TREATING ARSENIC or PFAS IN SMALL PUBLIC WATER SYSTEMS

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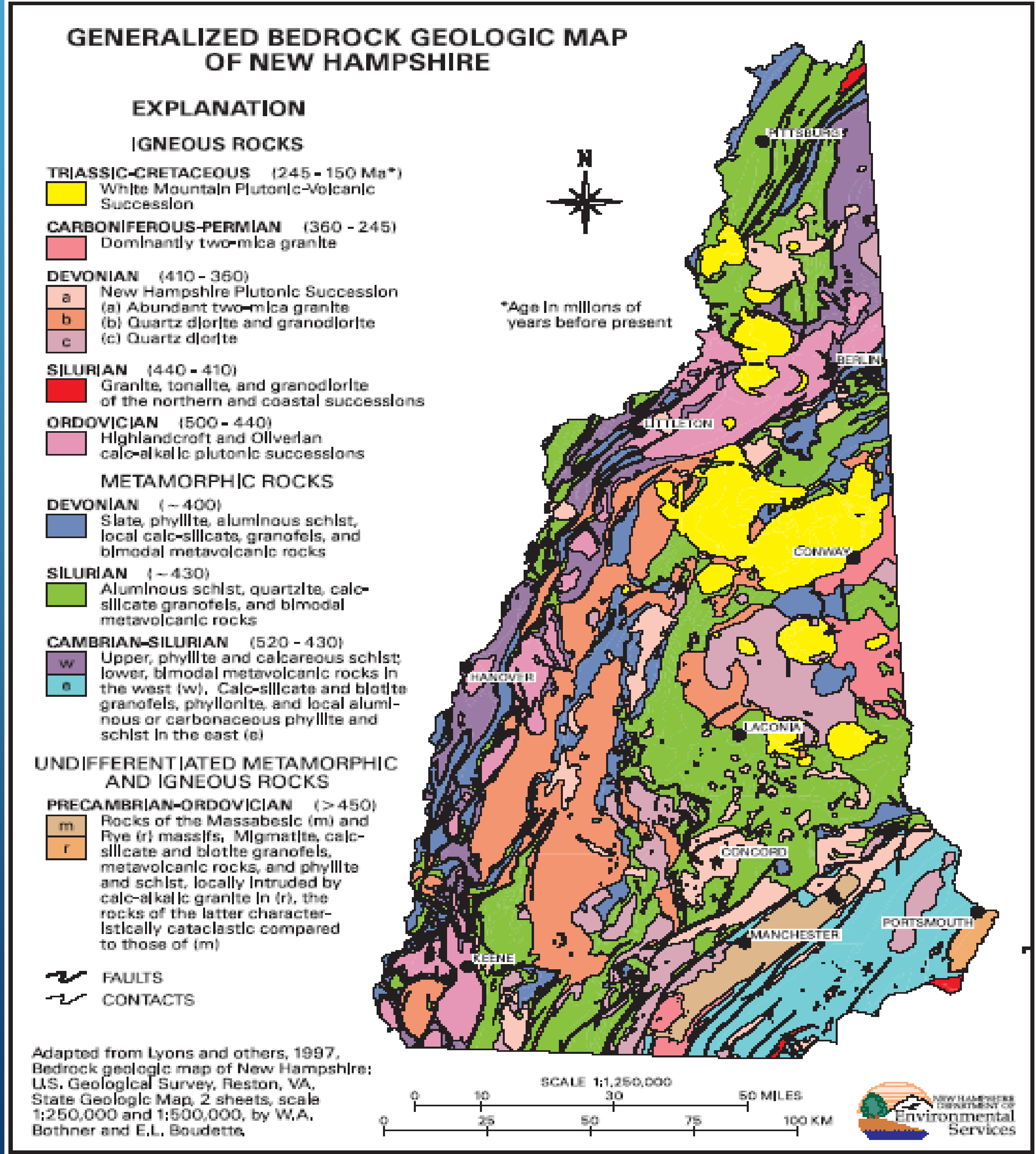
OUTLINE

The basics but not the chemistry

Choosing the “Best” Technology

Treatment Technologies

NH Geology


GENERALIZED BEDROCK GEOLOGIC MAP OF NEW HAMPSHIRE
EXPLANATION
IGNEOUS ROCKS
TRIASSIC-CRETACEOUS (245 - 150 Ma*)
White Mountain Plutonic-Volcanic Succession
CARBONIFEROUS-PERMIAN (360 - 245)
Dominantly two-mica granite
DEVONIAN (410 - 360)
New Hampshire Plutonic Succession
(a) Abundant two-mica granite
(b) Quartz diorite and granodiorite
(c) Quartz diorite
a
b
c
SILURIAN (440 - 410)
Granite, tonalite, and granodiorite of the northern and coastal successions
ORDOVICIAN (500 - 440)
Highlandcroft and Oliverian calc-alkalic plutonic successions
METAMORPHIC ROCKS
DEVONIAN (~400)
Slate, phyllite, aluminous schist, local calc-silicate, granofels, and bimodal metavolcanic rocks
SILURIAN (~430)
Aluminous schist, quartzite, calc-silicate granofels, and bimodal metavolcanic rocks
CAMBRIAN-SILURIAN (520 - 430)
w
e
Upper, phyllite and calcareous schist; lower, bimodal metavolcanic rocks in the west (w). Calc-silicate and biotite granofels, phyllonite, and local aluminous or carbonaceous phyllite and schist in the east (e)
UNDIFFERENTIATED METAMORPHIC AND IGNEOUS ROCKS
PRECAMBRIAN-ORDOVICIAN (>450)
m
r
Rocks of the Massabesic (m) and Rye (r) massifs. Migmatite, calc-silicate and biotite granofels, metavolcanic rocks, and phyllite and schist, locally intruded by calc-alkalic granite in (r), the rocks of the latter characteristically cataclastic compared to those of (m)
FAULTS
CONTACTS
N
*Age in millions of years before present
PITTSBURG
BERLIN
LITTLETON
CONWAY
HANOVER
LACONIA
CONCORD
PORTSMOUTH
MANCHESTER
KEENE
Adapted from Lyons and others, 1997, Bedrock geologic map of New Hampshire: U.S. Geological Survey, Reston, VA, State Geologic Map, 2 sheets, scale 1:250,000 and 1:500,000, by W.A. Bothner and E.L. Boudette.
SCALE 1:1,250,000
0
10
30
50 MILES
0
25
50
75
100 KM
NEW HAMPSHIRE DEPARTMENT OF Environmental Services

THE BASICS

ARSENIC:

- National MCL is 10 ppb
- NH MCL is 5 ppb effective 7/1/21
- Negatively charged with a valence of 3 or 5
- Estimated in 20% of NH bedrock wells over 10 ppb
- Estimated in 30% of NH bedrock wells over 5 ppb

THE BASICS

PFAS, PFOA, and the list goes on:

- No National MCL
- Measured in PPT (parts per trillion)
- NH MCLs: PFOA-12, PFOS-15, PFNA-11, PFHxS-18
- Complex man made chemical chain
- It is everywhere!
- Very difficult to treat

A PRACTICAL GUIDE TO CHOOSING THE "BEST" TREATMENT

1. How much space do you have? It doesn't matter how good it is if it doesn't fit!
2. How much time do you have to monitor it. If the best system needs to be checked every day, that just might not be practical. Be realistic.
3. Is the system complex with many components or simple with few moving parts? Is it in a room that gets checked routinely or "out of sight out of mind"?
4. Lower capital cost usually means higher operating cost. Consider both. Which is easier to manage, one large initial cost or repeated smaller ongoing costs?
5. Sometimes cheaper is just plain cheap. Evaluate value, not price. What do you give up for a lower price and what do you gain by spending more?

ARSENIC REMOVAL TECHNOLOGIES

- Anion Exchange for arsenate (AS V)
  - Impact from sulfates and hardness
  - Ability to dispose of backwash
  - Prevention of corrosion
- Adsorption
  - pH, silica, phosphates, valence
  - Disposal of exhausted media “special waste”
- Co-precipitation / filtration
  - Oxidation
  - How much iron is enough iron
  - pH
  - Ability to dispose of backwash
- RO
  - POU (Point of Use)
  - Ability to dispose of effluent

Arsenic III and Arsenic V
Speciating Arsenic

- Essential to speciate arsenic
- How much AS III and AS V
- Some technologies will not remove AS III
- Best done in the field. Many labs will speciate if within an hour of taking the sample

ANION EXCHANGE

- Removes negatively charged particles from water.
- Most commonly used for arsenic and uranium removal
- Anion Exchange for arsenate (only AS V)
  - Interference from hardness
  - Capacity consumption from sulfates
  - Ability to dispose of backwash
  - Prevention of corrosion


KINETICO
CP Series
INSPECTORS TEST

Solar salt brine tank

ADSORPTION

- Media designed to attract and retain arsenic
- Capacity impacted by pH, silica, phosphates, valence
    - Lose significant capacity as pH approaches 8
- Removes AS III and AS V, but much more capacity for V
- Resin based and metal oxide based options
- Disposal of exhausted media “special waste” – cannot throw it in the trash
- POE (Point of Entry) or POU (Point of Use)

Metsorb: Titanium oxide

MetSorb™ Application

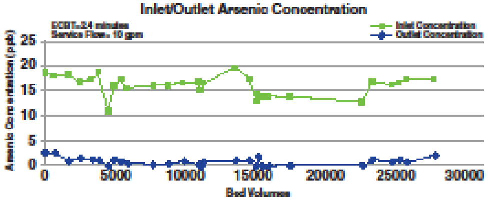
MetSorb adsorbent media is applicable in a wide range of water treatment processes, from large-scale municipal systems to small-scale residential treatment units. Regardless of the system size, there are operational design parameters that must be considered to ensure effective, trouble-free performance of the MetSorb adsorbent media.

Groundwater or surface water is simply pumped in a down-flow mode through a single or multiple fixed bed pressure vessel containing the MetSorb media. The multiple pressure vessel design is either assembled in Parallel Flow or Series Flow when additional adsorption protection is deemed necessary. Flow to each vessel is measured and totalized to record the volume of water treated. Pressure differential through each vessel is also monitored. Periodic back-washing is typically performed at start-up and every 8-10 weeks thereafter depending on usage and water quality.

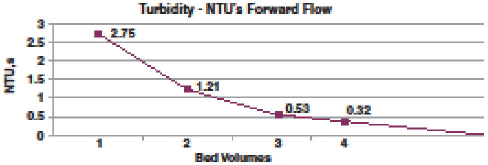
Dual vessels containing MetSorb plumbed in series for added consumer protection

Operational Design Parameters

Service Flow Rate	8-10 gpm/ft²
Flow Direction	Downward Flow
EBCT	1.5-3 Minutes
Typical Pressure Drop	< 5 psi
Backwash Flow Rate	8-10 gpm/ft²
Backwash Volume	5-7 Bed Volumes
Typical Freeboard	35 - 40%
Minimum Bed Depth	2 Feet
Maximum Feed Temperatue	150°F



Example of arsenic removal from drinking water supply well



Stability of MetSorb allows fast cleanup after backwash, placing in service flow promptly

MetSorb Disposal

MetSorb is operational in numerous locations across the US and Canada providing much experience in managing the exhausted media. Arsenic (or "heavy metal") laden MetSorb HMRG 16/60 has been evaluated using both the EPA TCLP (CFR 40-RCRA Regs.) and California WET methods and has been found to be nonhazardous and safe for landfill disposal. Since each application differs, however, we recommend exhausted MetSorb HMRG 16/60 be evaluated following all federal, state, and local regulations regarding necessary approvals for landfill disposal.

NOTES:

- Graver recommends treatment system monitoring to determine media breakthrough and changeout.
- Pre-filtration for particulates can greatly reduce frequency of backwash.
- High levels of iron and magnesium can influence efficiency of MetSorb adsorption.
- EBCT of 3 minutes is recommended for challenging water qualities.
- Backwash water discharged to sewer or POTW. Direct discharge according to state and local regulations.

Concept of lead-lag
Rebed, change order of tanks

Oxidation and Activated Alumina

COPRECIPITATION

Remove arsenic with iron

- Co-precipitation / filtration
  - Oxidize iron and arsenic to form solid particle
  - How much iron is enough iron
    - Typically at least 20 iron to 1 arsenic
    - Arsenic of .030 mg/L (30 ppb) requires .6 mg/L (ppm) iron
    - May need to add iron with chem feed
  - Ideal pH 7 to 7.8
  - Media is heavy, requires a lot of water to backwash
  - Ability to dispose of backwash with ferric iron and arsenic

Clack MTM® is used for reducing iron, manganese and hydrogen sulfide from water supplies.

MTM®

Clack MTM® is a granular manganese dioxide filtering media used for reducing iron, manganese and hydrogen sulfide from drinking water. Its active surface coating oxidizes and precipitates soluble iron and manganese. Hydrogen sulfide is oxidized to sulfur. The precipitates are filtered out in the granular bed and removed by backwashing.

MTM® consists of a light weight granular core with a coating of manganese dioxide. MTM® is an example of contact oxidation where the media itself provides the oxidizing potential. This allows for a much broader range of operation than many other iron removal medias. A pH level as low as 6.2 can be treated. Dissolved oxygen is not essential. The media's light weight reduces backwash water requirements.

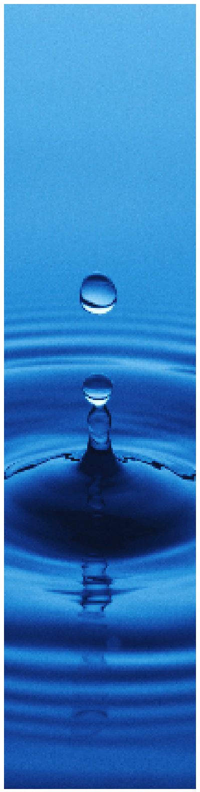
MTM® requires either continuous or intermittent regeneration to maintain its oxidizing capacity. For continuous regeneration a solution of potassium permanganate (or chlorine then potassium permanganate) can be pre-fed to maintain capacity. In the latter case, the manganese dioxide coating acts as a catalyst to enhance the oxidation reaction and as a buffer to reduce any excess potassium permanganate concentration and prevent it from entering the service lines. Continous feed regeneration using Cl_2, $KMnO_4$ or both is required for all systems that are larger than 3 cubic feet.

For intermittent regeneration use of a regenerating solution of 1½ to 2 ounces (dry weight) of potassium permanganate per cubic foot is usually sufficient. Upon start-up a new bed should be backwashed and caution taken to insure that the lightweight media is not backwashed to drain. A new bed should be regenerated the evening of installation. **Operating the filter after its oxidizing capacity is exhausted will reduce its service life and may cause staining.**

Untreated water should periodically be monitored for raw water parameters. Treated water should periodically be monitored for manganese and if present iron and hydrogen sulfide. When using intermittent regeneration take treated water samples shortly before a regeneration and immediately after a regeneration to monitor how the filter system is functioning. Elevated treated water manganese concentrations before regeneration may mean that the filter media is being destroyed or bed reduction capacity has been exceeded. Take corrective actions as necessary.

Low pH, lack of chlorine oxidant or lack of permanganate oxidant are the most likely conditions leading to media destruction.

Addition of other chemicals to influent or backwash water which contacts MTM® media may inhibit iron, manganese or hydrogen sulfide removal or may break down or coat MTM® media. Before adding any chemical to the influent or backwash water, other than chlorine or potassium permanganate, the chemical's compatibility with MTM® should be thoroughly tested.



ADVANTAGES
- Broad operating range for iron reduction
- Lower pressure loss through the bed with high flock holding capacity
- Effective hydrogen sulfide, iron and manganese reduction.
- Light weight requires lower backwash rates and reduces pumping requirements
- Chlorine can be beneficial in extending filter run times
- Low attrition loss for long bed life
- Lower shipping cost

PHYSICAL PROPERTIES
- Color: Dark brown
- Bulk Density: 45-50 lbs./cu. ft.
- Specific Gravity: 2.0 gm/cc
- Effective Size: 0.43 mm
- Uniformity Coefficient: 2.0
- Mesh Size: 12 x 50

CONDITIONS FOR OPERATION
- Water pH range: 6.2-8.5
- Maximum water temp: 100°F/38°C
- Bed depth: 24-36 in.
- Freeboard: 50% of bed depth (min.)
- Service flow rate: Continuous 2-5 gpm/sq. ft., intermittent flows up to 10 gpm/ft.[2]
- Backwash flow rate: At 60°F 8-10 gpm/sq. ft. for tanks ≤ 12" diameter, 10-12 gpm/sq. ft. for tanks ≥ 13"
- Backwash expansion rate: 20-40% of bed depth (min.)

MAXIMUM PRACTICAL LIMIT
- Iron 15 ppm
- Manganese 5 ppm
- Hydrogen Sulfide 2 ppm

INFLUENT AND BACKWASH LIMITATIONS
- Oil: None present
- Polyphosphates: None present
- Air Scour not allowed

METHODS OF REGENERATION
- Intermittent or continuous feed regeneration can be used on systems up to 3 cubic feet.
- Continuous feed regeneration using Cl_2, $KMnO_4$ or both is required for all systems that are larger than 3 cubic feet.

INTERMITENT $KMnO_4$ REGENERATION REQUIREMENTS
- $KMnO_4$ Dosage 1.5-2.0 oz (by dry weight)/ft[3]
- Use an injector size that is two sizes larger than one that is sized for a typical softener application
- Draw/slow rinse time greater than 50 minutes
- Down flow rinse (Fast Rinse) 8 minutes minimum
- Rinse until all traces of $KMnO_4$ are gone

INTERMITTENT CAPACITIES
- 10,000 gallons of water containing 1 mg/L Iron per cu.ft. regeneration
- 5,000 gallons of water containing 1 mg/L Manganese per cu.ft. regeneration
- 2,000 gallons of water containing 1 mg/L Hydrogen Sulfide per cu.ft. regeneration
- For dilute solutions mg/L = ppm
- 37,850 mg $KMnO_4$ demand
- $KMnO_4$ demand = [1 x mg/L Fe] + [2 x mg/L Mn] + [5 x mg/L H_2S]

Example Calculation:

Soluble Fe = 3.0 mg/L Fe, Soluble Mn = 0.3 mg/L Mn, H_2S = 0.2 mg/L H_2S

$KMnO_4$ demand = [1 x 3.0 mg/L Fe] + [2 x 0.3 mg/L Mn] + [5 x 0.2 mg/L H_2S]

$KMnO_4$ demand = [3.0 mg/L] + [0.6 mg/L] + [1.0 mg/L]

$KMnO_4$ demand = 4.6 mg/L

$$\left(\frac{37{,}850 \text{ mg } KMnO_4 \text{ demand per cu. ft. regen.}}{4.6 \text{ mg/L } KMnO_4 \text{ demand}}\right) \times \left(\frac{1 \text{ gallon}}{3.785 \text{ Liters}}\right) =$$

2,174 gallons per cu. ft. regenerated

PHYSICAL PROPERTIES
- Color: Dark brown
- Bulk Density: 45-50 lbs./cu. ft.
- Specific Gravity: 2.0 gm/cc
- Effective Size: 0.43 mm
- Uniformity Coefficient: 2.0
- Mesh Size: 12 x 50

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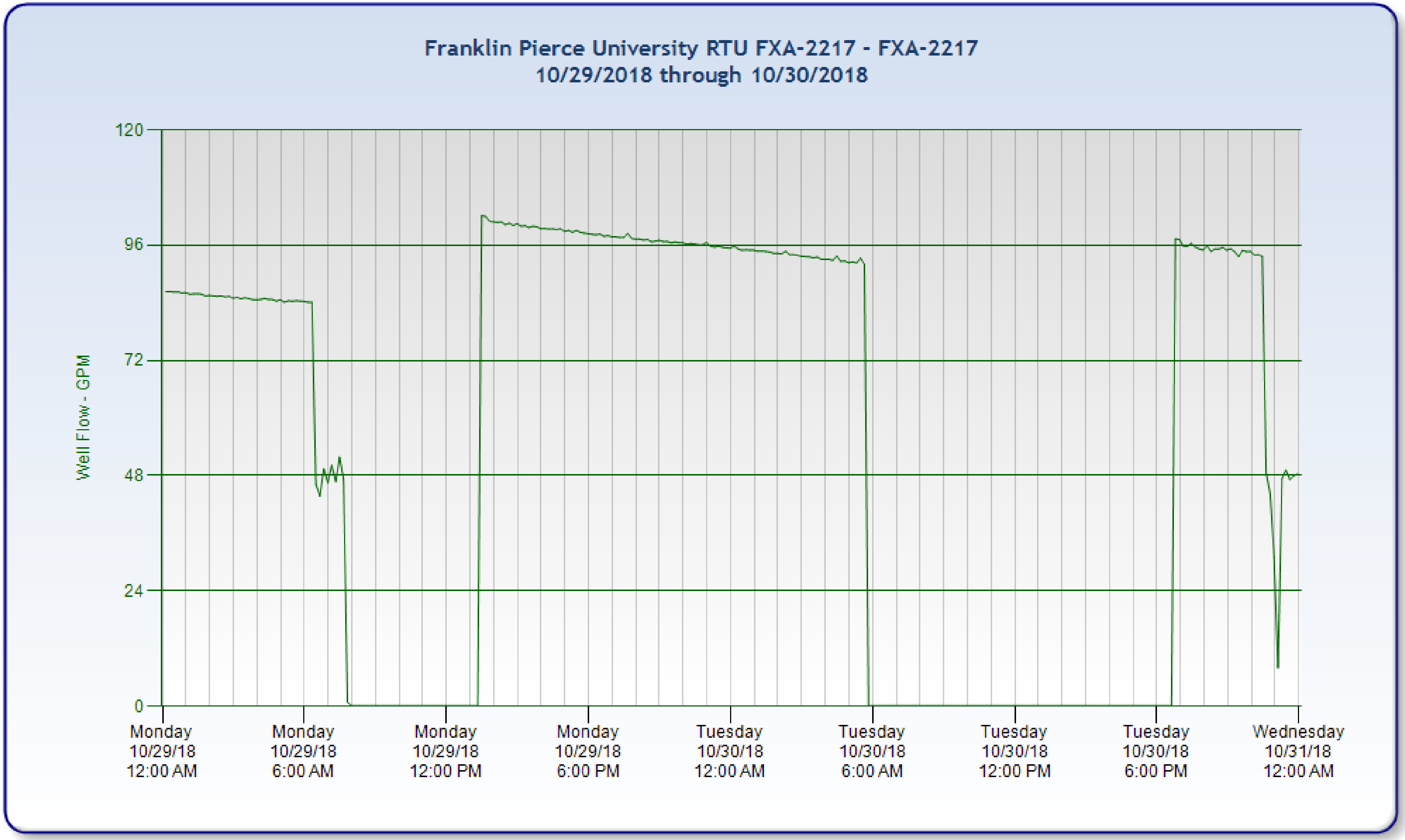
MAXIMUM PRACTICAL LIMIT
- Iron 15 ppm
- Manganese 5 ppm
- Hydrogen Sulfide 2 ppm

Well flow decreases due to drawdown
Could impact backwash flow rate




HAYWARD
TRUE UNION BALL CHECK
FLOW
1223


DANGER
HYDROCHLORIC ACID
DANGER
CHLORINE
DANGER
CHLORINE
DANGER
CHLORINE
DANGER
CHLORINE
UN2582
2582
8


POTABLE WATER
NON-POTABLE WATER
NON-POTABLE WATER
Secondwind
For Service or Assistance Call
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REVERSE OSMOSIS (RO)

- RO removes 90% to 95% of all TDS
  - Does not remove AS III as well as AS V
  - POE (Point of Entry) or POU (Point of Use)
    - Very expensive to treat all the water
    - Reasonable for centralized POU (One RO to multiple locations)
    - Can use small residential RO for specific locations if not too many
  - Waste volume a consideration. Waste to product can be 3:1.
  - Ability to dispose of effluent high arsenic content

KINETICO
REVERSE OSMOSIS SYSTEM
TL SERIES

CHOOSING THE "BEST" SYSTEM

Anion Exchange:

- Pro – long media life, low maintenance, low operating cost, not pH dependent, also removes uranium
- Con – only removes AS V, produces corrosive water, backwash disposal, doesn't tolerate iron, manganese, or hardness

Adsorption:

- Pro – no moving parts, no backwash disposal, removes both III and V
- Con – can have high operating cost with media replacement, pH dependent, doesn't tolerate iron and manganese

Coprecipitation:

- Pro – long media life, very high capacity for AS and high water volume, also removes iron and manganese
- Con – high backwash flow and volume, might have to filter backwash, requires the most operator time, most complex system (chem feeds, backwashing filters, and potential discharge filter)

Reverse Osmosis:

- Pro – only treats drinking water, removes many other contaminants, low operating cost
- Con – can be high capital cost, can waste a lot of water, not practical in larger multi building systems

BUT I ALREADY HAVE AN ARSENIC TREATMENT SYSTEM…

DO I NEED TO GET A NEW ONE???

- Blended systems with treated water between 5 and 10 ppb
- Adsorbers that require frequent or expensive rebeds

PFAS REMOVAL TECHNOLOGIES

- Adsorption
  - Carbon or specialty resin
  - Disposal of exhausted media “special waste”
- RO
  - POU (Point of Use)
  - Ability to dispose of effluent

ADSORPTION

- Activated Carbon (GAC) – requires 10 minutes of EBCT – systems are big
- Resin based specialty media designed to attract and retain PFAS compounds – requires 3 minutes EBCT
- Disposal of exhausted media “special waste” – cannot throw it in the trash
- POE (Point of Entry) or POU (Point of Use)

POU adsorbers

REVERSE OSMOSIS (RO)

- Removes 90% to 95%of all TDS
- Removes all PFAS compounds
- Include carbon or resin after the RO for redundancy
- POE (point or entry) or POU (point of use)
- Very expensive to treat all the water
- Reasonable for centralized RO (one RO treats multiple locations)
- Can use small residential ROs if not too many locations – testing cost
- Waste volume a consideration. Waste to product can be 3:1
- Ability to dispose of effluent

Centralized RO

SIZING SYSTEMS

All media rated for contact time by the manufacturer

- EBCT (Empty Bed Contact Time) – how long it takes the water to travel through the media
- Flow per cubic foot of media
- Flow per square foot of tank cross section

- Must consider flow rate, flow volume, and water content – media loading

SEQUENCING OF EQUIPMENT

- Considerations
  - Water chemistry required for next step
  - Pressure drop across pieces
  - Backwash requirements
  - Well recovery rate, other demands


TREATED WATER

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water systems, inc.

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QUESTIONS?

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