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Summary Report

Violation of Total Coliform Rule at Reservoir 3 Outlet – Samples Collected July 19 and 20, 2012

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EXECUTIVE SUMMARY

Routine regulatory monitoring at the outlet of Portland's Reservoir 3 in Washington Park revealed the presence of *E. coli* bacteria in a sample collected on Thursday, July 19th, 2012 with the results being available on Friday morning, July 20th, 2012. *E. coli* bacteria are considered an indicator of fecal contamination which can introduce a variety of harmful microbes to the drinking water distribution system.

Drinking water regulations require that three follow-up samples be collected within 24 hours after receiving a coliform bacteria detection result to confirm the presence of coliform bacteria. These samples were collected on Friday, July 20, 2012 within four hours after receiving the *E. coli* detection result. As part of the bureau's response plan to positive samples, Reservoir 3 was isolated from the distribution system immediately after the last follow-up sample was collected. Concurrently, four investigative samples were collected from sites upstream and downstream of Reservoir 3.

Results of the follow-up monitoring indicated presence of total coliform bacteria (no *E. coli* bacteria) in one of the downstream follow-up samples. None of the four investigative samples tested positive for coliform bacteria. The detection of total coliform bacteria in a required follow-up sample that has been triggered by an initial *E. coli* detection constitutes a violation of the Total Coliform Rule governing microbiological contaminants in drinking water.

This triggered a mandatory public notification as required by the Public Notification Rule. (Note that this was the second such incidence of a Total Coliform Rule violation by the Portland Water Bureau in the 21 years since the regulation has been in effect. The other incident occurred in November of 2009 when water from the same location, Reservoir 3 outlet, tested positive for *E. coli* bacteria in both the initial and follow-up samples).

On Saturday July 21st, a “Boil Water Notice” was issued to all Portland Water Bureau customers west of the Willamette River and to customers of the following water districts served by Portland Water Bureau: Burlington Water District, Valley View Water District, Palatine Hill Water District, City of Tigard, Lake Grove Water District and West Slope Water District. Also on Saturday, twelve samples were collected throughout the affected portion of the water distribution system, three to meet compliance resampling requirements, and nine to investigate the extent of potential bacteriological contamination in the distribution system. On the following day the Boil Water Notice was lifted when test results indicated that no coliform bacteria were detected in any of the twelve samples collected the previous day.

The Water Bureau investigated possible sources of the *E. coli* by inspecting the reservoir perimeter, inspecting the bottom of the drained reservoir, and conducting a genetic test on the isolated *E. coli* from the July 19th sample. The perimeter inspection revealed no evidence of a contamination source. When the drained reservoir was inspected, there was evidence of bird activity (nest building) over the reservoir outlet piping and probable human introduced food – whole limes. A genetic testing lab analyzed the strain of the *E. coli* from Portland’s water sample and compared this to an extensive library of *E. coli* strains associated with different warm blooded animals. This test was inconclusive. The Water Bureau also analyzed the *E. coli* sample for disease causing potential. The most prevalent pathogenic *E. coli* species, H1:0157, was not detected in the sample. A genetic testing lab also tested the *E. coli* sample for virulence factors and determined that the *E. coli* found in the sample had a negligible risk for illness potential. These tests did not address other non-*E. coli* pathogens that are potentially present in water contaminated with fecal material.

The source of the *E. coli* that was detected in water from Reservoir 3 remains unknown. The *E. coli* bacteria did not appear to be a disease-causing type although the risk posed by possible co-contaminants such as *giardia*, viruses or *cryptosporidium* is difficult to assess. Bull Run water treatment has consistently exceeded the regulatory requirement for disinfection efficacy. Also the water feeding Reservoir 3 from the distribution system did not test positive for coliform bacteria in any routine or investigative samples. This indicates that a deficiency in treatment of raw water was not a likely source of the detected bacteria. Since no *E. coli* bacteria were detected in the follow-up samples, the contamination is presumed to have been a short duration event and likely originated at Reservoir 3.

Analysis of public health data during the time of the incident showed no apparent public health impact from the contamination event. The Portland Water Bureau is planning several follow-up actions to prevent a recurrence of this type of incident, and to reduce the risk of adverse health effects from microbes in the drinking water distribution system.

INTRODUCTION

The experience of issuing a Boil Water Notice for an acute violation of a drinking water regulation deserves thorough review and documentation. The following summary includes background on Portland’s water system, a regulatory framework, water quality and public health data and descriptions of Water Bureau response, investigation and follow-up actions. In light of the incident Portland Water Bureau is refining its Boil Water Notice Guidelines to continue to improve timeliness, accuracy and ease of communication with our customers. However, this report is limited to the water quality aspects of the incident and not the many associated public information issues. The summary is a joint effort between the Portland Water Bureau and the Multnomah County Health Department.

BACKGROUND

Portland's Water System

Portland, Oregon is supplied with unfiltered drinking water from the Bull Run watershed, a protected area in the Mt. Hood National Forest. This surface water is chlorinated near its source and flows about 10 miles west to the Lusted Hill treatment facility. At this point, the combination of chlorine concentration and contact time, CT, has met the disinfection requirements of the EPA Surface Water Treatment Rule. This ensures a minimum of 4-log (99.99%) reduction of viruses and a 3-log (99.9%) reduction of *giardia* parasites. At Lusted Hill the water is stabilized with ammonia to maintain a chloramine disinfectant residual throughout the distribution system and the pH is adjusted with caustic soda to reduce corrosion of household plumbing.

The Portland Water Bureau maintains a supplemental groundwater system for augmenting supply to meet high demand in the summer or for mitigating high turbidity caused by storm events in the watershed. Portland's drinking water system serves a population of about 900,000 including customers within the City's distribution system and people served by 19 other water purveyors that purchase water wholesale from the Portland Water Bureau.

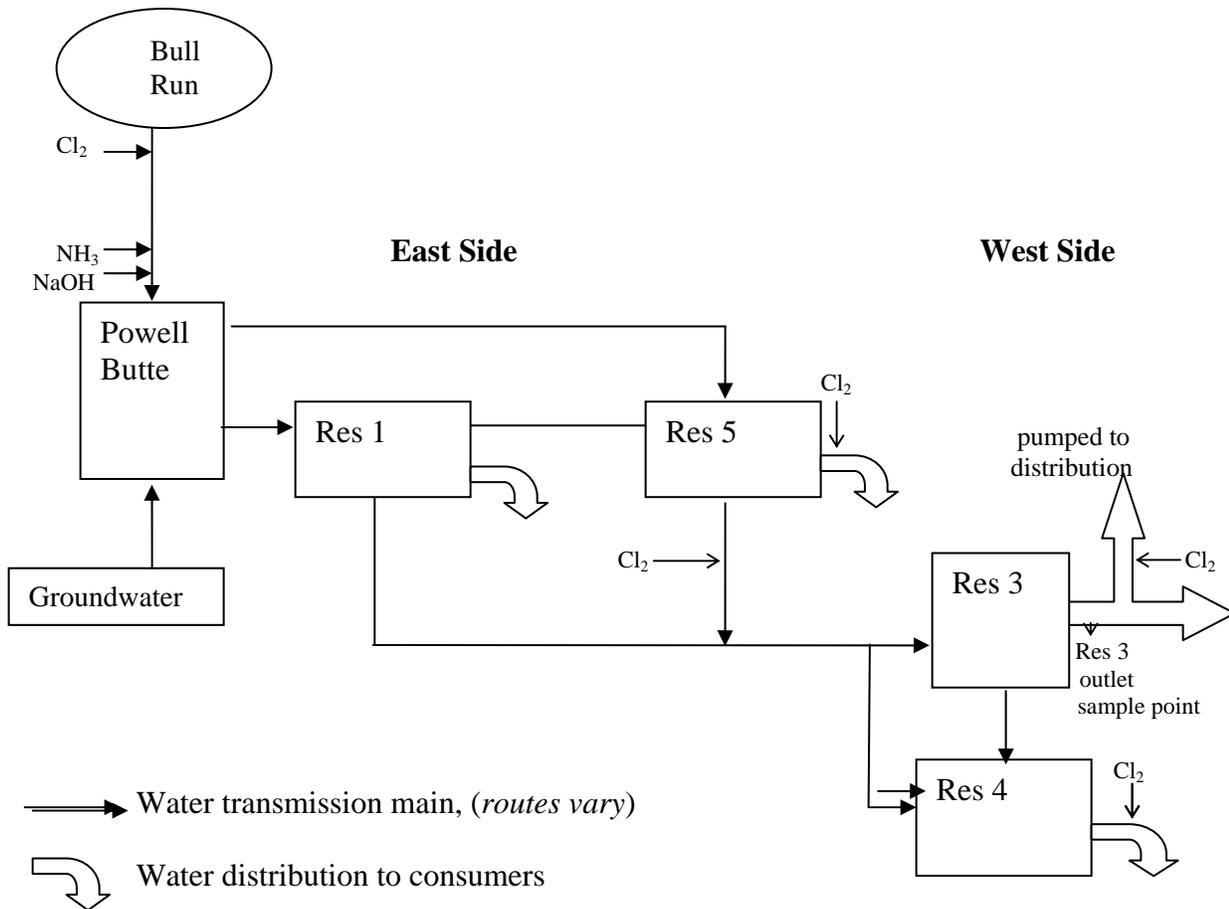
The distribution system for Portland's water incorporates approximately 60 closed tanks and four open reservoirs for water storage. Two of the open reservoirs, (Reservoir 1 and Reservoir 5), are located at Mount Tabor Park on the east side of the Willamette River. A third reservoir at Mount Tabor, Reservoir 6, has not been operated for several years. The other two open reservoirs, (Reservoir 3 and Reservoir 4), are located at Washington Park on the west side of the Willamette River. The use of the open reservoirs and other tanks throughout the system is modified depending on system demands.

The distribution paths through these reservoirs will vary depending on maintenance work or customer demands (seasonal or diurnal). A simplified diagram showing the open reservoir supply and distribution paths is shown as Figure 1. The open reservoirs at Mount Tabor are accessible to the public and have been so for decades. There has been no public access to either of the Washington Park reservoirs until recently; in 2006 the grand staircase that leads to the walkway around Reservoir 3 was rehabilitated and reopened to the public during daytime hours. Reservoir 4 has no public access because its chlorination facilities are too near to permit safe public access.

Three of the open reservoirs, Reservoir 3, Reservoir 4 and Reservoir 5, have facilities that can be used for booster chlorinating the outlet water. This replaces chlorine lost to the atmosphere from the open reservoirs so that remaining free ammonia nitrogen can combine to re-form the chloramine disinfectant. All of the water leaving Reservoir 4 and Reservoir 5 is booster chlorinated. At Reservoir 3 only a portion of the outlet water that is pumped to some large storage tanks is booster chlorinated. Reservoir 1 does not currently receive booster chlorine because there is a relatively small amount of free ammonia nitrogen available to combine with any added chlorine. [\(The addition of booster chlorine to a chloramine water system is limited by the amount of available ammonia nitrogen that can combine with the chlorine. Booster chlorination must be carefully controlled; too much chlorine can actually reduce the strength of the chloramine disinfectant or cause formation of undesirable disinfection by-products\).](#)

Note that Reservoir 4 has been off line since September 2011 because its storage capacity is unneeded at this time. Reservoir 1 had been off line since May 2012 to permit historic renovations on its gatehouse. It was brought back into service in September 2012.

FIGURE 1 – Portland’s Open Reservoir System



Water Quality Testing Requirements for Bacteriological Contamination

A crucial task for any drinking water supplier is to ensure that treated water remains free of disease-causing microscopic organisms (bacteria, viruses and parasites) as it travels through the distribution system to customers. In addition to using sanitary practices for operation, maintenance and construction of water distribution systems all public water providers are required by law to routinely monitor for the risk of water being contaminated with disease-causing microbes.

A key monitoring approach is testing for the presence of coliform bacteria in water mains. This involves taking water samples from mains, and testing them in a laboratory. Coliform bacteria are “indicator” organisms; their presence suggests a potential distribution system integrity problem. The federal Environmental Protection Agency (EPA) Total Coliform Rule (TCR) governs this approach to monitoring; it has been in effect since 1991. The bacteriological monitoring required by the rule must include tests for total coliform bacteria and a subset of these bacteria called *Escherichia coli*, (*E. coli*). The latter type of bacteria is associated with fecal contamination. The TCR specifies the number of samples to be collected and tested for coliform bacteria each month; this number is based on the population served by the water supplier. Portland must test a minimum of 210 samples per month.

The TCR defines microbial water quality violations – i.e., situations that represent potential water contamination and risk for illness. It also requires follow-up actions based on results of water testing. Specifically, when a total coliform test indicates presence of bacteria in any routine sample, utilities must collect three follow-up samples (a repeat sample from the original positive site, one upstream sample and one downstream sample) within 24 hours to determine whether there is a potentially significant water quality problem. If any of the three samples from the second round tests positive for total coliform and either the initial positive sample or any of the three samples in the second round of sampling also tested positive for *E. coli*, the utility is in acute violation of the Total Coliform Rule.

The only possible exception to such a violation would be in the event that the repeat sample from only the original sample site tested positive for coliform while the upstream and downstream samples tested negative. In this case a utility may be able to identify a contaminated sample tap as the cause of the coliform detections.

See Figure 2 for a diagram that depicts the regulatory approach to the testing requirements for follow-up samples. *E. coli* is a type of bacteria that is common in the feces of humans and other mammals, as well as birds and reptiles. There are many different types of *E. coli* bacteria. Most types of *E. coli* do not cause disease; a few types do. When *E. coli* is found in follow-up specimens, testing does not determine whether or not they are capable of causing disease in humans. When used in follow-up testing, *E. coli* are considered “indicator” bacteria, indicating contamination with human or animal feces. This contamination carries with it the possibility that disease-causing organisms are present in the water. Such a violation triggers a requirement to issue a “Boil Water Notice” within 24 hours after the confirming test result is received, and after consultation with the Oregon Health Authority Drinking Water Program (OHA-DWP).

FIGURE 2 – Actions Following Coliform Bacteria Detection

1 st Round (single sample)		2 nd Round (any of 3 samples)		TCR Required Action
Total Coliform Result	<i>E. coli</i> Result	Total Coliform Result	<i>E. coli</i> Result	
+	-	-	-	none
		+	-	Collect another round of 3 follow-up samples
		+	+	Acute Violation of TCR → Boil Water Notice
+	+	-	-	none
		+	-	Acute Violation of TCR → Boil Water Notice
		+	+	Acute Violation of TCR → Boil Water Notice

Portland’s TCR Monitoring Program

The Portland Water Bureau collects and tests 220 - 300 water samples each month from about 75 different locations throughout the water distribution system. Many of these samples are collected at the outlets of Portland’s open reservoirs that are in service at that time. The Water Bureau has a staff of Water Quality Inspectors who are specially trained in the procedure for collecting bacteriological

samples. The inspectors use calibrated instruments to take field measurements of water temperature, pH, and chlorine residual as each sample is collected.

Stable temperature indicates that the sample is representative of water from the water main before it is collected in a pre-labeled sterile bottle. Most TCR samples are collected from dedicated water quality sampling stations (WQSS); these feature custom taps within locked enclosures to prevent accidental contamination. Water Quality Inspectors transport the samples to the Water Bureau Laboratory for testing. The Portland Water Bureau operates a laboratory accredited by the State of Oregon for drinking water analyses. Routine TCR samples are tested for presence or absence of total coliform and *E. coli* bacteria using the Colilert® test system.

When follow-up sampling is required, the Quanti-Tray® test method is used to measure the number of total coliform and *E. coli* bacteria present per 100mL volume of each sample. This number is expressed as the Most Probable Number (MPN) – a statistical method that accounts for sampling and laboratory variation. Both the Colilert® and Quanti-Tray® laboratory methods have an 18 hour¹ turn around time to produce results; both are accepted by the EPA.

Although not a regulatory requirement, the Water Bureau Laboratory contracts with Legacy Emanuel Laboratory to run a further laboratory test on any sample that tests positive for total coliform. This additional test can determine the species of coliform, and if *E. coli* is present, whether it is the 0157:H7 strain that can cause serious illness in people.

DESCRIPTION OF INCIDENT

Thursday, July 19, 2012

On Thursday, July 19, Water Bureau Inspectors made regular TCR sampling rounds, collecting 13 routine samples.

Friday, July 20, 2012

Bacteriological tests on Thursday's samples were completed and reported on Friday July 20th around 9:30 am.¹ One sample representing outlet water from Reservoir 3 (WQSS #113) tested positive for both total coliform and *E. coli* bacteria.² The chlorine residual as measured during sample collection was typical for the season at 1.20 mg/L and the temperature at 15.1 degrees C was within the normal range. The data were validated and electronically reported directly to OHA-DWP around 10:30 am. Following standard Water Bureau Laboratory procedure, some of the sample that had tested positive was used to prepare a Tryptic Soy Agar (TSA) plate for overnight incubation. This plate was delivered on Saturday to Legacy Emanuel Laboratory which uses a different test method (Vitek 2) to identify the genus and species of bacteria and to determine whether the sample contains the disease-causing 0157:H7 *E. coli* strain. The PWB Water Quality Engineer telephoned the OHA DWP duty engineer to report the *E. coli* detection, and also phoned the Multnomah County Health Officer to alert him of the episode of potential water contamination. Concurrently, a Water Quality Inspector was

¹ The current state of the science in coliform bacteria testing relies on a process of incubating samples in a nutrient medium for a specified period of time at a specified temperature. In 2010 the Portland Water Bureau switched from a 24 hour test method to an 18 hour test method for coliform bacteria testing. For regulatory compliance testing there is no EPA approved method that can provide coliform bacteria results in less than 16 hours.

² Water from WQSS #113 is tested four times per week; the sample collected on Wednesday, July 18th had tested negative for coliform bacteria.

dispatched to collect the three required follow-up samples. In the case of coliform bacteria detection at any of Portland's open reservoir outlets, the state has requested that the upstream follow-up sample be replaced with a second downstream follow-up sample. This change to the standard procedure was instituted in 2010 after a similar *E. coli* detection incident at Reservoir 3; it accounts for the increased vulnerability of open reservoirs to bacterial contamination such that the upstream sample would likely be free of contamination. At 11:04 am when the last of the three follow-up samples had been collected, PWB Operating Engineers began the process of isolating Reservoir 3 from the distribution system. Isolation was completed by 11:30 am.³ Concurrently, the Water Quality Engineer and Water Quality Inspector walked the perimeter of Reservoir 3 looking for a possible source of fecal contamination. Earlier in the spring a pest control contractor had installed bird abatement netting at the south end of the reservoir near the outlet because PWB industrial painters had observed bird activity (swallows) and nest building under the outlet gatehouse. No bird activity or nests were observed during the perimeter inspection. The usual decaying leaf litter was accumulated at the water's edge on the reservoir walls. Nothing unusual was noted.

In addition to the three required follow-up samples, four investigative samples were collected. At the time of the incident Reservoir 1 was out of service and all water feeding Reservoir 3 was supplied from Reservoir 5. Reservoir 4 was also out of service so the area it normally feeds at lower elevations near the Willamette River was supplied by a combination of water from Reservoir 3 and water delivered by other routes (not shown in Figure 1) via transmission mains from Reservoir 5 or directly from Powell Butte. Samples were collected at both outlets from Reservoir 5 to investigate the possibility that the detected bacteria had been introduced at that open reservoir. Another two samples were collected downstream from Reservoir 3 in areas that would likely be receiving water that had passed through Reservoir 3 on the previous day when the contaminated sample was collected. Following PWB policy, all seven samples collected on Friday were tested by the Quanti-tray® method to provide results in terms of bacterial density.

After the 2009 Res 3 *E. coli* detection incident Portland Water Bureau developed an internal response procedure to prepare for a public notice if follow-up water quality tests confirmed *E. coli* bacteria in Portland's drinking water. Accordingly, the Water Quality Manager, acting as incident commander, notified the Portland Water Bureau Administrator, public information staff, wholesale customers, customer service manager, operational analysis staff, emergency operations center, and the engineering mapping group. A Multnomah County health specialist coordinated with the PWB customer service supervisor to refer any health complaints to the county for follow-up investigation. A Boil Water Advisory public notice was drafted using a prepared template containing language required by state drinking water regulations.

Saturday, July 21, 2012

On Saturday, July 21 at 8:00 am the PWB Lab reported that the downstream follow-up sample from 840 SW King Avenue tested positive for total coliform at a level of 1 MPN per 100 mL. No *E. coli* bacteria were detected in the sample. The Total Coliform Rule defines this occurrence as a violation of a maximum microbiological contaminant level (see Figure 2) and requires public notification for this potential acute health risk. The other two follow-up samples both measured <1 (negative) for total coliform by Quanti-Tray® and the four investigative samples also measured <1 (negative) for total

³ After the *E. coli* detection incident in 2009, the time to isolate Reservoir 3 was reduced from 3 hours to 30 minutes by automating several of the large valves that feed water into and out of the reservoir.

coliform bacteria. Again, a TSA culture was prepared from the Friday sample that tested positive for total coliform and sent to Legacy Emanuel laboratory, this time to determine the species of coliform bacteria. The Water Bureau incident commander mobilized the Water Bureau Emergency Operations Center by calling the EOC manager who opened the EOC facility and made call-outs for assigned Water Bureau personnel to report to the EOC. The Water Bureau issued a Boil Water Notice at approximately 12:30 pm on Saturday after consulting with the OHA Drinking Water Program office. PWB staff turned off supply to all Benson Bubbler drinking fountains and the Portland Parks Bureau was notified to turn off drinking fountains located in public parks. The Boil Water Notice was applied to all Portland Water Bureau customers west of the Willamette River including six wholesale customers that might have received water from Reservoir 3: Burlington Water District, Valley View Water District, Palatine Hill Water District, City of Tigard, Lake Grove Water District, and West Slope Water District. Within the Portland Water Bureau distribution system, the area subject to the Boil Water Notice most likely included some distribution pressure zones that do not receive water from Reservoir 3. However, given the complexity and variation of the west side pressure zone boundaries plus the need to provide speedy concise public notification, it was necessary to include the whole west side. The Boil Water Notice was distributed through the following actions:

- Distributed state approved Boil Water Notice and media release via Flashnews to all Portland metropolitan area media outlets, including foreign language outlets.
- Posted the Boil Water Notice in its entirety on the Portland Water Bureau website (www.portlandoregon.gov/water) with a link on the City of Portland homepage (www.portlandonline.com)
- Established a webpage on the PWB website that contained the BWN, general information, the FAQ document and contact information for resource agencies: www.portlandoregon.gov/water/boilwaternotice
- Distributed the BWN via Facebook and Twitter accounts.
- Coordinated with Portland Bureau of Emergency Management to implement its Public Alerts system to notify customers in the affected area. Approximately 100,000 phone numbers were called with approximately 33% successfully reached.
- Posted a map of the affected area on the Portland Water Bureau website.
- Directly notified by phone affected wholesalers - Burlington Water District, Valley View Water District, Palatine Hill Water District, City of Tigard, Lake Grove Water District, and West Slope Water District. (Other West side wholesalers not included in the BWN were also contacted).
- Directly contacted major hospitals and other institutions with sensitive or transient populations by phone in the affected area.
- Held a press conference that was broadcast on major local television stations; also contacted major television markets and asked them to post a 'crawl' with the advisory information.

- Coordinated with Multnomah County Health Department to contact all restaurants, schools, nursing homes, pools, spas, traveler accommodations, and day care facilities in the affected area. This was done with an automated phone calling system.
- Contacted Portland State University, Lewis and Clark University, Portland Community College, and the Oregon College of Arts and Crafts.

The PWB activated its Customer Service Call Center and worked with Multnomah County Health Department to answer health related questions. A document addressing frequently asked questions was created, distributed and updated during the day as customer calls highlighted new issues. Concurrently, Water Quality Inspectors collected the three required follow-up samples associated with the Reservoir 3 downstream site where total coliform was detected. Another nine sample sites within the affected area were identified for investigative monitoring. These sites were selected using the PWB hydraulic model to determine where the water from Reservoir 3 would likely have been distributed since the *E. coli* contaminated sample was first collected on Thursday, July 19th. The total of twelve samples were collected and delivered to the PWB lab by 2:00 pm so that results would be available early the following morning, Sunday, July 22nd. For each sample site, upstream and downstream resampling locations were identified in the event that a total coliform detection was reported the next morning.

Sunday, July 22, 2012

At 7:30 am, the PWB Laboratory reported that all twelve samples collected on Saturday July 21st showed no presence of total coliform bacteria. After consultation with OHA Drinking Water Program the Boil Water Notice was lifted by issuing a notice of correction. This was distributed by the same method as the Boil Water Notice.

Monday, July 23, 2012

Reservoir 3 draining was completed and the floor of the reservoir near the outlet piping was inspected. (See the Incident Investigation section). Legacy Emanuel Laboratory reported that the *E. coli* strain 0157:H7 was not present in the *E. coli* positive sample collected July 19th.

Thursday, July 26, 2012

Legacy Emanuel Laboratory reported that the species of total coliform identified in the sample collected on July 20th was *Enterobacter cloacae*, a type that is commonly identified in Portland's water when coliform bacteria are detected in the course of TCR compliance sampling.

Friday, August 3, 2012

Cleaning was completed and Reservoir 3 was put back in service.

INCIDENT INVESTIGATION – WATER QUALITY

The Water Bureau used several investigative methods to try to find the source of the *E. coli* contamination. Also, the Multnomah County Health Officer and other County Health Department staff analyzed epidemiological data to determine whether there was any evidence of adverse health effects related to the episode of contamination. The methods and results are described below.

Distribution System Sampling

On Thursday, July 19th, when the Reservoir 3 sample containing *E. coli* was collected, a companion sample immediately downstream was also collected. These samples were collected within 16 minutes of each other. The routine of collecting a companion sample downstream from each reservoir outlet sample was begun after the 2009 incident when *E. coli* was detected at the outlet of Reservoir 3. The reasoning was that this would provide a ready confirmation of any contamination at the reservoir when results were reported together the following day.

Another TCR monitoring revision that was made in 2010 was the addition of a daily sample from the Powell Butte outlet. The reasoning here was to determine whether coliform bacteria detected in the distribution system were being introduced prior to that point due to a water treatment system failure.

Other samples collected on July 19th included outlet samples from Reservoir 5 which was exclusively feeding Reservoir 3. There were two other samples from the West side of the city collected on July 19th; one close by that was likely fed from Reservoir 3 and another in outer Northwest that would likely represent water that had passed through Reservoir 3 on the previous day or earlier. Other samples collected on July 19th were from the East side of the Willamette River. Of all these routine samples collected on July 19th only the Reservoir 3 outlet sample tested positive for coliform bacteria.

Friday July 20, 2012 Follow-up Bacteriological Monitoring after Res 3 *E. coli* detection:

<u>Sample Site</u>	<u>Description/Location (PZ=pressure zone)</u>	<u>Sample Type</u>
WQSS #113	Reservoir 3 outlet	Repeat resample; this site was EC+ in a 7-19-12 sample
WQSS #194	901 SW King Ave	Downstream resample
A1 Downstream from from wqss #194	840 SW King Ave	Downstream resample (TC+)
WQSS #191	Reservoir 5 outlet Represents water feeding Res 3 - taken to determine contamination of feed to Res 3.	Investigative (sample not required by regulation)
WQSS #209	Reservoir 5 outlet Represents water feeding Res 3 – taken to determine contamination of feed to Res 3.	Investigative (sample not required by regulation)
WQSS #205 (A1 & not a TCR site)	NW Lovejoy & 22 nd Ave, near Good Samaritan Hospital. Downtown distribution from Res 3. PZ=WP 299	Investigative (sample not required by regulation)

WQSS #195

SW Alder & 16th Ave
Downtown distribution from
Res 3. PZ=WP 229

Investigative (sample not
required by regulation)

NOTES:

Of the four investigative sample sites listed, there is one, WQSS 205, which is not routinely monitored for TCR compliance. PWB has many such sample stations installed for occasions such as this bacterial investigation. Three of the four investigative sites have Eclipse® sampling stations installed. One site, WQSS 205, is a Water Plus All-in-One® station (A1). The two outlet samples from Reservoir 5 represent the supply to Reservoir 3 because there was no water supplied to Reservoir 3 directly from Powell Butte at the time. The other two investigative samples represent water that is distributed close to Reservoir 3 such that contaminants would have likely reached those sites by the time samples were collected.

Saturday July 21, 2012 Follow-up Bacteriological Monitoring after Res 3 E. coli Incident

<u>Sample Site</u>	<u>Description/Location (PZ=pressure zone)</u>	<u>Sample Type</u>
A1 Downstream from from wqss #194	840 SW King Ave	Repeat resample; this site was TC+ in a 7-20-12 sample
WQSS #194	901 SW King Ave	Upstream resample
Hose bib	731 SW King Ave	Downstream resample
WQSS 15	2839 SW Sam Jackson Pkwy Represents Sam Jackson Tank which is fed by Res 3. PZ=WP 299	Investigative (sample not required by regulation)
WQSS 16	Zoo at N. line of zoo parking lot East of Knights Blvd. Represents Arlington tank which is fed by Res 3. PZ=Arlington 865 Tank	Investigative (sample not required by regulation)
WQSS 17 (not a TCR site)	NW 19 th Ave & Everett Street Downtown distribution from Res 3. PZ=WP 229	Investigative (sample not required by regulation)
WQSS 18 (not a TCR site)	NW 24 th Ave & Hoyt Street Downtown distribution from Res 3. PZ=WP 299	Investigative (sample not required by regulation)
WQSS 89	Calvary Outlet on NW Skyline Blvd. Represents Calvary tank which receives water from Res 3. PZ=Calvary 1044 Tank	Investigative (sample not required by regulation)

WQSS 93	NW Millpond & Brittney Ct. Represents water pumped to Forest Park Tank via Res 3. PZ=Greenleaf 697 Miller	Investigative (sample not required by regulation)
WQSS 164	SW Richardson & Corbett St. Distribution from Res 3 towards the SW. PZ=WP299	Investigative (sample not required by regulation)
WQSS 182	SW Santa Monica & Altadena Represents water from Bertha tank, some of which may have passed through Res 3. PZ=Bertha 805 25th	Investigative (sample not required by regulation)
WQSS 187	SW Barbur & Whitaker Represents water from Sam Jackson and Broadway Drive Tanks, some of which may have passed through Res 3. PZ=Broadway Drive 396 Gibbs	Investigative (sample not required by regulation).

NOTES:

Of the nine investigation sample sites listed there are two, WQSS 17 & WQSS 18, that are not routinely monitored for TCR compliance. PWB has many such sample stations installed for occasions such as this bacterial investigation. All nine investigative sites have Eclipse® sampling stations installed. The surveillance sites in the WP 229 and the WP 299 pressure zones have the highest probability of representing water that has passed through Reservoir 3 in the time interval since the *E. coli* detection in the 7/19 sample. This was determined by using a hydraulic model analysis. Other samples had lower probability of representing water that had passed through Reservoir 3 but were included to be conservative. Upstream and downstream sample locations were identified in advance for all 12 sample sites in the event of a positive total coliform result at any site.

Monitoring in Wholesale Customer Affected Areas

Of the six wholesale customers within the affected area, two collected bacteriological test samples on Friday after notification by PWB that the Reservoir 3 outlet sample tested positive for *E. coli*. Both of these systems tested water at sites representing PWB intake to their systems. Another wholesale customer collected a sample at an unspecified location on Saturday after learning that the BWN was issued. The remaining three wholesale customers did not collect bacteriological samples until after Saturday. All sample results were negative for total coliform bacteria. While OHA Drinking Water Program allowed the BWN to be lifted for all affected wholesalers during this incident, the agency did specify that in the future all affected wholesalers must test their water to demonstrate bacteriological quality before the BWN could be lifted for their systems. It is the responsibility of each system to determine the number and location of samples to support this.

Reservoir Draining and Inspection

On Monday July 23rd, Reservoir 3 was drained in preparation for inspection and cleaning. To enter the drained reservoir, a secured stairway entry hatch was unlocked and opened. The operating engineer observed a mud bird nest that was attached below the rim of the hatch; the nest broke away and fell into the reservoir when the hatch was opened. Three whole limes and one expiring bird were found on the floor of the reservoir. There were many birds pecking at leaf debris in the reservoir at the time of the inspection. Operating engineers confirmed that this is typical after a reservoir is drained prior to cleaning.

Analysis of *E. coli* Illness-Causing Potential

Two samples were submitted to the Institute for Environmental Health (IEH) /Molecular Epidemiology, Inc. (MEI) Laboratories in an effort to determine if the *E. coli* detected at Reservoir 3 could cause illness:

1. The Colilert[®]-18 enrichment broth from the July 19 sample that tested positive for *E. coli*.
2. A culture on TSA agar from the July 19 sample that tested positive for *E. coli*.

IEH/MEI used a qualitative multiplex polymerase chain reaction (PCR) method (AOAC PTM 100701) that detects salmonella bacteria, Shiga toxin-producing *E. coli* (STEC) variations most commonly associated with disease (O157:H7, O26, O45, O103, O111, O121, O145), and toxin and adhesion genes that are associated with the potential for *E. coli* to cause illness. Both samples tested negative indicating that the *E. coli* detected at Reservoir 3 was highly unlikely to cause illness. The absence of *E. coli* O157:H7, the strain most commonly identified and associated with the most severe forms of disease, confirmed earlier results from the Legacy Emanuel Laboratory.

Genetic Analysis of *E. coli*

The *E. coli* isolated from the broth and TSA agar were also analyzed by Pulsed-Field Gel Electrophoresis (PFGE) using restriction enzyme Xba I. This method produces distinct Restriction Fragment Length Polymorphism (RFLP) patterns for *E. coli* that can be compared to local contamination sources and/or to MEI's database in an attempt to identify the source of contamination. MEI's database has one of the largest collection of *E. coli* RFLP patterns currently composed of >150,000 patterns. The resulting RFLP patterns from the two samples were compared to each other and to *E. coli* RFLP patterns in MEI's database. The isolates from the broth and TSA agar were indistinguishable from each other but were dissimilar from any pattern in the database including *E. coli* isolates from water and fecal samples collected during the PWB November 2009 Reservoir 3 *E. coli* incident.⁴

IEH/MEI Recommendations

According to Mansour Samadpour, Ph.D., President and CEO of MEI laboratories, source identification through *E. coli* subtyping is best employed as part of a comprehensive study which samples local sources of *E. coli* (e.g., wildlife) over time. Relying solely on existing *E. coli* fingerprint

⁴ During the November 2009 *E. coli* detections at Reservoir 3 which resulted in a boil water notice, PWB submitted isolates from the original and resample *E. coli* detections along with scat samples collected around the reservoir from 4 unidentified birds, 1 rodent, and 1 unidentified non-human mammal (likely a raccoon or skunk). No *E. coli* was isolated from the rodent. The RFLP patterns from the *E. coli* isolated from the water and the remaining five scat samples are stored in MEI's database.

libraries from other locations results in positive source identification less than 60% of the time. Even when local sources are sampled, successful identification of a single isolate is not guaranteed. For example, when *E. coli* was detected at Reservoir 3 in 2009, the Water Bureau collected wildlife scat samples from the vicinity of the reservoir. Despite these efforts, results from the 2009 investigation were also inconclusive. Opportunistic collection of scat samples over a limited time period likely missed the source of the contamination. Given these facts along with the fact that genetic subtyping provides no information on the virulence of the strain or the potential introduction of other microbial contaminants, Dr. Samadpour advised that *E. coli* subtyping is not an appropriate tool to employ during uncommon detections of *E. coli* in finished drinking water.

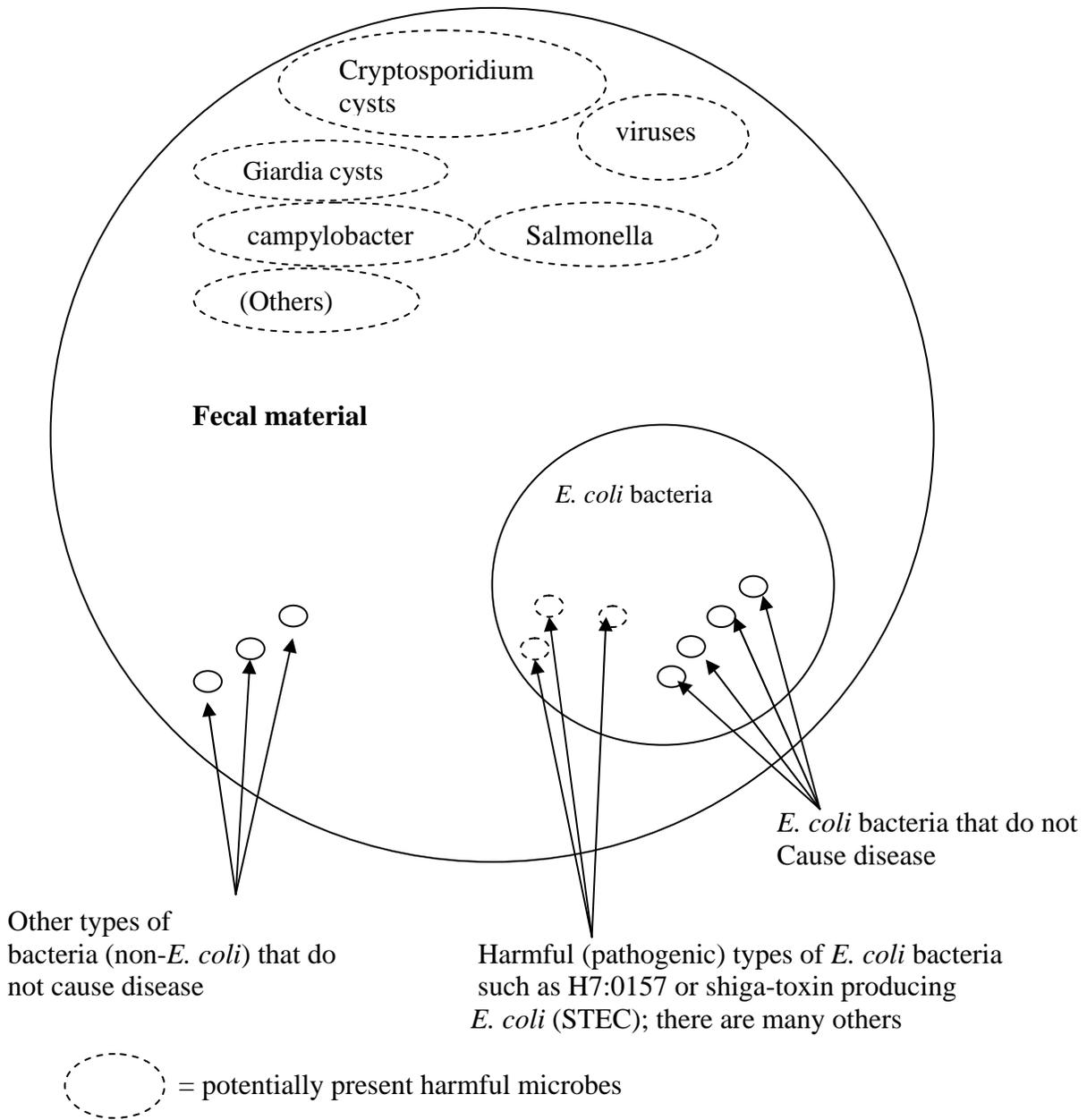
In the event that *E. coli* is detected in the finished drinking water, Dr. Samadpour recommends that the isolate be submitted for an analysis of illness-causing potential to attempt to establish whether the isolate represents a public health concern. While offering some valuable information, there are two important limitations to the utility of this test during a contamination event that should be considered:

- Illness-causing potential test results may not be available for several days, in many cases after the event has been resolved.
- Since *E. coli* is a fecal indicator and fecal matter may contain other disease causing microbes that were not tested, it is not possible to state that the contamination event was harmless. See Figure 3.

Water Quality Investigation Conclusions

The investigation conducted by the Portland Water Bureau did not reveal the source of the *E. coli* detected at the Reservoir 3 outlet sampling station in the sample collected on July 19, 2012. Water quality monitoring during and after the incident indicates that the source was transient and low intensity. The detection of bacteria in two samples at the reservoir outlet with no bacteria detection at the entry point to the distribution system or elsewhere in the distribution system indicates that the bacteria were most likely introduced at Reservoir 3 and did not result from a deficiency in Portland's raw water treatment. The specific source of the *E. coli* remains unknown. The genetic subtyping test was inconclusive and MEI laboratory has advised that this test is not likely to yield source information without creating a substantial library of test results using scat samples collected from the immediate area. When *E. coli* was detected at Reservoir 3 in 2009, the Water Bureau conducted an extensive investigation to determine the source. Results from that investigation were also inconclusive.

FIGURE 3 – Venn Diagram of Some Fecal Constituents



INCIDENT INVESTIGATION – HEALTH IMPACT (Multnomah County Health Department)

Overview

On Friday, July 20th Multnomah County Health Department (MCHD) was notified by the Portland Water Bureau (PWB) that a water sample taken from the outlet of Washington Park Reservoir 3 on Thursday, July 19th tested positive for the presence of *E. Coli* bacteria. A second sample was taken on July 20th and came back positive on Saturday, July 21st for total coliform bacteria (no *E. coli*) at a most probable number (MPN) of one (1). A Boil Water Notice was issued in response to these positive tests around 12:30 pm on Saturday, July 21st. Samples taken from the reservoir and several other sites in the water system on Saturday July 21st came back negative for the presence of total coliform bacteria, indicating that the contamination event had ended. The boil water order was lifted early Sunday morning July 22nd.

Following issuance of the boil water notice on Saturday, July 21st MCHD and PWB agreed to have all complaints of illness or health concerns forwarded to MCHD for follow-up and analysis. An MCHD epidemiologist communicated with PWB to ascertain the affected zip codes, and the date(s) of last negative bacterial tests on water. It was confirmed that the last prior water sample testing negative for the presence of fecal coliforms and *E. coli* was taken on July 18th. Thus, the potential exposure period began at the earliest on July 18th. The zip code areas receiving potentially contaminated water were: 97201, 97204, 97205, 97207, 97208, 97209, 97210, 97219, 97221, 97231, 97239, 97240, 97280, and 97296.

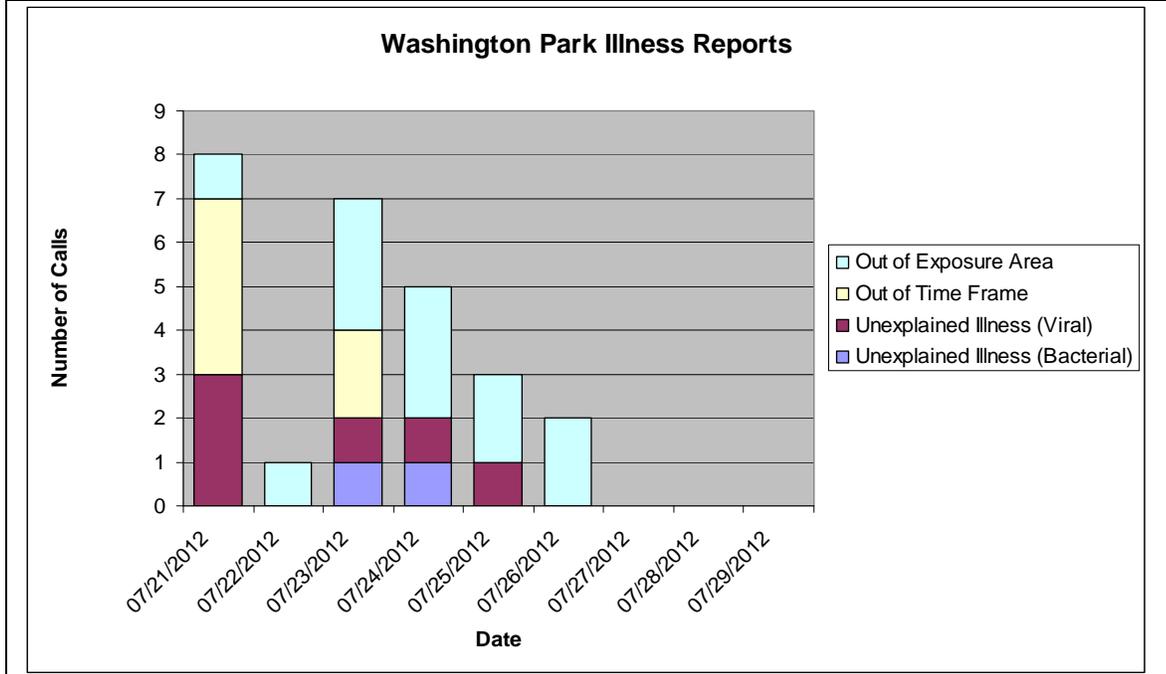
Three strategies to assess a rise in illness related to the water contamination event were employed:

- 1) Interviewing persons reporting illness around the time of the contamination event,
- 2) Monitoring of the Oregon Public Health Epidemiology User System (ORPHEUS) for laboratory confirmed and presumptive cases of enteric illness, and
- 3) Monitoring of OHSU hospital admissions data via the Bio-sense syndromic surveillance system to detect any evidence of an upsurge in gastro-intestinal (GI) illness reports.

1) Reports of Illness Related to Water:

In order to assess whether the contamination event was associated with GI illness, a brief exposure and clinical symptom questionnaire was created to interview individuals reporting illness. Overall 26 individuals called to report illness between July 21st and July 29th. Among these reports, 12 (46%) were from individuals who had not consumed water or been to the affected zip codes during the exposure period; 6 (23%) reports were from individuals who had illness onsets prior to the contamination event. Of the remaining 8 (31%) reports, 6 (23% of all reports) had symptoms consistent with a norwalk-like viral illness, while 2 (8% of all reports) had symptoms consistent with an enteric bacterial illness.

Figure 1. Portland Water Bureau Reports of Illness July 21-29, 2012



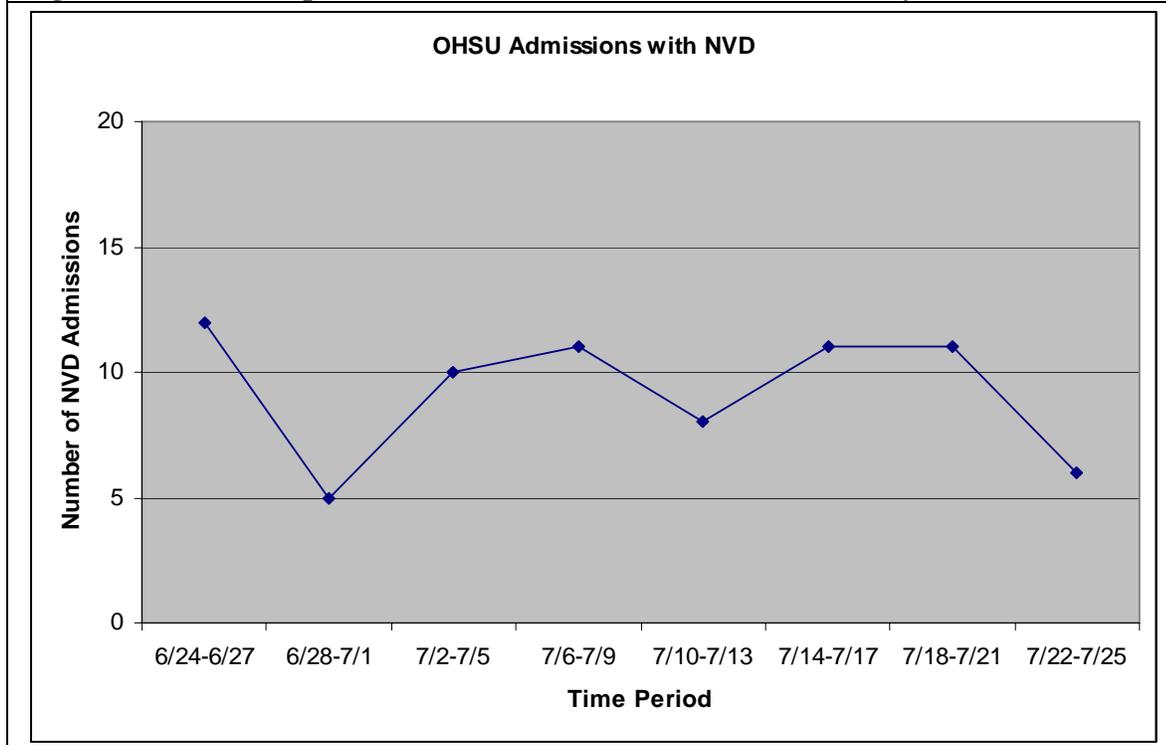
2) Orpheus Enteric Illness Report Monitoring

Cases of enteric illness were monitored via ORPHEUS for onset of illness occurring between July 20th and July 31st. This interval represents the period during which illness from an exposure to Reservoir 3 would likely occur. Over this time period, five cases of enteric disease were reported for the exposure area -- two *Campylobacter*, one *Giardia*, and 2 non-typhoidal *Salmonella spp.* Locally, *Campylobacter* and *Salmonella* infections have not been associated with drinking water contamination. The case of *Giardia* occurred in a person with a recent history of travel to Mexico. One case of *E. coli* 0157 was identified in a person residing outside the exposure area. Based on laboratory information, the organism in this case was not related to the *E. coli* from the reservoir specimen. While Legionellosis is not considered an enteric disease, a single case of *Legionella* (which can be water-borne) was reported in an immuno-compromised person.

3) OHSU Bio-sense Hospital Admissions Monitoring

Syndromic surveillance data for GI illness including as nausea, vomiting, or diarrhea (NVD) from OHSU was received from the Oregon Health Authority for the period of June 24th, 2012 thru July 25th, 2012. We requested data from the period preceding the period of potential contamination and exposure in order to establish a baseline for “before and after” Comparison. Data was analyzed to include all cases from the exposed zip codes that presented at the OHSU emergency department. The resulting data show no increase in hospital admissions due to NVD illness (Figure 2).

Figure 2. OHSU Hospital Admissions for GI Illness June 24th-July 25th 2012



Conclusions

Our surveillance included interviewing persons with complaints of illness who contacted the Water Bureau, evaluating individual cases of reportable enteric diseases, and analyzing OHSU emergency department chief complaint data. These analyses failed to provide evidence of a detectable increase in gastro-intestinal illness in the wake of the potential water contamination event. Specifically:

- The number of individuals who had symptoms that were plausibly associated with the contamination event was extremely small. Given that the area receiving potentially contaminated water included a population of approximately 100,000 consumers, the eight (8) self-reported illnesses falls well within the expected baseline level of illness in a population of this size.
- There was no upswing in the number of cases of bacterial GI illness reported by health care providers or laboratories. In addition, the level of contamination documented in water tests was extremely small relative to the numbers of bacteria typically required to result in illness.
- Local syndromic surveillance data did not suggest any increase in GI illness in the community.

These findings support the conclusion that the Reservoir 3 water contamination event that occurred between July 19th and July 21st, 2012 did not result in a detectable increase in gastro-intestinal illness. MCHD recognizes that public health surveillance is not perfect; it can fail to detect significant outbreaks. Despite this, MCHD is comfortable that if there had been significant contamination, we would have expected to see noticeable increases in both complaints of illness as well as in reports by health care providers. No such increase in illness was observed. Instead we observed constant low numbers most likely reflecting baseline enteric illness levels within the affected zip codes.

FOLLOW-UP ACTIONS

Preventive Actions

Continue bird abatement measures at Res 3; Improve as needed.

After the reservoir was drained, operating engineers found several other small entry points where birds could access the Reservoir 3 outlet gatehouse structure over the water. These have been sealed. Operators will continue to watch for bird nesting activity and take action to remove nests or deter any nesting.

Investigate the addition of booster chlorination at Res 3 outlet

Although the purpose of booster chlorination is to maintain adequate disinfectant residuals in the distribution system, there may be an added benefit of inactivating bacteria introduced at the open reservoir. The water leaving Reservoir 3 has routinely good chlorine residual and therefore not much free ammonia nitrogen to combine with added chlorine. Therefore the chlorine boost would need to be relatively small and well controlled. To provide for control of booster chlorination at this point it would be necessary to install a precision flow meter on the Reservoir 3 outlet line to pace the addition of the booster chlorine. Portland Water Bureau will investigate the feasibility of adding booster chlorination at the Reservoir 3 outlet.

Evaluate R2A-HPC testing as an indicator of open reservoir water quality

Heterotrophic plate count (using R2A agar) was added to the PWB distribution system monitoring routine this year on a seasonal basis. This analysis is not required by drinking water regulations. Water providers use it to gauge the re-growth of certain types of bacteria within a distribution system and proactively address water quality problems. PWB has been using the R2A-HPC test since early 2012 to determine baseline levels (in colony forming units per milliliter) for its distribution system. Reservoir 3 outlet water has been tested eight times this year and did show a notable though gradual rise before the incident and a drop below the detection limit after the reservoir was drained and cleaned. This is an expected result since the test would reflect the accumulation of biomass in a reservoir between cleaning cycles. Increasing HPC values can indicate an issue within that portion of the distribution system, so it may be a useful surrogate for potential water quality issues. Reservoir 3 outlet monitoring for R2A--HPC has been increased to a weekly frequency during the summer/fall when the reservoir is online to better understand what this parameter indicates for Reservoir 3 water quality.

Remove Reservoir 3 from the PWB distribution system

This action is required to comply with the Long Term 2 Enhanced Surface Water Treatment Rule. Portland Water Bureau is following a compliance schedule that removes Reservoir 3 from service by December of 2020.

Palliative Actions

Improve response time for a future incident

In the event that *E. coli* is detected anywhere in the PWB distribution system, the Emergency Operations Center will be mobilized no later than the following morning when bacteriological test results are due. The goal is to complete preparations for public notification before getting confirmation of the *E. coli* result in the second sample so that the public notice can be issued as soon as possible.

Prepare BWN documents in Spanish, Vietnamese and Russian.

For Portland Water Bureau, the OHA Drinking Water Program has not specified translation of public notices in languages for non-English speaking consumers. The Public Notice Rule states that in this case PWB must determine whether it is appropriate to provide a translated public notice to reach a large proportion of non-English speaking persons served by the water system. Translations were not provided for this incident but OHA advised PWB that this could be necessary for any similar future incident. The Water Bureau will prepare Boil Water Notice templates in Spanish, Vietnamese and Russian and adopt a policy to send the BWN notice information to all foreign language media for translation/publication to address these non-English speaking consumers in any future public notices.

Coordinate with affected wholesale customers to collect follow-up samples.

Before making a decision to lift a Boil Water Notice in affected wholesale customer systems, OHA would like to know whether these systems determined that the water received from Portland was tested and determined to be free of bacteriological contamination. In this incident the OHA Drinking Water Program allowed the BWN to be lifted without this information. (Three of the six affected wholesale customers collected and analyzed bacteriological samples on the day that the BWN was issued. The other three systems collected samples at a later date). In a future incident, the affected wholesale customers must collect one or more samples to determine that contamination is not present before the BWN can be lifted in those systems. PWB Lab has offered to analyze bacteriological samples collected by affected wholesale customers if any system is unable to arrange for timely analysis through their normal laboratory.

Improve message consistency and delivery to the public and sensitive users.

Portland Water Bureau is working with Multnomah County Health Division and OHA on consistent messaging to affected customers. A November 2012 meeting was held to craft boiler plate messaging and talking points for all agencies. A Frequently Asked Questions (FAQ) template was provided to both of these groups for review. The final document will be translated to Spanish, Vietnamese and Russian. For the City website, the PWB Public Information group has created a web page template that can be activated with relevant documents and information and featured on the PWB site and City home pages. Portland Water Bureau also met with OHA risk communication staff in December 2012 to coordinate notification of sensitive users, such as hospitals or clinics.