BRITISH COLUMBIA | Ministry of Water, Land and Resource Stewardship

Seawater Intrusion and Groundwater Conservation

Islands Trust Webinar - March 5, 2025

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Outline

- Introductions
- Seawater Intrusion
  - What is SWI
  - Why it matters (why people should care)
  - What we know about SWI
  - What can we do (prevent, manage)

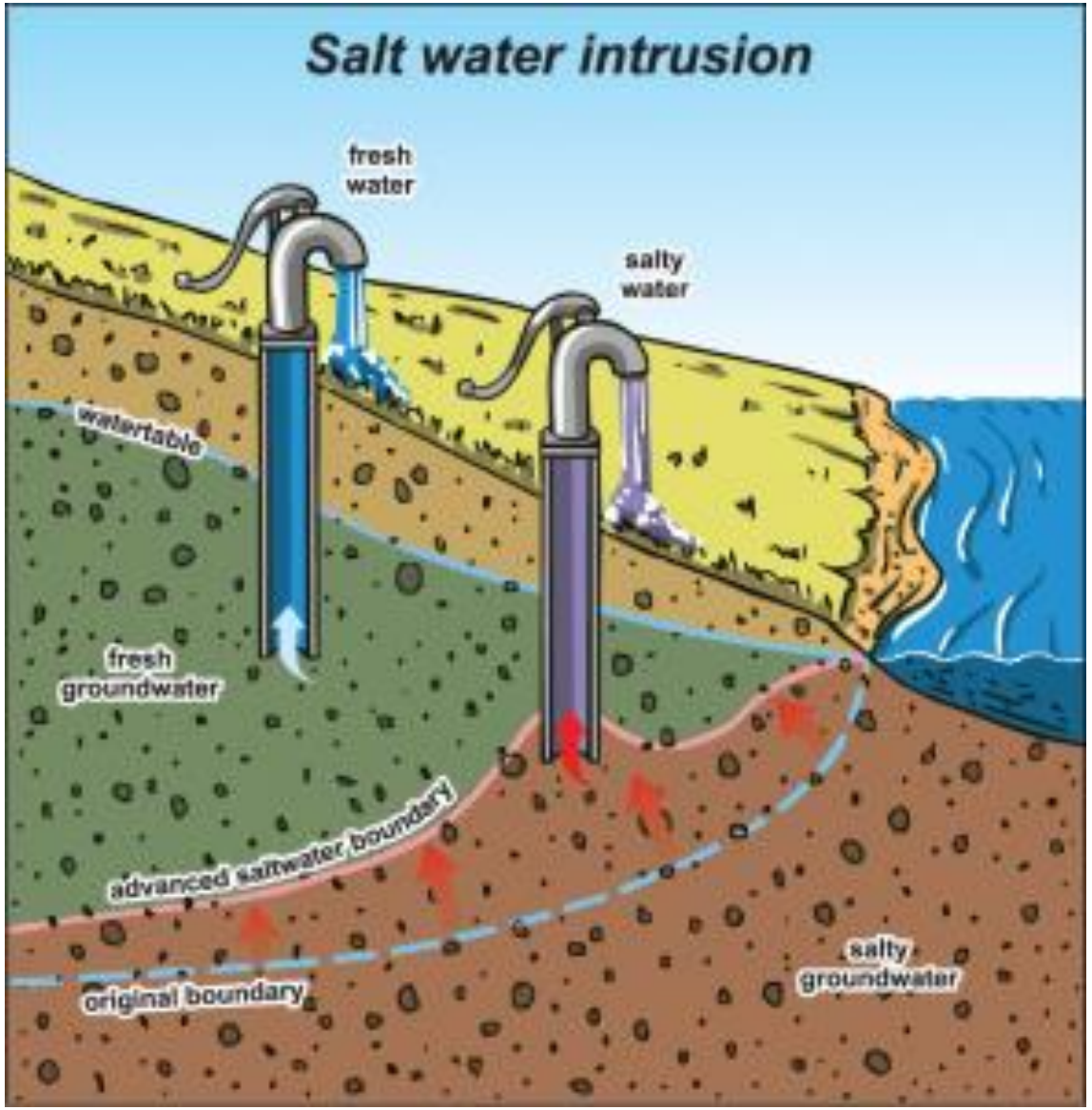
Groundwater Conservation

- Why?
- Conservation practices
- Storage
- Rainwater Harvesting
- Monitoring and Sampling
- Resources

Seawater Intrusion

What is Seawater Intrusion?

- Occurs when saline water is drawn into a freshwater aquifer
- This can affect one well or multiple wells in an area
- Can be from natural processes or caused by human activities
  - Sea level rise
  - Storm surges
  - Pumping
  - Overuse
  - Leaks
- Freshwater floats like a lens above seawater with a transition zone between the freshwater and seawater



What is Sea Water Intrusion?

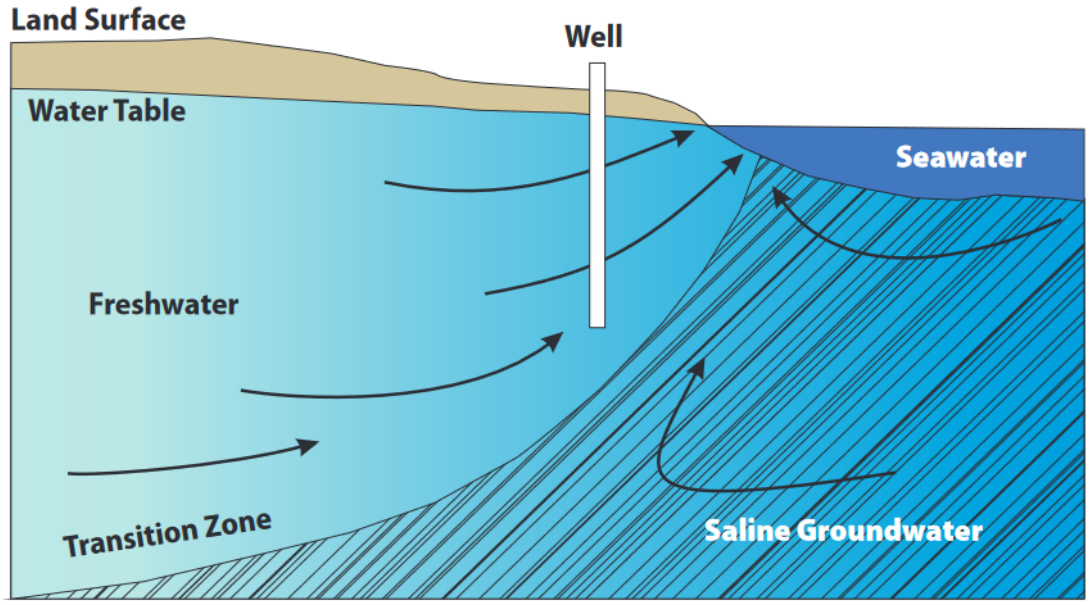


Figure 1: Under non-pumping conditions there is an equilibrium established between fresh and saline groundwater at depth.

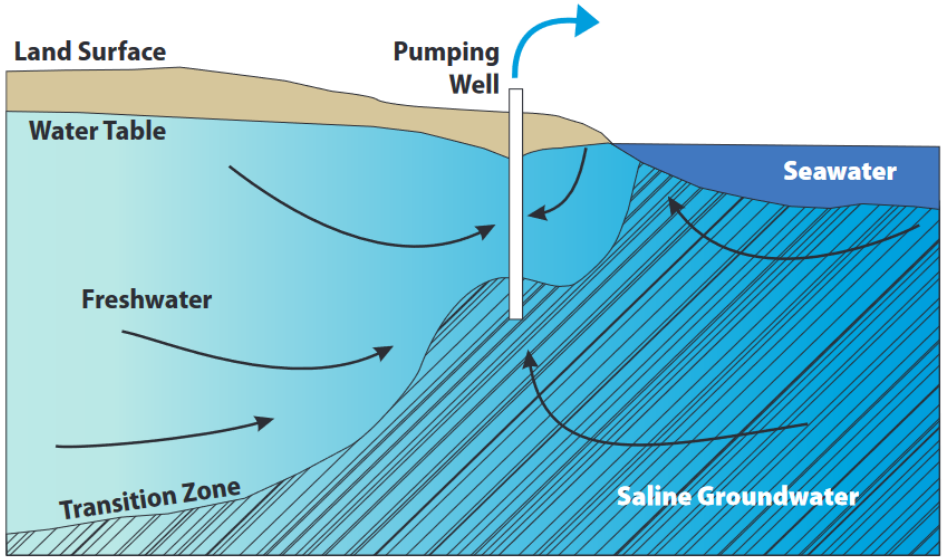
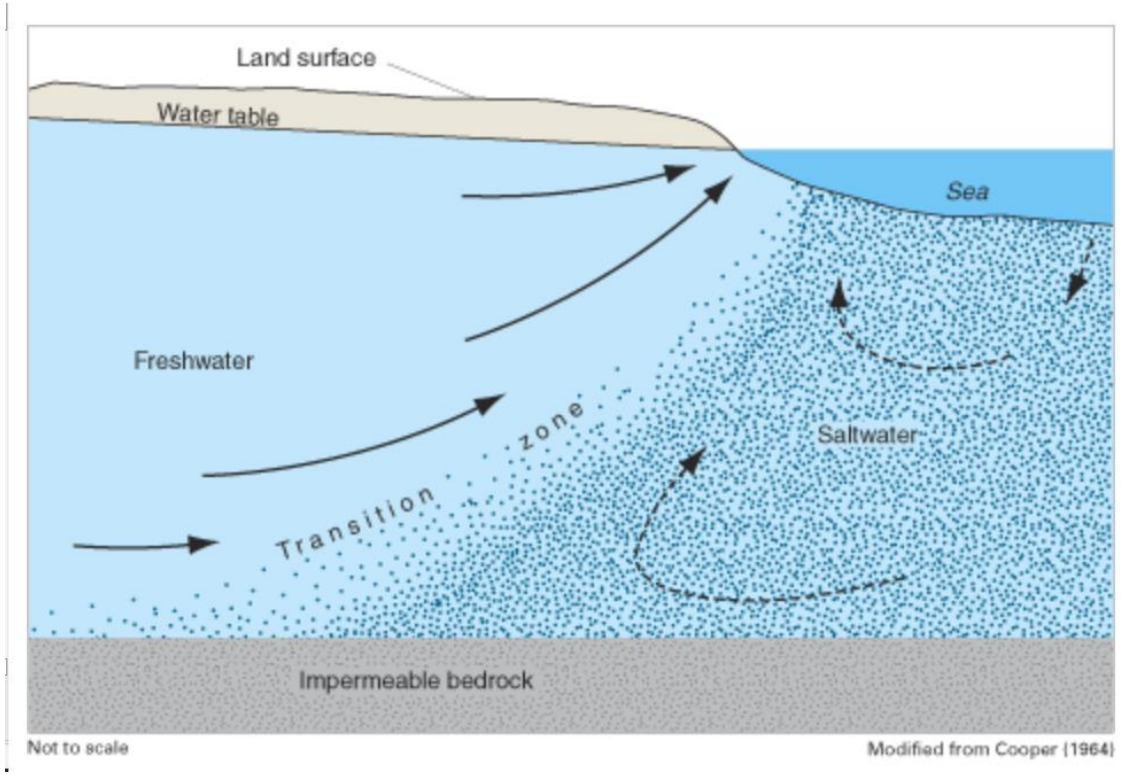


Figure 2: Pumping or other disturbances (e.g. sea level rise, reduced recharge) can lead to upconing or inland movement of the freshwater-saltwater interface. If a single well is over-pumped or multiple wells are pumping, a large area of the aquifer may be impacted by salinity.

Transition Zone



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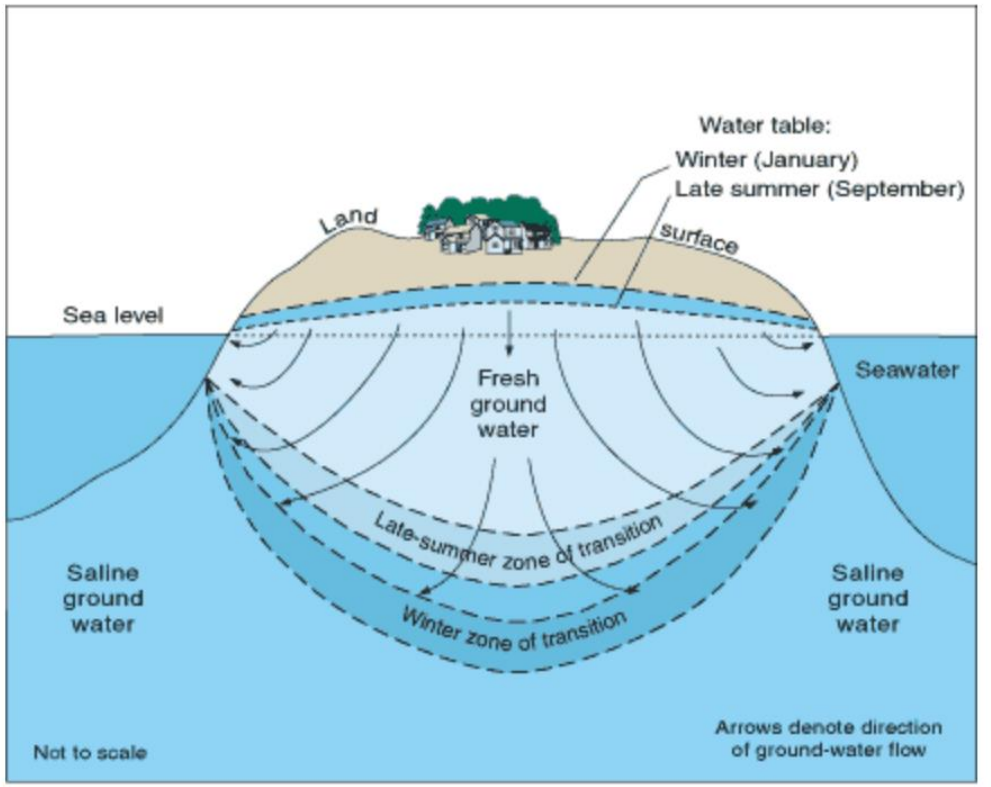

https://pubs.usgs.gov/fs/old.2000/fs-057-00/

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Fun fact: Seawater is denser than freshwater due to the salinity, this results in more complex flow dynamics

-> density-dependent flow

Activities that can Contribute to Intrusion

- Groundwater pumping
- Dewatering excavations
- Decreased groundwater recharge
- Exacerbated by climate change and sea level rise

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Coastal Island Vulnerability

- High density in certain areas
- Small parcels
- High volume of well users close to the coast
- Higher risk of storm surges and floods
- Less recharge capacity
- Sea level rise

- Peninsulas
- Bedrock aquifers
- Increased seasonal use during summer from visitors (during drought)
- Low to moderate slope

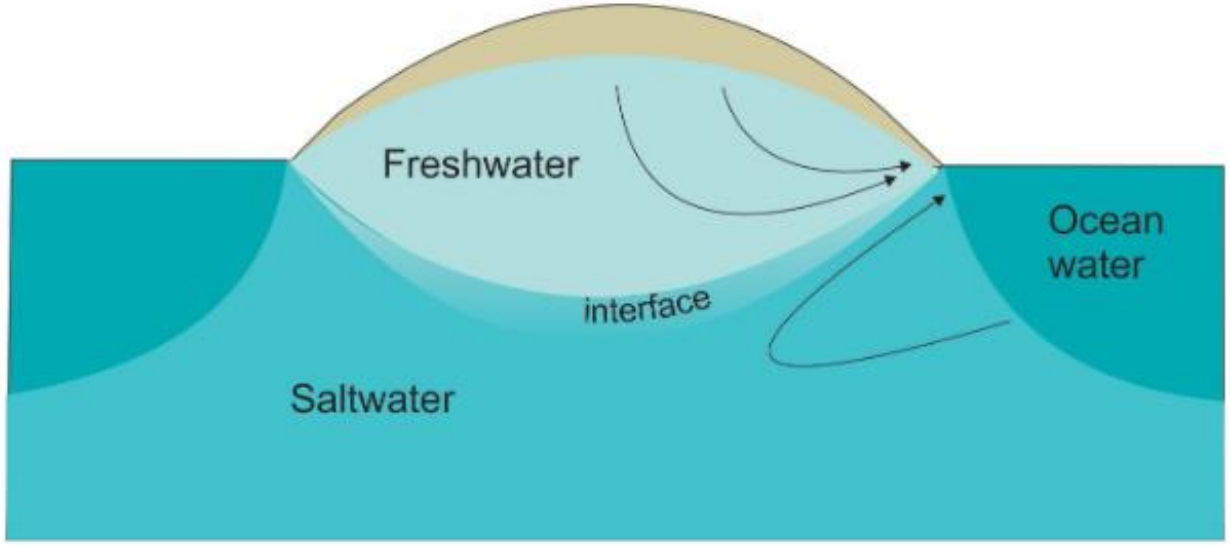

Image Credit: Klassen and Allen 2016

Why does Seawater Intrusion Matter and why Should I Care?

- We are seeing more wells with sea water intrusion & at-risk areas being developed
- Changing climate is causing more impacts (i.e. deepening groundwater levels due to longer drought periods)
- Has impacts to well owners and operators
- This can be very difficult and expensive to reverse (well may have to sit, trucking in water, additional monitoring and testing…)
- It is a growing issue
- Well operation causing sea water intrusion violates *Water Sustainability Act* S.58 (any well use)
- Can affect single wells or wells in an area

How Can It Affect Well Owners/Operators

- Health risks to those at risk (hypertension, elderly, young children)
- Impacts to property values
- Possible damage to plumbing
- Possible damage to garden and landscaping or not being able to use water for watering (risks to your food security)
- Costs of trucking and storing freshwater if needed
- Affecting the aquifer and others that use it like your neighbours
- Impacts to your water source can be complicated, expensive and timely to reverse

Seawater Intrusion & Drinking Water

- Aesthetic objectives
  - Chloride ≤ 250 mg/l
  - Sodium ≤ 200 mg/l
  - TDS of ≤ 500 mg/l

- US EPA Sodium Advisory < 60 mg/l
  - Hypertension (i.e. high blood pressure)
  - Elderly and children more at risk as are people with decreased kidney function

- Challenges for water treatment systems

Table A–1. Average concentrations of major dissolved constituents of seawater (from Hem, 1989, p. 7)

Constituent	Concentration (milligrams per liter)
Chloride	19,000
Sodium	10,500
Sulfate	2,700
Magnesium	1,350
Calcium	410
Potassium	390
Bicarbonate	142
Bromide	67
Strontium	8
Silica	6.4
Boron	4.5
Fluoride	1.3

Reference:
https://pubs.usgs.gov/circ/2003/circ1262/
https://www.epa.gov/sites/default/files/2014-09/documents/support_cc1_sodium_dwreport.pdf

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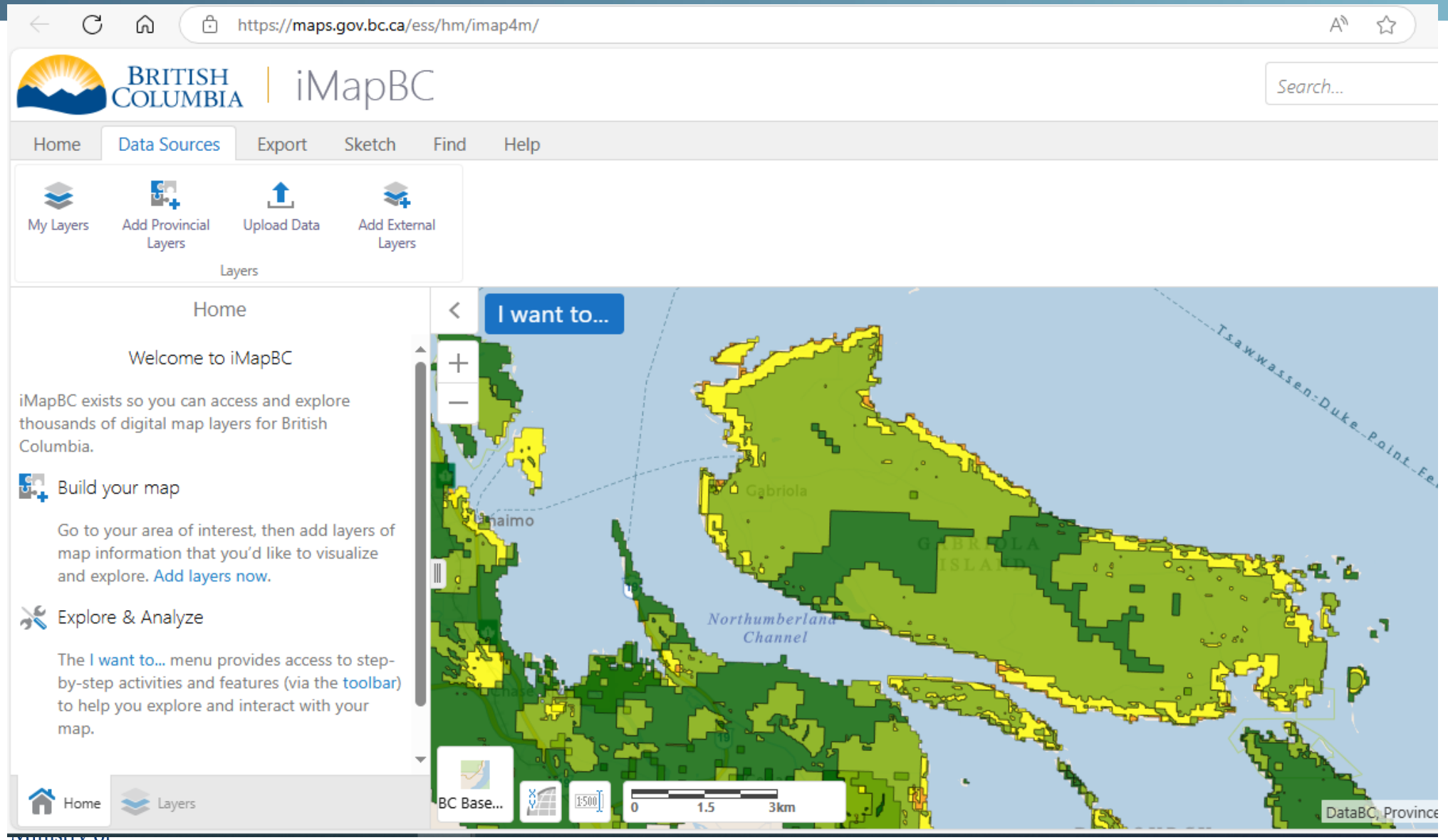
What we Know

- We know about higher risk areas or properties based on data received from compliance files, licensing files, or from third parties
- We can estimate risk based on topography, site conditions, site location and well information
- The Gulf Islands typically exhibit a higher risk for seawater intrusion
  - A seawater intrusion advisory has been developed for well drilling and operation on the Southern Gulf Islands - sea_water_intrusion_advisory__s_gulf_islands_final.pdf
- Known properties and cases of seawater intrusion are increasing
- This is a growing issue for coastal aquifers and aquifer management
- Prevention and mitigation early is critical
- This is a complex issue involving various groups and agencies

Resources, Tools and Mapping

- Studies and reports:
  - Risk of Saltwater Intrusion in Coastal Bedrock Aquifers: Gulf Islands, BC, Jeanette Klassen and Diana Allen, January 2016 - Report Link
  - GIS Modelling of Sea Water Intrusion Risk along British Columbia's Coast, Tim Sivak and Mike Wei, May 2021 - Report Link
- Best Practices for Prevention of Saltwater Intrusion - Best Practices Link
- Seawater Intrusion Advisory – Southern Gulf Islands – Advisory
- iMap BC with "Aquifer Vulnerability to Sea Water Intrusion" layers - iMapBC


https://maps.gov.bc.ca/ess/hm/imap4m/
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Search...
Home
Data Sources
Export
Sketch
Find
Help
My Layers
Add Provincial Layers
Upload Data
Add External Layers
Layers
Home
Welcome to iMapBC
iMapBC exists so you can access and explore thousands of digital map layers for British Columbia.
Build your map
Go to your area of interest, then add layers of map information that you'd like to visualize and explore. Add layers now.
Explore & Analyze
The I want to... menu provides access to step-by-step activities and features (via the toolbar) to help you explore and interact with your map.
I want to...
Gabriola
Northumberland Channel
Tsawwassen-Duke Point Fe
BC Base...
1:500
0
1.5
3km
DataBC, Province
Home
Layers

Data Gaps and Issues

- Difficult to know and have data for seawater intrusion unless it is provided to us
- We can assume risk based on available information and conditions, but don’t exactly know what is going on without data
- Residential impacts not widely known
- Many well owners do not want to report this issue
- Area-based issues exist
- Complex issue that can be difficult to manage

Data Gaps and Issues

- Seawater intrusion is likely occurring in unknown areas but is not being managed or identified by well owners and operators
- Many well owners do not monitor their groundwater levels or water quality at all or frequently enough
- Knowledge gaps exist and there is opportunity for education and outreach on this issue

What Can We Do?

How can well owners or operators, government and municipalities prevent and manage seawater intrusion?

Best Practices

- The most descriptive resource currently for drillers and well owners/operators
- Outlines:
  - What is seawater intrusion, causes and what is a high-risk area
  - Indicator parameters (used as our operational thresholds)
  - Best practices for drilling in higher risk areas
  - Best practices for pump set up and well operation
  - Monitoring options

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Best Practices for Prevention of Saltwater Intrusion (gov.bc.ca)

What is saltwater intrusion and why is it a concern?

Saltwater intrusion occurs when saline (salty) water is drawn into a freshwater aquifer. Saltwater intrusion can affect one well, or multiple wells in an aquifer, making the water unpotable (unpleasant to drink). People with hypertension should not drink groundwater with a high salt content. The health of plants and fertility of soil can be negatively impacted if irrigated with saline groundwater. Once saltwater intrusion occurs, the changes in the aquifer may be permanent or may take many years to recover.

What causes saltwater intrusion?

Saltwater intrusion can occur due to either natural processes or human activities. In aquifers adjacent to the coast and on islands like the Gulf Islands, freshwater floats as a lens above the saltwater, forming a wedge that extends inland from the shoreline *(see Fig. 1)*. Salinity typically increases gradually at the base of the freshwater lens, but in fractured rock aquifers a single fracture can deliver saltwater to a well *(Fig. 3)*. The

While intermixing of freshwater and seawater is one of the main causes of saltwater intrusion in coastal B.C., groundwater within deeper aquifers may also be salty due to geologic processes and interactions between rocks and water over a long time period (e.g. millennia). If a well draws water from one of these deeper aquifers, it can cause saline water to migrate or mix with fresher groundwater in shallow aquifers. Isolated areas of saltwater have also been found at relatively shallow depths e.g.< 50 m in some areas such as Saanich, Mayne Island, Saltspring Island and near Parksville.

What areas are at highest risk?

Areas at highest risk of saltwater intrusion include locations:

- Close to the coast;
- Where there is a low to moderate slope;
- On peninsulas or in areas with a limited source area for groundwater recharge;
- Where there is a high density of wells;

Regulatory Requirements

Well operation

58 (1) A person must operate a well in accordance with the regulations and any directions of an engineer in respect of the well.

(2) A person must not operate a well in a manner that causes or is likely to cause

(a) the intrusion of saline groundwater, sea water or contaminated water into

(i) the aquifer from which that well diverts water,

(ii) another aquifer, or

(iii) a stream that is hydraulically connected to an aquifer referred to in subparagraph (i) or (ii), and

(b) a significant adverse impact on

(i) the quality of water in

(A) the aquifer from which a well diverts water,

(B) another aquifer, or

(C) a stream that is hydraulically connected to an aquifer referred to in clause (A) or (B), or

(ii) the existing uses made of the water diverted from

(A) a well that diverts water from the aquifer,

(B) a well that diverts water from another aquifer, or

(C) a stream that is hydraulically connected to an aquifer referred to in clause (A) or (B).

Water Sustainability Act

Sea water intrusion water quality indicators - Thresholds and Guidelines

Well should only be pumped if water produced meets these operational thresholds

Groundwater quality parameter	Operational threshold for prevention of sea water intrusion[1]	Drinking Water Quality Guideline[2] (guideline type)	BC Water Quality Guidelines for Aquatic Life, Wildlife & Agriculture[3]		
			Aquatic life (Long-term)	Livestock	Irrigation
Chloride (mg/L)	150	250 (AO)	150	600	100
Electrical conductivity (EC) (µS/cm)	1000	ng		ng	
Total Dissolved Solids (mg/L)	700	500 (AO)		ng	

AO=Aesthetic Objective, related to the taste or odour of water, and pleasantness for drinking
ng=No guideline

[1] Province of B.C., 2017. Best Practices for the Prevention of Salt Water Intrusion.
[2] Health Canada, 2020. Guidelines for Canadian Drinking Water Quality.
[3] Province of B.C. 2021. B.C. Approved Water Quality Guidelines: Aquatic Life, Wildlife and Agriculture.

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What does the Province do?

- Internal consolidation of information for more effective management, licensing etc.
- Education and outreach
- Information to well owners and operators
- Development of advisories for seawater intrusion
- Information and support to drillers and well pump installers
- Make informed decisions for licensing (non-domestic) with known seawater intrusion or high risk
- Work with Island Health and other governments and agencies
- Compliance and enforcement when needed

What can Well Owners do?

- Conserve water
- Hire a registered well driller or well pump installer to maintain their well and system
- Submit groundwater samples for lab analysis of water quality
- Monitor the water levels
- Monitor for seawater intrusion parameters (like a handheld conductivity meter) and/or submit samples for lab analysis
- Follow local drought restrictions
- Consider implementation of other water sources and options like storage or rainwater harvesting
- Follow Best Practices for Prevention of Saltwater Intrusion
- Report any violations of the Water Sustainability Act - Identifying and reporting natural resource violations - Province of British Columbia

What can Organizations and Governments do?

- Consider implementation of bylaws or incentives to support sustainable groundwater use such as:
  - Requiring alternate sources
  - Requiring storage
  - Permits required to drill wells in certain areas
  - Use limits during drought
  - Conservation incentives
- Consider seawater intrusion risk, water distribution and availability in development and planning
- Ensure that any non-domestic development and groundwater use apply for a license prior to use
- Identify any known or suspected seawater intrusion
- Encourage and support regional efforts/organizations
- Report any violations of the Water Sustainability Act - Identifying and reporting natural resource violations - Province of British Columbia

Groundwater Conservation and Drought Preparation

Why?

- We need water and it is not infinite
- Can help support groundwater levels year-round and in drought
- Water security and sustainability
- Beneficial for property value
- Save money on trucked water

2024 DROUGHT LEVELS AT A GLANCE

Drought Levels:		4		5		*	Not updated outside of core drought season									
BASINS	20-Jun	27-Jun	4-Jul	11-Jul	18-Jul	25-Jul	1-Aug	8-Aug	15-Aug	22-Aug	29-Aug	5-Sep	12-Sep	19-Sep	26-Sep	3-Oct
Central Coast	1	1	1	2	3	3	3	3	3	3	3	2	2	3	0	0
West Vancouver Island	0	1	1	2	3	4	4	4	5	5	4	4	4	4	2	1
East Vancouver Island	1	2	2	3	4	4	4	4	5	5	4	4	4	4	3	2
Haida Gwaii	0	0	0	1	1	2	2	2	3	4	4	3	3	3	0	0

Prepared By: Water Management Branch - Ministry of Water, Land and Resource Stewardship

BC Drought Information Portal

Conservation Practices

- Conserve year-round
- Prepare for drought before it happens
- Hire a registered well pump installer or registered driller to look at your pump timing and/or pump depth
- Install and use low-flow appliances
- Maintain and check your well and system for proper operation and to make sure there are no leaks
- Follow local restrictions
- Check nearby observation wells if applicable
- Monitor your well

check for rebates in your area

Conservation Ideas

Indoor

- Shorter showers
- Don’t run the tap if you don’t need to
- Fix leaks
- Full loads of laundry and dishes
- Fill the sink to handwash
- Keep cold water in the fridge

Outdoor

- Limit lawn watering and water in the early morning or evening
- Rainwater collection
- Drought tolerant landscaping
- Efficient garden watering
- Check for leaks!
- Be mindful of hose and outdoor water use

Storage

- Supplement your well use during times of drought
- Store water from your well during the winter when groundwater levels are higher
- Use the storage for trucked water if your well goes dry
- Use storage for rainwater collection
- Gives you more flexibility and even having storage capacity can limit panic and unexpected expenses if your well goes dry

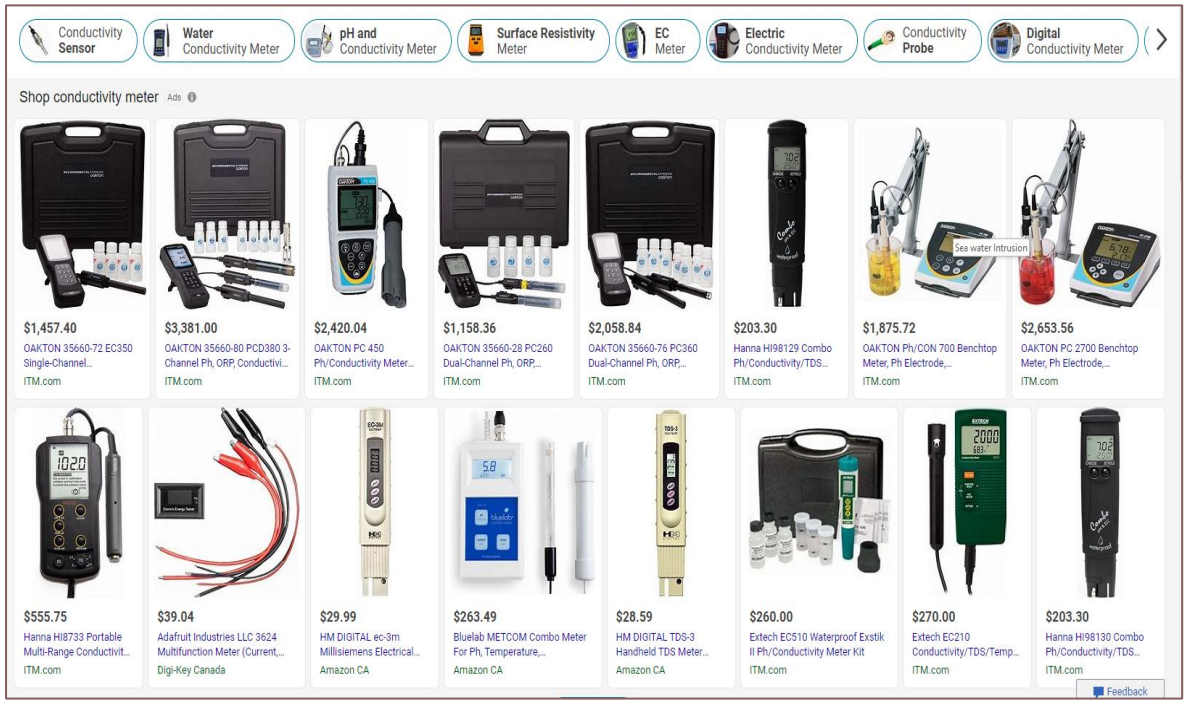
Rainwater Harvesting

- Can be collected for potable or non-potable uses
- Rainwater use is not regulated in BC
- May need construction permits – check with your local municipality
- Non-potable uses
  - Outdoor for water plants and garden, cleaning etc.
  - Indoor use for toilets, washing clothes etc.
- Advised to consult or retain professionals when planning and constructing rain harvesting systems
- Do your research and ensure that your system and construction meets requirements, is safe and efficient

Potable use requires appropriate infrastructure and treatment

Monitoring and Sampling

- You must hire a qualified professional to install/remove monitoring equipment within the well (this is to protect your source, well and the aquifer)
- The type of monitoring you can do will depend on your set up and system, needs, budget etc.
- You can monitor water levels and also you can monitor sea water intrusion indicators like conductivity (hand held meter or possibly meter installed in a well)
- Monitoring can identify: indicator concentrations, water use, conservation, leaks, drought management needs/timing and other benefits
- Consult with a professional on the best option for your system
- Best to have baseline sampling and monitoring data prior to sea water intrusion to assess any trends



There are many different types of monitors that could be used to monitor for sea water intrusion

Resources

- bc_gov_drywellbrochure.pdf
- Drought preparation and response - Province of British Columbia
- BC Drought Information Portal
- Rainwater Harvesting Best Practices Guidebook (RDN)

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Thank you!

Questions and Discussion

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Sea Water Intrusion Mitigation
Well pump set-up and Operation

- Reduce pump depth
- Avoid excessive drawdown of groundwater level below sea level
- Adjust pumping rate & frequency
- Timing
- Increase storage (pump in wet season)
- ★ Leak prevention ★
- Stop use (may be necessary during drought periods or to allow a well to freshen)
- Monitor water quality during pumping tests

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Well pump set-up and well operation:

Reduce use: Conserve water, install low water use appliances and irrigation systems, xeriscape gardens, and consider options for water re-use.

Pump depth: Reduce the pump depth.

Low-volume, high-frequency pumping: Increase the frequency and reduce the duration of well pumping ("well sipping") to minimize drawdown in the well and the surrounding aquifer.

Pump timing: For multi-well systems, program the wells to pump at different times rather than simultaneously.

Increase storage: Increase water storage (e.g. cisterns) and pump in wet season for use in drier periods, or augment the supplies using water from other sources such as rainwater collection. Ensure water in tanks or cisterns is kept free from contaminants by following health guidelines for water storage and disinfection.

Prevent leaks: Install water meters or other alarms/indicators so that leaks can be detected and fixed quickly. Many intrusion problems start with over-pumping because of an unchecked leak.

Discontinue use: If a well is severely impacted by saltwater intrusion, it may be necessary to discontinue using it for a period of time, and use alternate sources, to give the well time to recover, or the well may need to be decommissioned permanently. Refer to the *Water Sustainability Act* (*reference 6*) for the regulations regarding well operation and saltwater intrusion.

Well and System Maintenance

- Important for longevity of well and system
- Can prevent and identify leaks
- Inspect your system and wells regularly
- Conduct any maintenance as soon as possible
- Work on the well and/or pump must be done by a registered well driller or registered well pump installer (depending on work to be done)

Even small leaks can lead to big impacts on your system

- Check appliances
- Monitor your system
- Be on lookup for any changes and possible leaks
- Can cause sea water intrusion

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High Risk Factors

- Can vary from site to site and well to well
- Close to the coast (no “safe” distance but typically ~100 m)
- Low to moderate slope
- On peninsulas or areas with limited groundwater recharge
- High well density
- High pumping rates from a single or multiple wells
- Non-pumping groundwater level is at or below sea level