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Salt Water Intrusion in Coastal Aquifers

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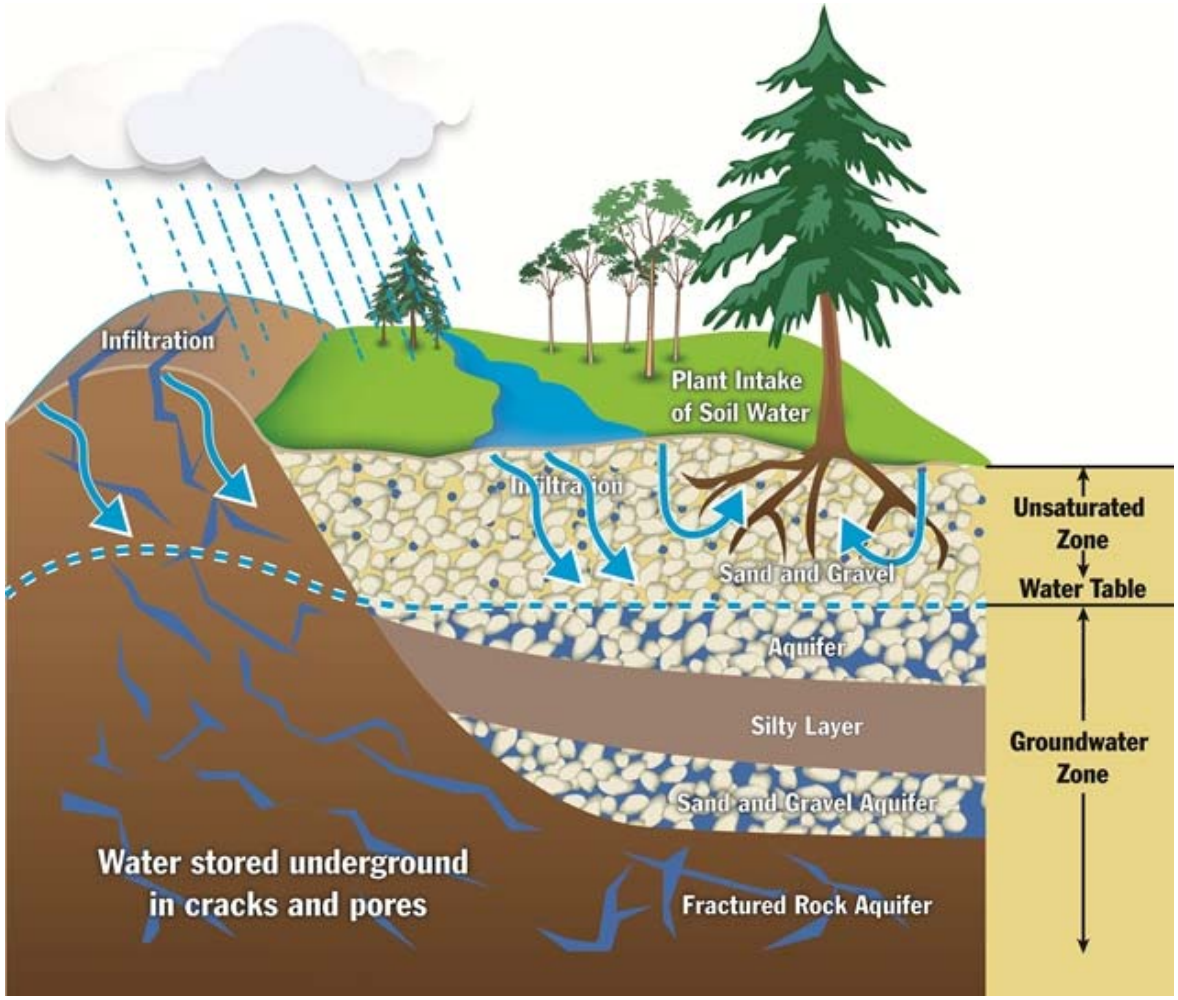
L. Pilgrim, P.Geo.

Agenda

1. What is SWI?
2. What are the causes?
3. Indicator parameters of SWI
4. What is happening in our region?
5. Conclusions

What is Salt Water Intrusion?

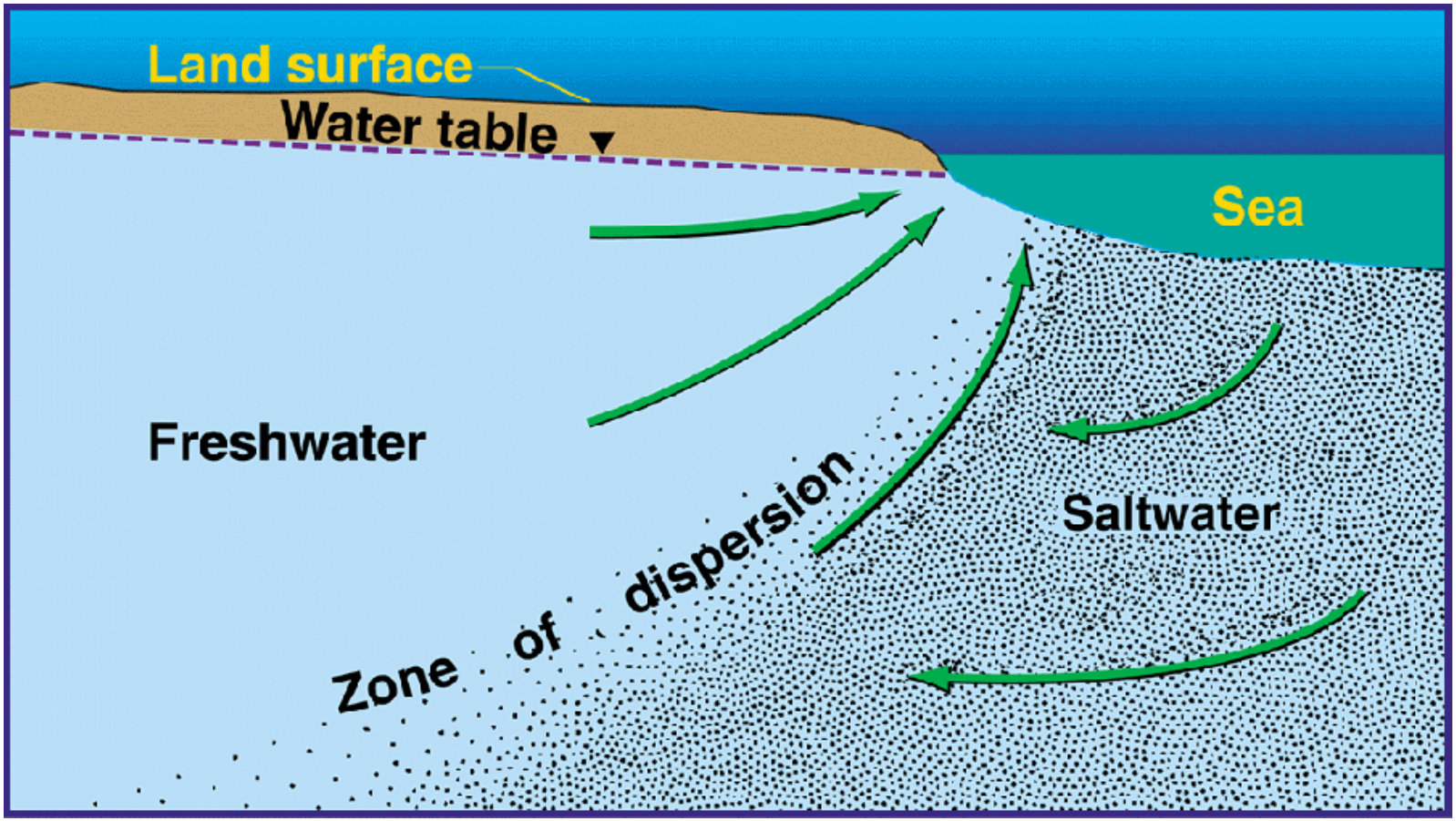
Natural Conditions of Groundwater Flow



SWI

- **Process where seawater infiltrates a coastal aquifer impacting the groundwater**
- **Highly due to density**
- **Greatly affected by the characteristics of the aquifer**
- **Direct relationship between recharge rate and SWI**
- **Saltwater - fresh water interface**

SWI


Land surface
Water table
Sea
Freshwater
Saltwater
Zone of dispersion

What Causes Salt Water Intrusion?

SWI

Factors that affect the saltwater - fresh water interface:

1) **Sea level rise**
2) **Subsidence**
3) **Decrease in recharge**
4) **Increase in pumping/extraction**

Causes – Global Scale

Rising of Sea Water Level

- Caused by global warming, resulting in increase in the quantity of salt water putting pressure on fresh water aquifers

Change in Precipitation

- Slower recharge rate to replenish the amount of fresh water in the aquifer, making it more susceptible to the inland movement of salt water

Climatic Changes

↑ CO_2 emissions + ↑ surface water temperature = ↑ evaporation rate (decrease in recharge)

Causes – Regional Scale

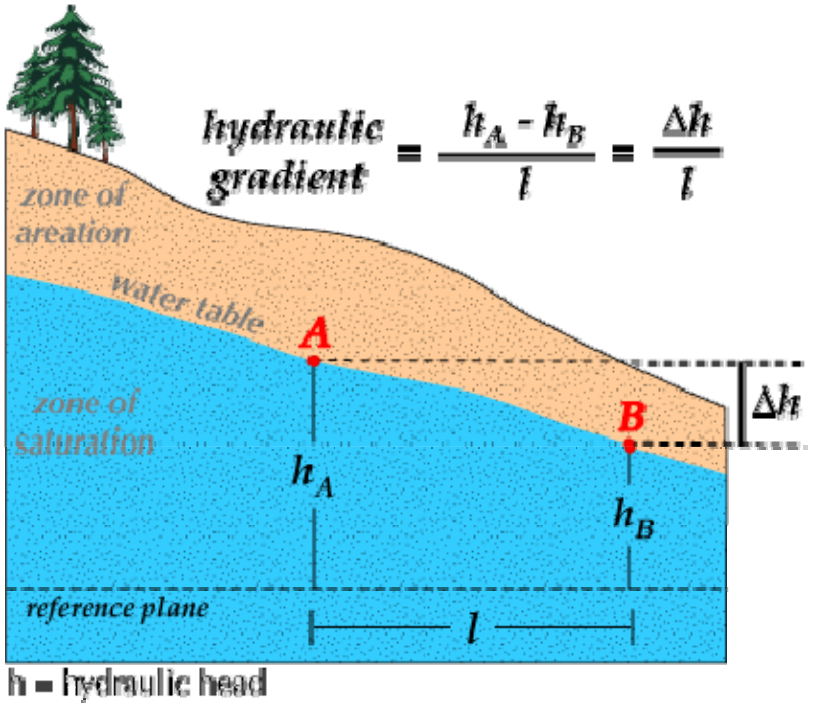
Soil Type

- permeability

Bedrock Type

- fractures

Thickness of water bearing zone



Topography

- Areas with moderate slope potentially more susceptible

Causes – Local

Increase Consumption of Water

- Increase in fresh water demand (groundwater and surface water)

Pumping

- Increase in fresh water demand and longer duration of pumping from an aquifer increases the potential for drawing in salt water along coastal aquifers

Agriculture/Processing

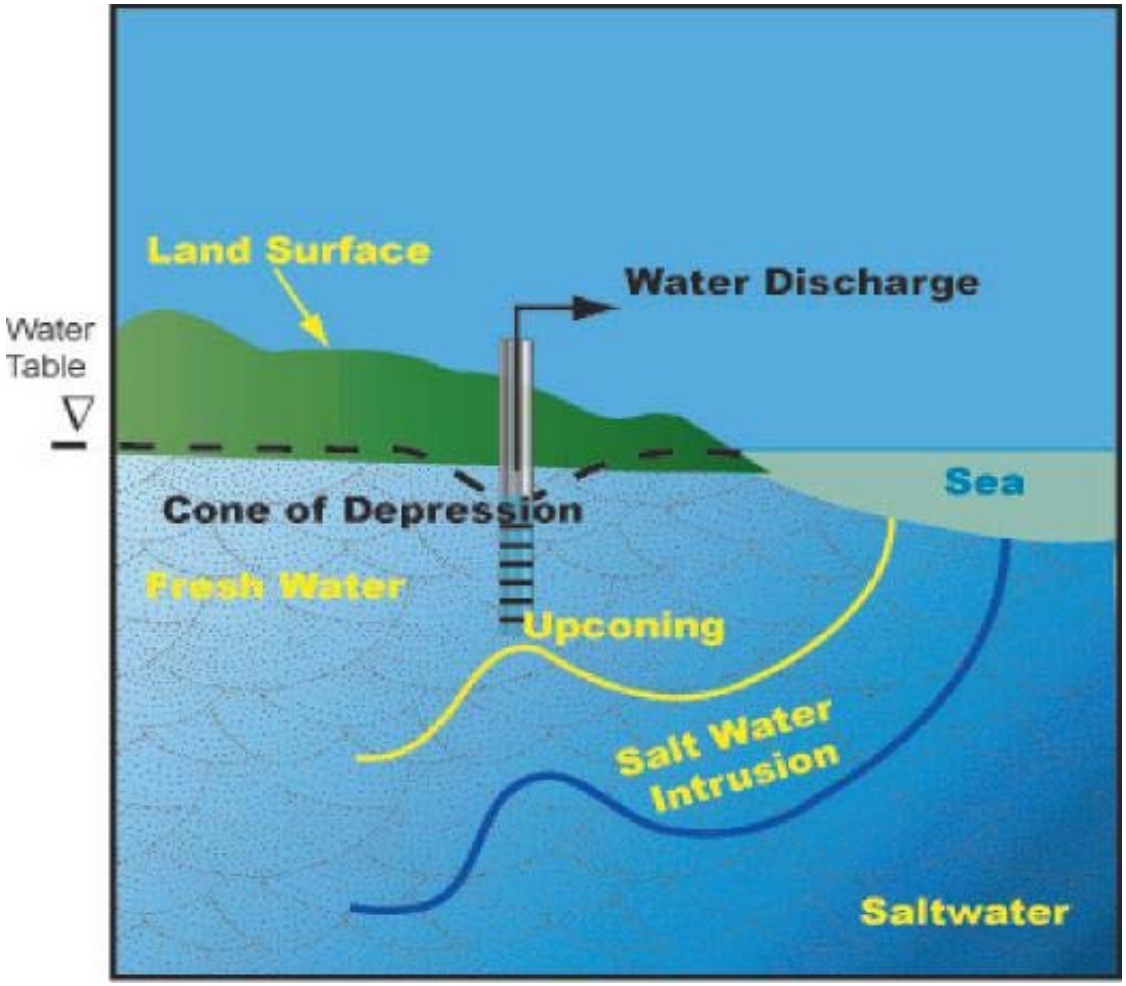
- Human activity requiring an abundance of fresh water

Increase in Development

- Paved surfaces etc., prevent the natural recharge of an aquifer
- Greater potential for impacts
- Aging infrastructure may lead to impacts infiltrating into potable wells and pumping systems

SWI

SWI induced by pumping conditions



Causes

Saltwater can contaminate freshwater aquifers when one or more of the following mechanisms occur:

- Lateral or horizontal intrusion occurs when excessive water withdrawals from an aquifer cause saline water from the coast to move inland
- Vertical movement or upconing of saltwater can occur near a discharge well when water moves toward the wellhead and saltwater in the deeper aquifers rises up
- Cross-aquifer contamination can be caused by wells that are open to multiple aquifers or have casings that have been corroded or broken.

Indicator Parameters

Indicator Parameters

Need an understanding of the aquifer conditions

- Bedrock and surficial geology
- Transmissivity

Need an understanding of the well construction

- Screen placement
- Distance from coast
- Groundwater elevation

Need to obtain baseline monitoring data!!!!!

Indicator Parameters

- Transition zone typically characterized by:

  TDS = 1000 – 35,000 mg/L

  Chloride = 250 – 19,000 mg/L

- Typical Bromide concentration in seawater is ~ 45-65 mg/L.

- Aesthetic Objectives

Parameter	CDWQG
Chloride	> 250 mg/L
Bromate	0.01 mg/L
Sodium	≤ 200 mg/L
TDS	≤ 500 mg/L-
Conductivity	-

Indicator Parameters

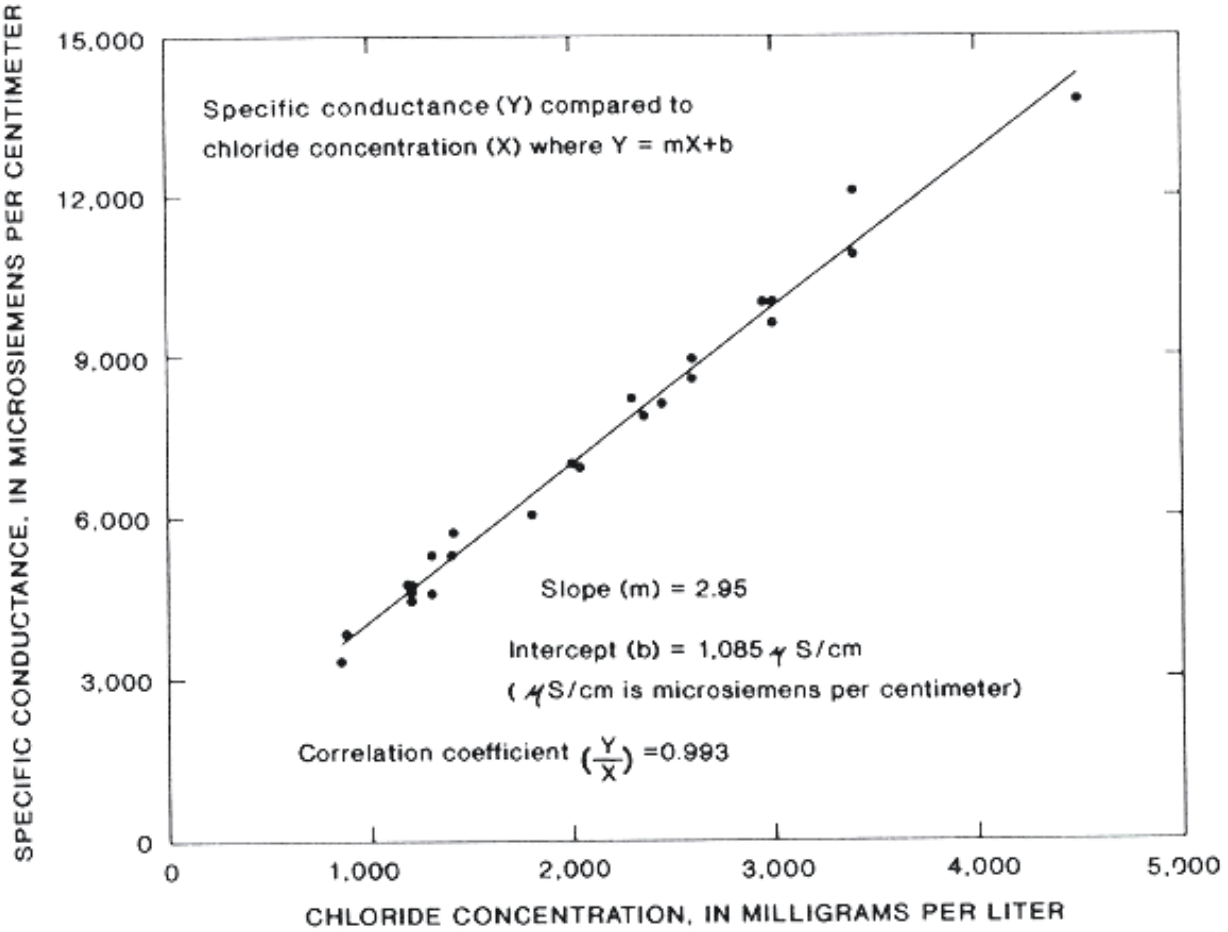
Cl/Br ratio

- Chloride
  - Essential element
  - Highly mobile
  - Very soluble and not easily removed from potable water supplies
- Bromide
  - Could be a result of SWI, dissolution from sedimentary bedrock or human activities/discharge

Parameter	CDWQG
Chloride	> 250 mg/L
Bromate	0.01 mg/L
Sodium	≤ 200 mg/L
TDS	≤ 500 mg/L-
Conductivity	-

Groundwater Monitoring

- Strong correlation between conductivity and chloride



What is Happening in Our Region?

Atlantic Canada

Atlantic Canada has the largest length of populated coastline in Canada

Minimal studies conducted to date

No regional trends to date

Atlantic Canada

Warmer temperatures and more precipitation expected, affecting the recharge rate

Sea level rise is projected to be~ 60 cm by 2100

Land is subsiding in Atlantic Canada by ~20 cm/100 years

Will result in vulnerability along the coastline and to infrastructure

Atlantic Canada

Regional Adaptation Collaborative (RAC)

- Federal program focused on climate change
- Initiative for all provinces and territories

Atlantic Climate Adaptation Solutions Association (ACASA)

- Focus on Atlantic Region
- Collaborative effort between 4 Atlantic Provinces
- Different government departments and universities
- Also studying effects on coastal erosion, flooding and groundwater management

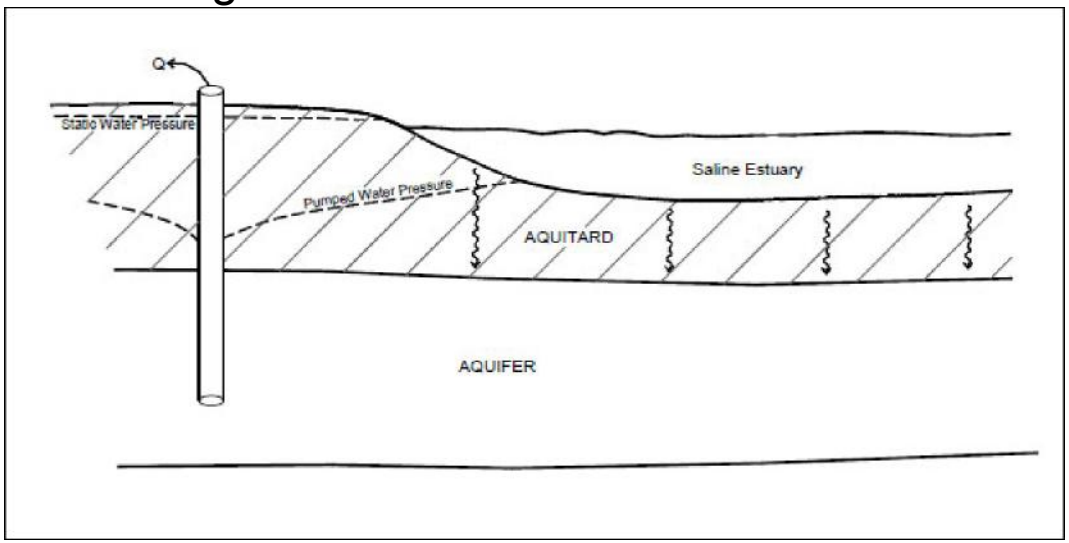
Atlantic Canada

New Brunswick

- SWI due to over pumping in coastal aquifers (Point du Chene, NB)
- SWI due to over pumping for processing

Prince Edward Island

- Vulnerable to SWI due to natural conditions including subsidence, increased tidal action and large estuaries



Atlantic Canada

Newfoundland

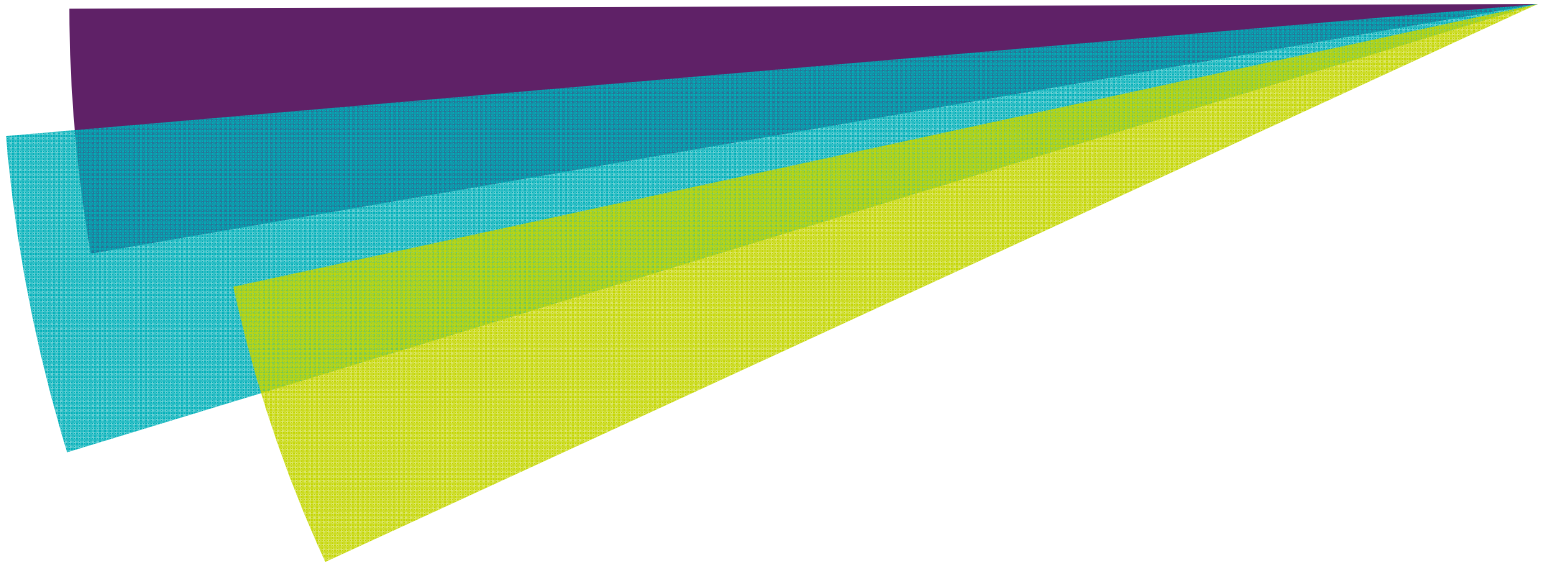
- SWI case study on southwest coast of NL conducted by NLDEC
- Provide baseline data

Nova Scotia

- ACASA conducted studies in Pugwash and Wolfville, NS.
- NS has significant groundwater flow towards the coast
- Sandstone bedrock, low permeability
- Pugwash - salinity likely due to dissolution of gypsum
- Wolfville - salinity likely due to human impacts

Concluding Statements

- Increase risk of SWI due to demand for freshwater
- Requires a better understanding of existing conditions
- Requires more monitoring and study
- Expected to become a more significant issue with climate change.
- Need to plan for the future!



Contact us

Lynn Pilgrim, P.Geo.
Environmental Geoscientist

Amec Foster Wheeler
Fredericton, NB

lynn.pilgrim@amecfw.com
amecfw.com