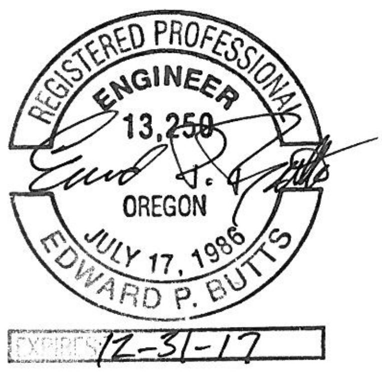
City of Harrisburg, Oregon

Water Supply System
Taste and Odor Report & Pilot Study Results



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Introduction and Background

The City of Harrisburg Oregon, with a 2015 estimated population of 3635, currently obtains all of its municipal potable water supply from a series of five (5) deep groundwater wells (although the city has access to up to 5 wells, for all practical purposes and for this report, the following 4 wells constitute the city's most reliable water supply sources):

Group 1	Group 2
Well #4------ 40 GPM	Well #8--375 GPM
Well #5-----400 GPM	
Well #6-------60 GPM	
Well #7------120 GPM	
Total: 500 GPM	Total: 375 GPM

(Group 1 total with Well #7 but without #5=225-250 GPM)

All of the wells derive water from an alluvium (unconsolidated, i.e., sand and gravel or sand) aquifer. City Well #4 is a 12" diameter well, finished to a depth of 400' in 1966. The well is currently capable of a sustained flow rate of approximately 40 GPM. City Well #5 is an 12" diameter well, finished at a depth of 395' in 1996 in an alluvial formation and produced a sustained flow rate of approximately 475 GPM, however, this well cannot be operated concurrently with Well #7 due to on-site power limitations. City Well #6 is a 12" diameter well, drilled in 2002, to a depth of 320'. The current flow rate from City Well #6 averages 60 GPM. Finally, the newer well, City Well #8 is a 8" diameter well, constructed in 2007 to a finished depth of 236' and obtains all of its water from a sand formation. The well was originally test pumped at a flow rate of 400 GPM, however, the present discharge rate is limited to approximately 375 GPM. All four of the city wells currently in service utilize submersible pumps. The total combined flow from all four wells average approximately 900 GPM (1.30 MGD). Water from Wells #4-#7 is combined into a common delivery main and routed to the two combined 2,500,000 gallon ground-level water storage reservoirs at the City Shops where it receives disinfection through the use of chlorine before entering the reservoirs. A booster pump station then receives the water from the reservoir and pumps to the distribution system. According to tracking data obtained from the city, the 2016 typical water usage (average day demand) within the city is approximately 257 GPM or .377 MGD (Million Gallons per Day), summer days average .63 MGD (437 GPM) and maximum day demands are typically just under 1.0 MGD (694 GPM). These figures equate to a typical per capita (per water user) average daily demand of 102 GPCD (Gallons per Capita per Day) and a maximum per capita demand of between 275-300 GPCD, both are well within the normal expected ranges of 100-125 GPCD and 200-300 GPCD, respectively. Peak hour demands are estimated to be between 1,200-1,500 GPM, which are totally handled by the booster pump station and reservoir storage. Water obtained from all wells receives no treatment of any kind other than chlorination for disinfection. Complaints of a "sulphur" odor and taste have been received by the city during operation of the wells. Assuming a future population of 6,140 in Year 2027, the future water demands are projected to rise to 435 GPM for average day demands, 738 GPM for typical summer day demands, and to 1,173 GPM for the maximum day demands

Water Analysis and Pilot Testing Results

Results of past and recent water quality analysis tests have been examined to determine any potential contaminants that may contribute to the taste and odor problems as well as verify the lack of any contaminants that could pose a hazard to individuals who may consume the water. The most recent water analysis for inorganic (heavy metals), volatile organic contaminants (VOC), and synthetic organic contaminants (SOC) was performed in January of 2016 which yielded no contamination due to any single contaminant in water that may have posed any immediate threat to public health, other than an Arsenic level at 50% of the maximum contaminant level (MCL). Additional analysis was performed during pilot testing in December of 2015 to determine the possible presence of any secondary contaminants in the water which are known to cause or affect taste and odor problems. In December of 2015, a series of pilot testing was conducted on two of the four operating city wells to ascertain the possible cause of the taste and odor complaints as well as eliminate any wells not contributing to the problem. Test results indicated that water extracted from the sand and gravel aquifer was the sole contributor to the taste and odor causing substances. Pilot testing was conducted on City Well #5, which was felt to be representative of the Group 1 wells and on City Well #8. Results from the pilot tests indicated iron levels at or just over the MCL of .30 mg/l and manganese at levels approximately 300%-400% of the MCL of .05 mg/l at Well #5 and were just below the MCL for iron and 250%-300% of the MCL for manganese at Well #8. The results of these tests indicated that no specific element or compound (other than the previously suspected Hydrogen Sulfide and ammonia gas) were present in levels high enough to cause the taste and odor concerns. (the test and pilot study results are included in the Appendix).

Most Likely Cause of Taste and Odor Problems

Consideration of all likely causes related to the taste and odor concerns from water extracted from the aquifer reveals the most likely causes to be a reaction occurring between existing organic (Carbon based) constituents with the chlorine used for disinfection, along with naturally occurring ammonia gas and/or residual Hydrogen Sulfide gas in the raw water. Levels of both gases are high enough in water from both wells to result in the common taste and odor issues often found in sand and gravel aquifers. Staining and brown/black coloring seen on water fixtures is most likely the result of precipitation of iron and/or manganese caused by chlorination along with the higher pH levels.

Causes of Taste and Odor Complaints in Drinking Water

Undesirable tastes and odors in drinking water are normally a result of a combination of factors. The materials that contribute to these observed problems can come from many sources, including those found in nature as well as manmade. Problems related to taste and odor in water do not usually present any particular health hazard, however people are naturally concerned that the water they drink be at least palatable, and if possible, pleasant-tasting. One of the most common complaints related to taste and/or odor of a drinking water is related to the use of chlorine as a disinfecting agent or oxidant. Referred to as: "chlorine taste", the use of chlorine itself becomes one of the major sources of taste and odor complaints. Chlorine is noticeable and sometimes offensive to some individuals at levels as low as .2-.4 mg/L, a typical residual value.

Generally, surface water sources are more commonly linked to taste and odor problems than groundwater supplies. This is mostly due to the presence of algae, bacteria, and decayed vegetation. Most tastes and odors in groundwater supplies are caused by bacterial actions within the groundwater aquifers or the dissolution of salts and minerals as groundwater percolates and flows through geologic deposits. Intrusion of salt or mineralized water may also cause taste or odor problems. Dissolved gases, such as hydrogen sulfide, ammonia, and methane, may also exist which will often separate from a water solution at atmospheric pressure or upon heating causing primarily an odor problem. Hydrogen Sulfide (Chemical Symbol: H_2S) is characterized as a swampy-musty odor at low concentrations or, when present at higher concentrations, a "rotten-egg" odor; and is attributed to anaerobic bacterial action on organic sulfur, elemental sulfur, sulfates, or sulfites. Levels of hydrogen sulfide as low as .10 mg/l (milligrams per liter) can cause taste and odor problems in drinking water. High salt content, as indicated by total dissolved solids (TDS) or conductivity, can result in taste problems but does not usually result in odor complaints. Situations that are primarily due to human activity that result in tastes and odors in groundwater occur as a result of chemical dumping, landfill disposal, or industrial waste disposal. Analysis of water for synthetic organic chemicals is used to eliminate this possibility. Iron and/or manganese may also impart taste problems, notably resulting in a taste described as metallic or "rusty", but in low concentrations usually does not cause odor complaints. Finally, ammonia gas (Chemical Symbol: NH_3), can also result in taste and odor complaints, particularly when it is present in water at concentrations of .20 mg/l (milligrams per liter) or higher or when combined with chlorine used for disinfection. All of the above possible causes have been considered and investigated in preparation of this report.

Taste and Odor Mechanism in the Human Body

Sensations of taste and odor are the result of chemical stimulation of the appropriate human nerve cells, Because of this action, tastes and odors are known as the "chemical senses." Taste and odor affect the quality of water in various ways, including reducing aesthetic desirability, effecting the enjoyment of certain foods and beverages, and in some cases, destroying the palatability of drinking water. Taste and odor differ in both the nature and location of the receptor nerve sites. Nerve sensors for odors are found high in the nasal cavity while the nerve sites for taste are distributed over the tongue. In the case of water, odor sensations are stimulated by vapors and do not require physical contact, whereas with taste sensations, physical contact is required with the taste buds in the mouth.

Tasting is a complex sensation, resulting in a combination of taste, odor, temperature, and physical feel, also known as flavor. Laboratory tests exist to determine the level of taste and/or odor in a water sample as well as to determine the palatability. For odors, the test is referred to as a Threshold Odor Number (TON), measured by a scale of 0 (no odor) up to a level as high (or higher) as 10,000 with a TON of 3 the recommended limit. In the case of taste, even though a taste threshold test (TTT) exists, the major concern is to determine the acceptability of drinking water from a judgment based on sensory evaluations. This judgment is made through use of a "Taste Rating Test" in which a panel of water consumers taste and rate various samples of water, usually obtained through separate treatment processes. Although taste and odor problems are seldom connected to toxicologic effects, they are nevertheless important considerations as they may be a first alarm signal for a potential health hazard and play an obvious role in the aesthetic quality of the water as well as an important role in the consumer's evaluation of their drinking water supply.

Treatment Techniques for Control of Taste and Odor Problems

Most taste and odor problems are dealt with by eliminating the substance causing the problem. Usually, once the offending substance is identified, the proper treatment system can be selected. Treatment techniques for taste and odor control can be divided into three major categories:

1) Filtration
2) Demineralization
3) Disinfection/Oxidation

Often, a combination of two or more of the above processes may be necessary to completely eliminate a specific taste and odor problem.

Filtration

Filtration, specifically filtration using activated carbon media, also known as Granular Activated Carbon or GAC, is generally the most successful method of eliminating taste and odor problems. Although the process resembles filtration, the more appropriate term of "contactor" is preferred when considering GAC. The reason for this difference is due to the mechanics of the removal of contaminants when using GAC. This is because the contaminants are removed by "contacting" the GAC media much more than is due to any specific filtering action. A chemical process occurs as the water contacts the GAC media, resulting in removal of the offending taste and odor contaminants. The process by which this occurs is referred to as adsorption. Adsorption is defined as the adhesion of a gas, vapor, or dissolved material on the surface of a solid. One particle of activated carbon has an extremely large surface area owing to its structure of pores similar to those found in a sponge. The process of adsorption should not be confused with the similar term of absorption. Using a sponge analogy, a sponge will absorb water containing a taste and odor and when the water is squeezed from the sponge, the taste and odor will still be present in the water. In adsorption using activated carbon, however, the water is brought into contact with the carbon particles (sponge), and when the water leaves the carbon particles, the taste and odor constituents remain with the carbon. This results in water free from taste and odor. The adsorptive capacity of activated carbon is directly related to the surface area of the carbon particles that come into contact with the water. For this reason, manufacturers of activated carbon try to maximize the pore space of carbon media. There are two basic types of activated–carbon filter systems in current use: 1) Cartridge filters; and the 2) activated-carbon filter bed. Cartridge type carbon filters are very popular today and are used extensively in residential, commercial, and small industrial applications. Cartridge filters, however, have a very limited life and must be replaced when the carbon no longer has the ability to remove taste and odors. The bed-type of activated carbon filter is designed to treat water in larger commercial and industrial water systems as well as most municipal water systems. The bed-type filter must be periodically backwashed to remove trapped dirt and other material from the carbon. Gradually, the carbon bed's ability to remove taste and odors will be reduced and eventually "exhausted" due to the saturation of the pore spaces with organic material. At this point, the media must either be "re-fired" or burned to re-activate the carbon, or replaced. Depending on the specific application and filter loading, this interval can vary from 1-5 years. Another use of carbon for the removal of taste and odors is by the use of powdered activated carbon (PAC). With PAC, the carbon (which is identical to GAC except for the particle size) is injected into the water at some point during the treatment process, similar to the process used to inject chemicals needed for disinfection or coagulation. The PAC adheres to the material causing taste and odor problems and is then filtered or settled out before the water is delivered to customers.

Unlike GAC, PAC is generally used for only one time and is disposed of, along with the adsorbed contaminants, with the backwash sludge generated in a treatment plant. The use of PAC is popular in surface water treatment plants or other treatment facilities where filtration is already present or needed to remove turbidity or other contaminants. Reverse osmosis is another filtration process occasionally used to remove taste and odor contaminants, although usually in low volumes. This process consists of a membrane, with very small pore spaces, that is capable of removing contaminants at the ionic and molecular level. This process requires high pressures to operate and is extremely limited for use in larger water systems due to the cost and complexity of the process.

In addition to filtration utilizing granular carbon, proprietary filter medias are also available for the removal of organics and taste and odor causing compounds. One such media is a filter media commonly referred to as "Pyrolucite" (manganese dioxide). In the Pacific Northwest, one firm that works with this media is ATEC Systems Inc., from Bainbridge Island, Washington. Through many years of application and design experience, ATEC Systems has developed many variations of pyrolucite and other filtration medias for specific applications. This firm also has the capability of performing on-site pilot testing to verify the proper application and effectiveness of the type and blend of filter media used for removal of specific compounds and elements. In the case of Harrisburg, a proprietary blend of media, referred to as AS-741M, was used for all the pilot testing procedures.

Demineralization

Another process used for removal of tastes and odors in drinking water is demineralization. Demineralization includes processes such as: electrodialysis, ion-exchange, and distillation. This process is primarily used when high levels of salts (calcium and sodium based) are the offending contaminants resulting in taste and odor complaints. Demineralization, as reverse osmosis, requires high levels of pressure and/or electrical power to produce a reasonably small quantity of finished water and is usually limited to residential and small water systems.

Disinfection/Oxidation (Chemical)

The third major technique used to treat taste and odor problems in drinking water is the process of disinfection/oxidation. Although oxidation is an actual process that includes disinfection, the two processes are often thought of as separate treatment processes. Oxidants, which include chlorine, chlorine dioxide, potassium permanganate, and ozone, are primarily used to control hydrogen sulfide or organically caused taste and/or odor problems. This is usually accomplished by introduction of an oxidant as a part of treatment. In surface water supplies, oxidants are used to control taste and order problems due to algae, biofouling, or organics; while in groundwater, oxidants are primarily used to control taste and/or odor issues related to hydrogen sulfide or organics. The chemistry of oxidation is directly associated with electron theory. A chemical substance is said to be oxidized when it loses electrons to a second substance. This loss of electrons increases the oxidation state (valence) of the substance. Simultaneously, a second compound in the reaction (the oxidizing agent) gains the lost electrons. This process is commonly referred to as an oxidation-reduction, or a "redox" reaction. Oxidizing agents are those elements or compounds that contain an atom that can feasibly gain electrons. For example, the use of chlorine as an oxidant for the removal of Hydrogen Sulfide gas results in the reduction of

Hydrogen Sulfide to elemental sulfur or sulfate due to the transference of electrons.

This process is essentially the same for all oxidants, although some oxidants are more powerful oxidizing agents that others. Oxidation reaction rates are affected by pH and temperature. Chlorine and ozone are examples of two oxidants that are affected by pH, both are much more effective for most treatment at pH values of 7 or less than above. One additional factor in the effectiveness of oxidants is contact time. Generally, a longer contact time will result in a greater and more thorough reaction between the oxidant and contaminant, resulting in a higher level of removal.

Oxidation (Aeration)

Aeration (or air stripping) is a mechanical process in which water is sprayed into an open vessel, trickled through a column filled with specialized plastic packing material, and/or injected with an outside source of air. This process is quite effective for the removal of many volatile containments, however, is quite limited by itself in treatment of taste and odor problems. The process is very pH and temperature dependant and is sometimes used for the removal of Hydrogen Sulfide gas at levels of 3-4 mg/L or less although, for highest removal efficiency, usually must be combined with either an oxidant or media/GAC filtration. Most odor-producing compounds, (except Hydrogen Sulfide) are not volatile enough to be effectively removed by aeration alone. For effective removal of hydrogen sulfide using aeration, the pH of the water must be kept below 7.5 to insure adequate removal. In the case of Harrisburg, the typical pH of well water is around 7.75-8.0, negating the effectiveness of utilizing aeration solely for gas removal. Although aeration is limited in its efficiency for the removal of taste and odor problems caused by hydrogen sulfide or organics, the process is very effective at removing taste and/or odor problems associated with the presence of many other volatile organic containments (VOC) known to cause T&O problems, even at low concentrations.

Specific Treatment Techniques for Harrisburg

The above discussion outlines the techniques commonly used for taste and odor problems in surface or groundwater sources. In the case of Harrisburg's water supply, adequate evidence exists to conclude the most likely cause of the taste and odor problem to be:

1) Residual Hydrogen Sulfide gas

and/or

2) Ammonia Gas

Residual Hydrogen Sulfide: Given the chlorination now performed, the current pH level and contact time within the vessel will most likely result in a residual level of hydrogen sulfide gas. This treatment process could conceivably be enhanced by lowering the pH of the water back to a level of 6.5-7.0, however, the pH may likely be needed to be elevated back to the current level of 8.0-8.2 to prevent Lead and Copper corrosion issues in residences or the distribution system. This scenario would depend on other water quality factors as well as the mixing characteristics from the other city wells. Pre-chlorination is currently performed to aid in the oxidation of the gas although the current pH level is once again an impediment. Given the currently elevated pH level and potential impact on Lead and Copper corrosion, the best overall approach for the removal of hydrogen sulfide appears to be through use of an adsorbing or other type of filter media capable of removing the gas without impacting the pH.

Ammonia: Although the water quality analysis did not reveal any other specific organic contaminant causing the taste and odor problem, it is possible that the chlorination now employed is combining with an unknown organic compound, resulting in the formation of ammonia and the taste and odor problem. The most effective method for the removal of ammonia is again through the use of activated carbon or a specialized filter media.

Additional Factors

In addition to the levels of Hydrogen Sulfide and Ammonia gas now observed in all of the Harrisburg wells, the wells are also exhibiting an elevated level of entrained air in water produced from the wells. Based on the specific well designs, this problem is not felt to be an issue with the well construction causing cascading water but a natural condition of the water entering the well itself. In addition to causing problems with the efficacy of disinfection, entrained air will also interfere with the treatment process by creating air-binding within the filter media, resulting in channeling of flow within the filter bed during operation and upsetting of the bed during backwash and normal operation. A method of removing this air must be employed to the water before the water can be allowed to enter the filter vessels. This can be performed in various ways, however, the most viable solution in this case would be through use of a "deaerator" or "degassing".

The second pilot performed in 2016 used a Mazzei De-Aerator to simulate the removal of entrained air prior to filtration. Initial water quality results on Well #5 showed that the majority of taste and odor issues were removed in post filtration. A water quality test was performed at 24 hours and 48 hours post filtration to verify that no further issues will arise during the period that the water resides in the reservoir. Water quality showed that after 48 hours the water showed signs of Nitrogen, Sodium, and Tannin that was not shown in raw water samples. For this reason the recommendation would be to move away from the Well #5 location and drill another well at the Well #8 on the city owned property.

Switching to Surface Water

Although a comprehensive study was not conducted, an alternative solution of switching or augmenting water supplies through the use of surface water was explored. In comparison to the likely success that will be realized through even partial treatment of the existing groundwater sources, a transition to surface water is not only believed to be unnecessary but economically unviable. The projected capitol cost for a surface water intake and packaged filter plant (Ref: CH_2M Hill Study-2008) is $6,196,950.00 (2017 Dollars) with a projected Operation and Maintenance (O&M) cost of $421,680.00 per year. In comparison, full scale implementation of treatment of the groundwater sources is projected to cost less than $3,000,000 with estimated annual O&M costs less than $100,000 per year.

Treatment Recommendations and Estimated Costs

After consideration of all relevant factors, the following procedure is recommended to effect taste and odor removal from the City of Harrisburg's water system. The project is split into two different tasks. The first, Priority 1A, includes the construction of a new 26' wide by 32' long by 10' height filter building. The filter building will be constructed with three steel or ductile iron booster pump cans for installation of the future booster pumps. The filter building will initially house four 48" diameter filters that are capable of up to 375-400 GPM of water production, a De-Aerator for removal of entrained gases prior to filtration, and above and below ground piping for the filter building connection to the existing pump station piping. The building will have new electrical equipment along with chemical feed for KMnO4 (Potassium Permanganate). The backwash water will be intercepted and stored using a 4,000 gallon collection tank along with a pump and force main to send water to the adjacent wastewater treatment plant at a rate of 200-250 GPM as to not overwhelm the treatment plant. Along with the filter treatment building and piping at Well #8 site, the piping on the existing reservoirs at City Shops will be reconfigured and a 4" backfeed valve added to backfeed both reservoirs. The backfeed valve will allow the Well #8 treated water to backfeed the existing reservoirs through the distribution system. The estimated total price for Priority 1A is $580,665.00.

Priority 1B is an expansion to the filter system at Well #8. An additional well will be constructed on city owned property allowing the city to produce an additional 375 GPM for a total of estimated 750 GPM. The new well will utilize submersible pump and a pitless adapter, with a tie in to the existing Well #8 piping. Priority 1B also adds three 400 GPM, 25 HP booster pumps into the filter building, piping of booster pumps, upgrades to the electrical equipment in the filter building for three booster pump starters, and the addition of four 48" diameter additional filters. A new 1.5 million gallon bolted steel reservoir, compliant with the current seismic codes, will be constructed at the Well #8 site for (2) total. Abandonment of the existing 2.0 million gallon reservoir at the City Shops will be performed. Existing Wells #5 and #6 will be retained in a backup, supplemental, and emergency use role. After Priority 1B is completed the city sources shall be capable of producing an estimated 750 GPM of filtered water. The total estimated price for Priority 1B is $2,153,542.00.

Each Priority also includes mobilization and bonding, plan review and regulatory fees, and estimated engineering and inspection. All required special inspections for the reservoir and pump station concrete, rebar, bolt tests, and rock compaction are included in the inspection pricing. Regulatory fees and plan review pricing includes fees due to both Oregon Water Resources for water right amendments and Oregon Health Authority for plan review of the proposed system. Pricing under plan review and regulatory fees do not include any county or city building permits or electrical permits as they are presently unknown, but will likely be included within the line item costs for both. The total price including both Priorities 1A and 1B and regulatory fees and engineering is estimated to be $2,734,207.00.

Summary and Conclusions

1) The City of Harrisburg's water system is served exclusively from groundwater sources through the use of five individual deep water wells.

2) The typical daily demand of the water system averages 250-260 GPM with maximum daily demands of approximately 440 GPM. The maximum pumping capacity from all wells is approximately 900 GPM.

3) All of the source water from Wells #4-#7 is combined and delivered to two (2) water storage reservoirs at the City Shops. Well #8 pumps directly into the distribution grid. The only common treatment received by all wells is chlorination at the reservoir inlet for disinfection purposes and at the wellhead for Well #8.

4) Based on results from several water analyses on water from all wells and pilot testing for water from Wells #5 and #8, the most likely contributor to the taste and odor problem is manganese, hydrogen sulfide, and ammonia gas contained in water from all wells.

4) Removal of the gases and manganese can be provided through the use of filtration, utilizing a specialized and proprietary blend of filter media. Pilot testing has preliminarily confirmed the removal efficacy of this process.

5) The second round of pilot testing on Well #5 showed that the filtration system will not remove taste and odor problems as well as using filtration on Well #8. The recommendation is to utilize filtration at Well #8 along with drilling of an additional well within the city owned property to provide a second source and water to the city for future demands.

6) The existing 2.0 million gallon reservoir is structurally unsound and will need to be abandoned. A new 1.5 million gallon reservoir will be constructed at the Well #8 site along with a new booster pump station.

City of Harrisburg, Oregon
Water Treatment Plant
Cost Estimate: 1-16-2017

Priority 1A

1. Mobilization and Bonding---$43,025.00
2. Site Work and Prep, 26' W x 32' L x 10' H CMU Building---------------$124,000.00
3. 3-Booster Pump Cans @ $3,000/each--------------------------------------- $9,000.00
4. 4-48" Diameter Pressure Filters with media------------------------------- $88,500.00
5. Estimated Freight--- $4,000.00
6. (1) De-Aerator System-- $62,500.00
7. Filter piping and Valves---$16,225.00
8. Under/Above Ground Piping Installation------------------------------------ $30,000.00
9. Electric Equipment and Installation-- $25,000.00
10. Reconfigure Piping and Add Backfeed Valve at 500,000 Gal. Res----- $25,000.00
11. Chemical Feed (KMnO4)-- $12,500.00
12. 4,000 Gallon Backwash Tank, Excavation, and 4" Force Main---------- $15,500.00
13. Estimated Control Revisions-- $3,000.00
14. Labor--- $15,000.00
15. Construction Contingency of 10%---$47,325.00
16. Estimated Engineering and Inspection-------------------------------------- $56,790.00
17. Estimated Plan Review and Regulatory Fees-------------------------------- $3,300.00

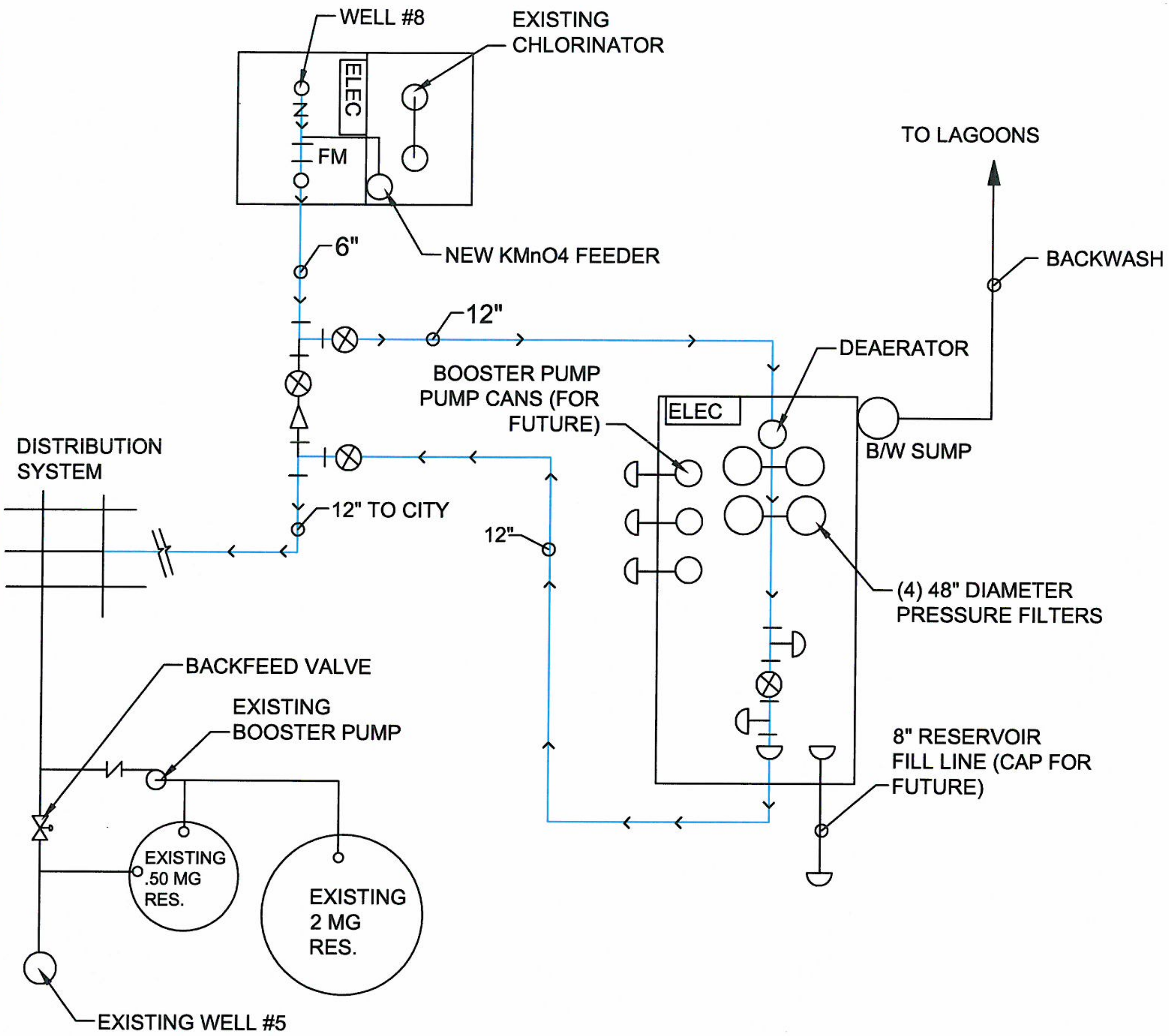
Estimated Priority 1A Subtotal: $580,665.00
(Well #8 Capacity: 375 GPM)

Priority 1B

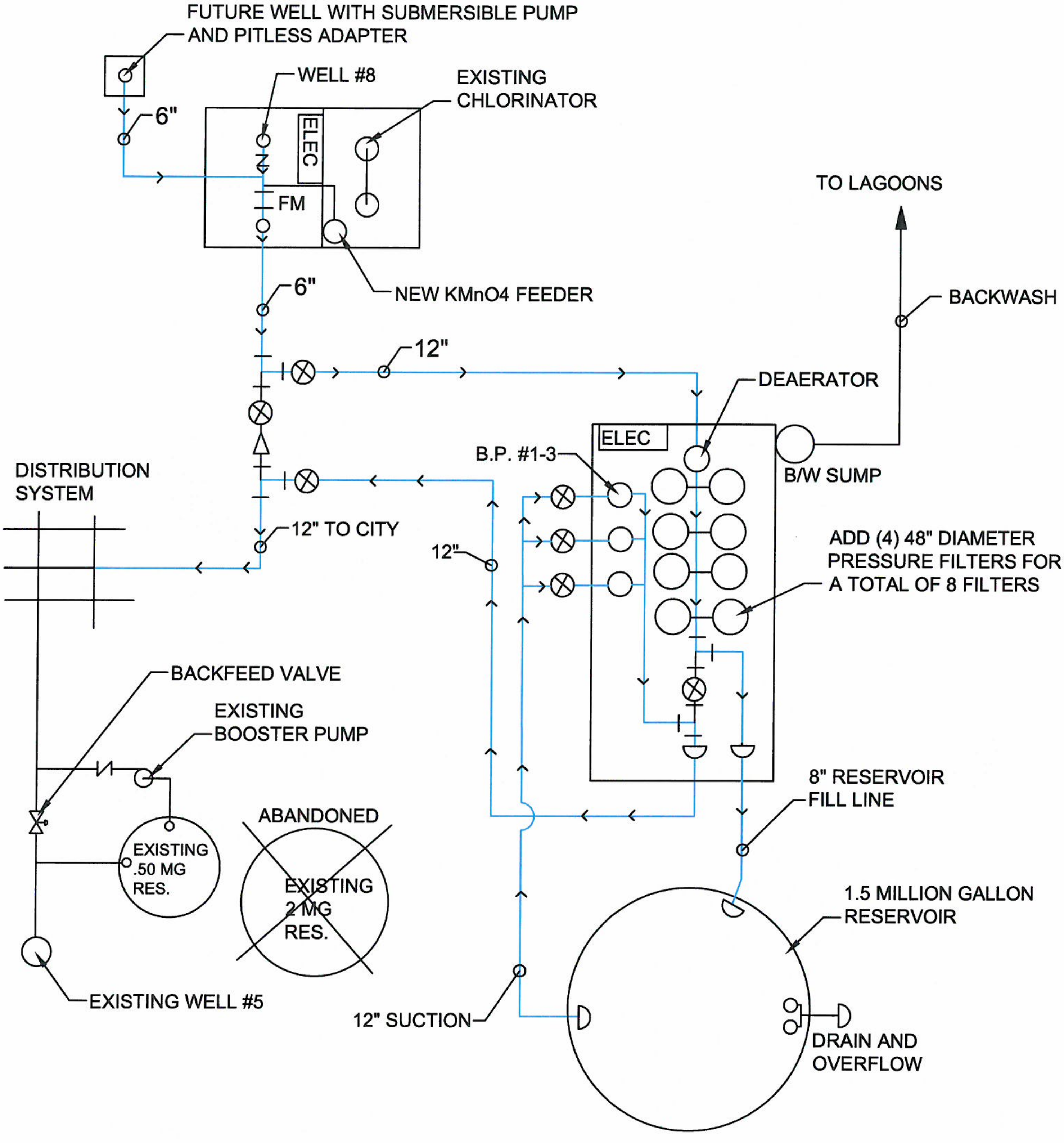
1. Mobilization and Bonding--$160,100.00
2. Additional 250' Well at Well #8 Site, Pump, and Pitless Adapt-------$205,500.00
3. Underground Piping from New Well to Existing Wellhouse----------- $13,500.00
4. 3-400 GPM, 25 HP Vertical B.P. and Piping-------------------------------- $50,000.00
5. Electrical Equipment and Installation (VFD for Booster Pumps)------- $42,000.00
6. 4-48" Diameter Pressure Filters with Media------------------------------$88,500.00
7. Estimated Freight-- $4,000.00
8. 1.5 Million Bolted Steel Gallon Reservoir------------------------------$1,139,500.00
9. Estimated Control Revisions-- $48,000.00
10. Labor-- $10,000.00
11. Construction Contingency of 10%--$176,110.00
12. Estimated Engineering and Inspection------------------------------------ $211,332.00
13. Estimated Plan Review and Regulatory Fees-------------------------------- $5,000.00

Estimated Priority 1B Subtotal: $2,153,542.00
(Well #8 and New Well Capacity: 750 GPM)

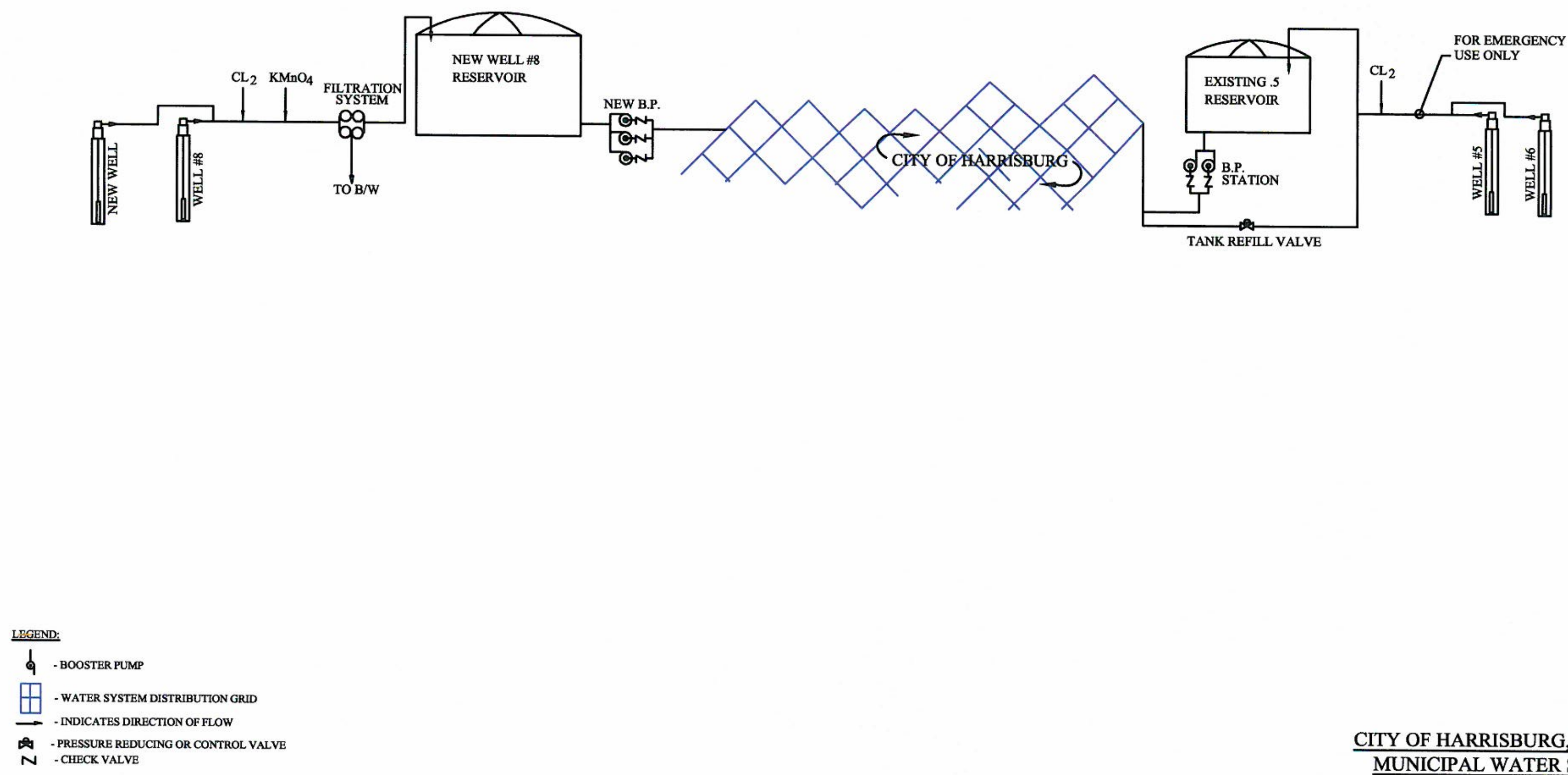
Estimated Priority 1A and 1B Total: $2,734,207.00



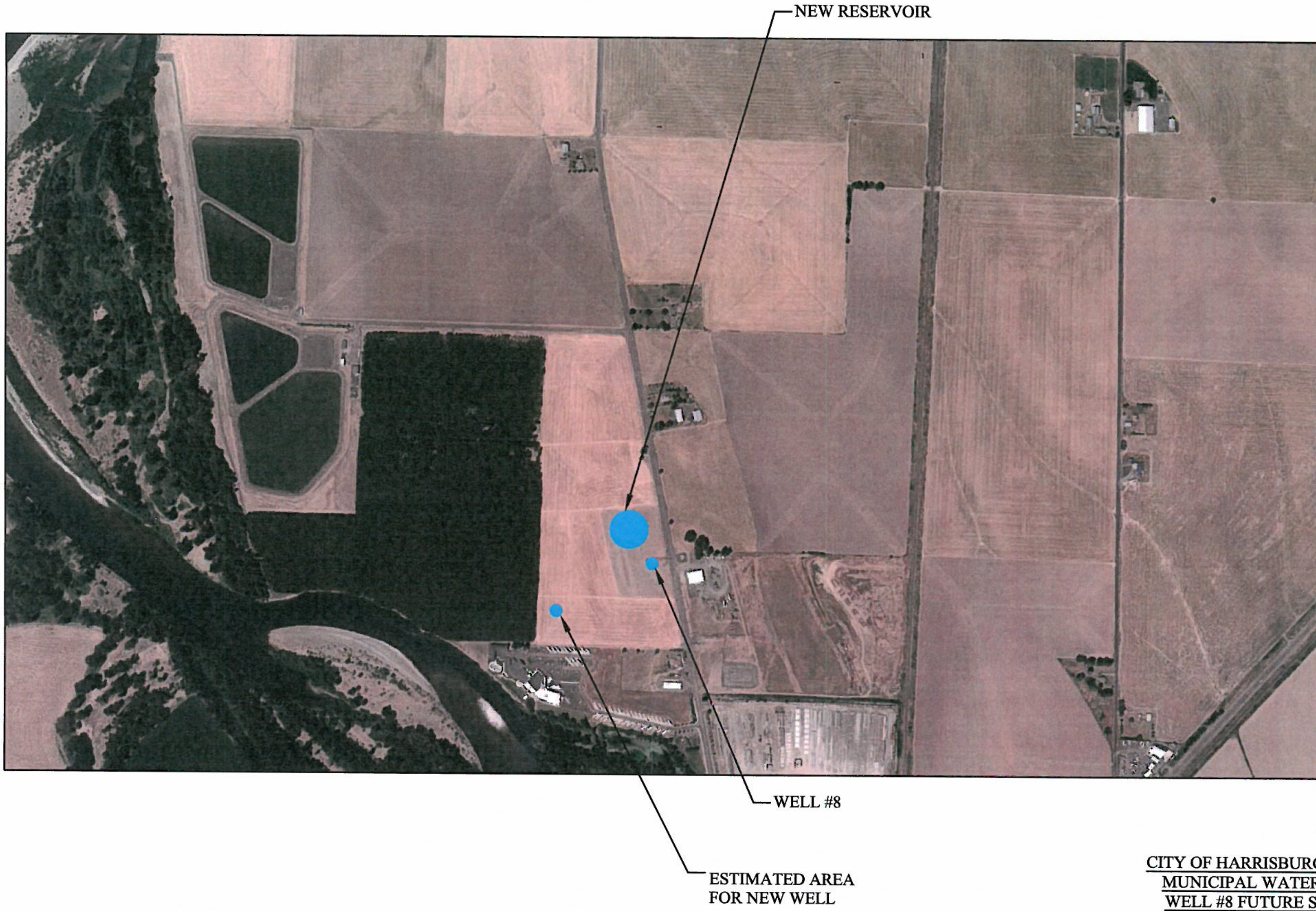
CITY OF HARRISBURG, OREGON
PRIORITY 1A



CITY OF HARRISBURG, OREGON
PRIORITY 1B



CITY OF HARRISBURG, OREGON
MUNICIPAL WATER SYSTEM
YEAR 2040 CONCEPT DESIGN



CITY OF HARRISBURG, OREGON
MUNICIPAL WATER SYSTEM
WELL #8 FUTURE SITE PLAN