City Council Open Reservoir Work Session Follow-Up
Portland Water Bureau

Floating Covers at Tabor & Washington Park
Feasibility, Cost and Practicality

Floating covers at Tabor and Washington Park are technically feasible and satisfy the requirements of LT2 as covers for the open reservoirs, as a temporary solution. However, there are issues that need to be addressed and may make floating covers non-viable alternatives.

Issues to address:

Cost

A planning level construction cost estimate for floating covers at Reservoirs 1, 3, 4, & 5 and recommended infrastructure and seismic upgrades is estimated to be $257.1 million ($212.5 million in construction costs with contingencies plus $44.6 million in the soft costs for design and permitting). We estimate that just installing floating covers would cost $25 million ($20.6 million construction & contingencies plus $4.3 million in the soft costs for design and permitting).

These numbers have a low confidence level. This planning estimate does not include any detailed design analysis and could be higher as the design develops and permits and land use reviews are completed.

PWB's stewardship charge is to plan ahead for the future water needs of the city, not just current water needs. Major supply components of water systems are typically planned and built to last for 50 to 100 years so that infrastructure can be in place before the demands are exceeded or the existing infrastructure fails. Floating covers are not considered a permanent solution nor do they meet the objective of providing infrastructure for current needs and into the future.

Floating covers have a typical life span of 15 to 20 years. Because of the proximity of trees to our reservoirs and the debris associated from them the life span would probably be at the lower end of the replacement cycle. Floating covers alone as a temporary solution does nothing for modernizing the infrastructure.

In addition, an estimate of annual maintenance costs for cleaning, security and chemicals is approximately $2.4 M per year (double the cost of the current open reservoirs).

Necessary Infrastructure and Seismic Upgrades

In order to install floating covers, there are infrastructure and seismic upgrades that need to be done to the structures.

To the casual passer-by the reservoirs may look fine, particularly when full. From an engineering perspective, that is not the case. These century old reservoirs are rated in

“Poor Condition” as bureau assets. Over 100 years of the combined effects of temperature changes, weathering and loading have literally worn the reservoirs out. Each time the bureau drains the open reservoirs, every 6 months or so, the bureau patches and repairs. Severe joint failure is becoming more and more common. Cracking and spalling (chunks breaking off), particularly in the wetted zones, is evident everywhere.

Flexible liners have been added to three (two hypalon and one asphalt) of the five reservoirs to both reduce leakage from the reservoirs and prevent the intrusion of groundwater. Properly functioning concrete reservoirs do not need flexible liners. It is telling commentary on the poor condition of the reservoirs that liners had to be added. It is similarly telling how long ago the liners started being added. In the case of Reservoir 6 the asphalt liner was added in 1965 to repair leaks. Reservoir 3 had a hypalon liner installed first in 1978 and then replaced in 2003. Reservoir 5 had a hypalon liner installed in 1998. The life of the hypalon liners is about 15-20 years.

The liners do not solve the long term problem. They stop leakage and intrusion for a time. But the reinforced concrete continues to undergo all the effects listed above. Structurally, the reinforced concrete basins continue to deteriorate. Risk increases for more damaging types of failure and the bureau is at a disadvantage because personnel cannot see under the liners. Liners obviously do nothing for the risks associated with open exposure to the environment outlined above.

Design standards have advanced greatly since the 1900s. Design standards and formulae used in the 1900s were much simpler and did not account for many of the risks and conditions that are common practice today. Current analytical tools result in much stronger designs, designs that can handle a wider variety of conditions. Of particular relevance, is the improved understanding of earthquakes, the forces earthquakes generate and solutions to resist earthquake forces. The open reservoirs do not meet current seismic design standards. The Water Bureau’s open reservoirs would likely be severely damaged and likely not hold water in the event of a significant earthquake like an earthquake occurring on the East Bank Fault, West Hills Fault or from the Cascadia Subduction Zone.

If the reservoirs are to remain operational for any length of time, they need extensive infrastructure repairs, renewal and modernization. All of the open reservoirs are over 100 years old and have exceeded their life expectancy and are due for replacement regardless of what happens with LT2.

Due to the condition of the floors and walls of the reservoirs, liners and covers would be required. Liners and floating covers whether temporary or permanent limit access to the reservoir for making repairs and maintenance of the structure itself. The necessary repairs and improvements should all occur before covering the reservoirs; otherwise the investment in liners and covers will be lost until some future Council authorizes the needed work.

Friends of Reservoirs say that PWB has put $45 million into reservoirs in recent years, citing Stayton and Black & Veatch contracts. Is that accurate and will the benefit of the improvements disappear once reservoirs are taken off line. The Mt Tabor and Washington Park Security and Deferred Maintenance Project was initiated after the Independent Review Panel (IRP) was finished in summer 2004 and project elements were based upon the recommendations of the panel. The project elements were carefully chosen to maximize long term value to the water system and were not dependant upon the final outcome of LT2 and the potential impacts to the open reservoirs. The improvements were designed by HDR, Black & Veatch, and in-house engineering staff and constructed by Slayden.

The project included security cameras and other security features, new electrical, new access gates, card key access to gatehouses, new valves and valve vaults, new control valves, PRV vault and 48 inch emergency bypass pipe (to bypass from Tabor 411 to Tabor 302), new decorative fencing and pedestrian walkway at Washington Park, rehabilitation of the interior of Gatehouse 5, replacement of the door on GH 5, painting of doors and window trims, sidewalk repairs at all reservoirs and other miscellaneous work. An additional bypass connection was added at SE 60th and Hawthorne towards the end of the project in 2010.

Total cost of the project was approximately $26.9 M, which includes construction costs of $23.6 M and design costs of $3.3 M. Of the $26.9 M, approximately $1.0 M (construction costs of $900,000 and an estimate of the proportionate design costs) could be considered lost value if Reservoirs 1, 4, 5 and 6 are decommissioned. This includes some of the valves and controls (primarily at Res 6 Outlet gatehouse, drain valves, conduit valves), water quality instrumentation installation and the valve platform at Res 1. The valves and water quality instrumentation can be salvaged and reused in the water system, which would reduce the $1.0 M to a smaller amount, but no attempt has been made to quantify the salvage value.

Specific Issues to Address Before Lining & Covering

- The required Tabor pipe replacement would be the original $40 M Tabor adjustment project identified in 2002 and again in the 2009 LT2 Storage Recommendations. This is the long term pipe replacement and renewal that was deferred with the plan to leave the site with the understanding that we would have to eventually replace the pipes before they deteriorate and fail. We already have some pipes that are in poor condition and need to be replaced.
- Concrete repairs or replacement of reservoir floor and wall panels
- Seismic upgrade of structures
- New infrastructure to support, operate and maintain the floating covers.
    - Floating covers require drainage/dewatering since they create several acres of impermeable surface.
    - Pumps on the floating cover for dewatering.
    - Grillage and support systems for the liners and covers
    - Stormwater management

Operations and Maintenance of Floating Covers
Operations and maintenance (O&M) requirements and O&M costs will be higher with floating covers than the current open reservoirs. Currently the open reservoirs are cleaned approximately every 6 months and enclosed reservoirs are cleaned every five years. The top surface of the floating covers would need to be cleaned every 3-4 months due to a significant increase in bio-loading.

Our experience with working on these facilities in the past is that due to their age and condition, and the number of unknowns, the level of effort tends to be underestimated.

The following is an excerpt from a document titled, "**Security Issues / Mitigation Proposal"**, Friends of Reservoirs Website at http://www.friendsofreservoirs.org/resources/IRP/Security%20Issues%20Mitigation%20Proposal_2.pdf

> **"13) What water security risks are NOT eliminated by the proposed burial of the Mt Tabor reservoirs and the floating covers on the Washington Park reservoirs?**
> We can think of a few. You can ask for more. Access to the water and infrastructure supply would remain available to a determined attacker, despite these constructions. For example:
>
> - 3 x 3 x 5 foot personnel access (two per cell), 5 x 5 x 5 foot equipment access hatches (two per cell), and vents (multiple), which are potential targets of attack, located in open parkland. Recently in El Paso two such hatches that were vandalized and the doors stolen. [9]
> - Floating covers do not protect potable water. They pond polluted water on their surface, and attract birds and animals by providing a new habitat of shallow ponded water. They are prone to seam failure, which can suddenly introduce polluted water into the water beneath. They can easily be opened with a knife. Significant sanitary issues related to these covers were raised by the California Department of Health Services in 1997 in its publication Sanitary Assessment of Flexible-Membrane Floating Covers for Domestic Water Reservoirs"[lO]. A copy of this paper has been provided to your chairman for distribution to the Reservoir Review Panel. Images from this report are included in this section. Concerns raised by this report are the reason the City of Manhattan Beach, CA decided not to use floating covers to cover its reservoir in 1999. [11]…"

Time frame for compliance

- Kelly Butte is supposed to be under construction as of July 1, 2012. If we stop working on Kelly Butte we will not be in compliance with our current approved schedule.

- Tabor Adjustments design is supposed to be complete and submitted to OHA by March 31, 2013 and complete by December 31, 2015.

- In order to change compliance schedules and project approach PWB would need OHA's approval to switch how we are complying and the schedule impacts.

- OHA is unlikely to accept a change in approach or compliance schedule if they determine that the request reflects a suspension of effort to comply or delay compliance during the period the rule is being reviewed by the EPA.

- Changing to a different solution requires starting over with planning and design. The land use process normally requires that the level of design be a least 60% when submitted for review so that the impacts to land use can be determined.

- It appears a project with floating covers would need to go through the same type of land use reviews and permitting process as a project that would build buried storage at Tabor or Washington Park. It appears *possible* to meet the approval criteria of the various land use reviews, but very difficult to make a strong case for approval of the proposal. Because of the historic designation and public involvement requirements this is likely to be a 20 month review process, including appeals. This does not include any public outreach time used in developing the design. Review fees are relatively inconsequential, but the building permit fees are probably about 1 percent of the construction and materials costs. The land use review, especially with opposition, will likely mean we would not complete construction before December 2015 meaning we would not be in compliance at Tabor.

Zoning & Land Use
Public sentiment previously was opposed to the floating covers because of aesthetics. Now that the structures are historical the aesthetics become more of a challenge and may not meet the land use requirements.

"Choosing floating covers for any of Portland's reservoirs illustrates a -lack of consideration and understanding of the significant resources represented- by the Washington Park Historic District. Floating covers are aesthetically inappropriate in a park or vista area and this point has been discussed by the Water Bureau in previous memorandums. The covers could arguably go against various established zoning codes for historic resources." "Potential Impacts of the Reservoir Projects at Mount Tabor Park and Washington Park", Friends of Reservoirs Website at http://friendsofreservoirs.org/resources/IRP/Potential%20Impacts%20of%20the%20Reservoir%20Projects.pdf

The zoning is essentially the same at both Mt. Tabor and Washington Park. The expected reviews are:

- **Type IV Historic Demolition Review.**
  If more than 50 percent of a structure is demolished (in the course of seismic upgrading, or concrete repairs, or installing the liner and floating cover, or grillage, for example), it is likely to be deemed a demolition. This land use review includes a hearing in front of the Landmarks Commission, which makes a recommendation. The decision is made in a public hearing in front of City Council. Any appeal goes straight to Oregon State Land Use Board of Appeals (LUBA). This review takes approximately an additional 4 months. It is not clear how it can be coordinated with the other reviews, which depend upon an approval of this Historical Review before we could proceed with other reviews.

- **Type III Historic Design Review.**
  Elements that will require review: The cover, its framework, visible elements of the surface drainage system, reservoir liner, removal and replacement of concrete panels, and any other visible changes totaling less than 50% of the structure. The hardest approval criteria for us to meet require: “The historic character of the property will be retained and preserved.” And “New additions, exterior alterations, or related new construction will be compatible with the resource's massing, size, scale, and architectural features.” **A geosynthetic material cover does not have historic character, nor will it be compatible with the reservoirs’ architectural features.**

- **Type III Environmental Review**
  This requires analyzing alternatives and selecting the one with the “least significant detrimental impact.” We will have trouble proving that the temporary covers at Tabor is the least impact since the original plan was to abandon the site and build elsewhere. This environmental review would be comparable to the review that Kelly Butte has already gone through where burying the reservoir has less impact than the covers. Burying the reservoir is considered a temporary impact since you can restore the surface after construction. This land use review is expected at Washington Park regardless of whether the project installs floating covers or a new buried reservoir since the current plan is to build within the existing footprint.

- **Type III Conditional Use Review (only if demo is involved)**
  According to the land use definitions if any reservoir is deemed to be demolished, its replacement will require a conditional Use (CU) review. The CU review requires that “views, landmarks, or habitat areas are protected or enhanced.”

- **SHPPO Review**
  In addition to these reviews, because we would be modifying existing FERC permitted facilities at Tabor, a FERC permit would be required which would also trigger a SHPPO historic review to assure compliance with Section 106 of the National Historic Preservation Act of 1966.

  In short, installing reservoir covers will involve essentially the same reviews as replacing the reservoir storage. **The reservoir covers may have a harder time satisfying the approval criteria for the Historic Design Review than an approach that would leave the reservoirs appearing much as they do today.**

Treatment at the Reservoir Outlet

We looked at the "treatment at the outlet" option before the rule was finalized. After the rule became final and we had lost our legal challenge, we looked at the option again and gave serious consideration to whether or not treatment at the outlet makes sense and concluded fairly quickly that it does not.

While it is technically possible, it is not practical to treat at the reservoirs. The water in the open reservoirs is considered, for all intents and purposes under the rule, “raw water” that must be treated for crypto, Giardia and viruses. Meeting the requirements of the rule by trying to treat for Giardia and viruses with either chlorine or chloramines would require the building of enclosed storage facilities to allow for sufficient “contact time” for the disinfectants to do their work before the water enters into the distribution system. In order to meet the requirements of the rule by using U.V., we know that we would have to build a treatment plant the size of the one we thought we might have to build at Bull Run if we had not received the treatment variance.

Why is that? Because treatment for Giardia and viruses would require a much higher dose of U.V. than for crypto alone. Assuming that it was going to cost $100 million to build a UV plant in Bull Run, our “back of the envelope” estimation is that it will take at least that much (times 2) to build two plants of similar size at Tabor and Washington Park. That ~$200 million estimate does not include any of the following considerations:

- Where those plants would be built? We know that if land became available it would add to the ~$200 cost of the U.V. plants.
- Cost of two new treatment plants does not include the cost of potential clear wells or storage tanks to ensure contact time. Those would add additional millions.
- In addition to the very significant capital costs to build two new treatment plants in town, we would have the O&M (operations and maintenance) costs of:
    - Staffing two new plants,
    - Maintaining and operating 115+ year-old reservoirs that are showing their age,
    - Ongoing power costs for the plants and the pumping that would be required. U.V. consumes a significant amount of power and our "green" gravity fed system would require expensive pumping (right now 80% of our system is fed by gravity).

Portland and the Rochester, New York water systems have key differences that make treatment at the outlet of the open reservoirs much more expensive for Portland than Rochester.

Rochester serves a population about 1/4 the size that we do. Their average daily demand (ADD) is 20 MGD (million gallons per day). Rochester has a filtration plant upstream of their open reservoirs which removes organic matter and reduces the formation of disinfection by-products with their use of free chlorine to disinfect. Rochester has three open finished water reservoirs downstream of their filtration plant;

Rush, Highland, and Cobbs Hill. They have over 230 MG of storage, or over 10 times their ADD, which allows great flexibility in how they operate. They also have the ability to bypass the reservoirs and pump from another treatment plant. Rush Reservoir is in a rural setting and feeds Highland and Cobbs Hill, which are historic landmarks and located in parks within the city. Rochester has an approved compliance plan to complete all work to meet LT2 by the end of 2024.

Rochester has proposed to install UV reactors inside one of its existing gatehouses and to build a small structure for the other reactors to treat for *Cryptosporidium* and *Giardia*, at Highland and Cobbs Hill Reservoirs. They believe they can achieve chlorine contact time for virus inactivation downstream inside their pipes before serving customers. Because they use free chlorine for virus inactivation already in their system, and add free chlorine downstream of their open reservoirs, they can potentially use much smaller sized UV reactors for *Cryptosporidium* and *Giardia*. The much smaller UV reactors and proposed utilization of their existing gatehouse to house the reactors translates into substantially less cost. The system has not been designed yet so Rochester staff does not know for certain if this approach will work.

Portland has a different system. Portland average daily demand is approximately 100 MGD, 5 times that of Rochester. Portland uses chloramines to maintain disinfection residual below Lusted Hill, after introducing free chlorine for virus inactivation at Headworks and using the conduits to achieve chlorine contact time. Chloramines are a weaker, but more persistent disinfectant that maintains residual in the outer reaches of Portland's distribution system. Portland changed from a free chlorine disinfection process to chloramines in 1957 because of difficultly in maintaining chlorine residual.

Portland would be required to treat for *Cryptosporidium*, *Giardia* and viruses at the reservoir outlets, which requires a much higher UV dose, hence much larger equipment than could fit into the existing gatehouses. Portland would not be able to easily or economically use free chlorine to disinfect below the open reservoirs to inactivate virus (and use smaller UV reactors like Rochester proposes to use) because:

- The first services to customers below the reservoirs are too close to achieve contact time in the pipes, so large buried chlorine contact tanks or clearwells would have to be constructed next to the reservoirs, similar to burying a reservoir.
- Free chlorine must be added to chloraminated water in large enough quantities to achieve breakpoint chlorination to inactivate viruses which creates taste and odor problems and forms trihalomethanes (THM's) and haloacetic acids (HAAs). These are known as disinfection byproducts (DBPs), and are formed when chlorine reacts with precursors such as natural organic material which is found in the open reservoirs and unfiltered systems. These precursors are removed by filtration, but since Portland's system is unfiltered there is no mechanism for removal. DBP's are carcinogenic and highly regulated by EPA's Disinfection By-Products Rule (DBP). The Stage 2 DBP Rule recently went into effect and is more restrictive.

- If free chlorine were to be used for virus inactivation, a system for adding ammonia back in to reform chloramines would have to be designed, potentially along with pH adjustment. This is essentially the same type of chemical feed system as Lusted Hill. All of this adds up to significant additional costs and risks to water quality in the distribution system.

In addition, the UV reactors would need to be a larger size for Portland's higher demands. For these reasons, the most likely configuration for Portland would be to install one UV facility downstream and below the outlets of the open reservoirs (one at Mt. Tabor and one at Washington Park). This would require pumping back up into the distribution system, which would eliminate the sustainable and elegant gravity feed system and add more long term operational costs. Each UV treatment facility would inhabit a footprint of approximately 3-5 acres, and would include a UV reactor building, chemical storage and feed equipment, equipment storage and maintenance areas, pump station, standby backup power, parking, employee work areas, and other support structures.

There would still be a significant maintenance investment needed for the reservoirs if they were kept for water storage. The oldest reservoirs are 118 years old and all are rated in poor condition as they are beyond what is known as "useful life" for engineered structures. In their current condition, it is highly likely they would be severely damaged in a Cascadia Subduction Zone earthquake and be inoperable at a time of greatest need. The on site piping would also be severely compromised in an earthquake since much of it is the same vintage as the reservoirs and needs replacement.

Both Mt Tabor and Washington Parks are zoned open space, with environmental overlays. In addition, the reservoirs are in Historic Districts. Environmental review requires an analysis of least detrimental impact to the resource, which can include locating the impact elsewhere if the Environmental Protection zone is affected. Given that there are other potential locations for treatment outside of the parks, this may not meet the least impact test. For the open space zone, conditional use review, Type III would be required. One of the criteria is showing that "privacy and safety" of the area is protected. This could be very difficult with locating an industrial scale use next to residential and park use. Another criterion is that the use is compatible with the purpose and character of the open space zone, and that views and landmarks are protected. Historic land use reviews as previously discussed for the floating covers would also apply for this type of facility.

For these reasons, treatment at the outlets could be significantly more expensive than construction of new buried storage. The option of treatment at the outlet was analyzed in a 2002 technical memo and in 2004 by the Independent Review Panel. The treatment option was unanimously rejected by the IRP because of cost. The costs developed for the IRP did not take into account the additional mitigation costs associated with Historic Landmark status of the reservoirs and park, infrastructure renewal for seismic hardening, or costs of other land use approval requirements due to the significant impacts.

Miscellaneous Questions

Benefit of Sunlight

In highly controlled settings, processes similar to sunlight are used to provide water treatment; however, natural sunlight is not strong enough to provide demonstrable improvement in water quality. The exposure to sunlight actually has a greater number of negatives than positives. Sunlight is not a controllable treatment method, and cannot be relied upon to adequately disinfect drinking water.

There are water quality issues with sunlight and the exposed water surfaces of open reservoirs. Exposure to sunlight has the potential to raise temperatures and encourage the growth of algae and bacteria which has been a recurring problem at the open reservoirs. Sunlight can also contribute to an increase in disinfection byproducts downstream; the loss of chlorine residual, corrosion control concerns because of pH reduction; and taste and odor issues.

Climate Change

A Portland Water Bureau analysis of the range of potential climate change impacts on the drinking water system indicates that significant adaptation strategies are in place and that the water supply system appears resilient and robust for a number of years into the future. The bureau is also committed, however, to prepare and monitor for climate change impacts as an important additional adaptation strategy now and into the future.

In 2002, the Water Bureau conducted a study of the potential impacts of climate change on the Bull Run water source.[1] The information and results from this study have informed the bureau's programmatic actions and programs with regard to climate change for the past 10 years.

The research findings show that the long-term potential impacts of climate change on the Bull Run watershed must be placed in the context of variable climate patterns that already exist in the historic record. The potential impacts of significant concern include climactic shifts from past patterns. The possible shifts include more rainfall in the mid-winter months and less snowpack to contribute to the streams flowing into the reservoirs in the spring. The estimated effect of this potential shift is an increase in the average number of days per year during the summer high-demand season when the city must rely on its secondary groundwater source to supplement water stored in Bull Run reservoirs. The other potential impacts of concern include increases in rainfall intensity; damage from wind storms; and higher temperatures in the summer, which may lengthen the periods of high fire risk attributable to dry vegetation. Many of these potential impacts of concern could increase erosion, which, in turn could cause elevated turbidity levels in the unfiltered Bull Run supply. Turbidity, or the amount of suspended sediments in water, is regulated under the federal Safe Drinking Water Act.

[1] Richard N. Palmer and Margaret Hahn. 2002. The Impacts of Climate Change on Portland's Water Supply: An Investigation of Potential Hydrologic and Management Impacts on the Bull Run System. University of Washington. Seattle, WA.

In addition, potentially higher summer temperatures could increase the demand for water for outdoor use. This potential demand, however, must be placed in the context of a decade long decrease in system-wide and per capita water demands and a likely downward trend in future demands from wholesale water customers outside of the City of Portland.

The Water Bureau has actively sought to address many of the vulnerabilities and risks represented by climate change impacts. Improving the resilience of the water system has been accomplished over time through a careful asset management program that provides adaptation capacity such as having adequate storage to meet peak-event demands and the hardening important infrastructure facilities such as pump stations, pipelines, and river crossings. The Water Bureau's secondary groundwater supply enables it to provide water when conditions are such that the Bull Run is not available or sufficient to meet demands. The groundwater supply currently supplements the Bull Run for summer peak-season needs and is a backup supply when the Bull Run is partially or totally unavailable due to elevated turbidity levels or emergency conditions. The Water Bureau has ensured that water rights in the Columbia South Shore Well Field are available to meet existing and future needs through State-approved extensions and an approved Water Management and Conservation Plan. This single adaptation strategy significantly protects Portland water customers from the potential impacts of climate change on the surface water supply portion of the municipal water system.

In addition, the Water Bureau and water providers in the region have implemented conservation programs, which have contributed, along with other important factors such as building and plumbing code changes, land use changes and higher efficiency water appliances, in significant reductions in per capita water demands. This overall trend in reduced per capita demand provides an added buffer to any potential impacts on supply that might result from climate change. Lastly, the Water Bureau, as a member of the Water Utility Climate Alliance, is committed to enhancing its ability to study, analyze and understand potential climate change impacts on the Portland drinking water system using cutting-edge science and building collaborative relationships with other large drinking water utilities and the scientific community.

In-town storage volumes
We have 265 Million Gallons (MG) and are proposing to reduce the volume to 212 MG by the end of 2020.

Terminal storage for the Portland water system is defined in the Status and Condition Report as the five open reservoirs at Mt Tabor and Washington Park, plus the covered storage at Powell Butte, Kelly Butte, Sam Jackson, and Mayfair Tank. These are generally the larger volumes and water has the ability to move from higher to lower service areas as supply; they are primarily gravity fed and also have local service areas.

Distribution storage – is primarily water pumped to storage and then gravity fed out; generally serves a localized area, typically used in only one service area.

We typically do not use 100% of storage capacity. We normally operate water storage tanks between 50 to 90% of capacity but do periodically fill to just below overflow level. The rationale is to make sure we don't have an overflow, it improves water quality, and it allows us to take facilities out of service for cleaning and maintenance. The 90% range would be more typical of the summer operations and the 50% would be winter type demands. Balancing water quantity and quality of stored water is very dynamic in nature and is managed on a day to day and seasonal basis.

	Current System, MG	**Proposed System, MG**
Terminal Storage Facilities		
Powell Butte (MG), Res #1	50	50
Powell Butte (MG), Res #2	NA	50
Tabor 1 & 5 (MG)	61	0
Tabor 6 (1 side only) (MG)	32	0
Washington Park Res 3 (MG)	16	15
Washington Park Res 4 (MG)	18	0
Kelly Butte (MG)	10	25
Mayfair (MG)	5	5
Sam Jackson (MG)	3	3
Total Terminal Storage Volume (MG)	**195**	**148**
Distribution Storage Volume (Tanks such as Arlington, Denver, Vernon, etc.)		
Tanks in service (MG)	62	64
Tanks that were decommissioned (MG)	8	0
Subtotal Distribution Storage (MG)	**70**	**64**
TOTAL STORAGE VOLUME (MG)	**265**	**212**

The following response assumes that both Bull Run and the Columbia South Shore wellfield are both out of service at the same time and we are operating on storage only.

The average retail demand for Portland residences is approximately 60 MGD. Based on the current 265 MG storage being 75% full at the time of an emergency and we reduce to average demand this equates to about 3.3 days storage and about 2.5 days with 212 MG total storage considering Portland retail customers only.

Can We Defer Kelly Butte and Washington Park for A Year?
We cannot delay Kelly Butte or Washington Park and meet the current compliance schedules. EPA and OHA have stated that we must show continuous progress in complying with the approved schedule. Delaying a year does not show progress and we do not have the extra time in the schedules. Kelly Butte construction was supposed to start July 1, 2012. PWB informed the state we would be removing the existing tanks in Sept/Oct 2012, and then preparing the site for the new reservoir construction. There is no extra time in the schedule for further delays. Construction at Kelly Butte already needs every day between now and Dec 31, 2014 to complete the reservoir and have it operational to meet scheduled EPA deadline. Any delay means we are out of compliance. Once we remove the tank at Kelly Butte we must get the new reservoir on line and operational within 24 months to meet operations restrictions.

Washington Park schedule is similar. We need to start design by Jan 2013 and be ready to submit land use early in 2014. Under the assumption that we can expect 20 to 24 month land use reviews for the historical sites, this means the land use has to be submitted by Jan 2014 in order to be complete and submit 100 % signed plans and specs to OHA by March 31, 2016 for construction to start by July 1, 2016.

Can a Third Tank at Powell Butte Replace Kelly Butte?
A third tank at Powell Butte does not provide all the benefits of having storage at Kelly Butte.

A 2007-2008 evaluation of Eastside storage operating conditions shows that PWB has operated for short periods using as little as 14 MG of the total storage at Mt Tabor during non-emergency conditions. Subsequent tests have been run to operate the water system using only the existing 10 MG Kelly Butte Reservoir for short periods of time during low demand periods. These 24 to 48 hour tests have been successful.

Why Does Kelly Butte Need A Capacity of 25 Million Gallons?
25 MG is the maximum storage capacity that can be constructed at the 427-foot elevation on Kelly Butte. Replacing the storage at Mt Tabor with two 12.5 MG cells at Kelly Butte allows one cell to be cleaned or taken out of service for maintenance while the other provides adequate operational storage. A 12.5 MG cell allows PWB to meet the 10 MG minimum storage requirement for current system demands and leaves flexibility to meet potentially higher demand conditions in the future and to maintain service pressures during limited emergency, or unusual operating conditions. The

bureau will have to rely on its robust transmission system to delivery demand beyond the initial emergency event. Having a total of 25 MG available at Kelly Butte also helps to diversify the geographic location of emergency storage across the City, rather than concentrating more storage at Powell Butte.

Re-Chlorination at the Reservoirs

Portland's water supply is treated with chlorine at Headworks for virus inactivation and the distance the water travels between Headworks and Lusted Hill provides adequate contact time to meet regulations. At Lusted Hill ammonia is added to form Chloramines which are a weaker, but more persistent disinfectant that maintains residual in the outer reaches of Portland's distribution system.

When chloraminated water is exposed to the atmosphere as it is in the open reservoirs, the chloramine compound begins to break down; chlorine is lost to the air and ammonia is freed up. Additional chlorine is added at the outlets of the open reservoirs to maintain the appropriate chlorine and ammonia balance to retain chloramines and assure correct residual disinfection to meet regulatory requirements as the water reenters the distribution system.