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Factors Influencing the Development of a Ground-Water Protection Strategy by the State of Tennessee

Carol D. Henry
Edwin W. Morse
Paula L. Magnuson
James J. Geraghty

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FACTORS INFLUENCING THE DEVELOPMENT OF A GROUND-WATER PROTECTION STRATEGY BY THE STATE OF TENNESSEE

Carol D. Henry
Edwin W. Morse
Paula L. Magnuson
James J. Geraghty

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CONTENTS

		Page
1.0	EXECUTIVE SUMMARY	1-1
2.0	INTRODUCTION	2-1
2.1	Background	2-1
2.2	Objective	2-2
3.0	GROUND-WATER PROTECTION STRATEGIES	3-1
3.1	Policies	3-1
3.1.1	Nondegradation	3-2
3.1.2	Limited degradation	3-3
3.1.3	Differential protection	3-3
3.2	Methods	3-5
3.2.1	Setting of water-quality standards	3-5
3.2.2	Classification of aquifers	3-7
3.2.3	Classification of contaminants and sources	3-10
3.2.4	Control of land uses	3-11
3.2.5	Control of discharges	3-13
4.0	OVERVIEW OF NATIONAL ACTIVITIES	4-1
4.1	EPA's Ground-Water Protection Strategy	4-1
4.1.1	Objectives	4-1
4.1.2	Implementation program	4-2
4.1.2.1	Strengthen state programs	4-2
4.1.2.2	Survey inadequately addressed sources	4-3
4.1.2.3	Develop guidelines	4-3
4.1.2.4	Improve intra- and inter-agency coordination	4-6
4.2	Other Federal Programs	4-6
4.3	State Programs	4-13
4.3.1	Overview	4-13
4.3.2	Elements of state strategies	4-17
4.3.2.1	Standards	4-17
4.3.2.2	Control of discharges	4-19
4.3.2.3	Aquifer classification	4-23
4.3.2.4	Land-use control	4-27
4.3.2.5	Contaminant and source classification	4-31
4.3.3	Remedial-action and enforcement activities	4-33

CONTENTS
(cont'd)

	Page
5.0 BASIS FOR ACTION IN TENNESSEE	5-1
5.1 Strategy Options	5-1
5.2 Hydrogeologic Considerations	5-2
5.2.1 Major aquifers	5-2
5.2.2 Ambient water quality	5-3
5.3 Institutional Framework	5-7
5.3.1 State agencies	5-7
5.3.2 Interagency coordination	5-11
5.4 Regulatory Programs	5-11
5.4.1 Permits and Quality Assurance Program	5-11
5.4.2 State Superfund Program	5-12
5.4.3 Underground Injection Control Program	5-14
5.4.4 Underground Storage Tank Program	5-15
5.4.5 Other programs	5-16
5.5 Draft Ground-Water Management Strategy	5-17
6.0 CONCLUSIONS	6-1
6.1 Factors Influencing the State Strategy	6-1
6.1.1 Hydrogeology	6-1
6.1.2 State programs	6-2
6.1.3 Political factors	6-3
6.1.4 Economics	6-3
6.2 Outlook	6-4
7.0 REFERENCES	7-1
APPENDIX A: DESCRIPTIONS OF MAJOR FEDERAL STATUTES RELEVANT TO THE PROTECTION OF GROUND-WATER QUALITY	A-1
APPENDIX B: WATER-QUALITY STANDARDS AND GUIDELINES	B-1
APPENDIX C: TENNESSEE DRAFT GROUND-WATER MANAGEMENT STRATEGY	C-1

TABLES

Page

1. Summary of Federal Programs and Activities Related to the Protection of Ground-Water Quality..... 4-7
2. Relationship Between Sources of Contamination and Federal Statutes..... 4-9
3. Ground-Water Related Activities of Federal Agencies 4-12
4. Ground-Water Policies Adopted by States..... 4-15
5. Summary of State Ground-Water Quality Standards.... 4-20
6. State Ground-Water Classification Systems..... 4-24
7. Methods Adopted by States to Implement Ground-Water Protection Programs..... 4-28
8. Aquifer and Well Characteristics in Tennessee..... 5-5

FIGURES

1. Principal Aquifers in Tennessee..... 5-4
2. Organization of the Bureau of Environment, TDHE.... 5-8
3. Organization of the Division of Ground-Water Protection..... 5-10
4. Development of the Tennessee Ground-Water Protection Strategy..... 5-20

ABBREVIATIONS

AEA	Atomic Energy Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (Superfund)
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERRIS	Emergency Response Remedial Investigation Sites
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FLPMA	Federal Land Policy and Management Act
HLPSA	Hazardous Liquid Pipeline Safety Act
HMTA	Hazardous Materials Transportation Act
MCL	Maximum Concentration Limit
mg/l	milligrams per liter
NEPA	National Environmental Policy Act
NJPDES	New Jersey Pollution Discharge Elimination System
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OGWP	Office of Ground Water Protection
OTA	Office of Technology Assessment
PALs	Preventive Action Limits
ppb	parts per billion
ppm	parts per million
RA	Reclamation Act
RCRA	Resource Conservation and Recovery Act
RMCL	Recommended Maximum Concentration Limit
SDWA	Safe Drinking Water Act
SMCRA	Surface Mining Control and Reclamation Act
SPDES	State Pollution Discharge Elimination System
T.C.A.	Tennessee Code Annotated
TDHE	Tennessee Department of Health and Environment
TDR	Transferable Development Right
TDS	total dissolved solids
TSCA	Toxic Substances Control Act
UMTRCA	Uranium Mill Tailings Radiation Control Act
UIC	Underground Injection Control
USDW	Underground Source of Drinking Water
USGS	U.S. Geological Survey
UST	Underground Storage Tank
WRDA	Water Research and Development Act

1.0 EXECUTIVE SUMMARY

In August 1984 the U.S. Environmental Protection Agency published its Ground-Water Protection Strategy, which calls for increased cooperation with and guidance to states and regions for development of their own ground-water policies. Developing a state strategy is a major undertaking in terms of time, staffing requirements, and funding. An agency or task force must be designated to coordinate ground-water programs throughout the state and evaluate the state's uses of and relative dependence on ground water before the state's goals in ground-water protection can be defined.

The goals of ground-water protection chosen by a state may be reflected in policies of nondegradation, limited degradation, or differential protection. Nondegradation calls for equal protection of all ground water at background levels; a policy of limited degradation protects all ground water equally at a specified set of standards, which may be different from background conditions. Finally, a policy of differential protection may be chosen in which aquifers receive different levels of protection depending, for example, on their use, hydrogeologic characteristics, or vulnerability to contamination. Once an overall policy is adopted, methods must be chosen for its implementation. These methods might involve development of ground-water standards; classification of aquifers according to, for example, existing water quality or hydrogeologic setting;

adoption of land-use controls; or development of permit programs to control discharges. Finally, a set of regulations must be adopted with enforcement guidelines for effective implementation of the strategy.

The State of Tennessee has produced a draft ground-water management strategy that classifies the state's aquifers into two categories and requires enforcement of standards already developed in the state's Underground Injection Control Program. Comments are now being solicited on the draft strategy, to be considered in future revisions. In the meantime, the state has received interim authorization under RCRA and also has its own Superfund Program, so that several programs already are in place regarding the protection of ground water. The strategy may eventually lead to more comprehensive regulations, but the elements of existing regulations will continue to control many ground-water protection activities in the state.

2.0 INTRODUCTION

2.1 BACKGROUND

Contamination of ground water by organic and inorganic chemicals, radionuclides, and/or microorganisms is occurring in every state of the United States, at the same time that the nation's dependency on ground water has been increasing steadily. Ground water is now the source for approximately 50 percent of the nation's drinking-water needs, about 40 percent of the nation's irrigation requirements, and for about 80 percent of home and livestock uses in rural areas (U.S. Congress, 1984).

In recent years, to deal with the issue of ground-water protection, several new federal laws have been enacted, new regulations have been adopted, and existing regulations have been modified. In 1972, for instance, Congress extended the Clean Water Act (CWA) to cover spills of hazardous substances. The Resource Conservation and Recovery Act (RCRA) was enacted by Congress in 1976 to regulate, through the U.S. Environmental Protection Agency (EPA), all aspects of active hazardous-waste management. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) was enacted in 1980, giving EPA the authority and funding to initiate clean-up or to require others to do so, without first determining liability. Other regulations that address ground water either directly or indirectly include the Safe Drinking Water Act (SDWA), the Federal Insecticide,

Fungicide, and Rodenticide Act (FIFRA), and the Toxic Substances Control Act (TSCA).

These statutes were enacted at different times for different purposes and therefore have led to inconsistencies in the regulation of ground water and potential sources of contamination. In an effort to establish consistency and to take on the role of leadership in ground-water protection, EPA developed a ground-water protection strategy, which was first officially published in 1980; the elements of a revised strategy were published in August 1984. Generally, the strategy calls for: (1) improved internal coordination of ground-water programs, (2) increased support to state agencies, (3) development of guidelines that provide consistency among national and state ground-water protection programs, and (4) studies of the need for additional regulation of inadequately addressed sources. In response to the adoption of this strategy by EPA, many states have developed formal ground-water management strategies of their own. The State of Tennessee issued its draft ground-water management strategy in October 1985.

2.2 OBJECTIVE

In December 1985, Martin Marietta Energy Systems, Inc., retained Geraghty & Miller, Inc., (G&M) to compile and update information relating to the development of a ground-water management strategy in Tennessee. The project was undertaken because waste-disposal and other activities at the Oak Ridge

National Laboratory in Oak Ridge, Tennessee, could be affected by regulations that would be promulgated in response to adoption of the state's ground-water strategy. Because the state strategy is still in preliminary form, G&M also was assigned the task of compiling information on strategies in other states, so that a range of possible elements could be defined that might eventually make up Tennessee's strategy.

3.0 GROUND-WATER PROTECTION STRATEGIES

3.1 POLICIES

The development of a ground-water protection strategy is a function of many elements, including the goals for ground-water protection, institutional constraints and guidelines, economic interests, public awareness and pressures, availability of funding, and the characteristics of the hydrogeologic environment. A state's goals may reflect: (1) needs for ground water as a resource, (2) uses of ground water and the quality and quantity required for these uses, and (3) the history of natural resource protection practices. States with a high demand and short supply of ground water, for instance, would establish policies different from those in states where demand is low and ground water is abundant.

Once a state has clearly defined its goals, it establishes a policy reflecting those goals. Existing and proposed ground-water protection policies fall along a continuum from maintaining the quality of ground water at natural or background levels to setting standards based on current and anticipated uses of ground water. Along this continuum there are three basic policy options, (1) nondegradation, (2) limited degradation, and (3) differential protection (Henderson, et al., 1984). Nondegradation calls for the protection of ground water at its existing quality level. Limited degradation allows the degradation of all ground water, regardless of use, to certain standards (for

example, drinking-water standards). Differential protection is a use-oriented policy, calling for different levels of ground-water quality protection based on current or future ground-water needs, current ground-water quality, and/or hydrogeologic characteristics of aquifers.

3.1.1 Nondegradation

A nondegradation policy protects the ground water at existing levels, and in some cases improves water quality. The policy, which is based on the assumption that all ground water is equally valuable to people and the natural environment, is best suited to regions characterized by: (1) high-quality and sole-source aquifers, (2) heavy dependence on ground water for drinking-water supplies, (3) large numbers of private wells, and (4) unconfined aquifers where localized contamination would eventually spread to endanger larger areas. Waivers for specific activities where it is impossible to achieve nondegradation are generally required under this approach.

A nondegradation policy protects ground water for any future needs, and protects humans and the environment against the uncertainties in setting numerical standards for safe levels of contamination. The policy prevents contamination by substances that presently have unknown effects on humans and the environment.

A nondegradation policy is generally very expensive to

implement because of the strict standards that must be met. Furthermore, it may be unrealistic in some states, in the light of current industrial, agricultural, or mining practices. An area rich in oil and/or natural gas, for example, is likely to place a lower priority on ground-water protection because restrictions on the development of these economic resources would be seen as detrimental.

3.1.2 Limited Degradation

A limited degradation policy is designed to preserve ground-water quality according to either prescribed numerical standards or general narrative guidelines (see section 3.2.1). This policy aims to maintain ground water at as high a standard as possible but acknowledges that some degradation of existing quality is inevitable. Some proponents of the policy argue that it protects all ground water but only to the extent necessary to protect health and welfare. Some opponents of the policy view it as economically inefficient because it considers all aquifers to be of equal value. Still others consider the policy undesirable because it allows a degree of degradation in water quality.

3.1.3 Differential Protection

A differential protection policy is designed to protect ground-water resources only as needed to satisfy present and future uses. This policy tends to be linked to aquifer classification systems (see section 3.2.2), which distinguish

between aquifers or ground-water regions on the basis of geologic characteristics, population dependency, depth, vulnerability to contamination, types of uses, environmental importance, salinity levels, and availability of alternative water supplies. Higher quality aquifers are afforded the highest levels of protection under this policy. Less stringent controls are applied in some areas to accommodate industrial and other activities that may degrade water quality. The policy is based on the assumption that not all ground-water resources are of equal value and that protection priorities should be set accordingly.

This policy explicitly supports the development of cost-effective management and protection techniques. It also provides an incentive for industrial development in areas where aquifers are less vulnerable and therefore might be viewed as requiring less stringent ground-water quality standards. It is especially attractive to industrialized states that simultaneously may have to deal with severe contamination and the need to protect higher quality waters. On the other hand, in states with uniformly high water quality and few threats of contamination, there is likely to be little public support for such a policy.

One risk in allowing differential protection of aquifers is that estimates of future population patterns and water needs may prove inaccurate. Also, in areas where aquifers are not isolated from each other, the possibility exists that

lower quality water from less protected aquifers may migrate to more valuable aquifers.

3.2 METHODS

Many methods are available to implement a ground-water protection policy, some of which can be applied to all of the three basic policies. The methods include development of water-quality standards; classification of aquifers, contaminants, and sources; provision of incentives to maintain or upgrade water quality; control of land use through zoning, permitting, or other methods; and control of discharges through permitting. The same general level of ground-water quality protection might be achieved under different policies, depending on the mix of methods used.

3.2.1 Setting of Water-Quality Standards

Ground-water quality standards specify maximum contaminant levels to provide a level of protection to aquifers, or stated differently, a level of permissible degradation. Ground-water standards may affect facility designs, industry-specific effluent limitations, or enforcement actions based on imminent hazard. Generally, ground-water standards may be considered reactive protection techniques, in that actions are taken only when the standard is exceeded.

The use of standards is tied to the policy adopted for ground-water protection; standards can be applied uniformly, or differentially, to offer varying degrees of protection.

Standards under a policy of nondegradation would by definition be ambient conditions. The term "ambient conditions," however, may refer to either the level of contamination at the time the policy takes effect or to background levels measured outside an existing area of contamination. Only under the latter circumstance would a policy of nondegradation indicate that clean-up is required. Under limited degradation, ground water would be allowed to be degraded from ambient or background to the level of the standard. Clean-up would be required whenever standards were exceeded. Under a policy of differential protection, different standards are set for different aquifers.

Standards may be numerical or in the form of narrative guidelines. Numerical standards may include the federal primary drinking-water standards under the SDWA, health advisories or recommended maximum contaminant levels (RMCLs) issued by EPA, or other standards based on toxicological or other evidence. Some standards may reflect specific ground-water problems; for example, a state may establish a standard for a locally used pesticide that is considered carcinogenic. One problem with establishing numerical standards is that so many chemicals exist (curently on the order of 50,000 to 75,000, with 700 to 800 new ones being developed each year), which makes it virtually impossible to develop a comprehensive set of standards (Henderson, et al., 1984).

Narrative standards focus on regulating contaminant

discharges that may impair designated uses of ground water; they describe a level of protection but set no precise numbers or levels of quality. For example, a narrative standard may prohibit a discharge that could cause a public health hazard or could interfere with present and future uses of ground water. Narrative standards are generally applied on a case-by-case basis and place on the discharger the burden of proving that planned activities will not violate the standards. Narrative standards are useful when insufficient data are available to establish numerical standards. However, narrative standards can create a substantial administrative burden by requiring a case-by-case determination of violations.

Ground-water standards are generally enforced through permit programs. A minimal policy may simply recognize existing permit systems for land disposal of sewage and underground injection of waste. A more comprehensive program may include permit requirements for all existing or potential discharges to ground water. The compliance point related to ground-water discharges may be at the point of discharge or at a specified distance from a facility or property boundary. In some cases, the compliance point may be the point of use, which could be off-site; in this case, a zone of mixing or attenuation is recognized.

3.2.2 Classification of Aquifers

The objective of ground-water classification is to

provide a systematic approach by formally designating the use of, and water-quality goal for, the ground-water resource. An underlying assumption in a classification system is that certain activities that conflict with ground-water protection are nevertheless essential to social and economic development. The primary value of a classification system is that it provides a basis for deciding where such activities can be accommodated with the least impact on valuable aquifer systems.

States employing a classification system may map aquifers and then impose restrictions according to those maps, or may evaluate site-specific conditions and impose restrictions on a case-by-case basis. Aquifers may be classified according to their use, quality, required level of protection, hydrogeologic characteristics, and economic and social values. The criteria for use-based ground-water classifications may be potability before or after treatment, irrigation or livestock needs, industrial uses, mining and energy development, and limited waste disposal. Classifications by water quality may relate to natural ambient water quality, i.e., establishing one class for fresh water and one for saline water, or may relate to existing water quality, i.e., distinguishing between water which has been contaminated and that which remains in its natural state. Generally, classification systems based on water quality involve the adoption of numerical standards.

Classifications that establish required levels of protection may be based on an evaluation of the vulnerability of the aquifer to contamination. One operational method developed through EPA funding to determine vulnerability is a numerical rating system referred to as DRASTIC. A DRASTIC index number is determined, based on weighted ratings for the following seven key hydrogeologic factors: (1) depth to the water table, (2) net recharge to ground water, (3) aquifer media, (4) soil media, (5) topography, (6) impact of the unsaturated zone, and (7) hydraulic conductivity of the aquifer.

Ground-water classifications based on hydrogeologic characteristics may involve the protection of recharge areas or the evaluation of potential yield of an aquifer. If, for example, an aquifer is so low in permeability that it could not serve as a major source of drinking water or could not allow significant migration of contaminants, that aquifer could be afforded a lower level of protection than a highly transmissive high-yield aquifer. Hazardous-waste sites might be allowed over an aquifer of very low permeability but not over a high-yield aquifer.

Classification may serve as the basis for implementing other elements of ground-water protection, such as numerical water-quality standards or non-numerical guidelines for uses, discharge permits, and land-use controls. Classification also may be used to establish priorities for enforcing

abatement programs.

3.2.3 Classification of Contaminants and Sources

Contaminant classification is a tool for establishing priorities for ground-water protection on the basis of contaminant toxicity. Commonly, the most harmful pollutants or waste types are singled out, and these become the primary focus of the regulatory effort. Development of a classification system and a set of regulations is generally easier if contaminants rather than aquifers are the focus. Contaminant classification is most useful in states where an immediate response is needed to deal with a threat of specific pollutants or where only a few contaminants threaten ground water. Contaminant classification provides a vehicle for responding to contamination once discovered; it does not focus on prevention of contamination.

Source classification provides yet another vehicle for managing ground-water contamination. Industrial discharges are classified according to their chemical characteristics, contaminant concentrations, volumes, toxicity, and the type of facility from which they originate. High-risk sources such as hazardous-waste sites are singled out for stringent regulation. Source classification is the traditional approach for controlling surface-water contamination, as applied in EPA's promulgation of industry-specific effluent guidelines (Henderson, et al., 1984).

3.2.4 Control of Land Uses

Land-use planning and control, which embody the concepts of ground-water classification and differential protection, can be important tools for protecting ground water. Land-use controls may take additional factors into consideration, such as economic impacts of protection measures, consistency with zoning, and current development patterns.

Planning for future land uses, allocation of ground water, and protection of water sources can occur at all levels of government, including interstate river basin commissions. State and local governments commonly control land uses through watershed management plans designed to protect critical recharge zones. These or other plans can be implemented through specific land-use controls, which fall into four basic categories: zoning regulations; siting, development, and construction regulations; public acquisition programs; and transferable development rights (TDRs).

Zoning ordinances generally list prohibited and special uses of land within each zone. Zoning regulations that protect ground water may set limits on the density of residential development or prohibitions on landfills overlying high-quality, high-yield ground-water sources. Other zoning restrictions may include: locating septic systems away from water-supply wells and poorly drained soils; restricting the percentage of lots that may be covered by structures or pavements; locating water-supply wells away from roads subject to

salting; and restricting the amount of vegetation that can be removed from lots.

Existing siting, development, and construction regulations can be modified to minimize ground-water contamination or to enhance the entry of high-quality water into recharge zones. The modifications could address design criteria and permissible technologies for altering surfaces and vegetation, changing natural drainage, and providing artificial drainage. The regulations also may specify the percent of land that can be covered with an impermeable surface (which reduces aquifer recharge) or the amount of land that should be dedicated for open space.

Property acquisition tends to be very expensive, but provides control of activities in and around well fields, critical recharge zones, and high-quality aquifers. In some cases, the purchase of partial ownership rights or easements provides the needed level of control. For example, purchases can be made that allow the new owner to restrict uses of land for waste disposal, industrial purposes, high density residential developments, and specific agricultural practices.

A TDR system restricts the possible uses of valuable land areas yet provides the owner of a restricted parcel of land the opportunity to be compensated for that restriction. Typically, all land parcels in a TDR program are assigned an equal number of development rights, but potentially harmful development is prohibited in designated zones of the program

area. Those owning land in protected zones cannot use rights to develop their own land but may sell their development rights to an owner of unprotected land having an equal number of development rights (Henderson, et al, 1984).

3.2.5 Control of Discharges

Adoption of a discharge permit program is another method often implemented as part of a ground-water protection strategy. A permit program provides a mechanism for establishing site-specific facility requirements, monitoring compliance, taking legal action, and permitting and licensing projects that generate valuable data for the government on ground-water hydrology, contamination, or protection techniques. Discharges that may be regulated are: well injections; seepage from surface impoundments or landfills; and any other discharge which may adversely affect ground water. Generally, agricultural practices are exempt.

Permits may limit the amounts and concentrations of contaminants in effluents, establish the zone of discharge or boundary for contaminant discharges from a facility, and set requirements for monitoring programs. Facility design requirements may be addressed either in the discharge permit or separately. There are two approaches to setting effluent limits for discharges: the first is based on the calculated impact of the discharge on ground-water quality and the second is based on available pollution control technologies (Henderson, et al., 1984). The allowable extent of a zone of

discharge is based on the nature of the ground-water contamination, which is influenced by migration rates, soil characteristics, and aquifer locations. Zones of discharge may be limited to certain types of contaminants and/or to selected aquifers. Monitoring requirements such as numbers of wells, sampling frequency, and analytical tests, may be specified in the permit.

Facility designs that help protect ground water include: limiting the amount and type of wastes disposed of in land impoundments; sealing the bottoms and sides of impoundments with impermeable clay or synthetic liners to prevent movement of leachate to ground water; constructing collection wells and drains that discharge to treatment systems; and utilizing the natural cleansing properties of soils to reduce and disperse certain contaminants.

4.0 OVERVIEW OF NATIONAL ACTIVITIES

4.1 EPA's GROUND-WATER PROTECTION STRATEGY

4.1.1 Objectives

Protection of ground water is not covered comprehensively by any single federal law, nor is one federal agency or office responsible for overseeing and coordinating all ground-water protection programs and activities. However, EPA has been the lead agency over the past several years, responsible for several pertinent federal acts, including the SDWA, RCRA, and CERCLA (see section 4.2).

EPA created a ground-water task force to: (1) identify areas of serious inconsistencies among programs and institutions at local, state, and federal levels; (2) assess the need for greater program coordination within EPA; and (3) help strengthen states' capabilities to protect ground-water resources. In August 1984, the EPA issued a document entitled "Ground Water Protection Strategy," which summarizes the findings of the task force and provides a description of a strategy developed to protect the nation's drinking water. The goal of the strategy is to provide a foundation from which agencies can work toward "preserving, for current and future generations, clean ground water for drinking water and other uses, while protecting the public health of citizens who may be exposed to the effects of past contamination" (U.S. EPA, 1984).

4.1.2 Implementation Program

The EPA strategy includes four major tasks:

1. Strengthen state ground-water programs.

2. Assess problems that may exist from inadequately addressed sources of contamination, i.e., leaking storage tanks, surface impoundments, and landfills.

3. Issue guidelines for EPA decisions affecting ground-water protection and clean-up.

4. Strengthen internal organization programs and coordination with other federal and state agencies.

4.1.2.1 Strengthen State Programs

In 1985, a $7 million appropriation was made for a grant program to assist states in developing strategies, tools for ground-water management, and data systems. Funding is anticipated to be renewed on an annual basis. Technical support is provided to states in several areas, including: (1) scientific issues; (2) state program design and implementation; (3) identification of research needs; (4) data management; and (5) training. In addition, EPA made a commitment to provide research and technical guidance on such issues as the technology for controlling presently unregulated sources (see Section 4.1.2.2). This support is provided through EPA headquarters, regions, and laboratories and through other appropriate federal agencies, i.e., the U.S. Geological Survey (USGS) and the Nuclear Regulatory Commission (NRC).

4.1.2.2 Survey Inadequately Addressed Sources

An EPA review has established that several known sources of ground-water contamination, including landfills, surface impoundments, and leaking storage tanks, are not presently being regulated under RCRA Subtitle C or the Underground Injection Control (UIC) program. As a consequence, the agency has initiated actions to further evaluate these threats and to determine if more extensive federal and/or state requirements and regulations are needed.

When the ground-water strategy was first developed, regulations for above-ground tanks and some underground tanks were in place. Since that time, EPA has adopted comprehensive regulations under RCRA for control of underground storage tanks and also for the types and quantities of hazardous waste controlled under the Act. Other inadequately addressed sources identified in the strategy were pesticides and fertilizers, septic tanks, mining operations, unregulated drilling, natural gas pipelines, and sinkholes. The strategy stated that steps to define the nature, extent, and severity of contamination from these sources would be addressed by EPA.

4.1.2.3 Develop Guidelines

EPA's guidelines for ground-water protection are based on the beneficial-use criterion, which is a recognition that added protection is required for some unique, valuable

ground-water resources. This approach was intended to provide the basis for comprehensive ground-water management, land-use planning, facility siting, and the issuance of permits. The primary mechanism selected by EPA is based on a policy of differential protection and is a three-tiered classification system of ground water, which would be applied through all appropriate EPA programs. The first tier, or Class I water, includes irreplaceable drinking-water supplies and aquifers associated with ecologically vital systems. The second tier, or Class II water, is for drinking-water supplies or potential drinking-water supplies. The third tier, or Class III water, is non-drinkable water that is characterized by poor quality and also by isolation from drinking-water aquifers. A classification decision would be made in connection with a permit or a clean-up operation. The system is therefore reactive; classifications are made in response to proposed land-use activities.

Guidelines for implementation of the classification system are currently under development. The general approach is to designate a classification review area in the vicinity of a proposed federally-permitted facility, pesticide application area, Superfund clean-up site, or other EPA action site. The review area will probably have a radius of about two miles, unless special hydrogeologic conditions exist. If there is a water-supply well in the review area, the area will be designated Class II (current water supply) or possibly Class I (irreplaceable supply). To determine if

it is Class I, the size of the population served is examined and an analysis of hydrogeologic conditions is made to determine whether or not the aquifer is vulnerable to contamination (see the discussion of DRASTIC in section 3.2.2). Also, an economic test is made to determine whether or not the supply is irreplaceable. Finally, if the aquifer discharges to a wetland that is the habitat for an endangered species, the aquifer could be designated Class I.

Some applications of the classification system have not yet been resolved. For example, pesticide use and facility siting may be banned above Class I aquifers. The Superfund office may make a distinction between potential water-supply aquifers and current drinking-water supplies in determining the degree of restoration to be required at a contamination site. Public hearings regarding the guidelines for classifying ground water will be held in the near future.

4.1.2.4 Improve Intra- and Inter-Agency Coordination

In April 1984, the Office of Ground-Water Protection (OGWP) was established by EPA to assume leadership of the agency's enhanced ground-water protection effort. The responsibilities assigned to the OGWP include:

- providing program coordination, guidance on the use of grant funds, and technical data to states and regional ground-water offices;
- developing an information access system for regions, states, and site managers, and coordinating research among federal and state agencies;

- working with other agencies, i.e., USGS, Department of Energy (DOE), and NRC, as well as outside interests, i.e., trade and industry groups, to exchange information; and
- assessing EPA's effectiveness in implementing the ground-water strategy.

EPA also developed criteria in an attempt to achieve consistency among regional ground-water programs. The criteria include requirements for the development of ground-water policies; coordination of regional ground-water programs, state work programs, and site assessments; and organization of technical assistance, regional training, and public response.

4.2 OTHER FEDERAL PROGRAMS

The Office of Technology Assessment (OTA) has identified 16 principal pieces of federal legislation that authorize activities relating to ground-water contamination. A brief explanation of the statutes is provided below, along with descriptions of several special programs, including DOE's CERCLA program.

Table 1 summarizes the relationship between federal statutes and ground-water protection activities, including ground-water investigation; corrective actions for contaminated ground water; measures to prevent contamination; and adoption of standards for contaminants. Generally, the statutes focus on ground-water monitoring and on standards at

TABLE 1. SUMMARY OF FEDERAL PROGRAMS AND ACTIVITIES RELATED TO THE PROTECTION OF GROUND-WATER QUALITY

	Investigations/detection				Correction		Prevention				
Statutes	Inventories of sources[a]	Ambient groundwater monitoring	Groundwater monitoring related to sources[a]	Water supply monitoring	Federally funded remedial actions	Regulatory requirements for sources[a]	Regulate chemical production	Standards for new/existing sources[a]	Aquifer protection	Standards	Other[b]
Atomic Energy Act			X		X	X		X		X	
Clean Water Act	X	X	X		X			X		X	X
Coastal Zone Management Act											X
Comprehensive Environmental Response, Compensation, and Liability Act	X		X		X						
Federal Insecticide, Fungicide, and Rodenticide Act			X				X	X			
Federal Land Policy and Management Act (and associated mining laws)			X					X			
Hazardous Liquid Pipeline Safety Act	X							X			
Hazardous Materials Transportation Act	X							X			
National Environmental Policy Act											X
Reclamation Act					X						
Resource Conservation and Recovery Act	X		X			X		X			
Safe Drinking Water Act	X		X					X	X	X	
Surface Mining Control and Reclamation Act			X		X			X			
Toxic Substances Control Act			X				X	X			
Uranium Mill Tailings Radiation Control Act			X		X	X		X			
Water Research and Development Act											X

[a]Programs and activities under this heading relate directly to specific sources of groundwater contamination. Table 13 summarizes the sources addressed by the statutes.
[b]This category includes activities such as research and development and grants to the States to develop groundwater-related programs.

Source: U.S. Congress, 1984

specific sources of ground-water contamination. Only one statute, the SDWA, addresses aquifer protection (Sole Source Aquifer program).

Table 2 summarizes the relationship between sources of contamination and the 16 federal statutes that address ground water either directly or indirectly. The table is organized by OTA source categories:

> Category I - sources designed to discharge substances;
>
> Category II - sources designed to store, treat, and/or dispose of substances discharged through unplanned release;
>
> Category III - sources designed to retain substances during transport or transmission;
>
> Category IV - sources discharging substances as a consequence of other planned activities;
>
> Category V - sources providing a conduit or inducing discharge through an altered flow pattern;
>
> Category VI - naturally occurring sources whose discharge is created and/or accelerated by human activity (U.S. Congress, 1984).

The table illustrates the complexities of the current system of regulation and points out the need for implementation of the ground-water strategy to better coordinate the many activities covered by these statutes.

Appendix A summarizes the objectives and major provisions of the 16 statutes, lists the federal agencies responsible for their implementation, and indicates the responsibilities of the states under the statutes. The

Table 2. Relationship Between Sources of Contamination and Federal Statutes[a]

Sources	Federal statutes															
	AEA	CWA	CZMA	CERCLA	FIFRA	FLPMA	HLPSA	HMTA	NEPA[b]	RA	RCRA	SDWA	SMCRA	TSCA	UMTRCA	WRDA[c]
Category I																
Subsurface percolation		E										A				
Injection wells (waste)				F								A				
Injection wells (non-waste)												A				
Land application		D		F							A					
Category II																
Landfills				F							A, B			A		
Open dumps (including illegal dumping)				F							B					
Residential (or local) disposal					C											
Surface impoundments				F		A					A		A			
Waste tailings						A									A	
Waste piles				F		A					A		A			
Materials stockpiles					C											
Graveyards																
Animal burial																
Aboveground storage tanks		A		F							A			A		
Underground storage tanks		A		F							A			A		
Containers				F	C						A			A		
Open burning/detonation sites				F	C						A					
Radioactive disposal sites	A														A, F	
Category III																
Pipelines				F			A									
Materials transport/transfer operations				F				A								
Category IV																
Irrigation practices		C, E														
Pesticide applications		C, E			A											
Fertilizer applications		C, E														
Animal feeding operations		C, E														
Deicing salts applications																
Urban runoff		C, E														
Percolation of atmospheric pollutants																
Mining and mine drainage		C, E				A							A, F			
Category V																
Production wells						A						A				
Other wells (non-waste)						A										
Construction excavation		C, E														
Category VI																
Groundwater-surface water interactions		C, E														
Natural leaching										F						
Salt-water intrusion/brackish water upconing		C, E	E													

[a]Key: A = Requires compliance with specified Federal requirements (some programs in this group may be implemented by States if they meet certain Federal criteria).
B = Authorizes funding of optional State programs that address specific sources.
C = Establishes Best Management Practices (BMPs) or recommended procedures for certain sources.
D = Establishes Federal criteria that must be met in order to receive funds for specific projects related to a source of contamination.
E = Establishes a grnt program to States (funds may be used at the State or local level to address contaminants or sources).
F = Funds Federal cleanup of contaminated groundwater and associated sources.

[b]NEPA does not apply to any particular source. The environmental impacts of projects involving the use of Federal funds may be subject to Federal agency review.

[c]WRDA does not apply to any particular source. The act provides research funds to States. Projects may focus on particular sources.

Source: U.S. Congress, 1984

National Environmental Policy Act (NEPA), the first law specifically enacted to protect the environment, establishes a national policy on environmental quality and requires federal agencies to prepare an Environmental Impact Statement (EIS) for each major federal action significantly affecting the environment. Although NEPA does not directly address ground water, the EIS process provides a mechanism for evaluating impacts on ground water from proposed projects and regulatory programs.

The CWA provides authorization and funding for state and regional monitoring and planning activities, authorizes programs related to potential sources of ground-water contamination, and provides for the development of water-quality criteria.

The SDWA authorizes development of drinking-water standards, an underground injection control program, and designation of sole-source aquifers. These programs are designed to protect human health, drinking-water supplies, and aquifer recharge areas.

Several statutes authorize preventive measures and federally funded remedial-action programs for specific sources of ground-water contamination. The objectives of these statutes, which include RCRA, Surface Mining Control and Reclamation Act (SMCRA), Uranium Mill Tailings Radiation Control Act (UMTRCA), Hazardous Materials Transportation Act (HMTA), and CERCLA, focus on protecting public health and the

environment rather than on protecting ground water per se.

FIFRA and TSCA regulate the production and use of pesticides and other chemical substances. The application of these statutes to ground water, however, has been limited.

Three statutes relate to ground-water protection. The Coastal Zone Management Act (CZMA) provides a mechanism to protect coastal communities from salt-water intrusion; the Federal Land Policy and Management Act (FLPMA) authorizes the management of public lands in a manner that protects the ecological, environmental, and water-resource quality; and the Water Research and Development Act (WRDA) authorizes the establishment of State Water Resources Research Institutes to conduct research and development relating to water resources. Projects funded under this program relate to ground-water quality.

Table 3 summarizes the ground-water-related activities of several federal agencies. In addition to the DOE programs described in the table, a DOE CERCLA program has been developed; the program is described in DOE Order 5480.14, dated April 26, 1985. Also on the national level, a consensus-forming group of governmental, industrial, and private concerns known as the Ground Water Policy Forum was convened by the Conservation Foundation. This group has endorsed a comprehensive approach to ground-water protection, recommending a ten-point program which includes classification systems and the adoption of state ambient ground-water

TABLE 3. GROUND-WATER RELATED ACTIVITIES OF FEDERAL AGENCIES

Department of Agriculture—Agriculture Research Service: ARS is conducting a limited number of research projects related to groundwater recharge and the impacts of agricultural activities on groundwater quality.

Department of Agriculture—Forest Service: The Forest Service is conducting environmental research projects on the fate and transport of pesticides (under the National Agricultural Pesticide Impact Assessment Program).

Department of Commerce—National Bureau of Standards: NBS is responsible for projects regarding the development of quality assurance standards that are used by other Federal agencies (e.g., EPA and DOE) to monitor the analytical performance of laboratories.

Department of Defense: The Army, Navy, and Air Force are participating in a program to identify and evaluate hazardous waste disposal sites on military installations and to undertake remedial actions at certain sites to control the migration of wastes (Installation Restoration Program).

The Army Toxic and Hazardous Materials Agency (USATHAMA), Air Force Occupational Environmental Health Laboratory, Air Force Engineering and Service Center, and Navy Energy and Environmental Support Activity provide technical support for the Installation Restoration Program and conduct research related to these efforts.

The Army Medical Bioengineering Research and Development Laboratory develops water quality criteria for certain munitions compounds.

The Army Corps of Engineers is working with EPA (under an interagency agreement) on design and construction of remedial action projects for CERCLA-designated sites. Research projects are also being conducted to support these activities.

Environmental Protection Agency—Office of Research and Development: EPA's Environmental Photographic Interpretation Center in Warrenton, VA, is responsible for acquiring and interpreting overhead imagery to support programs of EPA as well as other Federal agencies. Activities include conducting inventories of abandoned wells, mines, and hazardous waste sites, identifying failures in septic tank systems, and supporting emergency (e.g., oil spills) response activities.

EPA's Environmental Monitoring Systems Laboratory in Las Vegas, NV, the Robert S. Kerr Environmental Research Laboratory in Ada, OK, and the Environmental Research Laboratory in Athens, GA are conducting studies related to prediction (e.g., studies of those characteristics of aquifers that influence contaminant behavior) and monitoring (e.g., protocols for designing groundwater sampling programs). Other research activities related to source control, health effects, and treatment technologies are also being conducted at other EPA facilities.[a]

Department of Energy: Programs have been established for identifying and decommissioning nuclear materials storage and processing facilities that have become contaminated. Hydrogeologic investigations are being conducted at some of these sites. These programs include the Formally Utilized Sites Remedial Action Program and the Surplus Facilities Management Program.

Department of Housing and Urban Development: Environmental assessments are conducted related to housing projects; groundwater impacts are considered.

Department of the Interior—Bureau of Land Management: BLM is conducting inventories of hazardous waste sites on public lands.

Department of the Interior—National Park Service: Groundwater monitoring studies are conducted at various national parks to develop baseline data and to determine the extent and impacts of groundwater contamination from sources such as septic tanks and agricultural activities.

Department of the Interior—U.S. Geological Survey: The Water Resources Division of USGS is responsible for collection and analysis of hydrogeologic information (including groundwater data), maintaining computerized data bases, conducting research, and coordinating Federal activities with respect to the use and acquisition of water data.

Department of the Interior—Fish and Wildlife Service: FWS is conducting inventories of hazardous waste sites for all FWS lands and facilities.

Department of the Interior—Bureau of Indian Affairs: BIA is planning to conduct inventories of hazardous waste sites on or near Indian reservations.

National Science Foundation: The Division of Civil and Environmental Engineering, Directorate for Engineering (the Hydraulics, Hydrology, and Water Resources Program, and the Environmental and Water Quality Engineering Program) supports research projects on topics such as subsurface transport and wastewater treatment. Policy-related research is conducted by the Division of Research and Analysis, Directorate for Scientific, Technological and International Affairs.

Nuclear Regulatory Commission: Research projects are conducted related to the fate and transport of radioactive substances in support of regulatory activities.

[a]EPA also supports several other types of activities related to groundwater. For example, EPA established a consortium called the National Center for Ground Water Research in September 1979. The consortium consists of the University of Oklahoma, Oklahoma State University, and Rice University; and the Ground Water Research Branch of the Kerr Laboratory serves as the center's immediate technical liaison. The primary objective of the center is to identify long-term problems and needs related to groundwater quality protection (e.g., transport and fate of contaminants and subsurface characterization) (Canter, 1982). EPA also provides funding to the Ground Water Clearinghouse at the Holcomb Research Institute. The clearinghouse contains an extensive file of groundwater models and assists the States in model selection and application (see OTA, 1982).

Source: U.S. Congress, 1984

standards. Some of these recommendations have been incorporated into legislation proposed by the U.S. Senate's Subcommittee on Energy and the Environment.

4.3 STATE PROGRAMS

4.3.1 Overview

Thus far, at least half of the states have enacted programs or policies directed at comprehensive ground-water protection, mainly as an outcome of (1) discoveries of contamination beginning in the 1970's, (2) delegation to the states of various federal programs and (3) the issuance of EPA's original draft Ground-Water Strategy. Commonly, the states have initiated their programs by setting up some type of task force, which establishes the overall goals and begins the process of working out inter-agency agreements. At later stages, the tools for implementation are selected and the actual implementation programs are established. Experience in numerous states, including Massachusetts, Michigan, New Jersey, and Florida, has shown that four or more years may elapse from initial policy development to the promulgation of final regulations. Other states still have not resolved all the issues and are continuing to develop their approaches.

The task force often consists of a committee of state departments and commissions, commonly known as a Strategy Development Task Force. In other instances, as in Wisconsin, legislative commissions assume the responsibility for

developing new laws mandating comprehensive ground-water protection and remedial action. Members of the task force compile programs, policies, and data, and identify areas of conflict and overlap in agency responsibilities. One common problem is poor coordination among water agencies, solid and hazardous-waste management agencies, and departments of transportation, public works, mines, and oil development. One of the key questions addressed by members of the task force is whether or not new legislation is required or a coordinating mechanism using existing authorities will suffice. A minimum of two years is usually needed to complete the analytical process and develop a draft approach.

The Strategy Development Task Force establishes which ground-water policy (nondegradation, limited degradation, or differential protection) is to be the basis for action. A partial survey prepared by EPA shows that state approaches are fairly evenly split between nondegradation and limited degradation (Table 4).

TABLE 4. GROUND-WATER POLICIES ADOPTED BY STATES

STATES	NONDEGRADATION	LIMITED DEGRADATION	DIFFERENTIAL PROTECTION
Alabama			
Alaska			
Arizona		X	X
Arkansas			
California	X		
Colorado	X		X
Connecticut			X
Delaware			
Florida		X	X
Georgia	X		
Hawaii			
Idaho	X	X	X
Illinois			X
Indiana			
Iowa	X		
Kansas			
Kentucky			
Louisiana			
Maine	X		
Maryland		X	X
Massachusetts			X
Michigan	X		
Minnesota	X	X	
Misissippi			
Missouri	X		
Montana	X		
Nebraska			
Nevada	X	X	
New Hampshire	X		
New Jersey	X	X	
New Mexico		X	
New York		X	
North Carolina			X
North Dakota			
Ohio			
Oklahoma			
Oregon		X	
Pennsylvania		X	
Puerto Rico			
Rhode Island	X		

TABLE 4. (Continued)

STATES	NONDEGRADATION	LIMITED DEGRADATION	DIFFERENTIAL PROTECTION
South Carolina	X	X	
South Dakota			
Tennessee	X		
Texas			
Utah			
Vermont		X	X
Virgin Islands		X	
Virginia			
Washington	X	X	X
West Virginia			
Wisconsin		X	
Wyoming		X	X
TOTAL	16	17	12

Source: U.S. EPA, March 1985

4.3.2. Elements of State Strategies

Once a state's goals have been established, members of the task force must choose the most appropriate methods of implementation (see section 3.2). The national trend is toward the enactment of ground-water standards, enforced through permit programs, as the core of state ground-water protection programs.

4.3.2.1 Standards

The methods of setting and enforcing ground-water standards vary from state to state. Wisconsin and Florida laws mandate that ground-water quality standards be enforced in all state programs that affect ground water. In California, standards have been adopted by some of its nine regional water-quality control boards. The state legislature of Wisconsin created an administrative process, independent of state programs, for establishing standards. The standards are enforceable by all state agencies that issue permits for activities potentially affecting ground water. In contrast, the Massachusetts classification system was adopted in conjunction with the state ground-water discharge permit program and is not presently enforced by other agencies such as the state hazardous-waste group.

Regulators generally consider that numerical standards provide a more effective basis for enforcement than narrative standards. The majority of the states that have enacted

ground-water programs have adopted a set of numerical ground-water standards based on federal drinking-water standards. New Mexico has adopted standards for constituents listed in the federal drinking-water regulations and also for some other constituents. Some standards adopted by New Mexico differ from the levels set by the federal government; metals standards, for example, are different because they reflect agricultural concerns, and standards have been set for radioactive constituents, which are of special concern in the state and are not covered by federal drinking-water limits. Wisconsin adopted Preventive Action Limits (PALs), which are set at 20 percent of the enforceable standard, to provide a mechanism for ground-water protection; if these limits are reached, regulatory action is imposed. New York and New Jersey have established standards for numerous organics for which no federal standards exist. Numerical water-quality standards adopted by states and federal standards and guidelines are presented in Appendix B.

The State of Connecticut, by contrast, has adopted narrative standards as part of its mapped aquifer classification system. The standards generally describe the uses of ground water and the types of discharges that would be allowed under each classification. Through its permit system, which covers all ground-water discharges, the state establishes site-specific effluent concentrations and compliance standards. It also uses currently available standards for designated uses rather than adopting new

statewide standards. The Connecticut regulators have expressed the opinion that this approach streamlines the regulatory process and allows more flexibility in the discharge permit program, because it takes into account site-specific information on ground-water use, attenuation of contaminants, and surface-water relationships. Table 5 summarizes the status of states in developing numerical and narrative standards.

4.3.2.2 Control of Discharges

Most states have adopted discharge permit programs in conjunction with ground-water standards, generally modeled after surface-water discharge permits. Some variation occurs in the program scope; the programs in New York and Massachusetts apply only to actual discharges whereas the program in New Jersey covers potential discharges. The New Jersey Pollution Discharge Elimination System (NJPDES) is a comprehensive permit program that controls all aspects of development and waste disposal that could affect ground water.

The point of compliance for ground-water standards differs from state to state, but is almost always within the property boundary. Some states, i.e., New Mexico, have a performance-based system that allows the discharger to take into account the effects of attenuation in the unsaturated

TABLE 5. SUMMARY OF STATE GROUND-WATER QUALITY STANDARDS

ALABAMA	Use federal drinking-water standards by reference.
ALASKA	Class A surface-water standards plus state drinking-water standards apply to ground water.
ARIZONA	Adopted ground-water standards based on federal drinking-water standards in July 1985.
ARKANSAS	No standards.
CALIFORNIA	The state regulates inorganic salts. Also, some districts have water-quality standards for ground-water uses.
COLORADO	No standards.
CONNECTICUT	No numerical standards. Drinking-water standards and other local standards are used in discharge permit program, with guidance of ground-water classification system.
DELAWARE	Federal drinking-water standards are applied to ground water.
FLORIDA	Standards cover primary and secondary drinking-water constituents, maximum concentration limits (MCLs) for eight other organics, and natural background levels for other constituents.
GEORGIA	Use federal drinking-water standards as a guide.
HAWAII	No standards.
IDAHO	Federal drinking-water standards apply to ground water.
ILLINOIS	State drinking-water standards, including federal drinking-water standards, seven pesticides, and cyanides apply to ground water.
INDIANA	No standards.
IOWA	No standards.
KANSAS	Drinking-water standards are used for ground-water quality assessment and enforcement. Several are more stringent than federal criteria.
KENTUCKY	No standards.
LOUISIANA	No standards.
MAINE	Federal primary drinking-water and health advisories for 150 parameters.
MARYLAND	Federal drinking-water standards, incorporated by reference into state ground-water classification system.
MASSACHUSETTS	Used as the basis of the ground-water discharge permit. Emphasis and responsibility is placed on local regulations.
MICHIGAN	No standards.

MINNESOTA	The state adopted national primary and secondary drinking-water standards.
MISSISSIPPI	The state has adopted federal drinking-water standards.
MISSOURI	Numerical ground-water standards for 23 contaminants, plus standards for other beneficial uses which include drinking-water criteria and additional organics and inorganics.
MONTANA	The state has set standards for all drinking-water parameters and all other substances that would be deleterious to beneficial use.
NEBRASKA	The state has adopted primary drinking-water standards and most of the secondary drinking-water standards.
NEVADA	No standards.
NEW HAMPSHIRE	Narrative standards including, by reference, drinking-water MCLs.
NEW JERSEY	Standards for approximately 30 parameters which include nutrients, metals, and organics. Used for ground-water clean-up, evaluation of potable supplies, and in permitting discharges.
NEW MEXICO	Numerical standards for 35 parameters, plus a generic "toxic pollutant" standard defining acceptable levels of protection for human and animal health.
NEW YORK	Numerical standards and effluent limitations (multiple of standard) for 83 pollutants, including various metals, inorganics, pesticides, and some organic solvents. Enforcement is based on monitoring of effluent at point of discharge.
NORTH CAROLINA	The state has standards for 19 contaminants.
NORTH DAKOTA	No standards.
OHIO	No standards.
OKLAHOMA	Standards may be developed for ground-water basins.
OREGON	No standards.
PENNSYLVANIA	The state has proposed regulation of ten inorganic and six organic contaminants.
RHODE ISLAND	The state has adopted ground-water quality standards by reference.
SOUTH CAROLINA	Standards have been proposed and these include state primary drinking-water MCLs, as well as organics which are not allowed in concentrations which would interfere with use.
SOUTH DAKOTA	No standards.
TENNESSEE	Narrative standards to protect beneficial uses and public health.

Table 5. (Continued)

TEXAS	The state has established a ground-water protection standard for the waste management unit. The standard is based on environmental standards that establish numerical concentration limits for individual contaminants.
UTAH	Standards are being developed.
VERMONT	No standards.
VIRGINIA	The state has numerical standards for 35 contaminants.
WASHINGTON	No standards.
WEST VIRGINIA	No standards.
WISCONSIN	The state has enforceable standards and preventive action limits.
WYOMING	Standards for 26 contaminants, depending on class, pH, and total dissolved solids (TDS).

zone, treatment, and liners to show compliance with the standards, whereas other states, i.e., New York, specify the effluent quality at the point of discharge. North Carolina recognizes the mixing zone in three dimensions, requiring compliance with the standards at a depth of 20 feet below land surface and within 250 feet of the facility boundary. Massachusetts has a petition process through contaminated zones can be mapped for classification purposes.

4.3.2.3. Aquifer Classification

Classification of ground water is an element in many ground-water management programs; to date, 17 states have adopted ground-water classification systems. In most of these systems, fresh ground waters are placed into one class, considered potable or potentially potable. Non-drinking-water classes are generally limited to deep saline ground waters or very limited saline zones near the coast. Contaminated zones, or exempted aquifers, although recognized as a class in some states, have not yet been designated by any of those states.

Table 6 summarizes the classification systems adopted by 17 states. Connecticut is the only state with a system that maps and classifies all of its fresh ground waters; the system is used to provide land-use and siting guidance. Hydrogeologic, land-use, and water-quality information provides the basis for the classification system. Florida and New Jersey, among other states, have provisions for

TABLE 6. STATE GROUND-WATER CLASSIFICATION SYSTEMS

State	Number of Classes	Criteria for Classification
Alaska	2	. Drinking water, agriculture, aquaculture, and industrial use; . Marine ground waters.
Connecticut	4	. Suitable for public and private drinking-water supplies without treatment; . May be suitable for public or private drinking-water supplies without treatment; . May have to be treated to be potable; . May be suitable for waste-disposal practices.
Florida	4	. Single-source aquifers for potable water use with TDS content of less than 3,000 milligrams per liter (mg/l); . Potable water use with TDS content less than 10,000 mg/l; . Non-potable water use from unconfined aquifers with TDS content of 10,000 mg/l or greater; . Non-potable water use with TDS content of or greater than 10,000 mg/l from confined aquifers.
Idaho	3	. Potable water supply (general designation); . Special resource waters (aquifer specific); . Other beneficial uses.
Iowa	5	. Based on vulnerability to contamination.
Maine	2	. Drinking water; . Other beneficial uses.

Table 6. (continued)

State	Number of Classes	Criteria for Classification
Maryland	3	. TDS less than 500 mg/l; . TDS between 500 and 6,000 mg/l; . TDS greater than 6,000 mg/l.
Massachusetts	3	. drinking-water quality; . saline; . below drinking-water quality.
Montana	4	. Suitable for public and private water use with little or no teatment; . Marginally suitable for public and private use; . Suitable for industrial and commercial uses; . May be suitable for some industrial and other uses.
New Jersey	4	. Nondegradation - Central Pine Barrens; . Potable without treatment, TDS less than 500 mg/l; . Conversion to fresh potable water, TDS 500-10,000 mg/l; . Reasonable beneficial use, TDS greater than 10,000.
New Mexico	2	. TDS less than 10,000 mg/l; . TDS greater than 10,000 mg/l.
New York	3	. Fresh water for potable use; . Saline waters with chloride between 250 mg/l and 1,000 mg/l; . Saline waters with chloride in excess of 1,000 mg/l.
North Carolina	5	. Fresh waters for drinking-water use; . Brackish waters at greater than 20 feet below surface for recharge use; . Fresh waters at less than 20 feet below surface for recharge use; . Brackish waters less than 20 feet below surface;

Table 6. (continued)

State	Number of Classes	Criteria for Classification
		. Not suitable for drinking or food processing.
Tennessee	2	. Beneficial use; . Underground injection (TDS greater than 3,000 mg/l and/or contaminated beyond treatability.
Vermont	2	. Aquifers that supply or in the future could supply community water supplies; . All other ground waters.
Virginia	4	. Based on physiographic provinces.
Wyoming	7	. Domestic; . Agricultural; . Livestock; . Aquatic life; . Industry; . Hydrocarbon and mineral deposits; . Unsuitable for any use.

Adapted from U.S. Environmental Protection Agency, May 1985.

special protection classes but have designated only a few of these classes. Florida may map zones of influence for all public-supply wells and critical recharge areas in its special protection category, whereas New Jersey has mapped only one large area, the 560-square-mile Central Pine Barrens, as a special protection class. Because they fail to designate in a tangible form aquifers requiring different levels of protection, few of the state classification systems accomplish the stated objectives of the EPA strategy (see section 4.1.2.3). Furthermore, they differ very little from strategies based solely on ground-water standards. Table 7 lists, by state, the implementation policies regarding three methods of ground-water protection: setting ground-water quality standards, adopting discharge permit programs, and developing ground-water classification systems.

4.3.2.4 Land-Use Control

Other approaches used to guide state protection efforts include controlling land uses in critical recharge zones and working with local communities to adopt protective zoning. Land-use controls are typically applied on a local level and frequently involve more detailed mapping and subdivision of aquifers than do state classification systems. Thus, state classification and mapping programs may provide the overall framework for land-use controls, but the final designation of critical areas for local land-use regulation may differ from the state pattern.

TABLE 7. METHODS ADOPTED BY STATES TO IMPLEMENT GROUND-WATER PROTECTION PROGRAMS

STATE	GROUND-WATER QUALITY STANDARDS	GROUND-WATER DISCHARGE PERMIT[1] PROGRAM	GROUND-WATER CLASSIFICATION[2]
Alabama	Yes	No	No
Alaska	Yes	Yes	Yes
Arizona	Yes	Yes	No
Arkansas	No	No	No
California	Yes	Yes	2
Colorado	No	No	No
Connecticut	No	Yes	Yes
Delaware	Yes	No	No
Florida	Yes	Yes	Yes
Georgia	No	No	No
Hawaii	No	No	No
Idaho	Yes	No	Yes
Illinois	Yes	Yes	No
Indiana	No	No	No
Iowa	No	No	Yes
Kansas	Yes	Yes	2
Kentucky	No	No	No
Louisiana	No	No	No
Maine	Yes	Yes	Yes
Maryland	Yes	Yes	Yes
Massachusetts	Yes	Yes	Yes
Michigan	No	Yes	No
Minnesota	Yes	No	No

TABLE 7. (Continued)

STATE	GROUND-WATER QUALITY STANDARDS	GROUND-WATER DISCHARGE PERMIT PROGRAM[1]	GROUND-WATER CLASSIFICATION[2]
Mississippi	No	No	No
Missouri	Yes	Yes	No
Montana	Yes	Yes	Yes
Nebraska	Yes	Yes	No
Nevada	No	Yes	No
New Hampshire	Yes	Yes	No
New Jersey	Yes	Yes	Yes
New Mexico	Yes	Yes	Yes
New York	Yes	Yes	Yes
North Carolina	Yes	Yes	Yes
North Dakota	No	No	No
Ohio	No	No	No
Oklahoma	No	Yes	2
Oregon	No	Yes	No
Pennsylvania	No	Yes	No
Rhode Island	Yes	Yes	No
South Carolina	No	No	No
South Dakota	No	No	No
Tennessee	Yes	No	Yes
Texas	No	No	2
Utah	No	No	No
Vermont	No	No	Yes
Virginia	Yes	Yes	Yes
Washington	No	Yes	No

TABLE 7. (Continued)

STATE	GROUND-WATER QUALITY STANDARDS	GROUND-WATER DISCHARGE PERMIT[1] PROGRAM	GROUND-WATER CLASSIFICATION[2]
West Virginia	No	Yes	No
Wisconsin	Yes	Yes	No
Wyoming	Yes	Yes	Yes

1 Programs of permits which place restrictions on ground-water discharges rather than facility design.

2 Programs with more than one ground-water class.

3 Beneficial of permits which place restrictions on ground-water discharges rather than facility design.

States generally appear more willing to use approaches other than classification to protect their ground waters. Massachusetts, for example, established a grant program for purchasing critical recharge areas. The program appears to be providing an incentive to communities to enact local protection measures. New York also has established a funding mechanism for purchasing of critical well fields and recharge areas, and a New York law gives the state land-use control in critical recharge areas. Local land-use controls that protect ground-water quality have been implemented in numerous communities in New Jersey, Connecticut, and Florida. There is increased interest in this type of protection, and it can be anticipated that similar programs will be enacted in many other states, particularly where suburban-type development is encroaching on well field areas.

4.3.2.5 Contaminant and Source Classification

Some states have adopted programs to address ground-water contamination by commonly used chemicals such as pesticides. Florida regulations, for example, require that ground-water samples be analyzed for Temik and EDB under certain monitoring programs. Counties on Long Island, New York, have banned some household-cleaning fluids to protect their ground water. California has a registration program for farmers using pesticides and has developed a computerized data base that includes information such as the number of pounds of pesticides applied to farmland. These data are

used to develop and implement pesticide monitoring programs.

Recent activities relating to ground-water protection through classification of sources have included development of regulations on underground storage tanks. At least eight states and numerous local communities have adopted their own underground tank laws. Most of these state and local regulations have requirements similar to those mandated by RCRA under its Underground Storage Tank (UST) program. In addition, many local programs have more stringent inspection, testing, and tank replacement programs. Some of the local laws, for example, specify double-walled tank construction in well field recharge areas or critical aquifers (Suffolk County, NY, and Dade County, FL).

States are required to enact underground tank laws within three years of the adoption of the federal UST program. It is likely that many states, owing to the large number of underground tanks involved, will delegate to local agencies the implementation of the federal regulations. The California law requires that each county develop regulations to implement the law, except where municipalities wish to enact their own regulations. The longest standing local program is that of Suffolk County, NY, which claims that through its testing and mandatory replacement program it has reduced the incidence of leaks from 15 percent to 2 percent.

A number of states have adopted laws aimed at eliminating special sources. For example, Florida's Water

Quality Assurance Act targeted hazardous-waste disposal as the major source of ground-water problems. The Act prohibits land disposal of wastes and requires the establishment of county collection, treatment, and disposal facilities. In addition, it establishes a comprehensive monitoring program and sets standards to be implemented by all state agencies. Connecticut has passed a package of laws, including one that establishes a ground-water permit program that ties quality and quantity issues together and another that requires the polluter to provide alternative water supplies to affected well owners.

4.3.3 Remedial-Action and Enforcement Activities

State enforcement efforts generally focus on existing polluters and dischargers. Many states have prepared inventories of waste generators and waste impoundments, and then have developed a prioritized system for enforcement. The Water Resources Commission in Michigan, for example, mandated that the inventory and assessment of ground-water contamination sites be one of the first steps in the state ground-water program; more than 700 sites were investigated during this phase. In contrast, Connecticut mapped all of its ground-water basins and assigned classifications to ground-water segments prior to undertaking its systematic enforcement program.

Because methods for predicting the effectiveness of clean-up techniques are still in their infancy, most clean-up

projects are in actuality monitored experiments. In one state, a proposal has been accepted in which clean-up would cease when analyses of ground-water samples show very little change in concentrations from one year to the next, regardless of the numerical values. In other states, a clean-up goal is established with a minimum and maximum period for the clean-up activities. For example, one consent decree called for clean-up operations for at least 10 years but not to exceed 20 years. Michigan has passed legislation setting priorities for clean-up of abandoned disposal sites and well contamination incidents.

The federal drinking-water standards generally are cited as the minimal criteria for clean-up. However, most states also employ technology-based criteria for remedial actions, taking costs into account. In other words, the best practicable technology short of clean closure may be required. In some instances, this could require clean-up to above drinking-water or ground-water standards. For example, in New Jersey the NJPDES permit system allows a discharge of total volatile organics with concentrations of up to 50 parts per billion (ppb); historically, water-supply wells have not been shut down unless the pumped water contains greater than 100 ppb. However, in the enforcement program, the state attempts to set clean-up criteria at 10 ppb or lower. Michigan's policy is to clean-up to background water quality, and Florida enforces a "free from" standard for most toxic constituents.

5.0 BASIS FOR ACTION IN TENNESSEE

5.1 STRATEGY OPTIONS

Tennessee has a number of specific ground-water problems for which there are no established programs or which may require modifications of existing programs. These problems include:

- Overproduction of aquifers - Overpumping of some aquifers may cause excessive subsidence of land surface and irreversible loss of porosity, permeability, and productivity of the aquifer. In karst areas, ground-water pumpage may accelerate karst development and may trigger sinkhole collapse. Overproduction may also induce movement into an aquifer of salt water from greater depths.

- Improperly abandoned wells - Abandoned wells that are not adequately sealed may provide avenues for contaminants to move vertically through strata of low permeability and to reach aquifers.

- Septic systems which are improperly constructed or are inappropriate for their geologic settings - Septic systems of traditional design may contaminate usable aquifers in areas where there is insufficient soil cover.

- Unapproved land disposal of wastes

- Disposal of hazardous substances at sanitary landfills

- Lack of public awareness of ground-water problems and remedies

- Lack of coordination of ground-water programs

- Lack of hydrogeologic data

Specific remedies for each problem may be addressed in the state strategy. However, the major unresolved policy

questions are: (1) Should ground-water regulations be tailored to specific hydrogeologic situations (differential protection)? and (2) If so, on what basis should aquifers be classified?

Possible criteria for aquifer classification include:

- Water use (type and amount of use)
- Aquifer productivity (well yield)
- Water quality
- Aquifer vulnerability

The way in which these issues may be addressed in the strategy will depend on a number of factors specific to Tennessee, including the hydrogeology of the state, the structure of ground-water related programs and agencies, and the political and economic realities of implementing the policies set forth in the strategy.

5.2 HYDROGEOLOGIC CONSIDERATIONS

5.2.1 Major Aquifers

More than half of the population of Tennessee relies on ground water for drinking water supplies. Twenty-one percent of water consumed in the state (exclusive of thermoelectric use) is ground water. Of this, about 55 percent is withdrawn for public and domestic supplies, 42 percent for self-supplied industrial use, and 1 percent for irrigation (Bradley and Hollyday, 1985). Nearly all water for public,

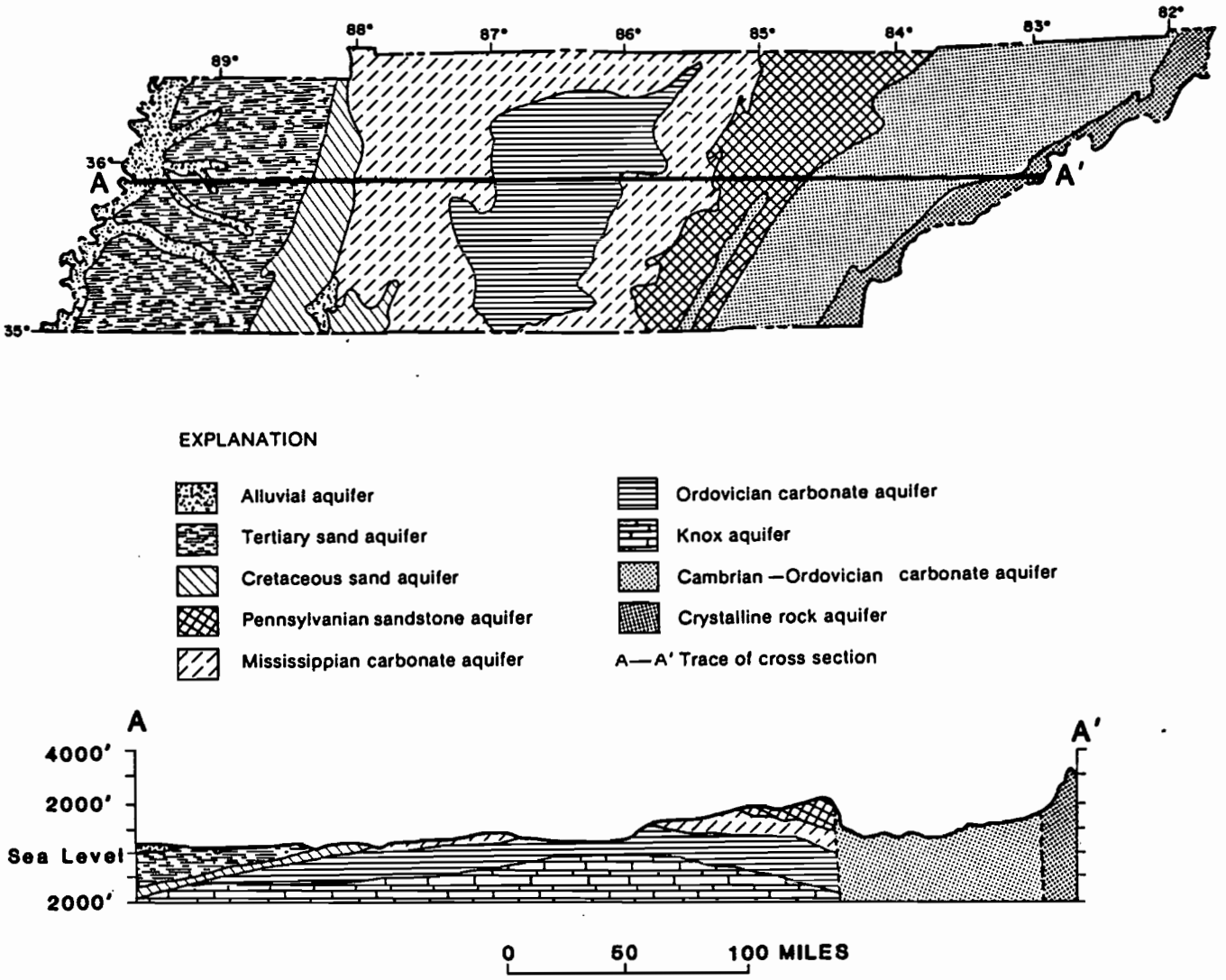
industrial, and rural uses in western Tennessee is supplied by ground water. Memphis, the state's largest city, is completely supplied by ground water.

Nine principal aquifers have been identified in Tennessee, as illustrated in Figure 1 and briefly described in Table 8. Generally, the most prolific aquifers are the alluvial, Tertiary, and Cretaceous sands of the western part of the state and the alluvial sands and cavernous limestones that occur erratically in the central and eastern parts of the state. In the remaining bedrock formations, ground-water yields from wells are generally low except in areas of fracturing. Even where fracturing is present, the porosity and permeability decrease with depth so that, in most areas, adequate supplies cannot be obtained from depths greater than a few hundred feet.

5.2.2 Ambient Water Quality

The natural quality of ground water is commonly expressed in terms of chemical properties that affect or limit its use. The chemical parameter most referenced as a measure of quality is TDS; in addition, pH and other specific parameters such as hardness, iron, and sulfate may render water unusable unless treated. Water with less than 1,000 mg/l dissolved solids is considered fresh. By comparison, typical sea water contains 34,000 mg/l dissolved solids.

The concentration of dissolved solids in ground water



(FROM BRADLEY & HOLLYDAY, 1985)

FIGURE 1. PRINCIPAL AQUIFERS IN TENNESSEE

TABLE 8. AQUIFER AND WELL CHARACTERISTICS IN TENNESSEE

[Ft = feet; gal/min = gallons per minute; Sources: Reports of the U.S. Geological Survey and Tennessee State agencies]

Aquifer name and description	Well characteristics				Remarks
	Depth (ft)		Yield (gal/min)		
	Common range	May exceed	Common range	May exceed	
Alluvial aquifer: Sand, gravel, and clay. Unconfined.	10 - 75	100	20 - 50	1,500	Large iron concentrations in some areas. Local contamination at some landfills.
Tertiary sand aquifer: A multiaquifer unit of interbedded sand, clay, silt, and some gravel and lignite. Confined, unconfined in the outcrop area.	100 - 1,300	1,500	200 - 1,000	2,000	Includes Memphis Sand of Claiborne Group and Fort Pillow Sand of Wilcox Group. Problems with large iron concentration in some places.
Cretaceous sand aquifer: A multiaquifer unit of interbedded sand, clay, marl, and gravel. Confined, unconfined in the outcrop area.	100 - 1,500	2,500	50 - 500	1,000	Includes McNairy and Coffee Sands, and Tuscaloosa Formation. Water used primarily in the outcrop area.
Pennsylvanian sandstone aquifer: A multiaquifer unit, primarily sandstone and conglomerate, interbedded with shale and some coal. Unconfined near land surface, confined at depth.	100 - 200	250	5 - 50	200	Permeability is from fractures, faults and bedding-plane openings. Principal water-bearing units are Rockcastle Sandstone and Sewanee Conglomerate. Large iron concentrations are a problem.
Mississippian carbonate aquifer: A multiaquifer unit of limestone, dolomite, and some shale. Unconfined or partly confined near land surface; may be confined at depth.	50 - 200	250	5 - 50	400	Water occurs in solution openings and bedding-plane openings. Principal water-bearing units are Ste. Genevieve (Monteagle), St. Louis and Warsaw Limestones and Fort Payne Formation. Susceptible to pollution. Water generally hard; large iron, sulfide, or sulfate concentrations problems in some areas.
Ordovician carbonate aquifer: A multiaquifer unit of limestone, dolomite, and shale. Partly confined to unconfined near land surface; confined at depth.	50 - 150	200	5 - 20	300	Principal water-bearing units are Bigby, Carters, Ridley, and Murfreesboro Limestones. Water generally hard; some large sulfide or sulfate concentrations in places. Units susceptible to contamination.
Knox aquifer: Primarily dolomite With some limestone. Confined.	700 - 1,200	1,400	1 - 10	20	A deep aquifer; occurs under most of Middle and west Tennessee. Away from Central Basin, water generally has large concentrations of dissolved solids.
Cambrian-Ordovician carbonate aquifer: Extremely faulted multiaquifer unit of limestone, dolomite, sandstone, and shale; structurally complex. Unconfined; confined at depth.	100 - 300	400	5 - 200	2,000	Principal water-bearing units are carbonate rocks in Chickamauga Limestone, Knox Group, and Honaker Dolomite. Water is generally hard. Brine below 3,000 ft.
Crystalline rock aquifer: A multi-aquifer unit of dolomite, granite gneiss, phyllite, and metasedimentary rocks overlain by thick regolith; alluvium and colluvium in some valleys. Generally unconfined.	50 - 150	200	5 - 50	1,000	Large yields occur primarily in valleys with dolomite or deep colluvium and alluvium. Shady Dolomite is a principal aquifer. Low pH and large iron concentrations may be problems in some areas.

Source: Bradley and Hollyday, 1985

depends on the type of rock in which the ground water resides and the length of time that the water has been in the ground. Ground water in limestones and dolostones, which are relatively soluble, generally contains higher concentrations of dissolved solids than ground water of similar age in shales or sands. On the other hand, shales may contribute high sulfate levels to ground water and sands may yield water with objectionable levels of dissolved iron.

Dissolved solids concentrations increase with the length of time that the ground water has been in contact with the host formations. In most areas, there is an increase in dissolved solids with depth. Saline water and even brines (dissolved solids content greater than 35,000 mg/l) are found at depths ranging from several hundred to a few thousand feet. Ground-water pollution is a local problem in Tennessee, especially in industrialized areas and where aquifers are vulnerable to contamination from surface sources such as landfills and septic tanks.

The Cretaceous and Tertiary sand aquifers in the western part of the state yield water with relatively low levels of dissolved solids throughout their thicknesses, although dissolved iron is a problem in some places. In most areas, these sands are afforded some protection from surface pollution by a blanket of wind-deposited silt and clay. The sandstone and carbonate aquifers of the central part of the state have usable yields of fresh water to depths of about

200 feet, although in some places fresh water can be obtained from the Knox Formation at depths of several hundred feet. Water from these formations is usually hard and may have high levels of sulfate derived from the associated shales. The Cambrian and Ordovician aquifers of eastern Tennessee are generally saline below depths of about 300 feet.

5.3 INSTITUTIONAL FRAMEWORK

5.3.1 State Agencies

In Tennessee, the authority for ground-water management lies primarily within the Department of Health and Environment (TDHE), the organization of which is shown in Figure 2. Some specific ground-water-related issues are dealt with in other agencies. The Division of Geology, within the Department of Conservation, administers a permitting program for underground injection wells (oil and gas well brine disposal) and the Department of Agriculture is responsible for enforcement of pesticide application standards.

Within the TDHE, the Office of Water Management coordinates the activities of four water-related divisions: Ground Water Protection, Water Pollution Control, Water Supply, and Construction Grants and Loans. Of these, the recently created Division of Ground-Water Protection is the focal point for ground-water planning. Included within the division are groups responsible for regulation of underground storage tanks, underground injection, subsurface sewage

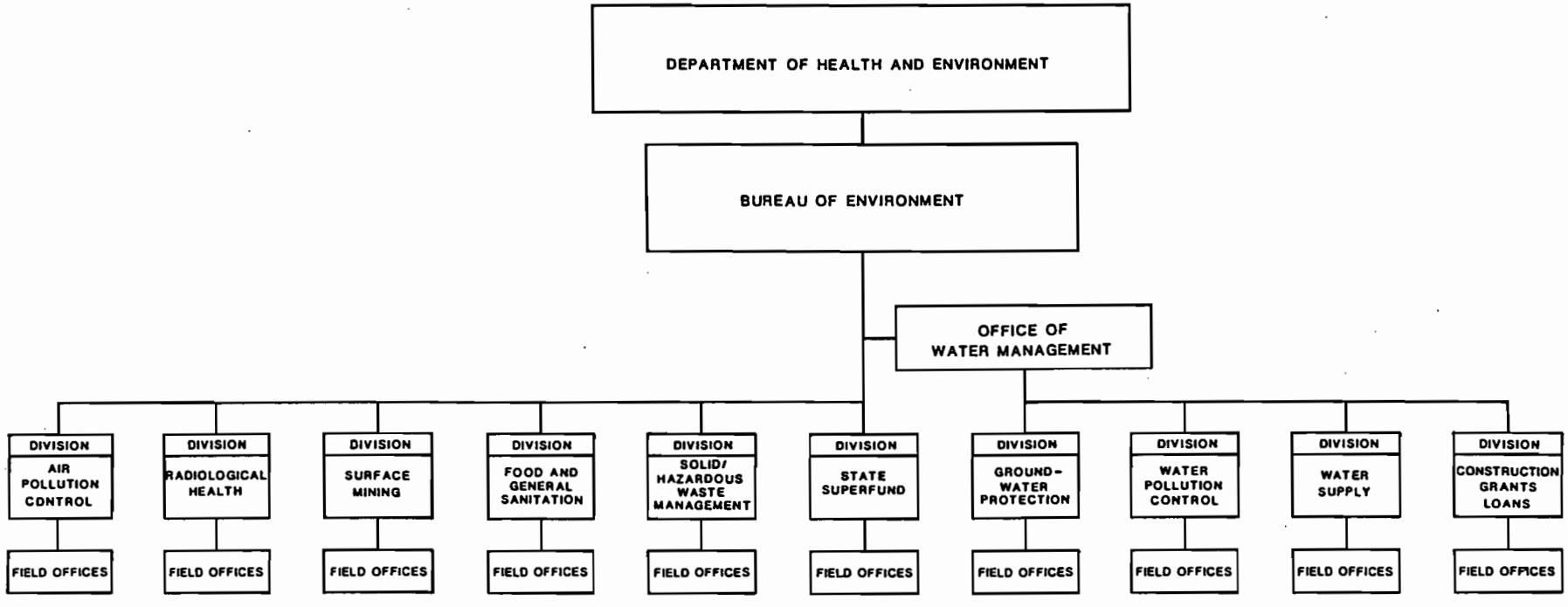


FIGURE 2. ORGANIZATION OF THE BUREAU OF ENVIRONMENT, TDHE

disposal (septic tanks), licensing of water well drillers, and collection of water well records. The organization of the Ground Water Protection Division is shown in Figure 3.

The other divisions under the Office of Water Management are concerned more with the uses of surface water or ground water. The Division of Water Pollution Control deals primarily with sewage treatment and discharge of effluents to surface water; the Division of Water Supply is concerned with the final quality of public drinking-water supplies; and the Division of Construction Grants and Loans aids in financing sewage treatment and water-supply systems.

Other divisions within TDHE that deal with ground-water issues are Solid/Hazardous Waste Management, State Superfund, Surface Mining, and Radiological Health. The State Superfund group, which was formerly a part of the Division of Solid/-Hazardous Waste Management, was recently given division status.

The Division of Solid/Hazardous Waste Management is responsible for processing permits for facilities that treat, store, or dispose of hazardous and solid non-hazardous wastes. The Superfund Division works closely with the EPA CERCLA program and administers the state's program for remediation of contamination from inactive hazardous substances sites. Because Tennessee does not have primacy for permitting of surface mining in the state, this program is administered by the federal Office of Surface Mining. The

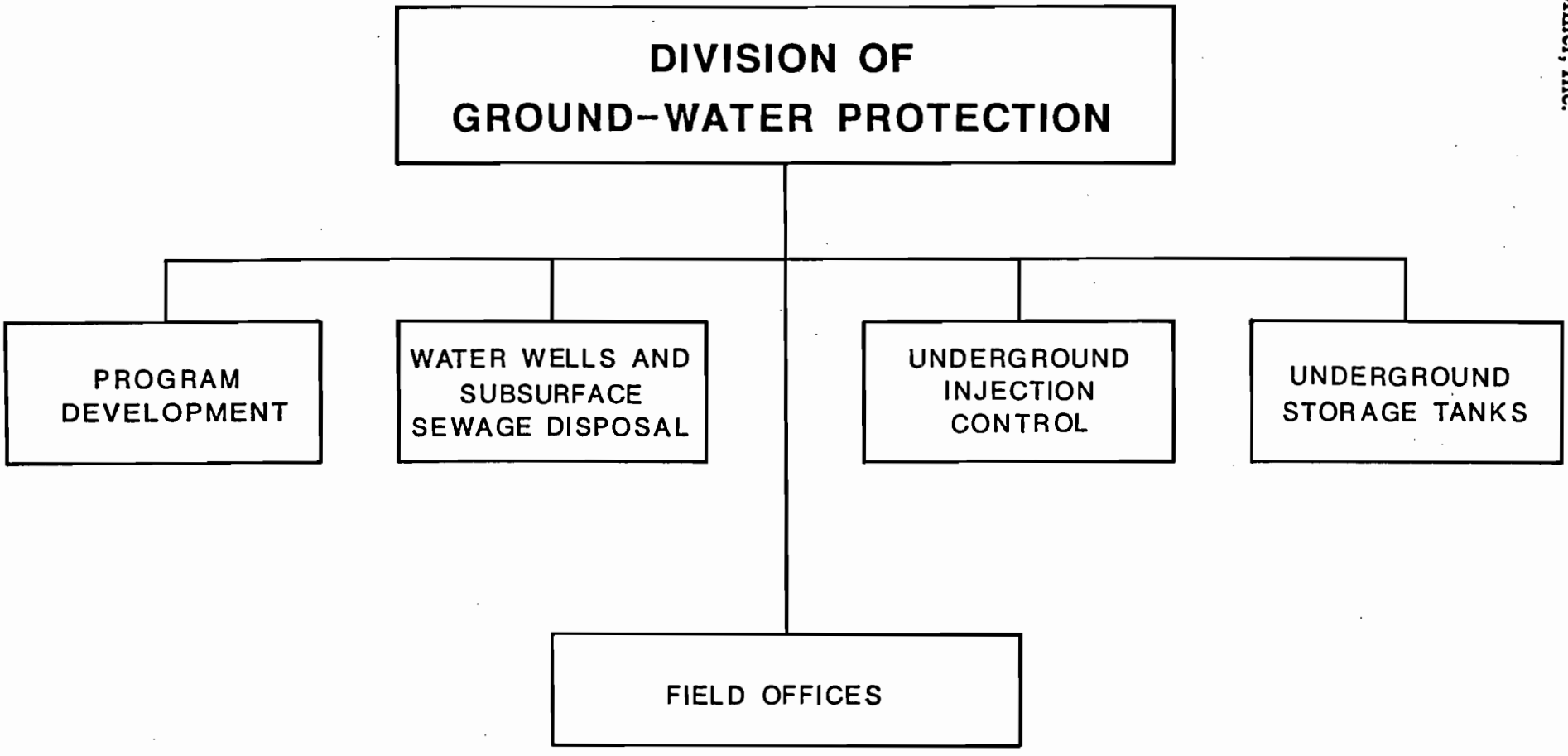


FIGURE 3. ORGANIZATION OF THE DIVISION OF GROUND-WATER PROTECTION

Division of Radiological Health administers the state's program for licensing the use of radiological materials, which includes enforcing standards for point-source discharges of radioactive materials to the environment.

5.3.2 Interagency Coordination

At present, the divisions within TDHE are formally coordinated through the Bureau of the Environment and the Office of Water Management. As the ground-water strategy evolves, there is ongoing informal communication among divisions to resolve questions of overlapping or conflicting programs. A more formal vehicle of coordination which is commonly used is the interagency or interdepartment task force. Methods of coordination between state and federal agencies are generally specified in each federal program.

5.4 REGULATORY PROGRAMS

5.4.1 Permits and Quality Assurance Program

The Division of Solid/Hazardous Waste Management is authorized by the Hazardous Waste Management Act (T.C.A. Section 68-31) to issue permits for the operation of facilities actively used for treatment, storage, or disposal of solid and hazardous wastes. Included in the permit program are landfills (sanitary and hazardous), surface impoundments, and tanks containing hazardous waste. Petroleum products and hazardous materials that are not wastes are excluded from the authority of this program, and will be regulated under the

state's UST program administered within the Division of Ground Water Protection. The state has received primacy for the Permits and Quality Assurance program and is now in the process of also applying for primacy for items covered in the federal Hazardous and Solid Waste Amendments of 1984. State statutes equivalent to those amendments are effective as of February 2, 1986. It is estimated that primacy for these programs will be obtained in 1987.

5.4.2 State Superfund Program

The State Superfund Program was created by the Tennessee Hazardous Waste Management Act of 1983 to supplement the EPA CERCLA program of identification, investigation, remediation, and monitoring of inactive hazardous substance sites in Tennessee. The program is funded by the Waste Remedial Action Fund, which is maintained by fees levied on hazardous-waste generators and transporters, with matching allocations from the State General Fund. The law defined the state's authority to issue Commissioner's Orders to responsible parties, and to order the investigation, containment, clean-up, monitoring, and maintenance of sites. The law also authorized the Commissioner of TDHE to act immediately in emergency situations to abate "imminent and substantial danger," to recover from responsible parties the cost of investigation and remediation, and to levy punitive damages and in some cases to seek civil and criminal penalties.

Unlike some federal programs such as RCRA, UIC, and UST,

there is no provision for granting primacy to states for the CERCLA program. The EPA CERCLA and Tennessee Superfund groups work cooperatively, with a division of responsibilities for the inventory, investigation, evaluation, and remediation of hazardous substance sites in the state. The State Superfund Division maintains a comprehensive master list of suspected inactive hazardous substance sites, which includes those sites on EPA's Emergency Response Remedial Investigation Sites (ERRIS) list of Tennessee sites. The Site Inspections Group within the State Superfund Division is funded by EPA to screen sites on the ERRIS list. The screening involves a site inspection, sampling, and hazard ranking using the Mitre system. Those sites that score above a set cutoff in the hazard ranking are placed on the EPA National Priorities List. During this process, any sites perceived to pose an "imminent hazard" are submitted to the Commissioner of Health and Environment for emergency remediation.

The State Master List is also subjected to hazard ranking, using the Tennessee Priority Assessment System, from which the most serious sites are nominated for the State Superfund Eligible Sites List. This list is promulgated by the Solid Waste Disposal Control Board and is forwarded to the Commissioner who issues Commissioner's Orders to the responsible parties.

5.4.3 Underground Injection Control Program

Tennessee has recently adopted regulations for underground injections of waste as authorized by T.C.A. Section 69-3-105; however, primacy has not yet been granted for this program. As part of the state regulations (1200-4-6-.05), ground water is classified as either suitable for beneficial uses or suitable for waste injection. The classification system lists beneficial uses and sets water-quality standards for these uses. It strictly defines ground water suitable for injection of wastes as water (1) not currently being used for the defined beneficial uses, (2) having a TDS content of more than 3,000 ppm and being unusable for beneficial purposes, and (3) having no potential for future use for the defined beneficial uses because:

(a) it is in a zone of commercially producible minerals, hydrocarbons, or geothermal energy;

(b) it is at a depth which makes recovery of water for beneficial uses impractical;

(c) it is so contaminated that it would be impractical to render it fit for beneficial uses;

(d) it is located over a Class III well mining area subject to subsidence or collapse; or

(e) it has been contaminated prior to the effective date of the regulations by a permitted well.

The regulations also define five classes of injection wells based primarily on type of fluid injected and proximity to an Underground Source of Drinking Water (USDW). Until

Tennessee receives primacy for this program, owners of injection wells are required to obtain both a federal and a state permit. In addition, a third permit is now required from the Division of Geology for Class II oil and gas wells.

5.4.4 Underground Storage Tank Program

An Underground Storage Tank Section has been created within the Division of Ground-Water Protection. It is expected that state regulations for underground tanks will be written after promulgation of EPA UST regulations. The state UST program is intended to regulate underground tanks not covered by the state Permits and Quality Assurance program for treatment, storage, or disposal of wastes. The UST program, therefore, includes tanks containing petroleum products and the hazardous products listed in Section 101(14) of CERCLA. Small residential or farm tanks for motor fuel or heating oil are exempt from the regulations.

The first phase of the program is an inventory of underground tanks; owners are required to report location, contents, uses, and construction details. The state UST group is currently accepting these notifications but has not begun a comprehensive program of mailing the notification forms to tank owners. The state has applied for federal funds to fully develop its UST program and to implement the notification phase.

Beginning May 8, 1987, Tennessee will be able to apply to EPA for approval of its UST program. To gain approval the state must demonstrate the capability to inspect and enforce requirements that are no less stringent than the federal program.

5.4.5 Other Programs

The state has instituted a number of other programs that have an impact on its ground-water strategy. Because of public opposition to development of hazardous-waste landfills in Tennessee, the Legislature included in the state's Hazardous Waste Management Act a provision for a grant of $1,000,000 to any county that accepts such a facility. The Responsible Waste Disposal Incentive Fund, which was established for this purpose, has never been used, and the state still does not have a permitted hazardous-waste landfill.

The Governor has designated Tennessee Technological University in Cookeville as a Center of Excellence for the study of water supplies, including ground water. The Center was granted research funding to study ground-water quality and to recommend a network of wells for monitoring ground-water quality in Tennessee, and has been contracted to study the impact on ground-water quality of impoundments in the state.

Septic tanks are regulated by the Subsurface Sewage Disposal group within the Division of Ground Water Protec-

tion. To administer this program, TDHE maintains a large staff of inspectors and administrators in eight regional field offices, with district offices in nearly every county.

The state is attempting to assure safe and proper construction of water-supply wells by licensing drillers and setting construction standards for state approval of new wells. This program is administered by the Water Wells group within the Division of Ground-Water Protection. The Water Wells group is also responsible for maintaining a data base of wells, including locations, depths, construction details, yields, water quality, water use, and lithologic logs. The state's well abandonment regulation is not specific. It simply requires that abandoned wells be "...properly protected for the purpose of maintaining the original quality of the ground-water source."

In order to broaden its base of ground-water data, the state has contracts with the USGS to estimate aquifer recharge rates and potential yields, using primarily stream flow data, and to develop inexpensive methods of delineating recharge areas.

5.5 DRAFT GROUND-WATER MANAGEMENT STRATEGY

The early legislation and regulations dealing with water pollution dealt more with surface water than ground water. More recently, the importance of managing and protecting ground-water resources has been recognized. Because of the

existing patchwork of ground-water legislation, there is a need for comprehensive planning to enact new legislation, revise existing laws, and coordinate efforts to manage and protect this resource.

With this objective, a task force was appointed within the Division of Ground-Water Protection to develop a ground-water management strategy. The product of this task force, the "Tennessee Draft Ground Water Management Strategy of October 1, 1985," is given in Appendix C. This document, which is deliberately nonspecific, has been distributed along with a questionnaire to solicit public comment. The Tennessee Environmental Council, a nonprofit organization, was commissioned to evaluate the questionnaire responses and to conduct public hearings to discuss the draft strategy. Concurrently, the Conservation Foundation, a Washington, D.C., organization, will assemble a panel of experts to discuss strategy options and will issue a guidance report in about August 1986.

Based on the reactions to the draft strategy, the task force will write a second draft strategy, which also will be circulated for comment. A third and final draft strategy then will be written and submitted to EPA for approval as early as October 1986. The final approved strategy document will be adopted by the Water Quality Control Board, where it will guide case decisions, and/or it will be adopted by the State Legislature, in which case it could influence future

laws and regulations. The process for adoption of a ground-water strategy is illustrated in Figure 4.

The first draft strategy lists eight guiding principles. Five general goals are given and 14 work elements or problem areas to be addressed are enumerated. Some specific policy items are left open for discussion. Tennessee officially has a policy of nondegradation, as expressed in the following wording of the 1977 Water Quality Control Act:

> "...it is declared to be the public policy of Tennessee that the people of Tennessee, as beneficiaries of this trust, have a right to unpolluted waters."

However, the strategy does not restate this policy and in fact Principle 4 notes that there are now two classes of ground water and that "...from time to time, studies will be made to determine the feasibility and desirability of amending this classification and for providing different levels of protection."

The strategy acknowledges that aquifers may have different degrees of vulnerability and that recharge areas for aquifers might require special protection, possibly at local levels of government.

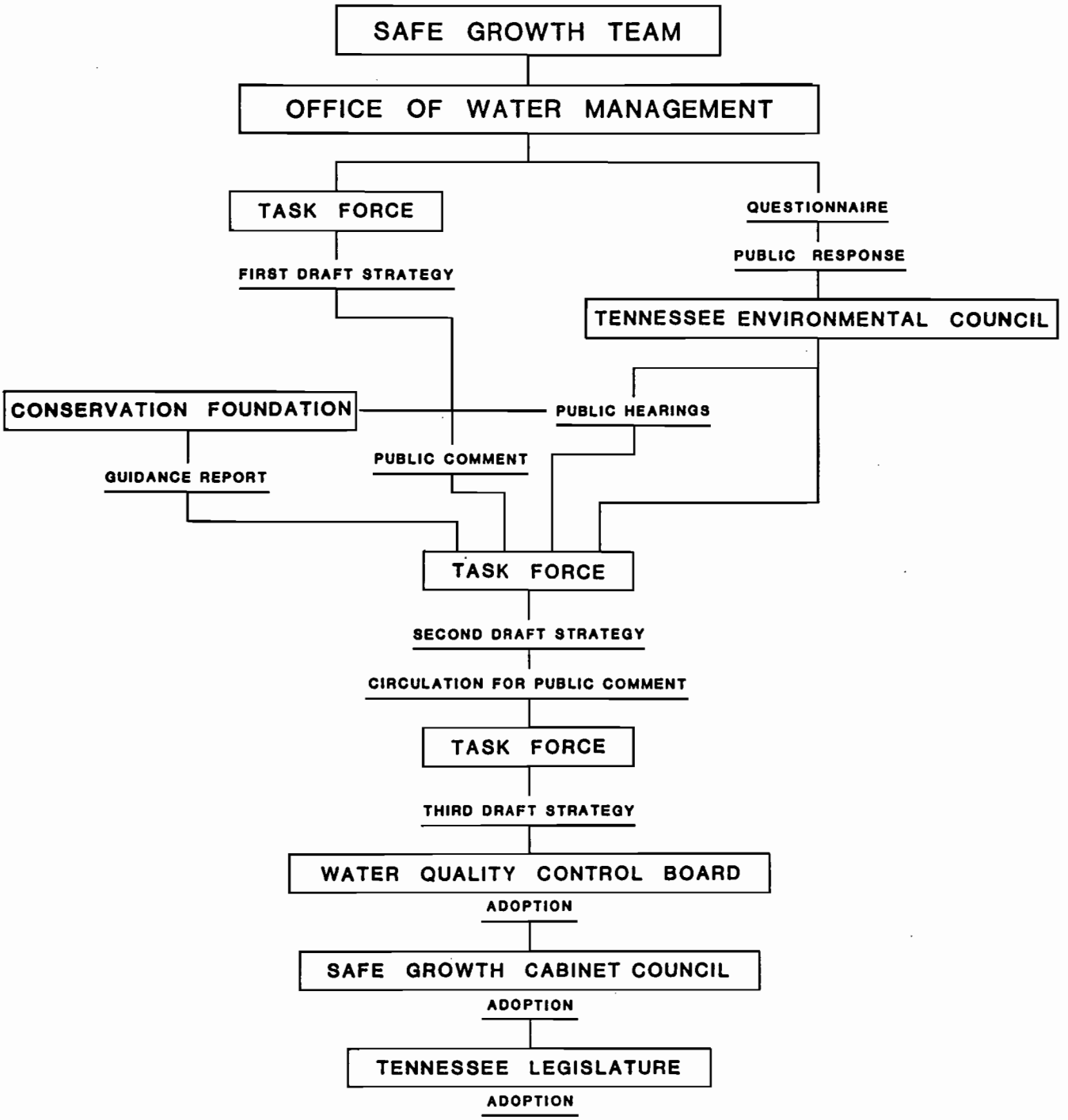


FIGURE 4. DEVELOPMENT OF THE TENNESSEE GROUND-WATER PROTECTION STRATEGY

6.0 CONCLUSIONS

6.1 FACTORS INFLUENCING THE STATE STRATEGY

6.1.1 Hydrogeology

Aquifers in Tennessee occur in a variety of hydrogeologic settings and, based on their productivity and water quality, are of varying importance as sources of water supplies. These aquifers differ in vulnerability to both contamination and to damage from overproduction. The rate of ground-water movement varies drastically not only from one type of aquifer to another but from one topographic setting to another. Some aquifers are sole sources of water supply whereas others could be replaced by alternative supplies.

To provide the same level of protection to each aquifer most cost effectively would require tailoring a set of standards for each situation. For example, protection of a vulnerable aquifer might require expensive precautions, which would be wasteful if applied in all situations. If the resources available for ground-water protection and cleanup are limited, the value of each aquifer must be assessed so that funds can be allocated to protect the maximum amount of ground water while assuring that no area of the state is deprived of water supplies because of loss of an aquifer. From the standpoint of hydrogeology, differential protection is the most logical policy. The effectiveness of the system would depend on the complexity of aquifer classification.

6.1.2 State Programs

Tennessee currently has programs that address many potential sources of ground-water contamination, including facilities for treatment storage and disposal of hazardous waste, sanitary landfills, inactive hazardous substances sites, waste disposal wells, subsurface sewage disposal, and underground storage tanks. In addition, the state licenses drillers and has well construction standards that must be met for approval of public supply wells. Some of these programs, such as UST, are not yet fully developed, and some of the agency sections are understaffed for proper implementation of programs. Increases in staff will be necessary to administer ground-water programs currently under way. Funding for additional staff and for possible creation of a new agency section to manage a program of differential protection might be difficult to obtain. The inadequacy of the hydrogeologic data base also might be an obstacle to adoption of a complex system of aquifer classification.

On the other hand, centralization of authority for ground-water issues in the Division of Ground Water Protection will facilitate coordination of programs and will eliminate many of the problems experienced by other states that have adopted strategies. In this respect, Tennessee might be in a better position than most states to implement an innovative strategy.

6.1.3 Political Factors

In order for a ground-water strategy to have any meaning, it must be adopted by the Water Quality Control Board or the State legislature, and therefore must be politically acceptable. A complex program of differential protection is less attractive politically than the much more simple concept of nondegradation. The simpler program would be easier to translate into legislation and would be more understandable to the public. Differential protection, which provides an incentive for new industry to locate to areas where aquifers are less vulnerable, could adversely impact local economies, and the net political reaction to differential protection would probably be negative. Finally, the public perception of differential protection is that one aquifer will not receive as much protection as others and, therefore, that some citizens will be placed at higher risk than others.

6.1.4 Economics

Implicit in each of the factors listed above is economics. In the short term, a program of differential protection would be more costly to institute because it would require studies to develop a workable system of aquifer classification and to develop water-quality standards. A somewhat larger regulatory staff would probably be necessary to administer the program, owing to its complexity. For industry, differential protection would probably mean somewhat greater costs for hydrogeologic investigations to gather

the data necessary for classification of aquifers at specific sites.

However, in the long term, the savings from avoiding unnecessary measures to protect and cleanup less valuable ground waters could more than offset the initially higher costs of differential protection. The real cost of a policy of nondegradation should include not only the administrative cost of implementation but the cost to industry of compliance and the cost to the state of the possible loss of industry.

6.2 OUTLOOK

The most controversial policy option of the Tennessee Ground-Water Strategy will probably be nondegradation versus differential protection. The first draft strategy suggests that differential protection should be considered, and the existing classification of aquifers in Tennessee is a first step in that direction. However, input to the first draft has been primarily from the technically inclined Ground Water Management Strategy Task Force. The complexion of the strategy may change in later drafts as public input is incorporated.

It is likely that some form of differential protection will eventually be adopted as a policy of the state. However, as noted earlier, there are several very different bases for classifying aquifers, and a classification system can have any degree of complexity. The best classification

system might incorporate a combination of criteria including water use (type and amount), aquifer productivity, water quality, and aquifer vulnerability. The hydrogeology of the state favors a complex system; however, for political and practical reasons it is likely that a relatively simple system will be adopted.

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APPENDIX A

DESCRIPTIONS OF MAJOR FEDERAL STATUTES RELEVANT TO THE PROTECTION OF GROUND-WATER QUALITY

Statute	Objectives and provisions relevant to groundwater protection	Responsible Federal agencies	Relationship to the States
Atomic Energy Act of 1954, 42 U.S.C. 2011[a]	One purpose of the act is to encourage the development and use of atomic energy for peaceful purposes consistent with the common defense and security and the health and safety of the public. The act authorizes the regulation of the development and utilization of atomic energy, including the storage and disposal of radioactive wastes.	Department of Energy Nuclear Regulatory Commission Environmental Protection Agency—Office of Radiation Programs	Regulation of certain radioactive materials is delegated by NRC to the States that participate in the Agreement States Program. Pursuant to the Low-Level Radioactive Waste Policy Act of 1980, States are currently engaged in regional and individual planning efforts to site new disposal facilities.
Clean Water Act of 1977, 33 U.S.C. 1251-1378[b]	The objective of the statute is to restore and maintain the physical, chemical, and biological integrity of the Nation's waters. Activities authorized by the act include: — the construction of sewage treatment works and the use of alternative waste management techniques (Section 201); — the establishment of effluent standards and the regulation of point discharges of pollutants (Sections 302, 306, 307, and 402); — the development of ambient water quality criteria (Section 304); — regulation of the disposal of dredged or fill materials (Section 404); — establishment of State or regional water quality management plans, and the establishment of a program to develop Best Management Practices to control non-point source pollution in rural areas (Section 208); — responses to oil discharges into navigable water (Section 311).	Environmental Protection Agency—Office of Water Programs Operations, Office of Water Regulations and Standards, and Office of Water Enforcement and Permits Department of Agriculture—Soil Conservation Service and Agricultural Stabilization and Conservation Service (Section 208) Department of Transportation—U.S. Coast Guard (Section 311)	States (or local planning agencies) were required by Section 208 to submit areawide water quality management plans to EPA that identified and proposed solutions to water quality problems (including point and non-point sources affecting surface water and groundwater). Funding for Section 208 activities was terminated in 1981. Grants under Sections 106 and 205(j) are now being used to support planning activities. State (or interstate agency) grants are authorized (Section 106) to assist with the administration of water pollution control activities required by the act. Funds are also available from Sections 205(g) and (j) which are reserves from State construction grant allotments. While Section 205(g) funds are used primarily to support construction grant programs (for sewage treatment works), Section 205(j) funds are authorized to support State water quality management planning. Regulatory authority for Section 402 is delegated to States for the point discharges of pollutants into navigable waters.[c] Section 303 requires States to adopt water quality effluent standards for such discharges consistent with Federal standards.
Coastal Zone Management Act of 1976, 16 U.S.C. 1451	One policy specified in the statute is to preserve, protect, develop, and where possible, restore or enhance the resources of the Nation's coastal zone for this and succeeding generations. The act authorizes funding to encourage and assist the States in the development and	Department of Commerce—National Oceanic and Atmospheric Administration	States are eligible to receive grants if a coastal zone management program is developed that meets minimum Federal requirements.

Statute	Objectives and provisions relevant to groundwater protection	Responsible Federal agencies	Relationship to the States
	implementation of management programs with respect to the use of land and water resources in the coastal zone, including efforts to mitigate salt-water intrusion.		
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601	The statute does not contain an explicit policy statement. The act authorizes the Federal Government to respond whenever there is a release or threat of release of hazardous substances, pollutants, or contaminants into the environment which may present an imminent and substantial danger to public health or welfare. Responses are financed by excise taxes levied on petroleum and chemical feedstocks. The act also establishes liability for the cost of response actions on responsible parties and provides for compensation of expenses incurred by the government.[d]	Environmental Protection Agency—Office of Emergency and Remedial Response Department of Transportation — U.S. Coast Guard Department of the Interior	States may enter into a Cooperative Agreement with EPA and assume lead responsibility for remedial actions, or States may enter into a contract with EPA whereby EPA assumes lead responsibility. In either case, States are required to assure payment of 10 percent of the costs (or 50 percent if the site is publicly owned), assume responsibility for all future operation and maintenance required at the site, and assure the availability of an authorized hazardous waste disposal facility if necessary for the disposal of wastes removed during remedial activities.
Federal Insecticide, Fungicide, and Rodenticide Act, as amended 7 U.S.C. 136[e]	The statute does not contain an explicit policy statement. The act requires the registration of all pesticides based on the submission of specified data (Section 3), the classification of pesticides for general or restricted uses (Section 3), and suspension and cancellation of pesticides causing unreasonable adverse effects on the environment (includes water, air, land, plants, man and other animals, and their interrelationships) (Section 6). The act also requires the establishment of procedures for the storage and disposal of pesticide containers and excess pesticides (Section 19), as well as formulation of a National Monitoring Plan for pesticides (Section 20).	Environmental Protection Agency—Office of Pesticide Programs	Authority is delegated to States for enforcement of FIFRA provisions (e.g., ensuring that pesticides are used in compliance with any Federal restrictions) if States adopt and implement adequate pesticide laws, regulations, and enforcement procedures.[f] States may also assume responsibility for the training and certification of pesticide applicators if Federal approval of a plan for such activities is obtained. Federal funding of State programs is available to those States that enter into cooperative agreements with EPA.
Federal Land Policy and Management Act of 1976, 43 U.S.C. 1701, and associated mining laws.[g]	The statute specifies that it is the policy of the United States that public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values. The act authorizes the regulation of the use of public lands, including mining operations.	Department of the Interior—Bureau of Land Management	Mining regulations may not preempt State laws and regulations regarding the conduct of mining operations or reclamation on Federal lands. States may enter into agreements with BLM to provide for joint administration and enforcement of regulatory programs

Statute	Objectives and provisions relevant to groundwater protection	Responsible Federal agencies	Relationship to the States
Hazardous Liquid Pipeline Safety Act of 1979, 49 U.S.C. 2001	The statute does not contain an explicit policy statement. The act requires the establishment of Federal regulations for the movement of hazardous liquids by pipeline (and their storage incidental to such movement) and pipeline facilities in or affecting interstate or foreign commerce; such regulations must consider the extent to which they contribute to public safety.	Department of Transportation—Office of Pipeline Safety Regulation	Federal regulations do not apply to intrastate pipelines and associated facilities for which there are applicable State regulations, provided that the State agency is certified annually by DOT.
Hazardous Materials Transportation Act of 1974, 49 U.S.C. 1801[h]	The policy underlying the statute is to protect the Nation adequately against the risks to life and property which are inherent in the transportation of hazardous materials in commerce. The act requires the establishment of Federal regulations for the transportation of hazardous materials (including hazardous wastes) in commerce.	Department of Transportation—Office of Hazardous Materials Regulation	State regulations that are inconsistent with Federal requirements are preempted. Although there is not a formal delegation of authority, States may enter into cooperative agreements with DOT to obtain technical and financial assistance. States may also establish requirements for certain activities not addressed by Federal regulations (e.g., routing the transport of hazardous materials).
National Environmental Policy Act of 1969, 42 U.S.C. 4371	The purposes of the statute include: the declaration of a national policy to encourage productive and enjoyable harmony between people and the environment, and the promotion of efforts to prevent or eliminate damage to the environment and biosphere and to stimulate human health and welfare. The act directs Federal agencies to utilize a systematic, interdisciplinary approach in planning and decisionmaking that may have an impact on the environment and to prepare environmental impact statements for major Federal actions significantly affecting the quality of the human environment.	All Federal agencies[i]	States have opportunity to review and comment on Federal actions under this and other programs under intergovernmental review provisions authorized by Executive Order 12372.
Reclamation Act of 1902, 43 U.S.C. 390(b)	The policy underlying the statute supports the participation and cooperation of the Federal Government with States and local interests in developing water supplies for domestic, municipal, industrial, and other purposes. Some projects funded under the act are for the development of underground water supplies that are contaminated due to natural leaching (e.g., high salt concentrations) or human activities and thus require treatment prior to use.	Department of the Interior—Bureau of Reclamation	Water rights for reclamation projects must be obtained through States' water rights systems. States are involved in project planning activities.

Statute	Objectives and provisions relevant to groundwater protection	Responsible Federal agencies	Relationship to the States
Resource Conservation and Recovery Act of 1976, 42 U.S.C. 690	The objective of the statute is to promote the protection of health and the environment and to conserve valuable material and energy resources. Subtitle C of the act requires the establishment of regulations for hazardous waste generators, transporters, and owners or operators of facilities who treat, store, or dispose of such wastes. Subtitle D requires the establishment of Federal guidelines for State solid waste management plans.	Environmental Protection Agency—Office of Solid Waste	Regulatory authority for Subtitle C is delegated to States that establish programs that incorporate minimum Federal requirements. Programs may be more stringent than Federal requirements. Financial assistance is authorized to the States for development and implementation of such programs. Although Subtitle D of the act does not mandate the development of State solid waste plans, States are required to meet certain minimum requirements to obtain EPA approval and qualify for Federal financial assistance. (Subtitle D State grants have not been available in 1982 and 1983.)
Safe Drinking Water Act of 1974, 42 U.S.C. 300f	The statute does not contain an explicit objective but is designed to assure that public water systems meet minimum standards for the protection of public health. The act requires the establishment of contaminant standards for drinking water (Part B), the establishment of regulations for underground injection (Part C), and the protection of sole source aquifers (Part C).	Environmental Protection Agency—Office of Drinking Water	States may assume primary enforcement responsibility for public water systems (PWS) to ensure compliance with national drinking water regulations if minimum Federal requirements are met. States may establish standards that are more stringent than Federal standards and may also set standards for substances not addressed by the Federal regulations. Regulatory authority for the Underground Injection Control (UIC) Program is also delegated to those States that establish programs that incorporate minimum Federal requirements. Programs may be more stringent than Federal requirements. Financial assistance is authorized to States for the development and implementation of both the PWS and UIC programs. States, municipalities, partnerships, associations, companies, corporations, or individuals may petition EPA to designate a sole source aquifer. Once an aquifer is so designated, any of these parties may petition EPA to review the potential of a project to contaminate the aquifer and create a significant hazard to public health.

Statute	Objectives and provisions relevant to groundwater protection	Responsible Federal agencies	Relationship to the States
Surface Mining Control and Reclamation Act of 1977, 30 U.S.C. 1201	One purpose of the statute is to establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations. The act requires the establishment of regulations for surface mining of coal (and the surface effects of underground coal mining) and authorizes reclamation of abandoned mine lands.	Department of the Interior—Office of Surface Mining Department of Agriculture—Soil Conservation Service	Regulatory authority is delegated to States that establish programs that incorporate minimum Federal requirements. Financial assistance is authorized to States for the development and implementation of such programs.
Toxic Substances Control Act of 1976, 15 U.S.C. 2601 Toxic Substances Control Act of 1976, 15 U.S.C. 2601 (continued)	The primary purpose of the act is to assure that chemical substances and mixtures do not present an unreasonable risk of injury to health or the environment.	Environmental Protection Agency—Office of Toxic Substances	Grants are available for States to establish programs to prevent or eliminate unreasonable risks to health or the environment in association with chemicals for which EPA is either unable or unlikely to take action under TSCA. States may not establish or continue requirements (e.g., testing requirements or other regulatory actions) for chemicals for which EPA has prescribed rules or orders unless they are identical to the Federal requirements, prohibit the use of the chemical, or are adopted under the authority of other Federal laws. Exemptions may be approved by EPA under specified circumstances.
Uranium Mill Tailings Radiation Control Act of 1978, 49 U.S.C. 7901l	The purpose of the statute is to stabilize and control both inactive mill tailings in a safe and environmentally sound manner and to minimize or eliminate radiation hazards to the public. The act requires the establishment of regulations for mill tailings at uranium or thorium processing mills and authorizes remedial actions at inactive sites.	Department of Energy Nuclear Regulatory Commission Environmental Protection Agency—Office of Radiation Programs	Regulatory authority for active uranium mills is delegated by NRC to the States that participate in the Agreement States Program. States may enter into cooperative agreements with DOE for remedial action projects; the agreements define the responsibilities of the parties. States are required to pay 10 percent of the costs, concur with the remedial action plan, and acquire private lands, as necessary, to be used as a permanent disposal site for residual radioactive materials.
Water Research and Development Act of 1978, 42 U.S.C. 7801	The purpose of the statute is to assist the Nation and the States through water resources science and technology to address a variety of water quality and quantity concerns. The act authorizes the establishment of a water resources research and tech-	Department of the Interior	States are required to designate the college or university at which the Institute is established if there is more than one land grant college within a State. Two or more States may cooperate in the establishment of a regional Institute.

Statute	Objectives and provisions relevant to groundwater protection	Responsible Federal agencies	Relationship to the States
	nology institute at one college or university in each State, the support of a research and development effort for saline and other quality impaired water, and the establishment of a research assessment and technology transfer program.		Financial assistance for the institutes is available on a cost sharing basis, and matching grants are available for individual projects to supplement funds from non-Federal sources.

[a] Legislation passed subsequent to the Atomic Energy Act also authorizes Federal agency activities with respect to radioactive material. *The Reorganization Plan No. 3 of 1970* established the Environmental Protection Agency; responsibility for establishing environmental standards for radioactive materials was transferred to EPA from the Atomic Energy Commission. *The Energy Reorganization Act of 1974* established the Nuclear Regulatory Commission; NRC is responsible for licensing (and related regulatory functions) of nuclear reactors and facilities used to receive, store, and dispose of radioactive waste. *The Energy Reorganization Act of 1977* established the Department of Energy; DOE is responsible for the safe handling of DOE generated waste (including the decommissioning of contaminated Federal property), the selection, acquisition, and development of high-level waste repositories (pursuant to the Nuclear Waste Policy Act of 1982, Public Law 97-425), and the coordination of a national planning effort for the selection of low-level disposal sites (pursuant to the Low Level Radioactive Waste Policy Act, Public Law 96-573).

[b] This statute amends the Federal Water Pollution Control Act Amendments of 1972.

[c] Despite conflicting Federal judicial decisions about authority under Section 402 to regulate discharges into groundwater, a number of States have established such programs.

[d] The statute also creates a new Federal agency known as the Agency for Toxic Substances and Disease Registry within the U.S. Public Health Service of the Department of Health and Human Resources. In addition, CERCLA requires the promulgation of regulations for the assessment of damages from a release of oil or hazardous substances resulting in injury to, destruction of, or loss of natural resources. Executive Order 12316 delegates responsibility for the development of these regulations to the Department of the Interior. Advance notices of proposed rule-making were published by DOI in 1983 (43 FR 1084, Jan. 10, 1983 and 48 FR 34788, Aug. 1, 1983).

[e] Federal Environmental Pesticide Control Act of 1972, Public Law 92-516; Public Law 94-140, Nov. 28, 1975; Public Law 95-396, Sept. 30, 1978; and Public Law 96-539, Dec. 17, 1980.

[f] States may not authorize the sale or use of pesticides prohibited by EPA under FIFRA and may not impose or continue any requirements for pesticide labeling or packaging in addition to or different from those required by EPA. However, a State may provide registration for additional uses of federally registered pesticides formulated for distribution and use within the State to meet special local needs (if such use has not previously been prohibited by EPA).

[g] Regulations promulgated by the Department of the Interior for mining operations are authorized by both the Federal Land Policy and Management Act and the following statutes: The Mineral Leasing Act of 1920 (30 U.S.C. 181-287) and Materials Act of 1947 (30 U.S.C. 601-604) authorize mining of minerals such as coal, phosphate, asphalt, sodium, potassium, sand, stone, gravel, and clay on Federal lands; The U.S. Mining Laws (30 U.S.C. 22) authorize mining of "locatable" minerals such as gold, silver, lead, iron, and copper on Federal lands; The Geothermal Steam Act of 1980 (30 U.S.C. 1001-10025) regulates the development of geothermal steam on Federal lands.

Regulations for onshore oil and gas production have been promulgated by DOI and are administered by BLM under the authority of 17 laws, Attorney General's Opinions, and Secretary's Orders (43 CFR 3160). Authority is primarily derived from the Mineral Leasing Act, as amended and supplemented (30 U.S.C. 181 et seq.), and the Mineral Leasing Act for Acquired Lands, as amended (30 U.S.C. 351-359). The regulations contain provisions for protection of environmental quality including the protection against contamination of freshwater-bearing and other usable water containing 5,000 ppm or less of dissolved solids (43 CFR 3162.5). While not explicit, these regulations provide authority for groundwater monitoring and corrective and preventive activities. BLM is in the process of developing additional guidance to lessees for the protection of groundwater (Spector, 1984).

[h] As amended by Public Law 94-474, Oct. 11, 1976.

[i] The Council on Environmental Quality is responsible for issuing regulations regarding the preparation of environmental impact statements for use by Federal agencies.

[j] Legislation listed in footnote a is also applicable to this statute in that it regulates radioactive substances.

Source: U.S. Congress, 1984

APPENDIX B

WATER-QUALITY STANDARDS AND GUIDELINES

Table . C.3 Substances With State Standards Or Federal Standards Or Guidelines For Water Quality That May be Applied to Groundwater.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals									
1. Acenapthene									0.02[c]
2. Acrylonitrile	NH	0.035/10 day-0.003/1 mo.	NH	0.035/10 day - 0.003/1 mo.	1				0.000058[d]
3. Alachlor			NY	0.035	1				
4. Aldicarb (Sulfoxide and Sulfone)	CA,NY	0.001-0.007	NY,WI	0.00035-0.01	2				
5. Aldrin	CA,IL	Limit of quantification-0.001	IL,NY, MD,VA, NJ	None-0.001	5				0.000000074[d]
6. Amiben			NY	0.0875	1				
7. Atrazine			NY	0.0075	1				
8. Baygon	CA	0.009			1				
9. Benefin			NY	0.035	1				
10. Benzene	CA,FL, NH,NY	0.0007-.001 S	NM,NH NY,WI	Non detectable-0.1;S	4	RMCL[e]		0.07	0.00066[d]
11. -Benzene hexachloride (-BHC)	CA	0.0007			1				
12. -Benzene hexachloride (-BHC)	CA	0.0003			1				
13. Benzidine			MD,NJ	None-0.0001	1				0.00000012[d]

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
14. Benzo (a) pyrene			NY	None detectable	1			0.025	
15. Bis (2-chloroethyl) ether			NY	0.001	1				0.00003[d]
16. Bromacil (a uracil)			NY	0.0044	1				
17. Bromodichloromethane									0.00019[d,f]
18. Butachlor			NY	0.0035	1				
19. Captan	CA	0.35	NY	0.0175	2				
20. Carbaryl			NY	0.0287	1				
21. Carbofuran	NY	0.015	WI	0.05	1			0.005	
22. Carbon tetrachloride	CA,FL, NH	0.003-0.005;S	MN,NH, NM,NY	0.005-0.01;S	5	RMCL[e]		-	0.0004[d]
23. Chlordane	CA,IL, NH	0.000055;S	IL,MD,NH, NY,VA	None-0.01;S	6			0.008	0.00000046[d]
24. Chlorobenzene									0.488[g]
25. Chloroform			MN,NY	0.1-0.2	2				0.00019[d]
26. Demiton			MD	0.0001	1				
27. Di (2-ethyl hexyl) phthalate (DEHP)			NY	0.0042	1				15.0[h]

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
28. Di-n-butyl phthalate			NY	0.770	1			0.025	34.0[h]
29. Diazinon	CA	0.014	NY	0.0007	2				
30. Dibromochloropropane (DBCP)	CA,NH	0.001; 0.00005/ lifetime	NH,WI	0.00005/ lifetime	2				
31. Dibromoethane (DB)	CA,FL	Limit of quantification 0.00002	WI	0.00001	1				
32. Dicamba			NY	0.00044	1				
33. Dichlorobenzene (m-)	CA	0.02-0.13			1				0.04[h]
34. Dichlorobenzene (o-)	CA	0.01-0.13	WI	0.75	1				0.40[h]
35. Dichlorobenzene (p-)	CA	0.0003-0.13	NY	0.0047	2	RMCL[e]			0.40[h]
36. Dichlorodiphenyl-trichloroethane (DDT)	IL	0.05	IL,MD, NY,VA, NJ	None-0.05	4				0.000000024[d]
37. 1,2-Dichloroethane	CA,FL	0.001-0.003	MN,NM, WI	0.0005-0.2	3	RMCL[e]			0.00094[d]
38. 1,1-Dichloroethylene (Vinylidiene chloride)	NH	1.0/1day-0.07/lifetime	MN,NH, NM,WI	0.00024 0.005;1.0/day 0.07/lifetime	3	RMCL[e]		0.07	0.000033[d]
39. 1,2-Dichloroethylene (cis and trans)	CA,NH	Limit of quantifica-tion;S	NH	S	2				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
40. Dichloromethane (Methylene chloride)	CA,NH	0.004;S	NH	S	1			0.15	0.00019d,f
41. 2,4-Dichlorophenol									3.09[g]
42. 2,4-Dichlorophenoxyacetic acid (2,4-D)	IL	0.01	NY,FL, NB,WI, MT,IL,MA NC	0.0044-0.1	2				
43. 1,2-Dichloropropane	CA	0.01			1				
44. Dicyclopentadiene (DCPD)									0.112[i]
45. Dieldrin	CA,IL	Limit of quantification 0.001	IL,MO NY,VA	None-0.001	5				0.000000071[d]
46. Diethyl phthalate									350.0[g]
47. Diiosopropylmethyl phosphate (DIMP)									0.45[i]
48. Dimethoate	CA	0.14			1				
49. 2,4-Dimethylphenol	CA	0.4			1				0.40[c]
49a. Dinoseb			WI	0.013					
50. 1,4-Dioxane	NH	0.02/10 day	NH	0.02/10 day	1				
51. Dioxins[j]			MD	None	1				
52. Diphenamide	CA	0.04			1				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
53. Diphenyl hydrazine			NY	None detectable	1				0.000042[d]
54. Dithane			NY	0.00175	1				
55. Endosulfan			MD	0.000003	1				0.074[h]
56. Endrin			MD,NY, VA,NJ, FL,NB, WI,MT,IL MA,NC	None-0.0002		3			0.001[h]
57. Ethion	CA	0.035			1				
58. Ethyl Benzene									1.4[h]
59. Ethylene glycol	NH	19.0/1 day	NH	19.0/1 day	1			5.5	
60. Ethylene thiourea (ETU)			NY	None detectable	1				
61. Ferbam			NY	0.00418	1				
62. Fluoranthene									0.042[h]
63. Folpet			NY	0.056	1				
64. Formaldehyde									
65. Gasoline[j]	NH	None	NH	None	1				
66. Guthion			MD,NY	0.00001-0.00044	2				
67. Heptachlor	CA,IL	0.00002-0.001	IL,MD, NY,VA	None-0.001	5				0.00000028[d]

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
68. Heptachlor epoxide	CA,IL	0.0001-0.002	VA,IL	0.001	3				
69. Hexachlorobenzene (HCB)			NY	0.00035	1				0.00000072[d]
70. Hexachlorophene			NY	0.007					
71. Hexane (n-)									
72. Isopropyl N (3-chloro-phenyl) carbamates (CIPC)	CA	0.35							
73. Kepone			NY	None detectable	1				
74. Lindane (-BHC)			IL,MD, FL,NB, WI,MT MA,NC	None-0.004	4	0.004			
75. MBAs (Foaming Agents)[j]			MN,NY, VA	0.05-0.5	3		0.5		
76. Malathion	CA	0.16	MD,NY	0.001-0.007	3				
77. Maneb			NY	0.00175	1				
78. Methoxychlor			NY,VA FL,NB, WI,MT,IL MA,NC	0.00003-0.35	2	0.1			
79. 2-Methyl-4 chloro-phenoxyacetic acid (MCPA)			NY	0.00044	1				
79a. Methylene chloride									

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Orgsnic Chemicals (Continued)									
80. Methyl ethyl ketone	NH	1.0/10 day	NH	1.0/10 day	1				
81. Methyl methocrylate			NY	0.007	1				
82. Methyl parathion	CA	0.03	IL,NY	0.0015-0.1	3				
83. Mirex			MD	None	1				
84. Naphthalene									NA[k]
85. Nitralin			NY	0.035	1				
86. Oil and Grease[j]			IL,MT, NC,VA, WY	Virtually free 10.0	5				
87. Other hydrocarbons[j]	NH	Prohibited	NH	Prohibited	1				
88. Paraquat			NY	0.00298	1				
89. Parathion	CA	0.03	MD,IL	0.00004	2				
90. Pentachloronitrobenzene (PCNB)	CA	0.0009	NY	None detectable	2				
91. Pentachlorophenol (PCP)	CA	0.03	NY	0.021	2				1.01[g]
92. Petroleum hydrocarbons[j]			VA	1.0	1				
93. Phenols[j]	CA,PA	0.001	IL,MN, NY,NC, MN,VA, WY,NJ, FL,MO,NC	0.0001-3.5	9				3.5[g]
94. Phorate (also Disulfoton)			NY	None detectable	1				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
95. Polychlorinated biphenyls (PCBs)[j]	NH,NY	0.0001;0.001/ 1 month - 0.0003/lifetime	MD,MN, NH,NM, NY,NC, NJ	None - 0.001	6				0.00000079[d]
96. Polynuclear aromatic hydrocarbons (PAHs)[j]	NH	0.025/7 day	NH	0.025/7 day	1				0.0000028[d]
97. Propachlor			NY	0.035	1				
98. Propanil			NY	0.07	1				
99. Propazine			NY	0.016	1				
100. Pthalate esters[j]			NC	None detectable	1				individual[1]
101. RDX (Cyclonite)									0.03368[i]
102. Simazine			NY,WI	0.07525-2.15	1				
103. Styrene (vinyl benzene)			NY	0.931	1				
104. 1,2,4,5-Tetrachloro-benzene									0.038[h]
105. 2,3,7,8-Tetrachloro-benzo p-dioxin (TCDD)			NY	0.000000035	1				
106. Tetrachloroethane (1,1,1,2- and 1,1,2,2)	CA	0.04	MN,NM	0.02	3				0.00017[d](1,1,2,2)
107. Tetrachloroethylene (or perchloroethylene, PCE)	FL,NH	0.003; S	NH,NM, WI	0.001-0.020	2	RMCL[e]		0.020	0.0008[d]
108. Thiram			NY	0.00175	1				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
109. Toluene	CA,NH	0.1;1.0/10 day	NH,NM MN,WI	0.3-15.01;1.0/10 day	4			0.34	14.3[h]
110. Toxaphene			MD,NY, NJ,FL, NB,WI, MT,IL,MA NC	None - 0.005	2				0.00000071[d]
111. 1,1,1 Trichloroethane	CA,FL, NH	0.2-0.3 (1,1,1); S	NH,WI	0.2-1	2	RMCL[e] (1,1,1)		1.0 (1,1,1)	18.4[h](1,1,1) 0.0006[d](1,1,2)
111a. 1,1,2 Trichloroethane			WI	0.0006					
112. 1,1,2-Trichloroethylene (TCE)	CA,NH	0.005-0.075	MN,NH NM,NY, WI	0.0018	5	RMCL[e]		0.735	0.0027[d]
113. 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)			NY	0.035	1				
114. 2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP, or Silvex)			NY,FL, NB,WY, MT,IL,MA NC	0.00026-0.01	1	0.01			
115. Trifluralin			NY	0.0035	1				
116. Trihalomethanes[j] (TTHMs)						0.10			
117. Trinitrotoluene (TNT)									0.04424[i]
118. Trithion	CA	0.007			1				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
A. Organic Chemicals (Continued)									
119. Vinyl chloride	CA,FL, NY	0.001-0.005	NY,WI	0.000015-0.005	2	RMCL[e]			0.002[d]
120. Xylenes[j]	CA,NH	0.62; S	NH,WI	S	1			0.62	
121. Zineb			NY	0.00175	1				
122. Ziram			NY	0.00418	1				
B. Inorganic Chemicals									
123. Aluminum			MN,NM, WY	0.1-5.0	3				
124. Ammonia			WY	0.02-0.5	1				
125. Ammonia nitrogen			VA	0.025	1				
125a. Antimony			FL	0.146					
126. Arsenic	PA	0.01	MN,NM, NY,WY, NJ,FL, NB,WI, MT,IL,MA MO,NC	None-1.0	4	0.05			0.0000022[d]
127. Barium			NM,NY, WI,MT, WY,NJ, FL,NB,IL MA,MO	0.00067-5.0	2	1.0			
128. Beryllium			WY,MO	0.011-1.1	1				0.0000037[d]
129. Boron			AK,IL, MN,NM, WY,MO	0.3-5.0	5				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
B. Inorganic Chemicals (Continued)									
130. Cadmium			IL,NM, NY,VA, WY,NJ, FL,NB, WI,MT,MA, MO,NC	0.0001-1.0	5	0.010			0.010[h]
131. Chlorides[j]			MN,NM, NY,VA,WY, FL,IL,NC	0.05-2000	5		250		
132. Chlorine			AK,MO	Not specified - 0.01	2				
133. Chromium			NM,NY,WI, WY,NJ,NB, MT,IL,MA MO,NC	0.05=0.1	2	0.05			0.050[h] (hexavalent) 170.0[h] (trivalent)
134. Cobalt			MO,MN, NM,WY,MO	0.05-1.0	4				
135. Copper	IL	5.0	IL,MO,NY, NM,WY,NJ, FL,NB,MA,MO	0.01-1.0	5				1.0[c]
136. Cyanides[j]	IL,PA	0.01-0.2	MO,NM, NY,VA, IL,MN, WY,NJ,MO	0.005-0.2	8				0.200[h]
137. Fluorides[j]	IL,KY, MO,NH, PA,TN, WI,MO	1.0-2.2	IL,NM, NY,VA, NJ,WI, NB,MT,MA	1.4-2.4	10	1.4-2.4			
138. Heavy metals[j]			AK	Not specified	1				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
B. Inorganic Chemicals (Continued)									
139. Iron	IL	1.0	NM,NY,IL VA,WY,MA, NJ,NB,	0.3-5.0	4		0.3		
140. Lead			NM,NY,MT, WY,NJ,FL, WI,IL,MA, MO,NC	0.004-5.0	2	0.05			0.050[h]
141. Lithium			VA,WY	2.5	2				
142. Manganese	IL	0.15	MN,NY,VA, WY,NJ,FL, NB,IL,MA,MO	0.05-1.0	4		0.05		
143. Mercury			IL,NM,MT, NY,VA,WY, NJ,FL,NB, WI,MA,MO, NC	0.00005-0.002	4	0.002			0.000144[h]
144. Molybdenum			MN,NM	1.0	2				
145. Nickel			IL,MN,MO, NM,VA,NC, WY,FL	0.013-1.0	5				0.0134[h]
146. Nitrates[j]			NU,NM,NY, NJ,FL,NB, WI,MT	Not specified - 10.0	3	10.0 (as N)			
147. Nitrates[j]			NC,VA,WY	0.025-10.0	3				
148. (NO_3+NO_2)-N[j]			VA,WY,MA MO	0.5-100	2				
149. Phosphates[j]			NJ	Not specified					

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
B. Inorganic Chemicals (Continued)									
150. Selenium			NM,NY,WI WY,NJ,FL, NB,MT,IL MA,MO,NC	0.01-0.05	2	0.01			0.010[h]
151. Silver			IL,NM,WI, NY,WY,NJ, FL,NB,MA, MO	0.0001-0.05	3	0.05			0.050[h]
152. Sodium	AK,FL, ME	20-250	VA,NJ	25-100	4				
153. Sulfates[j]			MN,NM,NY, VA,WY,NJ, FL,IL,MA	10-600	5	250			
154. Vanadium			VA,WY	0.1	2				
155. Zinc			MD,NM,NY, VA,WY,NJ, FL,NB,IL, MA,MO	0.05-25	5	5.0			5.0[c]
C. Biological Substances									
156. Coliform bacteria	WI	None	MD,NJ,FL, MT,AK,MA, NC	4/100	2	1/100ml			
D. Radionucleides									
157. Beta particle and photon radioactivity[j]						4 mrem			
158. Gross alpha particle activityj			WY,FL,NB, MT,NC	15		15 PCi/l			

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
D. Radionuclides (Continued)									
159. Gross beta[j]	PA	1000 pCi/l	IN,IL, MT,VA,NC	50-1000 pCi/l	5				
160. Radium 226	PA,WI	None-3.0	IN,IL,VA	1.0-3.0	5				
161. Radium 226 and 228, combined[j]			NM,WY,FL, NB,MT,NC	5-30 pCi/l	1	5.0 pCi/l			
162. Radon 222	PA	10							
163. Strontium 90			IN,IL,VA, WY,MT	2.0-10.0	4				
164. Tritium	AK,MT	20,000 pCi/l	MT	20,000 pCi/l					
165. Uranium			NM,WY,VA	0.03-5.0	3			10.0 pCi/l	
E. Other Measures									
166. Alkalinity[j]			VA	10-500	1				
167. ABS (alkyl benzene sulfonate)[j]			PA	0.5	1				
168. CCE (Carbon chloroform extract)[j]			PA	0.2	1				
169. COD (Chemical oxygen demand)[j]			MD	10.0	1				
169a. Color (units)			AK	75					
170. DO (Dissolved oxygen)[j]			MN,MD,AK	1.0-6.0	2				
170a. Foaming Agents			NY,NJ,NB, AK,MA	0.5					
171. HCO_3 (Bicarbonate)			MN	5.0 meq/l	1				

Table . Continued.

Chemical	STATE STANDARDS[a] Drinking Water States	Drinking Water Range[b] (mg/l)	Groundwater Quality States	Groundwater Quality Range[b] (mg/l)	Total No. of States	FEDERAL STANDARDS AND GUIDELINES (mg/l) National Drinking Water Regulations Primary	Secondary	Long Term* (1-2 Yrs)	Ambient Water Quality Criteria for Human Health
E. Other Measures (Continued)									
171a. Odor and Taste			NJ,FL,NB	None-10.0					
171b. Oil and Grease			WY,NB,AK NC	None-3					
171c. pH Range			NY,WY,NJ, FL,NB,AK, MA,MO	5-9.0					
172. Residual carbonate			AK	1.25	1				
173. RSC (Residual sodium carbonate)			WY	1.25 meq/l	1				
174. SAR (Sodium absorption ratio)[j]			WY	8.0	1				
175. Specific conductance[j]			MN,MT,	<1000->15,000	2				
175a. Temperature (°C)			AK	15					
176. TDS (Total dissolved solids)[j]			MN,NJ,IL, NM,VA,NC, WY,AK,	250-5000	3		500.0		
177. Total hardness[j]			MN,MD, VA	near 300	3				
178. Turbidity[j]	TN,VA	0.5-2.0/2 day			2	1-5 TU			

Table . Continued.

a. State standards are listed only if they are more stringent or cover additional substances than standards established by the Federal Safe Drinking Water Act.

Sources of information on State standards are (API, 1983) and the OTA State survey. All Federal standards were established by EPA unless otherwise indicated.

b. All standards are in milligrams per liter (mg/l, equivalent to parts per million) unless otherwise indicated. Other units used include mrem (millirem), pCi/l (picocuries per liter), meq/l (milliequivalents per liter), and TU (turbidity units).

The entries in the range column are of three types.

1) Some entries provide information on the lowest and highest concentrations that the States use as standards. If States use the same standard for a substance, a single value is given. Note that the entries do not distinguish among the different ways that a standard might be applied (e.g., different standards may be applied to different classifications of groundwater).

2) Some entries, such as Federal health advisories (SNARLs), are time-dependent and are expressed in terms of concentation per unit time. "S" represents a State standard that is the same as the SNARL.

3) "Not specified" indicates that a State has a standard but the value was not contained in the information sources.

c. Ambient water quality criteria for human health are theoretically derived based on organoleptic effects (i.e., unpleasant taste and odor; see also footnote g), carcinogenicity (see footnote d), or toxicity (i.e., adverse effects other than cancers, see footnotes g and h). In this case, the value indicated is based on controlling unpleasant taste or odor either of water consumed directly or of water consumed indirectly via aquatic organisms found in ambient waters. Note that there is no demonstrated relationship between unpleasant taste or odor and adverse health effects.

d. The value indicated is based on an increased risk of one additional cancer in one million people exposed (10^{-6} risk level) through ingestion of contaminated water and contaminated aquatic organisms. The water quality criteria document values for 10^{-5} and 10^{-7} risk levels are generally ten times higher and lower than the 10^{-6} risk level, respectively.

According to the EPA Notice of Water Quality Criteria Documents (45 FR 79318, Nov. 28, 1980), for the maximum protection of human health from potential carcinogenic effects due to exposure to this chemical through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentation should be zero (assuming that the chemical's behavior is consistent with the non-threshold concept for carcinogens, see app. H.1). The notice further states that:

- zero concentration may not be attainable at the present time;
- concentrations are thus estimated that may result in an incremental increase of cancer over a lifetime at the 10^{-5}, 10^{-6}, and 10^{-7} risk levels; and
- the estimated risk range ia presented for information purposes and does not represent an EPA judgement on an "acceptable" risk level.

Table . Continued.

e. Recommended Maximum Contaminant Levels (RMCLs) were proposed on June 12, 1984 (49 FR 24330). Proposed values would result in no known or anticipated adverse health effects with an adequate margin of safety and serve as non-enforceable health goals for public water systems.

f. The value indicated is for the category halomethanes, not for the individual chemical.

g. Different criteria are available for both toxicity and organoleptic effects from ingestion of contaminated water and contaminated aquatic organisms. The value indicated is derived from available toxicity data for the protection of public health. Criteria based on taste and odor data are more stringent than the toxicity level; however, there is no demonstrated relationship between unpleasant tastes and odors and adverse health effects.

h. The criterion indicated is for the protection of human health from the toxic properties (i.e., all adverse effects other than cancers) of the substances through ingestion of contaminated water and contaminated aquatic organisms.

i. Criteria levels shown were established by the Army Medical Bioengineering Research and Development Laboratory.

j. Standards is for a group of chemicals or an indicator of water quality, not a single chemical.

k. "Not available" indicates that a criterion for human health has not been published due to the insufficiency of available data. However, criteria are available for aquatic life.

l. A level is not established for the protection of human health from total phthalate esters. Levels to protect human health from toxic properties of the following individual phthalate esters have been set for ingestion of water and contaminated aquatic organisms:

dimethylphthalate --	313.0 mg/l
diethylphthalate --	350.0 mg/l
dibutyl-phthalate --	34.0 mg/l
di-2-ethylhexyl-phthalate --	15.0 mg/l

*EPA Health Advisories

Source: Office of Technology Assessment with additions by Geraghty & Miller, Inc.

APPENDIX C

TENNESSEE DRAFT GROUND-WATER MANAGEMENT STRATEGY

TENNESSEE DRAFT GROUND WATER MANAGEMENT STRATEGY

OCTOBER 1, 1985

DIVISION OF GROUND WATER PROTECTION
TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT
150 NINTH AVENUE NORTH
TERRA BUILDING
NASHVILLE, TN 37219-5404

TENNESSEE DRAFT GROUND WATER MANAGEMENT STRATEGY

In 1977, the Tennessee General Assembly enacted the Water Quality Control Act which was amended in 1984 and 1985. Its declaration of policy and purpose is stated below and expresses the policy of the Ground Water Management Strategy.

> "Recognizing that the waters of Tennessee are the property of the state and are held in public trust for the use of the people of the state, it is declared to be the public policy of Tennessee that the people of Tennessee as beneficiaries of this trust, have a right to unpolluted waters. In the exercise of its public trust over the waters of the state, the government of Tennessee has an obligation to take all prudent steps to secure, protect, and preserve this right.
>
> It is further declared that the purpose of this law is to abate existing pollution of the waters of Tennessee, to reclaim polluted waters, to prevent the future pollution of the waters, and to plan for the future use of the waters so that the water resources of Tennessee might be used and enjoyed to the fullest extent consistent with the maintenance of unpolluted waters."

Prior to the mid 1970's, environmental concern focused mainly on natural resources and pollutants that were obvious. Surface water, air quality, or obvious sources of contamination such as uncontrolled hazardous waste dumps, were of primary concern. Only in rare instances was ground water quality considered, as few knew or really understood how seriously the resource was threatened.

At present, ground water contamination has become a major environmental issue and will probably continue to be one for years to come. The attention of agencies at all levels of government, as well as that of industry and environmentalists, is now focused on this vital resource. As contamination has appeared in well water, forcing many wells to be abandoned, the public has expressed growing concern about the health implications of inappropriate use and disposal of chemicals and refuse. As concern has increased, so have demands for expanded management of ground water.

The State of Tennessee has conducted numerous ground water studies and projects over the years, particularly since 1947. Although much more information remains to be gathered, sufficient data exists to form the basis of a ground water management strategy and program.

Existing Programs

Ground water programs presently administered by the Division of Ground Water Protection are briefly discussed below.

Water Well Construction - The Water Well Drillers Act of 1963 (TCA 69-11-101) requires drillers to submit information on all water wells to the Department of Health and Environment. This data base is vital for the implementation of any ground water management plan. It is also invaluable to consultants, industries, municipalities, governmental agencies and for providing technical assistance to the general public.

The Water Well Drillers Act of 1963 also gives the authority to license water well drillers to the Commissioner of the Department of Health and Environment. It created the Board of Ground Water Management to serve the Commissioner in an advisory capacity. The Board examines applicants for water well drillers' licenses, determines their competence, and makes corresponding recommendations to the Commissioner.

The Drillers Act gives the authority to promulgate rules and regulations governing the construction of water wells to the Department of Health and Environment.

Subsurface Sewage Disposal - The subsurface sewage disposal program involves the regulation of sewage disposal by means of septic tanks and absorption fields (drain lines) or approved alternative systems. Five metropolitan counties in Tennessee have separate subsurface sewage disposal programs. The other ninety counties fall under the scope of the state program and are under authority of the Department of Health and Environment, Division of Ground Water Protection. Environmentalists have responsibility for the program in these ninety counties.

Major activities include:

a. Approval of subdivisions for subsurface sewage disposal,

b. Permitting of individual lots for subsurface sewage disposal,

c. Determining suitability of soil and design of disposal systems,

d. Construction inspection of disposal systems,

e. Permitting subsurface sewage disposal system installers,

f. Permitting of septic tank pumpers,

g. Establishing standards for subsurface sewage disposal,

h. Enforcing program statutes and regulations,

i. Providing technical assistance and consultation on subsurface sewage disposal systems.

Underground Injection Control - The Tennessee Water Quality Control Board adopted rules to regulate underground injection of fluids. They became

effective September 8, 1985. An underground injection control section will be established in the Division of Ground Water Protection to implement the regulations. These regulations affect the disposal of all types of liquid waste by means of wells. They classify ground waters for certain uses and control pollution of ground water.

Underground Storage Tanks - The Hazardous and Solid Waste Amendments of 1984 provided for the regulation of underground storage tanks by the U.S. Environmental Protection Agency. EPA was directed to develop regulations by November 1986. The Division of Ground Water Protection has been designated by the Governor to manage this work at the State level. The Division will document the inventory reports of tank owners as required by federal law. The Division has applied for an E.P.A. grant to fund this part of the program.

Current Situation

Water use information and other studies have determined the following facts:

1. Slightly more than one-half (51%) of the population of Tennessee depends on ground water for drinking water.

2. Twenty-one percent (21%) of the water withdrawal in the State (exclusive of thermoelectric use) is ground water, providing more than 250 million gallons per day for public and rural domestic supplies.

3. Ground water provides 190 million gallons per day to self-supplied industries, and more than 13 million gallons per day for irrigation and livestock watering.

4. In West Tennessee, nearly all public supplies, industries, and rural residents use ground water. Memphis, the largest city in Tennessee, is totally supplied by ground water.

5. Several agencies at all levels of government administer programs which directly influence the management of ground water resources. There is little coordination between these programs.

6. The natural quality of ground water in Tennessee is generally good and potable water can be obtained from the subsurface in most areas.

7. Natural factors and human activities can and in some places have rendered ground water unfit for drinking.

In view of the above, it is the strategy of the State of Tennessee that the Tennessee Ground Water Protection Program will be based on the following principles.

Principle 1

Ground water is of critical importance to the State of Tennessee and it must be protected through action at all levels of government.

Principle 2

Maximum protection will be provided for all existing and potential underground sources of drinking water.

Principle 3

The strategy for developing a program will be based on existing ground water information. Appropriate modification will be made when new information becomes available.

Principle 4

Initially, the ground waters of the State will be divided into two classes in accordance with the classification contained in the Rules of the Water Quality Control Board, Chapter 1200-4-6 Section .05; that is, water for beneficial uses and water for receiving underground injection of fluids. From time to time, studies will be made to determine the feasibility and desirability of amending this classification and for providing for different levels of protection.

Principle 5

Protection of ground water must be accomplished initially through existing state and local regulatory programs. State regulatory programs include those federal programs delegated to the State to administer.

Principle 6

The State must encourage local and regional agencies to address ground water protection. The State will provide technical assistance and information to local officials and regional planning agencies to protect public water supplies using ground water sources.

Principle 7

Appropriate mechanisms need to be established to coordinate ground water protection throughout existing programs which influence or impact the quantity and/or quality of ground water.

Principle 8

Public input must be sought regarding the development and implementation of ground water protection programs.

Future Direction for Ground Water Management

An all encompassing Ground Water Protection Program will address a paramount State concern, the protection of Tennessee's ground water resources. Protection, rather than correction, appears the most economical way to assure that an adequate supply of high quality ground water will be available now and in the future.

The protection program charts a course for ground water protection and management for the future. It identifies goals and outlines work elements which are based on the eight ground water protection principles. This program outlines an incremental approach to ground water protection. It also maintains the flexibility to respond to one of the fastest changing areas of natural resource management, and seeks public cooperation in shaping a program to assure that Tennessee maintains an abundant and safe supply of ground water in the future.

Goals

Goals of the Tennessee Ground Water Protection Program are as follows:

I. To develop and implement a program that will prevent ground water from becoming contaminated and which will correct or properly manage known or suspected cases of contamination.

II. To provide maximum protection of existing and potential underground sources of drinking water.

III. To develop the Tennessee Ground Water Protection Program with adequate flexibility to respond to the rapidly expanding ground water science and technology.

IV. To impress local and regional agencies with the importance of addressing ground water protection.

V. To provide technical assistance to protect public water supplies using ground water sources.

Work Elements

Work on some of the elements presented here began a number of years ago. However, much more needs to be done. The Tennessee Ground Water Protection Program will include the following work elements:

1. Continue the computerized well records part of the water well construction program.

2. Continue enforcement of the Water Well Drillers Act, licensing of drillers, well inspection and enforcement of well construction standards.

3. Continue to provide technical assistance to individuals, industry and municipalities.

4. Continue investigation and documentation of individual problems with leaking underground storage tanks. Gather data to be used in preparing suitable regulations.

5. Continue the Subsurface Sewage Disposal Program and examine the need for improvements to provide greater ground water protection.

6. Implement the administration of the Underground Injection Control Regulations.

7. Continue ground water level monitoring cooperative program with the U.S. Geological Survey, and plan and implement a statewide ground water quality monitoring network.

8. Evaluate the need for modernization of the Water Well Drillers Act and the rules and regulations. Since the Water Well Drillers Act became law in 1963, and rules and regulations for well construction were prepared shortly afterward, they both might need to be revised to reflect changing times. Certain practices have been initiated since 1963 that were essentially unknown at that time.

9. Delineate aquifer recharge areas for public water supply systems using ground water sources. This program will provide planning agencies and local officials with information on the areas where their ground water supplies are most vulnerable to contamination.

10. Begin study of the situation regarding abandoned wells, exploratory holes and develop methods of correcting any problem. Man has been digging wells for a variety of purposes since the pioneers entered Tennessee. Until recent years, no regulations existed to require that they be properly filled or plugged when abandoned. As abandoned open holes provide direct avenues for contamination of the ground water system, some means should be developed to locate and properly plug such holes.

11. Identify and document current areas and causes of contamination.

    Many activities of our society can and do result in degradation of ground water. They include over-pumping of aquifers, pollution of surface waters, improper well construction, extraction of fuels and minerals from the subsurface, drainage of poorly developed Karst regions, injection of wastes to the subsurface, disposal of wastes in dumps, inadequate waste landfilling techniques, inadequate subsurface sewage disposal, spills of hazardous materials and wastes, storage of hazardous materials in leaking underground facilities, and poorly managed agricultural and forestry practices. A comprehensive look at such situations in Tennessee would be beneficial to planning and management for the protection of our ground water resources.

12. Provide for coordination of the various programs impacting ground water. A number of agencies impact ground water quantity, quality and protection. Department of Health and Environment divisions, other than Ground Water Protection, include Solid Waste Management, Water Pollution Control, Water Supply, Surface Mining, Radiological Health and Construction Grants and Loans. In the Department of Conservation is the Oil and Gas Board, staffed by the Division of Geology. Also some activities of the Departments of Agriculture and Transportation potentially impact ground water quality and quantity. A mechanism should be devised to coordinate ground water related activities in these agencies.

13. Examine the situation regarding wastewater impoundments and determine the need for improved ground water protection. The high potential for waste pits, ponds and lagoons to contaminate the ground water system is obvious. Studies should be made to determine how ground water protection measures may be improved.

14. Examine the current legal situation as it pertains to ground water in Tennessee with respect to ownership and water use rights. Also, examine possible future problems resulting from competing uses. Historically, states east of the Mississippi River, including Tennessee, have relied upon the English common law as modified by the American doctrine of reasonable use as their water law. In Tennessee, there is no statutory law other than that pertaining to regulatory agencies such as the Department of Health and Environment. Also, there is no case law other than litigation resulting from drainage problems created by railroad construction. The need for statutory law in dealing with anticipated problems such as those created by competing uses and drought conditions should be considered.

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