Dr. Karen W. Weaver
Mayor

CITY OF FLINT, MICHIGAN

Angela Wheeler
City Attorney

October 11, 2018

Mr. Nathan Gambill
Assistant Attorney General
Michigan Department of Attorney General
Environment, Natural Resources, and Agriculture Division
525 West Ottawa Street
P.O. Box 30755
Lansing, MI 48909

Re: Third Proposed Amended Administrative Consent Order-Response to Paragraph 3.5 Part A

Dear Nate:

I am providing you with the revised response to paragraphs 3.5 Part A of the Third Proposed Draft Administrative Consent Order based on our meeting on Wednesday October 10, 2018.

The City has signed the following SOP's (See Attachments):

1. Phosphoric Acid Addition at Control Station #2
2. Sodium Hydroxide Addition at Control Station #2
3. Sodium Hypochlorite Addition at Control Station #2
4. Sodium Hypochlorite Addition at Distribution Storage Facilities
5. Sodium Hypochlorite Testing
6. Hydrant Inspection, Testing and Maintenance
7. Backflow Preventer Testing and Repair

8. Control Charting of Water Quality Parameters

9. Maintaining Distribution System Chlorine Residual

10. Emergency Repair of Water Mains

Please confirm that the City has satisfied the requirements of 3.5 Part A. Also, I will be in contact with you based on the remainder of our discussion during this meeting.

Sincerely,

Angela Wheeler
City Attorney

Enclosures

Cc: Ms. C. Heidi Grether, Director, MDEQ
Ms. Amy Epkey, Administration Deputy Director, MDEQ
Mr. Eric Oswald, Director of Drinking Water and Municipal Assistance Division, MDEQ
Mr. Aaron Keatley, Chief Deputy Director, MDEQ
Ms. Linda Holst, Acting Director, Water Division, Region 5, USEPA
Mr. Tom Poy, USEPA
Mr. Anthony Ross, Deputy Project Manager, Region 5, USEPA
Mr. Steve Branch, City of Flint, City Administrator
Mr. Robert Bincsik, City of Flint, DPW Director
Mr. Hughey Newsome, City of Flint, Chief Financial Officer
Dr. Pamela Pugh, City of Flint, Chief Public Health Advisor
Ms. Makini Jackson, City of Flint, Human Resources/Labor Relations Director

PHOSPHORIC ACID ADDITION AT CONTROL STATION 2 SOP

SOP #111

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

STAFF ACKNOWLEDGEMENT

I certify that the requirements of this SOP have been communicated to me and that I am trained in its use. A copy of this page will be distributed to the employee training record file.

Name	Date

APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bruesch Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

CSII	Control Station 2
GLWA	Great Lakes Water Authority
gph	gallons per hour
lb/gal	pounds per gallon
MGD	million gallons per day
mg/L	milligrams per liter
mL	milliliter
mL/min	milliliters per minute
mL/hr	milliliters per hour
PO_4	phosphate
PPE	personal protective equipment

2 KEY PERSONNEL AND RESPONSIBILITIES

- Operator:
  - Complete daily check of phosphate dose and pumping equipment, including metering pump, tote, and hose fittings for drips and leaks.
  - Adjust feed rate to achieve target phosphate residual concentration.

3 SCOPE/PURPOSE

The purpose of this SOP is to operate and adjust (as needed) the phosphate feed system flowrate at Control Station 2 to achieve the target phosphate residual in the finished water.

4 HEALTH AND SAFETY

The following PPE is required while inside the building where the bulk phosphoric acid is stored:

- Chemical resistant apron
- Chemical resistant gloves
- Face shield

Additionally, the facility is equipped with an emergency eyewash station.

5 PROCEDURE

Equipment Required:

- One 220-gallon tote of 75% phosphoric acid with containment
- Two 4 gph LMI feed pumps (one in service, one on standby)
- One 1000 mL calibration column
- Two digital timers (one is needed for the procedure, plus one spare)
- Daily record sheet

Procedure:

1. Read the influent supply flow from control panel in CSII. Record the flow on the daily sheet.
2. Check stroke and speed on feed pump. Record stroke and speed on the daily sheet.
3. Determine feed rate in milliliters per minute (mL/min):
    a. Open the fill valve on the calibration column, fill calibration column to slightly above the 1000 mL mark and close the fill valve.
    b. Close the valve on the supply line from the tote and reopen the valve to the calibration column.
    c. Watch the level drop in the calibration column. When it reaches the 1000 mL mark, start the timer.
    d. After one minute, close the valve to the calibration column and open the valve to the tote. Read the liquid level (mL) in the calibration column. Subtract the liquid level reading from 1000 mL. The difference is the feed rate in mL/min.
    e. Record the feed rate on the daily sheet.
4. Determine the feed concentration in mg/L (or parts per million, ppm):
    a. Multiply the influent flow rate (MGD) by the density of water, 8.34 lb/gal, to obtain million pounds of water being treated per day. Divide this result by 24 to obtain million pounds of water treated in one hour.
    b. Take the mL/min calculated above, multiply by 60 to get mL/hour, then divide by 3785 mL/gal to convert to gallons of phosphate fed per hour. Multiply by the density of phosphate (13.14 lb/gal), and multiply by 0.75 (the percent strength of the phosphate solution). This yields the pounds of pure phosphate fed per hour.
    c. Divide the pounds of pure phosphate by the million pounds of water, and this gives you the concentration for the hour in mg/L.
5. Adjust pump feed rate as needed. If the calculated PO_4 concentration is outside of the target residual concentration, adjust the pump feed rate and repeat steps 2 and 3.

6 DATA RECORDING AND MANAGEMENT

Following the procedure, record the following data on the daily log sheet:

- Initial and final phosphate pump feed rate in mL/min and lb/hr
- Influent flow rate (MGD)
- Initial and final calculated PO_4 concentration

7 REFERENCES

None.

SODIUM HYDROXIDE ADDITION AT CONTROL STATION 2 SOP

SOP #121

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

STAFF ACKNOWLEDGEMENT

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bruzath Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

CSII	Control Station 2
GLWA	Great Lakes Water Authority
gph	gallons per hour
lb/gal	pounds per gallon
MGD	million gallons per day
mg/L	milligrams per liter
mL	milliliter
mL/min	milliliters per minute
mL/hr	milliliters per hour
NaOH	sodium hydroxide (caustic soda)
PPE	personal protective equipment

2 KEY PERSONNEL AND RESPONSIBILITIES

- Operator:
  - Complete daily check of sodium hydroxide dose and pumping equipment, including metering pumps, tote, and hose fittings for drips and leaks.
  - Adjust feed rate to achieve target pH concentration.

3 SCOPE/PURPOSE

The purpose of this SOP is to operate and adjust (as needed) the sodium hydroxide feed system flowrate at Control Station 2 to achieve the target pH of the finished water.

4 HEALTH AND SAFETY

The following PPE is required while inside the building where the bulk sodium hydroxide is stored:

- Chemical resistant apron
- Chemical resistant gloves
- Face shield

Additionally, the facility is equipped with an emergency eyewash station.

5 PROCEDURE

Equipment Required:

- One 273-gallon tote of 25% caustic soda with containment
- Two 10 gph LMI feed pumps (one in service, one on standby)
- One 1000 mL calibration column
- Two digital timers (one is needed for the procedure, plus one spare)
- Daily record sheet

Procedure:

1. Prior to traveling to CSII, read the pH from the online analyzer at the lab tap. Record the pH on the daily sheet.
2. Read the influent supply flow from control panel in CSII. Record the flow on the daily sheet.
3. If a change in dosage is needed, calculate the new settings using the CHEAT SHEET and adjust the feed pumps accordingly.
4. Check stroke and speed on feed pump. Record stroke and speed on the daily sheet.
5. Determine feed rate in milliliters per minute (mL/min):
    a. Open the fill valve on the calibration column, fill calibration column to slightly above the 1000 mL mark and close the fill valve.
    b. Close the valve on the supply line from the tote and reopen the valve to the calibration column.
    c. Watch the level drop in the calibration column. When it reaches the 1000 mL mark, start the timer.
    d. After one minute, close the valve to the calibration column and open the valve to the tote. Read the liquid level (mL) in the calibration column. Subtract the liquid level reading from 1000 mL. The difference is the feed rate in mL/min.
    e. Record the feed rate on the daily sheet.
6. Determine the feed concentration in mg/L (or parts per million, ppm):
    a. Multiply the influent flow rate (MGD) by the density of water, 8.34 lb/gal, to obtain million pounds of water being treated per day. Divide this result by 24 to obtain million pounds of water treated in one hour.
    b. Take the mL/min calculated above, multiply by 60 to get mL/hour, then divide by 3785 mL/gal to convert to gallons of sodium hydroxide solution fed per hour. Multiply by the density of caustic soda (10.7 lb/gal), and multiply by 0.25 (the percent strength of the sodium hydroxide solution). This yields the pounds of pure sodium hydroxide fed per hour.
    c. Divide the pounds of pure sodium hydroxide by the million pounds of water, and this gives the concentration for the hour in mg/L.

7. Adjust the pump feed rate as needed. If the pH is outside of the target range, adjust the pump feed rate and repeat steps 3 through 6.

6 DATA RECORDING AND MANAGEMENT

Following the procedure, record the following data on the daily log sheet:

- Initial and final sodium hydroxide feed rate in mL/min and lb/hr
- Influent flow rate (MGD)
- Initial and final pH

7 REFERENCES

None.

SODIUM HYPOCHLORITE ADDITION AT CONTROL STATION 2 SOP

SOP #131

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bucek Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

CSII	Control Station 2
GLWA	Great Lakes Water Authority
gph	gallons per hour
lb/gal	pounds per gallon
MGD	million gallons per day
mg/L	milligrams per liter
mL	milliliter
mL/min	milliliters per minute
mL/hr	milliliters per hour
NaOCl	sodium hypochlorite
PPE	personal protective equipment

2 KEY PERSONNEL AND RESPONSIBILITIES

- Operator:
  - Complete daily check of chlorine dose and pumping equipment, including metering pumps, tote, and hose fittings for drips and leaks.
  - Adjust feed rate to achieve target chlorine residual concentration.

3 SCOPE/PURPOSE

The purpose of this SOP is to operate and adjust (as needed) the sodium hypochlorite feed system flowrate at Control Station 2 to achieve the target finished water free chlorine concentration.

4 HEALTH AND SAFETY

The following PPE is required while inside the building where the bulk sodium hypochlorite is stored:

- Chemical resistant apron
- Chemical resistant gloves
- Face shield

Additionally, the facility is equipped with an emergency eyewash station.

5 PROCEDURE

Equipment Required:

- One 220-gallon tote of 12.2 percent sodium hypochlorite with containment
- Two 4 gph LMI feed pumps (one in service, one on standby)
- One 1000 mL calibration column
- Two digital timers (one is needed for the procedure, plus one spare)
- Daily record sheet

Procedure:

1. Prior to traveling to CSII, read the free chlorine residual (in mg/L) from the online analyzer (i.e., Hach CL17) in the water treatment plant basement. Record the free chlorine residual on the daily sheet. **Note that the target free chlorine residual leaving CSII may vary seasonally.**
2. Read the influent supply flow from control panel in CSII. Record the flow on the daily sheet.
3. Calculate the dosage needed to reach the target residual:
    a. (dosage needed) = (target residual) – (residual at basement analyzer)
4. If a change in dosage is needed, calculate the new settings using the CHEAT SHEET and adjust the feed pumps accordingly.
5. Check stroke and speed on feed pump. Record stroke and speed on the daily sheet.
6. Determine feed rate in milliliters per minute (mL/min):
    a. Open the fill valve on the calibration column, fill calibration column to slightly above the 1000 mL mark and close the fill valve.
    b. Close the valve on the supply line from the tote and reopen the valve to the calibration column.
    c. Watch the level drop in the calibration column. When it reaches the 1000 mL mark, start the timer.
    d. After one minute, close the valve to the calibration column and open the valve to the tote. Read the liquid level (in mL) in the calibration column. Subtract the liquid level reading from 1000 mL. The difference is the feed rate in mL/min.
    e. Record the feed rate on the daily sheet.
7. Determine the feed concentration in mg/L (or parts per million, ppm):
    a. Multiply the influent supply flow rate (MGD) by 8.34 to obtain million pounds of water being treated. Divide this result by 24 to obtain million pounds of water treated in one hour.
    b. Take the mL/min calculated above, multiply by 60 to get mL/hour, then divide by 3785 to convert to gallons of sodium hypochlorite solution fed per hour. Multiply by the weight of bleach (10.15 lb/gal), and multiply by the percent strength of the

chlorine solution (for example, for 12.2% strength, multiply by 0.122). This gives the pounds of pure chlorine fed per hour.

c. Divide the pounds of pure chlorine by the million pounds of water, and this gives the feed rate for the hour in mg/L.

8. Adjust the pump feed rate as needed. If the free chlorine residual concentration from the online analyzer in the water treatment plant basement is outside of the target residual concentration, adjust the pump feed rate and repeat steps 3 through 7.
9. Record the free chlorine residual (in mg/L) from the online analyzer (i.e., Hach CL17) in the water treatment plant basement.

6 DATA RECORDING AND MANAGEMENT

Following the procedure, record the following data on the daily log sheet:

- Initial and final sodium hypochlorite pump feed rate in mL/min and lb/hr
- Influent flow rate (MGD)
- Initial and final free chlorine residual concentration

7 REFERENCES

None.

SODIUM HYPOCHLORITE ADDITION AT DISTRIBUTION STORAGE FACILITIES SOP

SOP #132

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Brimsek Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

CSII	Control Station 2
GLWA	Great Lakes Water Authority
gph	gallons per hour
lb/gal	pounds per gallon
MGD	million gallons per day
mg/L	milligrams per liter
mL	milliliter
mL/min	milliliters per minute
mL/hr	milliliters per hour
NaOCl	sodium hypochlorite
PPE	personal protective equipment

2 KEY PERSONNEL AND RESPONSIBILITIES

- Operator:
  - Complete a weekly check of the chlorine injection system, including all piping and connections for leaks.
- Operations Foreman:
  - Calculate applied dosage and injection system settings and communicate to operator.

3 SCOPE/PURPOSE

The purpose of this SOP is to operate and adjust (as needed) the sodium hypochlorite feed system flowrate at the Westside and Cedar Street Reservoirs to achieve the target distribution system free chlorine concentration.

4 HEALTH AND SAFETY

The following PPE is the minimum required while on-site at the pump stations and reservoirs:

- General
  - Closed-toed shoes
  - City employee identification
- While inside the building where the bulk sodium hypochlorite is stored
  - Chemical resistant apron

- Chemical resistant gloves
- Face shield

Additionally, each facility is equipped with an emergency eyewash station.

5 PROCEDURE

Prior to entering the premises, note surroundings and exterior building condition including exterior lights, doors, windows, and individuals. Do not enter the facility if it appears unsafe.

1. The Operations Foreman calculates the applied dosage and injection system settings using the CHEAT SHEET and notifies the Operator.
2. Enter the reservoir and disarm the alarm.
3. **Start the injection system:**
    a. Open the sodium hypochlorite barrel valve.
    b. Open feedline valve.
    c. Turn on the LMI pump with appropriate setting.
4. Perform a draw down calibration ensuring the pump is working and the proper dosage is being injected into the reservoir. If dosage is incorrect, adjust the speed and stroke of the chemical feed pump accordingly.
5. **Note: If the injection system fails to start, notify the Operations Foreman immediately so that filling of the reservoir can be halted until the system is operating properly.**
6. Perform a chemical inventory of amount of sodium hypochlorite solution on hand and report to the Operations Foreman.
7. Manually check the injection lines and fittings for deformation and wear.
8. Visually inspect the chemical feed pump for leaks and proper operation.
9. Notify the Operations Foreman the time in which the injection system was turned on and the settings.
10. Prior to exiting the facility, ensure that the surrounding area is safe and re-arm the alarm, turn out the lights, and verify that the reservoir entry door is locked.
11. Return to check that the injection system after it has been running for 2 to 3 hours, noting any concerns with the pump or injection lines.
12. **Turn off the injection system when filling is almost completed:**
    a. Turn power off.
    b. Close injection valve.
    c. Ensure proper operation.

d. Notify the Operations Foreman time of shut-off.

13. Report back to the water treatment plant.
14. **Chlorine Injection System Failure Contingency Plan:**
    a. The operator is to notify the Operations Foreman immediately. The Operations Foreman will close the valve at the reservoir to avoid reduced chlorinated water from entering the reservoir. The operator will then assess to see why the failure occurred and make a plan to rectify the situation. If repair is needed and time is an issue than the original chlorinator can be used as a backup.

6 DATA RECORDING AND MANAGEMENT

Following the procedure, record the following data on the daily log sheet:

- Time injection system was turned on.
- Dosage of chlorinator solution.
- Inventory of sodium hypochlorite solution on site.
- Notes of any wear, deformation, or malfunction of equipment.
- Time injection system was turned off.

7 REFERENCES

None.

SODIUM HYPOCHLORITE TESTING SOP

SOP #133

Rev: 0.0

Date: 01/31/2018

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bimrah Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

g/L	grams per liter
PPE	personal protective equipment
mL	milliliter
N	normal (equivalent per liter)

2 KEY PERSONNEL AND RESPONSIBILITIES

- Laboratory Technician:
  - Confirm sodium hypochlorite strength and record to calculate correct dosing.

3 SCOPE/PURPOSE

This SOP uses the iodometric method to determine the percent concentration of sodium hypochlorite (concentrated liquid bleach) used as a disinfectant at the water treatment plant and reservoirs.

Under acidic conditions, hypochlorite reacts with iodide to produce an equivalent amount of triiodide (I^{3-}). The released I^{3-} is titrated with standard thiosulfate solution to a colorless end point. The number of digits of thiosulfate required is proportional to the hypochlorite concentration in the original bleach sample.

Samples of concentrated sodium hypochlorite solution should be stored in a cool, dark place until analyzed and should be analyzed as soon as practical.

4 HEALTH AND SAFETY

The following personal protective equipment (PPE) is required while inside the building where the bulk sodium hypochlorite is stored:

- Chemical resistant apron
- Chemical resistant gloves
- Face shield

Additionally, the facility is equipped with an emergency eyewash station.

Once the sample is collected and taken to the lab for analysis, the following PPE is required:

- Chemical resistant gloves
- Laboratory coat
- Safety glasses

5 PROCEDURE

Equipment Required:

- Glass sample bottle
- One 125 mL Erlenmeyer flask
- Reagents:
  - Potassium iodide powder pillow (Hach Catalog No. 2059996)
  - Acid reagent powder pillow, 25 mL (Hach Catalog No. 104299)
  - 2.26 N thiosulfate titrant solution cartridge (Hach Catalog No. 2686901)
- Starch indicator solution (Hach Catalog No. 34932)
- Titrator (Hach Catalog No. 1690001)
- Piston pipet, 0.1 – 1.0 mL

Procedure:

1. Collect a sample from the concentrated sodium hypochlorite solution (approximately 5-10 mL) in a clean glass sample bottle. Take the bottle to the lab for analysis.
2. Insert a clean delivery tube into the 2.26 N thiosulfate titrant solution cartridge. Attach the cartridge to the titrator body.
3. Flush the delivery tube by turning the deliver knob to eject a few drops of titrant. Reset the counter to zero and wipe off the tip.
4. Fill the 125-mL Erlenmeyer flask to the 75-mL mark with deionized or tap water.
   Note: The level of residual chlorine found in tap water will not interfere in the test.
5. Add the contents of one potassium iodide powder pillow to the flask and swirl to mix.
6. Add the contents of one acid reagent powder pillow to the flask and swirl to mix.
7. Attach a clean tip to a calibrated piston pipet.
8. Use the pipet to dispense 0.2 mL of the sodium hypochlorite sample below the solution level in the flask.
9. Swirl to mix. The solution will turn dark brown.
10. Place the delivery tube tip into the solution and swirl the flask while titrating with the thiosulfate titrant until the solution is pale yellow.
11. Add one dropper of starch indicator solution to the flask and swirl to mix. A dark blue or green color will develop.
12. Continue the titration until the solution becomes colorless. Record the number of digits required.
13. Calculate the g/L chlorine:
    a. g/L chlorine = Digits Required x 0.5
    b. Divide the g/L chlorine by 10 to obtain the % (by volume) chlorine (trade percent).

6 DATA RECORDING AND MANAGEMENT

Record the results of the test on the daily test log sheet.

7 REFERENCES

Method adapted from ASTM Method D2022.

HYDRANT INSPECTION, TESTING, AND MAINTENANCE SOP

SOP #321

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

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STAFF ACKNOWLEDGEMENT

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bruesch Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

AWWA	American Water Works Association
EAM	enterprise asset management
GIS	geographic information system
GPS	global positioning system
PPE	personal protective equipment

2 KEY PERSONNEL AND RESPONSIBILITIES

- Water Distribution Superintendent:
  - Maintain schedule and generate work orders for hydrant inspection, testing and maintenance.
  - Identify additional planning/scheduling activities and resources for each hydrant (such as establishing additional traffic control measures, coordinating with valve exercising, performing customer notification, and assessing the hydraulic impact).
  - Maintain records of hydrant maintenance.
  - Ensure all repairs, map discrepancies, and other issues are properly communicated to the responsible parties and ensure identified repairs/replacements are executed within a timely manner.
- Water Distribution Operator (2):
  - Perform field inspection, testing and maintenance of hydrants as generated by work orders.
  - Prepare records of field testing, inspection and maintenance for each hydrant and enter into enterprise asset management (EAM) system.

3 SCOPE/PURPOSE

The purpose of this SOP is to ensure regular and consistent execution of the preventive maintenance, inspection, and testing of hydrants throughout the distribution system. The hydrant maintenance program shall be conducted in accordance with the American Water Works Association (AWWA) Manual M17 Fire Hydrants: Installation, Field Testing, and Maintenance. Per the referenced publication, "all hydrants should be inspected regularly, at least once a year, to ensure their satisfactory operation (most manufacturers recommend twice per year)." In addition, "it is good practice to conduct flow tests on all parts of the distribution system approximately every 10 years to identify the service areas affected by significant changes in the distribution system. An accurate and digital record should be kept of each flow test so it is readily available."

The City of Flint owns a number of different fire hydrant models; therefore, maintenance and testing practices may vary. Service personnel should apply maintenance practices consistent with the make and model of the hydrant in accordance with manufacturer's recommendations.

This SOP should be used in coordination with a comprehensive asset management plan and hydraulic model. Any updates to condition, status, or operation of valves shall be relayed to the appropriate staff so that information is consistent across distribution system operations.

This SOP does not cover hydrant installation and replacement procedures, which would include inspection before installation, installation or replacement, and testing and/or inspection after installation.

4 HEALTH AND SAFETY

One of the most significant health and safety risks during hydrant maintenance is vehicle traffic. The field service team should use trucks, temporary signs, and traffic cones to prevent automotive accidents and injury to staff. In addition, a flag crew may be needed to direct traffic in some locations. Trucks should be parked between oncoming traffic and the work area to provide a barrier. In addition, the following personal protective equipment (PPE) should be worn during maintenance activities:

- City employee identification
- Hard hat
- High visibility safety vest
- Knee pads (as needed)
- Safety glasses
- Steel-toed boots
- Work gloves

5 PROCEDURE

Equipment Required:

- Water system map (with clear labels for pipe diameter, street names, parcel addresses, critical water users, and all hydrant/appurtenance identification numbers)
- Traffic cones
- Temporary signs/arrow boards (warning lights, strobe lights, arrow boards, traffic maintenance signs)
- Pruning shears
- Wrench
- Approved lubricating oil (and funnel)
- Spare parts (cap, stem, nut, bonnet, etc.)
- Scraper, wire brush, and/or sand-paper

- Spray paint and primer (if applicable)
- Plastic tarp or newspaper
- Approved cleaning agent and paper towels
- GPS unit (optional)
- Digital camera (optional)

Procedure:

Once a work order is received from the Water Distribution Superintendent, identify the 2-person maintenance crew to perform the hydrant maintenance.

1. Prior to driving to the site, perform the necessary pre-planning activities. This includes reviewing system maps, GIS, as-builts, and asset history to identify hydrants that are in busy intersections, high-profile of sensitive customers, or may result in a potential hydraulic impact as well as reviewing the manufacturer's manual for the specific hydrants to be inspected. Notify the Water Service Center Supervisor if additional planning/coordination is needed.
2. Identify the best route to conduct the work. This includes identifying the starting and ending point (hydrant location), sequence of hydrants to be completed for the day, and potential parking areas.
3. Upon arrival to the site, assess the site for safety (including the appropriate PPE) and set up the appropriate traffic control measures. This may include: warning lights, strobe lights, arrow boards, traffic maintenance signs, cones, flagmen (if necessary), safety vests and/or other PPE. Document the following information on the work order:
    - Operator last name
    - Inspection date
    - Arrival time
4. Locate and access the fire hydrant identified on the work order. Identify the unique identification number for the hydrant on the appropriate water system map and confirm the actual field location is a correct match. Verify the following information in the field and document it on the work order:
    - Hydrant ID number
    - Map grid/page number
    - Street
    - Cross street
    - Address
    - GPS position (if applicable)
    - Other location notes (i.e. measurements from the property line)
    - Hydrant source main size
    - Map discrepancies (if applicable)
5. Clear the area of excessive debris, vegetation, or dirt (within a 3-foot clearance). There should be no obstructions, including the ground, preventing easy coupling of hoses or turning of spanners. The hydrant should be visible from all approaches. There should be

no brush or tree limbs that could interfere with anyone approaching the hydrant and attempting to connect to it or operate it. Where needed, perform minor corrections, such as pruning and minor digging. Document more significant work on a new work order.

6. Check hydrant information against records (to be provided on work order) and note any discrepancies. Document the following information on the work order:
    - Manufacturer[1]
    - Model
    - Year
7. Visually inspect hydrant for leaks, rust, or any obvious cap/chain defects. Caps should be free from cracks and turn freely. Chains should be attached to caps and the hydrant body and turn freely.
8. Loosen the top cap and open the hydrant a few turns to allow air to vent, and then tighten the cap and open the hydrant fully. A full tear down is required to look for internal damage, gasket, and tread conditions. Pay special attention to all seals and threads, and note any wear.
9. Replace any components, if required.
10. Before putting the hydrant back together, make sure the operating nut, all nozzle outlets, and all seals/threads are cleaned and lubricated (in compliance with manufacturer recommendations).
11. Re-assemble the hydrant and fully tighten all caps.
12. Locate, access, and exercise the fire hydrant isolation valve in accordance with manufacturer recommendations. Valves should open and close properly and should not leak at either the stem or the nozzle. Tighten leaky packings on older hydrants. Document any valves that are difficult to operate, have bent stems, or do not open/close fully on the work order for follow-up.
13. Turn on the hydrant fully and test for adequate, sustained water pressure and proper drainage. Also check for any leaks around the operating stem, nozzles, any seals or packing, and at the flanges. Replace the o-rings if necessary.
14. Open and close the hydrant with the nozzle caps in place to check for seal leakage. Verify that hydrant main (bottom) valve completely closes. Refer to appropriate manufacturer's manual for step by step instructions.
15. If a wet barrel hydrant, drain the hydrant in accordance with manufacturer's instructions.
16. Thoroughly clean the exterior of the hydrant, washing off any dirt, bird droppings, or loose debris.
17. Confirm paint is in good condition. Touch up hydrants with chips or rust using an approved spray paint. A plastic tarp or newspaper should use used to protect sidewalk or nearby vegetation. Remove any surface rust using scraper or wire brush. Roughen

[1] The City of Flint estimates approximately six various hydrant manufacturers are currently in-use (all dry barrel). This includes the following: A.P. Smith, Darling, E.J., Mueller, T.C. and Waterous.

any shiny surfaces with light sanding (to improve paint adhesion). Apply spot primer to coat areas of bare metal. Apply a top coat with a polyurethane enamel compatible paint as directed by the hydrant manufacturer (typically sprayed to minimum 4 mil dry coat thickness).

18. Visually inspect the hydrant for damaged or missing parts. Document any operational deficiencies, leaks, vandalism, and other relevant observations in addition to the following information on the work order:
    - Operated (yes/no)
    - Drained (yes/no)
    - Flow observed (yes/no)
    - Close direction
    - Number of turns
    - Fire hydrant condition (operable/inoperable)
    - Specific hydrant discrepancy (by category and details)
    - Specific repair activity required to return the hydrant to full operability
    - Picture taken (for raises or other conditions)
    - Time work order completed
    - Comments (other relevant observations or items requiring additional maintenance on the work order)

19. Restore the area to a clean and safe condition. This includes clearing the area of any tools/materials used and any traffic control devices.

6 DATA RECORDING AND MANAGEMENT

Following completion of a hydrant test, inspection or maintenance work order, enter all necessary information, including the date of maintenance, hydrant identification, condition, test results and personnel completing the maintenance, into the EAM system.

The Water Distribution Superintendent must be notified of any additional required maintenance or if the hydrant is inoperable or in disrepair. The Water Distribution Superintendent shall assign work orders for any follow-up items and coordinate updates to the asset management plan.

7 REFERENCES

American Water Works Association. (2016). *M17 Fire Hydrants: Installation, Field Testing, and Maintenance, Fifth Edition.* Denver, CO: AWWA

BACKFLOW PREVENTER TESTING AND REPAIR SOP

SOP #341

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

STAFF ACKNOWLEDGEMENT

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Name	Date

APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bruesch Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

AWWA	American Water Works Association
CCRM	Cross Connection Rules Manual
MDEQ	Michigan Department of Environmental Quality
PPE	personal protective equipment

2 KEY PERSONNEL AND RESPONSIBILITIES

- Cross-Connection Control / Backflow Prevention Program Administrator:
  - Oversee cross-connection and backflow prevention control program
  - Generate work orders for inspection, testing, maintenance, and repair of backflow prevention assemblies
- Operator or contractor with valid Michigan journey or master plumbing license with documented training that complies with the requirements of the cross-connection and backflow prevention program for testing, repair, and maintenance of backflow prevention assemblies:
  - Complete work orders generated by the Cross-Connection Control / Backflow Prevention Program Administrator
  - Follow up field work by recording maintenance or repair in established database, or return of field documents to the utility

3 SCOPE/PURPOSE

The purpose of this SOP is to outline the procedures for regular testing and as-needed repair of backflow prevention devices. Refer to the Michigan Department of Environmental Quality (MDEQ) Cross Connection Rules Manual (CCRM), latest edition for guidance on backflow prevention rules promulgated by the State of Michigan.

This SOP does not cover the comprehensive cross-connection program, which should be maintained in parallel for an up to date record of existing backflow prevention assemblies within the distribution system including the following information. (Refer to AWWA M14, latest edition for more detail.)

- Location of backflow preventer
- Description of hazard isolated
- Type, size, make, model, static line pressure, and serial number

4 HEALTH AND SAFETY

Backflow prevention assemblies are often located on customer property and may be installed in hazardous areas including confined spaces. Prior to any work, the area should be evaluated for hazardous conditions and personal safety by the operator maintainer. Additionally, the following PPE should be worn:

- City employee identification or a City-approved contractor identification card
- Hard hat or bump cap (as needed for overhead hazards)
- Safety glasses
- Steel-toed boots
- Work gloves

In the event that a confined space entry is required, refer to the appropriate safety standard for air monitoring and support personnel.

5 PROCEDURE

Equipment Required:

- Use only equipment approved by the manufacturer of the backflow prevention assembly.
- All field test kits must be calibrated prior to use and must be recalibrated as needed according to the manufacturer's recommendations to ensure that the instruments are operable and accurate when used.

Procedure:

1. All backflow assemblies are to be tested in accordance with the MDEQ CCRM and AWWA M14. Testing must occur under the following circumstances:
    a. At the time of installation or relocation, including assemblies re-installed seasonally.
    b. After any repairs.
    c. At a minimum of every 3 years, or in accordance with the approved cross-connection control program.
2. Individual testing procedures will depend on the make, model, and type of the backflow preventer. Use only tools approved by the manufacturer of the assembly to service and test the unit.
3. If a repair is required, obtain the repair information from the manufacturer of the backflow assembly and complete according to their recommendations. Document the repair type and completion date.
4. Prior to testing or repair of a device, provide notice to the property owner of date and approximate time of inspection.

5. Reference AWWA M14 for field test procedures for a variety of backflow prevention assemblies.

6 DATA RECORDING AND MANAGEMENT

Following the test, generate a report including the following records (AWWA M14, MDEQ CCRM):

- Assembly owner's name and mailing address (if customer-owned)
- Assembly location building address and physical location within the building
- Type of device including manufacturer's name, model number, serial number, and size of assembly
- Description of application (i.e. equipment or system served)
- Initial test results (pass-fail of first check and second check, relief valve discharge, air inlet opening, static line pressure)
- Test equipment manufacturer, model number, serial number, and calibration information.
- Repair history, repairs made during test, repair parts used, and/or cleaning performed
- Final test results after repair, as applicable
- Printed name, signature and certification number of the tester
- Date and time of test

Upon the receipt of results from an assembly testing event, the Cross-Connection Control / Backflow Prevention Program Administrator should review the results and order repairs or investigate inconsistencies as necessary.

7 REFERENCES

American Water Works Association. (2015). *M14 Backflow prevention and Cross-Connection Control Recommended Practices, Fourth Edition*. Denver, CO: AWWA.

Michigan Department of Environmental Quality. (2008). *Cross Connection Rules Manual, Fourth Edition*. Lansing, Michigan: Michigan Department of Environmental Quality.

CONTROL CHARTING OF WATER QUALITY PARAMETERS

SOP #422

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. & Cornwell Engineering Group Date: 01/31/2018

Approved by: Robert Bucsh Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

CSII	Control Station 2
LCL	lower control limit
RTCR	Revised Total Coliform Rule
UCL	upper control limit
WEWQPM	weekly enhanced water quality parameter monitoring
WQP	water quality parameter

2 KEY PERSONNEL AND RESPONSIBILITIES

- Water Quality Laboratory Supervisor:
  - Enter data into control chart spreadsheets
  - Review control charts to identify if there are any observed variances that may have an attributable cause
  - If variances are observed that may have an attributable cause, convey that information to the Operations Supervisor so that actions to resolve the variance can be implemented.
- Water Plant Superintendent:
  - Based on information provided by the Water Quality Laboratory Supervisor, take appropriate actions to increase or decrease the system pH, chlorine residual, or orthophosphate residual as needed to bring the system back into control.

3 SCOPE/PURPOSE

The purpose of this SOP is to outline the procedures for using the control chart tools developed by the Cornwell Engineering Group to generate control charts of water system data. These tools consist of three Microsoft Excel-based spreadsheets:

- Flint Distribution System WQP Control Charts v1.2
- Flint Distribution System Chlorine Residual Control Charts v1.2
- Flint CSII and Tap WQP Control Charts v1.2

The first tool generates monthly median control charts for orthophosphate residual, pH, and alkalinity at the ten Enhanced Water Quality Parameter Monitoring Sites that the City of Flint maintains in the distribution system. The second tool generates monthly median control charts for chlorine residual at the twenty-five Revised Total Coliform Rule (RTCR) Monitoring Sites that the City of Flint maintains in the distribution system. The last tool generates weekly median

control charts for orthophosphate residual and pH at Control Station 2 (CSII) and tap sampling locations at the Flint Water Treatment Plant.

The charts generated by these tools are Shewhart control charts, which are statistical tools originally developed to manage manufacturing processes by monitoring parameter variability. Control charts use subgroups (aka "binning") to reduce the inherent variability of each sampled parameter. Because these tools are designed to assess data recorded on a weekly or daily basis, these data have been sub-grouped by month (for weekly data) or by week (for daily data). Each chart displays the median of the monthly or weekly subgroup, as well as an upper control limit (UCL) and a lower control limit (LCL) based on the historical trends of the entire data set.

Control charts reduce the variability inherent in monitoring water quality parameter (WQP) data and instead display the monthly trend relative to historical performance. If the monthly median is plotted above the UCL or below the LCL, it suggests that the observed change in that WQP is not due to natural variability. Therefore, it is likely that there is an attributable cause (e.g. chemical feed pump is not dosing accurately, change in treatment chemical used, etc.) for the observed change in the WQP.

The distance between the UCL and LCL will narrow as more data are available in a subgroup (e.g. more than four samples per month) and will increase as fewer data are available. Therefore, the UCL/LCLs may appear "wavy" because more data were collected in some months than in others. The locations of the UCL and LCL will also change over time as more data are added to the historical record. As the treatment processes become more stable, the UCL and LCL will converge towards one another.

Control charts are most useful when compared to corrosion control treatment goals. If the goal is to maintain a minimum orthophosphate residual, the LCL should be maintained above that value. If the goal is to stay within a desired pH range, the UCL and LCL should fall within that range.

For more information on control charts and how they can be applied to evaluate data for the Lead and Copper Rule please see: "Controlling Lead and Copper Rule Water Quality Parameters" (Cornwell, Brown, and McTigue 2015).

4 HEALTH AND SAFETY

There are no inherent health or safety risks from using the control chart tools to analyze data. Water system staff implementing treatment or operations changes in response to observed variances that may have an attributable cause should follow the SOPs for those operations.

5 PROCEDURE

The following procedures outline how data are to be entered into the control chart tools.

Flint Distribution System WQP Control Charts:

1. This tool is designed to allow for easy generation of monthly control charts for WQP data (pH, alkalinity, and orthophosphate residual) recorded in the Weekly Enhanced Water Quality Parameter Monitoring (WEWQPM) spreadsheets. The Data Entry form is arranged similarly to the WEWQPM spreadsheets to allow data to be copied directly from the WEWQPM spreadsheets into this tool.
2. On the Data Entry worksheet, click the hyperlink in Cell C2 to navigate to the first empty column.
3. Copy the sample date data from Column C of the WEWQPM spreadsheet and paste into the empty Sample Date column for pH (Rows 5 - 15), orthophosphate residual (Rows 19 - 29), and alkalinity (Rows 33 - 43).
4. Copy the pH data from Column G in the WEWQPM spreadsheet and paste into the empty pH column on the Data Entry worksheet (Rows 5 - 15).
5. Copy the Phosphate data from Column N in the WEWQPM spreadsheet and paste into the empty Phosphate column on the Data Entry worksheet (Rows 19 - 29).
6. Copy the Total Alkalinity data from Column H in the WEWQPM spreadsheet and paste into the empty Total Alkalinity column on the Data Entry worksheet (Rows 33 - 43).
7. After all data have been entered into the Data Entry worksheet, return to the Dashboard using the hyperlink in Cell B2.
8. At the Dashboard, select the WQP to be charted using the upper left dropdown.
9. Select the time period for charting the WQP data. Buttons are provided to quickly display the last six months or last one year of data, or select a custom range start and end date by using the left-right scroll buttons.
10. The tool can allow for side-to-side comparisons between two WQP monitoring locations. Use the drop down menus for WQP Site I and WQP Site II to select the sites for comparison.
11. The tool also allows comparison of median values for the three parameters (pH, Orthophosphate and Alkalinity) between two WQP monitoring locations and all locations to evaluate the whole system. For a selected WQP (from the dropdown) and selected time period (from the dropdown), the tool generates a single (third) chart showing the data for all of the WQP locations.

Flint Distribution System Chlorine Residual Control Charts:

1. This tool is designed to allow for easy generation of monthly control charts for MOR data (chlorine residual) recorded in the Monthly Operating Report (MOR) spreadsheets. The Data Entry form is arranged similarly to the MOR spreadsheets to allow data to be copied directly from the MOR spreadsheets into this tool.
2. On the Data Entry worksheet, click the hyperlink in Cell C2 to navigate to the first empty row.
3. Copy the Free Chlorine Residual data from Column BL to CJ in the MOR spreadsheet and paste into the empty columns on the Data Entry worksheet (Columns E to AC) with the corresponding dates.

4. After all data have been entered into the Data Entry worksheet, return to the Dashboard using the hyperlink in Cell B2.
5. Select the time period for charting the WQP data. Buttons are provided to quickly display the last six months or the last one year of data, or select a custom range start and end date by using the left-right scroll buttons. Data prior to 1/01/2016 have not been entered into this tool so start dates prior to 1/31/2016 cannot be selected.
6. The tool can allow for side-to-side comparisons between two WQP monitoring locations. Use the drop down menus for WQP Site I and WQP Site II to select the sites for comparison.

Flint CSII and Tap WQP Control Charts:

1. This tool is designed to allow for easy generation of monthly control charts for WQP data (pH, orthophosphate residual, and chlorine residual) recorded in the Monthly Operating Report (MOR) spreadsheets. The Data Entry form is arranged similarly to the MOR spreadsheets to allow data to be copied directly from the MOR spreadsheets into this tool.
2. On the Data Entry worksheet, click the hyperlink in Cell B1 to navigate to the first empty row.
3. Using the MOR monthly spreadsheet, copy pH data for the CSII and Tap locations from Columns AE and AF, respectively, from the MOR monthly spreadsheet and paste into Columns E and F on the Data Entry worksheet. Copy orthophosphate data for the CSII and Tap locations from Columns C and E, respectively, and paste into Columns G and H in the Data Entry worksheet. Copy chlorine residual data for the CSII and Tap locations from Columns W and AB, respectively, and paste into Columns I and J in the Data Entry worksheet.
4. After all data have been entered into the Data Entry worksheet, return to the Dashboard using the hyperlink in Cell A1.
5. Select the time period for charting the WQP data. Buttons are provided to quickly display the last six months or last one year of data, or select a custom range start and end date by using the left-right scroll buttons.
6. The tool allows for charting of pH, orthophosphate residual or chlorine residual data at the two WQP sites (CSII and Tap). Select the WQP from the dropdown to choose which WQP to evaluate.

6 DATA RECORDING AND MANAGEMENT

After the control charts have been generated, they should be reviewed to identify points that are above the UCL or below the LCL. Such points are outside the natural variation to be expected, so the Water Treatment Superintendent may need to make process adjustments to bring the system back into control. Such adjustments might be increasing or decreasing chemical feed targets, calibrating chemical feed pumps or flow meters, verifying proper operation of equipment, etc.

7 REFERENCES

Cornwell, D., Brown, R., & McTigue, N. (2015). *Controlling Lead and Copper Rule Water Quality Parameters.* Journal-American Water Works Association, 107(2), E86-E96.

MAINTAINING DISTRIBUTION SYSTEM CHLORINE RESIDUAL

SOP #441

Rev: 0.0

Date: 04/13/2018

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

STAFF ACKNOWLEDGEMENT

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. & Confluence Engineering Group Date: 04/13/2018

Approved by: Robert Bruish Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

CIP	Capital Improvement Plan
CRM	Chlorine Residual Management
CSII	Control Station 2
DBP	Disinfection Byproduct
MDEQ	Michigan Department of Environmental Quality
MOR	Monthly Operating Report
RTCR	Revised Total Coliform Rule
WQP	Water Quality Parameter

2 KEY PERSONNEL AND RESPONSIBILITIES

- Water Quality Laboratory Supervisor:
  - Oversee sample collection and analysis of data using provided spreadsheet tools.
  - Communicate with Water Plant Superintendent and Distribution Superintendent when distribution system chlorine residual goal of 0.5 mg/L in ≥ 95% of monthly samples is not met.
- Water Plant Superintendent:
  - Based on information provided by the Water Quality Laboratory Supervisor, modify dosage at CSII or Cedar Street Reservoir as needed to meet distribution system residual goal.
- Distribution Superintended:
  - Implement operations and maintenance strategies to improve residuals locally or regionally.

3 SCOPE/PURPOSE

Maintenance of an adequate disinfectant residual throughout the distribution system is paramount to protecting public health. In addition to providing microbial control, disinfectant residuals provide oxidizing conditions to help stabilize pipe scales, and can serve as an indicator of distribution system integrity. Therefore, a key aspect of distribution system water quality management and optimization is to identify appropriate disinfectant residual level(s) and strategies for monitoring and maintaining them on an on-going basis. The purpose of this SOP is to outline the procedures for tracking and maintaining chlorine residual within the distribution system. Several Microsoft Excel-based spreadsheet tools have been developed to track residual levels at the plant tap and throughout the distribution system, specifically:

- Flint CSII and Tap WQP Control Charts v1.2 (refer to SOP#422)
- Flint Distribution System Chlorine Residual Control Charts v1.2 (refer to SOP#422)
- Chorine Residual Management Tool v4

The first tool generates weekly median control charts for chlorine residual (as well as orthophosphate and pH) at CSII and tap sampling locations at the Flint Water Treatment Plant. The second tool generates monthly median control charts for chlorine residual at the twenty-five Revised Total Coliform Rule (RTCR) Monitoring Sites that the City of Flint maintains in the distribution system. Control charts are particularly useful for assessing variability in process control within treatment plants, and success meeting the desired finished water chlorine residual goal. Consult *SOP 422: Control Charting of Water Quality Parameters* for additional information and instructions for use.

The CRM Tool was developed to allow for tracking and analysis of chlorine residual levels and comparison to the free chlorine residual goal of 0.5 mg/L in ≥ 95% of the monthly samples collected. Review of the graphics created in this tool allow for seasonal and site-specific analysis compared to the goal. The CRM Tool also tracks disinfection byproduct (DBP) sampling and performs DBP compliance calculations.

4 HEALTH AND SAFETY

There are no inherent health or safety risks from using the CRM Tool to analyze data. Water system staff implementing treatment or operations changes or conducting additional water quality sampling should follow the SOPs for those operations.

5 PROCEDURE

1. Collect and analyze chlorine residual measurements from all RTCR and chlorine residual only surveillance monitoring locations within the distribution system each week. A minimum of 100 chlorine residual measurements should be collected each month distributed across the RTCR monitoring locations. HACH Pocket Colorimeter II, HACH DR 900 or equivalent colorimetric methods are acceptable.
2. Enter the free chlorine residual sample results from the RTCR monitoring into the Monthly Operating Report (MOR).
3. Enter the MOR data from distribution system and plant tap sites into the CRM Tool (see CRM Tool Instructions tab for step-by-step instructions).
4. Enter data into the control chart spreadsheets (see corresponding SOPs and spreadsheet tools for instructions).
5. Review the charts to verify:

a. Free chlorine residual at the plant tap is at or above the minimum finished water target.

b. 95% of monthly samples are ≥ 0.5 mg/L as free chlorine.

6. Take appropriate steps to rectify issues when identified. These may include:

    a. Chlorine dose modifications – regional or system-wide improvements

        i. At Plant – Increase or decrease the system chlorine dose at CSII. Consult *SOP 131: Sodium Hypochlorite Addition at Control Station 2* and *SOP 133: Sodium Hypochlorite Testing*.

        ii. At Storage Facilities – Increase or decrease chlorine dose at Distribution Storage Facilities. Consult *SOP 132: Sodium Hypochlorite Addition at Distribution Storage Facilities* and *SOP 133: Sodium Hypochlorite Testing*.

        iii. Track potential unintended consequences of increased dose, such as customer complaints (consult *SOP 421: Customer Complaint Tracking*) and formation of disinfection byproducts (using CRM Tool).

        iv. Consider cost-benefit of increased dosing versus water age and pipe wall demand management options summarized below.

    b. Reduce water age – localized, regional, or site-specific improvements (Consult *SOP 442: Water Age Management*)

        i. Install/move auto-flushers to problematic areas and conduct gentle bulk water turnover flushing. Consult *SOP 431: Conventional Flushing for Water Turnover*.

        ii. Modify reservoir operations to improve mixing and turnover.

        iii. Verify valve positions to minimize artificial dead-ends and improve water circulation.

    c. Reduce pipe wall demand – localized, regional or site-specific improvements

        i. Conduct unidirectional flushing where feasible to remove accumulated sediments that may be exerting a disinfectant demand. Consult *SOP 432: Unidirectional Flushing*.

        ii. Determine timing for pipe repair and replacement in affected area per the Capital Improvement Plan/Asset Management Plan.

7. Document dates of response strategies and verify site-specific, local, regional, or system-wide impacts using statistics and charts developed in CRM and control chart tools. Modify response strategies, as needed, and as system operations evolve.

6 DATA RECORDING AND MANAGEMENT

The Water Quality Laboratory Supervisor should review chlorine results on a daily basis and enter into MORs. Data from MORs should be uploaded into spreadsheet tools each month to review site-specific and monthly trends, confirm that plant and distribution system residual goals are met, and assess effectiveness of response strategies.

7 REFERENCES

City of Flint. Standard Operating Procedure 131: Sodium Hypochlorite Addition at Control Station 2.

City of Flint. Standard Operating Procedure 132: Sodium Hypochlorite Addition at Distribution Storage Facilities.

City of Flint. Standard Operating Procedure 133: Sodium Hypochlorite Testing.

City of Flint. Standard Operating Procedure 421: Customer Complaint Tracking.

City of Flint. Standard Operating Procedure 422: Control Charting of Water Quality Parameters.

City of Flint. Standard Operating Procedure 431: Conventional Flushing for Water Turnover.

City of Flint. Standard Operating Procedure 432: Unidirectional Flushing.

City of Flint. Standard Operating Procedure 442: Water Age Management.

MAINTAINING DISTRIBUTION SYSTEM CHLORINE RESIDUAL

SOP #441

Rev: 0.0

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Approved by: Robert Bruish Date: 10-10-18

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RTCR	Revised Total Coliform Rule
WQP	Water Quality Parameter

2 KEY PERSONNEL AND RESPONSIBILITIES

- Water Quality Laboratory Supervisor:
  - Oversee sample collection and analysis of data using provided spreadsheet tools.
  - Communicate with Water Plant Superintendent and Distribution Superintendent when distribution system chlorine residual goal of 0.5 mg/L in ≥ 95% of monthly samples is not met.
- Water Plant Superintendent:
  - Based on information provided by the Water Quality Laboratory Supervisor, modify dosage at CSII or Cedar Street Reservoir as needed to meet distribution system residual goal.
- Distribution Superintended:
  - Implement operations and maintenance strategies to improve residuals locally or regionally.

3 SCOPE/PURPOSE

Maintenance of an adequate disinfectant residual throughout the distribution system is paramount to protecting public health. In addition to providing microbial control, disinfectant residuals provide oxidizing conditions to help stabilize pipe scales, and can serve as an indicator of distribution system integrity. Therefore, a key aspect of distribution system water quality management and optimization is to identify appropriate disinfectant residual level(s) and strategies for monitoring and maintaining them on an on-going basis. The purpose of this SOP is to outline the procedures for tracking and maintaining chlorine residual within the distribution system. Several Microsoft Excel-based spreadsheet tools have been developed to track residual levels at the plant tap and throughout the distribution system, specifically:

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4 HEALTH AND SAFETY

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5 PROCEDURE

1. Collect and analyze chlorine residual measurements from all RTCR and chlorine residual only surveillance monitoring locations within the distribution system each week. A minimum of 100 chlorine residual measurements should be collected each month distributed across the RTCR monitoring locations. HACH Pocket Colorimeter II, HACH DR 900 or equivalent colorimetric methods are acceptable.
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5. Review the charts to verify:

a. Free chlorine residual at the plant tap is at or above the minimum finished water target.

b. 95% of monthly samples are ≥ 0.5 mg/L as free chlorine.

6. Take appropriate steps to rectify issues when identified. These may include:

   a. Chlorine dose modifications – regional or system-wide improvements

      i. At Plant – Increase or decrease the system chlorine dose at CSII. Consult *SOP 131: Sodium Hypochlorite Addition at Control Station 2* and *SOP 133: Sodium Hypochlorite Testing*.

      ii. At Storage Facilities – Increase or decrease chlorine dose at Distribution Storage Facilities. Consult *SOP 132: Sodium Hypochlorite Addition at Distribution Storage Facilities* and *SOP 133: Sodium Hypochlorite Testing*.

      iii. Track potential unintended consequences of increased dose, such as customer complaints (consult *SOP 421: Customer Complaint Tracking*) and formation of disinfection byproducts (using CRM Tool).

      iv. Consider cost-benefit of increased dosing versus water age and pipe wall demand management options summarized below.

   b. Reduce water age – localized, regional, or site-specific improvements (Consult *SOP 442: Water Age Management*)

      i. Install/move auto-flushers to problematic areas and conduct gentle bulk water turnover flushing. Consult *SOP 431: Conventional Flushing for Water Turnover*.

      ii. Modify reservoir operations to improve mixing and turnover.

      iii. Verify valve positions to minimize artificial dead-ends and improve water circulation.

   c. Reduce pipe wall demand – localized, regional or site-specific improvements

      i. Conduct unidirectional flushing where feasible to remove accumulated sediments that may be exerting a disinfectant demand. Consult *SOP 432: Unidirectional Flushing*.

      ii. Determine timing for pipe repair and replacement in affected area per the Capital Improvement Plan/Asset Management Plan.

7. Document dates of response strategies and verify site-specific, local, regional, or system-wide impacts using statistics and charts developed in CRM and control chart tools. Modify response strategies, as needed, and as system operations evolve.

6 DATA RECORDING AND MANAGEMENT

The Water Quality Laboratory Supervisor should review chlorine results on a daily basis and enter into MORs. Data from MORs should be uploaded into spreadsheet tools each month to review site-specific and monthly trends, confirm that plant and distribution system residual goals are met, and assess effectiveness of response strategies.

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City of Flint. Standard Operating Procedure 422: Control Charting of Water Quality Parameters.

City of Flint. Standard Operating Procedure 431: Conventional Flushing for Water Turnover.

City of Flint. Standard Operating Procedure 432: Unidirectional Flushing.

City of Flint. Standard Operating Procedure 442: Water Age Management.

EMERGENCY REPAIR OF WATER MAINS SOP

SOP #311

Rev: 0.0

Date: 01/31/2018

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

STAFF ACKNOWLEDGEMENT

I certify that the requirements of this SOP have been communicated to me and that I am trained in its use. A copy of this page will be distributed to the employee training record file.

Name	Date

APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. Date: 01/31/2018

Approved by: Robert Bruesch Date: 10-10-18

1 DEFINITIONS AND ACRONYMS

AWWA	American Water Works Association
EAM	enterprise asset management
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
mg/L	milligram per liter

2 KEY PERSONNEL AND RESPONSIBILITIES

- Water Distribution Foreman:
  - Oversee main repair and disinfection
  - Determine and implement any follow-up activities
  - Document the break, including the type, repair conditions and activities, process used for disinfection and all sampling results, in the enterprise asset management (EAM) system
- Water Distribution Operator (2-4):
  - Conduct repairs and field disinfection process
  - Collect and analyze samples for disinfectant residual and document results
  - Collect bacteriological samples and deliver to the water quality laboratory for analysis
- Laboratory Technician:
  - Analyze bacteriological samples and report results to Water Distribution Foreman

3 SCOPE/PURPOSE

The purpose of this SOP is to outline the procedures for repairing a main break, including any necessary flushing, disinfection and water quality testing to be conducted before a main is placed back into service. The procedures presented herein are based on the *Water Research Foundation Report #4307 – Effective Microbial Control Strategies for Main Breaks and Depressurization* (2014) and should be used in conjunction with AWWA Standard C651 – Disinfecting Water Mains. As not all breaks can be repaired in the same manner, crews should use their best judgment when implementing the procedures below.

4 HEALTH AND SAFETY

Main repair often involves several types of hazards, including:

- Traffic Hazards: The field service team should use trucks, temporary signs, and traffic cones, barricades, and flashers to prevent automotive accidents and injury to staff. In

addition, a flag crew may be needed to direct traffic in some locations. Trucks should be parked between oncoming traffic and the work area when possible to provide a barrier.

- Heavy Construction / Mechanized Equipment Hazards: Heavy or mechanized equipment may be needed for excavation, trenching, grading, etc. Staff operating the equipment must have the proper training and licensure. Ensure proper distances from the equipment are maintained. Use hand signals / radios to communicate with the operator and spotters as needed when moving equipment. Make eye contact with the operator before coming in the vicinity of the equipment.
- Trenching and Confined Space Entry: If trench work is required, consult the relevant excavation procedures for benching, sloping and shoring depending on depth and conduct work in accordance with the Occupational Safety and Health Administration (OSHA) standards for trenching and excavation. Where applicable, staff working in the trench must have the proper confined space entry training and certification.
- Hazardous Chemicals: Disinfection procedures involve the use of chlorine, which can present various hazardous to staff and the public. Staff should be trained in the use of the specific chemicals to be used and how to address any emergencies that may arise. In addition, staff should follow all precautions when working with chlorine solutions.

Crews should be able to recognize and respond to the potential hazards, and must have the proper training, including knowledge of proper sanitary procedures during repair, and certifications to the complete the applicable tasks. In addition, proper PPE should be worn at all times and will vary depending on the specific repair activity. PPE may include:

- City employee identification
- Chemical resistance apron
- Face Shield
- Hard hat
- High visibility safety vest
- Knee pads
- Safety glasses
- Steel-toed boots
- Work gloves and/or chemical resistant gloves

5 PROCEDURE

Equipment Required:

- Traffic cones, barricades, and flashers
- Temporary signs/arrow boards (warning lights, strobe lights, arrow boards, traffic maintenance signs)
- Water system maps
- Field tools for isolating and repairing the pipe section (e.g., pry bar, valve key or valve box keys for all saws, pipe wrenches, buckets, shovels, welding equipment, pick axes, ladders, flashlights, pipe clamps, couplings, etc.)

- One percent chlorine solution in spray bottles
- One of the following NSF/ANSI 60 certified disinfection chemicals:
  - Chlorine gas
  - Sodium hypochlorite solution
  - Calcium hypochlorite tablets
- NSF/ANSI 60 certified dechlorination chemical, if needed
- Sterile sample bottles treated with sodium thiosulfate, transport cooler, ice packs
- Field chlorine test kit
- Night lights
- Portable dewatering pumps and accessories
- Surface runoff diversionary equipment (sandbags, trench covers, etc.)
- Backfill material or bedding (sand, crushed stone, etc.)

Procedure:

An overview of the procedure based on break type is summarized in Table 1. As not all breaks will fall into these categories and as site conditions (i.e., ability to locate and operate appropriate valves and hydrants) impact the ability to implement the procedures below, crews should use their best judgment when modifying the procedures below and ensure practices comply with AWWA Standard C651. Additional details are provided below.

Table 1: Categories of Main Break Types and Repair Response Procedures (Adapted from Kirmeyer et al., 2014 and AWWA Standard C651-15)

Main Break Type	Type 1	Type 2	Type 3	Type 4
Description				
Description	Controlled pipe repair without depressurization	Controlled pipe repair with depressurization after shutdown	Uncontrolled pipe break with possible water contamination or loss of sanitary conditions during repair	Uncontrolled pipe break with a likelihood of water contamination or loss of sanitary conditions during repair
Pressure Conditions	Positive pressure maintained during break and repair	Pressure maintained during break and excavation, followed by controlled shutdown for repair	Loss of pressure at break site / possible local depressurization (less than 20 psi) adjacent to the break (e.g., severe erosion requires pressure to be reduced prior to exposing the pipe)	Loss of pressure at break site / widespread depressurization (less than 20 psi) in the system (e.g., pipe blowout and loss of pressure prior to shutdown)

Main Break Type	Type 1	Type 2	Type 3	Type 4
Risk of Microbiological Contamination	No signs of contaminant intrusion	No signs of contaminant intrusion	Possible contaminant intrusion	Possible / actual contaminant intrusion
Procedures				
Assess Break	Excavate to at least 1' below the pipe invert No shutdown needed; maintain pit water level below break	Excavate to at least 1' below the pipe invert Perform controlled shutdown after pipe is exposed and secured from trench soil/water contamination and maintain pit water level below break	Uncontrolled shutdown Document possible contamination Shut-off customer services in affected area	Immediate or uncontrolled shutdown Document likely contamination Shut-off customer services in affected area
Repair	Repair pipe under positive pressure Disinfect repair parts Swab accessible components with 1% chlorine solution	Repair pipe following controlled shutdown Disinfect repair parts Swab accessible components with 1% chlorine solution	Repair pipe following partial of uncontrolled shutdown Disinfect repair parts Swab accessible components with 1% chlorine solution	Repair pipe following uncontrolled or immediate shutdown Disinfect repair parts Swab accessible components with 1% chlorine solution
Disinfection	Not required	Not required	Conduct slug chlorination (CT of 100 mg/L-min)[1]	Conduct slug chlorination (CT of 100 mg/L-min)[1]
Flushing	Conduct scour flush at 3 fps for a minimum of 3 pipe volumes and confirm water is visually clear Dechlorinate if needed	Conduct scour flush at 3 fps for a minimum of 3 pipe volumes and confirm water is visually clear Dechlorinate if needed	Conduct scour flush at 3 fps for a minimum of 3 pipe volumes and confirm water is visually clear Dechlorinate if needed	Conduct scour flush at 3 fps for a minimum of 3 pipe volumes and confirm water is visually clear Dechlorinate if needed

Main Break Type	Type 1	Type 2	Type 3	Type 4
Disinfectant Residual Sampling	Check free chlorine level at break site; continue flushing until residual levels have returned to typical levels[3]	Check free chlorine level at break site; continue flushing until residual levels have returned to typical levels[3]	Check free chlorine level at break site; continue flushing until residual levels have returned to typical levels[3]	Check free chlorine level at break site; continue flushing until residual levels have returned to typical levels[3]
Public Notification	No boil water advisory needed	No boil water advisory needed	Instruct customers to flush premise plumbing upon return to service Determine if boil water advisory is needed based on depressurization extent and presence of contamination[2]	Instruct customers to flush premise plumbing upon return to service Issue boil water advisory or "Do Not Drink" Order
Bacteriological Sampling	No sampling needed	If a full pipe section is required during the repair, collect one set of samples; however, the pipeline may be returned to service prior to obtaining the results	Collect bacteriological samples; main may be returned to service prior to completion of the testing depending on the depressurization extent and presence of contamination[2]	Collect bacteriological samples; await confirmation of sample results before placing line back into service

1. In highly tuberculated pipes, a higher CT should be considered to compensate for possible lower flushing efficiency. If exposure of customers to high levels of chlorine cannot be controlled, a minimum free chlorine level of 4 mg/L must be maintained for at least 16 hours in conjunction with flushing, coliform sampling and public notification.
2. If depressurization is limited to the pipe section, or area flushed or disinfected, then a boil water advisory is not needed and main can be returned to service prior to receiving the bacteriological sample results. However, if the area of depressurization is larger than the treated area, then a precautionary boil water advisory should be considered and/or the main should not be released for service until the sample result is confirmed to be absent of coliforms.
3. Residual levels should be at least 90% of ambient or pre-break levels and not more than 4.0 mg/L as required by State and Federal regulations.

1. Upon arrival at the site, evaluate the site for safety (including the appropriate PPE) and set up the appropriate traffic control measures. This may include: warning lights, strobe lights, arrow boards, traffic maintenance signs, cones, flagmen (if necessary), safety vests and/or other PPE. Locate and mark buried utility lines and valves in the vicinity. Check for potential contamination sources, such as septic systems, underground storage tanks, service connections without proper backflow prevention devices, and presence of multistory buildings.
2. If necessary, isolate the pipe section by slowly adjusting valve settings, maintaining positive pressure to reduce backflow or runoff contamination. Where possible, service disruptions should be minimized; however, it may be necessary to isolate certain areas to minimize the potential for contamination. Close or throttle valves, particularly service connections that do not have proper backflow prevention, as needed, to isolate the repair area. If possible, notify impacted customer of the potential disruption. Use caps or covers to protect existing mains or service connections.
3. Excavate the break. Provide the necessary benching, sloping and/or shoring depending on depth and conduct work in accordance with the Occupational Safety and Health Administration (OSHA) standards for trenching and excavation. Install temporary devices to divert surface water runoff around the repair site. Use portable dewatering pumps to maintain water levels at least one foot below the pipe invert during repair.
4. Repair the pipe using the appropriate materials (i.e., fittings, joints, gaskets, clamps), sizes and other necessary repair equipment. During the repair:
    a. Maintain positive pressure, where possible, to prevent contamination from backflow into the pipe. At the start of, at least once during and at the end of the repair, confirm and document if positive pressure is maintained in the immediately vicinity of the break site by visually observing a steady flow or spray of water coming from the pipe, or observation of a hose bib or hydrant located near and at a higher elevation than the break site. Pressure above 20 psi should be maintained outside the immediate repair area. If pipe cannot be repaired under pressure, do no depressurize the pipe until the pipe is exposed.
    b. Maintaining a dewatered trench to at least 1' below the pipe invert.
    c. Visually inspect the interior and exterior of all new materials (pipes, fittings, valves, etc.) to ensure there is no visible damage, debris or contamination.
    d. Remove any visible debris from exposed areas of the existing pipe.
    e. Keeping all parts, tools and materials used in the repair in a clean and sanitary condition. Clean and disinfect prior to use or installation with a 1 percent chlorine solution. If any interior areas of the pipe were exposed to the environment during the repair, spray or swab any accessible upstream and downstream interior of the existing pipe areas with a 1 percent chlorine solution. If the repair requires new piping to be installed in any section, the new pipe must be inspected, cleaned and disinfected from both ends by swabbing with 1 percent chlorine solution.
    f. Maintain pipe caps, plugs or other protective coatings until materials are ready to be installed.

g. Complete all pipe and fitting joints in the trench before stopping work. If work requires more than one day, store materials on-site in a secure area.

5. If needed, disinfect the pipe in accordance with the described outlined in AWWA Standard C651. For disinfection of repaired mains, the following methods can be used:

   a. Tablet method: involves the use of calcium hypochlorite tables in the repaired or replaced pipe section and contact time with an initial free chlorine concentration of 25 milligrams per liter (mg/L). Note that pipe materials must be evaluated for compatibility and that this method may only be used when pipes and appurtenances are kept clean and dry during construction. Cleaning and flushing of the main prior to disinfection cannot be performed with this method.

   b. Continuous feed method: involves filling the main with potable water to remove air pockets, then flushing to remove particulates, and refilling the main with chlorinated water at a dose of 25 mg/L until stable concentrations are reached within the pipe (i.e., a free chlorine residual of not less than 10 mg/L after a holding period of 24 hours).

   c. Slug method: involves filling the main with potable water to remove air pockets, flushing to remove particulates, followed by slow flush with a high concentration of chlorine – 100 mg/L – for at least 3 hours. The use of cross connection control and backflow prevention must be used to ensure the high chlorine concentration does not affect the distribution system.

   d. Spray method: involves a 30-minute exposure to free chlorine at not less than 200 mg/L. Refer to chlorination method 2 in AWWA Standard C652 – Disinfection of Water Storage Facilities.

   The slug method may be preferable as it requires reduced contact time. However, alternative methods (tablet method, continuous feed method, or spray disinfection) are available. Evaluate the scene and select the best method for disinfection based on site conditions, length and diameter of the main, type of joints present, available materials and equipment, type of break and associated risk for microbiological contamination. If highly chlorinated water is likely to impact fish or plant life or other downstream users), dechlorination must be performed to neutralize the remaining chlorine residual prior to discharge. If dechlorination is necessary, follow the procedures outlined in AWWA Standard C655 – Field Dechlorination.

6. Target a unidirectional flush towards the water main break. Open the necessary hydrants to complete the flush. Flush with potable water at a velocity of 3.0 feet per second (fps) in the pipe for a minimum of three pipe volumes to remove debris, and verify that the discharge is visually clear.

7. Check for typical system chlorine residual in the main using a field chlorine test kit and flush the pipe section until typical system residuals are detected (i.e., to at least 90% of ambient or pre-break levels and not more than 4.0 mg/L as required by State and Federal regulations). Collect samples from the immediate and surrounding areas around the repair site.

8. For high risk breaks (Types 3 and 4), notify affected customers about the break, schedule, and concerns. Instruct customers to flush their home plumbing after repairs

are completed. If contamination was likely to occur, perform issue a precautionary boil water notice. In the event that a boil water advisory is needed, the Water Distribution Superintendent should immediately contact the appropriate staff the Geneseee Coutny Health Department and Michigan Department of Environmental Quality to notify them of the situation and to coordinate the public notification.

9. For medium risk breaks (Type 2) where a full pipe section was required and high risk breaks (Types 3 and 4), conduct coliform sampling in accordance with AWWA Standard C651. For Type 2 and some Type 3 breaks, the main may be returned to service prior to the completion of the bacteriological results. For Type 4 results, await until sample results are received and show the absence of coliforms. In the event that coliforms organisms are detected, repeat the flushing and resample for coliforms. If the confirmation coliform sample also shows the presence of coliforms, repeat disinfection using the continuous-feed or slug method until no coliform organisms are present. For any positive coliform results, the Water Distribution Superintendent should immediately notify Michigan Department of Environmental Quality and follow any required procedures.
10. Flush hydrants, if needed, to remove any debris.
11. Return the main to service by opening any closed valves, using a sequence that avoids low or negative pressures.
12. Backfill and compact pipe bedding per applicable AWWA pipe installation standard.
13. Repair ground surface to at least original conditions.

6 DATA RECORDING AND MANAGEMENT

Following a main break, enter all necessary information into the EAM system. This includes:

- Date and approximate type of break
- Nature of break (i.e., circumferential, longitudinal, both, shear, hole, split, blowout, joint, sleeve, other)
- Apparent cause of break (i.e., water hammer, defective pipe, corrosion, deterioration, improper bedding, operating pressure, temperature, differential settlement, improper installation, other)
- Type of break (based on Table 1 above)
- Location and field conditions (paved/unpaved, traffic conditions, type of soil, side of street, weather conditions,)
- Pipe data (type of main, class, length, diameter, bedding, backfill, compaction)
- Type of repair (clamp, sleeve, etc.)
- Repair materials used
- Potential contamination issues (e.g., muddy trench water flowing into broken pipe, leaking sewer pipe in trench, catastrophic pipe failure where pipe is open)
- Problems encountered
- Water quality test results
- Field observations, including inoperable valves or hydrants or incorrect locations of mains, valves, hydrants, underground utility locations, service connections, etc.

- Estimate the cost associated with the repair (materials, manpower, time, overtime, etc.)

The Water Distribution Superintendent shall assign work orders for any follow-up items, such as valve replacements.

7 REFERENCES

AWWA. (2015). *C651-14 Disinfecting Water Mains.* AWWA

AWWA. (2011). *C652-11 Disinfection of Water Storage Facilities.* AWWA

Kirmeyer, G. J., Thomure, T. M., Rahman, R., Marie, J. L., LeChevallier, M. W., Yang, J., ... & Schneider, O. (2014). Effective Microbial Control Strategies for Main Breaks and Depressurization. Denver, CO: Water Research Foundation.