Senior Service College Fellowship Program

AEPI and USAWC Civilian Research Project

Strategic Value of Water to the National Guard



Abundant U.S. Water? The Water-Energy Nexus



Lake Lanier Water Mining the High Plans Colorado River Basin

(photos from Google Images)

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USAWC CIVILIAN RESEARCH PROJECT

Strategic Value of Water to the National Guard

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Abstract

Water's fundamental importance to national security is not well understood throughout the National Guard. The National Guard's primarily compliance-minded association with water requires a paradigm shift to that of water sustainability in order to fully support the National Guard of the future. Sources of water, its availability, and quality must be completely understood at the local level for the National Guard's success both in training and in times of disaster. Understanding the complex dimension of water governance, basic water concepts, water terms, its major consumers, as well as its direct connection with energy within every state and territory will enable the National Guard not only to be successful but be a resource (of information and plans) in times of disaster. Partnering with federal, state, and local water authorities as well as prior planning of this finite natural resource will not only allow the National Guard to complete its state and federal missions but will ensure that soldiers and airmen do not become victims of the disasters they are called upon to relieve.

My philosophy for gathering this information is, "It is better for the National Guard to have planned and not need water plan than to react to an unplanned water crisis." It is not speculation that water in the next three or four decades, maybe sooner, will be at a crisis level in several areas within the United States unless drastic and unlikely steps are taken.

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Abbreviations

ACT	Alabama-Coosa-Tallapoosa River Basin
ACF	Apalachicola-Chattahoochee-Flint River Basin
DoD	Department of Defense
DSCA	defense support of civil authorities
JFHQ	Joint Force Headquarters
GDF	Gaz de France
HLD	homeland defense
kWh	kilowatt hour
MW	megawatt
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
ppm	parts per million
RWE	Rheinisch-Westfälisches Elektrizitätswerk
S-3	Operations
TVA	Tennessee Valley Authority
U.S.	United States
USGS	U.S. Geological Survey
VHS	viral hemorrhagic septicemia

1. Problem Statement

Water's fundamental importance to national security is not well understood throughout the National Guard. The National Guard's primarily compliance-minded association with water requires a paradigm shift to that of water sustainability in order to fully support the National Guard of the future. Sources of water, its availability, and quality must be completely understood at the local level for the National Guard's success both in training and in times of disaster. Understanding the complex dimension of water governance, basic water concepts, water terms, its major consumers, as well as its direct connection with energy within every state and territory will enable the National Guard not only to be successful but be a resource (of information and plans) in times of disaster. Partnering with federal, state, and local water authorities as well as planning for this finite natural resource will not only allow the National Guard to complete its state and federal missions, but will ensure that soldiers and airmen do not become victims of the disasters they are called upon to relieve.

This research provides information from a plethora of sources to provide a base of knowledge and awareness for National Guard planners and water resource managers to begin to address water within their respective states and territories. I make an effort to relate at each juncture its relevance to the National Guard's mission of homeland defense (HLD) or its state and federal mission of disaster response. My philosophy for gathering this information in this research paper is, "It is better for the National Guard to have planned and not need a water plan than to react to an unplanned water crisis." It is not speculation that water in the next three or four decades, maybe sooner, will be at a crisis level in several areas within the United States unless drastic but unlikely steps are taken.

2. Background (Water 101)

A. General

Approximately 70 percent of the earth's surface is water, but most of it is not immediately available for human consumption because approximately 97 percent of all water is salt water. Of the remaining 3 percent, about two-thirds is contained in ice caps and glaciers, leaving less than 1 percent remaining for consumption. This remaining 1 percent is located in aquifers lakes, rivers, streams, wetlands, and permafrost. Most ground water consists of ice caps, glaciers, permanent snow, ground ice, and permafrost, which constitute approximately 70 percent of all fresh water, whereas both ground and surface water constitute approximately 30 percent of the remaining fresh water. Thus, despite the abundance of water, only a very small percentage of fresh water is available.

It is important to keep in mind that water is actually a finite natural resource. Water cannot be destroyed or created, but it can be misused, abused, and polluted.[1]

B. Availability

The availability of fresh water is rarely considered an issue until it is not available. Although the United States is ranked as the fourth most water rich country in the world, [2] water is not always available where or when you want or need it. Most people in the United States do not understand this and therefore place little to no priority on water conservation. Despite the abundance of water in the United States, in many areas, fresh water is becoming elusive.[3] Reasons for the lack of fresh water vary from contamination common throughout the United States to its being locked up in glaciers and snow pack (in eight states); saline, that is, at 30–50 parts per million (ppm); brackish, at 0.5 to 30 ppm (thirty-five states); or simply just unavailable (four states).

C. Relevance to the National Guard

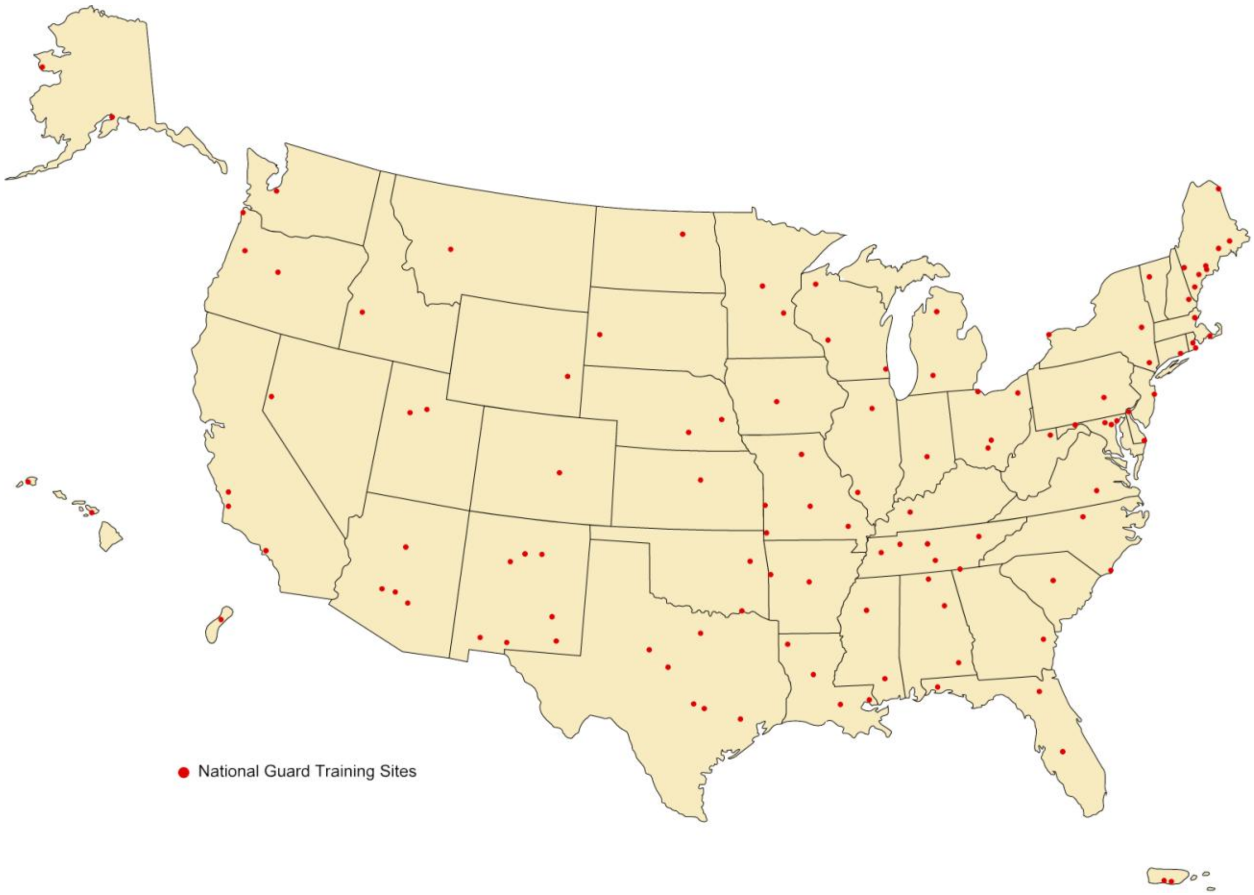

Figure 1. National Guard Training Sites (Army National Guard S-3)

The National Guard is an integral part of local communities throughout the United States. Its Soldiers are active members of these local communities. Training sites are widespread across the United States and its territories (Figure 1). The availability of fresh water is essential to the success of the more than 120 Army National Guard training sites across the U.S and its territories. An in-depth understanding of the U.S. water issues is essential as many (eight to twelve) of the National Guard training sites are located in water challenged parts of the country (Arizona and New Mexico). The majority of National Guard training sites do not control their water supplies, relying on municipalities or privatization for both supply and wastewater treatment.

3. Sources

A. Ground Water

Ground sources include hyporheic zones (regions beneath and lateral to stream beds, where there is mixing of shallow ground water and surface water) and aquifers. Groundwater supplies the majority of the nation's community water systems and almost half of its irrigation. There is currently no tracking or monitoring system that can accurately provide a nationwide assessment and evaluation of underground conditions, availability, or quality trends.[4] Since ground water cannot be seen, it is frequently a victim of that old cliché "out of site out of mind." Without accurate knowledge of water's availability, it is impossible to accurately predict the effect of water withdrawals from ground water resources, frequently resulting in over-pumping (water mining) what is present.

B. Precipitation

Precipitation includes rain, hail, snow, and fog. The collection of precipitation is called water harvesting, which is frequently not done in urban environments, resulting in runoff. Runoff is primarily a cause of manmade impermeable surfaces, such as roofs, roads, parking lots, and sidewalks. Many municipalities require new construction to install retention ponds to reduce runoff.

C. Surface Water

Surface water, such as oceans, lakes, reservoirs, and rivers, are more easily measured because they are visible. Depletion or rise is directly observable. Unfortunately, surface water receives the majority of pollution from such things as mining, agricultural runoff, and industrial pollution as well as human and pet fecal material. A relatively new source of water pollution gaining attention is personal care products and drugs. The effects on humans of drugs disposed of in the water supply have not been studied in any detail. Endocrine disrupters, drugs, flame retardant, plasticizers, and fertilizers have been linked to the feminization of fish.[5] Determining the affects on humans of the minute doses of personal care products and prescription drugs consumed in water will require further study. These new pollutants may be of interest to the Army National Guard as its reverse osmosis water purification units are able to remove most of them, unlike most water treatment facilities. If governors and other state and federal agencies realize the utility of these units, they could call upon the National Guard.

D. Biological

Plants are biological sources of water. Currently, there are no processes developed for extracting water from plants, but they may be developed in the future if water sources diminish.

E. Desalination

Large-scale desalination typically uses extremely large amounts of energy as well as specialized, expensive infrastructure, making it very costly compared with the use of fresh water. The large energy reserves of many Middle Eastern countries, along with their relative water scarcity, have led to extensive construction of desalination in this region. By mid-2007, Middle Eastern desalination accounted for close to 75 percent of total world capacity.

4. Hydrology (the Water Cycle)

The water cycle begins with evaporation of water from the oceans, lakes, reservoirs, and soil as well as from transpiration of trees and plants. The evaporated water then forms clouds that produce rain. Rainwater flows into lakes and rivers or is absorbed by the soil and fills aquifers. The water in lakes, rivers, and many aquifers (fossil aquifers have extremely limited charge and discharge) then either evaporates back to the atmosphere or eventually flows back to the ocean, completing the cycle. Interruptions in the cycle by natural causes, such as droughts and floods, or by humans, such as for use in the production of goods and services, deforestation, or interrupting the water’s path to the oceans through dams, reservoirs, and levees, all negatively affect the water cycle, resulting in disruption of available water until it can be reincorporated into the cycle. All water on the planet has been reused millions of times as it continuously passes through the cycle.

5. Complex Governance of Water

A. Federal

Ultimately, water is a state responsibility, but there is no shortage of federal assistance and control. There are thirteen major federal agencies involved in water management (Appendix A), but many other federal agencies and subagencies play a part in water management within the United States Most of these agencies are involved in establishing or enforcing regulatory compliance and do not have a strategic missions. The National Guard has developed relationships with many of these agencies in its HLD operations, which could easily be expanded to involve the sustainable use of water.

B. State

States differ on where their water-related organizations are situated in agencies. Many are based within a state's environmental or safety agencies, whereas other states place their water agencies in their natural resource departments. Other states use commissions, divisions, or a bureau of water/water management. A few states subdivide water management even further, with separate agencies for ground, surface, and aquifer water. Individual state's Joint Force Headquarters (JFHQ) again have fostered relationships with the state agencies through their participation in emergency management as well as their liaisons at the governor's office. Again, it would be easy to expand the relationships to cover water issues.

C. County

Most counties have a local water district or county water department. Depending on a county's commission, some combine water with power and light districts or departments. There are also commissions, usually regional or specific to a reservoir, lake, aquifer, or river, which protect and provide advice on the health of their particular county or region. Land grant colleges, while not regulatory, have county extension services that also can provide information and guidance on soil and water, both surface and ground.

D. Local

Waterwebster provides examples of several agencies per state as a starting point for a user to further explore.[6] For example, Chicago and the surrounding communities receive their water from Lake Michigan, one of the Great Lakes, which as a group are the largest supply of fresh surface water in the world. There are seven water bureaus in Chicago: the Bureau of Administrative Services, Bureau of Water Distribution, Bureau of Water Treatment, Bureau of Water Quality, Bureau of Water Engineering, Bureau of Water Services, and Bureau of Water Pumping. [7] In many small towns, only one water agency handles all water issues.

E. Compacts

Under 20th-century interpretation of the U.S. constitution's compact clause (Article 1, Section 10, Clause 3), states may, with the consent of Congress, form agreements to solve common problems, and in the twentieth century interstate compacts became a means of using negotiation, rather than lawsuits, to settle water-rights claims.

It is interesting to note in reviewing the U.S. water compacts (Appendix B) that there are water issues not just among states, but with Canada and Mexico as well. The complex nature of water, its ownership, or lack thereof is evident through the need for at least 28 water compacts along with the significant number of federal and states agencies as well as local municipalities involved in the governance of water. Despite the involvement of numerous agencies and binding compacts, water is rarely viewed strategically. As water becomes scarcer, as it is projected to become, disputes between water "haves" and the "have nots" will increase. Water disputes, whether perceived or real, have and will continue to divide towns, counties, states, and even countries.

"Whiskey is for drinking. Water is for fighting over." Attributed to **Mark Twain**

F. Observation

Although cooperation between multiple agencies with responsibility for water offers the opportunity to create an integrated water plan, most agencies do not work with each other. Each agency has its own charter and often shuns cooperating with other agencies to avoid the impression of getting into the other agency's business. Recently, there has been a concerted effort for agencies to form interagency groups not only to work together, but to share information.

6. Major Consumers of Water

By far the two largest consumers of water in the United States are energy and agriculture (39 percent each).[8] Appendix C provides population and employment data for the United States.

A. The Water-Energy Nexus

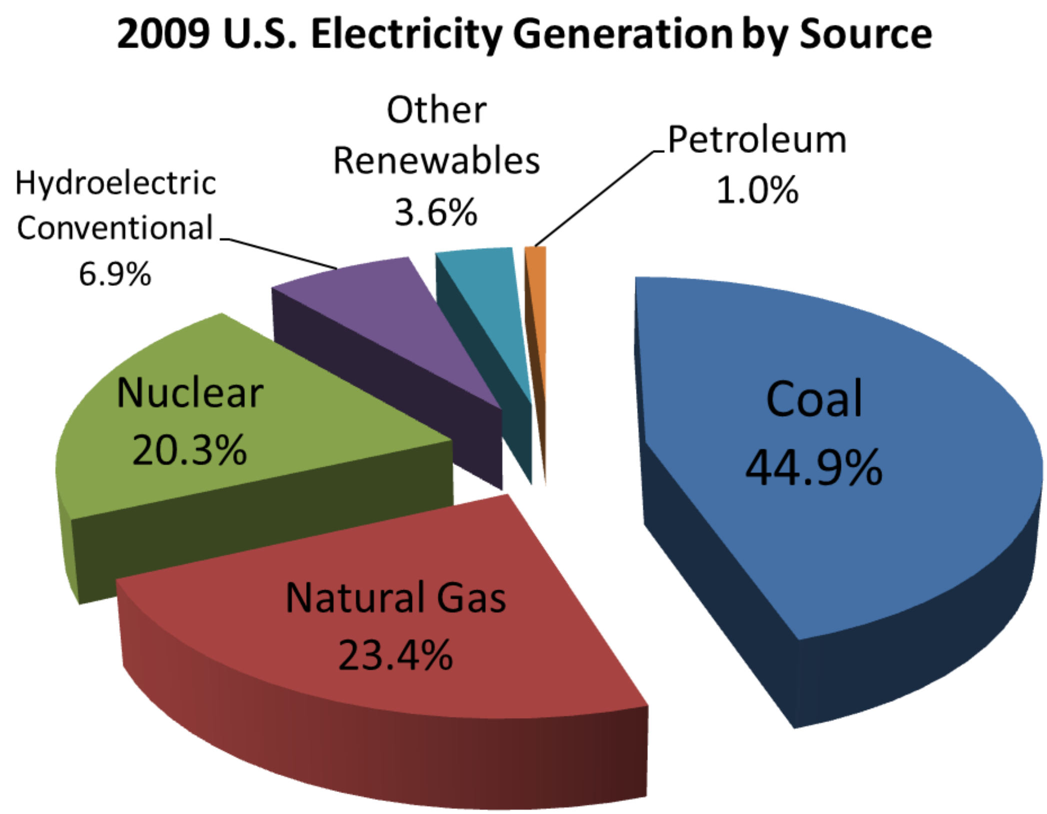

Figure 2. 2009 Electricity generation by source[9]

Energy (electricity) sources (Figure 2) require water for cooling in all but hydroelectric and renewable energy (approximately 10.5 percent combined); thus, the direct link between water and energy validates water's strategic value. Approximately 45 percent of energy is produced by coal. Over 85 percent of the coal that is mined is used in the U.S. production of energy. Coal is transported by barge, train, truck, belt, and slurry pipelines, all consuming energy that is dependent upon water, further substantiating the strategic value of water.

Power plant cooling requires more water than any other activity when fresh and saline withdrawals are combined. A 500-megawatt (MW) closed-loop power plant requires 7,000 gallons per minute, which equals 10.1 million gallons per day. Of the 195 million gallons per day used in 2000 for cooling thermal power plants, 70 percent was fresh water and 30 percent saline. Even though it seems as though significant amounts of water are consumed in cooling power plants, only about 3 percent of this water is actually consumed through evaporation. [10] The rest of the water is heated from the cooling process and then either reused on returned to its source. Chart 1 shows various amounts of water consumed in the production of energy.

Gallons of water requirement per energy unit[11]	
Gasoline	5 gallons of water to produce 1 gallon
Nuclear	720 gallons per MW
Subcritical Pulverized Coal	520 to 990 gallons per MW
Supercritical Pulverized Coal	450 to 840 gallons per MW
Integrated Gasification Combined Cycle	310 to 450 gallons per MW
Natural Gas Combined Cycle	190 to 340 gallons per MW

Chart 1. Energy water requirements

Average energy use for water treatment drawn from southern California studies is 652 kilowatt hours (kWh) per acre-foot (AF), where one AF = 325,853 gallons.[12]

In 2005, U.S. electrical consumption was 32 billion kWh. U.S. consumption is expected to reach 36 billion kWh by the year 2020 and 46 billion kWh by the year 2050. These projected energy increases in the next several decades will require increased volumes of water to produce the energy. The competition for the limited water resources for the production of energy will only exacerbate water shortages in the future. Energy is directly tied to water and will be in the conceivable future; thus, they should be viewed strategically as one. Only future advancements in the production of renewable energy will break the water-energy nexus.

B. Agriculture

U.S. Agriculture produces 70 to 75 percent of food consumed in the United States using less than 2 percent of the work force. (Appendix C)

Agriculture in many parts of the country is the largest consumer of water. Not only is water consumed in the production of crops and livestock, it is also polluted by pesticide and fertilizer runoff as well as the runoff from large livestock and dairy operations. Agriculture also receives large subsidies for water, reducing the incentive to conserve this limited natural resource. Agriculture, in many cases (as in the confinement operations of livestock), uses the old, accepted practice of spreading livestock waste on fields as a fertilizer, which has caused water pollution through runoff. Faced with the massive amounts of animal waste in these operations and the requirement to supply cheap meats and produce to U.S. and foreign markets, there are few viable solutions to this problem. Combined with the fact that virtual water is being sent to countries through sales of agriculture products, agriculture is the most damaging industry to U.S. water supplies.

7. Privatization

Most privatization contracts allow cities to set fair profit margins and therefore control water prices to some extent.

In the early nineteenth century, most Americans received their water from private companies.[13] Private companies, with an eye on the bottom line, took care of the affluent parts of town and let other parts of a town's systems fall into disrepair. Eventually, towns either took the systems over or bought them.[14] For many U.S. municipalities, privatization is being considered as an efficient and effective way to fix their aging infrastructure problems and provide good quality water to their customers.

European companies are currently investing in U.S. companies (Chart 2) that are helping to privatize U.S. water. Approximately 15 percent of U.S. water companies were privatized by 2000.[15] Some Americans may not approve of foreign ownership of such things as municipal water supplies. Chart 2 shows the major foreign water companies, their country, and their subsidiaries in the United States.[16] The parent companies own more than 50 percent of the subsidiary companies.

Company	Country	U.S. Subsidiary
Vivendi	(France)	US Filter, Aqua Alliance, PSG
Suez	(France)	United Water, Calgon, JMM-OSI
RWE	(Germany)	American Water, Azurix, Hydro-Aerobics
Kelda	(United Kingdom)	Aquarion

Chart 2. International water companies and their U.S. subsidiaries

The two largest water corporations in the world are GDF Suez (53rd) and RWE (89th).[17] GDF Suez and RWE capture nearly 40 percent of the world's fresh water market share. These multinationals are now gaining a foothold in the United States, where they operate through a number of subsidiaries. These companies and others, such as Nestlé, a Swiss owned company, are also well established in the U.S. bottled water industry.

Privatization partnerships have been both bad and good. The Bechtel Corporation's attempted water system privatization in Cochabamba, Bolivia, resulted in an uprising and several deaths. The contract was ultimately cancelled followed by the resignation of Bolivia's president, all over water services and price. On the other hand, Indianapolis has had a successful partnership with Veolia Water (a French firm) that has lasted for over 100 years.[18] The bottom line with privatization is "the devil is in the details": good contracts make or break privatization partnerships.

There are legitimate security concerns regarding how water supplies would be affected if privatized-water-supplying countries such as France and Germany no longer were allies of the United States although these countries do not own the U.S. water, they may very well own part or most of the infrastructure to supply and treat water.

8. Water Concerns of Interest to the National Guard

A. ***Ogallala, or High Plains, Aquifer*** (South Dakota, Wyoming, Kansas, Nebraska, Oklahoma, Utah, New Mexico, and Texas)

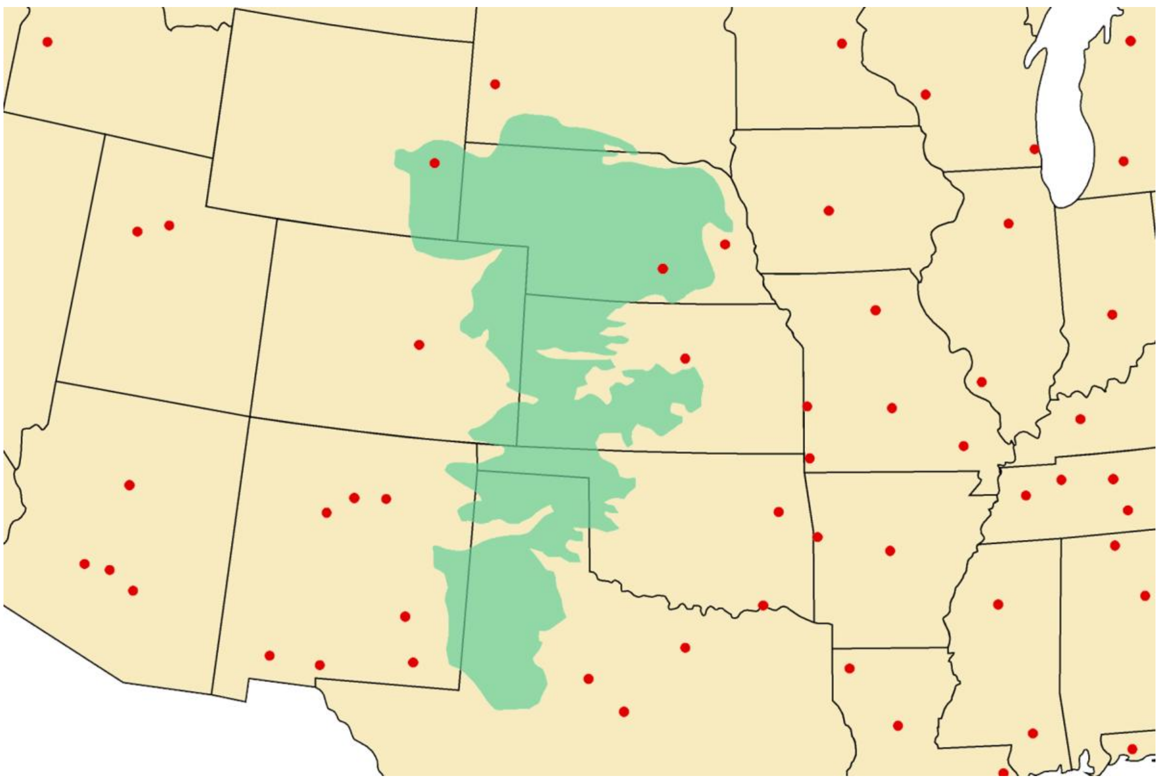

Figure 3. Ogallala Aquifer

Ogallala Aquifer underlies about one-sixth of the U.S. land mass, on which lives only 1 percent of the population (Figure 3). However, it permits the production of 35 percent of the nation's food.[19] In addition, the aquifer provides drinking water to 82 percent of the people who live within its boundary.[20] Recharge in the area ranges from 0.024'' per year in Texas and New Mexico, to 6''per year in southcentral Kansas. Currently, the eight states using the Ogallala are mining more water than is being replenished. This non-renewable fossil aquifer is currently 50 percent depleted.[21] Estimates suggest that there are only 40 more years of water left at the current rate of withdrawal.[22] Others estimate it could take 6,000 years to refill naturally if it were ever to be fully withdrawn.[23]

B. ***Lake Lanier and the Apalachicola-Chattahoochee-Flint River Basin*** (Georgia, Alabama, Florida)

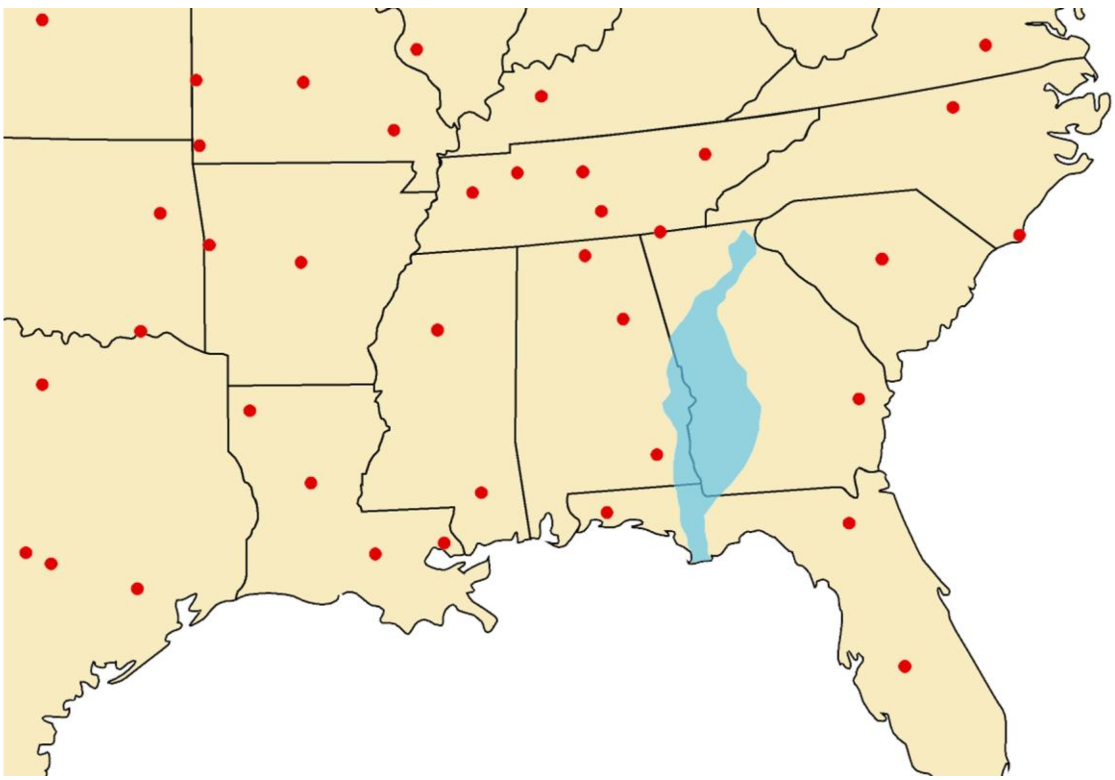

Figure 4. Apalachicola-Chattahoochee-Flint River Basin

Litigation over water rights and use in the Lake Lanier and the Apalachicola-Chattahoochee-Flint River Basin (Figure 4) has been ongoing in some form since the 1970s. Dr. Mark Risse of Conserve Georgia and a professor at the University of Georgia said that Atlanta gets 60 percent of its water from Lake Lanier.[24] Despite that, Atlanta generally receives more than 40 inches of rain a year; this area has suffered from ten droughts from 1756 to 2002,[25] plus the recent drought of 2006 to 2008. These droughts have lasted a total of over 30 years.

During the 2006–08 drought Florida and Alabama claimed they suffered from reduced water flow down the Chattahoochee River. Buford dam was completed by the U.S. Army Corps of Engineers in 1956, creating Lake Sidney Lanier. The lack of flow into the Chattahoochee River—a source of cooling water for the Farley Nuclear Power Plant—threatened down-river fisheries, endangered species, and navigation. Atlanta was within 120 days of running out of water as Lake Lanier was literally drying up.

In July 2009, in a 97-page decision,[26] U.S. District Judge Paul Magnuson ruled that Atlanta has 3 years to obtain congressional approval to keep using Lake Lanier for drinking water. His reasoning is based upon the three authorized purposes for Buford Dam: flood control, hydroelectric power, and downstream navigation. Supplying Atlanta with drinking water is not one of the authorized purposes.

In 2008, Georgia legislators resurfaced what they believed was a solution to Georgia's current water problem. They again argued that the 1818 land survey delineated the Georgia-Tennessee border roughly a mile south of where it should be. Historians had known this for at over a century. The Georgia legislature solution created the Georgia-North Carolina and Georgia-Tennessee Boundary Line Commission to examine the boundary. If the line is adjusted Georgia will control a small portion of Lake Nickajack and its ample water supply.[27]Droughts and the increased population in the Atlanta area are anticipated to continue to exacerbate water issues within the Apalachicola-Chattahoochee-Flint River Basin.

C. Colorado River Basin and its Tributaries

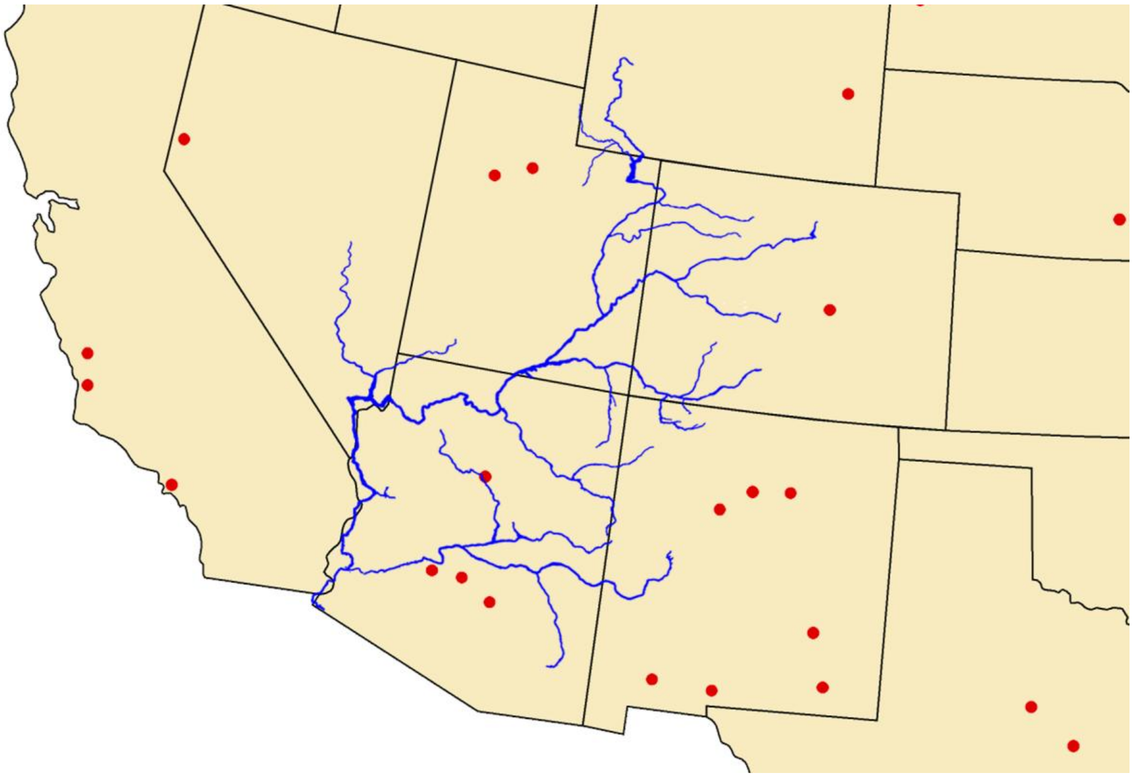

Figure 5. Colorado River and its tributaries

The southwestern United States has been inhabited for over 11,000 years. In his book "Collapse," Jared Diamond devotes a whole chapter to prehistoric human occupation of the U.S. Southwest and his reasons (water is one) why these prehistoric groups no longer occupy the area.[28] Marc Reisner's book "Cadillac Desert" is entirely devoted to the American West and its disappearing water. He calls the Colorado River (Figure 5) the American Nile.[29] With the exception of some unusually wet years, little freshwater has reached the Gulf of California since 1960.[30] The 1922 Colorado River Compact over-appropriated water, allowing 15 million acre feet per year to be withdrawn by the seven signatory states; however, current estimates put the flow of the Colorado closer to the range of 13.2 to 14.3 million acre feet per year. What will happen when each state decides to use their entire allotment as described in the compact?

D. Climate Change

The State Department, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), Department of Interior, Department of Agriculture, Corps of Engineers, Navy, and many other federal agencies advocate climate control. There is also widespread consensus that dry places will get drier and wet places will be wetter in the future.

Climate changes are warming the world's waters each year. Extended periods of hot weather, increased evaporation, and lack of rain will require discharges of water from reservoirs. Unnatural, man-induced movement of water may allow the spread of water-borne problems such as viral hemorrhagic septicemia (VHS) and zebra mussels within the United States. Both are serious threats to the sport and commercial fishing industries.[31] Mussels also impact water transportation and water infrastructure by adhering to vessels, causing additional drag, thus additional power consumption, and clogging water lines that are used to cool hydropower turbines, causing plants to be shut down to remove them.

Studies indicate that Glacier National Park may lose its glaciers by the end of the decade. A recent article in the *New York Times* claims that only 25 of the 150 glaciers are left, and they may be irreversibly damaged by 2030 (two were lost just this year). [32] If global warming causes ice packs at the poles to melt and raise sea levels, what can be done for coastal areas making up 17 percent of U.S. land mass[33] and the 160 million that live there? These hard questions must be asked and solutions found prior to the occurrence. Climate change concerns like this cannot be ignored.

9. Additional Research Topics

A. Risks and risk mitigation of sea-level rise on National Guard Bureau buildings, grounds, and training sites.

B. Security implications for National Guard Bureau operations by the privatization of water supply and wastewater treatment by non-U.S. entities.

C. Aging U.S. water Infrastructure's affects on national security and National Guard Bureau operations.

10. Conclusion

Water shortages, aging infrastructure, the water-energy Nexus, and higher demands on both energy and water due to increasing populations in the upcoming decades require the National Guard to view water as a critical strategic asset. The National Guard through its dual missions can be called upon by governors, or if warranted, by the president, to serve and protect the people of the United States when natural disasters and major infrastructure failures occur. The National Guard itself will fail its mission to serve and protect without a strategic plan integrating water planning considerations. Water is a strategic enabler that will permit the National Guard to remain relevant and prepared to execute its state, defense support of civil authorities (DSCA), HLD, and federal missions.

"*We are now faced with the fact that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history there is such a thing as being too late. Procrastination is still the thief of time. Life often leaves us standing bare, naked and dejected with a lost opportunity*." **Dr. Martin Luther King, Jr.**

11. Recommendations

As the National Guard continues the transition from a strategic reserve to an operational force, it must be trained and prepared to deploy anywhere in the world as well as perform its stateside missions of DoD DSCA and HLD. Training is performed on both federal and state facilities throughout the United States and its territories. In order to support this training these facilities must have water.

The National Guard must foster a strategic understanding of water issues between U.S. states, territories, and its bordering neighbors, enhancing its ability to perform its state and federal missions. The National Guard should partner with water agencies at all levels, enabling it to gain further knowledge on national water issues and possibly participate in the interagency development of a strategic sustainable water management plan with goals addressing the next 20 to 30 years.

Below are a few recommendations regarding water to allow the National Guard to begin to have a strategic picture of water within the United States and its territories:

A. The National Guard should partner with both federal and state water agencies as well as individual state or territory National Guards to gain awareness of water issues within the United States and its territories. This should be relatively inexpensive and may involve no more than having meetings and gathering the facts to publish specific information unique to a state or territory. This will provide rudimentary information to the National Guard on water issues that can be built on in the future.

B. Water availability studies should be conducted at all Army National Guard training sites that furnish water to its soldiers. These studies should contain long-term local population changes, capabilities of local water sources, water quality issues or concerns, as well as current and maximum surge capacities. These studies will be complicated because most Army National Guard training sites do not produce their own water nor treat their waste but rely on public or private sources to accomplish this. These studies should be relatively inexpensive to complete and will involve partnering with local and state water agencies, as well as federal agencies, especially when water resources are common to multiple states or countries.

C. Infrastructure, such as levees, locks, and dams, should be considered strategically by the National Guard. As these structures continue to age, they will continue to degrade and will most likely be reason for a state or federal call-up if a catastrophic failure occurs. Such occurrences as the levee failures in New Orleans during the Katrina Hurricane may well have been anticipated if State Joint Operations Centers were monitoring infrastructure information. This is not a recommendation that the National Guard perform the jobs of other state and federal agencies, but to have situational awareness of infrastructure weaknesses within the states and territories.

D. The final recommendation is to have annual water meetings with federal and state agencies as well as the state and territory National Guards to discuss water issues within the United States and its territories. This would allow federal, state, and local agencies to understand the National Guard mission and vice versa. This meeting of water agencies would allow for the sharing of lessons learned as well as to give all National Guards a common picture of water and water issues throughout the United States

Glossary

Acre foot - The amount of water needed cover 1 acre to a depth of 1 foot. It is equivalent to 326,000 gallons or 43,560 cubic feet of water, and weighs 2.7 million pounds.[34] Acre feet are generally used when addressing water in great volume such as agriculture and appropriations to states in legal compacts.

Consumptive use -The amount of withdrawn water lost to the immediate environment through evaporation, plant transpiration, incorporation in products or crops, or consumption by humans and livestock.

Over-drafting (water mining) - When water is removed from the ground faster than it is replenished. "The Florida Everglades, the real tropical wetland in North American, was essentially mined not to use its water but to get rid of its water to create land for farming, suburban development."[35] Water mining on the coasts results in saline intrusion into aquifers and other fresh water sources, leading to their contamination.

Virtual water - The amount of water required to grow and manufacture products traded around the world. The world's biggest virtual water exporter is the United States It exports approximately one third of all the water it withdraws. The U.S virtual water exports are primarily in the form of grains and meat.[36]

Virtual water trade - When goods and services containing water are exchanged. When a country imports one ton of wheat instead of producing it domestically, it is saving about 1,300 cubic meters of real indigenous water. If the importing country is water-scarce, the water saved can be used toward other means. If the exporting country is water-scarce, however, it has exported 1,300 cubic meters of virtual water because the real water used to grow the wheat will no longer be available for other purposes.

Appendix A

Federal Agencies Involved in U.S. Water

1. Bureau of Reclamation
2. Bureau of Labor Statistics/Waste Treatment
3. Environmental Protection Agency
4. Federal Emergency Management Agency
5. Health and Human Services
6. Department of Agriculture
7. Homeland Security
8. National Oceanic and Atmospheric Administration
9. Occupational Safety and Health Administration
10. State Department
11. Tennessee Valley Authority (TVA)
12. U.S. Army Corps of Engineers
13. U.S. Geological Survey (USGS)

Appendix B

North American U.S Water Compacts [37]

1. **Alabama-Coosa-Tallapoosa (ACT) River Basin Compact** (Alabama and Georgia)
2. **Amended Costilla Creek Compact** (Colorado and New Mexico)
3. **Animas-La Plata Project Compact** (Colorado and New Mexico)
4. **Apalachicola-Chattahoochee-Flint (ACF) River Basin Compact** (Alabama, Florida, and Georgia)
5. **Arkansas River Basin Compact (Arkansas-Oklahoma)**
6. **Bear River Compact** (Idaho, Utah, and Wyoming)
7. **Belle Fourche River Compact** (South Dakota and Wyoming)
8. **Big Blue River Compact** (Kansas and Nebraska)
9. **Caddo Lake Compact** (Louisiana and Texas)
10. **California-Nevada Interstate Compact** (California and Nevada) where both states have ratified the compact and are abiding by it even though Congress has not ratified it
11. **Canadian River Compact** (New Mexico, Oklahoma, and Texas)
12. **Colorado River Compact** (Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming)
13. **Connecticut River Compact** (Connecticut, Massachusetts, New Hampshire, and Vermont)
14. **Great Lakes Basin Compact** (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Ontario, Pennsylvania, Quebec, and Wisconsin)
15. **Kansas- Oklahoma Arkansas River Basin Compact** (Kansas and Oklahoma)
16. **Klamath River Compact** (California and Oregon)
17. **Pecos River Compact** (New Mexico and Texas)
18. **Red River Compact** (Arkansas, Louisiana, Oklahoma, and Texas)
19. **Republican River Compact** (Colorado, Kansas, and Nebraska)
20. **Rio Grande Interstate** (Colorado, New Mexico, and Texas)
21. **Sabine River Compact** (Louisiana and Texas)
22. **Snake River Compact** (Idaho and Wyoming)
23. **South Platte River Compact** (Colorado and Nebraska)
24. **Susquehanna River Basin Compact** (Maryland, New York and Pennsylvania)
25. **Upper Colorado River Basin Compact**(Arizona, Colorado, New Mexico, Utah and Wyoming)
26. **Upper Niobrara River Compact** (Nebraska and Wyoming)
27. **Wabash Valley Compact Act** (Illinois and Indiana)
28. **Yellowstone River Compact** (Montana, North Dakota, and Wyoming).[38]

Additional source for U.S. water Compacts http://ocid.nacse.org/tfdd/domesticCompacts.php

Appendix C

U.S. Population and Employment

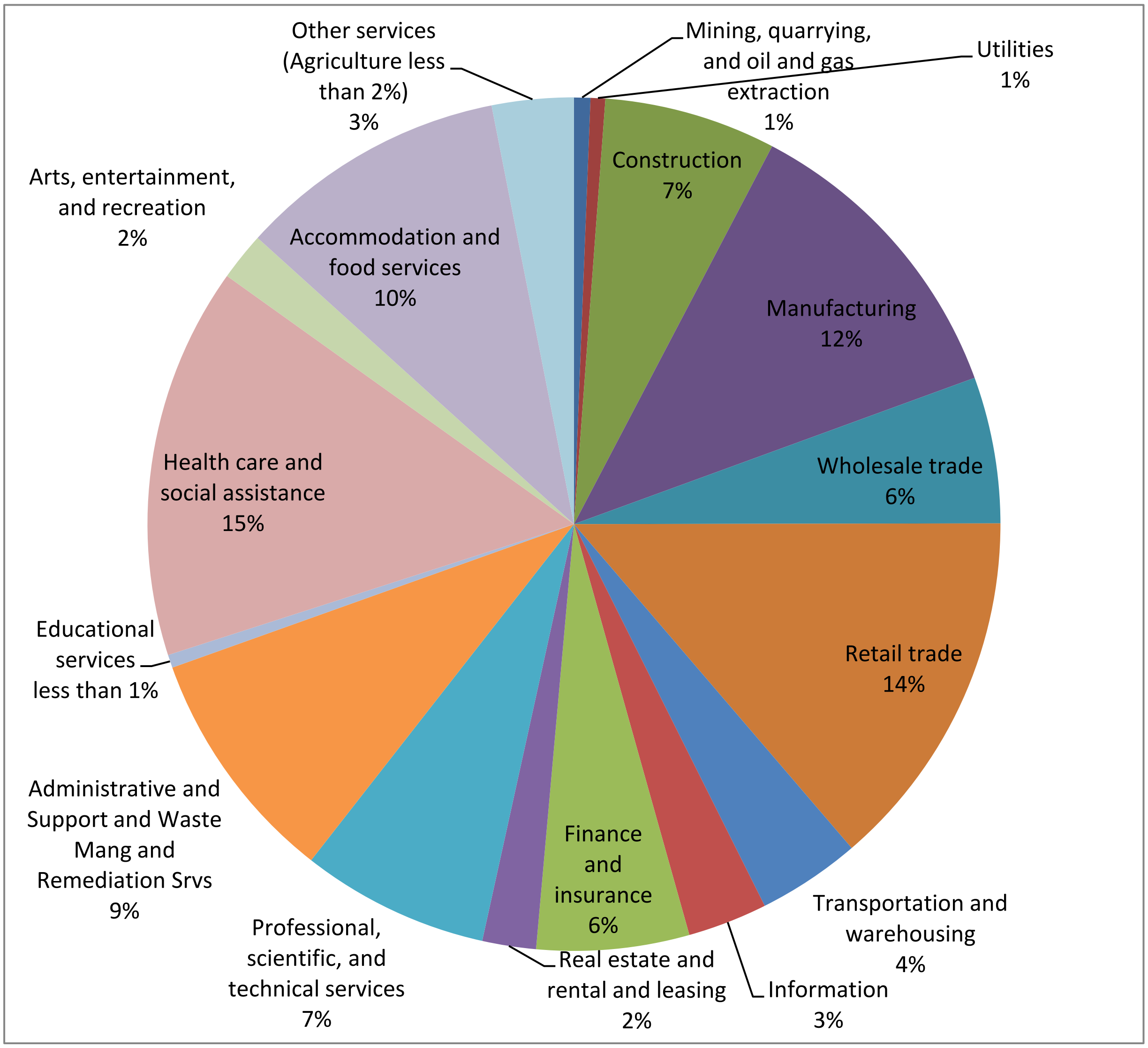

Figure C-1. 2005 U.S. Employment Statistics
Data extracted from 2005 Census Detailed Statistics web page.[39]

U.S. Agriculture produces 70 to 75 percent of food consumed in the United States using less than 2 percent of the work force (Figure C-1). The aggregate import share of U.S. food consumption in 2005 was 7 percent when based on value, but 15 percent based on volume. [40] Foods, such as fish, shellfish, coffee, cocoa, and spices, help boost overall import shares due to their relatively low domestic production volumes. Canada and Mexico are now the two top markets for U.S. exports, expected to generate a combined $26 billion in demand for U.S. agricultural products.[41] Agriculture's market share of global Gross Domestic Product has risen from 43 percent in 1996 to 50 percent in 2006,[42] again with fewer than 2 percent of the working population. Agriculture is a major user of ground and surface water in the United States, accounting for 80 percent of consumptive use, over 90 percent in many western states.[43]

Examples of virtual water requirements for food production are as follows:

- Between 250 and 650 gallons per pound of rice
- 130 gallons per pound of wheat
- 65 gallons per pound of potatoes
- Quarter pound hamburger
    - 3,000 gallons for the burger
    - 40 gallons for the bun
    - Slightly less than 4 gallons for the cheese
    - This does not include condiments, pickles, onions, lettuce, and tomatoes.[44]

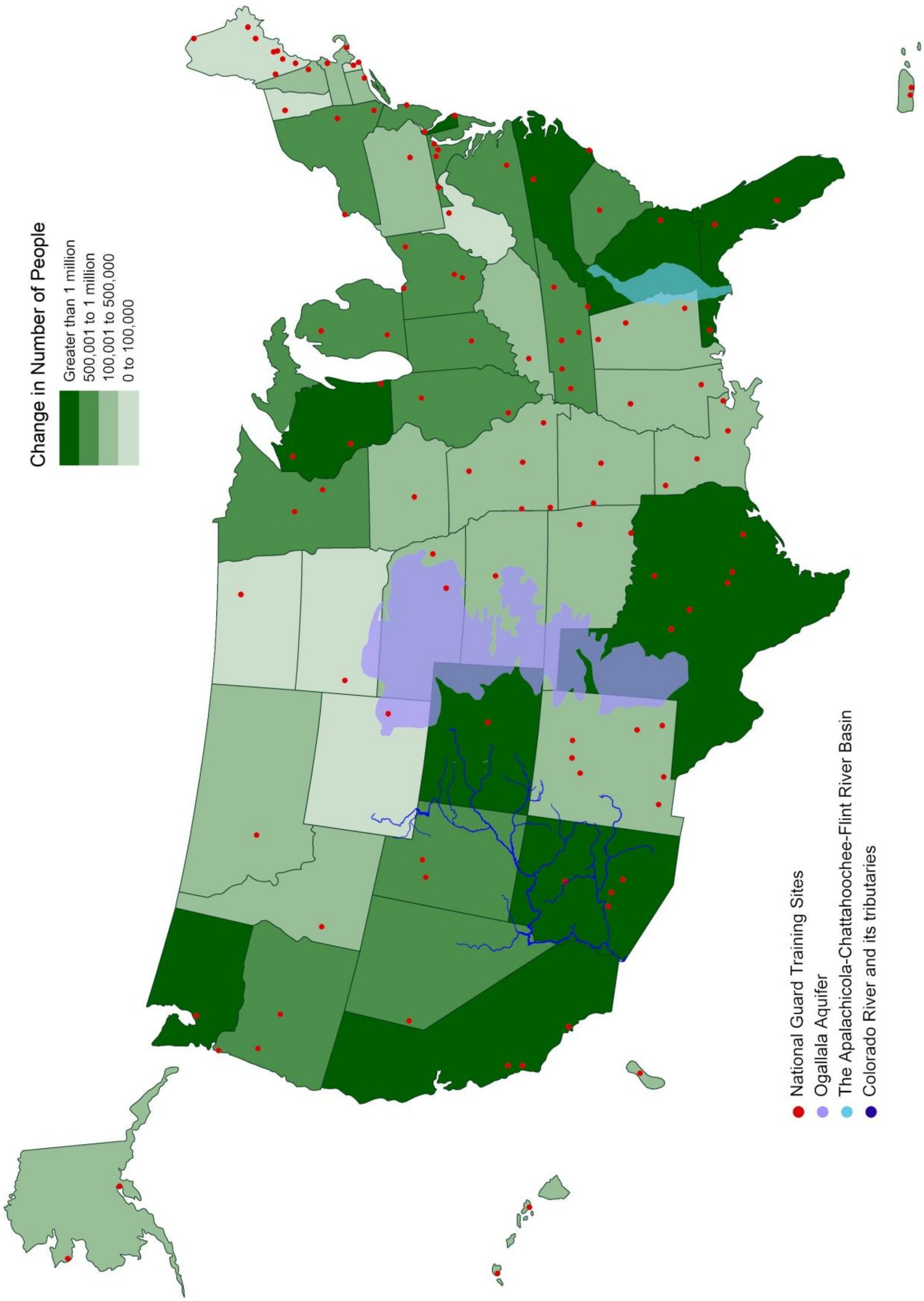

Figure C-2. Numeric change in resident population for the United States and its territories: 1990-2000

The U.S. population is approximately 309,094,400,[45] with 81 percent **r**esiding in cities and suburbs as of mid-2005 (the worldwide urban rate was 49 percent). The Census Bureau projects a U.S. population of 439 million in 2050, which is a 46 percent increase from 2007 (301.3 million).[46] More urbanization is also expected with the growing population.

As the U.S. population grows, there is increasing demand for water in those states that face the most water challenges. Figure C-2 shows significant population increases in the southern and southwestern states.

The Western Advisory Commission (1998) speculated that of the ten fastest growing states between 1998 and 2025, five would be in the Colorado Basin.[47]

End Notes

[1] (DeVilliers, 2001, p. 33)
[2] (Workman, 2007)
[3] (GAO, 2003)
[4] (USGS, 2010)
[5] (Schreck, 2007)
[6] (Waterwebster, 2009)
[7] (Chicago Water Tower, 2002)
[8] (Hoffman, 2007)
[9] (Cardenas, 2010)
[10] Ibid.
[11] (Carney, 2009)
[12] (Hoffman, 2007)
[13] (Glennon, 2009, p. 247)
[14] (Corporate Accountability International)
[15] (Glennon, 2009, p. 247)
[16] (AfricanWater.Org)
[17] (CNNMoney, 2010)
[18] (Midkiff, 2007, pp. 98-99)
[19] (Midkiff, 2007, p. 28)
[20] (Dennehy, 2000)
[21] (Butts, 1997, p. 70)
[22] (Midkiff, 2007, p. 22)
[23] (NGWA, 2010)
[24] (Risse, 2010)
[25] (Stooksbury, 2003)
[26] (Magnuson, 2009)
[27] (Golden Ink , 2010)
[28] (Diamond, 2005, pp. 136-156)
[29] (Reisner, 1986 revised 1993, pp. 120-144)
[30] (Since the Dams: Historical ecology of the Colorado Delta, 2001)
[31] (Schramm, 2010)
[32] (Press, 2010)
[33] (Glennon, 2009, p. 163)
[34] (USGS, 2010)
[35] (DeVilliers, 2001, p. 162)
[36] (Pearce, 2006, p. 5)
[37] (Wolf, 2007)
[38] (U.S. Fish & Wildlife Service, 2010)
[39] (US Census Bureau, 2009)
[40] (Jerado, 2008)
[41] (Dohlman, 2007)
[42] Ibid.
[43] (USDA, 2004)
[44] (Pearce, 2006, pp. 2-3)
[45] (U.S. Census Bureau , 2010)
[46] (U.S. Census Bureau, 2008)
[47] (DeVilliers, 2001, p. 241)

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