CHAPTER

12

Investigating the Missing Link: Effects of Noncompliance and Aging Private Infrastructure on Water-Quality Monitoring

Adam Cooper[a,*], *Alexa Fortuna*[a], *Satinder Ahuja*[b]

[a]Stetson University, DeLand, FL, United States [b]Ahuja Consulting for Water Quality, Calabash, NC, United States

***Corresponding author: E-mail: awcooper@ucsd.edu**

1 INTRODUCTION

The Flint water crisis (FWC) changed the way our nation prioritizes and respects water quality. Before Flint, many communities were under the impression that their water was safe regardless of where they lived. They were not fully aware of the harms of having lead in their drinking water. Alas, Flint opened the door to revolutionary research and increased accountability when it came to our country's water supply. The FWC was due to the switch in water supply from Lake Huron to the Flint River, to save money. The water was not treated with an anticorrosion chemical to prevent lead particles and solubilized lead from being released from the interior of water pipes, particularly those from lead service lines or those with lead solder. Flint opened the door to deliberation of policy changes and kick-started additional attention toward the issue of lead release in the United States.

Lead poisoning is a silent killer because it is tasteless, odorless, and mostly colorless. However, the effects of lead poisoning are extremely harmful and long-lasting. Lead can cause immediate acute poisoning but the subacute, moderate, long-term exposure impact of concern in Flint is more common, and much more insidious. Levels that may be relatively harmless in a single dose can cause long-term damage if ingested regularly, which is what happens when a water source contains high levels of lead. Effects of long-term lead exposure include,

https://doi.org/10.1016/B978-0-12-815730-5.00012-0

mainly, neurological decay, which severely affects children and the elderly. This is a poor warning sign for lead exposure in a community, because any resulting behavioral disturbance or loss of intellectual function would probably not be immediately linked by their physicians or families to lead poisoning, and instead accepted as an unrelated symptom (Abadin et al., 2007). (Additionally, the adverse effects from this event may take years to surface, as most negative health effects from low-level lead exposure develop slowly (National Toxicology Program (NTP), n.d.).) Following the repercussions of the high levels of lead found in the water supply in Flint, Michigan, the need to have better control of public water supplies was highlighted. Chemists Without Borders, a nonprofit dedicated to solving humanitarian issues through the mobilization of the international chemistry community, began a project entitled US Water Quality Study, under the direction of Dr. Sut Ahuja. This project plans to monitor water quality in various counties in the United States in an effort to raise the awareness of water quality in the country. This chapter explores the first community-based project that investigated the local water supply of DeLand, FL, and discusses possible remediation strategies to overcome issues found within their sample-collection methodology.

This project sought a partnership with the community organizations within Spring Hill, a neighborhood in DeLand. Spring Hill was chosen because of a high potential that this area possesses the right criteria for having unsafe drinking water. Spring Hill and Flint have a very similar demographic makeup, as well as Spring Hill's lack of a large water management department. Additionally, Spring Hill is geographically close to Stetson University, the location of Chemists Without Borders volunteers, Adam Cooper, and Alexa Fortuna. Because of these factors, it was decided that Spring Hill would be an excellent system to investigate and to explore possible solutions to the problem of lead release on a community level.

By analyzing and understanding previous literature, it is important to note that most of the literature/studies on lead contamination in the United States are either from the late 1980s and 1990s or post 2014. One can infer that this is because research on the topic of environmental racism and injustice follows almost exclusively after a major disaster strikes. There is an apparent lack of continuous research and testing being conducted by outside organizations as well as the federal government. The recent resurgence in research into lead contamination comes from the FWC, which began in 2014. Because of this reactionary research practice, there are significant gaps and lapses in continuous research to study long-term effects of blood lead levels, how policies have affected the progress in changing lead pipes to PVC pipes in poorer communities, and tracking which homes have tested positive for lead. However, these factors do not necessarily discount previous research. Specifically, a study found a significant correlation between the number of commercial hazardous waste facilities in a zip code and the percentage of people of color in the zip code's population (United Church of Christ Commission for Racial Justice, 1987). The Environmental Justice Movement began making a solidified foundation in 1994 with an executive order by President Clinton establishing the Environmental Justice Interagency Working Group (US EPA, 2013). There is both a notable internal and external perspective from this movement. The internal perspective looks at the group from the "ground up"—from the experience of communities that struggle daily with environmental degradation and with their disenfranchisement from the institutions and structures that control their living environments. The external perspectives cast a critical eye on the political economy of environmental degradation, including the structure of environmental decision-making in disaffected communities (Cole, 1992). We believe both perspectives are crucial to understanding the scope of the problem and shaping the solutions.

2 CASE STUDY: COMMUNITY-BASED LEAD TESTING

The Safe Drinking Water Act holds local and state governments accountable for providing acceptably clean water to the nation's citizens. Currently, action levels are set at 15 ppb for lead with mandatory action required if more than 10% of households test above this level. Regarding pipes and other vessels that contain or transport water, new infrastructure has a requirement that it must be made of "lead-free" materials, i.e., less than 0.25% lead for pipes, fittings, and fixtures and 0.2% lead for solder and flux (Environmental Protection Agency, 2007).

Analyzing this data from a local perspective, we decided to look at previous literature and primary data from DeLand in Volusia County, FL. The graph below (Fig. 1) depicts lead in Volusia County drinking water. It is apparent that DeLand, in comparison to other cities in the county, has an elevated level of lead compared to its counterparts. In past testing cycles, DeLand continuously tests at the threshold or right below the 15 ppb standard set by the EPA.

In 2014, 90% of households tested under the action level for lead. This result is based on the testing of a sample comprised of 30 households out of DeLand's 13,000. There were 10% of the homes that tested over the EPA standard action level at 19, 61, and 110 ppb. For these three homes, letters were sent out informing these residents of their elevated levels of lead, recommending that they flush water in the mornings, and to encourage the use of cold water for cooking. None of these households began a discussion with DeLand utilities about replacing their infrastructure (Konoval, 2014). After the FWC occurred, there were numerous studies conducted by both public and private companies and institutions. Among those was Chemists Without Borders members who concluded that there are several warning signs we can foresee in order to prevent the "next Flint." These signs are to be cautious with low-income areas, medium-sized cities, and old infrastructure (Kirkwood, n.d.). Dated infrastructure is increasingly more likely to contain pipes that test positive for alarming levels of lead.

Due to its proximity to Stetson University and factors aligning with that of an environmental

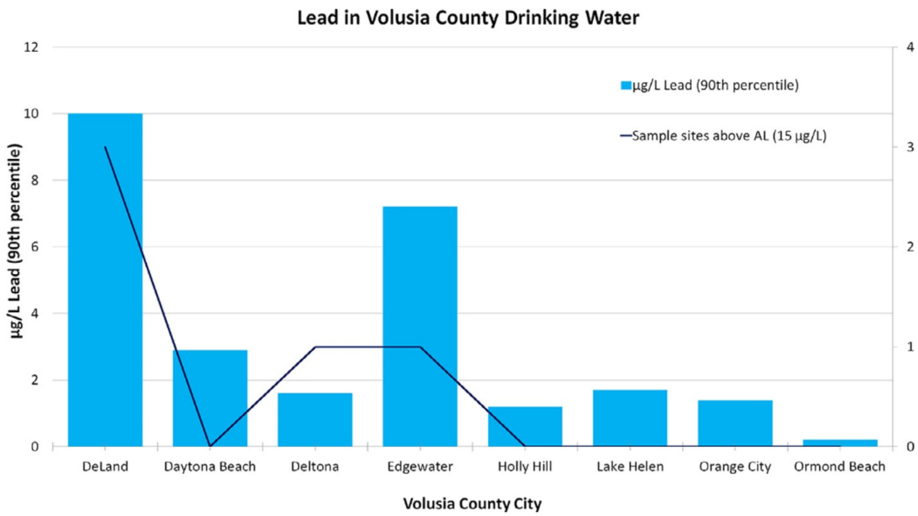

FIG. 1 Lead in Volusia County drinking water.

justice community, the Spring Hill community was used for this study. Spring Hill is a functionally segregated neighborhood found geographically in DeLand but has not been formally incorporated by the city. The community originally developed as a location for black citrus workers when DeLand was a primarily citrus-growing community. After Florida's Great Freeze in 1895, the workers were without jobs and did not have the mobility to pursue other work. During the Jim Crow era in the South, Spring Hill was formally segregated and the ramifications of this remain clear today. This is similar to the lingering effects of segregation found prominently across the United States (Gillmor and Doig, 1992). The 2016 Spring Hill Needs Assessment conducted by local Stetson University found that 89% of those that identify as Spring Hill residents are African American (Carey et al., 2016). This is in stark contrast to DeLand's 75% Caucasian population (Census Bureau, n.d.). Several factors (such as an unincorporated area next to a city, lacking sidewalks and public utilities, and designation as a food desert, etc.) led to the selection of Spring Hill as a test community for the community-based water testing (Carey et al., 2016).

In an interview with City of DeLand chief chemist Alex Konoval, sampling procedure for water testing was discussed. In all, 45 households (150% of the legal minimum of 30) are selected from a database of city water customers. Out of that, 30 households are chosen for initial testing. On noncompliance, the remaining 15 households are approached for water testing (Konoval, 2017).

Because of DeLand's sample-collection procedure, there is reasonable suspicion that the water collected may be skewed away from the Spring Hill community. On selection for testing, a city employee drops a sample-collection container and a letter of instruction on the doorsteps of selected customers (Grevatt, 2016). There is no personal contact with the customer (in the form of a phone call or in-person conversation), besides the letter of instruction. This can lead to noncompliance in key populations of the city, including those functionally illiterate and untrusting of the government. Political trust is a key factor in this equation. Scholars have defined political trust as a basic evaluative orientation toward the government founded on how well the government is operating according to people's normative expectations. Declining political trust contributes to dissatisfaction with incumbents and institutions, creating an environment in which it is difficult for those in government to succeed. To bridge this trust gap, we focused on approaching the population of Spring Hill through our partnership with the Spring Hill Community Center, a trusted resource and functional city hall for the unincorporated neighborhood. Other community centers, such as local churches and schools, were also considered to involve community leaders with this process.

Another population that may have higher rates of noncompliance are those anxious about lowered property value. If elevated lead levels are detected, the cost of replacing private infrastructure almost always falls on the homeowner. These projects can cost anywhere from $2000 to $20,000. There is little to no support from the government to help alleviate this newly presented financial burden. Additionally, if that homeowner wants to sell or rent his or her home, the owner is legally required to get consent from tenants or a buyer that they were informed that the house has tested positive for lead. This noncompliance has been seen in DeLand in the past, and attempts at incentivizing participation, including payment, have seen very little success (Konoval, 2017). The rate of noncompliance and potential bias motivated further screening of Spring Hill through community-based water testing.

Throughout this project, it became apparent that various city resources are failing certain demographics. To address this, nearby Stetson University's Center for Community Engagement is beginning to become more and more involved in providing support and awareness in the Spring Hill community regarding environmental health. From helping create a neighborhood garden to working with centers in the community with education and donations of supplies, the university can partner with local organizations to break the "college bubble" and utilize the university's resources to help those who are lacking resources. By mobilizing local university faculty, students, and citizen scientists, we can utilize low-cost screening devices in the community. We worked closely with the Spring Hill Resource Center in collaboration with Director Shirletha Dixon. Through conversations with numerous community members, it became apparent that one of the best ways to get participation from the community for lead testing is to involve community members in the process. This encourages ownership over projects rather than the feeling of being the subjects of a scientific survey (Spring Hill Resource Center, n.d.). In collaboration with Shilretha Dixon, a flyer (Fig. 2) and a sign-up sheet were created. A total of 20 community members signed up for testing and were followed through with multiple phone calls. Eight followed through with testing. Continued testing will be conducted in future years by volunteers with Stetson's Center for Community Engagement.

3 METHODS

The eXact LEADQuick with Bluetooth Photometer developed by Industrial Test Systems was chosen for this study because of its low cost, high analytical metrics, and simple methodology. It adapts a colorimetric determination from benchtop to field analysis. The assay is conducted with sequential addition of four reagents (Industrial Test Systems, 2015).

First, a 50-mL sample is collected from a water tap. Then, 5 drops of 18% nitric acid are added. This serves to solubilize any present lead particulate matter. Of this solution, 4 mL is transferred to the spectrophotometer cell, which reduces the number of further reagents needed. Five drops of AMP/tris buffer are added to the cell to ensure an alkali environment. Then, a reagent strip is swished in solution, delivering *meso*-tetra(*N*-methyl-4-pyridyl)prophine tetratosylate (TMPYP). This porphyrin indicator forms a colorimetric complex with soluble Pb^{2+} in solution. After 1 min, the device calibrates to the solution's intensity. Then, a reagent strip containing EDTA is swished in solution. The EDTA breaks apart the colorimetric TMPYP-Pb^{2+} complex, and the difference in intensity is used to calculate the concentration of lead, using Beer's law. Unfortunately, the device manufacturers do not provide information on the exact quantity of solid reagents or information about the spectrographic cell (Industrial Test Systems, 2015).

As with any colorimetric assay, inhibiting and competing metals are the main concern when trying to avoid interference. Water exhibiting hardness above 400 ppm shows interference through inhibiting the formation of the colorimetric TMPYP-Pb^{2+} complex (Industrial Test Systems, 2015). Fortunately, Volusia County exhibits water hardness at less than 120 ppm (Shampine, 1975). Two metal contaminants of note, mercury and cadmium, show interference through forming similar colorimetric complexes with TMPYP. The current methodology has a tolerance of concentrations of 70 ppb for cadmium and 10 ppb for mercury. However, these values are rarely seen within safe water systems, and interference would lead to high results during screening tests, thus highlighting them for further analysis (Industrial Test Systems, 2015).

Industrial Test Systems promotes very good analytical metrics. The LEADQuick device is advertised to have a detection limit of 3 ppb with an upper threshold of 500 ppb. Accuracy is marketed to be 3 ppb for lower values and 6% for larger values. The device gives readouts in 1 ppb steps (Industrial Test Systems, 2015). To assure the quality of data collected, the device was tested against prepared standards at Stetson.

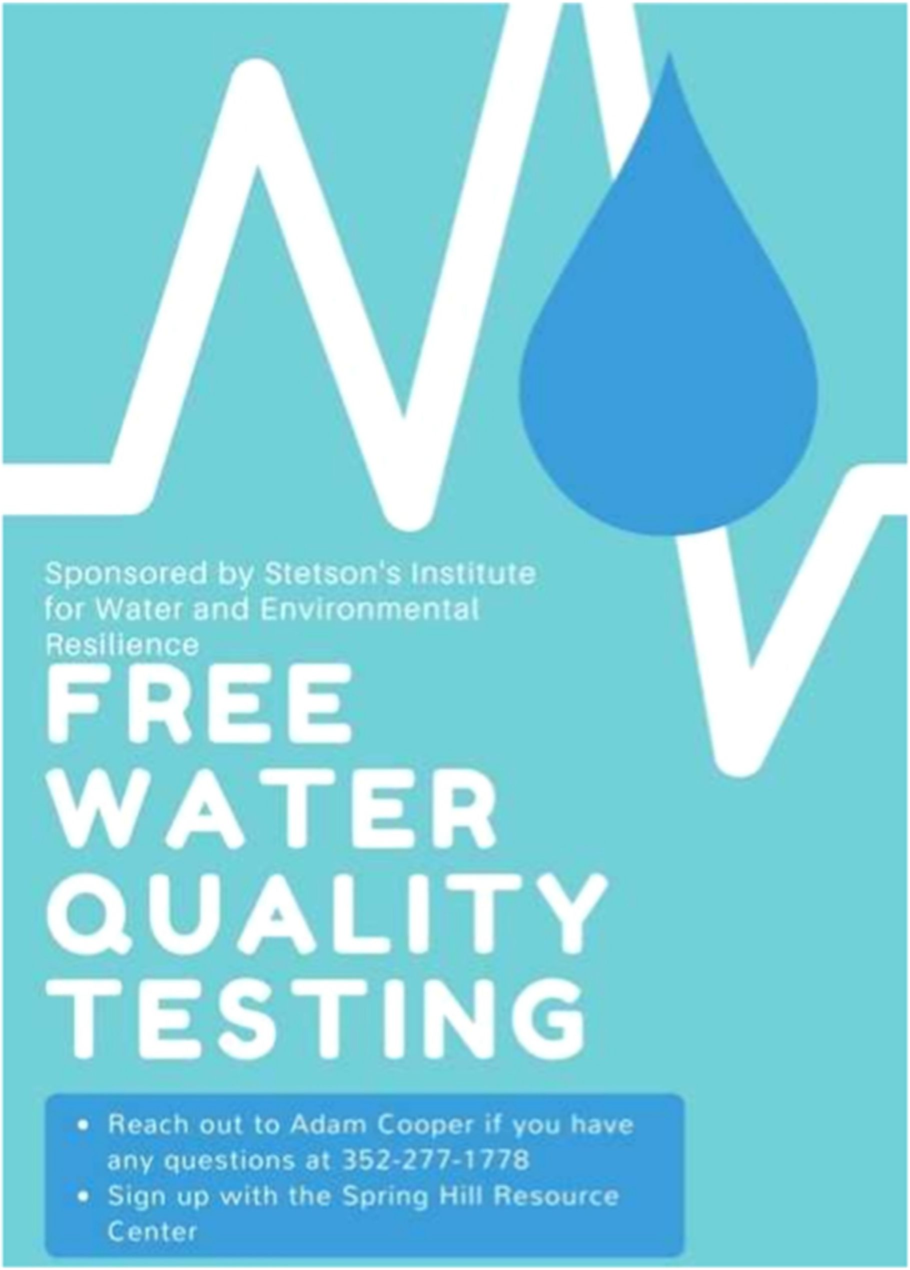

FIG. 2 Water screening flyer.

Solutions of lead were prepared through the dissolution of lead nitrate in deionized water, followed by serial dilution to arrive at desired concentrations. The methodology discussed earlier for LEADQuick was followed, with one modification: The step including addition of nitric acid was eliminated. This is due to the effect of nitric acid's causing lead nitrate to precipitate out of solution (Ostanova et al., 2002). The previously discussed procedure was followed, beginning with the addition of buffer to the system.

4 RESULTS AND DISCUSSION

First, commonly seen concentrations of lead above its action level were tested from 12.5 to 100 ppb (Fig. 3). The device performed admirably, with a relationship of 99.29% of expected concentration and a coefficient of determination of 0.9992. Then, levels of lead seen within EPA-compliant water samples were tested, ranging from 5 to 20 ppb (Fig. 4). The apparatus lost some accuracy, with a relationship of 100.67% of expected concentration and a coefficient of determination of 0.9313. The analytical metrics were deemed suitable enough for a field-based screening campaign, and so the next steps of community testing were followed.

All eight samples tested below the LEADQuick device's threshold of 3 ppb and thus gave an "LO" reading. This is not unexpected, as 26/30 samples collected in the 2014 DeLand survey were similarly below this threshold (Konoval, 2014). A map of sample sites can be seen in Fig. 5. Four residential locations were tested, as well as two after-school programs (the Boys & Girls Club, as well as the Chisholm Center) and two community centers (the Spring Hill Community Garden and the Spring Hill Resource Center). Samples were taken from either kitchen sinks at residential locations or at water fountains, as well as sinks at community centers.

Overall, our suspicions of elevated levels of lead in the Spring Hill community are luckily not supported by the data gathered. Further information will be collected in future years by other volunteers and interested Stetson chemistry students. The goal of this project was to establish a continued partnership with the Spring Hill Resource Center that will hopefully outlast this senior research project.

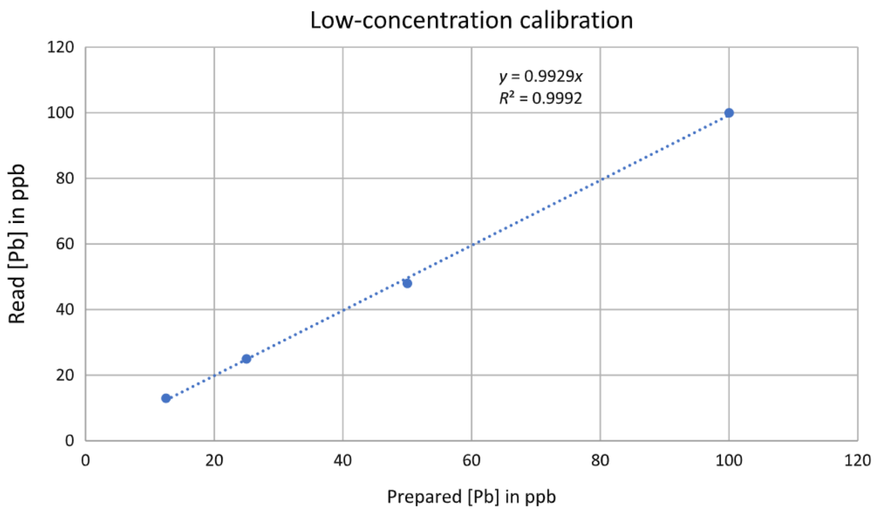

FIG. 3 Calibration curve for low concentrations of lead.

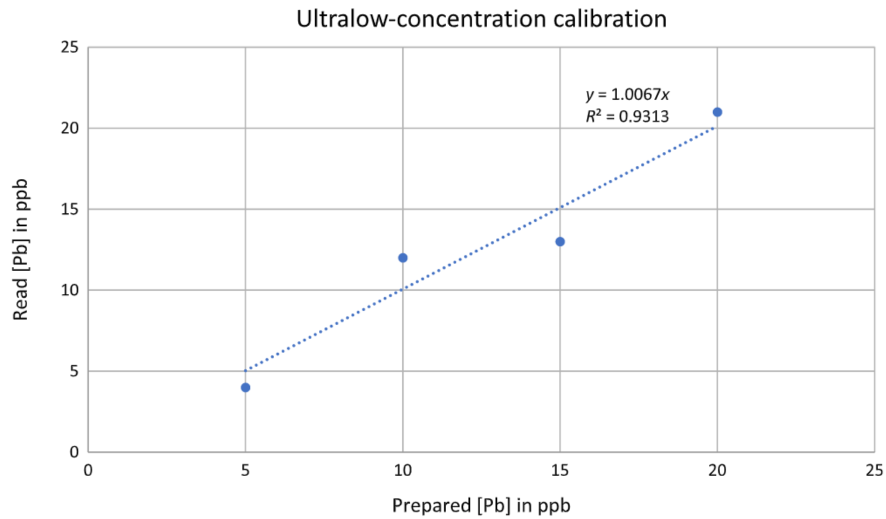

FIG. 4 Calibration curve for ultralow concentrations of lead.

Lead release is a community problem as much as it is a chemistry and policy problem. Working within a community is important to designing mitigation strategies. However, it is important to note that there was a relatively low involvement rate for the free water testing that was offered. This may very well be because citizens were being introduced to the program for the first time and were untrusting of the process or did not understand the need for it. Hopefully, with continued involvement and effort, the program will become more widely accepted in the community and will foster a relationship or partnership between Stetson and the Spring Hill community. This type of approach has found success in international development, such as the Himmotthan Society's E-WASH (Emergency Water and Sanitation-Hygiene) program (Water, Sanitation and Hygiene (WASH), n.d.). The combination of education as well as technological sampling and remediation implementation is a powerful tool for any community.

Part of what also empowers individuals and communities to demand participation in decisions that fundamentally affect their lives is the realization that power relationships within a decision-making structure are fluid and open to debate. Segmentation of housing markets, spatial mismatch of labor markets, and decentralization of metropolitan governance contribute to unequal access to economic opportunities, services, and the fragmentation of local control over land use and zoning in ways that affect community environmental health (Keister and Moller, 2000).

5 CONCLUSIONS

When analyzing and compiling possible policy recommendations, it is important to note that almost all previous literature and research point to the theory that poor communities—specifically those with a high concentration of minorities—are most at risk for occurrence of environmental injustice. The case study of Spring Hill was conducted to test this theory. However, our testing came up with negative test results. What does this tell us? The theory does not match the practice? Previous research

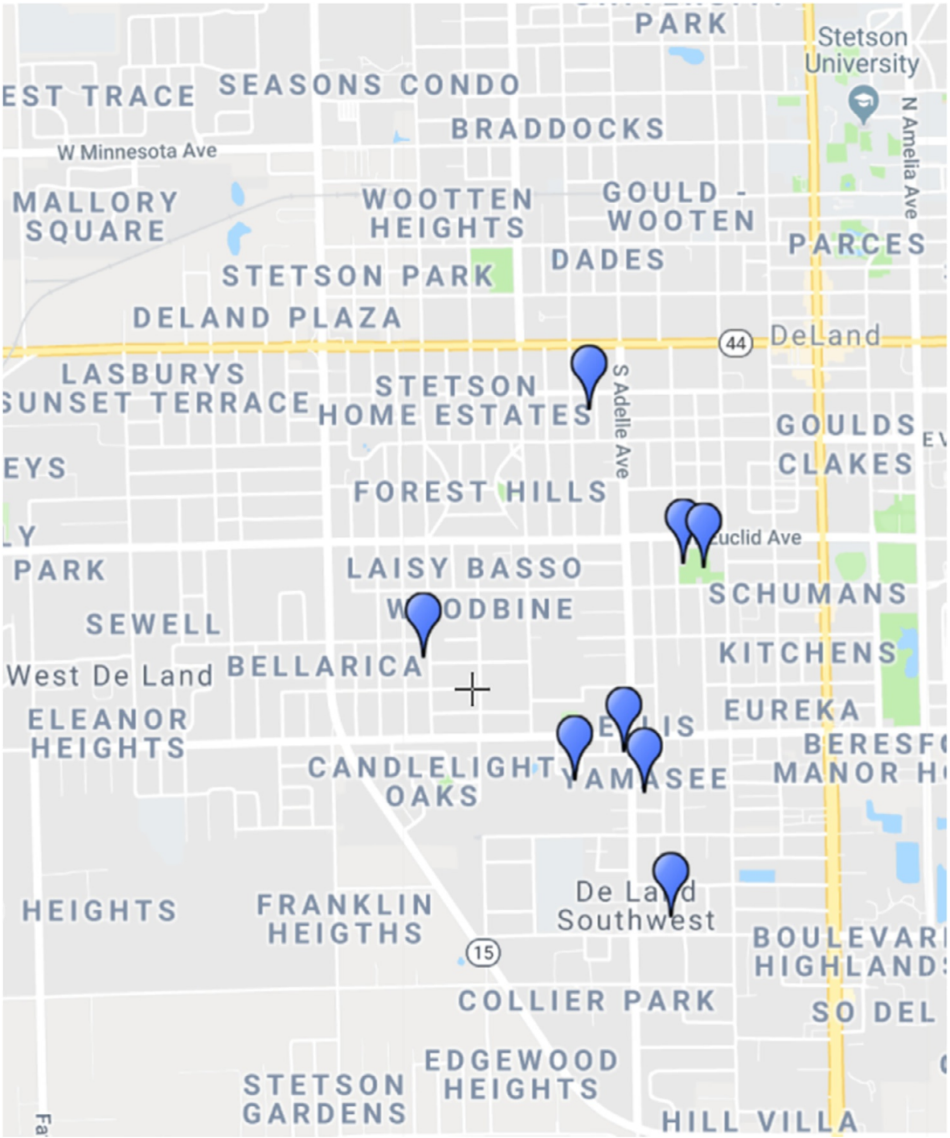

FIG. 5 Map of testing locations.

also pays most attention to major system failures, but not regulatory failures that occur on a local scale. Another consideration is that perhaps the threshold for required reporting lead levels (90% of consumer's water testing above 15 ppb) is too high. This threshold offers that a noticeably high level of lead can be present in drinking water before action must be taken. Shouldn't action be taken if there is any lead present? These unanswered questions lead us to offer the following policy recommendations:

(1) It would be advantageous if testing was conducted by a contracted private agency to the government. This would relieve the government of additional pressures while providing a third-party company the benefit of being unbiased.

(2) Lower the threshold for mandatory reporting on lead-level results. The current action level is a noticeably high amount of lead, allowing one-tenth of a population to be exposed to dangerous amounts. For the health and safety of citizens, this should be reconsidered.

(3) Continue with regulated testing more regularly. As prices for analytical methods fall and with the advent of affordable screening technologies, more thorough analysis in a community can be performed.

Throughout the course of our research and field-testing for this project, it became apparent that there are numerous stakeholders invested in this topic from numerous perspectives. Stakeholders are the backbone of a cause, and without it, action would be much more difficult, if not impossible, to achieve. Fortunately, now more than ever, we are seeing organizations and people come together to support the idea of providing safe, clean water to all people in our communities. Some front-runners for the cause are nonprofit organizations that make it their purpose and responsibility to connect communities with these resources. The Spring Hill Community Center, whom we partnered with on this project, provides the main representation for Spring Hill. Across the county, communities make requests to the Volusia County Council, which coordinates water distribution. Stetson University's Institute for Water and Environmental Resiliency is invested in the water quality of the community. In 2017, they hosted a panel regarding water quality in Volusia County. They hold an annual Water Summit, attended by elected officials from across the county. These meetings serve to increase dialogue on higher levels, which should result in further action being taken in underserved communities.

As citizens of our beloved planet, we should promote the idea: Everyone has a right to clean and safe drinking water. In 2010, the United Nations recognized "the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights" (General Assembly Resolution 64/292, n.d.). Comprehensive and sound water monitoring is essential to assure the quality of water delivered in our nation and across the world.

Acknowledgments

It was a pleasure to conduct this research to provide an example for other similar projects that can be conducted by volunteers worldwide for Chemists Without Borders. We would like to thank Dr. Ramee Indralingam and Kevin Winchell for support and direction with the community testing project, collaborating organizations (Spring Hill Resource Center, Center for Community Engagement and Bonner Program), and the Stetson Institute for Water and Environmental Resilience for financial support.

References

Abadin, H., Ashizawa, A., Stevens, Y.-W., Llados, F., Diamond, G., Sage, G., Citra, M., Quinones, A., Bosch, S.J., Swarts, S.G., 2007. Toxicological Profile for Lead, Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles. Agency for Toxic Substances and Disease Registry (US), Atlanta (GA).

Carey, E., Fernandez, G., Pollack, J., Schaefer, E., 2016. Public Health and Community Needs Assessment Report of Spring Hill Community 2015–2016.

Cole, L.W., 1992. Empowerment as the key to environmental protection: the need for environmental poverty law. Ecol. Law Q. 19, 619–683.

Environmental Protection Agency, 2007. Lead and Copper Rule.

General Assembly Resolution 64/292, The Human Right to Water and Sanitation, A/RES/64/292 (28 July 2010)

Gillmor, D., Doig, S.K., 1992. Segregation forever? Am. Demogr. 14, 48.

Grevatt, P., 2016. Clarification of Recommended Tap Sampling Procedures for Purposes of the Lead and Copper Rule (Memorandum). US EPA.

Industrial Test Systems, 2015. eXact LEADQuick Manual.

Keister, L.A., Moller, S., 2000. Wealth inequality in the United States. Annu. Rev. Sociol. 26, 63–81. https://doi.org/10.1146/annurev.soc.26.1.63.

Kirkwood, Julie. "Preventing the Next Flint" (AACC. Nov. 1, 2016).

Konoval, A., 2014. Certification of Notification of Lead and Copper Tap Sample Results. Florida DEP. Print.

Konoval, A., 2017. Interview With DeLand Chief Chemist.

National Toxicology Program (NTP), NPT Monograph on Health Effects of Low-Level Lead. Available online, http://ntp.niehs.nih.gov/ntp/ohat/lead/final/monographhealtheffectslowlevellead_newissn_508.pdf.

Ostanova, S.V., Chubarov, A.V., Drozdov, S.V., Patrushev, V.V., Tatarenko, A.A., 2002. Solubility of Lead Nitrate in Aqueous Solutions of Nitric Acid and Zinc Nitrate 2.

Shampine, W.J., 1975. Hardness of Water From the Upper Part of the Floridan Aquifer in Florida [Cartographic Material]/by William J. Shampine; Prepared by United States Geological Survey in Cooperation With the Bureau of Geology. Florida Department of Natural Resources.

Spring Hill Resource Center [WWW Document], n.d. https://www.deland.org/departments/spring-hill-resource-center (accessed 4.15.18).

U.S. Census Bureau Quick Facts: DeLand City, Florida [WWW Document], n.d. https://www.census.gov/quickfacts/fact/table/delandcityflorida/PST045216 (accessed 2.7.18).

United Church of Christ Commission for Racial Justice, 1987. Toxic Wastes and Race in the United States.

US EPA, 2013. Summary of Executive Order 12898—Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations [WWW Document]. US EPA. https://www.epa.gov/laws-regulations/summary-executive-order-12898-federal-actions-address-environmental-justice. [(Accessed February 2019)].

Water, Sanitation and Hygiene (WASH) [WWW Document], n.d.. Himmotthan. http://www.himmotthan.org/wash/whome.aspx (accessed 8.18.18).