United States Environmental Protection Agency

Using Geographical Information Systems (GIS) to Identify the Geographic Regions Where People That Use Ground Water are Most Vulnerable to Impacts from Underground Storage Tanks

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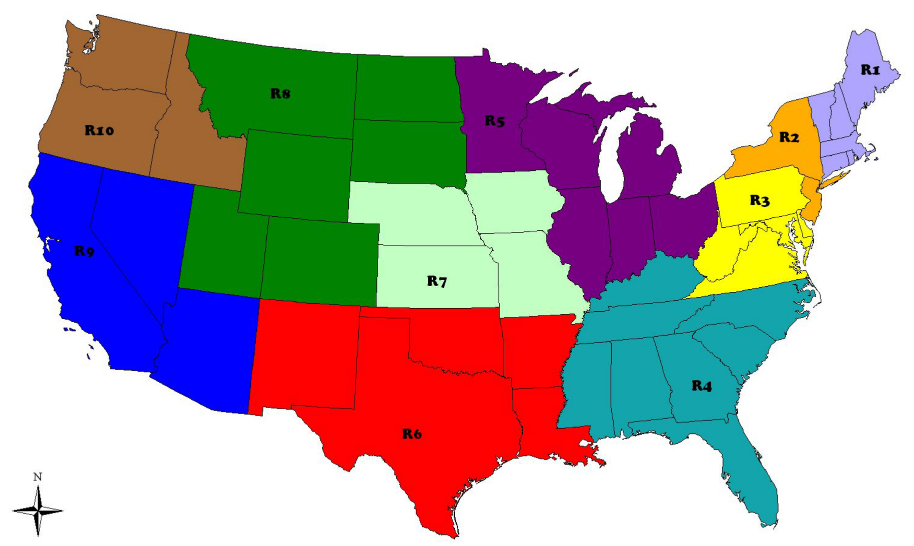
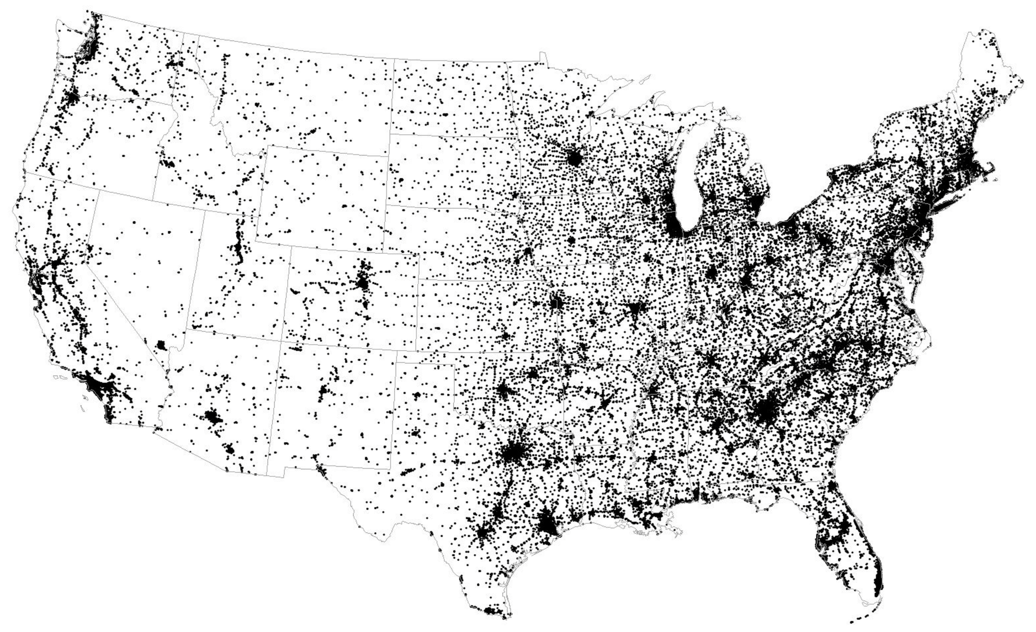
Background and Overview

Using Geographic Information Systems (GIS), the vulnerability of ground water supplies to contamination from underground storage tanks (USTs) was assessed. The analysis was conducted for the 48 contiguous states, and then again for groups of states corresponding to the EPA Regions. The long form of the 1990 U.S. census asked the respondents the source of water for their home. The choices were: (1) a public system such as a city water department or private company; (2) an individual drilled well; (3) an individual dug well; or (4) some other source such as a spring, creek, river, cistern, etc. The reported estimates for the numbers of drilled wells, dug wells, and other supplies of water were summed to obtain an estimate of the number of households in each census block group that obtained water from a private source. The 1990 census also reported the surface area [square miles] of each census block group. A data file was purchased from ESRI Business Solutions that contained the latitude and longitude of active retail gasoline service stations in the United States. Using Geographical Information System tools (GIS tools) and geo-referenced GIS coverage files on each census block group, the latitude and longitude of each active service station was used to assign the service station to a census block group. Then the number of service stations in each census block group was summed. A simple probability analysis was performed based on the distribution of service stations and the distribution of the households that obtained water from a private supply. Three separate indices were calculated. Each index was calculated for those census block groups that had at least one service station and at least one household that obtained water from a private source.

US EPA Regions



Vulnerability Index 1 is the density of service stations in each census block group. It is calculated as the number of service stations in each census block group divided by the area of each census block group in square miles. It provides an estimate of the potential for the water supplied to a household from a private source to be impacted by a service station. Vulnerability Index 1 describes the consumer's risk of having his water supply impacted.

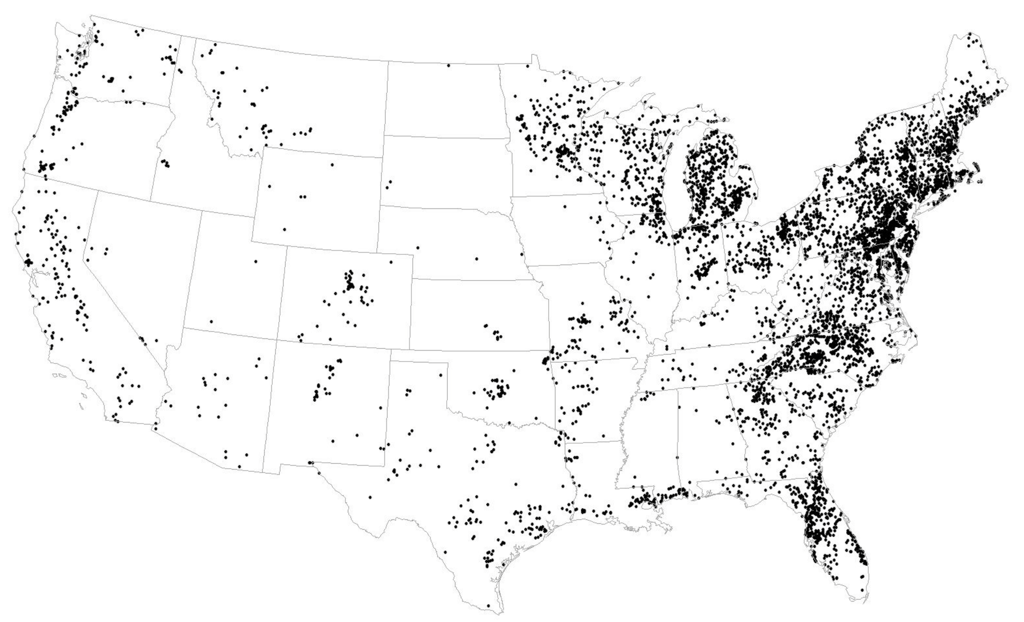


The location of every active gasoline service station in 2009.

91,308 Locations.

(ESRI Business Solutions, 2009)

Vulnerability Index 2 is the density of households in each census block group that obtain water from a private source. It is calculated as the number of households in each census block group that obtain water from a private source divided by the surface area in square miles of the census block group. It provides an estimate of the possibility that a release from a particular service station will impact the water supplied to a household that obtains water from a private source. Vulnerability Index 2 describes the risk that a release from a service station will impact someone's private water supply.

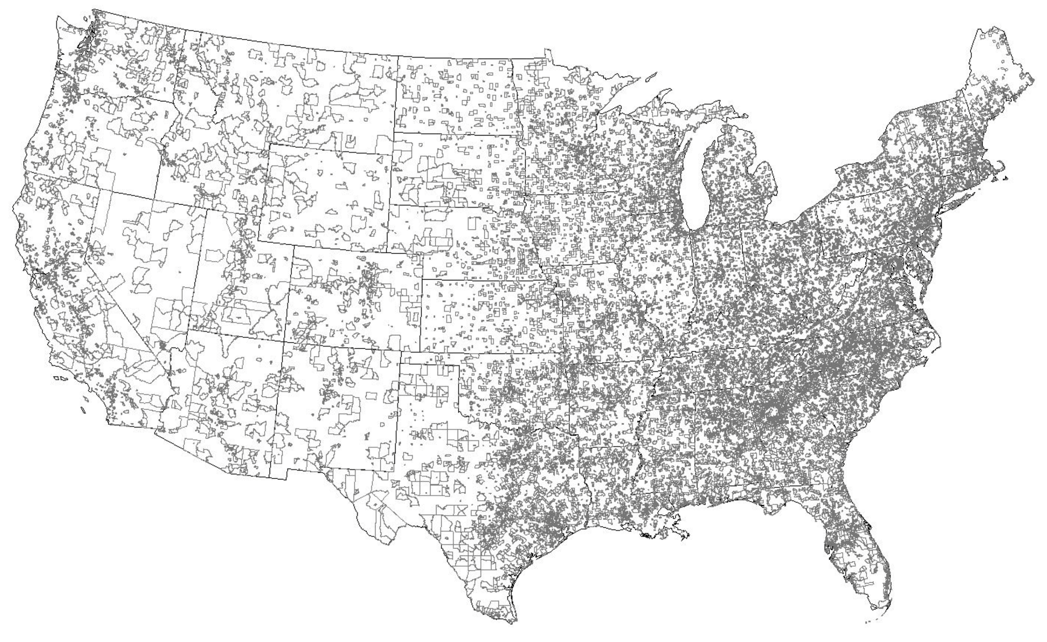


The distribution of people that drink water from private sources.

Each dot represents 1,000 people.

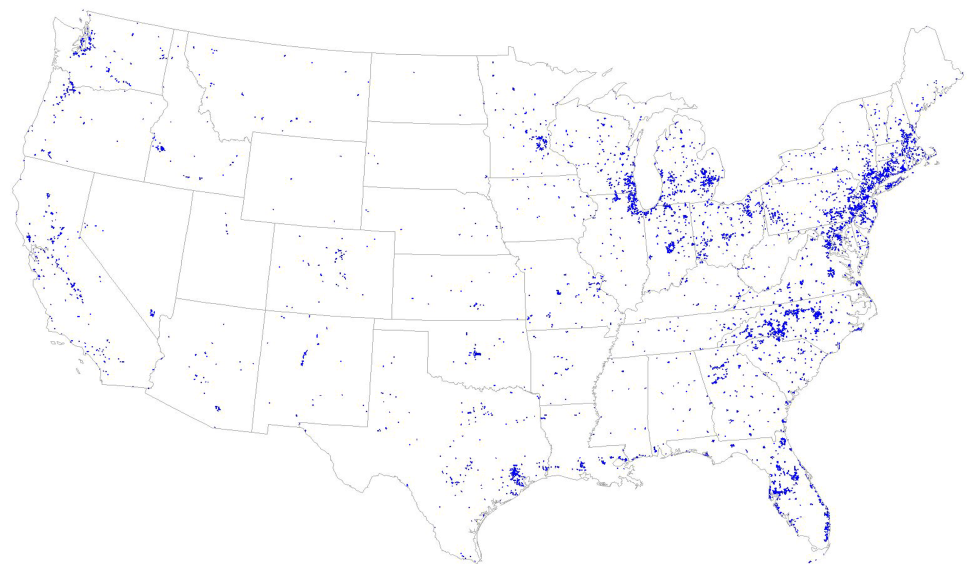
(1990 US Census)

Vulnerability Index 3 describes the potential risk to a community that obtains ground water from shallow sources. This index was calculated by multiplying Vulnerability Index 1 for each census block group and Vulnerability Index 2, the number of households in each census block group that obtain water from a private source. Vulnerability Index 3 describes the resource manager's risk that a release from a gasoline service station in their geographic area may impact the private water supply of a household in their geographic area.



1990 US Census block groups containing BOTH people drinking water from a private source and gasoline service stations.

33,167 census block groups.



Locations of census block groups where the value of Vulnerability Index 3 is in the upper 30% of all census block groups. This is the resource manager's risk of an impact.

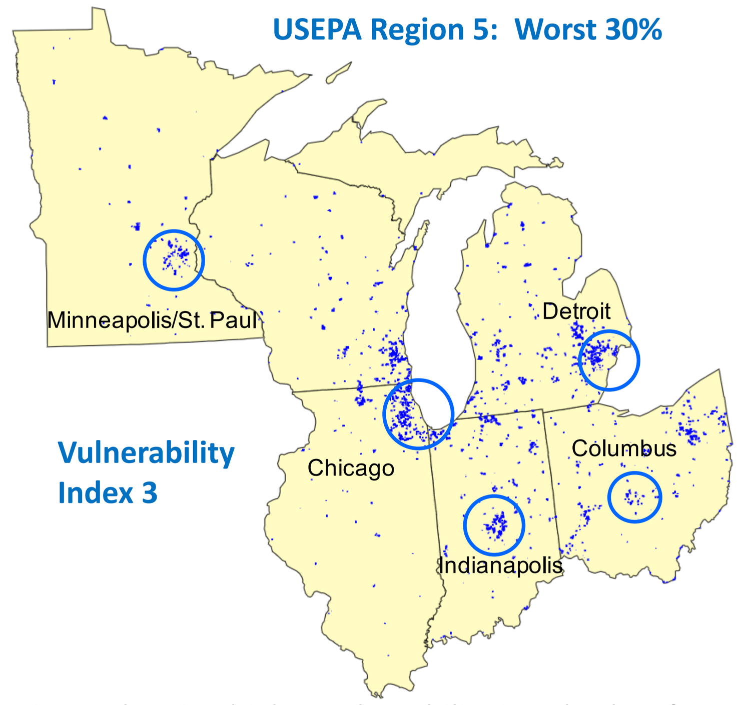


Figure showing higher vulnerability in suburbs of Minneapolis-St Paul, MN, Chicago, IL, Indianapolis, IN, Columbus, OH and Detroit, MI.

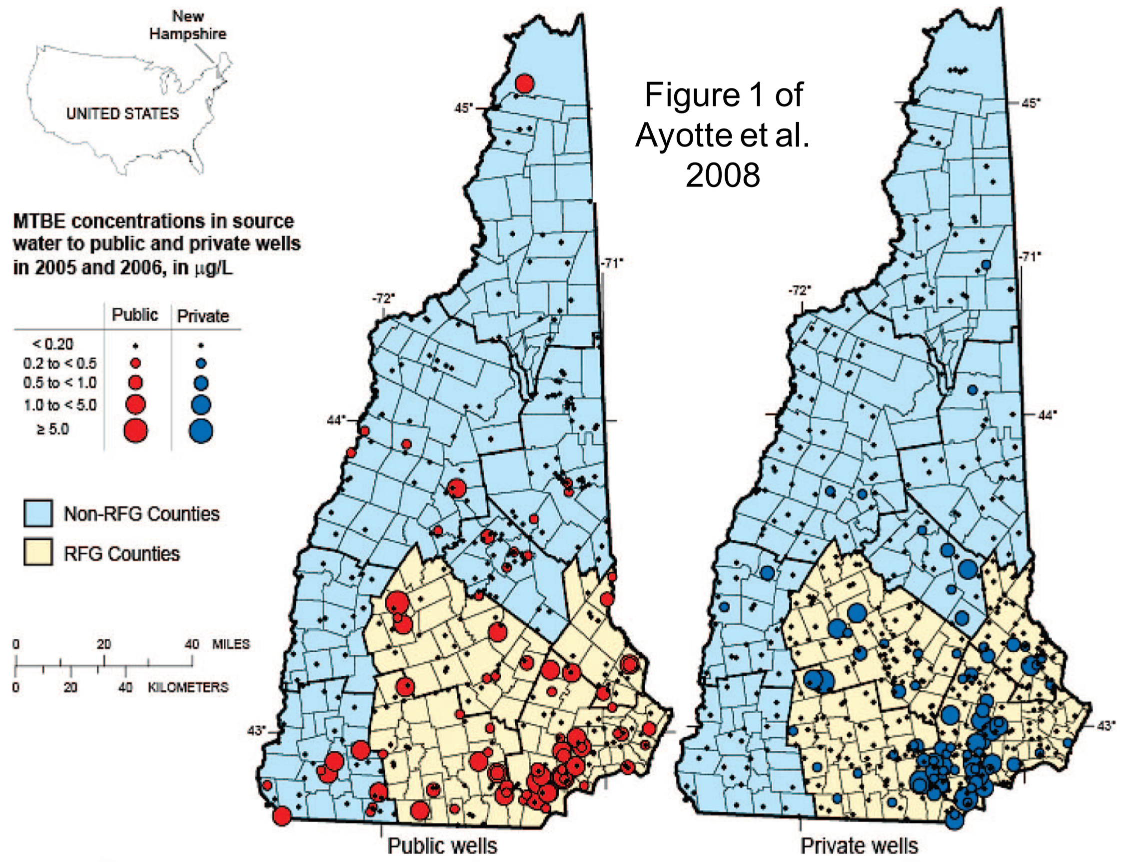
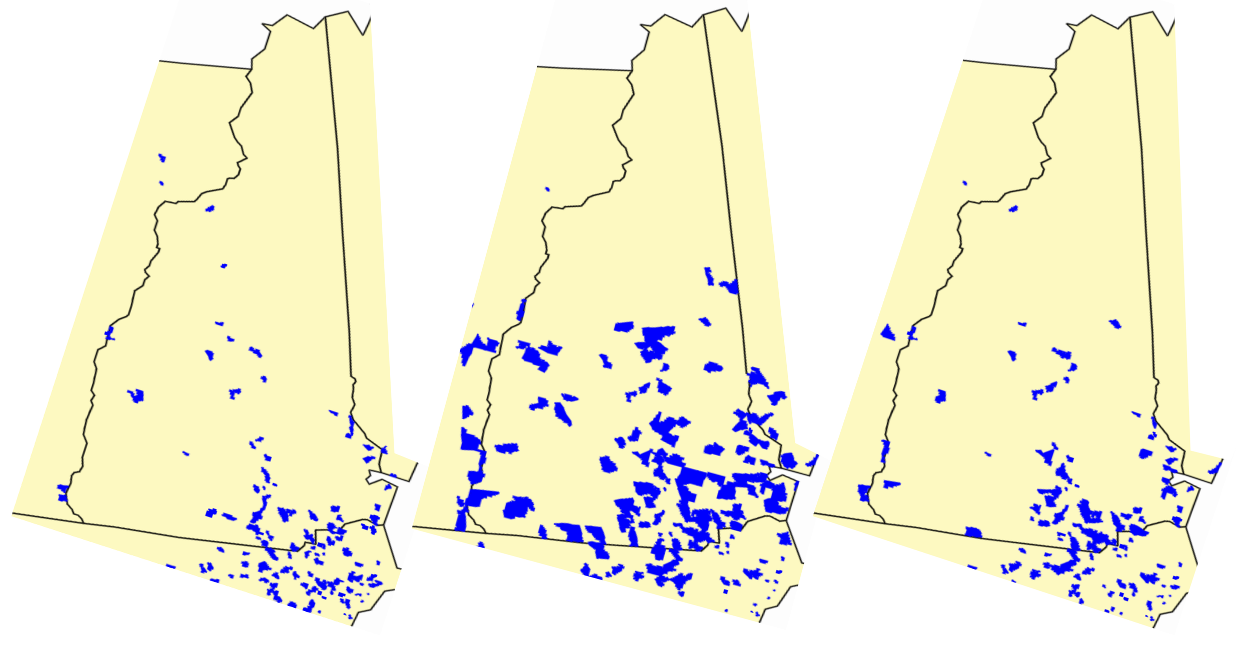


Figure 1 of Ayotte et al. 2008

Comparison between the distribution of MTBE contamination in water supply wells in New Hampshire and the estimate of Vulnerability from Indices 1, 2 and 3.



Vulnerability Index 1 Worst 30% | Vulnerability Index 2 Worst 30% | Vulnerability Index 3 Worst 30%

Conclusions and Future Directions

This analysis provides a screening approach to identify those areas in the US where ground water that is used for drinking water is most at risk from UST releases. These areas are at the greatest risk for potential impacts.

The vulnerability indices are based on two data sets: one from the 1990 census data for households dependent on private water wells for drinking water, and the other on recent locational data on fueling stations.

This screening approach can assist communities and states in identifying those localities that are particularly vulnerable. Additionally, the approach can serve as a useful tool for communities as they develop plans for sustainable water supply. These plans will be especially valuable as population growth or shifts in the US creates increasing demands for water.

This study is one example of how vulnerability can be assessed. Other GIS-based vulnerability assessments could be done in a similar manner considering other pathways for exposure such as vapor intrusion. Further improvements in such assessments will require more detailed understanding of the geological context, the local climate, and other features of the landscape.

The next step will require tools to understand the movement and redistribution of contaminated ground water that might impact water supply wells, distance to receptor, and facility-specific criteria such as overfill protection, spill containment, cathodic protection, etc.

Understanding the interaction between the supply of ground water, and the evolving demand for water at both spatial and temporal scales will help to ensure adequate and safe water supplies for the future. The U.S. EPA and USGS are working to move this understanding from the national and regional scale illustrated in this assessment to the local scale where decisions are made about ground water supply, UST siting, and regulatory inspection and cleanup prioritization.

References

Earle, Rob, John T. Wilson, Fran Kremer, Jim Weaver, David Burden. **GIS Analysis to Assess where Shallow Ground Water Supplies in the US are Vulnerable to Contamination by Releases of Motor Fuel from Underground Storage Tanks.** EPA/600/R-11/108. December 2011.

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