Proposed Water Treatment Plant

Report to the Special Town Meeting

Articles 17 and 18

September 26, 2016

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BACKGROUND

To provide drinking water the Town of Shrewsbury pumps groundwater from seven well sources located in the Blackstone River basin. This area is located in the northwestern section of Town in close proximity to Lake Quinsigamond. The underground aquifer located within this sub basin area is extremely high yielding and has benefited the Town throughout the years. All the wells are pumped to the current Treatment Plant, mixed together centrally, treated and then pumped out into the distribution system.

Typical of groundwater sources throughout all of New England, iron and manganese are present due to the underlying geological conditions in this area of the country. Our wells are very low in iron but contain manganese. Manganese is a mineral found in rock and soil formations and like calcium and iron, necessary for good health. However in concentrations of over 0.05 mg/l or 50 ppb, manganese can cause staining and other related issues.

The present treatment facility has been doing chemical addition for manganese control since the startup of the Plant in 1990. This process consists of a sequestering chemical with a blend of 50% polyphosphate and 50% orthophosphate. This chemical is intended to keep the manganese in solution and does not remove the manganese itself. At levels above 0.10 -0.15 mg/l the sequestering process becomes ineffective. We are currently encountering manganese above these levels. Manganese can only be removed by a full treatment process which is described in detail later in this report.

One of our main sources, Home Farm 6-1 has been increasing in manganese levels and reducing in yield over the last 3-5 years. To counter this two replacement wells have been developed and put on line. A full redevelopment of this main well was done in April 2015 which brought back yield but also concurrently increased the manganese level. Various well treatments such as liquid nitrogen freezing and other chemical treatments have been tried over the years with limited success. Bear in mind that when the original Home Farm 6-1 was brought on line in 1971, it was the largest municipal production well in all of New England rated at 3.0 million gallons per day (gpd).

There are presently four Home Farm wells with a fifth being developed this fall. Our present Water Management Permit, which authorizes daily and annual pumping volumes, allows up to 5.4 million gpd to be pumped from all our Home Farm wells combined and up to 7.8 million gpd from all our sources combined. Due to hydraulic constraints and other factors, these flow levels are not always advisable to be enacted. On an annual basis, our daily average use is not to exceed 4.17 million gpd. The present severe drought conditions have further increased manganese levels at five of our seven wells increasing the importance of a full manganese treatment facility. To demonstrate the cause of recent water discoloration problems, listed below are manganese levels from last fall to this summer:

Location	Mn Level 10/29/15	Mn level 08/10/16	% of increase
Home Farm 6-4	0.16	0.33	106.25%
Home Farm 6-3	0.13	0.61	369.23%
Home Farm 6-1	0.94	1.10	17.02%
Sewell #4	0.36	0.37	2.78 %
Home Farm 6-2	0.02	0.05	120.83%

Unfortunately, one of the common problems with pumping groundwater is the high level of manganese which the United States Environmental Protection Agency (USEPA) classifies as a secondary contaminant. Secondary contaminants are, fortunately, non-enforceable. However, being in compliance with the secondary maximum contaminant level (SMCL) of 0.05 milligrams of manganese per liter of water (mg/L) will help the Town of Shrewsbury mitigate the unwanted aesthetics, cosmetics and technical effects of having manganese-bearing water.

Aesthetically, manganese-bearing water, when exposed to oxygen, will give the appearance of black to brownish water. This discoloration can be misconstrued as a sign of poor-quality water. Cosmetically, manganese has the ability to stain clothing and kitchenware with a black to brownish color.

On the technical side, manganese may build up in pipelines, pressure tanks, water heaters and the like reducing the effective size of pipes, requiring more frequent replacement, and increasing the operation and maintenance costs due to the extra power needed to pump water through smaller pipes.

In terms of health, concern is raised due to high levels of manganese. DEP has issued several advisories and other information on this subject which can be viewed at **https://shrewsburyma.gov/719/Information-About-Manganese-in-Shrewsbury.**

The manganese levels in the Shrewsbury water distribution system typically range from 0.1 to 0.3 mg/L (often times 0.1 to 0.2 mg/L). These levels are about 2 to 6 times higher than the SMCL recommended by the USEPA. In the summer of 2016, for example, during which some areas of the Town experienced discolored water issues, manganese levels of the finished water were 0.34 mg/L on July 20th and 0.27 mg/L on August 12th. Thus, it is in the Town's interest to reduce its manganese levels for health, aesthetic, cosmetic, and technical reasons.

The proposal before Town Meeting is to construct a new 8,580 square foot 7 MGD (Million gallons day) water treatment facility adjacent to the existing facility that was constructed in 1990 (see attached floorplan). The current facility (6 MGD) was constructed primarily to deal with the removal of volatile organic compounds (VOC's) that are present in the groundwater and does not have the

internal capacity for modification to now treat for manganese. The current facility will then be demolished down to the floor slab. The floor slab will be left in place for potential use of solar panels.

PILOT TEST RESULTS

In order to settle on a technology, The Town in conjunction with our engineering firm Tata & Howard, ran pilot tests on three different products - Greensand Plus™, LayneOX™, and Mangazur®. The results were positive - each product reduced manganese levels to under 0.03 mg/L.

Table 1: Final Results of Pilot Tests for Greensand Plus™, LayneOX™, and Mangazur®

Location	Manganese (mg/L)
Home Farm 6-1	0.75
Home Farm 6-2	0.48
Combined (6-1,2,3,4)	0.34
Finished Water	< 0.03
Secondary MCL	0.05

The pilot tests show that Mangazur® performed significantly better than, if not just as well as, Greensand Plus™ and LayneOX™. A summary comparing the pilot test results of each product is shown in the table below.

Table 2: Comparison of Parameters and Characteristics on the Greensand Plus™, LayneOX™, and Mangazur® Pilot Tests

	Greensand Plus™	LayneOX™	Mangazur®
Filter Loading Rate (gpm/sf)	5	4.5	**10**
Number of Filters	8	8	**4**
Filter Size	12' Diameter	12' Diameter	12' Diameter
Filter Run Time (hr)	>24	24	**>100**
Backwash Rate (gpm/sf)	10-15	25	**6**
Backwash Flow Rate (gpm)	1150-1700	2800	**900**

	Greensand Plus™	**LayneOX™**	**Mangazur®**
Backwash Volume (gpd)	92,000-136,000	112,000	**6500**
Chlorine Dosage Required	0.9 ppm	0.9 ppm	0.9 ppm
Chlorine Usage per MG Treated	6 gal	6 gal	6 gal
KMnO4 Dosage Required	1.2 ppm	1.2 ppm	**0**
KMnO4 Usage per MG Treated	10 lbs	10 lbs	**0**
Potassium Hydroxide Required	14.8 ppm	14.8 ppm	14.8 ppm
Potassium Hydroxide per MG Treated	23 gal	23 gal	23 gal

For filters, Mangazur® had twice the loading rate compared to the other two products at 10 gallons per minute of water per square foot of media (gpm/sf). Since Mangazur® has twice the loading rate, it would need half the number of filters (4 filters at 7 MGD water consumption) compared to Greensand Plus™ and LayneOX™ (8 filters at 7 MGD water consumption). This reduction in the number of filters required would save the water treatment plant about 1500 square feet of space, illustrated in the Figure 1 below.

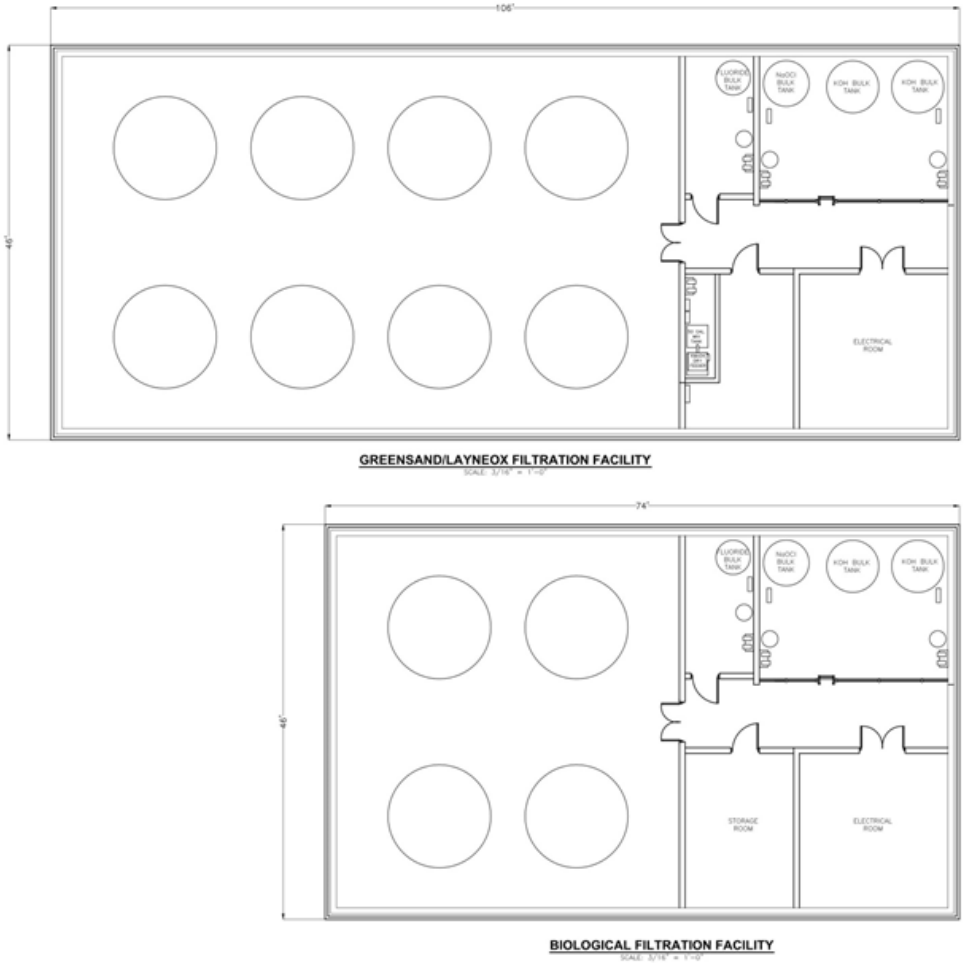


Figure 1: Comparison of Preliminary Layout of Water Treatment Plant Improvements between Greensand Plus™ or LayneOX™ (8 filters, top), and Mangazur® (4 filters, bottom).

The pilot tests showed that Mangazur® would require a backwash greater than 100 hours compared to Greensand Plus™ and LayneOX™ which would require a backwash every 24 hours. In addition, Mangazur® would require significantly less water for backwash at approximately 6,500 gallons per day (gpd) compared to the other products at a minimum of 92,000 gpd.

In terms of dosage, all three products use the same amount of chlorine at 0.9 parts chlorine per million parts water (ppm) and 14.8 ppm potassium hydroxide. However, Mangazur® does not require potassium permanganate ($KMnO_4$) treatment. As such, choosing Mangazur® would save the Town of Shrewsbury about 10 lbs of potassium permanganate treatment per million gallons of water to treat.

Based on the pilot test results, it is highly recommended that Mangazur® to be used to treat the Town of Shrewsbury's elevated manganese levels. The smaller footprint in space, less frequent

backwashes, less water use per backwash, and lack of potassium permanganate dosing makes this product significantly better than Greensand Plus™ and LayneOX™.

MOVING AHEAD WITH MANGAZUR®

Mangazur, unlike Greensand Plus and LayneOX, uses a biological process for removal of manganese from groundwater. It utilizes a naturally occurring organism known as *Leptothrix ochracea*, as shown in the figure below, to oxidize the manganese.

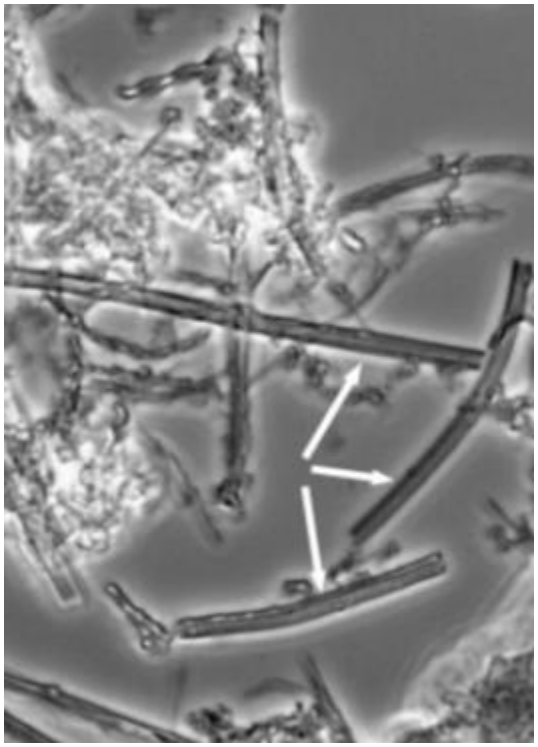


Figure 2: Leptothrix ochracea at 1000x magnification

L. ochracea is bound to the filter media known as Biolite™ "S" as biofilm. As groundwater passes through the filter, the organism oxidizes manganese and the manganese precipitate gets trapped in the filter. The trapped precipitate is backwashed to clear the filter of the precipitate, but the organism stays bound to the Biolite. Since the organism is bound to the Biolite, as opposed to the solids being bound to the filter with Greensand Plus™ and LayneOX™, less water is required for backwashing. In the field, it is expected for the Mangazur® to be backwashed every 3 to 14 days.

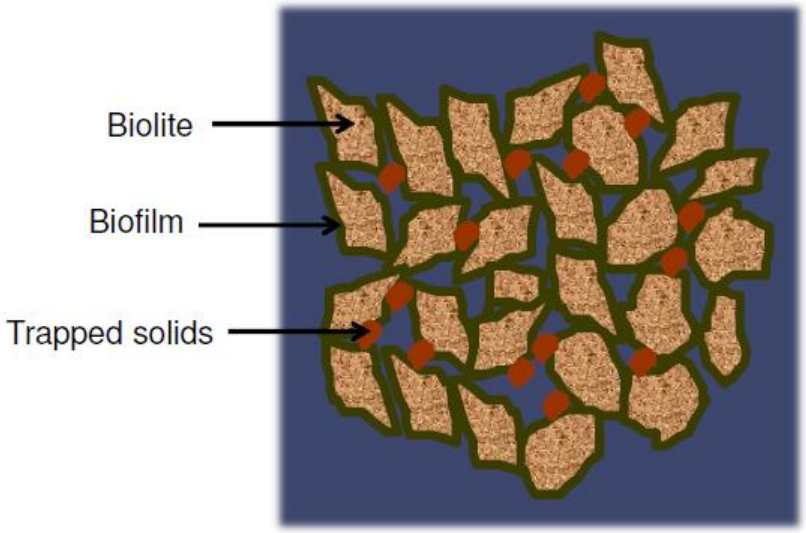


Figure 3: Representation of Mangazur® (black) on filter media BioLite "S" (brown) with manganese precipitate (red).

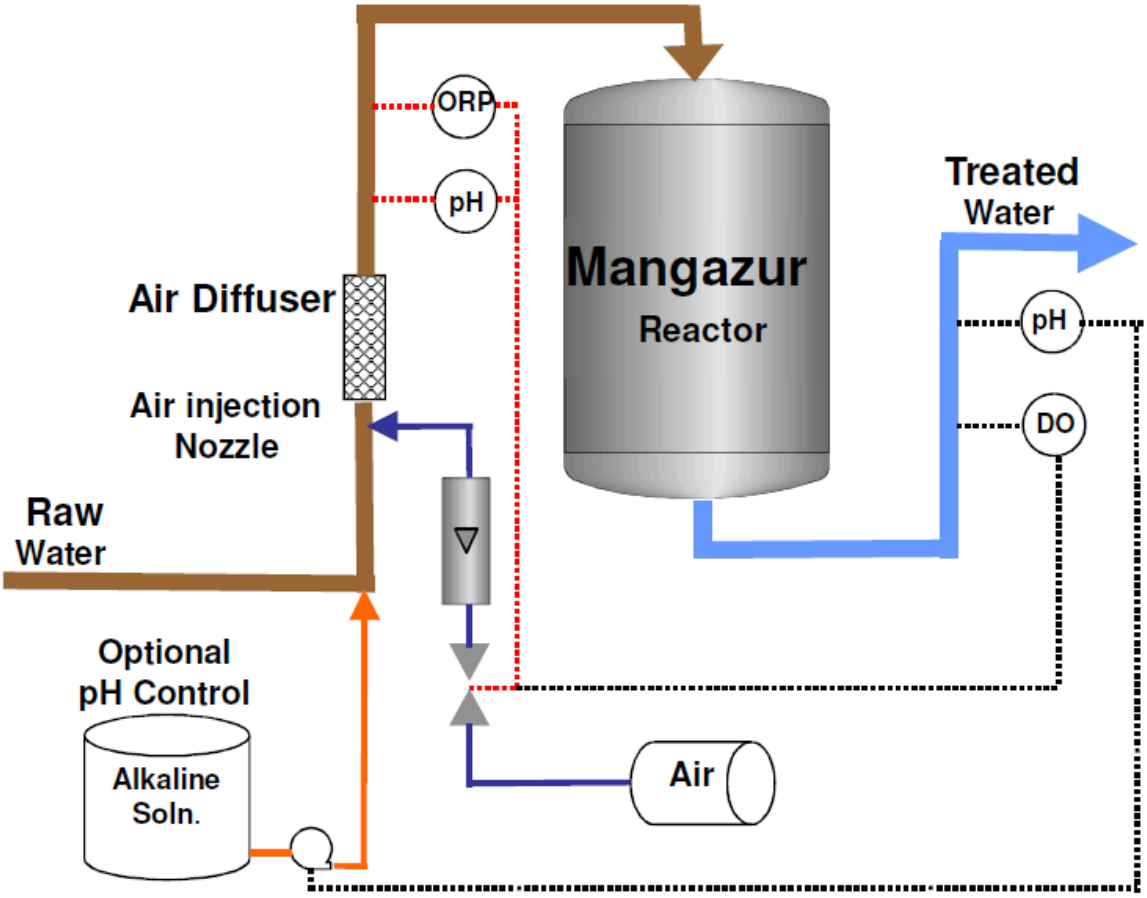


Figure 4: Flow Chart of a Single Stage Pressure Filter

NEW TECHNOLOGY APPROVAL

The Mangazur processes received MassDEP new technology approval on August 22, 2006, and as such are approved for use in the Commonwealth. The new technology approval is a rigorous process that requires manufacturers to submit operating and performance data to support use of their product.

There are currently 160 installations worldwide and 35 in North America. The North American installations range in size from 0.1 to 26.0 MGD. The Town of Middleborough, Massachusetts is about to put out to bid for an October 2016 bid opening, a 1.0 MGD facility using this same technology.

ALTERNATIVES

While there is no requirement that treatment for manganese be introduced, it is something whose time has come. There are two alternatives to the building of this new facility:

- Do nothing – Just maintain the current treatment process and continue to manage the water quality issues associated with high concentrations of this mineral through sequestration and blending; or
- Purchase water from another source – This question was studied in the recent alternate water study filed by the town manager earlier this year that can be found at **https://shrewsburyma.gov/DocumentCenter/Home/View/2380**.

ALTERNATIVE ENERGY

Recently, the Town of Shrewsbury filed for a grant of $12,500 to evaluate energy saving design elements for the water treatment plant. The evaluation will be used to determine what green technology is feasible to include in the design and will be used as a guideline in incorporating these technologies. The evaluation will include annual energy saving benefits. Major treatment processes that will be evaluated include backwash water recycling, heat pumps utilizing treated water for power, efficient pump motors, and other best practices in current water treatment facility design. Additionally, the assessment will evaluate site efficiencies including stormwater collection and water efficient landscaping and other building energy efficiencies including low flow fixtures, HVAC systems, insulation exceeding building code, renewable energy, building reuse, lighting, and others.

PROJECT COSTS AND SCHEDULE

The project is expected to cost a total of $14,985,000. The cost excludes pilot testing costs of $92,200, the initial $500,000 design cost appropriated in May of 2015 and an additional $95,000 for design on the September 26, 2016, Special Town Meeting Warrant. Of the $14.985 million, $12.8

million will be for construction costs, $1.185 million for contingency, and $0.9 million for bid and construction services.

Table 3: Estimated Project Costs (Via Bond Issues)

Construction Cost	$12,800,000
Contingency	$1,185,000
Bid and Construction Services	$900,000
TOTAL	$14,885,000

Construction will begin in the spring of 2017 and be concluded within 20 months thereafter.

Table 4: Schedule for Proposed Water Treatment Plant

Description of Work	**Proposed Date**
Begin Design and Permitting	February 2016
Submit Design to DEP SRF	October 2016
DEP Permission to Bid	December 2016
Bidder Prequalification	January 2017
Sub Bids	February 2017
General Bids	March 2017
Award Contract	April 2017
Begin Construction	April 2017
Complete Construction	October 2018

FINANCING

This project will be funded via two bonds. The first bond is for $13.985 million which will be at 2% interest through the Commonwealth's State Revolving Fund Program. The second bond is for construction services which will be in the amount of $900,000 at an estimated 4% interest through conventional financing. In addition, operation and maintenance costs of this new treatment process will be $200,000 per year more than current treatment expenses.

Table 5: Cash Flow Impact of Proposed Water Treatment Plant

Year	Proposed Debt Service/O&M - Treatment Facility					Current Debt Service		Total Debt Service and O&M
	Building & Equipment ($14.0M)*	Construction Services ($0.9M)	Total Debt Service	Additional O & M	Total Cost	Water Tank	Water System Imprv	
FY 2017						$133,438	$78,525	$211,963
FY 2018						$129,375	$77,300	$206,675
FY 2019	$931,870	$81,000	$1,012,870	$200,000	$1,212,870		$75,900	$1,288,770
FY 2020	$867,446	$79,200	$946,646	$204,000	$1,150,646		$69,550	$1,220,196
FY 2021	$867,582	$77,400	$944,982	$208,080	$1,153,062		$68,250	$1,221,312
FY 2022	$867,720	$75,600	$943,320	$212,242	$1,155,562		$66,950	$1,222,512
FY 2023	$867,861	$73,800	$941,661	$216,486	$1,158,147		$65,650	$1,223,797
FY 2024	$868,005	$72,000	$940,005	$220,816	$1,160,821			$1,160,821
FY 2025	$868,152	$70,200	$938,352	$225,232	$1,163,584			$1,163,584
FY 2026	$868,303	$68,400	$936,703	$229,737	$1,166,440			$1,166,440
FY 2027	$868,457	$66,600	$935,057	$234,332	$1,169,389			$1,169,389
FY 2028	$868,614	$64,800	$933,414	$239,019	$1,172,433			$1,172,433
FY 2029	$868,774	$63,000	$931,774	$243,799	$1,175,573			$1,175,573
FY 2030	$868,938	$61,200	$930,138	$248,675	$1,178,813			$1,178,813
FY 2031	$869,106	$59,400	$928,506	$253,648	$1,182,154			$1,182,154
FY 2032	$869,277	$57,600	$926,877	$258,721	$1,185,598			$1,185,598
FY 2033	$869,453	$55,800	$925,253	$263,896	$1,189,149			$1,189,149
FY 2034	$869,631	$54,000	$923,631	$269,174	$1,192,805			$1,192,805
FY 2035	$869,814	$52,200	$922,014	$274,557	$1,196,571			$1,196,571
FY 2036	$870,001	$50,400	$920,401	$280,048	$1,200,449			$1,200,449
FY 2037	$870,191	$48,600	$918,791	$285,649	$1,204,440			$1,204,440
FY 2038	$870,385	$46,800	$917,185	$291,362	$1,208,547			$1,208,547
Totals	$17,439,579	$1,278,000	$18,717,579	$4,859,473	$23,577,052	$262,813	$502,125	$24,341,990

* $14.0 Million used for illustrative purposes

IMPACT ON WATER RATES

In order to fund an additional expense of $1.1 million per year, rates will have to increase by 25% to 30% on or about January 1, 2018, depending on the level of consumption and rate class.

Rate study information, including the town manager's most recent rate study, can be viewed at **https://shrewsburyma.gov/713/Water-Rate-Studies.**

Table 6: Range of Possible Quarterly Charge Increases on Residential Customers

Consumption Level	Current Quarterly Charge	25% Increase	27.5% Increase	30% Increase
Minimum (≤ 5,000 Gallons)	$24.00	$30.00	$30.60	$31.20
Median Use (12,300 Gallons)	$51.01	$63.76	$65.04	$66.31
Average Use (14,425 Gallons)	$58.87	$73.59	$75.06	$76.53
25,000 Gallons (89th Percentile)	$98.00	$122.50	$124.95	$127.40
35,000 Gallons (96th Percentile)	$167.00	$208.75	$212.93	$217.10
60,000 Gallons (99th Percentile)	$339.50	$424.38	$432.86	$441.35

The Board of Selectmen currently has under review the series of rates scenarios prepared by the Town Manager and will develop and adopt a rate schedule for all classes of customers over the next several months.

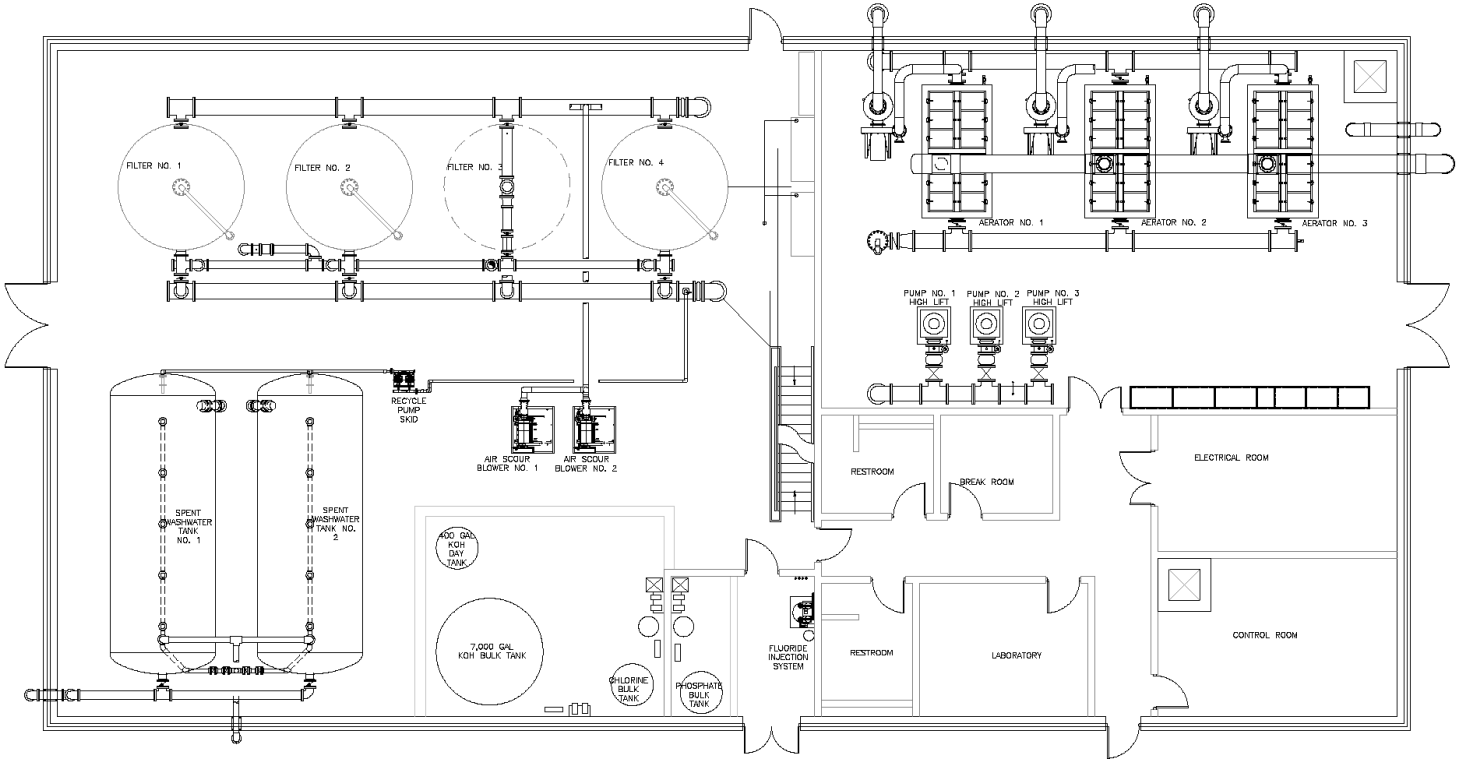
CONCLUSION

This past summer has demonstrated the difficulties in managing the levels of manganese in the Town's water supply through means other than treatment. While the system for the most part is stable relative to water discoloration, pressure fluctuations caused by changes in operations or due to water breaks or other interruptions will cause discoloration. Unfortunately, this summer the instances of water discoloration have been widespread and far more prevalent than in previous years.

The construction of this new treatment facility will alleviate water discoloration issues for the most part understanding that water breaks and system construction will cause discoloration issues to develop from time to time thereafter.

Respectfully Submitted,

Daniel Morgado, Town Manager
Robert Tozeski, Superintendent of Water and Sewer
Vincent Thai, EIT, Junior Civil Engineer – Compliance
September 1, 2016



FIRST FLOOR PROCESS PLAN

SCALE: 3/16" = 1'-0"

TOWN OF SHREWSBURY, MASSACHUSETTS

UPGRADES TO THE HOME FARM WTP

HOME FARM WATER TREATMENT PLANT FIRST FLOOR PROCESS PLAN

No.	Date	Description	Drawn By MVK	Designed By RSP	Checked By	Approved By

REVIEW SUBMITTAL NOT FOR CONSTRUCTION

TATA & HOWARD

T&H NO.: 3751
DATE: AUGUST 2016
SCALE: AS NOTED

20-D-1