**Field Hydrogeologic Study to Confirm Orchard Sources of Arsenic Contaminated Domestic Well Water**

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| **Title:** | Field Hydrogeologic Study to Confirm Orchard Sources of Arsenic Contaminated Domestic Well Water |
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| **Principal Investigators:** | Gary Robbins, Meredith Metcalf |

**Summary**

The purpose of this study was to further evaluate the correlation between historic orchards that were sprayed with lead arsenate and current bedrock groundwater arsenic contaminant conditions. Consistent with our previous work, the original sample location of the current study was Weston, Connecticut. We subsequently added additional data on water quality collected from the local sanitarian and additional well completion reports obtained from the Connecticut Department of Consumer Protection to our database to aid in evaluating flow conditions and site selection for sampling. However, field work was thwarted owing to difficulty obtaining permissions from homeowners to sample at Weston sites. The research area was then expanded to the Farmington River basin using a subset of shallow groundwater samples collected by the Helton lab at the University of Connecticut, as these sample locations were down gradient of historic orchards. The Helton lab samples were tested for arsenic and lead, but no contamination was found. Focus shifted back to the original research setting of Weston, Connecticut. After working with Weston Township officials and the Aspetuck Health District office for months, permission was granted to sample six township owned properties identified to be former orchards using 1934 and 1952 aerial imagery. From these locations, 66 soil samples were collected and laboratory tested for arsenic and lead. Analysis of these samples is ongoing. Additionally, members of the team initiated a door-to-door campaign to collect water samples for groundwater age dating from Weston residences down gradient of a former orchard that were identified to have wells with arsenic concentrations exceeding the drinking water standard. The samples were sent to the University of Nebraska Isotope Lab, and we are awaiting results. With these samples we hope to ascertain if there are elevated levels of arsenic and lead in former orchard soils, if arsenic is still leaching from these soils, and if the age of water is comparable to or younger than the era in which lead arsenate was spread on orchards.

**Introduction**

According to a study conducted by the United States Geological Survey (“USGS”), many townships in Connecticut experience elevated levels of arsenic contamination in the groundwater relative to other states in the contiguous United States (Flanagan et al. 2000). Arsenic poses a significant health concern as it is a potent carcinogen linked specifically to cancers of the liver, bladder, kidney, and skin (American Cancer Society 2023). Currently, the drinking water standard for arsenic is 10 parts per billion; however, arsenic testing of drinking water only became mandatory in Connecticut in 2021. This indicates the potential risk that residents may have unknowingly consumed elevated levels of arsenic over the long term. Arsenic, while a naturally occurring element, can also be released by agricultural and industrial processes. In the USGS study, they assumed that the elevated arsenic concentrations were caused by bedrock leaching of arsenic in the area; however, if the arsenic was from another source, questions arise as to who is liable for the contamination and is that source still leaching arsenic today? One suspected alternate origin of arsenic contamination is the legacy of lead arsenate applied on orchards up until the mid-1960s (Wolz). Used as a pesticide to deter gypsy moths from orchards, it was applied to various fruit trees at its peak, 2-3 times each year. Despite the risk it poses to public health, legacy lead arsenate contamination had not been considered a drinking water hazard in non-point source water sources because both constituents lead and arsenate ionize and readily bond to soils. However, under acidic conditions arsenic and other heavy metals are able to leach from the soil and percolate into the groundwater. The current average pH of rainwater in Connecticut is 5.6 and, while this is not acidic enough to mobilize lead, it is enough to cause arsenic to leach from the soils. To examine this potential leaching, a study focused within Eastern Connecticut was conducted by Mark Higgins, Gary Robbins, and Meredith Metcalf where they examined the relationship between arsenic contamination in drinking water wells and proximity to historic orchards (Higgins et al. 2021). They found that 67% of water wells sampled which had arsenic concentrations that exceeded 3μg/L were found within 250m of historic orchards, suggesting a relationship between proximity to orchards and groundwater arsenic contamination (Higgins et al. 2021). The authors looked to examine the same relationship in Weston, CT where they hypothesized that legacy pesticide contamination in former orchards is also the cause of the elevated arsenic concentrations observed in the township. The goal of this study is to examine if there is a correlation between bedrock geology, historic orchard soil arsenic concentrations, and arsenic contamination in domestic drinking water wells.

**Objective(s)**

* To ascertain the true source of arsenic contamination of the groundwater in Weston, Connecticut by comparing the various bedrock types, historic orchard soil arsenic concentrations, and domestic water well arsenic concentrations.
* If historic orchards are determined to be a source of contamination, to determine if they still contain leachable levels of arsenic posing harm to the local drinking water source.

**Results/Discussion**

The research team made numerous attempts to acquire permissions from private homeowners to sample at various sites throughout Weston via email, local government outreach, and door-to-door canvassing and was largely unsuccessful. Given the foregoing, the research team considered abandoning testing in Weston and conducting the study in a different location. A viability study was run in Farmington, CT using 75 samples selected from the Helton Lab at the University of Connecticut. These samples were collected from the main stretch of the Farmington River basin based on their location downgradient of a historic orchard. A sample was determined to be downgradient of a historic orchard using ArcMap and tracing flow lines generated by modpath flow modeling to see if a flowline which intersected a historic orchard also intersected a sample. Historic orchards were defined as a property which contained organized rows of trees and were identified using georeferenced aerial images from 1951 and a 1934 base map from the University of Connecticut Library. A control group of 25 samples not downgradient of orchards were also added. The 100 mapped samples selected were compared to the actual samples in storage and the dataset was reduced to 72 samples which were available for testing, 48 downgradient of orchards and 24 not downgradient of orchards. Some, but not all, of the samples were filtered to remove sediment, but samples were selected regardless of filtration. The samples were then sent to CESE to be tested for arsenic using EPA method 6020A. Of the 72 samples tested only ten exceeded the detection limit and, thus, further study in Farmington was abandoned.

Research focus shifted back to the Town of Weston, concentrating on the public vs. the private sector. After months of back and forth communication between the local health district office, the Selectwoman for the Town of Weston, and Weston Township offices, the research team was able to obtain permission to conduct soil sampling on six township owned parcels. Of those six sites, samples were only able to be collected from four as two of them had experienced significant levels of disturbance not present on the satellite imagery (i.e., parking lot construction). The remaining four sites, while not actively under construction, showed signs of the presence of outside fill. Initial results across all sites sampled, indicated no arsenic concentrations significantly higher than the background concentration; however, analysis of the data collected from these sites is still ongoing.

 Additionally, samples were collected from three private Weston water wells that were identified as having arsenic levels in excess of the drinking water standard of 10 parts per billon and were also downgradient of historic orchards for age dating, in order to determine the age of the groundwater relative to the time period which lead arsenate was used as a pesticide (i.e., 60-130 years ago). These samples were sent to the University of Nebraska Isotope Lab, and we are awaiting results. Six additional samples were budgeted but, given weather conditions, these samples cannot be collected until spring.

**Conclusions**

 Due to difficulties obtaining permissions to sample, there are no significant findings to present at this time. However, a Masters thesis by Alexander Drift is being developed and should be available in mid-April 2024. The research team would like to proceed in collecting the remaining six age dating samples this coming spring to be sent to the University of Nebraska Isotope Lab for testing. If further funding for this project is secured, the method for securing permissions to sample at former orchard sites would be modified to be more enticing to homeowners and additional shallow soil cores would be collected from these former orchard locations to screen for arsenic.

**Field Equipment** **Expense Report**

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| **Item** | **Model** | **Cost** |
| 48 Sample Bottles  | 250 and 500mL  | $267.50 |
| 6 Soil Probes | AMS 33” | $316.98 |
| Soil Probe Drive Handle | AMS Drive  | $215.08 |
| 12 Plastic Syringes  | Thermo Scientific Polypropylene Syringes  | $52.42 |
| 27 Mason Jars  | Ball 16oz Mason Jars  | $63.22 |
| 27’ Pipe | Galvanized ½” Pipe | 256.66 |
| Plywood  | ½” Plywood | $30.15 |
| Zip Lock Bags  | Zip Lock Bags, Sandwich and Gallon | $32.31 |
| Paper towels  | Bounty 8-pack | $23.20 |
| Colored Sand | Imagitarium Blue and White Aquatic Sand | $22.66 |
| Portable Xray Fluorescence (pXRF) | Eastern Connecticut State University | $3,000 |
| Center For Environmental Science and Engineering (CESE) Laboratory  | Water Testing- 72 samples (Farmington) | $1,964.94 |
| Center For Environmental Science and Engineering (CESE) Laboratory | Soil Leach testing- 66 samples (Weston) | $2,626.80 |
|  | Total: | $8,871.92 |

**Acknowledgements**

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