VEOLIA

FLINT, MICHIGAN

Water Quality Report

MARCH 12, 2015

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March 12, 2015

FROM

Veolia North America

TO

Emergency Manager Gerald Ambrose

Executive Summary

The City of Flint changed water sources, transitioning from Detroit's system to the Flint River. This change created water treatment challenges that have resulted in water quality violations. Aging cast-iron pipe has compounded the situation, leading to aesthetic issues including taste, odor and discoloration. Public interest and scrutiny of the drinking water system intensified following the distribution of required public notices of violation.

The City of Flint has made a number of good decisions regarding treatment changes that have improved water quality. However, this is a very complex water quality issue and the City is seeking additional advice on what to do to ensure healthful drinking water for the community.

Veolia appreciates the City's decision to seek independent third parties to review current treatment processes, maintenance procedures and actions taken to date, and provide ideas for improvement. We are pleased to present this final report to the City of Flint following our experts' 160-hour assessment of the water treatment plant, distribution system, customer service and communications programs, and capital plans and annual budget.

This report provides recommendations and a roadmap for improvement, though our engagement was limited in scope. Our assessment included reviewing actions taken by the City to date, validating the City's plans going forward, and making recommendations for ideas not being considered.

Although a review of water quality records for the time period under our study indicates compliance with State and Federal water quality regulations, Veolia, as an operator and manager of comparable utilities, recommends a variety of actions to address improvements in water quality and related aesthetics including: operational changes and improvements; changes in water treatment processes, procedures and chemical dosing; adjustments in how current technologies are being used; increased maintenance and capital program activities; increased training; and, an enhanced customer communications program.

We are also providing a recommended schedule and estimated costs for implementing changes. It is our desire to help Flint residents and public officials better understand the current situation so that informed decisions can be made to ensure safe drinking water for the city's customers.

Review of Actions Taken to Date

To address water quality issues, the city has made operational changes, sought help from the State, hired engineering firm Lockwood, Andrews & Newnam, Inc. (LAN) to provide additional advice, and hired Veolia for an assessment from a utility operator's perspective. The City has also reached out to different specialty vendors (chemical suppliers, filter companies and tank aeration companies) for information about products to help with the TTHM issues. These are logical steps to take.

Flint is not alone in dealing with TTHM problems, as many utilities across the country are facing this challenge. The City appears to be following standard steps that many of those communities are taking to successfully correct the problem.

Although the primary focus of this review was based on solving the TTHM problem, the public has also expressed its frustration over discolored and hard water. Those aesthetic issues have understandably increased the level of concern about the safety of the water.

The review of the water quality records during the time of Veolia's study shows the water to be in compliance with State and Federal regulations, and, based on those standards, the water is considered to meet drinking water requirements.

The City has been proactive in its efforts to reach out to the medical community, to set up a phone number and email address to receive complaints, to post State Water Quality reports, to provide the list of EPA required water tests, and offer to test the water at customers' homes.

From our review, these numerous efforts demonstrate how the city is trying to be transparent and responsive beyond what many other communities might do in similar circumstances.

State Report

The Michigan Department of Environmental Quality (MDEQ) has requested specific actions be taken related to the total trihalomethane (TTHM) issues. The February 2015 report from LAN (*Operational Evaluation Report TTHM Formation Concern*) indicated apparent reasons for the elevated levels of TTHM in the distribution system. These generally relate to high Total Organic Carbon (TOC) in the water source, improperly operating equipment both in the plant and the distribution system, less-than-optimal plant TOC removal and old cast-iron pipe in the distribution system. **Our assessment confirms that these reasons are likely given our on-site laboratory testing and analysis, as well as our first-hand observations.**

Due to time constraints, LAN's report to the State was submitted prior to Veolia's final analysis and recommendations, and contained a number of key initial and contingent steps the City should consider, including:

Initial Actions

- Hire a Third Party Water Quality Expert to Complete Independent Audit
- Obtain a THM Analyzer
- Carry Out Jar Testing
- Water Plant Optimization Softening
- Water Plant Optimization Disinfection of Filter Beds (Pre-Chlorination)
- Water Plant Optimization Polymer Aid to Coagulation and Flocculation
- Increase Water Main Flushing
- Water Modeling Cedar Street Pump Recirculation
- Water Modeling West Side Pump Recirculation
- Broken Valve Locations
- Increase Flushing

Contingent Actions

- Fix Ozone System
- Start Feeding Coagulant and Flocculation Polymer
- Convert to Lime and Soda Ash Softening
- Change Disinfection to Chloramine or Chlorine Dioxide Temporarily
- Install Pre-Oxidant at Intake
- Replace Filter Media Implement Advanced Treatment
- Increase Main Flushing
- Continue Valve Replacement
- Emphasize Cast Iron Pipe Replacement

Veolia's Recommendations

While many of Veolia's recommendations match the initial assessment provided by LAN, our approach, as an operator and manager of comparable utilities, considers a more comprehensive solution. These improvements include operational changes, differences in water treatment regimes and chemical dosing, increased maintenance, and increased training.

- **Addition of Permanganate** – The addition of a permanganate chemical will help reduce ozone demand as well as chlorine demand. The reduction of ozone is needed to help eliminate the possibility of violating the bromate limit. The addition of the chemical will require state approval, submission of design documents for approval, procurement of the equipment and installation. The State has indicated they will work with the City on expediting review and approval of any requested changes. The required dosage of permanganate is estimated to range from 0.5 mg/L to 1.2 mg/L with a corresponding price of $160,000 to $320,000 per year. (Please note – The water in the river is dynamic which means it will change with weather, seasons and other factors. The estimates provided are based on bench testing at a given time and as such require the operators to test water and to verify chemical dosages on a frequent basis.)
- **Reduction of Ozone Feed** – Treating water is a delicate balance - increasing ozone to fix the TTHM problem can raise bromate levels to a point of violation. The introduction of permanganate is being recommended to reduce the demand for ozone so that feed rates will not exceed 5 mg/L. The current ozone dosing has been as high as 8 mg/L and, as such, if allowed to continue, will increase the risk of violating the bromate levels.
- **Increase of Ferric Chloride** – Four coagulants were tested by Veolia -ferric chloride, ferric sulfate, polyaluminum chloride (PACI) and aluminum chlorohydrate (ACH). Ferric chloride and ACH were found to be the best choice of product for effectiveness in removing TOC, a precursor to TTHM formation. Current ferric chloride dosages are too low and dosages of 100 mg/L or more are recommended. Again, please note, that the amount of chemical needed changes with the nature of the river and as such, water must be tested multiple times a day with corresponding changes in chemical dosages. This increase to 100 mg/L is twice what is currently being fed and much higher than what had previously been fed last year. The increase in chemical costs could be up to $1,000,000 per year. This change in dosage (using ferric chloride) can be made immediately without state permit review.
- **Reduction of Lime** – Lime is currently being overfed. A higher dosage of lime does not necessarily mean better treatment. A review of different dosages with jar testing indicates that the current dosage of 280 mg/L can be reduced to 230 mg/L. This represents a potential range of savings of up to $270,000 per year. This change can be made immediately. It should be noted that the current softening equipment is in poor condition, which does complicate the treatment process with a poor balance of flow between the two basins, weirs that are not level causing bypassing with the softener basins, and simply old mechanical equipment that periodically breaks down. This equipment is not going to be needed when a change to lake water occurs. Addition of soda ash to help further reduce hardness in cold weather might require dosages up to 40 mg/L with an annual chemical cost up to $320,000. There have also been some questions or complaints from the public regarding hard water. The water entering the plant is currently 360 mg/L and the plant is reducing that level of hardness to about 210 mg/L. Optimization of the dosage can reduce the hardness

further to about 180 mg/L. This reduction however has been sporadic as equipment breakdowns and high flows have caused problems keeping the softening process on-line. As we have noted before, the dosage needs to be adjusted daily or more often based on process control monitoring. The raw water hardness in the summer is much less than in the winter. For illustration purposes, the difference could be 360 mg/L in raw water in winter compared with 220 mg/Lin the summer.

- **Eliminate Pre-Chlorination on the Filters** – The reduction of pre-chlorination on the filters during the summer months can help reduce TTHM formation. This action has to be considered carefully with procedures documented and reviewed for engineering principles. As such, it will take time for the design engineer to determine what could be done to assure the proper chlorine contact time and document that other safety protocols in water are met. This requires state approval. Any submission should be considered along with a possible change in filter media. If Granulated Activated Carbon (GAC) is installed then the pre-chlorination would be stopped or drastically reduced because of the chlorine impact on the GAC filter media. Veolia's initial investigation into changes in chlorine feed point indicate that the recommended action can be accomplished while maintaining the required regulatory contact time for disinfection.
- **Change Filters to Granulated Activated Carbon (GAC)** – The object of the other changes being made is to reduce the TOC before chlorine is added into the process. The plant by design is limited on the amount of TOC removal possible. A maximum removal of only 60% is likely if the plant is properly optimized. The change of filter media to GAC would provide the best reduction possible and provide better than 90% removal dramatically reducing the potential for TTHM formation and thus ensuring compliance with that parameter for the water system. The change in filter media; however, is complicated requiring approval by the state, design of the changes, procurement of the media and a contractor to install it. That will take time and is likely in a range of $1.5 million (more or less) in cost. The use of GAC also requires more testing and monitoring of the media and the TOC than with the current media. GAC will accumulate TOC and begin to become in effective after a period of time. Depending upon the level of TOC reaching the filters this could be as short as 3 months and as long as 9 months. The amount of TOC is dependent upon the river water quality and operation of the other plant processes. Once the ability of the filters to remove TOC is diminished, the GAC media has to be replaced if river water continues as a source. The change to lake water will not require TOC removal and the media could continue to be used as filter media for that new water source.
- **Corrosion Control** – The primary focus of this study was to assure compliance with the TTHM limits. That is not the only problem facing the city and its customers though. Many people are frustrated and naturally concerned by the discoloration of the water with what primarily appears to be iron from the old unlined cast iron pipes. The water system could add a polyphosphate to the water as a way to minimize the amount of discolored water. Polyphosphate addition will not make discolored water issues go away. The system has been experiencing a tremendous number of water line breaks the last two winters. Just last week there were more than 14 in one day. Any break, work on broken valves or hydrant flushing will change the flow of water and potentially cause temporary discoloration.
- **Eliminate a Storage Tank** - The water system has more storage than it requires, due to excess capacity in the water lines in combination with the storage tanks. The City has already employed LAN to update the hydraulic model. The hydraulic model should be used to help determine if water levels can be lowered further and even to remove some storage tanks from service. That decision may need to be made

seasonally. For example demand during water main breaks last week required extensive amounts of water. The excess storage is more a problem with TTHM formation for the system in summer than winter.

- **Prioritize Valve Replacement** - The hydraulic model shows long water age in portions of the system that appear to be contributing to the TTHM problems. LAN has updated the model to include the location of broken valves and that added information is being used to identify other system problems. The City has a contract for valve turning and repair work that should be focused on known broken valves, particularly in sections of the distribution system with old water age. This activity however must wait until warmer weather in fear of causing problems in the water system with lines freezing.
- **Target and Increase Flushing** – Flushing the fire hydrants can be useful in cleaning out lines to minimize discolored water complaints and also helping reduce the age of water. This DOES NOT mean just opening hydrants. The hydraulic model needs to be used to determine which hydrants should be opened and for how long to ensure the lines are properly cleaned. For example, this might require 15 minutes or even several hours of flushing depending on location. The flushing of hydrants also needs to include records of hydrant condition, color of water initially and after periodic increments plus chlorine residual testing. All of that information will help provide information to the engineers on the effectiveness of the procedure. Each crew doing the work should be trained to help explain the process to the public and also warn neighborhoods about flushing so that staining of laundry can be avoided.
- **Change to Lake Water** – The changes being made now to the water plant will not be the same changes required to treat lake water once it becomes available. A thorough analysis and plan needs to be made in preparation of that switch. This is going to need to include changes in how the plant is operated, like eliminating lime softening and reducing the dosages of many chemicals. Consideration will also have to be given to algae treatment when lake water is being used.
- **Operating Programs** – All of the changes discussed above are based on testing and techniques proposed by engineers and skilled operators of both LAN and Veolia. The staff will need further training and implementation of detailed protocols to successfully implement the changes and to ensure long-term success at the plant. This means the City needs to implement a series of programs to ensure success in these changes.
    - **Process Control Management Plan** (PCMP) – The amount of testing and resulting changes in chemical dosages, along with monitoring the impact on the water, will require a well-documented process that all operators follow. An example of this is jar testing, which is used by the operators to identify the most effective chemicals and dosages to optimize treatment. The staff understands the basic treatment process but needs further practice and training to become proficient in the use of routine process control to adjust for water quality. This is commonly referred to as a PCMP and is used as a standard operating procedure so that the operators on the day shift can communicate with the night shift, that operators are following the same treatment plan for water, that the adjustments are unified between different shifts and different people, that a desired water treatment quality is defined and variations from it signal alarms and that the staff knows what to do when the water quality setpoints begin to drift away from its desired quality levels.
    - **Lab QA/QC** – The operation of the water plant is dependent upon accurate lab results. Standard operating procedure needs to be set and lab technicians trained in that process. EPA and the State

set procedures and standards to be met and the staff should strive to meet those standards. The City has already purchased a TTHM analyzer but should also consider a TOC analyzer that can be an online continuous device to provide immediate information on influent and effluent levels of TOC. Part of the lab records should be historical review of data to help operators better understand the changes they make in the plant.

- **Maintenance Management** – The key to water equipment is having all the equipment effectively maintained and functioning properly. The current capital program is fixing many broken pieces of equipment and updating the plant to current standards. This however must be followed with a rigorous maintenance program that ensures the proper preventive maintenance, is able to predict when maintenance is needed to keep equipment functioning properly and responsive to changes in flows and source water quality.
- **Training** – The changes being suggested are new to the staff and as such training needs to be provided in what the changes involve, why they are being made, the impact on the water quality, and how best to run the plant. A good demonstration of skill level is for the staff to become certified by the State as a licensed water plant operator. Many utilities now require all operators to hold at least the minimum certification level as a starting point and offer incentives to increase their certification level.

- **Communication Program –** The city should lay out an immediate, written strategy for communicating with the public in the short-term, as well as a 6-to-12 month strategy that contemplates known, future events like the KWA pipeline and switch to lake water. A wide range of activities are underway to work with the public but a comprehensive and coordinated effort, with a strategic focus, will help the utility and its customers.
  - **Dedicated Communications Personnel –** The City has a single, dedicated public information officer, tasked with providing service to all of city government. The current focus on communications support for Public Works, and the anticipated needs over the next several years, indicate the city would benefit from the hiring of a staff person in Public Works who could establish a communications program designed to provide clear and concise information to a broad audience though a number of different channels. In the interim, the city could hire a communications intern, local communications firm, or somebody with experience who is able to provide reduced or no-cost services for the immediate future.
  - **Communications Planning – Public Notification** – The City should be congratulated on its efforts to keep the public informed. It is posting its monthly reports on the web page to provide transparency, though these reports are highly technical – and may be too technical for the customer base at large. They are valuable to those customers who do want this level of detail. The city should create a single-page dashboard of information that outlines the water utility's performance for the previous month, post the dashboard on the website, print copies for distribution at customer service or other reception areas, and be provided during speaking engagements or other events. This dashboard should be easy to understand, and include:
    - The number of water quality tests conducted the previous month
    - The number of violations reported

  - Whether these results are in or out of compliance
  - Information about other proactive measures such as main and hydrant replacements, or other programs to improve performance of the water utility
  - Benchmarking information so the reader has a greater understanding of how Flint compares with other similar utilities in the region and across the country

- **Public Meetings –**There should be additional, proactive coordination with neighborhood, community and civic groups to provide speakers on timely topics. Given the list of numerous responsibilities, the Public Works director cannot do it alone – the city should identify three or four other staff members, knowledgeable about the water utility who can also speak to various groups, provide information and answer questions. The development of an outreach strategy to target key neighborhood, community and civic groups also will advance the communications effort and the dissemination of information in both the short and long term.
- **Standard tools** – Work crews in the field are often the faces of the utility – the city should create standardized tools for communicating with the public that can be easily and quickly delivered to the community in the event of main breaks, flushing or pre-planned capital improvements. Tools should include:
  - Door hangers for individual distribution
  - Yard signs with simple messaging to be placed near work-sites
  - A simple tri-fold brochure with useful information about the utility and appropriate contact information
  - Specific flyers about a range of topics
  - Infographics about how the water system works, from the intake to the customer's site
- **Change in Billing Format –** The City currently has no real way to reach all customers on a regular basis and provide information. The city should consider changing from a billing postcard to using an envelope and bill stuffer. Monthly or bi-monthly bill inserts are typically used to provide educational material for customers and are standard ways to provide information. Understandably, budget considerations must be taken into account.
- **Use Public Affairs Programming and Opportunities –** The news media has been covering this topic quite extensively – there are other media-related opportunities that may reach a wider audience. Taking advantage of these opportunities will help the city relay information to its customers and the community.
  - Participate in regular editorial-board meetings to provide background information and updates on key milestones or events.
  - Identify a local weekly television program and offer to provide guests to speak about key milestones or upcoming events.

Conclusions and Next Steps

The focus of this report is to help assure TTHM compliance and then improve general water quality. The City had good results in its most recent TTHM tests, although that is to be expected with the changes made to date and the cooler weather which contributes to low TTHM formation. Warm weather will be a different situation both in the nature of the Flint River water quality and in the formation of TTHM. With those changes coming, the City needs to act quickly to make improvements before additional testing takes place this spring and summer. The summary below provides the recommended actions, a priority for their implementation and projected costs either operational or capital. The costs are rough orders of magnitude and will vary with changes in water quality, operational decisions, and engineering choices being made and in some cases require State approval. Although a priority is assigned many of these actions can take place simultaneously.

Priority	Action	Annual Operational Cost	One Time Capital Cost
1	Implement operating programs for process control, lab QA/QC, maintenance, and training. These programs are needed regardless of the TTHM issue and will help with transition to lake water. The City has decided upon a central maintenance software and the water system should be the first to utilize this program since costs are already budgeted. These programs should be initiated immediately.	$ 25,000	$ 250,000 - $ 350,000
2	Contract with your engineer and initiate discussions with the State on the reduction of chlorine prior to the filters and changing the filter media to GAC. This activity has the longest time frame for design and approval, but also is extremely critical to assuring reduced TTHM production. The current filter cleaning and maintenance project needs to be adjusted to take into consideration the change in filter media both to dispose of the anthracite instead of cleaning and to install the GAC. This entire project needs to be done by early July to assure a flow of water throughout the system. Several months are required for the engineering design, State approval, bidding of work and installation of GAC and as such needs to begin now.	$ 0	$1,500,000
	Contract with your engineer and initiate discussions with the State on the addition of 0.5 to 1.2 mg/L of either potassium permanganate (dry) or sodium permanganate (liquid). This will take time to get approved and to implement. The use of liquid tanks at the raw water pump station may be the quickest and least expensive alternative for a temporary measure.	$ 160,000 - $ 320,000	$ 50,000

	Contract with your engineer and initiate discussions with the State on the addition of a corrosion control chemical. This action can be submitted and discussed with the state at the same time as the other chemical and filter changes saving time and effort. A target dosage of 0.5 mg/L phosphate is suggested for improved corrosion control.	$ 50,000	$ 50,000
3	Increase the ferric chloride dosage to 100 mg/L depending on river water TOC levels. (Lower TOC levels can be treated with less ferric chloride.) This change can be made now and is allowed by the State.	$ 1,000,000	$ 0
	Reduce the ozone feed rate to 5 mg/. This change can be done now and does not require State approval.	($50,000 – $100,000	$ 0
	Reduce the lime dosage to minimize hardness levels after softening. This will eliminate magnesium removal during treatment, but will also reduce total hardness. A reduction in carbon dioxide dosing for recarbonation treatment also is expected due to the reduction in lime feed. This change can be made now and does not require State approval.	($270,000)	$ 0
4	Confirm with the engineer when the revised hydraulic model will be completed and if necessary for time to focus on areas of longest water age if that would speed up the effort. Identify impact of reducing tank levels or eliminating a tank seasonally to improve water age. Include with this effort a list of hydrants to flush along with time required to assure drawing fresh water through the system. The engineer has been assigned this task already and confirmation of the timing of a delivery is needed.	$ 0	Already Contracted
	Ask the engineer to identify closed valves on a map that are impacting water age and that can be bid for replacement as soon as weather permits. Have the engineer identify areas of the system where the valve contractor should be focused on finding and fixing closed valves.	$ 0	Already Budgeted
5	Implement the recommendations in the communications program including a person assigned to public works education, using envelopes instead of cards along with bill stuffers for education and provide training for staff. Envelopes and bill stuffers are expensive and might be done periodically and not every month. The cost of TTHM notices, Annual Water Quality Reports and City notices should be figured into if any additional costs would exist. Many of these changes are underway now by the City.	Position Being Budgeted	

Notes

- The costs provided are rough order of magnitude which final engineering will firm up but will fluctuate with final decisions on engineering, operating technique and water quality.
- The change from river to lake water will dramatically cut the chemical costs as less is needed once the change occurs. This means that potassium permanganate will likely not be needed, ferric will drop as much as it went up, ozone levels will be lower and little lime will be needed.

Results Expected

The real question is what changes can be expected from these results in lowering the TTHM, improving the aesthetics and preparing for the change to lake water.

- **TTHM** – The City has already made great strides in reducing the TTHM levels with the changes already made. The additional suggestions by Veolia will further reduce TTHM in the water and help get the city released from the notices being provided to customers.
- **Hardness** – The hardness entering the plant this winter is 360 mg/L with the current system reducing it to 210 mg/L and optimization will reduce to about 180 mg/L. During the summer the levels will be lower probably in the 140 mg/L to 150 mg/L range. The target set by the current best operating practices is 120 mg/L to 150 mg/L.
- **Discolored Water** – The discolored water is caused by the old unlined cast iron pipe. The water from the plant can have an impact on discolored water, but a greater concern is the breaks and construction work that disrupt the flow of water causing discoloration. A polyphosphate is suggested to help bind the old cast iron pipe reducing instances of discolored water. This along with improve flow of water and programmed hydrant flushing will help, BUT WILL NOT eliminate discolored water occurrences.
- **Change to Lake Water –** The recommendations include the suggestion of programs to help the staff better manage the treatment process, additional testing to adjust the plant and additional lab monitoring, a maintenance program focused on keeping equipment properly functioning and more training for staff to improve their skill level. Those actions will prepare the staff for the change of water sources when it comes next year in addition to developing a thorough plan for the switch.

Resourcing the world

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