Increase Safety and Reliability by Making the Ammonia Source Switch

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Now more than ever, utilities are seeking ways to introduce safer and more reliable alternative chemicals into the water treatment process. A past example of this was the transition from chlorine gas to liquid hypochlorite, which was considered an important safety innovation in water treatment processes. More-recent studies have confirmed the safety benefits of switching from ammonium hydroxide (aqua ammonia) to ammonium sulfate for monochloramine residual formation in the water treatment disinfection process for those utilities that elect to use chloramine disinfection.

Multiple utilities have already benefited from this next generation of process safety and reliability enhancement, including facilities operated by Tampa Bay Water, which is Florida's largest wholesale water provider. Following Tampa Bay Water's ammonium sulfate implementation, other utilities in the region are ready to make the ammonia source switch, including Pinellas County (county), which supplies potable water to more than 700,000 residents and visitors and is responsible for the treatment and distribution of approximately 50 to 55 mil gal per day (mgd). The county operates the Keller Water Treatment Facility (WTF) and the nearby Regional Treatment Facility (RTF), which is maintained for emergency purposes. The WTF receives high-quality water from Tampa Bay Water and is a major component of the county's water supply.

The county currently uses ammonium hydroxide for monochloramine residual formation; however, key issues related to operational reliability, maintenance, reporting, and safety have required ongoing and active management by the operations and maintenance (O&M) staff. Examples of these issues include frequent clogging of pipes and ammonia injectors, which requires aggressive cleanings due to precipitation and scale buildup. Additionally, ammonium hydroxide can affect health or cause serious injuries during periods of short exposure, so staff members are trained to handle this hazardous chemical and are required to wear personal protective equipment (PPE) due to the potential release of hazardous off-gas.

In order to improve system reliability and mitigate risks and costs, an evaluation was completed for the use of an alternative ammonia source chemical. Similar to Tampa Bay Water, it was anticipated that the county would benefit from this conversion, since ammonium sulfate is a much safer alternative to ammonium hydroxide. Ammonium sulfate will not contribute to scaling/precipitation issues due to its slightly acidic nature; therefore, the frequency of cleaning pipes and injectors will significantly decrease. As a result, both safety and operational reliability will increase, which will po-

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Figure 1. Bulk Tanks and Metering Pump Building

Figure 2. Metering Pump Skid

tentially lead to lower maintenance costs and reduced staff chemical exposure.

This article summarizes the ammonia conversion evaluation at the WTF, including:

- A pilot study to investigate how the switch would impact water quality
- Assessment of the existing equipment sizing and material compatibility (corrosion)
- Health and safety considerations for plant staff
- Conversion plan procedures
- Costs associated with the chemical conversion

The ammonia switch is the next big step in protecting WTF operators and reducing tedious paperwork.

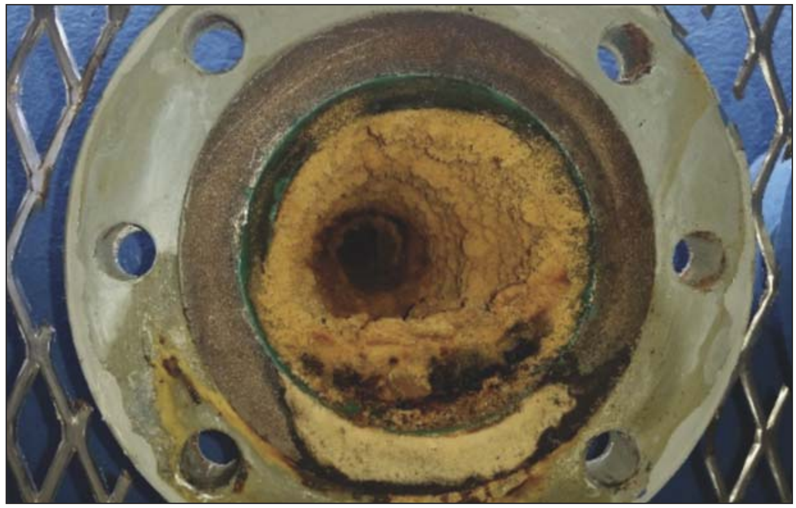

Figure 3. Clogged Injector Pipe due to Ammonium Hydroxide Precipitation

Existing Ammonia Feed System

The existing ammonia storage system consists of two parallel 6,000-gal storage tanks that were installed in 2002. The tanks are horizontal and cylindrical in shape and made of carbon steel laid on saddles, as shown in Figure 1. The tank interior and exterior shells were primed and finished with a baked phenolic coating. The tank nozzles are made of schedule 80 steel.

The tank piping and flanges are made of stainless steel. The gaskets are rubber and the bolts and nuts are made of 316 stainless steel. The tank saddle is steel (American Society for Testing and Materials [ASTM] A36) and the nameplate material is 316 stainless steel, as is the tank level indicator. The secondary containment area was last coated in 1998.

Three chemical feed pumps on one metering pump skid were installed, as shown in Figure 2. Each pump has a capacity of 19 gal per hour (gph). The chemical feed pumps head material is 316 stainless steel. Each pump has its own pulsation dampener; the bladder is ethylene propylene diene monomer (EPDM) and the housing is polypropylene. Polyvinyl chloride (PVC)/Teflon material is used for the pressure gauges and PVC is used for the back pressure valves. The chemical feed pump building has an ammonia gas detector.

There are a few types of materials used for the chemical pipe system at the WTF. The tanks discharge piping and valves are 316 stainless steel. There is a double-contained piping section outside the secondary containment of the chemical storage tanks area, which continues to the chemical feed pump building where the double containment ends inside the building. The 316 stainless steel piping connects to PVC schedule 80 piping, which is painted white. Both the suction and the discharge piping material for the chemical feed pumps are PVC schedule 80. There is an additional double-contained discharge piping section inside and outside of the chemical feed pump building. Continuing piping and chemical injectors are PVC, schedule 80, and 316 stainless steel. The injector discharges into the 36-in. effluent water pipe.

Existing Operations and Maintenance Challenges

The O&M issues currently experienced at the WTF include, but are not limited to, impacts to reliability from precipitation and clogging of ammonia injectors and pipe cleaning, as well as training and safety procedures related to chemical deliveries, handling, and system maintenance.

The use of ammonium hydroxide results in precipitate clogging the ammonia injectors (see Figure 3), which are cleaned every 90 days to maintain proper chemical feeding. Cleaning of the injectors is approximately a two-hour-and-fifteen-minute task for an operations staff person. Precipitate and scaling also build up and cause clogging of the pipes, requiring a cleaning approximately every two to four months. The O&M staff members conduct the pipe cleanings, and they are responsible for preparing the piping, conducting the bacteriological testing, flushing, and returning the pipeline into service. The entire process can take up to 34 hours.

The staff receives hazardous chemicals training annually. The training is provided to 17 staff members for about 20 hours every year. Handling ammonium hydroxide currently requires O&M staff to wear PPE, including gloves, goggles, and self-contained respirators. Operators bring a respirator with canisters to every ammonium hydroxide chemical delivery.

There is significant effort associated with the respirator program. The Occupational Safety and Health Administration (OSHA) recommends that respiratory programs include equipment selection; an evaluation of the worker's ability to perform work while wearing a respirator; the regular training of personnel; fit testing; periodic workplace monitoring; and regular respirator maintenance, inspection, and cleaning (OSHA, 1992). Medical monitoring requirements include medical evaluations before employees start work, periodically (every three to five years, or more often, if deemed necessary), and when an employee is transferred or terminated. Additionally, transport of aqua ammonia requires a hazardous materials certification for the delivery vehicle driver. Staff does not typically transport ammonia.

On rare occasions when facilities are shut down for prolonged periods, or in the event of a small spill, there may be need for staff transport. Ammonium hydroxide is a chemical that falls under the Supefund Amendments and Reauthorization Act (SARA) Title III, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and Department of Transportation (DOT) regulations. Under CERCLA, ammonium hydroxide spills of 1,000 lbs or more outside of containment units must be reported immediately to both state and national response centers. Failure to report spills can result in fines. Spills that are not contained and cleaned within 30 days trigger Florida Administrative Code (F.A.C.) 62-780, Contaminate Site Cleanup Criteria requirements, which requires a significant level of effort and funding.

Conversion Evaluation

Chemistry

Currently, the county is adding ammonium hydroxide in the finished water, following sodium hypochlorite (chlorine) addition, to form monochloramine. Ammonium hydroxide is a basic solution, which raises the pH of the water. If ammonium sulfate is used instead of ammonium hydroxide, the pH of the water will decrease, as ammonium sulfate is an acidic solution. In addition, the ammonium strength of the ammonium sulfate solution is lower than the ammonium hy-

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Table 1. Dose and Consumption for Ammonium Hydroxide and Ammonium Sulfate

Parameter	Unit	Ammonium Hydroxide	Ammonium Sulfate
Formula		$(NH_4)(OH)$	$(NH_4)_2(SO_4)$
Molecular Weight	g/mol	35	132
Strength	%	19% as ammonium	40% as ammonium sulfate
Ammonium Dose	mg/L	1.0	1.0
Chemical Dose (100%)	mg/L	2.06	3.88
Chemical Solution Consumption	**lb/MG**	**44.0**	**76.5**
	gal/MG	**5.7**	**8.0**

Table 2. Theoretical pH After Ammonium Hydroxide or Ammonium Sulfate Addition

Parameter	Keller WTF Raw Water	7 ppm of Chlorine	1.46 ppm of Ammonium Hydroxide*	2.75 ppm of Ammonium Sulfate*
Alkalinity	211	216	217	215
Calcium Hardness	186	186	186	186
TDS	500	500	500	500
Temperature	25	25	25	25
pH	7.95	8.36	8.52	8.17

* Equivalent of 0.75 ppm of ammonium (theoretical value)

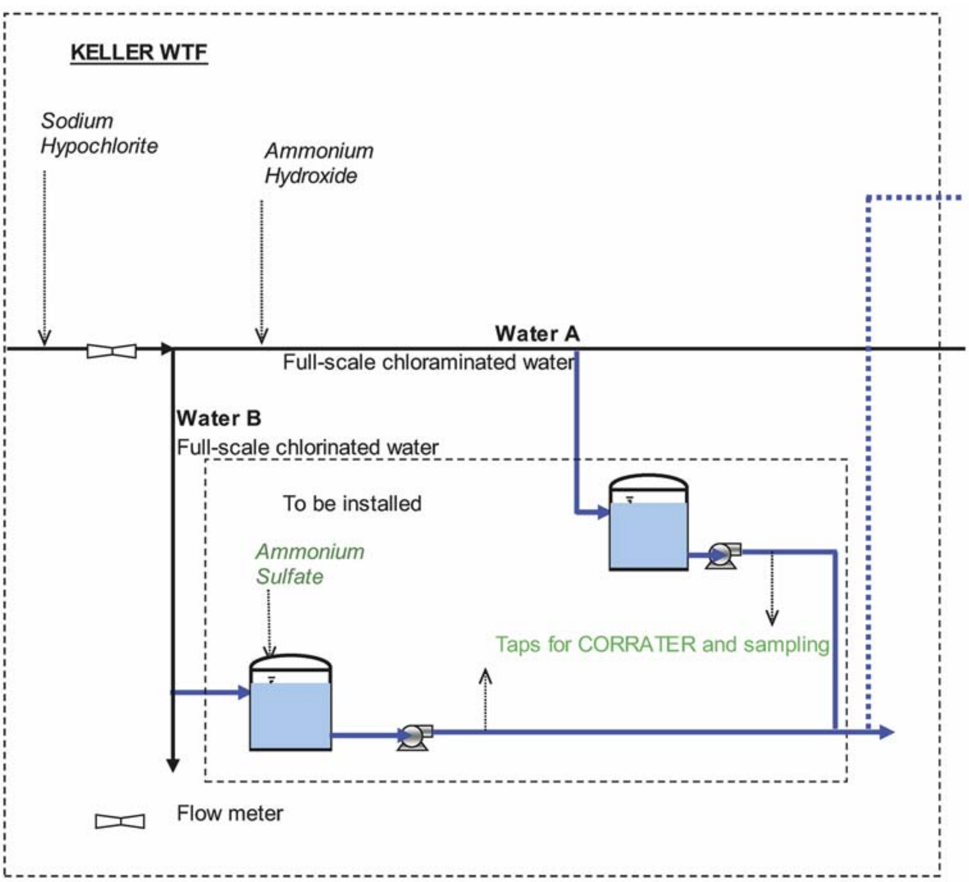

Figure 4. Keller Water Treatment Facility Process Flow Diagram

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droxide; therefore, more ammonium sulfate is required for the same dose of ammonium. Typically, 40 percent more ammonium sulfate volume is required compared to ammonium hydroxide. The differences are shown in Table 1.

The impact of switching to ammonium sulfate was evaluated to assess the changes in pH. Theoretical pH changes at the WTF were calculated using either ammonium hydroxide or ammonium sulfate, and the results are presented in Table 2.

As shown in Table 2, caustic will not need to be added for monochloramine stability; however, the county still has the capability to add caustic if needed. A pilot study was completed to confirm the impacts on water quality by switching to ammonium sulfate.

Pilot Study: Water Quality and Corrosion

A pilot study was performed on different waters at WTF to evaluate the impact on the water quality and corrosion rates by switching from ammonium hydroxide to ammonium sulfate. As part of the pilot, multiple monochloraminated source waters were compared. The following waters were tested, and are shown in Figure 4.

1. Existing monochloraminated water at WTF (Water A).
2. Existing chlorinated water at WTF with addition of ammonium sulfate (Water B)

Results

Two waters were tested in parallel to assess potential changes in water quality by switching to ammonium sulfate from ammonium hydroxide. Three tests were performed on each water to determine water quality and corrosion rates. The corrosion rates were measured using an analytical instrument with three different electrodes that represent most distribution system piping:

- Test 1 – Lead electrodes
- Test 2 – Copper electrodes
- Test 3 – Iron electrodes

Water A was taken from the monochloraminated water line at WTF just downstream of the ammonium hydroxide injection. Water B is chlorinated water in which ammonium sulfate was added (1 mg/L) just after sampling to best represent full-scale operation. Water quality analyses were performed during the three tests to ensure that the monochloramine residuals and free ammonia concentrations were similar in both waters. The results are presented in Table 3 for each of the three tests.

Total chlorine and monochloramine residuals were similar in both waters A and B. Free ammonia was lower in Water B than in Water A, which may suggest a better reaction with ammonium sulfate. As expected, the pH was slightly lower in Water B than in Water A since ammonium sulfate is an acidic solution, even though the difference was not as significant as the theory predicts.

A similar pilot evaluation was completed at the RTF, which included blending waters from Tampa Bay Water that had similar positive results to the WTF.

The corrosion rates for the three different electrodes are presented in Figure 5. The corrosion rates using either ammonium hydroxide (Water A) or ammonium sulfate (Water B) are similar and there are no significant differences between corrosion rates for the three electrodes tested. Each test was run around two hours with corrosion rate measurements made every 10 minutes.

Conversion Implementation

Equipment Sizing

The existing chemical storage and feed systems were assessed at each facility in terms of capacity to handle the additional volumes of ammonium sulfate required, as presented in Table 4. To determine the quantity of storage that would be sufficient, the bulk storage tank was designed to store 30 days of chemicals at average daily flow. The pump size was based on maximum dose at maximum flow. The design assumptions and design criteria are also presented in Table 4. The current size of the bulk tanks and feed pumps are adequate for conversion to ammonium sulfate.

Material Compatibility

Table 5 presents a summary of the material compatibility.

Health and Safety

The benefits of switching from ammonium hydroxide to ammonium sulfate were evaluated in terms of health and safety for O&M staff. Considerations include spill prevention and reporting, PPE, hazardous chemical training, fit testing, chemical monitoring, and gas detection equipment.

Spill prevention and reporting is required for the release of 1,000 lbs or more of ammonium hydroxide. Ammonium sulfate is not included in the list of hazardous substances, but is identified under the determination of reportable quantities (40 U.S. Code of Federal Regulations [CFR] 117.3). This list sorts the chemical into five categories that range from medium toxicity (A and B) to low toxicity (C and D). Ammonium sulfate falls into the D category, which requires only substance spills over 5,000 lbs to be reported to the National Response Center. Additionally, any personnel responsible for the cleanup must be properly trained, so it's recommended that the O&M staff is trained for handling ammonium sulfate.

Table 3. Monochloramination Water Quality at Keller Water Treatment Facility

Test	Water	Temp	TDS	pH	Total Cl_2	Free Cl_2	Mono	Free Ammonia
		°C	mg/L	SU	mg/L	mg/L	mg/L	mg/L
1 – Lead	A	26.1	231	8.1	2.7	0.27	2.53	0.33
	B	26.4	237	8.0	2.7	0.54	2.48	0.22
2 – Copper	A	35.0	232	8.2	2.3	0.24	2.17	0.35
	B	35.4	233	8.1	2.4	0.26	2.23	0.30
3 – Iron	A	39.3	230	8.4	2.0	0.66	1.96	0.39
	B	40.0	233	8.3	2.1	0.67	1.99	0.36

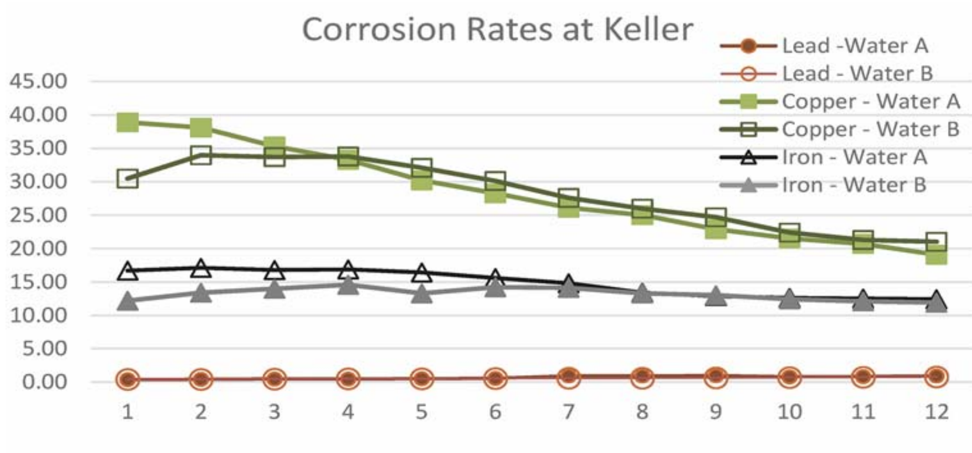

Figure 5. Corrosion Rates at Keller Water Treatment Facility

Table 4. Ammonium Sulfate Feed System Sizing at Keller Water Treatment Facility

Parameter	Unit	Keller WTF
Average Ammonia Dose	mg/L	1.0[1]
Maximum Ammonia Dose	mg/L	1.92[2]
Average Flow[2]	MGD	12
Maximum Flow	MGD	23
Ammonia Sulfate Strength	%	40
Specific Gravity	-	1.21
Consumption	lb/d of NH_3	99
	gal/d of solution	96
Calculated Storage Bulk Tank Capacity[3]	**gallons**	**2,866**
Firm Storage Bulk Tank Capacity[5]		**6,000** ✓
Calculated Pump Capacity[4]	**gph**	**15**
Firm Pump Capacity[5]		**38** ✓

[1] Actual average of ammonia dose is 0.94 mg/L from January 2016 to March 2017
[2] Data from January 2016 to March 2017
[3] Calculated from average ammonia dose and average flow
[4] Calculated from maximum ammonia dose and maximum flow
[5] Firm available capacity with largest pump or tank out of service

The National Fire Protection Association (NFPA) rating system is used to identify and rank the hazards of a chemical. The rating system presents valuable information under normal and emergency operating conditions. Chemical substances are rated for degree of health risks (blue diamond), flammability (red diamond), reactivity (yellow diamond), and special hazards (white diamond). The scale is from 0 to 4, meaning that the higher the number the higher the hazard. The hazard ratings for ammonium hydroxide (current tanks label) and ammonium sulfate are shown in Figure 6.

When comparing both chemicals, ammonium hydroxide presents a higher hazard in the health and flammability categories. For instance, ammonium hydroxide presents a level-three

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health risk and can affect health or cause serious injuries during periods of short exposure, despite medical treatment. Ammonium sulfate is considered a level zero, which indicates that the material does not pose serious health hazards. By switching to ammonium sulfate, potential health impacts to workers will be reduced or eliminated.

Based on information on the Material Safety Data Sheet (MSDS) for ammonium sulfate, the use of PPE is recommended when handling ammonium sulfate; however, practical experiences with other entities, including neighboring utilities, indicate that the use of PPE may not be necessary in normal operational practices. By switching from ammonium hydroxide to ammonium sulfate, the county has the option to remove the gas detection equipment and therefore not have to maintain it, which will result in labor and equipment cost savings, as presented in the cost section.

Tier 2 Changes

Toxic release inventory (TRI) reports are required for chemicals listed in Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) toxic chemical list. Any chemical listed under EPCRA as toxic requires annual reporting. Ammonium hydroxide does require reporting and a fee for the U.S. Environmental Protection Agency (EPA) to track the facilities that contain these hazardous chemicals. Ammonium sulfate will not require this level of reporting since the chemical is not toxic, which will provide additional cost savings due to not having to maintain and submit a report to EPA.

Operation Reliability

The precipitation in piping and clogging of injectors associated with ammonium hydroxide injection decreases the overall reliability of operations. It's expected that by switching from ammonium hydroxide to ammonium sulfate, there would be very little or no precipitation in piping or clogging of injectors, resulting in a higher reliability of the chemical feed systems. Additionally, the frequency of cleaning of pipes and injectors would be reduced; therefore, the risk of damage to the facility's infrastructure will decrease, and most importantly, the worker's frequent exposure to chemicals will also decrease, which is potentially a significant health benefit that cannot be quantified.

Table 5. Material Compatibility

Equipment	Material	Compatible with Ammonium Sulfate	Action
Bulk Tank (interior)	Carbon steel with baked phenolic resin liner	Carbon steel is not compatible. Liner is compatible	Inspect tank plate and liner
Bulk Tank (exterior)	Carbon steel lined w/baked phenolic resin, white painted	Yes	Keep
Secondary Containment	Coating	Yes	Replace Keller
Chemical Pumps	316 SS	Yes	Keep
Dampener	EPDM/polypropylene	Yes	Keep
Pressure Gauge	PVC/Teflon	Yes	Keep
Back Pressure Valve	PVC	Yes	Keep
Valves	316 SS	Not ideal	Replace with PVC in the future
	PVC	Yes	Keep
Piping	316 SS	Not ideal	Replace with PVC in the future
	PVC	Yes	Keep
Injector	PVC	Yes	Keep
	316 SS	Yes	Keep

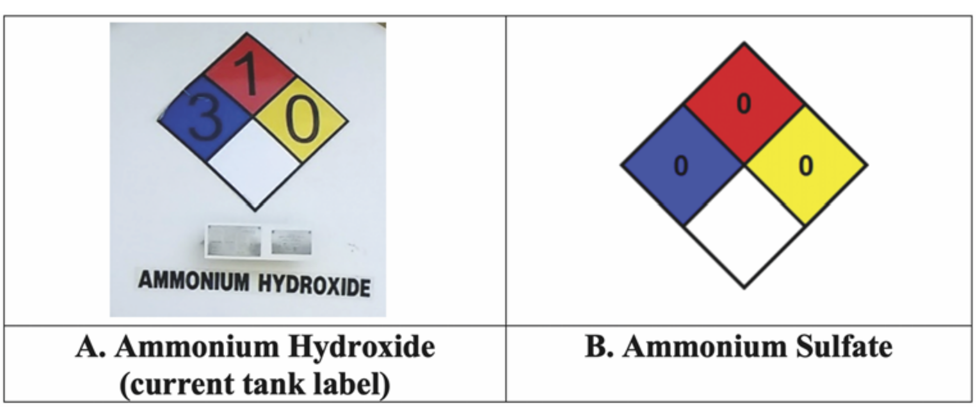

Figure 6. National Fire Protection Association Hazard Rating

Costs

Capital and Maintenance

Capital cost includes costs that may be necessary for switching to ammonium sulfate. Preliminary capital costs to implement ammonia conversion at the WTF are estimated to be $12,900. This cost includes disposal of ammonium hydroxide by a specialized firm, but does not include cleaning and flushing of the system.

The cost to replace aged infrastructure, including secondary containment coating, tank flange repairs, tank inspection, testing of tanks, and installation of a new tank liner are estimated to be $38,400 and are summarized in Table 6. These infrastructure maintenance repairs would be deemed an applicable cost to both chemical types.

Chemical Costs

The chemical costs to supply the required doses of ammonium hydroxide and ammonium sulfate were calculated using the annual average daily flow for each facility from January 2016 through March 2017. This allows for a comparison of the annual chemical solution costs. Ammonium sulfate has a higher feed rate an,d consumption to obtain the same monochloramine residual as ammonium hydroxide. Table 7 summarizes the approximate costs of the chemicals.

Operation and Maintenance Costs

The O&M costs were narrowed to include only the differential costs between the ammonia chemicals. For instance, maintenance associated with chemical feed pumps would be required, regardless of the type of ammonia being used. Based on discussions and information obtained from county staff, the following O&M costs were selected for inclusion in this analysis: injector rodding, pipe cleaning, gas detector maintenance, expendable PPE (respirator canisters for ammonia off-gas), training, and the cost associated with the Tier 2 report. Table 8 summarizes the costs. By switching from ammonium hydroxide to ammonium sulfate, the county will potentially save approximately $51,350 per year.

Conversion Implementation

The following recommendations were made for the ammonium sulfate conversion implementation:

1. Obtain all necessary permits required for the ammonium sulfate conversion.
2. When switching ammonia source, install a temporary feed system in place for ammonium sulfate.
3. Bulk tanks, piping, pumps, injectors, and appurtenances should be taken offline for draining, flushing, and cleaning to prevent any possible reactions between the two chemicals.
4. Perform bulk tank inspections and testing. Replace the tank interior liner(s), as required.
5. Perform an air pressure test to identify any system leaks.

Conclusions

The following summarizes the conclusions from the pilot evaluation:

1. Under full-scale representative chemical additions at the WTF, the pilot results show that pH was slightly lower with ammonium sulfate addition compared to ammonium hydroxide addition. This will benefit the water quality with a slightly reduced pH.
2. The pilot study results show that iron, copper, and lead corrosion rates on the WTF monochloraminated waters are similar using either ammonium hydroxide or ammonium sulfate.
3. The corrosion rates were mostly below 10 mi per year (mpy), with 1 mi equaling 1/1000 of an in., and therefore within accepted industry guidelines.
4. The monochloramine decay using ammonium sulfate was evaluated during the pilot study. The results show that the monochloramine residual was maintained around 2.5 mg/L after 72 hours. Therefore, switching to ammonium sulfate should still result in maintaining an acceptable level of monochloramine residual in the distribution system.

The following summarizes the conclusions related to health, safety, and reporting improvements:

1. By switching to ammonium sulfate, potential health impacts to workers will be reduced or eliminated.
2. Based on the NFPA rating system, ammonium hydroxide presents a higher hazard in the health risks (blue diamond) and flammability (red diamond) categories. Ammonium hydroxide presents a level-three health risk and can affect health or cause serious injuries during periods of short exposure, despite medical treatment. Ammonium sulfate is considered a level zero, which indicates the material has no serious health hazards.
3. Ammonium sulfate will not require reporting to EPA, which will provide the county with additional cost savings due to not having to maintain and submit a report to EPA.

The following summarizes the conclusions related to the facility conversion evaluation:

1. Typically, 40 percent more ammonium sulfate is required compared to ammonium hydroxide for the same dose of ammonium. The chemical feed rate will increase from 5.7 to 8 mgd.
2. The sizing calculation results indicate that the existing storage tanks and pumps have adequate capacity to accommodate the conversion.
3. Existing plastic materials are compatible with ammonium sulfate. The stainless steel isolation valves and piping, which are not ideal for ammonium sulfate, still have "good" compatibility and may remain until signs of corrosion occur.

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Table 6. Recommended Maintenance Costs

Description Item	Keller WTF
Repair of corroding tank flanges	$0
Tank inspection and testing	$3,200
Tank surface preparation and liner installation	$20,200
Secondary containment coating	$15,000
Total Cost	**$38,400**

Table 7. Chemical Costs

Description	Keller WTF	Unit
Current Dose	1.0	mg/L NH_3
Ammonium Hydroxide (lbs)	43.9	lb/MG NH_4OH
Current Gal Ammonium Hydroxide	5.7	gal/MG NH_4OH
Ammonium Sulfate (lbs)	80.9	lb/d $(NH_4)_2SO_4$
Gal Ammonium Sulfate	8.0	gal/d $(NH_4)_2SO_4$
Cost of Ammonium Hydroxide	$2,030	$/MG/year
Cost of Ammonium Sulfate	$5,800	$/MG/year
Average Daily Flow	12	mgd
Cost of Ammonium Hydroxide	$24,160	$/year
Cost of Ammonium Sulfate	$69,040	$/year
Cost Difference Per Mil Gal	**$10.32**	$/MG
Cost Difference	**$44,880**	Dollars
Cost Difference	**186%**	Percent

Table 8. Operations and Maintenance Summary Costs

Maintenance Item	Ammonium Hydroxide Cost	Ammonium Sulfate Cost
Injector Rodding	$1,100	$280[1]
Pipe Cleaning	$10,265	$1,710[1]
Gas Detector	$1,560	$0
Personal Protective Equipment	$2,770	$0
Chemical Training	$20,740	$0
Tier 2 Report	$16,900	$0
Total Yearly Cost	**$53,335**	**$2,000**

[1]Assumes one cleaning a year

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4. Some unions between the 316 stainless steel and the storage tank carbon steel are rusting. Based on field investigations, the gaskets have worn out and the carbon steel may be suffering from galvanic corrosion attack. The stainless steel is also showing discoloration.
5. The existing tank liners are 15 years old and may be near the end of their useful life.
6. By switching from ammonium hydroxide to ammonium sulfate, the county has the option to remove the gas detection equipment, and therefore would not have to maintain it, which will result in labor and equipment cost savings and increased worker safety.
7. It's expected that the precipitation in piping and clogging of injectors will be significantly reduced or eliminated, resulting in a higher reliability of the chemical feed systems.
8. Multiple facilities have already benefited from the conversion from ammonium hydroxide to ammonium sulfate, including several facilities operated by Tampa Bay Water and Pasco County. It will be beneficial to standardize this chemical and potentially reduce the chemical cost over the years, as neighboring utilities are converting to ammonium sulfate.

The following summarizes the conclusions of the cost evaluation:

1. The conversion from ammonium hydroxide to ammonium sulfate would cost approximately $12,900, including offsite chemical removal and disposal.
2. The cost to replace aging infrastructure, including the secondary containment coating, tank flange repairs, tank inspection, testing of tanks, and installation of new tank liners would cost approximately $38,400. These maintenance costs are recommended with or without the conversion.
3. The 40 percent increase in chemical volume would increase the chemical cost by approximately 10 dollars per mil gal treated.
4. By making the switch, the county will dramatically reduce rodding, pipe cleaning, and gas detector maintenance, and expendable PPE, Tier 2 report, and training, which were estimated to cost approximately $51,350 per year.

Results of Chemical Conversion to Date

Based on the results from the study and pilot, the county has implemented the conversion from ammonium hydroxide to ammonium sulfate at both the WTF and RTF to improve system reliability and operator safety. More specifically, the following was completed:

1. Replacement of the corroded carbon steel flanges at the tank penetrations and new rubber gaskets between the flange faces.
2. Replacement of the tank liners with an epoxy-based coating compatible with ammonium sulfate service.
3. Replacement of the secondary containment coating at the WTF with an epoxy-based coating compatible with ammonium sulfate service.
4. Evaluation of existing stainless steel piping and isolation valves. The existing piping and valves were found to be in acceptable condition for continued operation and did not require replacement.
5. Conversion approval by the Florida Department of Environmental Protection.

Pinellas County is now using ammonium sulfate at both the WTF and RTF. The county has seen the benefit from the new chemical, including improved reliability, reduced preventive maintenance, reduced reporting, and improved safety for O&M staff.