

Groundwater Vulnerability

Summary

All groundwater is vulnerable in relative terms and karst ground waters are even more vulnerable. “Groundwater Vulnerability” is an index of the factors that characterize the intrinsic vulnerability of karst groundwater in regards to hazards, vulnerability, and resource protection. The original purpose of this index was for use as an input for determining environmental suitability of land use practices for the 2006 Jefferson County Green Infrastructure Assessment. See “Appendix_Groundwater Vulnerability Methodology” for methods used to develop the index.

- *Hazards*: Population Density, Sensitive Karst Feature Density, Septic System Density
- *Vulnerability*: Stream Density, Sensitive Karst Feature Density, Groundwater Recharge Potential, Hydraulic Conductivity, Transmissivity
- *Resource Protection*: Source Water Protection Areas

Notes

- ◆ If maps of drinking water service areas were available, density of private wells could be incorporated into the index.
- ◆ An accurate map of sinkholes would be of use in increasing the overall accuracy of the index.
- ◆ Forthcoming geospatial data for wastewater service areas could be used to refine septic system density.
- ◆ The Source Water Protection Area dataset was obtained in 2004. A more recent version may be available from Scott Rodeheaver (WV Dept. of Health and Human Resources – Source Water Assessment and Wellhead Protection Program; Phone 304-558-6713).
- ◆ Incorporating fracture trace density into the index would aid in identifying areas of high seasonal water tables. Areas with high water tables are vulnerable to groundwater contamination as there is little to no attenuation of contaminated runoff in these areas. Conversely, a map of water table depths would be more helpful.
- ◆ All inputs were assigned equal weights. The index could be modified by weighting some inputs higher than others.

Input Data

1. Population Density [pop_den] - A measure of potential contamination from leaking sewer pipes and contamination from human-related activities e.g. used motor oil or pesticides.
2. Stream Density [stream_den] – Karst terrains are typified by a paucity of surface drainage relative to other landscapes. Thus, areas with less surface drainage (lower stream density) have a greater proportion of rainfall recharging groundwater than areas with more surface drainage. Calculated on a watershed basis. Stream density is not directly correlated to “Distance from Stream”.
3. Sensitive Karst Feature (caves and sinkholes) Density [krst_feat_den] - A measure of the likelihood of runoff entering directly into the groundwater through caves or sinkholes.
4. Groundwater Recharge Potential [gw_rchrg] - A measure of both the potential volume of water percolating into the ground and the probability that it will not enter a stream through surface runoff or shallow subsurface flow. Incorporates a topographic index and distance from streams.
 - 4.1. Topographic Index - Used to estimate the potential amount of runoff at a given point on the landscape by integrating topography and soil permeability. Can indicate areas of high seasonal water tables.
 - 4.1.1. Inputs
 - 4.1.1.1. Slope – Steeper slopes accumulate more water at bottom of slope.
 - 4.1.1.2. Upstream Drainage Area – The accumulated area draining to a given point.

- 4.1.1.3. Soil Permeability - A measure of how fast water percolates into the ground.
- 4.1.2. Topographic Index = $\text{Ln}(\frac{\text{upstream drainage area}}{\text{Tan}([\text{slope}] * [\text{soil permeability}])})$
- 4.2. Distance from Stream - The greater the distance from a stream the greater proportion of rainfall recharges groundwater rather than entering a stream or river through surface and subsurface runoff.
- 4.3. Groundwater Recharge Potential = Distance from Stream + Topographic Index
- 5. Hydraulic Conductivity [hydl_cond] - A measure of how fast groundwater water moves vertically.
- 6. Transmissivity [trnmsvty] - A measure of how fast groundwater moves horizontally.
- 7. Source Water Protection Area [swap] – Area delineated by West Virginia Bureau for Public Health for protection of public water supplies.
 - 7.1. There are three types of source water protection areas:
 - 7.1.1. Community: Serves at least 15 service connections used by year-round residents or regularly serves 25 year-round residents.
 - 7.1.2. Non-Transient Non-Community: Serves at least the same 25 nonresidential individuals during 6 months of the year.
 - 7.1.3. Transient Non-Community: Regularly serves at least 25 nonresidential individuals (transient) during 60 or more days per year.
- 8. Septic System Density [septic_den] - A measure of potential contamination from inadequately maintained or improperly sited septic systems. Approximated through use of locations of addressable buildings. Buildings within wastewater treatment plant collection areas (estimated) were excluded.