# CITY OF EUREKA, MISSOURI
# WATER QUALITY EVALUATION REPORT

**May 10, 2018**

**PREPARED FOR:**

CITY OF EUREKA
EUREKA, MISSOURI

**PREPARED BY:**


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Project Number 19500.000

**May 10, 2018**

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# WATER QUALITY EVALUATION REPORT

STATE OF MISSOURI
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**Date:** May 10, 2018

**To:** City of Eureka, Missouri

**From:** Bartlett & West, Inc.

**Re:** Public Water System Quality Review

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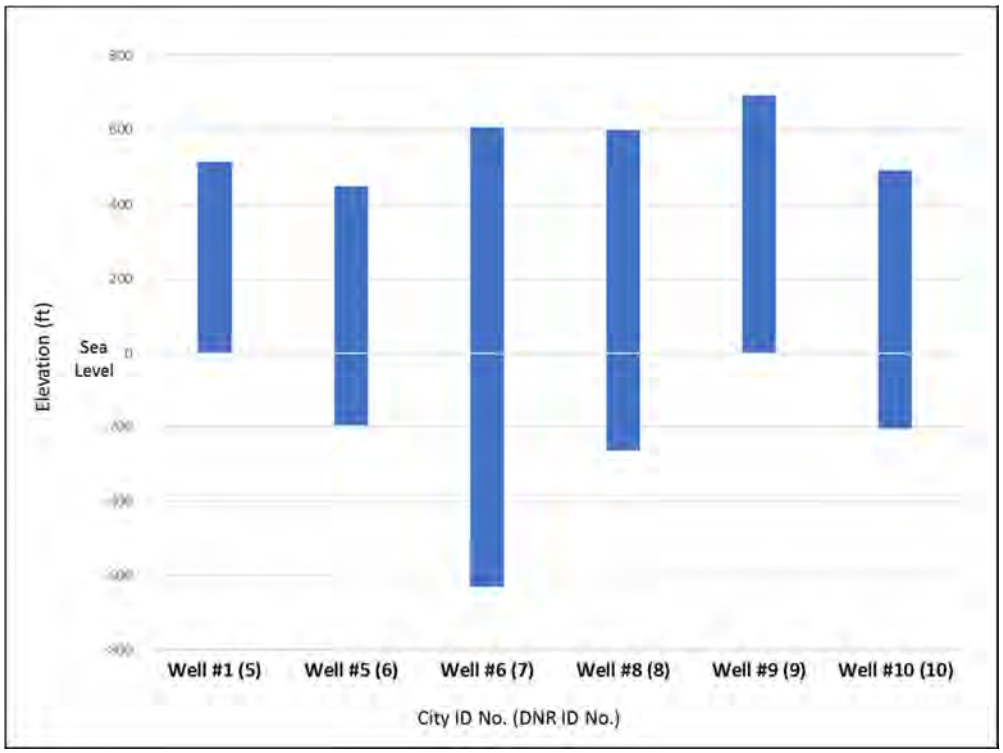
## Section 1. EXECUTIVE SUMMARY

The City of Eureka, MO operates a public water system (PWS) in the greater St. Louis metropolitan area, serving a population of about 10,000 plus commercial and industrial customers. The Eureka PWS includes six (6) wells located throughout the community; each well providing groundwater for its adjoining ion exchange (IX) water treatment plant (WTP). Softened potable water is disinfected and fluoridated at each WTP before entry into the City's distribution system. The distribution system consists of eight (8) pressure zones which are maintained by eight (8) booster pump stations with seven (7) ground storage tanks. Although the PWS utilizes a decentralized treatment approach to feed various pressure zones, valving exists to interconnect adjoining pressure zones allowing uninterrupted service during maintenance of key infrastructure. The recent average water demand for the City is 1.6 million gallons per day (mgd). Customers have complained about taste, odor, and household plumbing corrosion. The PWS has also identified concerns with water age, and ineffective tank mixing, that may also be related to customer complaints.

The six wells range in pumping capacity of 600 to 1,000 gallons per minute (gpm). The wells are open bottom hard rock wells ranging in depth from 500 to 1,235 feet. The following figure presents a representation of the well head elevation and bottom of well elevation for each well.



The geological formations in the area is known to yield highly mineralized water with elevated levels of total dissolved solids (TDS), and hardness. The water distributed by the PWS meets all primary (health related) drinking water standards. However, secondary (aesthetic) parameters that are likely contributing to the taste complaints, and are related to the corrosion issue are summarized below.

| | | RAW WATER | | FINISHED WATER | | |
|---|---|---|---|---|---|---|
| CONSTITUENT | | RANGE | | RANGE | | MCL |
| | | MIN | MAX | MIN | MAX | |
| | | | | | | |
| **Field Parameters** | | | | | | |
| pH | | 6.79 | 6.99 | 6.79 | 6.99 | |
| | | | | | | |
| **Other Parameters** | | | | | | |
| Solids, Total Dissolved | mg/L | 364 | 1430 | 404 | 1110 | 500 |
| | | | | | | |
| **General Chemistry** | | | | | | |
| Chloride | mg/L | 25 | 488 | 34 | 487 | 250 |
| Hardness, Total as $CaCO_3$ | mg/l | 300 | 399 | 23 | 151 | |
| Sulfate | mg/L | 24.2 | 63.3 | 24.2 | 64.1 | 250 |
| | | | | | | |
| **Inorganics, Metals** | | | | | | |
| Sodium, total | mg/L | 29 | 222 | 147 | 340 | |
| | | | | | | |

As can be seen from the data, the Ion Exchange treatment process is softening the water, as it was intended. However, an IX process will not remove dissolved solids or chlorides. A membrane treatment process such as Reverse Osmosis (RO) or electrodialysis reversal (EDR) is required. High TDS drinking water may have a salty or brackish taste, result in scale formation, and decrease the efficiency of hot water heaters and other home appliances. Chloride can contribute to taste issues and is associated with corrosion. Sulfate levels in the water are well below the secondary standard, so this constituent is unlikely to be a direct taste or odor contributor. However, even low concentrations of sulfate can become a source of taste and odor with hot water heaters. The pH is low, and is also contributing to the corrosion. There is no drinking water standard for sodium although it can contribute to taste, and may be of concern to people with heart related issues. The water quality parameters were examined for corrosive indexes, and found to be aggressive (corrosive).

The Eureka PWS already implements a water main flushing program, but is planning a more comprehensive program. It is recommended the City develop a hydraulic model of the system to help in calculating water age, and determine the best approach to flushing. If is also recommended that water quality parameters be monitored to further understand the results of the flushing.

There are various methods and equipment available to enhance mixing in tanks to prevent water stagnation in the upper portions of the tanks. In the City's case incorporating drop-in mechanical mixers will likely be the simplest and most cost effective. It is anticipated the cost will be in the range of $10,000 to $12,000 per tank for the mixer equipment, electrical wiring and conduit, and installation. The mixer motors are small, so there will be a minimal ongoing electrical cost, but it will be relatively small at around a couple hundred dollars per year per tank.

Softening the water makes it more aggressive. It is recommended that a finished water hardness of 170 mg/I (10 grains) be targeted to help reduce the aggressiveness, and reduce the amount of chemical need to stabilize the water.

To produce a slightly scale forming water (non-corrosive) will require pH adjustment to near 8.0 for each well site. One option is to feed sodium hydroxide (caustic soda). The dosages required are quite high and range from 45 to 90 mg/l. This will require approximately 5,000 gallons of chemical per month with an overall annual cost of around $275,000 (purchased at 50% solution). If aeration is also implement, as discussed below, the projected chemical use is reduced to around 2,100 gallons per month with an annual cost of around $137,000. A high-level cost estimate for a small building to house the chemical storage tanks and feed pumps and associated facilities is $1.1M for all six plant sites.

To help reduce the amount of caustic soda required an option is to aerate the water to allow a portion of the dissolved carbon dioxide to be removed. Removing the carbon dioxide will result in a raising of the pH. Aeration alone will most likely not raise the pH enough, so feeding caustic soda will still be required, but at a lesser amount. There are various forms of equipment that could be implemented for aeration. An option that would have merit for those plant sites will on-site storage tanks is an in-tank floating aeration system. For the three plant sites without on-site tanks adding aeration is more costly. High level costs to implement aeration for just the three sites with on-site tanks is $1.05M, and for the other three sites $1.63M for an overall total of $2.68M.

The table below presents the capital cost, annual chemical cost, and present worth over various time periods. The present worth analysis indicates the following:

- Investing in aeration provides a long-term cost reduction.
- It will take between 10 and 15 years to see the capital investment in aeration to pay off.

| 50% Caustic Soda Purchase | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | **Construction Project Cost** | **Annual Chem. Cost** | **Present Worth 5 Years** | **Present Worth 10 Years** | **Present Worth 15 Years** | **Present Worth 20 Years** |
| **Equation Factor[1]** | | | 4.7135 | 8.9826 | 12.8493 | 16.3514 |
| **No Aeration – Chem. Feed Only** | $1,066,610.00 | $275,023 | $2,362,932 | $3,537,035 | $4,600,467 | $5,563,626 |
| **With Aeration + Chem. Feed** | $2,685,070.00 | $137,512 | $3,333,231 | $3,920,282 | $4,451,999 | $4,933,578 |

If reduction in TDS, and chlorides is a path the City would like to go down, very high-level cost estimates for the RO equipment at each plant site is in the range of $300,000 to $600,000 per site depending on the processing capacity and water quality at each site. In addition to the RO equipment cost for removal of the existing IX equipment, piping and electrical modifications, and other required changes needs to be included. An overall cost to implement RO treatment was not developed. In addition, aeration and a lesser amount of caustic soda feed would still be required.

See Section 6 of the report for Recommendations and Time Frames.

## Section 2. INTRODUCTION

Eureka is a city in St. Louis County, Missouri, with a population of approximately 10,200, known in the Greater St. Louis Metropolitan Area as home of the Six Flags St. Louis amusement park. Since 1959, the City has operated a decentralized, groundwater-sourced public water system (PWS) that now serves approximately 10,000 customers through more than 3700 service connections (MoDNR, 2016). The Eureka PWS includes six (6) wells located throughout the community; each well providing groundwater for its adjoining, zeolitic ion exchange (IX) water treatment plant (WTP). Softened potable water is disinfected with on-site generated (OSG) sodium hypochlorite and fluoridated at each WTP before entry into the City's distribution system. The distribution system consists of eight (8) pressure zones which are maintained by eight (8) booster pump stations with seven (7) ground storage tanks providing 3,250,000-gallons of storage. Although the PWS utilizes a decentralized treatment approach to feed various pressure zones, valving exists to interconnect adjoining pressure zones allowing uninterrupted service during maintenance of key infrastructure (e.g., wells, treatment plant, storage tank, pump station, etc.)

Recent production numbers tabulated in Table 2-1 suggest the Eureka PWS produces on average 1.697 million gallons of drinking water per day (MGD). Based on a 24-hour operational day, this is an average production rate of 1178 gallons per minute (gpm). The PWS's firm production capacity (one well offline) is 3850-gpm for a 24-hour operational day, as tabulated in Table 3-1, allowing the system to support a maximum day peaking factor up to 3.27; more than enough for the default suggested regulatory 1.50 peaking factor (MoDNR, 2013) and future growth.

Customers have complained about taste, odor, and household plumbing corrosion. The PWS has also identified concerns related to water age, such as oversized watermains and ineffective tank mixing, that may be related to customer complaints. Bartlett & West was contracted by the City of Eureka to evaluate the quality of drinking water distributed to customers, how the water quality may relate to taste and odor complaints as well as household plumbing corrosion, and to recommended adjustments to treatment and/or distribution operations that may improve water quality.

**Table 2-1. City of Eureka PWS Monthly Water Production in Gallons.**

| Month | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| **January** | 35,296,000 | 41,697,000 | 33,673,000 | 34,894,000 | 40,076,000 |
| **February** | 38,173,000 | 37,668,000 | 32,192,000 | 36,546,000 | 34,512,000 |
| **March** | 42,245,000 | 37,367,000 | 36,342,000 | 36,546,000 | 36,983,000 |
| **April** | 53,555,000 | 36,799,000 | 35,275,000 | 37,342,000 | 37,984,000 |
| **May** | 41,311,000 | 48,032,000 | 46,999,000 | 45,605,000 | 49,577,000 |
| **June** | 46,967,000 | 53,722,000 | 50,127,000 | 73,016,000 | 69,018,000 |
| **July** | 63,313,000 | 70,886,000 | 53,516,000 | 60,176,000 | 86,534,000 |
| **August** | 67,264,000 | 62,105,000 | 61,672,000 | 63,951,000 | 74,206,000 |
| **September** | 67,049,000 | 52,610,000 | 62,109,000 | 52,797,000 | 65,359,000 |
| **October** | 47,209,000 | 38,202,000 | 50,477,000 | 48,708,000 | 52,890,000 |
| **November** | 30,695,000 | 27,254,000 | 35,979,000 | 38,303,000 | 36,025,000 |
| **December** | 42,332,000 | 38,109,000 | 33,941,000 | 37,099,000 | 36,175,000 |
| **Total (gallons)** | **575,409,000** | **544,451,000** | **462,382,000** | **564,983,000** | **619,339,000** |
| **Average (MGD)** | **1.576** | **1.492** | **1.267** | **1.548** | **1.697** |

Adapted from MoDNR (2016) and Eureka PWS 2016 MORs.

# Section 3. EXISTING FACILITIES

## 3.1. Source Water Supply

Six (6) bedrock groundwater wells provide the raw source water for the City of Eureka PWS's decentralized water treatment plants. The wells are located throughout the community with each well set at a different depth into the Ozark Aquifer of the Salem Plateau Groundwater Province. The Ozark Aquifer is the most widespread and widely used aquifer in Missouri, supplying nearly all the water supply needs on the Salem Plateau. Well construction varies from 500-ft to 1235-ft in depth with well capacities ranging from 600 – 1000 gpm (Table 3-1), suggesting the wells draw water from the sandstone members of the Gasconade Formation of the lower Ozark Aquifer (Miller and Vandike, 1995).

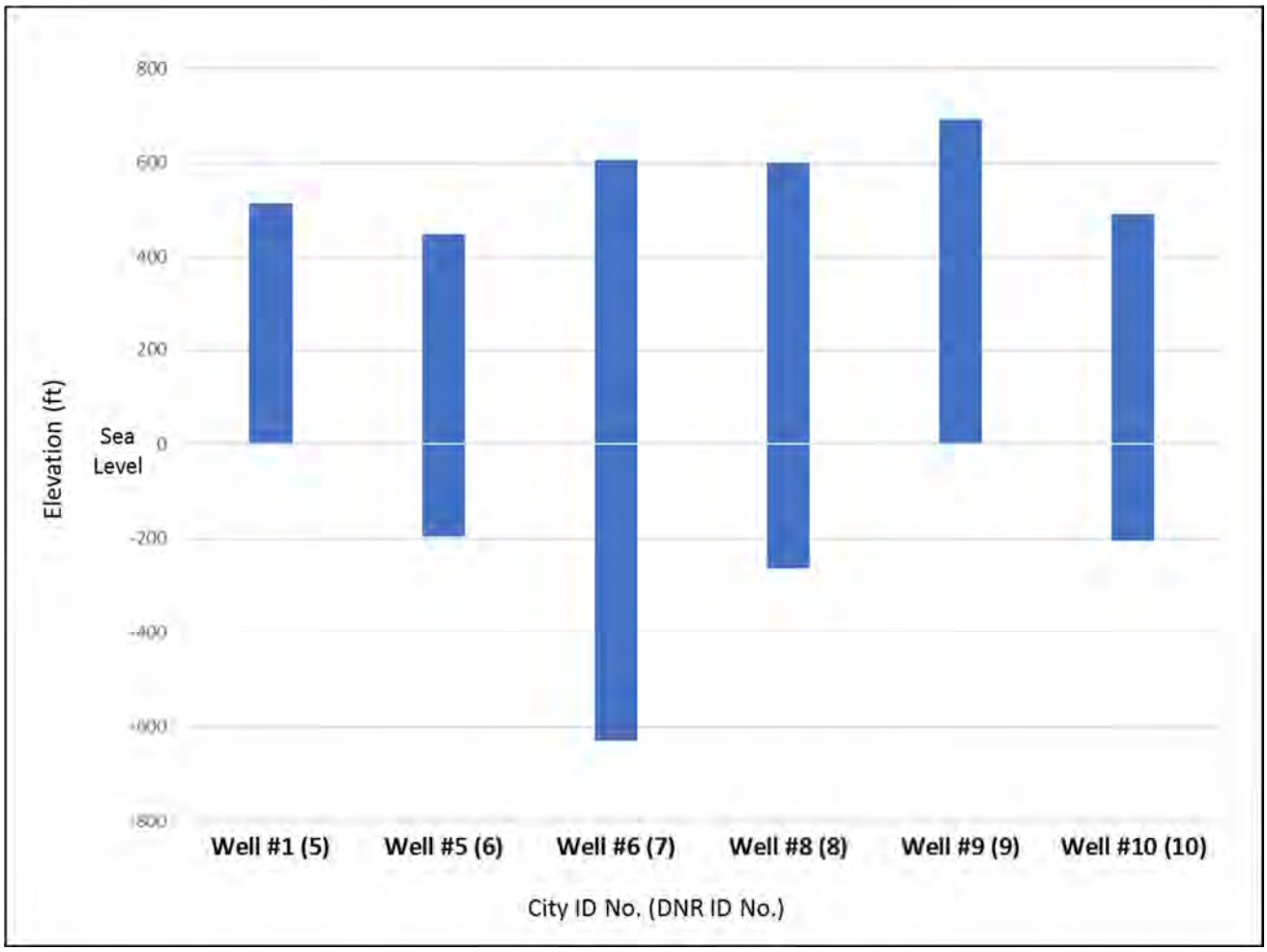
**Table 3-1. City of Eureka PWS Well Summary**

| MoDNR Well ID | Eureka Well ID | Well Location | Install Year | Casing Depth (ft) | Well Depth (ft) | Well Capacity (gpm) | Ground Elevation (MSL) | Bottom Elevation (MSL) |
|---|---|---|---|---|---|---|---|---|
| Well 1 | Capped | Howerton Rd. | - | - | - | - | - | - |
| Well 2 | Capped | Allenton Rd. | - | - | - | - | - | - |
| Well 3 | Monitoring | Viola Ln. | - | - | - | - | - | - |
| Well 4 | Abandoned | Brock Rd. | - | - | - | - | - | - |
| Well 5 | Well 1 | 533 Howerton Ln. | 1977 | 315 | 500 | 1000 | 507 | 7 |
| Well 6 | Well 5 | Drewel Park | 1990 | 315 | 645 | 1000 | 449 | -196 |
| Well 7 | Well 6 | 503 Vista Hills Ct. | 1996 | 570 | 1235 | 600 | 605 | -630 |
| Well 8 | Well 8 | 687 Viola Ln. | 2003 | 465 | 865 | 700 | 600 | -265 |
| Well 9 | Well 9 | 739 Brewster Rd. | 2017 | 475 | 635 | 800 | 664 | 29 |
| Well 10 | Well 10 | 1414 West Main St. | 2006 | 410 | 695 | 750 | 490 | -205 |
| | | | **Total Capacity (gpm)** | | | **4850** | | |
| | | | **Firm Capacity (gpm)** | | | **3850** | | |

Adapted from MoDNR (2016).
*All wells have 12-inch diameter casings

Figure 3-1 presents a representation of the well head elevation and bottom of well elevation for each well.

**Figure 3-1. Eureka Wells – Ground Elevation and Total Depth Elevation**




## 3.2. Source Water Quality

The Gasconade Formation in St. Louis County is known to yield a highly mineralized, sodium-chloride type water with total dissolved solids (TDS) content ranging from 256 – 9950 mg/L, hardness ranging from 68 – 2000 mg/L as $CaCO_3$, and iron generally less than 0.3 mg/L (Miller *et. al.*, 1974). Recent sampling of the PWS wells, tabulated in Appendix W and summarized in Table 3-2, reflect the water quality expected from the Gasconade.

**Table 3-2. Raw Water Quality Summary of City of Eureka PWS Wells**

| CONSTITUENT | | RANGE | | STATISTICS | | RL[1] | MCL[2] |
|---|---|---|---|---|---|---|---|
| | | MIN | MAX | AVE. | ST. | | |
| **Field Parameters** | | | | | | | |
| Temperature | °C | n.t. | n.t. | n.t. | n.t. | | |
| pH [4] | | 6.79 | 6.99 | 6.90 | 0.09 | | |
| **Other Parameters** | | | | | | | |
| Solids, Total Dissolved | mg/L | 364 | 1430 | 941 | 359 | 10 | 500 [3] |
| Total Organic Carbon | mg/L | n.d. | n.d. | n.d. | n.d. | | |
| **General Chemistry** | | | | | | | |
| Alkalinity, as $CaCO_3$ | mg/L | 270 | 294 | 282 | 10 | 1.0 | |
| Calcium, total | mg/L | 74.3 | 95.2 | 85.1 | 8.0 | 0.05 | |
| Chloride | mg/L | 25 | 488 | 300 | 167 | 50 | 250 [3] |
| Fluoride | mg/L | 0.2 | 0.6 | 0.4 | 0.1 | 0.2 | 4.0 (2.0 [3]) |
| Hardness, Total as $CaCO_3$ | mg/l | 300 | 399 | 357 | 37 | 0.5 | |
| Iron, total | mg/L | n.d. | n.d. | n.d. | n.d. | | 0.3 [3] |
| Magnesium, total | mg/L | 27.3 | 39.3 | 35.0 | 4.5 | 0.05 | |
| Manganese, total | mg/L | n.d. | n.d. | n.d. | n.d. | | 0.05 [3] |
| Nitrogen, Ammonia | mg/L | n.d. | n.d. | n.d. | n.d. | | |
| Nitrogen, Nitrate as N | mg/L | n.d. | n.d. | n.d. | n.d. | 0.1 | 10 |
| Sulfide, total | mg/L | n.d. | n.d. | n.d. | n.d. | | |
| Sulfate | mg/L | 24.2 | 63.3 | 42.8 | 12.9 | 32.0 | 250 [3] |
| **Inorganics, Metals** | | | | | | | |
| Sodium, total [4] | mg/L | 29 | 222 | 142 | 84 | 0.5 | |
| **Radionuclides** | | | | | | | |
| Gross Alpha [4] | pCi/L | -0.30 | 6.76 | 3.00 | 2.85 | | 15 |
| Radium-226/228 [4] | pCi/L | 0.18 | 1.10 | 0.46 | 0.35 | | 5 |

n.t. = not tested n.d. = not detected[1]

1. Reporting Limit (RL) is the lowest detectable concentration of a constituent reportable by laboratory used.
2. Maximum Contaminant Level (MCL) is the highest level of contaminant allowed in drinking water in accordance with USEPA National Primary Drinking Water Standards.
3. Secondary Maximum Contaminant Levels (SMCLs) are non-enforceable USEPA guidelines regulating contaminants that may cause cosmetic effects or aesthetic effects in drinking water.
4. Data adapted from finished water quality data. Some results may be affected by treatment processes such as ion exchange softening, aeration, and iron/manganese removal. See Section 3.2.6 for discussion regarding the adjustment of sodium.

### 3.2.1. Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is a measure of the quantity of solids that are dissolved in the water. Dissolved solids include calcium, magnesium, sodium, bicarbonate, nitrate, sulfate, chloride, etc.

Elevated TDS concentrations are not a health hazard, but are regulated as a secondary standard due to aesthetic concerns. High TDS drinking water may have a salty or brackish taste, result in scale formation, and decrease the efficiency of hot water heaters and other home appliances. The secondary (non-health) standard for TDS concentration is 500 mg/L (USEPA, June 2003).

TDS concentrations in the source water samples (Table 3-2) vary from 364 - 1430 mg/L with an average of 941 mg/L, indicating that groundwater from most wells exceeds the secondary (non-health) standard. Ion exchange softening, which is the PWS's primary treatment process, cannot reduce TDS as two sodium cations (net weight of 45.98 mg/mol) are exchanged for every calcium (40.08 mg/mol) or magnesium (24.30 mg/mol) cation. Reduction of TDS is achieved by utilizing a lime or lime-soda ash softening process or a membrane process such as nanofiltration (NF), reverse osmosis (RO), or electrodialysis reversal (EDR).

### 3.2.2. Alkalinity and pH

Alkalinity represents the concentration of chemical species that have the ability to neutralize acid. Carbonates, bicarbonates, hydroxides, silicates, and phosphates are the major constituents of alkalinity in water. Sufficient concentrations are required to resist pH levels from declining as acidic chemicals are added, such as chlorine, during the treatment process. The principal source of alkalinity in natural waters is the dissolved carbon dioxide species, bicarbonate ($HCO_3^-$), and carbonate ($CO_3^{-2}$). Noncarbonate contributors to alkalinity include hydroxide, silicate, borate, and organic ligands (Hem, 1992).

Levels of pH describe the concentration of free hydrogen ions in the solution. High pH (>7) correlates to low levels of free hydrogen ions and is classified as a basic solution, while low pH (<7) correlates to high levels of free hydrogen ions and is classified as an acidic solution. A pH of 7 is considered neutral. Generally, as the pH of the water increases, the amount of corrosion in the system decreases. Caustic soda (NaOH) is typically used to increase the pH of treated water before entering the distribution system.

### 3.2.3. Hardness

Multivalent cations in water, such as calcium ($Ca^{+2}$) and magnesium ($Mg^{+2}$), will react with soap to form a hard-to-remove scum. Hardness is the parameter, usually reported as an equivalent quantity of calcium carbonate ($CaCO_3$), indicating the potential scale formation based on water quality data. Carbonate hardness refers to precipitation of multivalent cations with bicarbonate ($HCO_3^-$) and carbonate ($CO_3^{-2}$) anions. Non-carbonate hardness refers to precipitation of multivalent cations with other anions, generally chloride ($Cl^-$) and sulfate ($SO_4^{-2}$). Excessive

amounts of hardness in the water can result in high soap consumption and objectionable scale in heating vessels and pipes. Various degrees of hardness are presented in Table 3-3. There is no drinking water limit for hardness, and is non-health related.

**Table 3-3. Degrees of Hardness.**

| Hardness (as mg/L $CaCO_3$) | Soft | Slightly Hard | Moderately Hard | Hard | Very Hard |
|---|---|---|---|---|---|
| Water Quality Association (Trade Association) | < 17 | 17 - 60 | 60 - 120 | 120 - 180 | > 180 |
| U.S. Geological Survey (Briggs and Ficke, 1977) | 0 - 60 | - | 61 - 120 | 120 - 180 | > 181 |

The hardness in the source water samples (Table 3-2) classify the water as very hard. Reducing hardness to moderately hard to hard levels is often desired, but not required. A hardness target of 125 – 150 mg/L as $CaCO_3$ is ideal. Softening is achieved by utilizing a lime or lime-soda ash softening process, an ion exchange process, or a membrane process such as nanofiltration (NF), reverse osmosis (RO), or electrodialysis reversal (EDR). Eureka PWS utilizes a zeolite cation exchange process to soften water to an average hardness of approximately 100 mg/L as $CaCO_3$, with finished water ranging from 23 – 151 mg/L as $CaCO_3$ (Appendix W). Details of the PWS's treatment facilities are discussed in Section 3.3 below.

### 3.2.4. Chloride

Natural sources of chloride in surface and groundwater is rainfall and the weathering of evaporate deposits, marine sediments/rocks, and a few chloride-containing igneous minerals. Chloride is prevalent in common pollutants, such as municipal and industrial sewage, road salting, landfill leachate, and commercial brines. Chloride is highly soluble and there are few natural precipitating reactions. A secondary(non-health) standard of 250 mg/L is established to avoid taste issues (USEPA, June 2003). Chloride can also become a wastewater discharge concern when using membrane treatment technology as the element becomes highly concentrated in the membrane waste product.

Chloride concentrations in the source water samples (Table 3-2) vary from 25 - 488 mg/L with an average of 300 mg/L, suggesting that groundwater from most wells exceed the secondary standard. Along with taste issues, elevated chloride is associated with increased rates of metal corrosion, depending on the alkalinity of the water (i.e., Larson Index), resulting in increased metal concentrations in the drinking water (McNeill and Edwards, 2001).

### 3.2.5. Sulfate

Sulfate is dissolved from many rocks and soils in especially large quantities from beds of gypsum and shale. Also, it is formed by the oxidation of sulfides of iron (pyrite) and may be present in large quantities when source water is associated with coal deposits (Hem, 1992). Sulfate water that contains significant amounts of calcium and magnesium causes the formation of hard scale and may increase the cost of softening water. Because of these aesthetic concerns, sulfate is regulated as a secondary (non-health) standard. The secondary standard for sulfate is 250 mg/L (USEPA, June 2003). Sulfate has a laxative effect for visitors or individuals new to the area that consume water with elevated levels of sulfate. Sulfate can also become a wastewater discharge concern when using membrane treatment technology as the element becomes highly concentrated in the membrane waste product.

Sulfate levels in the source water samples (Table 3-2) are well below the secondary standard, so this constituent is unlikely to be a taste or odor concern. However, even low concentrations of sulfate can become a source of taste and odor with hot water heaters, especially with softened water (Hack, 1981). A common method used to provide cathodic protection in water heater tanks is a sacrificial anode rod made of either magnesium or zinc. The rod provides a source of electrons so that the sacrificial anode is corroded instead of the steel tank wall. Unfortunately, the rod becomes a source of electrons for sulfate-reducing bacteria, such as *Desulfovibrio desulfuricans*, which chemically reduce sulfates to sulfides. Sulfides, especially hydrogen sulfide, can be corrosive to plumbing and water-using appliances, create "black water", discolor silverware and utensils, and generates a foul odor. Most people can taste hydrogen sulfide in drinking water with concentrations as low as 0.05 mg/L and smelling it during a shower at concentrations as low as 0.1 mg/L. Drinking water with sulfide concentrations between 0.5 to 1.0 mg/L is generally described as "musty" or "swampy" with concentrations greater than 1.0 mg/L described as smelling like "rotten eggs".

### 3.2.6. Sodium

Sodium is a common constituent in igneous rocks, marine sedimentary rocks, and clays; leaching out of rocks over time (Hem, 1992). Once sodium is brought into solution there are few recourses for its removal. While monovalent sodium ($Na^{+}$) adsorbs onto mineral surfaces they cannot compete for cation-exchange sites as effectively as divalent cations like calcium ($Ca^{+2}$) or magnesium ($Mg^{+2}$).

There is no drinking water standard for sodium, although the U. S. Environmental Protection Agency (USEPA) added sodium to the Drinking Water Contaminant Candidate List (CCL) in

1998, instigating a regulatory determination. To date, the USEPA has declined to issue any regulation for sodium. Nevertheless, the agency did concur with American Heart Association's recommendation of 20 mg/L as a protective guidance level for persons with heart and circulatory diseases; determined that sodium concentrations in drinking water greater than 120 mg/L can have an effect on salt-hypertensives; and noted a taste threshold of 30 mg/L (USEPA, July 2003).

It is difficult to determine if sodium in the source water exceeds any of these health advisories, since the sodium data listed in Table 3-2 is adapted from the finished water quality data which has been altered by the PWS's ion exchange softening process. Sodium in the finished water ranges from 147 - 340 mg/L with an average of 260 mg/L (Appendix W). Approximately 0.46 mg/L of sodium is added to the water for every 1 mg/L as $CaCO_3$ of hardness removed by ion exchange. Therefore, reducing the average source water hardness of 357 mg/L as $CaCO_2$ to the recent target hardness of 100 mg/L as $CaCO_3$ would result in approximately 118 mg/L of sodium added to the water supply. These assumptions generate calculated source water sodium concentrations ranging from 29 – 222 mg/L with an average of 142 mg/L; exceeding the taste threshold and health advisory for salt-hypertensives before more sodium is added as part of the ion exchange softening process.

### 3.2.7. Radionuclides

Radionuclides are regulated by the USEPA with the standards as listed in Table 3-4 (USEPA, June 2003).

**Table 3-4. Final Radionuclide Standards.**

| Contaminant | Maximum Contaminant Level (MCL) |
|---|---|
| Gross Alpha | 15 pCi/L |
| Combined Radium 226/228 | 5 pCi/L |
| Uranium | 30 μg/L |
| Beta Particle and Photon Radioactivity (Gross Beta) | 4 mrem/yr |

The finished water samples (Table 3-5) do not exceed the radionuclide primary standards. Radionuclides are reduced by the ion exchange softening process utilized by the PWS. Eureka Well No. 10 raw water (prior to treatment) exceeded the gross alpha particle activity MCL of 15 pCi/L one time in the past, reporting as high as 25 pCi/L in April 2009. This exceedance, along with the observation of other wells in the same aquifer having elevated radionuclides (GBA,

2011), was part of the justification for installation of ion exchange softeners at the well sites since the USEPA considers ion exchange a "best available technology" for small systems needing to reduce radionuclide concentrations. (USEPA, 2005).

## 3.3. Water Treatment Facilities

Each well location is equipped with a building housing water treatment equipment to soften, disinfect, and fluoridate the groundwater before entry into the Eureka PWS distribution system. Softening is provided by a zeolite cation exchange system that consists of two (2) ion exchange vessels that are regenerated by a brine feed system which includes brine pumps and a brine storage tank. A by-pass valve allows operators to control the finished hardness by blending raw water with softened water to achieve the PWS's expressed intentions to operate with a target hardness of 171 mg/L as $CaCO_3$ (10 grains per gallon). The blended water is disinfected with a hypochlorite solution that is electrochemically generated, at each site, from brine by using MIOX® on-site chemical generators. The hypochlorite solution is dosed so that a minimum free chlorine residual of 1.0 mg/L is provided to the distribution system. After the disinfectant, hexafluorosilicic acid (HFS) is added to the finished water for dental health. Targeting an optimal fluoride dose of 0.7 mg/L in drinking water is believed to reduce the incidence of dental caries in communities with inadequate oral hygiene.

Finished water from each water treatment plant (WTP) is delivered into the PWS's distribution system. The WTPs associated with Eureka Wells 1, 5, and 10 deliver finished water directly into the distribution system whereas the WTPs associated with Eureka Wells 6, 8, and 9 deliver finished water into on-site ground storage tanks for repumping into the distribution system. A discussion of the storage tanks, the booster pump stations, and the distribution system may be found in Section 3.4. A summary of the finished water quality leaving the WTPs is provided in Table 3-5.

**Table 3-5. Finished Water Quality Summary of City of Eureka PWS WTPs**

| CONSTITUENT | | RANGE | | STATISTICS | | RL[1] | MCL[2] |
|---|---|---|---|---|---|---|---|
| | | MIN | MAX | AVE. | ST. | | |
| **Field Parameters** | | | | | | | |
| Temperature | °C | n.t. | n.t. | n.t. | n.t. | | |
| pH | | 6.79 | 6.99 | 6.90 | 0.09 | | |
| **Other Parameters** | | | | | | | |
| Solids, Total Dissolved | mg/L | 404 | 1110 | 802 | 225 | 10 | 500 [3] |
| Total Organic Carbon | mg/L | n.d. | n.d. | n.d. | n.d. | | |
| **General Chemistry** | | | | | | | |
| Alkalinity, as $CaCO_3$ | mg/L | 268 | 305 | 285 | 12 | 1.0 | |
| Calcium, total | mg/L | 5.6 | 33.4 | 22.1 | 9.1 | 0.05 | |
| Chloride | mg/L | 34 | 487 | 284 | 146 | 50 | 250 [3] |
| Fluoride | mg/L | 0.4 | 0.8 | 0.6 | 0.1 | 0.2 | 4.0 (2.0 [3]) |
| Hardness, Total as $CaCO_3$ | mg/l | 23 | 151 | 96 | 41 | 0.5 | |
| Iron, total | mg/L | n.d. | n.d. | n.d. | n.d. | | 0.3 [3] |
| Magnesium, total | mg/L | 2.3 | 16.8 | 10.0 | 4.6 | 0.05 | |
| Manganese, total | mg/L | n.d. | n.d. | n.d. | n.d. | | 0.05 [3] |
| Nitrogen, Ammonia | mg/L | n.d. | n.d. | n.d. | n.d. | | |
| Nitrogen, Nitrate as N | mg/L | n.d. | 0.63 | 0.34 | 0.30 | 0.1 | 10 |
| Sulfide, total | mg/L | n.d. | n.d. | n.d. | n.d. | | |
| Sulfate | mg/L | 24.2 | 64.1 | 43.0 | 12.7 | 32.0 | 250 [3] |
| **Inorganics, Metals** | | | | | | | |
| Sodium, total | mg/L | 147 | 340 | 260 | 84 | 0.5 | n/a |
| **Radionuclides** | | | | | | | |
| Gross Alpha | pCi/L | -0.30 | 6.76 | 3.00 | 2.85 | | 15 |
| Radium-226/228 | pCi/L | 0.18 | 1.79 | 0.89 | 0.55 | | 5 |
| **Disinfection By-Products** | | | | | | | |
| TTHMs | µg/L | 0.7 | 13.8 | 3.7 | 5.0 | 0.5 | 80 |
| HAA5s | µg/L | n.d. | 1.7 | 0.9 | 0.8 | 1.0 | 60 |

n.t. = not tested n.d. = not detected[1]

1. Reporting Limit (RL) is the lowest detectable concentration of a constituent reportable by laboratory used.
2. Maximum Contaminant Level (MCL) is the highest level of contaminant allowed in drinking water in accordance with USEPA National Primary Drinking Water Standards.
3. Secondary Maximum Contaminant Levels (SMCLs) are non-enforceable USEPA guidelines regulating contaminants that may cause cosmetic effects or aesthetic effects in drinking water.

## 3.4. Distribution System

The Eureka PWS has a relatively new distribution system, consisting of eight (8) pressure zones with over 60-miles of mostly 2″ – 12″ PVC and 4″ – 8″ Transite piping (MoDNR, 2016). A minimum system pressure of 50-psi is supplied in each pressure zone by eight (8) booster pump stations (BPSs). Each BPS draws from one of seven (7) ground storage tanks, except for the Emerald View BPS which acts as an in-line booster. A summary of distribution system components is tabulated in Table 3-6. Figure 3-2 shows a map of the well, storage tank, and booster station locations. Water quality of the final product delivered to customers is discussed in Section 3.5 below.

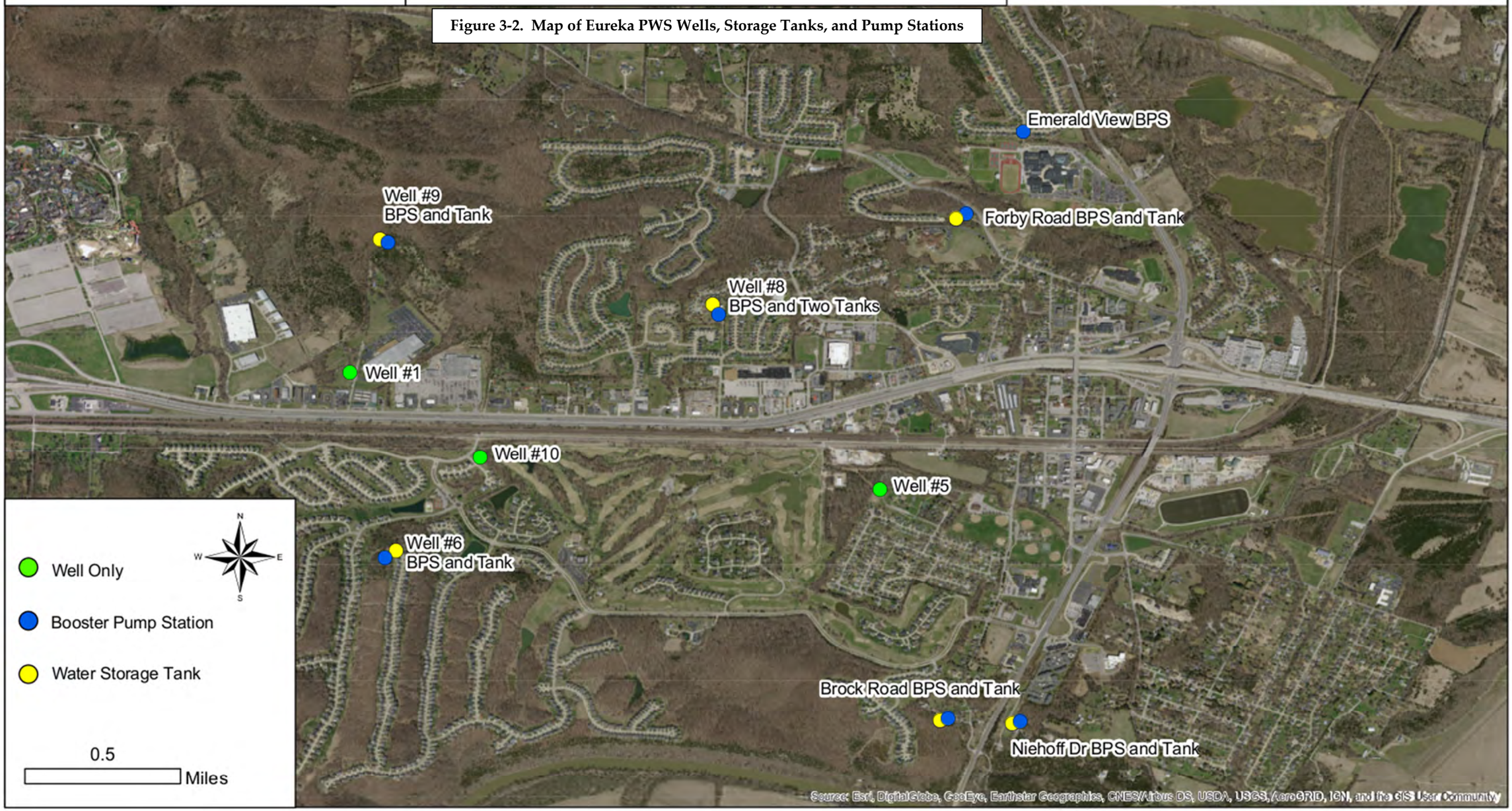
**Table 3-6. Summary of Eureka PWS Pressure Zones, Storage Tanks, and Pump Stations**

| Pressure Zones | | | Ground Storage Tanks | | Booster Pump Stations | |
|---|---|---|---|---|---|---|
| Name[1] | Tank / BPS Location | Source[2] (Typical) | Dimensions (ft H x ft D) | Volume (gal) | | Discharge (psi) |
| Palasades / Brock | 109 Brock Rd. | 1, 5, & 10 | 40 x 46 | 500,000 | | 108 |
| Legends | 503 Vista Hills Ct. | 6 (Plant) | 40 x 47 | 500,000 | | 112 |
| Old Viola | 687 Viola Ln. | 8 (Plant) | 32 x 52 | 500,000 | | 62 |
| New Viola | 687 Viola Ln. | 8 (Plant) | 32 x 33 | 250,000 | | 110 |
| Arbors | 739 Brewster Rd. | 9 (Plant) | 20 x 69 | 500,000 | | 95 |
| Augustine / Niehoff | 765 Niehoff Dr. | 5,10 | 60 x 37 | 500,000 | | 60 |
| Forby | 360 Forby Rd. | 1, 5, & 10 | 40 x 46 | 500,000 | | 61 |
| Emerald View | 4589 Emerald View Ct. | 1, 5, & 10 | - | - | | 108 |
| | | | **Totals** | **3,250,000** | | |

1. Pressure zone name derived from a significantly served subdivision or from the location of the booster pump station.
2. Eureka PWS Well(s) that commonly serve the pressure zone.

| City of Eureka, MO | Bartlett & West | PN: 19500.000<br>March 2018 |
|---|---|---|

Figure 3-2. Map of Eureka PWS Wells, Storage Tanks, and Pump Stations



## 3.5. Finished Water Quality

### 3.5.1. Total Dissolved Solids (TDS)

As discussed in Section 3.2.1 above, the PWS's primary treatment process cannot reduce elevated levels of TDS in the source water. High TDS drinking water may have a salty or brackish taste, result in scale formation, and decrease the efficiency of hot water heaters. Since reduction of TDS is achieved by utilization of a lime softening or a membrane processes, it will not be possible to address any TDS related water quality concerns without a change to the current water treatment approach. Appendix R includes a short summary related to implementation of Reverse Osmosis treatment for the PWS.

### 3.5.2. Chloride and Sodium

As discussed in Section 3.2.4 above, chloride concentrations in the source water generally exceed the secondary drinking water standard (non-health), existing at concentrations associated with taste issues and increased rates of metal corrosion. Outside of membrane softening, few water treatment processes reduce chloride concentration. Therefore, the zeolite cation exchange process used by the PWS cannot address any chloride related water quality concerns.

As discussed in Section 3.2.6 above, sodium concentrations in the source water generally exceed the taste threshold and health advisory for salt-hypertensives. The cation exchange process used by the PWS adds approximately 0.46 mg/L of sodium to the water for every 1 mg/L as $CaCO_3$ of hardness removed, resulting in a finished water with sodium concentrations ranges from 147 - 340 mg/L with an average of 260 mg/L (Appendix W). Outside of membrane softening, few water treatment processes reduce sodium concentration. Therefore, the zeolite cation exchange process used by the PWS cannot address any sodium related water quality concerns.

### 3.5.3. Alkalinity, Hardness, pH, and Corrosion Indices

Corrosion is a complex series of oxidation/reduction reactions that return refined or processed metal into a stable ore state. Corrosion will occur wherever a galvanic cell can be established. This can occur because of a direct connection of two dissimilar metals or an indirect connection through an electrolyte such as water. In the context of drinking water distribution systems, corrosion occurs between the carried product (drinking water) and the wetted surface of carrier material (pipe, valve, meter, etc.) A drinking water is referred to as corrosive if its chemical characteristics promote galvanic activity, such as: dissolution of protective barriers on metallic surfaces, preventing the formation of passivating films, and insufficient suppression of microbial growth. While there is no single indicator of a water's corrosive tendencies, there is a collection

of correlative indices that can be aggregated to provide a preponderance of evidence for or against corrosive tendencies. Many of these indices are built around lab and field observations associated with alkalinity, hardness, and pH.

1. The Langelier Index (LI) is an equilibrium model that indicates the saturation of water with respect to calcium carbonate by utilizing water temperature, ionic strength, calcium hardness, total alkalinity, and pH. The LI can be interpreted as the pH change required to bring water to calcium carbonate equilibrium. The LI is probably the most widely used indicator of corrosion or scale potential. It is purely an equilibrium index and deals only with the thermodynamic driving force for calcium carbonate scale formation and growth. It provides no indication of how much scale will form or calcium carbonate will precipitate to bring water to carbonate equilibrium.

**Table 3-7. Langelier Index (LI) Values and Predicted Effects.**

| LI Value | Predicted Effect |
|---|---|
| Positive | Water is "nonaggressive" and scale can form. |
| Close to Zero | Borderline scale/dissolution potential. Changes in temperature could change the index. |
| Negative | Water is "aggressive" and may dissolve scale and cement linings. |

2. The Calcium Carbonate Precipitation Potential (CCPP) is a calculation using calcium hardness, total alkalinity, dissolved inorganic carbon, and pH to determine the amount of calcium carbonate that could theoretically precipitate. Water oversaturated with calcium carbonate will have a positive CCPP and a negative CCPP if undersaturated. The CCPP provides a theoretical indication of how much scale could form (or dissolve) to bring the water to carbonate equilibrium. A common guidance for water treatment facilities is to produce a finished water with CCPP between 0 – 10 mg/L $CaCO_3$ to encourage the development of a thin protective scale inside distribution piping without contributing to excessive scale deposition.

3. The Aggressiveness Index (AI) was originally developed for monitoring the aggressiveness of water in asbestos-cement pipe to either deposit a protective scale or to dissolve the pipe's cement. The AI is a simplified version of the LI, looking only at calcium hardness and total alkalinity.

**Table 3-8. Aggressiveness Index (AI) Values and Predicted Effects.**

| AI Value | Predicted Effect |
|---|---|
| ≥ 12 | Water is "nonaggressive" and scale may form. |
| 10 – 11.9 | Water is "moderately aggressive" toward scale and cement. |
| < 10 | Water is "extremely aggressive" toward scale and cement. |

4. The Ryznar Stability Index (RSI) attempts to correlate an empirical database of scale thickness observed in municipal water systems to the system's water quality. Like the LI, the RSI utilizes water temperature, ionic strength, calcium hardness, total alkalinity, and pH to calculate calcium carbonate saturation.

**Table 3-9. Ryznar Stability Index (RSI) Values and Predicted Effects.**

| RSI Value | Predicted Effect |
|---|---|
| < 6.2 | Scale tendency of water increases as the index decreases. |
| 6.2 – 6.8 | Scale formation may create a protective corrosion inhibitor film. |
| 6.8 – 7.5 | Insufficient scale formation to create a protective corrosion inhibitor film. |
| > 7.5 | Mild steel corrosion becomes an increasing problem. |

5. The Larson-Skold Index (LSI) describes the corrosivity of water towards mild steel based upon evaluation of in-situ corrosion of steel lines in moderately alkaline Great Lakes waters. The index is a ratio of sulfate and chloride to total alkalinity (Larson and Skold, 1958).

**Table 3-10. Larson-Skold Index (LSI) Values and Predicted Effects.**

| RSI Value | Predicted Effect |
|---|---|
| < 0.8 | Chlorides and sulfate unlikely to interfere with natural film formation. |
| 0.8 – 1.2 | Higher than desired corrosion rates due to interference with natural film formation. |
| > 1.2 | A tendency toward high corrosion rates. |

6. The Chloride-to-Sulfate Mass Ratio (CSMR) is based on observations of lab-synthesized drinking waters in contact with lead and copper materials. The observations suggest an

important relationship between the ratio of chloride-to-sulfate and the galvanic corrosion of lead. High concentrations of chloride relative to sulfate (CSMR > 0.5) tend to result in increased galvanic corrosion of lead solder connected to copper pipe (Edwards & Triantafyllidou, 2007).

To ascertain the corrosive tendencies of Eureka PWS's raw and finished, the water quality data collected in Appendix W was entered into a water quality modeling program. The results, presented in Table 3-11, indicate the well/WTP sampled, the date sampled, and a color-coded output of modeled corrosion indices. Indices suggesting a moderately aggressive water are colored red. Indices suggesting a strongly aggressive water are bolded and colored red.

**Table 3-11. Modeled Corrosivity Indices Without any Additional Treatment.**

| Sample Information | | Modeled Water Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Name / ID | Date | $CO_2$ (mg/L) | Aggressive Index | Ryznar Index | Langelier Index | CCPP mg/L | Larson-Skold | CSMR |
| | | | | | | | | |
| Eureka Well #1, Raw | 10/24/17 | 83.8 | 11.5 | **7.87** | -0.54 | -69.7 | 0.82 | 5.96 |
| Eureka Well #5, Raw | 10/24/17 | 95.8 | 11.6 | **7.70** | -0.45 | -65.9 | 0.39 | 7.71 |
| Eureka Well #6, Raw | 10/24/17 | 53.2 | 11.7 | **7.52** | -0.26 | -28.3 | 0.41 | 10.21 |
| Eureka Well #8, Raw | 10/24/17 | 52.6 | 11.7 | 7.43 | -0.22 | -23.0 | 0.57 | 6.57 |
| Eureka Well #9, Raw | 10/24/17 | 57.6 | 11.7 | 7.29 | -0.14 | -15.7 | **4.92** | 1.01 |
| Eureka Well #10, Raw | 10/24/17 | 74.1 | 11.7 | **7.55** | -0.33 | -41.9 | 0.56 | 7.51 |
| | | | | | | | | |
| Eureka Well #1, Finished | 05/22/17 | 92.4 | 11.2 | **8.41** | -0.80 | -89.2 | 1.05 | 5.31 |
| Eureka Well #1, Finished | 10/24/17 | 88.1 | 11.0 | **8.74** | -0.97 | -94.8 | 0.83 | 5.94 |
| | | | | | | | | |
| Eureka Well #5, Finished | 05/22/17 | 103 | 10.4 | **10.09** | **-1.65** | -125 | 0.56 | 5.27 |
| Eureka Well #5, Finished | 10/24/17 | 96.0 | 11.1 | **8.75** | -0.98 | -106 | 0.39 | 7.80 |
| | | | | | | | | |
| Eureka Well #6, Finished | 05/22/17 | 52.2 | 11.1 | **8.71** | -0.86 | -63.5 | 0.40 | 9.96 |
| Eureka Well #6, Finished | 10/24/17 | 53.0 | 11.2 | **8.53** | -0.77 | -60.7 | 0.40 | 10.33 |
| | | | | | | | | |
| Eureka Well #8, Finished | 05/22/17 | 54.6 | 11.0 | **9.01** | **-1.00** | -67.5 | 0.60 | 5.93 |
| Eureka Well #8, Finished | 10/24/17 | 53.1 | 11.3 | **8.23** | -0.61 | -51.8 | 0.58 | 6.48 |
| | | | | | | | | |
| Eureka Well #9, Finished | 05/22/17 | 58.1 | 11.2 | **8.35** | -0.67 | -53.5 | **3.17** | 2.02 |
| Eureka Well #9, Finished | 10/24/17 | 58.1 | 11.1 | **8.42** | -0.71 | -54.5 | **4.03** | 1.42 |
| | | | | | | | | |
| Eureka Well #10, Finished | 05/22/17 | 74.6 | 10.6 | **9.80** | **-1.45** | -96.5 | 0.57 | 6.90 |
| Eureka Well #10, Finished | 10/24/17 | 73.4 | 11.2 | **8.55** | -0.82 | -78.9 | 0.57 | 7.28 |
| | | | | | | | | |

Inspection of Table 3-11 indicates that the groundwater from all six wells is moderately to strongly aggressive toward carbonate equilibrium (AI, LI, RSI) as well as galvanic corrosion (LSI, CSMR). Typical of ion exchange softening, the treated water leaving the WTPs becomes notably more aggressive with respect to carbonate equilibrium. One approach to establishing carbonate

equilibrium is pH adjustment which can be accomplished by aeration ($CO_2$ removal) or chemical addition. This approach is discussed further in Section 5.3.3.

### 3.5.4. Sulfate, Softened Water, and Sulfide Generation

As discussed in Section 3.2.5 above, the cathodic protection of water heaters can encourage the growth of sulfate-reducing bacteria, resulting in the generation of corrosive and odorous sulfides within customer's piping. While this phenomenon can occur even in very hard water, it can be exacerbated by softened water if a thin protective mineral coating is unable to form on metallic surfaces.

### 3.5.5. Disinfection By-Products

While disinfectants are effective in controlling many microorganisms, they react with natural organic and inorganic matter in source water and distribution systems to form disinfection by-products (DBPs). A running annual average (RAA) of regulated DBPs is included in Appendix W. Currently there are no DBP concerns since the maximum detected concentration of TTHMs was 0.018 mg/L is well below the MCL of 0.080 mg/l, and no HAA5s have been detected.

### 3.5.6. Lead and Copper

In 1991, the USEPA promulgated the Lead and Copper Rule (LCR) to control lead and copper in drinking water. Minor revisions to the LCR monitoring and reporting process occurred in 2000 and 2004 with additional implementation requirements promulgated in 2007. The LCR requires systems to monitor drinking water at customer taps. If more than 10% of customer taps sampled have lead concentrations exceeding an action level of 15 µg/L or copper concentrations exceeding an action level of 1.3 mg/L, the system must undertake additional actions to control corrosion as well as inform the public about steps they should take to protect their health. Often the solution involves customers replacing lead service lines, replacing lead soldered plumbing, and removing electrical ground connections on water pipes.

Examination of Eureka PWS's 2016 Annual Water Quality Report and data from the PWS's LCR sampling results (Appendix W) indicate that sampled lead concentrations ranged from 2.06 – 39.6 µg/L, with 90% of samples less than 6.67 µg/L, and sampled copper concentrations ranged from 0.0412 – 0.472 mg/L, with 90% of samples less than 0.178 mg/L. The PWS is in compliance with lead and copper requirements.

# Section 4. CURRENT CONCERNS

## 4.1. Stagnation in Ground Storage Tanks

Eureka PWS operators have observed static condensation lines on the outsides of several ground storage tanks during the summer. This may indicate thermal stratification is occurring inside of the tank, where a layer of isolated, stagnant water floats on top of the fresh water delivered during the tank's fill cycles. When stratification occurs in the summer the warmer stagnant layer can promote the loss of disinfectant residual, accelerate the development of DBPs, and encourage biological growth (biofilm, insects, and crustaceans) in the tank. Tank stratification can result in regulatory violations and the development of aesthetic problems like taste and odor complaints. The primary solution to stagnation is improving mixing efficiency which is discussed in Section 5.2 below.

## 4.2. Aesthetic Complaints (Taste & Odor and Corrosion) from Customers

Over the years, Eureka PWS has received aesthetic complaints from all over the distribution system: taste and odor and excessive household piping corrosion. As part of the due diligence leading up to this report, Eureka PWS provided Bartlett & West with a list of homes representing several distribution pressure zones associated with aesthetic complaints. A drinking water survey was created and sent to every resident on the list. With a 89% response rate, the survey data is summarized in Appendix D. A majority (73%) of surveyed customers responded with a belief that aggressive (corrosive) drinking water was responsible for replacement of water-using appliances and household plumbing repairs. Of those surveyed (47%) noticed some form of unpleasant taste and (20%) noticing some form of unpleasant odor. Three-quarters of the taste and odor concerns were from respondents living south of I-44.

# Section 5. ALTERNATIVES

## 5.1. No Action

As outlined in Section 4 above, the Eureka PWS has identified two significant concerns they desire to resolve: storage tank stagnation and aesthetic complaints. There are no regulatory or health concerns, so inaction is a plausible alternative. Regarding the aesthetic complaints, analysis of raw and finished water quality (Section 3.2 and Section 3.5) suggests that taste, odor, and corrosion concerns will continue to be a problem for the PWS, unless changes are made to the treatment process. Chloride, sodium, total dissolved solids (TDS), and the tendency for the drinking water to act aggressively toward piping materials are likely the primary cause of the aesthetic complaints. While these conditions cannot be completely resolved without altering the treatment process, measures discussed within this Section can be taken to improve the aesthetic quality of the drinking water. A proactive approach to resolving drinking water quality concerns is a recommended approach.

## 5.2. Reduce Water Age

Beyond the source water and the treatment processes, the water distribution system is the next component of a drinking water system that can affect water quality. The time it takes for drinking water to travel from source to consumers is called water age – it is influenced by system flow velocities, pipe lengths, and storage volumes. Water age has regulatory implications as several reactions, such as DBP formation, can require days in a distribution system to develop; disinfection residuals must be maintained to the most remote areas of a distribution system. Water age can also have aesthetic implications as it relates taste and odor nuisances. Water age in distribution system can be minimized by managing the residence time of water within storage tanks and by enacting a frequent flushing program.

### 5.2.1. Increase Tank Replenishment

While each storage facility should be evaluated individually for its given turnover goal, a starting recommendation is for water systems to operate with a 3 – 5 day complete water turnover (Kirmeyer *et. al.*, 1999). With 3.25 million gallons of storage in the distribution system and an average daily production of 1.7 MGD a complete stored water turnover should occur every 2 days. Nonetheless, this replenishment rate may not hold true for every pressure zone. Therefore, it is recommended that PWS operators examine the demands of each pressure zone and adjust storage levels so that a complete water turnover occurs in each pressure zone every 3 – 5 days. One method is fluctuating the water levels more in the tank, increasing the measure between the

low-water level "turn-on" and the high-water level "turn-off." Another method is to lower both the low-level and high-level water levels so that less water is stored, although adequate storage volume must be maintained for emergency situations and fire protection.

### 5.2.2. Flushing Program

Dead-end water lines and oversized water mains can develop stagnant conditions that promote bacterial growth, resulting in the loss of disinfectant residuals and other water quality problems. These problems can proliferate into other areas of the distribution system, making it difficult to pinpoint the primary problem areas. Many water systems establish a distribution system flushing program to address biofilm, microbial growth, and tuberculation problems in distribution system mains. Unidirectional flushing at relatively high velocities (≥ 6 feet per second) can remove material from smooth pipe surfaces, however flushing is less effective in cleaning heavily tuberculated pipe and large diameter pipes (≥ 12 inches) that may require pigging or swabbing (Miller *et. al.*, 2013). Conventional flushing can be employed, when unidirectional flushing is unavailable or ineffective velocities would be reached, to encourage the circulation of fresh water in the distribution system, reducing the overall average water age of the system.

Once a year, either in the spring or fall, the Eureka PWS exercises a distribution flushing protocol targeting dead end lines (MoDNR, 2016). The PWS is also planning a more comprehensive main flushing program. As part of this planning, it is recommended that the PWS develop a model of its distribution system. Distribution models are an invaluable tool for identifying low-use areas with high water age, identifying valving needs for unidirectional flushing, quantifying a recommended flushing frequency, and quantifying the length of flushing necessary (at least three pipelines of water volume) for conventional flushing.

It is recommended that monitoring and testing be made part of any flushing program to create a quantitative metric to gauge the success of the flushing program. Water quality parameters of concern should be measured in the distribution system before and after flushing. Disinfectant levels and turbidity should be monitored during unidirectional flushing to ensure that they have returned to baseline levels before terminating any single flush (Miller *et. al.*, 2013).

It is also recommended to include storage tanks in the flushing program, with flushing scheduled in early summer (McCool, 2008), as tank flushing typically provide better results over "chasing" water quality problems in the distribution system. Tanks can be overfilled until overflowing water has a disinfectant residual equal to the incoming fresh water. Tanks can also be "dumped" using a nearby discharge hydrant.

### 5.2.3. Active Water Storage Tank Mixing

Active mixing systems consist of mechanical mixing components that continuously operate to prevent stratification from forming in a storage tank. One type of mechanical mixer is an impeller-type mixer that sits at the base of the tank and circulates the water throughout the tank. A second type of mixer utilizes an air compressor and air bubbler technology to inject an air stream into the tank, inducing mixing as well as providing air stripping of DBPs and VOCs. There are also electrically powered direct flow mixers that pull from the floor of the tank and direct a "sheet" of water to the surface, creating an induced mixing flow in the tank.

| Active Water Storage Tank Mixing | |
|---|---|
| Advantages | Disadvantages |
| Continuous mixing | Higher installation and operational costs |
| Installation through hatches w/o taking tanks out of service | More moving parts; more maintenance |

An example of an impeller-type mixer is the proprietary, active submersible mixing system by PAX Water Technologies™ for potable water tanks (Appendix E). The mixer sits on a tripod at the base of the tank (Figure 5-1) and is electrically powered by an externally mounted power supply. PAX Water Technologies™ also offers a solar powered unit. The mixer can be installed without taking the tank out of service by either lowering the unit through a hatch or by using a diver.

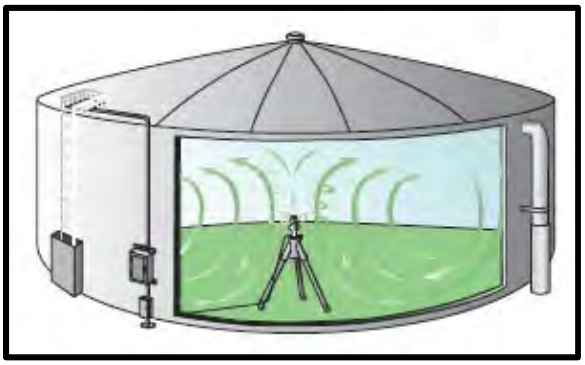


**Figure 5-1. PAX Water Technologies™ Submersible Mixer.**

An example of a direct flow mixer is the proprietary GridBee® mixer system by the Medora Corporation (Appendix E). The mixer has a tubular shape (Figure 5-2) and sits on the floor of the tank with its endplate inlet 2-inches off the tank floor. Powered by a standard 110-volt, 0.5-horsepower (hp) pump, water ejects from the outlet nozzle slot along the top of the unit to create a constant "sheet" of water moving to the surface. The constant flow induces mixing in the entire

tank. The mixer can be installed while the tank is in service by dropping it through a hatch (12-inches or larger) with a retrieval chain.

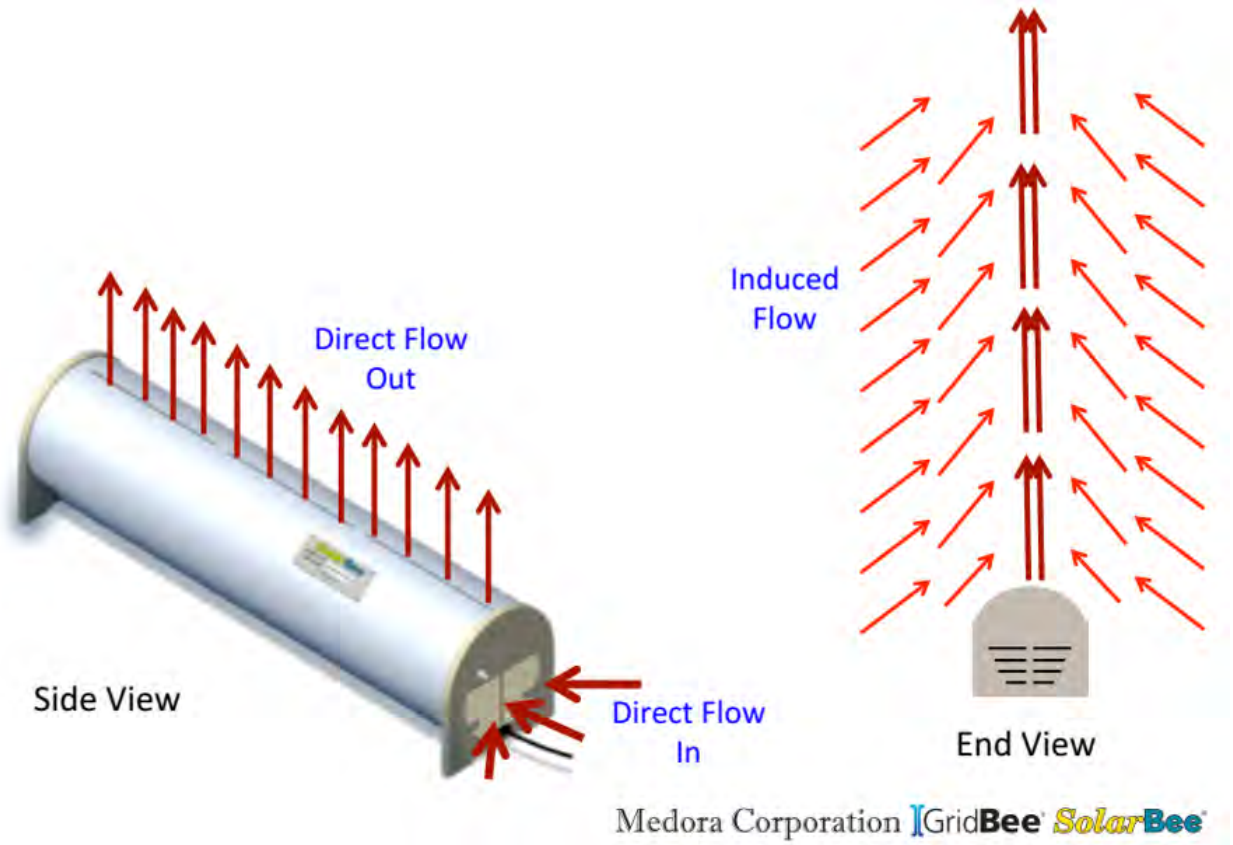



**Figure 5-2. GridBee® Submersible Mixer by the Medora Corporation.**

Active mixing provides the advantage of continuously mixing stored water, minimizing the residence time of water within storage tanks and preventing stratification. Therefore, it is recommended that the PWS consider installing active mixing in each ground storage tank. Although there are other active mixing devices available in the marketplace, the abovementioned mixers offered by PAX Water Technologies™ and the Medora Corporation can be installed while storage tanks remain in service.

### 5.2.4. Construction Costs to Reduce Water Age

Increasing tank replenishment, developing a distribution model, and developing a robust distribution flushing plan are planning and operational activities with no direct construction costs. Based on information provided by the supplier, the probable cost for a GridBee® GS-9 unit is around $7,000 per tank. The mixers can be installed by the supplier (for additional cost), but the mixers can also be installed by local contractors or even PWS staff. The probable cost of mixer

installation, including the addition of a 120-volt electrical circuit, is between $10,000 to $12,000 per tank.

### 5.2.5. OMR&R Costs to Reduce Water Age

Increasing tank replenishment, developing a distribution model, and developing a robust distribution flushing plan are planning and operational activities that will no doubt require PWS staff time as well as engineering support. Conversations with active mixer suppliers suggest an annual operation and maintenance (O&M) cost of $200 - $500 per million gallons of storage.

## 5.3. Corrosion Control

### 5.3.1. Tighter Operation of Softening Goal

Although the PWS has expressed intentions to operate the softeners with a target hardness of 171 mg/L as $CaCO_3$ (10 grains per gallon), collected data (Appendix W) indicates the actual finished water hardness ranges from 23 – 151 mg/L as $CaCO_3$ (1.3 – 8.8 grains per gallon) with an average hardness around 100 mg/L as $CaCO_3$ (5.8 grains per gallon). Considering that groundwater from all six wells is already moderately to strongly aggressive before softening and that the softening process creates a more aggressive water, it is critical that PWS operators maintain a target hardness of 171 mg/L as $CaCO_3$ (10 grains per gallon) at every WTP. It is recommended that operators regularly monitor the finished water hardness leaving each WTP and make the necessary adjustment to the softening bypass to maintain the target hardness. Each plant is equipped with a Hach APA 6000 on-line hardness analyzer, that is connected to the PWS instrumentation and control system It is recommend that an alarm be added to indicate when the finished water hardness false below a set value, such as 150 mg/l.

### 5.3.2. Customer Education

The ion exchange softening system at the WTPs did not go online until 2013, so it is possible that many businesses and homes served by the Eureka PWS continue to use point-of-use water softening systems. It is also possible that these point-of-use softeners have not been set to reflect the PWS's incoming softened water. This could result in an already aggressive water being over-softened to an even more aggressive and brackish tasting water. Maintaining the uncontentious position of "neither recommending or discouraging the use of point-of-use softeners" is recommended, however that does not preclude the PWS from educating customers about the advantages and disadvantages of further softening their drinking water. It is not uncommon for municipal water utilities to biennially publish a "Hard vs. Soft Water" article in their monthly billing newsletter that defines hardness, explains how the system already softens the source

water, recognizes that modern appliances may have softened water requirements, and communicates the adverse health consequences of over-softened water.

### 5.3.3. pH Adjustment by Aeration

As mentioned in Section 3.5.3, the Langelier Index (LI) can be interpreted as the pH change required to bring water to calcium carbonate equilibrium. A review of calculated LIs for the WTP finished waters on Table 3-11 indicates that corrosion potential could be reduced by simply raising the pH of the finished water. There are two common methods of increasing pH: aeration and chemical addition. Aeration will be discussed in this subsection with chemical addition address in Section 5.3.4 below.

Because it is a gas dissolved in water, carbon dioxide ($CO_2$) can be stripped from water through aeration. The removal of $CO_2$ from water results in a change to the water's carbonate equilibrium, causing an increase in the pH of the water. Aeration is a common post-treatment process used after ion exchange and membrane softening processes to reduce the aggressiveness (corrosivity) of finished drinking water. Aeration is often coupled with the addition of caustic chemicals (sodium hydroxide, soda ash, etc.) to achieve an optimal pH – the aeration step reducing the quantity of chemicals needed to achieve the pH goal. Based on the calculated $CO_2$ content of finished waters (Table 3-11), aeration appears to be a reasonable option for the Eureka PWS, to accomplish some of the pH adjustment.

For Eureka WTP sites with on-site storage tanks, Medorda Corporation has an in-tank aeration system (GridBee® In-Tank THM/VOC Removal System) developed to remove THMs and VOCs by aeration. In general, the system consists of an in-tank low head pump to bring water from the bottom of the tank up through spray nozzles at the water surface. The pump runs continuously to aerate the water as well as providing some level of tank mixing. If needed, an in-tank mixer can also be included. Conversations with the manufacture indicate the THM/VOC removal system would be able to remove approximately 50% of the dissolved $CO_2$. For Eureka PWS's tank, the aeration system would utilize a 15-hp motor as well as a 2-hp blower mounted on the top of the tank. The blower forces air into the tank with the air escaping out through the tank vent, creating air movement to remove the degassed $CO_2$ from the tank headspace. Figure 5-3 depicts the GridBee® in-tank aeration unit with additional information in Appendix E. The probable equipment cost for a GridBee® SN15 unit, installed by the manufacture, is $93,000 per tank.

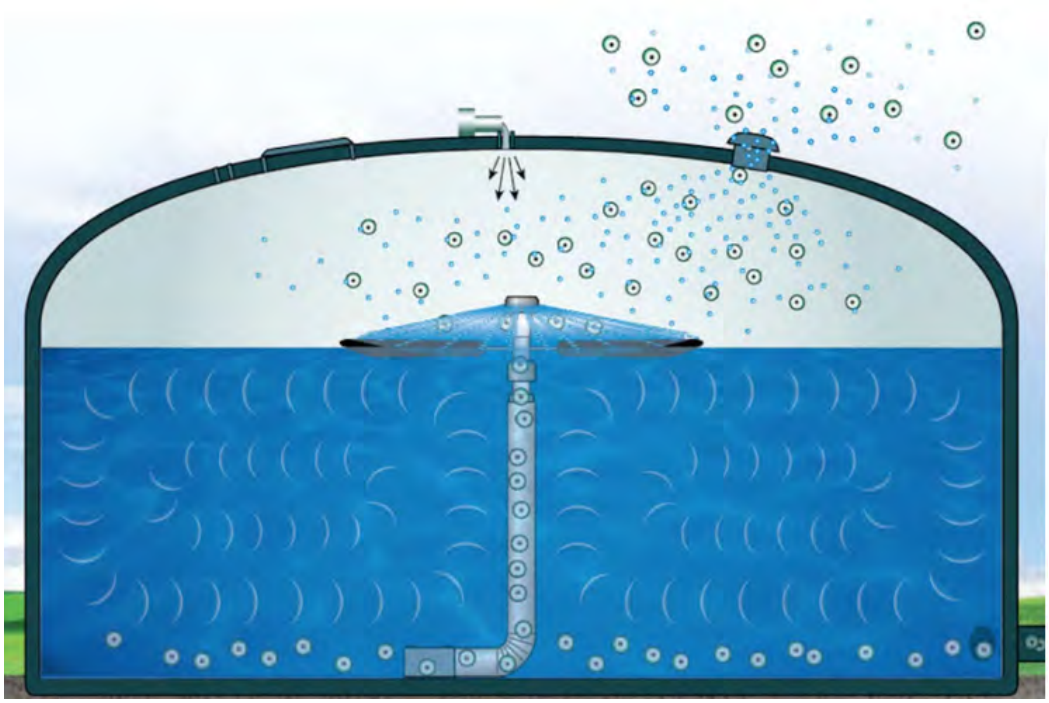


**Figure 5-3. GridBee® THM/VOC Removal System, In-Tank Aeration Unit.**

For aeration to be effective in removing $CO_2$, it is critical that all the water from the WTP first pass through the in-tank aeration unit before the addition of any caustic chemicals or delivery to the distribution system. Discussion with PWS staff indicate that WTP sites with on-site storage tanks operate in this recommended flow pattern. A schematic drawing of this addition to the treatment process is shown in Figure 5-4.

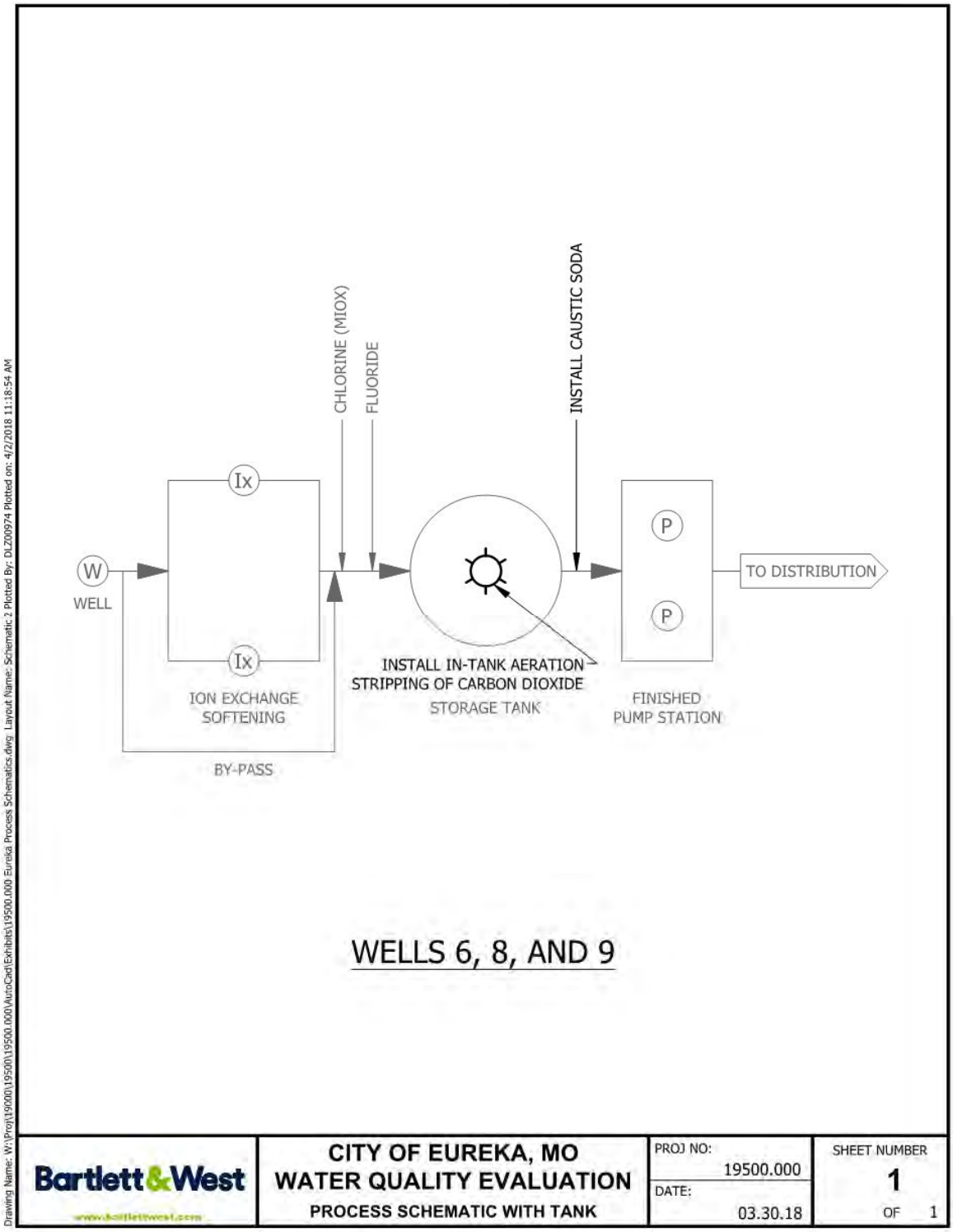



**Figure 5-4. In-Tank Aeration Schematic**

For those WTP sites where an on-site storage tank is unavailable, Medora Corporation has an in-line skid system (GridBee® Skid-Mounted THM/VOC Removal System) that can be utilized. The manufacturer estimates only 40% $CO_2$ removal will be achieved because the single-pass design of the in-line system instead of the recirculation design of the in-tank system. The in-line system also requires re-pumping the water, so there will be additional electrical costs associated with the in-line system. At an estimated 35 psi (80 feet) of additional pumping head, the estimated additional yearly electrical cost is shown in Table 5-1.

**Table 5-1. Repumping Cost Associated with In-Line Aeration.**

| Well No. | Average Annual Additional Electrical Cost for Repumping |
|---|---|
| 1 | $4,814.74 |
| 5 | $4,763.67 |
| 10 | $2,674.51 |

Figure 5-5 shows the GridBee® in-line, skid-mounted aeration unit with additional information provided in Appendix E. The approximate cost of the equipment is as follows:

- Well 1: 2 skids at 475-gpm per skid at 30-hp each. Equipment budget $169,600
- Well 5: 2 skids at 550-gpm per skid at 50-hp each. Equipment budget $198,400
- Well 10: 1 skids at 530-gpm per skid at 40-hp each. Equipment budget $93,100

**Figure 5-5. Skid Aeration Unit.**

A schematic drawing of this addition to the treatment process is shown on Figure 5-6.

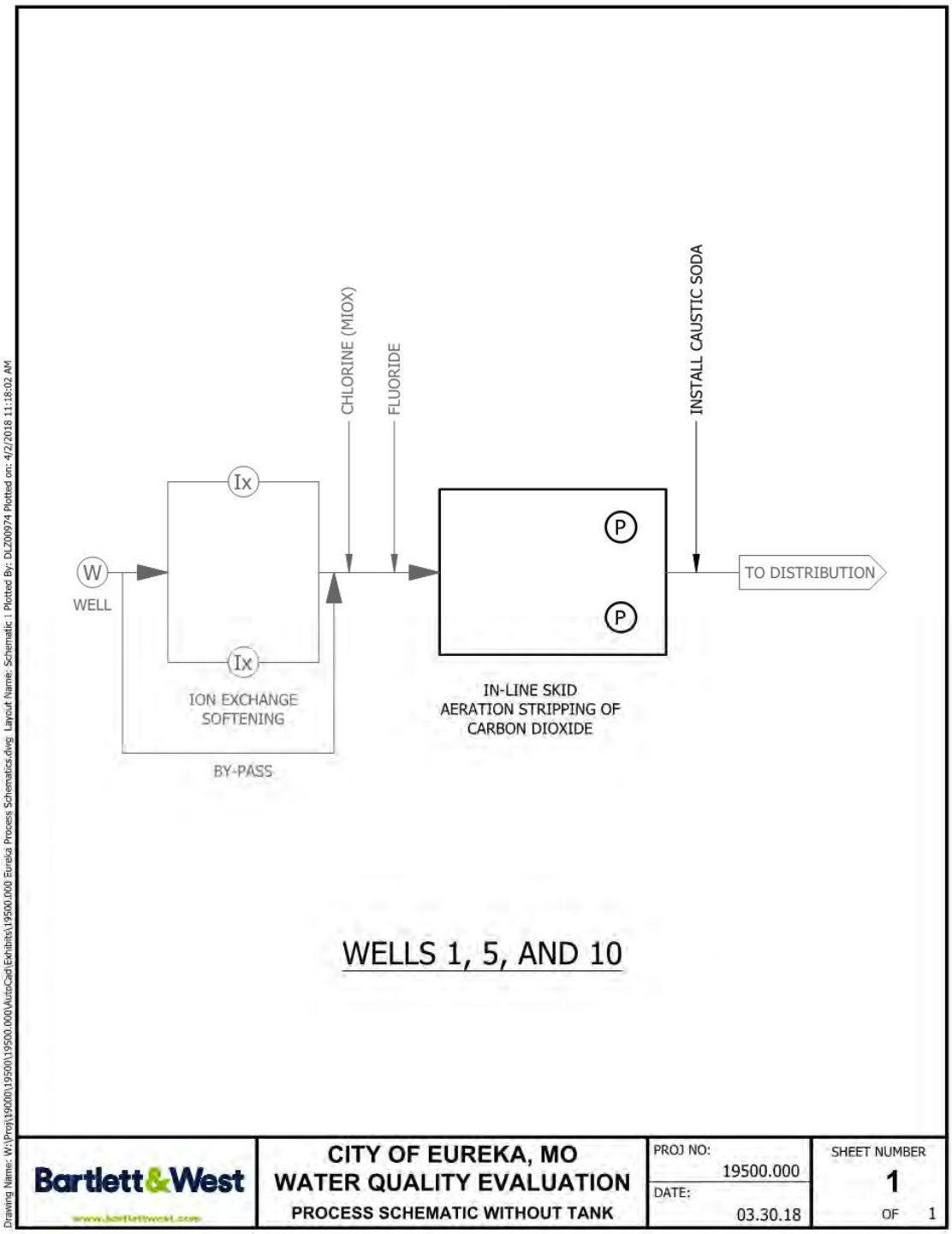



**Figure 5-6. Skid Aeration Schematic**

### 5.3.4. pH Adjustment by Caustic Soda Feed

As discussed in Section 3.5.3 the need to create a non-corrosive water is critical. A review of corrosion indices after chemical addition can be found in Appendix W. The finished water pH needs to be raised to near a pH of 8 to result in a slightly scale forming water. Although proposed aeration solutions suggested a 40% - 50% removal of dissolved $CO_2$, the subsequent increase of pH will be insufficient to reach an optimal pH for favorable corrosion indices. Because aeration, alone, cannot provide the needed results, this section will discuss the other common method: addition of a caustic chemical.

Eureka PWS has discussed implementing a caustic soda (sodium hydroxide; NaOH) feed system at each WTP to mitigate corrosion concerns. Implementation of a caustic soda feed system is certainly recommended and is a common post-treatment process used after ion exchange and membrane softening processes to reduce the aggressiveness (corrosivity) of finished drinking water. Aeration is often coupled with the addition of caustic soda to achieve an optimal pH – the aeration step reducing the quantity of chemicals needed to achieve the pH goal. Table 5-2 presents information related to the annual chemical costs both with and without the inclusion of aeration. Detailed cost information is provided in Appendix S. Additional information on feed rates and quantities can be found in Appendix C.

**Table 5-2. Average Annual Caustic Soda Cost.**

| | No Aeration | | With Aeration | |
|---|---|---|---|---|
| **Well No.** | **30% Solution** | **50% Solution** | **30% Solution** | **50% Solution** |
| **Eureka #1** | $114,014.48 | $73,732.37 | $57,007.24 | $36,866.19 |
| **Eureka #5** | $135,366.21 | $87,540.39 | $67,683.10 | $43,770.19 |
| **Eureka #6** | $62,926.75 | $40,694.29 | $31,463.37 | $20,347.15 |
| **Eureka #8** | $52,261.21 | $33,796.96 | $26,130.60 | $16,898.48 |
| **Eureka #9** | $5,819.11 | $3,763.18 | $2,909.55 | $1,881.59 |
| **Eureka #10** | $54,888.70 | $35,496.14 | $27,444.35 | $17,748.07 |
| **System Total** | $425,276.45 | $275,023.33 | $212,638.23 | $137,511.66 |

In general, the feed system would consist of the following components at each water treatment plant site.

- Bulk storage tank
- Transfer pump
- Day tank and scale
- System to dilute from 50% (Purchased) to 30% (Feed) in the day tank.
- Chemical feed pump
- Chemical spill containment

The table in Appendix S also presents purchase volumes for 30% and 50% solution. Caustic soda with solution strengths of 50% and above will start to crystalize at a temperature around 45$^{O}$F. Therefore, when larger volumes are required it is common to purchase at 50% (buying less water) then dilute on-site for ease of feeding. However, the storage area must be heated to maintain a temperature above 55$^{O}$F. Based on the costs presented, purchasing as 50% and diluting to 30% for feeding would be the best option.

### 5.3.5. New Buildings to House Corrosion Control Equipment

There does not appear to room within the existing plant site buildings to house the new caustic soda feed equipment and skid mounted aeration units for those sites where they would be needed. Therefore, a small building is anticipated. Those sites only requiring chemical storage would include a single room building of approximate size 12-ft x 14-ft. Those sites requiring a skid aeration unit would include two rooms with overall approximate size of 12-ft x 20-ft. The buildings would include an overhead door into the chemical storage room and a man-door. The room for the aeration skid would include a double 6-ft wide door. The buildings could be constructed of masonry block or metal stud framing. The building would include new electrical panels to power the equipment, lights, and electric heater. The chemical storage area would include short walls or sunken basin for chemical spill containment. Heating, ventilation, and plumbing will also be required. The building and site specifics will be discussed with the PWS and finalized during preliminary design.

### 5.3.6. Construction Costs for Corrosion Control

Table 5-3 presents a summary of the engineers' opinion of probable construction costs and present worth analysis over 5, 10, 15, and 20 years. Details of the construction cost estimates are included in Appendix S. These costs are at a concept level, and in some instances the unit costs are averaged across the associated sites. The overall project cost estimate for chemical feed without the addition of aeration is $1,066,600. The overall project cost estimate for chemical feed plus the addition of aeration is $2,685,000.

**Table 5-3. Engineer's Opinion of Probable Construction Costs and Present Worth Analysis.**

| 50% Caustic Soda Purchase | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | **Construction Project Cost** | **Annual Chem. Cost** | **Present Worth 5 Years** | **Present Worth 10 Years** | **Present Worth 15 Years** | **Present Worth 20 Years** |
| **Equation Factor[1]** | | | 4.7135 | 8.9826 | 12.8493 | 16.3514 |
| **No Aeration – Chem. Feed Only** | $1,066,610.00 | $275,023 | $2,362,932 | $3,537,035 | $4,600,467 | $5,563,626 |
| **With Aeration + Chem. Feed** | $2,685,070.00 | $137,512 | $3,333,231 | $3,920,282 | $4,451,999 | $4,933,578 |

1. Interest Rate of 2.0%

| 30% Caustic Soda Purchase | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | **Construction Project Cost** | **Annual Chem. Cost** | **Present Worth 5 Years** | **Present Worth 10 Years** | **Present Worth 15 Years** | **Present Worth 20 Years** |
| **Equation Factor[1]** | | | 4.7135 | 8.9826 | 12.8493 | 16.3514 |
| **No Aeration – Chem. Feed Only** | $1,066,610.00 | $425,276 | $3,071,151 | $4,886,698 | $6,531,115 | $8,020,475 |
| **With Aeration + Chem. Feed** | $2,685,070.00 | $212,638 | $3,687,340 | $4,595,114 | $5,417,322 | $6,162,003 |

1. Interest Rate of 2.0%

The present worth analysis indicates the following:

- Purchasing 50% caustic soda is more feasible than purchasing 30% caustic soda.
- Investing in aeration provides a long-term cost reduction.
- It will take between 10 and 15 years to see the capital investment in aeration to pay off.

# Section 6. RECOMMENDATION

## 6.1. Recommendations

The following recommendations are provided:

1. Conduct field jar testing to confirm the calculated dosages of caustic soda are correct.

2. Conduct field testing with SolarBee to confirm the pH change noted through aeration.

3. After steps 1 and 2 are complete, adjust cost estimates as appropriate.

4. Concurrently with recommendations 1 through 3, it is recommended the City engage with a consultant and the Missouri Geological Survey to review details of the water producing formation, well construction information, and any water quality and water quantity testing completed on each well from various depths. It may be prudent to compete quality testing of some, if not all, of the wells at various depths. This testing will come at a cost, so estimates from a well driller will be required. An option may be to blank off sections of a well contributing the poorest water quality. However, the blanking off a section, could impact the well production rate. Well 6, should be of particular focus, since it has a substantially lower bottom elevation than the other wells.

5. The City has obtained a MO-DNR permit to add caustic soda feed equipment at each plant location. It is recommended that a caustic soda feed system be installed at one of the plants. Operate for several months, and summarize both effect on finished water quality, and customer comments. Feeding 30% caustic soda without aeration to Well 6 will have an estimated monthly cost of $5,200+.

6. Pending the outcome of the prior recommendations it may be necessary to modify the caustic soda construction permit to accommodate greater feed quantities than may have been anticipated previously. An in-depth preliminary design for caustic soda feed at each plant site would be completed. This preliminary design will establish if a separate building is required at each site, what site modifications will be required to accommodate the chemical feed building, and preliminary electrical design. Updated cost estimates would need to be developed based on the preliminary design.

7. Develop aeration options to a preliminary design level. Updated cost estimates would need to be developed based on the preliminary design.

8. City decides what treatment processes, and which sites to move forward to full final design and construction. A phased approach may be appropriate

9. Maintain closer control over the hardness level being distributed. Target 170 mg/l (10 grains).

10. Continue with and enhance the flushing program throughout the distribution system. It is recommended the City develop a hydraulic model of the system to help in calculating water age, and determine the best approach to flushing. If is also recommended that water quality parameters be monitored to further understand the results of the flushing.

11. Conduct depth temperature profiling of storage tanks. Install mechanical mixers in any tanks showing signs of insufficient mixing. Conduct depth temperature profiling of storage tanks following installation of the mixers.

12. Provide periodic public education in relation to use of in-home water softeners to have them properly set, given the incoming hardness from the PWS.

## 6.2. Time Frame

The following general time frame is anticipated.

Recommendations 1, 2, and 3: Within 45 days.

Recommendation 4: Concurrent with 1 through 3. If field testing is complete this step could take more time. Anticipated time frame of 45 to 75 days.

Recommendation 5: Accounting for planning, installation, and completing the trial, and summary of results, 4 to 6 months.

Recommendations 6 and 7: Within 2 months

Recommendation 8: 6 months to design and permit, 2 months for bidding and executing contract documents, and 6 to 12 months for construction depending on the final improvements and number of sites involved.

Recommendations 9, 10, and 12: Ongoing

Recommendation 11: To account for planning, obtaining a construction permit, and installation the anticipated time frame is within 12 months.

## Section 7. REFERENCES

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# APPENDIX C

# Calculations

## Caustic Soda Chemical Feed Summary - 30%

Eureka, MO

| | Processing Rate (gpm) | | | | | |
|---|---|---|---|---|---|---|
| **Well No.** | #1 | #5 | #6 | #8 | #9 | #10 |
| **Well Cap (gpm)** | 1000 | 1000 | 600 | 700 | 800 | 750 |
| | | | | | | |
| **Dosage @ 100% NaOH (mg/L)** | 75 | 90 | 45 | 45 | 45 | 65 |
| **No Aeration Avg Feed Rate (gph)** | 11.27 | 13.53 | 4.06 | 4.73 | 5.41 | 7.33 |
| | | | | | | |
| **Avg hrs/day** | 6.56 | 6.49 | 10.06 | 7.16 | 0.70 | 4.86 |
| **Min. Bulk Tank Size @ 30% (gal)** | 2220 | 2635 | 1225 | 1017 | 113 | 1069 |
| **Min. Day Tank size @ 30% (gal)** | 148 | 176 | 82 | 68 | 8 | 71 |
| | | | | | | |
| **Dosage @ 100% NaOH (mg/L)** | 37.5 | 45 | 22.5 | 22.5 | 22.5 | 32.5 |
| **Aeration Avg Feed Rate (gph)** | 5.64 | 6.76 | 2.03 | 2.37 | 2.71 | 3.66 |
| | | | | | | |
| **Avg hrs/day** | 6.56 | 6.49 | 10.06 | 7.16 | 0.70 | 4.86 |
| **Min. Bulk Tank Size @ 30% (gal)** | 1110 | 1318 | 613 | 509 | 57 | 534 |
| **Min. Day Tank size @ 30% (gal)** | 74 | 88 | 41 | 34 | 4 | 36 |

## Caustic Soda Chemical Feed Summary - 50%

Eureka, MO

| | Processing Rate (gpm) | | | | | |
|---|---|---|---|---|---|---|
| **Well No.** | #1 | #5 | #6 | #8 | #9 | #10 |
| **Well Cap (gpm)** | 1000 | 1000 | 600 | 700 | 800 | 750 |
| | | | | | | |
| **Dosage @ 100% NaOH (mg/L)** | 75 | 90 | 45 | 45 | 45 | 65 |
| **No Aeration Avg Feed Rate (gph)** | 5.88 | 7.06 | 2.12 | 2.47 | 2.82 | 3.82 |
| | | | | | | |
| **Avg hrs/day** | 6.56 | 6.49 | 10.06 | 7.16 | 0.70 | 4.86 |
| **Min. Bulk Tank Size @ 50% (gal)** | 1159 | 1376 | 639 | 531 | 59 | 558 |
| **Min. Day Tank size @ 50% (gal)** | 77 | 92 | 43 | 35 | 4 | 37 |
| | | | | | | |
| **Dosage @ 100% NaOH (mg/L)** | 37.5 | 45 | 22.5 | 22.5 | 22.5 | 32.5 |
| **Aeration Avg Feed Rate (gph)** | 2.94 | 3.53 | 1.06 | 1.24 | 1.41 | 1.91 |
| | | | | | | |
| **Avg hrs/day** | 6.56 | 6.49 | 10.06 | 7.16 | 0.70 | 4.86 |
| **Min. Bulk Tank Size @ 50% (gal)** | 579 | 688 | 320 | 266 | 30 | 279 |
| **Min. Day Tank size @ 50% (gal)** | 39 | 46 | 21 | 18 | 2 | 19 |

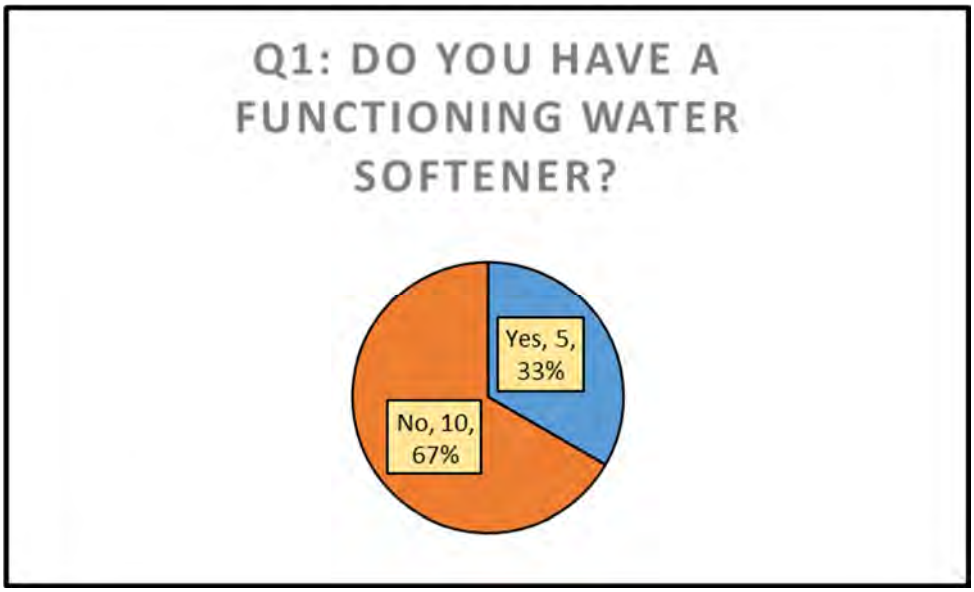
# APPENDIX D

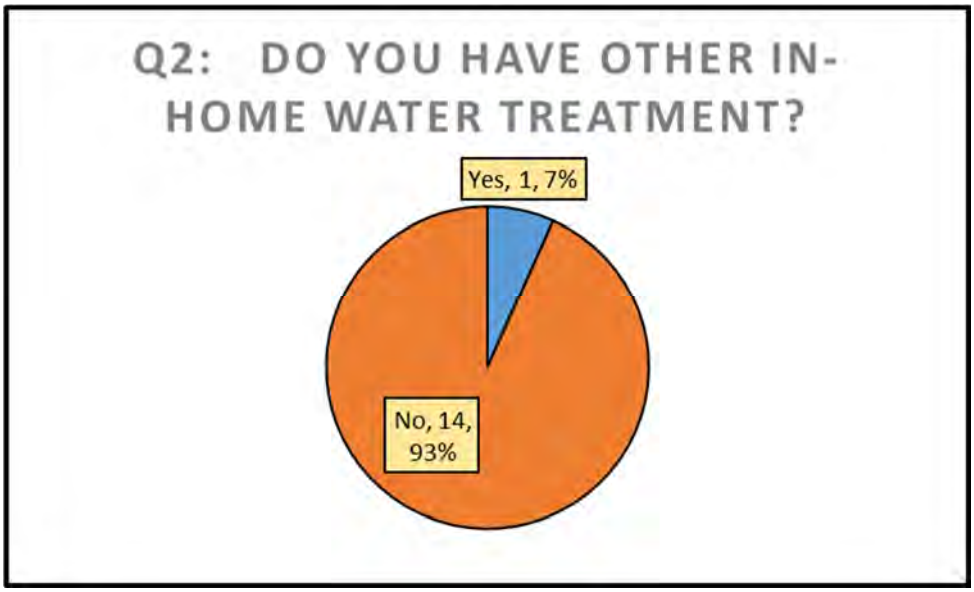
# Drinking Water Survey

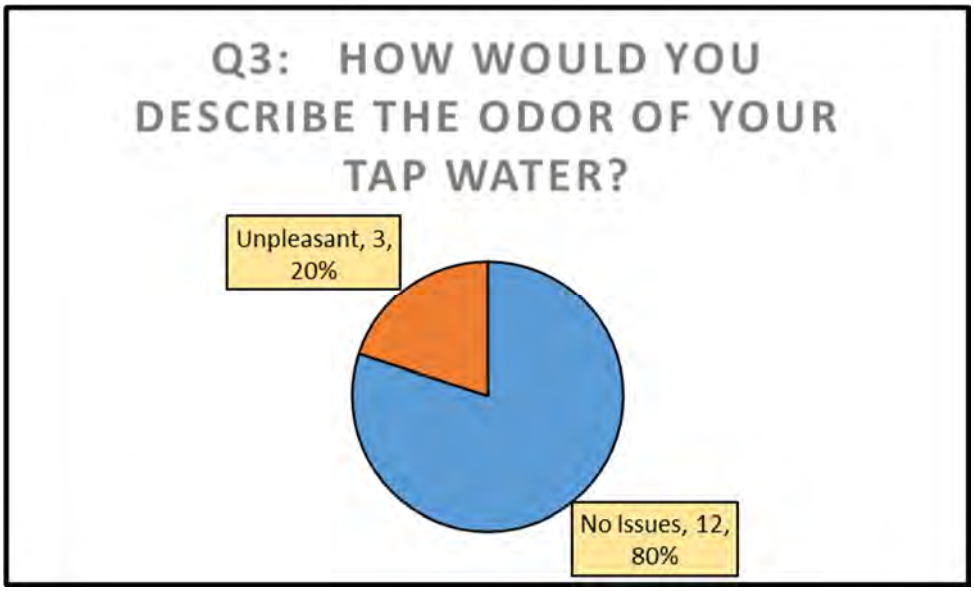
**Eureka PWS Water Quality Review – Survey Responses**
**City of Eureka, Missouri**

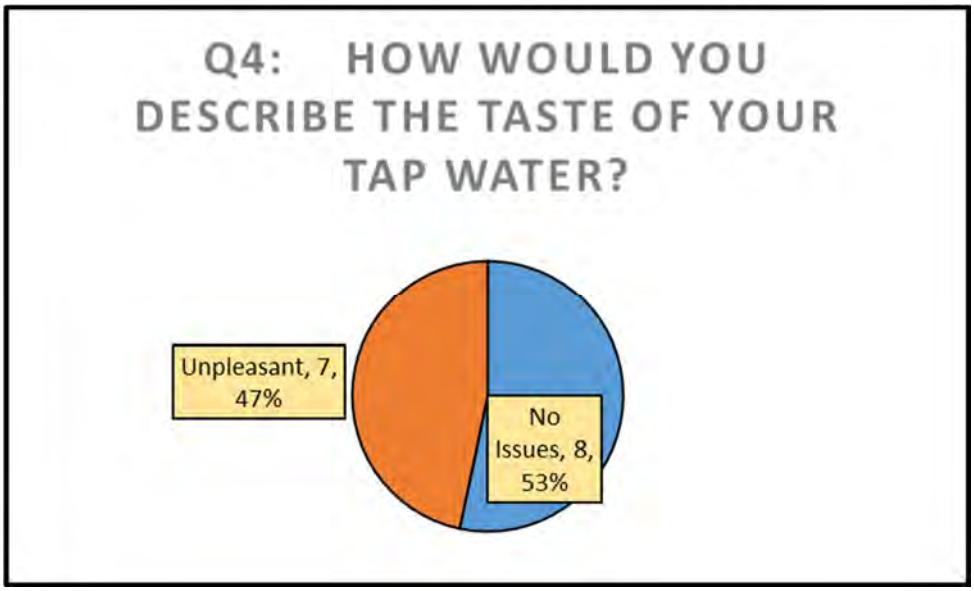
The City of Eureka provided a list of homes which represented a wide distribution area. The list gave addresses of homes that are spread through every zone in the water distribution system. Bartlett & West created a survey to send to these residents which consisted of key questions related to their water quality. A tremendous response was received by those surveyed with a 89% return rate. The following charts represent the results of those responses.

Generally speaking the vast majority of responses stated that they have in fact experienced corrosion in their home. This was evident by people needing to replace appliances and other plumbing. Those that lived south of I-44 noticed the most unpleasant taste and odor qualities in their water with taste being the dominate characteristic noted.



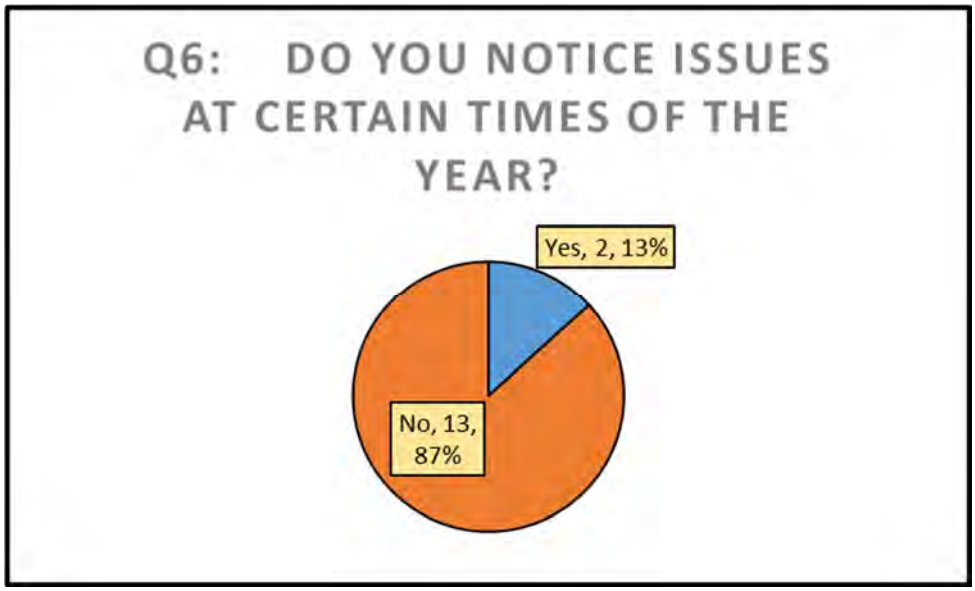






5. Please check as many taste qualities as you find applicable to the taste of your tap water. Skip if you do not experience any taste concerns. (# of Responses)

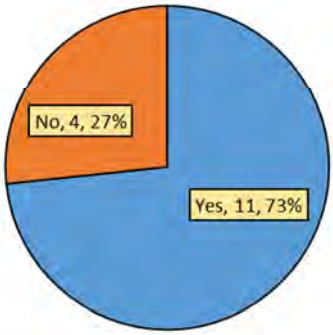
| | | |
|---|---|---|
| ☐ Earthy (3) | ☐ Septic (1) | ☐ Chemical |
| ☐ Chlorinated (3) | ☐ Sulfide | ☐ Petroleum |
| ☐ Grassy (1) | ☐ Fishy | ☐ Metallic (3) |
| ☐ Swampy (3) | ☐ Medicinal | ☐ Other_____ |




7. Which of the following, if any, apply to your tap water? Please check all that apply. (# of Responses)
   - ☐ Sediments (rust, particles, etc.) (5)
   - ☐ Calcium (Hardness) Deposits (10)
   - ☐ Hard Water (6)
   - ☐ Sulfur Odor (1)
   - ☐ Iron (Red) Deposits (2)
   - ☐ Manganese (Black) Deposits (1)
   - ☐ Overly Soft Water
   - ☐ Other (please identify): _____

8. Generally, what does your tap water look like? (# of Responses)
   - ☐ Clear (15)
   - ☐ Cloudy (1)
   - ☐ Dirty
   - ☐ Colored

## Q9: HAVE YOU EXPERIENCED ANY CORROSION OF YOUR PLUMBING WITHIN YOUR HOME?



# APPENDIX E

# Equipment

PAX Water Technologies™ Submersible Mixer
GridBee® Electrical Submersible Mixers by Medora Corporation
GridBee® THM/VOC Removal Systems by Medora Corporation

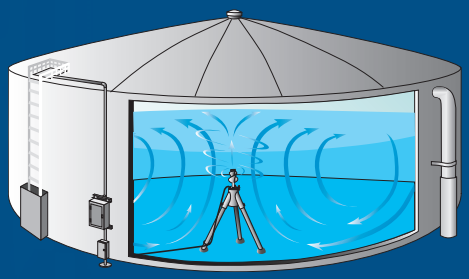
# PAX Water Technologies™
# Submersible Mixer

ANY TANK. ANY SIZE.™

# PAX Water Mixer
# Product Specifications

Using a PAX Water Mixer will...

- Lower DBP Production
- Reduce Nitrification Risk
- Prevent Ice Damage



PAX Water Mixer circulates residual throughout the entire tank.

...and is more economical and reliable than Deep Cycling, Draft Tube Mixers and Passive Nozzles.

Smallest Footprint (Easy Installation)
Low Energy Requirements (Solar or Grid Powered)
SCADA Ready
Optional Chemical Injection System

NSF

Find out how a PAX Water Mixer can help you.
Call our Water Quality Specialists today at **1-866-729-6493**
or visit **www.paxwater.com**

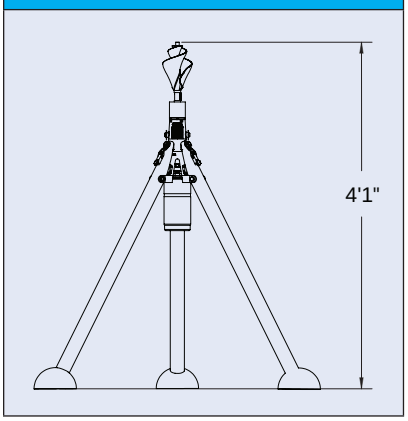
PAX
WATER TECHNOLOGIES™

ANY TANK. ANY SIZE.™

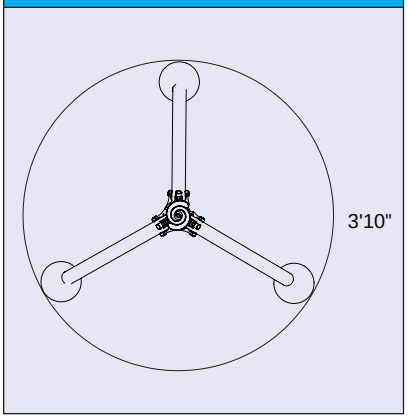
# PAX Water Mixer PWM400
# Product Specifications

The PAX Water Mixer is an active, submersible mixing system for cost effective management of drinking water quality in storage tanks and reservoirs. The mixer easily installs without service disruptions or tank modifications, and mixes on-demand to rapidly eliminate stratification, uniformly distribute disinfectants and prevent conditions favorable to nitrification. Efficient and effective mixing of large volumes is made possible by the patented impeller's characteristic axial jet which establishes a stable flow structure throughout the storage volume.

**SIDE VIEW**




**TOP VIEW**




ANSI/NSF STANDARD 61

| MIXER SPECIFICATIONS | |
|---|---|
| Power supply requirement | 120 VAC, GFCI-protected, 15 Amp circuit |
| Customer supplied power switch | NEMA 3R, fused, safety disconnect switch |
| Motor Type | 48VDC, Water-filled, water-lubricated, brushless motor |
| RPM | 1200 |
| Nominal power draw | 280 Watts @ 1200 RPM |
| Impeller specifications | 8.25" Tall x 4.5" Diameter, SS 316, balanced to 0.4 gram-inches |
| Footprint diameter | 3' 10" (1.17m) |
| Height | 4' 1" (1.24m) |
| Weight: Mixer Assembly | 62 lbs (28.2 kg) |
| Weight: Control Center | 24 lbs (10.9 kg) |
| Material: Control Center | Stainless Steel NEMA 3R Enclosure |
| Material: Stand | 316 Stainless Steel |
| Material: Motor Housing | 316 Stainless Steel |
| Material: Motor Seals | Chlorine/chloramine-resistant NBR rubber |
| Material: Feet | Chlorine/chloramine-resistant EPDM rubber |
| Wiring | UL-listed Submersible Pump Cable 14 AWG XLPE |

Find out how a PAX Water Mixer can help you.
Call our Water Quality Specialists today at **1-866-729-6493**
or visit **www.paxwater.com**

PAX WATER TECHNOLOGIES™

01/2011 ©2011 PAX Water Technologies, Inc.

# GridBee® Electrical Submersible Mixers
# by Medora Corporation

Medora Corporation

www.medoraco.com
866-437-8076
info@medoraco.com

GridBee®

# *GS Electric Submersible Mixers*

*Effective. Efficient. Affordable.*

***Full Specifications, Videos, Case Studies, White Papers, Questionnaires, etc. available at:***

***https://www.medoraco.com/resources***

GridBee® SolarBee®

# Water Quality Challenges in Potable Tanks

AWWA estimates 65% of all potable tanks have water quality problems:

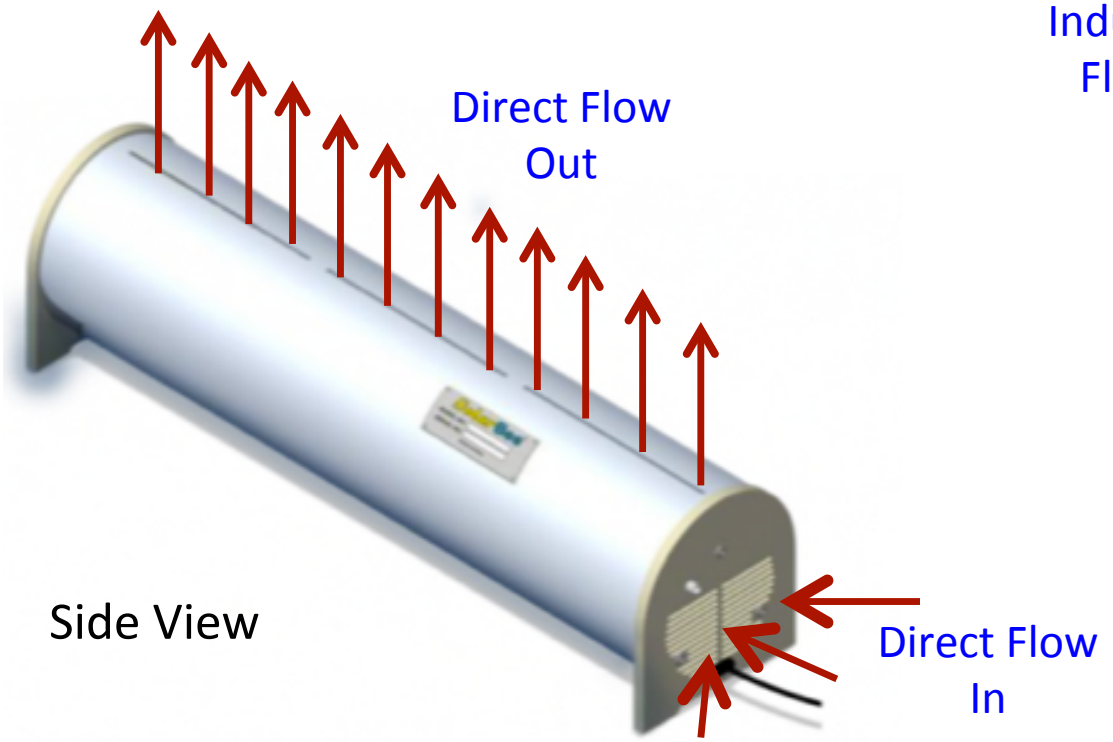
- Inlet / outlet design
- Short-circuiting
- Water age issues

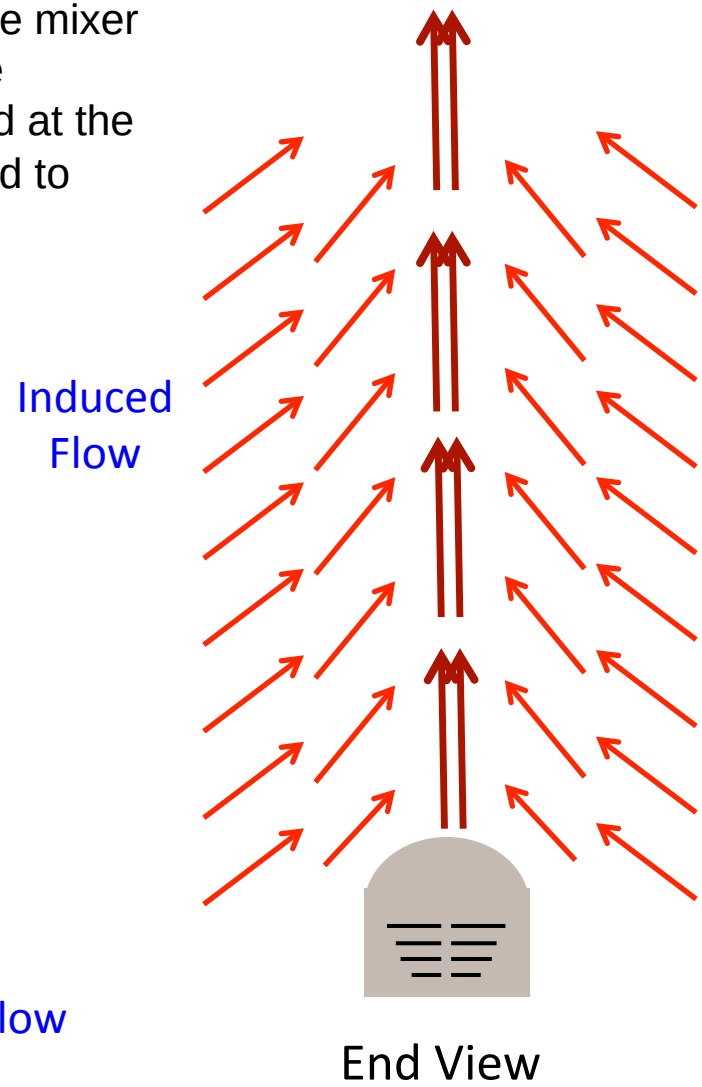
- Temperature stratification
- Stagnation / dead zones
- Biofilm build up

- Loss of residual
- Nitrification events
- Risk of ice damage
- DBP Formation (TTHM's)

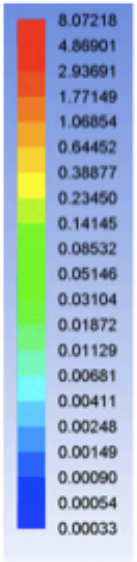
# How does the GS Mixer mix?

Direct flow is pulled horizontally across the floor of the tank, the direct flow enters the GS mixer through the endplate and exits through the slots on top. The direct flow leaves the mixer as a "sheet" of water dragging other water with it to the surface. During operation, visible flow can be observed at the surface above the GS mixer. The GS mixer is designed to operative at a full speed and full flow continuously.

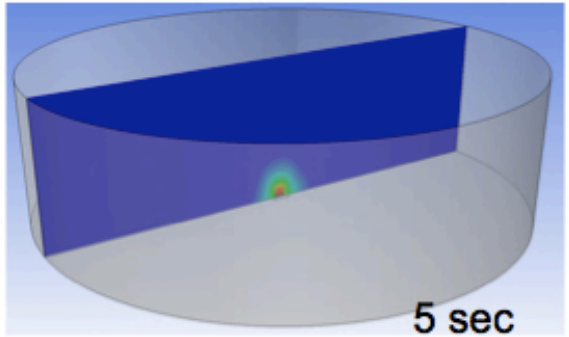


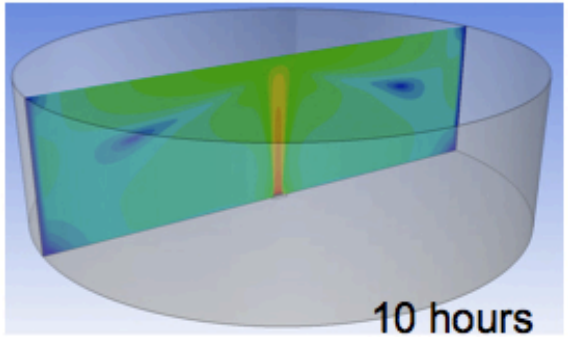



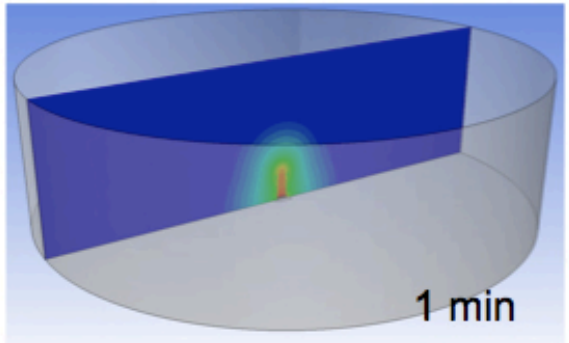
# Computational Fluid Dynamics (CFD) Flow Modeling
# GridBee GS-12 in a 5MG Tank

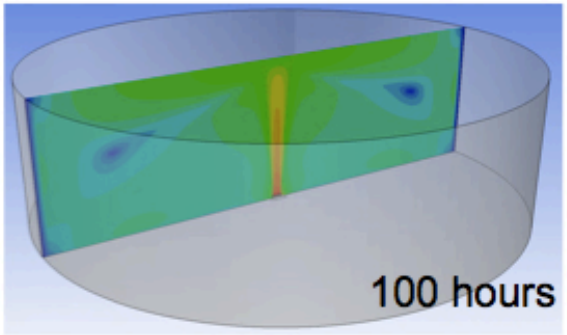


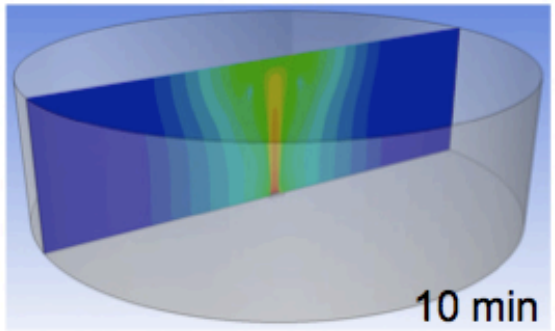

ft/sec

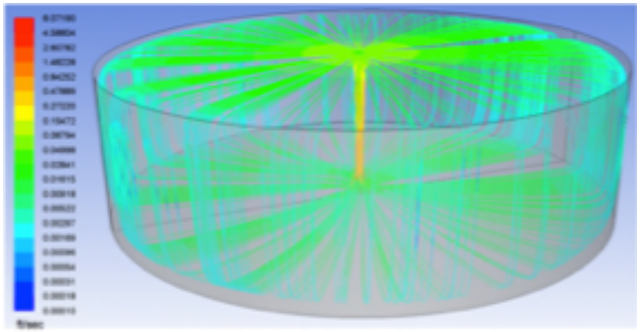


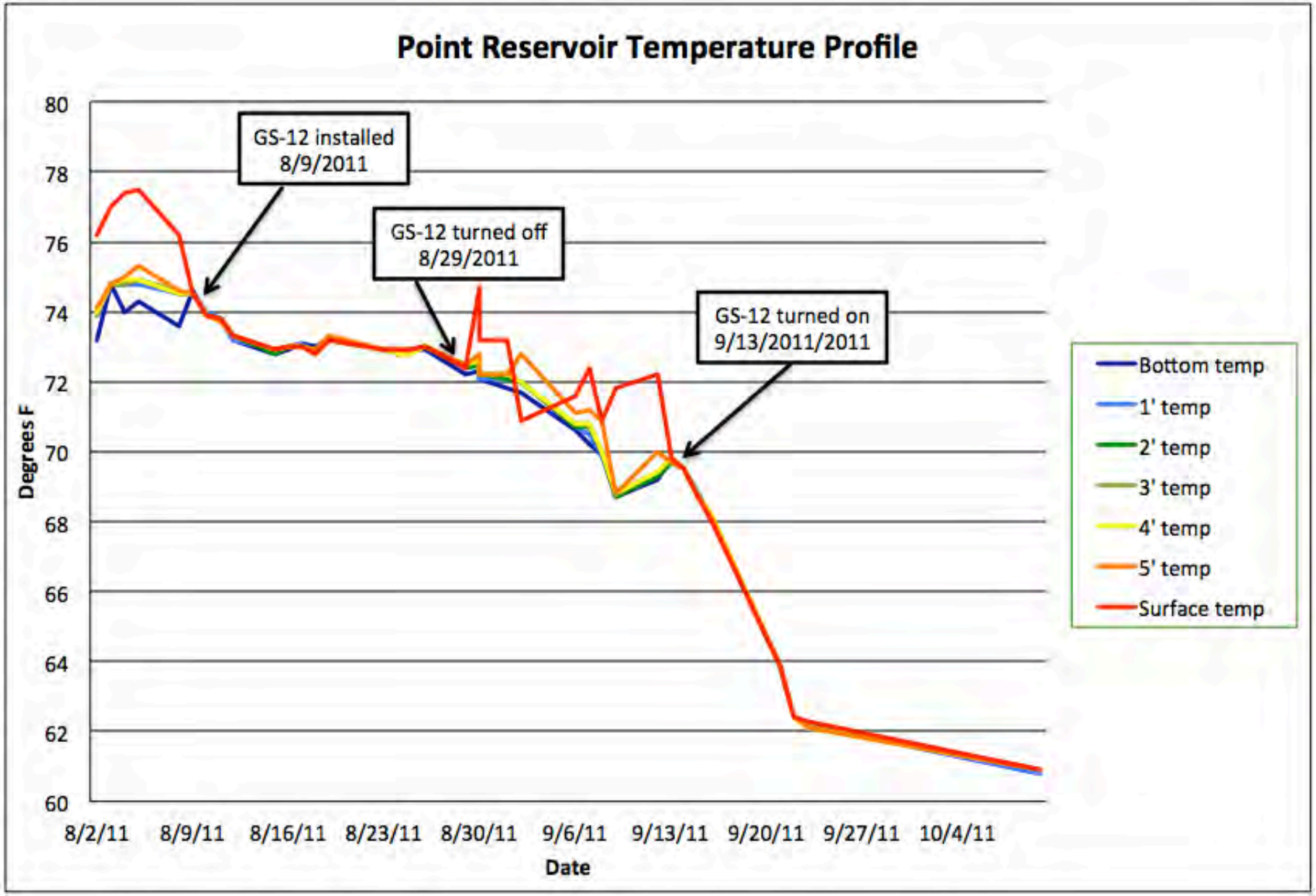



*5 Million Gallon Reservoir*

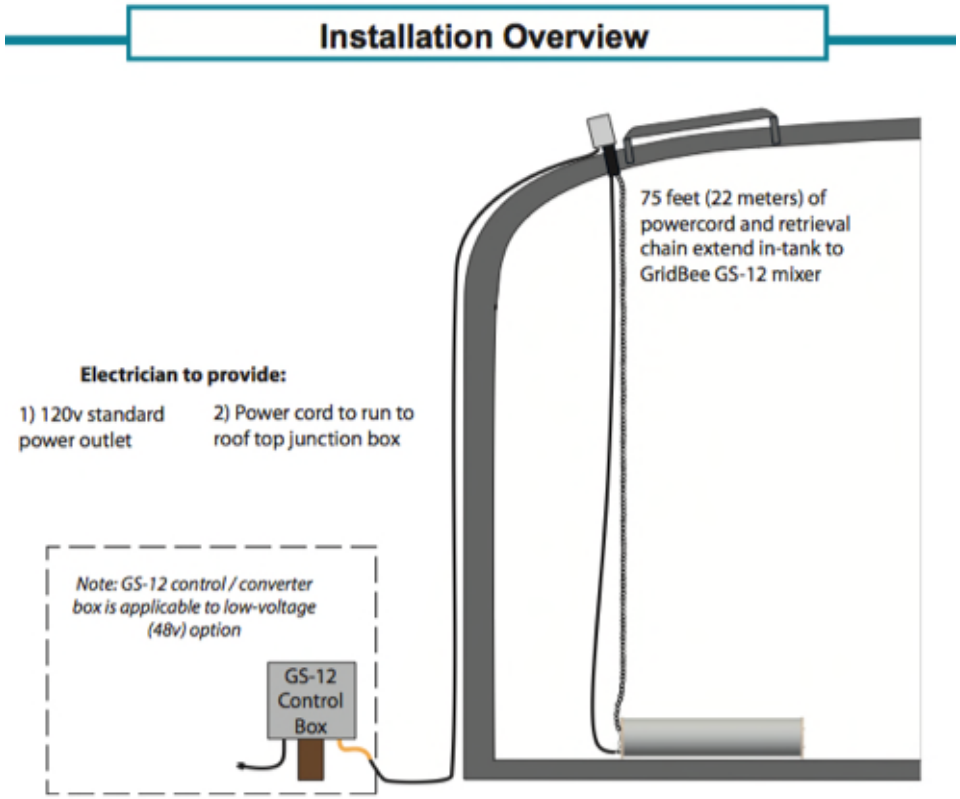
# Model GS-12 Test Data

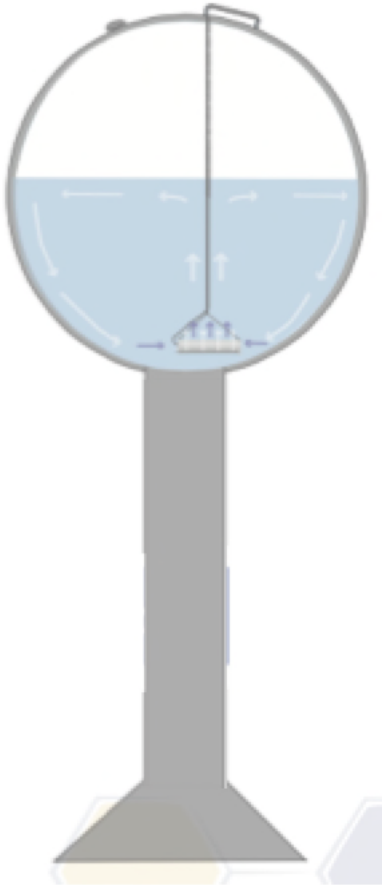


# GS Series Mixer Installation

GS Mixers are designed: to be installed directly under the hatch (no need to center it in tank), to be set on the floor (no need to attach), mixers are smooth running (they will not fall over).

Suspension Kit is Included with the GS Mixer, typically used in elevated tanks, tanks with sloped bottoms and tanks with sediment layer.

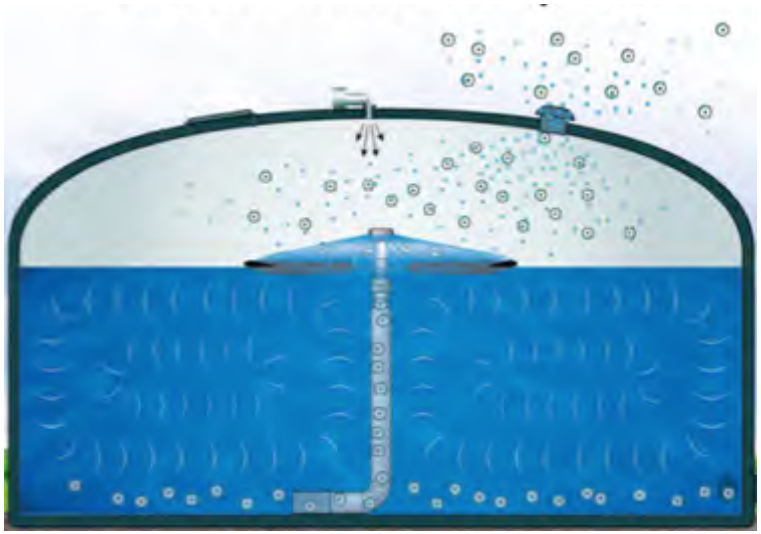


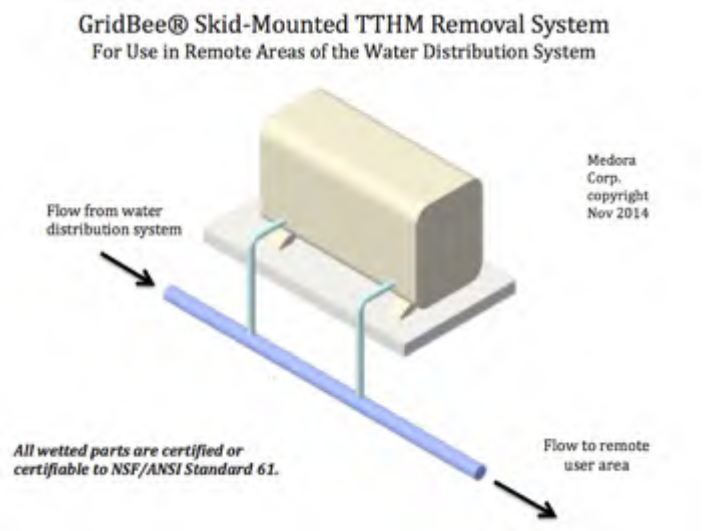
# GridBee® THM/VOC Removal Systems
# by Medora Corporation

# GridBee® – THM / VOC Removal Systems

In-Tank / In-Clearwell Design



Skid-Mounted Design

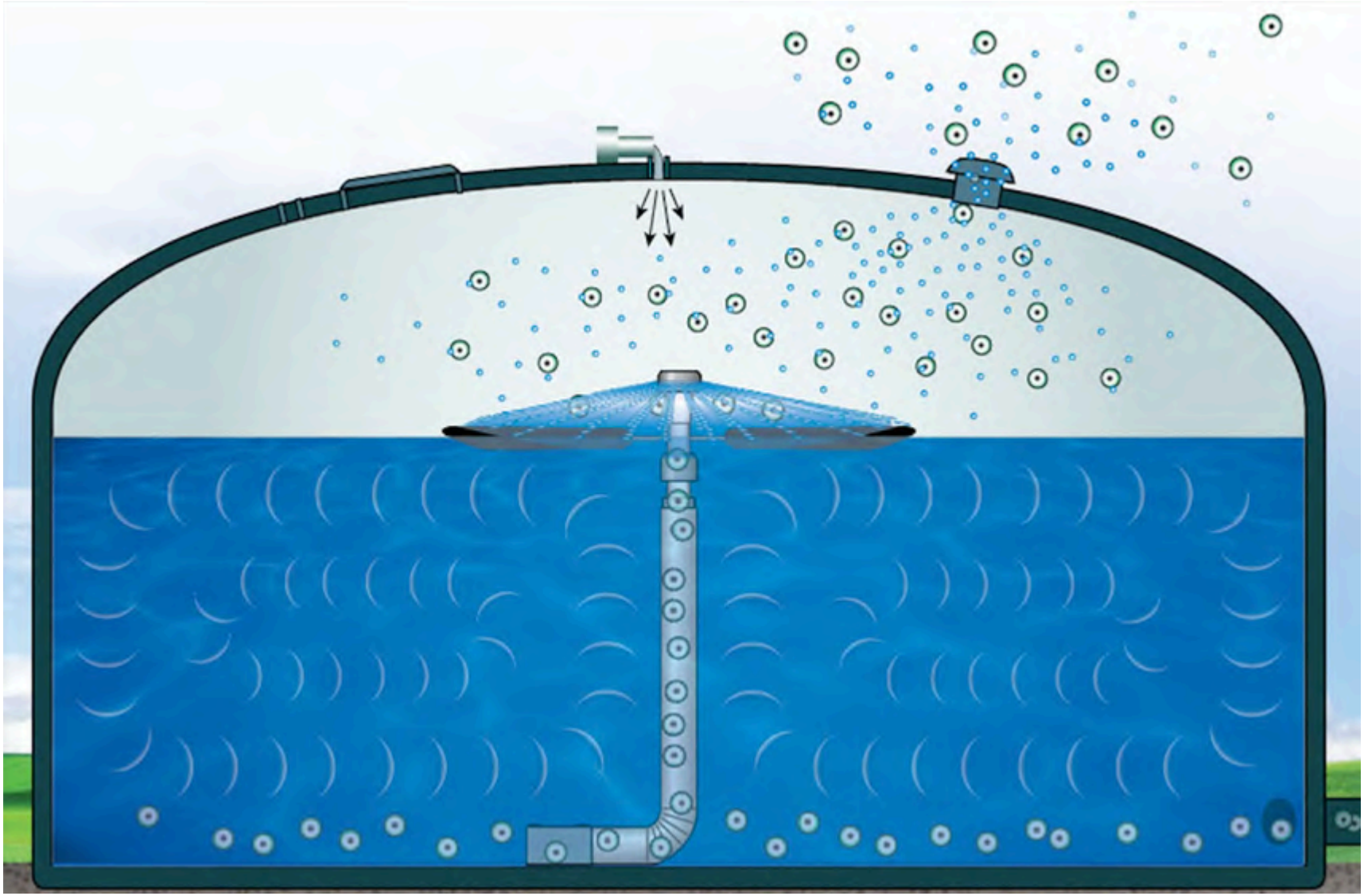



Medora Corporation
www.medoraco.com
866-437-8076
info@medoraco.com

GridBee® SolarBee®

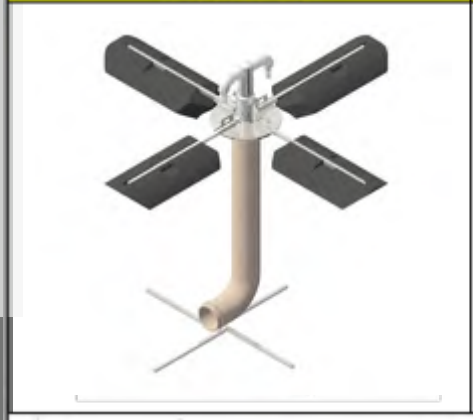
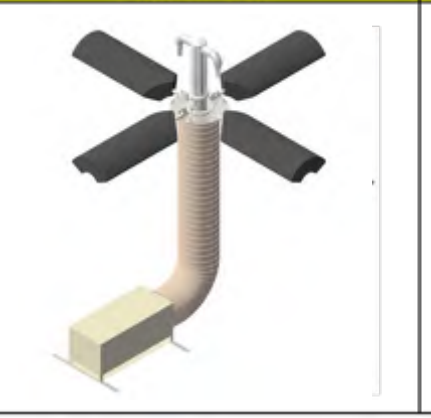
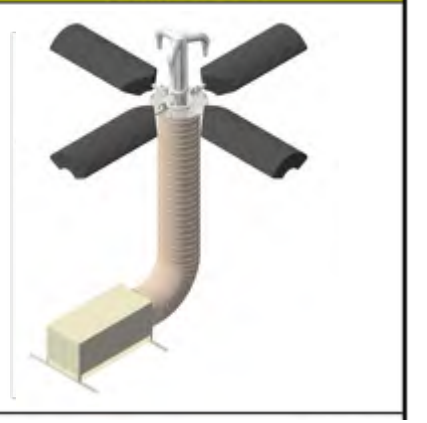
# In-Tank / In-Clearwell Floating Spray Nozzle Design

THM / VOC Removal System



# Standard pre-manfuactured sizes

3, 5, 10 & 15 HP Floating Spray Nozzle machines

| Model SN3 | Model SN5 | Model SN10 | Model SN15 |
|---|---|---|---|
|  | |  |  |
| **0.20 MGD** | **0.33 MGD** | **0.66 MGD** | **1.0 MGD** |

**System design is based on:** Tank size, shape, configuration, mean and peak water fill rates and daily flow-through rates, maximum and minimum THM / VOC levels, species, amount of reduction desired, off-peak needs, other. Often a mixer is included for supplemental blending of treated with untreated water, or ice protection of the tank in cold climates.

# SN1 SMALL TANK THM & VOC REMOVAL SYSTEM

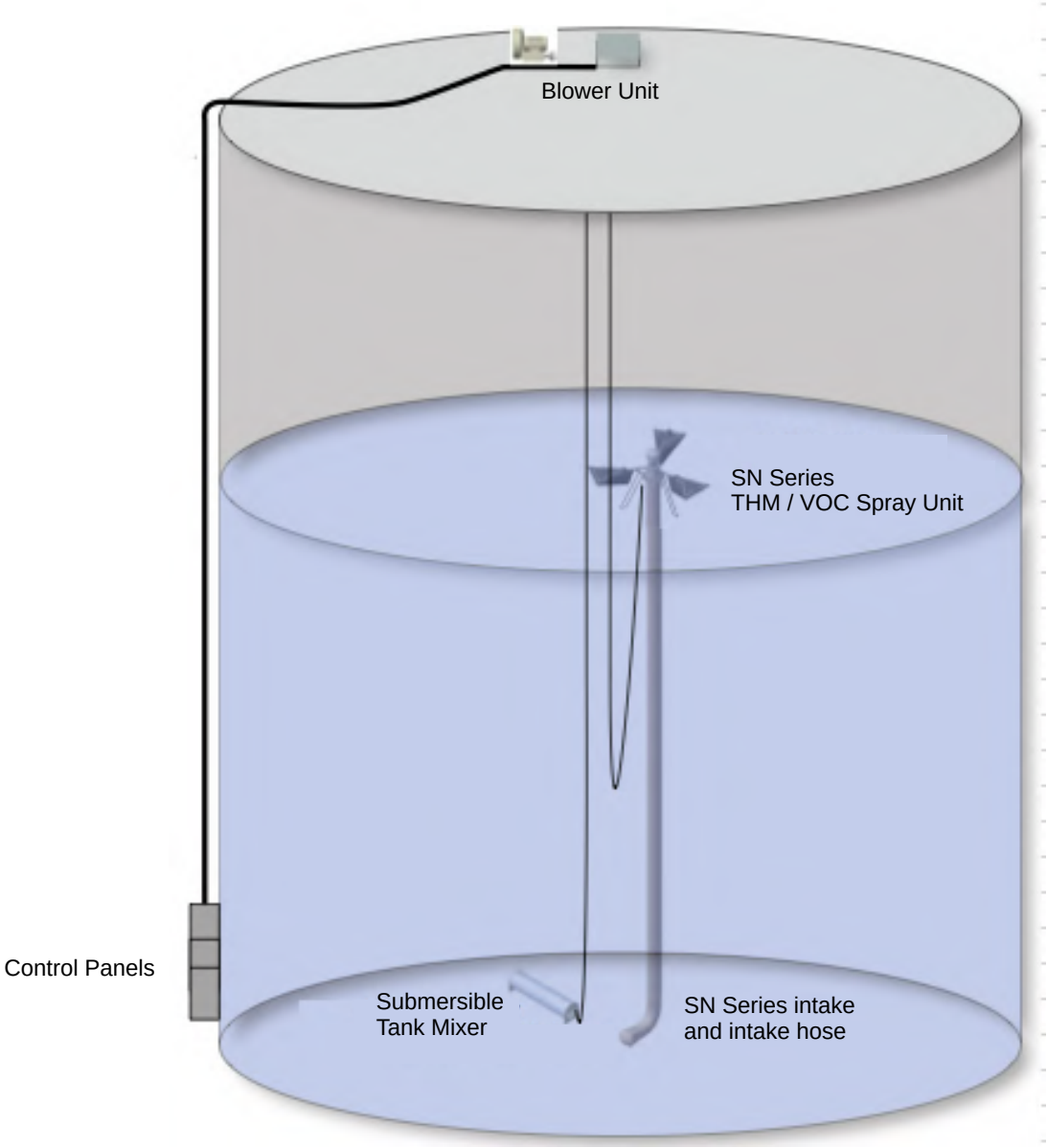
**SN1 Systems Self-Installed start less than $20,000!**

**For Small Potable Storage Tanks & Reservoirs**

*Now there's an effective & affordable solution for active trihalomethane removal in small tanks!*

The SN1 is a natural progression of Medora's industry leading THM & VOC removal spray aeration offering. Specifically built with small tanks in mind, now even the smallest of drinking water distribution systems can achieve reliable and economical THM removal.

# In-Tank – THM / VOC Removal System - in a GST Tank




This is a sketch of a typical THM / VOC single system supplied in in a GST Tank.

This system can be installed in clearwells and all types of tanks.

Multiple SN units can be installed in a clearwell or tank to treat higher volumes of outflow to distribution.

Blower can be installed at ground level with ducting to the top of the tank.

Various types and sizes of mixers are available to help prevent un-treated water from leaving the tank.

# In-Tank - SN Series Floating Unit

***Performance Guaranteed***
***No Need to Drain the Tank, No Disruption in Service***
***Portable – Scalable – Factory Placement***

# Ventilation System: 2hp Blower Unit

Medora Corporation

www.medoraco.com
866-437-8076
info@medoraco.com

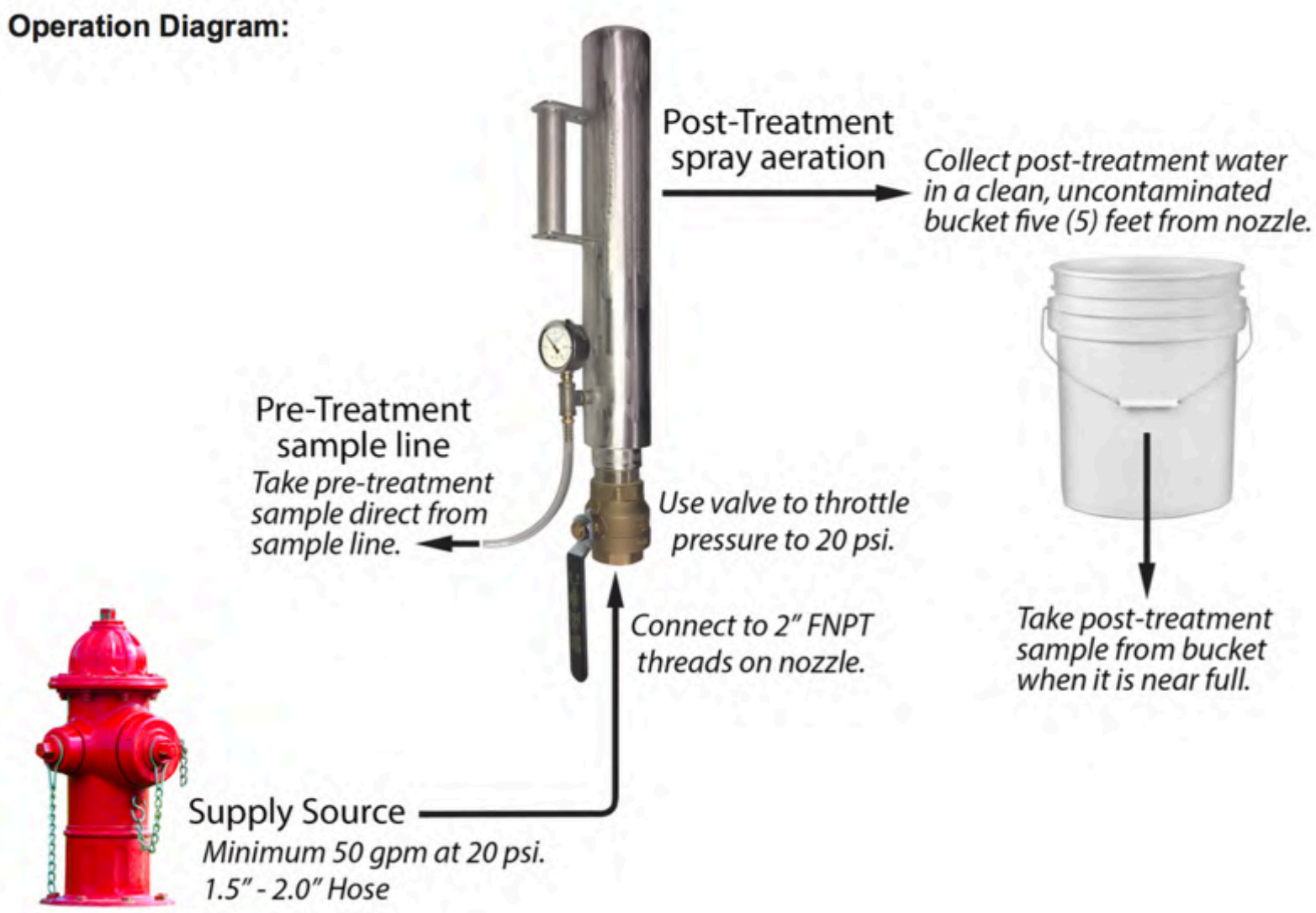
# GridBee®

# THM / VOC Field Test Unit

The Field Test unit is available for loan and, it can be used to help determine / confirm what is going on in various parts of the system and help determine the best overall solution.

GridBee® SolarBee®

# GridBee® THM / VOC Field Test Unit



# GridBee® THM / VOC Field Test Unit

**Use / Access**
It is available for loan. There is no cost to use or have access to the Field Test Unit.

**Shipping**
- Comes in a heavy duty plastic case.
- Total weight with case ~50 lbs.
- Can be shipped UPS or FedEx.
- Medora covers the cost of shipping to the site.
- The Customer covers the cost to ship the unit to the next destination.

**Testing Personnel / Costs**
The Customer or their Engineer is responsible for the field testing.
The Customer is responsible for the lab test cost.
No field services or testing costs are provided by Medora Corporation.

**Field Test Unit Assembly**
The Field Test Unit is preassembled with the following components:
- Spray Aeration Nozzle
- Pressure Throttle Valve
- Pressure Gauge
- Pre-Treatment Sampling Hose

**Contact us for more details**

# GridBee® Skid-Mounted THM/VOC Removal System

For Use in Remote Areas of the Water Distribution System

**SN IN-LINE SKID**

**Design:** This unit was designed over a 2-year period, and is based on experience in building 1000's of pump skids over 40 years, and also 100's of THM removal systems

**1.** City distribution line: The system is connected into the distribution system with (2) "tees". Flow is never impeded to the users. For a "looped" area, one skid unit is required for each side of the loop. The system treats virtually all water that flows to the users, and can be designed for virtually any gpm and MGD in the affected region.

**2.** The City engineer is responsible to construct a pad, construct an enclosure to match the neighborhood, and perform the electrical and water main tie-in.

**3.** Equipment supplied includes the spray nozzle TTHM removal system, tank, a pump with control box, and isolation valves. This unit has a 25 year design life.

**4.** Typical skid footprint is 8 ft long x 4 ft wide x 6 ft tall. It is shipped assembled.

# APPENDIX R

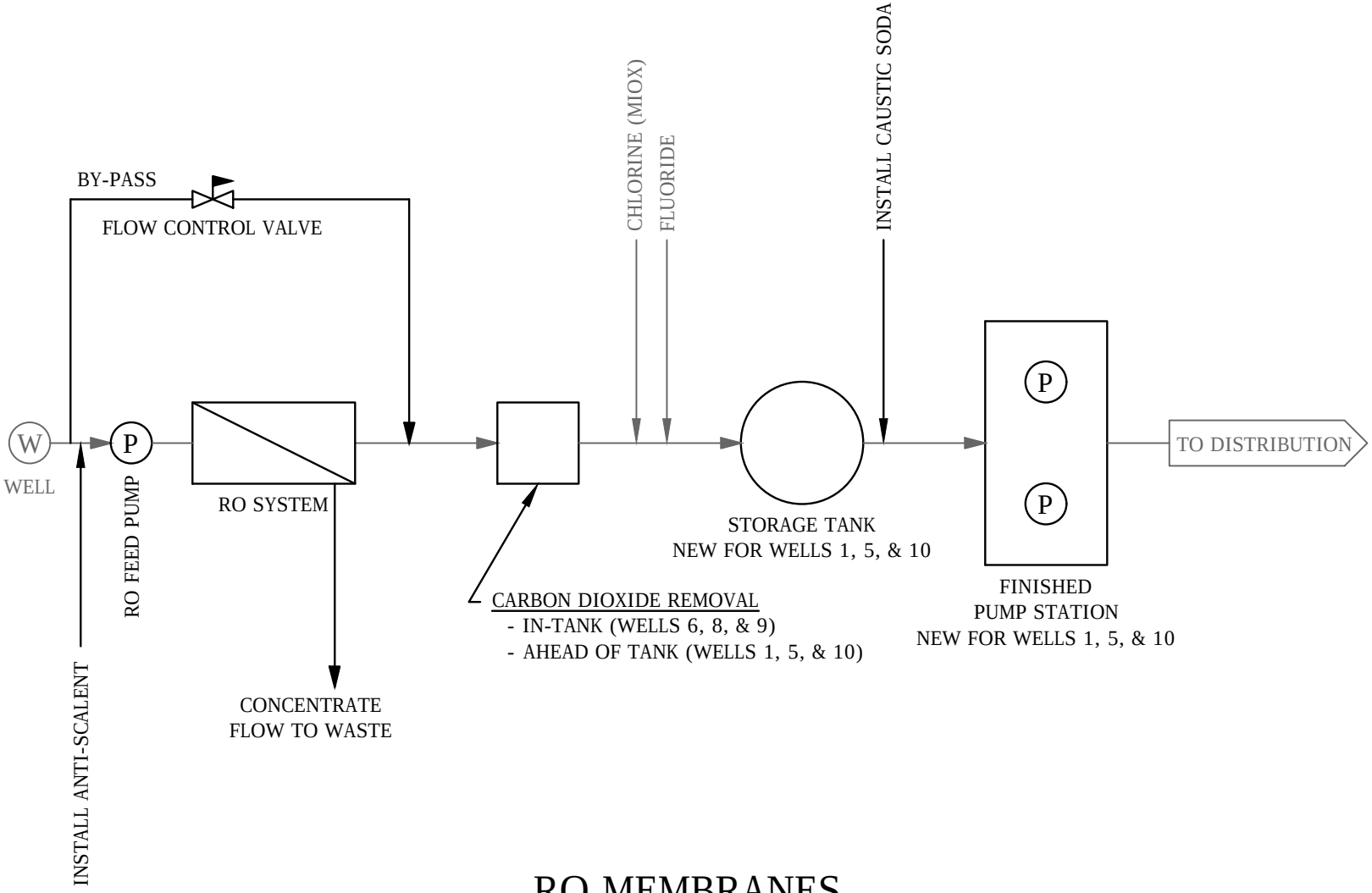
# Reverse Osmosis

**Eureka, MO**
**Incorporation of RO Membranes**

In order to reduce the TDS level in the water a different treatment technology will be required. The most probable alternative is the removal of the Ion Exchange softening units, and the incorporation of RO membrane systems. The anticipated changes that would be involved are outlined below.

- Remove the IX filters, and use that space for the RO membrane skids.
- Since Iron and Manganese were not detected in the raw water, no pre-treatment will be required ahead of the RO membranes. Further documentation will be required if this alternative is pursued. The Silt Density Index (SDI), will also need to be confirmed on the raw water to be feed directly to the RO membranes.
- No treatment on the by-pass line, but further documentation will be required if this alternative is pursued.
- Addition of an anti-scalent chemical feed ahead of the RO membranes to prevent scaling of the membrane modules.
- The process will still require aeration after the RO Membranes to strip CO2 to raise the pH. Wells 6, 8, and 9 would likely utilize the in-tank aeration system as discussed in the report. Wells 1, 5, and 10 would likely look at incorporation of an induced draft aeration unit.
- RO systems cannot discharge into high pressures. Thus, a small tank will be required at Wells 1, 5, and 10. A finished water pumping station will also be required at these sites.
- The process will still require a caustic soda feed system for final pH adjustment. Most likely the small building will still be required to house this equipment. If space is available to fit within existing building(s) that option would be utilized.
- Concept level cost for just the RO skids are in the range of $300,000 to $600,000 per site depending upon well capacity and RO by-pass ratio at each site. In addition, there will be additional cost for piping and electrical modifications.
- Since there are multiple plant sites, and chemical cleaning should only be required on a quarterly basis or even less frequently. Thus, one option to minimize cost would be to create a mobile CIP system that is mounted in a trailer. The trailer would be moved from plant to plant as cleaning is needed. The concept level cost for just the CIP equipment is $75,000. In addition the cost for the trailer will and electrical panel in the trailer will need to be added.

A simple RO process schematic is attached, and a concept level table summarizing the various flows through a RO membrane treatment process, and blended finished water quality for a few select parameters.




# RO MEMBRANES SCHEMATIC

Bartlett & West
www.bartlettwest.com

CITY OF EUREKA, MO
WATER QUALITY EVALUATION
PROCESS SCHEMATIC RO MEMBRANE

PROJ NO: 19500.000
DATE: 03.30.18

SHEET NUMBER 1 OF 1

**Eureka, MO**
**Concept Reverse Osmosis Flow Rates**

| Well | Raw Flow | RO Feed Flow | Concentrate Flow | Permeate Flow | % By-Pass | By-pass Flow | Finished Flow | Finished to Raw % | | Blended Hardness | Blended TDS | Blended Chloride | Approx Skid $ $ 0.75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1000 | 700 | 140 | 560 | 30 | 300 | 860 | 86% | | 115 | 540 | 74 | $ 604,800 |
| 1 | 1000 | 550 | 110 | 440 | 45 | 450 | 890 | 89% | | 165 | 754 | 107 | $ 475,200 |
| 5 | 1000 | 650 | 130 | 520 | 35 | 350 | 870 | 87% | | 162 | 489 | 196 | $ 561,600 |
| 5 | 1000 | 620 | 124 | 496 | 38 | 380 | 576 | 58% | | 174 | 523 | 212 | $ 535,680 |
| 6 | 600 | 390 | 78 | 312 | 35 | 210 | 522 | 87% | | 152 | 446 | 177 | $ 336,960 |
| 6 | 600 | 360 | 72 | 288 | 40 | 240 | 528 | 88% | | 171 | 498 | 200 | $ 311,040 |
| 8 | 700 | 455 | 91 | 364 | 35 | 245 | 609 | 87% | | 148 | 355 | 123 | $ 393,120 |
| 8 | 700 | 420 | 84 | 336 | 40 | 280 | 616 | 88% | | 167 | 396 | 140 | $ 362,880 |
| 9 | 800 | 480 | 96 | 384 | 40 | 320 | 704 | 88% | | 137 | 174 | 11 | $ 414,720 |
| 9 | 800 | 400 | 80 | 320 | 50 | 400 | 720 | 90% | | 168 | 209 | 14 | $ 345,600 |
| 10 | 750 | 525 | 105 | 420 | 30 | 225 | 645 | 86% | | 133 | 319 | 116 | $ 453,600 |
| 10 | 750 | 450 | 90 | 360 | 40 | 300 | 660 | 88% | | 172 | 405 | 150 | $ 388,800 |

Note: Concentrate Flows Based on Assumed 80% Permeate of Feed Flow

| | | |
|---|---|---|
| Minimum | $ | 311,040 |
| Average | $ | 432,000 |
| Maximum | $ | 604,800 |

# APPENDIX S

# Cost Estimates

# Chemical Supply Costs

Eureka, MO

**General**

| Well No. | #1 | #5 | #6 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|
| Storage at Site (Y/N) | N | N | Y | Y | Y | N |
| Well Cap (gpm) | 1,000 | 1,000 | 600 | 700 | 800 | 750 |
| Total production gal/yr (gal) | 144,130,000 | 142,623,000 | 132,284,000 | 109,953,000 | 10,245,838 | 80,102,000 |
| Avg prduction gal/day (gal) | 393,875 | 389,697 | 362,312 | 300,903 | 33,505 | 218,791 |
| Avg processing hrs/day (hrs) | 6.56 | 6.49 | 10.06 | 7.16 | 0.70 | 4.86 |

**No Aeration**

| | | | | | | |
|---|---|---|---|---|---|---|
| Dosage @ 30% souln. (mg/L) | 75 | 90 | 45 | 45 | 45 | 65 |
| Avg. gal product/hr (gph) | 11.27 | 13.53 | 4.06 | 4.73 | 5.41 | 7.33 |
| Bulk Tanks Size (gal) | 2,300 | 2,700 | 1,300 | 1,100 | 150 | 1,100 |
| Day Tank Size (gal) | 150 | 180 | 90 | 70 | 10 | 80 |
| | | | | | | |
| Annual Gal of Solution @ 30% (gal) | 27,006 | 32,064 | 14,905 | 12,379 | 1,378 | 13,001 |
| Annual lbs of Solution at 11.11 lb/gal of solun. (lbs) | 300,038 | 356,227 | 165,597 | 137,529 | 15,313 | 144,444 |
| Annual Cost of 30% Solution @ $0.38/lb of solun. | $114,014 | $135,366 | $62,927 | $52,261 | $5,819 | $54,889 |
| | | | | | | |
| Annual Gal of Solution @ 50% (gal) | 14,094 | 16,733 | 7,779 | 6,460 | 719 | 6,785 |
| Annual lbs of Solution at 12.76 lb/gal of solun. (lbs) | 179,835 | 213,513 | 99,254 | 82,432 | 9,178 | 86,576 |
| Annual Cost of 50% Solution @ $0.41/lb of solun. | $73,732 | $87,540 | $40,694 | $33,797 | $3,763 | $35,496 |

**Aeration + Caustic**

| | | | | | | |
|---|---|---|---|---|---|---|
| Dosage @ 30% souln. (mg/L) | 37.5 | 45 | 22.5 | 22.5 | 22.5 | 32.5 |
| Avg. gal product/hr (gph) | 5.64 | 6.76 | 2.03 | 2.37 | 2.71 | 3.66 |
| Bulk Tanks Size (gal) | 1,200 | 1,400 | 700 | 600 | 100 | 600 |
| Day Tank Size (gal) | 80 | 90 | 50 | 40 | 10 | 40 |
| | | | | | | |
| Annual Gal of Solution @ 30% (gal) | 13,503 | 16,032 | 7,453 | 6,189 | 689 | 6,501 |
| Annual lbs of Solution at 11.11 lb/gal of solun. (lbs) | 150,019 | 178,113 | 82,798 | 68,765 | 7,657 | 72,222 |
| Annual Cost of 30% Solution @ $0.38/lb of solun. | $57,007 | $67,683 | $31,463 | $26,131 | $2,910 | $27,444 |
| | | | | | | |
| Annual Gal of Solution @ 50% (gal) | 7,047 | 8,367 | 3,889 | 3,230 | 360 | 3,392 |
| Annual lbs of Solution at 12.76 lb/gal of solun. (lbs) | 89,918 | 106,757 | 49,627 | 41,216 | 4,589 | 43,288 |
| Annual Cost of 50% Solution @ $0.41/lb of solun. | $36,866 | $43,770 | $20,347 | $16,898 | $1,882 | $17,748 |

Bartlett & West
1719 SOUTHRIDGE DRIVE SUITE 100 ▪ JEFFERSON CITY MO 65109
573.634.3181 ▪ FAX 573.634.7904 ▪ 866.869.8031
WWW.BARTWEST.COM

# Engineer's Estimate

**Date:** 03/30/18
**Project No.:** 19500.000

## Engineers Project Cost Estimate
## Cost Estimate Without Aeration
### City of Eureka, MO

**All Well Treatment Plant Sites**

| ITEM | DESCRIPTION | UNIT | QUANTITY | UNIT COST | EXTENSION |
|---|---|---|---|---|---|
| 1 | Sodium Hydroxide Chemical Feed System | LS | 1 | $20,000.00 | $20,000.00 |
| 2 | Foundation, Floor Slab, Spill Containment | LS | 1 | $12,500.00 | $12,500.00 |
| 3 | Building and Doors to House Equipment and Chem Feed | LS | 1 | $30,000.00 | $30,000.00 |
| 4 | Heating and Ventilation, Plumbing | LS | 1 | $24,000.00 | $24,000.00 |
| 5 | Electrical Power, Lights | LS | 1 | $24,000.00 | $24,000.00 |
| 6 | Instrumentation and Control | LS | 1 | $4,000.00 | $4,000.00 |
| | | | | Total Estimated Construction Cost: | $114,500.00 |
| | | | | Construction Contingencies (15%): | $17,180.00 |
| | | | | Total Estimated Construction Cost with Contingencies Per Site: | $131,680.00 |
| | | | | Total Estimated Construction Cost with Contingencies for 6 Sites: | $790,080.00 |
| | | | | **Total Estimated Construction Cost:** | **$790,080.00** |
| | | | | ***Non-Construction Costs (35%):** | **$276,530.00** |
| | | | | **Total Estimated Project Cost:** | **$1,066,610.00** |

This project cost opinion was prepared using bid tabulation information available at the time of preparation and is prepared in good faith using engineer's judgment and experience. The engineer makes no guarantee as to the actual costs for construction. At the time of preparation, the third party utility relocation needs were unknown, and therefore, are not included in this estimate. In addition, other project costs such as right-of-way and easement acquisition, permitting, and fees are not included in this estimate.

*Non Construction Costs Include:

Engineering Report
Surveying and Field Verification
Geotech
Final Design
Permitting
Bidding and Advertising
Construction Observation
Construction Administration
Legal Fees
Bond Counsel
Interest During Construction
Financing Fees
Construction Staking
Environmental Report

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# Engineer's Estimate

**Date:** 03/30/18
**Project No.:** 19500.000

## Engineers Project Cost Estimate
## Cost Estimate With Aeration
### City of Eureka, MO

**Wells 1, 5, and 10 (No On-Site Tank)**

| ITEM | DESCRIPTION | UNIT | QUANTITY | UNIT COST | EXTENSION |
|---|---|---|---|---|---|
| 1 | Skid Mounted Aeration and Repumping System Installed (Ave Cost of the 3 Sites) | LS | 1 | $157,000.00 | $157,000.00 |
| 2 | Sodium Hydroxide Chemical Feed System | LS | 1 | $15,000.00 | $15,000.00 |
| 3 | Piping, Fittings, Valves For Aeration System | LS | 1 | $20,000.00 | $20,000.00 |
| 4 | Foundation, Floor Slab, Spill Containment | LS | 1 | $15,000.00 | $15,000.00 |
| 5 | Building and Doors to House Equipment and Chem Feed | LS | 1 | $40,000.00 | $40,000.00 |
| 6 | Heating and Ventilation, Plumbing | LS | 1 | $38,000.00 | $38,000.00 |
| 7 | Electrical Power, Lights | LS | 1 | $57,000.00 | $57,000.00 |
| 8 | Instrumentation and Control | LS | 1 | $8,000.00 | $8,000.00 |
| | | | | Total Estimated Construction Cost: | $350,000.00 |
| | | | | Construction Contingencies (15%): | $52,500.00 |
| | | | | Total Estimated Construction Cost with Contingencies Per Site: | $402,500.00 |
| | | | | Total Estimated Construction Cost with Contingencies for 3 Sites: | $1,207,500.00 |

| Wells 6, 8, and 9 (On-Site Tank) | | | | | |
|---|---|---|---|---|---|
| ITEM | DESCRIPTION | UNIT | QUANTITY | UNIT COST | EXTENSION |
| 1 | In-Tank Aeration System (Installed by Manufacture) | LS | 1 | $93,000.00 | $93,000.00 |
| 2 | Sodium Hydroxide Chemical Feed System | LS | 1 | $17,000.00 | $17,000.00 |
| 3 | Foundations, Slabs, Floors | LS | 1 | $12,500.00 | $12,500.00 |
| 4 | Building and Doors to House Equipment and Chem Feed | LS | 1 | $30,000.00 | $30,000.00 |
| 5 | Heating and Ventilation, Plumbing | LS | 1 | $30,000.00 | $30,000.00 |
| 6 | Electrical Power, Lights | LS | 1 | $40,000.00 | $40,000.00 |
| 7 | Instrumentation and Control | LS | 1 | $4,000.00 | $4,000.00 |
| | | | | Total Estimated Construction Cost: | $226,500.00 |
| | | | | Construction Contingencies (15%): | $33,980.00 |
| | | | | Total Estimated Construction Cost with Contingencies: | $260,480.00 |
| | | | | Total Estimated Construction Cost with Contingencies for 3 Sites: | $781,440.00 |
| | | | | | |
| | | | | **Total Estimated Construction Cost:** | **$1,988,940.00** |
| | | | | ***Non-Construction Costs (35%):** | **$696,130.00** |
| | | | | **Total Estimated Project Cost:** | **$2,685,070.00** |

This project cost opinion was prepared using bid tabulation information available at the time of preparation and is prepared in good faith using engineer's judgment and experience. The engineer makes no guarantee as to the actual costs for construction. At the time of preparation, the third party utility relocation needs were unknown, and therefore, are not included in this estimate. In addition, other project costs such as right-of-way and easement acquisition, permitting, and fees are not included in this estimate.

*Non Construction Costs Include:

Engineering Report
Surveying and Field Verification
Geotech
Final Design
Permitting
Bidding and Advertising
Construction Observation
Construction Administration
Legal Fees
Bond Counsel
Interest During Construction
Financing Fees
Construction Staking
Environmental Report

# APPENDIX W

# Water Quality Data

# EUREKA

Public Water System ID Number: MO6010258

# 2016 Annual Water Quality Report

***(Consumer Confidence Report)***

***This report is intended to provide you with important information about your drinking water and the efforts made to provide safe drinking water.***

***Attencion!***

Este informe contiene información muy importante. Tradúscalo o prequntele a alguien que lo entienda bien.
[Translated: This report contains very important information. Translate or ask someone who understands this very well.]

## What is the source of my water?

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and groundwater wells. As water travels over the surface of the land or through the ground, it dissolves naturally-occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity.

**Our water comes from the following source(s):**

| Source Name | Type |
|---|---|
| WELL #10 ASHTON | GROUND WATER |
| 1 HOWRTN LANE W5 | GROUND WATER |
| WELL #8 VIOLA | GROUND WATER |
| 5 DREWEL PARK W6 | GROUND WATER |
| 6 LEGENDS W7 | GROUND WATER |

## Source Water Assessment

The Department of Natural Resources conducted a source water assessment to determine the susceptibility of our water source to potential contaminants. This process involved the establishment of source water area delineations for each well or surface water intake and then a contaminant inventory was performed within those delineated areas to assess potential threats to each source. Assessment maps and summary information sheets are available on the internet at http://maproom.missouri.edu/swipmaps/pwssid.htm. To access the maps for your water system you will need the State-assigned identification code, which is printed at the top of this report. The Source Water Inventory Project maps and information sheets provide a foundation upon which a more comprehensive source water protection plan can be developed.

## Why are there contaminants in my water?

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline (800-426-4791).

Contaminants that may be present in source water include:
A. Microbial contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.
B. Inorganic contaminants, such as salts and metals, which can be naturally-occurring or result from urban stormwater runoff, industrial, or domestic wastewater discharges, oil and gas production, mining, or farming.
C. Pesticides and herbicides, which may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses.
D. Organic chemical contaminants, including synthetic and volatile organic chemicals, which are byproducts of industrial processes and petroleum production, and can also come from gas stations, urban stormwater runoff, and septic systems.
E. Radioactive contaminants, which can be naturally-occurring or be the result of oil and gas production and mining activities.

In order to ensure that tap water is safe to drink, the Department of Natural Resources prescribes regulations which limit the amount of certain contaminants in water provided by public water systems. Department of Health regulations establish limits for contaminants in bottled water which must provide the same protection for public health.

## Is our water system meeting other rules that govern our operations?

The Missouri Department of Natural Resources regulates our water system and requires us to test our water on a regular basis to ensure its safety. Our system has been assigned the identification number MO6010258 for the purposes of tracking our test results. Last year, we tested for a variety of contaminants. The detectable results of these tests are on the following pages of this report. Any violations of state requirements or standards will be further explained later in this report.

## How might I become actively involved?

If you would like to observe the decision-making process that affect drinking water quality or if you have any further questions about your drinking water report, please call us at **636-938-6655 Ext: 401** to inquire about scheduled meetings or contact persons.

## Do I need to take any special precautions?

Some people may be more vulnerable to contaminants in drinking water than the general population. Immunocompromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/CDC guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline (800-426-4791).

## Terms and Abbreviations

**Population**: 10000. This is the equivalent residential population served including non-bill paying customers.
**MCLG**: Maximum Contaminant Level Goal, or the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
**MCL**: Maximum Contaminant Level, or the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.
**SMCL**. Secondary Maximum Contaminant Level, or the secondary standards that are non-enforceable guidelines for contaminants and may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water. EPA recommends these standards but does not require water systems to comply
**AL**: Action Level, or the concentration of a contaminant which, when exceeded, triggers treatment or other requirements which a water system must follow..
**TT**: Treatment Technique, or a required process intended to reduce the level of a contaminant in drinking water.
**90th percentile**: For lead and Copper testing. 10% of test results are above this level and 90% are below this level.
**Range of Results**: Shows the lowest and highest levels found during a testing period, if only one sample was taken, then this number equals the Highest Value.
**RAA**: Running Annual Average, or the average of sample analytical results for samples taken during the previous four calendar quarters.
**LRAA**: Locational Running Annual Average, or the locational average of sample analytical results for samples taken during the previous four calendar quarters.
**TTHM**: Total Trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform) as a group.
**HAA5**: Haloacetic Acids (mono-, di- and tri-chloracetic acid, and mono- and di-bromoacetic acid) as a group.
**ppb**: parts per billion or micrograms per liter.
**ppm**: parts per million or milligrams per liter.
**n/a**: not applicable.
**NTU**: Nephelometric Turbidity Unit, used to measure cloudiness in drinking water.
**nd**: not detectable at testing limits.

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Wednesday, March 22, 2017

# EUREKA

Public Water System ID Number: MO6010258

## 2016 Annual Water Quality Report

***(Consumer Confidence Report)***

# *Contaminants Report*

EUREKA will provide a printed hard copy of the CCR upon request. To request a copy of this report to be mailed, please call us at **636-938-6655 Ext: 401**. The CCR can also be found on the internet at www.dnr.mo.gov/ccr/MO6010258.pdf.

*The state has reduced monitoring requirements for certain contaminants to less often than once per year because the concentrations of these contaminants are not expected to vary significantly from year to year. Records with a sample year more than one year old are still considered representative.*

## *Regulated Contaminants*

| Regulated Contaminants | Collection Date | Highest Test Result | Range of Sampled Result(s) (low – high) | Unit | MCL | MCLG | Typical Source |
|---|---|---|---|---|---|---|---|
| BARIUM | 9/29/2015 | 0.0646 | 0.0646 | ppm | 2 | 2 | Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits |
| FLUORIDE | 9/29/2015 | 1.01 | 1.01 | ppm | 4 | 4 | Natural deposits; Water additive which promotes strong teeth |
| NITRATE-NITRITE | 8/16/2016 | 0.7 | 0.027 - 0.7 | ppm | 10 | 10 | Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits |
| TETRACHLOR OETHYLENE | 4/28/2016 | 1.78 | 0 - 1.78 | ppb | 5 | 0 | Discharge from factories and dry cleaners |

| Disinfection Byproducts | Sample Point | Monitoring Period | Highest LRAA | Range of Sampled Result(s) (low – high) | Unit | MCL | MCLG | Typical Source |
|---|---|---|---|---|---|---|---|---|
| (HAA5) | DBPDUAL-01 | 2016 | 0 | 0 - 0 | ppb | 60 | 0 | Byproduct of drinking water disinfection |
| (HAA5) | DBPDUAL-02 | 2016 | 0 | 0 - 0 | ppb | 60 | 0 | Byproduct of drinking water disinfection |
| TTHM | DBPDUAL-01 | 2016 | 1 | 0 - 2.66 | ppb | 80 | 0 | Byproduct of drinking water disinfection |
| TTHM | DBPDUAL-02 | 2016 | 5 | 4.71 - 4.71 | ppb | 80 | 0 | Byproduct of drinking water disinfection |

| Lead and Copper | Date | 90th Percentile: 90% of your water utility levels were less than | Range of Sampled Results (low – high) | Unit | AL | Sites Over AL | Typical Source |
|---|---|---|---|---|---|---|---|
| COPPER | 2013 - 2015 | 0.178 | 0.0412 - 0.472 | ppm | 1.3 | 0 | Corrosion of household plumbing systems |
| LEAD | 2013 - 2015 | 6.67 | 2.06 - 39.6 | ppb | 15 | 1 | Corrosion of household plumbing systems |

| Radionuclides | Collection Date | Highest Value | Range of Sampled Result(s) | Unit | MCL | MCLG | Typical Source |
|---|---|---|---|---|---|---|---|
| COMBINED RADIUM (-226 & -228) | 4/6/2016 | 2.2 | 0 - 2.2 | pCi/l | 5 | | Erosion of natural deposits |
| GROSS ALPHA PARTICLE ACTIVITY | 7/7/2016 | 8.5 | 0 - 8.5 | pCi/l | | | Erosion of natural deposits |
| GROSS ALPHA, EXCL. RADON & URANIUM | 7/7/2016 | 8.5 | 0 - 8.5 | pCi/l | 15 | 0 | Erosion of natural deposits |
| RADIUM-226 | 4/6/2016 | 1.1 | 0 - 1.1 | pCi/l | 5 | 0 | |
| RADIUM-228 | 4/6/2016 | 1.1 | 0 - 1.1 | pCi/l | 5 | 0 | |

| Microbiological | Result | MCL | MCLG | Typical Source |
|---|---|---|---|---|
| No Detected Results were Found in the Calendar Year of 2016 | | | | |

## *Violations and Health Effects Information*

During the 2016 calendar year, we had the below noted violation(s) of drinking water regulations.

| Compliance Period | Analyte | Type |
|---|---|---|
| No Violations Occurred in the Calendar Year of 2016 | | |

Additional Required Health Effects Language:

Infants and children are typically more vulnerable to lead in drinking water than the general population. It is possible that lead levels at your home may be higher than at other homes in the community as a result of materials used in your home's plumbing. If you are concerned about elevated lead levels in your home's water, you may wish to have your water tested and flush your tap for 30 seconds to 2 minutes before using tap water. Additional information is available from the Safe Drinking Water Hotline (800-426-4791). Certain minerals are radioactive and may emit a form of radiation known as alpha radiation. Some people who drink water containing alpha emitters in excess of the MCL over many years may have an increased risk of getting cancer.

### Special Lead and Copper Notice:

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. EUREKA is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline (800-426-4791) or at http://water.epa.gov/drink/info/lead/index.cfm. You can also find sample results for all contaminants from both past and present compliance monitoring online at the Missouri DNR Drinking Water Watch website http://dnr.mo.gov/DWW/indexSearchDNR.jsp. To find Lead and Copper results for your system, type your water system name in the box titled Water System Name and select *Find Water Systems* at the bottom of the page. The new screen will show you the water system name and number, select and click the Water System Number. At the top of the next page, under the *Help* column find, *Other Chemical Results by Analyte*, select and click on it. Scroll down alphabetically to Lead and click the blue Analyte Code (1030). The Lead and Copper locations will be displayed under the heading *Sample Comments*. Scroll to find your location and click on the *Sample No*. for the results. If your house was selected by the water system and you assisted in taking a Lead and Copper sample from your home but cannot find your location in the list, please contact EUREKA for your results.

Wednesday, March 22, 2017

# EUREKA

Public Water System ID Number: MO6010258

# 2016 Annual Water Quality Report

***(Consumer Confidence Report)***

## *Optional Monitoring (not required by EPA)*

### *Optional Contaminants*

*Monitoring is not required for optional contaminants.*

| Secondary Contaminants | Collection Date | Your Water System Highest Sampled Result | Range of Sampled Result(s) (low - high) | Unit | SMCL |
|---|---|---|---|---|---|
| ALKALINITY, CACO3 STABILITY | 9/29/2015 | 316 | 316 | MG/L | |
| CALCIUM | 9/29/2015 | 24.5 | 24.5 | MG/L | |
| CHLORIDE | 9/29/2015 | 193 | 193 | MG/L | 250 |
| HARDNESS, CARBONATE | 9/29/2015 | 115 | 115 | MG/L | |
| MAGNESIUM | 9/29/2015 | 13.1 | 13.1 | MG/L | |
| PH | 9/29/2015 | 7.35 | 7.35 | PH | 8.5 |
| POTASSIUM | 9/29/2015 | 3.97 | 3.97 | MG/L | |
| SODIUM | 9/29/2015 | 219 | 219 | MG/L | |
| SULFATE | 9/29/2015 | 42.7 | 42.7 | MG/L | 250 |
| TDS | 9/29/2015 | 671 | 671 | MG/L | 500 |
| TRICHLOROFLUOROM ETHANE | 1/29/2016 | 6.01 | 0 - 6.01 | UG/L | |
| ZINC | 9/29/2015 | 0.0206 | 0.0206 | MG/L | 5 |

Secondary standards are non-enforceable guidelines for contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water. EPA recommends these standards but does not require water systems to comply.

**CITY OF EUREKA, MO**

**WATER QUALITY ANALYSIS SUMMARY**

**GENERAL PARAMETERS, METALS, RADIONUCLIDES, ORGANICS, AND DBPs**

| CONSTITUENTS | | RESULTS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Well #1 | Well #5 | Well #6 | Well #8 | Well #9 | Well #10 | Well #1 | Well #1 | Well #5 | Well #5 | Well #6 | Well #6 | Well #8 | Well #8 | Well #9 | Well #9 | Well #10 | Well #10 | MCL |
| | | Finished | Finished | Finished | Finished | Finished | Finished | Raw | Finished | Raw | Finished | Raw | Finished | Raw | Finished | Raw | Finished | Raw | Finished | |
| | | 5/22/2017 | 5/22/2017 | 5/22/2017 | 5/22/2017 | 5/22/2017 | 5/22/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | 10/24/2017 | |
| **Field Parameters** | °F | | | | | | | | | | | | | | | | | | | |
| Temperature | °C | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | |
| pH | | 6.80 | 6.79 | 6.99 | 6.95 | 6.97 | 6.89 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | |
| | | | | | | | | | | | | | | | | | | | | |
| **Other Parameters** | | | | | | | | | | | | | | | | | | | | |
| Conductivity | mS/cm | | | | | | | | | | | | | | | | | | | |
| Solids, Total Dissolved | mg/L | 650 | 918 | 1070 | 856 | 440 | 889 | 1430 | 674 | 1140 | 1110 | 1040 | 990 | 828 | 780 | 364 | 404 | 846 | 848 | 500 [3] |
| Total Organic Carbon | mg/L | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | |
| Turbidity | NTU | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | <0.2 | <0.2 | <0.2 | <0.2 | 0.3 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | |
| | | | | | | | | | | | | | | | | | | | | |
| **General Chemistry** | | | | | | | | | | | | | | | | | | | | |
| Alkalinity, as $CaCO_3$ | mg/L | 287 | 305 | 268 | 278 | 299 | 285 | 276 | 278 | 292 | 292 | 270 | 268 | 274 | 276 | 294 | 298 | 286 | 283 | |
| Calcium, total | mg/L | 33.4 | 5.61 | 22.1 | 14.3 | 22.2 | 7.03 | 77.5 | 23.0 | 95.2 | 27.9 | 87.8 | 27.1 | 84.8 | 32.9 | 74.3 | 20.2 | 90.8 | 28.9 | |
| Chloride | mg/L | 170 | 338 | 444 | 290 | 48.9 | 322 | 212 | 211 | 488 | 487 | 439 | 440 | 307 | 302 | 24.5 | 34.4 | 332 | 321 | 250 [3] |
| Fluoride | mg/L | 0.60 | 0.67 | 0.61 | 0.60 | 0.38 | 0.36 | 0.40 | 0.60 | 0.60 | 0.80 | 0.40 | 0.70 | 0.50 | 0.80 | 0.20 | 0.60 | 0.30 | 0.60 | 4.0 |
| Hardness, Total as $CaCO_3$ | mg/l | 151 | 23.4 | 99.6 | 63.7 | 90.6 | 29.5 | 325 | 99.4 | 399 | 121 | 374 | 119 | 365 | 151 | 300 | 82.8 | 377 | 123 | |
| Iron, total | mg/L | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.3 [3] |
| Magnesium, total | mg/L | 16.4 | 2.3 | 10.8 | 6.79 | 8.54 | 2.85 | 32.0 | 10.2 | 39.3 | 12.4 | 37.6 | 12.5 | 37.3 | 16.8 | 27.3 | 7.90 | 36.4 | 12.4 | |
| Manganese, total | mg/L | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.05 [3] |
| Nitrogen, Ammonia | mg/L | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | |
| Nitrogen, Nitrate | mg/L | 0.59 | 0.63 | <0.1 | <0.1 | 0.49 | 0.51 | 0.7 | 0.7 | 0.6 | 0.6 | <0.1 | <0.1 | <0.1 | <0.1 | 0.6 | 0.6 | 0.6 | 0.6 | 10 |
| Sulfide, total | mg/L | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | <0.05 | <0.05 | <0.5 | <0.5 | <0.05 | <0.05 | <0.05 | <0.5 | <0.5 | <0.05 | <0.05 | <0.05 | |
| Sulfate | mg/L | 32.0 | 64.1 | 44.6 | 48.9 | 24.2 | 46.7 | 35.6 | 35.4 | 63.3 | 62.4 | 43.0 | 42.6 | 46.7 | 46.6 | 24.2 | 24.3 | 44.2 | 44.1 | 250 [3] |
| | | | | | | | | | | | | | | | | | | | | |
| **Inorganics, Metals** | | | | | | | | | | | | | | | | | | | | |
| Barium, total | mg/L | 0.07 | <0.05 | <0.05 | <0.05 | <0.05 | 0.08 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 2 |
| Copper, total | mg/L | 0.05 | 0.10 | 0.07 | <0.05 | 0.09 | 0.08 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 1.3 (90%) |
| Lead, total | µg/L | <0.05 | <0.05 | <0.05 | 0.6 | <0.5 | 0.8 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 0.015 (90%) |
| Potassium, total | mg/L | 6.92 | 3.43 | 10.1 | 5.03 | 1.40 | 1.59 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | |
| Sodium, total | mg/L | 179 | 339 | 340 | 243 | 147 | 313 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | |
| Zinc, total | mg/L | <0.05 | <0.05 | <0.05 | 0.05 | 0.05 | <0.05 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 5 [3] |
| | | | | | | | | | | | | | | | | | | | | |
| **Radionuclides** | | | | | | | | | | | | | | | | | | | | |
| Gross Alpha | pCi/L | 0.66 | -0.30 | 6.76 | 4.55 | 1.20 | 5.13 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 15 |
| Radium-226 | pCi/L | 0.45 | 0.25 | 0.69 | 0.25 | -0.10 | 0.97 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 5 (226+228) |
| Radium-228 | pCi/L | 0.31 | 0.35 | 1.10 | 0.61 | 0.18 | 0.19 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 5 (226+228) |
| Combined Radium (226 &228) | pCi/L | 0.76 | 0.60 | 1.79 | 0.86 | 0.18 | 1.15 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | |
| | | | | | | | | | | | | | | | | | | | | |
| **Disinfection By-Products** | | | | | | | | | | | | | | | | | | | | |
| Total THMs | µg/L | 2.4 | 2.7 | 0.7 | 0.7 | 13.8 | 1.8 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 80 |
| Halo Acetic Acid $_5$ | µg/L | <1.0 | <1.0 | 1.7 | 1.5 | 1.1 | 1.3 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 60 |
| | | | | | | | | | | | | | | | | | | | | |
| **Organics, Volatile Organic Chemicals (VOC)** | | | | | | | | | | | | | | | | | | | | |
| Tetrachloroethylene | µg/L | 0.6 | 1.6 | <0.05 | <0.5 | <0.5 | <0.5 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | 5 |
| Trichlorofluoromethane | µg/L | 4.5 | <0.5 | <0.05 | <0.5 | 2.1 | <0.5 | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | n.t. | N.A. |

n.t. = not tested n.d. = not detected

Notes:

1. Minimum Detection Limit (MDL) is the lowest detectable concentration of a constituent.
2. Maximum Contaminant Level (MCL) is the highest level of contaminant allowed in drinking water in accordance with USEPA National Primary Drinking Water Standards.
3. Secondary Maximum Contaminant Levels (SMCLs) are non-enforceable USEPA guidelines regulating contaminants that may cause cosmetic effects or aesthetic effects in drinking water.

| | | | |
|---|---|---|---|
| Water System No.: | MO6010258 | Federal Type: | C |
| Water System Name: | EUREKA PWS | Federal Source: | GW |
| Principal County / City Served: | ST LOUIS / EUREKA | System Status : | A |
| Local Name: | | Activity Date : | 1/1/1959 |
| Operating Category Code: | C3 | Permit Date : | 3/26/2013 |
| GWR Monitoring Status: | GWR - TRIGGERED SOURCE WATER MONITORING | | |

**TTHM Locational Running Annual Average**

| Site | Monitoring Period | Locational Running Annual Avg. | Samples |
|---|---|---|---|
| DBP - DISINFECTION BY PROD | 01-01-2008 to 12-31-2008 | 3.0 ug/L | 1 |
| DBPDUAL-01 - POLICE DEPT - 120 CITY HALL DR | 01-01-2017 to 12-31-2017 | 2.0 ug/L | 1 |
| | 01-01-2016 to 12-31-2016 | 1.0 ug/L | 2 |
| | 01-01-2015 to 12-31-2015 | 6.0 ug/L | 1 |
| | 01-01-2014 to 12-31-2014 | 6.0 ug/L | 1 |
| DBPDUAL-02 - 111 N VIRGINIA | 01-01-2017 to 12-31-2017 | 0.0 ug/L | 1 |
| | 01-01-2016 to 12-31-2016 | 5.0 ug/L | 1 |
| DBPMAX | 01-01-2011 to 12-31-2013 | 18.0 ug/L | 1 |
| | 01-01-2010 to 12-31-2010 | 2.0 ug/L | 1 |
| | 01-01-2009 to 12-31-2009 | 0.0 ug/L | 1 |

**HAA5 Locational Running Annual Average**

| Site | Monitoring Period | Locational Running Annual Avg. | Samples |
|---|---|---|---|
| DBP - DISINFECTION BY PROD | 01-01-2008 to 12-31-2008 | 0.0 ug/L | 1 |
| DBPDUAL-01 - POLICE DEPT - 120 CITY HALL DR | 01-01-2017 to 12-31-2017 | 0.0 ug/L | 1 |
| | 01-01-2016 to 12-31-2016 | 0.0 ug/L | 2 |
| | 01-01-2015 to 12-31-2015 | 0.0 ug/L | 1 |
| | 01-01-2014 to 12-31-2014 | 0.0 ug/L | 1 |
| DBPDUAL-02 - 111 N VIRGINIA | 01-01-2017 to 12-31-2017 | 0.0 ug/L | 1 |
| | 01-01-2016 to 12-31-2016 | 0.0 ug/L | 1 |
| DBPMAX | 01-01-2011 to 12-31-2013 | 0.0 ug/L | 1 |
| | 01-01-2010 to 12-31-2010 | 0.0 ug/L | 1 |
| | 01-01-2009 to 12-31-2009 | 0.0 ug/L | 1 |

# Eureka PWS Corrosion Indicies

| Sample Information | | Water Quality Input | | | | | | | Modeled Water Quality | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name / ID | Date | TDS (mg/L) | Field pH | Alkalinity | Calcium (mg/L) | Field Temp (°C) | Chloride mg/L | Sulfate mg/L | $CO_2$ (mg/L) | DIC (mg/L) | Aggressive Index | Ryznar Index | Langelier Index | CCPP mg/L | Buffer Intensity | Larson-Skold | CSMR |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #1, Raw | 10/24/17 | 1,430 | 6.80 | 276.0 | 77.5 | 16.1 | 212.0 | 35.6 | 83.8 | 89.1 | 11.5 | **7.87** | -0.54 | -69.7 | 3.260 | 0.82 | 5.96 |
| Eureka Well #5, Raw | 10/24/17 | 1,140 | 6.80 | 292.0 | 95.2 | 12.8 | 488.0 | 63.3 | 95.8 | 96.2 | 11.6 | **7.70** | -0.45 | -65.9 | 3.650 | 0.39 | 7.71 |
| Eureka Well #6, Raw | 10/24/17 | 1,040 | 7.00 | 270.0 | 87.8 | 15.6 | 439.0 | 43.0 | 53.2 | 79.3 | 11.7 | **7.52** | -0.26 | -28.3 | 2.280 | 0.41 | 10.21 |
| Eureka Well #8, Raw | 10/24/17 | 828 | 7.00 | 274.0 | 84.8 | 17.8 | 307.0 | 46.7 | 52.6 | 80.1 | 11.7 | 7.43 | -0.22 | -23.0 | 2.260 | 0.57 | 6.57 |
| Eureka Well #9, Raw | 10/24/17 | 364 | 7.00 | 294.0 | 74.3 | 18.9 | 24.5 | 24.2 | 57.6 | 86.2 | 11.7 | 7.29 | -0.14 | -15.7 | 2.470 | **4.92** | 1.01 |
| Eureka Well #10, Raw | 10/24/17 | 846 | 6.90 | 286.0 | 90.8 | 13.9 | 332.0 | 44.2 | 74.1 | 88.8 | 11.7 | **7.55** | -0.33 | -41.9 | 3.000 | 0.56 | 7.51 |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #1, Finished | 05/22/17 | 650 | 6.80 | 287.0 | 33.4 | 15.3 | 170.0 | 32.0 | 92.4 | 94.1 | 11.2 | **8.41** | -0.80 | -89.2 | 3.540 | 1.05 | 5.31 |
| Eureka Well #1, Finished | 10/24/17 | 674 | 6.80 | 278.0 | 23.0 | 16.1 | 211.0 | 35.5 | 88.1 | 90.7 | 11.0 | **8.74** | -0.97 | -94.8 | 3.390 | 0.83 | 5.94 |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #5, Finished | 05/22/17 | 918 | 6.80 | 305.0 | 5.6 | 11.9 | 338.0 | 64.1 | 103 | 101 | 10.4 | **10.09** | **-1.65** | -125 | 3.900 | 0.56 | 5.27 |
| Eureka Well #5, Finished | 10/24/17 | 1,110 | 6.80 | 292.0 | 27.9 | 12.8 | 487.0 | 62.4 | 96.0 | 96.3 | 11.1 | **8.75** | -0.98 | -106 | 3.660 | 0.39 | 7.80 |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #6, Finished | 05/22/17 | 1,070 | 7.00 | 268.0 | 22.1 | 16.1 | 444.0 | 44.6 | 52.2 | 78.5 | 11.1 | **8.71** | -0.86 | -63.5 | 2.240 | 0.40 | 9.96 |
| Eureka Well #6, Finished | 10/24/17 | 990 | 7.00 | 268.0 | 27.1 | 15.6 | 440.0 | 42.6 | 53.0 | 78.7 | 11.2 | **8.53** | -0.77 | -60.7 | 2.270 | 0.40 | 10.33 |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #8, Finished | 05/22/17 | 856 | 7.00 | 278.0 | 14.3 | 16.4 | 290.0 | 48.9 | 54.6 | 81.6 | 11.0 | **9.01** | **-1.00** | -67.5 | 2.340 | 0.60 | 5.93 |
| Eureka Well #8, Finished | 10/24/17 | 780 | 7.00 | 276.0 | 32.9 | 17.8 | 302.0 | 46.6 | 53.1 | 80.7 | 11.3 | **8.23** | -0.61 | -51.8 | 2.290 | 0.58 | 6.48 |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #9, Finished | 05/22/17 | 440 | 7.00 | 299.0 | 22.2 | 18.9 | 48.9 | 24.2 | 58.1 | 87.6 | 11.2 | **8.35** | -0.67 | -53.5 | 2.490 | **3.17** | 2.02 |
| Eureka Well #9, Finished | 10/24/17 | 404 | 7.00 | 298.0 | 20.2 | 18.9 | 34.4 | 24.3 | 58.1 | 87.3 | 11.1 | **8.42** | -0.71 | -54.5 | 2.490 | **4.03** | 1.42 |
| | | | | | | | | | | | | | | | | | |
| Eureka Well #10, Finished | 05/22/17 | 889 | 6.90 | 285.0 | 7.0 | 13.3 | 322.0 | 46.7 | 74.6 | 88.7 | 10.6 | **9.80** | **-1.45** | -96.5 | 3.010 | 0.57 | 6.90 |
| Eureka Well #10, Finished | 10/24/17 | 848 | 6.90 | 283.0 | 28.9 | 13.9 | 321.0 | 44.1 | 73.4 | 87.9 | 11.2 | **8.55** | -0.82 | -78.9 | 2.970 | 0.57 | 7.28 |
| | | | | | | | | | | | | | | | | | |

# Corrosion Indices and Chemical Treatment

**Process Data** Number of Data Sets: **48** to process (max 500)

## Step 1: Water Quality Data - User Input

| Data Set # | Site # or Name | Sample Date | TDS mg/L | pH | Alkalinity mg/L $CaCO_3$ | Calcium mg/L $Ca^{2+}$ | Temp. C° for pH Measurement | Temp. C° for Field Operations | Chloride mg/L $Cl^-$ | Sulfate mg/L $SO_4^{2-}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | Eureka Well #1, Raw | 10/24/17 | 1,430 | 6.80 | 276.0 | 77.5 | 16.1 | 16.1 | 212.0 | 35.6 |
| 3 | Eureka Well #1, Finished | 05/22/17 | 650 | 6.80 | 287.0 | 33.4 | 15.3 | 15.3 | 170.0 | 32.0 |
| 4 | Eureka Well #1, Finished | 10/24/17 | 674 | 6.80 | 278.0 | 23.0 | 16.1 | 16.1 | 211.0 | 35.5 |
| 5 | Eureka Well #1 IX (NaOH) | σ Finished | 662 | 6.80 | 282.5 | 28.2 | 15.7 | 15.7 | 190.5 | 33.8 |
| 6 | Eureka Well #1 IX (Air) | σ Finished | 662 | 6.80 | 282.5 | 28.2 | 15.7 | 15.7 | 190.5 | 33.8 |
| 7 | Eureka Well #1 IX (Air+NaOH) | σ Finished | 662 | 6.80 | 282.5 | 28.2 | 15.7 | 15.7 | 190.5 | 33.8 |
| 8 | Eureka Well #1 IX (NaOH+Air) | σ Finished | 662 | 6.80 | 282.5 | 28.2 | 15.7 | 15.7 | 190.5 | 33.8 |
| 9 | | | | | | | | | | |
| 10 | Eureka Well #5, Raw | 10/24/17 | 1,140 | 6.80 | 292.0 | 95.2 | 12.8 | 12.8 | 488.0 | 63.3 |
| 11 | Eureka Well #5, Finished | 05/22/17 | 918 | 6.80 | 305.0 | 5.6 | 11.9 | 11.9 | 338.0 | 64.1 |
| 12 | Eureka Well #5, Finished | 10/24/17 | 1,110 | 6.80 | 292.0 | 27.9 | 12.8 | 12.8 | 487.0 | 62.4 |
| 13 | Eureka Well #5 IX (NaOH) | σ Finished | 1,014 | 6.80 | 298.5 | 16.8 | 12.4 | 12.4 | 412.5 | 63.3 |
| 14 | Eureka Well #5 IX (Air) | σ Finished | 1,014 | 6.80 | 298.5 | 16.8 | 12.4 | 12.4 | 412.5 | 63.3 |
| 15 | Eureka Well #5 IX (Air+NaOH) | σ Finished | 1,014 | 6.80 | 298.5 | 16.8 | 12.4 | 12.4 | 412.5 | 63.3 |
| 16 | Eureka Well #5 IX (NaOH+Air) | σ Finished | 1,014 | 6.80 | 298.5 | 16.8 | 12.4 | 12.4 | 412.5 | 63.3 |
| 17 | | | | | | | | | | |
| 18 | Eureka Well #6, Raw | 10/24/17 | 1,040 | 7.00 | 270.0 | 87.8 | 15.6 | 15.6 | 439.0 | 43.0 |
| 19 | Eureka Well #6, Finished | 05/22/17 | 1,070 | 7.00 | 268.0 | 22.1 | 16.1 | 16.1 | 444.0 | 44.6 |
| 20 | Eureka Well #6, Finished | 10/24/17 | 990 | 7.00 | 268.0 | 27.1 | 15.6 | 15.6 | 440.0 | 42.6 |
| 21 | Eureka Well #6 IX (NaOH) | σ Finished | 1,030 | 7.00 | 268.0 | 24.6 | 15.9 | 15.9 | 442.0 | 43.6 |
| 22 | Eureka Well #6 IX (Air) | σ Finished | 1,030 | 7.00 | 268.0 | 24.6 | 15.9 | 15.9 | 442.0 | 43.6 |
| 23 | Eureka Well #6 IX (Air+NaOH) | σ Finished | 1,030 | 7.00 | 268.0 | 24.6 | 15.9 | 15.9 | 442.0 | 43.6 |
| 24 | Eureka Well #6 IX (NaOH+Air) | σ Finished | 1,030 | 7.00 | 268.0 | 24.6 | 15.9 | 15.9 | 442.0 | 43.6 |
| 25 | | | | | | | | | | |
| 26 | Eureka Well #8, Raw | 10/24/17 | 828 | 7.00 | 274.0 | 84.8 | 17.8 | 17.8 | 307.0 | 46.7 |
| 27 | Eureka Well #8, Finished | 05/22/17 | 856 | 7.00 | 278.0 | 14.3 | 16.4 | 16.4 | 290.0 | 48.9 |
| 28 | Eureka Well #8, Finished | 10/24/17 | 780 | 7.00 | 276.0 | 32.9 | 17.8 | 17.8 | 302.0 | 46.6 |
| 29 | Eureka Well #8 IX (NaOH) | σ Finished | 818 | 7.00 | 277.0 | 23.6 | 17.1 | 17.1 | 296.0 | 47.8 |
| 30 | Eureka Well #8 IX (Air) | σ Finished | 818 | 7.00 | 277.0 | 23.6 | 17.1 | 17.1 | 296.0 | 47.8 |
| 31 | Eureka Well #8 IX (Air+NaOH) | σ Finished | 818 | 7.00 | 277.0 | 23.6 | 17.1 | 17.1 | 296.0 | 47.8 |
| 32 | Eureka Well #8 IX (NaOH+Air) | σ Finished | 818 | 7.00 | 277.0 | 23.6 | 17.1 | 17.1 | 296.0 | 47.8 |
| 33 | | | | | | | | | | |
| 34 | Eureka Well #9, Raw | 10/24/17 | 364 | 7.00 | 294.0 | 74.3 | 18.9 | 18.9 | 24.5 | 24.2 |
| 35 | Eureka Well #9, Finished | 05/22/17 | 440 | 7.00 | 299.0 | 22.2 | 18.9 | 18.9 | 48.9 | 24.2 |
| 36 | Eureka Well #9, Finished | 10/24/17 | 404 | 7.00 | 298.0 | 20.2 | 18.9 | 18.9 | 34.4 | 24.3 |
| 37 | Eureka Well #9 IX (NaOH) | σ Finished | 422 | 7.00 | 298.5 | 21.2 | 18.9 | 18.9 | 41.7 | 24.3 |
| 38 | Eureka Well #9 IX (Air) | σ Finished | 422 | 7.00 | 298.5 | 21.2 | 18.9 | 18.9 | 41.7 | 24.3 |
| 39 | Eureka Well #9 IX (Air+NaOH) | σ Finished | 422 | 7.00 | 298.5 | 21.2 | 18.9 | 18.9 | 41.7 | 24.3 |
| 40 | Eureka Well #9 IX (NaOH+Air) | σ Finished | 422 | 7.00 | 298.5 | 21.2 | 18.9 | 18.9 | 41.7 | 24.3 |
| 41 | | | | | | | | | | |
| 42 | Eureka Well #10, Raw | 10/24/17 | 846 | 6.90 | 286.0 | 90.8 | 13.9 | 13.9 | 332.0 | 44.2 |
| 43 | Eureka Well #10, Finished | 05/22/17 | 889 | 6.90 | 285.0 | 7.0 | 13.3 | 13.3 | 322.0 | 46.7 |
| 44 | Eureka Well #10, Finished | 10/24/17 | 848 | 6.90 | 283.0 | 28.9 | 13.9 | 13.9 | 321.0 | 44.1 |
| 45 | Eureka Well #10 IX (NaOH) | σ Finished | 869 | 6.90 | 284.0 | 18.0 | 13.6 | 13.6 | 321.5 | 45.4 |
| 46 | Eureka Well #10 IX (Air) | σ Finished | 869 | 6.90 | 284.0 | 18.0 | 13.6 | 13.6 | 321.5 | 45.4 |
| 47 | Eureka Well #10 IX (Air+NaOH) | σ Finished | 869 | 6.90 | 284.0 | 18.0 | 13.6 | 13.6 | 321.5 | 45.4 |
| 48 | Eureka Well #10 IX (NaOH+Air) | σ Finished | 869 | 6.90 | 284.0 | 18.0 | 13.6 | 13.6 | 321.5 | 45.4 |
| 49 | | | | | | | | | | |

## Step 2: Indices Water Quality Results

| Data Set # | pH | $CO_2$ mg/L $CO_{2(aq)}$ | DIC mg/L as C | Aggressive Index AI | Ryznar Index RI | Langelier Index LI | CCPP mg/L as $CaCO_3$ | Buffer Intensity mM/pH | Larson's Ratio $Alk/(Cl^- + SO_4^{2-})$ | CSMR | Cu II mg/L | Pb II mg/L | pH @ 25°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | |
| 2 | 6.80 | 83.8 | 89.1 | 11.5 | 7.87 | -0.54 | -69.70 | 3.260 | 0.82 | 5.96 | 15.90 | 0.18 | 6.74 |
| 3 | 6.80 | 92.4 | 94.1 | 11.2 | 8.41 | -0.80 | -89.20 | 3.540 | 1.05 | 5.31 | 17.70 | 0.18 | 6.73 |
| 4 | 6.80 | 88.1 | 90.7 | 11.0 | 8.74 | -0.97 | -94.80 | 3.390 | 0.83 | 5.94 | 16.30 | 0.18 | 6.74 |
| 5 | 6.80 | 90.2 | 92.4 | 11.1 | 8.56 | -0.88 | -92.00 | 3.470 | 0.93 | 5.64 | 17.00 | 0.18 | 6.74 |
| 6 | 6.80 | 90.2 | 92.4 | 11.1 | 8.56 | -0.88 | -92.00 | 3.470 | 0.93 | 5.64 | 17.00 | 0.18 | 6.74 |
| 7 | 6.80 | 90.2 | 92.4 | 11.1 | 8.56 | -0.88 | -92.00 | 3.470 | 0.93 | 5.64 | 17.00 | 0.18 | 6.74 |
| 8 | 6.80 | 90.2 | 92.4 | 11.1 | 8.56 | -0.88 | -92.00 | 3.470 | 0.93 | 5.64 | 17.00 | 0.18 | 6.74 |
| 9 | | | | | | | | | | | | | |
| 10 | 6.80 | 95.8 | 96.2 | 11.6 | 7.70 | -0.45 | -65.90 | 3.650 | 0.39 | 7.71 | 21.40 | 0.17 | 6.71 |
| 11 | 6.80 | 103 | 101 | 10.4 | 10.09 | -1.65 | -125 | 3.900 | 0.56 | 5.27 | 23.70 | 0.16 | 6.71 |
| 12 | 6.80 | 96.0 | 96.3 | 11.1 | 8.75 | -0.98 | -106 | 3.660 | 0.39 | 7.80 | 21.40 | 0.17 | 6.71 |
| 13 | 6.80 | 99.6 | 98.8 | 10.9 | 9.17 | -1.19 | -115 | 3.780 | 0.46 | 6.52 | 22.50 | 0.17 | 6.71 |
| 14 | 6.80 | 99.6 | 98.8 | 10.9 | 9.17 | -1.19 | -115 | 3.780 | 0.46 | 6.52 | 22.50 | 0.17 | 6.71 |
| 15 | 6.80 | 99.6 | 98.8 | 10.9 | 9.17 | -1.19 | -115 | 3.780 | 0.46 | 6.52 | 22.50 | 0.17 | 6.71 |
| 16 | 6.80 | 99.6 | 98.8 | 10.9 | 9.17 | -1.19 | -115 | 3.780 | 0.46 | 6.52 | 22.50 | 0.17 | 6.71 |
| 17 | | | | | | | | | | | | | |
| 18 | 7.00 | 53.2 | 79.3 | 11.7 | 7.52 | -0.26 | -28.30 | 2.280 | 0.41 | 10.21 | 9.51 | 0.17 | 6.94 |
| 19 | 7.00 | 52.2 | 78.5 | 11.1 | 8.71 | -0.86 | -63.50 | 2.240 | 0.40 | 9.96 | 9.11 | 0.18 | 6.94 |
| 20 | 7.00 | 53.0 | 78.7 | 11.2 | 8.53 | -0.77 | -60.70 | 2.270 | 0.40 | 10.33 | 9.46 | 0.17 | 6.94 |
| 21 | 7.00 | 52.6 | 78.6 | 11.2 | 8.62 | -0.81 | -62.10 | 2.250 | 0.40 | 10.14 | 9.28 | 0.17 | 6.94 |
| 22 | 7.00 | 52.6 | 78.6 | 11.2 | 8.62 | -0.81 | -62.10 | 2.250 | 0.40 | 10.14 | 9.28 | 0.17 | 6.94 |
| 23 | 7.00 | 52.6 | 78.6 | 11.2 | 8.62 | -0.81 | -62.10 | 2.250 | 0.40 | 10.14 | 9.28 | 0.17 | 6.94 |
| 24 | 7.00 | 52.6 | 78.6 | 11.2 | 8.62 | -0.81 | -62.10 | 2.250 | 0.40 | 10.14 | 9.28 | 0.17 | 6.94 |
| 25 | | | | | | | | | | | | | |
| 26 | 7.00 | 52.6 | 80.1 | 11.7 | 7.43 | -0.22 | -23.00 | 2.260 | 0.57 | 6.57 | 8.31 | 0.18 | 6.95 |
| 27 | 7.00 | 54.6 | 81.6 | 11.0 | 9.01 | -1.00 | -67.50 | 2.340 | 0.60 | 5.93 | 9.28 | 0.18 | 6.94 |
| 28 | 7.00 | 53.1 | 80.7 | 11.3 | 8.23 | -0.61 | -51.80 | 2.290 | 0.58 | 6.48 | 8.39 | 0.18 | 6.95 |
| 29 | 7.00 | 53.8 | 81.1 | 11.2 | 8.54 | -0.77 | -59.50 | 2.310 | 0.59 | 6.20 | 8.82 | 0.18 | 6.95 |
| 30 | 7.00 | 53.8 | 81.1 | 11.2 | 8.54 | -0.77 | -59.50 | 2.310 | 0.59 | 6.20 | 8.82 | 0.18 | 6.95 |
| 31 | 7.00 | 53.8 | 81.1 | 11.2 | 8.54 | -0.77 | -59.50 | 2.310 | 0.59 | 6.20 | 8.82 | 0.18 | 6.95 |
| 32 | 7.00 | 53.8 | 81.1 | 11.2 | 8.54 | -0.77 | -59.50 | 2.310 | 0.59 | 6.20 | 8.82 | 0.18 | 6.95 |
| 33 | | | | | | | | | | | | | |
| 34 | 7.00 | 57.6 | 86.2 | 11.7 | 7.29 | -0.14 | -15.70 | 2.470 | 4.92 | 1.01 | 8.42 | 0.18 | 6.96 |
| 35 | 7.00 | 58.1 | 87.6 | 11.2 | 8.35 | -0.67 | -53.50 | 2.490 | 3.17 | 2.02 | 8.50 | 0.18 | 6.96 |
| 36 | 7.00 | 58.1 | 87.3 | 11.1 | 8.42 | -0.71 | -54.50 | 2.490 | 4.03 | 1.42 | 8.50 | 0.18 | 6.96 |
| 37 | 7.00 | 58.1 | 87.5 | 11.2 | 8.38 | -0.69 | -54.00 | 2.490 | 3.55 | 1.72 | 8.50 | 0.18 | 6.96 |
| 38 | 7.00 | 58.1 | 87.5 | 11.2 | 8.38 | -0.69 | -54.00 | 2.490 | 3.55 | 1.72 | 8.50 | 0.18 | 6.96 |
| 39 | 7.00 | 58.1 | 87.5 | 11.2 | 8.38 | -0.69 | -54.00 | 2.490 | 3.55 | 1.72 | 8.50 | 0.18 | 6.96 |
| 40 | 7.00 | 58.1 | 87.5 | 11.2 | 8.38 | -0.69 | -54.00 | 2.490 | 3.55 | 1.72 | 8.50 | 0.18 | 6.96 |
| 41 | | | | | | | | | | | | | |
| 42 | 6.90 | 74.1 | 88.8 | 11.7 | 7.55 | -0.33 | -41.90 | 3.000 | 0.56 | 7.51 | 14.80 | 0.17 | 6.82 |
| 43 | 6.90 | 74.6 | 88.7 | 10.6 | 9.80 | -1.45 | -96.50 | 3.010 | 0.57 | 6.90 | 15.40 | 0.17 | 6.82 |
| 44 | 6.90 | 73.4 | 87.9 | 11.2 | 8.55 | -0.82 | -78.90 | 2.970 | 0.57 | 7.28 | 14.70 | 0.17 | 6.82 |
| 45 | 6.90 | 74.0 | 88.3 | 11.0 | 8.97 | -1.04 | -87.50 | 2.990 | 0.57 | 7.08 | 15.00 | 0.17 | 6.82 |
| 46 | 6.90 | 74.0 | 88.3 | 11.0 | 8.97 | -1.04 | -87.50 | 2.990 | 0.57 | 7.08 | 15.00 | 0.17 | 6.82 |
| 47 | 6.90 | 74.0 | 88.3 | 11.0 | 8.97 | -1.04 | -87.50 | 2.990 | 0.57 | 7.08 | 15.00 | 0.17 | 6.82 |
| 48 | 6.90 | 74.0 | 88.3 | 11.0 | 8.97 | -1.04 | -87.50 | 2.990 | 0.57 | 7.08 | 15.00 | 0.17 | 6.82 |
| 49 | | | | | | | | | | | | | |

# Corrosion Indices and Chemical Treatment

**Step 3:** Chemical Addition Inputs

| | Soda Ash $Na_2CO_2$ mg/L | Caustic Soda NaOH mg/L | Limestone $CaCO_3$ mg/L | Sulfuric Acid $H_2SO_4$ mg/L | Carbon Dioxide $CO_2$ ± mg/L | Ortho-phosphate as $PO_4^{-3}$ mg/L | Gas Chlorine $Cl_2$ mg/L | Liquid Chlorine NaOCl mg/L | Fluoride $H_2SiF_6$ mg/L |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | 60.0 | | | | | | | |
| 3 | | 75.0 | | | | | | | |
| 4 | | 75.0 | | | | | | | |
| 5 | | 75.0 | | | | | | | |
| 6 | | | | | -45.1 | | | | |
| 7 | | 37.5 | | | -45.1 | | | | |
| 8 | | 68.0 | | | -8.1 | | | | |
| 9 | | | | | | | | | |
| 10 | | 65.0 | | | | | | | |
| 11 | | 105.0 | | | | | | | |
| 12 | | 80.0 | | | | | | | |
| 13 | | 90.0 | | | | | | | |
| 14 | | | | | -49.8 | | | | |
| 15 | | 45.0 | | | -49.8 | | | | |
| 16 | | 81.0 | | | -5.9 | | | | |
| 17 | | | | | | | | | |
| 18 | | 35.0 | | | | | | | |
| 19 | | 45.0 | | | | | | | |
| 20 | | 45.0 | | | | | | | |
| 21 | | 45.0 | | | | | | | |
| 22 | | | | | -26.3 | | | | |
| 23 | | 22.5 | | | -26.3 | | | | |
| 24 | | 41.0 | | | -4.3 | | | | |
| 25 | | | | | | | | | |
| 26 | | 30.0 | | | | | | | |
| 27 | | 50.0 | | | | | | | |
| 28 | | 40.0 | | | | | | | |
| 29 | | 45.0 | | | | | | | |
| 30 | | | | | -26.9 | | | | |
| 31 | | 22.5 | | | -26.9 | | | | |
| 32 | | 41.0 | | | -4.9 | | | | |
| 33 | | | | | | | | | |
| 34 | | 25.0 | | | | | | | |
| 35 | | 45.0 | | | | | | | |
| 36 | | 50.0 | | | | | | | |
| 37 | | 45.0 | | | | | | | |
| 38 | | | | | -29.1 | | | | |
| 39 | | 22.5 | | | -29.1 | | | | |
| 40 | | 41.0 | | | -6.9 | | | | |
| 41 | | | | | | | | | |
| 42 | | 45.0 | | | | | | | |
| 43 | | 75.0 | | | | | | | |
| 44 | | 60.0 | | | | | | | |
| 45 | | 65.0 | | | | | | | |
| 46 | | | | | -37.0 | | | | |
| 47 | | 32.5 | | | -37.0 | | | | |
| 48 | | 59.0 | | | -5.1 | | | | |
| 49 | | | | | | | | | |

**Step 4:** Indices Water Quality Results After Chemical Addition

| | Site # or Name | pH | Alkalinity mg/L $CaCO_3$ | Calcium mg/L $Ca^{2+}$ | $CO_2$ mg/L $CO_{2(aq)}$ | DIC mg/L as C | Aggressive Index AI | Ryznar Index RI | Langelier Index LI | CCPP mg/L as $CaCO_3$ | Buffer Intensity mM/pH | Larson's Ratio $Alk/(Cl^- + SO_4^{2-})$ | CSMR | Cu II mg/L | Pb II mg/L | pH @ 25°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | |
| 2 | Eureka Well #1, Raw | 7.56 | 351.1 | 77.5 | 18.4 | 89.1 | 12.4 | 6.92 | 0.32 | 25.2 | 0.944 | 1.04 | 5.96 | 3.01 | 0.16 | 7.50 |
| 3 | Eureka Well #1, Finished | 7.84 | 380.8 | 33.4 | 11.1 | 94.1 | 12.3 | 7.15 | 0.34 | 16.6 | 0.624 | 1.39 | 5.31 | 2.00 | 0.16 | 7.77 |
| 4 | Eureka Well #1, Finished | 8.00 | 371.8 | 23.0 | 7.3 | 90.7 | 12.3 | 7.33 | 0.34 | 11.8 | 0.466 | 1.11 | 5.94 | 1.35 | 0.17 | 7.94 |
| 5 | Eureka Well #1 IX (NaOH) | 7.92 | 376.3 | 28.2 | 9.1 | 92.4 | 12.3 | 7.23 | 0.34 | 14.2 | 0.540 | 1.24 | 5.64 | 1.66 | 0.17 | 7.85 |
| 6 | Eureka Well #1 IX (Air) | 7.10 | 282.5 | 28.2 | 45.2 | 80.1 | 11.4 | 8.26 | -0.58 | -43.69 | 2.010 | 0.93 | 5.64 | 7.73 | 0.17 | 7.04 |
| 7 | Eureka Well #1 IX (Air+NaOH) | 8.07 | 329.4 | 28.2 | 5.7 | 80.1 | 12.4 | 7.20 | 0.43 | 14.6 | 0.384 | 1.08 | 5.64 | 1.06 | 0.17 | 7.99 |
| 8 | Eureka Well #1 IX (NaOH+Air) | 7.92 | 367.6 | 28.2 | 8.7 | 90.2 | 12.3 | 7.24 | 0.34 | 13.9 | 0.520 | 1.21 | 5.64 | 1.58 | 0.17 | 7.86 |
| 9 | | | | | | | | | | | | | | | | |
| 10 | Eureka Well #5, Raw | 7.49 | 373.3 | 95.2 | 24.8 | 96.2 | 12.4 | 6.81 | 0.34 | 33.3 | 1.230 | 0.49 | 7.71 | 4.71 | 0.15 | 7.40 |
| 11 | Eureka Well #5, Finished | 8.86 | 436.4 | 5.6 | 1.2 | 101 | 12.6 | 7.90 | 0.48 | 6.78 | 0.754 | 0.80 | 5.27 | 0.62 | 0.23 | 8.72 |
| 12 | Eureka Well #5, Finished | 7.93 | 392.1 | 27.9 | 9.5 | 96.3 | 12.3 | 7.40 | 0.27 | 11.1 | 0.564 | 0.52 | 7.80 | 1.99 | 0.15 | 7.83 |
| 13 | Eureka Well #5 IX (NaOH) | 8.30 | 411.1 | 16.8 | 4.3 | 98.8 | 12.5 | 7.45 | 0.42 | 11.5 | 0.416 | 0.63 | 6.52 | 1.14 | 0.17 | 8.19 |
| 14 | Eureka Well #5 IX (Air) | 7.10 | 298.5 | 16.8 | 49.9 | 85.2 | 11.2 | 8.87 | -0.89 | -60.17 | 2.200 | 0.46 | 6.52 | 10.10 | 0.15 | 7.01 |
| 15 | Eureka Well #5 IX (Air+NaOH) | 8.31 | 354.8 | 16.8 | 3.6 | 85.2 | 12.4 | 7.56 | 0.38 | 9.42 | 0.359 | 0.55 | 6.52 | 0.92 | 0.16 | 8.20 |
| 16 | Eureka Well #5 IX (NaOH+Air) | 8.09 | 399.8 | 16.8 | 6.8 | 97.2 | 12.3 | 7.67 | 0.21 | 6.37 | 0.465 | 0.62 | 6.52 | 1.57 | 0.16 | 7.98 |
| 17 | | | | | | | | | | | | | | | | |
| 18 | Eureka Well #6, Raw | 7.61 | 313.8 | 87.8 | 15.2 | 79.3 | 12.4 | 6.80 | 0.40 | 29.3 | 0.786 | 0.47 | 10.21 | 2.55 | 0.16 | 7.54 |
| 19 | Eureka Well #6, Finished | 8.11 | 324.3 | 22.1 | 4.8 | 78.5 | 12.3 | 7.47 | 0.32 | 9.21 | 0.359 | 0.48 | 9.96 | 0.92 | 0.17 | 8.04 |
| 20 | Eureka Well #6, Finished | 8.08 | 324.3 | 27.1 | 5.3 | 78.7 | 12.4 | 7.32 | 0.38 | 12.0 | 0.373 | 0.49 | 10.33 | 1.01 | 0.17 | 8.00 |
| 21 | Eureka Well #6 IX (NaOH) | 8.10 | 324.3 | 24.6 | 5.0 | 78.6 | 12.4 | 7.39 | 0.35 | 10.6 | 0.366 | 0.48 | 10.14 | 0.97 | 0.17 | 8.02 |
| 22 | Eureka Well #6 IX (Air) | 7.30 | 268.0 | 24.6 | 26.4 | 71.5 | 11.5 | 8.32 | -0.51 | -27.71 | 1.260 | 0.40 | 10.14 | 4.38 | 0.17 | 7.24 |
| 23 | Eureka Well #6 IX (Air+NaOH) | 8.18 | 296.2 | 24.6 | 3.7 | 71.5 | 12.4 | 7.39 | 0.40 | 10.7 | 0.313 | 0.44 | 10.14 | 0.74 | 0.17 | 8.11 |
| 24 | Eureka Well #6 IX (NaOH+Air) | 8.09 | 319.3 | 24.6 | 5.1 | 77.5 | 12.3 | 7.41 | 0.34 | 10.1 | 0.363 | 0.48 | 10.14 | 0.96 | 0.17 | 8.01 |
| 25 | | | | | | | | | | | | | | | | |
| 26 | Eureka Well #8, Raw | 7.48 | 311.54 | 84.8 | 19.9 | 80.1 | 12.3 | 6.85 | 0.31 | 25.0 | 0.994 | 0.65 | 6.57 | 2.97 | 0.17 | 7.43 |
| 27 | Eureka Well #8, Finished | 8.33 | 340.56 | 14.3 | 3.1 | 81.6 | 12.4 | 7.56 | 0.38 | 8.68 | 0.347 | 0.74 | 5.93 | 0.67 | 0.19 | 8.25 |
| 28 | Eureka Well #8, Finished | 7.79 | 326.05 | 32.9 | 10.0 | 80.7 | 12.2 | 7.31 | 0.24 | 10.5 | 0.560 | 0.69 | 6.48 | 1.57 | 0.18 | 7.74 |
| 29 | Eureka Well #8 IX (NaOH) | 8.03 | 333.30 | 23.6 | 6.0 | 81.1 | 12.3 | 7.39 | 0.32 | 10.2 | 0.401 | 0.71 | 6.20 | 1.06 | 0.18 | 7.97 |
| 30 | Eureka Well #8 IX (Air) | 7.30 | 277.00 | 23.6 | 27.1 | 73.8 | 11.5 | 8.25 | -0.48 | -25.96 | 1.290 | 0.59 | 6.20 | 4.20 | 0.17 | 7.25 |
| 31 | Eureka Well #8 IX (Air+NaOH) | 8.14 | 305.15 | 23.6 | 4.2 | 73.8 | 12.4 | 7.35 | 0.39 | 10.9 | 0.328 | 0.65 | 6.20 | 0.77 | 0.18 | 8.08 |
| 32 | Eureka Well #8 IX (NaOH+Air) | 8.05 | 328.30 | 23.6 | 5.6 | 79.8 | 12.3 | 7.38 | 0.33 | 10.4 | 0.385 | 0.70 | 6.20 | 1.00 | 0.18 | 7.99 |
| 33 | | | | | | | | | | | | | | | | |
| 34 | Eureka Well #9, Raw | 7.32 | 325.28 | 74.3 | 30.3 | 86.2 | 12.1 | 6.89 | 0.22 | 20.8 | 1.450 | 5.44 | 1.01 | 4.24 | 0.18 | 7.28 |
| 35 | Eureka Well #9, Finished | 7.85 | 355.30 | 22.2 | 9.7 | 87.6 | 12.1 | 7.37 | 0.24 | 8.96 | 0.553 | 3.77 | 2.02 | 1.46 | 0.18 | 7.81 |
| 36 | Eureka Well #9, Finished | 8.12 | 360.56 | 20.2 | 5.3 | 87.3 | 12.3 | 7.18 | 0.47 | 13.9 | 0.389 | 4.88 | 1.42 | 0.89 | 0.19 | 8.07 |
| 37 | Eureka Well #9 IX (NaOH) | 7.85 | 354.80 | 21.2 | 9.7 | 87.5 | 12.1 | 7.41 | 0.22 | 8.16 | 0.553 | 4.22 | 1.72 | 1.46 | 0.18 | 7.81 |
| 38 | Eureka Well #9 IX (Air) | 7.30 | 298.50 | 21.2 | 29.2 | 79.5 | 11.5 | 8.09 | -0.39 | -22.08 | 1.390 | 3.55 | 1.72 | 4.11 | 0.18 | 7.26 |
| 39 | Eureka Well #9 IX (Air+NaOH) | 8.03 | 326.65 | 21.2 | 5.9 | 79.5 | 12.2 | 7.31 | 0.36 | 10.9 | 0.388 | 3.89 | 1.72 | 0.93 | 0.19 | 7.99 |
| 40 | Eureka Well #9 IX (NaOH+Air) | 7.95 | 349.80 | 21.2 | 7.5 | 85.6 | 12.2 | 7.32 | 0.31 | 10.5 | 0.462 | 4.16 | 1.72 | 1.17 | 0.19 | 7.91 |
| 41 | | | | | | | | | | | | | | | | |
| 42 | Eureka Well #10, Raw | 7.45 | 342.30 | 90.8 | 25.0 | 88.8 | 12.3 | 6.86 | 0.30 | 27.6 | 1.230 | 0.67 | 7.51 | 4.49 | 0.16 | 7.37 |
| 43 | Eureka Well #10, Finished | 8.74 | 378.84 | 7.0 | 1.4 | 88.7 | 12.5 | 7.84 | 0.45 | 7.51 | 0.553 | 0.75 | 6.90 | 0.53 | 0.21 | 8.62 |
| 44 | Eureka Well #10, Finished | 7.93 | 358.07 | 28.9 | 8.7 | 87.9 | 12.3 | 7.35 | 0.29 | 11.6 | 0.514 | 0.72 | 7.28 | 1.70 | 0.16 | 7.84 |
| 45 | Eureka Well #10 IX (NaOH) | 8.18 | 365.33 | 18.0 | 4.9 | 88.3 | 12.4 | 7.52 | 0.33 | 9.15 | 0.388 | 0.73 | 7.08 | 1.11 | 0.17 | 8.08 |
| 46 | Eureka Well #10 IX (Air) | 7.20 | 284.00 | 18.0 | 37.1 | 78.2 | 11.3 | 8.67 | -0.74 | -43.53 | 1.700 | 0.57 | 7.08 | 6.93 | 0.16 | 7.12 |
| 47 | Eureka Well #10 IX (Air+NaOH) | 8.24 | 324.66 | 18.0 | 3.8 | 78.2 | 12.4 | 7.56 | 0.34 | 8.54 | 0.333 | 0.65 | 7.08 | 0.86 | 0.17 | 8.14 |
| 48 | Eureka Well #10 IX (NaOH+Air) | 8.09 | 357.82 | 18.0 | 5.9 | 86.9 | 12.3 | 7.62 | 0.24 | 6.87 | 0.411 | 0.71 | 7.08 | 1.27 | 0.16 | 8.00 |
| 49 | | | | | | | | | | | | | | | | |

**Eureka PWS Water Quality Review – Lead and Cooper Summary**
**City of Eureka, Missouri**

| PBCU Sample Summary Results - Lead Summary | | | | | | |
|---|---|---|---|---|---|---|
| Mon Period | Type | # Samples | Measure | Units | Analyte Code/Name | Last Sample Date |
| 1/1/2013 12/31/2015 | 90% | 20 | 0.00667 | MG/L | PB90 - LEAD SUMMARY | 9/2/2015 |
| 1/1/2013 12/31/2015 | 95% | 20 | 0.0107 | MG/L | PB90 - LEAD SUMMARY | |
| 1/1/2013 12/31/2015 | AL | 1 Exceeding Action Level | | | PB90 - LEAD SUMMARY | |
| 1/1/2010 12/31/2012 | 90% | 20 | 0.00915 | MG/L | PB90 - LEAD SUMMARY | 6/22/2012 |
| 1/1/2010 12/31/2012 | 95% | 20 | 0.00951 | MG/L | PB90 - LEAD SUMMARY | |
| 1/1/2010 12/31/2012 | AL | 0 Exceeding | | | PB90 - LEAD SUMMARY | |
| 1/1/2008 12/31/2010 | 90% | 20 | 0.00591 | MG/L | PB90 - LEAD SUMMARY | 7/7/2009 |
| 1/1/2008 12/31/2010 | 95% | 20 | 0.00885 | MG/L | PB90 - LEAD SUMMARY | |
| 1/1/2008 12/31/2010 | AL | 0 Exceeding | | | PB90 - LEAD SUMMARY | |

| PBCU Sample Summary Results - Copper Summary | | | | | | |
|---|---|---|---|---|---|---|
| Mon Period | Type | # Samples | Measure | Units | Analyte Code/Name | Last Sample Date |
| 1/1/2013 12/31/2015 | 90% | 20 | 0.178 | MG/L | CU90 - COPPER SUMMARY | 9/2/2015 |
| 1/1/2013 12/31/2015 | 95% | 20 | 0.432 | MG/L | CU90 - COPPER SUMMARY | |
| 1/1/2013 12/31/2015 | AL | 0 Exceeding Action Level | | | CU90 - COPPER SUMMARY | |
| 1/1/2010 12/31/2012 | 90% | 20 | 0.232 | MG/L | CU90 - COPPER SUMMARY | 6/22/2012 |
| 1/1/2010 12/31/2012 | 95% | 20 | 0.242 | MG/L | CU90 - COPPER SUMMARY | |
| 1/1/2010 12/31/2012 | AL | 0 Exceeding Action Level | | | CU90 - COPPER SUMMARY | |
| 1/1/2008 12/31/2010 | 90% | 20 | 0.173 | MG/L | CU90 - COPPER SUMMARY | 7/7/2009 |
| 1/1/2008 12/31/2010 | 95% | 20 | 0.185 | MG/L | CU90 - COPPER SUMMARY | |
| 1/1/2008 12/31/2010 | AL | 0 Exceeding Action Level | | | CU90 - COPPER SUMMARY | |