ARSENIC TREATMENT PERFORMANCE IN NEW HAMPSHIRE

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Three years from the effective date (January 2006) of the new arsenic drinking water standard of 10 ppb, about 94% of the 205 water systems impacted by this standard in New Hampshire have achieved compliance. The remaining 12 systems (6%) still serving water above 10 ppb are well on their way to addressing this contaminant, but either are implementing long-term, major source water and infrastructure upgrades (3%), or are still optimizing new treatment operations (3%). All are under enforcement agreements with NHDES, as the state employs both technical assistance and enforcement to achieve compliance with the drinking water standards. New Hampshire has not issued any exemptions or variances to the Arsenic Rule, though federal requirements allow for an exemption of up to 9 years for very small systems with arsenic levels below 35 ppb.

About ¼ of the impacted systems installed new shallow replacement or blending wells to meet the new standard. However, the majority (74%) installed treatment (Figure 1).

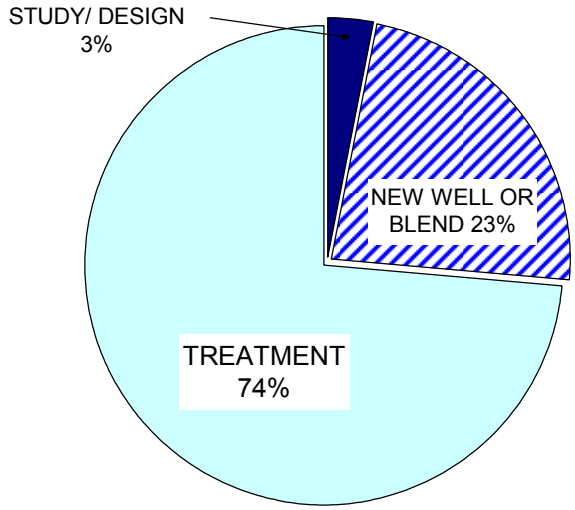
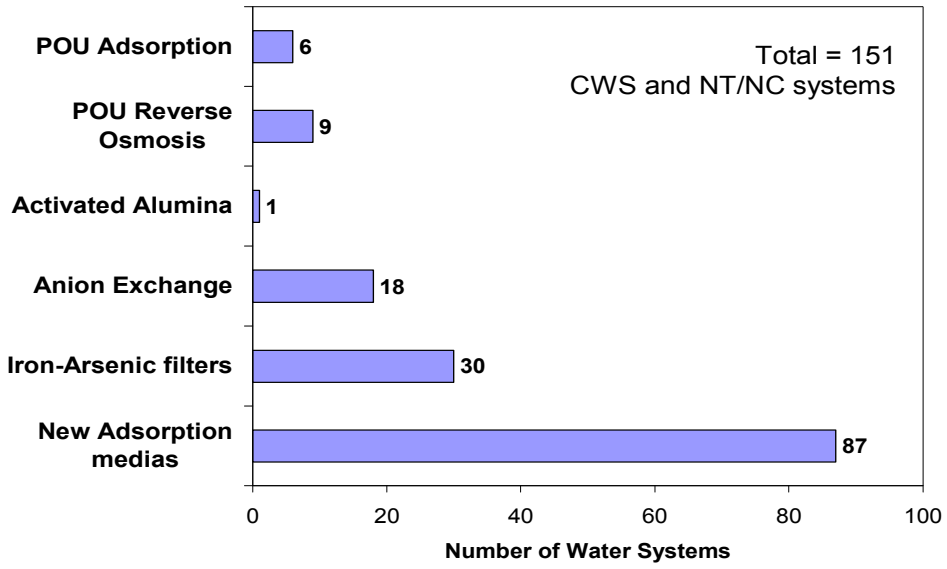


Figure 1 - NH Arsenic Compliance Strategies (April 2009)

This article examines the performance of the three most common arsenic treatment technologies currently in use by NH small water systems. They are: adsorption, oxidation-filtration, and anion exchange (Figure 2). Arsenic exists primarily as inorganic species in groundwater, either as As-V (Arsenate) or As-III (Arsenite). At ambient groundwater pH (typically 6 to 9), the As-III species H_2AsO_3 is *uncharged*, and thus poorly removed by all treatment technologies. Conditions for As-III presence include reduced redox or low dissolved oxygen, often co-occurring with hydrogen sulfide and ferrous ion. On the other hand, the oxidized As-V species ($H_2AsO_4^-$ and $H_2AsO_4^{2-}$) are *negatively charged*, and thus are much more efficiently removed by treatment. Testing must be used to establish the ratio of As-III to V in your well water. Establishing the raw water conditions up front is important to ensure that treatment is designed to capture both species.

Figure 2
NH Arsenic Treatment Technologies (April 2009)



A. ADSORPTION TREATMENT

Iron and other metal-based sorbents have flourished in the wake of the Arsenic Rule, based on their simplicity of operation and maintenance, especially for very small water systems. About 87 systems in NH have installed some type of adsorptive media to date (Figure 2). Common tradenames installed in NH are iron-based sorbents Adedge E-33, Resintech ASM-HP-10, Siemens GFH, and SolmeteX ArsenXnp. Others include Dow Adsorbsia (titanium) and Isolux (zirconium) metal oxides.

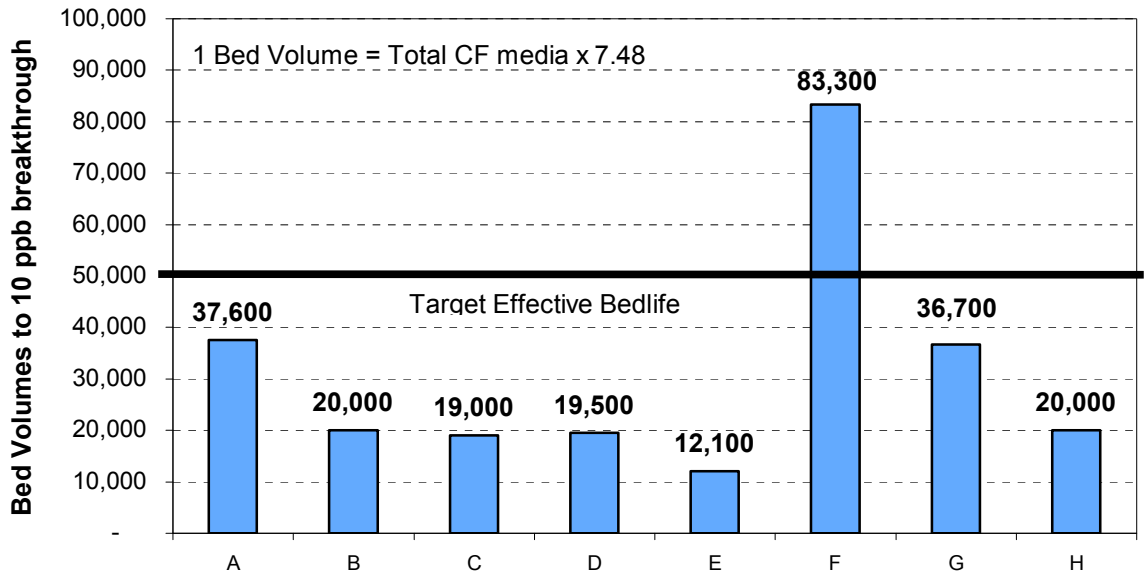
The main operating burden of adsorption treatment is the ongoing costs of media replacement each time it becomes exhausted. EPA's Arsenic Demonstration Program (www.epa.gov/ORD/NRMRL/wswrd/dw/arsenic), has shown that useful bedlife for arsenic adsorptive media of around 50,000 bed volumes (BV) is effective performance. In practice, any change-out more frequent than annual is not sustainable. Bedlife performance of different media in NH have ranged from 6,000 to over 80,000 bed volumes, and more typically around 20,000 BV (Table 1 and Figure 3). Adsorptive media bedlife is impacted most significantly by high water pH (>7.5), silica (>20 mg/L), and phosphate (>0.1 mg/L as P). Furthermore, bedlife for As-III is typically ⅓ to ¼ of the performance compared to when arsenic is present as As-V.

Table 1 – Arsenic Media Bedlife to 10 ppb Breakthrough

Water System	Bed Volumes to 10 ppb Breakthrough*	Typical Raw Water Characteristics		
		Total As, ppb	pH, su	Other
A	37,600	20	8	Iron pre-filters
B	20,000	60	8	
C	19,000	35	8.3	11 ppb As-III
D	19,500	65	7.7	
E	12,100	13	8	Iron modified Alumina
F	83,300	11	7.2	--
G	36,700	29	7.1	26 mg/L Silica
H	20,000	38	7.9	0.12 mg/L Mn

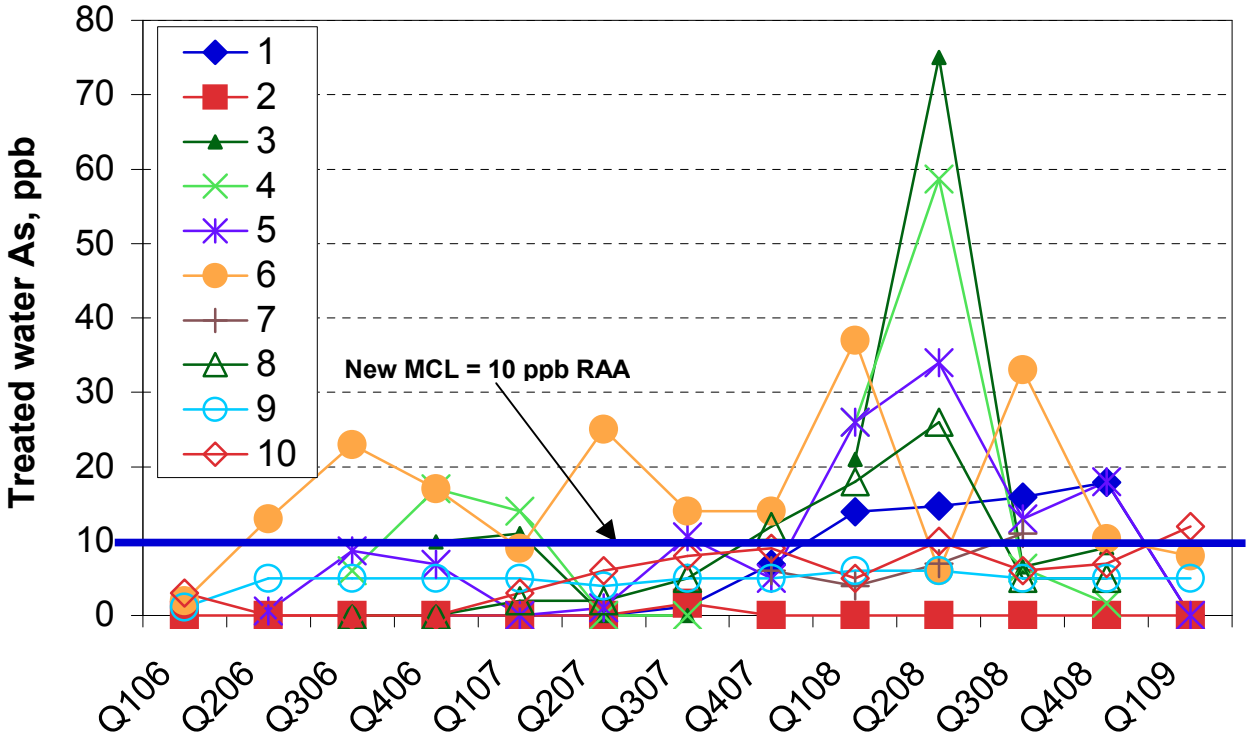
* Estimated by NHDES based on approximate daily water demands for the water system.
Bed Volume = total volume of installed adsorptive media (CF) x 7.48 gal/CF

Figure 3 - Adsorptive Media Bed Volumes to 10 ppb Breakthrough



Aside from its relative simplicity of operation, another benefit of adsorption treatment is its gradual breakthrough, allowing systems some flexibility in scheduling filter changeout without incurring water quality violations. However, some NH systems have been struggling to keep up with this maintenance either due to poor financial planning, or shorter than expected media performance, or both. Examples of adsorption treatment compliance in NH are shown in Figure 4, with levels often bouncing above the 10 ppb standard.

Figure 4 – Adsorption Treatment Examples



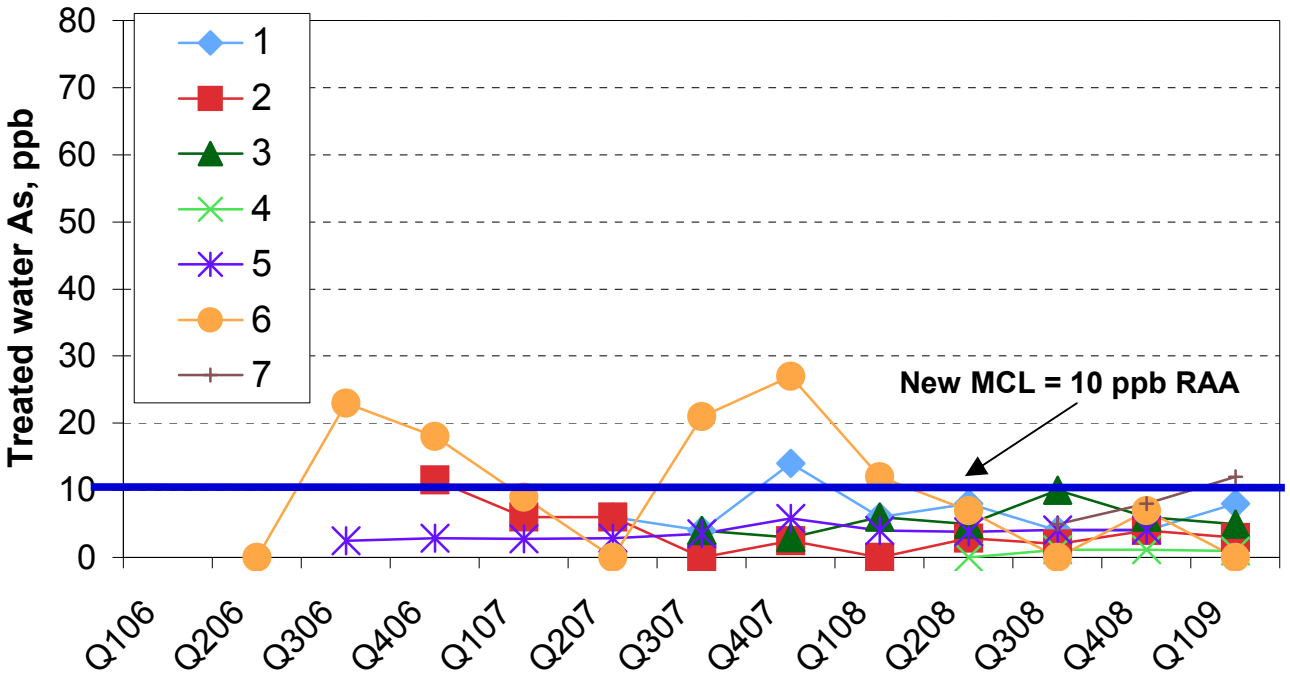
Special operating requirements for this technology are:

- Proactive planning and budgeting for capital intensive filter media changeouts.
- Pre-oxidation of As-III, if present.
- Treatment evaluation sampling to establish lead/lag filter loadings and changeout scheduling prior to incurring water quality violations.
- Management of bed 'fluffing' backwash by filtration prior to discharge. Systems with backwash recycle / no onsite discharge avoid a Groundwater Discharge Permit.
- Testing and disposal of spent arsenic media in accordance with state and federal requirements, including a Toxicity Characteristic Leaching Procedure test, and regulated transport and disposal at a permitted landfill for this special waste.

B. OXIDATION / FILTRATION

Iron oxides (i.e., rust) are a natural magnet for arsenic. Iron-arsenic removals are best accomplished when both contaminants are oxidized simultaneously, such as with the addition of a strong oxidant such as chlorine or potassium permanganate. Highest removals are obtained with Fe:As ratios of 20:1 (by weight), and water pH ≤7.5 (www.epa.gov/ORD/NRMRL/wswrd/dw/arsenic). About 30 NH water systems (Figure 2) are currently operating iron-arsenic filters, some inadvertently, to accomplish iron-arsenic removals. With the exception of one or two systems (Figure 5, system #6), treatment performance with this technology has been relatively more consistent than comparable adsorption treatment operations with respect to maintaining compliance with the 10 ppb standard.

Figure 5 – Iron-Arsenic Oxidation Filtration



Special operating requirements for this technology are:

- Maintenance of proper pre-oxidation chemical feed and residual concentration.
- Adequate backwash rate and bed expansion (10 to 22 gpm/SF depending on the density of the filtration media).

- Management of iron-arsenic backwash either by filtration or settling prior to discharge, or discharge to sanitary sewer or community septic system. Systems with backwash recycle / no onsite discharge avoid a Groundwater Discharge Permit.
- Testing and disposal of dewatered Fe-As backwash solids in accordance with state and federal requirements, including a Toxicity Characteristic Leaching Procedure test, and regulated transport and disposal at a permitted landfill for this special waste.

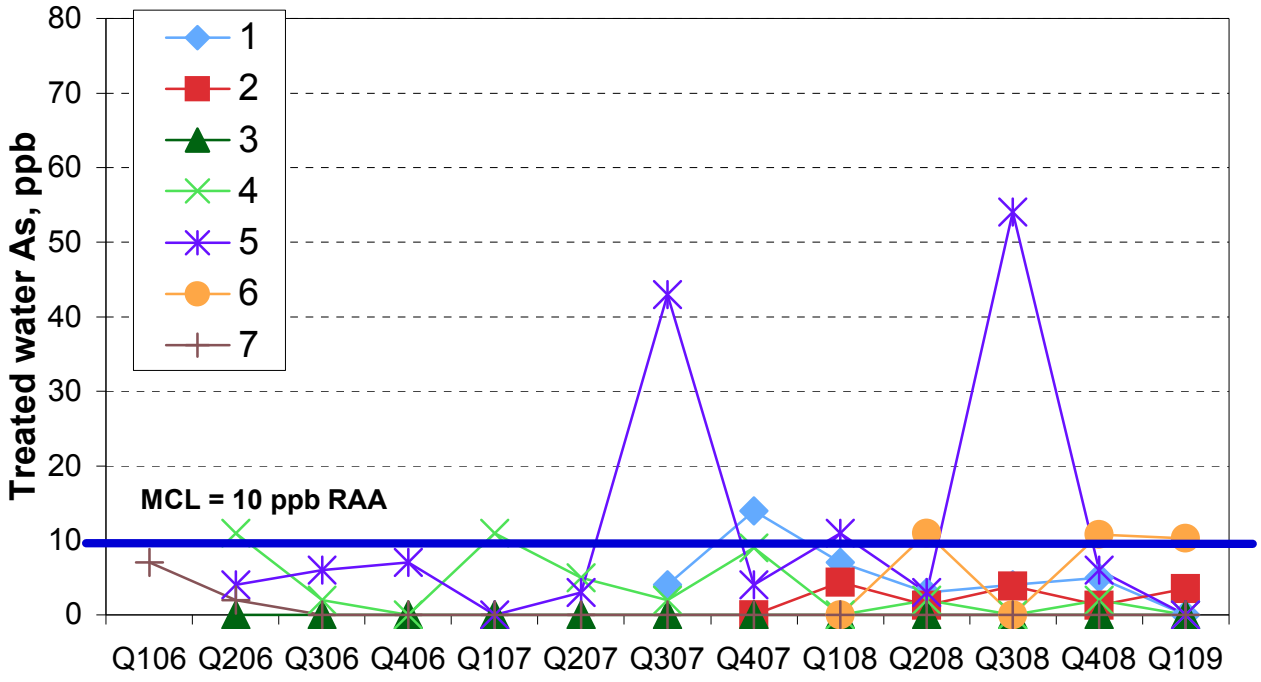
C. ANION EXCHANGE

Ion exchange alkylyzers (for anion removal) perform very efficiently for arsenic removal within the full range of ambient water pH of 6 to 9. Arsenic must be present as, or converted to As-V valence prior to anion exchange, since the As-III species is uncharged at ambient pH conditions.

Thus far, 18 anion exchange systems are operating in NH for arsenic removal. One system (#5) experienced 'bridging' of the salt tank resulting in improper regeneration and arsenic dumping as shown in Figure 6.

Special operating requirements for this technology are:
- Pre-oxidation of As-III, if present.
- Managing post-alkalinity and pH to avoid corrosion control problems.
- Design of regeneration cycle based on sulfate loading.
- Maintenance of brine tank to avoid arsenic dumping.
- Brine regenerant discharge to sanitary sewer or community septic system only.

Figure 6 – Ion Exchange Treatment Examples



SUMMARY

The majority (74%) of NH water systems impacted by the change in arsenic standard have installed treatment. Of these, the most common technologies applied are adsorption, oxidation/filtration, and anion exchange. A comparison of operations history for these 3 technologies shows that all require close operator and owner oversight to avoid serving water above the 10 ppb standard.

DES' Drinking Water and Groundwater Bureau provides ongoing technical assistance to improve small system compliance rates via its Small Systems Help Center (www.des.nh.gov, A to Z topics), as well as year-round operator outreach and education seminars. Questions regarding arsenic treatment and compliance in NH may be obtained by contacting the author at (603) 271-3108 and Cynthia.Klevens@des.nh.gov.