KEEPING IT CLEAN: A COMPARISON OF STATE-LEVEL GROUNDWATER QUALITY PROTECTION PROGRAMS

A Thesis

by

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ABSTRACT

Rather than assess the efficacy of a specific groundwater quality program, this research explored what it means to protect groundwater quality at the state level. Specifically, it examined how groundwater quality protection as a broader goal was translated into actions and management at the state level, and how those actions and management approaches were carried out. The management approaches and programs in three different states in the U.S. were explored in detail, and then compared. The comparison was not performed in order to rank programs, merely to discern what efforts are being taken in the U.S. today.

The states selected were Wisconsin, Arizona and Florida. The aim in using these three states was to try to find out the average approaches and middle-of-the-road programs being relied on today to protect groundwater quality. These three states were chosen because each had a population with a strong reliance on groundwater as the primary source of drinking water. However, none had such a strong interest that it might have extreme programs.

The research reflected several interesting pieces of information, though it ultimately raised more questions about information sharing and developing programs. Most notable, was the lack of data collected, tracked and analyzed by state agencies. Also, all of the states allocated authority differently among agencies, and also interacted with their respective health departments to varying degrees. Last, that without adopting a precautionary approach, states could take more advantage of opportunities to get ahead

of groundwater contamination problems by educating citizens and working more closely with industries, and imposing more oversight at the beginning of permitting processes for different types of land uses that are known to impact groundwater. These efforts are already successful with the agricultural industry.

DEDICATION

For my husband, Travis, in thanks of his love, support, and saint-like patience.

For my Uncle Lee, who is proud of me.

For Mama Albrecht, who told me this was a good idea.

She was right, per usual.

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INTRODUCTION AND LITERATURE REVIEW OF THE IMPORTANCE OF GROUNDWATER QUALITY MANAGEMENT

Groundwater and Human Health

Nearly 50% of the U.S. population depends on groundwater[1] as a primary drinking water source, and that percentage is growing. (*National Ground-Water Monitoring Network*, 2011; Underground Storage Tanks, 2015). Because of the heavy reliance on groundwater as a source of drinking water, managing the quality of groundwater is critical to protecting human health. There are already numerous instances of groundwater contamination impacting human health. Some examples are nitrates in well water causing Blue Baby Syndrome (Knobeloch, 2000), hexavalent chromium causing a variety of cancers (Esquivel, 2015), and chlorinated organics causing childhood leukemia and perinatal deaths. (Lagakos, 1986; Stewart, 1990). These examples may be extreme, but in reality groundwater quality is suffering nationally with as yet unknown health consequences. Recently, in a nation-wide "survey of about 2,100 private domestic wells, 23% of sampled wells contained one or more contaminants at a concentration greater than a human-health benchmark. These contaminants were most often inorganic chemicals…." (Towne, 2011, at 6; *see* DeSimone, 2009).

[1] For purposes of this thesis, it should be assumed that groundwater refers only to fresh groundwater sources, including with regard to data, unless otherwise specified.

Proactivity and Mitigation

Prior to the twentieth century, groundwater quality was less of a concern because there were fewer contaminants to begin with, because existing contaminants were present at much lower concentrations, and because most contaminants were naturally occurring substances that were removed by natural filtration processes. (De Roos, 2003; Hayes, 2006). Today a much greater number of contaminants, made of both natural and unnatural substances, is introduced to groundwater at rates exceeding natural filtration processes. (De Roos, 2003; Hayes, 2006). This results in volumes, concentrations, and types of contamination that are nearly irreversible. (De Roos, 2003; Hayes, 2006).

The Environmental Protection Agency (EPA) has developed a National Primary Drinking Water Contaminant list that includes microorganisms, disinfection byproducts, disinfectants, radionuclides, and organic and inorganic chemicals that are all associated with a detrimental human health impact. However, monitoring requirements for contaminants are required either by federal or state laws, only after they have been tied to a health crisis or other severe health implication. New items for monitoring are added to the EPA's list, and state lists, as they arise; but, it can takes weeks, months, years or more, for a contamination problem to present itself as a human health issue. (Ashford and Caldart, 2008; Sampat, 2000; Stewart, 1990).

This reactive approach is most often attributed to the resource strain inherent in screening for every potential contaminate, as well the economic impacts that can result from more pro-active approaches. (Ashford, 2007). Regardless of the justifications behind it, this approach is embedded in environmental decision making in the United

States. This means that most potential contaminants are viewed as safe, until they are found to be dangerous. (Ashford, 2007).

Although the reactive approach serves more immediate purposes and is a tool for risk management (Ashford, 2007) it can ultimately lead to tremendous demands being places on a variety of resources, particularly if costly cleanup projects are required to manage or mitigate a contamination problem. (Stewart, 1990). Just assessing the size of a contaminant plume in groundwater can cost hundreds of thousands of dollars. (Stewart, 1990). If a plume boundary is determined with confidence and treatment is pursued, the treatment process is likely to take years to decades to complete and cost millions or billions of dollars. (Greene, 1994; Stewart, 1990). In the end, treatment for contamination may not even be effective. In fact, there are numerous approaches to groundwater remediation, but the efficacy of each is generally unknown.

In many cases, there is simply no way to fully remediate a groundwater source. (Kavanaugh, 2013). For example, the chemical dibromochloropropane was applied as a pesticide to three million acres of land in California's San Joaquin Valley from 1955 to 1979. (Stewart, 1990). Fifteen years after the cessation of its use as a pesticide, dibromochloropropane continued to migrate, ultimately contaminating 20 million acre-feet of groundwater. (Stewart, 1990). Later, dibromochloropropane was connected to a rise in sterility and cancer cases in humans. (Arax, 1995). Because of this, 2,600 consumptive wells were closed due to irreparable dibromochloropropane contamination, and several communities in the San Joaquin Valley had to find new sources of drinking water. (Arax, 1995). Similarly, in Fresno, California, a plume of dibromochloropropane

closed 29 major wells in fast developing areas. (Arax, 1995). In response, the City installed five carbon filtration systems priced at $800,000 each, but the City still faces problems with supplying safe drinking water to residents. (Arax, 1995).

Federal Laws

The Federal Water Pollution Control Act of 1948 was the first federal law to tackle water pollution. Upon amendment in 1972, this law became more commonly known as the Clean Water Act (CWA). (33 U.S.C. §§1251-1387; History of Clean Water Act, 2015). Among other things, the 1972 amendments gave the EPA authority to implement pollution control programs. The CWA was amended again in 1981 and 1987, both times amendments requiring advancements for water treatment facilities were included. Additionally, the achievements of the CWA have been augmented by the enactment of various state laws that require the EPA's involvement in setting quality criteria for pollutants. (History of Clean Water Act, 2015).

Section 1252 of the CWA addresses groundwater protection specifically, and obligates federal, state and local cooperation in the development of comprehensive programs to improve and preserve the quality of groundwater.[2] Previously, the EPA promoted the development of Comprehensive State Ground Water Protection Programs (CSGWPPs), which were plans that allowed states to tailor their goals and priorities to the unique groundwater quality needs of their states. (National Water Quality Inventory, 1998). Importantly, one of the intentions behind CSGWPPs is for the EPA to pass on

[2] 33 U.S.C. § 1252. "The administer shall . . . prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground water and improving the sanitary condition of surface and underground waters."

authority to manage quality issues and flexibility in the management approach to state governments. (National Water Quality Inventory, 1998). Wisconsin and Florida were among some of the first states to develop a CSGWPP. (National Water Quality Inventory, 1998). Though the EPA continues to work with states today to develop CSGWPP, most states make these efforts on their own without the EPA's involvement.

The Safe Drinking Water Act (SDWA) was passed by Congress in 1974, and was twice amended in 1986 and 1996. Because 50% of the United States relies on groundwater a primary source of drinking water, the SDWA plays a critical role in preserving a safe relationship between human health and groundwater and as a drinking water source. (Pesticides in Groundwater, 2015). The SDWA authorizes the EPA to take measures that keep water safe for human consumption, specifically by protecting source water.[3] (42 U.S.C. § 300g; National Water Quality Inventory, 1998). The EPA draws authority over groundwater resources from the SDWA, and uses it to ensure the quality of base flows and aquifer sources. (National Water Quality Inventory, 1998). Such protection is achieved through the following four primary programs, though other efforts are taken as well: the Wellhead Protection Program, the Sole Source Aquifer Program, the Underground Injection Control Program, and the Source Water Assessment Program. (National Water Quality Inventory, 1998).

The 1996 SDWA amendments include Section 1429, which obligates the EPA to review the State of groundwater and groundwater quality protection programs across the country. However, over time Section 1429 requirements seem to have been subsumed

[3] Notably, the SDWA only applies to public systems.

into the National Water Quality Inventory Report to Congress. This report is produced in varying formats and level of detail, and with changing focus: it most often gives attention to current problems and emerging issues, as opposed to addressing trends in groundwater quality protection. (*Safe Drinking Water Act Amendments of 1996*, 2012; *National Water Quality Inventory Report to Congress*, 2013). The most recent Inventory Report available is from 2004. The most recent version that addresses groundwater quality is from 1998.

State Legislation and Programs

State-level management of groundwater quality is important for two key reasons. First, though some federal laws and regulations impact how groundwater quality is managed, most of the day-to-day responsibilities fall to state agencies. For example, the SDWA regulates wellhead protection programs for consumptive wells. The SDWA also requires permits and adherence to certain standards for underground injection wells, and additionally, spurred additional federal regulations for underground injection wells.[4] Yet, most states administer the wellhead protection and underground injection well programs. (Getches, 2009).

States are also authorized to enact legislation that is stricter than federal legislation, and may promulgate additional protections, regulations, and management programs. (National Water Quality Inventory, 1998). Most states do. (National Water Quality Inventory, 1998). Though some states have enacted relatively comprehensive groundwater quality protection laws and programs (Getches, 2009), each set of laws,

[4] 33 U.S.C. §§1251-1387.

regulations, policies and programs vary as to numeric standards, agency integration, and programmatic or technological approaches. (Stewart, 1990). These variations are largely reflective of challenges and problems unique to each state such as land use, geological formation or the rate at which water moves within major aquifers.

Second, the SDWA only applies to aquifers used as sources of drinking water.[5] As a result, the groundwater in any aquifers not currently used to provide drinking water is not covered by SDWA and is completely unprotected. This means that numerous aquifers around the country are at risk for contamination, or are already contaminated. State-level groundwater quality protection legislation, and state-level programs that surpass SDWA requirements, are important in filling this void and providing increased protection to more aquifers.

Land Use Practices

The term "land use practices" references how humans manage and modify land for different purposes. Research suggests that land use practices have a direct impact on groundwater quality, most often through use-related modifications creating incidental pathways for contaminants and pollutants to access groundwater. (Sampat, 2000). Related, many common land uses have associated contaminants. (Sampat, 2000). Some of the most commonplace land uses in the United States are municipal landfills, crop farming and underground storage tanks.

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[5] An aquifer may not be used as a drinking water source for many reasons such as salinity levels, production costs, or already existing adequate drinking water sources.

Municipal Landfills and DEET

Studies show the clays and linings typically used for landfills will eventually breach. (Christenson, 2003). In many cases, linings will breach long after a landfill is closed and well after the post-closure monitoring period is over. (Christenson, 2003). Many landfills in the United States are already at an age where they have already begun to breach and release chemicals and materials such as metals, volatile organic compounds, semi-volatile organic compounds, inorganic compounds, nitrates, radionuclides, and pathogens into groundwater. (Christenson, 2003; Cooper, 1973). Because of this, state agencies "consistently cite landfills as a high-priority source of ground water contamination." (Christenson, 2003). However, officials have not prioritized landfill conditions and stringent rules regarding the placement of landfills and the constructions of landfills are absent in many states. (Christenson, 2003; Ground Water Quality, 2000; Ground Water Quality 2002).

N,N-diethyltoluamide (DEET) is an inorganic chemical commonly used in insect repellents, and is contained in over 225 commercially-available products. (DEET Chemical Summary, 2007). DEET is commonly found in landfills around the country, and is increasingly found in groundwater supplies. (Dougherty, 2010; Martinet, 2005; Masoner, 2014; Crabbe, 2005). A 2011 study of 19 active landfills concluded that DEET was found in significant concentrations in 95% of the samples. (Masoner, 2014; Technical Announcement, 2014). Prior to that, the EPA found DEET in 75% of streams tested; all of the streams tested were connected to aquifers. (DEET Chemical Summary, 2007).

Health effects resulting from the toxicity of DEET range from skin irritations to impaired cognitive function, depending on the concentration and length of exposure. (DEET, Pesticide Information Profile, 1997; Health Effects in Humans, 2004). A study carried out by the Pesticide Information Project of Cooperative Extension Offices targeted Everglades National Park Employees because of their repeated and extensive exposure to DEET. The study concluded that employees "having extensive DEET exposure were more likely to have insomnia, mood disturbances and impaired cognitive function than were lesser exposed co-workers." (Risk Characterization, 2000). Other adverse health effects include neurological impacts such as seizures, encephalopathy, tremor, slurred speech, coma, and death following ingestion or application to the skin not consistent with label warnings and directions. (DEET Chemical Summary, 2007).

Many personal care products and pharmaceutical products are being detected in relatively low levels in surface water across the country. Although found at low levels, the impact to the environment and to human health are beginning to show. (Fallik, 2013). As a result, increased attention is now being given to this issue; particularly concerning products are called "emerging contaminants." (Contaminants of Emerging Concern Including Pharmaceuticals and Personal Care Products, 2015). Interestingly, studies of emerging contaminants are conducted in surface waters or at wastewater treatment facilities because the highest concentrations of emerging contaminants are found there. (Fallik, 2013; *see* Contaminants of Emerging Concern Including Pharmaceuticals and Personal Care Products, 2015). Because of its increased presence

in water sources and the impact it has on human health, DEET is now an emerging contaminant of concern. (Masoner, 2014).

Farming Practices and Atrazine

Farms occupy 930 million acres of the United States and apply more than 750 million pounds of pesticides annually. (Ruhl, 2000). Those pesticides (which include insecticides, herbicides, and fungicides), can all access groundwater sources used for consumption. (Ruhl, 2000). In fact, nationwide, pesticides from every major chemical class have been found in groundwater sources. (Ruhl, 2000). Despite the prevalence of pesticide contamination, crop farming practices are not well regulated, though individual states are beginning to implement more restrictions and regulations on the use of pesticides in order to prevent further contamination. (Ruhl, 2000).

The primary channels of pesticide to groundwater are spills, misuse during handling or storage, runoff to surface waters connected to aquifers, and direct infiltration through soils and through drainage controls. (Ruhl, 2000). Pesticide infiltration is more severe when crops are flood irrigated or sprayed prior to intense rainfall (though the latter is better avoided today due to improved education about pesticide use and application benefits). (Ruhl, 2000).

States consistently report that farming practices are a major source of groundwater contamination. In fact, a 2009 investigation by the *New York Times* found that "in some towns, atrazine concentrations in drinking water have spiked, sometimes for longer than a month. But the reports produced by local water systems for residents often fail to reflect those higher concentrations." (Duhigg, 2009). A number of states

have begun developing and implementing pesticide management plans that seek to improve pesticide application and groundwater monitoring.

Atrazine is one of the most widely used herbicides in the United States, second only to glyphosate. (Aviv, 2014; Ruhl, 2000). As of 2001, Atrazine is also the most commonly detected pesticide in drinking supplies in the United States, and is most often found in groundwater drinking supplies. (Gillom, 2007; Sass, 2006). Atrazine generally enters groundwater by migrating from soils. (Atrazine, 2007). Once in groundwater, it is slow to degrade; it also produces deethylatrazine as a degradate. (Atrazine, 2007).

The EPA continuously conducts evaluations on Atrazine (Atrazine Registration, 2013; EPA Begins New Scientific Evaluation of Atrazine, 2009; Triazine Cumulative Risk Assessment, 2006), but has concluded several times that human harm is unlikely. (Atrazine Registration, 2013). However, independent studies indicate there are both immediate and future human health implications. One study found that Atrazine can disrupt the endocrine system, and also noted that there were documented health implications for other mammals, amphibians, fish and insects. (Ground Water Quality, 2000; Ground Water Quality, 2002). Another study suggested a link between low sperm quality in men exposed to Atrazine. (Ackerman, 2007). In 2009 new research indicated that Atrazine was a potential cause of birth defects, low birth weights and menstrual problems when consumed at concentrations *below* federal standards. (Duhigg, 2009) (Emphasis added). Finally, in 2011 the National Cancer Institute conducted a study that explored cancer rates among 57,310 licensed pesticide applicators over a span of 13 years. (Bearne, 2011). The National Cancer Institute ultimately concluded "there was

no consistent evidence of an association between Atrazine use and any cancer site." (Bearne, 2011). However, other studies indicate that animals exposed to Atrazine before birth may be more vulnerable to cancer later in life. (EPA Begins New Scientific Evaluation of Atrazine, 2009; Triazine Cumulative Risk Assessment, 2006).

Underground Storage Tanks and Benzene

Some of the most extensive groundwater contamination is the result of leaking underground storage tanks (USTs) and other subsurface impoundments. (Saracine, 2002). USTs hold a variety of materials from metals to industrial byproducts, but are most commonly used to hold petroleum products: millions of gallons of petroleum products are kept in USTs across the country. (Sampat 2000). The EPA estimates that 569,000 USTs in the United States contain petroleum or other hazardous substances. (Underground Storage Tanks, 2015).

USTs generally develop leaks from faulty installation or poor maintenance. (Sampat, 2000). They are not often replaced or maintained because doing so is costly, requiring excavation and significant labor. (Sampat, 2000). Tanks currently in use are often several decades old, rusted and leaking a "steady trickle of chemicals into the ground," such as benzene. (Towne, 2011). In the United States, roughly 100,000 USTs are leaking. (Towne, 2011; Sampat 2000; Uzochukwu, 2009). In particular, Leaking Underground Storage Tanks (LUSTs), containing fuel products are the starting point for chemicals such as such as benzene, toluene, and gasoline additives like methyl tert-butyl

ether to reach groundwater.[6] (A very short history of MTBE in the U.S., 2014; Sampat, 2000; U.S. Geol. Survey, 1995; *What is an MTBE?, 2014;*). Moreover, products such as fuels and solvents contain synthetic chemicals that are not removed by natural filtration processes. (Sampat 2000).

The primary source of Benzene leaking into soil and groundwater is from USTs containing petroleum products. (Saracine, 2002). Benzene has already been established as a problematic contaminant. It has several known health implications including increased risk of cancers (in particular several types of acute phase leukemia), as well as aplastic anemia and bone marrow abnormalities. (Kasper, 2004; Smith, 2010; Huff, 2007). In addition, Benzene causes severe damage to the liver, kidney, lung, heart and brain, and can cause DNA and chromosomal damage. (Rana, 2005). Benzene also has serious consequence for reproductive health: exposure to Benzene has caused irregular menstruation cycles and decreased ovary size in women, while men experience an abnormal amount of chromosomes in sperm, which impacts male fertility and fetal development. (Rana, 2005). Additionally, benzene has been directly linked to neural birth defects like spina bifida and anencephaly. (Kasper, 2004; Smith, 2010; Huff, 2007). The American Petroleum Institute has stated, "it is generally considered that the only absolutely safe concentration for benzene is zero." (*Toxilogical Review, Benzene*, 1948).

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[6] The health impacts of MTBE combined with the fact that it is water soluable make MTBE a serious concern in groundwater quality management; however it has already been largely phased out of use across the county. Additionally, the decline in use of MTBE is largely because of its impact to air quality and federal requirements under the Clean Air Act. At least 25 states have banned MTBE as an additive.

Contaminant Interaction and Byproducts

As more chemicals and substances contaminate groundwater resources, greater consideration needs to be paid to the potential consequences of the effects of interaction and byproducts. A 1999 study demonstrated that common concentrations of Aldicarb, Atrazine, and Nitrate interacted in groundwater, forming new compounds and byproducts that negatively impacted human health. (Porter, 1999). The effects included poor immunity, disruptions to the endocrine and neurological systems, learning disabilities and increased aggression, and were most notable in children. (Porter, 1999). More recently, studies have shown that men exposed to Atrazine in combination with other pesticides are more likely to suffer non-Hodgkin's lymphoma. (De Roos, 2003; Hayes, 2006).

The problem of compound interactions is complicated by the more recent development of highly complex chemicals. In recent decades chemical companies have produced hundreds of highly toxic chemicals considered to be less ecologically damaging because they have short half-lives in soils: however, the half-life of a contaminant can be completely different in water than it is in soil. (De Roos, 2003; Hayes, 2006). For example, the herbicide Alachlor has a half-life of 20 days in soil, but nearly four years in groundwater. (De Roos, 2003; Hayes, 2006).

There are relatively few ground water quality standards at either the state or federal level for the byproduct compounds of common contaminants or their degradates. (Sampat, 2000), though more states are beginning to consider interactions as a serious problem. Though the EPA has started to develop a risk assessment for chemical

interactions and compound products under its cumulative risk assessment policy, it continues to focus primarily on chemical pollutants in isolation, and to encourage case-by-case state-level assessments of interactions in groundwater through grants. (Cumulative Risk Webinar Series, 2014).

RESEARCH QUESTIONS AND METHODOLOGY

Analytical Approach

This thesis is an exploratory analysis of how states with a high reliance on groundwater as a primary drinking water source are engaged in the management and protection of groundwater quality. Related research often assesses the efficacy of a specific groundwater quality protection program. This research does not. Program efficacy can be influenced by aquifer characteristics, flow paths, climate, and other unique and site-specific environmental conditions. Because of these variables, it would be difficult and unfair to draw comparisons among different states. Moreover, no effort is made here to rank or evaluate state programs, regulations, laws or policies.

Rather, this research seeks a deeper understanding of how state agencies function to keep groundwater clean and safe. Additionally, a greater understanding of how states measure success, failure, track data, and work cooperatively between agencies is sought.

Research Questions and Expectations

The questions motivating this research are twofold. First, how is groundwater quality protection as a broader goal translated into actions and management at the state level; and second, how are those actions and management approaches carried out. Although this research is exploratory, there are some expectations regarding the findings.

First, that any groundwater quality protection program is the result of a catastrophe or controversy, either at the state or national level. A state-level problem is

anticipated to be the trigger, however, a national issue that led to or influenced federal environmental legislation that is implemented or administered by the states, may also be the cause. The relationship between a major event and rules and regulations pertaining to groundwater quality is expected because it is the same relationship that exists for many environmental rules and regulations. For example, the Endangered Species Act is the result of concern over the rapid decline of many species of animals.

Second, that given the extent to which Americans rely on groundwater for drinking water, groundwater will be subject to drinking water standards and will not be subject to separate quality standards. Although this is the expectation, there is also hope that some additional standards may be developed at the state-level to address more localized quality problems within the state. Third, that because so many Americans rely on groundwater sources for drinking water, there should be ample information publicly available to demonstrate what efforts are made to protect it, and the resources that the managing agencies have to carry out these efforts.

Fourth, that of the three land use practices reviewed in this research (solid waste landfills, farming practices, and USTs), farming practices will receive the most regulatory attention. This is expected because it is easier to be pro-active in preventing the over-use or misuse of pesticides, than it is to discover and rectify problems and landfill and UST sites after they have been installed. This is because so much information can be collected and reviewed before a pesticide is even used, and because even after a pesticide is used, it is easier to identify the problem and use the information

collected to resolve it. Conversely, it is much more difficult to identify and remedy a problem at a landfill or UST site once the landfill or UST has been installed.

Scoping

Because many states administer federal programs, as well as their own programs, it is easiest to develop a comprehensive picture of state-level efforts by reviewing state programs and supporting data. As well, it is easiest to garner a deep understanding of program intricacies by asking questions of state agency staff, since they are the individuals actively managing groundwater protection programs. Also, many state agencies make state-specific research, reports, and data available to the public. Federal reports and data, such as those developed by the United States Geological Survey (USGS), are often less state-specific, or produce state-specific studies covering periods of time too narrow to be useful for this particular research. Choosing states to review required several considerations, though ultimately three states were chosen.

In 2010, 21% of water withdrawals for consumptive purposes, came from groundwater. (Maupin, 2010). Nearly all groundwater withdrawals were from freshwater sources. (Maupin, 2010). Although groundwater withdrawals account for only one-fifth of all water withdrawals, roughly 50% of the country's population relies on groundwater as a primary drinking source. (*National Ground-Water Monitoring Network*, 2011; Underground Storage Tanks, 2015). This percentage is expected to increase in the years ahead. Because of this, the first element considered was what percentage of groundwater withdrawals are used for consumptive purposes.

Drinking water (public and private combined) is the primary consideration when looking at consumption. The data used for this first step comes from the 2010 United States Geological Survey report on Estimated Uses of Water.[7] Using this data, states were assessed for two things: where they ranked centrally among all states for percentage of groundwater allocated for drinking supplies, and where they ranked in the top half of all states for volume (Mg/d) of groundwater allocated for drinking water. (See Appendices A-C). These two selection methods were chosen in an effort to ensure that the states reviewed were not likely to take extreme actions in their groundwater quality programs as a result of either an intense surplus or dearth of groundwater supplies, but that there was a degree of reliance on groundwater for drinking supplies sufficient enough to make the states relevant to this research.[8] The results of these considerations are listed below, by state:

Alabama: Only 5% of Alabama's water needs are met by groundwater. It ranks thirteenth for percentage of groundwater allocated for drinking water purposes at 64.37%. It ranks twenty-third for volume of groundwater allocated to drinking water supplies at 321.1 Mg/d. (Maupin, 2010).

Alaska: Some 55% of Alaska's water needs are met by groundwater. It ranks forty-fifth for percentage of groundwater allocated for drinking water purposes at 8.64%. It ranks

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[7] Maupin, Molly, et al., *Estimated Use of Water in the United States in 2010*, United States Geol. Survey (2010), *available at* http://pubs.usgs.gov/circ/1405/pdf/circ1405.pdf.

[8] Neither the total volume of groundwater withdrawals, nor the total volume of groundwater withdrawals for consumptive purposes were considered because the physical size of the state and population size can largely affect total volumes and skew the comparison.

forty-seventh for volume of groundwater allocated to drinking water supplies at 43.02 Mg/d. (Maupin, 2010).

Arizona: Some 42% of Arizona's water needs are met by groundwater. It ranks thirty-sixth for percentage of groundwater allocated for drinking water purposes at 24.01%. It ranks fifth for volume of groundwater allocated to drinking water supplies at 612 Mg/d. (Maupin, 2010).

Arkansas: Significantly, 69% of Arkansas' water needs are met by groundwater. Interestingly, it ranks fiftieth for percentage of groundwater allocated for drinking water purposes at 1.89%. However, it ranks thirty-sixth for volume of groundwater allocated to drinking water supplies at 612 Mg/d. (Maupin, 2010).

California: A substantial 60% of California's water needs are met by groundwater. It ranks thirty-fifth for percentage of groundwater allocated for drinking water purposes at 24.16%. However, it ranks first for volume of groundwater allocated to drinking water supplies at 2952 Mg/d. (Maupin, 2010).

Colorado: Just 14% of Colorado's water needs are met by groundwater. It ranks forty-fourth for percentage of groundwater allocated for drinking water purposes at 10.9%. However, it ranks thirty-seventh for volume of groundwater allocated to drinking water supplies at 154 Mg/d. (Maupin, 2010).

Connecticut: Just 26% of Connecticut's water needs are met by groundwater. However, it ranks first for percentage of groundwater allocated for drinking water purposes at 92.78%. It ranks thirtieth for volume of groundwater allocated to drinking water supplies at 200.88 Mg/d. (Maupin, 2010).

Delaware: Some 52% of Delaware's water needs are met by groundwater. It ranks twenty-seventh for percentage of groundwater allocated for drinking water purposes at 38.21%. It ranks forty-sixth for volume of groundwater allocated to drinking water supplies at 59.28 Mg/d. (Maupin, 2010).

District of Columbia: Some 50% of D.C.'s water needs are met by groundwater. However, it ranks fifty-first for both percentage of groundwater allocated for drinking water purposes at 0% and volume of groundwater allocated to drinking water supplies at 0 Mg/d. D.C. withdraws only 0.11 Mg/d from surface and ground water combined and uses the groundwater portion (0.5 Mg/d) for irrigation. (Maupin, 2010).

Florida: A sound 64% of Florida's water needs are met by groundwater. It ranks twentieth for percentage of groundwater allocated for drinking water purposes at 56.02%. It ranks second for volume of groundwater allocated to drinking water supplies at 2223.2 Mg/d. (Maupin, 2010).

Georgia: Just 28% of Florida's water needs are met by groundwater. It ranks thirty-first for percentage of groundwater allocated for drinking water purposes at 29.11%. It ranks eighteenth for volume of groundwater allocated to drinking water supplies at 356.7 Mg/d. (Maupin, 2010).

Hawaii: Some 63% of Hawaii's water needs are met by groundwater. It ranks sixteenth for percentage of groundwater allocated for drinking water purposes at 61.43%. It ranks twenty-sixth for volume of groundwater allocated to drinking water supplies at 258.03 Mg/d. (Maupin, 2010).

Idaho: Just 25% of Hawaii's water needs are met by groundwater. It ranks forty-seventh for percentage of groundwater allocated for drinking water purposes at 6.85%. It ranks twenty-fourth for volume of groundwater allocated to drinking water supplies at 297.5 Mg/d. (Maupin, 2010).

Illinois: Only 8% of Illinois' water needs are met by groundwater. It ranks twenty-first for percentage of groundwater allocated for drinking water purposes at 53.86%. It ranks tenth for volume of groundwater allocated to drinking water supplies at 460.62 Mg/d. (Maupin, 2010).

Indiana: Like Illinois, only 8% of Indiana's water needs are met by groundwater. It ranks twenty-first for percentage of groundwater allocated for drinking water purposes at 66.25%. It ranks eighth for volume of groundwater allocated to drinking water supplies at 482.4 Mg/d. (Maupin, 2010).

Iowa: Some 21% of Iowa's water needs are met by groundwater. It ranks twenty-fifth for percentage of groundwater allocated for drinking water purposes at 45.58%. It ranks thirty-ninth for volume of groundwater allocated to drinking water supplies at 91.54 Mg/d. (Maupin, 2010).

Kansas: A substantial 80% of Kansas' water needs are met by groundwater. It ranks forty-ninth for percentage of groundwater allocated for drinking water purposes at 5.47%. It ranks thirty-fifth for volume of groundwater allocated to drinking water supplies at 160 Mg/d. (Maupin, 2010).

Kentucky: Only 5% of Kentucky's water needs are met by groundwater. It ranks forty-ninth for percentage of groundwater allocated for drinking water purposes at 5.47%. It

ranks thirty-ninth for volume of groundwater allocated to drinking water supplies at 160 Mg/d. (Maupin, 2010).

Louisiana: Just 18% of Louisiana's water needs are met by groundwater. It ranks thirty-second for percentage of groundwater allocated for drinking water purposes at 27.07%. It ranks fourteenth for volume of groundwater allocated to drinking water supplies at 423.9 Mg/d. (Maupin, 2010).

Maine: Only 24% of Maine's water needs are met by groundwater. It ranks eighteenth for percentage of groundwater allocated for drinking water purposes at 61.07%. It ranks forty-fourth for volume of groundwater allocated to drinking water supplies at 60.63 Mg/d. (Maupin, 2010).

Maryland: Just 18% of Maryland's water needs are met by groundwater. It ranks seventh for percentage of groundwater allocated for drinking water purposes at 67.23%. It ranks thirty-second for volume of groundwater allocated to drinking water supplies at 174.2 Mg/d. (Maupin, 2010).

Massachusetts: Some 34% of Massachusetts' water needs are met by groundwater. It ranks fourteenth for percentage of groundwater allocated for drinking water purposes at 63.41%. It ranks twenty-ninth for volume of groundwater allocated to drinking water supplies at 227.43 Mg/d. (Maupin, 2010).

Michigan: Only 6% of Michigan's water needs are met by groundwater. It ranks fifteenth for percentage of groundwater allocated for drinking water purposes at 62.77%. It ranks twelfth for volume of groundwater allocated to drinking water supplies at 429.66 Mg/d. (Maupin, 2010).

Minnesota: Just 19% of Minnesota's water needs are met by groundwater. It ranks nineteenth for percentage of groundwater allocated for drinking water purposes at 58.7%. It ranks eleventh for volume of groundwater allocated to drinking water supplies at 434.24 Mg/d. (Maupin, 2010).

Mississippi: Some 68% of Mississippi's water needs are met by groundwater. It ranks fortieth for percentage of groundwater allocated for drinking water purposes at 15.08%. It ranks sixteenth for volume of groundwater allocated to drinking water supplies at 391.5 Mg/d. (Maupin, 2010).

Missouri: A sound 21% of Missouri's water needs are met by groundwater. It ranks thirty-ninth for percentage of groundwater allocated for drinking water purposes at 19.6%. It ranks twenty-first for volume of groundwater allocated to drinking water supplies at 343.9 Mg/d. (Maupin, 2010).

Montana: Only 4% of Montana's water needs are met by groundwater. It ranks thirtieth for percentage of groundwater allocated for drinking water purposes at 32.39%. It ranks fortieth for volume of groundwater allocated to drinking water supplies at 85.76 Mg/d. (Maupin, 2010).

Nebraska: Some 59% of Nebraska's water needs are met by groundwater. It ranks forty-eighth for percentage of groundwater allocated for drinking water purposes at 5.9%. It ranks twenty-fifth for volume of groundwater allocated to drinking water supplies at 282.6 Mg/d. (Maupin, 2010).

Nevada: Some 46% of Nevada's water needs are met by groundwater. It ranks forty-second for percentage of groundwater allocated for drinking water purposes at 13.68%.

It ranks thirty-fourth for volume of groundwater allocated to drinking water supplies at 166.6 Mg/d. (Maupin, 2010).

New Hampshire: Just 24% of New Hampshire's water needs are met by groundwater. It ranks fourth for percentage of groundwater allocated for drinking water purposes at 75.81%. It ranks forty-second for volume of groundwater allocated to drinking water supplies at 68.17 Mg/d. (Maupin, 2010).

New Jersey*:* Only 32% of New Hampshire's water needs are met by groundwater. It ranks third for percentage of groundwater allocated for drinking water purposes at 81.09%. It ranks seventh for volume of groundwater allocated to drinking water supplies at 495.72 Mg/d. (Maupin, 2010).

New Mexico: A sound 50% of New Mexico's water needs are met by groundwater. It ranks forty-first for percentage of groundwater allocated for drinking water purposes at 15.07%. It ranks twenty-seventh for volume of groundwater allocated to drinking water supplies at 235.5 Mg/d. (Maupin, 2010).

New York: Only 12% of New York's water needs are met by groundwater. It ranks second for percentage of groundwater allocated for drinking water purposes at 86.51%. It ranks fourth for volume of groundwater allocated to drinking water supplies at 612.48 Mg/d. (Maupin, 2010).

North Carolina: Just 6% of North Carolina's water needs are met by groundwater. It ranks eleventh for percentage of groundwater allocated for drinking water purposes at 61.24%. It ranks fifteenth for volume of groundwater allocated to drinking water supplies at 423.34 Mg/d. (Maupin, 2010).

North Dakota: Only 12% of North Dakota's water needs are met by groundwater. It ranks thirty-fourth for percentage of groundwater allocated for drinking water purposes at 24.59%. It ranks forty-eighth for volume of groundwater allocated to drinking water supplies at 34.75 Mg/d. (Maupin, 2010).

Ohio: Just 10% of Ohio's water needs are met by groundwater. It ranks twenty-fourth for percentage of groundwater allocated for drinking water purposes at 50.48%. It ranks ninth for volume of groundwater allocated to drinking water supplies at 473.79 Mg/d. (Maupin, 2010).

Oklahoma: Some 36% of Oklahoma's water needs are met by groundwater. It ranks thirty-third for percentage of groundwater allocated for drinking water purposes at 24.69%. It ranks thirty-eighth for volume of groundwater allocated to drinking water supplies at 152.4 Mg/d. (Maupin, 2010).

Oregon: Just 32% of Oklahoma's water needs are met by groundwater. It ranks forty-sixth for percentage of groundwater allocated for drinking water purposes at 8.17%. It ranks thirty-third for volume of groundwater allocated to drinking water supplies at 170.4 Mg/d. (Maupin, 2010).

Pennsylvania: Only 8% of Pennsylvania's water needs are met by groundwater. However, it ranks twelfth for percentage of groundwater allocated for drinking water purposes at 64.99%. It also ranks thirteenth for volume of groundwater allocated to drinking water supplies at 427.05 Mg/d. (Maupin, 2010).

Rhode Island: Just 27% of Rhode Island's water needs are met by groundwater. It ranks tenth for percentage of groundwater allocated for drinking water purposes at

65.26%. However, it ranks fiftieth for volume of groundwater allocated to drinking water supplies at 23.73 Mg/d. (Maupin, 2010).

South Carolina: Only 5% of South Carolina's water needs are met by groundwater. It ranks sixth for percentage of groundwater allocated for drinking water purposes at 67.55%. It ranks twenty-eighth for volume of groundwater allocated to drinking water supplies at 230.52 Mg/d. (Maupin, 2010).

South Dakota: A sound 54% of South Dakota's water needs are met by groundwater. It ranks thirty-seventh for percentage of groundwater allocated for drinking water purposes at 23.5%. It ranks forty-first for volume of groundwater allocated to drinking water supplies at 81.63 Mg/d. (Maupin, 2010).

Tennessee: Only 6% of Tennessee's water needs are met by groundwater. It ranks thirty-seventh for percentage of groundwater allocated for drinking water purposes at 72.28%. It ranks fifth for volume of groundwater allocated to drinking water supplies at 338.4 Mg/d. (Maupin, 2010).

Texas: Some 21% of Texas' water needs are met by groundwater. It ranks thirty-eighth for percentage of groundwater allocated for drinking water purposes at 20.34%. It ranks third for volume of groundwater allocated to drinking water supplies at 1434.3 Mg/d. (Maupin, 2010).

Utah: Some 25% of Utah's water needs are met by groundwater. It ranks twenty-ninth for percentage of groundwater allocated for drinking water purposes at 36.16%. It ranks seventeenth for volume of groundwater allocated to drinking water supplies at 370.8 Mg/d. (Maupin, 2010).

Vermont: Just 10% of Vermont's water needs are met by groundwater. It ranks eighth for percentage of groundwater allocated for drinking water purposes at 66.35%. However, it ranks forty-ninth for volume of groundwater allocated to drinking water supplies at 27.87 Mg/d. (Maupin, 2010).

Virginia: Only 7% of Virginia's water needs are met by groundwater. It ranks eleventh for percentage of groundwater allocated for drinking water purposes at 65.22%. However, it ranks thirty-first for volume of groundwater allocated to drinking water supplies at 194.35 Mg/d. (Maupin, 2010).

Washington: Some 33% of Washington's water needs are met by groundwater. It ranks twenty-second for percentage of groundwater allocated for drinking water purposes at 53.8%. However, it ranks sixth for volume of groundwater allocated to drinking water supplies at 576 Mg/d. (Maupin, 2010).

West Virginia: Only 3% of West Virginia's water needs are met by groundwater. It ranks twenty-eighth for percentage of groundwater allocated for drinking water purposes at 36.5%. However, it ranks forty-third for volume of groundwater allocated to drinking water supplies at 65.34 Mg/d. (Maupin, 2010).

Wisconsin: Just 12% of Wisconsin's water needs are met by groundwater. It ranks twenty-sixth for percentage of groundwater allocated for drinking water purposes at 45.01%. It ranks twenty-first for volume of groundwater allocated to drinking water supplies at 339.3 Mg/d. (Maupin, 2010).

Wyoming: Only 12% of Wyoming's water needs are met by groundwater. It ranks forty-third for percentage of groundwater allocated for drinking water purposes at

10.92%. It ranks forty-fifth for volume of groundwater allocated to drinking water supplies at 60.5 Mg/d. (Maupin, 2010).

After ranking states based on percentage of groundwater allocated for drinking supplies, the center range of 21 states (the ten states lying on either side of the mid-ranking state) states were: Hawaii, North Carolina, Maine, Minnesota, Florida, Illinois, West Virginia, Iowa, Ohio, Kentucky, Wisconsin, Delaware, Washington, Utah, Montana, Georgia, Louisiana, Oklahoma, North Dakota, California and Arizona.

The top half of states ranked based on volume (Mg/d) of groundwater allocated for drinking water were: California, Florida, Texas, New York, Arizona, Washington, New Jersey, Indiana, Ohio, Illinois, Minnesota, Michigan, Pennsylvania, Louisiana, North Carolina, Mississippi, Utah, Georgia, Iowa, Missouri, Wisconsin, Tennessee, Alabama, Idaho, Nebraska and Hawaii.

There were 14 states that fell into both groups were: California, Arizona, Louisiana, Florida, Georgia, Ohio, Iowa, Utah, Hawaii, North Carolina, Wisconsin, Washington, Illinois, and Minnesota.

The next step was to delineate those states that were early initiators in planning for groundwater quality protection by passing legislation.[9] This is an important factor

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[9] *National Water Quality Inventory, 1998 Report to Congress, Ground Water and Drinking Water Chapters*, Envtl. Prot. Agency (Aug. 2000), *available at* http://water.epa.gov/type/drink/protection/upload/2006_08_28_sourcewater_pubs_guide_nwiq98305b_protchap.pdf. In the mid-1990's the EPA launched a program under which it worked with states to develop EPA endorsed Comprehensive Groundwater Protection Programs. *Id.* These programs covered quality, quantity, and planning. *Id.* While these programs are important to the history of groundwater quality protection, the EPA no longer manages this program formally, though it will assist states in developing plans when requested. *Id.* Additionally, most states, with or without state legislation, have programs in place designed to meet federal requirements. *Id.* Those states that had EPA approved programs are likely to have changed or modified these programs over time, but these alterations are more difficult to track than

for requesting programmatic, enforcement action, budgetary and staff data. This step assumes that states that passed groundwater quality specific legislation early on are likely to have long-standing programs, or long histories of groundwater quality protection, and therefore are more likely to have large data sets and more programmatic information available.

The above 14 states were reviewed to determine which had passed significant comprehensive legislation that directly addressed groundwater quality management or that contained provisions directly addressing groundwater quality management beyond management requirements under federal legislation. This query was performed by conducting a broad overview of state-level environmental legislation, reviewing legislative histories, reviewing archived news articles, and in reading recent and current reports pertaining to groundwater management**.** The following was found:

Arizona: Environmental Quality Act of 1986.[10]

California: Follows federal legislation.[11]

Florida: Water Quality Assurance Act of 1983.[12]

Georgia: Follows federal legislation.[13]

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changes to legislation and so have not been used as a criterion for state selection. *Id.* However, it is worth noting that the last tally of states with EPA approved programs or programs submitted for approval, is from the 1998 National Water Quality Inventory Report to Congress. *Id.* In the 1998 report, the following 12 states had EPA endorsed plans: Nevada, Oklahoma, Alabama, Georgia, Wisconsin, Illinois, Delaware, Rhode Island, Connecticut, Vermont, Massachusetts, and New Hampshire. *Id.* Additionally, Washington, Florida, Pennsylvania and Maine were developing programs for EPA approval. *Id; See also Guidelines for Preparation of the Water Quality Assessments and Electronic Updates (1997),* 2013).

[10] Ariz. Rev. Stat. § 49 (1986).

[11] *See* Cal. Water Code § 10750 et seq. (1992); *see also Key Legislation*, CAL. DEP'T OF WATER RES. (Jan. 15, 2015), *available at* http://www.water.ca.gov/groundwater/groundwater_management/legislation.cfm; *see also* Groundwater Management, CAL. DEP'T OF WATER RES. (July 28, 2015), *available at* http://www.water.ca.gov/groundwater/groundwater_management/index.cfm.

[12] Fla. Stat. §§376.30- 376.319 (1983).

Hawaii: Follows federal legislation.[14]

Illinois: Groundwater Protection Act of 1987.[15]

Iowa: Groundwater Protection Act of 1987.[16]

Louisiana: Follows federal legislation.[17]

Minnesota: Groundwater Act of 1989.[18]

North Carolina: Adopted classifications and water quality standards for groundwater in 1979. This adoption was not part of broader legislation.[19]

Ohio: Follows federal legislation.[20]

Utah: Water Quality Act of 1953.[21]

Washington: Water Resources Act of 1971.[22]

Wisconsin: Comprehensive Groundwater Protection Act of 1983.[23]

States that follow federal legislation were disregarded because comparisons between them would be moot. Of the states that passed legislation, most took action in

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[13] *See* Ga. Code Ann. §§ 12-5-70—204 (1964).
[14] *See Safe Drinking Water*, HAWAII DEP'T OF HEALTH (Oct. 15, 2015), *available at* http://health.hawaii.gov/sdwb/.
[15] 415 Ill. Comp. Stat. Ann. 55/1 (1987).
[16] Iowa Code Ann. § 455E (1987).
[17] *See Aquifer Sampling and Assessment Program,* Fiscal Years 2007 – 2009, LOUISIANA DEP'T OF ENVTL. QUALITY (2009), *available at* http://www.deq.louisiana.gov/portal/Portals/0/evaluation/aeps/Triennial%20Summary%20Report%202009.pdf; *see also Drinking Water Protection Program History*, LA. DEP'T OF ENVTL. QUALITY (Nov. 1), *available at* http://www.deq.louisiana.gov/portal/PROGRAMS/DrinkingWaterProtectionProgram/ProgramHistory.aspx.
[18] Minn. Stat. § 103 (2015).
[19] N.C. Gen. Stat. Ann. 15A (1979).
[20] *See Rules, Laws, Policies and Guidance*, OHIO ENTL. PROT. AGENCY (Nov.1, 2015), *available at* http://www.epa.ohio.gov/ddagw/rules.aspx.
[21] Utah Code § 19-5 (1953); *See also* Utah Division of Water Quality, 2008 Salt Lake County Watershed Symposium Presentation, UTAH DIV. OF WATER QUALITY (Oct. 29, 2008), *available at* http://slco.org/watershed/pdf/LALWatershed_Symposi.pdf.
[22] Wash. Rev. Code § 173-200 (1971); Wash. Rev. Code § 90.48 (1971); Wash. Rev. Code § 90.54 (1971); *see also* Water Well Construction Act, Wash. Rev. Code § 18.104 (1971).
[23] Wis. Stat. § 160 (1984).

the 1980's. In an effort to have more comparable data across states, North Carolina, Utah and Washington were not reviewed because their respective legislation isn't close enough in time to other legislation. For example, there would be a 12-year gaps in data and programmatic decisions between the Washington legislation and the 1983 Florida legislation.

The remaining states for review were sorted by geographic location. Many other characteristics can be inherent to location such as climate, topography, geology and ecosystems that could impact how groundwater quality is managed. Because this thesis seeks to understand approaches in groundwater quality management in different states, the states selected were not isolated to a particular region. Arizona and Florida stand out as being very different from each other and from the other four states left.

The remaining four states are Illinois, Iowa, Minnesota and Wisconsin. They all fall within the same mid-western region of the country. Because, based on their proximity to each other, these states were likely to have similarities in their water quality problems, hydrogeological, and climate etc., only one was selected. Wisconsin was picked as the third and final State of comparison based on the year its legislation was passed. Using the year of legislation keeps all legislation reviewed within a three-year span of enactment (Arizona, 1986; Florida, 1983; Wisconsin, 1983). In effect, it gives all states a reasonably similar starting point and may allow for a sounder comparison. Using one of the other three remaining states would widen the time gap.

After the vetting process outlined above, the groundwater protection programs of Florida, Arizona and Wisconsin were reviewed. For each state, the origins of state

legislation, agency development, and descriptions of relevant state programs were included. In addition, the responsibilities of relevant state agencies and the dynamics between agencies within each state were reviewed. Budget and staff allocation, along with performance metrics for select programs were included. Performance metric information was included where data was available.

Last, rules policies, permitting practices and groundwater monitoring for the following land use types were be explored: municipal landfills, farming practices and USTs. These land use practices were chosen because they are common to Wisconsin, Arizona and Florida. One chemical contaminant associated with each land use practice was selected for review. For each contaminant it is determined whether there are any groundwater quality standards or particular monitoring requirements. This was done to offer a constant among states for comparison. The contaminants were specifically chosen based on their impact to human health and an increased likelihood of groundwater contamination based on their presence at each land use type. The following contaminants were selected:

- N,N-diethyltoluamide (DEET) because it is as an emerging contaminant. It is particularly concerning given the increased frequency with which it is discovered in groundwater and in surface waters with groundwater connectivity, and because of the human health impacts it is being tied to. Landfills seem to be a primary pathway for DEET to enter groundwater sources.

- Atrazine because it is a well-known groundwater contaminant with a strong association to agricultural practices. Although there is some debate over its human health impacts, most states take it very seriously.
- Benzene was selected because it is a common groundwater contaminant that results from leaking USTs. It is very well established as having serious negative implications for human health.

Each contaminant is matched to known human health effects, oversight and relevant groundwater quality standards in Table 1, below. Notably, the health effects for Atrazine are debated, but its use is heavily managed through oversight of farming practices. Conversely, the health effects of Benzene are known and un-debated, but the oversight of Benzene (specifically from USTs) is minimal.

	DEET	**Atrazine**	**Benzene**
Known human health effects	Yes; emerging contaminant of concern	Debated	Yes
Degree of oversight and management	None	Extensive; primarily through pesticide application management	Moderate; leak detection required at UST sites.
Groundwater Quality Standards	None at Landfills; no SDWA standard; no known groundwater or drinking water quality standards	Yes; not specific to farms/agricultural sites; SDWA drinking standard of 3 µg/L enforced by all states	Yes; not specific to UST sites; SDWA drinking standard of 5 µg/L enforced in Wisconsin and Arizona, but in Florida it is 1 µg/L

Table 1: Contaminant Health Effects and Management Review.

Resources

A variety of information sources were used to gain a comprehensive understanding of the groundwater quality protection programs in Wisconsin, Arizona and Florida. The primary information sources used include: interviews with academics and officials to request data and obtain clarity regarding program elements and program operations; federal and state reports on groundwater quality; USGS reports and data, legislative histories; law review and journal articles; statutes and regulations pertaining to groundwater quality protection programs; regulations and reports concerning land use trends; news articles from reputable news sources such as the *New Yorker Magazine*, *LA Times,* and *The New Republic*; and peer reviewed publications from private organizations and universities.

Data for agency budgets, the number of staff, inspection and enforcement actions, and efficacy metrics for selected programs were evaluated. This data was either provided by state agencies (publicly available or by request), or was collected from the Executive Budgets in each state. The Executive Budgets were relatively easy to find, however, the level of detail varied significantly not only among states and agencies, but even across years within the same state. Inspection and enforcement action data was much more difficult to obtain, and was nearly impossible to align for comparison between the states. However, it was still useful in developing an understanding of the programmatic efforts made to protect groundwater quality within a given state.

The results of this research are presented in the following sections.

WISCONSIN

This section aims to deliver a comprehensive review of the agencies, laws and programs used to manage groundwater quality in Wisconsin. This section also seeks to provide detailed insight into the management of three common types of land uses in a way that allows for comparison to Arizona and Florida.

First, there is a review of the origins and motivations behind state-level efforts to protect groundwater. This is achieved by reviewing the historical development of the laws and agencies responsible for Wisconsin's groundwater quality, as well as those responsible for environmental and human health. Second, there is an overview of the relevant agencies, their programmatic responsibilities, and their level of interaction with each other. Monitoring and research efforts are noted, as well as budgetary and staffing resources. This part also states and explains any programmatic data available for water well inspections, leaking underground storage tanks, and the Clean Sweep program.

Third, there is an explanation of how groundwater quality standards are set and changed. This part reviews the agencies involved in setting groundwater quality standards, and the way in which they share and communicate information. Last, the permitting processes and management of landfills, farming, and USTs are reviewed. Groundwater quality standards for contaminants associated with each land use type are also addressed.

A Brief History of Relevant Legislation and Agency Development

Historically, matters of public health have always held sway in the management of Wisconsin groundwater. This is because of the large percentage of residents that rely on groundwater as a primary drinking source (at present, this number is roughly 60% of Wisconsin residents). (*Groundwater,* 2014). In fact, in 1876 the State Board of Health was the first agency tasked with managing groundwater quality in Wisconsin. Twenty-one years later, in 1897, the State's Geological and Natural History Survey began supporting the Board of Health's efforts by providing supplementary research and reports pertaining to groundwater consumption and quality. (Wirth, 1985). Then, in 1903, the State Laboratory of Hygiene was created. (Wirth, 1985). It worked jointly with the Board of Health to monitor both bacteriological and chemical materials in groundwater. Additionally, the Public Service Commission[24] began studying and recording the effects of groundwater pumping on quality in 1907, and continues to do so today, thus providing Wisconsin with one of the most complete sets of recorded data on pumping in the nation. (Wirth, 1985).

The years 1913 and 1914 saw the enactment of waste disposal statutes and regulations. Those rules were substantially related to efforts by the Board of Health to increase oversight for plumbing services and plumbing construction standards. (Wirth, 1985). With these rules, plumbing became more regulated, and plumbers were required to hold state issued licenses. A few years later, in 1919, the state legislation created the

[24] The Public Service Commission was previously called the Railroad Commission.

Bureau of Sanitary Engineering to review plumbing plans and public water system plans. (Wirth, 1985).

In 1935 and 1936 regulations for well drilling and private well construction were instituted. (Wirth, 1985). Wisconsin's Pure Drinking Water Law was also passed in 1936 to regulate pump installation and protect wellheads. The Pure Drinking Water Law was amended in 1953 to include registration requirements for pump installers, and requirements for reviewing plumbing plans and plans for public water systems.

The Natural Resources Council of State Agencies (NRCSA) was created in 1951 to conduct studies, collect and analyze data, and make recommendations about the protection and management of all of Wisconsin's natural resources. This included groundwater. (Wirth, 1985). The NRCSA did much to promote research, monitoring, and awareness for groundwater quality issues before it was disbanded in 1977. (Wirth, 1985).

Throughout the 1960's, organizational changes were made to a number of state agencies. Significant to groundwater quality management is that the Governor transferred the Board of Health's groundwater responsibilities to the Wisconsin Department of Resource Development in 1965. In 1967, the Wisconsin Department of Resource Development and the Wisconsin Conservation Department were merged to create the Wisconsin Department of Natural Resources (DNR), as it exists today. (Thomas, 1991).

In the 1970's, the state enacted several environmental laws that reflected citizen concerns, as well as elements of some federal environmental laws. Table 2 shows

changes in the state legislation in chronological order and aligns them with related federal legislation throughout the 1970's. The Safe Drinking Water Act of 1973 and the Resource Conservation and Recovery Act of 1974 are the pieces of federal legislation that afford protections to groundwater. Until Wisconsin passed Act 410 in 1983 and 1985 respectively, there was no corresponding state legislation.[25] No correlating legislation exists for the Resource Conservation and Recovery Act.

Federal Legislation	State Legislation
N/A	Statutes designed to improve solid waste disposal efficiency (1967). This arose from citizen concern and state need.
Clean Water Act (as amended in 1972)[26]	Pollutant Discharge Elimination Systems (1973)
Resource Conservation and Recovery Act (1976)	Hazardous Waste Management Program (1977)
Clean Water Act (as amended in 1972)	Point Source Pollution Act (1977)
Resource Conservation and Recovery Act (1976)	Statutes designed to improve solid waste disposal efficiency (1967)
Clean Water Act (1977 amendments)	Revisions to metallic mining reclamation act (1977)
Resource Conservation and Recovery Act (1976)	Trial programs for alternatives to the mound system instituted (1979)[27]
N/A	Changes to private sewer system/septic system management (1979). This arose from citizen concern.

Table 2: Chronological Comparison of Federal and State Legislation.

[25] Chapter 140 adopted federal quality standards, although these were enforced in Wisconsin prior to the passage of Chapter 140.

[26] The Clean Water Act refers specifically to the legislation produced by the 1972 amendments to the 1948 Federal Water Pollution Control Act. The amendments produced such significant changes, that the resulting legislation was considered "new."

[27] Septic systems were structured to produce effluent and release it into an engineered drainage basin called mounds. Mounds became problematic as the system degraded, especially if built in permeable soils.

In 1983, the state legislature passed Act 410, otherwise known as the Comprehensive Groundwater Protection Act. (*Summary of Wisconsin Groundwater Law*, 2013). Wisconsin was politically well-positioned to create this comprehensive legislation given its 100-year history of prioritizing groundwater quality, in addition to the momentum of the national environmental movement. However, the true impetus for passing Act 410 was a real and significant concern over groundwater quality implications to human health resulting from an increase in both mining operations and hazardous waste disposal on land surfaces.

The lead up to the passage of Act 410 was not without controversy. Several years prior to the passage of Act 410, the legislation began reviewing rules and regulations for both hazardous waste disposal sites and mining practices. Human health concerns sparked the review, which ultimately resulted in proposed rule changes that contained specific provisions of non-degradation of the environment by those two industries. The proposed changes were not well received by the mining and waste disposal industries, and they expressed their frustrations over being targeted so specifically. In response, the DNR revisited the changes, and by 1980 had developed a broader set of proposed rules that established a holistic framework for groundwater protection policies. The new set of rules addressed land disposal of solid, liquid, toxic, and hazardous substances, in addition to mining and mining activities. The 1980 proposed rules were the basis for Act 410.

Chapter 160 of the Wisconsin Statutes was written to give some specificity to the

requirements of Act 410. Chapter 160 expanded the State's legal, organizational, and financial capacity for controlling groundwater quality. It also specifically calls for pollution prevention.

Chapter 160 contains three notable accomplishments specific to groundwater. First, it obligates agencies to a cross-management effort in protecting groundwater quality. To achieve this, Chapter 160 created the Groundwater Coordinating Council (GCC),[28] a non-regulatory entity that coordinates cross-agency efforts and encourages cross-agency information sharing and communication.

Additionally, Chapter 160 required cooperation across all levels of government. The effect of this was that local governments became partners with the state agencies in protecting groundwater. Some examples of this are that: zoning authority at the local level was expanded in order to encourage groundwater protection; counties can, under DNR supervision, regulate well construction and pump installation for certain types of private wells; counties are allowed to adopt ordinances regulating disposal of septage on land so long as the regulations are consistent with DNR requirements;[29] and cities, villages, or towns may adopt necessary groundwater regulations if their respective county does not. Another unique and interesting feature of Chapter 160, is that property assessors must consider "the time and expense of repairing or replacing a contaminated well or water supply when assessing the market value of real property and they must consider the 'environmental impairment' of the property value due to the presence of a

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[28] In many respects, the GCC picks up where the NRCSA leaves off in 1977, though they remain very different entities.
[29] Wis. Stat. Ann. § 113.07(3).

solid or hazardous waste disposal facility." (*Fiscal Year 2014 Report to the Legislature*, 2014).

Second, Chapter 160 entitles all groundwater aquifers to equal protection. At the time Chapter 160 was written, the EPA promoted a nationwide aquifer classification system under which the amount of protection an aquifer received correlated to its potential use, value, or vulnerability. The Wisconsin legislature rejected this system because it would result in some aquifers having no protection, and ultimately could put large volumes of groundwater suitable for human consumption at risk in the future. Instead, the legislature gave all aquifers equal protection to ensure the availability of high quality groundwater in the future. (*Summary of Wisconsin Groundwater Law*, 2013).

Third, Chapter 160 called for numeric (as opposed to simply descriptive) groundwater quality standards. The legislature emphasized the importance of numerical standards, recognizing at that time that:

> most groundwater regulatory programs were not based on numerical standards. The legislature intends, by the creation of this chapter, to minimize the concentration of polluting substances in groundwater through the use of numerical standards in all groundwater regulatory programs. The numerical standards, upon adoption, will become criteria for the protection of public health and welfare, to be achieved in

groundwater regulatory programs concerning the substances for which standards are adopted.[30]

Although Wisconsin was already enforcing EPA developed standards, Chapter 160 created an outlet for the state to develop more stringent standards, or even additional standards for contaminants that might be more localized to Wisconsin and therefore unaddressed by the EPA. Moreover, the numerical standards put in place consisted of a two-tiered system whereby triggers exist for mitigation and entirely remedial requirements. Initial numeric standards originated from studies conducted by the Wisconsin Department of Health Services (WDHS).

Two decades later, the state passed Act 310, also known as the Groundwater Protection Act of 2003. (*Summary of Wisconsin Groundwater Law*, 2013). Although this legislation focused on improving groundwater management for quantity reasons, Act 310 formally recognized the connection between surface and groundwater. (*Summary of Wisconsin Groundwater Law*, 2013). In particular, it addressed the impact of wells and over-pumping on both groundwater quantity and quality. Another major component of Act 310 is the designation of two groundwater management areas: one is in Southeastern Wisconsin and the other is in the Lower Fox River Valley. Within these two management areas, multi-level governments and an array of state agencies are engaged in addressing problems resulting from over-pumping.[31] The problems are not just issues

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[30] Wis. Stat. Ann. § 160.001.

[31] This is another example of successful cross-agency and multi-level government cooperation as called for by Chapter 160.

of quantity, but quality as well, such as raised levels of radium, arsenic and salinity caused by excessive pumping.

Agency Integration and Programs

Wisconsin groundwater quality is primarily managed by the Department of Natural Resources (DNR) and the Department of Agriculture, Trade and Consumer Protection (WDATCP). The Department of Health Services (WDHS) helps in standard setting, and in managing human health related issues that may arise from groundwater quality matters. The Wisconsin Geological and Natural History Survey (GNHS) offers research support. The Department of Safety and Professional Services (DSPS) offer support in various in efforts, as needed. The Groundwater Coordinating Council (GCC) serves as a guiding entity on groundwater quality issues. It does this primarily by helping to coordinate information sharing and open dialogue about groundwater quality issues among all relevant state agencies, and across levels of government.

Groundwater Coordinating Council

The GCC is not a regulatory agency, but it works closely with regulatory agencies that manage groundwater quality. Primarily, it advises and assists those agencies in coordinating the exchange of information concerning: agency budgets for groundwater programs, groundwater monitoring data, data management systems, publicizing information and developing community education programs, unifying laboratory analysis methods and facility standards, and research activities and the appropriation and allocation of state funds for research.

The GCC has been meeting since 1984, and for more than 30 years has coordinated groundwater protection efforts across the state. It has done this largely by creating special subcommittees to quickly address emerging problems. In 2011, the GCC consolidated its broader efforts into two subcommittee groups: Research and Monitoring, and Outreach and Partnerships. Consolidating these subcommittees helps to streamline efforts, specifically, it helps in more quickly identifying what scientific research and monitoring needs should be prioritized and funded.[32]

Wisconsin Department of Natural Resources

The DNR has statutory authority to protect, maintain, and improve the quality and management of all water in the state, and without distinction between public and private water.[33] The DNR operates multiple programs to manage groundwater quality.

Waste and Materials Management

Mining

The WMM program regulates metal mining activity. There are two distinct approval processes, one for non-ferrous mining[34] and one for ferrous mining.[35] Though there two approval processes, regulations only exist for ferrous mining projects. The regulations require that iron mining projects be evaluated for environmental impact prior

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[32] Wis. Stat. Ann. § 20.285(1)(a). The GCC, DNR and the Board of Regents of the University of Wisconsin have worked together since 1992 to solicit and fund research and monitoring programs for groundwater management. *Id*; *Wisconsin Groundwater Coordinating Council, Executive Summary Fiscal Year 2015 Report to the Legislature*, GROUNDWATER COORDINATING COUNCIL (Aug. 28, 2015), *available at* http://dnr.wi.gov/topic/groundwater/documents/GCC/Report/ExecutiveSummary.PDF. Five projects were selected for funding in 2015 through the Joint Solicitation process. *Id.*

[33] Wis. Stat. Ann. § 281.11.

[34] Wis. Stat. Ann. § 293.

[35] *Id.* The regulatory framework for ferrous mining projects was recently created through enactment of 2013 Wisconsin Act 1 in March of 2013. *Id.*

to approval. They also include provisions concerning groundwater withdrawals, mining waste site design, and operation and protection of groundwater quality. Compliance with groundwater quality standards is required.

Land Use and Contaminants: Solid Waste Landfills and DEET

Owners and operators of landfills must complete both a local permitting process and a DNR permitting process through the WMM program. The local process varies between counties and municipalities. In addition to the WMM process, the applicant must meet and local requirements and obtain any approvals required at the local level, such as construction or zoning permits. Applicants must apply for any local permits at least 120 days prior to submitting the feasibility report to WMM. (*Wisconsin's landfill siting process*, 2015). Generally, the applicant negotiates a financial contribution, or other incentive, in order to obtain local approvals. There is also an arbitration process in place to help resolve issues between applicants and local governments. . (*Wisconsin's landfill siting process*, 2015).

The WMM process is the same regardless of location. It requires a site inspection to evaluate how well the proposed site will be able to comply with site-specific criteria and facility performance standards.[36] (*Wisconsin's landfill siting process*, 2015). To request a site inspection, the applicant must make a written request that includes basic information such as ownership and landfill type. Any known potential impacts to endangered or threatened species, as well as potential impacts to areas of historic, scientific or archeological importance, must also be included in the

[36] Wis. Code Ann. § 504.04.

request.[37] During the inspection WMM staff also evaluates whether the landfill falls within a floodplain or require setbacks because of its location.

Post-inspection, the applicant must submit a site report detailing information about the landfill and its intended contents.[38] The site report is evaluated by DNR staff, including a hydro-geologist, environmental engineer, and a waste management specialist. After the review, WMM issues an opinion letter to the applicant either approving or discouraging continuation of the permitting process. (*Wisconsin's landfill siting process*, 2015). This is neither an approval nor rejection, rather, it is an early indicator of the likelihood of success in receiving a permit. (*Wisconsin's landfill siting process*, 2015). Subsequently, a feasibility report is required (sometimes pre-feasibility reports are required if the opinion letter is negative).

Feasibility reports require a comprehensive site investigation that examines geologic and hydro-geologic information, engineering plans, environmental site assessments, evidence that there is a need for the landfill, and baseline data for soil and groundwater at the site.[39] A DNR hydro-geologist leads the investigation with assistance from DNR staff specialists in waste management and other programs. A favorable investigation indicates that the landfill is technically feasible and the permitting process can continue.

If the feasibility report receives a positive response, two more steps must be met. (*Wisconsin's landfill siting process*, 2015). First, an environmental analysis must be

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[37] Wis. Stat. Ann §§ 29.604(4), 44.40; Wis. Code Ann. §§ 504.04, 509.
[38] Wis. Code Ann. §§ 509. A site-specific geotechnical investigation is not required. *Id.*
[39] Wis. Code Ann. § 512.

conducted. At this point the DNR hydro-geologist analyzes the significance and severity of any impacts by the landfill on the public's health and welfare, as well as on the environment. In some cases, groundwater investigation reports that include proposals for further evaluations as well as remediation recommendations at landfills that exceed groundwater quality standards. Based on this analysis, the hydro-geologist makes a recommendation as to whether an environmental impact statement is needed. If an environmental impact statement is needed, the permitting process stops until it is completed.

Second, the applicant must submit a Plan of Operation report that details the following pieces of information: the final engineering design, design calculations, details on the phases of construction, proposed construction documentation, sequencing of operations, daily operation plans, monitoring plans, closure design, post-closure management plan, and a detailed estimate of the costs for construction, operation, closure and long-term care of the landfill.[40] In some cases, the WMM may impose special groundwater monitoring requirements such as monitoring for particular substances or monitoring at a particular frequency or location. Additionally, owners and/or operators must meet financial responsibility obligations for design, construction, operation, closure and post-closure.[41] Failure to meet financial responsibility requirements will prevent the permit from being issued.

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[40] Wis. Code Ann. § 514.
[41] *Id.*

Once all reports and requirements are met, a summary of the proposed project is posted in a local newspaper by the DNR hydro-geologist. (*Wisconsin's landfill siting process*, 2015). The notice requests comments and alerts citizens that they may request a public hearing.[42] Final feasibility determinations are made only after comments are considered and all issues raised at public hearings are addressed.

Once a positive final feasibility determination is made, WMM issues the permits and landfill construction can begin. Once the landfill is constructed, the owner must submit a very detailed report to WMM describing the construction of the landfill and must note of any changes that occurred in the previously submitted construction plan.[43] Only after the DNR engineer approves the construction plan and conducts a final inspection of the landfill, can a license be issued.[44] Although staff relies heavily on the information submitted by the applicant, WMM is pro-active in monitoring groundwater conditions at the landfill during the life of the landfill, and after its closure to ensure compliance requirements are met. (*Pharmaceuticals and personal care products in the environment*, 2015).[45]

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[42] Public hearings are not automatically scheduled.

[43] Wis. Code Ann. §516. Examples of some requirements are surveys of various grades, field and laboratory soil test results, engineering plan sheets documenting the constructed grades, the precise location of all leachate collection storage and removal structures, and the specifications of materials and photo documentation. *Id.*

[44] DNR has a zero tolerance policy for waste acceptance at unlicensed facilities.

[45] *Pharmaceuticals and personal care products in the environment*, WIS. DEP'T OF NATURAL RES. (Dec. 18, 2015), *available at* http://dnr.wi.gov/topic/healthwaste/pharm.html. DNR is very proactive on several fronts regarding groundwater quality both with regard to enforcing rules and regulations and in advancing understanding in different aspects of groundwater quality. *Id.* For example, in 2012, the DNR funded a study titled "Wisconsin Household Pharmaceutical Waste Collection: Challenges and Opportunities," which was the first in the nation to estimate quantities of pharmaceutical waste generated by households and what it might take to keep this waste from being flushed or landfilled, and ensure that it is destroyed instead. *Id.*

The entire permitting and licensing process emphasizes technical aspects of construction. The construction-centric approach aims specifically to minimize the risk of environmental pollution during the lifetime of the landfill and after its closure. In addition, the WMM program monitors and regulates groundwater at proposed, active, and inactive solid waste facilities and landfills. Another reflection of the effort to prevent pollution from landfills is the state's reduction in the number of active landfills. In just a few decades the number of active landfills has declined from thousands to fewer than 80.

Additionally, DNR has stringent requirements regarding the collection and treatment of liquids and gases generated by the compounding waste. Landfill operators must adhere to strict monitoring policies, and to report and respond to any pollution problems immediately. DNR staff conducts regular inspections and review monitoring results to ensure that monitoring is conducted and to review monitoring results.

In order to ensure a rapid and thorough response to any incidents, owners or operators are required to have a designated contingency fund. Money from this fund is also used to pay for monitoring services, and for maintaining the landfill after it closes. Demonstrating financial ability to sustain a contingency fund is a condition of permitting and licensing by DNR.

Landfills do have requisite monitoring for leachate, and for some substances such as Ammonia nitrogen, Mercury, Camium and Lead. When landfill monitoring indicates a substance at the proposed site exceeds a quality standard, an investigation is conducted to determine the extent of the problem. DNR staff review the results of such site

investigations. However, DEET is not one of these substances, and is not monitored for at landfill sites.[46] This is particularly surprising since a recent study indicated that DEET is a growing problem in surface water, and Wisconsin has high rates of groundwater-surface water interaction. The study showed that DEET was present in 58% of base-flow samples, in 82% of stormflow samples, and 90% of pore water samples. Additionally, the levels at which DEET was detected in all the sample areas were great enough as to be toxic to human health and have endocrine-disrupting potential. (*Organic Waste Compounds,* 2006; U.S. Geol. Survey, 2013).

GEMS Database

WMM also maintains a Groundwater and Environmental Monitoring System (GEMS) database of groundwater quality data from more than 600 solid waste facilities and landfills. This database contains a variety of information including environmental monitoring data from landfill owners, labs, and consultants. WMM only accepts applications and supporting materials electronically so that information can be uploaded directly to the GEMS database and is immediately available to DNR staff.

Reports generated from GEMS data are used to evaluate whether groundwater quality is adversely impacted by landfills. One way in which GEMS reports are used to evaluate the impact of landfills, is to asses the effectiveness of remedial actions at active and closed landfills by comparing data over time. (*Public Access to Landfill Environmental Monitoring Data*, 2015). Reviewing remedial actions is helpful in

[46] Wis. Code Ann. § 507. Benzene is monitored at landfills. *Id.*

ensuring remediation efforts are effective, and in developing new remediation plans when needed.

Remediation and Redevelopment

The Remediation and Redevelopment (RR) program has primary responsibility for managing environmental cleanup projects at closed landfills, and also any projects that fall under various state laws such as the Spill Law, Environmental Repair Law, the Land Recycling Law and State Brownfield Initiatives, and the Drycleaner Environmental Response Fund. Additionally, RR is responsible for cleanup obligations associated with federal regulations and programs such as Superfund Sites, Hazardous Waste Corrective Action, LUSTs and Brownfields. In handling a cleanup project, the bulk of RR's responsibilities are providing technical assistance, clarifying legal liability, providing financial assistance (especially to local governments), and performing technical oversight for cleanup projects.[47] Apart from its broader duties to prevent and mitigate contamination as problems arise, the RR also manages several programs.

Cleanup Of Groundwater Contamination

RR works with agencies at varying levels of government (including the EPA Removals Program), to handle groundwater contamination cleanup. For cases in which the contamination poses a risk to public health, welfare, or to the environment, but in which the responsible party is either unable or unwilling to take handle the cleanup, or does not have the financial means to pay for it, RR steps in to ensure that cleanup occurs. In these cases, RR hires private contractors to conduct the cleanup with oversight by

[47] Wis. Stat. Ann. § 700; Wis. Code Ann. § 140.

DNR staff. The contractors are paid out the state's Environmental Fund, which is a fund used for a number of things including research, monitoring, and emergency remediation expenses. When possible, the RR and legal staff from the DNR attempt to recover costs from responsible persons after the cleanups are undertaken.

Investigation, Cleanup and Redevelopment of Brownfields

The release of hazardous substances from brownfields is a constant threat to groundwater quality. To address this, RR promotes a variety of efforts encouraging local governments and private businesses to cleanup and redevelop brownfield properties. It does this primarily through technical and financial assistance programs in conjunction with the DNR and grant programs for local governments such as the Brownfields Green Space and Public Facilities Grant program. The RR also makes a point of targeting brownfield sites with known and identified groundwater contamination. In addition to encouraging cleanup at sites with groundwater contamination, the RR issues assurances and general liability clarification letters to help property owners and investors understand the extent of their current and future responsibilities.

Dry Cleaner Environmental Response Fund

The Dry Cleaner Environmental Response Fund program reimburses dry cleaner owners and operators for certain expenses associated with the cleanup of soil and

groundwater that was contaminated by dry-cleaning solvents. Licensing fees paid by the dry-cleaning industry for potential contamination events directly fund this program.[48]

Land Use and Contaminants: Underground Storage Tanks and Benzene

The DNR is responsible for managing Underground Storage Tanks (USTs), including investigating and managing remediative actions required to mitigate for UST associated contamination.[49] These responsibilities are carried out by RR. RR maintains regulatory oversight of both aboveground and underground petroleum, as well as hazardous substance storage tanks.[50]

In Wisconsin, Federal UST requirements are the rule. USTs used for vehicle fueling stations are federally regulated and require permits that must be obtained from DNR. To obtain or renew a permit, an applicant must demonstrate that they meet the financial responsibility requirements. Tanks whose operators do not meet the financial responsibility requirements will not be permitted and will be shut down. Additionally, insurance carriers must notify DNR when a policy is terminated by the carrier or by the insured. Because they are federally regulated, USTs containing fuel are subject to periodic inspections for leak detection, spill and overfill protection, and record keeping purposes. DNR employees and private contractors perform these inspections.

In addition to DNR's operation of PEFCA and its oversight obligations of USTs,[51] DNR has access to the Petroleum Inspection Fund (PIF), which has an annual

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[48] Wis. Stat. Ann. §§ 169, 700.
[49] Wis. Code Ann. §§ 700-754.
[50] Wis. Stat. Ann. § 310.
[51] Wis. Code Ann. § 700.

budget of $100,000.[52] The PIF helps cover expenses relating to the closure of abandoned USTs.[53] Under PIF, an owner must authorize DSPS to access and remove the UST.[54] (Department of Safety and Professional Services, 2014). Once authorized, DSPS hires a contractor to remove the UST. The contractor will perform services including excavation and backfill, removal of the islands, scrapping the tank(s) and piping, and soil assessment (when required). Once the UST is removed, DSPS places a lien on the property for an amount equivalent to the cost of closure.

Other departments assist in managing information related to USTs and Leaking Underground Storage Tanks (LUSTs).[55] The DATCP manages the tank registration database and is also primarily responsible for developing tank system regulations.[56] DATCP also handles the installation, registration, maintenance and abandonment of petroleum tanks.[57] When closing a LUST, DNR staff establishes the risk level, closure criteria, and determine whether the contamination can be resolved through natural process or requires additional treatment.[58]

In Wisconsin, the most common sources of volatile organic compounds (VOC) such as Benzene are landfills, underground storage tanks, and hazardous substance spills. (*Volatile Organic Compounds*, 2014). A recent report by the USGS stated that gasoline containing Benzene most frequently contaminants groundwater through USTs

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[52] The 2009 Wisconsin Act 28 created Wis. Stat. Ann. §§ 35; 101.14.
[53] *Id.*
[54] Additionally, the Department of Justice has authorized DSPS to remove tanks under the PIF program in judgments served for non-compliance with tank closure requirements.
[55] Wis. Code Ann. § 746.
[56] Wis. Stat. Ann. § 93-94.
[57] Wis. Stat. Ann. § 93.
[58] Wis. Code Ann. § 746.

and their distribution pipelines. (*Description, Properties, and Degradation of Selected Volatile Organic Compounds Detected in Ground Water,* 2006). Though Benzene is not the most common VOC, it is still regularly detected and is highly problematic. Statewide, 60 different VOCs have been found in Wisconsin groundwater in thousands of wells. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2012). Benzene is monitored for in landfills and hazardous spill sites, but there no benzene-specific monitoring required at UST sites. Leaks are dealt with as they arise. However, Benzene cannot exceed 5 µg/l in groundwater in the state.

Petroleum Environmental Cleanup Fund Act

The Petroleum Environmental Cleanup Fund Act (PECFA) program has been running since 1989. This program is an important part of groundwater quality control in Wisconsin because it oversees the repair or closure of LUSTs.

PECFA seeks to address and mitigate petroleum contamination by providing audits, issuing owner invoices for necessary cleanup services, performing technical reviews of site investigations, evaluating the feasibility of remedial options, approving funding for scopes of work. DNR maintains a list of PECFA registered consulting firms authorized to perform this work. Additionally, PECFA authorizes payments for remediation services. Since the program began, it has reimbursed approximately 1.53

billion dollars to petroleum storage tank system owners for expenses related to the investigation and remediation of petroleum-contaminated sites.[59]

Although DNR staff leads the PECFA program, DSPS has some administrative authorities. These include, summarizing site investigation requirements, determining when remediation funding is terminated, tracking the status and transfer of ownership, staff training, and dispute resolution for certain petroleum-contaminated sites.[60]

The PECFA program administers two databases and a GIS map, all of which are available to the public.

- Remediation and Redevelopment Tracking System: lists the status of sites undergoing investigation and/or cleanup.
- Sites Map: maps the locations of the majority of sites available on the Remediation and Redevelopment Tracking System (open and closed). Data regarding financial tools and liability clarification actions is available.
- Registry of Closed Remediation Sites: includes information on closed sites with residual groundwater or soil contamination exceeding enforcement standards. The location of the contamination and the concentration detected at the time the closure are also listed.[61]

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[59] Wis. Stat Ann. § 747; *Wisconsin Groundwater Coordinating Council Report to the Legislature*, WIS. DEP'T OF NATURAL RES. (2015), *available at* http://dnr.wi.gov/topic/groundwater/documents/GCC/AgencyActivities/DNRactivities.PDF.

[60] Wis. Stat. Ann. § 746.

[61] The registry of Closed Remediation Sites was developed in 2001 to replace the requirement to record groundwater use restrictions at the County Register of Deeds Office. In 2006, Wisconsin passed Act 418 to replace the use of deed restrictions for certain sites with residual contamination with conditions of closure and placement on the GIS Registry. The registry is updated bi-annually.

The Registry of Closed Remediation Sites is most central to the PECFA program because it allows future owners or users of a property to learn whether there is any soil and/or groundwater contamination on the property. It also states whether the current owner still has any responsibilities or obligations to meet in order to comply with conditions of closure.[62] Additionally, well drillers are supposed to check the registry so they can determine whether a well is going to be built on a registered property. If so, the driller must contact regional Drinking Water and Groundwater (DWG) staff before well construction begins to discern whether additional casing or other construction techniques may be required. Sites regulated by the DSPS and WDATCP are also included in RRTS, the GIS Registry, and the Sites Map. Because of the magnitude and expanse of PECFA, the program receives substantial annual budgets. Last year PECFA had a budget of nearly 12 million dollars.

Figure 1 shows that the PECFA program (in addition to UST enforcement actions on the part of DNR), has driven the number of LUSTs down over the last two decades. Although DNR data indicates that the number of LUSTs impacting groundwater has not been a large problem in the last twenty years, it is arguable that the work performed to reduce the overall number of existing LUSTs in the state helps keep those numbers down. Figure 1 also indicates that LUSTs impacting groundwater has been relatively low in most years, not exceeding 10 except for years 1999 and 2000 when the numbers of LUSTs impacting groundwater were 27 and 12 respectively.

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[62] Wis. Stat. Ann §§ 716, 726, 749; Wis. Codes Ann. §§ 811, 812.

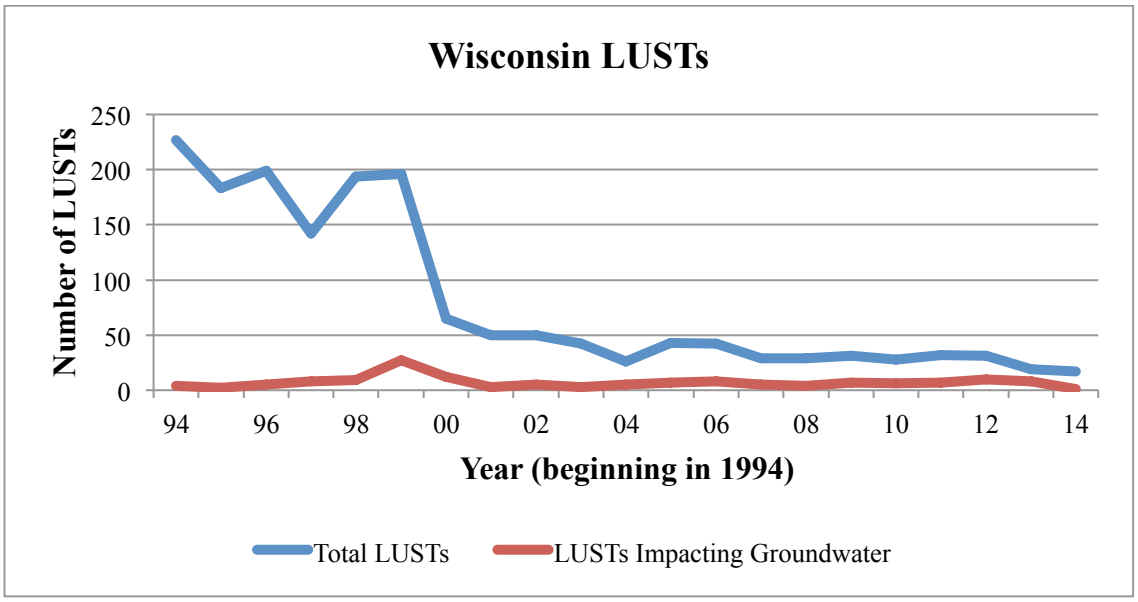

Figure 1: Wisconsin LUSTs from 1994-2014. Data obtained from the BRRTS.

Well Construction and Private Wells

DNR takes well construction very seriously because many groundwater problems can be prevented by the safe, secure and responsible construction of a well. Well construction is a critical aspect of groundwater management because when wells are not properly constructed and maintained (even after closure or abandonment), there is potential for water runoff of all types to enter the wellhead or for holes in the well to allow poor quality water or contaminants in. In addition, when leaks occur there is also an opportunity for anything external to the well to interact with groundwater. This can be very problematic depending on what geological formations or land uses are immediately external to the well.

DNR requires notice prior to new construction and replacement well construction. After construction is completed, drillers must submit Well Construction

Reports to the DNR detailing the construction process. These reports are included in a database managed by the Wisconsin Geological and Natural History Survey. DNR also licenses and educates well drillers and pump installers to ensure pumps and wells are constructed in ways that won't contaminate groundwater.[63]

Because of the importance placed on well construction, DNR sets and enforces standards for well construction, pump installation, and well filling and sealing to preserve quality and protect public health.[64] DNR staff conduct inspections during the construction period because once construction is complete it is difficult, if not impossible, to ascertain what may have been done incorrectly or where the problem lies. Equally as difficult, and very costly, is remedying a problem after construction is complete.

DNR staff enforces construction standards for private wells by conducting surveillance inspections during construction. DNR also reviews well construction reports and soil and groundwater samples, when available. Past violations include: failing to fill and seal exploratory boreholes, failing to obtain well water quality samples, failure to notify well owners of unsafe water test results, false well construction reports, and well drilling by unlicensed contractors.

In an effort to head off any well construction problems, DNR staff also perform consultations for well construction with staff from WMM, RR, as well as the Watershed

[63] Wis. Code Ann. § 812; Wis. Stat. Ann. § 146.
[64] Wis. Code Ann. § 812.

Management (WM) program and the Department of Commerce, and consultants and licensed well drillers.[65]

Figure 2 shows that owing to these efforts, DNR has met or exceeded its goals of the number of wells inspected during construction in the last few years, except for 2012. This is most likely because DNR experienced a reduction in full time staff during the same time frame as reflected by Figures 3 and 4.

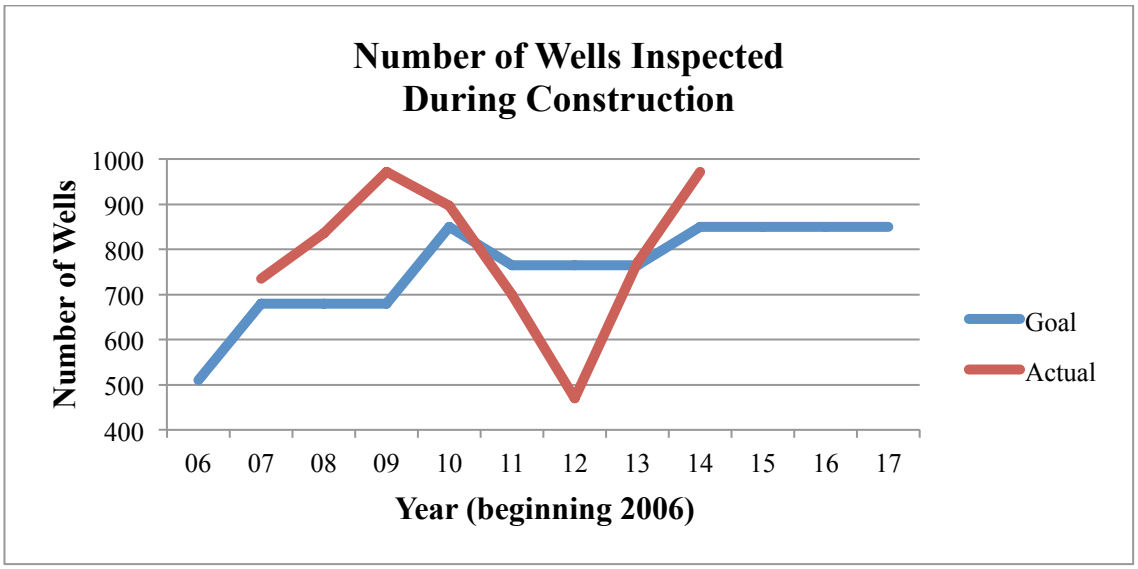

Figure 2: Number of Wells Inspected During Construction. Data obtained from the State of Wisconsin Executive Budgets.

Although DNR has most of the management responsibilities for well construction, the Department of Health Services (WDHS) is also involved. WDHS

[65] Wis. Codes Ann. § 141.

reviews the toxicity levels of constituents used in well construction and repairs to ensure that products used will not cause and overexposure to chemicals. WDHS staff also review correspondence sent to well owners by WDNR representatives.

Public Water Supply Systems

The DNR oversees monitoring of public water systems to ensure safe drinking water supplies through its Public Water Supply program. Specifically, it works with owners and operators of water systems to maintain the reliability and credibility of samples and sample analysis in order to meet federal SDWA standards.[66] In addition, DNR staff work to educate well owners and operations as to the proper operation and maintenance of water systems to ensure that SDWA standards are met.

The Public Water Supply program also maintains a Drinking Water System database that is an important tool for enforcing SDWA regulations against public water systems. The database contains several types of data and information pertaining to drinking water and groundwater quality. For example, the database includes the monitoring and reporting requirements for each public water system and the results of each system's drinking water sampling. It also contains any violations incurred for failing to post required information or exceeding the maximum contaminant levels (MCLs).

Drinking Water and Groundwater

The Drinking Water and Groundwater (DWG) program regulates and implements statutory groundwater quality standards for public water systems, private

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[66] Wis. Stat. Ann. § 809-811.

drinking water supply wells, well abandonment, and high capacity wells.[67] This program also bears most of the responsibility of coordinating with other agencies and programs to ensure statutorily required actions take place. Some examples of this are groundwater monitoring, certain types of data management, relaying hydro-geologic advice, and staffing the GCC.[68]

Additionally, this program coordinates Wisconsin's Source Water Protection program through two different efforts: Wellhead Protection and Source Water Assessments. Both aspects of the Source Water Protection program are the result of the amendments to the SDWA. The 1986 amendments require all new wells to have wellhead protections in place. The 1996 amendments require source water assessments for all public drinking water systems.

Wellhead Protection

The state's Wellhead Protection (WHP) program aims to reduce the risk of groundwater contamination in recharge zones. This is especially so for those areas that are connected to sources for public water supply wells. The WHP program requires plans for any new municipal wells. These plans must be approved by the DNR before the new well can be become operational. WHP plans are not required for public supply wells from before 1992, though the DNR encourages them to be written and instituted retroactively.

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[67] Statutory groundwater quality standards are found in Wis. Codes Ann. § 140.
[68] Wis. Stat. Ann. § 160.

In 2014, DNR and the Wisconsin Rural Water Association began working together to develop a pro-active strategy to support efforts to protect wellheads in communities with wells that are either likely to be, or known to be, susceptible to contamination.[69] Staff from the Wisconsin Rural Water Association work on plans for individual communities, as well as area wide plans for multiple water supply systems. Cooperatively, DNR staff review the draft plans and local ordinances, and lend technical advice to local officials responsible for carrying out wellhead protection. Presently, more than 400 communities have a WHP plan for at least one well, and 15% of Wisconsin public water systems are protected by WHP plans. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015).

Source Water Assessments

Source Water Assessments are reports created by DNR staff that provides two critical pieces of information about public water suppliers: the source of drinking water, and the degree to which the source may be susceptible to contamination. These assessments also review potential impacts on source water quality and are a critical tool for land use planning purposes. Each assessment includes a map of the source water assessment area and information about the potential contamination sources in assessment areas. The assessments also include a susceptibility determination based on presence of potential contamination sources and related contamination factors such as well construction, intake location and geology. Last, the assessment contains

[69] This is yet another example of the cross-management and multi-level government cooperative approach called for in Chapter 160.

recommendations for source water protection based on the susceptibility determination. Currently, DNR staff is responsible for completing more than 11,000 assessments.

Underground Injection Control

The Underground Injection Control program is required by the SDWA of 1974. The purpose of the UIC program is to protect groundwater from contamination that may result from the use of injection wells. Injection wells are built to store a variety of fluids underground. These fluids range from industrial wastes to byproduct fluids from producing natural gas. (*Underground Injection Wells*, 2012). They can be hazardous, but are not always. Injection wells that place hazardous waste either above an aquifer or directly into any aquifer that is used as a source of drinking water are banned across the country. Every state is required to establish a regulatory program to enforce underground injection well standards. The regulations cannot be less strict than the EPA's rules. The DNR has managed this program since 1983.

Water Quality

The Water Quality (WQ) program manages statewide implementation of DNR's groundwater quality standards. WQ's primary means of doing this is through the issuance of discharge permits to facilities, operations, and other activities that discharge treated wastewater and residuals to groundwater.

Wastewater Discharges

WQ is solely responsible for issuing Wisconsin Pollutant Discharge Elimination System (WPDES) permits to communities, industrial facilities, and large privately owned water systems that discharge treated domestic or industrial wastewater to

groundwater sources.[70] All WPDES permits require both initial and on-going groundwater monitoring and data submittal that DNR uses to evaluate facility compliance with groundwater quality standards. Additionally, any groundwater monitoring systems at existing facilities are evaluated and upgraded as needed prior to a permit re-issuance or renewal.

WQ maintains a database called the System for Wastewater Applications, Monitoring, and Permits. Through this database, holders of WPDES permits can access facility-specific information including: address, contacts, location, permit requirements, monitoring results, current information on groundwater, wastewater, and biosolids treatment/management, and wastewater treatment facility permit violations. Historical sampling data from groundwater monitoring wells is also available. Sampling data is added monthly.

Septage and Sludge Management

WQ regulates septage and the treatment, use, and disposal of municipal wastewater treatment plant sludge.[71] WQ also regulates the land application of industrial sludge, liquid wastes, and by-product solids.[72] The regulations for land application of any waste material include treatment quality standards, site requirements, and

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[70] Wis. Stat. Ann. §§ 206, 214. The most common systems are spray irrigation, seepage cell, subsurface absorption systems, and ridge and furrow treatment systems, all of which are regulated. *Id.*
[71] Wis. Stat. Ann. §§ 113, 204, 214. These statutes incorporate federal septage and sludge standards. *Id.*
[72] Wis. Stat. Ann. § 214. Wisconsin became the fourth state delegated authority by the EPA to implement municipal sludge regulations, through its delegated National Pollutant Discharge Elimination Permit program, in July of 2000. *Id.*

restrictions designed to prevent nutrients and contaminants from leaching into groundwater.[73]

Land application site approval is required by DNR regulations. The approval process includes considerations such as any site-specific rules or regulations applicable to the proposed site, loading rates, nutrient levels, and time of year. WQ takes land application seriously because of the volume of waste produced annually combined with growing competition for acceptable land spreading sites; this dynamic has already led to several instances of unacceptable impacts to groundwater. (*Wisconsin Groundwater Coordinating Council Report to the Legislature,* 2015). Because of the increasingly limited potential to apply septage on land, WQ operates a financial incentive program to entice wastewater treatment plants to accept and treat septage. (*Wisconsin Groundwater Coordinating Council Report to the Legislature,* 2015).

WQ heavily promotes compliance as a preventative measure. Septage operators are required to fulfill compliance training hours as part of their mandatory continuing education requirements.[74] WQ has begun working with the Bureau of Law Enforcement to increase compliance; as a result of its work with law enforcement, WQ anticipates more enforcement actions and an increased number of audits in the future. (*Wisconsin Groundwater Coordinating Council Report to the Legislature,* 2015). WQ also manages a statewide database that records and monitors the treatment and disposal of municipal

[73] Wis. Stat. Ann. §§ 113, 204, 214.
[74] Wis. Stat. Ann. § 114.

sludge, septage, and industrial land-applied wastes. It also contains an inventory and a history of all sites used for land application.

Watershed Management

The Watershed Management (WM) program coordinates watershed protection efforts throughout the state. WM implements DNR's groundwater quality standards by issuing discharge permits to concentrated animal feeding operations (CAFOs) and dischargers of contaminated storm water. WM field staff handles compliance and enforcement actions. WM is also responsible for integrated basin planning. This requires WM staff to develop basin guidelines that help in assessing groundwater, and in developing recommendations for the protection and enhancement of the basin's groundwater.

Agricultural Runoff and Groundwater Quality

The DNR has implemented some broad agricultural performance standards, though it focuses more narrowly on livestock operations. Livestock operations, generally CAFOs, are required to obtain WPDES permits from WQ.[75] This program is very important as the number of large-scale livestock operations is expected to grow in the future. Prior to receiving a permit, CAFOs are obligated to submit nutrient management plans stating how, when, where, and in what amounts, manure is applied to land, wastewater is processed, and what nutrients are used on crop fields. Groundwater monitoring at or near a CAFO site is generally voluntary, but is sometimes required as a condition of the permit.

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[75] Wis. Stat. Ann. § 243.

As it pertains to agricultural practices, the WPDES permits include setback requirements from public wells and karst formations, and restrict winter applications of manure. Acute manure related groundwater incidents (e.g., well contaminations) are responded to quickly in an effort to protect groundwater.[76] When such an incident occurs, DNR issues a Notice of Discharge to initiate the enforcement process.[77]

Stormwater and Groundwater Quality

Storm water discharges are regulated through the following permit systems:

- municipal permits to control polluted runoff that may enter municipal storm sewer systems. The DNR has also developed runoff performance standards;
- permits for owners of construction sites with one or more acre of land disturbance. This aims to control erosion during construction and to establish practices limiting post-construction pollutant discharge after construction is completed; or
- permits for certain industrial facilities to address potential contamination of stormwater from outside activities and outdoor storage of materials.[78]

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[76] Wis. Stat. Ann. §§ 50.04(3), 243; Wis. Codes Ann. § 151, 151.07. Rules and regulations require all crop and livestock producers to develop and implement nutrient management plans. *Id.* Wis. Codes Ann. § 50 provides technical standards for planning and implementation requirements for all nutrient management plans. *Id.*

[77] Wis. Stat. Ann. § 243; *Notice of Discharge*, WIS. DEP'T OF NATURAL RES. (Nov. 13, 2014), *available at* http://dnr.wi.gov/topic/nonpoint/noticesOfDischarge.html. A Notice of Discharge addresses "unacceptable practices at animal feeding operations with less than 1,000 animal units. *Id.* Local governmental units (typically county land conservation offices) work with department staff to identify and categorize discharges at animal feeding operations." *Id.*

[78] Wis. Stat. Ann. § 216.

Additionally, the storm water permit program regulates storm water discharges from municipal, industrial and construction sites. (*Storm Water Runoff Permits*, 2014).

Monitoring and Research

DNR is obligated to work with other agencies and the GCC to manage a groundwater monitoring and sampling program that is specifically intended to check for harmful contaminants.[79] This monitoring has been on-going since the enactment of Act 410.[80] (Executive Summary Fiscal Year 2015 Report to the Legislature, 2015; *List of all groundwater research and monitoring program projects funded fiscal years 1985-2014*, 2015). The primary intention of monitoring is to determine whether the groundwater quality standards are being met,[81] however another goal for this monitoring is to discern any relationships that exist between the contaminants identified through monitoring and land uses. The monitoring results are continuously evaluated, and are used to improve the management of land use practices that impact groundwater. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015).

Several types of monitoring approaches are used including problem-assessment monitoring, regulatory monitoring, at-risk monitoring, and management-practice monitoring. The expenses of these monitoring efforts, as well as the establishment of a

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[79] Wis. Stat. Ann. § 160.27.

[80] *Wisconsin Groundwater Coordinating Council Report to the Legislature*, GROUNDWATER COORDINATING COUNCIL (Aug. 28, 2015), *available at* http://dnr.wi.gov/topic/groundwater/documents/GCC/Report/ExecutiveSummary.PDF. For Fiscal Years 2013-2015, DNR committed $291,964 for upgrades to the groundwater level monitoring network with a focus on the following five elements: A fixed network of groundwater level monitoring locations; a statewide assessment of groundwater quality; a fixed network of groundwater quality monitoring sites; surface water monitoring stations; and water use reporting. *Id.*

[81] Wis. Stat. Ann. § 160.27.

data management system for collecting and managing the groundwater data, is covered by the state's Environmental Fund. In addition, the Environmental Fund is also used to cover the costs of monitoring studies that focus on contamination processes in groundwater, cleanup technology, mechanisms to prevent contamination, and the environmental and health effects of the contamination. Other monitoring studies focus on characterizing aquifers and assessing the connectivity between surface and groundwater.

In addition to the standard monitoring efforts and the monitoring studies, the Governor and the legislature include a biennial groundwater research appropriation in the state budget that is dispensed to DNR. This appropriation has been issued since 1989, and exists to ensure the state has the means to obtain basic data pertaining to geology, soil, and groundwater hydrology.

Since 2007, the data collected from monitoring and research projects has been made public via the Groundwater Retrieval Network database. Although managed by the DWG, this database includes data compiled from the DWG, WMM, and WM programs. All together, there is information available on 300,000 wells. These wells represent public and private water supply wells, monitoring wells, non-potable wells, and groundwater extraction wells. DWG staff continues to improve the database by adding more data and increasing the number of monitoring sites. Most recently, DWG has made improvements in the database with increased data on public water supply wells. Specifically, DWG staff worked with RR, WMM, and the WM programs to improve data concerning significant potential contamination sources threatening wells.

Last, with financial support from DNR and WGNHS, DWG staff has developed a map-based data bank that holds hydro-geologic data and related information. Impressively, the map-based data bank aligns and integrates spatial and tabular data to reflect the dynamics between potential contaminant sources, high-capacity wells, public water system vulnerability, wellhead protection, and any related drinking water and groundwater needs. Extensions and improvements of this program are already underway. DWG staff aim to put the maps on-line where they are publicly available and convert them into real-time maps that well drillers and realty professionals can use to ensure the safest possible drinking water well location and construction.

Budget and Staff

Budget and staff are an important consideration in reviewing state programs because many failures or successes may be attributed to resource allocation. DNR divides its total budget among a few departments including Land, Forest and Recreation, Air and Waste, Enforcement and Science, Water, Conservation Aids, Administration and Technology. Below, the total budgets and staff are shown for the entirety of DNR, as well as for the departments of Water, Air and Waste, and Enforcement and Science.

Figure 3 shows that the number of full-time employees (FTE) has declined and is expected to decline further in 2016 and 2017. Meanwhile, the total budget has actually increased (albeit only marginally so) in the same amount of time, and apart from years 2011 and 2012, has not experienced any dramatic fluctuations. Changes in both budget and FTE numbers were relatively steady.

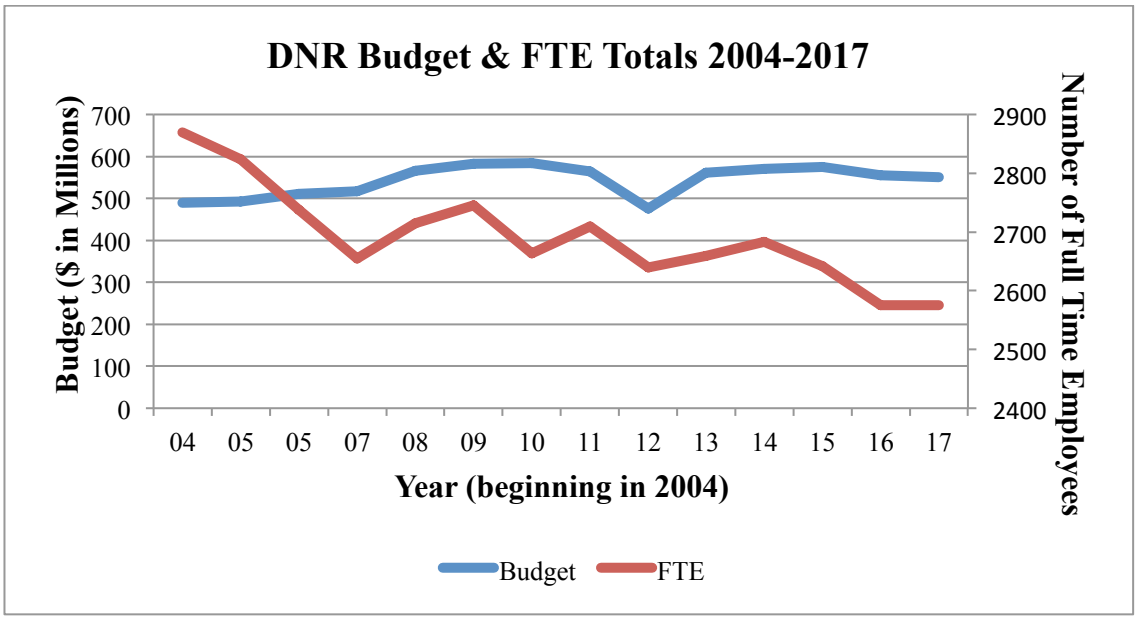

Figure 3: Wisconsin Department of Natural Resources Budget and Full Time Employee Count and Projections from 2004-2017. Data obtained from the State of Wisconsin Executive Budgets.

Within the context of the relatively steady changes in budget and FTE numbers for the entirety of DNR, Figures 4-6 exhibit unexpected patterns. Figure 4 shows that while the budget for the Water Division increased, the number of FTEs has undergone significant pendulum swings.

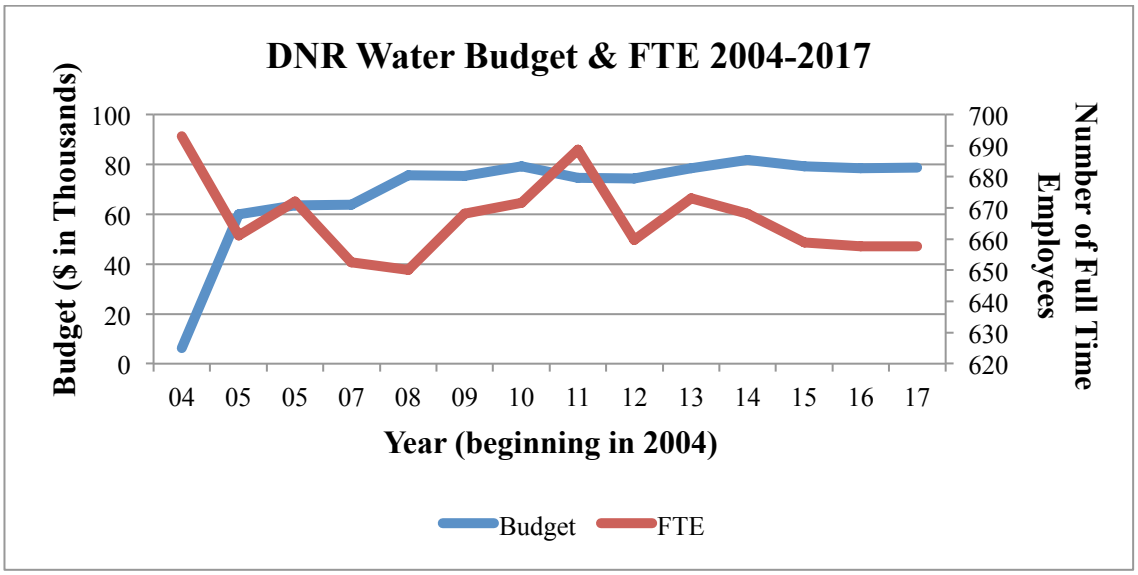

Figure 4: Wisconsin Department of Natural Resources, Water Division Budget and Full Time Employee Count and Projections from 2004-2017. Data obtained from the State of Wisconsin Executive Budgets.

Figure 5 shows the reverse of Figure 4, exhibiting steady FTE numbers for the Air and Waste Division (with some potential increases in 2016), and a budget that changes wildly every year. Although the range of fluctuation in the Air and Waste budget is small, it is probably more strongly felt because the overall budget is much smaller than, for example, the Water Division budget.

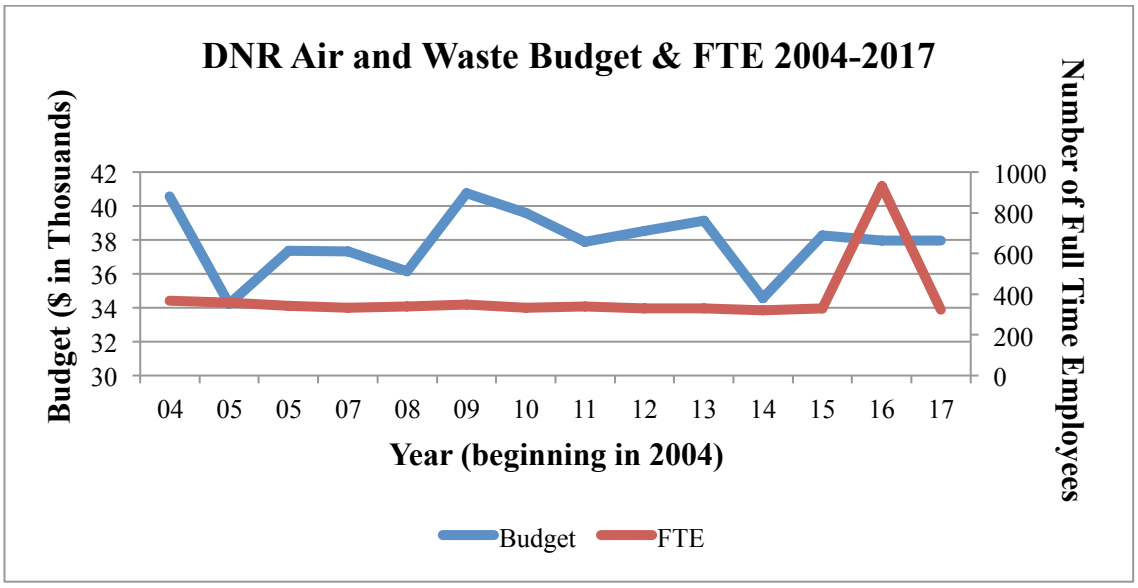

Figure 5: Wisconsin Department of Natural Resources, Air and Waste Division Budget and Full Time Employee Count and Projections from 2004-2017. Data obtained from the State of Wisconsin Executive Budgets.

Figure 6 shows that the number of FTEs and the budget for the Science and Enforcement Division has been steady across years with the exception of 2014 and 2015 when both saw declines, and 2015 when the number of FTEs further declined. However, both the number of FTEs and the budget are expected to rebound in 2016 and 2017, respectively.

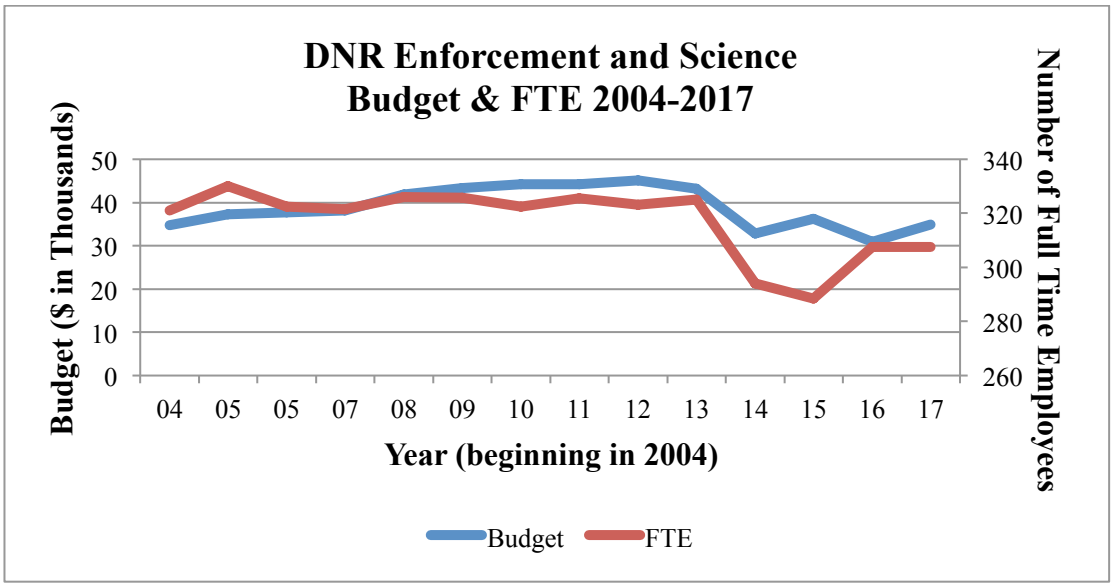

Figure 6: Wisconsin Department of Natural Resources, Enforcement and Science Division Budget and Full Time Employee Count and Projections from 2004-2017. Data obtained from the State of Wisconsin Executive Budgets.

Comparing figures 3 through 6 reveals that for years 2004 through 2017:

- The Air and Waste division accounts for less than one percent of the total DNR FTE numbers.
- The Enforcement and Science division claims between 10-12.25% of all FTE positions within DNR.
- The Water division claims between 23-25.5% of all FTE positions available within DNR.
- For all three divisions addressed here, each respective division budget amounts to less than one percent of the entire DNR budget during the period reviewed.

Wisconsin Department of Health Services

DHS is the primary resource for information about the potential health risks of drinking water contaminants and is responsible for investigations of suspected cases of water-borne illness. Its staff includes toxicologists, public health educators, and epidemiologists, who ensure that the most current information is used to make decisions, and that the latest approaches in handling investigations and assisting the public are used. Families experiencing highly contaminated drinking water, especially water containing volatile substances such as Benzene and Vinyl Chloride, often receive assistance and advice from WDHS until a safe water supply is located. (Department of Health Services Fiscal Year 2014 Report to the Legislature, 2014).

WDHS continuously studies potential groundwater and drinking water issues as they relate to human health. (Department of Health Services Fiscal Year 2014 Report to the Legislature, 2014). Some examples of its efforts are exposure bio-monitoring, disease surveillance, and capacity and vulnerability assessments. WDHS works with staff from all levels of government to accomplish this. The information gleaned from these studies is used for a few reasons including identifying any problem areas that need to be prioritized within the state. Additionally, WDHS makes an effort to synthesize the results of its studies, and make them publicly available.

WDHS is responsible for developing and maintaining standardized advisory language based on scientific information in order to ensure a consistent message is communicated to the public about groundwater contamination and health risks. (Department of Health Services Fiscal Year 2014 Report to the Legislature, 2014).

WDHS works with DNR, DATCP and other relevant agencies and partners (including local and tribal public health agencies) to update education and outreach materials.

WDHS is also required by statute to make recommendations of health-based enforcement standards for groundwater quality, and otherwise assists DNR as necessary.[82] The degree of involvement of WDHS in setting numerical standards for groundwater quality is quite notable as equivalent agencies in many other states are significantly less involved in the standard setting process. It is quite possible that WDHS would be less involved were it not for the fact that Act 410 calls for direct and active participation in standard setting on the part of WDHS. The legislative intent in Act 410 heavily emphasizes that public health is the premise on which groundwater quality should be protected, and not for other reasons such as environmental protection which was the case in many other states at the time. This same intent appears in throughout Chapter 160 of the Wisconsin Statutes.[83] This is obligation is reinforced by Wisconsin Statute 160.13, which charges WDHS with developing health protecting groundwater quality standards.

Budget and Staff

Figure 7 shows that the WDHS budget has been relatively steady, with slight positive growth. The number of FTEs did take a dip from about 2009 to 2012, however, this seems to be tied to minor waning in the budget during the same time period. In the

[82] Wis. Stat. Ann. § 160.
[83] Wis. Stat. Ann. § 160.001.

last decade, the WDHS has been bolstered significantly, and future projections for both budget and FTE numbers seem closely tied and very substantial.

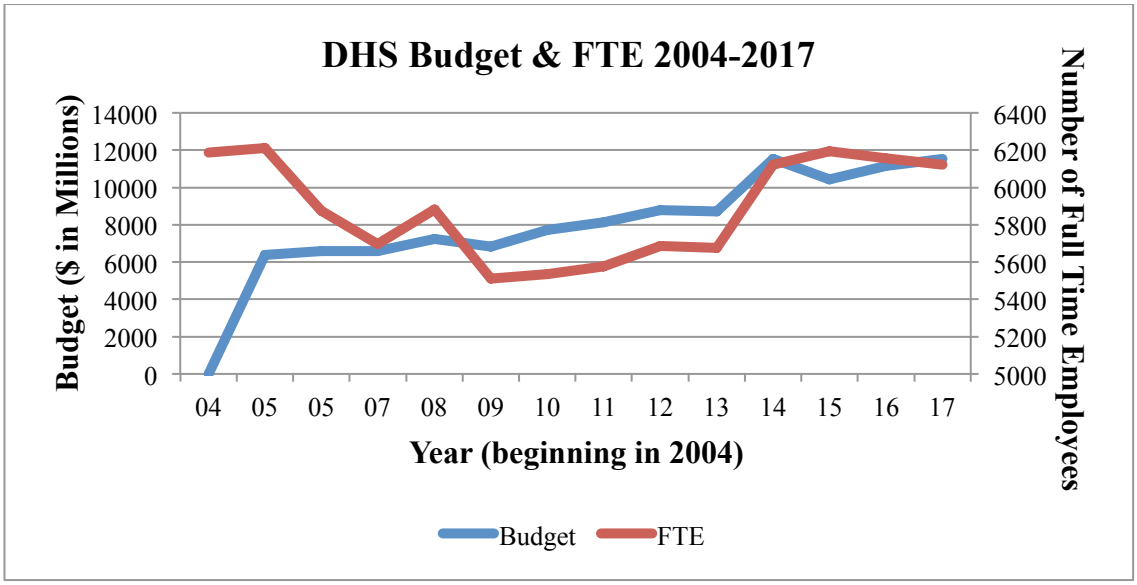

Figure 7: Wisconsin Department of Health Services Budget and Full Time Employment Counts and Projections from 2004-2017. Data obtained from the State of Wisconsin Executive Budgets.

Wisconsin Department of Agriculture, Trade and Consumer Protection

The Department of Agriculture, Trade and Consumer Protection (WDATCP) protects groundwater quality through pesticide and nutrient management programs.[84] These programs are pre-emptive and strive to prevent groundwater contamination. To achieve this, WDATCP regulates storage, handling, use, and disposal of pesticides, as well as the storage and handling of bulk quantities of fertilizer. WDATCP is authorized

[84] Wis. Stat. Ann. § 92.05. WDATCP is authorized to create a statewide nutrient management program. *Id.*

to issue outright prohibitions on application practices or the use of certain pesticides. There are enforcement standards for a number of known and potential groundwater contaminants, including more than 30 pesticides; Atrazine is of particular concern and receives a lot of attention from WDATCP. Another significant part of WDATCP's efforts are working with and educating landowners so that they comply with groundwater quality standards and other aspects of groundwater law.

Land and Water Resource Management

Since 2008, there has been increased focus across the state on the connection between land use practices and water quality. Changes were made to the state budget to reflect this in fiscal years 2008-2009 and funding for the Land and Water Resource Management (LWRM) program's cost-share allocation increased from $520,000 dollars to $6.5 million dollars. However, owing to budget shortfalls, it wasn't until fiscal years 2013-15 that $2.5 million dollars was actually allocated to the LWRM program. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015). Of this amount, $2,012,000 dollars was used issued to counties for landowner cost-sharing efforts, and $175,000 dollars was put in a reserve to fund grants for the Nutrient Management Farmer Education program. The balance was used for other aspects of the program. Notably, since 2013 the total monetary requests from counties exceeded available funds by $3,534,292.

Land and Water Resource Management Program

DNR rules establish the procedures for ensuring compliance with agricultural performance standards, including nutrient management. However, it is the WDATCP

that manages the agricultural performance programs through its Land and Water Resource Management (LWRM) program.[85] In order to meet the expectations set by DNR rules, WDATCP adopted the United States Department of Agriculture's Code 590, which sets out nutrient management standards.[86] Specifically, Code 590 addresses surface runoff, and implementation and enforcement procedures for nutrient management. Every year, a statewide Nutrient Management Plan (NMP) is updated to address new problems and meet Code 590 obligations.

A NMP aims to reduce nutrient loss through leaching, runoff, erosion, and gaseous exposures. All Wisconsin farmers mechanically applying nitrogen, phosphorus, or potassium nutrients from manures or fertilizers are subject to the NMP rules. Presently, there are 5,000 NMPs that cover 2.3 million acres. This is an increase from 1.5 million acres in 2006.

Farmer Education

Farmer education is a critical element in the LWRM program. It provides unique and individualized information to farmers such as specific information about their soils, and the ability of their soils to accept nutrients for optimal crop production. There is also a review of compliance requirements and what tools are available to farmers.

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[85] Wis. Code Ann. § 151.

[86] Wis. Code Ann. § 50; *Wisconsin Groundwater Coordinating Council Report to the Legislature*, GROUNDWATER COORDINATING COUNCIL (Aug. 29, 2014), *available at* http://dnr.wi.gov/topic/groundwater/documents/GCC/AgencyActivities/DATCPactivities.PDF. A variety of considerations are made such as field slope and soil temperature, among others. *Id; see also Nutrient Management*, *Natural Resource Conservation Practice Standard*, U.S. DEP'T OF AGRICULTURE (2014), *available at* https://efotg.sc.egov.usda.gov/references/public/wi/590.pdf.

One web-accessible tools is the 590 Nutrient and Manure Application Restriction Maps, which are GIS-based map system that can assist farmers in making decisions about how and where to apply nutrients to their cropland. Another web-based tool is the Runoff Risk Advisory Forecast, which notifies farmers 10 days in advance of poor conditions for spreading manure and nutrients.

Agricultural Clean Up

Land Uses and Contaminants: Farming Practices and Atrazine

Pesticide contamination is well documented in Wisconsin owing to longstanding presence of the agriculture industry. Pesticide contamination is usually the result of field applications, pesticide spills, misuse, or improper storage and disposal. In Wisconsin the most commonly detected pesticide compounds in groundwater are Atrazine and metabolites of Atrazine, Alachlor, and Metolachlor.[87] In response to this, Wisconsin designated portions of the state to be Atrazine Prohibition Areas. Since designating these areas, the state has conducted studies of pesticides and weed management. One interesting finding was that a majority of corn growers were interested in using Atrazine, but that half the respondents successfully controlled weeds without it. (*Final Report on the 2010 Survey of Weed Management Practices*, 2011).

Results and data from related Atrazine studies are publicly available in DATCP's pesticide database. The information available includes test results from roughly 13,000 wells tested with the immunoassay screen for Atrazine and over 5,500 wells tested by

[87] Metabolites are associated chemical compounds that form when pesticide compounds break down in the soil and groundwater.

the full gas chromatography method. (Pesticides, Fiscal Year 2014 Report to the Legislature, 2014). Of wells tested with the immunoassay screen, Atrazine was detected in approximately 40%. (Pesticides, Fiscal Year 2014 Report to the Legislature, 2014). About 1% of wells had levels of Atrazine exceeding the groundwater ES of 3 μg/L.[88] (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015). Of the 5,500 wells tested by full gas chromatography, Atrazine was detected in 38%, and was detected at levels exceeding the ES in about 8%. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015). In 2013, DATCP used the collected data to map locations tested and Atrazine levels of private drinking water wells that had been tested for Atrazine. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015).

Pesticide use surveys indicate that Atrazine use has declined from peak levels in the late 1980's and is now plateaued. This trend is likely the direct results of many of DATCP's research and education efforts, as well as advocacy for its stringent management. For example, significant detections of Atrazine in groundwater have led to rule revisions; the latest revision came into effect in April 2011. As part of this most recent revision, 101 prohibition areas were added. With this revision, the total Atrazine Prohibition Areas amount to 1.2 million acres.[89]

Another example is the 2008 prohibition on the use of Simazine in a portion of the Lower Wisconsin River Valley. Simazine is an herbicide related to Atrazine.

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[88] The ES for Atrazine includes Atrazine and three of its metabolites.
[89] A set of maps for 101 prohibition areas is available from the Environmental Quality Section covering 1.2 million acres that have been incorporated into the rule.

DATCP continues to perform routine testing of private wells for Simazine both inside and outside of Atrazine Prohibition Areas to determine if additional actions are needed to protect groundwater from Simazine.

Clean Sweep

Since 1990, WDATCP has operated the Agricultural Clean Sweep grant program, which assists farmers in responsibly disposing of unwanted pesticides, farm chemicals, and empty pesticide containers.[90] Proper disposal of these materials can be very expensive and transporting them safely to a disposal site can also be difficult.

Figure 8 shows that although it took a few years for this program to catch on with the agricultural community, it has met or exceeded its goal for volume of waste collected every year. The 2015 goal was slightly raised from the 2014 goal, however, the actual volume collected for 2015 is not available yet. Notably, Figure 8 also shows that the intended goals were raised for years 2016 and 2017.

[90] Since 2004, DATCP has managed the state's household hazardous waste program, which includes the state's prescription drug collection program.

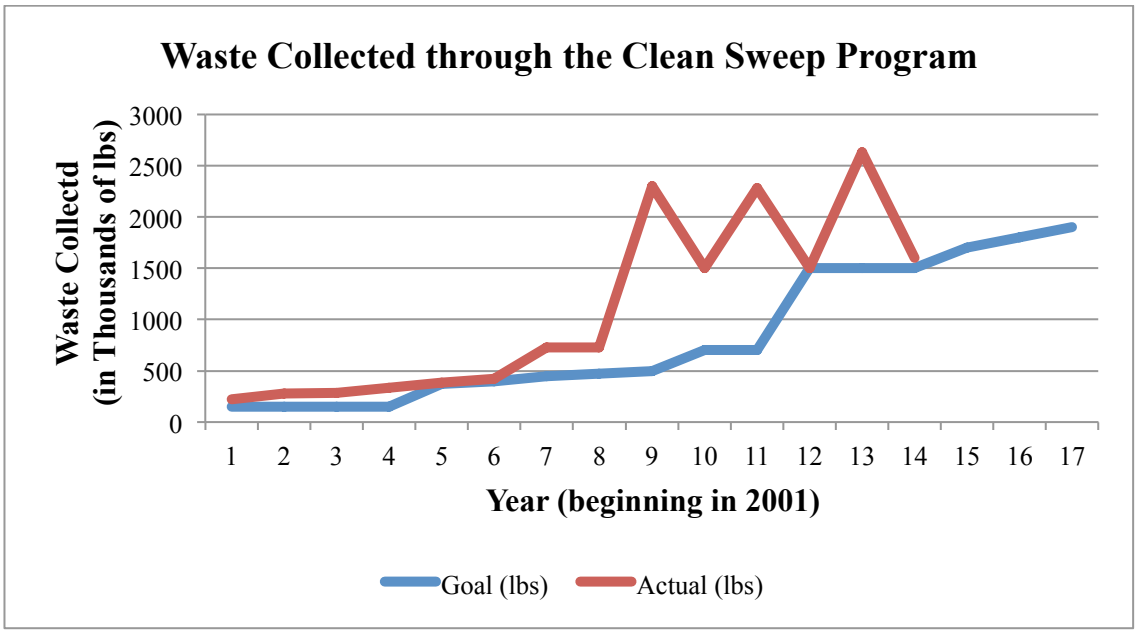

Figure 8: Volume of Waste Collected at Wisconsin Clean Sweep Collection Sites. Data obtained from the State of Wisconsin Executive Budgets.

WDATCP also manages the Agricultural Chemical Cleanup Program, which addresses point sources of contamination by assisting with a portion of the cleanup costs associated with pesticide and fertilizer contamination. So far, the program has received over 1,400 reimbursement applications for more than $41.3 million in financial aid. To date, this program has also worked on more than 520 cases involving soil and/or groundwater remediation related to improper storage and handling of pesticides and fertilizers, and assisted with over 1,000 acute agrichemical spills.

Research and Monitoring

WDATCP conducts several annual surveys to investigate the occurrence of pesticides in groundwater resulting from nonpoint sources. In the past, the results were

compiled in a groundwater survey database. In 2011, WDHS issued a grant to WDATCP to merge the groundwater survey database with a monitoring well database. The new database (online since early 2012), combined the data, and added a GIS feature enabling users to search the database within user-defined geographic areas. The database currently holds information for over 62,000 public and private wells.

Results from a search in the database include information such as location, well characteristics, pesticide and nitrate sample results, and data from hundreds of agricultural chemical cleanup cases. Results currently contain nearly 800,000 pesticide and nitrate-N sample analytical results. Additionally, DATCP funds up to $200,000 dollars of research annually.

Budget and Staff

Figure 9 shows that the FTE numbers at WDATCP only incurred incremental increases since 2007, though it is expected to increase substantially in 2017. Figure 9 also shows that the DATCP budget fluctuated wildly between 2009 and 2013, and although it returned to somewhat more regular levels it is expected to increase in 2017.

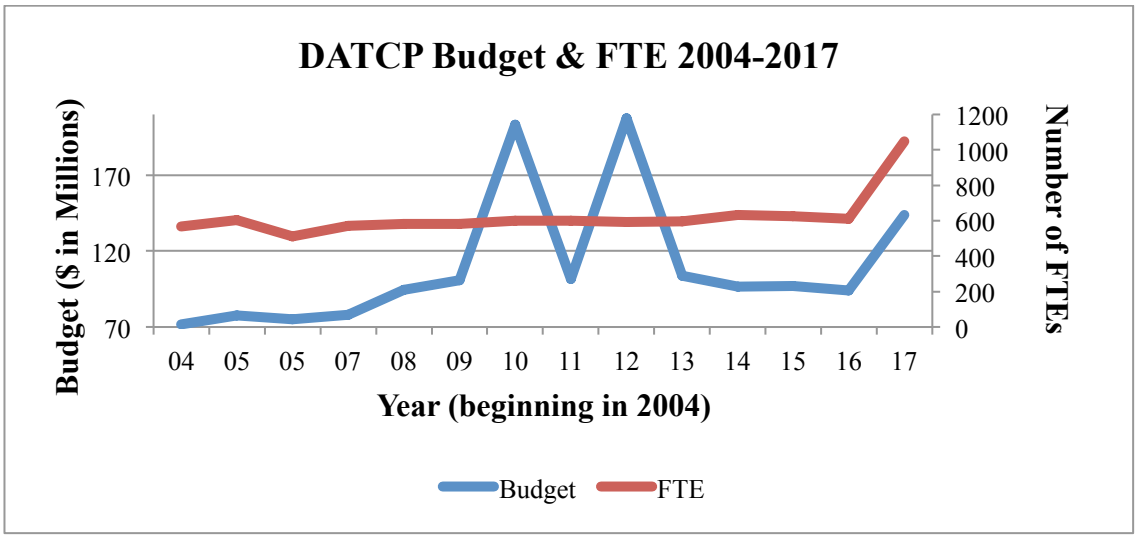

Figure 9: Wisconsin Department of Agriculture, Trade and Consumer Protection Budget and FTE 2004-2017. Data obtained from the State of Wisconsin Executive Budgets.

Wisconsin Department of Safety and Professional Services

The Department of Safety and Professional Services (DSPS) is in regular communication with DNR regarding matters of mutual concern such as large onsite sewage systems, Underground Injection Control regulations, septage disposal and water well regulations. When asked, DSPS assists in developing onsite sewage system policies, but otherwise serves in an advisory role on an as-needed basis to DNR. DSPS also manages a database concerning on-site sewage system design, installation and maintenance. Presently, DSPS is working to add information about reporting and recording of inspection and maintenance for onsite sewage systems. (Department of Safety and Professional Services, 2014).

Wisconsin Geological and Natural History Survey

The Wisconsin Geological and Natural History Survey (GNHS) manages three programs helpful in understanding groundwater in the state: Groundwater, Soil, and Geology. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015). The Groundwater program is most directly related. It performs basic and applied groundwater research, provides technical assistance, maps, and educational services that aid in statewide water management. (Wisconsin Geological and Natural History Survey, 2014). The Soil and Geology programs create some of the state's most useful resources including maps and research about groundwater recharge, occurrence, quality, movement, and protection.

Largely, GNHS focuses on issues of water quantity, but it is currently working on two quality-related projects. The first is a study of the impacts to groundwater quality from leaking sewers, and the second documents the impact in land use conversion from agriculture to residential in un-sewered subdivisions.

GNHS manages a variety of data in both database and GIS map formats. DNR relies on three in particular. First, the Hydro-geologic Data Viewer that provides current hydro-geologic data searchable by location parameters. Presently, the database is for use of the state only, but DNR and GNHS may open it to the public in the future.

Second, DNR also make extensive use of the Physical Properties of Wisconsin's Bedrock Aquifers and Aquitards database. Available to the public, it includes information about porosity and density of core samples collected from across the state. Last, and also available to the public, GNHS manages a database containing well

constructor's reports submitted to DNR after well construction completion. Only wells installed between 1936 and 1995 are accounted for; wells built after 1995 are too new to be included in the database.

Standards

The DNR, with some assistance from WDHS, is responsible for establishing numerical groundwater quality standards.[91] The standards are regulatory, and are used to enforce cleanup and compliance, as criteria for a well replacement program, and to advise private home-owners on the safety of their home well water supply. The standards are adopted in Chapter 140, as are evaluation and response procedures for any violations.[92] Presently, groundwater quality standards are in place for 138 substances of public health concern, 8 substances of public welfare concern, and 15 indicator parameters.[93] However, the standards are ever-changing as groundwater quality problems are mitigated or resolved, and as new substances and information emerge. When the standards are changed or added to, the DNR makes extensive efforts to publicize the standards and any changes to them, as well as educate citizens of any health risks posed by the regulated substances. To do this, DNR regularly updates a table listing health and welfare based enforcement standards, public drinking water standards,[94] and health advisory levels (HALs).

The substances that are regulated are those that have either been detected in

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[91] Wis. Stat. Ann. § 160.
[92] Wis. Code Ann. § 140.
[93] *Id.* An indicator parameter substance is a physical characteristic or substance, such as pH, temperature or hardness, which may indicate the presence of a contaminant. *Id.*
[94] Wis. Code Ann. § 809.

groundwater or have a reasonable probability of entering groundwater. Although authority to set groundwater quality standards rests with DNR and WDHS, state agencies with regulatory authority over activities that could result in groundwater contamination, periodically provide DNR with a list of substances related to those activities. The substances identified by the various state agencies are then reviewed and considered for groundwater standard development. There is also opportunity for private citizens to petition for the addition or removal of a substance from the list.[95]

The review process for a substance begins with DNR ranking the severity of the potential harm. It does this by considering things such as: whether the substance has already been found at levels exceeding SDWA standards (for those substances with SDWA standards); whether it may be a carcinogenic, mutagenic, teratogenic, or have any interactive effects;[96] and whether the concentration of the contaminant or the extent to which the contamination exists, or is likely to increase. DNR has statutory authority to consider other relevant information as it deems necessary. Another consideration is whether a potential contaminant amounts to a public health concern or a public welfare concern. Public health concerns include anything that will cause or contribute to mortality, illness (chronic or acute), or cause any other adverse human health effects or changes.[97] Public welfare concerns generally include any other non-health related consequences such as aesthetics, suitability for other uses, and adverse effects on plant

[95] Wis. Stat. Ann. § 160.05(2)
[96] Wis. Stat. Ann. § 160.05.
[97] Wis. Stat. Ann. § 160.05(6).

or animal life.[98] This distinction impacts what agency is ultimately responsible for setting a standard, as illustrated in Table 3.[99]

DNR creates two types of standards: the Preventative Action Limit (PAL) and the Enforcement Standard (ES). The PAL indicates the onset of a significant problem. When a PAL is exceeded, groundwater flow condition assessments, contaminant fate estimates, contamination severity assessments, and an analysis of mitigating response actions, are all required. PALs may be retroactively instituted in remediation cases.[100] When an ES is exceeded, source control measures and groundwater remediation actions, are triggered.

DNR establishes ES groundwater quality standards for substances of public welfare concern. These standards are based on federal numbers and state drinking water quality standards. They aim to address water supply aesthetic concerns, primarily taste and odor. PAL groundwater quality standards for substances of public welfare concern are set at 50% of the established ES.[101]

After this review process, DNR sends a pared down list of substances that are a public health concern to DHS requesting that DHS staff review available toxicity information for listed substances and provide that information and recommendations for

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[98] *Id.*
[99] *Id.* Public health concerns include anything that will cause or contribute to mortality, illness (chronic or acute), or cause any other adverse human health effects or changes. *Id.* Public welfare concerns generally include any other non-health related consequences such as aesthetics, suitability for other uses, and adverse effects on plant or animal life. *Id.*
[100] Wis. Code Ann. § 140.02.
[101] Wis. Stat. Ann. § 160.15.

groundwater enforcement standards (ES).[102] This process is much more complicated than the process for substances of public welfare concern, and it considers a wider number or variables including things such as cancer risk, established acceptable daily intakes, and federal guidelines. Many ES standards are based on established federal numbers,[103] however WDHS has statutory liberty to consider significant technical information that may have been obtained after federal guidelines, reference doses or acceptable daily intake values, were set. PAL groundwater standards for substances of public health concern are set at 20% of the ES, or if the substance is a carcinogen, mutagen, teratogen, or has interactive effects, 10% of the ES.[104] DNR then proposes the DHS recommendations (along with DNR calculated Preventative Action Limits (PALs)) be adopted into Chapter 140.[105]

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[102] Wis. Stat. Ann. § 160; Personal Communication with Bill Phelps , Hydrogeologist, Bureau of Drinking Water & Groundwater Wisconsin Department of Natural Resources September 2, 2015.

[103] Personal Communication with Bill Phelps , Hydrogeologist, Bureau of Drinking Water & Groundwater Wisconsin Department of Natural Resources September 2, 2015. Standards based on federal guidelines are always changed when the federal guidelines changes. *Id.* Additionally, when new technical information becomes available, which was not considered at the time a federal number or RfD/ADI/cancer risk level was established DNR requests that DHS review that information and recommend revised groundwater quality standards, as appropriate. *Id.*

[104] Wis. Stat. Ann. § 160.15.

[105] Changes to the administrative code are done through state administrative rulemaking process pursuant to Wis. Stat. Ann. §§ 160.07, 227; Wis. Codes Ann. § 140. Wis. Stat. Ann. § 160.07. Changes to the standards must be made pursuant to Statute 160.07. *Id.*

	Enforcement Standard	Preventative Action Limit
Substance of Public Health Concern: anything that will cause or contribute to mortality, illness (chronic or acute), or cause any other adverse human health effects or changes	DNR reviews information provided by its staff, other agencies, or citizens, and refers any that are of public health concern to WDHS. WDHS makes recommendations, which are then proposed for adoption in Chapter 140 by DNR.	Set at 20% of the ES, or 10% if the substance is deemed to be a carcinogen, mutagen, teratogen, or has interactive effects.
Substance of Public Welfare Concern: anything that will cause or contribute to non-health related consequences such as aesthetics, suitability for other uses, and adverse effects on plant or animal life	DNR reviews information provided by its staff, other agencies, or citizens, and sets standards. DNR sets the final standard.	Set at 50% of the ES.

Table 3: Groundwater Standard Setting in Wisconsin.

DHS is involved with standard setting in two other ways. First, DHS reviews new technical information pertaining to existing standards and recommends revisions to DNR as needed. Second, DNR periodically asks DHS for assistance in developing state drinking water health advisory levels (HALs) for new substances found in groundwater. HALs are used to advise homeowners on the safety of their well water supply, and also identify site specific "levels of concern" in evaluating the need for groundwater remediation at contamination sites.[106] A drinking water HAL can be

[106] Personal Communication with Bill Phelps , Hydrogeologist, Bureau of Drinking Water & Groundwater Wisconsin Department of Natural Resources September 2, 2015.

developed relatively quickly by DHS based on a review of available toxicity information.

When developing standards, DNR staff is obligated by statute to "give highest rankings to those substances which pose the greatest risks to the health or welfare of persons in the state, taking into consideration, among other things, the following characteristics: carcinogenicity, teratogenicity, mutagenicity and *interactive effects*."[107] This consideration may only be a small factor in deciding whether a contaminant may impact public health, however it is incredibly notable that interactive effects influence the PAL standards for Substances of Public Health Concern. If the substance has interactive effect potential, the PAL is set at 10% of the ES. Additionally, pesticide mixtures and their health implications are addressed in the Groundwater Coordinating Council's 2015 Report to the Legislature. (Pesticides, Fiscal Year 2014 Report to the Legislature, 2014). This suggests that Wisconsin is giving increasing attention to the issue.

Observations

Wisconsin has a long history of groundwater management beginning with the onset of its groundwater pumping study in 1907 and its 1936 Pure Drinking Water Law that preceded any comparable federal legislation. It has continued to be an early implementer of comprehensive groundwater quality protection policies and programs. This includes the Chapter 160 requirement for stratified involvement from different agencies and levels of government.

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[107] Wis. Stat. Ann § 160.05(4). (Emphasis added).

On the whole, Wisconsin agencies and local governments seem to do an effective job of meeting the Chapter 160 mandate that environmental protection efforts be made across all levels of government and span relevant agencies and entities. The approach to the Wellhead Protection (WHP) program is one example. Under the WHP, staff from DNR and the Wisconsin Rural Water Association (WRWA) join to help communities likely to be susceptible to contamination, develop sound plans for new municipal wells. Operating since 2014, already more than 400 communities have a WHP plan for at least one well, and 15% of Wisconsin public water systems are protected by WHP plans. (*Wisconsin Groundwater Coordinating Council Report to the Legislature*, 2015).

Another example is the development of solid waste landfills which require owners and operators to meet and complete DNR requirements and processes as well as requirements and processes mandated by the locality in which the landfill will be sited. Without completing all requirements, the DNR will not approve the landfill for operation.

In fact, the Chapter 160 requirements have pervaded nearly every aspect of groundwater management, not just programs and land use management. Monitoring and standard setting are also impacted by Chapter 160's call for cross-agency management. For example, DNR is obligated to work with other agencies and the GCC to perform groundwater monitoring specifically intended to check for harmful contaminants. DNR also works cooperatively with other agencies and the GCC to identify what groundwater quality research should be prioritized and funded. When it comes to research funding,

there is also a cross-agency approach. For example, in 2011, WDHS issued a grant to WDATCP to merge the groundwater survey database with a monitoring well database and open the database to all agencies.

When it comes to setting groundwater quality standards, staff from DNR and DHS seem to surpass the statutory requirements. They work together to ascertain when something amounts to public health concern, as well as to educate the public and promote environmentally responsible actions that keep everyone safe. Although DNR staff make final decisions about standards, DNR staff utilize and engage DHS staff and their knowledge and expertise in a way that many other state environmental agencies fail to do with their respective DHS counterparts.

A specific note about standard setting is that in Wisconsin, interactive effects of substances in groundwater inform rules for PALs. If a substance has interactive effects, the PAL is set at 10% of the ES. Unless the substance is a carcinogen, mutagen or teratogen, the PAL is set at 20% of the ES. This is the only example of the interactive effects policy having a direct impact on a groundwater quality standard.

Agricultural practices and wellheads seem to be the focus of DNR and DATCP with regard to groundwater protection. To that end, both subjects seem to be well managed, and information and data well recorded. Programs such as the Clean Sweep are proving a success, and even though its not always met, the goal for number of wells inspected during construction is on the rise. However, while these areas seem to shine, monitoring requirements at landfills seem to be minimal, not in terms of regularity of

monitoring and reporting requirements, but in the scope of monitoring.[108] In comparison to the groundwater quality standards itemized in Chapter 140 of the Wisconsin Administrative Code, landfills only have to monitor for a handful of substances. There is even less preventative action required at UST sites (though when problems arise at UST sites they are well documented). USTs are subject to periodic inspection for soundness and leak detection, but no monitoring, reporting or scheduled inspections are required on a regular basis.

In conducting research for this thesis, Wisconsin was one of the easiest states to obtain information for. The state has a long history of environmental action, particularly regarding water resources, groundwater in particular, and agricultural practices. Much of the information needed was available through a database or a DNR webpage. The biennial Executive Budgets for the state also contained a wealth of information about the programs run under each state agency. They are among the most thoroughly explained budgets reviewed. Additionally, information requests and requests for clarifications were largely welcomed and responded to quickly and thoroughly.

A summary of this section if available in Appendix D.

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[108] Wis. Code Ann. § 507.18, Appendix I.

ARIZONA

Like the Wisconsin section, this section on Arizona sets out to create a comprehensive review of the agencies, laws and programs used to manage groundwater quality in Arizona. This section also aims to provide detailed insight into the management of three common types of land uses in a way that allows for comparison to Wisconsin and Florida. It follows the same structure as the Wisconsin section, although tables and figures may be different depending on the data and information available from agencies and organizations in Arizona. For example, Arizona does not have a Clean Sweep program, but does have data on the number of pesticide inspections conducted at pesticide facilities and other sites of pesticide use.

A Brief History of Relevant Legislation and Agency Development

Most of Arizona's water history is oriented around issues of groundwater volume and surface water infrastructure projects, namely the Central Arizona Project (CAP).[109] (*Central Arizona Project*, 2016). Although somewhat overlooked, groundwater quality issues in Arizona have been very influential in the development of water laws in the state. This includes laws that concern quality issues.

The year 1938 marked the first Groundwater Study Commission to operate in Arizona. It was appointed in response to several pieces of litigation concerning water rights and pumping. Because of this, the main focus of the group was to study the

[109] The CAP is a 336-mile long diversion canal in Arizona that diverts water from the Lower Colorado River into central and southern Arizona. The CAP is the largest and most expensive canal system constructed in the United states. It is managed and operated by the Central Arizona Water Conservation District.

impact of groundwater pumping across the state. A significant result of this work was that the state legislature was persuaded to appropriate money to the USGS to perform a more detailed and extensive study of groundwater conditions. (*A History of Water Management in Arizona*, 2016). This marked the first time that groundwater was studied scientifically for state planning purposes in Arizona.

By 1945, Arizonians had become heavily (and increasingly) reliant on groundwater for consumptive, agricultural and industrial uses. This reliance in part led to the CAP, a large surface water project. By 1945, the CAP was already in the early stages of planning. However, the CAP required financial support from the Federal Government owing to its scale. The Federal Government was hesitant to contribute to CAP without first ensuring Arizona's groundwater resources for the future. In particular, there was concern that taking municipal pressures off of groundwater would result in a spike in unchecked agricultural use. The Federal Bureau of Reclamation (Bureau) issued an ultimatum: Arizona would receiving funding for the CAP only after it put groundwater restrictions in place. In response, the Arizona legislature passed the Groundwater Code of 1945, but the Bureau was not satisfied by the Code's singular requirement that all wells must be registered with the state.

In 1948, the Bureau notified Arizona that its Groundwater Code was unsatisfactory, and that funding for CAP would not be approved without more meaningful groundwater regulation. In response, the state legislature adopted the 1948 Groundwater Code. The 1948 Groundwater Code created specially designated Critical Groundwater Ares in which drilling new irrigation wells was prohibited. The Bureau

agreed to provide some funding for CAP based on these changes, however, there were still no pumping limits for existing wells.

Three years later, in 1951, concern over continued pumping at historic levels began to grow, and to some extent, concern over the impact of over pumping on quality bean to develop. In response, a Second Groundwater Study Commission was assembled to assess groundwater resources. This Commission was charged with researching the condition and volume of groundwater resources and drafting a new groundwater bill. However, it failed to do either and was ultimately disbanded.

In 1977, the Groundwater Code of 1948 was amended to clarify limitations and permissions for the sale and transportation of groundwater. The amendments were drafted by representatives from the agricultural, mining and municipal sectors, all of which would have otherwise been severely limited in moving groundwater owing to a 1976 court ruling. Notably, the amendments stipulated that damages be paid in two circumstances: first, to any landowner whose land or business suffers because of the transports, and second where water is moved out or away from a Critical Groundwater Area.[110] Even more notably, a new (and third) 25-member Groundwater Study Commission was established to aid in the implementation of the amendments. The new Commission worked to reduce the overdraft of groundwater, and assessed water quality, including the water chemical quality of aquifers and springs around the state. (Arizona Water Resources: News Bulletin, 1978).

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[110] *Id.*

The attention to groundwater quality in Arizona was relatively new, and most likely influenced by the 1972 passage of the CWA. The CWA obligated Arizona to assess and address impairments in surface waters. The first assessment was conducted in 1976, and revealed extreme systematic problems in managing septic systems and wastewater. From this, concerns about public health emerged rapidly. The Water Quality Control Council[111] and the Arizona Department of Health Services (ADHS) were jointly responsible for implementing tools and programs to meet CWA requirements. After the 1976 assessment results, they mandated better secondary treatments for wastewater and required more stringent management of septic systems, in addition to requiring National Pollutant Discharge Elimination System permits.[112] (Colby, 2007).

In 1979, the Groundwater Study Commission released a Draft Report of Tentative Recommendations. (*A History of Water Management in Arizona*, 2016; *Arizona Water Resources: News Bulletin*, 1980; *Arizona Water Resources: Project Information*, 1980). At the same time, the US Secretary of the Interior again notified Arizona that the CAP project would not continue to receive funding unless the state passed groundwater regulations that protected both the quality and quantity of groundwater. (*A History of Water Management in Arizona*, 2016; *Layperson's Guide to Arizona Water*, 2007). The 1948 amendments had done nothing to reduce groundwater

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[111] This Council worked to track and manage water quality issues in Arizona. It's duties were assumed by ADEQ when it was formed in 1986.

[112] Colby, Bonnie, and Katharine L. Jacobs, Arizona Water Policy: Management Innovations in an Urbanizing Arid Region 121, 122 (2007). By 2004, Arizona had largely resolved the water quality problems of the 1970's, though it faced new problems and continues to today. *Id.*

pumping and it had continued wholly unrestricted. The results were staggering drops in aquifer levels, earth fissuring, and land subsidence, all of which concerned the Bureau.

On June 11, 1980, the legislature passed the Groundwater Management Act, which was based on final recommendations made by the Groundwater Study Commission. Once the act was passed, the US Secretary of the Interior authorized CAP funding and by 1984 the CAP began delivering water to Central Arizona. The Arizona Department of Water Resources (ADWR) oversaw implementation of the new legislation.

Much of the new legislation approached groundwater quality management through addressing the high rates of groundwater-surface water interaction across the state, and still did not regard groundwater quality as a serious issue. Like many other states at the time, Arizona's Water Quality Control Council and ADHS relied on soil to sufficiently filter out pollutants and naturally maintain the quality of groundwater at safe levels. These agencies had assumed that because most of the aquifers in the state lie deep under the soil that potential for contamination was minimal to begin with. However, the new legislation did impose a few direct requirements, such as groundwater quality monitoring. (*Arizona Water Resources: News Bulletin*, 1980). Separately, from the 1960's through the 1980's, there were nation-wide improvements in groundwater testing, as well an improved understanding of synthetic chemicals. The convergence of the groundwater monitoring requirements and the improved knowledge and technology pertaining to synthetic chemicals ultimately revealed that Arizona actually had a serious

groundwater contamination problem. Pesticide contamination was rampant and industrial solvents prolific. In fact,

> . . . by 1986 industrial solvents, most prominently the volatile organic compounds trichloroethane, trichloroethylene, and perchloroethylene had been detected in 389 wells and 30 different sites in a total of 122 square-mile sections. Drinking water wells were contaminated by VOCs at 10 of the sites; others have been discovered since then, and cleanup continues in most of them to the present day. (Bonnie Colby, 2007).

Lawmakers were galvanized by the severity of the contamination. With stakeholder input, they wrote and passed the Environmental Quality Act (EQA) in 1986. (Hawke, 1986). It's primary purpose: to protect groundwater as a drinking water resource.[113] (Hawke, 1986). At the time, the EQA was heralded as the most comprehensive and stringent groundwater protection law in the country.[114] (*Arizona's Environmental Quality Act, A Legislative Milestone*, 1987; Hawke, 1986).

In accordance with the EQA, the Water Quality Control Council was disbanded, and the duties it shared with the ADHS were fully assumed by the newly created

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[113] McKinnon, Shaun, *Unabated use of groundwater threatens Arizona's future*, THE ARIZONA REPUBLIC (Aug. 2, 2009), *available at* http://archive.azcentral.com/arizonarepublic/news/articles/2009/08/02/20090802 bucket-groundwater.html. Significant depletion of the state's resulting from unchecked pumping also encouraged a major overhaul of groundwater management, though to a lesser degree than quality issues. *Id.*

[114] Ariz. Rev. Stats. § 49-264. The EQA was also highly lauded for a unique feature: private citizen lawsuits. *Id.* The EQA includes a provision that gives private citizens authority normally solely reserved for the attorney general to file private suits against the state for failure to uphold the provisions and mandates of the EQA and against the Director for failure to perform a nondiscretionary duty. *Id.* Suits may be filed for the enforcement of statutes, rules, permits and order, or for violations of standards, permits, discharge permits, or other rules. *Id.* Citizens who prevail in these suits are entitled to attorney's fees under the EQA. *Id.* Suits may be barred only when there are de minimus violations and if the Director or attorney general is already taking action. *Id.*

Arizona Department of Environmental Quality (ADEQ). Additionally, the EQA eliminated the Board of Pesticide Control,[115] which had been operable since 1956. Pesticide managed was reallocated across three other existing agencies: the Arizona Department of Agriculture (ADA) is responsible for adopting pesticide application rules including identifying buffer zones and pesticide management areas; the Industrial Commission is responsible for farmworker safety via its Occupational Safety and Health Division; and ADEQ operates all other programs related to groundwater quality. ADEQ is almost entirely responsible for groundwater quality. It manages several programs (some specifically geared toward land use practices or industries), and handles all monitoring and most reporting requirements for the state.

Agency Integration and Programs

Nearly all of the relevant programs are managed by ADEQ or the ADA.

Arizona Department of Environmental Quality

ADEQ is the primary agency managing groundwater quality, and the majority of groundwater quality protection programs belong to ADEQ. This agency has three divisions, two of which are relevant to groundwater quality: the Waste Programs Division and the Water Quality Division. The Waste Programs division is responsible for landfills. The Water Quality Division handles most of ADEQ's groundwater quality

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[115] *A Performance Audit of the Board of Pesticide Control*, Office of the Auditor General (Sept. 1983), *available at* http://azmemory.azlibrary.gov/cdm/ref/collection/statepubs/id/6577. Although the EQA was ultimately the tool by which the Board of Pesticide Control was disbanded, a performance audit conducted by the Joint Legislative Oversight Committee in 1983 cites the Board as being ineffective and having taken too few disciplinary actions to serve its purpose of protecting the public through regulating the sale and use of agricultural pesticides in Arizona. *Id.* It was recommended at the time that the Board be merged with the Commission of Agriculture and Horticulture. *Id.*

protection programs. Broadly, it works to identify water pollution problems, to develop water quality standards to address those pollution problems, and to regularly conduct monitoring and assessment of groundwater throughout the state. More specifically, it is responsible for: pollution control, monitoring and assessment, compliance management, cleanup of contaminated soil and water, education, outreach and financial assistance and policy development. Because of its broad ranges of responsibilities, the Water Quality Division's programs influence water supply planning and operations at the local level.

ADEQ relies on several permit systems and programs to prevent groundwater pollution. Each of these aims to control discharges that could migrate to aquifers from facilities such as wastewater treatment plants, mining operations, industrial facilities, on-site sewage disposal systems, direct reuse of reclaimed water as well as discharges to drywells. Any discharges, including effluent reuse, recharge projects and discharge of water to aquifers or streambeds, must meet water quality standards. (*Arizona Water Atlas*, 2014).

Aquifer Protection Permits

The Aquifer Protection Permit (APP) program regulates the discharge of pollutants into aquifers.[116] (*Aquifer Protection Permits*, 2016; *Water Quality Programs*, 2009). The APP program is enforceable based on groundwater quality standards. (*Aquifer Protection Permits*, 2016). However, requests for enforcement data were not

[116] Ariz. Rev. Stats. § 49-201. The term "discharge" means the addition of a pollutant from a facility directly to an aquifer or to the land surface or the vadose zone in such a manner that there is a reasonable probability that the pollutant will reach an aquifer. *Id.* This does not regulate any naturally occurring pollutants such as arsenic and uranium, which appear in areas throughout the State.

responded to and data was not available in Executive Budgets, or publicly available reports or databases.

The APP program is applicable to facilities that discharge pollutants either directly into an aquifer, to the vadose zone, or to the land surface in such a way that it has the potential to migrate to an aquifer.[117] (*Aquifer Protection Permits*, 2016). The APP sets out specific discharge limits, monitoring and reporting requirements. They may also require facilities to undertake special measures to protect human health and the environment from harmful pollutants.[118] (*Aquifer Protection Permits*, 2016). These are determined on a case-by-case basis. Unless exempted, or operated so that there is no possibility of pollutant migration to an aquifer, the following require an APP:[119]

1. Surface impoundments, pits, ponds, and lagoons;
2. Solid waste disposal facilities, except for mining overburden and wall rock that has not been subject to mine leaching operations;
3. Injection wells;
4. Land treatment facilities;
5. Facilities adding pollutants to a salt dome, salt beds, or salt formations, drywells, underground caves, or mines;
6. Mine tailings piles and ponds;
7. Mine leaching operations;

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[117] *See* Ariz. Rev. Stats. §§ 49-201(12), 49-241—252, 49-261; Ariz. Admin. Codes § R18-9-101—403.
[118] *See* Ariz. Rev. Stats. §§ 49-107, 49-111, 49-241.01, 49-243, 49-244, 49-245.
[119] Ariz. Rev. Stats. § 49-250. There are currently that may be statutorily exempt from requiring an APP. *Id.* In addition, there are four class exemptions and two activities to which the program does not apply. *Id.*

8. Septic tank systems;
9. Underground water storage facilities (if wastewater-effluent is used);
10. Sewage or wastewater treatment facilities;
11. Wetlands designed and constructed to treat municipal and domestic wastewater for underground storage.

Of the 11 facility types that require an APP, sewage collection systems and septic tanks receive some more focused attention because they have been long-standing groundwater pollution problems in Arizona. (*Aquifer Protection Permits*, 2016).

Before issuing an APP, ADEQ staff analyzes the constituents in the applicant facility's discharge, and simultaneously considers the availability of any technology relevant to the facility that could be used to improve discharge quality. ADEQ's Division of Water Quality then establishes a numeric discharge limit for the facility, and mandates what technologies and Best Management Practices (BMPs) must be used to achieve the limit. For the most part, cost considerations are not made when discharge limits are set, though in some cases prohibitive costs are considered. Regardless of what technology is in place or otherwise available, the discharge quality must meet Arizona's aquifer water quality standards, which are the equivalent of the maximum contaminant level for pollutants set by the SDWA. Otherwise, an APP will not be issued.

Both general and individual APPs are issued. General permits may be issued for activities that are subject to uniform regulations, and which generally have smaller facilities that produce environmentally low-risk discharges. (*General Permits and How*

They Protect the Environment, 2016). Individual permits may be issued for facilities that require individualized evaluation.

ADEQ is required to publish a list of applications submitted for individual APPs. When an individual APP is likely to be issued, ADEQ makes a public notice and requests comments on the permit prior to its approval.[120] Particularly controversial applications may merit a public hearing.[121] The Director of ADEQ is also required to issue public notices in generally circulated newspapers when individual permits are prepared or tentatively denied.[122]

The APP program is very functional despite the strict limits it poses on business and industry development. In fact, "Since its inception in 1986, the APP program has permitted more than 2,000 facilities, ranging from mines to power plants to wastewater treatment plants, and has issued general permits to regulate discharges from tens of thousands of septic tanks." (Bonnie, 2007).

Enforcement and tracking data for the APP program is limited. None is recorded in Executive Budgets or other documents available through the Governor's Strategic Planning and Budgeting Office. ADEQ's Water Quality division was able to provide only two years' due to changes in the tracking system used.[123] For fiscal year 2012, the APP program goal for new and renewed permits was 151, and 227 were incurred.[124] For

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[120] Ariz. Rev. Stats. § 49-241-252; Ariz. Admin. Code § R18-9-101-403; *Aquifer Protection Permits*, Ariz. Dep't of Envt'l Prot. (Jan. 7, 2016), *available at* https://www.azdeq.gov/environ/water/permits/app.html.
[121] *Id.*
[122] *Id.*
[123] Email communication with Mahota Hadley, Environmental Planner, Water Quality Division, Arizona Department of Environmental Quality on May 27, 2015.
[124] *Id.*

the year 2013, the goal was 121 new and renewed permits issued and 170 achieved.[125] Notably, in both years, the APP program qualified as a measure to protect human health and ensure safe drinking water.

Drywell Program

Drywells may only receive stormwater runoff or certain types of discharges.[126] Because stormwater has the potential to pick up sediments and a variety of pollutants, drywells are designed with grate covers and settling chambers. This helps filter the stormwater before it drains into soil, and eventually to aquifers. (*Groundwater Protection In Arizona,* 2002). Even still, contaminants may still end up in aquifers, and as a result, all drywells must be registered with ADEQ.[127] (*Groundwater Protection In Arizona,* 2002). Registration requires a fee and the submission of site-specific information about the location and owner of the drywell. (*Groundwater Protection In Arizona,* 2002).

There are some cases in which an APP may also be required to use a drywell. For example, owners may also need to obtain an APP if their drywell is located in an area where motor vehicles are fueled or where hazardous substances are present. (*Groundwater Protection In Arizona,* 2002). Also, a drywell that receives discharges other than stormwater must obtain an APP. Accidental spills may also result in drywell closure, an enforcement action, or necessitate an APP. Accidental or not, if other fluids are received by the drywell, the drywell may then be considered an underground

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[125] *Id.*
[126] Ariz. Rev. Stats. § 49-250(23).
[127] Ariz. Rev. Stats. § 49-331—336.

injection well that requires separate and additional permitting from both ADEQ and the EPA.

ADEQ manages a Drywell Database, but it is geared more toward owners of drywells. (*Groundwater Protection In Arizona,* 2002). Very specific information is required in order to search it, such as facility name, address, or registration number. There is also a related database that captures permit information for planned drywells, however it provides no information as to the outcome of the permitting process.

Enforcement and tracking data for the Drywell program is limited. None is recorded in Executive Budgets or other documents available through the Governor's Strategic Planning and Budgeting Office. ADEQ's Water Quality division was only able to provide two years' worth of data for the Drywell program as a result of changes in the tracking system used.[128] In 2012, 328 drywells were registered, and in 2013 an astounding 1,787 were registered.[129] The drywell program was categorized as a program designed to protect human health and ensure safe drinking water. For the remaining programs reviewed in this thesis, no enforcement or tracking data was available.

Clean Closure Approval

Instead of an APP permit, ADEQ can issue a clean closure approval for drywells. To receive a clean closure approval, facilities must be closed in such a clean condition that post-closure monitoring is not needed. (*Groundwater Protection In Arizona,* 2002). Because an APP can take a long period of time to obtain and a clean closure approval

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[128] Email communication with Mahota Hadley, Environmental Planner, Water Quality Division, Arizona Department of Environmental Quality on May 27, 2015.
[129] *Id.*

greatly expedites the closure process, this program encourages facilities to evaluate the impact of discharges and remediate soils if necessary on their own.[130] (*Groundwater Protection In Arizona,* 2002).

Recharge Permit

ADEQ issues APPs for aquifer recharge projects using treated wastewater. For more common type of recharges projects, such as surface water runoff collection, ADEQ certifies a Recharge Permit that is issued by the ADWR. (*Groundwater Protection In Arizona,* 2002). Certification is contingent on ADEQ finding the project will not cause contaminants to leach from the vadose zone or cause a contaminant plume to migrate. As part of the certification process, ADEQ reviews and approves a proposed water quality monitoring plan for the recharge project. (*Groundwater Protection In Arizona,* 2002).

Pesticide Groundwater Quality Protection Program

The Pesticide Groundwater Quality Protection program works to prevent and eliminate aquifer pollution from the routine use of agricultural pesticides. (M*anaging Pesticides to Protect Water Quality*, 2009). Agricultural pesticides are those used in the following agricultural sub-industries (*Arizona's Pesticide Groundwater Quality Program,* 2015):

- Greenhouses (commercial or research)
- Cropland
- Food and fiber production
- Forests

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[130] Ariz. Rev. Stats. § 49-252.

- Irrigation ditches
- Rangeland
- Ground applied seed protection
- Soil fumigation
- Tree farms
- Sod farms
- Aquatics

This program is built on a few different elements, each of which contributes to the overall success and comprehensiveness of the program.

Groundwater Protection List

The Groundwater Protection List (GPL)[131] identifies active ingredients in pesticides that have the potential to contaminate groundwater, and sets specific numeric standards for them. (*Water Quality Programs,* 2015). ADEQ consults with the Arizona Department of Water Resources (ADWR) and ADA before it sets specific numeric values for pesticide ingredients. ADEQ is statutorily obligated to create this list and to revise it annually.[132] Revisions may from new pesticide registrations, the discontinued use of pesticides, or for several other select reasons.[133] Revisions can be made to the numeric standards, as well as rules regarding the administration of the GPL and enforcement provisions. Any changes must be posted for public comment before they

[131] Ariz. Rev. Stats. § 49-301—310; Ariz. Admin. Codes § R18-1-500; R18-6.
[132] Ariz. Rev. Stats. § 49-305; Ariz. Admin. Codes § R18-6-301(A)(1)-(2).
[133] Ariz. Admin. Codes § R18-6-301(A)(1)-(2).

are finalized.[134] The final list is published in the state's annual pesticide report.

ADEQ is obligated to regulate the use of any GPL ingredients when they are intended to be used for agricultural practices, specifically when they will be "applied or injected into the soil by groundwater application equipment or chemigation, or if the application site will be flood or furrow irrigated within 72 hours of application of the pesticide based on label recommendations." (*Arizona's Pesticide Groundwater Quality Program*, 2015). Although unlikely to occur, use of this pesticide for non-agricultural practices would not be regulated by ADEQ unless it appears separately on the Water Quality Standards list.

Users of pesticides containing GPL ingredients are subject to requirements in use. For example, anyone who performs these types of applications must adhere to the BMPs developed by ADEQ. Also, any agricultural activity that uses listed ingredients is subject to special application and reporting regulations. Last, users of pesticides on the GPL or containing listed ingredients must report the use to the ADEQ and pesticide vendors must make quarterly sales reports to the ADEQ.

Within a year of listing an ingredient on the GPL, ADEQ must conduct both soil and groundwater testing to assess whether the ingredient has compromised groundwater as a result of agricultural use. If the ingredient is found in groundwater, ADEQ must pursue compliance and enforcement actions against the registered users. If the ingredient is a known carcinogen, mutagen, teratogen or is toxic to humans and is detected at a harmful level, ADEQ is required to notify the ADA so that the ADA can

[134] Ariz. Rev. Stats. § 49-305; Ariz. Admin. Codes § R18-6-301(A)(1)-(2).

cancel the registration of all agricultural pesticides containing the active ingredient.

The Department is also responsible for operating a continuous monitoring program that detects the appearance of any listed ingredients in groundwater. If any of the listed ingredients are found in groundwater as a result of agricultural practices, ADEQ has the authority to demand modifications in the application or use of the pesticide. ADEQ is also authorized to cancel the pesticide registration depending on the extent of the contamination detected (though generally ADEQ will recommend that the ADA cancel it). If the registration is cancelled the product may no longer be used.

New Pesticide Product Registration

The New Pesticide Product Registration program evaluates the mobility and persistence data submitted to ADA with new pesticide product registration applications.[135] Under the EQA, applicants registering new agricultural pesticides with the ADA are also required to submit groundwater protection data for review and approval to ADEQ. (*Arizona's Pesticide Groundwater Quality Program,* 2015). Applicants must submit the product chemistry and environmental fate studies of the active ingredients in the pesticide. This information is also reviewed for technical completion: ADEQ weighs the adequacy, validity and completeness of the data submitted in rendering registration decisions. A poor review on these counts can prevent a successful registration. Additionally, the pesticide manufacturers are expected to provide detailed information and data to ADEQ in order for it to make a determination on mobility.

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[135] *See* Ariz. Admin. Codes § R18-6-103.

Based on all of the information provided, ADEQ performs a technical review of the data submitted and determines whether the pesticide has any active ingredients that pose a threat to groundwater. If so, the active ingredient is added to the GPL. Anyone with plans to use a pesticide containing a GPL ingredient must also provide ADEQ with their intended BMPs. Otherwise, the registration will be incomplete. If none of the ingredients merit placement on the GPL, but ADEQ has concerns about an ingredient, it may require special monitoring or implement use regulations. ADEQ's review is also used to establish a registration cancellation procedure for those registration applicants that are successful. The cancellation procedure is triggered if the pesticide is found in groundwater or at specified soil depths where groundwater contamination is likely.[136]

Since 2001, ADEQ has been giving conditional registration status for agricultural pesticides valid for one year.[137] This allows for temporary registration of products for which not all data on mobility and persistence has been reviewed by ADEQ. Products are eligible for this only if they contain an active ingredient determined to be of reduced risk by the EPA, or the active ingredient is important for agricultural success. Conditional registration is annually renewable for no more than three years.

Annual Report

Based on the GPL and information received through user and manufacturer reports, the ADEQ creates an annual report on pesticide usage in the state for the legislature. The report contains information about the conditions of state water

[136] Depth requirements are at or below eight feet of soil, below the crop root zone, or below the microbial zone.
[137] Ariz. Rev. Stats. § 49-310.

resources, goals, suggestions and needs for management, and is also the publication site of the final GPL every year.

Land Use and Contaminants: Farming Practices and Atrazine

Only two pesticides, Dibromochloropropane and Ethylene Dibromide, were detected in Arizona groundwater prior to 1980. Both were used from the 1950's to the 1970's in citrus and cotton fields, but were eventually banned because of their potential for carcinogenicity. (*Arizona's Pesticide Groundwater Quality Program*, 2015). In the late 1990's and early 2000's different pesticides were detected in groundwater including Atrazine, Methomyl, Metribuzin and Prometryn. For all of those pesticides the contamination was localized and was not indicative of a regional or statewide problem. Additionally, all of the detections were below health-based guidance levels. (*Arizona's Pesticide Groundwater Quality Program*, 2015).

Since 2002, Atrazine hasn't been mentioned in any of the annual Director's Repots or Water Quality Assurance Revolving Fund summaries. It also does not appear in any of the Pesticides Annual Reports except for its presence on the GPL list. Because it is on the GPL, pesticides that contain Atrazine as an active ingredient are very strictly regulated and it is monitored for in groundwater by the ADA. The enforcement standard for Atrazine in groundwater is 3^2 μg/L.

Monitoring for Pesticides

ADEQ conducts regular groundwater testing and monitoring for ingredients on the GPL to determine whether any of the GPL ingredients have reached a groundwater supply. If any of the listed ingredients are found in groundwater as a result of

agricultural practices, ADEQ has the authority to demand modifications in pesticide application or use, or even cancellation of registration depending on the extent of the contamination detected, though generally ADEQ will recommend that the ADA cancel it. If the registration is cancelled the product may no longer be used. Some pesticides are subject to special monitoring or regulations, whether or not they are on the GPL simply because ADEQ developed concerns about them during the registration review process. If discovered in an aquifer, ADEQ may require changes in the application or use of these pesticides, but has to request that the ADA cancel the registration.

Reclaimed Water Permits

Reclaimed water use is very much encouraged throughout Arizona. However, there are strict regulations regarding the use of reclaimed water.[138] Permits are required for reclaimed water for:

- An owner or operator of a sewage treatment facility that generates reclaimed water for direct reuse;
- An owner or operator of a reclaimed water blending facility;
- A reclaimed water agent;
- An end user;
- A person who uses gray water;
- A person who directly reuses reclaimed water from a sewage treatment facility combined with industrial wastewater or combined with reclaimed water from an industrial wastewater treatment facility; and

[138] Ariz. Rev. Stats. § 49-245.02; Ariz. Admin. Codes §§ R18-9-6—7, R18 -11-3.

- A person who directly reuses reclaimed water from an industrial wastewater treatment facility in the production or processing of a crop or substance that may be used as human or animal food.

Additionally, all wastewater treatment facilities providing reclaimed water for reuse must have an individual APP. An APP for reclaimed water requires special monitoring and reporting on the quality of the reclaimed water. This is to ensure that established effluent limitations for reclaimed water quality classes are met. There are five classes of reclaimed water, each of which demands a different combination of minimum treatment requirements and numeric quality criteria.

Land Use and Contaminants: Solid Waste Landfills and DEET

The Waste Programs Division of ADEQ manages municipal solid waste landfills.[139] At present there are 43 municipal landfills in Arizona. These facilities must have a Solid Waste Facility Plan approved by ADEQ. (*Arizona Solid Waste Management Plan*, 1981; *eMaps*, 2015). The application process requires a significant amount of technical information, but its relatively straight forward procedurally.[140] An applicant provides a complete application to ADEQ for review, a long with a $20,000

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[139] *Arizona Solid Waste Management Plan*, ARIZ. DEP'T ENVTL. QUALITY (Mar. 1981), *available at* http://www.azdeq.gov/environ/waste/solid/download/aswmp_1981.pdf. A municipal solid waste landfill is any landfill that accepts household waste and household hazardous waste. *Id.* Arizona is very attentive to rules, regulations, policies and planning efforts pertaining to waste. *Id.* It developed its first solid waste management plan in 1981, just after the 1980 Groundwater Management Act and five years before the passage of the 1986 Environmental Quality Act. *Id; Landfill Tonnage Reports*, ARIZ. DEP'T ENVTL. QUALITY (Jan. 5, 2016), *available at* http://www.azdeq.gov/environ/waste/solid/index.html. In addition, since 2002 the state has tracked very closely the volume of waste that winds up in landfills every year, and even every quarter. *Id.*

[140] Ariz. Rev. Stats. § 49-762.04.

initial fee.[141] The application is reviewed and the applicant has time to provide any missing information, after which ADEQ posts public notice that a 30-day public comment period has opened. After the public comment period, the applicant may provide information or data to ADEQ to address comments that have raised issue of concern. ADEQ then renders a final decision either granting or denying the application. The decision is appealable.[142] (*Municipal Solid Waste Facility Plan Application Instructions,* 2015). If the application is granted, a public hearing may be required depending on both the number and nature of the comments received during the comment period.[143]

Once an application is granted, the applicant becomes the permittee: the person responsible for facility compliance.[144] (*Arizona Solid Waste Management Plan*, 1981). At this point, ADEQ sends the permittee a final invoice, which can cost up to $200,000 depending on how many hours the permit team needed to process the application.[145] When the invoice is paid, ADEQ issues the permit.

Permittees must notify ADEQ within 30 days prior to the facility becoming operational.[146] The notice must include information such as a description of the waste to be stored at the site, the type and volume of waste handled, descriptions and methods of

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[141]Ariz. Admin. Codes § R18-13-702(A).
[142] Ariz. Rev. Stats. § 41-1092.
[143] Ariz. Rev. Stats. § 49-762.04(A)(6); Ariz. Admin. Codes §§ R18-1-516, R18-1-525. The time frame for this process varies from up to 94 days to up to 156 days depending on whether a public hearing is required.
[144] 40 C.F.Rr. § 258; Ariz. Rev. Stats. § 49-762 et seq. Often the "permittee" may be more than one entity including the landfill owner and the landfill operator, should they be two separate entities. *Id.*
[145] Ariz. Admin. Codes § R18-13-702(A). The permit team assigned to your project will bill at a rate of $122 per hour up to a maximum fee of $200,000. *Id.*
[146] Ariz. Rev. Stats. § 49-762.07.

waste management intended at the site, and a diagram of the facility. Arizona also requires that landfills have a response action plan in the event there is a leak,[147] and that the permittee demonstrates financial assurance annually to deal with leaks or other problems that may arise.

Municipal solid waste landfills are subject to Federal construction and monitoring requirements. Arizona does not have any additional rules or regulations for municipal facilities beyond Federal requirements.[148] Under Federal regulations groundwater monitoring is required to ensure protection of aquifers. Owners and/or operators must monitor for 62 constituents ranging from acetone (a solvent commonly found in nail polish remover) to lead.[149] Benzene is also one of the constituents that owners and operators are obligated to monitor for.[150] Benzene has a groundwater enforcement standard of 5 µg/L . N,N-Diethyl-meta-toluamide (DEET), is not on the list.[151]

Under the federal law if any of the 62 constituents is detected at a "statistically significant higher level than the established background level" the landfill owner/operators must notify ADEQ immediately and the facility must begin a narrower monitoring program within 90 days of detection. Part of this program includes

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[147] Ariz. Admin. Codes § R18-8-264(A).
[148] 40 C.F.R. 257-58.
[149] 40 C.F.R. 258, Appendix I.
[150] *Id.*
[151] *See Id.*

monitoring for an expanded list of 214 constituents.[152] N,N-Diethyl-meta-toluamide (DEET), is also absent from the expanded list.[153]

Land Use and Contaminants: Underground Storage Tanks and Benzene

The responsibilities for USTs fall to ADEQ's Waste Programs Division (WPD). (*Petroleum Contaminated Soils*, 2008; Underground Storage Tanks, 2006). WPD oversees the development of operational requirements, and enforces any rules or regulations that apply to USTs. WPD prepares registration forms and manages the permit process for USTs. WPD is very pro-active. It carries out inspections on a periodic basis and assists owners and operators in compliance matters to resolve any problems quickly. ADEQ also approaches UST management with a pre-emptive approach. ADEQ emphasizes preventative action and rapid remedial action, and as a result uses fees and fines to deter non-compliance. For example, ADEQ imposes non-compliance fines of up to $25,000 per day for oil-contaminated soils and groundwater.

Because Arizona has identified USTs[154] as a significant environmental risk within the state, most of WPD's work revolves around preventing and resolving leaks. This is achieved through monitoring and regulations.[155] (*Petroleum Contaminated Soils*, 2008). USTs must be monitored for releases. There are a variety of methods and tools used in detecting releases such as: inventory control; manual tank-gauging; precision

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[152] 40 C.F.R. 258, Appendix II.
[153] *See Id.*
[154] Ariz. Rev. Stats. § 49-1001. USTs are defined as the storage tanks themselves, and in some circumstances associated pipe systems. *Id.*
[155] Ariz. Rev. Stats. § 49-1001. "Release" means a spill, leak, emission, discharge, escape, leach or disposal of a regulated substance from an underground storage tank into groundwater, surface water or soils. *Id.* USTs are not obligated to subscribe to any BMPs. *Id.*

tightness testing; automatic tank gauging and vapor monitoring; groundwater monitoring; and interstitial monitoring. (*Petroleum Contaminated Soils*, 2008; Tank-System Site Assessment, 2013). A UST with a suspected release is generally revealed in one of three ways: 1) soil analytical results confirm a release at the time of UST Permanent Closure; 2) site checks (soil borings, groundwater sampling, etc.) in response to suspected releases confirm a release; or 3) the project manager or a case manager of the site discovers that a new release has occurred through soil, groundwater, or soil vapor analysis.[156]

When a suspected release is discovered, the owner or operator must completely empty the UST and it pipe system. (Tank-System Site Assessment, 2013). Then all of the equipment must be thoroughly inspected by a tank service provider who identifies the cause of the release. (Tank-System Site Assessment, 2013). Usually, the cause is equipment related, and if necessary, a tightness test of the system must be performed. If the tightness test indicates that the system is not tight enough or contaminated media (soil, groundwater, etc.) is present, a site check is required to confirm the release.

A site check measures for the presence of a contaminant that is being contained in the UST. (Tank-System Site Assessment, 2013). Certain criteria are used to help identify the location of the leak and determine the sampling protocol necessary to complete the site check. Those criteria include the nature of the substance contained in the UST, the cause for suspicion of release, the type of backfill, depth to groundwater,

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[156] Email communication with Jason Kocer, Unit Manager, Site Investigation and Remediation Unit, Arizona Department of Environmental Quality on October 9, 2015.

and the substance and the site. Samples are collected in areas where evidence, such as stained soils or odors, indicates a release may have occurred. If a suspected release is located in the system pipes, soil samples are collected from 20 feet beneath the pipes and fittings.

When a leak is confirmed, the owner or operator must notify ADHS immediately, and ADEQ within 24 hours; ADHS and ADEQ work together to resolve the leak. The owner or operator must also cease operations and perform corrective actions before it may be used again.[157] An investigation as to the cause of the leak must be initiated within 72 hours and completed within 90-days.[158] Within 14-days a report on the release must also be submitted to ADEQ. ADEQ determines what the response action will be and the Environmental Services section of ADHS assists in carrying out the response measures. Additionally, from the time the leak is confirmed, the UST is placed on a public database noting the leak until the necessary repairs are made.[159]

In addition to the monitoring requirements, USTs are subject to a number of operational regulations. For example, USTs are regulated for spill containment, overfill prevention, release response and tank abandonment and/or removal. USTs must be fitted with spill containment and overfill protections such as [160] automatic flow shut-offs or a high level alarms. A non-compliant UST may be subject to a stop use order from

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[157] Ariz. Admin. Codes §§ R18-12-260--264.01; Ariz. Rev. Stats. § 49-1001-1093.
[158] Ariz. Rev. Stats. § 49-1023; Ariz. Admin. Codes § R18-12-260(A).
[159] Ariz. Rev. Stats. § 49-1023.
[160] Ariz. Rev. Stats. § 49-1001. USTs installed prior to December 22, 1988, that contain motor fuel, used oil and emergency generator oil must have been retrofitted with a spill and overfill prevention device. *Id.*

ADEQ.[161] A stop use order requires immediate suspension of use of the tank and prohibits delivery to the tank while the owner or operator brings the tank back into complete compliance.[162]

In addition to the spill containment and overfill technology required for a UST, all USTs containing fuels and oils such as gasoline must be registered with ADHS. They are also subject to additional ADEQ requirements. For example, in addition to being notified of any releases, ADEQ must also be made aware of information such as the location of the tank, changes in service, repairs or modifications to USTs, and tank removal. In addition, ADEQ requires notice of abandonment, closure or removal 30 days prior to taking action. The removal or closure of tanks is subject to ADEQ closure requirements that demand removing the stored substance, purging the tank, disconnecting lines; removing any contaminated soils; and performing a site assessment for contamination and corrective action. Owners of USTs containing fuel must maintain detailed records of repairs, modifications, leak tests, and any virtually any other events concerning the UST. These records are important for inspections, abandonments, removal or closures.

ADEQ manages publicly available databases for USTs and LUSTs. Although these databases are helpful in assessing the status of particular USTs and LUSTs, they are not practical for comprehensive analysis. For example, it is possible to determine the number of reported LUSTs in a specified time frame, but it involves manual counting

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[161] Ariz. Rev. Stats. § 49-1023.
[162] Ariz. Rev. Stats. § 49-1023.

and independently organizing the data. Another example is that data on the number of known leaks is not readily available from the LUST database. This is primarily because the LUST database tracks leaking UST systems, and one system may have multiple leaks in a year.[163] Yet another scenario is that multiple UST systems may be located in the same UST basin, and only one release is reported for the basin area. Still, knowing how many systems have leaks is beneficial. Figure 10 shows a steady decline in the number of reported leaks over the past twenty years.

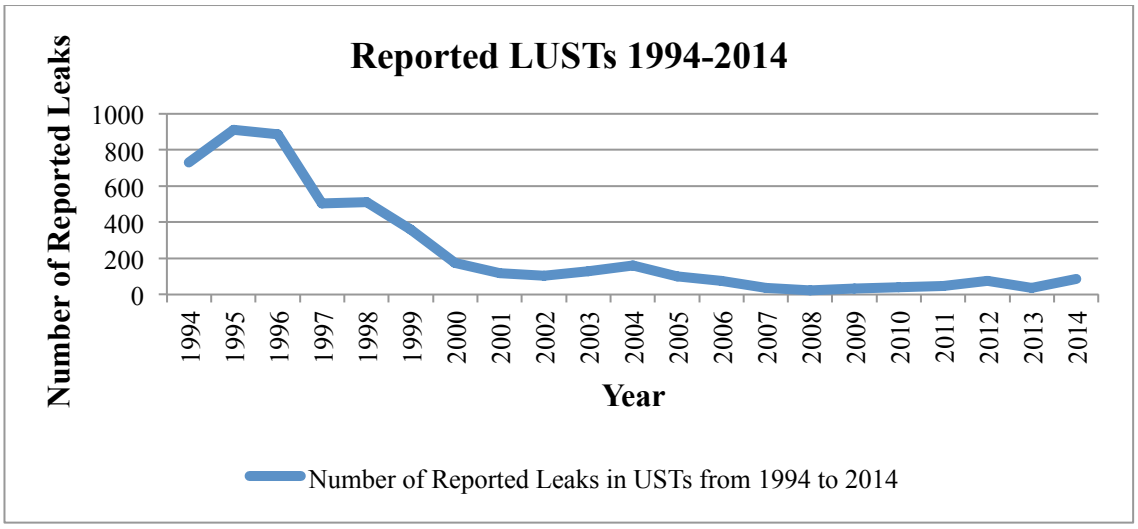

Figure 10: Arizona Reported LUSTS 1004-2014. Data provided by ADEQ.

[163] Email communication with Jason Kocer, Unit Manager, Site Investigation and Remediation Unit, Arizona Department of Environmental Quality on October 9, 2015.

There are no requirements for monitoring specific to Benzene at UST sites. However, Benzene is regulated and appears on the Numeric Aquifer Water Quality Standards: Drinking Water Protected Use.[164] Benzene in drinking water should not exceed 5 μg/L.[165]

Monitoring and Research

Although ADEQ has eliminated or significantly reduced the presence of contaminants first found in Arizona's groundwater in the 1970's, many contaminants still enter groundwater in variety of ways. As a result, ADEQ has continued to conduct groundwater monitoring throughout the state; this program is called the Ambient Monitoring Program.

ADEQ has been able to characterize each of the 51 groundwater basins identified throughout the state. Under the Ambient Monitoring Program, groundwater sampling is conducted in each basin in accordance with that basin's sampling plan. Samplings plans differ depending on land uses, contamination history and any concerns unique to the basin.

The sampling plan is developed by ADEQ prior to any sampling beginning. Sampling methods are not uniform across the state, but generally include some version or combination of systematic, grid-based random sampling, stratified random sampling, and random sampling to determine regional groundwater quality. Some areas merit denser sampling sites depending on the land uses within them.

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[164] Ariz. Admin. Codes § R18-11-406(C).
[165] *Id.*

The samples are analyzed for inorganics, oxygen and hydrogen isotopes. The samples are also checked for VOCs, currently registered pesticides, banned pesticides, perchlorate, and other substances of concern. In addition to random site sampling, each basin has a designated index well used as a constant in comparing groundwater quality changes over time. These wells are sampled at regular intervals.

ADEQ adds all of this data to its Groundwater Database, and also presents the results publicly in two formats: a long form Open File Report and a condensed four-page Fact Sheet. Additionally, sampling results are automatically disclosed to the owner of the well site from which a sample was taken.

Arizona is still experiencing a population influx to areas that rely on public water systems using groundwater. This level of monitoring helps assure people that their water meets SDWA standards, and for state planning purposes. The data is compiled to illustrate anticipated quality issues in a given basin or region, as well as changes in quality in a given basin over time, and shared with the public in that form. So far, Ambient Monitoring Program reports have been completed for 20 groundwater basins.

Budget and Staff

Figure 11 illustrates changes over the last decade in the number of full time employees (FTEs), as well as changes in the total budget for ADEQ, and the budgets for the Water Quality and Waste Programs. All of these variables have fluctuated greatly. ADEQ's budget was severely reduced in 2010, as was that of the Water Quality division. Although the Waste Program budget also fluctuated, the impact was much less severe and it appears to have begun increasing in the last few years.

Notably, the pattern of the Water Quality budget's fluctuation closely mimics the pattern of change in ADEQ's larger budget. The extent of the fluctuation for the Water Quality division budget is such that it ranges from comprising between 8-81% of ADEQ's total budget across the years, even when changes to ADEQ's total budget are accounted for.

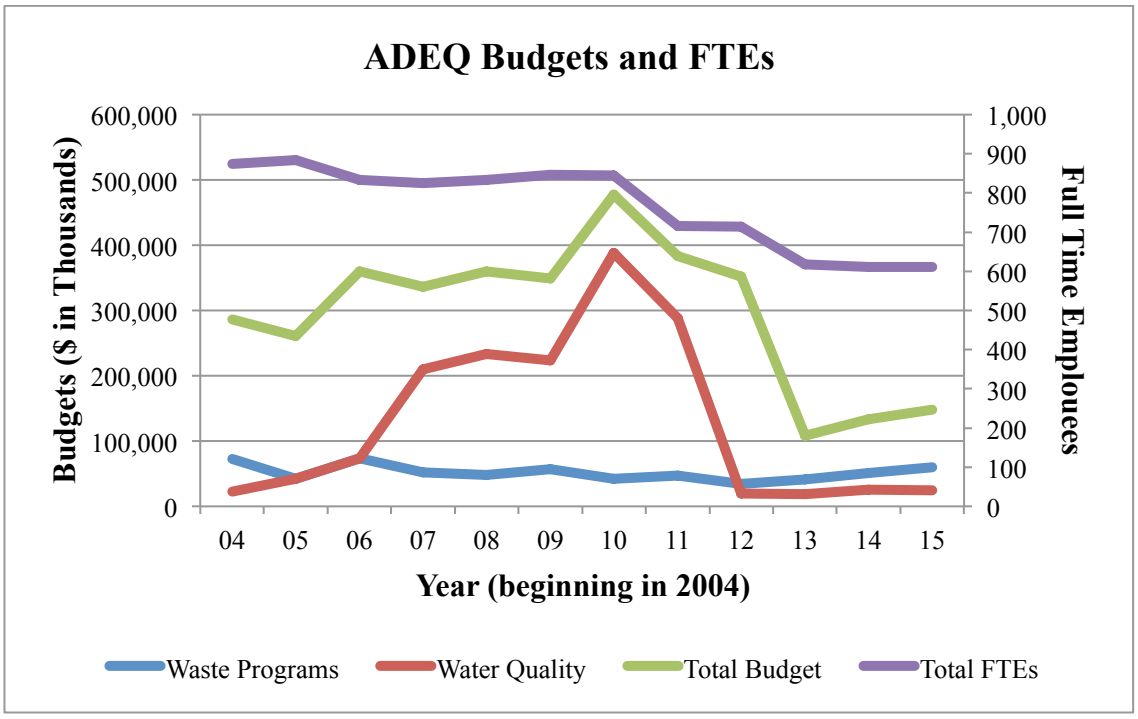

Figure 11: Arizona Department of Environmental Quality, Budgets and Full Time Employee Numbers for 2004-2015. Data from Arizona Executive Budgets.

Despite the potential for extreme change in budget year-to-year, Figure 12 shows the changes to operating budget and FTEs for Groundwater Regulation (which falls

under Water Quality) has only fluctuated between 1-5% with regard to its total share of ADEQ's total budget or number of employees. Budget allocations for the last few years suggest an upward swing. Even though budget trends indicate that ADEQ may continue to operate under reduced budgets as compared to 2004 numbers, Groundwater Regulation is likely to sustain or improve since it experiences small fluctuations. This is an important piece of information because the management of the APP program falls under Groundwater Regulation efforts.

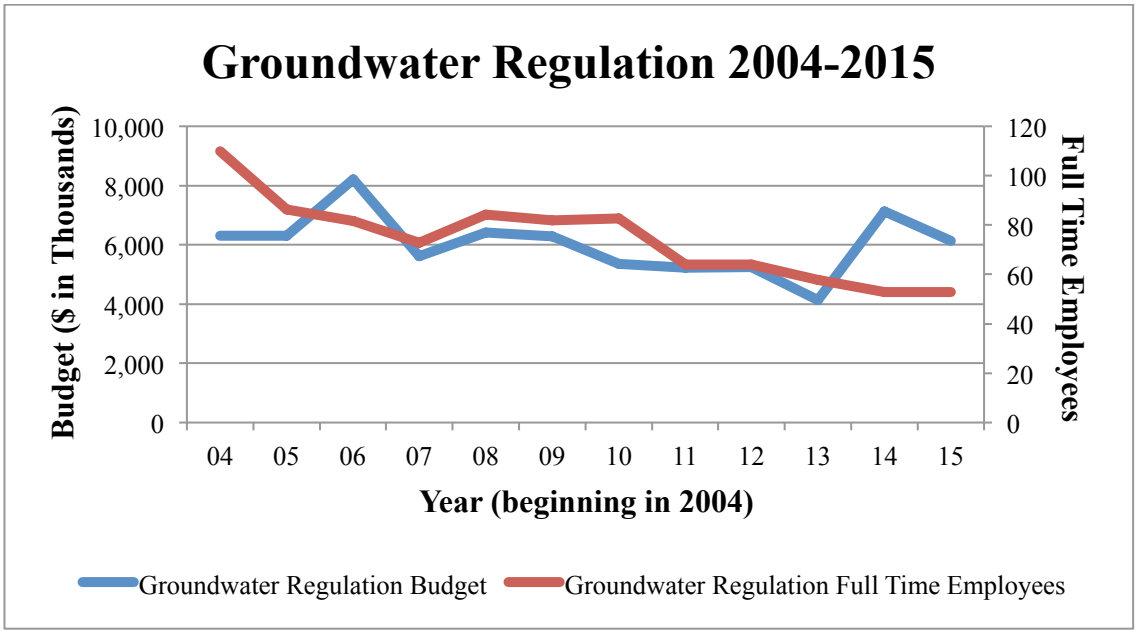

Figure 12: Arizona Department of Environmental Quality, Groundwater Regulation Budget and Full Time Employee Numbers for 2004-2015. Data from Arizona Executive Budgets.

Arizona Department of Agriculture

The ADA plays an important role in preventing pesticide contamination in groundwater. This is particularly so with regard to pesticide use and compliance.

Pesticide Use and Compliance

Education and Training

The ADA is responsible for training and certifying pesticide applicators and advisors. As part of the certification process (and for other professional licensing), the ADA offers a variety of classes, tests, and continuing education courses. These are intended to enhance the agricultural industry and to prevent problems in the agricultural community, including pesticide misuse. Beyond licensing related education, there is also free educational programming available such as classes, seminars, and on-site visits and consultations performed by ADA staff. Figures 13 and 14 illustrate the popularity of these offerings. Figure 13 suggests that the number of outreach and educational opportunities correlates to the number of participants. In other words, the more opportunity, the greater the number of participants. Figure 14 shows there is an overall increase in the number of On-Site Visits and Consultations conducted.

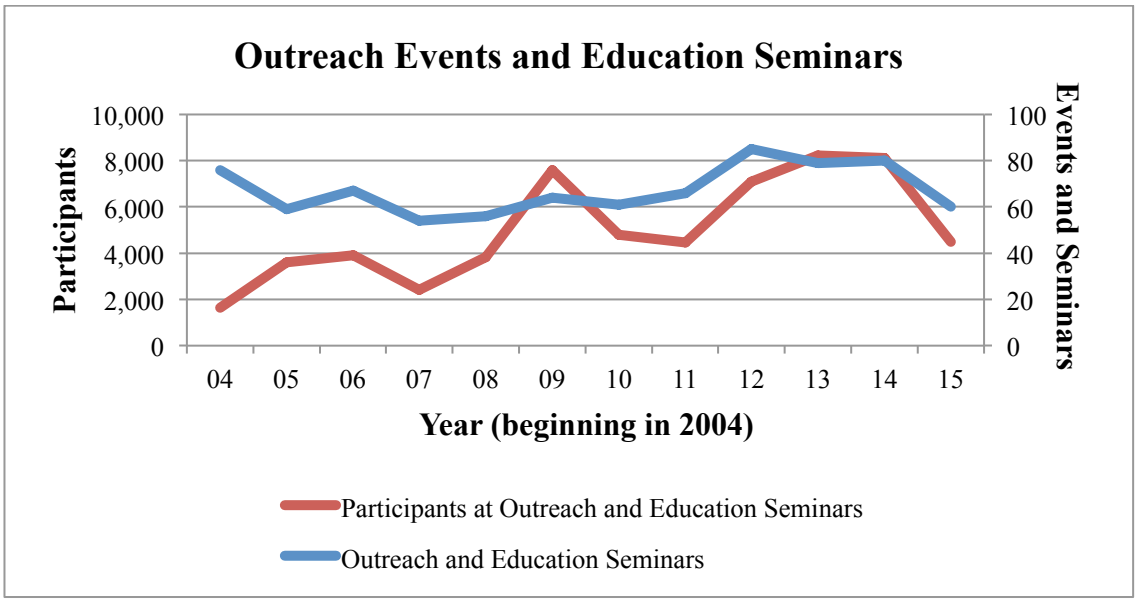

Figure 13: Arizona Outreach Events and Educational Seminars. Data from Arizona Executive Budgets.

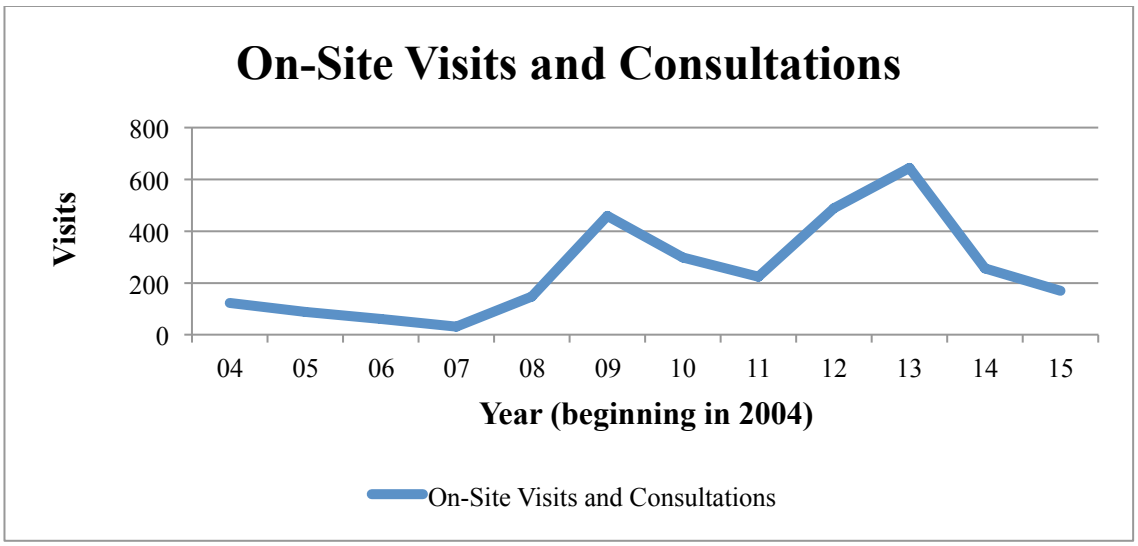

Figure 14: On-Site Visits and Consultations. Data from Arizona Executive Budgets.

Apart from the more hands-on education opportunities, the ADA offers other services. For example, the ADA performs product sampling and publicizes summary findings. These reports help ensure quality control, and to protect and inform the agricultural industry of problematic products

Registration

The ADA is responsible for registering and licensing feed, fertilizer, seed and pesticide companies and products. Once registered, information about products and licensed companies is available in several searchable databases including: trainer search, fertilizer license search, seed dealer search and pesticide registration search. The Pesticide Registration Search lets people search for all types of pesticide information including active ingredients, product name, pesticide type, and even pest name.

Inspections and Investigations

Any regulated growers or applicators of pesticides must report their use to the ADA by completing a Form 1080 Pesticide Application Reporting. Form 1080 records detailed information about the crops grown, the acreage, the grower information, the pesticide seller information, the pesticides used, EPA registration number, active ingredients, and the rate of application per acre. In addition, application equipment tag numbers, the time and date of application, and the wind direction and velocity at the time of application are also recorded.

The ADA conducts pesticide use inspections on a regular basis throughout the year to verify the information submitted on Form 1080, and check for any other problems related to pesticide storage or use. Any incidents of misuse discovered during

the inspection are reported and must be corrected. When needed or requested, ADA staff works with violators to correct misuse incidents (and any other problems), usually through on-site consultations or follow up site visits.

Figure 15 indicates that in the early years of conducting pesticide use inspections, the inspections yielded a significant number of misuse cases. However from 2008 to the present, the number of misuse cases identified relative to the number of inspections conducted seems to lower. While a direct correlation is uncertain, the data does demonstrate that misuse cases are identified during inspections and in that regard, inspections are a valuable tool in preventing pesticide contamination in groundwater.

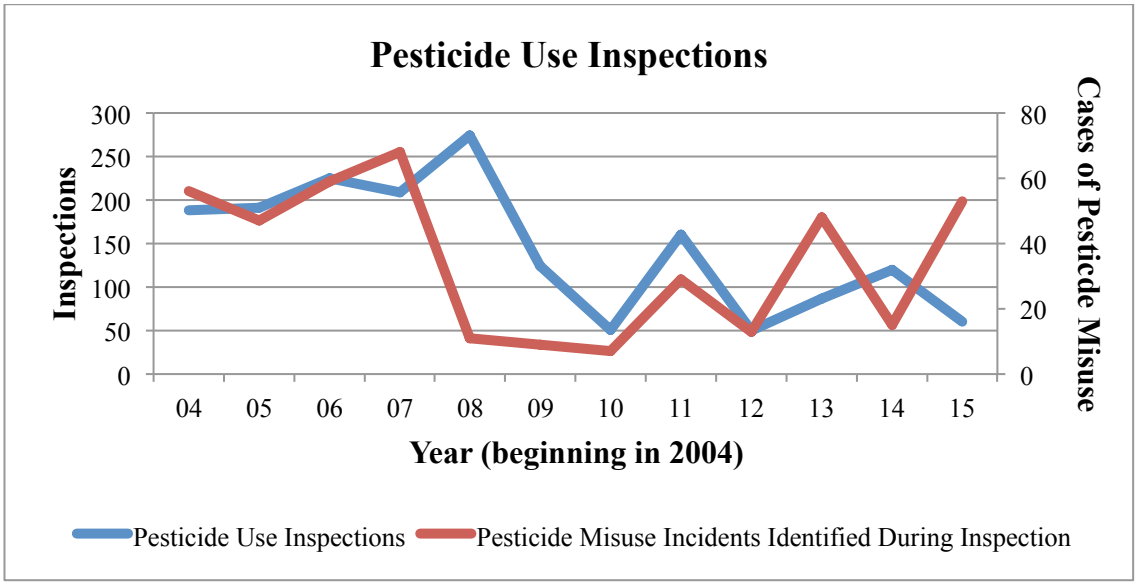

Figure 15: Arizona Pesticide Use Inspections and Misuse Incidents Identified. Data from Arizona Executive Budgets.

In addition to Form 1080 inspections, the ADA conducts investigations of groundwater impairments caused by pesticides or other agriculture related impairments. The investigations can be triggered either by complaints received or of the ADA's own initiative. Where the ADA finds a violation has occurred, remediative action must be taken within statutorily specified periods of time or the violation is escalated.

Buffer Zones

Buffer zones are an important tool in preventing runoff of pesticides and groundwater contamination. The rules in Arizona require that in order to protect human health, buffer zones be constructed in such a way as to ensure sufficient distance between an application site and residences, health care centers, and schools or childcare centers.[166] However, neither the ADA nor another agency creates buffer zones for recharge zones, watersheds, or other channels through which a pesticide might migrate into groundwater sources.[167] These sensitive areas are ostensibly protected by the use of BMPs encouraged in the application of pesticides.

Monitoring and Research

In the past, the ADA had designated pesticide management areas, however that approach has largely been abandoned "because of the "constantly changing agricultural urban interface, [staff] are no longer able to pinpoint and predict areas where complaints may be generated." Currently, there are no designated pesticide management areas, but

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[166] *Buffer Zones*, ARIZ. DEP'T OF AGRICULTURE (Jan. 7, 2015), *available at* https://agriculture.az.gov/sites/default/ files/BufferZones.pdf. The buffer zones range in distance from just 50 feet to ¼ of a mile depending on the method of application and distance to residences, health care centers, and childcare centers. *Id.*

[167] Ariz. Rev. Stats. § 3-2-6.

information from past Pesticide Management Areas, as well as current and future pesticide monitoring information is being posted on the ADA's website.

Monitoring services are available at no charge by ADA staff. Citizens and agribusinesses alike may call to make a monitoring appointment. For those who are applying pesticides, especially where applications may be made in sensitive areas or areas in which complaints have been made in the past, inspectors and monitors alike are available to oversee the pesticide application. Though the service is free, opportunities for assistance may be limited by staff, budget, or time of request constraints.

Additionally, the ADA oversees the state Agricultural Laboratory. The lab has two units: Food Safety and Chemistry. The Chemistry unit has three responsibilities that are important to groundwater quality protection. First, the Feed and Fertilizer Product project makes determinations as to whether marketplace samples are the same quality as label products indicate. Second, the Pesticide Formulations project makes determines as to the overall quality of pesticide products by analyzing commercially available pesticides. Third, the Forensic Chemical Residue project analyzes investigative samples for chemical contaminates subject to regulatory enforcement. Related to this research, the ADA must publish a list of pesticides which it finds to be highly toxic, odoriferous, or otherwise of concern. This list is separate from the GPL and is not enforceable in any way. The ADA creates this list with information obtained from these three efforts, narrower studies conducted as needed, and work with other agencies.

Budget and Staff

Figures 16 and 17 reflect the overall budget and FTEs for the ADA. They also reflect the portion of the budget and number of FTEs allocated specifically for the Pesticide Compliance and Agricultural Consultation and Training programs. Since 2008, there has been an agency-wide decline in the budget and number of FTEs. Despite a few minor upticks in both, the overall trend is one of decline. Figure 16 shows that the budget and FTE allocations for the Pesticide Compliance and Agricultural Consultation and Training programs is a small fraction of the agency total.

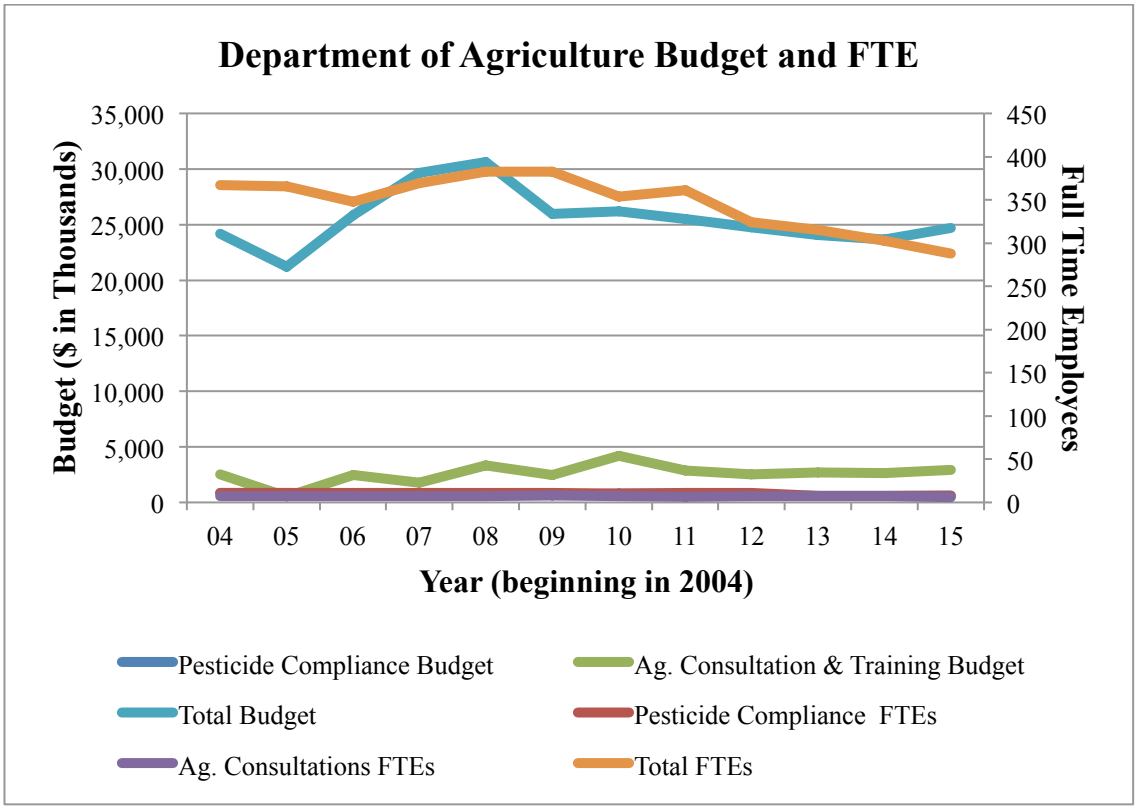

Figure 16: Department of Agriculture Budgets and Full Time Employees. Data from Arizona Executive Budget.

Figure 17 offers a closer look at the budgets and number of FTEs for the Pesticide Compliance and Agricultural Consultation and Training programs. Pesticide Compliance hasn't experienced many changes. With respect to the Consultation and Training program, FTE numbers haven't incurred drastic changes, however, the budget escalated for several years before peaking in 2010, and has been reduced every year since then.

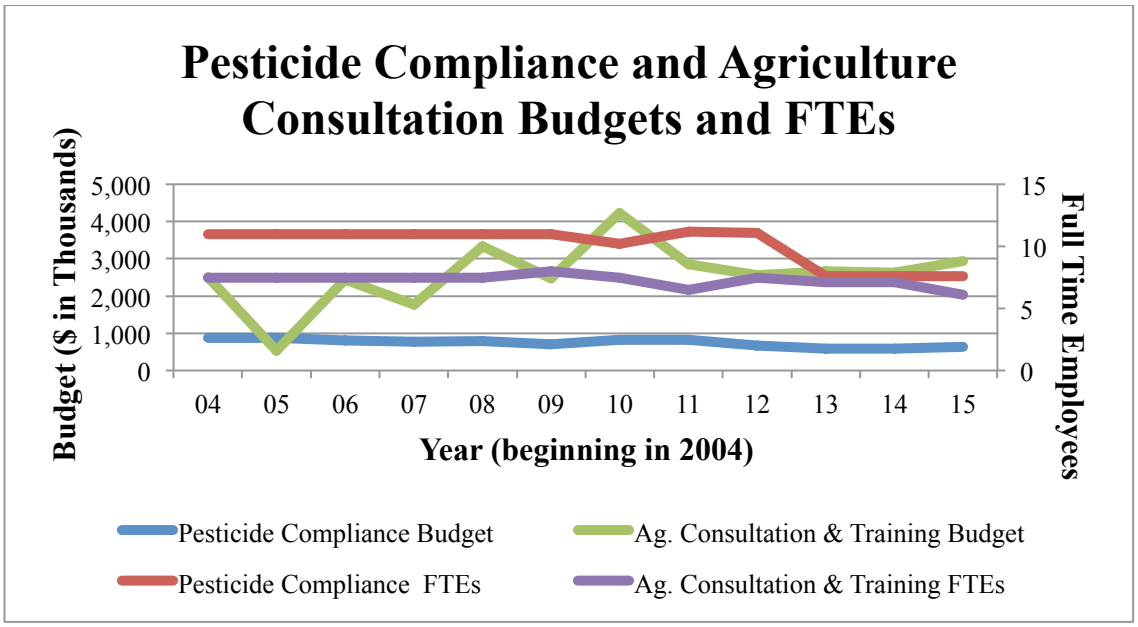

Figure 17: Pesticide Compliance and Agricultural Consultations. Data from Arizona Executive Budget.

Arizona Department of Water Resources

ADWR is primarily responsible for managing and allocating the state's groundwater supplies. It achieves this primarily by collecting, managing and analyzing groundwater data, which in turn guides groundwater policies and management across the state. ADWR handles nearly all of the hydrogeological studies in the state. The Arizona Geological Survey does some work in hydrogeology, but primarily focuses on geological issues including earth fissures, earthquakes, mineral and geothermal studies.

Wells must be registered with the ADWR, and ADWR compiles well registrations, ownership information, associated water rights and pumping information into a publicly searchable database. Apart from well registration, ADWR does very little pertaining to groundwater quality management, but it is a very strong resource for ADEQ via the data it provides.

Budget and Staff

Figure 18 reflects drastic reductions in both budget and FTEs without any recovery since 2008. Going forward, these resource reductions will likely lead to a reduction in the information ADWR typically makes available to ADEQ and other agencies.

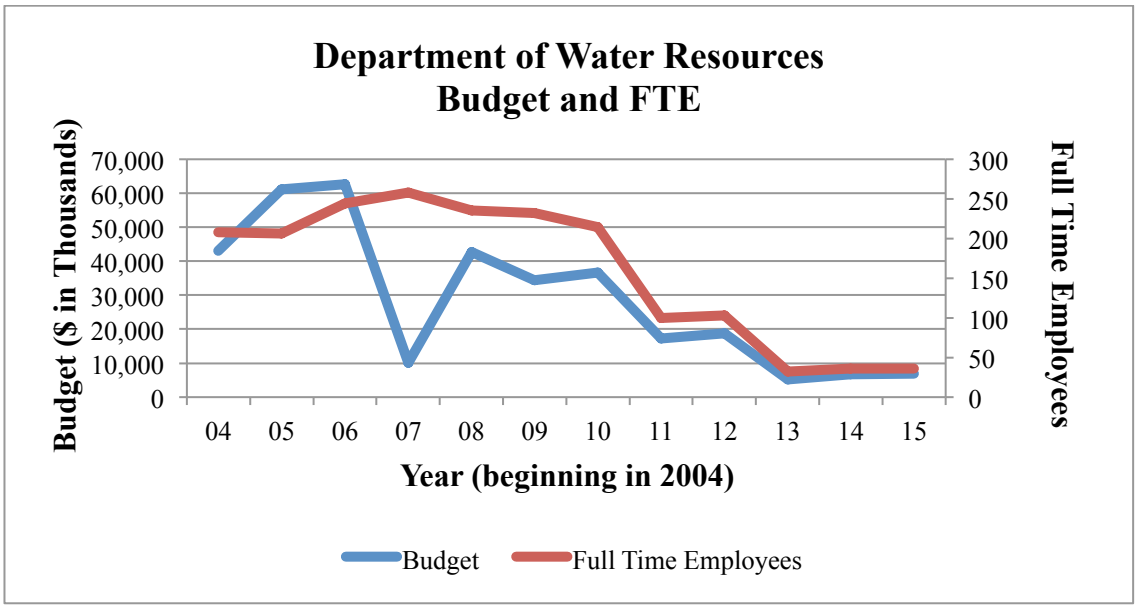

Figure 18: Department of Water Resources Budget and Full Time Employees. Data from Arizona Executive Budget.

Arizona Department of Health Services

Presently, this ADHS participates only in authorizing laboratories to conduct environmental testing. Previously, this department had the authority to approve changes to aquifer designations from drinking water to other purposes that require less stringent standards. However, currently only the Director of ADEQ may approve such changes. Notably, this department is absent from any level of participation in determining what chemical ingredients should be placed on the GPL. It is also absent in assessing the health impacts of any other groundwater contaminants. Its only involvement is to approve analytic methods and laboratory testing for water quality samples.[168]

[168] Ariz. Admin. Codes § R18-11-403—404.

Standards

Because groundwater is so heavily relied on for drinking water, all aquifers in the state are designated for drinking water and are subject to drinking water standards under the EQA. ADEQ sets water quality standards for multiple water uses and sources. This includes standards for aquifer water quality and, separately, drinking water quality. Both the drinking water quality standards list and the aquifer quality standards list are based on the SDWA Maximum Contaminant Level (MCL) guidelines and are almost identical. The only difference is that under the SDWA standards Arsenic is allowable up to .010 µg/L, while under the Arizona aquifer quality standards Arsenic is only allowable up to .05 µg/L.[169] Another difference is that Arizona has a drinking water quality standard for Isophorone even though it is not listed in the SDWA standards or Arizona's aquifer quality standards list.[170]

These differences are permissible because states are always allowed to adopt rules and regulations so long as they don't undermine federal rules or regulations. In Arizona, the Director of ADEQ is authorized to adopt numeric limits for additional contaminants beyond those created under the SDWA, or adopt standards more stringent than those required by the SDWA. Additionally, citizens may petition ADEQ to list a contaminant not on the SDWA standards list or to implement more stringent requirements than the SDWA standards. A key requirement in adopting or changing any

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[169] *Compare Table of Regulated Drinking Water Contaminants*, U.S. ENVTL. PROT. AGENCY (Dec. 8, 2015), *available at* http://www.epa.gov/your-drinking-water/table-regulated-drinking-water-contaminants *with* Ariz. Admin. Codes § R18-11 Table 1.
[170] *Id.*

numeric standards, either aquifer quality, drinking water, or otherwise, is that the standard must be based on impact to human health or environmental health.

The need for so many separate sets of standards is confusing because all aquifers in the state fall under a drinking water use classification.[171] However, multiple standard sets can be explained by the fact that it is possible for an aquifer to be designated for a use other than drinking water,[172] although too date, no aquifers have been reclassified for non-drinking water protected use.[173] For an aquifer designation to be downgraded, a petitioner must show that the aquifer is not to be used for drinking water, that it is hydrologically isolated from other aquifers, and that the prospective benefits of the designation outweigh the prospective costs. [174]

At present, there are no statutory or regulatory requirements that allow, require, or even suggest that interactions be considered in setting groundwater quality standards, although standards must be justified by an impact to human health or environmental health. Current monitoring as performed by any of the relevant agencies only evaluates isolated chemicals, and does not intentionally check for byproducts or degredates.

Observations

ADEQ is responsible for the majority of the groundwater quality protection programs, including some programs that target pesticide use. Overall trends in the budget and the number of FTEs are in decline, which may pose a problem in sustaining

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[171] *What are aquifer water quality standards*, U.S. ENVTL. PROT. AGENCY (Jan. 7, 2015), *available at* http://www.azdeq.gov/environ/water/standards/. In Arizona, there are drinking water quality standards, surface water standards, reuse quality standards, groundwater quality standards, and more. *Id.*
[172] Ariz. Rev. Stats. § 49-224(B-C); Ariz. Admin. Codes § R18-11(A).
[173] *See supra* note 172.
[174] Ariz. Rev. Stats. § 49-224(B-C); Ariz. Admin. Codes § R18-11(A).

the programs currently in place. The impact of such reductions may be magnified by the fact that ADEQ's programs are largely bureaucratic and comprised over permitting processes and data collection, as opposed to active engagement or education with citizens, permittees, or applicants. One exception to this would be the ADA's efforts in outreach, education and free monitoring services to citizens and agribusinesses.

The APP program seems to be the most direct regulatory program for substances entering groundwater. The program requires BMPs, and imposes treatment measures and other requirements on various facilities that create discharges likely to enter groundwater or the vadose zone. It also sets case-specific numeric quality limits tailored to what will be in the discharge. At minimum, the discharges must meet SDWA drinking water standards, but may be more stringent.

The wellhead protection and drywell permit programs are also heavily relied on. Like the APP program, the wellhead protection and drywell permit programs aim to prevent excessive amounts of harmful substances from entering groundwater, and the accumulation of harmful substances in groundwater. Though Arizona seems to have fewer programs in place for groundwater protection, it has provided ample resources to these three preventative measures. Assuming these programs are successful, cleanup and mitigation programs that are managed in other states may be less necessary. However, Arizona does not have very thorough data tracking systems in place, or at least none that are publicly available or could be made available on request.

Interestingly, outside of wellhead management and the drywell permit program, pesticide use seems to be at the crux of groundwater quality protection efforts in

Arizona. To that end, ADEQ and ADA largely share responsibilities over regulating farming practices, including registering pesticides for use in the state, the authority to cancel registration, and creating its GPL and setting numeric limits for active ingredients that may be found in groundwater. Somewhat contradictory to the very thorough approach taken in the past, is that since 2001 ADEQ has been issuing conditional pesticide registrations for pesticides that may be very useful to the agricultural industry, but for which there is incomplete mobility data. Also notable, is that Atrazine has not been as extensive a problem in Arizona groundwater as in other states. It hasn't appeared in any major ADEQ or ADA reports since 2002.

Overall, Arizona seems to default to federal standards and requirements in how it functions to protect groundwater quality. (*See Arizona Solid Waste Management Plan*, 1981; Artiola, 2009; *Layperson's Guide to Arizona Water*, 2007). For example, unlike Wisconsin and Florida that manage Underground Injection Control through state agencies, EPA offices located in Arizona mange the UIC program. Even with respect to certain land uses that may put groundwater quality at risk, the policies and standards reflect federal requirements without going very much further to address any unique attributes to Arizona. With respect to setting groundwater quality standards, the effort is minimal. While there are a few slight differences between the SDWA standards for drinking water and the Arizona aquifer quality standards and drinking water standards, the state largely defaults to SDWA standards. For this reason, it is not surprising that there is no consideration for byproduct interactions in groundwater.

Notably, DHS is completely absent from setting quality standards either for the GPL, the Aquifer Water Quality Standards or the Drinking Water Quality Standards. This is very interesting given that standards are primarily put in place to protect human health. However, it does receive notice of some groundwater quality incidents, such as leaks in USTs that may impact public health and DHS does work with relevant agencies in those circumstances. In those cases, its primary role is only to notify citizens that may be effected by the problem and to approve any sampling procedures.

A summary of this section is available in Appendix E.

FLORIDA

This section follows the same structure as the sections on Wisconsin and Arizona, aiming to provide a comprehensive review of the laws, policies, and agencies that Arizona employs to protect groundwater quality, and environmental and human health. It also seeks to illustrate the approaches in three land use types in a way that is comparable with Wisconsin and Arizona. The tables and figures in this section are slightly different from those used in the sections on Wisconsin and Arizona because of differences in the available data.

A Brief History of Relevant Legislation and Agency Development

Much of Florida's groundwater regulation is actually the result of severe flooding events around the state, and the water quality problems they caused. Several hurricanes and tropical storms struck the central and southern parts of the state from the 1920's to the 1940's resulting in large-scale destruction, economic disaster and thousands of deaths. (*Extreme Weather, From Floods to Droughts*, 2016; *Floridians Seek More Federal Relief*, 2016; *From Marshes to Farms*, 2016). The extent of the damage and the impact of these floods was exacerbated by a number of diversion and damming projects that made many parts of central and southern Florida impossible to drain after such violent storms. (*From Marshes to Farms*, 2016). Ironically, many of the damn and diversion projects were built to control water movement in the state; they were specifically intended to prevent flooding and make more land available for agriculture and development. However, many of the structures were not built to withstand the

intense storms and hurricanes suffered by Florida. Up to the early 1960's, the bulk of water-related legislation in Florida centered around flood control and mitigation. (*Extreme Weather, From Floods to Droughts*, 2016; *Floridians Seek More Federal Relief*, 2016).

Beginning in the 1960's, the ecological impacts of the large-scale draining and flood control projects began to occur. One well-known example is of deer populations declining by staggering numbers in the Everglades National Park. The deer suffered from immobility due to floods, and from inaccessibility to food when floodwaters rose too high and were slow to recede. (*An Environmental Awakening, 2011; New Era of Development*, 2016). Ecological shifts, such as the one experienced by deer populations, were augmented by the on-set of the national environmental movement. The momentum of such environmental awareness led to the 1969 creation of the Florida Department of Air and Water Pollution Control. This department was created by the legislature with the mission of maintaining and improving environmental quality throughout the state, including the quality of water resources.[175]

In 1972, the Florida legislature passed the Florida Water Resources Act. This Act created five regional Water Management Districts (Districts) that are responsible for all surface and groundwater within their boundaries. (Borisova, 2013). Their responsibilities include water supply, flood protection, natural systems management, and

[175] Fla. Stat. Ann. § 69-109. In 1971, the agency's name was changed to the Florida Department of Pollution Control. *Id.*

water quality.[176] (Maloney, 1980; *A Groundswell of Environmentalism*, 2016; *The Early Years as a Flood Control District*, 2009). Uniquely, the District boundaries are along natural watershed boundary lines.

Prior to the existence of the Department of Air and Water Pollution Control, the State Board of Health had general control over all underground water, lakes, rivers, streams, canals, ditches, and coastal waters of the state and managed to control pollution.[177] (Maloney, 1980). The Board of Health retained its water responsibilities until 1975 when it was merged with the Florida Department of Air and Water Pollution Control to create the Florida Department of Environmental Regulation (FDEP). (Maloney, 1980). FDEP is regulatory entity that uses air and water quality standards, along with waste management regulations, to achieve its goals of keeping water, air, and land free of pollutants and contamination. This merger was a direct result of increased awareness about the relationship between human health and environmental quality.

Concurrent with the 1975 creation of FDEP, was the creation of the Environmental Regulation Commission (ERC).[178] (Maloney, 1980). The ERC is a

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[176] *The Early Years as a Flood Control District*, SOUTH FLA. WATER MGMT. DIST. (Mar. 12, 2009), *available at* http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/nr_2009_0312_60anniversary_1949.pdf. The South Florida Water Management District was actually created in 1949 as the Flood Control District in the areas most severely affected by floods in south-central Florida. *Id.* It's primary job was to build flood control infrastructure. *Id.* It was converted to a Water Management District in 1972, and at the same time its duties were changed; however, this particular District still emphasizes flood control and mitigation. *Id.*

[177] *125 Years of Florida Public Health*, Fla. Dep't of Public Health (Jan. 7), *available at* http://www.floridahealth.gov/about-the-department-of-health/125-years-of-florida-public-health/. Unlike many other states, the Department of Health was not created as a result of health issues tied directly to environmental or water quality problems. *Id.* The Board of Health was created by the state legislature on February 20, 1889, out of concern over yellow fever epidemics in port cities such as Jacksonville. *Id.*

[178] The Florida Senate, Interim Report 2012-120 (Sept. 2011), *available at* https://www.flsenate.gov/Published Content/Session/2012/InterimReports/2012-120ep.pdf.

citizenry board comprised of seven board members from around the state. Each member is appointed by the governor and is subject to senatorial confirmation.[179] The members represent agriculture, industries, local government, citizens, the environmental community, and the scientific and technical community. Each member is obligated to a four-year term, and may serve repeatedly without restriction. Although FDEP provides administrative and personnel services, the ERC is a distinct entity, and is allowed to use external legal counsel and scientific or technical consultants.[180]

Originally the ERC was a standard setting authority that developed its own rules and standards in response to concerns raised by the public or to scientific developments. It also was responsible for making decisions on rules proposed by other agencies. However, over time the role of the ERC has changed substantially and has become increasingly limited. A 1980 amendment removed its adjudicatory powers and its authority over grants and federal disbursements.[181] In 1995, another amendment removed ERC as the exclusive standard-setting body in the state. After the 1995 amendment, ERC only remained responsible for select types of standards, and even to that end there are special circumstances in which the legislature must approve an ERC decision before it becomes enforceable.[182] The ERC still works closely with FDEP, but FDEP is now the primary standard setter.[183]

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[179] Fla. Stat. Ann. §§ 20.255(6), 373, 376.
[180] The Florida Senate, Interim Report 2012-120 (Sept. 2011), *available at* https://www.flsenate.gov/PublishedContent/Session/2012/InterimReports/2012-120ep.pdf.
[181] Fla. S.B. 1260 (1980).
[182] Fla. H.B. 855 (1995).
[183] *See infra* note 180. In 1993, the Florida Department of Natural Resources was assumed by FDEP, giving FDEP greater responsibilities and authorities. *Id.* Nearly all programs were subsumed under FDEP

In 1983 the legislature passed the Water Quality Assurance Act (WQAA); a piece of legislation designed to aggressively prevent groundwater contamination. The WQAA was a direct response to a report written by the Florida Task Force on Water Issues that concluded that groundwater contamination had become a major threat, and that then-current groundwater problems could transfer to surface waters if not managed.[184] The WQAA is notable because it is an original piece of legislation, meaning that it does not mimic any federal legislation, rather it was created to address a unique problem arising in Florida. (Hopping, 1983).

The WQAA focused on a range of activities and land uses impacting groundwater such as pesticide use, hazardous waste management, septic tanks construction and management, and the mandatory plugging of all abandoned artesian wells. It also provided funding to create and expand groundwater protection programs. The feature of WQAA with the most utility, was the establishment of the Ground Water Quality Monitoring Network, which obligates the state to regular and consistent groundwater monitoring by FDEP.

In 1996, the state legislature established a second Florida Department of Health. (*About Us*, 2016). It is significantly less involved in water management than its previous incarnation, but it does continue to assess and test private wells used to provide drinking

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authority, except for those oriented toward wildlife management. *Id.* Those programs were assigned to a new Florida Fish and Wildlife Conservation Commission. *Id.*

[184] Fla. Admin. Code 83-310; Fla. Stat. Ann. §§376.30- 376.319; *Water Quality and Natural Systems*, Water Matters Mag. (Oct. 2011), *available at* https://www.swfwmd.statestatestatestatestatestatestatestatestatestate.fl.us/documents/publications /watermatters/oct-2011/4.html. Contaminant transference from groundwater to surface water is probably in Florida because of the extent of groundwater-surface water interactions. *Id.*

water. It will even provide alternative drinking water to a homeowner whose well water is, or is likely to become, contaminated with ethylene dibromide, a pesticide that has been problematic since the 1980's. (*Drinking Water*, 2016).

Agency Integration and Programs

Florida groundwater quality is primarily managed by the Florida Department of Environmental Protection (FDEP) and five Water Management Districts (Districts). The Department of Agricultural and Consumer Services (DACS) and the Department of Health (DOH) play minor roles. The agencies tend to manage statewide issues and statewide programs, while the Districts have more regional areas of focus and also address very specific water quality problems. Together these entities handle issues of quality, quantity and compliance.

It is difficult to capture surface water in Florida because of the geographical and topographical formations of Florida, and the intense weather patterns. Luckily, most of Florida overlies high quality groundwater sources. However, so much of the groundwater and surface water are connected,[185] that contamination in one source would easily be expressed in another over time. As a result, the agencies and Districts alike make an effort to be holistic in their management approaches.

Water Management Districts

There are five Districts in Florida that cover the entire state. Notably, the Districts were drawn around the natural hydrologic boundaries of the five major

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[185] *Ground Water Program*, FLA. DEP'T OF ENVTL. PROT. (June 2015), *available at* http://www.dep.state.fl.us/water/groundwater/index.htm. Florida also has unique geological formations the result of which is that many of Florida's lakes and rivers are sourced by groundwater as well. *Id.*

watersheds in Florida. This allows for more comprehensive and holistic understanding of the changes experienced in each. Each District is responsible for the administration of flood protection programs and plans, and technical investigations. (Borisova, 2013). In addition to the responsibilities assigned by the state, FDEP has delegated each District with certain regulatory responsibilities to manage within their watersheds. These include managing the consumptive use of water, aquifer recharge, surface water management, issuing well permits and managing well construction.[186] (Borisova, 2013; *South Florida Water Management District Well Permitting Submittal Locations*, 2015).

The Districts add a unique intermediary layer of government absent in other states, especially with respect to groundwater. They manage state and Federal programs and they liaison between all levels of government. This creates unique managerial perspectives that many agencies lack. Of note, the Districts collect and manage much of the hydrogeological data that geological surveys in other states are responsible for. The Florida Geological Survey focuses on geomorphology and does not address hydrogeology.

Northwest Florida Water Management District

Figure 19 shows data from the Northwest Florida Water Management District. This data shows an overall decline in well permits issued in the last ten years. In this

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[186] *Water Management Districts*, FLA. DEP'T OF ENVTL. PROT. (June 5, 2014), http://www.dep.state.fl.us/secretary/watman/. As part of their surface water management programs, the districts administer the Department's stormwater management program. *Id.* This increases the districts' contacts with local governments by directing the districts to help with the development of the water elements in local government comprehensive plans. *Id.*

District, the well permit issuance counts are inclusive of permits for construction, repair, and abandonment.[187] None of these permit types are counted separately.

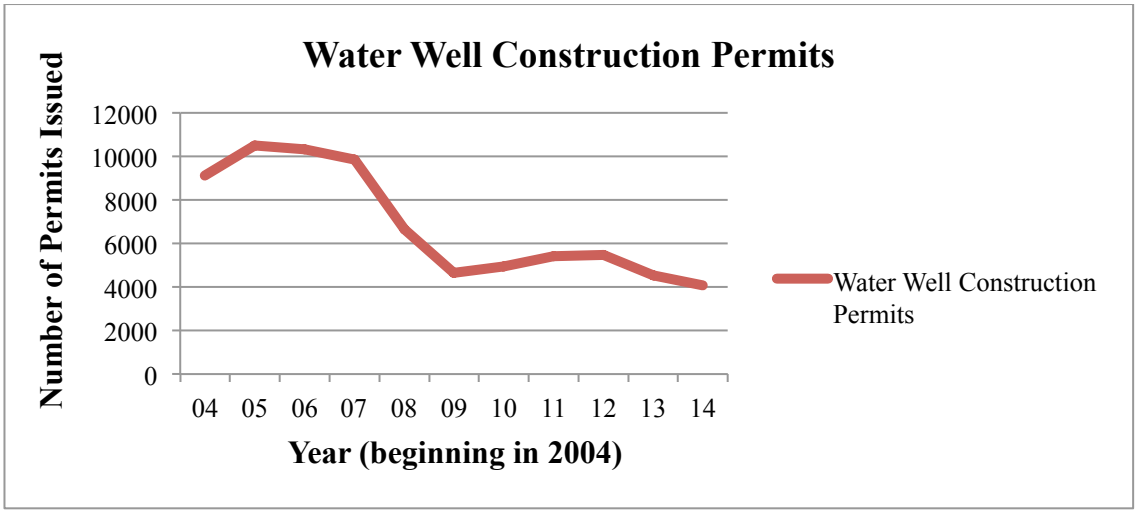

Figure 19: Well Construction Permits Issued by the Northwest Florida Water Management District. Data provided by the Northwest Florida Water Management District.

District staff conduct construction and compliance inspections where required by either statute[188] or District rules. This is the standard for all of the Districts. Grouting, setbacks, and the volume of sediment in produced water are some examples of items subject to inspection and compliance. When a violation is identified, all of the Districts respond by following statutory procedures and District rules in order to rectify the violation. (*Water Well Construction Disciplinary Guidelines and Citations Dictionary,*

[187] Email Communication with Tom Brown, Well Construction Program Manager, Northwest Florida Management District, Nov. 12, 2015. The water well construction permit data from each of the five Groundwater Management Districts includes wells constructed expressly for consumptive use, as well as other types of wells such as wells for agriculture and industry. *Id.*
[188] Fla. Stat. Ann. § 373.333.

2014). These procedures include such steps as issuing notices of violation or compliance orders, assessing points against licenses, administering fines, revoking permits, requiring permits or modifications of permits, requiring environmental restoration, and requiring monitoring and/or requiring reporting.[189]

It is not standard for the Northwest Florida District to track or tally the number of construction inspections performed in a given period.[190] The District also does not track compliance rates or the number of enforcement actions in a given year.[191]

In addition to conducting inspections, District staff investigates complaints received. Data for complaints received was not available, but Table 4 shows the number for complaints investigated was available for the most recent three years:

Year	Complaints Investigated
2012	62
2013	59
2014	54

Table 4: Florida Well Construction Complaints Investigated by Year. Data provided by the Northwest Florida Water Management District.

[189] Email Communication with Tom Brown, Well Construction Program Manager, Northwest Florida Management District, Nov. 12, 2015.
[190] *Id.*
[191] *Id.*

Although there is little context to this data and only three years were available, it is interesting to note that when averaged across years, the mean number of complaints investigated per month is 4.86, or approximately one per week.

Suwanee River Water Management District

Figure 20 shows data from the Suwanee River Water Management District that reflects an overall decline in well permits issued in the last ten years. In this District the well permit issuance counts are inclusive of permits for construction, repair, and abandonment. These permit types are not separable on the District's e-Permitting site.

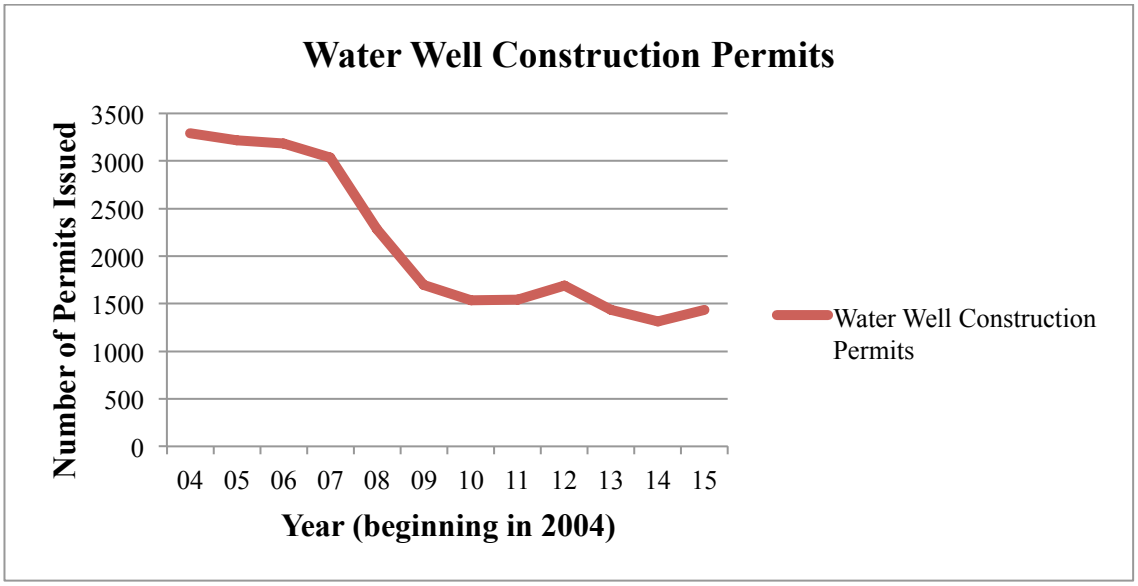

Figure 20: Well Construction Permits Issued by the Suwannee River Water Management District. Data obtained from the Suwannee River e-Permitting Website.

As a result of limited staff resources, District staff generally performs construction inspections when owners or drillers report an issue.[192] No data was available for inspections performed. Records for enforcement cases have been carefully kept over the last decade, however there is no compilation of this information. Moreover, the methods, databases, and information collected have changed within the same time frame.[193] As a result, data compilation for enforcement actions was difficult to obtain, in particular if they occurred prior to the installation of the Districts e-Regulatory system in 2014.[194] The information available was not insightful and so is not included here.

St. Johns River Water Management District

Figure 21 shows data from the St. Johns River Water Management District that reflects an overall increase in well permits issued in the last ten years, though there are periods marked by declines, such as in 2007, 2008, and 2012. In this District, the well permit issuance counts are inclusive of permits for construction, repair, and abandonment.[195] In this District permits for new water wells are counted separately. Figure 21 includes a separate data line for new water well permits. The comparison between all well permits and new well permits in Figure 21 shows that most permits are for new water wells.

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[192] Email Communication with Warren Zwanka, Senior Hydrologist, Suwannee River Water Management District, Nov. 2, 2015.
[193] *Id.*
[194] *Id.*
[195] In this district permits for construction, repair, and abandonment are referred to as new, extended, and modified, but for purposes of this research, terms have been streamlined for easier comparison.

The St. Johns River District tracks the number of site inspections performed. These inspections are important because they are conducted during the construction period or when any modifications are performed, and thus help to ensure that wells are sound. This data is available only from 2008 to the present, but it shows a strong and steady increase over the last few years.

For this District, data for compliance was not available, and data for the number of enforcement actions was too limited to be useful for this research. The only data item for enforcement actions that was obtainable reflected a single warning letter sent in 2015; the violation giving cause for the letter was unspecified. This District also investigates complaints, but that data was not available either.

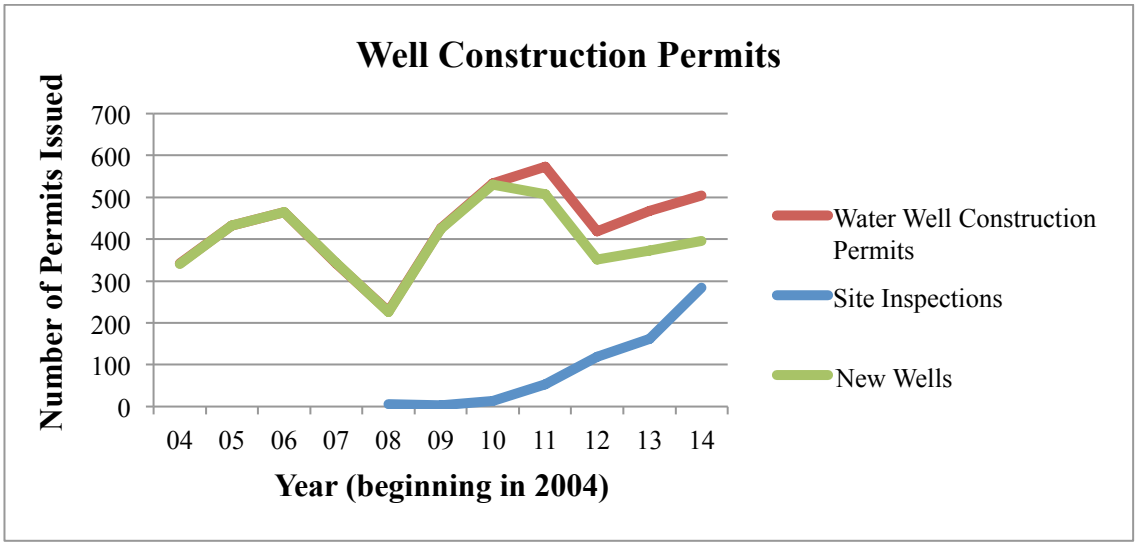

Figure 21: Well Construction Permits Issued by the St. Johns River Water Management District. Data provided by the St. Johns River Water Management District.

Southwest Florida Water Management District

Figure 22 shows data from the Northwest Florida Water Management District reflecting an overall decline in well permits issued in the last ten years. In this District, the well permit issuance counts are inclusive of permits for construction, repair, and abandonment. None are counted separately.

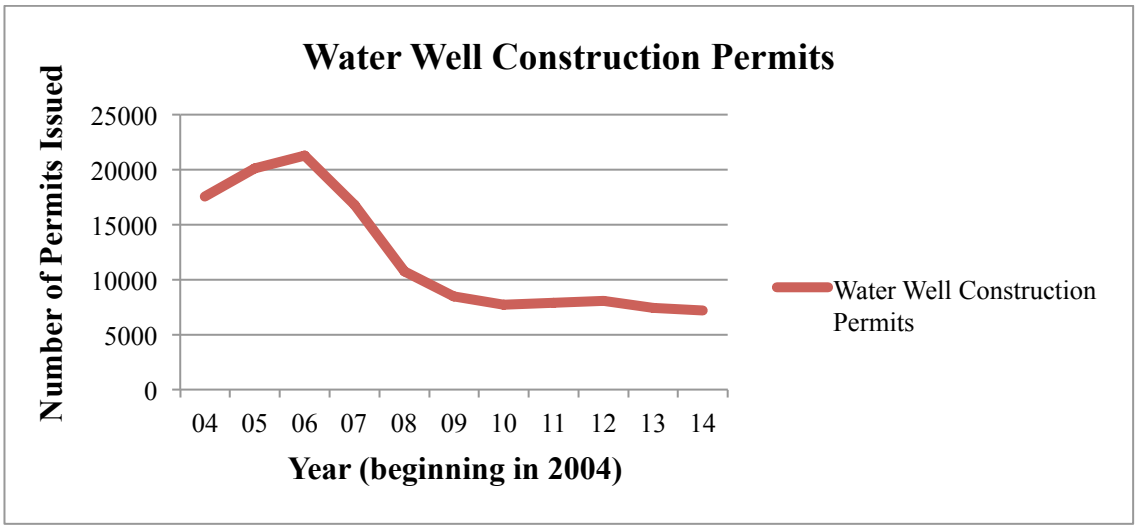

Figure 22: Well Construction Permits Issued by the Southwest Florida Water Management District. Data provided by the Southwest Florida Water Management District.

This District complies with all of the statutory inspection requirements, but it also makes special efforts for any wells that are used for public supply: almost all grouting of well casings and plugging of abandoned wells is witnessed by District staff or staff from one of its three well construction permitting delegations which exist at the

county level.[196] For all other wells, the District requires that at minimum 20% be inspected at random for construction compliance.[197] Data on the number of inspections performed was not available, however data on some specific types of violations was.

Figure 23 shows the number of violations found during inspections for two types of violation categories: The Ethylene Dibromide (EDB) Construction Standards and Well Contractor Violations. The EDB program demands more stringent well construction standards in areas where the soil has been contaminated by the pesticide EDB.[198] (James, 2013). Wells in the EDB program are subject to mandatory inspections by District staff.[199] Well Contractor violations can include working without a permit, with an expired license, violating any rules or regulations pertaining to construction, or using a false license.[200] Violations in both categories have been in a consistent decline since 2005.

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[196] Email Communication with David Arnold, Well Construction Manager, Water Use Bureau, Southwest Florida Water Management District, Nov. 17, 2015.
[197] *Id.*
[198] Fla. Admin. Code § 62-524; *Tips About Getting Water Management Permits*, SOUTHWEST FLA. WATER MGMT. DIST. (1999), *available at* https://www.swfwmd.state.fl.us/files/database/site_file_sets/45/Tips_Regarding.pdf. Areas within 14 of the 16 counties subject to Southwest Florida Management District authority have been contaminated. *Id.*
[199] *Id.*
[200] Fla. Admin. Code § 62-531.

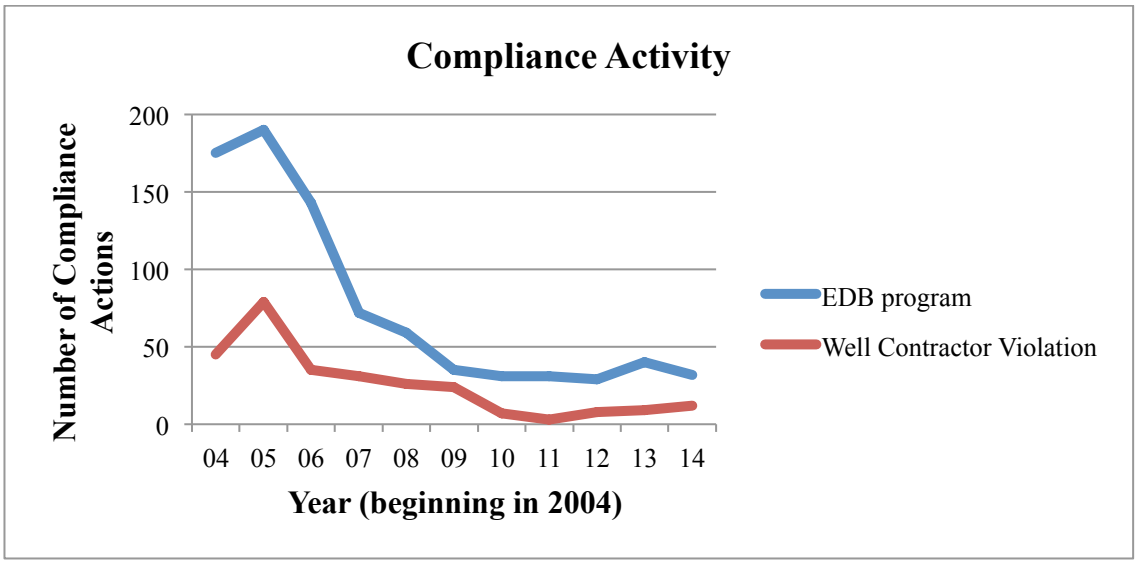

Figure 23: Well Construction Compliance Activity from the Southwest Florida Water Management District. Data provided by the Southwest Florida Water Management District.

South Florida Water Management District

The South Florida Water Management District deletes the majority of its well permitting information soon after processing, and so does not compile data for permitting, compliance, inspection or enforcement actions.[201] Although this District makes permitting decisions, it relies on 17 different offices within its region to accept applications for water well permits.[202] However, the accepting agencies are not obligated to track or compile data either, or to keep any data collected for a specified

[201] Email Communication with Kellie Madison, Technical Services Section Leader, Water Use Bureau, South Florida Water Management District, Nov. 2, 2015.

[202] *Id.*; *South Florida Water Management District Well Permitting Submittal Locations*, SOUTH FLA. WATER MGMT. DIST. (Oct. 20, 2015), *available at* http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/well_permit_submittal_location_list.pdf. Interestingly, most of the submittal locations are county health departments. *Id.*

period of time.[203] Moreover, even if data is collected, the type and volume may vary between the accepting agencies. As a result, no data suitable for review or analysis was available for this District.

Florida Department of Environmental Protection

FDEP oversees most of the programs used to protect groundwater quality. Some programs focus on parts of hydrologic systems such as springs, base flows and aquifers, while other programs focus on potential impacts to quality such as agricultural pesticide use and wellhead construction.

The Ground Water Management Program

In Florida groundwater discharges can provide as much as 80% of the total flow of surface waters. (*The Hydrology and Water Quality of Select Springs*, 2001). Because of this, Florida developed a Ground Water Management Program (GWMP) that works to manage the effect of water quality in groundwater-surface water interactions, and quantity issues.[204] (Olexa, 2014). Specifically, the GWMP works to improve or maintain the quality of groundwater, surface water, base flows and springs. Springs are a particularly prized natural resource in Florida because they constantly contribute fresh potable water to sources around the state. The GWMP focuses on issues as they arise, but it also has several specific activities that are geared toward maintaining spring quality. (*Ground Water Management*, 2013). These include:

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[203] Email Communication with Kellie Madison, Technical Services Section Leader, Water Use Bureau, South Florida Water Management District, Nov. 2, 2015.
[204] The GWMP is part of the Florida's comprehensive watershed management strategy.

Spring Water Quality Monitoring

Roughly 100 springs are routinely monitored on a quarterly basis by FDEP and Districts. The monitoring program uses indicators to determine spring quality. Some indicators are nutrients, salinity, and several chemicals.

Groundwater and Springs Quality STORET Database

The data collected by the monitoring program is entered into a publicly available centralized database that also includes water quality data amassed by other agencies. From this database, water quality information can be catalogued and mapped. Together these data are used to identify impaired springs, develop total maximum daily loads,[205] create assessments, and conduct groundwater-surface water interaction investigations.

Groundwater and Springs Assessments

FDEP staff performs assessments using Spring Water Quality Monitoring data. These assessments align water quality data with information on land use practices and changes in land use in the area the sample was taken from. They also account for factors such as hydrologic conditions, flow patterns, and climate. This information leads to a greater understanding of changes in water quality over time, in the efficacy of BMPs, and influences on transport and fate of substances in the subsurface. The assessments are also used to prioritize and develop spring or watershed restoration efforts.

FloridaSprings.Org

The FloridaSprings.org website aims to provides educational resources to the

[205] Based on the results of routine spring monitoring and assessing, Total Maximum Daily Loads are developed to prevent nutrient loading and to restore water quality in springs with impaired water.

general public. It has pre-developed materials and activities for school-age children, and some slightly more technical information is also available. The website also includes information about springs in Florida's State Park System, and a link to the KARST film production of "*Water's Journey, the Hidden Rivers of Florida*." Though this website is very educational, there are not any regular face-to-face programs to engage the public on the topic of the importance of springs in Florida.

Agrichemical Effects

The GWMP gives FDEP authority to review pesticides proposed for registration with the Florida Department of Agriculture and Consumer Services (FDACS). FDEP reviews the potential of proposed pesticides to adversely impact ground water resources. (*Ground Water Management*, 2013). After FDEP completes a review it provides a technical report to FDACS. (*Ground Water Management*, 2013). The report states how a product will move in the environment, and if and how a product will adversely affect groundwater and surface water via groundwater transport. The GWMP also allows FDEP some oversight in the development of agricultural BMPs.

Additionally, the FDEP participates in monthly Pesticide Registration Evaluation Committee meetings to consider potential water quality impacts. (*Ground Water Management*, 2013). Beginning in 2013, the FDEP coordinates a pilot study in which pesticide samples are added to water bodies that are already sampled by FDEP's Department's Strategic Monitoring Program. The resulting data is published in the FDEP's Integrated Assessment Reports, and is used in making decisions about pesticides in the future.

The Aquifer Protection Program

FDEP operates the Aquifer Protection Program to support FDEPs overarching regulatory goals and programs relevant to groundwater supplies, in particular those regulations associated with groundwater and wells. (*Aquifer Protection Program,* 2001). Because all aquifers in Florida are subject to drinking water standards, the Aquifer Protection Program is critical in preserving groundwater quality.

Underground Injection Control Program

The FDEP has a team of geologists and engineers allocated to the Underground Injection Control (UIC) program. The primary goal of the UIC program is to ensure that the disposal of treated fluids is done lawfully and without impairing Underground Sources of Drinking Water (USDW). Although all aquifers receive quality protection by FDEP, USDWs are defined as those aquifers containing a total dissolved solids concentration of less than 10,000 milligrams per liter. Because these sources are so pure, they are prioritized for quality degradation prevention. The UIC program works to implement and enforce UIC regulations, especially where a USDW is adjacent to UIC injection zones.[206] (*Aquifer Protection Program,* 2001). The UIC program requires monthly reports regarding the physical and chemical characteristics of the injection wells to ensure that USDWs are protected and to take enforcement actions where necessary.

Regulation of Well Construction and Contractors

Both well construction and well construction contractors are regulated to ensure the quality of water wells. (*Water Well Construction Program,* 2014). This prevents

[206] Fla. Admin. Code § 62-528

against contamination and preserves both water quality and public health.

Well Construction

FDEP works closely with the five Water Management Districts (Districts) to manage well construction. Although FDEP is responsible for developing rules and regulations for licensing and permitting, it delegates oversight responsibilities to the Districts. The Districts adopt FDEP's rules and regulations regarding well siting, construction, repair, plugging, and abandonment.[207]

Regulations for well construction are specifically designed to protect water quality for purposes of public health.[208] The construction requirements reflect a consideration to the quality of the materials available and any chemicals already in groundwater. For example, solvent-bonded couplings are prohibited in areas where groundwater contamination by solvent compounds already occurs.[209] Although there are very specific construction standards in place, additional requirements may be imposed if needed to ensure public health.[210] For example, requirements for well depth and casing length may be changed from the minimum statutory requirements in order to protect public health.

Wells that fail to meet construction standards must be abandoned and plugged; abandonment and plugging actions also require permits.[211] Additionally, virtually any

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[207] *Id.*
[208] *See* Fla. Admin. Code §§ 62-524.200, 62-524.710. Exemptions are limited, require strong scientific evidence, and are issued on a case-by-case basis. *Id.*
[209] Fla. Admin. Code § 62-524.550(2)(b)
[210] Fla. Admin. Code §§ 62-524.550, 62-532.500.
[211] Fla. Admin. Code § 62-524.550(2)(k)

action concerning a potable water well is a statutory violation if it is not permitted.[212] This includes: construction, plugging, abandonment, operation and use for human consumption without quality testing or after finding contaminants.[213] Such violations amount to a second-degree misdemeanor.[214]

Last, newly constructed potable water wells must be tested for contamination before they become operational.[215] FDEP will only accept test results that come from samples collected by and analysis conducted by the DOH. Well construction permit applicants are responsible for any costs associated with the testing.[216]

Water Well Contractor Licensing and Permitting

The Districts implement additional programs and procedures for water well contractor licensing and permit issuance.[217] Like the well construction regulations, rules and regulations regarding contractors are also issued by FDEP. At minimum all water well contractors are required to be licensed by the state prior to engaging in any construction, repair, or closure and abandonment of a well. In order to become licensed, or to renew an existing license, contractors must complete 12 hours of approved continuing education unit credits.[218] Proof of course completion must be submitted to the Administrator of the Florida Water Well Contractor Continuing Education Program for approval. In order for the credits to be approved, contractors must take at least six

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[212] Fla. Admin. Code §§ 62-524.740, 62-531, Fla. Stat. Ann. § 373.309.
[213] Fla. Admin. Code § 62-524.740(1).
[214] Fla. Admin. Code § 62-524.740(2).
[215] Fla. Admin. Code §§ 62-524.600, 62-524.420.
[216] Fla. Admin. Code § 62-524.600.
[217] Fla. Stat. Ann. § 373.
[218] Fla. Stat. Ann. § 373.323-324; Fla. Admin. Code § 62-531.

hours related to water well construction practices and applicable water well construction rules, but not more than six related to safety and business practices. Any well contractor found to have committed a violation by taking unpermitted action or acting without the appropriate licensure is subject to penalties such as fines and license suspension.[219]

Water Well Contractor Information Clearinghouse

The Water Well Contractor Information Clearinghouse (WWCIC) is a database containing the names, license numbers, and contact information for licensed water well contractors around the state. The database is jointly compiled by FDEP and Districts, and is accessible to the public.[220]

Florida Water Well Identification Program

Under the Florida Unique Well Identification (FLUWID) program every well is tagged with a unique alphanumeric ID to streamline information exchanges between agencies and departments regarding information unique to each well. The ID is printed on weather resistant adhesive labels that are attached to either the wellhead or a pump house depending on the unit. FLUWID encourages comprehensive data analysis by cross-referencing available information. In addition, the IDs can be linked to construction permits, well completion reports, and water quality sampling testing results. Notably, FDEP developed the FLUWID program on its own, not in response to a mandate or any rules or regulations. Presently, some 92,1000 wells have been tagged.

Source Water and Wellhead Protection Programs

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[219] Fla. Admin. Code § 62-524.740(2); 62-531.
[220] Fla. Stat. Ann. § 373.335; Fla. Admin. Code § 62-531.

Since 1998, the Wellhead Protection program has served as a pollution prevention and management program for groundwater sources. The primary feature of this program is the requirement of a 500-foot radius Wellhead Protection Area[221] (WPA) around all wells serving public water systems (with few exceptions). (*Wellhead Protection,* 2016). Within the WPA, local governments limit or restrict land uses in order to protect aquifers from contamination. When requested by a local government, the District with jurisdiction provides scientific modeling of public supply wells to identify wellhead protection areas and assists local governments in developing programs for those areas. Also, this program prohibits new installations from being placed too close to a wellhead. Ultimately, FDEP delineates and manages the WPAs even though the Districts provide much of the data.

Clean Sweep Program

Proper disposal is often an expensive and time-consuming regulatory burden to environmentally sound handling and disposal of pesticides. Because of this, pesticides are often not disposed of properly or in a timely manner. FDEP began operating a Clean Sweep Program in 1995. Then, it focused on removing lead arsenate (a citrus pesticide now banned by the EPA) from crop farms. It successfully collected 70,000 pounds. The program continued, expanding in the first few years to collect a variety of toxic and hazardous materials such as chlordane and DDT.

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[221] Fla. Admin. Code § 62-521; Wellhead Protection (Jan 30, 2013), *available at* http://www.dep.state.fl.us/ water/groundwater/wellhead.htm. A WHPA is defined as "the surface and subsurface area surrounding a public water supply well, through which contaminants are reasonably likely to move toward and reach the well." *Id.*

The program is now open to farmers, nursery operators, golf course operators, and pest control services. Each site is allowed a one-time opportunity to dispose of any cancelled, suspended or otherwise unusable pesticides. The most recent data reflects 2,000 participates and more than 1,550,000 pounds of pesticides (775 tons) since the program began. (*Operation Cleansweep for Pesticides*, 2015).

Figure 24 shows almost identical trend lines for the budget and the volume of pesticides collected across years. Though not shown below, the trend line for the number of participants across years almost exactly mimicked the trend lines for the budget and the volume collected across years.

The data suggests that when the program budget is increased, the volume of pesticides collected also increases. Despite the success of this program, it was not funded for year 2010 through 2014, but will be funded for the 2015-2016 budget year. Interestingly, participants in fiscal year 2010-2011 pooled funds together to cover the cost of the program. Figure 24 reflects this showing that although there was zero funding from the government, there was a small collection of pesticides (11,208 lbs).

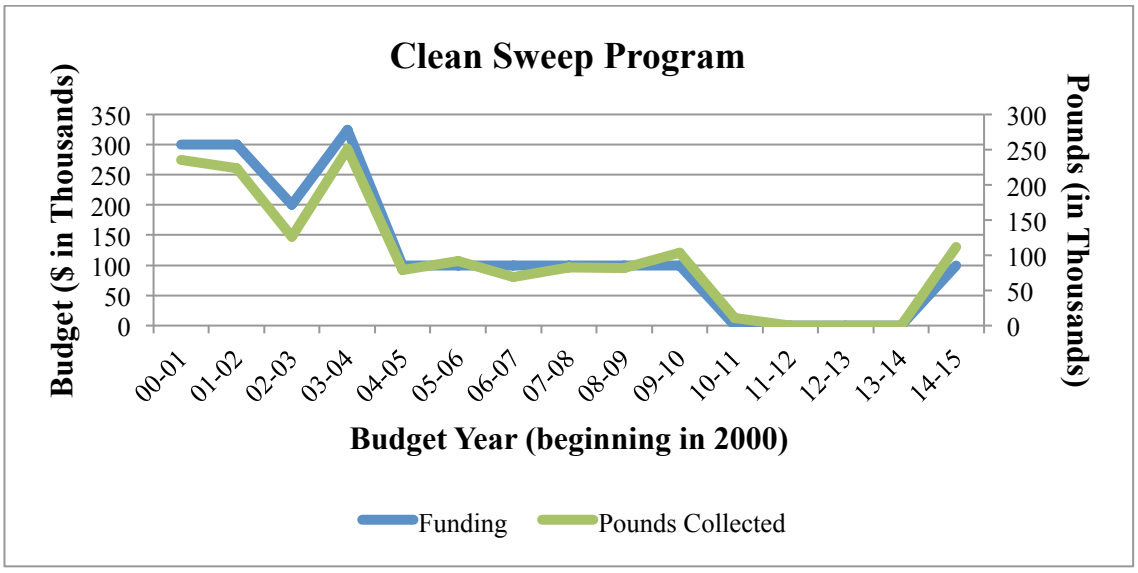

Figure 24: Florida Clean Sweep Program. Data from the FDEP Waste Webpage.

Land Use and Contaminants: Solid Waste Landfills and DEET

FDEP's Solid Waste Section is responsible for permitting and enforcement actions at all types of landfills and waste sites. Landfills are classified depending on the type of waste received and the volume of waste received. Class I and II landfills receive general, household, commercial, industrial, and agricultural wastes that are considered to be non-hazardous, and are generally referred to as Municipal Solid Waste landfills.[222]

Permits applications require a completed Form 62-701.900(1) as well as a map or photograph showing all airports within five miles and a topographic map showing the proposed fill area, any borrow area, access roads, grades required for proper drainage and cross sections of lifts, special drainage devices if necessary, fencing, and equipment

[222] Fla. Admin. Code §§ 62-701.300, 62-701.520.

facilities. [223] A report must also be submitted with the application stating: the current and projected population and area to be served; the anticipated type, annual quantity, and source of solid waste, expressed in tons; the intended active life of the facility; the final design height of the facility, and the maximum height of the facility during its operation; and the source and type of cover material.[224] FDEP staff determines the impact of the proposed landfill based on the volume of waste received annually.

In addition, there are several requirements relevant to the hydrogeology of the intended site. These include hydrogeological and geotechnical investigations,[225] a water quality monitoring plan[226] contact information for an FDEP approved laboratory selected to perform the water quality monitoring,[227] and a site map to reflect landfill dimensions, the locations of proposed and existing water quality monitoring wells, locations of soil borings, and any previously filled waste disposal areas.[228] Technical operational plans[229] and statements demonstrating financial assurance documentation are required before final approval is given.[230]

A unique feature of the landfill permitting process is a traning requirement for landfill operators. This requirements has been in place since 1988, when the passage of

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[223] Fla. Admin. Code § 62-701.330(3).
[224] Fla. Admin. Code § 62-701.330(3); *Landfill Disposal*, FLA. ENVTL. DEP'T OF PROT. (1999), *available at* http://www.dep.statestatestatestatestatestatestatestatestatestate.fl.us/waste/quick_topics/publications/shw/recycling/swm_99/chapters/landfill.pdf. An important aspect of landfill permitting for these classes is the lining requirements. Since 1985, Florida has required landfill liners. At that time single layer clay or geomembrane liners were permitted; presently, composite or double liners are required. *Id.*
[225] Fla. Admin. Code § 62-701.410.
[226] Fla. Admin. Code § 62-701.510.
[227] Fla. Admin. Code § 62-160.
[228] Fla. Admin. Code § 62-701.330(3).
[229] Fla. Admin. Code § 62-701.500(2), (6)-(11).
[230] Fla. Admin. Code § 62-701.630.

the Solid Watse Management Act made training mandatory for all landfill operators. (*Landfill Disposal*, 1999). Training requirements were developed by a Committee composed of solid waste professionals from local governments, private industry, educational institutions and FDEP staff. (*Landfill Disposal*, 1999). There are four ways for a landfill owner to provide this training, but the selected method along with plans for continued training must be included in the application. The training method must also be approved by FDEP staff.[231]

Permit applications must be submitted with an application fee of $10,000.[232] In addition, a Ground Water Monitoring Plan must be submitted for approval with a fee of $500.[233] The Solid Waste Section reviews an application with 30 days of receiving it, and within that time will request any additional information from the applicant.[234] Applicants have 90 days to respond or the application will be denied.[235] Upon receiving the response, Solid Waste Section staff has another 30 days to review the application and request any information needed only for purposes of clarification.[236] Barring any extensions or extenuating circumstances, decisions on permits should be made with 90 days of the application being completed.[237]

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[231] Fla. Stat. Ann. § 403.716.
[232] Fla. Admin. Code § 62-4.050. Closure fees for both are $7500. *Id.*
[233] Fla. Admin. Code § 62-4.050
[234] Fla. Admin. Code § 62-4.055
[235] Fla. Admin. Code § 62-4.055(2). If the applicant believes any Department request for additional information is not authorized by law or rule, the applicant may request a hearing pursuant to Fla. Stat. Ann. § 120.57.
[236] Fla. Admin. Code § 62-4.055
[237] Fla. Admin. Code § 62-4.055.

The ground water monitoring requirements are illustrated in Table 5. The monitoring requirements fall within two categories of Field Parameters and Laboratory Parameters.[238] Chemical parameter testing is performed in a laboratory. Presently, there is no requirement to test for DEET, though testing for Benzene is required. Benzene may not appear in groundwater at levels exceeding 1 μg/L. Notably, there is also no standard for drinking water monitoring for DEET. (Florida Health Chemical Analyte List, 2015).

Field Parameters	Laboratory Parameters
Static water level in wells before purging	Sodium
Specific conductivity	Total ammonia – N
pH	Chlorides
Dissolved oxygen	Iron
Turbidity	Mercury
Temperature	Nitrate
Colors (by observation)	Total dissolved solids (TDS)
Sheens (by observation)	Those parameters listed in 40 CFR 258 Appendix I (Criteria for Municipal Solid Waste Landfills; Benzene listed)

Table 5: Florida Ground Water Monitoring Requirements.

Generally, landfills install a two-ring network of wells around the landfill site to conduct groundwater monitoring. The inner-wells are close to the disposal areas and are

[238] Fla. Admin. Code § 62-701.510.

used for early detection of contaminant migration.[239] The outer-wells are considered compliance wells because they are at or near the boundary of the landfill site; these are used to ensure detection of off-site impacts.[240] The landfill permit includes specific conditions that detail site monitoring requirements for both the frequency of monitoring, the specific analytes to be monitored for, and monitoring methods.[241]

Land Use and Contaminants: Underground Storage Tanks and Benzene

FDEP's Solid Waste Section is responsible for permitting and enforcement actions for USTs. FDEP has pre-approved storage tank systems and equipment for use within Florida.[242] (*Storage Tank Compliance*, 2016). In addition, FDEP, without endorsing any in particular manufacturers has a list of manufacturers and their product information and contact information.[243] (*Approved Storage Tank System Equipment List*, 2016). Whatever system is selected, it must be completely registered with the state 30 days prior to the tank becoming operational.[244]

If the tanks contain any petroleum products, the registrant is required to demonstrate financial ability to pay the costs of any corrective actions required as a result of a discharge or leak from the tank.[245] There is registration fee of $50.00 per tank

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[239] Email communication with Mark Stuckey, P.G., Division of Waste Management, Florida Department of Environmental Protection on January 29, 2016.
[240] *Id.*
[241] *Id.*
[242] Fla. Admin. Code § 62-761.
[243] Fla. Admin. Code §§ 62-761.850, 62-762.851.
[244] Fla. Admin. Code § 62-761.400. The owner or operator of any facility, or the owner or operator of a storage tank system shall register the storage tank system with the Department on Form 62-761.900(2). *Id.*
[245] 40 C.F.R. 280, Subpart H; Fla. Admin. Code § 62-761.800(2).

required within 30 days of registration.[246] Once the registration fees are paid, FDEP sends the owner a registration placard which has to be publicly displayed at the site of the tank. [247] Receipt of the placard makes the registration complete and the tank may be used at that point. [248]

Although the tank registration process is relatively straightforward, FDEP has authority to revoke the placard and thereby invalidate the registration for violations such as failing to respond to a leak, failing to operate leak detection and failing to maintain financial responsibility.[249] (*Storage Tank Compliance*, 2016). Revocation of a placard, or rejection of a registration, is preceded by a letter from FDEP staff 30 days prior to the revocation or rejection.[250] In response, owners notify FDEP when the problem is rectified, and their registration is reinstated. [251] FDEP manages a website where active tanks in violation and tanks with invalid registrations are listed, along with location and ownership information. [252]

When any changes are made to the storage tank system the owners must notify the County that has jurisdiction over the tank site.[253] The County government must also be notified within 24 hours of any incidents concerning the storage tanks.[254] (*Storage Tank Compliance*, 2016). Incidents include a malfunction or structural weaknesses in

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[246] Fla. Admin. Code § 62-761.800(2).
[247] Fla. Admin. Code § 62-761.800(2).
[248] 40 C.F.R. 280, Subpart H; Fla. Admin. Code § 62-761.800(2).
[249] Fla. Admin. Code §§ 62-761.400(3), 62-761.500, 62-761.610, 62-761.800, 62-761.820.
[250] *Id.*
[251] *Id.*
[252] *Id.*
[253] Fla. Admin. Code § 62-761.450.
[254] *Id.*

the system, odors of regulated substances contained in the tank, soil stains, and leaks indicating chemical contamination from petroleum products. [255]

In Florida, the drinking water quality standard for Benzene is 1 µg/L, however, Benzene is rarely monitored for in groundwater at UST sites. (Florida Health Chemical Analyte List, 2015).

Groundwater monitoring at UST sites is referred to as "external monitoring."[256] Although external monitoring is still used in some cases, it is generally not used because mandatory system upgrades required in the 1990's improved primary and secondary containment. This means that UST systems have release detection devises installed in them.[257] These devises should identify a UST leak almost immediately and before any substance could migrate to groundwater.

If external monitoring is used, then monthly monitoring checks are required by statute.[258] The monitoring parameters for external monitoring depend on the substance contained in the UST. For example, in cases of gasoline storage, monitoring requirements would be monthly checks for odor or sheen on groundwater in the monitoring well.[259]

Notably, in 1983, Florida was one of the first states in the union to pass legislation and adopt rules for storage tank systems. (Storage Tank Compliance, 2016).

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[255] *Id.*
[256] Fla. Admin. Code § 62-761.
[257] Email communication with Mark Stuckey, P.G., Division of Waste Management, Florida Department of Environmental Protection on January 29, 2016.
[258] Fla. Admin. Code § 62-761.
[259] Email communication with Mark Stuckey, P.G., Division of Waste Management, Florida Department of Environmental Protection on January 29, 2016.

Since then, over 28,000 facilities have reported discharges of petroleum products from storage tank systems. (Storage Tank Compliance, 2016). Figures 25-27 reflect patterns of UST inspections and releases in the last few years. Florida has begun recording information about USTs and leak trends in significant detail. However, this is a relatively recent effort and to date only four years of data are available because Florida recently accepted a grant that provides funding for this research.[260]

Figure 25 shows that the number of UST facilities has not changed much from 2011 to 2014, but the number of facilities inspected has declined every year. The change in percentage rates for compliance among the facilities inspected changed drastically between 2012 and 2013. Given that there are only four years of data it is difficult to speculate about why this change occurred, however, it may be because the number of facilities inspected declined in the same period.

[260] Email Communication with Roberta Dusky, Environmental Specialist III, Florida Department of Environmental Protection, Northwest Florida Management District, Oct. 28, 2015.

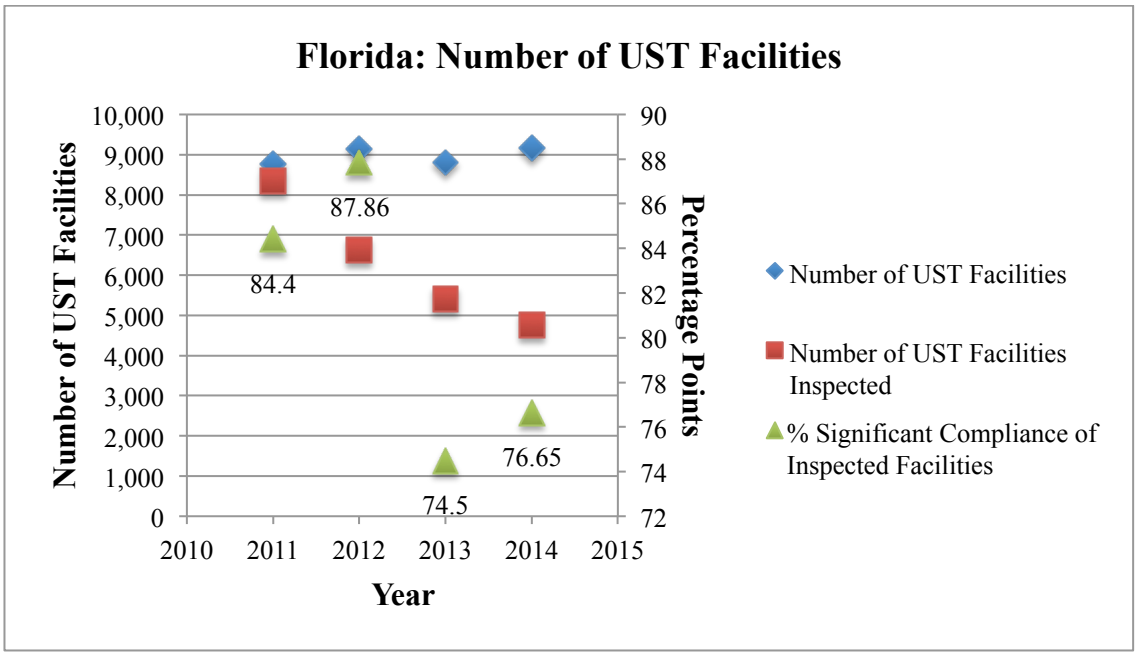

Figure 25: Florida UST Facility Inspections. Data provided by FDEP.

Figure 26 reflects a slight increase in the number of individual USTs, and a decline in the total number of confirmed releases. It is unclear what may have caused the decline in total number of confirmed releases, but Figure 27 provides more insight into the causes of UST leaks in the same time period.

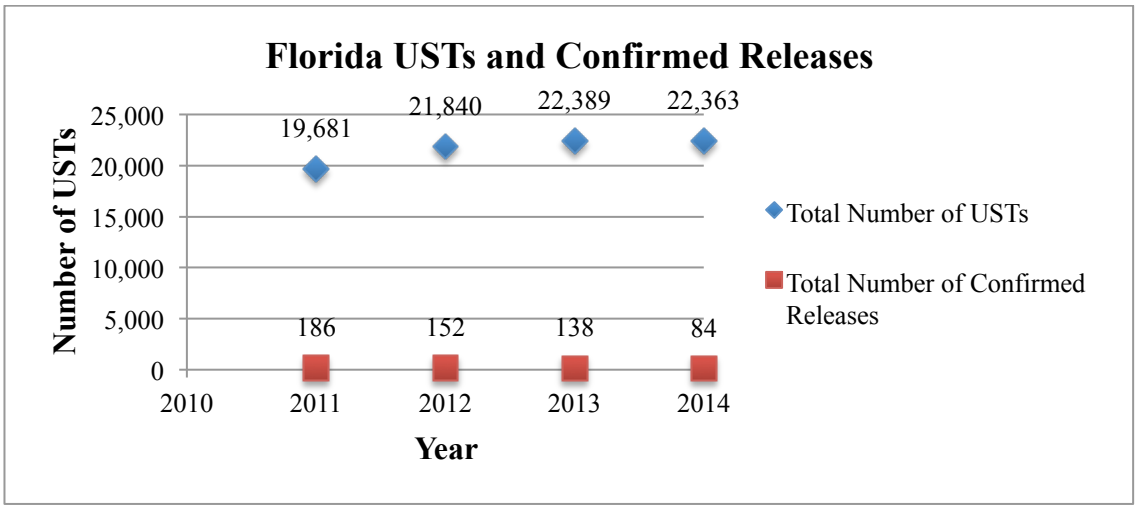

Figure 26: Florida USTs and Confirmed Releases. Data provided by FDEP.

Figure 27 shows a significant and steady decline in the Physical and Mechanical Damage category leading to releases that could contribute to the decline in total number of confirmed releases. However, there were also sharp declines in the Other and Unknown categories which are much less telling.

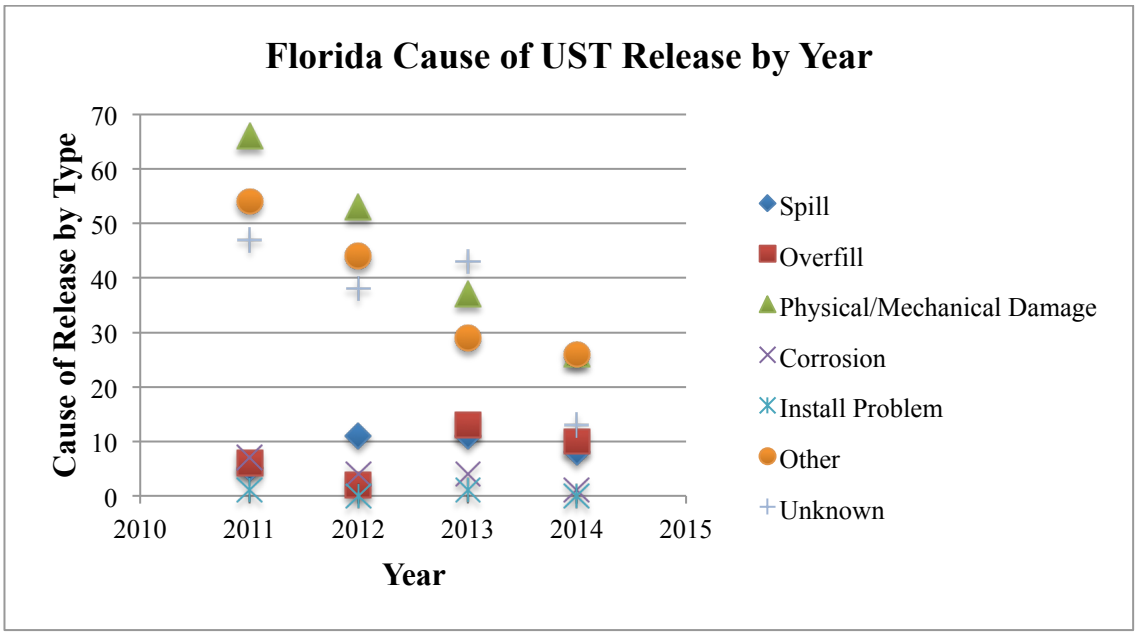

Figure 27: Florida UST Releases By Cause Type. Data provided by FDEP.

Monitoring and Research

FDEP oversees the Ground Water Quality Monitoring Network (GWQMN), which was first created by the state legislature in 1983.[261] The purpose of the GWQMN is to enable FDEP to "detect or predict contamination of the state's ground water resources."[262] The GWQMN collects data on the chemical and physical characteristics of water from the three major aquifer systems of the state, and uses the data to establish baseline quality standards for those aquifer systems. The data is also used to discern trends in ground water quality, and to identify connections between quality and land use activities. (*Organization and Establishment of Florida's Statewide*

[261] Fla. Stat. Ann. § 403.063.
[262] Fla. Stat. Ann. § 403.063.

Ground Water Quality Monitoring Network, 2011). Making these connections allows FDEP and the Districts to detect and predict changes in groundwater quality.

The GWQMN is divided into two sub-groups. The Background Network defines baseline water quality levels by sampling and tracking data from 1700 wells that pull from all the major potable aquifers in Florida. (*Background Water Quality Monitoring Network*, 2011). Current samples pulled from these wells are tested for contamination indicators such as pesticide, trace metals, and volatile organic compounds. (*Background Water Quality Monitoring Network*, 2011). The results are analyzed for FDEP and used to guide other programs and prioritize FDEP activities.

The second sub-group is the Very Intense Study Area Network. This network is designed to study the impacts of various land uses on groundwater quality. The areas of focus are chosen based on the belief that they are highly susceptible to groundwater contamination based on the land use types and hydrogeology of the area. (*Visa Network*, 2013). Well samples from these areas are compared with established baselines; differences between the two are then reviewed in light of known changes in land uses. (*Visa Network*, 2013). This analysis allows staff to assess whether and how land use affects groundwater quality, and to predict the impact of siting similar land uses within the same area. (*Visa Network*, 2013). Some land use types currently be studied are citrus operations, ferneries, cropland agriculture, single family housing, light, heavy and urban industrial, and urban/suburban border areas. (*Visa Network*, 2013).

FDEP is the lead agency and is responsible for setting groundwater quality goals and priorities, and developing strategies. However, FDEP has contracted with all five Districts and other agencies to carry out the fieldwork involved.

In addition to the statewide monitoring networks, FDEP conducts monitoring and research under its Spring Water Quality Monitoring efforts. The GWMP also has monitoring and research aspects, although those efforts change depending on what problems and needs FDEP has prioritized. Last, state statutes require any installation or operation that discharges directly into groundwater to develop a monitoring program that is approved by professional geologists or engineers.[263] However, there is not a categorical type of operation that discharges into groundwater sources, such that FDEP could develop rules with more specificity for a targeted industry.

Budget and Staff

It is difficult to determine total expenditures made on groundwater quality protection programs because FDEP splits groundwater related duties among many divisions. The multi-division approach is the result of FDEP's recognition of the groundwater-surface water interaction that occurs in most of the state. (*Florida's Ground Water Quality Monitoring Program: Hydrogeologic Framework*, 1992). Figures 28-31 account only for FDEP totals and the five departmental divisions within FDEP that are most involved in groundwater protection.

Figure 28 reflects two important pieces of information. First, that the divisions most involved in groundwater protection are allocated very small budgets in comparison

[263] Fla. Stat. Ann. § 62-520.600.

to the total FDEP budget. Second, that the FDEP total budget experienced a dramatic decline beginning in the 2007-2008 fiscal year, from which it has not recovered. In fact, it seems to have largely plateaued since 2009.

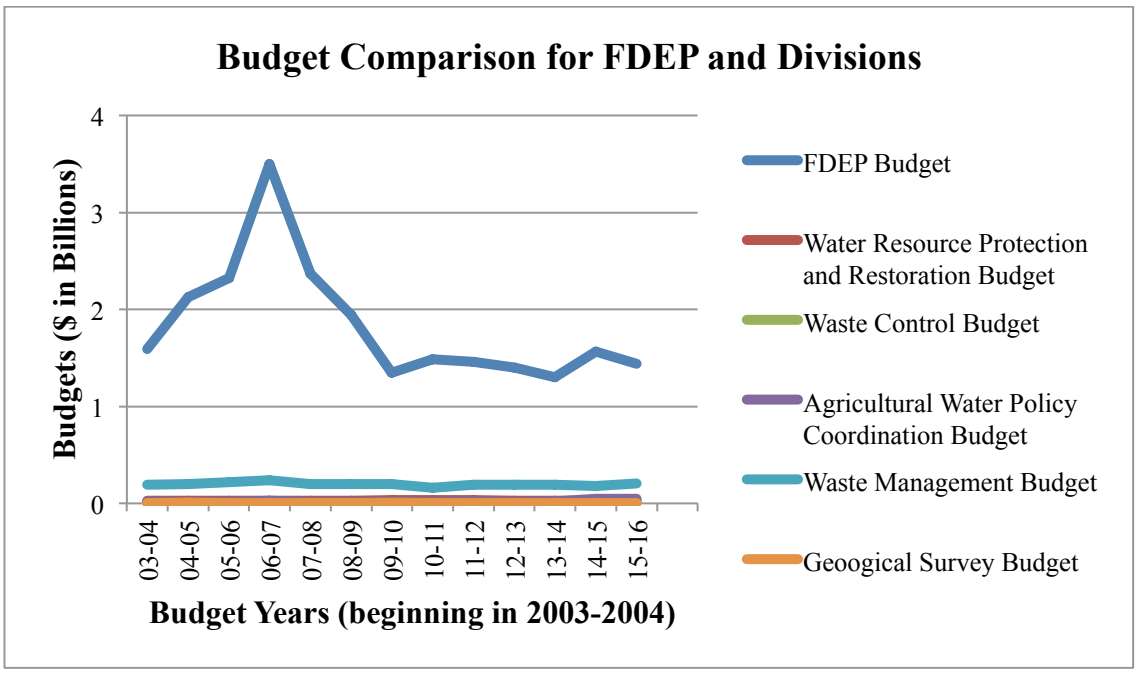

Figure 28: Budget Comparison for FDEP and Divisions. Data from Florida Executive Budgets.

Figure 29 provides a budget comparison of the divisions only. This figure shows three important pieces of information. First, the Waste Management Budget receives the most funding of the five most relevant divisions. Second, that the budget for Agricultural Water Policy Coordination is beginning to increase. Third, that with the exception of the budget for the Agricultural Water Policy Coordination, all of the

budgets seem to sustain without change across the last decade. It is notable that these budgets sustained despite the FDEP budget taking an overall decline during the same period of time.

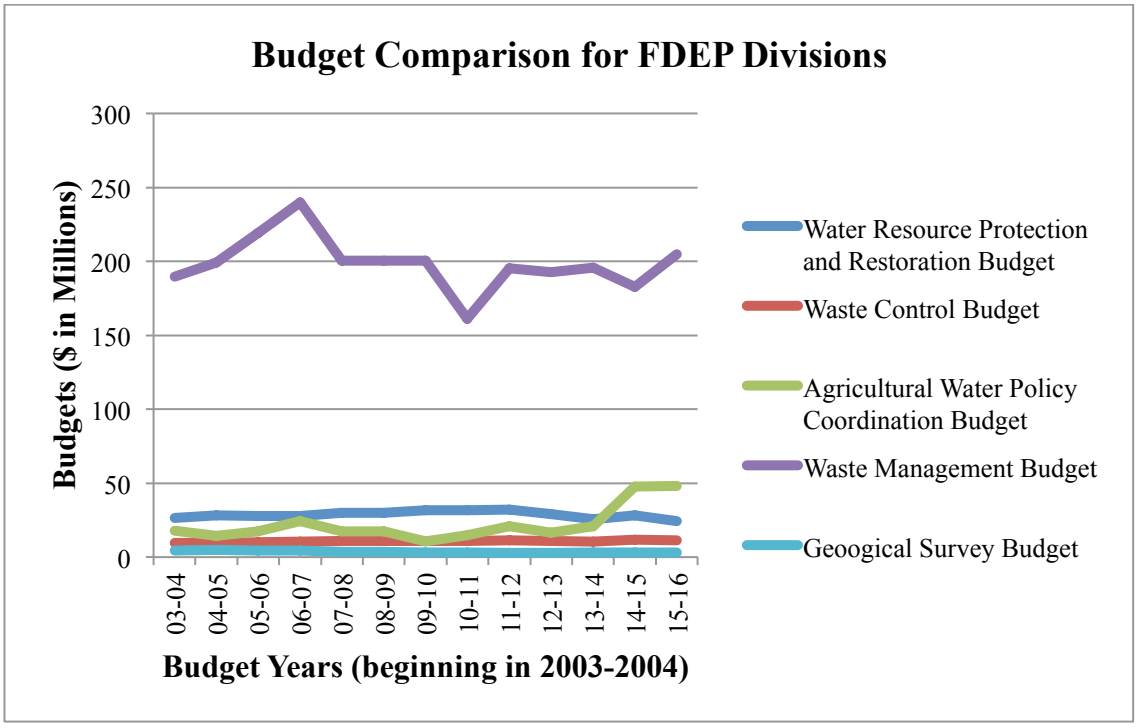

Figure 29: Budget Comparison for FDEP Divisions. Data from Florida Executive Budgets.

Figure 30 shows the FTEs numbers for FDEP and for the five divisions. This data reflects two interesting pieces of information. First, that by comparison these five divisions are allocated relatively few FTEs, even though they have significant budgets as shown in Figure 28. Second, that although FDEP FTEs are declining, the shift is slow and does not align with changes to the FDEP total budget.

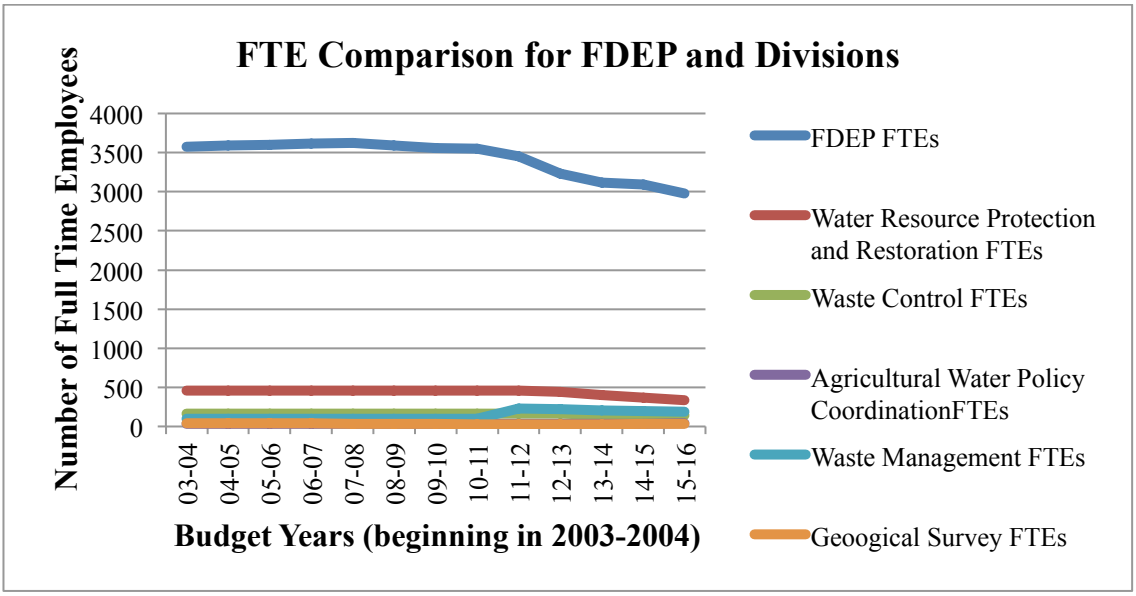

Figure 30: FTE Comparison for FDEP and Divisions. Data from Florida Executive Budgets.

Figure 31 shows the comparison of FTE numbers among the divisions only. Two notable pieces of information are revealed in Figure 31. First, the Water Resource Protection and Restoration has the highest number of FTEs, even though it had a relatively low budget, and not the highest budget of all the divisions as shown in Figure 28. Second, Waste Management has had the highest budget (*see* Figure 28), but until 2010 it had a relatively low number of FTEs. That number rose for a year, then declined, although not to 2009 levels.

Most notably, it does not appear that the budgets or FTE numbers for any of the divisions were impacted by reductions that impacted FDEP as a whole.

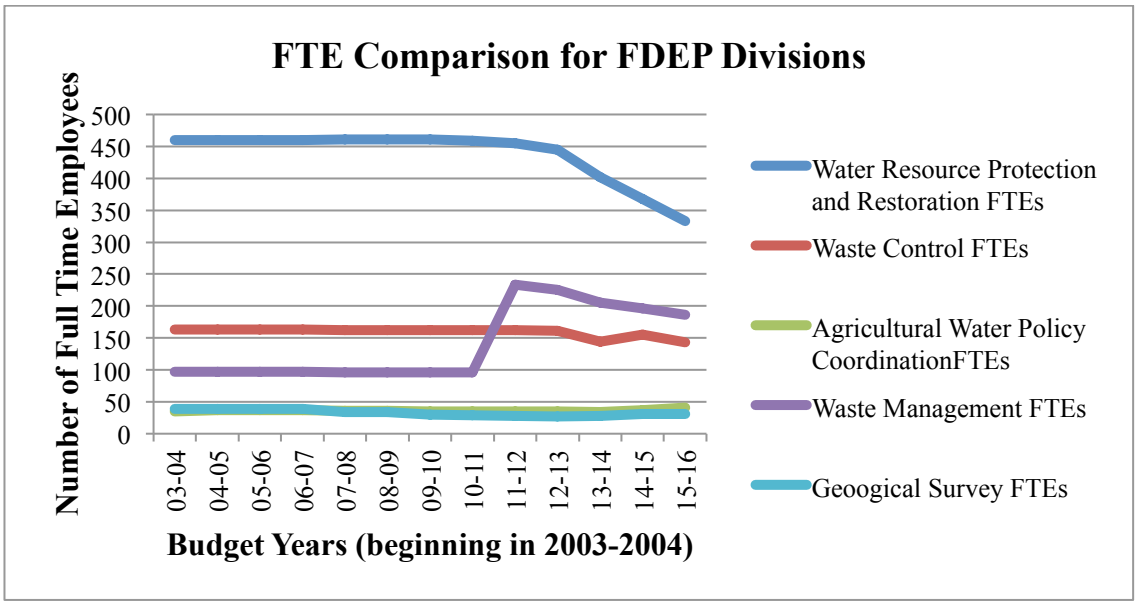

Figure 31: FTE Comparison for FDEP Divisions. Data from Florida Executive Budgets.

Florida Department of Health

Although an early iteration of the Florida Department of Health (DOH)[264] was responsibly for water resources, water quality and matters of public health, it has not been involved in decision making or enforcement for any of those issues since the 1975 formation of FDEP. Presently, the DOH's main environmental duty is to certify laboratories used by FDEP. When it comes to groundwater specifically, the DOH is responsible for managing ethylene dibromide (EDB) contaminations. In the 1980's large portions of the state experienced EDB contamination in groundwater resulting from several decades of its use as a pesticide in citrus operations. The contamination migrated to source wells used for both public and private water supplies. Since EDB

[264] Previously called the Board of Health.

emerged as a serious contaminant, the DOH has been responsible for well contamination investigations. It assesses damage incurred from chemical releases such as EDB, and also from dry cleaners, petroleum sites, and other common sources of contamination. (*Drinking Water,* 2016). When contamination is a problem, DOH is also responsible for delineating areas of contamination and providing alternative water sources. (*Delineation Program,* 2015).

Budget and Staff

Figures 32 shows that in fiscal year 2005-2006, DOH began receiving an influx in funding which has largely been sustained in the last decade. Figure 33 shows that an increase in FTE numbers started in the same budget year, but spiked in the fiscal year 2008-2009. The FTE numbers have receded since the budget year 2009-2010, but have remained much higher than they were prior to 2008-2009.

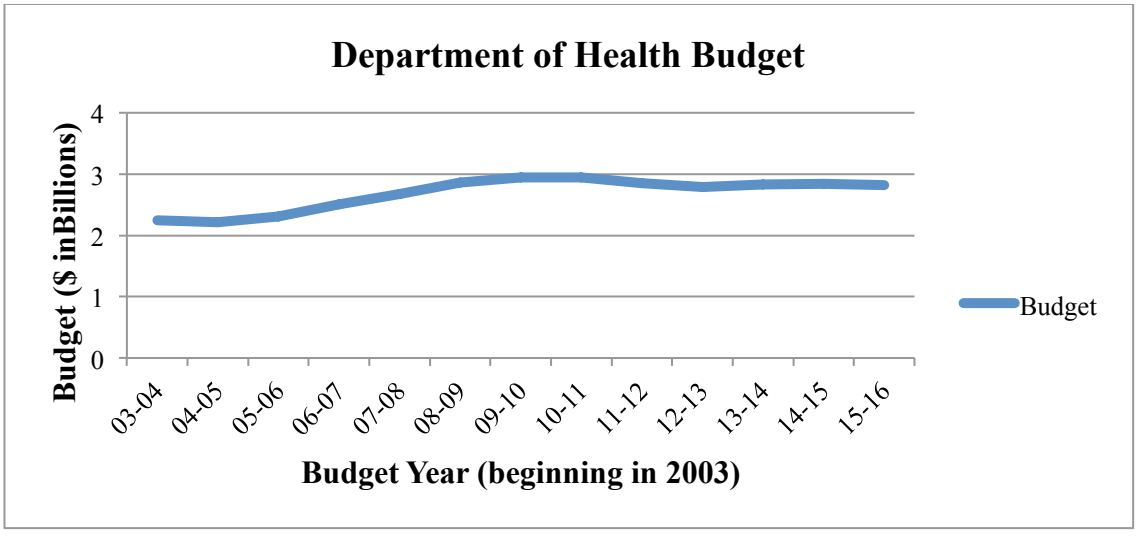

Figure 32: Florida Department of Health Budget. Data from Florida Executive Budgets.

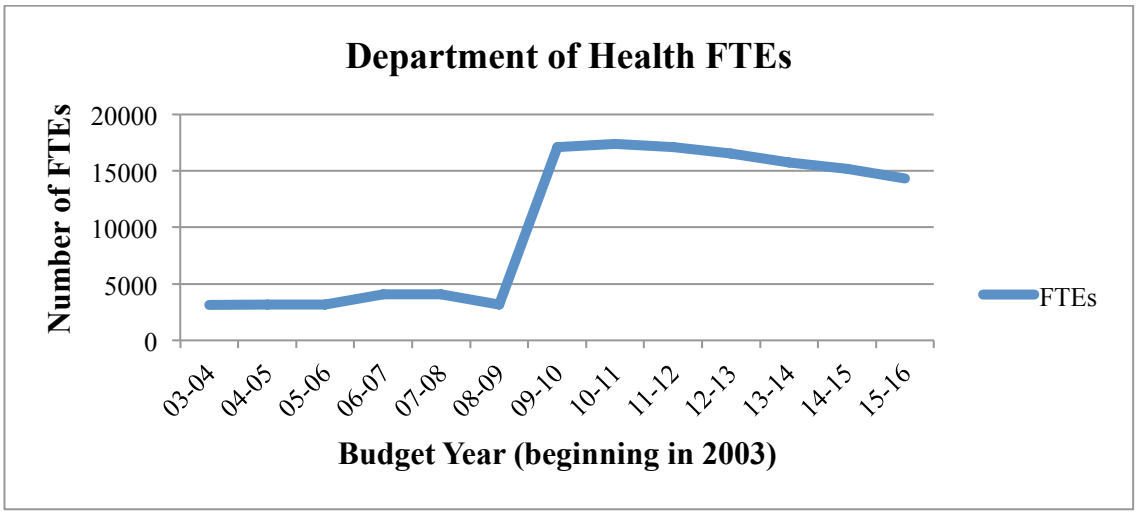

Figure 33: Florida Department of Health Full Time Employees. Data from Florida Executive Budgets.

Florida Department of Agriculture and Consumer Services

FDACS regulates agricultural practices that may affect water through a few divisions and offices. The Division of Agricultural Environmental Services (DAES) is responsible for pesticide registration, use regulation, pest control practices, fertilizer registration and inspection, among other duties. DAES works to "decreas[e] the number of pesticide, pest control, fertilizer, feed and seed licensees and products that are unlawful, unsafe or unethical." (*Division of Agricultural Environmental Services*, 2016). Additionally, DAES has enforcement authority.[265]

All of FDACS' legal services and functions are consolidated under the Office of Agricultural Law Enforcement (OALE). The OALE coordinates with the Bureau of Investigative Services, the Bureau of Uniform Services, and the Division of

[265] Fla. Stat. Ann. § 388, 482, 487, 570, 576, 578, 580.

Administration to handle complaints and discoveries of violations. The OALE shares regional and field offices with partner agencies in order to address violations quickly and thoroughly.

The Office of Agricultural Water Policy (OAWP) was established in 1995 by the state legislature to coordinate work on water quantity and quality challenges between federal, state and local agencies and the agricultural industry. (*Office of Agricultural Water Policy*, 2016). OAWP is actively engaged in the development of Best Management Practices (BMPs) for both quality and quantity. (*See Agriculture and Water Quality*, 2013). OAWP works with agriculture industry members, FDEP, the university system, the Districts, and other stakeholders, to create BMPs that are economically and technically feasible. Because some BMPs are very expensive to implement, cost-share programs are available to some members of the agricultural industry. Under a cost-share program, the expense of the BMP is offset by a contribution from the University of Florida system or an agency. In return for the financial assistance, the contributor will be able to study the impact of the BMP at the site of implementation.

The BMPs currently in place focus on Cow/Calf operations, Citrus growers, Equine operations, Nurseries, Vegetable and Agronomic Crops, Sod operations, and Specialty Fruit and Nut Crops. There are also new BMPs that aim to protect at risk wildlife. Some BMPs are required, depending on the nature of the agricultural operation, a BMP may be required, but most BMPs are voluntary and are subsidized by

state grant programs or university research programs.[266] (*BMPs at a Glance*, 2016). FDACS makes a great effort to persuade farms and operations to enroll in BMPs, and OAWP field staff work directly with the agriculture industry to educate and assist in the enrollment process. One incentive to encourage enrollment in BMPs is that it provides a presumption of state water quality standard compliance.

Once enrolled in a BMP, FDACS assists the operations with accurate implementation. As funding allows, OAWP works jointly with FDEP, the University of Florida, Districts, and other stakeholders to monitor the effectiveness of BMPs in protecting water quality. (*BMPs at a Glance*, 2016). FDACS usually contracts with the University of Florida, Districts, and other public and private entities to provide supplemental education support and technical assistance to industry members.

The Division of Agricultural Environmental Services is responsible for agricultural pesticide registration, pesticide testing and regulation, and pesticide compliance. Some pesticides are classified as "restricted us" and can only be applied by certified applicators. This Division ensures that applicators are trained and licensed specifically for the handling and application of these restricted pesticides.

The Licensing and Enforcement Division conducts routine inspections and record audits of pesticide manufacturers, distributors and retailers. This is to ensure that restricted-use pesticides are sold only to licensed applicators, and that storage and labeling standards are followed. (*Bureau of Licensing and Enforcement*, 2016). The

[266] *BMPs at a Glance*, FLA. DEP'T OF AGRICULTURE AND CONSUMER SERV. (Jan. 16, 2016), *available at* http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy/Enroll-in-BMPs/BMPs-at-a-Glance. Areas that are part of FDEP Basin Management Plans must implement BMPs or conduct water quality monitoring. *Id.*

Licensing and Enforcement Division also investigates reports of pesticide misuse and violations such as applications by unlicensed applicators, incorrect use, improper storage or unauthorized sale of pesticides. It does impose enforcement actions, and may also require attendance at training and educational programs.

Land Use and Contaminants: Farming Practices and Atrazine

Agricultural chemicals, including Aldicarb, Alachlor, Bromacil, Simazine, and EDB have caused serious local and regional (in the case of EDB) problems. (*Drinking Water & Human Health in Florida*, 2016). However, Atrazine doesn't seem to have become problematic in any part of the state and is not prohibited for use. (*Weed Management Chemicals*, 2011). Atrazine has not been detected in drinking water source wells sampled at random across the sate.[267]

Atrazine users must obtain an application license and keep detailed records of use, but this is the same for all pesticides.[268] Although registration and use requirements are in place, there are not strict requirements for groundwater monitoring. DATCP staff sample potable source wells quarterly to ensure that the drinking water quality standard for Atrazine of 3 μg/L is met, but there are not monitoring requirements in place for landowners. (*Health Chemical Analyte List*, 2016). If Atrazine were detected in the DATCP samples at levels of 50% of the guidance (1.5 μg/L), DATCP staff would resample the well in which it was detected and then send notification letters to those registered for use

[267] Email communication with Charlie Clark, Environmental Administrator, Pesticide Registration Review Section, Florida Department of Agriculture and Consumer Services on January 29, 2016. Although DATCP does sometimes detect Atrazine in surface waters, they have always been found at 1,000 to 10,000 times less any aquatic benchmark used to indicate a serious problem. *Id.* Although there are protocols for exceeding a TMDL, presently there are no TMDLs in place for pesticides. *Id.*

[268] Fla. Admin. Code § 5E.

of Atrazine products.[269] If the exceedance was detected in the immediately subsequent quarter, DATCP would open an investigation as to whether Atrazine (or any pesticide in exceedance of a standard) was being used properly, or whether the label instructions needed to be altered.[270]

Budget and Staff

Figure 34 shows that FDACS operated with a relatively consistent budget until fiscal year 2012-2013 when it received a staggering increase that has not been reduced since. Figure 34 also reflects how small the allocations are for relevant FDACS divisions compared to the entire FDACS budget.

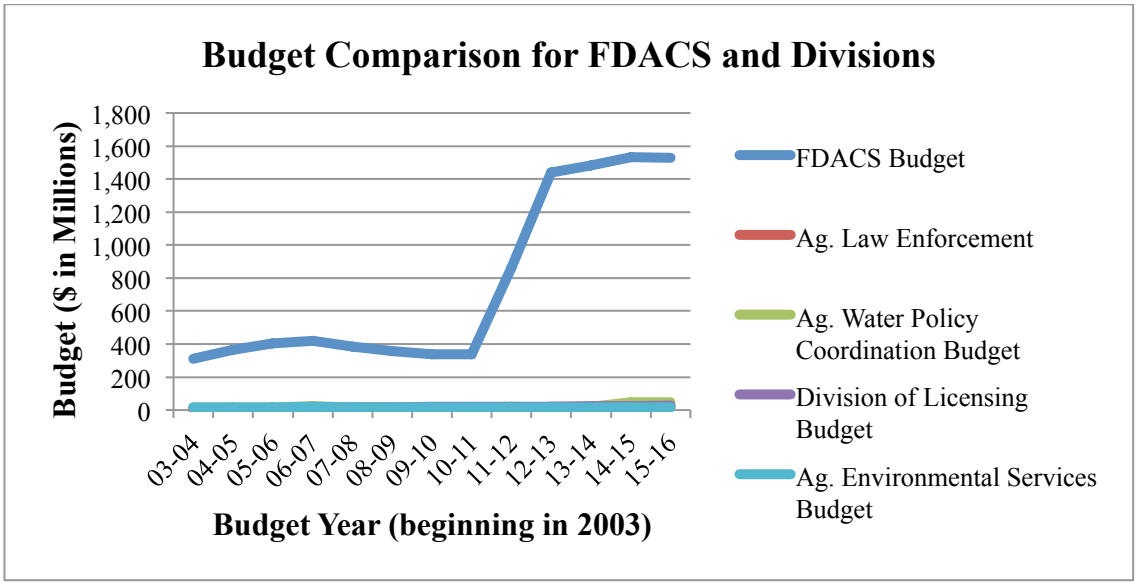

Figure 34: Budget Comparison for FDACS and Divisions. Data from Florida Executive Budgets.

[269] Email communication with Charlie Clark, Environmental Administrator, Pesticide Registration Review Section, Florida Department of Agriculture and Consumer Services on January 29, 2016.
[270] *Id.*

Figure 35 suggests that the Agricultural Law Enforcement Division benefited from the fiscal year 2012-2013 increase in the total FDACS budget, since it experienced a substantial increase in the same fiscal year. Figure 35 also shows that the budget for Agricultural Water Policy Coordination experienced an increase a few years after the increase in the total FDACS budget, while the Division of Licensing has seen a small and steady increase over the last ten years. The Agricultural Environmental Services budget sustained across years with relatively little fluctuation.

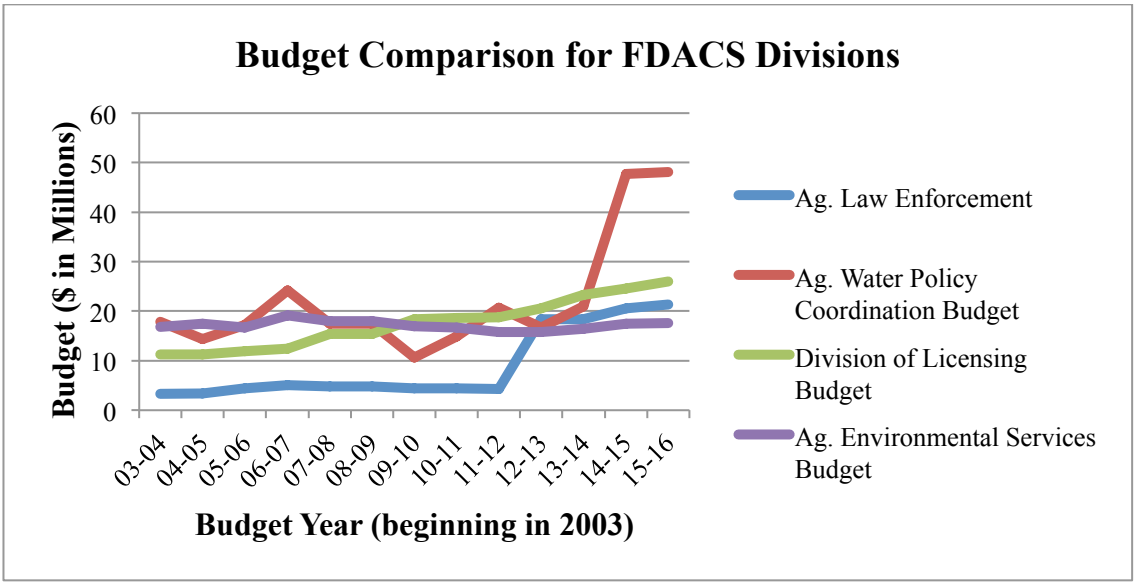

Figure 35: Budget Comparison for FDACS Divisions. Data from Florida Executive Budgets.

Figure 36 shows that full time employee numbers (FTEs) for FDACS slowly declined over the past decade, despite a sharp increase in the budget in fiscal year 2012-2013. By comparison, the FTE allocations for other divisions are relatively minor.

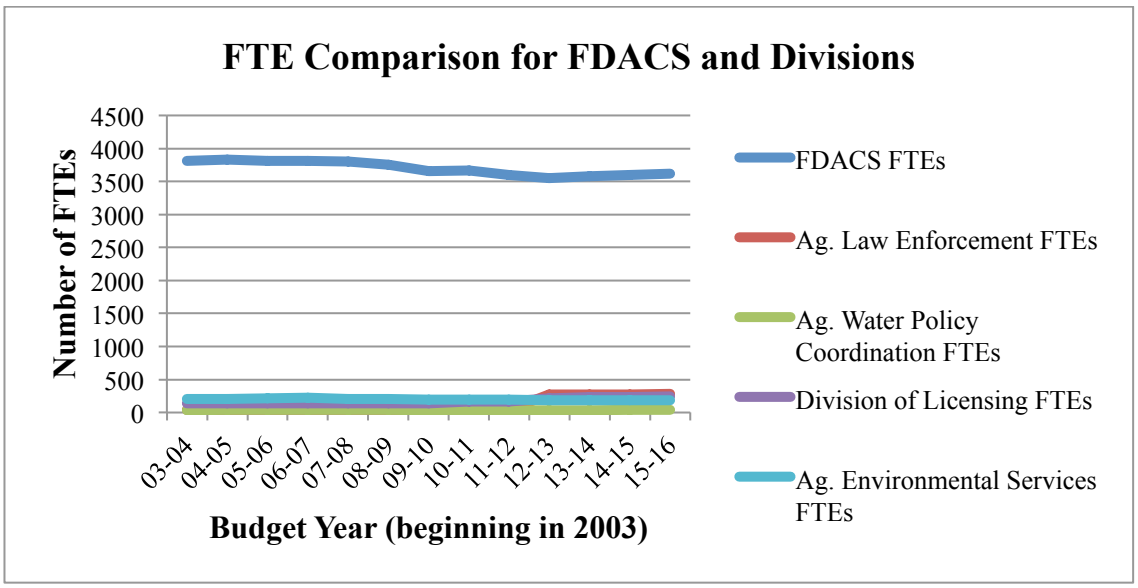

Figure 36: FTE Comparison for FDACS and Divisions. Data from Florida Executive Budgets.

Figure 37 shows that Agricultural Law Enforcement FTEs rose sharply in the same year it received a budget increase. FTEs for Agricultural Water Policy Coordination maintained without significant change, though there was a slight raise starting in fiscal year 2013-2014 when the division also received a budget increase. The Division of Licensing has seen increases in the number of FTEs since fiscal year 2010-2011. Figure 37 also shows that the Agricultural Environmental Services FTEs have been reduced slowly and steadily since fiscal year 2006-2007.

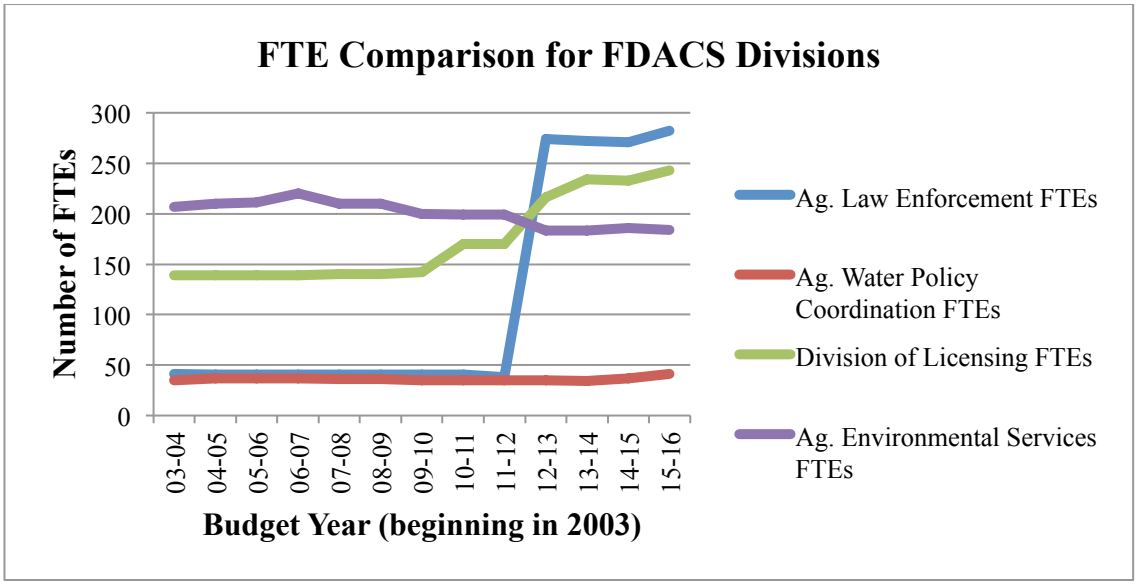

Figure 37: FTE Comparison for FDACS Divisions. Data from Florida Executive Budgets

Standards

Groundwater quality standards in Florida are equivalent to the drinking water standards. (*Groundwater Program*, 2015). Groundwater is assigned a classification based on its use. The standards that apply to that groundwater are dependent on that classification.[271] Classes F-I and G-I receive the most protection because they are potable water sources.[272] Both must have a total dissolved solids content of less than 3,000 mg/L. G-II is potable water that has fewer than 10,000 mg/L total dissolved solids. G-II sources are also heavily protected. In fact, the groundwater quality standards for all Class I and II wells are the same as drinking water quality standards.

[271] Fla. Admin. Code § 62-520.
[272] Fla. Admin. Code § 62-520.460. *Class G-I and F-I waters are different only in that F-I water* is in surficial aquifers (i.e., shallow aquifers that are close to the surface) in northeast Flagler County. *Id.*

Distinctions between other classifications are contingent on the intended use and the amount of total dissolved solids.[273] No other classes are designated for potable uses. Poorer quality groundwater may receive less protection depending on its class and its uses. (*Groundwater Program,* 2015). Monitoring and reporting requirements also depend on the class.[274]

FDEP is responsible for establishing groundwater quality standards.[275] Currently, most groundwater in the state is protected by quality standards that are equivalent to drinking water standards. Nearly all of the current drinking water standards are adoptions of the EPA's standards that were created to meet SDWA requirements.[276] FDEP does have authority to propose new standards or changes to current standards, so long as they meet or exceed the EPA's. Any proposed changes must be approved by the ERC.[277] The ERC is not involved in developing or changing standards, and is merely an approval body.[278] (The Florida Senate, Interim Report 2012-120, 2011). If the ERC does not approve a standard, it generally requests additional information that is presented later at a public hearing.[279] (The Florida Senate, Interim

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[273] Fla. Admin. Code § 62-520. G-III is non-potable water use, ground water in an unconfined aquifer with a total dissolved solids content of 10,000 mg/L or greater, or with a total dissolved solids content of 3,000-10,000 mg/L and has no reasonable potential as a future source of drinking water. *Id.* Last, G-IV water is non-potable water use, ground water in confined aquifers with a total dissolved solids content of 10,000 mg/L or greater. *Id.*
[274] Fla. Admin. Code § 62-520.410.
[275] Fla. Admin. Code § 62-520; Email communication with Edward Bettinger, Environmental Health Program Consultant, Florida Department of Health on January 27, 2016.
[276] Email communication with Marian Fugitt, Source and Drinking Water Program, Florida Department of Health on February 3, 2016.
[277] Email communication with Eric Shaw, Environmental Manager, Water Quality Division, Florida Department of Environmental Protection on January 27, 2016.
[278] *Id.*
[279] *Id.*

Report 2012-120, 2011). After the hearing, the ERC renders a final decision.[280] (The Florida Senate, Interim Report 2012-120, 2011).

FDEP manages standard setting through its Water Quality Standards Program (WQSP). WQSP has a Standards Development Section that is responsible for the development of water quality standards, for surface water and groundwater.[281] The Standards Development Section is responsible for reviewing, establishing, and revising all water quality standards.[282] In doing this, WQSP considers things such as classification, current criteria, the anti-degradation policies of the state,[283] moderating provisions, and special protection of certain waters. The section also reviews petitions to change the classification of a water resource and approvals for Site Specific Alternative Criteria. (*Alternate Surface Water Quality Standards,* 2015).

When a chemical is found in drinking water sources and no Maximum Contaminant Level (MCL) has been established by the EPA, the DOH creates Health Advisory Levels (HALs) for that chemical. (*Health Chemical Analyte,* 2016). MCLs and HALs are different metrics even though they both restrict the permissible volume of

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[280] *Id.*

[281] It is also responsible for the coordination of bio-assessment training and implementation, and for providing technical support to other Department programs. The WQSP has second division called the Aquatic Ecology and Quality Assurance Section. *Alternate Surface Water Quality Standards Site Specific Alternative Criteria*, FLA. DEP'T OF ENVTL. PROT. (Dec. 7, 2015), *available at* http://www.dep.state.fl.us/water/sas/qa/; *Quality Assurance*, FLA. DEP'T OF ENVTL. PROT. (Dec. 7, 2015), *available at* http://www.dep.state.fl.us/water/sas/qa/index.htm; *Quality Management Plan*, FLA. DEP'T OF ENVTL. PROT. (Feb. 2014), *available at* http://www.dep.state.fl.us/mainpage/default.htm. The Aquatic Ecology and Quality Assurance Section handles Quality Assurance issues for water, waste and resource management programs pursuant to the Water Quality Assurance Act. *Id.* It does this by providing technical support for WQAA related programs, conducting field and laboratory audits to determine compliance with the WQAA, and providing scientific training on a variety of WQAA topics. *Id.*

[282] Fla. Admin. Code §§ 62-302, 62-4).

[283] Fla. Admin. Code §§ 62-4.242, 62-520.

a contaminant in water resources. A MCL is the volume of a chemical allowable in drinking water to ensure immediate public safety. (*Chemical Contaminants*, 2016). A HAL is the concentration determined by the DOH to not cause adverse human health effects if consumed over a person's lifetime. (*Chemical Contaminants*, 2016). DOH shares its development of HALs with FDEP for purposes of standard review and standard setting.

There are broad narrative criteria that establish minimum quality requirements.[284] These criteria state that "all groundwater shall at all places and at all times be free from domestic, industrial, agricultural, or other man-induced non-thermal components of discharges in concentrations *which, alone or in combination with other substances*, or components of discharges (whether thermal or non-thermal)" are harmful to plants, animals, or organisms native to soils, and are carcinogenic, mutagenic, teratogenic, or toxic to humans, or otherwise pose a danger to public health, safety, or welfare, or are acutely toxic to surface waters connected to groundwater.[285] The language "alone or in combination with other substances" indicates that there is regulatory support for

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[284] Fla. Admin. Code § 62-520.400.

[285] Fla. Admin. Code §§ 62-520.400(1)-(2), 62-520.420. (Emphasis added). This rules applies, unless specific criteria are established. *Id.* The minimum criteria shall not apply to Class G-IV ground water, unless the Department determines there is a danger to the environment, public health, safety or welfare. *Id;* Fla. Admin. Code § 62-520.310(2). Emphasis on groundwater-surface water is evident by the many references to it in the groundwater standards. *Id.* The broad narrative standards touch on impairments that may be "acutely toxic to surface waters," and again state that "notwithstanding the classification and criteria for ground water set forth in this chapter, discharge to ground water shall not impair the designated use of contiguous surface waters." *Id.*

considering the consequences of interactions or byproducts when setting groundwater quality standards if the effect would be harmful.[286]

Observations

Florida's management approach places a heavy emphasis on the groundwater-surface water interactions that occur throughout the state as a result of the hydrogeology there. Although there are some separate standards for surface water and drinking water, they are generally the same. Further, in Florida the groundwater quality standards are the same as drinking water standards given the high percentage of reliance on groundwater as the primary drinking water source. The strong links between surface and ground water interactions and the similarity in standards are likely reason for concentrating groundwater management under FDEP; this structure allows one agency to manage all water sources somewhat holistically, although it relies on other agencies for particular things.

A downside to this centralized approach, is that there is less communication between FDEP and other agencies than there could be to ensure a truly comprehensive approach.

For example, FDEP's lack of engagement with FDACS is surprising given the magnitude of the farming industry in Florida and the impact of such land uses on groundwater. For example, FDACS staff is responsible for aspects of groundwater protection such as creating BMPs and carrying out enforcement and compliance actions.

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[286] Fla. Admin. Code § 62-520.400. (Emphasis added). "The minimum criteria shall not apply to Class G-IV ground water, unless the Department determines there is a danger to the environment, public health, safety or welfare." *Id.*

It may be the case that these simply are construed as being groundwater protection measures from the perspective of the legislation, or there may be other reasons for the lack of communication. The lack of engagement with FDOH is also surprising because much of the statutory and regulatory intent prioritizes public health and welfare. FDOH does contribute to FDEP's setting of standards through its HAL recommendations, but it does not have any authority over standards.

In contrast to the lack of multi-agency management is the OAWP. OAWP was established by the state legislature to coordinate work on water quantity and quality challenges between federal, state and local agencies and the agricultural industry. OAWP leads BMP development, but although it is obligated to work with entities, it does this as needed and its impact is still confined to the agricultural industry. Similarly, there is significant cooperation with the WMDs, and this unique feature of an added layer of government does much in the way of relaying regional problems to the state agencies and working to resolve localized problems more quickly. The Wellhead Protection program is an example of this as the WMDs provide much of the localized data necessary to the program while FDEP determines the areas of delineation and manages the Wellhead Protection Areas.

Florida's Water Well ID program is also a unique example of agency integration. The program is significant not only in that it helps in the exchange of well information across agencies and the WMDs, but that it is a completely un-mandated act of organization in groundwater quality protection. In addition, the Clean Sweep program,

although more common across states, is also an effort for which there is no legal requirement to put on.

Another highlight among all of Florida's efforts is the seriousness with which well construction is taken. Significant education is required before well contractors can be licensed to construction wells. Also, construction standards are very logical and allow for some flexibility and innovation where reason suggests it. For example, FDEP shares coordination and expansion authority with local governments that are allowed to implement small-scale, localized protection strategies as they see fit. Also, there is lots of flexibility in requiring additional construction features, plan information, or education prior to issuing permits, licenses, or authorizing construction plans. These demands over and above standards must be justified by scientific evidence, but the availability to impose them is unusual since these requirements are generally strictly statutory or regulatory in other states.

Standard setting in Florida is somewhat piecemeal-FDOH makes suggestions, FDEP reviews standards every three years at its triennial review and may make changes there. Otherwise, FDEP seems only to adopt standards when the EPA makes a requirement change. And the ECR approves standard changes, even though it has no real authority anymore and FDEP Directors make authorize changes to standards.

Of note is the lack of detailed information presented in the websites for these agencies, or in public reports or studies, regarding groundwater quality protection or regulations for land use practices. Broad explanations and outlines of requirements are provided, as well as references to pertinent statutes and regulations, but there are no

directions or instructions readily available to provide a comprehensive understanding of how groundwater is managed across land uses, how groundwater quality is monitored, or even how standards are set or enforced. Fortunately, staff from various agencies is very responsive and helpful in answering questions and providing data.

A summary chart of the section on Florida is available in Appendix F.

DISCUSSION

Answering the Research Questions

The research questions for this thesis asked (1) how groundwater quality protection as an overarching goal is translated into an action, and (2) how are those actions and management approaches carried out. In answering the first question, it seems that for Wisconsin, Arizona and Florida, the goal of protecting groundwater is largely translated into acts of regulating and enforcing pesticide use.

In answering the second question as it relates to agricultural practices, many of the agricultural efforts were in preventing the incorrect disposal or use of pesticide products. For example, both Wisconsin and Florida operate Clean Sweep programs in which farmers can offload expired, banned, or otherwise unused pesticides at no cost. Doing so helps to prevent from accidental spills resulting from mishandling, or improper disposal.

Pesticide regulation and applicator licensing programs were also common to all three states. All three states took special care when registering pesticides to make note of their potential as contaminants, and required all information about the pesticide and its intended use to be provided before a pesticide would be registered. One interesting difference among the states is that in Wisconsin and Arizona, the respective Departments of Agriculture were charged with responsibilities involving pesticides and groundwater, but in Florida, the Department of Environmental Protection over-see pesticide registration and survey sampling for pesticides.

Additionally, farmer education and outreach (including educational events, consultations and on-site visits), were all tools utilized in all three states. However, education efforts were more prominent in Wisconsin and Arizona where there is a high level of engagement. Florida held educational events and also promoted enrollment in BMPs. Though not all BMPs are required in Florida, the state does work hard to provide supplemental funding for new BMP related technologies as well as partnerships with the University of Florida and other institutions to cover some expenses.

Certainly, these states had other programs and management efforts in place to achieve the goal of groundwater quality protection, some of them similar and similarly managed. For example, Wisconsin and Florida both made great efforts to regulate well construction. This is achieved by strict licensing programs, routine inspections during construction, and heavy penalties for violations of constructor's licenses or construction regulations. Arizona also has constructors licensing requirements and obligates those building new wells to issue notice to its Department of Water Resources, however, overall Arizona's concern regarding groundwater wells pales in comparison to Wisconsin and Florida.

Additional Observations

Apart from the focus on farming practices and well construction, setting groundwater quality standards was an action taken in all states to protect groundwater quality, however it was done very differently in each state. Although all states seemed to use the SDWA standards as a starting point for groundwater, the process for creating additional standards or making changes to the standard was different in every state.

Perhaps most notable with regard to standards, is the role that the respective Departments of Health played in each state. Given that the standards are set for human health protection purposes, it was surprising to find that the Departments of Health were not more involved in the process. In Wisconsin, there was a lot of interaction and consideration of Health Department input, most likely because Act 410 obligates both agencies to cooperate in standard setting. However, in Arizona there was very little interaction or input given by the Health Department at all. In Florida, the Health Department was involved only when a standard was being created for a contaminant that was not already addressed by the SDWA.

In reviewing the standard setting process for groundwater, an interesting and considerable gap in information emerged: although all states have enforcement and compliance measures for their programs, there was not much data available to reflect the number of enforcement actions or what compliance efforts were required of violators. The Wisconsin Department of Natural Resources did have this data available, however it was grouped into three categories: Hazardous Waste, Public Drinking Supply and Private Drinking Supply. Because it was divided into these three categories, it was difficult to infer any kind of trend.

Overall, Wisconsin and Florida seem to have the most invested in their groundwater quality protection programs. Notably, both were among some of the first states to develop a Comprehensive State Ground Water Protection Programs with the EPA in the 1990's. Both states had significantly more information and data available, and more availability from staff in different agencies to answer questions than did

Arizona. This impression of Arizona's resources and investment in groundwater quality is also derived from Arizona's reliance on the Central Arizona Project which is a large surface water source.

A surprising discovery was that Wisconsin was the only state whose groundwater quality protection programs actually originated from the intent to protect public health in 1936. Of course human health influenced groundwater quality protection in Arizona and Florida, but that came much later with the onset of the national environmental movement. Even when it did happen, Arizona was somewhat resentful of having to pass legislation that required groundwater quality protections.

Land Use Practices

Landfills and pesticide management were the two areas of land use practice that spurred differences between the states. There were many similarities with regard to landfill practices, but a few interesting and unique differences emerged in comparing them. Some examples are that:

- In Wisconsin, a public notice is posted requesting comments when the landfill is still in the permitting process. The notice alerts citizens that they may request a public hearing.
- Arizona requires a response and action plan for any environmental emergencies or operational problems that might emerge before a permit is issued.
- Florida mandates that landfill operators received several hours of training on a regular basis before it issues a permit, and in order to renew a permit.

Construction requirements for landfills tended to follow federal guidelines, although Florida has taken measures to require more substantial landfill liners. Otherwise, the process is effectively the same among all states. Also, none of the states have monitoring requirements, or groundwater or drinking water quality standards for DEET.

With respect to USTs, most states seem to follow federal rules and regulations, although there are some slight differences in permitting processes. For example:

- Wisconsin requires insurers to notify DNR if owners fail to meet financial responsibilities to cover spills.
- Arizona requires several site inspections before a permit will be issued.
- In Florida FDEP can revoke a UST registration immediately if a violation occurs and is not dealt with in a reasonable amount of time.

Construction standards and monitoring systems did display slight variations, though none were too significant. Compliance and enforcement were equally stringent, and all states require demonstration of financial responsibility and immediate action when a leak is discovered. Interestingly, there are drinking water quality standards in place ranging from 0.0005 µg/L to 5 µg/L, however, there is no Benzene specific monitoring required. Instead, all systems must have some monitoring system in place, and problems are dealt with as they arise. Additionally, although most systems require leak detection features, many leaks are still discovered through site checks and other in-person checks. Generally, leaks are reported after extensive damage has occurred to the surrounding soil and it is noticeable by either soil coloration or smell.

Every state had different policies and programs in place to manage farming practices and pesticide use. Some examples of unique features in each state are:

- Wisconsin offers free groundwater monitoring services and consultations to any pesticide users, applicators and facilities that hold pesticides.
- Arizona uses the GPL to help identify what pesticides may be very problematic, and institute special water quality standards for them.
- Florida has a special Agricultural Law Enforcement Division under FDACS to stay ahead of violations and ensure that compliance is taken seriously.

Even when there are similar programs, they may be prioritized differently. For example, Wisconsin and Florida both manage Clean Sweep programs. Wisconsin has operated its program since 1990, without any interruption and with much success. DATCP, Wisconsin's Agricultural agency operates this program. Florida has been operating its program since 1995, and although successful, budgetary constraints required that it stop for a few years until funding was available again. FDEP, Florida's Environmental Quality agency operates this program.

Ultimately, all three states place great stake in managing pesticide application, and ensuring that all pesticides used and sold within the state are registered. This helps the relevant agencies to track what is being used and at what volumes. They also all thoroughly research the potential impacts of new pesticides. Additionally, they all track problematic pesticides within their own states and try to raise awareness about appropriate handling and application for them. Atrazine was very problematic in Wisconsin and Arizona, but hasn't been a problem in Florida. Regardless, all states had

a drinking water quality standard for Atrazine of 3 µg/L. This is in line with the SDWA guidelines.

Expectations

In addition to the questions posed, there were some expected findings for the results of this research. First, it was anticipated that the origins of groundwater protection law would result from some major event or environmental catastrophe. This was incorrect. Florida's 1983 Water Quality Assurance Act was related to issues of groundwater quality that occurred in large part because of flooding disasters and dam and diversion projects built to prevent flooding. However, the relationship is not direct, nor immediate. Moreover, it was considered to be an original piece of legislation that targeted Florida specific problems, and did not reflect any of the pieces of federal legislation passed around the same time that for the most part did occur in response to major environmental events. Arizona's legislation was written in order to receive federally funding for the Central Arizona Project; a project oriented around issues of supply and not quality. Wisconsin's legislation seems to be an evolutionary step in its long history of ensuring public health safety, a history begun in 1876 when the Board of Health managed water quality for public supply.

Second, there was an expectation that groundwater quality standards and drinking water standards would be the same (or highly similar) because of the dependency on groundwater as a drinking water source. This was met. The groundwater quality standards in Florida are the same as the drinking water standards, both based on the EPA's standards issued under the Safe Drinking Water Act. Arizona

and Wisconsin have some distinction between sets of standards, but both are based on the SDWA standards in both states. Interestingly, in effect aquifers in all three states are treated as drinking water sources and are afforded significant protection. However, Arizona and Florida there is the potential to petition for a change in aquifer designation that could lower the level of protection.

Third, because of the reliance on groundwater as a primary drinking water source there was an expectation that data and reports would be more readily available, even if by request. This expectation was somewhat augmented upon the realization that aquifers were given such great statutory protections. However, in reality there were a surprising number of instances in which data requested did not exist. This was particularly so with enforcement and compliance data requests, as well as site inspection requests for USTs, landfills, and well construction. Of particular note was that the Arizona Department of Environmental Quality saw a decline in reports generated from 2001 to the present. In the 1990's and early 2000's, ADEQ produced a significant amount of information and data, but that has been drastically reduced. In 2001, five reports with between four-nine subsections were available including a comprehensive Annual Report. Only four reports were available for 2014, with no sub-sections or other supporting material.

The reduction in available information is likely the result of declines in budgets and full-time employee numbers. To begin with, all of the agencies discussed in this research receive a small portion of the FTEs and budget relative to the totals for the state. In particular, Arizona has experienced declines in budgets and FTE's relatively consistently, although there have been points of minor improvements. In Wisconsin, the

total FTEs are down, though the budget seems to have maintained. In Florida, the budget and FTEs have been on a steady decline.

Last, while this research reviewed three land use practices that impact groundwater quality, there was an expectation that farming practices would receive the most regulatory attention. This expectation was met. Though the research did not provide a clear reason as to why it receives more attention than other land use practices, the assertion made in the introduction is made again here: that agriculture is an industry in which it is easier to be preventative. In other words, it is easier to regulate the use of specific and known pesticides, and to stay ahead of the problem of groundwater contamination by pesticides.

CONCLUSIONS

Overall, the states have done a good job of tailoring programs to their unique needs and interests. One exception may be in groundwater quality standard settings. Here, most states defaulted to the SDWA standards. This is not terribly surprising given that most agencies in the United States (at all levels of government), assume that things are safe until it is proven that they are harmful. This principle is likely the reason there is no standard at all for DEET in landfills.

Although the agencies were conservative in their cautionary measures, there was a lot of emphasis on outreach and education, in particular with regard to pesticide use and application. Groundwater quality monitoring and research also seems to be better supported and funded, which helps many agencies in develop priorities for their programs. These efforts are a good means to mitigating damage incurred by groundwater contamination, and in the states reviewed they seemed to be well supported and well funded.

Unfortunately, education and outreach don't go as far for USTs and landfills, and aren't pursued nearly as much. This may be a missed opportunity to bolster preventative measures at these land use sites. The approach used with pesticides may be a template for how to engage with other types of land users. Permit requirements such as Florida's requirement for training for landfill operators is a step in the right direction. Public notice for comment and notification to citizens that they may request a hearing on the installment of a landfill is also a good example of engaging the community. It also

provides citizens, agency staff and landfill applicants with a good venue to educate each other about science and concerns for public health. Additionally, increased monitoring at UST sites could also improve the likelihood of finding leaks early.

Overall, the greatest improvement that could be made by the states is obtaining, tracking and analyzing more data resulting from its programs. For all agencies (thought some more than others), the lack of detailed data on various topics relating to available was a surprise. It should be noted that Wisconsin has very comprehensive databases containing scientific information about its groundwater, and Florida has begun to develop more comprehensive databases. However, the data gap for more basic data on the various programs operated begs the question: how do these agencies review programs and decide what works? Of course, budgetary and staff resources also play in to program review, but what is the point of managing programs if there is no way to determine its success.

Last, what emerged most clearly from this research was actually another question altogether: do state agencies communicate with their counterparts in other states in developing programs and policies? In comparing these states it seemed that each of their standout programs and policies might be useful in other places. Certainly Wisconsin, Arizona and Florida are all so geographically different that there may be little incentive or practicality in sharing ideas, but it may not be futile. Moreover, it would very worthwhile for states within more homogenous regions to share successes, failures, and concerns. At present, it is unclear to what degree sharing information across state lines

occurs, but it would be interesting to know how information sharing across states impacts the development of state policies, laws and programs.

NOMENCLATURE

Introduction and Throughout

CSGWPP	Comprehensive State Ground Water Protection Programs
CWA	Clean Water Act
DEET	N,N-diethyltoluamide
EPA	Environmental Protection Agency
FTE	Full-Time Employees
LUST	Leaking Underground Storage Tanks
MCL	Maximum Contaminant Levels
SDWA	Safe Drinking Water Act
USGS	United State Geological Survey
UST	Underground Storage Tanks

Wisconsin

CAFO	Concentrated Animal Feeding Operation
DEET	N,N-diethyltoluamide
DNR	Wisconsin Department of Natural Resources
DSPS	Wisconsin Department of Safety and Professional Services
DWG	Drinking Water and Groundwater
ES	Enforcement Standard
GCC	Groundwater Coordinating Council
GEMS	Groundwater and Environmental Monitoring System

GNHS	Wisconsin Geological and Natural History Survey
HAL	Health Advisory Levels
LWRM	Land and Water Resource Management
NMP	Nutrient Management Plan
N-P-K	Nitrogen, Phosphorus, and Potassium (Nutrients)
NRCSA	Natural Resources Council of State Agencies
PAL	Preventative Action Limit
PEFCA	Petroleum Environmental Cleanup Fund Act
PIF	Petroleum Inspection
RR	Remediation and Redevelopment Program
WDATCP	Wisconsin Department of Agriculture, Trade and Consumer Protection
WDHS	Wisconsin Department of Health Services
WHP	Wellhead Protection
WM	Watershed Management Program
WMM	Waste and Materials Management
WPDES	Wisconsin Pollutant Discharge Elimination System
WQ	Water Quality Program
VOC	Volatile Organic Compound

Arizona

ADA	Arizona Department of Agriculture
ADATCP	Arizona Department of Agriculture, Trade and Consumer Protection
ADEQ	Arizona Department of Environmental Quality

ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
APP	Aquifer Protection Permit
BMP	Best Management Practices
Bureau	Federal Bureau of Reclamation
CAP	Central Arizona Project
EQA	Environmental Quality Act
GPL	Groundwater Protection List
WPD	Waste Programs Division

Florida

DACS	Department of Agricultural and Consumer Services
DAES	Division of Agricultural Environmental Services Division
District	Water Management District
DOH	Department of Health
EDB	Ethylene Dibromide
ERC	Environmental Regulation Commission
FDEP	Florida Department of Environmental Regulation
FLUWID	Florida Unique Well Identification
GWMP	Ground Water Management Program
GWQMN	Ground Water Quality Monitoring Network
HAL	Health Advisory Levels
MCL	Maximum Contaminant Level

OALE	Office of Agricultural Law Enforcement
OAWP	and the Office of Agricultural Water Policy
UIC	Underground Injection Control
USDW	Underground Sources of Drinking Water
WPA	Wellhead Protection Area
WQAA	Water Quality Assurance Act
WQSP	Water Quality Standards Program

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APPENDIX A

FRESH WATER RESOURCE USE

State	Surface Water Withdrawals (Mg/d)	Groundwater Withdrawals (Mg/d)	%GW
KANSAS	800	3200	80
ARKANSAS	3540	7780	69
MISSISSIPPI	1240	2610	68
FLORIDA	2230	3970	64
HAWAII	248	423	63
NEBRASKA	3320	4710	59
ALASKA	391	478	55
SOUTH DAKOTA	287	339	54
DELAWARE	144	156	52
D.C.	0.05	0.05	50
NEW MEXICO	1590	1570	50
NEVADA	1420	1190	46
ARIZONA	3540	2550	42
CALIFORNIA	18800	12300	40
OKLAHOMA	1140	635	36
MASSACHUSETTS	703	361	34
WASHINGTON	3320	1600	33
NEW JERSEY	1320	612	32
OREGON	4600	2130	32
TEXAS	15800	6830	30
GEORGIA	3210	1230	28
RHODE ISLAND	98	36.5	27
CONNECTICUT	600	216	26
IDAHO	13000	4250	25
UTAH	3110	1030	25
MAINE	309	99.4	24
NEW HAMPSHIRE	277	89.7	24
IOWA	2420	650	21
MISSOURI	6750	1810	21
MINNESOTA	3080	736	19
LOUISIANA	6960	1570	18
MARYLAND	1210	260	18
COLORADO	9440	1540	14
NEW YORK	5020	704	12
NORTH DAKOTA	994	139	12
WISCONSIN	5400	754	12
OHIO	8510	929	10
VERMONT	389	41.6	10
INDIANA	1920	720	8
PENNSYLVANIA	7480	657	8
ILLINOIS	12200	853	7
VIRGINIA	4140	299	7
MICHIGAN	10100	693	6
NORTH CAROLINA	10400	694	6
TENNESSEE	7230	470	6
ALABAMA	9470	494	5
KENTUCKY	4130	199	5
SOUTH CAROLINA	6440	339	5
MONTANA	7360	268	4
WEST VIRGINIA	3410	121	3

(*See* Maupin, 2010).

APPENDIX B

GROUNDWATER ALLOCATIONS FOR DRINKING SUPPLIES

Rank	State	%Public Drinking Supply	%Private Drinking Supply
1	CONNECTICUT	62.5	30.28
2	NEW YORK	64.91	21.59
3	NEW JERSEY	65.03	16.06
4	NEW HAMPSHIRE	38.68	37.12
5	TENNESSEE	64.04	8.23
6	SOUTH CAROLINA	33.63	33.92
7	MARYLAND	34.31	32.92
8	VERMONT	33.65	32.69
9	INDIANA	48.75	17.5
10	RHODE ISLAND	43.29	21.97
11	VIRGINIA	23.75	41.47
12	PENNSYLVANIA	34.4	30.59
13	ALABAMA	56.68	7.69
14	MASSACHUSETTS	52.91	10.5
15	MICHIGAN	29.44	33.33
16	HAWAII	60.99	0.44
17	NORTH CAROLINA	27.95	33.29
18	MAINE	27.87	33.2
19	MINNESOTA	47.96	10.73
20	FLORIDA	50.63	5.39
21	ILLINOIS	43.02	10.83
22	WEST VIRGINIA	28.26	25.54
23	IOWA	47.54	5.91
24	OHIO	48.98	1.51
25	KENTUCKY	35.68	9.9
26	WISCONSIN	34.62	10.4
27	DELAWARE	28.72	9.49
28	WASHINGTON	29.44	7.06
29	UTAH	35.34	0.82
30	MONTANA	24.48	7.91
31	GEORGIA	19.76	9.35
32	LOUISIANA	24.08	2.99
33	OKLAHOMA	20.47	4.22
34	NORTH DAKOTA	21.94	2.65
35	CALIFORNIA	23.01	1.15
36	ARIZONA	22.94	1.07
37	SOUTH DAKOTA	21.92	1.58
38	TEXAS	16.54	3.79
39	MISSOURI	16.19	3.41
40	MISSISSIPPI	13.37	1.71
41	NEW MEXICO	13.44	1.64
42	NEVADA	11.18	2.5
43	WYOMING	9.36	1.55
44	COLORADO	8.44	2.46
45	ALASKA	5.69	2.95
46	OREGON	5.35	2.82
47	IDAHO	4.99	1.86
48	NEBRASKA	4.97	0.93
49	KANSAS	5	0.47
50	ARKANSAS	1.72	0.16
51	D.C.	0	0

(*See* Maupin, 2010).

APPENDIX C

VOLUME OF GROUNDWATER ALLOCATED FOR DRINKING SUPPLIES (Mg/D)

Rank	State	Drinking Supply
1	CALIFORNIA	2952
2	FLORIDA	2223.2
3	TEXAS	1434.3
4	NEW YORK	612.48
5	ARIZONA	612
6	WASHINGTON	576
7	NEW JERSEY	495.72
8	INDIANA	482.4
9	OHIO	473.79
10	ILLINOIS	460.62
11	MINNESOTA	434.24
12	MICHIGAN	429.66
13	PENNSYLVANIA	427.05
14	LOUISIANA	423.9
15	NORTH CAROLINA	423.34
16	MISSISSIPPI	391.5
17	UTAH	370.8
18	GEORGIA	356.7
19	IOWA	351
20	MISSOURI	343.9
21	WISCONSIN	339.3
22	TENNESSEE	338.4
23	ALABAMA	321.1
24	IDAHO	297.5
25	NEBRASKA	282.6
26	HAWAII	258.03
27	NEW MEXICO	235.5
28	SOUTH CAROLINA	230.52
29	MASSACHUSETTS	227.43
30	CONNECTICUT	200.88
31	VIRGINIA	194.35
32	MARYLAND	174.2
33	OREGON	170.4
34	NEVADA	166.6
35	KANSAS	160
36	ARKANSAS	155.6
37	COLORADO	154
38	OKLAHOMA	152.4
39	KENTUCKY	91.54
40	MONTANA	85.76
41	SOUTH DAKOTA	81.36
42	NEW HAMPSHIRE	68.17
43	WEST VIRGINIA	65.34
44	MAINE	60.63
45	WYOMING	60.5
46	DELAWARE	59.28
47	ALASKA	43.02
48	NORTH DAKOTA	34.75
49	VERMONT	27.87
50	RHODE ISLAND	23.73
51	D.C.	0

(*See* Maupin, 2010).

APPENDIX D

WISCONSIN SUMMARY SHEET

I. Relevant Legislative History and Major Ground Water Quality Events

- ❖ Comprehensive Groundwater Protection Act, 410, is passed in 1983 and immediately implemented.
- ❖ The act places responsibility on all levels of government and establishes an expectation of cooperative effort across all levels of government and relevant agencies and departments.
- ❖ A second Comprehensive Groundwater Protection Act, 310, is passed in 2003 further clarifying goals and obligations

II. Agencies & Programs

Groundwater Coordinating Council

The GCC advises and assists state agencies in coordinating non-regulatory programs and coordinating the exchange of information related to groundwater management.

Department of Natural Resources

a. Waste and Materials Management
  - a.1. Mining
  - a.2. Land Use and Contaminants: Solid Waste Landfills and DEET
  - a.3. GEMS Database

b. Remediation and Redevelopment
  - b.1. Cleanup of Groundwater Contamination
  - b.2. Investigation, Cleanup and Redevelopment of Brownfields
  - b.3. Dry Cleaner Environmental Response Fund
  - b.4. Land Use and Contaminants: Underground Storage Tanks and Benzene
  - b.5. Petroleum Environmental Cleanup Fund Act

c. Well Construction and Private Wells

d. Public Water Supply Systems

e. Drinking Water and Groundwater
  - e.1. Wellhead Protection
  - e.2. Source Water Assessments
  - e.3. Underground Injection Controls

f. Water Quality
  - f.1. Wastewater Discharges
  - f.2. Septage and Sludge Management

g. Watershed Management
  - g.1. Agricultural Runoff and Groundwater Quality
  - g.2. Stormwater and Groundwater Quality

Department of Health Services

The Department of Health Services (DHS) is statutorily obligated to make recommendations for health-based enforcement standards for groundwater quality and to set out the procedure for developing the recommended standards

-Assesses groundwater and human health by conducting such studies as: exposure bio-monitoring, disease surveillance, and capacity and vulnerability assessments

Department of Agriculture, Trade and Consumer Protection

a. Land and Water Resource Management
  - a.1. Land and Water Resource Management Program
  - a.2. Farmer Education

b. Agricultural Clean Up
  - b.1. Land Use and Contaminants: Farming Practices and Atrazine
  - b.2. Clean Sweep

<table>
<tr><th colspan="3">WISCONSIN SUMMARY SHEET CONTINUED</th></tr>
<tr><td colspan="3">Department of Safety and Professional Services
is in regular communication with DNR regarding matters of mutual concern such as large onsite sewage systems, Underground Injection Control regulations, septage disposal and water well regulations.
DSPS staff assists when asked in developing onsite sewage system policies</td></tr>
<tr><td colspan="3">Wisconsin Geological Natural and History Survey
a. The Groundwater program
b. The Soil program
c. Geology programs
d. Databases
d.1. Hydrogeologic Data Viewer database
d.2. Physical Properties of Wisconsin’s Bedrock Aquifers and Aquitards database.
d.3. Well constructor’s report database</td></tr>
<tr><th colspan="3">III. Groundwater Quality Standard Setting</th></tr>
<tr><td colspan="3">❖ All groundwater is entitled to equal protection
❖ The DNR is responsible for establishing numerical groundwater quality standards. SDWA standards are often the basis, but the DHS is also very involved in making final determinations.</td></tr>
<tr><th colspan="3">IV. Land Use & Standards</th></tr>
<tr><td>Municipal Solid Waste Landfills & DEET</td><td>Underground Storage Tanks & Benzene</td><td>Farming Practices & Atrazine</td></tr>
<tr><td>Not regulated or monitored in soil or groundwater.

No standards.</td><td>Not monitored in groundwater. It is required for landfill testing.

Groundwater Quality Standards
5 µg/l enforcement standard
0.5 µg/l preventative action limit</td><td>Groundwater Quality Standards
3^2 µg/l enforcement standard
0.3^2 µg/l PAL</td></tr>
</table>

APPENDX E

ARIZONA SUMMARY SHEET

I. Relevant Legislative History and Major Ground Water Quality Events

- ❖ Enactment of CWA, poor surface water quality, and ultimatum by federal government to withhold funding for infrastructure result in major overhaul to environmental legislation and programs. Stakeholders are heavily involved.
- ❖ Groundwater Management Act is passed in 1980, groundwater monitoring required. Contamination by pesticide and industrial solvents were discovered to be a serious groundwater problem.
- ❖ Environmental Quality Act of 1986 is passed and implemented immediately. Agencies are restructured and new rules and responsibilities are assigned.
- ❖ Surface water quality improves, but with new technology in the 1990's and 2000's it becomes clear that groundwater is problematic.
- ❖ Programs and monitoring are ramped up, and emphasis on groundwater quality continues.

II. Agencies & Programs

Department of Environmental Quality

a. Aquifer Protection Permits
b. Drywell Program
c. Clean Closure Approval
d. Recharge Permits
e. Pesticide Groundwater Quality Protection Program
    e.1. Groundwater Protection List
    e.2. New Pesticide Product Registration
    e.3. Annual Report
    e.4. Land Use and Contaminants: *Farming Practices and Atrazine*
    e.5 Monitoring for Pesticides
f. Reclaimed Water Permits
g. Land Use and Contaminants: Solid Waste Landfills and DEET
h. Land Use and Contaminants: Underground Storage Tanks and Benzene
i. Monitoring and Research

Department of Agriculture

a. Pesticide Use and Compliance
    a.1. Education and Training
    a.2. Registration
    a.3. Inspections and Investigations
b. Buffer Zones
c. Monitoring and Research

Department of Health Services

Authorizes laboratories to conduct environmental testing.

Department of Agriculture, Trade and Consumer Protection

a. Land and Water Resource Management
    a.1. Land and Water Resource Management Program
    a.2. Farmer Education
b. Agricultural Clean Up

Arizona Department of Water Resources

ADWR is primarily responsible for managing and allocating the State's groundwater supplies. It also handles nearly all of the hydrogeological studies in the state. Apart from well registration, ADWR does very little pertaining to groundwater quality management, but it is a very strong resource for ADEQ via the data it provides.

<table>
<tr><th colspan="3">ARIZONA SUMMARY SHEET CONTINUED</th></tr>
<tr><td colspan="3">Arizona Geological Survey
AGS does some work in hydrogeology, but primarily focuses on geological issues including earth fissures, earthquakes, mineral and geothermal studies.</td></tr>
<tr><th colspan="3">III. Groundwater Quality Standard Setting</th></tr>
<tr><td colspan="3">❖ All aquifers in the state receive equal protection and are designated for drinking water. However there is potential for some aquifers to be downgraded for other uses. In this case they would no long be subject to drinking water standards.
❖ ADEQ sets standards, largely based on federal SDWA guidelines. The aquifer standards and drinking standards are nearly identical. DHS plays no role in developing standards for either.</td></tr>
<tr><th colspan="3">IV. Land Use & Standards</th></tr>
<tr><td>Municipal Solid Waste Landfills & DEET</td><td>Underground Storage Tanks & Benzene</td><td>Farming Practices & Atrazine</td></tr>
<tr><td>Not regulated or monitored in soil or groundwater.

No standards.</td><td>Not monitored in groundwater. It is required for landfill testing.

Groundwater Quality Standards
0.0005 µg/L enforcement standard</td><td>Groundwater Quality Standards
3^2 µg/l enforcement standard</td></tr>
</table>

APPENDIX F

<table>
<tr><th colspan="3">FLORIDA SUMMARY TABLE</th></tr>
<tr><th colspan="3">I. Relevant Legislative History and Major Ground Water Quality Events</th></tr>
<tr><td colspan="3">❖ 1969 creation of the Florida Department of Air and Water Pollution Control – result of ecological implications resulting from large scale dam and diversion projects
❖ 1972 Florida Water Resources Act creates five Water Management District
❖ 1983, legislature passes the Water Quality Assurance Act specifically to protect groundwater quality</td></tr>
<tr><th colspan="3">II. Agencies & Programs</th></tr>
<tr><td colspan="3">Water Management Districts
Each District is responsible for the administration of flood protection programs and plans, and technical investigations for water resources within its jurisdiction. There are five districts, and the jurisdiction of each is defined by watershed boundaries.</td></tr>
<tr><td colspan="3">Department of Environmental Protection
a. Ground Water Management Program
a.1. Spring Water Quality Monitoring
a.2. Ground Water and Springs Quality STORET Database
a.3. Ground Water and Springs Assessments
a.4. FloridaSprings.org
a.5. Agrichemical Effects
b. Aquifer Protection Program
b.1. Underground Injection Control Program
b.2. Regulation of Well Construction and Contractors
c. Source Water and Wellhead Protection Programs
d. Clean Sweep Program
e. Land Use and Contaminants: Solid Waste Landfills and DEET
f. Land Use and Contaminants: Underground Storage Tanks and Benzene
g. Monitoring and Research</td></tr>
<tr><td colspan="3">Department of Health
DOH authorizes laboratories used for environmental analysis by FDEP, and works to manage ethylene dibromide (EDB) contamination in groundwater.</td></tr>
<tr><td colspan="3">Department of Agriculture and Consumer Protection
DACP is responsible for pesticide regulation and use. It also encourages enrollment in BMPs to protect groundwater.</td></tr>
<tr><th colspan="3">III. Groundwater Quality Standards</th></tr>
<tr><td colspan="3">❖ All aquifers are protected by FDEP, however, the amount of protection varies depending on the use classification of the groundwater. Groundwater that is potable are subject to drinking water quality standards.
❖ FDEP sets standards, largely based on federal SDWA guidelines. Groundwater and drinking water standards are the same. DOH contributes in setting HAL only when there is no federal guideline.</td></tr>
<tr><th colspan="3">IV. Land Use & Standards</th></tr>
<tr><td>Municipal Solid Waste Landfills & DEET</td><td>Underground Storage Tanks & Benzene</td><td>Farming Practices & Atrazine</td></tr>
<tr><td>No standards.</td><td>Groundwater Quality Standards
Benzene is 1 µg/L</td><td>Groundwater Quality Standards
3^2 µg/l enforcement standard
0.3^2 µg/l PAL</td></tr>
</table>