2015 UPDATE

Open Drinking Water Reservoirs Are Sources
Of Public Health Benefits

Covered Drinking Water Reservoirs Are Sources
Of Increased Public Health Risk

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In 1883 Dr. Robert Koch published an article entitled: About Detection Methods for Microorganisms in Water. That historic paper marked the introduction of the application of microbial indicators for surveillance of water hygiene. Koch described for the first time the methodology for microbial measurement in water and showed its value as a measure of water performance. Open reservoirs at Mount Tabor and Washington Park were built for the betterment of Portland health; public health scientists and engineers knew exactly what they were doing and why.

The integrity of Portland’s drinking water system and public health relies on open reservoirs at Mount Tabor and Washington Park. Open reservoir ecosystems provide safe drinking water naturally reducing microbial and environmental chemicals. Covered reservoirs cannot because of their inefficient and completely different ecosystem. Portland’s open reservoirs built over 100 years ago providing natural drinking water without illness; drinking water safer from disease and toxic & carcinogenic chemicals than covered reservoirs. (EPA case studies)

Open Reservoir Public Health and Engineering Assessments and Support Studies

“No waterborne disease outbreak or water quality incident of public significance has ever been recorded in connection with Portland’s open reservoirs.”


“All features in good condition. ...a detailed maintenance program could extend the useful life of the open reservoirs to the year 2050.”


“All of the open reservoirs are historically significant, and thus are eligible for inclusion in the National Register of Historic Places and for local landmark status.”


“The reservoirs are historically significant as examples of early engineering, and serve as monuments to the social history of the City’s growth and development. They provide an early example of a planned landscape, including the views and vistas into and out of the landscape.”

Open Reservoir Study, Facilities Evaluation, City of Portland, 2001
Preface

Portland Water Bureau Goal-2011

“To enhance public trust and confidence in the Water Bureau as being fiscally responsible with ratepayer funds as well as the stewards of the water system.”


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Portland Water Bureau Message to Community- 2011

“Rumors that covered storage puts the public’s health at risk are false and malicious in their intent. Buried water storage facilities only need to be washed of natural sediments every 5 years. An open reservoir must be cleaned two times a year.”

The alleged debris from open reservoirs has never been conclusively demonstrated through a chain of custody process that would confirm it originated from reservoir by Portland Water Bureau. Portland Water Bureau Disregards the many EPA Case Studies Confirming Microbial and Chemicals Deaths from Covered Reservoirs; While, the Scientifically Supported Public Health Benefits of Portland’s Open Reservoirs are Documented by Not Having Any Illness Since they Were Built Over 100 Years Ago.

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The 2004 City of Portland Open Reservoirs Independent Review Panel reviewed the document Public Health Benefits of Open Reservoirs that clearly outlined the public health integrity of open reservoirs vs. covered reservoirs. The Panel voted by a majority to retain open reservoirs, with the recommendation of adding more security and reservoir maintenance. The scientific principles of the open reservoir public health benefits will be given throughout this document. Scientific principles of why covered reservoirs place public health at risk will also be reviewed; covered reservoirs’ health risks are profound such as retention of radon and chloroform gases because they cannot efficiently be removed from enclosed saturated water. EPA acknowledges the cancer risk from radon in water is higher than the cancer risk from any other drinking water contaminant. Open reservoirs support public health by removing radon efficiently through vaporization harmlessly into the air. There is no safe level of radon. (EPA)
History, along with public health and epidemiology* data have shown for over 100 years open reservoirs have provided safer and healthier drinking water. US covered reservoirs have clearly demonstrated exceptionally poor water quality, deaths from chemicals and microorganisms, poor maintenance, along with many examples of defective engineering. *Portland’s open reservoirs and others around the US have not been subject to any of those complications.*

Covered reservoirs place public health at risk because of the following deficiencies:

- Cannot efficiently remove and volatilize gases such as radon and chloroform
- Cannot break down unwanted disinfection byproducts such as haloacetic acids
- No sunlight to inhibit the buildup of biofilm, break down toxic chemicals, and stop the bacterial nitrification process
- Cleaning schedules of +5 years that allow sedimentation and biofilm build up, providing protection for and harboring pathogenic microorganisms (E.coli)

*the branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health.*
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I. Introduction

Portland’s quality of life begins with the Bull Run drinking water system that was built around, and supports our open reservoirs at Mount Tabor and Washington Park. For over 100 years these reservoirs have not had a chemical or microbial public health incident. The 3 boil water alleged events in the last few years called by the Portland Water Bureau resulted in no illnesses from open reservoir drinking water. The Mount Tabor event did not meet EPA boil water alert threshold, but was subjectively implemented at great cost and hardship to citizens and businesses.

Until recent years Portland boil water orders were extremely rare and would historically originate; from turbidity in Bull Run rain events decades ago as a result of illegal logging, distribution system pipe breakage, deferred maintenance, etc. Never resulting in illness from Portland’s open reservoirs. Yet in the last few years Portland has had the alleged action for 3 boil water alert events. What could be a common denominator for an alleged E.coli positive if the open reservoirs have had no illnesses in the past? The 2005 change in Portland Water Bureau management led to the implementation of poor water sampling techniques that abandoned the EPA methodology of using gloves as a contaminant barrier. (EPA sampling below). PWB’s policy of sampling without gloves presents an extremely high risk of microbial contamination resulting in the recent boil water alerts, in exchange for 25¢ pair of gloves. PWB currently uses only hand sanitizer. Hand sanitizer is a protocol banned by CDC for food handlers. (2) Drinking water is more sensitive than food and must have a greater barrier of protection because of contamination types and soil levels.

![EPA- Correct Technique for Sanitary Water Sample](image)

The latest PWB scientifically unsupported boil water alert unnecessarily cost Portland millions of dollars in; lost foodservice business, soft drink bottling, and perishable foods that had every supermarket destroying produce/vegetables.

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Portland Water Bureau - E.coli Bacteria Water Sampling Using

Unsanitary Technique is Highly Susceptible to Contamination

No gloves as a barrier, splashing water stream, incorrect sample holding

Poor methods lead to scientifically unsound sampling technique (2)

II. Covered Reservoirs Demonstrate Low Water Quality That Risks Public Health

vs. Portland’s Open Reservoir’s Health Benefits

Portland’s open reservoirs continue to provide safe and healthy drinking water without public health incident. US covered reservoirs cannot come close to demonstrating such a healthy drinking water record as the open reservoirs. Covered reservoirs have a long history of negative public health issues and poor drinking water quality performance. New EPA rule RTCR does not require covered water tanks to be inspected and cleaned.
Amplified water quality problems that are found in covered reservoirs can generate negative public health impacts* that are routinely not observed in open reservoirs;

*Sediment buildup- Open reservoirs are cleaned every 6 months providing continued superior water quality without sediment or biofilm buildup. Less chlorine is needed to meet water quality standards because open reservoirs are frequently cleaned. Conversely covered reservoirs are cleaned every +5 years promoting sediment and other debris to build up, while enhancing the harboring and risk of pathogenic microorganisms. Sediment enters the tank one particle at a time and eventually accumulates enough for bacteria, protozoa and even viruses to use it as a habitat to grow and become a serious health problem.

Sediment removal process of covered reservoir storage facility

Because there are many years of Portland Water Bureau distribution system neglect, deferred maintenance, and debris buildup, chlorine disinfection performance declines. Portland Water Bureau operators do not ask why, they just add more chlorine. Over time the additional chlorine breaks down because of interaction with sediment and biofilm, known as “chlorine demand”. The disinfection byproducts themselves become a toxic contaminant in the covered reservoir that can cause cancer. This is the approach the Portland Water Bureau has taken by adding 14% more chlorine as we saw last Fall 2014 and in May because they don’t maintain the distribution system professionally. Conversely in the open reservoirs any cancer causing disinfection byproducts are efficiently removed by vaporizing, and aerobic bacterial breakdown of chemicals.

The scientific principle methods of vaporizing and aerobic bacterial breakdown are not available to covered reservoirs, making closed storage in covered reservoirs unhealthy.

- Toxic chemicals such as NDMA from ammonia have negative effect on health.
• Chlorine generates chloroform and other cancer causing disinfection byproducts
• Wastes money adding chlorine for negative public health benefit
• Chlorine does not penetrate biofilm efficiently increasing chlorine demand

Portland Water Bureau has ignored City of Portland’s Auditor’s deferred maintenance reports for over a decade placing distribution system and covered reservoir’s water quality at great risk. Instead of constantly adding more and more treatment chemicals, PWB should simply follow the Auditor’s report and maintain the distribution system properly. Countless numbers of biological contaminants can use the sediment on the floor of covered water tanks to generate a stronghold in drinking water system. These microorganisms (Enterobacter) then grow into an unmanageable health concern as we have seen in Portland over the past years. Why should we care what is on the bottom of a water storage tank? The water we drink comes off of the bottom of water storage tanks. Open reservoirs cleaned twice a year give the community a healthy advantage.

*Biofilm buildup* - +5 years of covered reservoirs not being cleaned or inspected allows a substantial biofilm buildup that also harbors pathogenic microorganisms. Covered reservoirs do not allow sunlight Ultraviolet Radiation (UVR) to breakdown and manage biofilm. Open reservoirs provide natural sunlight UVR penetration to efficiently manage biofilm, contributing to safe and healthy water. Biofilms not only protect bacteria from disinfection but also provide an environment where disinfectant injured cells can repair cellular damage and grow. *Enterobacter cloacae* are a fecal opportunistic pathogen frequently found in Portland’s drinking water due to poor water system maintenance that can recover after being injured from monochloramine exposure.

**Biofilm**- Biofilm is an accumulation of living/dead organic and inorganic material collected on an infrastructure i.e. pipe surface, having a similar consistency and texture of egg whites. Biofilm can protect microbes from disinfection and allow microbes injured by environmental stress and disinfectants to recover and grow. In addition, biofilms may increase pipe corrosion, adversely affect pipe hydraulics and reduce the utility/usefulness of total coliforms as indicator organisms. Microbial growth in biofilms may result in deterioration of water quality, generation of bad tastes and odors, and proliferation of macro invertebrates.

Contamination and material in the biofilm may subsequently be released into the flowing water under various circumstances. As a result, biofilms can act as a slow-release mechanism for persistent contamination of the water. The organisms and their products may decrease disinfectant levels (by increasing disinfectant demand), posing a direct public health risk. Biofilms in drinking-water pipe and distribution system networks can be responsible for a wide range of water quality and operational problems. Biofilms contribute to;
- loss of distribution system disinfectant residuals i.e. chlorine levels,
- increased bacteria exposure,
- reduction of dissolved oxygen,
• red or black water problems due to iron- or sulfate-reducing bacteria,
• microbial influenced corrosion,
• hydraulic roughness
• reduced material life (3)

The prolonged neglect of Portland’s water distribution system has resulted in what was to be expected; biofilm buildup and accumulation of sediments impacting public health. Over time the flushing of pipes becomes more of a challenge. Because of the PWB maintenance neglect and debris buildup, the reduced water quality greatly places our public health at risk. Microorganisms in biofilms and sedimentation can include bacteria (coccoid, rod shaped, filamentous, and appendage) fungi, parasites and viruses. A primary reason water utilities become concerned with biofilms in drinking water systems is due to growth of coliform bacteria within the pipe and distribution network. EPA has shown in one year ~7000 water systems violated drinking water microbial standards. (4)

Primary, secondary and opportunistic microorganism pathogens can accumulate in the biofilm. The biofilm may extend the survival of pathogens by protecting them from disinfectants. These pathogens may be sloughed from the biofilm into the water column due to changes in the flow rate. The persistence of microbial contamination in a distribution system long after the cause of the distribution system problem has apparently been corrected, suggests that there may be an isolated pocket(s) of static or slow-flowing water, biofilm erosion or sloughing that is occurring (as a slow-release mechanism). Poor system maintenance is a leading contributor of waterborne disease.

Covered reservoir deficiencies and biofilm

Because bacteria adhere to almost every surface, they form architecturally complex communities. In the water distribution system biofilm, cells grow in multicellular aggregates that are encased in an extracellular matrix (slime) produced by the bacteria themselves (5). The extracellular polymeric matrix is an important structural component of biofilm. It plays a critical role in the attachment and colonization of microorganisms on a surface and also acts as a diffusion barrier to small molecules. (6) For example Bacillus subtilis and other bacteria form biofilm whose constituent cells are held together by the extracellular matrix and one of the main matrixes competent is the protein TasA which is a form of amyloid fibers and binds cells together in the biofilm (7). The matrix, which is composed of polysaccharides, proteins, nucleic acids and water, are what enables the biofilm to attach to the surfaces. One of the most important functions of the matrix is to protect the bacteria from various stress and factors such as UVR, and extreme pH values. (8) The covered reservoirs’ +5 year cleaning schedule enhances biofilm and debris buildup. The open reservoirs’ 6 month year cleaning schedule allows very little time for biofilm to establish itself and grow because of continuous exposure of solar UVR. Solar UVR wavelengths of biological importance are mainly composed of UVA (320 to 400 nm) and UVB (290 to 320 nm). Besides its implication in damaging proteins and membranes, UVA
indirectly damages DNA by creating reactive oxygen compounds (e.g., H$_2$O$_2$, O$_2^-$, etc.) by photo oxidation of O$_2$ which cause single-strand breaks in DNA. (9)(10)(11)

In contrast, covered reservoirs are cleaned +5 years, or over 10 times longer than open reservoirs. Covered reservoirs have no solar UVR exposure to inhibit growth thus biofilms and sediments increase allowing for distribution system microbial buildup and public health issues.

![Figure 1.](image)

Wild bacteria are “hairy” cells with extracellular polymers which stick to surfaces, concentrate nutrients, and protect bacteria from disinfectants.

Examples of bacteria participating in biofilm buildup
Portland Water Bureau Poor Maintenance of the Water

Portland’s Poorly Maintained Distribution System Places Public Health at Risk

Biofilm and Sediment Build Up From Poorly Maintained Distribution System
Chlorine concentration is decreased after reacting with biofilm and sediment debris reducing disinfection effectiveness throughout drinking water distribution system. There is ongoing and continuous buildup of biofilm and sediment debris in covered reservoirs too. Covered reservoirs promote the harboring of microorganisms because cleaned +5 years and no solar UVR exposure.

Buildup is not seen in open reservoirs because of routine cleaning 2x year and continuous solar UVR exposure inhibiting growth of biofilm.

Covered reservoir’s darkness and lack of sunlight protects biofilm and permit growth allowing for increasing number of microorganisms
*Microbial pathogens*- covered reservoirs have a long history of harboring microbial pathogens such as Salmonella that have resulted in deaths in Gideon, Missouri and Alamosa, Colorado. **Open reservoirs have never had such occurrences.** Portland’s open reservoirs have an occasional alleged *E. coli* show up in a water sample (however sampled without gloves, the sample is rejected). But even an *E. coli* showing up in an open reservoir water sample, it remains inconclusive since the bacterium may have originated upstream in another part of the system. Originating in another part of the system would not be surprising since deferred maintenance acknowledged by the CoP Auditor’s reports confirm the PWB system’s **water quality maintenance record procedure is below industry standard and problematic.**

**Disinfectant decay**-Portland Water Bureau uses chloramine as a disinfectant. The ammonia component of the disinfectant is nitrogen based. Covered reservoirs have no sunlight to inhibit the bacterial breakdown of the ammonia/nitrogen by Nitrobacter sp., etc., so disinfectant decay takes place. Open reservoirs are fully exposed to sunlight inhibiting the bacterial breakdown of chloramine disinfectants. Sunlight exposure on chloramine has little effect on chloramine decay. (World Health Organization)(11)

**Chemical** –Covered reservoirs retain unwanted gases like radioactive radon gas. Because they are not efficient in volatilization the gas remains in the water to be released in schools, homes and work places. There is no safe level of exposure to radon gas. (USEPA) Over the years chemical exposures in covered reservoirs such as lead paint, hot mopped coal tar, and axel grease have been applied to inside reservoir walls communicating with drinking water. None of this contamination has taken place with open reservoirs.

**Nitrification**-Once the accelerated decay of chloramine takes place from biofilm and sediment exposure, a second unwanted chemical process takes place in the darkness of covered reservoirs known as nitrification. Nitrification bacteria continue breaking down and processing nitrogen to nitrates, nitrites, nitrosamines, and NDMA. All are unwanted chemicals that can be toxic and carcinogenic. **Open reservoir sunlight inhibits this bacterial metabolism action and activity stopping nitrification process.**

**Disinfection Byproducts**-Disinfection byproducts from chlorine and chloramine chemical reactions are common in any drinking water distribution system. Open reservoirs allow a natural removal of the unwanted disinfection by products in two ways the covered reservoirs cannot. **Open reservoirs act as a point of degradation before they enter our homes, schools and work places.** Open reservoirs allow disinfection byproducts such as toxic **Trihalomethane** THM chloroform to harmlessly evaporate into the atmosphere and be broken down by sunlight. Because open reservoirs are highly oxygenated aerobic bacteria naturally break down toxic **Haloacetic acids** HAA before they are consumed. **Covered reservoirs are not efficient in removing gases like chloroform because they are not open to the atmosphere as the reservoirs are in Washington Park and Mount Tabor.** The covered reservoirs
have an anaerobic atmosphere (lack of oxygen) that does not allow for highly oxygenated aerobic bacterial breakdown of Haloacetic acids as is seen in the open reservoirs.

* Odors and Tastes - Open reservoirs do not create off odors or tastes because they are cleaned often, 2 X year and generate an efficient healthy aerobic ecosystem. Covered reservoirs create off odors and tastes for many reasons. Because they are cleaned +5 years, far less than open reservoirs, sediments and biofilms harbor unwanted sulfuric bacteria and others. These bacteria create off odors and flavors similar to rotten eggs, etc. This process is promoted by having an anaerobic ecosystem that supports offensive water characteristics. There is no efficient way for these offensive toxic and carcinogenic gases to escape until they reach homes, schools and work places.

-No Scientific Basis to Blame Open Reservoirs for Drinking Water Contamination

Portland Water Bureau has ignored warnings for over a decade about the water distribution system deferred maintenance and placing water quality at great risk. Since 2004 the City of Portland Auditor’s Office has acknowledged their concern of PWB in 3 separate studies, about their poor management and maintenance practices. Instead of addressing distribution system deferred maintenance PWB resources have been used for unneeded projects such as added covered reservoirs that leak and are structurally unsound. Portland does not need any more water storage capacity because of continued declining customer usage. Utilizing New York City’s approach, Portland could have successfully proposed a waiver from the EPA LT2 open reservoir regulation. The scientifically supported public health principles of open reservoirs that EPA was interested in were already available and could have been provided to the Oregon Health Authority. PWB withheld that scientific information.

The biggest public health challenge to Portland drinking water has never been the open reservoirs, but the poor system maintenance leading to buildup of biofilm and sediments harboring unwanted and pathogenic microorganisms. The lack of planning, investment, and maintenance of the water distribution system infrastructure has today left the users of Portland drinking water in a position of serious public health risk; such as exposure to Enterobacter sp., pathogens responsible for a number of infections such as bacteremia, lower respiratory tract infections, urinary tract infections, and septic arthritis.
EPA Drinking Water Bacteria Schematic 2014 – is now outdated
for current drinking water bacterial public health applications

**Total Coliform, Fecal Coliform and E. coli**

Current “old school” Way of Measuring Water Quality Risk

**Total coliform**-

Total coliform bacteria are common in the environment (soil or vegetation) and are generally harmless. If a lab detects only total coliform bacteria in drinking water, the source is probably environmental and fecal contamination is unlikely. However, if environmental contamination can enter the system, pathogens could get in too. It is important to find and resolve the source of the contamination.

**Fecal coliform**-

Fecal coliform bacteria are a subgroup of total coliform bacteria. They exist in the intestines and feces of people and animals. The presence of fecal coliform in a drinking water sample often indicates recent fecal contamination. That means there is a greater risk that pathogens are present.

**E. coli**-

E. coli is a subgroup of the fecal coliform group. Most E. coli bacteria are harmless and exist in the intestines of people and warm-blooded animals. However, some strains can cause illness. The presence of E. coli in a drinking water sample may indicate recent fecal contamination. There may be a greater risk that pathogens are present. E. coli identification can receive a lot of media coverage. A specific strain of E. coli bacteria known as E. coli O157:H7 causes most of those outbreaks. When a drinking water sample is reported as “E. coli present,” it does not mean that O157:H7 is present.
However, it does indicate recent fecal contamination event. Boiling or disinfecting contaminated drinking water destroys all forms of *E. coli*, including O157:H7.

**Future Drinking Water Bacterial Analysis Diagram**

![Diagram showing bacterial analysis]

**Water Quality Sampling - Acknowledging Additional Indicator Organisms Providing a more Reliable Bacterial Analysis**

**Conclusion**- City of Portland must retain the open reservoirs at Mount Tabor and Washington Park in order to preserve the integrity of our drinking water system. The open reservoirs’ public health principles of sunlight, oxygenation, and open air volatilization provide the answers why there have been no public health issues since the reservoirs were built over 100 years ago. Distribution system maintenance, cleaning, relining of corroded pipes and flushing of accumulated sediments can help reduce the habitats where bacteria grow in the water system. However in one study coliform bacteria can reappear within one week after flushing a section of a distribution system, presumably because the organisms were growing in other parts of the pipe network. (WHO) This is the problem in Portland. The drinking water system continues to fail because of poor Portland Water Bureau management practices. KOIN TV channel 6 journalist Carla Castaño’s report from Fall 2013 identified the canary in the coal mine. Carla’s investigative research proved serious opportunistic and other pathogens are just waiting for an outbreak throughout the system because of poor maintenance. Portland’s water system needs immediate attention now.

Increases in coliform occurrences have been related to distribution systems with a large number of storage tanks. (WHO) When water velocity slows in these areas, sediments can precipitate, creating habitats for bacterial growth. No sunlight to inhibit biofilm growth and greater volumes of
sedimentation from +5 year cleaning schedules allows habitats for coliform growth to flourish. Routine flushing and valve maintenance program is helpful for identifying closed valves and improving the circulation in the distribution system and needs to be applied properly.

The EPA is reviewing the EPA LT2 drinking water regulation through 2016 so there is time to stop the destruction and disconnecting of our open reservoirs. New York City and other utilities in New York along with New Jersey are now in discussion for the EPA waiver. City of Portland can stop the unnecessary removal of the open reservoirs and join the discussion with EPA; so citizens now and future generations can have safe and healthy drinking water from open reservoirs. Portland’s open reservoir ecosystems are the stronghold of our drinking water system providing public health benefits by removal of toxic and carcinogenic chemicals before entering homes, schools and work places. Covered reservoirs cannot provide these benefits.

The Radon gas efficiently and harmlessly volatilizes into the atmosphere above the open reservoirs before it can enter our homes, schools and work places. Covered reservoirs cannot efficiently remove Radon from our drinking water, thus entering our buildings allowing exposures to alpha and beta particles along with gamma rays through our showers, toilets, washing machines and sinks. EPA is clear there is no safe level of Radon exposure, along with daughter progeny. The open reservoirs are the stronghold of our drinking water system; allowing sunlight, volatilization, and microbial oxygenation as the basis for our drinking water integrity. We need them for safe and healthy drinking water efficiently removing toxic and carcinogenic chemicals.

EPA established the Revised Total Coliform Rule (RTCR) 78 FR 10269, February 13, 2013, Vol. 78, No. 30. The purpose is to increase public health protection through the reduction of potential pathways of entry for fecal contamination into distribution systems. The RTCR establishes a maximum contaminant level (MCL) for E. coli and uses E. coli and total coliforms to initiate a “find and fix” approach to address fecal contamination that could enter into the distribution system. It requires public water systems (PWSs) to perform assessments to identify sanitary defects and subsequently take action to correct them. The Portland Water Bureau has had no success in controlling and “fixing” exposure to pathogenic microorganisms in our drinking water system because they do not meet the industry standards of maintenance. (City of Portland Auditor’s reports)

Please see www.bullrunwaiver.org and SCIENTIFIC and PUBLIC HEALTH BASIS to RETAIN OPEN RESERVOIR WATER SYSTEM for the CITY OF PORTLAND, OREGON.
References-

2. Portland Water Bureau- 2014, CDC 2002
8. Romero, Diego, Aguilar, Claudio, Losick, Richard; Kolter, Roberto Amyloid fibers provide structural integrity to Bacillus subtilis biofilms Proceedings of the National Academy of Sciences of the United States of America. 2010
10. Ohio State University Extension Fact Sheet. Ultraviolet Radiation penetrates water. 2008
11. Park Science. Lake Clarity, UV penetration. 2014
Appendix 1 –

-US EPA -Case Studies of Covered Reservoirs Providing Poor Water Quality

Open reservoirs are incorrectly accused by the Portland Water Bureau of greater water quality risk as compared to covered reservoirs. History and epidemiology* has shown for over 100 years just the opposite is true. It has been the US covered reservoirs that have clearly demonstrated exceptionally poor water quality, deaths from microorganisms and chemicals, poor maintenance and defective engineering. Portland’s open reservoirs and others around the US have not been subject to those complications.

*the branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health.

Contaminant-Anything found in water (including microorganisms, minerals, chemicals, radionuclides, etc.) which may be harmful to human health.

US EPA -Case Studies

1. December 1993 Gideon Missouri Salmonella outbreak in covered reservoir causing several deaths. Bird contamination
2. A 1993 outbreak of Campylobacter jejuni was traced to untreated well water that was contaminated in a storage tower facility that had been cleaned the previous month (Kramer et al. 1996). Fecal coliform bacteria were also detected in the stored water during the investigation.
3. Poor covered reservoir management and decisions placed public health at great risk for decades. An old grease coating on a storage tank interior in the state of Florida was suspected of causing water quality problems in the distribution system such as taste and odor, high chlorine requirements and a black slime at the customers tap. The Wisconsin Avenue 500,000 gallon elevated tank was originally coated with a petroleum grease coating when it was built in 1925. In 1988, the storage facility was cleaned and the grease coating was reapplied. Petroleum products were known since the 1920’s to be toxic and carcinogenic such as PAH’s. In 1993, a tank inspection revealed that the grease had sagged off the tank walls and deposited a thick accumulation of black loose ooze in the bottom bowl of the tank (6-8 inches deep). A thin film of grease continued to coat the upper shell surfaces. Although this material had performed well as a corrosion inhibitor, it was introducing debris into the distribution
system as well as creating a possible food source and environment for bacteria. The City decided to completely remove the grease and reapply a polyamide epoxy system.

4. The East Bay Municipal Utility District used hot-mopped coal tar as the standard interior coating system for tanks through the 1960’s then discontinued its use due to concerns over VOCs. When manufacturer’s directions and AWWA standards are not followed correctly, these coatings can leach organics into the finished water. Volatile organic compounds could be introduced to the stored water if sufficient curing time is not allowed after coating application. Coal tar coating systems are not common in eastern U.S. as the coatings installed in the 1950s and 1960s have mostly been replaced or the tanks themselves have been removed from service. However, coal tar is still in use elsewhere in California where it is often applied over an epoxy system on tank floors.

5. Three finished water steel elevated spheroids at the City of Brookfield Water Utility in Brookfield, Wisconsin were the subject of a field study conducted to document the underwater cleaning process and its water quality impacts. The time since last cleaning was 15 years for one tank and 7 years for the other two tanks. The tank with the longest cleaning interval contained the most accumulated sediment (28 inches maximum depth compared to 4-12 inches in the other two tanks), and the highest HPC bacteria levels before cleaning (1300/mL compared to 640 and 80/mL in the other two tanks). As a result of underwater cleaning, HPC bacteria and turbidity levels are significantly reduced.

Appendix 2

Groundwater Use - Columbia South Shore Well field History of Radon exposures

The table below shows history of when highly radioactive groundwater has been used as our drinking water/augment for extended periods of time.

**MGD = millions of gallons per day.** (1 MGD is about 700 gallons per minute)

**BG = billion gallons**

<table>
<thead>
<tr>
<th>Start date</th>
<th>Days used</th>
<th>Total Volume Pumped (BG = Billion Gallons)</th>
<th>Range of Daily Production (MGD= Million-Gallons per Day)</th>
<th>Reason for Groundwater Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 30, 2013</td>
<td>7 days</td>
<td>0.03 BG</td>
<td>0 - 5 MGD</td>
<td>Maintenance</td>
</tr>
<tr>
<td>Date</td>
<td>Days</td>
<td>BG</td>
<td>MGD</td>
<td>Type</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>August 6, 2012</td>
<td>18</td>
<td>0.03</td>
<td>0 - 5 MGD</td>
<td>Maintenance Operation</td>
</tr>
<tr>
<td>February 23, 2012</td>
<td>5</td>
<td>0.22</td>
<td>23.6 - 52.4 MGD</td>
<td>Turbidity* (Not a full Bull Run shutdown)</td>
</tr>
<tr>
<td>January 21, 2012</td>
<td>11</td>
<td>0.82</td>
<td>18.0 - 83.6 MGD</td>
<td>Turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>August 9, 2011</td>
<td>6</td>
<td>~0.03</td>
<td>0 - 22.3 MGD</td>
<td>Maintenance Operation</td>
</tr>
<tr>
<td>January 16, 2011</td>
<td>17</td>
<td>~1.3</td>
<td>8.5 - 88.7 MGD</td>
<td>Turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>August 9, 2010</td>
<td>6</td>
<td>~0.03</td>
<td>4.1 - 5.4 MGD</td>
<td>Maintenance Operation</td>
</tr>
<tr>
<td>September 28, 2009</td>
<td>31</td>
<td>~1.1</td>
<td>36.0 MGD</td>
<td>Supply Augmentation</td>
</tr>
<tr>
<td>August 5, 2009</td>
<td>7</td>
<td>~0.03</td>
<td>4 - 5 MGD</td>
<td>Maintenance Operation</td>
</tr>
<tr>
<td>November 13, 2008</td>
<td>9</td>
<td>~0.65</td>
<td>27.4 - 96.0 MGD</td>
<td>Turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>August 18, 2008</td>
<td>6</td>
<td>~0.003</td>
<td>4.7 - 6.4 MGD</td>
<td>Maintenance</td>
</tr>
<tr>
<td>Date</td>
<td>Duration</td>
<td>Flow</td>
<td>MGD 1</td>
<td>MGD 2</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>September 28, 2007</td>
<td>13 days</td>
<td>~0.43 BG</td>
<td>18.3 - 36.4 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>June 25, 2007</td>
<td>60 days</td>
<td>~1.44 BG</td>
<td>7.7 - 87.1 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>November 7, 2006</td>
<td>14 days</td>
<td>~1.1 BG</td>
<td>27.8 - 92.2 MGD</td>
<td>Turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>August 14, 2006</td>
<td>78 days</td>
<td>~3.58 BG</td>
<td>4.5 - 72.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>July 27, 2004</td>
<td>29 days</td>
<td>~1.01 BG</td>
<td>36.5 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>January 29, 2004</td>
<td>4 days</td>
<td>~0.04 BG</td>
<td>18.4 MGD</td>
<td>Turbidity* (Not a full Bull Run shutdown)</td>
</tr>
<tr>
<td>July 22, 2003</td>
<td>63 days</td>
<td>~3.7 BG</td>
<td>20.8 - 72.6 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Oct. 8, 2001</td>
<td>12 days</td>
<td>~0.44 BG</td>
<td>6.9 - 45.8 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Aug. 9, 2000</td>
<td>41 days</td>
<td>~1.7 BG</td>
<td>10.0 - 36.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Nov. 25, 1999</td>
<td>19 days</td>
<td>~1.5 BG</td>
<td>19.0 - 89.0 MGD</td>
<td>Flood and turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>Date</td>
<td>Duration</td>
<td>Turbidity</td>
<td>Daily Flow</td>
<td>Event Description</td>
</tr>
<tr>
<td>---------------</td>
<td>----------</td>
<td>-----------</td>
<td>------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Dec. 28, 1998</td>
<td>5 days</td>
<td>~0.35 BG</td>
<td>29.0 - 93.6 MGD</td>
<td>Turbidity* (rain on snow event)</td>
</tr>
<tr>
<td>Sept. 4, 1996</td>
<td>27 days</td>
<td>~0.7 BG</td>
<td>13.0 - 31.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Feb. 7, 1996</td>
<td>8 days</td>
<td>~0.5 BG</td>
<td>4.9 - 86.6 MGD</td>
<td>Flood and turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>Nov. 28, 1995</td>
<td>27 days</td>
<td>~0.7 BG</td>
<td>5.1 - 29.8 MGD</td>
<td>Landslide in Bull Run watershed (Damage to conduits, not a turbidity event)</td>
</tr>
<tr>
<td>Aug. 2, 1994</td>
<td>73 days</td>
<td>~2.5 BG</td>
<td>2.0 - 36.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Aug. 17, 1992</td>
<td>45 days</td>
<td>~1.5 BG</td>
<td>17.0 - 30.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Aug. 7, 1990</td>
<td>23 days</td>
<td>~0.22 BG</td>
<td>4.7 - 14.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Sept. 4, 1987</td>
<td>88 days</td>
<td>~5.3 BG</td>
<td>28.0 - 86.0 MGD</td>
<td>Supply augmentation</td>
</tr>
<tr>
<td>Feb. 25, 1986</td>
<td>22 days</td>
<td>~1.2 BG</td>
<td>21.0 - 84.0 MGD</td>
<td>Turbidity* in Bull Run supply</td>
</tr>
<tr>
<td>July 20, 1985</td>
<td>19 days</td>
<td>~0.38 BG</td>
<td>21.0 MGD</td>
<td>Supply</td>
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</table>
Appendix 3- Commissioners’ Answers from Q&A – Correction of Scientific Misinformation

Mt. Tabor Q&A
On November 19, 2014, Portland Parks & Recreation hosted a community meeting to discuss the future of the Mt. Tabor reservoirs. At that meeting, an organized group presented Commissioners Fritz and Fish with a flyer.

1. Question from public about radon in drinking water-

“Well-reasoned science suggests that some underground reservoirs pose increased health threats to humans, including cancer from radon, heavy metals, bacteria, and nitrification. Given that Mt. Tabor’s water system already provides healthy water, why are you not taking substantive action to keep the system functional?”

Response from Commissioner Fish and Portland Water Bureau-

1. Council comment-

Radon dissipates via natural mechanisms in both uncovered and covered reservoirs. In covered storage reservoirs, radon dissipates through vents in the reservoirs (the vents allow for air flow between the reservoir and the outside environment as water levels rise and fall throughout the day).

Scientifically correct answers-

Public answer-

Reservoirs such as Powell Butte 2 cannot remove radon gas like open reservoirs are designed to do. The extremely small vents used in the covered reservoir provide only 0.035% efficiency, allowing the radon gas to remain in our drinking water continuing into our showers, washing machines and toilets. The purpose of vents in the covered storage is to let air into the reservoir allowing water to flow freely into outlet. Without vents a vacuum is created disrupting water flow. Open air uncovered reservoirs are 100% efficient in volatilization and with a boost from the reservoir fountain and waterfall inlets. Covered reservoirs are over 99% covered with little access to let radon escape.
2. Council comment-
Radon is a colorless, tasteless, odorless radioactive gas produced during the breakdown of uranium, a naturally occurring mineral in rocks and soil. The overall exposure of radon from Portland’s drinking water is low.

2. Public answer-
Radon being colorless, odorless and tasteless has nothing to do with radioactive drinking water we will receive from Portland Water Bureau covered reservoirs. The overall exposure is relevant because there “is no safe level” of radon. (USEPA)
See Appendix 2 for extended Columbia South Shore Well field drinking water exposure and use for as long as 3 months. EPA warns that radon is the highest cancer causing risk contaminant in drinking water. Open air reservoirs quickly and efficiently remove the radon because they aerate and volatilize the gas before it enters our homes, schools, and work places.

3. Council comment-
The primary route of radon exposure is inhalation of the air in a home. According to the Environmental Protection Agency (EPA), radon in soil under homes is the biggest source of radon in indoor air and presents a greater risk of lung cancer than radon in drinking water. It is estimated that only 1-2 percent of radon in the air comes from drinking water, and only when and if it is present in the drinking water source. Radon has never been detected in the Bull Run surface water supply (2014 Water Quality Report, page 2). Radon is sometimes found in groundwater and it has previously been detected at varying levels in the Columbia South Shore Well Field. In Portland Water Bureau’s system, groundwater typically constitutes less than 5 percent of the total annual water supply. Additionally, radon has a half-life (the amount of time for half of the substance to decay) of 3.8 days. This means that radon will continue to decay and dissipate as it travels from the groundwater wells throughout the distribution system to a home.

3. Water from the Columbia South Shore Well Field has +370 pCi; for example at 20% water augmentation (a level that was proposed in October 2014 but was opposed by public) radon translates to over 70 pCi in the drinking water. Estimates from Portland Water Bureau are outdated and underestimate exposures through showers, washing machines, sinks etc. Radon from water aerosols quickly and begins decay process producing 8 radioactive daughter progeny that will disperse to dust particles, carpet fibers, lungs, linens etc.
As radon moves through covered reservoir and closed water system it will continue to be present regardless of half-life which will be minimal. The only solution to stop radon exposure in our homes, schools and work places is open reservoirs and their volatilization properties. Please see www.bullrunwaiver.org and SCIENTIFIC and PUBLIC HEALTH BASIS to RETAIN OPEN RESERVOIR WATER SYSTEM for the CITY OF PORTLAND, OREGON.
Appendix 4 – Open reservoir comments from Dr. Gary Oxman

Joe Meyer of KBOO Radio on May 10, 2011, interviewed Dr. Gary Oxman, highly-respected Multnomah County Public Health Director (retired 2013), about Portland’s open reservoirs.

Q. What about Portland’s current water?
Dr. Oxman: “I think Portland’s water is superb. We have a wonderful water source in Bull Run watershed. Well designed system and responsibly run system and we have excellent water.”

Q. Are there any known public health issues today?
Dr. Oxman: “No there really aren’t. If you are talking, are there diseases caused by our water – environmental diseases, chemical diseases, bacterial diseases, microbial diseases – no we have not been aware of or detected any diseases or sign of illness associated with our water system.”

Q. If Portland does cover reservoirs will you expect fewer illnesses?
Dr. Oxman: “We are not detecting any illnesses associated with water in Portland. No I would not expect we would get fewer illnesses after covering reservoirs.” (emphasis added)

Q. Anything else to say?
Dr. Oxman: “Great drinking water system here in Portland. Levels of citizen involvement that we have in the debates, of what the directions are a very positive thing. What we need to do as a community is to come together and debate the issues honestly, debate them openly, a lot of different factors that will influence the decisions that our policy makers will make. Council and other elected officials, and I think we need to be an active part of that process, part of the gift we can give to future generations here in Portland.”