FILTER RESULTS REPORT – FINAL

City of Newark
Point-of-Use Filter Study
August – September 2019

Newark, NJ

City of Newark Department of Water and Sewer Utilities

November 19, 2019

CDM Smith

Table of Contents

List of Figures

List of Tables

Appendices

This page intentionally left blank.

Executive Summary

The City of Newark (Newark) has exceeded the Lead and Copper Rule (LCR) Action Level for lead since early 2017. A study conducted on the cause of the exceedances found that the corrosion control mechanism in the Pequannock Gradient (i.e. the "higher" pressure gradient above 200 feet generally covering the western half of Newark) was no longer effective. That study is summarized in the "Pequannock WTP Corrosion Control Review and Recommendations – Final," (Pequannock Report) dated March 15, 2019 by CDM Smith Inc. (CDM Smith) (CDM Smith, 2019). The issue was found to be isolated to the Pequannock Gradient while Newark's other gradient, the Wanaque Gradient (generally covering the eastern half of Newark), was providing effective corrosion control in the distribution system. A detailed review of the Wanaque Gradient's corrosion control is summarized in the "Wanaque Gradient Corrosion Control Review," dated June 28, 2019 by CDM Smith (CDM Smith, 2019).

Newark received a draft of the Pequannock Report in early October 2018 identifying the issues found with corrosion control in the Pequannock Gradient and Newark immediately commenced the distribution of point-of-use (POU) filters to affected homes (i.e. homes in the Pequannock Gradient with suspected lead service lines and/or lead solder in copper indoor plumbing) as a temporary protective measure to reduce lead concentrations at the tap until the new corrosion control chemical could be added and protective scales on lead pipes formed. Dosing of the new corrosion control chemical, zinc orthophosphate, commenced in early May 2019. Newark is closely monitoring lead levels at customer taps as the transition to phosphate-based lead scales on lead service lines and lead-containing plumbing components occurs with the objective of lowering lead levels.

The POU filters provided to residents by Newark are PUR filters, a brand of parent company Helen of Troy. Approximately 34,000 faucet-mount style and 1,000 pitcher-style filters were provided to residents in the Pequannock Gradient with suspected lead service lines or older homes with suspected lead solder in copper indoor plumbing. All filters provided by Newark are certified to the National Sanitation Foundation/American National Standards Institute (NSF/ANSI) Standard (NSF 53 Standard) for lead reduction, which certifies that the filter reduced lead to a maximum concentration of 10 parts per billion (ppb) in laboratory testing when challenged with an influent concentration of up to 150 ppb of lead under the test conditions required in the standard. The standard requires testing at a pH of both 6.5 and 8.5. (NSF International Standards, 2018)

Initial Filter Testing

In early July 2019, Newark tested three (3) of the POU filters at homes that were selected as sites to be monitored and studied during the implementation of the orthophosphate treatment. The study required these homes to maintain their lead service lines and undergo additional sampling while the orthophosphate treatment is being implemented and optimized. As part of that monitoring, the drinking water at these homes was tested for lead under stagnated conditions (at least 6 hours of stagnation) throughout their entire service line – from the faucet to the water main in the street. The New Jersey Department of Environmental Protection (NJDEP) requested

that Newark test post-filter samples from the three (3) monitoring sites. Newark made the decision to test the filters under similar challenging conditions. The filters were tested with a stagnation period of 6+ hours, and two of the three filters did not reduce lead to 10 ppb or below under these challenging conditions. The filters were retested in early August 2019 with similar results. The flushed filtered water samples (i.e., the water collected after the water was run for 10 minutes to clear out the stagnated water in the service line) were all below 10 ppb for both the July and August tests.

Based on these results, it was determined that an expanded sampling program with a broader sampling pool was needed to evaluate samples that were more representative of water passing through the POU filters. These samples would be based on a variety of stagnation times and other factors to better represent anticipated exposure to lead from drinking water and the efficacy of the filters before a determination regarding filter performance could be made.

Expanded Filter Testing Program Goal

The question that the expanded filter testing program (conducted in August and September 2019), sought to address is whether the POU filter types provided by the City of Newark, which were certified per the NSF 53 Standard for lead, are reducing lead levels to 10 ppb or below under the current water chemistry conditions in Newark when the filters are properly installed and maintained. A secondary objective of this study was to collect information on filter usage, installation, and maintenance in order to provide recommendations on proper filter use. This report provides the results of the testing, analysis of the results and recommendations for maximizing the effectiveness of the filters.

Filters Tested

In total, there were 337 sampling events (i.e. sampling a specific faucet filter, pitcher filter, refrigerator filter or no filter) as part of this program in 316 independent home visits. Of those filters tested in accordance with the final protocol discussed in this report, 265 PUR filters were tested and analyzed. The final protocol (**Section 2**) comprised of unfiltered and filtered sample pairs representing samples taken when the faucet is initially turned on (first draw), samples taken from the volume of water in the service line, and flushed samples which are samples collected after the stagnated water from the service line has passed through the faucet and the water from the water main in the street is collected. The unfiltered and filtered sample pairs are taken from adjacent volumes of water along the plumbing and service line. Due to the variability of lead in water, the sample pairs do not represent true "before and after" unfiltered and filtered lead levels.

Section 3 provides a characterization of the 265 PUR filters tested under this protocol based on a variety of conditions that the samplers encountered during the study.

Since the intent of this study was to evaluate the effectiveness of the filters only when they were properly installed and maintained, improperly installed and maintained filters were eliminated leaving 198 PUR filters in the final pool of filters. Eliminated from the final pool were 67 filters with red indicator lights suggesting that they may have been used beyond the manufacturer's recommended life, filters with improperly installed cartridges, filters reported to have been used with hot water which is contrary to the manufacturer's instructions and pitcher filters with

replacement cartridges that were not certified to the NSF 53 Standard to remove lead. A summary of the 198 PUR filters analyzed and their associated samples in this study is provided in **Table ES-1**. Of the 198 filters, 189 filters were faucet-mount filters and 9 filters were pitcher filters.

Table ES-1 Overview of Sample Pool Quantities

Category	No. Filters	No. Unfiltered Samples	No. Filtered Samples
Total PUR Filters Analyzed	265	787	786
Total PUR Filters Eliminated	67	195	195
Total PUR Filters Properly Installed and Maintained	**198**	**592**	**591**

Results

For the purposes of this evaluation, a filter is considered "passing" if lead levels were 10 ppb or below, consistent with the NSF 53 Standard requirement, in all filtered samples collected under the protocol developed for this study. **Table ES-2** provides the overall results from the 198 PUR filters tested and analyzed. As shown, 97.9% of the 189 faucet-mount filters supplied water with lead levels at 10 ppb or below for the first draw, service line and flushed samples. Of the 9 pitcher filters tested and analyzed, 8 of the filters supplied water with lead levels of 10 ppb or below. For both the faucet and pitcher filters, flushing for at least 5 minutes prior to filtering increased the percentage of filtered samples with lead levels at 10 ppb or below.

Table ES-2 Overall Results for PUR Filters Reported to be Properly Installed and Maintained

Filter Type	No. Filters	No. of Filters with All Samples 10 ppb or Less (Passing)	% Filters with All Samples 10 ppb or Less (Passing)	No. Filters with Flushed Samples 10 ppb or Less (5-Minute Flush) (Passing)	% Filters with Flushed Samples 10 ppb or less (5-Minute Flush) (Passing)
Faucet	189	185	97.9%	188	99.5%
Pitcher	9	8	88.9%	9	100%
Total	**198**	**193**	**97.5%**	**197**	**99.5%**

Notes: (1) Unfiltered lead levels for 98 of the 198 filters tested were less than 10 ppb in the unfiltered adjacent samples. (2) Due to the small sample size of the pitcher filters, the results may not represent all conditions.

Table ES-2 includes all filters that were properly installed and maintained and represents the likelihood of water leaving a filter in Newark under current water quality conditions with lead concentrations of 10 ppb or less. However, with the intentional variability of this study to be reasonably representative of water passing through the POU filters, several filters may not have been challenged with lead levels in the unfiltered water over 10 ppb. **Table ES-3** provides the results by unfiltered lead concentrations in an adjacent sample volume for faucet-mount filters and for a smaller sample of pitcher filters. As lead concentrations can vary greatly throughout a service line with each incremental volume of water, it is unknown if the filtered water samples vary significantly from the adjacent unfiltered sample. It is not possible to obtain a true "before and after" sampling event with POU filters installed on home plumbing. Based on the limited data set in **Table ES-3,** the filters did not reduce lead to 10 ppb or below in the three (3) samples when

the unfiltered lead levels were above the NSF 53 certification challenge water of 150 ppb. The filters were 98.9% effective at reducing lead to 10 ppb or below when the unfiltered lead levels in the adjacent water samples were between 10 and 150 ppb. When the unfiltered lead levels were at 10 ppb or below prior to going through the filter, 96.2% of the filtered samples did not detect any lead when analyzed (i.e. were "non-detect") indicating that the filters can continue to reduce lead levels below 10 ppb to minimize exposure.

Table ES-3 All Filtered Lead Sample Results from Properly Installed and Maintained PUR Faucet and Pitcher Filters Compared with Unfiltered Lead Levels

Unfiltered Lead Levels	No. Filters (Max Unfiltered Concentration)	Number of Sample Pairs	Filtered Sample 10 ppb or Below	% Filtered Samples 10 ppb or Below
Faucet Filters				
Unfiltered 10 ppb or below	96	379	379[4]	100.0%
Unfiltered > 10 ppb and < 150 ppb	91	182	180	98.9%
Unfiltered > 150 ppb	2	3	0	0.0%
Pitcher Filters				
Unfiltered 10 ppb or below	2	11	11	100.0%
Unfiltered > 10 ppb and < 150 ppb	7	16	14	87.5%
Unfiltered > 150 ppb	0	0	0	N/A

Notes: (1) Results represent all samples (i.e. first draw, service line and flushed samples) from properly installed and maintained PUR filters. (2) Due to the small sample size of the pitcher filters, the results may not represent all conditions. (3)The sample pairs do not represent a true "before and after" sampling event with POU filters installed on home plumbing. (4) Samples with unfiltered lead levels of 10 ppb or below reached non-detect 96.2% of the time after filtering.

Section 4 of this report presents the results based on specific characterizations such as unfiltered lead levels at time of sampling, stagnation times, time since cartridge was last replaced, and service line materials. **Section 5** provides additional interpretation of the results including confidence levels of the study results. In summary, the results of this study show when filters are properly installed and maintained, the reliability of the filters to reduce lead levels to 10 ppb or below is related to the lead levels in the water being filtered. In addition to lead concentration, other factors may impact filter performance as evident by the three (3) filters with unfiltered lead levels in all unfiltered samples below 100 ppb that did not reduce lead to less than 10 ppb as shown in **Table ES-3** and as further discussed in this report. Flushing the water prior to filtering for a minimum of 5 minutes, or 8 minutes for those with longer lead service lines of 75-feet or greater, after several hours of not using the water was shown to improve the performance of the filters at reducing lead levels to 10 ppb or below in the filtered samples. Drinking the water directly from the main in the street, by first flushing the stagnated water, reduces the amount of time the water is in contact with the lead service line and other lead components in home plumbing, which helps to reduce lead levels before going through the filters.

Recommendations

Based on the expanded study conducted with 265 total PUR filters and a subset of 198 PUR filters that were properly installed and maintained, the filters are effective for reducing lead to 10 ppb or below per the NSF 53 certification requirements in Newark's Pequannock Gradient, particularly when used in combination with flushing. A summary of the results is provided in

Section 6 and in **Table ES-4**. Flushing with the filter in the "off" position (i.e. bypass) for at least five (5) minutes (or 8 minutes for properties with longer service lines) prior to using the filter for drinking or cooking is important to minimize exposure to lead. As shown in **Table ES-4**, flushing prior to filtering increased the percentage of filters that provided filtered water with lead levels at 10 ppb or below from 97.5% to 99.5%.

The POU filters, paired with flushing, are recommended for continued use while the corrosion control in the Pequannock Gradient is optimized and effectively protecting residents from lead service line and/or lead-containing materials in their interior plumbing. According to the results of this study, the precautionary measure taken by Newark to provide bottled water to Pequannock residents with lead service lines during the expanded filter study is not necessary when residents properly use and maintain the filters in combination with flushing.

Table ES-4 Summary of Filter Study Results

Scenario	No. Filters	Passing Filter[1] Filters <= 10 ppb	% Passing
All PUR Filters	265	256	96.6%
PUR Filters Properly Installed and Maintained[2]	198	193	97.5%
PUR Filters Properly Installed and Maintained After 5 Minutes of Flushing	198	197	99.5%

Notes: (1) A "passing" filter is a filter that had all filtered samples at or below 10 ppb. If one filtered sample (either first draw, service line or flushed sample) was not below 10 ppb, it was not considered as "passing". (2) Unfiltered lead levels for 98 of the 198 filters tested were less than 10 ppb in the unfiltered adjacent samples. Samples with unfiltered lead levels of 10 ppb or below reached non-detect 96.2% of the time after filtering.

The following recommendations provided in **Section 6** are intended to further reduce exposure to lead, help residents achieve maximum filter performance and effectiveness, and regain public confidence in the reliability of the Pequannock drinking water supply when flushing and properly using filters:

- Emphasize flushing for 5 minutes or more prior to use of filters to reduce lead levels in the unfiltered water
- Provide specific considerations for pitcher filters including using the proper cartridges, installation requirements and flushing
- Continue and enhance public education on how to flush effectively and on proper filter installation and use
- Continue to provide access to filters and cartridges certified to reduce lead
- Continue to improve corrosion control treatment in the water supply
- Continue to replace lead service lines
- Follow-up on site specific recommendations in Section 5.2

Section 1
Background

The City of Newark (Newark) has exceeded the Lead and Copper Rule (LCR) Action Level for lead since early 2017. A study conducted on the cause of the exceedances found that the corrosion control mechanism in the Pequannock Gradient (i.e. the "higher" pressure gradient above 200 feet generally covering the western half of Newark) was no longer effective. That study is summarized in the "Pequannock Water Treatment Plant (WTP) Corrosion Control Review and Recommendations – Final," (Pequannock Report) dated March 15, 2019 by CDM Smith, Inc. (CDM Smith) (CDM Smith, 2019). The issue was found to be isolated to the Pequannock Gradient while Newark's other gradient, the Wanaque Gradient (generally covering the eastern half of Newark), was providing effective corrosion control in the distribution system. A detailed review of the Wanaque Gradient's corrosion control is summarized in the "Wanaque Gradient Corrosion Control Review," dated June 28, 2019 by CDM Smith (CDM Smith, 2019).

Newark received a draft of the Pequannock Report in early October 2018 identifying the issues found with corrosion control in the Pequannock Gradient and Newark immediately commenced the distribution of point-of-use (POU) filters to affected homes (i.e. homes in the Pequannock Gradient with suspected lead service lines and/or lead solder in copper indoor plumbing) as a temporary protective measure to reduce lead concentrations at the tap until the new corrosion control chemical could be added and protective scales on lead pipes formed. Dosing of the new corrosion control chemical, zinc orthophosphate, commenced in early May 2019. Newark is closely monitoring lead levels at customer taps as the transition to phosphate-based lead scales on lead service lines and lead-containing plumbing components occurs with the objective of lowering lead levels.

The POU filters provided to the residents by Newark are PUR filters, a brand of parent company Helen of Troy. Approximately 34,000 faucet-mount style and 1,000 pitcher-style filters were provided to residents in the Pequannock Gradient with suspected lead service lines or older homes with suspected lead solder in copper plumbing. All filters provided by Newark are certified to the National Sanitation Foundation/American National Standards Institute (NSF/ANSI) 53 Standard (NSF 53 Standard) for lead reduction, which certifies that the filter reduced lead to a maximum concentration of 10 parts per billion (ppb) in laboratory testing when challenged with an influent concentration of up to 150 ppb of lead under the test conditions required in the standard. The standard requires testing at a pH of both 6.5 and 8.5. (NSF International Standards, 2018) Although the filters are also certified to the NSF/ANSI 42 Standard, which targets aesthetic-related water concerns, such as chlorine, iron and taste and odor compounds, evaluating the filters to this standard was not included as part of this study as it is not specifically related to lead.

In early July 2019, Newark tested three (3) of the POU filters at homes that were selected as sites to be monitored and studied during the implementation of the orthophosphate treatment. The study required these homes to maintain their lead service lines and undergo additional sampling while the orthophosphate treatment is being implemented and optimized. As part of that

monitoring, the drinking water at these homes was tested for lead under stagnated conditions (at least 6 hours of stagnation) throughout their entire service line – from the faucet to the water main in the street. The New Jersey Department of Environmental Protection (NJDEP) requested that Newark test post-filter samples from the three (3) monitoring sites. and Newark made the decision to test the filters under similar challenging conditions. The filters were tested with a stagnation period of 6+ hours, and two of the three filters did not reduce lead to 10 ppb or below under these challenging conditions. The filter cartridges were replaced after the first round of sampling. The filters were retested with the new cartridges in early August 2019 with similar results. **Table 1-1** provides the highest lead concentrations resulting from the July and August testing of the original 3 homes tested under 6+ hour stagnated conditions. The "first draw" samples represent the first two 500 mL samples coming from the tap. The "service line" samples represent the volume of water in contact with the lead service line during the stagnation period. The "10-minute flush" samples represent water from the water main after a 10-minute flush to flush out the stagnated water. After a 10-minute flush, all filtered results were at or below 10 ppb.

Table 1-1 Maximum Lead Values from Original Filters Tested (July and August Sampling) Under 6+ Hour Stagnation

Original Test Homes	First Draw		Service Line		10 Minute Flush	
	Unfiltered (ppb)	Filtered (ppb)	Unfiltered (ppb)	Filtered (ppb)	Unfiltered (ppb)	Filtered (ppb)
Test Home No. 1 (PUR Pitcher Filter)	26.9	11.1	112	50.0	11.6	9.94
Test Home No. 2 (PUR Faucet Filter)	31.8	<1	135	1.93	7.32	<1
Test Home No. 3 (PUR Faucet Filter)	N/A	1.22	1670	83.0	37.3	2.12

Note: Homes were tested more than once under these conditions. The maximum lead results from the testing are shown. Red text indicates filtered results exceeding 10 ppb.

The goal of the initial July 2019 sampling of the three (3) original filters was to challenge the filters and consider a worst-case scenario at these homes, i.e. samples from the lead service line after 6+ hours of stagnation time. Based on these results, it was determined that an expanded sampling program with a broader sampling pool was needed to evaluate samples that were more representative of water passing through the POU filters. These samples would be based on a variety of stagnation times and other factors to better represent anticipated exposure to lead from drinking water and the efficacy of the filters before a determination regarding filter performance could be made.

The question that the expanded filter testing program (conducted in August and September 2019) sought to address is whether the POU filter types provided by the City of Newark, which were certified per the NSF 53 Standard for lead, are reducing lead levels to 10 ppb or below under the current water chemistry conditions in Newark when the filters are properly installed and maintained. A secondary objective of this study was to collect information on filter usage, installation, and maintenance in order to provide recommendations on proper filter use. This report provides the results of the testing, analysis of the results and recommendations for maximizing the effectiveness of the filters.

1.1 Comparison with the Lead and Copper Rule

This report does not compare the filtered lead levels with the 15 ppb Lead Action Level of the LCR. The 15 ppb per the LCR is intended to assist in determining the effectiveness of corrosion control treatment in a system without POU filters on the taps. It is intended to be an action level, or indicator, that corrosion control treatment is likely not optimized. It is not a health-based standard, the health-based goal for lead is 0 ppb. Therefore, the 15 ppb is not relevant to evaluate the effectiveness of a POU filter. The 10 ppb level, as used in this study, was based on the expectation that a POU filter certified to the NSF 53 Standard would perform as required for the filters to achieve that certification.

Section 2
Sampling Methodology

2.1 Study Objectives

The primary objective of the sampling study was to collect enough samples to determine if the POU filters provided by the Newark were reducing lead to levels of 10 ppb or below under the current water chemistry conditions in Newark when the filters are properly installed and maintained. A secondary objective of the sampling process was to collect information on filter usage, installation, and maintenance in order to provide recommendations that will maximize the effectiveness of the filters.

2.2 Filter Sample Pool

The filters targeted for sampling were from residential homes ranging from single to three family homes, with a PUR faucet or pitcher filter, located in the Pequannock Gradient, throughout the four wards - North, South, West and Central, and preferably homes that have previously shown to have elevated lead levels in compliance testing for the LCR in 2018 or 2019. The primary selection of filters for sampling were taken from homes that previously tested 30 ppb or above in LCR first-draw compliance sampling. Additional homes were added to the sampling pool comprised of residents who volunteered for sampling and scheduled an appointment with Newark. In addition, door-to-door sampling was performed between scheduled appointments from residents who provided access and met the filter sampling requirements. Filters other than the PUR filters targeted for sampling, such as filters installed in a refrigerator door, were sampled when requested by the residents.

The total sampling pool size to achieve a high confidence in the dataset was based on using a binomial distribution model. The model is highly dependent on the consistency of the results and was regularly updated throughout the study to refine the target sample pool size for a high confidence in the study results.

2.3 Sampling Protocol

After the three (3) initial test homes were sampled twice, the effort to obtain a larger sample pool commenced on August 10, 2019. A sampling protocol was prepared in collaboration with Newark, NJDEP and the Environmental Protection Agency (EPA) and is included in **Appendix A**. The details by which to conduct the sampling were finalized on August 14, 2019 and placed into effect by the sampling teams. The final text of the protocol document was finalized on September 4, 2019. Minor revisions were made between August 14th and September 4th including how to handle different scenarios encountered in the field, such as a filter with a red light indicating it is being used past its recommended life or sampling of a refrigerator door filter when requested. These minor revisions did not impact the sampling protocol for the PUR filters that were properly installed and maintained.

The sampling teams included employees from Newark, CDM Smith, the NJDEP and the EPA in teams typically of 3 to 4 people. All samplers were trained at Newark's facility and new samplers shadowed experienced samplers prior to conducting their own field work.

A total of six (6) samples were taken at each home with a PUR filter with a green or yellow indicator light indicating the filter's life was within the recommended lifespan of the filter. Three (3) samples were unfiltered and three (3) samples were filtered. A summary of the samples in the order the samples were taken is as follows:

- **First draw filtered** – A 500 mL filtered sample was collected immediately when turning on the tap. This is the volume from 0-500 mL in the plumbing and typically encompassed the faucet, braided hosing, and some interior plumbing.
- **First draw unfiltered** – Immediately after the filtered first draw sample was collected; a 500 mL unfiltered sample was taken. This is the volume from 500 mL to 1,000 mL in the plumbing and typically encompassed some of the interior plumbing.
- **Service line filtered** – Based on the approximate location of the service line, typically located at between 5,000 to 9,000 mL for homes in Newark, a 500 mL filtered sample was collected. This was done by filling and dumping the appropriate number of bottles to reach the estimated location of the service line. Service lines in Newark are typically lead or copper.
- **Service line unfiltered** – Immediately after the 500 mL filtered service line sample, an unfiltered 500 mL sample was collected also targeting the water in the service line.
- **Flushed unfiltered (5 minutes)** – Using a timer that was started at the start of the first draw filtered sample, after five minutes has passed, an unfiltered 500 mL sample was collected. It was estimated that this volume of water would encompass water from the water main in the street, and not the water sitting in the individual service line, for the majority of homes in Newark.
- **Flushed filtered (5 minutes)** – The filter was turned on and after 10 seconds of running the water through the filter, a filtered 500 mL sample was collected. This sample also targeted the water from the water main in the street, and not the water sitting in the individual service line, for the majority of homes in Newark.

Both filtered and unfiltered samples were collected. Each sample volume represents a sequential (adjacent) segment of plumbing. Lead concentrations vary between samples depending on the surfaces they were in contact with for a period of time and accumulation of particulate lead in the sample collected as the sample travels along the service line and interior plumbing. The sample pairs do not represent a true "before and after" sampling event with POU filters installed on home plumbing. Therefore, even the adjacent samples collected could have different unfiltered lead concentrations due to the inherent variability of the piping conditions.

At the time each sample was collected, certain information was recorded to identify any potential patterns that may correlate with the collected data. The information was initially collected using

paper forms. Starting on August 19, 2019, the information was collected using an app, Survey 123 for ArcGIS by Esri. The information recorded at the time of sampling included the following:

- Service line material (before meter)
- Home plumbing material (after meter)
- Indication of any recent plumbing changes within home or recent road construction
- Sample point location within home (e.g. first floor, second floor)
- Time since most recent water usage at faucet being sampled
- Time since most recent water usage in home
- Major water uses on date of sampling
- Exact or approximate date of last filter replacement
- Filter type (faucet or pitcher)
- Common filter uses (drinking, cooking, cleaning dishes)
- Residents' indication of cold and/or hot water use through filter
- Type of filter unit
- Type of filter cartridge
- Filter status indicator light color
- Whether or not the filter cartridge was installed properly

After collection, the samples were preserved and sent to one of three certified laboratories between August 14, 2019 and September 6, 2019 – the City of Newark Laboratory in Little Falls, NJ, the New Jersey Department of Health Laboratory in Trenton, NJ, and the Environmental Protection Agency – Region 2 Laboratory in Edison, NJ – for analyzing total lead using EPA Method 200.8 or EPA Method 200.9. Turbidity was also analyzed as part of the test procedures for lead. All three laboratories, along with Newark and CDM Smith, reviewed and signed a Quality Assurance Project Plan (QAPP) developed by NJDEP which is included as **Appendix B.**

2.4 Assumptions

To gather the data required in the sampling protocol, several assumptions needed to be made. These assumptions are listed below.

- The volume discarded to target the water located in the service line and the water in the water main was determined based on previous sequential sampling events performed in Newark where the full volume of the service line was calculated and analyzed. This data was used in lieu of calculating the length of the service line for each sampled home.

- Filter cartridges were not altered or disrupted during sampling. The make and model number of the cartridge was determined by the color of the cartridge reported by the sampler. The filter housing on the faucet filters was not opened until after sampling was completed. It was assumed that cartridges installed in PUR filters were PUR brand cartridges.
- It was assumed that the information reported by the homeowner and collected by the sampler was generally accurate unless otherwise stated. This includes indication of any recent plumbing changes, major water uses on date of sampling, date of last filter replacement, common filter uses, and indication of hot water use through filter. The time since water was last used as reported by the resident questioned is not considered to be accurate as many homes sampled were multi-family homes with unknown water usage in other units, which would affect actual stagnation times. Furthermore, the definition of "water use" may be interpreted differently by residents, e.g. some may not consider flushing the toilet as water use.
- It was assumed that the pipe material observed inside the home between the exterior wall and the meter was consistent from the water main to the meter although Newark's material inventory indicates that some homes may have different materials between the main and the curb and between the curb and meter (i.e. partial lead service lines) and several observed materials did not match what was in the inventory. Newark will be verifying the materials below grade during the Lead Service Line Replacement Program. In the interim, the lead results were evaluated based on the observed material with the understanding that many of the service lines reported as copper, galvanized, unknown or other may still have a partial lead service line between the main and curb according to the inventory.
- It was assumed that filters that were not reported to have visible malfunctions (red or no indicator lights, improperly installed cartridges, etc.) by the sampler or reported misuse of the filter by the resident (i.e. hot water usage), were operating as expected and properly installed and maintained.

Section 3
Overview of Filters Tested

This section provides an overview of the types of POU filters tested and characteristics of the homes and conditions at the time of the testing.

3.1 All Filters

In total, there were 337 sampling events (i.e. sampling a specific faucet filter, pitcher filter, refrigerator filter or no filter) as part of this program in 316 independent home visits as shown in **Table 3-1**. Sampling occurred between July 8, 2019 and September 6, 2019. Of those filters tested in accordance with the final protocol after August 14, 2019 as discussed in Section 2.3, 265 PUR filters were tested and analyzed. The remaining filters were tested either prior to the protocol being developed, were not PUR filters or were disqualified for various reasons as discussed below.

Prior to August 14, 2019, including the original three test homes (each sampled twice), 21 PUR filters were sampled. Because the sample types and information collected did not meet the requirements of the final protocol, these samples are excluded from the analysis. Of the 21 PUR filters sampled prior to the final protocol, three (3) homes exceeded 10 ppb in filtered water samples. These include two of the original homes, which exceeded 10 ppb in two separate sampling events, and one additional home that had a result of 26.8 ppb in the service line filtered sample. All filtered samples from the remaining 18 filters tested were at or below 10 ppb. All filtered flushed samples for all 21 PUR filters tested prior to the final protocol being implemented were at or below 10 ppb. The filtered flushed samples were taken between 5 and 10 minutes as the protocol had not yet been finalized. The 21 PUR filters tested prior to finalizing the protocol on August 14, 2019 are disqualified from the analysis as their results cannot be directly compared with the results from the larger study.

Other reasons for disqualification of PUR filters in this study included mismatched bottle labels and chain-of-custody (CoC) forms (4 filters), homes with double filtration units (1 filter), homes not located in the study area (1 filter), or homes where the samples were not analyzed due to improper use of filter (1 filter). In total, 28 PUR filters were disqualified as shown in **Table 3-1**. Additionally, 6 homes sampled did not have filters and 38 filters were tested that were confirmed to not be filters manufactured by PUR (i.e. either a refrigerator filter or another manufacturer's faucet or pitcher filter). By removing the disqualified filters from analysis, ultimately, 265 PUR filters were tested and analyzed in this study. **Table 3-1** provides an overview of the types of filters tested including the specific models tested for the 265 PUR filters when the information was available.

Figure 3-1 provides the geographic locations of all the sites tested in Newark in the North, South West and Central Wards. The circles represent homes with the 265 PUR filters with maximum unfiltered lead concentrations tested in the house. The squares represent maximum unfiltered lead levels in all other homes not included in the analysis.

Table 3-1 Summary of Filters Tested – PUR Filters with Final Protocol

Category	Number of Filters Tested
All Filter Sampling Events	337
Number of Independent Homes Tested	316
Disqualified Filters (Pre-final protocol, mis-labeled bottles, double filtering, not in survey area, not analyzed)	28
Non-PUR Filters Tested	38
No Filter at Home (Only unfiltered tested)	6
PUR Filters Tested and Analyzed	265
PUR Faucet Filters Tested and Analyzed	240
FM_2000B	11
RF_3375	2
RF_9999	8
Unknown	1
FM_3333B	223
RF_3375	80
RF_9999	143
FM-3700B[1]	5
RF_9999	5
PFM800HX	1
RF_9999	1
PUR Pitcher Filters Tested and Analyzed	25
PPT111R	15
CRF_950Z[2]	12
PPF951K	3
PPT111W	10
CRF_950Z[2]	4
PPF951K	6

Notes:

1. The model FM-3700B was not supplied by Newark, however, it is the same technology as the FM-2000B and FM-3333B except in chrome rather than black or white. The filter cartridge inside the housing (RF-9999) is one of the cartridge models provided by Newark. These filters are included in the analyses in Sections 4 and 5.
2. The pitcher cartridge model CRF-950Z was not supplied by Newark as confirmed by PUR and Newark's shipping and inventory records. This cartridge model is not certified to the NSF 53 Standard to remove lead and therefore was not included in the analyses in Sections 4 and 5.

As mentioned in Section 2.2, homes that previously tested at or above 30 ppb in LCR first-draw compliance sampling were targeted for the sampling pool. A total of 65 filters were sampled that previously tested at 30 ppb or above in compliance sampling and 46 filters were sampled that previously tested at or above 50 ppb in compliance sampling.

3.2 PUR Filters in Overall Analysis

As discussed in Section 3.1, 265 PUR filters were included in the overall analysis. This section reviews the conditions encountered when sampling the 265 PUR filters including:

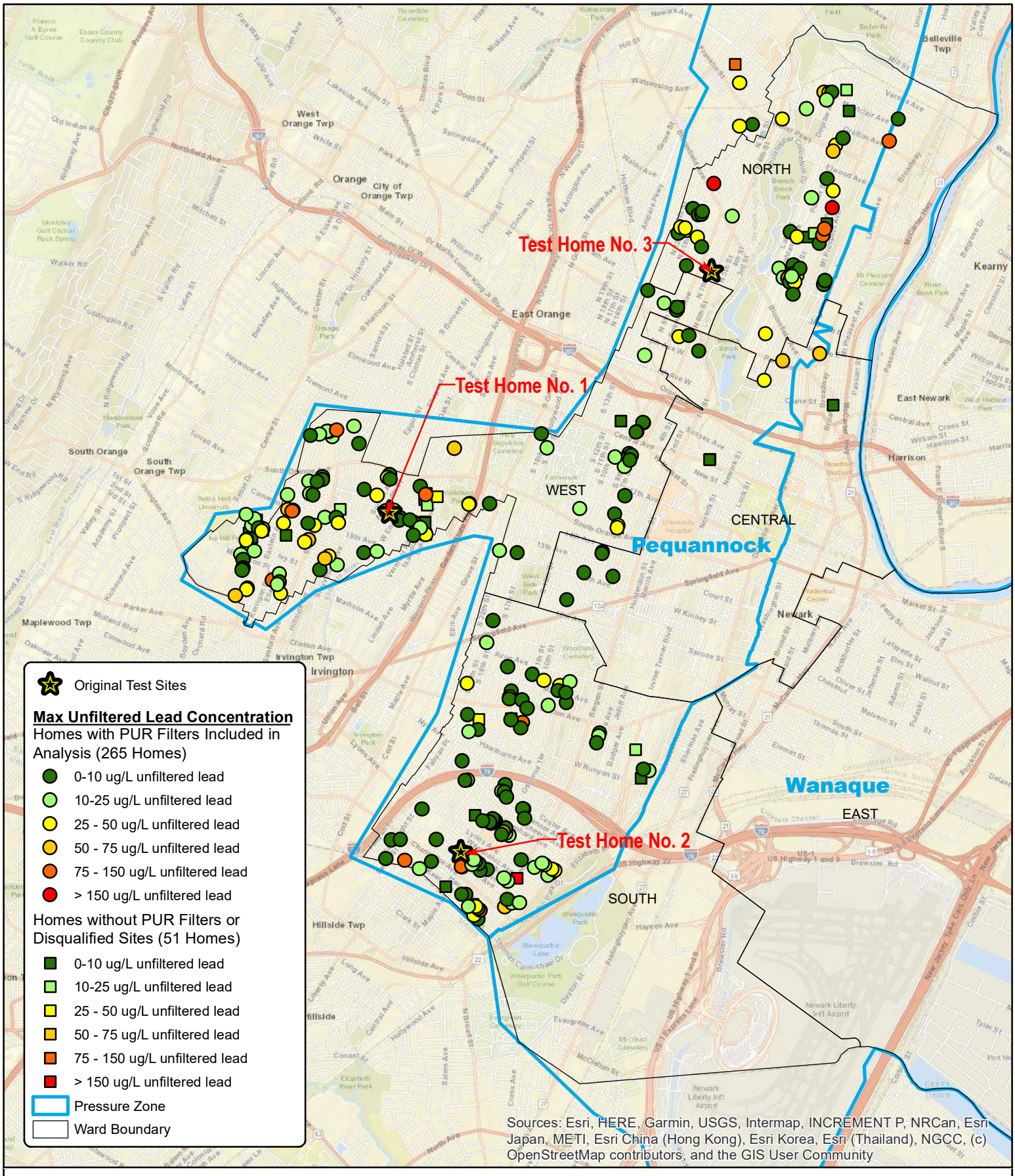


Figure 3-1
Map of Unfiltered Lead Results
(Maximum Unfiltered Lead Concentration by Property)

Data Collected: August - September 2019

CDM Smith

Angellja G:\NewarkLeadServiceLine\02_MXD\SamplingResultsMaps\SamplingOfFilters\FilterSampling_Unfiltered.mxd 11/15/2019

- Unfiltered lead levels at time of sampling
- Stagnation time at faucet tested and for entire house at time of sampling as reported by the resident
- Time since cartridge last replaced as reported by the resident and the color of the filter indicator light
- Service line material observed at the meter
- Residents' indication of cold and/or hot water use through the filters
- Verification that the cartridge was installed properly

3.2.1 Unfiltered Lead Levels

Table 3-2 includes all 265 PUR filters tested and analyzed that were not disqualified for reasons stated in Section 3.1. As can be seen from the table, the first draw and service line unfiltered lead levels that were stagnated in the home plumbing and service line, respectively, are on average more than twice the unfiltered lead levels in the flushed samples. The maximum unfiltered lead concentrations were similar; however, the maximum unfiltered flushed sample was taken from a home with a long service line and it is suspected that the water in the main was not reached and the sample was actually a service line sample. This is discussed further in Section 5.1.

Table 3-2 Summary of the Unfiltered Lead Results Encountered During Filter Testing (265 PUR Filters, 790 Total Unfiltered Samples Analyzed)

Statistic	Unfiltered First Draw (ppb)	Unfiltered Service Line (ppb)	Unfiltered 5 Minute Flush (ppb)
N (Number of Samples)[1]	263	263	264
N (Number Samples >10 ppb)	116	120	49
10th Percentile	0.5	0.5	0.5
50th Percentile	8.4	7.9	3.8
90th Percentile	40.4	39.1	13.7
Average	16.0	17.1	7.6
Maximum	306.0	379.0	392.0
Standard Deviation	27.6	31.3	24.8

Note: (1) Although the protocol was followed, not all sampling events resulted in 6 analyzed samples due to sampling or laboratory error. When only one sample in a set of 6 samples was impacted, the remaining samples were kept in the analysis.

3.2.2 Stagnation Time

Table 3-3 provides statistics on the stagnation time in homes where PUR filters were tested. The typical stagnation period for the house was reported to be approximately 2 hours. Some homes, however, are multi-family units and one unit may not be aware of water usage in another unit. Additionally, water usage may be interpreted differently by some residents who may not be considering flushing the toilet and other activities as using water.

Table 3-3 Stagnation Time in Homes Reported by Resident (265 PUR Filters Analyzed)

Stagnation Time Statistics	Time Since Faucet Tested Used (Hours)	Time Since Last Water Use in Home (Hours)
Minimum	0	0
Average	5.0	3.2
Median	2.6	2.0
Maximum	168	24

3.2.3 Filter Cartridge Age

Figure 3-2 provides the approximate date of last filter cartridge replacement (i.e. cartridge age) based on input from the residents. Many of the filters in the "less than one week" category are a result of the sampler providing a new filter cartridge to residents that had a red light indicator on their filter or no filter at all. When this situation was encountered, the samplers would assist in the installation and conditioning of the filter and then return later that day or week to sample.

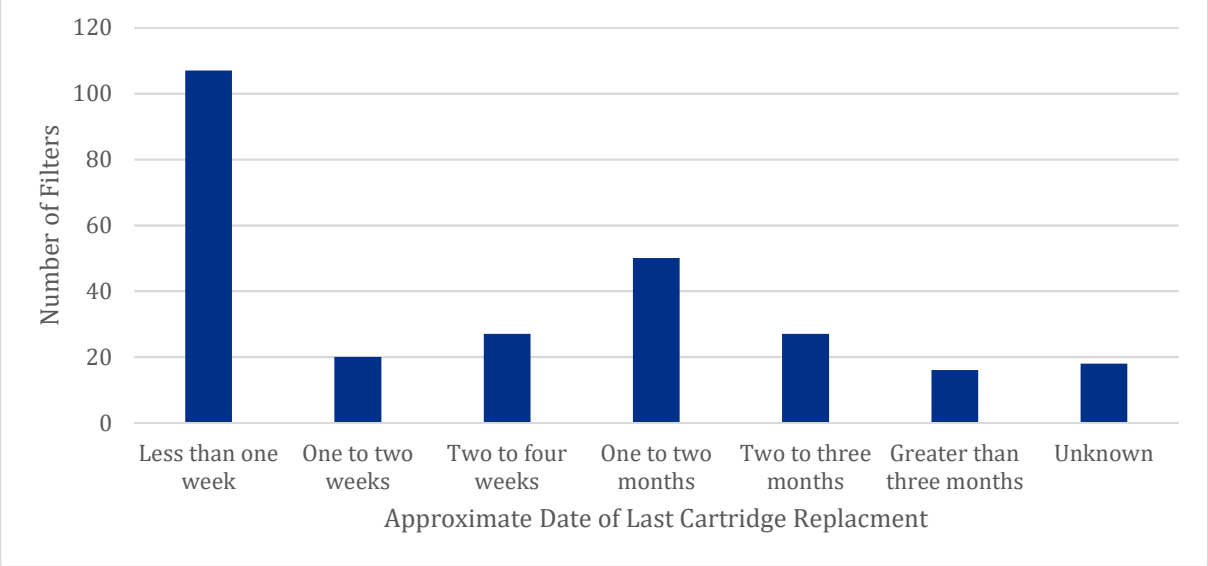


Figure 3-2 Approximate Date of Last Filter Cartridge Replacement (265 PUR Filters Analyzed)

Table 3-4 shows the relationship between the estimated approximate date of the last time the filter cartridge was reported to be replaced and the indicator light on the filter. A "green" indicator light means that the filter is within the recommended life identified by the manufacturer. A "yellow" indicator light means that the filter is approaching the end of its recommended life and should be replaced. A "red" indicator light means that the filter is being used beyond its recommended life and should be replaced immediately. Since the faucet filter indicator is based on volume of water used, the longevity of the filter adjusts based on the usage by the resident (i.e. a filter that is not used very often will maintain a green indicator light longer than a filter that is used more frequently). The pitcher filter cartridge is less sophisticated and is based solely on time, rather than volume used, and therefore the indicator to notify a resident to replace a cartridge does not adjust based on usage.

As expected, **Table 3-4** shows that the number of filters with a red indicator light increased with cartridge age and the number of filters with a green indicator light decreased with cartridge age. Of the 16 PUR filters that were reported to be replaced more than three (3) months prior to the sampling, nine (9) had a red light indicator, one (1) had a yellow light indicator and six (6) had a green light indicator.

Table 3-4 Approximate Date of Last Filter Cartridge Replacement Compared with Filter Indicator Lights (265 PUR Filters Analyzed)

Time Since Filter Cartridge Last Replaced (Cartridge Age)	Green Light	Yellow Light	Red Light	No Light	Totals
Less than one week	107				**107**
One to two weeks	20				**20**
Two to four weeks	25	2			**27**
One to two months	39	5	6		**50**
Two to three months	15	4	7	1	**27**
Greater than three months	6	1	9		**16**
Unknown	12	3	3		**18**
Totals	**224**	**15**	**25**	**1**	**265**

3.2.4 Service Line Material

Prior to sampling, the sampler requested to inspect the pipe material in the home. When access was provided, only a portion of the service line could be seen. According to Newark's pipe material inventory, many of the addresses sampled have different pipe materials between the main and curb and curb and meter and several observed materials did not match what was in the inventory. Newark will be verifying the materials below grade during the Lead Service Line Replacement Program. In the interim, the lead results were evaluated based on the observed material with the understanding that many of the service lines reported as copper, galvanized, unknown or other may still have a partial lead service line between the main and curb according to the inventory. **Table 3-5** provides the service line material observed for the 265 homes analyzed with PUR filters and those that are listed as "lead" in the inventory either as a partial lead service line or a full lead service line.

Table 3-5 PUR Filters Tested by Service Line Material (265 PUR Filters Analyzed)

Service Line Material	No. Homes Material Observed at Meter[2]	No. Homes Listed as Having Lead (Full or Partial) in Inventory	No. Homes Listed as Non-Lead (Full Service Line) in Inventory
Copper	132	92	40
Lead	96	86	10
Galvanized[1]	5	5	0
Other (i.e. Plastic, Brass, etc.)	4	4	0
Unknown (No Access Provided)	28	24	4
Totals	**265**	**211**	**54**

Notes: (1) Galvanized steel pipes may be lead-lined and are considered as lead in Newark's inventory. (2) Materials observed in the home at the meter are not necessarily consistent with what is buried between the home and the water main in the street. According to Newark's inventory, there are likely more lead service lines (partials) than observed during the filter study.

3.3 City of Newark Provided Filters and Cartridges

This study focused only on the PUR filters being used by residents that were of the same make and model, or similar, as the filters distributed by Newark and were tested using the final protocol developed with NJDEP and the EPA. The following PUR models and cartridges were distributed by Newark to residents as confirmed with inventory records provided by PUR, shipping information and Newark's invoices:

- Faucet-mounts
  - FM-2000B with cartridge RF-3375 or RF-9999
  - FM-3333B with cartridge RF-3375 or RF-9999
  - Sample horizontal models with Bluetooth, such as PFM800HX
- Pitchers
  - PPT111R with cartridge PPF951K
  - PPT111W with cartridge PPF951K

Filter models not provided by Newark but included in the study:

- Faucet-mount – FM-3700B (This filter has the same filter body as FM-2000B and FM-3333B but in a chrome color) with cartridge RF-3375 or RF-9999

All other filters and cartridges that were tested in this study, including other PUR models and models from other manufacturers, were excluded from the analysis. Residents may have directly purchased these other models and replacement cartridges, and some do not meet the NSF 53 for lead such as the PUR CRF-950Z pitcher filter cartridge which was encountered at 16 homes during the sampling.

3.4 Filters Properly Installed and Maintained

Utilizing the information presented in this Section, a determination of whether or not the filters were properly installed and maintained was made and the final pool of filters for evaluating the filtered lead levels was further reduced. In order to evaluate the effectiveness of the filters, the study intended to focus only on filtered results from filters that were installed and maintained per the manufacturer's instructions. To determine if a filter was properly installed and maintained, the samplers confirmed several items including:

- Checking the indicator light color, which indicates if the cartridge is within its expected life (green or yellow light) or beyond its expected life (red light) per the manufacturer's recommendations. Faucet-mount filters operate by volume and estimate 100 gallons of use before the light turns red. Pitcher filters operate on a timer and estimate 40 gallons of use in 2 months before the light turns red.
- Confirming with the resident that only cold water was used with the filter. Hot water can damage the lead reduction technology of the filter cartridge. Residents were asked if they

used cold water, hot water or both. Use of hot water cannot be confirmed by inspecting the cartridge. It is suspected that the number of homes using hot water through the filter may be under-reported based on the number of homes stating they use the filter for washing dishes.

- Checking the installation of the cartridge in the filter housing. For the pitcher filter, this was done prior to sampling. For the faucet filter, the filter housing was opened only after the sampling was complete. The samplers checked that there was a cartridge installed and that it was properly seated in the housing.
- Checking that the correct cartridge was being used. The sampler checked the type of cartridge being used and provided a description of the cartridge including color and any markings. From the description, it was determined if the cartridge was the model that Newark provided or a different model that may not be certified to remove lead.

3.4.1 Filters Not Properly Installed and/or Not Properly Maintained

Of the 265 PUR filters analyzed, 26 filters had a red indicator light or no light at all indicating that the filters may have been used beyond the manufacturer's recommended life. Additionally, at least another 10 filters were encountered as red but not tested as recorded by the samplers and therefore a total of 36 filters, or a minimum of 13 percent of the filters encountered in the field, were found with red indicator lights during this program. The samplers also found 4 filters that did not have cartridges installed properly.

A total of 32 filters, or over 12 percent of PUR filters tested, were reported by the residents to have been used with hot water, which is contrary to the manufacturer's instructions. It is suspected that this percentage could be much greater considering the number of residents who stated that they wash dishes with filtered water (94 out of 265 PUR filters). According to the instructions that come with the PUR filters, running water above 82 degrees Fahrenheit through the filter can damage the filter and make it less effective. In addition, representatives of Helen of Troy stated that the filters maximize their performance if operated on a cycle with no more than two minutes of use, followed by 18 minutes of rest.

Lastly, for PUR pitcher filters, it appears that 16 homes were utilizing cartridges (CFR-950Z) that are not certified to meet the NSF 53 Standard to remove lead. The samplers reported that these cartridges had "blue tops and blue bottoms". The only pitcher filter cartridges that PUR sells that have blue tops and blue bottoms are not certified to the NSF 53 Standard to remove lead. The filters certified to remove lead and provided by Newark have white tops and blue bottoms.

The results from filters with a red indicator light or no light, were stated to be used with hot water, were not properly installed or did not have the correct replacement cartridge were removed from the analyses in Sections 4 and 5 except where specifically noted. Some of these eliminating criteria overlap, as shown in **Table 3-6**. A total of 67 filters of the 265 PUR filters analyzed were eliminated from the pool of "properly installed and maintained filters".

Table 3-6 Reasons for Filter Elimination Matrix (265 PUR Filters Analyzed)

Filter with Red or No Indicator Light	Filters with Improperly Installed Cartridges	Filters Used with Hot Water	Replacement Cartridges Not Certified to NSF 53 Standard	Total
	X			3
			X	13
		X		24
		X	X	1
X				17
X		X		7
X			X	1
X	X		X	1
PUR Filters Eliminated from Pool – Not Properly Installed/Maintained				**67**

3.4.2 Filters Properly Installed and Maintained

Of the remaining filters, a total of 198 PUR filters were sampled under the final protocol with green or yellow indicator lights, were used with cold water only per the resident, were reported to be installed properly by the sampler, and had the correct replacement cartridge type. Only filters confirmed to not meet these criteria were removed from the analysis. If information was unknown in a specific category, it was not eliminated. A summary of the final count of filters selected for analysis is included in **Table 3-7**.

Table 3-7 PUR Filters Properly Installed and Maintained - Filtered and Unfiltered Samples

Category	No. Filters	No. Unfiltered Samples	No. Filtered Samples
Total PUR Filters Analyzed	265	787	786
Total PUR Filters Eliminated	67	195	195
Total PUR Filters Properly Installed and Maintained	**198**	**592**	**591**

Section 4
Results

This Section summarizes the results from the filter sampling program in the City of Newark and focuses on the 198 PUR filters that were believed to be properly installed and maintained. **Figure 4-1** provides a map of the filtered results by location. All filter locations represented with a circle are the 198 PUR filters of the type of filter provided by the City of Newark that were tested with the approved protocol, were properly installed, had the correct filter cartridge, had a green or yellow indicator light, and only cold water was reported to be used with the filter. Lead levels are represented by color in terms of maximum filtered concentration tested at that home through a PUR filter. The gray squares represent other filters that were tested but do not meet the stated above criteria.

4.1 Results by Filter Type

For the purposes of this evaluation, a filter is considered "passing" if lead levels were 10 ppb or below, consistent with the NSF 53 Standard requirement, in all filtered samples collected under the protocol developed for this study. Although the filters are advertised to remove 99% of lead, this metric is not part of the NSF certification, and therefore, it is not an appropriate measure to evaluate filter effectiveness. Furthermore, since samples represent adjacent volumes, the pre- and post-filter data specific to each volume sampled necessary to calculate percent reduction, is not available.

Table 4-1 provides the overall results for the PUR faucet and pitcher filters that were properly installed and maintained. As described in **Section 3**, this includes filters that had a green or yellow indicator light at the time of sampling, were properly installed as verified by the sampler, were reported by the resident to not be used with hot water, and had a cartridge certified for removing lead manufactured by PUR. As shown, only nine (9) PUR pitcher filters met these criteria which does not provide a statistically significant sample to evaluate the pitcher filters on their own. Additional information on the pitcher filters is included in Section 5.6. As shown in **Table 4-1,** flushing for 5 minutes prior to filtering increased the percentage of the filtered samples with lead levels at or below 10 ppb from 97.5% without flushing to 99.5% with flushing.

Table 4-1 Overall Results for PUR Filters Reported to be Properly Installed and Maintained (198 PUR Filters)

Filter Type	No. Filters	No. Filtered Always 10 ppb or less (Passing)	% Filtered Always 10 ppb or less (Passing)	No. Filtered 10 ppb or less (5-Minute Flush) (Passing)	% Filtered 10 ppb or less (5-Minute Flush) (Passing)
Faucet	189	185	97.9%	188	99.5%
Pitcher	9	8	88.9%	9	100%
Total	**198**	**193**	**97.5%**	**197**	**99.5%**

Noted: (1) Of the 198 filters, 98 filters did not see lead above 10 ppb in the unfiltered adjacent samples. (2) Due to the small sample size of the pitcher filters, the results may not represent all conditions.

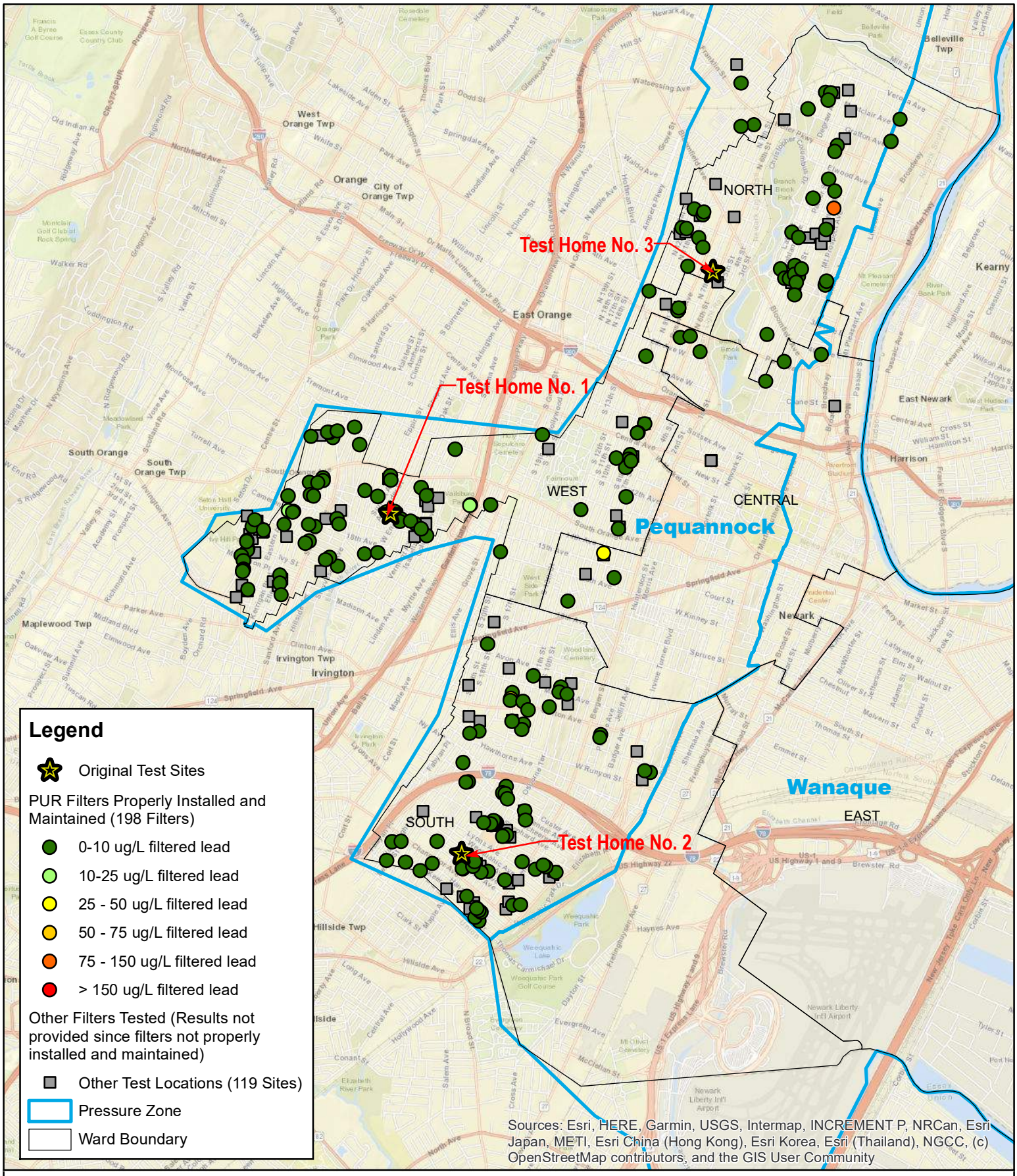


Figure 4-1
Map of Filtered Lead Results
(Maximum Filtered Lead Concentration by Property – Only PUR Filters, Properly Installed and Maintained)
Data Collected: August - September 2019

CDM Smith

Angellja G:\NewarkLeadServiceLine\02_MXD\SamplingResultsMaps\SamplingOfFilters\FilterSampling_Filtered.mxd 11/15/2019

The 10 ppb level was used as the passing criteria in accordance with the NSF 53 Standard that the POU filters tested in this study were certified under. It is anticipated that NSF will be reducing the standard in the near future to 5 ppb or below. In Newark, 91.9% of the filters properly installed and maintained resulted in filtered lead levels of 5 ppb or below in all samples using the current PUR filter technology. After 5 minutes of flushing, 98.0% of the flushed filtered samples had lead levels of 5 ppb or below. It is important to note that the certification is based on challenging the filters with an influent concentration of up to 150 ppb of lead using a particular challenge water under specific laboratory test conditions. The challenge water and conditions used in the laboratory testing may differ from actual conditions experienced by various water systems who may utilize the filters. The change in certification should be accompanied with the inclusion of testing other water chemistries utilized by various water purveyors to include a more comprehensive water chemistry data set and challenge conditions. If prior testing as part of the NSF certification process showed that the filters already achieved levels below 5 ppb, the filters do not need to be recertified. If not, the filter manufacturers may need to modify their filters to be retested and recertified by NSF.

Table 4-1 includes all filters that were properly installed and maintained and represents the likelihood of water leaving a filter in Newark under current water quality conditions with lead concentrations of 10 ppb or less. However, with the intentional variability of this study to be reasonably representative of water passing through the POU filters, several filters may not have been challenged with lead levels in unfiltered water over 10 ppb. **Table 4-2** indicates that of the 198 properly installed and maintained PUR filters, 98 of the filters did not have unfiltered water samples with lead above 10 ppb. As lead concentrations can vary greatly throughout a service line with each incremental volume of water, it is unknown if the filtered water samples started with lead concentrations over 10 ppb or not.

Table 4-2 PUR Filter Results Based on Unfiltered Lead Levels Above or Below 10 ppb (Properly Installed and Maintained Filters)

Unfiltered Water Lead Results	No. Filters	No. Filters Always 10 ppb or Below (Passing)	% Filters Always 10 ppb or Below (Passing)
All Unfiltered Samples = 10 ppb or Below	98	98	100%
At Least One Unfiltered Sample > 10 ppb	100	95	95%
Total Filters (All Unfiltered)	**198**	**193**	**97.5%**
Unfiltered Flushed Samples = 10 ppb or Below	162	162	100%
Unfiltered Flush Sample > 10 ppb	36	35	97.2%
Total Filters (Flushed Unfiltered)	**198**	**197**	**99.5%**

As shown in **Table 4-2**, the number of unfiltered samples with lead concentrations above 10 ppb decreased from 100 to 36 with a 5-minute flush. Lowering lead levels before going through the filter improves the performance of the filter. This is discussed further in Section 4.2.

4.2 Results by Unfiltered Lead Levels

Considering the unfiltered dataset of the 198 PUR filters that were properly installed and maintained, the unfiltered lead levels encountered are shown in **Table 4-3**.

Table 4-3 Summary of the Unfiltered Lead Results Encountered During Filter Testing for the Properly Installed and Maintained Filter Dataset (198 PUR Filters, 591 Total Unfiltered Samples Analyzed)

Statistic	Unfiltered First Draw (ppb)	Unfiltered Service Line (ppb)	Unfiltered 5 Minute Flush (ppb)
N (Number of Samples)[1]	196	197	198
N (Number Samples >10 ppb)	79	86	36
10th Percentile	0.5	0.5	0.5
50th Percentile	7.7	7.6	3.7
90th Percentile	40.4	44.5	13.7
Average	15.3	16.7	7.8
Maximum	306.0	151.0	392.0
Standard Deviation	27.8	24.1	28.3

Note: (1) Although the protocol was followed, not all sampling events resulted in 6 analyzed samples due to sampling or laboratory error. When only one sample in a set of 6 samples was impacted, the remaining samples were kept in the analysis.

For the samples in the 198 PUR filter dataset for properly installed and maintained filters, stagnation time as reported by the resident average 4.9 hours since the kitchen faucet was used and 3.2 hours since the water in the house was last used. The maximum stagnation time as reported by the resident was 168 hours since the kitchen faucet was used and 24 hours since the water in the house was last used. The statistics are virtually the same for the subset of 198 PUR filters as the larger 265 PUR filter dataset presented in **Table 3-3**.

Table 4-4 provides the number of filtered samples that were 10 ppb or less based on the unfiltered lead levels in the adjacent sample. The samples are divided into unfiltered lead levels of 10 ppb or below, between 10 ppb and 150 ppb and greater than 150 ppb. In total, there were 591 "paired" samples where an unfiltered sample and a filtered sample were taken immediately adjacent to each other with no wasted water between the samples with the exception of the flushed samples which included a 10 second delay in the protocol between samples when switching back to the filtered water.

Table 4-4 All Filtered Lead Sample Results from Properly Installed and Maintained PUR Filters Compared with Unfiltered Lead Levels

Unfiltered Lead Levels	Number of Sample Pairs	Filtered Sample 10 ppb or Below	% Filtered Samples 10 ppb or Below
Unfiltered 10 ppb or below	390	390	100.0%
Unfiltered > 10 ppb and < 150 ppb	198	194	98.0%
Unfiltered > 150 ppb	3	0	0.0%

Notes: (1) Results represent all samples (i.e. first draw, service line and flushed samples) from properly installed and maintained PUR filters. (2) The sample pairs do not represent a true "before and after" sampling event with POU filters installed on home plumbing. (3) Samples with unfiltered lead levels of 10 ppb or below reached non-detect 96.2% of the time after filtering.

Table 4-4 illustrates the benefit of reducing the lead levels in the water prior to running the water through the filter. In the three (3) cases when the unfiltered lead levels were greater than 150 ppb, the filters in Newark did not reduce lead to 10 ppb or below. When the unfiltered lead levels were between 10 and 150 ppb, 98.0% of the filtered samples were reduced to 10 ppb or less. When the unfiltered lead levels were at 10 ppb or below prior to going through the filter, 96.2% of the filtered samples did not detect any lead (i.e. were "non-detect") indicating that the filters can continue to reduce lead levels to minimize exposure.

Table 4-5 provides similar results to **Table 4-4** broken down into samples filtered from a faucet filter or a pitcher filter. The three (3) filtered samples from the faucet filters where the lead level in the adjacent sample was 150 ppb or greater and was not able to reduce levels to 10 ppb or below in any of these samples. The pitcher filters were not challenged with lead levels over 150 ppb based on the adjacent unfiltered lead levels. Based on 183 samples, the faucet filters reduced lead levels to 10 ppb or below in 98.9% of samples with adjacent unfiltered lead levels between 10 and 150 ppb. As mentioned previously, there is not a sufficient enough sample pool size for the pitcher filters to make conclusive statements as many of the pitcher filters tested did not meet the final criteria.

Table 4-5 All Filtered Lead Sample Results from Properly Installed and Maintained PUR Faucet and Pitcher Filters Compared with Unfiltered Lead Levels

Unfiltered Lead Levels	No. Filters	Number of Sample Pairs	Filtered Sample 10 ppb or Below	% Filtered Samples 10 ppb or Below
Faucet Filters				
Unfiltered 10 ppb or below	96	379	379	100.0%
Unfiltered > 10 ppb and < 150 ppb	91	182	180	98.9%
Unfiltered > 150 ppb	2	3	0	0.0%
Pitcher Filters				
Unfiltered 10 ppb or below	2	11	11	100.0%
Unfiltered > 10 ppb and < 150 ppb	7	16	14	87.5%
Unfiltered > 150 ppb	0	0	0	N/A

Notes: (1) Results represent all samples (i.e. first draw, service line and flushed samples) from properly installed and maintained PUR filters. (2) Due to the small sample size of the pitcher filters, the results may not represent all conditions. (3)The sample pairs do not represent a true "before and after" sampling event with POU filters installed on home plumbing. (4) Samples with unfiltered lead levels of 10 ppb or below reached non-detect 96.2% of the time after filtering.

Table 4-6 provides additional data on the filtered samples where the unfiltered adjacent sample was at 10 ppb or below to evaluate how much the filter is removing lead beyond the NSF 53 Standard. The number of filtered samples with lead levels at 5 ppb or below and the number of filtered samples with non-detect (ND) lead levels when the unfiltered paired sample is 10 ppb or below are provided in **Table 4-6**. As mentioned, "paired" samples are not before and after filter samples. Instead, they were taken immediately adjacent to each other and lead levels can vary greatly between adjacent samples. The "before" unfiltered lead levels for the filtered samples are unknown.

Table 4-6 Number of Filtered Lead Samples at or Below 5 ppb and Non-Detect (ND) When Unfiltered Lead Levels at 10 ppb or Less

Unfiltered Lead Levels at 10 ppb or Below	No. of Sample Pairs	No. Filtered Sample 5 ppb or Below	% Below Unfiltered	No. Filtered Sample ND	% Below Unfiltered
First Draw Samples	117	117	100%	117	100%
Service Line Samples	111	111	100%	106	95.5%
Flushed Samples	162	161	99.4%	152	93.8%
Total	390	389	99.7%	375	96.2%

As shown in **Table 4-6** the filtered water was below 5 ppb in 99.7% of the paired samples and below non-detect in 96.2% of the paired samples when the unfiltered lead level was 10 ppb or below.

4.3 Results by Cartridge Type

Two different filter cartridges for the PUR faucet-mount systems are certified to meet the NSF 53 Standard for lead, RF-3375 and RF-9999. Only one pitcher cartridge by PUR is certified to meet the NSF 53 Standard for lead, PPF951K. **Table 4-7** presents the results by type of filter cartridge for the 198 PUR filters that were properly installed and maintained. The results are provided both by filter and by sample. Both filter cartridges reliably produced water at 10 ppb or below approximately 99% of the time. The pitcher cartridge, PPF951K, was less effective but there is not a large enough dataset to make a strong conclusion.

Table 4-7 Lead Removal Statistics by Cartridge Type for Faucet and Pitcher Filters – PUR Filters Properly Installed and Maintained

Filter Type	Cartridge Type	Total Filters	No. Filters Always 10 ppb or Below	% Filters Always 10 ppb or Below	Total Samples	No. Samples 10 ppb or Below	% Filtered Samples 10 ppb or Below
Faucet	**RF-3375**	63	62	98.4%	188	186	98.9%
Faucet	**RF-9999**	126	123	97.6%	376	373	99.2%
Pitcher	**PPF951K**	9	8	88.9%	27	25	92.6%
Total		**198**	**193**	**97.5%**	**591**	**584**	**98.8%**

Due to the small sample size of the pitcher filters, the results may not represent all conditions.

4.4 Results by Service Line Material

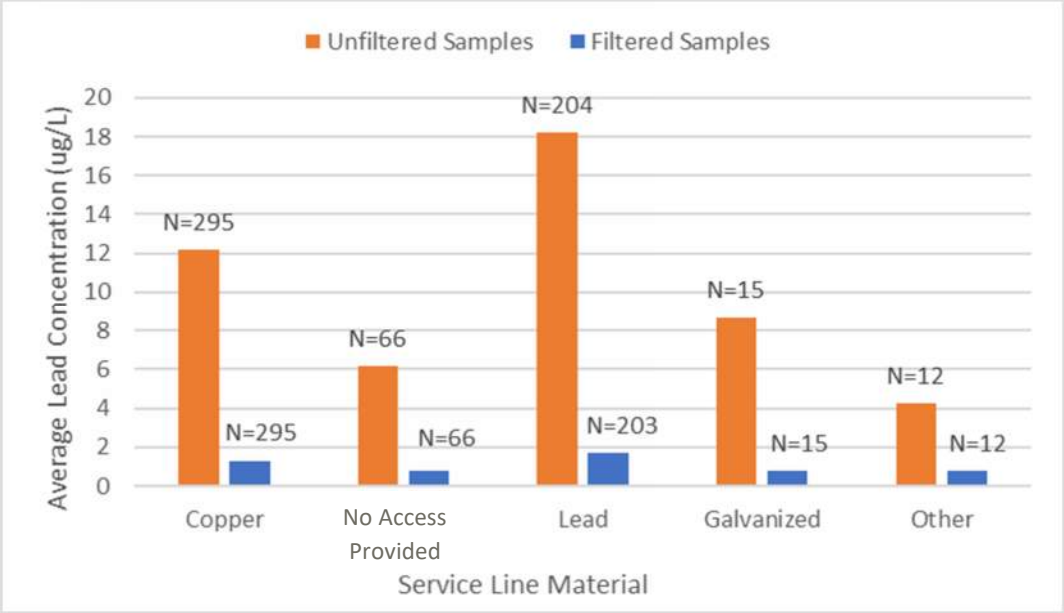
The results were compared by service line material to understand the difference in lead levels with different service line materials. **Table 4-8** provides the service line material observed at the meter and the number of filters tested and samples taken for each material type. As mentioned in Section 3.2.4, the material observed at the meter does not necessarily indicate the material for the rest of the service line that is buried and unknown. Newark's inventory suggests that some of the homes sampled may have different materials between the main and curb stop and the curb stop and meter. The materials reported herein were observed just upstream of the meter.

Table 4-8 Service Line Material Observed – PUR Filters Properly Installed and Maintained

Service Line Material Observed at Meter	No. PUR Filters Properly Installed and Maintained	No. Samples from PUR Filters Properly Installed and Maintained
Copper	99	295
Lead	68	203
Galvanized	5	15
Other	4	12
No Access Provided	22	66
Total	**198**	**591**

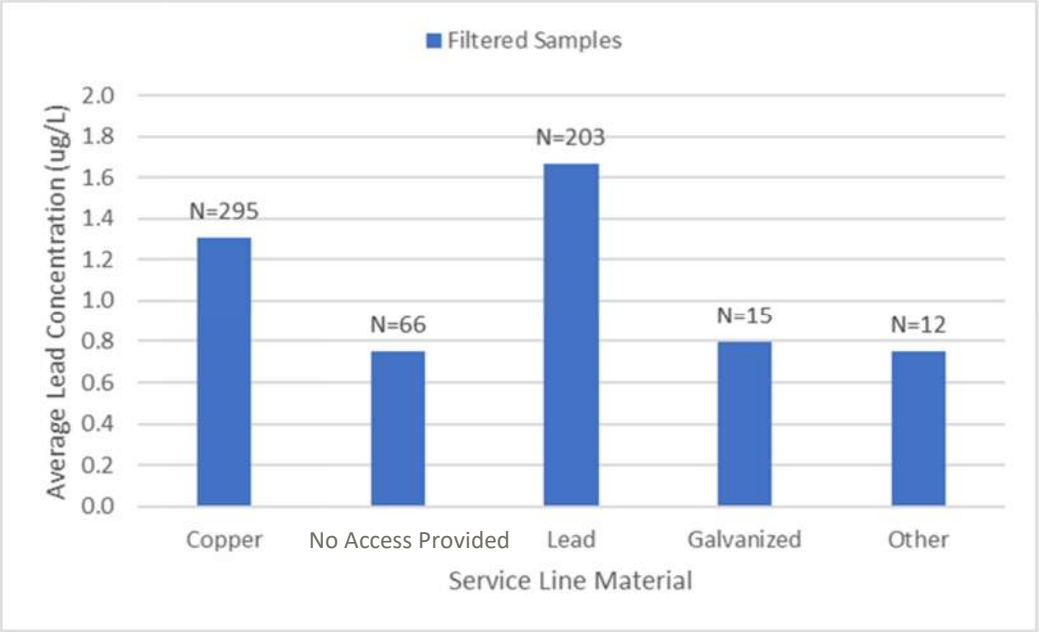
Note: The material observed at the meter may differ from the buried service line material as suggested by Newark's inventory.

Figure 4-2 present a comparison of average lead levels by service line material observed at the meter for unfiltered and filtered samples, respectively, in all homes sampled with PUR filters that were properly installed and maintained. **Figure 4-3** illustrates the results from the filtered samples at a smaller scale. It is clear from both graphs that lead service line increased lead levels in both the unfiltered and filtered water samples.



Note: This graph is based on materials observed at the meter. The material observed at the meter may differ from the buried service line material as suggested by Newark's inventory.

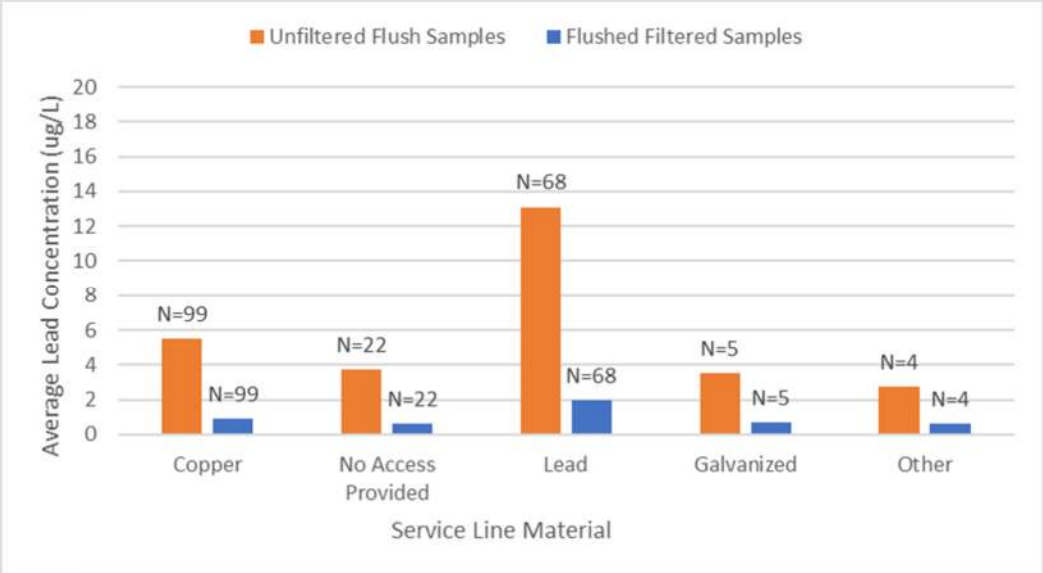
Figure 4-2 Average Unfiltered and Filtered Lead Concentrations by Service Line Material for All Samples (Homes with PUR Filters Properly Installed and Maintained)



Note: This graph is based on materials observed at the meter. The material observed at the meter may differ from the buried service line material as suggested by Newark's inventory.

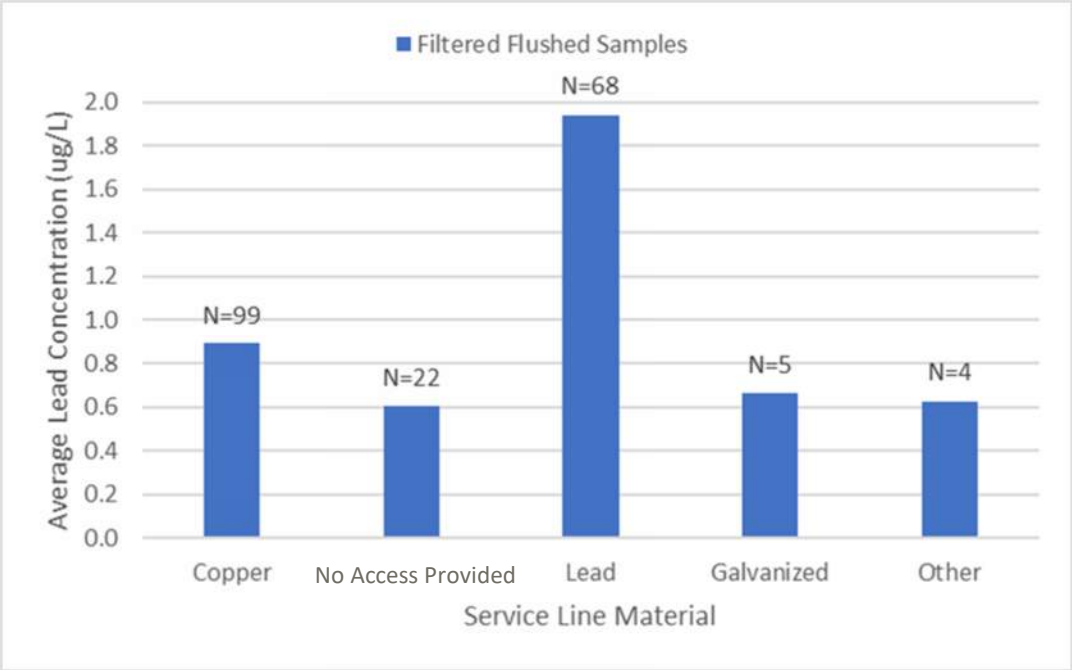
Figure 4-3 Average Filtered Only Lead Concentrations by Service Line Material for All Samples (Homes with PUR Filters Properly Installed and Maintained)

Figure 4-4 and **4-5** present the same comparison as **Figures 4-2** and **4-3** but with unfiltered and filtered samples, respectively, after 5 minutes of flushing in all homes sampled with PUR filters that were properly installed and maintained. Similar to the results for all samples, the lead levels in the flushed water samples are higher for lead service lines than the other service line materials.



Note: This graph is based on materials observed at the meter. The material observed at the meter may differ from the buried service line material as suggested by Newark's inventory.

Figure 4-4 Average Unfiltered and Filtered Lead Concentrations by Service Line Material for Flushed Samples (Homes with PUR Filters Properly Installed and Maintained)



Note: This graph is based on materials observed at the meter. The material observed at the meter may differ from the buried service line material as suggested by Newark's inventory.

Figure 4-5 Average Filtered Only Lead Concentrations by Service Line Material for Flushed Samples (Homes with PUR Filters Properly Installed and Maintained)

As can be seen in **Figures 4-2, 4-3, 4-4** and **4-5**, lead service lines clearly contribute higher lead values than materials observed to be non-lead in all samples and in flushed samples. Once the service line materials are verified during the Lead Service Line Replacement Program, the data will be updated to include partial lead service lines.

Section 5
Interpretation of Results

As presented earlier, the goal of this study was to determine if the POU filter types provided by the City of Newark are reducing lead to levels of 10 ppb or below under the current water quality conditions in Newark when the filters are properly installed and maintained. A filter is considered "passing" if lead levels were 10 ppb or below, consistent with the NSF 53 Standard requirement, in all filtered samples collected under the protocol developed for this study. This section reviews the results from **Section 4** and provides additional analysis and context in scaling the sample pool to the larger affected population in the Pequannock Gradient.

5.1 Confidence Levels

Table 5-1 provides the actual realized passing rate of the sample pool based on the number of filters tested. As shown in **Table 5-1** and in the results presented in the previous section, the filters reliably provided drinking water with lead levels of 10 ppb or below, consistent with the NSF 53 Standard requirements. The passing rate of all filters in the sampling pool that were installed and maintained properly and tested under all conditions is 97.5%. The passing rate increased to 99.5% with samples that were flushed for 5 minutes prior to filtering.

Table 5-1 Passing Rates Based on 95% and 99% Confidence Levels

Scenario	No. Filters	No. Passing Filters (< or = 10 ppb)	Actual Passing Rate of Pool	Confidence Level (CL)	Minimum Passing Rate for Full Population at CL
PUR Filters properly installed and maintained consistently providing less than or equal to 10 ppb in all filtered samples (first draw, service line and 5-minute flushed)	198	193	97.5%	90 CL	95.4%
				95 CL	94.8%
				99 CL	93.5%
PUR Filters properly installed and maintained providing less than or equal to 10 ppb (5-minute filtered flushed samples only)	198	197	99.5%	90 CL	98.0%
				95 CL	97.6%
				99 CL	96.7%

Note: (1) Of the 198 filters, 98 filters did not see lead above 10 ppb in the unfiltered adjacent samples.

To determine the anticipated passing rate for the entire affected population in the Pequannock Gradient, a statistical binomial distribution model was used to estimate passing rates at various confidence levels based on sample pool size and variability. The minimum passing rates at the 90, 95 and 99 percent confidence levels are shown in **Table 5-1**. This states, for example, that the study is 95% confident that the passing rate for the entire affected population is equal to or greater than 94.8% when the PUR filters are properly installed and maintained and both stagnated and flushed water samples are run through the filters. Furthermore, the study is 95%

confident that the passing rate is equal to or greater than 97.6% when the water is flushed for 5 minutes prior to filtering. With a larger sample pool size, the passing rate at a given confidence level merges closer to the theoretical passing rate, or actual realized passing rate of the sample pool. A description of the method used for the binomial distribution is included in Appendix C.

When filters are properly installed and maintained, the reliability of the filters to reduce lead levels to 10 ppb or below is largely dependent, but not solely dependent, on the lead levels in the water being filtered as shown in **Tables 4-2, 4-3** and **4-4**. For the three (3) water samples where lead levels were above 150 ppb in the unfiltered samples, the filters were unable to reduce lead levels to 10 ppb or below. **Table 5-2** provides the data from **Table 4-4** showing the actual passing rate based on unfiltered lead levels with the addition of the 95 percent confidence level (95 CL) for the larger affected population. The table consisting of unfiltered lead levels of 0 to 10 ppb, greater than 10 ppb to 150 ppb, and over 150 ppb in the adjacent sample. As mentioned previously, the results represent adjacent sample volumes and not pre- and post-filter data specific to each volume sampled.

Table 5-2 All Filtered Lead Sample Results from Properly Installed and Maintained PUR Filters Compared with Unfiltered Lead Levels

Unfiltered Lead Levels	Number of Sample Pairs	Filtered Sample 10 ppb or Below	Actual Passing Rate of Pool	Minimum Passing Rate for Full Population at 95 CL
Unfiltered 10 ppb or below	390	390	100.0%	99.2%
Unfiltered > 10 ppb and < 150 ppb	198	194	98.0%	95.4%
Unfiltered > 150 ppb	3	0	0.0%	0.0%

Notes: (1) Results represent all samples (i.e. first draw, service line and flushed samples) from properly installed and maintained PUR filters. (2)The sample pairs do not represent a true "before and after" sampling event with POU filters installed on home plumbing. (3) Samples with unfiltered lead levels of 10 ppb or below reached non-detect 96.2% of the time after filtering.

For additional confidence in the filters, residents in Newark can flush for a minimum of five (5) minutes to reduce the unfiltered lead levels prior to filtering. Flushing for a minimum of 5 minutes increases the passing rate of the filter as it avoids consuming the water that has been sitting in the service line for an extended period of time. Drinking only the water directly from the main in the street, by first flushing the stagnated water, reduces the amount of time the water is in contact with the lead service line and other lead components in home plumbing, which helps to reduce lead levels before going through the filters.

The 198 properly installed and maintained PUR filters tested reflected a wide range of conditions representative of water usage throughout the day including varying unfiltered lead levels (see **Tables 4-4** and **4-5**), cartridge types (see **Table 4-7**) and service line materials (see **Figures 4-2** through **4-5**). This final sample pool includes only the 198 PUR filters that were identified to be properly installed and maintained per the criteria in Section 3.4. If the entire sample pool of 265 PUR filters is considered, including those filters that were not installed properly, had a red indicator light, were reported to be used with hot water and/or were using a cartridge that is not certified to remove lead and not provided by Newark, the passing rate drops slightly to 96.6%. Regardless, it is critical that residents understand the importance of proper installation and maintenance of filters combined with flushing and filtering to maximize their benefits.

5.2 Review of Filters Not Achieving Goal

The results of this study show that 97.5% of filters under a variety of conditions will reliably reduce lead levels to 10 ppb or below. There are five (5) total filters in the 198 filters that were believed to be properly installed and maintained that did not meet the passing criteria.

This section provides an analysis of the PUR filters that were properly installed and maintained but did not reduce lead levels to 10 ppb or below:

- Failure 1 – 0828-74 – West Ward
  - This home is a single-family home with a copper service line at the meter and interior copper plumbing. The time since the water was last used in the home at time of testing was estimated at 3 hours.
  - This address uses a faucet filter model FM-3333B with a RF-9999 filter cartridge that was replaced approximately one to two months ago. The resident stated that the filter is used for washing dishes, however, reported to only use cold water through the filter.
  - The unfiltered lead in this home was 34.8 ppb in the first draw sample, 33.0 ppb in the service line sample and 6.85 ppb after 5 minutes of flushing.
  - The filtered lead in this home was 9.02 ppb in the first draw sample, 16.6 ppb in the service line sample and 1.04 ppb after 5 minutes of flushing. Only the service line sample was not reduced to less than 10 ppb.
  - Analysis: Confirm that this home does not have a partial lead service line (i.e. a portion of the buried service line could be lead even if copper at the meter), confirm that there is not a galvanized section of piping in the home plumbing that may be contributing to lead levels, and review the proper use of the filter with the resident. Recommend replacement of the filter cartridge and that the filter not be used for washing dishes as one may occasionally use hot water when washing dishes. Recommend removing the filter housing and clear the screen of any build-up of particles. The home should also be checked to see if the electrical grounding is on the water service line. If it is, it should be moved off the service line.
- Failure 2 – 0829-21 – West Ward
  - This home is a single-family home with a lead service line at the meter and interior copper plumbing. The time since the water was last used in the home at time of testing was estimated at 4 hours.
  - This address uses a faucet filter model FM-3333B with a RF-9999 filter cartridge that was replaced by a team of samplers under this program approximately two days prior to the testing.
  - The original filter cartridge that was replaced was reported to be used with both hot and cold water and had a red indicator light indicating that it was beyond its expected

life. The resident stated that the previous cartridge was used for washing dishes, but the new cartridge was only used for food preparation.

- The unfiltered lead in this home was 57.2 ppb in the first draw sample, 54.9 ppb in the service line sample and 11.5 ppb after 5 minutes of flushing.
- The filtered lead in this home was less than 1 ppb in the first draw sample, 11.5 ppb in the service line sample and 1.35 ppb after 5 minutes of flushing. Only the service line sample was not reduced to less than 10 ppb.
- Analysis: Confirm that this home does not have a galvanized section of piping in the home plumbing that may be contributing to lead levels and review the proper use of the filter with the resident. Recommend replacement of the filter cartridge and that the filter not be used for washing dishes as one may occasionally use hot water when washing dishes. Recommend removing the filter housing and clearing the screen of any build-up of particles. The home should also be checked to see if the electrical grounding is on the water service line. If it is, it should be moved off the service line.

- Failure 3 – 0904-318 – Central Ward
  - This home is a three-family home with a copper service line at the meter and interior copper plumbing. A faucet on the second floor was tested. The time since the water was last used in the home at time of testing was estimated at one hour.
  - This address uses a faucet filter model FM-3333B with a RF-3375 filter cartridge that was replaced approximately two to four weeks prior to the testing.
  - The filter is reported to be used only for food preparation and with cold water.
  - The unfiltered lead in this home was 306 ppb in the first draw sample, 151 ppb in the service line sample and 42.3 ppb after 5 minutes of flushing.
  - The filtered lead in this home was 32.6 ppb in the first draw sample, 25.6 ppb in the service line sample and 6.22 ppb after 5 minutes of flushing. Both the first draw and service line were not reduced to less than 10 ppb.
  - Analysis: The lead levels in this home exceeded the challenge water concentration (150 ppb) used in the NSF challenge water for the certification. Confirm that this home does not have a partial lead service line (i.e. a portion of the buried service line could be lead even if copper at the meter), confirm that there is not a galvanized section of piping in the home plumbing that may be contributing to lead levels, confirm the electrical system is not grounded to the service line entering the home and review the proper use of the filter with the resident. Recommend replacement of the filter cartridge and full flow flushing without the aerator to help reduce lead levels. Recommend removing the filter housing and clearing the screen of any build-up of particles. The home should also be checked to see if the electrical grounding is on the water service line. If it is, it should be moved off the service line.

- Failure 4 – 0905 -593595 – North Ward
  - This home is a single-family home with a longer than typical lead service line and interior copper plumbing. The faucet tested was located at the back of the house. The time since the water was last used in the home at time of testing was estimated at 12 hours.
  - This address uses a faucet filter model FM-20008B with a RF-9999 filter cartridge that was replaced approximately two to four weeks prior to the testing.
  - The filter is reported to be used only for drinking and coffee preparation. This filter was originally installed on the second-floor bathroom and was moved to the kitchen faucet for testing. Confirmation is necessary with the resident that hot water was not used when it was used in the bathroom.
  - The unfiltered lead in this home was 36.3 ppb in the first draw sample, 72.5 ppb in the service line sample and 392 ppb after 5 minutes of flushing.
  - The filtered lead in this home was 2.42 ppb in the first draw sample, 2.89 ppb in the service line sample and 77.3 ppb after 5 minutes of flushing. Only the 5-minute flushed sample was not reduced to less than 10 ppb.
  - Analysis: This home has a service line longer than 97 percent of all lead service lines in the Pequannock Gradient. The 5 minutes of water use at a flowrate of 0.96 gallons per minute (gpm) was not enough to reach the water in the water main and the "flushed" sample was, in fact, the stagnated water in the lead service line. A longer flush is needed at this location to lower lead levels to improve filter performance. In addition, the lead levels in this home exceeded the challenge water concentration (150 ppb) used in the NSF challenge water for the certification. It is recommended to review the proper use of the filter with the resident. Confirm with the resident how the filter was used when installed in the bathroom. Recommend replacement of the filter cartridge and full flow flushing without the aerator to help reduce lead levels. Recommend removing the filter housing to clear the screen of any build-up of particles. Retest this home with a longer flush or higher flowrate. The home should also be checked to see if the electrical grounding is on the water service line. If it is, it should be moved off the service line.
- Failure 5 – 0906-869 – South Ward
  - This home is a single-family home with a copper service line at the meter and interior copper plumbing. The time since the water was last used in the home at time of testing was estimated at 5.5 hours.
  - This address uses a pitcher filter model PPT111R with a PPF951K filter cartridge that was reported to be last replaced two to four weeks ago.
  - The filter is reported to be used with only cold water for drinking and preparing coffee.

- The unfiltered lead in this home was 52.0 ppb in the first draw sample, 61.6 ppb in the service line sample and 9.28 ppb after 5 minutes of flushing.
- The filtered lead in this home was 32.3 ppb in the first draw sample, 23.2 ppb in the service line sample and 8.8 ppb after 5 minutes of flushing. The first draw and the service line samples were not reduced to less than 10 ppb.
- Analysis: Confirm that this home does not have a partial lead service line (i.e. a portion of the buried service line could be lead even if copper at the meter) and confirm that there is not a galvanized section of piping in the home plumbing that may be contributing to lead levels. Recommend replacement of the filter cartridge with instructions on installation. Recommend cleaning the aerator of any build-up of particles. The home should also be checked to see if the electrical grounding is on the water service line. If it is, it should be moved off the service line.

5.3 Comparison with Original Filters Tested

The three original filters that were tested in July and early August under challenged conditions showed results consistent with the filters discussed in Section 5.2. The results of the original filters showed that two of the three filters tested after a stagnation time of 6 hours or greater did not remove lead to below 10 ppb in the service line samples. The results also showed that even after an extended stagnation time, once the water in the service line is flushed, the lead levels were below 10 ppb. One anomaly with the original filters was the pitcher filter that did not remove lead to 10 ppb or below with the first draw sample. This is addressed further in Section 5.6.

At the time of the sampling of the three original filters, a larger sample pool size was not available to understand the limitations of the filters and place the challenge filter testing into context. Therefore, out of an abundance of caution, the City of Newark distributed bottled water while the expanded filter testing program was ongoing. The expanded testing was intended to understand if the issue was pervasive or limited to specific conditions. As presented above and with the original challenge filters, flushing combined with filtering will reduce lead to 10 ppb or below even in homes with lead levels above 150 ppb in the service line samples. The one exception is Failure 4 discussed above (Section 5.2), which required a longer flush than 5 minutes to reach the main and is further discussed in Section 5.4.

5.4 Flushing

As mentioned above, the results of this study show that 97.5% of the filters that were properly installed and maintained provided drinking water with lead levels of 10 ppb or below. To increase the percentage of filters achieving the 10 ppb or below level, a 5-minute flush followed by filtering increased the passing rate to 99.5%. The only filter that did not pass after a 5-minute flush was the filter discussed in Section 5.2 (Failure 4) with the longer than typical service line. In fact, the filters were 100% effective in providing drinking water with lead levels of 10 ppb or below when the water was flushed long enough to reach the water main prior to filtering.

While there are many variables that can impede filter performance, the primary constraint in achieving filtered lead levels of 10 ppb or below appears to be when the filters encounter high

lead level in the unfiltered water above 150 ppb. The data shows that significant reductions in lead levels can be accomplished by flushing the stagnated service line water that has been in contact with a lead service line or lead-containing materials in the interior home plumbing for an adequate amount of time. The important factor is to make sure that the water from the water main in the street is reached. The majority of homes in Newark reach the service line with 5 minutes of water use at a moderate flowrate (1.0-1.5 gpm) Flushing is an interim solution as Newark's new corrosion control treatment system works to provide a protective layer on the lead pipes.

A 5-minute flush is adequate for most homes to reach the water main to avoid over-challenging the filters with high lead levels. A "flush" in a home can be running the tap or it can include any other water use other than for drinking and cooking (i.e. showering, flushing toilet, washing dishes, etc.). In the Pequannock Gradient of Newark's distribution system, while the corrosion control treatment is not optimized, even with flushing to reach the main, a POU filter device certified to remove lead is recommended for drinking and cooking due to particulate lead that can be picked up from the service line or home plumbing as it passes through. It is recommended that this practice continue until the new corrosion control is optimized or the lead service line and other lead-containing plumbing materials are replaced.

One home in the sample pool, Failure 4 in Section 5.2, does not appear to have reached the main after 5 minutes of water use, flowing at a flowrate of 0.96 gpm at the faucet, which is a lower flowrate than typically seen in other homes that were sampled. This home has a long service line and the faucet tested was located at the back of the house. The centroid of this property to the water main in the street is estimated at 111 feet and the service line is estimated to be over 75-feet in length. Assuming a 1-inch diameter service line, this home would need to flush for approximately six (6) minutes to reach the service line at the same flowrate of 0.96 gpm. More specific information on the service line diameter and length of interior plumbing would be needed to confirm the required flushing time.

In reviewing all 14,952 homes in the Pequannock system with lead service lines, only 388 homes had distances from the centroid of the property to the water main in the street over 110 feet (approximately 2.6 percent of lead service lines in Pequannock). These homes may likely need to flush at a rate greater than 1 gpm for 5 minutes and/or flush for a longer period than 5 minutes at the same flow rate. The longest distance from the centroid of the property to the main in the street is 175 feet of all lead service lines in the Pequannock area. At a rate of 0.96 gpm, approximately 7.5 minutes of flushing would be required for a 1-inch lead service line plus some additional length for any extensive interior plumbing. The median flowrate in the sample pool in this study was 1.44 gpm. At this flowrate, 5 minutes of water use (plus additional time for extensive interior plumbing) prior to using the filter is adequate to reach the water main in the vast majority of homes in Newark. In summary, most homes in the Pequannock Gradient with lead service lines can be flushed completely with moderate water flow (i.e. flushing the toilet, showering, washing dishes, etc.) for a minimum of 5 minutes. It is recommended that homes with longer service lines and/or extensive indoor plumbing flush for an additional 2 to 3 minutes, depending on length of piping, to reduce lead levels prior to filtering for drinking and cooking. Flushing for 8 minutes at a moderate flowrate should reach the water main for all properties in Newark.

Regarding the frequency of flushing, an extended period of water stagnation is typically defined as 6 hours or more. The data collected during this study did not require a preplanned or requested stagnation time; rather stagnation times relied on residents to report water use within the home. The definition of "water use" may be interpreted differently by residents, e.g., some may not consider flushing the toilet as water use. Relatedly, many homes tested were within multi-family homes with unknown usage in the other units, which would affect actual stagnation time. Based on this, the stagnation times reported by resident are likely to be inaccurate and therefore not appropriate to compare with lead levels in water.

5.5 Service Line Material

As shown on **Figures 4-2** through **4-5**, the lead levels in the unfiltered and filtered samples where the service line material was lead, as identified at the meter by the sampler, are significantly greater than the lead levels found in any other service line material observed at the meter. Lead levels in all unfiltered samples were 50% greater when the service line was identified as lead at the meter compared with copper. Lead levels in filtered and unfiltered flushed samples were found to be 54% and 138% greater, respectively, in water samples taken from homes with service lines identified as lead at the meter compared with service lines identified as copper at the meter.

It is clear from the lead levels in the unfiltered water samples that the filters in homes with lead service lines are more likely to be challenged with high lead levels. Replacing lead service lines is an effective way to reduce lead levels from water piping which will improve the effectiveness of the filter.

5.6 Pitcher Filters

Of the 265 PUR filters tested with the final protocol, 25 were PUR filter pitchers. Of the 25 pitcher filters tested, only nine (9) were properly installed and maintained with the correct replacement filter cartridge certified to the NSF 53 Standard reduce lead. Several of the pitchers, a total of 16, were reported to be using a filter cartridge with a blue top which indicates that the cartridge is a CRF-950Z which is not certified to remove lead. The test results from these pitchers were not included in the evaluation to determine the effectiveness of the filters when properly installed and maintained.

Because there were only nine (9) pitcher filters, there are not enough results to provide a statistical basis for determining the effectiveness of the pitcher filters on their own. However, some general observations are noted herein.

In a conversation between employees of CDM Smith and employees of Helen of Troy on September 20, 2019, it was discussed that the pitcher filters utilize a different technology than the faucet filters. The pitcher filters have larger pores than the faucet filters as there is not as much head pressure on the filter cartridge. The percent removal would be expected to be less with the pitcher filters than the faucet filters filtering the same water based on this, however, both styles of filters are certified to meet the NSF 53 Standard.

Based on the study results, however, flushing before filtering is effective for pitcher filters as evident in that there were no failures with pitcher filters in samples collected from the faucet

after the water was flowing for at least 5 minutes through the faucet in the final data set of 198 PUR filters.

In addition to the pitcher filters having larger pores, based on field observations during the study, it is more difficult to ensure that the pitcher cartridges are properly installed compared with the faucet filters. The pitcher will still function with a poorly installed filter, whereas, it is more difficult to close a faucet filter housing around a filter cartridge if it is not installed correctly. A pitcher filter cartridge that is not installed correctly may allow for unfiltered water to flow around the rim of the cartridge into the pitcher reservoir contaminating the filtered water.

In a call with representatives of Helen of Troy, Newark, CDM Smith, NJDEP and the EPA on September 20, 2019, it was conveyed by the Helen of Troy representatives that the pitcher filters should only be used to filter a maximum of 2 gallons per day up to the total usage of 40 gallons per day until the cartridge must be replaced. It was also discussed between CDM Smith and Helen of Troy on September 4, 2019 that the pitcher filters measure time to replace cartridges estimating general water usage, whereas the faucet filter measures actual gallons passing through the filter. The faucet filter measurement method more accurately represents the actual water usage through the filter.

5.7 Newark's Water Chemistry

As with every water system, the water chemistry of Newark's Pequannock Gradient is unique. Specific to lead chemistry and pipe scales, the system is currently undergoing a conversion to utilize zinc orthophosphate as the corrosion inhibitor. The scales prior to the orthophosphate addition were a mixture of tetravalent lead (Pb (IV)) and carbonate-based (Pb(II)) scales. With the addition of orthophosphate, it is expected that low solubility lead phosphate compounds will form when in contact with soluble lead (Pb (II)) and deposit on the lead pipes.

The PUR POU filters distributed by Newark use a combination of activated carbon and ion exchange to remove lead (Helen of Troy, 2019). Particulate lead is generally removed by trapping particles in the filters (function of the filter media size) while soluble lead is generally removed by the process of adsorption or in the ion exchange process (Bosscher, Lytle, Schock, Porter, & Del Toral, 2019). Specific information about the filter media is propriety to the filter manufacturer. The NSF 53 Standard test to determine if a filter, such as the PUR filters, can claim the NSF 53 certification is based on very specific challenge water using carbonate chemistry (NSF International Standards, 2018). For Newark, the water chemistry varies from this challenge test water.

The use of orthophosphate has been a successful approach for minimizing corrosion of lead-containing materials (USEPA, 2016). As noted in the Pequannock WTP Corrosion Control Review and Recommendations – Final Report dated March 15, 2019 by CDM Smith Inc., the addition of orthophosphate can readily lower dissolved lead levels; however, total lead concentrations can persist at elevated levels for a longer period of time (Giammar, 2017). Research is ongoing to further evaluate Newark's changing water chemistry.

Because elevated lead concentrations due to particulate lead cannot be predicted, the interim practice of flushing combined with the use of POU filters is important for residents receiving

water from the Pequannock Gradient who have lead service lines or lead-containing plumbing materials in their home.

Section 6
Recommendations

Based on the expanded study conducted with 265 total PUR filters and a subset of 198 PUR filters that were properly installed and maintained, the filters are effective for reducing lead to 10 ppb or below per the NSF 53 certification requirements in Newark's Pequannock Gradient, particularly when used in combination with flushing. A summary of the results is provided in **Table 6-1**. A filter is considered "passing" if lead levels were 10 ppb or below in all filtered samples collected under the protocol developed for this study.

Filters that are "properly installed and maintained" include filters that meet the following criteria:

- Correctly installed based on inspection by sampler
- Only cold water used through filter as reported by the resident
- Green or yellow light indicating filter is within the manufacturer's recommended useful life of the cartridge
- Correct replacement cartridge used (NSF 53 certified to remove lead)

Flushing, with the filter in the bypass position, for at least five (5) minutes prior to using tap water for drinking or cooking is important to minimize exposure to lead, even when using a filter. As shown in **Table 6-1**, flushing prior to filtering increased the percent passing of PUR filters properly installed and maintained from 97.5% to 99.5%.

Table 6-1 Summary of PUR Filters Analyzed

Scenario	No. Filters	Total Filters <= 10 ppb	% Passing
All PUR Filters	265	256	96.6%
PUR Filters Properly Installed and Maintained	198	193	97.5%
PUR Filters Properly Installed and Maintained After 5 Minutes of Flushing	198	197	99.5%

Note: (1) Of the 198 filters, 98 filters did not see lead above 10 ppb in the unfiltered adjacent samples.

The POU filters, paired with flushing, are recommended for continued use in the interim while the corrosion control in the Pequannock Gradient is optimized and effectively protecting residents from lead service line and/or lead-containing materials in their interior plumbing. According to the results of this study, the precautionary measure taken by Newark to provide bottled water to Pequannock residents with lead service lines during the expanded filter study is not necessary when residents properly use and maintain the filters in combination with flushing.

The following recommendations are intended to further reduce exposure to lead, help residents achieve maximum filter performance and effectiveness, and regain public confidence in the reliability of the Pequannock drinking water supply when flushing and properly using filters:

- **Emphasize flushing prior to use of filters to reduce lead levels in the unfiltered water**
  - To achieve maximum benefits from the filters, it is recommended that residents flush for a minimum of 5 minutes after the water has not been used for several hours prior to filtering. Flushing should be done through the bypass (i.e. with the filter in the "off" position).
  - Lead levels are significantly lower in the flushed samples than the first draw and service line samples. As shown in 197 PUR filters, once water from the water main was passed through the filters, rather than the water in the service line, 100% of the samples passing through filters that were properly installed and maintained had lead concentrations at or below 10 ppb. The home that did not see 10 ppb or below in the flushed sample had a longer than average service line. A longer flush would likely be required for this home in order to get lead levels below 10 ppb.
  - Flushing for a minimum of 5 minutes at a moderate flowrate (1.0 to 1.5 gpm) or higher is adequate for most homes in the Pequannock system to discard the stagnated water in the service line and reach the water in the water main. Homes with a longer yard should flush for 8 minutes at a moderate flowrate to reach the water from the water main.
  - Based on Newark's water rates, flushing the water for 5 minutes will cost less than $0.03 per flush.
- **Specific considerations for PUR pitcher filters**
  - Because of the limited amount of data on the performance of pitcher filters, residents who are able to use faucet filters should be advised to do so. Residents using either a pitcher filter or a faucet filter should also flush before using water for drinking or cooking.
  - The plumbing fixtures in some homes may make it difficult to install a faucet filter. For such residents, it is particularly important that they flush and properly use and maintain pitcher filters.
  - Flushing for pitcher filters should be done at the faucet. Once flushed for a minimum of 5 minutes, or 8 minutes for properties with longer service lines, collect the water from the main to filter with the pitcher rather than the water that may have been sitting in the service line to the home.
  - Residents should only use pitcher filter cartridges certified to remove lead to the NSF 53 Standard.
  - PUR has provided an updated video for installing pitcher cartridges, which is posted on Newark's website. In addition, PUR has developed a new pitcher cartridge (a second generation of the PPF951K cartridge with the same model number) certified for lead removal that is easier to install, which will be used by Newark for future replacement cartridges.

- PUR recommends filtering a maximum of 2 gallons per day through a pitcher filter for a maximum usage of 40 gallons prior to changing the filter cartridge.

- **Continue and enhance public education on how to flush effectively and on proper filter installation and use**

  - Public education and awareness will be required to regain public confidence in relying on the filters for their drinking water.

  - Continue providing videos and flyers on social media, television and print media regarding proper installation of a filter and replacement cartridges and how to flush effectively.

  - It is recommended that additional information regarding the filter use be provided to the residents with each filter and/or package of cartridges to clarify the instructions provided with the filter.

  - Public education is recommended to cover the following information to residents:

    - *Information on flushing for a minimum of 5 minutes, or longer if a resident has a longer service line, to improve the performance of the filters. Newark to reach out to the residents with longer service lines to provide the proper information on flushing.*

    - *Critical information to convey to the residents with each filter and/or package of cartridges should include information on flushing, the indicator light, using cold water only in the filter, and the correct replacement cartridges to be used.*

    - *Instructions on performing routine maintenance on their filters and fixtures to maximize performance. These maintenance activities include removing the filter housing and clearing the screen (or aerator) of any build-up of particles, cleaning the aerator from a faucet without a filter-mount of any build-up of particles, and performing flushing with the aerator and filters detached to help reduce lead levels.*

    - *Operating PUR faucet filters on a cycle with no more than two minutes of use, followed by 18 minutes of rest to maximize performance according to the manufacturer and only using PUR pitcher filters to filter 2 gallons per day.*

    - *Filters should not be used for washing dishes due to the tendency to use hot water and to run the water through the filter for more than two minutes. It is recommended that residents that have used filters for washing dishes, replace the filter cartridge and be instructed that the filter not be used for washing dishes.*

    - *Safe uses of unfiltered water should be discussed such as showering, washing dishes, laundry and washing hands to avoid over-use of the filters and inadvertently using with hot water through the filters.*

- **Continue to provide access to filters and cartridges certified to reduce lead**
  - It is recommended that Newark educate the public to replace incorrect cartridges in their pitcher filters with the lead-reducing cartridges certified to NSF standards for those that were not already replaced by the samplers. Specifically, Newark should reach out to the filter study participants that were using the incorrect pitcher cartridge and provide replacements. To be sure they are using the correct cartridge, residents should be encouraged to get their replacement cartridges through the Newark filter distribution program.
  - Awareness through printed information and photos of the correct and incorrect cartridges are recommended to be included on the website and in public communication material.
- **Continue to improve corrosion control treatment in the water supply**
  - Optimize the corrosion control treatment with additional studies and close monitoring of the system.
  - Provide residents with updates on the progress of the corrosion control treatment with the quarterly newsletter and with updates on the website (www.newarkleadserviceline.com).
- **Continue to replace lead service lines**
  - It is recommended that Newark continue their lead service line replacement program, which will help to reduce the lead levels seen in the unfiltered samples and maximize the effectiveness of the POU filters.
- **Follow-up on site-specific recommendations in Section 5**
  - Newark to follow-up with the five residences with filter failures discussed in Section 5.2 to verify that the additional recommended analysis was completed and the information provided to the residents.

Works Cited

Bosscher, V., Lytle, D., Schock, M., Porter, A., & Del Toral, M. (2019). POU Water Filters Effectively Reduce Lead in Drinking Water: A Demonstration Field Study in Flint, Michigan. *Journal of Environmental Science and Health*, 484-493.

CDM Smith. (2019). *Pequannock WTP Corrosion Control Review and Recommendations - Final.* Edison.

CDM Smith. (2019). *Wanaque Gradient Corrosion Control Review.* Edison.

Giammar, D. (2017). *Processes Controlling the Time for Orthophosphate to Achieve Effective Corrosion Control.* Water Research Foundation.

Helen of Troy. (2019). *PUR Filter Website*. Retrieved from PUR Filters: https://www.pur.com/the-lab/water-filters-how-do-they-work

NSF International Standards. (2018, July 15). NSF/ANSI 53 - 2018 - Drinking Water Treatment Units - Health Effects. Ann Arbor, Michigan, USA: NSF International.

USEPA. (2016). *Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems. Office of Water (4606M).*

Water Research Foundation. (2019). Processes Controlling the Development of Effective Lead Corrosion Control with Orthophosphate - WRF #4686. *The Water Research Foundation Webinar.*

Zhao, J., Giammar, D., Pasteris, J., Dai, C., Yeunnook, B., & Hu, Y. (2018). Formation and Aggregation of Lead Phosphate Particles: Implications for Lead Immobilization in Water Supply Systems. *Environmental Science & Technology*, 12612-12623.

Appendix A
Sampling Protocol

This page intentionally left blank.

Memorandum

To: *Kareem Adeem, Acting Director,*
Department of Water & Sewer Utilities, City of Newark

From: *Sandy Kutzing, P.E., CDM Smith*

Date: *September 4, 2019*

Subject: Sampling Protocol for Point of Use (POU) Filter Testing – Multiple Filters (version 5)

A protocol was provided on August 5, 2019 for filter sampling at three (3) homes in the City of Newark (City). Based on the protocol review and the results, it was determined that a larger sampling pool is needed with more representative samples passing through the point of use (POU) filters based on actual usage to access exposure and efficacy of the filters.

The goal of the original protocol dated August 5, 2019 was to challenge the filters and consider the worst-case scenario at three (3) homes, i.e. samples from the lead service line after 6+ hours of stagnation time. There were two (2) rounds of sampling conducted, one round for all three homes conducted on July 8-10, 2019 and a second round for two (2) of the three (3) homes conducted on August 6, 2019. Not all of the filters met the expected lead reduction in the samples taken from the stagnated water in the lead service line. However, the faucet filters did operate as expected for the first draw and flushed samples with filtered lead levels at 2 ppb or lower. The pitcher filter tested did not reduce lead levels as expected for the filtered first draw and flushed samples in addition to the stagnated sample from the lead service lines.

The goal of this protocol is to obtain samples from more homes with filters in the Pequannock system with varying periods of stagnation to better represent varying water usage by residents and differing lead sources and lead levels in the City. Samples in the lead service line are targeted to compare with the results of the worst-case scenario samples that were previously analyzed. First draw samples on premise plumbing for homes both with and without lead service lines will also be targeted. Both filtered and unfiltered samples will be taken, however, the testing does not represent before and after filtration as each sample volume represents a different section of plumbing.

Selecting Samples

The sample sites that tested above 50 ppb in recent LCR Compliance Sampling will be targeted for both homes with lead service lines and homes without lead service lines. In addition, door-to-door sampling will be conducted to obtain a large pool of samples. The field team will attempt to verify whether or not there is a lead service line at the meter when on-site to perform the sampling. This will be noted in the field notes.

Filters with green and yellow indicator lights will be targeted for testing. Several filters with red indicator lights will also be tested and recorded. If the indicator light is red, the sampler will test the filter, replace the filter cartridge, condition the new filter and stress the importance of replacing the filter cartridge on a regular basis with the resident. The sampler will attempt to schedule a return visit later that day or the following day to test the new filter.

Single family homes will be targeted, however, multi-family homes (maximum 3 family) will also be sampled especially if on the list of sites that experienced lead levels above 50 ppb in previous compliance sampling. Many single family homes have been converted to two or three-family homes in Newark and these will be sampled, preferably on the first floor.

Based on the site audit data for several homes in the City, it appears that the 6th and 7th liter typically represents the water in a service line in single family homes. Therefore, for homes with the distance from home to water main is 40-feet or less, the 6th liter will be sampled. The 7th liter will be sampled for homes with the distance from home to water main is over 40-feet, if the faucet being sampled is on the second floor, or if there is extensive piping after the meter. The sample location may be adjusted in the field at the discretion of the samplers as needed and will be noted in the field notes. In addition to the service line samples, first draw samples and flushed samples will be taken for analysis at each home.

The following samples will be taken at each home visited:

1. **Pequannock, lead service line** (based on sampling category from sampling pool, verified on-site, or high confidence based on materials database)
    a. First draw sample – filtered 500 mL sample, then unfiltered 500 mL sample
    b. 6th or 7th liter (or adjusted based on estimated service line location) – filtered 500 mL sample, then unfiltered 500 mL sample (adjust location of sample based on approximate lead service line length, significant indoor plumbing or faucet not on first floor)
    c. 5 minute flush – unfiltered 500 mL sample, then filtered 500 mL sample
2. **Pequannock, no lead service line** (based on sampling category from sampling pool, verified on-site, or high confidence based on materials database)
    a. First draw sample – filtered 500 mL sample, then unfiltered 500 mL sample
    b. 6th or 7th liter (or adjusted based on estimated service line location) – filtered 500 mL sample, then unfiltered 500 mL sample
    c. 5 minute flush – unfiltered 500 mL sample, then filtered 500 mL sample

Preparing the Samples

Samples will be taken from the kitchen sink in increments of 500 mL. Aerators, both on filter units and on taps without filters, are to remain, and should be unaltered, during sampling. Only cold water is to be sampled. The sampler shall collect the information listed in the Field Notes sheet included in Attachment No. 1 and record in the Survey 1,2,3 app. It is important to determine when the water was last used in the home and also at the kitchen faucet specifically. The sampler will also ask questions on how the filter is typically used.

Each sample is provided a unique ID which includes the date, address and sample number. The ID is automatically generated by the app. Water sample location along the service line (i.e. first draw, service line and which liter it was taken at, flushed) is to be included in the field notes.

Bottles shall be labeled prior to collecting the samples with waterproof labels and a "Sharpie" pen. The tops of the bottles are to be labeled in addition to the labels on the sides of the bottles. The samples are to be taken at the kitchen faucet continuously by running the cold water tap at a flowrate that would typically be used by the residents to fill a glass of water. It is critical to open the faucet gently and to keep the flow continuous and at a constant flowrate to avoid disrupting insoluble lead particles on the pipe walls.

The samples must be chilled in a cooler with ice and brought to 239 Central Avenue at the end of each day. The samples must be preserved with concentrated nitric acid to a pH of less than 2 Standard Units (S.U.). A single source of concentrated nitric acid for all samples collected, will be used to reduce the potential for any variability between acid sources. The concentrated nitric acid will be added to the water samples, after collection, at the sample processing location at 239 Central Avenue, Newark, NJ by the samplers. Safety googles and nitrile gloves must be worn when preserving samples. Preservation status of the samples must be annotated on the chain of custody.

Once the sample is preserved, it does not need to be chilled with ice. A chain of custody form shall be completed for each sampling location and placed into a plastic bag inside the cooler along with any additional paperwork required by the individual laboratories. The chain of custody forms must be checked with the labels both at the sampling site and again when packed for the laboratory. The samples can be held and dropped off at the laboratory the following day, however, this will impact turnaround time and add 1 day to the analysis. Overnight samples shall be stored in a secure location to not break the chain of custody. The samples shall be transported by a member of the sampling team (i.e. Sample Runner) to the laboratories. An example chain of custody is included in Attachment No. 2.

Conducting the Sampling

The specific procedures for sample collection of the faucet filters and pitcher filters are as follows. All sample bottles shall be certified, pre-cleaned HDPE wide-mouth single-use bottles.

Pequannock, Lead Service Line

Faucet Filter Sampling

1. Place the filter in the "on" position. Start a timer and turn on the faucet.
2. Collect a first draw 500 mL sample in a new bottle with the filter "on" (i.e. first draw, filtered sample).
3. Immediately following the first sample, turn the filter "off" and collect a 500 mL sample in a new bottle with the filter "off" (i.e. second draw, unfiltered sample).
4. For the 7th liter samples, collect and dump 10 x 500 mL samples to drain using "waste" bottles to reach the 13th 500 mL sample in the line, or start of the 7th liter. The first 9 should be unfiltered (filter "off") and the final 10th waste bottle should be filtered (filter "on"). This location should represent the water in the lead service line for most homes with lead service lines in the Pequannock area. Adjust the location of the sample as needed for houses less than 40-feet from the main or for other reasons discussed above.
5. One (1) 500 mL sample shall be collected with the filter in the "on" position in a new 500 mL bottle (i.e. service line, filtered sample).
6. The filter shall be switched to the "off" position and one (1) 500 mL sample shall be collected in a new 500 mL bottle (i.e. service line, unfiltered samples).
7. Continue running the faucet with the filter in the "off" position until 5 minutes is reached on the timer. The unfiltered flowrate can be taken during this time by recording the time to fill a 500 mL bottle.
8. When 5 minutes is reached on the timer, collect a flushed, unfiltered sample (i.e. 5 minute flushed, unfiltered sample).
9. Turn the filter to the "on" position and run the water for 10 seconds. Collect a flushed sample (i.e. 5 minute flushed, filtered sample).
10. Measure the flowrate with the filter "on" by recording the time to fill a 500 mL bottle.
11. The following parameters shall be tested by a certified laboratory for each sample:
    - 500 mL bottles: total lead

Pitcher Filter Sampling

1. Start a timer and turn on the faucet.
2. Collect a first draw 500 mL sample in a new bottle (i.e. first draw, filtered sample).

3. Collect a second 500 mL sample immediately after the first sample in a new bottle (i.e. second draw, unfiltered sample).

4. Collect and dump 10 x 500 mL samples to drain using "waste" bottles to reach the 13th 500 mL sample in the line, or start of the 7th liter. This location should represent the water in the lead service line for most homes with lead service lines in the Pequannock area. Adjust the location of the sample as needed for houses less than 40-feet from the main or for other reasons discussed above.

5. Collect two (2) 500 mL samples consecutively in new 500 mL bottles (i.e. service line samples – filtered and unfiltered),

6. Continue running the faucet until 5 minutes is reached on the timer. The flowrate can be taken during this time by recording the time to fill a 500 mL bottle.

7. When 5 minutes is reached on the timer, collect two flushed sample (i.e. 5 minute flushed samples – filtered and unfiltered).

8. If the pitcher has a new filter cartridge that has not yet been used to filter water, run water through the filter by filling the top portion 3 times with flushed water from the faucet after all of the sampling is complete. If the filter has been used to filter water for the resident, this step is not required.

9. Shake the first 500 mL sample and pour it into the filter pitcher and filter the entire sample. Pour the filtered water into a new 500 mL bottle and discard the first bottle.

10. The second sample should not be filtered through the pitcher as it represented unfiltered water.

11. The third sample (i.e. filtered service line) should follow the same protocol as the first sample (step #9).

12. The fourth (i.e. unfiltered service line) and fifth (i.e. unfiltered flushed) samples do not get filtered.

13. The sixth sample (i.e. filtered flushed sample) should follow the sample protocol as the first sample (step #9)

14. The following parameters shall be tested by a certified laboratory for each sample:

    - 500 mL bottles: total lead

Guidance on Different Field Scenarios

The following provides some guidance on handling various field scenarios:

1. Resident does not have a PUR filter provided by the City or any other filter.
    a. Provide the resident with a filter, install and condition. If the sampler does not have a filter, report this address to the City for a filter to be delivered.
    b. Offer to come back to test the filter once it's been in use.
2. Resident has a PUR filter but also uses another type of filter – typically a refrigerator door filter that they use for drinking water.
    a. If the resident also has a PUR filter, test the PUR filter per the protocol in this document.
    b. After the flushed filtered/unfiltered samples are collected from the PUR filter, collect a flushed sample from the fridge filter.
    c. Collect the information from the fridge filter and record it in the field notes on the app.
3. Resident does not have a PUR filter but has another type of filter.
    a. Test the filter per the protocol in this document.
    b. If it is a refrigerator door filter, Take a first draw from the refrigerator door filter. Second sample should be unfiltered second draw sample. No other samples should be taken.
4. Multiple residents in the same building request sampling.
    a. Test only from the lowest floor that the sampler has access to.
5. Filter indicator light is red.
    a. Assist the resident in changing out the filter cartridge with a new cartridge and condition the filter.
    b. Schedule a return visit to test the new filter.
6. Resident has a new filter that has not been used yet.
    a. Schedule a return visit once the filter has been used for at least 1 day.
7. Resident is currently using water.
    a. Schedule a return visit to a time when the water will not be in use.
8. Low flow through filter.

a. If it takes more than 1 minute to fill a 500 mL bottle, stop sampling and replace the filter with a new cartridge. Assist the resident with conditioning the filter and schedule a return visit.

Further Studies

Results will be provided on a rolling basis as they are analyzed. This testing protocol will be modified and/or expanded as needed based on the results.

Total lead (soluble and particulate lead combined) will be analyzed with the collected samples under this testing protocol. Soluble lead and particulate lead particles will be analyzed under a separate study involving ultrafiltration at the three (3) original test locations in the Pequannock area and additional homes if possible.

Attachments:

Attachment No. 1 – Field Notes
Attachment No. 2 – Chain-of-Custody Example

City of Newark Filter Testing Field Notes

Address:_____

Account No.: _____

Sample	Filtered / Unfiltered	Volume (Total Lead) (mL)	Time since turned faucet on (0 for 1st draw) (seconds)	Approx cumulative volume (at start of sample) (mL)	Notes
1	Filtered	500		0	Start timer before turning on faucet.
2	Unfiltered	500		500	
3	Filtered	500		6000	With 2 waste bottles, collect and dump 10 bottles (9 unfiltered, 1 filtered). Collect 13th sample in a new bottle for a filtered sample in the LSL. (Adjust if a very long or short service line)
4	Unfiltered	500		6500	Turn off filter. Immediately collect the 14th bottle in a new bottle for an unfiltered sample in the LSL.
5	Unfiltered	500		5 minutes from start	Run water unfiltered until 5 minutes from start of testing. Sample unfiltered at 5 minutes.
6	Filtered	500		5 minutes from start (approx)	Turn on filter, flush for 10 seconds and then sample filtered.

DATE AND TIME OF SAMPLE DATE _____ TIME _____

SAMPLES COLLECTED BY: _____ SIGNATURE: _____

HOMEOWNER/TENANT QUESTIONS

NAME? TENANT/HOMEOWNER? _____

TIME SINCE MOST RECENT WATER USAGE AT KITCHEN FAUCET: HOURS: _____ (STAGNATION)

TIME SINCE MOST RECENT WATER USAGE IN HOUSE: _____ (STAGNATION)

ANY MAJOR USES OF WATER TODAY AND WHEN? (i.e. showers, laundry, dishes, etc.) _____

FREQUENCY OF USE OF FILTER? WHAT IS IT USED FOR? _____

COLD AND/OR HOT WATER USE THROUGH FILTER? _____

WHEN WAS FILTER CARTRIDGE LAST REPLACED (APPROX)? _____

HAVE THEIR BEEN ANY RECENT PLUMBING CHANGES? _____

HAS THEIR BEEN ANY RECENT CONSTRUCTION IN YOUR AREA? _____

RESIDENCE TYPE (BASED ON OBSERVATION)? _____

SAMPLER ITEMS TO COMPLETE

SERVICE LINE MATERIAL: _____

PLUMBING MATERIAL (I.E. COPPER, PEX, ETC.): _____

APPROX LENGTH FROM MAIN TO HOUSE (NOTE EXTENSIVE INTERIOR PLUMBING): _____

FAUCET LOCATION AND FLOOR: _____

SECONDS TO FILL 500 ML BOTTLE (UNFILTERED) (secs): _____

SECONDS TO FILL 500 ML BOTTLE (FILTERED) (secs): _____

FILTER TYPE - FAUCET OR PITCHER _____

FILTER AND CARTRIDGE BRAND AND MODEL NO.: _____

LIGHT INDICATOR ON FILTER (GREEN, YELLOW, RED) _____

SAMPLER TO CONFIRM FILTER INSTALLED PROPERLY. VISUAL CHECK BEFORE SAMPLING AND OPEN FILTER HOUSING AFTER SAMPLING. CONFIRM CATRIDGE INSTALLED PROPERLY. _____

COMMENTS/NOTES: _____

Attachment No. 2

CHAIN OF CUSTODY FORM
CDM Smith
Filter Testing

SAMPLING LOCATION	CLIENT INFORMATION	LABORATORY INFORMATION	
SEQUENTIAL SAMPLING ADDRESS:	CLIENT: Sandra Kutzing, CDM Smith kutzingSL@cdmsmith.com	NAME:	DATE OF DROP OFF:
Account No.:	ADDRESS: 110 Fieldcrest Ave, #8, 6th Floor Edison, NJ 08837	ADDRESS:	TURNAROUND TIME:

MEDIA TYPE	PRESERVATIVES	SAMPLE TYPE	ANALYSIS	BILLING INFORMATION
1. Surface Water	1. HCL, pH <2	G = Grab	Total Lead	
2. Groundwater	2. HNO3, pH <2	C = Composite		
3. Leachate	3. NaOH, pH >12			
4. Field QC	4. H2SO4, pH <2			
5. Soil/Sediment	5. Zinc Acetate, pH >9			
6. Oil	6. Ice Only			
7. Waste	7. Not Preserved			
8. Other Drinking Water	8. Other			

Sample No.	Sample ID		Media Type	Sample Type	Preserve	Volume (mL)	Date Sampled	Time Sampled	Analysis - Total Lead	Comments
1		-FILTERED-FD-1	DW	G	2	500			x	
2		-UNFILTERED-FD-2	DW	G	2	500			x	
3		-FILTERED-SL-3	DW	G	2	500			x	
4		-UNFILTERED-SL-4	DW	G	2	500			x	
5		-UNFILTERED-FLUSH-5	DW	G	2	500			x	
6		-FILTERED-FLUSH-6	DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	
			DW	G	2	500			x	

SAMPLER SIGNATURE:	RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	DATE/TIME:

Appendix A - Sampling Protocol

Appendix B

Quality Assurance Project Plan (QAPP)

This page intentionally left blank.

Quality Assurance Project Plan (QAPP)
For
Newark Filter Evaluation Study
August 2019 Version 1

Approvals

Newark Water Department:

Program Sponsor: Kareem Adeem | Kareem Adeem | 9/5/19
Print Name | Signature | Date

New Jersey Department of Environmental Protection:

Project Officer: Patricia Gardner | Patricia Gardner | 9/5/19
Print Name | Signature | Date

Quality Assurance Officer: Debra Waller | Debra Waller | 9/10/19
Print Name | Signature | Date

Third Party Firm- CDM Smith Inc:

Project Manager: Sandra Kitay | Sandra Kitay | 9/5/19
Print Name | Signature | Date

Reviewed by:

Laboratory: NJ DOH Environmental + Chemical Laboratory Svcs.
Name of Laboratory

Laboratory Manager: Douglas R. Haltmeier — 9/10/19
Print Name | Signature | Date

Laboratory QA Officer: Michael (Tina) Fan — 9/10/19
Print Name | Signature | Date
For SYR-QAO

Laboratory: EPA Region 2 Laboratory
Name of Laboratory

Laboratory Manager: John Bourbon
Print Name | Signature | Date

QA Officer: Donna Ringel
Print Name | Signature | Date

Laboratory: _____
Name of Laboratory

Laboratory Manager: _____
Print Name | Signature | Date

Laboratory QA Officer: _____
Print Name | Signature | Date

Reviewed by:

Laboratory: _____
Name of Laboratory

Laboratory Manager: _____
Print Name Signature Date

Laboratory QA Officer _____
Print Name Signature Date

Laboratory: EPA Region 2 Laboratory
Name of Laboratory

Laboratory Manager: John Bourbon J.R. Bourbon 9/5/19
Print Name Signature Date

QA Officer: Donna Ringel Carol Lynn for D. Ringel 9/5/19
Print Name Signature Date

Laboratory: _____
Name of Laboratory

Laboratory Manager: _____
Print Name Signature Date

Laboratory QA Officer: _____
Print Name Signature
Date

Reviewed by:

Laboratory: _____
Name of Laboratory

Laboratory Manager: _____
Print Name Signature Date

Laboratory QA Officer _____
Print Name Signature Date

Laboratory: EPA Region 2 Laboratory
Name of Laboratory

Laboratory Manager: John Bourbon
Print Name Signature Date

QA Officer: Donna Ringel
Print Name Signature Date

Laboratory: City of Newark Water Dept
Name of Laboratory

Laboratory Manager: SELENE SAMUEL Selen Samuel 9/5/19
Print Name Signature Date

Laboratory QA Officer: JIGNESH RANA Jignesh 9/5/19
Print Name Signature Date

Table of Contents

1.0 Objective & Goals/Background

1.1 Objective and Goals

The overall objective for this QAPP is to assess concentrations of lead in filtered and unfiltered drinking water at selected sampling sites within Newark Water Department's service area, including homes where existing analytical data, collected through compliance monitoring and customer requested sampling, indicates elevated levels of total lead in unfiltered drinking water. The overall goal of this QAPP is to produce a robust data set for use in any possible future policy decisions regarding lead in drinking water; including determining if properly installed, used and maintained filters distributed by the City of Newark are effectively removing lead from drinking water. Any future data use, that is not in line with the objective stated may require a secondary use of data QAPP.

1.2 Background

Lead is a toxic metal that can be harmful to human health when ingested. Young children are particularly sensitive to the effects of lead because their bodies are still undergoing development. Lead can get into drinking water if it is present in the source water or by interaction of the water with plumbing materials containing lead (through corrosion). Common sources of lead in drinking water include solder, fluxes, pipes and pipe fittings, fixtures, and sediments. It is possible that different drinking water outlets in a given building could have dissimilar concentrations of total lead.

Since 2017, the City of Newark (Newark) through compliance monitoring and additional data collected through customer requested sampling has found elevated levels of lead in drinking water in some homes/buildings. On July 9, 2019, Newark incurred its 5th consecutive lead action level. Due to lead action level exceedances, starting in the first half of 2017, Newark was and is required to take additional actions as required by the federal Lead and Copper Rule (LCR, 40 CFR Part 141.89). These required actions were memorialized by Newark and the Department in a Compliance Agreement and Order ("CAO"), dated July 25, 2018 and a Supplemental Compliance Agreement and Order ("SCAO"), dated March 29, 2019. The orders memorialized actions such as filter distribution which are above and beyond what is required by the LCR.

On May 7, 2019, Newark began using a new corrosion control treatment (CCT) chemical, zinc orthophosphate, within the Pequannock Service Area. As part of the ongoing monitoring and evaluation of the new CCT, three homes were selected for a pilot study. The pilot study was initiated on behalf of the Newark Water Department by CDM Smith. Test results of two of these locations within the Pequannock Service Area, provided to Newark on August 9, 2019, have shown that drinking water samples through PUR® water filters may not be removing lead to the low levels expected by the city, state, and federal officials.

Out of an abundance of caution, the City is notifying residents that these filters may not

be working as expected under all conditions as it continues to test filters and filtered water to assess why the water filters in those two homes did not consistently remove lead to levels below the filter certification level of 10 ppb as expected.

2.0 Project/Task Organization

2.1 Program Sponsor: Newark Water Department (NWD)

The Program Sponsor has the overall responsibility for the execution of the Filter Evaluation Study. They are responsible for notification to the City of the sampling program status, obtaining funds for sampling, selecting the Project Manager, requesting/enlisting the assistance from other City departments if needed, approving the QAPP(s), approving the final report for the study results and coordinating with other City officials to make the results of the testing available to the public.

2.2 Project Officer: NJ Department of Environmental Protection (NJDEP)

The Project Officer has the authority to direct the execution of all activities relating to the implementation of Filter Evaluation Study, with special focus on ensuring compliance with the QAPP. They will be responsible to assess field collection functions and work with partner agencies (Newark, CDM Smith and EPA) and direct corrections when necessary to maintain the data accuracy as defined in this plan. If any changes or modifications are made to this plan regarding data collection, as it relates to the objectives(s) and data accuracy required in this project, the Project Officer will ensure that the QAPP and Sampling Protocol is updated and that all original signees of the QAPP will be notified. Final sampling protocols, sample pool size, and sample site selection and any final report will be subject to the approval of the Project Officer.

<u>The Project Officer Responsibilities Include</u>

- Oversight of the Filter Evaluation Study
- Prepare the QAPP for the Project
- Approve final sampling design after consultation with NWD, CDM and EPA
- Approve sample target locations after consultation with NWD, CDM and EPA
- Maintenance of the original signed QAPP
- Review of Laboratory Report & Data Package (LRDP) received from Laboratory
- QA/QC of study data
- In consultation with the Project Manager, identify limitations in the use of any laboratory data due to information provided in the accompanying Field Notes and Chain of Custody and sign-off on final data set
- Final report sign-off with the Sponsor
- Maintain records of training

2.3 Project Manager: CDM Smith Inc Project Manager

The Project Manager reports to the Program Sponsor, both of whom shall be guided by the direction of the Project Officer. The Project Manager is responsible for overseeing the execution of Filter Evaluation Study. This involves the prioritization of homes to be sampled and adherence with the approved Sampling Protocol and QAPP. They serve as the liaison between the Water Department, State Agencies, Federal Agencies and laboratories.

The Project Manager Responsibilities Include:

- Managing the Sampling Protocol
- Oversight of Field Teams to ensure that they adhere to the Sampling Protocol and the QAPP
- Purchasing of equipment needed for lead sampling, ensuring sample bottles, water-proof labels and nitric acid are provided by Department of Health Laboratory
- Coordination with Laboratories, for analysis of total lead in drinking water
- Coordination with Residents and Field Teams to establish sampling schedules, and the protocols they must follow
- Determining targeted sampling locations in consultation with the Program Sponsor and Project Officer
- Review of the Chain of Custody and Field Notes prepared by Field Sampling Teams
- In consultation with the Project Officer identifying limitations in the use of any laboratory data due to information provided in the accompanying Field Notes and Chain of Custody
- Maintenance of documents, reports, and records listed in Section 14 of the QAPP
- Provide updates to Project Partners, the Program Sponsor and the Project Officer
- Retention of other relevant records such as applicable:
    - Purchase orders for analytical costs (copies)
    - Agreement with Laboratory that includes sampling, analysis, and reporting
    - Receipts and invoices (originals or copies)

2.4 Field Sampling Team Lead

The Field Sampling Team Lead responsibilities include:

- General oversight for assigned field sampling event(s)
- Document field activities including any changes to procedures outlined in the Sampling Plan or QAPP, determination of lead service lines, irregular service line

length, filter indicator light, type of filter used, any other pertinent information observed or provided by the homeowner.

- Oversight of proper completion of field notes and COC forms for each assigned residence in the Sampling Protocol which require sign-off by Field Team Lead:
  - City of Newark Filter Testing Field Notes Application (Appendix A)
  - Chain of Custody Form (Appendix B)
- Ensuring that Field Sampling Team has all relevant sampling supplies including sampling bottles, labels, chains of custody, and filter replacements prior to collection of samples
- Preparation of labels for drinking water outlets to be sampled
- Supervision of field activities such as sample collection, flushing and replacement of filters (if required)
- Notifying residents prior to sampling
- Identification of drinking water filters needing to be replaced and install replacement
- Verifying that the *City of Newark Lead Sampling Protocol* (Appendix D) was followed at each sampling site ensuring collection information required in field notes at each sampling site including period of stagnation and typical filter operation
- Supervision of the sampling event
- Prepare samples for shipment and delivery to laboratory per certified laboratory instructions and Sampling Protocol
- Ensuring that samples are delivered to laboratory within the time period specified by the certified laboratory and Sampling Protocol (i.e. by the Sample Runners).

2.5 Laboratory Manager

The Laboratory Manager is responsible for:

- Ensuring that the Laboratory is certified by the NJDEP Office of Quality Assurance for analysis of lead in drinking water (EPA Region 2 Laboratory is NELAP accredited for lead in drinking water as detailed in Section 3.0 of this QAPP)
- Ensuring that the analytical requirements of the QAPP are followed
- Overseeing the laboratory analyses performed in the Laboratory
- Ensuring that the LQAO meets their requirements within the QAPP
- Providing the Lab Report and Data Package to the Project Manager and Project Officer within the agreed timeframe
- Ensuring sample bottles, water-proof labels and nitric acid are provided to the Project Manager.

2.6 Laboratory's Quality Assurance Officer (LQAO)

The LQAO is responsible for reviewing the QAPP and resolving any Quality Control (QC) and Quality Assurance (QA) issues that may arise during the project. The LQAO

should have experience and knowledge of the analytical processes employed. Issues that may compromise the analysis of the samples must be immediately communicated to the Laboratory Manager, Project Manager, and Project Officer. Any result reported not meeting the acceptance criteria for the method must be indicated as such and therefore considered "qualified" data. The symbols used for any qualified data must be explained in the Laboratory Report or within the LRDP. Any sample results associated with qualified data will require reanalysis using the remaining sample volume, whenever possible.

2.7 Field Sampler or Field Sampling Team

The Field Sampler or Field Sampling Team, whether affiliated with NWD, Environmental Consulting Firm and/or a state or federal agency, is responsible for ensuring that field activities are conducted in accordance with this QAPP and the Sampling Protocol.

3.0 Special Training Needs/Certification

Sampling will be performed by the NWD, an Environmental Consulting Firm, or a state or federal agency – i.e., designated Sampling Team staff. Staff performing the sample collection will be properly trained in sampling techniques. The Project Manager in coordination with the Program Sponsor will be responsible for all training. Records of the training will be maintained by the Program Officer.

The Laboratory must be a drinking water laboratory certified by New Jersey (in accordance with the requirements of N.J.A.C. 7:18) for the analysis of lead using USEPA approved drinking water methods. EPA Region 2's laboratory may also perform analyses for this QAPP.

Assessments of laboratory capability are conducted on a routine (two to three year) basis by the NJDEP Office of Quality Assurance (except for EPA Region 2 which is accredited by the New Hampshire Environmental Laboratory Accreditation Program who is responsible for the assessment). The NJ Certified Laboratory Manager has responsibility for correction of all deficiencies in their laboratory.

4.0 Project Description

The goal of this project is to obtain drinking water samples from homes with filters in the Pequannock section of Newark Water Department's system with varying periods of stagnation to represent varying water usage by residents and differing lead sources and lead levels in the City. Samples in the lead service line are targeted to compare with the results of the worst-case scenario samples that were previously analyzed. First draw samples on premise plumbing for homes both with and without lead service lines will also be targeted. Both filtered and unfiltered samples will be taken, however, the testing does not represent before and after filtration as each sample volume represents a different section of plumbing.

Single family and multi-family homes that had elevated lead results in the most recent Lead and Copper Rule compliance sampling will be targeted. In addition to targeted homes, door-to-door sampling will be initiated to gather a larger pool of samples. Samples will be taken at the kitchen sink at varying intervals to represent residential usage as well as differing lead sources within premise plumbing, the service line and the City's piping.

The Field Sampling Team will try to determine if there is a lead service line based on a visual inspection of the meter and make a note in the Field Notes application. Both lead service lines and non-lead service lines will be sampled.

The Field Sampling Team will conduct a sampling event following the *City of Newark Lead Sampling Protocol* at each residence (Appendix D). The Sampling Team will consist of the Field Sampling Team Lead and the two additional Field Sampler(s). The NJ Certified Laboratory(ies) or EPA Region 2's laboratory as specified in Section 8 of the QAPP will perform the analysis for lead. The sampling protocol maybe modified throughout the project as needed. If there are modification to the protocol the Project Manager will notify the Project Sponsor, Project Officer, Field Team leads and all field samplers, and provided an updated protocol. The updated protocol will also be provided to all signatories and will be added as an addendum to the QAPP.

5.0 Lead Data Quality Objectives and Criteria for Measurement

5.1 Precision

A laboratory fortified matrix (LFM) and a duplicate LFM (LFMD) shall be analyzed with each batch of twenty or fewer samples tested each day. This testing is to access precision where the Relative Percent Difference (RPD) must be less than 20%.

5.2 Bias

In order to identify any bias due to contamination of the water sample from lead sources, Laboratories will perform analysis of Laboratory Fortified Blanks (LFB). The LFB must be carried through the same preparation scheme as the samples including sample digestion, if applicable. The acceptance criterion for the results is to be within plus or minus 15% recovery of the known value as established by the requirements of the approved methods used for this QAPP. In addition, bias or accuracy is also assessed by the Laboratory with the analysis of acceptable calibration verification standards and method blanks required by the approved methods (i.e. EPA Methods 200.8 or 200.9).

5.3 Representativeness

The selection of sample locations, analyses, and sample sizes is designed to collect samples that are representative of concentrations of lead in City of Newark's drinking

water. Kitchen faucets with and without a filter as well as filtered pitchers are to be sampled at varying intervals to represent residential usage as well as differing lead sources within premise plumbing, the service line and the City's piping. The sampling effort is designed to identify the effectiveness of drinking water filters in residential homes, where there is a potential for cold water consumption that may require corrective action due to sampling results exceed 15 µg/L of lead. Final sampling protocols, sample pool size, and sample site selection must be approved by the Project Officer.

5.4 Comparability

Comparability is the degree to which data can be compared directly to similar studies. This is accomplished by maintaining uniformity with collection procedures, analyses and reporting. The approved analytical methods for lead analysis in drinking water listed in Section 7.1 of this QAPP are referenced in the Code of Federal Regulations at 40 CFR141.89 and 40 CFR 141.23 Appendix A to Subpart C. Use of these methods allows for the comparison of data to USEPA's drinking water lead action level of lead concentrations greater than 15 µg/L.

Filtered and unfiltered initial first draw, 7th liter, and the flush sample analytical results from the same drinking water faucet will be compared to assist in determining the source of lead contamination

5.5 Completeness

In order to satisfy the objective of the project, the sampling effort will initially aim for over 225 filter samples to be collected from residential kitchen faucets according to the *City of Newark Lead Sampling Protocol* (Appendix D). Samples will be collected from specified sampling locations, with the goal that one hundred percent (100%) of samples will be analyzed and reported. However, some samples may not meet the data quality requirements of the QAPP and may not generate valid data. The data set will continually be evaluated if the data variability increases or when some samples are disqualified from the analysis due to data quality issues. Additional sampling may be conducted as needed to meet overall objectives. Improperly qualified data (i.e. data associated with failing method blanks or calibration verification standards and samples that are not properly collected or preserved) will not be included in the results for this QAPP.

5.6 Sensitivity

The Laboratory must use a reporting limit (RL) that is less than or equal to 2 µg/L for lead in drinking water samples. This RL is lower than the regulatory Practical Quantitation Level (PQL) for lead of 0.005 mg/L (5 µg/L) from 40 CFR141 Subpart I of the National Primary Drinking Water Regulations. The reporting limit of 2 µg/L, required in this QAPP, is achievable with any of the approved USEPA methods listed in Section 7.1 of this QAPP. The laboratory must include the analysis of a 2ppb standard (or lower) on each day of testing with an acceptance criterion of 50-150 percent recovery. For the purposes of this QAPP, the RL is defined as the lowest concentration that each participating

laboratory uses to prepare the calibration curve for the analysis.

6.0 Field Monitoring Requirements

Sampling will be performed according to the *City of Newark Lead Sampling Protocol* (Appendix D). Sampling may take place either in the morning hours before any usage or in the afternoon hours after residents return from work or school. The sampling effort will aim for over 225 filters sampled under various conditions representing water consumption throughout the day. The data set will be evaluated based on several different identifiers such as type of filter, stagnation time and the current filter light indicator.

6.1 Monitoring Methods

Sampling will be performed according to the *City of Newark Lead Sampling Protocol* (Appendix D). Equipment and supplies that will be needed to perform the sample collection are powder-free latex (preferably non-colored) or nitrile disposable gloves, pre-cleaned, plastic, wide-mouth 500 mL single use rigid sample containers, chain of custody (COC) forms, indelible ink/marker, waterproof sample labels, a timing device, a smart phone or tablet for completion of field notes and at least one cooler with ice for each Field Sampler's water samples. If the cap of the sample bottle is tightened properly, there is no need to worry about melted ice contamination of the sample. However, to be conservative, the samples can be sealed in sealable bags and then put on ice. There is no need for dry ice unless shipping out-of-state. The COC is found in Appendix B. All sample collectors must use the same chain of custody record and provide a completed COC form to the laboratory. Documentation associated with the pre-cleaned sample bottles must be maintained by the Laboratory and made available upon request.

The samples must be preserved with concentrated nitric acid to a pH of less than 2 Standard Units (S.U.). A single source of concentrated nitric acid for all samples collected, will be used to reduce the potential for any variability between acid sources. The concentrated nitric acid will be added to the water samples, after collection, at the sample processing location at 239 Central Avenue, Newark, NJ by the samplers. Safety googles and nitrile gloves must be worn when preserving samples. The pH must be measured and recorded upon receipt at the testing laboratory and must include date and time of measurement and acid addition. Preservation status of the samples must be annotated on the COC. If the samples are not acidified in accordance with the requirements of this QAPP, the analysis of the samples must not proceed.

Samples will be transported by the Sampling Team (i.e. Sample Runner) to the laboratory as described in Section 9 of the QAPP.

6.2 Field Quality Control

Field blanks will not be collected for this project.

The samples must be collected in unused, pre-cleaned 500 mL, rigid, wide-mouth plastic bottles. Sample containers are not to be reused. Documentation associated with the pre-cleaned sample bottles must be maintained by the Laboratory and made available upon request.

7.0 Analytical Requirements

7.1 Analytical Methods

The Laboratory must use one of the USEPA approved drinking water methods listed in the table below for the analysis of lead. Any of these methods can be used provided that the Laboratory is certified to analyze lead using one of these methods. They must be capable of reporting lead to a reporting limit of less than or equal to 2 µg/L.

Laboratory	Analyte	Analytical Method	Sample Matrix	Reporting Limit*
NJDOH	Total Lead	EPA Method 200.8	Drinking Water	1 ug/L
USEPA Region 2	Total Lead	EPA Method 200.8	Drinking Water	1 ug/L
Newark WD	Total Lead	EPA Method 200.9	Drinking Water	2 ug/L

Once samples are acidified with concentrated nitric acid to a pH of less than 2 S.U., the samples must sit for 16 hours, after which the pH measurement is repeated. The pH must be less than 2 S.U. before proceeding with the analysis.

The turbidity of samples must also be measured and recorded regardless of the analytical method being used for lead analysis. If the turbidity of the sample is greater than 1 NTU, the sample must be digested prior to analysis. Samples digested prior to analysis must be indicated in the electronic data submittal which is required with the Lead Laboratory Report & Data Package (LRDP). The turbidity measurements must be provided with the Lead Results in the electronic data submittal.

All samples must be determined in the Laboratory's calibration range and, if not, shall be diluted and re-analyzed.

7.2 Analytical Quality Control

The approved analytical methods found in Section 7.1 include protocols for the analysis of required quality control samples. All quality control results must be assessed and evaluated on an on-going basis. Acceptance criteria are those specified within the

analytical method used or as contained in this QAPP. If any sample result(s) is qualified, this must be clearly indicated on the Laboratory Report and included in the LRDP. The Project Officer and Project Manager must be consulted in order to determine how to address the qualified results. Samples associated with qualified results shall be reanalyzed using the remaining initial sample volume, when possible. If the quality control associated with the reanalysis is acceptable the results can be reported. If the quality control is unacceptable on the reanalysis, then the sample shall be recollected whenever possible. Note, the relative percent difference of the LFM/LFMD should not be used as the sole reason to reject a result if all other method quality control criteria are met. All raw data, qualified or not, shall be retained by the Laboratory for a period of no less than ten years. Records of the analysis shall be retained by the water system for a period of no less than twelve years in accordance with 40 CFR 141.89.

8.0 Sample Handling and Custody Requirements

Chain of Custody (COC) procedures will be followed according to the information provided in the *City of Newark Lead Sampling Protocol* (Appendix D). The COC form (Appendix B) will be used for this project. Each sample is provided a unique ID.
The sample ID numbering system shall be:
DATE(MMDD)-STREET ADDRESS- FILTERED/UNFILTERED- SAMPLE TYPE ABBREVIATION-SAMPLE NO.

Sample Type: FD=First Draw, SL=Service Line, Flush= Flushed

Example: 0809-100 MAIN ST-Filtered-FD-1

Water sample location along the service line (i.e. first draw, service line, flushed) is to be included in the notes on the chain-of-custody and on the field notes.

The raw samples will be transported by Field Sampling Team to Newark Water Department sample processing location as specified in *City of Newark Lead Sampling Protocol* (Appendix D). Samples will be checked in, COC reviewed and samples will be acidified. Samples will remain in the custody of the Project Manager and will be stored overnight. Sample Runners will transport the acid-preserved samples to the Laboratory the following morning.

Analyte	Sample Volume	Container	Preservation (Note1)	Holding Time
Total Lead (Pb)	500 mL	unused 500 mL rigid plastic wide-mouth – pre-cleaned	Reagent Grade Concentrated Nitric Acid (HNO_3) pH < 2	6 months

Note 1. Sample preservation will be performed at the sample processing station. Any water sample not acidified with concentrated nitric acid to a pH of 2 S.U. within 14 days of sample collection must not be analyzed.

8.1 Sample Archive/Disposal

The samples received by the Laboratory for each residence, including any digestates, will be eligible for disposal at a minimum of 30 days unless otherwise directed by the Project Manager after the final report has been distributed. Samples including any digestates will not be archived unless a written request is provided to the Laboratory.

9.0 Instrument/Equipment Requirements

9.1 Instrument/Equipment Testing, Inspection and Maintenance

All laboratory equipment will be tested, calibrated, and maintained in accordance with existing approved SOPs approved by the Laboratory. There are no field instruments anticipated for this project.

9.2 Instrument/Equipment Calibration and Frequency

The USEPA approved analytical methods for lead listed in the National Primary Drinking Water Regulations at 40 CFR 141.23 and Appendix A to Subpart C require that the instrument calibration be performed on a daily basis (i.e. EPA Methods 200.8 or 200.9).

9.3 Inspection/Acceptance of Supplies and Consumables

Sample containers are pre-cleaned, plastic, wide-mouth 500 mL single use rigid sample containers. Sample containers are not to be reused. Documentation for the pre-cleaned sample bottles must be available upon request. Sample gloves are to be powder-free latex (preferably non-colored) or nitrile disposable gloves.

10.0 Data Management

The N.J.A.C. 7:18 certified Laboratory will provide the analytical results in micrograms per liter (µg/L) or ppb (parts per billion) and to at least three (3) significant figures (i.e.19.6 µg/L or 204 µg/L) to the Program Officer. For the sample results produced by the EPA Region 2 Laboratory will provide results, including any results that exceed the 15 ug/L, once validated to Ms. Christine Ash of EPA Region 2, Water Division.

The Laboratory will provide a final electronic copy of the Lead Laboratory Report & Data Package (LRDP) for that will consist of: 1) cover sheet which includes the analytical results with a description of all qualifiers referenced in the laboratory reports, 2) the chain of custody in PDF format and 3) an electronic data submittal (Excel, CSV, etc.) that includes the information outlined in the table provided in Appendix C.. Information required in each field includes, but is not limited to, the Field ID (Sample Location ID Code), the Laboratory Sample ID, the Laboratory Name and NJ Laboratory Certification ID number, whether the sample was filtered, the date and time of collection and analysis, the analytical method, the analytical result in µg/L or ppb, the reporting limit in µg/L or ppb, detection level in µg/L or ppb, turbidity in NTU and whether the sample was

diluted or digested and any other qualifiers.

The LRDP must include explanations of any procedural deviations or anomalies associated with the sample handling and analysis of the project. This report will be completed within the agreed upon timeframe as defined in the contract.

11.0 Assessments/Oversight

The Project Officer will be responsible for the oversight of all activities relating to this project. He/she will assess field collection functions and make corrections when necessary to maintain the data accuracy as defined in this plan. If any changes or modifications are made to this plan regarding data collection, as it relates to the objectives(s) and data accuracy required in this project, all original signees of the QAPP will be notified.

Formal field audits by QA personnel, Program Sponsor, Project Manager, or NJDEP may be conducted for this project. However, identification of problems related to technical performance will be the responsibility of the staff working on this project.

The Field Team Lead will assess any problem that arises in the field. If necessary, modifications to technical procedures may be considered. Any changes in technical procedures will be documented in the field notes and evaluated to determine if there will be any impact to the data. This information must be included in the Final Project Report.

The Laboratory personnel will perform self-audits and institute corrective actions in accordance with their respective written procedures.

12.0 Data Review, Verification, Validation, and Usability

12.1 Data Review, Verification and Validation

Data review of all laboratory generated data is performed by the Laboratory Quality Assurance Officer (LQAO). It is the responsibility of the LQAO, or their designee to ensure that all data generated are correct and of known and documented quality. The LQAO, if also the analyst performing the testing, cannot perform the review of the data and shall designate another analyst familiar with the testing to perform the data review. For EPA Region 2 laboratory the data review will be performed by either the LQAO, Laboratory Management or a peer analyst not directly involved with the analysis.

The Project Officer in consultation with the Project Manager and the Field Teams will review the Laboratory Report & Data Package (LRDP) and identify any limitations on the use of the data and include these limitations. The Project Manager would include any limitations on the use of data as part of the Final Project Report.

12.2 Reconciliation with User Requirements

Providing that the Field Sampling Notes and LRDP of this QAPP are satisfied, the data will be useable for the purpose intended and no further assessment is required. If any data are determined to be unusable by the Project Office in consultation with the Project Manager and Program Sponsor, re-sampling may be required.

13.0 Reporting, Documents and Records

The Final Project Report at a minimum should include: a description of the project; a summary of all project data collected, including both laboratory data and field data; final laboratory data packages; a discussion of the field and laboratory activities, as well as any deviations or modifications and an evaluation of the data in meeting the project objectives.

Original documents (X) will be stored as follows:

Document	Project Officer	Project Manager	Program Sponsor	Time of Storage
QAPP	X	Copy	Copy	12 years
Field Notes	Copy	X	Copy	12 years
Chains of Custody	Copy	X	Copy	12 years
Field Sampling Notes	Copy	X	Copy	12 years
Laboratory Report & Data Package	X	Copy	Copy	12 years
Final Project Report	Copy	X	Copy	12 years

Note: The Laboratory shall also retain all raw data records, as required, for a period of no less than 10 years.

Appendix A: Newark Filter Testing Field Notes

Attachment No. 1

City of Newark Filter Testing Field Notes

Address:_____

Account No.:_____

Sample	Filtered / Unfiltered	Volume (Total Lead)	Time since turned faucet on (0 for 1st draw)	Approx cumulative volume (at start of sample)	Notes
		(mL)	(seconds)	(mL)	
1	Filtered	500		0	Start timer before turning on faucet.
2	Unfiltered	500		500	
3	Filtered	500		6000	With 2 waste bottles, collect and dump 10 bottles (5 unfiltered, 1 filtered). Collect 13th sample in a new bottle for a filtered sample in the LBL. (Adjust if a very long or short service line)
4	Unfiltered	500		6500	Turn off filter. Immediately collect the 14th bottle in a new bottle for an unfiltered sample in the LBL.
5	Unfiltered	500		5 minutes from start	Run water unfiltered until 5 minutes from start of testing. Sample unfiltered at 5 minutes.
6	Filtered	500		5 minutes from start (approx)	Turn on filter, flush for 10 seconds and then sample filtered.

DATE AND TIME OF SAMPLE DATE _____ TIME _____

SAMPLES COLLECTED BY: _____ SIGNATURE: _____

HOMEOWNER/TENANT QUESTIONS

NAME? TENANT/HOMEOWNER? _____

TIME SINCE MOST RECENT WATER USAGE AT KITCHEN FAUCET: HOURS: _____ (STAGNATION)

TIME SINCE MOST RECENT WATER USAGE IN HOUSE: _____ (STAGNATION)

ANY MAJOR USES OF WATER TODAY AND WHEN? (i.e. showers, laundry, dishes, etc.) _____

FREQUENCY OF USE OF FILTER? WHAT IS IT USED FOR? WHEN BYPASS FILTER? _____

COLD AND/OR HOT WATER USE THROUGH FILTER? _____

WHEN WAS FILTER CARTRIDGE LAST REPLACED (APPROX)? _____

HAVE THEIR BEEN ANY RECENT PLUMBING CHANGES? _____

HAS THEIR BEEN ANY RECENT CONSTRUCTION IN YOUR AREA? _____

RESIDENCE TYPE (BASED ON OBSERVATION)? _____

SAMPLER ITEMS TO COMPLETE

LEAD SERVICE LINE AT METER? _____

PLUMBING MATERIAL (I.E. COPPER, PEX, ETC.): _____

APPROX LENGTH FROM MAIN TO HOUSE (NOTE EXTENSIVE INTERIOR PLUMBING): _____

FAUCET LOCATION AND FLOOR _____

FLOWRATE MEASURED W/ FILTER (gpm): _____

FLOWRATE MEASURED W/O FILTER (gpm): _____

FILTER TYPE - FAUCET OR PITCHER _____

FILTER AND CARTRIDGE BRAND AND MODEL NO.: _____

LIGHT INDICATOR ON FILTER (GREEN, YELLOW, RED) _____

SAMPLER TO CONFIRM FILTER INSTALLED PROPERLY. VISUAL CHECK BEFORE SAMPLING AND OPEN FILTER HOUSING AFTER SAMPLING. CONFIRM CATRIDGE INSTALLED PROPERLY. _____

COMMENTS/NOTES: _____

Appendix B: Chain of Custody

Attachment No. 2

CHAIN OF CUSTODY FORM
COM Smith
Filter Testing

SAMPLING LOCATION	CLIENT INFORMATION	LABORATORY INFORMATION
SEQUENTIAL SAMPLING ADDRESS:	CLIENT: Sandra Kuting, COM Smith kuting3L@comsmith.com	NAME: / DATE OF DROP OFF:
Account No.:	ADDRESS: 110 Fieldcrest Ave, 8B, 8th Floor Edison, NJ 08837	ADDRESS: / TURNAROUND TIME:

MEDIA TYPE
1. Surface Water
2. Groundwater
3. Leachate
4. Field QC
5. Soil/Sediment
6. Oil
7. Waste
8. Other Drinking Water

PRESERVATIVES
1. HCL, pH <2
2. H2SO4, pH <2
3. NaOH, pH >12
4. H2SO4, pH <2
5. Zinc Acetate, pH >9
6. Ice Only
7. Not Preserved
8. Other

SAMPLE TYPE
G = Grab
C = Composite

ANALYSIS: TOTAL LEAD

BILLING INFORMATION

SAMPLE INFORMATION

Sample ID	LABORATORY SAMPLE ID	MEDIA TYPE	SAMPLE TYPE	VOLUME (mL)	DATE SAMPLED	TIME SAMPLED	TOTAL LEAD	COMMENTS
0.								
1.		DW	G	500			X	
2.		DW	G	500			X	
3.		DW	G	500			X	
4.		DW	G	500			X	
5.		DW	G	500			X	
6.		DW	G	500			X	
7.		DW	G					
8.		DW	G					
9.		DW	G					
10.		DW	G					
11.		DW	G					
12.		DW	G					
13.		DW	G					
14.		DW	G					
15.		DW	G					
16.		DW	G					
17.		DW	G					
18.		DW	G					
19.		DW	G					
20.		DW	G					
21.		DW	G					
22.		DW	G					
23.		DW	G					
24.		DW	G					
25.		DW	G					
26.		DW	G					
27.		DW	G					
28.		DW	G					
29.		DW	G					
30.		DW	G					
31.		DW	G					
32.		DW	G					
33.		DW	G					

SAMPLER SIGNATURE:	RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	DATE/TIME:

Appendix C: Example Template for Electronic Submittal of Lead Results

Field ID	Laboratory Sample ID	Laboratory Name	Lab Certification ID	Date Sampled	Time Sampled	Analytical Method	Date of Analysis	Time of Analysis HH:MM	Concentration (µg/L)	Reporting Limit (µg/L)	Detection Limit (µg/L)	Dilution Factor	Digested (Y/N)	Qualifier	Turbidity (NTU)

Appendix C

Binomial Distribution Statistical Analysis

Newark Filter Testing – Statistical Analysis of Sample Pool

Point-of-use filters are tested for Pb removal. Each test corresponds to an independent test (or trial). Results are either "PASS" (successful removal) or "FAIL" relative to a selected Pb level (e.g., 10 ppb). Each test has an associated PASS rate (probability of successful removal) dependent on environmental conditions, filter characteristics, Pb concentrations, and other factors. The PASS rate is unknown and therefore a hypothetical target.

Binomial Distribution

An appropriate statistical model is the binomial distribution model, which has the following probability function:

$$P(X = x) = \frac{n!}{(n-x)!\,x!} p^x (1-p)^{n-x}$$

where x is the number of filters that PASS, n is the number of filters tested, and p is the hypothetical target PASS rate. The corresponding cumulative probability function is:

$$P(X \leq x) = \sum_{i=0}^{x} \frac{n!}{(n-i)!\,i!} p^i (1-p)^{n-i}$$

To illustrate, suppose that with current data we have x = 56 PASS filters, n = 60 filters tested, and p = 0.90 hypothetical target PASS rate. This results in a cumulative probability of $P(X \leq 56)$ = 0.8626, i.e., given p = 0.90, the probability of obtaining up to 56 PASS filters in 60 filters tested is 0.8626 (86.26 %).

Confidence Interval

The actual realized PASS rate is symbolized by $\hat{p}$ (p-hat) = x/n. A confidence interval can be constructed for $\hat{p}$ using the F distribution:

$$x/(x + (n-x+1)F_{\alpha/2,2n-2x+2,2x}) \leq \hat{p} \leq x/(1 + (n-x)/(x+1)F_{1-\alpha/2,2x+2,2n-2x})$$

This is a 2-sided confidence interval. For a 1-sided lower confidence limit (LCL),

$$x/(x + (n-x+1)F_{\alpha,2n-2x+2,2x}) \leq \hat{p}$$

For the current data illustration, given α = 0.05, the LCL95 is 0.8539, i.e., we can be 95% confident that the current PASS rate is ≥ 0.8539 (85.39%).

Note that n is in the denominator. Therefore, as the number of filters tested increases, the 2-sided confidence interval will narrow, and the 1-side lower confidence limit (LCL) will increase. This can be plotted, as shown in **Figure 1**:

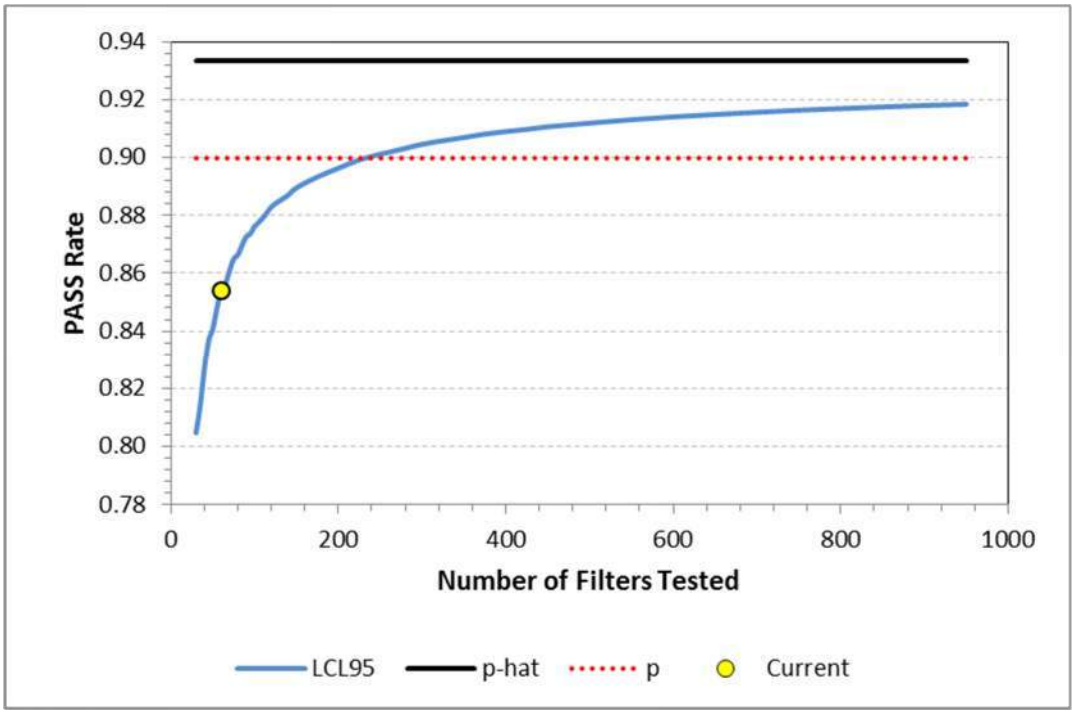


Figure 1 – Power analysis for $\hat{p}$ (p-hat), 95% confidence.

The LCL is the appropriate statistic because we want to be a selected % confident (e.g., 95%) that the actual realized PASS rate $\hat{p}$ (p-hat) is at or above the hypothetical target PASS rate p. Note that for the calculation to be conducted, $\hat{p}$ must be > p. If $\hat{p} \leq p$, then no amount of additional filter testing will be useful, since the LCL cannot exceed $\hat{p}$, assuming, of course, that $\hat{p}$ remains constant.

Therefore, assuming that results will remain constant with increasing numbers of filters tested, we can follow along the blue LCL95 line until it intersects the hypothetical target PASS rate (p = 0.90, the red dotted line in **Figure 1**) to determine the required number of filters to be tested. From the workbook application, this number is estimated to be ≥ 225 filters, as shown below:

n	LCL95
30	0.804673956
35	0.813837515
40	0.826589635
45	0.836611619
50	0.840769875
55	0.847919217
60	0.853902795
65	0.85624221
70	0.860890831
75	0.864928752
80	0.866418363
85	0.869720592
90	0.872660407
95	0.873688407
100	0.876176029
110	0.879180377
120	0.882927638
130	0.885082344
140	0.886999743
150	0.889542468
175	0.893317891
200	0.896308841
225	0.899199814
250	0.901169556
275	0.902850574

Confidence Level

For the 1-sided LCL, the α necessary to achieve a hypothetical target PASS rate (p = 0.90 in the current illustration) can be determined numerically, thus providing the current % confidence level. The results can be plotted, as shown in **Figure 2**. This represents an alternative approach; the same results can be achieved via Figure 1 by varying the required α.

For the current illustration, the % confidence level is 72.84, i.e., about 73% confidence that the actual realized PASS rate is above the hypothetical target PASS rate (0.90). To achieve 95% confidence, the estimated number of filters tested would have to be increased to $n \geq 225$; and to achieve 99% confidence, to $n \geq 425$. Exact numerically-determined results are provided in the workbook application.

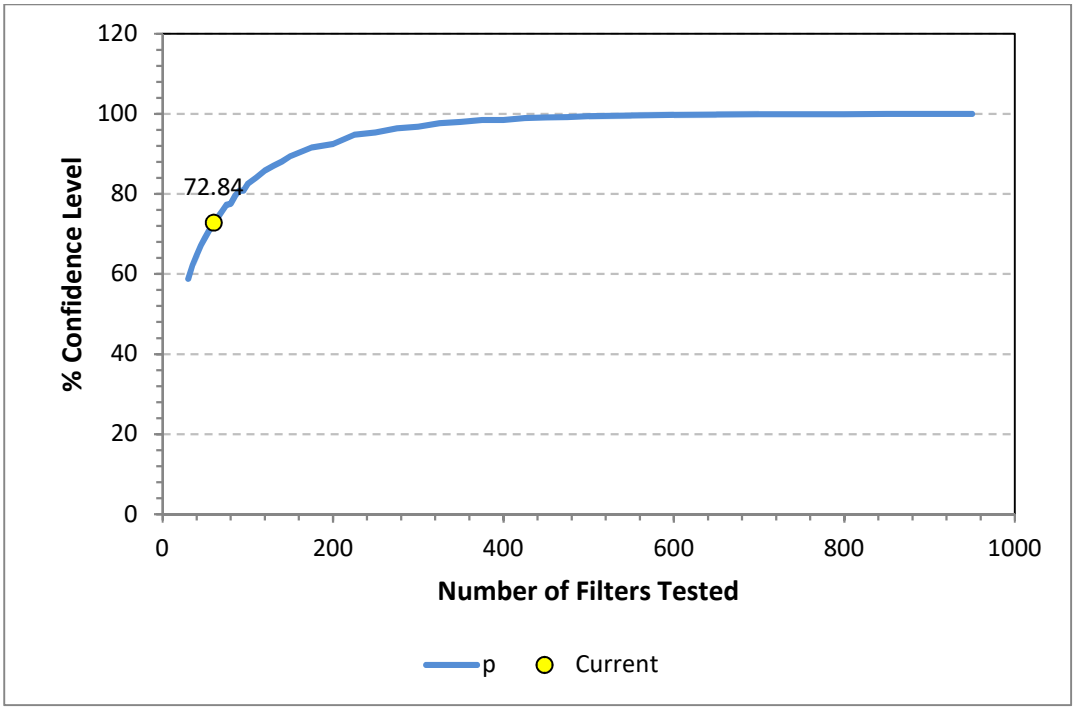


Figure 2 – Power analysis for % confidence level, p = 0.90.

Workbook Application

The calculations provided herein were obtained using the associated workbook application. The workbook application was developed specifically for the Newark project to be a tool to allow rapid calculations of probabilities and numbers of filters required for testing. It can be used to analyze current data or to examine "what-if" scenarios.

Enter values for the binomial distribution model parameters (cells B5:B8) to obtain calculated results (cells B11: B14) and to update the first chart (**Figure 1**). Click the "Calculate" button (or press "Ctrl-Shift-E") or press the "Reset" button followed by the "Calculate button, to calculate % Confidence Levels and to update the second chart (**Figure 2**).

The workbook application contains macros assigned to the "Reset" and "Calculate" buttons, so the workbook must be opened with "macros enabled" in order for the % Confidence Levels (**Figure 2**) calculation feature to work.

Do not change the name of the "Results" sheet and be careful with making any substantial modifications to the contents, structure, or format of the "Results" sheet, or to the code, as this could render the application unusable. Adding additional sheets should not affect the calculations. Do not delete or modify the named ranges specified in the workbook.

CDM Smith®

cdmsmith.com