CASE STUDY: ARSENIC, MANGANESE, AND IRON REMOVAL FROM GROUNDWATER SOURCES IN NEWMARKET, NH

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Arsenic (As), iron (Fe), and manganese (Mn) are some of the most abundant elements found in our earth's crust. These elements are typically found in mineral deposits, which can dissolve and enter groundwater supplies. Industrial byproducts can be another source of arsenic and manganese contamination. The presence of these contaminants in a drinking water system can cause aesthetic problems and potentially impact the health of your customers depending on concentration and duration of exposure.

Arsenic is one of the World Health Organization's (WHO) 10 chemicals of major public health concern. Long term exposure to arsenic from ingestion can cause health problems such as skin lesions and an increased risk of developing certain types of cancer (1). Exposure to elevated levels of manganese can potentially cause nervous system damage. Early childhood exposure to arsenic or manganese in drinking water has been linked to negative impacts on cognitive development in children (1,2). Iron in drinking water is generally considered to be only an aesthetic contaminant for most customers.

2018 Drinking Water Maximum Contaminant Levels (MCL) (mg/L)

Agency	As	Mn	Fe	Fe+Mn
NYSDOH	0.01	0.3	0.3	0.5
NHDES	0.01	0.3*	0.3**	N/A
EPA	0.01	0.3*	0.3**	N/A

* Health Advisory, ** SMCL

For many years, the Town of Newmarket, NH (Newmarket) supplied over 3,500 services using two gravel pack wells which required minimal treatment for disinfection and corrosion control.

Per New Hampshire Department of Environmental Services' (NHDES) source water capacity requirements, regulation ENV-DW-404, a large community water system's total developed groundwater source capacity shall equal or exceed the design maximum day demand and equal or exceed the average day demand with the largest producing well out of service.

Due to an expanding population, extended periods of drought, and inability to meet source capacity requirements, Newmarket sought additional water sources.

In 2016, they developed the "MacIntosh" well and identified the future site of the "Tucker" well. The sites both have similar water quality, but the MacIntosh well was selected for development first. While elevated levels of sodium (~130 mg/L), chloride (~130 mg/L), iron (~0.3 mg/L), and manganese (~0.04 mg/L) were present in the MacIntosh Well, arsenic (0.01 mg/L) was the contaminant of primary concern.

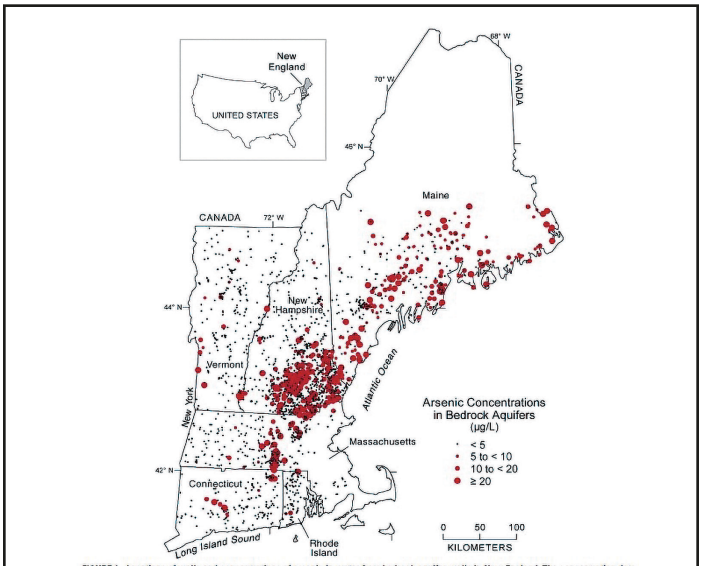

FIGURE 1. Locations of wells and concentrations of arsenic in water from bedrock aquifer wells in New England. The concentration data are shown with circles sized by concentration ranges. Number of samples = 2470.

As, Mn, and Fe are commonly found at elevated levels in the groundwater of southern New Hampshire. (3)

After consideration of available treatment technologies, a facility was constructed in 2017 to allow water from the two gravel-packed well sources to be blended with the MacIntosh well water to meet regulatory and aesthetic water quality standards.

Existing blending facility in Newmarket, New Hampshire

Problems with long term feasibility of the blending facility operation began to surface shortly after start-up. Due to the volume of water required for the blend, and its dependence on the

existing wells, violation of the source water capacity requirements continued. With increased pumping, groundwater arsenic concentrations began to increase above the 0.01 mg/L MCL, while sodium and chloride levels decreased. In 2019, legislation was passed lowering the NH MCL for arsenic to 0.005 mg/L, which will go into effect in July 2021. Therefore, treatment for arsenic removal would be needed for sustainable, long term operation of the new well sources.

Typical treatment methods for arsenic in drinking water are blending, adsorption, ion exchange, oxidation and filtration, or coagulation and filtration. After a preliminary evaluation, Newmarket selected iron-arsenic coprecipitation followed by manganese dioxide coated media filtration as the preferred treatment method. Coprecipitation of iron and arsenic is a treatment method by which arsenic is coagulated with an iron salt to form precipitate which can be filtered out of solution. A high ratio of iron to arsenic and a pH between 5-7 is typically required. The decision was driven by the lower estimated operating costs compared to other methods.

Wright-Pierce was competitively selected to manage a pilot system for the new treatment, design of the new facility, coordination with regulatory agencies, and assistance with procuring funding for the project.

Newmarket's treatment process starts with pH adjustment and the addition of sodium hypochlorite for the oxidation of arsenic and manganese to the correct species for removal. Ferric sulfate is added to increase the iron to arsenic ratio (57:1 based on piloting) since the raw water's dissolved iron concentration was found to be variable and too low for coprecipitation. The iron-arsenic floc and oxidized manganese is then removed from the water by pressure filtration using GreensandPlus™ media. Prior to entering distribution, filtered water pH is adjusted, chlorine residual is increased, and a polyphosphate corrosion inhibitor is added. Waste product from filter backwash and analyzers is stored on-site and periodically discharged to Newmarket's wastewater treatment plant.

The 0.83 MGD treatment facility will be constructed on the site of the existing blending facility. Design challenges included:

- Incorporating the existing blending facility
- Treating two well sources together
- Use of a 1.2 acre sloping site with significant ledge
- Value engineering to stay within budget constraints

A difficult site for expansion in Newmarket, New Hampshire

With Wright-Pierce's assistance, Newmarket was able to secure over $5.7 million in loans and grants for the project through the New Hampshire Drinking Water Groundwater Trust Fund. Installation of a third pressure filter, well station improvements, and a dissolved iron sampler were bid as alternates for cost control purposes.

The project is anticipated to start construction in summer 2020 and be completed by fall 2021.

Other water treatment facilities recently designed by Wright-Pierce include Topsfield, MA (Fe and Mn removal, 2019), Dedham, MA (Fe and Mn removal, 2020), and South Berwick, ME (As removal, 2018).

Iron and manganese treatment facility in Topsfield, Massachusetts

Wright-Pierce, doing business in NY as Wright-Pierce Engineering Consultants, is an award winning, multidisciplinary engineering firm that has been providing water, wastewater, and civil infrastructure services since 1947. The firm provides complete engineering services from initial planning through design, bidding, and construction administration.

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References:

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