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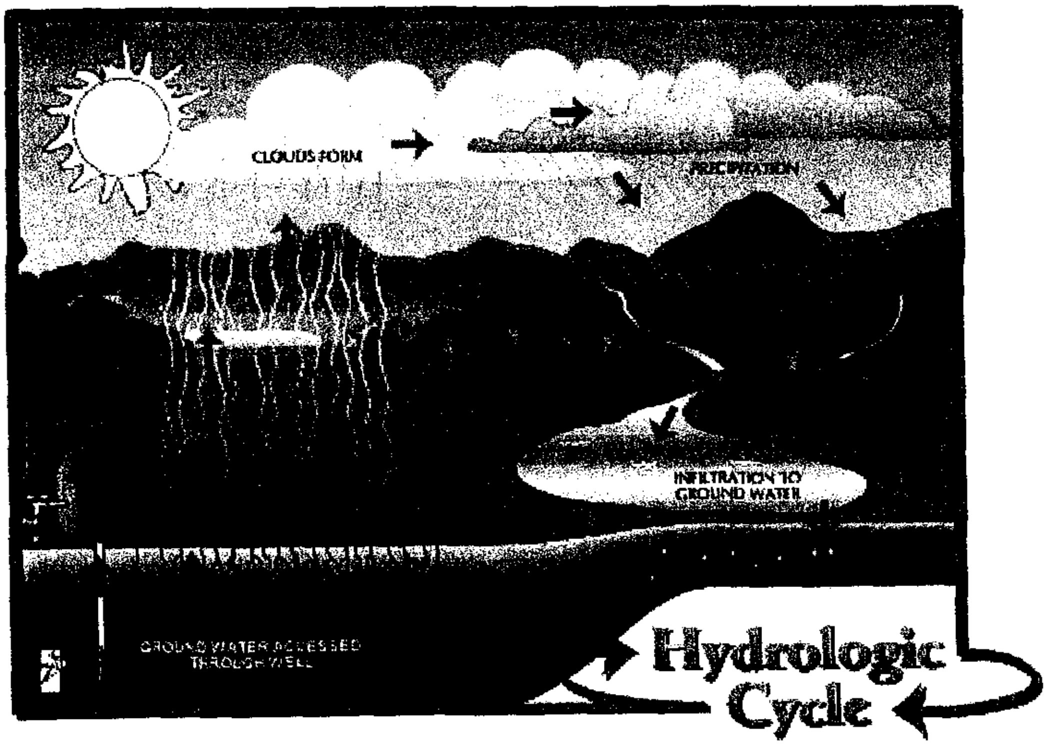
GROUND WATER IN REGION 8 STATES

A Report on the Status of Ground-Water Management and Protection



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GROUND WATER IN EPA REGION 8 STATES

A Report on the Status of Ground-Water Resources, Management and Protection

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2003

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EXECUTIVE SUMMARY

Introduction

Ground water is a critical resource in EPA Region 8, which includes the states of Colorado, Utah, Wyoming, North Dakota, South Dakota and Montana. Ground water is an important source of water for public water supply, agricultural, industrial, and household uses in each of these states. It also serves as a significant source of recharge water for lakes, streams, and wetlands (EPA, 1999).

The purpose of this document is to provide a general overview of the nature and status of ground-water resources within EPA Region 8, including:

- ground-water occurrence and use;
- a description of some common threats to ground-water resources;
- a summary of what EPA and its partners are doing to protect ground water; and
- findings and recommendations compiled by EPA Region 8 staff.

Ground-Water Occurrence and Use

Within the Region 8 states, ground water occurs in two types of geologic formations; unconsolidated surficial deposits and semi-consolidated to consolidated bedrock formations. Unconsolidated deposits include clay, silt, sand and gravel that was deposited in river valleys and intermontane basins. Where these deposits are thick and permeable, they comprise high-yielding aquifers. Ground water that occurs in these types of aquifers is typically directly connected to streams and rivers. Unconsolidated, surficial deposits were the first aquifers to be developed because they were readily accessible and yielded relatively large quantities of water to wells. However, they are also sensitive to contamination from land-use activities. Recharge to these types of aquifers is primarily via infiltration of rain and snow across the areal extent of the aquifer.

Ground water also occurs in the sedimentary bedrock formations (sandstone, siltstone, limestone) that underlie many of the large structural basins that occur throughout the Region 8 states. These bedrock formations comprise aquifers that store large volumes of water but do not yield water to wells as readily as the unconsolidated deposits. Many sedimentary bedrock aquifers will yield only moderate amounts of water, though some sandstone and limestone formations will yield enough water to supply municipal and irrigation wells. Recharge to these types of aquifers is more limited than recharge to surficial unconsolidated aquifers. Ground water also occurs within the fractured igneous and metamorphic rocks that comprise the Rocky Mountains. These aquifers are typically low-yielding and often will not provide significant amounts of water to wells. This is because water only occurs and moves within the fractures within the rock.

The major aquifers and aquifer systems within the Region 8 states have been mapped in detail by the USGS and State Geological Surveys. However the water quality, recharge and discharge areas and flow systems within these aquifers are not as well characterized.

Ground-water use within the Region 8 states is significant. In 1995, more than 3.8 billion gallons of ground water were withdrawn every day for human use. Irrigation and livestock watering accounted for 75% of this use, while domestic and public drinking water accounted for 17% of the total use. From 75% to 90% of public water systems in each state in Region 8 depended on ground water to serve their customers in the year 2000. More than 2.6 million people in Region 8 relied solely on ground water supplied by community water systems in 2000. Another 2.2 million people in Region 8 got their water from community water systems that use both ground water and surface water, in the year 2000. As the population increases in the West, especially in the mountainous areas, ground water use is increasing dramatically for domestic use.

Key Conclusions and Recommendations

Ground-Water Management Should Be Aquifer-Based. Aquifers are the natural units of management for ground water just as a stream, lake or watershed is a natural unit of management for surface water. Ground-water management often proceeds without all parties recognizing that they are managing the same aquifer. This has resulted in a fragmented, often ineffective, and sometimes contradictory, non-resource-based approach to ground-water management. Effective ground-water protection and management relies on recognition by state and local governments that surface water and ground water are hydraulically connected. Watershed management has typically ignored the connection between ground water and surface water, even though ground water can be a critical factor with regard to both the quantity and quality of streams and lakes. Integration of ground-water management and surface-water management at the state and local level is critical.

Monitoring Should Be A Key Element Of Ground-Water Management. There are insufficient data to truly determine the status of ground-water quality for most major aquifers and aquifer systems in Region 8. While there are many monitoring efforts conducted by numerous agencies, there is little consistency in monitoring programs, data are not shared effectively among the programs, various entities are often not aware of monitoring by others, many of the data are not entered on computer databases, and many databases are not compatible. Also, the amount of monitoring being done is very limited relative to the size of the resource. The result is a patchwork of data useful for informed management decisions on a localized, site-specific level, but of less value for making state or region-wide conclusions about status and trends. An up-to-date assessment of the existing data is needed in each Region 8 state to identify data needs so that a more comprehensive, coordinated ground-water monitoring network can be developed to focus on monitoring high priority aquifers or regions.

Prevention of Contamination Is More Effective Than Cleanup. Because cleaning up aquifers after they are contaminated is difficult and expensive, preventing contamination is much more sensible than trying to clean it up. However, federal and state governments spend hundreds of millions of dollars per year on ground-water remediation, and only a few million dollars per year on prevention of contamination. Nationally, the average capital costs for ground-water remediation systems range from a low of approximately $500,000 for passive systems to a high of about $3,500,000 for pump and treat systems (USEPA 1999b and USEPA 2001). Annual operating costs for such systems add an average cost of approximately $70,000 to $700,000 per year. Significantly more money should be allocated to prevention efforts, including:

- public education regarding how contamination occurs;
- assessments of sensitivity and vulnerability of aquifers and ground water;
- well head protection/source water assessment and protection;
- management of recharge areas; and
- ambient monitoring to determine water quality trends.

Non-Point Source Contamination Of Ground Water Is Still A Significant Problem. Federal, state and local governments have made insufficient progress in establishing effective programs aimed at reducing non-point source contamination. The most common non-point source contaminants include agricultural chemicals, sediment and urban runoff.

Effective Ground-Water Management Requires Adequate Funding. Currently, ground-water characterization, monitoring and management is inadequately funded throughout most of the country, including EPA Region 8. As ground-water development and use increases in Region 8 and elsewhere it will be necessary to strengthen the commitment to sustainable development of ground-water resources. In the future, federal, state and local governments will face serious issues related to providing a safe, sustainable water supply to satisfy beneficial uses. Tough decisions will be required related to choosing between: protection versus remediation of ground water, and mining of ground-water resources vs. sustainable development. To prepare for these management issues it is vital to provide adequate funding for ground-water/aquifer characterization, monitoring and conjunctive management of ground water and surface water.

Current Issues in Ground-Water Management

The following are current areas of research related to ground water:

- microorganisms in ground water;
- organic wastewater contaminants such as pharmaceuticals, fragrances, dyes, antibiotics, caffeine, and hormones;
- fractured rock aquifers;
- fuel oxygenates such as MTBE; and
- perchlorate

GROUND WATER IN EPA REGION 8 STATES

I. INTRODUCTION

Ground water is an important resource in EPA Region 8 states (Figure 1), which include Colorado, Utah, Wyoming, North Dakota, South Dakota and Montana. Ground water is a significant source of water for *public water supply*, agricultural, industrial, and *private domestic* (household) uses in each of these states. It is a critical source of water for lakes, streams, and wetlands (U.S. EPA, 1999a). Please note that italicized words are defined in the glossary (Appendix A).

The purpose of this report is to describe the nature and status of ground-water resources in EPA Region 8. It is written for water managers at the city, county, state and federal level, and for the interested public. It includes:

- An introduction to ground-water occurrence and use;
- A description of some common threats to ground-water resources;
- A summary of what EPA and its partners are doing to protect ground water; and
- Findings and recommendations.

I.A. WHY CARE ABOUT GROUND WATER?

Ground water is an essential natural resource. It is water found beneath the Earth's surface, which supplies wells and springs.

Ground water also contributes to flow in many streams and rivers, and helps maintain lake levels. It strongly influences river and *wetland* habitats for fauna and flora. The U.S. Geological Survey estimated that the ground-water contribution to all streamflow in the Nation may be as large as 50% (Winter and others, 1999).

The United States relies heavily on ground water to meet its water needs. Ground water accounts for about 25 percent of all fresh water used in the Nation today. Ground water provides about 40 percent of the Nation's public water supply. It is the source of private domestic (household) water

In the continental U.S. about 86.5% of our *fresh water* is beneath the ground, 13.4% is in lakes, 0.13% is in the atmosphere, 0.05% is glacier ice, and only 0.03% is in streams and rivers! (GWMR 2001). Fresh water is low in salts and is usable for most purposes, as opposed to sea water.

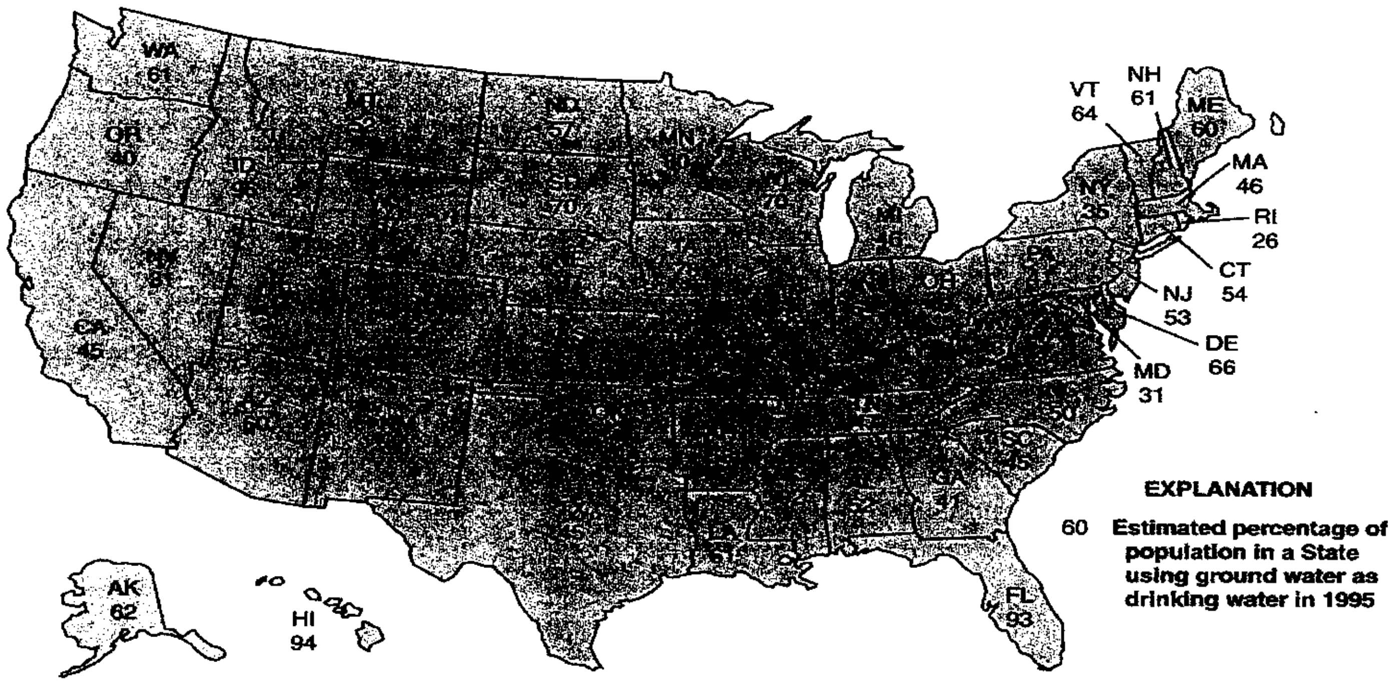


Figure 1. Use of Ground Water for Drinking Water (after Solley and others, 1998)

for more than 40 million people, including most of the nation's rural population. It is a significant source of drinking water in every state in the Nation (Figure 1). Ground water is also the Nation's principal reserve of fresh water and represents much of the potential future water supply.

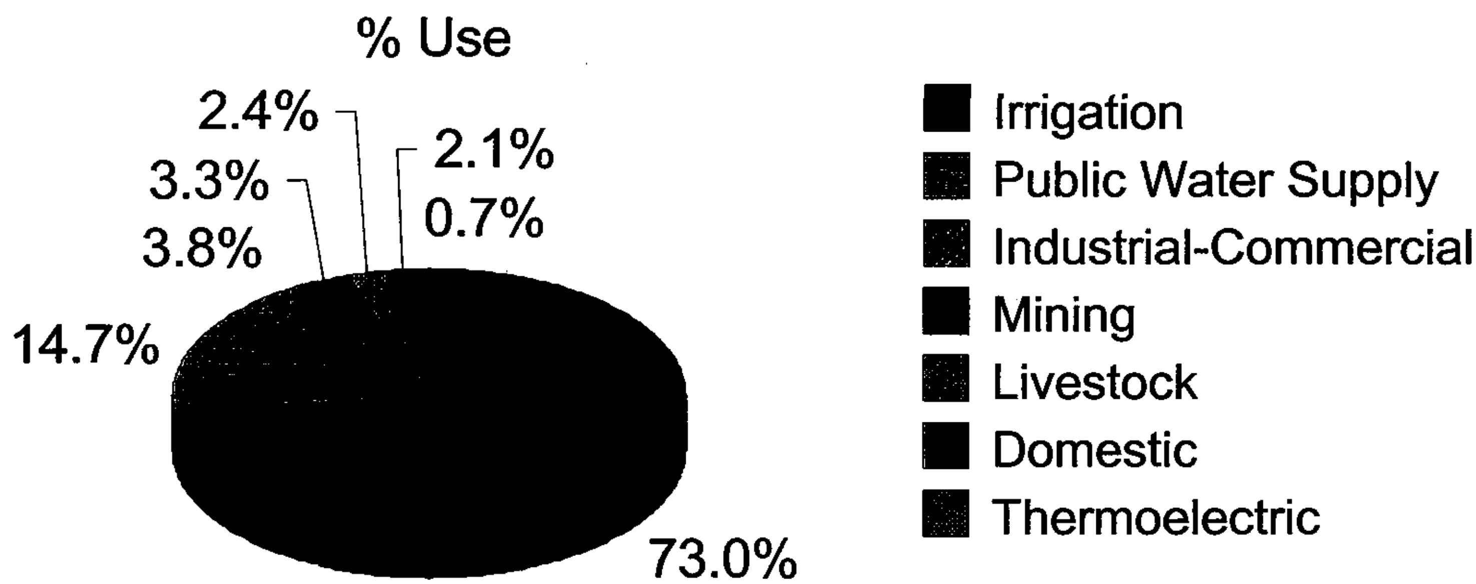
Within Region 8, 78% of the Public Water Systems rely on ground water (U.S. EPA, 2001). Drinking water from ground-water sources is served to about 2.5 million people in Region 8, through nearly 6,000 public water systems. Approximately 1 million rural residents within Region 8 rely on ground water from springs and wells for their private domestic (household) needs (Solley and others, 1998). Since much of the surface water in the *semi-arid* to *arid climates* of Region 8 is already appropriated for use, many areas are relying on ground water to meet the needs of growing populations. Colorado's Denver metropolitan area and Utah's Salt Lake City area are two well-known examples where ground water is being used to meet the demands of rapidly growing urban populations. Ground water is also the source of much of the water used for irrigation in Region 8, supporting millions of dollars worth of food production (Figure 2).

Ground-Water Contamination

In 1991, Russell and others estimated that up to a trillion dollars will be spent in the following 30 years on cleanup of contaminated soil and ground water across the Nation. (Russell and others, 1991)

A recent study by the Worldwatch Institute (Sampat, 2000) reported that toxic chemicals from man-made sources are contaminating ground water on every inhabited continent. This first global survey of ground-water pollution shows that pesticides, nitrogen fertilizers, industrial chemicals, and heavy metals are contaminating ground water. The damage is often worst in the very places where people most need the resource. Since ground water moves slowly through an aquifer, it is commonly difficult to flush out or dilute toxic chemicals. Cleanup efforts are expensive and sometimes unsuccessful.

Figure 2. Fresh Ground-Water Withdrawals by Water-Use Category in Region 8



Source: Solley and others, 1998

Ground-Water Protection

In 1999, EPA released the "Safe Drinking Water Act, Section 1429 Ground Water Report to Congress" (EPA, 1999a). EPA reviewed the status and effectiveness of state ground-water protection programs and examined our Nation's approach to protecting ground water. The findings of this report include:

- From what we know at most locations around the Nation, ground water is generally of good quality but can be threatened by point and nonpoint sources of contamination, as well as depletion by overpumping.
- State water-quality agencies have made considerable progress in implementing federal and state programs aimed at specific contamination concerns.
- Most state agencies responsible for ground-water protection agree that a comprehensive, resource-based approach is best to protect ground water.
- States have identified three primary barriers to achieving a more comprehensive approach:
    1) A fragmentation of ground-water programs among many different state agencies with conflicting priorities and goals, which impedes effective management;
    2) A lack of scientific understanding of ground-water resources both locally and regionally (e.g., the physical nature of the aquifers, behavior of contaminants, interaction of ground water and surface water, etc.); and
    3) A lack of funding targeted directly to protecting ground-water resources. Ground water protection is often not a high priority for funding. Mandated programs usually prevail for funding.

The EPA report concluded that the critical management question is how to increase efforts to prevent new ground-water contamination while concurrently cleaning up contaminated ground water.

I.B. BASIC HYDROGEOLOGY

Ground water is present in *aquifers*, geologic units that are capable of storing and transmiting usable quantities of water to wells or springs (see glossary, Appendix A). The ground water present in aquifers occurs under either *water table (unconfined)* or *artesian (confined)* conditions (Figure 3). Unconfined aquifers have no geologic beds such as clay above them that prevent a ground water connection to the atmosphere. In an unconfined aquifer, the depth to the water table varies from at or near the land surface to hundreds of feet below the land surface. On a

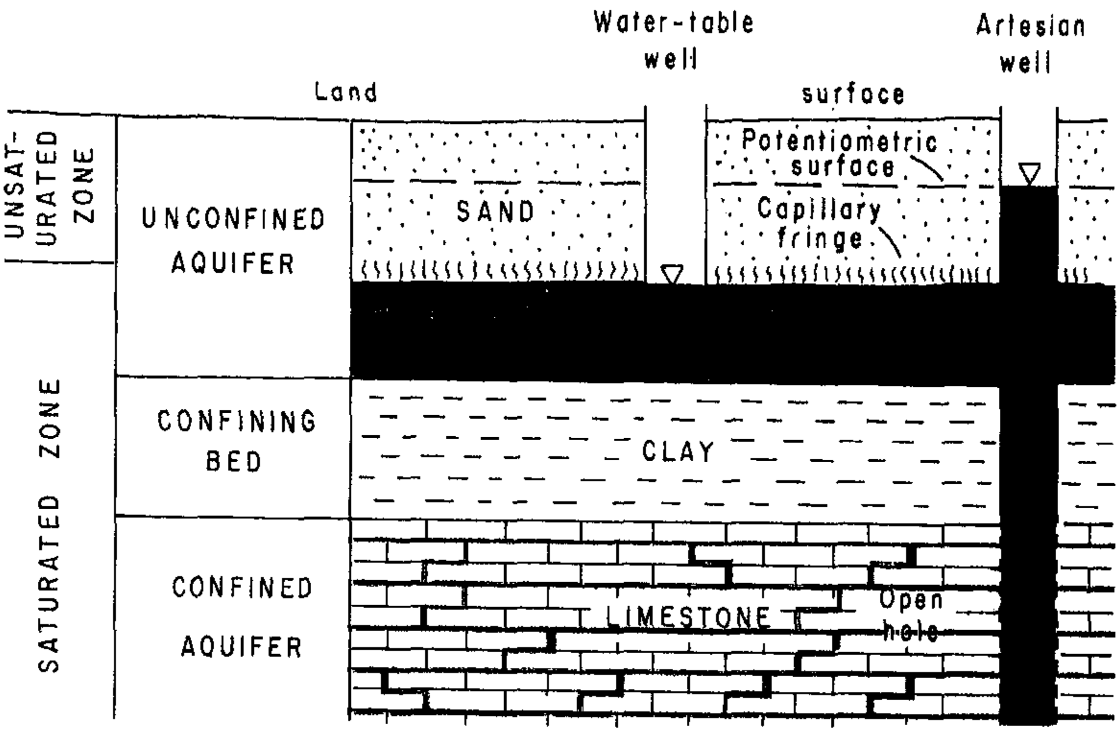


Figure 3. Aquifers and Confining Beds (Heath, 1983)

regional scale the configuration of the water table is commonly a subdued replica of the land-surface topography. Confined aquifers are overlain by geologic material that does not transmit water readily, such as clay. This results in the water in the aquifer being under pressure that is significantly greater than atmospheric pressure.

Ground water interacts with surface water through *recharge* and *discharge* zones (Figure 4). Ground-water recharge occurs where precipitation or surface water infiltrates soil under sufficient *hydraulic head* to reach *saturated zones*. Ground-water discharge occurs as *evapotranspiration* to the atmosphere, or as ground-water flow into streams, springs, lakes, or wetlands. *Hydraulic gradient*, *hydraulic conductivity*, and *porosity* govern the movement of ground water from recharge to discharge zones. Discharge to surface water can occur from *alluvial* deposits into streams, from glacial deposits into lakes, and from aquifers into wetlands. Aquifers may also be hydraulically connected to each other. Major discharge from bedrock aquifers may also occur via large springs.

The areal extent of ground-water flow systems (which may include several aquifers) varies from a few square miles or less to tens of thousands of square miles. The age of ground water increases steadily along a particular flow path from an area of recharge to an area of discharge (Figure 4). In most aquifers, the velocities of ground-water flow generally are low (e.g., feet per year) compared to the velocities of streamflow (e.g., feet per second).

The relatively slow movement of ground water through the subsurface allows long contact of the water with the minerals that make up the geologic units of an aquifer. These minerals will dissolve to a greater or lesser degree so that ground water increases in mineral content along the flow path. Wide variations occur in the chemical character of ground water, even within small regions, due to the many variables in chemical processes of the subsurface. The dissolved minerals in ground water will affect its usefulness for various purposes. However, most ground water contains no suspended matter and fewer bacteria than surface water, making untreated ground water superior in sanitary quality to untreated surface water in many cases (Driscoll 1986).

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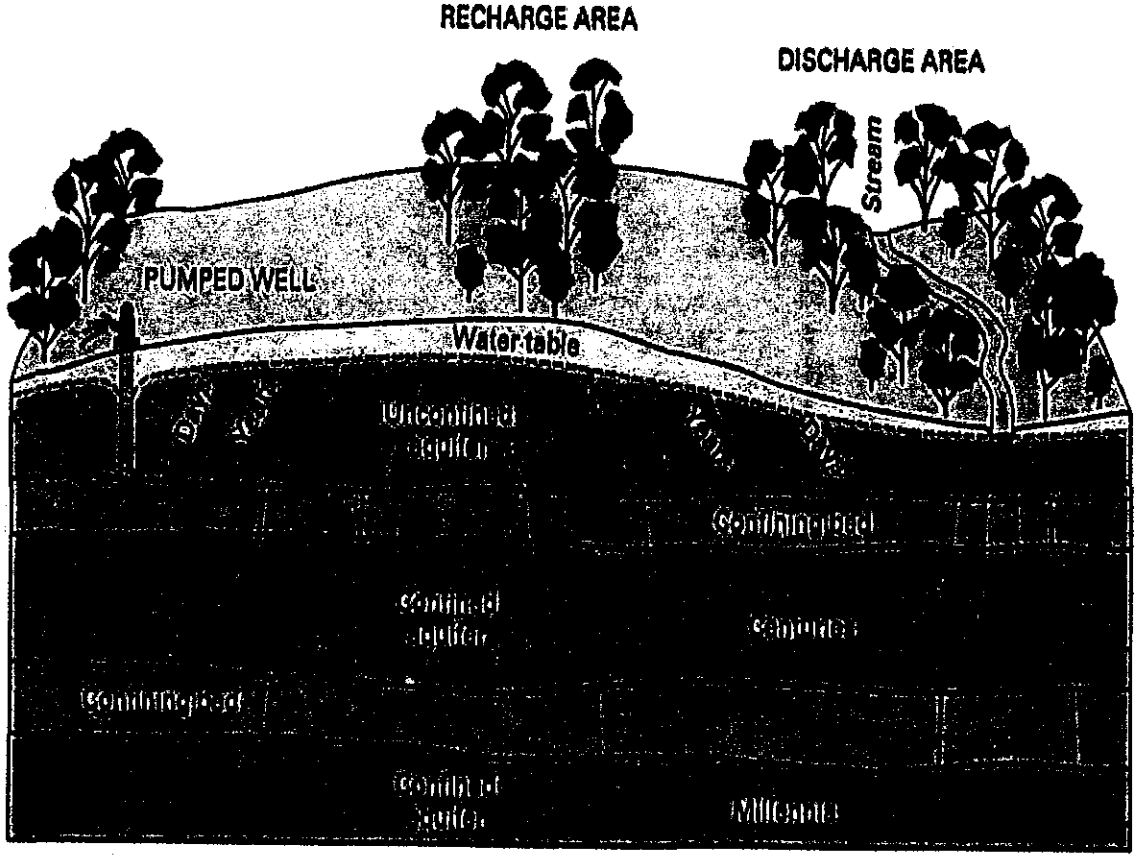


Figure 4. Ground-Water Recharge and Discharge Zones (Winter and others, 1999)

Ground-Water/Surface-Water Interaction

Recently, scientists have become more knowledgeable about the complex interaction that exists between ground and surface water (Figure 5 and Winter and others, 1999). Recent research attention has been focused on the *hyporheic zone*, the subsurface zone beneath a stream or lake where ground water and surface water are in constant interaction. The chemical, biological and hydraulic processes that occur in this zone are very important for maintaining suitable water quality and ecological conditions in overlying surface waters.

Since much ground-water contamination occurs in shallow aquifers that are directly connected to surface water, ground water can be a major and potentially long-term contributor to surface-water contamination.

Understanding this link between ground water and surface water is important for managing both water quantity and quality. Ground water supplies significant amounts of baseflow to streams and rivers for most of the year, and provides inflow to wetlands. Ground-water withdrawals are reducing stream flows in some areas. In 1996, the Montana Department of Natural Resources prohibited ground water withdrawals from 5 basins in order to protect instream flows. Ground water withdrawals from the Arkansas River valley-fill aquifer in Colorado has affected streamflow to such an extent that Kansas sued Colorado for violating the Arkansas River Compact. The U.S. Supreme Court agreed with Kansas.

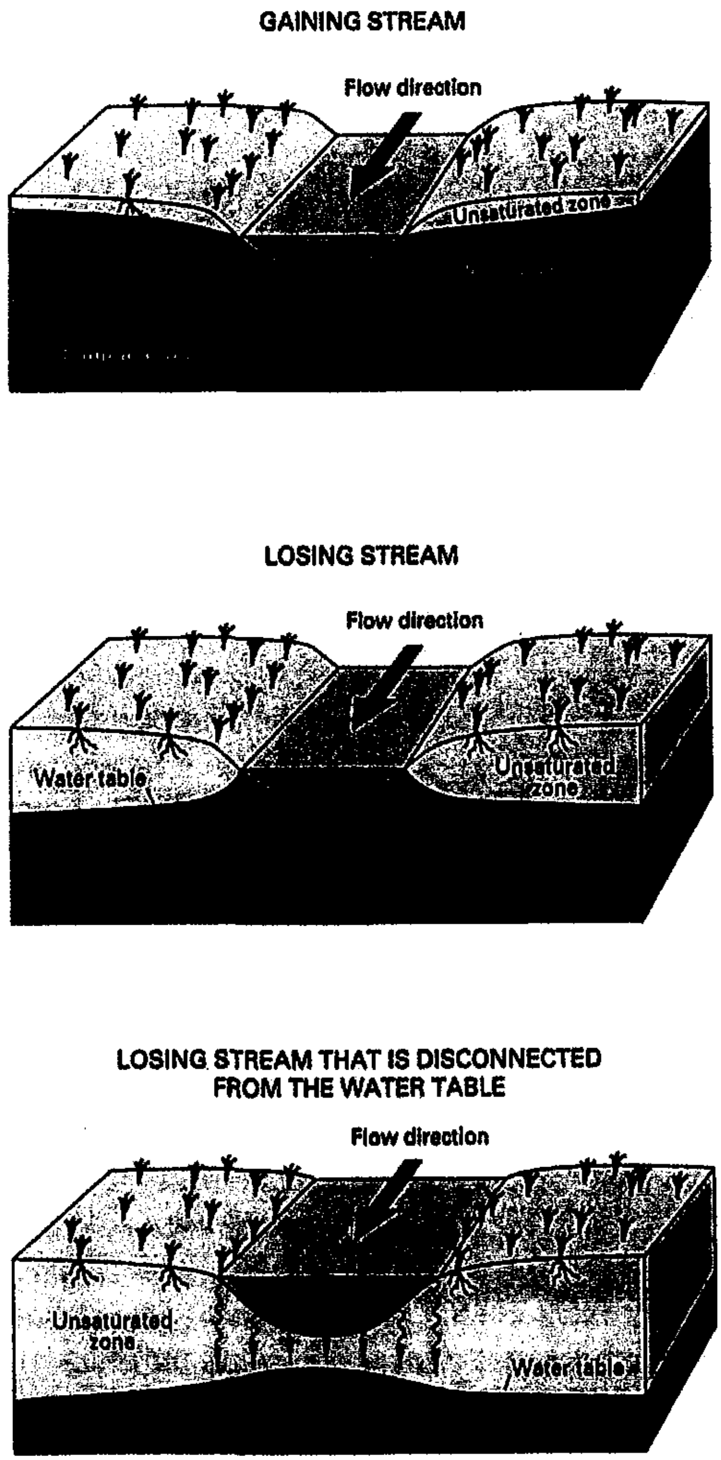


Figure 5. Interaction of Streams and Ground Water (Winter and others, 1999)

I.C. GROUND-WATER CLASSIFICATION

Like the classification framework for surface water that employs a hierarchy of units for resource characterization and management purposes (i.e., watersheds, basins, hydrologic units, etc.), a similar framework for ground water can be useful for understanding, classifying and mapping ground-water resources. The hierarchical classification presented here is based on mappable features that control ground water occurrence, flow and quality. In order of descending scale, the classification units are ground-water regions, hydrogeologic settings, aquifers, aquifer zones, and aquifer sites.

Heath (1984) built on the work of Meinzer (1923) and Thomas (1952) to map 15 ground-water regions in the United States, as shown in Figure 6.

GROUND-WATER CLASSIFICATION SUMMARY

UNIT	DEFINITION
Ground-Water Region	Geographic areas in which the composition, arrangement, and structure of rock units that affect the occurrence and availability of ground water are similar. See Figure 6 (Heath, 1984).
Hydrogeologic Settings	An association of hydrostratigraphic units as defined by mappable hydrogeologic features; these units delineate the typical geologic and hydrologic configurations that are found in each Ground-Water Region.
Aquifers	A water-bearing geologic formation, group of formations, or part of a formation that yields usable quantities of water to a well or spring.
Aquifer Zones	Subdivisions of aquifers with differing hydrologic conditions; includes recharge and discharge areas as well as unconfined and confined areas.
Aquifer Sites	Springs and sinks may be single points, clusters of points, or linear features along streams.

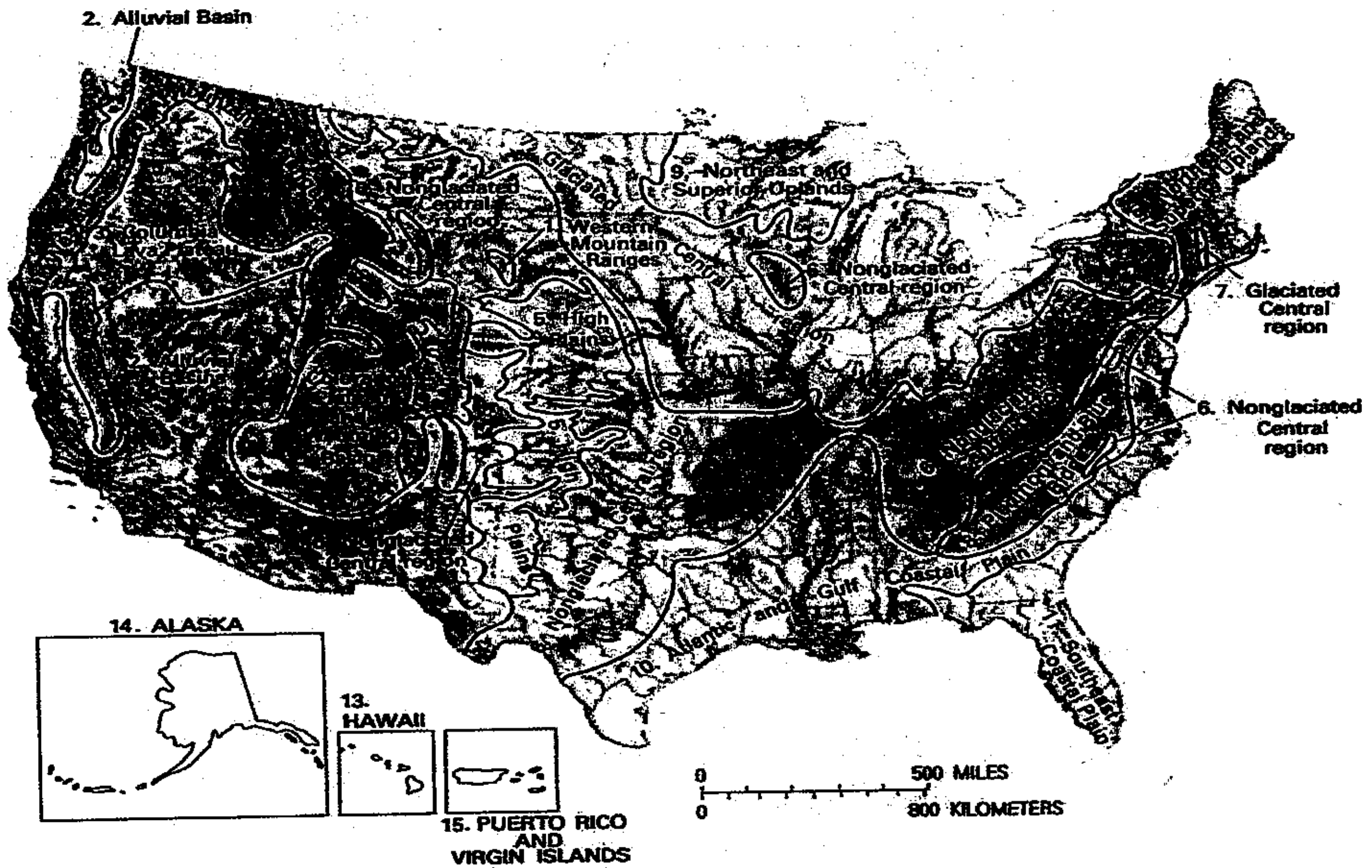


Figure 6. Ground-Water Regions of the U.S. (Heath, 1984)

I.D. GROUND -WATER SENSITIVITY AND VULNERABILITY

The concepts of *ground-water sensitivity* and *vulnerability* are a response to the increasing public concern regarding ground-water contamination, and the need to protect clean ground water from future contamination. A number of methods have been developed to assess the sensitivity and vulnerability of ground water or aquifers. Furthermore, scientists have developed ways to determine vulnerability of ground water or aquifers to water quality degradation by specific contaminants or groups of contaminants. In 1996, the American Society of Testing and Materials (ASTM) published a Standard Guide for Selection of Methods for Assessing Ground Water or Aquifer Sensitivity and Vulnerability (ASTM , 1996).

Ground-water or aquifer sensitivity is the *potential* for ground water or an aquifer to become contaminated based on intrinsic hydrogeologic characteristics. Sensitivity is not dependant on land-use practices or contaminant characteristics. Instead, it is primarily controlled by the hydrogeologic properties and processes on the surface and in the subsurface. Hydrogeologic properties that significantly affect ground-water or aquifer sensitivity include: soil properties, *vadose zone* characteristics, depth to ground water, recharge, aquifer geology and hydrology.

Ground-water or aquifer vulnerability is the relative ease with which a contaminant can migrate to ground water or an aquifer under a given set of land use practices, contaminant characteristics, *and* sensitivity conditions. Vulnerability assessments determine the potential impact to ground water or an aquifer from specific land uses or contaminants.

> **Ground-water sensitivity**: the potential for ground water to become contaminated based on hydrogeologic characteristics such as soil properties, depth to ground water, recharge, etc.
>
> **Ground-water vulnerability**: the relative ease with which a contaminant can migrate to ground water under a given set hydrogeologic and land use conditions.

Sensitivity and vulnerability assessment methods can be applied to a variety of hydrogeologic settings, whether or not they contain specifically identified and mapped aquifers. The methods developed to date are most applicable to hydrogeologic settings or aquifers where intergranular ground-water flow is dominant. These include unconsolidated geologic deposits such as alluvium and terrace deposits, valley-fill aquifers, glacial outwash and consolidated rocks such as sandstone and siltstone. There are very few methods developed for hydrogeologic settings dominated by flow in fractured rocks or flow in solution openings. This is primarily because it is difficult to obtain field data that describe flow in fractured rock settings.

Most methods provide a relative ranking or assessment of sensitivity or vulnerability. It is important to note that a low sensitivity or vulnerability does not mean that ground water or an aquifer cannot become contaminated, nor does a high sensitivity or vulnerability mean that an aquifer is contaminated. Ground-water sensitivity and vulnerability maps have been prepared for aquifers, watersheds, counties, regional areas and even states. It is very important that the scale of the data available for the assessment be compatible with the area to be assessed and the scale of the resulting map products.

Ground-water or aquifer sensitivity and vulnerability assessments can be important tools for land-use planners and water resource managers. Sensitivity maps can help determine the most hydrogeologically acceptable setting for specific land-use activities (e.g., waste disposal, siting of industrial and commercial facilities, agricultural land uses, and urban land uses). Sensitivity and vulnerability maps can also help:

- prioritize ground-water protection and remediation activities,
- prioritize areas for monitoring,
- insure efficient allocation of resources for clean up and restoration,
- point out special hydrogeologic characteristics that may influence clean up efforts, and
- evaluate land-use activities to aid in development of pollution liability insurance.

Ground-water or aquifer sensitivity and vulnerability assessments are not intended to replace site-specific investigations. Specific land-use and planning decisions should be made only after considering site-specific hydrogeologic data and information such as the potential contaminant(s), potential exposure pathways, and population at risk.

II. GROUND-WATER OCCURRENCE AND USE IN EPA REGION 8

II.A. MAJOR AQUIFERS AND AQUIFER SYSTEMS

The United States Geological Survey (USGS) and the State Geological Surveys have delineated, mapped and characterized the major aquifers and aquifer systems in each of the Region 8 states (USGS 1988). Well-maintained data on the development and use of ground water from these aquifers will help assure sound management of the resource. Data should include the sensitivity and vulnerability of the aquifers to contamination, and water quality trends within the aquifers. Tables 1 through 6 include information on geology and water quality for the major aquifers and aquifer systems within each Region 8 state. Figures 7 through 12 are maps of the major aquifers and aquifer systems within each of the Region 8 states. There are numerous USGS and State Geological Survey reports and publications that provide very detailed information on the geology, hydrology and water quality for the aquifers and aquifer systems included in the tables and maps. This report provides only a summary of the major aquifers and aquifer systems.
The USGS Ground Water Atlas of the United States provides more detail on ground water in all states in EPA Region 8 (Robson and Banta, 1995) and (Whitehead, 1996).

TABLE 1

MAJOR AQUIFERS/AQUIFER SYSTEMS IN COLORADO

Major Aquifers and Aquifer Systems	Geology and Water Quality
Arkansas Valley-Fill Aquifer	Unconsolidated, fluvial deposits in a 1-5 mile band along Arkansas River and tributaries. TDS often high, sulfate commonly exceeds SMCL.
South Platte Valley-Fill Aquifer	Unconsolidated fluvial deposits underlying 4000 square miles along South Platte River and tributaries. Nitrate commonly exceeds MCL.
High Plains Aquifer	Unconsolidated to semi-consolidated fluvial deposits. Underlies 13,000 square miles in northeast Colorado. Locally sulfate exceeds SMCL.
San Luis Valley Aquifer System	Very thick unconsolidated to semi-consolidated fluvial and volcanic basin-fill deposits. Shallow unconfined aquifer < 130 feet thick and lower confined aquifer several thousand feet thick
Denver Basin Aquifer System	Four bedrock aquifers (Laramie-Fox Hills, Arapahoe, Denver & Dawson) within a 3,200-foot thick sequence of Mesozoic sedimentary rocks. Laramie-Fox Hills underlies 6300 square miles. TDS increases in lower aquifers, sulfate is high along aquifer margins; hydrogen sulfide and methane occur locally in deeper parts.
Piceance Basin Aquifer System	Two important aquifers underlie 1600 square miles northeast of Grand Junction. Upper aquifer includes stream valley alluvium, the Uinta Fm. and upper part of Green River Fm., lower aquifer is middle part of Parachute Creek member of Green River Fm. TDS, sodium, fluoride, boron and lithium increase with depth. Nitrate, calcium, magnesium and sulfate decrease with depth.
Leadville Limestone Aquifer	Underlies much of northwest Colorado, Flow controlled by fractures and solution openings, many springs discharge from aquifer. Below 1000 feet TDS concentrations increase significantly.

Source: USGS (1988)

MCL is a Primary Maximum Contaminant Level. It is risk-based and enforceable under the Safe Drinking Water Act. It is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.
SMCL is a Secondary Maximum Contaminant Level. This is not an enforceable standard, but a guideline based on taste, odor or appearance.
TDS is Total Dissolved Solids, a measure of the salts in the water. The SMCL for TDS is 500 mg/L.

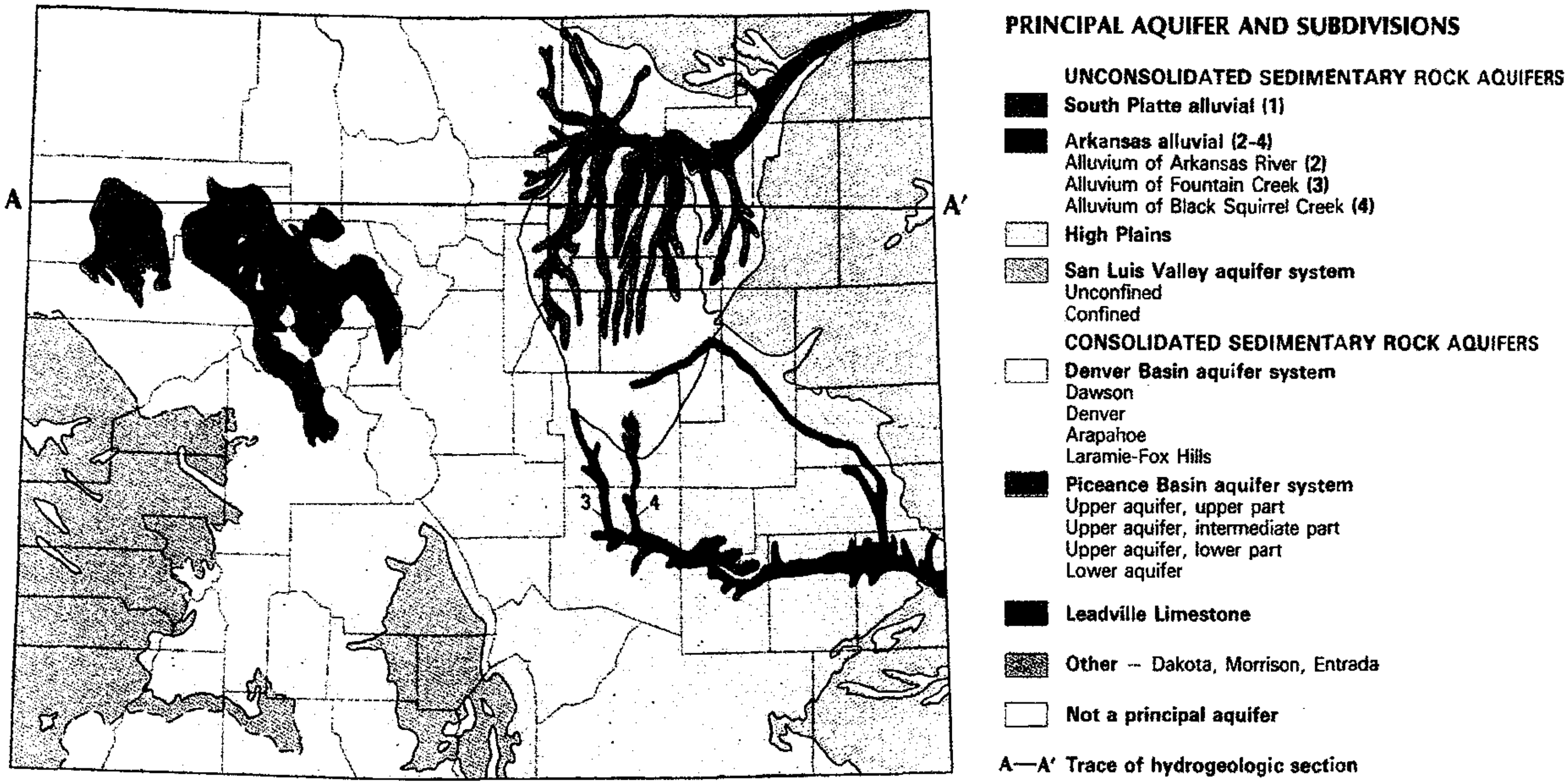


Figure 7. Map of Major Aquifers in Colorado (Modified from USGS, 1988)

TABLE 2

MAJOR AQUIFERS/AQUIFER SYSTEMS IN MONTANA

Major Aquifers and Aquifer Systems	**Geology and Water Quality**
Cenozoic Aquifers	• Western alluvial and basin-fill deposits. Occur primarily along streams, mostly unconfined, TDS generally < 500 mg/l. • Western glacial deposits. Glacial till and glaciolacustrine deposits, generally a few hundred feet thick. • Eastern alluvial deposits and terrace deposits. Generally unconfined, most productive aquifers in eastern Montana, TDS generally > 1000 mg/l. • Eastern glacial deposits. Includes several units, generally unconfined. • Fort Union Formation. Includes several members of Ft. Union, ground water occurs under confined and unconfined conditions, flow is toward local or major surface drainages, TDS commonly > 1000 mg/l.
Mesozoic Aquifers	• Hell Creek/Fox Hills. Includes basal sandstone of Hell Creek Fm and underlying Fox Hills Fm., water is both confined and unconfined, TDS generally < 1000 mg/l. • Judith River Formation. Water is both confined and unconfined. • Eagle Sandstone. Water is both confined and unconfined, TDS commonly > 2000 mg/l. • Kootenai. Confined conditions predominate, TDS commonly < 1000 mg/l. • Ellis Group. Includes several formations, water is both confined and unconfined.
Paleozoic Aquifer	• Madison Group. Includes several formations but Madison Limestone is primary aquifer, typically deep, TDS increases away from outcrop.

Source: USGS (1988)

SMCL is a Secondary Maximum Contaminant Level. This is not an enforceable standard, but a guideline based on taste, odor or appearance. TDS is Total Dissolved Solids, a measure of the salts in the water. The SMCL for TDS is 500 mg/L.

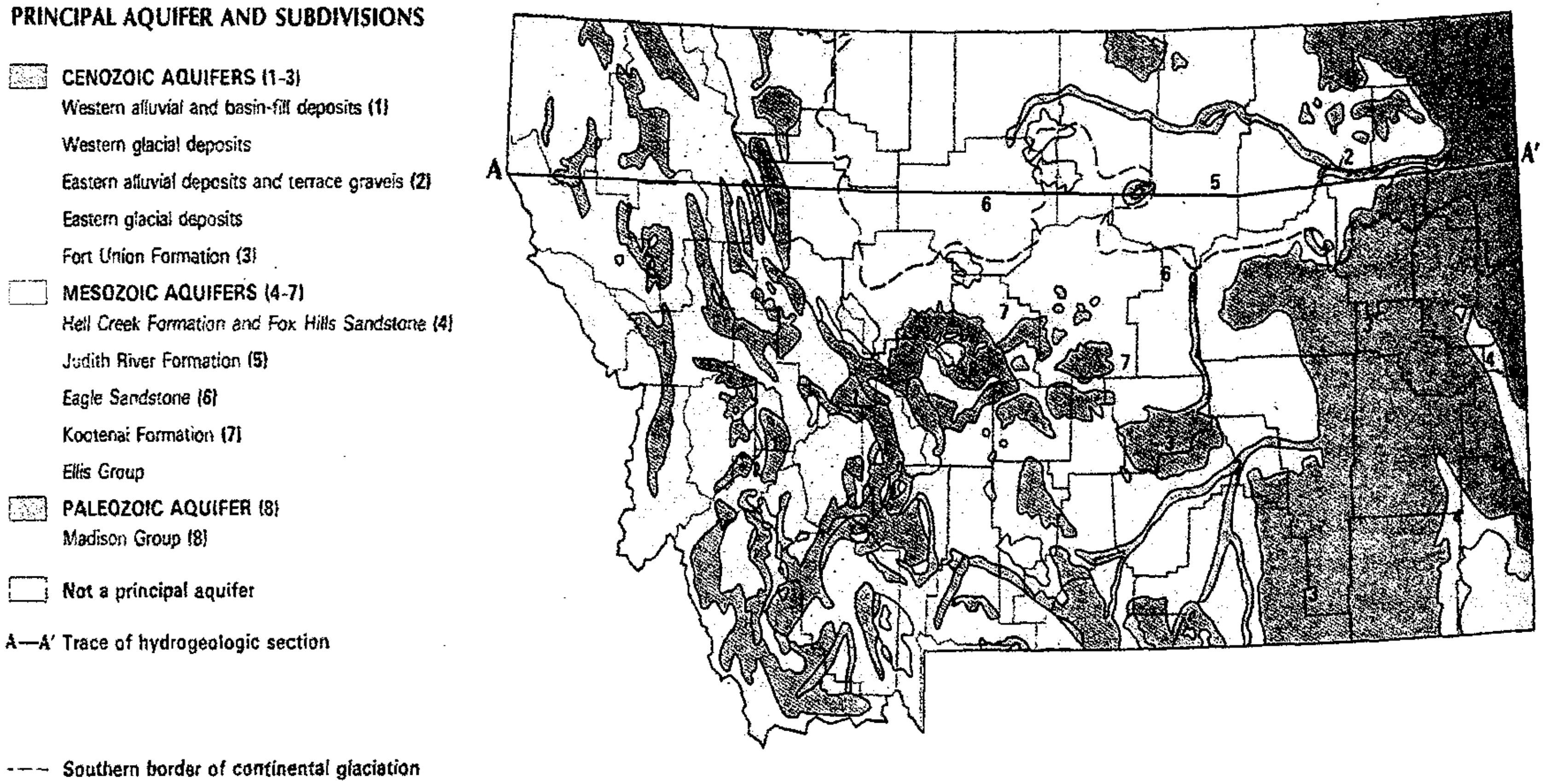


Figure 8. Map of Major Aquifers in Montana (Modified from USGS, 1988)

TABLE 3

MAJOR AQUIFERS/AQUIFER SYSTEMS IN NORTH DAKOTA

Major Aquifers and Aquifer Systems	**Geology and Water Quality**
Unconsolidated aquifers	Includes surficial and deep glacial aquifers and stream alluvial aquifers, often hydraulically connected to underlying bedrock aquifers, TDS greater in deeper aquifers
Fort Union Aquifer System	Uppermost bedrock aquifer system, variable extent and thickness, yield and quality is variable
Hell Creek-Fox Hills Aquifer System	Hell Creek/Fox Hills. Includes basal sandstone of Hell Creek Formation and underlying Fox Hills Formation. Water is both confined and unconfined. Occurs in central and western ND, dependable yields.
Dakota Aquifer System	Underlies most of state but water too saline in west, use restricted primarily to livestock watering in southeast part of State.
Madison Group Aquifer	Aquifer is very deep, high TDS, and not used

Source: USGS (1988)

TDS is Total Dissolved Solids, a measure of the salts in the water.

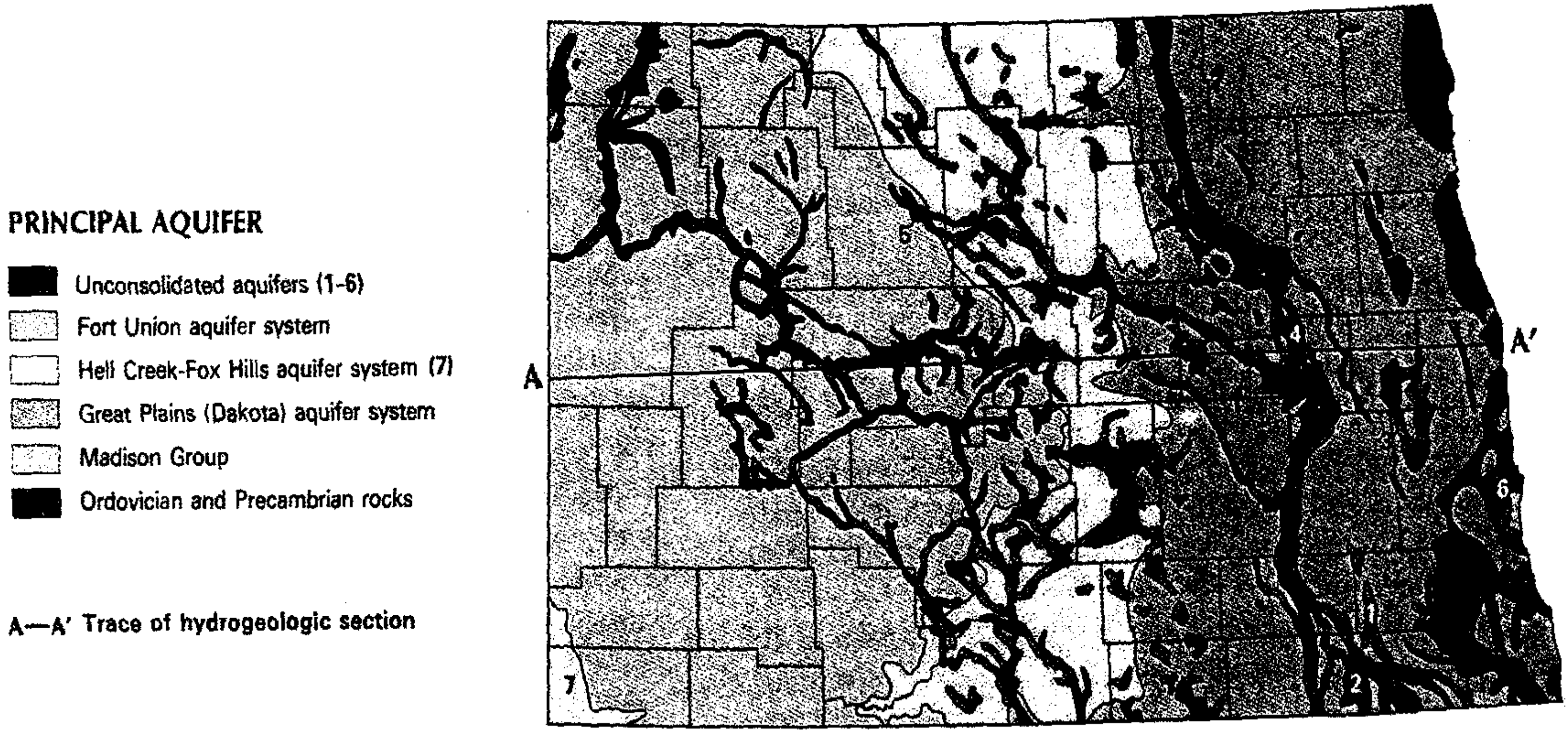


Figure 9. Map of Major Aquifers in North Dakota (Modified from USGS, 1988)

TABLE 4

MAJOR AQUIFERS/AQUIFER SYSTEMS IN SOUTH DAKOTA

Major Aquifers and Aquifer Systems	Geology and Water Quality
Glacial-Drift and Alluvial Aquifers	Occurs mostly in eastern half of state, predominantly glacial outwash and stream alluvial deposits, some buried outwash aquifers, locally nitrate exceeds MCL.
High Plains Aquifer	Occurs in south-central South Dakota, composed of unconsolidated and slightly consolidated sandstone in Ogallala and Arikaree Formations, 90% of use is for irrigation, locally selenium exceeds MCL.
Fort Union, Hell Creek and Fox Hills Aquifers	Occur primarily in northwest part of State, composed of very fine sandstone, generally confined, locally selenium and molybdenum concentrations are high.
Niobrara-Codell Aquifer	Occurs in eastern South Dakota, composed of shale, chalk, and fine-grained sandstone, water is slightly saline.
Dakota-Newcastle Aquifers	Underlie most of State, generally confined and composed of sandstone interbedded with shale and siltstone, primarily used for livestock watering. Water is slightly to moderately saline, TDS typically exceeds 2000 mg/l except in southeast part of State.
Inyan Kara, Sundance, Minnelusa, Madison Red River and Deadwood Aquifers	Aquifers are confined over most of extent, development limited mainly to the area near the Black Hills, elsewhere development limited by great depth. Composed of interbedded sandstones, siltstones, limestones and shales. Fluoride concentrations commonly exceed MCL of 2 mg/L; radium 226 and gross alpha exceed MCL in parts of Madison and Inyan Kara..

Source: USGS (1988)

MCL is a Primary Maximum Contaminant Level. It is risk-based and enforceable under the Safe Drinking Water Act. It is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.
SMCL is a Secondary Maximum Contaminant Level. This is not an enforceable standard, but a guideline based on taste, odor or appearance.
TDS is Total Dissolved Solids, a measure of the salts in the water. The SMCL for TDS is 500 mg/L.

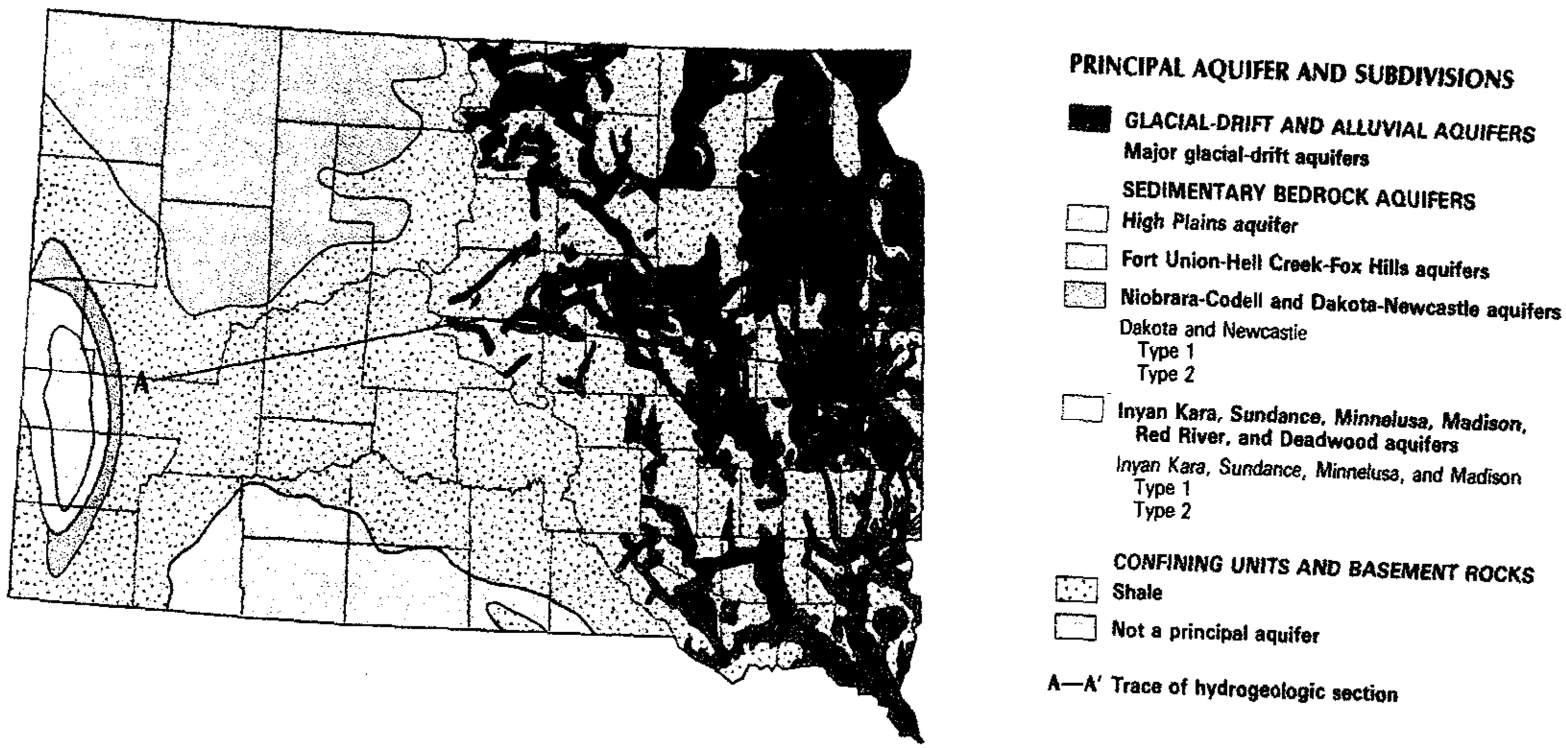


Figure 10. Map of Major Aquifers in South Dakota (Modified from USGS, 1988)

TABLE 5

MAJOR AQUIFERS/AQUIFER SYSTEMS IN UTAH

Major Aquifers and Aquifer Systems	**Geology and Water Quality**
Unconsolidated Basin-Fill and Valley-Fill Aquifers	Occur in 12 intermontane valleys in western Utah. Recharge areas are near mountain fronts and discharge occurs to lakes and playas in central portion of basins. TDS generally less than 1000 mg/L, higher near discharge areas.
Sandstone and Carbonate Rock (Colorado Plateau Aquifers)	Underlie thousands of square miles in southeast Utah. TDS in the sandstones generally less than 1000 mg/L in the recharge area, increasing downgradient with depth. Carbonate aquifer not extensively used.

Source: USGS (1988)

SMCL is a Secondary Maximum Contaminant Level. This is not an enforceable standard, but a guideline based on taste, odor or appearance.
TDS is Total Dissolved Solids, a measure of the salts in the water. The SMCL for TDS is 500 mg/L.

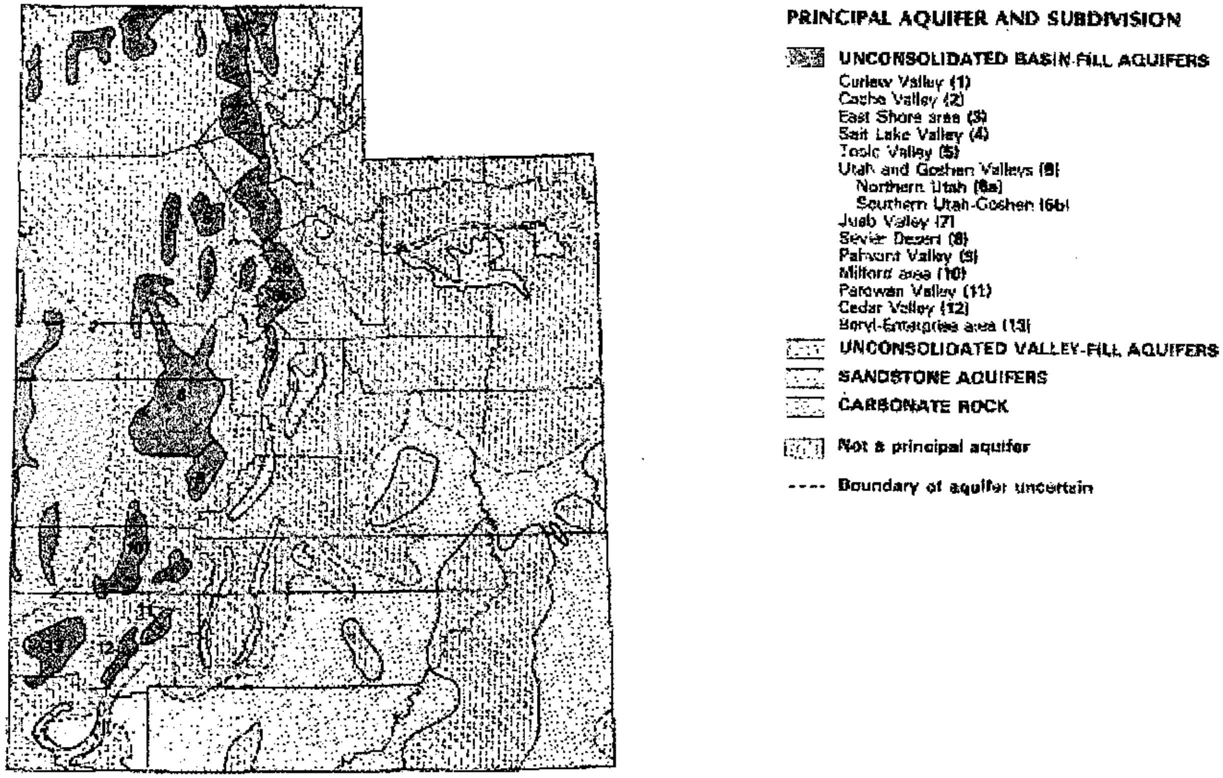


Figure 11. Map of Major Aquifers in Utah (Modified from USGS, 1988)

TABLE 6

MAJOR AQUIFERS/AQUIFER SYSTEMS IN WYOMING

Major Aquifers and Aquifer Systems	**Geology and Water Quality**
Alluvial Valley-Fill Aquifers	Occur in valleys and terraces of most large streams in Wyoming and are generally less than 50 feet thick, TDS generally less than 1000 mg/L, selenium exceeds MCL in some irrigated areas.
High Plains and Equivalent Aquifers	Consist of semi-consolidated sands and gravels and occur in the southeast part of the State. TDS concentrations generally less than 500 mg/L, nitrate exceeds MCL in some agricultural areas.
Sedimentary Aquifers in Structural Basins	Extensive beds of sandstone, coal and shale comprise shallow aquifers within the 13 structural basins in Wyoming. These are the most widespread and most extensively-used aquifers in terms of numbers of wells. Thickness may reach 5000 feet. TDS concentrations typically greater than 500 mg/L.
Carbonate and Sandstone Aquifer System	Also occurs in 13 structural basins, exposed along mountain fronts and buried deeply away from mountain fronts. Thickness may be several thousand feet. TDS is generally low in outcrop areas and higher where buried deeply.

Source: USGS (1988)

MCL is a Primary Maximum Contaminant Level. It is risk-based and enforceable under the Safe Drinking Water Act. It is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.
SMCL is a Secondary Maximum Contaminant Level. This is not an enforceable standard, but a guideline based on taste, odor or appearance.
TDS is Total Dissolved Solids, a measure of the salts in the water. The SMCL for TDS is 500 mg/L.

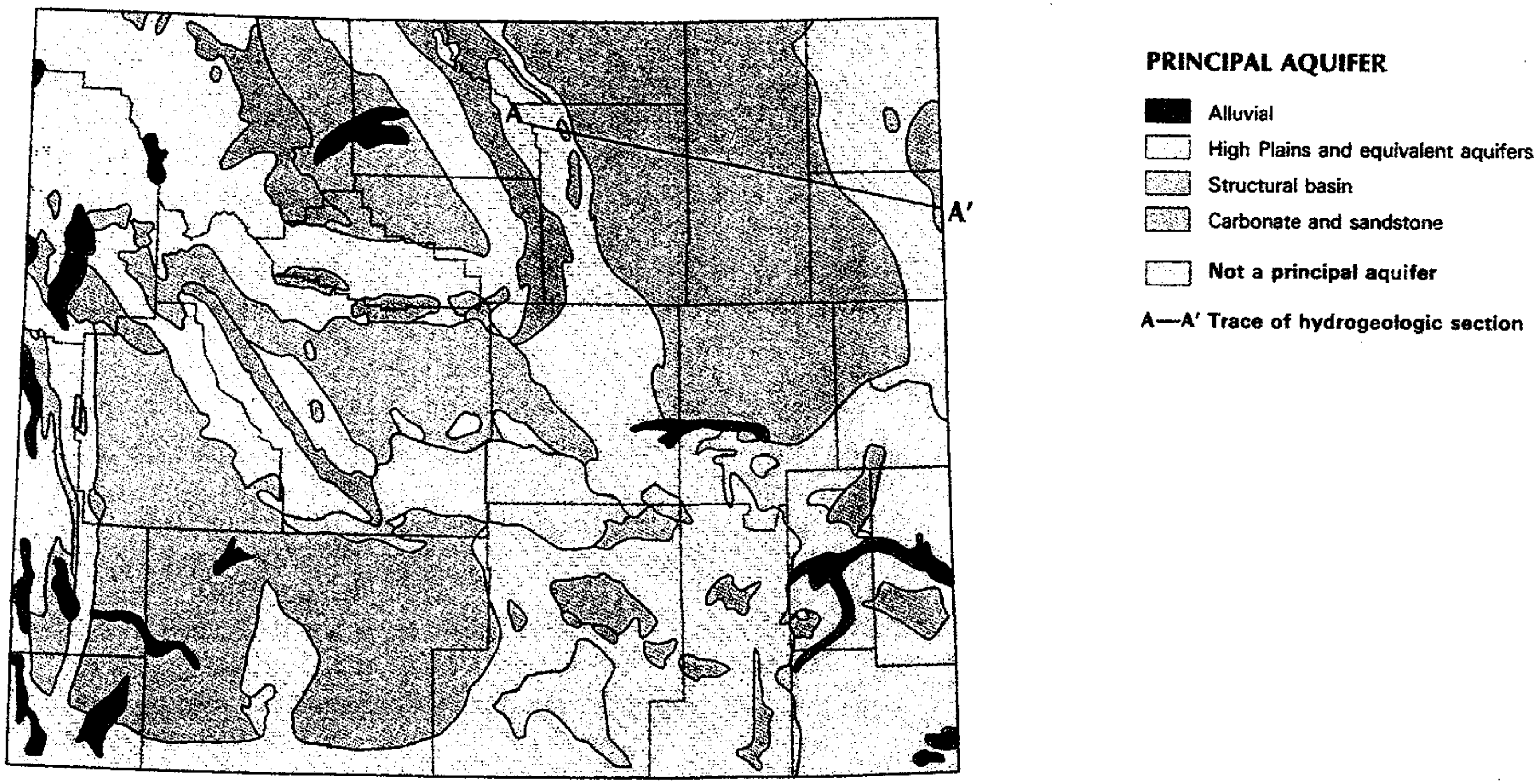


Figure 12. Map of Major Aquifers in Wyoming (Modified from USGS, 1988)

II.B. GROUND WATER USE

Irrigating crops and watering livestock account for approximately 75% of total ground-water use across the Region. Potable water for public water supplies and private domestic uses account for another 17%.

In 1995, more than 3.8 billion gallons of fresh water were withdrawn every day for human use in Region 8 (Table 7). Agriculture and public and private domestic water supply are the most common uses across the Region. Irrigating crops and watering livestock account for approximately 75% of total ground-water use across the Region. Public and private domestic water supply accounts for another 17% (see Figure 2). Other important uses of ground water include direct use by industry, mining, and thermoelectric power generation (Figure 2).

While the top two use categories are the same in all Region 8 states, total withdrawal and use varies considerably (Table 7). For example, in 1995 an estimated 204 million gallons of fresh ground water were withdrawn per day in Montana. About 40% was used for irrigation. By contrast, daily withdrawals in Colorado were more than 10 times greater, and 90% was used for irrigation. More ground water is withdrawn for public water supply uses in Utah than in all of the other five states in the Region combined. Daily withdrawals for public water supply use in Utah were roughly 293 million gallons per day (mgal/day) in 1995. This is almost three times the amount used in the next highest state, Colorado.

Agricultural Use

Agricultural use is the predominant use of ground water in all six Region 8 states. Irrigated agriculture accounts for 73% of the total ground-water withdrawn across the Region (Figure 2), which is approximately 2.8 billion gallons per day (Table 7). Approximately 2 billion gallons of ground water per day were used to irrigate crops in Colorado alone. This accounts for 90% of ground-water use in this state.

Agricultural withdrawals vary significantly from year to year, as shown by USGS water use data from 1985, 1990 and 1995 (Figure 13). Irrigation withdrawals were highest Region-wide and in five of six states during 1990. The most important factor influencing ground water use for irrigation is the amount of water available from precipitation and runoff during the growing season. During years when surface water and precipitation is less available, a larger proportion of the water used for agriculture is withdrawn from the ground. For example, use of ground water for irrigation in South Dakota increased from 85 million gallons per day in 1995 to approximately 137 million gallons per day in 2000 (Amundson 2002), while other uses remained relatively constant. Changes in irrigation techniques to conserve water have contributed to declines seen between 1990 and 1995 in Figure 13 (Solley and others, 1998).

TABLE 7

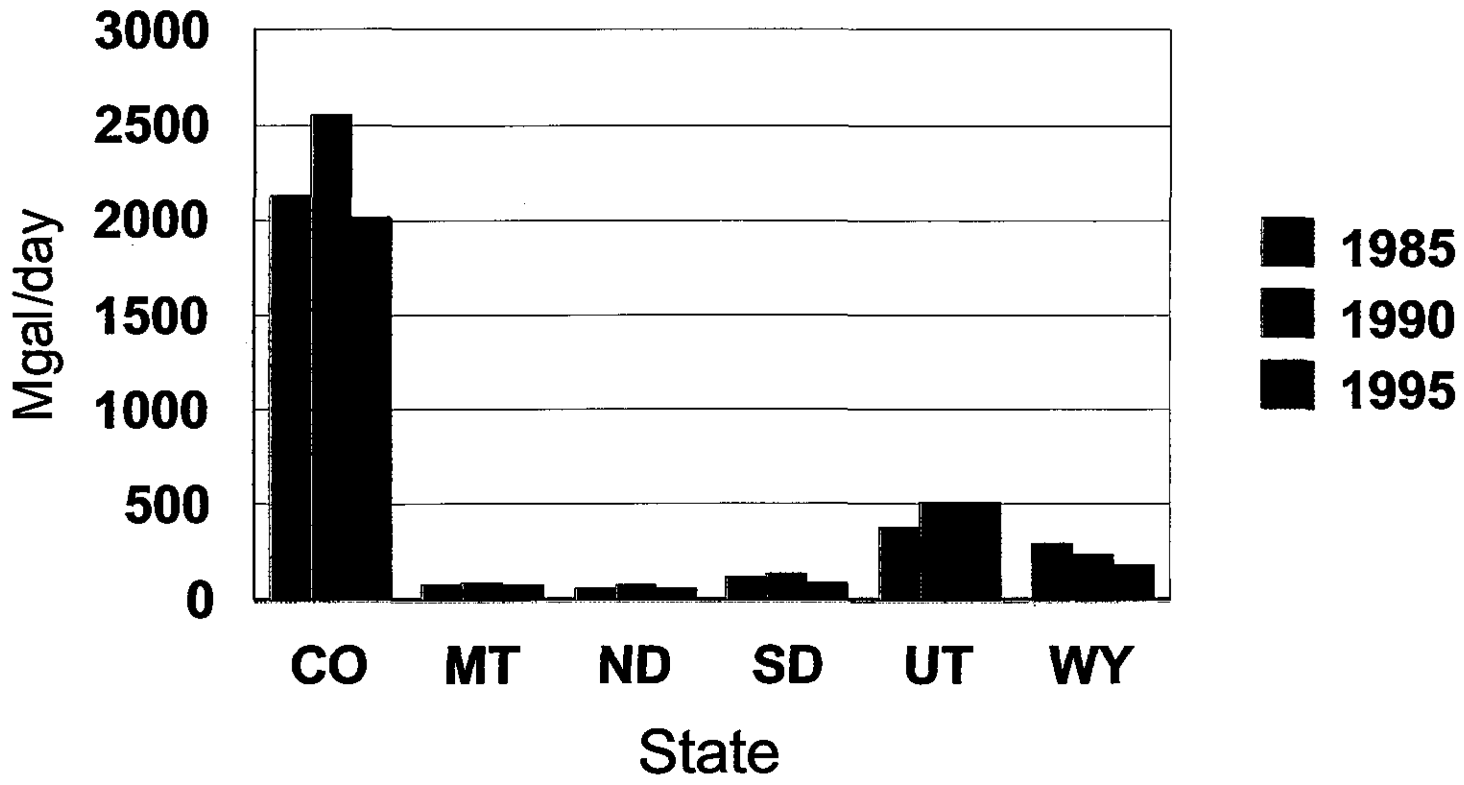
FRESH GROUND-WATER WITHDRAWALS BY WATER-USE CATEGORY AND STATE

1995
Million Gallons per Day

USES	COLORADO	MONTANA	NORTH DAKOTA	SOUTH DAKOTA	UTAH	WYOMING	TOTALS
Public Supply	100	55	30	53	293	38	569
Private Domestic	27	17	12	9.3	7.7	9.7	82.7
Commercial	7.7	0	0.1	6.1	3.8	0.9	18.6
Irrigation	2,020	82	59	85	393	181	2,820
Livestock	23	16	14	18	7.6	13	91.6
Industrial	37	31	3.6	4.1	55	1.6	132.3
Mining	25	2.8	3.8	7.8	16	71	126.4
Thermoelectric	22	0	0.3	3.4	0	1.0	26.7
TOTAL	2,260	204	123	187	776	316	3,866

SOURCE: (Solley and others 1998, page 15). Figures may not add to totals because of independent rounding.

Figure 13. Irrigated Agricultural Use in Region 8 by Year



Source: Solley and others, 1998

Public Water Supply and Private Domestic Water Supply Use

No matter where they live, people need access to clean, safe water in and around their homes. This water is used to meet many needs, such as drinking, cooking, bathing, flushing toilets, and watering landscapes. Throughout Region 8, ground water is a major source of water for these uses. People receive their water either from public water supplies, which serve 25 or more persons, or private domestic water supplies, usually wells, which serve fewer people. Private domestic wells may serve only a single home. Approximately 3.5 million people across the Region relied upon ground water in 1995 (Solley and others, 1998). Public water supply and private domestic water supply combined form the second largest use of ground water for all six states; roughly 650 million gallons were used every day in 1995 (Table 7). This table also shows a state-by-state breakdown of the volumes of ground water withdrawn for both uses. Utah consumes the most ground water for these purposes; withdrawals for public and private domestic water supply combined were more than 300 million gallons per day.

Ground water is an important source for public and private domestic water supply uses in every state in Region 8, providing for over 3.5 million people across the Region in 1995 (Solley and others, 1998).

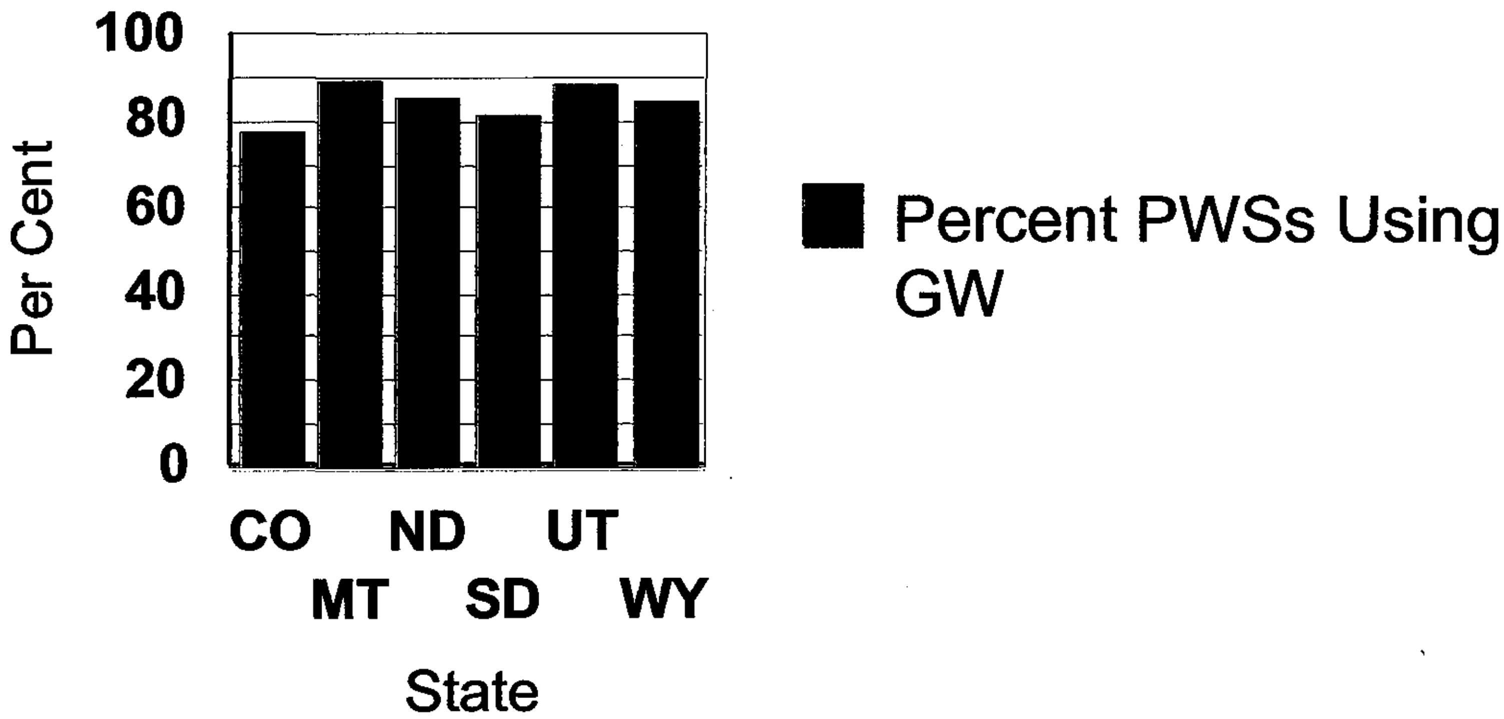
Public Water Supply

Public water supply is the second largest use of ground water in the Region by volume. This use accounts for approximately 15% of total usage (Figure 2), or 569 million gallons per day in 1995 (Table 7). There are different kinds of public water systems. Most familiar is the community water system, which serves people in their homes. The remaining kinds of water systems serve the public where they work, go to school, or at places such as rest stops and camp grounds. All commonly use ground water as their source of supply. Approximately 75% to 90% of public water systems in each state in Region 8 depended on ground water to serve people in their homes, at work, or at play in the year 2000 (Figure 14).

In Region 8, community water systems serving 100,000 or more people typically rely on surface water for their source. However, most other community water systems rely on ground water (USEPA, 2001a). More than 2.6 million people in Region 8 relied solely on ground water supplied by community water systems for drinking, bathing, cooking, and watering their lawns in the year 2000. Another 2.2 million people in Region 8 got their water from community water systems that use both ground water and surface water, in the year 2000. (Hutchinson, 2002)

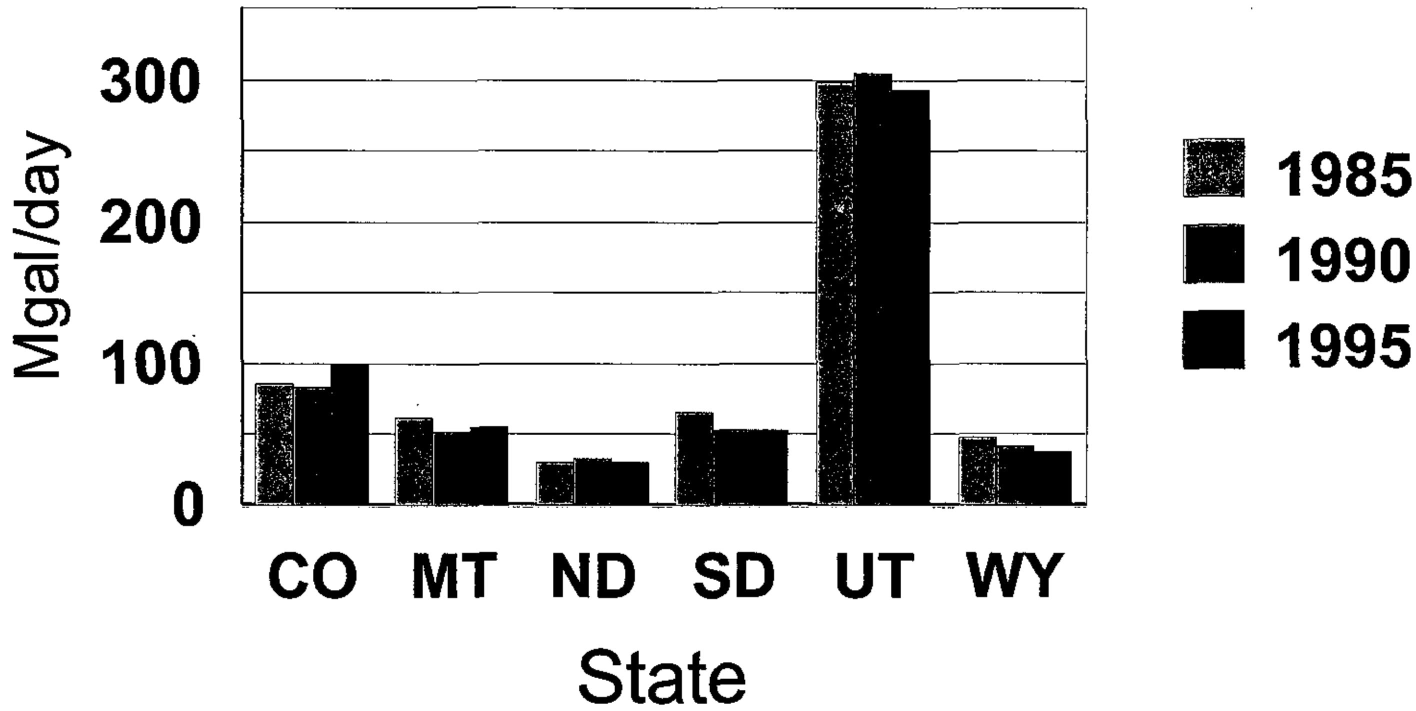
Trends in ground-water use for public water supply have been highly variable from state-to-state from 1985 to 1995 (Figure 15). Colorado has seen a marked increase in ground-water withdrawals for public water supply. In general, other states have generally held steady or declined. While new public water systems using ground water have been created in each state during this time period, others have switched over to surface water, often in conjunction with consolidation of smaller public water systems into larger, regional systems. This has created variable trends among the states as seen

Figure 14. Region 8 Ground-Water-Based Public Water Supplies by State



Source: USEPA 2001a

Figure 15. Public Water Supply Use in Region 8 by Year



Source: Solley and others, 1998

in Figure 15. Notably, over the period from 1985 to 1995 there was also a decrease in per capita water use, the first such decrease since 1950 (Solley and others, 1998).

Private Domestic Water Supply

People living outside of established urban or suburban areas commonly have private wells for their domestic water needs. Water use information derived from Public Water Systems does not include ground-water use from private springs and wells. Approximately 1 million people in the Region relied on ground water from private wells for drinking, bathing and other domestic uses in 1995. The number of people using private wells varies considerably from state-to-state; Figure 16 shows the estimated population served in each state by private domestic wells over the decade from 1985-1995.

The rural population, using private wells, has increased notably in Colorado, Utah, and Montana from 1990 to 1995. Population growth in rural areas results in more and more residents relying on their own wells to provide water. For example, in Colorado private domestic withdrawals increased by about 60% over this time from 17 mgal/day to about 27 mgal/day (Solley and others, 1998).

Ground-Water "Mining"

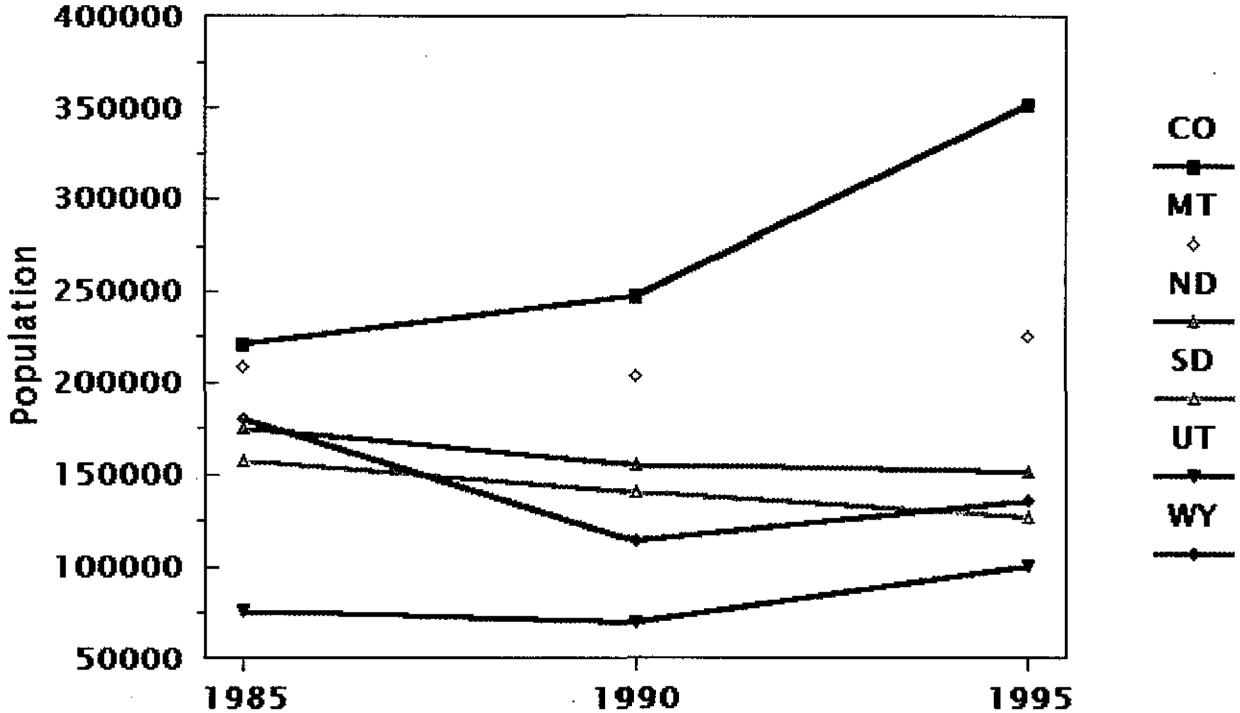
There are large volumes of ground water in Region 8. However, the quality of the water stored in the aquifers, and the ease with which it may be withdrawn, limits the use of these resources. The amount of ground water available to wells at any given time is based on complex processes involving hydrology, climate and geology. Natural fluctuations in water levels are common in aquifers. These generally depend on a balance between discharge and recharge to maintain levels within a certain range. Human activities can affect ground-water levels, particularly when withdrawals exceed the natural recharge rate of an aquifer or portion of an aquifer.

The term ground-water "mining" or overdraft describes situations where withdrawals and net discharges from an aquifer exceed the rate of recharge. Individual aquifers, or portions of aquifers, that are being depleted at rates greater than natural recharge are common across the Region. For example, declines in water levels between 1940-1980 in the heavily used High Plains Aquifer are more than 100 feet in many areas. Since 1980, advances in irrigation technology, such as the use of center pivot irrigation systems, and improved management practices have reduced ground-water pumpage throughout much of the aquifer. This has slowed the rate of water-level decline, but overdraft conditions still exist. The cost of drilling new, deeper wells in areas of water-level decline can often become economically prohibitive. Thus, the depletion of aquifer levels is a growing problem in areas such as Douglas County, Colorado and Salt Lake City, Utah, and in some agricultural areas.

Approximately 1 million people in the Region relied on ground water from private wells for drinking, bathing and other domestic uses in 1995.

Figure 16. Rural Domestic Ground Water Use

Estimated Population using Ground Water
from Rural Domestic Wells and Springs



Source: Solley and others, 1998

The impacts of these overdrafts are becoming increasingly apparent. Many wells on the edges of the Denver Ground Water Basin south and east of Denver are beginning to dry up due to extensive development. Elsewhere, overdrafts and consequent water-level declines are impacting stream flow in rivers such as the Arkansas River in Colorado. In Montana, the State Engineer closed 23 basins from additional surface water withdrawals. Five of these basins are also closed to additional ground-water withdrawals, in order to maintain streamflows sufficient for basic ecological functions.

The ground-water use data discussed in section II.B of this report do not include data for the year 2000. The USGS is currently compiling data for ground-water use in each of the 50 states for the year 2000. The data summary, expected to be available as a USGS report in 2003, will be used to update this report. During the interim period, information on ground-water use in the Region 8 states can be obtained from State Engineers Offices and local USGS offices.

III. GROUND-WATER QUALITY IN REGION 8

III.A. NATURAL GROUND-WATER QUALITY

Natural ground-water quality varies between and within aquifers, depending on such factors as the type of rock or sediment through which the water flows and local biological and chemical conditions. Freeze and Cherry (1979, Chapters 3 and 7) and Hem (1985) offer good discussions of natural water quality.

Total dissolved solids (TDS) concentrations reflect the amount of dissolved minerals found in water. TDS is primarily the result of chemical interactions between ground water and the rocks or sediments through which the water moves. Sodium, magnesium, calcium, chloride, bicarbonate, and sulfate make up more than 90% of the TDS in uncontaminated water (Freeze and Cherry, 1979). In some areas in Region 8, the use of ground water for human consumption and agricultural purposes is limited by high TDS.

EPA has set a recommended TDS standard of 500 mg/L (parts per million) for drinking water. The 500 mg/L standard is a secondary standard for public water supplies. It is not an enforceable standard, but a guideline based on taste, odor, or appearance. Concentrations above 1,000 mg/L are not uncommon in aquifers in each of the Region's states. For example, on the Fort Peck Tribal Reservation in Montana, ground water with TDS greater than 1,000 mg/L is sometimes consumed. Surface waters are not dependable because of scanty and erratic precipitation. Shallow ground water is available on most of the Reservation; however, where it is found, it is often of poor quality. In addition, the ground water in the confined bedrock aquifers underlying the Reservation is not a highly developed source because of high to very high salinity and other mineral content. Of a sampling of wells in select areas on the Reservation, all wells greater than 100 feet deep had TDS greater than 1,000 ppm.

The amount of TDS in ground water is important for management of the resource because most State ground-water classification schemes are based on TDS (see section IV.B).

Other naturally-occurring constituents in ground water include potassium, iron, manganese, fluoride, arsenic, and radon. In high concentrations, these substances may stain fixtures, cause incrustations to develop on pipes and fixtures as solids precipitate, affect the taste and color of water, and may adversely affect human health. Some aquifers in the Region contain water that exceeds EPA drinking water standards for some of these constituents (see tables in Section II.A). High naturally-occurring concentrations of fluoride, for example, are common in the bedrock aquifers in western South Dakota.

III.B. CONTAMINATION AND THREATS TO GROUND WATER

Human activities associated with agricultural, mining, industrial, rural and urban land uses affect ground-water quality in Region 8. Ground-water contaminants include a variety of organic and inorganic constituents including nutrients (e.g., nitrate, phosphate), volatile organic compounds (e.g., benzene, solvents), pesticides, metals, dissolved solids, bacteria, and viruses. Examples of human activities that can impact ground-water quality are summarized in the following sections. For a comprehensive discussion of all sources of ground-water contamination, see USEPA (1990).

Sources of Ground-Water Contamination

Each State in Region 8 is required by the Clean Water Act Section 305(b) to submit a report about water quality every two years. Ground water was included in these reports for the first time in the year 2000 report from each state.

Each report has a summary of selected potential sources of ground-water contamination, which include point sources and non-point sources. The significance of the sources is ranked by:

- the number of source types;
- the location of sources relative to ground water withdrawn for human consumption and agricultural purposes;
- the size of population;
- relative risks posed to humans;
- the hydrogeologic sensitivity or vulnerability of specific aquifers; and
- the findings of state and federal ground-water monitoring efforts.

Table 8 summarizes the most problematic contaminant sources. Each state report is referenced below.

- **Colorado.** "Status of Water Quality in Colorado 2000", October 2000, Prepared by the Water Quality Control Division with assistance from Mesa Technical Consultants.

- **North Dakota.** "North Dakota Water Quality Assessment, 1998–1999. The 2000 Section 305(b) Report to the Congress of the U.S.", by the North Dakota Department of Health, Division of Water Quality, Bismarck, ND.

- **South Dakota.** "The 2000 South Dakota Report to Congress, 305(b) Water Quality Assessment, Water Years 1995-1999", Prepared by South Dakota Department of Environment and Natural Resources, Pierre, South Dakota.

- **Montana.** "Montana Water Quality 1998". 305(b) Report.

- **Utah.** "Utah Water Quality Assessment Report to Congress 2000", Division of Water Quality, Department of Environmental Quality, September 2000.

- **Wyoming.** "Wyoming's *2000 305 (b)* State Water Quality Assessment Report", Wyoming Department of Environmental Quality, April 2000.

The most commonly cited sources in Region 8 are: animal feedlots, underground storage tanks, surface impoundments, septic systems, large industrial facilities, and spills.

TABLE 8
SOURCES OF GROUND-WATER CONTAMINATION BY STATE

CONTAMINANT SOURCE	COLORADO	MONTANA	NORTH DAKOTA	SOUTH DAKOTA	UTAH	WYOMING
Agricultural Activities						
Ag chem facilities			X	X	X	
Animal feedlots	X	X	X	X	X	
Drainage wells						
Fertilizer applications		X		X		X
Cropping and irrigation practices		X				
Pesticide applications						
On-farm agricultural mixing and loading procedures			X			
Storage and Treatment						
Land application						
Material Stockpiles						
Storage tanks (above ground)			X	X	X	
Storage tanks (below ground)	X	X	X	X	X	X
Surface impoundments	X		X	X	X	
Waste piles						
Waste tailings						

TABLE 8 (continued)
SOURCES OF GROUND-WATER CONTAMINATION BY STATE

CONTAMINANT SOURCE	COLORADO	MONTANA	NORTH DAKOTA	SOUTH DAKOTA	UTAH	WYOMING
Disposal Activity						
Deep injection wells						
Landfills	X			X		
Septic systems	X	X		X	X	X
Shallow injection wells						
Other						
Hazardous waste generators						
Hazardous waste sites	X					
Large industrial facilities	X	X	X			X
Material transfer operations						
Mining and mine drainage	X	X		X		
Pipeline and sewer lines				X		
Salt storage and road salting					X	
Salt water intrusion						
Spills	X	X	X		X	X
Transportation of materials						
Urban runoff					X	
Saline seeps		X				
Small scale manufacturing and repair shops	X					

SOURCES: State 305(b) reports except for Wyoming. For Wyoming, personal communication with Kevin Frederick, WDEQ.

Agriculture

Agricultural activities, such as irrigated crop farming, grazing and livestock production, are one of the most widespread sources of ground-water contamination in the Region.

The most common contaminant is nitrate. Other common contaminants are sediments, nutrients and pesticides. Nitrate levels above the 10mg/L drinking water standard set by the EPA can have both long and short-term health effects. Nitrate is particularly dangerous to infants because it can cause "blue baby syndrome" (methemoglobenemia). Documented cases in Region 8 include a death of a baby in South Dakota in 1965 (Virgil, 1965).

[illegible]

Irrigated agriculture can contribute to elevated nitrate levels in aquifers when inorganic and organic fertilizers leach into ground water. Dissolved solids and salinity may increase in ground water and surface water when water is reused many times for irrigated agriculture (Figure 17).

Pesticides and their associated metabolites (breakdown by-products) are also a concern in agricultural areas in Region 8. Even with the relatively low use of pesticides, pesticides occur in ground water and surface water in every state (Reetz, 1998). Although detections of pesticides above EPA drinking water standards are uncommon, the human impacts of many of these pesticides and their metabolites are poorly understood and monitoring for them is very limited. These compounds may be a future concern if they persist and accumulate in ground water. In a 1996 assessment conducted by EPA, the most frequently detected pesticides in ground water in 19 western states included the fumigants ethylene dibromide (EDB) and 1,2 dichloropropane; the insecticides aldicarb, carbofuran, and chlordane; and the herbicides alachlor and atrazine (Reetz, 1998). Extrapolating this information for Region 8 is difficult, but the available data indicate that some of these contaminants are also found in the Region.

For example, in Teller County, Colorado, high levels of EDB were detected in five municipal supply wells in 1994. During the 1960s and 1970s, a pesticide containing EDB was used extensively in the area to help control the pine beetle. EPA conducted site investigations from 1996 to 1999 to determine the source of the EDB and its distribution in the aquifer. The source was identified and eliminated, and a monitoring system was established, as well as a treatment system for the EDB.

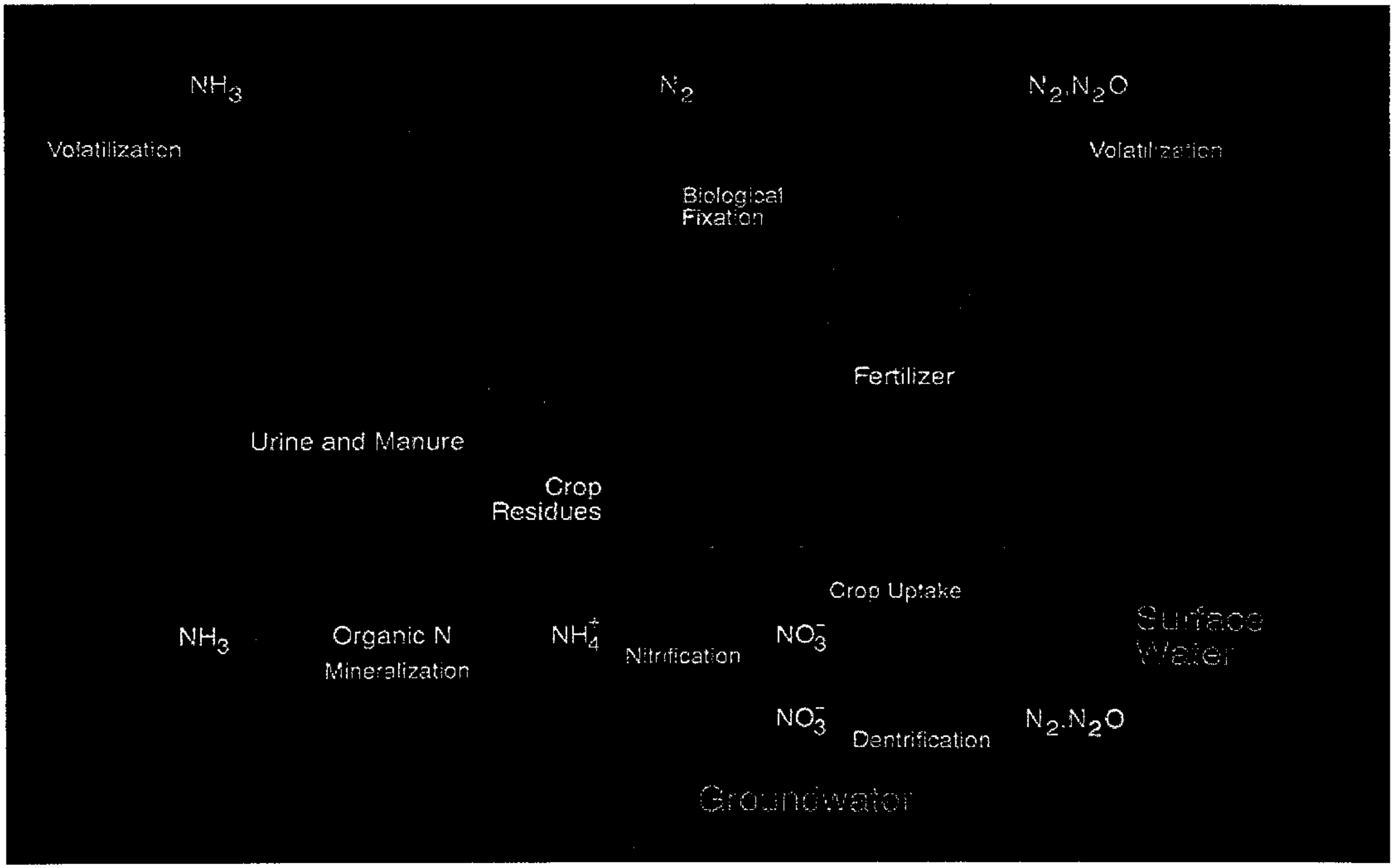


Figure 17. Nitrate in Ground Water

Improperly managed animal feedlots generate large amounts of waste that can result in increased concentrations of certain pollutants in ground water. There are about 238,000 animal feeding operations (AFOs) in the U.S., including livestock (such as beef and swine) and poultry. AFOs are agricultural enterprises where animals are kept and raised in confinement. AFOs annually produce more than 500 million tons of animal manure. This compares to EPA estimates of about 150 million tons of human sanitary waste produced annually (assuming a population in the U.S. of 285 million people). By this estimate, all confined animals generate three times more raw waste than is generated by humans in the U.S. (USEPA 2003). AFOs can pollute surface water and ground water with nutrients (nitrogen and phosphorus), organic matter, solids, pathogens, salts, metals, pesticides, antibiotics, and hormones. Pollutants enter ground water by leaching from lagoons and stockpiles, through spills, and leaching from cropland after application of manure.

Mining

Past and present mining activities, though closely associated with surface-water contamination, are also a source of ground-water contamination in Region 8. In the Rocky Mountains, there are hundreds of large active mines and tens of thousands of inactive mine sites (Reetz, 1998). Some of these sites are serious enough to be included in the Superfund program, such as the Kennecott mine in Utah and the Summitville mine in Colorado. Approximately one half of the Superfund sites in Region 8 are related to mining. Nine of the top eighteen mine-impacted watersheds in the nation are in Region 8, eight of which are in Colorado (Reetz, 1998).

Types of sources at hardrock mining sites include: mine waste such as waste rock and tailings; underground workings; and processing facilities such as leach pads and mills. Ground-water contamination at hardrock mine sites occurs as a result of physical and chemical interactions between exposed ore bodies, water, air, and microorganisms. In areas where coal or metallic ores have been mined, precipitation that falls on and percolates into mill tailings or waste rock can oxidize sulfide minerals. This results in low-pH (acidic) water which can dissove metals and transport them into underlying ground water. This mineralized water can move into wells or surface streams and ponds. **Large concentrations of arsenic, copper, iron, zinc, lead, manganese, radium, selenium, and sulfate can result from the leaching of sulfide-rich mill tailings and can contaminate large areas of aquifers.** Since this oxidization process can continue for hundreds of years, remediation of such sites is an expensive and long-term process.

For example, the Leadville Mining District is a very large hardrock mining district located in Lake County, Colorado. Silver mining continued until 2002 when the last operating mine closed. Within the Leadville District, the ore was mined by underground methods. A number of mine adits and shafts currently discharge water from the mine pool (ground water). The mine waste and draining adits and shafts comprise the most serious sources of contamination. High concentrations of heavy metals such as zinc and copper in streams that drain the District and in the Arkansas River present a significant risk to aquatic life. In 1983 a large part of the District was listed on the National Priorities List, regulated under CERCLA. As part of the remedy, two large water treatment plants are currently being operated to treat adit discharge. One of the current priorities under CERCLA is to develop a remedy for contaminated ground water. This will require a more detailed characterization of the mine pool(s) and more detail on the magnitude of heavy metals loading to the Arkansas River via ground water. As with many hardrock mining sites it will be necessary to continue operation of the mine waste and water treatment remedies for many decades into the future.

Underground Storage Tanks

Most states in Region 8 report that leaking underground storage tanks (USTs) are a high-priority source of ground-water contamination (Figure 18). USTs are generally found in urban and suburban areas. They are primarily used to store petroleum products that contain volatile organic compounds such as MTBE (a gasoline additive), benzene, toluene, ethylbenzene and xylene (BTEX compounds). There are thousands of USTs across the Region. Montana, for example, indicates that there have been nearly 1,000 confirmed releases from USTs and that half of these have impacted ground water (personal communication, John Arrigo, MDEQ). The impacts of leaking tanks can be locally significant. MTBE and other additives are more mobile than the BTEX compounds and can contaminate greater volumes of ground water.

Table 9 summarizes UST activities in each state in Region 8 as of early 2002. The table shows confirmed releases, but this does not necessarily mean that ground water was impacted. The large number of cleanups initiated compared to the number of confirmed releases shows the preventative nature of the UST program with regard to ground water contamination.

Waste Disposal

> Unsuitable design and poor management of septic systems can cause concern, particularly when they are used to dispose chemical wastes.

Liquid and solid waste disposal is perhaps the best known source of ground-water contamination and is locally significant across the Region. Waste disposal includes a broad category of activities and potential sources such as septic systems, landfills, surface impoundments, waste injection wells, the application of stabilized waste as fertilizer, and illegal dumping.

Shallow injection wells, such as septic systems, storm drains, dry wells, and cesspools are locally important sources of ground-water contamination in the Region. For more information on this source, see www.epa.gov/safewater/uic/classv.html. By volume, onsite sewage disposal from septic systems is the largest discharger to the subsurface in the waste disposal category (Figure 19). Unsuitable design and poor management of septic systems can contaminate ground water, particularly when they are used to dispose chemical wastes. Standard septic designs are particularly poor in thin soil and fractured rock settings that are common in mountainous areas. Human wastes and nearly any household chemical poured down the drain of a home served by a septic system can reach the local ground-water system. Nitrate and bacteria are contaminants found in ground water in areas with a high density of septic systems.

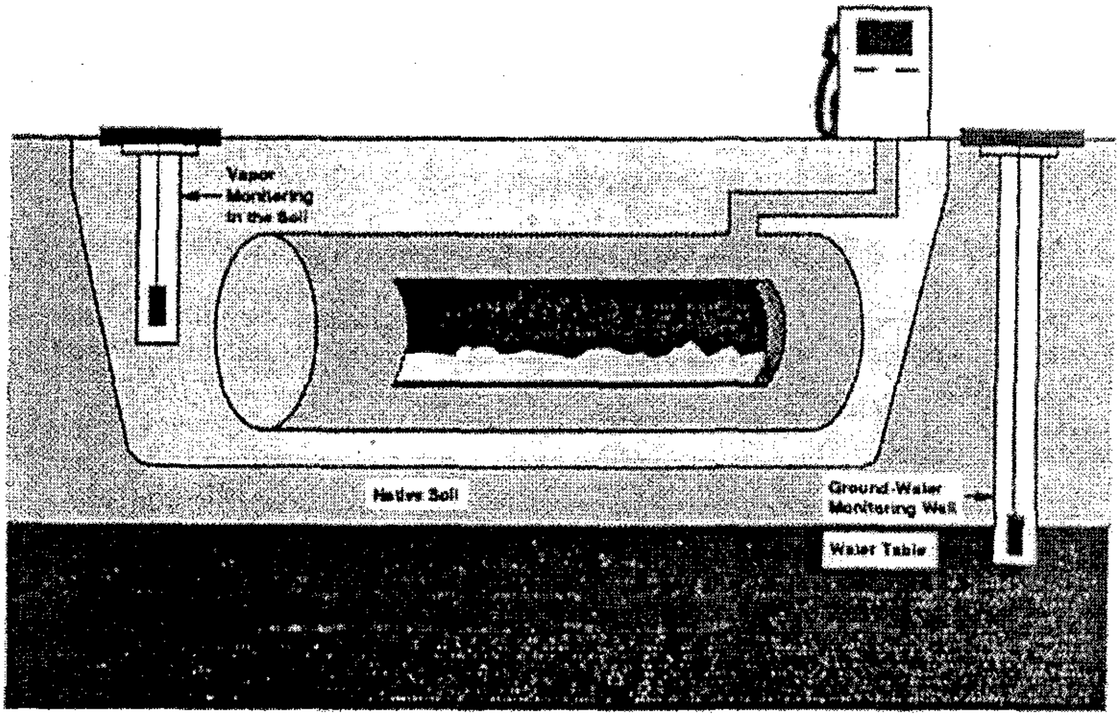


Figure 18. Underground Storage Tank with Monitoring Well

TABLE 9
OFFICE OF UNDERGROUND STORAGE TANKS
FY02 SEMI-ANNUAL ACTIVITIES
2002

DEFINITION	COLORADO	MONTANA	NORTH DAKOTA	SOUTH DAKOTA	UTAH	WYOMING	TOTALS
Number of Confirmed Releases	5,552	2,962	812	2,257	3,875	1,963	17,421
Number of Cleanups Initiated***	5,082	2,213	811	2,139	3,607	949	14,801
Number of Cleanups Initiated State Lead / TF $s	234	39	15	12	10	120	430
Number of Cleanups Completed***	4,074	1,756	754	1,731	3,247	496	12,058
Number of Cleanups Completed State Lead / TF $s	199	16	14	2	7	6	244
Number of Emergency Responses	32	42	3	18	4	61	160
TOTAL							

Source: USEPA UST Access Database, 2002
*****RP Lead and/or State Lead with State Money**

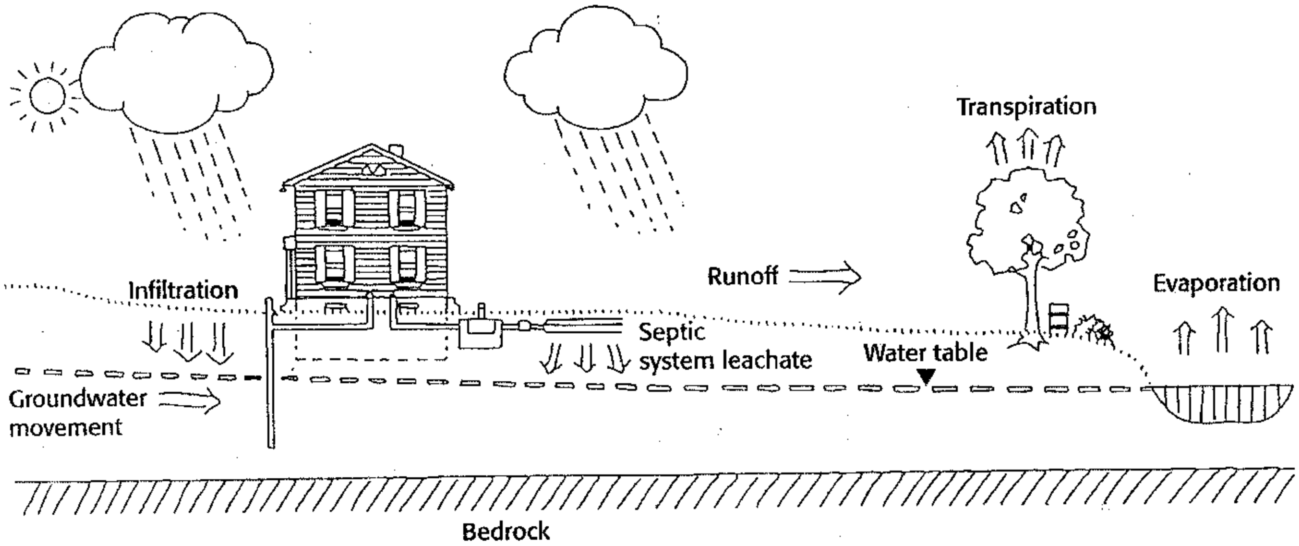


Figure 19. Septic Tank Schematic

Oil and Gas Production

Oil and gas production activities are also a potential source of ground-water contamination in localized areas. These activities can contaminate ground water by a variety of mechanisms. Oil wells produce brines (very salty waters) that are separated from oil and stored in surface impoundments. Seepage from these impoundments and the brine wastewater that has been injected into wells can contaminate ground water in addition to impacting surface waters and riparian habitat.

Over the past five years natural gas is being produced at significantly increasing rates in Colorado, Wyoming, Montana, and Utah. Natural gas in these areas is produced by withdrawing large amounts of ground water from geologic strata containing coal seams and methane. Coalbed methane (CBM) is released when the water table is lowered. CBM production in southwest Colorado (San Juan Basin) has raised environmental concerns by landowners and homeowners for over a decade due to apparent effects caused by reinjection of produced water into deep aquifers.

Currently, CBM development in the Powder River Basin in Wyoming and Montana. is causing concerns about surface-water and ground-water quality. For example, the ratio of sodium ions to calcium and magnesium ions present in water, in part, dictates the suitability of that water for crop irrigation. This ratio is known as the sodium-adsorption ratio (SAR). Elevated SAR values have been reported for some coalbed methane ground waters. Introduction of higher SAR water from CBM discharge into the Powder River has the potential to affect the use of water by irrigators downstream of those CBM discharges. A prominent concern is the potential destruction of soils suitable for agricultural use.

Hazardous Waste Sites

Accidental spills and poor waste management practices have contaminated a number of sites in Region 8 with hazardous substances. EPA administers the clean up and control of many of these hazardous waste sites primarily under the authorities of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response Compensation and Liability Act (CERCLA or Superfund). The RCRA Corrective Action program priorities are active facilities where poor waste management and handling practices create risks due to human exposure and ground-water contamination.

The Region's Superfund program has identified dozens of sites with known ground-water contamination; at least 20 of the 52 active National Priority List (NPL) sites in Region 8 involve some ground-water contamination issues. Contaminants affecting ground water at Superfund sites vary depending on past activities. Common contaminants include cleaning solvents, petroleum products, pesticides, PCB's, dioxins, acid rock drainage, metals, and radioactive materials. Ground-water contamination at many of these sites is significant and requires complex and costly remediation activities. For example, past mining and processing activities at the Kennecott South site in Copperton, Utah have resulted in a plume of sulfate in the local aquifer that covers more than 77 square miles. Along the South Platte River in South Denver, hexavalent chromium from a plating facility has contaminated ground water along a two-mile reach of the alluvial floodplain aquifer. Historical solvent use and disposal at the former Lowry Air Force Base in the Denver area created a trichloroethylene plume nearly two miles long in the water-table aquifer.

Urban and Suburban Sources

Urban and suburban land uses are also a locally significant source of ground-water contamination in the Region. Spills and runoff from industrial areas and roadways, park and golf course maintenance activities, fertilizer, pesticide and herbicide use on lawns and golf courses (Figure 20), fuel and solvent use, and other activities collectively make urban nonpoint sources of contamination significant. In addition, urban areas generally have higher concentrations of leaking storage tanks and hazardous waste sites affecting ground water. Pesticides and other organic chemicals associated with petroleum products and solvents are commonly detected in ground water in urbanized areas.

Figure 20. Fertilizer, Herbicide, and Pesticide Use On Lawns Can Contaminate Ground Water

III.C. GROUND-WATER QUALITY MONITORING AND DATA: STRENGTHS AND LIMITATIONS

Introduction

There is insufficient information available to effectively characterize the overall quality of ground water in most Region 8 aquifers. Federal, State and local agencies have only recently begun to focus their attention on monitoring ambient ground-water quality for analytes such as nitrates, volatile organic compounds, and pesticides. Ground-water samples are relatively expensive to collect and analyze. Furthermore, the data are not necessarily stored on a database available to others, or they may never be entered on an electronic database. Inadequate funding for assessment and monitoring prevents comprehensive understanding of the Region's ground water. Thus, many State monitoring programs focus on the most heavily used aquifers and those that are considered most vulnerable to contamination.

Currently, ground-water monitoring in Region 8 is conducted by a variety of Federal, State, and Tribal programs. Federal efforts are primarily by the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (USEPA), and the Department of Agriculture (DOA). Ground-water monitoring is also conducted by some counties and other special districts. The USGS National Water Quality Assessment (NAWQA) Program studies, Safe Drinking Water Act monitoring requirements, pesticide studies conducted by the DOA, or State and special district studies have stimulated some localized ground water monitoring.

Other Federal agencies with monitoring programs include the National Park Service, National Oceanic and Atmospheric Administration, Department of Defense/Corp of Engineers, Bureau of Indian Affairs, Bureau of Land Management , Office of Surface Mining, Bureau of Reclamation, U.S. Forest Service, and the Department of Energy. Their monitoring is localized and limited. Though efforts are increasing, data are currently limited to selected aquifers scattered across the Region.

The USGS National Water Quality Assessment (NAWQA) Program

Despite the lack of comprehensive Region-wide data, there are a number of aquifer and watershed-based water-quality monitoring activities. The USGS's National Water Quality Assessment (NAWQA) Program is developing comprehensive and consistent trend data for ground and surface waters in selected aquifers and watersheds across the United States. The program builds partnerships with Federal, State and local agencies to collect and assess the necessary data.

To date, the NAWQA Program has completed assessments on:

- the South Platte River Watershed in Colorado;
- the Red River of the North Watershed in North Dakota and Minnesota;
- the Upper Snake River Watershed in Idaho and Wyoming;

- the Rio Grande River Watershed in Colorado and New Mexico; and
- the Upper Colorado River Watershed in Colorado and Utah

NAWQA assessments in the High Plains (Ground Water Study in Colorado, South Dakota, Wyoming), Yellowstone River Watershed in Wyoming and Montana, the Great Salt Lake Watershed in Utah, and the Northern Rockies Intermontane Basins in Montana and Idaho will produce more information on ground-water and surface-water quality in the next several years. The USGS also compiles extensive atlas information on the location, geology, geography and hydrologic characteristics of the major aquifers across the U.S. and conducts some monitoring and studies in each of the Region's States. See Appendix C for a list of USGS NAWQA study websites/links.

State Ground-Water Quality Monitoring

Many State ground-water protection programs generate water-quality data. The nature and extent of these programs vary across States, and some, such as South Dakota's monitoring network, are developing into comprehensive State-wide efforts. Existing state ground-water quality data and program efforts are summarized every two years in Water Quality Assessment Reports to Congress, referenced in section III.B of this report. See section IV.B for more information on State ground-water classification, permits, and standards. Appendix B contains State ground-water program contacts and websites.

Colorado

Since 1992, all of the major shallow aquifers in agricultural areas of Colorado have been assessed for water quality. This work has been performed in response to Colorado Senate Bill 126 and Clean Water Act 305(b) report requirements. The Water Quality Control Division of the Colorado Department of Public Health and Environment is responsible for collecting ground-water samples from the various shallow aquifers and evaluating the water quality results for impacts from agricultural chemicals. To date the aquifers assessed include the South Platte River alluvium, the San Luis Valley alluvium, the Lower Arkansas River alluvium, the Ogalala Aquifer, and the Western Slope (i.e., Green, Colorado, and San Juan rivers) alluvium.

Montana

The Montana Groundwater Assessment Program (see Section IV.B for more information) includes a statewide network of monitoring wells in which static water levels are measured quarterly; about 70 of the wells are equipped with continuous water-level recorders. The State collects about 200 ground-water quality samples statewide on an annual basis. This data, as well as that from other hydrogeologic studies, are stored in the Bureau of Mines and Geology's Groundwater Information Center (GWIC). Data from GWIC are easily transferred to GIS for display and analysis and can be exported electronically or on paper.

The Montana Department of Agriculture performs long-term ground-water monitoring for the presence of agricultural chemicals. The current statewide monitoring network is limited to eight monitoring wells in selected areas based on lithological and hydrological characteristics and agricultural systems typically found in the state. Additional wells will be installed as funding permits.

North Dakota

Ambient ground-water quality monitoring is conducted by several State agencies, with most conducted by the State Water Commission (SWC) and the State Health Department. The monitoring programs have been developed to assess ground-water quality and/or quantity in the major aquifer systems located throughout the state. Analytes include inorganics, organics, and selected agricultural chemical compounds.

In 1992, the Division of Water Quality initiated an Ambient Ground Water Monitoring Program to determine the occurrence of 50 selected agricultural pesticides in the 50 most vulnerable aquifer systems in the State within a 5-year period. Approximately 1200 wells have been monitored. Tables IV-15 to IV-19 of the North Dakota Year 2000 305(b) report summarize synthetic organic chemical and nitrate detections in selected aquifer systems. The Ambient Ground Water Quality Database maintains records for approximately 1,393 different wells, from which 1,969 samples have been collected to date.

South Dakota

The DENR (Department of Environment and Natural Resources) implemented the Statewide Ground Water Quality Monitoring Network in 1994 and completed well installation in 1998. It is a permanent network of 145 monitoring wells at 80 sites in 24 sensitive shallow aquifers in South Dakota. The network goals are to assess (a) the present ground water quality, (b) the impact of agricultural chemicals on ground water, and (c) long-term trends in water quality in sensitive aquifers. Parameters being analyzed are major ions, trace elements, radionucludes, volatile organics, and pesticides. In 1999, all 145 wells were sampled.

Utah

The Department of Environmental Quality monitoring program was recently expanded to monitor ground water in parts of the state where there are concerns about water quality. Current projects include Cedar Valley/Iron County baseline ground-water quality study, Millard County baseline water quality study, Mammoth Creek septic tank impact study, and the East Canyon Creek ground-water/surface-water interface study.

The Utah Department of Agriculture has collected almost 2000 ground-water samples from private domestic wells in rural areas of the state over the past several years. The samples are tested for general inorganic, bacterial, and selected pesticide analyses, and the results are provided to the well owners. The Department is emphasizing agricultural areas where ground-water sampling has not been done in the past to the same extent as other areas of the state. The Department of Agriculture is also determining the vulnerability of major ground-water basins to contamination. The results will direct future ground-water monitoring activities.

Wyoming

There are two significant statewide ground-water monitoring efforts in Wyoming: (1) ground-water monitoring associated with implementation of the State Management Plan for Pesticides in Ground Water (SMPPGW), and (2) planning for future ground-water monitoring under the Statewide Ambient Ground-Water Monitoring Program.

Aquifers that are vulnerable to contamination by agricultural contaminants are monitored under the SMPPGW. Using the ground-water sensitivity and vulnerability maps from the Wyoming Ground-Water Vulnerability Mapping Project, a technical committee, comprised of members of the WDEQ, USGS and WDA, determines the sampling locations for vulnerable aquifers within each county in Wyoming. Ground-water wells at these locations are sampled in the spring and fall each year in three or four counties and analyzed for selected agricultural chemicals. Sampling by the USGS has occurred in 14 Wyoming counties (out of a total of 23 counties). Once all Wyoming counties have been selected for sampling a decision will be made as to if and when sampling will be done again under this program.

In 1998, the WDEQ began to develop a program to routinely monitor ambient ground-water conditions in selected, high priority aquifers or portions of aquifers. A statewide map which depicts four classes of Ground-Water Protection Priority Areas was completed in 2000. These Areas were delineated based on aquifer sensitivity, primary use of water, and land use (vulnerability). The Statewide Ground-Water Sensitivity Maps, produced as part of the Wyoming Ground-Water Vulnerability Mapping Project, were used as the base map for delineating and depicting the Ground-Water Protection Priority Areas. WDEQ is determining 1) how many wells to sample in each Priority Area, 2) which analytes will be included, 3) what the cost will be, and 4) who will conduct the sampling. WDEQ will implement the monitoring program and distribute the monitoring program data to the public and to all interested government and quasi-government agencies.

Compliance Monitoring

Compliance monitoring associated with regulatory requirements also generates an extensive amount of site-specific monitoring data for ground-water contamination sites, primarily from Superfund, RCRA, Underground Storage Tank, DOE, and DOD sites; ground-water data are also collected as part of permitting requirements for mining and waste disposal. The data from these studies are not generally placed in a common database and often are not electronically available. Therefore, it has been difficult to use these data for more than individual site-specific purposes. To acquire such data would require contacting the regulatory or oversight agency directly.

Drinking Water Monitoring

The monitoring requirements of the Safe Drinking Water Act (SDWA) mandate that public water systems monitor the quality of their water **after treatment**. Therefore, drinking water systems data is an indication of the quality of *treated* water rather than the quality of the *raw* source waters. However, many small/rural systems only chlorinate their drinking water; in those cases the data do represent raw source water.

Additionally, even though there are standards for over 80 drinking water contaminants, plus monitoring requirements for dozens more, the SDWA allows States to grant "monitoring waivers" to public water systems. These waivers are based on either "non-use" of a contaminant or "low-vulnerability" of the water system's source. Water systems are allowed to forego monitoring for certain periods of time. Waivers are relatively new and are not granted widely. Variations in the stringency of monitoring waiver programs from state to state have led to differences in the amount of monitoring that has actually been required and performed by public water systems.

Data and Information

There are three primary electronic databases used to store ground-water data in Region 8. They are: EPA's STORET database, EPA's SDWIS (Safe Drinking Water Information System), and the USGS National Water Information System (NWIS) Database. Many of the State agencies, such as the Colorado Department of Public Health and Environment, have developed their own databases where they store ground water quality data.

Prior to 1999, the USGS placed its NWIS database onto STORET. Since 1999, databases have been incompatible and cannot be merged. NWIS is the most complete database for ground-water information in Region 8. Its data are available through the USGS web site at water.usgs.gov/nwis. EPA uses STORET for surface-water data, ground-water data, and air, sediment, soil, and biological information. In theory, if the EPA provides funding for ground-water data collection to another federal agency, state agency, or other group, then the data must be entered into STORET; in practice, that does not always occur. EPA is asking that volunteer monitoring data and tribal data be entered on STORET. STORET does not include any public water supply data or RCRA ground-water monitoring data. Some CERCLA site data are being entered into STORET, but this is on a site-by-site basis and is not mandatory. The EPA Region 8 contact for STORET is Marty McComb at mccomb.martin@epa.gov (Phone 303-312-6963, EPR Program Support).

The EPA SDWIS database stores data about public drinking water supplies from ground-water and surface-water sources. It includes locations of public water systems and indicates whether or not the system is in compliance with drinking water standards. SDWIS does not include analytical results (concentration levels) unless there was a violation of a drinking water standard. The public does not currently have access to the SDWIS database due to security concerns, but the public may access specific information through a Freedom of Information Act request (www.epa.gov/region08/about/foia/foia.html). EPA is currently in the process of deciding what SDWIS data will be available to the public versus what will be restricted.

The 1996 Amendments to the Safe Drinking Water Act require EPA to develop a new "national drinking water contaminant occurrence database." This database will contain information on both regulated and unregulated contaminants (physical, chemical, microbial and radiological) found at a "quantifiable level," not just those in violation of EPA standards. This information will help EPA determine for which new contaminants it should develop standards. It will also provide a more complete picture of drinking water quality in the Region. For more information on this database, see www.epa.gov/ncod.

IV. GROUND-WATER PROTECTION AND MANAGEMENT PROGRAMS

IV.A. EPA GROUND-WATER PROTECTION PROGRAMS AND AUTHORITIES

In 1984 U.S. EPA issued its "Ground-Water Protection Strategy", which combined its statutory authorities and a preventative approach to groundwater management. State and local ground-water protection programs were developed and implemented out of the initiatives and legislation stimulated by the strategy.

Many EPA programs are implemented at the state level through delegation of the program to state agencies. Others are implemented directly by the EPA Regional office. Table 10 below summarizes federal authorities to assess, protect and remediate ground-water quality, and state or local activities associated with those authorities. Program delegation status is included under the "State activities" heading in Table 10.

Even with these authorities, the EPA's ability to prevent contamination of ground water or address existing contamination is limited. Some of the limitations exist because EPA does not have authority to address issues that are not covered by current laws. Other limitations stem from the fragmented nature of the authorities themselves. For example, EPA's authorities to address ground-water quality issues lie under five different statutes which are implemented and/or overseen by seven different EPA Programs. Workloads specific to each legal authority, and the complexity of the legal landscape makes effective coordination among ground-water programs difficult. Inadequate staff and funding combined with a relatively weak emphasis on ground water further hamper efforts to coordinate programs.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Sole Source Aquifer Safe Drinking Water Act Section 1424 (e) authorized 1974, revised 1986 Orientation: Pollution Prevention Ongoing	Allows individuals and organizations to petition the EPA to designate aquifers or portions of an aquifer as the "sole or principal source" of drinking water for an area. If so designated, all federally assisted projects planned for the area are subject to review by EPA to determine their potential for contaminating the aquifer. There are approximately 70 SSAs across the U.S.	States do not administer the SSA program. SSAs in Region 8 by State Montana: Missoula Valley Aquifer Utah: Western Uinta Arch Paleozoic Aquifer System at Oakley and the Castle Valley Aquifer System near Castle Valley Wyoming: Elk Mountain Aquifer
Wellhead Protection Program (WHP) Safe Drinking Water Act Section 1428 authorized 1986, revised 1996 Orientation: Pollution Prevention Ongoing	The goal of this program is to prevent contamination of ground water used for community water supplies. Steps: *form a local team; * delineate the part of the aquifer that provides water to a public water supply well or wellfield (wellhead protection area (WHPA)); * identify and characterize potential sources of contaminants within the WHPA; * develop and implement a management plan for the WHPA * plan for possible spills (contingency plans) * do WHP for new wells	States were required to prepare WHP Programs for EPA approval. All of the states in Region 8 have approved WHP Programs. Local governments, communities, or public water systems develop and implement WHP plans, covering all six steps, for their individual public water systems in accordance with the state's WHP Program. Local participation is voluntary in all Region 8 states except Utah. Participation is optional, but encouraged, for tribes. As resources allow, the Region provides technical assistance and financial support.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Source Water Assessment Program		
Safe Drinking Water Act Section 1453 authorized 1996 Initial completion expected 2003 (42 months after state program approval) Assessment updates are desirable, but not required. Protection is desired but not required. Orientation: Pollution Prevention	The goal of this program is to provide information meant to form a basis for local protection activities, including wellhead protection, to all public water systems and their customers. Source Water Assessments are to be completed for all public water systems, including these steps: * Delineation of a source water protection area and/or wellhead protection area * Inventory of potential sources of contamination in these areas * Susceptibility determination for each public water supply source to contamination An assessment report is sent to each public water system and available to the public. SWAPs are not intended to replace existing programs, but to focus federal, state and local attention on protecting the sources of safe drinking water. State and local governments were very involved in helping EPA develop the SWAP strategy.	States with primary enforcement authority for the Public Water Supply Supervision Program are required to establish and complete Source Water Assessment Programs. Wyoming does not have primary enforcement authority and has a voluntary SWAP. SWAP is optional for Tribes. The Region provides technical support for source water assessments and funding for technical service providers. All six Region 8 states have approved SWAPs. Protection of sources of drinking water is expected to take place on the local level using local authorities and existing state and federal programs, including wellhead protection programs, state ground-water protection strategies, sole source aquifer designations, and other established programs, such as those under the CWA or RCRA.
Ground Water Rule		
Safe Drinking Water Act Section 1412(b)(8) authorized 1996 The final rule is expected to be published in the Federal Register in 2004. Orientation: Public Health Protection	Sets criteria to determine whether public water systems using ground water must disinfect their water for additional protection against bacteria and viruses.	States with primary enforcement authority are expected to set criteria. May coordinate with Source Water Assessments or other state ground-water assessment and protection efforts. EPA Region 8 will directly implement in Wyoming and on Tribal Lands.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Underground Injection Control Program Safe Drinking Water Act Sections 1421 through 1426 authorized 1974 amended 1981, 1984 Orientation: Pollution Prevention Ongoing	Through permits, EPA's Underground Injection Control Program protects all underground sources of drinking water from contamination by requiring that all wells injecting liquids into the ground meet specific construction and operation standards. There are five classes of injection wells. Class I: Deep injection wells for hazardous and nonhazardous waste. Class II: Brine injection wells related to oil and gas production. Class III: Solution mining wells injecting water, steam, or other fluids to recover minerals. Class IV: Shallow wells injecting hazardous waste. BANNED Class V: All other injection wells. A 1999 rule specifically regulates cesspools (banned) and septic systems serving more than 20 people and regulates motor vehicle waste disposal wells. Other Class V wells may need to be permitted by rule or individually.	This program may be delegated to states whose rules and regulations meet the requirements for the part(s) of the program delegated. 1422 delegations in Region 8 include only UIC well Classes I, III, IV, and V. These programs have been delegated to North Dakota, Utah, and Wyoming. Section 1425 delegations are special to UIC Class II wells (oil & gas-related). This program has been delegated to all six Region 8 States. EPA Region 8 implements all UIC programs on Tribal Lands. Class IV well closure is up to the implementing authority, with EPA over-file enforcement authority for nonperformance by the delegated agency.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Hazardous Waste Programs		
Resource Conservation and Recovery Act Subtitle C - general authorized: 1976 amended: 1984, 1992, 1996 RCRA enhanced the 1965 Solid Waste Disposal Act Orientation: Pollution Prevention and Remediation Ongoing	RCRA Subtitle C is a comprehensive program to ensure that hazardous waste is managed safely from when it is generated, through storage, transportation, or treatment, and during and after disposal. EPA and/or states issue permits, inspect facilities, and require corrective action to address contamination that may affect ground water or other environmental media, or human health.	State hazardous waste programs may be authorized to operate in lieu of federal standards. The state program and regulations must meet or exceed federal standards. EPA retains over-file enforcement authority for nonperformance by the delegated agency. All six Region 8 states are authorized for at least the base program under RCRA Subtitle C. The Region directly implements RCRA Subtitle C on Tribal Lands.
Corrective Action Program		
Resource Conservation and Recovery Act Subtitle C, Hazardous and Solid Waste Amendments authorized: 1976, amended 1984 Orientation: Pollution Prevention and Remediation Ongoing	The RCRA Corrective Action program is specifically focused on active facilities where human exposure and ground-water contamination risks exist as a result of poor waste management and handling practices. EPA and/or states administer the clean up and control of these hazardous waste sites.	States may be approved for implementation in lieu of the federal program. All six R8 states are authorized to implement the Hazardous Waste Programs. The Region directly implements this program on Tribal Lands. There are 57 facilities in the Corrective Action category in Region 8.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Solid Waste Management Programs Resource Conservation and Recovery Act Subtitle D - general authorized: 1976 amended: 1984, 1992, 1996 RCRA enhanced the 1965 Solid Waste Disposal Act Orientation: Pollution Prevention Ongoing	RCRA Subtitle D addresses the management of solid waste, municipal solid waste, and hazardous waste exempt from Subtitle C, such as household hazardous waste. The goal of this program is to manage solid waste in an environmentally sound manner and to maximize reuse. EPA's primary role is to develop national goals, provide leadership and technical assistance, and develop guidance and educational materials.	State and local governments implement RCRA subtitle D.
Municipal Solid Waste Landfill Criteria Resource Conservation and Recovery Act Subtitle D Orientation: Pollution Prevention Ongoing	Under RCRA Subtitle D, EPA has set technical requirements for Municipal Solid Waste Landfills to ensure that human health and the environment, including vulnerable ground water, are protected. EPA provides funding and technical assistance for the implementation of these regulations in Indian Country.	States and local governments are the primary regulatory entities for RCRA Subtitle D provisions, including regulations. All six R8 states are authorized to implement the Municipal Solid Waste Program. While EPA does not directly implement a RCRA Subtitle D permit program for municipal solid waste landfills in Indian Country, facilities located in Indian Country must comply with the regulations in 40 CFR part 258.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Underground Storage Tanks Program Resource Conservation and Recovery Act Subtitle I Authorized 1984 Orientation: Pollution Prevention and Remediation Ongoing	The UST program is a comprehensive regulatory program for underground storage tanks that contain petroleum or certain hazardous substances. These regulations are designed to ensure that operators of new tanks and tanks already in the ground pre- vent, detect, and clean up the releases. Regulations include minimum standards for new tanks and technical requirements to upgrade, replace or close existing tanks to meet leak detection and prevention standards by December 22, 1998. Operators are also required to demonstrate that they are financially capable of cleaning up releases and compensating third parties for resulting damages.	State programs in Montana, North Dakota, South Dakota, and Utah are approved for implementation in lieu of the federal program. In addition, Colorado and Wyoming are implementing their state programs under Cooperative Agreements with EPA. The Region directly implements the program in Indian Country.
Comprehensive Environmental Response Compensation and Liability Act (CERCLA or Superfund) General authorized: 1980 funding extended: 1984 (5-year funding), amended: 1986 (Superfund Amendments and Reauthorization Act) Orientation: Remediation Ongoing	The goal of this program is to clean up abandoned waste disposal sites and ground water contaminated with hazardous substances. The program also provides for federal emergency response where immediate action is needed to limit or prevent further endangering human health or the environment. EPA administers the clean up of these hazardous waste sites under the authority and funding of CERCLA. Accidental spills and poor waste management practices have resulted in a number of CERCLA sites in Region 8. At least 20 of the 52 active sites in Region have ground-water contamination issues.	States are key players in remediation of contaminated sites, including operations and maintenance of remedies. The state may be the entity with greatest enforcement authority to require implementation of institutional controls or other remedies based on state statute or regulation. CERCLA actions are usually closely coordinated with appropriate state agencies, as needed. States are Natural Resources Trustees under CERCLA, requiring that EPA keep them informed of actions within their boundaries.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Clean Water Act 1977 amendment to the 1972 Water Pollution Control Act. Orientation: Pollution Prevention and Remediation Ongoing	Provides authority for federal regulation of pollutant discharges to waters of the US (surface water). Goals of the Act are to eliminate pollutant discharges and to achieve water quality that is fishable and swimmable in all waters of the US. While not regulated under the CWA, ground-water quality can have a profound effect on surface-water quality. This is addressed through several programs under the CWA, but not by direct permits.	States may have permitting programs for waste water discharges that target impacts to ground water. All 6 states in Region 8 have some kind of ground water permitting program (see section IV.3).
Non-Point Source Program Clean Water Act Section 319 authorized: 1987 Orientation: Pollution Prevention and Remediation Ongoing	The Non-Point Source Program provides funding to states, tribes, and others for effective management of diffuse sources of contaminants to reduce or prevent pollution of surface waters. Solutions must consider impacts to ground waters. Funding may be used to carry out ground-water quality protection activities, including assessments, as part of a comprehensive non-point source pollution control program.	States may target 319 funding to ground-water projects. Tribes need to achieve "treatment as a state status" pursuant to Section 518 of the Clean Water Act to receive 319 funding.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Section 106 Clean Water Act Authorized: 1985 Orientation: Assessment and Pollution Prevention Ongoing	Section 106 provides funding for state water-quality monitoring activities, including a recommended minimum 15% for ground-water quality programs, including the development of state ground-water strategies.	All six R8 states traditionally devote more than the 15% minimum to ground-water quality programs, including ambient ground-water quality monitoring programs and Wellhead Protection programs. All are under the state PPGs. Tribes may use CWA special studies funds to assess and monitor ground water in Indian Country.
Total Maximum Daily Loads Clean Water Act Section 303 (d) Authorized: 1972, Regulations issued: 1985, 1992 Orientation: Remediation Ongoing	Requires the quantification of specific pollutants impairing the quality of a surface-water body. Loading from ground water should be considered in the TMDL, but is not required to be addressed. EPA is required to perform TMDLs if the state has not done so.	States carry out TMDLs as part of their water-quality programs.

TABLE 10
EPA PROGRAMS AND AUTHORITIES TO PROTECT AND REMEDIATE GROUND WATER

FEDERAL PROGRAM	DESCRIPTION	STATE ACTIVITIES
Federal Insecticide, Fungicide, & Rodenticide Act		
Authorized: 1978, Amended: 1988 Orientation: Pollution Prevention Ongoing	FIFRA provides federal control of pesticide distribution, sale, and use. All pesticides used in the United States must be registered by EPA. Registration and proper labeling ensure that pesticides will not cause unreasonable harm to the environment, including ground water. EPA must classify a product or some uses of a product as "restricted use" if they may cause unreasonable adverse effects to human health or the environment, including leaching into ground water. Restricted-use pesticides are limited to use by certified pesticide applicators.	To be legally used in a state, a pesticide must also be registered there. States can be more restrictive than EPA based on local conditions. States are primarily responsible for enforcing pesticide regulations. In addition, six Region 8 tribes also have their own pesticide programs. States/Tribes may choose to certify pesticide applicators under FIFRA Section 11(a)(2). All six R8 states have such programs for commercial applicators. In states/tribes that do not develop their own plan for applicator certification, EPA (or in the case of tribes, the state within which the tribe is located) administers an applicator certification program in accordance with FIFRA Section 11(a)(2). All six R8 states have generic State Management Plans for pesticides which include frameworks for real-time ground-water monitoring.

IV.B. STATE GROUND-WATER PROTECTION PROGRAMS

All of the Region 8 states have developed ground-water protection efforts that exceed Federal requirements. The primary elements within all Region 8 ground water protection programs include ground-water classification, in-situ ground-water quality standards, and ground-water discharge permitting. The elements are described in general below. Table 11 contains the relevant statute or rule and web page to access detailed information on each program for each state. See Appendix B for additional state contacts and web sites.

Ground-Water Classification

The purpose of the classification scheme determines how ground water is classified. Schemes are typically based on the current and/or potential beneficial uses of the resource (e.g., drinking water use, agricultural use, industrial use) and the classified areas differ in terms of boundary criteria (e.g., political, aquifer or aquifer zone, watershed, permitted discharge facility). *Ambient* ground-water quality (such as TDS or specific conductance) is commonly used to define the various classes of ground water.

All Region 8 states have classified some ground water resources, established in-situ ground-water quality standards, and set up ground-water discharge permitting.

Most state ground water classification schemes are based on TDS. For example, in North Dakota and South Dakota ground water is classified as either drinking water use if the TDS level is less than 10,000 ppm, or no specific beneficial uses if the TDS level exceeds 10,000 ppm. The classifications are used to establish in-situ water-quality standards (see below) for implementing ground-water protection programs, permitting discharges to ground water, and setting cleanup goals at contaminated sites. In North Dakota, a second classification system based on aquifer sensitivity (using the EPA DRASTIC model, described in the box below) is also used to prioritize ground-water monitoring to track the occurrence of agricultural chemicals and to help determine state activities in the UIC Class V program.

The DRASTIC model is a ground water sensitivity assessment tool that incorporates the following parameters: D = depth to water; R = recharge; A = aquifer matrix; S = soil type; T = topography; I = impact of the vadose zone; C = hydraulic conductivity.

In Colorado, a public hearing process in front of the State Water Quality Control Commission is required to classify specific ground water to set ground-water quality standards for protection and regulatory purposes. The classification scheme includes: domestic use–quality; agricultural use–quality; surface water quality protection; potentially usable quality; and limited use and quality.

TABLE 11
OVERVIEW OF STATE GROUND-WATER PROTECTION PROGRAM ELEMENTS

	Colorado	Montana	North Dakota	South Dakota	Utah	Wyoming
Classification System	5 CCR (Code of Colorado Regulations) 1002-41.4 www.cdphe.state.co.us/op/regs/100241.pdf	ARM 17 (Administrative Rules of Montana, Title 17) Chapter 30, Subchapter 10 www.deq.state.mt.us/dir/legal/Chapters/CH30-10.pdf	Chapter 33-16-02.1-10 www.health.state.nd.us/ndhd/environ/wq	ARSD 74:54:01:03 www.legis.state.sd.us/rules/index.cfm	UAC R317-6-3 www.deq.state.ut.us/publicat/code/r317/r317-006.htm	WDEQ Chapter 8 http://deq.state.wy.us
In-Situ Ground-Water Quality Standards	5 CCR 1002-41.5 www.cdphe.state.co.us/op/regs/100241.pdf	MTDEQ Circular WQB-7 www.deq.state.mt.us/wqinfo/Circulars/WQB-7.pdf	Chapter 33-16-02.1-10 www.health.state.nd.us/ndhd/environ/wq	ARSD 74:54:01:04 www.legis.state.sd.us/rules/index.cfm	UAC R317-6-2 www.deq.state.ut.us/publicat/code/r317/r317-006.htm	WDEQ Chapter 8 http://deq.state.wy.us
Discharge Permits	5 CCR 1002-61 www.cdphe.state.co.us/op/regs/100261.pdf	ARM 17, Chapter 30, Subchapter 10 www.deq.state.mt.us/dir/legal/Chapters/CH30-10.pdf	Chapter 33-16-02.1-11 www.health.state.nd.us/ndhd/environ/wq	ARSD 74:54:02 www.legis.state.sd.us/rules/index.cfm	UAC R317-6-6 www.deq.state.ut.us/publicat/code/r317/r317-006.htm	WDEQ Chapter 9 http://deq.state.wy.us

The State of Utah has established four ground-water classes with subclasses defined within Class I.

UTAH GROUND-WATER CLASSIFICATION

- Class IA or pristine ground water has a total dissolved solids level of less than 500 milligrams per liter (mg/l) and no contaminant concentrations that exceed State ground-water quality standards.
- Class IB or irreplaceable ground water is a source of water for a community public drinking water system for which no reliable supply of comparable quality and quantity is available because of economic or institutional constraints.
- Class IC or ecologically important ground water is a source of ground-water discharge important to the continued existence of wildlife habitat.
- Class II or drinking water quality ground water has a total dissolved solids level greater than 500 mg/l and less than 3000 mg/l and no contaminant concentrations that exceed state ground-water quality standards.
- Class III or limited use ground water has a total dissolved solids level greater than 3000 mg/l and less than 10,000 mg/l and/or one or more contaminants that exceed state ground-water quality standards.
- Class IV or saline ground water has a total dissolved solids level greater than

Application of Water-Quality Standards to Ground Water

Water-quality standards include maximum (or, for a few parameters, minimum) levels allowed by State regulation for potential contaminants. Standards are determined based on state ground-water classification systems, ground-water clean-up goals and ground-water discharge permit requirements. Table 11 gives web locations for standards in each state. Numeric standards set by the Region 8 states include the *Maximum Contaminant Levels* (MCLs) and *Secondary Maximum Contaminant Levels* (SMCLs) for public drinking water supplies as established by the Safe Drinking Water Act regulations. Additionally, in Colorado, some numeric standards are set based on Ambient Water Quality Criteria (existing quality in the aquifer), recommended agricultural use values, and/or human-health risk assessment levels. In South Dakota, the standards for some potential toxic pollutants, primarily pesticides, are set at laboratory detection limits (i.e., nondetectable levels).

Region 8 states have applied existing water-quality standards to ground water using state statutes or rules administered under state ground-water protection programs. Some of the states have established preventative action limits as an early warning of the presence of pollution before beneficial uses are adversely affected, and to achieve more stringent protection for higher quality ground water. For example, in Utah preventative levels are set in the ground-water discharge permits (see section below on permits). The levels are set at 10 to 50 percent of the standard; if pollutant concentrations are detected that exceed the protection levels, then the source of the problem must be corrected.

Montana's nondegradation rules apply to any activity resulting in a new or increased source which may cause water-quality degradation due to *carcinogens*. Degradation is defined as "a change in water quality that lowers the quality of high-quality waters for a parameter." The State determines whether a proposed activity may cause degradation based on information submitted by an applicant. Contaminants other than carcinogens are regulated under an anti-degradation policy. The policy allows for an increase in concentration of a contaminant in ground water, but not an exceedance of a standard.

Ground-Water Discharge Permits

In many states, facilities that discharge waste or pollutants directly or indirectly into ground water (other than those regulated under UIC or NPDES) may be required to apply for a ground-water discharge permit. The goal of this program is to allow economic development while maintaining ground-water quality; in most cases, a limited zone of pollution is permitted and quarterly compliance monitoring is instituted by the permittee. Ground-water quality standards and/or protection levels are used to determine the discharge requirements.

Facilities required to apply for ground-water discharge permits are identified in the regulations. For example, Colorado requires all facilities under certain standard industrial classifications (SIC) to apply for permits and some of these facilities are covered under a general permit for their SIC. In Utah, facilities that pose little or no threat to ground-water quality or that are permitted by other State ground water protection programs (e.g., septic tanks, discharges from permitted RCRA units) receive a permit by rule.

In South Dakota, a discharge plan includes three permits: a ground-water quality variance; a facility construction permit; and a discharge permit.

Generally, a facility needing a permit would submit information to the state that describes the extent and quality of the ground water, the volume and composition of the discharge, how the discharge will be controlled or treated to meet standards and/or protection levels, and proposed inspection/monitoring plans to ensure compliance with the terms of the permit. In some States (e.g., Utah), the permitting process requires a contingency plan to bring the facility into compliance in the event of a significant release of contaminants to ground water from the facility. In South Dakota, a discharge plan includes three permits: a ground-water quality variance; a facility construction permit; and a discharge permit from the Ground Water Quality Program (GWQP).

State Management Initiatives

In addition to federally mandated programs, the Region 8 states have characterized and protected their ground-water resources with a wide variety of tools. Some case studies are given below to highlight various approaches and share ideas that have worked.

1. Wyoming Ground Water Vulnerability Assessment

The Wyoming Ground Water Vulnerability Mapping Project was undertaken to: 1) develop a mapping product that could assess the relative sensitivity of the state's shallow ground-water resources to potential contamination, and 2) assess the vulnerability of shallow ground-water resources to agricultural chemical application. This project is innovative because current land use is considered via a two-step process. In the first step, the USEPA DRASTIC model is used to look at aquifer sensitivity as a function of geohydrology, depth to water, slope, soils, and recharge. In the second step, sensitivity is combined with data on pesticide use to determine relative ground-water vulnerability to pesticide application across the state. The resulting vulnerability map shows portions of aquifers that are vulnerable to pesticide application. Sensitivity and vulnerability maps are available for each County in Wyoming at a scale of 1:100,000.

A product of the project is a dynamic, GIS-based tool to aid in planning, decision-making, and public education related to the management of ground-water resources. The tool could be used to plan for pesticide use and wellhead protection; management of underground injection control facilities; local land-use planning; facilities management; industrial siting; and education.

2. Wyoming Subdivision Rule

The WDEQ Water Quality Division's Subdivision Application Review Program was designed and implemented in response to legislation enacted by the State Legislature in 1997. WDEQ reviews all applications for subdivisions submitted to county commissioners to determine the adequacy and safety of proposed water supply and wastewater systems. The purposes of the Subdivision Review Program are: 1) to ensure that an adequate quantity of potable water is available to prospective lot buyers; 2) to protect water supplies from sources of contamination due to improper design and placement of wastewater systems; 3) to avoid costly water supply and wastewater system modifications at the expense of the state; and 4) to fulfill the requirements of the 1997 statute. Individual counties determine what constitutes a subdivision application for review. The WDEQ limits its review to water supply and wastewater system adequacy, safety and compatibility with each other under site-specific conditions. A report from the developer must be submitted to WDEQ with relevant engineering and/or geologic information on the proposed water supply and wastewater systems. The Subdivision

Review Program ensures that adequate consideration has been given to water supply and wastewater issues prior to approval of a subdivision application at the county level.

3. Montana Ground-Water Assessment Plan

In 1991, Montana's legislature passed the Ground Water Assessment Act to address a significant overall lack of information on the state's ground-water resources. The Act established a comprehensive program to assess and monitor ground water for the long term. This program consists of two parts: the Ground-Water Monitoring Program that will establish a state-wide network of wells; and the Aquifer Characterization Study that will identify and characterize important aquifers throughout the state. Both programs are conducted by the Montana Bureau of Mines and Geology (MBMG); they receive guidance and oversight from the Montana Ground Water Steering Committee, also established by the Act.

A network of approximately 830 wells were established to monitor the principal surficial and bedrock aquifers that are widely used for water supply. The water level in each well is measured quarterly with about 10 percent of the wells having continuous water-level monitoring. A long-term water-quality network has also been established. Data from the program is entered into an electronic data base and available through the MBMG.

For the Aquifer Characterization Study, the state was divided into 28 study units based on county boundaries and general watersheds. MBMG will compile information on the geology and ground-water resources of each study unit. Additional drilling and testing to more accurately map the geology and determine the distribution and properties of aquifers will be conducted. MBMG will also collect and analyze ground-water samples to evaluate water quality and to better understand ground-water flow systems. The report for each study area will discuss the availability of ground water, the potential for further development, overall water quality, and the interaction between ground water and surface water. Each report will also address issues related to ground-water management, protection, and development. Currently, five study areas are in some stage of characterization and three more have been prioritized for efforts over the next few years. Various information/reports are available via the Internet and/or published documents.

4. South Dakota Statewide Ground-Water Quality Monitoring Network

South Dakota has designed and implemented a statewide monitoring network to assess shallow ground-water quality. The goal of this monitoring effort is to systematically examine the water quality and determine if any changes are occurring, including impairment from nonpoint source pollution. This monitoring network is designed to make the network and information as usable as possible for the greatest number of people.

This monitoring network will: 1) help formulate sensible and workable water management and land use regulations for South Dakota, based on information from South Dakota's aquifers, rather than information from some other part of the country; and 2) allow early recognition of water-quality problems so that preventative measures can be taken.

The aquifers are being monitored over much of South Dakota, with 146 water-quality monitoring wells at 80 sites in 24 shallow aquifers. These aquifers are among the most likely to be impacted by human activities because of their near-surface occurrence combined with overlying land use. Each water-quality monitoring well in the network contains dedicated sampling equipment, drastically reducing manpower needs and ensuring representative samples. Ground-water samples from the network are being analyzed for major ions, trace metals, radionuclides, volatile organic compounds, and pesticides.

Results of this comprehensive monitoring have shown areas of elevated nitrate concentrations in shallow aquifers. Also, the results of nearly 1,000 water sample analyses have shown low-level pesticide detections. In the future the well samples will analyzed for pesticide metabolites to ensure the ground water is safe for drinking.

5. Utah Mandatory Source Water Protection Program

The SDWA amendments of 1986 mandate the development of State Wellhead Protection Programs. In response, the State of Utah adopted rules for its EPA-approved Drinking Water Source Protection (DWSP) Program. These rules set forth minimum requirements public water suppliers must implement to protect their ground-water sources of drinking water. In 2000, the State adopted additional rules for its DWSP Program that also required PWSs using surface-water sources and ground-water sources under the direct influence of surface water to implement these requirements. The new rules were in response to the 1996 amendments to the SDWA calling for development of an EPA-approved Source Water Assessment and Protection Program.

The Utah DWSP Program differs from other Region 8 states' Well Head Protection/Source Water Assessment and Protection programs because the Utah DWSP Program is the only WHP/SWAP Program in Region 8 that requires implementation of local protection measures by PWSs that serve people for long periods of time. The Utah DWSP Program of 1993 required all PWSs using ground-water sources to develop protection plans under a schedule enacted within the rules; these local protection plans must include all of the elements provided within EPA guidance on WHP Programs and be approved by the DDW-UDEQ. The expanded rules of 2001 further require all PWSs (that serve people water for long periods of time and that use surface-water sources and ground water under the direct influence of surface water) to complete protection programs. These programs must control the three most significant potential contaminant sources, with the goal of eliminating or reducing the risk of source water contamination.

6. Colorado Public Water System Organic Waiver Program

As authorized under the 1986 SDWA, the CDPHE has developed the Public Water System Organic Waiver program which was approved by the EPA in 1999. Through this program, the CDPHE can grant monitoring waivers for selected volatile and synthetic organic contaminants to public water supply systems within Colorado. Waivers can be granted based on lack of use of a particular organic contaminant or a determination that the PWS well has a low susceptibility to contamination based on hydrogeologic criteria.

In order to implement the program the ground-water PWSs in Colorado were grouped into three categories based on system size and a preliminary qualitative determination of susceptibility. The groups to be reviewed included: 1) PWSs with wells more than 200 feet deep and protected spring sources, 2) PWSs with wells less than 200 feet deep and a population served of greater than 175 people, and 3) PWSs with wells less than 200 feet deep and a population served of less than 175 people.

Waiver applications from individual PWSs are initially reviewed to determine if a use waiver is appropriate. A use waiver can be issued if the PWS can demonstrate that there is no historical or current use of the organic contaminant within the area of influence of the PWS well(s). A PWS can also request that CDPHE determine if a waiver can be granted based on the more stringent susceptibility criteria. In order to be considered for a susceptibility waiver a PWS must prove that its source water comes from a confined aquifer.

IV.C. TRIBAL GROUND-WATER PROTECTION PROGRAMS

Introduction

Governments and jurisdictions of 27 tribes and 26 reservations are found within EPA Region 8 boundaries. This section gives example success stories related to ground-water management at two reservations. Find out more about the Region 8 Tribal Assistance Program at www.epa.gov/region08/tribes or the EPA headquarters Indian Programs at www.epa.gov/indian/programs.htm. The EPA Office of Ground Water and Drinking Water Tribal Program information is at www.epa.gov/safewater/tribal.html.

Tribal Ground-Water Management Initiatives

Spirit Lake Nation Reservation

The Spirit Lake Sioux Nation (in northeastern North Dakota) received several grants from EPA under Clean Water Act Section 106 to examine the connection between the surface waters and underlying aquifers on the Reservation. The goal of this study is to monitor and protect the quality and/or quantity of their surface-water and ground-water resources. Another goal is to build technical capacity within tribal government by involving tribal staff in scientific procedures.

There are several issues related to protection of the Reservation aquifers, the Tokia and Warwick. The Warwick aquifer is the primary drinking water source for more than 15,000 people and the City of Devils Lake. Protection of the two aquifers is affected by: current agricultural activity in areas overlying the aquifers (irrigation); future development of ground water for irrigation; and continued development of the aquifers for municipal uses. Integration of all existing data and studies, and collection of water levels and water-quality data were completed in Phase 1 Based on Phase 1 information, it was determined that a direct hydraulic connection exists between the Warwick aquifer and overlying lakes and wetlands.

Phase II actions are:

- ✓ Collecting ground-water and surface-water level data and water-quality data in the collection network;
- ✓ Refining the GIS database to include all wells and test bores drilled during past 40 years;
- ✓ Verifying locations of wells;
- ✓ Building a GIS database of crop type distribution, pesticides/herbicide use, and irrigation permits for ground-water withdrawal; and
- ✓ Determining optimal locations for additional monitoring wells, constructing 24 wells and obtaining water-quality samples.

Wind River Assessments

The Shoshone and Northern Arapaho Tribes on the Wind River Reservation in Wyoming received Clean Water Act 106 funding from EPA to conduct a Water Resource Assessment and Protection (WRAP) Program, described below. The Wind River Environmental Quality Commission began Phase 1 of the Program in 1999.

Phase 1

The purpose of this Program is to assess the quality of the Reservation's valuable water resources and protect them from sources of contamination. The project is modeled after the EPA's Source Water Assessment and Protection Program. However, the Tribes' WRAP is not limited in scope to public water supplies, but is directed at all surface- and ground-water resources identified as critical to the Tribes. As more information is collected by the WRAP Program, new areas of concern are identified. For example, the database of ground-water use, water wells, and ground-water quality needs to be updated as new data are collected, and GIS maps of potential sources of contamination such as NPDES discharge points and UST locations need to be updated.

Phase 2

Phase 2 emphasizes protecting water quality in the shallow aquifer, which supplies water to thousands of domestic wells on the Reservation. The aquifer is affected by individual septic systems, and fertilizer, pesticide and herbicide applications, which need further investigation. The Tribe needs to delineate the Reservation's primary aquifers and their recharge areas. Long-term monitoring of water levels and water quality in the primary aquifers is needed to establish baseline conditions for comparison to future conditions. This information will be invaluable to the Tribes and EPA as more oil and gas development comes to the Reservation, including exploration for coal bed methane.

Products from Phase 2 are:

- ✓ An assessment of the effects of the rural home site and agricultural land use on the quality of ground water in the shallow aquifers;
- ✓ Assessment of radioactive trace element concentrations in ground water in the Crowheart area;
- ✓ A long-term baseline ground-water-quality monitoring program; and
- ✓ A Tribal Wellhead Protection Program compatible with the State's Well Head Protection Program.

IV.D. CITY/COUNTY AND OTHER SUCCESS STORIES

Many local governments in EPA Region 8 have enacted programs to protect their ground-water resources. Citizens have also led initiatives for ground water protection independently of governments. Some examples are given below.

1. Septic Tanks: Castle Valley

Castle Valley is in Grand County, Utah, in the east central part of the state. Castle Valley is increasing popular as a site for vacation and retirement homes. Many new homes have been built on 5-acre lots, each with its own well and septic system. In 1999 most of the population of 274 in Castle Valley were living within the limits of the incorporated Town of Castle Valley. The Utah School and Institutional Trust Lands is considering selling a number of lots which may lead to a significant number of new homes in Castle Valley. The increase in development and its potential impact on the quality of ground-water resources has caused concern among local government officials who wish to preserve the high quality of ground water in the valley-fill aquifer system.

In response to these concerns, the Utah Geological Survey (UGS) completed a study of the valley-fill aquifer and has recommended locations for future public water supply wells for the Town. This information was used by the Town and EPA to designate the Castle Valley alluvial aquifer as a Sole Source Aquifer (see description in Table 9). Using EPA funds, the UGS is completing an evaluation of the potential impacts of additional septic tanks on the valley-fill aquifer. The authors will recommend a minimum house lot size for future development to protect ground-water quality and public health. The UGS is also using EPA funding to complete a petition to the Utah Water Quality Board to classify the ground water in the valley-fill aquifer for future regulatory and protection actions. The Town of Castle Valley will be hiring a land-use planning consultant who will use the results of these UGS efforts.

2. Feedlots: CAFO law in Colorado

Amendment 14 to the Colorado Revised Statutes was a citizen-based initiative approved by the electorate on November 3, 1998. This statute required the Air Quality Control Commission (AQCC) and the Water Quality Control Commission (WQCC) to develop regulations for housed commercial swine feeding operations. All existing and new hog operations subject to Amendment 14 were to be in compliance with the air and water quality regulations by July 1, 1999.

The purpose of water quality Regulation No. 61, Section 13 is to ensure that the storage and land application of waste from housed commercial swine feeding operations does not contaminant Colorado's water resources. This rule requires an owner/operator to develop a geohydrologic report for facilities where residual solids or swine feeding process wastewater are to be stored in lined earthen impoundments or land applied. The report must define the local ground-water flow system and its potential connections to surface waters. It must also include the locations of all existing wells/springs within one mile of the proposed site, baseline ground-water quality data for the site, and the plans for ground-water monitoring wells at the facility.

3. *Mining: Zortman/Landusky Mines, Montana*

The Zortman and Landusky mines are located in the south-central portion the Little Rocky Mountains of north-central Montana; they are near the southern portion of the Ft. Belknap Indian Reservation. Modern mining within this historic mining district occurred from the late 1970s until the mid-1990s. The mine companies used open-pit techniques to extract gold and silver ore by conventional heap leaching methods. The last active leach pad was constructed in 1991 and mining ceased in 1995. The Zortman and Landusky operations disturbed about 385 acres and 814 acres of land, respectively. Water-quality data collected over 20 years from ground-water monitoring wells indicate that streams draining the mining district and ground waters within the syenite ore bodies have been contaminated as a result of mining operations.

Potential sources of contamination include mine pits, spent ore heaps, waste rock dumps, underground workings and process water ponds. Increased ground-water discharge from the shear zone to Swift gulch has been observed since 1999. The extent to which ground water within the syenite discharges to the flanking sedimentary rocks is unknown, but it is thought to be minimal.

In January 1998 the owners of the mines filed for reorganization under Chapter 11 of the federal Bankruptcy Code. Since 1998 the Montana Department of Environmental Quality (MDEQ) has managed the site and taken the lead on remediating ground-water and surface-water contamination and restoring disturbed lands. From 1998 to 2002, a multi-agency Technical Workgroup made up of MDEQ, US Bureau of Land Management, EPA, and the Ft. Belknap Tribes helped guide the restoration efforts at the mines. A Record of Decision (ROD) which specifies the interim and final restoration activities has been signed.

The MDEQ has issued an Montana Pollution Discharge Elimination System permit which includes the post-closure, long-term monitoring program. The monitoring program includes contaminant source monitoring, early warning monitoring and compliance monitoring for both surface and ground water. The environmental closure of the Zortman /Landusky mines has focused on: 1) preventing further contamination of ground water within the syenite ore; 2) preventing further contamination of surface water within the affected drainages; 3) assuring that contaminated ground water or surface water does not impact the Madison Limestone; and 4) completion of restoration activities that are compatible with future Tribal use of the mined lands. The MDEQ is preparing to finish implementation of the preferred alternative and initiate the post-closure, long-term water resources monitoring program.

4. *Growth: Mountain Ground-Water Study, Jefferson County, CO*

The Jefferson County Commissioners in 1998 initiated the Mountain Ground-Water Study (MGWS). The study has been conducted by the USGS with guidance and oversight from a Steering Committee comprised of representatives of Federal, State and local governments as well as the public. Funding for the MGWS has been provided by Jefferson County, the USGS, and EPA. The MGWS was completed in 2001.

The major goal of the MGWS is a detailed description of ground-water resources in the Turkey Creek watershed in western Jefferson County. Extensive data and information have been collected on the occurrence, flow, and quality of ground water in fractured rock aquifers which underlie the forty-seven square mile watershed. The data have been analyzed with a variety of characterization tools including outcrop mapping, water-quality analyses, collection and analyses of evapotranspiration data, hydrograph analyses, and ground-water modeling (Precipitation and Runoff Modeling System - PRMS). A sound conceptual understanding of the aquifers/ground-water flow systems within the watershed will result from these analyses.

The growth in western Jefferson County and the increased demand for ground water for domestic supply necessitates management of this source of water so it not depleted. The results of the MGWS will be used by State and County governments to develop ordinances to protect ground-water supplies in western Jefferson County.

5. *Class V Wells: Protecting the Missoula Valley Aquifer*

From 1990 to 1993, the EPA awarded grant monies to the Missoula City and County Health Department to study the sources of widespread chemical contamination in the Missoula Valley aquifer. The ground-water contamination was caused by shallow disposal systems, also called Class V wells (which include septic systems, storm drains, dry wells, and cesspools). In 1986, tetrachloroethylene (perc or PCE), a solvent used in dry cleaning processes, had been detected in fifteen of the City's water wells. Three of these wells had PCE concentrations exceeding EPA's drinking water standards and had to be shut down. The Disposal System Initiative encouraged local government officials, private business owners, and concerned citizen groups to collaboratively protect their sole source of drinking water. They agreed to several actions including: 1) the closure of over 300 shallow disposal systems without a single facility going out of business; 2) the development of innovative, cost-effective, and environmentally sound waste reduction and disposal alternatives to using shallow disposal systems; and 3) the establishment and enforcement of a City/County-wide ordinance prohibiting the use of shallow disposal systems. As a result, the amount of contaminants entering the Missoula Valley aquifer were dramatically reduced and the three supply wells were reopened. PCE detections in wells were reduced from a high of twelve wells in 1989 to no wells in 1997.

6. *Principal Aquifer Studies: Salt Lake City, Utah*

The Salt Lake Valley, a large inter-montane valley, is home to the largest population center in Utah. The Valley is underlain by a major aquifer, referred to as the Principal Aquifer, comprised of a few hundred feet of unconsolidated valley-fill deposits. The aquifer supplies water to thousands of domestic, commercial and industrial wells and to more than 200 public drinking water wells. Because this aquifer supplies drinking water to a large population, and the aquifer is situated beneath the metropolitan area, the UDEQ and local water suppliers have long been aware of the need to adequately characterize and protect this valuable ground-water supply. Numerous studies have been completed to characterize the aquifer and guide management and protection efforts. The hydrology, geology and water chemistry of the Principle Aquifer has been characterized in more detail than most of the major aquifers within Region 8.

The Utah DWSP Program requires that PWSs delineate protection zones for their ground-water sources. These protection zones are based on ground-water travel time or hydrogeologic boundaries. The USGS assisted the water suppliers to estimate these travel-time zones for the Principle Aquifer. The USGS determined the hydrologic properties necessary to estimate ground-water velocity in the Principal Aquifer in the southeast part of the Valley and described the hydrogeology of the recharge areas and water quality of the Principal Aquifer.

In response to the Utah DWSP Program requirements, wellhead protection areas (WHPAs) were delineated for nine of the major water suppliers in the Valley. This project included 129 existing and planned public supply wells. For this delineation project, the ground-water modelers started with a previously-developed USGS model, then modified the model to obtain sufficient detail in order to estimate the smaller travel-time zones near the wells. The available data and the significant conceptual understandings of the Principle Aquifer permitted the modelers to accurately delineate the WHPAs. Thus, the cumulative hydrogeologic characterization of the Principle Aquifer has proven to be a critical element in the management of ground-water resources within the Salt Lake Valley as local protection measures have been applied to the WHPAs determined from these efforts.

V. MEETING THE CHALLENGES OF GROUND-WATER MANAGEMENT IN REGION 8

CONCLUSIONS

1. **Aquifer Studies.** In the Region 8 states, the major aquifers and aquifer systems have been delineated and their geology and hydrology fairly well characterized. In general, aquifers in Colorado and Montana are not as well characterized as in the other Region 8 states. However, much remains to be done to fully characterize ground-water quality conditions and ground-water/surface-water interactions of these systems.

2. **Ground-Water Availability.** The amount of ground water available for human use has decreased significantly over the past 50 years due to over-exploitation. The United Nations has warned that by the year 2025, more than two-thirds of the world's population will live with significant water-shortage problems. Within Region 8, there are some locations, such as the southern part of the Denver Basin, where ground water is being "mined," or withdrawn, at a faster rate than it is replaced. As the use of ground water increases within the Region, the risk of "mining" will also increase. Adequate supplies for all desired uses will be reduced as increased demands occur in the semi-arid climate of the west, where recharge is slow. Declines in aquifer water levels can also have a negative impact on the ability of ground water to sustain ecosystems. It is very important for resource managers at the local, state and federal levels to recognize that ground-water supplies are finite. Future management and use of ground-water resources will be constrained by the limited amount of recharge and storage.

3. **Ground-Water Use.** There has been a tremendous population growth in the Rocky Mountain states from 1990 to 2000, particularly in parts of Colorado (30.6 % growth between 1990 and 2000), Utah (29.6 %) and Montana (14%). This growth has been supported in large part by the increased use of ground water for drinking water supplies. In Utah, approximately 38% of all 1995 fresh ground water withdrawals were used for public supply needs, up more than 20 % from the 1960s. In addition, growing municipal and public supply demands are shifting water use away from agricultural uses to municipal water use (Moore and others, 1990).

The rural west is almost 100% dependent on ground water for drinking water, and it is becoming increasingly important for private domestic drinking-water supplies. Between 1990 and 1995, the number of people relying on ground water for domestic uses in Region 8 increased by about 230,000; roughly 70% of these residents are served by private wells. Growth in rural areas will probably continue to be a major source of increased ground-water use.

4. **Ground-Water Contamination.** Ground-water quality data indicate that many of the surficial, unconsolidated aquifers in the western states are being contaminated by a variety of land uses. Waste disposal, agricultural land uses, mining and urbanization have had the greatest impact on ground-water quality. Since 1976, state and federal environmental protection

agencies have implemented a variety of programs to correct past waste disposal practices and to clean up a number of existing ground-water contamination problems at some of the worst waste disposal sites. However, to date, there has not been the same success in managing non-point sources of ground-water contamination which rely heavily on the use of voluntary best management practices. The effectiveness of these programs is difficult to evaluate.

It is generally assumed that ground water is safe for consumption without treatment. However, much of the ground water in the Rocky Mountain West may require treatment to meet Safe Drinking Water Act drinking water standards unless federal, state and tribal agencies, local governments, industry and landowners dedicate themselves to protect ground-water resources in the future. Treatment requirements will create a financial burden for individual domestic well users as well as communities dependent upon ground water.

5. Ground-Water Management Programs. Currently ground-water management is highly fragmented: that is, different water supply and water quality agencies within federal, state and local governments have a variety of regulatory and non-regulatory responsibilities. This fragmentation makes it very difficult to effectively manage the resource. For example, within Region 8, permits to construct water supply wells are issued by each State Engineer's Office. However, local governments typically have the responsibility to assure that there is adequate availability of water to support proposed land uses. This is problematic since local land use authorities are not always compatible with sustainable ground-water management.

Management of ground-water quality is typically the responsibility of State Health Departments or State Departments of Environmental Quality, while the federal government has had limited direct responsibilities. However, EPA, in partnership with state governments, is typically responsible for ground-water cleanup at hazardous-waste sites which are being addressed under Superfund and RCRA. EPA also has oversight responsibility for state ground-water management programs funded by the Safe Drinking Water Act and the Clean Water Act. These management programs apply primarily to public water supplies. Consequently, private domestic water supplies are not protected other than by limited, local regulations that may require testing before sale of the property. EPA commonly provides technical and scientific support to state ground-water management programs. Similarly, the United States Geological Survey plays a key role in characterizing and monitoring ground-water resources and providing technical support to state programs.

State Health Department and EPA ground-water staff have been reduced over the past 10-15 years. The financial and technical capacity to deal with ground-water protection and management has been eroded, and coordination between ground-water management agencies and programs has decreased. As a result, there has not been a focus on the resource, but on the narrow issues that each agency/program deals with. Coordination between ground-water and surface-water programs/agencies is minimal.

RECOMMENDATIONS

1. Ground-Water Management Should Be Aquifer-Based. Just as surface water is characterized, mapped and managed on a stream-by-stream, lake-by-lake, or watershed basis, ground water should be managed on an aquifer and aquifer-system basis. Aquifers are the natural units of management for ground water just as a stream, lake or watershed is a natural unit of management for surface water.

It is quite common for a single aquifer to underlie multiple jurisdictions. Ground-water management often proceeds without all parties recognizing that they are managing the same aquifer. This has resulted in a fragmented, often ineffective, and sometimes contradictory, non-resource-based approach to ground-water management. There is enough knowledge and understanding of aquifers and aquifer systems to adopt a fundamental shift to aquifer management.

Effective ground-water protection and management relies on recognition by state and local governments that surface water and ground water are hydraulically connected. Watershed management has typically ignored the connection between ground water and surface water, even though ground water can be a critical factor with regard to both the quantity and quality of streams and lakes. Integration of ground-water management and surface-water management at the state and local level is critical

2. Monitoring Should Be A Key Element Of Ground-Water Management. There are insufficient data to truly determine the status of ground-water quality for most major aquifers and aquifer systems in Region 8. While there are many monitoring efforts conducted by numerous agencies, there is little consistency in monitoring programs, data are not shared effectively among the programs, various entities are often not aware of monitoring by others, many of the data are not entered on computer databases, and many databases are not compatible. Also, the amount of monitoring being done is very limited relative to the size of the resource. The result is a patchwork of data useful for informed management decisions on a localized, site-specific level, but of less value for making state- or region-wide conclusions about status and trends.

An up-to-date assessment of the existing data is needed in each Region 8 state to identify data needs so that a more comprehensive, coordinated ground-water monitoring network can be developed to focus on monitoring high-priority aquifers or regions. Analytical parameters should include selected indicator parameters that are common to all monitoring locations and individual parameters that are important locally and should include water-use data. These ground-water monitoring programs should be coordinated and funded by state and federal agencies. The U.S. Geological Survey, in cooperation with the EPA, should also be funded to prepare National Water Quality Summaries (for major aquifers/aquifer systems in each state) every 5 years. These assessments have been previously prepared under Clean Water Act authorities; however, the last assessment was in 1986. The future compilation of these assessments is currently uncertain.

The USGS National Water Quality Assessment Program (NAWQA) is one of the few federal programs that is evaluating ground-water quality nationally. The NAWQA assessments being conducted in Region 8 offer valuable information about ground-water quality and trends as the Program's efforts progress in selected watersheds. The NAWQA Program and other key ground-water quality studies should be fully supported by the appropriate state and federal agencies. Appendix C gives the web sites describing each study in the Program within Region 8.

3. Prevention of Contamination Is More Effective Than Cleanup. Because cleaning up aquifers after they are contaminated is difficult and expensive, preventing contamination is much more sensible than trying to clean it up. Ironically, federal and state governments spend hundreds of millions of dollars per year on ground-water remediation, and only a few million dollars per year on prevention of contamination. Nationally, the average capital costs for ground-water remediation systems range from a low of approximately $500,000 for passive systems to a high of about $3,500,000 for pump-and-treat systems (USEPA 1999b and USEPA 2001). Annual operating costs for such systems add an average cost of approximately $70,000 to $700,000 per year. Significantly more money should be allocated to prevention efforts, including:

- public education regarding how contamination occurs;
- assessments of sensitivity and vulnerability of aquifers and ground water;
- well-head protection/source-water assessment and protection;
- management of recharge areas; and
- ambient monitoring to determine water quality trends.

Individual sewage disposal systems (ISDS) or septic tanks are often improperly installed and managed. With the recent population growth in rural areas of Region 8, the number of ISDS is increasing dramatically. Many local health departments are concerned about potential contamination of ground water if ISDS leak. Furthermore, within the fractured rock settings of the Rocky Mountains and the Colorado Plateau, the traditional ISDS design is often not suitable and is more prone to failure than ISDS installed in other hydrogeologic settings. This is due primarily to the typically thin soils and high degree of preferential flow in these settings. Most ISDS are designed and constructed to operate effectively in thick soil, porous media hydrogeologic settings. A new approach is needed for regulating septic-tank design, installation and maintenance that recognizes the limitations of fractured rock settings in the Rocky Mountains and the Colorado Plateau.

4. Non-Point Source Contamination Of Ground Water Is Still A Significant Problem. Federal, state and local governments have made insufficient progress in establishing effective programs aimed at reducing non-point source contamination. The most common non-point source contaminants include agricultural chemicals, sediment and urban runoff.

EPA made the following recommendations related to non-point source contamination of ground-water resources in a 1994 report to Congress (U.S.EPA 1995):

- Pesticides and fertilizers should be applied only according to label instructions;
- Site-specific assessment should be conducted to accurately identify and protect vulnerable ground water;
- Ground-water recharge areas and wellhead areas should be identified and protected;
- Flood irrigation should be used more carefully.

While these are common-sense recommendations, they rely on mainly voluntary measures and best management practices. There are no data that demonstrate that voluntary measures have been effective across Region 8.

5. Effective Ground-Water Management Requires Adequate Funding. Currently, ground-water characterization, monitoring and management is inadequately funded throughout most of the country, including EPA Region 8. As ground-water development and use increases in Region 8 and elsewhere, it will be necessary to strengthen the commitment to sustainable development. In the future, federal, state and local governments will face serious issues related to providing a safe, sustainable water supply to satisfy beneficial uses. Tough decisions will be required related to choosing between protection versus remediation of ground water, and mining of ground-water resources vs. sustainable development. To address these management issues, it is vital to provide adequate funding for ground-water/aquifer characterization, monitoring and conjunctive management of ground water and surface water.

CURRENT ISSUES IN GROUND-WATER MANAGEMENT

1. Microorganisms in Ground Water. Research has recently revealed a better understanding of the occurrence and fate of microorganisms in ground water. A wide variety of microorganisms (such as bacteria, viruses and parasites) occur in the subsurface, including pathogenic microorganisms. Contamination of ground-water public water supply systems by pathogenic microorganisms has been implicated in several incidents of water-borne illnesses in Region 8 during the past 5 years. Congress directed the EPA to promulgate a rule requiring ground-water public water supply systems to develop barriers to contamination by pathogenic microorganisms. The final Ground Water Rule is expected in 2003. See www.epa.gov/safewater/protect/gwr/gwr.html for more information.

2. Organic Wastewater Contaminants. This group of products includes selected pharmaceuticals and personal care products including fragrances, dyes, antibiotics and other medicines, caffeine, and hormones. These products have recently been detected in ground water (at sub-microgram per liter levels). Their extent of occurrence is unknown, as are the transport and fate characteristics. Much remains to be learned before it is known if this group of products will present a significant ground-water management problem. However, ongoing development of analytical methodologies capable of detecting these products in water is helping to create the capability to study their occurrence in ground water. The USGS has sampled for these products in ground water in a few select areas within Region 8.

3. Fractured-Rock Aquifers. Large areas within Region 8 are underlain by fractured-rock aquifers. It has long been recognized that ground-water occurrence and flow through fractured rock is significantly different than ground-water flow through porous media such as sand or gravel. However, the recent growth in the Rocky Mountains has stimulated interest in better understanding ground-water occurrence, flow, quality and ground-water interaction with surface water in a fractured-rock setting. Fractured-rock aquifers are limited in their ability to yield adequate amounts of water to domestic wells. In mountainous settings, ground water in fractured-rock aquifers is highly connected to surface water. Consequently, stream flows are sensitive to over development of ground water. The hydrogeology of fractured-rock aquifers has developed into an important research and management topic.

4. MTBE and Other Fuel Oxygenates. A new contaminant threat to ground water was identified when the USGS discovered MTBE (methyl tertiary butyl ether) in ground-water samples from monitoring wells in the metro Denver area in the early 1990's. MTBE has been used in U.S. gasoline at low levels (< 7 percent) since 1979 but was added at higher concentrations (11-15 percent) in some gasoline nearly a decade ago to fulfill the oxygenate requirements of the 1990 Clean Air Act. Studies have increasingly detected MTBE in ground water throughout the country. Low levels of MTBE (20-40 ppb) can make drinking-water supplies undrinkable due to its offensive taste and odor. The health effects of MTBE are being studied (see www.epa.gov/mtbe/).

Numerous states and Congress are considering reducing or eliminating the use of MTBE to protect water resources and public health. Such a ban could result in the use of substitute oxygenates (e.g., ethanol, ETBE (ethyl tertiary butyl ether), TAME (tertiary amyl methyl ether), TAEE (tertiary amyl ethyl ether), DIPE (diisopropyl ether), DME (dimethyl ether), and TBA (tertiary butyl alcohol)) to comply with the Clean Air Act. Ethanol is already in widespread use, for example, in the Denver area. However, oxygenates substituted for MTBE may have negative effects on ground water. The environmental fate of substitute oxygenates released from leaking underground storage tanks and other spills needs further investigation to assess threats to ground-water quality.

5. Perchlorate (ClO_4^-). Perchlorate is both a naturally occurring and man-made chemical. Most of the perchlorate manufactured in the U.S. (as ammonium perchlorate) is used as the primary ingredient of solid rocket propellant; ammonium perchlorate is also used in certain munitions, fireworks, the manufacture of matches, and analytical chemistry. Wastes from the manufacture and improper disposal of perchlorate-containing chemicals are increasingly being discovered in water resources. The perchlorate anion can persist for many decades under typical ground-water and surface-water conditions. In Region 8, the known releases of perchlorate to ground water have been in Utah. However, additional inventory of potential facilities and/or sites is needed where perchlorate chemicals have been used, stored, or disposed of in the Region. According to EPA, perchlorate is a contaminant which requires additional research in the areas of health effects, treatment technologies, analytical methods, and occurrence. Perchlorate is of particular concern because it may be an endocrine disrupter and the current advisory limit in drinking water is very low (2 ppb). See www.epa.gov/safewater/ccl/perchlorate/ for more information.

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APPENDIX A

GROUND-WATER GLOSSARY

GROUND-WATER GLOSSARY

Abandoned well – a well whose use has been permanently discontinued or which is in a state of disrepair so that it cannot be used for its intended purpose.

Acid mine drainage – drainage of water from areas that have been mined for coal or other mineral ores; the water has low pH because of its contact with sulfur-bearing material and is harmful to aquatic organisms.

Adsorption – removal of a pollutant from air or water by collecting the pollutant on the surface of a solid material.

Agricultural pollution – farming wastes, including runoff and leaching of pesticides and fertilizers, erosion and dust from plowing, improper disposal of animal manure and carcasses, crop residues, and debris.

Alluvium – a general term for clay, silt, sand, gravel, or other unconsolidated material deposited by a stream or other body of running water; the term applies to stream deposits of recent time. Adjective: alluvial.

Ambient water quality – describing the chemical, physical, and biological characteristics of water as monitored beyond the immediate influence of human activities.

Anisotropy – the conditions under which one or more hydraulic properties of an aquifer vary from a reference point.

Aquifer – an underground geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Aquifer test – a test involving the withdrawal of measured quantities of water from, or addition of water to, a well (or wells) and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition in order to determine hydraulic properties of an aquifer.

Aquitard – an underground geologic formation that is slightly permeable and yields minor amounts of water in comparison to an aquifer; may function as a confining bed.

Arid climate – term applied to an area where the climate is dry, usually considered as areas with precipitation less than 10 inches per year.

Artificial recharge – recharge by deliberate or incidental actions of man.

Atmosphere – the gaseous layer that surrounds the earth. Synonym: air.

Attenuation – the process by which a compound is reduced in concentration over time, through absorption, adsorption, degradation, dilution, and/or transformation.

Bedrock – a general term for any consolidated rock.

Biodegradable – capable of decomposing under natural conditions.

Bioremediation – use of living organisms to clean up oil spills or remove other pollutants from soil, water, or wastewater.

Brackish – mixed fresh and salt water.

Brine – a solution containing appreciable amounts of NaCl and other salts

Capillary fringe – a zone in the soil just above the water table that remains saturated or almost saturated by water under less than atmospheric pressure.

Community water supply – a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

Concentration – the relative amount of a substance mixed with another substance; e.g., 1 milligram of iron per 1 liter of water or 1 mg/l.

Condensation – the process in which water vapor is cooled to the liquid phase.

Cone of depression – a depression in the water-table surface around a well, or group of wells, from which water is being drawn. Synonym: cone of influence.

Confined aquifer – an aquifer whose upper boundary is defined by a layer of geologic material that does not transmit water readily (see "aquitard"), resulting in the ground water in the aquifer being confined under pressure significantly greater than atmospheric pressure. Synonym: artesian aquifer.

Confining layer – geologic material through which significant quantities of water cannot move. Synonyms: aquitard, confining bed.

Contaminant – any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

Contamination -- introduction into water, air, and soil of microorganisms, chemicals, toxic substances, wastes, or wastewater in a concentration that makes the medium unfit for its next intended use.

Contamination source inventory – an inventory of potential contaminant sources within delineated source water protection areas.

Cuttings – spoils left from drilling boreholes and/or wells.

Dense non-aqueous phase liquid (DNAPL) – non-aqueous phase liquids such as chlorinated hydrocarbon solvents or petroleum fractions with a specific gravity greater than 1.0. These liquids sink through the water column until they reach a confining layer. Because they are at the bottom of aquifers instead of floating on the water table, typical monitoring wells may not indicate their presence.

Discharge area – an area in which subsurface water, including both ground water and water in the unsaturated zone, is discharged to the land surface, to a surface water, or to the atmosphere.

Dispersion -- the spreading and mixing of chemical constituents in ground water caused primarily by mixing due to microscopic variations in water flow rates within and between pores.

Downgradient – the direction that ground water flows; similar to "downstream" for surface water.

Drainage well – a well drilled to carry excess water off agricultural fields; because they act as a conduit from the land surface to the ground water, drainage wells can contribute to ground-water pollution.

DRASTIC – EPA methodology used to evaluate the sensitivity of an aquifer that considers 1) depth to ground water, 2) recharge, 3) aquifer matrix, 4) soil type, 5) topography, 6) impact of the vadose zone, and 7) hydraulic conductivity.

Drawdown – the drop in the water table or level of water in the ground when water is being pumped from a well; the difference between the water level in a well before pumping and water level in a well during pumping.

Evaporation – the process in which liquid water is transferred into the atmosphere from the soil and surface-water bodies.

Evapotranspiration – the combined loss of water to the atmosphere from land and water surfaces by evaporation and from plants by transpiration.

Extraction well – a discharge well used to remove ground water or air.

Feedlot – a confined area for the controlled feeding of animals (CAFO) that tends to concentrate large amounts of animal waste that cannot be absorbed by the soil. The waste may be carried to nearby streams or lakes by rainfall runoff or may percolate into the underlying ground water.

Flow line – the path that a particle of water follows in its movement through saturated, permeable rocks.

Fresh water – water that generally contains less than 1,000 milligrams per liter of dissolved solids (USGS).

Geological log – a detailed description of all underground features (depth, thickness, type of formation) discovered during the drilling of a well.

Ground-water discharge – the removal of water from the saturated zone across the water-table surface, together with the associated flow toward the water table within the saturated zone.

Ground water – that part of the subsurface water in the saturated zone.

Ground-water divide – a ridge in the water table or potentiometric surface from which ground water moves away in both directions.

Ground-water flow system – flow of ground water from areas of recharge to areas of discharge.

Head – the height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point.

Heavy metals – metallic elements with high atomic weights (eg., mercury, chromium, cadmium, arsenic, and lead); can damage living things at low concentrations and tend to accumulate in the food chain.

Hollow-stem auger drilling – conventional drilling method that uses augers to penetrate the soil; as the augers are rotated, soil cuttings are conveyed to the ground surface via auger spirals.

Hydraulic connection – a measure of the degree of potential interchange of ground water between adjacent aquifer units.

Hydraulic conductivity – the rate at which water can move through a permeable media; a measure of the ease with which a fluid will pass through a porous material, determined by size and shape of the pore spaces in the material and their degree of interconnection as well as by the viscosity of the fluid.

Hydraulic head – the sum of the elevation head and pressure head at a given point in an aquifer.

Hydraulic gradient – in general, the direction of ground-water flow due to changes in the depth of the water table; the change in hydraulic head per unit of distance in a given direction.

Hydraulic testing – a methodology employed to determine the various physical properties of an aquifer to transmit and store water. Synonym: pumping test.

Hydrogeology – the geology of ground water, with particular emphasis on the geologic environment of ground water.

Hydrologic cycle – movement or exchange of water between the atmosphere and earth; the circulation of water in and on the earth and through earth's atmosphere through evaporation, condensation, precipitation, runoff, ground-water storage and seepage, and re-evaporation into the atmosphere. Synonym: water cycle.

Hydrology – the science dealing with the properties, distribution, and circulation of water.

Impermeable – the property of a material or soil that does not allow, or allows only with great difficulty, the passage of water.

Individual sewage disposal system (ISDS) – see "septic system".

Infiltration – the downward entry of water through the land surface into the underlying soil or sediment.

Infiltration rate – the quantity of water that can enter the soil in a specified time interval.

Injection well – a well into which fluids are injected for purposes such as waste disposal, improving recovery of crude oil, or solution mining.

Inorganic chemicals – chemical substances of mineral origin with no organic elements.

Irrigation – applying water or wastewater to land areas to supply the water and nutrient needs of plants.

Irrigation return flow – surface and subsurface water which leaves the field following application of irrigation water.

Karst – a geologic formation of irregular limestone deposits with sinks, underground streams, and caverns.

Landfills – sanitary landfills are disposal sites for non-hazardous solid wastes spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day; secure chemical landfills are disposal sites for hazardous waste, selected and designed to minimize the chance of release of hazardous substances into the environment.

Leachate – water that collects contaminants as it trickles through wastes, pesticides, or fertilizers; leaching may occur in farming areas, feedlots, and landfills and may result in hazardous substances entering surface water, ground water, or soil.

Leaching – the process by which soluble constituents are dissolved and filtered through the soil by a percolating fluid.

Light non-aqueous phase liquid (LNAPL) – a non-aqueous phase liquid with a specific gravity less than 1.0 such as most common petroleum hydrocarbon fuels and lubricating oils; because the specific gravity of water is 1.0, most LNAPLs float on top of the water table.

Lithology – mineralogy, grain size, texture, and other physical properties of granular soil, sediment, or rock.

Maximum Contaminant Level (or MCL) – the maximum concentration of a specific contaminant that is allowed in public drinking water.

Mining of an aquifer – withdrawals of ground water over a period of time in excess of natural recharge and capture. Synonym: overdraft.

Mining waste – residues resulting from the extraction and processing of raw materials from the earth.

Monitoring – periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

Monitoring well – a well used to obtain water quality samples or measure ground-water levels.

Nitrate – a compound (NO_3) containing nitrogen that can exist in the atmosphere or as a dissolved ion in water and which can have harmful effects on humans and animals; a plant nutrient and inorganic fertilizer, nitrate is found in septic systems, animal feedlots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps.

Non-aqueous phase liquid (NAPL) – contaminants that remain undiluted as the original bulk liquid in the subsurface; eg., spilled oil.

Non-community water system – a public water system that is not a community water system; eg., the water supply at a camp site or national park.

Non-point sources – diffuse pollution sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet) generally carried off the land by storm water runoff; common non-point sources are agriculture, forestry, urban, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Non-potable – water that is unsafe or unpalatable to drink because it contains pollutants, contaminants, minerals, or infective agents (e.g. bacteria, viruses, etc.).

Non-transient, non-community water system – a public water system that regularly serves at least 25 of the same non-resident persons per day for more than six months per year.

Organic chemicals/compounds – animal- or plant-produced or synthetic substances containing mainly carbon, hydrogen, nitrogen, and oxygen.

Organism – any form of animal or plant life.

Overburden – rock and soil cleared away before mining.

Overdraft – the pumping of water from a ground-water basin or aquifer in excess of the supply flowing into the basin; results in a depletion or mining of the ground water. Synonym: mining of ground water.

Parts per billion (ppb) / parts per million (ppm) – units commonly used to express contamination ratios, as in establishing the maximum permissible amount of a contaminant in water, land, or air.

Pathogens – microorganisms (eg., bacteria, viruses, or parasites) that can cause disease in humans, animals, and plants.

Perched ground water – unconfined ground water separated from an underlying main body of ground water by an unsaturated zone; zone of pressurized water held above the water table by impermeable rock or sediment; often a result of clay lenses in the soil.

Percolation – the movement of water downward and outward through subsurface soil layers, sometimes continuing downward to ground water.

Permeable – the degree to which the pore or void spaces in soils and rock are interconnected; if spaces in rocks are connected and large enough that water, other liquids, or air can move freely through them, the rock is said to be permeable; eg., sand is more permeable than clay because the pore spaces between sand grains are larger than pore spaces between clay particles.

Permeability – the rate at which liquids or air pass through soil or other materials in a specified direction.

Pesticide – substance intended for preventing, destroying, repelling, or mitigating any pest; any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Piezometer – a nonpumping well, generally of small diameter, for measuring the elevation of the water table.

Plume – a visible or measurable discharge of a contaminant from a given point of origin; can be chemical or thermal in water.

Point source – a stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution (eg., a pipe, ditch, ore pit, factory smokestack, etc.).

Pollutant – any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution – the presence of a substance in the environment that because of its composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects.

Porosity – the degree to which the total volume of soil, gravel, sediment, or rock has pores or cavities through which fluids (including air) can move.

Potable water – water that is safe for drinking and cooking.

Potentiometric surface – the surface to which water in an aquifer can rise by water pressure; an imaginary surface representing the static head of ground water, of which the water table is one type.

Precipitation – moisture falling from the atmosphere in the form of rain, snow, sleet, or hail.

Prior appropriation – a doctrine of water law that allocates the rights to use water on a first-come, first-served basis.

Private domestic water supply – a water source developed for use by a single residence.

Public water system – a system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 individuals.

Public water supply – see "public water system".

Pumping test – a test conducted to determine aquifer or well characteristics. Synonyms: aquifer test, hydraulic test.

Quality assurance / quality control – a system of procedures, checks, audits, and corrective actions to ensure that all EPA research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

Radioactive substances – substances that emit ionizing radiation.

Radon – a colorless naturally occurring, radioactive, inert gas formed by radioactive decay of radium atoms in soil or rocks.

Raw water – intake water prior to any treatment or use.

Recharge – addition of water to the saturated zone, usually by infiltration and percolation from the soil surface.

Recharge area – a land area in which water that is infiltrated eventually reaches the saturated zone.

Recharge rate – the quantity of water per unit time that replenishes or refills an aquifer.

Remediation – cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site.

Riparian rights – entitlement of a land owner to certain uses of water on or bordering the property, including the right to prevent diversion or misuse of upstream waters.

River basin – the land area drained by a river and its tributaries.

Runoff – that part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water; the flow of water from the land to oceans or interior basins by overland flow and stream channels.

Safe water – water that does not contain harmful bacteria, toxic materials, or chemicals and is considered safe for drinking even if it may have taste, odor, color, and certain mineral problems.

Safe yield – the amount of ground water that can be withdrawn from a basin annually without producing an undesired result.

Salinity – the percentage of salt in water.

Salts – minerals that water picks up as it passes through the air, over and under the ground, or from households and industry.

Saturated zone – the area below the water table where all open spaces are filled with water under pressure equal to or greater than that of the atmosphere; a subsurface zone in which all the open spaces are filled with water under pressure greater than atmospheric; the upper surface of the saturated zone is the water table.

Secondary maximum contaminant level (or SMCL) – the maximum concentration of a specific contaminant that is recommended in public drinking water based on aesthetics.

Seepage – percolation of water through the soil from unlined canals, ditches, laterals, watercourses, or water storage facilities.

Semi-arid climate – term applied to an area where the climate is intermediate between arid and humid, usually considered as areas with precipitation ranging from 10 to 20 inches per year.

Semi-confined aquifer – an aquifer partially confined by soil layers of low permeability through which recharge and discharge can still occur.

Septic system – an on-site system designed to treat and dispose of domestic sewage; a typical septic system consists of a tank that receives waste from a residence or business and a system of tile lines or a pit for disposal of the liquid effluent that remains after decomposition of the solids by bacteria in the tank. Synonym: individual sewage disposal system.

Septic tank – an underground storage tank for wastes from homes not connected to a sewer line.

Sewage – the waste and wastewater produced by residential and commercial sources and discharged to sewers or septic systems.

Soft water – any water that does not contain a significant amount of dissolved minerals such as salts of calcium or magnesium.

Solubility – the amount of mass of a compound that will dissolve in a unit volume of solution.

Source water protection area – the area delineated by a state for a public water supply or including numerous such suppliers, whether the source is ground water or surface water or both.

Specific yield – the amount of water a unit volume of saturated permeable rock will yield when drained by gravity.

Spring – a concentrated discharge of ground water appearing at the ground surface as a current of flowing water.

Standards – norms that impose limits on the amount of pollutants or emissions produced; EPA establishes minimum standards, but the States or Tribes are allowed to be stricter.

Static water levels – elevation or level of the water table in a well.

Storage – water stored in an aquifer or other geologic unit.

Stratification – separating into layers.

Stratigraphy – study of the formation, composition, and sequence of sediments, whether consolidated or not.

Surface runoff – precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of non-point source pollutants into rivers, streams, or lakes.

Surface water – all water naturally open to the atmosphere and found over the land surface in streams, ponds, and wetlands.

Susceptibility analysis – an analysis to determine whether a public water supply is subject to significant pollution from known potential contaminant sources.

Tailings – residue of raw material or waste separated out during the processing of mineral ores.

Transient water system – a non-community water system that does not serve 25 of the same nonresidents per day for more than six months per year.

Transmissivity – a measure of the ability of an aquifer to transmit water.

Transpiration – the process by which water passes through living organisms, primarily plants, and into the atmosphere.

Treatment – any method, technique, or process designed to remove solids and/or pollutants from solid waste, waste streams, effluents, and air emissions.

Turbidity – a cloudy condition in water due to suspended silt or organic matter.

Unconfined aquifer – an aquifer whose upper boundary is the water table; an aquifer containing water that is not under pressure. Synonym: water-table aquifer.

Unsaturated zone – the area above the water table where pores are not fully saturated, although some water may be present; a subsurface zone containing water under pressure less than that of the atmosphere, including water held by capillarity, and containing air or gases generally under atmospheric pressure; limited above by the land surface and below by the water table. Synonym: vadose zone.

Vadose zone – the zone between land surface and the water table within which the moisture content is less than saturation and pressure is less than atmospheric; the capillary fringe is included in the vadose zone. Synonym: unsaturated zone.

Viscosity – the molecular friction within a fluid that produces flow resistance.

Water budget – the division of the water present within an aquifer or watershed into the major components of the hydrologic cycle; these components are precipitation, runoff, evapotranspiration, deep percolation, and change in storage. Synonym: water balance.

Watershed – all land and water within the confines of a drainage divide; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point.

Water supply system – the collection, treatment, storage, and distribution of potable water from source to consumer.

Water table – the upper surface of an unconfined aquifer at which the pressure is atmospheric; it is the level at which water stands in wells that penetrate the uppermost part of an unconfined aquifer.

Well – a bored, drilled, or driven shaft, or a dug hole whose depth is greater than the largest surface dimension and whose purpose is to reach underground water supplies or oil or to store or bury fluids below ground.

Wellfield – area containing one or more wells that produce usable amounts of water or oil.

Well point – a hollow vertical tube, rod, or pipe terminating in a perforated pointed shoe and fitted with a fine-mesh screen.

Wellhead protection area – a protected surface and subsurface zone surrounding a well or wellfield supplying a public water system. The zone is protected to keep contaminants from reaching the well water.

Wetlands – an area that is saturated by surface water or ground water with vegetation adapted for life under those soil conditions (also called swamps, bogs, fens, marshes, and estuaries).

Yield – the quantity of water (expressed as a rate of flow or total quantity per year) that can be collected for a given use from surface-water and ground-water sources.

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APPENDIX B

STATE AND EPA GROUND-WATER WEBSITES

APPENDIX B

State and EPA Ground-Water Program Websites

COLORADO

The Department of Public Health and Environment, Water Quality Control Division is responsible for ground water quality programs, including ground water quality monitoring, CDPS groundwater discharge permits, and Source Water Protection. The Division has convened a state ground water protection council comprised of all state agencies involved with ground water protection.

http://www.cdphe.state.co.us/wq/wqhom.asp

The Office of the State Engineer, Division of Water Resources is responsible for ground water quantity issues including well permits and water rights issues.

http://www.water.state.co.us/grnd.htm

MONTANA

The Department of Environmental Quality is responsible for several ground water quality programs, including ground water remediation, Montana Ground Water Pollution Control System permits, subdivision sanitary review, and the Source Water Protection Program. The Department of Environmental Quality has a collaborative role in the Montana Ground Water Plan.

http://www.deq.state.mt.us/wqinfo/index.asp

Department of Natural Resources and Conservation, Water Resources Division is responsible for the use, development, and protection of water resources, including ground water in Montana. They are responsible for water well permitting, water rights, and the Montana Ground Water Plan (http://www.dnrc.state.mt.us/wrd/gw_plan.htm).

http://www.dnrc.state.mt.us/wrd/home.htm

The Department of Agriculture is responsible for protecting ground water and the environment from impairment or degradation due to the use or misuse of agricultural chemicals (pesticides and fertilizers). The program includes ground water quality monitoring and public education.

http://www.agr.state.mt.us/programs/asd/groundh2o.shtml

Information on Montana's ground water resources is available on line through the Montana Natural Resource Information System.

http://nris.state.mt.us/wis/mtgwres.htm

NORTH DAKOTA

The Department of Health is responsible for the Ground Water Protection Program, including ambient ground water quality monitoring, Source Water Protection, and Underground Injection Control.

http://www.health.state.nd.us/ndhd/environ/wq/gw/gwindex.htm

The Department of Agriculture is responsible for developing the state's water protection strategy for pesticides.

http://www.state.nd.us/agr/divisions.html#pe

SOUTH DAKOTA

The Department of Environment and Natural Resources (DENR), Ground Water Quality Program is responsible for managing ground water resources through oversight of clean up efforts, ambient ground water quality monitoring, ground water discharge permits, the Underground Storage Tank Program, the Underground Injection Control Programs, and Source Water Assessment and Protection Programs.

http://www.state.sd.us/denr/DES/Ground/groundprg.htm

The DENR, Water Rights Program is responsible for ground water rights issues, water well construction standards, technical assistance for proper plugging of abandoned wells, and the observation well network.

http://www.state.sd.us/denr/des/waterrights/wr_organization.htm

Information about aquifers and ground water resources is available from the DENR Geological Survey.

http://www.sdgs.usd.edu/index.html

UTAH

The Department of Environmental Quality (DEQ), Division of Water Quality's mission is to protect and enhance the quality of Utah's ground and surface waters. Activities include ground water permits for waste water discharges and UIC permits.

http://www.deq.state.ut.us/eqwq/Dwq_info.htm

The DEQ, Division of Environmental Response and Remediation is responsible for the Underground Storage Tank Program and ground water remediation.

http://www.deq.state.ut.us/EQERR/errhmpg.htm

The DEQ, Division of Drinking Water is responsible for the Drinking Water Source Protection Program.

http://www.deq.state.ut.us/eqdw/source_protection_intro.htm

The Utah Department of Natural Resources (DNR), Division of Water Resources is responsible for the management of water resources in Utah, including ground water. They have primary responsibility for the Utah Water Plan, which includes management of ground water in the state.

http://www.nr.state.ut.us/wtrresc/Waterplan/uwrpff/TextOnly.htm

For information about ground water resources in Utah, contact the Utah DNR, Geological Survey.

http://www.ugs.state.ut.us/

The UT DNR, Water Rights Division oversees the drilling of water wells. Resources include water well logs for all wells more than 30 feet deep drilled in the state.

http://nrwrt1.nr.state.ut.us/wellinfo/default.htm

The Utah Department of Agriculture and Food, Agricultural Water Quality and Environmental Programs is responsible for ground water quality issues related to agricultural practices and chemicals.

http://ag.utah.gov/mktcons/nps.htm

WYOMING

The Wyoming Department of Environmental Quality, Water Quality Division is responsible for source water and wellhead protection, ground water vulnerability, subdivision planning, septic systems, underground storage tanks, and underground injection control.

http://deq.state.wy.us/wqd.htm

The Wyoming State Engineer's Office, Division of Ground Water permits water wells in Wyoming and manages a ground water data collection program, including well logs.

http://seo.state.wy.us/gw/gw.html

The Wyoming Department of Agriculture is responsible for water quality issues related to agricultural practices.

http://wyagric.state.wy.us/ADMIN/wda.html

US EPA WEBSITES

General Information

Main US EPA website	http://www.epa.gov
Region 8 website	http://www.epa.gov/region8/

Freedom of Information Act requests
Region 8
http://www.epa.gov/region08/foia/foia/html

Program-specific websites

Safe Drinking Water Act

General Information
http://www/epa.gov/safewater/

Sole Source Aquifer Program
http://www.epa.gov/safewater/ssanp.html

Underground Injection Control Program
http://www.epa.gov/safewater/uic.html
http://www.epa.gov/region8/water/uic/index.html

UIC Class V Program
http://www/epa.gov/safewater/uic/classv.html

Source Water Assessments and Protection, Wellhead Protection Programs
http://www.epa.gov/safewater/protect.html
http://www.epa.gov/region8/water/swap/index.html

Public Water Supply Supervision (Drinking Water) Program
http://www.epa.gov/safewater/pws/pwss.html
http://www.epa.gov/region8/water/dwhome/dwhome.html

Ground Water Rule
http://www.epa.gov/safewater/protect/gwrfs.html

National Drinking Water Contaminant Occurrence Database
http://www.epa.gov/ncod/

Resource Conservation and Recovery Act - Solid and Hazardous Waste Programs

General Information

http://www.epa.gov/epaoswer/osw/index.htm
http://www.epa.gov/region08/land_waste/index.html

Hazardous Waste Program

http://www.epa.gov/epaoswer/osw/index.htm
http://www.epa.gov/region08/land_waste/rcra/rcrahwaste.html

Corrective Action Program

http://www.epa.gov/epaoswer/hazwaste/ca/index.htm
http://www.epa.gov/region08/land_waste/rcra/rcrahazclean.html

Municipal Solid Waste

http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/index.htm
http://www.epa.gov/region08/land_waste/landfills/landfills.html

Underground Storage Tanks/Leaking Underground Storage Tanks

http://www.epa.gov/swerust1/index.htm

Comprehensive Environmental Response Compensation and Liability Act (Superfund)

General Information

http://www.epa.gov/superfund/
http://www.epa.gov/region08/superfund/

Clean Water Act

General Information

http://www.epa.gov/OW/
http://www.epa.gov/region08/water/

Non Point Source Program (Polluted Runoff)

http://www.epa.gov/owow/nps/
http://www.epa.gov/region08/water/nps/

TMDLs

http://www.epa.gov/owow/tmdl/
http://www.epa.gov/region08/water/tmdl/

Septic Systems

www.epa.gov/owm/mtb/decent/index.htm

APPENDIX C

USGS NAWQA SUMMARY

USGS NAWQA SUMMARY

General USGS ground-water information may be found at http://water.usgs.gov/ogw. This includes ground water data, publications, field methodologies, and links to other ground water programs.

USGS DISTRICT OFFICES

http://co.water.usgs.gov

http://ut.water.usgs.gov

http://mt.water.usgs.gov

http://nd.water.usgs.gov

http://sd.water.usgs.gov

http://wy.water.usgs.gov

These websites have information on water resource investigations, real-time data, and drought / flood information within each of these States.

The website for the USGS Water Resource Discipline's **National Research Program** is:

http://water.usgs.gov/nrp/

Information on current research activities as well as links to State water research activities can be accessed.

USGS NAWQA SUMMARY

A general table of all the individual NAWQA study basins, their year of startup, and the States covered may be found at:

http://water.usgs.gov/nawqa/nawqamap.html#TABLE