Contaminant Loading from Near-Shore Onsite Wastewater Treatment Systems Threatened by Sea-Level Rise

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Introduction

- Nearly 50% of all Nova Scotians rely on Onsite Wastewater Treatment Systems (OWTS) for domestic treatment[1].
- OWTS performance relies on a prescribed depth of unsaturated soil to attenuate and degrade contaminants.
- Nova Scotia has the highest sea-level rise (SLR) projections in Canada, with some coastlines predicted to experience greater than 1m of SLR by 2100[2].
- Coastal aquifers are often characterized by a saltwater wedge, a zone of saline groundwater that intrudes at depth due to density differences between the fresh and saline water[3]. As the saltwater wedge moves landward and upward to adjust to rising sea levels, groundwater tables rise synchronously[4].
- Rising groundwater tables can inundate OWTS, leading to decreased contaminant filtration performance[5].

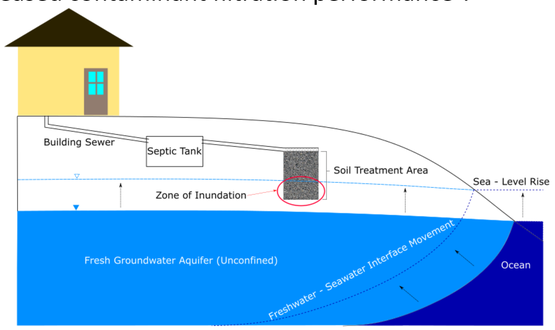


Figure 1: Conceptual cross section of rising sea levels impacting the groundwater table elevation and inundating near-shore OWTS.

Theory & Modelling Framework

- By combining field data, OWTS filter contaminant transport modelling, and regional SLR modelling, the impact of rising sea levels on contaminant loading can be estimated.

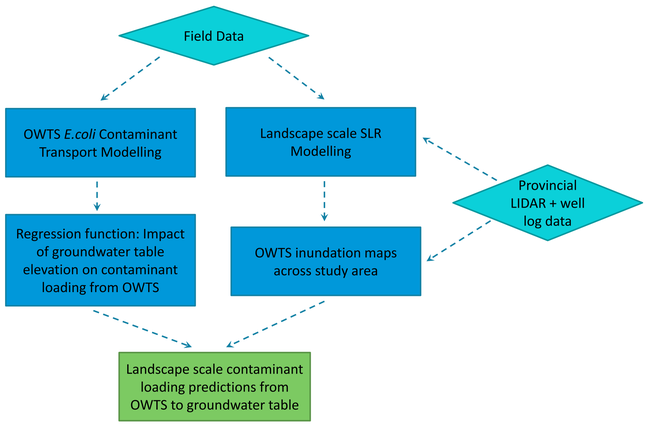
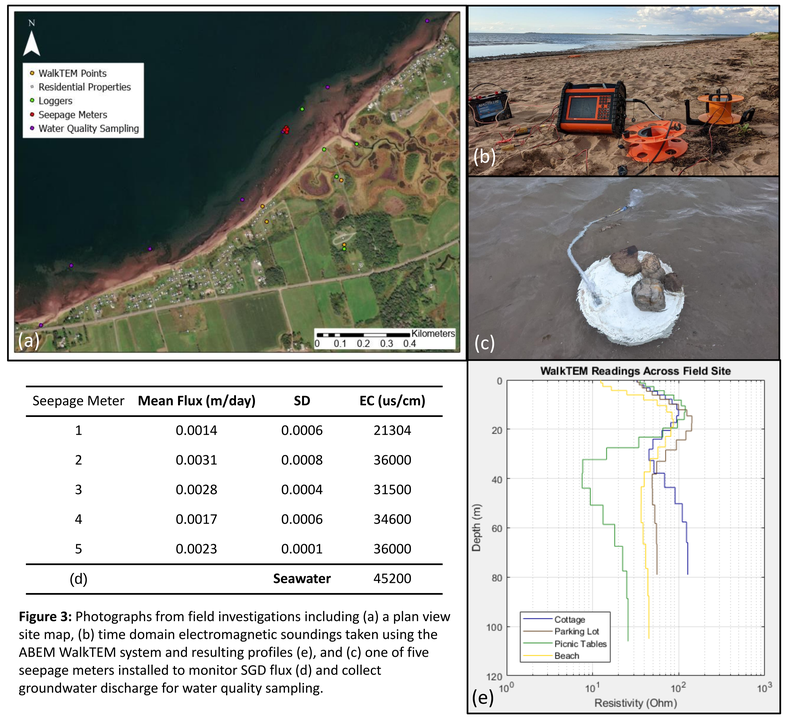


Figure 2: Flow chart describing the modelling framework enabling the prediction of contaminant loading from OWTS resulting from SLR.

Field Investigations

- Field investigations with the intent of parameterising a groundwater flow model and investigating surface water quality were conducted during the fall of 2020 through summer 2021.
- Field activities included: time domain electromagnetic resistivity to investigate lithology and saltwater wedge conditions, seepage meters to measure SGD flux, continuous water level monitoring, and shoreline water quality sampling.



Seepage Meter	Mean Flux (m/day)	SD	EC (us/cm)
1	0.0014	0.0006	21304
2	0.0031	0.0008	36000
3	0.0028	0.0004	31500
4	0.0017	0.0006	34600
5	0.0023	0.0001	36000
(d)		**Seawater**	45200

Figure 3: Photographs from field investigations including (a) a plan view site map, (b) time domain electromagnetic soundings taken using the ABEM WalkTEM system and resulting profiles (e), and (c) one of five seepage meters installed to monitor SGD flux (d) and collect groundwater discharge for water quality sampling.

Modelling Contaminant Loading

- HYDRUS 1D was used in combination with field data to parameterize an *E.coli* transport model of an OWTS under unsaturated conditions.
- Septic bed inundation due to SLR was represented by shortening the unsaturated vertical length of the filter, and re-running the simulation to steady state contaminant loading.
- A quadratic line of best fit was formulated to predict *E.coli* contaminant loading into the groundwater across continuous SLR.

Figure 4: Vertical OWTS filter. Three standard layers used in modelling contaminant transport shown (from top down): the gravel distribution trench, a thin biofilm, and a long sand filter. Arrows indicate septic tank effluent percolation.

Modelling Sea-Level Rise

- A regional scale groundwater flow model is being developed using MODFLOW to determine the impacts of SLR on OWTS filter inundation.
- Groundwater flow conditions including head values across the study site and SGD flux gathered during field investigations will be used for model calibration.
- A fixed head boundary representing annual mean higher-high tide conditions will represent the seaward boundary. This fixed head condition will be increased by 0.25, 0.5, 0.75, 1 and 1.25m respectively to represent SLR, and resulting septic filter inundation will be assessed.

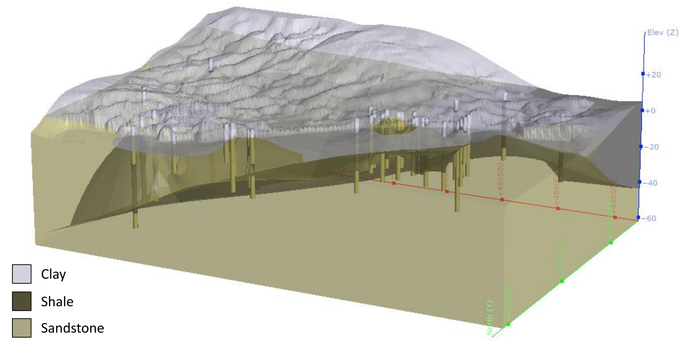


Figure 5: Working geologic model developed using Leapfrog Geo, derived from a series of Nova Scotia well logs as well as field investigations.

Discussion

- Future modelling will aid in the assessment of risk as rising sea levels threaten OWTS filtration performance.
- Flux and water quality data from seepage meters will be repeated in fall 2021 to provide a seasonal dimension to SGD-derived contaminant loading.
- Landscape scale OWTS inundation maps derived from hydrologic modelling will aid in the future development and coastal planning for current and future shoreline infrastructure.

Acknowledgements & References

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