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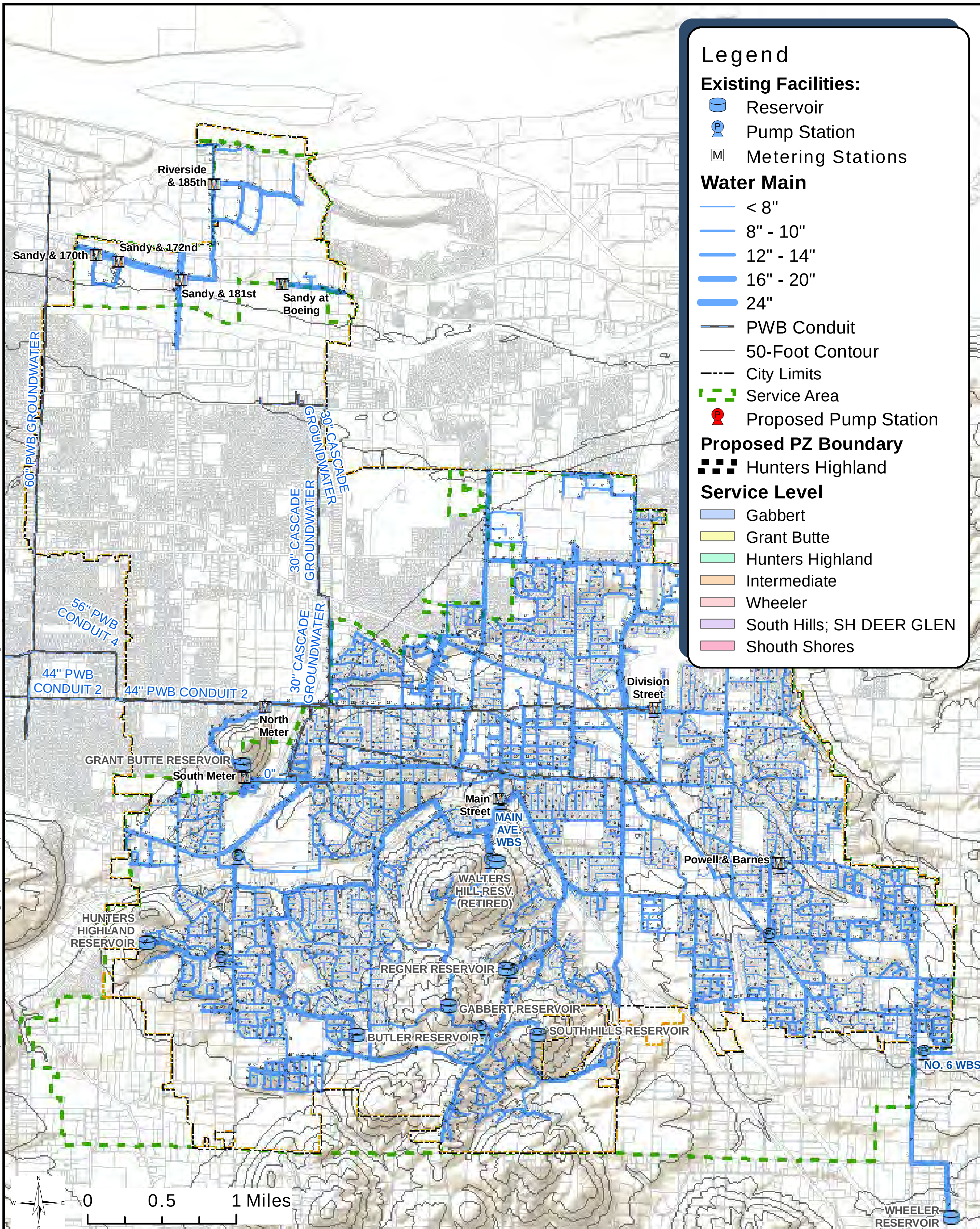
APPENDIX A
SYSTEM MAPS



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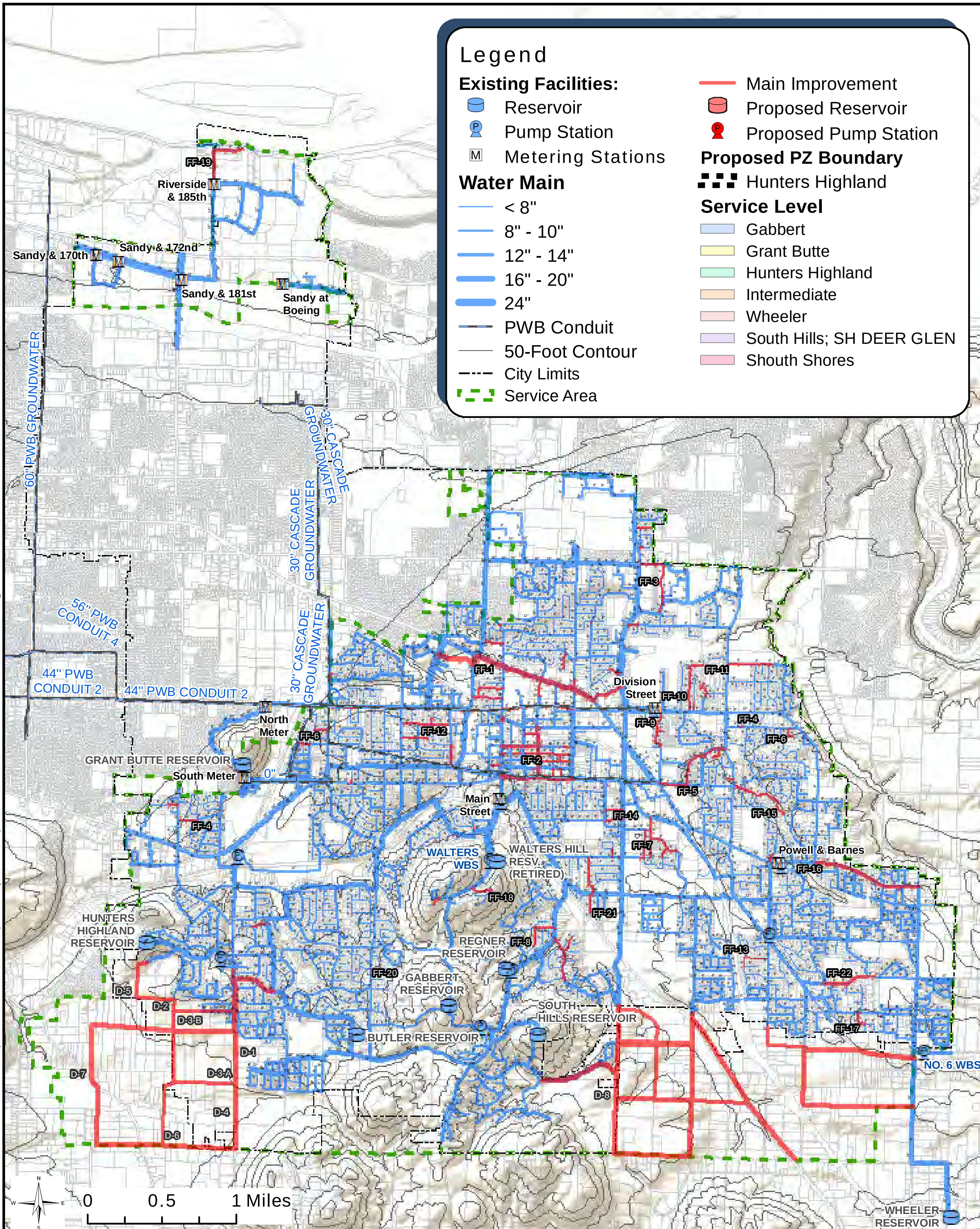
CITY OF GRESHAM 1905

City of Gresham, Oregon
Water System Master Plan

Plate 1
Existing System Map

February 2022

20-2749



City of Gresham, Oregon
Water System Master Plan

Plate 2
Proposed System Map

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APPENDIX B
CITY OF GRESHAM-ROCKWOOD WATER PEOPLE'S UTILITY DISTRICT IGA

INTERGOVERNMENTAL AGREEMENT
BY AND BETWEEN
CITY OF GRESHAM AND THE
ROCKWOOD WATER PEOPLE'S UTILITY DISTRICT
Relating to the Construction and Operation of Water Facilities
City of Gresham Contract No. 2046

This Intergovernmental Agreement is entered into by and between the City of Gresham and the Rockwood Water People's Utility District.

RECITALS

Whereas, the City of Gresham (Gresham) and Rockwood Water People's Utility District (Rockwood) entered into an Intergovernmental Agreement Relating to Water Rights (Water Rights IGA), which is on file with the Gresham City Clerk as Contract No. 1827, and

Whereas, pursuant to the Water Rights IGA, Gresham and Rockwood share perpetual use of certain water rights, and

Whereas, the Water Rights IGA provides that Gresham and Rockwood, with or without the involvement of third parties, shall mutually negotiate and agree to an intergovernmental agreement for the installation, construction, maintenance and operation of wells, treatment facilities and distribution facilities, and

Whereas, this IGA Relating to the Construction and Operation of Water Facilities (Joint Operations Agreement) generally provides as follows:

- Rockwood will have lead responsibility for the well operations with Gresham sharing in off-hour standby
- Gresham will have responsibility for constructing its well(s) that will be tied in with Rockwood's wells
- All wells will be operated as joint facilities
- Gresham will have lead responsibility for design, construction and maintenance of a transmission pipeline, and the cost will be shared 50%-50%
- Gresham will purchase 50% of the treatment, detention and pumping facilities that Rockwood owns or is constructing
- Both parties participate in developing water management and conservation plans and groundwater protection programs

AGREEMENT

Now, therefore, it is hereby agreed:

1. As used in this Joint Operations Agreement, the following definitions apply:

"Durable Flow" is the maximum sustainable flow of water from wells in the immediate vicinity when all water rights impacting the immediate vicinity are in full use.

"Gresham Well No. 1" is a well constructed and owned by the Gresham at or near 192nd and Halsey.

"Immediate Vicinity" is the area from the east side of 181st to the west side of 201st and one quarter mile on each side of the centerline of Halsey Street.

"Treatment Facilities" are the treatment plant, detention reservoirs, pumping stations located at the Rockwood Offices at or near 196th and Halsey.

"Water Facilities" are wells, treatment plant, detention reservoirs, pumping stations and transmission lines necessary to beneficially use the water rights from wells in the immediate vicinity for domestic and other uses.

2. Capacity. This Joint Operations Agreement is based on the following assumptions and limits regarding the Water Facilities.

Maximum City of Gresham rights per Water Right IGA		10 mgd
Projected Limits of Durable Flow in the Immediate Vicinity	8000 gpm	11.5 mgd
Rockwood Well No. 1 constructed capacity	2500 gpm	3.6 mgd
Rockwood Well No. 2 constructed capacity	4500 gpm	6.5 mgd
Combined Rockwood Well No. 1 and No. 2 allowable capacity	5000 gpm	6.0 mgd
Gresham Well No. 1 constructed capacity	4500 gpm	6.5 mgd
Gresham Well No. 1 allowable capacity	3000 gpm	4.3 mgd
Treatment, detention, pumping capacity	10,000 gpm	14.4 mgd

Gresham may use water above the allocable capacity of Gresham Well No. 1 with construction of additional wells and/or operation during non-constrained time.

3. Well Construction. Each party shall be responsible for the construction of their own wells, including but not limited to the well, pumps, motors, controls and pipeline to point of common connection with the treatment facilities. Rockwood must approve the location and capacity of the wells constructed under the shared water rights permit. Rockwood approves the location and capacity of Gresham Well No. 1.

4. Purchase Treatment Facilities. Rockwood currently owns the treatment facilities. Portions of these treatment facilities are new construction and portions are existing facilities modified to accommodate well use. Gresham shall purchase from Rockwood one half of the treatment facilities. Thereafter, Gresham and Rockwood shall jointly and equally own the treatment facilities. The value of existing assets is determined to be $830,000. Gresham's share is $415,000. The value of newly constructed improvements, including costs to modify existing facilities, shall be based on actual project costs. The value of newly constructed assets is expected to be approximately $2,000,000, Gresham's share being

approximately $1,000,000.

5. Well Operation. The operation of wells includes the operation of facilities for treatment, detention, pumping into transmission pipeline, monitoring, testing and reporting as required by regulations and/or operational protocol. Operation shall also include obtaining both liability and property insurance customary in the industry for such facilities.
    a. Rockwood shall have the lead responsibility to operate the wells.
    b. Gresham shall designate staff to assist as needed and to share off-hours duty on alternating weeks.
    c. Operating decisions shall be based on call for water from Gresham and Rockwood. The use of the wells shall be rotated, initially among the two Rockwood wells and one Gresham well.
    d. The parties may add more wells up to maximum 10,000 gpm (14.4 mgd) treatment capacity.
    e. All wells shall be outfitted with means to adjust flow rates to assist in managing supplies.
    f. Rockwood shall make all decisions on which well(s) to use.
    g. Selected information will be transmitted by telemetry (SCADA system) to be received and sent from Gresham and Rockwood locations. Gresham and Rockwood operations staff will decide what information is selected for transmission via telemetry.

6. Operating Costs. All operations and maintenance costs for the treatment facilities, except electricity, chlorine and ammonia, shall be considered a fixed cost and shall be based on the ownership of the treatment facilities and therefore shall be equally divided between Gresham and Rockwood. Electricity, chlorine, ammonia costs shall be variable costs and apportioned based on volume of water delivered to each party.
    a. Rockwood shall be responsible for the initial payment of all invoices relating to operations and maintenance costs.
    b. Rockwood will coordinate with Gresham to develop an estimate of such costs to include in each party's annual operating budget.
    c. Rockwood will invoice Gresham in advance for the fixed costs and in arrears for the variable costs. Invoices shall be sent in July and/or January of each year and Gresham will pay in August and/or February.
    d. Overruns or underruns of fixed costs in the prior fiscal year will be applied to the invoice for the next fiscal year. For example, audited FY 2004-2005 costs will be used to adjust the projected costs for FY 2006-2007.
    e. Repair/maintenance costs not anticipated in budget process will be the responsibility of Rockwood. After work completed, Rockwood shall bill Gresham for proportionate share of the actual cost of such work. If non-emergency repairs are projected to be over $100,000, Rockwood shall furnish to Gresham an estimate of the costs prior to commencement of work.
    f. Gresham staff will participate in repairs and maintenance as coordinated by Rockwood.

7. Joint Operations Team. Rockwood and Gresham shall each designate staff that will coordinate the use of water and the operation of the water facilities.

8. Water Transmission Line Construction. A water transmission line shall be constructed from the treatment facilities along a power right-of-way to a termination point between Bella Vista (Rockwood) and Grant Butte (Gresham) reservoirs.
   a. Right-of-way for the transmission line to be acquired by Gresham. Gresham may also acquire rights of way for the purpose of a trail following the same route as the transmission line.
   b. Rockwood and Gresham shall each be responsible to design and construct pipelines from the termination point to their respective terminal reservoirs, Bella Vista and Grant Butte
   c. Gresham has lead responsibility for the design and construction of the transmission pipeline. Gresham may elect to have the design performed by staff or consultant. Gresham may elect to contract for professional services through Rockwood to expedite design and/or construction.
   d. Prior to engaging a professional services contract and contract for construction, both parties will approve each contract according to their respective approval process
   e. Gresham shall consult with Rockwood, but final decisions relating to design and construction shall be made by Gresham
   f. Each party shall pay one-half of the cost of the design, construction and construction administration.
   g. As part of pipeline project, a rock base that will be adequate for subsequent trail pavement will be constructed to allow for paving by the Gresham Parks Division upon completion of water line.

9. Water Transmission Line Operation. Gresham shall have the lead responsibility for operation of the water transmission line. This includes, but is not limited to, routine underground locates and valve maintenance. Gresham shall invoice Rockwood for work performed. Costs for operations and maintenance costs as well as for major repair, relocation, reconstruction of the transmission pipeline shall be shared equally.

10. Payment for Facility Costs. Gresham will make payment to Rockwood for one-half of the existing assets, pursuant to paragraph 4, within 60 days of execution of this agreement. Rockwood will make progress payments to Gresham for one-half the cost of the design and construction of the transmission pipeline, as invoiced by Gresham. Gresham's share of newly constructed treatment improvements funded by Rockwood will be credited against amounts due from Rockwood until Rockwood's share of the transmission pipeline exceeds Gresham's share of the treatment improvements.

11. Emergency Response Plan. Rockwood and Gresham have prepared Emergency Response Plans. Rockwood and Gresham shall coordinate and cooperate in the

implementation of the ERP's during emergencies. Use of wells will be considered important tools in maintaining water supply in emergencies.

12. Separate Operations. Rockwood or Gresham may construct wells outside the immediate vicinity. The constructing party may elect to operate these wells separately from initial wells described above or may elect to operate these wells as part of this Joint Operations Agreement. The parties, to the maximum provided by Water Rights IGA, may utilize shared Water rights for such separate operations

13. Right of First Refusal. In the event that either party elects to discontinue using the well system or either party terminates either the Water Rights IGA or this Joint Operations Agreement, the other party has the right of first refusal to acquire the wells, treatment facilities and distribution facilities constructed or acquired under this Joint Operations Agreement.
    a. The value of capital facilities acquired will be based on their original cost, less depreciation
    b. If Gresham opts out, all water rights will be transferred to Rockwood
    c. If Rockwood opts out, water rights equal to the capacity of constructed wells will be transferred to Gresham. More water rights may be transferred by mutual consent
    d. The value of the water rights transferred pursuant to this section will be the documented costs to acquire and maintain the transferred quantity of water rights

14. Term of Agreement. This Joint Operations Agreement shall be:
    a. Effective as of the latest date of signature by the parties ,
    b. Perpetual and may not be assigned or terminated without the express written consent of each party, which consent shall not unreasonably be withheld, and
    c. Subject to termination for material default of either the Water Rights IGA or this Joint Operations Agreement.

15. Notices. All notices, payments and other communications to the Parties under this Joint Operations Agreement must be in writing, and shall be addresses respectively as follows:

City of Gresham	City of Gresham Attention: Water Division Manager Department of Environmental Services 1333 NW Eastman Parkway Gresham, Oregon 97030
Rockwood	Rockwood Water People's Utility District Attention: General Manager 19601 NE Halsey Portland, Oregon 97230-7489

All notices shall be given (i) by personal delivery to the Party, (ii) certified or registered mail, return receipt requested, or (iii) by electronic communication followed immediately by registered or certified mail return receipt requested. All notices shall be effective and shall be deemed delivered (a) if by personal delivery, on the date of delivery, (b) if by certified or registered mail on the date delivered to the United States Postal Service as shown on the receipt; and (c) if by electronic communication, on the date the confirmation is delivered to the United States Postal Service as shown on the actual receipt. New Parties shall, upon entering into this Joint Operations Agreement, notify the other Parties of their contact person, address and telecopy number. A Party may change its address from time to time by notice to the other Parties.

16. Waiver. The failure of a Party to insist on the Strict performance of any provision of this Joint Operations Agreement or to exercise any right, power of remedy upon a breach of any provision of this Joint Operations Agreement shall not constitute a waiver of any provision of this Joint Operations Agreement or limit the Party's right thereafter to enforce any provision or exercise any right.

17. Modification. No Modification of this Joint Operations Agreement shall be valid unless made in writing and duly executed by the Parties.

18. Implied Covenants. The Parties agree that in construing this Joint Operations Agreement no covenants shall be implied between the Parties except the covenants of good faith and fair dealing.

19. Governing Law. This Joint Operations Agreement shall be governed by and interpreted in accordance with the laws of the State of Oregon.

20. Further Assurances. Each Party shall take from time to time, for no additional consideration, such actions and execute such instruments as may be reasonably necessary or convenient to implement and carry out the intent and purpose of this Joint Operations Agreement.

21. Remedies Not Exclusive. Each and every power and remedy specifically given to the non-defaulting Parties shall be in addition to every other power and remedy now or hereafter available at law or in equity (including the right to specific performance), and each and every power and remedy may be exercised from time to time and as often and in such order as may deemed expedient. All such powers and remedies shall be cumulative, and the exercise of one shall not be deemed a waiver of the right to exercise any other or others. No delay or omission in the exercise of any such power or remedy and no renewal or extension of any payments due under this Joint Operations Agreement shall impair such power or remedy or shall be construed to be a waiver of any default.

22. Survival of Terms and Conditions. The provisions of this Joint Operations Agreement shall survive its termination to the full extent necessary for their enforcement and the protection of the Party in whose favor they run.

23. Successors and Assigns. This Joint Operations Agreement shall bind and inure to the benefit of the Parties and their successors and assigns.

24. Time is of the Essence. A material consideration of the Parties entering into this Joint Operations Agreement is that Parties will make all payments as and when due and will perform all other obligations under this Joint Operations Agreement and the Water Rights IGA in a timely manner. Time is of the essence of each and every provision of the Joint Operating Agreement and Water Rights IGA.

25. Counterparts. This Joint Operations Agreement may be executed in counterparts, all of which taken together shall constitute a single Agreement.

26. Limitations. This Joint Operations Agreement shall not be construed to create a partnership between the Parties or to authorize any Party to act as agent for any other Party or Parties except as expressly provided in this Joint Operations Agreement.

27. Attorneys' Fees. If any suit or action is instituted to interpret or enforce the terms of this Joint Operations Agreement, the prevailing Party shall be entitled to recover from the other Party such sums as a court may adjudge as attorneys' fees at trial, on appeal, or on any petition for review, and in any proceedings in bankruptcy or arbitration, in addition to all other sums provided by law.

28. Arbitration. Any controversy, dispute or claim arising out of or relating to this Joint Operations Agreement, or the breach thereof, shall be settled by arbitration in accordance with the rules, then obtaining of the U.S. Arbitration and Mediation of Portland, and judgment upon the award rendered may be entered in any court having jurisdiction thereof. The arbitration board shall not have the power to grant the consent of an Owner to any action where this Joint Operations Agreement requires the consent of an Owner. The decision of the arbitration board shall be final and binding upon all Parties hereto, and there shall be no appeal to any court there from. Expenses of arbitration shall be borne by the losing Party.

29. Specific Performance. The Parties stipulate that the remedies at law in the event of any default or threatened default by either Party hereto and the performance of or compliance with the terms of this Joint Operations Agreement are not and will not be adequate, that such terms may be specifically enforced by a decree for the specific performance thereof or by an injunction against a violation thereof of otherwise, and that the remedied of specific performance and injunction against a violation thereof or otherwise, and that the remedies of specific performance and injunction will not impose undue hardship upon either Party. The Parties agree

that any arbitrator shall have the authority to order specific performance or to issue an injunction as provided for herein.

30. Mutual Indemnification. Each Party shall, within the limits of the Oregon Tort Claims Act, ORS 30.260-30.300, save, defend and hold harmless the other Party or Parties from any claim for damages or injury arising from the alleged to have arisen from the sole negligence or willful act of the Party in the performance of this Joint Operations Agreement. Each Party shall be solely liable for any fine or penalties attributable to its performance of its duties under this Joint Operations Agreement and that are caused by its willful conduct or gross negligence.

31. Entire Agreement. This Joint Operations Agreement, including all attached exhibits, contains the entire and final understanding of the Parties relating to the construction and operation of water facilities. This Joint Operations Agreement may only be amended by the mutual agreement of the parties.

IN WITNESS WHEREOF, the Parties have executed this Joint Operations Agreement as of the Effective Date.

CITY OF GRESHAM

By: Charles J. Becker
Mayor

By: [signature]
City Manager

Date: 8/18/04

Approved as to form:

David R. Ris
David R. Ris, Sr. Asst. City Attorney

ROCKWOOD WATER PEOPLE'S UTILITY DISTRICT

By: Herb Brown
President

By: Harvey Barr
District Manager

Attest: Larry Dixon
District Secretary

Date: 7/20/04

Approved as to form:

____
Clark I. Balfour, District Counsel

INTERGOVERNMENTAL AGREEMENT
BY AND BETWEEN
ROCKWOOD WATER PEOPLE'S UTILITY DISTRICT
AND THE CITY OF GRESHAM

For the Implementation of the 2020 Groundwater Development Master Plan and the Construction and Operation of Joint and Independently Owned Groundwater Supply Systems and relating to City of Gresham Contract No. 5794, formerly Contract No. 2046, (Joint Operations Agreement) and City of Gresham Contract No. 1827 (Water Rights IGA)

This Intergovernmental Agreement No. 310774 (GDMP Agreement) is entered into by and between the Rockwood Water People's Utility District and the City of Gresham.

RECITALS

Whereas, the City of Gresham ("Gresham") and Rockwood Water People's Utility District ("Rockwood") are parties to an existing intergovernmental agreement relating to water rights, which is on file with the Gresham City Clerk as Contract No. 1827, as amended ("Water Rights IGA"); and

Whereas, Gresham and Rockwood are parties to an existing intergovernmental agreement relating to the construction and operation of water facilities, which is on file with the Gresham City Clerk as Contract No. 5794, as amended ("Joint Operations Agreement"); and

Whereas, pursuant to the Water Rights IGA and the Joint Operations Agreement, Gresham and Rockwood have each developed and constructed their owns wells, and have, from time to time, entered into additional agreements for the development and construction of joint wells;

Whereas, Gresham and Rockwood wish to coordinate in the Implementation of the 2020 Groundwater Development Master Plan which consists of joint and independently constructed improvements, in order to apply for Water Infrastructure Finance and Innovation Act (WIFIA) funding;

NOW, THEREFORE, this Agreement identifies each party's obligations for the development, construction, connection, and operation of joint groundwater supply through the implementation of the 2020 GDMP and the Parties agree as follows:

AGREEMENT

a. Rockwood will have the lead responsibility for:
   i) the maintenance and operation of the Halsey Cascade Treatment and Pumping Facility;
   ii) all independent and joint wells connected to the Cascade Facility;

iii) the pumping, treatment and distribution of all groundwater produced and transmitted from the site; and

iv) the selection of the transmission line(s) used to transport water to the terminal reservoirs operated by both Rockwood (Bella Vista) and Gresham (Grant Butte).

b. Rockwood will be responsible for the selection and operation of the wells connected to the Cascade Facility which include Cascades 3, 4, 5, 7 and 9 and any future wells developed by either party that are connected to the Cascade Facility.

c. Rockwood will have the lead responsibility for the maintenance and operation of Cascade Well No. 6 providing that the total investment and reliable groundwater yield is expected to be shared equally Maintenance and operation of Cascade Well No. 6 will include the pumping, treatment and distribution of all groundwater produced and transmitted from the site to either the terminal reservoir at Cleveland Street or distributed directly into distribution systems operated by either Rockwood or Gresham.

d. Gresham will have lead responsibility for the maintenance of the joint transmission pipeline(s) (current 30 inch and a tentatively planned 36 inch transmission lines) to both Bella Vista and Grant Butte terminal reservoirs. Gresham will be responsible for all locating and marking of facilities as required by law.

e. Wells and appurtenances which are independently owned other than Cascades 5, 6, and 9 will be operated by the owner of such facility unless both parties mutually agree that it will be operated by Rockwood.

f. All funding of the operation and maintenance of the joint groundwater facilities shall be based and an equal share of fixed costs and a percentage share by use of variable costs by each party. Fixed costs will be shared 50/50. Variable costs will be based on the percentage of water used by each party.

g. Both parties shall equally fund the updating of the joint water management and conservation plan and a groundwater protection program covering the zone of influence for all jointly and independently operated wells.

1. As used in this GDMP Agreement, the following definitions apply:

"Durable Flow" is the maximum sustainable flow of water when all groundwater sources are in production simultaneously.

"Cascade Treatment Facility" comprises a treatment plant(s), detention reservoirs, pumping stations and appurtenances located at the Rockwood Offices at or near 196th and Halsey.

"Immediate Vicinity – shall be within the boundaries of the Rockwood People's Utility District (RWPUD) and the City boundaries of Gresham.

"Joint Facility" are all locations whose development and investment are shared equally or on an agreed upon basis. Joint facilities will be operated in a concerted fashion to serve the benefit of the parties in meeting current or future water demands of the parties.

"Water Facilities" are wells, treatment plant, detention reservoirs, pumping stations and transmission lines necessary to beneficially use the water rights from wells in the immediate vicinity for domestic use either jointly or independently by the parties.

"Zone of Influence" – the groundwater recharge area as defined in the City of Gresham Wellhead Protection Plan.

2. Capacity. This GDMP Agreement is based on the following assumptions and limits regarding the Cascade Water Facility.

	gpm	mgd
Maximum Durable Flow in Immediate Vicinity (Cascade Well Nos. 3, 4, 5, 7, 9)	19,500	28.0
Maximum City of Gresham rights per Water Right IGA as amended		18.0
Rockwood Cascade Nos. 3&4 Well allowable capacity	6,500	9.4
Gresham Share Cascade No. 5 Well constructed capacity	3,500	5.0
Rockwood Share Cascade 5 Well constructed capacity	1,500	2.2
Rockwood Cascade No. 7 Well allowable capacity	3,000	4.3
Gresham Cascade No. 9 Well constructed capacity	3,000	4.3
Cascade Treatment Facility constructed capacity	10,000	24.0

3. Well Construction. Each party shall contribute equally to the development and construction of all wells and appurtenances which will be considered as joint facilities unless otherwise stipulated through an adopted inter-governmental agency agreement. Each party shall be responsible for the construction of their own independent wells, including but not limited to the well, pumps, motors, controls and pipeline to point of common connection with the treatment facilities.

4. The parties shall develop a Groundwater Asset Registry (Attachment A) of all either joint or independently owned groundwater assets. The value of the assets within the registry shall serve as a basis for any future transactions to be considered by the parties. The registry shall be reviewed and updated every 5 years following the authorization of this agreement. The update and asset values shall be conducted by a mutually agreed upon third party and the values for each asset shall also be mutually agreed to. The Groundwater Asset Registry shall then be provided in writing to each agency's designated representative. The designated representatives shall be the General Manager (Rockwood) and the City Manager (Gresham).

5. Purchase of Independent Facilities. Rockwood and Gresham currently own groundwater assets either jointly or independently of each other. If the parties mutually agree that it is beneficial that some or all of the independent groundwater facilities be jointly owned, the following method will be used to determine the value of the asset.

The value of the asset shall be listed within the Groundwater Asset Registry. If an asset is not contained within the registry, the value of the asset shall be mutually agreed upon in writing by each party's designated representative. The benefited party shall remit 50% of the value to the owner after which equal ownership of the asset shall be transferred through an IGA to the benefitting party. As an example, the value of existing Rockwood asset is determined to be $800,000. Gresham's share is $400,000. Gresham shall purchase from Rockwood one half the value of the asset. Thereafter, Gresham and Rockwood shall jointly and equally own the asset.

6. Well Operation. The operation of wells includes the operation of facilities for treatment, detention, pumping into transmission pipeline, monitoring, testing and reporting as required by regulations and/or operational protocol. Operation shall also include obtaining both liability and property insurance customary in the industry for such facilities.
   a. Rockwood shall have the lead responsibility to operate all jointly owned wells (including Cascade No. 9) and jointly owned facilities at the Cascade Groundwater Facility. Independently owned facilities shall be operated by the owner of that asset unless otherwise agreed upon.
   b. Operating decisions shall be based on call for water from Gresham and Rockwood. The use of the wells shall be rotated, between the joint and independent well assets of Rockwood and Gresham connected to the Cascade Treatment Facility.
   c. All wells shall be outfitted with means to adjust flow rates to assist in managing supplies.
   d. Rockwood shall make all decisions on which well(s) to use related to the Cascade Facility.
   e. Selected information will be transmitted by telemetry (SCADA system) to be received and sent from Gresham and Rockwood locations. Gresham and Rockwood operations staff will decide what information is selected for transmission via telemetry.

7. Operating Costs. The cost of operation and maintenance of assets which fall under the definition of joint facilities: the treatment facilities pump maintenance and wells except electricity, treatment chemicals, chlorine and ammonia, shall be divided into two components.
   a. The first component is considered a Fixed Cost and consists of all costs not related to a unit of water produced. Fixed costs are repair and maintenance items, telemetry, minor capital improvements, compliance testing, and labor. Fixed cost shall be equally divided between Rockwood and Gresham.
   b. The second component will be the Variable cost. Electricity, treatment chemicals, chlorine, and ammonia are variable costs and apportioned based on volume of water delivered to each party during the fiscal year.
   c. Rockwood shall be responsible for the initial payment of all invoices relating to groundwater operation and maintenance costs.
   d. Rockwood will provide Gresham an operational invoice in advance for the fixed and variable costs which are anticipated for the following fiscal year starting in

July. Invoices shall be sent in July and January of each fiscal year and Gresham will pay in August and/or February.

e. For future budget preparation, by November 1 of the current fiscal year, Rockwood will calculate the costs of operating all joint facilities, determine the fixed and variables charges based on experienced demands for the prior fiscal year. Rockwood will balance the calculated contribution for each party based on their fixed and variable use and assign future operation contributions based on the prior year experience for future budgeting purposes. Rockwood will coordinate with Gresham to develop an estimate of such costs to be included in each party's future annual operating budget.

f. Overruns or underruns of fixed and/or variable costs in the prior fiscal year will be applied to the invoice for the next fiscal year. Audited FY 2019-2020 costs and individual demands will be used to determine the actual contribution by each party for the previous year and future budgets adjusted to reflect the new projected costs for FY 2020-2021.

g. Repair/maintenance costs not anticipated in budget process will be the responsibility of Rockwood. After work completed, Rockwood shall bill Gresham for proportionate share of the actual cost of such work. If non-emergency repairs are projected to be over $100,000, Rockwood shall furnish to Gresham an estimate of the costs prior to commencement of work.

h. Gresham staff will participate in repairs and maintenance as coordinated by Rockwood if needed.

8. Joint Operations Team. Rockwood and Gresham shall each designate staff that will coordinate the use of water and the operation of the water facilities.

9. Water Transmission Line Construction. A redundant water transmission line shall be constructed from the Cascade Treatment Facility to a termination point between Bella Vista (Rockwood) and Grant Butte (Gresham) reservoirs.

   a. Rockwood and Gresham shall each be responsible to design and construct pipelines from the termination point to their respective terminal reservoirs, Bella Vista and Grant Butte
   b. Gresham has lead responsibility for the design and construction of the transmission pipeline.
   c. Gresham shall consult with Rockwood, but final decisions relating to design and construction shall be made by Gresham.
   d. Each party shall pay one-half of the cost of the design, construction and construction administration.
   e. To achieve the desired goal at the most effective cost, an existing transmission line(s) owned by Rockwood may be utilized. In the case where an existing asset is being shared, the value of the asset shall be calculated to allow for Gresham to purchase an equitable share of the asset such that it will then be equally owned by Rockwood and Gresham.

10. Water Transmission Line Operation. Gresham shall have the lead responsibility for operation of the water transmission lines. This includes, but is not limited to, routine underground locates and valve maintenance. Gresham shall invoice Rockwood for

work performed. Costs for operations and maintenance as well as for major repair, relocation, reconstruction of the transmission pipeline shall be shared equally.

11. Payment for Facility Costs Rockwood will make progress payments to the City for one-half the cost of the design and construction of the transmission pipeline, as invoiced by the City.

12. Emergency Response Plan. Rockwood and Gresham have prepared Emergency Response Plans. Rockwood and Gresham shall coordinate and cooperate in the implementation of the ERP's during emergencies. Use of wells will be considered important tools in maintaining water supply in emergencies.

13. Independent Operations. Rockwood or Gresham may construct wells outside the immediate vicinity. The constructing party may elect to operate these wells separately from initial wells described above or may elect to operate these wells as part of this GDMP Agreement. The parties, to the maximum extent provided by Water Rights IGA, may utilize shared Water rights for such separate operations

14. Right of First Refusal. In the event that either party elects to discontinue using the well system or either party terminates either the Water Rights IGA, the Joint Operations Agreement, or the GDMP Agreement, the other party has the right of first refusal to acquire the wells, treatment facilities and distribution facilities constructed or acquired under the Agreements.
    a. The value of capital facilities acquired will be based on their original cost, less depreciation
    b. If Gresham opts out, all water rights will be transferred to Rockwood
    c. If Rockwood opts out, water rights equal to the capacity of constructed wells will be transferred to Gresham. More water rights may be transferred by mutual consent
    d. The value of the water rights transferred pursuant to this section will be the documented costs to acquire and maintain the transferred quantity of water rights

15. Notices. All notices, payments and other communications to the Parties under this GDMP Agreement must be in writing, and shall be addressed respectively as follows:

City of Gresham	City of Gresham Attention: Department Director Department of Environmental Services 1333 NW Eastman Parkway Gresham, Oregon 97030
Rockwood	Rockwood Water People's Utility District Attention: General Manager 19601 NE Halsey Portland, Oregon 97230-7489

All notices shall be given (i) by personal delivery to the Party, (ii) certified or registered mail, return receipt requested, or (iii) by electronic communication followed immediately by registered or certified mail return receipt requested. All notices shall be effective and shall be deemed delivered (a) if by personal delivery, on the date of delivery, (b) if by certified or registered mail on the date delivered to the United States Postal Service as shown on the receipt; and (c) if by electronic communication, on the date the confirmation is delivered to the United States Postal Service as shown on the actual receipt.

16. Waiver. The failure of a Party to insist on the Strict performance of any provision of this GDMP Agreement or to exercise any right, power of remedy upon a breach of any provision of this GDMP Agreement shall not constitute a waiver of any provision of this GDMP Agreement or limit the Party's right thereafter to enforce any provision or exercise any right.

17. Modification. No Modification of this GDMP Agreement shall be valid unless made in writing and duly executed by the Parties.

18. Implied Covenants. The Parties agree that in construing this GDMP Agreement no covenants shall be implied between the Parties except the covenants of good faith and fair dealing.

19. Governing Law. This GDMP Agreement shall be governed by and interpreted in accordance with the laws of the State of Oregon.

20. Further Assurances. Each Party shall take from time to time, for no additional consideration, such actions and execute such instruments as may be reasonably necessary or convenient to implement and carry out the intent and purpose of this GDMP Agreement.

21. Remedies Not Exclusive. Each and every power and remedy specifically given to the non-defaulting Parties shall be in addition to every other power and remedy now or hereafter available at law or in equity (including the right to specific performance), and each and every power and remedy may be exercised from time to time and as often and in such order as may deemed expedient. All such powers and remedies shall be cumulative, and the exercise of one shall not be deemed a waiver of the right to exercise any other or others. No delay or omission in the exercise of any such power or remedy and no renewal or extension of any payments due under this GDMP Agreement shall impair such power or remedy or shall be construed to be a waiver of any default.

22. Survival of Terms and Conditions. The provisions of this GDMP Agreement shall survive its termination to the full extent necessary for their enforcement and the protection of the Party in whose favor they run.

23. Successors and Assigns. This GDMP Agreement shall bind and inure to the benefit of the Parties and their successors and assigns.

24. Time is of the Essence. A material consideration of the Parties entering into this GDMP Agreement is that Parties will make all payments as and when due and will perform all other obligations under this GDMP Agreement and the Water Rights IGA in a timely manner. Time is of the essence of each and every provision of the GDMP Agreement and Water Rights IGA.

25. Counterparts. This GDMP Agreement may be executed in counterparts, all of which taken together shall constitute a single Agreement.

26. Limitations. This GDMP Agreement shall not be construed to create a partnership between the Parties or to authorize any Party to act as agent for any other Party or Parties except as expressly provided in this GDMP Agreement.

27. Attorneys' Fees. If any suit or action is instituted to interpret or enforce the terms of this GDMP Agreement, the prevailing Party shall be entitled to recover from the other Party such sums as a court may adjudge as attorneys' fees at trial, on appeal, or on any petition for review, and in any proceedings in bankruptcy or arbitration, in addition to all other sums provided by law.

28. Arbitration. Any controversy, dispute or claim arising out of or relating to this GDMP Agreement, or the breach thereof, shall be settled by arbitration in accordance with the rules, then obtaining of the U.S. Arbitration and Mediation of Portland, and judgment upon the award rendered may be entered in any court having jurisdiction thereof. The arbitration board shall not have the power to grant the consent of an Owner to any action where this GDMP Agreement requires the consent of an Owner. The decision of the arbitration board shall be final and binding upon all Parties hereto, and there shall be no appeal to any court there from. Expenses of arbitration shall be borne by the losing Party.

29. Specific Performance. The Parties stipulate that the remedies at law in the event of any default or threatened default by either Party hereto and the performance of or compliance with the terms of this GDMP Agreement are not and will not be adequate, that such terms may be specifically enforced by a decree for the specific performance thereof or by an injunction against a violation thereof of otherwise, and that the remedied of specific performance and injunction against a violation thereof or otherwise, and that the remedies of specific performance and injunction will not impose undue hardship upon either Party. The Parties agree that any arbitrator shall have the authority to order specific performance or to issue an injunction as provided for herein.

30. Mutual Indemnification. To the fullest extent permitted by law Rockwood and Gresham each agree to reimburse, defend, save, hold harmless, and indemnify the other, its elected officials, officers, agents, and employees from any and all threatened or actual claims, suits, or actions, damages, losses or expenses, including attorneys' fees to the extent they arise from or in connection with any third party claim but only to the extent caused by, resulting from, arising out of, or relating to the intentional or negligent activities or omissions of indemnitor, its officers,

employees, subcontractors, agents, or anyone for whose acts the indemnitor is responsible. The indemnitee may, at any time at its election assume its own defense and settlement in the event that it determines that indemnitee is not adequately defending the indemnitee's interests, or that it is in the best interests of the indemnitee to do so.

31. Term of Agreement. This GDMP Agreement shall be:
    a. Effective as of the latest date of signature by the Parties,
    b. May not be assigned without the express written consent of each Party which consent shall not unreasonably be withheld.
    c. May be terminated at any time by mutual written agreement.
    d. May be terminated by either party in the event of a material breach of the Contract by the other that is not cured. Prior to such termination, however, the party seeking the termination shall give to the other party written notice of the breach and of the party's intent to terminate. If the Party has not entirely cured the breach within ten (10) calendar days of the notice, then the party giving the notice may terminate the Contract at any time thereafter by giving a written notice of termination.
    e. In the event of termination under Section 31(d), the Parties shall pay costs as provided under Section 7a. and b., up to and including the date of termination.

32. Effect on other Agreements. To the extent that the provisions of this GDMP Agreement are inconsistent with the provisions of the Water Rights IGA or the Joint Operations Agreement, the Parties intend for this GDMP Agreement to control. Except as expressly provided in this Agreement, the Parties do not intend for this Agreement to affect, modify, repeal, replace, or amend any other term, condition, or provision of the Water Rights IGA or the Joint Operations Agreement, which shall remain in full force and effect subject to this Agreement.

33. Entire Agreement. The Implementation of the 2020 Groundwater Development Master Plan and the Construction and Operation of Jointly and Independently Owned, including any attached exhibits, contains the entire and final understanding of the Parties relating to the construction and operation of water facilities. This GDMP Agreement may only be amended by the mutual agreement of the parties.

IN WITNESS WHEREOF, the Parties have executed this GDMP Agreement as of the Effective Date.

CITY OF GRESHAM	ROCKWOOD WATER PEOPLE'S UTILITY DISTRICT
By: [signature]	By: [signature]
Mayor	President

By: Eric Schmidt Digitally signed by Eric Schmidt Date: 2020.10.13 14:05:54 -07'00'	By:
City Manager	General Manager
	Attest:
	District Secretary
Date: 10/13/2020	Date: 9/23/2020
Approved as to form:	Approved as to form:
David Ross Digitally signed by David Ross Date: 2020.10.12 14:38:57 -07'00'	
David Ross, Sr. Asst. City Attorney	Tommy Brooks, District Counsel

APPENDIX C
NEW SOURCE WATER QUALITY EVALUATION TECH MEMO, CONFLUENCE, OCTOBER 2020

confluence ENGINEERING GROUP LLC
517 NE 92nd Street, Seattle, WA 98115 ph (206) 527-6832 fx (206) 527-3148 confluence-engineering.com

To:	Jason Branstetter, PE City of Gresham	Subject:	Technical Memorandum on New Source Water Quality Evaluation
From:	Virpi Salo-Zieman, PE Chris McMeen, PE Melinda Friedman, PE Confluence Engineering Group	Project:	City of Gresham, New Source Water Quality Evaluation
Date:	October 12, 2020		

1.0 INTRODUCTION

The City of Gresham Water Division (the City) is in the process of evaluating alternatives for long term water supply. Currently, the majority of the City's supply is through a wholesale contract with the Portland Water Bureau (PWB). PWB water is primarily surface water from the Bull Run Watershed (PWB BR) but may also include groundwater from the PWB's Columbia South Shore Wellfield (CSSWF). The remainder of the City's current supply is groundwater from Rockwood Water People's Utility District (Rockwood Water) that supplements PWB water to meet peak seasonal demands. All the supplies carry chloramine residual for secondary disinfection.

The City has partnered with Rockwood Water to develop additional groundwater sources to potentially replace the PWB supply when the current wholesale contract expires. The additional groundwater sources are planned to be drilled into the sand and gravel aquifer, which is currently used by Rockwood Water and PWB at their CSSWF. The purpose of this study is to conduct a high-level, desk-top evaluation of compatibility between groundwater and PWB supplies, and to identify potential risks associated with converting from surface water to 100% groundwater. This evaluation is based on available information for existing conditions since the new wells have yet to be drilled. This work concentrates on key water quality parameters related to corrosion control, pipe scale stability, aesthetic impacts, and on-going regulatory compliance.

2.0 WATER QUALITY

Since the City does not operate its own sources of supply, compliance monitoring is currently limited to ensuring distribution water quality. This includes periodic lead and copper tap samples and water quality parameters (WQPs), disinfection byproducts (DBPs), chlorine residuals, and microbial indicators (coliform). Past lead tap samples and distribution system pH monitoring in 2018 were available in excel format. The rest of the WQPs and chlorine residual data were in handwritten monthly report forms, and therefore, not readily available for statistical analysis. They were, however, visually screened, and typical operating values were identified.

Chemical source water monitoring results were available from Rockwood Water wells and additional information was downloaded from the Oregon Health Authority's (OHA) database. This included the locational running annual average for the regulated DBPs and the 90th percentile lead and copper tap sample results.

Finished water quality for PWB supplies were obtained from previous work with PWB (Corrosion Control Pilot Study Data, 2015-2017, Confluence), and used with permission.

2.1 Gresham Data

Based on OHA's database, Gresham takes 80 coliform samples a month. The database included one chlorine residual level for each week of samples. It is unclear what this residual level represents. The median chlorine residual between January 2017 and June 2020 for the weekly results was 1.34 mg/L. Significantly lower residuals have been reported in the monthly report forms. Visual screening of these reports indicated that in some areas, chlorine residuals have dropped near zero and there is significant temporal and spatial variability. Gresham monitors and reports total chlorine residuals.

WQP monitoring, indicating that although it varies, pH remained above 7.5. The median results for the sites varied between pH 8.0-8.3, with a range between 7.6-8.6. PWB BR supply has very low alkalinity making it susceptible to pH swings. Seasonally low pH in the autumn months may indicate nitrification occurrence.

Figure 2 and Figure 3 present Disinfection Byproduct (DBP) locational running annual averages (LRAA) for each monitoring location, calculated for each quarterly sampling event. While individual results were not available, the averages show that Gresham has maintained compliance with DBPs, and the LRAA has remained around half the established MCLs (0.060 mg/L for HAA5 and 0.080 mg/L for TTHM).

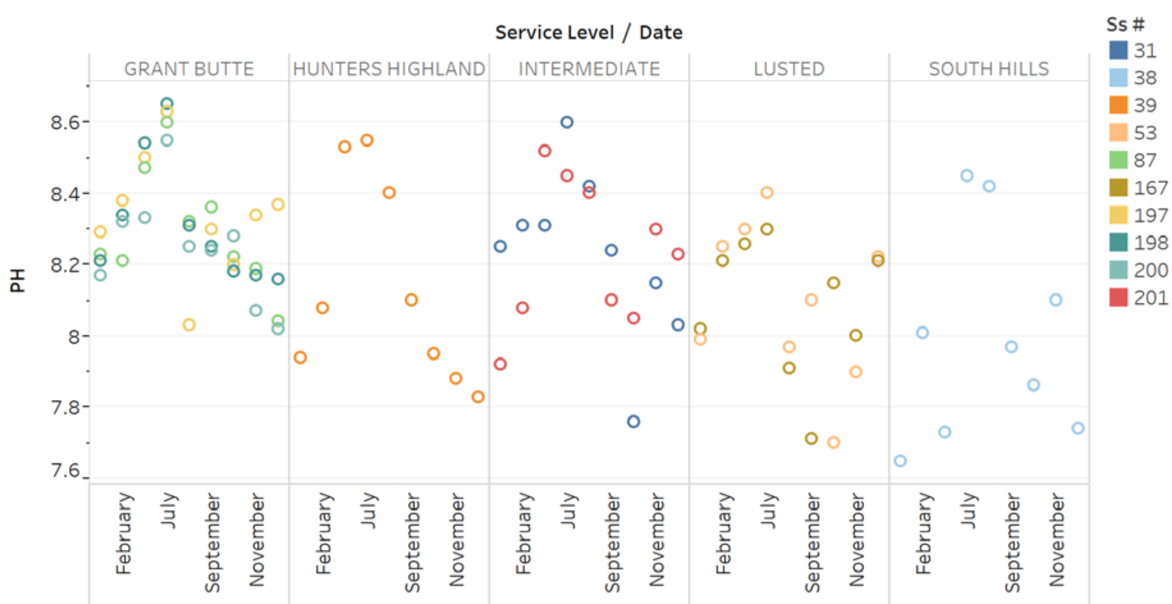


Figure 1 pH results in the Gresham distribution system in 2018 sorted by the service level.

summarizes the City's lead and copper tap sample results. Until 2016, Gresham was part of the PWB's regional monitoring for lead and copper and approximately 20 sites were sampled from within the

Gresham service area. After that, Gresham began its own monitoring and collected 64-70 samples every six months. Based on these results, Gresham has exceeded the 90^{th} percentile lead action level four times. Copper levels have remained low. The City has reportedly removed all known lead service connections from the water distribution system and has never used lead service lines.

Table 1 Summary of lead and copper tap sample results

Monitoring Period	Sample Count in Gresham	Lead (mg/L)		Copper (mg/L)
		90th Percentile	Max Results	90th Percentile
2020 spring	65	0.012	0.033	0.2
2019 fall	64	0.011	0.054	0.219
2019 spring	64	0.017	0.43	0.24
2018 fall	64	0.01	0.024	0.156
2018 spring	65	0.016	not available[1]	0.184
2017 fall	70	0.016	0.026	0.26
2017 spring	70	0.0145	0.026	0.19
2016 fall	19	0.0174/0.0197[2]	0.0231	0.31[2]
2016 spring	22	0.013/0.0159[2]	0.0279	0.288[2]

[1] Individual tap sample results were not available for spring 2018 monitoring cycle;
[2] The results for these sample sets include the 90^{th} percentile (used for compliance) for the regional system and theoretical calculated 90^{th} percentile for only Gresham samples.

According to the OHA database, Gresham must maintain a minimum pH of 7.5 throughout the distribution system and has not had any excursions since January 2018.
Figure 1 pH results in the Gresham distribution system in 2018 sorted by the service level.
presents pH results from 2018 WQP monitoring, indicating that although it varies, pH remained above 7.5. The median results for the sites varied between pH 8.0-8.3, with a range between 7.6-8.6. PWB BR supply has very low alkalinity making it susceptible to pH swings. Seasonally low pH in the autumn months may indicate nitrification occurrence.

Figure 2 and Figure 3 present Disinfection Byproduct (DBP) locational running annual averages (LRAA) for each monitoring location, calculated for each quarterly sampling event. While individual results were not available, the averages show that Gresham has maintained compliance with DBPs, and the LRAA has remained around half the established MCLs (0.060 mg/L for HAA5 and 0.080 mg/L for TTHM).

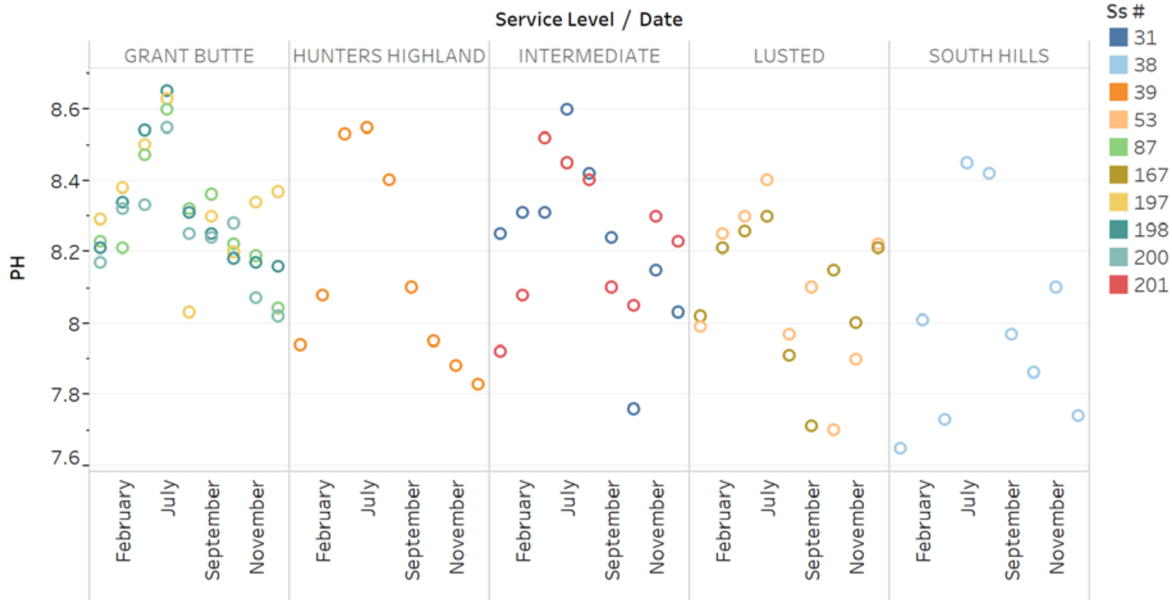


Figure 1 pH results in the Gresham distribution system in 2018 sorted by the service level.

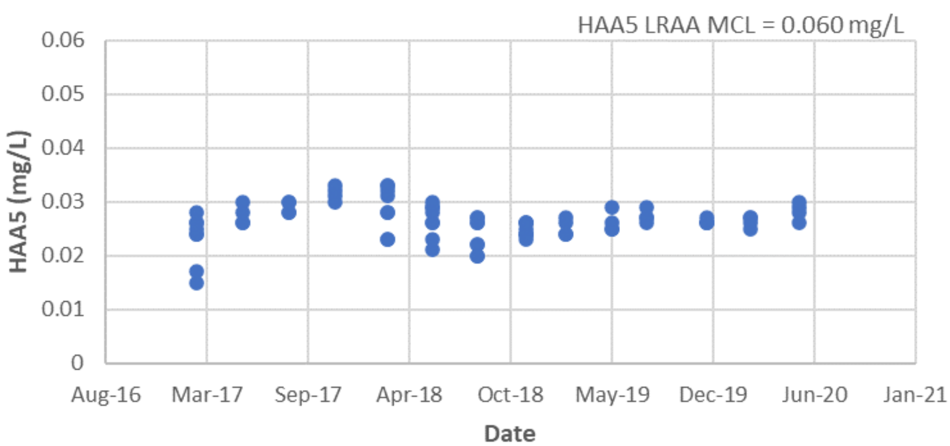


Figure 2 Locational Running Annual Averages for HAA5

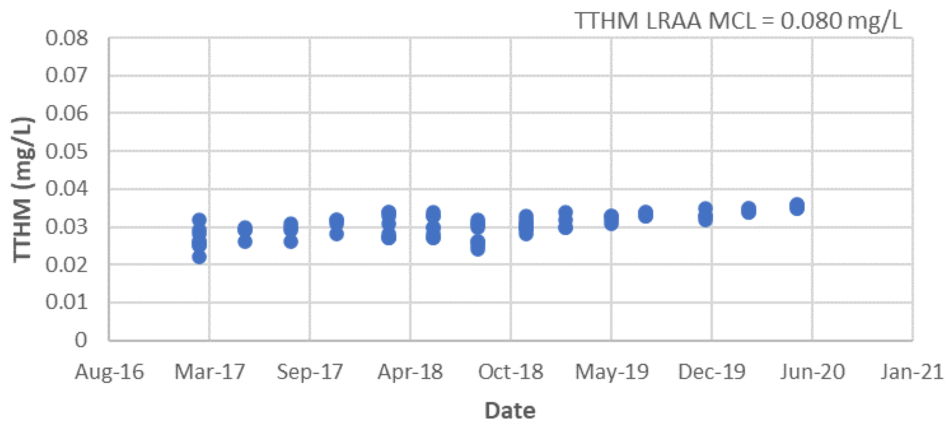


Figure 3 Locational Running Annual Averages for TTHM

2.2 PWB Supply

90% of PWBs supply comes from Bull Run watershed. Bull Run (PWB BR) is an unfiltered surface water supply that is treated for disinfection and pH adjustment. Starting in 2022, the PWB BR will also have alkalinity adjustment for interim corrosion control. Filtration treatment is planned to be in place by 2027.

As mentioned above, PWB also maintains groundwater supply from their CSSWF. CSSWF consists of 28 wells that pump water from several different aquifers. One of these is the Sand and Gravel Aquifer (SGA) that is also used by Rockwood Water, and is anticipated to be the target aquifer for the future Rockwood Water/Gresham well development. According to PWB's Conceptual Geologic Cross Section through the Columbia South Shore Wellfield (https://www.portlandoregon.gov/water/article/751921, accessed July 15, 2020), PWB has 15 wells in the Sand and Gravel Aquifer (SGA) and the cross sections show that Wells P1, 4, 6, 7, 8, 11 and 14 are in the SGA.

Table 2 summarizes several key water quality parameters from these wells, in addition to the finished water from the complete wellfield and Bull Run. CSSWF finished water represents a blend of all the wells that were running and treated. Figure 4 provides a visual comparison of several water quality parameters across these supplies. These box and whisker plots display the median water quality values, with upper and lower bars showing the range, and the grey boxes providing the 10th and 90th percentile statistics for the data set, when sufficient data allowed. Less data were available from the individual wells that pump from the SGA and therefore, only the range of water quality is shown in the graphs. Total organic carbon (TOC) data was not available from the SGA wells.

PWB adjusts the pH at both supplies and therefore, the finished water pHs match closely. Median pH 8.0 was based on the 2015-2017 data. Since then, PWB has increased their treatment target to pH 8.2 and will further increase the pH to ≥ 8.5 with the improved corrosion control treatment facility in 2022. Interestingly, the SGA wells appear to have naturally high pH. There is a large difference in alkalinity levels between the PWB BR and the wells. Bull Run water is extremely low in alkalinity and even with the future adjustment to at least 25 mg/L as $CaCO_3$, it is significantly lower than alkalinity of the well water. SGA wells appear to be in the lower end of alkalinity of the CSSWF wells. The pH and alkalinity ranges of the SGA wells equate to an approximate dissolved inorganic carbon (DIC) range of 17-23 mg C/L for the SGA wells.

Total Dissolved Solids (TDS) is higher in the groundwater than in the Bull Run water while Total Organic Carbon (TOC) levels are quite a bit lower in well water than in PWB BR, which is typical of groundwater resources in the Pacific Northwest.

Table 2 Water Quality of PWB Supplies

Parameter	Units	PWB - Bull Run Finished Water			PWB - CSSWF Finished Water			PWB Wells in Sand and Gravel Aquifer	
		Median	Min	Max	Median	Min	Max	Min	Max
pH	pH units	**8.0**	7.7	8.5	**8.0**	7.5	8.81	7.9	8.6
Temperature	°C	**10.9**	3.1	18.6	**16**	15	18	13.2	15.6
Conductivity	umhos/cm	**28**	20	30	**196**	148	262	125	213
Calcium	mg/L	**1.45**	1.3	2.2	**17**	14	19	12	19
Hardness	mg/L as CaCO3	**7**	5	9	**79**	64	148	51	80
Alkalinity	mg/L as CaCO3	**9.4**	6.8	15	**95**	75	170	73	93
DIC[1]	mg/L as C		1	4	**23**	18	44	17	23
TDS	mg/L	**27.5**	8	40	**130**	120	150	98	150
Chloride	mg/L	**2.9**	2.3	3.7	**4**	4	5	1.2	2.6
Sulfate	mg/L	**0.4**	0.35	0.46	**5.2**	4.7	6.6	1.5	9
$Cl:SO_4$-ratio	--	**7.6**	6.1	8.7	**0.8**	0.75	0.87	0.23	1.07
Total Iron	mg/L	**0.049**	0.016	0.096	**0.016**	0.009	0.179	0.009	0.101
Total Manganese	mg/L	**0.006**	0.0008	0.018	**0.028**	0.018	0.124	0.012	0.062
Total Chlorine	mg/L	**2.3**	1.7	2.9	**2.5**	1.9	2.7	not applicable	

[1] Median DIC is based on paired pH and alkalinity results while the ranges are based on the ranges of pH and alkalinity measured at the supply.

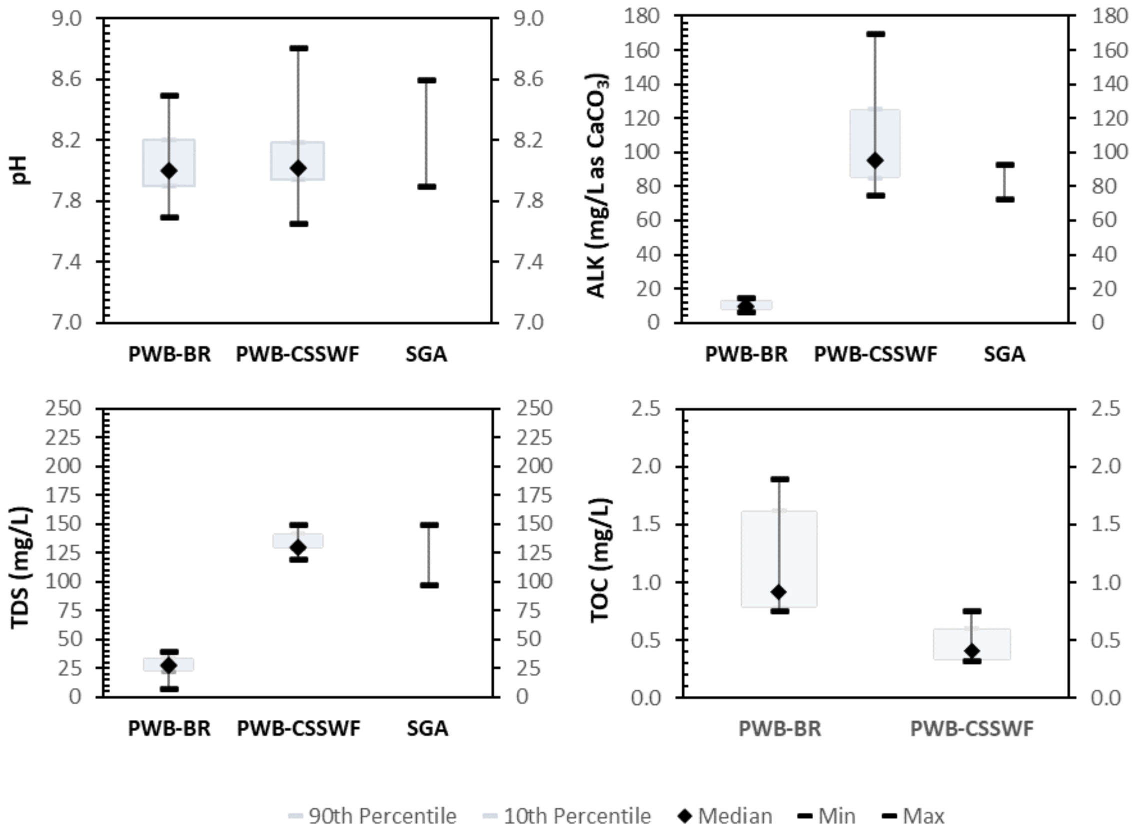


Figure 4 Comparison of finished water quality of PWB's Bull Run (PWB BR), Columbia South Shore Wellfield (PWB-CSSWF) and range of results observed at the wells in Sand and Gravel Aquifer (SGA) (2015-2017)

3.0 METALS SOLUBILITY AND SCALE STABILITY

Water!Pro_6.75 software (Schott Software) tool was used to model lead and copper solubility as a function of the different water chemistries of the supplies. Geochemist Workbench was used to assess scale stability and solubility of iron and manganese. These models are based on thermodynamic equilibrium between the bulk water chemistry and pipe scales. While these are useful tools, the models tend to over-predict soluble concentrations. Rather than predicting absolute values to be expected at customers taps, they are used to predict trends in solubility. Additional limitations with use of theoretical models include:

- Models assume conditions at equilibrium
  - The time component to reach equilibrium under varying distribution system water quality conditions is not known.
  - Frequent source water changes likely prevent equilibrium from being reached.
- Models represent specific chemistry conditions
  - Real world distribution system conditions vary considerably seasonally, spatially, etc.
  - Models do not consider impacts of competing ions, other chemical, physical, and microbial conditions that affect scale formation and stability in distribution systems.

- Solubility models can be used to predict relative metal solubility from scales in equilibrium with the prevailing water quality but should not be used to predict actual metal release concentrations.
- Lead solubility models assume pure lead surfaces (such as lead service lines), and only account for lead in the (2+) oxidation state, such as lead carbonates. They do not account for the potential formation of Pb(4+), which has lower solubility compared to Pb(2+), and can form in highly oxidized environments, such as in the presence of high free chlorine residuals (for example ≥ 0.8 mg/L).
- Solubility models do not consider particulate lead, which can be a concern under dramatically changing water quality conditions that can lead to sloughing of scales.

3.1 Lead and Copper

Based on the current industry knowledge on lead and copper corrosion theory, optimal corrosion control can be achieved by forming and maintaining passivating scales on the pipe surfaces. The most desirable conditions support the formation of insoluble and adherent scales (such as lead and copper oxides). Bulk water quality plays a major role in types of scales and scale stability. Increased release from scales can be expected with dramatically changing water quality conditions when scales are trying to reach a new equilibrium. Stable pH, adequate dissolved inorganic carbon (DIC) levels and buffer capacity, and oxidizing conditions are all important for scale stability. In addition to water quality and scales, copper solubility and release are related to the age of pipe materials and scales. In this analysis, fresh copper surfaces and the presence of cupric hydroxide, the more soluble intermediate copper scale, are assumed as a conservative measure.

Lead and copper solubilities are dependent on pH and alkalinity. Figure 5 presents the model-predicted theoretical lead and copper solubilities for the different supplies over a range of pHs. Typical operating pH was pH 8.0 at PWB in 2015-2017. PWB BR 2022 reflects the expected water quality conditions after the improved corrosion control treatment facility is in service (pH 8.5 and alkalinity of 25 mg/L as $CaCO_3$). According to OHA's database, minimum pH of 7.8 is required at the Cascade Wells entry point in Rockwood Water while their distribution has the same requirement as Gresham (pH 7.5). This entry point pH is also included in the Figure 5.

The pH range observed in Gresham system was 7.6-8.6 in 2018 which can result in very dramatic differences in lead solubility level for the low DIC PWB BR supply. Lead solubility at pH 7.6 can be more than double the solubility predicted at pH 8.6. Very little difference in the lead solubility is predicted between pH 7.6 and 8.2 for the groundwater supplies that have higher DIC, and there is a cross-over point at approximately pH 8 where groundwater lead solubilities are predicted to be higher than Bull Run water.

Copper solubility behaves differently than lead. Across the range of pH considered (Figure 4), Bull Run surface water is predicted to have lower copper solubility levels than groundwater. For all of the waters considered, copper solubility is predicted to decrease with increasing pH, with decreasing benefit above pH 8.1, and modest levels throughout the range.

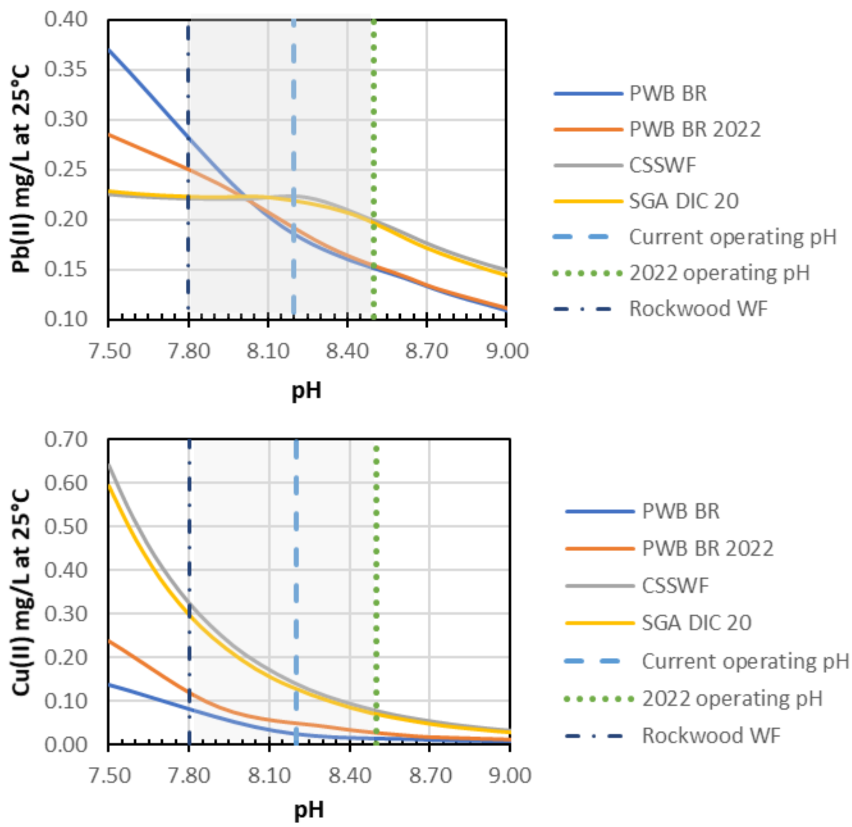
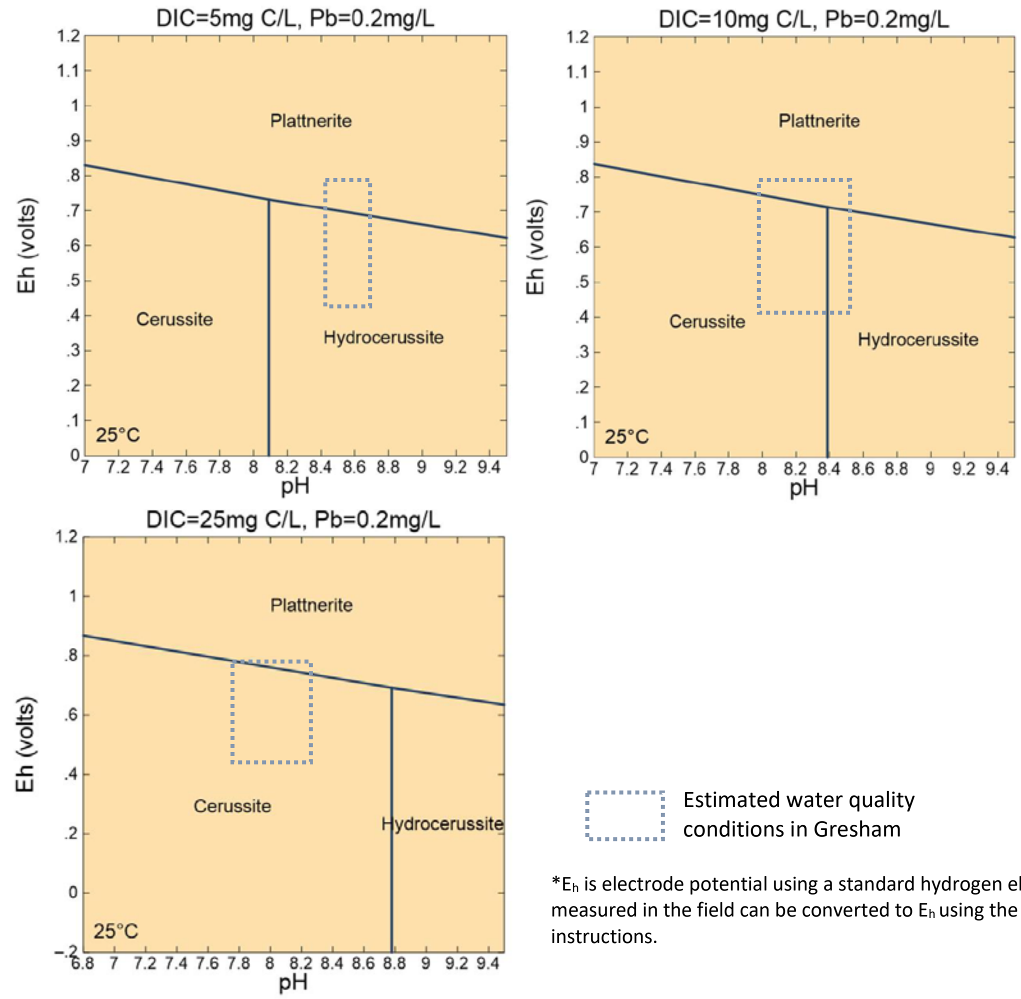


Figure 5. (a) Lead and (b) Copper solubility curves as a function of pH for the different supplies.

Modeling of groundwater conditions predicted that the limit of pH adjustment should be around pH 8.3 to avoid excessive calcium carbonate precipitation. This would mean that the same pH goal of pH 8.5 that will be used for the PWB BR supply is not advisable with the groundwater supplies.

Because of differences in water chemistry, the lead scale type is also predicted to be different under the PWB BR and groundwater conditions**.** Figure 6 includes several lead scale stability diagrams that were developed for different water quality conditions. The scale stability diagram shows the predicted stable scale type in relation to pH and E_h. E_h is oxidation-reduction potential measured against standardized hydrogen electrode and is related to Oxidation-Reduction Potential (ORP). A manufacturer of a specific ORP probe would provide details how to convert the measured ORP to E_h. E_h is often about 200mV higher than the measured ORP and is temperature dependent. The oxidation reduction potential is highly dependent on the oxidants available and their concentrations. For instance, and of particular interest here, chloramine has lower oxidation potential than free chlorine.

The rectangles drawn on the stability diagrams illustrate the estimated areas for example water quality conditions in Gresham system. The first diagram is for Dissolved Inorganic Carbon – 5 mg/L (DIC 5) which is close to the conditions that PWB BR will be in 2022. It predicts that the stable lead scale type is hydrocerussite. The third diagram is for DIC 25 which is close to the groundwater condition and predicts that the stable scale type is cerussite. The diagram in between, is for DIC 10 representing a blend of these two different supplies. While these diagrams are not specifically created for Gresham's water quality conditions, they suggest that the lead scale type will change with the source types increasing the risk of scale sloughing and release of particulate lead. With two different supplies for the city, the scale change may be unavoidable unless high enough oxidation potential can be maintained throughout the distribution system to promote the formation of plattnerite. Plattnerite is Pb(4+) oxide and less soluble than the hydrocerussite or cerussite scales.



*E_h is electrode potential using a standard hydrogen electrode. ORP measured in the field can be converted to E_h using the manufacturer's instructions.

Figure 6 Estimated scale stability diagrams for lead at 25°C under the following water quality conditions: PWB BR 2022 (DIC 5), groundwater wells (DIC 25), and a hypothetical blend of these two (DIC 10). These assume equilibrium with the theoretical soluble lead concentration of 0.2 mg/L.

Copper scale types are not sensitive to these water quality conditions. Cupric hydroxide would remain as the predicted stable scale.

3.2 Iron, Manganese, and Other Metals

Iron and manganese occur naturally in the supplies and are common precursors of discolored water events. Once they enter the distribution system, they tend to accumulate inside the pipes in large quantities over time if an active and comprehensive main cleaning program is not in use. The distribution systems may also include several internal sources of iron, especially if any unlined cast iron pipes remain in service. Based on the GIS data for the City's distribution mains, cast iron is a prevalent pipe material type. Some of the cast iron pipes were installed prior to 1950s and could be unlined. Changes in hydraulics or chemistry, can dislodge or dissolve these deposits leading to discolored water events, with co-occurrence of other metals that may have adsorbed to the iron pipe wall and concentrated over a long period of time.

While iron oxides have low solubility and iron would not remain in solution for long, the particulate release and simultaneous release of regulated metals pose potential public health concerns in addition to discolored water events. Trace elements such as arsenic, mercury, thallium, or lead can accumulate with the iron and manganese and be released as well. These metals have not been detected in the Rockwood Water sources. Based on OHA database, PWB groundwater supplies have very low levels of arsenic. Lead has also been detected at low levels a few times at a couple of the wells, but not consistently. Neither thallium nor mercury have been detected at the wells. The highest detected results for arsenic at the wellfield was 0.003 mg/L.

For manganese, the most critical chemistry change would be dropping ORP and pH, especially below pH 8 when manganese(2+) would occur in the dissolved form, and could later precipitate in customer washing machines, dishwashers, etc.

4.0 AESTHETICS

Taste, odor, and color can be different between the PWB BR and any of the groundwater supplies. While at least part of the system has received groundwater before, there could be locations that have been solely supplied PWB BR water and most customers are accustomed to that water. Groundwater tends to have higher mineral contents and hardness than surface water, and that is the case here; PWB BR water is especially soft. This can feel different for the customers. Calcium carbonate precipitation potential (CCPP) is used to measure the tendency of calcium carbonate to precipitate in the distribution system. This may be seen as a white film or precipitate forming inside the pipes and customers' water fixtures, glassware and so on. The calculated CCPPs for the supply conditions along with other indices are shown on Table 3. Median water quality was used for the supplies except for PWB SGA for which the estimated ranges of water quality shown in Table 2 were used. The CCPP for each supply is negative indicating that there is no concern over precipitation. However, as noted above, the pH of the groundwater supplies should remain at or below pH 8.3 to avoid excessive precipitation. The Langelier's saturation index is like CCPP and predicts if calcium carbonate is expected to precipitate or dissolve. A Langelier's index of less than 0 suggests undersaturated conditions with regards to calcium carbonate while more than 1 suggests excessive scaling. Each of these indices is highly susceptible to pH, so when the higher pH conditions occur, some precipitation is likely. Additional paired data sets from the sources are needed to evaluate potential ranges of indices.

Table 3 Calculated corrosion and other indices for the different supply conditions

Index	Description	Unit	PWB BR	PWB BR 2022	PWB CSSWF	PWB SGA
Langelier's Saturation Index	Predicts if $CaCO_3$ will precipitate or dissolve; optimal 0-1.	Unitless	-2.3	-1.4	-0.2	> -0.4*
CCPP	Measure of tendency to precipitate or dissolve $CaCO_3$; >0 oversaturated	mg/L as CaCO3	-6.9	-5.8	-2.1	> -3.3*
Buffer Intensity	Avoid pH 8.3, the lowest buffer intensity in natural waters;	mM/pH	0.015	0.03	0.124	0.083-0.149*

Index	Description	Unit	PWB BR	PWB BR 2022	PWB CSSWF	PWB SGA
Larson's Ratio	Developed for evaluation of potential corrosion of cast-iron or steel pipes; <0.8 unlikely to cause corrosion	Unitless	0.48	0.18	0.12	0.04
Aggressivity Index	Aggressiveness toward asbestos cement pipe; > 12 nonaggressive	Unitless	10	10	12	11-12
Ryznar Index	Tendency to dissolve CaCO3 (for steel piping); >7 mildly aggressive to steel	Unitless	13	11	8	8-9

'*depends on pH; Langelier's index and CCPP values shown are based on pH 7.9

The comparison of these indices suggests that the SGA well water is more likely to form carbonate scales, is less aggressive to asbestos cement and steel pipe, and has significantly higher buffer intensity than the PWB BR water.

5.0 RADON

Monitoring data available for Gresham indicates that radon is present in the groundwater in the Sand and Gravel Aquifer. The OHA database does not include any data for Radon from PWB or Rockwood Water. However, PWB's website notes that they regularly monitor for radon and it has been detected at levels 131-390 pCi/L at the CSSWF (https://www.portlandoregon.gov/water/article/542151; Frequently Asked Questions about Radon in Portland's Drinking Water, accessed on July 16, 2020). It is therefore very likely that Gresham's groundwater supplies will contain radon at levels in the 100 – 400 pCi/L range. It is not known if exploration in other aquifers will yield different results.

Radon in the Gresham Area

It is understood that the most significant public health risk from radon occurs in indoor air and is a function of the naturally occurring emission of radon gas from soil into homes. Radon is clearly a public health issue of significance in some geographic (and geologic) settings. Modern building codes include methods to reduce that risk where local geology indicates, while older homes may not have those protections.

Multnomah County states that radon levels in the County are about twice the national average (Multnomah County Health https://multco.us/health/staying-healthy/radon, Accessed on August 10, 2020). The State of Oregon has a Radon Awareness Program that promotes testing and mitigation of radon. The program appears to refer to EPA's Indoor Air Quality standards although also acknowledges that water supply can be a source of radon in the indoor air quality. The program includes zip-code specific mapping of radon data. Results in the 97030 -zip code from 214 tests show an average of 3 pCi/L in indoor air, with 26% of samples exceeding EPA recommended maximum level (at which taking corrective action is recommended) of 4 pCi/L.

Regulatory Background

Radon has had a complex, and still unresolved drinking water regulatory history over the last 30 years. In 1991, the Environmental Protection Agency (EPA) published a proposed rule for Radon-222, including the establishment of a MCL of 300 pCi/L. The 1996 reauthorization of the Safe Drinking Water Act directed EPA to arrange for the National Academy of Sciences' risk assessment for radon, withdraw the 1991 proposed rule, and propose of a new regulation with an MCL, and an alternative MCL for radon with multimedia programs to mitigate radon levels in indoor air.

On August 6, 1997, EPA formally withdrew the proposed 1991 Rule. (Federal Register Vol. 62, No 151 Pp 42221-42222). A new proposed Radon Rule was released in November 1999 providing two options for the maximum level of radon allowable in community water supplies. The SDWA directed EPA to not only propose and finalize an MCL for radon in drinking water, but also to make available a higher alternative MCL (AMCL) accompanied by a multimedia mitigation (MMM) program to address radon risks in indoor air. The proposed MCL is 300 pCi/L, and the proposed AMCL is 4,000 pCi/L. If the proposed rule were finalized as written, the drinking water standard that would apply to the City would depend on whether or not the State develops an MMM program. Currently the 1999 proposed rule remains unsettled, and the Safe Drinking Water Act requirement for development of a revised Radon Rule remains unfulfilled.

Contribution of Drinking Water to Radon Exposure Risk

EPA estimated that radon from drinking water, on average, contributes only 1-2% of the radon in indoor air (Federal Register / Vol. 64, No. 211 P. 59249). Cothern (1989) provided an estimate of the contribution from groundwater to household radon concentration as shown in Table 4.

Table 4 Increments of atmospheric radon per 1,000 pCi/L in water supply

Dwelling Type	Floor Area Sq ft (m2)	Room Volume Gal (L)	Air Change Rate hour-1	Average Radon Increment (pCi/L)
Small Apartment	680 (63)	40,000 (150,000)	0.25	0.51
New brick home	1500 (140)	90,000 (340,000)	0.50	0.11
Old frame home	1500 (140)	90,000 (340,000)	1.00	0.05
Large older structure	3000 (280)	180,000 (680,000)	2.00	0.01

As noted by the author, these outcome values depend on a number of factors, including the rate of air exchange within the structure, seasonal weather, and water use patterns. Using these ratios, and the value of 300 pCi/L (typically found in local groundwater), water may be contributing 0.003 – 0.15 pCi/L to indoor air.

The National Academy of Sciences (NAS, 1999) analyzed this same question, concluding that it is reasonable to use a transfer coefficient to estimate water supply contributions to indoor air:

$$\overline{\Delta C_a} = \overline{C_w} \times Transfer\ Coefficient$$

Where: $\overline{\Delta C_a} = average\ incremental\ radon\ throughout\ dwelling\ from\ the\ water\ supply$
$\overline{C_w} = average\ radon\ concentration\ in\ water$
Transfer efficiency – 1×10^{-4}

Based on this, with a water supply concentration of 300 pCi/L, the estimated additional radon to indoor air is 0.03 pCi/L.

Based on the modest levels of radon anticipated in Gresham's groundwater, it does not appear to pose significant additional risk to customers' health. Due to regulatory uncertainty, it will be prudent as Gresham looks forward to include consideration of radon removal treatment in future source or storage facility development. Fortunately, with levels very close to a potential future MCL, and ability to provide aeration at reservoirs, along with relatively rapid natural decay, it is likely that the City would be able to implement effective treatment. Other options for removal, like Granular Activated Carbon (GAC) filtration may be evaluated as well.

6.0 CHLORINE CONVERSION

With the transition of away from PWB supplies, Gresham and Rockwood Water together could decide to convert the secondary disinfectant from chloramine to free chlorine. Because of the continuing reactions with free chlorine and formed chloramines, mixing these different disinfectants is not recommended.

It is not likely that primary disinfection (requirements to provide primary microbial disinfection for viruses or *Giardia*) would be required for the groundwater sources. The conversion to free chlorine would simplify the treatment process, remove concerns over nitrification and nitrogenous disinfection byproducts, and likely increase metals stability in the distribution system. Free chlorine is, however, a more reactive disinfectant, leading to the risk of needing to boost chlorine in the distribution system and potential of forming higher levels of currently regulated disinfection byproducts.

Figure 7 summarizes the benefits and risks associated with the chlorine conversion. These should be further assessed prior to implementation, with monitoring and mitigation plans developed to mitigate risks.

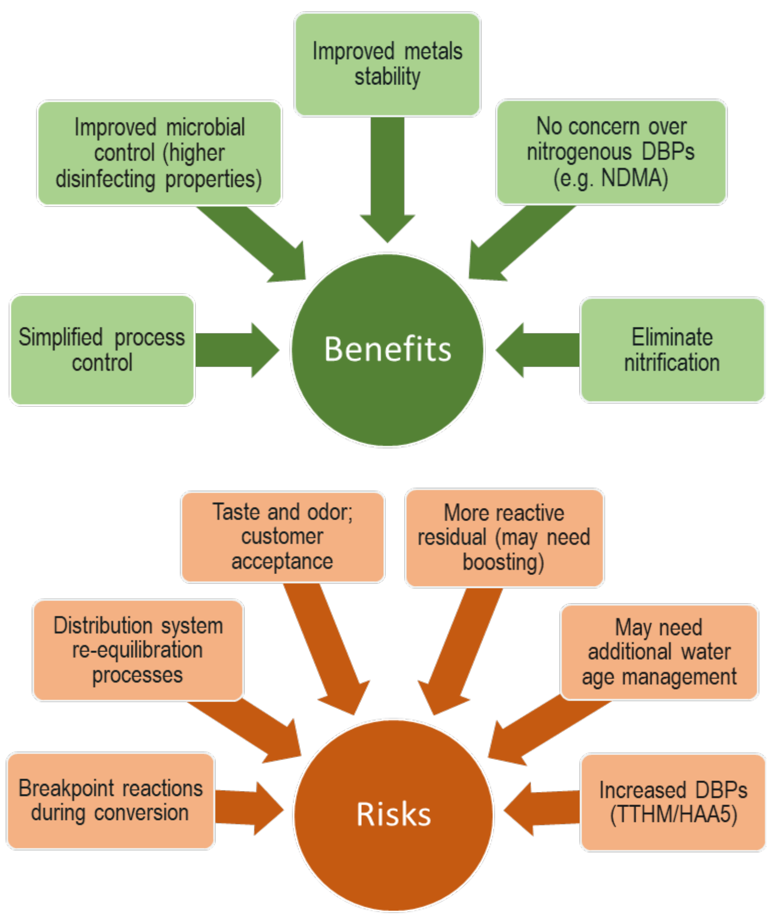


Figure 7 Risks and Benefits of Conversion to Free Chlorine Secondary Disinfection

7.0 FINDINGS

Since the future wells are yet to be drilled and tested for water quality, this high-level desktop evaluation was based on data available from currently used sources assuming those reflect the water quality of the future supplies. The key consideration for the water quality and compatibility of the sources is the continued use of PWB BR and if chloramine remains as the secondary disinfectant. Mixing of different disinfectants is not recommended.

Groundwater is currently blended with the PWB BR supply in the distribution system at approximately a 30-60% blend ratio in the summer. The distribution system water quality does not appear stable with respect to pH and chlorine residuals. pH swings from pH 7.6 to 8.6 and given the occasional low chlorine residuals, nitrification may be occurring within distribution and distribution storage. Once PWB BR has alkalinity adjustment installed in 2022, the pH swings may decrease. The groundwater sources have higher alkalinity and will be able to better maintain stable pH.

Gresham has had several lead action level exceedances. Although the upcoming PWB BR corrosion control treatment improvements should reduce lead levels at taps, it is unclear how significant roles nitrification or the variable distribution system water quality play in lead corrosion. Based on the theoretical models, different lead scale types dominate under groundwater and PWB BR conditions. This is unavoidable unless steady blend of both source types can be maintained throughout the distribution system. The City should complete a comprehensive corrosion optimization study especially with the implementation of a new source. Moving to 100% groundwater with free chlorine residual with a more consistent pH, alkalinity, and DIC will help to stabilize scale types and reduce lead corrosion.

Free chlorine disinfection would be beneficial for metals solubility and scale stability, and the total organic carbon data from the groundwater sources do not suggest a problem with elevated DBPs, however seasonal bench-scale testing is needed to verify and to assess demand/decay rates. Low levels of iron and manganese have been loaded into the distribution system over time. Moving to groundwater wells would likely increase the loading (unless removal treatment is provided, as currently planned) but would not change the scale types. From an aesthetic point of view, groundwater can be harder, more easily cause visible precipitates, and if also converted to free chlorine, would change the smell and taste of the water. The hardness, and levels of free chlorine residual that would likely be used in the Gresham system are typical of many groundwater systems.

The regulatory data for the Rockwood Water wells did not show any detections of unorthodox compounds, such as synthetic or volatile organic chemicals that would have regulated limits. Any data from the past unregulated contaminant monitoring or other monitoring efforts were not available for this evaluation.

Radon was raised as an issue of concern for this work. While the levels of radon identified in area wells do not appear to be high enough to make a significant incremental increase in radon exposure within homes and businesses, the local area does have somewhat elevated natural radon levels, and it may be necessary at some future point to remove radon as a primary treatment step. Options generally include air stripping and GAC filtration.

8.0 RECOMMENDATIONS

While there are clear differences in the supply characteristics, blending of surface and groundwater sources is a common practice. The sources available to Gresham have been used in Gresham, Rockwood

Water, and Portland Regional Supply network, and aside from lead exceedances, there have not been any significant reported incidents due to their blending or occasional use. The most significant change (chemistry-wise) would be the conversion to free chlorine. After a period of re-equilibration, this conversion would likely stabilize pipe scales, including lead. However, based on experience in other systems, some objection from customers to the changed taste of the water should be anticipated and included in conversion planning and communication.

It is noted that the available data were limited and based primarily on source water quality, rather than in the distribution system. Distribution systems are giant reactors impacted by location, pipe material, existing pipe scales and biofilm, and past and current water quality. To position the City better for the new source, the following are recommended:

1. Confirm water quality
    - Complete additional monitoring to better understand the water quality at the sources and in the distribution system. This includes monitoring and analyzing finished water quality from the currently used groundwater sources, obtaining data from the new source including expected finished water quality once available, monitoring for more than regulated parameters, for instance silica, TOC, ORP, total and dissolved metals, and indices over a wider range of chemistry conditions. Targeted monitoring plans should be developed.
    - Invest in recording the available water quality data in the distribution system in spreadsheets, or another tool from which data can be extracted and analyzed.
    - Evaluate the data available from the continuous monitoring equipment.
    - Compare water quality data with system operational data, such as water age and use of the groundwater sources.
    - Evaluate available chemical and microbial data from the wells in the area related to unregulated contaminants, such as polyfluoroalkyl substances (PFAS) that will likely be regulated in the future.
2. Complete a corrosion control study
    - Study the impact of blending of different supplies, alternating supplies, and changing disinfectant residual.
    - Establish appropriate optimal water quality parameters for the supply points-of-entry and within the distribution system.
    - Please note that OHA would determine if a study is required prior to the new source integration. It would be good to approach them ahead of time to determine if a study is required and what the extent of the study would be.
3. Integration planning
    - Develop a comprehensive understanding of distribution system water quality and possible reasons for changes.
    - Assess hydraulic changes (increased water age, creating new hydraulic mixing areas, and stagnation zones) that could occur due to the new source integration.

- Conduct bench-scale jar tests to evaluate seasonal DBP formation potential of all sources if transitioning to free chlorine, as well as chlorine demand/decay characteristics of the well supplies.
- Prepare the distribution system for the transition. This would likely include distribution system flushing (unidirectional, controlled flushing) or deeper main cleaning depending on the conditions. Understanding the baseline conditions and the effects of current maintenance and cleaning practices would be the first steps.
- Develop planning-level cost estimates for radon removal.

4. Assess distribution pipe materials and any areas with unlined cast iron mains. These can be enormous internal sources of accumulated metals and biofilm that if disrupted, can cause long-lasting impacts.

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murraysmith

APPENDIX D
SEISMIC RESILIENCE PLAN INTEGRATION TECH MEMO, CAROLLO, MARCH 2021

City of Gresham
Water System Master Plan

Technical Memorandum
SEISMIC RESILIENCE PLAN INTEGRATION

FINAL | June 2021

City of Gresham
Water System Master Plan

Technical Memorandum
SEISMIC RESILIENCE PLAN INTEGRATION

FINAL | June 2021

REGISTERED PROFESSIONAL ENGINEER
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SEP 13, 2016
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EXPIRES: 06/30/23

Contents

Tables

Figures

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Abbreviations

ALA	American Lifelines Association
ASCE	American Society of Civil Engineers
City	City of Gresham
CSZ	Cascadia Subduction Zone
DIP	ductile iron pipe
ENR CCI	Engineering News Record Construction Cost Index
GIS	geographic information system
MCER	maximum considered earthquake
ORP	Oregon resilience plan
P	pipeline
PGD	permanent ground displacement
PS	pump station
PWB	Portland Water Bureau
R	reservoir
Seismic CIP	seismic capital improvement plan
Seismic Plan	water system seismic resilience plan

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Section 1

INTRODUCTION

Communities in the Pacific Northwest are becoming increasingly aware of the major threat that a catastrophic seismic event will have on our communities. The most significant seismic hazard in our region are Cascadia Subduction Zone (CSZ) earthquakes. The CSZ earthquake with a magnitude of 8.0 to 9.0 or 9.2 – similar to recent events in Japan, Chile, or Indonesia – has an estimated probability of occurrence off the Oregon Coast on the order of 10 to 40 percent over the next 50 years (Goldfinger and others, 2012).

The CSZ earthquake will result in significant damage to our urban infrastructure, disrupting daily life and our local economy. The City of Gresham (City) has been preparing its water system for withstanding such a large seismic event since 1999. In response to the state's adoption of the Oregon Resilience Plan, the City developed a plan that identifies system-wide improvements needed to strengthen all elements of the water system.

The City conducted the Water System Resiliency Study for seismic events in 2016. Results from the Study were merged with the City's previous efforts toward resilience into the 2016 Water System Seismic Resilience Plan (Seismic Plan). The purpose of this report is to identify recommendations from the Seismic Plan that will be integrated into the 2021 Water System Master Plan.

The Seismic Plan merged previous City efforts toward resilience with new, up-to-date evaluations of reservoir, pump station, and distribution system assets. The Seismic Plan provided a clear path forward to resilience, including cost estimates for all recommended improvements and a realistic timeframe for construction.

Elements of the plan include:

- Water system performance objectives.
- Identification of geotechnical hazards from two earthquake planning scenarios.
- Detailed evaluations of reservoir, pump station, and distribution system assets.
- Recommended resilience design standards.
- Recommended improvement projects to enhance water system resilience.

Section 2

BACKGROUND

2.1 Resilience Planning Criteria

Resilience planning performance objectives were established as part of the Seismic Plan. Objectives were determined based on developing and prioritizing improvements to deliver a resilient water system that will meet customers' needs following anticipated seismic events. Generally, the City is following recommendations for water systems outlined in the 2013 Oregon Resilience Plan (ORP) for its Water System Resilience Plan. The ORP presents target states of recovery following a magnitude 9.0 Cascadia Subduction Zone earthquake for critical public services.

The City selected two statistically possible earthquake events for resilience planning:

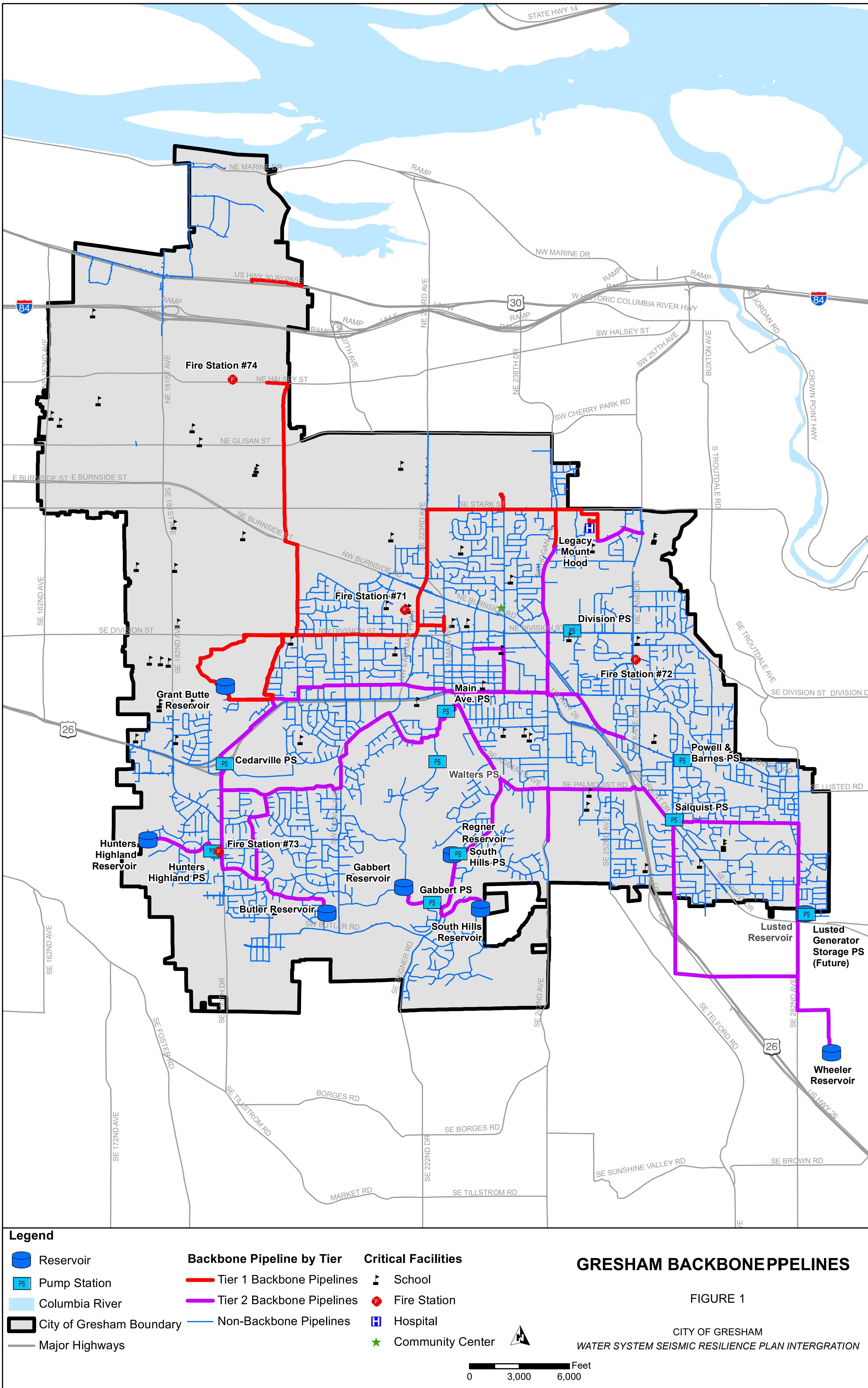
1. The magnitude 9.0 (M9.0) CSZ earthquake with a 500-year return period.
2. The second is the Risk-targeted maximum considered earthquake (MCER) as defined per American Society of Civil Engineers (ASCE) 7-10 Minimum Design Loads for Buildings and Other Structures.

Four seismic structural performance levels (as outlined in ASCE 41-13 Seismic Evaluation and Retrofit of Existing Buildings) are applicable to the City's critical water system backbone: operational performance, immediate occupancy, life safety, and collapse prevention. The following objectives were selected by the City for resilience planning of their critical water system backbone:

1. Structural Performance Objectives:
    a. M9.0 CSZ Earthquake: **Immediate Occupancy**.
    b. Risk-targeted MCER: **Life Safety**.
2. Nonstructural Performance Objectives:
    a. M9.0 CSZ Earthquake: **Position Retention**.
    b. Risk-targeted MCER: **Not Considered**.

2.2 Water System Backbone

A water system "backbone" is the infrastructure required to maintain adequate supply to critical customers and at critical locations in the City following the design earthquake event. To meet the ORP guidelines, the backbone system should withstand the earthquake, with little to no damage, and remain pressurized. Gresham currently receives water from both the Portland Water Bureau (PWB) and from wellfields. In the future Gresham plans to only receive water from wellfields. As shown in Figure 1, the City identified a critical backbone that connects its wellfield and significant supply connections from the City of Portland to critical facilities and extends across the water system to allow for emergency supply connections. The Seismic Plan identified critical customers and prioritized the backbone projects.



GRESHAM BACKBONE PPELINES

FIGURE 1

CITY OF GRESHAM

WATER SYSTEM SEISMIC RESILIENCE PLAN INTERGRATION

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2.3 Seismic Hazards Assessment

Understanding the specific, local geotechnical hazards is crucial for understanding the impacts of an earthquake on infrastructure. The strong shaking caused by the potential earthquakes will likely generate relatively large horizontal reaction forces on the reservoirs and pump stations, as well as transient ground strains parallel and perpendicular to pipelines. The Seismic Plan presented the results of a seismic hazards assessment of the City's water system service area. Two controlling earthquake events were considered the most likely sources of seismic hazards for the City:

- A CSZ event with magnitude 8.5 to 9 at a distance of 70 to 80 miles.
- A local shallow event with a magnitude of about 6.5 at a distance of a few miles.

Strong ground motions can result in a variety of permanent ground displacements (PGD) from the hazards of soil liquefaction, lateral spreading, and slope failure. Earthquake hazard maps show generally none to low liquefaction hazard within the City's water service area, with an exception in some areas along Johnson Creek with low to medium liquefaction hazard zones. Additionally, the City has low probability of lateral spreading due to liquefaction, and only a few areas at risk of landslides. Detailed seismic hazard evaluation results are presented in the Seismic Plan.

2.4 Resilience Evaluation

The Seismic Plan evaluated the seismic performance of the City's reservoirs, pump stations, and pipes given the established hazards as further described below. The evaluations led to recommendations on improvements at each facility to meet the established performance objectives under both earthquake scenarios. These recommendations are presented in the Seismic Capital Improvement Plan (Seismic CIP).

2.4.1 Reservoirs

Reservoir performance assessments followed the ASCE 41 13 seismic evaluation guidelines. The evaluations included reviewing as-built drawings and previous evaluations as available, facility visual inspections, completing a seismic screening checklist, performing structural calculations as required, and performing freeboard water sloshing calculations. Improvements were identified at each reservoir such as lowering the overflow elevations to increase the freeboard (thereby protecting roof structures from sloshing water), providing flexible joints at pipe connections, securing floor grating, and various structural improvements specific to each tank/reservoir.

2.4.2 Pump Stations

Pump station performance assessments followed the ASCE 41 13 seismic evaluation guidelines. The evaluations included reviewing as-built drawings and previous evaluations as available, facility visual inspections, completing a seismic screening checklist, performing structural calculations as required, and assessing onsite backup power. Improvements were identified at each pump station including structural improvements to pump station buildings, and non-structural improvements such as bracing piping, pumps, and other equipment to meet the performance objectives. The evaluation of nonstructural components conducted as part of this study focus on seismic bracing of these components but does not consider their structural and functional ruggedness (operability after an earthquake).

2.4.3 Distribution System

The seismic performance of the City's distribution system piping followed the American Lifelines Association (ALA) approach. Each pipe was assigned an estimated "fragility" based on its material, age, and joint type. Using geographic information system (GIS), ground movement parameters provided from the hazard assessment were also assigned to each pipe segment resulting in a repair rate per 1,000 feet. Very few repairs were calculated (42 total) due to the general low hazards in the City's service area and to the relatively strong pipe materials used (mostly ductile iron pipe [DIP]).

2.5 Resilience Design Standards

Seismic resilient design standards were developed for the City for backbone and non-backbone piping, considering the risk of failure due to liquefaction or landslide. To meet the City's goals and ORP guidelines, the backbone system should survive the earthquake and thus requires higher design standards. In general, high-risk backbone piping is recommended for replacement with seismic joint DIP, and low-risk backbone pipe is recommended for replacement with restrained-joint DIP. Exceptions are further described in the Seismic Plan.

An opportunity exists for additional distribution system resilience by hardening the non-backbone system during scheduled pipe replacement. These pipelines have been identified as non-critical, but water losses due to leaks or major breaks on these lines may potentially drain the backbone system. Design standards for non-backbone pipelines have been developed to address this opportunity and are summarized in the Seismic Plan. In general, high-risk non-backbone piping is recommended for replacement with restrained-joint DIP, and low-risk non-backbone pipe is recommended for standard design.

Section 3

SEISMIC RESILIENCY CAPITAL IMPROVEMENT PLAN

The purpose of the Seismic CIP is to provide the City with a guideline for the planning and budgeting of improvements to meet the City's seismic resilience goals over a 50-year timeframe consistent with ORP guidelines. Recommendations from the evaluations of each of the facilities were selected and prioritized for inclusion in the Seismic CIP.

Recommended projects have been assigned a project name associated with the type of project. Project naming is consistent with the Seismic Plan. The following abbreviations were used:

- "R" = Reservoir.
- "PS" = Pump Station.
- "P" = Pipeline.

Project phasing is developed for the 10-year planning period (Short-Term; 2021 through 2026); a 25-year planning period (Mid Term; 2027 through 2041); and a 50-year planning period (Long-Term; 2042 through 2066). Project timing has been adjusted from the planned timing in the Seismic Plan to account for projects completed since the Seismic Plan published and to account for the City's current CIP plan.

The following sections present an overview of the recommended improvements, general cost estimating assumptions, detailed project descriptions, cost opinions for each recommended project, a summary of the final Seismic CIP, and a list of other general recommendations.

3.1 Projects Completed Since Seismic Plan Published

Since the development of the Seismic Plan, modifications to Hunter's Highland Reservoir (R-3) have been completed, and the City is currently completing modifications at Grant Butte Reservoir (R-2) and at the Grant Butte Reservoir Inlet/outlet (P-1). Cedarville Pump Station (PS-1) has also been resolved since the Seismic Plan development. R-2 included site improvements, reducing freeboard, additional seismic cables, additional circumferential strand wrapping, and vault modifications. P-1 involves replacement of backbone ductile iron pipeline in a high-risk zone with a seismic DIP system. This pipeline is at the inlet and outlet of the Grant Butte Reservoir. R-3 work included site improvements, reducing freeboard, wall retrofit, flexible pipe connections, seismic isolation valve, and vault modification. These reservoirs were categorized as short-term projects in the Seismic Plan.

3.2 Project Prioritization

Projects were prioritized in the Plan based on criticality of infrastructure and ability of each facility to meet the desired level of service goals. These prioritizations were generally used to schedule the projects in the short and medium term after also considering City scheduling preferences.

3.3 Cost Estimating Assumptions

Opinion of probable project costs were developed using a Class 4 budget estimate, as established by the American Association of Cost Estimators. For the Seismic Plan, all project costs were initially calculated in 2016 dollars and were based on an Engineering News Record Construction Cost Index (ENR CCI) 20-City Average of 10337 (June 2016). Costs include the following: construction, engineering, legal, administration, planning, and contingency. For this report, costs have been updated to 2021 dollars using the ENR CCI 20-City Average of 11699 (February 2021). From the base opinion of probable project costs, a 50 percent adjustment for Engineering, Legal, Admin, and Planning and 30 percent adjustment for contingency is assumed for the construction cost estimate. An additional 14 percent for the City overhead and 0.57 percent for Corporate Activities Tax are added from the construction cost estimate for the total probable project cost.

3.4 Project Descriptions

The following sections provide detailed project descriptions, cost estimates, and timing for each recommended project. Projects are listed by type. Figure 2 shows the location of each project.

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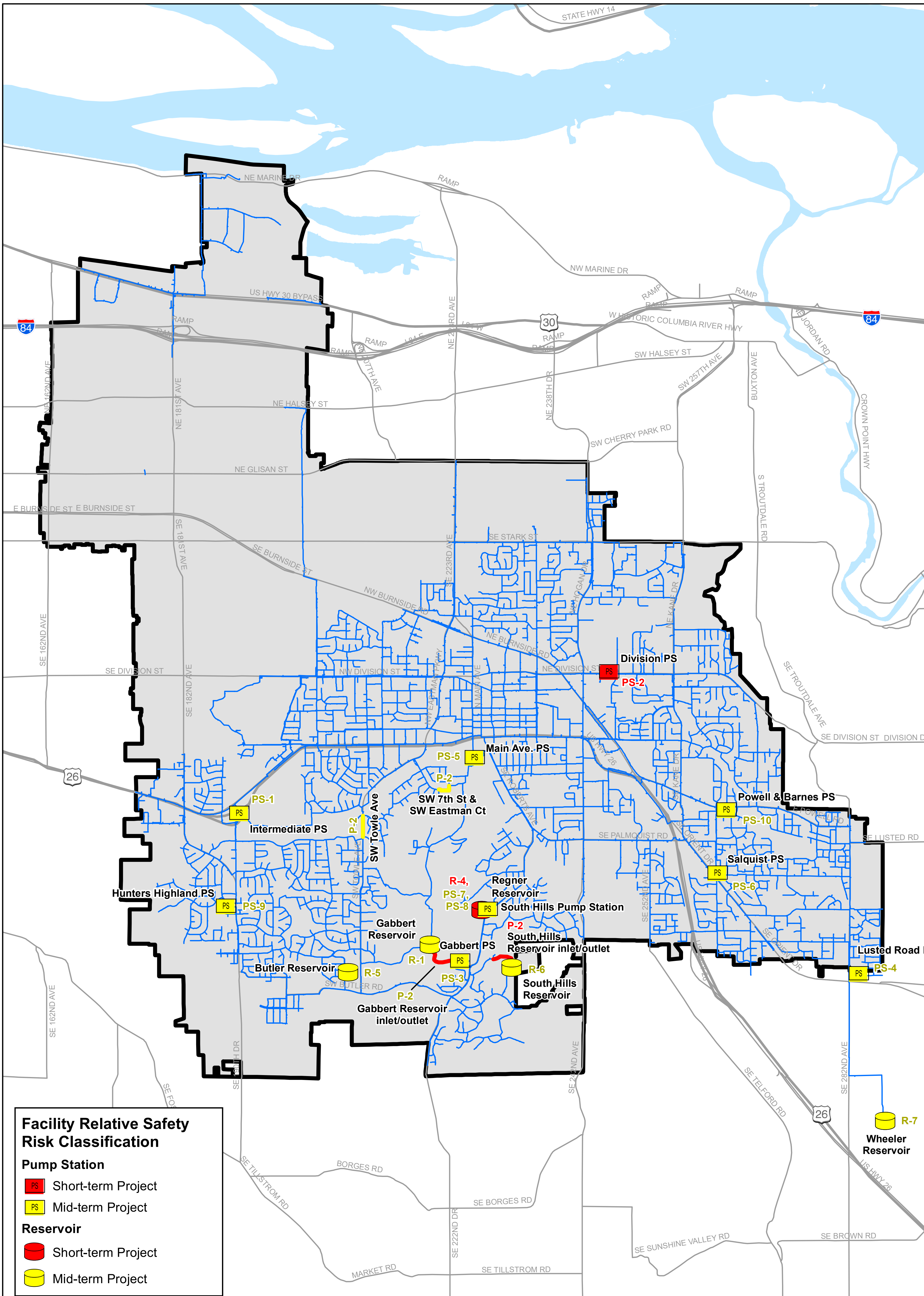

Legend

Pipeline Project

- Short term Project
- Mid-term Project
- Columbia River
- City of Gresham Boundary
- Major Highways

0 3,000 6,000 Feet

RECOMMENDED SEISMIC CAPITAL IMPROVEMENTS PLAN

FIGURE 2

CITY OF GRESHAM

WATER SYSTEM SEISMIC RESILIENCE PLAN INTEGRATION

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3.4.1 Storage

The following storage resilience projects were identified in the Seismic Plan following site visits and high-level structural analysis for each storage facility. Seismic recommendations for the reservoirs are listed below, with a summary of the reservoir estimates in Table 1. Details for each project can be found in the Seismic Plan. Lowering tank overflows was recommended at several tanks to increase freeboard and prevent sloshing water from damaging roof structures during an earthquake. Cost allowances for relocating overflow piping are included in the project estimates below. Alternatively, the City could choose to operate their tanks at a lower level rather than reconstruct the overflow.

- **R-1 Gabbert Reservoir:** Recommendations for Gabbert Reservoir include reducing freeboard, additional structural analysis, installation of a flexible joint, changing pipe materials, and vault modifications. The reservoir modifications are estimated for the mid-term. Project costs are estimated at approximately $139,000, with a placeholder of $229,000 for additional seismic work.
- **R-4 Regner Reservoir:** Recommendations for Regner Reservoir include reducing freeboard, strengthening lower ring beam, additional seismic cable, additional circumferential strand wrapping, fitting replacements, miscellaneous bracing, seismic isolation valves, and vault modifications. The reservoir modifications are to be completed in the short term. Project costs are estimated at approximately $912,000, with a placeholder of $99,000 for additional seismic work.
- **R-5 Butler Reservoir:** Recommendations for Butler Reservoir include reducing freeboard, pipe bracing, and vault modifications. The reservoir modifications timing is for the mid-term. Project costs are estimated at approximately $68,000, with a placeholder for $99,000 for additional seismic work.
- **R-6 South Hills Reservoir:** Recommendations for South Hills Reservoir include embankment fill removal, reducing freeboard, additional seismic cables, circumferential strand wrapping, tank wall evaluation, seismic isolation valve, miscellaneous supports and bracing, and vault modifications. The reservoir modifications timing is for the mid-term. Project costs are estimated at approximately $1,062,000, with a placeholder of $359,000 for additional seismic work.
- **R-7 Wheeler Reservoir:** Recommendations for Wheeler Reservoir include reducing freeboard, miscellaneous supports and bracing, and vault modifications. The reservoir modifications timing is for the mid-term. Project costs are estimated at approximately $68,000, with a placeholder of $99,000 for additional seismic work.

Table 1 Estimated Reservoir Costs and Timing

Project ID	Reservoir	Project Cost	Additional Seismic Work	Estimated Budgetary Total	Timing
R-1	Gabbert Reservoir	$139,000	$229,000	$368,000	Mid-term
R-4	Regner Reservoir	$912,000	$99,000	$1,011,000	Short-term
R-5	Butler Reservoir	$67,500	$98,500	$166,000	Mid-term
R-6	South Hills Reservoir	$1,062,000	$359,000	$1,421,000	Mid-term
R-7	Wheeler Reservoir	$67,500	$98,500	$166,000	Mid-term
	Total	**$2,248,000**	**$884,000**	**$3,132,000**	

3.4.2 Pumping

The following pump station resilience projects were identified following site visits and a high-level structural analysis for each facility. Seismic recommendations for the pump stations are listed below, with a summary of the estimated reservoir costs in Table 2. Details for each project can be found in the Seismic Plan.

- **PS-2 Division Street Pump Station:** Recommendations for Division Street Pump Station include replacement of the pump station building with a new building and miscellaneous bracing, as well as studies on the existing piping and electrical transformer concrete pad. The pump station modifications are projected for the short term. Project costs are estimated at approximately $339,000, with a placeholder of $41,000 for additional seismic work.
- **PS-3 Gabbert Pump Station:** Recommendations for Gabbert Pump Station include shaped blocking between roof trusses, a plywood sub-diaphragm, miscellaneous bracing, and flexible connections on piping. Additional studies include a geotechnical investigation, piping materials, and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated at approximately $311,000, with a placeholder of $181,000 for additional seismic work.
- **PS-4 Lusted Road Pump Station:** Recommendations for Lusted Road Pump Station include miscellaneous bracing and flexible connections on piping, and additional studies on the diaphragm to sheer wall connection, pipe materials, and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated at approximately $30,000, with a placeholder of $64,000 for additional seismic work.
- **PS-5 Main Street Pump Station:** Recommendations for Main Street Pump Station include replacement of the pump station building, flexible connections on piping, and miscellaneous bracing. Additional studies include a geotechnical investigation, pipe material investigation, and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated at approximately $463,000, with a placeholder of $181,000 for additional seismic work.
- **PS-6 Salquist Pump Station:** Recommendations for Salquist Pump Station include blocking between roof and end trusses, a plywood subdiaphragm, miscellaneous bracing, and flexible pipe connections. Additional studies include pipe material investigation and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated at approximately $151,000, with a placeholder of $50,000 for additional seismic work.
- **PS-7 South Hills Generator Building:** Recommendations for South Hills Generator Building include roof replacement and miscellaneous bracing. Additional studies include analysis of walls around the roll up door and a geotechnical investigation. The pump station modifications are projected for the mid-term. Project costs are estimated at approximately $163,000, with a placeholder of $65,000 for additional seismic work.
- **PS-8 South Hills Pump Station:** Recommendations for South Hills Pump Station include roof replacement, flexible pipe connections, and miscellaneous bracing. Additional studies include wall-foundation connection, a geotechnical study, pipe material investigation, and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated at approximately $322,000, with a placeholder of $181,000 for additional seismic work.

- **PS-9 Hunters Highland Pump Station:** Recommendations for Hunters Highland Pump Station include miscellaneous bracing and flexible pipe connections. Additional studies include the diaphragm to sheer wall connection, pipe material investigation, and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated to be approximately $63,000, with a placeholder of $53,000 for additional seismic work.
- **PS-10 Powell and Barnes Pump Station:** Recommendations for Powell and Barnes Pump Station include miscellaneous bracing and flexible pipe connections. Additional studies include pipe material investigation and electrical transformer anchorage. The pump station modifications are projected for the mid-term. Project costs are estimated to be approximately $21,000, with a placeholder of $50,000 for additional work.

Table 2 Estimated Pump Station Costs and Timing

Project ID	Pump Station	Project Cost	Additional Seismic Work	Estimated Budgetary Total	Timing
PS-2	Division Street PS	$339,000	$41,000	$380,000	Short-term
PS-3	Gabbert PS	$311,000	$181,000	$492,000	Mid-term
PS-4	Lusted Road PS	$30,000	$64,000	$94,000	Mid-term
PS-5	Main Street PS	$463,000	$181,000	$644,000	Mid-term
PS-6	Salquist PS	$151,000	$50,000	$201,000	Mid-term
PS-7	South Hills Generator Building	$163,000	$65,000	$228,000	Mid-term
PS-8	South Hills PS	$322,000	$181,000	$503,000	Mid-term
PS-9	Hunters Highland PS	$63,000	$53,000	$116,000	Mid-term
PS-10	Powell and Barnes PS	$21,000	$50,000	$71,000	Mid-term
	Total	**$1,863,000**	**$866,000**	**$2,729,000**	

3.4.3 Piping

Pipeline recommendations are shown in Figure 2 and summarized in Table 3. Six project groupings have been developed, based on the backbone tier, risk, and existing pipeline material. This report assumes that lower priority pipeline will be addressed in the City's ongoing pipeline replacement program. The pipelines identified for inclusion in the Seismic CIP are estimated to $2.2 million. The City has prioritized piping for Gabbert Reservoir inlet/outlet piping and South Hills Reservoir inlet/outlet piping for the short term. These pipelines are part of P-2 and cost estimates together total approximately $1.2 million. The other pipelines in P-2 are expected to be completed in the mid-term and total to an estimate of $1.0 million.

Table 3 Estimated Pipeline Costs, Timing, Priority and Risk

Project ID	Timing	Risk	Existing Pipeline Material	Cost
P-2 – Gabbert Reservoir Inlet/outlet	Short-term	High	Ductile Iron	$519,000
P-2 – South Hills Reservoir inlet/outlet	Short-term	High	Ductile Iron	$860,000
P-2 – SW Towle Ave	Mid-term	High	Ductile Iron	$636,000
P-2 – SW 7th St& SW Eastman Ct	Mid-term	High	Ductile Iron	$524,000
			Total	**$2,539,000**

3.5 CIP Summary

Table 4 provides a summary of all recommended Seismic CIP projects by timing. As seen in the table, the total Seismic CIP estimate is estimated to cost $8.4 million. The breakdown of estimated costs and project timing are presented graphically in Figure 3.

Table 4 Recommended Seismic CIP by Priority (in millions of $)

Facility	Short Term (2021-2026)	Mid-Term (2027-2041)	Total
Pump Stations	$0.38	$2.35	**$2.73**
Reservoirs	$1.01	$2.12	**$3.13**
Pipelines	$1.38	$1.16	**$2.54**
Total	**$2.77**	**$5.63**	**$8.40**

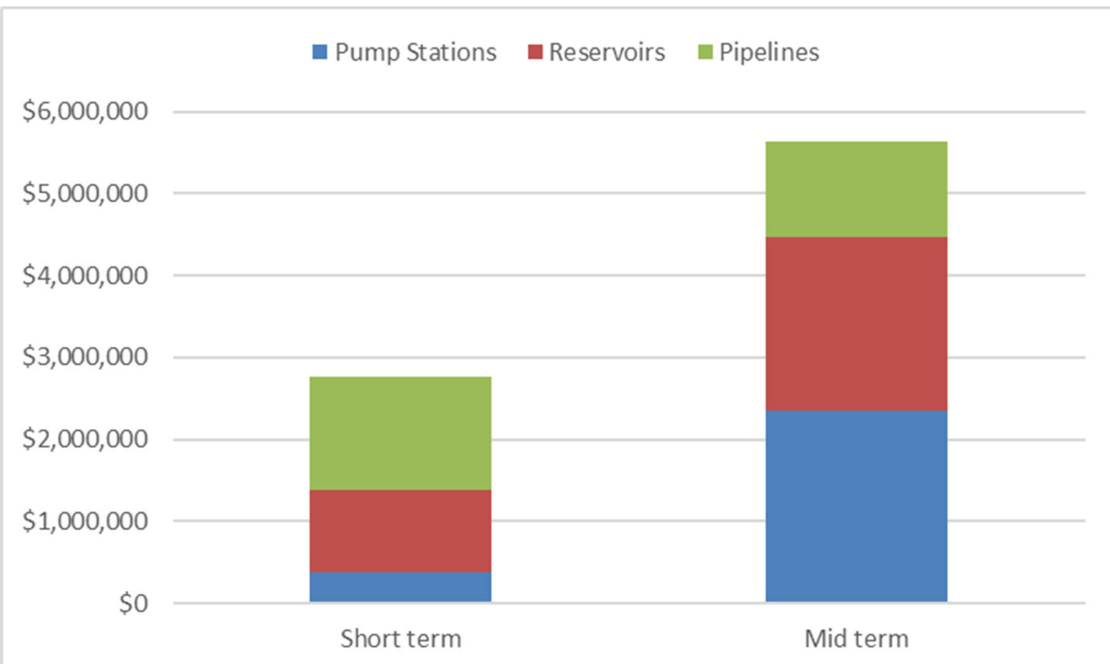

Figure 3 Seismic CIP by Priority and Facility Type