**MEMORANDUM TO THE PRESIDENT**

**From:** **Peter H. Gleick**

**Subject:** **Global Water: Threats and Challenges Facing the U.S.**

## PROBLEM

Four critical challenges and threats related to freshwater resources are likely to require U.S. unilateral, bilateral, or multilateral action during the new presidential administration. Several others will require the special attention of senior members of the administration. These issues have the potential to affect U.S. diplomatic relations with neighboring countries and allies and are likely to affect economic and political security in the United States. Below is a short assessment of these top problems and specific recommendations for addressing them.

**Threats to national interest and security.** There is a growing risk of political insecurity and instability in regions where access to fresh water is a problem. These include the Middle East, southern Africa, the central Asian republics, and south Asia, including India, Pakistan, Bangladesh, and Nepal. Other less predictable hot spots are likely to appear. Diplomatic efforts to reduce the risks of conflict must now include an environmental component; military preparedness should also include environmental threat analysis.

**A continuing global water crisis.** Access to basic water services, including clean drinking water and sanitation services, is still unavailable for between 2 and 3 billion people worldwide. International efforts to spotlight this problem are necessary, as are multilateral efforts to solve it. The failure to provide basic services will lead to direct and indirect public health ramifi-

cations for the United States. The United States should play a leading role in addressing these problems, in redirecting foreign aid budgets, and in encouraging international aid organizations to refocus efforts toward meeting basic water needs.

**Lack of a national water policy.** The nation's limited freshwater endowment is used inefficiently and ineffectively, in part because of the lack of basic national water policy. If this waste continues unabated, it will impoverish this and future generations, destroy the limited remaining aquatic ecosystems, and threaten the world's future food supply. Increasing the productive use of water nationwide will benefit farmers, cities, and the natural environment. Federal and state programs and top-level political support are required.

**Growing consequences of the greenhouse effect.** Global climate change is increasingly likely to affect vital U.S. sectors in the coming years, including many related to freshwater resources. Climate change will affect the reliability of the nation's water supply and quality, hydroelectric generation, and food security. The nation could also begin to see changes in the magnitude, frequency, and costs of extreme events, such as flooding and drought. The recently completed national assessment highlighted many of the most important problems, but follow-up work is still needed on the part of the nation's water community.

## BACKGROUND

### *Water Availability and Use in the United States*

The United States, as a nation, is well endowed with water. However, the country's resources are unevenly distributed and inefficiently used. The United States has spent billions of dollars over the last century to develop an engineering infrastructure (including dams, reservoirs, aqueducts, waste treatment facilities, and flood control levees) necessary for the management of water resources. These facilities have had tremendous positive effects on the nation and its economy, but they have also been accompanied by severe negative effects, including degrada-

tion of natural ecosystems, a false sense of protection against floods, and complacency toward water-quality problems.

An average of around 4,200 billion gallons of precipitation fall each day on the United States, while 2,800 billion gallons per day evaporate back into the atmosphere. Of the remainder, only 100 billion gallons are consumptively used by the nation's farms, cities, and industry. These numbers suggest—misleadingly—that the nation as a whole has no problem with water scarcity and that far more water could be used.

Several additional factors must be taken into account. First, water availability varies enormously by region and time. Second, the western United States receives far less precipitation and has far more evaporation than the eastern portion of the country. Third, water that humans do not use is not "wasted"—it meets critical ecological needs for flora and fauna. "Instream" uses of water (i.e., water left in a river or stream to meet environmental and other needs), only recently recognized by a few federal and state laws, must be maintained to keep fish and other wildlife populations healthy. Finally, although humans only "consume" around 100 billion gallons per day, far more water is withdrawn for human uses. Most of the time, this additional water is returned to the stream, river, or lake after use. Sometimes it is taken from one watershed and returned to another. Sometimes the water itself is returned but degraded in quality. Thus the overall impact of human water use is far greater than that suggested by the measure of how much water is consumed.

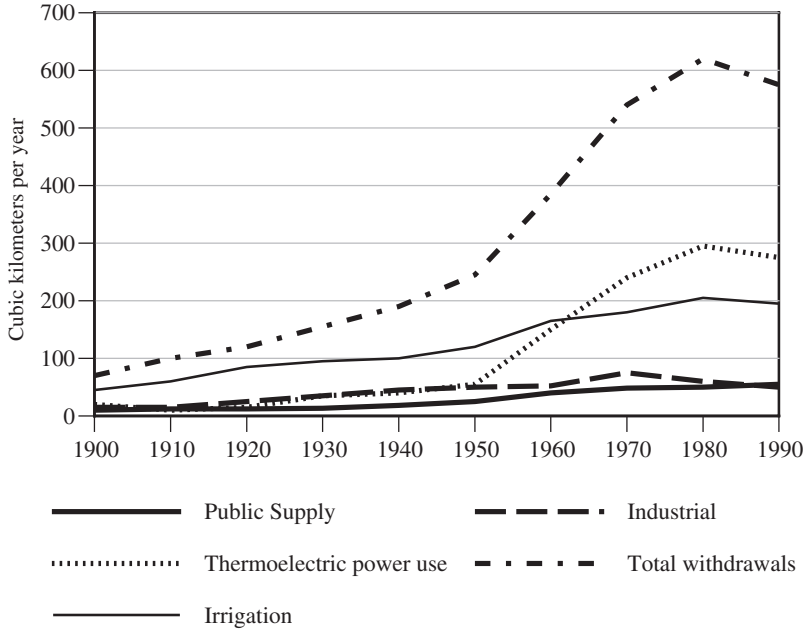
Building water infrastructure, including reservoirs, dams, aqueducts and pipelines, has required an enormous economic investment. In the United States, total capital investment for water infrastructure during the past century has been estimated at $400 billion (unnormalized); most of this money took the form of federal subsidies that will never be repaid. In the western United States, limited availability and growing demand for water led to the construction of hundreds of the world's most massive dams on every major river. By the mid-1990s, the United States (largely though the actions of the U.S. Bureau of Reclamation and the Army Corps of Engineers) had built more than 80,000 dams and reservoirs, nearly 90,000 megawatts of hydroelectric capacity, and more than 15,000 municipal wastewater treatment plants. During the same boom in construction, more than

60 percent of the inland wetlands of the United States was lost, half of all stream miles was significantly polluted, and many major fisheries were destroyed.[1]

As the new century begins, these traditional approaches to water planning, although still firmly entrenched in many water-planning institutions, are beginning to change. Water needs in the United States are no longer increasing, even though the economy and population continue to grow. Concern for the environment has led to restrictions on when and where new projects can be built. And the costs of new water infrastructure now often exceed the costs of improving water-use efficiency and productivity.

Throughout the first three-quarters of this century, water withdrawals increased, as shown in Figure 1. In 1900, estimated U.S. water withdrawals for all

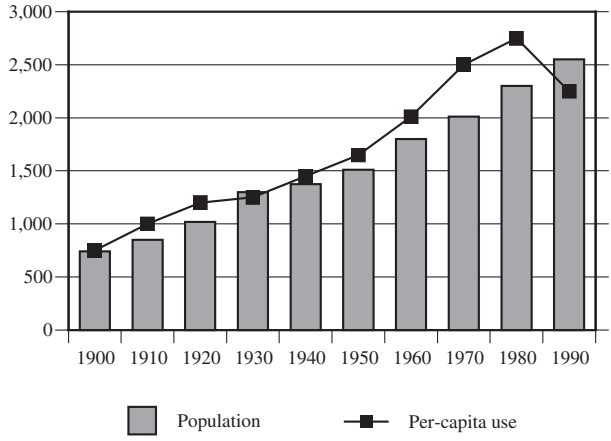
**Total water withdrawals in the United States: 1900–1990**




SOURCE: P.H. Gleick, *The World's Water 1998–1999*, (Washington, D.C.: Island Press, 1998).

**Figure 1**

**Total U.S. population and per-capita water withdrawals: 1900–1995**

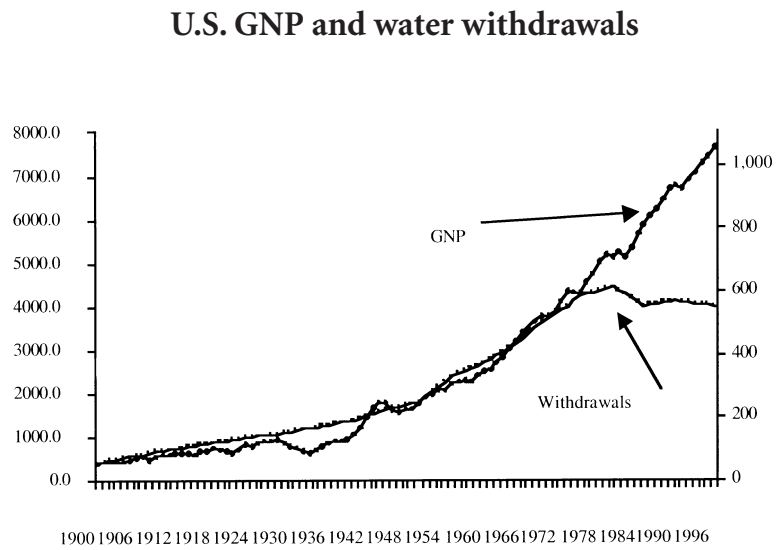



SOURCE: P.H. Gleick, *The World's Water 1998–1999*, (Washington, D.C.: Island Press, 1998).

**Figure 2**

purposes were 56 cubic kilometers per year ($km^3$/yr). By 1950, total water withdrawals were 250 $km^3$/yr, and by 1970, withdrawals doubled to more than 500 $km^3$/yr. Water use in the United States peaked in 1980 at more than 610 $km^3$/yr—a tenfold increase in water withdrawals during a period in which population increased by a factor of four. Water withdrawals were not only growing in an absolute sense, they were growing in a per-capita sense (see Figure 2). In 1900, freshwater use was less than 700 cubic meters per person per year ($m^3$/p/yr). By the late 1970s and early 1980s, it had increased to nearly 2,300 $m^3$/p/yr. These increases in water demands, more than any other factor, drove the incredible burst of construction of water infrastructure.[2]

Beginning in the early 1980s, these trends of increased water withdrawals ended in the United States and withdrawals began to decline despite continued increases in population and economic wealth—a dramatic departure from the expectations and experience of water planners. Water withdrawals have now dropped nearly 10 percent from their peak in 1980, as shown in Figure 1. The two largest components of U.S. water use—irrigation and water for thermoelectric power plant cooling—have declined by about 10 percent. Industrial water use has




NOTE: U.S. gross national product (in 1996 dollars) and total U.S. water withdrawals (cubic kilometers per year), from 1900 to 1999. Note that the two curves diverged in the late 1970s/early 1980s, indicating that the United States has become more efficient in its use of water per dollar of GNP.
SOURCE: P.H. Gleick, Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

**Figure 3**

dropped even more dramatically, falling nearly 40 percent from its height in 1970 as industrial water-use efficiency has improved and as the mix of U.S. industries has changed. Yet industrial output and productivity have continued to soar, clearly demonstrating the possibility of breaking the link between water use and industrial production. Figure 3 shows how the link between water use and gross national product (GNP) changed dramatically starting in the late 1970s. The key message here is that improving the productive use of existing water resources, through reducing waste and inefficiency, is a relatively fast and inexpensive way to meet new water needs.

*Water and U.S. Security Interests*

In the past decade there has been a major rethinking of the field of international security. With the end of the cold war and the break up of the Soviet Union,

the world has witnessed growing concern over regional conflicts, civil, religious, and ethnic wars within regions, and, particularly, the connections between environmental degradation, scarcity of resources, and regional and international politics and disputes. These latter issues have loosely been grouped under the term "environment and security" and interest in them has engendered a wide range of innovative studies.[3] (See Homer-Dixon memo.)

History shows that access to resources has been a proximate cause of war, resources have been both tools and targets of war, and environmental degradation and the disparity in the distribution of resources can cause major political controversy, tension, and violence. In 1989, then Secretary of State James Baker said, "The strategic, economic, political, and environmental aspects of national security and global well-being are, today, indivisible."

In 1994, then UN Ambassador Madeleine K. Albright stated, "We believe that environmental degradation is not simply an irritation, but a real threat to our national security. . . . Left unaddressed, it could become a kind of creeping Armageddon. . . it could, in time, threaten our very survival."

In 1997, Secretary of State Albright said, "Not so long ago, many believed that the pursuit of clean air, clean water, and healthy forests was a worthy goal, but not part of our national security. Today environmental issues are part of the mainstream of American foreign policy."[4]

The argument and focus of debate has now shifted from "whether" to "when, where, and how" environmental and resource problems will affect regional and international security. In the past several years there has been considerable progress in understanding the nature of the connections between water resources and conflict and in evaluating regional cases where such connections may be particularly strong. There has also been progress in identifying policies and principles for reducing the risk that freshwater disputes will lead to conflict.

Progress has been more than academic. For example, in October 1994, Israel and Jordan signed a peace treaty that explicitly addressed water disputes in the Jordan River Basin. U.S. diplomats, academics, and nongovernmental organizations played leading roles in facilitating this treaty. In 1996, India and Bangladesh signed a treaty that moves toward resolving their long-standing dispute concerning river flows in the

Ganges/Brahmaputra system. In 1997, the International Law Commission finalized the Convention on the Non-Navigational Uses of Shared International Watercourses, which was approved by the United Nations General Assembly.

The ultimate goal of U.S. foreign policy related to the risks of conflicts over water must be efforts to reduce those risks. Various approaches exist for reducing water-related tensions, including legal agreements, the application of proper technology, institutions for dispute resolution, and innovative water management. Unfortunately, these mechanisms have never received the international support necessary to resolve many conflicts over water. Efforts by the United Nations, aid agencies, and local communities to ensure access to clean drinking water and adequate sanitation can reduce the competition for limited water supplies and the economic and social impacts of widespread waterborne diseases. Improving the efficiency of water use in agriculture can extend limited resources, increase supplies for other users, strengthen food self-sufficiency, reduce hunger, and decrease expenditures for imported food. In regions with shared water supplies, third-party participation in resolving water disputes can also help end conflicts. The United States can play important roles in each of these areas.

**The failure to provide basic sanitation services and clean water to billions of people around the world is perhaps the greatest failure of human development in the 20th century.**

*Global Water Crisis and Human Health*

The failure to provide basic sanitation services and clean water to billions of people around the world is perhaps the greatest failure of human development in the 20th century. As a result of this failure, water-related diseases such as cholera, dysentery, and parasitic diseases are on the upswing in many developing countries. Nearly 250 million cases are reported every year, with between 5 million and 10 million deaths. Yet the world is falling further behind in its efforts to provide these basic services. Between 1990 and 1997, 300 million more people were added to the 2,600 million already without adequate sanitation services. The failure to completely satisfy basic human needs for water and water services is the result of rapid population growth, underinvestment, growing urbanization, and misdirected priorities.[5] The United States is at risk from water-related diseases that may increasingly be imported by travelers and visitors to the country and from diseases that

may get a toehold in the continental United States itself. Recent experience with West Nile fever should be studied carefully for lessons on public health education, prevention, and detection.

Eliminating water-related diseases requires more than merely constructing infrastructure or providing clean water. It also requires maintaining and operating that infrastructure, teaching children about adequate hygiene habits, identifying other transmission routes such as unclean handling of food, and controlling disease vectors. In some regions, governmental intervention may be necessary to provide basic water needs; in other places these needs can be met by traditional water providers, municipal systems, or private purveyors within the context of market approaches. Although additional financial resources are necessary, more than money is needed. The U.S. government can play a major role in changing the priorities of aid organizations regarding how money is currently spent. And the United States can play a major role in encouraging the United Nations and other international organizations to refocus efforts in this critical area.

*Climate Change*

Leading climate scientists believe that humans are now on the verge of changing the Earth's climate. Indeed, a growing number of scientists believe that some human-induced climatic changes are already beginning to occur or are unavoidable even if efforts to reduce gas emissions begin now. These climatic changes—the so-called "greenhouse effect"—will have widespread consequences for every aspect of life on Earth. Among the most important will be impacts on water resources, including effects on both the natural hydrologic system and the complex water-management schemes that have been built to alter and control that system.[6]

Water managers, policy makers, and the public must begin now to think about the implications of climatic change for long-term water planning and management. Changes may be necessary in the design of projects not yet built. Modifications to existing facilities may be required to permit them to continue to meet their design objectives. New projects may need to be built or old projects removed: New institutions may need to be created or old ones revamped to cope with possible changes.

Global climate changes will have major effects on the timing and magnitude of precipitation, evaporation, and runoff. Although specific regional impacts will depend on future changes that are only incompletely understood, some consistent and robust results can be described. In the arid and semiarid western United States, modest changes in precipitation can have large impacts on water supplies. In the Rocky Mountains and the Sierra Nevada, warming will increase the ratio of rain to snow, accelerate spring snowmelt, and shorten the overall snow season, leading to more rapid, earlier, and greater spring runoff. Sea-level rise will affect coastal aquifers and developments.

Climate-induced changes will affect the size, frequency, and consequences of extreme events, which have great economic and social costs for U.S. residents. Flooding, the nation's most costly and destructive natural disaster, could become more common and more extreme. Recent research suggests that greenhouse warming is likely to increase the number of intense precipitation days and flood frequencies in more northerly portions of the nation and that the frequency and severity of droughts could also increase in some regions.

Climate change will also affect water quality, though much less research has been done on this aspect of the problem. Potential negative impacts include reduction in dilution flows, increased storm surges, and higher water temperatures. Low flows in western rivers could increase salinity levels; warmer waters could threaten aquatic life directly and by reducing dissolved oxygen levels. An increase in days with more intense precipitation could increase agricultural and urban pollutants washed into rivers and streams.

There are many opportunities for reducing the risks of climatic variability and change for U.S. water resources. The precautionary approach taken in many international agreements, including the United Nations Framework Convention on Climate Change is applicable:

> *Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures . . . should be cost-effective so as to ensure global benefits at the lowest possible cost.*[7]

Decisions about water planning in the United States, the design and construction of new infrastructure, the type and acreage of crops to be grown, urban water allocations and prices, reservoir operation, and management have traditionally relied upon the assumption that future climatic conditions would be the same as past conditions. This reliance on the past record now may lead people to make incorrect—and potentially dangerous or expensive—decisions.

**This emphasis on planning and demand management rather than construction of new facilities marks a change in traditional water-management approaches. . . .**

One of the most important coping strategies must be to begin planning for future changes. The academic community has advocated this position for a decade. In 1990, the Climate and Water Panel of the American Association for the Advancement of Science concluded:

> Among the climatic changes that governments and other public bodies are likely to encounter are rising temperatures, increasing evapotranspiration, earlier melting of snowpacks, new seasonal cycles of runoff, altered frequency of extreme events, and rising sea level. . . . *Governments at all levels should re-evaluate legal, technical, and economic procedures for managing water resources in the light of climate changes that are highly likely* [Emphasis in original].[8]

Similarly, the Intergovernmental Panel on Climate Change urged water managers to begin "a systematic re-examination of engineering design criteria, operating rules, contingency plans, and water allocation policies" and stated with "high confidence" that "water demand management and institutional adaptation are the primary components for increasing system flexibility to meet uncertainties of climate change." This emphasis on planning and demand management rather than construction of new facilities marks a change in traditional water-management approaches, which in the past have relied on the construction of large and expensive infrastructure.[9]

In 1997, the American Water Works Association, the largest professional association of water utilities and providers in the United States, published a set of recommendations asking both governmental and private water managers to

- re-examine engineering design assumptions, operating rules, system optimization, and contingency planning for existing and planned water-management systems under a wider range of climatic conditions than traditionally used;

- explore the vulnerability of both structural and nonstructural water systems to plausible future climate changes, not just past climatic variability; and

- re-evaluate legal, technical, and economic approaches for managing water resources in the light of possible climate changes.[10]

## RECOMMENDATIONS

Advance preparation will position the United States to avoid the worst of the coming problems and will also permit the nation to play a constructive role in international affairs related to water. Below are specific recommendations for action.

*A New Water Policy for the American People*

Most water policy decisions can and should be made at the local, regional, or state level. But some water-management decisions and policies affect interstate interests, involve federally managed resources, or involve agencies of the federal government. In the middle of the last century, President Truman established a water resources policy commission. The commission issued a report on national water policy directions in 1950.[11] This water policy is out-of-date and the commission should be revived to assess the current state of the nation's water systems and recommend where and how the federal government should take action to improve water planning and management and reduce the risks that the nation will suffer from water-related problems in the future. Such a policy needs to include expanded data collection and improved data dissemination on national water resources availability and use.

*Water and U.S. Security Interests*

The links between water and security suggest two separate areas where U.S. policy actions may be appropriate. The first is to ensure that U.S. foreign policy and

security organizations are prepared to identify and analyze potential threats to U.S. interests. The second is to enable U.S. diplomatic systems to participate in reducing the risks of conflicts around the world.

More attention by military planners is needed to explicitly monitor and track water-related threats to security and U.S. interests. An easy and valuable first step would be a series of workshops within the War College system on critical issues and regional threats. Similar workshops could be held with security analysts at the State Department, the Central Intelligence Agency (CIA), and other appropriate and interested agencies. A second step would be to ensure that responsibility for environmental security analysis is clearly delegated in the new presidential administration.

Reducing the risks of water-related conflicts will require that appropriate diplomatic resources be developed and maintained within the State Department, perhaps under the undersecretary of state for global affairs. To the extent possible, the administration should also encourage independent nongovernmental participation in "second-track" negotiations. (See Homer-Dixon and Claussen memos.)

*Global Water Crisis and Human Health*

The United States should play an active role in improving development aid for nations focusing on meeting basic needs for water. This can include helping United States and international aid organizations refocus spending priorities toward meeting basic water needs rather than building new infrastructure, increasing financial contributions to international organizations with this focus, and providing formal governmental technical assistance. Action is also required to encourage U.S. pharmaceutical companies to develop and disseminate inexpensive medicines targeted at preventable water-related diseases. This action could include federal tax credits for research on new medicines and treatments and credits for donation of effective expertise, equipment, and medicines in developing countries. National health organizations must also carefully monitor the prevalence and sources of water-related disease outbreaks in the United States itself. (See Smith memo.)

*Climate Change*

Some impacts on U.S. water resources from climate change appear unavoidable. The recent national assessment took the first comprehensive step toward understanding how climatic changes will affect the nation. This work included an analysis of the vulnerability of the nation's water resources to climate changes.[12] The assessment should be an ongoing and regular effort: An update should be initiated during the next four years.

Actions are required at the international level to reduce U.S. contributions to the rate of climate change. In addition, national actions are required to begin to adapt and mitigate changes that are likely to occur. Where extensive infrastructure has been built and is operated by the federal government, there are opportunities for rethinking how we operate and manage our water systems.

Current federal laws and policies affecting water use, management, and development are inefficient and unresponsive to changing conditions. The new administration has several promising opportunities to reduce risks to the nation's water resources from future climate changes. It is vital to note that most of the recommendations below make sense even in the absence of severe climatic changes—hence, they fall under the category of "no regrets" recommendations—we should have no regrets implementing them quickly:

- establish incentives for using, conserving, and protecting water supplies;
- ease constraints on transferring water among competing uses within a basin;
- encourage flexible management of water;
- re-evaluate the operation of existing federal infrastructure to address climatic changes;
- postpone costly and irreversible decisions to build water-related infrastructure; and
- encourage more research into specific impacts on U.S. water resources.