CORNWELL
ENGINEERING GROUP

Date: February 27, 2018

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From: David Cornwell and Richard Brown, *Cornwell Engineering Group*

Project: City of Flint, MI
Water Distribution System Optimization Plan

Subject: DRAFT Whole House Flushing Efforts in Flint, MI

The purpose of this memorandum is to document the whole house flushing efforts in Flint, MI by Cornwell Engineering Group (Cornwell) as part of the Flint Water Distribution System Optimization Plan.

In June 2017, Richard Brown (from Cornwell) visited with Robert Bincsik, the Water Service Center Supervisor, for the City of Flint to discuss protocols developed for whole house flushing and profile sampling associated with full lead service line replacements (FLSLRs). These protocols have been used by other water systems in research studies conducted by Cornwell and were targeted for use by City of Flint staff in future FLSLR activities. These procedures were also recently adapted in the new AWWA standard on lead line replacement (AWWA, 2017). Copies of the protocols and customer flushing brochure are attached.

In October 2017, Richard Brown and Robert Bincsik exchanged email and phone calls as well as attachments with editable versions of proposed sampling and flushing protocols. These were proposed for use by Cornwell staff before, during and after FLSLRs at two houses selected by the City of Flint. The objective of this effort was not only to collect samples and conduct flushing, but to demonstrate both how the written procedures are implemented and some of the logistical considerations associated with these efforts. The demonstrations were also to be performed so that the City of Flint staff could be better prepared to implement and perform these flushing and sampling efforts on their own during future FLSLRs.

Cornwell staff described and summarized the logistical requirements, described what Cornwell staff's role would be and what logistical support was requested from the City of Flint staff, and what was the proposed schedule. These items were discussed and agreed upon with a plan as follows for two houses in the City of Flint system:

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- Cornwell staff to arrive on Sunday, October 22
- Cornwell staff to meet with City of Flint staff Monday, October 23
- Cornwell staff to conduct sampling before and after FLSLR, conduct a whole house flush to remove lead particulate material remaining after FLSLR, and conduct sampling 1 day after the flush (total time for these efforts was expected to be 2 to 4 days)

City of Flint staff was asked to have candidate locations selected and available during the week when Cornwell staff would be in Flint to conduct sampling and flushing. Cornwell staff was informed that the activities planned were not expected to be a problem to conduct and that the City of Flint staff would be able to identify some houses to choose from for the proposed sampling and flushing effort. During discussions on Monday, October 23rd, City of Flint staff indicated that they expected that it would not be difficult to identify houses and convince volunteers to participate (given that the planned efforts are expected to improve lead levels in the house after FLSLR), and that their biggest concern was finding homes with safe and suitable access over the course of the testing.

On Monday and Tuesday (October 23rd and 24th), no efforts were possible because: a) no houses could be identified for sampling prior to FLSLR, and b) all FLSLRs were canceled on these days due to poor weather. When FLSLRs resumed on Wednesday and Thursday (October 25th and 26th), there was no progress in finding any homeowners that were willing to allow access for the planned sampling and flushing inside the house. At this point, it was decided that prospects were not good for identifying suitable houses and willing participants. Cornwell and the City of Flint staff agreed to abandon the trip's effort. Overall, two Cornwell staff (Richard Brown and Sebastian Negron), were onsite in Flint from October 22 – 26, 2017, along with an Arcadis staff member (Devi Thirunarayanan), who was onsite from October 23 – 26, 2017.

To date, no participants have been identified, and as such, no further efforts will be completed under this task.

REFERENCES

American Water Works Association (AWWA). (2017). *C810-17 Standard for Replacement and Flushing of Lead Service Lines.* AWWA.

City of Flint, MI
Utility Guidelines on How to Collect and Analyze Water Samples for Lead Profile

SUMMARY

These are instructions for a sampling protocol used to create a profile of lead and other metals in a home's plumbing. "Profiling" is a sampling strategy to identify the location(s) and source(s) of lead contributing to lead in household drinking water, including lead solder or a lead water service pipe. To create the profile, twelve or more one liter tap water samples will be collected in sequence from a faucet in the home from a continuously flowing faucet. Each of these 1-liter samples will be analyzed for total and dissolved lead concentration, and possibly other metals.

MATERIALS FOR SAMPLE COLLECTION

Utility staff should prepare a kit for sample collection with the following suggested items:

- Twelve (or more) one-liter wide mouth sample bottles, glass, polypropylene, or HDPE. Prepare bottles (clean and acid washed) and label as per normal lead collection procedures. Do not add a preservative (acid) to the sample prior to collection.
- Permanent marking pen or sample bottle labels.
- Lead-free wet wipes for hand cleaning (optional).
- Data collection form/chain of custody.

PREPARATION

Select the home to be sampled.

Set up sample containers before you start. The faucet must run continuously while you fill the twelve (12) containers without allowing any water to flow to drain.

1. If possible find an assistant to help with sampling. Taking a profile requires rapidly handling the twelve (12) or more bottles without losing any water from a continuously flowing faucet at the sampling location. Having an assistant is very helpful.
2. **Choose the appropriate time of day for the sample collection event - home plumbing system must not have been used for at least six hours**. This is typically early morning before any water has been used, including shower, toilet, automatic sprinklers, etc. If the home is vacant during the day, and water is stagnant in the home plumbing for six hours, it is possible to collect the samples in the late afternoon.

3. Read through this protocol to be sure your bottles are ready and that you understand the procedure. Once the tap is open and sampling begins, sample collection must be completed. If the process is interrupted, the entire collection must be rescheduled for another day using clean bottles.
4. Select a water faucet from which to sample:
   a. The faucet should be one that is used often by the family, such as the kitchen sink faucet.
   b. There is adequate room to arrange both empty and full sample bottles.
5. Label the sample bottles (e.g., “1” through “12”) with marker or on container labels before sampling.
6. Set all twelve (12) bottles (with caps removed) near the sample tap so the sampling can be done without interruption. Align them numerically 1 - 12 and place on one side of the sink to facilitate filling.
7. Make sure there is adequate room to handle sample bottles quickly without spilling them.

PROCEDURE

WARNING
USE COLD WATER ONLY.

WARNING
ONCE THE WATER TAP IS OPEN AND SAMPLING BEGINS, SAMPLE COLLECTION MUST BE COMPLETED. IF THE PROCESS IS INTERRUPTED, THE ENTIRE COLLECTION MUST BE RESCHEDULED FOR ANOTHER DAY USING CLEAN BOTTLES.

WARNING
DO NOT ADJUST FLOW DURING THE ENTIRE SAMPLING PERIOD. AS SOON AS THE FAUCET IS TURNED ON, ALL WATER MUST BE COLLECTED. THE WATER MUST REMAIN FLOWING AND CONSTANT UNTIL ALL TWELVE (12) CONTAINERS ARE FILLED.

1. Do not collect any profile samples until after water in household has been stagnant >6 hr.
2. Fill out data form to record time and location of sampling event.
3. Wipe hands with wet wipes (optional).
4. Do not adjust flow during the entire sampling period. As soon as the faucet is turned on, all water must be collected – don't let any water flow to the drain. The water must remain flowing and constant until all twelve (12) containers are filled.
5. Record time at start and end, so that sampling velocity can be estaimted (e.g., if it takes 6 min to collect twelve 1-L bottles then samping flow rate was about 2 L/min)
6. Start with bottle labeled "1" and procced to "2", "3", etc. Open COLD water faucet to allow cold water to flow at a rate that would normally be used by the homeowner (usually about 80% open) — cold water only. Then fill bottles "2", "3", and so on until all twelve (12) bottles are filled, not allowing any water to go down the drain between bottles.
7. Once all of the sample bottles are collected:
   a. Turn off water.
   b. Cover each sample container tightly.
8. Review the sample tracking sheet.
   a. Are all the bottles accounted for?
   b. Is the information for each sample bottle complete?
   c. Were there any difficulties with the sample protocol to note?
9. Transport sample bottles to the laboratory and prepare the samples for analysis as described in the next section. Preparation needs to be completed on the same day as the samples were collected so please arrange for same day delivery to the laboratory.

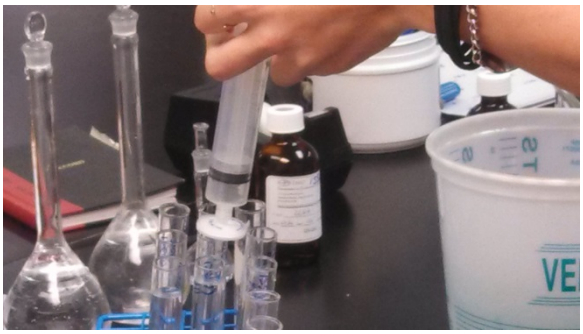
SAMPLE PREPARATION

WARNING
SAMPLE MUST NOT BE ACIDIFIED UNTIL AFTER IT IS FILTERED FOR THE DISSOLVED SAMPLE.

WARNING
THESE INSTRUCTIONS ARE FOR ANALYSIS BY STANDARD METHOD 3111B. ADJUST PRESERVATION METHOD TO YOUR METHOD IF YOU DO NOT USE SM 3111B.

Note: Sample preparation at your utility may vary based on the analytical method used by your laboratory but in all cases, the "dissolved" sample must be filtered with the filter specified here, and acidified after filtration. This must be done within 24 hr of sampling.

1. In addition to your usual analysis procedures you will need:
   a. Filters (see later discussion)
   b. Filter appurtenances (syringes, etc.)
2. From each of the twelve (12) sample containers prepare two samples for analysis, labeled "total" and "dissolved" (i.e., filtered).
3. For the "dissolved" sample, shake or mix the one liter sample well. Lead particulates tend to adhere to the sample container.
   a. After mixing the 1-L sample remove the minimum volume needed for metals analysis – typically 50 mL from the 1-L bottle (see later filter discussion). Limit amount used for filtration as much as possible (i.e., leave as much sample in the 1-L bottle as possible)
   b. Record the volume that was removed and the volume remaining in the original 1-L bottle for later calculations
   c. Filter the removed water into a new sample bottle using the luer-lock plastic syringes and filters or vacuum filter apparatus and the designated filter paper.
   d. Record the filtering date and time.
   e. Add nitric acid to lower the pH to <2. Mix and allow to stand >16 hour before analysis.
   f. Label this new sample bottle as "dissolved".



Samples for dissolved metals must be filtered using the filter specified in this method. The filter specified does not sorb or leach lead. The filter can be in a syringe, as in the picture here, or in a filter holder.

4. For the "total" sample, **do not filter and do not transfer to any other bottle until after acidification.**
    a. **Acidify the remaining approximate 950 mL in the original 1-L bottle**. It is necessary to acidify the whole remaining sample to dissolve all the particles including those sticking to the bottle.
    b. After acidifying the sample to pH< 2 and mixing the 1 L bottle, allow it to stand for >16 hours.
    c. Record the date and time.
    d. Label this sample bottle "total".
5. Repeat this procedure creating total and dissolved samples from each of the twelve (12) containers.
6. Analyze all sample bottles (24 total) for lead and other metals. The research team requests any water systems that are willing and able to report results of full metal scan (e.g., ICP) to report all these data. Concentrations need to be reported as µg/L for each bottle. Reported results must include the concentrations of each sample and the volume of sample removed from the 1 L container for the dissolved and the volume remaining in the original container for the total.

FILTER MEDIA

Filter media recommendations are based on EPA 2014 (A Systematic Evaluation of Dissolved Metals Loss during Water Sample Filtration, EPA/600/F-11/029b, Updated August 2014, https://nepis.epa.gov/Adobe/PDF/P100KSNL.pdf). This includes the following:

- 00.45 µm pore size
- Syringe filters with luer-lock fittings
- Smaller diameter syringe filters (for this project assume syringe filters 30 mm or less are acceptable)
- NO prefilter
- Filter media (see Table C-1)
    - Mixed cellulose ester (MCE)
    - polypropylene (PP) media and MCE are the most preferred types in the EPA document, but our experiences have been that PP are hard to use (hard to push water through filter) and so are not recommended
    - Polyethersulfone (PES) and nylon are also acceptable (we can discuss)
    - Note that the housing of most syringe filters is PP, but PP in this document means that the 0.45 µm filter is made of polypropylene
- Use one filter and a new disposable PP syringe per sample
- The filters listed in the following table are acceptable – other alternatives are available but please contact EE&T to discuss any alternatives

Table C-1
Acceptable filter media for this study

Filter media material	URL
Recommended (or similar from another mfr.)	
Mixed cellulose ester	https://www.sterlitech.com/mce-syringe-filter-mce4525200.html
Could be considered (if you cannot find above)	
Polyethersulfone	http://www.envexp.com/products/18-Filtration/FILSYRG-Syringe_Filters/2SFIL2-Syringe_Filters/SF045E-Syringe_Filters_-_PES%2C_25mm%2C_0_45%C2%B5m%2C_200pk

HOW TO PERFORM FLUSHING

SUMMARY

This method describes steps for flushing of household plumbing during a whole-house, high-velocity flushing event. The following document describes the details of flushing steps, The goal of flushing steps outlined below is to develop pipe velocities inside the house as high as possible in order to loosen, dislodge, and mobilize particles containing lead so they will flow through household plumbing and discharge to the drain. Sample profiling after flushing will continue in subsequent months to assess not only if the high velocity flushing practices initially reduce lead levels, but also how long the improvement lasts.

PROCEDURES AND RECOMMENDED PRACTICES

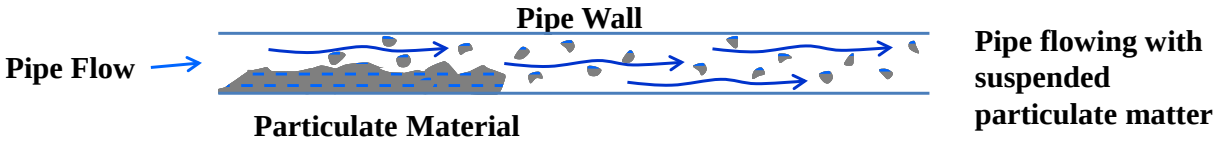
1. After the stagnant water sample has been collected, the whole house will be flushed as outlined below.
   1.1. The aerators from the sampling location are either removed the night before sampling or earlier (see Appendix C)
2. Start at lowest level in house (e.g., basement). Remove screens and aerators from all faucets on this floor. Make sure all faucets are wide open and flowing to drain. Keep the taps open and proceed.
   2.1. Move to next highest floor level in the house and open all faucets with aerator off on this level. Keep these faucets on.
   2.2. Repeat if there is a third or higher floor level.
   2.3. Use of bathtub and laundry sink faucets, when available, is encouraged and recommended.
   2.4. The desired approach is to open ALL taps during flush. At minimum, the following are required: a) all bathtub taps, b) all laundry sinks, c) at least one other tap on each floor (one of these must be the profile sampling location)
3. Once the highest level in house is reached and all faucets in the house are open, continue running all faucets in the house for 30 minutes.
4. Collect samples at 2, 5, 10, 20, and 30 min during whole house flush at the main faucet used for the profiles (optional)
   4.1. Turbidity
   4.2. 1-L sample for total lead (not a profile, just one sample at each sample time)
5. After 30 minutes, turn off all faucets starting at lowest level in the house.
   5.1. Turn off faucets in the same order they were originally turned on
6. Return to the house the day after the flushing and collect profile samples from the sampling location after the water has been stagnant overnight at least six (6) hours, using the sampling profile procedures outlined in Appendix C.
7. Depending on lead results additional flushing may be recommended, as well as additional profile sampling (continuing at minimum until 4 months after flush).

CORNWELL ENGINEERING GROUP

WHOLE-HOUSE, HIGH VELOCITY FLUSHING TO REMOVE LEAD PARTICLES

For City of Flint, MI

WHERE DOES LEAD COME FROM?	Lead in water can be dissolved or in particles The lead in your tap water comes from the lead pipes that may be present from the street to your house or from faucets or indoor plumbing with lead. When the street is disturbed by construction lead particles can come loose from the pipes. Some particles may still be present from the corrosion events and these need to be removed from your home plumbing.
WHY SHOULD YOU CONDUCT A FLUSH?	Lead particles can be released at random if they are in your pipes, but more particles can be released during construction that disturbs the lead lines



WHEN SHOULD "HIGH VELOCITY FLUSHING" BE DONE?	• When the City of Flint informs you about a disturbance, or • If you have had high lead results. This type of flushing can dislodge (break loose) lead containing particles in pipes inside the house as well as in the service line between the house and the street.

CAUTION – SHORT TERM CONSEQUENCES

Research has shown flushing can produce long-term benefits, typically after 2 months, but prior to this the lead may actually be higher – see precautions described in "follow up."

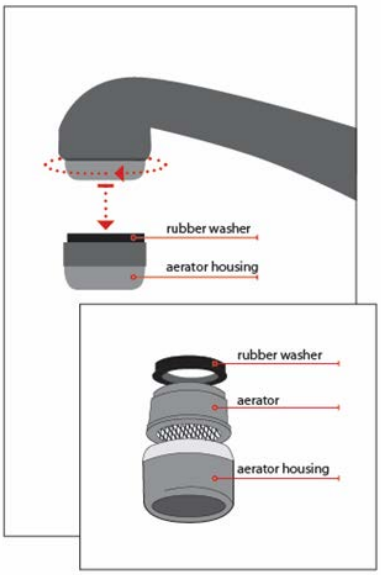
WHICH FAUCETS IN YOUR HOUSE TO FLUSH?	All faucets inside your house that can flow to a drain without overflowing in your house should be flushed.
HOW OFTEN?	After you perform a flush, the City of Flint or DEQ staff will work with you to take lead samples. You will be advised if more flushing is needed.

PROCEDURE

ALL FILTERS IN THE HOME MUST BE REMOVED OR BY-PASSED

When possible, it is best to flush at times of the day when neighbors don't use a lot of water – so best to flush from mid-morning to dinner time or late at night

1. Find all the faucets that have good drains, including those in the basement and on all floors in your house.
2. Remove all in-home filters or by-pass them. You cannot flush through a filter.
3. Remove aerators and screens from all faucets or shower heads.
4. Be sure to include the laundry tub, the bathtub, or shower (shower head removed) as flushing points.
5. After all the aerators are removed, open the faucets in the basement or lowest floor in the house. Leave all faucets running at the highest rate possible –using COLD water only.



6. After faucets are all open on the lowest floor, open faucets on the next highest floor of the house. Continue until faucets are open on all floors, including tubs and showers (shower head removed).
7. After all faucets are opened, leave them ALL running for at least 30 minutes.
8. After 30 minutes, turn off the 1st faucet you opened (lowest floor), and continue to turn off other faucets in the same order you turned them on.
9. Re-install aerators/screens at each faucet – you may need to discard old screens/aerators and replace with new ones if too old or worn.

CAUTION – MESS FROM WATER SPRAY

Make sure the drain is open and clear so water can flow freely to drain

Make sure water can drain as fast as water is flowing from tap during flushing

When faucet is open at high rate, especially since aerators/screens are removed, it can create a mess due to water spray. Take precautions to either contain or monitor the spray.

FOLLOW UP

(WHAT SHOULD I DO ON DAYS AFTER THE FLUSH?)

- Run tap water each morning for at least 5 min to displace water that has been sitting in pipes inside the house and in the service line. This could include taking a shower, running dishwasher, or running the faucet. Do this BEFORE using any water for drinking, cooking, infant formula, etc.
- Clean debris from aerators and screens, once a month for 6 months.
- After 6 months, clean debris from aerators/screens twice a year (for example, in April/October when daylight savings time changes).