Ground Water Protection Issues: Proactive Ground Water Resource Management and the Wyoming Ground Water Vulnerability Mapping Project

Christopher S. Arneson, Hamerlinck, J. D., and Gloss, S. P.

presented by

Steven P. Gloss

UNIVERSITY OF WYOMING, WYOMING WATER RESOURCES CENTER
Laramie, Wyoming

In, Wyoming Water Law, CLE International
Cheyenne, Wyoming, November 20-21, 1997

Introduction

Ground water is one of this nation's most precious and yet potentially most vulnerable resources. Fifty percent of our public water supplies utilize groundwater. One need only look at the rather poor success rate in remediating contaminated ground water, the extremely high cost of these activities, and the value of ground water to society to make this judgment. It is clear that protecting ground water quality makes far more sense than trying to clean it up. Indeed the National Academy of Sciences, through its National Research Council (NRC), recently reviewed the last decade of cleanup efforts in this country and concluded in fact that current policies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) as administered by the U. S. Environmental Protection Agency (EPA) do not reflect the technical limitations we face (NRC, 1994). In other words, regulatory policy has driven our cleanup standards rather than our knowledge of science and technology. The lack of current technology to address many of the nation's most severe and most prevalent ground water contamination issues ought to further suggest that protecting ground water quality is the preferred strategy.

In the United States, between 300,000 and 400,000 sites have been found to have either contaminated soil and/or ground water. The estimated cost to clean up these sites ranges from $250 billion to $1 trillion in 1993 dollars spent over the next 20-30 years. Cleanup levels are usually targeted to achieve background levels, drinking water standards, or risk-based levels representing the 10^{-4} to 10^{-6} range. To date, the family of technologies employed in ground water cleanup have been so called "pump and treat" methods. Such methods are in place at about 3,000 sites nationwide (1 percent of contaminated sites). Approximately one in ten of these have achieved cleanup targets (NRC, 1994). Most others have reached some "steady state" situation where further significant reduction in contaminate levels is unlikely. This should not suggest that pump and treat is a failed technology. In fact it has and will continue to have many useful applications in the containing contaminant plumes, reducing contaminant levels, and in some cases meeting health based cleanup targets. However, it is a technology which has often been asked to perform beyond its capabilities.

In Wyoming, somewhere between 65 and 75 percent of the state's residents are dependent wholly or in part on ground water for their drinking water. This figure reaches over 90% for rural residents. There are 200+ public water supply (PWS) systems in Wyoming relying wholly or in part on ground water. These systems serve approximately 225,000 people. Sixty-five of these exceeded some Maximum Contaminant Level (MCL) as defined by EPA during the 1992-93 year (DEQ/WQD, 1994). Despite these occurrences (some of which are natural and not related to contamination by man), ground water in Wyoming is generally of good to high quality. The focus of Wyoming's efforts, therefore, has been on protection of ground water instead of remediation.

Protecting ground water has become the resource manager's choice due to the seriousness and general intractability of cleaning up contaminated ground water. This has led to a variety of protection strategies and management policies in various stages of development around the United States. Central to this protection effort and as a means of assessing priority and allocating finite fiscal resources has been the concept of assessing the relative vulnerability of ground water to pollution before it is contaminated.

Ground Water Management Legislation and Policy

Within the United States, no single piece of national legislation exists to protect ground water. Congress has passed at least 16 statutes that authorize programs which may be used as tools to protect ground water and much of that power is passed on to the individual states to implement. Of these statutes, the most commonly known are the Clean Water Act and the Safe Water Drinking Act. While these statutes were initially passed in 1946 and 1974 respectively, before 1987 most attention was given to surface water quality (Danielson, et. al., 1991).

The Clean Water Act (CWA) applies to ground water by authorizing EPA to make grants to the states for the development of ground water protection strategies and authorize a number of programs to prevent water pollution from a variety of potential sources. While the CWA was initially intended to protect surface waters, several of the sections have been applied to ground water over the years. The CWA was amended in 1987 to include Section 319, which required states to prepare nonpoint-source assessment reports, categorize nonpoint pollution, list processes for the identification of necessary "Best Management Practices," and to discuss available state and local programs on a watershed by watershed basis (Doppelt, et. al., 1993). In addition, Section 319 authorizes funding to control non-point source pollution. Under Section 319, states may obtain grants for water quality protection activities, educational materials and programs, and special studies and projects.

The Safe Water Drinking Act (SWDA) of 1974 was adopted to ensure that public water supply systems meet minimum national standards for public health, regulate underground disposal of wastes, and designate areas that rely on a single aquifer for their water supply. EPA, as the agency charged with enforcing these standards, defined Maximum Contaminant Levels (MCLs) for coliform bacteria, turbidity, and inorganics, as well as several organic chemicals within drinking water supplies of the U.S. These MCLs were amended in 1976 to include radionucleides and amended again in 1986 to expand greatly the number of substances included. Other significant changes adopted in 1986 were the provision for states to adopt programs to protect wellhead areas of Public Water Supply (PWS) wells from contaminants posing health risks, and the regulation of underground injection wells through the Underground Injection Control (UIC) program. The Wellhead program assists states in the development of WHP plans to delineate Wellhead protection areas for each PWS, inventory potential contaminant risks within that area, and develop a plan detailing measures to be taken to protect each well. In 1996, the SDWA was amended once again to include provisions for the Source Water Protection Program (SWPP) or Section 1453, Section 1429 which establishes a ground water protection funding program, and the Ground Water Disinfection Rule. (Congress elected to not allocate funding for the Section 1429 program in the recent budget.) The Source Water Protection Program allocates substantial funds to the Drinking Water State Revolving Fund (Wyoming's share will be $12.5 million) to allow states with primacy over the PWSS program to create source water assessment programs. Although Wyoming is the only state that does not maintain primacy over this program, enabling legislation is planned to allow Wyoming to obtain these funds for source water protection efforts.

Wyoming maintains primacy over all programs created as a part the SDWA as defined by the Wyoming Environmental Quality Act with the exception of the Public Water Supply Supervision Program (Frederick, 1992). These programs are administered by the Wyoming Department of Environmental Quality, Water Quality Division (DEQ/WQD). In order to fill Wyoming's obligations under the 1987 amendments to the CWA, the state is finalizing its Statewide Management Plan (SMP) for Pesticides. Fundamental to the development of this SMP is the assumption that potential for ground water contamination from pesticide use in the State was minimal, if not altogether absent, as determined from historic ground water monitoring information, absence of citizen complaints, and general knowledge of pesticide use and relative ground water vulnerabilities within the state. The focus of the SMP logically becomes one of protection of ground water resources in the State's agricultural areas, through prevention mechanisms, to maintain ground water quality for its existing and future beneficial use. With an eye toward minimizing the potential for over-regulation in areas of low ground water vulnerability or conversely, under-protection of highly vulnerable ground water, the SMP will contain a policy of differential BMPs based on the vulnerability of ground waters (Frederick, 1992).

To determine these vulnerability values, DEQ/WQD, in cooperation with the Wyoming Department of Agriculture and the Wyoming Water Resources Center (WWRC) elected to undertake an aquifer sensitivity study for the agricultural areas within Wyoming. The resulting map delineations address the requirement that the state's management plan for pesticides includes a means to identify geographic areas where ground water is susceptible (i.e. vulnerable) to effects from pesticides applied at the surface. Identification of these vulnerable areas will also assist state agencies and their local partners with identifying and prioritizing areas for ground water monitoring.

The Wyoming Ground-Water Vulnerability Mapping Project was begun in 1992. Funded by the DEQ/WQD and the Wyoming Department of Agriculture through the EPA Section 319 program, the seven-year project was envisioned as a proactive effort to reduce the potential for pollution of the state's aquifers.

Assessing Ground Water Vulnerability in Wyoming

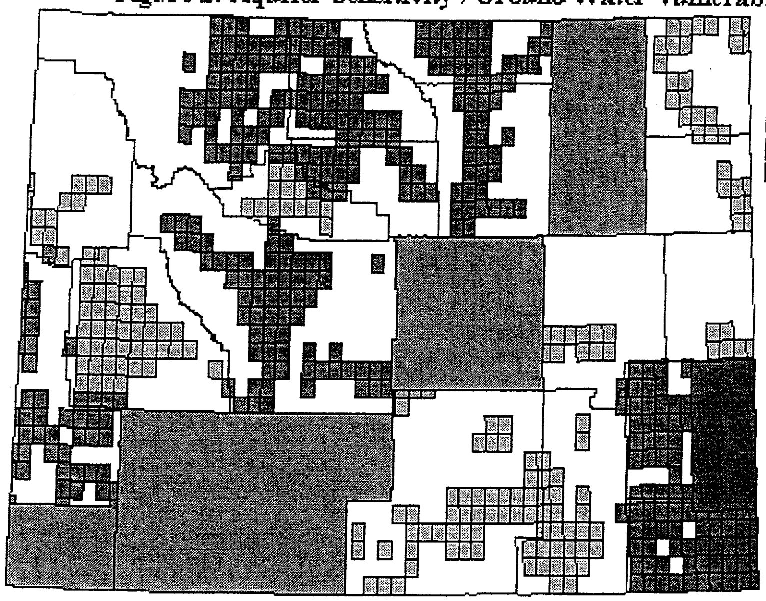
A modified form of EPA's DRASTIC model (Aller, et. al., 1987) was chosen to delineate aquifer sensitivity ratings in Wyoming. The original DRASTIC model uses seven independent hydrogeologic parameters that affect contaminant transport from the soil to the surface to the aquifer: **D**epth to Ground Water, **R**echarge, **A**quifer Media, **S**oils, **T**opography, **I**mpact of the Vadose Zone, and Saturated Hydraulic **C**onductivity. For a given area, each of the parameters is rated (1-10) and then combined to produce a composite contamination potential index. Problems exist with this approach, however. If preserving water quality is the primary concern, saturated hydraulic conductivity should be ignored because it plays a role in contaminant transport only after it reaches the aquifer. In Wyoming it was decided to alter the DRASTIC model to include only the remaining six parameters to better reflect the travels of a potential contaminant before it reaches the aquifer. In addition, the DRASTIC model contained independent weights for each of the layers based on the proposed use of the final sensitivity product. This approach leads to several sensitivity products which can each be used for a single type of land use. To increase the potential applications of the single final sensitivity product, layer weights were arbitrarily assigned equal values.

In Wyoming a unique additional step was added to the aquifer sensitivity process by introducing into the analysis potential land uses that could cause contamination. Initially in our project this contaminant layer consists of agricultural and urban land use practices. This potential contaminant layer has been used as a seventh parameter in the final ground water vulnerability product. Similar to the previous layers, each category was given a unique rating based on actual pesticide application rates for each county and overlaid on the sensitivity layer.

To handle the data organizational needs of this project a Geographic Information System (GIS) was used. A GIS, simply defined is a computer-based information technology which stores, analyzes, and displays both spatial and non-spatial data. Its primary advantage is that it allows the integration of data layers from a multitude of sources and scales into one integrated system. This makes it an excellent tool for managing the ground water modeling process, analyzing the results, and updating and archiving spatially-referenced data sets (Richards, et. al., 1993).

Goshen County in southeastern Wyoming was chosen as a pilot study area to be mapped as Phase I of the project. Because funding was not available to map the entire state at a 1:100,000 scale initially, Phase II included two separate scales of mapping efforts. First, all of Wyoming was mapped for aquifer sensitivity at a regional scale of 1:500,000. Additionally, critical agricultural areas in priority counties of Wyoming were mapped at 1:100,000 scale. These counties were chosen by considering hydrogeologic characteristics of the county, amount of agricultural land, and availability of data (Needham, 1994). Within these 10 priority counties critical areas were delineated by USGS 7.5 minute quadrangle boundaries. (Figure 1)

Figure 1: Aquifer Sensitivity / Ground Water VulnerabilityMapping Progress



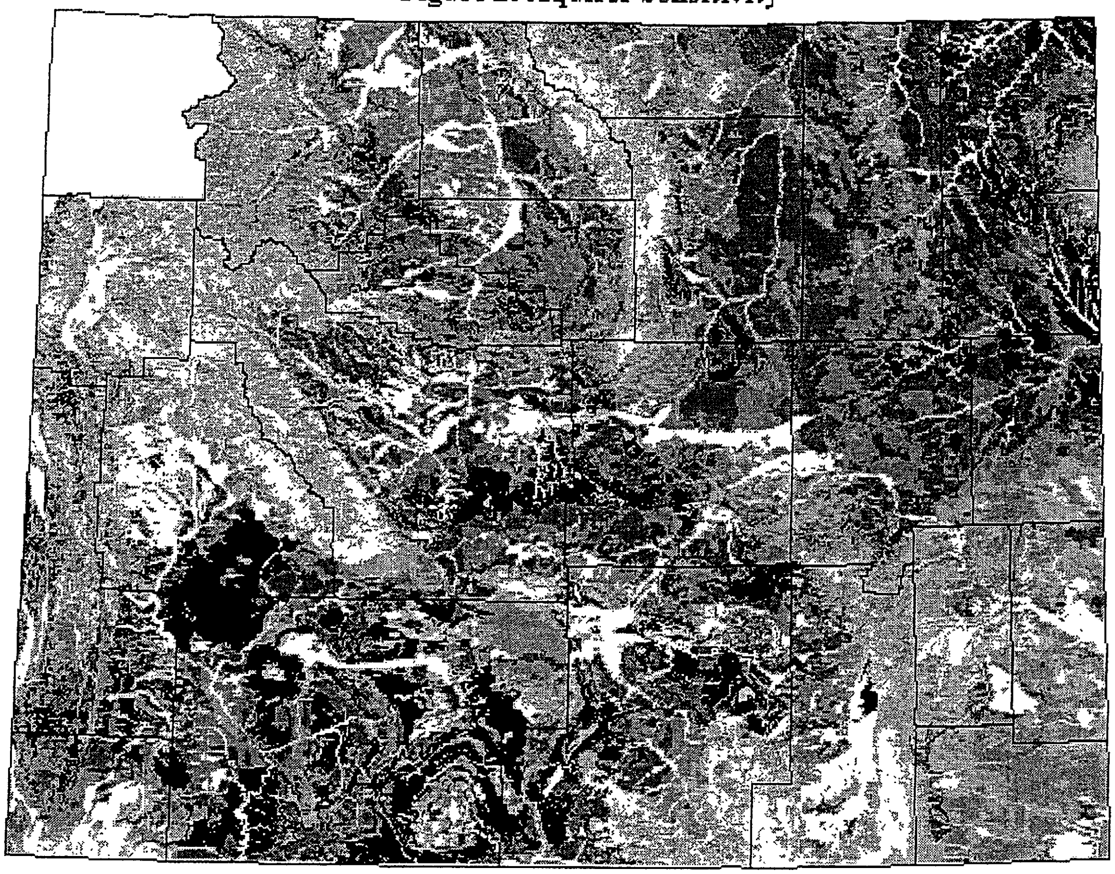
<u>Data Requirements</u> - The data needs of this project included many digital map layers that did not previously exist in Wyoming. A surficial geology map of Wyoming was specifically created for this project by the Wyoming State Geological Survey and digitized by the WWRC. This map was produced by interpreting 1:58,000-scale aerial photographs and then verifying in the field. The WWRC also cooperated with the USGS to create a digital version of the 1:500,000-scale Bedrock Geology map of Wyoming. Ground water levels and yields were produced from historic well permit records archived at the Wyoming State Engineer's Office in a tabular database and had to be imported into a GIS format. These wells were used to produce the *Depth to Initial Ground Water* map, as well as some analysis in the Vadose layer. Infrared 1:58,000-scale aerial photographs were interpreted and digitized to produce the agricultural cropland layer. Using these photos, delineations were made for irrigated cropland, non-irrigated cropland, and urban areas for the critical areas. They were then digitized into the GIS.

The *Depth to Initial Ground Water* layer was creating by applying an interpolation routine to the ground water wells. These wells went through several quality control procedures designed to exclude outliers and wells that were drilled through the shallowest aquifer to a deeper formation. *Recharge* was defined by applying a percentage of precipitation value to each of the surficial soil units and then multiplying to the precipitation layer to generate a value in inches. In this study, *Aquifer Media* was renamed to *Geohydrologic Setting* and was produced through a rating procedure applied to deep geologic units. Two separate *Soils* layers were created based on the two mapping scales. By analyzing surficial geology, bedrock geology, watershed boundaries, and elevation, a series of decision rules was created to delineate the soil units. The *Land Surface Slope* layer was created by resampling the 3-arc-second Digital Elevation Model (DEM) from a 90 meter resolution to 100 meters and then applying a slope calculation routine. The *Impact of Vadose* layer was created by rating the geologic information using depth to ground water to define the formation and previous research to specify the characteristics of the formation.

Results - The final 1:500,000-scale sensitivity map for Wyoming was produced by overlaying the six parameter layers. The statewide layer had a range of values from 6-60. (figure 2) The map was classified into five sensitivity ranges which were then utilized for the county-level maps to allow visual comparison across county lines. Nine county sensitivity maps were produced at approximately 1:100,000-scale as well as color maps showing the individual parameters which are useful as independent products.

Ground Water Vulnerability to Agricultural Contaminants was then calculated by combining the county-wide aquifer sensitivity digital layers with the cropland map.

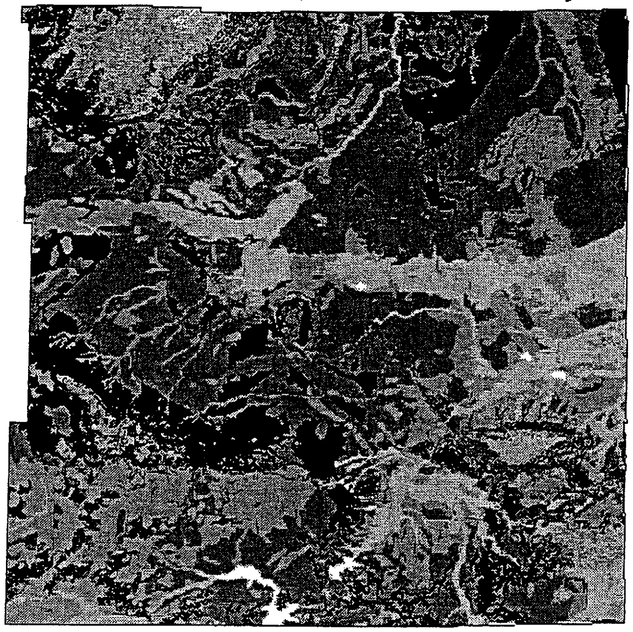
Figure 2: Aquifer Sensitivity



(figure 3) Recharge in the irrigated areas was recalculated to be highly sensitive and each county was given a different rating for cropland based on the amount of pesticides and fertilizers applied based on current literature. Because no reliable statewide land-use layer exists for Wyoming, no vulnerability analysis was done at a statewide 1:500,000 scale.

The final results of this project will be published as a Ground Water Vulnerability Handbook with appendices for each county. As new counties are completed appendices will be added.

Figure 3: Natrona County Ground Water Vulnerability



Applications

The final maps produced by the project are intended for regional planning and education efforts and should not be used for site-specific evaluations. As a result these products are not appropriate for regulatory practices within the state. Nevertheless, valid uses of the products include assessment and planning tools at both the state and local level, education, monitor well siting, and Wellhead protection area delineations.

Pesticide Management Plan - The final maps will serve as assessment and planning tools to enable implementation of Wyoming's State Management Plan (SMP) for pesticides (WGWPSC, 1997). This plan is currently awaiting EPA's final revisions. According to EPA guidelines for the development of SMPs, 12 specific components must be considered and included in the SMP. They are: (1) state's philosophy toward protecting groundwater, (2) legal authority, (3) prevention actions, (4) public awareness/participation, (5) records/reporting progress, (6) resources, (7) monitoring, (8) roles/responsibilities of state agencies, (9) enforcement mechanisms, (10) basis for aquifer vulnerability assessment & planning, (11) information dissemination and (12) responding to detections of pesticides in ground water (Frederick, 1992). This plan, when finalized, will enable state government, with local partners, to identify and prioritize areas for ground water monitoring. The establishment of these areas will provide a reasonable likelihood that contamination from pesticides representing an unreasonable risk to the environment will not go undetected. SMP ground water monitoring programs must include components to: 1) establish ambient ground water quality conditions (i.e. baseline monitoring); 2) determine and evaluate potential sources where pesticides in ground water have been detected (i.e. problem identification monitoring); and 3) define the extent of impairment and need for remedy where pesticides in ground water pose a threat to either human health or the environment (i.e. Response or Evaluation monitoring). In addition, in June 1996, EPA issued a notice of proposed rulemaking, the intent of the rule being to restrict the use and sale of five pesticides that were identified as either probable or possible human carcinogens (alachlor, atrazine, cyanazine, metolachlor, and simazine) to only those states which have EPA-approved SMPs; it is reasonable to expect that additional pesticides will be treated similarly in the future. By obtaining EPA approval of its SMP, Wyoming will be able to continue the use of the above-mentioned pesticides in accordance with the SMP.

Education - The products will serve as educational and planning tools to inform, educate and assist communities, rural homeowners, pesticide users, Public Water System (PWS) operators, city/county government officials and planners, businesses and industry, local resource management organizations and agencies, and state agencies in implementing ground water protection efforts to protect ground water quality in sensitive and vulnerable areas, especially those used to provide drinking water. Where these aquifers are used to provide drinking water, both communities and rural homeowners now have the ability to evaluate the degree to which their drinking water supply may be susceptible to such a release, be it from either a point- (e.g. spill, leaking tank, etc.) or a non-point source (e.g. fertilizer/pesticide application).

UIC Vulnerability

Ground water vulnerability to shallow Underground Injection Control (UIC) wells is also due for completion soon. This product will combine the initial aquifer sensitivity layer with a digital representation of Class V (five) injection wells to relate vulnerability to a landuse apart from agriculture. Class V permits, the largest class of injection wells, are wells that do not fall under the other four UIC classes. Class I wells are those which inject large amounts of hazardous fluids. Class II are oil recovery reinjection wells. Class III are uranium solution mining wells and Class IV are radioactive waste injection wells (Hamerlinck et al., 1993). Class V wells are generally shallow injection facilities (e.g., above or into the water table) that include automobile floor drains, large septic system leachfields, and aquifer recharge wells, among others.

Wellhead Protection

Many communities within Wyoming are establishing Wellhead Protection Management Committees to develop and implement local Wellhead Protection (WHP) plans to protect their drinking water supplies from existing and potential contaminant sources that lie within their well or wellfield area. The success of such plans depends upon the effectiveness of implementing educational programs, management practices and local controls to minimize or reduce the potential for toxic substances to be released into the aquifer and potentially impair the drinking water supply. WHP plans typically include measures to take in the event of a disruption to the water supply system, and important factors to consider when evaluating sites for new wells or well fields. Ground water vulnerability maps will serve as a tool for delineating these WHPAs.

Wyoming has just finalized its State Wellhead Protection Plan (WWHPSC, 1997) to serve as a tool to aid communities in this effort. This plan recognizes the role that ground water vulnerability maps can provide in this effort.

Other Applications

Planning tools: Sensitivity and vulnerability maps can be used as planning tools by communities, rural homeowners, pesticide users, Public Water System (PWS) operators, city/county government officials, city/county planners and resource management organizations and agencies to make well-informed decisions regarding the need to protect ground water used for drinking water supplies as well as for other uses. Descriptions of several ways in which these maps may be used as planning tools are detailed below.

Communities, local elected officials, city/county planners, PWS operators: In Wyoming, ground water is used to supply drinking water for approximately 75% of the state's population served by Public Water Systems (generally municipal systems), and nearly all rural households; much of this water is supplied from shallow aquifers. These aquifers are also used to provide ground water for irrigation, stock watering and industrial use throughout much of the state. Several communities are now recognizing that ground water vulnerability maps can be a beneficial tool in developing their long-range plan. The city of Lander, for example, has just included ground water vulnerability in its Lander 2020 Plan which will serve to guide municipal development long past the turn of the century. In addition, several local conservation districts are including this information in their local land use plans.

Pesticide users, resource management organizations and agencies: As mentioned earlier, Wyoming's pesticide management plan must also describe how detections of pesticides in ground water will be addressed, or responded to. In those instances where pesticides have been detected in ground water at allowable levels, state agencies will coordinate with local partners to discuss options for implementation of pesticide Best Management Practices (BMPs) and educational programs to reduce pesticide leaching to ground water. BMPs are methods, measures or practices designed to prevent or reduce pollution. They include structural and nonstructural controls as well as operation and maintenance procedures (Logan, 1991). In those instances where pesticides have been detected in ground water at unacceptable levels, state agencies (with input from the public) will use appropriate authorities to protect the ground water users and restore ground water quality to acceptable conditions.

Future Uses

One of the more recent trends in ground water management has been the legislation of liability with regards to ground water contamination. Recently states have grappled with statutes attaching monetary liability to parties responsible for contaminated waters even though these parties followed all laws and regulations with regards to pesticide application. Existing federal legislation provides for liability for misuse and wrongful disposal of pesticides, but it does not meaningfully address the question of who should be liable for injuries from lawful pesticide use. Therefore by applying a strict liability interpretation, producers can be held accountable for "blameless contamination." Several states such as Connecticut, Arizona, and Georgia have dealt with this liability issue by issuing exemptions for producers that follow proper application procedures for pesticides, implement a plan to minimize potential for contamination, maintain all records relating to their applications, and register with the local state agency (Centner, 1991). Should the need for local legislation arise in Wyoming, ground water vulnerability maps could serve as an initial tool to locate areas where potential exists for easy contamination.

Enhancements to the vulnerability projects in the future could include adding additional land use layers to the model. These layers potentially including landfills, sewage treatment facilities, and feedlots, among others could lead to a comprehensive "Ground Water Vulnerability to Permitted Facilities" map. However, research is necessary to establish relationships between the contaminant potential of these inherently different facilities before development of any such regional planning products can be attempted.

References

Aller, L., Bennett, T., Lehr, J.H., Petty, R., and G. Hackett. 1987. DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings. U.S. Environmental Protection Agency. EPA/600/S2-87/035. Cincinnati, Ohio.

Centner, T.J., "Blameless Contamination: The Challenge of Regulating Liability in Agriculture," Groundwater and Public Policy Series: Issue 9. Groundwater Policy Education Project. 1991.

Danielson, LE., and D.E.M. Patte, "Federal Policies and Programs to Protect Groundwater Quality," Groundwater and Public Policy Series: Issue 12. Groundwater Policy Education Project. 1991.

Doppelt, B., Scurlock, M., Frissell, C., and J. Karr. 1993. Entering the Watershed: A New Approach to Save America's River Ecosystems. Washington, D.C.: Island Press.

Frederick, K.D., 1992. "Assessing Vulnerability of Aquifers in Wyoming to Contamination: a DRASTIC/GIS Approach," unpublished manuscript.

Hamerlinck, J.D., Wrazien, D.R., and S. Needham. 1993. Underground Injection Well Database Development for Groundwater Vulnerability Assessment Applications. In Proceedings, GIS/LIS '93, Minneapolis, MN, pp. 270-281.

Logan, T.J., "Agricultural Best Management Practices," Groundwater and Public Policy Series: Issue 5. Groundwater Policy Education Project. 1991.

Kavanaugh, M. 1994. "Cleanup of Contaminated Ground Water: A Major Policy Dilemma." In WSTB Newsletter, Water Science and Technology Board, National Research Council, Vol. 11, No. 3.

National Research Council. 1993. Ground Water Vulnerability Assessment: Predicting Relative Contamination Potential under Conditions of Uncertainty. Washington, D.C.: National Academy Press.

National Research Council. 1994. Alternatives for Ground Water Cleanup. Washington, D.C.: National Academy Press.

Needham, S. 1994. "Assessing Vulnerability of Aquifers in Wyoming to Contamination, Phase One: Vulnerability Mapping of Goshen County Wyoming Using a Geographic Information System." Unpublished Report. Laramie, Wyoming: Wyoming Water Resources Center.

Richards, C.J., H. Roaza, and R.M. Roaza. 1993. Integrating Geographic Information Systems and MODFLOW for Ground Water Resource Assessments. Water Resources Bulletin, 29(5):847-853.

Wyoming Department of Environmental Quality, Water Quality Division. 1994. 1994 Wyoming Water Quality Assessment. Cheyenne, Wyoming.

Wyoming Ground Water and Pesticides Strategy Committee. 1997. "Generic State management Plan for Pesticides in Ground Water for the State of Wyoming" (Draft), Cheyenne, Wyoming.

Wyoming Wellhead Protection Strategy Committee. 1997. "Wyoming State Wellhead Protection Plan" (Draft), Cheyenne, Wyoming.