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resources & energy

Development of a Numerical Model to Support Regional Cumulative Effects Groundwater Management within the NAOS Area

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EcoNomics

Overview

- Context
- Methodology
- Modelling Tool Development
  - Conceptualization
  - Numerical Model
- Continued Work

Context

- Alberta Government has committed to manage and protect water resources through the Water for Life Strategy

Goals

- Safe secure drinking water
- Healthy aquatic ecosystems
- Reliable quality supplies for a sustainable economy

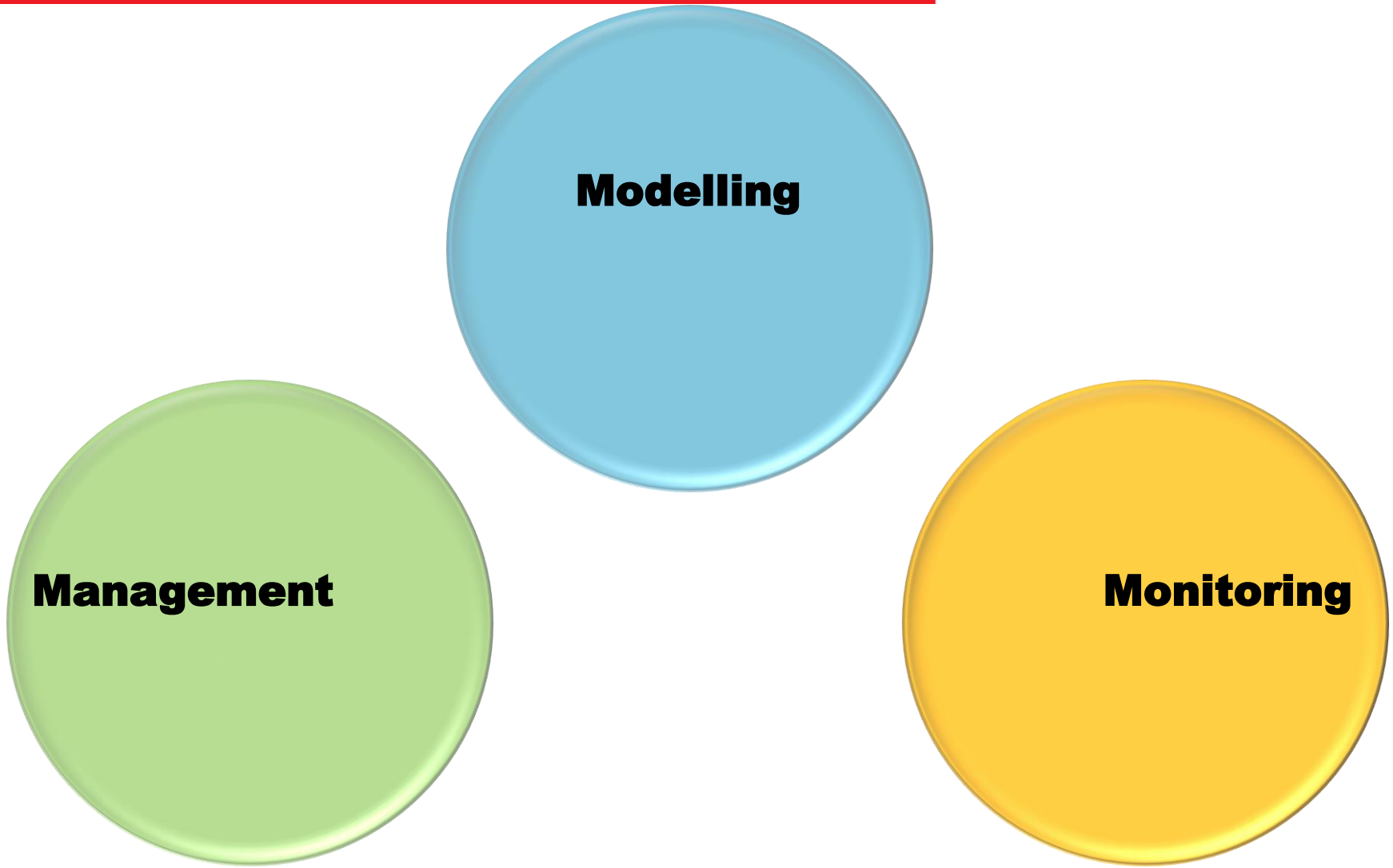
Key Directions

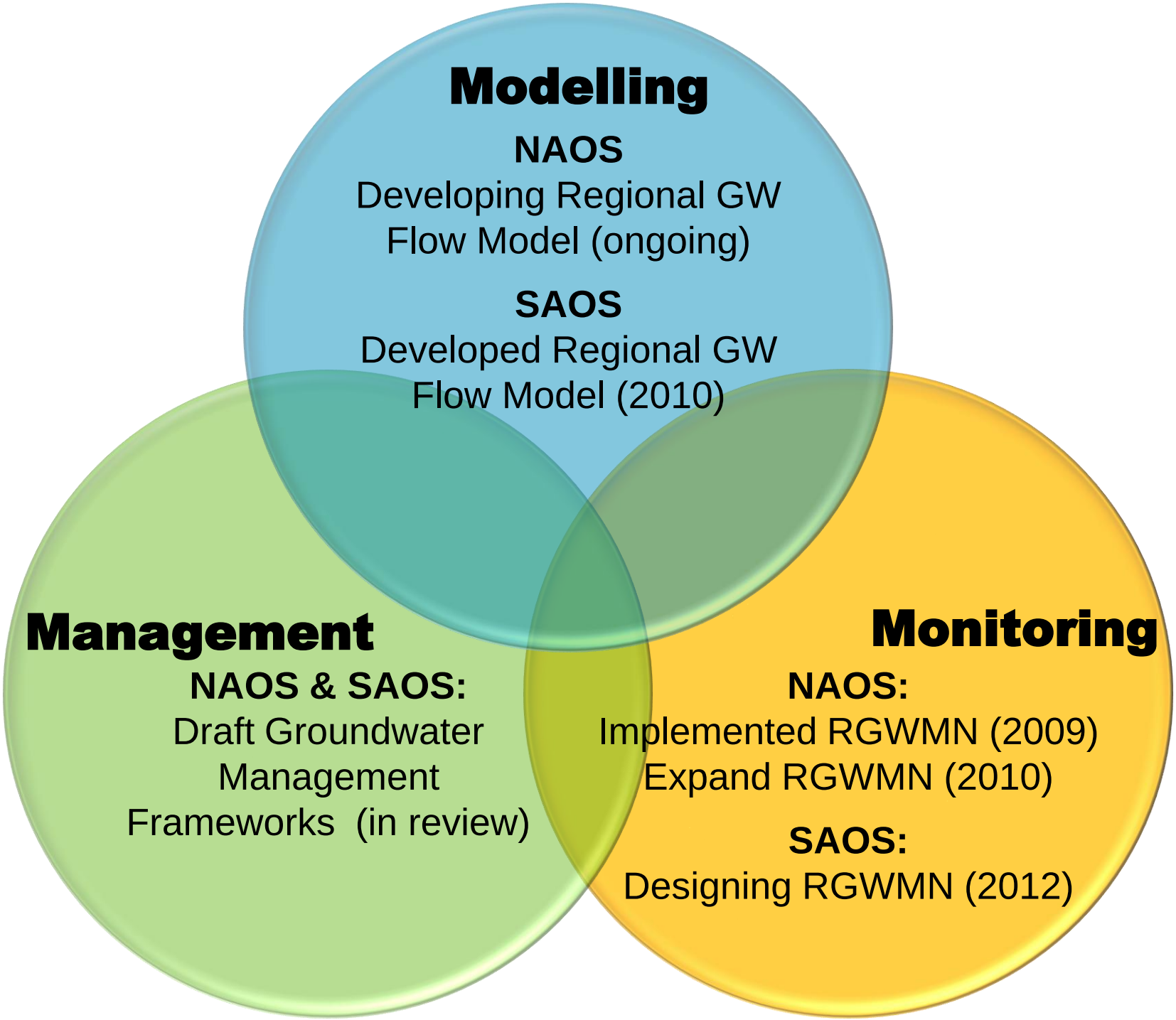
- Knowledge and Research
- Partnerships
- Conservation

Concern within AOS

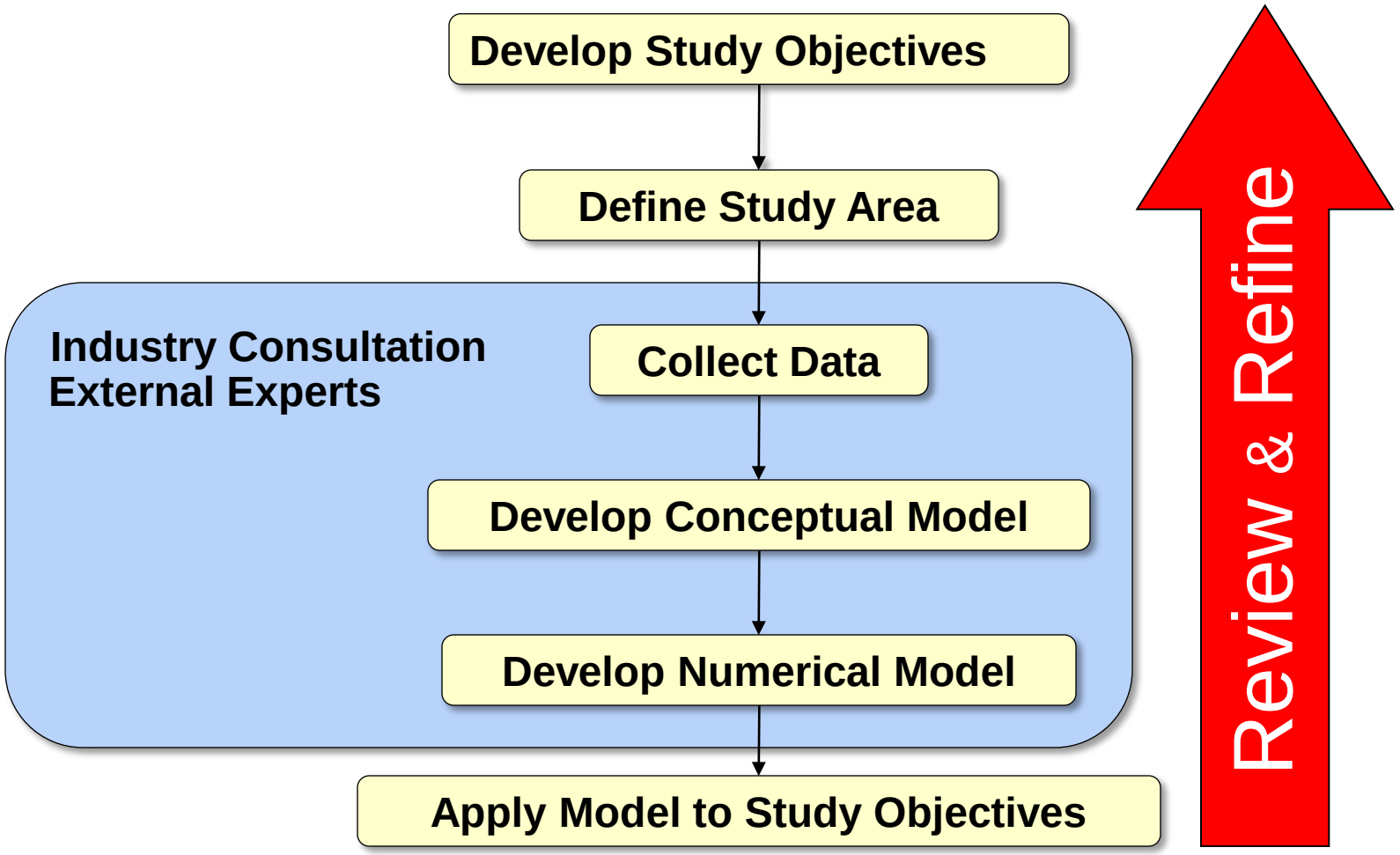
Potential cumulative impacts of historic, current, and future development on:

Develop & Integrate Tools



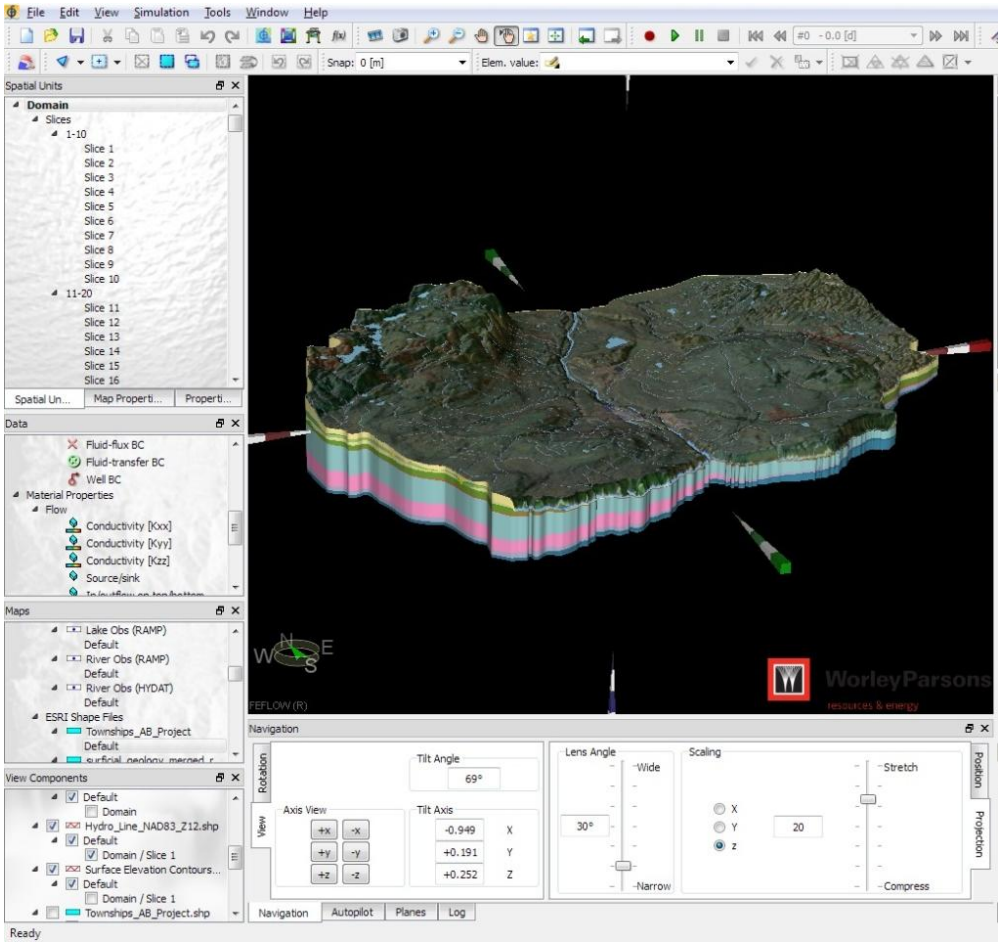

Modelling
NAOS
Developing Regional GW Flow Model (ongoing)
SAOS
Developed Regional GW Flow Model (2010)
Management
NAOS & SAOS:
Draft Groundwater Management Frameworks (in review)
Monitoring
NAOS:
Implemented RGWMN (2009)
Expand RGWMN (2010)
SAOS:
Designing RGWMN (2012)

Methodology



Cumulative Impact Assessment

- Develop numerical modelling tools
  - Quantify potential cumulative impacts from regional oil sands development
  - Support Groundwater Management Framework
  - Expand the NAOS RGWMN



Industry Participants

ATHABASCA OIL SANDS CORP.

cenovus ENERGY

Esso Imperial Oil

Syncrude Securing Canada's Energy Future

SUNCOR ENERGY

Husky Energy

TOTAL

DOVER Operating Corp.

Canadian Natural

External Experts

Alfonso Rivera

- Director of Geoscience for the Geological Survey of Canada
- Member of expert panel that reviewed the NAOS Groundwater Management Framework

René Therrien

- Chair, Department of Geology and Geological Engineering at Université Laval
- Member of the Royal Society of Canada Expert Panel

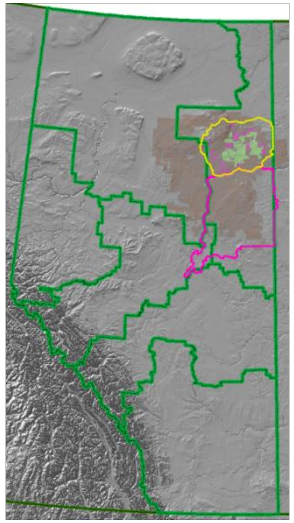
Study Area

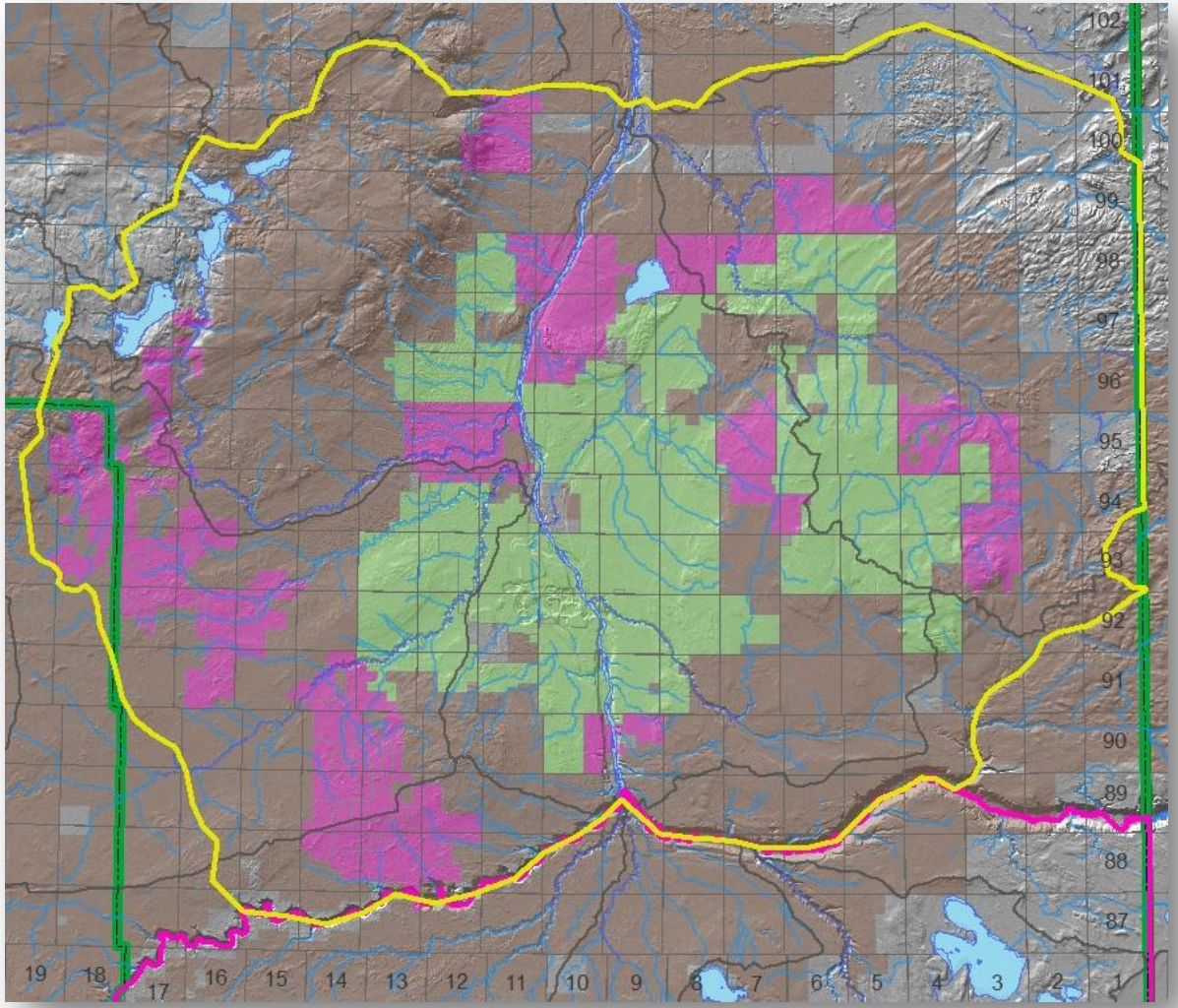
NOAS Model Domain
Groundwater Model Study Area
Land Use Planning Regions
Sub-Basins
Hydrology

Oil Sand Leases

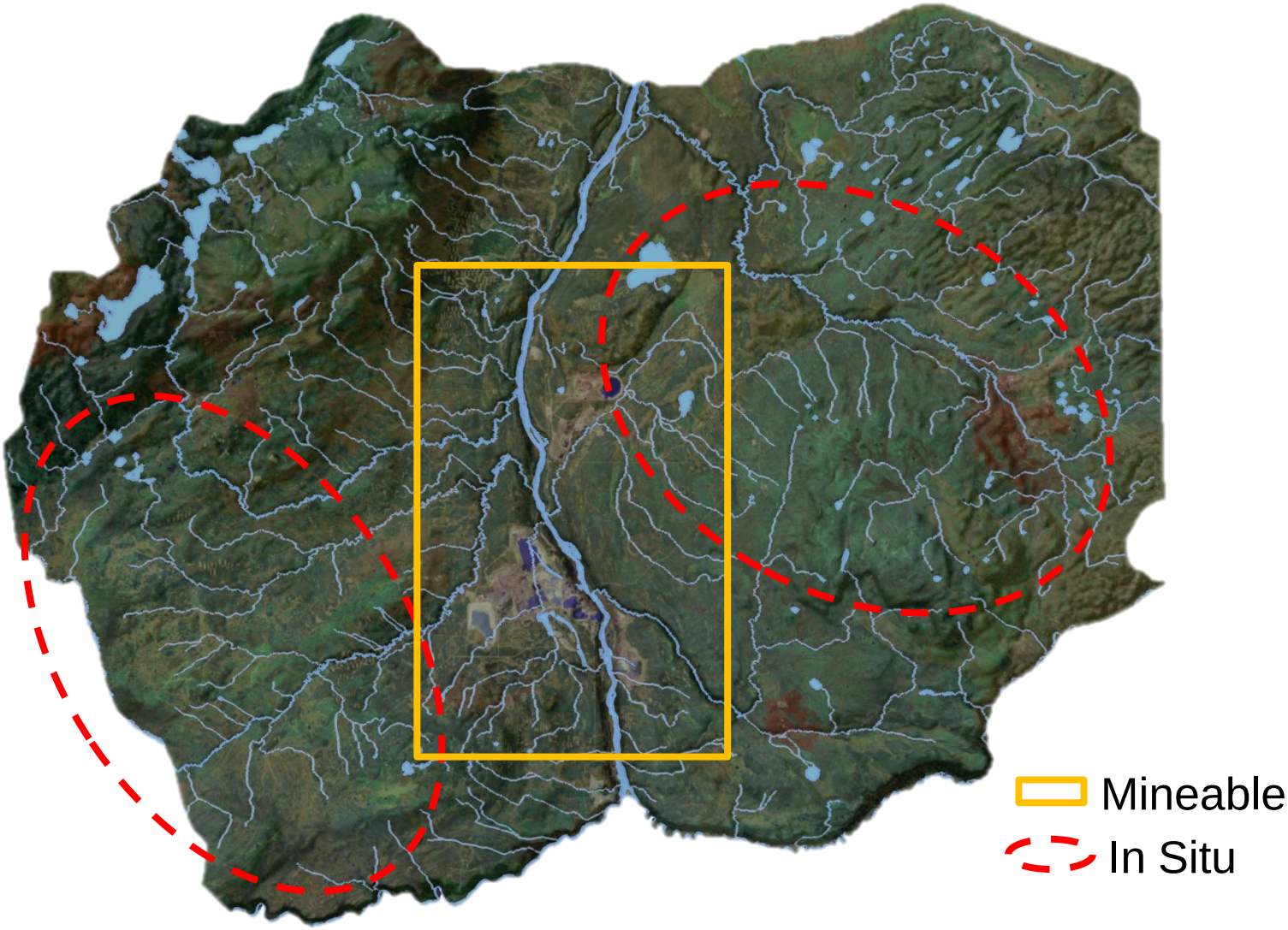
Status

No Activity
Producing
Proposed



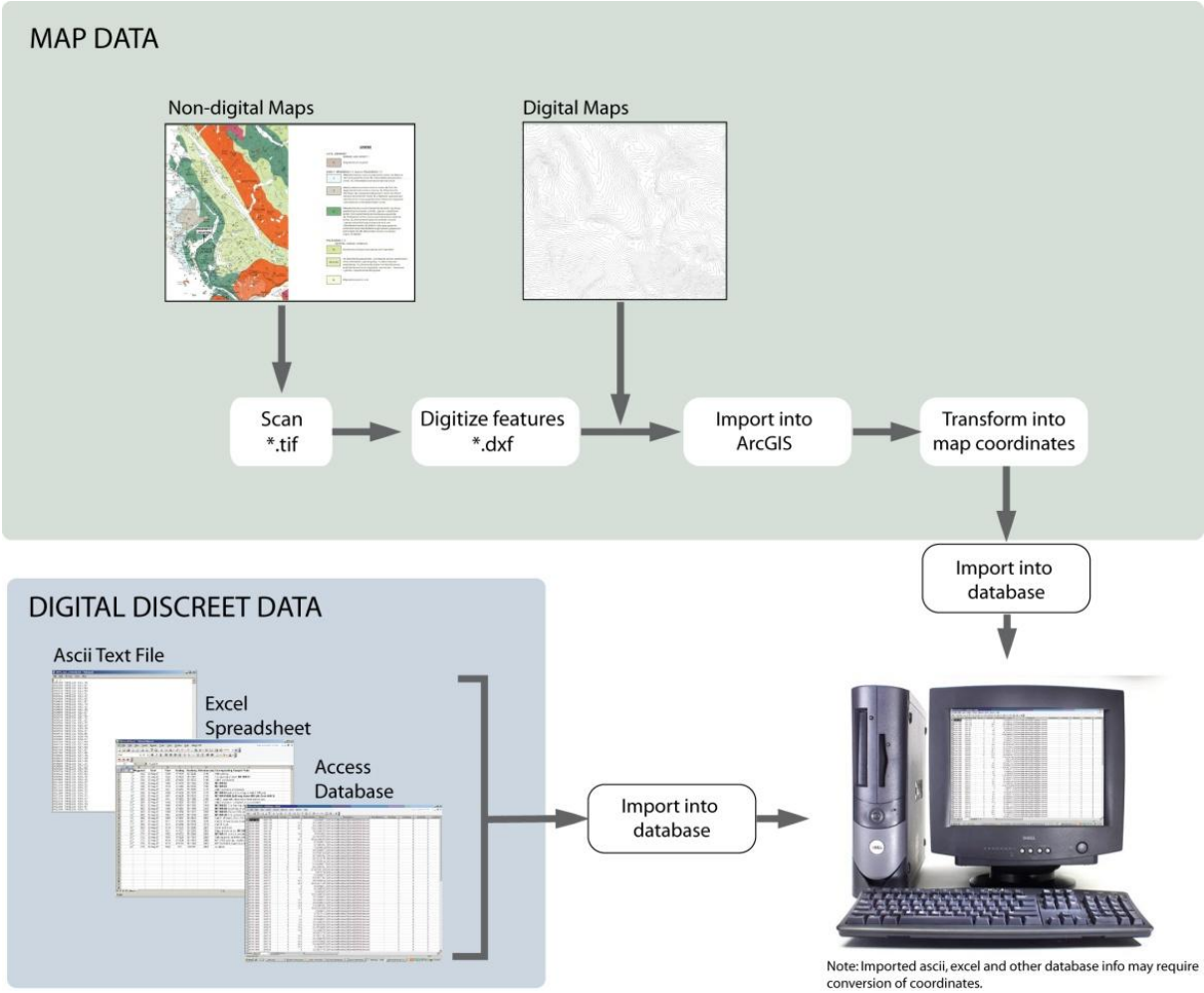


Study Area



Data Compilation

- Geology & Hydrogeology
- Hydrology & Meteorology
- Land Use
- Oil & Gas Production



Physiography

Groundwater Model Study Area

Hydrology

Province Boundary

Physiology Region

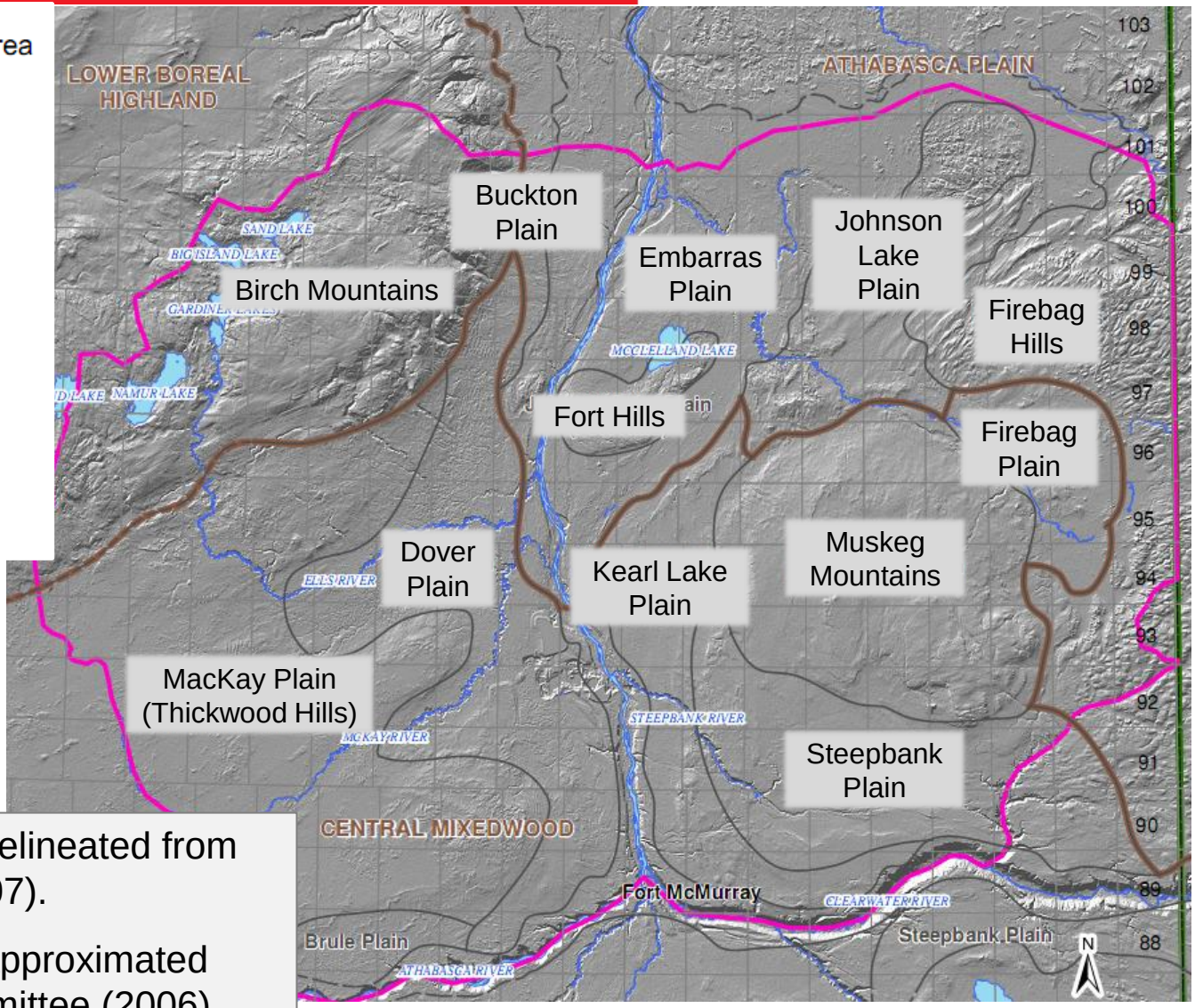
Based Upon Report

Extrapolated from Report

Boreal Forest SubRegions

Based Upon Report

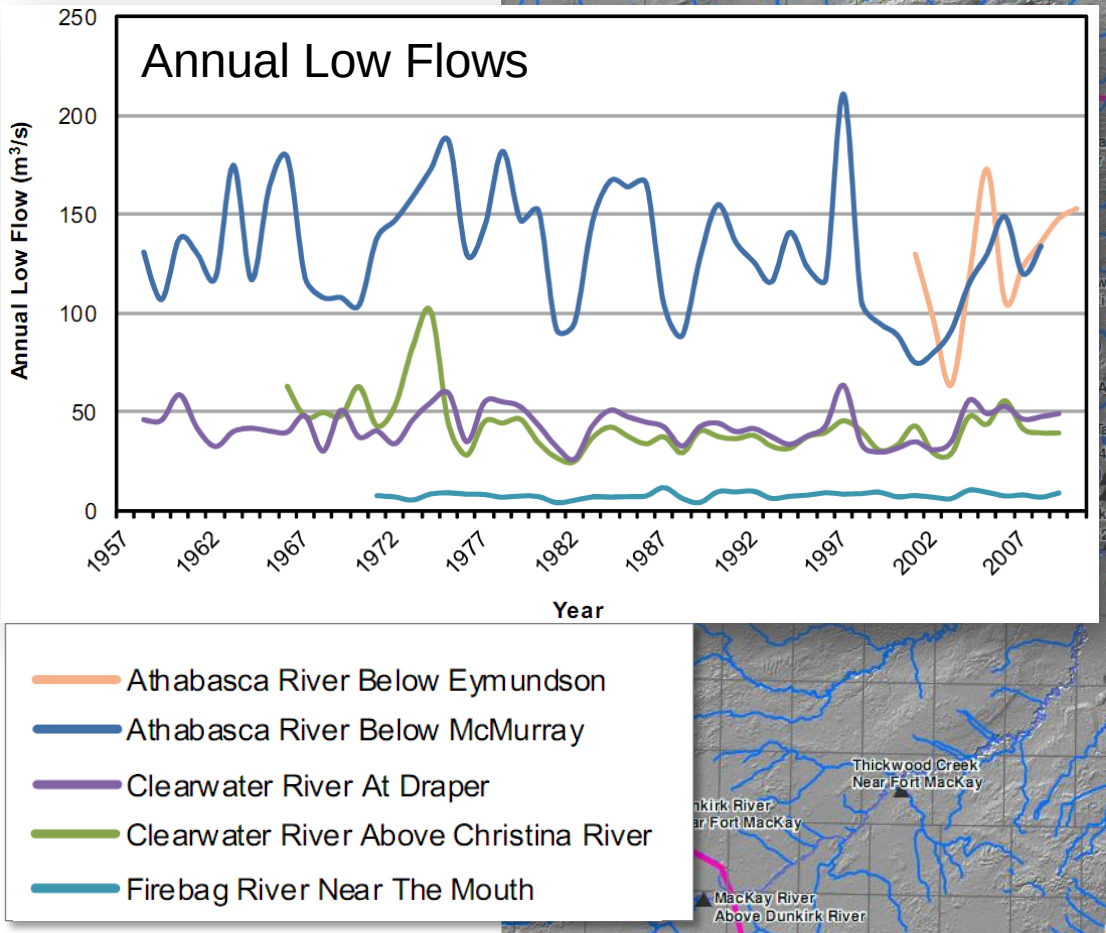
Extrapolated from Report

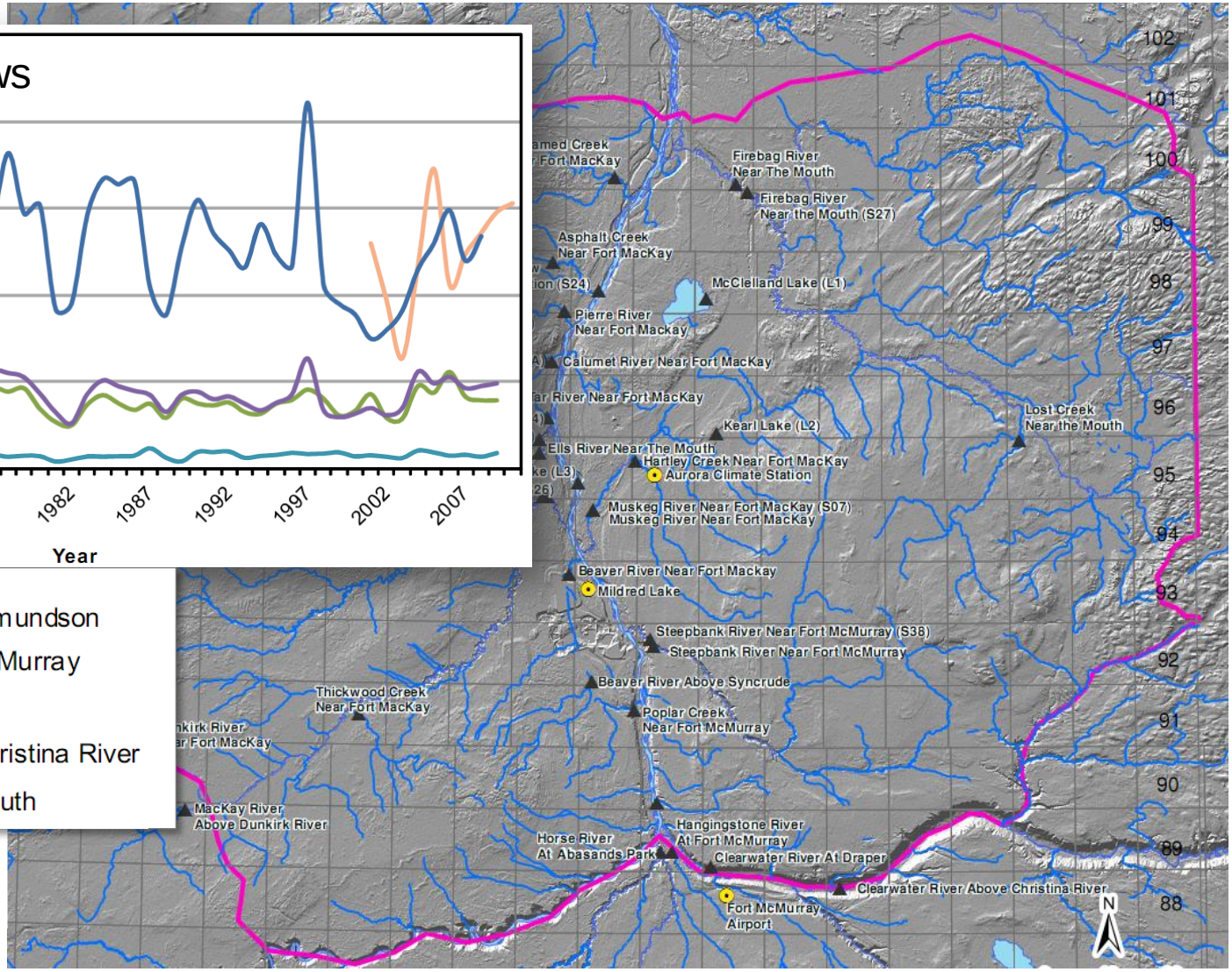


Physiography boundaries delineated from Andriashek & Atkinson (2007).

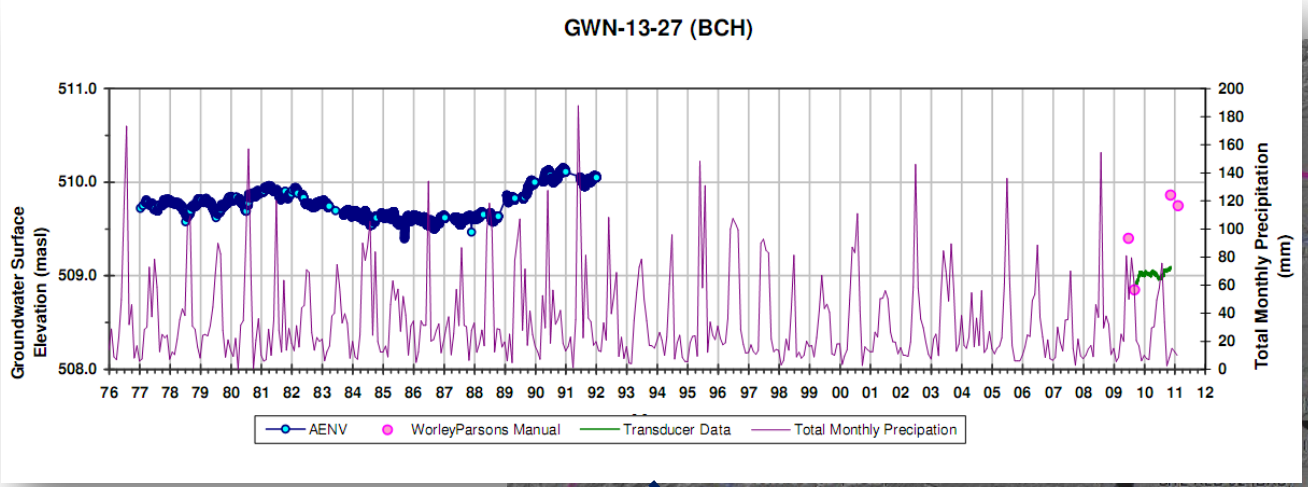
Boreal Forest Subregions approximated from Natural Regions Committee (2006).

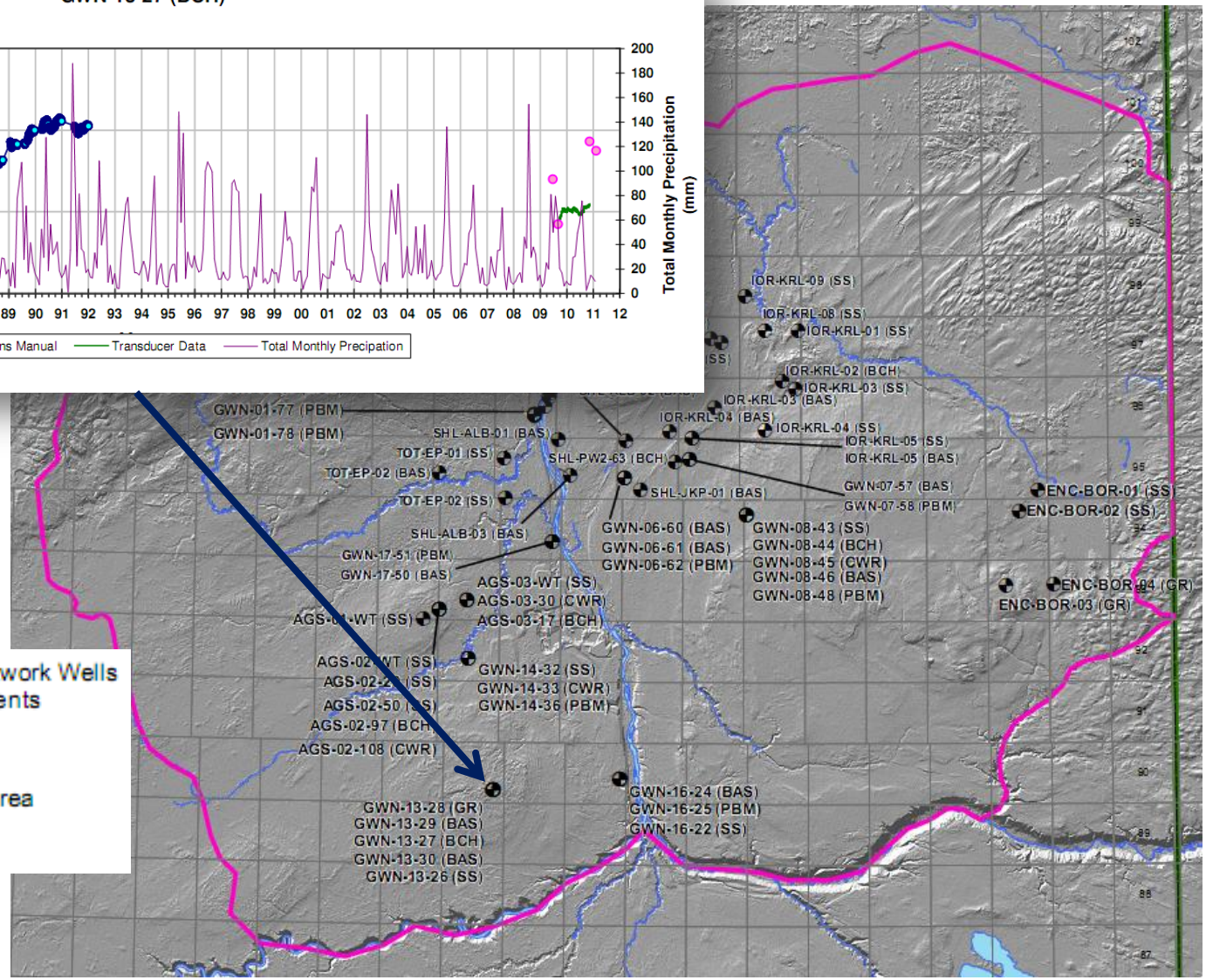
Hydrology


Annual Low Flows
Annual Low Flow (m³/s)
250
200
150
100
50
0
1957
1962
1967
1972
1977
1982
1987
1992
1997
2002
2007
Year
Athabasca River Below Eymundson
Athabasca River Below McMurray
Clearwater River At Draper
Clearwater River Above Christina River
Firebag River Near The Mouth

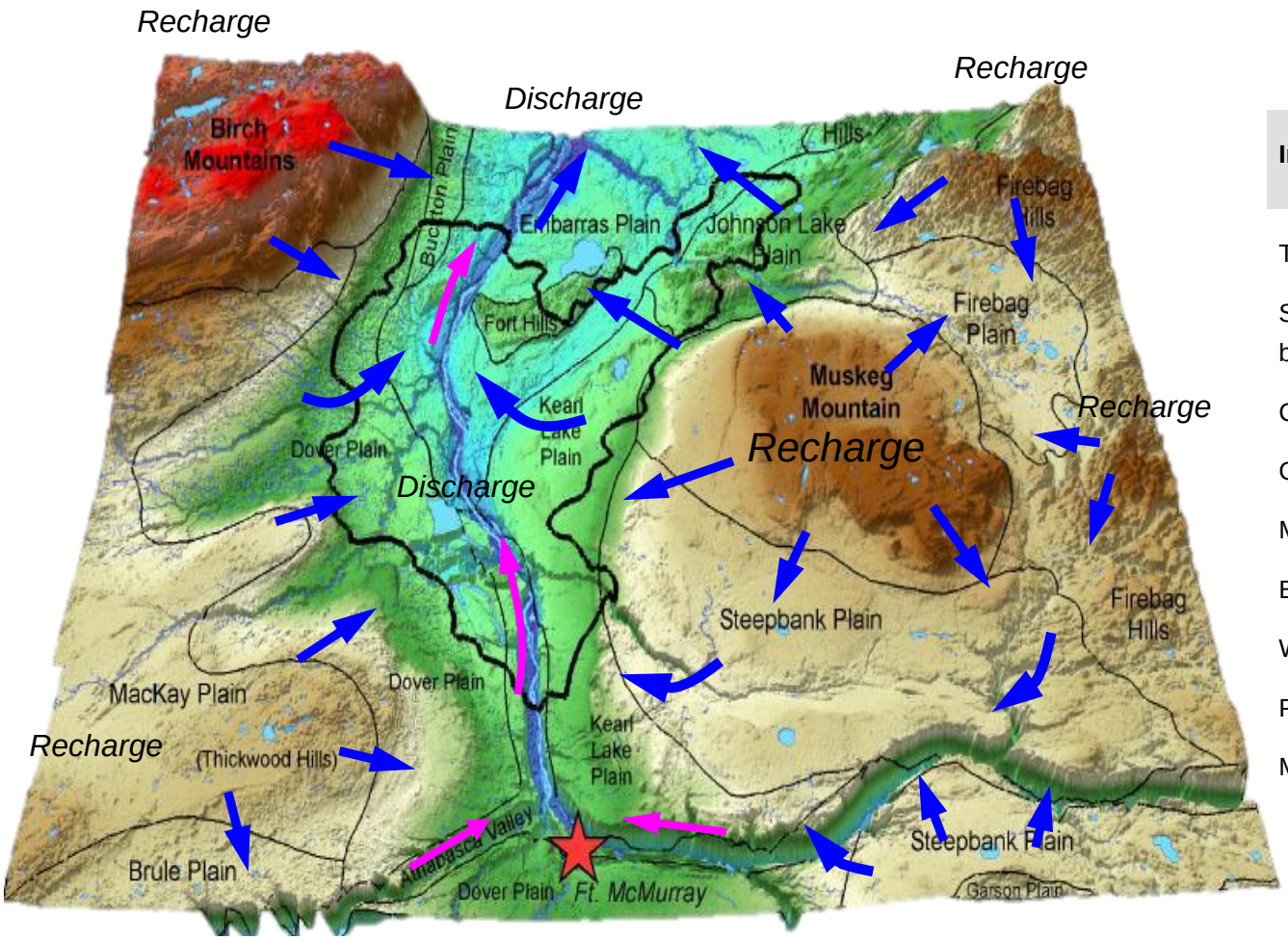

Firebag River Near The Mouth
Firebag River Near the Mouth (S27)
Asphalt Creek Near Fort MacKay
McClelland Lake (L1)
Pierre River Near Fort Mackay
Calumet River Near Fort MacKay
Kearl Lake (L2)
Lost Creek Near the Mouth
Ells River Near The Mouth
Hartley Creek Near Fort MacKay
Aurora Climate Station
Muskeg River Near Fort MacKay (S07)
Muskeg River Near Fort MacKay
Beaver River Near Fort Mackay
Mildred Lake
Steepbank River Near Fort McMurray (S38)
Steepbank River Near Fort McMurray
Beaver River Above Syncrude
Poplar Creek Near Fort McMurray
Thickwood Creek Near Fort MacKay
MacKay River Above Dunkirk River
Hangingstone River At Fort McMurray
Horse River At Abasands Park
Clearwater River At Draper
Clearwater River Above Christina River
Fort McMurray Airport
N

Hydrogeology





System Dynamics



Interval	Groundwater flow velocity (m/y)
Till	<1
Surficial sands and buried channels	<1 to 140
Clearwater	<1 to 7
Grand Rapids	13
McMurray oilsands	<1 to 2
Basal McMurray	<1 to 35
Waterways	<1
Prairie Evaporite	--
Methy	<1 to 3

Modified from Andriashek & Atkinson 2007

Hydrostratigraphy

Period	Group	Formation	Hydrostratigraphy	
Quaternary		Surficial Deposits	Undifferentiated Overburden	
		Sands		Sand Aquifer 1
		Tills		Till Aquitard 1
		Sands		Sand Aquifer 2
		Tills		Till Aquitard 2
		Coarse Fluvial Sediments	Bedrock Channel Aquifer	
Cretaceous	Colorado	La Biche	Colorado Aquitard	
		Viking (Pelican)		
		Joli Fou		
	Upper Mannville	Grand Rapids	Upper Grand Rapids 1 Aquifer	
			Upper Grand Rapids 2 Aquifer	
			Lower Grand Rapids 1 Aquifer	
			Lower Grand Rapids 2 Aquifer	

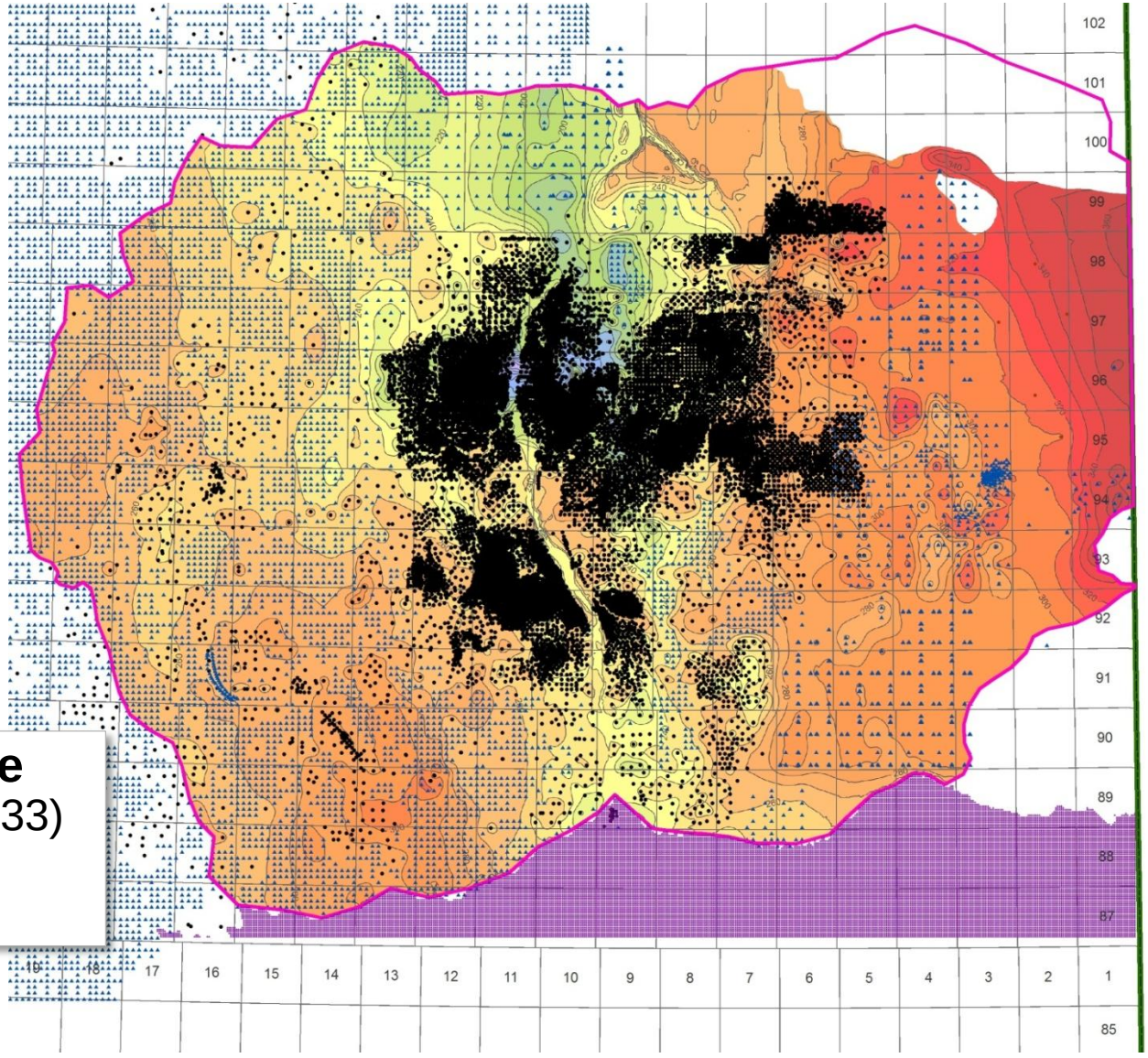
Continued

Hydrostratigraphy (continued)

Period	Group	Formation		Hydrostratigraphy
Cretaceous	Mannville	Clearwater		Clearwater Aquitard
		McMurray	Upper	
			Middle (Top Water)	Middle McMurray Top Water Aquifer
			Middle (Bitumen)	McMurray Aquitard
			Lower (Bitumen)	
			Lower (Basal Sand)	McMurray Basal Sand Aquifer
Sub-Cretaceous Unconformity				
Devonian	Beaverhill Lake	Waterways		Beaverhill Lake-Cooking Lake Aquifer/Aquitard
		Slave Point		
		Fort Vermillion		
	Elk Point	Watt Mountain		
		Muskeg		Prairie Aquitard/Aquiclude
		Keg River		Keg River Aquifer
		Contact Rapids		Contact Rapids Aquitard
		Basal Red Beds/La Loche		Basal Aquifer

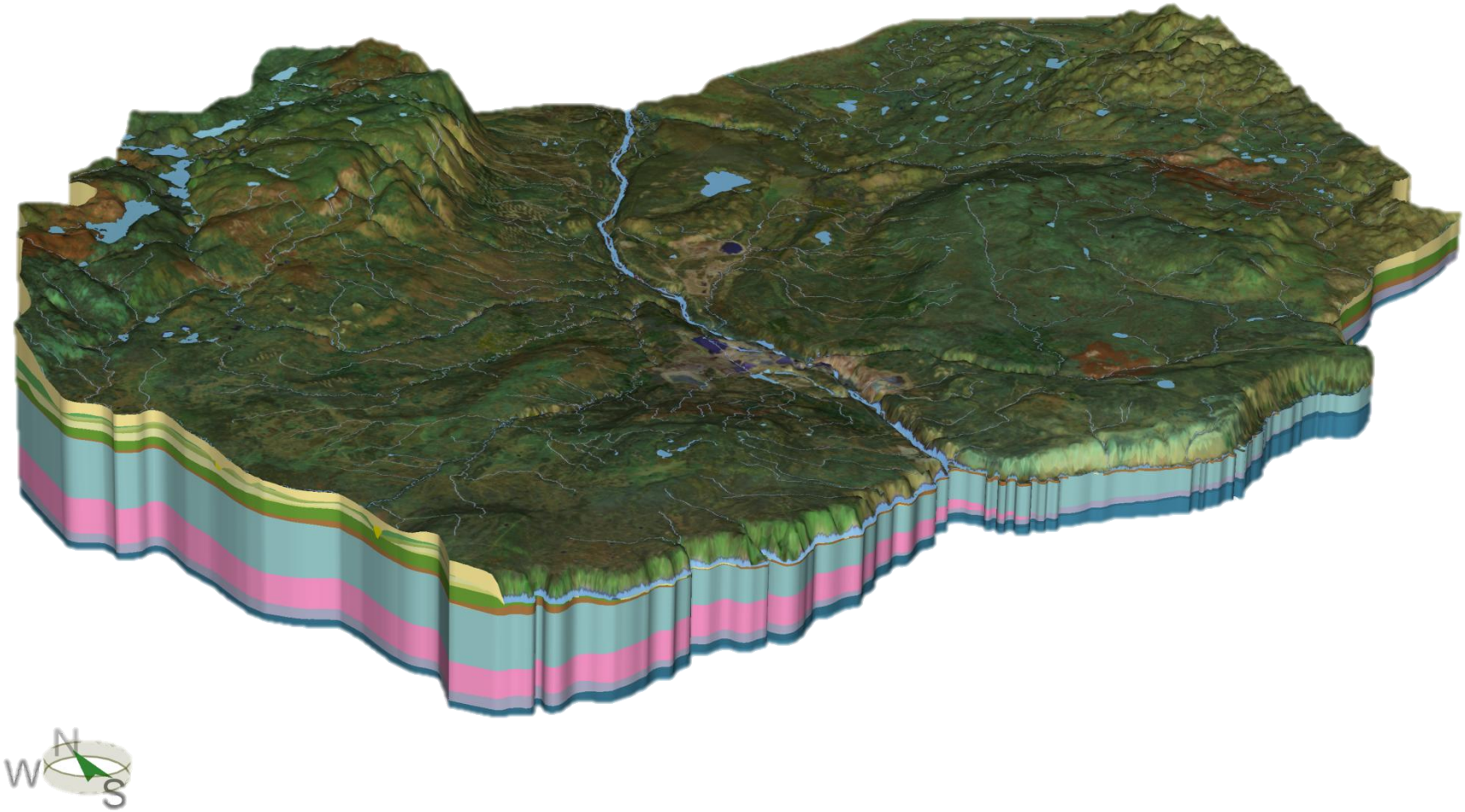
Surface & Isopach Development

- Data compiled in relational databases
- Developed database tools to QA/QC data
- Linked databases to visualization software



Devonian Surface
Operator Tops (50,433)
Grid Data (10,485)
Control Points (5)

Conceptualization



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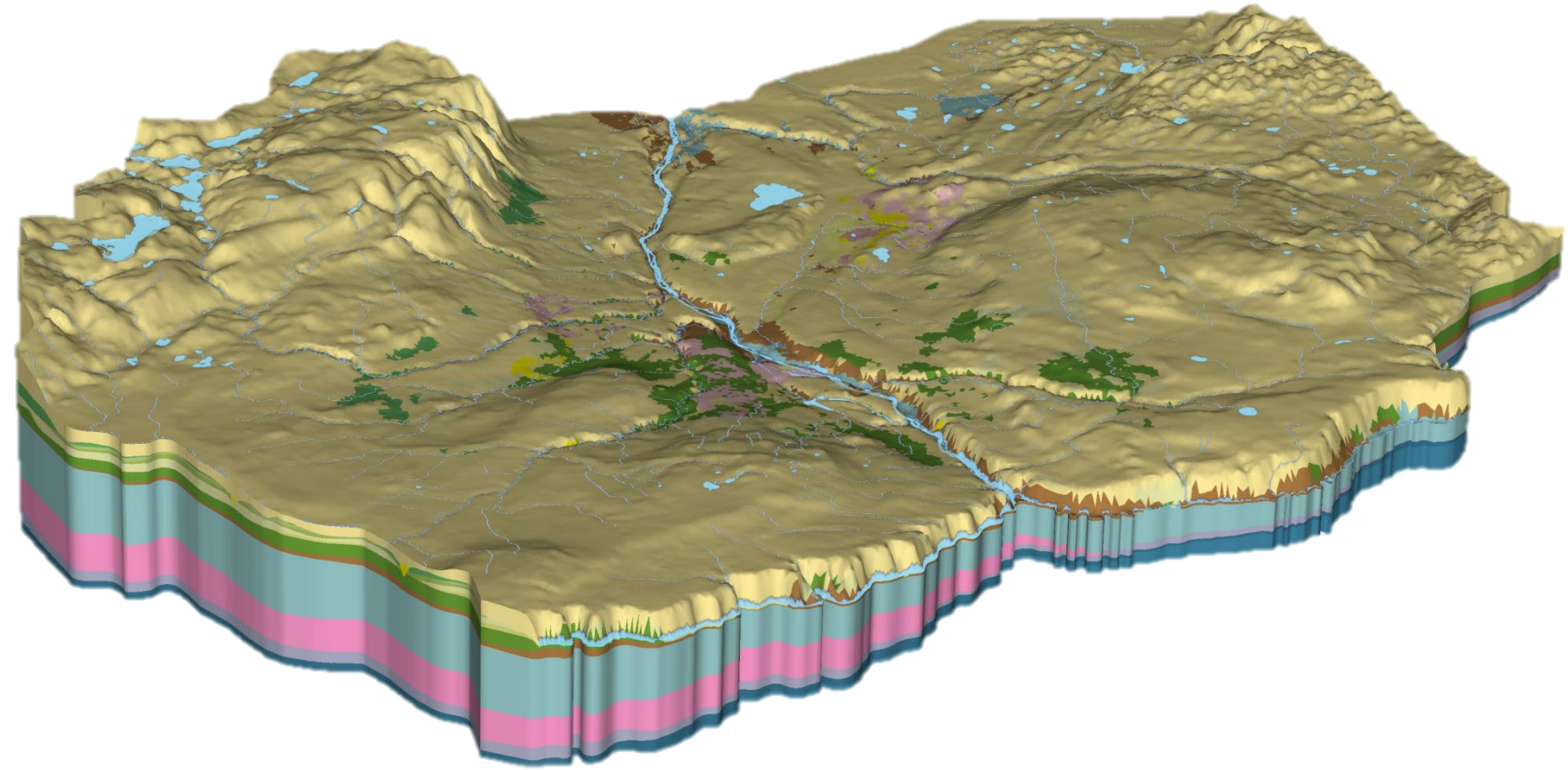
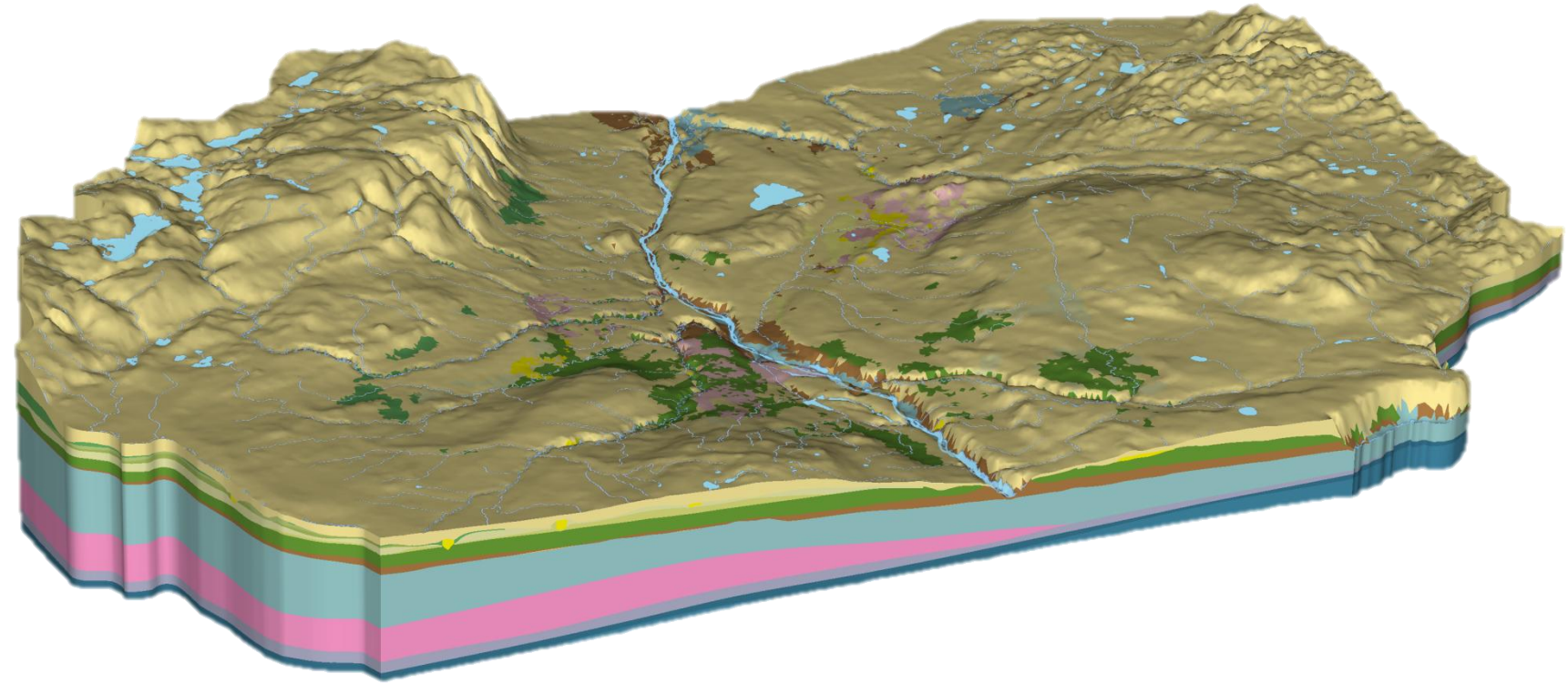


- UNDIFFERENTIATED OVERBURDEN AQUIFER/AQUITARD
- SAND AQUIFER 1
- TILL AQUITARD 1
- SAND AQUIFER 2
- TILL AQUITARD 2
- BEDROCK CHANNEL AQUIFER
- COLORADO AQUITARD SYSTEM
- UPPER GRAND RAPIDS 1 AQUIFER
- UPPER GRAND RAPIDS 2 AQUIFER
- LOWER GRAND RAPIDS 1 AQUIFER
- LOWER GRAND RAPIDS 2 AQUIFER
- CLEARWATER AQUITARD
- TOP WATER AQUIFER
- MCMURRAY AQUITARD
- MCMURRARY BASAL SAND AQUIFER
- BEAVERHILL LAKE-COOKING LAKE AQUIFER/AQUITARD
- PRAIRIE AQUITARD/AQUICLUDE
- KEG RIVER AQUIFER
- CONTACT RAPIDS AQUITARD
- BASAL AQUIFER

Conceptualization



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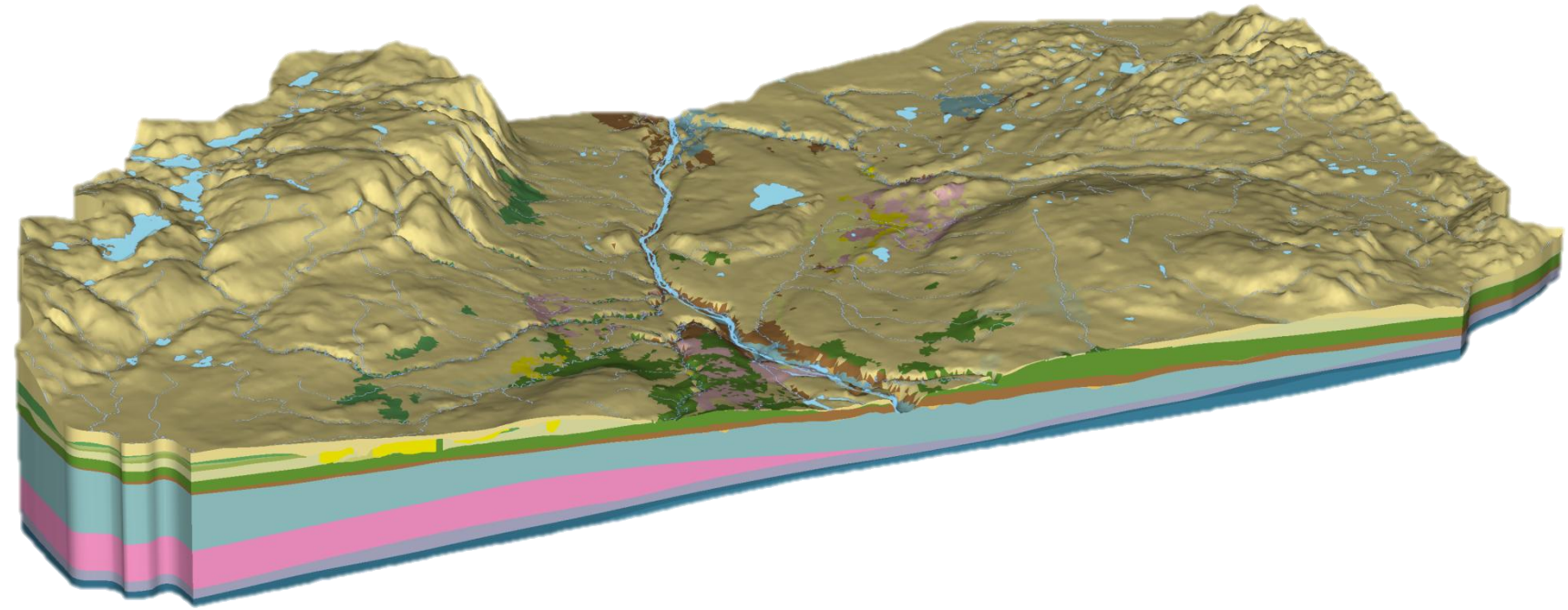

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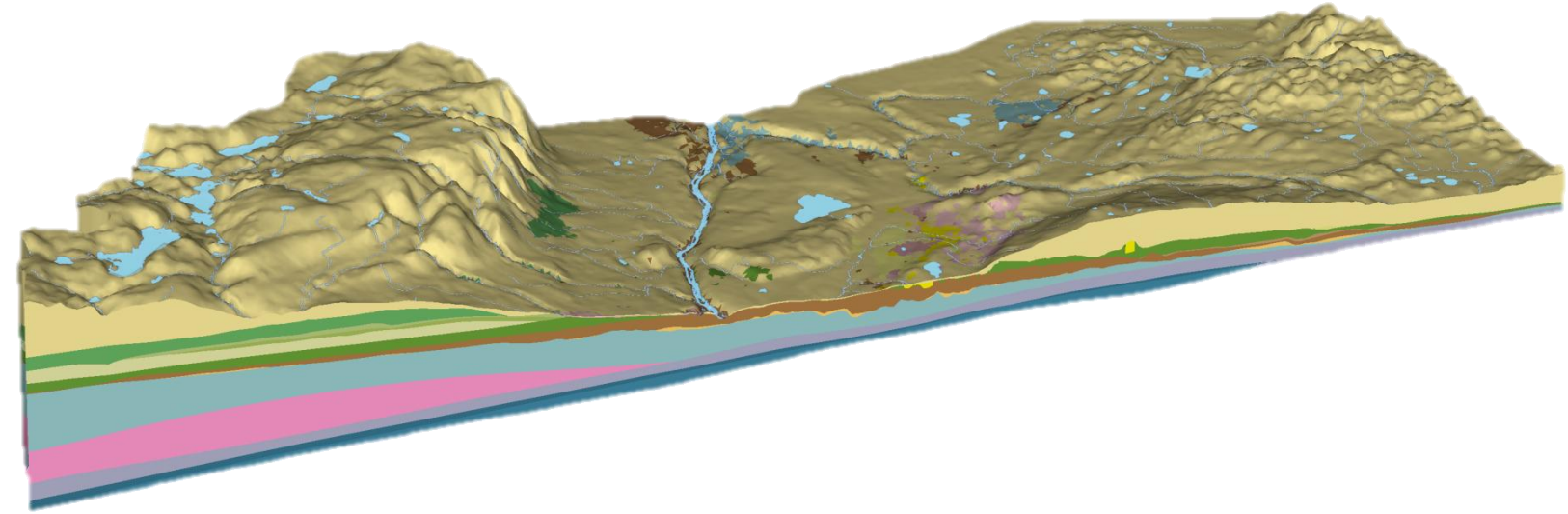

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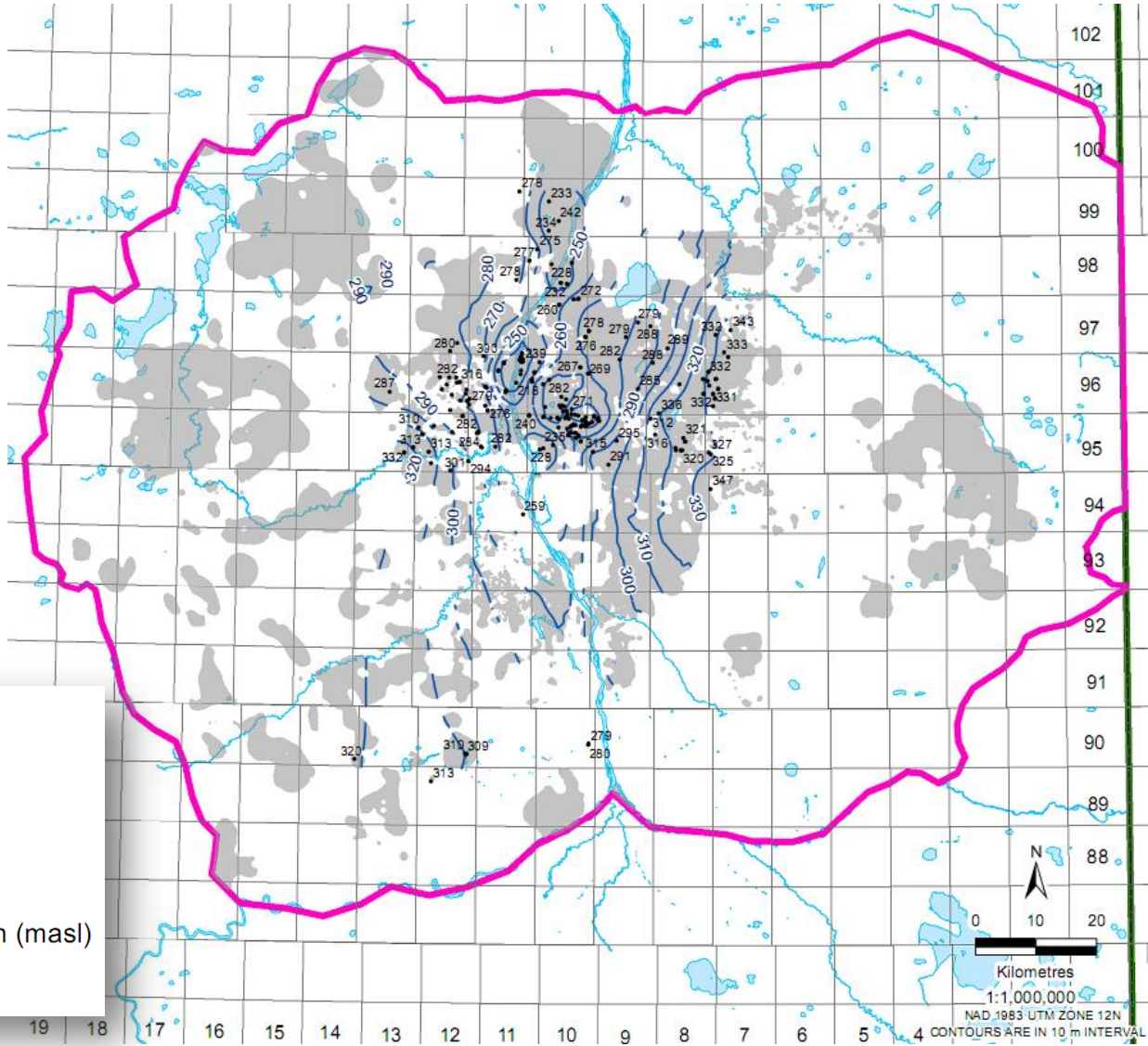
Calibration Data

- 1,019 Unique Wells
- 853,266 Water levels
- Date range: 1974 to 2011
- Includes NAOS RGWMN Data

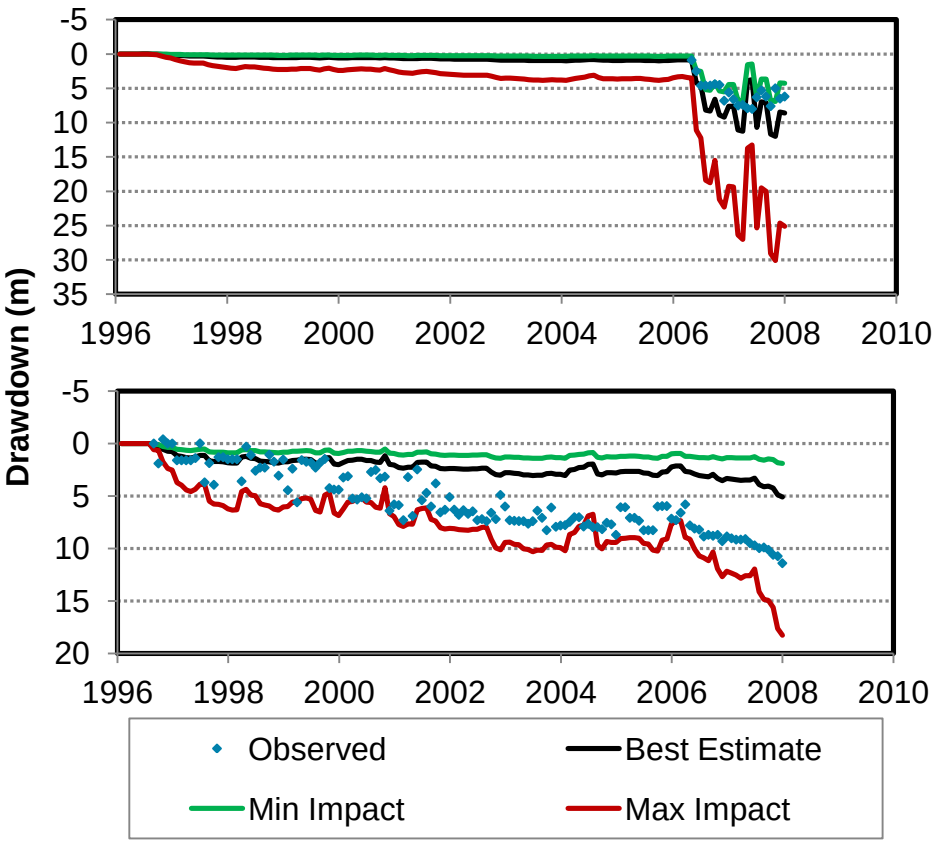


Model Design & Calibration

21 layer FEFLOW model (3.0 million elements)

Calibration Methodology

1. Manual steady state calibration
2. Automated (PEST) to optimize parameters and assess confidence bounds
3. Initial transient calibration for McMurray Basal Sand Aquifer
4. Full transient calibration (future)



Continued Work

- Complete transient model calibration (*Phase 2*)
- Define a scenario(s) for analysis (*Phase 2*)
- Apply scenario results to identify locations for the expansion of the NAOS RGWMN (*Phase 2*)
- Develop tools to facilitate communication of results with the public (*Phase 3*)
- Develop a model update schedule (*Phase 2*)

Questions?

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