PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Nick Fish, Commissioner
Michael Stuhr, P.E., Administrator

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April 19, 2017

Carrie Gentry
Oregon Health Authority
Portland State Office Building
800 NE Oregon St., Suite 611
Portland, Oregon 97232

**RE: Interim Lead Reduction Plan**

Dear Carrie,

The Portland Water Bureau has begun implementation of the Interim Lead Reduction Plan. The attached report provides a 90-day update.

Please let us know if you have any questions. We will continue to update you on our efforts in our quarterly Lead Hazard Reduction Program reports.

Sincerely,

Yone Akagi
Water Quality Manager

Portland Water Bureau

# Interim Lead Reduction Plan Update

April 19, 2017

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# Introduction

On December 2, 2016, the Portland Water Bureau (PWB) submitted an Interim Lead Reduction Plan to the Oregon Health Authority as part of its commitment to reducing customer's exposure to lead in water using existing treatment and water system facilities. Section 3.2 of the Lead Reduction Plan outlined the actions to be taken by the PWB as part of the plan. The following is an update on those actions.

# Action Item Updates – Section 3.2

### *3.2.1. Conduct Comprehensive Corrosion Control Treatment Study*

***A comprehensive corrosion control treatment study that evaluates the effectiveness of each of the following treatments: (i) alkalinity and pH adjustment, (ii) Calcium hardness adjustment; and (iii) Phosphate or silicate based corrosion inhibitor.***

On March 8, 2017, the Portland City Council approved a contract with Confluence Engineering Group to perform a Corrosion Control Treatment Pilot. On March 9, PWB, Confluence Engineering Group, Cornwell Engineering Group, HDR, and Black & Veatch held the first workshop to begin work on the Corrosion Control Treatment Pilot. The pilot will study the effectiveness of pH and alkalinity adjustment and the use of a phosphate based corrosion inhibitor as potential corrosion control treatment. This work is anticipated to produce a treatment recommendation by July 2018.

### *3.2.2. Raise pH from 8.0 to 8.2*

***PWB's existing facility should raise the pH from (8) to pH (8.2).***

On February 8, 2017 the PWB increased the target pH at the Lusted Hill treatment facility from 8.0 to 8.1. Once the results of the Spring 2017 LCR Tier 1 home monitoring have been analyzed, the PWB anticipates increasing the target pH to 8.2. This is likely to occur by June 2017. The timing is in line with the EPA's 2016 guidance for optimal corrosion control treatment.

### *3.2.3. Manage Water Age*

***Comprehensive water age management plan including (a) storage tank drain/fill practices to reduce water age; (b) ongoing unidirectional and hot spot (high water age or high lead tap) flushing program.***

The PWB has a comprehensive program in place to optimize system water quality. The goal of this program is to understand and improve water age, chlorine demand/decay, as well as nitrification and microbial regrowth in the system. The PWB accomplishes this through a three pronged approach: monitoring, proactive mitigations, and remediation (if necessary).

Reducing water age is critical as it can improve water quality by stabilizing the chlorine residual, decreasing microbial growth, decreasing temperature during certain times of the year, as well as other indirect benefits such as reduced disinfection byproduct (DBP) formation and fewer taste and odor issues.  PWB actively manages water age in the distribution system through a variety of techniques including the following:  a robust nitrification monitoring and action plan, additional non-regulatory monitoring throughout the distribution system, storage tank management and conduit manipulations, and conventional and unidirectional flushing.  These are discussed in further detail in the subsequent paragraphs.

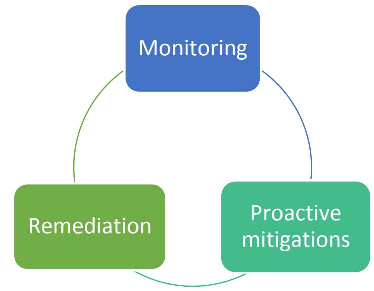



*Figure 1: Three pronged approach to optimize system water quality.*

### Nitrification Monitoring and Action Plan

In 2013, Portland implemented a large-scale nitrification program that took a more holistic approach to evaluating and managing water quality.  The program shifted emphasis from sampling only in problem areas to sampling in all areas hydraulically connected to problem areas.  The goal is to discover where the water quality problems originated, with the overall goal of targeting mitigation efforts at these locations. The 2013 plan is included in Appendix I.  This plan is updated annually to include relevant changes, and Portland's 2016 plan is included in Appendix II.

In Portland's system, nitrification occurs predominantly in late summer and early fall.  This time period corresponds to both the highest water temperatures in the distribution system as well as decreased water usage after Labor Day (and therefore increased water age).

As mentioned above, the monitoring plan is reevaluated annually.   Sites are selected based upon three criteria: 1) areas known or anticipated to have water quality issues, 2) areas that feed problem areas (areas upstream of the problem areas), and 3) areas not monitored under an existing program.


*Figure 2.  Impacts of nitrification on water quality.*

Nitrification monitoring involves substantial sampling in the system.  In 2016, approximately 600 samples were collected at approximately 60 sites and tested for over 4300 analytes.  Parameters monitored under the nitrification program include those tested in the field and in the laboratory. Monitoring takes place weekly or biweekly (depending on the site) and includes the following analytes:

- nitrite
- nitrate
- HPC-R2A (heterotrophic plate count with R2A agar)
- free ammonia

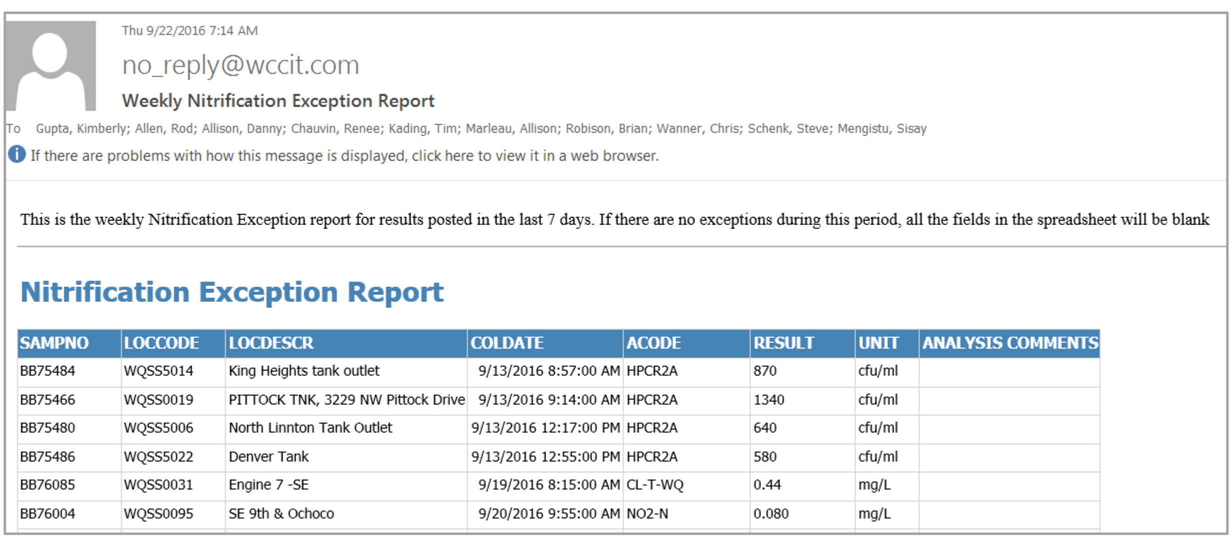
- chlorine residual
- pH
- temperature
- ORP (oxidation reduction potential)
- turbidity

Operational targets and action levels have been set for many of these parameters, some of which are listed in Table 1. It is important to note that these are 2015 targets and are subject to change.

*Table 1. Nitrification Targets and Action Levels (2015 targets).*

| Indicator | Target | Action Level 1 | Action Level 2 | Action Level 3 |
|---|---|---|---|---|
| Total Chlorine (mg/L) | | | | |
| • Tanks | 1.0 | <1.0 | <0.5 | |
| • DS Sites | >0.5 | <0.5 | <0.5 | <0.1 |
| Nitrite-N (mg/L) | <0.020 | >0.050 | >0.1 | |
| Nitrate-N (mg/L) | Background | Increase relative to background | | |
| HPC-R2A (cfu/ml) | <500 | >500 or a significant increase from the previous sampling date | >1000 | |
| Free Ammonia-N (mg/L) | <0.05 (pipes) 0.05-0.15 (tanks) | >0.10 (DS) >0.2 (tanks) | >0.35 | |
| pH | As close to 8 as possible | Less than target | | |

The data collected is used to make operational changes, so it is imperative that it is disseminated as it becomes available. This is accomplished by auto-generating weekly emails from PWB's Laboratory Information System (LIMS) with the list of parameters/sites that exceed trigger levels (Figure 3). Regular meetings are also held with stakeholders, including operations managers, operators and engineers, to discuss the results and make operational decisions in a timely manner.


Thu 9/22/2016 7:14 AM
no_reply@wccit.com
Weekly Nitrification Exception Report
To Gupta, Kimberly; Allen, Rod; Allison, Danny; Chauvin, Renee; Kading, Tim; Marleau, Allison; Robison, Brian; Wanner, Chris; Schenk, Steve; Mengistu, Sisay
If there are problems with how this message is displayed, click here to view it in a web browser.

This is the weekly Nitrification Exception report for results posted in the last 7 days. If there are no exceptions during this period, all the fields in the spreadsheet will be blank

**Nitrification Exception Report**

| SAMPNO | LOCCODE | LOCDESCR | COLDATE | ACODE | RESULT | UNIT | ANALYSIS COMMENTS |
|---|---|---|---|---|---|---|---|
| BB75484 | WQSS5014 | King Heights tank outlet | 9/13/2016 8:57:00 AM | HPCR2A | 870 | cfu/ml | |
| BB75466 | WQSS0019 | PITTOCK TNK, 3229 NW Pittock Drive | 9/13/2016 9:14:00 AM | HPCR2A | 1340 | cfu/ml | |
| BB75480 | WQSS5006 | North Linnton Tank Outlet | 9/13/2016 12:17:00 PM | HPCR2A | 640 | cfu/ml | |
| BB75486 | WQSS5022 | Denver Tank | 9/13/2016 12:55:00 PM | HPCR2A | 580 | cfu/ml | |
| BB76085 | WQSS0031 | Engine 7 -SE | 9/19/2016 8:15:00 AM | CL-T-WQ | 0.44 | mg/L | |
| BB76004 | WQSS0095 | SE 9th & Ochoco | 9/20/2016 9:55:00 AM | NO2-N | 0.080 | mg/L | |

*Figure 3. Sample of automated email sent out from PWB's LIMS system with parameters that exceed trigger levels.*

In anticipation of nitrification season and the water quality issues that may occur during this timeframe, Portland takes a number of proactive measures prior to the onset of nitrification. These include:

- Seasonally increasing the chloramine target leaving the treatment plant
- Taking distribution system tanks out of service (where needed and feasible) to reduce water age
- Adjusting tank operations
- Adjusting regulator settings
- Deployment of autoflushers
- Unidirectional flushing of pressure zones that experienced water quality issues in the prior year
- Increased conventional flushing in known problem areas

These proactive mitigations are implemented each year prior to the onset of nitrification and most are undone after the nitrification season ends.

Although the nitrification action plan seeks a proactive approach to nitrification management, there are times when issues are observed and reactive mitigations must be employed to improve water quality. Portland has developed a toolbox of mitigation strategies to use when issues arise. The toolbox is divided into tiers, and mitigation strategies are based on the severity of the issue observed. Mitigation strategies in PWB's toolbox include:

- Ensuring optimization of chlorine and ammonia injection points
- Increasing sampling
- Adjusting pumping operations to bring fresher water to an area
- Lowering tank operating levels
- Deep cycling tanks
- Draining and refilling tanks with fresh water
- Cleaning tanks ahead of schedule
- Taking storage out of service (where possible based on hydraulics)
- Conventional flushing (including the use of autoflushers)
- Unidirectional flushing
- Increasing the chloramine target leaving the treatment plant

Examples of the use of several of these mitigation strategies in PWB's system and the results are shown in the following figures.

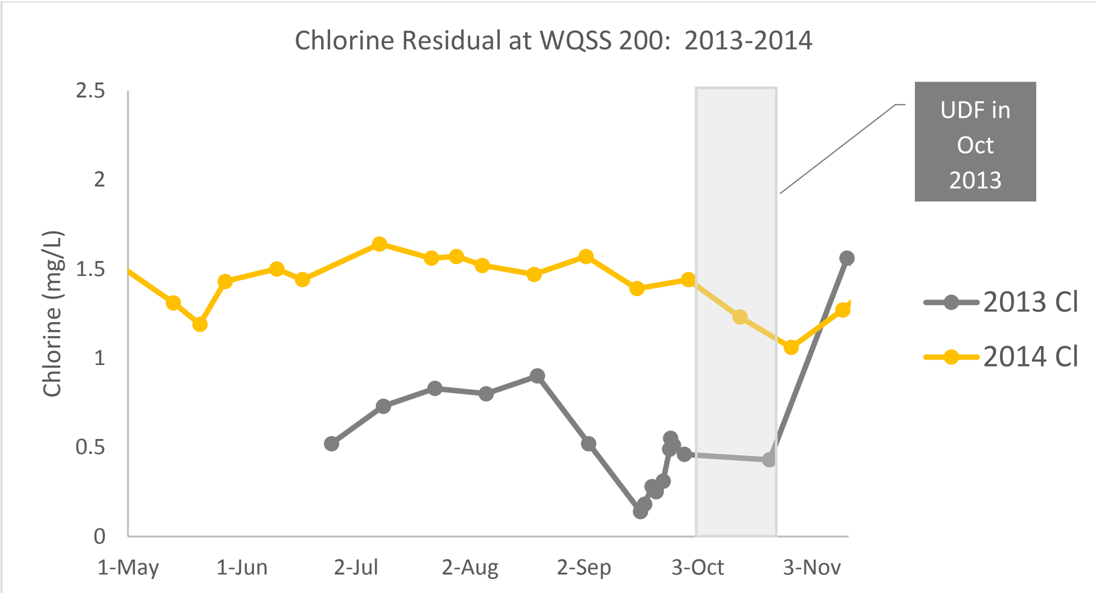



*Figure 4. Example of the effects of unidirectional flushing (UDF) on chlorine residual at a distribution site in PWB's system. This figure compares 2013 and 2014 chlorine residual at a water quality sampling station. After UDF of that area in 2013, chlorine residual increased and remained higher the following year.*

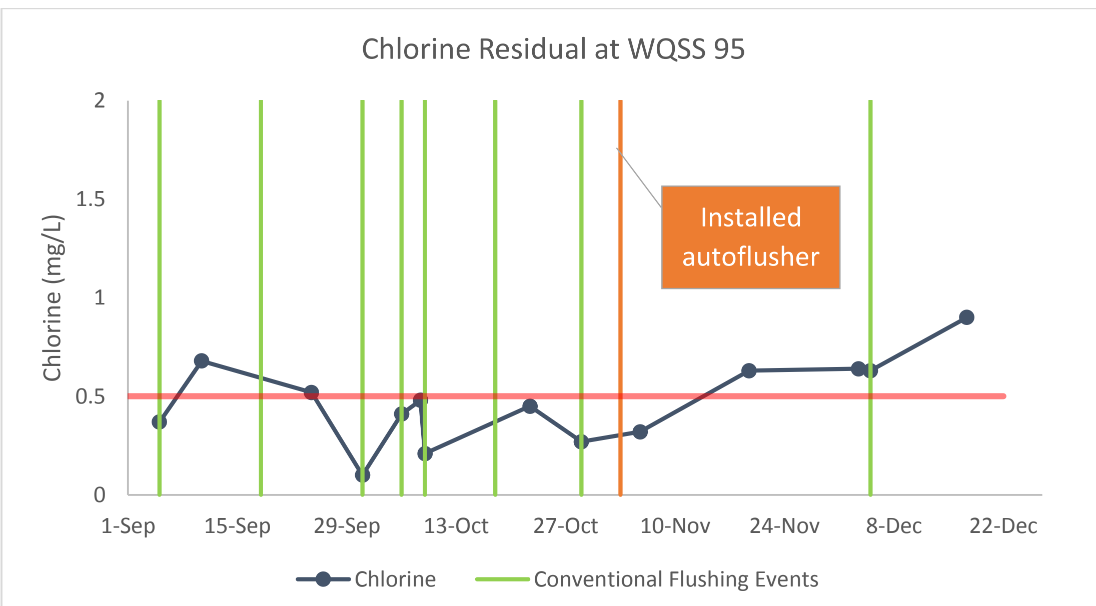



*Figure 5. Example of the effects of installing an autoflusher on chlorine residual at a distribution site in PWB's system. Frequent conventional flushing was not successful at keeping the chlorine residual at this site above the 0.5 mg/L target. Chlorine residual increased at this site after the installation of the autoflusher.*

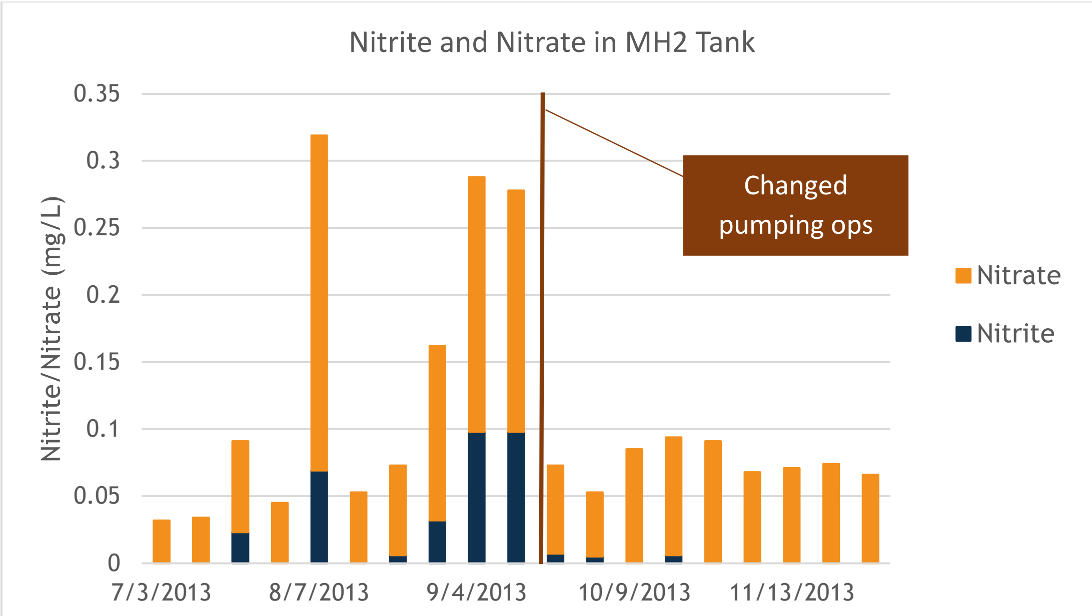



*Figure 6. Example of the effects of changing pumping operations on nitrification in one tank in PWB's system. After pumping operations were changed, nitrate and nitrite levels decreased for the remainder of the 2013 nitrification season.*

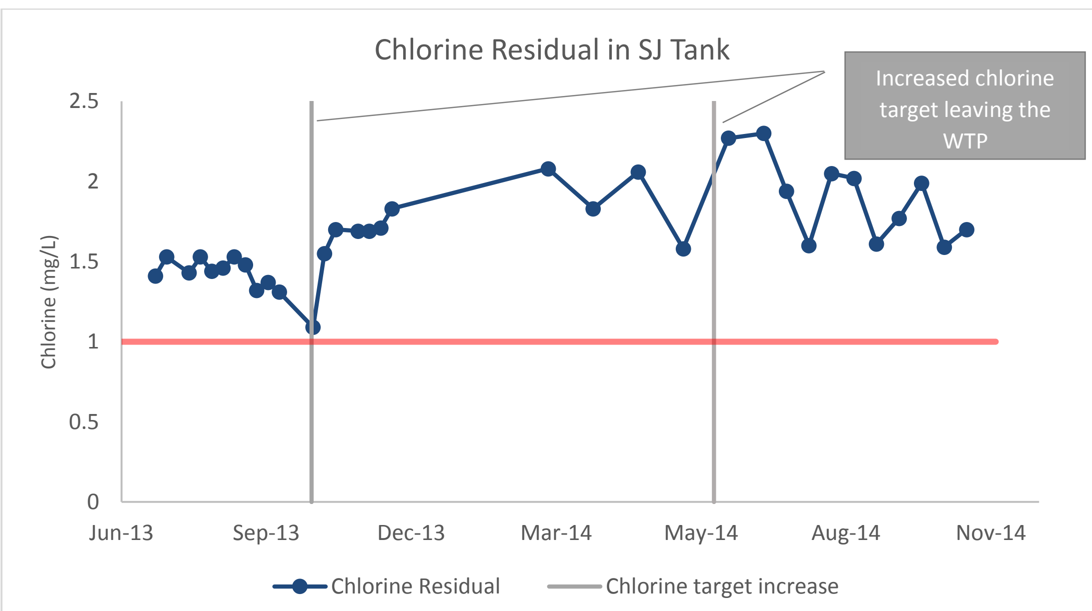



*Figure 7. Result of chlorine target increase at the treatment plant in one of PWB's tanks. The increase chlorine target resulted in increased chlorine levels in the tank.*

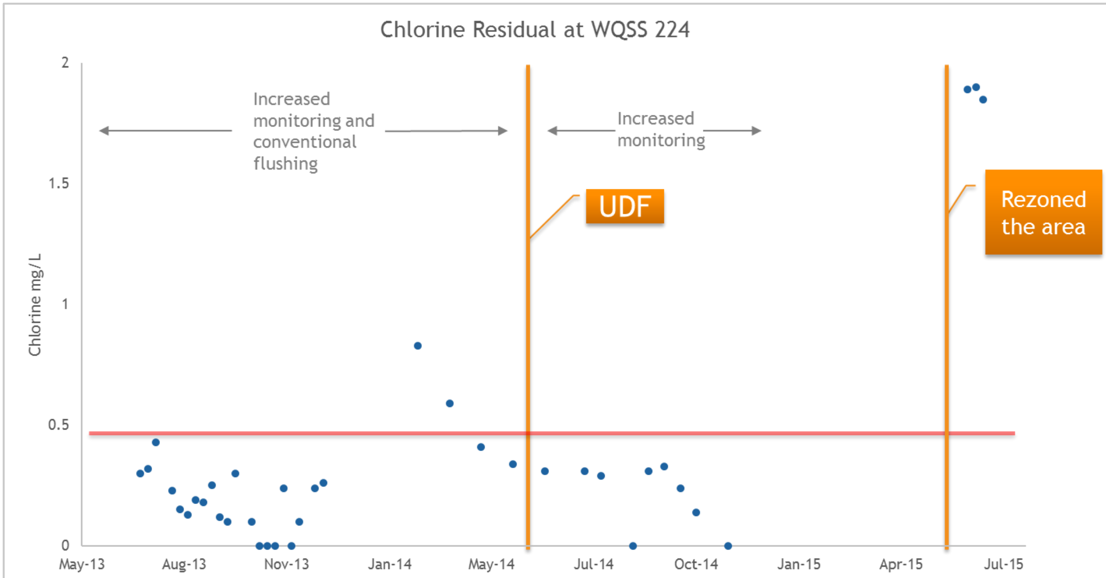



*Figure 8. Example of a multi-mitigation strategy employed in PWB's system where several mitigation strategies were deployed to increase chlorine residuals at a distribution site.*

Overall the nitrification program has been very successful. This is illustrated in Figure 9 which depicts one area in PWB's system over two years and how the nitrification activity has declined since the program was implemented.

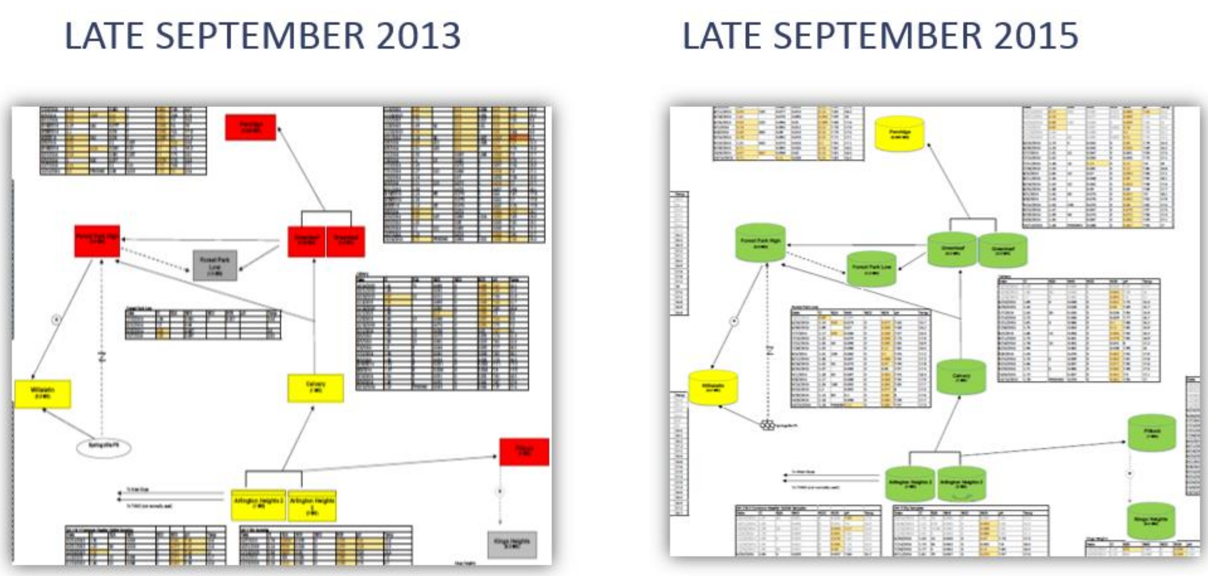



*Figure 9. A graphical depiction of 2015 nitrification results as compared to 2013 (before proactive mitigations were implemented). Green = good water quality; yellow = moderate nitrification/water quality issues observed; red = significant nitrification/water quality issues observed.* This tank cascade had significantly improved water quality in 2015 compared to 2013.

### Additional Non-Regulatory Monitoring in the Distribution System

In addition to the nitrification program, Portland conducts a significant amount of other non-regulatory monitoring in the distribution system (Figure 10). These monitoring programs include chlorine residual monitoring at tanks (online monitors and/or grab samples); ORP and temperature at select tanks; pH, chlorine residual and free ammonia surveys throughout the distribution system; pH and turbidity monitoring at existing TCR sites; customer complaint monitoring; ongoing metals monitoring at premise plumbing surrogate stations; and other investigative monitoring as necessary.

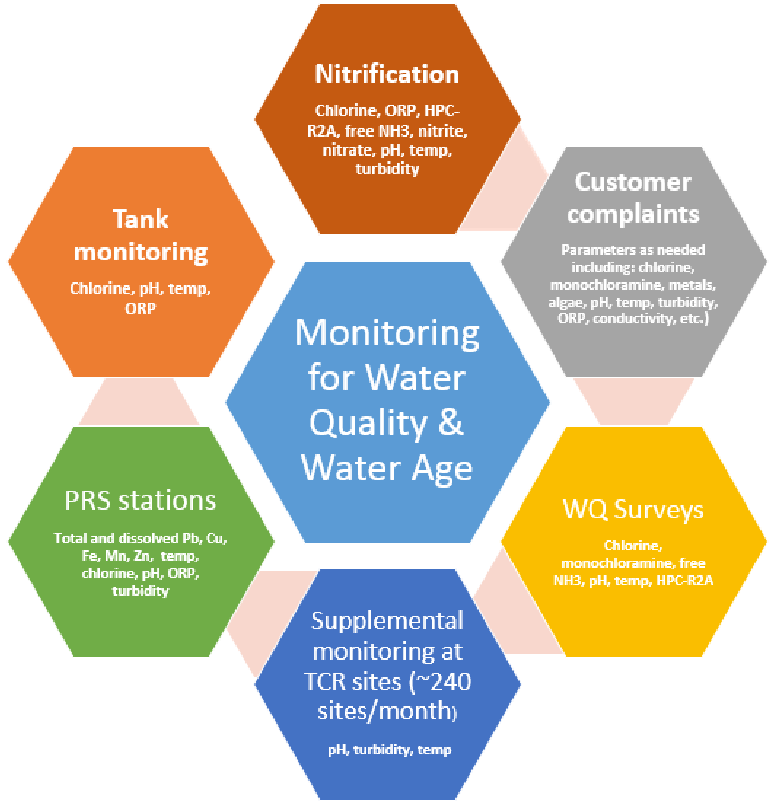



*Figure 10. Types of monitoring programs in PWB's system to improve water quality.*

### Storage Tank Management and Conduit Manipulation

PWB actively manages storage tank drain/fill practices to reduce water age. As mentioned in the nitrification section, prior to PWB's nitrification season, PWB takes storage tanks out of service for the season to reduce water age (as appropriate). Storage tank levels are also lowered where appropriate to reduce detention time in tanks. Tank operations are also modified to more effectively promote deep cycling of the tanks, and pumping operations may also be modified to bring fresher water up to the farther reaches of the system faster. Prior to changing tank or pump station operations, hydraulic modeling is first conducted to ensure that customer level of service and fire-flow can be met.

In addition to deep cycling tanks, mechanical mixers are used in several tanks where deep cycling alone was not able to promote adequate mixing. In tanks where stratification is suspected, temperature monitoring and grab sampling from various elevations in the tank is employed to determine if the tank is stratified. Since 2013, Portland has installed four mechanical mixers in previously stratified tanks (see Figure 11). Stratification data from one of these tanks pre- and post-mixer installation is illustrated in Figure 12.

*Figure 11. Schematic of the Gridbee GS-12 mixer: the type of mixers installed in PWB's tanks.*

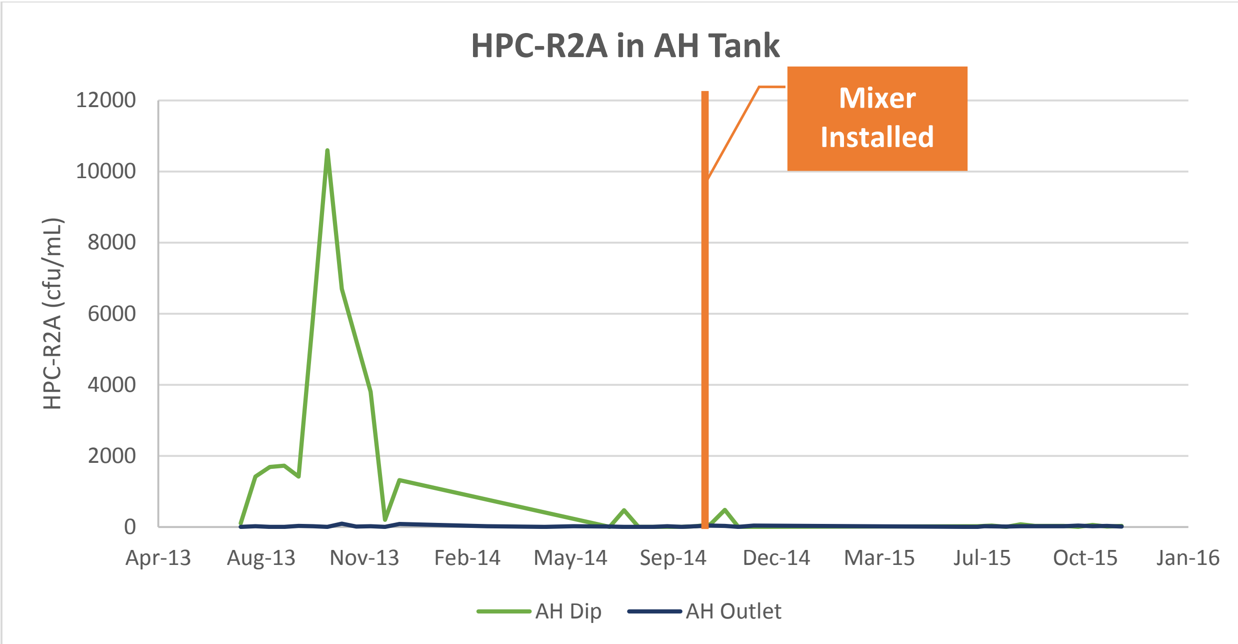



*Figure 12. Figure 12. Example of the effects of a mechanical mixer in one distribution system tank that was seeing significant stratification. After the mixer was installed, both dip and outlet samples had minimum HPC-R2A levels.*

Additionally, tanks are drained and refilled with fresh water if dictated by water quality. If microbial growth/chlorine demand is significant, a tank may be taken out of service and cleaned earlier than scheduled.

PWB also attempts to manipulate the supply conduits that bring water to town from Bull Run to decrease water age, when possible. There are two interties on the three conduits between the Headworks and Lusted Hill facilities which essentially divide each conduit into three segments. These interties can be operated to take sections of conduit out of service to decrease water age.

### Conventional and Unidirectional Flushing

PWB uses both conventional and unidirectional flushing (UDF) to improve water quality in the distribution system. Conventional flushing is typically utilized when bulk water turnover is desired. This is an effective tool for reducing water age, increasing chlorine residual, and responding to customer complaints. However, the effects can be temporary so it is not a good long term strategy for an area that has ongoing water quality issues. The PWB has both dedicated staff and two autoflushers (Figure 13) that perform conventional flushing in the system.


*Figure 13. Autoflusher used in PWB's system.*

As an unfiltered system, UDF is a very important tool for maintaining the cleanliness of the system. The overall goal of the UDF program is to achieve a scouring velocity to remove biofilm, sediment, and metal accumulations from distribution system pipes. In 2013, PWB's UDF program shifted from a systematic to a targeted program that focuses on areas in the system that have experienced water quality issues. Since 2013, PWB has unidirectionally flushed 34 pressure zones[1] and over 120 miles of pipeline. Each year the plan for the UDF program is determined based on water quality results from the previous year, with the areas that experienced water quality issues prioritized. However, UDF may be deployed immediately if a significant biofilm regrowth or discolored water issue is occurring. PWB's 2016 annual report for the UDF program is included in Appendix III.

*Figure 14. UDF in PWB's system.*

Currently, the PWB does not employ flushing to respond to high lead home results. However, this can be incorporated into our program going forward. The PWB will also continue to evaluate additional mechanisms to improve water age management and distribution system optimization and incorporate those changes into the program. See Section 3.2.4 for more details.

### *3.2.4. Target Flushing and Public Education and Outreach Based on Investigative Sampling*

***Use current LCR tap sampling results as a basis for an investigative sampling program to identify problem areas (age, construction) to target flushing, public education and outreach and prioritize LSL (lead service line) replacement, if applicable.***

As stated in the December 2, 2016 Interim Lead Reduction Plan, the recently completed Water Quality Corrosion Study evaluated the geographic distribution of Lead and Copper Rule (LCR) and customer requested lead in water test results. This analysis did not identify any problem areas or hot spots in the distribution system and showed that elevated lead in water results, when found, were spread throughout customer taps in the distribution system. An example spatial analysis from Q4 of the Water Quality Corrosion Study is shown in Figure 15. In this quarter approximately 1,500 voluntary customer samples and 32 LCR Tier 1 Home samples were analyzed.

[1] In the case of very large pressure zones, for instance Tabor 411 PZ and Washington Park 229 PZ, the entire pressure zone was not flushed.

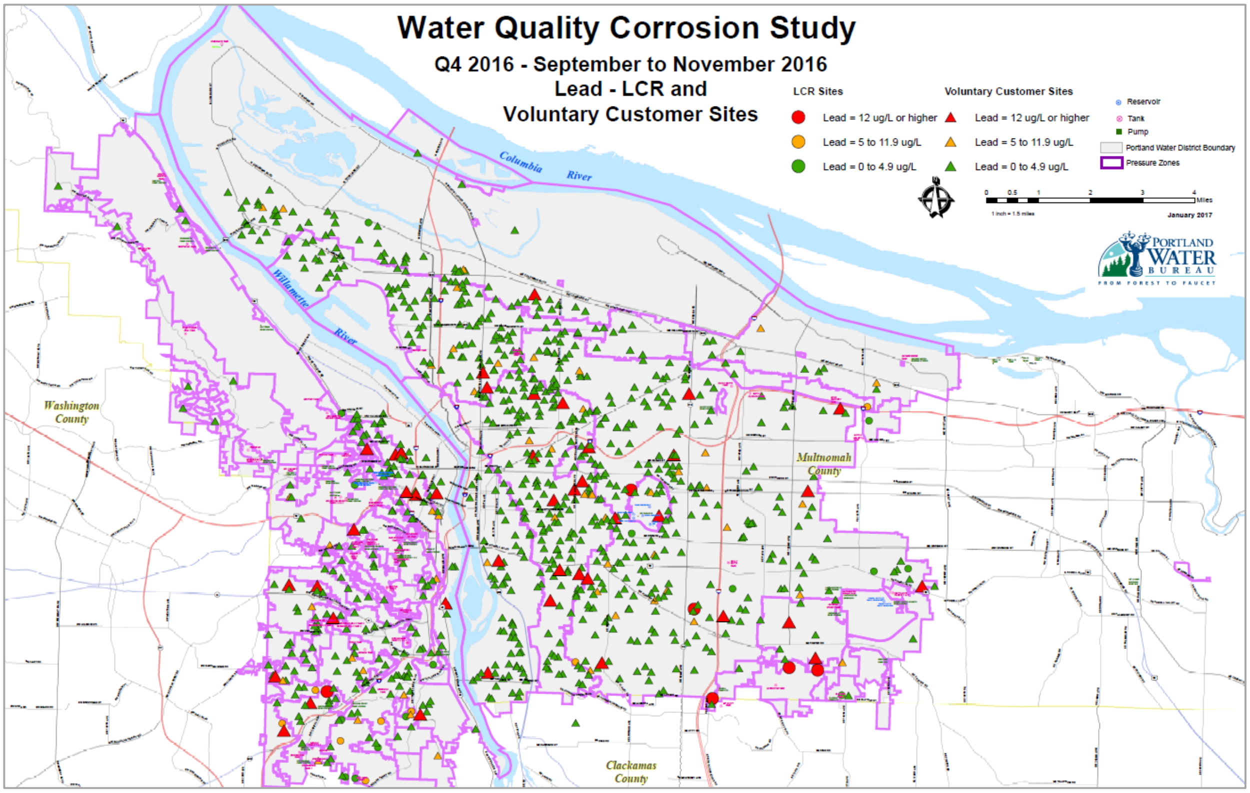



*Figure 15. Geographic distribution of lead results for LCR sites and customer requested lead tests during Q4 of the Water Quality Corrosion Study.*

A further analysis of Tier 1 home results from the past four years of regulatory monitoring was also performed (see Figure 16 on following page). The median value of results for all of the participating homes was calculated and mapped, differentiating between homes whose median value was above the action level for lead in water (red) and those below the action level (blue). The distribution system pressure zone boundary mapped alongside these results to determine if any pressure zones had multiple homes with elevated results. The respective map showed that each home with a median lead in water level above the action level for lead was in a separate pressure zone. However, the analysis did show that two homes with elevated median results above the action level for lead (LCRH0032 and LCRH0041) were in the same cascade of pressure zones (Lexington 658 and Lexington 463) and receive water through the same storage tank. As a result, additional investigative sampling and public education and outreach will be performed in the Lexington pressure zone cascade.

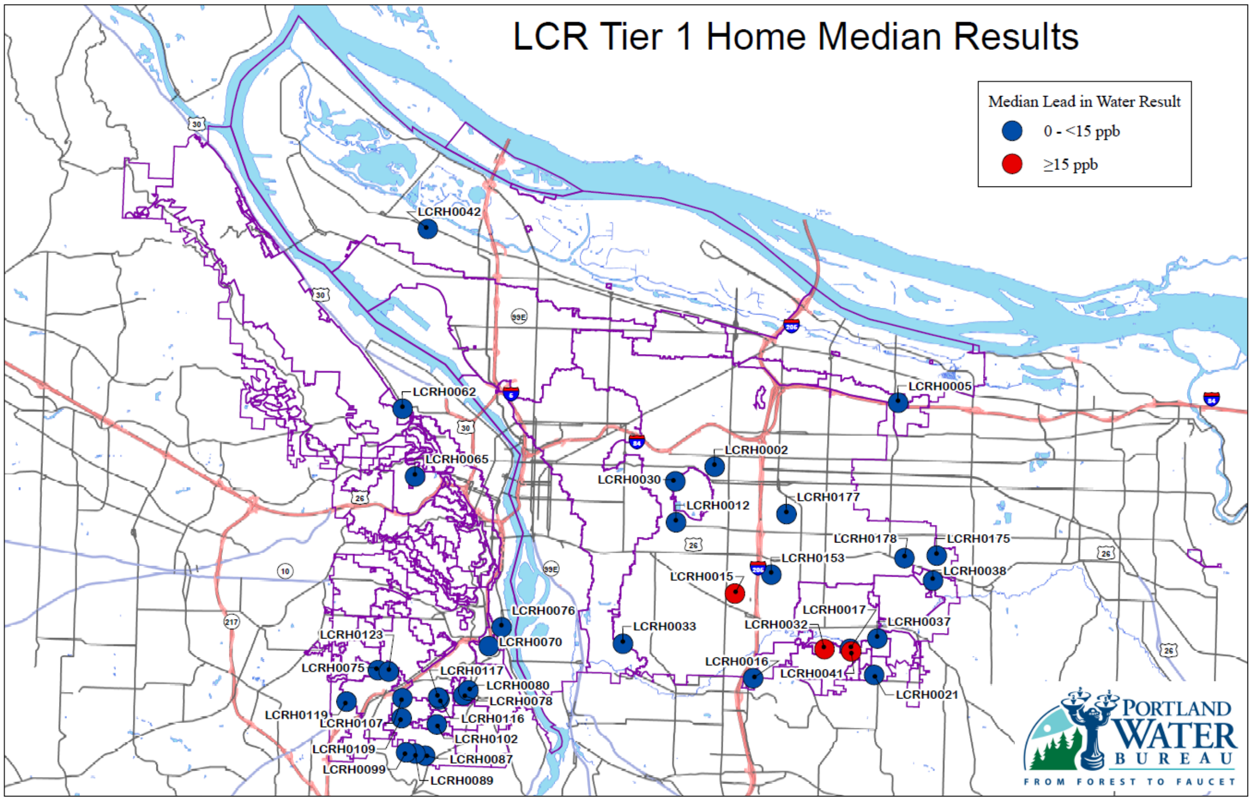



*Figure 16. Analysis of Tier 1 homes by pressure zone showing median lead results over a four-year period.*

Portland Water Bureau field samplers will test for lead in water from locations in the pressure zone cascade and immediately near the LCR homes with elevated median results. Additionally, targeted outreach will be performed to other high-risk homes in those pressure zones. Using tax records, PWB will mail an informational mailer with a business reply card to request a free lead-in-water test to all homes in these pressure zones that were built between 1970 and 1985. This the time-frame when copper pipes joined by leaded solder was most commonly used and are the homes most likely to have elevated levels of lead in water. The results from distribution system sampling and customer lead in water tests will be used to determine if aggressive unidirectional flushing should be performed in areas of these pressure zones.

### 3.2.5. Target Flushing and Investigative Sampling Based on Water Quality Complaints

***Tracking of customer water quality complaints to identify problem areas for flushing and investigative sampling.***

Portland Water Bureau has tracked customer water quality complaints to identify areas for flushing as well as follow-up investigative sampling since the 1980s, with the program seeing significant updates in 2015 and 2016. The current process for investigating, monitoring and reporting water quality complaints, as well as planned improvements, are outlined below.

## PWB Troubleshoots Complaint with Customer

When customers report water quality issues by phone or email, PWB water quality staff will respond within one business day with most complaints being addressed when the call is received. Staff ask detailed questions to determine the extent of the issue observed by the customer. This includes determining if the issue is at all faucets, if it is with the cold or hot water supply, and when the issue was first noticed by the customer. For color, taste and odor calls, customers are also asked to flush their plumbing to see if the issue resolves. For taste/odor calls specifically, customers are asked to fill a glass with water and take it outside or to another room to see if the issue persists. By gathering this information, staff can evaluate the complaint and its potential cause. For some complaints, staff may suggest that customers find out if their neighbors are having a similar issue.

## PWB Investigates Address of Complaint

After gathering information from the customer, staff use the following tools to research the customer's address, their location in the distribution system, and determine if PWB crews are working nearby.

**Water quality database**: All water quality complaints are tracked by address in this database (see Figure 17 and Figure 18 for examples). When a call comes in, staff record in the database the customer's location and contact information, the type of water quality complaint, the cause of the issue (if known), and the action taken to address the complaint. The database allows staff to view the history of complaints for trends at any given address. This is the same database where customer sampling for lead and other parameters is tracked.

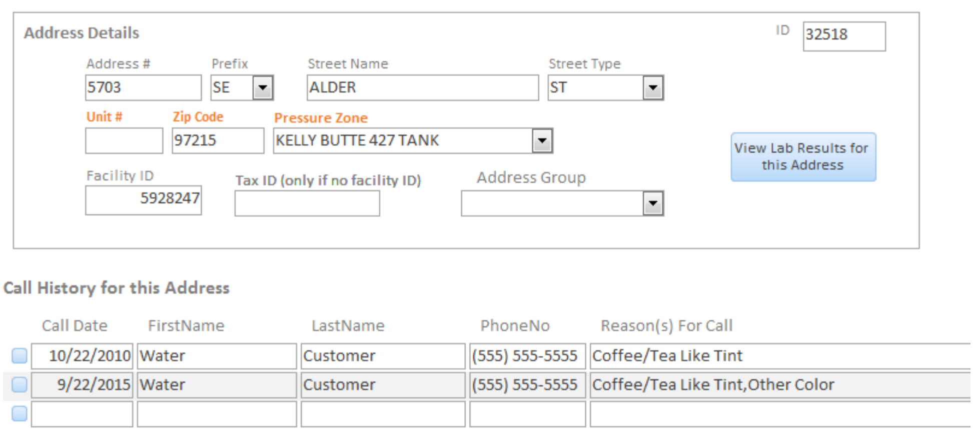
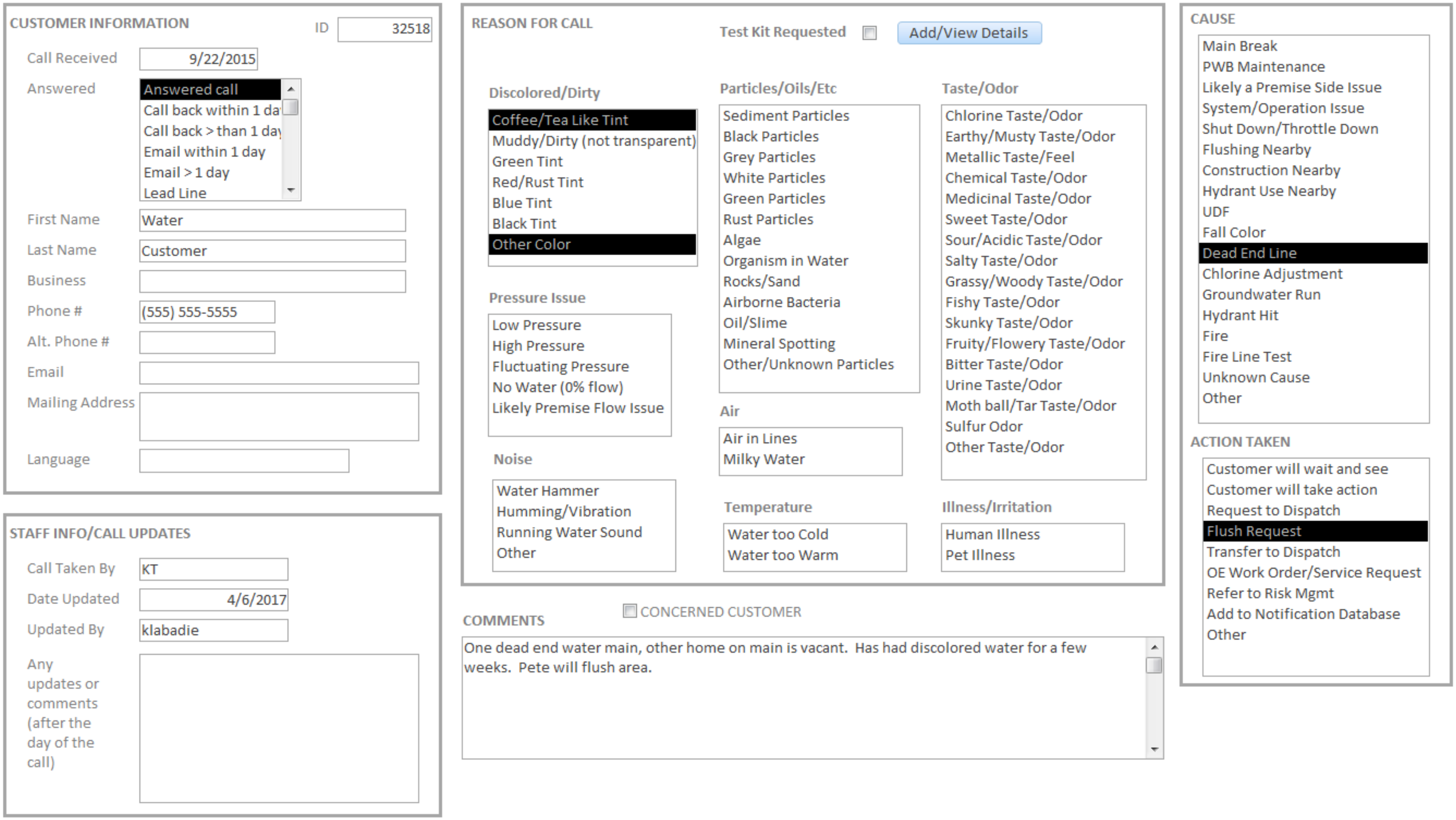



*Figure 17. Screenshot from the water quality database, with identifying customer information removed. This example shows two discolored water quality complaints from this address, one in 2010 and one in 2015.*



CUSTOMER INFORMATION
ID 32518
Call Received 9/22/2015
Answered
Answered call
Call back within 1 da
Call back > than 1 day
Email within 1 day
Email > 1 day
Lead Line
First Name Water
Last Name Customer
Business
Phone # (555) 555-5555
Alt. Phone #
Email
Mailing Address
Language

STAFF INFO/CALL UPDATES
Call Taken By KT
Date Updated 4/6/2017
Updated By klabadie
Any updates or comments (after the day of the call)

REASON FOR CALL
Test Kit Requested
Add/View Details

Discolored/Dirty
Coffee/Tea Like Tint
Muddy/Dirty (not transparent)
Green Tint
Red/Rust Tint
Blue Tint
Black Tint
Other Color

Pressure Issue
Low Pressure
High Pressure
Fluctuating Pressure
No Water (0% flow)
Likely Premise Flow Issue

Noise
Water Hammer
Humming/Vibration
Running Water Sound
Other

Particles/Oils/Etc
Sediment Particles
Black Particles
Grey Particles
White Particles
Green Particles
Rust Particles
Algae
Organism in Water
Rocks/Sand
Airborne Bacteria
Oil/Slime
Mineral Spotting
Other/Unknown Particles

Air
Air in Lines
Milky Water

Temperature
Water too Cold
Water too Warm

Taste/Odor
Chlorine Taste/Odor
Earthy/Musty Taste/Odor
Metallic Taste/Feel
Chemical Taste/Odor
Medicinal Taste/Odor
Sweet Taste/Odor
Sour/Acidic Taste/Odor
Salty Taste/Odor
Grassy/Woody Taste/Odor
Fishy Taste/Odor
Skunky Taste/Odor
Fruity/Flowery Taste/Odor
Bitter Taste/Odor
Urine Taste/Odor
Moth ball/Tar Taste/Odor
Sulfur Odor
Other Taste/Odor

Illness/Irritation
Human Illness
Pet Illness

COMMENTS
CONCERNED CUSTOMER
One dead end water main, other home on main is vacant. Has had discolored water for a few weeks. Pete will flush area.

CAUSE
Main Break
PWB Maintenance
Likely a Premise Side Issue
System/Operation Issue
Shut Down/Throttle Down
Flushing Nearby
Construction Nearby
Hydrant Use Nearby
UDF
Fall Color
Dead End Line
Chlorine Adjustment
Groundwater Run
Hydrant Hit
Fire
Fire Line Test
Unknown Cause
Other

ACTION TAKEN
Customer will wait and see
Customer will take action
Request to Dispatch
Flush Request
Transfer to Dispatch
OE Work Order/Service Request
Refer to Risk Mgmt
Add to Notification Database
Other

*Figure 18. The screen shot above from the water quality database shows the customers information and the details of the complaint. The cause of the complaint and action taken is also selected. In this example, the address is on a dead end water main/street which is the cause of discolored water. A hydrant flush request was submitted to resolve the discoloration issue. When applicable, the Kit Requested box can also be checked, at the top/center of page. Clicking the add/view details button brings up a form with water testing and sample bottle details.*

**Distribution system GIS map**: This map allows staff to see which water main and storage tank an address is served from. Additionally, all water quality complaints are mapped from the water quality database, allowing staff to identify trends on the street or neighborhood level as complaints are reported by customers. Staff can also view hydrant flushing data near a given address to determine when nearby hydrants were last flushed.


*Figure 19. Thick yellow/red lines on water services indicate a water quality complaint at these addresses in the past 6 months. In this example, customers complained of a coffee/tea like tint to the water. The cause of the discoloration was hydrant flushing in the area. The green circle on the upper left indicates that this fire hydrant was flushed in the previous 12 months. Dates and other data can also be displayed on the map for complaints and hydrant flushes.*

**PWB fleet tracking system**: Staff can view the real time location of PWB fleet vehicles and determine if PWB field crews are the cause of the water quality issue. This is important since most discolored water complaints are due to crews performing maintenance or operational work in the distribution system.

If a cause for the water quality issue is not easily identifiable, water quality staff will also consult with other PWB staff including construction dispatch, field crews, and operational analysis, as well as other city bureaus as needed.

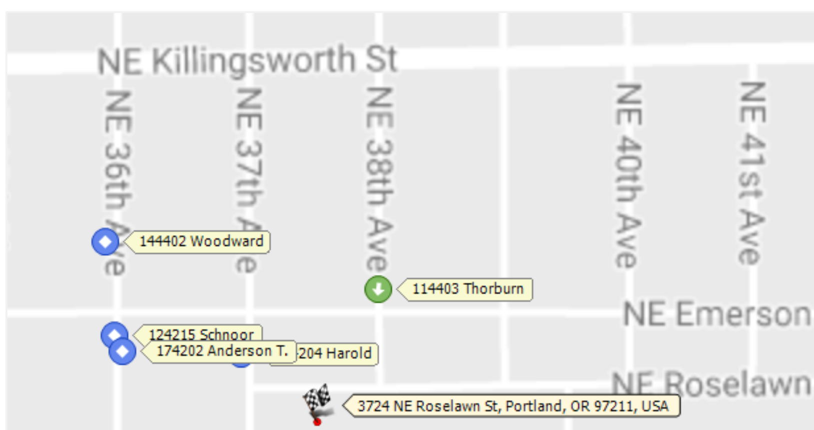



*Figure 20. This screen shot from the fleet tracking system shows an address that reported discolored water. In this example, construction crews (blue/green circles) were replacing fire hydrants in the area, which caused temporary discoloration.*

## Actions taken by Portland Water Bureau to Address Customer Complaints

After the complaint is evaluated PWB will take steps to resolve the issue. Table 2 provides examples of how PWB responds to color, taste, odor, illness, and water temperature complaints.

*Table 2. Water quality complaints and actions taken to address complaint.*

| Water Quality Complaint | Duration | Typical Cause of Complaint | Actions Taken |
|---|---|---|---|
| Perceived water quality problem but no actual issue, such as seasonal fall color tint. | Varies | Customer lacks knowledge of Portland's source waters or seasonal aesthetic changes. | Staff educates customer. **Metals testing of water** is also offered, which is available for free to any PWB customer. |
| Discoloration, taste or odor issue, *which clears after premise side flush of cold water.* | One time or intermittent. | Premise plumbing issues, such as water standing overnight in old iron pipes or water heater issues. | Staff educates customer and offers **free metals testing of water**. Customer advised to flush premise plumbing and clear aerator screens. Customer asked to call back if flushing faucet no longer resolves the issue. |
| Discoloration, taste, or odor issue, *which persists after premise side flush of cold water.* | Temporary, lasts less than 1 day. | Water main break, hydrant flushing/use, system maintenance, fire line tests, other or unknown causes. | Staff educates customer. Hydrant spot flushing may be required if issue does not resolve in expected time period. For some cases, distribution system sampling may occur[2]. If cause of water quality issue is unknown, staff will investigate further. |
| | Lasts more than 1 day, or occurs intermittently. | Ongoing system maintenance or hydrant use, dead end water mains, sediment in water mains, source water changes, old water age, other or unknown causes. | Staff educates customer and offers **free metals testing of water**. Hydrant spot flushing is ordered, with evaluation of turbidity, chlorine, pH, color and odor. Unidirectional flushing may be necessary. Water samples from distribution system may also be required*. If cause of water quality issue is unknown, staff will investigate further. |
| Illness (human or pet) | Varies | Customer has an illness or skin irritation. | Staff educates customer and offers **free metals testing of water**. Customer is advised to consult their health care provider. |
| Unusually warm water temperature, *which persists after premise side flush of cold water.* | Varies | Seasonal water temperature fluctuations, high water age/low water use area. | Staff evaluates complaint and determines if hydrant spot flushing is appropriate. |

[2] PWB has rapid response test kits ready to deploy for immediate field sample collection.

## Complaint Monitoring and Reporting

Water quality complaint data is monitored in several ways. Each time a new complaint is reported, staff check the complaint database and map to determine if similar complaints have been reported in that area. A water quality complaint report is emailed out to almost 30 staff members weekly, providing a detailed summary of the number and types of calls received over the previous 7 days (see Figure 21). This report query can be run for any date range, and complaint data can also be summarized by pressure zone.

Additional database queries and reports are developed as needed for specific investigations. Staff can query complaints by location, pressure zone, type of complaint, cause of complaint, and action taken to address the complaint. The water quality complaint GIS map layer is also utilized by various PWB staff to investigate complaints or inform operational changes.

| | |
|---|---|
| **Total # of Calls/Emails/Requests** | **107** |
| Phone calls to Water Line | 105 |
| Emails to Water Line | 2 |
| **Total # of Pressure Calls** | **4** |
| High Pressure | 1 |
| No Water (0% flow) | 2 |
| **Total # of Discolored/Dirty Calls** | **23** |
| Coffee/Tea Like Tint | 21 |
| Red/Rust Tint | 1 |
| Black Tint | 1 |
| **Total # of Taste & Odor Calls** | **3** |
| Chlorine Taste/Odor | 2 |
| Other Taste/Odor | 1 |
| **Particles/Oil/Algae/Etc** | **3** |
| Sediment Particles | 1 |
| Grey Particles | 1 |
| Oil/Slime | 1 |
| **Other Calls** | **0** |
| **Total Informational Calls** | **53** |
| Meter Leak/Curb Stop | 1 |
| Plumbing/meter question | 8 |
| Test kit/results questions | 5 |
| Transfer/Referral | 12 |
| Wholesale customer inquiry | 2 |
| WQ/Treatment Questions | 25 |
| **Cause of Complaints** | |
| Main Break | 7 |
| PWB Maintenance | 8 |
| Unknown Cause | 7 |
| Dead End Line | 1 |
| Groundwater Run | 1 |
| **Lead/Metals Test Request Summary** | |
| Requests taken by Water Line | 21 |
| Requests taken by Lead Line | 139 |
| **Action Taken** | **8** |
| Request to Dispatch | 4 |
| Flush request | 4 |

**For period between**

**03/06/2017 and 03/12/2017**

***Click here to view this report for a different date range***

***Click here to view Water Line calls by pressure zone***

*Figure 21. Example of weekly water quality report emailed to PWB staff.*

## Improvements to Current Program

PWB has and will continue to expand complaint monitoring and investigative sampling programs, particularly with regard to turbidity, color and metallic taste and odor complaints.

These improvements include:

- A water quality investigation checkbox was added to the complaint database. This will improve tracking of complaints that require additional investigation, such as distribution system sampling.
- PWB made significant improvements to the complaint database beginning in January of 2016. Since the level of detail tracked in the database has grown siginificantly, PWB is now able to create annual water quality complaint reports to view trends and make comparisons to previous years.
- PWB can now create a report of complaints where the cause of the complaint was marked as *unknown*. This will allow PWB staff to easily review complaints where a cause could not be determined, and evaluate for possible trends in the system.

- For complaints where investigative sampling is required, PWB is now mailing customers a premise side test kit that includes both a standing and a running sample, instead of just a standing sample as was typically done. Upon return to the PWB, the water samples are analyzed for lead, copper, iron, zinc and manganese within 1-2 weeks, instead of the typical 4-6 weeks for analysis. Water Quality staff will also follow up with customers that have not returned the investigative water sample to PWB for analysis within 2 weeks.
- PWB will add metals testing, when appropriate, to investigative sampling when samples are collected from hydrants or other locations in the distribution system.

### 3.2.6. Homeowner Incentives

***Accelerate and provide incentives, such as homeowner subsidy, for lead service line (LSL) or premise plumbing replacement if/where applicable.***

As Portland does not have lead service lines, many of the programs designed to aid homeowners in premise plumbing replacement are not applicable to PWB's system. However, programs in other jurisdictions may be instructive of how a homeowner subsidy program could operate.

In May of 2016, EPA released a memo clarifying that complete service line replacement is an eligible Drinking Water Revolving Loan Fund (DWSRF) expense. The memo notes that such projects support the public health protection of the Safe Drinking Water Act. The memo clarifies, "The statutory and the regulatory provisions governing the use of DWSRF funds do not require the public water system to have control over all portions of a project that is funded by the DWSRF."

The Report of the Lead and Copper Working Group to the National Drinking Water Advisory Council in December 2015 recommended the following:

> "Planning and Financing Options: EPA should provide a template and guidance for planning LSL replacement programs, including reference to options to assist customers replace their portion of lead service lines. Small systems may wish to refer to a national information source, such as one provided by EPA; large systems may wish to tailor such information to their circumstances."

According to the DWSRF Regional Coordinator for Region 10 in a presentation given at a conference for Washington state's Infrastructure Assistance Coordinating Council, DWSRF can be used to replace premise plumbing fixtures with more water efficient fixtures as part of a water conservation project. There are not currently examples of where this has been done, or to what scale. If a feasible program is identified and adopted by federal or state agencies, PWB will be a full partner in promoting the program as widely as possible to its customers.

### 3.2.7. Establish Interim Water Quality Parameters (WQPs)

***State sets additional interim WQPs (authority under 141.82 (h)) such as pH, alkalinity, and LSI (Langelier Saturation Index).***

The PWB is working with OHA to determine the appropriate WQPs for monitoring pH at the entry point and in the distribution system. The revised WQPs are expected to be in place beginning the July 2017 monitoring period.

### 3.2.8. Increase Unidirectional Flushing and Encourage Premise Plumbing Flushing

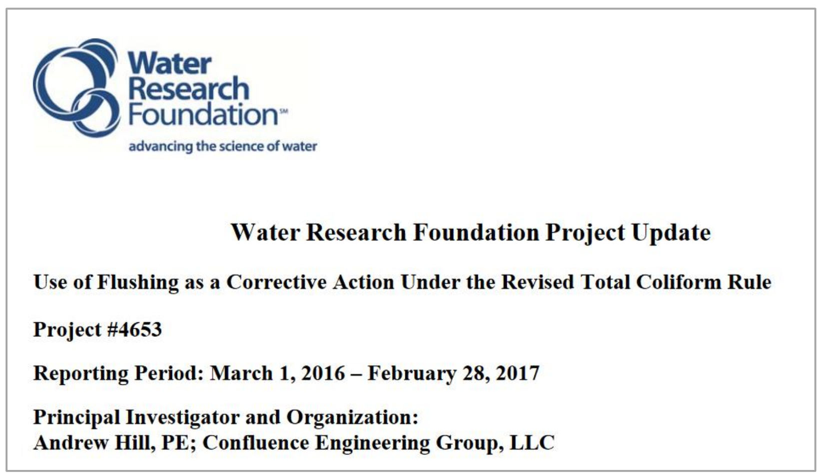
In addition to the previously mentioned steps, PWB is currently engaged in the following activities to adjust water quality in the distribution system and increase education/outreach regarding lead in water.

#### Flushing Study and Increased Unidirectional Flushing

Unidirectional flushing (UDF) can decrease nitrification and other microbial growth, which can be factors in lead release. There is also ongoing work in the water industry evaluating the effects of high-velocity flushing on the removal of particulate lead from premise plumbing.

PWB is working with Confluence Engineering Group, Seattle Public Utilities (SPU), and the Water Research Foundation to develop a unidirectional flushing guidance for the water industry. Specific objectives of this project are as follows:

- Assess mobilization and removal of microorganisms, nutrients, and microbially active sediments as a function of flushing technique, velocity and pipe type.
- Evaluate bulk water response to changes in pipe surface conditions due to flushing. Demonstrate impacts of flushing practices on disinfectant demand and residual stability.
- Use findings to provide the basis for investing in preventative flushing for biofilm control, and to provide guidance on the applicability, benefits and potential risks of various types of reactive flushing in response to coliform events.
- Provide protocols and guidance to ensure that flushing is indeed a corrective action under the RTCR, and that scarce resources are used effectively to meet intended water quality objectives.


Water Research Foundation
advancing the science of water

**Water Research Foundation Project Update**

**Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule**

**Project #4653**

**Reporting Period: March 1, 2016 – February 28, 2017**

**Principal Investigator and Organization:**
**Andrew Hill, PE; Confluence Engineering Group, LLC**

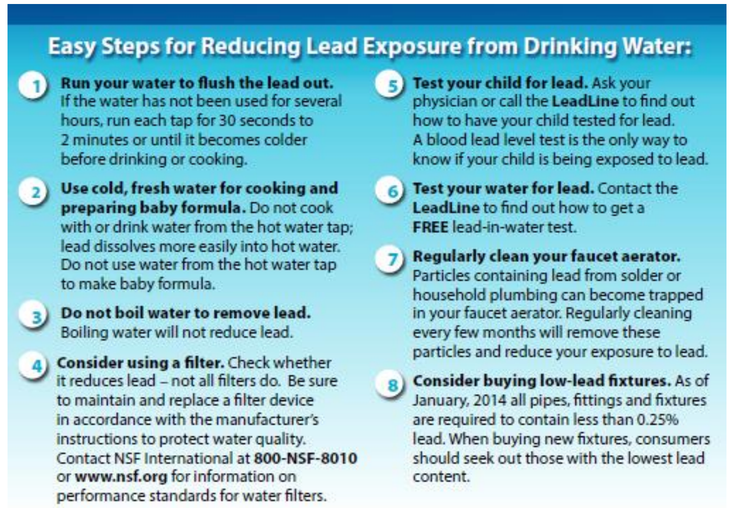
*Figure 22. Screen shot of flushing study project update for most recent reporting period.*

Through this study, adjustments and improvements will be identified that can be made to PWB's existing unidirectional flushing program to more effectively improve water quality. The project is slated to be completed by 2019; SPU has completed their flushing trials and PWB anticipates completing flushing trials this summer.

## Outreach/Education on Flushing Premise Plumbing

Flushing of premise plumbing by customers is an easy and effective method to reduce lead levels at the customer tap. As part of its existing lead education program, PWB encourages all customers to flush their premise plumbing after water has been standing for an extended period of time. Premise side flushing is promoted a variety of ways, including:

- PWB's website
- Printed brochures (see Figure 23)
- The annual Consumer Confidence Report
- Lead related email and phone communication with customers
- Results letters mailed to customers (see Appendix IV)



**Easy Steps for Reducing Lead Exposure from Drinking Water:**

1. **Run your water to flush the lead out.** If the water has not been used for several hours, run each tap for 30 seconds to 2 minutes or until it becomes colder before drinking or cooking.
2. **Use cold, fresh water for cooking and preparing baby formula.** Do not cook with or drink water from the hot water tap; lead dissolves more easily into hot water. Do not use water from the hot water tap to make baby formula.
3. **Do not boil water to remove lead.** Boiling water will not reduce lead.
4. **Consider using a filter.** Check whether it reduces lead – not all filters do. Be sure to maintain and replace a filter device in accordance with the manufacturer's instructions to protect water quality. Contact NSF International at **800-NSF-8010** or **www.nsf.org** for information on performance standards for water filters.
5. **Test your child for lead.** Ask your physician or call the **LeadLine** to find out how to have your child tested for lead. A blood lead level test is the only way to know if your child is being exposed to lead.
6. **Test your water for lead.** Contact the **LeadLine** to find out how to get a **FREE** lead-in-water test.
7. **Regularly clean your faucet aerator.** Particles containing lead from solder or household plumbing can become trapped in your faucet aerator. Regularly cleaning every few months will remove these particles and reduce your exposure to lead.
8. **Consider buying low-lead fixtures.** As of January, 2014 all pipes, fittings and fixtures are required to contain less than 0.25% lead. When buying new fixtures, consumers should seek out those with the lowest lead content.

*Figure 23. Example of PWB printed outreach on flushing premise side plumbing. This is a section from PWB's annual lead brochure that is provided once per year in all water bills and included with all lead results letters. Flushing premise plumbing is the first easy step listed.*

PWB offers customers with elevated lead in water levels test kits that include running (flushed) water samples, and has documented up to a 90% reduction in lead levels between standing and running samples (see Table 3) . When customers first request a lead test kit, they are sent an initial standing kit to collect water that has been standing in the pipes for 6 hours or longer. If that initial standing sample is found to have elevated lead levels, PWB calls the customer to offer either a standing/running test kit (2 samples) or a faucet/pipe/running test kit (3 samples).

*Table 3. When comparing lead results from standing samples above the action level to running water results, reductions in lead were noted for 100% of homes. The average precent reduction was 93%.*

| 2010-2015 customers who collected a single set of running and standing samples and had a result above the action level in the standing sample (n=67). | |
|---|---|
| Percent of homes that saw a reduction in the running sample. | 100% |
| Percent of homes that saw an 90% or better reduction in the running sample. | 85% |
| Percent of homes that saw an 80% or better reduction in the running sample. | 96% |
| Percent of homes that went from above the action level to below the action level. | 97% |
| Average percent reduction. | 93% |

Results from the standing/running samples allow customers to compare lead levels between the standing and flushed water. Results from the faucet/pipe/running samples allow for this same comparison, while also comparing lead levels of standing water in the faucet to standing water in the pipe. The type of follow-up test kit sent to the customer depends on the sampling location and the customer's needs. Both test kits provide customers with actual results from their own tap showing how flushing can dramatically decrease lead levels.

Some PWB customers have expressed concerns with flushing premise side plumbing to reduce lead, as they think it wastes water or they are concerned they will forget to flush the plumbing before consuming water. In response to this PWB has also developed outreach materials on water filtration for customers who seek an alternative to premise side flushing (see Figure 24).

PWB will continue to conduct outreach and education on the importance of flushing premise plumbing and provide follow-up test kits for customers with elevated lead results. Additionally, PWB will begin calling customers who were mailed a follow-up test kit but have not returned their water samples after one month.

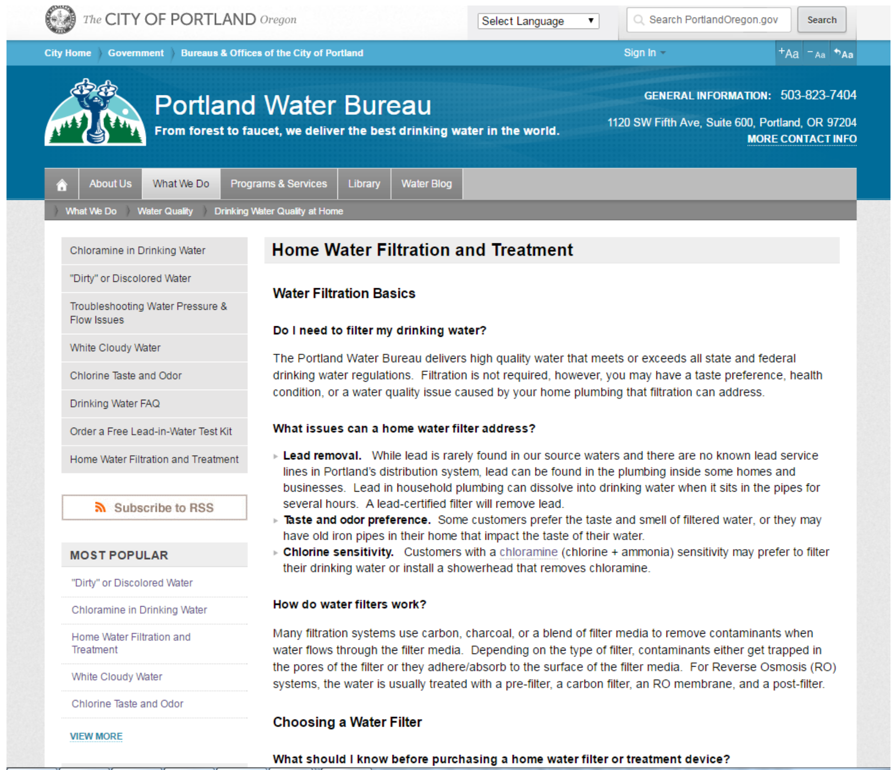



*Figure 24. Screenshot of PWB webpage that provides guidance on water filtration. This information is helpful for customers that seek lead reduction alternatives.*

### 3.2.9. Implement Changes in Lead Hazard Reduction Program (LHRP) to Protect Vulnerable Populations

The PWB's LHRP consists of Water Treatment and Monitoring, Free Lead-In-Water Education and Testing, Public Outreach and Education, and Home Lead Hazard Reduction.

**Water Treatment and Monitoring**: As mentioned in 3.2.2 and 3.2.7, PWB is currently in the process of incrementally increasing pH from 8.0 to 8.2 and working with OHA to revise WQPs for improved monitoring.

**Free Lead-in-Water Education and Testing**: In addition to the current activities to promote lead in water testing and educate customers how to reduce exposure to lead, the PWB is working with the Multnomah County Health Department and OHA to identify other means to increase these efforts. These improvements are documented in the LHRP quarterly reports submitted to OHA.

**Public Outreach and Education**: In September 2017, the PWB contracted with Program Design and Evaluation Services to evaluate the Outreach and Education aspect of the LHRP. Evaluation surveys are being sent to service recipients in April and May 2017. Results of the evaluation along with recommendations are expected in Fall 2017.

**Home Lead Hazard Reduction**: The Portland Housing Bureau has completed the work on their current Lead Hazard Control Program grant funded by the Housing and Urban Development (HUD). The request for proposals for the next round of funding has been issued. If HUD receives funding to continue this program and Portland is awarded additional funding, PWB will be working with the Housing Bureau to identify potential improvements in the program.

The status of these efforts will be reported to OHA on a quarterly basis along with the other accomplishments of the LHRP.

# NITRIFICATION MONITORING AND ACTION PLAN

**Prepared by:**

**Kimberly Gupta**
**Water Quality Compliance**
**June 18, 2013**

# 1 OBJECTIVE

While it is recognized that nitrification in the Portland Water Bureau's (PWB) distribution system is a seasonal issue, the extent of nitrification in the system is largely unknown. The last thorough documented study of nitrification was conducted over a decade ago, and since that time both treatment (i.e., pH adjustment) and operational changes have occurred that could affect both the extent and location of nitrification in the system. More recent studies (in 2011 and 2012) have indicated that nitrification continues to occur in various areas of the system. Because it is impossible to effectively mitigate an issue when the full extent is unclear, an important objective of this monitoring plan is to further the understanding of nitrification in PWB's system. In particular, if nitrification can be identified in its infancy, control measures can hopefully be taken in attempts to deal with the issue before it worsens as water travels through the system.

The goals of this plan are to establish a robust monitoring program that will provide more targeted and baseline information on nitrification throughout the system, establishing initial nitrification triggers and responses (which will likely need to be adjusted based on the information gathered from the monitoring program), evaluating tank stratification, measuring total organic carbon (TOC) at the outlet of the open reservoirs in late summer/fall, and testing other field mechanisms that may provide a more rapid detection of nitrification than standard laboratory methods. This plan should be revised at the end of 2013's nitrification season with lessons learned.

# 2 INTRODUCTION

Nitrifying bacteria are ubiquitous in the environment, and a baseline level of nitrification occurs continuously to some extent in all chloraminated distribution systems. These baseline levels are typically of minor concern as long as they do not progress into full scale nitrification episodes. Left unchecked, the bacteria responsible for nitrification can survive and proliferate under conditions typically observed in water distribution systems.

## *2.1 Background*

Nitrification is the bacteriological oxidation of ammonia to nitrate via a two-step process:

$$NH_3 + O_2 \rightarrow NO_2^- + 3H^+ + 2e^-$$
$$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$$

Nitrification is carried out by two distinct types of bacteria: ammonia oxidizing bacteria (AOBs) that utilize ammonia as a substrate to produce nitrite (genera include Nitrosomonas, Nitrosospira, etc.) and nitrite oxidizing bacteria (NOBs) that utilize nitrite as a substrate to produce nitrate (genera include Nitrobacter, Nitrospira, etc.). Optimal growth conditions vary between species, however, average optimal growth conditions for nitrifying bacteria tend to be around pH 7-8 and at temperatures greater than 20C. NOBs tend to be slower growers and more sensitive to environmental conditions than AOBs, which is a likely reason that full nitrification is less prevalent than incomplete nitrification in any given system.

Nitrification in the distribution system is promoted when the following factors are present individually or in conjunction with one another:

- <u>Chloramine demand/decay and water age</u>. This is a root cause of nitrification. As water ages, chloramine concentrations decrease through demand and autodecomposition (also termed decay) in the distribution system. As this happens, free ammonia is released that becomes the substrate for the growth of nitrifying bacteria. This is compounded by decreased disinfection capacity as the residual decays and reacts with other constituents.

- Presence of free ammonia. This can occur due to 1) overdose at the treatment plant or 2) through demand and decay of the chloramine residual as it moves through the system.
- Poor mixing within storage tanks. Poor mixing is especially significant in tanks with large storage to demand ratios and in tanks that are only operated within a tight top band (floaters).
- High water temperatures, especially above 15C. Seasonal variations in water temperatures affects when nitrification occurs, and water systems whose water temperature exceeds 15C for several months are more susceptible to nitrification. Higher water temperatures result in a two-fold problem – an increase in the bacterial growth rate and an increased decomposition rate of chloramine.
- Dirty areas in the distribution system. Sand, deposits, biofilm, and corrosion products can harbor bacteria and exert disinfectant demand.

The effect of nitrification of water quality includes the loss of chlorine residual, increased nitrite and/or nitrate above background levels, increased heterotrophic bacteria, and localized decreases in pH.

Nitrification does not cause a direct impact to public health or regulatory compliance; however, as mentioned previously, it does decrease chlorine residuals which can have indirect public health and regulatory ramifications. Indirect public health effects include the loss of protection against pathogens introduced by breaches in the system (i.e., cross connections) and the proliferation of heterotrophs and other types of more harmful bacteria. Indirect regulatory ramifications include impacting compliance with the Surface Water Treatment Rule (disinfectant depletion), Total Coliform Rule (possible increased coliform occurrence), and Lead and Copper Rule (increased corrosion through localized reductions in pH and alkalinity).

## *2.2 PWB Historical Studies*

PWB has evaluated nitrification previously and several of the documented studies are summarized in the subsequent paragraphs.

### 1998-2000 Study

A nitrification study conducted by Curt Ireland in 1998-2000 showed that nitrification occurred throughout the distribution system. Locations included:

- WQSSs: 2 (SE 52nd and Madison), 17 (NW 19th and Everett), 31 (SE 2nd and Salmon), 33 (SE 3rd and Ankeny), 80 (SE 52nd and Lincoln), 85 (Res 3 outlet), 86 (Res 4 outlet), 88 (Res 6 outlet), 89 (Calvary outlet), 93 (NW Millipond and Brittany, 94 (SW 18th and Morrison), 95 (SE 9th and Ochoco), 97 (Riverwood), 99 (Res 1 outlet)
- Tanks = Linnton, Denver

The study found that the peak of the nitrification season for PWB occurs in mid-late fall (Figure 1). This follows conventional wisdom because this corresponds to the time when the combination of conditions contributing to nitrification is at their worst: lower demand (and thus higher water age in the system), high water temperatures (increased growth rate of bacteria and increased decay of chlorine residual leading to lower disinfecting capability and increased food source for microorganisms), and a healthy, proliferating nitrifying community (nitrification is more difficult to stop once it is in full swing).

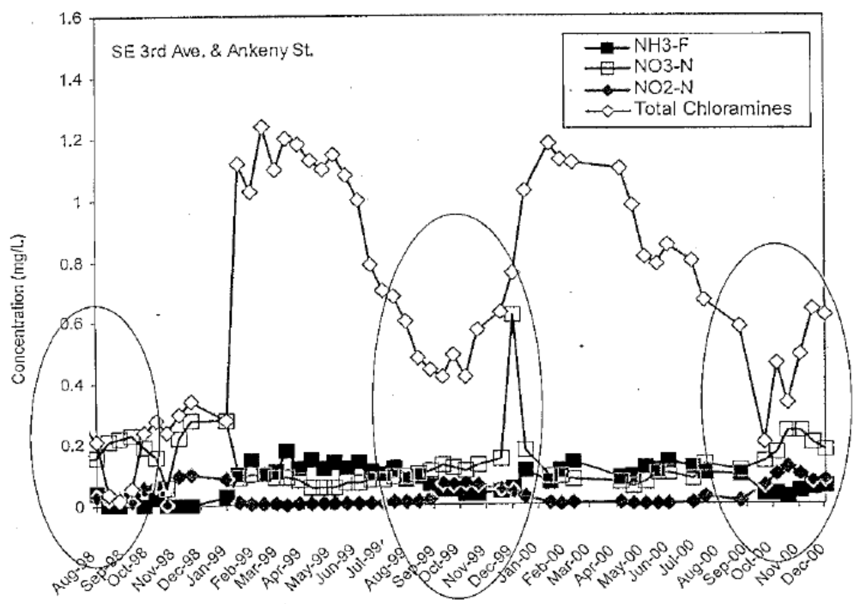



**Figure 1. Seasonal trends in free ammonia, nitrate, nitrate and total chloramines at WQSS 33 (3rd and Ankeny).**

## 2011 Tank monitoring study

In 2011, a nitrification monitoring program was conducted on select tanks. Chlorine, free ammonia, temperature, nitrite, and nitrate were monitored at a subset of tanks (59 in total). Ten of the tanks monitored shows signs of nitrification (chlorine residual less than 1 ppm and exceedances of one or more nitrification parameters). These sites are as follows:

- Alto, Bertha 1 and 2, Council Crest, Halsey, Linnton, Nevada, Rivergate, Stephenson, and Willamette Heights.

Several additional tanks showed conditions ripe for nitrification (chlorine residual less than 1 ppm). These sites are as follows:

- Forest Park, Greenleaf 1 and 2, Kings Heights, Mayfair, Penridge, Pittock, Portland Heights 1, 2 and 3, and Rocky Butte

Several improvement measures were taken to improve water quality in these areas as a result of this study (Arlington Tank #1 taken out of service, modifications to the altitude valve that controls the level of Greenleaf Tank, etc.).

## 2012 R2A study

In 2012, a nitrification monitoring program was conducted at select TCR sites. Sites 'qualified' for nitrification monitoring if pH, temperature, or chlorine residual fell below chronic limits in two consecutive samples or acute limits in one sample. Nitrification monitoring consisted of analyzing for pH, temperature, chlorine residual, nitrite, free ammonia, and HPC-R2A (nitrate was added later in the program). The following WQSSs exceeded nitrification triggers for multiple parameters:

- 31 (Engine 7), 34 (St. John's Precinct, North), 38 (Hayden Island Mobile Park ), 39 (Engine 17), 63 (7-11 Linnton), 69 (NE Cornfoot and Alderwood), 97 (SW Riverwood), 105 (Upper Linnton), 108 (Roswell), 157 (OHSU), 159 (NE 162nd and Stanton), 169 (NE 24th and Emerson), and 182 (SW Santa Monica and Alta Dena)

Other problematic sites included:

- 8 (Conduit 4), 21 (NE 10th and Tillamook), 33 (SE 3rd and Ankeny), 37 (Columbia School), 53 (Margaret Scott Elem), 71 (Interstate), 89 (Calvary Outlet), 91 (Res 5 Outlet), 95 (SE 9th and Ochoco), 99 (Res 1 Outlet), 113 (Res 3 outlet), 183 (SW Doschdale and Dosch), and 195 (Res 4 outlet)

# 3 PROPOSED MONITORING PLAN

As mentioned previously, additional work is necessary to more thoroughly understand nitrification in PWB's system. While recent studies have provided valuable information, they evaluated only select areas of the distribution system at certain times in the nitrification season and included limited baseline data, which makes the ability to draw conclusions in many cases difficult. In development of this plan, the idea was to collect baseline data for large areas of the distribution system including TCR sites, tanks, wholesaler connections, and areas of similar water that were not represented by any other monitoring. Sites were chosen based on known problem areas, historic data, and recommendations from stakeholders.

## *3.1 Distribution System Sampling Plan*

### Plan Development

The plan for selecting the distribution system sites was as follows:

- Storage tank sites were selected based on evaluation of 1999-2000 and 2011 tank monitoring data in conjunction with stakeholder feedback. Three areas (Council Crest, Forest Park, and Linnton) were selected for monitoring. While we known that Linnton, Council Crest, and Forest Park tanks have water quality issues, it is unclear where in the cascade these issues are starting (i.e., in the case of Forest Park, is the issue starting in Forest Park or in one of the pressure zones that supply it?). In attempts to answer these questions, the entire cascade for each of these three areas will be monitored to determine where nitrification is starting.
- Wholesaler connection sites were chosen based on location and stakeholder feedback. There are several wholesalers that pull directly off the distribution system as opposed to the conduits or Powell Butte, and four of these connections were selected. These wholesaler connections are West Slope, Valley View, Burlington, and Palatine.
- TCR monitoring sites were chosen based on a tiered approach. The results of 2011 tank monitoring and 2012 HPC-R2A monitoring were evaluated to select the initial pool of TCR sites. Two years of chlorine residual data from all TCR sites was then analyzed to ensure that any problematic sites were not missed (two sites were added to the plan based on this data). The sites were then plotted graphically to determine if a relative geographical distribution was achieved (two sites were added to accomplish that goal). When multiple options existed, the hydraulic model was consulted to see which sites were most indicative of the water quality for the area (i.e., not on a hydraulic boundary, etc.). Attempts were also made to choose sites in as many areas of similar water as possible. After that process was complete, the full list of eligible TCR sites was compared with existing TCR routes, and routes were modified where possible to accommodate nitrification monitoring.
- The areas of similar water (ASWs) samples were chosen based on evaluation of all locations where existing TCR and proposed nitrification monitoring was occurring or was planned. Four areas of similar water were identified that are not sampled either as part of the TCR or planned nitrification monitoring. Sites were then selected in these ASWs (Denver, Nevada, Rocky Butte, and Sherwood) to augment our understand of the water quality in these areas.

The plan is discussed in further detail in the subsequent sections.

### Sampling locations and frequency

Samples will be collected at the following locations:

- *Total Coliform Rule (TCR) Sites*. 23 sites will be monitored by Water Quality Inspectors (WQIs) every two weeks. 19 of these samples will be collected as part of the routine TCR route, and 4 will be collected on a special nitrification route. Samples at the open reservoir outlets (those that are in-service) and Powell Butte (assuming 5 sample sites total) will be collected weekly. Upper Linnton and Roswell represent known areas of problematic water quality, and although they are not TCR sites, they are on the TCR route and will be collected biweekly during routine TCR monitoring.

- *Tanks*. At 20 tanks (Council Crest, Forest Park, and Linnton cascades), samples will be collected by Operating Engineers (OEs) weekly as part of a special nitrification route.
- *Wholesaler Connections*. There are several wholesaler connections that pull off the distribution system and four were selected for monitoring. These include West Slope, Valley View[1], Burlington, and Palatine. These areas will be monitored by the OEs/WQIs weekly.
  *Areas of Similar Water.* There are 4 areas of similar water that are not captured under any other type of monitoring. The areas of similar water to be sampled are Denver, Nevada, Rocky Butte, and Sherwood. These sites will be monitored by the WQIs weekly.

A map illustrating the sample locations is shown in Figure 2.

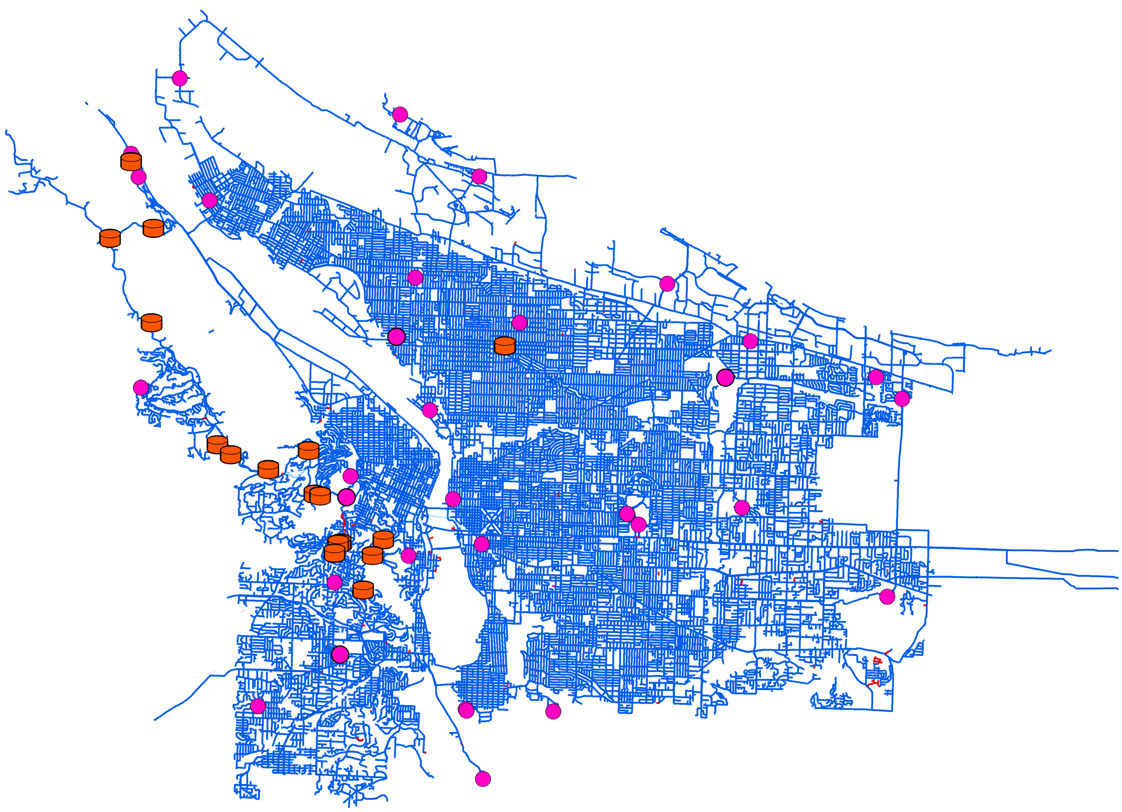


**Figure 2. Map of locations to be monitored.**

## Water quality parameters to be analyzed

Samples are to be collected twice weekly on Mondays and Wednesdays by OEs and WQIs. All selected sites except TCR sites will be sampled weekly and will be monitored for the standard suite of nitrification parameters: total chlorine, pH, temperature, free ammonia, nitrate, and nitrite (Table 1). HPC-R2A analysis will be conducted every other week. The Water Bureau Laboratory will be conducting all of the laboratory analysis.

[1] Valley View has two connections to PWB's system: 5328 54th Street (centerline of the road) and 4400 SW Patton Road. More investigation is underway to determine which is the primary supply.

**Table 1. Parameters to be analyzed**

| Parameter | Field | Laboratory |
|---|---|---|
| Total chlorine | x | |
| pH | x | |
| Temperature | x | |
| Free ammonia | | x |
| Nitrate | | x |
| Nitrite | | x |
| HPC-R2A | | x |

A detailed summary of all sites and analyses proposed under this plan is shown in Table 2.

## Timeline

The tentative start date for monitoring is June 24 and will extend into the late fall as water quality parameters dictate.

**Table 2. Summary of Proposed Sampling and Analysis. F = field parameters (chlorine residual, temperature, pH), LC = laboratory chemistry (free ammonia, nitrite, nitrate), and R2A = HPC R2A**

| LOCATION DESCRIPTION | | SAMPLER | MONDAY WEEKS 1 & 3 | WEDNESDAY WEEKS 1 & 3 | MONDAY WEEKS 2 & 4 | WEDNESDAY WEEKS 2 & 4 |
|---|---|---|---|---|---|---|
| Tanks | Penridge | OE | F, LC, R2A | | F, LC | |
| | Forest Park | OE | F, LC, R2A | | F, LC | |
| | Greenleaf | OE | F, LC, R2A | | F, LC | |
| | Calvary | OE | F, LC, R2A | | F, LC | |
| | Pittock | OE | F, LC, R2A | | F, LC | |
| | Willalatin | OE | F, LC, R2A | | F, LC | |
| | Arlington Heights 2 | OE | | | F, LC | |
| | Arlington Heights 3 | OE | | | F, LC | |
| | Arlington Heights 2 DIP SAMPLE | OE | | | F, LC, R2A | |
| | Arlington Heights 3 DIP SAMPLE | OE | | | F, LC, R2A | |
| | Whitwood | OE | F, LC, R2A | | F, LC | |
| | North Linnton | OE | F, LC, R2A | | F, LC | |
| | Vernon High | OE | F, LC, R2A | | F, LC | |
| | Vernon Low | OE | F, LC, R2A | | F, LC | |
| | Council Crest | OE | | F, LC | | F, LC, R2A |
| | Bertha1 | OE | | F, LC | | F, LC, R2A |
| | Bertha 2 | OE | | F, LC | | F, LC, R2A |
| | Portland Heights 2 | OE | | F, LC | | F, LC, R2A |
| | Portland Heights 3 | OE | | F, LC | | F, LC, R2A |
| | Portland Heights 2 DIP SAMPLE | OE | | F, LC, R2A | | |
| | Portland Heights 3 DIP SAMPLE | OE | | F, LC, R2A | | |
| | Marquam Hill 1 | OE | | F, LC | | F, LC, R2A |
| | Marquam Hill 2 | OE | | F, LC | | F, LC, R2A |
| | Sam Jackson | OE | | F, LC | | F, LC, R2A |
| Wholesaler Connections | West Slope | OE | | F, LC | F, LC, R2A | |
| | Valley View (there are two VV connections so this needs to be investigated further) | Logan | | F, LC | | F, LC, R2A |
| | Burlington | Logan | | F, LC | | F, LC, R2A |
| | Palatine | Logan | | F, LC | | F, LC, R2A |

| LOCATION DESCRIPTION | | SAMPLER | MONDAY WEEKS 1 & 3 | WEDNESDAY WEEKS 1 & 3 | MONDAY WEEKS 2 & 4 | WEDNESDAY WEEKS 2 & 4 |
|---|---|---|---|---|---|---|
| Areas of Similar Water | Denver | Logan | | F, LC, R2A | | F, LC |
| | Nevada | Logan | | F, LC, R2A | | F, LC |
| | Rocky Butte | Logan | | F, LC, R2A | | F, LC |
| | Sherwood | Logan | | F, LC, R2A | | F, LC |
| TCR Sites | Res 1 Outlet (WQSS 99) | Sarah | F, LC, R2A | | F, LC, R2A | |
| | Res 5 Outlet (WQSS 191) | Sarah | | F, LC, R2A | F, LC, R2A | |
| | Res 5 Outlet (WQSS 209) | Sarah | | F, LC, R2A | F, LC, R2A | |
| | Res 3 Outlet (WQSS 113) | Sarah | F, LC, R2A | | F, LC, R2A | |
| | Powell Butte (WQSS 83) | Sarah | | F, LC, R2A | F, LC, R2A | |
| | WQSS 11 | Logan | | F, LC, R2A | | |
| | WQSS 26 | Sarah | | F, LC, R2A | | |
| | WQSS 30 | Sarah | | | | F, LC, R2A |
| | WQSS 31 | Sarah | | | | F, LC, R2A |
| | WQSS 34 | Sarah | | | F, LC, R2A | |
| | WQSS 37 | Sarah | | | F, LC, R2A | |
| | WQSS 38 | Sarah | | | F, LC, R2A | |
| | WQSS 53 | Sarah | | F, LC, R2A | | |
| | WQSS 63 | Sarah | | | F, LC, R2A | |
| | WQSS 67 | Sarah | | | F, LC, R2A | |
| | WQSS 69 | Sarah | | F, LC, R2A | | |
| | WQSS 71 | Sarah | F, LC, R2A | | | |
| | WQSS 93 | Logan | | F, LC, R2A | | |
| | WQSS 95 | Sarah | | | | F, LC, R2A |
| | WQSS 97 | Sarah | | | | F, LC, R2A |
| | WQSS 105 | Sarah | | | F, LC, R2A | |
| | WQSS 108 | Sarah | | | | F, LC, R2A |
| | WQSS 159 | Sarah | | F, LC, R2A | | |
| | WQSS 169 | Sarah | F, LC, R2A | | | |
| | WQSS 177 | Sarah | | | F, LC, R2A | |
| | WQSS 182 | Logan | | F, LC, R2A | | |
| | WQSS 187 | Logan | | F, LC, R2A | | |
| | WQSS 217 | Daby | | F, LC, R2A | | |

## 3.2 Information dissemination

The ability for decision makers to have the data in a timely manner is key. Exceptions-like reports will be auto generated to a very small, select group of stakeholders. This will allow key personnel access to the data as it becomes available. Short meetings will also be held regularly to discuss these results. For wholesaler customers, dissemination of information in biweekly reports is proposed. Also, nitrification will be added as a standard topic at the quarterly Wholesaler Operations Water Quality Subgroup Meetings.

## 3.3 Related monitoring

**Temperature Stratification**

Stratification in storage tanks can significantly impact water age, and thus nitrification. As a result, evaluation of tank stratification at select locations will be conducted. Temperature is relatively easy to measure and is an excellent indicator of stratification. To conduct this study, two strings of temperature probes were purchased. The strings have five adjustable-level temperature probes that are reusable and can be redeployed as necessary. The probes will be programmed to collect temperature data in 15 minute intervals. The probes will be deployed into Linnton Tank and Reservoir 1.

**Side by Side Comparison Studies**

Two side by side comparison studies are planned for this nitrification season. The first will be an evaluation of a free ammonia test kit that has received mixed reviews from other utilities. The second comparison study will seek to compare HPC-R2A results with those obtained from an adenosine triphosphate (ATP) field kit. ATP is a principal energy carrier molecule in all living organisms; it essentially functions as the energy source to drive energy requiring reactions within cells. While heterotrophic plate count (HPC) is a standard method of monitoring general microbial quality in drinking water, it is a time-consuming test that does not provide results for seven days. The proposed ATP test kit is a field test that, according to the vendor, provides results in minutes. This side by side will attempt to determine whether ATP testing is a viable early warning indicator of nitrifying activity in PWB's distribution system. There is a particular vendor that has had promising results in drinking water applications and an attempt is underway to borrow/rent a unit for the summer.

**TOC Analysis at the Open Reservoir Outlets**

Total Organic Carbon (TOC) is analyzed monthly at the Reservoir 5 outlet (it is unclear at this time why this is the only reservoir monitored). Since most utilities are filtered systems, TOC is much more variable in PWB's system than most. TOC exerts chlorine demand and can act as a carbon source for some bacteria, and it could impact nitrification in our system. As the nitrification season progresses, this plan proposes to begin bi-weekly TOC sampling at all in-service open reservoir outlets. This data will be evaluated in conjunction with nitrification data to determine whether TOC influx from the open reservoirs impacts the extent/duration of nitrification in the system.

# 4 PROPOSED ACTION PLAN

## *4.1 Preventing and Mitigating Nitrification Episodes in the System*

Since the process of chloramination itself provides the food source for AOBs, optimizing treatment is the first step in nitrification control. The chlorine to ammonia ratio and free ammonia entering the system at the entry point has been largely optimized in PWB's system. As a result, the next place to evaluate nitrification control measures is in the distribution system. There are certain water quality parameters that impact nitrification over which we have little control, such as temperature and TOC; however, other parameters such as water age, chlorine residual, and free ammonia can be affected by changes in operations. Particularly effective measures include taking storage out of service either permanently or seasonally in problematic areas, increased flushing (both spot and unidirectional), booster chlorination, increased storage tank turnover (where possible), optimized pumping/regulator operations, and routine tank cleaning.

### Nitrification triggers and response levels

Draft trigger and response levels have been proposed to start more aggressively tackling nitrification in PWB's system. These trigger and response levels are estimates and will need to be revised once more data is collected in our system. Also, action level responses in many cases will be a function of multiple parameters being exceeded.

**Table 3. Nitrification triggers and potential response levels**

| Parameter | Target | Alert Level | Action Level 1 | Action Level 2 | Action Level 3 |
|---|---|---|---|---|---|
| Total Chlorine (mg/L) | >1.0 | | <1.0 | <0.8 | <0.50 |
| Nitrite-N (mg/L) | <0.010 | | >0.010 | >0.020 | >0.050 |
| Nitrate-N (mg/L) | Background (Based on 10 years of data, the average nitrate entering the system is 0.025 mg/L) | Increase relative to background | | | |
| R2A HPC (cfu/ml) | <200 | >200 or a significant increase from the previous sampling date | >300 | >400 | >500 |
| Free Ammonia-N (mg/L) | <0.05 (pipes)<br>0.05-0.15 (tanks) | >0.10 (DS)<br>>0.2 (tanks) | >0.35 | >0.40 | |
| pH | As close to 8 as possible | Less than target | | | |

Action Level 1: Evaluate increased sampling
Ensure optimization at chlorine and ammonia injection points (both at the plant and booster chlorination sites)
Evaluate pumping operations to see if operations could be altered/synchronized up the cascade to bring fresher water to the area
Evaluate whether tanks can be cycled more effectively
If at a wholesaler connection, evaluate recent wholesaler consumption data

Action Level 2: Continue performing action level 1 responses
Drain and refill tanks with fresh water (disinfect if necessary)
Clean tank
Evaluate whether additional storage can be taken offline (may not be possible based on hydraulics)
Perform flushing in the area
Notify affected wholesalers

Action Level 3: Perform UDF of the area (and in the process look for erroneously closed valves)
Evaluate breakpoint chlorination

# 2016 NITRIFICATION MONITORING AND ACTION PLAN

**Prepared by:**

**Kimberly Gupta**
**Water Quality Compliance**
**April 2016**

# 1 OBJECTIVE

This plan is the nitrification monitoring and action plan for the PWB for 2016. Per the 2013 plan, this plan is upgraded annually to reflect changes in monitoring, etc. The goals of this plan is to describe PWB's nitrification monitoring plan for this year, enumerate trigger/response levels and potential mitigation strategies, and list the proactive measures to be taken before the onset of nitrification season.

# 2 INTRODUCTION

Nitrifying bacteria are ubiquitous in the environment, and a baseline level of nitrification occurs continuously to some extent in all chloraminated distribution systems. These baseline levels are typically of minor concern as long as they do not progress into full scale nitrification episodes. Left unchecked, the bacteria responsible for nitrification can survive and proliferate under conditions typically observed in water distribution systems.

## *2.1 Background*

Nitrification is the bacteriological oxidation of ammonia to nitrate via a two-step process:

$$NH_3 + O_2 \rightarrow NO_2^- + 3H^+ + 2e^-$$
$$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$$

Nitrification is carried out by two distinct types of bacteria: ammonia oxidizing bacteria (AOBs) that utilize ammonia as a substrate to produce nitrite (genera include Nitrosomonas, Nitrosospira, etc.) and nitrite oxidizing bacteria (NOBs) that utilize nitrite as a substrate to produce nitrate (genera include Nitrobacter, Nitrospira, etc.). Optimal growth conditions vary between species, however, average optimal growth conditions for nitrifying bacteria tend to be around pH 7-8 and at temperatures greater than 20C. NOBs tend to be slower growers and more sensitive to environmental conditions than AOBs, which is a likely reason that full nitrification is less prevalent than incomplete nitrification in any given system.

Nitrification in the distribution system is promoted when the following factors are present individually or in conjunction with one another:

- <u>Chloramine demand/decay and water age</u>. This is a root cause of nitrification. As water ages, chloramine concentrations decrease through demand and autodecomposition (also termed decay) in the distribution system. As this happens, free ammonia is released that becomes the substrate for the growth of nitrifying bacteria. This is compounded by decreased disinfection capacity as the residual decays and reacts with other constituents.
- <u>Presence of free ammonia</u>. This can occur due to 1) overdose at the treatment plant or 2) through demand and decay of the chloramine residual as it moves through the system.
- <u>Poor mixing within storage tanks</u>. Poor mixing is especially significant in tanks with large storage to demand ratios and in tanks that are only operated within a tight top band (floaters).
- <u>High water temperatures, especially above 15C</u>. Seasonal variations in water temperatures affects when nitrification occurs, and water systems whose water temperature exceeds 15C for several months are more susceptible to nitrification. Higher water temperatures result in a two-fold problem – an increase in the bacterial growth rate and an increased decomposition rate of chloramine.
- <u>Dirty areas in the distribution system</u>. Sand, deposits, biofilm, and corrosion products can harbor bacteria and exert disinfectant demand.

The effect of nitrification of water quality includes the loss of chlorine residual, increased nitrite and/or nitrate above background levels, increased heterotrophic bacteria, and localized decreases in pH.

Nitrification does not cause a direct impact to public health or regulatory compliance; however, as mentioned previously, it does decrease chlorine residuals which can have indirect public health and regulatory ramifications. Indirect public health effects include the loss of protection against pathogens introduced by breaches in the system (i.e., cross connections) and the proliferation of heterotrophs and other types of more harmful bacteria. Indirect regulatory ramifications include impacting compliance with the Surface Water Treatment Rule (disinfectant depletion), Total Coliform Rule (possible increased coliform occurrence), and Lead and Copper Rule (increased corrosion through localized reductions in pH and alkalinity).

# 3 PROPOSED MONITORING PLAN

Sites were chosen based on known problem areas, historic data, and recommendations from stakeholders.

## *3.1 Distribution System Sampling Plan*

### Plan Development

The procedure for selecting the distribution system sites was as follows:

- Storage tank sites were selected based on 2015 nitrification data, 2015 TCR data, 2015 tank monitoring data, review of any other non-regulatory data collected in the system, and stakeholder feedback.
- Wholesaler connection sites were chosen based on location and stakeholder feedback. There are several wholesalers that pull directly off the distribution system as opposed to the conduits or Powell Butte, and four of these connections were selected. These wholesaler connections are West Slope, Valley View, Burlington, and Palatine.
- TCR monitoring sites were chosen based on 2015 nitrification data, 2015 TCR data, and any other non-regulatory data collected in the system.

### Sampling locations and frequency

Samples will be collected at the following locations:

- *Total Coliform Rule (TCR) Sites*. 28 sites will be monitored by Water Quality staff typically every two weeks. Samples will be collected as part of the routine TCR when possible. When not possible, these sites will be collected as part of a special nitrification route. Roswell represents a known area of problematic water quality, and although it is not a TCR site, it is on the TCR route and will be collected biweekly during routine TCR monitoring.
- *Tanks*. 27 tanks samples will be collected by Operating Engineers (OEs) weekly as part of a special nitrification route.
- *Wholesaler Connections*. West Slope, Valley View[1], Burlington, and Palatine wholesale connections will be monitored weekly by WQ staff.

A map illustrating 2016's sample locations is shown in Figure 1.

[1] Valley View has two connections to PWB's system: 5328 54$^{th}$ Street (centerline of the road) and 4400 SW Patton Road. 4400 SW Patton Road is the primary source of supply.

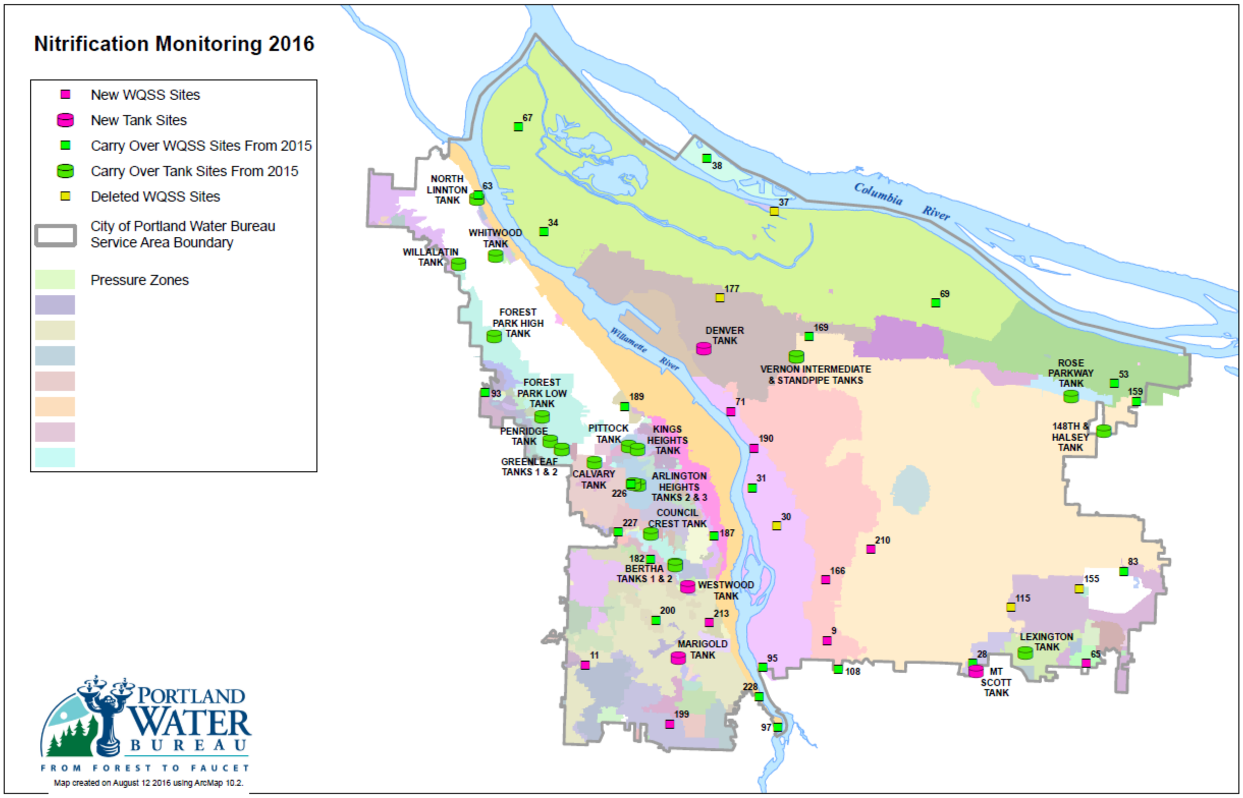



**Figure 1. Map of locations to be monitored.**

## Water quality parameters to be analyzed

Table 3-1 lists the parameters to be monitored. Table 3-2 lists the analyses and schedule. The Water Bureau Laboratory will be conducting all of the laboratory analysis.

**Table 3-1. Parameters to be analyzed**

| Parameter | Field | Laboratory |
|---|---|---|
| Total chlorine | x | |
| pH | x | |
| Temperature | x | |
| ORP | x | |
| Turbidity | x | |
| Free ammonia | x (select samples) | x |
| Nitrate | | x |
| Nitrite | | x |
| HPC-R2A | | x |

A detailed summary of all sites and analyses proposed under this plan is shown in Table 2.

## Timeline

The tentative start date for monitoring is June 24 and will extend into the late fall as water quality parameters dictate.

**Table 3-2. Sample sites and frequency of monitoring.**

**F =** pH, chlorine, temperature; **F-SL1000 =** pH, chlorine, nitrite, free ammonia; **Temp** = temperature; **ORP =** ORP; **LC =** nitrite, nitrate, free ammonia (to be analyzed by the lab)**, R2A** = HPC-R2A (to be analyzed by the lab).

| | LOCATION DESCRIPTION | LIMS ID | SAMPLER | Tues WEEKS 1 & 3 (W1D2, W3D2) | Thurs WEEKS 1 & 3 (W1D4, W3D4) | Tues WEEKS 2 & 4 (W2D2, W4D2) | Wed WEEKS 2 & 4 (W2D3, W4D3) | Thurs WEEKS 2 & 4 (W124, W4D4) |
|---|---|---|---|---|---|---|---|---|
| Tanks | Penridge (7308 NE Penridge Avenue) | WQSS0188 | OE | F, LC, R2A | | | F-SL1000, Temp | |
| | Forest Park High (9936 NW Wind Ridge) | WQSS5002 | OE | F, LC, R2A | | | | |
| | Forest Park Low | WQSS5015 | OE | F, LC, R2A | | | | |
| | Greenleaf (360 NW Greenleaf Road) | WQSS5003 | OE | F, LC, R2A | | | | |
| | Calvary (635 NW Skyline Blvd) | WQSS5004 | OE | F, LC, R2A | | | | |
| | Pittock (4191 NW Monte Vista Terrace) | WQSS0019 (copper tube) | OE | F, LC, R2A | | | F-SL1000, Temp | |
| | Willalatin (NW Skyline Blvd & Willalatin Road) | WQSS0064 | OE | F, LC, R2A | | | | |
| | Arlington Heights 2 and 3 Common Header (3900 SW Fairview Blvd) | WQSS5011 | OE | F, LC, R2A | | | | |
| | Whitwood (9798 NW Springville) | WQSS5005 | OE | F, LC, R2A | | | | |
| | North Linnton (11159 NW 3rd Avenue) | WQSS5006 | OE | F, LC, R2A | | | | |
| | Kings Heights | WQSS5014 | OE | F, LC, R2A | | | F-SL1000, Temp | |
| | Vernon Standpipe High - (1906 NE Prescott St) | WQSS5007 | OE | F, LC, R2A | | | | |
| | Vernon Standpipe Low - (1906 NE Prescott St) | WQSS5008 | OE | F, LC, R2A | | | | |
| | Denver | | OE | F, LC, R2A | | | | |
| | Council Crest (3045 SW Council Crest Dr) | WQSS5013 | OE | | | F, LC, R2A | | |
| | Bertha 1 and 2 Common Header (4715 SW Council Crest Drive) | WQSS0045 (copper tube) | OE | | | F, LC, R2A | | |
| | Portland Heights 2 and 3 Common Header (2787 Talbot Road) | WQSS5012 | OE | | | F, LC, R2A | | |
| | Marquam Hill 2 (Near 3340 SW Marquam Hill Road) | WQSS5010 | OE | | | F, LC, R2A | | |

| | LOCATION DESCRIPTION | LIMS ID | SAMPLER | Tues WEEKS 1 & 3 (W1D2, W3D2) | Thurs WEEKS 1 & 3 (W1D4, W3D4) | Tues WEEKS 2 & 4 (W2D2, W4D2) | Wed WEEKS 2 & 4 (W2D3, W4D3) | Thurs WEEKS 2 & 4 (W124, W4D4) |
|---|---|---|---|---|---|---|---|---|
| | Sam Jackson (SW Sam Jackson Park Road and Marquam St) | WQSS0015 | OE | | | F, LC, R2A | | |
| | Vermont Hills | WQSS5016 | OE | | | F, LC, R2A | | |
| | Arnold | WQSS5021 | OE | | | F, LC, R2A | | |
| | Marigold | | OE | | | F, LC, R2A | | |
| | Westwood | | OE | | | F, LC, R2A | | |
| | Lexington Tank | WQSS5017 | OE | | | F, LC, R2A | | |
| | NE 148th and Halsey (Dip because no other good sampling point) | WQSS5018 | OE | | | F, LC, R2A | | |
| | Rose Parkway | WQSS5019 | OE | | | F, LC, R2A | | |
| | Mt. Scott | | OE | | | F, LC, R2A | | |
| Wholesale Connections | West Slope (3900 SW Fairview Blvd Portland) | WQSS0226 | WQMO | F, LC, R2A, ORP | | F-SL1000, Temp, ORP | | |
| | Valley View (4400 SW Patton Road, Portland) | WQSS0227 | WQMO | F-SL1000, Temp, ORP | | F, LC, R2A, ORP | | |
| | Burlington (**WQSS 63** is being used as a surrogate) | WQSS0063 | WQMO | F, LC, R2A, ORP | | F-SL1000, Temp, ORP | | |
| | Palatine ( 10509 SW Riverside Dr) | WQSS0228 | WQMO | F, LC, R2A, ORP | | F-SL1000, Temp, ORP | | |
| TCR Sites | Powell Butte | WQSS0083 | WQMO | | | F-WQ, LC, R2A | | |
| | WQSS 9 | WQSS0009 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 11 | WQSS0011 | WQMO | F-SL1000, Temp, ORP | | | | |
| | WQSS 28 | WQSS0028 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 31 | WQSS0031 | WQMO | | | F, LC, R2A, ORP | | |
| | WQSS 34 | WQSS0034 | WQMO | | F-SL1000, Temp, ORP | | | |
| | WQSS 38 | WQSS0038 | WQMO | | F-SL1000, Temp, ORP | | | |
| | WQSS 53 | WQSS0053 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 65 | WQSS0065 | WQMO | | | F, LC, R2A, ORP | | |
| | WQSS 67 (Purdy) | WQSS0067 | WQMO | | F-SL1000, Temp, ORP | | | |

| | LOCATION DESCRIPTION | LIMS ID | SAMPLER | Tues WEEKS 1 & 3 (W1D2, W3D2) | Thurs WEEKS 1 & 3 (W1D4, W3D4) | Tues WEEKS 2 & 4 (W2D2, W4D2) | Wed WEEKS 2 & 4 (W2D3, W4D3) | Thurs WEEKS 2 & 4 (W124, W4D4) |
|---|---|---|---|---|---|---|---|---|
| | WQSS 69 | WQSS0069 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 71 | WQSS0071 | WQMO | | | F-SL1000, Temp, ORP | | |
| | WQSS 93 | WQSS0093 | WQMO | | F-SL1000, Temp, ORP | | | |
| | WQSS 95 | WQSS0095 | WQMO | | | F, LC, R2A, ORP | | |
| | WQSS 97 | WQSS0097 | WQMO | F, LC, R2A, ORP | | | | |
| | WQSS 108 | WQSS0108 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 159 (162nd & Stanton) | WQSS0159 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 166 | WQSS0166 | WQMO | | | | | F-SL1000, Temp, ORP |
| | WQSS 169 (NE 24th & Emerson) | WQSS0169 | WQMO | | | F, LC, R2A, ORP | | |
| | WQSS 182 (Altadena & Santa Monica) | WQSS0182 | WQMO | F-SL1000, Temp, ORP | | | | |
| | WQSS 187 (SW Barbur & Whitaker) | WQSS0187 | WQMO | | F-SL1000, Temp, ORP | | | |
| | WQSS 189 (Willamette Heights Tank) | WQSS0189 | WQMO | F, LC, R2A, ORP | | | | |
| | WQSS 190 | WQSS0190 | WQMO | | | F-SL1000, Temp, ORP | | |
| | WQSS 199 | WQSS0199 | WQMO | | F-SL1000, Temp, ORP | | | |
| | WQSS 200 (Bertha 750) | WQSS0200 | WQMO | F, LC, R2A, ORP | | | | |
| | WQSS 210 | WQSS0210 | WQMO | | | F, LC, R2A, ORP | | |
| | WQSS 213 | WQSS0213 | WQMO | | F-SL1000, Temp, ORP | | | |

## *3.2 Information dissemination*

The ability for decision makers to have the data in a timely manner is key. Exceptions-like reports will be auto generated to a very small, select group of stakeholders. This will allow key personnel access to the data as it becomes available. Short meetings will also be held regularly to discuss these results. For wholesaler customers, dissemination of information in biweekly reports is possible.

# 4 PROPOSED ACTION PLAN

## *4.1 Preventing and Mitigating Nitrification Episodes in the System*

There are certain water quality parameters that impact nitrification over which we have little control, such as temperature and TOC; however, other parameters such as water age, chlorine residual, and free ammonia can be affected by changes in operations. Particularly effective measures include taking storage out of service seasonally in problematic areas, increased flushing (both spot and unidirectional), deep cycling tanks/decreasing tank levels (where possible), modified pumping/regulator operations, and increased tank cleaning (relative to their schedule).

### Nitrification triggers and response levels

Draft trigger and response levels are listed in Table 4-1. Also, action level responses in some cases will be a function of multiple parameters being exceeded.

**Table 4-1. Draft nitrification triggers and potential response levels**

| Parameter | Target | Action Level 1 | Action Level 2 | Action Level 3 |
|---|---|---|---|---|
| Total Chlorine (mg/L) | >1.0 (tanks)<br>>0.5 (pipes) | <1.0 (tanks)<br><0.5 (pipes) | <0.5 (tanks)<br><0.5 (pipes) | <0.1 (DS) |
| Nitrite-N (mg/L) | <0.010 or background level | Increase relative to background | >0.3 | |
| Nitrate-N (mg/L) | Background (Based on 10 years of data, the average nitrate entering the system is 0.025 mg/L) | Increase relative to background | | |
| R2A HPC (cfu/ml) | <500 | >500 or a significant increase from the previous sampling date | >1000 | |
| Free Ammonia-N (mg/L) | <0.05 (pipes)<br>0.05-0.15 (tanks) | >0.10 (DS)<br>>0.2 (tanks) | >0.35 | |
| pH | As close to 8 as possible | Less than target | | |

<u>Action Level 1</u>: Evaluate increased sampling
Ensure optimization at chlorine and ammonia injection points (both at the plant and booster chlorination sites)
Evaluate pumping operations to see if operations could be altered/synchronized up the cascade to bring fresher water to the area
Evaluate whether tanks can be cycled more effectively
Perform flushing in the area

<u>Action Level 2</u>: Continue performing action level 1 responses
Drain and refill tanks with fresh water (disinfect if necessary)
Clean tank
Evaluate whether additional storage can be taken offline (may not be possible based on hydraulics)
If at a wholesaler connection, evaluate recent wholesaler consumption data
Notify affected wholesalers

Action Level 3: Perform UDF of the area (and in the process look for erroneously closed valves)
Evaluate breakpoint chlorination

## Proactive measures

Proactive measures to decrease nitrification and water age in the system will be send out in a separate document. These should be completed in early June before the onset of nitrification season.

# Annual Report: Unidirectional Flushing Program, Year End 2016

**2016 Highlights and Summary**

PWB flushed 150,728 feet (28.5 miles) of water main during 2016. Flushing has been completed in both the St. Johns and Lexington Pressure Zones. We subsequently began flushing in the Vernon 270 Pressure Zone and have flushed over 5 miles of the mains in that zone. Also, we responded to several customer water quality complaints, and one TC+. Further, we collected surveillance samples in several areas where UDF had been conducted previously. Our flush planning paradigm has also evolved steadily over the year, optimizing time in the field and aligning it with recommendations from the Confluence WRF consultants. All this information will be discussed in further detail below.

**Weather Notes:**

Our flushing activity has been significantly impacted by weather events such as heavy rainfall. Portland International Airport received 43.24 inches of rainfall, which is 7.21 inches above normal (2016 National Weather Service Data). Nearly half of this rain (19.65 inches) fell in the last quarter of 2016.

I. **Flushing Field Activities**

   A. **St Johns, Vernon 270 PZ** – Flushing has been completed within this Pressure Zone (Figure 1).

   - The purpose of flushing this area was to improve overall water quality. Figures 2 and 3 show how chlorine residual and water clarity were both increased as a result of flushing in this area.
     - We flushed 83,495 feet (15.81 miles) of main. Some of our work was delayed by: 1) heavy rainfall in January, and 2) repairs on a 20-inch main that had to be completed and main back in service prior to UDF.
       a. A CSA assisted us with field work and data entry for 2.5 months.
       b. On occasion, the WQ samplers also helped with field work and data entry.

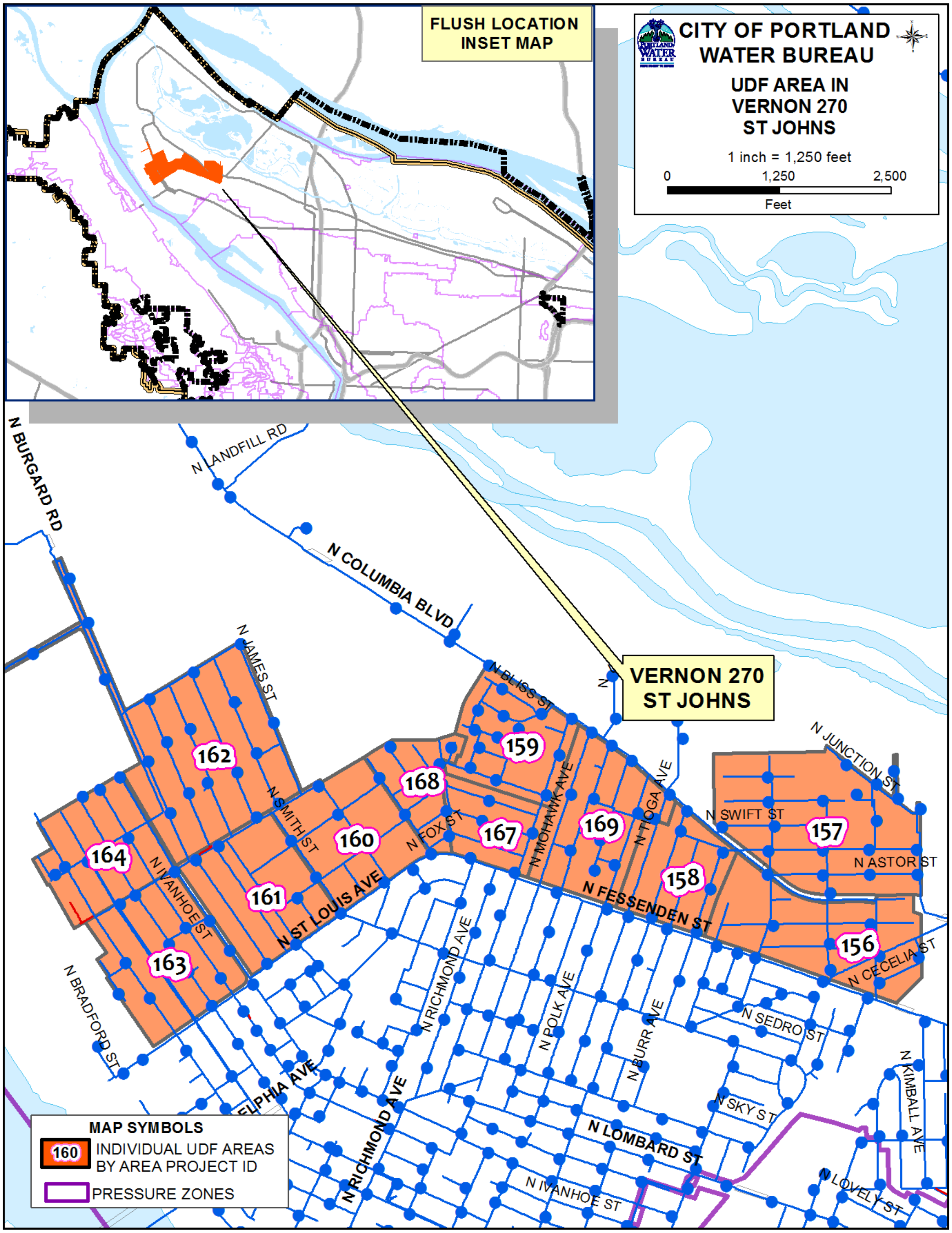



*Figure 1. St. Johns UDF for 2016. The orange color denotes the full extent of flushing, and Area Project ID numbers are shown within each area.*

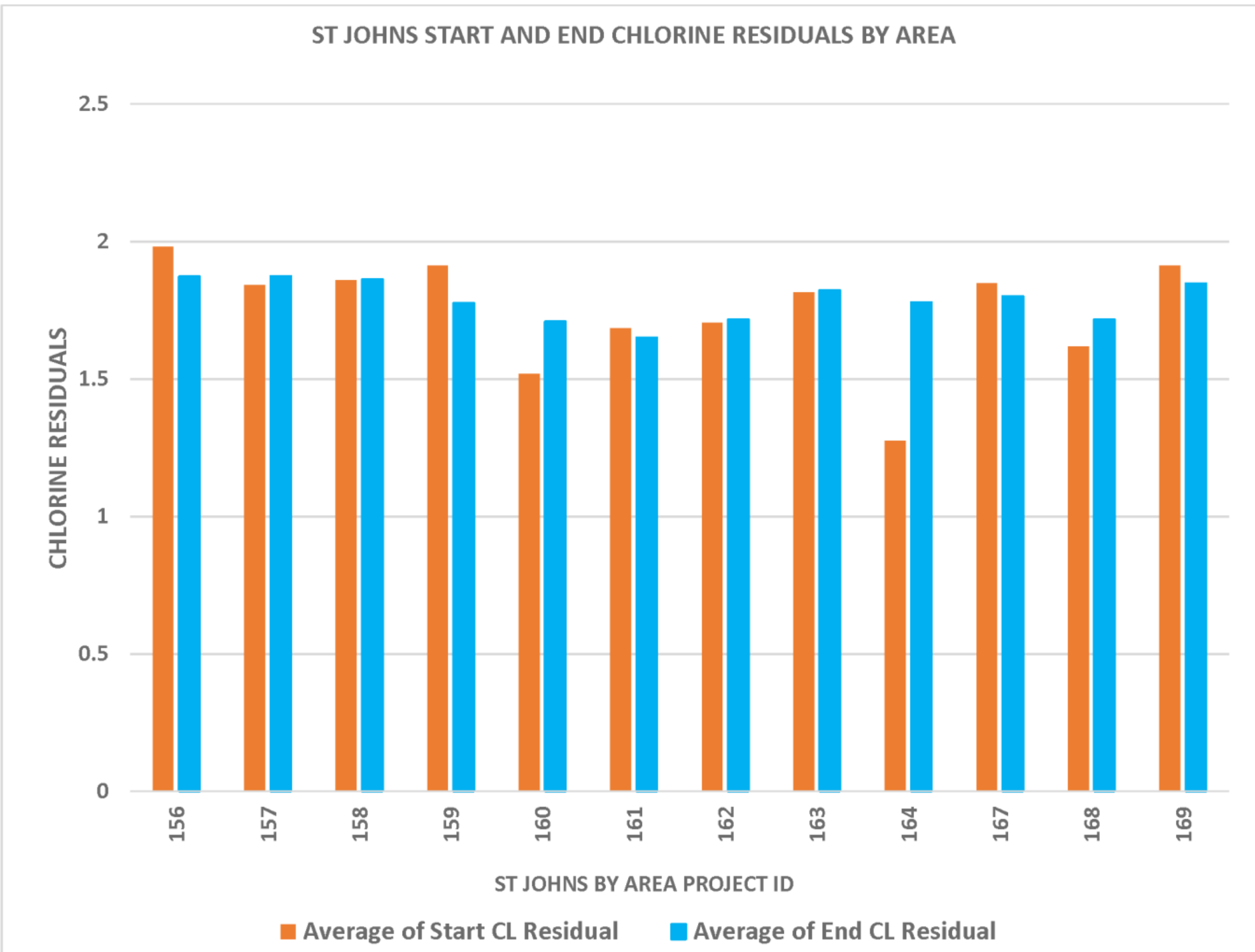



*Figure 2. The average starting and ending chlorine residuals for each Area Project ID in St. Johns.*

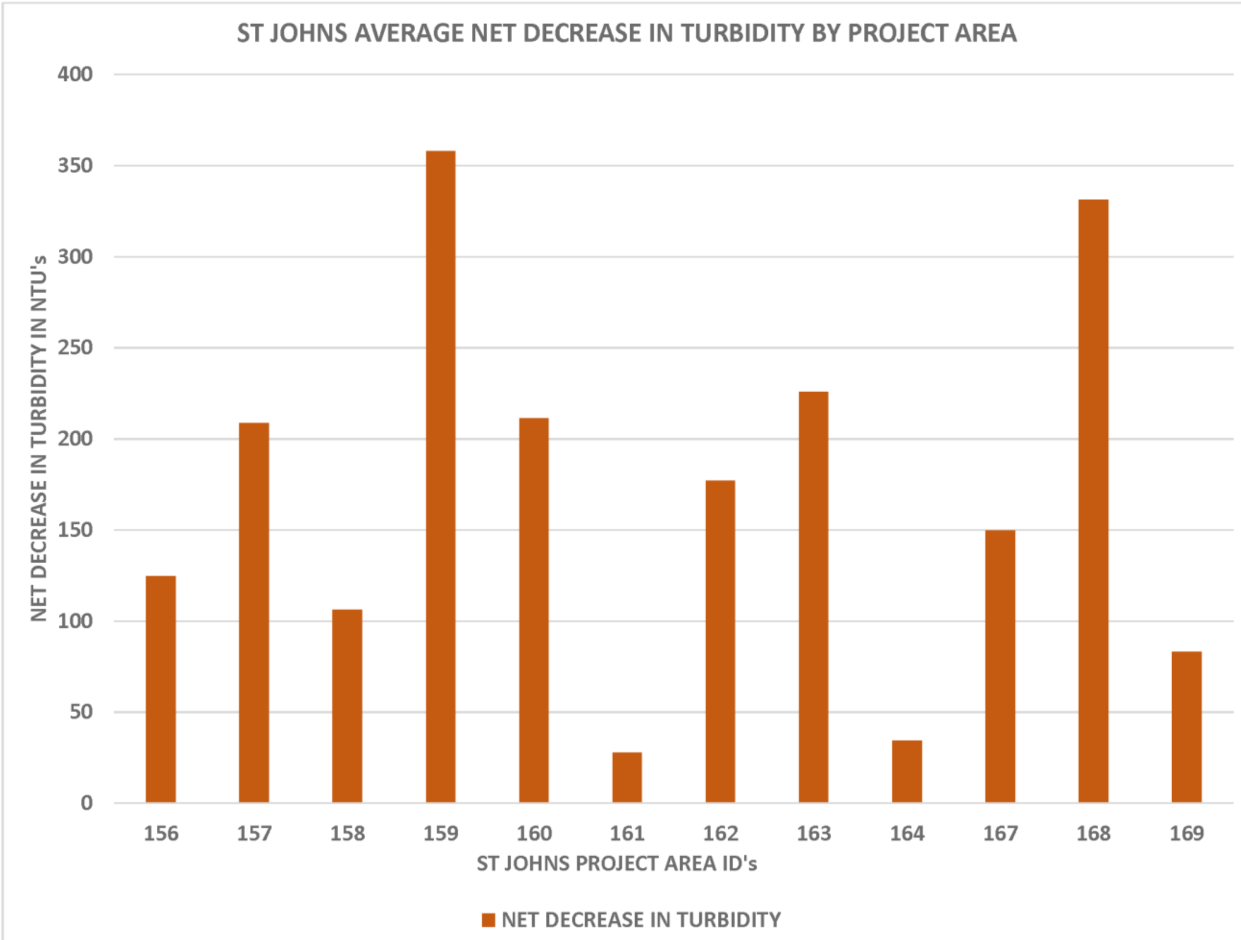



*Figure 3. Average increase in water clarity (measured as decrease in turbidity) for each Area Project ID in St. Johns.*

**B. Lexington Pressure Zones** – Targeted UDF

- The purpose of flushing this area (Figure 4) was to increase system chlorine residuals after the tank was cleaned. We optimized flushing near pressure regulators by coordinating with the OE's to turn the regulators off during those flushes. On the larger mains (8" to 12"), flushing at target velocities was not always possible due to the factors listed below.
    - System pressure – Under normal conditions services at higher elevations operate near the minimum pressure threshold. We mitigated pressure loss by modeling each flush to ensure system pressure was maintained while flushing, then stationing a UW at the highest elevation hydrant to monitor system pressure during each flush.
        a. System pressure did not appear to be affected by flushing.

- Inadequate drainage – The BES infrastructure here is predominantly surface drainage, with catch basins daylighting to drainage ditches. The drainage ditches are vastly undersized for hydrant flow, and also connect directly to Johnson Creek. Both of these components were problematic, which made flushing extremely challenging.
    a. We mitigated risk by reducing hydrant flow rate on larger mains.
    b. On some unimproved streets the risk of damaging property with hydrant flow was too great, and mains could not safely be flushed.
- UDF still increased both chlorine residuals and water clarity in most mains in the Lexington pressure zones (Figures 5 and 6).

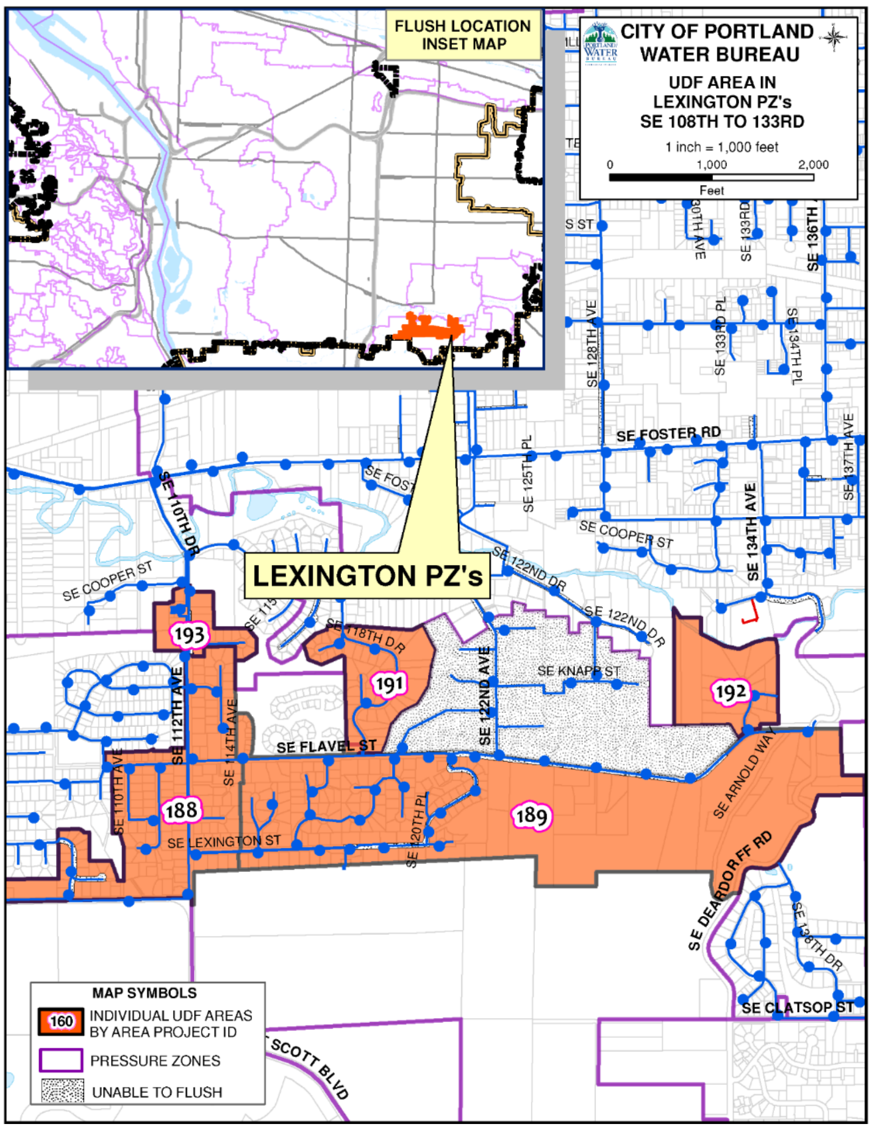



*Figure 4. Lexington Pressure Zone UDF for 2016. The orange color denotes the area flushed, and Area Project ID numbers are shown within each area.*

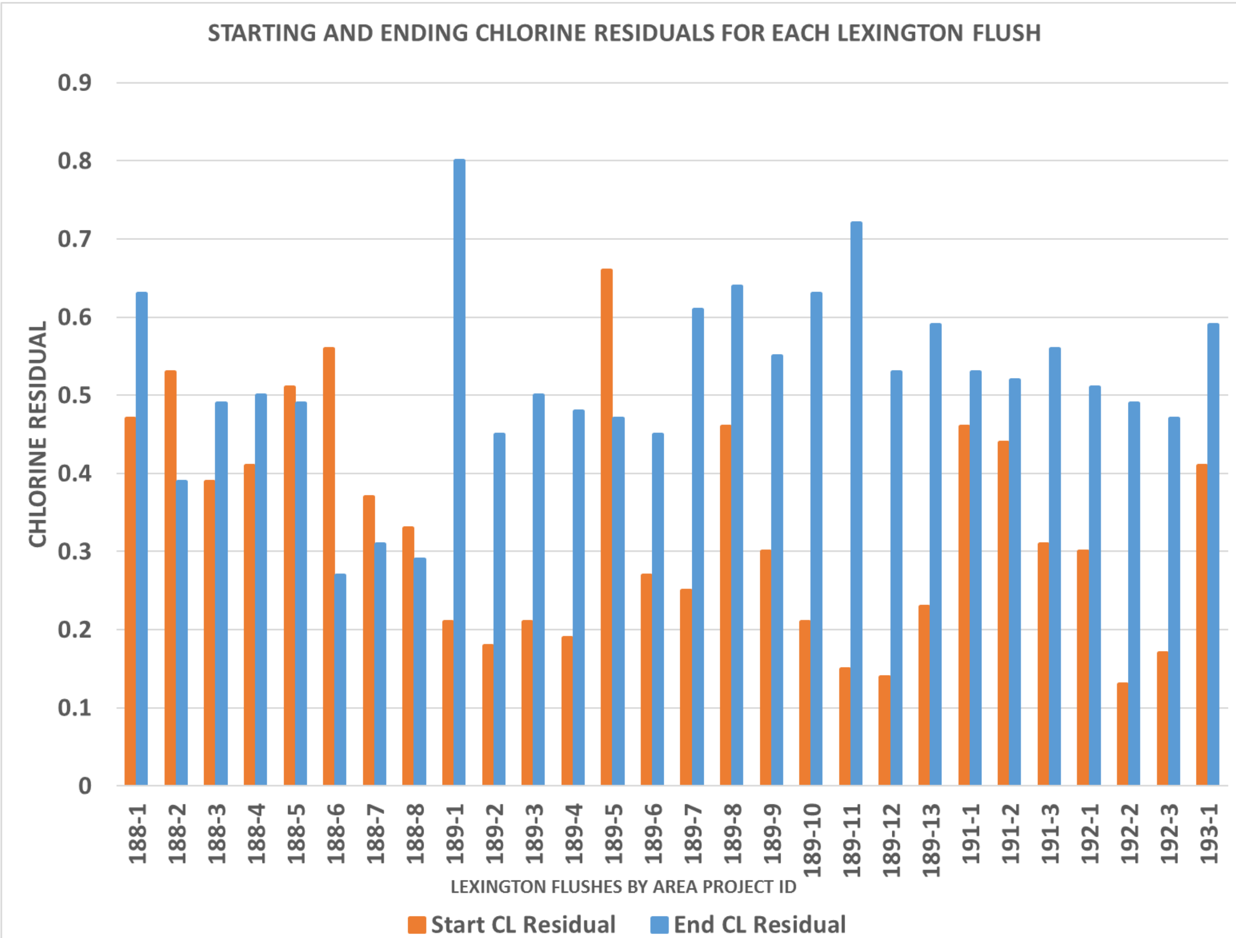



*Figure 5. Starting and ending chlorine Residuals for all flushes in the Lexington PZ. For numbers on the x axis, the first number is the project ID and the second number is the flush number within that project ID.*

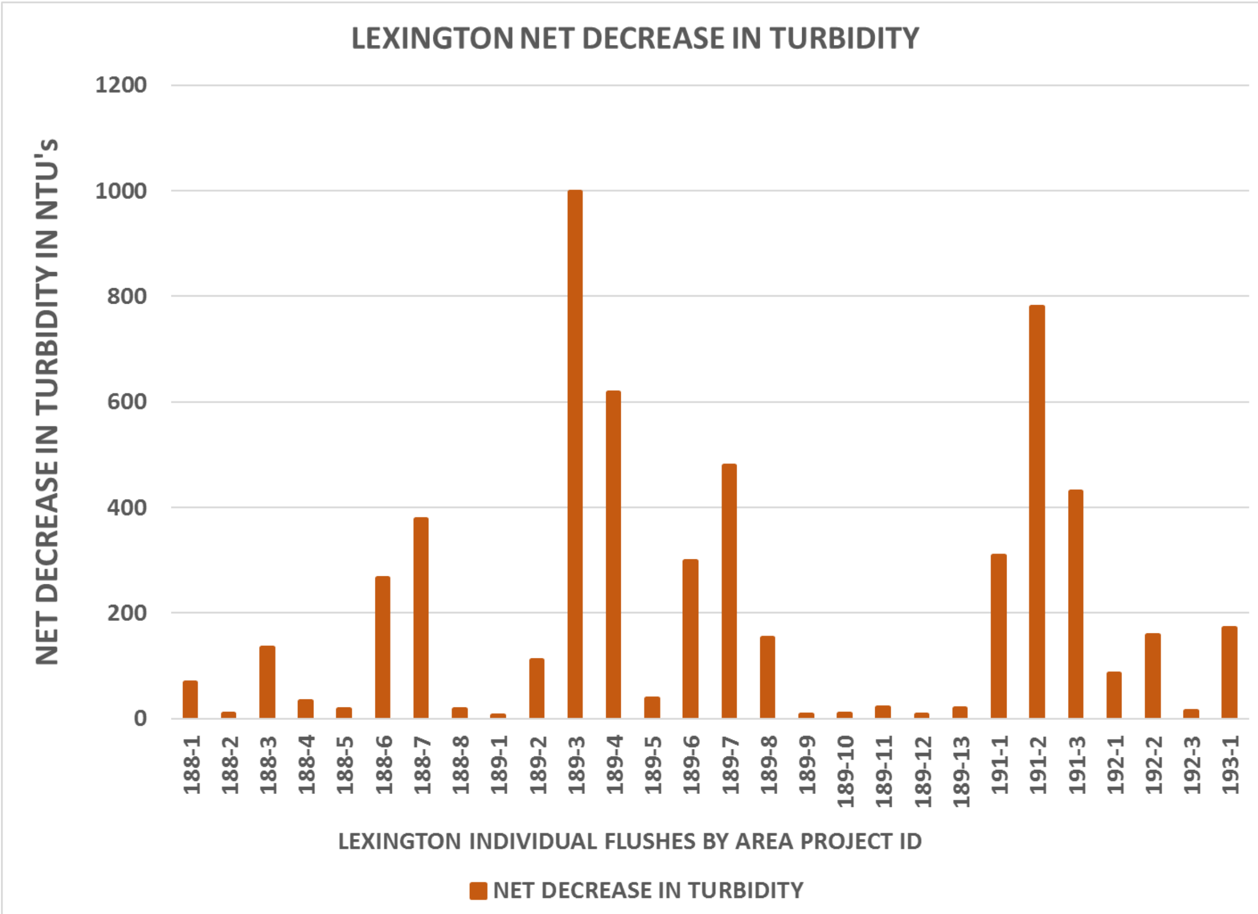



*Figure 6. Average increase in water clarity (measured as decrease in turbidity) for all flushes in the Lexington PZ. For numbers on the x axis, the first number is the project ID and the second number is the flush number within that project ID.*

**C. East of the Railroad Cut, Vernon 270 PZ** – ongoing

- After completing St. Johns, we moved to a new portion of Vernon PZ (Figure 7) to continue work toward our goal of water quality improvement. Some of the factors that make this area attractive for wintertime UDF are listed below.
  - Relatively flat terrain with most streets having curbs and gutters.
  - The presence of BES sedimentation sumps helps reduce the risk of CSO.
  - We flushed 24,363 feet (4.6 miles) of main in this section of the PZ this year.

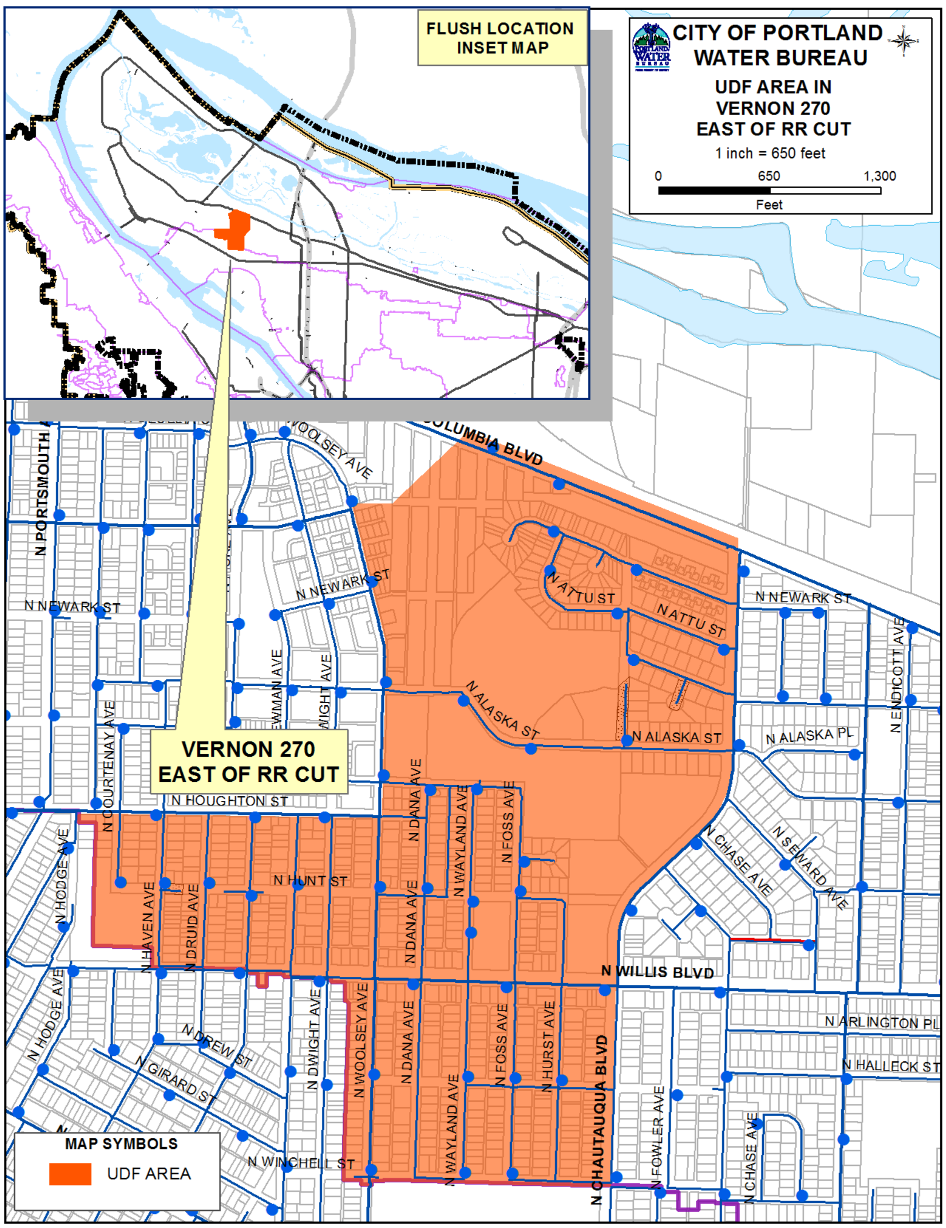



*Figure 7. Vernon 270 East of Railroad Cut UDF for 2016. The orange color denotes the area flushed.*

**D. SE 86th Ave, Kelly Butte 427 Tank PZ –** Customer complaint

- The purpose of this flush was to address a customer complaint of high iron and turbidity. The customer's complaint had been followed up on and verified with iron surveillance sampling throughout the area. Test results indicated elevated levels of iron, and it was thought that UDF could solve the problem.
  - The area was not flushed as planned due to a paved-over gate and broken hydrant. Work orders were submitted and we asked for these repairs to be made a high priority.

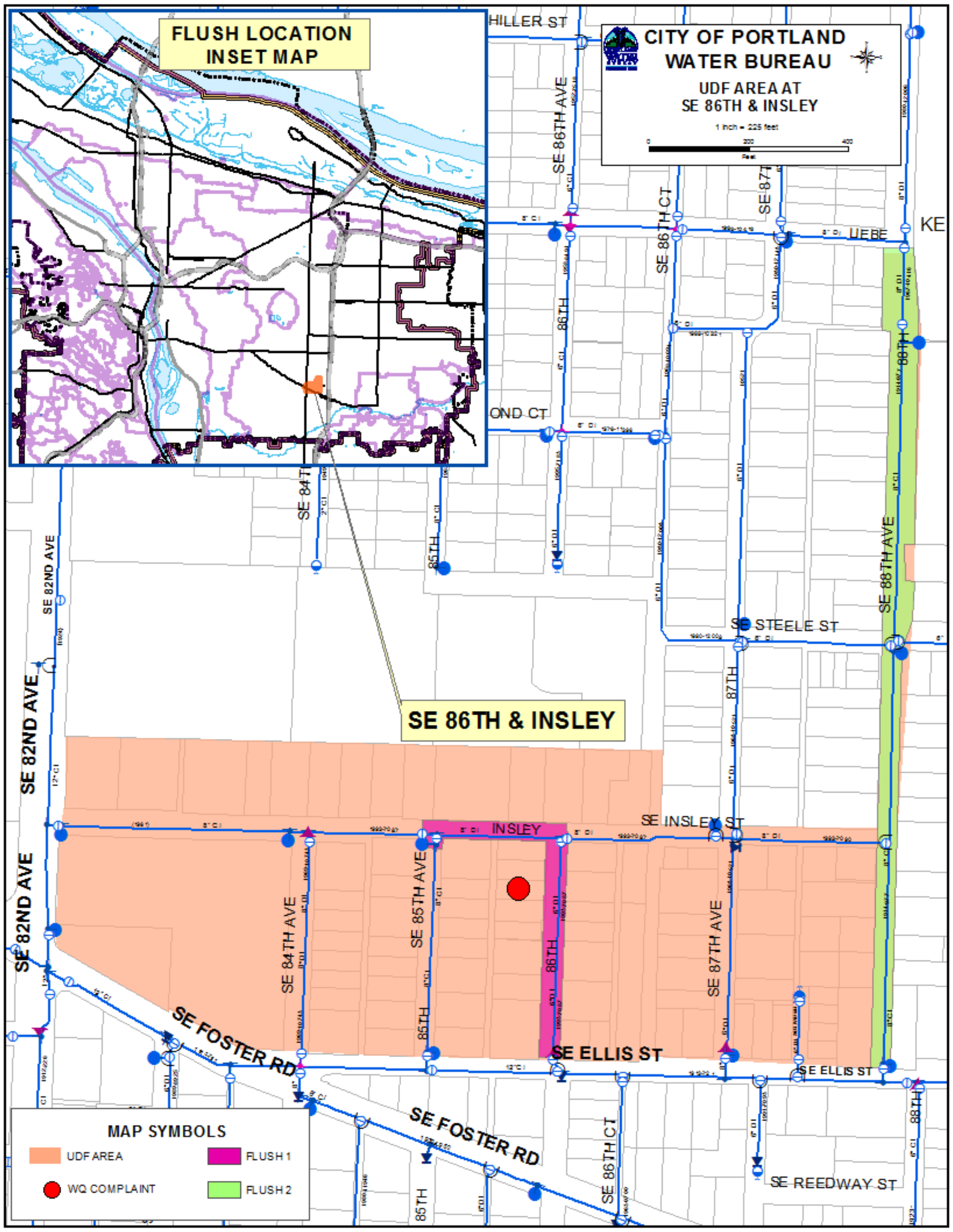



*Figure 8. SE 86th Ave, Kelly Butte 427 Tank PZ. The peach color denotes the area affected, and the mains to be flushed are highlighted in pink and green.*

**E. SE 11th Ave and Division St, Kelly Butte 280 PZ** – Customer assistance/new fire service

- A fire systems contractor failed a fire flow test given by the fire department due to 'debris' in the line.
  - The flush area has numerous restaurants, bakeries, etc., so the flush occurred between 2am-5am. This decreased the potential for delivering dirty water to our customers. No issues were noted with the flush.
  - The fire systems contractor then passed phase 1 of the flow test.


*Figure 9. SE 11th & Division. The mains that were flushed are highlighted in pink.*

**F. NW 19th Ave and Overton St, Washington Park 229 PZ** – Customer assistance/new fire service

- Another fire systems contractor failed a fire flow test given by the fire department due to 'debris' in the line.
  - This flush area also has restaurants, bars, etc., so the flush occurred between 2am-5am. This decreased the potential for delivering dirty water to our customers.
  - The contractor then passed the flow test.
  - Because of increased development, the number of large mains, and the density of eating establishments, this area (and Washington Park 229 in general) is a priority for UDF. However, we have paused flushing this pressure zone in the near term due to staffing issues and the impending input from the WaterRF Tailored Collaboration Project on flushing.

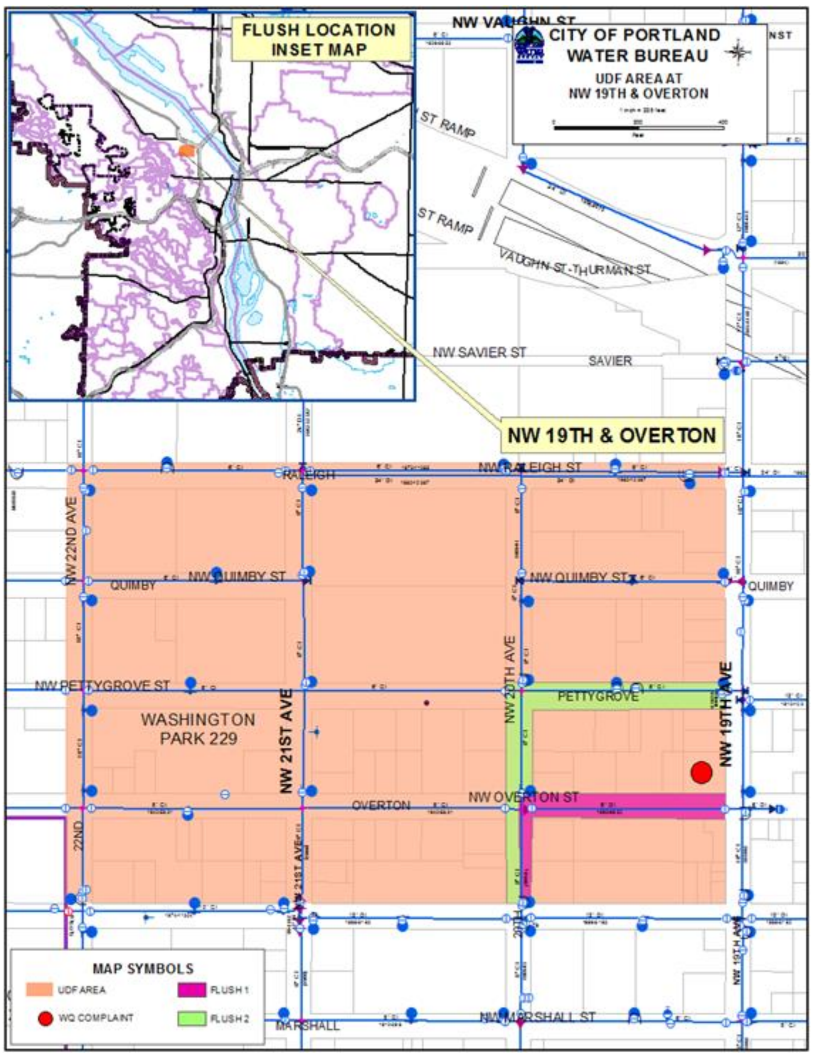



*Figure 10. NW 19th & Overton. The peach color denotes the area affected, and the mains that were flushed are highlighted in pink and green.*

**G. N Fremont & Albina, Vernon 362 Tank** – Customer complaint

- Purpose of this flush was to address customer complaint about high turbidity.
  - We flushed a 12" main near the customer.
  - Ops Analysis approved the flush, BES permitted the discharge, and a Hose Monster apparatus was used to release water at 1800 gpm.
  - We also flushed 6 other mains between 3:00 am and 10:00 am.
  - We found a broken gate, and notified M&C.
  - We had to flush from a 0.75" meter at 705 N Cook St. due to lack of hydrant/BO. The Planning & CIP group has begun a review.

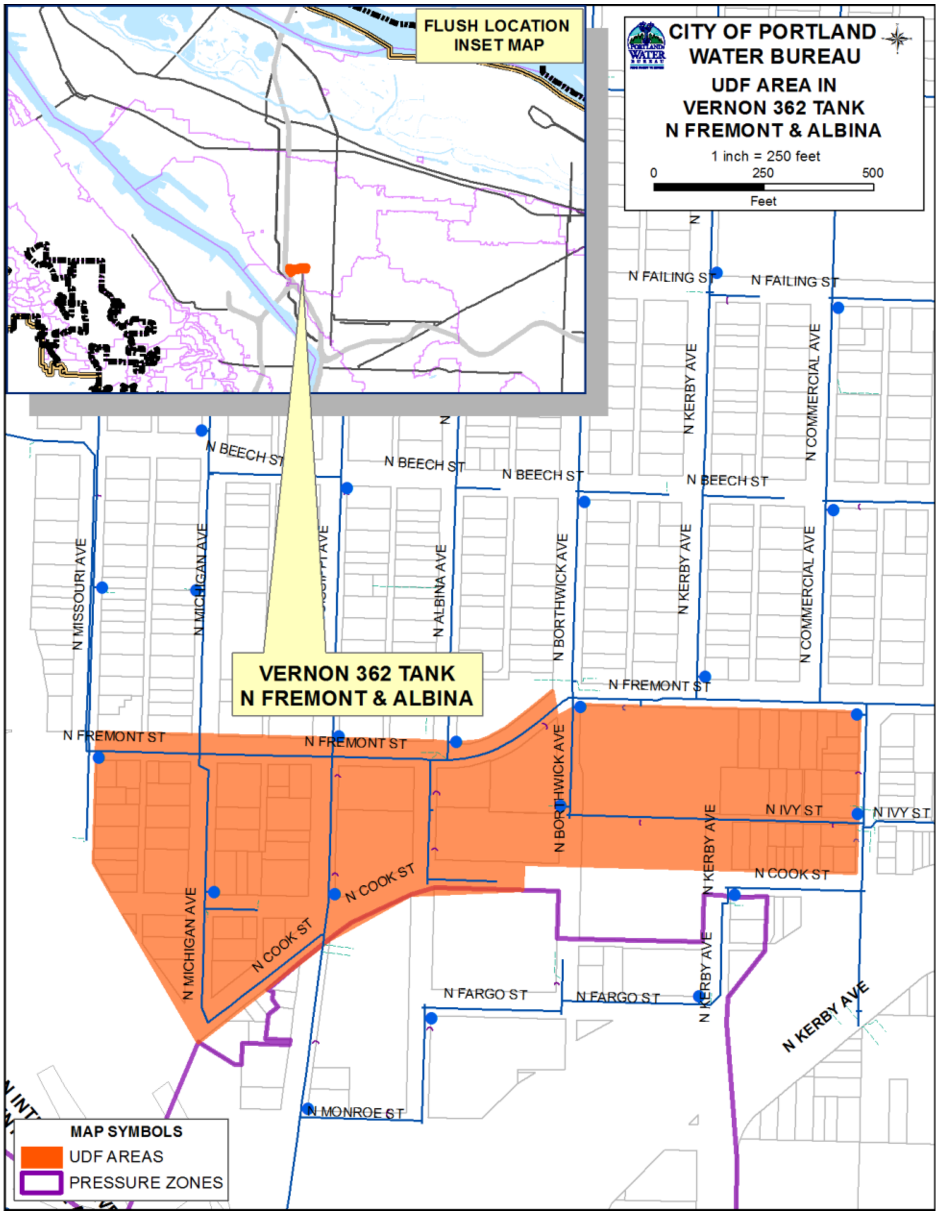



*Figure 11. N Fremont & Albina. Flushing in the Vernon 362 Tank Pressure Zone. The orange color denotes the area flushed.*

## II. Pre-Flush Planning

- Our flush planning paradigm has changed significantly. Previously, we would identify flushes on the fly and in the field, but now we plan, model, and map each flush in the office. Each flush is now mapped to an individual map sheet (Figure 12). One side of the map sheet has the main to flush, the gates\hydrants to operate, and tabular ‘gate card’ data such as asset ID and field location. The other side has a custom form for recording flush test data.
  - This procedure will save planning and modeling time when the area is flushed in the future.
  - Maps will be available for WQ response flushing events.
  - Each map provides detailed information to the flushing field crew.
  - Field time will be directed toward flushing, not planning routine flushes.
  - Facilitates data entry by others.

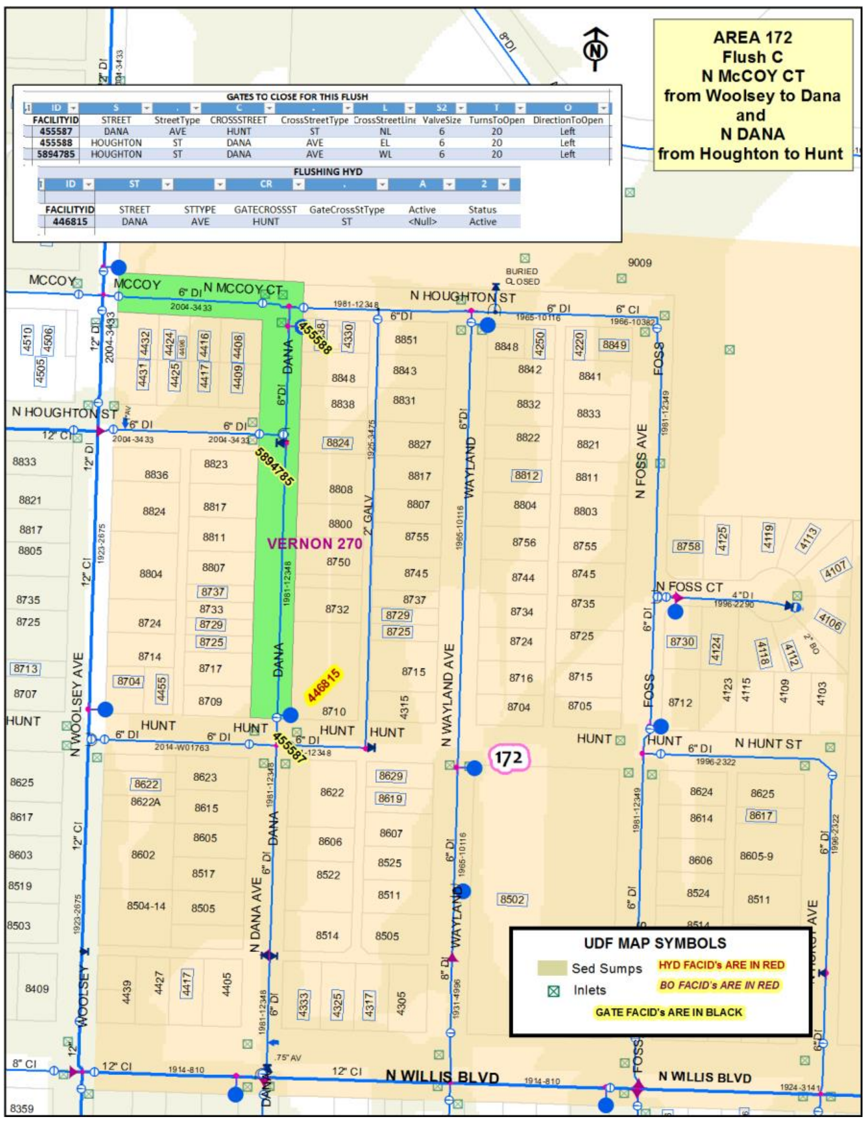



*Figure 12. Example of the individual flush maps used by field crews.*

## III. Surveillance Sampling

- Surveillance samples were collected in areas that were unidirectionally flushed in 2013 and 2014.
- Surveillance samples were collected in Bertha, Council Crest, and Greenleaf. An example of these data for Bertha is shown below.

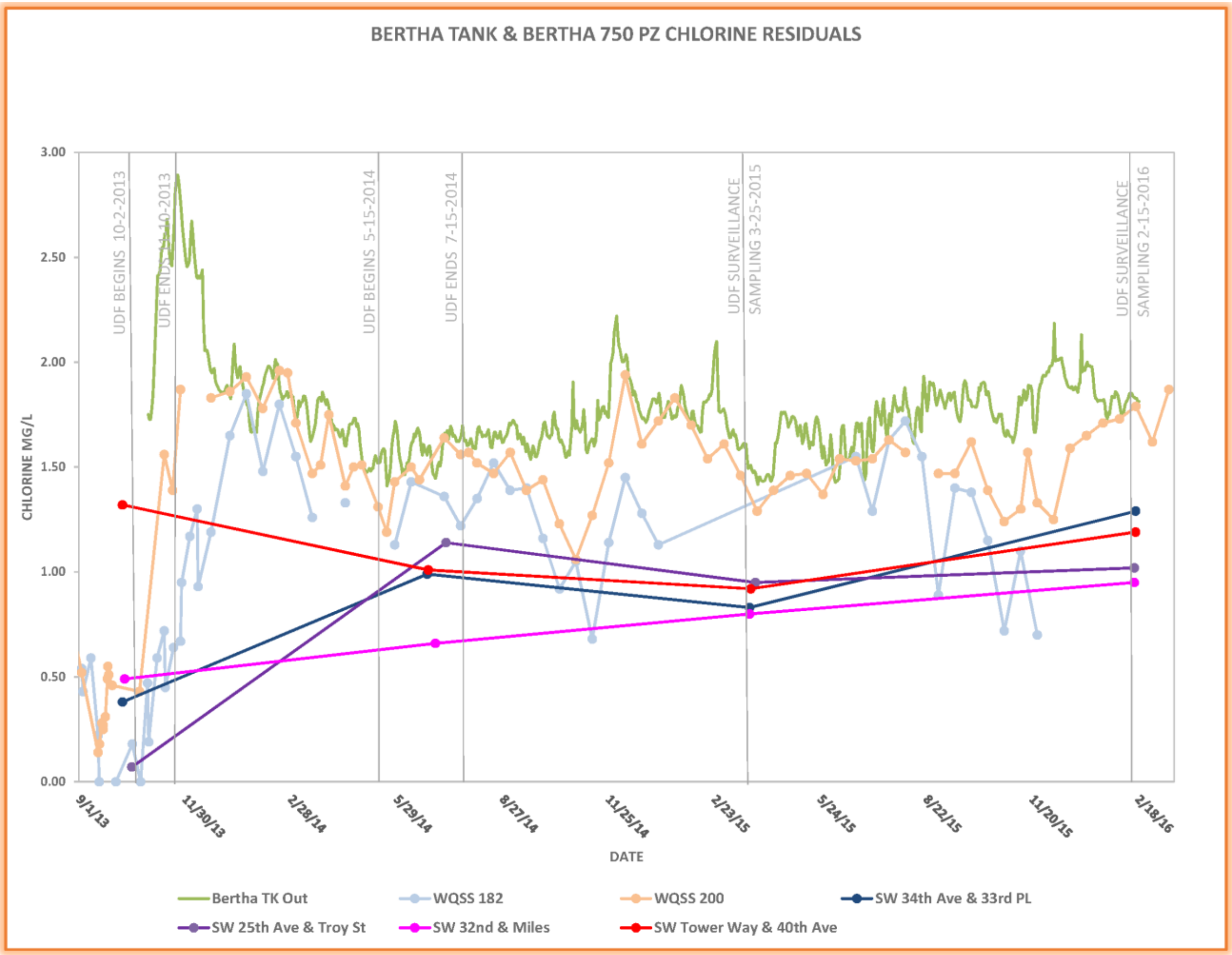



*Figure 12. Chlorine surveillance within the Bertha Tank and Bertha 750 Pressure Zones. Chlorine residuals varied widely across sites when surveillance began in late 2013, but afterward became less variable.*

## IV. Supporting Documentation

- A draft UDF Training Guide was developed for our CSAs.
- A draft UDF SOP was prepared in anticipation of the WaterRF Tailored Collaboration Project on flushing.
- A draft UDF Process Diagram has been generated.
- The St. Johns & Lexington UDF polygons have been uploaded to GIS.
- Our electromagnetic (Mag) meter has been calibrated and certified for 2017.
- Purchased equipment necessary to flush larger diameter mains for the Collaboration Project.

## V. Personnel

- We had 1 CSA this year for about 2.5 months, and also were occasionally assisted with UDF field work or data entry by other WQMO/CSA staff.
- WQMO staff responsibilities for the Collaboration Project have been assigned and are in progress.

Nick Fish, Commissioner
Michael Stuhr, P.E., Administrator

1120 SW 5th Avenue, Room 600
Portland, Oregon 97204-1926
Information: 503-823-7404
www.portlandoregon.gov/water

(Date)

(Customer Name/Address)

Dear Customer:

Thank you for participating in Portland's free lead in water testing program. The Portland Water Bureau has completed the analysis on your water sample.

Sample Collected: Sample Location:

Sample No: Sample Type:

**RESULT**

| Metal Analyzed | **Your Sample** (ppb) | EPA Standard (ppb) |
|---|---|---|
| Lead | | 15.0 |

**How to Interpret Your Result**

The result to the left is shown in parts per billion (ppb), which is a unit of measurement. One ppb is equivalent to one penny in $10,000,000.

The result of your sample is compared to the drinking water standard set by the Environmental Protection Agency (EPA).

**Compare your lead result to the EPA standard above**.

If the level of lead in your sample is above the EPA standard, it is advisable - especially if there are young children in the home - to reduce the lead level in your tap water as much as possible. For additional information about lead and how to reduce your exposure, see the other side of this letter and the enclosed brochure.

If you have any questions concerning your water analysis, please do not hesitate to call the Portland Water Bureau's Water Line at 503-823-7525.

Sincerely,

Portland Water Bureau

Water Line

503-823-7525

**Information on lead in water and how to reduce your exposure**

While lead is rarely detected in Portland's water system, some customers may be exposed to lead in drinking water through their home plumbing. At particular risk are customers whose homes were built before 1985 with copper pipe and lead solder. The major source of lead in the tap water of Portland homes is the corrosive action of water on household plumbing components that contain lead, such as faucets and lead-based solder.

Results after the water has been standing for several hours are the highest likely levels of lead in the water. They are not likely to represent the levels of lead in water during normal usage. If your water test shows that the level of lead in your household water is above the EPA standard, it is advisable - especially if there are young children in the home - to reduce the lead level in your tap water as much as possible. Exposure to lead can affect long-term health and development.

There are several easy ways to reduce your exposure to lead in drinking water:

- Avoid using water that has been standing in the pipes for several hours to cook, drink or make baby formula. Running the cold water tap until the water feels noticeably colder (about 30 seconds - 2 minutes) brings in fresh water from the distribution mains outside your home. This can reduce lead in water levels up to 90%.
- Use cold, fresh water for cooking and preparing baby formula. Do not cook with or drink water from the hot water tap; lead dissolves more easily into hot water.
- Consider using a filter: Check whether it removes lead. Not all filters do.
- If you choose a filter device, be sure to maintain it in accordance with the manufacturer's instructions once it is in use. Other water quality problems can develop from lack of maintenance.
- Consider buying low-lead fixtures. As of January 2014 all pipes, fittings and fixtures are required to contain less than 0.25% lead. When buying new fixtures, consumers should seek out those with the lowest lead content.
- For information on filter certification and lead-free components, contact NSF International at 877-867-3435 or visit www.nsf.org

The Water Bureau treats the water to reduce corrosion in plumbing by adjusting the pH of the water. Comparison of monitoring results before and after pH adjustment show over 50 percent reduction of lead with pH adjustment.

If you would like additional information on how to reduce your exposure from all sources of lead, contact the LeadLine at 503-988-4000 or www.leadline.org.

More information on lead and further steps that individuals can take to reduce their exposure are outlined in the enclosed brochure "A Guide to Lead in Drinking Household Plumbing and You Drinking Water".

**If you have any questions concerning your water analysis, please do not hesitate to call the Water Line at 503-823-7525.**