Groundwater Flow Model of Bainbridge Island, Kitsap County, Washington

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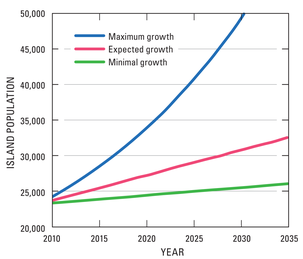
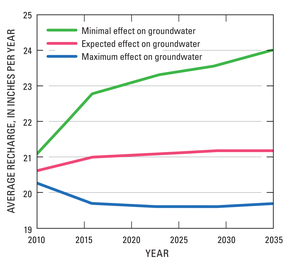
Produced in cooperation with the City of Bainbridge Island

Abstract:

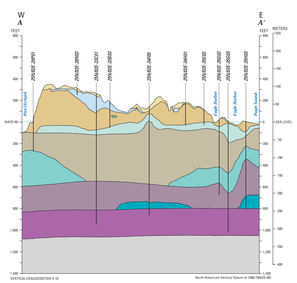
Saltwater intrusion into coastal groundwater wells was studied on Bainbridge Island, WA, using the variable-density groundwater modeling code SEAWAT and the parameter estimation tool PEST. Recharge fluxes were modeled using the Deep Percolation Model (DPM). Future projections of climate change scenarios and population growth forecasts were simulated to 2035 to assess the effects of groundwater withdrawals.



- Population growth estimates for three management scenarios were provided by the City of Bainbridge Island
- Population was geographically apportioned by Traffic Analysis Zone



- Recharge was calculated using the Deep Percolation Model (DPM)
- Impact scenarios are a combination of IPCC climate change scenarios A1B and B1 and projected to land use
- Septic returns from additional population distributions were added to recharge in areas without central sewer systems

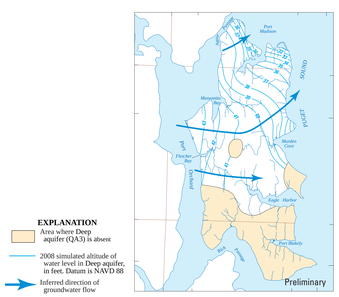


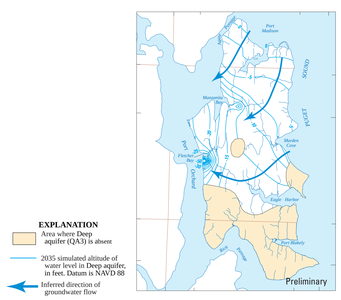
EXPLANATION

Hydrogeologic Units

- Vashon till confining unit (Qvt)
- Vashon aquifer (Qva)
- Upper confining unit (QC1), locally includes Permeable interbeds (QC1 pi)
- Sea-level aquifer (QA1)
- Middle confining unit (QC2)
- Glacio-marine aquifer (QA2)
- Lower confining unit (QC3)
- Deep aquifer (QA3)
- Basal confining unit (QC4)
- Bedrock (BR)

- The extents and thicknesses of 11 hydrogeologic units were identified from more than 400 drillers' logs
- Five aquifer units were identified, with more than two thirds of the wells in the shallow aquifers but 35 percent of groundwater extraction from the deepest aquifer, in which only a few wells were drilled





Predevelopment groundwater flow direction is from the Kitsap Peninsula east toward the study area, transporting water beneath Port Orchard Bay. Model simulations run out to 2035 under the high impact scenario suggest that increased groundwater withdrawals and decreased recharge from climate change may combine to reverse the direction of groundwater flow. The model predicts that under this scenario, pumping wells on Kitsap Peninsula would reverse the direction of groundwater flow starting in 2025.

S. Geological Survey

Model Inputs:

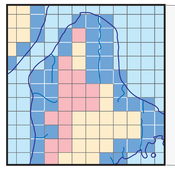
EXPLANATION

Area where Vashon till confining unit (Qvt) is

- Absent
- Present

Model cells

- Constant head
- Drain

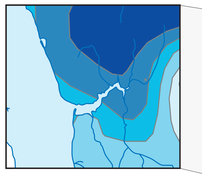


- 668 square kilometers modeled as 139x197x33 cell finite difference grid
- Cells are 800 square feet
- Model domain extended to topographic boundaries on all sides
- Sea level interface modeled as Constant Head boundary
- Lakes and eastern boundary of domain modeled as General Head boundaries

EXPLANATION

Thickness of the Deep aquifer (QA3), in feet

- Less than 75
- 76 to 150
- 151 to 225
- 226 to 300
- Greater than 300

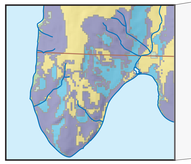


- Wells assigned to individual units based on depth
- Aquifer system heterogeneity was reduced to a simplified hydrogeologic framework
- Aquifer thicknesses interpolated using Arc GIS

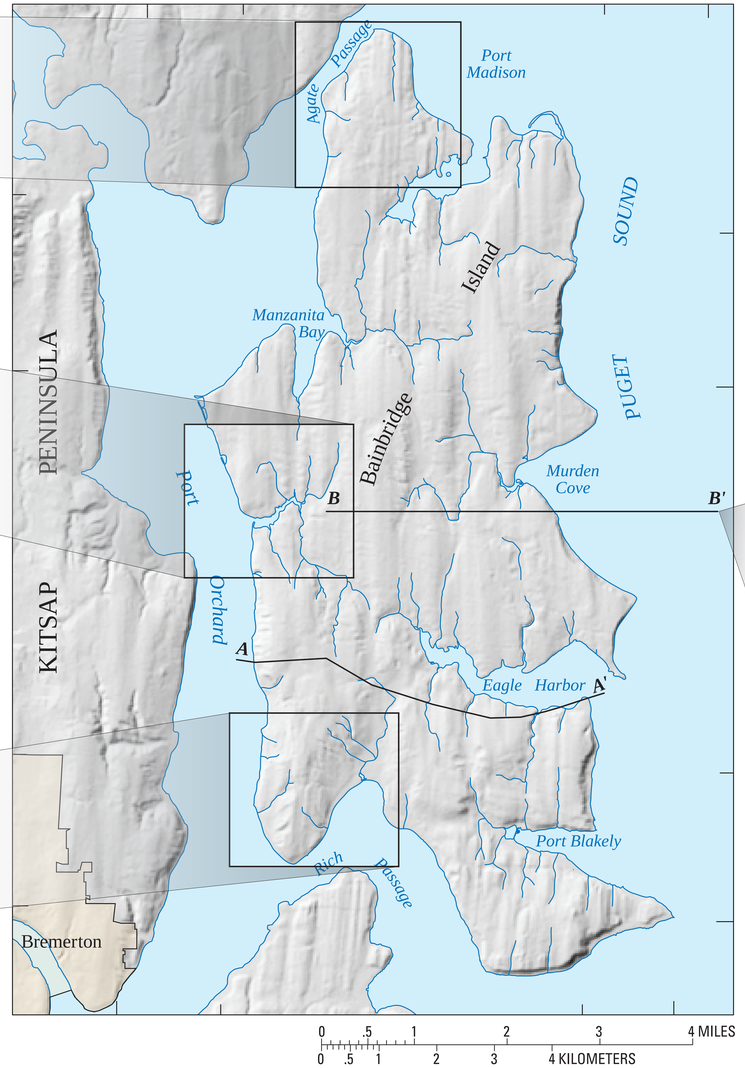
EXPLANATION

Mean annual recharge, in inches per year

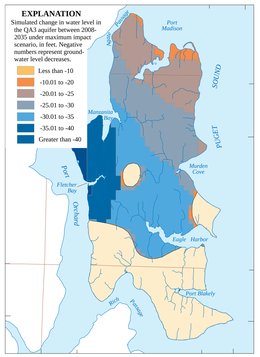
- 0 to 15
- 15.01 to 20
- 20.01 to 25
- 25.01 to 30
- Greater than 30



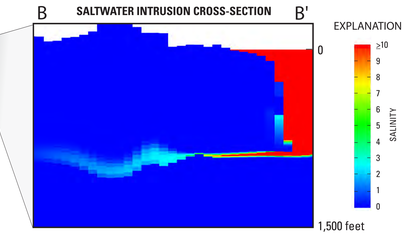
- Groundwater recharge to water table were simulated using DPM
- Simulations account for temperature, soil type, slope, aspect, and evapotranspiration
- Recharge from precipitation was augmented by septic returns assuming 30 percent consumptive use by domestic users



Model Results:



- Under the high impacts scenario, groundwater levels on the island are expected to drop as much as 40 feet
- Primary cause of drawdowns is potential increase in groundwater withdrawal on the Kitsap Peninsula, not increases in local pumpage
- Significant changes to water table contours are expected to reverse the direction of groundwater flow starting in 2025



- Local concerns about saltwater intrusion due to groundwater withdrawal from coastal wells appear to be unfounded
- Model predicts no significant effects on coastal wells prior to 2100, even under the maximum impact scenario
- If saltwater intrusion were to occur, the deep aquifer (QA3) would be expected to see the most impact

- Particle tracking was used to delineate recharge areas for the City's wells
- Wells in the sea-level aquifer are recharged from a small area to the northwest
- Water in the wells screened in the glaciomarine and deep aquifers was not recharged from the surface of Bainbridge Island within the last 1,000 years.

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