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# Drinking Water in the United States: Are We Planning For a Sustainable Future?

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**Abstract**

Maintaining drinking water quality and quantity is a resource management challenge worldwide. In the United States, there are federal, state and local laws to further drinking water quality protection, but few regulations that address water quantity. The first part of this article summarizes existing water protection laws, especially the division of water quality protection and local land use regulation between federal and state government. The second part assesses current water quality and quantity trends. The third part concludes the article with a discussion of drinking water case studies in the United States, to give a snapshot of current use and protection trends, highlighting planning tools, best management practices and solutions. Given the current status of water protection laws and policies in the U.S., this discussion of best management practices is targeted towards municipalities, with the aim of linking it to sustainable development policies.

**Author's Note**

Erin Derrington is an environmental consultant and a recent joint-degree graduate, receiving her Master in Environmental Science from Yale School of Forestry and Environmental Studies and her Juris Doctor from Pace School of Law in 2011. This article draws on research and analysis from her interdisciplinary thesis, *Protecting Drinking Water Quality for Human and Environmental Health: Assessing Efforts to Ensure Safe Drinking Water in the United States.*

**Keywords:** drinking water protection, security risk reduction planning.

## 1. Introduction

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Despite existing water quality protection laws at national, state, and local levels, water impairment trends suggest that drinking water security is at risk throughout the United States. Although each region faces different quality and quantity concerns, it is clear that proactive, multi-tiered solutions are necessary to ensure high quality water is available to meet the needs of growing populations (Ernst, 2004). Despite non-uniform development and population growth, the Census Bureau predicts that the U.S. population will increase from 275 million to 403 million between 2000 and 2050 (USCB, 2000). This growth will have negative impacts on water quality and availability, posing amplified resource management challenges (Fitzhugh, 2004).

While national action to support water security is desirable, this paper emphasizes municipal interventions that promote sustainable water use. Local land use planning, green infrastructure deployment, and targeted open space conservation efforts will be critical solutions to this resource stewardship problem (White, 2008). The first part of this article summarizes existing water protection laws and the federalist division of national and state water quality protection and local land use regulation. The second part then assesses current water supply status and regulatory trends. The third part concludes the article with a discussion of drinking water case studies and impairment in the United States to give a snapshot of current use and protection trends, highlighting planning tools, best management practices and applied solutions.

## 2. Drinking Water Protection Laws in the United States

### 2.1 National and State Water Quality Protection Laws

In 1972 the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), established the first comprehensive national water quality protection program. It mandated that federal agencies cooperate with state and local agencies to develop solutions "to prevent, reduce, and eliminate pollution in concert with programs for managing water resources" (CWA, 1972). Under the CWA, states were required to establish water quality standards based on "use designations," ranging from high-quality waters used for consumption and recreational use to low-quality waters, often used in industrial processes. These standards are the underpinning of permit-based limits on point source discharges and overall "total maximum daily loads" (TMDLs) for water bodies that do not meet use designations (CWA, 1972). While use classifications vary by state, domestic drinking water is generally the highest and most restrictive use designation. The CWA does not supersede state authority to regulate water allocation. East of the Mississippi, such authority is generally administered by water authorities and rooted in riparian rights frameworks, while allocation in the west is typically based on prior appropriation regimes. National legislation does not address water quantity management or allocation.

In 1974 Congress established the Federal Safe Drinking Water Act (SDWA) to address evidence of unsafe contaminant levels in drinking water (SDWA, 1974; Environmental Defense Fund v. Costle, 1977). The SDWA authorized the EPA to establish drinking water quality criteria and reporting requirements. The original approach to drinking water protection under the 1974 SDWA focused on water treatment. The 1986 amendments to the SDWA passed with "overwhelming" Congressional approval. They mandated "state-developed critical wellhead protection programs," increased drinking water quality criteria, and banned lead and copper in plumbing infrastructure (EPA, 1986). These amendments targeted improved source water assessment (EPA SDWA, 2009), source protection (EPA, 1996), and enhanced public participation to ensure high quality drinking water (EPA, 2004). Today, the SDWA is implemented through health-based standards –

maximum contaminant level goals (MCLGs) and maximum contaminant levels (MCLs) (Anisfeld, 2010). MCLGs are aspirational guidelines established to protect against any adverse human health effects, while MCLs are enforceable standards determined by balancing health risks against the cost and feasibility of implementing control measures.[1] Like the CWA, the SDWA regulates water quality, but does not, with the exception of the EPA's 1991 "lead and copper rule"[2] address quantity and infrastructure considerations needed to ensure systematic drinking water security.

Current EPA rulemaking is aimed at expanding the SDWA coverage of certain pollutants, as well as changing the regulatory scheme to target "contaminant groups" (US EPA Strategy, 2010). In November 2010, the EPA's Office of Chemical Safety and Pollution Prevention partnered with EPA's Office of Water to identify a list of 134 chemicals to be screened as potential endocrine system disrupters, and the two offices are continuing to collaborate to develop Human Health Benchmarks for pesticides in drinking water and a tool for states and the public to use to interpret drinking water information (with targeted publication dates in Spring, 2011) (EPA Strategy, 2010). Administrator Jackson reaffirmed the EPA's goal to "update our laws in a way that is sensible and practical for protection of the health of the American people," as well as "evaluate the feasibility and affordability of treatment technologies, and the costs and benefits of potential standards," noting the agency's continued efforts to regulate hexavalent chromium (EPA Testimony, 2011). She concluded her testimony emphasizing that "clean and safe water is the foundation of healthy communities, healthy families, and healthy economies" as well as the "right of all Americans" (EPA Testimony, 2011). Pending regulations will almost certainly increase monitoring and certain water quality standards. Given the EPA's emphasis on cost benefit analysis, increased drinking water standards may yield increased national watershed protection efforts. Additionally, states may take steps to protect their lands and waters so long as the substance of these laws is not preempted by or less stringent than existing federal legislation.

## 2.2 State Enforcement of Federal Water Protection Provisions

The federal Clean Water Act and Safe Drinking Water Act delegates the responsibility to establish and maintain water quality standards (WQS) and enforce maximum contaminant levels (MCL) to the states.[3] Today, use designations and TMDLs under the CWA and MCLs under the SDWA are driving interstate agreements for watershed protection, and can be used to initiate dialogs and

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[1] Despite the health-protective objective of these standards, some question their effectiveness. Studies suggest that current MCLs for several contaminants, such as arsenic, chromium, tetrachlorethylene and uranium, represent "significant lifetime cancer risks" (Anisfeld, 2010). Additionally, the SDWA only establishes enforceable standards for 114 of the 80,000 chemicals in use within the US (Environmental Working Group, 2011), (US EPA Administrator Jackson Remarks, 2010).

[2] The 1986 SDWA Amendments included a provision requiring EPA to regulate lead and copper in public water systems (EPA, 1986). The EPA's 1991 regulation focuses on contaminant levels from lead and copper in customer piping, requiring sampling at the faucet, and when action levels are exceeded, education and service line replacement. (EPA, 1991).

[3] The Safe Drinking Water Act enforcement is delegated to 49 of the 50 states (as of November 2010, Wyoming is the only state without a delegated reporting and enforcement program)(ECOS, 2010), and Clean Water Act permitting is approved for 47 of the 50 states (EPA, 2003).

litigation regarding interstate water quality issues. The EPA reports that virtually every state implements some comprehensive surface and groundwater protection program. This includes enacting legislation and regulations, coordinating activities of the agencies responsible for water management, performing surface and groundwater mapping and classification, monitoring ambient water quality, developing data management systems, and implementing remediation and pollution prevention programs. Nevertheless, the agency concludes that to ensure high quality water supplies "more comprehensive planning needs to be done to make the best decisions regarding remediation and the efficient use" of water resources (EPA, 1999).

Federal funding is a major driver in state-level water quality protection and remediation projects. The CWA's Clean Water State Revolving Fund (CWSRF) and the SWDA's Drinking Water State Revolving Fund (DWSDF) programs enable the EPA to provide grants to capitalize state loan funds. Through federal contributions, state matching, loan repayments and interest earnings, total CWSRF assets have grown to over $42 billion (World Water Forum, 2003). Clean Water Act and Safe Drinking Water Act financing can support statewide and regional watershed-based planning efforts and has led to integrated planning in several regions. Leading examples of successful interstate planning partnerships that further water quality protections include the Chesapeake Bay Commission, the Great Lakes Planning Commission, and the New York City Watershed Memorandum of Agreement (Anisfeld, 2010).

Conversely, other areas such as the Chattahoochee River and Colorado River Basins struggle to effectively manage water resources. These regions are experiencing challenges regarding how to plan the use of shared waterways, and these conflicts will likely be resolved in court (Clemons, 2004). Issues ranging from declining water quality, reduced availability, and insufficient or even dangerous infrastructure are gaining increasing attention in some areas. Some states are earmarking funds to allow communities to sell development rights in watershed areas in order to reserve future water harvest rights. Some states support this funding model through water quality targeted conservation and management improvement programs. For example, in 2004 the New Jersey legislature passed the New Jersey Highlands Water Protection and Planning Act (SB1, A2635), a "comprehensive, long-term approach to the protection and preservation of the drinking water and natural resources in the New Jersey Highlands Region, which is the source of the drinking water of more than half of the residents of New Jersey" (Rutgers, 2010). This Act required improved management capabilities and comprehensive plan conformity, encompassing efforts to "protect the natural, scenic, and other Highlands resources, including but not limited to forests, wetlands, stream corridors, steep slopes, and critical habitat for fauna and flora" within the watershed (7 NJAC 38, 2009). Enforcement of water quality and land use regulatory violations can also provide significant funding for environmental projects.

State water quality protection efforts can target point source and nonpoint source pollution in urban and rural areas, and further incentivize efficient water use and environmental benefits through funding and regulation. For example, in 2009 California approved an $11.14 billion water bond to support the "co-equal goals" of "providing a more reliable water supply system and protecting, restoring and enhancing the Delta system" (Family Water Alliance, 2010). Additionally, states are authorized to create water quality standards, pollution control and drinking water treatment requirements more stringent than federal policy, although currently only a handful do so.[4] For example, California's state standards for uranium and numerous volatile organic compounds (VOCs) and synthetic organic compounds (SOCs), are lower than national limits, and many were in place before national limits were established (CA Dept. Pub. Health, 2008). Through increased regulatory enforcement, enhancement of water quality standards, and participation in forward-looking watershed conservation initiatives, states play a vital role in water resource stewardship.

## 2.3 Local Land Use Zoning and Development Regulatory Authority

State delegation of land use and building development authority to municipalities provides powerful tools at the local level to further drinking watershed protection and water security planning efforts. Local land use laws can facilitate drinking water protection by restricting impervious surface coverage and limiting subdivisions (Newton County Board of Commissioners, Georgia, 2006). Encouraging high-density mixed use development to deter sprawl, establishing enhanced aquatic buffers, and creating septic management standards can also help protect aquatic ecosystems and water quality (EPA HDD, 2006). Local laws can also create open space requirements, establish designated growth areas, and incentivize cluster development, particularly in drinking watersheds (EPA Open Space Development, 2006; EPA Smart Growth, 2004).

Zoning laws can also further state and national management efforts. For example, in Suffolk County, New York, local zoning laws were amended to support watershed land acquisitions funded by the federal Clean Water State Revolving Fund. Similar "best management" development practices have been codified in the Towns of Clinton and Wappinger, in Dutchess County, New York (NYS DEC, 2011; NYS DEC). Model development principles identified by the Local Site Planning Roundtable included recommendations for both the natural and built environments such as buffer management, tree conservation, street design, runoff management, and open space stewardship (Hudson Partnership, 2006). The Town of Wappinger's 2010 Comprehensive Plan sought to "[p]reserve the quality and quantity of the Town's surface and groundwater resources through land use regulation, monitoring, testing and promotion of water-saving systems." It included requirements for runoff control, especially during construction, as well as establishing open space corridors and restrictions on sensitive area development (Town of Wappinger, 2010). The Wappinger Town Code reflects these principles in its chapters on watercourse

[4] Citing the importance of balancing growth and health protective environmental regulation, in 2010, Governor Christie issued Executive Order #2 establishing "Common Sense Principles" directing all New Jersey agencies to apply cost benefit analysis and "not exceed the requirements of federal law except when required by State statute or in such circumstances where exceeding the requirements of federal law or regulation is necessary in order to achieve a New Jersey specific public policy goal." The order requires agencies to redraft rules identified by the Governor's "Red Tape Review Group" to conform to national regulatory standards, effectively ending New Jersey's lead in establishing more stringent standards for these chemicals. Despite this lapsed leadership, in 2011, Delaware proposed standards to follow New Jersey's 2004 standards.

protection, stormwater management, water and zoning (Town of Wappinger, 2011). The Town of Wappinger's water management and watershed protection efforts show that zoning can directly enable water quality protection through source watershed conservation and adoption of development standards. In addition to direct water quality improvements and avoided treatment costs, planned development can also have indirect water quality and quantity benefits. By planning for growth in existing developed areas, undeveloped areas can be protected from sprawl and its associated impacts: more road area, impervious surfaces, and infrastructure needs (USDA, 2001).

Similarly, municipalities can amend and update building codes that encourage sustainable development and green infrastructure deployment, decreasing residential, commercial, and even industrial water demand (MN EQB, 2000; American Rivers, 2010). High density, mixed use, transit oriented development ("TOD") requires support from both zoning and building regulations, and can yield social, economic and ecological benefits (Holmes, 2008). The EPA reports that lower-density development "requires more land than higher densities to accommodate the same amount of growth" (EPA, 2006). Most states have delegated planning and development authority to local governments (Nicholas, 1999). Additionally, the International Code Council (ICC) a conglomerate of policy analysts and industry representatives has recently developed the "International Green Construction Code" (IGCC). Like the ICC's "International Energy Conservation Code," the IGCC can be adopted by states to require varying degrees of local-level code enforcement. The adoption of the IGCC could yield substantial water infrastructure benefits. Some states such as Maryland (Rodriquez, 2011), Arizona, Washington and Rhode Island (Public Works, 2011) have set a precedent of adopting the ICC's international standards at the state level while also empowering municipalities to enhance these standards.

Even without specific state-level guidance, local building codes can continue to accommodate growing populations while minimizing impacts to ecosystem functions and assets. Municipal land use laws are increasingly enacted to ensure development of sustainable communities. Reducing allowable impervious surface coverage and requiring projects to offset impacts of development and provide for water supply demands can have direct watershed stewardship benefits. Furthermore, the EPA encourages watershed protection through strategic local development planning that minimizes overall land disturbance and impervious surface cover (EPA, 2006). Some communities are implementing this model.

Municipal-level water quality protection efforts are codified primarily through local zoning laws and building codes that encourage low-impact development, efficient use, and demand reduction. The EPA reports numerous case studies where municipal storm water regulations (EPA GICS, 2010) and development restrictions such as open space management, compact development, and measures to reduce overall imperviousness of the built environment have improved water quality (EPA Scorecard, 2009). Despite the difficulty in determining how municipal land use policies contribute to water quality conditions, there are clear correlations between upland development activities and water quality. These impacts can be addressed through local policy and planning tools (Benoit, 2007). Best management practices and recommendations will be discussed in section 5.

# 3. The Status of Drinking Water Protection in the U.S.

## 3.1 Water Quality and Aquatic Ecosystems

National, state, and local regulations interact to form a mosaic of drinking water quality regulations across the United States. Nevertheless, drinking water quality remains a policy concern and a management challenge. There is considerable uncertainty that must be resolved concerning whether current environmental regulations are sufficiently protective of public health, water quality, and aquatic systems. Between 1991 and 2003 there were 183 documented outbreaks of waterborne disease.[5] Waterborne illness from drinking water contamination impacts estimated 19.5 million Americans annually, a figure that does not include illnesses caused by chemicals or toxins (The New York Times, 2009-2010).

In 2003, a NRDC study concluded that safe drinking water in U.S. cities is increasingly at risk, revealing troubling shortcomings in source water protection, water delivery infrastructure, and treatment systems (NRDC, 2003). The New York Times' *Toxic Waters* series echoed these findings (The New York Times, 2009-2010). In the EPA's 2009 report, "Water on Tap," the agency warned of threats, noting that "[s]hort-term disease outbreaks and water restrictions during droughts have demonstrated that we can no longer take our drinking water for granted" (EPA, 2009). In addition to known waterborne disease outbreaks and demand pressures on public water infrastructure, cumulative compound impacts of chemical contaminants from natural and human sources are being linked to long-term health impacts. The EPA's Toxic Control Substances Act identifies more than 83,000 chemicals in use in the United States (EPA TSCA, 2011). In a speech to the Association of Metropolitan Water Agencies, Administrator Jackson noted that the EPA is "not keeping pace with the increasing knowledge we have about chemicals in our products, our environment and our bodies" (EPA Administrator Jackson Remarks, 2010).

Although the EPA is taking steps to expand drinking water quality regulations, the Environmental Working Group reported that 316 contaminants were present in drinking water supplied to 256 million Americans in 45 states. They noted that the EPA has enforceable drinking water safety standards for 114 of the 316 substances detected (36%) (Environmental Working Group, 2011). However, some caution that strengthening standards does not necessarily ensure improved water quality or regulatory compliance. The New York Times surveyed five years of Clean Water Act discharge records, finding more than 506,000 self-reported violations from more than 23,000 facilities (Duhigg, 2009). The study also noted that violations of the CWA have risen steadily across the nation (Duhigg, 2009).

While the extent of surface and groundwater pollution is not well established, national data elucidating chemical, hydrological, and physical water parameters (Maddock, 1999) show declining trends in water quality and aquatic ecosystem health. In 2010, the USGS conducted a nationwide assessment of 2,888 monitoring sites and concluded that stream flows have been significantly altered in eighty-six

[5] About 75% of these outbreaks, except for the highly publicized 1993 Milwaukee cryptosporidium outbreak that infected 400,000 people, involved groundwater. About 65% involved individual wells, which are subject to less water quality regulation (Anisfeld, 2010).

percent of these rivers – a concerning finding given that flow alterations are a "primary contributor to degraded river ecosystems" (Carlisle, 2010). Analysis of state-integrated water quality reports indicates that about 50 percent of all assessed rivers and streams are "impaired" and 50 percent are rated as "good," with a small fraction rated as "threatened" (Anisfeld, 2010; EPA, 2011). Additional reports from the USGS' National Water Quality Assessment Program indicate ongoing water quality concerns associated with pesticides (Gilliom, 2006), volatile organic compounds (Zogorski, 2006), nutrient loading (Sprague, 2009),[6] trace elements (Mahler, 2006) such as mercury (Brigham, 2003), and overall aquatic ecology. Increasingly, water resources and surrounding ecosystems are burdened by growing populations, mounting withdrawals from water supplies, expanding impervious cover, deforestation, pollution, and shifting climatic patterns (The New York Times, 2009-2010).

## 3.2 Water Security Trends in the United States

### 3.2.1 Water Quantity

It is uncertain how much water extraction is sustainable at a national level. Although water use is monitored,[7] detailed water budgets assessing available water withdrawals are not available for the majority of U.S. watersheds. Nevertheless, the well-studied Ogallala basin that covers portions of eight High Plains states and California's Central Valley aquifers show irrefutable signs of unsustainable use (Gleick, 2010). The same trends are evident in surface water. WRI shows that per capita sustainably available water exceeds per capita withdrawals on a national level. But, what constitutes "water scarcity" or "water stress" is a complex issue, and national assessments may not capture regional variations. One scholar claims that "there is some strong evidence that the United States may have already passed the point of peak water, including peak renewable, nonrenewable, and ecological water" in numerous watersheds (Gleick, 2010). Compounding these use pressures, the EPA also predicts climate change will intensify some regional water management challenges. For example, the Southeast, Gulf, and Mid-Atlantic may experience longer droughts, more storm events, and higher floods, while the Northeast is likely to see decreased snow cover and possible saline intrusion into coastal aquifers (EPA 2011). Projections indicate that by 2050 nearly one in three U.S. counties will be facing water scarcity (NRDC, 2010).

[6] Nitrates in particular are nutrients that may pose human health concerns. See Ward et al., (2005, November). *Drinking-Water Nitrate and Health – Recent Findings and Research Needs.*
[7] In 2005, 44,200 million gallons a day were withdrawn for "public water supply," a term which includes public and private water suppliers that provide water to at least 25 people or have a minimum of 15 connections. USGS reports that an estimated 258 million people – about 86 percent of the U.S. population – relied on public water supplies for household use, and that about two-thirds of this water came from surface water sources (USGS, 2009).

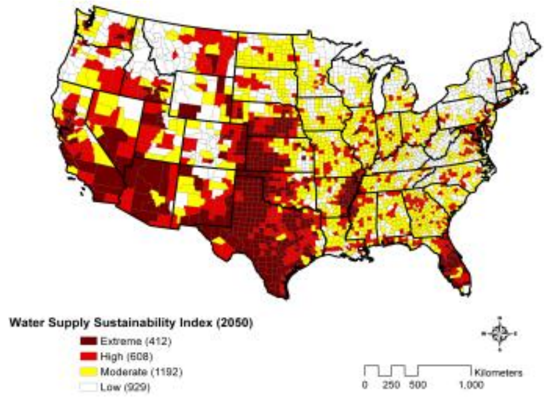


Figure 1: NRDC Water Sustainability Index – 2050 Projections (NRDC, 2010).

As Figure 1 demonstrates, while some water stress is predicted throughout the United States, arid areas such as the Colorado River Basin, the West Gulf of Mexico, and the Atlantic Slope Drainage will have concerns about water quantity and availability.

### 3.2.2 Water Quality

Debate surrounds whether current environmental regulations are sufficiently protective of public health, water quality, and aquatic systems. While some outbreaks are significant enough to be documented and publicized, as in the case of the 1993 cryptosporidium infection in Milwaukee, reported cases only reflect a small fraction of actual infections (Craun, 2006). Despite the considerable toll of waterborne illness, from occasional hospital visits to missed work and school days, this ongoing epidemic is not routinely portrayed as a human health "crisis." This may be because most waterborne illnesses in the United States do not result in death as frequently as in other countries. However, deaths do occur. Between 1971 and 2002, there were 764 documented waterborne disease outbreaks associated with drinking water, resulting in 575,457 cases of illness and 79 deaths (Reynolds, 2008). Recent reports suggest these illnesses may cost the healthcare system more than $500 million annually (Ledue, 2010).

Exposure to the numerous chemicals used in the United States ought to also be explored. Organic and synthetic chemicals may enter ground and surface water sources through numerous pathways. Some chemicals, such as arsenic,[8] occur naturally in the environment and result from human activities (EPA AIDW, 2010). Contamination risks differ between surface water and groundwater (Ritter, 2002), and may raise diverse human and environmental health concerns.

[8] Arsenic has been linked to long-term risks, including several types of cancer and blindness, as well as short-term effects such as skin discoloration, rashes, stomach pain, nausea, vomiting and diarrhea. In 2000, USGS published a national report showing that well water samples from many counties contained high levels of arsenic (USGS, 2000). In 2001, the EPA lowered the MCL for arsenic from 50 micrograms per liter to 10 micrograms per liter after the National Research Council published reports that higher levels posed greater health risks. Nevertheless, recent region specific USGS reports indicate that numerous water systems are in violation of this limit. See e.g. USGS, 2010. Assessment of Arsenic Concentrations in Domestic Well Water, by Town, in Maine, 2005–09.

Additionally, while the CWA limits point source pollution, nonpoint source pollution remains a leading cause of concern for our nation's surface waters (Anderson, 1999). In the United States, leading causes of impairment are assessed by water category. For rivers and streams, pathogens, sediments and nutrients are the top three causes of impairment, while for lakes, ponds, and reservoirs, mercury, polychlorinated biphenyls (PCBs), and nutrients are the three leading causes of impairments (EPA, 2011). Agriculture is the leading probable source of impacts to rivers and streams, while atmospheric deposition is the leading probable source of impairment in assessed lakes, ponds, and reservoirs (EPA Impacts, 2011).

National information on groundwater contamination is less available. However, in a 2010 report, more than 20% of 932 untreated public wells that the USGS sampled contained one or more chemical contaminants at concentrations greater than SDWA MCLs (Science Daily, 2010). The 2010 USGS study showed that naturally occurring contaminants such as arsenic and radon were present in about 75% of contaminated samples at levels greater than human health benchmarks. Anthropogenic pollutants including herbicides, insecticides, solvents, disinfection by-products, nitrates, and chemicals from gasoline were detected in 64% of contaminated samples, with about 25% of these detections exceeding existing health benchmarks (Science Daily, 2010). The sufficiency of MCLs to protect human health is also a complicated and much debated issue.

Thousands of potential contaminants may pose threats to water quality and human health, while only about 90 pollutants are currently regulated under the SDWA. The SDWA requires the EPA to review drinking water standards every six years to determine whether current health effects assessments, changes in technology, and/or other factors provide a basis to support regulatory revisions (EPA SYR, 2011). These reviews consider dose-response and exposure assessments to establish a risk characterization (EPA, 2000). Possible regulatory changes are then considered using a cost-benefit analysis framework, as required by the 1996 SDWA Amendments. Risk assessments today may provide more accurate estimates than in the past, with models that purport to "qualitatively and quantitatively" address uncertainties such as variability in physical and biological processes and model uncertainty in dose-response extrapolations (EPA, 2005). Unfortunately, acknowledging uncertainty in itself may not ensure health protective decision-making. The regulatory bottom line often boils down to a consideration of how much risk is economically acceptable, and ignoring ambiguous risks of cumulative exposure to toxins as acceptable costs of development or doing business. The precautionary principle dictates that great care should be taken in the face of uncertainty in order to ensure protective, data-driven standards for human and environmental health and optimal resource stewardship.

Drinking water quality data is reported on a system-by-system basis, with a regrettable scarcity of nationwide case studies. In part, the bifurcation of water quality reporting requirements for surface waters and drinking water systems reports confound analysis of national water quality trends. From the EPA's national surface water reports between 2002-2008, it is clear that a significant number of surface water systems are not meeting their use designations and are thus "impaired." Of the 26% of rivers and streams assessed, 50% are impaired and 24.1% were not meeting their use designation, as illustrated in Figure 2 (EPA, 2011).

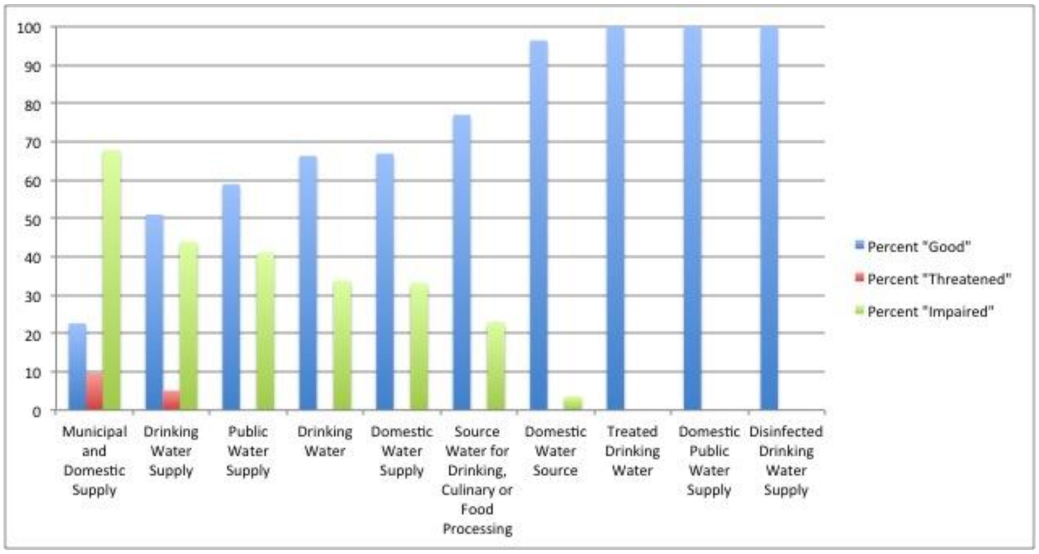


Figure 2: Public Water Supply Water Quality Attainment for Rivers and Streams. Adapted from US EPA's National Public Water Supply Data (EPA, 2011).

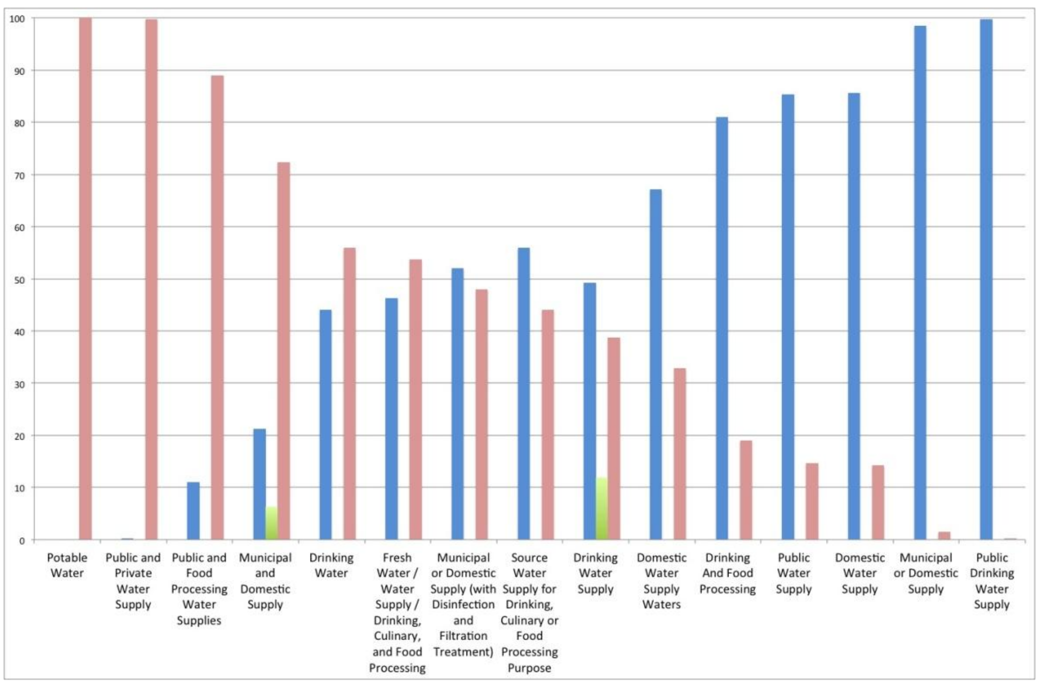


Figure 3: Public Water Supply Water Quality Attainment for Lakes, Reservoirs and Ponds. Adapted from US EPA's National Public Water Data (EPA, 2011).

Of the 42% of lakes, reservoirs and ponds assessed, 66% are impaired and 8.9% of these waters serve as public water supplies (Figure 3; EPA 2011). Overall, pathogens, sediment, and nutrients were the leading causes of impairment for all assessed rivers and streams, while mercury, polychlorinated biphenyls (PBCs), and nutrients were leading causes of impairment in assessed lakes, reservoirs, and ponds (EPA, 2011). This data is indicative of water quality challenges, as well as the much-cited criticism that the Clean Water Act's focus on point-source pollution is insufficient to prevent degradation of aquatic systems. As water quality declines it becomes more difficult to ensure drinking water security due to reduced availability of high-quality water sources.

## 3.2 Water Security – Regulatory Response

Use restrictions addressing water quantity concerns are relatively new regulatory phenomena that are increasingly found at the state and local levels, especially in more water-scarce areas. For example, Georgia's 2010 Water Stewardship Act requires local governments to adopt ordinances limiting outdoor water uses, mandates that agencies include water conservation measures in comprehensive plans, and encourages efficient use and water loss abatement activities throughout the state (GA WSA, 2010). In Tampa, Florida, the municipality restricts irrigation of lawns and landscaping, and limits new plant establishment (Tampa Code, 2010). It is reasonable to suspect that this trend will continue, as water availability is an increasing development concern. Additionally, while not addressed at length in this paper, water infrastructure deployment and maintenance are critically related to water quality and quantity concerns.[9] In a recent annual report from the Office of Ground Water and Surface Water, the EPA asserted that ensuring long-term sustainability of drinking water infrastructure is a key challenge. The EPA advocates a "multi-faceted approach to managing and sustaining the nations' water infrastructure assets" to address "both the supply and demand problems in order to better optimize available resources" (EPA, 2006).

Despite future water quality concerns, expanding delivery and treatment infrastructure are current management challenges receiving attention. Approximately 160,000 EPA regulated drinking water systems supply water to about 90 percent of the American population. Although there has not been a major reported waterborne outbreak since 1993, a recent National Academies report warns that "the ability of these drinking water systems to continue to meet increasing water demands over the coming decades cannot be taken for granted" (The National Academies, 2008). There are over 155,000 public drinking water systems (PWS) in the United States, and SDWA violations were reported in 33% of small PWS serving 3,300 or fewer customers and 30% of all large PWS. The EPA acknowledges that health-based violations in at least 10,615 public supply systems[10] that serve 17.7 million customers

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[9] In 2009, the American Society of Civil Engineers (ASCE) gave the United States' drinking water infrastructure a "D-" grade, noting that "drinking water systems face an annual shortfall of at least $11 billion in funding needed to replace aging facilities … and to comply with existing and future federal water regulations," a shortfall that does not fully account for growing demand (ASCE, 2010). A 2009 EPA needs assessment concluded that to comply with drinking water regulations, a $276.8 billion investment in infrastructure improvements would be needed over 20 years, requiring annual investments of $13.84 billion. A 2002 Congressional Budget Office report estimated annual costs between $24.6 and $41.0 billion (Copeland, 2010). Despite significant increases in population and usage (both total and per capita), the ASCE highlights low-hanging solutions that could yield long-term benefits.

[10] While public supply systems reported 10,615 health-based violations, EPA notes that primary agencies reported 18,169 health-based violations in 2009. Of the 18,169 agency reported violations, 50% of these violations were for exceedence of the Total Coliform Rule, 24% for chemical contaminant standards, 16% for the Stage 1 Disinfection Byproduct Rule, 6% for the Surface Water Treatment Rule, and 4% for the Lead and Copper Rule. EPA also acknowledges possible

are a cause for concern (EPA NPWSCR, 2011). In addition to the fact that some claim existing health-based standards are not sufficiently health protective (NRDC, 2003), compliance challenges may implicate environmental health equity issues, where smaller communities may face a disproportionate risk of drinking water that violates health standards. The EPA indicates that small systems account for approximately 91% of systems in significant noncompliance (EPA NPWSCR, 2011). While the EPA continues to take steps to provide compliance assistance and develop capacity for small systems, billions of dollars in investment and planning will be required to merely maintain current service levels (ASCE, 2010; Copeland, 2010).

# 4. Supply Trends and Approaches to Ensuring Drinking Water Security

In order to better understand public drinking supply challenges, the following section will highlight NRDC's tap water assessment reports and conclusions. Water supply management will briefly be discussed to further emphasize regional drinking water protection approaches. This article will conclude discussing case studies of successful interventions and literature-based discussion of best-management practices and recommendations.

## 4.1 NRDC's City Table Water Studies

In 2000, the Natural Resources Defense Council (NRDC) began their tap water quality assessments of major U.S. cities. By 2003, the NRDC published results from nineteen cities, ranked by water quality, "right to know" information availability, and source water protection. This data was assessed based on EPA compliance records and annual reports. Five "ranks" were possible – excellent, good, fair, poor, and failing. No city received perfect marks. In fact, if ranked numerically (with 4 being "excellent" and 0 being "failing"), the average score in this assessment was about a 6 out of 12 (Figure 4). While the report concluded that overall tap water quality varies widely between cities, NRDC warned that "there is one overarching truth that applies to all U.S. cities: unless we take steps now, our tap water will get worse" (NRDC, 2003).

Among overall water quality trends observed in this study, the NRDC found lead, pathogens, chlorination by-products, and naturally occurring carcinogens to be particularly ubiquitous (NRDC, 2003). Although the report found relatively few cities to be in outright violation of national standards, "[t]his fact did not necessarily imply low contaminant levels, but rather low standards: in short, the EPA has written most standards in a way that the vast majority of cities will not be in violation" (NRDC, 2003).

underreporting and inaccuracies in this data, and is taking steps to improve the quality of data available through SDWA reporting. (EPA NPWSCR, 2011).

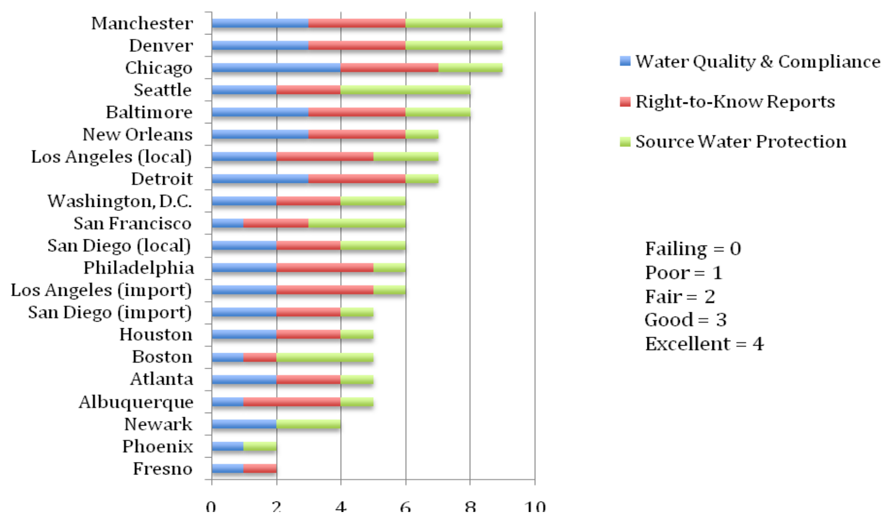


Figure 4: NRDC City Survey Summary. Adapted from NRDC, 2003.

The NRDC's study concludes that "in order to improve water quality and protect public health, we must invest in infrastructure, upgrade treatment and distribution facilities, improve public understanding through the efficacy of right-to-know reports, [and] safeguard source water" (NRDC, 2003). While it is difficult to quantify the state of water security throughout the United States, the NRDC study offers a persuasive example that continued system investments and improvements are necessary. Population growth and development pressures, along with shifting precipitation and temperature patterns associated with climate change, will continue to compound the challenge of maintaining safe and sufficient drinking water supplies. Multi-tiered protection and management approaches will remain critical systematic stewardship elements.

## 4.2 Approaches to Drinking Water Supply Management – Filtration and Conservation Overview

The Safe Drinking Water Act requires all public water supply utilities either filter their water supplies or demonstrate that their water quality meets current drinking water standards. Providers seeking to avoid filtration required under the Safe Drinking Water Act must demonstrate that their drinking water complies with primary (health related) and secondary (nuisance-related) standards. Water systems that can demonstrate this can apply for a "filtration avoidance determination" (FAD) (EPA, 1989). It is worth noting that only two of the nineteen cities assessed in the NRDC tap water study – Seattle and Boston – have SDWA FADs, and thus, are not required to filter their water supplies. In fact, only five large U.S. cities—New York City, Seattle, Boston, San Francisco, and Portland have standing FADs (Ferrara, 2011). Although these water utilities have found that protecting source water land is an efficient, economic way of complying with standards and avoiding filtration costs, FAD applications can also be arduous. For example, to achieve FAD approval, New York City's Department of Environmental Protection developed a detailed Long-

Term Watershed Protection and Filtration Avoidance Program (EPA, 1997).[11] New York's "multi-barrier," management practices aim to "reduce or eliminate pollutants at the source, control the transport of pollutants across the landscape and protect the stream corridor," while their "multi-tiered" modeling addresses terrestrial and aquatic systems to develop predictive loading models to address water quality concerns (EPA, 2000). These watershed management efforts and subsequent FAD allowed NYC to avoid construction of a $6 billion water filtration facility that would have been necessary to ensure the system's nearly 9 million users received water that met SDWA standards (Messina, 1994-1995).

Although more the exception then the norm, watershed conservation has been demonstrated to be a cost-effective approach to drinking water quality protection, and cities are increasingly looking upstream to assess watershed scale protection efforts (Cannon, 2008). Resource management agencies increasingly perceive implementation of conservation programs as being "crucial for restoring and protecting waters and watersheds" and are targeting funding to meet these ends (Arabi, 2007). Communities continue to lead the charge in water-supply sensitive smart growth innovation. For example, the Town of Bedford, New York, has authorized cluster development to preserve surface and groundwater supply areas, and New York's Freshwater Wetland Act empowers municipalities throughout the state to adopt broad wetland protection legislation (Nolon, 2000). Coordination of state and local laws that are protective of water quality and quantity will become increasingly important to ensuring drinking water security as populations grow and development pressures increase. While source water protection is not a panacea to water quality challenges, a patchwork of national, state, and local regulations and funding programs directly and indirectly incentivize watershed conservation for drinking water quality protection, thus recognizing the connection between aquatic ecosystem health and water quality. Case studies of water supply systems throughout the U.S. support the proposition that as quality and quantity pressures continue to grow, communities and water suppliers will need to work together to ensure drinking water needs are met.

## 5. Solutions to Drinking Water Concerns: BMPs and Recommendations

Despite federal protection efforts, drinking water supplies are stressed to varying degrees throughout the United States. These stressors can be attributed to water quality and quantity limitations, as well as infrastructure pressures, all of which can be linked to population growth, climate change, water extraction and land use trends (NRDC, 2010). Water quality impairments are often correlated to surrounding land uses, while water quantity sustainability is linked to regional availability, which is projected to be increasingly impacted by climate fluctuations. Although international

[11] This plan included (1) comprehensive water quality inventory, surveillance and monitoring planning; (2) new watershed regulation promulgation; (3) stakeholder outreach programs; (4) reservoir coliform remediation and spill protection; (5) sewage treatment facility upgrades; (6) septic systems reviews, inspections, and remediation actions; (7) enhanced water quality regulation enforcement; (8) expanded land acquisition efforts; (9) stream corridor protection; and (10) natural resources management considerations (EPA, 1997).

and national efforts to curb greenhouse gas emissions to mitigate climatic irregularities are certainly desirable, bottom-up local and regional solutions to reduce demand and protect water supplies are available now. As populations expand and weather patterns and temperatures become more erratic, supplying adequate quantities of high quality drinking water will be a growing sustainable development challenge.

## 5.1 Watershed Level Best Management Practices and Tools – Protecting Supply

Watershed level management is already espoused by the Environmental Protection Agency and funding is available to support coordinated planning and protection efforts (EPA Watershed Approach, 2011; EPA Watershed Academy, 2011). As the much-studied watershed management and filtration avoidance of the New York City water system exemplifies, the tangible economic benefits of improved water quality can incentivize source protection, but partnerships with local communities and system-wide watershed stewardship approaches are critical. There, downstream users fund upstream watershed protection efforts to ensure supply needs are met. The New York City approach to valuing ecosystem services and implementing cooperative resource stewardship planning is a testament to both the quantitative and qualitative values of watershed scale management. By building watershed considerations such as flow patterns and water budgets into regional development and land use planning efforts, upstream and downstream communities can benefit from expanded source water protection efforts. Both water quantity and quality planning considerations can guide land use decisions to ensure "low impact development." Using drainage maps, modeling, and watershed plans, municipal land use regulations can ensure that development incorporates strategies to safeguard water quality, protect soils and conserve biodiversity (Benoit, 2007). Watershed planning is a crucial, scalable tool that can help communities address aquatic system impairments (Iles, 2003; EPA Watershed Academy, 2011; Watzin et al., 2007).

Although national, state, and regional programs exist to regulate water quality, local land use and building codes are flexible tools for community development that can incorporate protective water and environmental management decisions. Growing bodies of literature advocate an "integrated water resource management" at the basin scale (Mitchell, 2005). The World Water Council recommends system-wide improvements in water extraction, delivery and use infrastructure as well as significant changes to water and ecosystem valuation (Cosgrove, 2000). Development policies are increasingly targeting needs of municipalities and watershed catchments.[12] Case studies suggest that local governments are already implementing scalable interventions to support sustainable aquatic system stewardship through resource inventories, goal-setting and performance benchmarks that consider environmental, social, and economic

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[12] EPA's System for Urban Stormwater Treatment and Analysis Integration Model (SUSTAIN) offers an ArcGIS platform to perform hydrologic and water quality modeling in watersheds, including land use and BMP simulation modules, to facilitate watershed planning and help identify management solutions at multiple scales.

criteria.[13] Developers and the community at large can achieve valuable benefits from watershed planning and best management practices (BMPs). For example, current BMPs of watershed development site design can involve aesthetically appealing surface water protection features and open space, reduce costs of water conveyance systems and flood risks, and facilitate achievement of National Pollutant Discharge Elimination System (NPDES) Stormwater Phase II and Total Maximum Daily Load permits.

Development BMPs that localities can mandate to support lower impact development include using bioengineering elements to reduce volume and slow velocity of water within drainage ways, preserving natural contours and avoiding extensive regrading at development sites, using natural drainage areas to site rain gardens, developing stormwater capture systems capable of reusing stormwater, and minimizing erosion and high velocity stormwater runoff (Benoit, 2007). To reduce development impacts in watershed areas, zoning and building codes can also require less than 10% effective impervious cover, encourage high density growth in areas that are already developed and offer conservation incentives in undeveloped or less developed upper watershed areas. These tools have been shown to be effective in improving water quality by reducing runoff volume, peak flow rates, and duration (Benoit, 2007). This is achieved by promoting aquifer recharge, infiltration, and evapotranspiration (Jaffe et al., 2010). Many of these interventions have already been incorporated into development codes to incentivize higher density lower impact construction around the nation. For example, the City of Seattle's Green Factor program requires 30% parcel vegetation in business and multifamily residential districts (EPA GICS, 2010; City of Seattle, 2010). The Seattle Department of Planning and Development reports that the Green Factor program improves air quality, creates habitat, and mitigates urban heat island effects, as well as reducing stormwater runoff, protecting receiving waters from pollution, and decreasing public infrastructure costs (City of Seattle, 2011).

In addition to local development regulations, overlay zoning, planned unit development, low impact transportation design, and collaborative conservation planning efforts can support sustainable terrestrial and aquatic resource uses, yielding ecological, social, and economic benefits (AWARE Colorado, 2007). Planned growth can be more sustainable growth, and numerous tools are available at the local, regional, and state levels to support proactive planning that incorporates watershed stewardship in order to protect drinking water supplies (EPA Watershed Handbook, 2008). Precautionary resource stewardship and community partnerships are critical to preserving, improving, and safeguarding invaluable drinking water supplies.

## 5.2 Recommendations for National Incentives for Watershed Protection and Water Security Planning

Watershed protection is a fundamental step in a multiple-barrier approach to protecting drinking water (Ernst et al., 2004). As World Bank environmental

[13] For example, the American Society of Landscape Architects' Sustainability Toolkit includes social, economic, and environmental sustainability design and planning models. Available at http://www.asla.org/ContentDetail.aspx?id=26060.

specialist David Cassells warns, "[p]rotecting forests around water catchment areas is no longer a luxury but a necessity. When they are gone, the costs of providing clean and safe drinking water to urban areas will increase dramatically" (Reuters, 2003). This article emphasizes watershed protection because, as established above, the tools to achieve effective source water stewardship are already available at the local level. Watershed management aimed at drinking water supply protection is only one element of NRDC's recommended interventions – their report stresses the need to protect supply, maintain and improve infrastructure, and ensure effective treatment (NRDC, 2003). Certainly, improving infrastructure and ensuring water quality standards and treatment that are human health protective are further steps needed to safeguard drinking water supplies, but these steps must be taken at state and national levels, where it can be more difficult to establish political consensus. Nevertheless, achieving these goals should not be divisive partisan issues.

The economic downturn should not be a justification to avoid much needed water security investments and stewardship programs. Indeed, low-cost interventions such as mandating green infrastructure and water protective development today could avoid higher system overhaul costs in the future (Dunn, 2007). Population growth and urbanization trends make green infrastructure solutions essential. Moreover, such solutions can be affordable interventions to protect and improve water quality (Dunn, 2007). As more case studies develop it will become increasingly clear: widespread action is needed at multiple levels to ensure that surface and groundwater in the United States is wisely used and adequately protected, and that infrastructure is sufficiently maintained and developed to meet the needs of growing populations. Water needs should be assessed to plan for sustainable secure supplies.

Maintaining high quality drinking water is critical for human development (UNDP & UNICEF, 2006). Despite the advancement of regulation and protection efforts at national, state, and local levels, drinking water quality and aquatic ecosystem health remain imperiled to various degrees throughout the United States. While drinking water quality and watershed protection legislation in the U.S. is not unsubstantial, clearly much more needs to be done to ensure sufficient safe drinking water for people while maintaining healthy ecosystems. The New York Times' *Toxic Waters* series asserts that Congress should expand the protections of the Clean Water Act, give state agencies more resources, and hold the EPA and states accountable for their failures, acknowledging that "some say changes will not occur without public outrage" (Duhigg, 2009). While increased top-down regulation of water discharges may anger some, increasing understanding about short-term and long-term human health impacts of declining water quality should be sufficient to provoke public support of enhanced drinking water protection. Already, Americans are more concerned about drinking water pollution than any other environmental issue (Gallup, 2009). If the history of environmental regulation is any indication, public outrage may be necessary to move Congress to national action. In the meantime, forward thinking communities can continue to work to strengthen state water quality standards and develop local land use laws that plan for water security and are protective of human and environmental health.

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