

# Buried Bedrock Channels in the Athabasca Oil Sands Region – Conceptual Understanding and Implications to Water Supply

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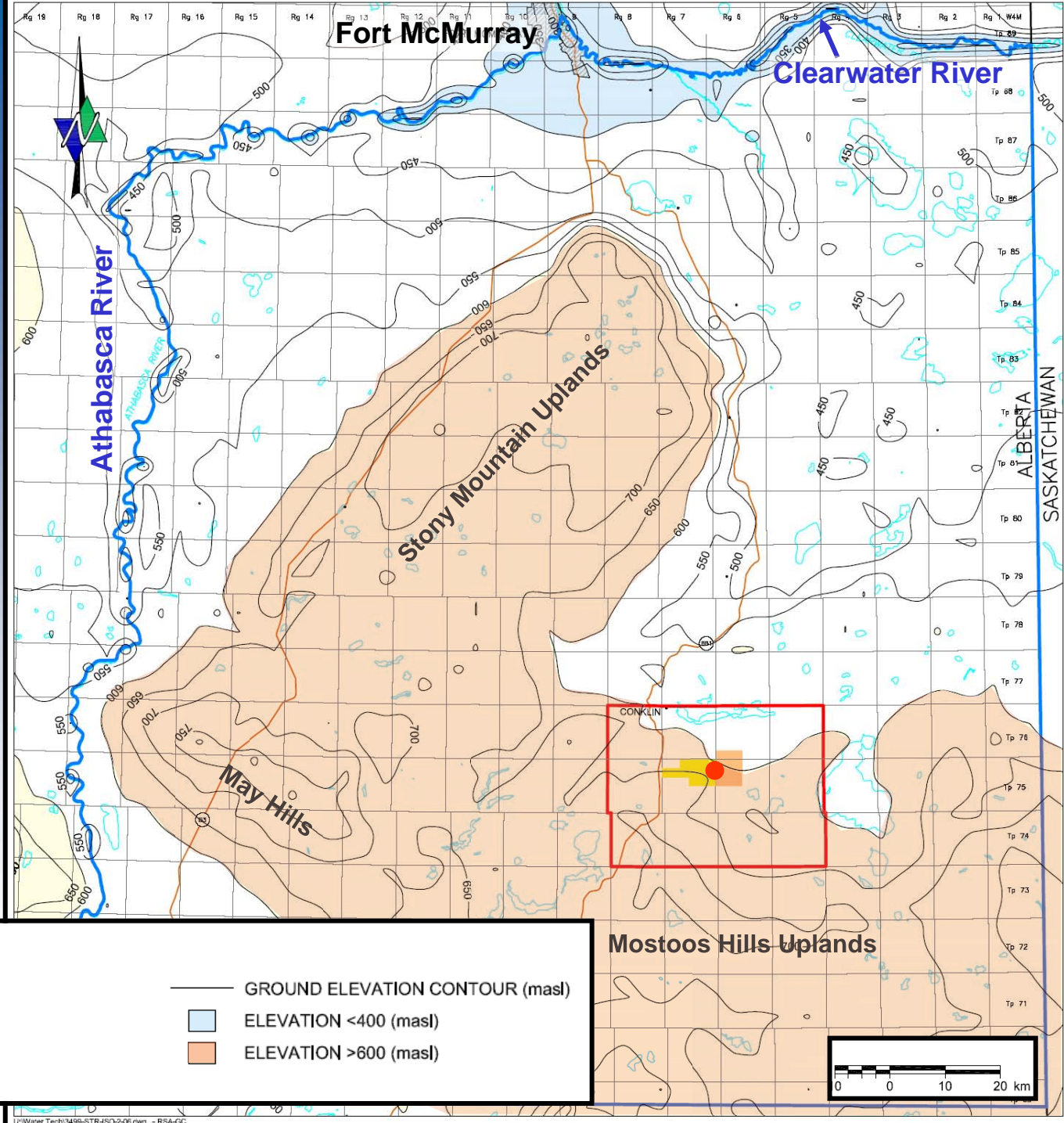
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# Presentation Outline

- Study area
- Regional and local geology
- Hydrogeology
  - hydraulic head mapping
  - groundwater chemistry
- Implications to water supply
- Summary/Conclusions

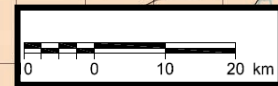
# Study Area and Surface Topography



## LEGEND

- DEVON JACKFISH PROJECT
- DEVON JACKFISH 2 PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)

- GROUND ELEVATION CONTOUR (masl)
- ELEVATION <400 (masl)
- ELEVATION >600 (masl)



# Regional and Local Geology



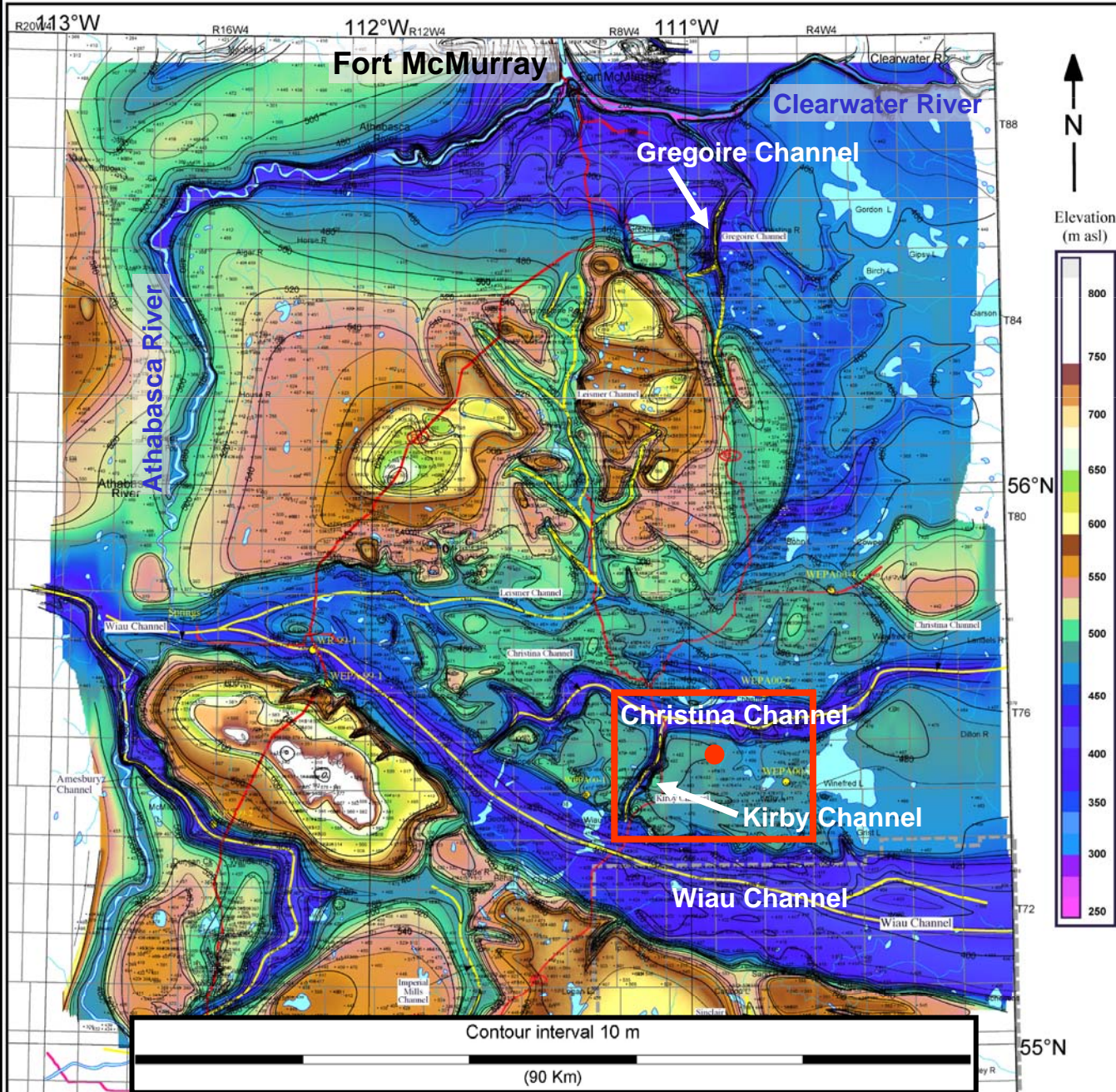


# Hydrostratigraphy

ERA	PERIOD	EPOCH	GROUP	FORMATION		REGIONAL HYDROSTATIGRAPHIC UNIT
CENOZOIC	QUATERNARY			GRAND CENTRE		UNDIFFERENTIATED OVERBURDEN AQUIFER / AQUITARD
				SAND RIVER		
				MARIE CREEK		
				ETHEL LAKE		
				BONNYVILLE		
				MURIEL LAKE		
	TERTIARY			BRONSON LAKE		TERRACE SAND AQUIFER
				EMPRESS UNIT 3	TERRACE SAND	
				EMPRESS UNIT 2		
				EMPRESS UNIT 1		
MESOZOIC	CRETACEOUS	U	COLORADO	LEA PARK		CHANNEL SAND AQUIFER
				LaBICHE	1st WHITE SPECKLED SHALE 2nd WHITE SPECKLED SHALE BASE OF FISH SCALES	
		VIKING		VIKING AQUIFER		
		JOLI FOU		JOLI FOU AQUITARD		
		L	MANNVILLE	GRAND RAPIDS 'A'		UPPER GRAND RAPIDS AQUIFER
				GRAND RAPIDS 'B'		
				GRAND RAPIDS 'C'		LOWER GRAND RAPIDS AQUIFER
				CLEARWATER SHALE		CLEARWATER SHALE AQUITARD
				CLEARWATER 'A'		CLEARWATER 'A' AQUIFER
				CLEARWATER 'B'		CLEARWATER AQUIFER / AQUITARD CLEARWATER 'B' AQUIFER
	CLEARWATER 'C'			CLEARWATER 'C' AQUIFER		
	WABISKAW MEMBER			WABISKAW BITUMEN AQUITARD WABISKAW AQUIFER / AQUITARD		
		McMURRAY			McMURRAY AQUIFER McMURRAY BITUMEN AQUITARD BASAL McMURRAY AQUIFER	

# Bedrock Topography (Andriashek, 2003)

- Channel width can range from less than 500 m to greater than 30 km
- Channel length can range from less than 10 km to greater than 200 km
- Can incise into Cretaceous bedrock greater than 150 m



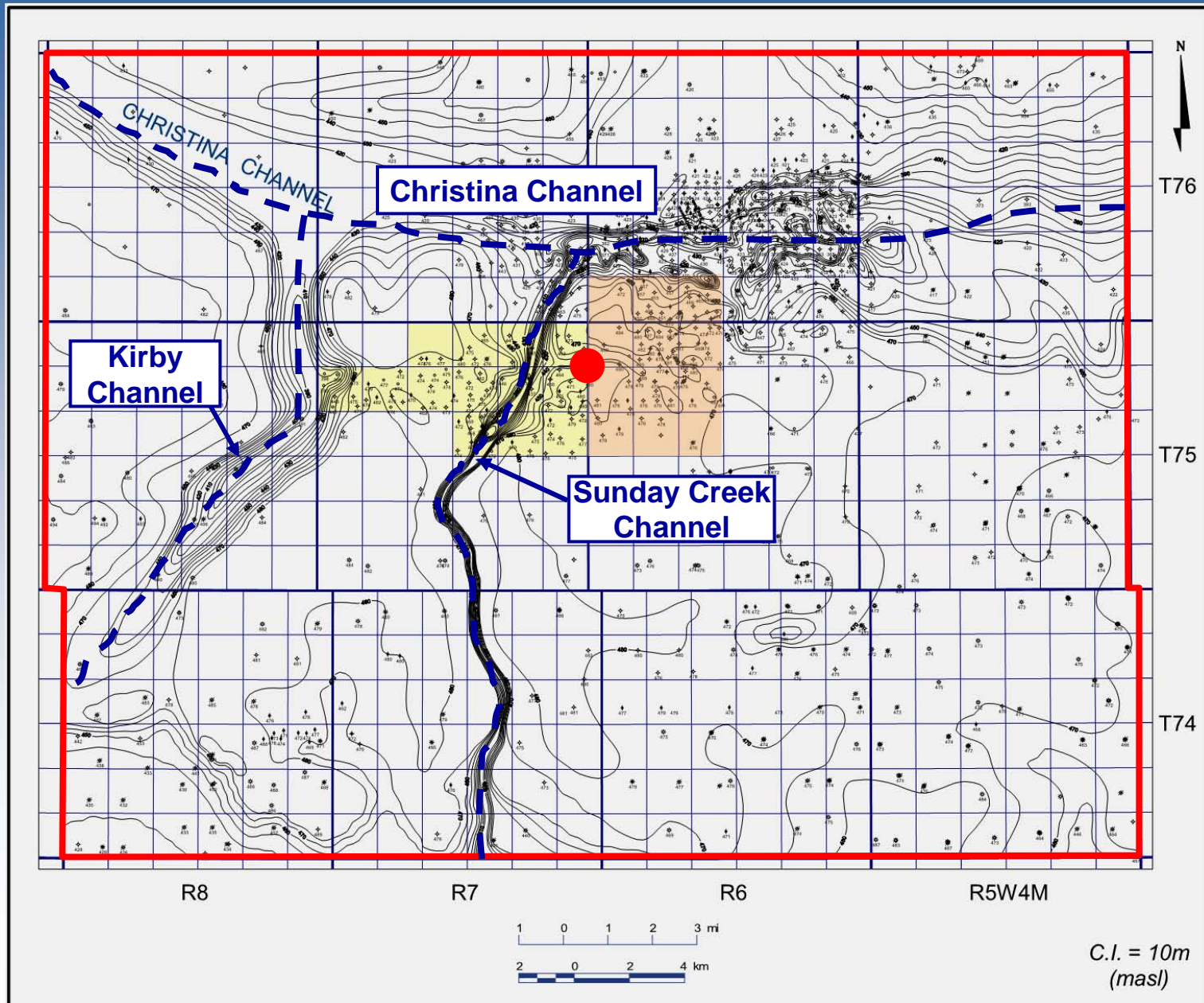
## Data Legend

- 400 - Bedrock elevation (in m asl) equal to value shown
- 400 - Bedrock elevation (in m asl) higher than value shown
- 400 - Bedrock elevation (in m asl) lower than value shown
- Channel talweg
- WEPA00-1 Alberta Geological Survey core hole

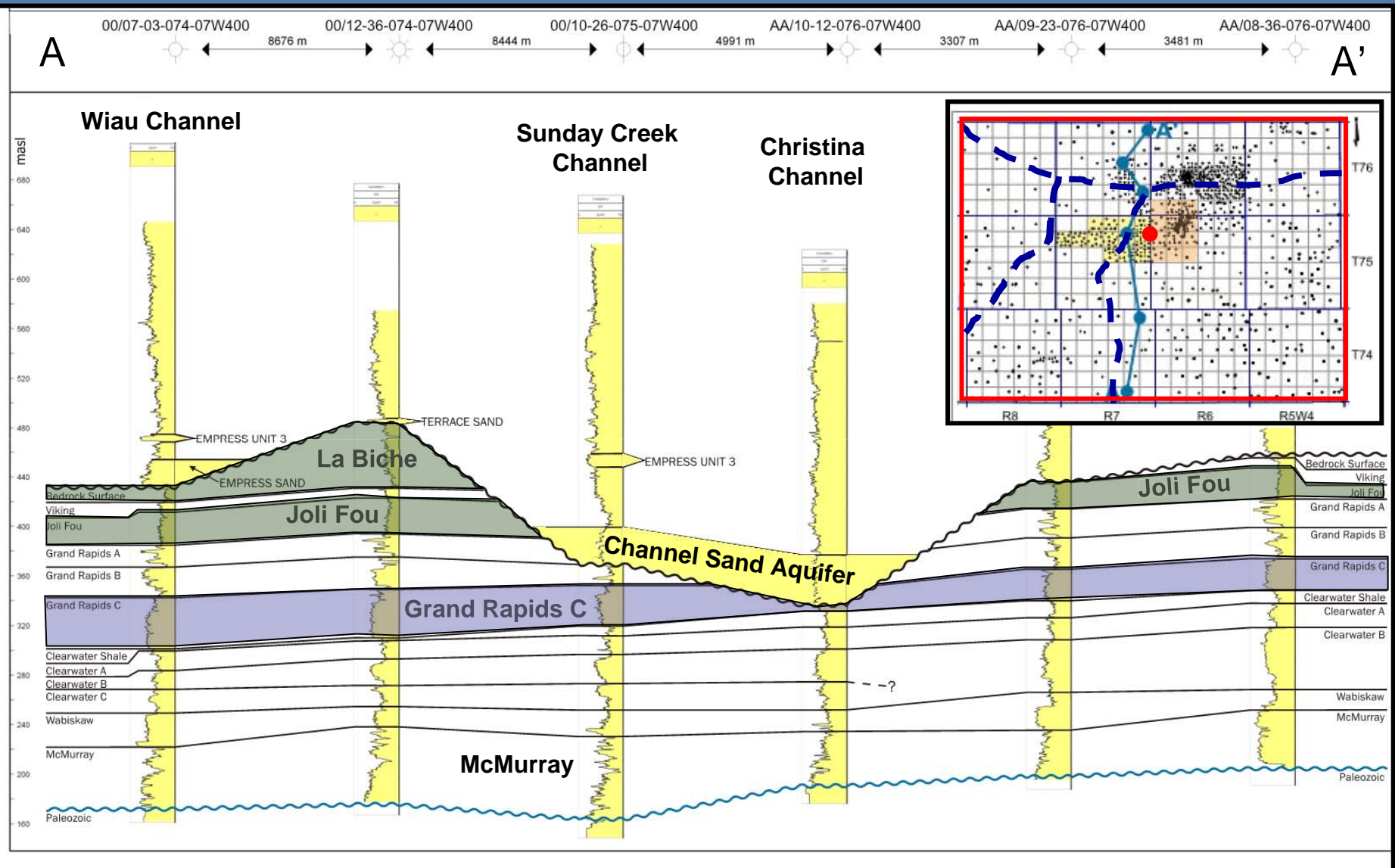
Andriashek, L.D. 2003. "Quaternary Geological Setting of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta" EUB/AGS Earth Sciences Report 2002-03



# Local Bedrock Topography



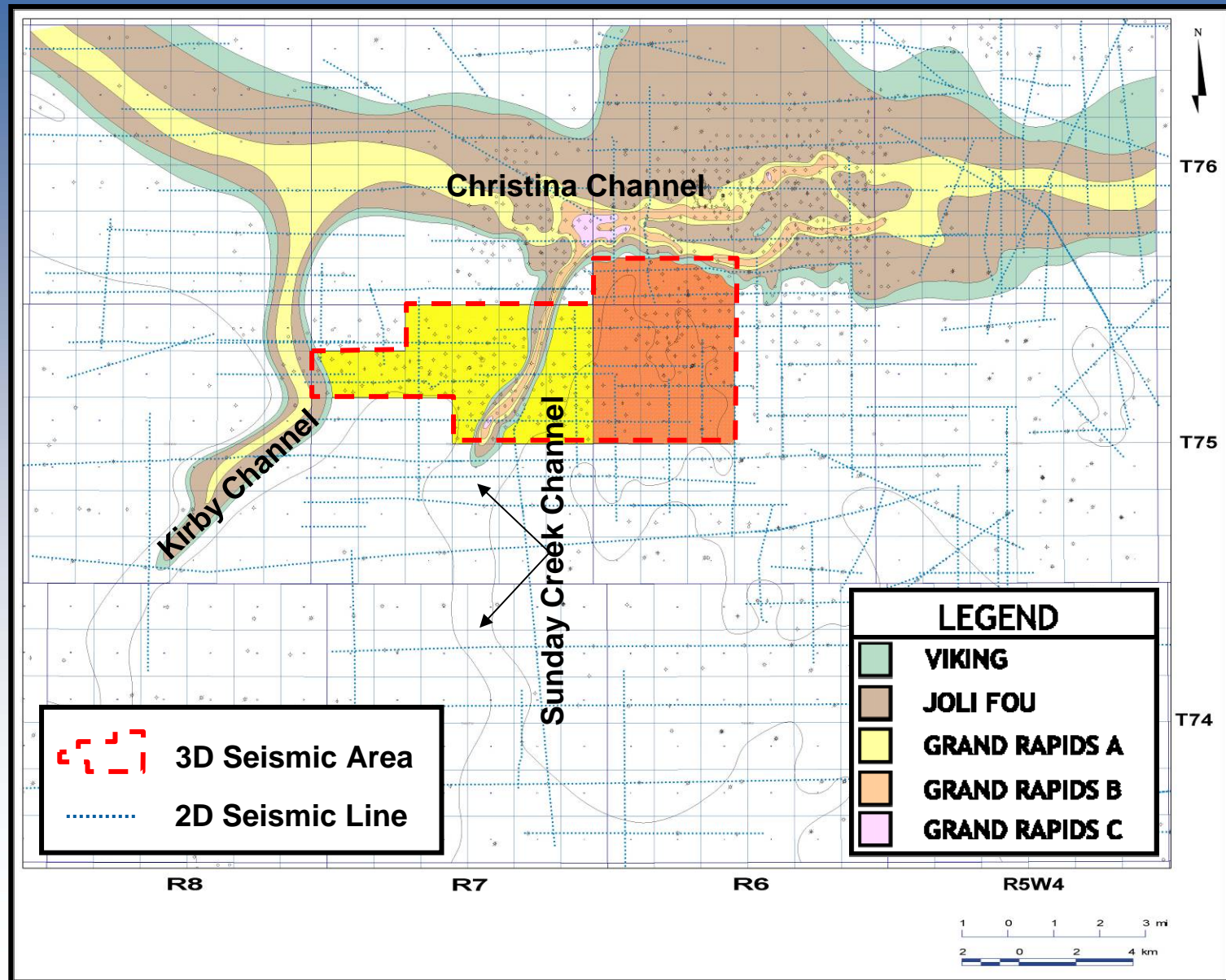
# South to North Structural Cross Section A-A'



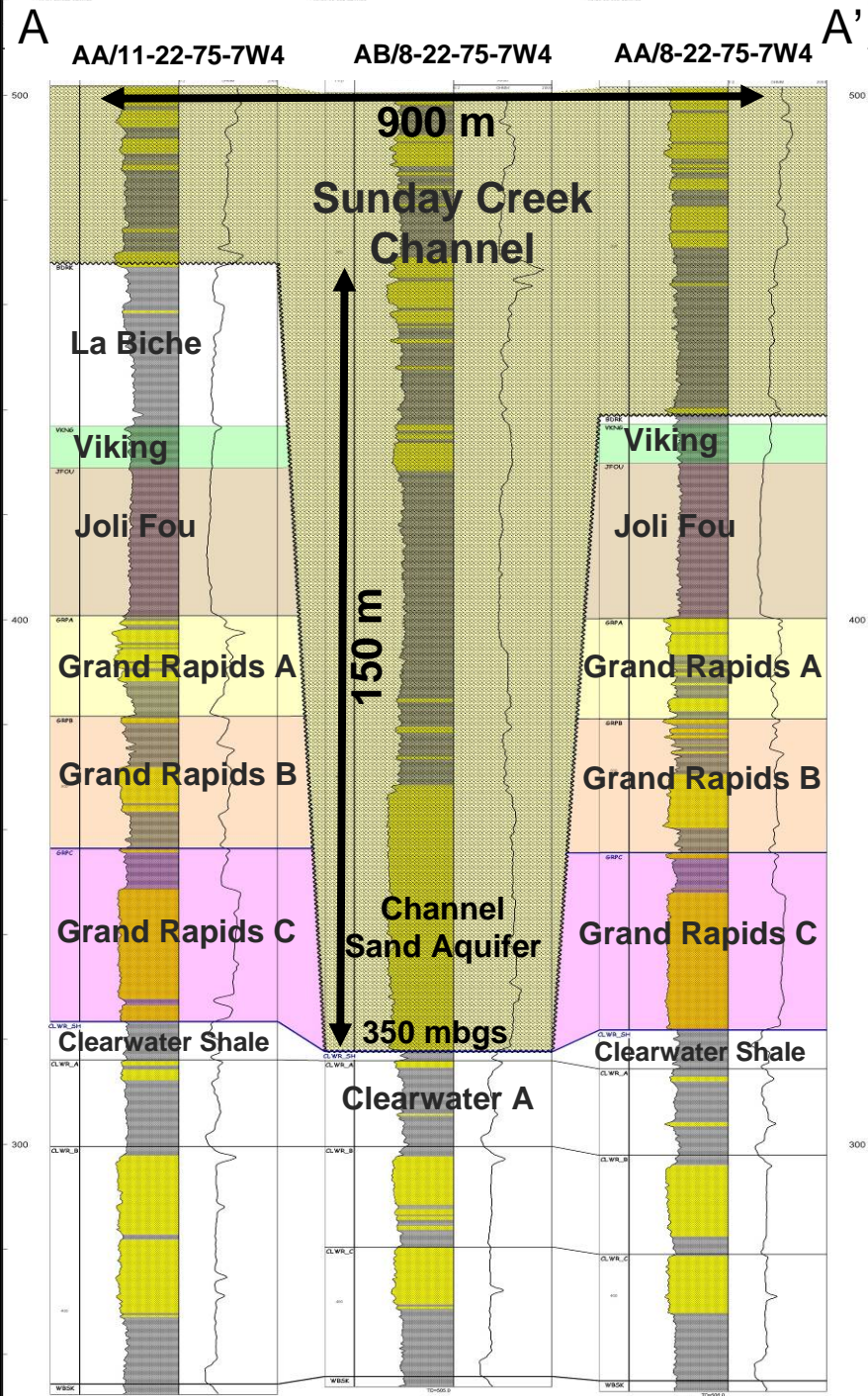
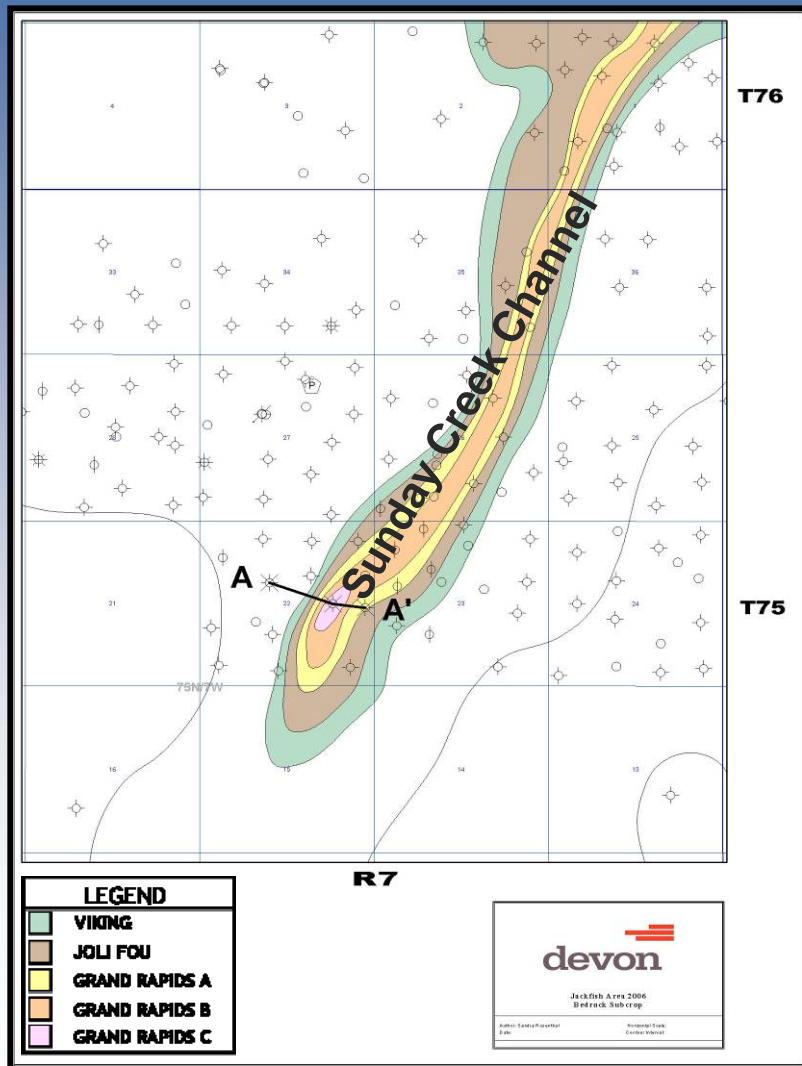


# Subcropping Cretaceous Formations

## An Integrated Interpretation



# Sunday Creek Channel Cross Section



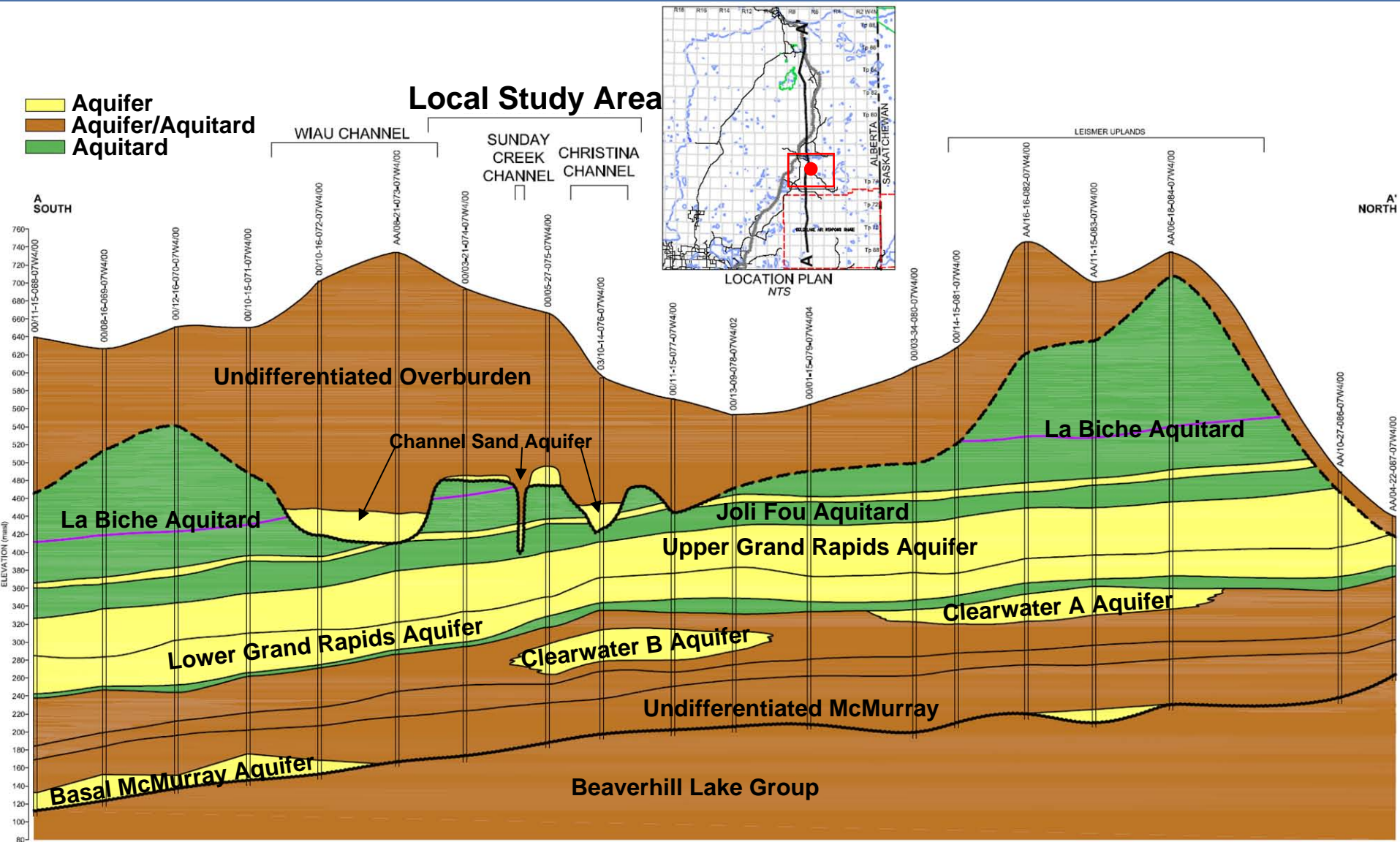


# Hydrogeology

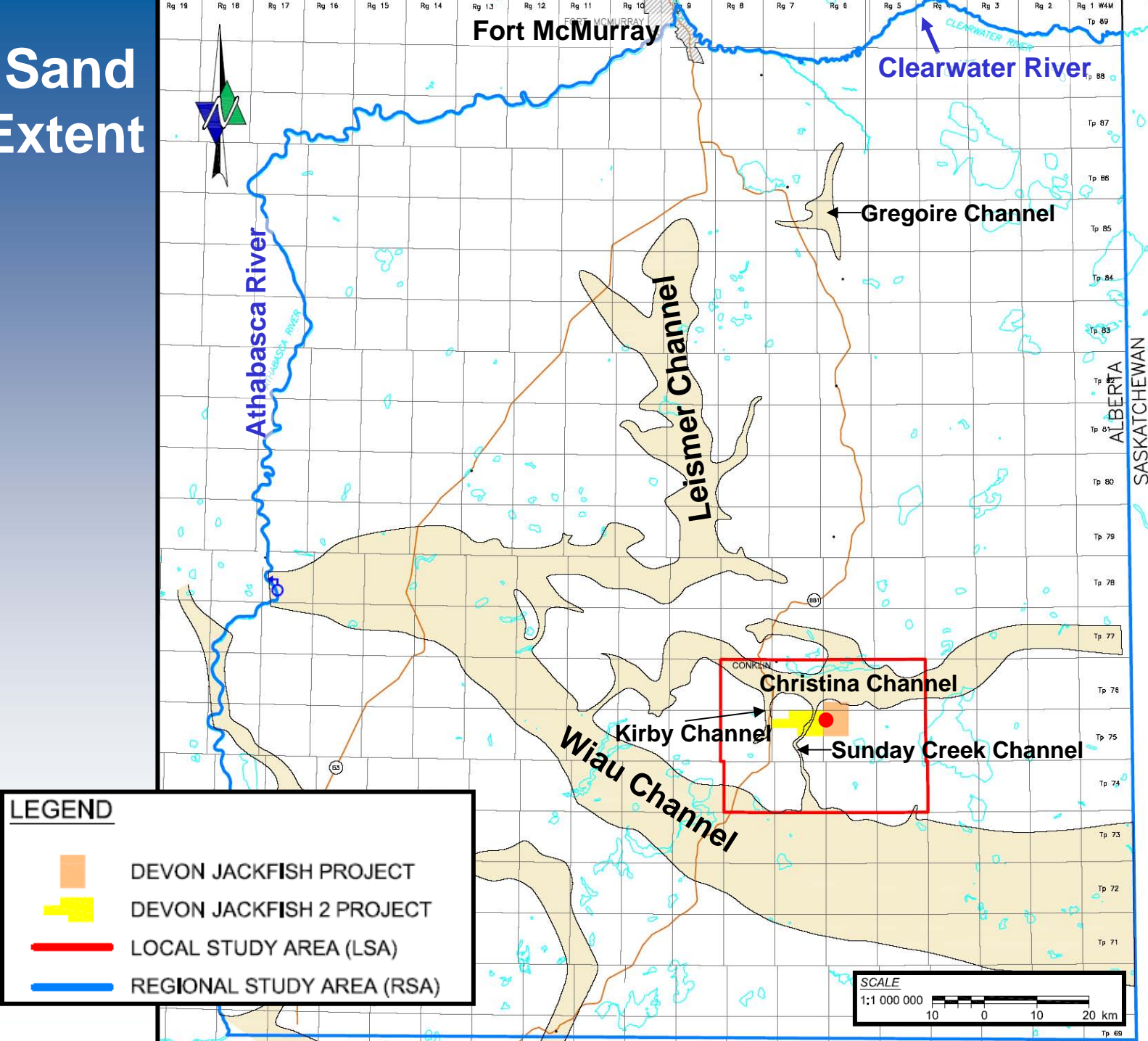




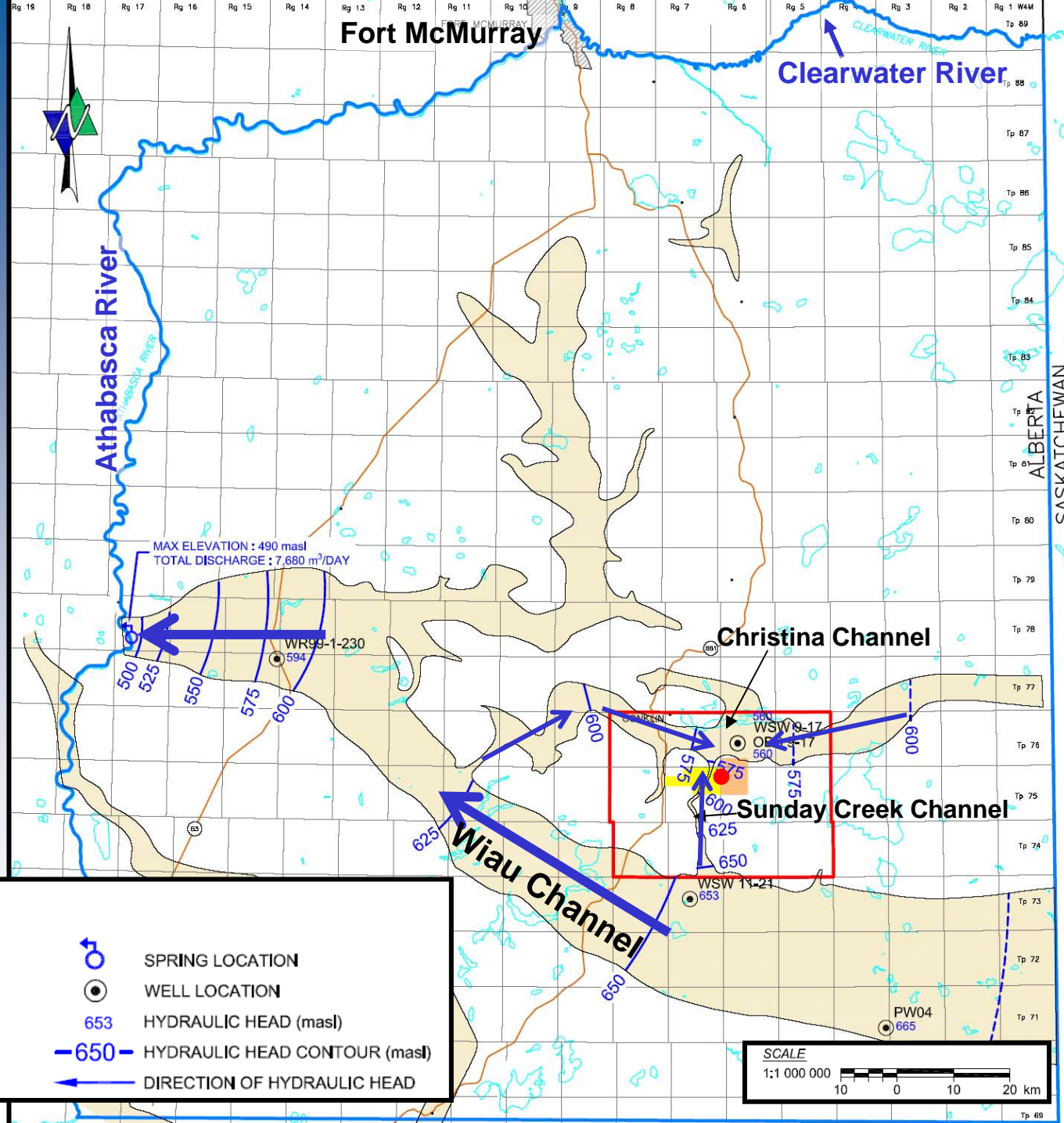
# South-North Regional Schematic Hydrostratigraphic Cross Section



# Channel Sand Aquifer Extent



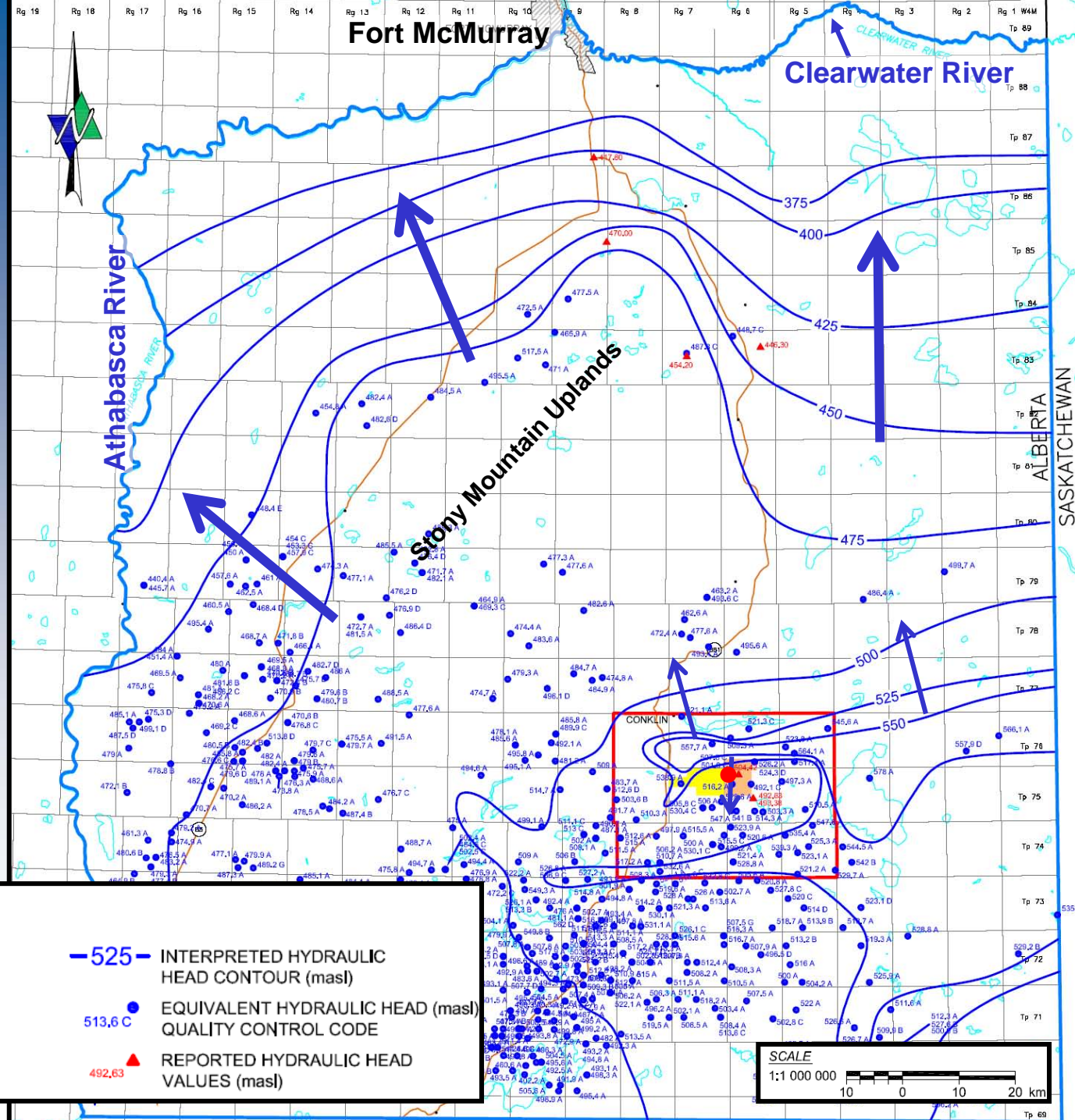
# Channel Sand Aquifer



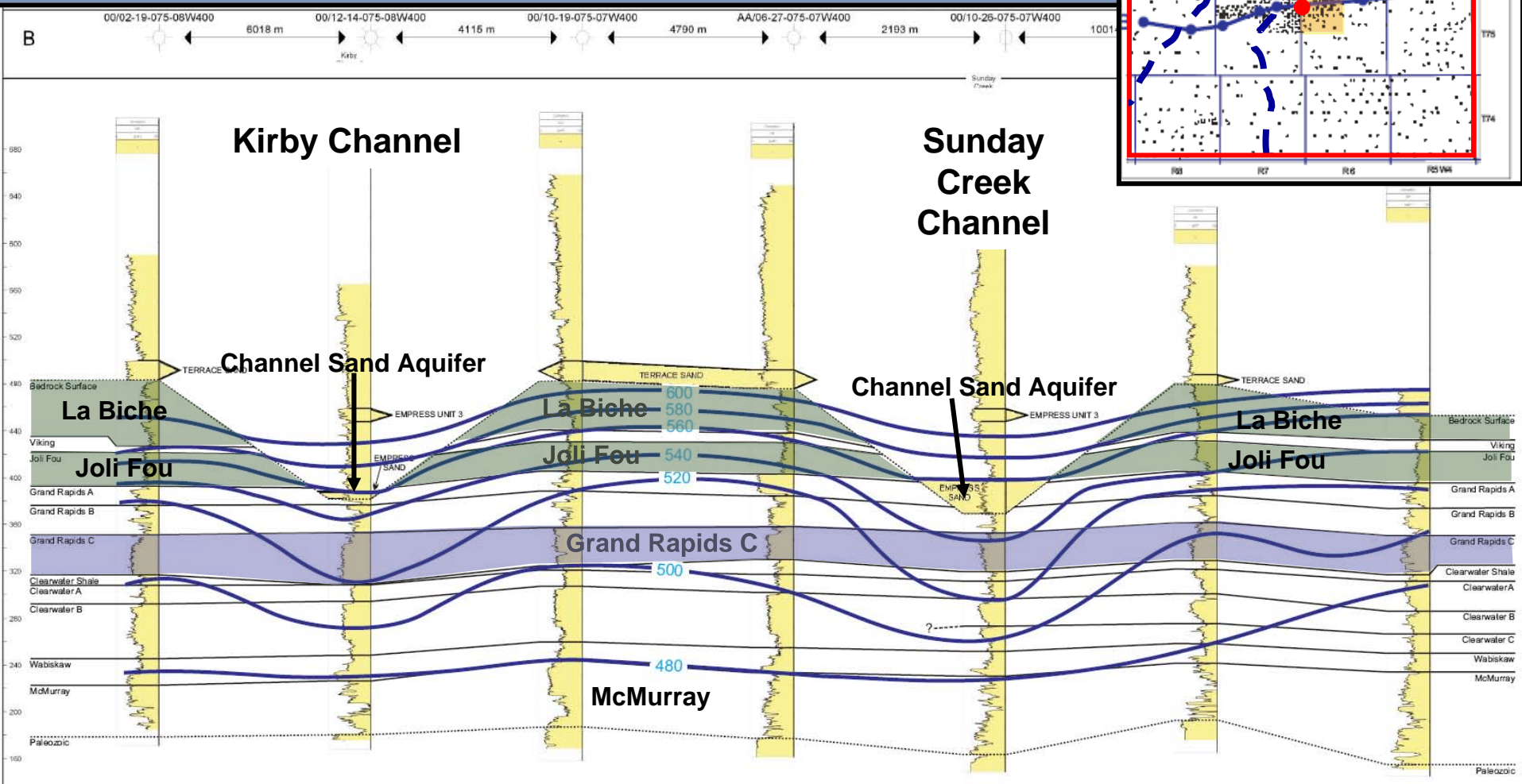


# Groundwater Flow

## Grand Rapids Formation

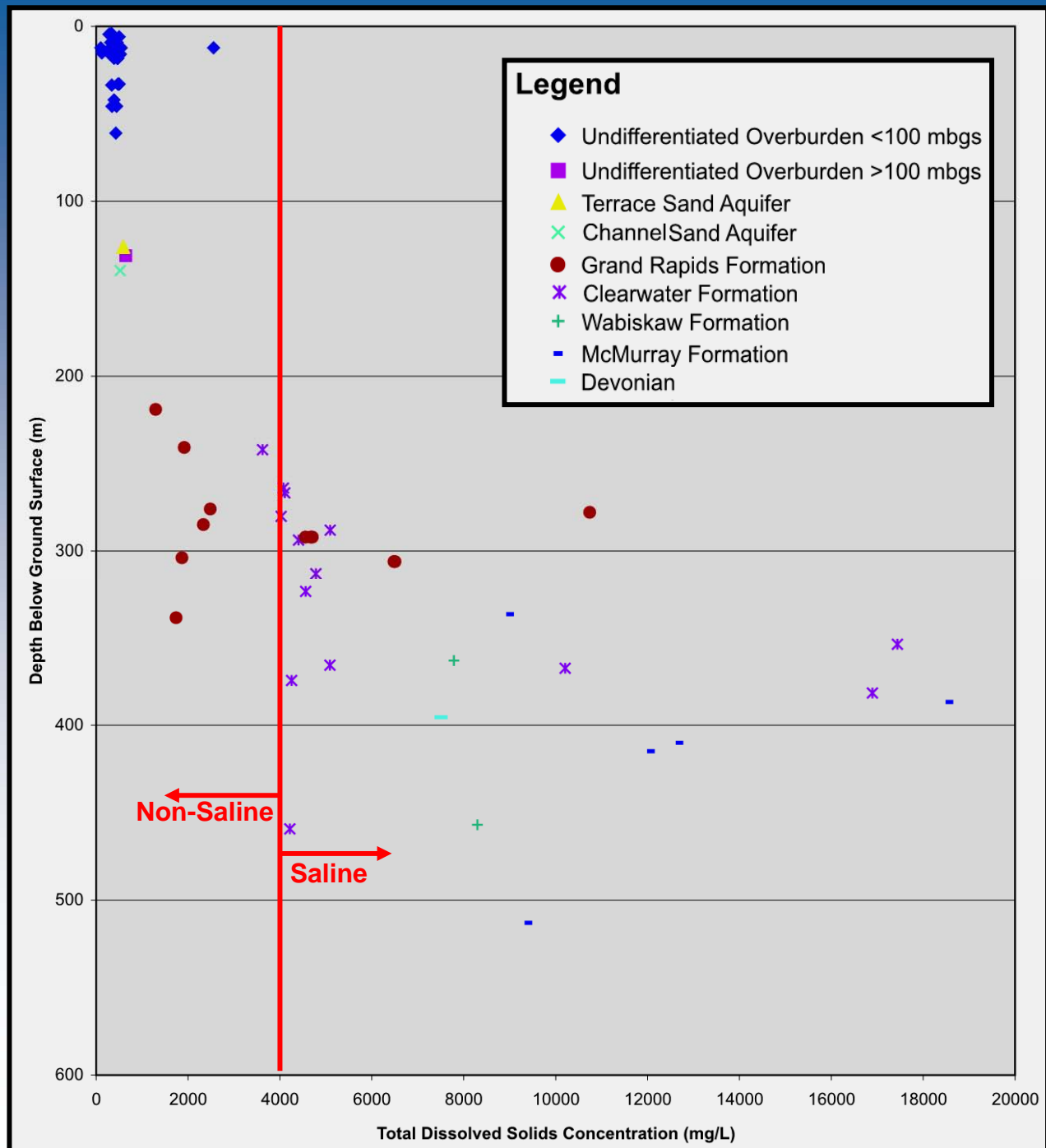


# West to East Structural Cross Section With Interpreted Hydraulic Head Contours



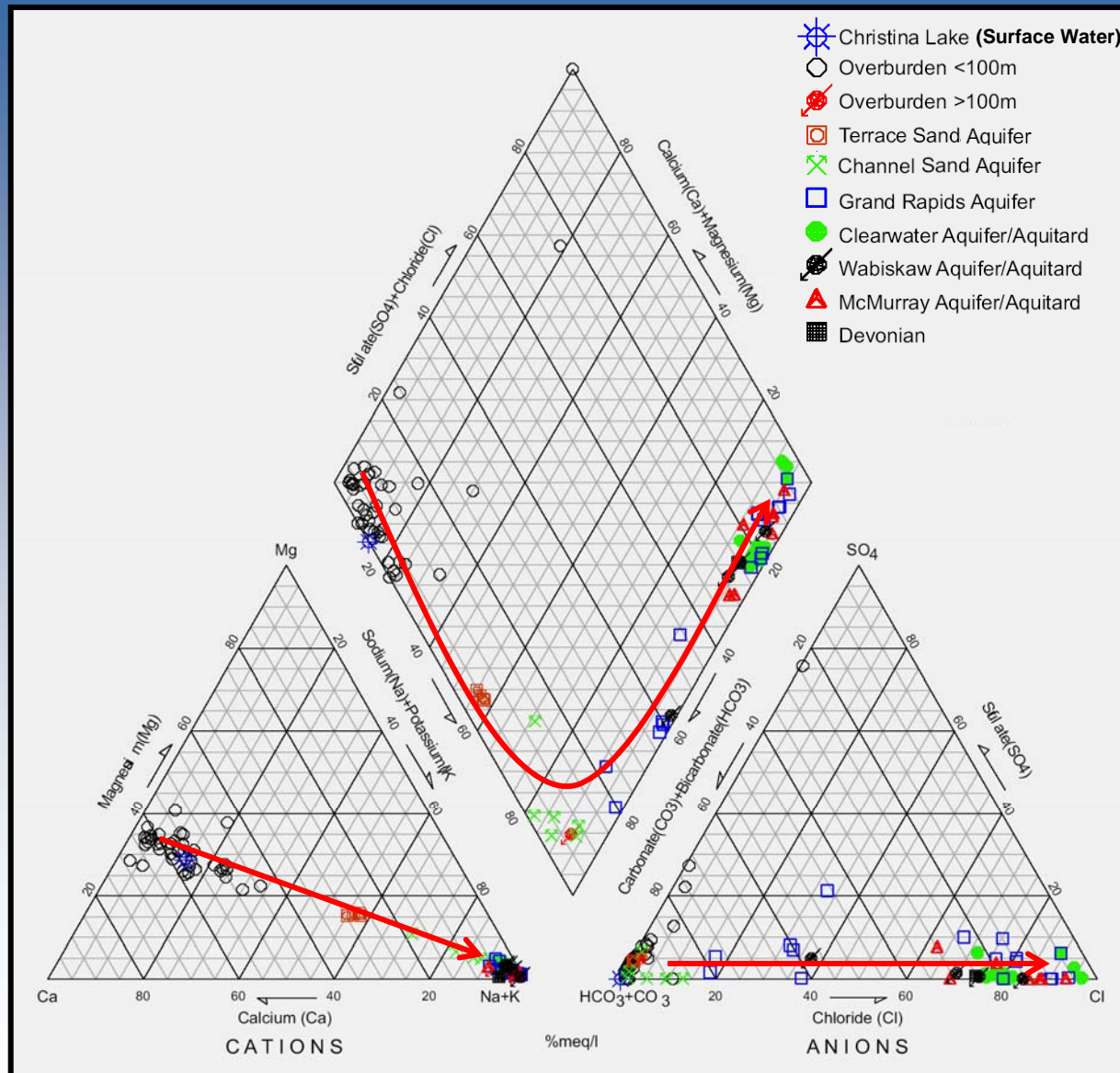
# Total Dissolved Solids Concentration versus Depth

- Increase in TDS with depth from less than 1,000 mg/L to greater than 18,000 mg/L



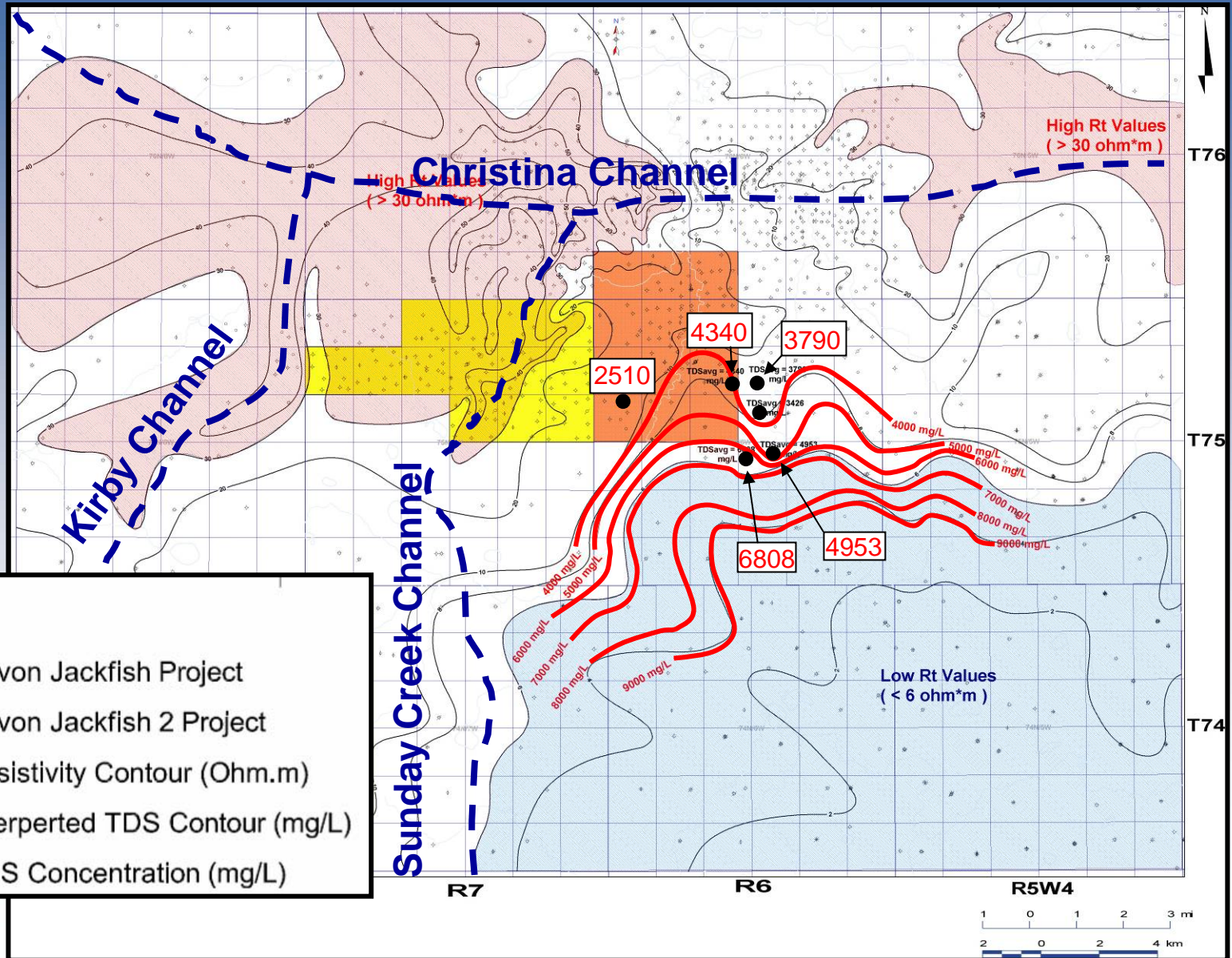


# Change in Groundwater Chemistry with Depth



Change in water type from calcium-bicarbonate to sodium-chloride

# Lower Grand Rapids Aquifer Average Resistivity ( $R_t$ ) and TDS Distribution





# Implications to Water Supply

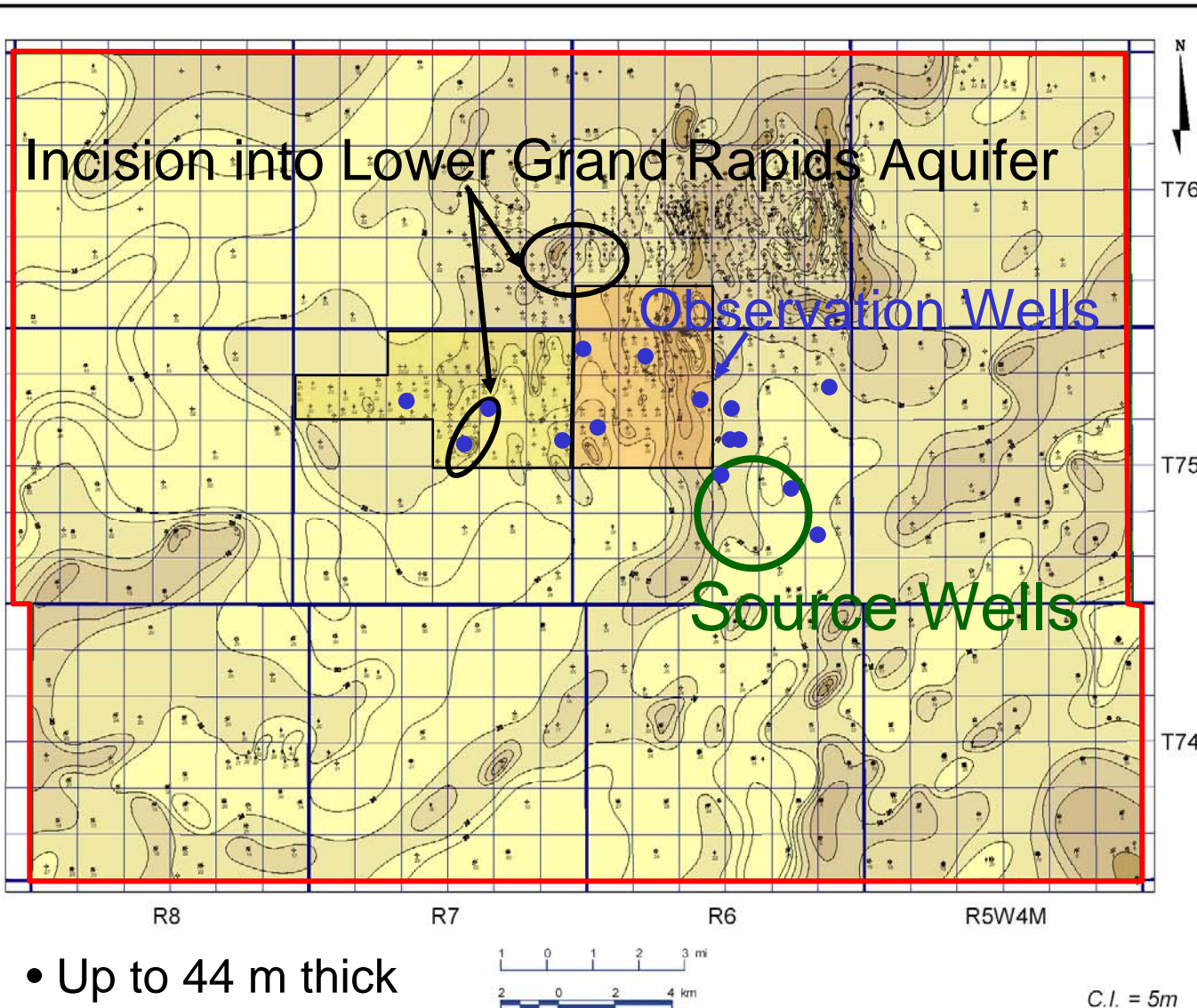




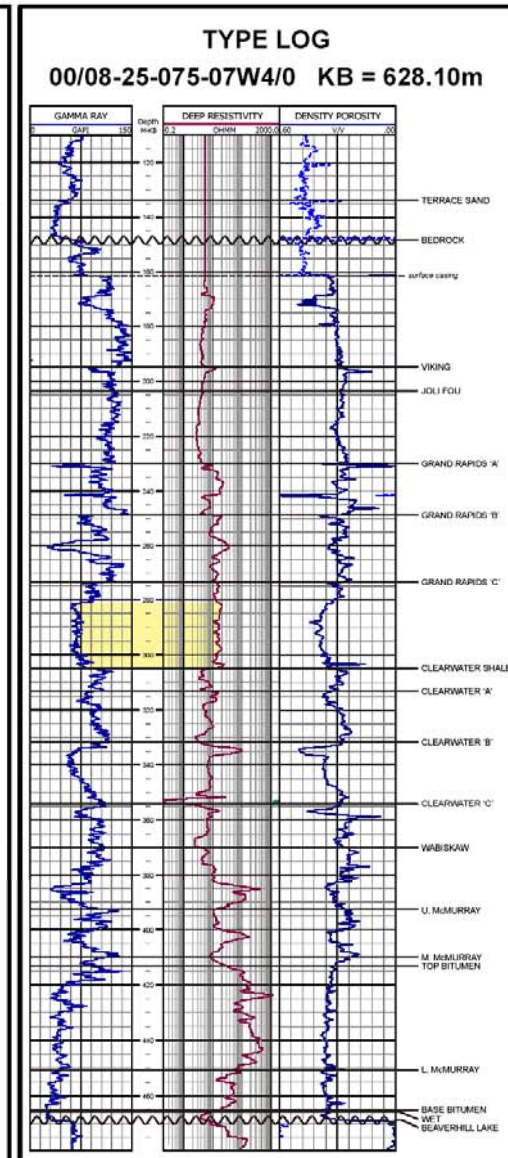
# Implications to Water Supply

- Source well deliverability is increased as a result of the groundwater mounding (higher available head) in the Grand Rapids
- Source wells have been located away from the deepest channel incisions to ensure saline groundwater is withdrawn
  - In accordance with the Alberta Environment *Water Conservation and Allocation Guideline for Oilfield Injection*
  - Sodium chloride water (TDS 4,000 to 10,000 mg/L) is easier to treat (for steam generation)
- As operations continue, pressure and groundwater chemistry will be monitored

# Lower Grand Rapids Aquifer Isopach



- Up to 44 m thick



# Summary/Conclusions

- An integrated approach is required when solving water supply challenges
- The depth of incision and subcropping Cretaceous formations strongly influences:
  - hydraulic head distribution within the channels and Cretaceous formations
  - groundwater chemistry of Cretaceous formations
- The presence of buried bedrock channels have important implications to water supply in terms of deliverability and source water chemistry