

University of Wisconsin-Extension

GEOLOGICAL AND NATURAL HISTORY SURVEY

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SUMMARY OF SURVEY OF GROUNDWATER VULNERABILITY
MAPPING PRACTICES IN THE UNITED STATES

By

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1992

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GROUNDWATER VULNERABILITY
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Many people have contributed their time and efforts to this document -- staff of state agencies; state geological surveys; U.S. Geological Survey headquarters and district offices; and U.S. Environmental Protection Agency headquarters and regional offices; and numerous individuals who took the time and care to respond to the survey on vulnerability mapping practices. To them, a debt of gratitude is owed. Of special note are the members of the Commission on Ground Water Protection of the International Association of Hydrogeologists and of the Subcommittee on Planning and Mapping of the Wisconsin Groundwater Coordinating Council, who initiated and encourage the survey.

This report is a product of the Wisconsin Geological and Natural History Survey groundwater protection program. It is published as part of the continuing joint efforts of the Wisconsin Geological and Natural History and the Wisconsin Department of Natural Resources to provide useful information needed for sound management and protection of the state's groundwater resource.

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INTRODUCTION

During 1989-1991, a survey was conducted by the Wisconsin Geological and Natural History Survey (WGNHS) in cooperation with the Commission on Ground Water Protection of the International Association of Hydrogeologists (IAH) to determine the current status of vulnerability mapping in the United States. Questionnaires (Appendix A) were sent to all state departments of environment, health, or natural resources (Appendix B); state geological surveys (Appendix C); the U.S. Geological Survey (USGS) district offices (Appendix D); the U.S. Environmental Protection Agency (EPA) regional offices (Appendix E); and several individuals.

The respondents were asked to give their opinions on the value of vulnerability mapping and on the purposes, uses, and misuses of vulnerability maps; to summarize activities in their states and parameters used in mapping; and to enclose examples of maps and reports. The initial response to questionnaires was excellent; 75 percent of state departments, 60 percent of state surveys, 50 percent of USGS offices, and 40 percent of EPA offices responded as of September 30, 1991. In December 1991, follow-up letters were sent to all agencies that did not respond to improve the response.

Their responses are briefly summarized in this report by state and responding organization, listing the opinion on vulnerability maps, mapping activities, and examples of maps and reports. Each state is included on a separate page so that additional comments or follow-up survey results can be added with ease. The excerpts are not direct quotes; they were extracted from the responses by the author, who takes full responsibility for any unintentional out-of-context quotes.

This report is a companion volume to "Groundwater Vulnerability Mapping Practices in the United States" published separately by the Wisconsin Geological and Natural History Survey as _____.

ALABAMA

Responsibility for groundwater

quality protection:

Department of Environmental Protection

Department of Environmental Protection

(11/2/90)

Contact:

F. Mason

Opinion:

Vulnerability maps and accompanying reports are necessary in regulatory programs such as UST, RCRA, waste site selection and siting.

Activity:

Comprehensive program to protect aquifers from surface contamination. The first phase of the program is the vulnerability assessment contracted with the U.S. Geological Survey.

Geological Survey of Alabama

(9/18/89)

Contact:

E.A. Mancini

Opinion:

Manufacture and use of vulnerability maps is vitally important in the decision-making process. Comprehensive and usable data must be portrayed in such a manner that will be understood by the non-technical individual.

Activity:

County environmental atlases include landfill suitability maps; parameters used: depth to bedrock and to water.

U.S. Geological Survey

(8/15/90)

Contact:

J.C. Scott

Activity:

Series of studies, contracted by the Alabama Department of Environmental Protection, to define areas susceptible to contamination (13 study areas covering the entire state).

Products:

Susceptibility maps at a scale of approximately 1:500,000; based on recharge areas, active solution activities (sink-holes), and closed contour depressions.

U.S. Environmental Protection Agency

Included in EPA Region IV (see Georgia).

ARIZONA

Responsibility for groundwater

quality protection:

Department of Environmental Quality

**U.S. Geological
Survey**

(6/29/90)

Contact:

R.D. Hutchison

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region IX (see California).

Note:

DRASTIC maps have been produced by the Arizona
Department of Environmental Quality.

ARKANSAS

Responsibility for
groundwater quality protection:

**Department of
Health**

(7/26/91)

Contact:

R. Cordova

Opinion:

Vulnerability maps are only as good as the knowledge and experience of the preparers and as the information upon which they are based. Verification of maps in field should be an integral part of a map-making program.

Activity:

In the process of constructing maps at the scale of 1:500,000 based on geologic factors, soil characterizations, and depth to water.

**Department of
Pollution Control
and Ecology**

(1/4/91)

Contact:

R.H. Desmarais

Opinion:

Vulnerability maps are useful guides, but final decisions can only be made after site-specific assessments have been made.

Activity:

None.

**Arkansas Soil and
Water
Conservation
Commision**

(3/5/92)

Contact:

D.T. Fugitt

Opinion:

Maps of groundwater vulnerability to contamination are an essential tool for the protection and management of groundwater resources. In addition to hydrogeology, other factors must be considered: timing in relation to monitoring and contaminant presence, contaminant fate and mobility, groundwater flow system, affected population density, and the quantity and quality of available data.

Activity:

An Agricultural DRASTIC map for the state at a scale of 1:500,000. The map was produced at an intracountry-level using data coverages digitized into a GIS.

**Arkansas
Geological
Commission**
(1/4/91)
Contact:
N.F. Williams

No activity in vulnerability mapping.

**U.S. Geological
Survey**
(7/9/90)
Contact:
E.E. Gann

Opinion:
Development of guidelines for uniform vulnerability mapping is an invaluable task that would make a significant contribution to ground water hydrology. A uniform and acceptable title, explanation (legend), and description of a map could provide some degree of safeguard against blatant misuse.

Activity:
None.

Product:
Potential for contamination indirectly shown on a statewide map (1:2,000,000) of recharge zones, which is based on permeability of surficial materials.

CALIFORNIA

Responsibility for groundwater

quality protection:

State Water Resources Control Board

**State Water
Resources Control
Board**

(8/19/91)

Contact:

J.M. Diaz

Opinion:

Generic vulnerability maps can be valuable tools for purposes such as local land use zoning, ground water recharge, or identification of areas susceptible to pollution but may not be as suitable for specific constituents.

Activity:

Few generic maps for the assessment of potential pesticide contamination have been constructed based on soil permeability. EPA constructed a site specific vulnerability map for one of the two sole-source aquifers in California.

**Department of
Water Resources**

(9/3/91)

Contact:

J.V. McDaniel

Activity:

Few unpublished, preliminary maps for isolated areas.

**U.S.
Environmental
Protection
Agency, Region IX**

(11/3/90)

Contact:

S.M. Ihnen

Opinion:

The fundamental concept of vulnerability - that some surface areas easily contribute to ground water contamination and others don't - is an important one. Unfortunately, the methods for assessing the degree of vulnerability are poor. In particular the DRASTIC methodology is scientifically dubious in concept and nearly worthless in application. County-wide averaging of DRASTIC scores, such as has been done in California to refute vulnerability as a regulatory tool, is a misapplication of that (already questionable) method.

Activity:

Of the four states in the EPA Region IX (Arizona, California, Hawaii, Nevada) only Arizona and California have produced any vulnerability maps.

Other

A demonstration DRASTIC map (approximate scale 1:150,000) of the Yolo County was prepared by the National Water Well Association for testing the DRASTIC system.

COLORADO

Responsibility for groundwater
quality protection:

Department of Health

**Office of the State
Engineer, Water
Resources
Division**
(1/14/91)
Contact:
S. Lautenschlager

No activity in vulnerability mapping.

**U.S.
Environmental
Protection
Agency, Region
VIII**
(4/8/91)
Contact:
M. Wireman

Opinion:
Vulnerability maps are derivative maps that show
quantitatively or qualitatively characteristics which determine
vulnerability of ground water to contamination.

Activity:
DRASTIC methodology tested in several states of the EPA
Region VIII (Colorado, South Dakota, Utah, Wyoming); maps
on scale 1:100,000.

Publication:
Assessment of Vulnerability of Shallow Ground-Water
Resources in the Greater Denver Area.

CONNECTICUT

Responsibility for groundwater
quality protection:

Department of Environmental Protection

**Department of
Environmental
Protection**
(1/30/91)
Contact:
A. Freund

No activity in vulnerability mapping.
Connecticut concentrates on wellhead protection.

**U.S. Geological
Survey**

Included in the New England District
(see Massachusetts).

**U.S.
Environmental
Protection Agency**

Included in EPA Region I (see Massachusetts).

DELAWARE

Responsibility for groundwater Department of Natural Resources and
quality protection: Environmental Control

**Department of
Natural Resources
and Environmental
Control**

No activity.

(8/12/91)
Contact:
A.J. Farling

**Delaware
Geological Survey**

Activity:
Maps of potential for ground water recharge (1:24,000) used to determine land suitability for septic systems and landfills. Potential for recharge based on lithology and thickness of Quaternary deposits, lithology of subcropping sediments, and the water table configuration. Maps are used routinely to regulate land use and septic system development.

(9/14/89)
Contact:
K.D. Woodruff

**U.S.
Environmental
Protection Agency**

Included in EPA Region III (see Pennsylvania).

Other

A demonstration DRASTIC map (1:125,000) of the New Castle County was prepared by the National Water Well Association for testing the DRASTIC system.

FLORIDA

Responsibility for groundwater
quality protection:

Department of Environmental Regulation

**Department of
Environmental
Regulation**
(1/28/91)
Contact:
G. Maddox

Opinion:
Vulnerability maps can be a useful general tool for planning purposes, but cannot directly help in site-specific instances. They have value as an acceptable first-round screening tool. Text explaining the limitations of maps, and how to use and not misuse them, should accompany the maps.

Activity:
Statewide vulnerability mapping initiated in 1986; DRASTIC methodology is used. Scheduled to be completed by June 1991. Verification of DRASTIC maps is being done by comparing them to sampling results from a background monitoring network.

Publication:
Application of DRASTIC Ground Water Pollution Mapping Methodology (J.W. Herr, South Florida Water Management District, 1990).

**Florida Geological
Survey**
(1/16/92)
Contact:
W. Schmidt

Opinion:
Vulnerability maps can provide a first-cut planning tool, but cannot replace detailed, site-specific studies in responsible decision making.

Activity:
DRASTIC maps for the Suwannee River Management District (scale 1:250,000) as a subcontract for the Florida Department of Environmental Regulation.

**U.S. Geological
Survey**
(2/3/92)
Contact:
C.B. Hutchinson

Opinion:
Vulnerability maps are very general and not accurate.

Activity:
Map of potential for contamination of the Upper Floridan aquifer; scale: 1 inch = 20 miles.

**U.S.
Environmental
Protection Agency**

Included in EPA Revision IV (see Georgia).

Other

Demonstration maps for surficial and confined aquifers of the Lake County (approximate scale 1:190,000) were prepared by the National Water Well Association for testing the DRASTIC system.

GEORGIA

Responsibility for groundwater

quality protection:

Department of Natural Resources

Georgia Geologic Survey, DNR

(9/29/89)

(8/1/91)

Contact:

J.A. Lineback

Opinion:

Vulnerability maps are valuable derivative maps, which geologists can provide to environmental regulators and local planners. They are one of the more beneficial tools that the applied hydrogeologists can produce, but they in no way are a substitute for site-specific investigations. It is far better to provide the best interpretation of the existing data that is possible with present capabilities than have done nothing out of fear of potential misuse.

Activity:

DRASTIC maps at the 1:100,000 scale are being prepared by means of a GIS; first for the identified significant recharge areas, and later for the entire state.

U.S. Environmental Agency, Region V

(1/14/92)

D. Froneberger

No systematic activity in the region (Alabama, Florida, Georgia, Kentucky, Mississippi, North and South Carolina, Tennessee).

HAWAII

Responsibility for groundwater
quality protection:

**Department of
Land and Natural
Resources**

(8/5/91)

Contact:

M. Tagomo

No activity.

**U.S. Geological
Survey**

(7/16/90)

Contact:

W. Meyer

Opinion:

Vulnerability maps are, at best, transient in value, and judgmental in nature. Unless they are updated annually, they can be misinterpreted and misused.

Activity:

None.

**U.S.
Environmental
Protection Agency**

Included in EPA Region IX (see California).

IDAHO

Responsibility for groundwater

quality protection:

Department of Health and Welfare

Department of Health and Welfare

(2/14/91)

Contact:

M.G. Rupert

Opinion:

Fundamental concept of vulnerability maps is that they do not represent absolute vulnerability of a particular map area to ground water contamination. They only show relative vulnerability of certain areas in relation to other locations in the study area. Vulnerability mapping is a very important component in the prioritization of ground water protection and monitoring programs. The best way to avoid the misuse of maps is through education of potential users, and by making sure that the standard warnings and caveats are on all maps. The major potential misuse of the maps is applying site-specific problems to a map generated for regional planning. Standardized maps are not essential because users often do not desire the same information.

Activity:

DHW initiated a cooperative Idaho Ground Water Vulnerability Project. The first vulnerability map for the Snake River Plain was completed in January 1991 (scale 1:250,000). The Idaho project uses three main parameters, which were deemed to be most important for evaluating vulnerability and for which there was the best data coverage: soils, depth to water, and recharge. The factor maps were compiled at a scale of 1:250,000 for soils and 1:100,000 for the other two parameters. Preliminary verification of the maps was made by comparing them with data obtained from a statewide monitoring program, and the areas of high vulnerability correlated well with known high occurrences of pesticides, nitrates, and VOCs.

U.S. Environmental Protection Agency

Included in EPA Region X (see Washington).

Other

A demonstration map of the Minidoka County (1:125,000) was prepared by the National Water Well Association for testing the DRASTIC system.

ILLINOIS

Responsibility for groundwater
quality protection:

**Illinois
Environmental
Protection Agency**
(1/24/91)
Contact:
R. Clarke

No activity in vulnerability mapping.

**Illinois State
Geological Survey**
(10/5/89)
Contact:
R.C. Berg

Opinion:
Vulnerability maps are a useful planning tool that can help planners and regulators make knowledgeable decisions regarding land use. They can be used for regional screening and evaluation of contamination potential, which allows one to direct emphasis to areas of highest priority. Information should be provided in a simple and understandable format. Standardized maps are not essential because users often do not desire the same information. The primary misuse of the maps is in attempting to extract site-specific information. The emphasis on regional mapping is not necessarily the preferred type of contamination potential mapping. Rather, it is the opinion of some that detailed site-specific vulnerability mapping should be the number one priority.

Activity:
Involvement for about 25 years. First, land suitability analysis for landfilling for specific counties (1:62,500); later statewide map of susceptibility to contamination (1:500,000).
Parameters used: depth to the uppermost aquifer and properties of the aquifer and its overlying and underlying units.

**U.S. Geological
Survey**

(7/19/90)

Contact:

K.L. Warner

Opinion:

Vulnerability maps are good screening tools for testing areas which may need more detailed study. There is often confusion in the nomenclature of vulnerability mapping; the "working definition" needs to be explicit.

Activity:

None.

**U.S.
Environmental
Protection**

Agency, Region V

(1/9/92)

Contact:: M. Didier

No EPA activities within Region V (Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin).

INDIANA

Responsibility for groundwater
quality protection:

**Department of
Environmental
Management**

(2/21/92)

Contact:

S. Roush

Activity:

Statewide vulnerability map at a scale of 1:250,000
published in 8 sections.

**Department of
Natural
Resources,
Division of Water**

(1/24/91)

Contact:

J.N. Simpson

Opinion:

Vulnerability maps could be useful for education,
protection, and pollution prevention activities.

Activity:

Indiana does not have a vulnerability mapping program,
per se, but it does have programs that address the ground
water vulnerability to some extent: ground water
availability maps, aquifer system maps.

**Department of
Natural Resources,
Geological Survey**
(11/6/89)
(11/11/91)
Contact:
T. Fleming

Opinion:

The methodology for evaluating vulnerability is still very much in a state of evolutionary flux, and much remains to be seen as to whether any "standardized" system can be effectively applied to the diverse continuum of hydrogeologic environments. Most of the current "standardized" systems for constructing vulnerability maps are so oversimplified that they tend to blur important physical distinctions between adjacent hydrogeologic settings. Currently available standardized systems appear to be best suited for only the most large-scale, general screening purposes and should be used only as a last resort for more local studies.

Probably the biggest factor leading to potential misuse of vulnerability maps is lack of familiarity by the map user with the method of map construction and subsequent limitations. The maps should be directed at a particular audience and that audience should be an active participant in the process of designing map format, scale, and application. This will help ensure that the final product is easily interpreted by the intended users, and will certainly help the users understand the limitations.

Activity:

Past activities - maps of suitability for waste disposal (1:100,000) included in county-scale environmental geology reports; and a series of maps covering the entire state (at a scale of 1:250,000) showing suitability for solid and hazardous waste disposal sites.

Ongoing activities include mapping the potential for contamination in two counties (at a scale of 1:48,000). Basic approach is a three-dimensional mapping down to the bedrock surface (deep-stacking).

Note:

Indiana Department of Environmental Management is working on a statewide vulnerability map (contact: Marty Risch, Chief, Ground Water Section).

**U.S. Environmental
Protection Agency**

Included in EPA Region V (see Illinois).

IOWA

Responsibility for groundwater

quality protection:

Department of Natural Resources

**Department of
Natural
Resources,
Geological Survey**

(8/5/91)

Contact:

B. Hoyer

Opinion:

It is difficult to define what vulnerability maps are. The subject is very complex; and there is little or no standardization.

Product:

Map of ground water vulnerability regions of Iowa at a scale of 1:500,000, based on the depth to aquifer and aquifer type.

**U.S. Geological
Survey**

(7/9/90)

Contact:

J.J. Majure

Opinion:

Vulnerability maps are often misunderstood and misused. Developing meaningful standards would be useful.

Activity:

None.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VII (see Kansas).

KANSAS

Responsibility for groundwater
quality protection:

Department of Health and Environment

**State Board of
Agriculture**
(2/4/91)

No activities in vulnerability mapping.
DRASTIC state map has been prepared by Department of
Health and Environment.

**Kansas Water
Office**
(7/25/91)

No activities in vulnerability mapping.

**Kansas Geological
Survey**
(9/8/89)
Contact:
D.O. Whittemore

Opinion:
Vulnerability maps are useful for general locations of areas
appropriate or not appropriate for selected activities. They
are useful as guides to planning for scientists and non-
scientists. The actual locations should be based on detailed
site work. The reliability of maps is only as good as the
reliability of the data. Computer automation of the mapping
procedure using a GIS is very valuable.

Activity:
Automation of the DRASTIC methodology in a GIS (the
ERDAS system) and construction of a county map
(1:24,000).

Other

A demonstration map of the Finney County (approximate
scale 1:400,000) was prepared by the National Water Well
Association for testing the DRASTIC system.

**U.S.
Environmental
Protection
Agency, Region
VII**
(3/13/92)
Contact:
J. Patrick Costello

No vulnerability maps constructed for this region (Iowa, Kansas, Missouri, Nebraska).

KENTUCKY

Responsibility for groundwater quality protection: Natural Resources and Environmental Protection Cabinet

NREPC,
Division of Water
(2/4/91)
Contact:
J.A. Wilson
J.A. Ray

Opinion:
Vulnerability maps would probably be more valuable if a universal set of assessment criteria could be established. The data contained in the maps are subject to misinterpretation and misrepresentation by the inexperienced.

Activity:
A pilot DRASTIC demonstration project in four areas of diverse geologic settings. The maps were constructed at the scale of 1:24,000. DRASTIC proved to be not applicable in karst terranes. Work began on a statewide groundwater sensitivity map at a scale of 1:500,000 based on potential groundwater velocity.

Kentucky
Geological Survey
(11/13/90)
Contact:
J. Dinger

Opinion:
Maps need to be done on a 1:24,000 scale to be effective.

Activity:
Statewide map of the suitability for solid waste disposal (1:1,000,000).

U.S. Geological
Survey
(7/12/90)
Contact:
J. Starn

Opinion:
The usefulness of the vulnerability mapping that is currently being done is questionable. More focused, use-based approach is needed. County-wide maps are useful in a vague way for planning, but open to misuse. The vulnerability of deeper aquifers (below the water table aquifer) needs to be addressed.

Activity:
None.

U.S.
Environmental
Protection Agency

Included in EPA Region IV (see Georgia).

LOUISIANA

Responsibility for groundwater
quality protection:

**Department of
Environmental
Quality, Ground
Water Protection
Division**
(2/5/92)
Contact:
L.K. Levy

Activity:
Compilation of the aquifer recharge potential maps of
1:250,000 quadrangles; statewide map compiled at a scale
of 1:750,000. Maps are based on soil characteristics,
surface slope, and surface runoff.

**DNR, Office of
Conservation**
(7/22/91)
Contact:
J.P. Batchelor

No activity.

**Louisiana
Geological Survey**
(8/19/91)
Contact:
B.C. Hanson

Opinion:
Vulnerability maps are very useful as long as the user
understands the criteria upon which they were developed.

Activity:
Assessment of aquifer vulnerability for a sole-source aquifer
study in the capitol region (scale 1:250,000).

MAINE

Responsibility for
groundwater protection:

**Department of
Environmental
Protection**

No activity in vulnerability mapping (7/24/91).

**Department of
Conservation,
Maine Geological
Survey
(11/16/90)**

Opinion:
Vulnerability maps have their place when talking about regional differences in vulnerability but they cannot substitute for site-specific investigations because of their implicit generalization.

Activity:
Attempts at vulnerability mapping using DRASTIC methodology were made to provide a tool for planners and regulatory agencies.

**U.S. Geological
Survey**

Included in the New England District (see Massachusetts).

**U.S.
Environmental
Protection Agency**

Included in EPA Region I (see Massachusetts).

Other

A demonstration map of the Cumberland County (1:62,500) was prepared by the National Water Well Association for testing the DRASTIC system.

MARYLAND

Responsibility for groundwater
quality protection:

Department of the Environment

**Department of the
Environment,
Water
Management
Administration**
(2/14/91)
Contact:
N. Lazarus

Opinion:
Vulnerability maps are a good planning tool and provide a
method which allows local and state agencies to set priorities
to address ground water pollution problems.

Activity:
None.

**Department of
Natural
Resources,
Maryland
Geological Survey**
(12/12/90)
Contact:
E.T. Cleaves

Opinion:
Vulnerability maps are necessary and needed applied
geology products which help translate the technical product
into a more usable form for non-specialists.

Activity:
Mapping of individual factors (such as land slope, depth to
water, etc.) and constraints on installation of septic tanks
(scale 1:24,000).

**U.S.
Environmental
Protection Agency**

Included in EPA Region III (see Pennsylvania).

MASSACHUSETTS

Responsibility for groundwater
quality protection: Department of Environmental Protection

**Department of
Environmental
Management**
(9/20/91)
Contact:
Susan Ziegler

No activity in vulnerability mapping.

**Office of
Environmental
Affairs, Geological
Survey**
(1/3/92)
Contact:
J.A. Sinnott

No activity in vulnerability mapping.

**U.S. Geological
Survey, New
England District**
(7/9/90)
Contact:
J.C. James, II

No vulnerability mapping done in the New England District
(Connecticut, Maine, Massachusetts, New Hampshire,
Rhode Island, Vermont).

**U.S.
Environmental
Protection
Agency, Region I**
(1/14/92)
Contact:
D. Heath

No activity in vulnerability mapping in the region
(Connecticut, Maine, Massachusetts, New Hampshire,
Vermont). The DRASTIC system has been used in Maine
with limited success to examine potential impacts from
agricultural fertilizers and pesticides.

MICHIGAN

Responsibility for groundwater

quality protection:

Department of Natural Resources

**Department of
Natural Resources**

(2/1/91)

Contact:

M. Beaulac

Activity:

Revision of a preliminary aquifer vulnerability map of Michigan contracted with the Michigan State University at East Lansing (Dr. David Lusch). Aquifer protection maps are being developed for some selected counties on an experimental basis by the Western Michigan University (Dr. Richard Passero). A new aquifer protection model (called AQUIPRO) is used for this map development process.

**Department of
Natural
Resources,
Geological Survey**

(11/26/90)

Contact:

R.C. Reed

No activity in vulnerability mapping.

**U.S. Geological
Survey**

(6/28/90)

Contact:

T.R. Cummings

Activity:

Map of the susceptibility of ground water to contamination (1:62,500) was prepared for a report on Kalamazoo County (WRIR 90-4028) in 1990, using the DRASTIC agricultural index.

**U.S.
Environmental
Protection Agency**

Included in EPA Region V (see Illinois).

MINNESOTA

Responsibility for groundwater
quality protection:

**Department of
Natural
Resources,
Division of Waters**
(11/30/90)
(8/23/91)
Contact:
J. Falteisek

Activity:
The Minnesota Ground Water Protection Act of 1989 mandated protection of sensitive ground water areas, and directed DNR to develop criteria for mapping of such areas. The criteria and guidelines for assessing sensitive areas were developed by a work group in 1990. The methodology is based on the vertical permeability of the subsurface materials and estimates of time of travel. Mapping is done by other state agencies.

Product:
Criteria and Guidelines for Assessing Geologic Sensitivity of Ground Water Resources in Minnesota, DNR, 1991.

**Minnesota
Pollution Control
Agency**
(1/22/91)
Contact:
E. Porcher

Opinion:
Vulnerability maps can be a useful tool for setting priorities for ground water protection efforts. Map uniformity is desired; with the development of different vulnerability assessment methods comes the risk of inconsistent results.

Products:
A statewide 1:500,000 map on ground water contamination susceptibility in Minnesota was prepared in 1989, using four components: aquifer materials, recharge potential, soil materials, and vadose zone materials.

Publication:
Ground Water Contamination Susceptibility in Minnesota (E. Porcher, 1989) - includes page-size maps of the susceptibility map and the four components.

**Department of
Health**
(9/20/91)
Contact:
B. Olsen

Opinion:
Vulnerability maps are very useful for educating the public and decision makers.

Activity:
Maps of the susceptibility of near-surface water based on vertical permeability (various scales: 1:24,000, 1:100,000, 1:250,000).

**Minnesota
Geological Survey**
(10/13/89)
Contact:
K. Harris

Opinion:
Vulnerability maps are intended to provide guidelines to the general public and local, state, and federal government agencies as to the susceptibility of ground water to pollution.

Activity:
County geologic atlas series includes maps at 1:100,000 scale on the susceptibility of ground water systems to pollution.
Parameters used: Permeability of surface and subsurface materials and depth to the water table.

**U.S.
Environmental
Protection Agency**

Included in EPA Region V (see Illinois).

MISSISSIPPI

Responsibility for groundwater
quality protection:

**Department of
Natural
Resources,
Bureau of Geology**
(9/14/89)
Contact:
M.B.E. Bograd

Opinion:
The danger of misuse or misrepresentation of maps is
outweighed by the possibility that good or proper decisions
will be made. An important problem of vulnerability maps is
scale.

Activity:
Sanitary landfill suitability maps (1:62,500).

**U.S. Geological
Survey**
(6/25/90)
Contact:
M.W. Gaydos

Opinion:
Concern about the possible misuse of vulnerability maps.

Activity:
None.

**U.S.
Environmental
Protection Agency**

Included in EPA Region IV (see Georgia).

MISSOURI

Responsibility for groundwater
quality protection:

**Department of
Natural
Resources, Water
Resources
Program**
(1/22/91)
Contact:
S. McIntosh

Opinion:
Vulnerability maps should be used as guidelines only or as a first step to show what types of site-specific data are needed.

Activity:
Attempt of compiling county-size maps (1:250,000) and state maps (1:500,000 - 1:1,000,000).

**Department of
Natural
Resources,
Division of
Geology and Land
Survey**
(9/19/89)
Contact:
J.H. Williams

Opinion:
Vulnerability maps should provide constraint or limitation information that would assist regulators to make decisions.

Product:
Geologic limitations for siting hazardous-waste isolation facilities (map 1:500,000).

**U.S. Geological
Survey**
(6/25/90)
Contact:
L.A. Waite

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VII (See Kansas).

MONTANA

Responsibility for groundwater
quality protection:

Department of Health and Environmental Sciences

**Department of
Health and
Environmental
Sciences**

(1/18/91)
Contact:
J.L. Arrigo

Activity:

No activity in vulnerability mapping. Plans are in progress for a ground water prioritization map, which considers water as ranking criterion.

**Department of
Natural Resources
and Conservation**

(1/14/91)
Contact:
M. Shapley

No activity in vulnerability mapping.

**U.S. Geological
Survey**

(6/27/90)
Contact:
J.A. Moreland

Opinion:

Scale problems limit usefulness of vulnerability maps and make them subject to misuse.

Activity:

None.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VIII (see Colorado).

NEBRASKA

Responsibility for groundwater
quality protection:

**Department of
Environmental
Control**
(7/29/91)
Contact:
D. Ehrman

Opinion:
Vulnerability maps are a useful tool as long as the user
thoroughly understands their limitations; for example, scale,
assumptions used.

Activity:
DRASTIC maps of various locations at the scale of 1:24,000.

**University of
Nebraska,
Conservation and
Survey Division**
(9/11/89)
Contact:
P.B. Wigley

Activity:
Statewide vulnerability mapping using the DRASTIC method.
The data layers were digitized using a GIS and mapped at a
scale of 1:250,000. The maps were combined to yield a
state map with a 1:1,000,000 scale.

Product:
Groundwater Vulnerability to Contamination in Nebraska,
1:1,000,000.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VII (see Kansas).

NEVADA

Responsibility for groundwater
quality protection:

**Department of
Conservation and
Natural Resources**
(1/18/91)
Contact:
R.M. Turnipseed

No activity in vulnerability mapping.

**Nevada Bureau of
Mines and
Geology**
(1/6/92)
Contact:
J.G. Price

No activity in vulnerability mapping.

**U.S. Environmental
Protection Agency**

Included in EPA Region IX (see California).

NEW HAMPSHIRE

Responsibility for groundwater
quality protection:

**Department of
Environmental
Services, Water
Supply Division**

(1/13/92)
Contact:
S. Pillsbury

Opinion:
Vulnerability maps are useful because they allow local and
state agencies to prioritize their efforts.

Activity:
Groundwater hazard maps (1:24,000) showing existing and
potential contamination sources and their proximity to public
water supplies.

**Department of
Environmental
Services,
Geological Survey**

(10/2/91)
Contact:
M.E. Dowse

No activity in vulnerability mapping.

**U.S. Geological
Survey**

Included in the New England District (see Massachusetts).

**U.S.
Environmental
Protection Agency**

Included in EPA Region I (see Massachusetts).

NEW JERSEY

Responsibility for groundwater
quality protection:

**Department of
Environmental
Protection,
Geological Survey**
(11/6/89)
Contact:
G. Carter

Opinion:
Vulnerability maps are very useful; however, they are data-density and scale dependent. What may be considered a "vulnerability map" is highly dependent upon the definition used to describe them. The term "vulnerability" implies the map depicts this degree of risk.

Standardization is most important as it pertains to establishing "standard" methods to evaluate vulnerability. Of secondary importance is the format of the map. The purpose of the map is important in determining its ultimate format and composition. For instance, a regional planning map should avoid sharp line boundaries to preclude enlarging the map for use in determining on which side of the line a particular piece of land is located. The optimum way to prepare a vulnerability map is through the use of a GIS.

Activity:
No vulnerability maps per se, only ground water impact area maps (1:24,000).

**U.S.
Environmental
Protection Agency**

Included in EPA Region II (see New York).

NEW MEXICO

Responsibility for groundwater
quality protection:

**New Mexico
Health and
Environment
Department,
Ground Water
Bureau**
(1/18/91)
Contact:
S. Castle

Opinion:
Vulnerability maps are a necessary tool in making
environmentally sound land use decisions. The indices must
be readily obtainable and scaled to suit local conditions.

Activity:
None at the state level. A GIS capability is being developed
and vulnerability mapping will be one anticipated application
of the system.

Note: The city of Albuquerque is in the process of
developing vulnerability maps.

**U.S. Geological
Survey**
(6/27/90)
Contact:
D.W. Wilkins

No activity in vulnerability mapping.

NEW YORK

Responsibility for groundwater
quality protection:

**Department of
Environmental
Conservation,
Division of Water**
(3/11/91)
Contact:
J.D. Gary

Opinion:
A vulnerability map should be based on time of travel data derived from detailed aquifer parameters, water table gradient, and depth to the water table. A lesser effort would be a gross qualitative effort open to misinterpretation and misuse. Even a vulnerability map based on highly quantitative data will still be subject to site specific exceptions.

Activity:
Vulnerability has not been specifically mapped, but a number of maps of individual parameters at a 1:24,000 scale are available and can be used for constructing vulnerability maps.

**New York State
Geological Survey**
(1/10/92)
Contact:
R.H. Fakundiny

No activity in vulnerability mapping.

**U.S.
Environmental
Protection
Agency, Region II**
(11/19/90)
Contact:
D. LaPosta

No activities in vulnerability mapping in the region (New Jersey, New York).

NORTH CAROLINA

Responsibility for groundwater quality protection: Department of Environment, Health and Natural Resources

Department of Environment, Health, and Natural Resources, Ground Water Section

(11/27/91)

Contact:

P.F. Nelson

K.C. Matson

Opinion:

There is a conceptual value to groundwater vulnerability maps on a regional and national scale. However, reliable maps are difficult to produce and substantiate. There is little, if any, statistical support for the DRASTIC method.

Activity:

Vulnerability mapping of the state under way using the DRASTIC method to assist in locating monitoring wells for a statewide interagency pesticide study. Approximate scale of county maps 1:200,000.

Department of Environment, Health, and Natural Resources,

Geological Survey

(1/13/92)

Contact:

C.H. Gardner

Opinion:

Vulnerability maps may be useful for regional planning or assessment, but have limited application to site-specific problems.

Activity:

None.

U.S. Environmental Protection Agency

Included in EPA Retion IV (see Georgia).

NORTH DAKOTA

Responsibility for groundwater
quality protection:

**Department of
Health, Division of
Water Quality**
(2/1/91)
Contact:
L.D. Glatt

Opinion:
Vulnerability maps can prove to be a useful tool in decision-making process relating to land use planning. However, the maps are not intended to replace a detailed site-specific hydrogeologic assessment.

Activity:
The North Dakota Weed Control Association in cooperation with the U.S. Soil Conservation Service and Department of Health completed a series of county ground water protection maps based on soil type and shallow ground water. Due to limited scope of the maps, they are intended only as an education tool.

**North Dakota
Geological Survey**
(12/4/89)
Contact:
E.C. Murphy

Opinion:
Vulnerability maps are extremely useful and are one of the more effective ways for scientists to communicate with non-scientists.

Activity:
Statewide map of suitability for solid waste disposal is being constructed at the scale of 1:1,000,000. The map is based on the characteristics of surficial sediments and aquifer materials.

**U.S. Geological
Survey**
(7/13/90)
Contact:
S. Cates

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VIII (see Colorado).

OHIO

Responsibility for groundwater
quality protection:

**Ohio
Environmental
Protection Agency**
(8/14/91)
Contact:
M.G. Baker

Opinion:
Vulnerability maps are of limited use.

Activity:
None. The Ohio Department of Natural Resources is working on DRASTIC maps (Contact: Rebecca Petty, Ground Water Resources Section).

**Department of
Natural
Resources,
Geological Survey**
(9/18/89)
Contact:
T.M. Berg

Activity:
Not directly involved with the preparation of vulnerability maps; provides the basic geology maps for the state DRASTIC program.

**U.S. Geological
Survey**
(6/25/90)
Contact:
S.M. Hindall

No activity in vulnerability mapping.

Note:
The Ohio Department of Natural Resources, Division of Water, has prepared county pollution potential maps using a DRASTIC system. Almost all the state is completed.

**U.S.
Environmental
Protection Agency**

Included in EPA Region V (see Illinois).

OKLAHOMA

Responsibility for groundwater
quality protection:

**Oklahoma Water
Resources Board**

(1/21/92)
Contact:
R. Fabian

Opinion:
Vulnerability mapping can be an important tool in assisting in
the prioritization of groundwater resources.

Activity:
Several maps are in the process of being developed using
the DRASTIC system (one county map at the 1:250,000
scale and one at 1:24,000 scale).

**Department of
Health**

(1/9/91)
Contact:
J.K. Leavitt

Activity:
Not directly, mapping contracted with the Oklahoma
Geological Survey.

**Oklahoma
Geological Survey**

(3/12/92)
Contact:
K.S. Johnson

Have not prepared any vulnerability maps.

Note:
EPA funded vulnerability mapping project conducted by the
Oklahoma State University (W.A. Pettyjohn).

**U.S. Geological
Survey**

(9/4/90)
Contact:
R.L. Hanson

No activity in vulnerability mapping.

OREGON

Responsibility for groundwater
quality protection:

**Department of
Environmental
Quality, Ground
Water Section**

(9/10/91)

Contact:

D. Terra

Opinion:

Vulnerability maps are a tool for managers to focus priorities for allocation of staff and resources.

Activity:

With assistance from the Oregon Ground-Water Vulnerability Task Force, a pilot demonstration project was initiated in June 1990. This project will map general, statewide ground-water vulnerability and detailed ground-water vulnerability in two study areas. The objective is to develop, test and demonstrate the utility of ground-water vulnerability assessment using the DRASTIC methodology. In addition, a GIS Ground-Water Data Base for Oregon is being developed, which will facilitate future vulnerability mapping.

**Water Resources
Department**

(8/16/91)

Contact:

K. Lite

No activity.

**Department of
Geology and
Mineral Industries**

(1/6/92)

Contact:

D.E. Wermiel

No activity.

**U.S. Geological
Survey, Tacoma,
WA**

(7/23/90)

Contact:

N.P. Dion

Activity:

In the near future the Oregon Office of the Pacific Northwest District will begin a project designed to formulate a methodology by which a three-dimensional ground-water flow mode, a DRASTIC analysis, and information on current and potential contaminant loading can be used conjunctively to answer questions concerning ground-water vulnerability.

**U.S.
Environmental
Protection
Agency, Region X**
(11/8/90)
Contact:
K. Youenes,
Seattle, WA

Opinion:
See Washington

Activity:
The Oregon Ground-Water Vulnerability Task Force was formed in 1989. This multi-agency work group is working on the assessment of general, statewide susceptibility of ground water to contamination, using a modified form of DRASTIC.

PENNSYLVANIA

Responsibility for groundwater
quality protection:

**Department of
Environmental
Resources**

(1/9/92)

Contact:

J.E. McSparran

No activity in vulnerability mapping.

**Pennsylvania
Geological Survey**

(1/17/92)

Contact:

M.E. Moore

Opinion:

With proper disclaimers, vulnerability maps can be useful tools for planners. Too often, though, they are viewed as "the last word" when, in fact, they are living documents.

Activity:

None.

**U.S. Geological
Survey**

(7/23/90)

Contact:

D.E. Click

Opinion:

Vulnerability maps need definition of their purpose. Generalization of multi-factor data summaries may be misleading and wrong for the applied use.

Activity:

None.

**U.S.
Environmental
Protection
Agency, Region III**
(11/30/90)
Contact:
P.A. Weber

Opinion:
Vulnerability maps are essential for protecting ground-water sources of drinking water. The biggest constraint is the quality of data.

Activity:
Identification of areas, within the region, which are most susceptible to ground-water contamination using the DRASTIC system. Thirty most vulnerable counties have been identified within this 5-state region (Delaware, Maryland, Pennsylvania, Virginia, West Virginia). The vulnerability formula includes groundwater users, known and potential contamination sources, and risk to affected users.
Map scales: 1:2,000,000 for multi-state assessment; 1:500,000 for Pennsylvania groundwater risk assessment; 1:100,000 for county DRASTIC evaluation; and 1:24,000 for a pilot county assessment.

RHODE ISLAND

Responsibility for groundwater

quality protection:

Department of Health and Environmental Control

**Department of
Environmental
Management**

(1/9/92)

Contact:

M.D. Bradley

Opinion:

Vulnerability maps are useful for generalized application.

Activity:

No activity in vulnerability mapping. Only mapping for the classification of groundwater. The major component is the critical portion of the recharge area to the groundwater reservoir (state map 1:420,000).

**Office of the State
Geologist**

(1/10/92)

Contact:

J.A. Cain

No activity in vulnerability mapping.

**U.S. Geological
Survey**

Included in the New England District (see Massachusetts).

**U.S.
Environmental
Protection Agency**

Included in EPA Region I (see Massachusetts).

SOUTH CAROLINA

Responsibility for groundwater
quality protection:

Department of Health and Environmental Control

**Department of
Health and
Environmental
Control**
(8/22/91)
Contact:
P. Stone

Opinion:
Vulnerability maps are useful for ground water professionals to help determine the relative degree of concern and effort needed for evaluations of actual or potential ground water contamination. Otherwise, such maps are subject to severe misuse in the decision - making process.

Activity.
None. The Department has purposely resisted producing vulnerability maps, and prefers the selection of proper assessment criteria and the inclusion of professional people in planning and decision making.

**South Carolina
Geological Survey**
(9/18/89)
Contact:
N.K. Olson

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region IV (see Georgia).

Other

A demonstration DRASTIC map (1:125,000) of the Greenville County was prepared by the National Water Well Association for testing the DRASTIC system in 1985.

SOUTH DAKOTA

Responsibility for groundwater
quality protection:

**Department of
Water and Natural
Resources,
Geological Survey**
(10/30/89)
Contact:
L.S. Hedges
M. Jarrett

Activity:
No one in the state is engaged in aquifer vulnerability
mapping. Vulnerability assessment of all public water supply
systems is under way.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VIII (see Colorado).

TENNESSEE

Responsibility for groundwater
quality protection:

**Department of
Health and
Environment,
Division of Water
Supply**
(11/19/90)
Contact:
D.R. Rima

Activity:
No activity in ground water vulnerability mapping.
Vulnerability maps of wellhead protection areas will be
developed in cooperation with the U.S. Geological Survey.

**Tennessee
Division of
Geology**
(1/27/92)
Contact:
E.M. Foust

Vulnerability maps are not produced by any state agency.

**U.S. Geological
Survey**
(7/2/90)
Contact:
W.R. Barron, Jr.

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region IV (see Georgia).

TEXAS

Responsibility for groundwater
quality protection:

**Texas Water
Commission**
(8/5/91)
Contact:
M. Hart

Opinion:
Vulnerability maps serve several purposes, including the need to evaluate local and regional ground water problems, and the distribution of limited resources for addressing these problems. Maps can also be used to educate the public about aquifers as part of a larger interconnected system, which is affected by human activities. The greatest worry is the misuse of the maps by well-meaning but uneducated individuals or groups with little understanding of hydrogeology or ground water contamination.

Activity:
Aquifer pollution potential mapping of Texas on a county by county basis using the DRASTIC system. The objective is to develop two maps for each county; one showing general vulnerability to ground water contamination, the other aimed at contamination from agricultural sources (scale 1:250,000). By July 1991, 10 of 254 counties were completed. Verification of vulnerability maps is being carried out with sampling programs in 6 counties where detail mapping is completed. Results should be released during FY 92.

Product:
Two statewide DRASTIC maps, general and agricultural, at a scale of approximately 1:2,000,000 were published in 1989.

**University of
Texas, Bureau of
Economic
Geology**
(9/11/89)
Contact:
C.W. Kreitler

Opinion:
Vulnerability mapping needs to be flexible so that the user can customize the maps to his own specific needs. Too much quantification is not always good. If too many variables are factored into one final numerical index (such as DRASTIC), critical parameters may be subdued by other parameters not important for vulnerability assessment of a particular setting.

Activity:
No vulnerability maps per se, only a series of environmental geology maps, which are an important precursor to vulnerability mapping.

**U.S. Geological
Survey**
(6/29/90)
Contact:
L.F. Land

Opinion:
Assigning a numerical index to a range of values causes vulnerability maps to be suspect.

Activity:
None.

Other

A demonstration DRASTIC map (1:125,000) of the Gillespie County was prepared by the National Water Well Association for testing the DRASTIC system in 1985.

UTAH

Responsibility for groundwater

quality protection:

Department of Environmental Quality

**Department of
Environmental
Quality**

(1/21/92)

Contact:

K.L. Alkema

Opinion:

At this point, vulnerability maps should only be used as an educational tool until inconsistencies in map design and content are removed.

Activity:

Cooperative vulnerability study of the Salt Lake County (expected completion: June 1992). Modified DRASTIC method is being used for mapping deep, semi-confined principal aquifer. In 1991 the Utah Department of Agriculture, in cooperation with the Utah State University, developed a state agricultural DRASTIC map to determine sensitive agricultural lands.

**Department of
Natural
Resources,
Division of Water
Resources**

(8/19/91)

Contact:

N.S. Stauffer, Jr.

No activity in vulnerability mapping.

**Department of
Natural
Resources, Utah
Geological and
Mineral Survey**

(1/16/92)

Contact:

G.E. Christenson

No activity in vulnerability mapping.

Product:

Geologic suitability for wastewater disposal in bedrock, Duchesne County, Utah, 1:100,000 (Plate 3, UGMS Special Study 72, 1990).

**U.S. Geological
Survey**
(6/29/90)
Contact:
J.S. Gates

Opinion:
Vulnerability maps should be carefully thought out and their meaning and degree of reliability fully explained. Cookbook approaches such as DRASTIC can be misleading.

Activity:
Maps of susceptibility to contamination based on recharge areas, vertical hydraulic gradient, and ground-water velocity.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VIII (see Colorado).

VERMONT

Responsibility for groundwater
quality protection:

Agency of Natural Resources

**Department of
Environmental
Conservation
(DEC),
Groundwater
Management
Section**
(1/10/91)
Contact:
D. Butterfield

Opinion:
We agree with the concept of vulnerability mapping provided
there are enough data to construct a useful map.

Activity:
None.

**DEC, Water
Supply Division**
(7/29/91)
Contact:
W. Ladue

Opinion:
Value of vulnerability maps depends on their quality.

Activity:
None.

**U.S. Geological
Survey**

Included in the New England District (see Massachusetts).

**U.S.
Environmental
Protection Agency**

Included in EPA Region I (see Massachusetts).

VIRGINIA

Responsibility for groundwater
quality protection:

**Department of
Health, Division of
Water Supply
Engineering**
(1/7/91)
Contact:
R.B. Taylor

Activity.
Virginia is in the beginning stage of looking at vulnerability
mapping.

**Virginia
Geological Survey**
(9/11/89)
Contact:
R.C. Milici

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region III (see Pennsylvania).

WASHINGTON

Responsibility for groundwater
quality protection:

Department of Ecology

Department of Ecology, Water Quality Program

(4/29/91)

Contact:

R. Palmquist and
J.D. Spina

Activity:

Washington State is addressing ground-water protection through various programs including the EPA Ground Water Vulnerability Project, which is designed to develop feasible criteria for assessing ground-water vulnerability. A Task Force was formed in 1989 and a pilot study was initiated in 1990 to evaluate the DRASTIC models developed for portions of Thurston and Franklin Counties before a state vulnerability map will be generated.

Department of Natural Resources, Division of Geology

(9/11/89)

Contact:

R. Lasmanis

No activity in vulnerability mapping.

U.S. Geological Survey, Pacific Northwest District

(7/23/90)

Contact:

N.P. Dion

Activity:

As a test of the capabilities of a GIS software, a vulnerability map of a small project area was produced using the DRASTIC parameters. Another vulnerability project included a county project in Clark County.

Other Products:

Statewide maps of factors for the selection of sites for the land disposal of waste at a scale of 1:750,000 (USGS, WRIR 84-4279, 1986).

Intergovernmental Resource Center

(1/13/92)

Contact:

R. Swanson

Opinion:

The biggest difficulty with vulnerability maps is explaining that despite technical limitations, there are many good applications of them. They are best when considering specific risks such as fertilizers, types of point sources, etc.

Activity:

A DRASTIC map of Clark County (1:72,000). Cooperatively working with the USGS to develop a method to assess vulnerability using GIS loading maps, the regional groundwater flow model, and susceptibility mapping. Compiling a literature review of conjunctive use of flow models and vulnerability mapping.

**U.S.
Environmental
Protection
Agency, Region X
(11/8/90)**
Contact:
K. Youenes

Opinion:

The EPA Region 10 conceptually defines ground-water vulnerability as the sum of hydrogeologic susceptibility and contaminant loading potential. In order to assess ground-water vulnerability, or the risk of ground-water contamination, it is assumed that it is necessary to consider the potential for introducing contaminants, at or near the surface, as well as the fate and transport of these contaminants once they are introduced.

Activity:

The EPA Region 10 is directly, or indirectly, involved with eleven separate ground-water vulnerability mapping projects in Idaho, Oregon, and Washington, involving local, state, and other federal agencies. These projects are part of the Ground-Water Vulnerability Project. In general, these projects are developing modified forms of DRASTIC to assess hydrogeologic susceptibility, and are developing a variety of methods for assessing contaminant loading potential. All projects are using ARC/INFO GIS to store and analyze data.

The Ground-Water Vulnerability Project is a multi-agency effort, involving local, state, and federal agencies in Idaho, Oregon, and Washington. The overall purpose of the project is to provide critical information to environmental managers for protecting vulnerable aquifers from contamination. The project has three basic goals: (1) develop feasible and credible criteria for assessing ground-water vulnerability; (2) develop a sound and defensible ground-water Geographic Information System (GIS) database for assessing ground-water vulnerability and related uses; and (3) ensure consistency and cooperation among local, state, and federal agencies, in assessing ground-water vulnerability and managing ground-water resources.

Other

A demonstration DRASTIC map (approximate scale 1:200,000) of the Pierce County was prepared by the National Water Well Association for testing the DRASTIC system in 1985.

WEST VIRGINIA

Responsibility for groundwater
quality protection:

**Division of Natural
Resources, Water
Resources Section**
(1/28/91)
Contact:
P.W. Campbell

Opinion:
Vulnerability maps are useful only in making "first-cut"
decisions. It is important that disclaimers appear on these
types of maps informing the user of the map limitations.

Activity:
The DNR, in cooperation with EPA, produced in 1990 the
DRASTIC map of Jefferson County at the scale of
1:100,000, as part of a demonstration project "Pesticides in
Ground Water". Mapping of this karst area indicated many
limitations of the DRASTIC system.

**Division of Natural
Resources, Waste
Management
Section**
(9/12/91)
Contact:
L. Baker

Opinion:
Vulnerability maps are useful for prioritizing statewide efforts.
They should be recognized as highly exaggerated models.

Activity:
A very preliminary statewide map at a scale of 1:500,000,
based on the DRASTIC methodology.

**West Virginia
Geological and
Economic Survey**
(10/6/89)

Activity:
Suitability maps for municipal landfill siting.

**U.S. Geological
Survey**
(6/29/90)
Contact:
D.H. Appel

No activity in vulnerability mapping.

**U.S.
Environmental
Protection Agency**

Included in EPA Region III (see Pennsylvania).

Other

Contact:
S. Carpenter, SCS

The U.S. Soil Conservation Service constructed a GIS vulnerability map of Jefferson County using the SEEPAGE model. It is interesting how much this map differs from the DRASTIC map produced by the EPA. It illustrates the contamination potential much better.

WISCONSIN

Responsibility for groundwater
quality protection:

Department of Natural Resources

**Department of
Natural
Resources, Water
Resources
Management**
(7/26/91)
Contact:
D. Lindorff

Opinion:
Vulnerability maps can be a useful tool in making land use
decisions. They are, however, only as good as the data
used to prepare them.

Product:
Groundwater Contamination Susceptibility in Wisconsin,
1987 (map 1:100,000 and report).

**Wisconsin
Geological and
Natural History
Survey**
(4/8/91)
Contact:
A. Zaporozec

Opinion:
Vulnerability assessment is the first step toward the
protection of ground water. Vulnerability mapping should
include both the susceptibility to contamination and
contaminant loading potential. The main problem associated
with vulnerability mapping is testing the validity of maps in
field and how to include the dynamic character of
vulnerability.

Activity:
Criteria and guidelines for assessing contamination potential
of ground water in Wisconsin are being developed;
completion anticipated in 1992. County mapping of the soils'
ability to attenuate contaminants is in progress (scale
1:100,000). By 1991, 14 out of 72 counties have been
mapped.

Other Products:
A map of Rock County showing potential of subsurface
materials to attenuate contaminants at the scale 1:100,000,
based on depth to water, depth to bedrock, and character of
rocks. Groundwater contamination potential of Barron
County (1:100,000), using a modified form of DRASTIC.

**U.S.
Environmental
Agency**

Included in EPA Region V (see Illinois).

Other

A demonstration DRASTIC map (1:125,000) of the Portage County was prepared by the National Water Well Association for testing the DRASTIC system in 1985.

WYOMING

Responsibility for groundwater
quality protection:

**Department of
Environmental
Quality,
Groundwater
Pollution Control**
(1/31/91)
Contact:
K.D. Frederick

Opinion:
Vulnerability maps are useful as prediction and planning
tools.

Activity:
Wyoming is in the process of initiating DRASTIC vulnerability
mapping for state agricultural areas subject to agricultural
chemical application.

Product:
Statewide Class V, injection well vulnerability map at the
scale of 1:500,000, using DRASTIC methodology.

**Geological Survey
of Wyoming**
(1/6/92)
Contact:
G.B. Glass

No opinion and no activity at this time.

**U.S.
Environmental
Protection Agency**

Included in EPA Region VIII (see Colorado).

OTHER RESPONSES

**U.S. Geological
Survey, Reston,
VA**
(9/22/89)
Contact:
P. Cohen,
Chief Hydrologist

Opinion:
The U.S. Geological Survey does not have particular reservations on the use of vulnerability maps, so long as they are recognized as screening tools and not decision-making tools, and that they are accompanied by sufficient documentation to fully describe the assumptions and methodologies used. In practice, the mapping of aquifer vulnerability entails the same technical elements that would be evaluated in any basic reconnaissance of a ground-water system. While the number of hydrogeologic variables evaluated would logically be a function of the complexity of the system, vulnerability maps are commonly based on only a limited number of hydrogeologic characteristics, principally the character of the soil, the unsaturated zone, and the depth to water. The Environmental Protection Agency DRASTIC Index evaluates seven variables, including the net recharge, and is intended to be compared on an area-by-area basis to identify areas that are relatively more susceptible to ground-water contamination. The principal characteristic of vulnerability mapping systems, or the use of DRASTIC, is that they are based on a characterization that is essentially static in time, which tends to be heavily weighted toward the properties of the rocks, and which is principally a one-dimensional estimate of the ease with which a surface contaminant can move downward to the water table.

Ralph C. Heath,
Consultant,
Raleigh, NC
(9/11/89)

Opinion:
One of the most important factors in vulnerability assessment has never been considered and that is proximity to streams and ground-water discharge areas. Ground water in such areas, where natural gradients have not been reversed, is least subject to contamination. To worry about the misuse of vulnerability maps, and not to release them for this reason, is useless because humans are capable of misusing everything.

**U.S.
Environmental
Protection
Agency,
Washington, DC**
(1/21/92)
Contact:
M. Ginsberg

Opinion:
The major concerns about vulnerability maps are: their development through the use of methods that were not field tested or were field tested, but are not appropriate to all areas; their development at a scale not appropriate to the data; their development by personnel lacking the necessary expertise; and the not infrequent detection of contamination in areas mapped as low vulnerability.

Activity:
Development of a technical assistance document on methods for assessing the sensitivity and vulnerability of the groundwater reservoir to contamination by pesticides.

Product:
The 1990 National Pesticide Study contains county assessments of sensitivity to pesticide contamination of groundwater based on agricultural DRASTIC. The 1991 report "Regional Assessment of Aquifer Vulnerability and Sensitivity in the Conterminous United States" (Pettyjohn and others, 1991) contains small-scale state maps of aquifer vulnerability to contamination from shallow (Class V) injection wells.

**Ontario Ministry of
the Environment**
(1/21/92)
Contact:
G.M. Hughes

Opinion:
Numerical rating systems, such as DRASTIC, are of little value and may be harmful. They are intended to allow people not competent in hydrogeology to make hydrogeologic decisions without responsibility.

Products:
Map of susceptibility of ground water to contamination in Ontario (1:1,000,000). The large-scale (1:50,000) groundwater susceptibility maps for planning purposes in the southwest region.

APPENDIX A. SURVEY QUESTIONNAIRE

QUESTIONNAIRE ON VULNERABILITY MAPPING

We hope that you are willing to answer the following questions and contribute thus to the success of our efforts. Thank you.

1. What is your opinion on the maps of ground-water vulnerability (susceptibility) to contamination (or contamination potential maps)?
2. What types of vulnerability maps have been constructed by you or your office and on what scale?
3. To what goals were the maps made?
4. Which parameters in general were used, and did you have reliable values?
5. Who are users of the maps and are hydrogeologists involved in the applications of the maps?
6. Can you give examples or case histories of the use and the misuse of maps or examples of the verification of vulnerability maps in field?
7. Do you know of other organizations (here or abroad) which developed vulnerability maps?
8. Can you send copies of the existing types of vulnerability maps with explanatory notes; can you give references to literature on vulnerability mapping or names of hydrogeologists working in this field?

Please send your answers and comments to:

Respondent's Name and Address:

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APPENDIX E.

U.S. ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICES

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