Jeff Reynolds, Raleigh, NC

Ground Water Quality

Ground water is a vital national resource that is used for myriad purposes. It is used for public and domestic water supply systems, for irrigation and livestock watering, and for industrial, commercial, mining, and thermoelectric power production purposes. In many parts of the Nation, ground water serves as the only reliable source of drinking and irrigation water. Unfortunately, this vital resource is vulnerable to contamination, and ground water contaminant problems are being reported throughout the country.

To ascertain the extent to which our Nation's ground water resources have been impacted by human activities, Section 106(e) of the Clean Water Act requests that each State monitor ground water quality and report the findings to Congress in their 305(b) State Water Quality Reports. Evaluation of our Nation's ground water quality is complex and early efforts to provide a National assessment of ground water quality relied on generalized overviews presented by the State resource managers. These overviews were most frequently based on known or suspected contamination sites and on finished water quality data from public supply systems. Unfortunately, these early assessments did not always provide a complete or accurate representation of ambient ground water quality conditions. Nor did they provide an indication of the extent and severity of ground water contamination problems.

EPA recognized that an accurate representation of our Nation's ambient ground water quality conditions required developing a set of guidelines that would ultimately yield quantitative data for specific hydrogeologic units within a State. EPA, in partnership with interested States, developed guidelines for assessing ground water quality that took into account the complex spatial variations in aquifer systems, the differing levels of sophistication among State programs, and the expense of collecting ambient ground water data. It was these guidelines that were used by States for reporting the 1996 305(b) ground water data.

The most significant change for 1996 was the request that States provide ground water information for selected aquifers or hydrogeologic settings (e.g., watersheds) within the State. The focus on specific aquifers or hydrogeologic settings provides for a more quantitative assessment of ground water quality than was possible in previous reporting cycles.

State response to the revised ground water guidelines was excellent. Forty States, one Territory, and two Tribes used the new guidelines to assess and report ground water quality data in 1996. Each of these reporting entities (hereafter referred to as States) used the data that was available to them and, as a consequence, there was wide variation in reporting style. This variation was anticipated by EPA and States involved in developing the guidelines as it is a direct reflection

Figure 6-1

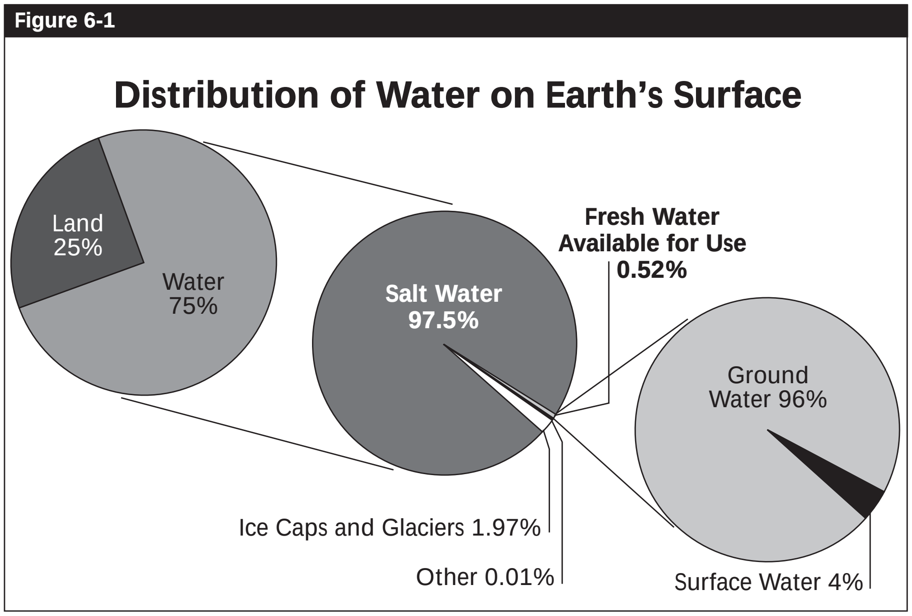
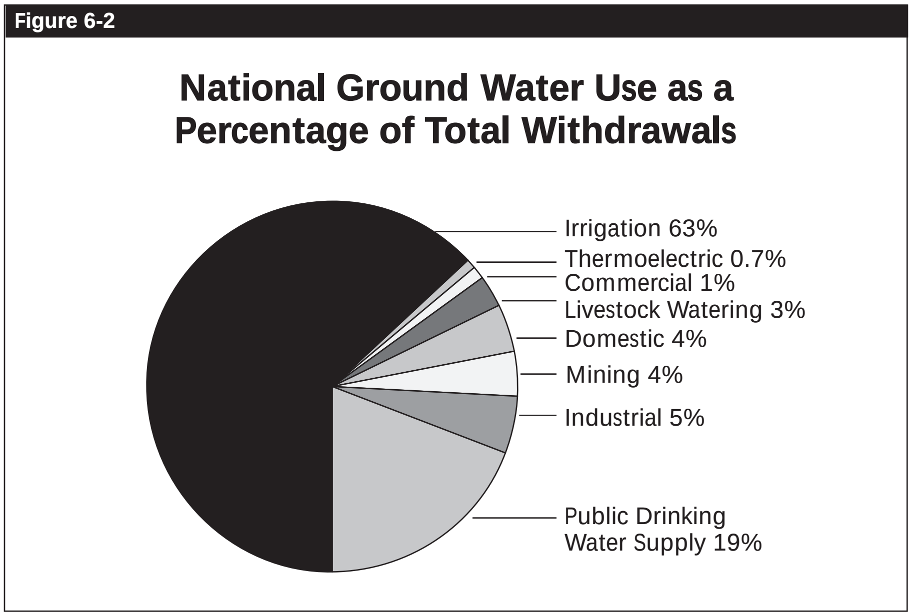

Distribution of Water on Earth's Surface

Figure 6-2


National Ground Water Use as a Percentage of Total Withdrawals

Source: Open-File Report 92-63, U.S. Geological Survey.

of the administrative, technical, and programmatic diversity among our States. This variation is expected to decrease in future 305(b) reporting cycles as many States have indicated they are developing plans to improve their data management to provide better coverage. Still other States indicated that the 1996 Guidelines provided incentive to modify their ground water programs to enhance their ability to provide more accurate and representative information.

Despite variations in reporting style, the 1996 305(b) State Water Quality Reports represent a first step in improving the assessment of State ambient ground water quality. For the first time, States provided quantitative data describing ground water quality. Furthermore, States provided quantitative information pertaining to contamination sources that have impacted ground water quality. This chapter presents the results of data submitted by States in their 1996 305(b) Water Quality Reports.

Ground Water Use in the United States

Although 75% of the earth's surface is covered by water, less than 1% is fresh water available for our use. It has been estimated that approximately 96% of the world's available fresh water reserve is stored in the earth as ground water. Figure 6-1 helps put these numbers into perspective.

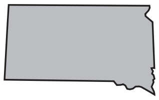
In the United States, ground water is used for agricultural, domestic, industrial, and commercial purposes. Ground water provides water for drinking and bathing, irrigation of crop lands, livestock watering, mining, industrial and commercial uses, and thermoelectric cooling applications. Figure 6-2 illustrates how ground water is used among these various categories. As shown, irrigation (63%) and public water supply (19%) are the largest uses of ground water withdrawls.

In 1990, the United States Geological Survey reported that ground water supplied 51% of the Nation's overall population with drinking water. In rural areas of the Nation, ground water supplied 95% of the population with drinking water. So our Nation's dependence on this valuable resource is obvious. In their 305(b) Water Quality Reports, States emphasized the importance of ground water as a drinking water resource.

Idaho is one of the top five States in the country for the volume of ground water used. Idahoans use an average of 9 billion gallons per day of ground water. Sixty percent of this water is used by agriculture for crop irrigation and stock animals. Thirty-six percent is used by industry, and 3% to 4% is used for drinking water. Even though the volume of ground water used for drinking water is relatively small in comparison to total ground water use, more than 90% of the population in Idaho rely on ground water for their drinking water supply. Currently, approximately 70% of the State's population is served by public systems regulated under the Safe Drinking Water Act (see description in Chapter 18); the remaining 30% obtain their drinking water through private systems typically represented by private wells.

Approximately 95% of the 11.5 million people in Illinois rely on public water supplies as a source of drinking water. About 4.1 million people use ground water as a source of public water supply. Furthermore, an estimated 400,000 residences in Illinois are served by private wells.

Kansas relies on ground water resources for public, rural-domestic, industrial, irrigation, and livestock water supplies. Over 90% of all water used within Kansas is supplied by ground water. Although irrigation continues to be by far the largest user of ground water, ground water provides approximately 85% of the drinking water in rural areas. A total of 637 community public water supplies are dependent on ground water, either solely or in combination with surface water sources. These supplies serve a total of 1,717,464 people.



South Dakota is heavily dependent on ground water to meet the needs of its population. More than 75% of the population use ground water for domestic needs. Over 80% of the State's public water supply systems rely on ground water and virtually everyone not supplied by the public water supply systems is dependent on ground water.

In 1990, the United States Geological Survey reported that ground water supplied 51% of the Nation's overall population with drinking water. In rural areas of the Nation, ground water supplied 95% of the population with drinking water. So our Nation's dependence on this valuable resource is obvious. In their 305(b) Water Quality Reports, States emphasized the importance of ground water as a drinking water resource.

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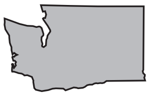
Ground Water Use

State	Uses of Ground Water Specific to Drinking Water	Other Uses
Alabama		40% of water is obtained from ground water
Alaska	85% of public drinking water systems in the State use ground water as their source	Ground water is the major source of fresh water for public and private drinking water supply systems, industry, and agricultural development
Arkansas	47.2% of total ground water withdrawals are used for drinking water	Between 1975 and 1980, ground water use increased from 2,596 to 4,056 million gallons per day (a 56% increase); it increased from 4,056 to 4,708 million gallons per day between 1980 and 1990 (a 16% increase)
Colorado	59 of 63 counties use ground water for drinking water; 29 of these counties rely solely on ground water	Ground water supplies approximately 18% of total water withdrawals; 96% is used for irrigation
Delaware	67% of the State's population is dependent upon public and private wells for domestic needs; Kent and Sussex Counties rely 100% on ground water for drinking water	Overall, ground water use increased 13.31%, whereas overall surface water use decreased 18.87%
Georgia	In 1990, ground water made up 24% of the public water supply and 92% of rural drinking water sources; for all practical purposes, ground water is the dominant source of drinking water for areas outside the larger cities of the Piedmont	In 1990, ground water made up 60% of irrigation use and 51% of the industrial and mining use

State	Uses of Ground Water Specific to Drinking Water	Other Uses
Indiana	Nearly 60% of the population uses ground water for drinking water and other household purposes; approximately 50% of the population served by public water supplies depends on ground water; over 0.5 million homes have private wells	Industry withdraws an average 190 million gallons/day; irrigation consumes 200 million gallons/day during the crop production season; and livestock depend on an average of 45 million gallons/day
Kentucky	Approximately 14% of the population (500,000 people) rely on private wells for drinking water; there are 362 public water supply systems using ground water as principal, partial, or supplemental supplies	Large ground water withdrawals (>10,000 gallons/day) increased from 37.8 million gallons/day in 1980 to 320 million gallons/day in 1995
Maine	More than 60% of all households draw their drinking water from ground water supplied from private or public wells; ground water is the source of approximately 98% of all water used by households with private supplies	Nearly 60% of water needed for livestock is supplied by ground water; ground water also supplies more than 60% of industrial needs
Maryland	Ground water supplied 450 public water supply systems in 1995, serving a population of 960,000	
Missouri	Ground water is the main source of drinking water in the Ozarks and Southeast Lowlands for both public and private supplies; the cities of Independence, Columbia, and St. Charles use ground water adjacent to the Missouri River	

State	Uses of Ground Water Specific to Drinking Water	Other Uses
New York	Approximately 6,000,000 people use ground water as a source of drinking water; 50% of these people are on Long Island and the remainder are in upstate New York	
South Carolina	Ground water is a source of drinking water for more than 60% of the population	
Tennessee	More than 50% of the population relies on ground water for drinking water supplies (one in five of these households relies on a private well or spring); community public water systems withdraw approximately 243 million gallons/day	
Texas	About 41% of municipal water is derived from ground water resources	In 1992, approximately 56% of the water used for domestic, municipal, industrial, and agricultural purposes was derived from ground water
Utah	Ground water is a major source of public drinking water supplies with almost 67% of the population dependent upon this resource	
Vermont	Approximately 60% of the population depend on ground water to meet their drinking water needs; in rural communities, ground water dependence is nearly 100%	
Virginia	Ground water is used solely or in part to supply 80% of the population with drinking water	Ground water accounts for approximately 22% of the water used exclusively for hydroelectric and thermoelectric purposes
Wisconsin	Ninety-seven percent of Wisconsin's villages and cities use ground water for drinking water, and 70% of the State's residents rely on ground water for their water supply	



Ground water is the source of drinking water for 60% to 70% of the population of Washington State. In large areas east of the Cascade Mountain Range, 80% to 100% of available drinking water is obtained from ground water resources. As a whole, over 95% of Washington's public water supply systems use ground water as their primary water source.

Ground water is also often directly connected to rivers, streams, lakes, and other surface waterbodies, with water flowing back and forth from one resource to the other. In some areas of the country, ground water contributes significantly to the water in streams and lakes.

The volume of ground water that is discharged to surface waterbodies, thereby maintaining streamflow during periods of low flow or drought conditions, was previously unrecognized and unquantified. This volume, estimated at 492 billion gallons per day, is measured using special instruments or estimated using stream gaging and hydraulic gradient data. When ground water contributing to stream baseflow maintenance is included with the other ground water uses, it becomes evident just how important it can be. As shown in Figure 6-3, stream baseflow maintenance accounts for 54% of ground water discharges. This baseflow contributes to maintaining healthy aquatic habitats in surface water.

With ground water playing such an important part in maintaining water flow in streams and lakes, the quality of the ground water can have an important effect on the overall condition of the surface water. Surface waters can become contaminated if the ground water serves as a means to transport contaminants to the surface water (and vice versa). This could affect drinking water supplies drawn from surface water, fish and wildlife habitats, swimming, boating, and fishing.

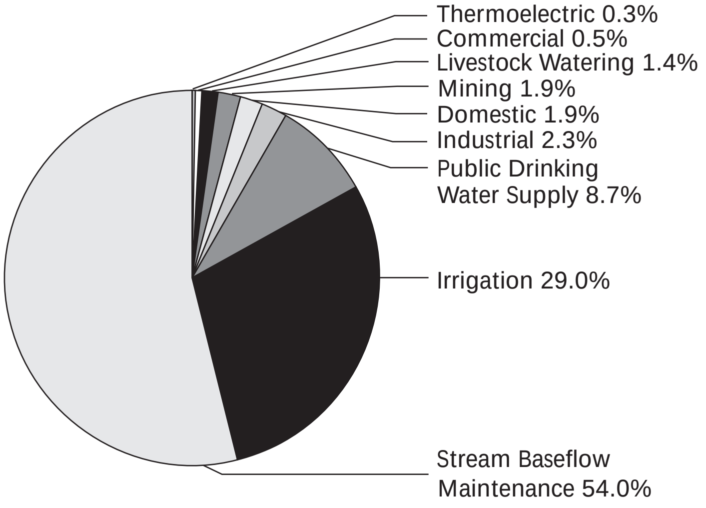
Thus, it is evident that ground water is a very important natural resource. Preserving the quality of our ground water resources ensures that our needs as a Nation will be met now and into the future.

Ground Water Quality

The evaluation of our Nation's ground water quality is complex. In evaluating ground water quality

Figure 6-3

Withdrawal and Discharge of Ground Water as a Percentage of Contribution



Source: Open-File Report 92-63, U.S. Geological Survey, and *National Water Summary 1986*, *Hydrologic Events and Ground-Water Quality*, U.S. Geological Survey, Water-Supply Paper 2325.

Ground Water/Surface Water Interactions

Nationwide, many water quality problems may be caused by ground water/surface water interactions. Substantial evidence shows that it is not uncommon for contaminated ground water to discharge to and contaminate surface water. In other cases, contaminated surface water is seeping into and contaminating ground water. In their most recent reports on water quality, several states reported ground water/surface water interactions leading to contamination of one medium by the other. A few examples follow:

■ The Arkansas Department of Health (ADH) is investigating cases of ground water contaminated by microscopic organisms normally found in surface water. Because surface water carries disease-causing protozoa and other organisms resistant to the chlorination used to disinfect most public wells, the ADH must determine if public drinking water wells are supplied by sources of ground water under the direct influence (GWUDI) to surface water.

The ADH has developed an objective method to determine if a well is supplied by GWUDI. Water quality information is used to determine the potential for contamination and then possible pathways of contamination are identified by evaluating the well's conformance to established construction standards. Two primary defects in well construction that provide possible pathways for surface water contamination are: (1) unsuitable below-ground construction, particularly shallow casings and insufficient grout; and (2) well sites characterized by poor drainage, high soil infiltration rate, and highly permeable outcrops.

Arkansas has more than 1,700 public drinking water supply wells. In the 3 years since the GWUDI program began, the ADH has used the above method to determine that 900 of these wells are not supplied by sources of ground water under the influence of surface water. For many of the wells evaluated, the ADH has recommended simple, above-ground construction repairs or site maintenance procedures that effectively closed the pathways of surface water contamination.

■ In South Carolina, ground water serves to recharge most of the streams; thus, contaminated ground water impacts surface waters more often than surface waters impact ground water. In the State's Ground Water Contamination Inventory, 79 cases of contaminated ground water discharging from surficial aquifers to surface water have been noted.

Detailed information on contaminant concentrations in both the aquifer and surface water is not available. However, in most of these cases, dilution of the contaminated ground water by uncontaminated surface water reduces the contaminant concentrations in the surface water to low or not detectable levels.

- No single program addresses the water quality concerns that arise from ground water/surface water interactions in Maine. However, contamination, or potential contamination, of surface water through baseflow of contaminated ground water is being evaluated at several locations. At an egg production facility in Turner, Maine, past practices that included excessive land spreading of chicken manure, hen carcass disposal, and septage disposal resulted in nitrate contamination of large areas of a sand and gravel aquifer. The majority of the shallow ground water at the site discharges to streams on the east and west sides of the property. Monitoring points have been established on these streams to evaluate the effects of past practices and current wastewater disposal on surface water quality. To date, surface waters within the property and along the property boundary show evidence of nitrate contamination.

- A similar situation occurs in Delaware. Past land-use practices, such as high septic system density and poultry houses, have contributed to nitrate contamination of ground water. This nitrate-contaminated groundwater discharges into the Rehoboth and Indian River bays contributing to eutrophication and algal bloom problems. In fact, it is estimated that certain subbasins within the Indian River Bay watershed contribute, through direct ground water discharge, almost 50% of the total nitrogen load that enters the bay. Furthermore, poultry-producing subbasins were found to be the source of greater nitrate loading than non-poultry-producing basins.

under Section 305(b) of the Clean Water Act, our goal is to assess if the resource has been adversely impacted or degraded as a result of human activities.

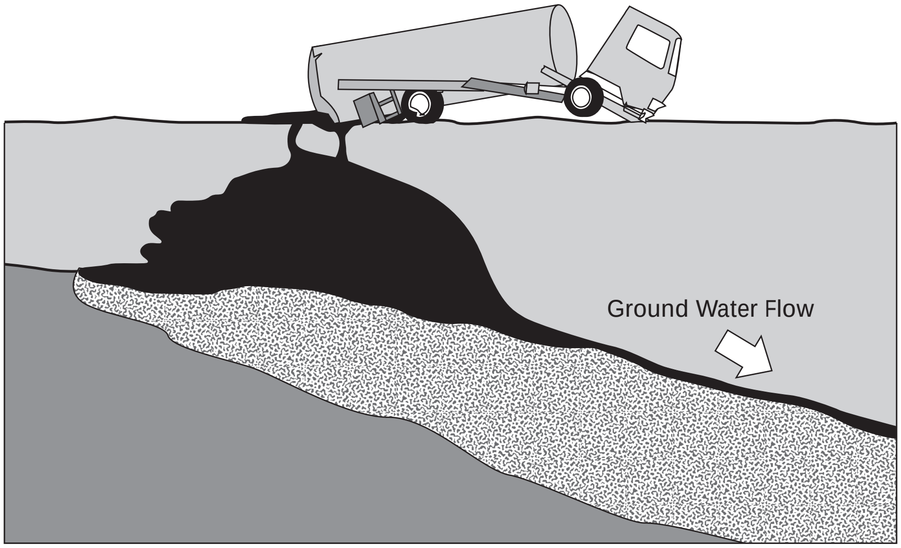
Not too long ago, it was thought that soil provided a protective "filter" or "barrier" that immobilized the downward migration of contaminants released on the land surface and prevented ground water resources from being adversely impacted or contaminated. The discovery of pesticides and other contaminants in ground water demonstrated that ground water resources were indeed vulnerable to contamination resulting from human activities. The potential for a contaminant to affect ground water quality is dependent upon its being introduced to the environment and its ability to migrate through the overlying soils to the underlying ground water resource. Figure 6-4 illustrates a petroleum spill onto the ground surface and the subsequent migration of the petroleum through the soils to the underlying ground water.

Ground water contamination can occur as relatively well defined, localized plumes emanating from specific sources such as leaking underground storage tanks, spills, landfills, waste lagoons, and/or industrial facilities (Figure 6-5). Contamination can also occur as a general deterioration of ground water quality over a wide area due to diffuse nonpoint sources such as agricultural fertilizer and pesticide applications, septic systems, urban runoff, leaking sewer networks, application of lawn chemicals, highway deicing materials, animal feedlots, salvage yards, and mining activities. Ground water quality degradation from diffuse nonpoint sources affects large areas, making it difficult to specify the exact source of the contamination.

Ground water contamination is most common in highly developed areas, agricultural areas, and industrial complexes. Frequently, ground water contamination is discovered long after it has occurred. One reason for this is the slow movement of ground water through aquifers, which, for finer-grained aquifers may be less than 1 foot per day. Contaminants in the ground water do not mix or spread quickly, but remain concentrated in slow-moving, localized plumes that may persist for many years. This often results in a delay in the detection of ground water contamination. In

Figure 6-4

Ground Water Contamination as a Result of Petroleum Spillage



some cases, contaminants introduced into the subsurface more than 10 years ago are only now being discovered. This also means that the practices of today may have affects on water quality well into the future.

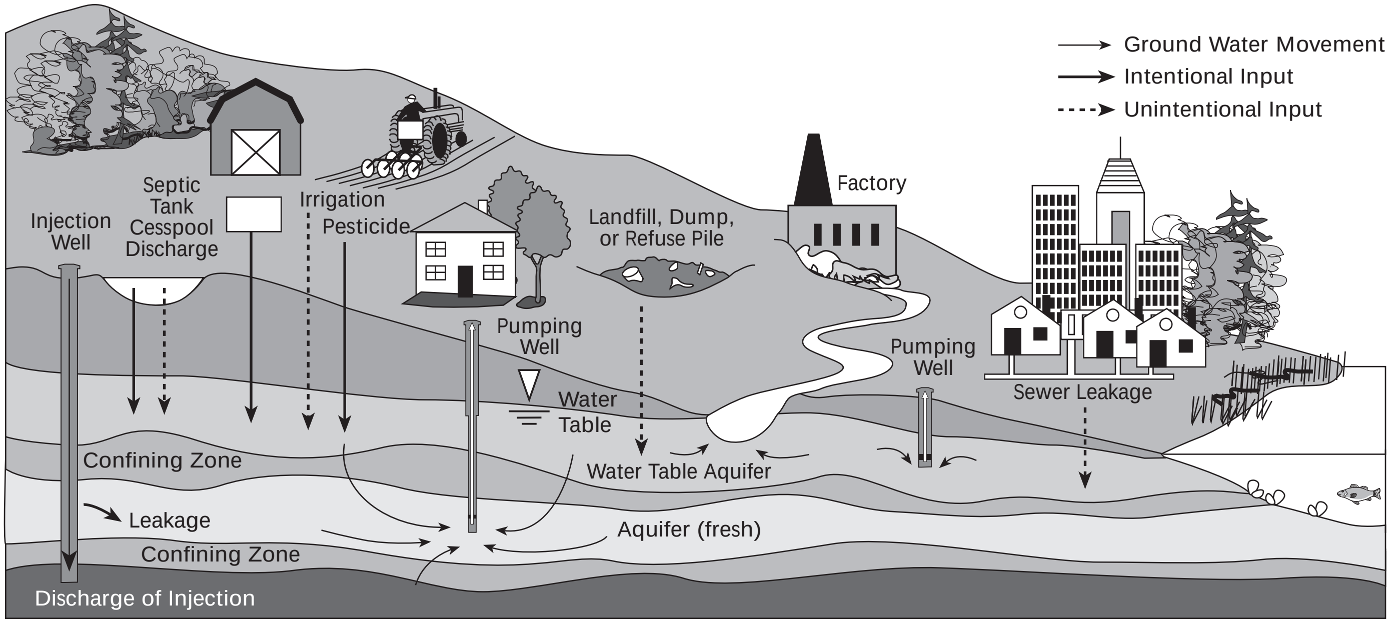
Shallow, unconfined aquifers are especially susceptible to contamination from surface activities. Ground water contamination in the surficial aquifers can also affect ground water quality of the underlying confined aquifers. Confined aquifers are most frequently susceptible to contamination when low-permeability confining layers are thin or absent, thus enabling the unretarded downward migration of contaminants. Recent studies in southern New Castle County of Delaware have demonstrated the long-term susceptibility of the underlying aquifers to contamination. In Delaware, stream channels have cut down through confining layers at periods of low sea level. When sea level rose, the stream channels were filled with sand and gravel. These highly permeable channels can act as conduits for contaminant migration.

Ground water contaminant problems are frequently serious and can pose a threat to human health and/or result in increased costs to consumers. In the 1996 Guidelines, States were asked to indicate the major uses (e.g., public water supply, private water supply, irrigation, industry, livestock watering) for water withdrawn from aquifers or hydrogeologic settings within the State. States were also asked to relate water use to uses that may have been affected by ground water contamination.

Although this information was considered optional, 20 States

Figure 6-5

Sources of Ground Water Contamination



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Ground Water Along Our Nation's Coasts

Communities along the U.S. coast have been attracting new residents and more industry at an ever-rising rate during the past two or so decades. This growth has been beneficial for the economy and tax base of these areas. However, now we are seeing the beginning of what could be unwelcome, even dangerous, effects on these communities and the environment. In fact, coastal communities may face critical water supply issues within the decade if ground water protection and conservation are not aggressively pursued.

EPA is forming a partnership between its internal Offices of Ground Water and Drinking Water and Wetlands, Oceans, and Watersheds, the Ground Water Protection Council, and the State of Florida to begin a water supply study in Florida. The results of this study will form the basis of research to characterize current national water quality and quantity in coastal areas.

The problem will be framed in terms of current drinking water needs, human health, and economic impact. EPA plans to share the results of this research with coastal communities through public outreach. Beginning with the most affected localities and in partnership with local and community organizations, EPA will inform coastal communities about the possible problems coming their way and how to avoid them. EPA will develop methods to help communities protect their source waters and drinking water and provide assistance to communities in putting these methods in place.

The problems of protecting coastal source water and drinking water have been neglected for too long—so long that real problems are arising. EPA hopes this project will significantly benefit ground water and drinking water quality all along the coast through improved characterization of ground water in coastal areas and better watershed management. Public education about problems in the coastal environment and how to solve them will encourage public involvement. Better management of resources—environmental, financial, and human—will lead to new and needed environmental improvements.

responded with information for a total of 66 aquifers or hydrogeologic units. Of these, 43 units reportedly supplied water for PWS, 45 units supplied water for private use, and 32 units supplied water for irrigation. Other important uses of the water included commercial (12 units), livestock (19 units), and industry (10 units).

When evaluating the different uses for ground water that have been affected by water quality problems, water supply for public and private use were the most frequently affected. Water supply to PWS was affected in 19 units (almost 45%) and water supply to private wells was affected in 23 units (>50%). Irrigation, commercial, livestock, and industry uses were less frequently affected. This may reflect lower water quality standards for these uses.

Ground Water Contaminant Sources

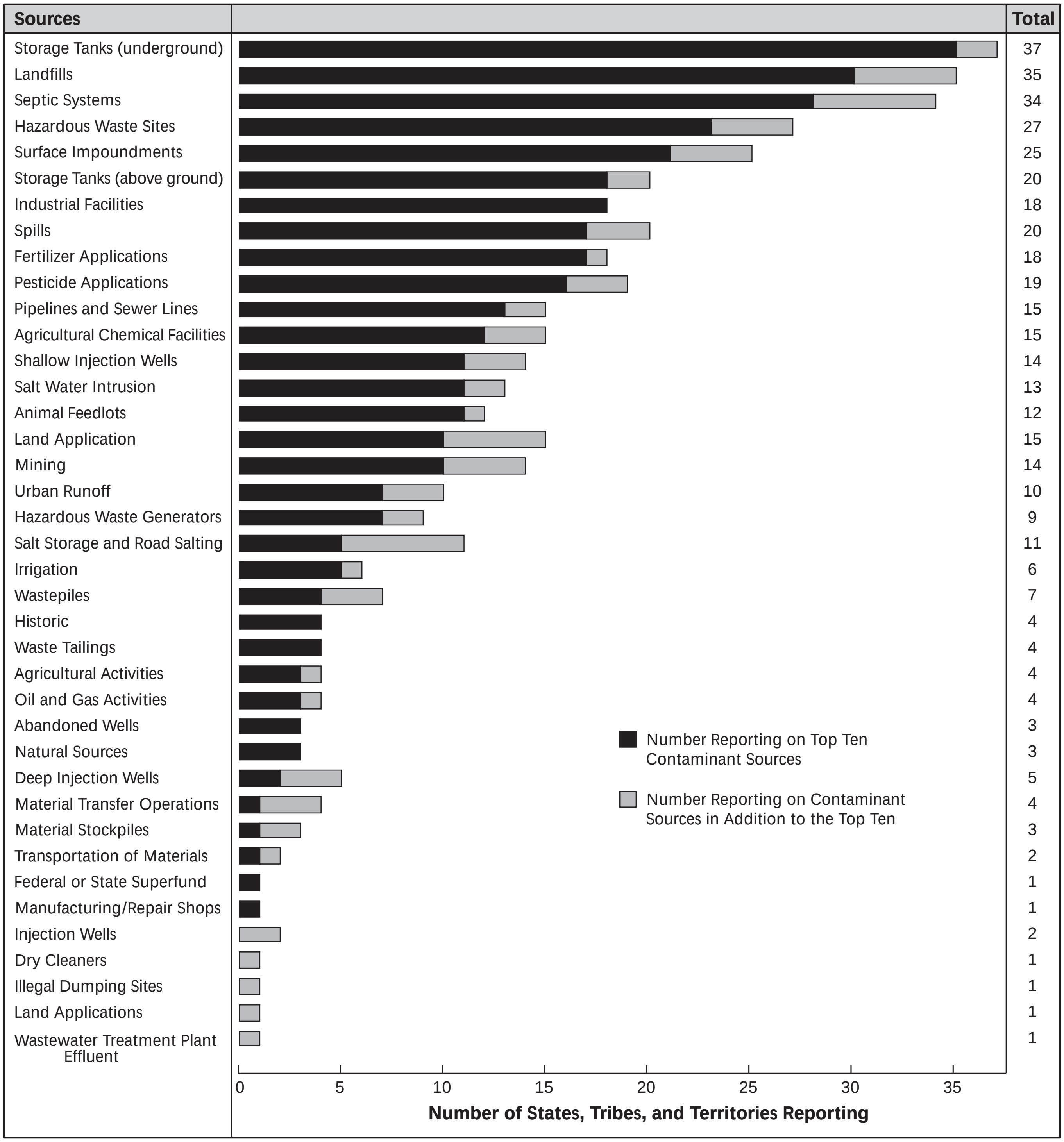
Ground water quality may be adversely impacted by a variety of potential contaminant sources. EPA developed a list of potential contaminant sources for the 1996 305(b) Guidelines and requested each State to indicate the 10 top sources that potentially threaten their ground water resources. The list was not considered comprehensive and States added sources as was necessary based on State-specific concerns. Factors that were considered by States in their selection include the number of each type of source in the State, the location of the various sources relative to ground water used for drinking water purposes, the size of the population at risk from contaminated drinking water, the risk posed to human health and/or the environment from releases, hydrogeologic sensitivity (the ease with which contaminants enter and travel through soil and reach aquifers), and the findings of the State's ground water protection strategy and/or related studies. For each of the indicated contaminant sources, States were also asked to identify the contaminants impacting ground water quality.

Thirty-seven States provided information related to contaminant sources. As requested in the 1996 Guidelines, most States indicated the 10 top contaminant sources threatening ground water quality. In some cases, they not only specified the 10 top sources, but provided additional information on sources of lesser, but still notable, importance. In a few other cases, they provided information on the majority of sources threatening ground water quality within the State.

Figure 6-6 illustrates the sources most frequently cited by States as a potential threat to ground water quality. As shown, leaking underground storage tanks (USTs) were specified by 35 out of 37 States as one of the top 10 potential sources of ground water contamination. Two other States noted that leaking USTs were a source of ground water contamination. Landfills, septic systems, hazardous waste sites, and surface impoundments were the next most frequently cited sources of concern.

Figure 6-6

Major Sources of Ground Water Contamination



Underground Storage Tanks

Leaking USTs were cited as the highest priority contaminant source of concern to States in 1996 (Figure 6-6). The high priority assigned to leaking USTs in 1996 is consistent with information reported by States during previous 305(b) cycles.

Although USTs are found in all populated areas, they are generally most concentrated in the more heavily developed urban and suburban areas of a State. USTs are primarily used to hold petroleum products such as gasoline, diesel fuel, and fuel oil. Because they are buried underground, leakage can be a significant source of ground water contamination that can go undetected for long periods of time (Figure 6-7).

States report that the organic chemicals associated with petroleum products are one of the most common ground water contaminants. Petroleum-related chemicals have adversely affected ground water quality in aquifers across the Nation. The most significant affects generally occur in the uppermost aquifer, which is frequently shallow and often used for domestic purposes. Petroleum-related chemicals threaten the use of ground water for human consumption because some (e.g., benzene) are known to cause cancer even at very low concentrations.

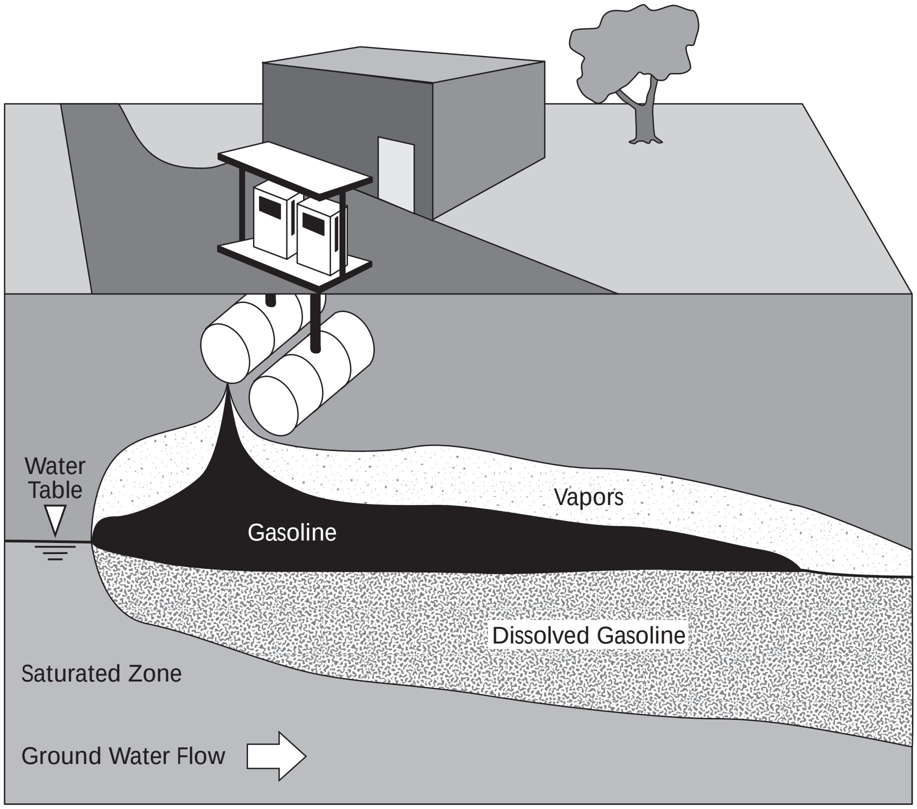
The primary causes of leakage in USTs are faulty installation and corrosion of tanks and pipelines. As of March 1996, more than 300,000 releases from USTs had been confirmed. EPA estimates that nationally 60% of these leaks have impacted ground water quality and, in some States, the percentage is as high as 90%.

In general, the threat from USTs was determined primarily based on the sheer number of leaking USTs.

- There were almost 61,000 facilities containing 155,308 registered USTs in Texas in 1994. During that same year, 4,894 cases of ground water contamination were documented as being under enforcement by the Texas Natural Resource Conservation Commission. Fifty-two percent of the contamination cases are within the 10 most populous

Figure 6-7

Ground Water Contamination as a Result of Leaking Underground Storage Tanks



Frequently Considered Factors

When identifying a contaminant source as a potential threat to ground water quality, States may consider a number of different factors such as

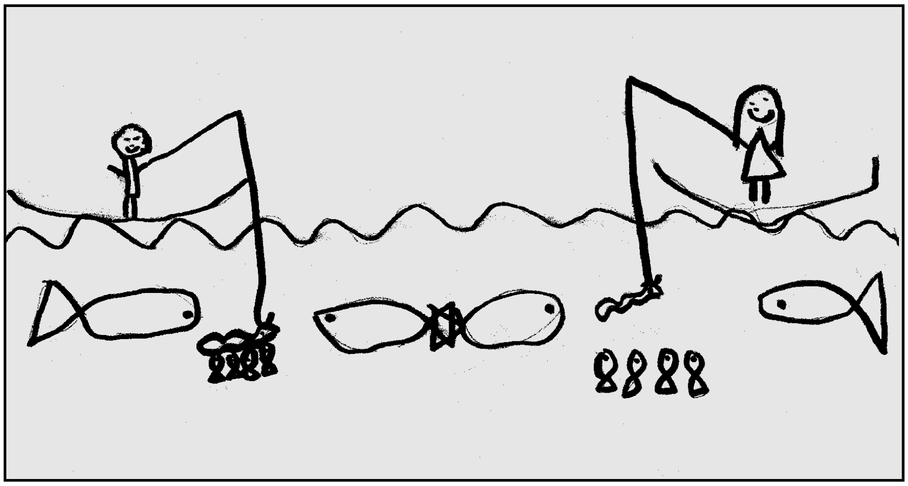
- Number of each type of source in the State
- Location of various sources relative to ground water used for drinking water purposes
- Size of the population at risk from contaminated drinking water
- Risk posed to human health and/or the environment from releases
- Hydrogeologic sensitivity (the ease with which contaminants enter and travel through soil and reach aquifers)
- Findings of the State's ground water protection strategy and/or related studies. States were asked in the *1996 Guidelines* to specify the factors they considered in reporting contaminant sources.

Number of States Reporting a Contaminant Grouping in Association with the Specified Source

Source	Leaking USTs	Landfills	Septic Systems
Petroleum Compounds	31	18	
Halogenated Solvents	9	19	5
Organic Pesticides	5	12	
Metals	3	20	
Nitrate		8	22
Bacteria		10	17
Inorganic Pesticides		10	
Protozoa			9
Viruses		5	15

Unquestionably, human health and the environment, the number and/or size of the contaminant sources, and the location of a source relative to a drinking water source were the most important factors considered. These three factors are reflected in the high priority assigned to leaking USTs, landfills, and septic systems (see Figure 6-7 of this report). Large numbers of each of these three contaminant sources have been documented in the States. Adverse impacts to drinking water as a result of releases from these three sources have also been reported. Releases are frequently known to be hazardous to human health.

The table shows the contaminants that States specified in association with leaking USTs, landfills, and septic systems. As shown, petroleum compounds were most frequently associated with leaking USTs. Nitrate, bacteria, and protozoa were most frequently cited in association with septic systems. The variability in contaminants associated with landfills reflects the diversity in disposed materials.



esse Xiong, 1st grade, Estes Hills Elementary, Chapel Hill, NC counties in Texas. Furthermore, leakage from storage tanks has been documented in 223 of 254 counties in the State and either has affected, or has the potential to affect, virtually every major and minor aquifer in the State.

- As of August 1996, the State of Arizona was tracking approximately 8,960 facilities having 30,000 USTs. Of these 30,000 USTs, 5,935 have reported leaks and 917 have or may have contaminated ground water.

- In the State of Delaware, there are over 9,000 regulated USTs (3,516 of which are currently in use) located at over 2,000 facilities. Over the period 1994-1995, 586 sites had confirmed releases with 80 having confirmed ground water releases.

- As of December 31, 1995, a total of 41,795 USTs have been registered at approximately 14,000 facilities in the State of Kentucky. Approximately 400 of these registered sites have ground water contamination at levels above the maximum contaminant levels for drinking water. On average, about 20 new USTs per year manifest ground water contamination above allowable limits.

The “registered USTs” and “facilities” described above represent tanks used for commercial and industrial purposes. Hundreds of thousands of household fuel oil USTs are not included in the numbers presented above. Many of these household USTs, installed 20-to-30 years ago as suburban communities were developed across the country, have reached or surpassed their normal service lifespans. Some of these tanks are undoubtedly leaking and threatening ground water supplies. Because household tanks are not regulated as commercial facilities are, however, it is not possible to determine the extent to which ground water quality is threatened by them. In addition, since the cost of replacing leaking USTs would be borne by the homeowner, there is little incentive for the homeowner to investigate the soundness of his/her home oil tank.

Recognizing the need to address and control the leaking UST situation, States across the Nation have taken action. One excellent example is Maine. In 1985, the Maine Legislature passed a law to regulate all underground petroleum storage tanks. This law required that all tanks be registered with the Maine Department of Environmental Protection (DEP) by May 1, 1986, regardless of size, use, or contents. This law also established procedures for abandonment of tanks and prohibited the operation, maintenance, or storage of petroleum in any storage facility or tank that is not constructed of fiberglass, cathodically protected steel, or other noncorrosive material.

To date, approximately 39,850 tanks have been registered, with only an estimated 4,000 tanks pending registration. Since 1986, approximately 27,750 inactive or old tanks have been removed from the ground. Figures 6-8 and 6-9 illustrate the effectiveness of this program. In Figure 6-8, the number of drinking water supply wells contaminated by leaking USTs has dropped dramatically. At the same time, as shown in Figure 6-9, the number of nonconforming USTs has decreased while the number of protected replacement USTs has increased. It is estimated by the Maine DEP that $3 of cleanup and third-party damage claim costs are avoided for every $1 spent on preventive measures.

Landfills

Landfills were cited by States as the second highest contaminant source of concern in 1996 (Figure 6-6). Landfills have consistently been cited as a high-priority source of contamination by the States. Landfills may be used to dispose of sanitary (municipal) and industrial wastes.

Municipal wastes, some industrial wastes, and relatively inert substances such as plastics are disposed of in sanitary landfills. Resulting contamination may be in the form of high dissolved solids, chemical and biochemical oxygen demand, and some volatile organic compounds.

Industrial landfills are site specific as to the nature of the disposed material. Common materials that may be disposed of in industrial landfills include plastics, metals, fly ash, sludges, coke, tailings, waste pigment particles, low-level radioactive wastes, polypropylene, wood, brick, cellulose, ceramics, synthetics, and other similar substances. Contamination from these landfills may be in the form of heavy metals, high sulfates, and volatile organic compounds. States indicated in their 1996 305(b) Water Quality Reports that the most common contaminants associated with landfills were metals, halogenated solvents, and petroleum compounds. To a lesser extent, organic and inorganic pesticides were also cited as a contaminant of concern.

Landfills of all types have long been used to dispose of wastes. In the past, little regard was given to the potential for ground water contamination in site selection. Landfills were generally sited on land considered to have no other uses. Unlined

Figure 6-8

Number of Private Drinking Water Supply Wells Contaminated by Leaking Underground Petroleum Storage Facilities in Maine (1986-1993)

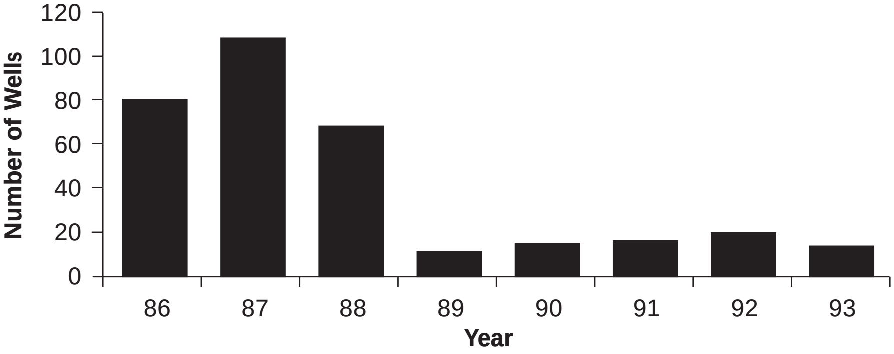
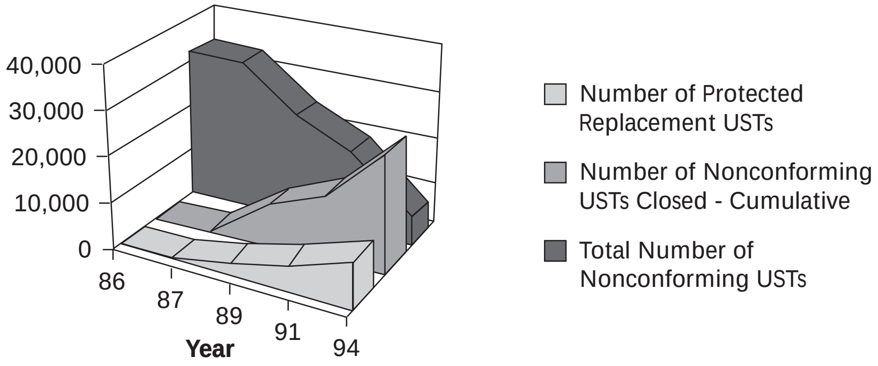


Figure 6-9

Changes in the Makeup of the Maine UST Population



abandoned sand and gravel pits, old strip mines, marshlands, and sinkholes were often used. In many instances the water table was at, or very near the surface, and the potential for ground water contamination was high (Figure 6-10). Although regulations involving the siting, construction, and monitoring of landfills have changed dramatically, past practices continue to cause a threat to ground water quality.

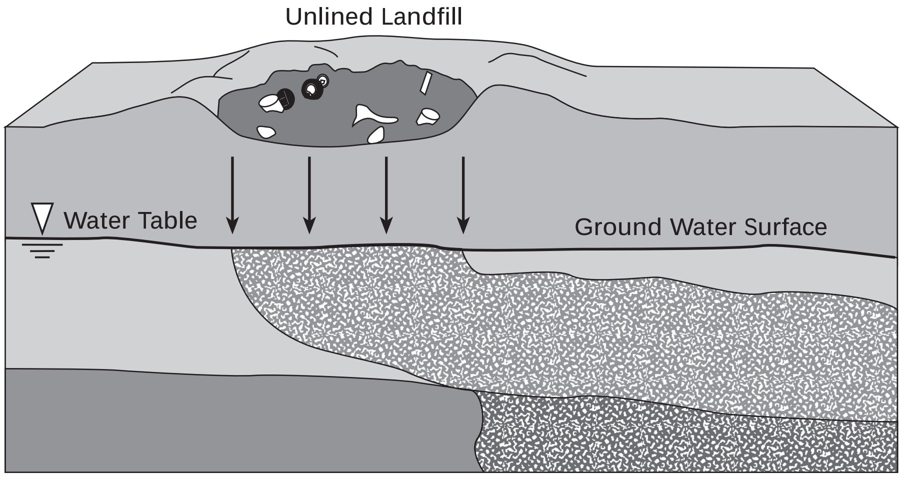
For example, although there are no currently active or operational solid waste disposal sites in the District of Columbia, historic records indicate that about 80 sites within the District of Columbia had been used as either a landfill or an open dump. Historic landfill sites continue to be discovered during routine environmental assessments and construction excavations. The exact location and materials disposed of are frequently unknown. Landfill sites that remain undiscovered have the potential to continue affecting ground water quality. Past handling and disposal practices cause concern because soil properties in the District of Columbia are unfavorable for use as a landfill. Specifically, soils are characterized by a relatively high permeability. In addition, the shallow depth to bedrock, high seasonal ground water level, and susceptibility to flooding make the area even more unsuitable.

To better govern municipal landfills, the State of Texas established a regulatory program in 1969 and began permitting new sites in 1975. From 1977 to 1981, previously existing landfills were either closed, permitted as grandfathered sites, or considered illegal/unauthorized sites. Records indicate from 1981 until 1994, 1,343 previously existing landfills (dumps), 1,810 permitted and grandfathered landfills, and 2,549 illegal/unauthorized sites have been closed. As a rule, ground water monitoring is not required at these 5,702 sites. In 1994, there were 360 active landfills operating under the jurisdiction of the Texas Natural Resource Conservation Commission. Of these sites, 196 were conducting ground water monitoring, 27 of which had documented ground water contamination.

A total of 391 municipal landfills have been identified in the State of Maine. As of December 1995, 206 landfills have been closed and capped. Seventeen landfills are partially closed with 168 yet to be closed. Of these 168 landfills, 45 are currently active sites and 123 are inactive sites that are no longer receiving solid waste. In all:

Figure 6-10

Ground Water Contamination as a Result of Unlined Landfill Disposal



- 184 landfill sites are situated on sand and gravel aquifers and ground water contamination has been documented at 46 of these sites

- 60 other sites have contaminated surface water and/or ground water and are considered to be substandard; 37 of these sites have serious ground water contamination.

- Hazardous substances in the ground water are confirmed or suspected at 41 municipal landfills. Public or private water supplies are threatened at 13 of these sites. Public water supplies appear to be threatened by hazardous contaminants at three sites. Contaminants at the remaining 10 sites appear to threaten private water supplies.

Recognizing the problems associated with old, inactive landfill sites, States are taking action to ensure that current and future landfills are less of a threat. In the State of Maine, active landfills are required to be licensed by the Department of Environmental Protection. Currently 57 landfills are licensed to operate in Maine. Eight of these are licensed to accept municipal solid waste only; 22 are licensed to accept special wastes (nonhazardous waste generated by sources other than domestic and typical commercial establishments), and 27 are approved to accept only construction and demolition debris. The landfills licensed to accept municipal solid waste and/or special wastes are secure landfills with leachate collection systems and treatment, thereby greatly reducing the risk of ground water contamination.

Septic Systems

As shown in Figure 6-6, septic systems were cited by 29 out of 37 States as a potential source of ground water contamination. States based their decisions most heavily on three factors, including the location of septic systems relative to sources of drinking water, the large number of residential septic tank systems, and human health. These findings are consistent with previous 305(b) reporting cycles in which septic systems were consistently ranked among the top five sources of ground water contamination.

Septic systems include buried septic tanks with fluid distribution systems or leachfields. Septic systems are designed to release fluids or wastewaters into constructed permeable leach beds, if present, and then to the shallow soil. Wastewaters are then expected to be attacked by biological organisms in the soil and/or degraded by other natural processes over time. Ground water may be contaminated by releases from septic systems when the systems are poorly designed (tanks are installed in areas with inadequate soils or shallow depth to ground water); poorly constructed or sealed; are improperly used, located, or maintained; or are abandoned.

A variety of wastewaters are disposed of in septic systems and, as a consequence, a variety of different chemicals may be present in the system. States stressed that one of the more common uses is for disposal of domestic sewage and liquid household wastes. Typical contaminants from household septic systems include bacteria, nitrates, viruses, phosphates from detergents, and other chemicals that might originate from household cleaners.

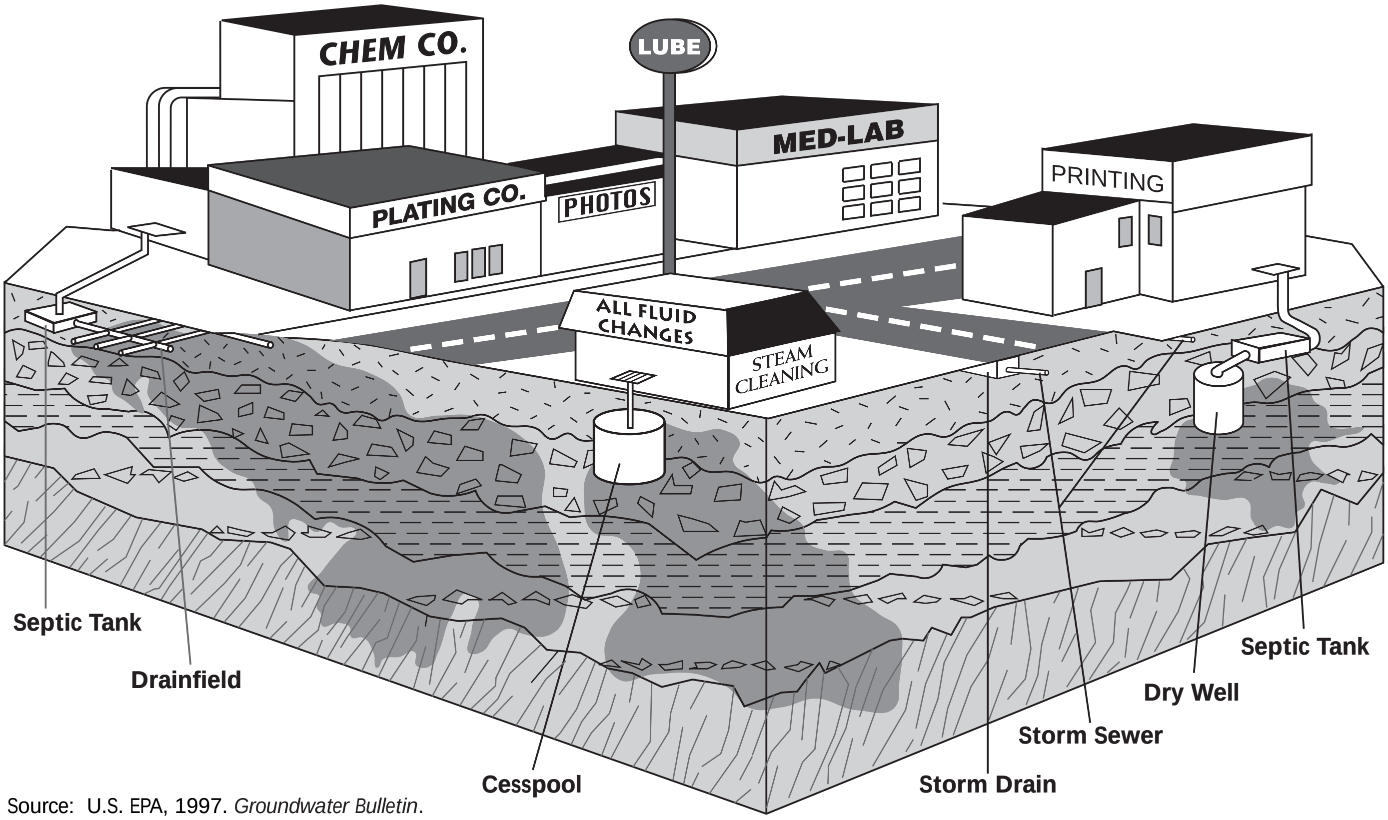
Septic systems are generally found in rural areas of the Nation. For example, Vermont is characterized by a large rural population. Due to the rural setting, homes and industries outside municipal service areas lack access to sewers. Septic systems are now and probably will remain a significant nonpoint source of contamination with approximately 220 indirect discharge sites. These sites represent discharges to the subsurface of over 6,500 gallons of sewage per day.

American households dispose of an estimated 3.5 billion gallons of liquid waste into these systems each day. Although the use of domestic septic systems is difficult to control, many States are initiating permitting processes. In addition, the local sale of products that pose a threat to ground water quality may be discouraged. Support of local collection programs may be encouraged through the increase in public awareness.

Although States most frequently cited domestic septic systems as a threat to ground water quality,

Figure 6-11

Ground Water Contamination as a Result of Commercial Septic Systems



Source: U.S. EPA, 1997. *Groundwater Bulletin*.

similar systems are also used by commercial and industrial facilities to dispose of process wastewaters (Figure 6-11). The most misused septic systems are those used by the automotive repair/service businesses that dispose of engine fluids, fuels, and cleaning solvents. As much as 4 million pounds of waste per year are disposed of by commercial sites into septic systems that have affected the drinking water of approximately 1.3 million Americans. The costs needed to clean up the contamination and supply new sources of drinking water have ranged from $30,000 to $3.8 million. States are currently enforcing waste management programs requiring businesses to properly dispose of their chemical waste.

State Overview of Contaminant Sources

For the first time in 1996, States were asked to provide information on the types and numbers of contaminant sources within a specified reporting area. Reporting contaminant source information for specific areas within States is new and not all States track this information in an easily accessible format. Of the States that do, 29 provided this information. The information is tabulated on a nationwide basis in Table 6-1.

Requesting this type of information served two purposes. First, it was possible to determine what contaminant sources have the greatest potential to impact ground water quality based on the sheer number of such sites in a given area. Second, it was possible to determine how many of these sites actually impacted ground water quality.

As shown in Table 6-1, leaking USTs represent the highest number of potential sources. Over 100,000 leaking UST sites have been identified in 80 different areas of the Nation. Of these, over 17,000 have confirmed releases of ground water contamination. The next big category of potential contaminant sources are septic systems. States reported the presence of 10,656 sources in a total of eight areas. Of these, 10,594 have confirmed releases. The next highest category were State sites, with a total of 2,614 confirmed ground water contamination incidents.

Ground Water Assessments

For the first time in 1996, States were asked to report data for aquifers or hydrogeologic settings (e.g., watersheds) within the State. Reporting data for specific aquifers or hydrogeologic settings within States is new. EPA recognized that not every State would be able to report ground water data on an aquifer-specific basis. EPA also anticipated that there would be wide variation in reporting style. The information reported by States in their 1996 State Water Quality Reports reflects the diversity of our Nation's individual ground water management programs.

Due to the diversity in reported data, evaluation of ground water quality on a national basis for 1996 is not possible at this time. However, the positive

Table 6-1. Summary of Contaminant Source Type and Number

Source Type	Units for Which Information Was Reported	Sites Reported Nationwide	Sites Listed and/or with Confirmed Releases Nationwide	Sites with Confirmed Ground Water Contamination Nationwide	Site Investigations Nationwide	Sites that are Stabilized or with Source Removed Nationwide
Leaking UST	80	100,921	40,363	17,827	22,362	9,367
UST Sites (no releases found)	21	2,210	—	—	—	—
Septic Systems	8	10,656	10,594	—	—	—
State Sites	65	7,017	5,751	2,614	5,348	2,935
Underground Injection	49	5,006	1,077	911	116	62
CERCLIS (non-NPL)	54	2,399	1,332	645	1,154	374
RCRA Corrective Action	74	2,114	283	289	54	37
MN Dept of Agriculture	1	600	164	50	119	—
DOD/DOE	77	404	234	166	115	53
Miscellaneous	55	229	905	514	72	40
Nonpoint Sources	17	171	190	62	32	27
NPL	63	167	250	204	57	22
Landfills	4	149	78	74	136	3
Wastewater Land Application	21	116	—	24	24	—

CERCLIS = Comprehensive Environmental Response, Compensation, and Liability Information System
DOD/DOE = Department of Defense/Department of Energy
MN = Minnesota
NPL = National Priority List (or Superfund)
RCRA = Resource Conservation and Recovery Act
UST = Underground Storage Tank
— = Not available

response from States showed they welcomed the changes made in 1996 and are developing and implementing plans to report more aquifer-specific information in the future.

Diversity of Reporting Units

Thirty-three States reported data summarizing ground water quality. In total, data were reported for 162 specific aquifers and other hydrogeologic settings. States that were unable to report ground water quality data for specific aquifers assessed ground water quality using a number of different hydrogeologic settings or "reporting units," including statewide summaries, reporting by county, watershed, basin, and sites or areas chosen for specific reasons such as potential vulnerability to contamination.

Sites with Corrective Action Plans Nationwide	Sites with Active Remediation Nationwide	Sites with Cleanup Completed Nationwide
6,143	6,301	19,379
—	—	—
—	—	—
791	1,216	3,166
32	28	204
41	21	49
37	79	52
—	—	—
26	22	39
12	5	32
3	21	36
25	38	24
—	—	0
7	5	0

Figure 6-12 presents an overview of the States that were able to provide ground water quality data for specific or “differentiated hydrogeologic units” within the State. A brief description of several ground water assessment methods and their rationale follows.

Florida – Very Intense Study Area

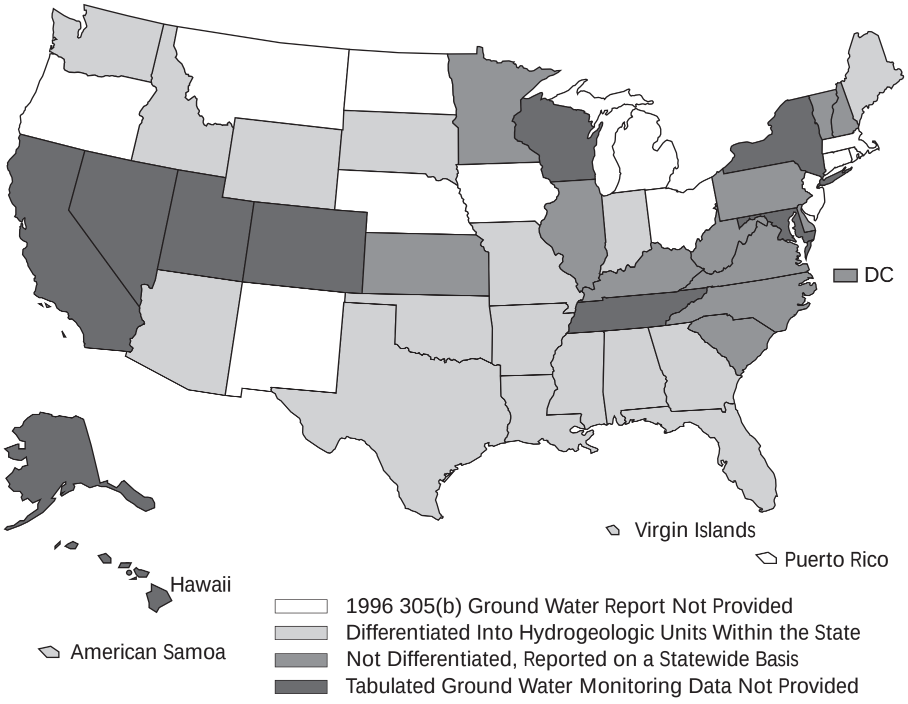
Florida’s Very Intense Study Area (VISA) Network, consisting of about 450 wells, began operating in 1990. The VISA Network monitors the effects of various land uses on ground water quality in specific aquifers in selected areas. The major land uses represented are intensive agriculture, mixed urban/suburban, industrial, and low impact. The VISAs were chosen based on their relative susceptibility to contamination. Currently, Florida has data on 23 VISAs and is in the process of analyzing the results of the first two rounds of sampling.

Wells in the VISA and Florida’s background networks are sampled in the same year for various water chemistry indicators and groups of contaminants. By comparing VISA and background results in the same aquifer system, lists of contaminants commonly associated with different kinds of land use can be developed. This process helps Florida to plan for and regulate land uses that are a threat to ground water quality.

For the 1996 report, Florida chose to present information for the North Lake Apopka VISA (Figure 6-13), which consists of 36 square miles in the Lake Apopka Basin. The vulnerability to contamination of the surficial and Floridian aquifers and Lake Apopka was an important consideration in choosing the study area. Because land use in the Lake Apopka Basin is over 50% agricultural, this VISA helps Florida evaluate the impacts of intensive agricultural growing, processing, and packing on ground water quality.

Figure 6-12

Summary of How Ground Water Data Were Reported



Arkansas – Ambient Ground Water Monitoring Program

The Arkansas Department of Pollution Control and Ecology initiated an Ambient Ground Water Monitoring Program in 1986 in order to gather background, ground-water quality data from various aquifers in the State. Samples are collected every 3 years and analyzed for general water quality indicators, including metals, petroleum hydrocarbons, and pesticides. Three rounds of sampling and analysis have been completed in some areas since inception of this program.

For 1996, Arkansas presented information for the nine currently active monitoring areas (Figure 6-14). The areas are in different counties covering the diverse geologic, hydrologic, and economic regimes within the State. Each area was chosen for a particular reason and with particular objectives in mind. For example, one area is characterized by the largest community using ground water to meet all of its needs and one objective of the monitoring program is to monitor water quality within an area of the underlying aquifer that is affected by public and commercial well use.

Figure 6-13

Locations and Descriptions of Very Intense Study Areas (VISA) in Florida

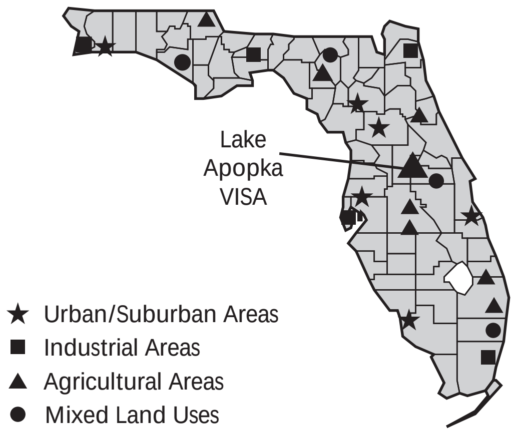
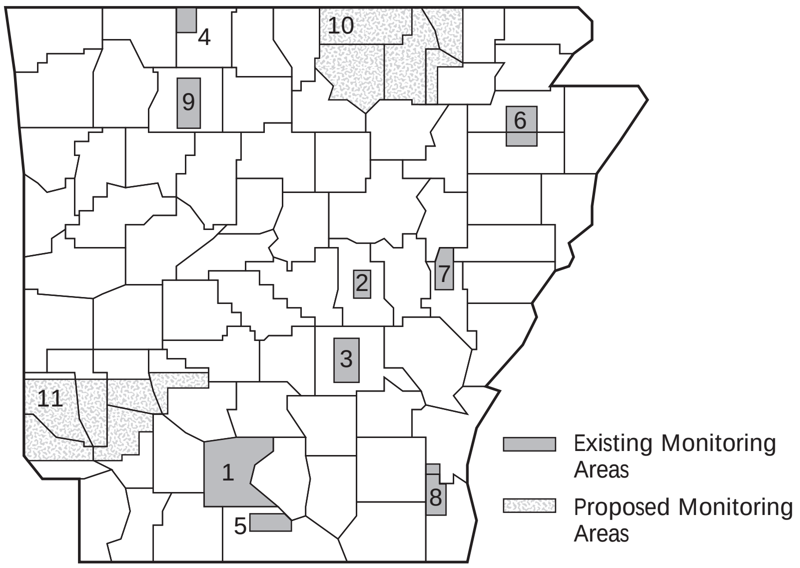


Figure 6-14

Arkansas Ambient Ground Water Monitoring Program



Existing monitoring areas include Ouachita (1), Lonoke (2), Pine Bluff (3), Omaha (4), El Dorado (5), Jonesboro (6), Brinkley (7), Chicot (8), and Buffalo River Watershed (9). Expansion areas will include Hardy (10) and Athens Plateau (11).

Wyoming – County Summary

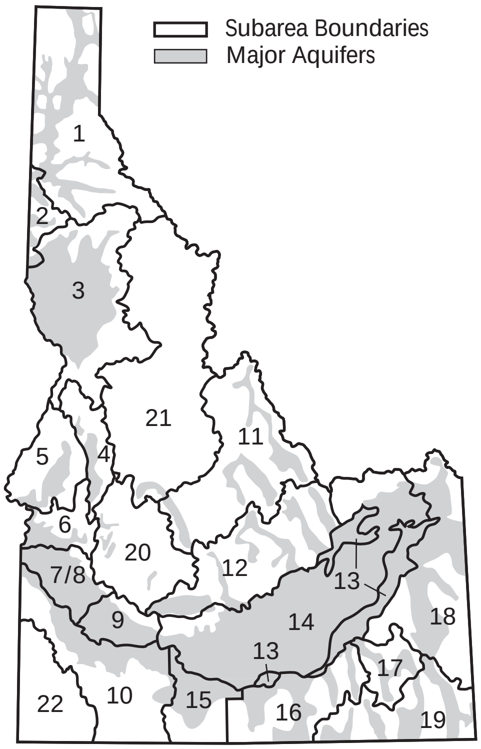
In 1992, the Wyoming Department of Environmental Quality, Water Resources Center and the State Engineer's Office implemented a prioritized approach for assessing aquifer sensitivity and ground water vulnerability at the county level on a statewide basis. Goshen County was selected as a pilot project area based on (1) the existence of recent studies and reports on ground water quality and aquifer characteristics; (2) Federal, State, and local interest in ground water and wellhead protection programs; and (3) the amount of related data and information available to complete sensitivity and vulnerability maps. Goshen County also ranked fourth out of 23 counties in overall vulnerability to contamination from pesticides. For 1996, Wyoming focused ground water assessment on the North Platte River alluvial aquifer located in Goshen County.

Indiana – Hydrogeologic Setting

To avoid the evaluation of ground water quality data across similar political boundaries, Indiana developed a system that allows for data to be analyzed according to similar surface and subsurface environments. This was achieved by first producing a document that describes all the hydrogeologic settings found in Indiana. These hydrogeologic settings provide a conceptual model to interpret the sensitivity to contamination of ground water in relation to the surface and subsurface environments. For ground water quality data for 1996, the State of Indiana selected five hydrogeologic settings considered to be highly vulnerable to contamination (i.e., principally outwash deposits or fans of glacial origin) and occurring in largely populated areas (i.e., areas of greatest water demand).

Figure 6-15

Idaho's Hydrogeologic Subareas



Hydrogeologic Subareas

1. North Idaho
2. Palouse
3. Clearwater
4. Long Valley/Meadows
5. Weiser
6. Payette
7. Boise Valley-Shallow
8. Boise Valley- Deep
9. Mountain Home
10. North Owyhee
11. Salmon
12. Central Valley
13. Snake River Plain Alluvium
14. Snake River Plain Basalt
15. Twin Falls
16. Cassia Power
17. Portneuf
18. Upper Snake
19. Bear River
20. Boise Mountains
21. Central Mountains
22. Southwestern Owyhee

Note: Boise Valley Shallow overlies Boise Valley Deep. Snake River Plain Alluvium (SRP) overlies SRP Basalt.

Idaho – Hydrogeologic Subareas

The State of Idaho is divided into 22 hydrogeologic subareas (Figure 6-15) for Statewide monitoring purposes. These subareas represent geologically similar areas and generally encompass one or more of the 70 major ground water flow systems identified within the State. Each flow system includes at least one major aquifer, with some systems being comprised of several aquifers that may be interconnected.

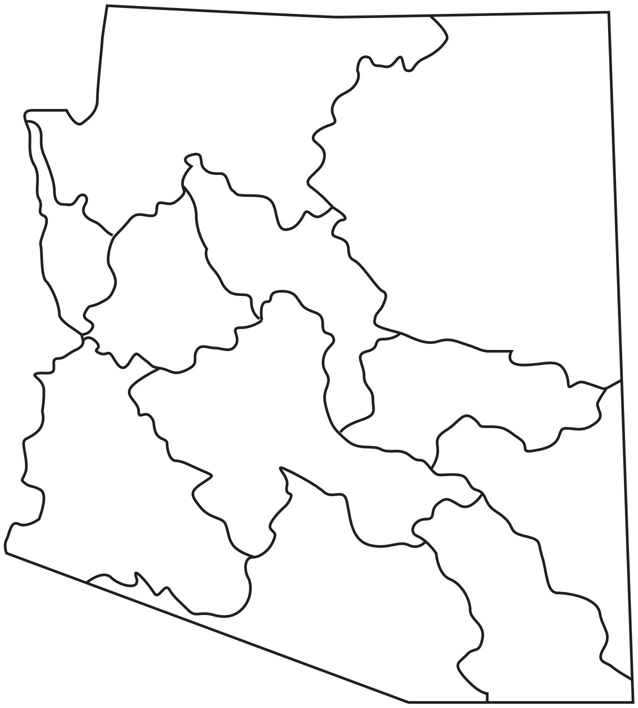
Idaho reported ground water quality data for 20 of the 22 hydrogeologic subareas. Subareas 21 and 22 were not included in 1996 because the ground water in these subareas is used by few people and the aquifer systems are isolated from other major aquifers.

Arizona – Watershed Zone

Arizona presented ground water quality data for all 10 "watershed zones" within the State (Figure 6-16). The watershed zones are delineated along USGS Hydrologic Unit boundaries and correspond to the State's 13 surface water basins. A few surface water basins were combined and one was split to form the 10 watershed zones. Each watershed zone is characterized in terms of several features, including size, population base, hydrologic provinces, ecoregions, ground water basins, hydrology, and geology. Investigations of potential ground water contamination problems have led to site remediation efforts through various State and Federal programs.

Figure 6-16

Arizona Watersheds

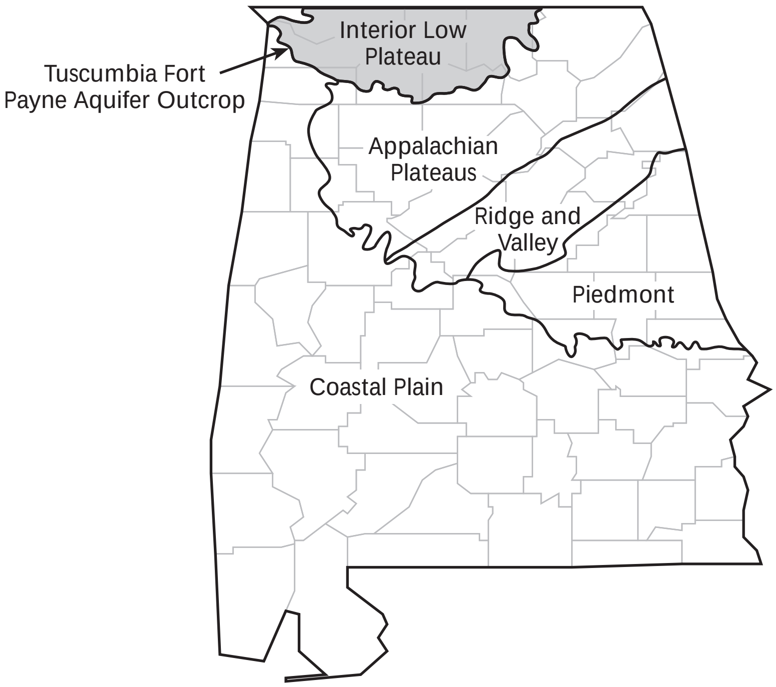


Alabama – Tuscumbia Fort Payne Aquifer

Alabama provided ground water quality data for the Tuscumbia Fort Payne Aquifer outcrop area located in northern Alabama adjacent to the Tennessee River (Figure 6-17). This area is underlain by the Tuscumbia Limestone and the Fort Payne Chert geologic formations. It is considered to be a unique karst area that is highly susceptible to contamination from surface sources. Surface and ground water interaction is fairly rapid due to recharge through sinkholes and other karst features. Because the area is heavily farmed and pesticides associated with farming are used, the Alabama Department of Environmental Management has accumulated ground water monitoring data for this area.

Figure 6-17

Alabama Physiographic Provinces



Texas – Trinity and Dockum Aquifers, Rio Grande Alluvium, and Laredo Formation

Ambient ground water quality monitoring is conducted continuously and extensively throughout the State of Texas. As a consequence, boundaries and various characteristics of all the State's major and minor aquifers have been identified, including water availability, recharge, and geologic formation. In addition, major entities using ground water have been identified within each river basin and the aquifer(s) used, the quality of water being developed, and the quantity of water needed for a 50-year planning period.

For 1996, Texas selected the Trinity and Dockum Aquifers, Rio Grande Alluvium, and Laredo Formation for assessment. These selections represent one major, one minor, and two undifferentiated/local aquifers, respectively. The main selection criterion was to select a range of recently monitored aquifers and to develop an initial methodology for the assessment of the aquifers. The refinement of the assessment methodology for subsequent 305(b) reporting cycles is of primary importance.

Extent of Coverage

States were encouraged to report ground water data for selected aquifers or hydrogeologic settings as part of the 1996 305(b) reporting cycle. EPA recognized that this was not always plausible and as a consequence, recommended that State ground water resources be assessed incrementally over time.

The extent of State coverage will increase as individual States develop and implement plans to assess ground water quality on an aquifer-specific basis. Greater quantities of ground water monitoring data will also become available as States complete source water delineations and source inventory/susceptibility analyses for public water supplies under the Source Water Assessment Program (see Chapter 18).

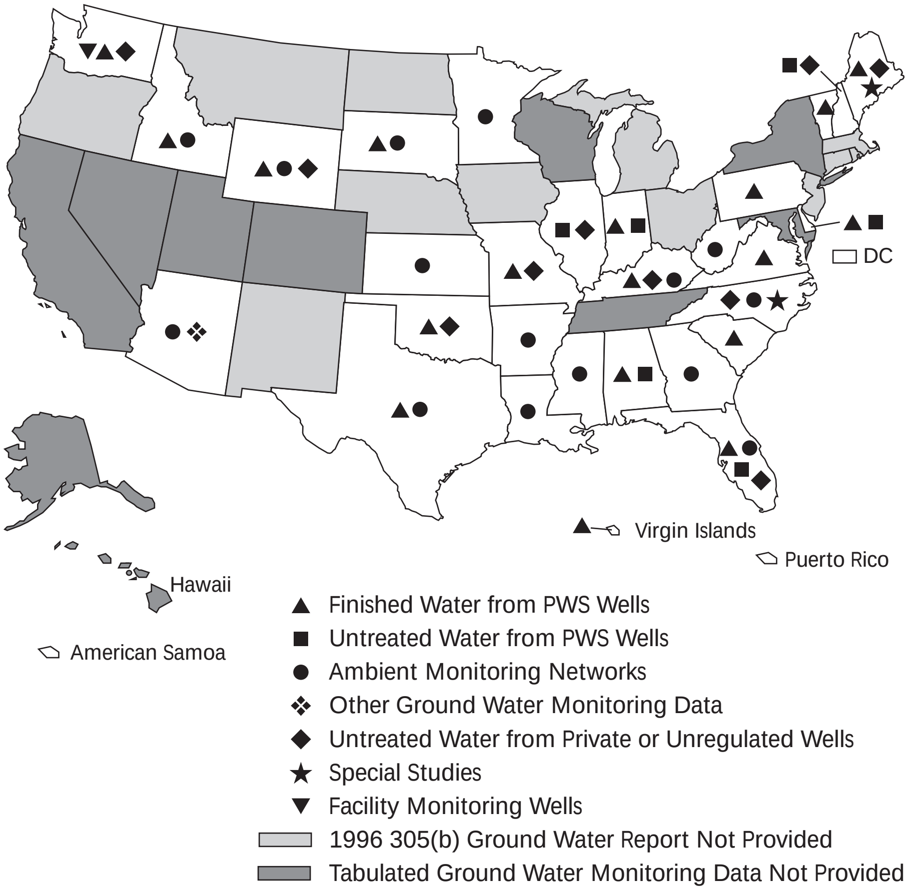
Ground Water Quality Data Sources

EPA recognizes that data collection and organization varies among the States, and that a single data source for assessing ground water quality does not exist for purposes of the *1996 Report to Congress*. As a consequence, EPA suggested several types of data that could be used for assessment purposes (e.g., ambient ground water monitoring data, untreated water from private or unregulated wells, untreated water from public water supply wells, and special studies).

States were encouraged to use available data that they believe best reflects the quality of the resource. Depending upon data availability and the judgment of the State ground water professionals, one or multiple sources of data were used in the assessments. The majority of the States opted to use multiple sources of data. As shown in Figure 6-18, States used data collected from ambient monitoring networks, public water supply systems, private and unregulated

Figure 6-18

Sources of Ground Water Data



wells, facility monitoring wells, and special studies.

Finished water quality data from public water supply systems were the most frequently used source of data (Figure 6-19). Ambient monitoring networks and untreated water quality data from private and unregulated wells were the next frequently used sources of data.

States used a variety of data sources to report on ground water quality. Although there was a strong reliance on finished water quality data from public water supply systems, these data were frequently reported in conjunction with other sources of data to provide a more meaningful assessment of ground water quality than was possible in previous reporting cycles.

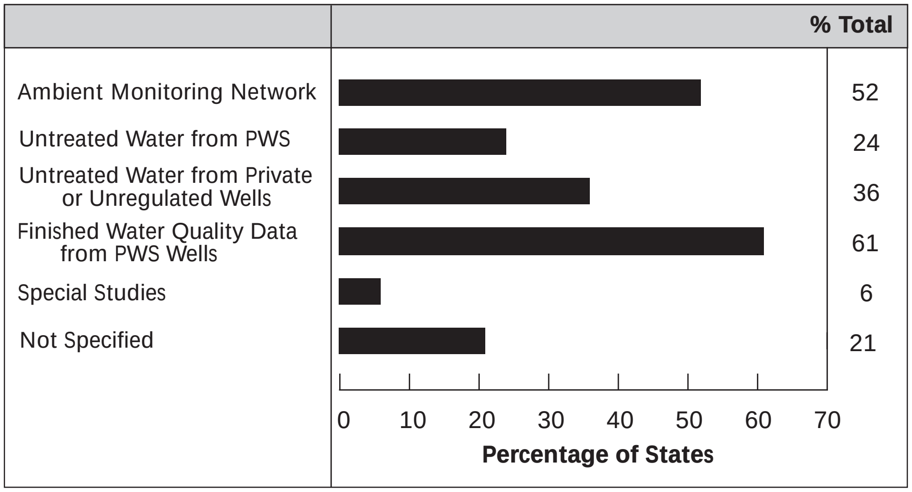
Parameter Groups/Analytes

The primary basis for assessing ground water quality is the comparison of chemical concentrations measured in ground water to water quality standards. For 1996, EPA suggested that States consider using maximum contaminant levels (MCLs) defined under the Safe Drinking Water Act. In general, most States used the MCL concentrations for comparison purposes. Exceptions occurred when State-specific standards were available.

It was not possible for States to sample and analyze ground water for every known constituent. For ease of reporting, EPA suggested that the ground water quality data be summarized into parameter groups. Parameter groups

Figure 6-19

Aquifer Monitoring Data



Note: Percentages based on a total of 33 States submitting data. Some States utilized multiple data sources.

recommended in the 1996 Guidelines include volatile organic compounds (VOCs), semivolatile organic compounds (SVOC), and nitrate. These three groups were recommended because they are generally indicative of contamination originating as a result of human activities. States were also encouraged to report data for any other constituents of interest.

Nationally, more States reported data for VOCs, SVOCs, nitrates, and metals than any other constituent or group of constituents. Parameter groups and individual constituents identified by States in their 1996 305(b) reports are summarized in Table 6-2.

As shown, States reported data for a wide variety of constituents. Organic as well as inorganic and microbial constituents were included in the ground water assessments depending upon State interests and priorities. Although the greatest quantity of data was reported for nitrate and VOCs, it was clear that States were also concerned with SVOCs, pesticides, metals, and bacteria.

Ground Water Quality Data

Ground water quality data reported by States in 1996 represent different sources, often with different monitoring purposes. As a consequence, national comparisons are not appropriate. Rather, ground water quality assessments are performed using comparable data groupings. Data most closely approximating actual ground water quality conditions (e.g., untreated ground water) are given special consideration in these assessments. Specifically, this report focuses on nitrate, VOCs, SVOCs, pesticides, bacteria, and metals. These parameter groups/constituents were selected as they are indicative of ground water degradation as a result of human activities.

Table 6-2. Summary of Parameter Groups/Constituents Reported by States in 1996

Nitrate		
VOC		
SVOC		
Bacteria		
Pesticides		
Radioactivity		
Metals		
Arsenic	Lead	Mercury
Iron	Antimony	Copper
Manganese	Beryllium	Zinc
Barium	Nickel	Strontium
Selenium	Thallium	Vanadium
Cadmium	Cobalt	Silver
Chromium	Molybdenum	Sodium
Inorganics		
Chloride	Magnesium	Boron
Fluoride	Potassium	Hardness
TDS	Aluminum	Silica
Alkalinity	Bromide	Bicarbonate
Calcium	Lithium	Specific Conductivity
Other		
Nutrients	Orthophosphorous	TOC

Nitrate

States reported data for nitrate more frequently than for any other parameter or parameter group. It was the second most frequently cited ground water contaminant after petroleum compounds. Twelve States specifically referenced nitrate as a widespread and significant cause of ground water contamination in their 1996 State Water Quality Reports.

The focus on nitrate as a ground water contaminant is justified. It is soluble in water, and consequently, is easily transported from the soil surface to the underlying ground water resource. Extensive application of nitrate in fertilizer to agricultural lands, residential lawns, and golf courses has resulted in widespread degradation of ground water resources. The misuse of septic systems and improper disposal of domestic wastewater and sludge have also caused ground water contamination. At exposures greater than 10 milligrams per liter, its presence in water can lead to methemoglobinemia or “blue-baby syndrome” (an inability to fix oxygen in the blood). It is also an environmental concern as a potential source of nutrient enrichment in coastal waters.

Table 6-3 presents ground water quality information for nitrate. As shown, 15 States reported nitrate data for ambient monitoring networks. Nitrate was measured at concentrations exceeding the MCL of 10 milligrams per liter in 8 of the 15 States for a total of 26 units and 267 wells impacted by nitrate. Thus, approximately 50% of the reporting States indicated elevated levels of nitrate in ground water collected from

Table 6-3. Nitrates

Monitoring Type	States Reporting	States Reporting MCL Exceedances	Units Impacted by MCL Exceedances	Wells Impacted by MCL Exceedances	Highest Number of Wells That Exceeded the MCL within a Single Unit	Average Number of Wells That Exceeded the MCL within a Single Unit
Ambient Monitoring Network	15	8	26	267	81 out of 681	10
Untreated Water from PWS	7	5	5	85	38 out of 346	17
Untreated Water from Private/Unregulated Wells	10	9	10	2,233	2,000 out of 250,000	23
Finished Water from PWS	18	11	18	230	101 out of 2,806	13
Special Studies	2	2	4	309	288 out of 9,000	No meaningful average

ambient monitoring networks. This percentage is even higher for States reporting data for untreated water from PWS and from private/unregulated wells (i.e., nitrate levels exceeding the MCL were reported by five out of seven States for untreated water from PWS and by nine out of ten States for untreated water from private/unregulated wells).

VOC/SVOCs/Pesticides

VOCs and SVOCs (including pesticides) were cited by States as among the top five contaminants of concern. This is not unexpected given that the number of identified man-made organic compounds totaled near 2 million in 1977 and was believed to be growing at a rate of about 250,000 new formulations annually.*

Organic compounds can be released to the environment through a number of different avenues. Generally, organic compounds are released to ground water via pesticide applications, disposal practices, and spills. As reported in their 1996 State Water Quality Reports, it was disposal practices that generated the most concern among States. Disposal practices that were cited as having the potential to adversely impact ground water quality included landfills, hazardous waste sites, surface impoundments, and shallow injection wells.

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* Giger, W., and P.V. Roberts. 1977. Characterization of refractory organic carbon. In *Water Pollution Microbiology*, Volume 2, Ralph Mitchell (ed.). New York: Wiley-Interscience.

Table 6-4. VOCs

Monitoring Type	States Reporting	States Reporting MCL Exceedances	Units Impacted by MCL Exceedances	Wells Impacted by MCL Exceedances	Highest Number of Wells That Exceeded the MCL within a Single Unit	Average Number of Wells That Exceeded the MCL within a Single Unit
Ambient Monitoring Network	10	7	16	30	5 out of 113	2
Untreated Water from PWS	6	5	5	77	51 out of 80	15
Untreated Water from Private/Unregulated Wells	3	2	5	96	52 out of 80	20
Finished Water from PWS	17	6	13	152	114 out of 603	12
Special Studies	1	1	2	19	9 out of 720	5

The organic compounds that pose the greatest threat to ground water quality are those that are relatively soluble, not easily converted to the vapor state, and not subject to chemical or biological degradation. Their presence in ground water is becoming increasingly pervasive and a cause for national concern due to the carcinogenic effects of many of the organic compounds.

Tables 6-4 through 6-6 present data related to VOCs, SVOCs, and pesticides. As shown, more States reported information for VOCs than for either SVOCs or pesticides. This is consistent with the fact that VOCs are the most frequently detected **class** of organic priority pollutants and they are the most frequently detected **individual** compounds impacting ground water quality at RCRA and CERCLA sites.*

Based on the information presented in Tables 6-4 through 6-6, it appears that ground water contamination by VOCs is indeed more prevalent than either SVOCs or pesticides. Seventy percent of the reporting States (i.e., 7 out of 10 States) indicated that VOCs were measured at levels exceeding MCL values in ground water collected from ambient monitoring networks as opposed to 43% (3 out of 7 States) for SVOCs and 25% (2 out of 8 States) for pesticides. Furthermore, VOCs were

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*Plumb, R.H. 1985. Disposal site monitoring data: observations and strategy implications. In *Proceedings: Second Canadian/American Conference on Hydrogeology, Hazardous Wastes in Ground Water: A Soluble Dilemma*, June 25-29, 1995, Banff, Alberta, Canada.

Table 6-5. SVOCs

Monitoring Type	States Reporting	States Reporting MCL Exceedances	Units Impacted by MCL Exceedances	Wells Impacted by MCL Exceedances	Highest Number of Wells That Exceeded the MCL within a Single Unit	Average Number of Wells That Exceeded the MCL within a Single Unit
Ambient Monitoring Network	7	3	3	5	3 out of 27	2
Untreated Water from PWS	4	3	3	10	7 out of 305	3
Untreated Water from Private/Unregulated Wells	3	1	2	4	2 out of 27	2
Finished Water from PWS	14	3	3	18	14 out of 10,985	6
Special Studies	0	0	0	0	0	0

measured at levels exceeding MCL values in a total of 16 units and 30 wells. Again, this can be compared to SVOCs impacting three units and five wells and pesticides impacting two units and five wells.

As was noted with nitrates, elevated levels of VOCs were found more frequently in untreated ground water collected from PWS and private/unregulated wells. Although VOCs were measured at levels exceeding MCL levels in ground water collected from PWS and private/unregulated wells in only five and two States, respectively, a total of 77 and 96 wells were impacted (Table 6-4). The same pattern was not observed for SVOCs (Table 6-5). Although elevated levels of pesticide were measured in untreated ground water collected from private/unregulated wells, these data include one area known to have been heavily contaminated by pesticide usage (Table 6-6).

Metals

States identified metals as the fourth highest contaminant of concern with respect to ground water degradation. As shown in Table 6-7, metals comprise a broad category of individual constituents that may be present in ground water singularly or in combination, depending on the contaminant source. Although normal background ground water conditions may be characterized by elevated metal concentrations in some parts of the Nation (e.g., southwestern United States), metals are generally considered an indicator of ground

Figure 6-6. Pesticides

Monitoring Type	States Reporting	States Reporting MCL Exceedances	Units Impacted by MCL Exceedances	Wells Impacted by MCL Exceedances	Highest Number of Wells That Exceeded the MCL within a Single Unit	Average Number of Wells That Exceeded the MCL within a Single Unit
Ambient Monitoring Network	8	2	2	5	3 out of 26	3
Untreated Water from PWS	2	1	1	2	2 out of 353	2
Untreated Water from Private/Unregulated Wells	5	4	4	101	76 out of 330	25
Finished Water from PWS	1	0	0	0	0	0
Special Studies	1	1	1	0	1 out of 42	1

water contamination resulting from human activities.

Metals are present in numerous commercial and industrial process and waste streams. Depending on handling and disposal practices, metals can be released to the environment and can impact ground water quality. Because metals are not easily broken down, they tend to be persistent and can affect ground water quality for long periods of time.

Ground water contamination by metals most frequently occurs as a result of improper operation and/or inappropriate design of landfills, disposal of liquid or solid mining wastes or tailings, or ineffective containment of nuclear wastes. States cited landfills, hazardous waste sites, surface impoundments, shallow injection wells, land application, industrial facilities, and mining as prime sources of metal contamination in ground water.

Table 6-7 presents the information reported by States for metals. Metals were most frequently tested and detected in ground water collected from ambient monitoring networks. Eleven States reported metal data for ambient monitoring networks. Metals were measured at concentrations exceeding MCL values in 7 of the 11 States for a total of 33 units and 195 wells impacted by metal contamination. Thus, approximately 65% of the reporting States indicated elevated levels of metals in ground water collected from ambient monitoring networks.

Figure 6-7. Metals

Monitoring Type	States Reporting	States Reporting MCL Exceedances	Units Impacted by MCL Exceedances	Wells Impacted by MCL Exceedances	Highest Number of Wells That Exceeded the MCL within a Single Unit	Average Number of Wells That Exceeded the MCL within a Single Unit
Ambient Monitoring Network	11	7	33	195	42 out of 419	6
Untreated Water from PWS	2	2	4	100	88 out of 272	25
Untreated Water from Private/Unregulated Wells	1	1	3	13	7 out of 26	4
Finished Water from PWS	6	4	10	175	135 out of 706	17
Special Studies	0	0	0	0	0	0

Metals were less frequently tested in ground water collected from either PWS or private/unregulated wells. Still, a total of 100 wells were found to exceed MCL values for metals in untreated ground water collected from PWS wells.

Bacteria

The sixth most common ground water contaminant cited in the 1996 State Water Quality Reports was bacteria. One of the most common sources of bacteria in ground water is septic systems. Other important sources include landfills, animal feedlots, surface impoundments, and pipelines and sewers.

High concentrations of disease-causing bacteria in ground water may be a source of human health problems. The most common diseases spread by these pathogenic bacteria are related to the consumption of contaminated drinking water (e.g., gastroenteritis, campylobacteriosis, and hepatitis).

For purposes of their 1996 State Water Quality Reports, States focused less on bacteria than on other contaminant groupings. Still, one out of the three States reporting data on bacteria indicated levels that exceeded MCL values. As shown in Table 6-8, ground water was impacted by bacteria in 10 ambient monitoring wells. In a special study conducted in the Boise River Valley by the State of Idaho, total coliform bacteria were detected at levels exceeding MCL values in 95 out of 720 samples.

Figure 6-8. Bacteria

Monitoring Type	States Reporting	States Reporting MCL Exceedances	Units Impacted by MCL Exceedances	Wells Impacted by MCL Exceedances	Highest Number of Wells That Exceeded the MCL within a Single Unit	Average Number of Wells That Exceeded the MCL within a Single Unit
Ambient Monitoring Network	3	1	1	10	10 out of 27	10
Untreated Water from PWS	1	1	1	1	1 out of 102	1
Untreated Water from Private/Unregulated Wells	1	0	0	0	0	0
Finished Water from PWS	3	3	3	404	381 out of 3,854	Meaningless
Special Studies	1	1	2	101	95 out of 720	50

This study focused on some of the more densely populated areas in Idaho and documented the threat to shallow ground water resources from historic and current land and water use practices.

Conclusion

Assessing the quality of our Nation's ground water resources is no easy task. An accurate and representative assessment of ambient ground water conditions ideally requires a well planned and well executed monitoring plan. Such plans are expensive and may not be compatible with State administrative, technical, and programmatic initiatives. As a consequence, EPA and interested States developed guidelines for the assessment of ground water quality that took into account the complex spatial variations in aquifer systems, the differing levels of sophistication among State programs, and the expense of collecting ambient ground water monitoring data. The newly developed guidelines incorporated the flexibility necessary to accommodate differences in State programs.

State response to the new guidelines was excellent. Thirty-three States reported ground water quality data for 162 aquifers and other hydrogeologic settings. From this response, it was evident that States welcomed the changes made in 1996. It was also evident that the flexibility purposely incorporated into the 1996 Ground Water Assessment Guidelines yielded a diversity in reported data. This diversity presented a challenge in assessing ground water quality. Some of the more challenging aspects were highlighted in this report. Following are changes that are expected to occur over time to improve our picture of ground water quality:

- State reporting styles varied significantly in 1996. Although this variability was expected, final data interpretation was challenging because data compilations required the use of a single defined data structure. When State data did not exactly conform to this structure, some interpretation on the part of EPA was necessary. With more specific directions and definitions in the Guidelines, States' ability to respond in a more structured reporting style will improve and the need for outside interpretation will lessen.

- As the direction and focus of ground water assessments becomes clearer, State response will grow and more accurate characterization of ground water quality will be possible.

- Because ground water monitoring is expensive, few States have access to ambient ground water quality data. EPA suggested a number of data sources that could be used in the absence of ambient ground water monitoring data. Although finished water quality data from PWS were one of those sources, these data do not provide the most accurate representation of ground water quality. As States continue to develop new sources of ground water data, the reliance on finished water quality data will decrease. Furthermore, it is expected that the variability in data sources and types will decease as States continue program development.

As the direction and focus of ground water assessment in the 305(b) program becomes clearer, State response will grow and more accurate characterization of ground water quality will result. The 1996 305(b) State Water Quality Reports were the first step toward that goal.