An Open-Source Web Tool for Visualizing Estimates of Well Capture Zones Near Surface Water Features

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Abstract

Identifying areas of the land surface and surface water features (e.g., rivers, lakes, etc.) likely to contribute groundwater recharge to a public groundwater supply well is typically a first step toward source water protection. Identifying the contributions from these areas is important for assessing contamination sources, developing land use management strategies, and mitigating groundwater risk for drinking water supply. Simple analytical solutions that employ Darcy's Law are unable to account for surface water boundary conditions within the flow system. Therefore, capture zone delineation is typically performed using three-dimensional, fully distributed numerical models that require considerable numbers of parameters, stratigraphic data, and user expertise. However, advanced analytical solutions exist that can provide approximations to such solutions using few parameters.In this work, the R Shiny web platform is developed to create an open-source application to allow Internet users to visualize potential flow systems near wells in the vicinity of surface water features. Assumptions include homogeneous stratigraphy and aquifer thickness, a steady state flow field, and relatively simple aquifer geometry. The web tool is currently being developed with a focus on Yukon Territory in northern Canada, where most of the population relies on groundwater, but less work has been done on the analysis of well vulnerability and source water protection than in southern Canada. The results are intended for estimation and education purposes and will be compared with numerical model results for some sites with pre-existing investigations. Abstract ID: 1168805

Plain Language Summary:

Water can flow into the groundwater system beneath the land surface or from surface water bodies like rivers and lakes. A capture zone map shows which land and surface water areas have groundwater flow paths that are likely to reach a groundwater well. Drawing this kind of map is often the first step for protecting drinking water from contamination. Simple equations can sometimes be used to draw these maps if there are no surface water bodies. If there are, then more complicated computer models are needed.

In this work, a freely available Internet app is developed to show what groundwater flow near wells and surface water could look like. The app development has focused on Yukon Territory in northern Canada, where most people use groundwater. The results show a rough estimate to educate people about the possible area where water flows to a well.

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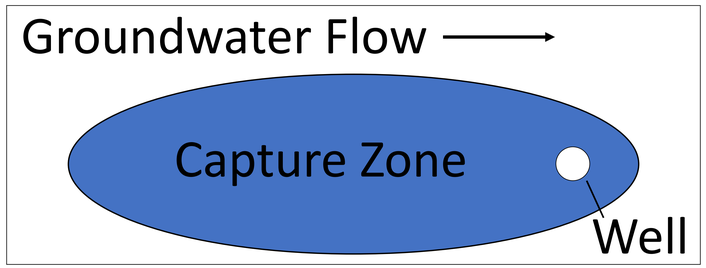
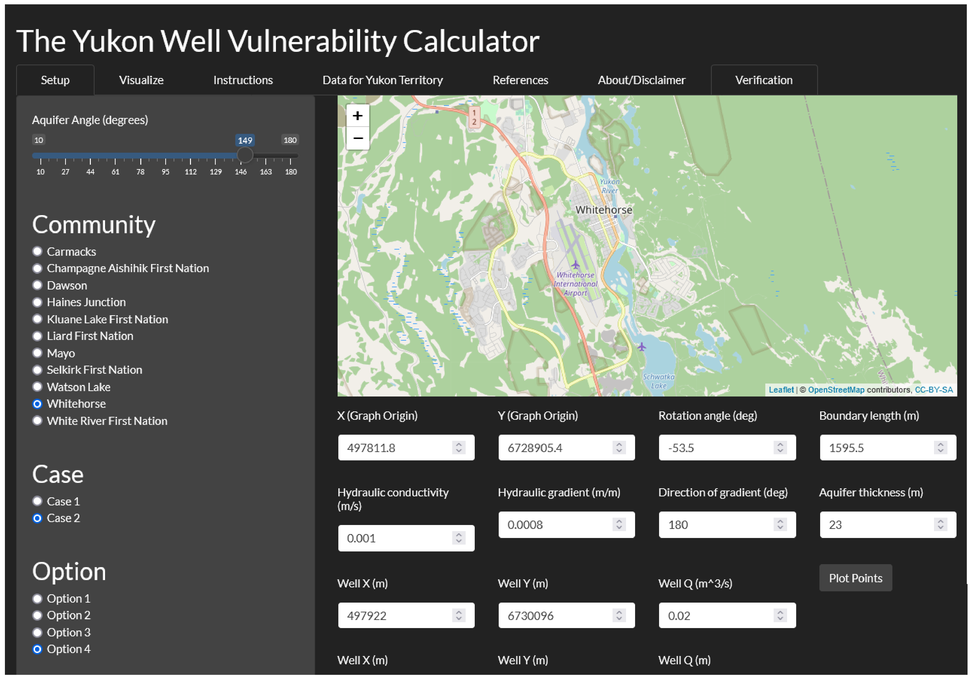
Introduction

- Protecting groundwater wells from contamination requires an estimate of the well's contribution area (i.e., capture zone)





Methods

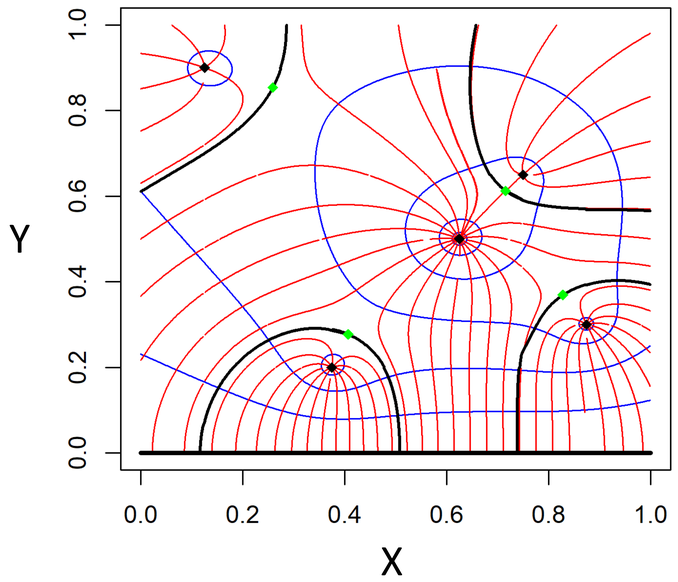
- 2D analytical approach; solve complex equations (Nagheli et al., 2020)
- Remove mathematical artifacts (Holzbecher, 2018)
- Merge segments that go through stagnation points

2D Analytical Method Advantages

- Fast (run time: minutes)
- Few parameters (well coordinates, pumping rates, hydraulic conductivity, and hydraulic gradient)
- Includes surface water features (constant head boundaries)

Results

- Able to re-create demonstration figures from Nagheli et al. (2020)



References

Holzbecher, E., 2018. Streamline visualization of potential flow with branch cuts, with applications to groundwater. J. Flow Vis. Image Process. 25(2):119–144. DOI: 10.1615/JFlowVisImageProc.2018025918.

Nagheli, S., Samani, N., Barry, D.A., 2020. Capture zone models of multi-well system in aquifers bounded with regular and irregular inflow boundaries. J. Hydrol. X 7, 100053. DOI: 10.1016/j.hydroa.2020.100053.

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