

# **STRATIFICATION AND MIXING IN BRACKISH LAKES SUBJECT TO ICE COVER**

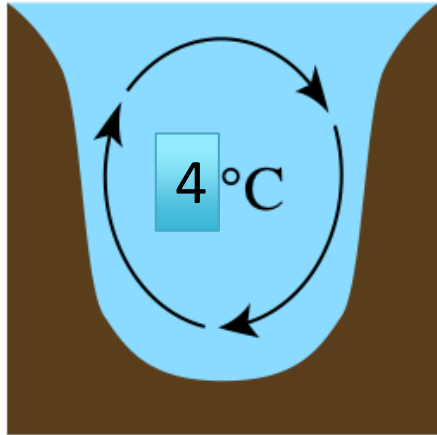


**GREG LAWRENCE, CYNTHIA BLUTEAU,  
TED TEDFORD AND ROGER PIETERS  
UNIVERSITY OF BRITISH COLUMBIA**

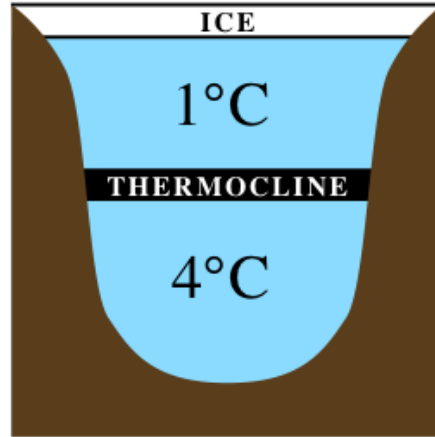
# PROPERTIES OF SALINE MINING LAKES SUBJECT TO ICE COVER

Lake	Location	S	Ice thickness	f
Zone 2 Pit	NWT	0.75	0.9	0.99
Grum Pit	Yukon	0.84	0.52	0.97
Brenda	BC	0.9	na	na
Tailings	NWT	1.0	0.9	0.99
Faro Pit	Yukon	1.1	0.6	0.93
Waterline Pit	BC	1.3	0.9	na
Vangorda Pit	Yukon	1.7	0.45	0.98
Base Mine	Alberta	2.0	0.6	na
Main Zone Pit	BC	2.4	0.6	na

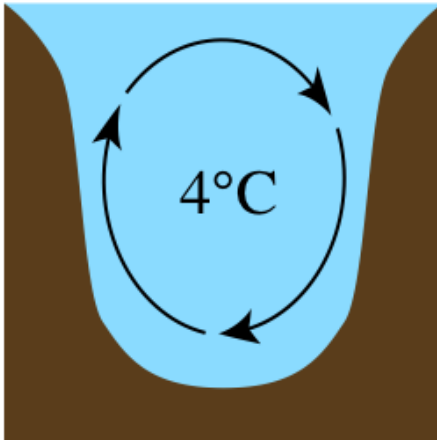
# TYPICAL SEASONAL CYCLE OF LAKES SUBJECT TO ICE COVER



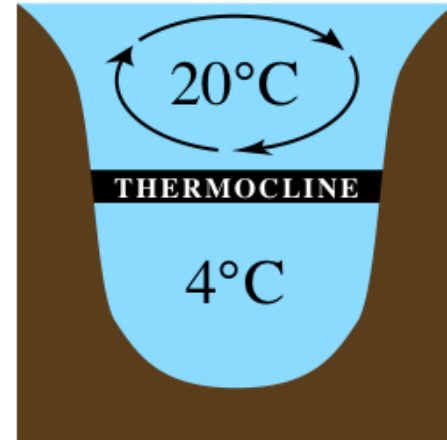
FALL



WINTER



SPRING



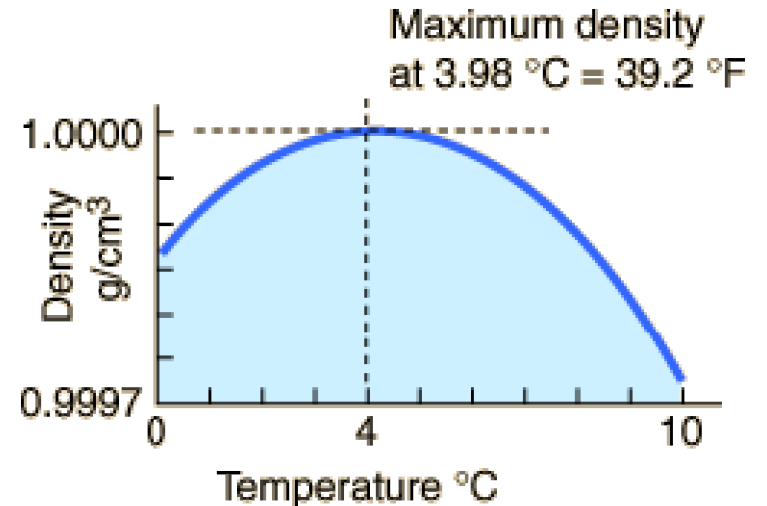
SUMMER

## FACTORS:

SURFACE HEATING AND COOLING

WIND

TEMPERATURE OF MAXIMUM DENSITY

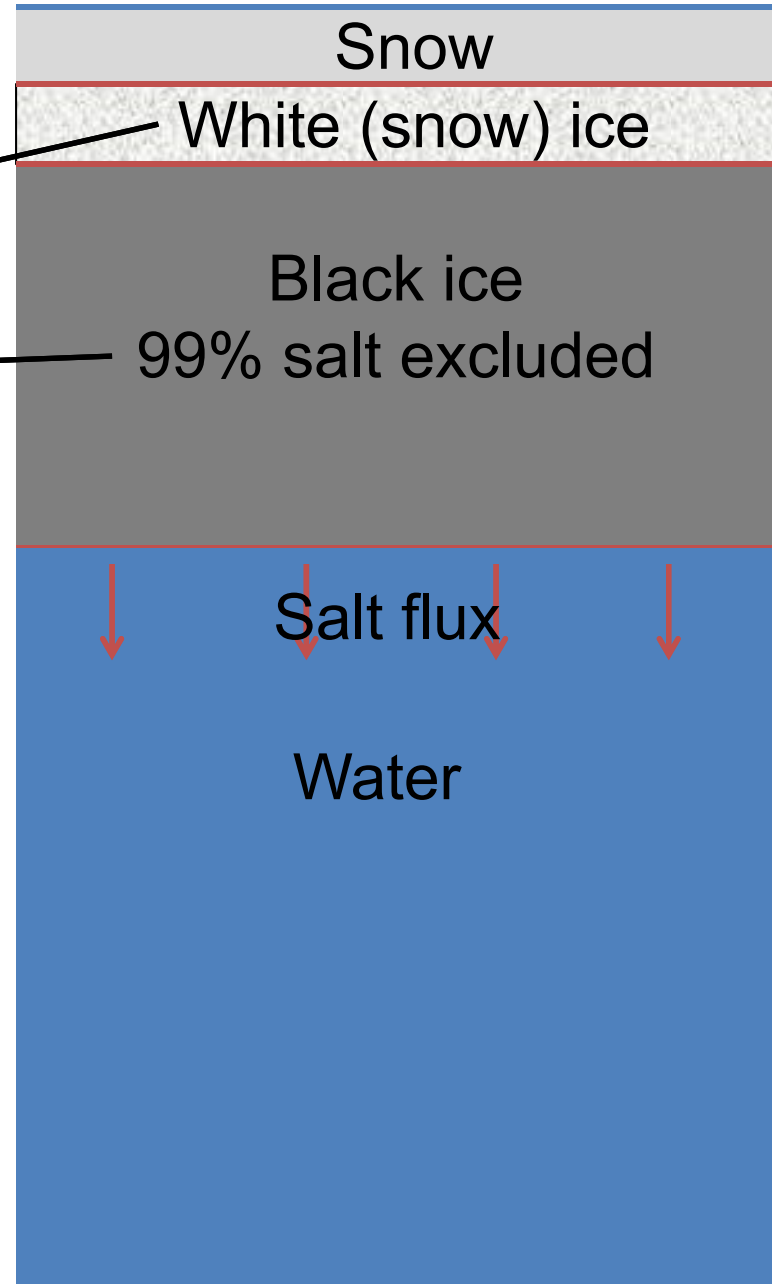
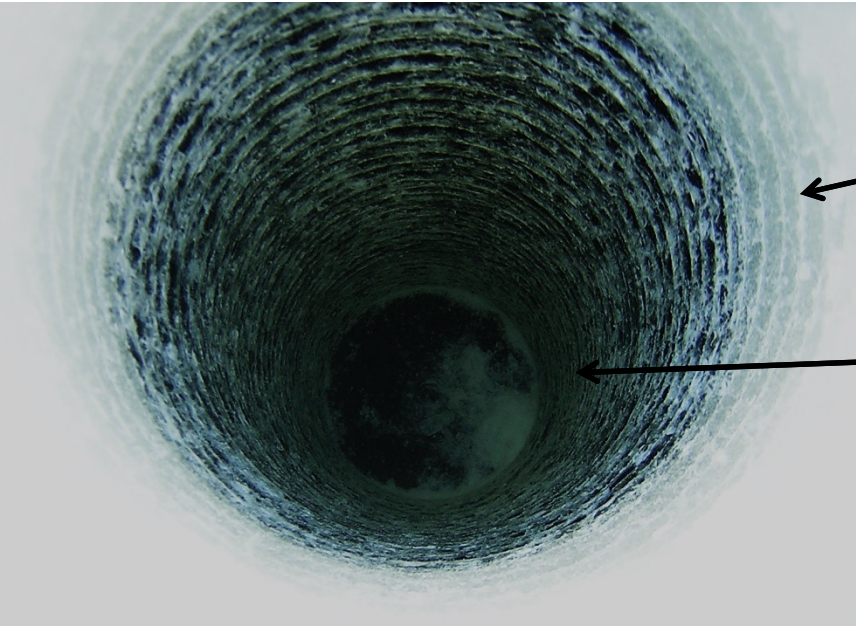




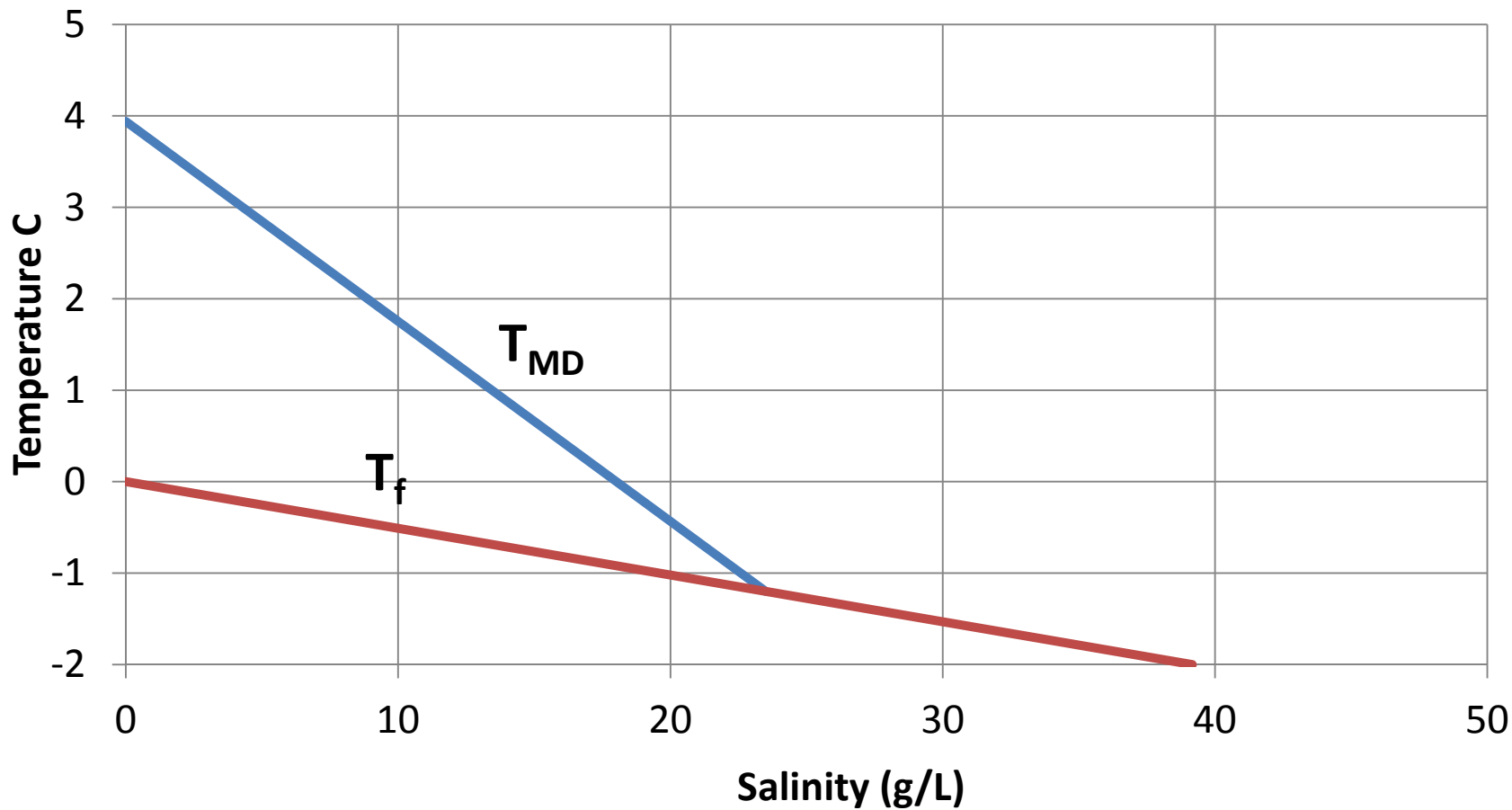


Snow on Tailings Lake (40cm); ice with cracks and frozen over bubble hole? R. Pieters

# Salt exclusion from ice



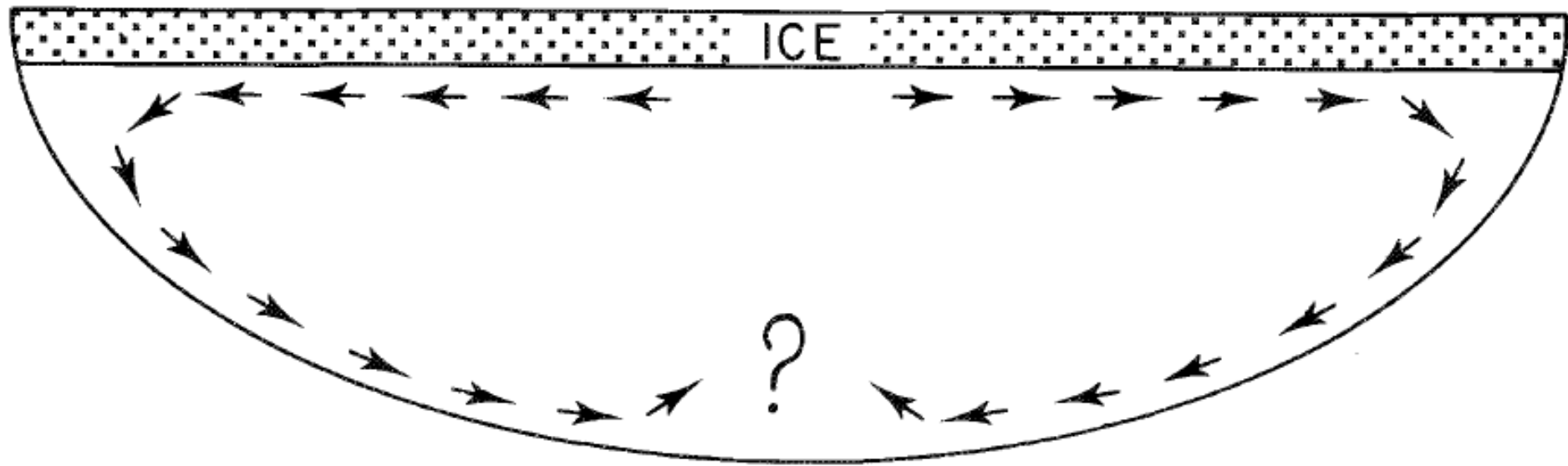
# Temperature of Maximum Density and Freezing Temperature



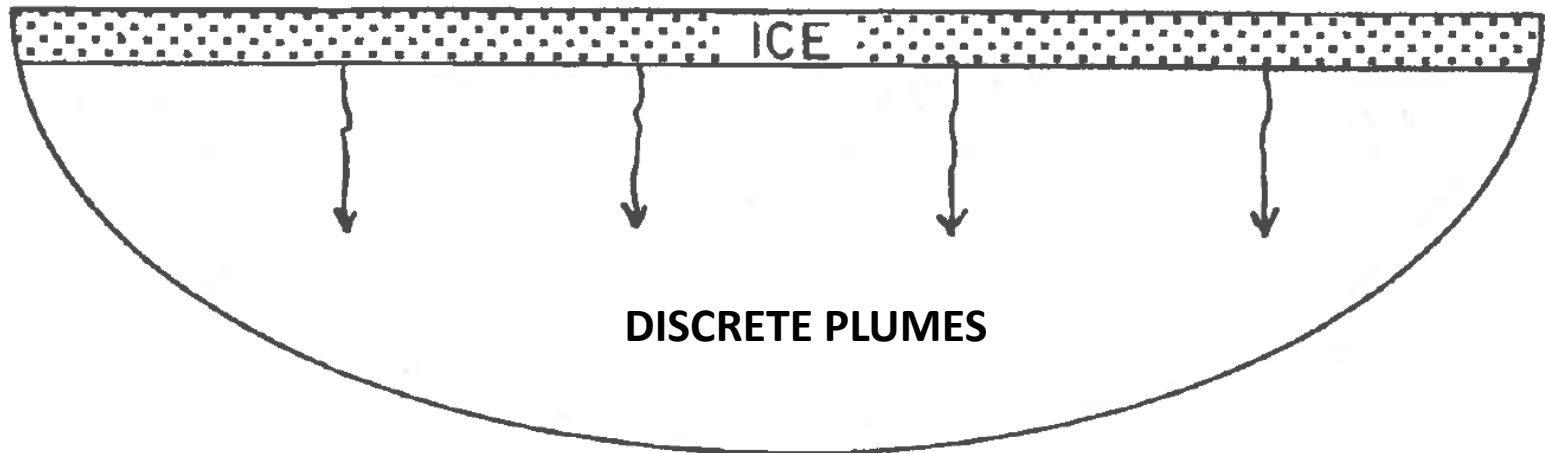
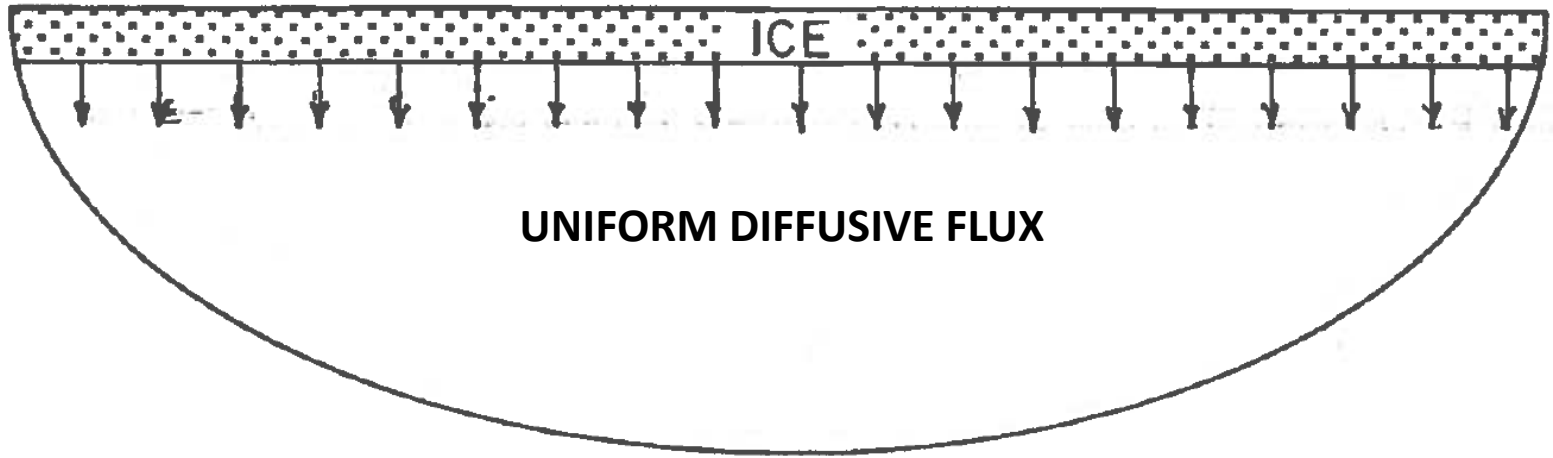
# Proposed model of mid-winter lake circulation

Welch & Bergmann 1985

$$S \approx 0.1 \text{ g/L}$$



# Alternative Salt Exclusion Mechanisms

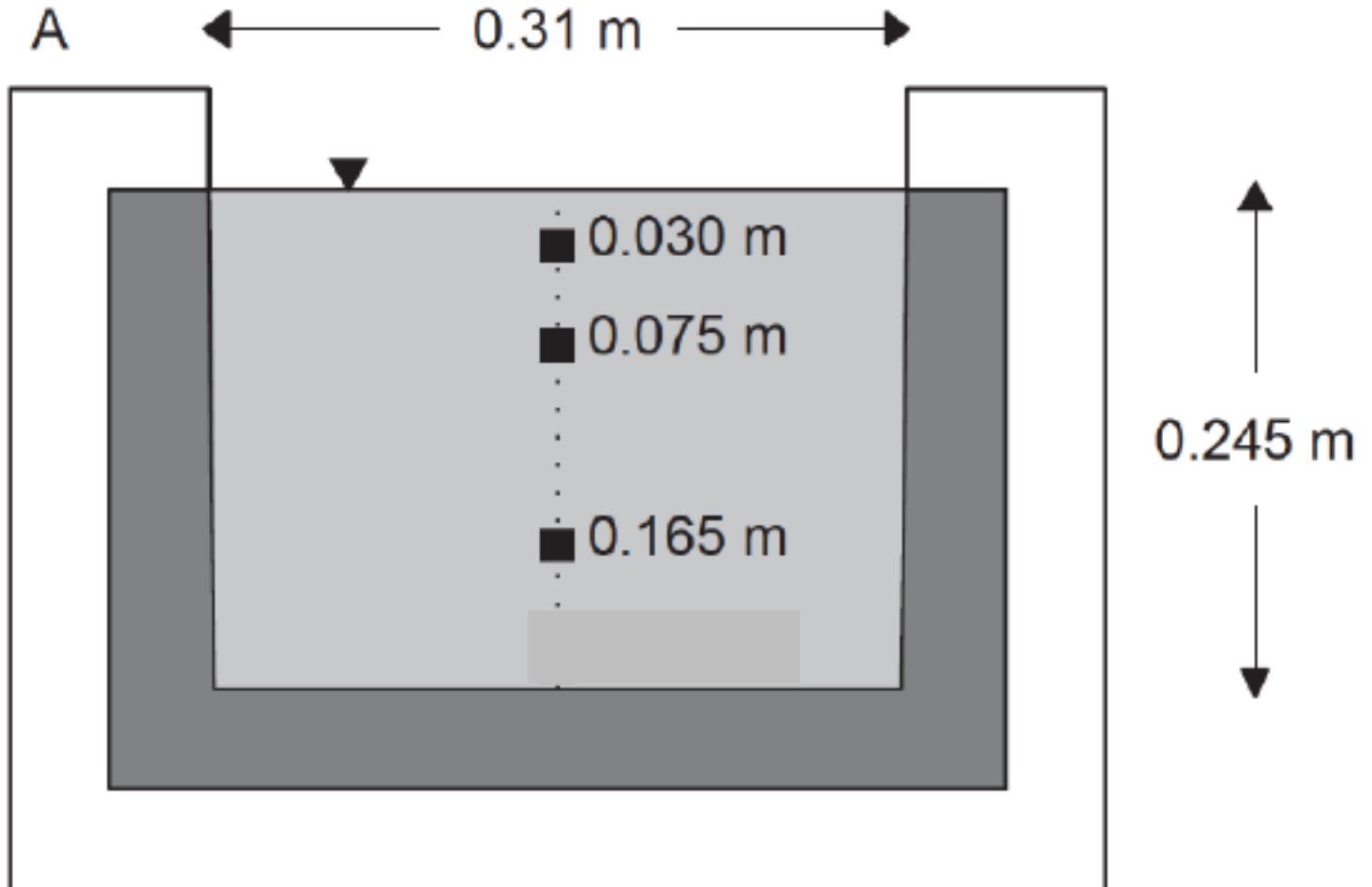




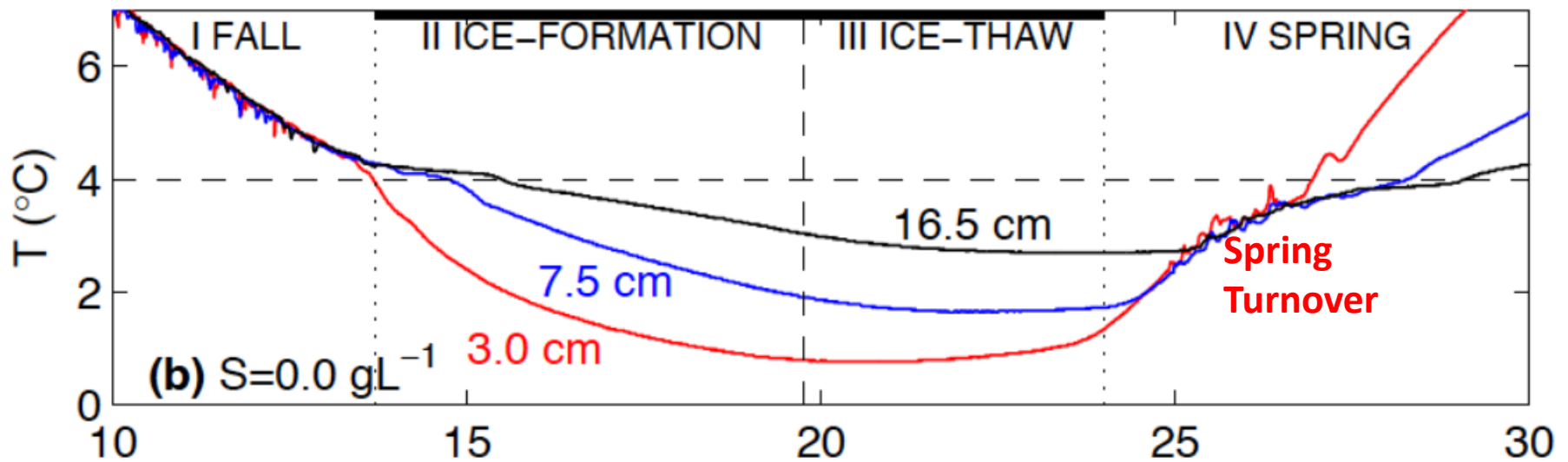
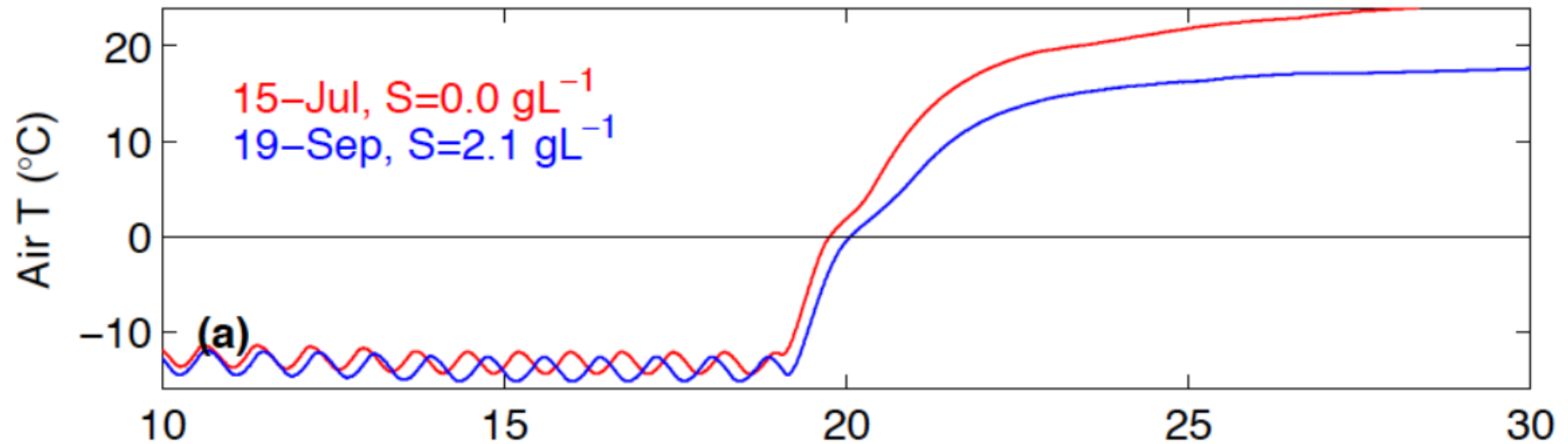
# Studies of Effects of Salt Exclusion

- Laboratory Lake – six pack container in freezer
  - Bluteau (2006)
- “Natural Lake” – Tailings Lake NWT
  - Pieters & Lawrence (2009)
- Base Mine Lake – Water cap over oil sands tailings
  - Lawrence, Tedford & Pieters (2015)

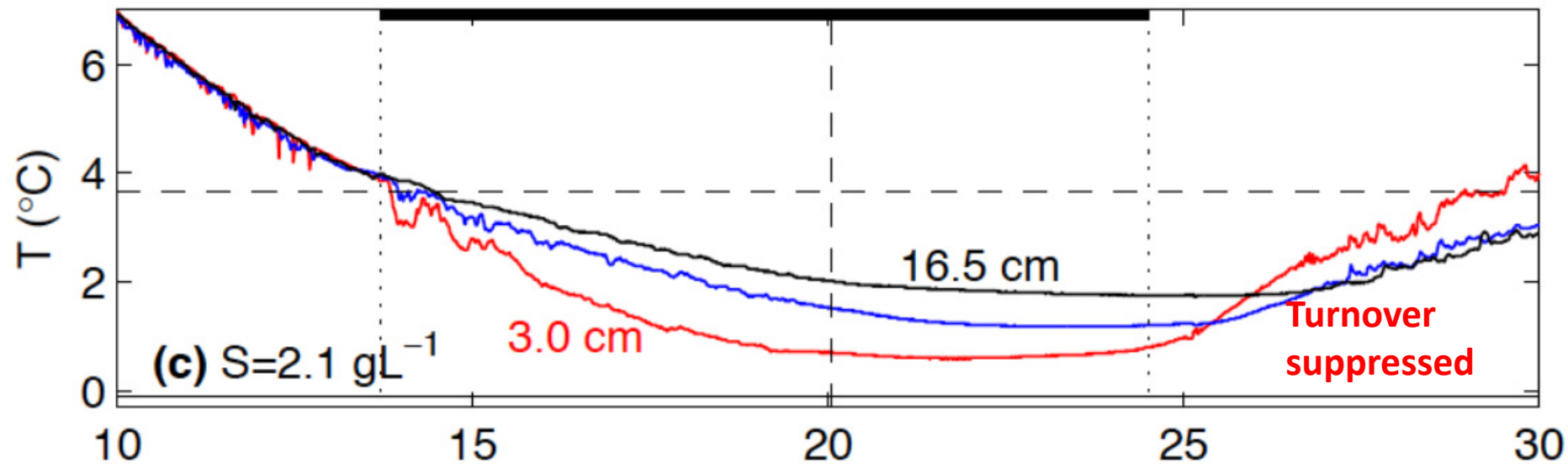
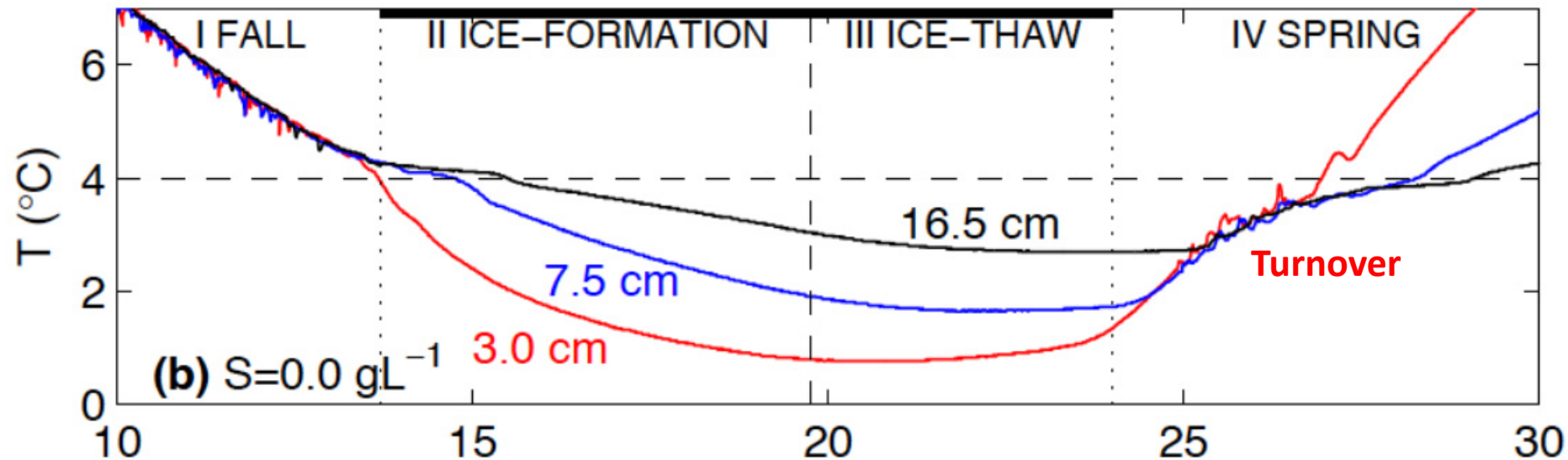
# Laboratory “Lake”



# Seasonal Cycle in Laboratory Lake (Fresh Water)



# Seasonal Cycle ( $S = 0$ and $S = 2.1 \text{ gL}^{-1}$ )



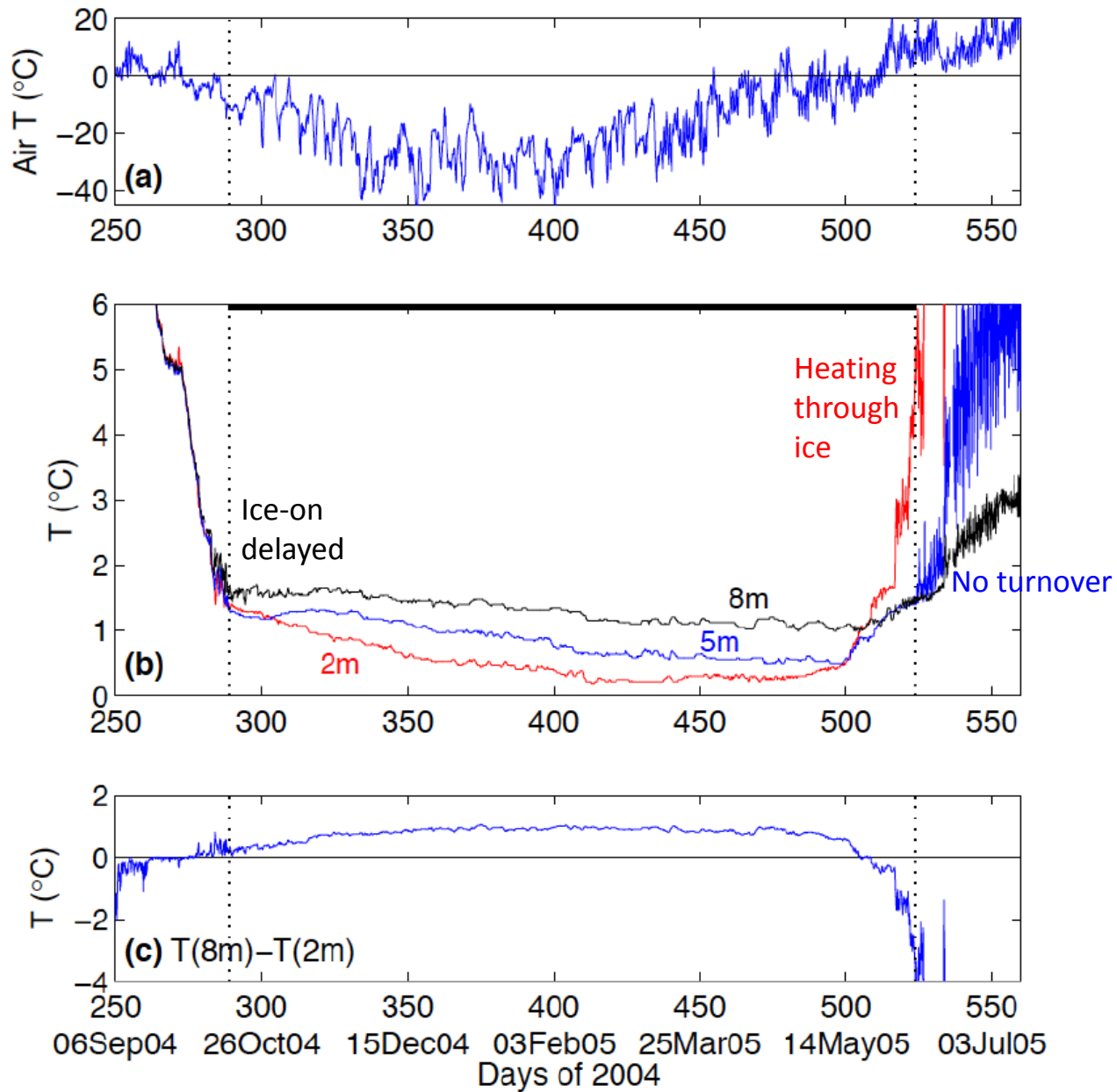
# TAILINGS LAKE, NWT



MIDNIGHT 18 JUNE 2014



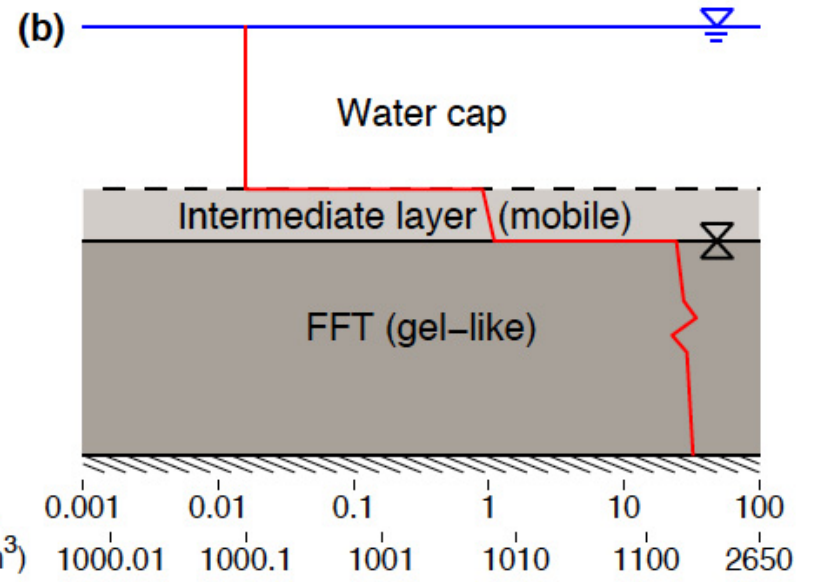
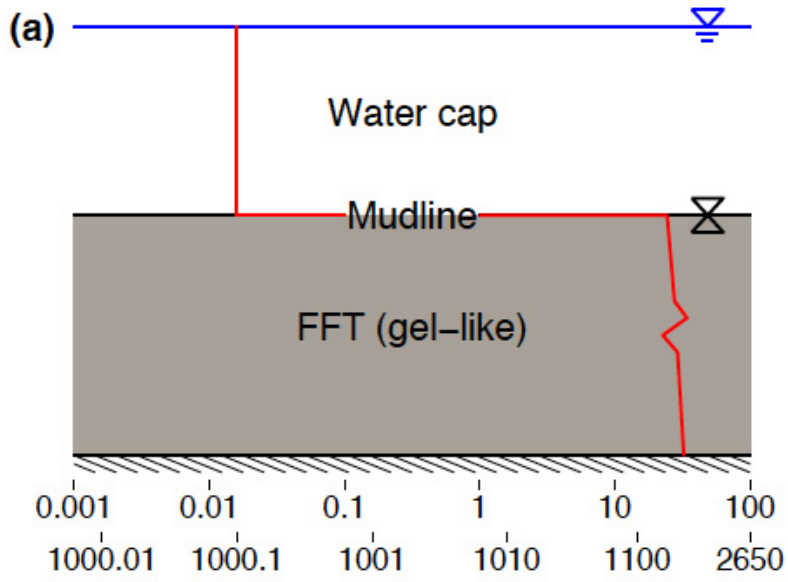
# TAILINGS LAKE TEMPERATURES



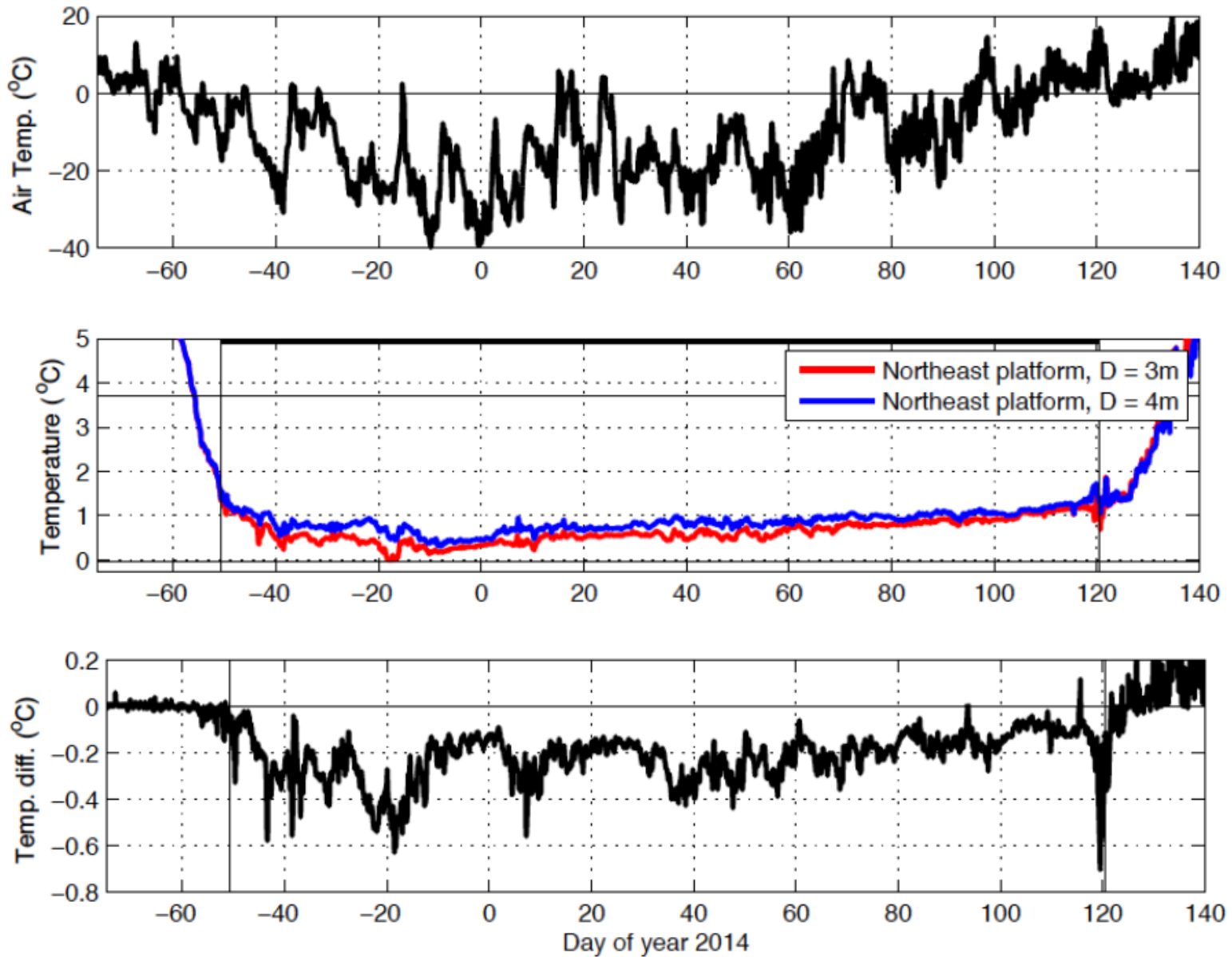
# BASE MINE LAKE





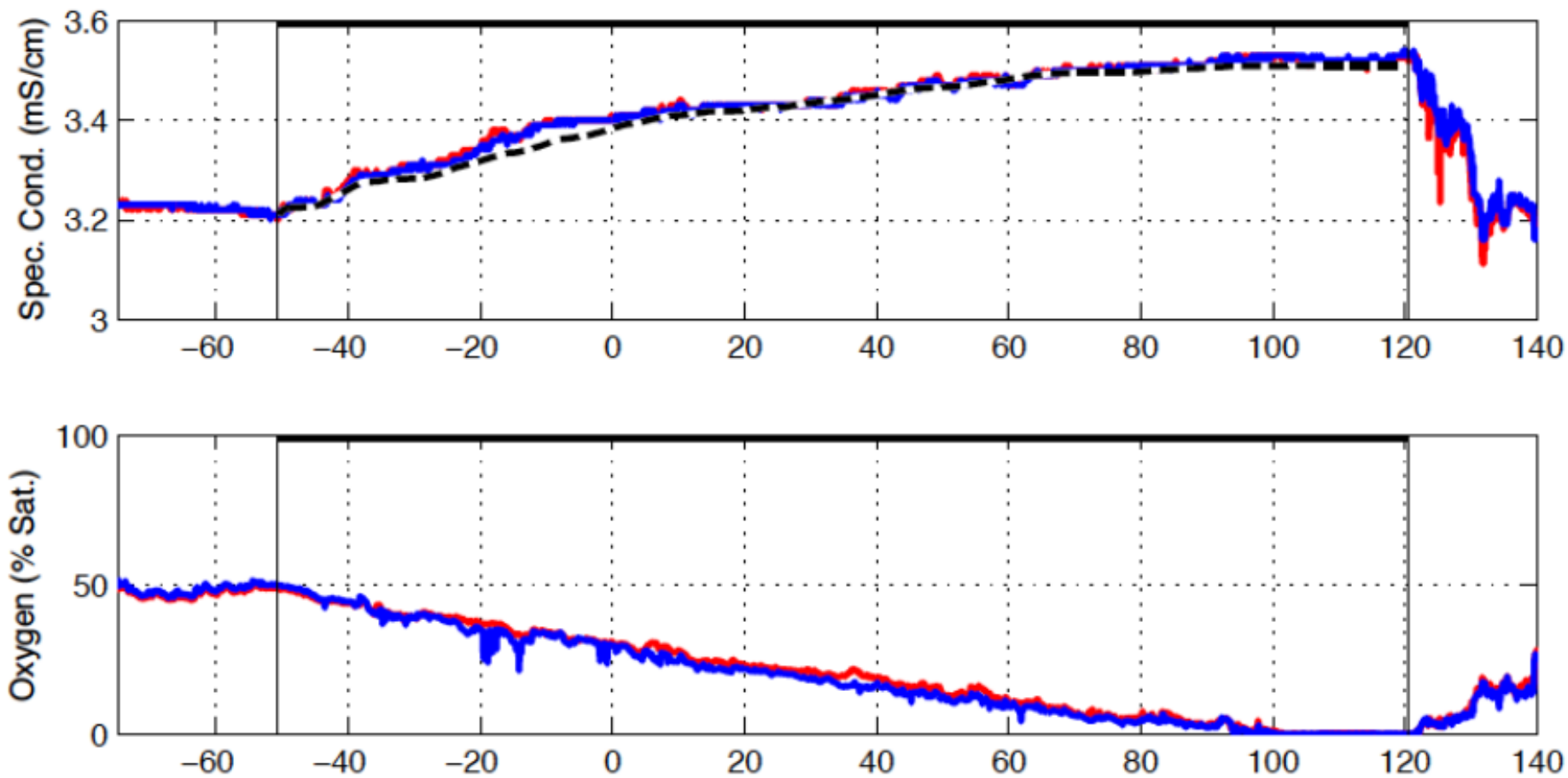


# BASE MINE LAKE TEMPERATURES





## Base Mine Lake Conductivity and Dissolved Oxygen



# Conclusions

- 1. Salt exclusion
  - Causes mixing under the ice
- 2. Fresh ice and snow melt and runoff
  - Creates fresh surface layer inhibiting spring turnover
- 3. Wind
  - Promotes spring turnover and oxygen replenishment
  - Delays ice-on
- 4. Snow melt before ice-off
  - Allows solar heating before ice off enhancing density stratification and inhibiting spring turnover