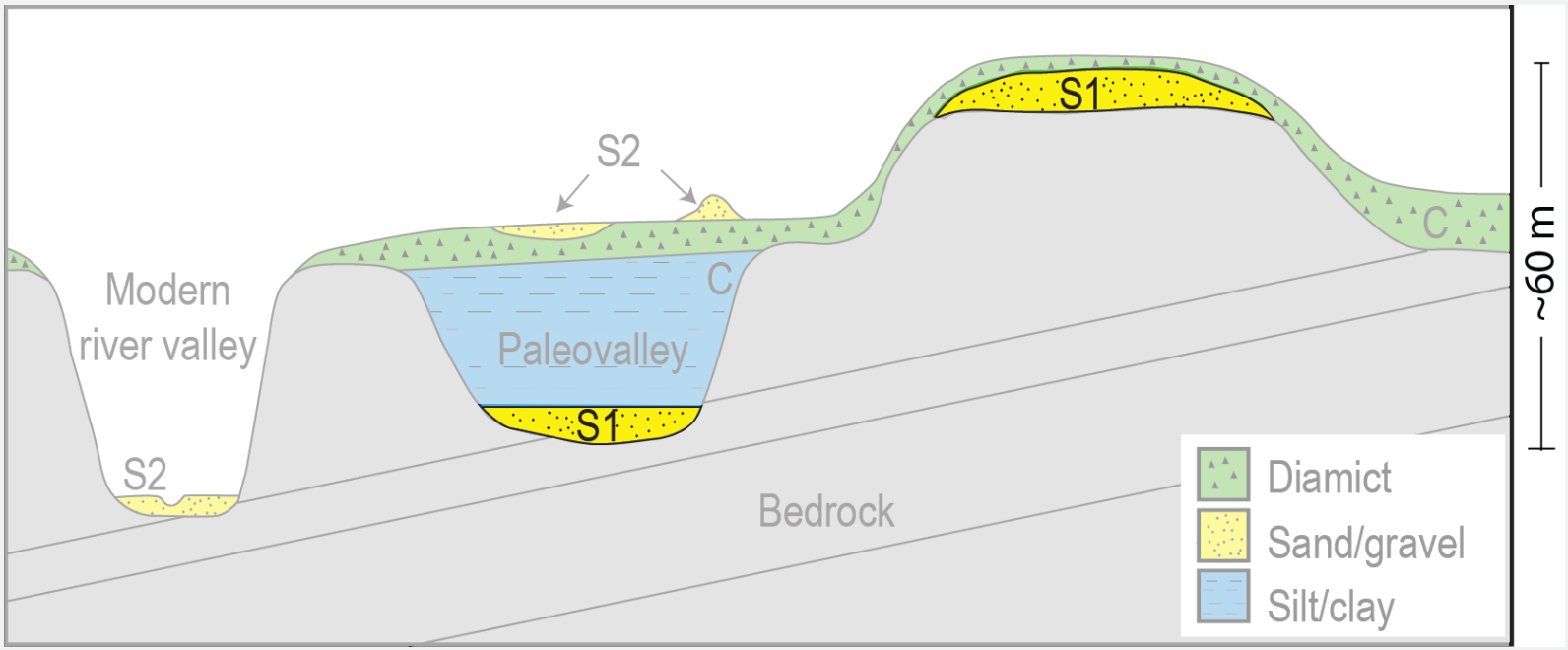
HSU C

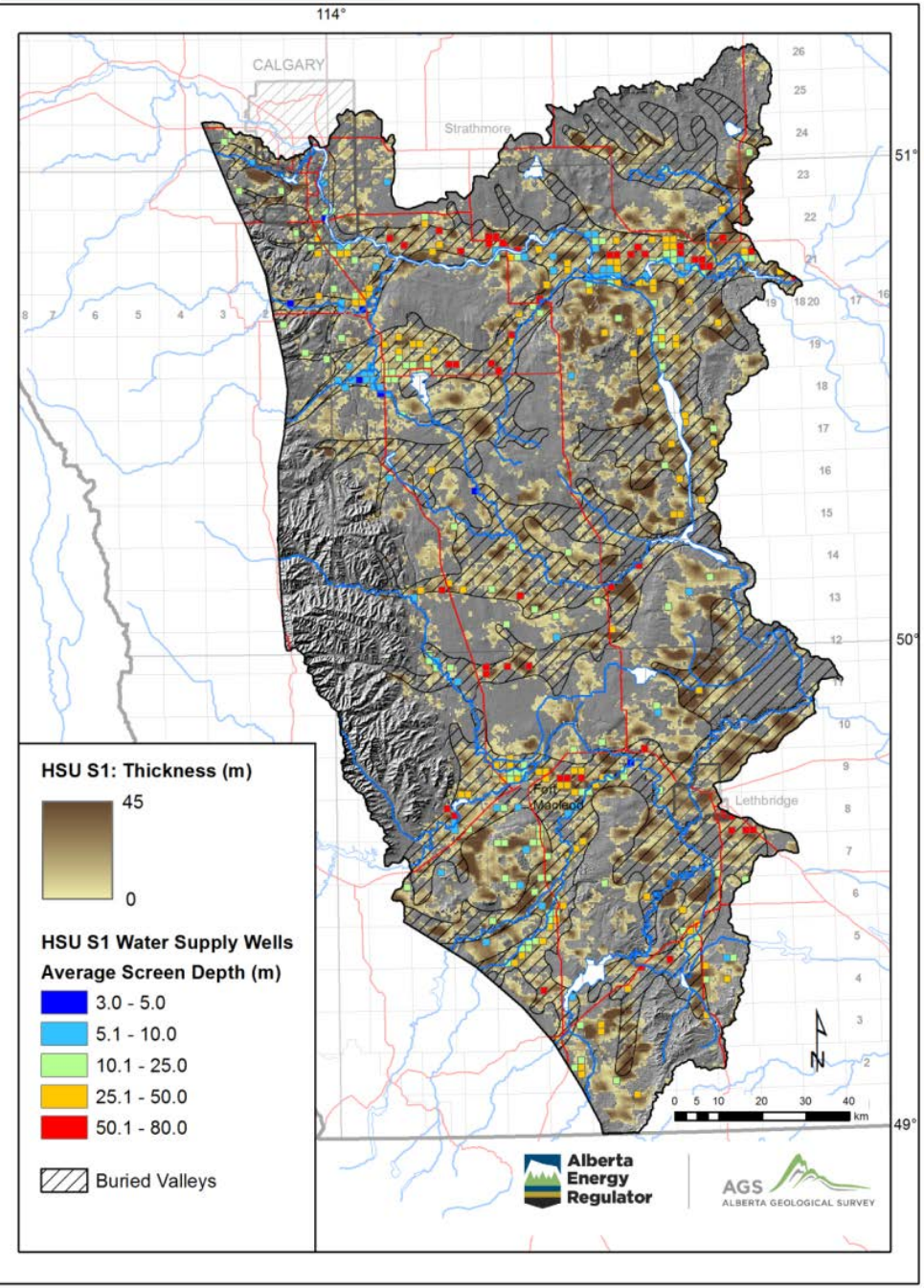

S2
S1
C
Modern
river valley
Paleovalley
C
S1
S2
Bedrock
~60 m
Diamict
Sand/gravel
Silt/clay

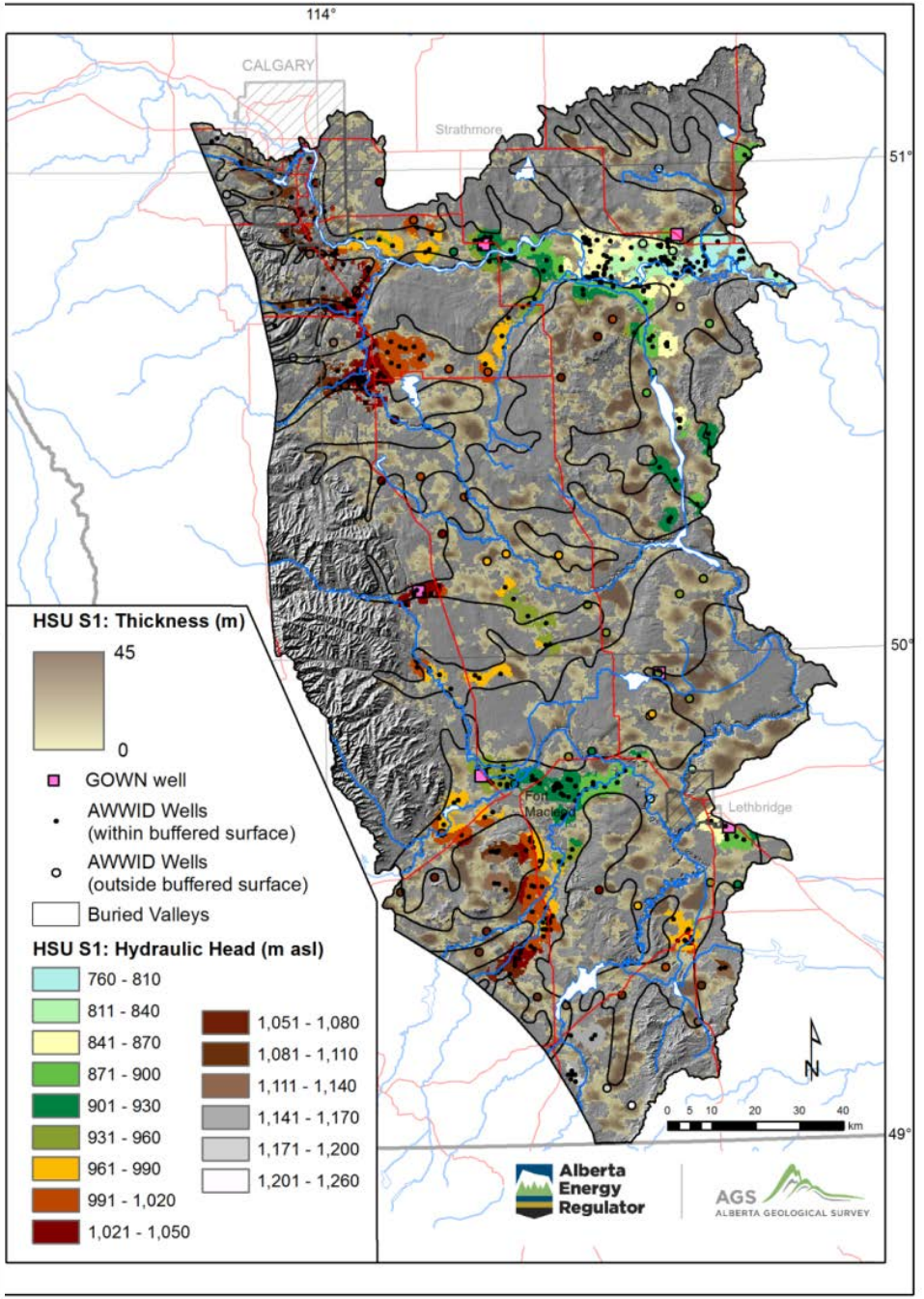

114°
CALGARY
Strathmore
Fort Macleod
Lethbridge
51°
50°
49°
HSU C: Thickness (m)
159
0
HSU C Water Supply Wells:
Average Screen Depth (m)
0.9 - 5.0
5.1 - 10.0
10.1 - 25.0
25.1 - 50.0
50.1 - 69.5
Inter-till Picks
0 5 10 20 30 40
km
Alberta Energy Regulator
AGS
ALBERTA GEOLOGICAL SURVEY

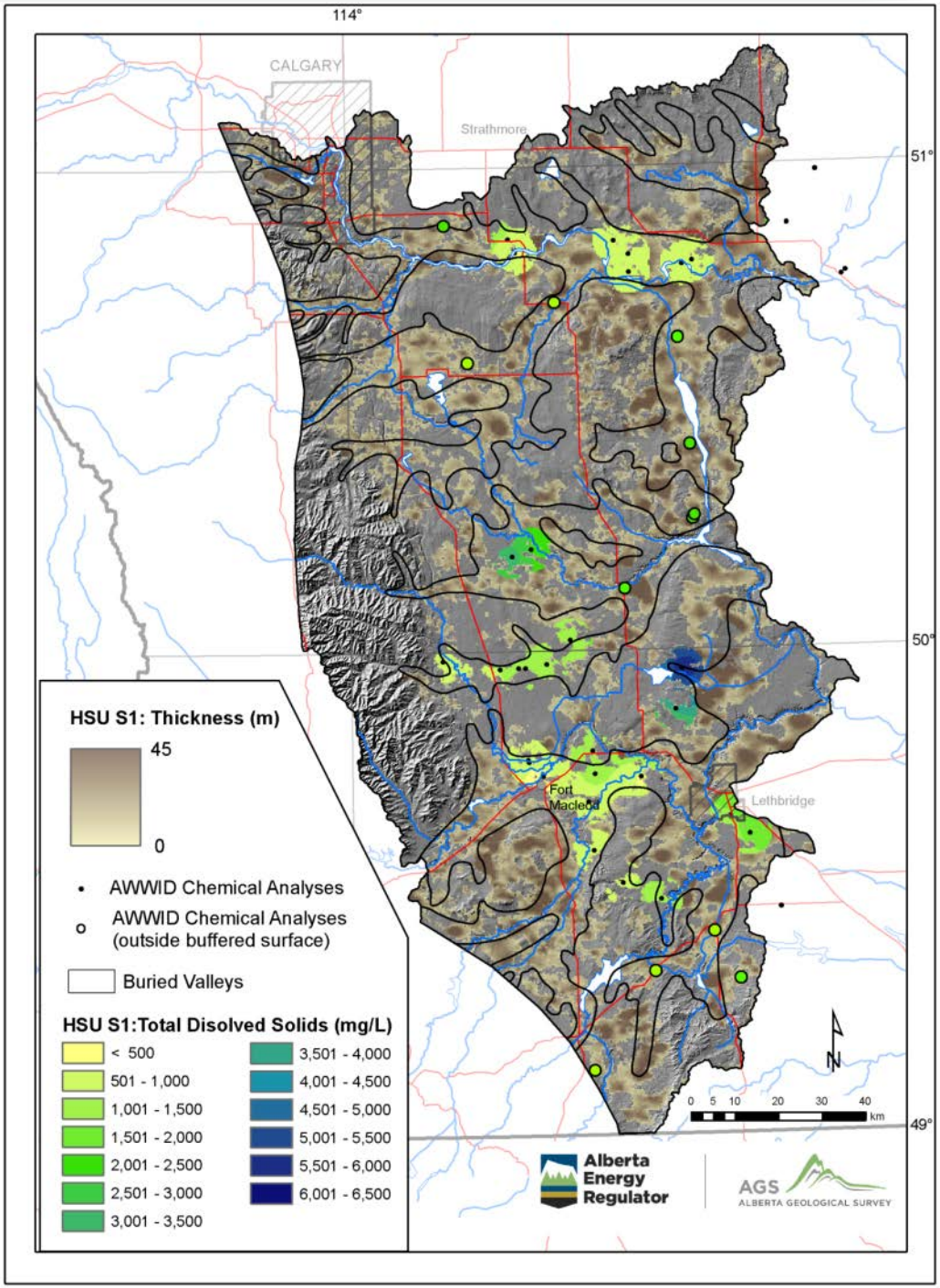

114°
CALGARY
Strathmore
Fort Macleod
Lethbridge
51°
50°
49°
HSU C: Thickness (m)
159
0
GOWN well
AWWID Wells
(within buffered surface)
AWWID Wells
(outside buffered surface)
HSU C: Hydraulic Head (m asl)
767 - 800
801 - 825
826 - 850
851 - 875
876 - 900
901 - 925
926 - 950
951 - 975
976 - 1,000
1,001 - 1,025
1,026 - 1,050
1,051 - 1,075
1,076 - 1,100
1,101 - 1,125
1,126 - 1,150
1,151 - 1,175
1,176 - 1,200
1,201 - 1,225
1,226 - 1,250
1,251 - 1,275
1,276 - 1,420
0 5 10 20 30 40
km
Alberta Energy Regulator
AGS
ALBERTA GEOLOGICAL SURVEY

HSU S1


S1
S2
C
Modern
river valley
Paleovalley
C
S1
S2
Bedrock
~60 m
Diamict
Sand/gravel
Silt/clay


114°
CALGARY
Strathmore
51°
50°
49°
Fort Macleod
Lethbridge
HSU S1: Thickness (m)
45
0
HSU S1 Water Supply Wells
Average Screen Depth (m)
3.0 - 5.0
5.1 - 10.0
10.1 - 25.0
25.1 - 50.0
50.1 - 80.0
Buried Valleys
0 5 10 20 30 40
km
N
Alberta Energy Regulator
AGS
ALBERTA GEOLOGICAL SURVEY


114°
CALGARY
Strathmore
51°
50°
49°
Fort Macleod
Lethbridge
HSU S1: Thickness (m)
45
0
GOWN well
AWWID Wells
(within buffered surface)
AWWID Wells
(outside buffered surface)
Buried Valleys
HSU S1: Hydraulic Head (m asl)
760 - 810
811 - 840
841 - 870
871 - 900
901 - 930
931 - 960
961 - 990
991 - 1,020
1,021 - 1,050
1,051 - 1,080
1,081 - 1,110
1,111 - 1,140
1,141 - 1,170
1,171 - 1,200
1,201 - 1,260
0 5 10 20 30 40
km
N
Alberta Energy Regulator
AGS
ALBERTA GEOLOGICAL SURVEY


114°
CALGARY
Strathmore
51°
50°
49°
Fort Macleod
Lethbridge
HSU S1: Thickness (m)
45
0
AWWID Chemical Analyses
AWWID Chemical Analyses (outside buffered surface)
Buried Valleys
HSU S1:Total Disolved Solids (mg/L)
< 500
501 - 1,000
1,001 - 1,500
1,501 - 2,000
2,001 - 2,500
2,501 - 3,000
3,001 - 3,500
3,501 - 4,000
4,001 - 4,500
4,501 - 5,000
5,001 - 5,500
5,501 - 6,000
6,001 - 6,500
N
0 5 10 20 30 40
km
Alberta Energy Regulator
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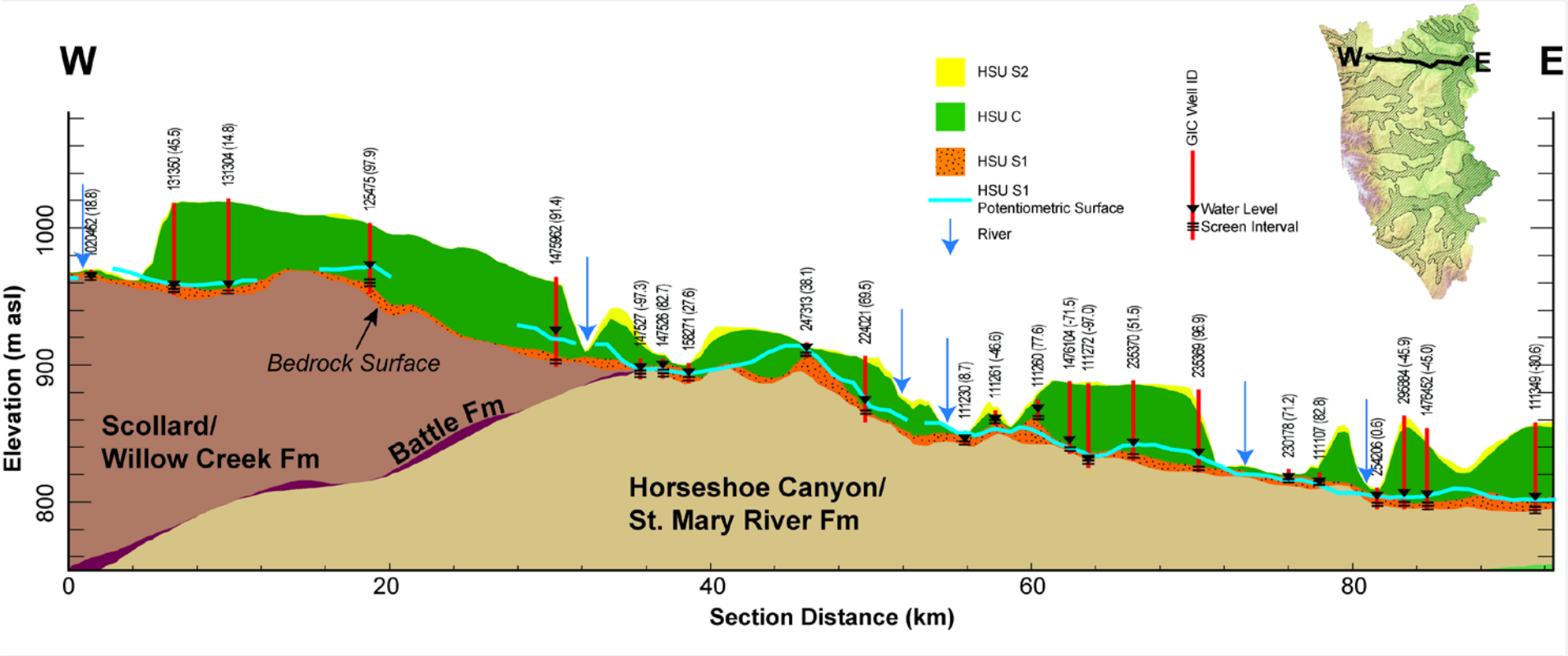
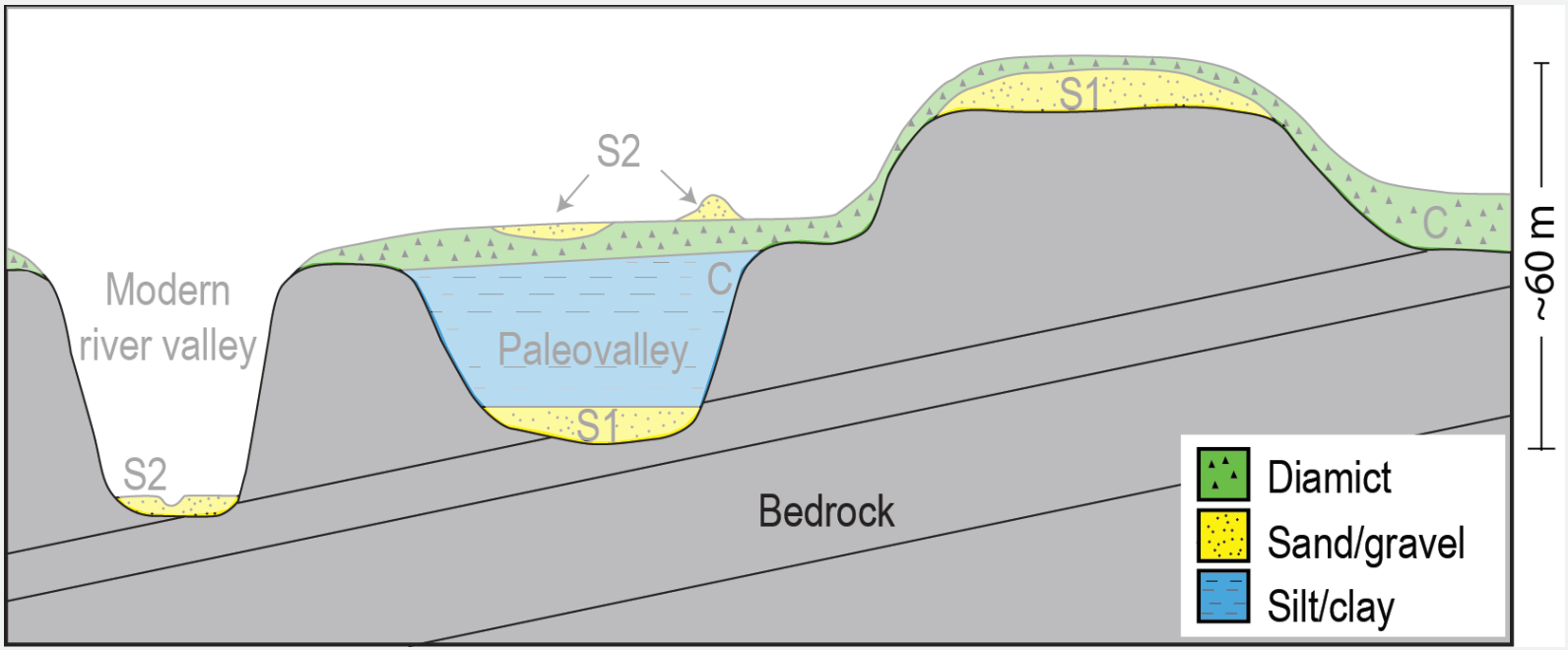
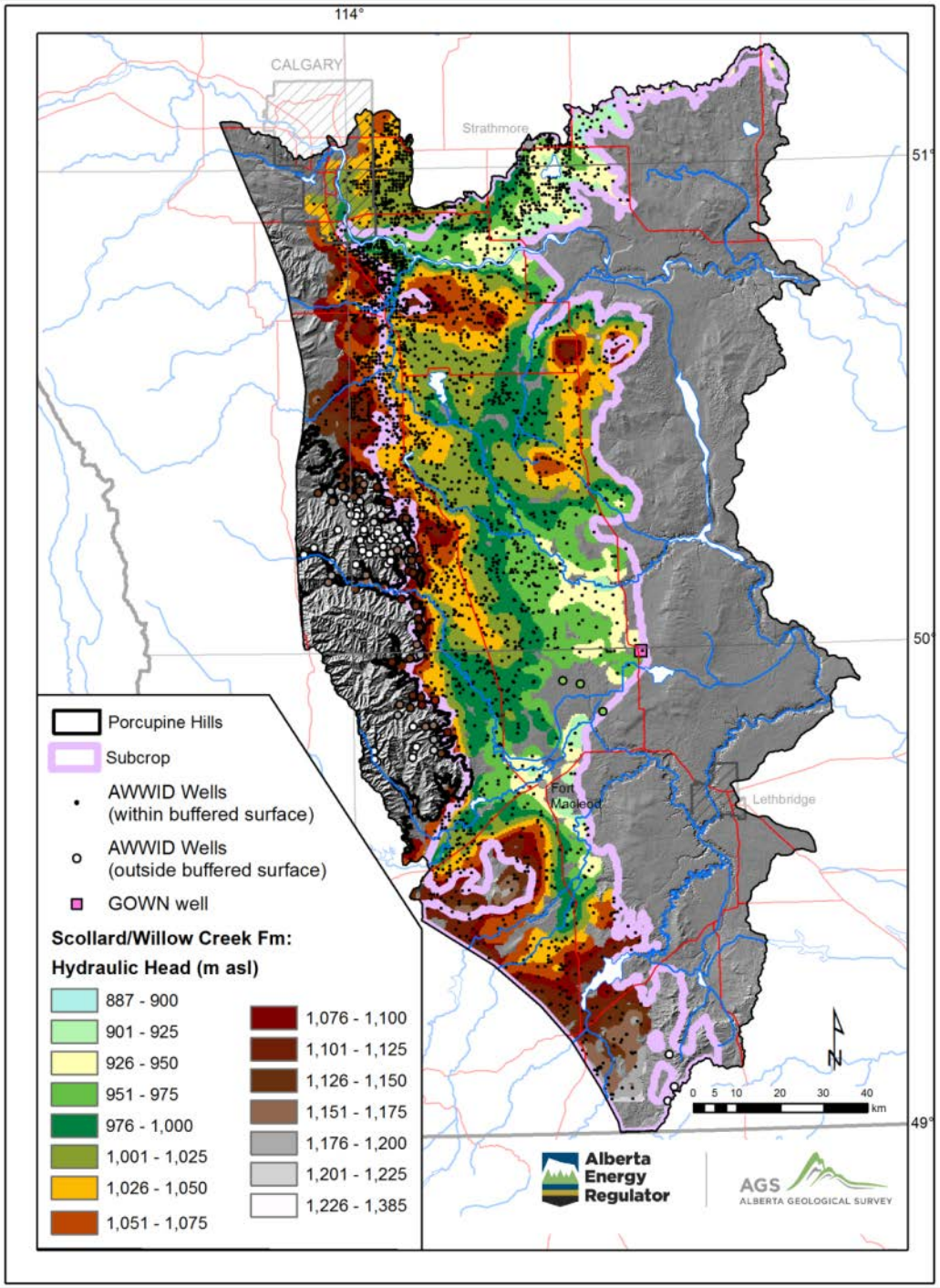
ALBERTA GEOLOGICAL SURVEY

S1 Cross Section



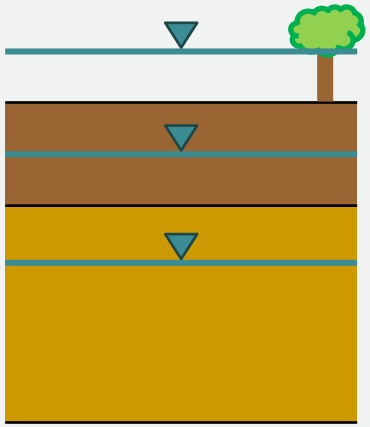
Bedrock Units

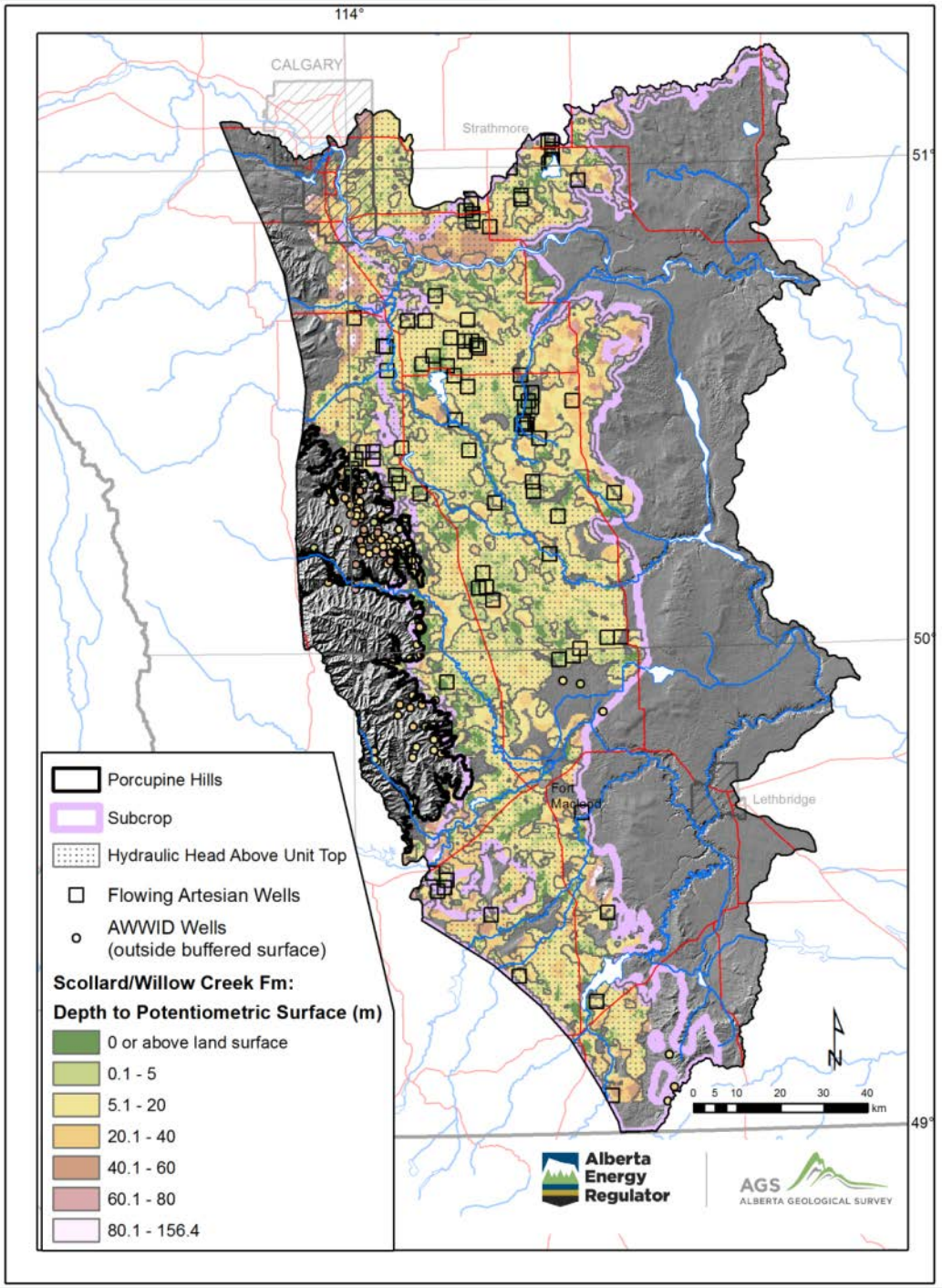



114°
CALGARY
Strathmore
51°
50°
49°
Fort Macleod
Lethbridge
Porcupine Hills
Subcrop
AWWID Wells (within buffered surface)
AWWID Wells (outside buffered surface)
GOWN well
Scollard/Willow Creek Fm:
Hydraulic Head (m asl)
887 - 900
901 - 925
926 - 950
951 - 975
976 - 1,000
1,001 - 1,025
1,026 - 1,050
1,051 - 1,075
1,076 - 1,100
1,101 - 1,125
1,126 - 1,150
1,151 - 1,175
1,176 - 1,200
1,201 - 1,225
1,226 - 1,385
0 5 10 20 30 40 km
N
Alberta Energy Regulator
AGS
ALBERTA GEOLOGICAL SURVEY

Unconsolidated

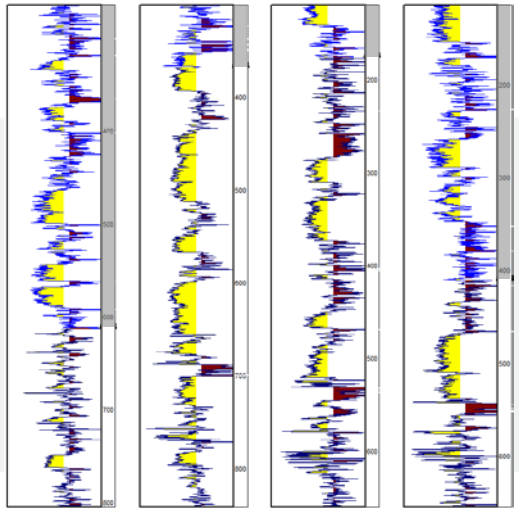
Scollard/
Willow Creek Fm

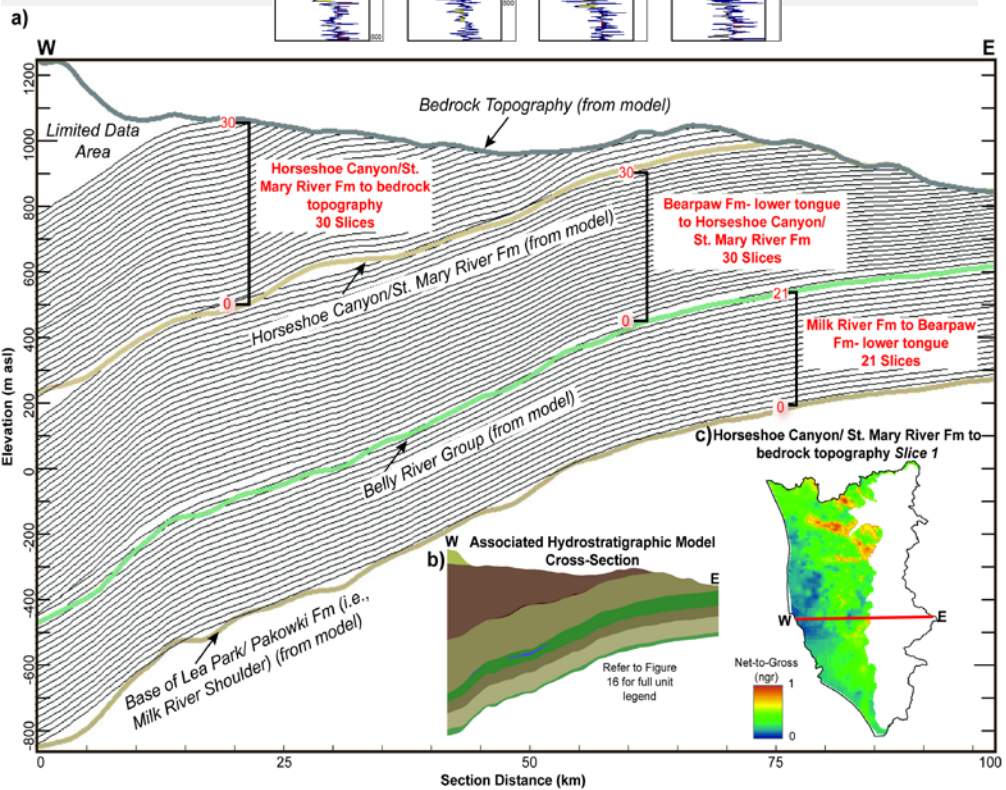


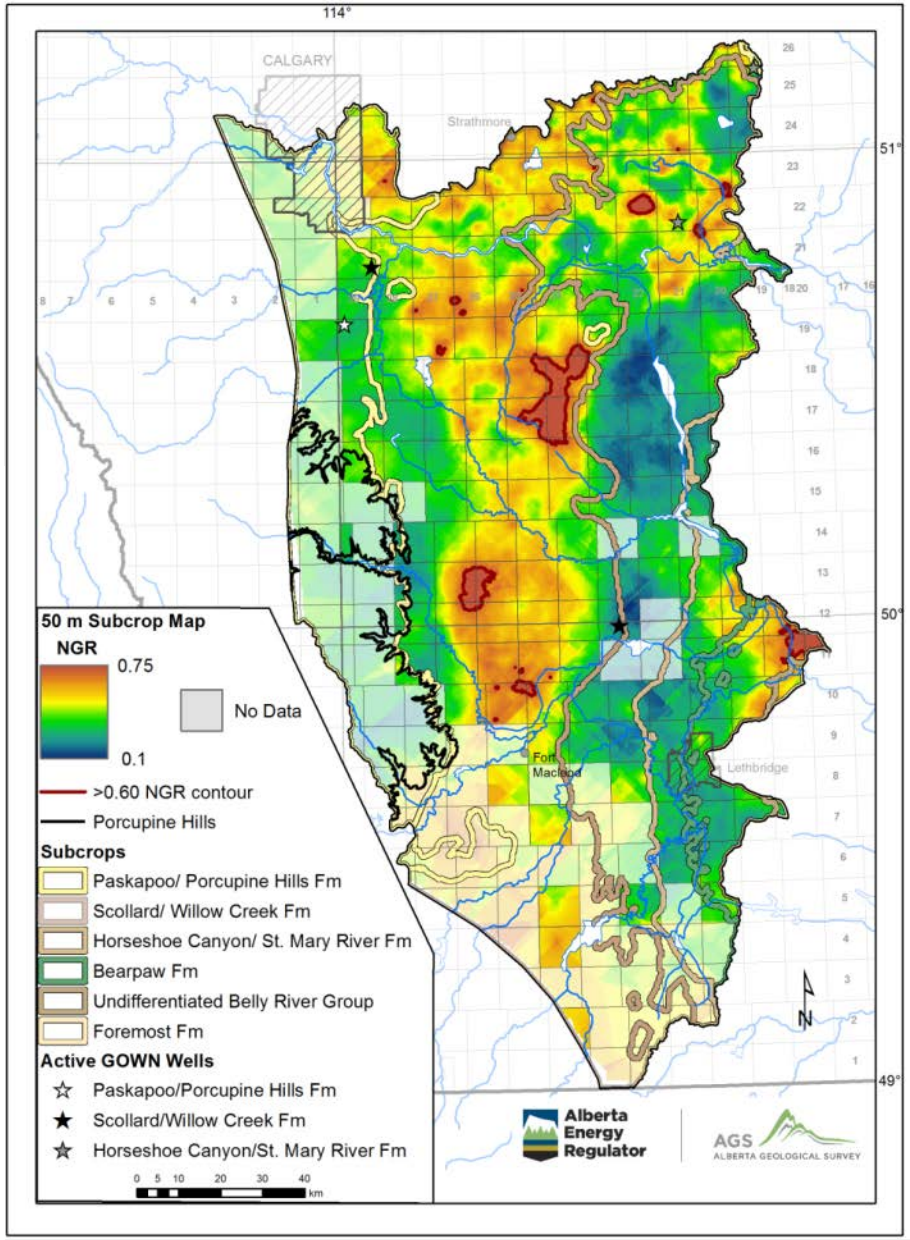


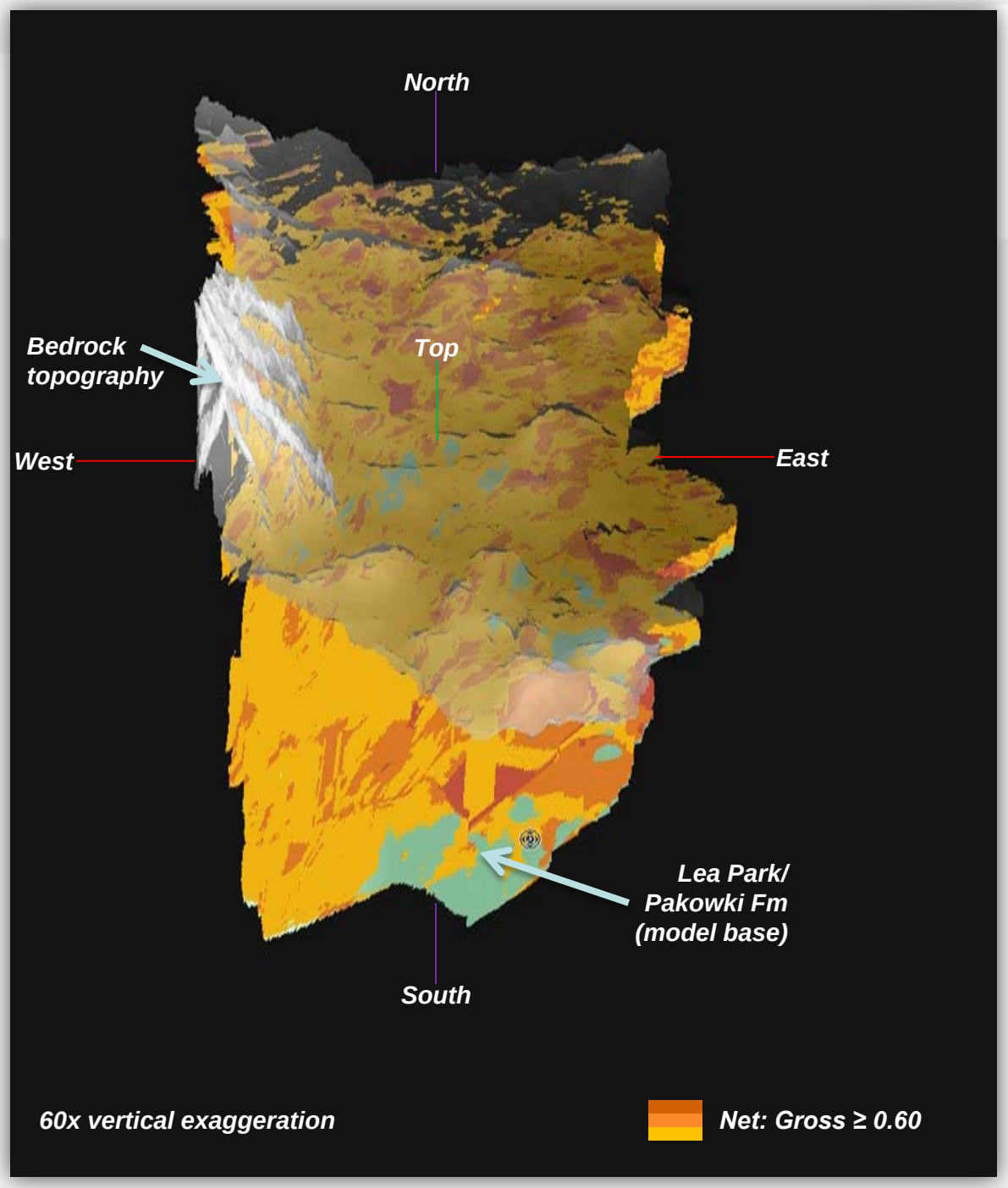
AGS

Distribution of Permeable Bedrock

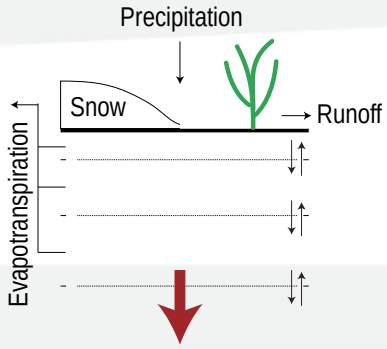


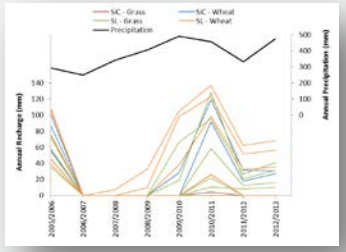


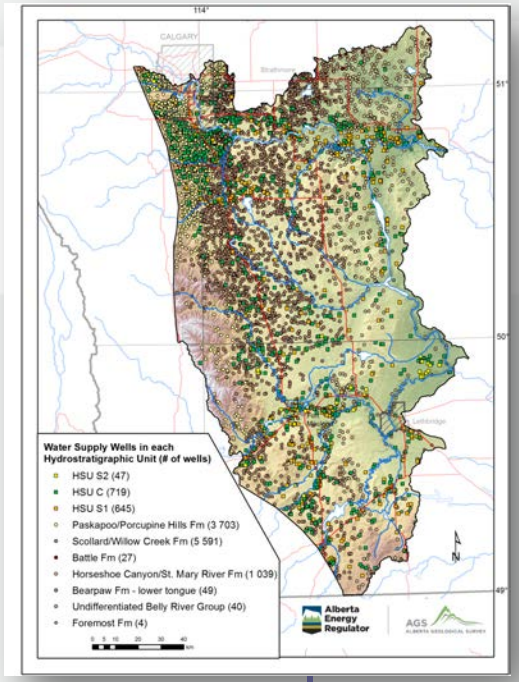


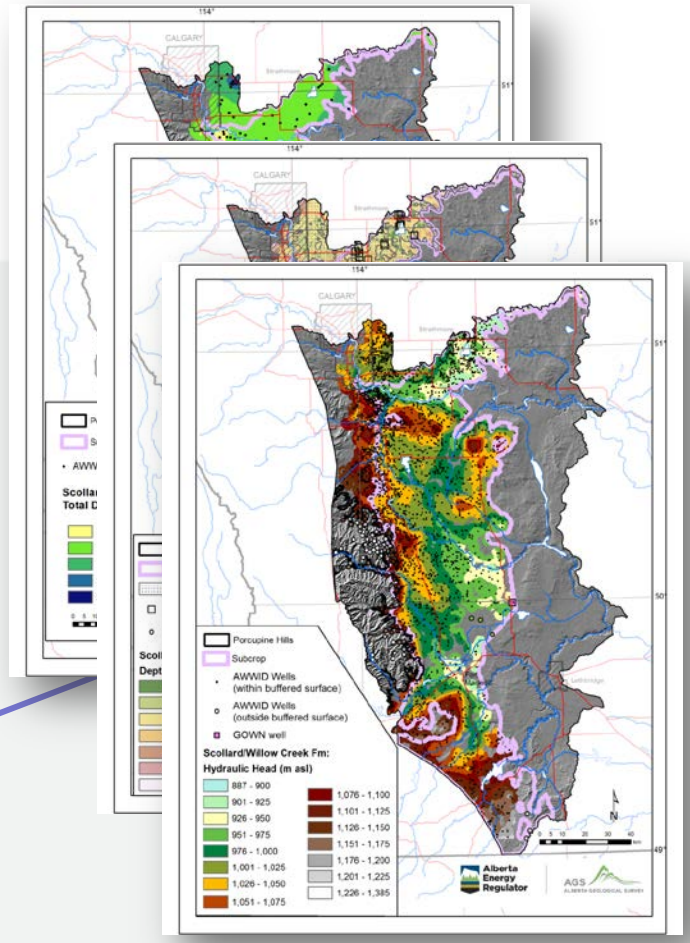


- Shallow depths (< 150 m): slice mapping complements existing water well data
- Deeper depths (>150 m): slice mapping provides info where data may be lacking

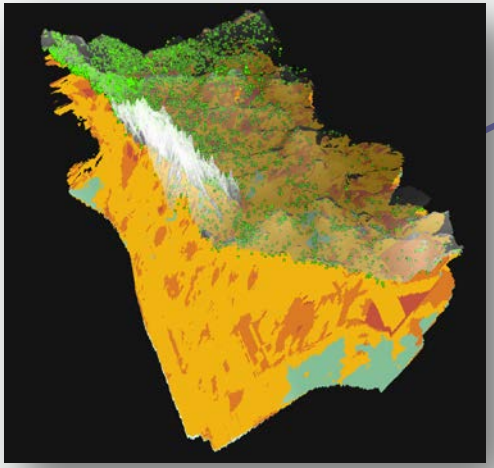


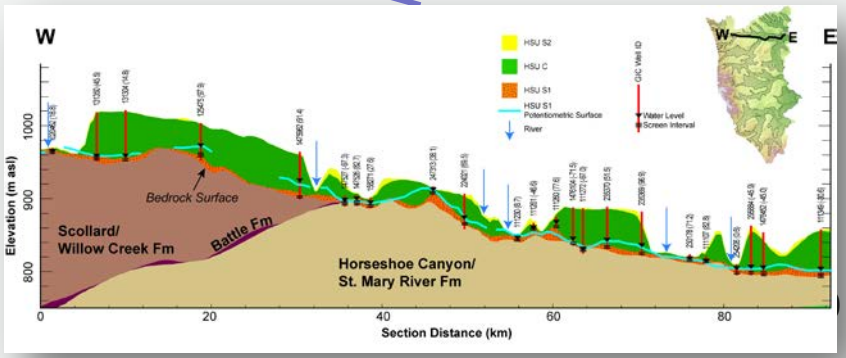






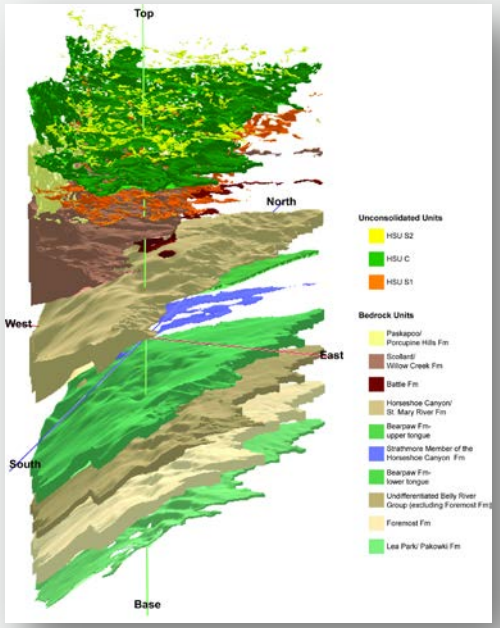
Hydrogeology

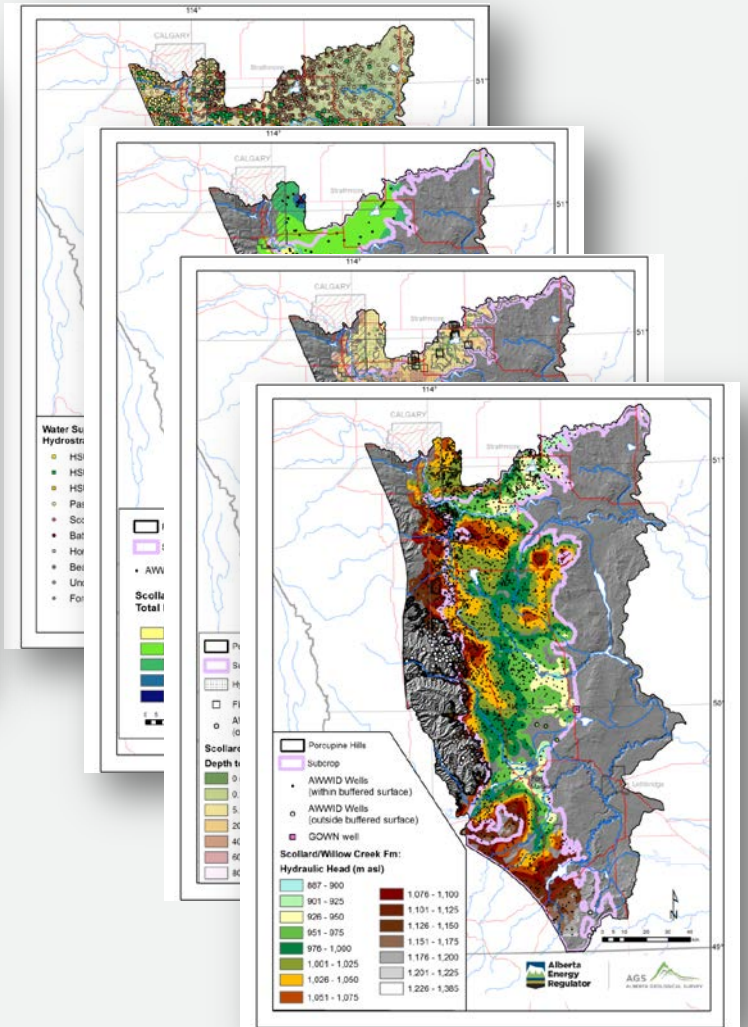


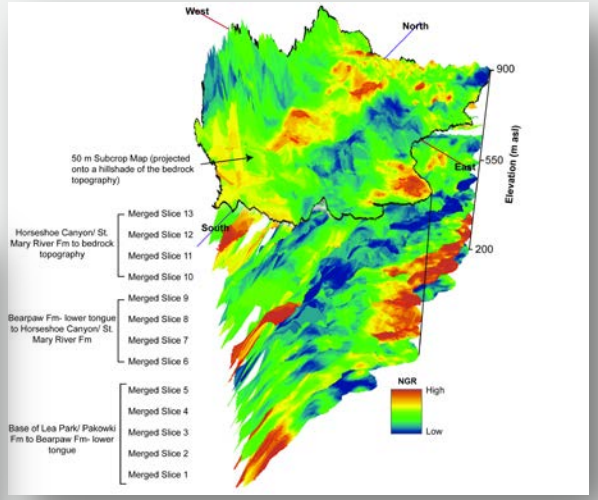


Summary

- Regional hydrostratigraphic characterization

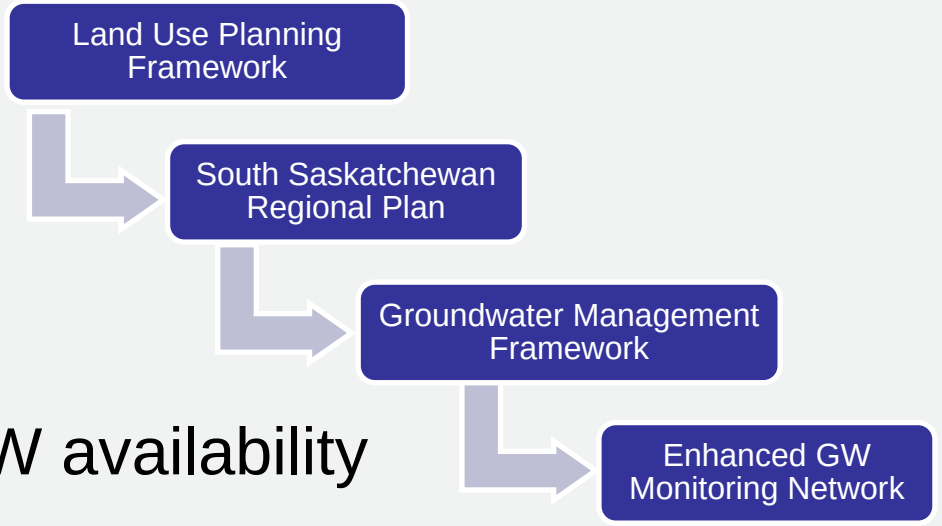






Summary

- Foundation for defining sub-regional aquifer units (& properties) and GW management units
- Helps focus:
  - Priority areas of interest
  - GW monitoring network
  - Robust assessment of GW availability
  - SW/GW interaction studies



Acknowledgements

- AGS -
  - G. Hartman
  - N. Nakevska
  - S. Mei
  - K. MacCormack
  - D. Palombi
  - P. Glombick (formerly at AGS)
  - D. Bechtel (formerly at AGS)
- Alberta Environment and Parks
- Alberta AgroClimatic Information Service
- UofC - Dr. Masaki Hayashi

Questions