Ground Water ...A Call to Action

Our ground water resources are in serious need of attention. Abundant, high-quality, low-cost ground water resources are fundamental to the long-term growth and vitality of our nation, yet this most important resource is often overlooked, if not neglected. Attention to the protection and management of ground water has consistently lagged behind that given to surface waters, meaning that historic and current water resource laws and policies deal primarily with the protection and management of our more visible lakes, rivers, and wetlands.

Key Message

These protection disparities and deficiencies can be partly attributed to the hidden nature of ground water. However, there is also a lack of appreciation of the fact that ground water is a key drinking water source nationwide; a critical resource for many sectors of our economy; and an integral part of the water cycle, providing baseflow to the majority of surface waters. Furthermore, many of us are not aware that the quality and quantity of our nation's ground water is now significantly threatened.

To reverse this trend, we must take swift and decisive action to ensure that ground water is meaningfully integrated into federal and state water resource conservation, management, and protection agendas. We must adopt new paradigms in water policy and science that demonstrate the interactive relationships among components of watersheds and ecosystems, and the essential role ground water plays in those systems. We must ensure that these new paradigms are based on solid scientific principles that allow us to better understand the role of ground water in maintaining watersheds so we can make wise water-policy, land-use, and water-use decisions accordingly.

Photo: Pat Tucci, USGS

A karst area of the White River National Forest, Colorado, showing the interface of ground water with surface water.

Toward a New Ground Water Paradigm

"Water promises to be in the 21st century what oil was to the 20th century: the precious commodity that determines the wealth of nations."

Maude Barlow, Tony Clarke | *"Who Owns Water?"* | *The Nation*, September 2002

why this urgent call to action?

Water demand, quality, and quantity are matters of national urgency. If we don't act now, we risk degrading and jeopardizing the future health and well-being of our citizens, our economy, and our ecological systems. Water is the essential lifeblood of all living creatures, yet it is already in short supply throughout much of the United States. Fresh water comprises less than one-half of a percent of all the water on earth, and ground water makes up about 97 percent of available fresh water. Ground water is about 60 times as plentiful as fresh water found in lakes and streams (USGS, 2006). In the United States, ground water is the drinking water source for about half the population—about 150 million people. The United States Geological Survey (USGS) estimates that in the year 2000, 84.5 billion gallons of ground water were withdrawn each day (Hutson et al., 2004), up from about 30 billion gallons per day in 1950 (Solley et al., 1998). About 68 percent of this was used for irrigation.

Over the past century, human activities have had a profound affect on ground water quality and quantity. Of greatest significance is the fact that as our population continues to grow, the demand for readily available, good-quality water—ground and surface water—continues to escalate. As demand for fresh water grows, ground water has increasingly become the nexus of many competing interests. It is an essential resource for sustaining the agricultural, commercial, and industrial sectors of our economy—including food production and processing, chemical manufacturing, energy production, mining, livestock operations, and many others. Ground water is fast becoming a prominent factor in other critical processes, such as carbon dioxide geosequestration, brackish water desalination, and emerging waste disposal needs.

Ground water is also essential to a variety of ecological functions, such as maintaining wetlands, contributing to in-stream flow levels, protecting onshore fresh drinking water supplies from saltwater intrusion, and preventing land subsidence, to name a few. Yet increased water demands press many communities and regions to withdraw ground water at rates that overstress the very aquifers that sustain them. In many areas of the United States, more water is withdrawn from aquifers than is replaced, lowering water tables and in-stream baseflow and stripping once-lush riparian areas of associated vegetation and wildlife. Human activities have altered many landscapes, changing the water balance and the physical, chemical, and biological processes that control water quality.

Harmful substances have entered ground water by way of leaks, spills, seepage, disposal, and burial. In the process, ground water has been degraded, placing an added strain on limited water supplies. Traditional land development practices often create and compound impervious surface areas, which prevents ground water recharge and increases flooding potential in nearby rivers and streams.

Ground Water—the Overlooked and Undervalued Resource

Ground water has too often been taken for granted and has suffered from a lack of emphasis on the part of local, state, and national leadership and a lack of funding for protection and research. Ground water protection and management laws and policies are often highly fragmented among multiple state and federal agencies and, as such, do not support a cohesive national approach to sustainable resource management.

At least 16 different federal laws relate directly or indirectly to ground water management. Many focus exclusively on ground water as a source for public drinking water supplies, neglecting its critical importance for other vital purposes, including surface water recharge and a source of drinking water for privately owned wells.

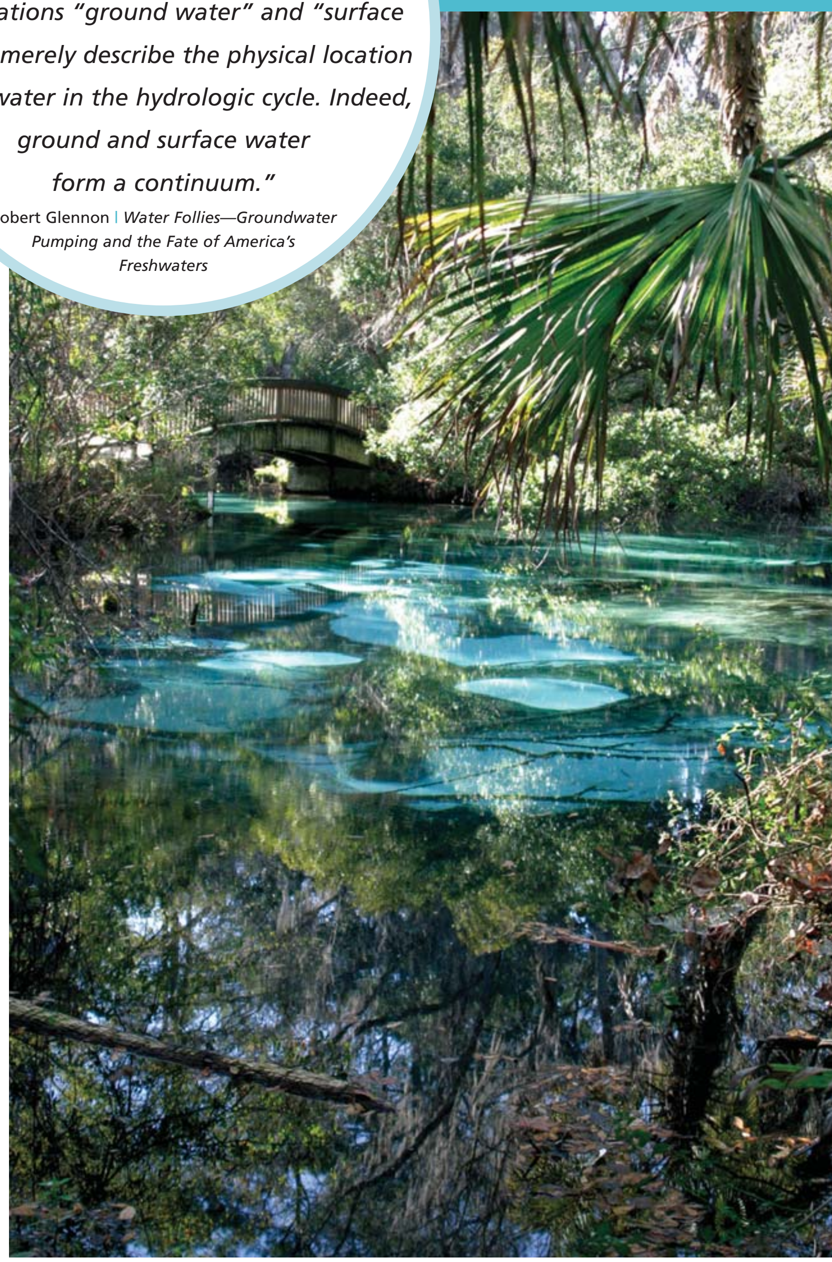
There is currently no national strategy for the comprehensive protection and management of the country's ground water resources. However, the growing competition for water resources demands that we adopt a coherent, comprehensive national ground water protection strategy that clearly articulates ground water protection and management goals and ensures that adequate support is directed toward accomplishing those goals.

If We Don't Take Action Now…

The good news is that our ground water problems are not insurmountable, but it is essential that we act swiftly, intelligently, responsibly, and with an eye to the future. If we don't take action now, it is inevitable that the state of ground water quality in many parts of this country will continue to decline—at a great cost to people and the places they live. When a water supply is no longer available because of overdraft, degradation, or hydrologic relocation, it is usually very difficult and expensive to replace.

"Ground water and surface water are not separate categories of water any more than liquid water and ice are truly separate. The designations "ground water" and "surface water" merely describe the physical location of the water in the hydrologic cycle. Indeed, ground and surface water form a continuum."

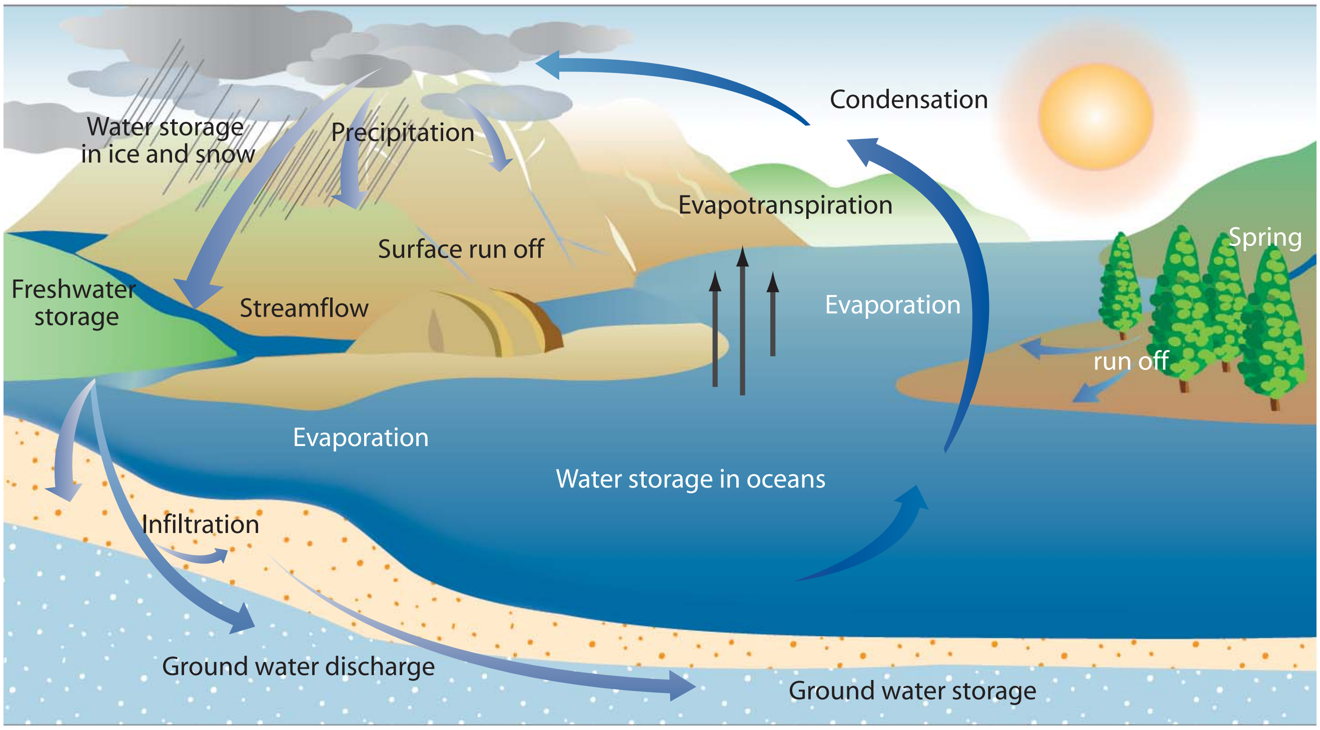
Robert Glennon | *Water Follies—Groundwater Pumping and the Fate of America's Freshwaters*



Fern Hammock Spring, Marion County, Florida. A spring is our window to an aquifer. It is an opening in the earth from which ground water flows to the surface, forming a natural pool of water. Florida's springs are formed because of the porous limestone (or "karst") topography.

Photo: Tom Scott FGS/FDEP

HYDROLOGIC CYCLE



Artwork by Poshen Wang

Figure 1. The movement and continual recycling of water between the atmosphere, the land surface, and underground is called the hydrologic cycle. This movement, driven by the energy of the sun and the force of gravity, supplies the water needed to support life. The hydrologic cycle is basic to our understanding of water. Understanding the hydrologic cycle is key to effective water resources management.

GROUND WATER IN THE NATURAL SYSTEM

Ground water plays a critical role in the hydrologic cycle and thus the maintenance of healthy watersheds and ecosystems. The idea that the water bodies (e.g., lakes, streams, ground water, oceans, wetlands) of this earth are isolated and separate entities is pure myth. In truth, all water is a part of a highly interactive and dynamic hydrologic cycle—the earth's circulatory system—that runs continuously above, upon, and below the earth's surface. (See Figure 1.) This cycle is powered by a series of natural processes that keep water on the move through evaporation, evapotranspiration, condensation, precipitation, infiltration, recharge, and discharge.

Even though it is out of sight, ground water is intrinsic to the hydrologic cycle, serving as a vast subsurface reservoir that is virtually everywhere at varying distances below the surface of the earth. Key to the ground water/surface water relationship is the role that ground water plays as the baseflow for many rivers and streams, allowing them to continue to flow during dry summer months. (See Figure 2.) In fact, based on a national representative sampling of streams, the U.S. Geological Survey has found that the

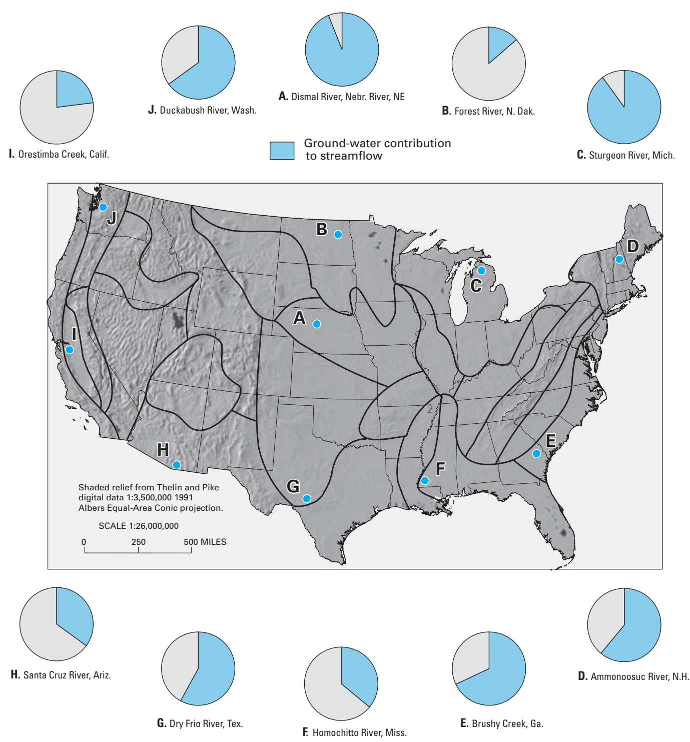
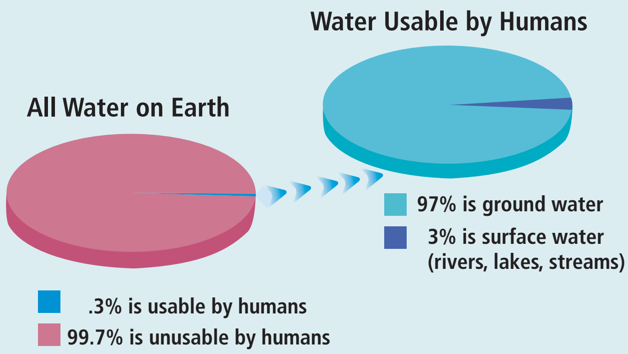


***Figure 2. Estimated ground-water contribution to streamflow is shown for specific streams in 10 of the regions.** In the conterminous United States, 24 regions were delineated where the interactions of ground water and surface water are considered to have similar characteristics. Blue portions of the pie charts indicate ground water contribution to streamflow in the various regions.*

Source: http://pubs.usgs.gov/circ/circ1139/htdocs/natural_processes_ of_ground.htm

GROUND WATER– WHY DO WE CARE?

WHY do we care? Because most of the earth's usable fresh water is in the ground.



Over 70 percent of earth's surface is covered with water, but 97 percent is unusable salt water, 2 percent is ice, and less than 1 percent is fresh and available for consumption. That really is "a drop in the bucket"! Of that tiny 1 percent of available fresh water, less than 5 percent is actually found in lakes, streams, and other surface areas. The rest is under our feet! Most of us are unaware of this huge volume of water under every inch of our planet. In some places it is within a few feet, in others, many thousands of feet.

Figure 3. *Source: USGS Water Science for Schools Website: http://ga.water.usgs.gov/edu/earthwherewater.html*

average ground water contribution to stream flow is 52 percent. (Winter et al., 1998)

Overdrafting ground water can and has dried up rivers, streams, lakes, and springs. This, in turn, can have a devastating impact on aquatic ecosystems, not to mention the people who depend on surface water for their water supply. Such changes typically happen gradually and are not necessarily noticed until ground water/surface water supplies are seriously diminished.

The Watershed Framework

The watershed provides a natural and logical framework for understanding and managing water resources, and ground water must be a recognized part of that framework. Any watershed-based water budget without a ground water component is incomplete. Any discussion about the health and integrity of a watershed that does not address ground water is incomplete. Any plans to conserve and protect or restore water resources within a watershed that do not account for ground water are incomplete. To include ground water in this framework we must view the watershed three dimensionally—as a unit with length, width, and depth.

> *"Knowledge carries with it the responsibility to see that it is used well in the world."*
>
> David Orr | *Earth in Mind*

States and communities need to work together across watersheds to develop and implement plans to protect their local water resources. This approach must be based on good science and have broad stakeholder involvement so that everyone understands how the complete hydrologic system functions within the three-dimensional watershed area. (See Figure 4.) This approach allows us to manage our water resources sustainably and gets us out of the bad habit of addressing land-use issues piecemeal.

3-DIMENSIONAL WATERSHED AREA

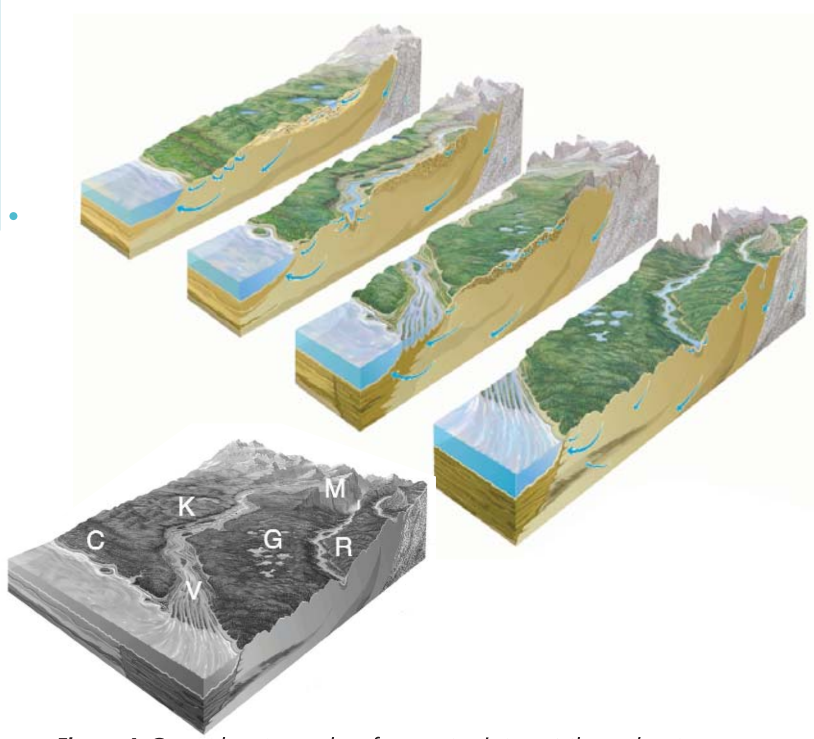


Figure 4. *Ground water and surface water interact throughout all landscapes from the mountains to the oceans, as depicted in this diagram of a conceptual landscape. M, mountainous; K, karst; G, glacial; R, riverine (small); V, riverine (large); C, coastal.*

Source: http://pubs.usgs.gov/circ/circ1139/htdocs/natural_processes_of_ground.htm

HUMAN IMPACTS ON GROUND WATER

While we have been tapping ground water for household, farm, business, and community uses for centuries, we have historically operated under the assumption that ground water would always be there for us. But we are learning that this is not the case. There are better ways to act so that ground water is protected and conserved. While we have become more knowledgeable about the nature of our impacts on ground water quality and quantity and have developed the tools to better evaluate and manage these resources, we need to strengthen our resolve to support the steps needed to reduce human impacts. The following sections provide a brief overview of some of the ways we degrade and deplete our ground water resources.

Overdrawing the Ground Water Account

In many places across the country, water budgets are running at a deficit. The resulting effects depend on several factors, including withdrawal and natural discharge rates, physical properties of the aquifer, and natural and human-induced recharge rates. (USGS, 2003) Ground water depletion is occurring at varying scales, ranging from single wells to enormous aquifer systems underlying several states.

The Ogallala Aquifer in the High Plains, for example, underlies eight states from South Dakota to Texas and has been intensively developed for irrigation since

LOS ANGELES' GROUND WATER IN THE BALANCE

Los Angeles' only local water supply is contained in the vast San Fernando Valley aquifer, a natural storage system capable of holding enough water to supply Los Angeles for five years. The city imports 85 percent of its drinking water from the Sierra Nevada Mountains (where the snowpack has recently been low) and the Colorado River; the San Fernando Valley ground water basin supplies the rest (15 to 30 percent). In dry years, the city can draw as much as 30 percent of its supply from the ground water, saving on the cost of importing water.

The aquifer has never been used to its maximum capacity, partly because it is used as a reserve water supply but also partly because for more than 20 years areas of the aquifer have been undergoing treatment for volatile organic compounds (VOCs), including trichloroethylene (TCE) and perchloroethylene (PCE) contamination from industrial sources, which are less dense than water and float at the surface of the water table. For this reason, ground water must be pumped so that contaminated water is not drawn into the drinking water supply. In fact, time and again the Department of Water and Power (DWP) has had to shut down or restrict wells contaminated with high levels of industrial solvents. There are multiple wellfields where pumping is restricted.

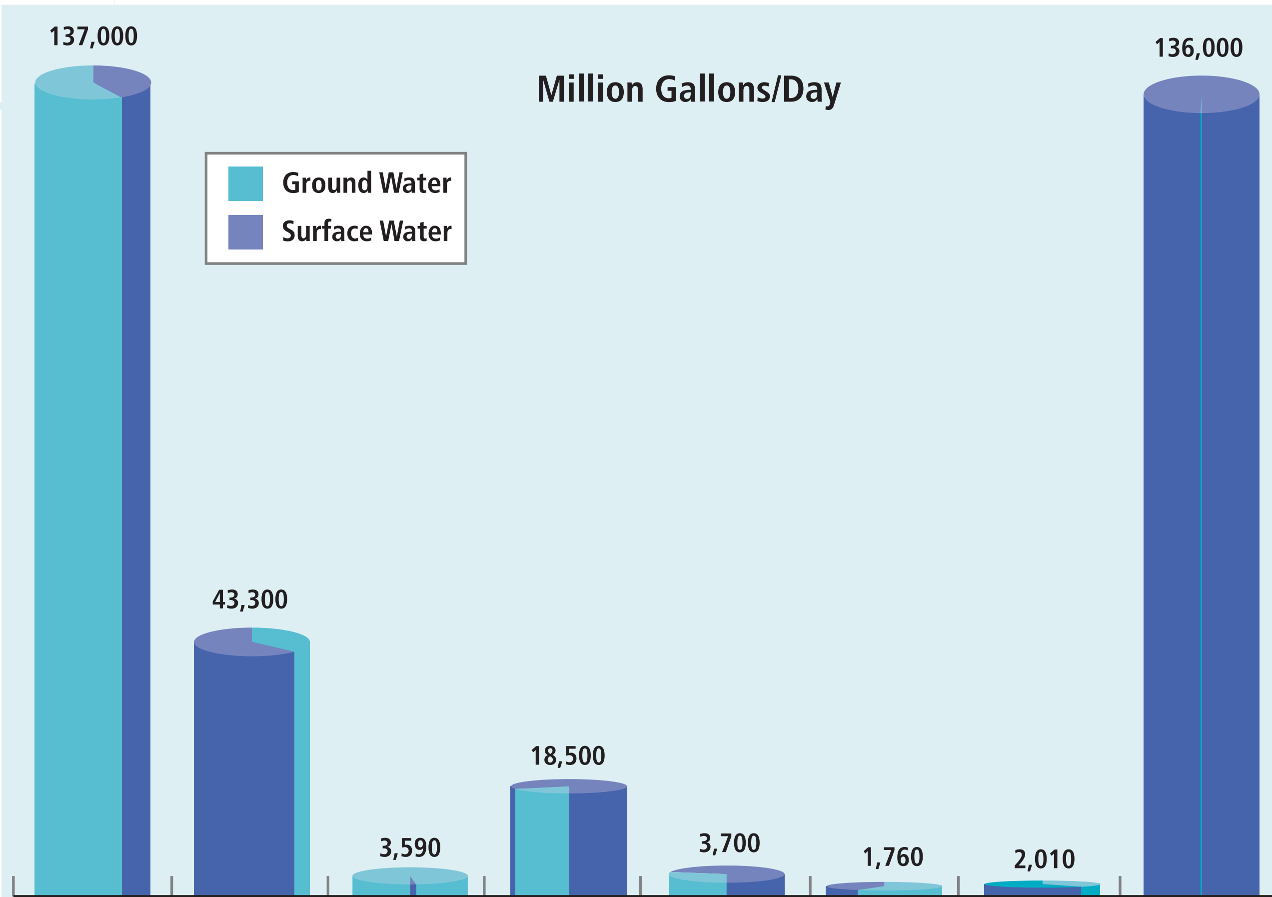
Now, more than four years after being warned that a creeping chromium plume was threatening this water supply, the DWP has had to shut down one well because of chromium contamination and restrict pumping in yet another wellfield because of VOC contamination. DWP officials are concerned that this contamination will spread and jeopardize the local water supply.

Because of the need to control the spreading contamination, the city will be able to draw only 10 percent of its supply from local ground water in 2007. This means that the DWP is going to need to import more water—at a cost of more than $7 million to the city's ratepayers. This situation has fueled frustration and a flurry of finger-pointing at government at all levels regarding who should have been remedying this situation much sooner.

This ground water threat comes as the DWP and Los Angeles County are spending hundreds of millions of dollars to increase the amount of water in the aquifer by undertaking projects to capture storm water and infiltrate the ground with it. State water bond money is also being sought for a $78 million project to enlarge Big Tujunga Dam to catch more winter-water runoff that now flows to the ocean.

Primary source:
http://www.presstelegram.com/news/ci_6008394

TOTAL FRESHWATER WATER WITHDRAWALS BY WATER-USE CATEGORY, 2000



	Agricultural Irrigation	Public Water Supply	Private Water Supply	Industrial	Aquaculture	Livestock	Mining	Thermo-electric Power
GW	41.5%	37.0%	98.3%	19.3%	28.6%	57.4%	38.2%	0.3%
SW	58.4%	63.0%	1.6%	80.5%	71.4%	42.4%	61.7%	99.3%

Figures may not sum to 100% because of independent rounding.

Figure 5. *Source: http://pubs.usgs.gov/circ/2004/circ1268/htdocs/text-total.html*

WWII. As a result, water levels in this "bread basket of the nation" have declined more than 100 feet in some areas, and the saturated thickness of the aquifer has been reduced by more than half in others. Water levels are recovering in some areas owing to the implementation of state and local management strategies, improved irrigation efficiency, low crop prices, and agricultural programs (McGuire et al, 2003), but unless the aquifer is replenished at a sustainable rate, the future viability of agriculture in the region is at risk.

Ground water overdraft is not limited to drought-prone areas of the country. Even in "water-rich" areas, such as Florida, overwithdrawal in certain highly populated coastal areas has caused serious water supply problems. Some of the negative effects of ground water depletion include dried-up wells, reduced surface water levels, degraded water quality, and land subsidence.

Saltwater intrusion is another ground water quality concern, particularly in coastal areas where changes in freshwater flows and increases in sea level both occur. As ground water pumping increases to serve water demand along the coast and sufficient recharge does not occur, coastal ground water aquifers are increasingly experiencing seawater encroachment.

THE WATER-ENERGY NEXUS

Energy production requires a reliable, abundant, and predictable source of water. Although some water is discharged for future use, the electricity industry is second only to agriculture as the largest user of water in the United States. Electricity production in the U.S. from fossil fuels and nuclear energy requires 190 billion gallons of water per day, accounting for 39 percent of all freshwater withdrawals in the nation—71 percent of that goes to fossil-fuel electricity generation. Coal, the most abundant fossil fuel, currently accounts for 52 percent of U.S. electricity generation, and each kWh generated from coal requires withdrawal of 25 gallons of water.

In everyday terms, we indirectly use as much water to turn on the lights and run appliances as we do to take showers and water lawns. According to the 2001 National Energy Policy, our growing population and economy will require 393,000 MW of new generating capacity (or 1,300 to 1,900 new power plants—more than one built each week) by the year 2020, putting further strain on the nation's water resources. (Sandia Labs, 2006) While water used for energy production comes primarily from surface water, ground water has become an integral part of the water-energy nexus because of overall competition for water resources.

Primary source: Sandia Labs, 2006

A less predictable phenomenon that is likely to have additional and potentially disruptive effects on the hydrologic cycle and hence water availability and quality is climate change. The amount, timing, and distribution of rain, snowfall, and runoff are changing for several reasons, and are leading to alterations in water availability as well as further intensifying competition for water resources. Changes are also likely in the intensity and duration of both floods and droughts, with related changes in water quality. Drought is an important concern in every region of the United States. Snowpack changes are especially important in the West, Pacific Northwest, and Alaska. While ground water supplies are less susceptible than surface water to short-term climate variability; they are more affected by long-term trends. (National Assessment Synthesis Team, U.S. Global Change Research Program, 2000, 2003)

Ground Water Degradation

In some ways, ground water is the victim of an out-of-sight, out-of-mind phenomenon. Everyday activities, such as pumping gas, flushing the toilet, throwing out unwanted paint and household cleaners, fertilizing the lawn, and building a new housing unit, can have harmful implications for ground water. In some commercial and industrial activities, fuel and hazardous materials are stored underground, and volumes of man-made wastes and industrial by-products are buried in landfills or disposed of underground. Any of these activities has the potential to release contaminants into ground water if not managed properly.

One of the most prevalent threats to ground water is the discharge of household wastes to onsite wastewater treatment (septic) systems. Too often, these wastes, which can contain pathogens, nutrients, metals, and even pharmaceuticals and personal-care products, are flushed down the drain or toilet and, too often, reach ground water. Other ground water threats from human waste sources include improperly treated and disposed of sludge and septage from municipal and industrial wastewater treatment sources and raw sewage escaping from leaking sewer lines on the way to a treatment facility.

Photo: Dave Belyea

A petroleum-contaminated former gas station in Eugene, Oregon. The site was a blight on the face of the community and a dumping ground for tire, garbage, and drums of potentially hazardous wastes. The site has since been transformed into a state-of-the-art biofuels station, and ground water cleanup is still under way.

STRAINED SURFACE WATER/GROUND WATER RELATIONS

The National Water-Quality Assessment Program (NAWQA) of the U.S. Geological Survey is the primary source of long-term, nationwide information on the quality of streams, ground water, and aquatic ecosystems. The following two examples are taken from recent NAWQA findings (http://water.usgs.gov/nawqa/xrel.pdf) that address the importance of surface water/ground water relations.

San Antonio's Edwards Aquifer

NAWQA findings showed that major streams in the San Antonio, Texas, area lose substantial amounts of water to the nearby highly permeable, faulted, and fractured carbonate outcrop of the Edwards aquifer. The streams in large part originate in and flow through what is now mostly undeveloped rangeland; however, these streams also flow through northern San Antonio, which continues to be developed. Some contaminants that are typical of urban runoff are finding their way to the recharge zone and ultimately to the aquifer. For example, chloroform, along with the herbicides atrazine, deethylatrazine, simazine, and prometon, were commonly detected in NAWQA samples from wells in the recharge zone. Findings on water quality in the Edwards aquifer and in the recharging streams point to a critical management issue because the aquifer is the principal water supply for the greater San Antonio region. While the concentrations detected for the 13 pesticides for which drinking water standards or guidelines have been established were substantially lower than their allowable maximums, standards for combinations of pesticides have not been established, and very little is known about these effects on human health.

Photo: Copyright © Larry Fellows, Arizona Geological Survey

Interactions between ground water and surface water aren't always as obvious as the hot spring along Hot Creek, California, pictured here. Greater attention and research on ground water-surface water interactions is critical for effective protection of all water resources.

The Platte River's Alluvial Aquifer

NAWQA findings showed that ground water withdrawals from the Platte River's alluvial aquifer induce infiltration from the river to the aquifer, where public water supply wells provide about 117 million gallons per day to Nebraska's large cities—Omaha, Lincoln, Grand Island, and Kearney. The aquifer provides 70 percent of Nebraska's drinking water and supports such key economic uses as crop irrigation.

Elevated concentrations of atrazine (at times exceeding the USEPA drinking water standard of 3 micrograms per liter) were detected in public supply wells in the Ashland wellfield, the primary source of public supply for the City of Lincoln, which has a population of about 200,000. The atrazine in the Ashland wellfield is found in induced recharge water from the Platte River. These atrazine hits are from spring runoff into the river. This river water is being drawn into the ground water via bank storage and pumping of the city wells (which are right next to the river). The USGS studies improved the City of Lincoln's understanding of the transport of pesticides from the Platte River through channel alluvium and into the ground water at the wellfields near the river. The city now carefully watches spring pumping and atrazine levels, tracking river water and well water much more closely for atrazine spikes. The NAWQA findings are also being used by the city to update its wellfield management plan.

The NAWQA findings also look at the Central Nebraska Platte River Basins where there is heavy agricultural use of fertilizers and herbicides, such as atrazine, alachlor, cyanazine, and metolachlor. In this case, the chemicals are leaching into the ground directly from the farms where they are used, mainly due to very shallow depth to water and very sandy soils. Atrazine is not routinely detected in ground water in other parts of the state.

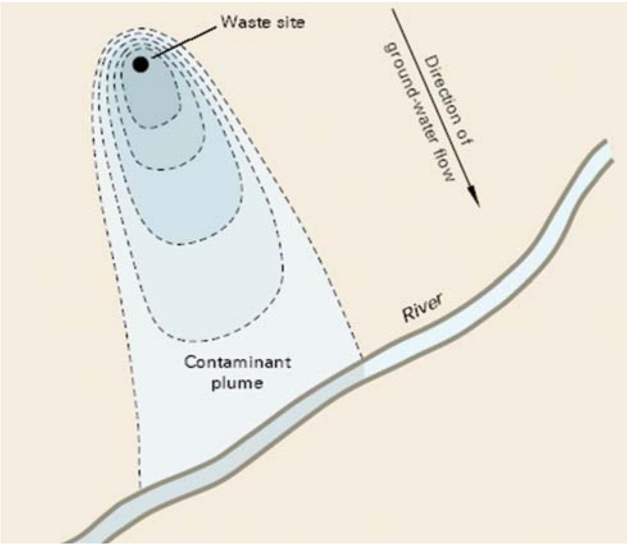


Figure 6. *The transport of contamination from a point source by ground water can cause surface water contamination, as well as extensive ground water contamination.*

Source: http://pubs.usgs.gov/circ/circ1139/pdf/part2.pdf

Contaminant sources—such as leaking underground storage tanks; storm water runoff; fertilizers, herbicides, and pesticides used in agricultural operations; animal wastes from densely packed feedlots and hog- and poultry-raising operations; toxic consumer and industrial products; and hazardous products and wastes spilled or leaked onto highways and parking areas—can all find their way to ground water if we are not careful. (See Figure 6.) Atmospheric transport and deposition (part of the hydrologic cycle) also transport substances, including mercury, pesticides, sulfuric acid from fossil-fuel combustion, and nitric acid, to the land surface and, by infiltration, to ground water.

Rearranging the Landscape

For the most part, our growth and development decisions over the past 100 years have not considered impacts on the hydrologic system. Physical alterations associated with urban and suburban growth, including attendant tree loss, stream channelization and damming, and loss of agriculture land, have had and continue to have significant impacts on both surface and ground water quality and availability. Other land uses such as agriculture, forestry, transportation, and mining contribute additional impacts.

Colorado land being cleared for new housing projects. Each and every time the landscape is modified, we must consider the impact on the hydrologic cycle, including the subsurface ground water environment.

Photo: Arthur Kuehne

Ground water flows directly into streams, rivers, lakes, and wetlands through stream beds or the bottoms of lakes or wetlands. This is a spring boil in the Bogue Chitto River, Louisiana.

Inasmuch as ground and surface waters are connected, our concern for and attention to the fact that contamination of ground water pollutes surface waters should speak loud and clear that these water resources should be given equal footing.

Each year more tracts of undeveloped land are turned into impervious surfaces, such as roads, parking lots, driveways, sidewalks, and rooftops, preventing rain and snowmelt from recharging ground water. Instead, this water rapidly passes over these surfaces, collecting oil, grease, road salt, heavy metals, pathogens, pesticides, and other contaminants. As water is transported in this manner, it causes accelerated erosion and flooding along the water pathway, disarranges river morphology and stability, and contaminates receiving waters and riparian systems.

There are numerous examples of land-development techniques that utilize or mimic the many benefits of natural hydrology while still allowing for development. Local land-use decision makers can adopt and apply land-use practices that consider the location and vulnerability of water resources, ensure long-term water supply availability and protection, and direct development to areas where there is adequate water supply and infrastructure.

DRAWING WISDOM FROM A WELL

Wells are our primary means for drawing water from beneath the land surface. They are also the primary link to our understanding of what is going on in the subsurface. Yet in many respects we remain uninformed. Current ground water monitoring and analysis data are generally insufficient to determine the availability, quality, and overall health of this resource. A June 2004 Government Accountability Office (GAO) report, *Watershed Management: Better Coordination of Data Collection Efforts Needed to Support Key Decisions*, states that "reliable and complete data are needed to assess watersheds…and allocate limited cleanup resources." But the report itself hardly mentions ground water.

As a nation, we simply do not have a clear picture of our ground water resources. In a survey of 28 states, the National Ground Water Association (NGWA) pointed out that increasing federal funding for cooperative ground water quantity and quality data collection and aquifer mapping is a key action the federal government could take to help promote ground water protection. The National Cooperative Geological Mapping Program is an example of one such program.

In its April 6, 2005, testimony before the U.S. Senate Energy and Natural Resources Committee, NGWA member David Wunsch told the Committee that there were glaring data gaps and that there is a need for a national clearinghouse for ground water information and data, including real-time data, to help maximize data-gathering efforts. On behalf of NGWA, Wunsch explained that top priorities for development of long-term ground water sustainability plans include:

- Research on water reuse and conservation.
- Alternative treatment systems.
- Development of brackish ground water supplies.
- Aquifer storage and recovery or artificial recharge.
- Emerging contaminants and development of remediation technologies.
- Development of models and data standards.

In spite of great advances in the fields of hydrogeology, mathematical modeling, and epidemiology, hydrologists still encounter significant data gaps when attempting to quantify interaction between surface and ground water, develop predictive models for ground water flow and contaminant transport, and link ground water contamination to human activities and public health impacts. Ground water reserves are predictable—given good data from adequate monitoring—and they are manageable—given sustained public commitment and investment. There is an urgent need for federal leadership in funding cooperative efforts with state and local governments to address data gaps.

Fragmentation of Ground Water Programs

If ground water characterization and monitoring are so important, why don't we just get out there and do it? Part of the answer can be attributed to program fragmentation. During the 1990s, states and USEPA successfully developed ground water protection program guidelines based on the goals, principles, and guidelines established in a document titled *Protecting the Nation's Ground Water: EPA's Strategy for the 1990s—The Final Report of the EPA Ground-Water Task Force*. However, around 1996, most USEPA regional offices experienced moderate to major reorganizations that resulted in fragmentation or disinvestment in ground water protection staff resources. At the same time, many state programs experienced similar reorganizations.

Since then, state and USEPA ground water protection programs have operated essentially at program-maintenance levels, at best, if not with significantly reduced staff and funding resources. States no longer have a comprehensive ground water protection advocate at the federal level because USEPA's technical ground water expertise was dispersed into other agency programs. Dissolution of the Ground Water Branch at most, if not all, regional USEPA offices has decreased federal emphasis on the importance of ground water, and the states lost a federal coordinating partner.

Water samples being taken from a spring in Clark County on Two Mile Creek, Kentucky. The spring is polluted with crude oil from a break in an oil pipeline. A significant percentage of the ground water in the state moves through karst aquifers. Most karst springs previously used for public water supply have been abandoned because of ground water contamination. Despite that, water from karst aquifers remains vital to the state because karst springs support the baseflow of the streams to which they discharge. In fact, most public systems in karst areas still use water from a karst aquifer when they withdraw from a stream or reservoir.

Source: http://www.uky.edu/KGS/water/general/karst/gwvulnerability.htm

OREGON'S SOUTHERN WILLAMETTE VALLEY GROUND WATER MANAGEMENT AREA

In May 2004, following a public comment period on the final Southern Willamette Valley ground water report and proposal for declaring a Ground Water Management Area, the Oregon Department of Environmental Quality (ORDEQ) issued a declaration that created the Southern Willamette Valley Ground Water Management Area (GWMA). In doing this, the ORDEQ, Department of Agriculture, Water Resource Department, Department of Human Services, and other state agencies were required to focus efforts on the development of an action plan to restore ground water quality.

The GWMA is the result of many years of studies and analyses of the shallow ground water in the lowlands of the Southern Willamette Valley. Studies beginning in the 1990s showed that shallow ground water contains nitrate at levels that are a concern. The Valley is one of Oregon's fastest-growing regions and depends heavily on ground water for both private and public drinking water, irrigation water, and other uses. In fact, ground water provides almost all of the drinking water in the study area. High levels of nitrate contamination in drinking water can pose a health risk. Oregon law requires that ORDEQ declare a ground water management area when there is confirmation of nitrate contamination in the ground water above 7.0 milligrams per liter (mg/L) and the suspected sources of nitrate are not facilities with permits, such as landfills or incinerators.

A citizen's Ground Water Area Management Committee was formed to strategize with the state agencies preparing the action plan. The Committee reviewed and commented on all potential options and approved the final plan prior to its use by the state on November 9, 2006. *The Southern Willamette Ground Water Management Area Action Plan* will now serve to guide activities aimed at reducing nitrate contamination in the area's ground water. To download a copy of the plan, go to: *http://groundwater.oregonstate.edu/willamette/Plan.htm*

Source: http://www.deq.state.or.us/WQ/pubs/factsheets/groundwater/sowillamettegwma.pdf

Consequently, protection efforts, except as they relate to protecting drinking water supplies, have lost ground at a time when the need is great—and growing. Even USEPA's recent Ground Water Rule (November 2006), which will increase protection against microbial pathogens in public water systems that use ground water, addresses a limited range of potential contaminants for a subset of ground water resources. There are too many instances where different entities collect limited-value data, and ground water management proceeds in a fragmented, often ineffective, and sometimes contradictory approach to ground water management.

GROUND WATER POLICY AND REGULATION

With regard to water use and allocation, water rights laws are complicated and often unclear. The evolving trends and practices of water law vary from state to state and often contribute to the wasteful and inefficient use of ground water. In many states, water law still reflects common-law court decisions from the late 19th and early 20th centuries. Ground water and ground water laws are of growing interest due to population growth, changing demographics and land use patterns, potential effects of new waste sources, climate change, and the high cost of getting water where we need it. Furthermore, water law has traditionally overlooked the fact that hydrologic systems do not stop at state boundaries, thus avoiding regional, watershed, or aquifer-based approaches. Thankfully, some states have revised, or are in the process of revising their water law to reflect current knowledge and reality.

With regard to water regulation, there has always been some confusion over which bodies of water are covered by the federal Clean Water Act (CWA), which requires permits for discharge of pollutants or discharges of dredged or fill materials into "navigable waters." The CWA defines "navigable waters" as "waters of the United States, including the territorial seas." However, "waters of the United States" is not specifically defined in the CWA. Nevertheless, court decisions, regulations, and agency policies have

Photo: Copyright © Bruce Molnia, Terra Photographics

These springs are discharging from glacial tills and moraines into a tidal inlet in Alaska.

established that "waters of the United States" applies only to surface waters, including rivers, lakes, estuaries, coastal waters, and some wetlands—and not ground water unless it is in direct communication with surface waters.

Regardless of the confusion over the term "navigable waters," the term "ground water" is included in several sections of the Clean Water Act including Section 102 (Comprehensive Programs for Water Pollution Control), and Section 104 (Research, Investigations, Training, and Information), Section 106 (Grants for Pollution Control Programs), and Section 319 (Nonpoint Source Management Programs).

Section 102 requires development of "comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground waters." It further states that "due regard shall be given to...the withdrawal of such waters for public water supply, agricultural, industrial, and other purposes."

Likewise, Section 106 allows for funding to be specifically allocated to support the development and implementation of the comprehensive ground water protection programs required in Section 102. However, guidance to states from USEPA on how to allocate these funds is based on USEPA's strategic plan. Without inclusion of ground water goals and targets in the USEPA strategic plan, beyond its use as a public drinking water supply, USEPA and the states are not encouraged to place a high priority on ground water protection or allocate substantial funding for ground water programs.

A few members of Congress have made several attempts to clarify the definition of "waters of the United States." The most recent attempt is the introduction of the Clean Water Restoration Act (CWRA). This bipartisan bill restores federal protection of waters and wetlands by clarifying Congress's original intent in the 1972 landmark Clean Water Act (CWA), commonly recognized to include inter- and intrastate waters.

The proposed CWRA would define "waters of the United States" to mean "all waters subject to the ebb and flow of the tide, the territorial seas, and all interstate and intrastate waters and their tributaries, including lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, natural ponds, and all impoundments of the foregoing, to the fullest extent that these waters, or activities affecting these waters, are subject to the legislative power of Congress under the Constitution." While still not expressly including ground water, some believe this clarification would strengthen the authority of federal-level ground water programs by emphasizing the interconnections between these surface water resources and ground water.

Inasmuch as ground and surface waters are connected, our concern for and attention to the fact that contamination of ground water pollutes surface waters should speak loud and clear that these water resources should be given equal footing. The Clean Water Act should include provisions that require USEPA and states to provide ground water with all the protection given to surface water.

IF WE KNEW THE REAL VALUE OF GROUND WATER…

If we knew the real value of ground water, would we be more willing to protect it? What, in fact, is the worth of ground water? Is it less than a penny per gallon, the average cost for tap water in the United States? Or is it the price we pay for bottled water, which can cost 240 to over 10,000 times more per gallon than a gallon of average tap water? (Natural Resources Defense Council [NRDC], 2007) (In fact, some bottlers use tap water as their source.) Is it the cost we pay to extract, treat, and deliver water? A Congressional Budget Office report (November 2002) estimates the average annual costs for water treatment systems to be between $11.6 – $20.1 billion annually (2000 – 2019).

Communities with ground water pollution problems become tainted and can suffer losses in property values, businesses, and jobs. Communities that have lost a water supply through contamination quickly learn

COST OF REMEDIATING SOURCE WATER POLLUTION

COMMUNITY	TYPE OF PROBLEM	RESPONSE TO PROBLEM	COSTS
Perryton, TX	Carbon tetrachloride in ground water	Remediation	$250,000
Camden-Rockland, ME	Excess phosphorus in Lake Chickawaukie	Advanced treatment	$6 million
Moses Lake, WA	Trichlorethylene in ground water	Blend water, public education	$1.8 million
Mililani, HI	Pesticides, solvents in ground water	Build and run treatment plant	$2.5 million plus $154,000/yr
Tallahassee, FL	Tetrachloroethylene in ground water	Enhanced treatment	$2.5 million plus $110,000/yr
Pittsfield, ME	Landfill leachate in ground water	Replace supply, remediation	$1.3 million
Rouseville, PA	Petroleum, chlorides in ground water	Replace supply	$300,000+
Atlanta, MI	VOCs in ground water	Replace supply	$500,000 – $600,000
Montgomery County, MD	Solvent, Freon in ground water	Install county water lines, provide free water	$3 million plus $45,000/year for 50 years
Milwaukee, WI	Cryptosporidium in river water	Upgrade water system, immediate water utility, city health department costs	$89 million to upgrade system; millions in immediate costs
Hereford, TX	Fuel oil in ground water	Replace supply	$180,000
Coeur d’Alene, Idaho	Trichloroethylene in ground water	Replace supply	$500,000
Orange County Water District, CA	Nitrates, salts, selenium, VOCs in ground water	Remediation, enhanced treatment, replace supply	$54 million (capital costs only)

Table 1. A sampling of localities of various sizes that have borne high, readily quantifiable costs due to source water pollution. *This table attempts to isolate community costs by excluding state, federal, and private industry funding. Also not included are such costs to individuals as lost wages, hospital and doctor bills, reduced property values, higher water bills, and, in extreme cases, death.*

Source: Steve Ainsworth, Paul Jehn. February 1996. “Source Water Protection: What’s in It for You?” Public Management (vol 78, no. 2) by the International City/County Management Association.

the value of ground water. For example, Hyde Park, New York, spent $4.6 million for a system to pipe Hudson River water treated at the Poughkeepsie Water Treatment Facility to about 270 properties in the city's Greenbush area. Local wells in the area were contaminated with pollutants such as MTBE from local gasoline stations and bacteria from septic systems. Residents in the Greenbush Water District were charged about $430 per year to cover construction costs. Ongoing costs for residents will depend on how much water they use. (*Environmental Evaluation & Cost-Benefit News*, 2005/07) (See Table 1 for other examples.)

There are no market-generated prices for ground water, or even estimates for market prices if water were traded. In fact, ground water is remarkably undervalued, largely because we have no consistent process for determining its total economic value. Typically, more value is placed on the extraction, treatment, and delivery of the ground water "product" than on the total value of the resource itself. How do we determine appropriate ground water protection strategies and establish priorities if we have no valuation basis for making these decisions? A fundamental question is: Where would we be without the ground water we use currently and will need in the future?

According to *Valuing Ground Water—Economic Concepts and Approaches*, a 1997 report published by the National Academy of Sciences, the undervaluation of ground water fosters misallocation of resources in two ways:

- The ground water resource is not efficiently allocated relative to alternative current and future uses/sources.
- Authorities responsible for resource management and protection devote inadequate attention and funding to maintaining ground water quality.

We are at a ground water crossroads that necessitates ingenuity and proaction in order to minimize potentially detrimental and costly consequences. Each of us shares responsibility for securing the availability, integrity, and ecological balance of our nation's water resources—for the long haul.

This hot spring is located between Echinus geyser and Green Dragon spring in the back basin area of the Norris geyser basin of Yellowstone National Park.

"It is circumstance and proper timing that give an action its character and make it either good or bad."

Agesilaus | King of Sparta
(444– 360 BC)

The longer we put off the inevitable task of establishing a consistent and comprehensive means for valuing ground water, the longer we delay the efficient (i.e., sustainable) allocation of ground water.

THE RESPONSIBILITY FOR GROUND WATER IS OURS

We are at a ground water crossroads that necessitates ingenuity and proaction in order to minimize potentially detrimental and costly consequences. Each of us shares responsibility for securing the availability, integrity, and ecological balance of our nation's water resources—for the long haul. It is way past time for us to recognize the significance of ground water to our national welfare—our public health, quality of life, and economic well-being. It is time for federal, state, and local decision makers to take concrete action to ensure that our hydrologic systems are monitored, understood, and managed sustainably for generations to come and that ground water has equal footing in this endeavor.

We must:

- Take swift and decisive action to ensure that ground water is meaningfully integrated into federal and state water resource conservation, management, and protection agendas.
- Adopt new paradigms in science, water policy, and law that demonstrate the interactive relationship among components of watersheds and ecosystems and the vital role that ground water plays in those systems.
- Ensure that these new paradigms are based on solid scientific principles.
- Clarify in federal law the national importance of our ground water resources as well as the financial commitment to effective and comprehensive protection and management of the nation's ground water resources.
- Make a financial commitment to effective and comprehensive protection and management of the nation's ground water resources.

A bottomland hardwood swamp at the confluence of Tubby Creek and the Wolf River (a small alluvial river) in the Holly Springs National Forest near Ashland, Mississippi. The Wolf River rises from ground water at Baker's Pond, north of Ashland, and flows northwest into Tennessee. The river area is home to a large variety of species that are dependent upon good quality water and is fed by the Memphis Sands Aquifer, which is used as a drinking water source for metropolitan Memphis and other Mid-South communities. It is one of many rivers in West Tennessee and Mississippi that prompted the Chickasaw to call the region "the land that leaks." The Wolf's fragile wetlands retain water long enough for it to be absorbed into the ground and serve as natural filters to cleanse polluted waters before they reach the aquifer.

GWPC'S *Call to Action*

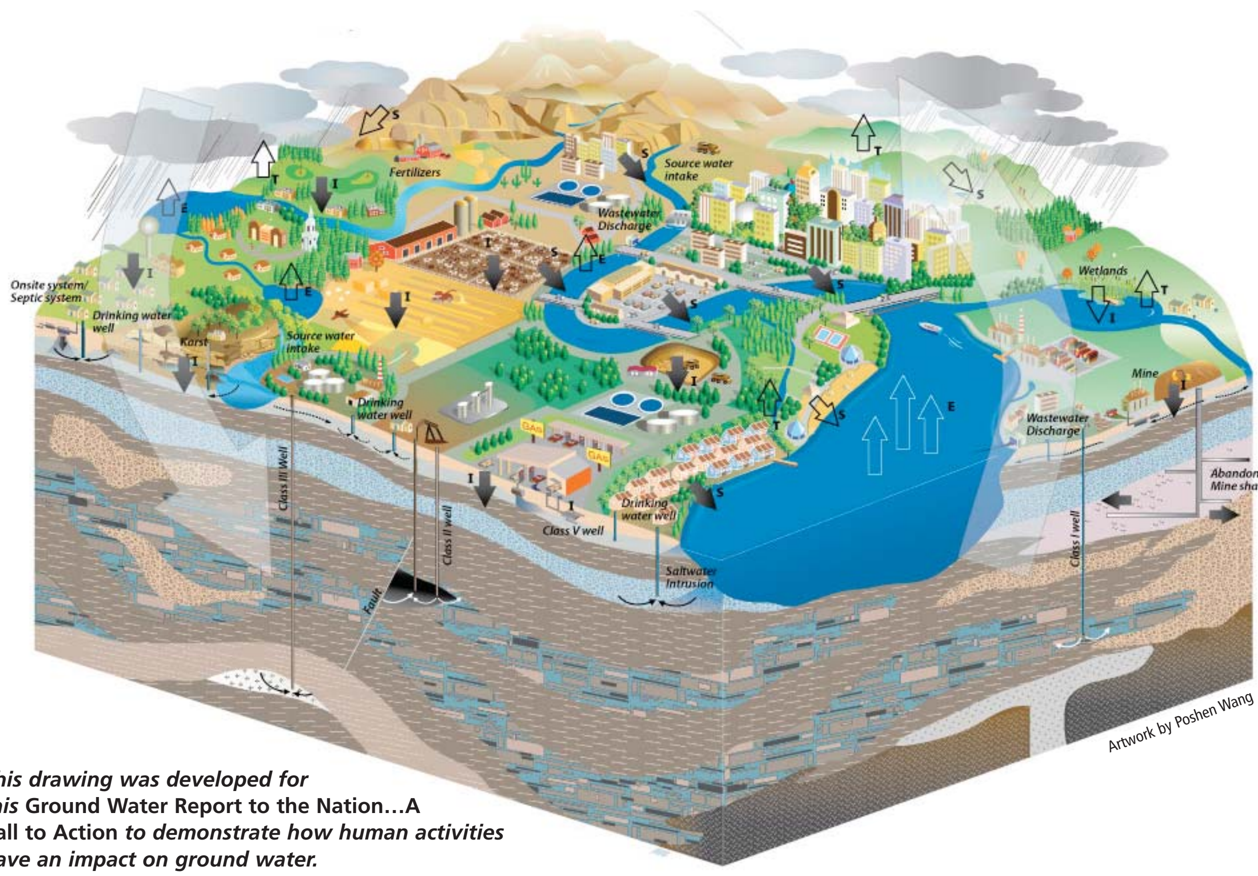
Call to Action

In 2006, the Ground Water Protection Council (GWPC) made a decision to move forward with a "Call to Action" to advance the protection of this vital ground water resource. As we will make clear in this report, circumstances surrounding the future of ground water are a cause for concern. The GWPC is committed to promoting these recommendations contained in this report, to monitor and report on their progress, and to serve as a resource for helping targeted audiences achieve the goals of these recommendations. We invite, indeed urge, the media, governmental agencies, academia, industry, and the various public- and private-sector entities targeted in this report, along with the public at large, to join us in making this endeavor a success. The speed with which we adopt a new ground water paradigm will determine the outcome.

It was difficult to prioritize the myriad ground water issues and human impacts that we would address in this first edition of our "Call to Action" for ground water. Even within the topics chosen for this edition, there are many aspects of science, policy, and education that could not be covered in a report of this size or targeted for particular audiences. For this reason, priority topics that were not focused on as sections in this edition will be covered in subsequent editions, and some topics selected for the sections in this edition may be updated over time.

The topics chosen for the first edition are: ● Ground Water Use and Availability, ● Ground Water Characterization and Monitoring , ● Ground Water and Source Water Protection, ● Ground Water and Land Use Planning and Development, ● Ground Water and Stormwater, ● Ground Water and Underground Storage Tanks, ● Ground Water and Onsite Wastewater Treatment Systems, ● Ground Water and Underground Injection Control, and ● Ground Water and Abandoned Mines.

Ground Water *Interactions*



This drawing was developed for this Ground Water Report to the Nation…A Call to Action *to demonstrate how human activities have an impact on ground water.*

Recommended Actions

To Congress:

Take legislative action, including:

- Appropriating the funding necessary to ensure the development and implementation of a national ground water protection strategy.
- Clearly defining ground water's coverage under the Clean Water Act and Safe Drinking Water Act §1429.
- Requiring explicit coordination between Clean Water Act and Safe Drinking Water Act programs.
- Directing that USEPA support state efforts to protect and manage ground water.

To USEPA:

Include more attention to ground water in the national water strategy, giving it scientifically appropriate weight with surface water with respect to programmatic emphasis, funding, research support, and public visibility.

Utilize existing federal laws as the statutory basis and funding authority for protecting and conserving ground water as a component of watersheds and ecosystems, including the reestablishment of an active ground water protection program.

To Governors and State Legislatures:

Support and authorize statewide ground water protection and conservation laws, regulations, and regulatory agencies and programs that recognize ground water as a critical component of state economies, watersheds, and public health protection.

Springs offer a unique opportunity to explore ground water and even encounter many resident plants and animals like the Manatee and, beneath the surface, native species like the secretive Greater Siren and the Loggerhead Musk turtles. Clean, clear water flowing from the aquifer at a constant temperature are essential ingredients that support the variety of life found in and around a spring in Jackson Blue Springs, Florida.

Photo: Tom Scott, FGS/FDEP

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