2016 ELISS National Forum on Drinking Water Safety in the United States
- Report -

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EXECUTIVE SUMMARY

Over the course of 15 months, ELISS Fellows from five different campuses across the United States worked to understand the state of drinking water in their local areas. Through numerous stakeholder interviews with public utilities, well drillers, lawyers, academics and the public they were able to identify various drinking water issues within their communities. Using this feedback, fellows organized a local forum series to bring together practitioners, academics, and impacted citizens to identify solutions to some of the issues facing their regions. This local forum series was the inspiration for the ELISS National Forum - groundwater and private well management represented an issue that each region faced and could make progress in.

The national forum brought together water experts with both local and national perspectives, and over 40 participants from around the country. Each local region identified a panelist that presented a challenge question to be addressed by the national forum attendees, ranging from technology to communication to emerging contaminants in groundwater. After a thorough question and answer session with local and national panelists, forum participants formed breakout groups to brainstorm creative solutions to local challenge questions. These sessions led to the identification of eight areas in need of improvement, with respect to groundwater and private wells:

- Streamlined Tools and Initiatives for Effective Private Well Water Management
- Effective Communication Between Local/State Agencies and Private Well Owners
- Improved Small Water Systems
- Improved Drinking Water Quality
- Improved Data Collection and Management
- Better and Standardized Private Well Water Regulations
- Safe Water Reuse and Groundwater Recharge
- Allocation of Funding to Water Research and Staff Expansion

Participants outlined creative solutions and actions that agencies and individuals can take to tackle these issues moving forward. By bringing together perspectives of local and national stakeholders, fellows were able to open channels of communication that didn't previously exist and cultivate an environment that promoted sharing of best practices and the generation of new ideas.

I. What is ELISS?

Emerging Leaders in Science & Society (ELISS) is a service learning program that helps graduate students develop a breadth of professional capacities through a project that also benefits their communities. The service project, called Idea Lab, integrates multidisciplinary expertise with multiple stakeholder perspectives to promote innovative approaches to societal challenges (http://elissfellows.org). Eighteen fellows from five campuses—University of Washington, University of California Irvine, Purdue University, Duke University, and the University of North Carolina Chapel Hill—were chosen to participate in the 2016 ELISS Fellowship program (Figure 1).

The 2016 Idea Lab focused on drinking water and, more specifically, how to promote a safe, sustainable, and affordable drinking water future in the United States. Fellows from each campus canvassed their regions for 6 months, conducting stakeholder interviews and identifying advisors who are experts in the drinking water field. Through this process, they assessed the current state of drinking water in their regions and identified relevant needs. Fellows from each campus then hosted a forum that focused on a specific aspect of drinking water in their region that warranted closer attention. Challenges identified at these local forums were then given national attention at the 2016 ELISS National Forum on Drinking Water Safety in the United States.

Figure 1. ELISS cohort - class of 2016

II. Groundwater as a Drinking Water Source

Groundwater is one of the country's most vital resources and, in some areas, the only source of fresh water. Approximately half of the nation's drinking water comes from groundwater sources, and it is widely used in agriculture and industry. The quality and abundance of groundwater, along with monitoring and regulations, can vary greatly from region to region. To identify relevant challenges nationally, it is important to consider groundwater characteristics both at a regional and national level—such as local groundwater contamination, the less regulated status of private wells, and the depletion of this vital resource (Fitts, 2002 and Reilly et al., 2008).

IIa. Groundwater in North Carolina's Research Triangle

Major challenges facing the Triangle region of North Carolina (Durham, Orange, Wake, Chatham Counties) include the rapid and accelerating population growth and urban development. The Triangle is projected to be one of the fastest growing regions in the United States reaching as many as 2.8 million residents by 2060 (Triangle J Council of Governments 2014). In addition to this growth, North Carolina as a whole ranks third in the nation for residents who rely on private wells. Currently, an estimated 18% of Triangle residents use private wells with around 150,000 residents in Wake County relying on groundwater (Maupin 2014 & Evan Kane Wake County).

Unfortunately, regulations for private well systems are minimal and focus primarily on new well construction. It was not until July of 2008 that the state of North Carolina required counties to implement a formal process of well permitting and testing (H.B. 2873, 2005-2006 Sess. N.C. 2005). There are no requirements for continued testing of existing wells and there is little data across North Carolina as to the location of private wells. Furthermore, a significant portion of the population in Wake County relies on groundwater that is treated and distributed by private utilities. Though these utilities are regulated under the federal Safe Drinking Water Act, complaints about water quality (e.g. discoloration and odor) and costs persist. (Hicks et.al 2014, Hicks et. al 2011). Overall, there remain opportunities to improve groundwater regulations, public health, and accurate data collection for private drinking water wells in the Triangle.

IIb. Groundwater in Seattle-King County

The vast majority of the Seattle-King County population relies on water delivery from Seattle Public Utilities (King County Dept. Of Natural Resources and Parks). Thirty percent of this population uses groundwater for drinking, and groundwater use is primarily located in suburbs east of Seattle and in the rural areas (Ibid). The Washington State Department of Ecology regulates groundwater in the state and maintains five groundwater management areas within different municipalities of King County, each with its own local governance and distribution arrangements. During interviews with UW fellows, local experts identified a lack of data sharing amongst municipal regulators for the effective monitoring and control of contaminants in drinking water as major issue facing municipal groundwater management. The majority of groundwater usage in this region occurs in smaller municipalities (King County Dept. of Natural Resources and Parks). When there is an absence of state regulation and lack of communication with other local municipalities regarding contaminant regulation, municipalities will often look to other states in setting standards for contaminants. However, other states often have different needs and rationales for such regulations that are not necessarily applicable to those of municipalities in King County.

IIc. Groundwater in Southern California

The current state of drinking water in California is complex because of the nature of water infrastructure, especially in southern California. As a semi-arid area that enjoys a Mediterranean climate, the region is not naturally water-rich (Carle, 2004). Approximately three-quarters of the precipitation in the state falls north of Sacramento, while roughly three-quarters of the water demand are in southern California (Carle, 2004). Even as the most populous state (39 million) in the nation, California uses only 20% of its water resources for residential, commercial, and industrial purposes (Mount & Hanak, 2016). Roughly 80% of water in California is used in the $50 billion dollar agriculture industry that produces valuable commodities for domestic and international use (Guo, 2015; Mount & Hanak, 2016). Historic drought in recent years has greatly increased the demand for groundwater and caused widespread overdraft and

associated water quality issues, such as salinity, heavy metals, and pathogens (Mount & Hanak, 2016). High demand and low local supply, combined with a changing climate and fragmented policies and governance, renders southern California a unique place to understand the issues facing water.

In addition to significant infrastructure changes, it is also important to protect this valuable resource through intelligent management of groundwater reserves. The cuts in water use and the recent drought have led farmers in the Central Valley to over-pump water from the groundwater basins (EPA, 2015; Guo, 2015). This has led to dangerous levels of depletion in the water table and has been correlated with an increase in seismic activity in the area (Amos, Audet, Hammond, Burgmann, Johanson, & Blewitt, 2013). It also increases the potential for seawater intrusion that can contaminate the groundwater basins. Recent policies have begun to address this lack of groundwater management in the agricultural sector. However, historic water right laws complicate and strain the dynamic between farmers and policy makers (Carle, 2004). As we look toward the future, it is clear that effective and sustainable groundwater management is necessary and should be enforced in a way that balances the needs of the environment and the urban population with the needs of farmers so that all Californians can have access to safe, sustainable, and affordable drinking water.

IId. Groundwater in Greater Lafayette, Indiana

Purdue University is located in Tippecanoe County, Indiana and is surrounded by a sparsely populated agricultural area. The area is located above the Teays River Aquifer, which consists of sand and gravel deposits (Grove 2009). It is well protected, providing a vast supply of high quality water that is mostly unaffected by surface level disturbances (i.e. drought and flooding). Groundwater supplied by the Teays River Aquifer is the main source of drinking water for Tippecanoe and some surrounding counties. In Tippecanoe County, there are three public water treatment facilities that supply drinking water from the Teays River Aquifer to the Greater Lafayette community of approximately 70,000 residents. Overall the region is not at risk for water scarcity or drought in the upcoming years, and the consumer confidence reports for municipal and other public water treatment facilities have consistently met the EPA drinking water standards (City of Lafayette Water Works Consumer Confidence Report 2014).

However, there are some specific challenges for drinking water quality for residents of the rural communities outside of the Greater Lafayette region who mostly receive their drinking water from privately owned household wells. While the populations of Lafayette and West Lafayette keep growing (Tippecanoe County has 346 people per square mile), a majority of the neighboring counties are comprised of small towns with low population density (e.g., Benton County has 22 people per square mile). This rural-urban migration results in abandoned wells, which are a potential source of groundwater contamination, and a lower tax base to fund maintenance and upgrades to systems (Gray 2013). There are some overarching issues regarding drinking water in the Greater Lafayette and surrounding communities that can impact groundwater quality in the area including: leakages in sewage systems, flooded wells that have been abandoned, and wells without appropriate wellhead protection (Powell 2016; Fox et al 2016; Saha et al., 1999). Despite having an abundant water supply compared with other regions, there still remains a need for a long-term well water management plan to ensure quality of fresh water for both citizens and businesses in the future.

III. Why a Forum on Groundwater Management?

The National Groundwater Association estimates that 44% of the U.S. population gets drinking water from groundwater that feeds into a municipal or private well. It is vital to protect these wells from contaminants, such as bacteria or heavy metals that may harm public health. While municipal and private wells are subject to different regulations, ensuring safe drinking water requires quality water sources, proper well construction, and accurate data to guide outreach, monitoring, and treatment efforts (http://www.ngwa.org).

The objective of this forum was to bring people from various regions and sectors together to explore ways of ensuring safer groundwater. This forum was designed to provide local groundwater experts (representatives from each ELISS campus region) an opportunity to convey regional groundwater perspectives to forum attendees and highlight groundwater challenges specific to their regions. This event brought together over 40 participants from various sectors throughout the country (e.g. federal agencies, county agencies, water organizations, law firms, universities) to brainstorm ways to improve groundwater management on both the local and national scales.

IV. Forum Structure

1. Introductory Remarks

   The forum opened with introductions by the founding director of the fellowship program, Dr. Melanie Roberts, who highlighted the importance of programs such as ELISS to graduate education. An overview of all the ELISS campus accomplishments was then presented by Andrew George, an ELISS Fellow from Duke University.

2. Panel Discussion + Q&A

   The second forum segment brought together a diverse group of experts to share their perspectives on areas for improvement in groundwater management (Figure 2). Two different groups of panelists participated in this session. The first group offered national perspectives on groundwater challenges, while the second group offered regional perspectives and was composed of representatives from each ELISS campus region. A one hour question and answer period followed the presentations, allowing attendees to ask questions and voice their opinions. Panelist information and presentation topics are as follows:

National Representatives

Alan Roberson (Washington, D.C.)

Alan Roberson is Director of Policy for Corona Environmental in Washington, DC. He is a leading expert in Federal and State regulations related to water resources, treatment and distribution systems. He has been involved in numerous regulatory development processes spanning his 30-year career in water.

TOPIC: *Increasing competition for groundwater use (i.e. residential, industrial, and agricultural) often leads to groundwater depletion as well as transition to surface water use. Many systems that currently utilize groundwater are smaller systems, and a report published by the National Research Council (1993) describes challenges to such systems.*

Cliff Treyens (Washington, D.C.)

Cliff Treyens has been the National Groundwater Association (NGWA) director of general public outreach, where he oversees the expansion of the Association's well owner outreach.

TOPIC: *There is a need for effective communication that encourages and educates well owners to routinely test their water and mitigate the risks to their own health. There is also a need to develop methods to evaluate the effectiveness of these outreach and communications programs.*

Holly Green (Washington, D.C.)

Holly Green serves as the Chief for the Prevention Branch in EPA's Office of Groundwater and Drinking Water. She manages the national Underground Injection Control Program and Source Water Protection Program.

TOPIC: *There are many federal authorities and resources that exist to assist in the regulation of groundwater contaminants.*

Local Representatives

Evan Kane (Raleigh, NC)

Evan Kane is the hydrogeologist for the private well program in the Wake County (NC) Department of Environmental Services. He provides technical assistance and performs public outreach and program planning to reduce consumption of contaminated groundwater.

TOPIC*: How do we support private well users in recognizing their role as their own water system operator and acting effectively in that role? Can we help them move from either complacency or fear to empowerment?*

Dr. Crystal Lee Pow Jackson (Raleigh, NC)

Dr. Lee Pow Jackson is an Environmental Program Consultant at the North Carolina Department of Health and Human Services Division of Public Health, where she works on the state's Private Well and Public Health program.

TOPIC*: Many contaminants impacting water quality of private wells are natural elements (e.g., arsenic and uranium) associated with geological formations. In NC there are available funds to mitigate anthropogenic contamination of private wells. However, there are no such funds for natural contaminants. How do we help homeowners mitigate these issues?*

Andrew Pappas (Indianapolis, IN)

Andrew Pappas is the Environmental Project Manager at the Indiana State Department of Public Health's Environmental Public Health Division. His team was recently funded by the Centers for Disease Control and Prevention to conduct a program assessment for the state and to increase the reach of the current unregulated drinking water program for Indiana.

TOPIC: *As the risk of emerging chemicals like personal care products (PCPs) and perfluorinated carbons meet long-acknowledged hazards such as nitrates and arsenic, markets will require lower-cost, high-efficiency water treatment technologies. How do we effectively utilize dynamic, data-driven treatment technologies to improve the cost of providing safe, clean water?*

Dr. Jian Peng (Irvine, CA)

Dr. Jian Peng is the Chief of the Water Quality Planning Section, Orange County Environmental Resources, and County of Orange, California. He also serves as a member at the Orange County Health Care Agency Well Standard Advisory Board that oversees the construction and abandonment of water wells in order to protect the health, safety, and welfare of the people of Orange County.

TOPIC: *With an increasing reliance on water reuse, how do we ensure the quality (and to some extent quantity) of drinking water pulled from groundwater basins?*

Linda DeBoldt (Seattle, WA)

Linda DeBoldt is a professional civil engineer with 33 years of experience in public works and engineering management. For the past three years, she has served as the Director of Public Works for the City of Redmond, Washington.

TOPIC: *How can local water agencies efficiently set regulatory limits for emerging groundwater contaminants in public drinking water supplies given (1) the lack of scientific knowledge regarding the presence and transport of these contaminants through groundwater aquifers, (2) the level of risk these chemicals pose to human health, and (3) the methods available to water utilities for addressing the risks?*

Figure 2. Diverse group of experts as ELISS national forum panelists to share their perspectives about improvement in groundwater management

3. Breakout Sessions

Participants divided into five breakout groups, each facilitated by a regional representative who led the group in brainstorming ways to mitigate their regional challenge. The goal of these breakouts was to discuss a challenge question presented by the representative, placing emphasis on resource and knowledge transfer that could benefit both regional and national participants. A secondary objective of the breakout sessions was to facilitate connections that would lead to the sustained sharing of ideas and resources between national and regional representatives (Figure 3).


Figure 3. Breakout session followed by reporting the main outcomes of the small group discussion

4. Closing Remarks

   The forum ended with closing remarks from Kasia Grzebyk, a UNC ELISS Fellow, where key findings of the event were summarized and next steps for the ELISS Fellows and participants were discussed.

V. Forum Insights

The ELISS Fellows performed an inductive content analysis, a qualitative method of synthesizing verbal and written information, to explore emerging themes and patterns from issues and ideas raised during the forum. They identified eight main themes that represent the major needs of U.S. groundwater systems and identified solutions proposed by forum participants for each identified need.

1. Streamlined Tools and Initiatives for Effective Private Well Water Management
2. Effective Communication Between Local/State Agencies and Private Well Owners
3. Improved Small Water Systems
4. Improved Drinking Water Quality
5. Improved Data Collection and Management
6. Better and Standardized Private Well Water Regulations
7. Safe Water Reuse and Groundwater Recharge
8. Allocation of Funding to Water Research and Staff Expansion

NEED 1 - Streamlined Tools and Initiatives for Effective Private Well Water Management

The panel identified various websites and coalitions that address private well water management. It was generally agreed upon that existing informational toolkits, and those still in development, remain underutilized and should be streamlined into an overarching, standardized source of information. To this point, a number of forum participants who work in various well water disciplines were not aware of many of these identified resources. Wellowner.org is one such tool for private well owners. This website provides a wealth of information regarding private well water testing and maintenance, and links to reviews from organizations that review water treatment technologies. While the development of these tools is a great step toward addressing the issues surrounding well water testing and maintenance, they remain difficult to navigate and in some cases rely on technical jargon and knowledge. Forum attendees also suggested that a large barrier to frequent well water testing is the long lag time from testing to treatment options.

Participants noted that there are many opportunities for improvement of this process as it can take weeks, if not months, to navigate from the time of water sampling to results.

Suggested Solutions: Forum participants were excited to hear about new tools being developed to mitigate private well issues, but felt they would also benefit from a coordinated effort to streamline, implement, and disseminate these tools more effectively and efficiently. Another discussed solution was that of making water testing more efficient, through partnerships between state agencies and universities to develop lower cost reliable testing methods or kits, improving sample submission forms, and easier access to qualified testing labs so that water can be collected, tested, and treated in a reasonable time frame.

NEED 2 - Effective Communication Between Local/State Agencies and Private Well Owners

The need for better communication to (1) educate and inform private well owners, (2) instill trust between private well owners and local/state agencies, and (3) clarify the allocation of responsibilities for private well management were recurring themes at the forum.

Concerns were raised that current resources and materials rely too heavily on technical information and are not easily interpreted by the general public. San Diego's "Toilet to Tap" campaign was given as an example to illustrate the importance of effective communication. This slogan hurt the progress of the water reuse program in the area because people weren't comfortable with the idea of drinking reclaimed water. The city has spent one million dollars on a public information campaign to combat this perception (Carroll 2014).

Failures in communication can also lead to mistrust in agencies whose intentions are to help private well owners mitigate their water quality issues. Forum participants identified the ambiguity around the responsibility for maintenance and regulation of private wells as an issue. It was suggested that well owners, utilities, and researchers should all be viewed as "risk managers", as they should frequently be considering ways to mitigate risks to wells. While well owners bear the responsibility to ensure private well safety, water experts, regulators and educators bear an ethical obligation to assist well owners. A barrier to achieving proper maintenance and regulation of private wells is owner's' view of their wells as private property. As such, it was agreed that it is often difficult to persuade private well owners to monitor or to make adjustments to their wells.

Suggested Solutions: Participants proposed several solutions to foster trust, increase effective communication and address the disconnect in regards to regulation and maintenance between well owners and regulatory agencies. First, there is no one-size-fits-all approach to motivating well owners; therefore, it is critical to engage private well owners and determine their needs and concerns. It was suggested that state and local governments should work with journalism departments at universities to produce Public Service Announcements promoting private well management for well owners. For many close-knit communities, relying on local religious and social functions such as church groups or Friday night football games could be leveraged to disseminate information to well owners. Collaboration can be a powerful tool to combat this issue. Community organizations, universities, and local, state, and federal agencies have the potential to boost engagement and outreach through collaboratives. For areas where external parties are testing private wells, the testing, results, and treatment advisements should occur immediately. Lengthy delays between those steps can decrease well-owner engagement, motivation to take action, and downplay the perceived risks associated with the advisements. Finally, international literature should be examined to determine how other countries are addressing well owner issues and whether any strategies are transferrable to the United States.

NEED 3 - Improved Small Water Systems

A common concern among forum participants was operation and maintenance practices of the many small water treatment and distribution systems that use groundwater as their source. Many challenges of these systems were identified at the forum, such as their aging workforce, as well as high operation and maintenance costs. Another concern that was brought up several times by attendees pertained specifically to operators of these small systems, as they are often volunteers or contractors who have much variability in their training.

Suggested Solutions: There was a consensus that the level of professionalism of these smaller systems must be raised. An overarching suggestion was to move from these small systems to larger systems. This could be done by physical consolidation of systems and/or extending nearby municipal lines from water utilities. Another suggestion was managerial consolidation where, for example, city water utilities with trained professionals could be responsible for managing these smaller systems. These suggestions could lead to an increase both in revenue and system capabilities, as well as alleviate communication efforts between utilities and residents.

NEED 4 - Improved Drinking Water Quality

Many concerns related to groundwater quality were raised during both panel talks and breakout sessions, with the protection of groundwater quality and removal of contaminants (both anthropogenic and naturogenic) as two emerging themes. In North Carolina, for example, there are three distinct geological regions that have natural contaminants associated with each of them (i.e. arsenic, uranium, and manganese) (Sanders et al., 2012). The city of Redmond, WA's aquifer was used as an example to illustrate anthropogenic groundwater contamination given that it is very shallow and therefore susceptible to contamination from storm water that contains metals (i.e. copper), motor oil, or nitrates from fertilizers (Fisher, et al., 2003). Other anthropogenic contaminants of concern in groundwater include pharmaceuticals, PPCPs (pharmaceuticals and personal care products) (Tillett 2009), and industrial proprietary mixes. Furthermore, many of these contaminants remain present in water even after it is treated for superficial water quality issues (i.e. taste and odor removal), which can have negative public health implications.

Suggested Solutions: Participants agreed that hazardous waste and storm water runoff needs to be controlled to prevent anthropogenic contamination of aquifers and wells. Treatment options for water were also discussed, and the general consensus was that the best treatment options are those that remove an entire suite of contaminants from water. Reverse osmosis (RO) is one such option; however RO units are expensive, maintenance can be difficult, and RO may not remove all contaminants found in well water. Another suggestion was to utilize geological data and information regarding contaminants to predict a safe depth at which wells should be drilled, thereby protecting public health by minimizing groundwater exposure to those contaminants that are typically found at a more shallow depth.

NEED 5 - Improved Data Collection and Management

Forum participants expressed a need for improved data collection and access to data. With respect to data collection, participants mentioned the need for better information related to well location, prevalence of diseases associated with well water contaminants, and the development and adoption of new technologies to identify such contaminants. On the issue of access to data, participants noted that public data sets often remain incomplete, or are in proprietary or poorly documented formats, and that restricted access to health and environmental data can stand as a roadblock to understanding health effects of contaminants and the ability to set effective regulatory standards.

Suggested Solutions: Participants identified several options to remedy data collection needs, including local government surveillance to locate wells, evaluation of hospital medical records for possible links to contaminants, and sensor technology that can identify contaminants present in water.

Furthermore, several participants noted the important role citizen science plays in data collection and data access. Several companies have produced tool kits for individuals to test their drinking water. Additionally, application platforms exist for people to find out drinking water quality in their area--for example, application developers in Washington, D.C. have launched "Tap It" for District residents to use their smartphones to discover water quality information in their area.

NEED 6 - Expand and Standardized Well Water Regulations

Participants identified regulations—both federal and local—as an ongoing area of concern for municipal well water. With regard to federal regulations, the Safe Drinking Water Act does not give the EPA authority to regulate private wells, only public water systems that serve over 25 people (42 U.S.C. § 300f(4)(C)). Most states have little to no regulation requiring testing or inspection of private wells. For private wells, states have adopted a variety of approaches to regulation, ranging from states such as New Jersey, which regulates both the initial construction and testing of private wells and requires testing of wells during property transactions, to North Carolina, which began requiring permitting and testing of newly constructed wells across the state in 2008.

Suggested Solutions: Participants proposed solutions at the federal, local and individual level for regulating contaminants in well water. Government regulators could look outside the U.S., such as to the E.U., which has a broad based contaminant ruling that regulates a suite of contaminants with treatment technologies. States and localities can also look to other states for regulatory frameworks, although some participants shared that in lieu of wholesale adoption of other states' contaminant standards, they should first assess their local needs for contaminants. With regard to private well owners, who are not regulated by the federal government like public water supplies or polluters, participants suggested that local governments provide advisors, testing, and education so that well owners may be able to adequately manage their wells.

NEED 7 - Safe Water Reuse and Groundwater Recharge

The issue of safe potable water reuse, both directly and indirectly (such as for groundwater recharge), was one of the issues highlighted at the forum. Reuse is critically important for areas such as the southwestern region of the United States, with growing demand and strained supply. Wastewater reuse and storm water capture can be utilized for groundwater recharge and injection for seawater intrusion barriers as well as drinking water supply. A major barrier to implementing water reuse and storm water capture and reuse is regulatory hurdles. In many areas of the United States, storm water is essentially considered as waste that needs to be removed as quickly and efficiently as possible, not as a resource. However, more and more places, such as Orange County, are making headway in both storm water capture and wastewater reuse to supplement drinking water supplies. One participant noted that large amounts of money and time have been spent on acquiring various storm water permits, as agencies must manage contaminants from urban areas, industrial facilities and construction sites. Similarly, emerging and unregulated contaminants (such as hormones, pharmaceuticals, disinfection by-products, etc.) pose an increasing threat to water reuse (Pruden, 2013).

Suggested Solutions: The United States can learn from other countries such as Singapore and Australia that were able to overcome regulatory and public perception barriers via effective public education campaigns and innovative strategies. In Australia, the Victorian government and Melbourne Water worked with radio, TV, and newspapers to broadcast the

most up to date water storage data, weekly rainfall, and ways to save water (Grant, et al., 2013). We can also look to places like Hong Kong, which has used a dual water supply system since the 1950s for seawater toilet flushing for 80% of its 7 million inhabitants (Leung, et al., 2012). Regulators should consider the direct/indirect and potable/nonpotable reuse of recycled water to supplement existing water supply

NEED 8 - Resources for water research and staff expansion

Participants stressed the importance of financial and personnel resources for designing water centered research, well water monitoring programs, and hiring experts in the area. Different studies are needed to help with monitoring the changes happening to groundwater sources such as geological studies, water filtration, aquifer recharge, and testing emerging contaminants. Funding not only impacts long term data collection but also human resources such as the hiring of experts to assess water quality and to work with local communities. One of the participants mentioned that the budget cuts in Indiana led to the loss of 55 monitoring wells. Another participant mentioned the need for their organization to hire and work with hydrogeologists and toxicologists.

Suggested Solutions: Additional funding would be ideal, but not always feasible. Other creative approaches for increasing resources include more collaboration between universities and communities and improving the water extension programs. Citizen science projects can enable communities to take action and be actively involved in water monitoring programs. Using sensor networks and autonomous data collection methods can help compensate for lack of personnel for data collection.

VI. Next Steps

The ELISS Fellows are exploring an opportunity to publish an article in Journal AWWA (American Water Works Association) summarizing their Idea Lab findings and forum outcomes. Furthermore, fellows from Duke University and UNC have been asked to help organize and present at a session of the 2017 NC Water Resources Research Institute (WRRI) annual conference in March 2017. ELISS Fellows from Purdue University will be presenting a poster entitled “Development of boundary-crossing competencies in Ph.D. students by hosting a regional stakeholder workshop” at the 2017 AAAS Annual Meeting.

Forum participants completed an exit survey at the close of the event and provided examples of how they will use new connections and knowledge to enhance water policy and practice.

- Participants shared that they will use knowledge gained at the forum to support rural water programs, influence policy development, and make better, more informed water management decisions about emerging contaminants in groundwater supplies.

- Over half of the participants noted that they would foster connections made at the forum and facilitate connections between other participants at the forum who are working on similar issues. For example, one participant will use knowledge transfer as a way to assist public agencies in implementing applicable requirements, while another will discuss forum themes at an organization meeting and determine the best mode of disseminating knowledge at the community level.

- Several participants mentioned that they will consider the importance of communication and empowerment of individuals in practice. For instance, one participant plans to use public health strategies identified at the forum to inform further development of outreach programs for private well users.

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42 U.S.C. § 300f(4)(C).

X. Supplemental Materials

Attendee list

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Cliff	Treyens	National Ground Water Association	ctreyens@ngwa.org
Victor	Udoewa	18F	

Panelist Bios

Linda De Boldt is a professional civil engineer with 33 years of experience in public works and engineering management. Linda worked for the City of Seattle for 30 years and last served there as the Chief Engineer for Seattle Public Utilities. For the past 3 years, she has served as the Director of Public Works for the City of Redmond, Washington. Since Redmond has a very shallow and prolific aquifer that is directly below the City's downtown urban area and that supplies 30-40% of the city's drinking water, she has a very keen interest in groundwater quality and well-head protection issues.

Holly Green serves as the Chief for the Prevention Branch in EPA's Office of Ground Water and Drinking Water, managing the national Underground Injection Control Program and Source Water Protection Program. Previously, Holly held leadership positions in EPA's national Water Quality Standards Program, focusing on water quality criteria implementation in Clean Water Act programs and national nutrients policy. Prior to EPA, Holly served as a Peace Corps Volunteer in Honduras working with communities to build, sustain and protect rural drinking water systems.

Crystal Lee Pow Jackson is an Environmental Program Consultant at the North Carolina Department of Health and Human Services' Division of Public Health. At NC DPH, she is currently working on the state's Private Well and Public Health program. Before joining NC DPH, Crystal completed her Doctorate in Environmental Toxicology from North Carolina State University in Raleigh, NC, where she researched the prevalence of endocrine disrupting compounds in surface waters throughout North Carolina and their association to anthropogenic sources and fish health.

Evan Kane is the hydrogeologist for the private well program in the Wake County (NC) Department of Environmental Services. In this role, he provides technical assistance and performs public outreach and program planning to reduce consumption of contaminated groundwater. Prior to joining Wake County, he worked for the state of North Carolina for 14 years in groundwater protection programs under the Safe Drinking Water Act, Clean Water Act, and state statutes.

Andrew Pappas is the Environmental Project Manager at the Indiana State Department of Public Health's Environmental Public Health Division. His team was recently funded by the Center for Disease Control to conduct a program assessment for the state and to increase the reach of the current unregulated drinking water program for Indiana. The program is focused on increasing testing rates for well-water users, improving the capacity of local health departments and minimizing the overall health impacts of unhealthy drinking water.

Jian Peng is the Section Chief of the Water Quality Planning Section, Orange County Environmental Resources, County of Orange, California. He also serves as a member at the Orange County Health Care Agency Well Standard Advisory Board that oversees the construction and abandonment of water wells in order to protect the health, safety, or welfare of the people of Orange County. Dr. Peng's main focus is the policy, management, and sciences related to water quality issues.

Alan Roberson is Director of Policy for Corona Environmental in Washington, DC. He is a leading expert in Federal and State regulations related to water resources, treatment and distribution systems. He has been involved in numerous regulatory development processes spanning his 30-year career in water. He retired from AWWA in 2016 as Director of Federal Relations after 25 years of service. Since 2009, he has served on the Fairfax Water Board of Directors and is currently Treasurer and Chair of the Water Quality & Supply Committee.

Cliff Treyens has been the National Ground Water Association's (NGWA) director of general public outreach since September 2003. At NGWA, Treyens has overseen the expansion of the Association's well owner outreach through WellOwner.org and two annual recognition events—National Groundwater Awareness Week and Protect Your Groundwater Day. Treyens also has spearheaded development of well owner tools including 27 online lessons, more than 20 webinars, a well owner app, well financing video, and a popular monthly tip sheet. He also recently led a research project for the CDC on the efficacy of private well owner outreach in reducing health risks in drinking water.

I. ELISS Fellows Bios

Can be found at the following link:
https://www.aaas.org/page/eliss-fellows-student-liaisons

II. For Further Reading

A. Local Forum Reports
   1. Purdue
      http://elissfellows.org/wp-content/uploads/2016/02/Purdue_LocalForumSummary_Final.pdf
   2. Triangle
      http://elissfellows.org/wp-content/uploads/2017/01/Triangle-Forum-Report.pdf
   3. UCI
      http://elissfellows.org/wp-content/uploads/2016/12/UCI-Local-Forum-Summary.pdf
   4. UW
      http://elissfellows.org/wp-content/uploads/2017/01/UW_LocalForum_Summary_Public.pdf

B. Research Triangle Environmental Health Collaborative Summit Recommendation Document http://environmentalhealthcollaborative.org/images/RTEHC_2015_Summit_Recommendations-FINAL.pdf

C. Water Resource Challenges and Opportunities for Water Technology Innovation
   https://www.whitehouse.gov/sites/whitehouse.gov/files/documents/Water_Resource_Challenges_and_Technology_Innovation_12_14.pdf

D. Groundwater Vulnerability Assessments: Prioritizing Water Safety in Times of Austerity
   https://www.cdc.gov/nceh/ehs/Docs/JEH/2013/nov-groundwater.pdf