United States
Environmental Protection
Agency

Robert S. Kerr Environmental
Research Laboratory
Ada OK 74820

Research and Development

EPA/600/S2-91/043 Oct. 1991

EPA

Project Summary

Regional Assessment of Aquifer Vulnerability and Sensitivity in the Conterminous United States

Wayne A. Pettyjohn, Mark Savoca, and Dale Self

The full report provides, in a generalized, largely graphic format, a representation of ground-water vulnerability, precipitation distribution, population density, potential well yield, and aquifer sensitivity for each of the 48 conterminous states. A classification scheme is developed based on an assessment of the vulnerability of surficial and relatively shallow aquifers. Aquifer sensitivity is related to the potential for contamination. That is, aquifers that have a high degree of vulnerability and are in areas of high population density are considered to be the most sensitive. About 46 percent of the land area of the conterminous United States consists of vulnerable Class I aquifers. Of this amount, 26.4 percent is Class Ia, 10.4 percent is Class Ib and Ib-v, 8.1 percent is Class Ic, and Class Id accounts for an additional 1.4 percent. The moderately vulnerable Class II aquifers cover about 1 percent of the United States, while the least vulnerable, Class III, makes up about 19 percent. The undefined systems, Class U, account for an additional 19 percent.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In 1974 Congress enacted the Safe Drinking Water Act (PL93-523) to protect public health and welfare, as well as existing and future underground sources of drinking water. To achieve this end, the U.S. Environmental Protection Agency (EPA), through the Underground Injection Control (UIC) program, has and is developing regulations for the protection of Underground Sources of Drinking Water (USDWs) from contamination by the subsurface emplacement of fluids through wells.

UIC regulations defined and established 5 classes of injection wells.

- Class I—used to inject hazardous and non-hazardous waste beneath the lowermost formation containing a USDW.
- Class II—used to inject brine from oil and gas production, enhanced oil recovery and for storage of hydrocarbons.
- Class III—used in conjunction with solution mining of minerals.
- Class IV—used to inject hazardous or radioactive wastes into or above a USDW (banned nationally).
- Class V—wells not included in Class I, II, III or IV which typically inject non-hazardous waste into or above a USDW. Also known as shallow injection wells.

Class V wells involve the disposal of waste such as agricultural drainage, storm water/industrial drainage, raw sewage and some industrial process water. According to the most recent inventory reported by EPA, there are approximately 170,000 Class V injection wells in the United States, but this estimate is probably far too low. An

assessment is provided in the Report to Congress, Class V Injection Wells.

The greatest number of shallow injection wells occurs in areas of high population density. The types most likely to be present in industrial/urban/suburban areas include storm water and industrial drainage wells, improved sinkholes, domestic waste water disposal wells, industrial process water and waste wells, auto service station waste disposal wells, and abandoned water supply wells used for waste disposal.

As a group, abandoned wells are the most pervasive and potentially dangerous of all the shallow injection wells; they are found in both rural and urban areas.

An evaluation of the potential for ground-water contamination caused by shallow injection wells is a major undertaking because of the vast number of wells and their wide distribution throughout an extensive array of diverse hydrogeologic settings. To limit the potential impact of shallow injection wells on the Nation's ground water, a scheme is needed to prioritize regions so that, initially, the most sensitive and productive or potentially productive ground-water areas receive maximum attention.

Although this investigation was designed specifically to answer a need in the Underground Injection Control program, the products are equally valuable to assess the potential for ground-water contamination from other surface or near surface sources.

Purpose and Scope

The purpose of this report is not to classify ground water or ground-water regions, but rather to provide, in a generalized, largely graphical format, a manual that displays, for each of the 48 conterminous states, a representation of ground-water vulnerability, precipitation distribution, population density, potential well yields, and aquifer sensitivity. This manual can be used by local, state, or federal regulatory agencies to rapidly assess and, in a general manner, prioritize ground-water protection activities relative to shallow injection wells and other surface or near surface sources of contamination.

In addition, the maps can be used to delineate areas that provide or potentially provide the greatest amount of ground water to the largest number of people. Likewise, they also can be used to evaluate the more remote areas. The maps can provide the investigator with a quick, inexpensive means to review the potential for ground-water contamination and thus develop rapid but generalized evaluations of large areas. This, in turn, would permit agencies to develop a protocol for shallow injection well permitting or impact evaluations.

Methodology

This manual is based entirely on published information. State and federal agency publications catalogs were examined to obtain information that appeared to fill the needs of the project. Several workers were assigned states in which they had actual experience to increase the accuracy of the products.

In most cases, aquifer vulnerability maps were prepared by outlining geologic units on a 1:500,000 scale base map. Each unit was assigned a classification that reflected published geologic and hydrogeologic descriptions. The geologic units were transferred to a page size map of the state, and the area of each unit was measured by planimeter.

Maps showing the distribution of precipitation were prepared by means of national climatological data that are stored on compact disks and the software package, MapMaker II. Climate data were stripped from the compact disks, and manipulated to obtain combined files of precipitation and latitude and longitude of each station. Rather than using a predetermined time interval, the entire period of record was used for each station. This data set and state/county boundary files were used as input to the MapMaker II program.

Population density maps were prepared by means of MapMaker II files. The population data are based on 1986 estimates.

Aquifer sensitivity maps represent composite illustrations in that they show the location of population centers that overlie vulnerable or Class I aquifers. Maps of this type indicate that even though the aquifer may be exceptionally vulnerable, only a small part of the system is highly susceptible to contamination, and these sites are represented by the location of municipalities, both large and small. Aquifer sensitivity maps were prepared by overlaying scanned maps of aquifer vulnerability and the latitude and longitude of cities. All population centers that fell outside of Class I aquifers were deleted.

U.S. Geological Survey reports and maps proved to be the major sources of information on potential well yield. The generalized maps were prepared by transferring published information to a map of appropriate scale. These data were then incorporated into a computer generated map.

Aquifer classification units do not necessarily match at state borders. This is the result of compiling geologic and hydrologic information that was obtained for each state. Consequently, a geologic unit in one state may have been described in such a manner that it appeared to be largely, for example, unconsolidated Class Ia material. The same earth materials in an adjacent state may have been described in such a broad sense that it only could be classified as "undifferentiated" or Class U.

Conclusions

Table 1 in the full report lists details concerning population, area, and water use in each of the conterminous states. These data indicate that about 42.4 percent of the population served by public water-supply systems use ground water as a source. Clearly, these subsurface reservoirs need to be protected against contamination.

About 46 percent of the land area of the conterminous United States consists of vulnerable Class I aquifers. Of this amount, 26.4 percent is Class Ia, 10.4 percent is Class Ib and Ib-v, 8.1 percent is Class Ic, and Class Id accounts for an additional 1.4 percent. The moderately vulnerable Class II aquifers cover about 14 percent of the United States, while the least vulnerable, Class III, makes up about 19 percent. The undefined systems, Class U, account for an additional 19 percent. The percentage of each class of aquifer present in each state is listed in Table 2 of the full report.

Although large areas of several states consist of vulnerable Class I aquifers, aquifer sensitivity is not necessarily high. Aquifer sensitivity is related both to vulnerability and population density. In aquifer sensitivity investigations, the potential effect of population density is best viewed by means of population centers, which generally are concentrated along water courses, shorelines, and transportation routes. Consequently, the areas where ground water is most likely to become contaminated by means of shallow injection wells are in and adjacent to towns, regardless of size. For example, all of the population centers in a county may amount to only a small percentage of the total area of the county. Therefore, the areal extent of an investigation of aquifer sensitivity could be much smaller than originally anticipated.

Specific examples of ground-water contamination are not described in this report. A review of example, however, would show that no state is free from contamination. Moreover, no example is unique to any one state.

*U.S. Government Printing Office: 1992 — 648-080/60039

Wayne A. Pettyjohn, Mark Savoca, and Dale Self are with the Oklahoma State University, Stillwater, OK 74078.
***Jerry Thornhill** is the EPA Project Officer, (see below).*
The complete report, entitled "Regional Assessment of Aquifer Vulnerability and Sensitivity in the Conterminous United States," (Order No. PB92-100148/AS; Cost: $43.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Robert S. Kerr Environmental Research Laboratory
U.S. Environmental Protection Agency
Ada, OK 74820

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati, OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA PERMIT NO. G-35

Official Business
Penalty for Private Use $300

EPA/600/S2-91/043