



CITY OF REDMOND

Community Development Department

411 SW 9th Street
Redmond, OR 97756
541-923-7724

www.redmondoregon.gov

REDMOND URBAN AREA PLANNING COMMISSION

411 SW 9th Street-COUNCIL CHAMBERS Redmond, OR 97756 or

Monday, November 21, 2022 6:30 pm

Oral comments can be provided in-person or virtually. For those who plan to provide oral comments virtually during the hearing, pre-register at planredmond@redmondoregon.gov (must pre-register before 4:00 p.m. on November 21st)

Stream the meeting live at: <https://www.redmondoregon.gov/government/city-council/council-meeting-info/meeting-agendas-minutes-and-video>

Agenda

UAPC Members

Teri
Jansen,
Chair

Ron
Osmundson,
Vice-Chair

Heather DeWolf

Norman
Schultz

Richard Bryant

Joseph
Zampko

Vacancy

Ex-Officio
Vacancy

I. CALL TO ORDER / INTRODUCTIONS

II. CITIZEN COMMENTS FOR ITEMS NOT ON THE AGENDA

III. PUBLIC HEARINGS

- a. Redmond Development Code Text Amendments & Zoning Map Amendment (711-22-000219-TA & 711-22-000220-ZMA)
- b. Redmond Comprehensive Plan Amendment (711-22-000225-TA) to Incorporate Water Master Plan & Wastewater Facility Plan into the Public Facilities Plan and as Supporting Plans to the Comprehensive Plan

IV. Next Meeting – December 5, 2022

V. COMMISSION MEMBER COMMENTS

VI. ADJOURN

Please note that these documents are also available on the City's website www.redmondoregon.gov; click on City Government, hover on Commissions and Committees, click on Urban Area Planning Commission. You may also request a copy from City Records Office 923-7751 or email kelly.morse@redmondoregon.gov

The City of Redmond encourages all citizens to participate in its programs and activities. This meeting location is accessible to people with disabilities. Requests for accommodation may include sign language interpreter service, assistive listening devices, materials in an alternate format or any other accommodation. If any accommodations are needed, please contact the ADA Coordinator at 541-504-3036 or access@redmondoregon.gov. Requests should be made as soon as possible, but at least 3 business days prior to the scheduled meeting. The City of Redmond does not discriminate on the basis of disability status in the admission or access to, or treatment, or employment in, its programs or activities.

**FINDINGS FOR TEXT AMENDMENTS TO THE REDMOND CITY CODE,
CHAPTERS 5 (PUBLIC PROTECTION), 7 (BUSINESS), AND 8 (DEVELOPMENT CODE); AND
ZONING MAP AMENDMENT**

HEARING DATE: November 21, 2022, 6:30 PM, Redmond City Hall Council Chambers

HEARINGS BODY: Redmond Urban Area Planning Commission

FILE NUMBER: 711-22-000219-TA, 711-22-000220-ZMA

FILE NAME: Redmond Development Code Text Amendment & Zoning Map Amendment

REQUEST: A Legislative Amendment to the Redmond City Code, Chapters 5 (Public Protection, 7 (Business), and 8 (Development Code) to Modernize Regulations, and Improve Clarity and Administration; and to Expand the Downtown Overlay District

APPLICANT: City of Redmond

REVIEWING STAFF: Kyle Roberts, AICP, Planning Director
Through John Roberts, AICP, Deputy City Manager

I. BACKGROUND

Summary:

The Redmond Development Code (RDC) is the primary mechanism to implement the City's Comprehensive Plan, regulate zoning, growth and development, land use activity, and other City policies related to Great Neighborhood Principles and livability. On June 28, 2022, the City Council adopted amendments to the RDC focused largely on Oregon House Bill 2001 (HB 2001). Cities were mandated to comply with HB 2001 requirements by June 30, 2022.

In light of the mandated HB 2001 timeframe requirements, there were additional details identified during the last amendment process that needed more time to be thoroughly vetted and discussed (e.g., reduced lot sizes, design elements, parking, deed restrictions, applicability of certain zone districts). As such, City Council requested the Planning Division immediately initiate another round of amendments to the RDC to finalize tangential requirements of HB 2001 or refine other elements to improve clarity and administration of the code. Moreover, the charge was to adopt these amendments by the end of December 2022.

The proposed amendments to the Development Code and zoning map amendment were initiated legislatively by the City. The findings and supporting materials, demonstrate the proposed text and map amendments are consistent with the Statewide Planning Goals, the Comprehensive Plan, and Development Code Section 8.0760. The four criteria set forth in Section 8.0760 are addressed herein, as well as applicable state laws and requirements.

Proposal:

The request is for a legislative amendment to update multiple sections of the Development Code as well as an amendment to the zoning map. The amendments to the code will modernize regulations, provide clarity, improve administration, add greater flexibility, and reduce barriers. Amendments to correct errors and to clarify language and procedures have also been made throughout the Development Code. Altogether, the proposed amendments will help the City better guide and manage growth.

Although numerous changes are proposed in this amendment package, the most substantive changes include:

- Reducing redundancy with the annexation process when an applicant is proposing a Planned Unit Development (PUD)
- Allowing an RV Park as a Conditional Use in some commercial and industrial zoning districts and updating the definitions for RVs and RV Parks
- Updating the M-1.5 zone and its permitted and conditional uses and updating conditional uses in the M-1 and M-2 zones
- Requiring a Pre-development application prior to the submittal of a Site & Design Review application
- Establishing a fee for in-lieu of parking in the Downtown Overlay District (DOD)
- Amending the zoning map to expand the existing DOD approximately 6 ½ blocks
- Updating workforce and affordable housing definitions and requiring deed restrictions
- Correcting rear setbacks for attached garages and revising minimum setback requirements for Accessory Dwelling Units (ADUs)
- Clarifying Large Lot Industrial zone regulations to bring into greater alignment with OARs
- Establishing a neighborhood meeting requirement for large-scale development proposals
- Reducing the multi-family complex off-street parking requirements
- Requiring that a Transportation Impact Analysis, approved by City Engineering, be provided at time of land use application submittal
- Modifying the landscaping standards for single-family detached dwellings, plexes, and townhouses

Exhibits:

The proposed amendments to the Redmond City Code Chapters 5, 7, and 8 (Development Code) are contained in Exhibit A. The proposed expansion of the Downtown Overlay District (zoning map amendment) is shown in Exhibit B. These two exhibits are attached hereto:

Exhibit A – Redmond Development Code Proposed Amendments

Exhibit B – Redmond Downtown Overlay District Boundary

Noticing:

Per ORS 197.610, a notice of proposed change to an implementing regulation and zoning map amendment was submitted to the Department of Land Conservation and Development (DLCD) on October 17, 2022. Per Section 8.1110 of the Redmond Development Code, a public hearing notice for the November 21st hearing was published in the *Bend Bulletin* on November 10, 2022.

Applicable Criteria:

The following are the applicable sections from the Oregon Revised Statutes, Oregon Administrative Rules, and the Redmond Development Code:

- Oregon Revised Statutes (ORS) – 197.610 and 197.797
- Oregon Administrative Rules (OAR), Chapter 660:
 - Division 15, Statewide Planning Goals and Guidelines
 - Division 46, Middle Housing in Medium and Large Cities
- City of Redmond Development Code:
 - Article I – Zoning Standards
 - Section 8.0760: Criteria for Amendments

II. FINDINGS & CONCLUSIONS

Findings:

Redmond Development Code, Article I – Zoning Standards: Amendments: Sections 8.0750 through 8.0770 set forth the procedure and standards for an amendment to the text of the Redmond Development Code and for an amendment to the zoning map. Specifically, Section 8.0760 sets forth the four review criteria that must be met when evaluating amendment requests. Findings for each criterion are presented below.

8.0760 Criteria for Amendments. The burden of proof is upon the applicant. The applicant shall show the proposed change is:

1. In conformity with all applicable State statutes;

FINDING: The following State statutes apply directly to this application:

ORS 197.610, *Submission of proposed comprehensive plan or land use regulation changes to Department of Land Conservation and Development;*

ORS 197.797, *Local quasi-judicial land use hearings; notice requirements; hearing procedures.*

ORS 197.610 requires local jurisdictions to submit proposed comprehensive plan or land use regulation changes to Department of Land Conservation and Development (DLCD). Notice of the proposed implementing amendments to the Redmond Development Code (RDC) has been provided to DLCD more than 35 days in advance of the first evidentiary hearing concerning the amendments.

ORS 197.797 sets forth noticing requirements. The applicable RDC standards that address amendment and legislative procedures and noticing requirements (i.e., Sections 8.0750-8.0770 and 8.1100-8.1125) were developed in compliance with the applicable State statute regarding noticing and public hearings. The relevant findings, incorporated by reference herein, show compliance with the aforementioned statutes.

Notice of the proposed text and zoning map amendments have been advertised in the local newspaper (public notice) as required by the RDC and State statute. Regarding statutory public hearing requirements, this proposal is legislative and not quasi-judicial. Sections 8.1100 through 8.1125 of the RDC implement the quasi-judicial statutory requirements in similar fashion and have been met. The Redmond Urban Area Planning Commission and City Council's public hearing and review processes meet the statutory requirements for the purpose of the review.

2. In conformity with the State-wide planning goals whenever they are determined to be applicable;

FINDING: The following State-wide planning goals have been determined to apply directly to this application:

Goal 1 – Citizen Involvement - calls for the opportunity for citizens to be involved in all phases of the planning process. The Redmond Urban Area Planning Commission serves as the City's formal citizen advisory commission to fulfill Goal 1 and is made up of Redmond area residents. The City has conducted numerous work sessions with the Planning Commission over the past three months regarding the proposed amendments.

Public notices and agendas for Planning Commission meetings where and when the proposed amendments were discussed were provided in accordance with law. All documents were available for public review. Further, public notice advertising the November 21st public hearing was published in the *Bend Bulletin*. The City continually provided public review and involvement opportunities during work sessions conducted by the Planning Commission.

Goal 2 – Land Use Planning – requires establishing a land use planning process and policy framework as a basis for all decisions and actions related to use of land and to assure an adequate factual base for such decisions and actions. Through the course of review of the amendments, input was received from City staff, Planning Commission, Central Oregon Builders Association, developers, and residents of the community. The proposed amendments will provide flexibility and reduce barriers to development, help incentivize affordable and workforce housing, provide for increased opportunity for public involvement, and will provide greater clarity and improve administration of the code.

Goal 10 – Housing – provides for the housing needs of citizens of the state. The City of Redmond adopted a Housing Needs Analysis (HNA) in 2019. This document serves as the City’s compliance document under Goal 10, OAR Chapter 660 Division 008, and ORS 197.296(3). This report concludes that Redmond should plan to accommodate development of 6,963 new dwelling units over the next 20 years in order to house the projected population growth. Of these, 100 units will be Accessory Dwelling Units (ADUs).

This code amendment package includes revisions to the Accessory Dwelling Unit (ADU) setback requirements. The existing code applies the same minimum setback requirements to an ADU as the primary dwelling (single-family detached dwelling) on the lot. This greatly limits the ability to develop a detached ADU. The proposed amendments to ADU setbacks will allow for greater flexibility. This will increase the probability that ADUs can be placed on single-family detached dwelling lots, thus helping to achieve the needed ADUs as identified in the HNA.

The HNA has concluded that over the next 20 years, 25% of new housing in Redmond is forecast to be multi-family to meet the diverse needs of the projected Redmond population. Moreover, Redmond has a deficit of land for multi-family housing, and Redmond has a deficit of housing affordable to extremely low, low, and middle-income households. Proposed amendments have been made to the off-street parking requirements for multi-family complexes. Dwelling units with lower capacity need fewer parking spaces. In addition, lower income households often have fewer vehicles, especially those living in affordable housing units. According to *localhousingsolutions.org*, “By reducing off-street parking, communities can lower development costs, potentially free up land for additional units, and reduce the cost of housing for residents.”

The proposed code amendment also more clearly defines what income levels qualify as “affordable” for low- and moderate-income households or Workforce Housing. Furthermore, deed restriction language is added to ensure affordable housing over the long-term and an inventory that remains more stable.

3. In conformity with the Redmond Comprehensive Plan, land use requirements and policies; and

FINDING: The Redmond Comprehensive Plan is the official land use policy statement of the Redmond City Council. The City frequently reviews and updates the Development Code to try and ensure it is aligned with the Comprehensive Plan. Updates to the Development Code in

this context helps ensure the Development Code remains modern and tailored to meet the changing needs of the community. As such, the proposed amendments touch on and implement policy statements contained in every chapter of the Comprehensive Plan.

Chapter 1 of the Comprehensive Plan identifies goals and policies that address citizen involvement. Goal 1 speaks to engagement and the opportunity for the community to be informed and involved in all phases of the planning process. As part of the code amendment package is a new provision that will require a developer proposing a substantial development to host a neighborhood meeting.

As the community continues to experience more growth and development, there continues to be an increasing interest to learn about and participate in the land use process. This desire to be more involved has been particularly evident the last three years in Redmond as seen by public testimony received at public hearings on certain types of development proposals.

The intent of holding a neighborhood meeting is to provide an opportunity for affected property owners to provide input on a project earlier on in the project development or planning phases. The idea behind this is that project specifics could be revised based on the feedback received at neighborhood meetings, prior to an official land use application being submitted for City review. This could result in the submittal of applications that are more responsive to neighborhood concerns and could expedite the review and public hearing processes.

Chapter 2 of the Comprehensive Plan identifies goals and policies that pertain to land use planning and procedures. Goal 1 of the chapter states the following:

Ensure that Redmond's Comprehensive Plan, implementation tools, and administration procedures build on the community's vision for the future and align with regional, state, and federal plans and regulations.

The Development Code serves as the major implementation mechanism of the Comprehensive Plan. These amendments to the Development Code create greater alignment with the Comprehensive Plan that contributes to advancing the community's vision for the future.

Chapter 9 of the Comprehensive Plan identifies goals and policies that address economic development in Redmond. Policy 9-1-2 calls for the need to provide adequate short-term supply of suitable commercial and industrial land to respond to economic development opportunities as they arise. In working closely with the City's economic development partnering agency, REDI (Redmond Economic Development Inc.), a need was identified to create a new industrial zoning district to respond to the City's challenge of having a constrained inventory of smaller lots zoned M-2 (Heavy Industrial).

To help remedy the issue, a new zone, M-1.5 (General Industrial) was recently introduced and adopted. It currently is not applied to any real property within the City limits. The purpose and intent of M-1.5 is to provide for general industrial uses that require less than 35% of property for outdoor storage of raw or assembled materials. It has similar standards to M-1 (Light Industrial) but allows for a limited amount of outdoor storage of products as allowed for on M-2. The proposed changes to the M-1.5 Intent and Use Table modernize the purpose of the zone district and create more consistency and transitional uses between M-1 and M-2 zones. Additionally, the proposed amendments to the RDC would allow permitted or conditional uses in the M-1.5 zone to be allowed through approval of a Conditional Use Permit in the M-1 or M-2 zones.

Goal 2 of Chapter 9 identifies the need to maintain and coordinate efforts in relation to the Large Lot Industrial (LLI) program. In working closely with REDI, the proposed code amendments provide for additional clarity in implementing the LLI provisions. The amendments will provide more specificity to allow greater understanding and buy-in from economic development partners, create more certainty, and aid in recruitment of industrial users.

Chapter 10 of the Comprehensive Plan identifies goals and policies related to housing in Redmond. Goal 2, Housing Opportunity, outlines policies to help provide opportunities for development of a range of housing types that are affordable to households of all income levels as described in the HNA. Policy 10-2-1(a) speaks to the need to identify barriers to residential development and identify alternatives for lowering or eliminating the barriers. As discussed earlier, this code amendment package includes revisions to ADU setbacks and multi-family complex off-street parking requirements both aimed at providing greater flexibility to support developing these needed units.

Chapter 15 of the Comprehensive Plan identifies goals and policies that address livability in Redmond. Policy 15-1-6 states that “Downtown Redmond shall offer diverse districts with mutually supportive functions, including a pedestrian focused core that attracts residents and visitors for entertainment, shopping, dining, civic activities and community events.” As part of the proposed amendment package is a zoning map amendment to extend the existing Downtown Overlay District (DOD) by 6 ½ blocks.

Although the DOD is an overlay that subjects development to additional review criteria to allow for more flexibility, heightened standards, and creativity, it is only overlaid/applied to the most central core (downtown) of the central business district zone (C-2). The DOD’s purpose speaks to Policy 15-1-6 and is, specifically, intended “to create and preserve areas within the C-2 Central Business District Zone that is vibrant and pedestrian-friendly where people can shop, work, and play in a traditional downtown setting. In general, this district will encourage a vibrant mix of pedestrian-oriented uses, including residential, shopping and entertainment uses and increase in the density and intensity of development.”

4. That there is a change of circumstances, further studies justifying the amendment or mistake in the original zoning.

FINDING: As mentioned previously, in light of the mandated HB 2001 timeframe requirements, there were additional details identified during the last amendment process that needed more time to be thoroughly vetted and discussed. This proposed code amendment package addresses many of those as well as other identified needed changes. Staff will initiate another round of code amendments in early 2023 to address the remaining substantive topics identified earlier in 2022 as well as others identified in this current round of code amendments.

The proposal to amend the zoning map is due to respond to changing circumstances. The proposal is to extend the existing DOD boundary north from Antler Avenue to Dogwood Avenue, bounded east-west by 4th Street and 7th Street; extending approximately 2 ½ blocks north and 3 blocks wide. The purpose of extending the DOD boundary is to respond to and be aligned with the real-time growth and development of the “downtown core,” which continues to spread further north in the C-2 Central Business District Zone. Recent development in the DOD includes a mix of shopping, dining, and entertainment establishments – all of which are desirable, pedestrian-oriented uses that the DOD is intended to encourage and preserve.

The extension of the DOD is an anticipated natural next step, as all other directions for growth are constrained by US Highway 97 to the east, Highway 126 to the south, and established residential to the east and west. Aligning the DOD with the growth that is occurring encourage that development can be reflective of the desired downtown core character – a vibrant and pedestrian-friendly area where people can shop, work, and play in a traditional downtown setting.

An additional reason that the amendment to the DOD was proffered is predicated on a long-standing Public Works Policy regarding calculation of System Development Charges (SDCs). There were existing circumstances that warranted a policy to address how SDCs were calculated in the proposed DOD expansion area. The policy clarified land use in the downtown core of Redmond to be equivalent to that of a Shopping Center. Simply, the proposed DOD expansion area functioned like the existing downtown core.

When Transportation SDCs are calculated per the policy, SDC rates are equitably applied to all land uses the same. This methodology indirectly serves as an additional incentive when working with development proposals in the downtown core.

Exhibit A Redmond Development Code Proposed Amendments

Proposed text amendments are shown in ~~strike-through~~ and in Red or Red Underline.

Amend the following throughout the RDC:

- Revise provisions to provide gender-inclusive language. For example, he or she.
- Replace “grandfathered” with “exempted.”
- Incorrect numbering and references.
- Remove all references to “multi-family dwellings,” and replace with “triplexes and quadplexes” where appropriate.
- Consistently reference approvals are at the discretion of the Community Development Director, or designee.
- Fix typos, syntax and grammatical errors.

Chapter 5: Public Protection

(***)

5.250 Definitions. For purposes of Sections 5.250 to 5.290 the following words and phrases mean:

Animal. Any domestic dog, domestic cat, fowl, reptile, livestock, exotic animal, or wildlife.

(***)

Fire Regulations

5.295 Open Burning.

1. All persons shall comply with the regulations for open burning, recreational fires and portable outdoor fireplaces of the Redmond Fire and Rescue District effective within the City or other applicable regulations. ~~No person shall burn waste or other material except in accordance with all applicable regulations.~~
2. A violation of this section is a Class B civil infraction.

(***)

Nuisances

5.325 Definitions. For the purposes of the Redmond Nuisance Code (Sections 5.237 to 5.390), the following definitions mean:

(***)

Control. The ability to regulate, restrain, manage, counteract or govern conduct that occurs on property.

Crowing Fowl. Crowing fowl means any male fowl from the order *galli formes*, including: roosters, drakes, turkeys, peacocks or pea fowl.

(***)

Exhibit A
Redmond Development Code Proposed Amendments

5.335 Public Nuisances. The following shall be deemed Public Nuisances within the City:

(***)

15. **Noise.** This section is adopted pursuant to the provisions of ORS 467.100:-

A. Definitions. As used in this section, the following mean:

(***)

3. **Unreasonably loud or raucous noise:**

(***)

n. **Clock or Church Chimes.** Operating a clock chime or tones or a church chime other than between the hours of 7:00 a.m. and 9:00 p.m. unless otherwise authorized by the City Manager. In addition, the duration of such chime or tones shall not exceed two minutes.

o. **Crowing Fowl.**

4. **Acts prohibited.** Except as permitted, no person within the boundaries of the City shall make unreasonably loud or raucous noise that disturbs, injures or endangers the comfort, repose, health, peace or safety of others. A violation of this section is a Class A civil infraction.

Chapter 7 – Business (Murals)

(***)

7.410 Definitions. For the purposes of Sections 7.405 to 7.420, the following mean:

(***)

Mural. A hand-painted, hand tiled, or digitally printed image on the exterior wall of a building or structure where the wall or surface is either on City-owned property, or has a mural agreement, and is viewable from another property or right-of-way.

(***)

Profanity. Vulgar or obscene language, abusive expletives, profane or inappropriate symbols.

(***)

7.420 Murals. The following standards shall apply to all murals.

1. **Standards**

(***)

Exhibit A
Redmond Development Code Proposed Amendments

E. Profanity, hate speech, racial vilification, propaganda, political messaging or nudity are not allowed.

(***)

Chapter 8 – Redmond Development Code (RDC)

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(***)

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(***)

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(***)

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(***)

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Exhibit A
Redmond Development Code Proposed Amendments

(***)

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(***)

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(***)

Introductory Provisions

8.0020 Definitions. As used herein, the following words and phrases shall mean:

(***)

Affordable Housing. Affordable housing is generally defined as housing within the means of a household that may occupy low- and moderate-income housing, meeting one of the thresholds defined in this section. Affordable Housing warrants low- and moderate-income affordability deed restrictions of at least 30 years. The affordability period may be adjusted based on the use of development incentives, modifications, variances or exceptions. ~~on which the occupant is paying no more than 30 percent of gross income for housing costs, including utilities, for a family at 80 percent of the Area Median Income (AMI). AMI is based on the most recent HUD Income Limits for the Bend-Redmond Metropolitan Statistical Area.~~

In the case of dwelling units for rent, “affordable” means housing for which rent and utilities are no more than 30 percent the gross annual household income for a family earning less than or equal to 60 percent the Area Median Income (AMI), based on the most recent HUD Income Limits for the Bend-Redmond Metropolitan Statistical Area.

In the case of dwelling units for sale, “affordable” means housing in which the mortgage, amortized interest, taxes, insurance, HOA and associated fees, if any, constitutes no more than 30 percent of such gross annual household income for a family earning less than or equal to 80 percent the Area Median Income (AMI), based on the most recent HUD Income Limits for the Bend-Redmond Metropolitan Statistical Area.

(***)

Exhibit A Redmond Development Code Proposed Amendments

Dwelling. As follows:

Accessory Dwelling Unit (ADUs). A secondary living unit, attached or detached, accessory to a single-family detached dwelling in a residential zone containing cooking facilities meeting the dimensional standards and other requirements of the zone district in which it is located.

Duplex. Two attached, or detached, dwelling units on a Lot or Parcel when neither is an accessory dwelling.

Dwelling Unit (DU). A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

(***)

- B. Live/Work Apartment: A residential multi-story, multi-unit building with a minimum of 50% of the building ground floor used as retail, office, or commercial space. Residential units may be rented or for sale (condominium or cooperative) units.

Manufactured Dwelling. Manufactured Dwellings. Means:

Residential trailer. A structure constructed for movement on the public highways that has sleeping, cooking and plumbing facilities, that is intended for human occupancy, that is being used for residential purposes and that was constructed before January 1, 1962.

Mobile Home. A structure constructed for movement on the public highways that has sleeping, cooking and plumbing facilities, that is intended for human occupancy, that is being used for residential purposes and that was constructed between January 1, 1962, and June 15, 1976, and met the construction requirements of Oregon mobile home law in effect at the time of construction.

Manufactured Home. A structure constructed for movement on the public highways that has sleeping, cooking and plumbing facilities, that is intended for human occupancy, that is being used for residential purposes and that was constructed in accordance with federal manufactured housing construction and safety standards and regulations in effect at the time of construction.

Manufactured dwelling does not include any building or structure constructed to conform to the State of Oregon Structural Specialty Code or the Low-Rise Residential Dwelling Code or any unit identified as a recreational vehicle by the manufacturer.

Multi-Family Complex. A building or group of buildings on a single lot containing a total of five or more dwelling units.

Quadplex. Four attached, or detached, dwelling units on a Lot or Parcel.

Single Family Detached Dwelling. ~~Single Family Detached Dwelling.~~ A detached building containing one dwelling unit, including manufactured homes.

Triplex. Any configuration of three attached, or detached, dwelling units on one Lot or Parcel.

Dwelling Unit. ~~A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.~~

(***)

Multi-family Complex. See *Dwelling, Multi-family Complex.*

~~**Multi-family Dwelling.** See *Dwelling, Multi-family.*~~

MUTCD: Manual of Uniform Traffic Control Devices, Federal Highway Administration.

(***)

Exhibit A

Redmond Development Code Proposed Amendments

Recreational Vehicle. A vehicle with or without motive power that is designed for use as Temporary living quarters for recreational, camping, or travel use, which either has its own motive power or is mounted on or drawn by another vehicle. Recreational vehicles include travel trailer, truck camper, and motor home.

Recreational Vehicle (RV) Park. ~~A parcel of land upon which two or more recreational vehicle sites are located, established, or maintained for occupancy by recreational vehicles, tents or other camping facilities, as temporary living quarters for recreation or vacation purposes.~~ A place where two or more recreational vehicles are located within 500 feet of one another on a lot, tract or parcel of land under common ownership and having as its primary purpose temporary living quarters and the renting of space and related facilities for a charge or fee. Approved Safe Parking and Vehicle Camping sites, per Chapter 5 of City Code, do not constitute an RV Park.

Recreational Vehicle Site. A plot of ground within a recreational vehicle park intended for the accommodation of a recreational vehicle, ~~tent~~, or other camping unit on a temporary basis. The site may include individual use areas for picnic tables, fire pits, private parking, and other private uses.

(***)

Workforce Housing. Housing that constitutes no more than 30 percent of such gross annual household income for a family ~~is affordable to households earning 60 80 to 120 percent of the~~ Area Median Income (AMI). AMI is based on the most recent HUD Income Limits for the Bend-Redmond Metropolitan Statistical Area. Workforce Housing warrants income-based deed restrictions of at least 30 years. The affordability period may be adjusted based on the use of development incentives, modifications, variances or exceptions.

8.0065 Establishment of Zones and Districts. (Identifies allowable zones and definitions for them):

(***)

M-1 Light Industrial Zone. To provide for light industrial uses such as light manufacturing, research, transportation facilities and similar uses which have a limited impact on surrounding properties and are compatible with clean non-polluting industries along with limited office and commercial activities which support these light industrial uses. Furthermore, uses associated with the M-1.5 General Industrial Zone can possibly be permitted.

M-1.5 General Industrial Zone. To provide for general industrial needs ~~uses~~ such as defined offices, industrial park activities, manufacturing, research, and contractor uses using less than 35% of the property for outdoor storage of raw or assembled materials. Development, site design and architecture should promote quality, compatibility, and aesthetics. ~~Such~~ Storage must be sufficiently screened by fences or landscaping. M-1.5 uses can be approved in either the M-1 Light Industrial Zone or M-2 Heavy Industrial Zone when approved through a Conditional Use Permit.

M-2 Heavy Industrial Zone. To promote the economic diversification by allowing a wide range of industrial and heavy commercial uses and providing sufficient land for industries that have a more pronounced impact on the urban environment because of noise, smoke, air, and other emissions or because of traffic and other operating characteristics associated with these industries. The M-2 zone also allows for heavy commercial uses in areas where previous

Exhibit A Redmond Development Code Proposed Amendments

subdivisions of land and current ownership patterns have resulted in separate ownerships of smaller M-2 zoned parcels lots in the ~~M-2 Zone area~~ and cannot, therefore, challenged to be readily used for industrial purposes. Furthermore, uses associated with the M-2 Heavy Industrial Zone can possibly be permitted.

(***)

(LLI) Large Lot Industrial Zone. That area within the City identified to attract, aid, or facilitate ~~attract and retain~~ business and industrial development projects focused on traded-sector industries activities that require an adequate supply of large, developable parcels of industrial land for industrial uses include warehousing and distribution centers.

ARTICLE I - ZONING STANDARDS SINGLE FAMILY DWELLING SETBACK STANDARDS

8.0140 Table B, Minimum Standards. The following minimum standards apply in each of the Residential zones:

Zone:					
Standard:	R-1	R-2	R-3, R-3A	R-4	R-5
Setback Distance – Feet					
Front Façade, excluding garage	10	10	10	10	10
Interior Side	5/10	5/10	5	5	5
Interior side yards must be a minimum of 5 feet on one side and 10 feet on the other side for single family, duplex, triplex, and quadplex residences. Where alley access is provided, both interior side yards may be reduced to 5 feet. Exceptions to the 10-foot setback are allowed (1) when the residential lot was created prior to the adoption of this standard (November 9, 2006); (2) on cul-de-sac lots; or (3) on flag lots.					
Street Side	10	10	10	10	10
Rear	20	20	20	15	5
<u>Attached</u> Garage, access from <u>alley or street</u>	20	20	20	20	20
Garage, access from alley	5	5	5	5	5
Setbacks					
ADUs: Specified in Section 8.0325.					
<u>Detached Accessory Structures: Specified in Section 8.0323</u>					
Cottage Clusters: Specified in Section 8.0143.					
Cottage Developments: Specified in Section 8.0285 et seq.					
Multi-family Complexes: Specified in Section 8.3035.4.E. Table A.					
Townhouses: Specified in Section 8.0142.					

(***)

8.0141 Single Family Detached Dwellings and Plexes Development and Design Standards.

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(***)

6. Driveways and Garages.

- a. A garage is required for each newly constructed residential structure and shall be of adequate size to accommodate a minimum of one vehicle, and shall at a minimum, meet the design requirements in Section 8.0500~~5~~ through 8.0515 (Off Street Parking and Loading Requirements) of the RDC.
 - i. Manufactured homes may meet this standard by substituting a garage with covered parking or carport.
 - ii. Triplexes and quadplexes may meet this standard by substituting garage or covered parking with uncovered, paved parking spot(s) per the design requirements in Section 8.0500~~5~~ through 8.0515.
- b. Driveways shall be of adequate size to accommodate a minimum of one vehicle, and shall at a minimum, meet the design requirements in Section 8.0515 (Parking Table and Diagram) of the Redmond Development Code.
- c. A single-family detached home that adds an ADU shall continue to meet the minimum parking spaces requirement for the primary home.
- d. Notwithstanding the applicable provisions of Sections 8.0500~~5~~ through 8.0515 (Off Street Parking and Loading Requirements) of the RDC, all required off street parking areas and driveways constructed in conjunction with single family detached dwellings or plexes may have alternative surfaces to concrete or asphalt and may include permeable surfaces to the extent they provide an all-weather surface sufficient for vehicular travel. Loose gravel, aggregate and similar surface treatments are not permitted for required parking spaces.

7. Off-street Parking. The minimum number of required off-street parking spaces for single-family detached dwellings and plexes are specified in Section 8.0500.

78. Landscaping. See Section 8.03440. Landscaping standards are as follows:

- a. On all lots which new single-family detached dwellings or plexes are constructed, landscaping shall be installed between the corresponding façade(s) of the structure and the edge of the street(s), public or private, for the entire length of the street frontage(s).
- b. Required landscaping can include, but is not limited to, a combination of the following materials: living plant material such as trees, shrubs, flowers, and lawn; and non-living materials such as walkways and courtyards consisting of brick, concrete, asphalt, decorative rock, or other approved materials. Applicable landscaping requirements are subject to the following:
 - i. Xeriscaping is encouraged. The minimum required allowance for plantings shall be 25%. Rock, rock

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- gardens and bark areas without plantings do not qualify as landscaping or xeriscaping.
- ii. The use of gravel is limited to spaces specified for the parking of RVs.
 - iii. Areas of exposed dirt are not allowed.
 - c. Street trees are required to be installed on all residential lots fronting on public or private streets, including lots already platted at the time of adoption of this ordinance, but not yet developed. Additional standards are located in Section 8.3035.5.K.

<u>Lot Width</u>	<u>Number of Street Trees Required</u>
<u>Corner Lot</u>	<u>Tree requirements will be based on each street frontage length.</u>
<u>50 feet and less</u>	<u>1</u>
<u>51-100 feet</u>	<u>2</u>
<u>101-150 feet</u>	<u>3</u>
<u>151 feet and more</u>	<u>One tree/40 feet of width fronting street.</u>

- i. Flag lots shall be exempt from street tree requirements unless the frontage portion of the flag lot is 30' or greater.
 - d. All landscaping and street tree installation shall be completed prior to issuance of a Certificate of Occupancy.
- 89. Fences.** See Section 8.0340.
- 910. Conversions.** Conversion of an existing single-family detached dwelling to a duplex, triplex, or quadplex is allowed, provided that the conversion does not increase non-conformance with applicable standards of the underlying zone and this section.

8.0142 Townhouse Development and Design Standards.

(***)

- 5. **Design Standards.** New townhouses shall meet the design standards in subsections A through F of this section.

(***)

- E. **Landscaping.** ~~See Section 8.3035(5).~~ Landscaping standards are as follows:
 - a. On all lots which new townhouses are constructed, landscaping shall be installed between the corresponding façade(s) of the structure and the edge of the street(s), public or private, for the entire length of the street frontage(s).
 - b. Required landscaping can include, but is not limited to, a combination of the following materials: living plant material such as trees, shrubs, flowers, and lawn; and non-living materials such as walkways and courtyards consisting of brick, concrete, asphalt, decorative rock, or other approved

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materials. Applicable landscaping requirements are subject to the following:

- i. Xeriscaping is encouraged. The minimum required allowance for plantings shall be 25%. Rock, rock gardens and bark areas without plantings do not qualify as landscaping or xeriscaping.
- ii. The use of gravel is limited to spaces specified for the parking of RVs.
- iii. Areas of exposed dirt are not allowed.
- c. Street trees are required to be installed on all residential lots fronting on public or private streets, including lots already platted at the time of adoption of this ordinance, but not yet developed. Additional standards are located in Section 8.3035.5.K.

<u>Lot Width</u>	<u>Number of Street Trees Required</u>
<u>Corner Lot</u>	<u>Tree requirements will be based on each street frontage length</u>
<u>50 feet and less</u>	<u>1</u>
<u>51-100 feet</u>	<u>2</u>
<u>101-150 feet</u>	<u>3</u>
<u>151 feet and more</u>	<u>One tree/40 feet of width fronting street</u>

- i. Flag lots shall be exempt from street tree requirements unless the frontage portion of the flag lot is 30' or greater.
- d. All landscaping and street tree installation shall be completed prior to issuance of a Certificate of Occupancy.

(***)

8.0143 Cottage Cluster Development and Design Standards.

(***)

7. **Design Standards.** New cottage clusters shall meet the design standards in subsections A through H of this section.

(***)

- E. Facades.** Cottages ~~within 20 feet of a street property line~~ must meet the architectural design standards for single-family detached dwellings in Section ~~8.0141(5)(B)~~ **8.0141(5).B.1 through 4.**

(***)

COMMERCIAL USE AND INDUSTRIAL USE ZONES

Exhibit A Redmond Development Code Proposed Amendments

(***)

8.0175 Downtown Design Overlay Zone District. In the Downtown Overlay District, the following regulations shall apply:

1. **Purpose.** The purpose of the Downtown Overlay District is to promote and sustain:
 - A. **Quality Economic Growth** – Assure opportunities for a stable, vital, diverse, and competitive economy in at the heart of the city.
 - B. **Vibrant Downtown** ~~;~~ Strengthen downtown as a vibrant, mixed-use district that draws a wide spectrum of residents and visitors.
 - C. **Downtown Appearance** ~~;~~ Improve and enhance the appearance of the built environment and natural features throughout downtown, especially along primary commercial corridors, and other major arterials.
 - D. **Historic Character** ~~;~~ Preserve and retain historic structures and cultural resources throughout downtown.
 - E. **Pedestrian Environment** ~~;~~ Improve and enhance the pedestrian environment throughout downtown, as well as the pedestrian connections to surrounding neighborhoods and civic resources.

(***)

4. **Development Standards.** In the Downtown Overlay District, the following dimensional standards shall apply:
 - A. **Minimum Building Setback:** Two (2) feet. Surface treatment needs to be of similar nature as adjoining sidewalk.
 - B. **Maximum Building Setback:** Ten (10) feet. Surface treatment beyond two feet from the sidewalk needs to be landscaped or treated with decorative pavers. Asphalt is prohibited. For full-block developments, a minimum of 50% of the primary street-facing building façade must be located at the minimum two (2) feet setback as described in 4.A.
 - C. ~~**Building Coverage:** Minimum of 50% of the site area, except for transit hubs.~~

(***)

5. **Building Height.** The intent of the building height standards is to set guidelines to assist the development of buildings in the downtown core that increase economic activity, and capital value and encourage investment in the downtown core. ~~revitalization in keeping with overall intentions for Redmond Downtown Redevelopment. Building height and density contribute to these results.~~ The following guidelines provide performance standards that encourage innovative design and development techniques within specific parameters. They are generally prioritized to include the following: Compatibility with existing downtown buildings and surrounding residential neighborhoods; Human scale related to building design, including height and massing, and its impact on solar access and views; Multi-story and mixed-use buildings for increased density and diversified use on premium land in the urban core; Development incentives for increased d height, based on Performance Bonuses.

(***)

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- C. Buildings within the ~~d~~Downtown ~~e~~Overlay ~~d~~District shall only be permitted to exceed 75 feet if they comply with the standards set forth below.
1. **Performance Bonus:** Additional building height above 75 feet may be approved if the project achieves a minimum of twelve (12) points from the following:

Workforce Affordable Housing: The project provides workforce <u>affordable</u> housing, per City standards, for <u>low- and</u> moderate-income households (no more than 80 percent of the HUD area median income), as a percentage of the total number of residential units built. These units shall remain dedicated to moderate income households for a period of at least twenty years. 3 points for 10%, 4 points for 15%, and 5 points for 20% of total number of residential units built for <u>affordable housing</u> moderate-income households.	3 - 5 pts.
Workforce Housing: The project provides workforce housing, per City standards. 1 point for 10%, and 2 points for 20% of total number of residential units built for workforce housing.	<u>1-2 pts.</u>
(***)	

(***)

7. **Off-Street Parking.** In addition to the standards of 8.0505 – 8.0515, the following standards shall apply for off-street parking in the Downtown Overlay District:
- D. **Off-Street Parking Requirements (Number of Spaces):**
1. Residential: Per State Condominium Code
 2. Non-Residential: 1 parking space per 500 net square feet
 3. For buildings over 75 feet in height: 1 parking space per 1000 net square feet.
- E. **Fee-In-Lieu of Parking:** The purpose of these provisions is to allow development in the Downtown Overlay District to reduce the number of off-street ~~on-site~~ parking spaces through payment of a fee in order to meet the parking requirements set forth in this Code. These provisions may be utilized for parking required for new construction or for an increase in required parking resulting from the change of use of an existing building.

Payment made to the City in-lieu of supplying the required off-street parking spaces for a project in the Downtown Overlay District may be provided as follows:

1. By the one-time payment of a non-refundable parking and mobility improvement fee to the City in the amount established in the City's Fee Schedule, paid prior to the issuance of Certificate of Occupancy. Fees collected shall be used to fund parking, street improvements or facilities to improve mobility or enhance pedestrian connectivity and safety in the Downtown Overlay District.
2. From time to time the City shall establish the value of off-street parking facilities on a per parking space basis, used to establish the above parking and mobility improvement fee. ~~Fees collected by the City from such payment shall be deposited in a parking fund and used only by the City to acquire or develop on-street or off-street parking and related facilities, which are determined to alleviate the need for parking spaces in the Downtown Overlay District.~~

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3. The City Engineering shall evaluate development proposals requesting to pay an in-lieu fee through conducting a Traffic Impact Analysis or parking study.
4. Any such request for parking in-lieu may be denied or reduced by the Community Development Director, or designee. The Director, or designee, shall determine:
 - a. Whether there is sufficient alternative parking within a two to four-block radius of the project location.
 - b. Whether approval of the request would have an adverse effect on surrounding neighborhoods.
 - c. Whether the request meets the Purpose and Intent of the Downtown Overlay District Zone.
- d. ~~Complies~~ Compliance with the Redmond Comprehensive Plan 2040 and support plans, as amended.

(***)

8.0180 Light Industrial (M-1), and Zone.
8.0182 General Industrial (M-1.5) Zones.
8.0185 Heavy Industrial (M-2) Zone.
8.0186 Large Lot Industrial (LLI) Zone.

(***)

1. **LLI Zone Regulations.** The following standards and regulations apply in the LLI Zone:
 - A. ~~Minimum lot size is 50 acres. The lot must~~ shall adhere ~~remain the size of its original minimum~~ to the designation as acknowledged by the Central Oregon Intergovernmental Council ~~until such time that a primary user is sited.~~
 - B. No property that is zoned LLI can be rezoned to another city zone within ten years of the LLI designation.
 - C. The minimum lot size is 50 acres. Division or separation of lots or parcels within the site to new lots or parcels less than the minimum size is not allowed until the site is developed with a primary traded sector use requiring a large lot.
 - D. ~~G.~~ Allowed uses are primarily focused on ~~limited to~~ traded sector uses as provided in Section 2 ~~per ORS 285B.280.~~
 - E. Uses allowed to support a primary user include: ~~until such time that a primary traded sector user occupies the site, at that time the following uses are allowed with the following provisions:~~
 1. Subordinate industrial uses ~~are allowed~~ that rely upon and support the primary traded sector use;
 2. Service commercial uses that support the traded sector uses ~~are allowed~~ if they are limited to 75000 square feet per use ~~and not more than 5% of the net developable area of the site in combination with retail uses;~~ and
 3. Retail uses ~~are allowed only as an accessory to a traded sector use and shall be limited to 75000 square feet and not more than 5% of the net developable area of the site in combination with service commercial uses.~~
 - F. ~~D.~~ **Conceptual Phased Site Development Plan.** A Conceptual Phased Site Development Plan is required for each primary traded-sector use as part of the Site and Design Review process in addition to the criteria and requirements outlined in Article IV of this code. In addition to the requirements outlined in Section

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8.3025, the following elements shall be considered as part of the Conceptual Phased Site Development Plan:

1. **Open Space.** Generally identify land provided for open space on the site.
2. **Connectivity and Trail Networks.** Prepare a A conceptual general transportation plan for streets, pedestrian connectivity and trail networks bicycle routes, and pedestrian paths. E.g., Provide a Connection of bicycle routes and pedestrian network of connectivity on the site for both utility and recreational purposes.
3. **Urban Site Design.** Generally D describe how the urban design elements (i.e., streets, open spaces, signage, and architecture) are integrated and coordinated throughout the site.
4. **Analysis of Anticipated Utility Consumption by Phase.** The plan shall include an A analysis of the anticipated utility consumption by phase for wastewater, water, power, natural gas, and any other utility infrastructure necessary to support the development.

2. **LLI Zone Uses Permitted.** The following uses are allowed outright or conditionally in the Large Lot Industrial Zone:

LAND USE:	ZONE:	RESTRICTIONS AND REQUIREMENTS:
Industrially Related Uses:	LLI	
Traded-Sector Uses	O	Per ORS 285B.280, traded sector means industries in which member firms sell their goods or services into markets for which national or international competition exists. This includes <u>warehousing, manufacturing, distribution centers</u> , research and development, and higher education institutions.
Subordinate Traded Sector Uses	O	After <u>a</u> the primary traded-sector use has been sited, subordinate traded sector uses are allowed. Subordinate means industries that rely upon and support <u>a</u> the primary traded sector use.
Service Commercial Uses	O	After <u>a</u> the primary traded-sector use has been sited, service commercial uses are allowed that support the traded sector uses and shall be limited to <u>75000</u> square feet <u>per structure</u> per use and not more than 5% of the net developable area of the site in combination with retail uses.
Service Retail Uses	O <u>C</u>	After <u>a</u> the primary traded-sector use has been sited, retail uses, <u>and eating and drinking establishments</u> are allowed as <u>a</u> an accessory to an outright permitted or conditional use and shall be limited to <u>75000</u> square feet per use <u>in the structure</u> and not more than 5% of the net developable area of the site in combination with service commercial uses.

O = Outright uses, C = Conditional Uses

3. **Minimum Standards.** See Table D, 8.0195.

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8.0190 Table C, Uses Permitted. The following uses identified below are allowed outright or conditionally in each of the Commercial and Industrial zones, ~~as follows:~~ Outright or conditional uses in the M-1.5 zone may be permitted Conditionally in the M-1 or M-2 zones; this allowance does not apply for uses Not Allowed ("N").

"O" means Permitted Outright
 "C" means Permitted Conditionally
 "N" means Not Allowed

Commercial/Industrial:	C-1	C-2	C-3	C-4	C-4A	C-5	M-1	M-1.5	M-2	DOD	Restrictions and Requirements:
(***) Residential Use above ground floor	O	O	O	O	N	N	N	N	N	O	Not in front of building.
Residential. Use on ground floor <25%	N	O	O	O	N	N	N	N <u>N</u>	N	O	
Residential Use on ground floor > 25%	N	N	N	N	N	N	N	N	N	N	
(***)											
Industrially Related Uses:	C-1	C-2	C-3	C-4	C-4A	C-5	M-1	M-1.5	M-2	DOD	Restrictions and Requirements:
Aircraft/Airport Service, Parking Lot, Maintenance	N	N	N	N	N	N	O	N	O	N	
Auto Wrecking, Recycling	N	N	N	N	N	N	C	N <u>C</u>	O	N	
Bakery, Wholesale Distribution	C	N	N	N	N	N	O	N <u>O</u>	O	N	
Batch Plants (Asphalt / Concrete)	N	N	N	N	N	N	N	O <u>C</u>	O	N	
(***)											
Lumber Mill	N	N	N	N	N	N	N	N <u>C</u>	O	N	
Manufacturing (Heavy Industrial)	N	N	N	N	N	N	N	N <u>C</u>	O	N	
(***)											
Tanning, Curing, Storing of Hides	N	N	N	N	N	N	N	N <u>C</u>	O	N	
Wholesale Printing and Distribution	N	N	N	N	N	N	O	O	O	N	
Wood Product Manufacturing and Assembly	N	N	N	N	N	N	O	O	O	N	
Offices and Office Products:	C-1	C-2	C-3	C-4	C-4A	C-5	M-1	M-1.5	M-2	DOD	Restrictions and Requirements:
Office	O	O	O	O	O	O	C	C	N	O	
Office Service and Supplies	O	O	O	O	O*	O	N	N <u>C</u>	N	O	
Offices related to Industrial Use	N	N	N	N	N	N	O	O	O	N	
Printing, Publishing	O	O	O	O	O	O	O	O	N	O	
Telemarketing, Call Center	O	O	O	O	O	O	C	C	N	N	
Public and Semi Public Uses:	C-1	C-2	C-3	C-4	C-4A	C-5	M-1	M-1.5	M-2	DOD	Restrictions and Requirements:
(***) RV Park, Public or Private	N <u>C</u>	N	N	N <u>C</u>	N	N <u>C</u>	N <u>C</u>	C	N	N	ORS 197.490 prohibits RV parks in Comm. Or Industrial zones <u>Refer to 8.0615(14)</u>
(***)											
Retail Uses:	C-1	C-2	C-3	C-4	C-4A	C-5	M-1	M-1.5	M-2	DOD	Restrictions and Requirements:
(***)											
Hardware Store	O	O	N	O	O*	O	N	O <u>C</u>	N	O	Only permitted w/primary service use in M zones
Heavy Equipment Sales	O	N	N	N	N	N	O	C	O	N	
Heavy Equipment Service	O	N	N	N	N	N	O	C	O	N	
Heavy Equipment Storage (outdoor)	N	N	N	N	N	N	N	C	O	N	

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Medical Supplies (Retail) Mobile / Manufactured Home Sales & Service	O O	O N	O N	O C	O N	N N	N N	O <u>C</u> N	N N	O N	
Novelty, Specialty, Variety Store	O	O	C	O	O*	O	N	N	N	O	Includes. music, art supply, electronic equipment, sporting goods Non storage-related; for retail sales
Outdoor Merchandise Display, Other	O	C	N	O	O	N	N	N <u>C</u>	N	C	
Pet Shop	O	O	N	O	O	O	N	N	N	O	
Plant Nursery	O	N	N	O	O	O	N	C	N	N	
Thrift Store – ¹	O	O	O	O	N	O	N	N	N	O	
Service Commercial Uses:	C-1	C-2	C-3	C-4	C-4A	C-5	M-1	M-1.5	M-2	DOD	
Appliance and Computer Repair	O	O	N	O	O*	N	N	<u>N</u>	N	O	Includes stereos, electronic equipment, residential appliances
Bank, Financial Institution	O	O	N	O	O	C	N	<u>N</u>	N	O	
Beauty & Barber Shops and Salons (includes spas)	O	O	O	O	O*	O	N	N	N	O	
Contractor Service	O	N	N	O	O	N	O	O	O	N	Enclosed within a building (except in M2 zone); includes equipment rentals and sale Includes. outdoor storage of equipment and building supplies
Contractor's Yard	C	N	N	N	N	N	O <u>C</u>	O	O	N	
(***)											

O* Maximum size = 10,000 square feet

O** Maximum size = 20,000 square feet

MIXED-USE ZONES

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8.0260 Table G, Uses Permitted. The following land uses are permitted outright or conditionally in each respective Zone as follows:

“O” means Permitted Outright

“C” means Permitted Conditionally

“N” means Not Allowed

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LAND USE:	ZONE:			REFERENCE / STANDARDS:
	MUN	MUE	MULW	
<u>Residential Uses:</u> **				All stand-alone residential uses listed in Table G may not occupy more than 20% of the net land area on the subject property zoned MUN.
(***)				
Live/Work Dwelling	O	O		See definitions of live/work houses, townhouses and apartments, and standards in RDC Section 8.3035, Design Review Criteria Live/work units must be a minimum of 2 stories
Residential Care Facility	C*	C		
Townhouse (3 or 4 units)	O*	O		See RDC Section 8.3035, Design Review Criteria. <u>8.0142, Townhouse Development and Design Standards</u>
(***)				
<u>Residential Uses:</u>				
Existing Single-Family Residential Use prior to May 2011			O	<u>An ADU is permitted to accompany existing single-family detached dwelling.</u>
(***)				

8.0261 MULW Special District Overlay.

(***)

MASTER DEVELOPMENT PLANS & PLANNED UNIT DEVELOPMENTS

(***)

8.0270 Master Development Plans. A Master Development Plan is required as a condition of annexation, or after annexation, but prior to or concurrent with rezoning from Urban Holding-10 to other City zoning districts. The specific requirements for a Master Development Plan are:

- Applicability.** This section applies to properties proposed for annexation or rezoning from Urban Holding-10, except that in the event that an applicant has applied for a Planned Unit Development application prior to or concurrent with rezoning from Urban

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Holding-10, the Master Development Plan approval criteria shall be those used for the Planned Unit Development application and the Great Neighborhood Principles.

(***)

3. Procedures for Review.

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C. Master Development Plan (MDP) or Partial Master Development Plan (PMDP) Submittal Requirements and Approval Process.

An application for approval shall include the submittal requirements set forth in the City's Land Use Review application form as well as the elements described below.

1. **Narrative.** A narrative shall set forth the goals and objectives of the plan and describe the urban characteristics of the planned area.
2. **Neighborhood Meeting.** Proof of a neighborhood meeting was conducted to provide an opportunity for ~~an~~ the applicant to meet with surrounding property owners to discuss the proposal. ~~Proof shall include, but is not limited to: invitation, notice, mailing, and posted signage.~~ See Section 8.0385 for meeting requirements.

(***)

11. **Transportation Analysis and Diagram.** Prepare a Transportation Impact Aalysis (TIA) including a grid street plan that is consistent with street spacing and connectivity guidelines in the *Redmond Transportation System Plan* (TSP) and adopted Area or Framework Plans. The TIA shall identify and sShow:

A. The proposed classification for all streets. ~~down to collector roadways.~~

B. ~~Show~~ The location of approved TSP improvement projects.

C. ~~and~~ Any capital improvements that may need to be added to the TSP in order to serve the plan area.

D. ~~Show~~ Proposed bicycle pedestrian, and trail routes.

E. ~~Show~~ Demonstrate how planned transportation facilities will connect to transportation facilities in adjacent urban areas.

(***)

14. **Great Neighborhood Principles.** MDPs shall address applicable Great Neighborhood Principles below. In instances where the property proposed for a MDP is located within the boundary of an adopted Area Plan, the MDP shall also address the Great Neighborhood Principles according to the specificity provided in the Area Plan.

(***)

- c. **Open spaces, greenways, recreation.** All new neighborhoods shall provide useable open spaces with recreation amenities that

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are integrated to the larger community. Central parks and plazas shall be used to create public gathering places and ~~when the cumulative number of lots or units (including phases of a project) exceed 23.~~ Central Parks and Plazas should be located in or near the center of the project to the extent practicable. New neighborhoods should retain and incorporate significant geological features such as rock outcroppings or stands of clustered native trees into the design and lot layout. Neighborhood and community parks shall be developed in locations consistent with the Redmond's Parks Master Plan.

(***)

- i. **Pocket parks/tot lots.** Fully developed "pocket parks" or "tot lots" shall be incorporated into medium and high density zoned residential subdivisions and site plans. These areas shall be developed for every twenty-five lots/units, a minimum of 3,000 square feet and privately maintained. Examples of amenities include: turf areas, benches, deciduous shade trees, irrigation, shrubs, natural or decorative features, and adequate trash receptable(s) and lighting.

(***)

8.0275 Planned Unit Development (PUD).

1. **Purpose and Applicability.** The purpose of a PUD is to:
 - A. Permit greater flexibility in land use regulations in all zones (e.g., reduction of minimum lot size requirements).
2. **Approval.** PUD approval is subject to:
 - A. Land use review and approval as Conditional Use.
 - B. Zoning standards, except as modified by the PUD.
 - C. Subdivision and Partitions Standards, except as modified by the PUD.
 - D. Site and Design Review Standards, except as modified by the PUD.
 - E. PUD Standards and Requirements.
 - F. ~~A public hearing with the Hearings Body following the procedure described in Land Use Administrative actions allowed under Article II.~~

(***)

5. **Review Procedure for PUD's.** The following procedure shall be followed in requesting approval of a PUD.
 - A. A pre-development meeting is required prior to submittal of an application.
 - B. Proof a neighborhood meeting was conducted for development proposals that generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, where a Transportation Impact Analysis (TIA) is required, See Section 8.0385 for meeting requirements.
 - CB. An applicant shall submit an electronic version of the complete application. The plan shall contain and show, at an engineer's scale of no less than 1" =10', the

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following information:

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~~D.G.~~ In considering the PUD, the City shall determine:

(***)

~~E.D.~~ The City Shall notify the applicant whether in its judgment the foregoing provisions have been satisfied and, if not, whether they can be satisfied with other alternatives or revision to the PUD.

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8.0285 Cottage Developments.

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5. Development Standards. CODs shall meet the following Standards unless otherwise specified. In the case that these standards conflict with other standards within Article I, III, or IV of the Redmond Development Code, these standards shall take precedence:
 - A. Cottage Developments (CODs) have no minimum site size but must include a minimum of 4 cottage units per development.
 - B. Densities.

Zone	Densities (per net acre)
R-1	Not applicable (CODs not allowed) <u>4 to 9 units / acre</u>
R-2	4 to 9 units / acre
R-3	4 to 10 units /acre
R-4	5 to 12 units / acre
R-5	8 or more units / acre

ARTICLE I – ZONING STANDARDS - ACCESSORY DWELLING UNIT STANDARDS

8.0325 Accessory Dwelling Units and Guest Houses. Accessory Dwelling Units (ADU's) and Guest Houses, when allowed in the underlying zone, are permitted subject to the following. The terms "accessory dwelling unit" and "guest house" are used synonymously herein except for the size limitations and are listed as separate and distinct uses in Table A; guest houses shall not contain kitchens.

1. Development Standards

~~1.A.~~ The size of a stand-alone accessory dwelling unit shall be no less than 300 square feet in gross floor area and no more than 900 square feet in gross floor area. Guest houses shall be no less than 300 square feet in gross floor area and no more than 1200 square feet in gross floor area.

B. ADU Setbacks:

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<u>Standard:</u>	<u>R-1</u>	<u>R-2</u>	<u>R-3 - R-3A</u>	<u>R-4</u>	<u>R-5</u>
Front*	10	10	10	10	10
Interior Side	5/10	5/10	5	5	5
Street Side	10	10	10	10	10
Rear**					
One-Story	10	10	10	10	5
One-Story, Abutting Alley	20	20	20	5	5
Two-Story	20	20	20	15	5
Two-Story, Abutting Alley	20	20	20	15	5
*The accessory dwelling unit cannot be located in front of the forward-most façade of the primary dwelling.					
**Deviation from rear setback may be granted administratively if acceptable off-street parking is provided for one vehicle and notice is provided to Affected Persons per Sections 8.1310 and 8.1335.B.					

2. C. If the accessory dwelling unit is located above a garage, the ADU shall not exceed the footprint of the garage.
- 3.2 An accessory dwelling unit must be able to function as a separate dwelling unit. This includes the following:
- A. The accessory dwelling unit must be separately accessible from the exterior. An interior entrance to the primary residence may be approved, pursuant to review and acceptance by the Community Development Director, or designee.
 - B. The accessory dwelling unit must have separately accessible utilities, unless served by the primary residence.
 - C. The accessory dwelling unit shall contain a kitchen.
 - D. The accessory dwelling unit shall contain a bathroom.
 - E. The accessory dwelling unit shall not be a Recreational Vehicle (RV) or portion thereof.
- 4.3 The finished floor height of an accessory dwelling unit shall be entirely above the natural or finished grade, whichever is higher, on all sides of the structure.
- 5.4 An accessory dwelling unit shall be located within the dimensional requirements of the zone district in which the property is located and cannot be located in front of the forward-most façade of the primary dwelling.
- 6.5 If the entrance is accessed via stairs, a covered porch, or other sufficient means of preventing snow and ice from accumulating on the stairs shall be provided.
- 7.6 Accessory dwelling units shall be developed in accordance with the requirements of this title which apply to residential development in general. These include, but are not limited to, all applicable International Building and Fire Code requirements related to adequate natural light, ventilation, fire egress, fire suppression, and sound attenuation between living units. This standard may not be varied.

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SUPPLEMENTARY PROVISIONS

8.0380 Temporary Use Permit (TUP).

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1. **Purpose.** The purpose of this section is to establish regulations for uses that are temporary in nature.
2. **Intent.** The intent of this section is to ensure that the temporary uses do not adversely impact the long-term uses of the same or neighboring sites or impact the general health, safety, and welfare of persons residing within the community. ~~EXHIBIT E~~
~~Exhibit E Page 26 of 32 Administrative Topics~~

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8.0385 Neighborhood Meeting.

1. **Purpose and Intent.** The purpose of the neighborhood meeting is to provide a forum for the applicant, surrounding neighbors, and interested members of the community to meet and consider a proposed land use application, and to discuss issues/concerns regarding the proposal prior to application submittal. Neighborhood meetings encourage citizen participation early in the development process, and an opportunity to revise the land use application to address the issues prior to application submittal.
2. **Applicability.** Neighborhood meetings are encouraged prior to submitting any land use application. The following application types or development proposals shall be subject to the neighborhood meeting requirements:
 - A. Development proposals that generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, where a Transportation Impact Analysis (TIA) is required.
 - B. Master Development Plans (and possibly PUDs).
 - C. Wireless and Broadcast Communications Facilities.
3. **Requirements and Procedures.** The neighborhood meeting must be held after a pre-development meeting with City staff, but before submittal of a land use application. The applicant shall be required to hold only one meeting prior to submitting an application for a specific site but may hold more if desired. If the development proposal is revised after the neighborhood meeting, and a major modification if requested, a second neighborhood meeting with a new notice shall be required before the revised application is submitted.
 - A. Location and Time. Neighborhood meetings shall be held in person at a location in reasonable proximity to the subject site. The meeting shall be held at a location open to the public, City staff, and at a facility that is ADA accessible. The meeting shall be held on a weekday evening, or weekends at any reasonable time. Applicants may provide a virtual component for participants to join in the meeting. The virtual component shall not be done in lieu of the in-person requirements. ADA accommodations when requested by attendee must be provided.
 - B. Notice - Mail. Mailed notice of the meeting shall be provided by the applicant to the neighboring property owners (within 750 feet outside city limits and 250 feet within city limits) and the Redmond Community Development Department between ten and 30 calendar days prior to the meeting. Notices must be sent first class and shall include the date, time, and location of the meeting, as well as a brief description of the development proposal and property location. The description shall take into consideration information provided by City staff at the pre-development meeting, include project contact information, a copy of the tax map or a GIS map that clearly identifies the location of the proposed development, and a conceptual site plan.

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Redmond Development Code Proposed Amendments

- C. Notice - Signage. The applicant shall also post notice of the neighborhood meeting on the subject site or on an access easement to the site within clear view of a public street at least seven days in advance of the meeting. The sign must display the meeting date, time, and address as well as project contact information.
- D. Meeting Requirements. The developer must provide a sign-in sheet for attendees to provide their name, address, telephone number, and email address. At the meeting, the applicant shall provide a conceptual site plan and describe the major elements of the proposal. Depending on the type and scale of the particular application, the applicant should be prepared to discuss proposed land uses and densities; traffic impacts; proposed building size and height; proposed access and parking; and proposed landscaping, buffering and/or protection of natural resource as applicable. Attendees will have an opportunity to speak at the meeting and may identify any issues that they believe should be addressed. If no one arrives within 30 minutes of the scheduled start time for the meeting, the applicant may close the meeting and this requirement will be considered met upon the applicant's submittal of documentation to that effect.
- E. Materials Submitted with Application. The neighborhood meeting notes that identify the major points discussed about the development, list of parties notified, signed affidavits of mailing and posting notices, copies of all materials provided by the applicant, and a signature sheet of attendees shall be included with the development application upon submittal.
- F. Validity Period. The land use application shall be submitted to the City within 180 days of the neighborhood meeting. If an application is not submitted in this timeframe, the applicant shall be required to hold a new neighborhood meeting.
- G. Denial. Failure of the applicant to hold a neighborhood meeting in accordance with these provisions prior to submittal of a land use application shall result in an incomplete application and the application may be rejected.

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WIRELESS AND BROADCAST COMMUNICATIONS FACILITIES

8.0420 Application Requirements. An applicant for a new wireless or broadcast communication facility shall submit the following information:

1. **Neighborhood Meeting.** Proof a neighborhood meeting was conducted to provide an opportunity for the applicant to meet with surrounding property owners to discuss the proposal. See Section 8.0385 for meeting requirements.

~~Public Meeting. Prior to submitting an application for a new wireless or broadcast communication facility, the applicant shall schedule and conduct a public meeting to inform the property owners and residents of the surrounding area of the proposal. It is the responsibility of the applicant to schedule the meeting/presentation and provide adequate notification to the residents of the affected area (the affected area being all properties within 1000 feet of the proposed site). Such meeting shall be held no less than 15 days and no more than 45 days from the date that the applicant sends notice to the surrounding property owners. The following provisions shall be applicable to the applicant's obligation to notify the residents of the area affected by the new development application:~~

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- A. ~~The applicant shall send mailed notice of the public meeting to all property owners within 1000 feet of the boundaries of the subject property (the subject property includes the boundary of the entire property on which the lease area for the facility lies). The property owner list shall be compiled from the Deschutes County Tax Assessor's property owner list from the most recent property tax assessment roll. The notice shall be sent a minimum of 15 days prior to the public meeting, and shall include at a minimum:~~
1. ~~Date, time, and location of the public meeting.~~
 2. ~~A brief written description of the proposal and proposed use, but with enough specificity so that the project is easily discernable.~~
 3. ~~The location of the subject property, including address (if applicable), nearest cross streets and any other easily understood geographical reference, and a map (such as a tax assessors map) which depicts the subject property.~~
- B. ~~Evidence showing that the above requirements have been satisfied shall be submitted with the land use application. This shall include: copies of all required notification materials; surrounding property owners list; and an affidavit from the property owner stating that the above listed requirements were satisfied.~~

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ARTICLE I – ZONING STANDARDS

Off-Street Parking & Loading Requirements

8.0500 Off-Street Parking. Parking space requirements are based on the following standards according to the use (note: all required handicapped parking is included in the calculation derived parking standards ~~within these charts~~). Manufacturing, warehousing, and other industrial uses may base the number of required parking spaces on the number of employees. When the number of employees is specified, persons counted shall be those working on the premises, including proprietors, during the largest shift at peak season.

Land Use	Standard:
<i>Residential</i>	
All residential uses within the Downtown Overlay District	1 space per Dwelling Unit (DU);
Apartment	2 spaces / DU; 1 space / Mgr., 1 space / 10 DU* plus:
Bed and Breakfast	1 space / per bedroom
Boarding House	1 space / per bedroom
Caretaker, Watchman living on-site	2 spaces / per dwelling unit DU
Cottage Clusters / and Cottage Developments	1 space / per cottage
<u>Duplex</u>	<u>1 space / DU</u>
Guest Houses	1 space / per Guest House
Homeless Shelter	4 .5 space / per room, or 1 space / per employee or service provider (fullest shift)

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Land Use	Standard:
Multi Family Complex (over 4 D.U.s) <u>(Apartments)</u> <u>Studio ≤600 sf</u> <u>Studio >600 sf / 1 bedroom</u> <u>2 bedrooms</u> <u>3 or more bedrooms</u> <u>Senior Housing Developments</u> <u>(55+ communities)</u>	<u>1 space / 10 DU; 1 space / Mgr. Plus: 2</u> <u>spaces / DU; 1 space / Mgr., 1 space / 10 DU</u> <u>1 space / DU</u> <u>1.5 space / DU (1 space per Affordable</u> <u>Housing DU)</u> <u>1.75 spaces / DU (1.5 spaces per Affordable</u> <u>Housing DU)</u> <u>2 spaces / DU</u> <u>1 space / DU (0.75 space per Affordable</u> <u>Housing DU)</u>
Triplex and Quadplex Residential Use other than Ground Floor Residential Use, Ground Floor < 25% Residential Care Facility (6 or more residents) Residential Care Home (5 or less residents) Single Family Detached Dwelling Duplex Townhouse <u>Triplex and Quadplex</u>	1 space per DU 2 spaces per DU 2 spaces per DU <u>4 .5 space / per each 2 rooms, 1 space /</u> <u>employee (fullest shift)</u> 2 spaces 2 spaces / per DU 1 space per DU 1 space / per DU <u>1 space / DU</u>
(***)	

8.0505 Off-Street Parking and Loading. General provisions are as follows:

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- Requirements for types of buildings and uses not specifically listed in these standards shall be determined by the Community Development Director, or designee ~~Hearings Body~~, based upon the requirements for comparable uses listed.

(***)

- Off-street parking spaces for Dwelling Units (DU) ~~dwelling~~s shall be located on the same parcel with those dwellings, or written contract of agreement shall be provided to the City that expressly permits shared use of parking areas which are off-site.

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- In any zone, every building having a gross floor area of 10,000 square feet or more, which is to be occupied for: manufacturing, storage, warehousing, goods display, retail sales, a hotel, a hospital, a mortuary, a laundry, dry cleaning establishment, or other uses similar requiring the receipt or distribution by vehicles, or materials or merchandise, shall provide one off-street loading berth, plus one additional loading berth for each additional 20,000 square feet of gross floor area. Each loading berth shall be provided with paved access, driveways and surfacing in the same manner as for off-street parking, except that each space shall be 10 feet wide and 22 feet long with a height clearance of at least 14 feet. A

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sight-obscuring screen, berm, or landscaping shall conceal all loading areas from view from public streets or roads.

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CONDITIONAL USES

8.0600 Authorization to Grant or Deny Conditional Uses. Uses designated herein as conditional uses may be permitted upon authorization by the Hearings Body in accordance with the standards and procedures established in this article. Before approving an application for a conditional use, the Hearings Body shall find the following criteria are either met, can be met by observance of conditions, or are not applicable:

1. The proposed use will be consistent with the Comprehensive Plan, the zoning ordinances and other applicable ordinances and standards of the City.
2. The location, size, design, and operating characteristics of the proposed use will have minimal adverse impact on the livability, value, or approximate development of abutting properties and the surrounding area.
3. The proposed use will not exceed operational capacity of City infrastructure including sewage system, water system or the transportation system.
4. That the proposed use will not conflict with, diminish, or substantially adversely affect the character and nature of the established neighborhood in which it is located.

8.0602 Neighborhood Meeting. Proof a neighborhood meeting was conducted for development proposals that generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, where a Transportation Impact Analysis (TIA) is required, See Section 8.0385 for meeting requirements.

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8.0615 Standards Governing Conditional Uses. A conditional use shall comply with the standards and criteria of the zone in which it is located and with the standards and criteria set forth in this section and in sections 8.0600 and 8.0605.

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14. Recreational Vehicle Park: A recreational vehicle park shall be built to State standards in effect at the time of construction and shall comply with the following provisions:

A. Use Standards

- ~~1. When in association with a mobile home park, the total number of recreational vehicle spaces with an overnight use shall not exceed 20 percent of the total maximum number of mobile home spaces allowable under these standards.~~
- 12.** No recreational vehicle park or overnight use area shall be permitted with access further than 1,000 feet from a designated arterial or collector street or private street of equal paved width. Further, such access roads shall be designed and constructed at the maximum design standards for right-of-way and/or pavement width (60 feet/36 feet). A lesser standard of not less than 30 feet may be approved by the hearings body if no street parking is allowed, sufficient off-street parking is provided and only if the proposed

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park plan is accompanied by an approved maintenance and enforcement management agreement.

- ~~23.~~ The design of recreational vehicle parks ~~and overnight use areas~~ shall be subject to site plan review and approval and ~~shall recognize, and have minimal adverse impacts on, the neighborhood.~~
- ~~34.~~ Management headquarters, recreational facilities, toilets, dumping stations, showers, coin-operated laundry facilities, and other uses and structures customarily incidental to operation of a recreational vehicle park and campground are permitted as accessory uses to the park.

B. Design Standards.

1. The maximum density of an RV park shall be 20 units per acre.
2. The space provided for each recreational vehicle site shall be not less than 1,200 square feet, exclusive of any space used for common areas, such as roadways, general use structures, walkways, common parking areas, and landscaped areas.
3. Roadways other than those described 2- above shall be not less than 30 feet in width if parking is permitted on the margin of the roadway, or less than 24 feet in width if parking is not permitted on the edge of the roadway, shall be paved with asphalt, concrete, or similar impervious surface, and designed to permit easy access to each recreational vehicle space. When a service drive provides only secondary access to all abutting recreational sites and those sites are all served by a roadway meeting the above standards, the secondary drive may be reduced to 14 feet if one-way and posted for no parking.
4. Entrance driveways shall be located not closer than 150 feet from the intersection of public streets.
5. A space provided for a recreational vehicle shall be covered with a dust-free crushed gravel, or paved with asphalt, concrete, or similar materials, and be designed to provide runoff of surface water. The portion of the space not occupied by a recreational vehicle and not intended as an access way to the recreational vehicle or part of an outdoor patio need not be paved or covered with gravel, provided the area is landscaped or otherwise treated to prevent dust or mud.
6. A recreational vehicle space shall be provided with piped, potable water and sewage disposal service. A recreational vehicle staying in the park shall have available water and sewage service provided by the park if the vehicle has equipment needing such service.
7. A recreational vehicle space shall be provided with electric service.
8. Trash receptacles for the disposal of solid waste material shall be provided in convenient locations for the use of guests of the park and shall be of such capacity and number so that there is no accumulation of uncovered trash at any time. Trash shall be removed from the property on a scheduled basis to prevent health hazard or nuisance.
9. No recreational vehicle or any other camping unit shall be used as a permanent residence ~~place of abode~~, dwelling, or business or for indefinite periods of time. Occupancy ~~and/or~~ placement extending beyond six months in any 12-period shall be presumed to be permanent occupancy. Any action toward removal of wheels of a recreational vehicle except for temporary

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- purposes of repair is hereby prohibited. Camping units other than recreational vehicles shall be limited to 30-days in any 60-day period.
10. The total number of parking spaces in the park, exclusive of parking provided for the exclusive use of the manager or employees of the park shall be equal to one space per recreational vehicle space. Parking spaces shall be covered with crushed gravel, or paved with asphalt, concrete, or similar material, providing a dust- free surface.
 11. The recreational vehicle park shall provide toilets, lavatories and showers for each sex as required by the State Building Agency Administrative Rules, Chapter 918. Such facilities shall be lighted at all times of night and day, shall be ventilated, and shall be provided with adequate floor drains to permit easy cleaning.
 12. Recreational vehicles or other camping units shall be separated from each other and from other structures by at least 8 10 feet. Any ~~an~~ Accessory structures such as attached awnings, ~~carports~~, or individual storage facilities shall, for purposes of this separation requirement, be considered to be part of the recreational vehicle.
 13. The recreational vehicle park shall be enclosed by a fence, wall, landscape screening, earth mounds, or by other designs ~~approved by the Community Development Director~~ which will complement the landscape and assure compatibility with surrounding properties ~~with the adjacent environment~~.
 14. Each recreational vehicle park shall set aside along the perimeter of the recreational vehicle park a minimum 10' strip which shall be site obscuring landscaped and used for no other purpose. Additional area for landscaping may be required through the design review process.

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8.0695 Non-Conforming Lots of Record. Any lot which is smaller than the minimum area required in any zone may be developed and occupied by an allowed use in that zone provided that:

1. The lot is a legal lot of record which includes, but is not limited to, lots in a duly platted and recorded subdivision on or before the effective date of these standards or parcels created by an approved land partitioning prior to the effective date of the subdivision ordinance.
2. The use conforms to all other requirements of that zone, including setbacks, access, and any applicable site design requirements.
3. If there is an area deficiency, a permitted residential use shall be limited to a single dwelling unit ~~any~~ and may include accessory structures and uses, including home occupations and garages.

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8.0750 Authorization to Initiate Amendments. An amendment to the text of these standards this chapter (Development Code), ~~or to the City Comprehensive Plan,~~ or an amendment to the Comprehensive Plan Map may be initiated by City Council, Planning Commission, or Community Development Director. A property owner may initiate a request for a map or text amendment by filing an application with the Community Development Department.

ARTICLE II - LAND USE PROCEDURES - INTRODUCTORY PROVISIONS

8.1010 Application Requirements.

1. Applications for development ~~actions~~ or land use actions shall:

- A. Be submitted by the property owner or a person who represents in writing that he or she has authority from the property owner as defined herein to make the application;
- B. Be completed on a form prescribed by the Community Development Director, or designee;
- C. Be filed with a Transportation Impact Analysis, approved by City Engineering, when required per Section 8.2815;
- D.~~G.~~ Be filed with a narrative statement or Burden of Proof, explaining how the application satisfies each and all of the relevant criteria and standards in sufficient detail for review and decision-making; and
- E.~~D.~~ Be accompanied by the appropriate filing fee.

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8.1115 Initiation of Legislative Changes. A legislative change may be initiated by application of individuals upon payment of required fees, or by the City Council, ~~or the Planning Commission,~~ or Community Development Director.

LAND USE ACTION

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8.1310 Administrative Land Use Decisions with Prior Notice.

- 1. Notice of the application shall be sent within ten (10) days of acceptance of the application to persons and parties ~~neighborhood associations~~ entitled to notice under Section 8.1335 herein. Such notice shall include all the information specified under Section 8.1340 except for those items specified in Subsections (g) and (j) unless the decision is referred to a hearing.
- 2. Any person may comment in writing on the application within fourteen (14) days from the date notice was mailed or a longer period as specified in the notice.
- 3. Notice of the ~~City's~~ decision and the appeal period shall be sent to all parties and ~~to all members of the Planning Commission and the City Council.~~
- 4. The applicant and all persons commenting as provided in this section constitute interested parties to the administrative decision. Any interested party can appeal the decision in accordance with Sections 8.1500 through 8.1560 herein.

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8.1321 Modification of Application

1. An applicant may modify an application at any time during the approval process up until the issuance of an administrative decision, or the close of the record for an application reviewed under a hearings process.

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8.1335 Notice of Hearing.

1. **Individual Mailed Notice.** Except for a legislative action, notice of a hearing shall be sent by mail to the following persons, and for a hearing provided twenty (20) days prior ~~to the hearing and shall be sent by mail to the following persons:~~
 - A. The applicant.
 - B. Owners of record of property as shown on the most recent property assessment roll of property located within at least one hundred feet (100') of the property which is the subject of the application. For the purpose of determining property notification, intervening public and private ways and water courses shall not be considered.
 - C. All owners of property located within two hundred fifty feet (250') of the property which is the subject of a Plan Amendment application or zone change application.
 - D. ~~For a solar access or solar shade exception application, only those owners of record identified in the application as being burdened by the approval of such an application.~~
 - D.E. The tenants of a mobile home park when the application is for the re-zoning of any park or all of a mobile home park.
 - E.F. The failure of a property owner to receive mailed notice shall not invalidate any land use approval.
2. **Posted Notice.**
 - A. Notice of a hearing should be posted by the applicant on the property for twenty (20) days prior to the hearing. Such notice should where practicable, be visible from an adjacent street.
 - B. At least twenty (20) days prior to any initial hearing, the applicant shall provide an affidavit attesting to the fact that notice has been posted as recommended by this section.
3. **Published Notice.** In addition to notice by mail and posting, notice of a hearing shall be published in a newspaper of general circulation in the city at least ten (10) days prior to the hearing.

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8.1515 Notice of Appeal. Every Nnotice of appeal shall include:

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8.1540 Hearing on Appeal.

1. The appellant and interested parties who have commented as part of the record ~~all other parties~~ to the decision ~~below~~ shall be mailed notice of the hearing on appeal at least twenty (20) days prior to any de novo hearing or deadline for submission of written arguments as

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- provided in ~~Section 8.1335~~.
2. ~~Except as otherwise provided in this chapter, I~~ the appeal shall be heard as provided in Section 8.1355 ~~8.1335~~ of the RDC ~~Redmond Code~~.
 3. The order of hearings body shall be as provided in Section 8.1330 of the RDC ~~Redmond Code~~.
 4. The record of the proceeding from which appeal is taken shall be a part of the record on appeal.
 5. The record for a review on the record shall consist of the following:
 - A. A written transcript of any prior hearing or meeting;
 - B. All written and graphic materials that were part of the record below;
 - C. The hearings body decision appealed from;
 - D. Written arguments, based upon the record developed below, submitted by any party to the decision;
 - E. Written comments submitted by the planning commission or individual planning commissioners, based upon the record developed below; and
 - F. A staff report and staff comment based on the record.
 6. In a review on the record, testimony shall be limited to arguments based on evidence in the record, no new oral or written evidence may be submitted except as otherwise permitted by the Hearings Body ~~City Council~~.

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SUBDIVISION APPLICATION PROCEDURE

- 8.2200 Pre-Application Meeting.** Prior to submitting a tentative subdivision plat each applicant or their representative is required to meet with the Community Development Director or a designated staff member(s) to review the proposal.

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- 2. Information concerning existing conditions:**

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- K. Existing covenants, conditions, and restrictions.
- L. Conditions specified on the approved A Traffic Impact Analysis (TIA) prepared in accordance with Section 8.2815 ~~of this Code~~.

(***)

- 8.2202 Neighborhood Meeting.** Proof a neighborhood meeting was conducted to for development proposals that generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, where a Transportation Impact Analysis (TIA) is required, See Section 8.0385 for meeting requirements.

- 8.2205 Application Submission.** Any person, authorized agent, or representatives, proposing a subdivision, shall include with an application and filing fee for a subdivision, a tentative plat together with improvement plans and other supplementary material as may be required.

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8.2236 Subdivisions may be created following two tracks: Track 1 (General) and Track 2 (Clear and Objective Standards).

1. **Track 1 – General Criteria. Subdivision Tentative Plans (No ‘Needed Housing’).** The City shall approve, approve with conditions, or deny a proposed subdivision. Approval, or approval with conditions shall be based on compliance with the following criteria:

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- K. The proposal complies with the Traffic Impact Analysis (TIA) Review provisions per Section 8.2815.

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2. **Track 2 – Subdivision, Tentative Plan Approval Criteria (‘Needed Housing’ & Clear and Objective Standards).** The planning division shall approve, approve with conditions, or deny a proposed subdivision. Approval, or approval with conditions, shall be based on compliance with the following criteria:

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- I. The proposed subdivision complies with the Traffic Impact Analysis (TIA) Review provisions per Section 8.2815.

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BOUNDARY LINE ADJUSTMENTS

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~~**8.2625 Final Plat Approval.** After the final plat has been reviewed and approved by the City, and when all signatures as required by the Deschutes County Surveyor other than the Development Services Director, County Clerk, and County Commissioner appear on the mylar, the City Engineer and Planning Director shall sign the final plat mylar and return it to the applicant to file with Deschutes County.~~

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**ARTICLE III – LAND DIVISION STANDARDS
DESIGN STANDARDS AND IMPROVEMENTS**

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8.2705 Blocks, Lots and Parcels

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5. **Through/Double Frontage Lots and Parcels.** Through lots or parcels, and lots or parcels with double frontage shall be avoided whenever possible, including lots or parcels created adjacent to Collector and Arterial Streets, but not including alley frontage as described in Section 8.2705(6) below, except when they are necessary due to an irregular parent lot or parcel configuration, or are necessitated by topography or other unique circumstance. ~~A Conditional Use Permit is required when a tract is proposed as a remedy for Through/Double Frontage Lots and Parcels.~~

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8.2710 Streets.

2. **Existing Streets.** Whenever existing streets, adjacent to or within a tract, are of inadequate width per City of Redmond Standards and Specifications and the City's approved Transportation System Plan ~~to accommodate the increase in traffic expected from the land division or by the City's transportation policies as determined through a transportation impact analysis,~~ additional right-of-way shall be provided at the time of the land division by the applicant. During consideration of the tentative plat for the subdivision or partition, the Hearings Body shall determine whether the improvements to existing streets, adjacent to or within the tract, are required. If so determined, such improvements shall be required as a condition of approval of the tentative plat. Improvements to adjacent streets shall be required where traffic on said streets shall be directly affected by the proposed subdivision.

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SUPPLEMENTARY PROVISIONS

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- 8.2815 Transportation Impact Analysis (TIA).** It shall be the burden of the developer to evaluate transportation system impacts ~~through studies prepared by a qualified registered professional engineer. When a transportation impact analysis is required, it must demonstrate that the following standards are met:~~ when a proposed development involves either a Subdivision, Site and Design Review, PUD, Master Plan, Comprehensive Plan Amendments, a change or expansion of use, or any other development that the City Engineer deems necessary.

1. The following vehicle trip generation thresholds shall determine the level and scope of transportation analysis required for a new or expanded development. Trip ends shall be calculated as per the Institute of Transportation Engineers manual, Trip Generation, current edition, or local trip generation studies prepared by a qualified registered professional engineer and approved by the City Engineer.
A. A development will be required to provide a Trip Generation Report per Section 8.2815(2) for developments which generate less than 200 daily or 20 p.m. peak hour vehicle trips. The Trip Generation Report shall be prepared by a professional engineer licensed in the state of Oregon. The Engineering Department will review and evaluate the Trip Generation Report to determine if a Transportation Impact Analysis (TIA) is required.

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Projects that generate less than 200 daily or 20 p.m. peak hour trip ends may be required to provide a TIA when, in the opinion of the City Engineer or his/her designee, significant capacity and/or safety problem is caused, or adversely impacted by the development. The City Engineer, or designee, shall determine the scope of this analysis.

- B. If a proposed development will generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, then a TIA shall be required per Section 8.2815(3). The TIA shall bear the stamp and signature of a licensed professional engineer especially qualified in traffic engineering by the State of Oregon. The City Engineer shall determine when a TIA has satisfied the requirements of the development's impact analysis.
2. When a Trip Generation Report is required, it must demonstrate the existing use, proposed use, existing trips per the ITE, and proposed trips per the ITE. Local trip rates may also be considered if supported by traffic counts conducted according to ITE guidelines. The report must include a conceptual site plan that shows adjacent roadways, alleys, roadway classifications, and access points.
3. When a TIA is required, it must demonstrate that the following standards are met:
- A.1. The standard of measurement that will determine the acceptability of traffic flow on City streets will be a delay-based level of service as defined by the Highway Capacity Manual, Special Report 209, third Edition (2000 update or subsequent document updates) published by the Transportation Research Board. The determination of LOS shall be calculated by a methodology that is approved by the City Engineer. The acceptable standard of LOS for City streets shall be LOS E during the peak 15 minutes of the peak hours of the average weekday. A lesser standard shall be acceptable at unsignalized intersections with low volume minor street approaches if the volume-to-capacity ratio is less than 0.90 and the 95th percentile vehicle queue is less than four vehicles during the peak hour.
 - B.2. The Average Daily Traffic (ADT) volume of Local Street roadways within the City of Redmond shall be less than 1,200 vehicles per day (VPD). Developments which add vehicle trips to Local Streets with an ADT greater than 1,200 VPD may be asked to provide mitigation in the form of additional access to the site, when in the opinion of the City Engineer, the residential livability is degraded by excessive local street traffic volume.
 - C.3. New development that will cause degradation below those levels shall be required to provide mitigating transportation system improvements that will restore the LOS to the accepted standard, as is practical, as determined by the City Engineer and pursuant to the adopted City's of Redmond Transportation System Plan. Where there are impacts to the State Highways, the City and ODOT shall work cooperatively to determine appropriate courses of action based on ODOT and City standards.
4. ~~The following vehicle trip generation thresholds shall determine the level and scope of transportation analysis required for a new or expanded development. Trip ends shall be calculated as per the Institute of Transportation Engineers manual, Trip Generation, 8th edition (or subsequent document updates), or local trip generation studies prepared by a qualified registered professional engineer and approved by the City Engineer. The City Engineer shall determine when a TIA has satisfied the requirements of the~~

Exhibit A

Redmond Development Code Proposed Amendments

~~development's impact analysis. The TIA shall bear the stamp and signature of a qualified registered professional Engineer with a license valid in the State of Oregon.~~

- ~~A. If a proposed development will generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, then a Transportation Impact Analysis (TIA) shall be required.~~
- ~~B. Projects that generate less than 200 daily or 20 p.m. peak hour trip ends may also be required to provide a Transportation Impact Analysis (TIA) when, in the opinion of the City Engineer or his/her designee, significant capacity and/or safety problem is caused, or adversely impacted by the development. The City Engineer, or designee, shall determine the scope of this analysis.~~
- ~~C. A development may be required to provide a Trip Generation Report for developments which generate less than 200 daily or 20 p.m. peak hour vehicle trips.~~

4.5. The TIA impact analysis area shall include at a minimum, the following intersections:

- A. All site access intersections.
- B. Nearest intersecting collector or arterial street upstream and downstream of the development.
- C. Any other collector or arterial street intersection that would experience an increase of 25 additional peak hour trips.
- D. Additional intersections requested by staff in the basis of anticipated impacts resulting from the development.

5.6. The TIA analysis shall include the following study time frames addressing:

- A. Existing conditions.
- B. Completion year of each significant phase of development.
- C. Five year forecast beyond final phase.

6.7. The following Tables are required in the TIA:

- A. Trip Generation (including phase breakdown if applicable)
- B. LOS Table (LOS for every analysis scenario at every study area intersection. Report LOS, delay, V/C ratio, 95% vehicle queue, and any additional pertinent analysis results)

7.8. The following Figures are required in the TIA:

- A. Vicinity/Locator Map.
- B. Site or Tentative Plan Map.
- C. Background Traffic Volumes (all study intersections and ,all analysis years)
- D. Trip Distribution and Assignment.
- E. Background + Site Generated Traffic Volumes (all study intersections and ,all analysis years).

8.9. Other Analysis Standards (as required by the study)

- A. Signal Warrants shall be performed where applicable per the Manual on Uniform Traffic Control Devices, current edition.
- B. Left Turn Lane Warrants shall be provided where applicable per ODOT criteria based on the Texas Transportation Institute (TTI) curves.
- C. Right Turn Lane Warrants shall be provided where applicable per ODOT criteria.
- D. The acceptability of sight distance at all study area intersections shall be determined per AASHTO (current edition) standards.
- E. Traffic signal progression analysis may be required if a new signal is proposed. The City Engineer shall approve the method of traffic signal progression analysis.
- F. Roadway improvements are to be based on the City of Redmond Standards and Specifications and ODOT design standards.

Exhibit A
Redmond Development Code Proposed Amendments

8.2820 Access Management Standards. All land use approvals divisions shall be in compliance with the following standards.

1. Driveway spacing and corner clearance as follows:

Roadway Classification	Minimum Access Driveway Spacing	Minimum Access Clearance to Corner	Intersection Spacing (Min.)
Local	No restrictions	30 feet	165 feet
Minor Collector	50 feet	80 feet	330 feet
Major Collector	165 feet	165 feet	330 feet
Minor Arterial	330 feet	330 feet	¼ mile
Major Arterial	ODOT Stds	ODOT Stds	ODOT Stds

(***)

4. Access shall be taken from the lower order street or alley unless otherwise approved by Public Works and/or ODOT through the land use review and approval process. Access to higher order streets may be allowed for emergency vehicles when restricted with a locked fire gate, bollards or similar, when approved or required by Redmond Fire and Rescue.
5. Unless adequate demonstration of site necessity, intersection safety and functionality are provided, through the land use review process, new lots and/or parcels will be limited to a single vehicular access. Existing lots may be permitted a secondary access when approved by the City Engineer.

(***)

9. Public Works may require supporting information, including but not limited to traffic count data, trip generation, trip distribution, truck and trailer turning/backing templates and/or on-site circulation diagram, Transportation Impact Analysis study, etc., in order to make a proper determination of access/driveway location.

10. Access/driveway locations may require alignment with existing driveways on the opposite side of the roadway as determined by Public Works or through the land use review and approval process.

~~11.40.~~ Access within the North Redmond US 97 Interchange Area Management Plan (IAMP) shall also conform to the 2007 "North Redmond US 97 Interchange Area Management Plan (IAMP)", as amended, provision of Chapter 9 Transportation Element of the Comprehensive Plan Addendum and Policy 12 n of Chapter 14 of the Comprehensive Plan.

ARTICLE IV – SITE AND DESIGN REVIEW STANDARDS

(***)

Exhibit A Redmond Development Code Proposed Amendments

8.3005 **Applicability of Site and Design and Review.**

Site and Design Review shall be required for any new development or use containing ~~structure(s) equal to or over 3,500 square feet in size (includes multiple structures).~~ a structure, or multiple structures, unless exempted in Section 8.3010.

8.3010 **Exemptions.** The following are exempt from Site Design and Review:

- Normal maintenance and repair.
- Hangar development entirely on and interior to airport property.
- Single family detached dwellings and middle housing, unless located on a lot within 100 feet of the canyon ~~and/or located within a zero lot line subdivision.~~
- Manufactured home in an approved manufactured home park.
- Additions to an existing building of less than 25% of the total building square footage, not to exceed 1,000 square feet.
- Any development that does not include the construction or alteration of a building which will have a negligible impact on the land as determined by the Community Development Director, or designee.
- Overhead electrical power transmission lines and poles greater than 12.5 kv.
- Child care facility in residential neighborhoods that utilize existing structures.

8.3015 **Procedure.** Prior to submitting a Site and Design Review application, the applicant shall be required to submit a Pre-development application and meet with the Community Development Director or designee to review the proposal.

A Site and Design Review application shall be submitted and reviewed by the Community Development Director, or designee, as an administrative land use decision with prior notice consistent with Section 8.1310. ~~The comment period under Section 8.1310(2) shall be at least fourteen (14) days.~~

A minor alteration, ~~minor modification~~ or major modification may be submitted for an approved Site and Design Review consistent with Section 8.1400. In addition to the procedures above, procedures to review Site and Design Review applications for properties in the C-2 Central Business District Commercial Zone and Downtown Overlay District are established in the ~~Downtown Architectural Design Standards~~ Sections 8.3040 and 8.3045.

8.3017 **Neighborhood Meeting.** Proof a neighborhood meeting was conducted to for development proposals that generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, where a Transportation Impact Analysis (TIA) is required, See Section 8.0385 for meeting requirements.

(***)

8.3030 Special Studies, Investigations and Reports. Special studies, investigations and reports may be required to ensure that the proposed development of a particular site does not adversely affect the surrounding community, does not create hazardous conditions for persons or improvements on the site. These may include Traffic Impact Aanalysis, ~~or~~ trip generation or parking studies/reports, impact of contaminated soils, soil conditions, flooding of waters and

Exhibit A

Redmond Development Code Proposed Amendments

excessive storm water runoff, tree preservation, and other concerns of the development's impact on adjacent properties or public facilities.

1. ~~A traffic generation statement prepared by a licensed Professional Engineer may be required at the time of application submittal at the discretion of the City Engineer, or designee.~~ An approved Transportation Impact Analysis (TIA) will be required prior to land use application completeness acceptance. A TIA approval memorandum, issued by the City Engineering, shall be included with the application submittal per Section 8.1010.

(***)

SUPPLEMENTARY PROVISIONS

(***)

- 8.3035 Design Review Criteria.** Prior to issuance of a building permit, the following applicable criteria shall be met.

(***)

4. **Architectural Requirements.**

(***)

- E. **Multi-Family Complexes.** This section establishes a process for the review of multi-family complexes development proposals in order to promote functional, safe, innovative, and attractive development that is compatible with the natural and man-made environment. The intent is to promote compatible development, foster the attractiveness and functional utility of multi-family development, protect public and private investments in the area, raise the level of community expectations for the quality of its environment.

1. **Table A. Minimum Standards.** The following minimum standards apply in each of the Residential zones:

Multi-Family Complex Standards:	R-4	R-5
Minimum Setback Distance		
Front	15	15
Side	15	15
Rear	20	15
Garage	20	20
Maximum Building Height	45	45
Maximum Density (Units/Net Acre)	<u>14.5</u>	<u>17.4</u>

(***)

6. **Building Alignment.** There shall be no window to adjoining window alignment when adjacent buildings are less than 30 feet apart. Frosted windows or similar are exempt from this standard.

Exhibit A
Redmond Development Code Proposed Amendments

(***)

13. **Storage.** All multifamily dwellings and complexes shall provide for storage of furniture, tools, equipment, building materials or supplies belonging to the occupants or management of the complex. Each dwelling unit shall have one assigned, securable storage area, a minimum 18 square feet, but shall be of a minimum size and dimension that is suitable to accommodate one bicycle of average size. Storage areas may be indoor, such as attached or detached garages, or within specific areas what are internal to each ~~swelling~~ dwelling unit. Storage areas may also be within outdoor structures such as within a separate storage building located on premises. The City may exempt or reduce the storage space requirement for “specialty housing”, such as senior housing or for housing for long-term infirm care.
14. **Off-Street Parking.** All off-street parking provisions addressed herein (including: number of spaces; loading areas; and design and improvement standards) shall be provided in conformance with Section 8.0500 through 8.0515 of the ~~City of Redmond Development Code~~. Plexes ~~Triplexes and quadplexes~~ shall comply with the City’s access policies regarding vehicle access and provide adequate pedestrian ways to safely navigate the parking areas and to connect to the public sidewalks. Adequate internal vehicle access shall be designed to minimize or eliminate vehicle/vehicle or vehicle/pedestrian conflicts in off~~o~~-street parking areas. If off-street parking areas are proposed to be placed between the primary building elevations and public streets, the application shall be subject to a public hearing pursuant to Article II – Land Use Procedures, Sections 8.1000 through 8.1720 of the ~~City of Redmond Development Code~~. ~~Parallel parking shall not be permitted on any common or shared driveways or private drives less than 28 feet in width for parking on one side, or less than 36 feet in width for parking on two sides.~~

(***)

8. **Traffic Impact Analysis (TIA).** The development must meet requirements per Section 8.2815 (Traffic Impact Analysis)
 - A. ~~The following vehicle trip generation thresholds shall determine the level and scope of transportation analysis required for a new or expanded development. Trip ends shall be calculated as per the current edition of the Institute of Transportation Engineers manual, Trip Generation, or local trip generation studies prepared by a qualified registered professional engineer and approved by the City Engineer. The City Engineer shall determine when a TIA has satisfied the requirements of the development’s impact analysis. The TIA shall bear the stamp and signature of a qualified registered professional Engineer with a license valid in the State of Oregon.~~
 1. ~~If a proposed development will generate 200 or more daily trip ends, or 20 or more p.m. peak hour trip ends, then a Transportation Impact Analysis (TIA) shall be required.~~
 2. ~~Projects that generate less than 200 daily or 20 p.m. peak hour trip ends may also be required to provide a Transportation Impact Analysis (TIA)~~

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- ~~when, in the opinion of the City Engineer, or his/her/its designee, significant capacity and/or safety problem is caused, or adversely impacted by the development. The City Engineer, or designee, shall determine the scope of this analysis.~~
- ~~3. A development may be required to provide a Trip Generation Report for developments which generate less than 200 daily or 20 p.m. peak hour vehicle trips.~~
- B. ~~The impact analysis area shall include at a minimum, the following intersections:~~
- ~~1. All site access intersections~~
- ~~2. Nearest intersecting collector or arterial street upstream and downstream of the development.~~
- ~~3. Any other collector or arterial street intersection that would experience an increase of 25 additional peak hour trips.~~
- ~~4. Additional intersections requested by staff.~~
- C. ~~The analysis shall include the following study time frames:~~
- ~~1. Existing conditions.~~
- ~~2. Completion year of each significant phase of development.~~
- ~~3. Five year forecast beyond final phase.~~
- D. ~~The following Tables are required in the TIA:~~
- ~~1. Trip Generation (including phase breakdown if applicable)~~
- ~~2. LOS Table (LOS for every analysis scenario at every study area intersection. Report LOS, delay, v/c ratio, 95% vehicle queue, and any additional pertinent analysis results)~~
- E. ~~The following Figures are required in the TIA:~~
- ~~1. Vicinity Map~~
- ~~2. Site or Tentative Plan Map~~
- ~~3. Background Traffic Volumes (all study intersections, all analysis years)~~
- ~~4. Trip Distribution and Assignment~~
- ~~5. Background + Site Generated Traffic Volumes (all study intersections, all analysis years)~~
- F. ~~Other Analysis Standards (as required by the study)~~
- ~~1. Signal Warrants shall be performed where applicable per the Manual on Uniform Traffic Control Devices, current edition.~~
- ~~2. Left Turn Lane Warrants shall be provided where applicable per ODOT criteria based on the Texas Transportation Institute (TTI) curves.~~
- ~~3. Right Turn Lane Warrants shall be provided where applicable per ODOT criteria.~~
- ~~4. The acceptability of sight distance at all study area intersections shall be determined per AASHTO (current edition) standards.~~
- ~~5. Traffic signal progression analysis may be required if a new signal is proposed. The City Engineer shall approve the method of traffic signal progression analysis.~~
- ~~6. Roadway improvements are to be based on the City of Redmond Standards and Specifications and ODOT design standards.~~
9. ~~City of Redmond Access Management Standards.~~ The development must meet requirements per Section 8.2820 Access Management Standards. ~~City of Redmond Access Management Standards. All land use approvals shall comply with the following standards:~~
- A. ~~Driveway spacing and corner clearance as follows:~~

Exhibit A

Redmond Development Code Proposed Amendments

Roadway Classification	Minimum Access Driveway Spacing	Minimum Access Clearance-Corner	Intersection Spacing
Local Street	No Restrictions	30 feet	165 feet
Minor Collector	80 feet	80 feet	330 feet
Major Collector	165 feet	165 feet	330 feet
Minor Arterial	330 feet	330 feet	¼ mile
Major Arterial	ODOT Stds	ODOT Stds	ODOT Stds

- ~~B. In all instances, access near an intersection shall be located beyond the influence of standing queues and opposing left turns sharing a continuous two-way left turn lane. This requirement may result in greater corner clearance or access spacing than the minimum distance indicated.~~
- ~~C. Every lot or parcel shall be permitted an access. In the event that the access management standards cannot be achieved, shared access with adjacent property shall be explored and provided where available.~~
- ~~D. Access shall be taken from the lower order street or alley unless otherwise approved by Public Works and/or ODOT through the land use process.~~
- ~~E. Unless adequate demonstration of site necessity, intersection safety and functionality, lots, parcels and/or developments will be limited to a single access as determined by Public Works through the land use process.~~
- ~~F. The access management standards apply to new development, redevelopment, subdivision, and partitioning of land.~~
- ~~G. Corner clearance is measured from the edge of right-of-way to the nearest edge of access. Spacing is measured from centerline of access/ intersection to centerline of access/intersection.~~
- ~~H. Adequate intersection sight distance and clear zone shall be maintained at all access/driveway locations per AASHTO standards (American Association of State Highway and Transportation Officials).~~
- ~~I. Access/driveway locations may require alignment with existing driveways on the opposite side of the roadway as determined by Public Works.~~
- ~~J. Public Works may require supporting information, including but not limited to traffic count data, trip generation, trip distribution, Transportation Impact Analysis study, etc., in order to make a proper determination of access/driveway location.~~
- ~~K. Access within the North Redmond US 97 Interchange Area Management Plan (IAMP) shall also conform to the "North Redmond US 97 Interchange Area Management Plan (IAMP)" provisions of Chapter 9 Transportation Element of the Comprehensive Plan Addendum and Policy 12 n of Chapter 14 of the Comprehensive Plan. (Amended by City Ordinance 2007-09, effective June 8, 2007)~~
- 10. Transportation Impact Analysis.** It shall be the burden of the developer to evaluate transportation system impacts through studies prepared by a qualified registered professional engineer. When a transportation impact analysis is required, it must demonstrate that the following standards are met:
 - ~~L. The standard of measurement that will determine the acceptability of traffic flow on City streets will be a delay-based level of service as defined by the Highway Capacity Manual, Special Report 209, Third Edition (2000 update or subsequent document updates) published by the Transportation Research Board. The~~

Exhibit A

Redmond Development Code Proposed Amendments

determination of LOS shall be calculated by a methodology that is approved by the City Engineer. The acceptable standard of LOS for City streets shall be LOS E during the peak 15 minutes of the peak hour of the average weekday. A lesser standard shall be acceptable at unsignalized intersections with low volume minor street approaches if the volume-to-capacity ratio is less than 0.90 and the 95th percentile vehicle queue is less than four vehicles during the peak hour.

- M. ~~The Average Daily Traffic (ADT) volume of Local Street roadways within the City of Redmond shall be less than 1,200 vehicles per day (VPD). Developments which add vehicle trips to Local Streets with an ADT greater than 1,200 VPD may be asked to provide mitigation in the form of additional access to the site, when in the opinion of the City Engineer, the residential livability is degraded by excessive local street traffic volume.~~
- N. ~~New development that will cause degradation below those levels shall be required to provide mitigating transportation system improvements that will restore the LOS to the accepted standard, as is practical, as determined by the City Engineer. Where there are impacts to the State Highways, the City and ODOT shall work cooperatively to determine appropriate courses of action based on ODOT and City standards.~~

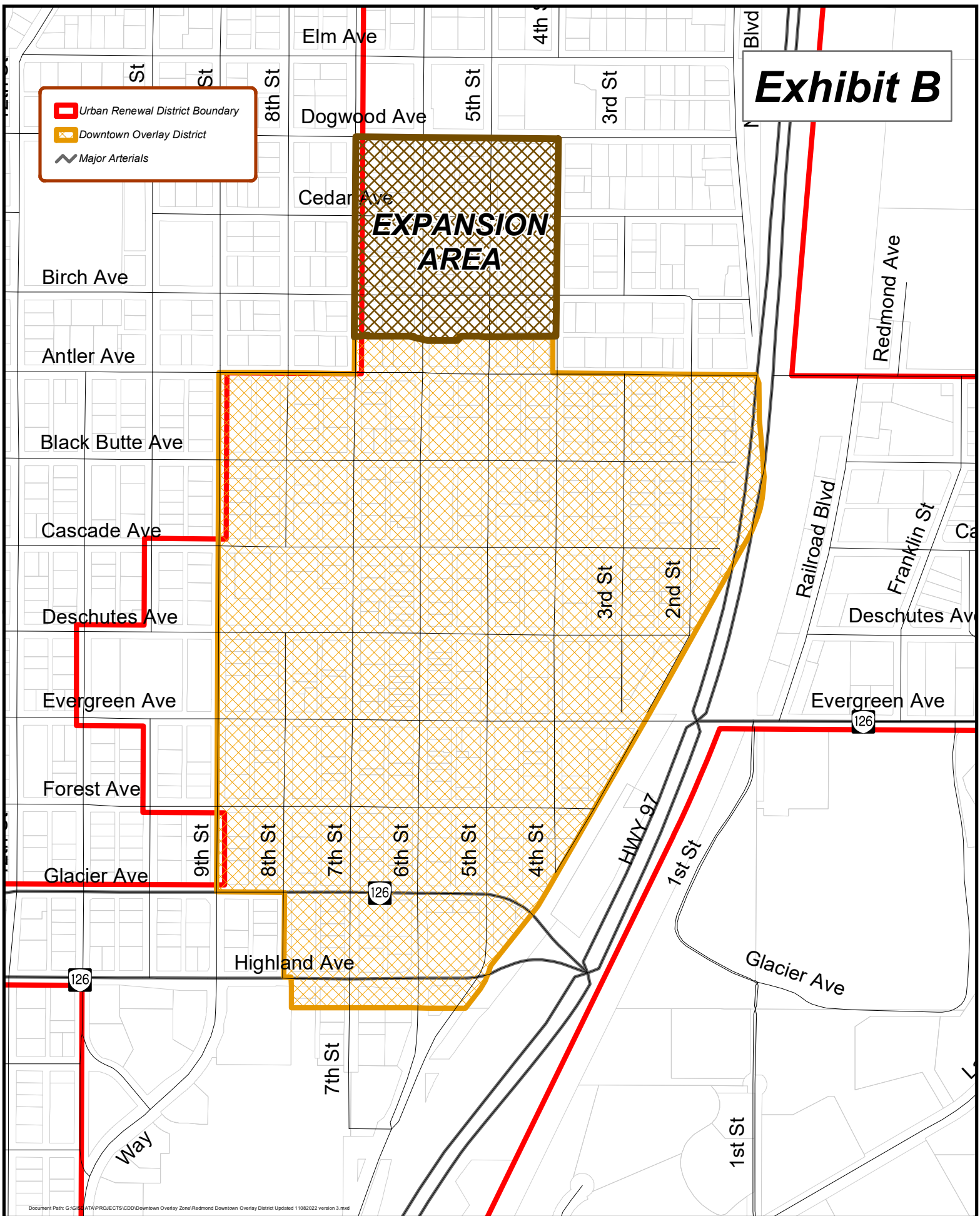
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Exhibit B

Urban Renewal District Boundary

Downtown Overlay District

Major Arterials



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Redmond Downtown Overlay District Boundary

FINDINGS FOR AN AMENDMENT TO THE REDMOND COMPREHENSIVE PLAN: INCORPORATE THE LATEST WATER MASTER PLAN AND WASTEWATER FACILITY PLAN INTO THE PUBLIC FACILITIES PLAN AND AS SUPPORTING PLANS TO THE COMPREHENSIVE PLAN

HEARING DATE: November 21, 2022, 6:30 PM, Redmond City Hall Council Chambers

HEARINGS BODY: Redmond Urban Area Planning Commission

FILE NUMBER: 711-22-000225-TA

FILE NAME: Redmond Comprehensive Plan Amendment

REQUEST: A Legislative Amendment to the Redmond Comprehensive Plan to Adopt and Incorporate the 2021 Water Master Plan, Updated 2018 Wastewater Facility Plan and Subsequent Amendment into the Public Facilities Plan and as Supporting Plans to the Comprehensive Plan

APPLICANT: City of Redmond

REVIEWING STAFF: Kyle Roberts, AICP, Planning Director
Through John Roberts, AICP, Deputy City Manager

I. BACKGROUND

Summary:

Redmond's Comprehensive Plan 2040 is the blueprint for the City's future development over the next 20 years. The Comprehensive Plan serves as the primary land use planning document, establishing a series of goals and policies that guide future growth and development. City leaders use the Comprehensive Plan to manage expected population and employment growth, coordinate public investments and make decisions about new and existing businesses, housing and neighborhoods, transportation, parks and trails, infrastructure, and more.

A major supporting plan to the Comprehensive Plan is the Public Facilities Plan (PFP). The PFP identifies the major public infrastructure needed during the next twenty years to support the City of Redmond's Comprehensive Plan. The PFP contains the Capital Improvement Plans (CIP) for Transportation, Water, Wastewater, and Parks. Individual master plans for Transportation, Water, Wastewater, and Parks provide background, analysis, and justification for the CIPs imbedded in the PFP. Naturally, as growth occurs, frequent updates are made to the master plans, pertinent reports, and documents that ultimately support and implement the Redmond Comprehensive Plan.

The City's Water Master Plan and Wastewater Facility Plan were updated relatively recently. For these master plans to be incorporated as part of the PFP and as supporting plans to the Comprehensive Plan, they must be formally adopted through a public hearing process and acknowledged by the Department of Land Conservation and Development (DLCD).

The proposed amendments to the Development Code and zoning map amendment were initiated legislatively by the City. The findings and supporting materials, demonstrate that incorporating these master plans are consistent with the Statewide Planning Goals, the Comprehensive Plan, and Development Code Section 8.0760. The four criteria set forth in Section 8.0760 are addressed herein, as well as applicable state laws and requirements.

Proposal:

The request is for a legislative amendment to adopt and incorporate the 2021 Water Master Plan, update to the 2018 Wastewater Facility Plan and subsequent amendment into the PFP and as supporting plans to the Redmond Comprehensive Plan.

These newly updated public facility plans will help assure that urban development in Redmond's urban growth boundary is guided and supported by types and levels of urban facilities and services appropriate for the needs and requirements of the areas to be serviced, and that these facilities and services are provided in a timely, orderly, and efficient arrangement, as required by Goal 11 of the Statewide Planning Program.

Exhibits:

The following exhibits make up the record in this matter:

Exhibit A – City of Redmond Water Master Plan, December 2021

Exhibit B – Update of 2018 Wastewater Facility Plan, November 2019

Exhibit C – Wastewater Facility Plan Amendment, October 2020

Noticing:

Per ORS 197.610, a notice of proposed additions to the Comprehensive Plan was submitted to the Department of Land Conservation and Development (DLCD) on October 17, 2022. Per Section 8.1110 of the Redmond Development Code, a public hearing notice for the November 21st hearing was published in the *Bend Bulletin* on November 10, 2022.

Applicable Criteria:

The following are the applicable sections from the Oregon Revised Statutes, Oregon Administrative Rules, and the Redmond Development Code:

- Oregon Revised Statutes (ORS) – 197.610 and 197.797
- Oregon Administrative Rules (OAR), Chapter 660:
 - Division 11, Public Facilities Planning
 - Division 15, Statewide Planning Goals and Guidelines
- City of Redmond Development Code:
 - Article I – Zoning Standards
 - Section 8.0760: Criteria for Amendments

II. FINDINGS & CONCLUSIONS

Findings:

Redmond Development Code, Article I – Zoning Standards: Amendments: Sections 8.0750 through 8.0770 set forth the procedure and standards for an amendment to the Redmond Comprehensive Plan. Specifically, Section 8.0760 sets forth the four review criteria that must be met when evaluating amendment requests. Findings for each criterion are presented below.

8.0760 Criteria for Amendments. The burden of proof is upon the applicant. The applicant shall show the proposed change is:

1. In conformity with all applicable State statutes;

FINDING: The following State statutes apply directly to this application:

ORS 197.610, *Submission of proposed comprehensive plan or land use regulation changes to Department of Land Conservation and Development;*

ORS 197.797, *Local quasi-judicial land use hearings; notice requirements; hearing procedures*.

ORS 197.610 requires local jurisdictions to submit proposed comprehensive plan or land use regulation changes to Department of Land Conservation and Development (DLCD). Notice of the proposed adoptions and additions to the Redmond Comprehensive Plan has been provided to DLCD more than 35 days in advance of the first evidentiary hearing concerning the amendment.

ORS 197.797 sets forth noticing requirements. The applicable RDC standards that address amendment and legislative procedures and noticing requirements (i.e., Sections 8.0750-8.0770 and 8.1100-8.1125) were developed in compliance with the applicable State statute regarding noticing and public hearings. The relevant findings, incorporated by reference herein, show compliance with the aforementioned statutes.

Notice of the proposed Comprehensive Plan amendment has been advertised in the local newspaper (public notice) as required by the RDC and State statute. Regarding statutory public hearing requirements, this proposal is legislative and not quasi-judicial. Sections 8.1100 through 8.1125 of the RDC implement the quasi-judicial statutory requirements in similar fashion and have been met. The Redmond Urban Area Planning Commission and City Council's public hearing and review processes meet the statutory requirements for the purpose of the review.

2. In conformity with the State-wide planning goals whenever they are determined to be applicable;

FINDING: The following State-wide planning goals have been determined to apply directly to this application:

Goal 1 – Citizen Involvement - calls for the opportunity for citizens to be involved in all phases of the planning process. The Redmond Urban Area Planning Commission serves as the City's formal citizen advisory commission to fulfill Goal 1 and is made up of Redmond area residents.

A public notice and agenda for the Planning Commission meeting where and when the proposed amendments will be discussed have been provided in accordance with law. All documents are available for public review. The public notice advertising the November 21st public hearing was published in the *Bend Bulletin*.

Goal 2 – Land Use Planning – requires establishing a land use planning process and policy framework as a basis for all decisions and actions related to use of land and to assure an adequate factual base for such decisions and actions. Through the course of review of the amendments, input was received from City staff, and input will be received from the Planning Commission and residents of the community through the public hearing process. The incorporation of the master plans' CIPs into the PFP and adding the master plans as supporting to plans to the Comprehensive Plan will support the implementation of the Comprehensive Plan, primarily Chapter 11.

Goal 11 – Public Facilities and Services – requires cities to plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban development. As mentioned earlier, as growth occurs, frequent updates are made to the master plans, pertinent reports, and documents. Information and data from the updated waster

and wastewater facility plans will be used to inform the basis for CIPs imbedded into the PFP. The CIPs provide for the budgeting and scheduling of identified needed infrastructure projects.

3. In conformity with the Redmond Comprehensive Plan, land use requirements and policies; and

FINDING: Chapter 1 of the Comprehensive Plan identifies goals and policies that address citizen involvement. Goal 1 speaks to engagement and the opportunity for the community to be informed and involved in all phases of the planning process. The Urban Area Planning Commission serves as the City's formal citizen advisory committee (as required by State Administrative Rule) and is made up of Redmond area residents. The Planning Commission is formally recognized through City Code and was appointed by the City Council. Thus, the Planning Commission is the appropriate public review and recommendation body to the City to meet this Comprehensive Plan policy.

Chapter 9 of the Comprehensive Plan identifies goals and policies that address economic development in Redmond. Goal 3 of the chapter identifies policies related to infrastructure planning. Policy 9-3-2 states that "The City will ensure that infrastructure planning is cost-effective, supports economic development, is consistent with the City's master plans for new area development, and supports cohesive development patterns across the City."

To ensure the planning of public infrastructure is consistent with the City's infrastructure master plans, said plans must be incorporated into the City's PFP and identified as ancillary plans to the Comprehensive Plan. In order to incorporate these plans, they must be formally adopted by the local governing body and acknowledge by DLCD.

Chapter 10 of the Comprehensive Plan identifies goals and policies related to housing in Redmond. Policy 10-4-1 of Goal 4, Infrastructure Planning, states the need to "Coordinate land use planning with the Capital Improvement Plan to ensure that infrastructure is available to support residential development..." As mentioned earlier, new data and information from the updated water and wastewater facility master plans will be incorporated into the PFP CIP.

Chapter 11 of the Comprehensive Plan addresses public facilities and services. The proposed amendment to incorporate the water and wastewater facility master plans into the PFP and Comprehensive Plan directly address all three of the goals outlined in Chapter 11 and many of the goals' policies.

4. That there is a change of circumstances, further studies justifying the amendment or mistake in the original zoning.

FINDING: This proposed amendment responds to a change of circumstances where there is new data and information from the updated Water Master Plan and Wastewater Facility Plan. These plans required updates due to growth and change in the community. New information and data will be used to inform the CIP imbedded in the PFP. These public infrastructure master plans provide foundational support to the Comprehensive Plan policies used to implement the Plan and Development Code.



CITY OF REDMOND

Water Master Plan

December 2021

Water Master Plan

City of Redmond

December 2021



Murraysmith

701 NW Arizona Avenue
Suite 200
Bend, Oregon 97703

Acknowledgements

Appreciation is expressed to all who contributed to the completion of this report.

City of Redmond

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David Stangel

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Brian Rowbotham

Dawn Wirz

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Executive Summary

Executive Summary

Introduction

The City of Redmond, Oregon (City) owns and operates a public drinking water system that serves a population of 36,122 people according to the Portland State University November 2021 estimate. This Water Master Plan (WMP) describes the City's existing water facility infrastructure and provides analysis and recommendations for improvements to serve existing and future water demands.

How This Plan Should Be Used

This WMP serves as the guiding document for future water system improvements, and should:

- Be reviewed annually to prioritize and budget needed improvement projects.
- Have mapping updated regularly to reflect development and construction.
- Have its specific project recommendations regarded as conceptual. (The precise location, specific timing, and exact site-specific details may be modified as part of the preliminary engineering phase of discrete projects.)
- Have its cost estimates updated and refined within the preliminary engineering and detailed design phases of individual projects.

Scope of Work

The City selected Murraysmith to develop a WMP for its water system. This scope of work includes the following major tasks and deliverables.

- Describe the City's existing water system.
- Develop and calibrate a hydraulic model.
- Develop population and water demand projections.
- Develop performance criteria for use in identifying deficiencies and sizing improvements.
- Evaluate the water system's hydraulic capacity to identify deficiencies for 5-year and 20-year planning horizons.

- Conduct a condition assessment of all wells and booster stations and provide a list of recommended improvements
- Identify an ongoing repair and replacement schedule for supply and distribution mains.
- Identify annual and instantaneous water rights and their regulatory status.
- Develop project recommendations and cost estimates for a capital improvement plan (CIP).

Organization of the WMP

This WMP is organized into four sections as described in the table below. Figures are located throughout the document. The water rights summary and calibration report are included in the appendix.

Table ES-1-1 | WMP Organization

Section	Description
Executive Summary	Purpose and scope of the WMP, summary of key components.
1 – Existing System Description	Description of the service area and overview of the existing system and facilities.
2 – Water Use Requirements	Population projections and water demand estimates for existing and future service areas.
3 – System Analysis	Overview of system performance criteria. Discussion of supply, storage, and pumping capacity, and distribution system hydraulic analysis and deficiencies for existing and future planning horizons.
4 – Capital Improvement Plan	Improvement project recommendations including cost estimates and timeframe for implementation.

Existing System Description

The existing service boundary is generally consistent with its City limits. The City's existing water distribution system is comprised of three pressure zones, relies entirely on groundwater and five typically active wells, five water storage reservoirs, and five booster pump stations. There are over 177 miles of water distribution system piping consisting of Ductile Iron, PVC, or Steel.

Near term changes to the City's existing system include a new reservoir (Reservoir 7), which will add 4 million gallons (MG) of gravity storage to the system and directly serve Zone 2. A new well (Well 8) fills the Reservoir 7 or can pump directly to the system if needed. A booster pump station is also being constructed at Reservoir 7 that serves Zone 1A. Antler Reservoir and the associated booster is planned for transition to stand-by in the Fall of 2022.

Zone 2 is currently served by gravity from the Forked Horn Butte (FHB) System Reservoir. The FHB System Reservoir is filled by the City's wells or boosters, located in Zone 2. The Transfer Station

boosts water from Zone 2 to the FHB Storage Reservoir. The Transfer Station also includes a set of valves that regulate the flow of water from the FHB Storage Reservoir back to Zone 2. A near-term modification to the system is planned that changes the Forked Horn Butte Pump Station (FHBPS) #1 supply from the System Reservoir to the Storage Reservoir becoming the primary source of supply to Zone 1 year-round. This has a number of benefits including: 1) reducing the pumping head at FHBS1, 2) increasing the turnover in the Storage Reservoir and 3) reducing the cycling of the FHB Storage water back to Zone 2. FHBPS #2 will then be a supplementary and backup pump station to serve Zone 1.

Advanced Meter Infrastructure (AMI) is used to monitor and track water consumption at customer meters. Water production is controlled and monitored by SCADA. The AMI program currently collects data every hour to every 6 hours. By the end of 2021, it will be fully converted to hourly readings.

Water Use Requirements

Population growth and corresponding water demand projections were developed for 5-year and 20-year planning horizons. Portland State Population Research Center data was used to estimate population growth of nearly 50,000 by the year 2040.

Current water demands were developed using historical data for years prior to 2020. The global pandemic impacted how water was used that are not anticipated to be representative for future years. The disruption to schools, businesses, hospitals, hotels, food service and recreational facilities was unprecedented.

The City's total historical per capita production, or total per capita demand, over the last five years has been relatively stable at approximately 215 gpcd. This value is comparable to other cities in the region.

Estimated demands and population projections were used to determine the water demand projections for average daily demand (ADD), maximum day demand (MDD), and peak hour demand (PHD) in the table below.

Table ES-1-2 | Demand Projections

Year	Population Estimate	ADD (gpm)	MDD (gpm)	PHD (gpm)
2019	30,812	4,450	10,500	20,400
2025	33,839	5,100	11,600	23,590
2040	48,575	7,400	16,360	33,250

The City summarizes customer water use as either residential or non-residential, with approximately 58 percent for residential purposes and 42 percent of systemwide by non-residential customers. The City has made successful efforts to reduce unaccounted for water, and as a result, unaccounted for water has been under 5 percent between the years of 2015-2019.

System Analysis

City has selected the following water distribution system performance criteria based on both regulations and industry standard practice to evaluate the water system. A calibrated hydraulic model was developed to assess existing pressure zones, service pressure, distribution main capacity, and storage sufficiency.

Table ES-1-3 | Performance Criteria

System Attribute	Evaluation Criterion
Water Supply	Provide MDD
Distribution Storage	Equalization Plus Emergency or Fire (Whichever is Greater)
Booster Pump Stations	Redundant pumps Capacity to meet greater of MDD+ fire flow or PHD Backup Power
Service Pressure	20 psi minimum during MDD + fire flow 45 psi minimum during PHD 60-80 psi target operating range
Distribution Piping	8-inch minimum future pipe diameter
Fire Suppression	Residential: 1,500 gpm for 2 hours Commercial 2,500 gpm for 2 hours Industrial: 3,500 gpm for 3 hours

The following general conclusions were developed through water system analysis and subsequent workshop with City staff.

Supply

- The City has adequate firm supply today, however two additional wells will be needed to meet projected demands through 2040. One of these, Well 8 is currently under construction.
- A backup power improvement at Well 4 is recommended.
- The City's current water rights are projected to be adequate through 2040.
- With the addition of Reservoir 7 as part of the South Redmond Facility, the City is projected to have adequate storage through 2040.

Pumping

- A pump improvement at the Well 6 reservoir booster station is recommended to meet firm capacity pumping requirements.

Distribution

- The existing system overall provides reliable water supply to customers.
- Pressures throughout the system are predominately adequate, with isolated hilltop areas experiencing low pressure due to elevation.
- High pressure locations are few and located in the canyon, west of NW Canyon Drive near NW Spruce Avenue.
- Some pipeline improvements are recommended to increase fire flow availability and to replace undersized mains.
- Investment in a GIS database of land use within the planning area is recommended.

Condition Assessment

A condition assessment evaluation was completed at the well and pumping facilities and provides recommendations for rehabilitation or replacement of system components for Wells 2, 3, 4, 5, 6, 7 and all three FHB booster pump stations: No1, No.2 and Transfer Station. Each facility was also reviewed for adherence to current state and federal standards. Generally, the system has been well maintained, however some deferred maintenance items relative to the electrical system and site security were identified for improvement.

All of the recommendations are included in the CIP, including:

- Arc Flash Study for all facilities
- Chlorine and electrical improvements at Well 4
- Accessibility and water quality improvements at Well 2
- Building improvements at Well 3
- Telemetry and Well 6

Capital Improvement Plan

The CIP provides a summary of proposed future improvements to pipelines, water supply, and booster stations based on system analysis presented in this WMP. Projects are grouped into two timeframes: 2021-2025 and 2026-2040. Projects such as the South Redmond Water Facility, that are currently under construction are not included in this table.

The CIP includes \$19 Million in improvements over the 5-year horizon and \$35 Million over the 6 to 20-year horizon.

Table ES-1-4 | 5-Year CIP Improvements (Years 2021-2025)

Project Type	Project Cost	Project Horizon
Distribution	\$6,539,000	2021-2025
Other	\$5,150,000	2021-2025
Supply	\$6,165,000	2021-2025
Upsizing	\$1,105,000	2021-2025
2021-2025 Total	\$18,959,000	2021-2025

Table ES-1-5 | 6 to 20-Year CIP Improvements (Years 2026-2040)

Project Type	Project Cost	Project Horizon
Distribution	\$9,718,000	2026-2040
Other	\$6,094,000	2026-2040
Supply	\$4,784,000	2026-2040
Upsizing	\$14,653,000	2026-2040
2021-2025 Total	\$35,249,000	2026-2040

Summary and Overall WMP Recommendations

This WMP constituted a significant investment of time and resources for City staff. This WMP utilized industry standard approaches by compiling and converting information to a GIS database and utilizing hydraulic modeling software to identify system deficiencies and refine recommended improvement projects.

Hydraulic modeling allowed for the evaluation of water system alternatives based on system hydraulics. A detailed condition assessment of pumping facilities identified short- and long-term improvements. The capital projects that have been identified provide a plan, phased over the next 20 years that will enable the City to continue providing quality water to its customers.

As a result of this WMP, the following recommendations are made.

- Implement short term (1-5 year) improvements as identified in the CIP to address existing capacity and condition issues.
- Continue improving the quality of available water system information and reassess long-term improvements (beyond 5 years) using future WMP updates, the soon to be developed GIS, hydraulic model and water consumption and production data.
- The past two years of COVID-19 impacts have created unprecedented conditions in many communities, including Redmond. How and when water was used has been impacted. Are these new patterns of water use the new normal or a relatively short-term phenomenon? The City also experienced a dry and hot summer in 2020 that resulted in high peak demands. Were these conditions exacerbated by a population staying closer to home and

using more water to irrigate their properties? During the last two years Redmond has continued to grow at high rate which may also have been impacted by a national trend of people leaving larger urban areas. The decision was made not to utilize 2020 or 2021 data (population or water use) due to the variability inherent in the information. Therefore, it is strongly recommended that the City adhere to its plan of updating the WMP in the 5-year timeline to assess whether the population and water use increases constitute a trend that will impact when additional supply, storage, and pumping improvements are required.



Section 1

Section 1

Existing System Description

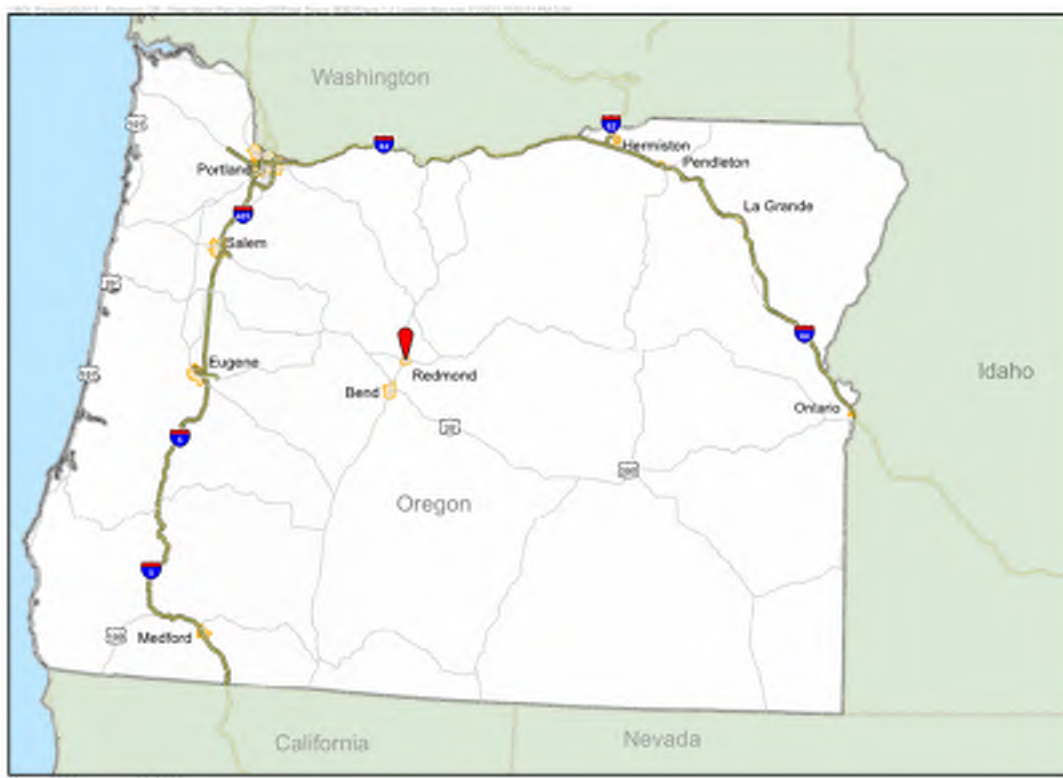
1.1 Introduction

This section provides an overview of the system location, service area, and existing water system infrastructure.

1.2 Location and Climate

The City of Redmond (City) is in the northeast corner of Deschutes County, located east of the Cascade Mountain Range, in the state of Oregon. The City is located on a plateau, with an elevation range from approximately 2,796 – 3,236 feet. The climate is typical of high desert with cool nights, sunny days, and an annual precipitation averaging 8 to 10 inches. July is typically the hottest summer month, with average highs around 82 degrees Fahrenheit (F) and peaks approaching 100 degrees F. Day time temperatures in winter are typically between 10 degrees F and 40 degrees F. Average annual snowfall is approximately 24 inches.

Figure 1-1 | Location of Redmond



1.3 Service Area

Redmond's existing water service area is relatively consistent with its city limits. Two small private water service providers are located within the City: Avion and Bentwood Water District. Both are located near some of the City's highest elevation service areas, near pressure Zone 1.

1.4 Water Supply & Water Rights

Water Supply and Water Rights were evaluated by GSI Water Solutions, Inc. in 2020. The technical memorandum "City of Redmond – Water Rights Summary", is presented as **Appendix A**. Conclusions from this technical memorandum indicated that the City holds a variety of water rights, all in good standing. Six available Tier 1 and Tier 2 groundwater rights authorize the use of up to 24.15 million gallons per day (MGD).

1.5 Distribution System

The City's existing water distribution system relies on groundwater as the only source of supply and serves a combination of commercial, residential, and industrial customers. Centralized facility monitoring and operational controls, as well as Advanced Meter Infrastructure (AMI), are used to control, track, and monitor water production and customer consumption. The AMI tracks metered water consumption, while supervisory control and data acquisition (SCADA) monitors and controls water production and operation of booster pumps. The existing system utilizes a number of storage tanks, some of which serve the system by gravity and others that must be boosted to match the hydraulic grade. **Figure 1-2** presents the existing system.

1.5.1 Pressure Zones

The water system consists of three pressure zones. The largest of these is Zone 2, serving the majority of the City. Zone 1 represents the highest service elevations in the system. Zone 1A is currently supplied by pressure reducing valve (PRV) from Zone 1; however, in conjunction with the new reservoir (7), a booster station will be constructed to serve Zone 1A directly. A new storage facility (7) is under construction to serve Zone 2 located on Forked Horn Butte (FHB) and will be at the same hydraulic grade as the existing Forked Horn Butte System Reservoir.

Table 1-1 summarizes typical operating hydraulic grade lines (HGLs) in the City's three pressure zones. The operational HGLs are paired with service elevations in each zone to present typical high and low static pressures. Low service elevations in Zone 1 may experience high pressures near 124 pounds per square inch (psi), while the highest elevations served by Zone 2 may experience low pressures close to 38 psi.

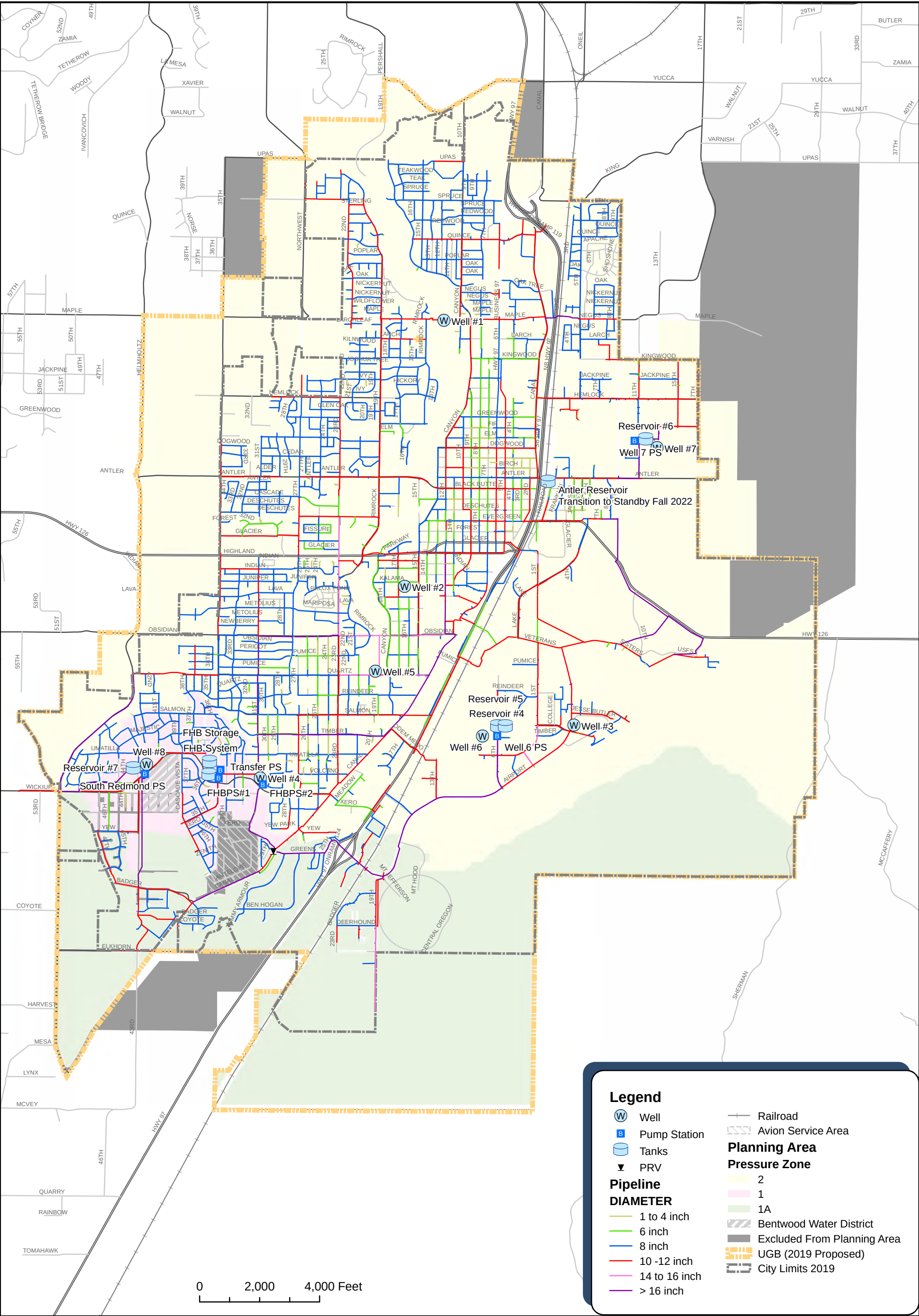


Table 1-1 | Pressure Zones

Pressure Zone	Typical ¹ Operational HGL (ft)	Zone High Service ² Elevation (ft)	Typical Low Pressure (psi) at Highest Service Elevation	Zone Low Service ² Elevation (ft)	Typical ¹ High Pressure (psi) at Lowest Service Elevation
Zone 1	3,345	3,232	49	3,060	124
Zone 1A	3,270	3,144	55	3,044	98
Zone 2	3,175 ³	3,088	38	2,924	111

Notes:

1. Typical refers to operating conditions.
2. High and low elevations and pressures may exclude single highest or lowest customer.
3. 3,180 feet is the overflow of the existing System Reservoir and Reservoir 7 (under construction).

1.5.2 Water Metering and System Data Collection

The City's distribution system is equipped with AMI capable of logging water consumption for each customer multiple times a day. This equipment currently collects data every hour to every 6 hours. The metering program is expected to be converted fully to hourly readings by the end of 2021.

The SCADA system records real time data quantifying production from wells, remote system pressures, tank levels, booster pump data, and valve status for several critical control valves.

1.5.3 Groundwater Supply

The City currently has seven groundwater wells. Wells 1 and 2 experience cascading water that results in air entrainment. The production of water with a large amount of entrained air can impact distribution system efficiency and result in customer complaints. As a result of these operational issues, Well 1 is considered available for emergency use only. Well 2 is also typically not used. A new well (8) is currently under construction which will pump directly into a new reservoir (7) that will float on Pressure Zone 2. **Table 1-2** summarizes the capacity of each well and indicates the availability of backup power for each well facility.

Table 1-2 | Groundwater Supply

Well Name	Well Capacity (gpm)	hp	Completed Well Depth (ft)	Static Water Level (ft) ²	Total Capacity of Booster Station From Ground Level Storage (gpm) ¹	Adequate Backup Power	Note
Well 1	1,000		300	168	N/A	Yes	Not Typically Used
Well 2	700	250	452	265	N/A	Yes	Not Typically Used
Well 3	1,125	200	452	315	N/A	Yes	
Well 4	3,000		765	362	N/A	Emergency Generation is inadequate	
Well 5	3,300	500	802	259	N/A	Yes	

Well Name	Well Capacity (gpm)	hp	Completed Well Depth (ft)	Static Water Level (ft) ²	Total Capacity of Booster Station From Ground Level Storage (gpm) ¹	Adequate Backup Power	Note
Well 6	2,275	300	855	336	4,000	Yes	Typically Pumps to Reservoirs 4 and 5
Well 7	2,300	300	860	326	4,400	Yes	Typically Pumps to Reservoir 6
Well 8 (New 2022)	3,000				N/A	Yes	Supply to fill New Reservoir 7

Notes:

1. The listed total pumping capacity for booster stations in this table is the simple sum of individual pump capacities. This is typically greater than the actual total station capacity.
2. From Well Log

Well 6 directly fills the adjacent Reservoirs 4 and 5. Well 7 directly fills Reservoir 6. Supply from these wells is then boosted from the reservoir to the system through booster pump stations. Well 7 can be used to pump directly to the system at a reduced capacity of approximately 1,750 gallons per minute (gpm), as an emergency operation capability. A similar configuration will be constructed at Well 8 where it will directly fill Reservoir 7, however will be capable of pumping to the system if needed. Well 6 does not have the capability to pump directly to the system.

1.5.4 Reservoirs

Figure 1-3 provides a hydraulic profile for the system and **Table 1-3** lists and characterizes the existing system's water storage.

The system is currently served by gravity from the FHB System Reservoir. The FHB System Reservoir is filled by the City's groundwater supply wells or boosters, located in Zone 2. A pump station, referred to as the Transfer Station, boosts water from Zone 2 near the FHB System Reservoir, to the FHB Storage Reservoir. The Transfer Station also includes a set of valves (Transfer Station Valves) that regulate the flow of water from the FHB Storage Reservoir back to Zone 2. The current operation of this facility has a moderating effect on the water level in the FHB System Reservoir, minimizing water level variation. When the water level in the FHB System Reservoir exceeds the set depth, the Transfer Station pumps take supply from Zone 2 near the FHB System Reservoir and boost it into the FHB Storage Reservoir. When the water level in the FHB System Reservoir drops below a set level, the Transfer Station Valves open, releasing water stored in the FHB Storage Reservoir back down to Zone 2 near the FHB System Reservoir. The way these facilities are configured and operate will change and are described further below **Table 1-3**.

The FHB Storage Reservoir does not directly serve Zone 1. Rather, the FHB Pump Station #1 (FHBPS #1) currently pumps from Zone 2 to Zone 1.

Table 1-3 | Water Storage Reservoirs

Reservoir Name	Zone Served	Floor Elevation (ft)	Diameter	Max Depth (ft)	Volume ¹ (Mgal)
FHB System Reservoir	Zone 2	3,160	132	20	2.0
FHB Storage Reservoir	Zone 2 via Transfer Station Valves	3,180	134	20	2.1
Reservoir 4 at Well 6	Zone 2 via Pump Station at Well 6	3,055	100	35	2.1
Reservoir 5 at Well 6	Zone 2 via Pump Station	3,055	100	35	2.1
Reservoir 6 at Well 7	Zone 2 via Pump Station at Well 7	3,040.5	120	43	3.5
Antler Reservoir (Standby Fall 2022)	Zone 2 via Pump Station at Antler	2,990.5	93	40	2.0
Reservoir 7 (NEW Fall 2022)	Zone 2 by gravity and Zone 1A by NEW Pump Station	3,160	189	20	4.0

Note:

1 Operational Volume.

Near term changes to the operation of the FHB Storage Reservoir will improve system energy efficiency by reducing the cycle of boosting and discharging water through the Transfer Station Valves. Under the near-term planned operations, water boosted to the FHB Storage Reservoir through the Transfer Station will be used to supply the FHBPS #1, serving Zone 1. This will allow the FHBPS #1 to take supply from the FHB Storage Reservoir instead of taking from Zone 2. Therefore, in the future, only the supply required to serve Zone 1 will be boosted through the Transfer Station. Some new, small sections of piping will be required to make this change. The ability to feed Zone 2 from the FHB Storage Reservoir through the Transfer Station Valves will still be available as a backup source of storage water. The new (Fall 2022) Reservoir 7, will add 4.2 million gallons (MG) of gravity storage to Zone 2. With the new reservoir available, it is unlikely that water from the FHB Storage Reservoir will be required in Zone 2. However, the ability to transfer water from the Storage Reservoir to Zone 2 will still be maintained.

Four boosted storage tanks are also currently active in the system. Two storage tanks are located at Well 6 (Reservoirs 4 and 5), and a third at Well 7 (Reservoir 6). At each of these reservoirs, the well pump fills one or more storage reservoir directly. The stored water and well supply is only delivered to the system through booster pumps out of the storage reservoir.

The Antler Reservoir is the fourth boosted storage reservoir. It supplies an industrial fire suppression system located north and south of E Antler Avenue between SE Railroad Boulevard and the railroad tracks. This reservoir, along with the associated pump station, fire laterals, and hydrants, are planned for near term decommissioning. The Antler facilities are shown in **Figure 1-4**. The Antler Reservoir fills daily from system pressure in the early morning by the automated opening of a flow control valve. The tank is emptied by its pump station daily. Supply from the booster stations at Well 6 uses a secondary control to run when this reservoir is filling. After

transitioning the Antler Reservoir to standby, fire service will be provided from the City's distribution system and associated hydrants. This area is supported by the nearby Reservoir 6 and Well 7 facilities. Fire flow analysis evaluates the adequacy of existing hydrants to serve required fire flows at existing hydrants. The required number and distance to hydrants to serve specific existing structures is not evaluated.

As noted above, Reservoir 7 is planned for near-term construction at the new South Redmond Facility located near SW Reservoir Drive, and SW Volcano Avenue. This reservoir will be the City's second storage reservoir providing gravity storage to Zone 2. The floor elevation will be 3,160 feet, with a maximum depth of 20 feet, to match the FHB System Reservoir. The storage volume for Reservoir 7 will be approximately 4.2 MG.

1.5.5 Booster Pump Stations

Several booster pumping facilities exist throughout the system. These include boosting to Zones 1 from Zone 2 with a PRV station that also conveys this supply to 1A, the Transfer Pump Station that fills the FHB Storage Reservoir, and the Well 6 and Well 7 Booster Stations that deliver well supply from boosted storage reservoirs to Zone 2. A future pump station is planned at the South Redmond Facility to directly serve Zone 1A in the near-term. A pump station is also located at Antler Reservoir for the purpose of boosting water to a local fire suppression system. This pump station will be transitioned to standby along with the reservoir and associated laterals in the near term.

As described above, the FHBPS #1 currently draws water from Zone 2 near the FHB Storage Reservoir and serves Zone 1. This operation will change in the near-term with the FHBPS #1 instead drawing water from the FHB Storage Reservoir. It will continue to serve Zone 1. The following table reflects this near-term change.

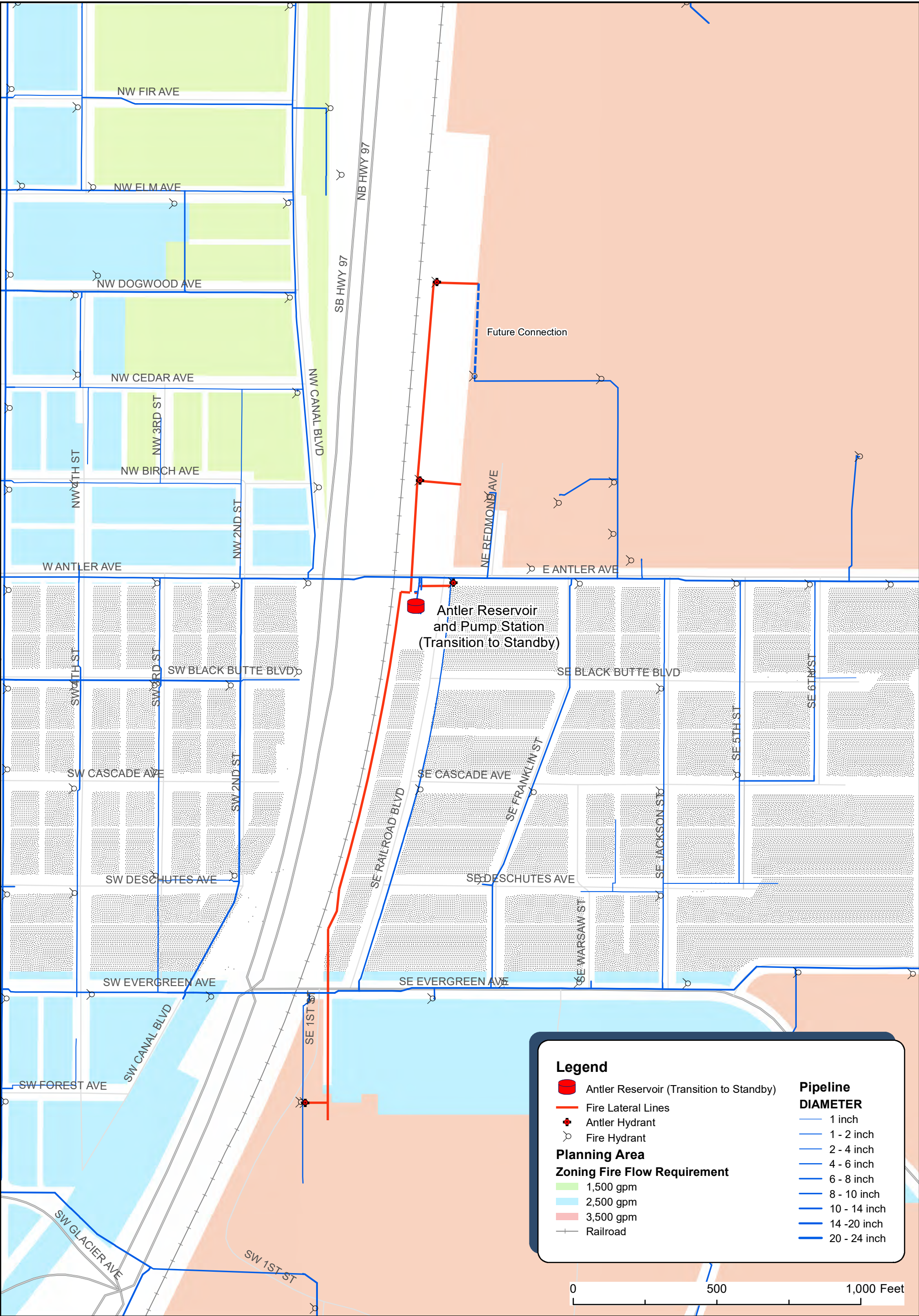


Table 1-4 | Existing Booster Pump Facilities

Pump Station Name	Pump Name	Supply Source	Discharge Zone	Individual Pump Capacity (gpm)
Well 6 Booster Station	W6 BSP1	Reservoirs 4 and 5 at Well 6	Zone 2	2,000
	W6 BSP2	Reservoirs 4 and 5 at Well 6	Zone2	2,000
Well 7 Booster Station	W7 BSP1	Reservoir 6 at Well 7	Zone 2	1,100
	W7 BSP2	Reservoir 6 at Well 7	Zone 2	1,100
	W7 BSP3	Reservoir 6 at Well 7	Zone 2	1,100
	W7 BSP4	Reservoir 6 at Well 7	Zone 2	1,100
FHBPS #1	FHBPS#1 P1	FHB Storage Reservoir	Zone 1	1,500
	FHBPS#1 P2	FHB Storage Reservoir	Zone 1	1,500
	FHBPS#1 P3	FHB Storage Reservoir	Zone 1	1,500
	FHBPS#1 P4	FHB Storage Reservoir	Zone 1	400
	FHBPS#1 P5	FHB Storage Reservoir	Zone 1	400
FHBPS #2	FHB Pump 3	Zone 2 Near Well 4	Zone 1	1,500
FHB Transfer Station	FHBTS P1	Zone 2 Near FHB Reservoir	FHB Storage Reservoir	1,500
	FHBTS P2	Zone 2 Near FHB Reservoir	FHB Storage Reservoir	1,500
Antler Pump Station (Standby Fall 2022)	Antler Pump	Antler Reservoir	Zone 2	2,200
NEW South Redmond Facility Pump Station	NEW SRFPS	NEW Reservoir 7	Zone 1A	7,200 (1A Firm)

Note:

- 1 Total pumping capacity in a station is not the same as the sum of individual pump plate capacities. The sum of individual pump capacities is often greater than the actual pump station capacity.

The FHB Pump Station #2 (FHBPS #2) consists of a single pump located near Well 4. As of the summer of 2018 and winter of 2019 calibration, the FHBPS #2 was the primary supply to Zone 1 during the winter months. The FHBPS #1 provides the majority of supply during the summer. With the near-term changes to FHBPS #1, it should be the primary (and lead) source of supply to Zone 1 during both summer and winter months, to support turnover of the FHB Storage Reservoir. The FHBPS #2 will then be a supplementary and backup pump station to serve Zone 1.

A new pump station is planned for near term construction as part of the new South Redmond Facility. It will draw water from Reservoir 7 and serve Zone 1A, as shown in **Figure 1-2** and **Figure 1-3**.

Any pump representing a source of supply, pumps water to the system against gravitational and friction forces that act on both the suction and supply side. These forces vary over an operating range. The capacities listed in

Table 1-4 for individual pumps are considered reasonable and conservative for the single pump indicated. Under varying field operating conditions, they may produce more or less flow. The listed capacities are considered to be the flow that the pumps will produce near their design point under normal conditions without excessive wear or damage to the pump.

1.5.6 Pipe

There are over 177 miles of water system piping varying from 2-inch to 24-inch in diameter. The length and diameter of existing distribution system pipelines are summarized in **Table 1-5**.

Table 1-5 | Distribution System Piping

Material And Diameter (in)		Length (ft)
CI	6-in	5,044
	8-in	1,689
	12-in	2,008
Copper	4-in or less	193
DI	4-in or less	578
	6-in	1,538
	8-in	86,945
	10-in	2,187
	12-in	76,493
	14-in	7,537
	16-in	8,591
	18-in	45,999
	24-in	3,031
	Unknown	209
PVC	4-in or less	6,924
	6-in	26,449
	8-in	405,598
	10-in	41,584
	12-in	81,906
	16-in	637
	18-in	381
	24-in	80
Steel	4-in or less	16,217
	6-in	53,905
	8-in	12,079
	10-in	26,383
	12-in	18,495
	14-in	293
	18-in	2,650
	20-in	49
Total		935,670

1.6 Summary

The water system operated by the City is supplied from groundwater and the service area closely matches the City limits. Three pressure zones define the system with the majority of the City served by Zone 2. Approximately 177 miles of pipe distribute water from seven reservoirs with booster pumps at Wells 6 and 7, Forked Horn Butte, Antler Reservoir (soon to be offline), and the new Redmond South Facility.



Section 2

Section 2

Water Use Requirements

2.1 Introduction

This section provides data and analysis describing recent historical system-wide production and water demand. Water production is the amount produced by the City's groundwater wells. Water demand is the amount utilized by customers. The difference between the quantity of water produced and demanded may be accounted for by factors such as distribution system leaks, pipe breaks, hydrant testing, operational consumption, or any other water loss or use that is not measured by system water metering. Ideally, water production and metered water demand are very similar in value. As a result, these terms are sometimes used interchangeably.

As customer activities vary over the course of a day and year, so does water demand. The magnitude of change in water demand is characterized with peaking factors. Planning demands and peaking factors are identified through analysis of historical demand and are used to identify the volume of water the system will be prepared to provide to customers under future conditions.

The global pandemic experienced in the year 2020 impacted the magnitude, timing, and spatial distribution of water use in communities throughout the United States. Businesses experienced disruption and nearly all activities associated with water use, including schools, residential in-home, hospital, manufacturing, hotel, food service, and some recreational activities were potentially impacted at different times and to varying degrees by either policy conditions or changes in consumer behavior. Any long-term changes to both residential and commercial activities as a result of the pandemic are not currently known. It is anticipated, however, that the year 2020 is likely not to be representative of years to follow. For this reason, the year 2019 is the last year used in analysis for this plan.

2.2 Definition of Terms

The main objective of historical water demand analysis is to identify characteristic water system use rates and factors to be applied in forecasting future water needs. Water distribution system performance analysis requires identification of both average and high demand conditions. This section provides the historical, current, and future water demands and how they were identified.

2.2.1 Consumption

Consumption refers to the actual volume of water used (and traditionally billed to) customers, measured at their connections to the distribution system.

2.2.2 Water Demand

The term "demand" often refers to system wide water use over a specified period of time. However, it may also be a volume used on an individual customer or customer type basis. The following definitions are used in discussion of planning demands in this report.

- Demand: The amount of water used by customers. This is the volume typically measured at the point of connection to the distribution system and is often synonymous with metered customer water use or consumption.
- Average Day Demand (ADD): Total annual water consumption or production divided by the number of days in the year.
- Maximum Day Demand (MDD): The maximum daily demand experienced by a system during a year.
- Peak Hour Demand (PHD): The highest hourly average demand during a year, typically identified as the highest average hourly demand that occurs on the day of maximum day demand.

2.2.3 Peaking Factors

Peaking factors, or the ratios of extreme to average demands are evaluated over several days or years of record. They are used to characterize the way demand is likely to deviate from average over the course of a year. The high demand ratios evaluated in this plan are:

- MDD:ADD: The ratio of Maximum Day Demand to Average Day Demand
- PHD:MDD: The ratio of Peak Hour Demand to Maximum Day Demand
- Max:PHD: The ratio of Maximum observed (sub-hourly) to Peak Hour Demand

2.3 Water Production

The annual volume of water produced by the City's wells is shown in **Table 2-1**. **Table 2-1** also presents population and per capita demand from 2015 to 2019. The overall per capita water use rate is equal to the total system water production divided by the resident population. Per capita demand is expressed in gallons per capita per day (gpcd). Population estimates for the service area are provided by Portland State University (PSU).

The City limits and the water service area are not identical, however PSU's estimate of City population provides a reasonable approximation of service area population over the past five years.

Table 2-1 | Historical Production and Total Per Capita Demand

Year	Total Production (MG) ²	Population ¹	Overall Gallons Per Capita Day (gpcd)
2015	2,130	27,050	216
2016	2,145	27,595	212
2017	2,226	28,265	216
2018	2,359	29,190	221
2019	2,173	30,600	195

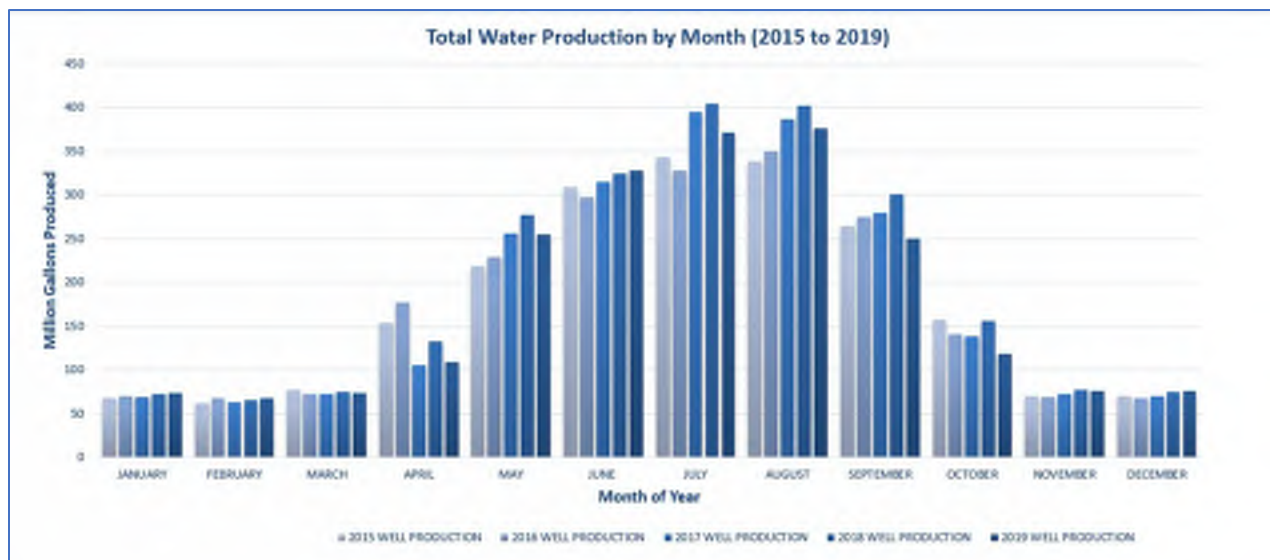
Notes:

1. PSU Population Estimates
2. Annual Production reported by the City of Redmond, Oregon

Overall production has slightly increased from 2015 to 2019. Population has also steadily grown over this time period. Aside from population growth, factors such as annual rainfall and seasonal temperatures can also impact the overall demand for water in a given year.

Figure 2-1 presents monthly total water production from 2015 to 2019. July and August, the hottest months of the year, typically see the highest system wide water demand when the need for outdoor irrigation is significant.

Figure 2-1 | Water Production by Month



2.4 Water Consumption

2.4.1 Per Capita Demand

Per capita demand is calculated based on the residential population. However, the water use incorporated in the calculation includes both residential and non-residential uses, such as

commercial, industrial, institutional, and operational water use. It also includes unmetered water use and loss such as system leakage, unauthorized connections, under reporting meters, etc.

The City's total historical per capita production, or total per capita demand, over the last five years has been relatively stable at approximately 215 gpcd. This value is comparable to other cities in the region. Per capita demand often decreases over time due to the influence of increasing population density, increasing water rates, and water conservation.

The relatively stable value of approximately 215 gpcd between 2015 and 2019 reflects an overall decreasing long-term trend, when compared with the results of previous analyses for the periods from 1977 to 2005 (260 gpcd) or from 2003 to 2005 (247 gpcd).

2.4.2 Historical Maximum Day Demand

One of the most important values, MDD is used for planning purposes as the required amount of firm capacity supply the system must be able to produce. Firm capacity supply is the amount of supply that can be provided to the system with the largest pump out of service. This suggests that with the largest source of supply offline, the system should be capable of maintaining or recovering storage reservoir water levels over the course of a 24-hour period, when water use is equal to MDD.

Over the course of a year, any net difference in storage volume is not significant when compared with total annual production. As a result, annual well production alone will reasonably approximate the annual total water required system wide. On a daily basis, however, changes in net storage can be significant compared to daily production. Net changes in storage are accounted for in the City's estimates of daily demand used to identify MDD.

Table 2-2 | Historical Average Day and Maximum Day Demand

Year	ADD (MG)	ADD (gpm) ¹	MDD (MG) ²	MDD (gpm)	Max Date	MDD:ADD
2015	5.8	4,030	12.8	8,889	7/1/2015	2.19
2016	5.9	4,100	12.0	8,333	8/15/2016	2.05
2017	6.1	4,240	14.0	9,722	8/2/2017	2.30
2018	6.4	4,450	14.6	10,139	7/25/2018	2.27
2019	6.0	4,150	13.6	9,455	08/07/2019	2.28

Notes:

1. The ADD listed is based on the City's annual production
2. MDD is based on the City's estimates of daily demand, which account for daily net difference in storage volume.

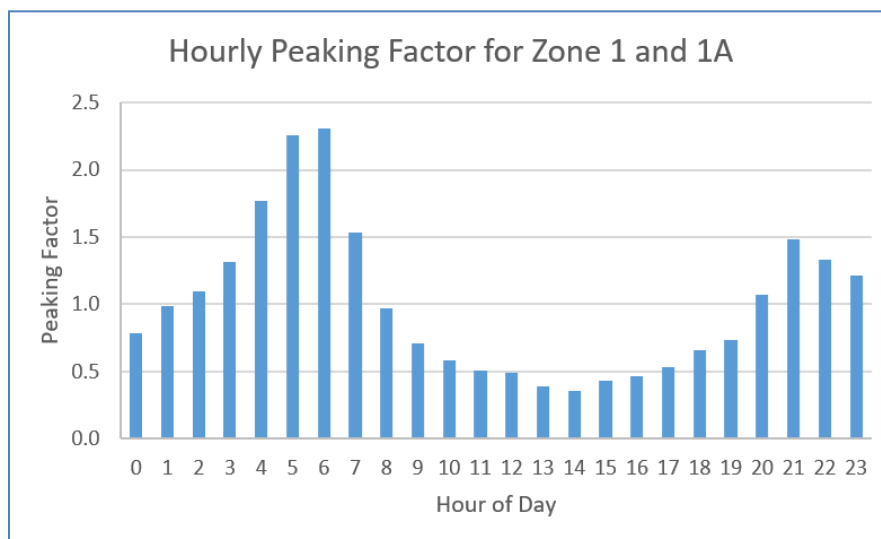
Based on **Table 2-2** the highest peaking factor or ratio of MDD:ADD from 2015 to 2019 was approximately 2.3. This peaking factor was selected for use as the existing planning MDD:ADD ratio. The highest ADD observed over the five years listed, is approximately 6.4 MGD. For planning purposes, the planning peaking factor is applied to the highest ADD to result in an existing planning MDD of 14.72 MGD, or 10,200 gpm. This conservative approach results in a planning MDD that is only slightly higher than the observed MDD in 2018.

2.4.3 Peak Hour Demand

The amount of water demanded by the system changes over the course of a day, as commercial and residential activities vary. The variation of demand over the course of a day is referred to as a diurnal demand pattern, or curve. This curve can be presented in terms of demand (gallons) consumed each hour or converted into a unitless pattern of hourly demand factors (hourly demand divided by average demand over the day). The highest hourly factor in the diurnal pattern that characterizes a period of high usage, represents the peak hour ratio PHD:MDD.

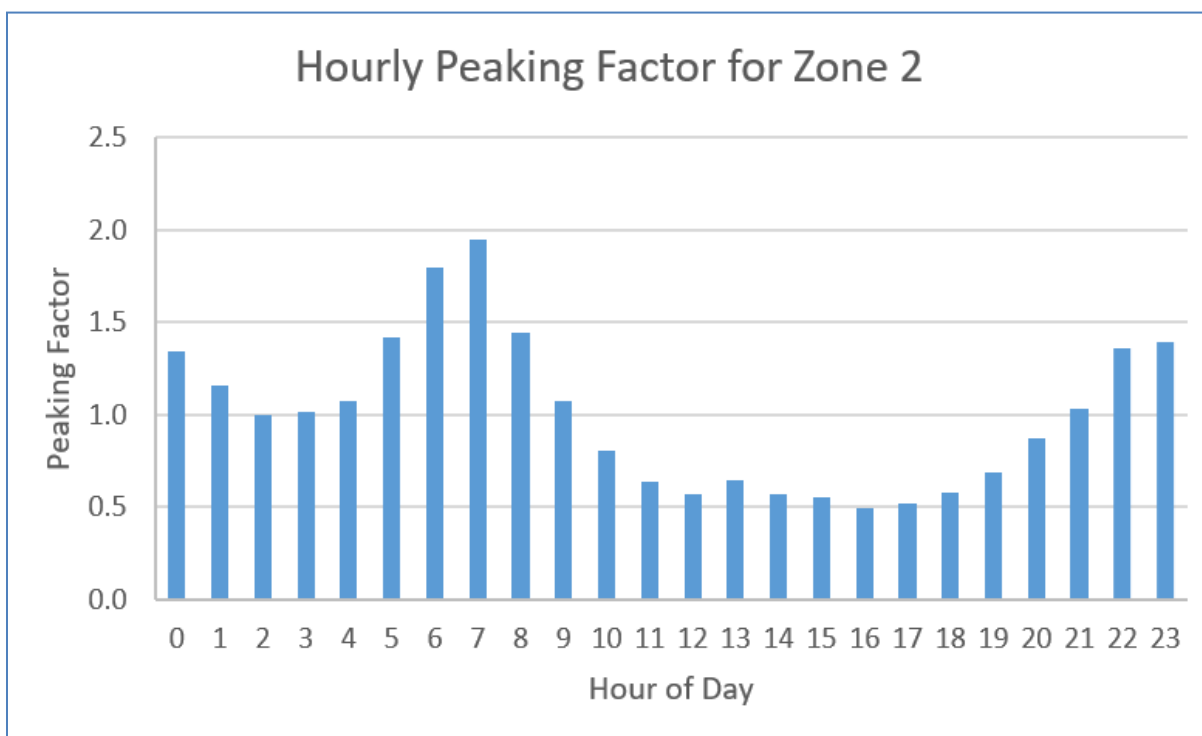
The diurnal demand curve shape and peak magnitude will vary by system due to customer type, and therefore land use. Outdoor water use and significant industries can also cause a peaking or flattening of these curves. Diurnal curves for the City were developed for Zone 1 plus 1A, and for Zone 2 for the summer period of high demand. Zone 1 plus 1A is considered primarily residential. Zone 2 represents a mixture of customer classes.

Figure 2-2 | Summer Demand Curve for Zone 1 plus 1A



The existing customers in Zone 1 plus 1A are considered primarily residential and show morning and afternoon peaks in demand associated with irrigation and other uses. Zone 2, by comparison, has a larger number of non-residential customers, with slightly less diurnal peaking.

Figure 2-3 | Summer Demand Curve for Zone 2

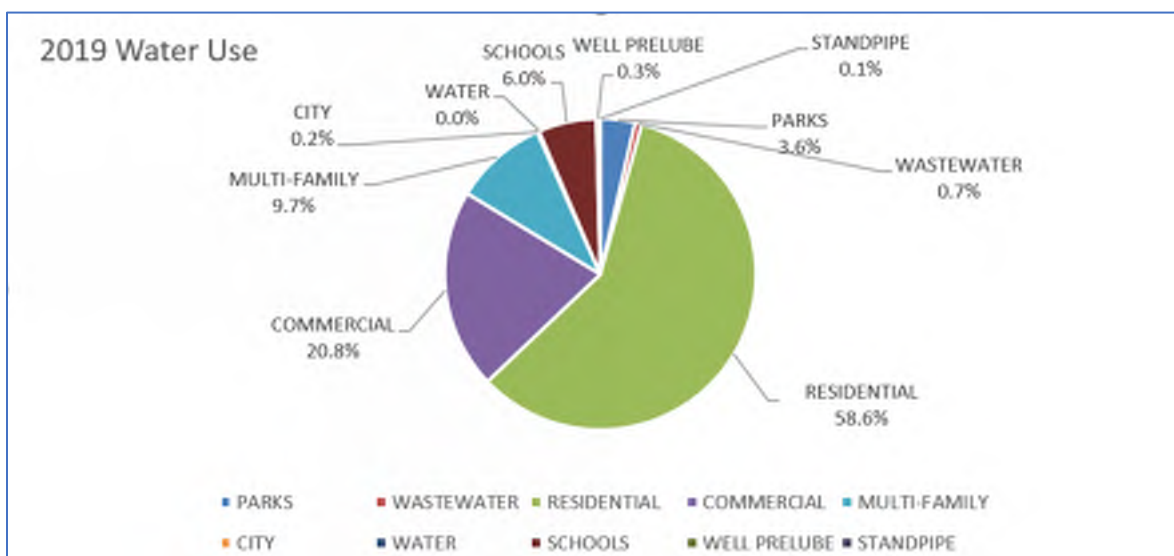


The development of diurnal curves using system SCADA information is further described in **Appendix B**. Analysis of SCADA information during a period of high demand indicated that the system wide peak hour factor was approximately 2.0, with a Zone 1 and residential PHD:MDD of 2.31. The Zone 2 PHD:MDD was 1.9.

2.4.4 Water Consumption by Customer Class

Data for demand by customer class is evaluated in this report primarily to identify planning loading rates to be associated with future development. The data presented in **Figure 2-4** was developed from metered water use by customer class summarized by the City. Commercial and industrial customers were summarized together by the City under the commercial category.

Figure 2-4 | Accounted for Water Use By Customer Type 2019



The uses shown in **Figure 2-4** are described as follows.

- Schools: Metered water use at schools
- Well Prelube: Metered water use associated with water operations at well facilities
- Standpipe: Metered water use associated primarily with construction
- Parks: Metered water use associated with parks
- Wastewater: Metered water use associated with wastewater treatment facilities
- Residential: Metered residential water use
- Commercial: Metered commercial and industrial water use
- Multifamily: Metered multifamily water use
- City: Metered use at city facilities
- Water: Metered water use associated with water system operations facilities

For the purposes of this report, water use is generalized as either residential (Residential and Multi-Family) or non-residential (all other).

The historical average residential water use per person is calculated for each year in **Table 2-3**. The residential fraction of water use is found by taking the ratio of metered residential to total metered use. This residential fraction is applied to total production.

The resulting residential per capita annual average use is scaled up to total production since the total water requirement within a system is slightly more than the metered use. Residential use per capita or per housing unit is used for planning purposes to estimate demand associated with future residential developments. The US Census Bureau estimate for the City of Redmond Oregon reports 2.57 Persons Per Household (2014-2018).

Table 2-3 | Historical Residential Use

Year	Residential Use (MG per year)	Accounted For Water Total (MG per year)	Residential Fraction ³	Total Production (MG per year) ²	Estimated Residential Use (MG per year)	Population ³	Estimated Residential (gpcd) ³
2015	1,419	2,043	0.69	2,130	1,470	27,050	149
2016	1,437	2,078	0.69	2,145	1,480	27,595	147
2017	1,479	2,161	0.68	2,226	1,514	28,265	147
2018	1,545	2,272	0.68	2,359	1,604	29,190	151
2019	1,417	2,076	0.68	2,173	1,478	30,600	132

Notes:

1. Includes Single Family and Multi Family water use
2. Annual Production summarized by the City of Redmond
3. PSU Population Estimates

Water use associated with water production, wastewater treatment, public facilities, and any use not associated with housing units is considered non-residential. While some portion of these uses may be related in some ways to residential consumption, they occur on lands considered non-residential, and often experience a different daily temporal pattern of water use than single-family and multi-family consumption.

The trend in per capita water use in the City is reasonably stable over the five-year historical period. A declining trend is typical of many communities as both water conservation and the number of higher density dwellings increase with time. The planning residential per capita demand selected is 150 gallons per person per day, consistent with the highest residential gpcd identified in **Table 2-3** over the last five years. Historical Non-Residential use is summarized in **Table 2-4**.

Table 2-4 | Historical Non-Residential Use

Year	Non-Residential Use (MG) ¹	Accounted For (MG)	Non-Residential Fraction	Total Production (MG) ²	Estimated Non-Residential Use (MG)
2015	623	2,043	0.31	2,130	660
2016	640	2,078	0.31	2,145	665
2017	682	2,161	0.32	2,226	712
2018	727	2,272	0.32	2,359	755
2019	659	2,076	0.32	2,173	695

Notes:

1. Includes water use that is not associated with areas containing housing units
2. Annual Production summarized by the City of Redmond

While residential use is spatially associated with housing units in the water distribution system, non-residential use can be more readily associated with developed non-residential acreage based on land use types. The City's Future Land Use Database identifies currently developed non-residential acres as summarized in **Table 2-5**.

The database provides land use zoning designations, as well as estimates of vacant, developable, and non-developable acres and provides the best currently available estimate of existing

developed acreage. The City's actual land use designations will continue to change over time, as will the development status of its acreage. A high-level review of this database using available aerial photography suggests it is conservative for planning purposes in terms of estimates of developed and vacant acreage. Continued tracking and improvement in accuracy of current and future development status is recommended to support future planning efforts.

Adjustments made by Murraysmith to this database for the purposes of this report are as follows.

- The developed acreage for Land Use Types PF, OSPR, and Park was re-calculated as the existing acreage minus the database assigned vacant acreage.
- The Airport was identified as having additional non-developed (redevelop-able) area of approximately 550 acres.
- Mixed use designations were assigned 60 percent residential and 40 percent non-residential per City direction.

Because detailed information reflecting the change in developed non-residential acreage was not available over each of the last 5 years, **Table 2-5** provides a summary of the estimated developed residential and non-residential acres and water use for 2019.

Table 2-5 | Existing Non-Residential Water Demand Per Acre

Land Use Category	2019 Fraction of Production	2019 Production Associated with Land Use (Million Gallons)	Developed Acres	Gallons/acre-day	Zoning Codes
Residential	0.68	1,478	2,283	1,823	R1, R2, R3, R3A, R4, R5, UH10, 60% of MULW, 60% of MUE, 60% of MUN,
Non-Residential	0.32	695	3,248	586	C1, C2, C3, C4, FG, Large Lot Industrial, M1, M2, 40% of MULW, 40% of MUN, OSPR, PARK, PF

The planning water use rate selected for non-residential areas was 600 gallons per acre per day. Non-residential use can vary widely, from storage facilities that use very little water over many acres of land, to food production or brewery facilities that can consume a large number of gallons per day within a relatively small footprint. Continued clarification of the City's developed and undeveloped areas by land use type is encouraged to support both tracking of water consumption within the developing service area, and improved accuracy for future planning efforts.

2.5 Unaccounted and Non-Revenue Water

Unaccounted for water is the volume of water production that may be lost due to unmetered use, system leaks, or other unknown losses. The City has observed an overall reduction in unaccounted for water, in comparison with years prior to 2015, and the rate of unaccounted for water is currently considered low at less than five percent.

Table 2-6 | Unaccounted Water

Year	Production (Mgal)	Accounted For Water (Mgal)	Unaccounted For Water (Mgal)	Unaccounted For Water (%)
2015	2,130	2,044	86	4.0%
2016	2,144	2,074	70	3.2%
2017	2,223	2,160	63	2.8%
2018	2,363	2,283	80	3.4%
2019	2,173	2,075	98	4.5%

The production values listed in **Table 2-6** represent the total of system well production for the year. Accounted for water listed in **Table 2-6** includes only metered use and known water consumption associated with operations. The City operates a water fill stand for water trucks, which is primarily used for dust control at construction sites. Water consumed from this stand is tracked and is often referred to as “stand pipe” water. The City also tracks what is referred to as pre-lube water. Some pumps are equipped with what is known as a pre-lube system. As a result, some non-production water may be associated with high volume pumps that are water lubricated. At pump start up, this water may be used to reduce mechanical friction in the lineshaft, improving efficiency and extending the life of equipment. In total, unaccounted for water is less than five percent of production in each year, and is often less than 3.5%. This is considered a low rate of unaccounted for water.

2.5.1 Non-Revenue Water

Non-Revenue Water is water that was produced but not paid for by a customer. This can include unaccounted for water, operational water use, hydrant flushing water, and unpaid accounts.

Non-revenue water for the City is equal to unaccounted for water, plus accounted for water that is not billed, and unpaid accounts. The only known unbilled water that is accounted for in the City includes well pre-lube water and any delinquent or unpaid water bill accounts. The volume of pre-lube water is less than 0.3 percent of production.

It can be concluded that non-revenue water and unaccounted for water are similar in value. In 2019 unaccounted for water was approximately 4.5 percent of production. Adding pre-lube water, the estimate of non-revenue water is close to 4.8 percent of production

Figure 2-5 | Non-Revenue Water

Production	Authorized Consumption	Billed Authorized Consumption	▪ Billed metered ▪ Billed unmetered (flat rate, annual)	Accounted For Water	Revenue Water
		Unbilled Authorized Consumption	▪ Unbilled metered ▪ Unbilled unmetered		Non-Revenue Water
	Lost Water	Apparent Losses	▪ Unauthorized use ▪ Data handling error ▪ Metering Inaccuracies	Unaccounted For	
		Real Losses	▪ Pipe or Tank Leakage ▪ Storage Tank overflows		

2.6 Future Water Demand Projections

The City's historical demand by customer class was used to identify planning demand loading rates per acre (or per residential unit) as shown in **Table 2-7** and **Table 2-8**. These demand rates were applied to undeveloped areas within the service area.

Table 2-7 | Average Day Demand for Future Residential Growth

Zoning Code	Zoning Name	Gallons/Unit-day	Units/Acre	Gallons/Ac-day	Category ¹
R1	Limited Residential	385	2	770	Residential
R2	Limited Residential	385	5	1,925	Residential
R3	Limited Residential	385	4	1,540	Residential
R3A	Limited Residential	385	4	1,540	Residential
R4	General Residential	385	4	1,540	Residential
R5	High Density Residential	385	8	3,080	Residential

Note:

1. The category is used to identify the fire flow requirement and demand peaking factors applied.

Each land use Zoning Code can be associated with a range of potential housing units per acre. **Table 2-7** identifies the number of units per acre applied for this planning effort. The planning number of people per unit (2.57) was identified from the US Census Bureau for the City of Redmond Oregon, number for Persons Per Household (2014-2018). The residential demand of 150 gpcd on an average annual basis was identified from the City's historical residential demand analysis. At a demand rate of 150 gpcd, and 2.57 people per housing unit, the resulting demand rate is 385 gallons per housing unit per day. This number is multiplied by the number of housing

units per acre in each zone category to present the resulting gallons per acre per day demand associated with each residential zoning code within developable residential lands in the planned service area.

The development category provided in **Table 2-7** is used to identify the fire flow requirement according to **Table 3-2**. This development category also defines the demand peaking factors associated with MDD and PHD used for new development according to **Table 2-9**.

Table 2-8 | Average Day Demand for Future Non-Residential Growth

Zoning Code	Zoning Name	Gallons/ Ac-day	Demand Peaking and Fire Requirement Category ¹
AIRPORT	Airport	600	Industrial
Airport Compatible	Airport Compatible	600	Industrial
C1	Strip Service Commercial	600	Commercial
C2	Central Business District Commercial	600	Commercial
C3	Special Service Commercial	600	Commercial
C4	Limited Service Commercial	600	Commercial
C4-A	Limited Service Commercial	600	Commercial
C5	Tourist Commercial	600	Commercial
FG	Fairgrounds	600	Industrial
Large Lot Industrial	Large Lot Industrial	600	Industrial
M1	Light Industrial	600	Industrial
M2	Heavy Industrial	600	Industrial
MUE	Mixed Use Employment	1,330	Mixed Use
MULW	Mixed Use Live Work	1,330	Mixed Use
MUN	Mixed Use Neighborhood	1,330	Mixed Use
OSPR	Open Space Park Reserve	600	Residential
PARK	Park	600	Residential
PF	Public Facility	600	Commercial
UH10	Urban Holding	600	Residential

Note:

- 1 The category is used to identify the fire flow requirement and demand peaking factors applied.

Commercial and industrial customer use can vary widely, and individual evaluation is recommended if demands are anticipated to exceed the planned rates that are currently typical for these land uses in the City.

Open Space Reserve and Parks zoning designations were considered non-residential for the development of planning demands. However, they are treated as residential in terms of peaking factors and fire flow requirements, and so they are listed as Residential in **Table 2-8**. Mixed Use zoning designations have commercial fire flow requirements. Mixed Use demand rates are 40 percent commercial and 60 percent residential, using the existing overall average residential loading rate of 1,820 gallons per acre per day.

2.7 Future Land Use Peaking Factors

Demand planning peaking factors for new development are summarized in **Table 2-9**. The demand within the existing combined Zone 1 plus 1A is considered to be primarily associated with residential use. As a result, residential planning peaking factors are based on observed peaking factors in Zones 1 and 1A. Peaking for commercial and industrial customers is often minimal or does not follow the same diurnal and seasonal pattern as residential use. An MDD:ADD peaking factor of 1.5 was selected for commercial and industrial customers as a factor of safety.

Table 2-9 | Demand Peaking Factors for Future Development

Land Use	MDD:ADD	PHD:MDD
Residential	2.30	2.30
Commercial	1.50	1.00
Mixed Use ¹	1.98	1.78
Industrial	1.50	1.00

Note:

1 Mixed Use Zones are evaluated as 60 percent residential and 40 percent commercial

Mixed Use zoning peaking factors are 40 percent commercial and 60 percent residential, according to the City's observation of the typical composition of mixed-use development in the past. These values are used to develop future demand estimates based on historical water use information and future development land use type.

2.8 Future Service Area

Figure 2-6 presents the existing and future growth areas within the Water Service Planning Area (WSPA) served by the City. Areas of near-term growth for the 2025 planning horizon were identified and are shown in the figure. The WSPA is used with future zoning and development densities identified as part of the 2040 Plan to identify both the magnitude and distribution of future demand to be served by the City of Redmond's water distribution system.

2.9 Population Projections

Population projections are provided by PSU's Population Research Center, June 30th 2018. These projections are summarized in **Table 2-10** below.

Table 2-10 | Projected City of Redmond Population

Year	Redmond UGB Population
2020	30,812
2025	33,839
2030	38,524
2035	43,473
2040	48,575

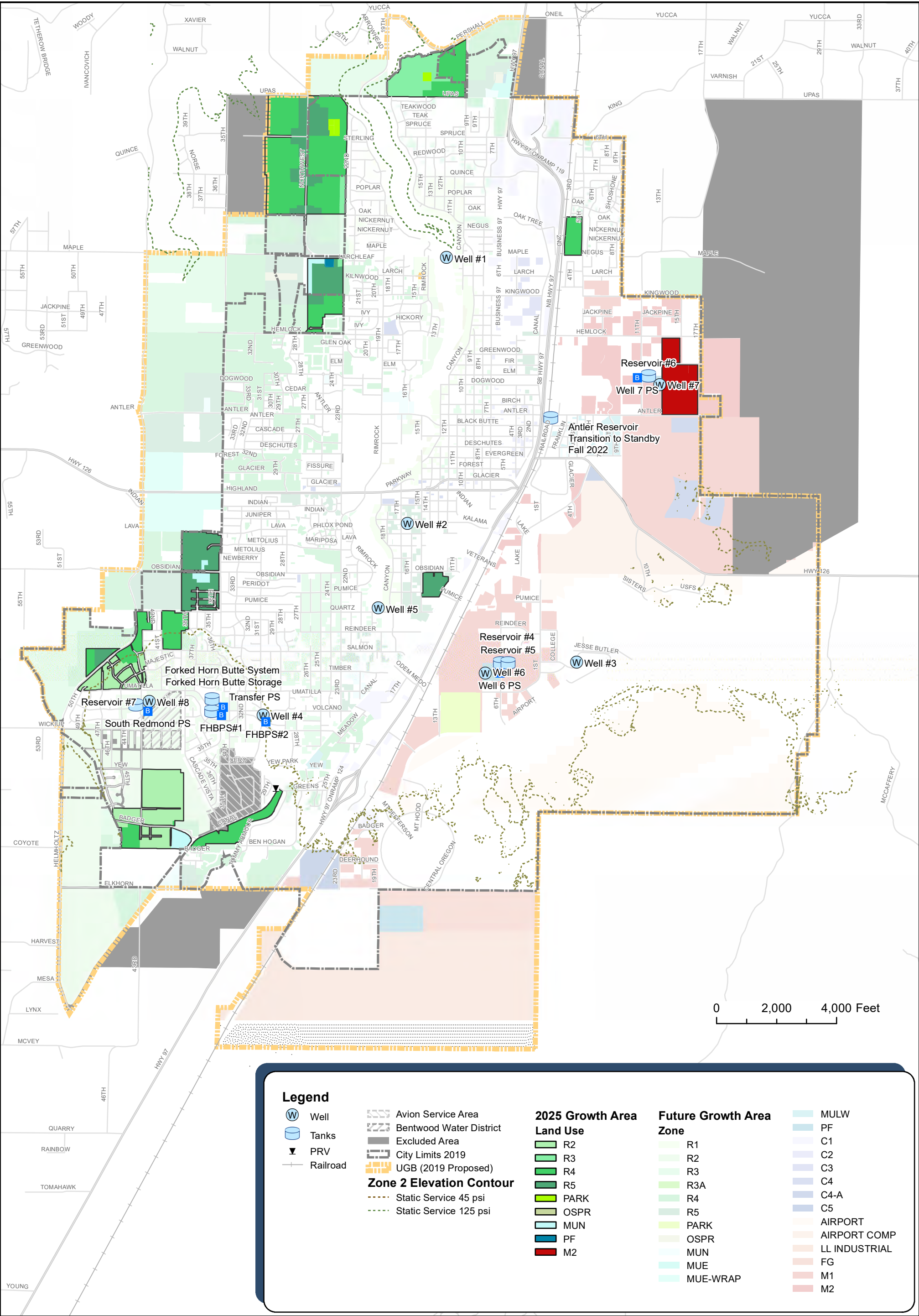
Analysis of the City's Future Land Use database growth areas suggests that full development of the service area may not be reached until after the 20-year planning horizon (2040). The number of housing units and potential residents at Buildout within the service area according to the available Future Land Use Database was compared with PSU's future population projections for the urban growth boundary (UGB). The population associated with Buildout of the available Future Land Use Database is projected to be reached within the UGB near the year 2058 according to PSU's population projections.

Although the UGB and the WSPA are not identical, the expansion areas of the WSPA are primarily commercial and industrial, and do not significantly impact estimates of Buildout residential population using the Future Land Use Database.

2.10 Future Demands

Existing planning system wide demands were selected as part of the analysis of historical demands and peaking factors. Booster station SCADA data was used to identify the distribution of existing demand between Zone 2 and the combined Zone 1 plus 1A, as well as the existing PHD:MDD for each zone. Further detail regarding the distribution of demand within each of these zones under existing conditions was established based on customer water meter data records.

When planning for future demands pipe sizes are designed for buildout of the system and are not significantly impacted by growth rate. Storage and supply are growth dependent, and could be impacted by the COVID-19 enabled acceleration of new water customers.



Future demands are developed by adding demands associated with new growth areas to the identified existing planning demands. Planning loading rates and planning peaking factors by land use were applied to near-term growth areas identified for development the 2025 horizon. Demands were also developed for buildout of the WSPA.

Demand growth between 2025 and 2040 was developed based on straight line interpolation between the development of the identified 2025 growth areas and buildout of the service area in 2058. **Table 2-11** presents planning demand under existing, 2025, 2040, and Build-out planning horizons by Zone, based on planning loading rates and available acres in the Future Land Use Database. Peaking factors are applied to future growth areas based on Land Use Type.

Table 2-11 | Existing and Future Planning Demand by Zone

Horizon	Zone	ADD (gpm)	MDD (gpm)	MDD+FIRE (gpm)	PHD (gpm)
Existing	Zone 1	370	840	3,340	1,940
	Zone 1A	280	630	4,130	1,460
	Zone 2	3,800	8,730	12,230	17,000
	Existing Total	4,450	10,200		20,400
2025	Zone 1	470	930	3,430	2,140
	Zone 1A	420	850	4,350	1,970
	Zone 2	4,210	9,820	13,320	19,480
	2025 Total	5,100	11,600		23,590
2040	Zone 1	580	1,180	3,680	2,720
	Zone 1A	1,020	1,990	5,490	3,980
	Zone 2	5,800	13,190	16,690	26,550
	2040 Total	7,400	16,360		33,250
Build-out	Zone 1	710	1,480	3,980	3,410
	Zone 1A	1,740	3,350	6,850	6,390
	Zone 2	7,710	17,240	20,740	35,030
	Buildout Total	10,160	22,070		44,830

To put the projected demands in **Table 2-11** into perspective, **Table 2-12** provides a comparison of the following demand projections.

1. Population Based: Population projections using constant per capita demand
2. Table 2-7, Table 2-8 and Table 2-9 Land Use Category Loading Based: Development of the future service area with land use based demands from analysis of the City's data, as provided in **Table 2-11**

Table 2-12 | Future Planning Demand Projection Comparison

Horizon	Population Projection Based ADD (gpm)	Land Use Based ADD (gpm)	Population Projection Based MDD (gpm) ²	Land Use Based MDD (gpm) ³
Existing Planning ¹ (Not Projected)	4,450	4,450	10,200	10,200
2025	5,050	5,100	11,620	11,600
2040	7,250	7,400	16,680	16,360
Build-out	10,420	10,160	23,960	22,070

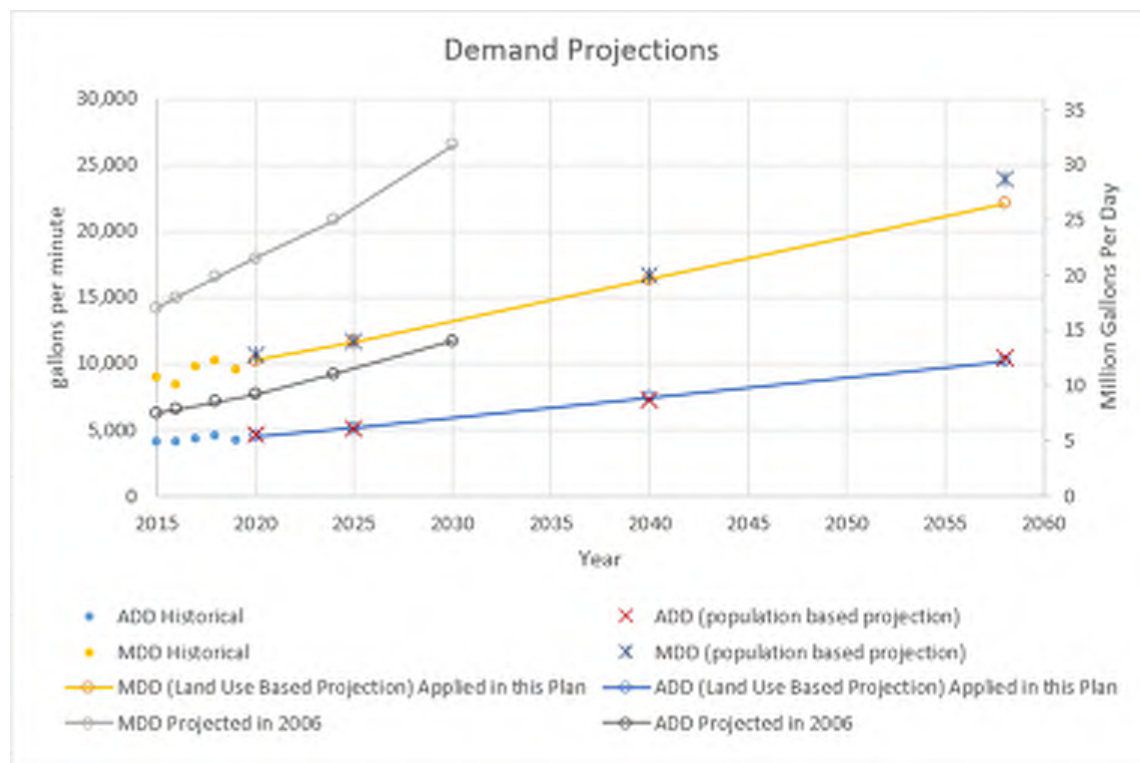
Notes:

- 1 Existing planning or design demands are based on analysis of historical demands and were not based on growth projections.
- 2 Applies existing system wide MDD:ADD of 2.3
- 3 Applies design MDD:ADD by Land Use Type according to **Table 2-9**

The Existing Planning values are included for reference in **Table 2-12**, but they are selected planning demands based on analysis of historical demand and not on projection. Historical per capita total water use within the City has been close to 215 gallons per capita day over the last five years. Population based demand projections using this value produce similar system wide demand projections to the land use based approach. The land use based approach, however, provides a spatial distribution of future demand needed for performance analysis.

Figure 2-7 provides a chart of the results of future demand projections system wide, in comparison with previous planning projections. Land Use Based Projections are used in this WMP.

Figure 2-7 | System Wide Demand Projections



This plan applies land use based water demand loading rates to future growth areas to develop planning future demands. **Figure 2-7** is used to compare the resulting projected demands with other available projection data. The overall per capita demand identified as 215 gpcd was used with PSU population projections to develop the corresponding population based ADD projection provided in **Figure 2-7**. Land use based and population-based projections produce similar results.

These projections are lower than those made in 2006 due to several factors.

- Per capita demands have declined since the period evaluated in 2006 (1977 to 2005). A declining trend is typical in per capita demand.
- Population projections have been revised.
- Actual demands as of 2019, used as the starting point for projections, are lower than projected in 2006.

It is recommended that the city develop and maintain a land use database with the number of developed and developable acres including land use type, for the planning area. This land use database can serve as the basis for better tracking water consumption by land use type for future water demand projection and planning efforts.



Section **3**

Section 3

System Analysis

3.1 Introduction

This section describes the system performance and capacity requirements against which the system is evaluated. The City has selected these water distribution system performance criteria based on both state and federal regulations and industry standard practice. Criteria are identified for the following categories.

- Distribution Network
- Fire Flow Service
- Storage
- Supply and Pumping

3.2 Evaluation Criteria

3.2.1 Distribution Network Criteria

Table 3-1 below describes requirements for the City's distribution system facilities and pipelines to convey supply with adequate pressure.

Table 3-1 | Requirements for Service Pressure and Pipelines

No.	Pipeline Type	Applicable Condition	Requirement	Regulation	Target	Target Discussion
1	Transmission Pressure	All Demand Conditions	>20 psi	OAR 333-061-0050 (8) (e)		
2	Distribution Pressure	MDD	<125 psi, >45 psi	OAR 860-036-1650 (In general 45-80 psi)	>60 psi	Ten States Standards 60-80 psi
3	Distribution Pressure	ADD	<125 psi, >45 psi	OAR 860-036-1650 (In general 45-80 psi)	<80 psi, >60 psi	Ten States Standards 60-80 psi
4	Distribution Pressure	PHD	>35 psi	Ten States Standards not less than 35 psi	>45 psi	OAR 860-036-1650 (In general water pressure between 45 psi and 80 psi in water mains),
5	All Pipeline Pressure	MDD+Fire	>20 psi	OAR 333-061-0050 (8) (e), Ten States Standards		

No.	Pipeline Type	Applicable Condition	Requirement	Regulation	Target	Target Discussion
6	Pump Station Suction Pressure	All Demand Conditions	>20 psi	OAR 333-061-0050 (7) (b), (NFPA, 10 States Standards, OAR 333-061-0050(8)(e))		
7	All Pipeline Velocity	MDD			<5 ft/sec	AWWA M 32, if velocities exceed 4-6 ft/sec under normal conditions, may have inadequate size or looping
8	All Pipeline Min Size	Min All New Pipelines	8-inch	Ten States Standards	8-in distribution, 12-in transmission	8-12-in pipelines generally support velocity targets, and adequate fire flow
9	All Pipeline replacement					Prioritized based on age, material, and leak or break history
10	New Pipeline looping		All pipelines will be looped unless approval is given based on specific justification for a dead-end.			
11	All Pipeline Flushing				As needed	Flushing in conjunction with fire flow testing

3.2.2 Fire Flow Criteria

Table 3-2 presents the City's Fire flow requirements. The system is evaluated to serve the single largest fire in each zone and only a single fire in the overall system, not multiple fires simultaneously.

Table 3-2 | Fire Flow Requirements by Land Use Category

Category	Fire Flow Requirement (gpm)	Duration (Hours)	Fire Storage Volume (MG)
Residential	1,500	2	0.18
Commercial and Mixed Use	2,500	2	0.30
Industrial	3,500	3	0.63

3.2.3 Storage Criteria

Table 3-3 presents requirements for water storage reservoirs.

Table 3-3 | Requirements for Storage Facilities

No	Requirement Type	Requirement
1	Equalization Volume	25% of MDD
2	Emergency Volume	1x ADD
4	Fire Storage	Volume Required to Serve the Largest Fire Flow Requirement (Rate x Duration) for the zone served.
3	Total Volume	Equalization Plus Emergency or Fire (Whichever is Greater)
5	Reservoir Inspection/Cleaning	Inspection and cleaning every 2-5 years
6	Reservoir Turnover	Target (not requirement) 3-5 day turnover

3.2.4 Booster Pumping Criteria

Requirements for Booster pumping facilities are presented in **Table 3-4**. Pumping and supply requirements often refer to Firm Capacity. Firm Capacity is the remaining capacity when the largest available pump or source is out of service. A single pump may commonly be out of service for repair or routine maintenance.

Table 3-4 | Supply and Boosting - Pumping Facilities Requirements

No.	Requirement Type	Requirement
1	Backup Power	Required for All Pumping Facilities (wells and boosters)
2	Supply Capacity	Adequate to provide MDD with largest pump out of service
3	Minimum Number of Pumps	Pump station should have a minimum of three pumps (two active and one standby) unless the pump station is redundant. Where multiple stations serve the same purpose, the total number of pumps among all stations are evaluated together.
4	Closed Zones	Closed Zone pumping is used only where gravity storage is not feasible
5	Boosting Capacity to Closed Zones	Where gravity storage is not provided, pumping capacity must be adequate to provide MDD+Fire or PHD, whichever is greater, with the largest pump out of service. Total capacity adequate to meet the sub hourly peak demands based on available SCADA data during high use periods.

3.3 Existing Performance Analysis

This section presents the results of existing system performance analysis based on design demand and the performance criteria discussed in **Section 3.2**.

3.3.1 Existing Supply and Backup Power to Meet MDD

This section analyzes firm capacity supply in comparison with MDD on a system wide and zone by zone basis. **Table 3-5** lists each well's total and firm capacity and indicates the availability of Backup Power to support total pumping capacity at each site.

The City currently does not use the Well 1 facility due to operational difficulties associated with entrained air from cascading water within the well. As a result, this well is not considered available supply in firm capacity analysis. Backup power at Well 4 is not adequate to power both Well 4 and the FHBPS #2 pump, it is only adequate to power one at a time.

Backup power for total capacity is recommended.

Table 3-5 | Firm Capacity Supply

Zone Served	Facility Name	Capacity (gpm)	Supply at Firm Capacity (gpm)	Adequate Backup Power?
Zone 2	Well 1	1,000	0	Yes
	Well 2	700	700	Yes
	Well 3	1,125	1,125	Yes
	Well 4	3,000	3,000	Yes
	Well 5	3,300	0	Yes
	Well 6	2,275	2,275	Yes
	Booster Station at Well 6	4,000	2,000	Yes
	Well 7	2,300	2,300	Yes
	Booster Station at Well 7	4,400	4,400	Yes
	Well 8 (New 2022)	3,000	3,000	Yes
Zone 2 Total			12,400	
Zone 1 through Storage Reservoir	FHBPS #1 ^{2,3}	4,500	3,000	Yes
	FHBPS #2 ⁴	1,100	1,100	Inadequate Backup Power
	(through FHB Storage Reservoir)	Transfer Pump Station ²	1,500	Yes
	Zone 1 Total		2,600	
Zone 1A	Zone 1A Pump Station (New)		7,200	Yes
Zone 1A Total			7,200	
System Wide Total Supply Only			12,400	

Notes:

1. The listed total pumping capacity in this table is the simple sum of individual pump capacities. This is typically greater than the actual total station capacity.
2. The Transfer Pump Station has two 1,500 gpm pumps that may work as alternates but cannot pump at the same time.
3. FHBPS #1 has three 1,500 gpm pumps and two 400 gpm pumps, however the 400 gpm pumps do not operate at the same time as the 1,500 gpm pumps due to operating pump head differences. The simple sum of the capacity of pumps that operationally run at the same time is provided. With one of these pumps out of service the firm capacity is approximately 3,000 gpm. The continuous rate of supply, however is limited by the Transfer Pump Station.
4. FHBPS #2 typically does not exceed 1,100 gpm during normal operations and hydrant testing conditions. Total capacity under emergency fire flow conditions may be higher. There is only one pump in this station, however it serves the same purpose as FHBPS#1.

Firm capacity supply is required to be adequate to meet MDD. Therefore, storage reservoirs should not experience net loss in storage volume over a day of MDD. For boosted zones, the supply capacity in a storage reservoir may limit the sustainable firm capacity supply available. Supply capacity to serve MDD without drawing down the volume stored in reservoirs is summarized in **Table 3-6**, which also takes into account the limited boosting capacity to provide supply.

Table 3-6 | Summary of Firm Capacity Supply to Meet MDD

Zone	MDD (gpm)	Firm Supply Capacity (gpm)	Firm Boosting Capacity (gpm)
Zone 1	840		2,600
Zone 1A	630		7,200
Zone 2	8,730	12,400	
System Wide	10,200	12,400	

Firm capacity well supply is adequate, system wide and zone by zone, to meet MDD, accounting for firm boosting capacity.

Even though supply is adequate for the 2025 horizon, construction of Well 9 is recommended in this horizon. Extended Period Simulation (EPS) modeling analysis has shown that the distribution system may have operational difficulties maintaining all system reservoir levels under MDD demands if Well 5 is out of service. This is due to transmission limitations and the location of Well 5 and the new Well 8. Construction of the planned Well 9 in the near term provides a strong backup supply option to support the system and ensure that storage tank water levels can be maintained under MDD conditions, if Well 5 is offline.

The firm boosting capacity to Zone 1 without drawing down the level in storage reservoirs is 1,500 gpm at FHBPS #1 plus 1,100 gpm at FHBPS #2. This is because FHBPS #1 relies on supply from the transfer pumps to avoid drawing down the FHB Storage Reservoir. The Transfer Station Pumps have a firm capacity of 1,500 gpm. Both FHBPS #2 and FHBPS #1 serve the same purpose so only one Transfer Station Pump is out of service under firm capacity conditions.

Firm supply and boosting capacity are adequate and no improvements are required.

3.3.2 Booster Station Capacity to Meet Fire and Peak Demands

Table 3-7 evaluates the pumping capacity of closed zone areas to supply their highest planning demands. Pumping capacity must be adequate to supply MDD+Fire or PHD whichever is greater on a firm capacity basis for Zones that are not served by gravity storage. This analysis utilizes firm pumping capacity that can draw down the level of storage reservoirs. The stored water volume is intended for use to supply for fire suppression and equalization requirements.

Zone 1 is served by FHBPS #1 with three 1,500 gpm pumps and two 400 gpm pumps, as well as FHBPS #2 with one 1,100 gpm pump. Under high demand conditions, with the largest pump out of service, only two 1,500 gpm pumps will run at FHBPS #1, and the 1,100 gpm pump at FHBPS #2. Therefore, the firm capacity to meet the highest demands in Zone 1 is approximately 4,100 gpm.

Table 3-7 | Summary of Firm Boosting Capacity to Supply Peak Demands to Closed Zones

Zone	MDD	MDD+Fire (gpm)	PHD	Firm Boosting Capacity Utilizing Storage (gpm)
Zone 1	842	3,342	1,945	4,100
Zone 1A	634	4,134	1,465	7,200 (New Fall 2022)

Zone 1 and Zone 1A under existing and future conditions have adequate boosting capacity. No improvements are required beyond the previously planned improvements at the South Redmond Water Facility and the reconfiguration of FHBS#1 to serve Zone 1 from the System Storage Reservoir.

Gravity storage reservoirs are considered reliable back up or as emergency sources of supply because they can deliver supply without the need for mechanical components or electrical power. However, Reservoirs 4, 5, and 6 cannot serve the system by gravity. These reservoirs rely on booster stations to deliver adequately pressurized water to the system. The reservoir booster stations pump well supply to the system (Zone 2) in addition to delivering the stored volume of water. Firm capacity analysis of these reservoir booster stations assumes the loss of the single largest reservoir booster pump among both reservoir booster stations.

Table 3-8 presents the capacity of reservoir booster stations to deliver both storage and well supply.

Table 3-8 | Booster Station Capacity to Deliver Storage and Supply

Booster Station	Total Station Capacity (MGD)	Firm Capacity (MGD)	Well Capacity at Station (MGD)	Remaining Station Firm Capacity to Deliver Storage (MGD)	Reservoir Volume Stored at Pump Station (MG)
Booster Station at Well 6	5.76	2.88	3.28	-0.40	4.2
Booster Station at Well 7	6.34	4.75	3.31	1.44	3.5

The 2,000 gpm pumps in the Well 6 reservoir booster station are the largest among the Well 6 and Well 7 booster stations. With one pump out of service at the Well 6 Booster Station, the remaining pump has shown that it can deliver as much or more than the capacity of Well 6. However, under demands greater than MDD or fire flow conditions little if any of the stored water at this site could be conveyed into the system if one of the boosters was out of service. Therefore additional firm boosting capacity is recommended at the Well 6 reservoir booster station. Each of the two existing pumps in the station has a 2,000 gpm capacity. A third 2,000 gpm backup pump is recommended. Additional distribution system improvements should also be assessed at the time the booster station is upgraded to validate adequate conveyance capacity.

3.3.3 Existing Storage Analysis

The City is currently in the process of constructing a new water storage tank (Reservoir 7) as part of the South Redmond Facility, located near Volcano Avenue. Reservoir 7 is evaluated as existing in this analysis, which analyzes storage on both a zone by zone, and system wide basis. Fire storage requirements are evaluated for the single largest fire in any zone, and not for multiple, simultaneous fire events.

Table 3-9 | Available Storage Volume by Zone

Zone	Storage Reservoir	Reservoir Volume (MG)
Zone 2	FHB System Reservoir	2.0
	Reservoir 7 (New Fall 2022)	4.0
	FHB Storage Reservoir	2.1
	Reservoir 4 at Well 6	2.1
	Reservoir 5 at Well 6	2.1
	Reservoir 6 at Well 7	3.5
Total Zone 2		15.8
Zone 1	FHB Storage Reservoir	2.1
Total Zone 1		2.1
Zone 1A	FHB Storage Reservoir (Backup PRV)	2.1
	Reservoir 7 (New Fall 2022)	4.2
Total Zone 1A		6.3
Total System Wide		15.8

Table 3-10 compares the Existing Available Storage volume with storage requirements based on the criteria presented in **Section 3.2**. The requirement is equal to Equalization storage plus either Emergency or Fire storage, whichever is greater. The Equalization Plus Emergency Requirement is the largest and represents the required storage volume in this case.

Table 3-10 | Existing Storage Analysis Summary

Zone	Total Storage Volume (MG)	Required Equalization (25% of MDD) (MG)	Emergency Volume 1XADD (MG)	Required Fire Volume (MGI)	Equalization Plus Fire Requirement (MG)	Equalization Plus Emergency Requirement (MG)
Total Zone 2	15.8	3.14	5.47	0.63	3.78	8.62
Total Zone 1	2.1	0.31	0.53	0.30	0.61	0.84
Total Zone 1A	2.3	0.23	0.40	0.63	0.86	0.63
Total System Wide	15.8	3.68	6.40	0.63	4.31	10.1

Notes:

1. The System Wide Equalization Plus Emergency requirement includes the total of emergency and equalization requirements for the entire system.
2. The System Wide Equalization plus Fire requirement includes the total system wide equalization requirement, only the single largest fire flow storage requirement system wide.
3. All tanks in the system serve Zone 2 by either gravity or booster pump station, or can serve Zone 2 by transfer station valves.

Under existing demand conditions the total reservoir storage volume of 15.8 MG available in Zone 2 and system wide, is adequate to provide the 10.1 MG of storage required by the Equalization plus Emergency storage requirement.

3.3.4 Multiple Pump Requirement

In addition to capacity requirements, each pump station is required to have a minimum of three pumps: two active and one standby. The FHBPS #2 has only a single pump; however, an additional pump station with multiple pumps serves the same zone. As a result, the number of pumps serving the zone is adequate.

The Well 6 Booster Station is an existing pump station that conveys supply produced by Well 6 and produces stored volume from Reservoirs 4 and 5. Because pumps in this station are used in series with the well pump to deliver flow from Well 6 to the system, the well pump and the booster pumps must both be operational to deliver Well 6 supply. The firm capacity of the booster pump station, with one pump out of service, is slightly less than the well pump design point flow. Additional capacity is recommended, which will also increase the number of pumps in the station and improve reliability to utilize the stored volume in Reservoirs 4 and 5 under peak demands or emergency conditions. Each existing pump at the Well 6 Booster Station is 2,000 gpm. An additional 2,000 gpm pump is recommended. At firm capacity, the Booster Station will then be able to deliver the well supply and a little over half of the onsite reservoir volume in one day.

Improvement: Add at least 2,000 gpm in new firm capacity to the Well 6 Booster Station to meet requirements for multiple pumps. This improvement will meet criteria for the number of pumps in a station, and allow the storage volume to be utilized during peak demand or emergency conditions.

3.3.5 Backup Power Requirement

Adequate backup power is available at all pumping facilities except for at Well 1 and Well 4. The emergency generator at Well 4 is inadequate to power both the well and the nearby FHBPS #2 at the same time. Improvements to provide adequate backup power are planned.

In the near-term, improvements to the facility at Well 1 are not planned. A future planned Well 9 is considered the replacement for Well 1.

3.3.6 Distribution System Hydraulic Analysis

A full update of the City's hydraulic model was completed in 2019 using the Infowater software which runs on EPANet. Existing system analysis assumes that near-term improvements anticipated for Fall 2022 at the South Redmond Facility and related to the operation of FHBS#1 have been completed. Baseline improvements considered "existing" in this analysis include:

- Conversion of the FHBPS#1 to draw water from the FHB Storage Reservoir to serve Zone 1

- Construction of the South Redmond Water Facility:
 - Construction of the new 4.0MG Reservoir 7 near Volcano Avenue
 - Construction of Well 8 that will feed Reservoir 7 directly
 - Completion of a new booster pump station that will connect to Reservoir 7, and construct a discharge pipeline to serve Zone 1A
- Transition to standby - Antler Reservoir, Antler Pump Station, and associated pipelines, fire laterals and hydrants.
- Wells 1 is not used due to operational issues associated with entrained air due to cascading water.

The demand conditions evaluated in the hydraulic analysis include ADD, MDD, PHD, and MDD+Fire. The status of gravity storage reservoirs used in the analysis were as follows.

- FHB System Reservoir, and Reservoir 7 are at 13.0 feet (65 percent) for steady state fire flow analysis, MDD, and PHD Scenarios.
- The gravity storage reservoirs are near full for ADD analysis evaluating potential high-pressure conditions.

Firm capacity analysis for booster stations and supplies included:

- The largest pump in FHBPS #1 is offline.
- Well 5 is offline.
- Total firm capacity supply is 12,400 gpm, and this is more than the 10,200 gpm needed to supply existing MDD system wide.

The Well 6 Booster Station is operationally controlled by the level in the FHB System Reservoir. During the summer 2018 hydraulic model calibration, only one pump in the booster station was operating as on/off control according to FHB System Reservoir Level.

Under the low FHB System Reservoir level condition evaluated for MDD+Fire performance (13.0 feet), the second pump would have also been on. The normal operating static pressure at this location for the MDD Scenario with the FHB System Reservoir at 13 feet is approximately 60 psi. For Fire flow analysis with improved firm capacity under the described baseline conditions, the pump station was modeled with the capability to deliver up to the existing capacity of the station, controlled not to exceed a discharge pressure of 57 psi, close to 3,180 feet HGL, or the full tank HGL for the FHB System Reservoir.

The booster pump assumed out of service in this scenario is the recommended new 2,000 gpm pump at the Well 6 booster station, intended to support reliability and redundancy. Allowing the use of both existing pumps at the Well 6 booster station as the firm boosting capacity condition provides an opportunity for high flow stress testing of transmission pipelines from the Well 6 booster station and nearby storage facilities, to the system.

In hydraulic model analysis, the Well 7 Booster Station controlled to provide supply to target 63 psi at the point of connection with the distribution system.

The results of hydraulic analysis and system wide pressures discussed in the following sections are presented in **Figure 3-1**. The results of Fire flow analysis are presented in **Figure 3-2**.

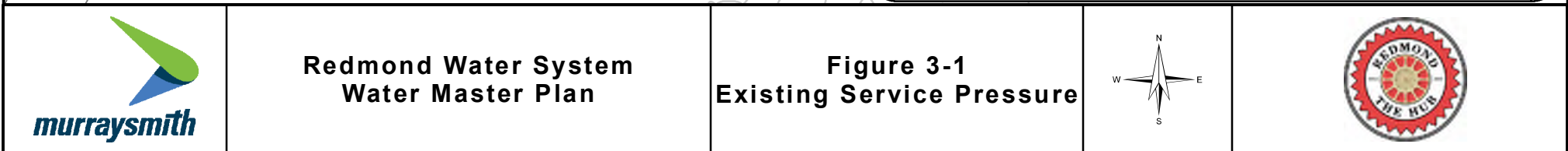
3.3.7 ADD Analysis

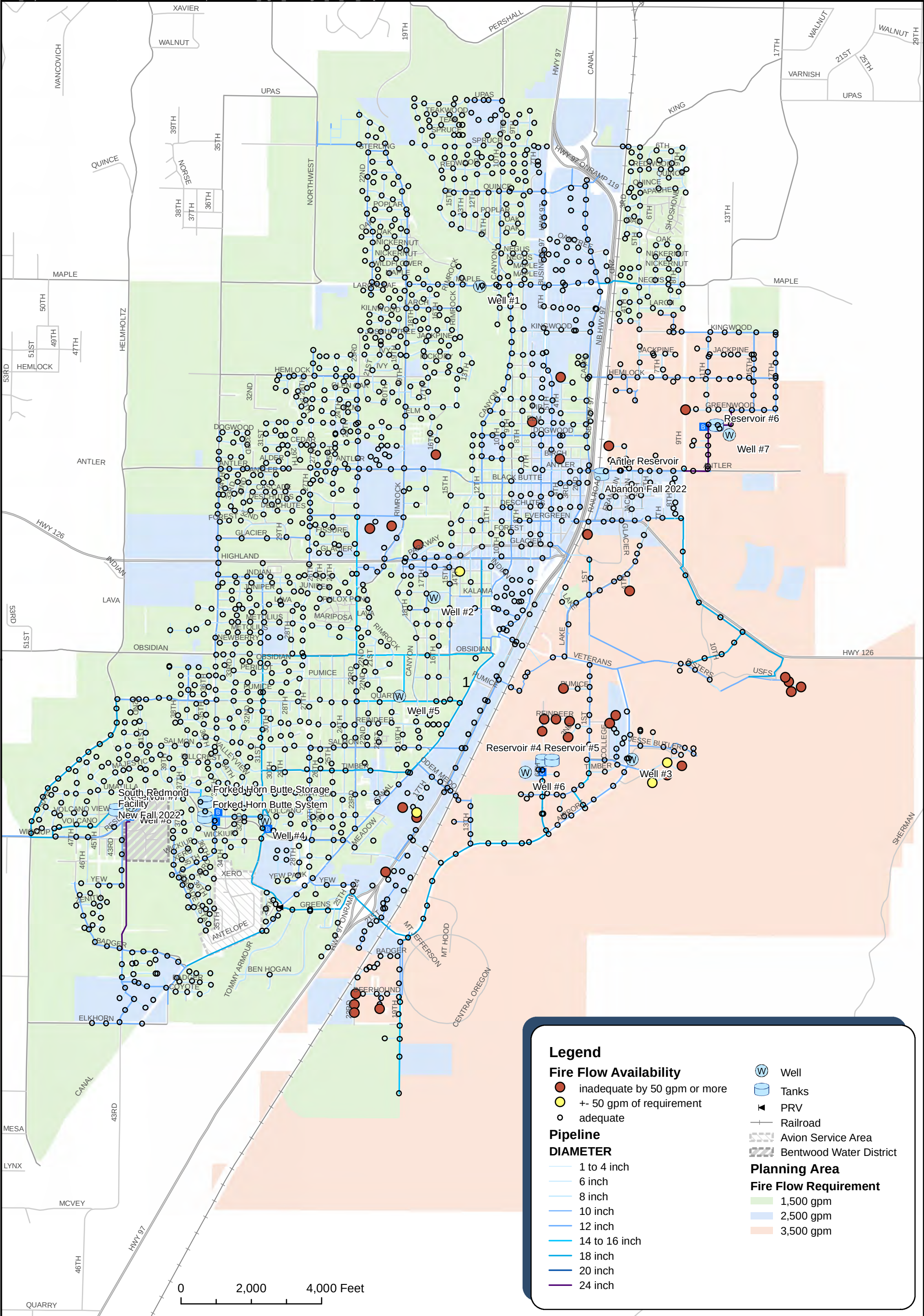
During periods of low winter use, operational changes, such as reduced maximum reservoir levels, may offset the influence of low demand on system pressures. For this reason, ADD is used for analysis to determine hydraulic model high pressure deficiencies. Pressure results are presented in **Figure 3-1**. A water meter serving the City's Water Pollution Control Facility (WPCF) was identified at elevation 2,878 feet in Zone 2, west of NW Canyon Drive near NW Spruce Avenue. This connection can experience pressures over 125 psi at the maximum operating HGL, unless pressure protection exists. Under the existing conditions ADD hydraulic analysis, the pressure at this location was close to 125 psi.

Service pressures in Zone 1 near the boundary of Zones 1 and 2, also experience high pressures over 100 psi. While these areas do not exceed the high pressure criteria, care should be taken to avoid any future operational conditions that would further increase in pressures to these customers.

Improvement: Verify the typical service pressure near the WPCF in Zone 2 west of NW Canyon Drive near NW Spruce Avenue by installing a pressure gage at a nearby hydrant or hose bib. High pressure pipelines may be at increased risk for pipe break or leakage. The City could assess the creation of a small lower pressure zone by installing a PRV station or alternately install an individual service PRV at the WPCF.

Note that existing pressures at the lowest elevations served by Zone 1 may exceed 100 psi. Through the modification of FHBS#1 the City will want to avoid any changes that could further increase service pressures in Zone 1.





3.3.8 MDD Analysis

In Zone 2, near the high elevation boundary with Zone 1, a small number of Zone 2 customers exist that are above elevation 3,070 feet. This is the high elevation limit that can be theoretically served with adequate pressure.

If existing customers near the boundary between Zones 2 and 1, have not reported low pressure issues, converting these customers to Zone 1 may not be warranted. Serving these customers from Zone 1 would result in a large change in their existing service pressure. Existing operating pressures may have, at times, neared 35 to 45 psi when served from Zone 2. If service is supplied from Zone 1, operating pressures to these customers may approach 110 to 120 psi.

Customer connections are also located in a small hilltop area at the end of SE USFS Drive that exceeds the maximum elevation that can be adequately served by Zone 2. Low pressure service areas are shown on **Figure 3-1**.

Improvement: Evaluate customer pressure at high elevation areas and determine if a small number of high elevation customers in Zone 2 would benefit from pressure zone boundary adjustment into Zone 1, making this change would significantly increase operating service pressure for these customers. Isolated existing hilltop areas may be addressed by individual service pumps if low service pressures are found to be problematic.

3.3.9 PHD Analysis

The same areas experiencing pressure below target under MDD experience pressures below target under PHD. While the criteria pressure requirement is reduced under PHD conditions, service pressure is similarly reduced.

Improvement: Same as MDD requirements

3.3.10 MDD + Fire Analysis

Firm Capacity Supply with a capacity upgrade at the Well 6 Pump Station was used to evaluate pipeline capacity to deliver supply and storage under MDD+Fire demand. Well 5 was offline as the largest supply in the system.

Zone 1 is supplied through the FHB Storage Reservoir using the two largest pumps in the FHBPS #1 pump station, having a combined capacity of 3,000 gpm. The FHBPS #2 is considered to have 1,100 gpm additional capacity supplied from Zone 2 near Well 4. The resulting pumping capacity to Zone 1 under MDD+Fire, PHD, and MDD conditions is 4,100 gpm.

The results of existing analysis indicate that available fire flow is generally adequate system wide. **Figure 3-2** | presents fire flow requirements and areas with inadequate fire flow availability, system wide. The majority of observed fire flow deficiencies were identified on dead-end pipelines. Per the fire flow analysis, the entire fire flow requirement must be adequately delivered

to the point of each hydrant service line connection with adequate residual pressure in the entire system. Dead end pipelines may result in enough friction headloss to lower system pressures below the 20 psi criteria when the required fire flow is delivered.

In instances where large fire flow requirements exist, such as 2,500 or 3,500 gpm, often multiple fire hydrants would be used to deliver fire flow in the field. Fire flow requirements however, establish a level of performance that the system is required to meet. Looping or upgrading dead end pipelines reduces the potential for high velocity conditions during fire flow and strengthens the distribution system network in addition to reducing the occurrence of water quality issues due to stagnant water. Locations that do not meet fire flow criteria are shown on **Figure 3-2** |.

Improvement: pipeline improvements to address fire flow deficiencies included in **Figure 3-3**.

3.3.11 Antler Reservoir Analysis

All analysis was completed assuming the Antler Reservoir has been transitioned to standby. Generally, fire flow availability in areas previously served by the reservoir were found to be adequate after the transition. Exceptions are shown on **Figure 3-2** |. Fire flow in the area of Antler Reservoir is supported by the Well 7 and Reservoir 6 facilities. Available active hydrant number and spacing were not evaluated.

Improvement: pipeline improvements to address fire flow deficiencies are shown included in **Figure 3-3**.

3.4 Future System Analysis

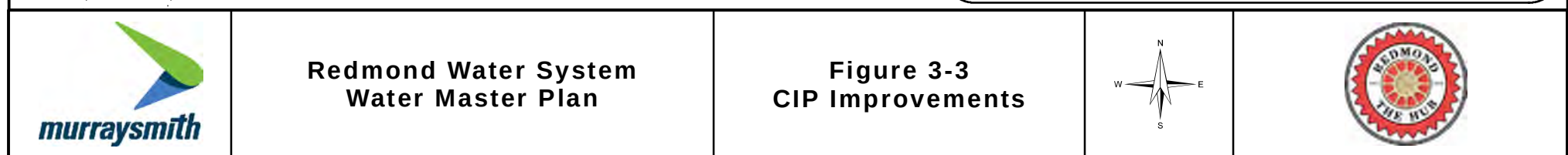
This section evaluates future system performance for 2025 and 2040 conditions in addition to a limited evaluation of Buildout to ensure pipes are sized to serve beyond 2040 conditions.

Future demands were developed based on existing per capita and per acre rates using population and land use projections respectively. The City's 2040 Comprehensive Plan identified the development type for lands within the planning area. The planning area is shown in **Figure 3-3**.

3.4.1 Future System Capacity Analysis

The existing system analysis assumed completion of several near-term system improvements as the baseline condition. Future analysis applies these same baseline improvements to serve the demand growth projected for future planning horizons.

In addition to the existing system baseline improvements, it is assumed that 2,000 gpm pumping capacity will be added to the Well 6 Booster to make both storage and well supply available at firm capacity.



3.4.1.1 Future Supply

Supply must be adequate to meet MDD with the largest pump out of service. This section evaluates future supply requirements by planning horizon and pressure zone. Supply must be boosted to pressure zones 1 and 1A. Boosting capacity is noted to confirm well supply can be conveyed to zones served by booster station. **Figure 3-3** shows the assumed location of proposed future well supplies.

Table 3-11 | 2025 Firm Capacity Supply to Meet MDD

Zone	MDD (gpm)	Firm Supply Capacity (gpm)	Firm Boosting Capacity (gpm)	Required New Supply Capacity (gpm)
Zone 1	930		2,600	0
Zone 1A	850		7,200	0
Zone 2	9,820	12,400		0
System Wide	11,600	12,400		0

This improvement supports the system in the 2025 horizon which is a transitional period before pipelines associated with transmission improvements and system growth and are completed. This supply will be required to support demand in future horizons.

Improvement: Construct Well 9 supply to support operations and storage reservoir levels, as well as future demands.

Table 3-12 summarizes the firm capacity supply and demand projected in the year 2040.

Table 3-12 | 2040 Firm Capacity Supply to Meet MDD

Zone	MDD (gpm)	Firm Supply Capacity (gpm)	Firm Boosting Capacity (gpm)	Required New Supply or boosting Capacity (gpm)
Zone 1	1,180		2,600	0
Zone 1A	1,970		7,200	0
Zone 2	13,210	12,400		3,960 ¹
System Wide	16,360	12,400		3,960

Note:

1. No supplies are planned in Zones 1 or 1A to serve future demand in those areas therefore supply will come from Zone 2. Boosting capacity is adequate to serve Zones 1 and 1A.

Zones 1 and 1A have no direct supply. Their firm boosting capacity is adequate to transmit firm capacity supply, if it is available. While Zone 2 itself would only require an additional 810 gpm by 2040, when the demand that will be required by Zones 1 and 1A are included, a total of nearly 4,000 gpm is required system wide. This additional supply can be located in Zone 2, because boosting capacity is adequate to convey the firm capacity supply from Zone 2 to the required zones. Without the addition of new firm capacity supply, a deficit of approximately 4,000 gpm will occur by 2040. Each new well is assumed to have a capacity of approximately 3,000 gpm. The addition of Well 9 in the 2025 planning horizon will not be adequate to meet the entire 4,000 gpm deficit. The addition of two new wells will provide more than the minimum required firm capacity

supply. With 6,000 gpm of new firm capacity supply, an excess of approximately 2,000 gpm firm capacity supply will be available to the system in the year 2040. Total firm capacity supply will then be 18,400 gpm. It should be noted that the aquifer under the City's service area typically yields highly productive wells and the capacity achieved by drilling a new well may exceed 3,000 gpm.

Boosting capacity is adequate to convey firm capacity supply to Zones 1 and 1A, so new supply is recommended in Zone 2.

Improvement: Construct a new well (Well 10) at Obsidian in this planning horizon with a minimum of 1,000 gpm capacity to meet projected 2040 MDD; however the assumed capacity is 3,000 gpm.

3.4.1.2 Future Storage

This analysis provides an evaluation of future pumping facility and storage requirements to accommodate projected future demands.

Future storage analysis assumes that improvements have been made to the Well 6 Pump Station near Reservoirs 4 and 5 to increase firm capacity by at least 2,000 gpm. This improved capacity is recommended to provide the stored volume plus well supply with the largest pump out of service. The Antler Reservoir and Pump Station are assumed to be standby only.

Table 3-13 presents storage requirements for the 2025 planning horizon.

Table 3-13 | 2025 Storage Reservoirs

Zone	Storage Volume (MG) ³	Required Equalization (25% of MDD) (MG)	Emergency Volume 1XADD (MG)	Required Fire Volume (MGI)	Equalization Plus Fire Requirement (MG)	Equalization Plus Emergency Requirement (MG)
Zone 1	2.1	0.34	0.68	0.30	0.64	1.02
Zone 1A	4.0	0.31	0.6	0.63	0.94	0.91
Zone 2	15.8	3.54	6.06	0.63	4.17	9.60
System Wide	15.8	4.18	7.34	0.63	4.81	11.52

Notes:

1. The System Wide Equalization Plus Emergency requirement includes the total of emergency and equalization requirements for the entire system.
2. The System Wide Equalization plus Fire requirement includes the total system wide equalization requirement, only the single largest fire flow storage requirement system wide.
3. Excludes storage that could be conveyed by PRV.

Comparison of the system's existing storage volume with the Equalization Plus Emergency Requirement shows that the existing water storage volume is adequate through 2025.

With recommended pump station improvements at the Well 6 Pump Station, the existing storage facilities will be more reliable to serve projected 2025 storage requirements. The existing storage volume is 15.8 MG, with 11.52 MG of storage is required.

Table 3-14 summarizes storage analysis for the 2040 horizon.

Table 3-14 | 2040 Storage Reservoirs

Zone	Storage Volume (MG) ³	Required Equalization (25% of MDD) (MG)	Emergency Volume 1XADD (MG)	Required Fire Volume (MGI)	Equalization Plus Fire Requirement (MG)	Equalization Plus Emergency Requirement (MG)
Zone 1	2.1	0.43	0.84	0.30	0.73	1.27
Zone 1A	4.0	0.72	1.47	0.63	1.35	2.19
Zone 2	15.8	4.75	8.35	0.63	5.38	13.10
System Wide	15.8	5.89	10.66	0.63	6.52	16.55

Notes:

1. The System Wide Equalization Plus Emergency requirement includes the total of emergency and equalization requirements for the entire system.
2. The System Wide Equalization plus Fire requirement includes the total system wide equalization requirement, only the single largest fire flow storage requirement system wide.
3. Excludes storage that could be conveyed by PRV.

The required 2040 storage volume is 16.6 MG and the available volume is 15.8 MG. This yields a slightly deficient (0.8 MG) in the 2040 planning horizon.

Planning for additional storage near the end of this horizon may be required to serve future demand, however actual water use will need to be evaluated as part of subsequent planning efforts. Excess firm capacity supply of 2,000 gpm could be considered to offset some of the equalization requirements. Firm pumping capacity may be used to meet demands in excess of MDD. Almost 2.9 MG of equalization supply may be offset by the planned additional production capacity, making production plus storage adequate for the system in 2040.

Recommended Improvements:

- Add 2,000 gpm firm capacity at Well 6 Pump Station, per recommendations, in the existing horizon to fully leverage the storage in Reservoirs 4 and 5.
- Re-evaluate system growth and demand to determine the need for new storage.

3.4.1.3 Future Booster Pumping Analysis

Future capacity pumping requirements evaluated in this section compare the available firm boosting capacity with MDD and fire flow requirements in closed zones. **Table 3-15** summarizes firm pumping capacity to closed zones in the 2025 planning horizon.

Table 3-15 | 2025 Firm Pumping Capacity to Supply Closed Zones

Zone	MDD	MDD+Fire (gpm)	PHD	Max (gpm)	Firm Boosting Capacity Utilizing Storage (gpm)
Zone 1	930	3,430	2,140	2,570	4,100
Zone 1A	850	4,350	1,970	2,360	7,200 (New Fall 2022)

Existing and planned firm boosting capacity exceeds the 2025 MDD and MDD+Fire requirements. No additional boosting capacity beyond the planned improvements at the South Redmond Facility are required.

Table 3-16 presents the firm boosting capacity to supply closed zones in the 2040 planning horizon.

Table 3-16 | 2040 Firm Pumping Capacity to Supply Closed Zones

Zone	MDD	MDD+Fire (gpm)	PHD	Max (gpm)	Firm Boosting Capacity Utilizing Storage (gpm)
Zone 1	1,180	3,680	2,720	3,260	4,100
Zone 1A	1,990	5,490	3,980	4,680	7,200 (New Fall 2022)

Existing and planned firm boosting capacity to closed zones exceeds the 2040 MDD and MDD+Fire requirements. Booster 1A was designed to serve estimated build-out demands plus fire suppression requirements which is projected to be approximately 7,000 gpm. No additional boosting capacity beyond the planned improvements at the South Redmond Facility and modifications to the FHBS#1 per prior discussion are required through 2040.

3.4.2 Future System Hydraulic Analysis

The model was used to evaluate 2040 and some buildout conditions to ensure adequate long term pipe sizing. The system is generally sized to convey future flows however some pipelines need to be upsized for fire flow conditions. As the City continues to grow, additional conveyance infrastructure will be needed, especially in the periphery. **Figure 3-3** presents the location of proposed pipeline improvements.

3.4.2.1 Future Service Levels and System Pressure

The existing pressure zone hydraulic gradelines are adequate to serve the majority of future growth areas included in the future planning WSPA. **Table 3-17** summarizes the operational HGL and zone elevations for each service level and compares the ground surface elevation in each pressure zone, with the maximum and minimum elevation that can be served while providing adequate pressure.

Table 3-17 | Future Operational Service HGL and System Elevations

Pressure Zone	Operational Hydraulic Grade Line (ft)	Adequate Pressure High Elevation (ft)	Service High Elevation (ft)	Adequate Pressure Low Elevation (ft)	Service Low Elevation (ft)
Zone 1	3,345	3,241	3,232	3,057	3,060
Zone 1A	3,270	3,166	3,114	3,039	3,038
Zone 2	3,173	3,069	3,088	2,892	2,860

Contours representing 3,069 feet elevation are shown on **Figure 3-3**. This is the theoretical high elevation boundary line above which adequate pressure cannot be provided by Zone 2 at the assumed low operational gravity storage tank level (HGL of 3,173 feet at 45 psi). Limited areas are currently served under existing conditions with elevations exceeding the Zone 2 maximum elevation. These are primarily located at the boundary with Zone 1, as well as in isolated existing service areas near the airport. Additional small isolated hilltop areas above the maximum elevation are associated with potential future growth north of the airport and north of Highway 126.

Contours representing 2,892 feet elevation are also shown on **Figure 3-3**. This is the theoretical boundary below which pressure will exceed the maximum pressure criteria at the high operational HGL for Zone 2 (3,180 ft). Limited areas associated with potential future growth may be located below the minimum Zone 2 service elevation. These areas may be designated as limited for development or localized pressure protection may be used.

3.4.2.2 Future Hydraulic Model Analysis and Modeled System Pressure

Future model hydraulic analysis includes ADD, MDD, PHD, and MDD+Fire scenarios to determine if additional improvements to the distribution network are required with future growth. These scenarios were evaluated for the 2025 and 2040 horizons with limited evaluation of the Build-out horizon to confirm adequate sizing of future pipelines.

Operational conditions in future analysis are the same as those used in the existing horizon analysis. The addition of recommended future boosting and supply capacity is assumed in each future horizon to evaluate pipeline transmission and service pressure.

The future distribution system development with growth assumes a 12-inch grid, supported by 8-inch looped infill in residential areas that require 1,500 gpm fire flow as shown in **Figure 3-3**. Commercial and mixed use areas with a fire flow of 2,500 gpm may require a higher density of 12-inch looped pipelines. Industrial and other areas with a 3,500 gpm fire flow requirement assume a minimum pipe size of 12-inch looped pipelines or greater.

Future hydraulic model results confirm the maximum and minimum service elevation calculations shown in **Table 3-17**. **Figure 3-3** illustrates future service areas that will experience high or low pressures outside of criteria when served from Pressure Zone 2. These areas include isolated hilltops near to and North of Hwy 126, and limited canyon and low elevations in the North end of the planning area.

The fire flow improvements identified under existing analysis were found to provide adequate fire flow under future scenarios in existing areas.

In order to continue to effectively transmit supply from Well 6 and Well 3, and Reservoirs 4 and 5 in the future, lower priority transmission pipeline improvements were identified. These include pipeline improvements 30-34, 36, 37 and 39. These improvements are intended to leverage supply and storage facilities and convey water to the rest of the system, without excessive headloss. They improve connectivity between Well 6 and Well 3, and the FHB System Reservoir, as well as the

rest of Zone 2. While these improvements are not directly associated with a specific performance requirement, they are recommended as operationally beneficial. In addition, a minimum pipeline improvement diameter of 12-inches was applied in areas with fire flow requirements of 3,500 gpm, and 18-inch minimum pipeline improvement diameter for pipeline improvement railroad crossings.

3.5 Condition Assessment

3.5.1 Introduction

To determine the condition of the water supply system, a review of specific wells and booster stations was performed with regard to both the existing condition of the facility and compliance with Oregon Administrative Rules (OARs), Oregon Health Authority (OHA) Sanitary Survey Inspection Criteria, Oregon Efficiency Specialty Code, Hydraulic Institute, and National Electrical Code. Additional assessment was provided in the Risk and Resiliency Assessment, Murraysmith (included in **Appendix C**), and an assessment by S&B, Inc., retained by the City (included in **Appendix D**).

Evaluations of Well No. 1, Antler Pump Station, and Well No. 8 are not assessed as these systems were not identified as critical for assessment and improvement by City staff. Well No. 1 will be replaced in the near term by Well No. 9 and the Antler Pump Station will be standby only. Well No. 8 is currently under construction.

3.5.2 Facility Condition Assessment

Each facility was evaluated using input from multiple sources to help identify problems and areas of concerns. Process problems relating to well water pumping, and treatment, were noted, along with operator safety, equipment operation, and facility construction concerns.

A Condition Assessment was delivered to operations staff in order to document their general assessment of each well facility. The questions in the Operator Condition Assessment cover the general facility condition, safety concerns, and operational deficiencies for each pump house, pump equipment, electrical equipment, and chlorination system. The assessment also evaluates the condition of site access and security, as well as well water quality or quantity problems.

The final evaluation process included an onsite review of each facility to further identify issues and identify potential improvements. Each facility inspection included a review of its layout, overall condition and state of its equipment, and identified potential improvement options. No testing or structural evaluations (e.g., equipment testing, destructive load) were performed during the onsite review. The Operator Condition Assessment survey is located with the detailed Condition Assessment in **Appendix C**.

Recommended improvements:

- Arc Flash study for each of well sites and pump station

- Well 4 - update electrical components; new switchboard, MCC and fans, plus upgrades to the chlorine and generator building.
- Well 3 - structural (roof, exhaust fan) with some minor facility plumbing improvements.
- Well 2 - site access with upgrades to the road and drainage. Water quality improvements at Well 2 are intended to address sand and air entrainment.
- Well 6 - telemetry based; updating the scales to integrate with SCADA.

Recommended improvements cover electrical, SCADA, structural and site improvements. The complete facility evaluation can be found in **Appendix C – Condition Assessment**.

3.6 Summary

Overall the existing system provides reliable water supply to customers under normal and peak demands as well as under fire flow conditions. Pressures throughout the system are predominately adequate, with a few isolated hilltop areas experiencing low pressure due to service elevation. Near-term improvements (considered existing in this analysis) include construction of the South Redmond Water Facility Well 8, Storage Reservoir 7, and South Redmond Booster Station to serve Zone 1A. Reconfiguring FHBS#1 to connect to the Storage Reservoir will improve the overall efficiency for how Zone 1 is served and will increase the turnover in that reservoir. Backup power and booster pumping redundancy improvements are recommended, in addition to pipeline improvements to increase fire flow availability to a relatively small number of existing fire flow deficiencies. Investment in a GIS database of land use within the planning area is recommended. This data will support future demand analysis within the service area and improved characterization of water use by land use type.

Two new wells will be required to serve demand growth through the year 2040. The first new well (Well 9) is recommended in the near term to support supply redundancy. The second new well (Well 10) is recommended to serve the 2025-2040 growth horizon. Additional pipeline improvements to improve transmission are recommended in the 2025-2040 horizon. Two water master plan updates in the next 20 years are recommended to reassess growth and per capita water use to better inform any improvements beyond 2025, in particular any additional storage. **Figure 3-3** indicates areas of potential new development within the service area that may experience high or low service pressure. Individual pressure reduction may be used to protect pipelines and facilities that may experience high pressure. Individual service pump may be applied in isolated high elevation hilltop areas.

Facility improvements have been identified through the Condition Assessment work. Electrical, SCADA, and structural upgrades to the existing wells and booster stations have been listed in the CIP Section, and are discussed in detail, in **Appendix C**.

Where new pipelines are constructed to serve development that are not specified in the capital improvement plan, 12-inch minimum looped pipeline should be used in areas serving 3,500 gpm

fire flow requirements, and 8-inch minimum looped pipeline should be used in areas serving 1,500 gpm fireflow requirements.

The following provides a list of improvements identified in this section.

- Create and maintain a land use GIS database that tracks the number of acres developed and developable within the WSPA, as well as land use type.
- Improve back up power at Well 4 near FHBPS #2.
- Evaluate customer pressure at high elevation areas and determine if a small number of high elevation customers in Zone 2 would benefit from pressure zone boundary adjustment into Zone 1, realizing this would significantly increase operating service pressure for these customers. Isolated existing hilltop areas in Zone 2 may be served by individual or private pumping if low service pressures are found to be problematic.
- If the high service pressure is of concern, near the WPCF in Zone 2 west of NW Canyon Drive near NW Spruce Avenue, consider individual pressure reduction.
- Pipeline improvements to address existing fire flow deficiencies are included in **Figure 3-3**.
- Construct Well 9 with a capacity of at least 3,000 gpm.
- Add at least one new pump (2,000 gpm) to the Well 6 pump station.
- Construct Well 10 at Obsidian as shown in **Figure 3-3**, of at least 3,000 gpm.
- Complete pipeline improvements to improve transmission and operations as shown in **Figure 3-3**.
- Arc Flash study for each of well sites and pump station
- Well 4 - update electrical components; new switchboard, MCC and fans, plus upgrades to the chlorine storage.
- Well 3 - structural (roof, exhaust fan) with some minor facility plumbing improvements.
- Well 2 - site access with upgrades to the road and drainage. Water quality improvements at Well 2 are intended to address sand and air entrainment.
- Well 6 - telemetry based; updating the scales to integrate with SCADA.

Section **4**

Section 4

Capital Improvement Plan

4.1 Introduction

Previous sections have outlined an overview of the existing system, projections of future growth, water demand and an analysis of existing and future water system requirements including supply, storage and distribution components. This section provides a summary of all proposed future improvements to address both hydraulic capacity and condition issues.

4.2 Capital Improvement Program

For the projects identified in this Capital Improvement Plan (CIP), the recommended facility sizes and designated locations are schematic. A Preliminary Engineering Report (PER) should be completed for each improvement project to identify the final sizing and location. A PER looks at a specific project in more detail than the analysis conducted within this WMP. During final design of each project, it will be necessary to confirm design flows, pipe and facility sizes, and pressure zone configurations based upon the current land use plan, proposed development, detailed soil surveys, soil investigations, utility conflicts, physical constraints and other relevant field conditions. This CIP, which addresses existing deficiencies and system expansion, is not anticipated to result in environmental impacts. Individual projects may result in temporary impacts during construction. The City is required to comply with environmental permitting requirements and provide mitigation measures in compliance with all local, state, and federal environmental regulations.

An estimate of project cost for each identified improvement was developed for this WMP. All costs identified in this section reference U.S. dollars. The Engineering News Record Construction Cost Index (ENR CCI) basis is 12,945 (Seattle, April 2021). The ENR CCI tracks the changes in price, as a mix of construction labor and materials, for a specific combination of construction labor, steel, concrete, cement and lumber using data from 20 cities across the United States. There is no escalation included for project cost in future years. To use the CCI to project future cost, multiply the past cost by the future CCI number and divide by the historic CCI number. **Appendix F** presents a detailed description of the methodology used for estimating these costs and the project unit costs, respectively. This description explains the procedures used in determining project costs and describes the assumptions made for construction, commonly occurring construction activities (such as erosion control), contingency factors, and other project costs.

In addition to the hydraulic modelling, a Risk and Resiliency (R&R) study (**Appendix D**) and a Condition Assessment (**Appendix C**) were performed to further evaluate the water system.

The R&R work is a response to the America's Water Infrastructure Act (AWIA), signed into law by Congress in late 2018, which provides guidelines to complete an assessment of the risks to and resilience of drinking water systems. The AWIA states that public water systems serving as many people as the City of Redmond's system will need to submit a certified letter that their Risk and Resilience Assessment has been completed prior to June 30, 2021. The R&R Assessment followed AWWA J100, and includes malevolent acts, natural hazards, and critical dependencies

The R&R work identified security type projects throughout the system; site fencing, card locks, security cameras, and intrusion alarms. The costs for this work are outlined in **Table 4-7**.

Recommendations from the Condition Assessment are outlined in **Table 4-5**, and include Arc Flash Studies for each well and booster station, switchboard and MCC upgrades, site improvements, and structural upgrades.

Identified piping CIP projects are prioritized into the 2025 and 2040 Planning Horizons.

Existing Assumed Baseline Improvements in this analysis include:

- South Redmond Water Facilities, Reservoir 7, Well 8, Booster Station to Zone 1A with discharge pipeline to 1A, previously planned.
- Change the operation of FHBPS #1 to take supply from FHB Storage Reservoir, previously planned.
- Transition to standby - Antler Reservoir along with associated pump and pipe infrastructure, previously planned.

2025 Planning Horizon improvements include:

- Pipeline improvements to address existing fire flow deficiencies as described in **Table 4-2** and **Figure 3-3**.
- Upsizing of developer constructed pipeline improvements from 8-inches to a size deemed appropriate for the long term transmission of water in the system.
- Improve backup power generation capability at Well 4.
- Add 3,000 firm capacity supply (Well 9).
- Incremental WMP update

2040 Planning Horizon improvements include:

- Add 2,000 gpm firm capacity to Well 6 Booster Station.
- Add 3,000 gpm firm capacity supply as Well 10 at Obsidian.

- Pipeline improvements to support operations and transmission as shown on **Figure 3-3** and listed in **Table 4-2**.
- Upsizing of developer constructed pipeline improvements from 8-inches to a size deemed appropriate for the long term transmission of water in the system
- Full WMP Update

Acquiring additional water rights is addressed in **Appendix A – Water Rights Summary**. This report by GSI identifies the City could exceed its maximum authorized rate of groundwater pumping by 2050.

Additional piping and facility projects are recommended to maintain the system, the level of redundancy, flexibility, supply and distribution of water. As the City reviews its system and budget each year the prioritization of projects may vary and the timeline shift somewhat from the recommendations. The pipeline improvements identified in **Table 4-2** indicate the CIP ID number, shown on **Figure 3-3**.

Table 4-2 provides the improved CIP diameter, the length of the pipeline improvement, the reason for the improvement, the relative priority of the pipeline improvement, the horizon in which the improvement is required, a description of the improvement and the project cost.

Upgrades to dead end pipelines to convey adequate flows at greater than 20 psi under fire flow conditions are rated as slightly lower in priority than fire flow improvements that involve system connectivity or looping. This is because short dead end pipelines that are inadequate to convey the entire fire flow to a single hydrant often impact a smaller number of customers. In addition, the benefit to overall system conveyance and connectivity of completing these improvements is smaller than improvements that increase overall system looping.

Pipeline improvements to serve future development are not assigned a CIP number as these projects are assumed to be constructed by developers. For specific developer driven pipeline improvements, the size upgrade from 8-inch to the indicated size is included in the CIP. These pipelines are indicated on **Figure 3-3** and are listed below.

Table 4-1 | City Funded Size Upgrades to Developer-Driven Pipeline Improvements

Horizon	D (in)	Length (ft)	Rounded Length (ft)	Cost to Upgrade
2025	12	12,971	13,000	\$1,105,000
2040	12	81,397	81,400	\$6,920,000
2040	16	48,598	48,600	\$6,035,000
2040	18	10,663	10,700	\$1,698,000

Table 4-2 | CIP Pipeline Improvements

CIP No.	D (in)	Length (ft)	Reason	Priority	Horizon	Description	Project Cost
2	12	474	Fire And Transmission	20	2021-2025	This is an upgrade to provide the required 3,500 gpm fire flow requirement by connecting waterlines in Yew and Xero.	\$231,000
3	8	421	Fire (Dead end)	23	2021-2025	This is an upgrade to provide the required 3,500 gpm fireflow by upsizing the line off Evergreen, east of 23rd Ave.	\$135,000
4	8	321	Fire (Dead end)	24	2021-2025	This is an upgrade to provide the required 3,500 gpm fireflow to Redmond High School off Rimrock.	\$119,000
6	12	761	Fire (Dead end)	34	2021-2025	This is an upgrade to provide the required 3,500 gpm at Southwest 2nd Court, off Reindeer Ave.	\$334,000
7	12	1,210	Fire (Dead end)	21	2021-2025	This is an upgrade to provide the required 3,500 gpm fireflow coming off Ochoco Way at SW Sisters Ave	\$555,000
8	12	524	Fire (Dead end)	35	2021-2025	This is an upgrade to provide the required 3,500 gpm fireflow at Southeast 4th Court, off SE Lake Road.	\$240,000
9	8	509	Fire	22	2021-2025	Improves fire flow availability at the end of SW 17th Place to meet 2,500 gpm commercial requirements	\$155,000
12	8	269	Fire	14	2021-2025	This is a looping improvement to provide the required 2,500 gpm fire flow at Elm Ave	\$96,000
13	8	1,380	Fire	16	2021-2025	This is an upgrade improvement to provide the required 2,500 gpm fire flow at NW 4th St north of NW Hemlock Ct	\$509,000
14	12	919	Fire	17	2021-2025	This is a looping improvement to provide the required 3,500 gpm fire flow at NE Greenwood Ave	\$430,000
15	8	774	Fire	18	2021-2025	This is an upgrade improvement to provide the required 2,500 gpm fire flow at NW 4th St north of NW Hemlock Ct	\$286,000
19	8	877	Fire	3	2021-2025	This new pipeline improves fire flow to serve the 2,500 gpm requirement. The pipeline on Dry Canyon Trail ties together 6-inch and 4-inch pipelines west of Sam Johnson Park. Additional improvement to the associated 4-inch pipeline for continuity would be reasonable.	\$267,000

CIP No.	D (in)	Length (ft)	Reason	Priority	Horizon	Description	Project Cost
20	12	384	Fire And Transmission	19	2021-2025	This looping improvement coming from Well 6 is required to serve the 3,500 gpm fire flow requirement. It also improves transmission of flow from the Well 6 and reservoirs 4 and 5 facility.	\$169,000
21	8	350	Fire (Dead end)	5	2021-2025	This improvement south of Evergreen Ave connecting to South 1st Street is required to provide the 2,500 gpm fire flow required on this dead-end pipeline with adequate residual pressure.	\$130,000
22	12	1,224	Fire	10	2021-2025	This looping improvement is required to serve the 3,500 gpm fire flow requirement near SE Jesse Butler Circle.	\$538,000
23	12	666	Fire	11	2021-2025	This looping improvement is required to serve the 3,500 gpm fire flow requirement near SE College Loop.	\$293,000
24	12	312	Fire	12	2021-2025	This looping improvement also supports the 3,500 gpm fire flow requirement near SE College Loop.	\$146,000
25	12	773	Fire and transmission	2	2021-2025	This looping improvement is required to provide the 2,500 gpm fire flow required at the end of NW 16th Place	\$301,000
27	8	335	Fire	15	2021-2025	This is a looping improvement to provide the required 2,500 gpm fire flow at NW Birch Ave	\$119,000
30	18	3,605	Well 6 Transmission	31	2026-2040	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97 at SW Quartz.	\$3,028,000
31	18	516	Well 6 Transmission	32	2026-2040	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97 across from Glacier and Highland Avenues.	\$571,000
32	18	1,181	Well 6 Transmission	30	2026-2040	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97 at Veterans Way.	\$941,000
33	12	1,602	Well 6 Transmission	26	2026-2040	This looping and transmission improvement is identified to support future transmission of storage at Well 6 and Reservoirs 4 and 5.	\$624,000

CIP No.	D (in)	Length (ft)	Reason	Priority	Horizon	Description	Project Cost
34	12	1,324	Well 6 Transmission	28	2026-2040	This looping and transmission improvement is identified to support future transmission of storage and supply near the railroad and Hwy 97 south of Odem Medo Way.	\$745,000
36	18	1,173	Well 6 Transmission	27	2026-2040	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97, coming off SW Meadow Lane.	\$1938,000
37	12	1,096	Well 6 Transmission	25	2026-2040	This looping and transmission improvement is identified to support future transmission of storage and supply near the railroad and Hwy 97, connecting SW Yew Ave to SW Xero Ave.	\$978,000
38	12	240	Looping	33	2026-2040	This looping improvement improves overall system looping and transmission reinforcing the 12-inch grid on SW 35th St north of W Antler Ave	\$113,000
39	12	1,353	Well 6 Transmission	29	2026-2040	This looping and transmission improvement is identified to support future transmission of storage from Well 6 and Reservoirs 4 and 5.	\$780,000
40	16	1,320	Fire	7	2021-2025	Existing pipelines are inadequate to serve 3,500 gpm fire flow requirement North of Elkhorn Drive. This pipeline on Elkhorn Drive supports both fire flow and future development.	\$632,000
41	12	360	Fire	8	2021-2025	Existing pipelines are inadequate to serve 3,500 gpm fire flow requirement North of Elkhorn Drive. This pipeline on SW 23rd street creates looping and supports fire flow North of Elkhorn Drive.	\$141,000
42	12	750	Fire (Dead end)	13	2021-2025	Existing dead end 8-inch pipeline along SW Pumice Ave is inadequate to provide 3,500 gpm fire flow.	\$330,000
44	12	871	Fire (Dead end)	4	2021-2025	Existing dead end 8-inch pipeline near Antler Reservoir (to be standby only) is inadequate to serve 3,500 gpm fire flow requirement. A new looping pipeline is recommended. The loop is for fire flow, and supports buildout growth.	\$383,000

Recommended water supply projects are summarized in **Table 4-3**.

Table 4-3 | Supply Improvements

Project Name	Priority	Horizon	Capacity (gpm)	Zone	Type	Project Cost
Well 9	1	2025	3,000	2	New	\$4,128,000
Obsidian Well	37	2040	3,000	2	New	\$4,128,000

Recommended distribution storage reservoir projects are summarized in **Table 4-4**.

Table 4-4 | Booster Station Improvements

ID	Priority	Horizon	Capacity gpm	Zone	Type	Comment	Project Cost
Well 6 Booster Station	33	2025	2,000	2	Capacity	Add a third pump for firm capacity	\$364,000

Recommended improvements from the condition assessment work are summarized in **Table 4-5**.

Table 4-5 | Condition Assessment Improvements

Project Name	Priority	Horizon	Project Cost
Arc Flash Study	1	2021-2025	\$25,000
Well No. 4 Improvements	3	2021-2025	\$182,000
Well No. 4 Chlorine and Generator Building	2	2021-2025	\$1,308,000
Well No. 2 Site and Wellhouse Improvements	2	2026-2040	\$17,000
Well No. 2 Water Quality Improvements Study	7	2026-2040	\$50,000
Well No. 3 Site and Wellhouse Improvements	2	2026-2040	\$215,000
Well No. 6 Telemetry Improvements	O&M	2026-2040	\$10,000

SCADA improvements as evaluated by S&B are summarized in **Table 4-6**.

Table 4-6 | SCADA CIP Improvements

ID	Priority	Horizon	Project Description	Project Cost
Phase 1	1	2021-2025	Forked Horn Butte Upgrades - Replacement VFDs	\$128,000
Phase 2	2	2021-2025	Upgrades to SCADA computers and hardware.	\$63,000
Phase 3	3	2021-2025	Automation Upgrades – Modernization of touch panels, water dispensing station (WDS) replacement.	\$45,000
Phase 4	4	2021-2025	All remaining upgrades to SCADA	\$128,000

Risk and resiliency improvements are summarized in **Table 4-7**.

Table 4-7 | Risk and Resiliency Improvements

Project Name	Priority	Horizon	Description	Project Cost
Fork Horned Butte Pump Station	3	2021-2025	Site fencing, card locks, and security camera	\$31,000
Fork Horned Butte Transfer Station	7	2021-2025	Site fencing, card locks, and security camera	\$31,000
South Redmond Facility	2	2021-2025	Card Entry Locks and Security Camera	\$6,000
Storage Reservoir	4	2021-2025	Security Camera(s)	\$3,000
System Reservoir	1	2021-2025	Security Camera(s)	\$3,000
Well 2	9	2021-2025	Site fencing, card locks, and security camera	\$31,000
Well 3	8	2021-2025	Site fencing, card locks, and security camera	\$31,000
Well 4	10	2021-2025	Card entry locks	\$3,000
Well 5	11	2021-2025	Card entry locks	\$3,000
Well 6	5	2021-2025	Card entry locks, intrusion alarms on hatches, camera	\$8,000
Well 7	6	2021-2025	Card entry locks, intrusion alarms on hatches, camera	\$8,000

4.3 CIP Summary

The CIP is comprised of water system projects recommended to correct deficiencies identified in previous section and estimated costs for each project. Identified CIP projects are grouped into two implementation timeframes: 2021-2025 and 2026-2040. CIP projects are summarized in **Table 4-8** and **Table 4-9**, and are illustrated in **Figure 3-3**. The CIP includes over \$18 million in improvement projects over the 5-year horizon and over \$24 million over the 2026-2040 horizon.

Table 4-8 | 5-Year Improvements (Years 2021-2025)

Project Type	Project Name/ID	Description	Project Cost
Supply	Arc Flash Study	Arc flash study for Wells Nos. 2 , 3 , 4 , 5 , 6 , 7, FHBPS Pump Station No. 1, and Transfer Station.	\$25,000
Supply	Well No. 4 Improvements	Replaces electrical components, integrates the chlorine equipment to SCADA install a fan in FHBPS#2.	\$182,000
Supply	Well No. 4	New Chlorine and Generator at Well No. 4 and 600kW generator.	\$1,308,000
Supply	Well 9	New Well	\$4,128,000
Supply	Well 3	Site fencing, card locks, and security camera	\$31,000
Supply	Well 4	Site fencing, card locks, and security camera	\$3,000
Supply	Well 5	Card entry locks	\$3,000

Project Type	Project Name/ID	Description	Project Cost
Supply	Well 6	Card entry locks	\$8,000
Supply	Well 7	Card entry locks, intrusion alarms on hatches, camera	\$8,000
Supply	FHB Station	Site fencing, card locks, and security camera	\$31,000
Supply	FHB Station	Site fencing, card locks, and security camera	\$31,000
Supply	South Redmond Facility	Card Entry Locks and Security Camera	\$6,000
Supply	Storage Reservoir	Security Camera(s)	\$3,000
Supply	System Reservoir	Security Camera(s)	\$3,000
Supply	Well 2	Site fencing, card locks, and security camera	\$31,000
Supply	FHB Upgrades	Add VFD's	\$128,000
Supply	SCADA Upgrades	SCADA visualization system graphics overhaul, reports development, and smart motor starter data context.	\$63,000
Supply	Automation Upgrades	Modernization of touch panels.	\$45,000
Supply	Remaining Upgrades	Other (non-FHB) Visualization, and Automation upgrades	\$128,000
Distribution	7	This is an upgrade to provide the required 3,500 gpm fireflow coming off Ochoco Way at SW Sisters Ave	\$555,000
Distribution	8	This is an upgrade to provide the required 3,500 gpm fireflow at Southeast 4th Court, off SE Lake Road.	\$240,000
Distribution	12	This is a looping improvement to provide the required 2,500 gpm fire flow at Elm Ave	\$96,000
Distribution	13	This is an upgrade improvement to provide the required 2,500 gpm fire flow at NW 4th St north of NW Hemlock Ct	\$509,000
Distribution	9	Improves fire flow availability at the end of SW 17th Place to meet 2,500 gpm commercial requirements	\$155,000
Distribution	14	This is a looping improvement to provide the required 3,500 gpm fire flow at NE Greenwood Ave	\$430,000
Distribution	15	This is an upgrade improvement to provide the required 2,500 gpm fire flow at NW 4th St north of NW Hemlock Ct	\$286,000
Distribution	19	This new pipeline improves fire flow to serve the 2,500 gpm requirement. The pipeline on Dry Canyon Trail ties together 6-inch and 4-inch pipelines west of Sam Johnson Park. Additional improvement to the associated 4-inch pipeline for continuity would be reasonable.	\$267,000

Project Type	Project Name/ID	Description	Project Cost
Distribution	21	This improvement south of Evergreen Ave connecting to South 1st Street is required to provide the 2,500 gpm fire flow required on this dead-end pipeline with adequate residual pressure.	\$130,000
Distribution	20	This looping improvement coming from Well 6 is required to serve the 3,500 gpm fire flow requirement. It also improves transmission of flow from the Well 6 and reservoirs 4 and 5 facility.	\$169,000
Distribution	22	This looping improvement is required to serve the 3,500 gpm fire flow requirement near SE Jesse Butler Circle.	\$538,000
Distribution	23	This looping improvement is required to serve the 3,500 gpm fire flow requirement near SE College Loop.	\$293,000
Distribution	24	This looping improvement also supports the 3,500 gpm fire flow requirement near SE College Loop.	\$146,000
Distribution	25	This looping improvement is required to provide the 2,500 gpm fire flow required at the end of NW 16th Place	\$301,000
Distribution	27	This is a looping improvement to provide the required 2,500 gpm fire flow at NW Birch Ave	\$119,000
Distribution	40	Existing pipelines are inadequate to serve 3,500 gpm fire flow requirement North of Elkhorn Drive. This pipeline on Elkhorn Drive supports both fire flow and future development.	\$632,000
Distribution	41	Existing pipelines are inadequate to serve 3,500 gpm fire flow requirement North of Elkhorn Drive. This pipeline on SW 23rd street creates looping and supports fire flow North of Elkhorn Drive.	\$141,000
Distribution	42	Existing dead end 8-inch pipeline along SW Pumice Ave is inadequate to provide 3,500 gpm fire flow.	\$330,000
Distribution	44	Existing dead end 8-inch pipeline near Antler Reservoir (to be standby only) is inadequate to serve 3,500 gpm fire flow requirement. A new looping pipeline is recommended. The loop is for fire flow, and supports buildout growth.	\$383,000
Distribution	2	This is an upgrade to provide the required 3,500 gpm fire flow requirement by connecting waterlines in Yew and Xero.	\$231,000
Distribution	3	This is an upgrade to provide the required 3,500 gpm fireflow by upsizing the line off Evergreen, east of 23rd Ave.	\$135,000
Distribution	4	This is an upgrade to provide the required 3,500 gpm fireflow to Redmond High School off Rimrock.	\$119,000

Project Type	Project Name/ID	Description	Project Cost
Distribution	6	This is an upgrade to provide the required 3,500 gpm at Southwest 2nd Court, off Reindeer Ave.	\$334,000
Other	Water Administration Building and Shop	Construction of new administrative building and shop at Well 6.	\$5,000,000
Other	WMP Update - Incremental	Calibration of water demands, documentation of improvements, update CIP.	\$150,000
Upsizing		City funded upsizing of developer pipelines	\$1,105,000
		TOTAL 2021 – 2025 CIP	\$18,959,000

Table 4-9 | 20-Year Improvements (Years 2026-2040)

Project Type	Project Name/ID	Description	Project Cost
Supply	Well 6	New Firm Capacity (Add a pump) to booster station.	\$364,000
Supply	Well No. 3	Drainage and structural improvements.	\$215,000
Supply	Well No. 6	Telemetry improvements, replace existing scales with digital scales integrated into SCADA.	\$10,000
Supply	Well No. 2	Improve access road to the wellhouse and site drainage, and repairs to wellhouse structure.	\$17,000
Supply	Well No. 2	Study to provide an analysis of water quality, and recommends improvements to treat water	\$50,000
Supply	Obsidian Well	New Well to meet future demands	\$4,128,000
Distribution	30	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97 at SW Quartz.	\$3,028,000
Distribution	31	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97 across from Glacier and Highland Avenues.	\$571,000
Distribution	32	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97 at Veterans Way.	\$941,000
Distribution	33	This looping and transmission improvement is identified to support future transmission of storage at Well 6 and Reservoirs 4 and 5.	\$624,000

Project Type	Project Name/ID	Description	Project Cost
Distribution	34	This looping and transmission improvement is identified to support future transmission of storage and supply near the railroad and Hwy 97 south of Odem Medo Way.	\$745,000
Distribution	36	This looping and transmission improvement is identified to support future transmission of storage and supply across the railroad and Hwy 97, coming off SW Meadow Lane.	\$1,938,000
Distribution	37	This looping and transmission improvement is identified to support future transmission of storage and supply near the railroad and Hwy 97, connecting SW Yew Ave to SW Xero Ave.	\$978,000
Distribution	38	This looping improvement improves overall system looping and transmission reinforcing the 12-inch grid on SW 35th St north of W Antler Ave	\$113,000
Distribution	39	This looping and transmission improvement is identified to support future transmission of storage from Well 6 and Reservoirs 4 and 5.	\$780,000
Other	WMP Update - Major	Complete hydraulic analysis, update water rights status, documentation of improvements, update CIP.	\$250,000
Other	Water Rights Exit Fee	Exit fee to make existing and pending permanent mitigation credits free from encumbrance.	\$5,844,000
Upsizing		City funded upsizing of developer pipelines	\$14,653,000
		TOTAL 2026 – 2040 CIP	\$35,249,000

Appendix



TECHNICAL MEMORANDUM

City of Redmond – Water Rights Summary

To: Carissa Shelley, Murraysmith

From: Trevor Grandy, GSI Water Solutions, Inc.
Adam Sussman, GSI Water Solutions, Inc.

CC: Josh Wedding, City of Redmond

Attachments: City of Redmond Water Rights Table

Date: January 22, 2021

Executive Summary

The City of Redmond (City) is currently engaged in a master planning process to project water demands over the next 30 to 50 years and develop a water supply strategy to meet those demands. At the request of Murraysmith, GSI Water Solutions, Inc. (GSI) has developed this technical memorandum to describe the City's water rights, the current status of the rights, and provide recommendations for ensuring an adequate supply of water rights to meet future demands. This information is intended to inform the City's water supply strategy to meet future demands.

Municipal Water Rights

The City holds seven water rights authorizing the use of up to 46.87 cfs (25.22 mgd) of water for municipal purposes. These seven water rights are in good standing with Oregon Water Resources Department (OWRD). One of these water rights authorizes the use of surface water from the Deschutes River and the other six water rights authorize the use of groundwater from various water supply wells throughout the City. These municipal use water rights are summarized in Table 1. An expanded water rights table is included in Attachment 1.

Table 1 City of Redmond's Municipal Water Rights

Water Right	Priority	Source(s) of Water	Authorized Rate (gpm)	Authorized Rate (cfs)	Notes
App. G-4981 Permit G-4700 Cert. 89447	9/5/1969	Wells 1, 2, 4, 5, 6, & 7	996.4	2.22	Transfer T-13391 adds Wells 8 & 9. City plans to add Well 3 via a Transfer
App. G-6865 Permit G-6793 Cert. 89448	3/27/1975	Wells 1, 2, 4, 5, 6, & 7	1481.1	3.30	Transfer T-13391 adds Wells 8 & 9. City plans to add Well 3 via a Transfer
App. G-11439 Permit G-10544 Cert. 89415	9/25/1985	Wells 1, 2, 4, 5, 6, & 7	3096.9	6.90	Transfer T-13391 adds Wells 8 & 9. City plans to add Well 3 via a Transfer
App. G-12731 Permit G-12401 Cert. 87796	11/25/1991	Wells 1, 2, 4, 5, 6, & 7	2244.2	5.00	Transfer T-13391 adds Wells 8 & 9. City plans to add Well 3 via a Transfer
App. G-9462 Permit G-8866 Cert. 82751	9/25/1985	Well 3	1099.6	2.45	City plans to add Wells 1, 2, and 4 through 9 via a Transfer
App. G-14908 Permit G-18292	1/13/1999	Wells 6, 7, 8, 9, 10, & 11	11220.8	25.00	Mitigation required; Maximum volume of 3,492 AF Permit Amend. T-13528 proposes to correct Well 9 location. Completion date: 5/9/2033
Available authorized rate:			20,139.0	44.87	
App. S-2231 Permit S-1177 Cert. 2016	4/22/1912	Deschutes River	897.7	2.00	Leased instream (IL-1346) until 12/31/2023
Total authorized rate:			21,036.7	46.87	

Municipal Groundwater Rights

The City's six municipal use groundwater rights are readily available and appropriate water from wells for distribution throughout the municipal service area. These six water rights authorize up to 44.87 cfs (24.15 mgd) of water. Four of the municipal use groundwater rights are certificated and authorize up to 17.42 cfs (9.37 mgd) of water from City Wells 1, 2, 4, 5, 6 and 7. Water right transfer T-13391, which was recently approved by OWRD, adds City Wells 8 and 9 as points of appropriation to these four water rights. Once the transfer is complete the City will need to develop and submit a Claim of Beneficial Use and seek new water right certificates confirming the addition of Wells 8 and 9. The City also plans to enhance operational flexibility by adding Well 3 to its certificated groundwater rights through a water right transfer. This transfer will likely be initiated following the completion of transfer T-13391. .

Additionally, the City holds Certificate 82751 which authorizes up to 2.45 cfs (1.32 mgd) of water from Well 3 for municipal use. The City plans to add Wells 1, 2, and 4 through 9 via a water right transfer to enhance operational flexibility, likely at the same time it adds Well 3 to its other water rights as described above. All of the City's groundwater rights, except Permit G-18292, were issued prior to 2002 when OWRD adopted the Deschutes Basin Groundwater Mitigation Program; these water rights do not require mitigation for use.

The City's Permit G-18292 authorizes up to 25.0 cfs (13.5 mgd) of groundwater for municipal use from City Wells 6, 7, 8, 9, 10 and 11 and also includes an annual volume limit of 3,492 acre-feet. This permit requires mitigation as required by the Deschutes Basin Groundwater Mitigation Program. For this permit, OWRD required mitigation assuming that use of the water is on average 50 percent consumptive. As a result, the "mitigation obligation" for Permit G-18292 is 1,746 mitigation credits. (One mitigation credit equals 1 acre foot of water legally protected instream). Concurrent with permit issuance, the City provided all 1,746 mitigation credits to OWRD. Permit Amendment T-13528 proposes to change the location of City Well 9 on Permit G-18292 and is currently under review at OWRD. The City is currently constructing Well 8 which is scheduled to be completed in winter/spring 2021.

Surface Water Certificate 2016

Finally, the City holds one surface water municipal use water right. Certificate 2016 authorizes the use of 2.0 cfs (1.08 mgd) from the Deschutes River. Certificate 2016 is currently leased instream under Instream Lease IL-1346 through December 31, 2023. It should be noted the authorized point of diversion for Certificate 2016 is not functional, nor has the City used the certificate for municipal supply for several decades. The City recently expressed interest in exploring the opportunity to permanently transfer Certificate 2016 instream to establish additional mitigation credits. GSI estimates the City could establish approximately 579 permanent mitigation credits by transferring Certificate 2016 instream.

Non-Municipal Water Rights

The City holds four water right certificates authorizing the use of water for irrigation. All four certificates are in good standing with OWRD. The source of water for three of these certificates is the City's Wastewater Treatment Plant (WWTP) effluent. Certificate 59049 authorizes the use of 2.30 cfs (1.24 mgd) for primary irrigation of 141.8 acres from the effluent flow from the City's WWTP. Certificate 59048 authorizes the storage of up to 286.0 acre-feet in a reservoir supplied by the effluent from the City's WWTP. The reservoir serves as the source for Certificate 59050 which authorizes use of the stored water for supplemental irrigation of 141.8 acres. The reservoir and place of use for these certificates is approximately 2-2.5 miles northwest of the City's WWTP.

GSI understands that the City may be looking at potential expansion of its WWTP facilities and potentially the need to irrigate with treated effluent. To the extent this is needed, the City should explore the opportunity to use "reclaimed water" as described in ORS 537.132, which does not require a water right. In addition, to the extent the City needs a water supply to operate the WWTP, it likely could add an additional point of appropriation (well) to one of its municipal groundwater rights.

Certificate 87589, the City's fourth non-municipal certificate, authorizes the use of up to 1.18 cfs (0.64 mgd) of groundwater for irrigation of 94.2 acres at Juniper Golf Club from a well located on the golf course (Oregon Well Log no. DESC 55844). Issuance of this water right required the City to provide 169.6 permanent mitigation credits. The City's four irrigation rights are summarized in Table 2.

Table 2 City of Redmond's Non-municipal Water Rights

Water Right	Priority, Type of Use	Source(s) of Water	Authorized Rate (cfs)	Authorized Volume (AF)	Notes
App. R-60935 Permit R-8336 Cert. 59048	10/23/1980, Storage for Irrigation	Redmond Municipal Sewage Treatment Plant	N/A	286.0	
App. S-58431 Permit S-44101 Cert. 59049	3/21/1979, Irrigation (141.8 acres)	Redmond Municipal Sewage Treatment Plant	2.30	567.2	Limited to 1/40 th of a cfs per acre and 4.0 acre-feet per acre
App. S-61422 Permit S-46323 Cert. 59050	3/20/1981, (Supp. Irrigation)	Sewage Effluent Storage Reservoir	N/A	286.0	Limited to 4.0 acre-feet per acre (combined with other water rights for same land); limited to deficiency in supply
App. G-16749 Permit G-16567 Cert. 87589	11/6/2006, Irrigation (94.2 acres)	A well in Deschutes River Basin (DESC 55844)	1.18	282.6	Limited to 1/80 th of a cfs per acre and 3.0 acre-feet per acre
Total authorized rate/volume:			3.48	1,421.8	

Water Rights on COID Certificate

The City also holds water rights on Certificate 94956, a certificate issued to Central Oregon Irrigation District (COID). These rights include 87.46 acres of municipal equivalent, 10.5 acres of pond maintenance equivalent and 122.97 acres of irrigation water rights. Currently, 74.357 acres of the municipal equivalent water rights and 102.4 acres of the irrigation water rights are leased instream on IL-1802. The City is currently using the remaining 13.1 acres of its municipal equivalent water rights for irrigation of Redmond Memorial Cemetery¹, 20.57 acres of its irrigation water rights for other irrigation uses, and the 10.5 acres of pond maintenance water rights for maintenance of Fireman's Pond. Finally, the City has an Intergovernmental Agreement (IGA) with COID to hold 76 acres of irrigation rights associated with Roberts Field, Redmond's Municipal Airport. A summary of the City's water rights on the COID certificate are in Table 3. As described below, several of these water rights may potentially be available for establishing mitigation credits for future use by the City; however, since the City-co-holds the water rights with COID, the district needs to consent to such a transaction.

¹ The City intends to use irrigation water rights to continue irrigating Redmond Memorial Cemetery and working with COID to transfer instream all 87.46 acres of the City's municipal equivalent on the COID Certificate.

Table 3 City of Redmond's COID Certificate Water Rights

Instream Lease	Use	Acres	Notes
<i>City Rights on COID Certificate Currently Leased Instream</i>			
IL-1802 (MP-259)	Municipal	74.357	Leased instream for Mitigation Project MP-259 (191.03 mitigation credits)
IL-1802 (MP-259)	Irrigation	102.4	Leased instream for Mitigation Project MP-259 (184.32 mitigation credits)
<i>City Rights on COID Certificate Currently in Use</i>			
	Municipal	13.1	Used for Irrigation for Redmond Memorial Cemetery
	Irrigation	20.57	
	Pond Maintenance	10.5	Used for Maintenance of Fireman's Pond
<i>City's IGA for Roberts Field</i>			
	Irrigation	76	Held by COID in connection with Roberts Field Airport
Total Acres		296.927	

Projected Demand for Groundwater Pumping - Mitigation and Instantaneous Rate

The City's largest groundwater right for municipal use, Permit G-18292, requires mitigation under OWRD's Deschutes Basin Groundwater Mitigation Program. Permit G-18292 is the City's only municipal water right issued after 2002, the year OWRD began requiring holders of newly issued water right permits provide mitigation to offset groundwater pumping effects on surface water. The City has established 2,318.3 permanent mitigations credits through several mitigation projects; 1,746.0 of these mitigation credits are assigned to meet the mitigation obligation condition in Permit G-18292. Thus, 572.3 of the current City-held mitigation credits are unassigned.

GSI forecasted water demand scenarios and evaluated the City's existing water rights to analyze the City's projected need for mitigation to meet future demands. Based on this analysis, GSI determined that the City has sufficient mitigation credits to meet demands through 2050. However, GSI also determined that the City may exceed the volume of water authorized under Permit G-18292 (3,492 acre-feet) between 2045 and 2050 and may exceed its total instantaneous rate of diversion under its municipal water rights (44.87 cfs) between 2045 and 2050. (See GSI's *Technical Memorandum Estimate of Mitigation Credit Demands – City of Redmond. January 12, 2021*). GSI will continue to work with the City to determine whether to pursue additional groundwater rights in the near-term to meet projected demands.

Summary

The City of Redmond holds a variety of municipal and non-municipal (irrigation) water rights; all of these water rights are in good standing. The City exclusively uses groundwater for its municipal supply which is authorized by six water rights authorizing up to 44.87 cfs (24.15 mgd).

The City is actively maximizing its ability to use its water rights that do not require mitigation by adding newly constructed City Wells 8 and 9 as points of appropriation and intends to add several wells to Certificate 82751, which currently only authorizes use of Well 3. The City plans to construct new wells to continue developing Permit G-18292.

Permit G-18292 authorizes 25.0 cfs of the 44.87 cfs authorized by the City's six available municipal water rights and requires mitigation. GSI estimates the City holds a sufficient amount of mitigation credits to meet demand through 2050. Beyond 2050, to the extent needed, the City currently holds 572.3 unused mitigation

credits and has the potential to develop additional mitigation credits through the transfer instream of water rights held by the City and water rights held by the City and COID.

In developing mitigation demand projections for the City, GSI determined that the City's maximum authorized rate of groundwater pumping (44.87 cfs) may be exceeded between 2045 and 2050. These findings suggest the City may need to acquire a new water use permit to authorize an increase in its maximum instantaneous rate of appropriation. GSI will continue to work with the City to determine whether and when to pursue a new water right.

Attachment 1

Expanded Water Rights Table

Water Rights Summary Memo – City of Redmond

Application	Permit	Transfer/ Permit Amendment	Certificate	Source	Priority Date	Type of Beneficial Use	Period of Use	Authorized Rate (cfs)	Authorized Volume (AF)	Status
For Potable Municipal Water Supply										
S-2231	S-1177	(IL-1346)	2016	Deschutes River	4/22/1912	Municipal	year round	2.00	-	Water right issued for municipal and hydroelectric generation, for 35 cfs. According to OWRD, the power claim (#244) has expired leaving 2 cfs of municipal use water. The 2 cfs of municipal use water right is leased instream under Instream Lease IL 1346 until December 31, 2023.
G-12731	G-12401	T-13391	87796	Wells 1, 2, 4, 5, 6 & 7 in the Deschutes River Basin	11/25/1991	Municipal	year round	5.00	-	T-13391 adds Well 8 and Well 9 to Cert. 87796; FO issued 12/24/2020
G-6865	G-6793	T-13391	89448	Wells 1, 2, 4, 5, 6 & 7 in the Deschutes Basin	3/27/1975	Municipal	year round	3.30	-	T-13391 adds Well 8 and Well 9 to Cert. 89448 FO issued 12/24/2020
G-4981	G-4700	T-13391	89447	Wells 1, 2, 4, 5, 6 & 7 in the Deschutes Basin	9/5/1969	Municipal	year round	2.22	-	T-13391 adds Well 8 and Well 9 to Cert. 89447 FO issued 12/24/2020
G-11439	G-10544	T-13391	89415	Wells 1, 2, 4, 5, 6 & 7 in the Deschutes Basin	9/25/1985	Municipal	year round	6.90	-	T-13391 adds Well 8 and Well 9 to Cert. 89415 FO issued 12/24/2020
G-9462	G-8866		82751	Well 3	11/7/1979	Municipal	year round	2.45	-	
G-14908	G-18292	T-13528		Wells 6, 7, 8, 9, 10 & 11 in the Deschutes Basin	1/13/1999	Municipal	year round	25.00	3492.0	Permit issued 5/9/2013; completion date is 5/9/2033. All required mitigation has been provided. Mitigation update required every 3 years; next update due by May 2022. T-13528 corrects the location of Well 9 (notice fee requested 1/11/21).

City Held, Not Potable

R-60935	R-8336		59048	Redmond Municipal Sewage Treatment Plant	10/23/1980	Storage	year round	N/A	286.0	
S-58431	S-44101		59049	Redmond Municipal Sewage Treatment Plant	3/21/1979	Irrigation (141.8 ac)	Apr 1-Oct 31	2.30	567.2	Limited to 1/40th of a cfs per acre and 4.0 acre-feet per acre
S-61422	S-46323		59050	Sewage Effluent Storage Reservoir (Redmond Municipal Wastewater Treatment Plant)	3/20/1981	Supplemental Irrigation (141.8 ac)	Apr 1-Oct 31	N/A	286.0	Limited to 4.0 acre-feet per acre in combination with any other rights for the same lands; limited to deficiency in supply
G-16749	G-16567		87589	A well in Deschutes River Basin (DESC 55844)	11/6/2006	Irrigation (94.2 acres)	Apr 1-Oct 31	1.18	282.6	Limited to 1/80th of a cfs per acre and 3.0 acre-feet per acre

Technical Memorandum

Date: February 17, 2021

To: Mr. Caccavano
City of Redmond, Oregon

Re: Water Distribution System Hydraulic Model Development and Calibration

Introduction

A Hydraulic model was developed for the City of Redmond (City) from the City's water utility Geographical Information System (GIS) in 2019. The model was calibrated for steady state analysis based on fire flow testing data collected in the field. After the completion of steady state calibration, Extended Period Simulation (EPS) calibration was completed using data collected from the City's water system Supervisory Control and Data Analysis (SCADA) data. Both steady state and EPS calibration results provide a high level of confidence in model results based on comparison with system SCADA data and field measurements.

Existing System Hydraulic Model Update

A full update of the City's hydraulic model was completed in 2019, using the hydraulic modeling software InfoWater 12.4 within the ArcGIS Desktop 10.5 software platform. Comparison of the City's current GIS data compared with the most recent hydraulic water model showed that many improvements to the water distribution system had been completed since the model was last updated. Due to the number and extent of updates that would be required to update the old model, a complete regeneration of the network from the GIS was determined to be the fastest and most thorough approach.

Network Connectivity

The updated hydraulic model network was developed based on the City's water distribution system GIS data. Additional elements and data adjustments were then required to create a fully connected hydraulic model. Some differences between the GIS and the completed model include:

- A unique model ID must be assigned to each hydraulic model element. Some IDs were generated where duplicated or missing.
- Model pipeline features must be split where pipes connect. Splits were added as required.

- Junctions must be located at pipeline end points and points of connection. Junctions were added as required.
- Fragments of pipeline or fittings that are not connected to the network must be identified and removed from the active network.
- Clarification of water pipeline connectivity, for example where pipelines may cross and not connect, is incorporated into the hydraulic water model.

Pipeline Attributes

Pipeline material and diameter data was obtained from the City's pipeline GIS. The Hazen-Williams coefficient was assigned based on material according to **Table 1**.

Table 1 | Pipeline Material and Hazen-Williams Coefficient

Material	Roughness
Brass	135
Cast Iron	125
Copper	135
Ductile Iron	130
PVC	150
Steel	145

Model Facilities

Model elements to represent facilities such as water storage tanks, booster pump stations, well supply sources, and system valves such as pressure reducing valves (PRVs) and flow control valves (FCVs) were then added to the developed network.

For functionality, the spatial location of some facilities details, such as the location and layout of specific pumps in a pump station and yard piping around facilities such as wells, pump stations, and water storage tanks are drawn in the model as conceptual-only. Elements, such as control valves that do not exist in the field may be added to the model to simulate the operational capabilities of a facility in the hydraulic model.

Steady state Calibration

Steady state calibration is typically the first step in hydraulic model calibration. Steady state calibration compares hydraulic behavior in the model with observed hydraulic behavior in the system over very short periods of time. The model is used to predict system pressures given specific boundary conditions, including well and pump station status and flows, tank levels, and approximate system demand as identified from monitored data. The model's predicted system pressure at a specific location is compared with the field measured pressure at the same location to determine the capability of the model to predict water system performance.

Demand Allocation

Steady state calibration utilized the same demand distribution as the old model, with total demand scaled down to match the average demand observed from SCADA data, at the time of fire hydrant flow testing.

Field Fire Hydrant Flow Testing

To verify the hydraulic model the City collected system performance data during field fire hydrant testing, for comparison with the model. The goal of fire flow testing is to stress the system by opening fire hydrants, resulting in system pressure loss. The drop in system pressure due to water loss (outflow from hydrants) is recorded. The flow rate required to cause this pressure loss must also be measured and recorded. A system pressure drop of 10 pounds per square inch (psi) or greater due to flowing hydrants is targeted, to assure that system pressure loss due to outflow is significantly more than other factors such as fluctuations in readings and pressure gauge sensitivity.

Hydrant testing uses flow pressure measurements from the small ports on the sides of the hydrants. Flow from the large central port cannot typically be measured with adequate accuracy. Pressure readings from the small ports are converted to hydrant flow using the below equation for each port flowed. Measured pressure is converted to flow based on the NFPA Fire Protection Hand Book equation.

$$Q = 29.84c_d d^2 \sqrt{p}$$

Q = flow in gallons per minute (gpm)

c_d = coefficient of discharge (0.7 to 0.9 depending on the shape of the outlet)

p = pressure in psi

d = inside diameter of the hydrant port in inches

The testing procedure and data forms were provided to field crew before the day of testing, in addition to a map of requested testing locations.

SCADA data for the day of testing provides operational information and support estimates of system demand on the day of testing. System pressures observed before opening hydrants and during hydrant flow tests are compared with model predicted pressures for steady state calibration. Results are evaluated according to **Table 2**.

Table 2 | Calibration Confidence

Calibration Confidence	Steady State	Flowing Hydrant
High	(Field Pressure – Model Pressure) Nearly all model discrepancies are within 5 psi	(Field Pressure Drop – Model Pressure Drop) Nearly all discrepancies are equal to or less than 10 psi

Calibration Confidence	Steady State	Flowing Hydrant
Moderate	(Field Pressure – Model Pressure) A few discrepancies are greater than 5 psi	(Field Pressure Drop – Model Pressure Drop) A few discrepancies are equal to or greater than 10 psi
Low	(Field Pressure – Model Pressure) Several model discrepancies are greater than 5 psi	(Field Pressure Drop – Model Pressure Drop) Several discrepancies are equal to or greater than 10 psi

Steady State Controls

The operations crew performing field testing captured instantaneous well flow rate, tank level, and system pressure data from the City’s SCADA system at the time of each flow test. Facility data and settings are provided in this section, including control valve, Well Pump, and Pump Station controls used in steady state calibration.

Boundary conditions required for testing include the water surface elevation of gravity reservoirs, and system controls for valves, and flow rates for wells and booster pumps. Boundary conditions were similar for all facilities during all flow tests, except for the flow from the pump station at Well 6. This pump station was not producing flow on approximately half the tests and it produced close to 2,750 gpm during the other half of the tests. As a result, model calibration results were evaluated using two scenarios, with the same boundary conditions except for the operation of the pump station at Well 6. Operational Condition 1 includes the use of the Well 6 pump station. The operation of Wells 6 and 7 themselves, does not impact system pressure because these wells pump only to ground level reservoirs. The Forked Horned Butte System Reservoir level ranged from 15.0 feet to 15.8 feet during testing. This level difference is equivalent to less than half of one psi in pressure. All except the last two tests ranged 15.5 to 15.8 feet, so 15.5 feet was used as the reservoir level for both operational scenarios.

Table 3 | Well Supply Operations

Facility Name	Setting Description	Flow (gpm)
Well #1		0
Well #2		0
Well #3		0
Well #4		0
Well #5		0
Pump Station at Well #6	Off in Control Condition 2	2,750 one pump used. Control Condition 1 only. On by timer 9 am to 11 am.
Pump Station at Well #7	Same in Conditions 1 and 2	1,200 gpm all tests. Limited by VFD target 63 psi
FHBPS#1	Same in Conditions 1 and 2	VFD target 83.6 psi
FHBPS#2	Same in Conditions 1 and 2	Start at 95 psi, control to VFD target 110.5 psi

Facility Name	Setting Description	Flow (gpm)
Transfer Pump Station	Same in Conditions 1 and 2	Off by Forked Horned Butte System Reservoir level based Control Settings (on 16.3 feet, off 15.8 feet)
Antler Pump Station	Same in Conditions 1 and 2	Off during testing, by timer control

Table 4 provides the system valve settings and controls used in both control scenarios.

Table 4 | Valve Operational Controls

Control Valve	Description	Control Setting
PRV at Canal and Zenith	Supply to Zone 1A	80 psi, 75 psi
Transfer Station Valve	Supply to Zone 2 from Storage Reservoir, by System Reservoir Level	15.5 feet open – 15.8 feet closed. 3,000 gpm max

Steady State Calibration Results

Table 5 Summarizes the results of steady state calibration.

Table 5 | Steady State Calibration Results

Test Number	Field Static	Model Static	Static Model Error	Field Flow	Model Flow	Field Drop	Model Drop	Flow Model Error	Control Scenario
8	64	65.6	1.6	54	56.3	10	9.2	-0.8	1
12	62	62.1	0.1	52	52.5	10	9.5	-0.5	1
13	78	80.1	2.1	59	50.1	19	29.9	10.9	1
15	96	96.0	0.0	74	73.4	22	22.5	0.5	1
14	104	107.0	3.0	68	66.4	36	40.5	4.5	1
11	88	87.8	-0.2	76	70.5	12	17.3	5.3	1
10	74	71.3	-2.8	60	58.0	14	13.3	-0.7	2
9	78	76.2	-1.8	68	67.1	10	9.1	-0.9	2
6	53	48.8	-4.3	44	44.0	9	4.8	-4.2	2
5	65	78.9	13.9	56	59.6	9	19.3	10.3	2
7	56	56.7	0.7	48	52.6	8	4.1	-3.9	2
3	58	49.1	-8.9	44	43.8	14	5.3	-8.7	1
4	110	114.1	4.1	62	72.5	48	41.6	-6.4	2
2	77	77.7	0.7	60	64.6	17	13.1	-4.0	2
1	51	47.3	-3.8	32	29.3	19	18.0	-1.0	2

Results generally indicated high confidence because most tests resulted in less than 5 psi static difference and less than 10 psi flow residual pressure drop difference between modeled and field measured results. Two static pressure results (tests 5 and 3), and two fire flow residual results (13 and 5) indicated potential model discrepancies. Static pressure discrepancies are typically the result of equipment error or discrepancies in PRV settings, elevation data, or system control.

Flowing residual pressure drop discrepancies may be due to a number of data, system control, or equipment discrepancies; however, the difference in pressure drop between the model and the field results were only slightly over 10 psi in both cases. If the discrepancy was not due to equipment error, then it indicates that the model conservatively estimates pressure loss in response to hydrant flow, slightly over estimating pressure loss in two test cases. Results of steady state calibration are also shown in **Figure 1**, and generally indicate high confidence.

Extended Period Simulation Data Collection and Calibration

Typically, EPS calibration is completed using a hydraulic model that has shown accuracy in steady state analysis. EPS calibration tests a greater range of demand and operational conditions over a longer period of time than steady state calibration. It also tests system controls, pattern of demand, and general tank volume and geometry.

In order to verify the model's capability to predict detailed system operation and performance over the course of several hours or days, EPS calibration was completed for both winter and summer periods. Two specific time periods were selected for EPS calibration. One set of facility control rules is applied over the calibration period, with a single distinct control set for summer and winter periods. Evaluation of SCADA data indicated that changes were made to control settings in the real system during each period, so sub-periods of consistent operations were selected for EPS calibration.

Summer EPS Calibration

The time period selected for summer EPS calibration was August 10th, 11th, and 12th of 2018. These dates were selected as a period of high use, during which the SCADA data demonstrated consistent operational controls.

Summer Demand Allocation

A spatial summer demand distribution was developed for the purpose of EPS analysis from water meter use data summarized by the City from August 5th through August 11th, 2018. The average customer use over these days was used to define a representative distribution of demand during a period of high use. Demand during this period ranged from 13 to 14.5 million gallons per day (MGD). For comparison, maximum day demand (MDD) in 2018 fell on July 25, 2018 with demand activity estimated by the City at approximately 14.6 MGD.

During the period of EPS simulation for calibration comparison with SCADA data, August 10th, through 12th, demand also approached MDD at 14.2 MGD. **Table 6** summarizes the periods used in model demand development and calibration during August 2018.

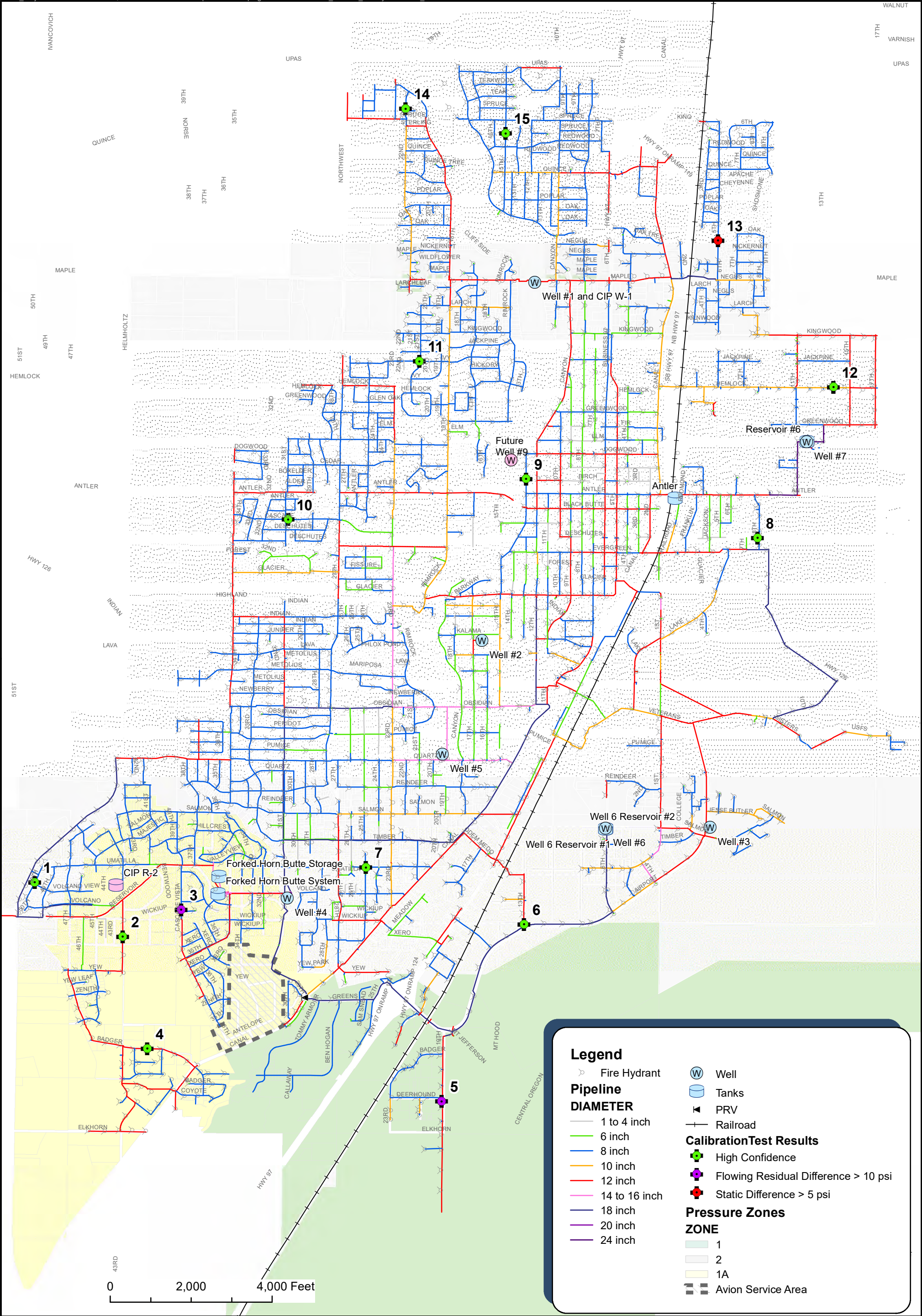


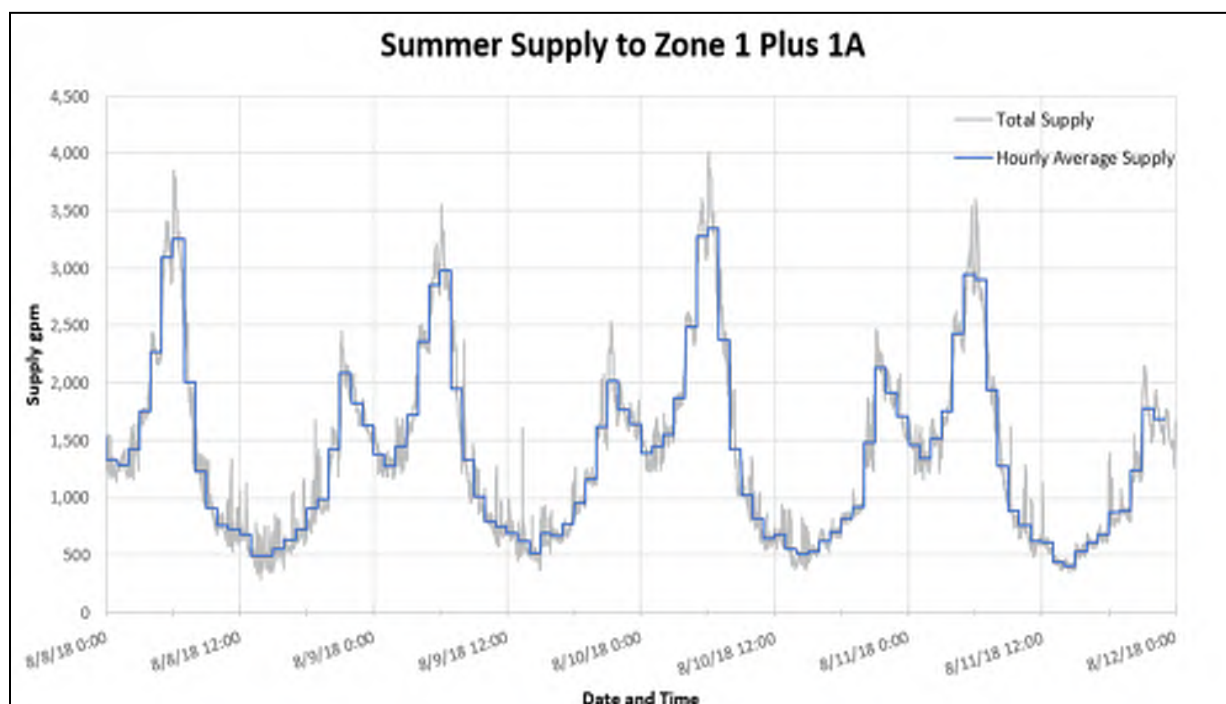
Table 6 | Summer Data Collection Periods

Date	Demand Activity (MGD)	Calibration (SCADA Model Comparison)	Diurnal Curve Development (SCADA)	Demand Distribution (Water Meter Data)
08/05/2018	13.4			Yes
08/06/2018	14.1			Yes
08/07/2018	14.1		Yes	Yes
08/08/2018	14.2		Yes	Yes
08/09/2018	14.5		Yes	Yes
08/10/2018	14.2	Yes	Yes	Yes
08/11/2018	13	Yes	Yes	Yes
08/12/2018	13.4	Yes		

Summer Demand Pattern Development

Hourly meter use data was not available for a large portion of customers at the time of EPS calibration, so SCADA data reporting facilities flow rates and tank levels on a one-minute basis was used. The average flow rate produced by facilities over the course of each hour of each day was summarized over this period. System wide hourly average use was developed, and the hourly average water pumped to Zones 1 +1A was subtracted to develop separate hourly usage for Zone 2 and Zones 1+1A. These hourly water use rates for each zone were used to develop two hourly peaking factor curves that characterize the pattern of use during a period of high demand. **Figure 2** presents SCADA data representing the sub hourly water demand for Zones 1+1A during the summer period of high use, as well as the hourly average of this data.

Figure 2 | Summer Hourly Total Supply to Zone 1 Plus 1A



The data presented in **Figure 2** is the sum of supply provided to the combined zone by the FHBPS#1 and FHBPS#2.

The maximum sub-hourly demand observed (Max Demand) and the peak hour demand (PHD) (highest hourly) demand for each day are shown in **Table 7**.

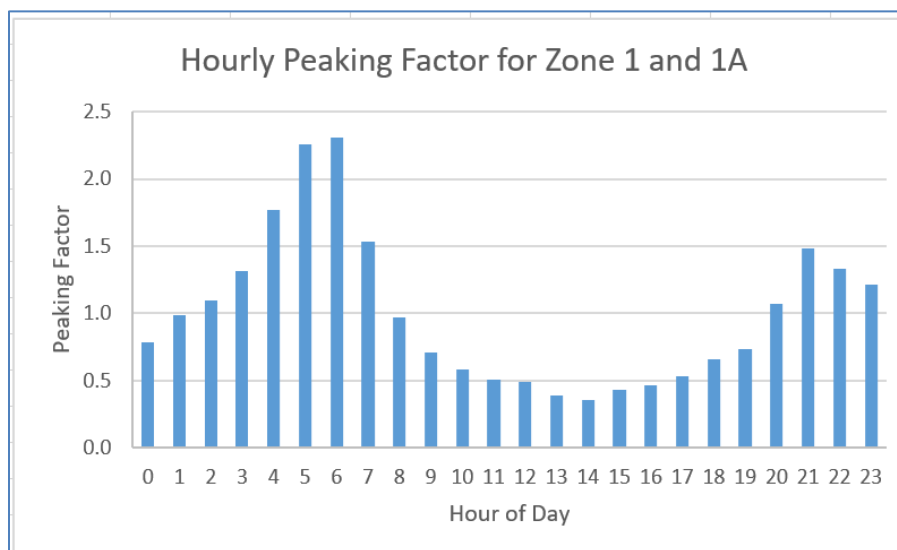
Table 7 | Closed Zone Observed Maximum Demands

Date	Zone 1 + 1A Specific Summer Daily Average Demand (gpm)	Zone 1+1A PHD (gpm)	Zone 1+1A Max Demand (gpm)	Max:PHD
8/7/2018	1,223	2,866	3,349	1.17
8/8/2018	1,355	3,253	3,845	1.18
8/9/2018	1,374	2,977	3,549	1.19
8/10/2018	1,427	3,346	4,014	1.20
8/11/2018	1,287	2,941	3,599	1.22

The planning factor Max:PHD of 1.2 was selected for planning purposes. This factor is used in consideration of the total short term maximum demand that a pump station may be called to produce for the combined Zone 1 + 1A.

The design Peak Hour Factor for planning (PHD Factor) for Zone 1+1A can be taken as the highest hourly peaking in the diurnal demand pattern for Zones 1 +1A as presented in **Figure 3**. The PHD factor for Zones 1+1A is 2.31.

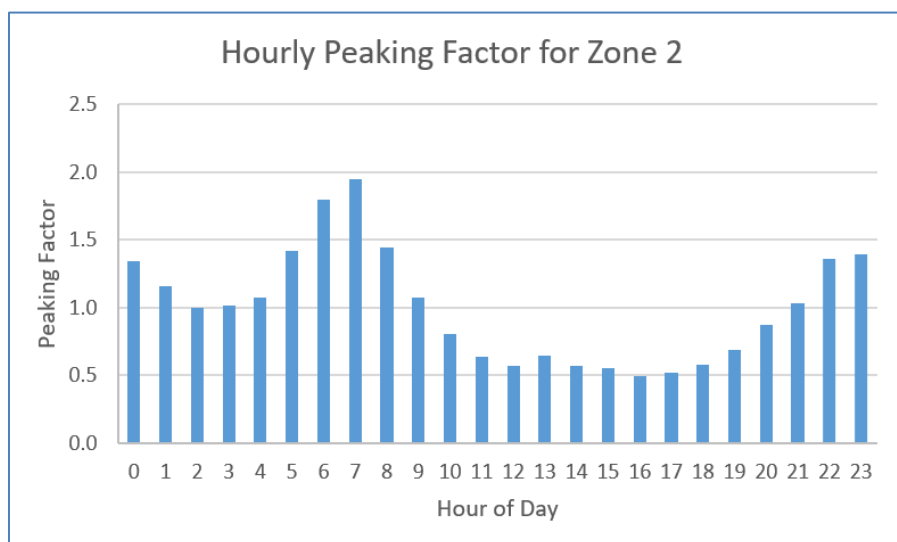
Figure 3 | Summer Hourly Diurnal Pattern for Zone 1 and 1A



During summer, it is typical for a smaller residential zone to show higher morning peaking due to irrigation and other uses. The rest of the system includes more commercial, industrial, and other uses, as well as a larger number of customers, resulting in lower maximum hourly peaking.

Figure 4 presents the hourly peaking factors for Zone 2. The PHD factor for Zone 2 was 1.9.

Figure 4 | Summer Hourly Diurnal Pattern for Zone 2



Summer Operations

Operational controls used in summer EPS calibration are provided in **Table 7**. These controls represent slight adjustments from initial typical operations data provided by the City. They may represent the unique time period of calibration control conditions and changing field conditions such as well pump wear, changing ground water levels, or real pipe friction. Changes include:

- Well 3 was operated at a slightly reduced speed ratio of 0.96, reducing the flow that would have been produced based only on its curve.
- Well 4 was operated at a slightly reduced speed ratio of 0.96, reducing the flow that would have been produced based only on its curve.
- Transfer Station was modeled as having only valve producing flow to Zone 2 from the Forked Horned Butte Storage Reservoir. The maximum flow rate set for this valve was 3,000 gpm.
- Antler Storage Fill control was set to a sustaining pressure of 75 psi instead of 80 psi. This restricted the fill rate to the Antler Reservoir from Zone 2 slightly more than a sustaining pressure of 80 psi.
- FHB Storage Low Level was set to 8 feet, the same as typical winter controls, instead of 14 feet, based on evaluation of SCADA water levels for the reservoir in this time period.
- FHBPS#1 was set to a target VFD pressure of 85 psi instead of 86 psi. This is considered a very small adjustment and may be based on a small elevation discrepancy between the model and system where this pressure is to be established.

- FHBPS#2 at Well 4 was set to VFD control to a 110.5 psi pressure target based on SCADA pressure data. This control method reproduced system operation well, despite the field controls for this pump station taking a different approach.
- At Well 6 Booster, only one pump was active during calibration and set to a slightly reduced 0.95 speed.
- The Well 6 pump speed was slightly reduced to 0.98.
- At Well 7 Booster, one of the pumps is VFD control set to 63 psi.

Table 8 summarizes model facilities controls used during calibration based on both SCADA data and the City.

Table 8 | Summer EPS Calibration Controls

Facility Name	Setting Description	Flow (gpm)
Well #1		Off
Well #2		Off
Well #3	Reduced Speed 0.96, Forked Horned Butte System Reservoir Level	8 – 19 ft
Well #4	Reduced Speed 0.96, Forked Horned Butte System Reservoir Level	15 – 19 ft
Well #5	Forked Horned Butte System Reservoir Level	14 – 18.5 ft
Well #6	Reduced Speed 0.98, Reservoir 4 and Reservoir 5 Level	24.5 – 31.9 ft
Pump Station at Well #6	One Pump Available 0.95 speed, Forked Horned Butte System Reservoir Level, Timer	15.8 – 16.9 ft, 8 am to 11 am
Well #7	Reservoir 6 Level	25 – 41 ft
Pump Station at Well #7	VFD Control, and level control Forked Horned Butte System Reservoir Level	63 psi (15 – 19 ft)
FHBPS#1	Zone 1 pressure, VFD Control	85 psi
FHBPS#2	Zone 1 pressure, VFD Control	Start at 95 psi, VFD target 110.5 psi
Transfer Pump Station	Forked Horned Butte System Reservoir level (Draws System Reservoir down and fills Storage Reservoir) Safety off based on Storage Reservoir Level	On 16.3 ft, off 15.5 ft System Reservoir Off 19 ft Storage Reservoir
Antler Pump Station	Timer, Antler Reservoir Level	On 4 am, off 31.4 ft
Antler Pump Station Control Valve	Sustain System Pressure during filling from Zone 2	75 psi

Chart figures in this report present SCADA data as smooth lines, and Model data as points connected by lines. Reservoirs are charted with depth in feet on the right axis, and well and pump flow rates are charted based on flow in gpm on the left axis. **Figure 4** shows the gravity storage tank for the system. Forked Horned Butte System Reservoir (FHB System) maintains a very stable level, due at least in part to the operation of the Transfer Pump Station, which is controlled to divert storage to the Forked Horned Butte Storage Reservoir (FHB Storage) if the FHB System exceeds approximately 16.3 feet. As a result the FHB System was operated in a fairly tight depth range during summer calibration. **Figure 5** shows very good agreement between the model and system SCADA data for the FHB System, FHB Storage, and the pump station flow rates serving Zone 1 Forked Horned Butte Pump Station #1 (FHBPS#1) and Forked Horned Butte Pump Station #2 (FHBPS#2).

Figure 5 | Summer Calibration, Summer Forked Horned Butte Reservoirs and Flows

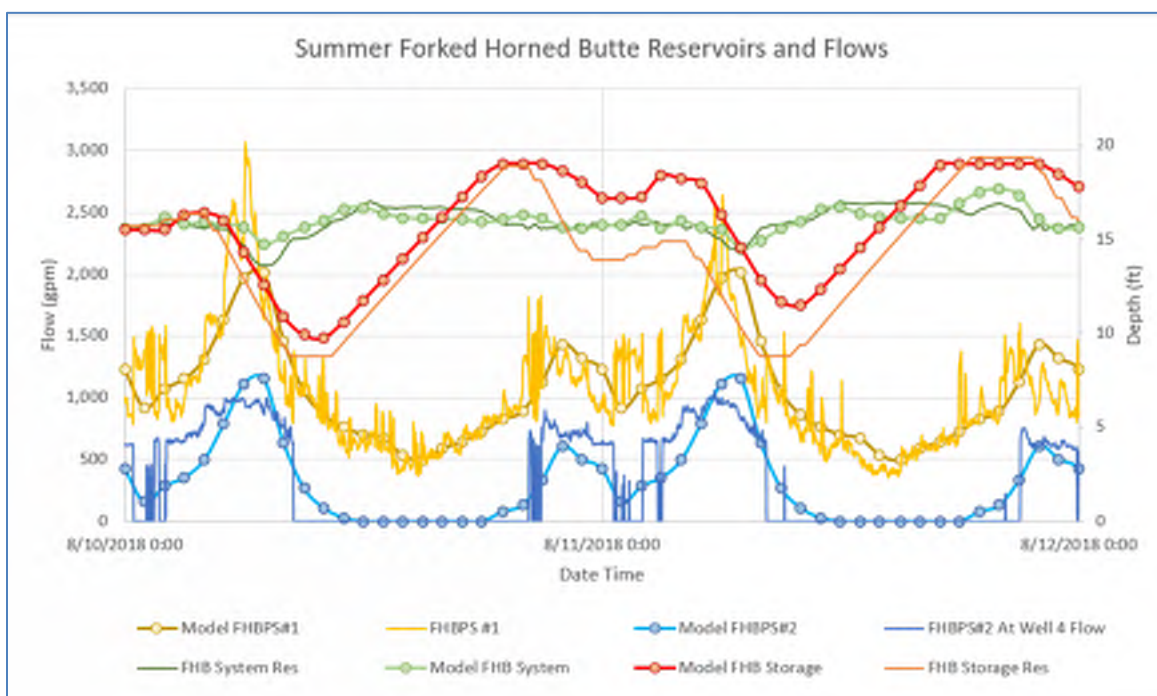


Figure 6 | Summer Calibration, Summer Well 6 and Reservoir 4

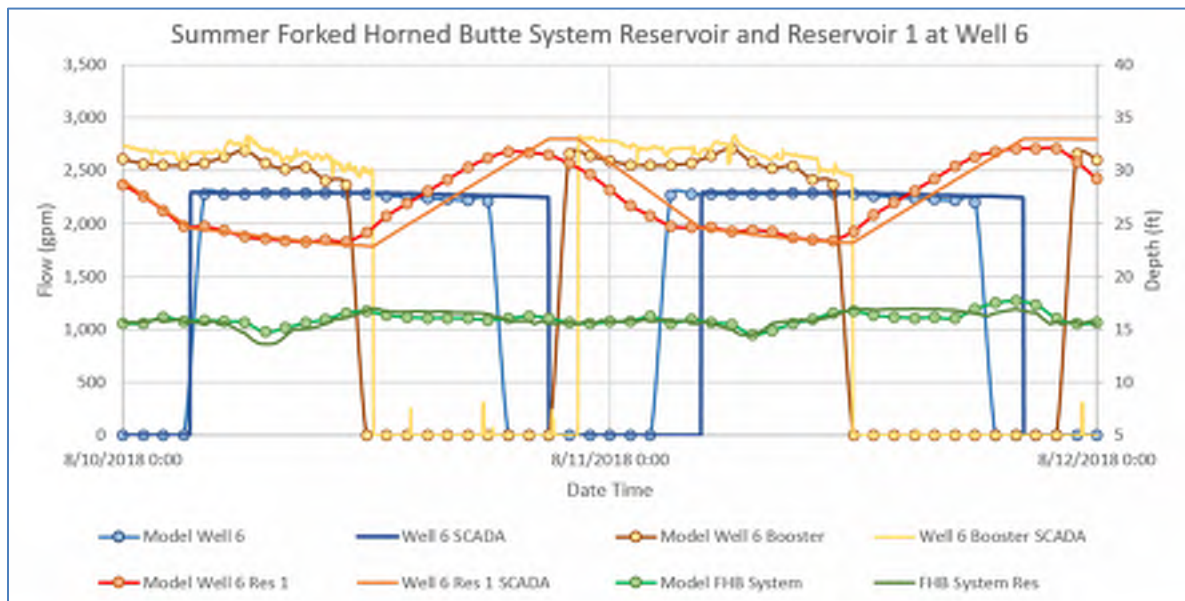


Figure 7 | Summer Calibration, Summer Well 7 and Reservoir 6 at Well 7

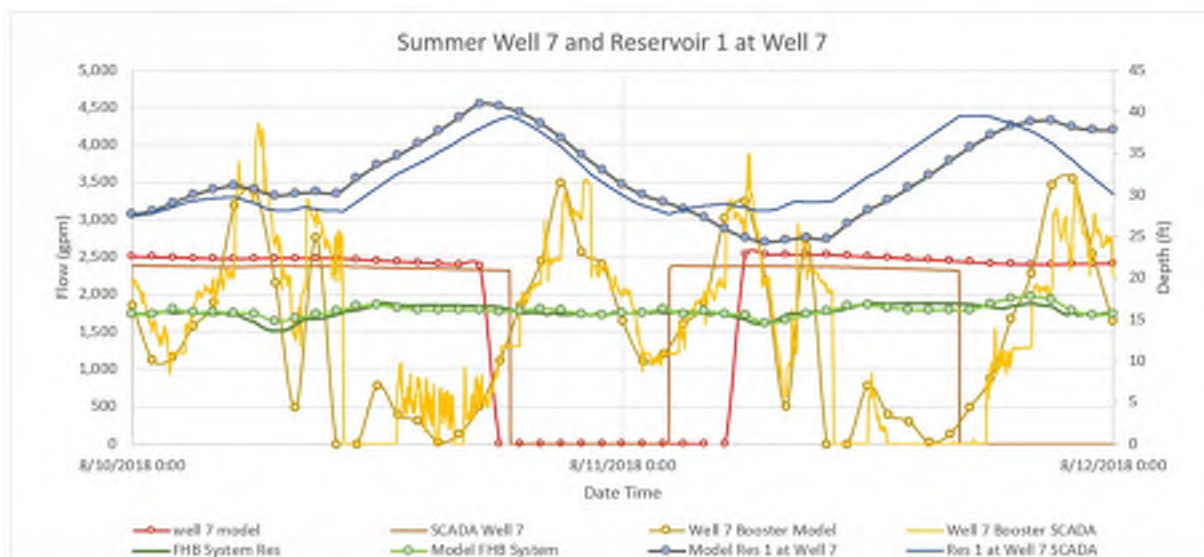


Figure 8 | Summer Calibration, Summer Antler Reservoir and Supplies

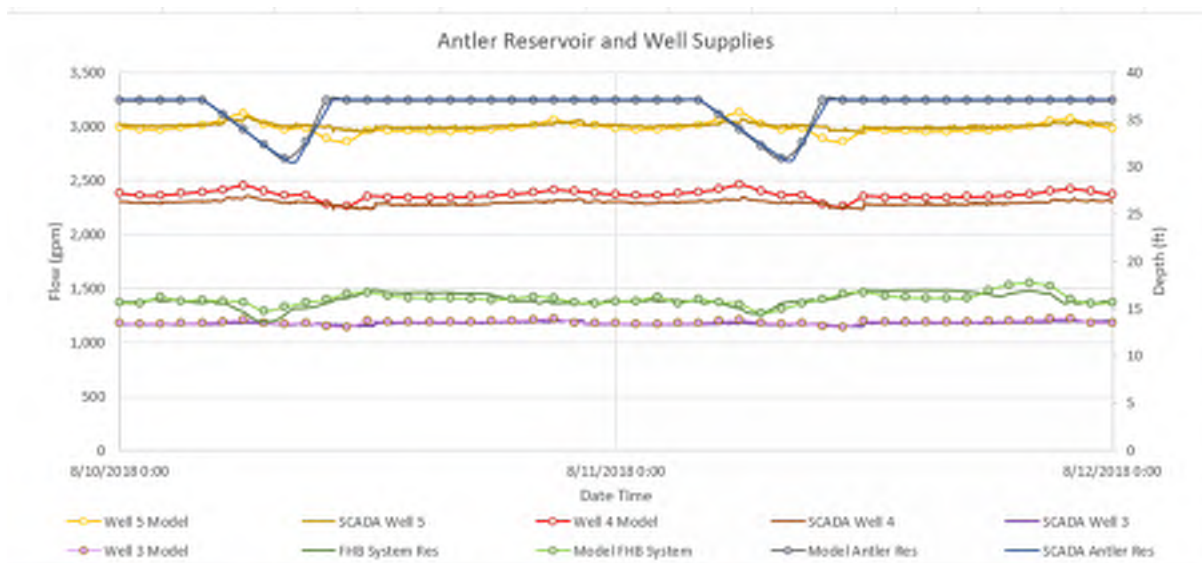


Figure 6 shows very good agreement between model results and system EPS SCADA data for Reservoir 4, Well 6 and the Well 6 Pump Station. Table 7 shows that system demand was not identical on the days of calibration, however the model repeats the average magnitude of modeled demand and diurnal curve on each of the calibration days. These modeled demands and diurnal curves were developed over several representative days. They are not identical to the actual demand on any single day, but they are representative of a typical high use period. Comparison of model results with actual field data provides confidence that the model generally predicts system performance well, even considering actual field variation. Figures 7 and 8 also show very good agreement between model results and SCADA data for Reservoir 6 near Well 7, and the Antler Reservoir and well supplies.

Winter Extended Period Simulation (EPS) Calibration

Similar to summer calibration, winter SCADA data was collected and evaluated over a period when water system operation was expected to be consistent for several days. Table 9 summarizes the period over which data was evaluated and used in winter representative demand development and model calibration.

Table 9 | Winter Data Collection Periods

Date	Demand Activity (MGD)	Calibration (SCADA Model Comparison)	Diurnal Curve Development (SCADA)
01/19/2019	2.31	Yes	Yes
01/20/2019	2.33	Yes	Yes
01/21/2019	2.50		Yes
01/22/2019	2.44		Yes
01/23/2019	2.38		Yes
01/24/2019	2.40		Yes
01/25/2019	2.43		Yes

The demand distribution for winter low demand modeling was taken from water meter data collected on January 7, 2019. SCADA and demand data was initially collected for the week of January 1st to January 7th. However, consideration of potential holiday disruptions to the distribution and pattern of demand that may have occurred around January 1st resulted in the decision to use only the 7th for demand distribution. Additionally, calibration and diurnal curve development efforts were shifted to data representing system demand between January 19th and 25th. Operational conditions were consistent during January 19th and 20th for calibration comparison of system and model performance. Diurnal curve development does not rely on consistent operational controls; it only requires selection of a representative period of use, when high quality SCADA data is available for its development. The resulting demand curves for Zones 1 +1A and Zone 2 are shown in **Figures 9 and 10**.

Figure 9 | Winter Diurnal Demand Curve for Zone 1 plus 1A

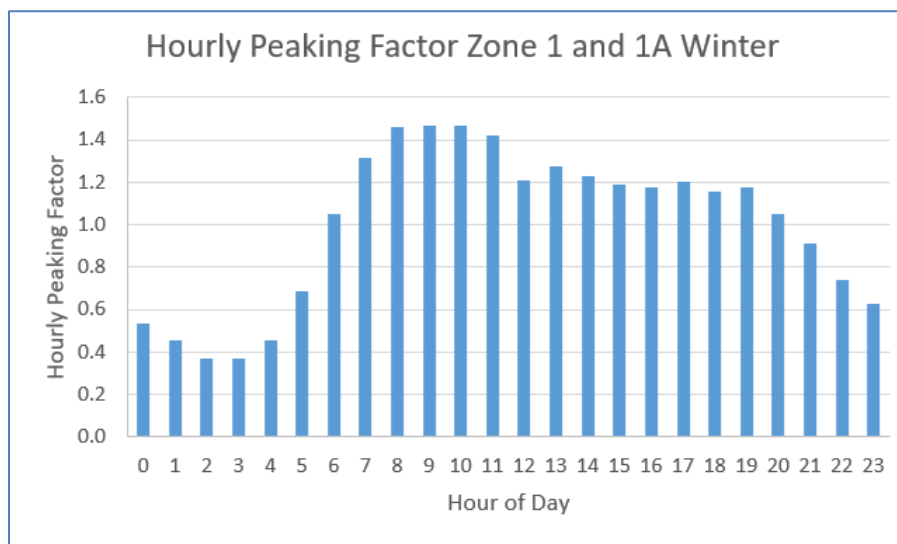
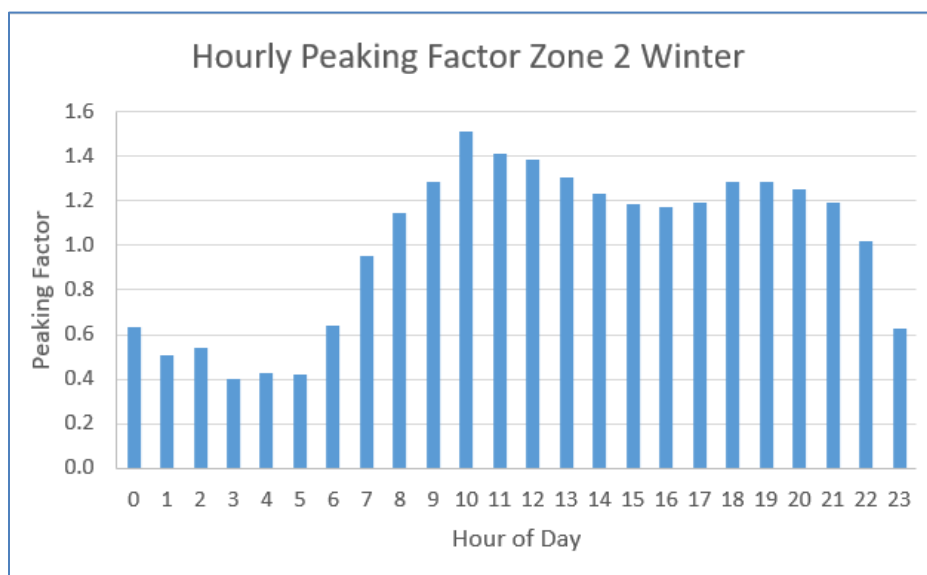


Figure 10 | Winter Diurnal Demand Curve for Zone 2



The winter diurnal curves from the City's SCADA data for this time period are typical and characteristic of winter demand curves, with significantly lower peaking compared with summer hourly demand.

Table 10 summarizes water system controls used for winter calibration. Changes to the model controls from the City's typical winter controls were made based on evaluation of SCADA data during the specific days used in calibration. These include the following.

- Well 4 was off during the winter calibration period.
- Well 5 was off during the winter calibration period.
- Well 6 was off during the calibration period, though SCADA data suggests it turned on during other winter days not in the calibration window.
- Well 6 Booster was operated as on/off by timer instead of the FHB System level. The speed was slightly reduced to 0.95 and only one pump was used.
- At Well 7 Booster only one pump was used.
- FHBPS#1 VFD control was set to 83.6 psi. Similar to summer this is slightly reduced from the field observed setting. This small difference may be due to a difference in elevation at which the pressure is set in the field and in the model.
- FHBPS#2 VFD controlled to 110.5 psi.
- Antler Reservoir sustaining pressure in Zone 2 during reservoir filling was set to 75 psi instead of 80 psi.

- FHB Storage was allowed to fill to 19.0 feet by the Transfer Pump Station instead of 19.3 feet based on SCADA data.
- At FHB Transfer Station Valve providing water from the FHB Storage to Zone 2, only one valve was used and a maximum flow rate was set to 3,000 gpm.

Table 10 provides a summary of winter model calibration controls.

Table 10 | Winter EPS Calibration Controls

Facility Name	Setting Description	Flow (gpm)
Well #1		Off
Well #2		Off
Well #3		Off
Well #4		Off
Well #5		Off
Well #6		Off
Pump Station at Well #6	One Pump Available 0.95 speed, Forked Horned Butte System Reservoir Level, Timer	15.8 – 16.9 ft, 8 am to 11 am
Well #7	Reservoir 6 Level	25 – 41 ft
Pump Station at Well #7	VFD Control, and level control Forked Horned Butte System Reservoir Level	63 psi (15 – 19 ft)
FHBPS#1	Zone 1 pressure, VFD Control	85 psi
FHBPS#2	Zone 1 pressure, VFD Control	Start at 95 psi, VFD target 110.5 psi
Transfer Pump Station	Forked Horned Butte System Reservoir level (Draws System Reservoir down and fills Storage Reservoir) Safety off based on Storage Reservoir Level	On 16.3 ft, off 15.5 ft System Reservoir Off 19 ft Storage Reservoir
Antler Pump Station	Timer, Antler Reservoir Level	On 4 am, off 31.4 ft
Antler Pump Station Control Valve	Sustain System Pressure during filling from Zone 2	75 psi

Figure 11 | Winter Calibration, Winter Forked Horned Butte Reservoirs and Pump Stations

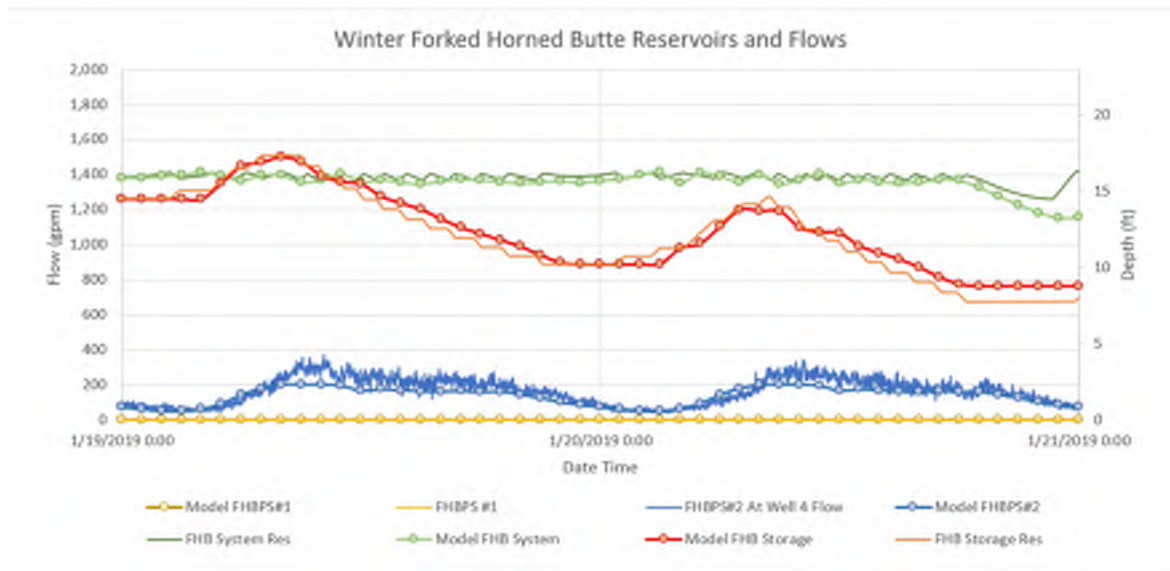


Figure 12 | Winter Calibration, Winter Reservoir 4 and Well 6

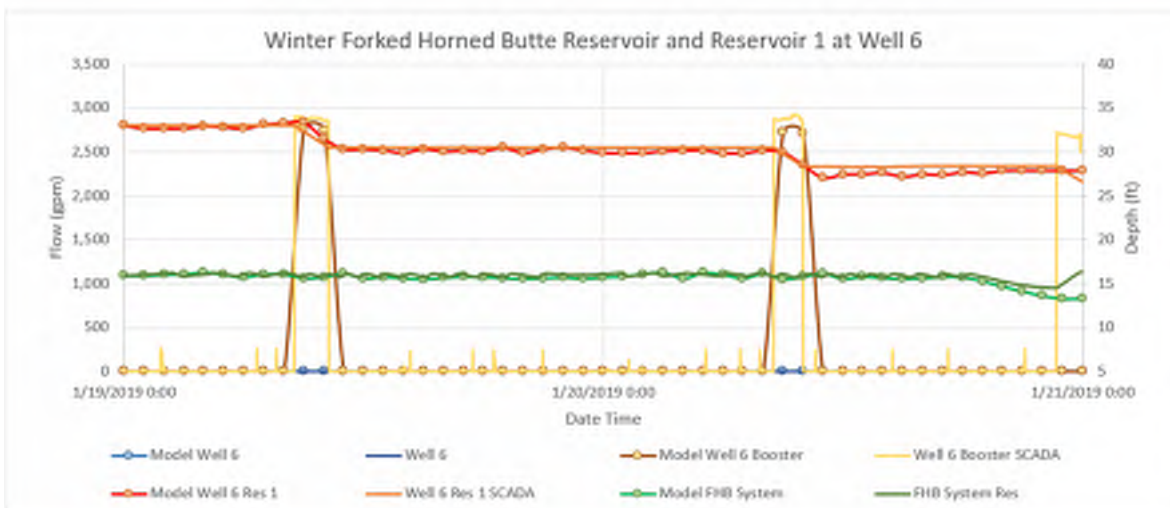


Figure 13 | Winter Calibration, Reservoir and Supplies at Well 7

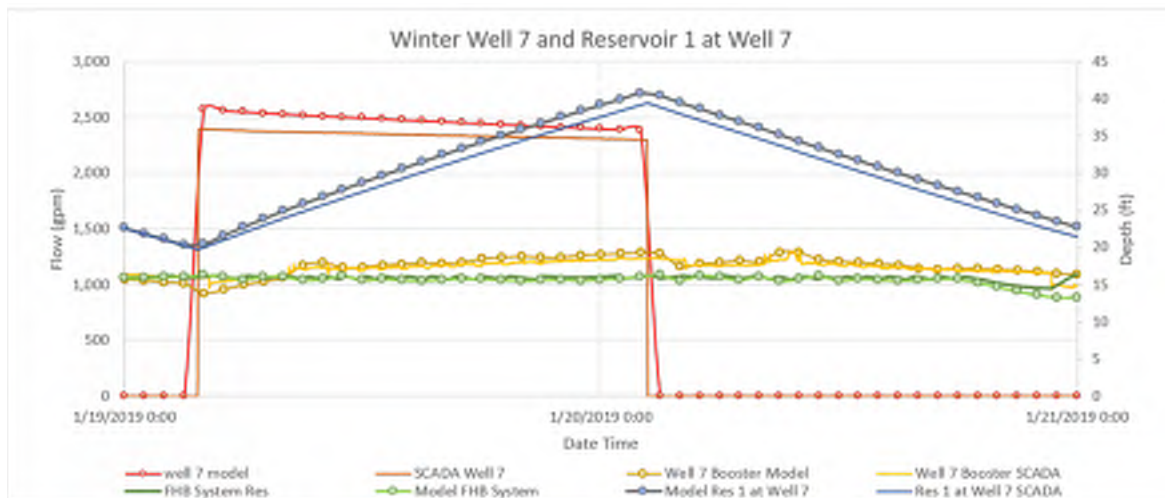
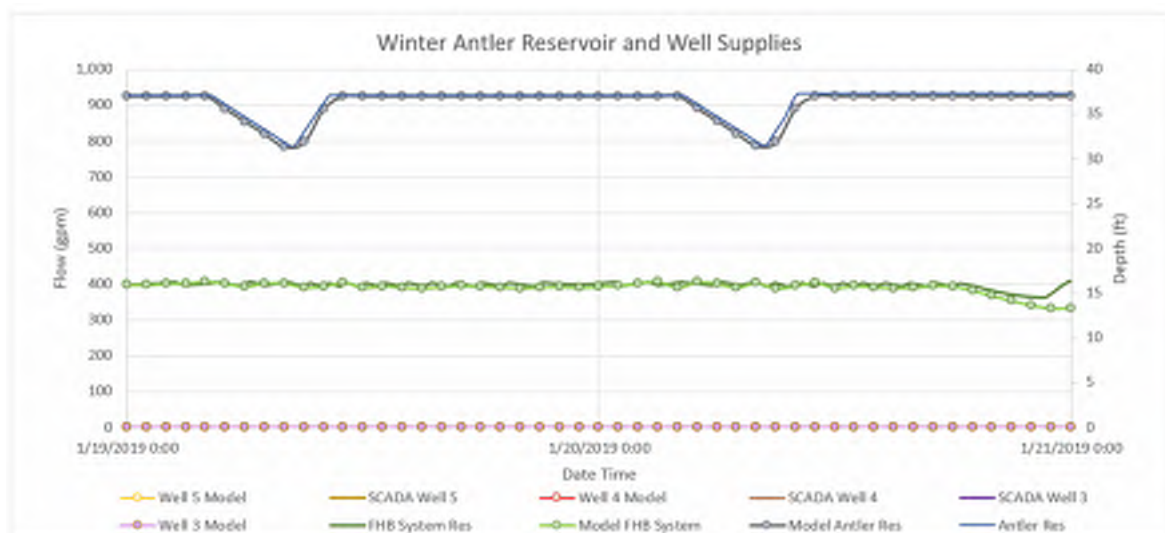


Figure 14 | Winter Calibration, Antler Reservoir and Supplies



Figures 11 through 14 show very good agreement between model results and SCADA data over the winter calibration period. In comparison with the summer period, this time frame overall is characterized by more consistent demand, so model results based on characteristic demands and curves can closely predict system performance.

Technical Memorandum

Date: April 14, 2020

Project: City of Redmond Water Booster 1A

To: City of Redmond, Oregon

From: Murraysmith, Inc.

Re: EPS Calibration and Simulation Results for Current Conditions

EPS Simulation Results

The following documentation has been developed to memorialize both the calibration of the extended period simulation (EPS) model and the subsequent analysis. The model was used to determine system operation once all or portions of the Forked Horn Butte Facility has been constructed, which includes a reservoir (serving Zone 2), booster station (serving Zone 1A) and well (serving the new reservoir directly) under both summer peak and winter conditions.

The Calibration Scenario results shown in **Figure 1-1** and **Figure 1-14** below represent system operations during the summer and winter calibration respectively.

A fundamental change in system operation is being proposed once the new Forked Horn Butte Facility is online. Currently the FHBPS#1 boosts flow from Zone 2 near the FHB System Reservoir to serve Zone 1. The current operation of the transfer station moderates the level in the FHB System Reservoir by pumping water to the FHB Storage Reservoir when the set level of the FHB System Reservoir is exceeded. The transfer station valves release flow from the FHB Storage Reservoir to Zone 2 to maintain levels in the FHB System Reservoir between 15 and 16 feet. Approximately an 8-foot depth is considered the minimum depth for the FHB Storage Reservoir. The demand served is the observed system-wide demand during the calibration period.

All non-calibration scenarios described below assume that service to Zone 1 is provided through a modified FHBPS#1. The modified FHBPS#1 boosts supply from the FHB Storage Reservoir to serve Zone 1. The Transfer Pump Station operation is also modified to fill the FHB Storage Reservoir based on a low level in the FHB Storage Reservoir of 12 feet, and high level of 19.5 feet. The Transfer Station valves provide supply from the FHB Storage Reservoir to Zone 2, if the FHB System Reservoir level drops below 13 feet. The transfer valves close again when the FHB System

Reservoir Level reaches 14 feet. This modified operation will allow the system to function more efficiently as less water will be pumped up to the Storage Reservoir and then reduced back to Zone 2 head. The Storage reservoir will still be available to augment the System Reservoir, however this should only occur under short peak demand periods during the summer. Water in the Storage Reservoir will be turned over by serving Zone 1 on an ongoing basis. FHBPS#1 will be the lead supply to Zone 1.

The New Well 8 will be controlled based on the level of the new reservoir, and the new Well 9 will be controlled based on the FHB System Reservoir, unless otherwise specified. Other existing well supply controls are modified as described in each scenario. Demand for summer scenarios other than calibration are equal to Maximum Day Demand (MDD). Demand for winter scenarios is equal to demand during the winter calibration period.

Results show that the loss of Well 5 under successive MDD conditions, results in inadequate available storage levels. Continuation of the scenario under MDD conditions, where supply equals or exceeds MDD, diminishes the influence of the reservoir levels at the beginning of the simulation, and provides insight on head losses throughout the system during periods of high demand.

A source of supply that can be used to compensate for the loss of Well 5 (largest source in the system) is recommended. The addition of Well 9 (3,000 to 3,500 gpm projected capacity) as proposed by the City was found to provide an adequate backup source for Well 5. The proposed Well 9 location gives it similar connectivity to the existing FHB System Reservoir, and the proposed new reservoir, which is also similar to the connectivity of the existing Well 5 to these reservoirs. The ability to fully utilize the capacity of Well 8 in Zone 2 will be limited without additional pipeline improvements. This memorandum does not identify optimum pipeline improvements to utilize Well 8, which will be identified as part of the upcoming Water Master Plan Update. Pipeline improvements on SW Helmholtz Way and SW Obsidian Avenue were evaluated to identify the level of benefit these improvements would provide in the case of the temporary loss of Well 8 or Well 5, in comparison with the addition of Well 9. The pipeline improvements evaluated, include extension of the existing 16-in pipeline on SW Helmholtz Way to SW Obsidian Avenue, and construction of a 12-inch pipeline from SW Helmholtz Way and SW Obsidian Avenue, to SW 35th Street.

In summary, the modified operation of the FHB System and Storage Reservoirs appears to work well and minimize the cycling of water between these two tanks. Modifications of the FHBPS#1 will be required, along with the addition short pipe segments to allow the booster to pump from the Storage Reservoir to Zone 1. Well 9 will be required to provide backup supply to the system if Well 5 or another large well was out of service in addition to it being needed to meet future projected demands. Additional pipe improvements are also recommended to allow for the full capacity of Well 8 to be utilized within Zone 2. Overall the FHB System Reservoir and New Reservoir can be balanced and operated within similar HGLs under both summer and winter peak conditions with relatively minor changes in well control settings. With Well 9 online and modified well controls under a scenario where Well 8 is offline the new reservoir levels can be maintained at

approximately 10 ft under successive maximum day demands. The scenarios (other than 1-1 and 1-14) below illustrate the pump operation and tank levels under a wide array of conditions.

Figure 1-1
Summer Calibration

Scenario Description: Summer Calibration. The calibration scenario shows the mediation of the FHB System Reservoir level using the operations of the Transfer Pump Station and valves.

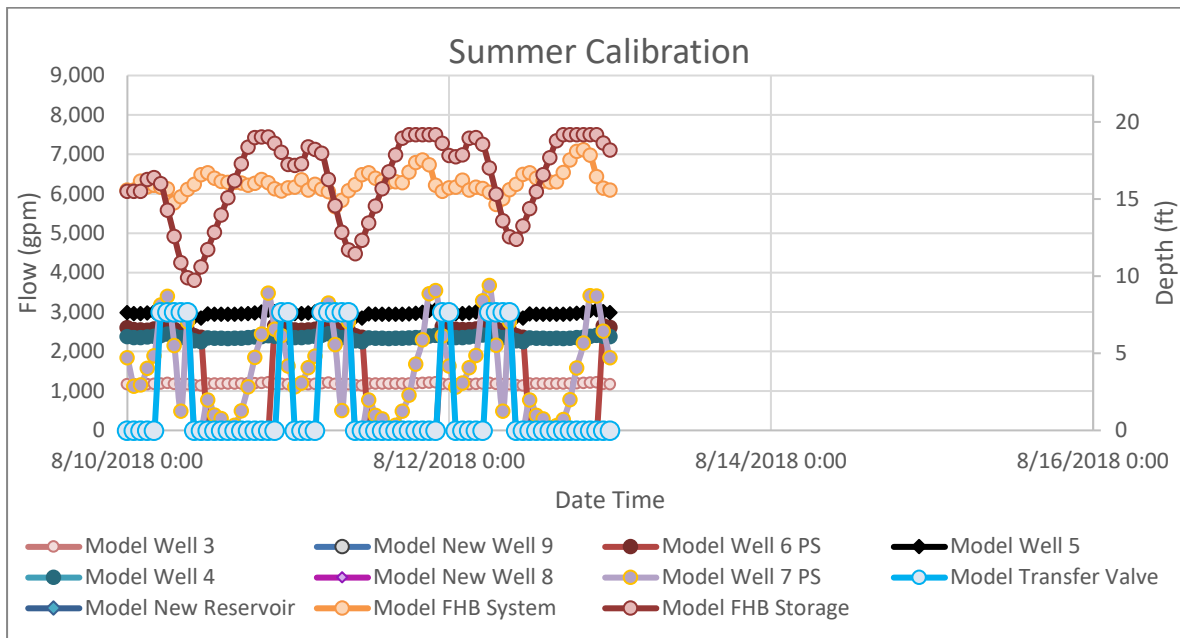


Figure 1-2
Summer - Addition of Well 8

Scenario Description:

ID: 1

Well 8: Online at approximately 3,000 gallons per minute (gpm) (On/off based on FHB System Reservoir 15 feet – 18 feet),

New Reservoir: Offline

Booster 1A: Not Online (Zone 1A served through existing options)

Well 9: Offline

Well 5: Online

Other system wells: Online with controls similar to the calibration period based on FHB System Reservoir level

Notes: Zone 1 is supplied from a booster from the Storage Reservoir. FHB System Reservoir level allowed greater range as the Transfer Pump Station generally only boosts water required for Zone 1. The FHB Storage Reservoir is filled from system wells based on a low level of 12 feet and high level of 19.0 feet. Without VFD control for Well 8 without the New Reservoir, the location of the highest elevation service on SW 49th St, near SW Wikiup Avenue, may experience pressures lower than 40 psi. Maximum velocities in this pipeline are expected to be less than 4 feet per second.

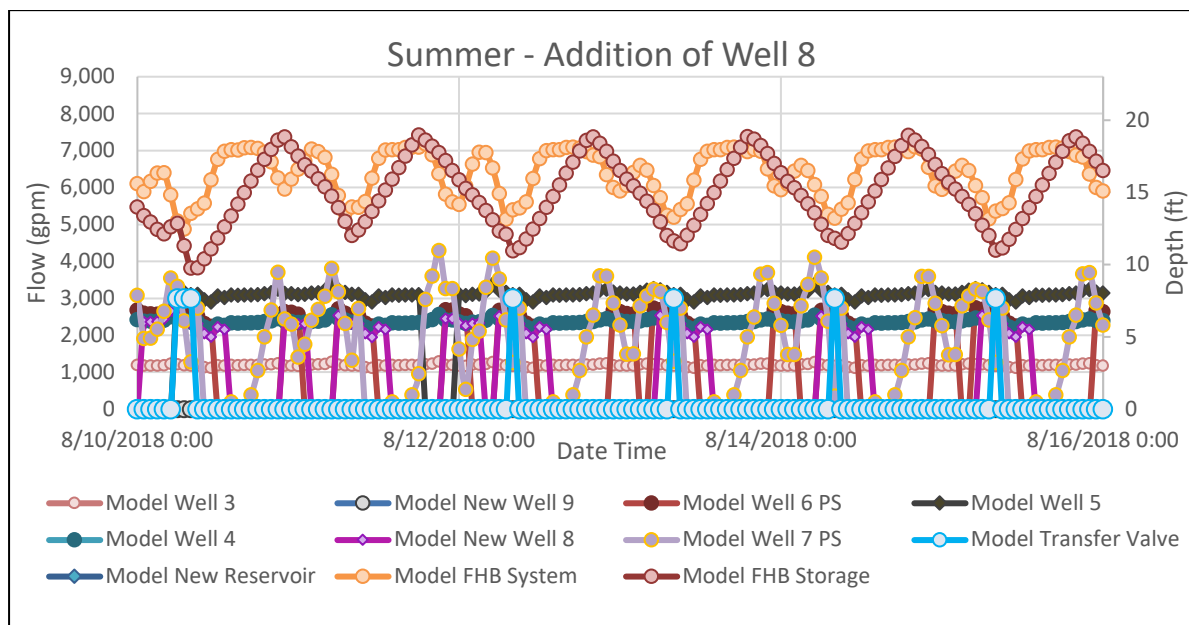


Figure 1-3
Summer Addition of Well 8 and New Reservoir

Scenario Description:

ID: 3a

Well 8: Online at approximately 3,000 gpm (New Reservoir 15 feet - 18.5 feet)

New Reservoir: Online

Booster 1A: Online and Serving Zone 1A

Well 9: Offline

Well 5: Online

Other System Wells: Supply Controls are adjusted to attain FHB System Reservoir Level >19 feet, Well 7 is operated as on/off.

Notes: The on and off settings of system supplies were adjusted to attain near-full levels in both reservoirs. Maximum pressures were up to 4 pounds per square inch (psi) higher at Well 7 than the calibration scenario, reaching 71 psi.

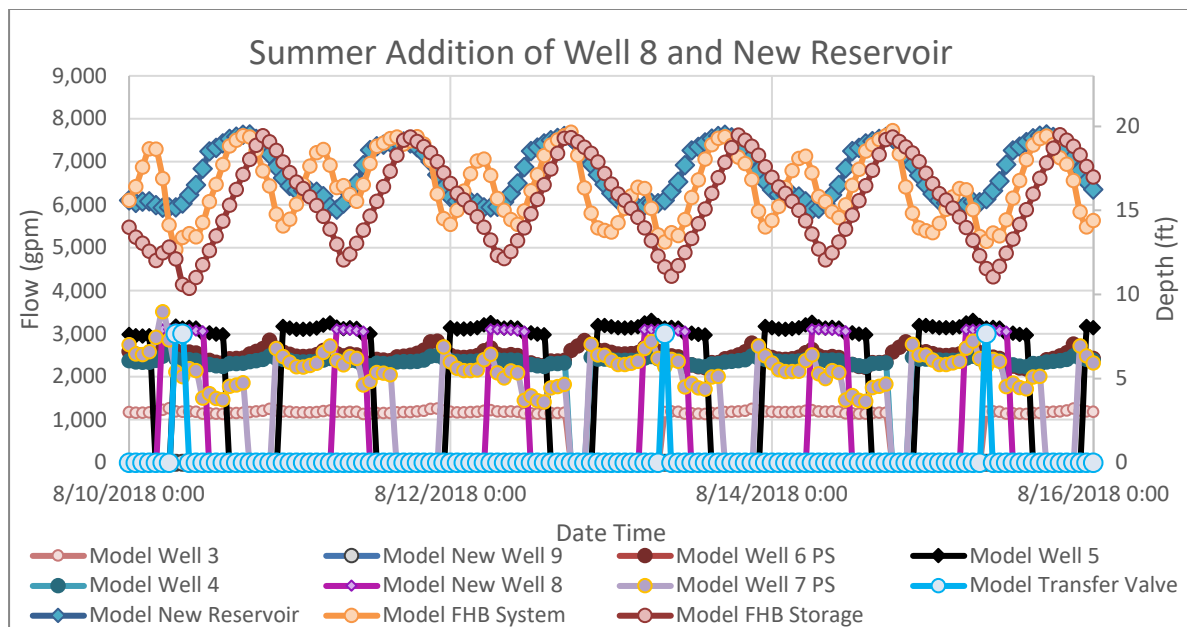


Figure 1-4
Summer Addition of New Reservoir, Well 8 Offline

Scenario Description:

ID: 3b

Well 8: offline (New Reservoir 15 feet - 18.5 feet)

New Reservoir: Online

Booster 1A: Online and serving Zone 1A

Well 9: Offline

Well 5: Online (FHB System Reservoir)

Other System Wells: Supply Controls are adjusted to attain FHB System Reservoir Level >19 feet, Well 7 is on/off.

Notes: With Well 8 offline, this scenario shows that significant head loss exists between the new reservoir and remaining available sources of supply under high demand conditions. New reservoir drops below 7.5 feet.

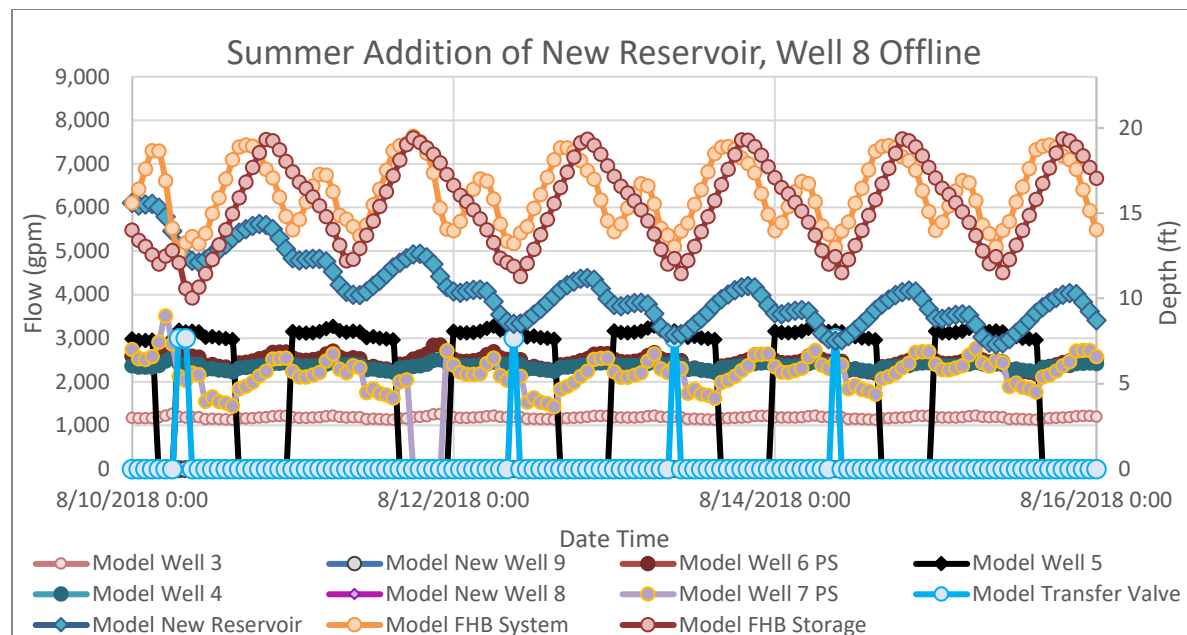


Figure 1-5
Summer Addition of New Reservoir, Well 8 Offline and add Well 9

Scenario Description:

ID: 3c

Well 8: Offline

New Reservoir: Online

Booster 1A: Online and serving Zone 1A

Well 9: Online at approximately 3,000 gpm (15 feet - 18 feet FHB System Reservoir)

Well 5: Online (FHB System Reservoir)

Other System Wells: Supply Controls are adjusted to attain FHB System Reservoir Level >19 feet, Well 7 is on/off

Notes: This Scenario shows that with only the addition of Well 9, supply produced by Well 5 is reduced, and significant improvement to storage level in the New Reservoir is not attained without additional supply control changes.

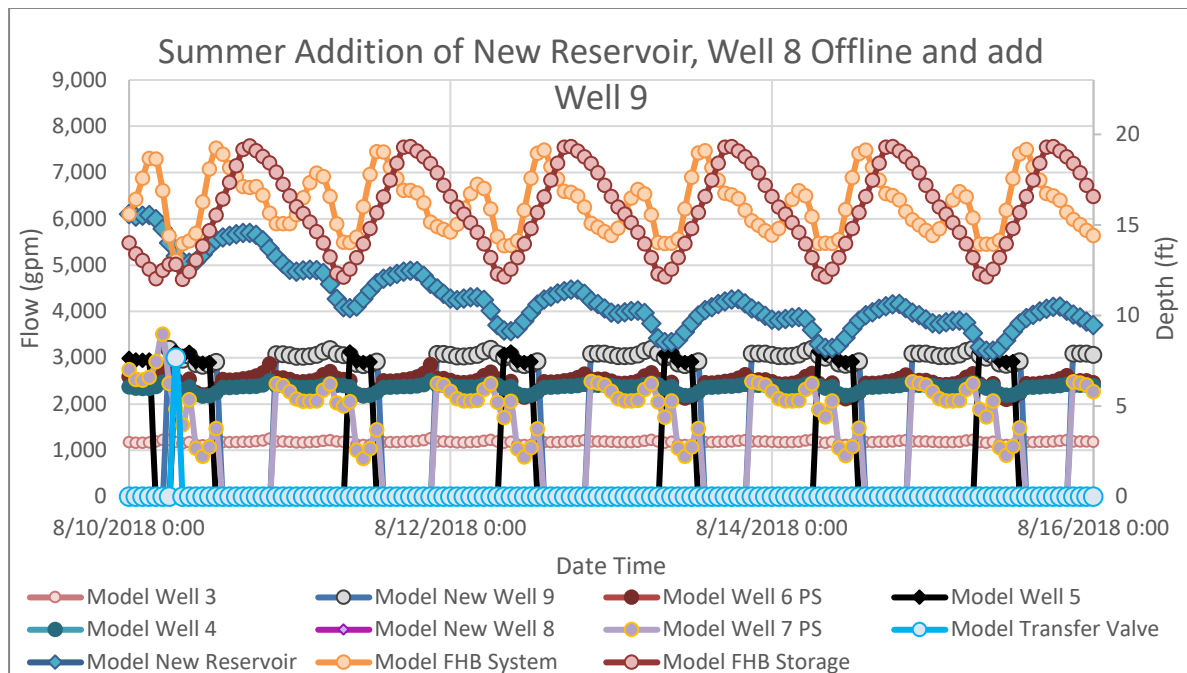


Figure 1-6

Summer Addition of New Reservoir, Well 8 Offline, Maximize Wells 5, 7 and 9

Scenario Description:

ID: 3.0.1

Well 8: Offline

New Reservoir: Online

Booster 1A: Online and serving Zone 1A

Well 9: Online at approximately 3,000 gpm (New Reservoir 15 feet – 19.8 feet)

Well 5: Online (New Reservoir 13 feet – 19.5 feet)

Other System Wells: Supply controls maximize use of wells 5, 9 and 7 to support the New Reservoir without the use of Well 8.

Notes: This scenario shows that a change in controls to maximize flow from wells 5, 7 and 9 can improve the level of the new reservoir sustained with the loss of Well 8. Maximum Pressures reach almost 8 psi higher near Well 9 when compared to this location under the Calibration Scenario, reaching approximately 107 psi.

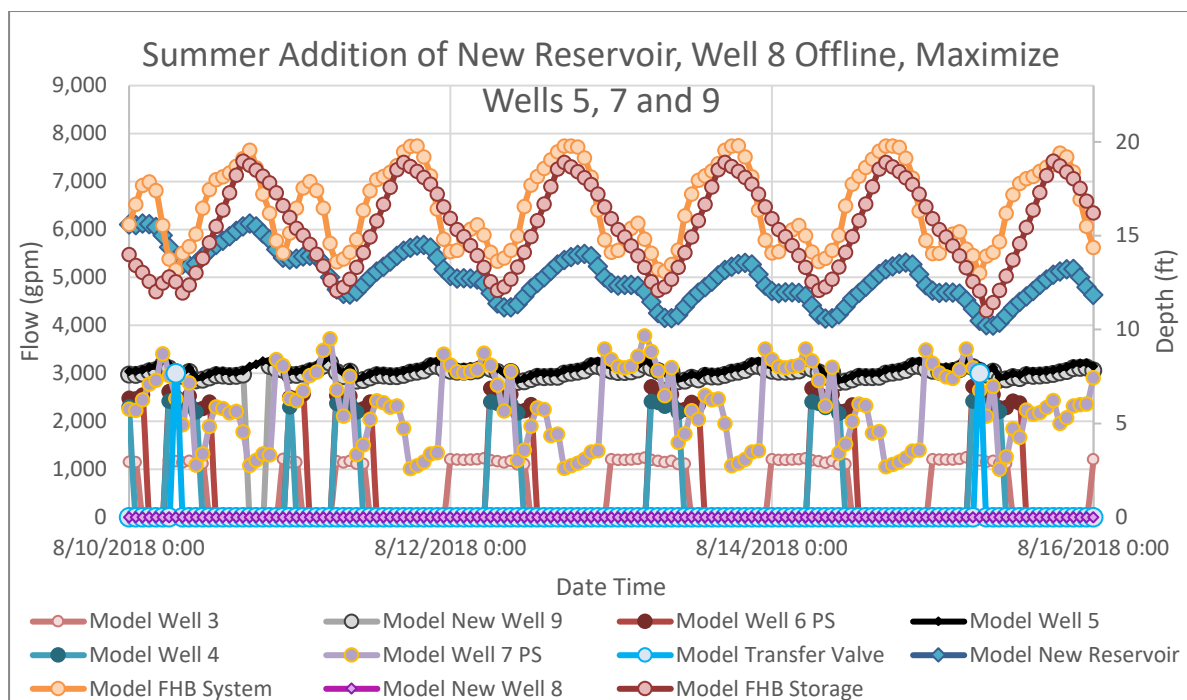


Figure 1-7

Summer Addition of New Reservoir, Well 8 Offline, Maximize Wells 5 and 9

Scenario Description:

ID: 3

Well 8: Offline

New Reservoir: Online

Booster 1A: Online and serving Zone 1A

Well 9: Online at approximately 3,000 gpm (New Reservoir 15 feet - 19.5 feet)

Well 5: Online (New Reservoir 13 feet – 18.5 feet)

Other System Wells: Controls are adjusted but well 7 booster remains VFD control

Notes: This Scenario changes supply controls to maximize the use of Wells 5 and 9, however it does not convert Well 7 to on/off controls. This Scenario attains adequate levels in the new reservoir. Maximum pressures reach approximately 5 psi higher than the calibration scenario at Well 9 with a maximum of approximately 104 psi at Well 9.

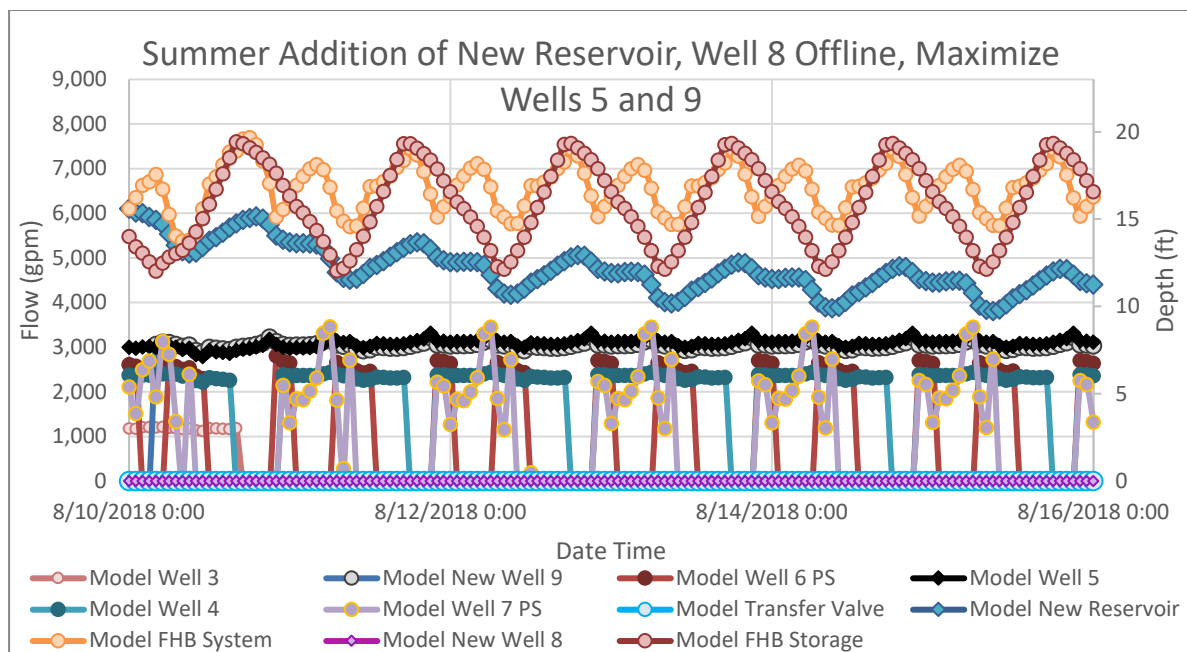


Figure 1-8
Summer Addition of New Reservoir and Well 8, Well 5 Offline

Scenario Description:

ID: 6.1

Well 8: Online at approximately 3,000 gpm (15 feet - 18.5 feet New Reservoir)

The New Tank: Online

Booster 1A: Online and serving Zone 1A

Well 9: Offline

Well 5: offline

Other System Wells: Supply Controls are the same as those used to attain FHB System Reservoir Level >19 feet in previous scenarios, when well 5 was online. Well 7 is on/off.

Notes: With supply settings that attained near filling of both tanks, the loss of Well 5 results in inadequate levels in the FHB System Reservoir, and FHB Storage Reservoir.

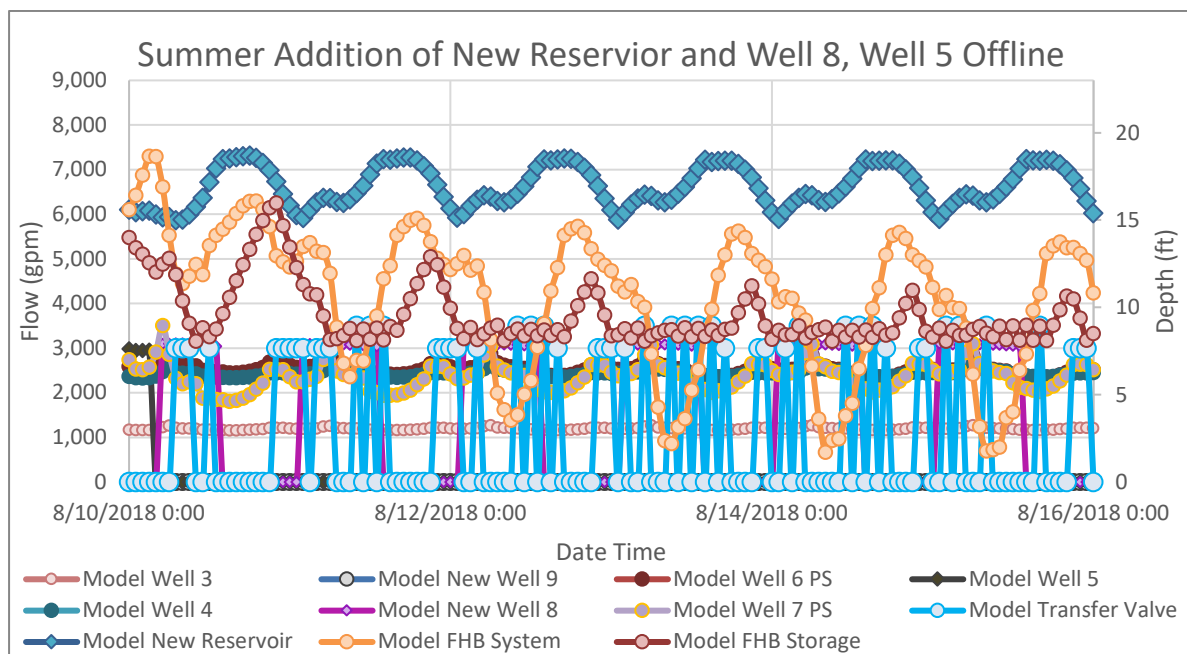


Figure 1-9

Summer Addition of New Reservoir and Well 8, Well 5 is offline, Well 9 is Available

Scenario Description:

ID: 6.1a

Well 8: Online at approximately 3,000 gpm (15 feet - 18.5 feet New Reservoir 7)

New Tank: Online

Booster 1A: Online and serving Zone 1A

Well 9: Online at approximately 3,000 gpm (15 feet – 19.5 feet FHB System Reservoir)

Well 5: Offline

Other System Wells: Supply Controls are adjusted to attain FHB System Reservoir Level >19 feet, Well 7 is on/off

Notes: This scenario shows that the loss of Well 5 can be managed with the addition of Well 9. Maximum pressures at Well 9 reach approximately 5 psi higher than the calibration scenario at approximately 104 psi near Well 9.

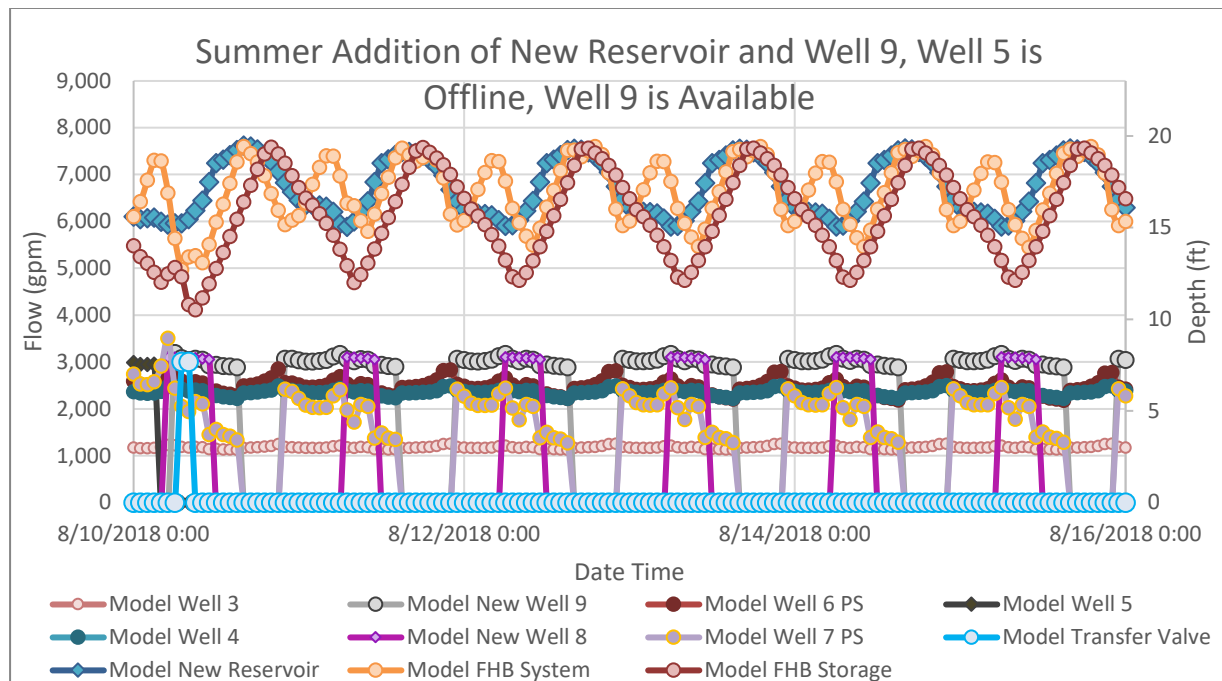


Figure 1-10
Summer Addition of New Reservoir, Well 8 offline, With Pipe Improvements

Scenario Description:

ID: 7.1

Well 8: Offline

New Tank: Online

Booster 1A: Online and serving Zone 1A

Well 9: Offline

Well 5: Online (FHB System Reservoir 14 feet – 18.8 feet)

Other System Wells: Supply Controls are the same as those used to attain FHB System Reservoir Level >19 feet in previous scenarios, when Well 8 was online. Well 7 is on/off.

Pipeline Improvements: 12-inch Improvement on Obsidian, 16-inch extended north on Helmholtz

Notes: This Scenario applies the changes to controls used to attain near filling of both reservoirs, and implements pipeline improvements on Helmholtz and Obsidian, instead of the addition of Well 9. Maximum pressures are approximately 4 psi higher than the calibration scenario at well 7. Slightly less storage volume is maintained in the New Reservoir when compared with the addition of Well 9.

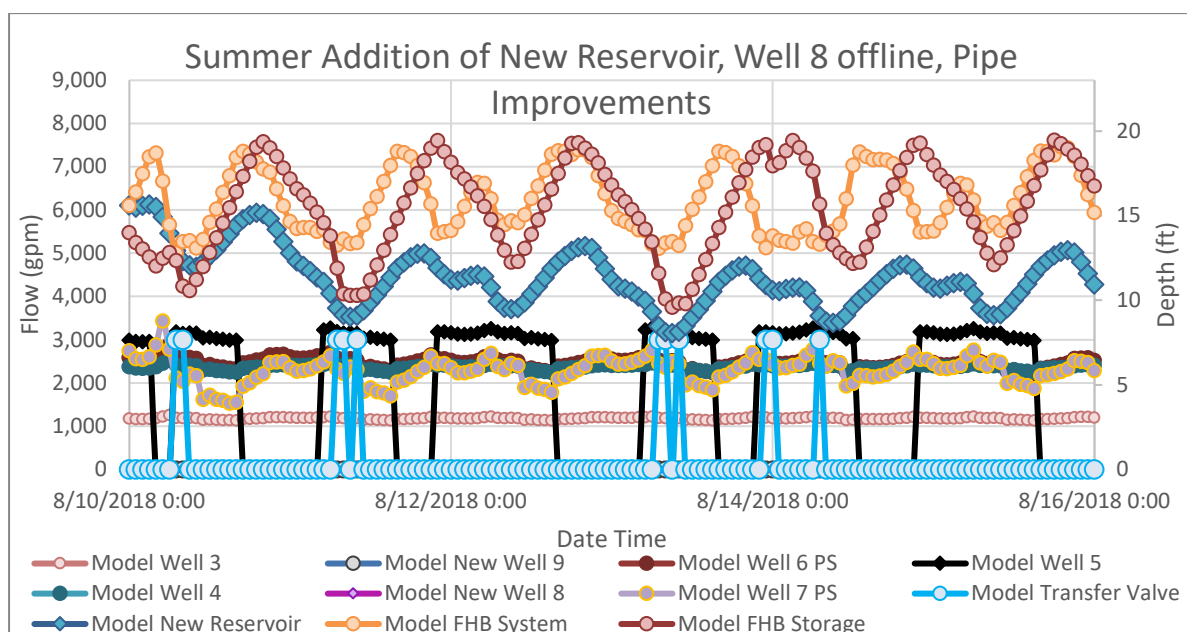


Figure 1-11

Summer Addition of Well 8 and New Reservoir, Well 5 is offline, With Pipeline Improvements

Scenario Description:

ID: 6.1c

Well 8: Online at approximately 3,000 gpm (15 feet - 18.8 feet New Reservoir)

New Reservoir: Online

Booster 1A: Online and serving Zone 1A

Well 9: Offline

Well 5: Offline

Other System Wells: Supply Controls are the same as those used to attain FHB System Reservoir Level >19 feet in previous scenarios, when well 5 was online. Well 7 is on/off

Pipeline Improvements: 16-inch extension Helmholtz, 12-inch Obsidian.

Notes: This Scenario applies the changes to controls used to attain near filling of both reservoirs, and implements pipeline improvements on Helmholtz and Obsidian, instead of the addition of Well 9. This scenario shows that while pipeline improvements may substitute for the construction of Well 9 in the case of the loss of Well 8, these pipeline improvements do not adequately substitute for the construction of Well 9 in the case of the loss of Well 5.

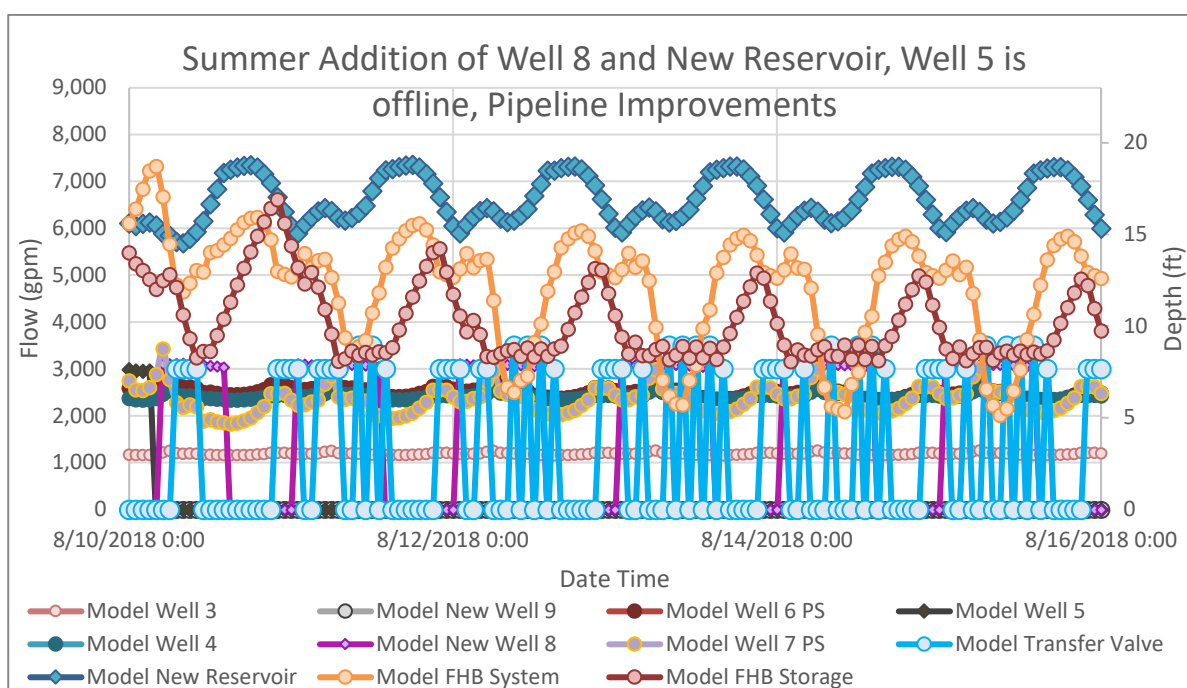


Figure 1-12
Summer Addition of Wells 8 and 9 at 3,500 gpm

Scenario Description:

ID: 6.1b

Well 8: Online at approximately 3,500 gpm (15 feet - 18.8 feet New Reservoir 7)

New Reservoir: Online

Booster Station 1A: Online and serving Zone 1A

Well 9 Online at approximately 3,500 (gpm)

Well 5: Offline

Other System Wells: Supply Controls are the same as those used to attain FHB System Reservoir Level >19 feet in previous scenarios, when well 5 was online. Well 7 is on/off

Notes: Max velocity near Well 9 is approximately 6.4 feet per second, maximum velocity near Well 8 is approximately 2.6 feet per second.

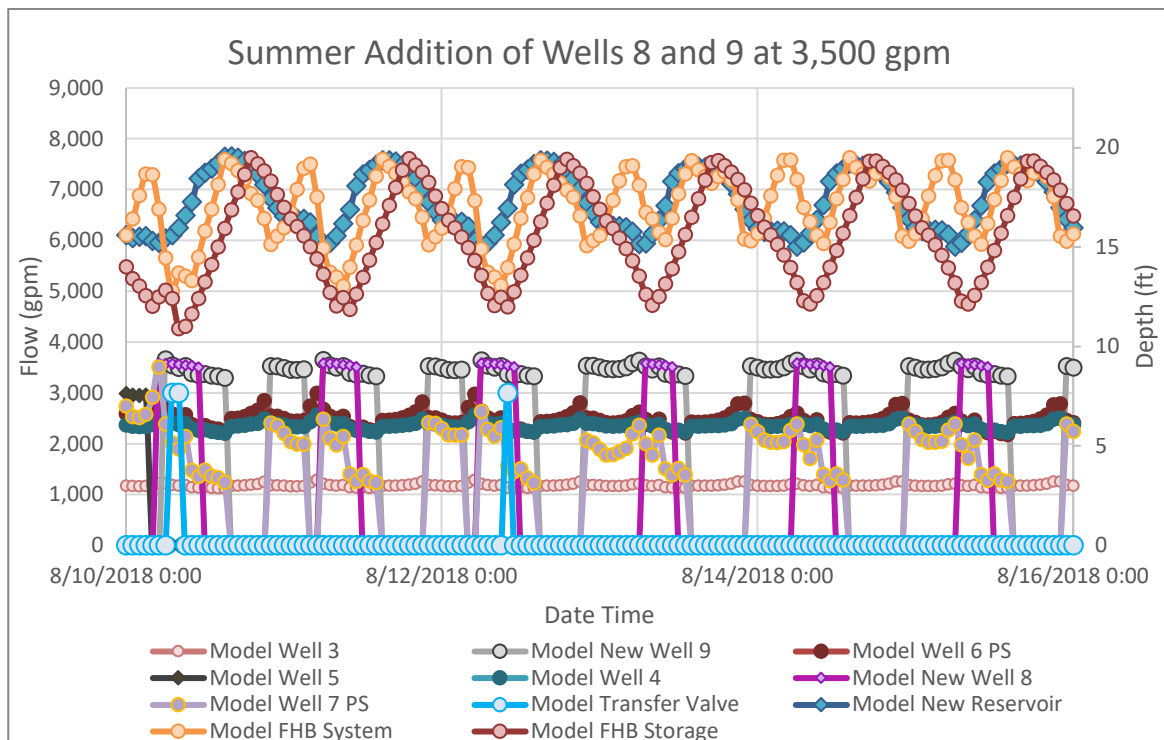
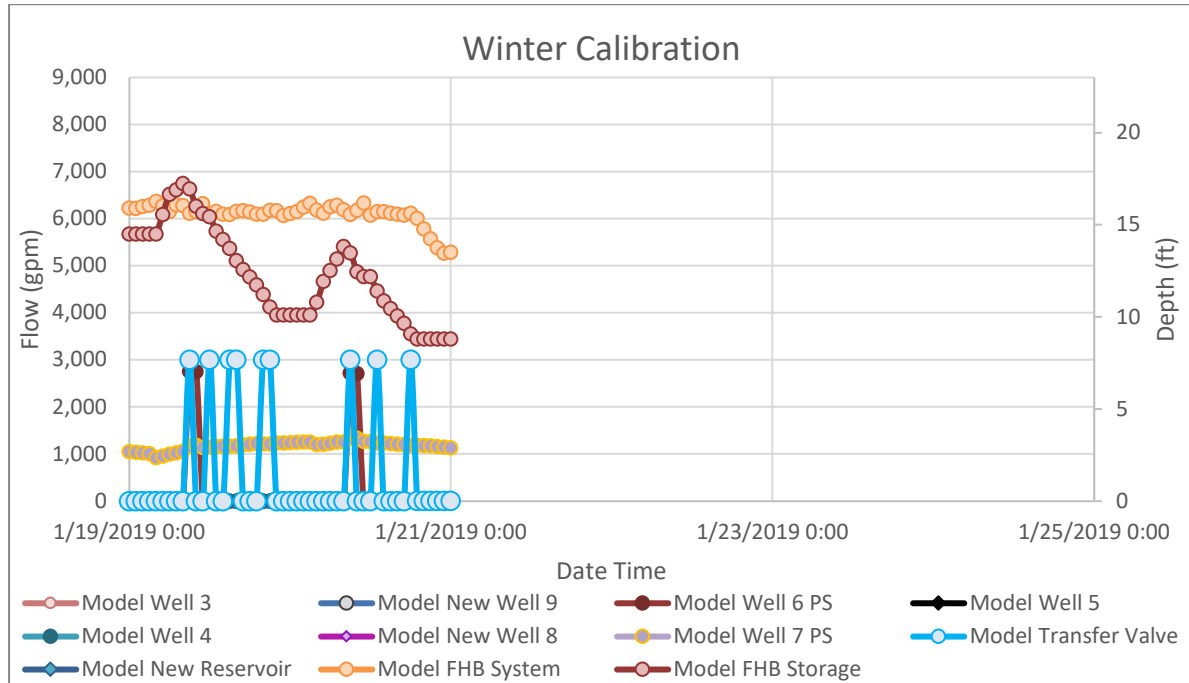


Figure 1-14
Winter Calibration

Scenario Description: Winter Calibration



Scenario Notes: A time frame with relatively consistent facility controls was used during calibration. A longer duration is used for simulation results.

Figure 1-15
Winter Scenario, Add Well 8 And New Reservoir

Scenario Description:

ID: 15

Well 8: Online at approximately 3,500 gpm (15 feet - 18.8 feet New Reservoir 7)

New Reservoir: Online

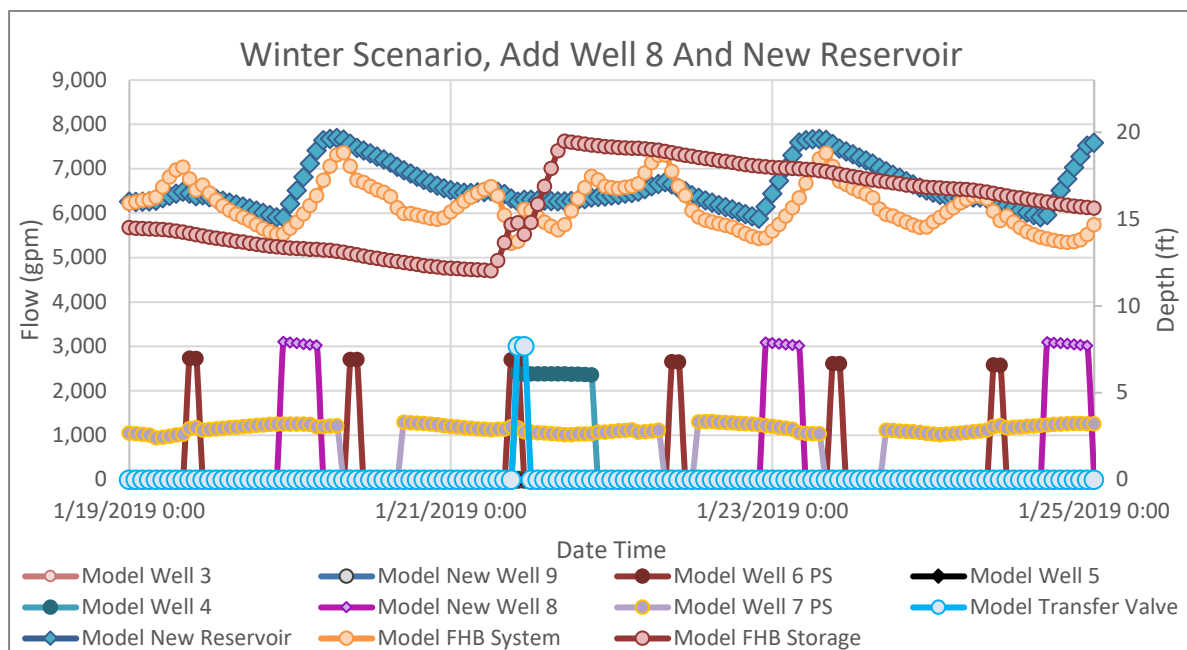
Booster Station 1A: Online and serving Zone 1A

Well 9 Offline

Well 5: On as needed

Other System Wells: Supply Controls are the same as those used to attain FHB System Reservoir Level >19 feet in previous scenarios, when well 5 was online. Well 7 is on/off

Notes: The Transfer Station pump could be controlled to fill the FHB Storage Tank to less than full during winter to shorten the turnover time, if desired.



Technical Memorandum

Date: July 27, 2021

Project: Water Facility Condition Assessment

To: City of Redmond, Oregon

From: Murraysmith
Will Kirby, PE
Dennis Galinato, PE

Note: In order to avoid redundancy of content, appendices to this technical memorandum have been removed.

Introduction

As part of the Water Master Plan effort, the City of Redmond, Oregon (City) is interested in evaluating the condition of their various pumping facilities. The City's goal is to use this information to develop improvement projects to address any identified condition deficiencies. In addition, the City would like to develop a formalized maintenance plan for their pumping facilities.

To determine the condition of the water supply system, a review of specific wells and booster stations was performed regarding both the existing condition of the facility and compliance with Oregon Administrative Rules (OARs), Oregon Health Authority (OHA) Sanitary Survey Inspection Criteria, Oregon Energy Efficiency Specialty Code (OEESC), Hydraulic Institute, and National Electrical Code (NEC). Additional assessment was provided in the Risk and Resiliency Assessment, Murraysmith (included in **Appendix 2**), and an assessment by S&B, Inc., integrators retained by the City (included in **Appendix 3**).

This technical memorandum summarizes the evaluation and review of the City's existing water pumping facilities and provides recommendations for the rehabilitation and replacement of system components to be included in the Water Master Plan Capital Improvement Plan. Ultimately, the replacement plan will be utilized to ensure that system components are repaired or replaced prior to failure. This memo will provide evaluation for the following facilities.

- | | |
|--------------------------------------|--------------|
| ▪ Forked Horn Butte No. 1 | ▪ Well No. 4 |
| ▪ Forked Horn Butte No. 2 | ▪ Well No. 5 |
| ▪ Forked Horn Butte Transfer Station | ▪ Well No. 6 |
| ▪ Well No. 2 | ▪ Well No. 7 |
| ▪ Well No. 3 | |

Evaluations of Well No. 1, Antler Pump Station, and Well No. 8 are not included as part of this memorandum as these systems were not identified as critical for assessment and improvement

by City staff. Well No. 1 will be replaced in the near term by Well No. 9 and the Antler Pump Station will be abandoned. Well No. 8 is still under construction.

The overall system evaluation was performed through desktop review of various codes, rules, and guidance; as-built engineering drawings of each facility; interviews and questionnaires with the City's operation staff; and an onsite review of each facility which took place on March 30, 2021.

The onsite facility review included a visual facility inspection by Murraysmith, Industrial Systems (electrical subconsultant to Murraysmith), and City operators in an effort to identify issues and improvements.

Facility Condition Assessment

Each facility was evaluated using input from multiple sources to help identify problems and areas of concerns. Process problems relating to well water pumping and treatment were noted, along with operator safety, equipment operation, and facility construction concerns.

A desktop review of facility as-built drawings was performed to identify site layout and buried piping sizes, and to determine general dimensions of components of each facility.

A Condition Assessment was delivered to operations staff in order to document their general assessment of each well facility. Staff assessments were reviewed to help gain an understanding of each facility that may not be apparent through review of the as-built plans. The survey results are included in **Appendix 1**.

The questions in the Operator Condition Assessment cover the general facility condition, safety concerns, and operational deficiencies for each pump house, pump equipment, electrical equipment, and chlorination system. The assessment also evaluates the condition of site access and security, as well as well water quality or quantity problems.

The final evaluation process included an onsite review of each facility to further identify issues and identify potential improvements. Each facility inspection included a review of its layout, overall condition and state of its equipment, and identified potential improvement options. No testing or structural evaluations (e.g., equipment testing, destructive load) were performed during the onsite review.

Operator Condition Assessment

As part of the Operator Condition Assessment, each facility was given a score of 1 (good), 2 (average), or 3 (poor) for each survey question (see **Appendix 1**). Scores of 0 or n/a indicate non applicability.

These scores were used to assess the general priority of potential improvements as discussed further. The score for each response is shown in **Table 1**. Poorly scoring items were discussed with the City. Projects identified from the Operator Condition Assessment can be found in the **Facility Capital Improvements** section.

Table 1 | Facility Condition Assessment Scores

Facility Element	Question No.	Assessment Criteria	Scores ²								
			Well No. 2	Well No. 3	Well No. 4	Well No. 5	Well No. 6	Well No. 7	FHBPS ¹ No. 1	FHBPS ¹ No. 2	FHBTS ¹
Pump House General Assessment	1	Condition of facility ventilation	1	1	3	1	1	1	1	1	1
	2	Condition of lighting	1	1	3	1	1	1	2	1	1
	3	Condition of plumbing	1	3	1	1	1	1	1	1	1
	4	Structural deficiencies	3	2	3	1	1	1	1	2	1
	5	Safety accommodations	1	1	1	1	1	1	1	2	1
Site Assessment	6	Condition of site and site accessibility	2	1	1	1	1	1	1	1	1
	7	Protection from vandals and trespassers	3	3	3	1	2	1	2	2	2
Equipment Assessment	8	Condition of pumps	1	1	1	2	1	2	1	1	1
	9	Condition of pipes and valves	1	1	1	-	-	-	1	1	1
	10	Condition of monitoring equipment	1	1	1	1	1	1	1	-	1
	11	Condition of motors	1	1	1	-	-	1	1	1	1
	12	Are components maintained at recommended schedules?	1	1	1	1	1	1	1	2	1
	13	Equipment access or maintenance concerns	1	1	1	1	1	1	1	3	1
Chlorination System Assessment	14	Chlorine located in separated vented room with leak detection, and alarms? SCADA notification?	1	1	1	1	1	1	-	-	-
	15	Automatic Chlorine switchover upon empty cylinder?	1	1	1	1	1	1	-	-	-
Water Assessment	16	Water quality issues	3	1	1	1	1	1	1	1	1
	17	Water quantity or pressure issues	1	1	1	1	1	1	-	1	1
Electrical Assessment	18	Motor control condition	2	1	2	3	1	2	1	1	-
	19	Electrical system condition	3	1	3	2	1	2	-	2	-
	20	Do control cabinets require open-door venting?	-	-	-	-	-	-	-	-	-
	21	Generator assessment	1	1	3	1	1	1	1	1	1
Average Score			1.50	1.25	1.65	1.22	1.06	1.16	1.13	1.41	1.06

- Notes:
- 1. FHBPS = Forked Horn Butte Pump Station, FHBTS = Forked Horn Butte Transfer Station.
 - 2. “—” denotes not applicable or was not rated by the City.

Code Compliance Assessment

Each facility was reviewed to determine compliance with current OARs, OHA Sanitary Survey Inspection Criteria, OEESC, Hydraulic Institute, and NEC. The following sections outline the specific codes, rules, or standards that were used in the assessment of the facilities. The **Facility Capital Improvements** section identifies projects that were identified from the code compliance assessment.

Oregon Administration Rules

The OAR rules that apply to drinking water systems and well construction set minimum design, construction, operations, and maintenance standards to help ensure that the drinking water system is protected from contamination that might harm the health of its consumers.

Oregon Health Authority Sanitary Survey Inspection Criteria

Further compliance assessment included a review of recent sanitary surveys and a review of each facility against the OHA's deficiency criteria and outstanding performance criteria.

Oregon Energy Efficiency Specialty Code

The OEESC provides requirements for new buildings, and for additions, alterations, renovations, or reports to existing buildings. This code specifically requires compliance with portions of ASHRAE 90.1. The City's facilities were compared with the OEESC standards for the potential to update facilities if alterations or additions are to be made in the future.

Several facilities were found to be non-compliant with OEESC, however, per OEESC, existing facilities do not need to meet the code unless there are to be alterations or additions to the building. Projects were identified in preliminary project identification and were discussed with the City; however, are not shown in the **Facility Capital Improvements** section, as they are not required projects.

Hydraulic Institute Recommendations

The Hydraulic Institute publishes standards for pumping systems. These standards provide recommendations for the construction of pumping facilities. The City's as-builts were compared with the standards provided in the Hydraulic Institute guidelines.

National Electrical Code

The NEC is a standard for the safe installation of electrical work. The City's facilities were examined for compliance with the code by Industrial Systems.

Facility Capital Improvements

Projects are developed based on compliance with code, applicable standards, and City-provided facility reviews. Aside from the code and facility assessment by Murraysmith and Industrial Systems, additional assessments by Murraysmith (Risk and Resiliency Report) and S&B Inc. (Report Section noted) have been included and are labeled as such.

Projects labeled HVAC/Architectural/Structural assume the buildings are designated semi-heated spaces. If the stations are not designated semi-heated (per the Building Official) they should be reevaluated as such and documented in a written document from the Building Official. Non-residential building codes may apply otherwise.

Project labels are as follows (XX corresponds to the facility label, ## is the project number).

- Civil: XX-C-##
- Mechanical: XX-M-##
- Telemetry and SCADA: XX-T-##
- Electrical: XX-E-##
- HVAC, Architectural, Structural: XX-H-##
- Miscellaneous: XX-MS-##

The following tables list the capital improvements for each facility individually.

Table 2 | Well No. 2 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
W2-C-01	Well No. 2 Site Improvements	Located in park, operators have difficulties accessing facility in the snow	Pave access road to wellhouse; provide snow storage and site drainage.
W2-E-01	Well No. 2 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
W2-T-01 ¹	Well No. 2 Hybrid Topology Implementation (S&B 4.2.2.3)	Existing Star Topology has a known single point of failure as the MTU serves as the communication hub. If the MTU were to fail, inter-station SCADA data set exchanges would be lost.	Overlay (6) peer-to-peer connections to serve as a secondary communication method for remote stations to complete their process control functionality in the event of an MTU communication failure. The peer-to-peer overlays will transition the SCADA WAN architecture from Star to Hybrid topology.

Project No.	Project Name	Deficiency	Project Description
W2-T-02 ¹	Well No. 2 HMI Upgrades (S&B 4.2.3.4.3)	Existing HMIs are technologically obsolete	Replace HMIs. Upgrade Automation software from TIAPortal v14 to v 17 for security patching and access to current software library functionalities.
W2-T-03 ¹	Well No. 2 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package
W2-H-01	Well No. 2 Wellhouse Repairs	Interior walls are crumbling	Provide repairs for the interior walls of the wellhouse
W2-MS-01	Well No. 2 Security Improvements	Wellhouse site is not fenced, and facility does not have security cameras.	Install site fencing, security cameras, and card locking system (per Risk and Resiliency Report)
W2-MS-02	Well No. 2 Water Quality Improvements Study	Well No. 2 water is sandy and has entrained air	Provide analysis of water quality, recommend improvements to treat water

Note:

1. S&B project combined with other stations.

Table 3 | Well No. 3 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
W3-C-01	Well Site No. 3 Drainage Improvements	Pump to waste systems potentially overflow site drainage.	Determine capacity of site drainage and pump to waste needs, replace existing 2" drain to airport drain system with upsized line
W3-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	Well does not have a water quality analyzer	Install water quality analyzer
W3-T-02 ¹	Well No. 3 Hybrid Topology Implementation (S&B 4.2.2.3)	Existing Star Topology has a known single point of failure as the MTU serves as the communication hub. If the MTU were to fail, inter-station SCADA data set exchanges would be lost.	Overlay (6) peer-to-peer connections to serve as a secondary communication method for remote stations to complete their process control functionality in the event of an MTU communication failure. Peer-to-peer overlays will transition the SCADA WAN architecture from Star to Hybrid topology.
W3-T-03 ¹	Well No. 3 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package

Project No.	Project Name	Deficiency	Project Description
W3-H-01	Well No. 3 Wellhouse Improvements	Concave box roof requires heat tape so snow doesn't leak water into the building Cracks are developing in the CMU structure and around pump-to-waste pipe penetration	Replace roof with insulated roof with higher slope including exhaust fan and new lighting, and seal cracking in CMU structure
W3-E-01	Well No. 3 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements.	Provide arc flash study
W3-MS-01	Well No. 3 Security Improvements	Wellhouse site is not fenced, and facility does not have security cameras.	Install site fencing, security cameras, and card locking system (per Risk and Resiliency Report)

Note:

1. S&B project combined with other stations.

Table 4 | Well No. 4/Forked Horn Butte Pump Station No. 2 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
W4-E-01	Well No. 4 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
W4-E-02	Well No. 4 Electrical Upgrades	Switchboard and MCC are old.	Replace Switchboard and MCC in Pumphouse.
W4-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	Well does not have a water quality analyzer	Install water quality analyzer
W4-T-02	Well No. 4 MTU Resiliency Measure (S&B 4.2.2.1.2)	Best practice action to add 1 relay to digital output of the MTU's PLC control panel for monitoring health of and to cycle the cellular modem when lack of communication is detected.	Add 1 relay to existing MTU PLC control panels
W4-T-03	Well No. 4 Telemetry improvements	Chlorine Scales not integrated into SCADA	Integrate chlorine scales into SCADA
W4-T-04 ¹	Well No. 4 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package

Project No.	Project Name	Deficiency	Project Description
W4-H-01	Well No. 4 Chlorine and Generator Building	Chlorine room is outdated and located away from the insertion point, Generator does not auto exercise, the Generator cannot operate both the Well and Booster pumps, and Generator location violates NEC working clearance in front of switchboard and ATS	Build new standalone Chlorine and Generator building near Well No. 4. Acquire new and install 600kW generator
W4-H-02	Well No. 4 Pumphouse Improvements	Pumphouse overheats in the summer (no fan).	Provide HVAC analysis and upgrade pumproom with required cooling needs. Insulate CMU Walls and install a wall fan.
W4-MS-01	Well No. 4/FHBPS No. 2 Security Improvements	New door lock system identified as part of the Risk and Resiliency Report	Install card locking system (per Risk and Resiliency Report)

Note

1. S&B project combined with other stations.

Table 5 | Well No. 5 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
W5-T-01	Well No. 5 VFD Replacement, Stand-Alone Drive Application (S&B 4.2.1.1.1)	Existing VFD nearing end of useful lifecycle	Replace VFD
W5-T-02 ¹	Well No. 5 Submersible Probe Replacement (S&B 4.2.1.2.2)	The submersible level probe is nearing the end of its useful lifecycle	Replace submersible probe
W5-T-03 ¹	Well No. 5 Hybrid Topology Implementation (S&B 4.2.2.3)	Existing Star Topology has a known single point of failure as the MTU serves as the communication hub. If the MTU were to fail, inter-station SCADA data set exchanges would be lost.	Overlay (6) peer-to-peer connections to serve as a secondary communication method for remote stations to complete their process control functionality in the event of an MTU communication failure. The peer-to-peer overlays will transition the SCADA WAN architecture from Star to Hybrid topology.
W5-T-04 ¹	Well No. 5 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	Well does not have a water quality analyzer	Install water quality analyzer
W5-T-05 ¹	Well No. 5 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package

Project No.	Project Name	Deficiency	Project Description
W5-E-01	Well No.5 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
W5-MS-01	Well No. 5 Security Improvements	New door lock system identified as part of the Risk and Resiliency Report	Install card locking system (per Risk and Resiliency Report)

Note:

1. S&B project combined with other stations.

Table 6 | Well No. 6 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
W6-E-01	Well No. 6 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
W6-T-01	Well 6 Booster #1 Simocode Motor Overload Replacement (S&B 4.2.1.1.2)	Existing smart overload device nearing end of useful lifecycle	Replace with Siemens 3UF7 Simocode Pro V smart overload device
W6-T-02 ¹	Well No. 6 Hybrid Topology Implementation (S&B 4.2.2.3)	Existing Star Topology has a known single point of failure as the MTU serves as the communication hub. If the MTU were to fail, inter-station SCADA data set exchanges would be lost.	Overlay (6) peer-to-peer connections to serve as a secondary communication method for remote stations to complete their process control functionality in the event of an MTU communication failure. The peer-to-peer overlays will transition the SCADA WAN architecture from Star to Hybrid topology.
W6-T-03 ¹	Well No. 6 HMI Upgrades (S&B 4.2.3.4.3)	Existing HMIs are technologically obsolete	Replace HMIs. Upgrade Automation software from TIAPortal v14 to v 17 for security patching and access to current software library functionalities.
W6-T-04	Well No. 6 Telemetry Improvements	Chlorine scales outdated and not integrated into SCADA	Replace existing scales with digital scales and integrate scales into SCADA
W6-T-05 ¹	Well No. 6 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package

Project No.	Project Name	Deficiency	Project Description
W6-MS-01	Well No. 6 Security Improvements	Door switches are not connected to SCADA, and site does not have security cameras	Connect door switches to SCADA, install card locking system and security cameras (per Risk and Resiliency Report)

Note:

1. S&B project combined with other stations.

Table 7 | Well No. 7 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
W7-E-01	Well No. 7 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
W7-M-01	Well No. 7 booster pump improvements	The existing booster pumps have been experiencing vibrations and failures which has been attributed to the pump quality. The City has been periodically replacing these pumps.	The City has an on-going effort to replace pumps. No additional actions necessary.
W7-T-01 ¹	Well No. 7 Submersible Probe Replacement (S&B 4.2.1.2.2)	The submersible level probe is nearing the end of its useful lifecycle	Replace submersible probe
W7-T-02 ¹	Well No. 7 Hybrid Topology Implementation (S&B 4.2.2.3)	Existing Star Topology has a known single point of failure as the MTU serves as the communication hub. If the MTU were to fail, inter-station SCADA data set exchanges would be lost.	Overlay (6) peer-to-peer connections to serve as a secondary communication method for remote stations to complete their process control functionality in the event of an MTU communication failure. The peer-to-peer overlays will transition the SCADA WAN architecture from Star to Hybrid topology.
W7-T-03 ¹	Well No. 7 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package
W7-MS-01	Well No. 7 Security Improvements	New door lock system, and security cameras identified as part of the Risk and Resiliency Report	Install card locking system, arm intrusion sensors, and security cameras (per Risk and Resiliency Report)

Note:

1. S&B project combined with other stations.

Table 8| Forked Horn Butte Pump Station No. 1 – Capital Improvements

Project No.	Project Name	Deficiency	Project Description
FHBPS1-T-01	Forked Horn Butte Pump Station No. 1 VFD Replacements (S&B 4.2.1.1.3)	VFD drives for all pumps excluding Pump No. 1 are past their useful lifecycle	Replace VFDs for Pump Nos. 2, 3, 4 and 5
FHBPS1-T-02	Forked Horn Butte Pump Station No. 1/Transfer Station Fiber Optic Cable (S&B 4.2.2.2.3)	Existing Profibus communication cable between FHBPS No. 1 and the FHBTS is technologically limited, a poor long-term solution, and is susceptible to electrical surge hazards. The cable requires replacement to improve the interconnectivity between the transfer and pumping stations, and to provide long-term viability.	Replace the existing communication cable with new outdoor-rated, 6-strand, multimode, fiber optic cable
FHBPS1-T-03 ¹	Forked Horn Butte Pump Station No. 1 Hybrid Topology Implementation (S&B 4.2.2.3)	Existing Star Topology has a known single point of failure as the MTU serves as the communication hub. If the MTU were to fail, inter-station SCADA data set exchanges would be lost.	Overlay (6) peer-to-peer connections to serve as a secondary communication method for remote stations to complete their process control functionality in the event of an MTU communication failure. The peer-to-peer overlays will transition the SCADA WAN architecture from Star to Hybrid topology.
FHBPS1-T-04	Forked Horn Butte Pump Station No. 1 RTU Upgrades (S&B 4.2.3.4.1.2)	Existing RTU is nearing the end of its useful lifecycle. New FHB site automation topology should change to simplify the application software and reduce cost.	Update architecture and revitalize the automation system by upgrading the RTU with a Remote IO control panel (serving data to the Transfer Station RTU). Use a component upgrade method, where the PLC chassis, HMI, and power supply are the only items changed within MCC section 04FA. Additional improvements include a copper/fiber switch for future fiber connection which will replace the existing Profibus cable used for LAN connection with the FHBTS
FHBPS1-T-05	Forked Horn Butte Pump Station No. 1 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package

Project No.	Project Name	Deficiency	Project Description
FHBPS1-E-01	Forked Horn Butte Pump Station No. 1 Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
FHBPS1-MS-01	FHBPS No. 1 Security Improvements	Pumphouse site is not fenced, and door switches are not armed	Upgrade site lighting; install card locking system, site fencing, and security cameras (per Risk and Resiliency Report).

Note:

1. S&B project combined with other stations.

Table 9 | Forked Horn Butte Transfer Station

Project No.	Project Name	Deficiency	Project Description
FHBTS-T-01	Forked Horn Butte Transfer Station Pressure Transmitter Additions (S&B 4.2.1.2.3)	Existing suction & discharge pressure transmitters are at the end of their useful lifecycle	Replace pressure transmitters
FHBTS-T-02	Forked Horn Butte Transfer Station RTU Upgrade (S&B 4.2.3.4.1.1)	Existing RTU is technologically obsolete and has reached the end of its useful lifecycle. Product is mature and products are no longer available.	Replace RTU using a back panel replacement method inside the MCC. Additional improvements include a transition to Cellular network communication and a dual path communication with the MTU. Add copper/fiber switch for future fiber connection which will replace the existing Profibus cable used for LAN connection to FHBPS No. 1
FHBTS-T-03 ¹	Forked Horn Butte Transfer Station Smart Motor Starter Data Context (S&B 4.2.1.1.4)	Current software packages on PLC requires update to establish new Data Context and improved operations	Upgrade software package
FHBTS-E-01	Forked Horn Butte Transfer Station Arc Flash Study	OSHA Standard 1910.269 mandates a complete arc flash study for electrical infrastructure. NEC article 110 contains warning label requirements	Provide arc flash study
FHBTS-MS-01	Forked Horn Butte Transfer Station Security Improvements	New door lock system, security cameras, and facility fencing identified as part of the Risk and Resiliency Report	Install card locking system, security cameras, and site fencing (per Risk and Resiliency Report)

Note:

1. S&B project combined with other stations.

Facility Capital Improvement Cost Estimates

The cost estimates for the capital improvements identified in **Tables 2 through 9** can be seen in **Table 10**. Detailed cost estimates can be found in **Appendix 3** and **Appendix 4**.

Table 10 | Facility Capital Improvement Cost Estimates

Project	Project Name	Cost Estimate
Well No. 2		
W2-C-01	Well No. 2 Site Improvements	\$16,000
W2-E-01	Well No. 2 Arc Flash Study	\$3,125
W2-T-01 ¹	Well No. 2 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725
W2-T-02 ¹	Well No. 2 HMI Upgrades (S&B 4.2.3.4.3)	\$3,110
W2-T-03 ¹	Well No. 2 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050
W2-H-01	Well No. 2 Wellhouse Repairs	\$1,000
W2-MS-01	Well No. 2 Security Improvements	\$30,500
W2-MS-02	Well No. 2 Water Quality Improvements Study	\$50,000
Well No. 3		
W3-C-01	Well Site No. 3 Drainage Improvements	\$59,000
W3-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270
W3-T-02 ¹	Well No. 3 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725
W3-T-03 ¹	Well No. 3 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050
W3-H-01	Well No. 3 Wellhouse Improvements	\$156,000
W3-E-01	Well No. 3 Arc Flash Study	\$3,125
W3-MS-01	Well No. 3 Security Improvements	\$30,500
Well No. 4		
W4-E-01	Well No. 4 Arc Flash Study	\$3,125
W4-E-02	Well No. 4 Electrical Upgrades	\$150,000
W4-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270
W4-T-02	Well No. 4 MTU Resiliency Measure (S&B 4.2.2.1.2)	\$120
W4-T-03	Well No. 4 Telemetry improvements	\$5,000
W4-T-04 ¹	Well No. 4 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050
W4-H-01	Well No. 4 Chlorine and Generator Building	\$1,308,000
W4-H-02	Well No. 4 Pumphouse Improvements	\$27,000
W4-MS-01	Well No. 4/FHBPS No. 2 Security Improvements	\$2,500

Project	Project Name	Cost Estimate
Well No. 5		
W5-T-01	Well No. 5 VFD Replacement, Stand-Alone Drive Application (S&B 4.2.1.1.1)	\$49,645
W5-T-02 ¹	Well No. 5 Submersible Probe Replacement (S&B 4.2.1.2.2)	\$1,440
W5-T-03 ¹	Well No. 5 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725
W5-T-04 ¹	Well No. 5 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270
W5-T-05 ¹	Well No. 5 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050
W5-E-01	Well No.5 Arc Flash Study	\$3,125
W5-MS-01	Well No. 5 Security Improvements	\$2,500
Well No. 6		
W6-E-01	Well No. 6 Arc Flash Study	\$3,125
W6-T-01	Well 6 Booster #1 Simocode Motor Overload Replacement (S&B 4.2.1.1.2)	\$4,615
W6-T-02 ¹	Well No. 6 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725
W6-T-03 ¹	Well No. 6 HMI Upgrades (S&B 4.2.3.4.3)	\$5,780
W6-T-04	Well No. 6 Telemetry Improvements	\$10,000
W6-T-05 ¹	Well No. 6 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$2,200
W6-MS-01	Well No. 6 Security Improvements	\$8,000
Well No. 7		
W7-E-01	Well No. 7 Arc Flash Study	\$3,125
W7-M-01	Well No. 7 booster pump improvements	NA
W7-T-01 ¹	Well No. 7 Submersible Probe Replacement (S&B 4.2.1.2.2)	\$2,390
W7-T-02 ¹	Well No. 7 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725
W7-T-03 ¹	Well No. 7 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$2,200
W7-MS-01	Well No. 7 Security Improvements	\$8,000
Forked Horn Butte Pump Station No. 1		
FHBPS1-T-01	Forked Horn Butte Pump Station No. 1 VFD Replacements (S&B 4.2.1.1.3)	\$48,990
FHBPS1-T-02	Forked Horn Butte Pump Station No. 1/Transfer Station Fiber Optic Cable (S&B 4.2.2.2.3)	\$2,255
FHBPS1-T-03 ¹	Forked Horn Butte Pump Station No. 1 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725

Project	Project Name	Cost Estimate
FHBPS1-T-04	Forked Horn Butte Pump Station No. 1 RTU Upgrades (S&B 4.2.3.4.1.2)	\$22,640
FHBPS1-T-05	Forked Horn Butte Pump Station No. 1 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,200
FHBPS1-E-01	Forked Horn Butte Pump Station No. 1 Arc Flash Study	\$3,125
FHBPS1-MS-01	FHBPS No. 1 Security Improvements	\$30,500
Forked Horn Butte Transfer Station		
FHBTS-T-01	Forked Horn Butte Transfer Station Pressure Transmitter Additions (S&B 4.2.1.2.3)	\$3,210
FHBTS-T-02	Forked Horn Butte Transfer Station RTU Upgrade (S&B 4.2.3.4.1.1)	\$53,530
FHBTS-T-03 ¹	Forked Horn Butte Transfer Station Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,200
FHBTS-E-01	Forked Horn Butte Transfer Station Arc Flash Study	\$3,125
FHBTS-MS-01	Forked Horn Butte Transfer Station Security Improvements	\$30,500

Note:

1. S&B project combined with other stations. Project cost listed is for the portion of costs related to the specific facility named. Additional project costs may be applicable. Full project costs can be found in **Appendix 3**.

Facility Capital Improvement Schedule

The Facility Capital Improvement Schedule was determined based on priority of individual stations, recommendations per S&B, Inc., and City input. Further details on S&B projects can be found in **Appendix 3**.

A general formula was created to give prioritization to projects. The formula takes the individual station's flow, and seasonal use along with weighting factors to generate a project factor. This factor was used to assign a year to the project along a 20-year horizon (2041), with projects starting in 2023. The formula takes the general form of the following.

$$F_{Project} = \frac{1}{W_{Total}} (W_{Flow} \cdot F_{Flow} + W_{Use} \cdot F_{Use})$$

Where:

$F_{Project}$ =	Overall Project Factor
F_{Flow} =	Station Flow Factor
F_{Use} =	Station Use Factor
W_{Total} =	Total Weight
$W_{Project}$ =	Overall Project Weight
W_{Flow} =	Station Flow Weight
W_{Use} =	Station Use Weight

The individual factors were calculated as follows.

$$F_{Flow} = Q/Q_{Max}$$

Where:

Q = Flow specific to the project (i.e., pump flow, or station capacity)

Q_{Max} = Largest capacity in the system = 3,300 gpm (Well No. 5)

The Use Factor, F_{Use}, was assigned a factor on whether the station is used in the winter (F_{Use} = 0.25), intermittently (F_{Use} = 0.50), in the summer (F_{Use} = 0.75), or annually (F_{Use} = 1.00).

The weight for the flow factor, F_{Flow} was assigned a value of 40, while the use factor, F_{Use} was assigned a value of 60.

Table 11 shows the relative priority of each pumping facility based on the above formula.

Table 11 | Facility Priority Ranking

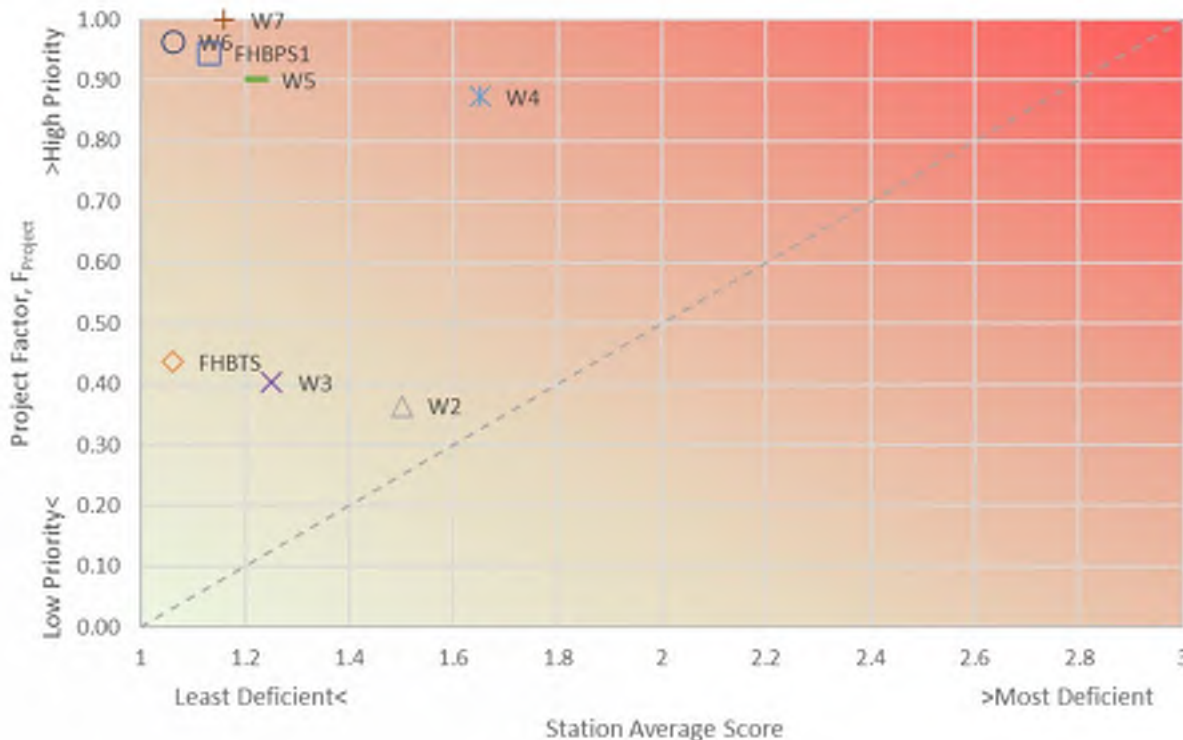
Facility	Firm Capacity/ Applicable Flow (gpm) ¹	Seasonal Use	Flow Factor, F _{Flow}	Use Factor, F _{Use}	Project Factor, F _{Project}	Priority Ranking
W7	4400	Annually	1.00	1.00	1.00	1
W6	4000	Annually	0.91	1.00	0.96	2
FHBPS1	3800	Annually	0.86	1.00	0.95	3
W5	3300	Annually	0.75	1.00	0.90	4
W4	3000	Annually	0.68	1.00	0.87	5
FHBTS	1500	Intermittent	0.34	0.50	0.44	6
W3	1125	Intermittent	0.26	0.50	0.40	7
W2	700	Intermittent	0.16	0.50	0.36	8

Note:

1. Capacity from WMP

Comparing each Facility's project factor with its average score from the Condition Assessment, we get **Figure 1**. This figure shows the relative priority of each facility and the assessed deficiency. The background shows a gradient of green (low priority, low deficiency) to red (high priority, high deficiency).

Figure 1 | Facility Priority vs Deficiency



As is shown in **Figure 1**, the high priority facilities are also trending to be low deficiency. Well 4 stands out as being medium priority while being the most deficient. Well 2 is shown as being the second-most deficient but lowest priority. This figure is ultimately used to guide project prioritization for the Facility Capital Improvement Schedule.

Figure 1 and **Table 11** were presented to the City in order to assign a project implementation horizon for each project.

The S&B projects were assigned implementation dates based on replacement timelines as provided in the report (see **Appendix 3**). While some improvements have specific implementation years listed, in general, the improvements outlined in the S&B report are broken into four phases.

1. Forked Horn Butte Upgrades (RTUs, VFDs, and Fiber)
2. SCADA Visualization (graphics overhaul + reports [optional])
3. Remaining Automation (WDS & HMIs)
4. All other upgrades

Table 12 shows the Facility Capital Improvement Schedule for all projects discussed in this memo.

Table 12 | Facility Capital Improvement Schedule Summary

Project	Project Name	Project Cost	Project Implementation
Well No. 2			
W2-C-01	Well No. 2 Site Improvements	\$16,000	2025-2040
W2-E-01	Well No. 2 Arc Flash Study ⁴	\$3,125	2021-2025
W2-T-01 ¹	Well No. 2 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W2-T-02 ¹	Well No. 2 HMI Upgrades (S&B 4.2.3.4.3)	\$3,110	Phase 3 ²
W2-T-03 ¹	Well No. 2 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
W2-H-01	Well No. 2 Wellhouse Repairs	\$1,000	2025-2040
W2-MS-01	Well No. 2 Security Improvements	\$30,500	2021-2025
W2-MS-02	Well No. 2 Water Quality Improvements Study	\$50,000	2025-2040
Well No. 3			
W3-C-01	Well Site No. 3 Drainage Improvements	\$59,000	2025-2040
W3-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270	Phase 4 ²
W3-T-02 ¹	Well No. 3 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W3-T-03 ¹	Well No. 3 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
W3-H-01	Well No. 3 Wellhouse Improvements	\$156,000	2025-2040
W3-E-01	Well No. 3 Arc Flash Study ⁴	\$3,125	2021-2025
W3-MS-01	Well No. 3 Security Improvements	\$30,500	2021-2025
Well No. 4			
W4-E-01	Well No. 4 Arc Flash Study ⁴	\$3,125	2021-2025
W4-E-02	Well No. 4 Electrical Upgrades	\$150,000	2021-2025
W4-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270	Phase 4 ²
W4-T-02	Well No. 4 MTU Resiliency Measure (S&B 4.2.2.1.2)	\$120	Phase 4 ²
W4-T-03	Well No. 4 Telemetry improvements	\$5,000	2021-2025
W4-T-041	Well No. 4 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
W4-H-01	Well No. 4 Chlorine and Generator Building	\$1,308,000	2021-2025
W4-H-02	Well No. 4 Pumpouse Improvements	\$27,000	2021-2025
W4-MS-01	Well No. 4/FHBPS No. 2 Security Improvements	\$2,500	2021-2025
Well No. 5			
W5-T-01	Well No. 5 VFD Replacement, Stand-Alone Drive Application (S&B 4.2.1.1.1)	\$49,645	2025 (Phase 4)
W5-T-02 ¹	Well No. 5 Submersible Probe Replacement (S&B 4.2.1.2.2)	\$1,440	2021-2024 (Phase 4)

Project	Project Name	Project Cost	Project Implementation
W5-T-03 ¹	Well No. 5 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W5-T-04 ¹	Well No. 5 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270	Phase 4 ²
W5-T-05 ¹	Well No. 5 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
W5-E-01	Well No.5 Arc Flash Study ⁴	\$3,125	2021-2025
W5-MS-01	Well No. 5 Security Improvements	\$2,500	2021-2025
Well No. 6			
W6-E-01	Well No. 6 Arc Flash Study ⁴	\$3,125	2021-2025
W6-T-01	Well 6 Booster #1 Simocode Motor Overload Replacement (S&B 4.2.1.1.2)	\$4,615	2021-2025 (Phase 4)
W6-T-02 ¹	Well No. 6 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W6-T-03 ¹	Well No. 6 HMI Upgrades (S&B 4.2.3.4.3)	\$5,780	Phase 3 ²
W6-T-04	Well No. 6 Telemetry Improvements	\$10,000	2025-2040
W6-T-05 ¹	Well No. 6 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$2,200	Phase 2 ²
W6-MS-01	Well No. 6 Security Improvements	\$8,000	2021-2025
Well No. 7			
W7-E-01	Well No. 7 Arc Flash Study ⁴	\$3,125	2021-2025
W7-M-01	Well No. 7 booster pump improvements	NA	Ongoing effort
W7-T-01 ¹	Well No. 7 Submersible Probe Replacement (S&B 4.2.1.2.2)	\$2,390	2022-2025 (Phase 4)
W7-T-02 ¹	Well No. 7 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W7-T-03 ¹	Well No. 7 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$2,200	Phase 2 ²
W7-MS-01	Well No. 7 Security Improvements	\$8,000	2021-2025
Forked Horn Butte Pump Station No. 1			
FHBPS1-T-01	Forked Horn Butte Pump Station No. 1 VFD Replacements (S&B 4.2.1.1.3)	\$48,990	2021 (Phase 1)
FHBPS1-T-02	Forked Horn Butte Pump Station No. 1/Transfer Station Fiber Optic Cable (S&B 4.2.2.2.3)	\$2,255	Phase 1 ³
FHBPS1-T-03 ¹	Forked Horn Butte Pump Station No. 1 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
FHBPS1-T-04	Forked Horn Butte Pump Station No. 1 RTU Upgrades (S&B 4.2.3.4.1.2)	\$22,640	2021 (Phase 1)

Project	Project Name	Project Cost	Project Implementation
FHBPS1-T-05	Forked Horn Butte Pump Station No. 1 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,200	Phase 2 ²
FHBPS1-E-01	Forked Horn Butte Pump Station No. 1 Arc Flash Study ⁴	\$3,125	2021-2025
FHBPS1-MS-01	FHBPS No. 1 Security Improvements	\$30,500	2021-2025
Forked Horn Butte Transfer Station			
FHBTS-T-01	Forked Horn Butte Transfer Station Pressure Transmitter Additions (S&B 4.2.1.2.3)	\$3,210	2021 (Phase 4)
FHBTS-T-02	Forked Horn Butte Transfer Station RTU Upgrade (S&B 4.2.3.4.1.1)	\$53,530	2021 (Phase 1)
FHBTS-T-03 ¹	Forked Horn Butte Transfer Station Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,200	Phase 2 ²
FHBTS-E-01	Forked Horn Butte Transfer Station Arc Flash Study ⁴	\$3,125	2021-2025
FHBTS-MS-01	Forked Horn Butte Transfer Station Security Improvements	\$30,500	2021-2025

Notes:

1. S&B project combined with other stations. Full project details can be found in **Appendix 3**.
2. No specific implementation year given.
3. Projects FHBPS1-T-04 (S&B 4.2.3.4.1.2) and FHBTS-T-02 (S&B 4.2.3.4.1.1) are required to be completed before project can be implemented.
4. Arc flash study likely to be provided as one project.

Preventative Maintenance

Currently there are no documented recurring preventative maintenance procedures for the City's pumping facilities. The City has provided maintenance and upkeep as necessary and has begun stockpiling critical materials such as impellers to minimize downtime in the event of a failure. The City is interested in documenting a routine maintenance schedule for their pumping facilities to limit downtime during critical periods. The following preventative maintenance schedule is based on manufacturer recommendations and institutional knowledge and serves as a template for City operations staff to use. The City should adopt this template for each station separately and regularly update to reflect the individual facility's needs. Additionally, as upgrades and modifications are made, the template should be re-assessed to reflect timelines more accurately.

Table 13 | Preventative Maintenance Schedule

Maintenance Operation	Description	Applicability	Frequency
Pumps			
Sensory Inspection	Visual inspection of motor casing, rotating components, (i.e., dry packing, leaks, paint chipping, excessive dust build up, etc.). Auditory inspection of motor (excessive noise), volute (crackling, knocking), bearing whine, etc. Smell for hot electrical components, oils. Gauge Temperature of motor, bearings (if accessible), and building. Make note of any changes.	Wells and Pump Stations	Daily (as operated)
Lubrication	Check water lube system, clean strainer Check oil levels, replenish as necessary	Wells	Monthly
Packing	Check if there is excessive wetting around packing (i.e., >20 drops minute or more than suggested by packing manufacturer, follower bottomed out, etc.). Check if packing is dry (follower too tight). Repack if leakage is no longer controlled by adjustment of follower gland.	Wells and Pump Stations	Monthly
Pump Inspection	Provide inspection for pump, including: pump performance (flow pressure at operating point and verification that point is on pump curve, dead head pressure, running amperage, motor efficiency, etc.), inspect wear surfaces (impeller, wear rings, volute, shaft), inspect seals/packing, bearings. Document data and note changes.	Wells and Pump Stations	Yearly
Well drawdown	Measure static and steady state well drawdown and record	Wells	Yearly
Motor/Pump Alignment	Measure vibration and provide realignment of pump, motor, lineshaft, bearings, and couplings (if applicable/necessary)	Wells and Pump Stations	Yearly inspection Realign as necessary
Motor Lubrication	Change oil in motors	Wells and Pump Stations	Yearly
Clean and Repaint motor/pump	Clean pumps, inspect for paint chipping and repaint as necessary	Wells and Pump Stations	Yearly
Bearing lubrication	Change oil on all thrust bearings	Wells and Pump Stations	Yearly or every 500 hours (operated)
Bearings	Replace bearings	Wells and Pump Stations	Every 5 years

Maintenance Operation	Description	Applicability	Frequency
Mechanical Seals	Replace mechanical seals (if applicable)	Wells and Pump Stations	Every 10 years
Motor Rewind	If there is indication of motor underperformance as evidenced by yearly electrical inspection, check winding resistance, insulation resistance and rewind motor if there is indication of excessive wear.	Wells and Pump Stations	As necessary
Replace Motor	On a premium efficiency motor, if there is damage to the fan, housing, rotor/stator, or if rewinding the motor is unlikely to increase the efficiency to proper level. Replace standard efficiency motors to premium efficiency motors.	Wells and Pump Stations	As necessary
Electrical			
Electrical inspections	Inspect motors, connections and worn parts. Clean and tighten lugs and connections. Use infrared camera for inspection where possible.	Motors	Yearly
Generator inspections	Inspection of overall condition of generator by manufacturer representative. Check fuel level, filter, battery and general conditions.	Generators	Yearly
Generator batteries	Replace generator batteries.	Generators	3 to 5 years
UPS Batteries	Replace UPS Batteries.	Electrical Rooms	3 to 5 years
Lighting inspection	Replace any burned out lights.	Well/Pump Buildings	Yearly
Emergency Lighting	Replace batteries for interior emergency lighting	Well/Pump Buildings	Every 4 years
Ventilation Inspection	Check temperature inside electrical panels, VFD and MCC enclosures. Verify VFD ventilation fans are working and there is adequate air flow. Replace filters as needed. Ensure buildings are not too hot for electrical equipment; verify fans and louvers are working.	Electrical Rooms	Yearly
Generator testing	Turn main power off and verify the ATS and generator function as required with successful transfer of power. Verify SCADA receives alarms and notification of ATS and generator state.	ATS & Generator	Every 5 years
Motor data inspection	Measure motor amperage and document. Compare motor amperage readings to historical values. If amperage has changed significantly then further inspect motor and pump and incoming voltage. Make note of annual power usage.	Motors	Yearly

Maintenance Operation	Description	Applicability	Frequency
Motor data inspection	Check motor run time counters on pumps and verify that lead/lag pumps are alternating equally. Document yearly records.	Motors	Yearly
Valves and Appurtenances			
Inspection and Exercising	Visual inspection of valve, exercise of valve (including positioning from fully open to fully closed and back), checking and cleaning strainers, and inspecting the pilot system (if applicable). If the valve is difficult to operate, the valve may need to be exercised multiple times during periods of flow to flush debris (never operate a valve under flow on the upstream side of a pump). If the valve is difficult to operate, the actuator may need to be relubricated (if applicable). Frequency of inspection and exercising depends on operating conditions (which may vary widely across the system). New valves are recommended to be inspected monthly or quarterly until operators are certain that the valve is not requiring more frequent maintenance. If operating well with less frequent inspection, the inspection and exercising frequency may be reduced to every 6 months.	Butterfly valves, gate valves, control valves, pressure reducing valves, ball valves	Inspect valves monthly to quarterly Exercise valves every 6 months
Control Valve Rebuild	Disassembly of valve, cleaning of all components (including the pilot system), inspection for damaged or worn parts, replacement of any damaged or worn parts, replacement of rubber and other soft components, and reassembly of the valve.	Control valves, pressure reducing valves	Every 3-5 years
Inspection (air/vac valves)	Visual inspection of valve. Special attention should be made to ensure that no foreign matter is preventing the valve from operating properly.	Air/Vac valves	Annually
External Inspection and Exercising (solenoid valves)	Visual inspection of main valve, weep holes, actuator and cover bolts, and pilot lock nuts, as applicable. Cleaning of control filter, Full cycling of valve, inspection of position indicator, and energization/de-energization of solenoids to confirm proper operation.	Solenoid valves	Every 6 months
Internal Inspection (solenoid valves)	Removal of actuator assembly, Inspection of actuator, inspection of ports, and inspection of body and seat. Rebuild any damaged parts as needed.	Solenoid valves	Every 2 years
Flow Meters and Pressure sensors	Calibrate sensors or validate sensor accuracies. Replace if accuracy is out of spec.	Flow meters and Pressure Sensors	Every 2 years

Maintenance Operation	Description	Applicability	Frequency
Diaphragm Replacement (solenoid valves)	Replacement of solenoid valve diaphragm and any elastomeric parts (if applicable)	Solenoid valves	Heavy Duty Service: every 2 years Medium Duty Service: every 6 years Light Duty Service: every 10 years
Miscellaneous			
Check Property	Provide visual inspection of structure, grounds, lights, etc. Take note of building temperature. Make note of changes.	Wells and Pump Stations	Daily
Clean Facility	Sweep floors and remove cobwebs	Wells and Pump Stations	Weekly
Heaters	Check heater operation	Wells and Pump Stations	Every 6 months
Air Filters	HVAC air filters	Wells and Pump Stations	Every 6 months
Paint Facility	Paint floors (if applicable) and walls	Wells and Pump Stations	As Necessary
Disinfection System			
Safety Equipment	Check/test chlorine sniffer/sensor units.	Wells	Monthly
Chlorine Tubing	Check, replace or repair chlorine tubing	Wells	Annually

Recommendations

Based on the analyses detailed in this memorandum, it is advised that the City consider the following projects and their suggested implementation horizons.

Table 14 | 2021-2025 (5-year horizon) Facility Capital Improvement Schedule

Project	Project Name	Project Cost	Project Implementation
All Facilities			
4	Arc Flash Study	\$25,000	2021-2025
5	Security improvements	\$143,000	2021-2025
Well No.2			
W2-T-01 ¹	Well No. 2 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W2-T-02 ¹	Well No. 2 HMI Upgrades (S&B 4.2.3.4.3)	\$3,110	Phase 3 ²
W2-T-03 ¹	Well No. 2 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
Well No. 3			
W3-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270	Phase 4 ²
W3-T-02 ¹	Well No. 3 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W3-T-03 ¹	Well No. 3 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
Well No. 4			
W4-E-02	Well No. 4 Electrical Upgrades	\$150,000	2021-2025
W4-T-01 ¹	Well No. 3 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270	Phase 4 ²
W4-T-02	Well No. 4 MTU Resiliency Measure (S&B 4.2.2.1.2)	\$120	Phase 4 ²
W4-T-03	Well No. 4 Telemetry improvements	\$5,000	2021-2025
W4-T-04 ¹	Well No. 4 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²
W4-H-01	Well No. 4 Chlorine and Generator Building	\$1,308,000	2021-2025
W4-H-02	Well No. 4 Pumphouse Improvements	\$27,000	2021-2025
Well No. 5			
W5-T-01	Well No. 5 VFD Replacement, Stand-Alone Drive Application (S&B 4.2.1.1.1)	\$49,645	2025 (Phase 4)
W5-T-02 ¹	Well No. 5 Submersible Probe Replacement (S&B 4.2.1.2.2)	\$1,440	2021-2024 (Phase 4)
W5-T-03 ¹	Well No. 5 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W5-T-04 ¹	Well No. 5 Water Quality Analyzer Addition (S&B 4.2.1.2.1)	\$8,270	Phase 4 ²
W5-T-05 ¹	Well No. 5 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,050	Phase 2 ²

Project	Project Name	Project Cost	Project Implementation
Well No. 6			
W6-T-01	Well 6 Booster #1 Simocode Motor Overload Replacement (S&B 4.2.1.1.2)	\$4,615	2021-2025 (Phase 4)
W6-T-02 ¹	Well No. 6 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W6-T-03 ¹	Well No. 6 HMI Upgrades (S&B 4.2.3.4.3)	\$5,780	Phase 3 ²
W6-T-05 ¹	Well No. 6 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$2,200	Phase 2 ²
Well No. 7			
W7-T-01 ¹	Well No. 7 Submersible Probe Replacement (S&B 4.2.1.2.2)	\$2,390	2022-2025 (Phase 4)
W7-T-02 ¹	Well No. 7 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
W7-T-03 ¹	Well No. 7 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$2,200	Phase 2 ²
Forked Horn Butte Pump Station No. 1			
FHBPS1-T-01	Forked Horn Butte Pump Station No. 1 VFD Replacements (S&B 4.2.1.1.3)	\$48,990	2021 (Phase 1)
FHBPS1-T-02	Forked Horn Butte Pump Station No. 1/Transfer Station Fiber Optic Cable (S&B 4.2.2.2.3)	\$2,255	Phase 1 ³
FHBPS1-T-03 ¹	Forked Horn Butte Pump Station No. 1 Hybrid Topology Implementation (S&B 4.2.2.3)	\$5,725	Phase 4 ³
FHBPS1-T-04	Forked Horn Butte Pump Station No. 1 RTU Upgrades (S&B 4.2.3.4.1.2)	\$22,640	2021 (Phase 1)
FHBPS1-T-05	Forked Horn Butte Pump Station No. 1 Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,200	Phase 2 ²
Forked Horn Butte Transfer Station			
FHBTS-T-01	Forked Horn Butte Transfer Station Pressure Transmitter Additions (S&B 4.2.1.2.3)	\$3,210	2021 (Phase 4)
FHBTS-T-02	Forked Horn Butte Transfer Station RTU Upgrade (S&B 4.2.3.4.1.1)	\$53,530	2021 (Phase 1)
FHBTS-T-03 ¹	Forked Horn Butte Transfer Station Smart Motor Starter Data Context (S&B 4.2.1.1.4)	\$1,200	Phase 2 ²

Notes:

1. S&B project combined with other stations. Full project details can be found in **Appendix 3**.
2. No specific implementation year given.
3. Projects FHBPS1-T-04 (S&B 4.2.3.4.1.2) and FHBTS-T-02 (S&B 4.2.3.4.1.1) are required to be completed before project can be implemented.
4. Recommend combining Arc Flash Study projects: W2-E-01, W3-E-01, W4-E-01, W5-E-01, W6-E-01, W7-E-01, FHBPS1-E-01, and FHBTS-E-01
5. Recommend combining Security Improvements projects: W2-MS-01, W3-MS-01, W4-MS-01, W5-MS-01, W6-MS-01, W7-MS-01, FHBPS1-MS-01, and FHBTS-MS-01

Table 15 | 2026-2040 (20-year horizon) Facility Capital Improvement Schedule

Project	Project Name	Project Cost	Project Implementation
Well No. 2			
W2-C-01	Well No. 2 Site Improvements	\$16,000	2025-2040
W2-H-01	Well No. 2 Wellhouse Repairs	\$1,000	2025-2040
W2-MS-02	Well No. 2 Water Quality Improvements Study	\$50,000	2025-2040
Well No. 3			
W3-C-01	Well Site No. 3 Drainage Improvements	\$59,000	2025-2040
W3-H-01	Well No. 3 Wellhouse Improvements	\$156,000	2025-2040
Well No. 6			
W6-T-04	Well No. 6 Telemetry Improvements	\$10,000	2025-2040

Supporting Work

- Operator Condition Assessment – Appendix 1
- Risk and Resiliency Assessment, Murraysmith – Appendix 2
- SCADA and Telemetry Assessment, S&B, Inc.– Appendix 3
- Cost estimates – Appendix 4



Technical Memorandum

Date: June 23rd, 2021

Project: City of Redmond AWIA Risk and Resilience Assessment

To: Joshua Wedding, Water Utilities Manager

From: Brian Rowbotham, PE
Carissa Shelley, PE

Re: AWIA Risk and Resilience Assessment
Technical Memorandum

Note: In order to avoid redundancy of content, appendices to this technical memorandum have been removed.



RENEWS 06-30-22

Introduction

Murraysmith, Inc. (Murraysmith) has prepared this technical memorandum (TM) summarizing the America's Water Infrastructure Act (AWIA) Risk and Resilience Assessment (RRA) completed for the City of Redmond (City). This TM provides a summary of Murraysmith's process and review of the City's water system assets, potential threats, existing water system risks including consequences, vulnerabilities, and threat likelihoods, and potential countermeasures to implement to help reduce those risks. This TM also provides a summary of the RRA findings and management recommendations.

Background

The Public Health Security and Bioterrorism Preparedness and Response Act (Bioterrorism Act) was passed by Congress in 2002 to address a wide range of security concerns within the United States. Title IV of the Bioterrorism Act amended the Safe Drinking Water Act with Section 1433 to address various threats to community water systems. Section 1433 required each community water system serving a population greater than 3,300 persons to conduct a Vulnerability Assessment focused on water system vulnerability to malevolent acts of terrorism and other international threats, certify its completion, and submit a copy to the Environmental Protection Agency (U.S. EPA). Pursuant to the U.S. EPA's Records Management Policy, the U.S. EPA intends to retire the studies and in 2018, the AWIA was signed into law (EPA, 2020).

The 2002 Bioterrorism Act is the basis for the AWIA. The purpose of the 2018 AWIA is to establish an ongoing culture of resilience and emergency preparedness within all water systems. The AWIA requires each community water system serving more than 3,300 people to complete a RRA focused on the risks to and resilience of its water system from malevolent acts and natural hazards, and complete or update their Emergency Response Plan (ERP) that incorporates the findings of the RRA. For water utilities that serve a population between 3,301 and 49,999, the

utility's RRA must be certified by June 30, 2021, and ERP certifications are due 6 months from the RRA certification date (EPA, 2020) or by December 31, 2021, whichever is earlier. Utilities are also required to review their RRA every 5 years, revise as necessary, and submit a recertification to the U.S. EPA.

RRAs evaluate a water system's assets against potential malevolent threats and natural hazards (EPA, 2019a). RRAs must include the following:

- The risk to the system from malevolent acts and natural hazards.
- The resilience of the pipes and constructed conveyances, physical barriers, source water, water collection and intake, pretreatment, treatment, storage, and distribution facilities, electronic, computer, or other automated systems (including the security of such systems) which are utilized by the system.
- The monitoring practices of the system.
- The financial infrastructure of the system.
- The use, storage, and/or handling of various chemicals by the system.
- The operation and maintenance of the system.

Data Collection

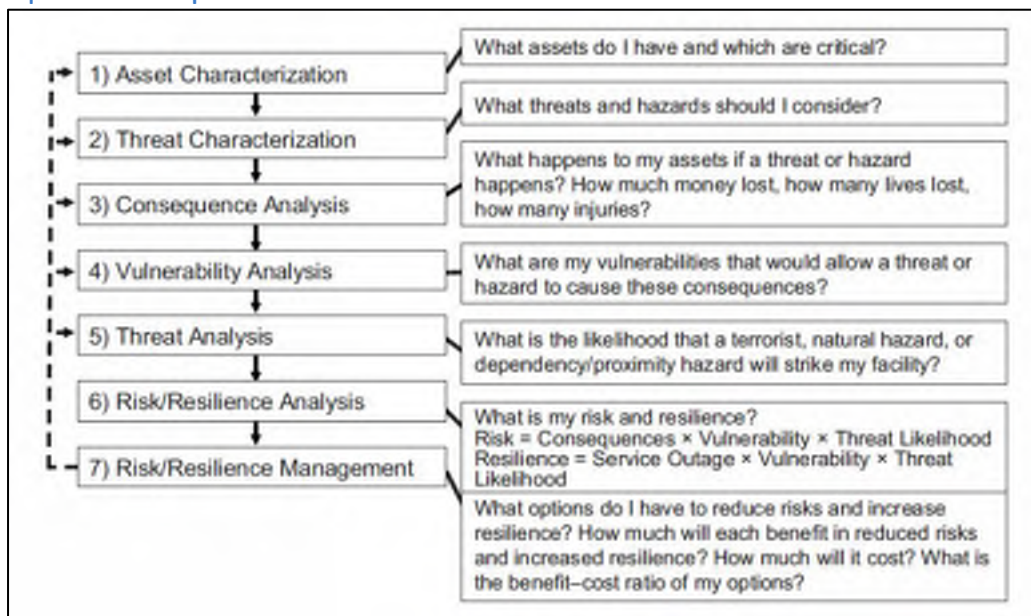
Murraysmith worked with the City to gather and review existing documentation that has been previously completed or is in the process of being completed. This information was used to validate which aspects of the RRA and ERP the City has already developed and to recommend the development of additional content required by the AWIA. Along with existing documentation a site visit was conducted on November 12th, 2020 to inventory the City's critical assets, backup generators, and security features at each asset site. The City provided a summary of their existing cybersecurity controls. Information summarized in the City's 2020 Water System Plan (WSP) update that Murraysmith is working to complete was also utilized.

Methodology

The U.S. EPA does not specifically require the use of any standards or methods in completing RRAs or ERPs. However, the U.S. EPA recommends the ANSI/AWWA J100-10 Risk and Resilience Management of Water and Wastewater Systems Standard (AWWA J100), in addition to tools from the U.S. EPA and other agencies and organizations, for the facilitation of a thorough RRA and ERP. The AWWA J100-10 provides a foundation for data collection using the Risk Analysis and Management for Critical Asset Protection (RAMCAP) seven-step process developed by American Society of Mechanical Engineers (ASME) (AWWA, 2010).

This RRA was completed for the City’s water system using the iterative, seven-step RAMCAP process shown in **Figure 1**.

Figure 1 | Seven-Step RAMCAP Process



The first five steps of the RAMCAP process involved determining the City’s water system critical assets and potential threats and the consequences, vulnerabilities, and threat likelihoods for every critical asset/threat (A/T) pair. These steps came together in step six, which indicates the City’s current or “baseline” level of risk for each A/T pair in terms of dollars per year. The first six steps of the RAMCAP process are required to meet AWIA RRA compliance.

RRAs may include Step 7 of the RAMCAP process, an evaluation of potential “countermeasures”, or capital and operational improvements to reduce risk and increase the resilience of the system. To meet the City’s ERP and long-term resilience goals, Step 7 was completed. This step involved understanding and comparing the risks identified in the RRA, identifying countermeasures to reduce these risks, and defining ways to increase resilience of the City’s water system assets. The City is then able to further evaluate these countermeasures in terms of their benefits and costs to develop a project list for implementation. This last step in the RAMCAP process also aligns with AWIA compliance for the ERP (EPA, 2019a; Landers, 2020). Below is a description of the City’s RRA organized in line with RAMCAP steps.

Risk and Resilience Assessment Development

RAMCAP Steps 1 & 2: Characterization of Assets and Threats (A/T Pairing)

To determine the City’s water system assets with potential risks, the physical facilities, cyber, and human elements were identified. Where applicable, facility assets were grouped based on

proximity (being located on the same site and having shared security features) and operation (function together). **Table 1** summarizes the assets that were assessed.

Table 1 | List of Critical Assets

Critical Asset	Facilities Included
Well 2	Well 2
Well 3	Well 3
Well 4	Well 4
Well 5	Well 5
Well 6	Well 6
	Well 6 Reservoir
Well 7	Well 7
	Well 7 Reservoir
South Redmond Facility	South Redmond Well
	South Redmond Reservoir
Facilities Warehouse	
Fork Horn Butte Transfer Pump Station	
Fork Horn Butte Booster Pump Station	
System Reservoir	
Storage Reservoir	
Distribution System Mains	
SCADA System	
Well 4 SCADA System	
IT/Security Systems	
Enterprise Systems	
Pressure Zone 1A PRV	

Well 1 was not included as a critical asset due to low demand and plans to decommission the facility in the near future.

The City uses a chlorine gas for disinfection at all well sites. Each facility has individual gas cylinders and injection systems. Storage and handling of these treatment components was not as a separate asset because it is not viewed as having a significant risk outside of the risk with the overall well asset.

The potential threats were identified that each of the assets may face. The AWWA J100 provides a list of threats as an all-hazards approach and includes malevolent threats, natural hazards, and dependency and proximity threats. Several threats were evaluated and not included in the risk and resilience assessments due to either inapplicability to the area and water system, not having a significant likelihood and/or consequence, or not having easily definable and implementable countermeasures. Additionally, threats that were similar in type and category and had comparable consequences were combined, such as Attack by 1 Assailant, 2-4 Assailants, 5-8 Assailants, and 9-16 Assailants. These groupings of threat were also carried over into vehicle

attacks, sabotage, and theft or diversion categories. **Table 2** summarizes the identified threats most likely to occur and posing the highest consequence to assets in the City’s water system.

Table 2 | City Threat Characterization

Threat Category	Threat Type
Malevolent Acts	Attack: Assault Team
	Attack: Automotive
	Product Contamination: Intentional (Chemical)
	Sabotage: Cyber Attack (Outsider)
	Sabotage: Physical Attack (Outsider)
	Theft or Diversion: Cyber Attack (Outsider)
	Theft or Diversion: Physical Attack (Outsider)
Natural Hazards / Dependency and Proximity	Earthquake
	Ice Storms

Identified critical assets and threats were then sorted into a matrix to list all resulting A/T pairs. A/T pairs were screened based on perceived threat likelihood, asset vulnerability, and consequence of the threat event to capture the highest priority A/T pairs to carry through the remaining steps of the RAMCAP risk assessments. On January 19th, 2021, a workshop was held with the City and Murraysmith as a collaborative exercise to review the City’s most critical A/T pairs. During this workshop, critical A/T pairs to be included in the risk assessments were reviewed and confirmed. 64 A/T pairs were selected for analysis in the RRA. The selected A/T pairs are indicated in **Appendix A**.

RAMCAP Steps 3, 4 & 5: Consequence, Vulnerability & Threat Likelihood Analyses

PARRE Software

Murraysmith used the Program to Assist Risk and Resilience Examination (PARRE) software provided by AEM Corporation (AEM) to complete the Consequence, Vulnerability, and Threat Likelihood Analyses and to calculate the baseline risk for each asset-threat pair. The PARRE tool is helpful in assessing a water system’s risk and resilience from malevolent threats and natural hazards. The tool also helps utilities evaluate improvements within its water system to increase security and resilience. AEM design PARRE to help water systems comply with AWIA requirements.

The Consequence Analysis establishes the total cost of consequence in dollars that would result from the selected threat occurring and impacting the selected asset. Consequence values are the number of fatalities, number of injuries, utility financial consequences, and the regional economic consequences that would result from a selected threat occurring on a selected asset. The Water Health and Economic Analysis Tool Calculator (WHEAT) was used to estimate these values to conduct the consequence analysis within PARRE (EPA, 2020b).

Water Health and Economic Analysis Tool Calculator (WHEAT)

WHEAT was developed by EPA to help utilities calculate likely health and economic outcomes, and particularly, to offer a detailed consequence analysis for asset-threat pairs. Equations provided in WHEAT were used to generate rough order of magnitude project costs for replacement of each asset. The replacement costs comprise the utility financial component of the consequence for each A/T pair. Additional cost factors were added to the cost equations to account for other project costs such as engineering and design, permitting, and sales tax. If there was a potential for serious injury or loss of life for the given A/T pair, the average cost for death or injury based on nationwide data was added to the utility financial impact (\$9,100,000 per death, \$955,500 per serious injury).

Estimates for regional economic impact for each A/T pair were based on the duration that the asset would be offline and unable to provide service to customers. For these costs, it was assumed that the City would supply alternative means of drinking water to the impacted customers (e.g., bottled water).

The sum of the utility financial impact and regional economic impact costs comprised the Consequence component of each A/T pair. Consequences are summarized in the PARRE output report provided as **Appendix A**.

Vulnerability Analysis

The Vulnerability Analysis determines the ability of each critical asset to withstand the specified threat. This analysis calculates the likelihood as a percentage that a selected threat would result in the estimated consequences if a malevolent event were successful, or a natural hazard or dependency/proximity threat would cause the estimated consequences. PARRE's Vulnerability Calculator was used to estimate the vulnerability likelihood.

For Malevolent Acts threats, the PARRE Vulnerability Calculator involves conducting a "Event Tree" analysis that examines probability of the success of each stage of an attack. Success probability is based on existing countermeasures including facility security features, structural components, mitigation measures, and their effectiveness in reducing damages from threats. The probability of success is compounded through each mitigation measure and security feature until a final probability of the threat is determined for each asset.

For Natural Hazard threats, the City ability to prepare their assets or operations, to respond to damage, to make repairs, and to recover utility operations was assessed by considering the City's current communication plans, parts inventory, staff training, emergency management systems, and recovery protocols in the City's emergency response plan.

Threat Likelihood Analysis

The Threat Likelihood is an estimated value between zero and one and indicates the likelihood of a malevolent event or natural hazard occurring at a critical asset within a 1-year period. For

malevolent threats, the PARRE software provides the option of performing a conditional threat likelihood analysis, which attributes a threat likelihood value of one to all A/T pairs. This alternative was selected to emphasize the consequence and vulnerability components of each A/T pair. PARRE also provides several order-of-magnitude threat likelihood values for natural hazard threats that can be chosen for the City based on site-specific information or professional judgement. The values provided by PARRE are based on historical frequency data for earthquakes related to the City's location.

Annual Threat Likelihood values for each A/T pair are summarized in **Appendix A**.

Step 6: Risk/Resilience Analysis

Baseline Risk Analysis

A Baseline Risk Assessment was conducted for each of the City's A/T pairs. The Baseline Risk value is a monetarized value calculated using the following formula.

$$\text{Risk (\$/year)} = \text{Consequence (\$)} \times \text{Vulnerability (\%)} \times \text{Threat Likelihood (\%/year)}$$

The Baseline Risk is the product of the previously determined consequence of a successful threat, vulnerability of an asset to the given threat, and likelihood of the threat occurring for each A/T pair. Higher Baseline Risk values indicate the A/T pair poses a higher risk to the City. On May 24th, 2021, a second workshop was held with the City and Murraysmith to review the findings of the risk and resilience analyses. Modifications to the consequence analysis were made based on City input which affected Baseline Risks.

Baseline Risks are summarized **Appendix A**.

Utility Resilience Index (URI)

The URI indicates the City's current overall state of resilience to withstand a threat event by considering the City's ability to respond to and recover from an event that impacts service or critical operations. The URI is calculated in PARRE. The URI can also be used to highlight deficiencies in the City's preparedness, allowing the City to plan, prioritize, and distribute limited sources when addressing an incident that may compromise the City's water system.

The City's calculated URI can be found in **Appendix A**.

The URI is calculated using 12 independent operational and financial indicators and assess the varying levels of action or capabilities that support system level resilience (Morley, 2012). Operational indicators include:

1. Development and implementation of an ERP for immediate response to incidents of all types;

2. National Incident Management System (NIMS) Compliance or training provided to key staff to support structure for response activities;
3. Mutual Aid and Assistance, e.g., Washington Water/Wastewater Agency Response Network (WAWARN) participation, for utility peer support for rapid response to incidents;
4. Emergency power for critical operations, as power is often a key factor in response after disasters;
5. Capabilities to meet minimum daily demand/treatment when production or treatment facility is nonfunctional;
6. Lead time for the repair, replacement, or recovery of critical parts and equipment and includes physical and cyber/process control systems; and
7. Percentage of response-capable staff who are available for critical operations and maintenance positions with cross-trained backup staff.

Financial indicators include:

1. Development and implementation of a Business Continuity Plan (BCP) to denote risk management principles that supports the utility's operations;
2. Utility Bond Rating (UBR) to represent a utility's ability and willingness to satisfy financial obligations;
3. Government Accounting Standards Board (GASB) Assessment to indicate the percentage of utility infrastructure evaluated and the overall commitment to asset management;
4. Unemployment level in the community served by the utility to provide insight on the fragility of the community to withstand a significant event; and
5. Median Household Income to also provide another perspective on the fragility of the community to withstand a significant event.

The URI is calculated within PARRE using a weighing scheme developed by Morely (2012) and based on utility-vetted prioritization of utility resilience indicators and elicited expert support.

Step 7: Risk/Resilience Management

Risk and Resilience Management is the process of considering the risks and existing countermeasures at each utility asset, determining mitigation actions to lower risk to an acceptable level at an acceptable cost, and implementing and managing the applied countermeasures (McLaughlin, 2015). The Risk and Resilience Management assessment consisted of identifying potential countermeasures in a Countermeasures Analysis, re-calculating

the risk (referred to as “Improvement Risk” for the A/T pair) based on the implementation of the identified countermeasures, and conducting a Cost-Benefit Analysis that evaluates the net benefit of the potential countermeasure considering the capital costs for implementing the countermeasures against the Improvement Risk.

Countermeasure Analysis

The Countermeasure Analysis allows the comparison of the risk of each critical asset-threat pair with existing countermeasures and the estimated risk of that asset after implementing additional countermeasures. The Countermeasure Analysis for each high-risk A/T pair consists of choosing potential countermeasures that may reduce the level of risk for the asset-threat pair. There are 16 standard countermeasures for consideration, and PARRE allows for custom entry if another asset-specific countermeasure is desired. For this analysis, two custom countermeasures were added: purchase of a spare pump and motor for pumping facilities and conducting a seismic evaluation of the asset to identify improvements tied to seismic code requirements. The full list of countermeasures considered is as follows:

1. Employee screening program
2. Backup power generation on-site
3. Guard(s)
4. Perimeter fencing
5. Hardened doors
6. Continuous process monitoring
7. Redundant water source(s)
8. Distribution of alternative drinking water
9. Site lighting
10. Emergency operating procedural plan
11. Intrusion sensors
12. Security cameras
13. Backflow prevention devices
14. Water/Wastewater Agency Response Network (WARN)
15. Hardened ladder access
16. Toxicity Monitoring
17. Purchase of Spare Pump and Motor
18. Conduct Seismic Evaluation

Conducting a seismic evaluation does not have a direct impact on baseline risk, but rather the recommended improvements coming out of the evaluation. For this reason, this countermeasure was not included in the Improvement Risk Assessment.

Potential countermeasure projects were selected to address each A/T pair, and the net benefit of the projects were evaluated. In general, the following countermeasures were evaluated for the water system:

1. **Security Cameras:** Install Closed Circuit Television (CCTV) cameras and associated equipment at the Water Division Office. These cameras should have wide-angle view capability to capture multiple attack routes. The views should include access doors and hatches. CCTV cameras will decrease the vulnerability of facilities to theft, vandal, or active shooter threats by increasing detection levels during an event. In addition, visible cameras will act as an additional level of deterrence for potential attackers.
2. **Card Lock Entry:** Install card entry locks at all facilities. Card lock entry would act as an additional level of deterrence for potential attackers and deter theft.
3. **Security Fencing:** Install security fencing around site to act as deterrent for malevolent threats.

These recommended countermeasures were evaluated for each A/T pair as shown in **Table 3**. Net benefit ratios were only calculated for those threat asset pairs resulting in a total risk of greater than \$100,000. Countermeasure projects were assigned to each A/T pair based on their effectiveness for reducing Baseline Risk. Net benefits were calculated for each countermeasure project based on calculated risk reduction (Baseline Risk minus Improvement Risk) divided by total estimated project costs. It is recommended that the City considers implementing the countermeasure projects with a higher net benefit to provide the highest value for reducing water system risk.

Project Recommendations

Based on the counter measure net benefit analysis the following countermeasures are recommended

- Security cameras installed at all asset locations
- Security Fencing installed at Fork Horned Butte sites, Well 2 and Well 3
- Card lock entry installed at all building locations

Project Timing Considerations

Once projects have been reviewed and budgeted, the City will need to schedule the projects for implementation. Timing considerations for potential project implementation includes:

- Projects considered high priority by the City
- Combining projects in accordance with the projects being of a similar nature or at a common facility
- Timing and funding considerations with the City's current Capital Improvement Program

Table 3 | Risk and Resilience Management Summary

No.	Asset	Threat	Recommended Countermeasures	Risk Reduction ¹ (\$/year)	Total Estimated Projects Cost ² (\$)	Net Benefit ³
1	System Reservoir	Attack - Chemical	Security Camera	\$11,875,000	\$3,000	396
2	South Redmond Facility	Attack – Chemical Sabotage – Outsider Attack – Car	Security Camera, Card Lock Entry	\$439,379	\$5,500	240
3	FHB Pump Station	Sabotage – Outsider Theft – Outsider	Fence, Security Camera, Card Entry Lock	\$479,235	\$30,500	31
4	Storage Reservoir	Attack - Chemical	Security Camera	\$107,434	\$3,000	21.3
5	Well 6	Attack – Chemical Sabotage – Outsider	Security Camera, Card Lock Entry, Alarm (storage hatch)	\$536,472	\$8,000	130
6	Well 7	Attack – Chemical Sabotage – Outsider	Security Camera, Card Lock Entry, Alarm (storage hatch)	\$583,971	\$13,250	195
7	FHB Transfer Pump Station	Sabotage – Outsider Theft – Outsider	Fence, Security Camera, Card Entry Lock	\$375,100	\$17,750	59
8	Well 3	Attack – Chemical Sabotage – Outsider Theft - Outsider	Fence, Security Camera, Card Entry Lock	\$552,829	\$30,500	54
9	Well 2	Attack – Chemical Sabotage Outsider	Fence, Security Camera, Card Entry Lock	\$376,886	\$30,500	25
10	Well 4	Attack – Chemical Sabotage Outsider	Card Entry Lock	\$57,452	\$2,500	46
11	Well 5	Attack – Chemical Sabotage Outsider	Card Entry Lock	\$34,452	\$2,500	28

Notes:

1. Risk Reduction values account for total risk reduction for asset-threat pair addressed by the recommended countermeasures shown. Values calculated in PARRE.
2. Total Estimated Project Costs are presented as rounded, AACE Type 5 costs that include a 30 percent contingency. Cost includes total package inclusive of all included assets and are in 2021 dollars. Project costs should be revised as scope of projects is more clearly defined.
3. Net Benefit calculated as Risk Reduction divided by Total Estimated Project Costs.
4. Project cost for cybersecurity improvements depended on recommendations provided by Cybersecurity Use Tool. Cost range shown is budget placeholder only and should be revised pending final City decision of which cybersecurity controls to implement.
5. Project Costs for the System and Storage Reservoirs are shared and reflected in the net benefit ratio. Total Project cost is \$3,000 for a camera to cover both reservoirs.

Summary and Certification

This memo documents the AWIA Compliant RRA for the City's water system following the AWWA J100 Standard and using U.S. EPA's PARRE software. Results of the RRA can be found in a report produced in PARRE and provided as **Appendix A**. The PARRE summary report contains an executive summary, overview of the assessment team and approach, City information, a breakdown of the data included in the Consequence, Vulnerability, and Threat Likelihood evaluations, and a summary of the Risk Assessment analyses. The AWIA Compliant RRA will be self-certified by the City by completing the online EPA certification statement before June 30th, 2021.

Next Steps

Murraysmith will continue working with the City to review and will determine required updates (if necessary) to the City's existing ERP to meet the new AWIA standards. This includes reviewing relevant AWWA standards to ensure the updated ERP aligns with the most up-to-date industry standards. A list of necessary and recommended updates to the ERP will be provided to the City so they can update the ERP.

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Appendix

A. PARRE Risk Assessment Summary Report

SCADA Asset Inventory

for



Assessment & Analysis Information

May 26, 2021

Presented by:

S&B Inc.



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Abbreviations Table

The abbreviations and definitions given here follow common industry practice.

Term	Definition
A	amp
AC	alternating current
Amp	ampere
ANSI	American National Standards Institute
API	application programming interface
ASTM	American Society for Testing and Materials
AWG	American wire gauge
BI	Business Intelligence
CSI	Construction Specifications Institute
dB	decibels
DC	direct current
DC	design consultant
DMR	Digital Mobile Radio (Tier 3)
HTML	Hyper-text Markup Language
HMI	Human-Machine Interface
HP	Horsepower
ICS	industrial control systems
IEEE	Institute of Electrical and Electronic Engineers
MCC	Motor Control Center
MTBF	Mean Time Between Failure
MTU	Master Telemetry Unit
NEC	National Electric Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NPT	National Pipe Thread
O&M	Operation & Maintenance
OSHA	Occupational Safety and Health Administration
PLC	Programmable Logic Controller
PRV	Pressure Reducing Valve
PtP	point-to-point
RFI	radio frequency interference
RMS	root mean square
ROI	return on investment
RTU	remote telemetry unit
SCADA	Supervisory Control and Data Acquisition
SME	Subject Matter Expert
SAI	SCADA Asset Inventory
TCP/IP	Transport Control Protocol / Internet Protocol

TSP	twisted shielded pair
UL	Underwriters Laboratory
UPS	uninterruptible power supply
V	volts
VAC	volts alternating current
VA	volt-ampere
VAR	volt-ampere reactive
VDC	voltage direct current
VFD	Variable Frequency Drive
VPN	Virtual Private Network
WAN	Wide Area Network



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May 26, 2021

City of Redmond
Water Utilities Department
via email: Joshua.Wedding@redmondoregon.gov
cc: Bruce.Sundseth@redmondoregon.gov

Attention: Joshua Wedding
Bruce Sundseth

Subject: City of Redmond, OR
SCADA Asset Inventory
Assessment & Analysis Writeup

Dear City of Redmond,

As part of MurraySmith's forthcoming Water System Report, S&B was asked to perform the evaluation of the City's water system and submit the findings for integration into their final report document. We have completed an assessment of your SCADA system assets. Our analysis compares your current state against industry best practices and future 'ideal state' conditions. We also evaluate the product lifecycles of your SCADA equipment and identify which items are approaching or have reached end of life. The document is holistic of the entire SCADA architecture (field devices, automation, networks, and visualization) and provides context in addition to traditional assessment information.

The SCADA Asset Inventory document outlines the following content, categorized by section:

1. Vision and Goals for the Utility's SCADA System
2. SCADA Standards of Design & Best Practice Selection Methodology
3. SCADA Asset Inventory & Health Assessment Summaries
4. Gap Analysis (comparing existing state against SCADA Standards), cost estimates associated with each gap closure, and organizational impacts.
5. Cost Summary
6. Gap Closure Analysis
7. Gap Closure Order-of-Solve Sequence

If you have any questions regarding this document or the gating procedure, please contact me directly via email (jstead@sb-inc.com) or phone (425-644-1700).

Yours truly,

Jordan Stead
S&B Inc.

Section 1 – Vision & Goals

1.1 Introduction

1.1.1 SCADA's Purpose

Supervisory Control And Data Acquisition [**SCADA**] is a powerful information platform for providing real time process control and monitoring of the water facilities within the City. The system provides the control necessary at reservoirs, pumping stations, inlet flow stations, and pressure reducing valve (PRV) facilities, to achieve the City's mission for overall hydraulic operation. The visioning process aims at setting a fifteen-year trajectory of evolution and change in support of the City's mission to deliver uninterrupted, reliable, safe drinking water to consumers.

This document sets forth the vision for SCADA master planning to meet the demands of the future and a trajectory for the evolution of the SCADA system.

1.1.2 Vision Vector Generation

Vectors have both magnitude and direction. The goal of the SCADA asset inventory (SAI) work was to produce vectors for change to the SCADA system. The master planning efforts will identify both the direction of change, and the magnitude of impact for SCADA evolution. Vision vectors set the trajectory of the SCADA master planning effort and are a representative of a broad set of interests across departments. They are anchored to the Utility's operational priorities and are used as a building block upon which to compare against industry best practices (see section #2).

1.1.2.1 Core Vision Vectors

S&B engineers provided a set of features and functions that a modern SCADA system must offer and fed them into a proposed core set of vision vectors of the SCADA Asset Inventory. These core values deliver high quality and long-term viability of the system. Stakeholders reviewed and adopted the following vision vectors as per industry best practice:

1. Improve the SCADA **visualization** software platform by increasing accessibility and providing advanced visualization/reporting tools.
2. Improve the **resiliency** of the water system by addressing common industry breakpoints found in communication, data, and utility power.
3. Reduce the **costs of service** and improve operational control of the water system by optimizing utility activities
4. Design a **flexible** SCADA system which can accommodate new technologies, programs and data integration opportunities in the future.

1.1.2.2 Vision Vector Trajectory

'Vision Vectors' directed the magnitude and direction of changes that will be required to achieve the 'ideal state' of the SCADA system which meets industry best practice. The costs and level of effort required to reach full maturity (benefits) for each vision vector will vary. Some vectors, like "Cost of Service" can be achieved with a lower level of cost/effort, while the "Flexible" is projected to have the highest cost/effort to reach full maturity.



1.1.3 Vision Vectors Articulated As Goals

1.1.3.1 Visualization

The SCADA system shall be a City-wide asset, with read-only process overview visualization screens and historical data reports available to all personnel to promote the sharing of information between unique workgroups. The SCADA system will be available for use on both fixed and mobile platform while meeting ICS-CERT and City security standards. But the SCADA software package is the operator's tool to control the water system, therefore, read/write capability will be given to operations/SCADA personnel, marshalled by unique access control credentials.

Dashboard screens to display key performance indicators (KPIs) will be used to provide high level overviews of key information. Dashboards will be customized to show unique summary SCADA information, specific to workgroups within the Utility (e.g. Operations, Management, Finance, etc.), which can be used to improve workflow outputs or decision making.

1.1.3.2 Resiliency

The SCADA system of the future must address and close vulnerabilities associated with a single point of failure. It must have multiple operational layers assuring service and be scalable with increasing demands of water infrastructure and SCADA data. These resiliency measures shall be present in all layers of SCADA – field devices, networks/communication, automation, and visualization. Section-2 of this document will identify 'Best Practice' solutions that provide stability and resiliency. The goal is to keep SCADA data "online", and deliver reliable, high-quality data flows for the SCADA system.

1.1.3.3 Cost of Service

The SCADA system will be designed to assist the City in improving the overall operations of the water system through efficiencies, optimization, and context to the information being displayed on SCADA screens/reports. The expected results will be a proactive approach to maintenance, improved response times, and transparent operational costs. When the required infrastructure is in place (e.g. smart motor starters, instrumentation, etc.) SCADA will take raw data inputs and perform basic analytics to provide key

performance indicators (KPIs) including cost of pumping (in kw/gallons pumped form), motor efficiency, station pumping efficiency, total dynamic head, net system demand (hourly/daily), reservoir volume rate of change, and hourly/daily changes in reservoir volume.

1.1.3.4 Flexible

The SCADA system shall be designed for long-term flexibility, where automation hardware and SCADA software accommodates new technologies with reduced impact and engineering efforts. Systems will be designed for future expansions and provisioned for multiple methods of project execution.

Section 2 – SCADA Standards

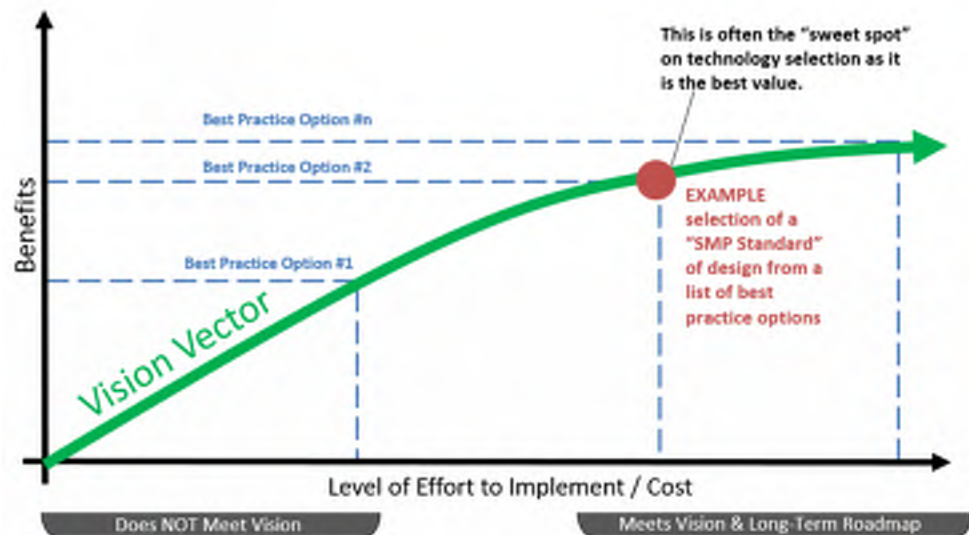
2.1 Introduction

This chapter identifies industry best practices for SCADA, designed to increase quality, resiliency, and performance standards. The visioning output from Section-1 set forth a statement of desired benefits and capabilities as 'Vision Vectors' directed toward understanding the magnitude and direction of changes required to achieve the articulated 'Ideal State'. Section-1 outputs were the inputs to Section-2 activities of selecting best practices.

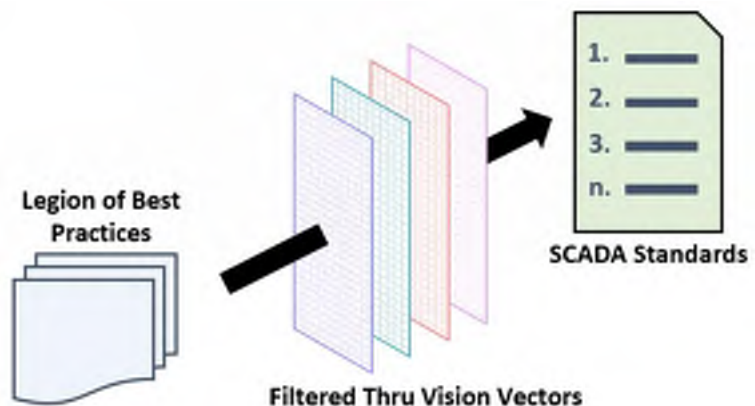
2.2 Selection Methodology

Section-1 'Vision Vectors' were used to filter through various industry best practices by the Consultant, S&B Inc, as well as considering the known preferences and adopted standards of the Utility. During the selection process, the Consultant moved through all four layers of SCADA: field devices, automation, networks, and visualization. The best practices which were evaluated varied in both costs to implement and Owner benefit.

Use-cases were applied to ensure thorough evaluation of all best practice options as filtered through the vision vectors from Section-1. The selected standards were typically the 'best value' point in the evaluation to justify the cost vs. benefit ratio.

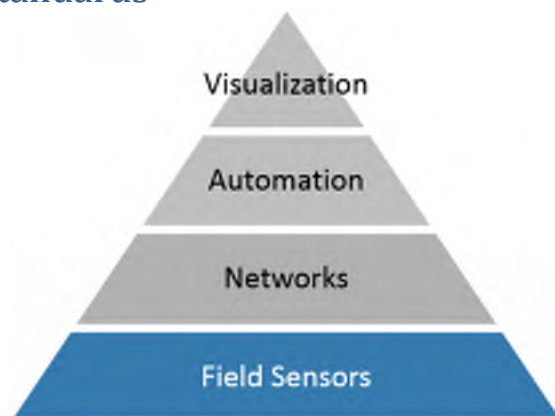


The final SCADA Standards, as selected by S&B Inc, were fed into the gap analytics work (Section-3 of this document). These SCADA Standards were used to anchor the Ideal State vision against the current state to qualify opportunities identified in the Gap Analysis.



2.3 SCADA Standards - Defined

2.3.1 Field Device Standards



2.3.1.1 General Instrumentation Selection Guidelines

To improve the life and long-term supportability of typical industrial instrumentation used, strict governance is applied to the instrumentation selection process. The following guidelines are applied to instrumentation selection:

1. **Suitability for Potable Water Application.** All instruments in contact with finished water where flow passes through the instrument and returns to the finished water system shall be listed as such with NSF-61 or equivalent markings. Review Annex C of the NSF-61 for instruments with only stainless steel in contact with potable water.
2. **Proven History.** The instrument's technology should have a proven history of success in the specific application where the design consultant is utilizing the instrument.
3. **Open Communication Standards.** The instrument should not use proprietary communication protocols, but rather open standards, providing flexibility between the instrument and the automation system. Examples of open standards include (but are not limited to): Ethernet/IP, Modbus, Modbus RTU, Modbus TCP, HART, Profibus, and Profinet. An exception to this rule is for instruments used with a packaged vendor system to communicate with the package's PLC – like a UV or ozone generation system.
4. **National Support Services.** The instrument manufacturer must offer nationally based product and technical support services for their equipment. The manufacturer must also have a proven history of technical competence and ability to solve technical support questions/issues.
5. **Local Support.** Most instrument manufacturers are located on the East Coast, and the local support systems for each manufacturer differs from region-to-region within the continental United States. Due to the support variances that occur nationally, it is paramount that the local support system is verified in the Utility's local market. The local support validation should include:
 - a. Manufacturer's staffing levels in the region
 - b. Owner and DC experience and feedback regarding the manufacturer's local support representative(s)
 - c. Verifying references of local support representatives.
 - d. Proven history of technical competence with ability to solve technical questions

6. **Premium Quality Instrument / Equipment Companies.** To ensure field equipment will meet or exceed their expected life, and reduce the probability of increased maintenance, field equipment should be selected only from well-established instrument, valve, and motor starter companies with established national and regional after-market support for parts and service. These manufacturers shall make industrial grade products known for excellent service in municipal treatment and distribution systems. Examples of such companies include (but are not limited to): Emerson, Endress+Hauser, Hach, Rotork, Rubicon, and Siemens.
7. **Post-Commissioning Validation.** When selecting an instrument, the post-commissioning performance of instrument shall be used as part of the required evaluation criteria to ensure a holistic view is used on instrument selection.
8. **Product Lifecycle History.** The instrument's product lifecycle should be equal to, or greater than its peers.
9. **Manufacturer / Model Uniformity.** Where possible, select the utility's standard instrument for the application.
10. **Maintenance Minded Installation Methods.** Instrument installations shall be designed with an expectation that regular maintenance will be required, so installations shall be designed for ease of operation, ease of maintenance, and longevity.
11. **Standard Sizes & Connections for Interchangeability and Replacement.** Field Instruments shall adhere to standard dimensional sizes and process connections to allow for multiple options of instrument/starter replacement in the future. Customized sizes are to be avoided as it will limit available options and increase lead time for future replacement efforts.
12. **24Vdc Powered Instrument Systems.** Wherever possible, 24Vdc (Volts direct current) powered devices shall be used for instrument power selection as it provides a safer working environment for future maintenance, longer backup times compared to equivalently sized alternating current units, more stable electronic environment, and resiliency during utility power transitions.
13. **Use of a Process Field Network.** A process field network shall be used anytime a device is supplying 2+ variable outputs. This reduces capital and maintenance costs as one connection can bring in multiple signals, and a process field network provides greater accuracy as there is no rounding of a 4-20mA analog signal. A process field network shall also be used for a single variable output when additional benefits of programming/diagnostic capabilities can be achieved.
14. **Calibration Through SCADA.** All instruments terminating into the SCADA control system shall have a SCADA user interface suitable to verify and/or calibrate the specific measurement values within the bounds of each device's measurement range as it provides helpful tools and removes the need for additional technical expertise, empowering the operations staff to maintain their system.

2.3.1.2 Measurement Devices

Measurement instruments are the primary instrument type used by the Utility, as they continuously stream values to the PLC for near-real-time updates to the process control system. These updates indicate that the device is always in working order. Additionally, the PLC can manage an array of setpoint parameters for the process variable being measured, allowing the operators to dynamically change the setpoint as needed, without having to be on-site to adjust or re-program the instrument.

2.3.1.3 Detection Devices

Detection devices measure binary conditions (true/false), and typically do not provide a “heartbeat” to the automation system to ensure the device is working at any given time. Detection devices, used in non-vendor supplied systems, should be used if any the following conditions are met:

1. Monitoring low-value assets,
2. Serving as a redundant sensor to a measurement type device,
3. Used for building/facility monitoring including but not limited to:
 - flood switch
 - smoke detector
 - hatch / door entry switch

2.3.1.4 PLC-Based Process Interlock Management

A PLC-based process interlock offers significantly higher operability than interlocks assigned to the device (typically motor starters), as pre-start and fail-safe conditions can be monitored through automation and given enable/disable features in SCADA. The Utility currently utilizes PLC-based interlocks and will maintain its alignment.

2.3.1.5 Redundant Measurement Devices

Redundancy in measurement devices is then chosen based on application specific criticality. Redundant forms of measurement in key process control functions are used to ensure the process control system can operate in varying environments and conditions. Typical applications used include “pressure control”, “level control” or “flow control” of the station, especially for those pumping to closed zones where no other station serves as a backup. Three types of redundancy are acceptable:

1. True Redundancy. Two or more devices are used to measure the exact same condition. In this application, it is recommended to use different methods of measurement for added resiliency.
 - e.g., a radar probe and submersible probe both measuring the same tank level
2. Instantiated Redundancy. Multiple process trains make up a single process.
 - e.g., a flow meter monitoring the discharge of each pump rather than a single flow meter on the combined discharge header
3. Inferred Data Redundancy. Inferred variables are substituted as the primary measurement value. This is the least accurate method for redundancy and requires communications speeds of 2 second update times or better.
 - e.g., two tanks at one facility of equal heights connected together and share one level transmitter.

2.3.1.6 Quick-Connect Cabling

Quick-connect cables are finger-safe electrical connection which take seconds to safely disconnect from electrical power and are the preferred alternative to traditional rigid/flex conduit connections. An electrical contractor installs the quick-connect cable by running a short, PVC coated, IP68 rated cable from the conduit hub to a mating receptacle mounted on the instrument. This installation removes the requirement to use an instrument technician or licensed electrical contractor to service the instrument. The Utility currently utilizes quick-connect cabling for instruments and will maintain its alignment.

2.3.1.7 Smart Motor Starters

Smart motor starters are the selected starter type as they offer onboard diagnostics, a lower O&M cost to the Owner post-commissioning, provide more information to the processor and produce the required pumping efficiency values.

Smart equipment is defined by three elements:

1. utilizing a process field network for data exchange to the PLC,
2. utilizing the internal logic blocks for motor control, and
3. providing the device's energy profile to the PLC.



The benefits of a smart motor starter are supported by three key components:

- **Local logic blocks** where each starter is configured for its motor profile and all local digital / analog signals, enabling safe operation if the processor were to ever be off or stopped. The local logic blocks handle sequencing of peripheral equipment (e.g. pump control valves, capacitors for harmonic filters, etc.) so that the motor starter can handle process safety interlocks even when operating in “Hand”.
- **Network control** of the motor starter from the PLC where the full data array of parameters can be edited locally or remotely, and read if there is a need for diagnostics. A single industrial ethernet cable can replace all PLC control inputs/outputs for fast installation. Motor starter values are able to be brought forward to the local HMI and SCADA visualization for a more complete look at pumping performance.
- The **power profile** of a motor starter is captured and monitored for performance. HMI and SCADA systems provide trending of power usage. At minimum (depending upon the smart motor starter type), values for amps, volts, and active horsepower are used as inputs into pumping efficiency and pumping performance monitoring by the SCADA system. These values help provide operators early warning indicators into abnormal pumping operations and potential motor wear.

A single process fieldbus connection can replace numerous physical wiring terminations, simplifying maintenance, troubleshooting, and other O&M tasks. Additionally, the fieldbus connection can offer more data to the automation system than a discretely wired connection as a processor can read the full array of values from the smart motor starter's control unit and local logic blocks.

A smart motor starter should be used when any of the following conditions are met by the application conditions:

- 3-Phase
- Greater than 2 HP load
- Supplies data for inferred process measurements

The smart motor controller, while useful for all connected motor loads, does not have economic benefits for small motor applications which typically include small ventilation fans. For larger loads where the motor provides pump operation, the smart motor controller data may be used by software modules to estimate flow based on differential pressure and applied energy. This practice is known as “inferred process measurement” generation.

Where small ventilation fans are used to eliminate confined space environments, the smart motor controller energy feedback provides confirmation of proper fan operation at a similar or slightly lower price as compared to installing an air flowmeter.

2.3.1.8 Station Pumping Efficiency

The Utility will monitor station pumping efficiency at all pumping facilities, at a minimum. On a project specific basis, the Utility may choose to elevate the efficiency monitoring capability from station to each individual pump. Four elements are required to calculate the pumping efficiency of a station and/or individual motor:

1. Power profile from a smart motor starter
2. Suction pressure (or suction side reservoir level)
3. Discharge pressure
4. Discharge flow

When all four elements are present, the automation system can provide a full picture of the power usage and overall pump performance.

As approximately 25% of the world's energy is consumed by electric motors, improving efficiency in motor operation can drastically reduce the energy demand and overall cost. The Utility will monitor pumping efficiency to establish a baseline pumping performance, used to identify the 'winner' and 'loser' pumps at a station. Contributing factors that play a role in the efficiency of a motor, or an entire pump station, may be mechanical in nature or the result of hydraulic conditions/ pipe arrangements contributing to head loss. Operators will see the most cost-effective pumps or pump stations to select for running first in a preferred sequencing. In cases involving VFDs, a pump's operational 'sweet spot' can be identified, while the SCADA visualization will alert if a pump falls outside of normal efficiency range via setpoint controls. The baseline requirement is to monitor for station pumping efficiency.

2.3.1.9 Station Power Monitoring

A pumping station's overall power consumption shall be monitored by a network connected power meter on a station-by-station basis. This power meter will provide oversight to the quality of power being fed from the local power utility and also provide power monitoring for peripheral equipment such as HVAC, package chemical dosing systems, etc. The power monitor will give the station's processor a holistic view of power consumption and alarm operators of any poor power conditions.

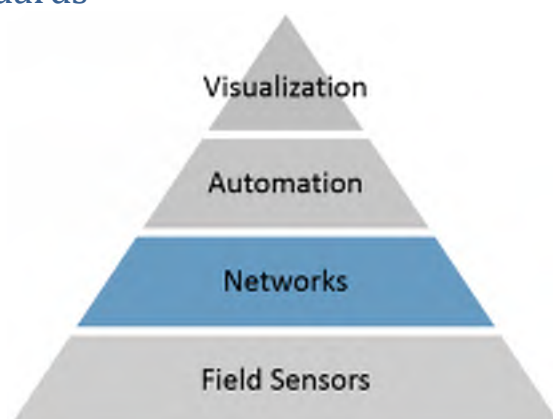
Other station types like PRVs, interties and reservoir sites do not require a power meter as these facilities will not realize economic or performance benefits from the power meter.

The Utility has standardized on using a Siemens model PAC4200 meter as it provides voltage (L-to-N and L-to-L), current, VA, kW, power factor, and total harmonic distortion monitoring.

2.3.1.10 Station Surge Protection

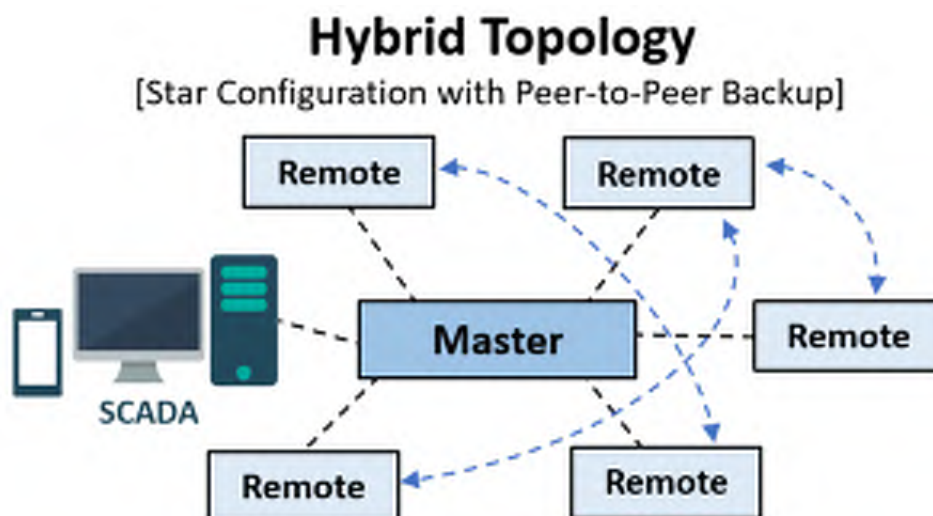
A water system is equipped with many electrical devices critical to the process control functionality of the facility. Such devices include the PLC, field devices, and motor starters. A method of resiliency is to use a surge protection device (SPD) to help mitigate electrical surges which can damage the SCADA equipment. Lightning strikes are the most common threat of electrical surges. The Utility has standardized on using the Siemens TPS units for station surge mitigation, and there is no reason to deviate from the standardization.

2.3.2 Network Standards



2.3.2.1 Hybrid Topology

Hybrid topology utilizes a centralized base architecture of Star, with an overlaid decentralized peer-to-peer communication system between facilities. The peer-to-peer connections are typically selected for specific sites which require data from peripheral remote facilities in order to complete its process control objectives. In a hybrid architecture, remote facilities may directly communicate when the primary central processor channel is inactive. The remote facility can also execute mission critical functions of pumping and flow control, in near real-time, using data derived from peer-to-peer queries. This overlaid peer-to-peer communication provides communication redundancy and added resiliency to the remote station's process control capability. Hybrid topology utilizes centralized computing and data archiving for the SCADA computer visualization software, a cost-effective solution when interfacing to the SCADA visualization systems.

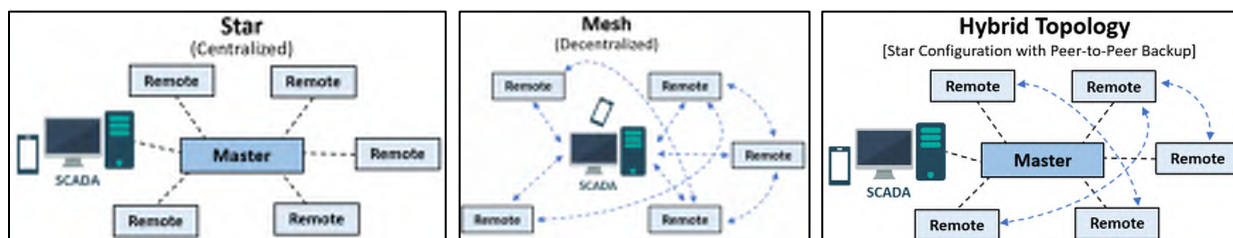


The use of hybrid topology is selected for its inherent resiliency with peer-to-peer overlay and its low cost to implement. The Utility's SCADA system currently resides on a Hub-and-Spoke (aka Star) topology, so only the select peer-to-peer connections require additional build-out.

2.3.2.1.1 Decision Context

During the network architecture evaluation process, the Consultant, S&B Inc, considered star, mesh, and hybrid topologies. Star architecture uses a communications hub to route communication to all remote stations and the SCADA visualization software system. Mesh architecture is decentralized where no communications hub is present, and SCADA data is shared with select remote stations and the SCADA visualization software will have an independent PLC connection with each remote facility. Hybrid uses a

start topology and overlays peer-to-peer communication at select sites (all sites which require SCADA data from another facility).



Star architecture (the Utility's existing topology) was not selected as it has a single-point-of-failure in the communications hub, which does not meet the resiliency vision vector. The Mesh architecture model requires communications systems to have highspeed and bandwidth to provide data exchanges every 5 seconds – but ideally every 2 seconds (as sub-two-second communication allows for inferred measurements to be used by remote processors). By selecting Hybrid, the Utility would improve the resiliency of the communication system, while also leaving the door open to move to a Mesh system in the future – as several of the required peer-to-peer connections would already be in place in a hybrid topology. Based upon the benefits and future flexibility, Hybrid Topology was selected.

2.3.2.2 Multi-Path Communication

Multi-Path communication shall be used as a resiliency strategy to negate communication outages at sites with high criticality ratings. In multi-path environments, SCADA communication are not restricted to a single media decision, instead it is a scalable model that can utilize more than one instance of media communication simultaneously. Dual-path or tri-path communication architectures address the most common failures in a SCADA system and eliminate single points of failure.

To mitigate the threat of a communication failure, the Utility shall utilize multi-path communication at high criticality sites, or sites where communication downtimes of 12-hours or more will impact process control of the water system.

2.3.2.2.1 Dual-Path Communication

Dual-Path communication is the multi-path method selected by the Consultant. It uses two pathways to transmit data between facilities using both a primary and secondary (backup) communication media. With cost as a factor, Dual-Path was selected over Tri-Path as it requires less communication lines to maintain.

2.3.2.3 Digital Communication Media

The Utility currently utilizes digital media formats for SCADA communication. Digital communication remains the preferred standard for the Utility. This best practice was selected as:

- Telecommunication companies are actively investing in digital infrastructures (unlike analog medias),
- Digital medias have superior speed and bandwidth compared to analog medias, and
- TCP/IP-based medias are capable of Multi-Path communication.

2.3.2.3.1 Private APN Cellular Solution

An Access Point Name (APN) private network is created by the cellular provider for exclusive use by the Owner. This network type does not have access to the internet, providing a high level of isolation and a secure solution in its native form. By inherent architecture, the private network offers the most secure and least flexible solution and is capable of peer-to-peer and peer-to-central processor communication

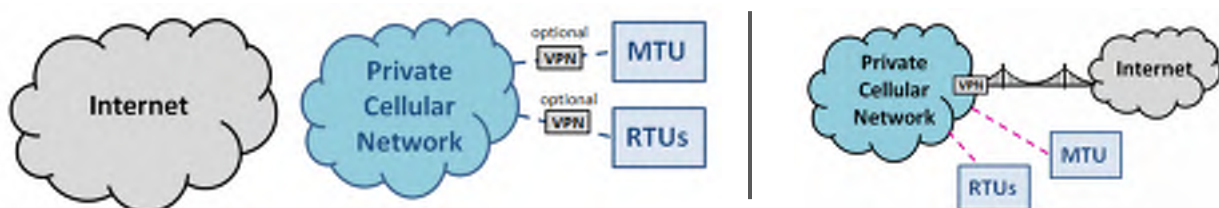
capabilities. An additional layer of security is also possible by employing VPN tunnels within the private network.

The Utility began use of a Verizon Private APN in 2020 have been pleased with the performance and reliability of the network around their water system. The SCADA Standard is to maintain this alignment and use a Verizon private APN for data plans for SCADA data transport.

2.3.2.3.1.1 Decision Context

During the network architecture evaluation process, the Consultant considered “Private Access Point Name (APN) cloud” or a “Public Facing, Static IP Solution” architectures and products. A Private APN is a private cellular network, set up by the carrier (e.g. Verizon, AT&T, etc.) without access to the internet. A Public Facing Static IP solution uses a private cloud bridged to the internet.

Security was the driving factor in the selection by the City in 2020. The APN solution was the only option which was independent from the internet, and requires a pre-configured SIM card from the carrier (e.g. Verizon, AT&T, or FirstNet) specific to each edge device/modem, to gain access to the private cloud. Additionally, the FirstNet network, specifically for first responders and critical infrastructure, was the preferred network to be used by the City, and their solution used a Private APN cloud.

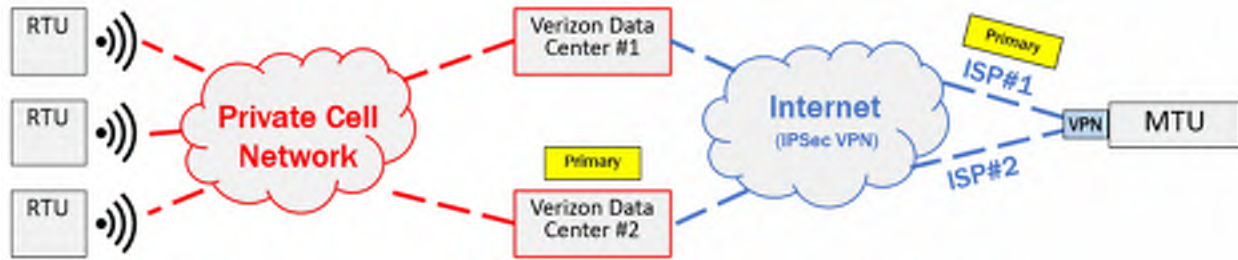


2.3.2.3.1.2 4G LTE

4G LTE is the selected standard of the Utility. The 4G LTE bandwidth and speed exceed the requirements of the SCADA system. In the future, when 5G is available in the service area, and industrial 5G modems are readily available in the marketplace, the Utility can choose to select 5G service as its new standard, which will require new, 5G compatible modems and antennas. Private cellular networks will support both 4G LTE and forthcoming 5G hardware devices simultaneously. Although 5G cellular is currently being constructed by all major carriers as the future replacement of the 4G LTE technology, it is expected 4G LTE will remain a supported technology for about 10 years after 5G launches. (This assumption is based upon 3G cellular remaining a supported technology 10 years after 4G LTE entering the US market in 2010 as the technological replacement). The Utility shall use cellular modem hardware with chipsets/firmware which enable backwards compatible communication, therefore when 5G is used by the Utility in the near future, the modems will also be capable of communicating on the 4G network.

2.3.2.3.1.3 VPN Network Build-out for Private APN Cellular Solution

Rather than use a cellular modem at the master telemetry unit to exchange data with various remote site, a specialized VPN appliance shall be utilized to read/write data sets from remote facilities. The VPN appliance uses high bandwidth internet connection from various internet service providers (ISP) through a secured tunnel to access the SCADA system’s private APN cellular network. This offers the Owner the ability to utilize 2 ISPs for access to the SCADA network: one primary and the other secondary. The pipeline bandwidth from the cellular provider to the Owner is drastically improved over a cellular modem approach and is minimally impacted by the quantity of remote telemetry units in the field communicating via cellular.



The Consultant has selected to utilize a VPN solution from Verizon for the following reasons:

- Improved bandwidth for remote station data exchange with the master telemetry unit (MTU)
- Communication redundancy to Private APN
- Proven network performance throughout the Utility

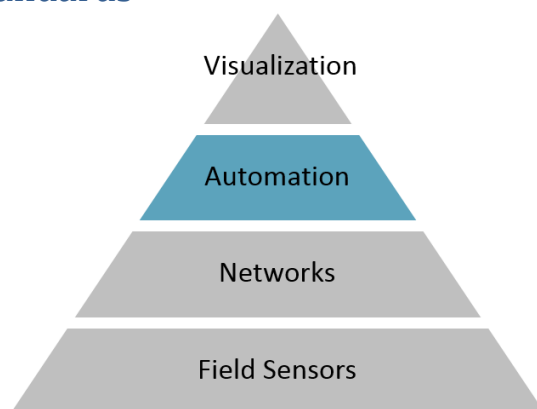
2.3.2.3.2 High Speed Internet (Secondary Media Type)

The SCADA Standard for secondary media types shall be the use of a high-speed internet connection (DSL, cable, fiber, etc.) in dual path communication applications. All leased medias will require a “static IP” connection to allow for remote access, and a local VPN appliance to provide security as data will transmit over public facing networks.

2.3.2.4 Data Packet Encryption

Data packet encryption shall be used for SCADA data transport over public facing networks. This encryption is done at the edge device (e.g., cellular modem) through device configuration. Encryption increases data packet size by approximately 20% and typically carries no additional engineering cost to invoke. The Utility currently encrypts data packets for remote station data exchange and will maintain its alignment.

2.3.3 Automation Standards



2.3.3.1 Siemens Automation Equipment

The City currently standardizes on Siemens automation equipment for its remote and master telemetry facilities. Currently 10 of 13 telemetry panels (77%) use a Siemens automation platform. Subscribing to a standard hardware platform from a single, reputable manufacturer is a leading best practice as it reduces the operations and maintenance (O&M) burden to Utility forces as personnel are trained on equipment from a single vendor and can become proficient with the products. The SCADA standards for automation will continue the City's alignment with Siemens automation products. The Siemens product lines for their S7-1500 processors, ET200SP IO, Comfort Panels, SCALANCE networking equipment, and SiTOP power supplies shall serve as the Utility's automation platform standards.

2.3.3.2 Local Automation Logic

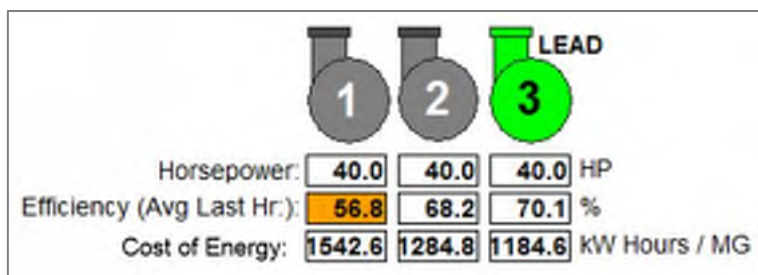
A "Local Automation" design occurs when the local station has full station control and can run its individual process control routine even if the communication to the central processor or peripheral RTU is lost. Local logic offers a higher resiliency to communication failures (one of the most common failure in SCADA systems). RTUs with local logic exceed the capabilities of central logic automation products in communication, processing, local logic, resiliency, versatility, and long-term support. Where requirements include smart motor controls, smart valve controls and stand-alone logic processing, local logic architecture is required. The Utility currently utilizes a local processor to perform process control functions and will maintain its alignment.

2.3.3.3 Emerging Process Control Features

Several process control or automation features are to be standard offerings for a water station, above and beyond common process control functions of pressure control, level control, flow control, pump staging, and others. Each feature is described in the following sections.

2.3.3.3.1 Station Pumping Efficiency

About 25% of the world's energy is consumed by electric motors and this statistic means improving efficiency in motor operation can drastically reduce the energy demand and hence, cost. It is best practice to monitor the pumping efficiency to establish a baseline of pumping performance and help identify the 'winner' and 'loser' pumps at a station. Contributing factors that play a role in



the efficiency of a motor, or an entire pump station for that matter, may be mechanical in nature, but may also be a result of hydraulic conditions and pipe arrangement contributing to head loss. Operators will see the most cost-effective pumps or pump stations to select for running first in the preferred sequencing. In cases involving VFDs, a pump's operational 'sweet spot' can be identified. Through SCADA visualization, operators can also be alerted if a pump falls outside of normal efficiency range via setpoint controls. In the example SCADA screen shot, Pump 1 is outside of the normal efficiency range and is colored orange to flag the condition, and Pump 3 is the top performing pump of the set and has been selected as the lead pump as it costs the least to run).

Four elements are required to calculate the pumping efficiency of a station and/or individual motor:

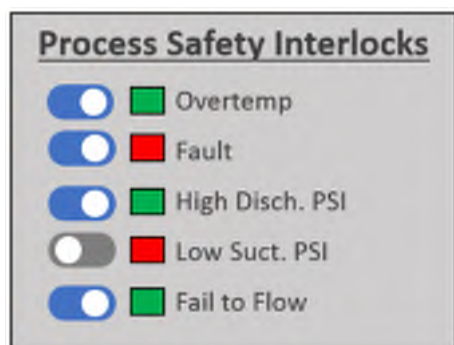
1. Power profile from a smart motor starter
2. Suction pressure (or suction side reservoir level)
3. Discharge pressure
4. Discharge flow

When all four elements are present, the automation system can provide a full picture of the power usage and overall pump performance. For greater granularity, individual pumping efficiency can be calculated if an individual flow meter and discharge pressure transmitter are present on the discharge piping (as the suction pressure measurement can be shared across all pumps). The associated picture is an example of the measured energy profile.

The Utility already monitors for station pumping efficiency and will continue with the SCADA Standard. The data will be brought forward to the SCADA visualization system and the operations staff will learn each station's typical pumping efficiency. When station efficiency dips below the normal threshold, the operations staff will know that one or more of the four elements in the efficiency calculation (power profile, suction pressure, discharge pressure, or discharge flow) must be investigated to find the source issue(s) in performance.

2.3.3.3.2 Digital Interlock Logic (for Smart Motor Starters)

Digital interlock logic uses software programming for control. Programming can reside in the motor starter and/or in the PLC, but most commonly in the PLC. Digital interlock logic provides a way to bypass and test interlock conditions when troubleshooting, without opening the door of the motor starter, and it removes the requirement of using a licensed electrical contractor to evaluate discrete relay control wiring. Digital interlock logic uses a visual programming interface to view the controls which is often considered more intuitive than discrete wiring. The PLC, which handles the interlock logic has an average mean time between failures (MTBF) of 25-50 years, making it the most reliable piece of equipment in SCADA. Therefore, the assignment of process safety interlocks are given to the most reliable device.



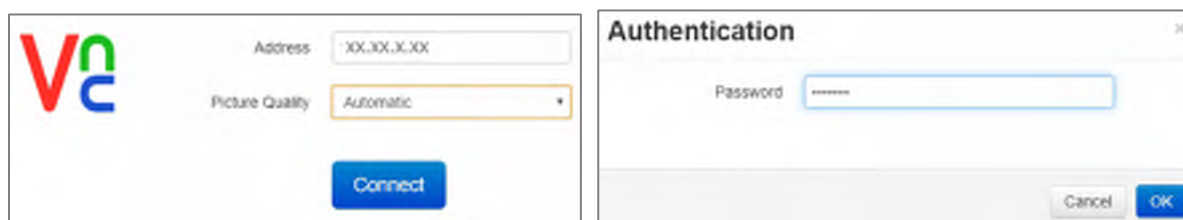
The Utility already standardizes on digital interlock logic and will continue to have all smart motor starters utilize the PLC-based process safety interlocks for process control and motor starting.

2.3.3.3.3 Remote Access to Touch Panel HMIs

The Siemens Comfort Series Touch Panel HMIs offer the ability for remote access viewing/commanding of the local station from an operator's work computer. This remote presence provides an additional method to remotely view or control a specific station in the water system, different from the SCADA visualization computer system, providing resiliency to the operability of the system. 'Read Only' or 'Read/Write' functionality are provided based upon a user's log-in credentials. Dual layer authentication

is required to gain viewing or command accessibility: 1) the VNC remote access connection requires a specific IP address as well as username/password for the 'computer to automation network tunnel', and 2) once the tunnel is authenticated, the Touch Panel HMI will require a different username/password to engage touch panel operation. This technology is offered as part of the touch panel HMI's standard features and provides a method of remote access without the need to purchase additional SCADA computer visualization system licenses.

The Utility recently standardized on utilizing remote access for touch panel HMIs, and will continue to utilize the technology and benefits.



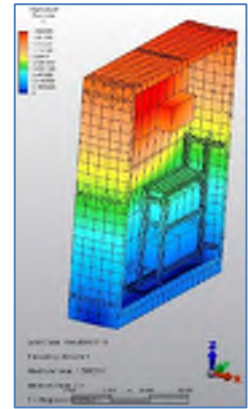
2.3.3.4 UL508A Control Panel Construction

The Utility currently subscribes to the industry standard of UL508A control panel construction and will maintain its alignment.

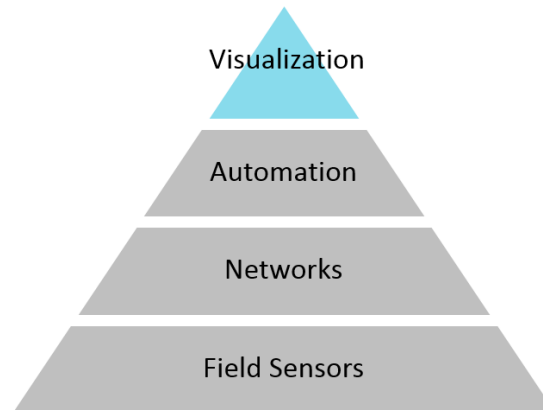
2.3.3.4.1 UL508A with Seismic Certification

UL508A does not consider seismic compliance part of its designation and the automation equipment mounted in the UL508A panels does not carry seismic certification (they do, however, typically carry vibration testing and certification). Therefore, a third-party ICC-ES AC-156 shake test is used to show compliance to Seismic Source International (ISS) standards. Results of the test include the required response spectrum (RRS) of a maximum flexible region (AFLEX) of 2.13g and a zero-period acceleration (ARIG) of 1.6g. Upon passing, an installation detail must be provided to ensure mounting of the control panel is also to ISS specifications.

The Utility has elected to elevate panel construction to seismically certified in addition to UL508A construction on a per-project basis. Only when the entire facility is built to seismic standards shall the associated control panel be seismically listed.

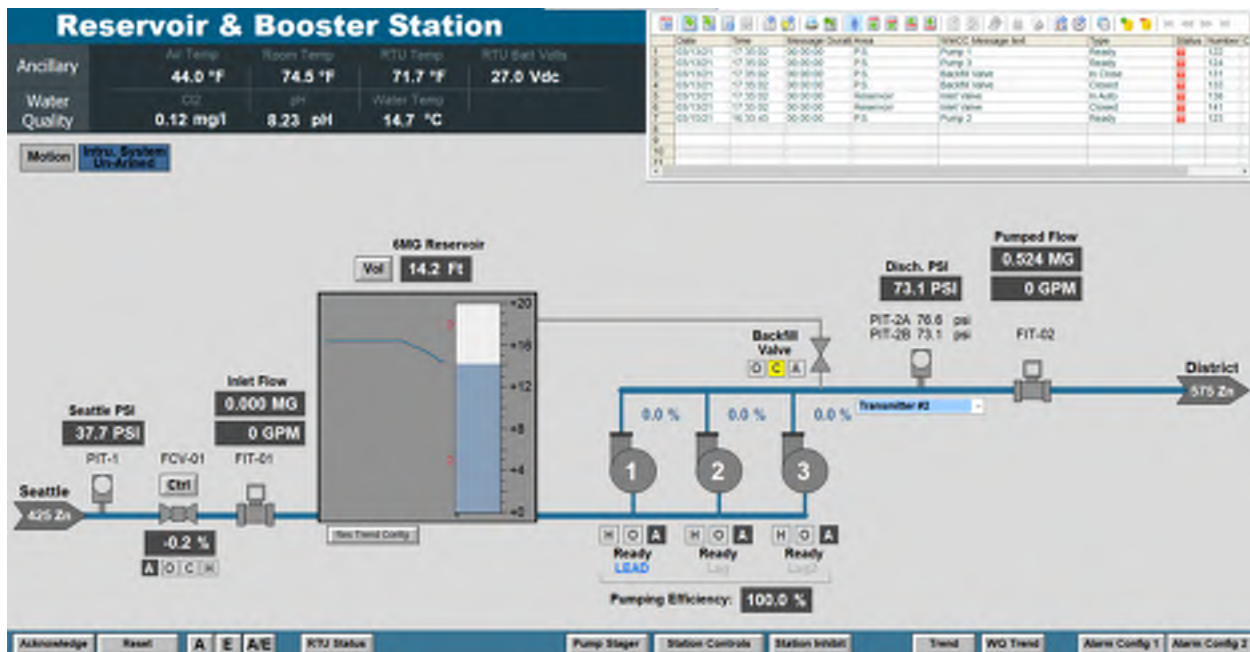


2.3.4 Computer Visualization Standards



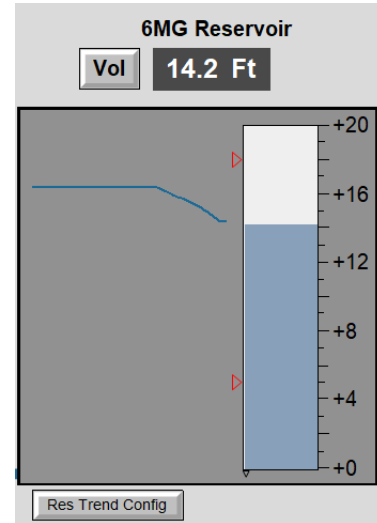
2.3.4.1 SCADA Process Control Screens

SCADA screens shall be process-control-oriented views, using simple symbols and lines, and void of 3D objects, multi-colored object pallets. This type of screen depiction follows the ISA101 SCADA visualization best practices which focuses on developing screens which concentrate on alerting the operations staff of abnormal and alarm conditions (i.e., an asset not in AUTO control), as opposed to normal conditions (i.e., pumps running, valves opening, etc.). The overall screen color pallets use Grey, white, and blue colors which are easier to view for longer periods of time and allow for distinct contrast to alarm/warning colors of red, yellow, and orange hues.

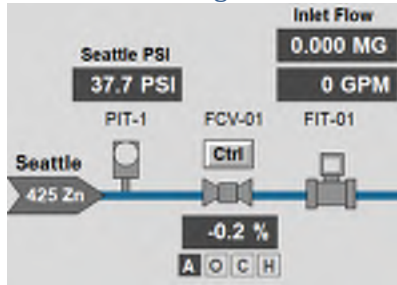


2.3.4.1.1 Reservoir Fill/Draw Context

A reservoir or tank shall have a built-in trend, to show the diurnal movement of the reservoir volume in relation to the level. This will help operators easily see if the tank is drawing down or filling up. The trend can be operator configured for any time range (1-hour, 12-hour, 24-hour, etc.). The reservoir level is also shown above the tank in dark grey with white letters. If reservoir volume is used, those values will be available via a pop-up window.

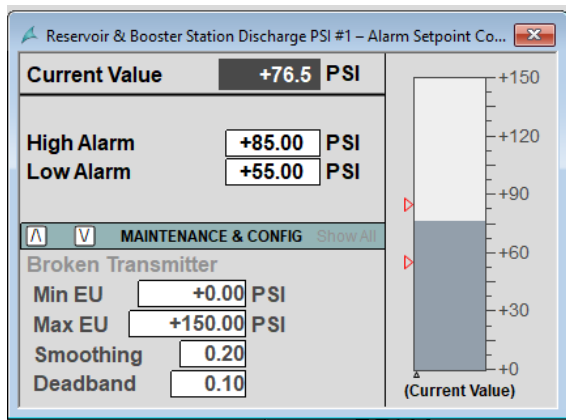


2.3.4.1.2 Analog Values



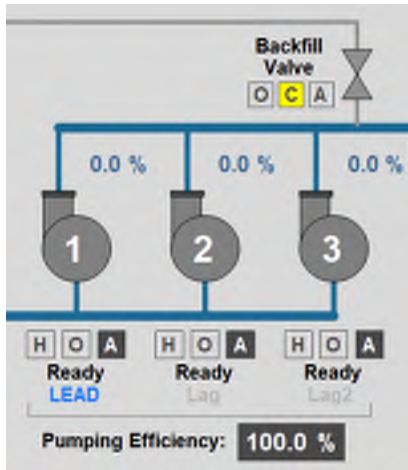
Key analog values shall be displayed in dark grey boxes with white letters for easy identification on screen. The background will turn red for an alarm condition for obvious alert to the operator(s). The grey boxes can be clicked to bring up the associated alarm configuration

2.3.4.1.3 Analog Value Alarm Setpoint Configuration



The grey boxes of an analog value shall be clicked to bring up the alarm setpoint configuration popup. The pop-up will show the associated HH,H,L,LL alarm setpoints which can be configured, as well as the configuration interface for the analog signal (so that the instrument can be turned thru the SCADA system). The pop-up shall feature a bar chart indication to visualize where the associated HH,H,L,LL alarm setpoints relative to a typical operating range and where the current value is reading. (In this example, the red triangles are showing the high and low setpoint of pressure).

2.3.4.1.4 HOA Switches



All HOA, AOCH, OCA type switches shall use a grey scale color scheme, such that any condition which is NOT Auto, will be identified in bright contrast color (i.e., red/orange/yellow) to alert an operator that the equipment is no longer automatically controlled by the PLC. The intent is to identify an abnormal condition to the operator.

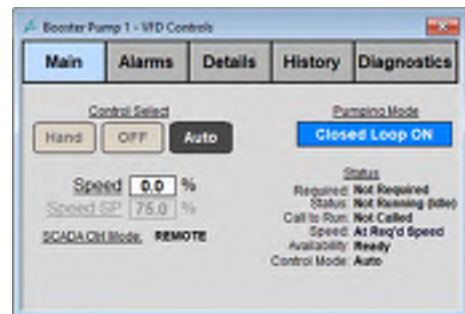
2.3.4.1.5 Key Performance Indicators (KPIs)

For each station, key performance indicators (KPIs) shall be shown in a dedicated KPI box on screen. These values are always shown on each station's process view screen so they are always viewable for the operators. In the example view, the KPI box is in dark grey below the station name.

Reservoir & Booster Station				
Ancillary	Air Temp 44.0 °F	Room Temp 74.3 °F	RTU Temp 71.7 °F	RTU Batt Volts 27.0 Vdc
Water Quality	CQ 0.12 mg/l	pH 8.23 pH	Water Temp 14.7 °C	

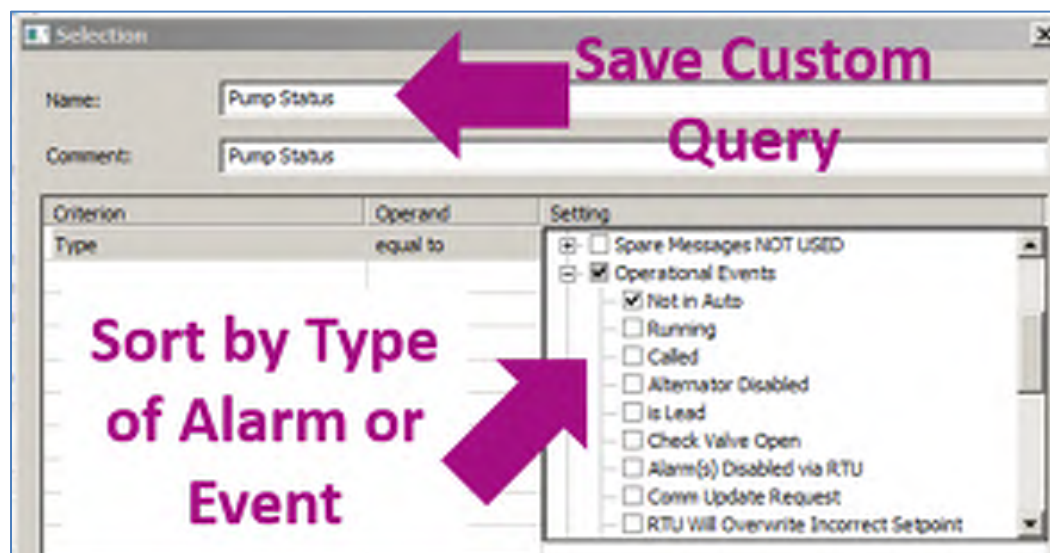
2.3.4.1.6 Tabbed Pop Ups

Pop-up controls for assets with lots of data values (e.g. VFDs, motor actuated valves, etc), shall use tabbed controls to reduce the pop-up size and provide better organization/navigation for the operators. In the example view, the "MAIN" tab of a VFD pop-up faceplate is selected.



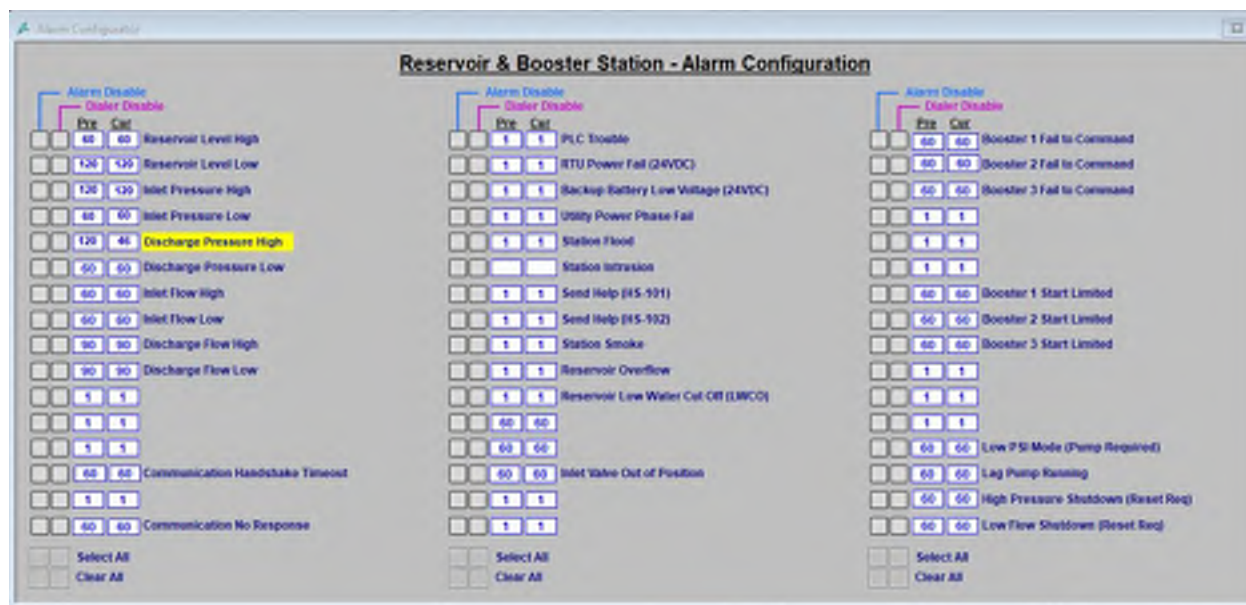
2.3.4.1.7 Alarms & Events Categorized in Database by Type

In addition to sorting alarms/events by the station, the SCADA system shall have alarms and events organized by type. This will allow operators to specifically query the database by a particular alarm/event type, like “not in auto” or “high-high” or “ajar”. These queries shall be capable of being saved and recalled at any time for fast use by the operations staff.



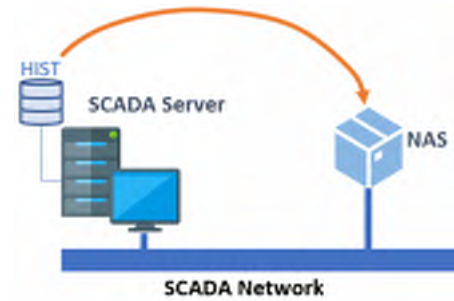
2.3.4.1.8 Alarms Delay Configurations

Alarms shall have individual, SCADA configurable, preset delays from the SCADA system classifying the state as an “alarm”, as well as a countdown of the current delay period when the PLC detects an alarm state. The preset and current delays will allow for the operations staff to configure alarm notifications based upon criticality. In the example view, the “discharge pressure high” alarm was detected by the PLC and had a preset delay value of 120 seconds, with 46 seconds remaining on the delay before the SCADA visualization system will alert the operator of an alarm condition).



2.3.4.2 Multiple Historized Data Storage Locations

SCADA data is archived for use by charting tools, reports, and alarm/event history tables. This data is extremely valuable as it is heavily relied upon for the operations staff to perform their duties and review historical events to understand how the process control system responded to field conditions. As a best practice, the historical SCADA data shall be stored in multiple locations for resiliency. Additional storage locations may be a network attached storage device (NAS), separate hard drive, separate computer, etc. These additional storage locations can be used as a backup file, or as an additional access point for a SCADA client computer to interact with SCADA archive data.



2.3.4.3 Reports using Historical SCADA Data

Historized SCADA data can be used as a data source for auto-generated SCADA reports. Reporting software is a standard software module most commonly provided as part of a SCADA computer visualization software bundle. Report templates are engineered per the Owner's request with templates used to automatically generate reports. Report generation cadence is typically daily, weekly and monthly, but the Owner can also run a set report at any time, even outside of the pre-set schedule. Reports can be formatted based on user need and can even be arranged to mimic Department of Health (DOH) report templates.

Common reports include:

- Pumped Water
- System Flow Summary
- Zone Flow Summary
- Water Quality Reports

The Consultant, S&B Inc, has selected the use of auto-generated reports with Excel and web-portal access capabilities. Reports will provide the Utility with context to thousands of historized data points, assisting staff to make informed decisions on normalized data. The auto generated reports are beneficial for cross-departmental use to improve the flow of data and assist in system planning efforts.

Month: **July-20**

WELL PUMPING REPORT
Daily Totals in Gallons (Gals)

July-2020	Well Pump Daily Total (MG)	Well Pump Daily Total (Gals)
1	16,078	16,078,000
2	15,593	15,593,000
3	17,351	17,351,000
4	16,887	16,887,000
5	17,941	17,941,000
6	17,845	17,845,000
7	17,227	17,227,000
8	17,395	17,395,000
9	17,233	17,233,000
10	18,072	18,072,000
11	16,574	16,574,000
12	18,132	18,132,000
13	17,469	17,469,000
14	18,175	18,175,000
15	17,189	17,189,000
16	16,849	16,849,000
17	18,588	18,588,000
18	17,373	17,373,000
19	19,831	19,831,000
20	15,100	15,100,000
21	17,218	17,218,000
22	17,605	17,605,000
23	16,677	16,677,000
24	20,063	20,063,000
25	17,765	17,765,000
26	17,739	17,739,000
27	19,667	19,667,000
28	18,200	18,200,000
29	17,904	17,904,000
30	17,634	17,634,000
31	18,970	18,970,000

2.3.4.4 Computer Architecture (General)

The SCADA visualization system will feature a dedicated "command center" computer with multiple monitors (and possibly the use of large-form factor, wall mounted units) for use by the entire water system staff, to provide a method to understand the current system conditions as well as more detailed view (station level or device level information). A reports computer (virtualized or physical) is used to operate the reporting environment, linking to the historical data sets, generating ad-hoc and auto-generated reports. This is the foundational requirements.

The SCADA software shall be scalable to accommodate both the Utility's operational needs of SCADA client access points (tablets, laptops, workstations, etc.), as well meet the City's IT governance and preferences, which may include the use of a SCADA Server.

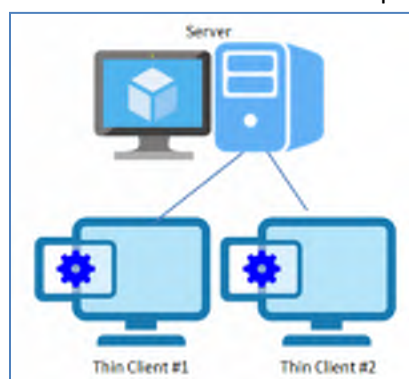


2.3.4.4.1 Thick Client

A thick client is a node running its own dedicated instance of SCADA visualization software locally. It can be in a workstation or in a client/server configuration. Thick client connections are acceptable, but if a Client-Server architecture is used, the only thick client shall be the SCADA server and reporting computer, which will reduce the software update burden for the Utility.

2.3.4.4.2 Thin Client

A thin client is a node running a “licensed session” of the SCADA visualization graphical user interface from a server where the server computer hosts the SCADA software program and performs all processing. If the thin client is web based the SCADA visualization can be viewed on the node's internet browser. Thin client can also utilize a terminal service session or a local application instance for visualization. Thin clients support a variety of devices (rugged, mobile, and non-hardware intensive) while being quickly and readily scalable to meet operational needs. Thin client viewing is capable of read-only and read/write functionality.



Thin client usage allows operations staff to access visualization on their own desktop, laptop computer or mobile device while in the field. Additional Utility staff or outside workgroups can also access SCADA reports, summary information or SCADA screens with read-only access (no SCADA control) from their own computers. Thin client viewing reduces IT maintenance as only the server computer(s) require software updates while client connections only require connection updates.

With increased flexibility in viewing data and a reduction in software maintenance efforts, if the Utility utilizes a Client-Server architecture, all clients shall be thin client types.

2.3.4.4.3 Mobile Client

SCADA visualization is offered in mobile specific app viewing platforms or HTML5 browsers on a mobile device. It is preferred to use an HTML5 browser view mode for mobile applications as it will avoid the Utility paying for a completely new, and parallel development of the thick/thin client development. (Mobile app viewing is a specifically engineered development, using a scaled down version of standard developments, designed for smaller screen size viewing).

Cell phones and ruggedized field tablets are common mobile device hardware used to view SCADA. They are especially popular for their ability to improve the operations staff's ability to make system adjustments away from a dedicated workstation computer. Mobile SCADA viewing allows for operational adjustments

in the field as well as both on and off-hours support of the SCADA system to acknowledge alarms or address operational anomalies.

Mobile access is an acceptable method to view SCADA screens. Remote Access must pass two layers username/password access points, and it is preferred that the wireless access be the Private APN cellular connection to ensure a public-facing network does not have access to the SCADA system.

Section 3 – Asset Inventory

3.1 Introduction

Section-3 is the assimilated inventory of key SCADA equipment. It represents the ‘current state’ of the City’s SCADA system. For this inventory assessment, the Consultant, S&B Inc, evaluates all the City’s water sites using telemetry and automated process control capability. The following sites/system were inventoried and documented in a standardized form output:

1. Master Telemetry Unit (includes Well 4 + Forked Horn Butte Booster #3)
2. Well 1 (site is slated to be abandoned in future)
3. Well 2
4. Well 3
5. Well 5
6. Antler Reservoir & Pump Station (site is slated to be abandoned in future)
7. Forked Horn Butte ‘Transfer Station’ (aka FHB #2 Res & PS)
8. Well 7 / Reservoir 6
9. Well 8 / Reservoir 7 / Booster 1A (Future Site to be Constructed)
10. Centennial Fountain
11. Water Dispensing Station
12. SCADA Visualization Computer System

3.2 Brief Summaries

3.2.1 Field Devices

3.2.1.1 Motor Starters

The City’s existing motor starters are comprised of VFDs, soft starts, and FVNR type units, each with varying years of expected life. The system was evaluated for the expect life remaining (measured in years) for each of the motor starters and their associated overload (OL) device. The format is ##/## for the associated MS/OL. VFDs have an integral overload and therefore are displayed in a ## format. Motor starters which are at or near end of life are highlighted in Red. The varying critically of these shortcomings will be explained in Section 4.

No.	Site	Well MS	MS#1	MS#2	MS#3	MS#4	MS#5	MS#6
1	MTU (Well 4 & FHB Bstr 3)	9	--	--	17	--	--	--
2	Well 2	14/9	--	--	--	--	--	--
3	Well 3	17	--	--	--	--	--	--
4	Well 5	4	--	--	--	--	--	--
5	Well 6 & Reservoirs	25/20	18/4	25/20	--	--	--	--
6	Well 7 & Reservoir #6	11/6	16	21/16	21/16	11/6	16/6	16/6
7	Well 8 Res 7 Booster 1A	20	20	20	20	20	20	20
8	FHB Transfer Station	--	9	13	--	--	--	--
9	FHB Water Pump Station	--	17	-3	-3	-3	-3	--
10	Water Dispensing Station	--	--	--	--	--	--	--
11	Centennial Fountain	--	--	--	--	--	--	--

Note: The Well 1 and Antler Res/PS sites are to be abandoned, therefore, inventories were not listed.

3.2.1.2 Instrumentation

The evaluation focused on core instrumentation at each of the City's existing facilities: level, pressure, flow, and water quality devices. A few field devices require replacement based upon product lifecycle or observed performance issues, and some field devices should be added to meet improved operations. Shortcomings are highlighted in Red. The varying critically of these shortcomings will be explained in Section 4.

No.	Site	Res. Level Device	Well Level Device	Flow	Pressure	Water Quality
1	MTU (Well 4 & FHB Bstr 3)	--	Probe	3 meters	Xmtr (2x)	none
2	Well 2	--	Probe	Mag Meter	Xmtr	CL2
3	Well 3	--	Probe	Mag Meter	Xmtr	none
4	Well 5	--	Probe	Mag Meter	Xmtr	none
5	Well 6 & Reservoirs	Probe (2x)	Probe	2 meters	Xmtr	CL2
6	Well 7 & Reservoir #6	PSI Xmtr (2x)	Probe	2 meters	Xmtr	CL2
7	Well 8 Res 7 Booster 1A	--	Probe	2 meters	Xmtr (3x)	CL2 + pH
8	FHB Transfer Station	PSI Xmtr & Probe	--	--	Xmtr (2x)	--
9	FHB Water Pump Station	--	--	Mag Meter	Xmtr (2x)	CL2 + pH
10	Water Dispensing Station	--	--	Pulse Meter	--	--
11	Centennial Fountain	Probe	--	--	--	CL2 + pH

Note: The Well 1 and Antler Res/PS sites are to be abandoned, therefore, inventories were not listed.

3.2.2 Networks

The City's existing network / communication system's current state has recently migrated from analog leased line to cellular. Almost the entire system has been moved, but a few stations remain on older technology. Shortcomings are highlighted in Red. The varying critically of these shortcomings will be explained in Section 4.

No.	Site	4G Cellular Private APN	Analog Leased Line	VPN Appliance	Hybrid Communication Overlay
1	MTU (Well 4 & FHB Bstr 3)	Yes (dual path)	--	Yes	--
2	Well 2	Yes	--	--	No
3	Well 3	Yes	--	--	No
4	Well 5	Yes	--	--	No
5	Well 6 & Reservoirs	Yes	--	--	No

6	Well 7 & Reservoir #6	Yes	--	--	No
7	Well 8 Res 7 Booster 1A	Yes	--	--	No
8	FHB Transfer Station	No	Yes	--	No
9	FHB Water Pump Station	No	n/a	--	No
10	Water Dispensing Station	--	--	--	n/a
11	Centennial Fountain	Yes	No	--	n/a

Note: The Well 1 and Antler Res/PS sites are to be abandoned, and were not listed. But both are 24 years old, and use analog leased lines for telemetry communication.

3.2.3 Automation

The City's existing SCADA automation's current state has several processors and HMIs which are either technologically obsolete or have reached "mature" status – where they are no longer supported by the manufacturer. Shortcomings are highlighted in Red. The varying critically of these shortcomings will be explained in Section 4.

No.	Site	Age	Technological Obsolescence	Mature Status	Supports Current TIAPortal Software
1	MTU (Well 4 & FHB Bstr 3)	1	No	No	Yes
2	Well 2	11	Yes (HMI)	No	No
3	Well 3	3	No	No	Yes
4	Well 5	7	No	No	Yes
5	Well 6 & Reservoirs	16	Yes (HMI)	No	No
6	Well 7 & Reservoir #6	4	No	No	Yes
7	Well 8 Res 7 Booster 1A	0	No	No	Yes
8	FHB Transfer Station	20	Yes	Yes	No
9	FHB Water Pump Station	16	Yes	No	No
10	Water Dispensing Station	25	Yes	Yes	No
11	Centennial Fountain	11	Yes (HMI)	No	No (HMI)

Note: The Well 1 and Antler Res/PS sites are to be abandoned, and were not listed. But both are 24 years old, and are technologically obsolescent, have mature equipment, and do not support the TIAPortal software.

3.2.4 Visualization

The City's existing SCADA visualization system is made up of both hardware and software. Some aspects of the system have reached technological obsolescence, "mature" status – where they are no longer supported by the manufacturer, or end of life. Shortcomings are highlighted in Red. The varying critically of these shortcomings will be explained in Section 4.

No.	Component of Visualization	Age	Years since last engineering	version
1	Computer Hardware (2x)	4	--	No
2	Operating System (2x)	4	--	MS Windows 10
3	SCADA Software (2x)	4	9	Siemens WinCC v7.4.1.2 2048 tag count, runtime
4	Reporting Software	4	9	Siemens Data Monitor v7.0
5	Alarm Notification	4	--	Win911 v7.14 (W07121206019C0D)

3.3 Itemized Asset Inventory Forms

(see the following pages for the itemized asset inventory forms)

(Cells in red represent deficiencies which must be addressed)

Note: The Well 1 and Antler Res/PS sites are to be abandoned, therefore, inventories were not compiled.

3.3.1 Well 2

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Well 2	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	Yes
Pump Station	--	Pressure Control	--
Well	Yes	Flow Control	--
PRV	--	Chemical Dosing Control	Flow Paced
Chemical Feed	Yes (CL2)	Remote Control Capability	Yes
Water Treatment Facility	--	Pumping Efficiency	Yes
Supplies Closed Zone	No	Digital Processed Interlocks	Yes
Station Criticality Rating	Moderate		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	24"H x 24"W x 10"D	Maximum Allowed Downtime per Day	TBD
Enclosure NEMA	12	Current WAN Media	Cellular (4G)
IO Count	11DI-1DO-8AI-1DP	Requires Dual Path	No
Comm. Processors	Cellular + Profibus	Primary Media	Verizon Private APN Cellular
PLC	Siemens IM151-8	Secondary Media	(not required)
I/O Form Factor	Siemens ET200S	Cellular Strength (indoor)	(unknown)
HMI	Siemens TP177-B (6")	Cellular Strength (outdoor)	(unknown)
Network Switch	None	VPN Appliance	(not required)
PLC Status	Good	Hybrid Communication	Required
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	• FHB Transfer Station
PLC is Capable of 2 NIC	No		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2010		
RTU Age	11 years old		
FUTURE Replacement RTU Information			
Model Number	D-16DI-8DO-12AI-DP-TP12-C-1	Comm. Media #1	Verizon Private APN Cellular
Replacement Method	Complete RTU	Comm. Media #2	(not required)
Enclosure Size	36x30x12	Hybrid Communication	Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	FHB Transfer Station
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	Yes (Siemens TIAStar)	SPD	none
Stand-Alone Drives	n/a	Power Meter.	none
Motor Starter Panels	n/a	Power Monitor Relay	none
Discrete Starters	n/a		

Smart Motor Starters	1		
VFD	--		
RVSS	300HP (1x)		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	Simocode		
Motor Starter #1 Details		Pump #1 Details	
MS#1 Type	RVSS	Pump 1 Type	(unknown)
MS#1 Model.	Siemens 3RW4446-6BC35	Pump 1 Model #	(unknown)
MS#1 Size	300HP	Pump 1 Sizing	(unknown)
MS#1 Protocol	Profibus DP		
MS#1 Overload	Simocode Pro V		
MS#1 Startup Year	2013		
Field Equipment			
Typical Instrumentation		Water Quality	
Res Level Sensor	--	pH	No – best to have active pH correction with CL2
Well Level Sensor	PMC MTM3213 (400/10ft cable, 0-50PSI)	CL2	Yes
Flow Meter	1" Mag Meter	Fluoride	--
Chemical Flow Meter	Yes	Turbidity	--
Suction PSI	Well Level	Conductivity	--
Discharge PSI	Siemens Sitrans P (0-150PSI)	Dissolved Oxygen	--
Additional PSI	--	CL2 Feed	Yes (1 pump)
Redundant PSI	No	Fluoride Feed	--
Control Valves	1		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	Yes
		ATS	Yes
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.2 Well 3

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Well 3	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	Yes
Pump Station	--	Pressure Control	--
Well	Yes	Flow Control	--
PRV	--	Chemical Dosing Control	Flow Paced
Chemical Feed	Yes (CL2)	Remote Control Capability	Yes
Water Treatment Facility	--	Pumping Efficiency	No
Supplies Closed Zone	No	Digital Processed Interlocks	Yes
Station Criticality Rating	Moderate		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	30"H x 24"W x 12"D	Maximum Allowed Downtime per Day	TBD
Enclosure NEMA	12	Current WAN Media	Cellular (4G)
IO Count	16DI-6DO-3AI	Requires Dual Path	No
Comm. Processors	Cellular	Primary Media	Verizon Private APN Cellular
PLC	Siemens S7-1512SP-1	Secondary Media	(not required)
I/O Form Factor	Siemens ET200SP	Cellular Strength (indoor)	(unknown)
HMI	Siemens TP-700	Cellular Strength (outdoor)	(unknown)
Network Switch	Scalance	VPN Appliance	(not required)
PLC Status	Good	Hybrid Communication	Required
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	• FHB Transfer Station
PLC is Capable of 2 NIC	Yes		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2018		
RTU Age	3 years old		
FUTURE Replacement RTU Information			
Model Number	C-24DI-8DO-8AI-TP12-C-1	Comm. Media #1	Verizon Private APN Cellular
Replacement Method	Back Panel Replacement	Comm. Media #2	(not required)
Enclosure Size	30x24x12	Hybrid Communication	Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	FHB Transfer Station
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	Yes (Eaton)	SPD	none
Stand-Alone Drives	n/a	Power Meter.	none
Motor Starter Panels	RVSS (30"H x 36"W x 16"D)	Power Monitor Relay	none
Discrete Starters	n/a		

Smart Motor Starters	1		
VFD	--		
RVSS	200HP (1x)		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	(none)		
Motor Starter #1 Details		Pump #1 Details	
MS#1 Type	RVSS	Pump 1 Type	(unknown)
MS#1 Model.	Siemens 3RW44	Pump 1 Model #	(unknown)
MS#1 Size	200HP	Pump 1 Sizing	(unknown)
MS#1 Protocol	Profinet		
MS#1 Overload	none		
MS#1 Startup Year	2010		
Field Equipment			
Typical Instrumentation		Water Quality	
Res Level Sensor	--	pH	No
Well Level Sensor	PMC MTM3213 (472/2ft cable, 0-60PSI)	CL2	No
Flow Meter	6" Mag Meter	Fluoride	--
Chemical Flow Meter	Yes	Turbidity	--
Suction PSI	Well Level	Conductivity	--
Discharge PSI	Siemens Sitrans P (0-150PSI)	Dissolved Oxygen	--
Additional PSI	--	CL2 Feed	Yes (1 pump)
Redundant PSI	No	Fluoride Feed	--
Control Valves	1		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	Yes
		ATS	Yes
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.3 MTU (Well 4 & FHB Booster #3)

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	MTU (Well 4 & FHB Bstr 3)	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	Yes (Well)
Pump Station	Yes	Pressure Control	Yes (Booster Pump #3)
Well	Yes	Flow Control	--
PRV	--	Chemical Dosing Control	--
Chemical Feed	Yes (CL2)	Remote Control Capability	Yes
Water Treatment Facility	--	Pumping Efficiency	Yes
Supplies Closed Zone	Supports WPS to Zn 1	Digital Processed Interlocks	Yes
Station Criticality Rating	High		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	72"H x 72"W x 18"D	Maximum Allowed Downtime per Day	0 Hrs
Enclosure NEMA	12	Current WAN Media	Cellular (4G) & Leased Lines
IO Count	22DI-10DO-7AI	Requires Dual Path	Yes
Comm. Processors	Cellular	Primary Media	FortiGate VPN & TNIS
PLC	Siemens S7-1512SP-1 & Siemens IM151-8	Secondary Media	Verizon Private APN Cellular
I/O Form Factor	Siemens ET200S (via RIO)	Cellular Strength (indoor)	(unknown)
HMI	None (uses WinCC SCADA)	Cellular Strength (outdoor)	(unknown)
Network Switch	Scalance	VPN Appliance	Fortigate 60E
PLC Status	Good	Hybrid Communication	Not required
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	(serves as comm. hub)
PLC is Capable of 2 NIC	Yes		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2020 (S7-1512 PLC)		
RTU Age	1 years old (PLC)		
FUTURE Replacement RTU Information			
Model Number	F-32DI-16DO-12AI-TP12-C-0	Comm. Media #1	Verizon Private APN Cellular
Replacement Method	Back Panel Replacement	Comm. Media #2	(FUTURE)
Enclosure Size	72x36x12	Hybrid Communication	Not Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	(serves as comm. hub)
I/O Form Factor	ET-200SP	Gel-Cell Batteries	38Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	--	SPD	none
Stand-Alone Drives	2	Power Meter.	none
Motor Starter Panels	--	Power Monitor Relay	none

Discrete Starters	--		
Smart Motor Starters	2		
VFD	2		
RVSS			
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Well 4 Motor Starter Details		Well 4 Pump Details	
MS Type	Siemens G150A VFD	Pump Type	(unknown)
MS Model.	6SL3710-1GE37-5AU0-Z +M23+M06+M90+M39+U90+N70+D02	Pump Model #	(unknown)
MS Size	600HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2010		
Motor Starter #1 Details		Pump #1 Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	125HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2018		
Field Equipment			
Typical Instrumentation		Water Quality	
Res Level Sensor	--	pH	No
Well Level Sensor	KPSI 330S (570ft cable, 0-86.693 PSI)	CL2	No
Flow Meter 1 (Well)	12" Siemens Mag5100W	Fluoride	--
FM2 (Well Pre-Lube)	12" Siemens Mag5100W		
Flow Meter 2 (Booster)	Omni R2		
Chemical Flow Meter	No	Turbidity	--
Suction PSI	Well Level	Conductivity	--
Discharge PSI (Well)	ABB Xmtr (0-200PSI)	Dissolved Oxygen	--
Discharge PSI (Bstr)	Siemens Sitrans P (0-150PSI)	CL2 Feed	--
Redundant PSI	No	Fluoride Feed	--
Control Valves	2 (Well & Pre-Lube)		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	2 (but undersized Well GenSet)
		ATS	Yes
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.4 Well 5

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Well 5	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	Yes
Pump Station	--	Pressure Control	--
Well	Yes	Flow Control	--
PRV	--	Chemical Dosing Control	Flow Paced
Chemical Feed	Yes (CL2)	Remote Control Capability	Yes
Water Treatment Facility	--	Pumping Efficiency	Yes
Supplies Closed Zone	No	Digital Processed Interlocks	Yes
Station Criticality Rating	Moderate		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	90"H x 24"W x 20"D	Maximum Allowed Downtime per Day	TBD
Enclosure NEMA	12	Current WAN Media	Cellular (4G)
IO Count	16DI-6DO-3AI	Requires Dual Path	No
Comm. Processors	Cellular + Profibus DP	Primary Media	Verizon Private APN Cellular
PLC	Siemens IM151-8	Secondary Media	(not required)
I/O Form Factor	Siemens ET200S	Cellular Strength (indoor)	(unknown)
HMI	Siemens TP-700	Cellular Strength (outdoor)	(unknown)
Network Switch	Scalance	VPN Appliance	(not required)
PLC Status	Good	Hybrid Communication	Required
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	• FHB Transfer Station
PLC is Capable of 2 NIC	No		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2014		
RTU Age	7 years old		
FUTURE Replacement RTU Information			
Model Number	G-32DI-16DO-12AI-DP-TP12-C-1	Comm. Media #1	Verizon Private APN Cellular
Replacement Method	Back Panel Replacement	Comm. Media #2	(not required)
Enclosure Size	90x24x20	Hybrid Communication	Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	FHB Transfer Station
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	--	SPD	none
Stand-Alone Drives	G150A (1x)	Power Meter.	(using power profile of drive)
Motor Starter Panels	--	Power Monitor Relay	none
Discrete Starters	--		

Smart Motor Starters	1		
VFD	600HP (1x)		
RVSS	--		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Motor Starter #1 Details		Pump #1 Details	
MS#1 Type	VFD	Pump 1 Type	(unknown)
MS#1 Model.	Siemens G150A	Pump 1 Model #	(unknown)
MS#1 Size	600HP	Pump 1 Sizing	(unknown)
MS#1 Protocol	Profibus		
MS#1 Overload	(integral to drive)		
MS#1 Startup Year	2005		
Field Equipment			
Typical Instrumentation		Water Quality	
Res Level Sensor	--	pH	No – best to have active pH correction with CL2
Well Level Sensor	Druck PTX (305ft cable, 0-20PSI)	CL2	No
Flow Meter	12" Mag Meter	Fluoride	--
Chemical Flow Meter	No	Turbidity	--
Suction PSI	Well Level	Conductivity	--
Discharge PSI	Siemens Sitrans P (0-200PSI)	Dissolved Oxygen	--
Additional PSI	--	CL2 Feed	Yes (1 pump)
Redundant PSI	No	Fluoride Feed	--
Control Valves	1		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	Yes
		ATS	Yes
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.5 Well 6 & Reservoirs

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Well 6 + Reservoirs		SCADA Inventory Field Audit	
			Project.	SCADA Asset Inventory
			Inspection Date	April 2021
			Inspector(s)	JRS
			By: S&B Inc	
Facility Information				
Facility Attributes		Process Control Functionality		
Reservoir	2 (2MG each)	Level Control	Yes (Well 6)	
Pump Station	Yes (2 pumps)	Pressure Control	Yes (Booster Station)	
Well	Yes	Flow Control	--	
PRV	--	Chemical Dosing Control	Flow Paced	
Chemical Feed	Yes	Remote Control Capability	Yes	
Water Treatment Facility	--	Pumping Efficiency	Yes	
Supplies Closed Zone	No	Digital Processed Interlocks	Yes	
Station Criticality Rating	Moderate			
Pressure Zone(s)				
RTU Information				
Existing RTU		Communication		
Existing Enclosure Size	60"H x 20"W (MCC Mount)	Maximum Allowed Downtime per Day	TBD	
Enclosure NEMA	1	Current WAN Media	Cellular (4G)	
IO Count	35DI-23DO-12AI-4DP	Requires Dual Path	No	
Comm. Processors	Cellular + Profibus DP	Primary Media	Verizon Private APN Cellular	
PLC	Siemens S7-314-2DP	Secondary Media	(not required)	
I/O Form Factor	Siemens S7300	Cellular Strength (indoor)	(unknown)	
HMI	Siemens TP-177B	Cellular Strength (outdoor)	(unknown)	
Network Switch	Scalance	VPN Appliance	(not required)	
PLC Status	Good	Hybrid Communication	Required	
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	• FHB Transfer Station	
PLC is Capable of 2 NIC	No			
Backup Power Type	DC			
Backup Power Size	7Ah battery, 4x			
Backup Power Time	~12 hours			
RTU Install Year	2005			
RTU Age	16 years old			
FUTURE Replacement RTU Information				
Model Number	X60MCC-48DI-32O-16AI-DP-TP12-C-1	Comm. Media #1	Verizon Private APN Cellular	
Replacement Method	Back Panel Replacement	Comm. Media #2	(not required)	
Enclosure Size	60x20 Recessed Hat (MCC Mount)	Hybrid Communication	Required	
PLC	Siemens S7-1512SP-1	Station Inter-Communication	FHB Transfer Station	
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)	
HMI	12" Touch Panel			
Network Switch	8-Port, Managed			
Motor Control				
Motor Control Infrastructure		Ancillary Power Infrastructure		
Motor Control Center	Siemens TIAstar	SPD	none	
Stand-Alone Drives	--	Power Meter.	9300	
Motor Starter Panels	--	Power Monitor Relay	none	

Discrete Starters	--		
Smart Motor Starters	3		
VFD	--		
RVSS	3		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	Simocode Pro V (3)		
Well #6 Motor Starter Details		Well #6 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW55	Pump Model #	(unknown)
MS Size	300HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2021		
Booster #1 Motor Starter Details		Booster #1 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW44	Pump Model #	(unknown)
MS Size	150HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2016		
Booster #2 Motor Starter Details		Booster #2 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW55	Pump Model #	(unknown)
MS Size	150HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2021		
Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	KPSI 330S (40ft cable, 0-15PSI span)	pH	Yes
Res #2 Level Sensor	KPSI 330S (40ft cable, 0-15PSI span)	CL2	Yes
Well Level Sensor	Druck PTX (420ft cable, 0-50PSI)	Fluoride	--
Flow Meter (Well)	12" Mag Meter	Turbidity	--
Flow Meter (Boosters)	12" Mag Meter	Conductivity	--
Chemical Flow Meter	No	Dissolved Oxygen	--
Suction PSI	Well Level & Res Levels	CL2 Feed	Yes (2 pumps)
Discharge PSI	Siemens Sitrans P (0-200PSI)	Fluoride Feed	--
Additional PSI	--	Sample #1	Well
Redundant PSI	No	Sample #2	Tank Outlet
Control Valves	4	Sample #3	Distribution
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	Yes
		ATS	Yes (ASCO 7000)
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.6 Well 7, Reservoir, and Boosters

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Well 7 + Reservoir + Boosters		SCADA Inventory Field Audit	
			Project.	SCADA Asset Inventory
			Inspection Date	April 2021
			Inspector(s)	JRS
By: S&B Inc 				
Facility Information				
Facility Attributes		Process Control Functionality		
Reservoir	Yes (3.5MG)	Level Control	Yes (Well 7 & Boosters)	
Pump Station	Yes (4 pumps)	Pressure Control	Yes (Booster Station)	
Well	Yes	Flow Control	--	
PRV	--	Chemical Dosing Control	Flow Paced	
Chemical Feed	Yes (2 pumps)	Remote Control Capability	Yes	
Water Treatment Facility	--	Pumping Efficiency	Yes	
Supplies Closed Zone	No	Digital Processed Interlocks	Yes	
Station Criticality Rating	Moderate			
Pressure Zone(s)				
RTU Information				
Existing RTU		Communication		
Existing Enclosure Size	72"H x 20"W (MCC Mount)	Maximum Allowed Downtime per Day	TBD	
Enclosure NEMA	1	Current WAN Media	Cellular (4G)	
IO Count	35DI-28DO-16AI-2AO-4DP-4PN	Requires Dual Path	No	
Comm. Processors	Cellular + Profibus DP	Primary Media	Verizon Private APN Cellular	
PLC	Siemens S7-314-2PN/DP	Secondary Media	(not required)	
I/O Form Factor	Siemens S7300 + ET200S	Cellular Strength (indoor)	(unknown)	
HMI	Siemens TP-700 (2x)	Cellular Strength (outdoor)	(unknown)	
Network Switch	Scalance	VPN Appliance	(not required)	
PLC Status	Good	Hybrid Communication	Required	
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	• FHB Transfer Station	
PLC is Capable of 2 NIC	No			
Backup Power Type	DC			
Backup Power Size	7Ah battery, 2x			
Backup Power Time	~6 hours			
RTU Install Year	2017 (PLC) / 2007(RTU)			
RTU Age	4 years old / 14 years old			
FUTURE Replacement RTU Information				
Model Number	X72MCC-48DI-400-20AI-4AO-DP-TP12-C-1	Comm. Media #1	Verizon Private APN Cellular	
Replacement Method	Back Panel Replacement	Comm. Media #2	(not required)	
Enclosure Size	72x20 Recessed Hat (MCC Mount)	Hybrid Communication	Required	
PLC	Siemens S7-1512SP-1	Station Inter-Communication	FHB Transfer Station	
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)	
HMI	12" Touch Panel			
Network Switch	8-Port, Managed			
Motor Control				
Motor Control Infrastructure		Ancillary Power Infrastructure		
Motor Control Center	Siemens TIAstar	SPD	none	
Stand-Alone Drives	--	Power Meter.	9300 (mounted in SWBD)	
Motor Starter Panels	--	Power Monitor Relay	none	

Discrete Starters	--		
Smart Motor Starters	7		
VFD	50HP (1x)		
RVSS	300HP (well), 50HP (booster 3x)		
FVNR	2HP (2x)		
Auto-Transformer	--		
Smart Overload Device	Simocode Pro V		
Well #7 Motor Starter Details		Well #6 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW40	Pump Model #	(unknown)
MS Size	300HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2007		
Booster #1 Motor Starter Details		Booster #1 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	50HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2017		
Booster #2 Motor Starter Details		Booster #2 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW44	Pump Model #	(unknown)
MS Size	50HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2017		
Booster #3 Motor Starter Details		Booster #3 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW44	Pump Model #	(unknown)
MS Size	50HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2017		
Booster #4 Motor Starter Details		Booster #4 Pump Details	
MS Type	RVSS	Pump Type	(unknown)
MS Model.	Siemens 3RW44	Pump Model #	(unknown)
MS Size	50HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2017		
Chlorine Booster #1 Motor Starter Details		Chlorine Booster #1 Pump Details	
MS Type	FVNR	Pump Type	(unknown)
MS Model.	Siemens Class 14	Pump Model #	(unknown)
MS Size	2HP	Pump Sizing	(unknown)
MS Protocol	Profibus (via Simocode)		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2007		
Chlorine Booster #2 Motor Starter Details		Chlorine Booster #2 Pump Details	
MS Type	FVNR	Pump Type	(unknown)
MS Model.	Siemens Class 14	Pump Model #	(unknown)
MS Size	2HP	Pump Sizing	(unknown)
MS Protocol	Profibus (via Simocode)		
MS Overload	Simocode Pro V (Profibus)		
MS Startup Year	2007		

Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	Siemens Sitrans P (0-xxxPSI)	pH	Yes
Res #2 Level Sensor	Siemens Sitrans P (0-xxxPSI)	CL2	Yes
Well Level Sensor	KPSI 330S (550ft cable, 0-100PSI)	Fluoride	--
Flow Meter (Well)	12" Siemens Mag5100W	Turbidity	--
Flow Meter (Boosters)	16" Siemens Mag5100W	Conductivity	--
Chemical Flow Meter	No	Dissolved Oxygen	--
Suction PSI	Well Level & Res Levels	CL2 Feed	Yes (2 pumps)
Discharge PSI	Siemens Sitrans P (0-200PSI)	Fluoride Feed	--
Additional PSI	--	Temperature	Yes
Redundant PSI	No		
Control Valves	5		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	Yes
		ATS	Yes
Notes			
City does not use the CL2 Boosters now that the well pumps into the Res (and not directly into distribution).			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.7 Well 8, Reservoir 7, and Booster 1A

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Well 8 + Reservoir 7 + Booster 1A		SCADA Inventory Field Audit	
			Project.	SCADA Asset Inventory
			Inspection Date	April 2021
		Inspector(s)	JRS	
		By: S&B Inc		
Facility Information				
Facility Attributes		Process Control Functionality		
Reservoir	1	Level Control	Yes (Well 8)	
Pump Station	Yes (6 pumps)	Pressure Control	Yes (Booster Station)	
Well	Yes	Flow Control	--	
PRV	--	Chemical Dosing Control	Flow Paced	
Chemical Feed	Yes (2 pumps)	Remote Control Capability	Yes	
Water Treatment Facility	--	Pumping Efficiency	Yes	
Supplies Closed Zone	No	Digital Processed Interlocks	Yes	
Station Criticality Rating	Moderate			
Pressure Zone(s)				
RTU Information				
Existing RTU		Communication		
Existing Enclosure Size	90"H x 24"W x 20"D	Maximum Allowed Downtime per Day	TBD	
Enclosure NEMA	1	Current WAN Media	Cellular (4G)	
IO Count	43DI-28DO-32AI-25AO-2DP-12PN	Requires Dual Path	No	
Comm. Processors	Cellular + Profibus DP	Primary Media	Verizon Private APN Cellular	
PLC	Siemens S7-1512SP-1	Secondary Media	(not required)	
I/O Form Factor	Siemens ET200SP	Cellular Strength (indoor)	(unknown)	
HMI	Siemens TP-1200	Cellular Strength (outdoor)	(unknown)	
Network Switch	Scalance	VPN Appliance	(not required)	
PLC Status	Good	Hybrid Communication	Required	
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	• FHB Transfer Station	
PLC is Capable of 2 NIC	No			
Backup Power Type	DC			
Backup Power Size	12Ah battery, 2x			
Backup Power Time	~6 hours			
RTU Install Year	2021 (soon to be installed)			
RTU Age	0 years			
FUTURE Replacement RTU Information				
Model Number	G-48DI-32O-32AI-4AO-DP-TP12-C-1	Comm. Media #1	Verizon Private APN Cellular	
Replacement Method	Complete RTU	Comm. Media #2	(not required)	
Enclosure Size	90x24x20	Hybrid Communication	Required	
PLC	Siemens S7-1512SP-1	Station Inter-Communication	FHB Transfer Station	
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)	
HMI	12" Touch Panel			
Network Switch	8-Port, Managed			
Motor Control				
Motor Control Infrastructure		Ancillary Power Infrastructure		
Motor Control Center	Siemens TIAstar	SPD	none	
Stand-Alone Drives	W150CP (700HP, 18-pulse)	Power Meter.	(using power profile of drive)	
Motor Starter Panels	--	Power Monitor Relay	none	

Discrete Starters	--		
Smart Motor Starters	7		
VFD	7		
RVSS	--		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Well #8 Motor Starter Details		Well #6 Pump Details	
MS Type	W150CP (700HP, 18-pulse)	Pump Type	(unknown)
MS Model.	6SL3710-3GJ41-0AS3	Pump Model #	(unknown)
MS Size	700HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		
Booster #1 Motor Starter Details		Booster #1 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	15HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		
Booster #2 Motor Starter Details		Booster #2 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	15HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		
Booster #3 Motor Starter Details		Booster #3 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	75HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		
Booster #4 Motor Starter Details		Booster #4 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	75HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		
Booster #5 Motor Starter Details		Booster #5 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	150HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		
Booster #6 Motor Starter Details		Booster #6 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	150HP	Pump Sizing	(unknown)
MS Protocol	Profinet		
MS Overload	(integral to drive)		
MS Startup Year	2021 (to be installed)		

Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	KPSI 330S (40ft cable, 0-10PSI)	pH	Yes
Well Level Sensor	Keller Microbore (620ft cable, 0-60PSI)	CL2	Yes
Flow Meter (Well)	12" Siemens Mag5100W	Fluoride	--
Flow Meter (Boosters)	18" Siemens Mag5100W	Turbidity	--
Chemical Flow Meter	No	Conductivity	--
Suction PSI	Siemens Sitrans P (0-150PSI)	Dissolved Oxygen	--
Discharge PSI 1 (Zn 1A)	Siemens Sitrans P (0-150PSI)	CL2 Feed	Yes (2 pumps)
Discharge PSI 2 (Zn 1A)	Siemens Sitrans P (0-200PSI)	Fluoride Feed	--
Suction PSI (Booster)	Siemens Sitrans P (0-50PSI)		
Redundant PSI	Yes (Booster Discharge)		
Control Valves	5		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	Yes
		ATS	Yes
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.8 Forked Horne Butte – Transfer Station

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	FHB Transfer Stn.	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	2 (2MG each)	Level Control	Yes
Pump Station	Yes	Pressure Control	--
Well	--	Flow Control	--
PRV	--	Chemical Dosing Control	--
Chemical Feed	--	Remote Control Capability	Yes
Water Treatment Facility	--	Pumping Efficiency	Yes
Supplies Closed Zone	No	Digital Processed Interlocks	Yes
Station Criticality Rating	High		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	42"H x 20"W (MCC Mount)	Maximum Allowed Downtime per Day	12-hours
Enclosure NEMA	1	Current WAN Media	Private Serial Line
IO Count	9DI-4DO-8AI-8DP	Requires Dual Path	No
Comm. Processors	Private Serial Line	Primary Media	Verizon Private APN Cellular
PLC	Siemens TI-545-1106	Secondary Media	(not required)
I/O Form Factor	Siemens 505 Series	Cellular Strength (indoor)	(unknown)
HMI	Siemens Coros OP-27	Cellular Strength (outdoor)	(unknown)
Network Switch	none	VPN Appliance	(future)
PLC Status	Mature / Obsolete	Hybrid Communication	Required
PLC is Capable of Digital Comm.	No	Station Inter-Communication	• Well8 Res7 Bstr1A
PLC is Capable of 2 NIC	No		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2001		
RTU Age	20 years old		
FUTURE Replacement RTU Information			
Model Number	X42MCC-16DI-8DO-12AI-DP-TP12-C-0	Comm. Media #1	Verizon Private APN Cellular
Replacement Method	Back Panel Replacement	Comm. Media #2	Private Serial
Enclosure Size	42x20 Recessed Hat (MCC)	Hybrid Communication	Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	Well8 Res7 Bstr1A
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	Yes (Siemens TIAstar)	SPD	none
Stand-Alone Drives	n/a	Power Meter.	9300 (Profibus DP)
Motor Starter Panels	n/a	Power Monitor Relay	none

Discrete Starters	n/a		
Smart Motor Starters	2		
VFD	2 (40HP)		
RVSS	--		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Booster #1 Motor Starter Details		Booster #1 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120 (PM240)	Pump Model #	(unknown)
MS Size	40HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2010		
Booster #2 Motor Starter Details		Booster #2 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120 (PM240)	Pump Model #	(unknown)
MS Size	40HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2014		
Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	Siemens Sitrans P (0-xxxPSI)	pH	No
Res #2 Level Sensor	Druck PTX (30ft cable, 0-10PSI)	CL2	No
Well Level Sensor	--	Fluoride	--
Flow Meter	--	Turbidity	--
Chemical Flow Meter	--	Conductivity	--
Suction PSI	Taylor Pressure Transmitter	Dissolved Oxygen	--
Discharge PSI	Taylor Pressure Transmitter	CL2 Feed	--
Additional PSI	--	Fluoride Feed	--
Redundant PSI	No		
Control Valves	--		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	--
		ATS	--
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.9 Forked Horne Butte – Water Pump Station

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	FHB Water Pump Stn.	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	--
Pump Station	Yes (5-pumps)	Pressure Control	Yes
Well	--	Flow Control	--
PRV	--	Chemical Dosing Control	--
Chemical Feed	--	Remote Control Capability	Yes
Water Treatment Facility	--	Pumping Efficiency	No
Supplies Closed Zone	No	Digital Processed Interlocks	Yes
Station Criticality Rating	High		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	24"H x 20"W (MCC Mount – 2x)	Maximum Allowed Downtime per Day	12-hours
Enclosure NEMA	1	Current WAN Media	Private Serial Line
IO Count	24DI-2DO-7AI-5DP	Requires Dual Path	No
Comm. Processors	Private Serial Line	Primary Media	(server to FHB Transfer Site)
PLC	Siemens S7-314-2DP	Secondary Media	(not required)
I/O Form Factor	Siemens S7300	Cellular Strength (indoor)	(unknown)
HMI	Siemens TP-177B	Cellular Strength (outdoor)	(unknown)
Network Switch	none	VPN Appliance	(future)
PLC Status	Good	Hybrid Communication	(not required)
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	(not required)
PLC is Capable of 2 NIC	Yes		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2005		
RTU Age	16 years old		
FUTURE Replacement RTU Information			
Model Number	X24MCC-RIO-16DI-8DO-12AI-DP-TP12-C-0	Comm. Media #1	Verizon Private APN Cellular
Replacement Method	Back Panel Replacement	Comm. Media #2	Private Serial
Enclosure Size	24x20 Recessed Hat (MCC)	Hybrid Communication	Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	Not Required
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	Yes (Siemens TIAstar)	SPD	Yes
Stand-Alone Drives	n/a	Power Meter.	none
Motor Starter Panels	n/a	Power Monitor Relay	none

Discrete Starters	n/a		
Smart Motor Starters	5		
VFD	5		
RVSS	--		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Booster #1 Motor Starter Details		Booster #1 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens G120	Pump Model #	(unknown)
MS Size	25HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2018		
Booster #2 Motor Starter Details		Booster #2 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens MicroMaster 440	Pump Model #	(unknown)
MS Size	25HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2006		
Booster #3 Motor Starter Details		Booster #3 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens MicroMaster 440	Pump Model #	(unknown)
MS Size	100HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2006		
Booster #4 Motor Starter Details		Booster #4 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens MicroMaster 440	Pump Model #	(unknown)
MS Size	100HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2006		
Booster #5 Motor Starter Details		Booster #5 Pump Details	
MS Type	VFD	Pump Type	(unknown)
MS Model.	Siemens MicroMaster 440	Pump Model #	(unknown)
MS Size	100HP	Pump Sizing	(unknown)
MS Protocol	Profibus		
MS Overload	(integral to drive)		
MS Startup Year	2006		
Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	Siemens Sitrans P (0-xxxPSI)	pH	No
Res #2 Level Sensor	Druck PTX (30ft cable, 0-10PSI)	CL2	No
Well Level Sensor	--	Fluoride	--
Flow Meter	--	Turbidity	--
Chemical Flow Meter	--	Conductivity	--
Suction PSI	Siemens Sitrans P	Dissolved Oxygen	--
Discharge PSI	Siemens Sitrans P	CL2 Feed	--
Additional PSI	--	Fluoride Feed	--
Redundant PSI	No		
Control Valves	--		
Altitude Valve	--		
PRV Valve	--		

Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	--
		ATS	--
Notes			
VFD / pump sizes should be validated for future use prior to upgrade project. Station's pumping demand is likely going to change with the addition of the Well 8 facility.			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.10 Water Dispensing Station

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Water Dispensing Station	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
Inspection Date	April 2021	Inspector(s)	
JRS		By: S&B Inc 	
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	--
Pump Station	Yes	Pressure Control	--
Well	--	Flow Control	Yes
PRV	--	Chemical Dosing Control	--
Chemical Feed	--	Remote Control Capability	No
Water Treatment Facility	--	Pumping Efficiency	No
Supplies Closed Zone	--	Digital Processed Interlocks	No
Station Criticality Rating	Low		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	20"H x 16"W x 8"D	Maximum Allowed Downtime per Day	TBD
Enclosure NEMA	4X	Current WAN Media	None
IO Count	11DI-5DO	Requires Dual Path	No
Comm. Processors	None	Primary Media	(none, option for cellular)
PLC	Koyo D4-440C-1	Secondary Media	(not required)
I/O Form Factor	D4 series	Cellular Strength (indoor)	(unknown)
HMI	DV-1000	Cellular Strength (outdoor)	(unknown)
Network Switch	none	VPN Appliance	(not required)
PLC Status	Mature / Obsolete	Hybrid Communication	(not required)
PLC is Capable of Digital Comm.	No	Station Inter-Communication	(not required)
PLC is Capable of 2 NIC	No		
Backup Power Type	DC		
Backup Power Size	(not required)		
Backup Power Time	0 hours		
RTU Install Year	1996		
RTU Age	25 years old		
FUTURE Replacement RTU Information			
Model Number	D-WDS-KTP7-C-4X	Comm. Media #1	(not required)
Replacement Method	RTU Replacement	Comm. Media #2	(not required)
Enclosure Size	36x30x12	Hybrid Communication	(not required)
PLC	Siemens S7-1200	Station Inter-Communication	(not required)
I/O Form Factor	S7-1200	Gel-Cell Batteries	(not required)
HMI	KTP-700		
Network Switch	None		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	--	SPD	--
Stand-Alone Drives	--	Power Meter.	--

Motor Starter Panels	--	Power Monitor Relay	--
Discrete Starters	--		
Smart Motor Starters	--		
VFD	--		
RVSS	--		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Booster #1 Motor Starter Details		Booster #1 Pump Details	
MS Type	--	Pump Type	(unknown)
MS Model.	--	Pump Model #	(unknown)
MS Size	--	Pump Sizing	(unknown)
MS Protocol	--		
MS Overload	--		
MS Startup Year	--		
Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	--	pH	--
Res #2 Level Sensor	--	CL2	--
Well Level Sensor	--	Fluoride	--
Flow Meter	4" Sensus Omni (10gal/pulse)	Turbidity	--
Chemical Flow Meter	--	Conductivity	--
Suction PSI	--	Dissolved Oxygen	--
Discharge PSI	--	CL2 Feed	--
Additional PSI	--	Fluoride Feed	--
Redundant PSI	No		
Control Valves	--		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	--
		ATS	--
Notes			
•			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

3.3.11 Centennial Fountain

 city of REDMOND oregon Redmond Public Works Building 15670 NE 85th St, Redmond, WA 98052	Centennial Fountain	SCADA Inventory Field Audit	
		Project.	SCADA Asset Inventory
		Inspection Date	April 2021
		Inspector(s)	JRS
By: S&B Inc 			
Facility Information			
Facility Attributes		Process Control Functionality	
Reservoir	--	Level Control	--
Pump Station	Yes	Pressure Control	--
Well	--	Flow Control	Yes
PRV	--	Chemical Dosing Control	--
Chemical Feed	--	Remote Control Capability	No
Water Treatment Facility	--	Pumping Efficiency	No
Supplies Closed Zone	--	Digital Processed Interlocks	No
Station Criticality Rating	Low		
Pressure Zone(s)			
RTU Information			
Existing RTU		Communication	
Existing Enclosure Size	20"H x 20"W x 10"D	Maximum Allowed Downtime per Day	TBD
Enclosure NEMA	12	Current WAN Media	DSL
IO Count	17DI-4DO-8AI	Requires Dual Path	No
Comm. Processors	None	Primary Media	DSL
PLC	Siemens IM151-8	Secondary Media	(not required)
I/O Form Factor	Siemens ET200S	Cellular Strength (indoor)	(unknown)
HMI	Siemens MP-277 (8")	Cellular Strength (outdoor)	(unknown)
Network Switch	none	VPN Appliance	Netgear FVS318
PLC Status	Good	Hybrid Communication	(not required)
PLC is Capable of Digital Comm.	Yes	Station Inter-Communication	(not required)
PLC is Capable of 2 NIC	No		
Backup Power Type	DC		
Backup Power Size	7Ah battery, 2x		
Backup Power Time	~6 hours		
RTU Install Year	2010		
RTU Age	11 years old		
FUTURE Replacement RTU Information			
Model Number	C-24DI-8DO-12AI-TP12-C-1	Comm. Media #1	DSL
Replacement Method	RTU Replacement	Comm. Media #2	
Enclosure Size	30x24x12	Hybrid Communication	Not Required
PLC	Siemens S7-1512SP-1	Station Inter-Communication	(Not Required)
I/O Form Factor	ET-200SP	Gel-Cell Batteries	12Ah (2x)
HMI	12" Touch Panel		
Network Switch	8-Port, Managed		
Motor Control			
Motor Control Infrastructure		Ancillary Power Infrastructure	
Motor Control Center	--	SPD	--
Stand-Alone Drives	--	Power Meter.	--
Motor Starter Panels	--	Power Monitor Relay	--
Discrete Starters	7		

Smart Motor Starters	--		
VFD	--		
RVSS	--		
FVNR	--		
Auto-Transformer	--		
Smart Overload Device	--		
Field Equipment			
Typical Instrumentation		Water Quality	
Res #1 Level Sensor	Keller Microbore (20ft cable, 0-5PSI span)	pH	Yes
Res #2 Level Sensor	--	CL2	Yes
Well Level Sensor	--	Fluoride	--
Flow Meter (Filter)	Yes	Turbidity	--
Chemical Flow Meter	--	Conductivity	--
Suction PSI	(Tank Level)	Dissolved Oxygen	--
Discharge PSI	--	CL2 Feed	--
Additional PSI	--	Fluoride Feed	--
Redundant PSI	No		
Control Valves	--		
Altitude Valve	--		
PRV Valve	--		
Motor Actuated Valve	--		
other		Ancillary Sensors	
		Generator	--
		ATS	--
Notes			
- Station Pumps are as follows: 1) Jet Pump 2) Leaper Jet 3) Sensor Wash 4) Bleach Pump 5) Filter Pump 6) Vault Blower 7) Sump Pump 1 8) Sump Pump 2 9) Surge Tank Drain Pump 1 10) Surge Tank Drain Pump 2			
Revision Log			
Date	Rev	Revision Description	By
5/14/2021	0	Initial Delivery to Utility	JRS (S&B Inc)

Section 4 – Gap Analytics

4.1 Introduction

Section-4 compares the City’s existing state of their SCADA system (Section-3) against the SCADA Standards – the ‘ideal state’ (identified in Section-2), and the gaps between the two states are identified. The Consultant, S&B Inc, identified the gaps separating the current state from the ‘Ideal State’ with recommendations for gap closure. The gap analytics task reviews equipment, technology and human resources. All gap closures include an accompanying ROM cost estimate to provide context to the scope of work, providing a holistic view to the Utility for needs/cost/benefits for informed decision making on future project execution selections.

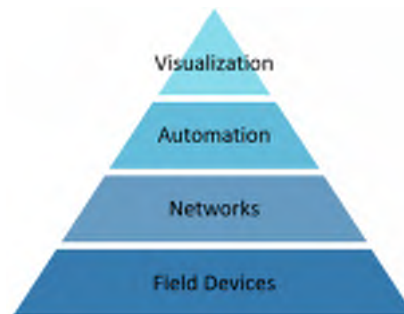
4.1.1 Cost Estimates Using Single Unit Responsibility Method

All gap closure cost estimates are performed using a “single unit responsibility” method, not a design/bid/build method, as the scopes of work are SCADA-centric, fit within existing equipment footprints, and do not represent changes in the electrical, mechanical, civil, or structural design. Additionally, “single unit responsibility” methods of upgrades and implementations help the City avoid typical cost bloating in upfront engineering, project management, and spec/plan development, as the majority of the work is performing functional replacements of equipment and technologies. Single Unit Responsibility is also a more cost-effective method to close the identified gaps in the Utility’s SCADA system. The City has traditionally followed the “single unit responsibility” method for such upgrades, so the Consultant has matched the Utility preference.

4.2 Gap Analytics Summaries

SCADA is a complex process control ecosystem, made up of four distinct layers:

1. Visualization
2. Automation
3. Networks
4. Field Device



In the following sub-sections, the Gap Analytics Summaries are organized by each SCADA layer to create a logical clustering of SCADA assets. Each layer is given an overall bill of health, relative to the current state condition, to help the Utility understand the what areas of SCADA should be prioritized.

4.2.1 Field Devices

The field devices' current state is in good overall health, as the water system's is adequately measured by sufficient instrumentation and controlled by smart motor starters. The quality of the equipment is very high and already meets the SCADA Standards. The Utility needs only to concentrate on replacement of equipment reaching end of life and considering options for resiliency. Three (3) areas of field devices require gap closures:



1. Smart Motor Starters
2. Measurement Device Replacements and Additions
3. Instrument Redundancy

4.2.1.1 Smart Motor Starters

All significant motor starters within the Utility are "Smart" type devices, meeting the SCADA standards. Details on each smart motor starter in the system (manufacturer, type, size, communication protocol and commissioning year) are found in the table below. Table cells highlighted in Red are high criticality items where the motor starter has exceed the expected life, and cells in yellow are warnings as the motor starters or overload devices are approaching end of life. Details on the gap closure requirements of the highlighted cells are found in the following sections.

Site	Well	P1	P2	P3	P4	P5	P6
MTU (Well 4 & FHB Bstr 3)	Siemens G150 VFD, 600HP, Profibus [2010]	Siemens G120 VFD, 125HP, Profibus [2018]	--	--	--	--	--
	Siemens 3RW44 RVSS + Simocode, 300HP, Profibus [2010]	--	--	--	--	--	--
Well 2	Siemens 3RW44 RVSS + Simocode, 300HP, Profibus [2010]	--	--	--	--	--	--
Well 3	Siemens 3RW44 RVSS 200HP, Profinet [2013]	--	--	--	--	--	--
Well 5	Siemens G150 VFD, 600HP, Profibus [2005]	--	--	--	--	--	--
Well 6 & Reservoirs	Siemens 3RW55 RVSS + Simocode, 300HP, Profibus [2021]	Siemens 3RW44 RVSS + Simocode, 150HP, Profibus [2005]	Siemens 3RW44 RVSS + Simocode, 150HP, Profibus [2021]	--	--	--	--

Well 7 & Reservoir #6	Siemens 3RW44 RVSS + Simocode, 150HP, Profibus [2007]	Siemens G120 VFD, 15HP, Profinet [2017]	Siemens 3RW44 RVSS + Simocode, 50HP, Profinet [2021]	Siemens 3RW44 RVSS + Simocode, 50HP, Profinet [2021]	Siemens 3RW44 RVSS + Simocode, 50HP, Profinet [2021]	CL2 P#1 Siemens FVNR + Simocode, 2HP, Profibus [2007]	CL2 P#2 Siemens FVNR + Simocode, 2HP, Profibus [2007]
Well 8 Res 7 Booster 1A	Siemens G150 VFD, 700HP, Profinet [2021]	Siemens G120 VFD, 15HP, Profinet [2021]	Siemens G120 VFD, 15HP, Profinet [2021]	Siemens G120 VFD, 75HP, Profinet [2021]	Siemens G120 VFD, 75HP, Profinet [2021]	Siemens G120 VFD, 150HP, Profinet [2021]	Siemens G120 VFD, 150HP, Profinet [2021]
FHB Transfer Station	--	Siemens MM440 VFD, 40HP, Profibus [2010]	Siemens MM440 VFD, 40HP, Profibus [2014]	--	--	--	--
FHB Water Pump Station	--	Siemens G120 VFD, 25HP, Profibus [2018]	Siemens MM440 VFD, 25HP, Profibus [2006]	Siemens MM440 VFD, 100HP, Profibus [2006]	Siemens MM440 VFD, 100HP, Profibus [2006]	Siemens MM440 VFD, 100HP, Profibus [2006]	--
Water Dispensing Station	--	[unknown]	--	--	--	--	--
Centennial Fountain	--	[vendor system]	[vendor system]	[vendor system]	[vendor system]	[vendor system]	[vendor system]

4.2.1.1.1 Well 5 VFD

The Well 5 site uses a Siemens G150, stand-alone drive. The drive has been in service for 16 years. S&B has observed “premium” quality drives last about 20 years, and Siemens advertises the average mean time between failures (MTBF) at 20+ years as well. The G150 drives is considered a premium quality drive, **therefore, the City should plan for VFD replacement at or before the year 2025.**



A freestanding, Siemens G150A enclosed, stand-alone drive product can be used to replace the existing Siemens G150A enclosed drive. Each drive enclosure comes with a door mounted operator panel and NEMA 1 filters. The network fieldbus connection would be upgraded from Profibus (serial) to Profinet (ethernet) to match current technology, which would require the Profibus cable running from the Drive to the PLC to be replaced with a Profinet cable. The drive footprint is the exact same as the existing unit (94.5”H x 23.6”W x 23.6”D”) and will fit within the existing space available. This scope of work would require an electrical contractor to replace the entire enclosed drive cabinet and land the associated electrical conductors.

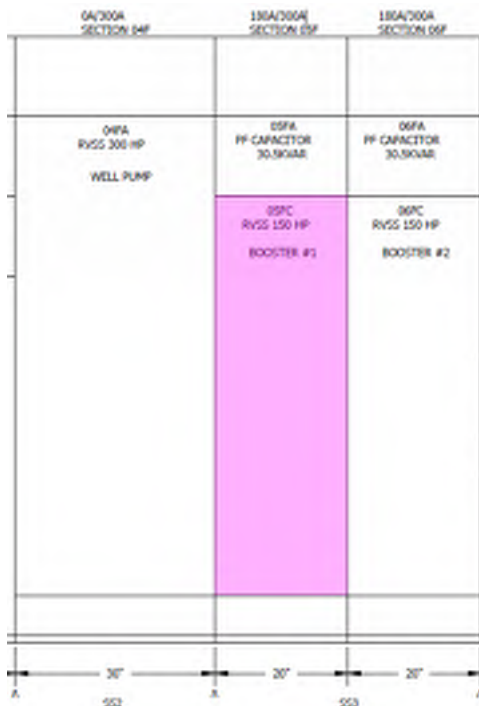
Minor application software for PLC and HMI will be written utilize the latest version of the VFD function block code set, providing improvements from the original 2005 code set. New application software programming is required to embed the local logic blocks within the drive for safe operation when in “HAND” operation. On-site commissioning is performed by the system integrator to commission the new drive and ensure proper functionality in automatic control and HAND operation.

The pricing table below assumes the use of City-staffed electricians to perform the electrical contractor installation services along with drive equipment and application software development in a single purchase order estimate.

Table 1 – Well 5 VFD Replacement, Stand-Alone Drive Application - Cost Estimate

Item Description	Unit Price	Qty	Extended Price
Design & Dwg updates	\$850	1	\$850
Siemens G150 Drive (600HP rated)	\$46,220	1	\$46,220
Installation Services (City staffed electrician)	\$5,200	0	\$0
Application Software Updates	\$1,200	1	\$1,200
Commissioning Services (each site)	\$1,375	1	\$1,375
Total:			\$49,645

4.2.1.1.2 Well 6 Site – Booster Pump 1 RVSS



The Well 6 site's Booster Pump #1 is mounted in a bucket section within a Siemens Motor Control Center, and uses a Siemens 3RW44 soft start, installed in 2016. The manufacturer lists the average MTBF of the Siemens 3RW44 soft start at 34 years, and S&B recommends planning for a 25-year life out of the RVSS units for a more conservative approach. But the motor starter has an associated smart overload device to provide the motor logic and enhanced power profile of the RVSS. The Siemens "Simocode" smart overload device has an anticipated life of 20 years. The Simocode unit is in the final years of life (4 years), therefore **the City should be planning for replacement in the near future.**



The City recently engaged in the functional replacement of Booster Pump #2 equipment in April 2021, and is an excellent example for methodology and cost. Functional replacements for the equipment within the MCC section are replaced, allowing for all field wiring to remain in place, and is a very cost-effective method of upgrading an aging motor starter. The table below outlines the functional replacements within the MCC Booster #1 bucket section:

Equipment	Old Model	New Model
Simocode	Siemens 3UF50 series, 62-630A	Siemens 3UF70 series, 62-630A

Minor application software for PLC and HMI will be written utilize the latest version of the Simocode overload block code set, providing improvements from the original 2005 code set. On-site commissioning is performed by the system integrator to commission the new RVSS and ensure proper functionality in automatic control and HAND operation.

The pricing table below assumes the use of City-staffed electricians to perform the electrical contractor installation services along with drive equipment in a single purchase order estimate. Design work is minimal as the Booster #1 replacement methodology can be templated and re-used for this Booster #2 application.

Table 2 – Well 6 Booster #1 RVSS Replacement - Cost Estimate

Item Description	Unit Price	Qty	Extended Price
Design & Documentation	\$400	1	\$400
Simocode	\$1,640	1	\$1,640
Installation Services (City staffed electrician)	\$3,000	0	\$0
Application Software	\$1,200	1	\$1,200
Commissioning Services (day)	\$1,375	1	\$1,375
Total:			\$4,615

4.2.1.1.3 Forked Horn Butte Water Pump Station VFDs

The Forked Horn Butte Water Pump Station site uses five (5) drives for the booster pumps, three (3) 100HP rated and two (2) 25HP rated units. Of the five drives, motor starter #3 (100HP rated) was replaced with a Siemens G120 unit in 2018, all remaining drives are the original Siemens MicroMaster 440 drives, mounted in an MCC. These remaining four MicroMaster 440 drives has been in service for 15 years. S&B has observed “standard” quality drives, like the MM440 drives at the station, last about 12-15 years, and Siemens advertises the average mean time between failures (MTBF) at 13+ years on those units. This means, the drives are operating 3 years past their expected lifecycle timeframe before failures are expected.

Therefore, there is an urgent need to replace the remaining drives (three 100HP and one 25HP) as the threat of failure is now much higher. City should plan for immediate VFD replacement.

01F	02F	03F	04F	05F	06F
A	A	A	A	A	A
			MTNL	MTNL	FCB
			E	E	D
					SPACE
					G
VFD	VFD	VFD	VFD	VFD	MCB
S-S 01 30/762	S-S 02 30/762	S-S 03 30/762	S-S 04 60/1524		

A cost-effective method for replacing the drives are to perform an equipment modernization by replacing



the MM440 unit (a “mature” product) with the G120 series from Siemens. The G120 is the functional replacement, and is a “premium” quality drive, expected to last 20 years. The G120 drives are smaller in height and width, and slightly deeper. The drives in each MCC bucket section could be exchanged while keeping all the other sub-components in place (feeder breaker, field terminals, filters, etc.). The G120 drive is a modular design where the control unit is a separate and exchangeable piece from the power module – meaning that the G120 can be setup to use Profibus network protocol (matching the MM440), and in the future can be changed to Profinet industrial ethernet by simply changing the control unit. This provides long term flexibility to the drive.

Minor application software for PLC and HMI will be written utilize the latest version of the VFD function block code set, providing improvements from the original 2005 code set. New application software programming is required to embed the local logic blocks within the drive for safe operation when in “HAND” operation. On-site commissioning is performed by the system integrator to commission the new drive and ensure proper functionality in automatic control and HAND operation.

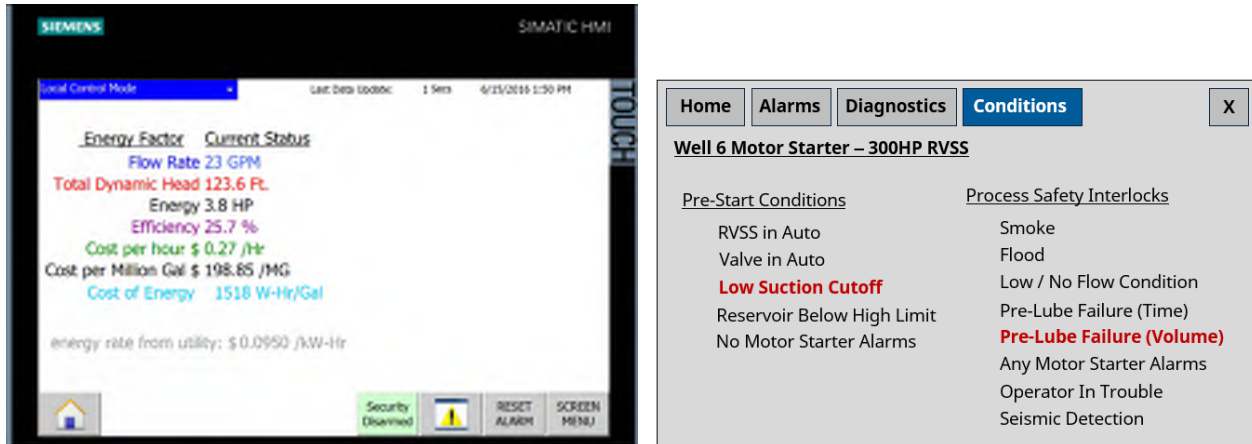
The pricing table below assumes the use of City-staffed electricians to perform the electrical contractor installation services along with drive equipment in a single purchase order estimate. A site visit by the system integrator will evaluate the motor starter cabinet and confirm sizing and airflow clearances, as well as take pictures for installation guides for the electrical contractor. It is expected the electrical contractor can exchange 3 VFDs in 4 days, as they will develop a rhythm in performing the upgrades as they are all very similar. The System Integrator will need to be onsite to commission the drives and control system as they come online, and it is anticipated they can arrive on the electrical contractor’s 2nd day and finish together on the 3rd day. A 15% contingency is added in capture any ancillary equipment which may need to be replaced if found to be in failure or any contractor overruns.

Table 3 – FHB Water Pump Station VFD Replacements - Cost Estimate

<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Extended Price</i>
Site Visit, Design, & Documentation	\$1,500	1	\$1,500
G120 Drive (25HP) w/ Profibus Control Unit	\$3,580	1	\$3,580
G120 Drive (100HP) w/ Profibus Control Unit	\$10,570	3	\$31,710
Control Power Transformer + SPD	\$390	4	\$1,560
Installation Services (City staffed electrician)	\$9,000	0	\$0
Application Software Updates	\$1,500	1	\$1,500
Commissioning Services (day)	\$1,375	2	\$2,750
<i>Sub Total:</i>			\$42,600
<i>15% Contingency</i>			\$6,390
<i>Total:</i>			\$48,990

4.2.1.1.4 Smart Motor Starter Data Context

The City has been utilizing smart motor starters since the early 2000s, but since that time the application software to provide context and improved operations has evolved. Modern tool sets include details on the motor's power profile, average energy usage, average efficiency, and costs to run the pump (in \$/Hr, \$/MG, and kW-Hrs/MG). These contextual values will provide indication to the operators of the best performing pumps in the system, and provide a method to qualify if a motor is not performing normally. Another key feature is brining forward the pre-start conditions and process safety interlocks on the HMI and SCADA visualization to allow the operations staff to see all items which would inhibit motor operation, and provide a quick method to troubleshoot a motor.



Although the smart motor starters are in place, the PLC's application software needs to be updated to calculate the contextual values and provide visual indication on the HMI Touch Panel and SCADA computer visualization systems. SCADA graphics are developed for each remote station as well as the SCADA computer system.

The pricing table below includes the application software associated with the various motor starters in the system. A system integrator field engineer is required to download software updates to each remote facility as well as to the master telemetry to expand the current SCADA data sets and bring them to the visualization interfaces. Two days of commissioning is planned to perform upgrades.

Table 4 – Smart Motor Starter Data Context - Cost Estimate

Item Description	Unit Price	Qty	Extended Price
App. SW for Wells 2, 3, 4, 5	\$1,050	4	\$4,200
App. SW for Wells 6 & 7	\$2,200	2	\$4,400
App. SW for FHBPS / FHBTS	\$1,200	2	\$2,400
App SW for MTU Data Assimilation from Remotes	\$1,400	1	\$1,400
App. SW for WinCC Screens	\$1,400	1	\$1,400
Shop Test	\$1,200	1	\$1,200
Commissioning Services (day)	\$1,375	2	\$2,750
Total:			\$17,750

4.2.1.2 Instruments

4.2.1.2.1 Water Quality Analyzers

Monitoring for water quality is a key task for any water utility. The City already has water quality monitoring at several sites, but a three source locations (Wells 3, 4, and 5) are missing water quality monitoring, as shown in the table below.

Site Name	Water Quality Measurement
Well 2	Chlorine
Well 3	None
Well 4 (MTU location)	None
Well 5	None
Well 6 & Reservoirs	Chlorine
Well 7 & Reservoir #6	Chlorine
Well 8 Res7 Bstr 1A (coming online in 2021)	Chlorine w/ active pH correction
FHB Water Pump Station	Chlorine w/ active pH correction
FHB Transfer Station	--
Water Dispensing Station	--
Centennial Fountain	Chlorine w/ active pH correction

The Well 3, 4, and 5 facilities could benefit from automated water quality monitoring. Each location would require a sample line of 3 gal/hr and a drain to accept the sample line waste. Sample and drain lines are often the most difficult aspect of retrofit installations and a site design to incorporate the water lines is needed to streamline the installation scope.

An analyzer which measures free chlorine residual with active pH correction and water temperature measurement is recommended for each site. A Rosemount FCL-02-241 unit or Kuntze Krypton Multi-K analyzer are proven analyzer products which provide all three measurements (free chlorine, pH, and temperature) in a pre-fabricated analyzer assembly. These units typically require a sample rate of 3 gallons/hour and are wall mounted with a 3/8" or 1/4" clear poly tubing for the sample line and a 2" drain line, with a 3" air gap.



For every station location, a new analog input card is added to the existing PLC chassis and new application software for PLC, HMI, and SCADA platforms will be written monitor the water quality and perform process safety responses for dosing, pumping, or valve control if the water quality is not within acceptable parameters. System integration services will be required to set up the analyzer instrument and commission the process control system.

The pricing table below assumes the use of City-staffed electricians to perform the electrical contractor installation services, analyzer instrumentation, system integration and commissioning services. The estimate assumes all water quality analyzers are upgraded in a single project to reduce one-off costs for electrical contractor and commissioning services. A Rosemount model FCL-02-241 unit was used for the pricing estimate as carries a UL Listing which is required when placed into a control panel (the Kuntze unit does not carry a UL Listing).

Table 5 – Water Quality Analyzer Additions - Cost Estimate

<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Extended Price</i>
Rosemount FCL-02-241 Analyzer	\$5,245	3	\$15,735
Kuntze Krypton Multi-K Analyzer	\$7,375	0	\$0
Misc. Tubing for Sample /Drain	\$200	3	\$600
New AI Card	\$450	3	\$1,350
Installation Services (City staffed electrician)	\$6,600	0	\$0
Application Software Updates (per station)	\$1,000	3	\$3,000
Commissioning Services (per station)	\$1,375	3	\$4,125
Total:			\$24,810

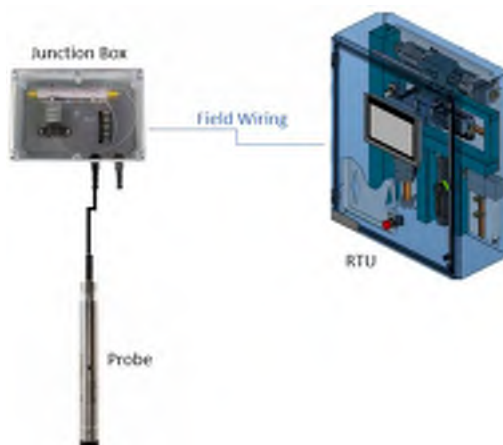
4.2.1.2.2 Submersible Level Probes

Reservoir and well levels are key analog signals used for process control and pumping efficiency calculations. A submersible probe type instrument is a very common device used in the industry and also throughout the City. Probe are considered “in-process” measurement devices and have a shorter lifespan due to eventual moisture intrusion into the probe body. It is typical to assume that a probe will last 7-10 years if the Utility is diligent about monitoring and replacing the desiccant/bellows devices in the local j-box of the probe – which is used to help combat against moisture intrusion. The table below outlines the submersible probes used in the water system, the model and configuration, installation year, and remaining life. Items in red represent devices which have exceed their expected life or have known performance issues. Items in yellow are approaching the end of their expected life.

Location	Probe	Year	Remaining Life
Well 2	PMC MTM3213 (400ft/10 cable, 0-50PSI span)	2020	6-9 years
Well 3	PMC MTM3213 (472/2 ft cable, 0-60PSI span)	2016	2-5 years
Well 4 (MTU location)	KPSI 330S (570ft cable, 0-86.693PSI span)	2018	4-7 years
Well 5	Druck PTX (305ft cable, 0-20PSI span)	2014	0-3 years
Well 6	Druck PTX (420ft cable, 0-50PSI span)	2020	6-9 years
Well 6 – Tank #1	KPSI 330S (40ft cable, 0-15PSI span)	2005	Ready for Replacement
Well 6 – Tank #2	KPSI 330S (40ft cable, 0-15PSI span)	2005	Known Issues, requires replacement
Well 7	KPSI 330S (550ft cable, 0-100PSI span)	2015	1-4 years
Well 8 (coming online in 2021)	Keller Microbore (620ft cable, 0-50PSI span)	2021 (future)	7-10 years
Well 8 - Res #7	KPSI 330S	2021 (future)	7-10 years

(coming online in 2021)	(40ft cable, 0-10PSI span)		
FHB Transfer Station – New Tank	Druck PTX (30ft cable, 0-10PSI span)	Assumed 2001	Ready for Replacement
Centennial Fountain	Keller Microbore (20ft cable, 0-5PSI span)	2014	Replacement already ordered on 5/4/21

As shown in the table, three (3) sites require immediate replacement, and two (2) sites are approaching end of life and will require replacement. Probes are one of the easier instrument to exchange, and City forces are capable of self-exchanging the probe equipment. Probes should be ordered with the same cable length and pressure span to ensure the probe can “plug-and-play” into the process control system without any PLC programming. Reservoir exchanges are the simplest. But well applications are typically sheathed down a stilling tube and require a small bore (0.63”- 0.69” diameter) probe to measure level, such as a Keller Microbore or Druck (GE) 1879 series probe. Probes are terminated in a local junction box along with a moisture mitigation device like a desiccant or aneroid bellow. Field wiring is then run between the RTU and the well probe junction box.



No new application software for PLC, HMI, and SCADA platforms are required when the replacement probes are ordered with the same pressure range 4-20mA outputs, making the exchange purely focused on equipment exchange.

The pricing estimate includes a specifically configured probe for each facility, and no electrical contractor or system integrator services should be required for the equipment exchange, as it can be performed by Utility forces. We have used Keller Microbore probes instead of Druck for the small bore size applications as the Druck factory is having 6+ week lead times compared to 2-week of Keller. And the Well 6 tanks are identical probes, so a quantity of 2 is used. All probes are quoted with the optional lighting protection for instrument resiliency.

Table 6 – Submersible Probe Replacement- Cost Estimate

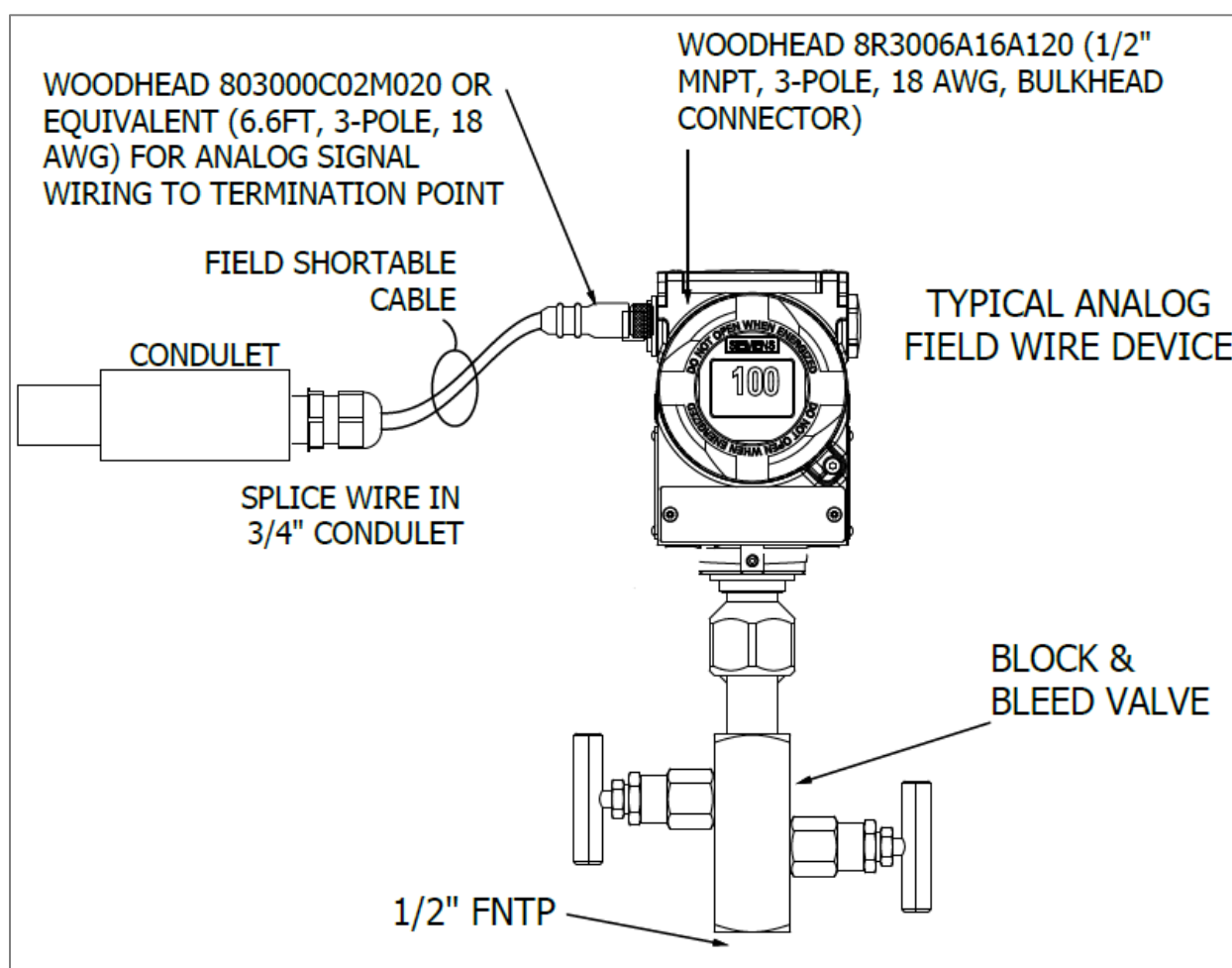
Item Description	Unit Price	Qty	Ext. Price
Well 5 (Keller Microbore)	\$1,440	1	\$1,440
Well 6 Tanks 1 & 2 (KPSI 330S)	\$1,030	2	\$2,060
Well 7 (KPSI 330S)	\$2,390	1	\$2,390
FHB Transfer Station – New Tank (KPSI 330S)	\$1,000	1	\$1,000
Total			\$6,890

4.2.1.2.3 Pressure Transmitters

Measuring pressure is a common task, but also a key variable for measuring pumping efficiency. Pressure transmitters have an expected life of 20-25 years. They are a highly resilient, long-lasting, instrumentation device. Currently only the FHB Transfer Station has pressure transmitters which have reached the age of replacement as they are 20-years old. Both the Transfer Station’s suction and discharge pressure are ready for functional replacements.

Location	Probe	Year	Remaining Life
FHB Transfer Station (Suction Pressure)	Taylor Pressure Transmitter	Assumed 2001	Ready for Replacement
FHB Transfer Station (Discharge Pressure)	Taylor Pressure Transmitter	Assumed 2001	Ready for Replacement

Replacement transmitters will use the same ½" NPT connection to thread into the existing process connection, making the mechanical exchange very simple. But the pressure transmitters' analog signal conductors are inside a rigid conduit, which typically requires an electrical contractor to re-terminate. It is a best practice to use M12 connectors from the rigid conduit to the instrument, so that the connections are finger-safe and will allow the operations staff to service the instrument in the future without the use of an electrical contractor (as shown in the associated figure). Additionally, the pressure transmitters should be ordered with a block-and-bleed valve to "burp" any trapped air, for improved serviceability.



The pricing estimate assumes that both pressure transmitters are ordered together in a single purchase order, and an electrical contractor is used to modify the ridged conduits to add a conduit hub with a cord-gripped connection to the M12 connector which is added to the pressure transmitter. The pressure transmitters would be pre-scaled by the system integrator prior to installation such that the pressure transmitters are "plug-and-play" ready into the process control system without any PLC programming required.

Table 7 – Pressure Transmitter Additions - Cost Estimate

Item Description	Unit Price	Qty	Ext. Price
<i>FHB Transfer Station (Siemens P320 + block & bleed valve + M12 connector)</i>	\$1,605	2	\$3,210
Installation Services (City staffed electrician)	\$250	0	\$0
Total:			\$3,210

4.2.1.2.4 M12 Quick-Connect Cabling Additions

The City does not currently use M12 quick-connect cabling on instruments. It is recommended that the City upgrade to quick-connect cabling only when an instrument requires service where the electrical connection must be disconnected. At such time, it makes sense to add the quick connect cabling. Unit pricing for one cabling set is show below for reference.



Table 8 - Quick Connection Cabling Cost Estimate (each)

Item Description	Price
<i>Micro cord set, 3P, 18AWG, 2m cord, (female)</i>	\$36
<i>Mating Bulkhead connector, 18AWG, 12" leads (male)</i>	\$17
Total	\$53/ea.

4.2.2 Networks

The SCADA networks' current state is in good health as it underwent an upgrade in 2020-2021, migrating from analog leased line to 4G Private APN cellular. One highly critical site requires several upgrades to strengthen the overall water system. The Utility should address three areas to close the gap between the current and ideal state, arranged as per the required order-of-solve:



1. A minor resiliency upgrade at the MTU
2. FHB Transfer Station upgrades
3. Hybrid Topology Overlay

Information about the existing communication system as well as the recommended gap closures are described in the following sections.

4.2.2.1 Verizon Cellular Network

The Verizon Private APN cellular solution was deployed in 2020-2021, and is used at 8 sites, as per the table below:

Site Name	Communication
Well 2	Verizon Private APN
Well 3	Verizon Private APN
Well 4 (MTU location)	Verizon Private APN & Analog Leased Line
Well 5	Verizon Private APN
Well 6 & Reservoirs	Verizon Private APN
Well 7 & Reservoir #6	Verizon Private APN
Well 8 Res7 Bstr 1A (coming online in 2021)	Verizon Private APN
FHB Water Pump Station	City Owned Leased Line Connection to MTU
FHB Transfer Station	(same LAN as FHB Water Pump Station)
Water Dispensing Station	--
Centennial Fountain	Verizon Private APN

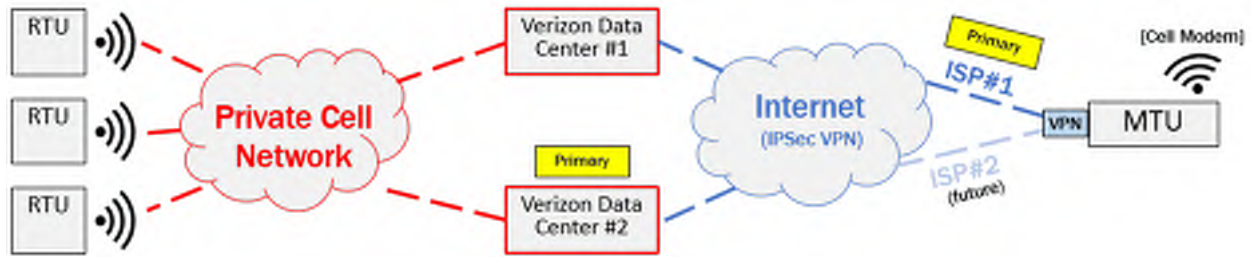
Note: The Well 1 and Antler sites use analog leased line, but are slated for decommissioning, and are therefore excluded from the analysis.

4.2.2.1.1 VPN Architecture for Private APN Buildout

Verizon offers a VPN architecture build-out for their Private APN solution – typically at no additional cost of the APN setup. The VPN architecture will enable the Utility headquarters to utilize an internet service provider (ISP) feed into the Private APN, providing increased bandwidth for SCADA data transport. The architecture is also scalable to utilize two ISPs for added resiliency. A specialized VPN appliance was added to the MTU in order to connect to the Verizon APN network and provide network administrations for managing ISP connection.

Currently, only one ISP provides service to the MTU location, so for added resiliency, the City's 2020-2021 communication upgrades project included a cellular modem which was also added to the MTU as the

secondary method to receive SCADA data from the remote facilities in case internet service is not available from the ISP. The City's Verizon VPN architecture is shown below:



4.2.2.1.2 Added Resiliency for MTU Cellular Modem

A recent best practice implemented by S&B is to add a 24Vdc relay to the PLC control panel, and provide PLC code to monitor the health of the modem, and when cellular communication timeouts occur, the PLC logic will command the cellular modem (using the 24Vdc relay) to power cycle the cellular modem. This automated method to auto-recover a cellular modem is a sample, yet effective, way to add resiliency to the secondary communication path at the master telemetry unit (MTU).

The cost to provide the relay and PLC application software for this added resiliency is show below. The pricing assumes an S&B field engineer will perform this work as an “add-on” service the next time they are on-site, so the City avoids the travel expense associated with this low-cost improvement.

Table 9 – Added Resiliency Measure to MTU - Cost Estimate

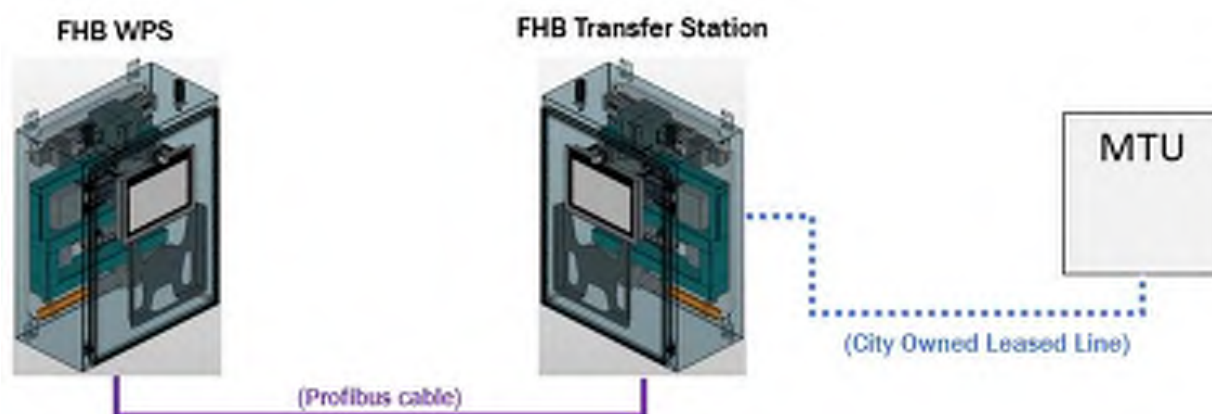
<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Ext. Price</i>
Relay	\$20	1	\$20
PLC Application Software	\$100	1	\$100
Field Service to add relay & update code (1-hr)	\$150	1	\$150
Total			\$120

4.2.2.2 Forked Horn Butte Transfer Station Upgrades

4.2.2.2.1 Transition to Cellular Communication

The Forked Horn Butte Transfer Station and Water Pump Station sites are inter-connected by a Profibus cable. Data from both sites are gathered together at the Transfer Station site which then communicates with the master telemetry unit, on behalf of both sites, over a City-Owned serial cable. This serial communication line is reliable, and is not leased through a 3rd party vendor, which is why it was not part of the initial cellular upgrades in 2020/2021.

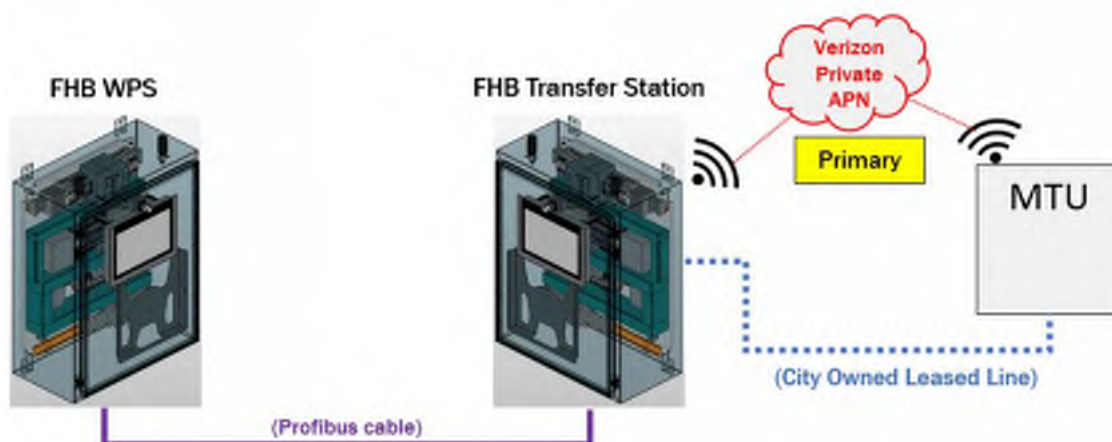
The Transfer Station currently uses a Siemens TI-545 processor, which is both technologically obsolete, and considered “mature” from the manufacturer. The TI-545 processor is 20 years old, and due to its vintage, does not support any digital communication (DSL, cable, fiber, cellular, etc.), it is only able to support serial communication. A move to digital communication with increase the data speeds and bandwidth so more volume of SCADA data can be shared at a faster rate between the FHB facilities and the MTU. But the benefits of digital communication cannot be realized until the processor is upgraded.



RTUs are expected to have a 15-20 year lifecycle due to technological obsolescence, rather than functional performance. The Transfer Station is 20 years old, and the Water Pump Station is 16 years old – both of which are in the timeframe of RTU replacement. Therefore, upgrading the communication system should be done in concert with the upgrades of the Forked Horn Butte RTUs, not as a stand-alone project. Please see section 4.3.3.4.1 for details regarding the FHB site's RTU upgrades which will include new hardware for digital communication.

4.2.2.2.2 Dual-Path Communication for FHB Transfer Station

All of the City's well sites operate on level control – where they pump based upon the reservoir levels at the Forked Horn Butte Transfer Site. This makes the Forked Horn Butte Transfer Site a highly critical site in the overall control strategy used by water system. Communication loss from the Transfer Site to the MTU (the telemetry communication hub) would inhibit automatic operation of the well pumps. To add resiliency to the water system, a simultaneous, secondary communication path between the FHB Transfer Station and MTU should be added. Following the standards of the recently upgraded stations, the Verizon Private APN would serve as the Primary communication path, and the existing lease line would serve as the secondary communication path.



As stated previously, the Transfer Station's PLC does not support digital communication (like cellular), but the replacement RTU (described in section 4.3.3.4.1) would come with the required hardware for digital communication use, and software to provide dual path communication functionality.

4.2.2.2.3 Fiber Optic Cable Replacement of Existing Profibus Cable

As described and shown previously, the Transfer Station links to the Water Pump Station using a Profibus communication cable (serial). The cable was installed 16-years ago and has served the City well. But for long-term viability, a digital communication cable is recommended.

A 6-strand, multimode, fiber optic cable assembly is the best solution to be installed in-place of the existing Profibus cable. Fiber optic media provides the fastest transit time and largest bandwidth. It also has resiliency to electrical spike hazards (which recently occurred at the FHB site in 2021 and ruined the serial communication module). The fiber optic cable exchange should occur after both the Transfer Site and Water Pump Station Sites are upgraded as both RTUs will have copper/fiber network switches to accommodate the fiber optic cable connections.



A 115ft, 6-strand, multimode, indoor/outdoor rated fiber optic cable will be installed by the City's electrician who will pull the fiber optic cable thru the existing 2" conduit, taking the place of the Profibus cable. New fiber WIC boxes will be mounted besides each RTU which will receive the fiber cable, and a fiber jumper cable spans between the WIC box and RTU (as shown in the associated figure). Pricing for the fiber optic cable, fiber WIC boxes, and fiber jumper cable are included in the estimate below. It is assumed the new FHB RTUs will be pre-provisioned with the PLC code sets for fiber communication, so no new PLC application software is required. System Integration services are expected to be a half-day's work, so the City should pair this commissioning work with other system work to fill an entire day of field engineering.

Table 10 – FHB New Fiber Optic Cable - Cost Estimate

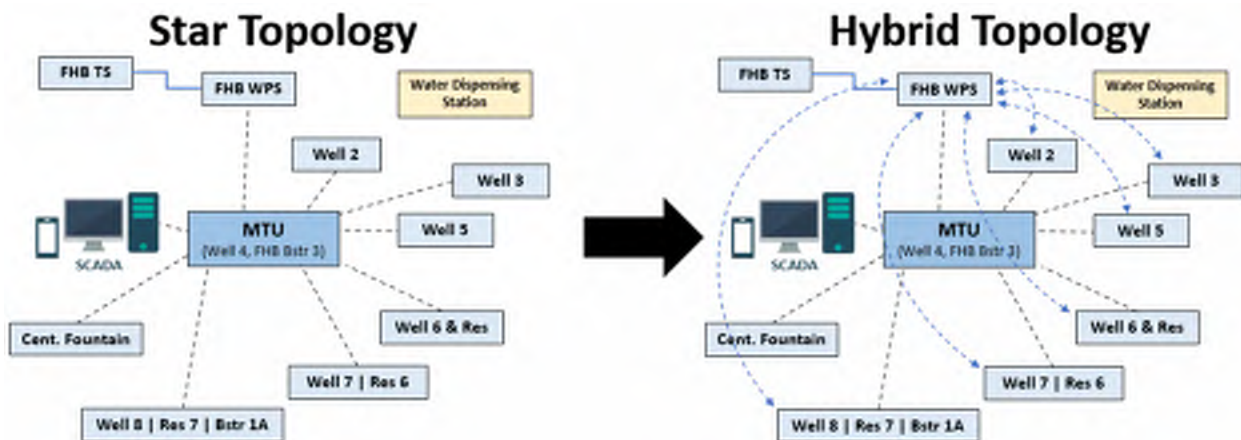
Item Description	Unit Price	Qty	Ext. Price
6-strand outdoor OM1 Multimode Fiber Cable	\$480	1	\$480
Fiber WIC Box + Adapter Plates + Patch Cables	\$200	2	\$400
Installation Services (City staffed electrician)	\$2,600	0	\$0
System Integrator Commissioning Services (1-day)	\$1,375	1	\$1,375
Total:			\$2,255

4.2.2.2.4 High Speed Connection to MTU

A future project to improve long-term viability is to upgrade the City-Owned leased line connection between the FHB site and MTU (Well 4 / FHB Booster #3) site. If there is a City project where the roadway is being dug up, it would be an ideal time to replace the private serial line with private fiber. Due to the close proximity and direct visual path between the two facilities, the City could alternatively add a [point-to-point wireless connection](#) between the two facilities using line-of-sight antennas mounted on a pole. This is a future upgrade that should be explored.

4.2.2.3 Hybrid Topology

The Utility's water system is made up of 10 telemetry-controlled water sites, utilizing 9 PLC control panels all communicating to a master telemetry unit (MTU), and one stand-alone water dispensing station unit. The water system currently uses a star topology with the MTU severing as the communication hub, routing all information to/from the remote facilities. In a transition to a hybrid architecture, the star topology remains in place, and peer-to-peer connections between specific remote sites are overlaid. Peer-to-peer connections are only made when a remote station requires the data of a peripheral site to maintain its process control "mission". These peer-to-peer connections are not required at all sites, but rather at select sites. The peer-to-peer communication path is a redundant data path for SCADA data to be sent in the event of a failure at the MTU (the communication hub).



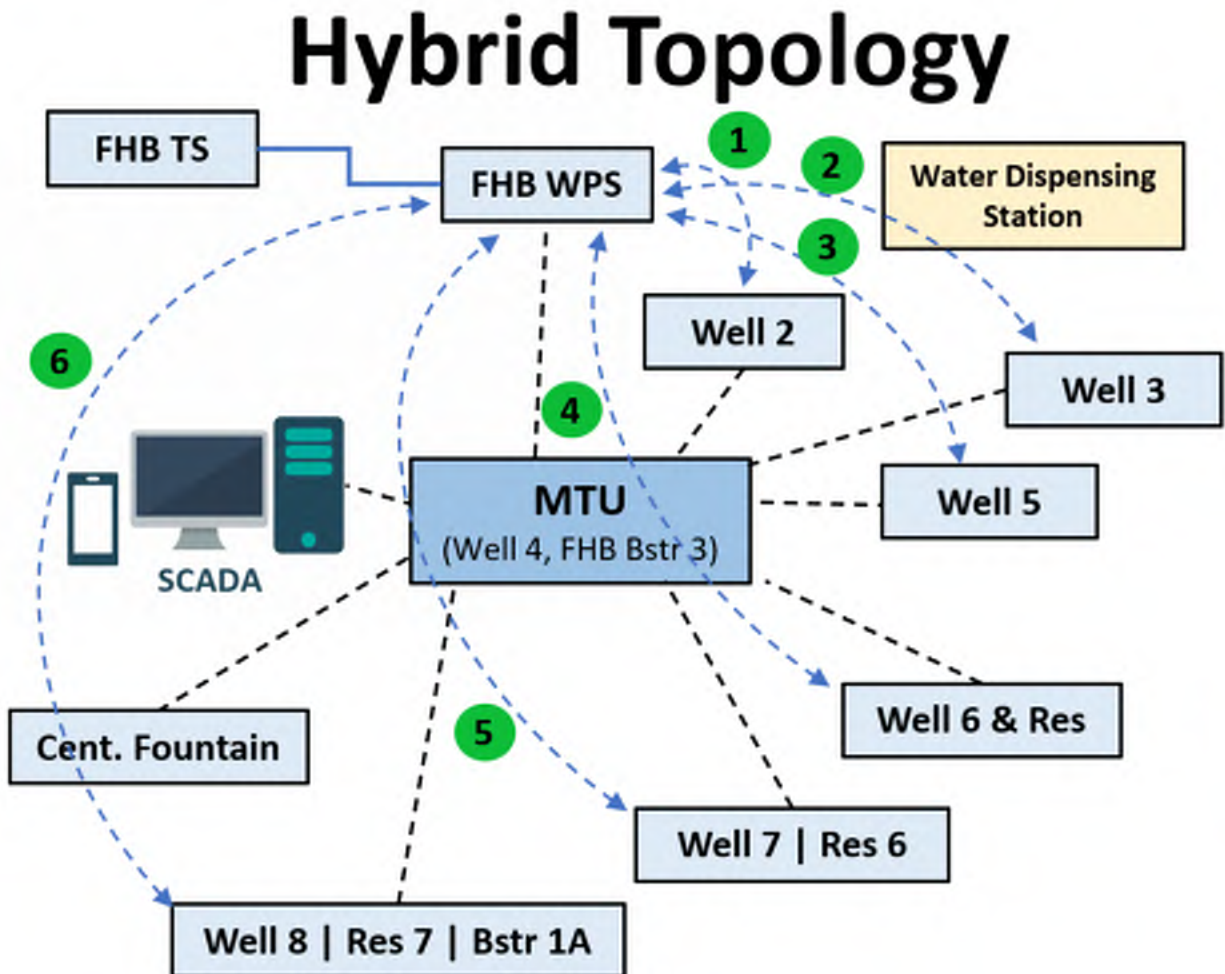
Note: The Well 1 and Antler sites use analog leased line, but are slated for decommissioning, and are therefore excluded from the analysis.

In order to implement hybrid topology, the Utility must be fully transition from analog communication (i.e. leased line) to TCP/IP digital communication – like cellular and high speed internet. Therefore, the transition can only occur after the Forked Horn Butte Water Pump Station site RTU is upgraded. This hybrid topology is added resiliency for the communication system and has a lower priority than other gap closures.

Below is the list and diagram of all stations in the City's system which will have a Hybrid topology 1:1 connection where a station either serves or receives data. As shown in the diagram, the Forked Horn Butte Water Pump Station site has high criticality in this future hybrid architecture topology.

	Hybrid Connection
1	FHB WPS $\leftrightarrow$ Well 2
2	FHB WPS $\leftrightarrow$ Well 3
3	FHB WPS $\leftrightarrow$ Well 5

	Hybrid Connection
4	FHB WPS $\leftrightarrow$ Well 6 & Reservoirs
5	FHB WPS $\leftrightarrow$ Well 7 Res 6
6	FHB WPS $\leftrightarrow$ Well 8 Res 7 Bstr 1A



Six (6) peer-to-peer connections are required for the Hybrid topology buildout, as shown in the associated figure. The blue dashed lines represent the peer-to-peer connection, and direction of the data flow. The Forked Horn Butte Water Pump Station (FHB WPS) is the high criticality site in the hybrid topology and should be prioritized first during the hybrid communication system implementation.

To implement the peer-to-peer overlay, creating the hybrid architecture, both communication and PLC programming is required to establish each 1:1 connection. The programming outlines rules and logic to share information with a specific RTU and how to sequence the data packet exchanges between facilities and communication medias. The cost estimates for the hybrid architecture buildout is found below. It is assumed the implementation would occur over two trips.

Table 11 –Hybrid Topology Implementation Cost Estimate

Item Description	Unit Price	Qty	Extended Price
<i>1:1 Connection Programming (each)</i>	\$4,000	6	\$24,000
<i>Drawings & Manual Documentation</i>	\$350	6	\$2,100
<i>Commissioning Services (each site)</i>	\$1,375	6	\$8,250
Total:			\$26,100

4.2.2.4 Data Packet Encryption

The Utility currently encrypts SCADA data packets for remote station data exchanges to the MTU over 4G cellular, which follows industry best practice. There is no additional cost to enable encryption on edge devices (i.e., cellular modems) as it is often a “checkbox” feature (depending upon the edge device used), but it creates a ~20% additional data load on the data packet size of each data exchange.

4.2.3 Automation



The SCADA automation's current state is in fair overall health as some of the processors and HMIs are either technologically obsolete and/or have reached "mature" status – where they are no longer supported by the manufacturer. The Utility must address three areas to close the gap between the current and ideal state:

1. Replacement of obsolete / mature equipment
2. Technology upgrades and replacements to support digital or dual path communication
3. Scheduled O&M replacements

4.2.3.1 Local Automation Logic

The Utility currently uses local automation logic for all remote facilities, where the process control functionality is performed the PLC at the station. This methodology follows the selected SCADA standards, and all new RTUs will continue to adhere, therefore, there is no gap closure required.

4.2.3.2 UL508A Control Panel Construction

The Utility currently subscribes to the industry standard of UL508A control panel construction and will maintain its alignment. There is no gap closure required.

4.2.3.2.1 UL508A with Seismic Certification

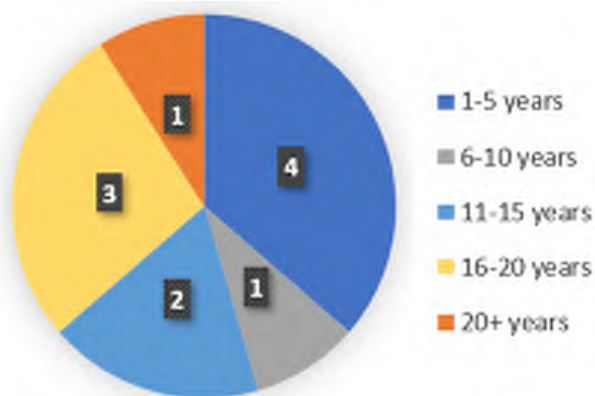
Seismically certified control panels are to be supplied only on projects where a site's facility is build to seismic standards (building construction, piping, equipment, etc). The City's new construction facilities are to be built for seismic resiliency, therefore, seismically listed control control panels would be supplied. But sites built without any seismic resiliency shall not be built to seismic standards. There is no gap closure required.

4.2.3.3 Existing Control Panel Health

4.2.3.3.1 RTU Lifecycle Index

RTUs have a lifespan of 15-20 years and require replacement when the product reaches end of life. End of life is typically achieved out of technical obsolesce, or component maturity, rather than equipment failure. As of May 2021, the RTU age ranges are well diversified, with four (4) RTUs at end of life, which will require immediate and near future replacement. The figure is supplied to help provide context to the RTU age diversity within the City.

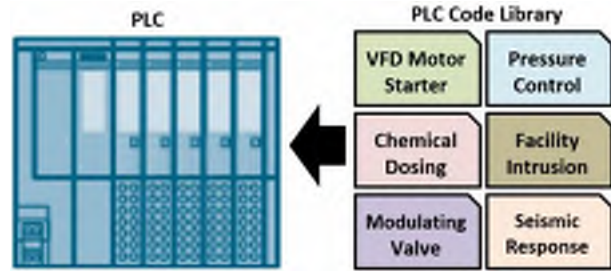
RTU Ages	Qty
1-5 years	4
6-10 years	1
11-15 years	2
16-20 years	3
20+ years	1



4.2.3.3.2 Technological Obsolescence

The City's existing water system is run by 11 PLC control panels. These remote telemetry unit (RTU) PLC control panels have a technological life of 15-20 years. Two (2) RTUs in the system have equipment which have reached "mature" status from the manufacturer – where no new hardware is produced to meet current technological needs. Four (4) other RTUs utilize a touch panel that cannot migrate past TIAPortal software version v14 (today we are using version v17). This means that new software updates, patching, or other migration options are not possible until the HMI touch panel is upgraded, and the TIAPortal software of the RTU is then upgraded to current standards.

It is also important for the ability of the automation equipment to be able to migrate to the most current software version to enable the City to utilize the system integrator's latest software blocks. S&B Inc, the City's system integrator, has a proven library of 110+ PLC code functions and controls, to modularly assemble the required elements for process control at each remote station. S&B's library is constantly refined to match new features and improved process control. But if the automation system's hardware is unable to migrate to the latest TIAPortal software, the City cannot utilize the latest library functions.



In the table below, the automation system is inventoried for its PLC and touch panel HMI units. Red highlighted items are "mature" or past the 20-year lifecycle mark, and yellow highlighted items cannot migrate past TIAPortal v14 (technological obsolescence). The items in red are in need of critical replacement, while items in yellow have some time (2-4 years) before they must be replaced.

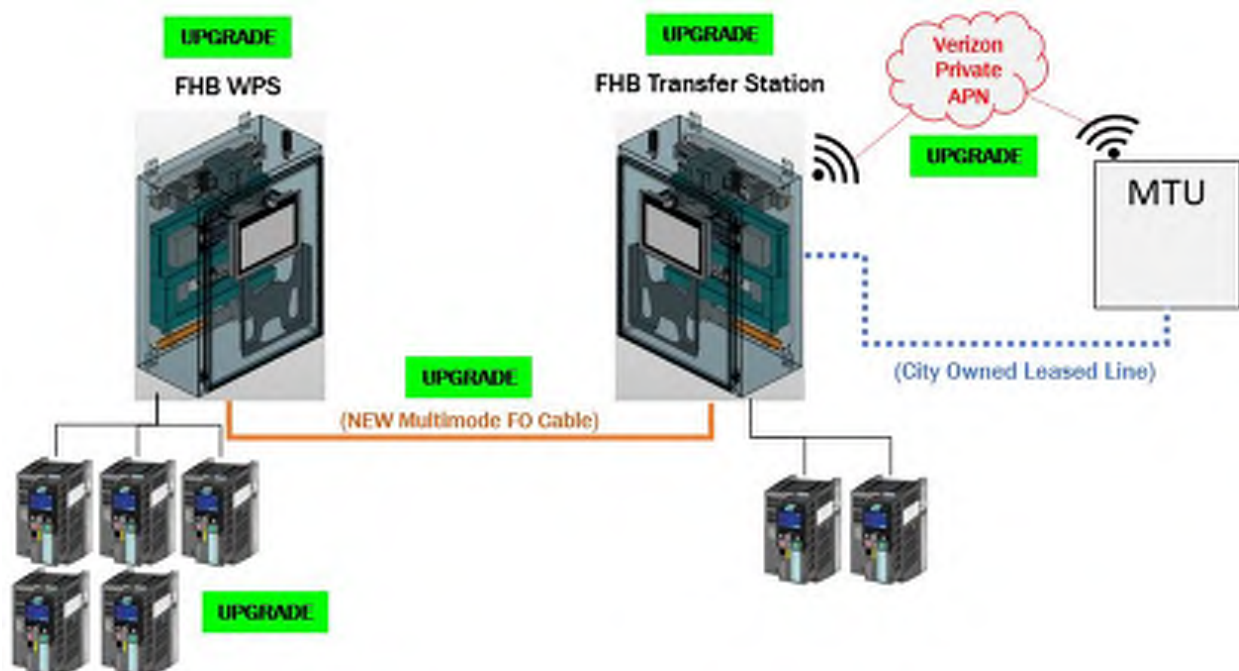
No.	Site	Age	PLC Type	HMI Type
1	MTU (Well 4 & FHB Bstr 3)	1	Siemens IM151-8	None. (Uses SCADA at MTU)
2	Well 2	11	Siemens S7-1512SP-1	TP177-B
3	Well 3	3	Siemens S7-1512SP-1	TP700 Comfort Panel
4	Well 5	7	Siemens IM151-8	TP700 Comfort Panel
5	Well 6 & Reservoirs	16	Siemens S7-314-2DP	TP-170B
6	Well 7 & Reservoir #6	4	Siemens S7-314-2PN/DP	TP700 Comfort Panel
7	Well 8 Res 7 Booster 1A	0	Siemens S7-1512SP-1	TP1200 Comfort Panel
8	FHB Transfer Station	20	TI-545-1106	Coros OP-27
9	FHB Water Pump Station	16	Siemens S7-314-2DP	TP-170B
10	Water Dispensing Station	25	Koyo D4-440C-1	DV1000
11	Centennial Fountain	11	Siemens IM151-8	MP-277 (8")

In the following sections, specific automation upgrades are outlined to address Forked Horn Butte Facilities, Water Dispensing Stations, and HMI issues at the Well 2 and Well 6 facilities.

4.2.3.4 Automation Upgrades

4.2.3.4.1 Forked Horn Butte Facilities

The Forked Horn Butte Transfer Station and Water Pump Station both have technological obsolescence issues which must be addressed using an RTU replacement method. But due to the interconnected relationship between the facilities from a process control and networking perspective, the two sites should be upgraded together as one large project. By upgrading both sites together, the architecture can change to allow the Water Pump Station to be a remote IO panel, and all PLC control for both facilities located at the Transfer Station, which reduces the costs to upgrade the RTUs, improves inter-facility communication, and simplifies the PLC's application software.



Note: Upgrades are already required for replacing the VFDs which have reached end of life (see section 4.3.1.1), a new fiber optic cable assembly (as described in section 4.3.2.2.3), and for the migration to cellular communication (see sections 4.3.2.2.1). With all the recommended changes, it is strongly recommended to perform all Forked Horn Butte Facility upgrades together as one large project as it will optimize the use of electrical contractor forces, and all application software can be tested and commissioned in a single project, reducing commissioning costs.

Details for each Forked Horn Butte RTU upgrade are explained in the following sections.

4.2.3.4.1.1 FHB Transfer Station RTU Upgrade

As described previously in the table above, the FHB Transfer Station is 20 years old, the PLC & HMI are “mature” products; additionally, the technology does not support the communication upgrades recommended in section 4.3.2.2. **Immediate RTU replacement is required to revitalize the hardware and support resiliency efforts in the water system’s communication network.**

The RTU is mounted inside the existing MCC. To replace the RTU, a new “open” style control panel is required to be assembled in a UL508A panel shop, using a “recessed hat” panel from Siemens (the MCC manufacturer) to fit in the allotted space. The panel design must take into account the current layout to ensure field wiring conductors can be re-used, minimizing butt-splices. The RTU would feature 24Vdc power distribution, Siemens S7-1512 PLC, communication co-processors (as required), IO, 12” touch panel display, cellular communication modem, serial communication modem, pluggable relays, and field terminals on an angled bracket for easy reading and termination. The RTU would feature hot swappable IO cards and use high density hardware to allow for future expansion within the enclosure space.

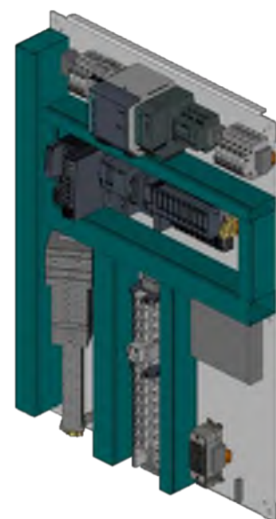


In an effort to meet the communication upgrades described previously, the RTU would also feature several items for future use. By adding the equipment in the design, the City avoids costs of installation and hardware configuration in the future. The provisioning of equipment includes two key components:

1. a copper/fiber network switch, capable of utilizing a future fiber link between the two FHB facilities (as described in section 4.3.2.2.3), replacing the existing Profinet cable currently in place, and
2. a second, isolated, industrial ethernet communication process will be added to the PLC chassis to accommodate the digital Wide Area Network (WAN) link to the master telemetry unit (as described in section 4.3.2.2.4).

To meet the needs of the current system, and future communication upgrades described above, an S&B model [X42MCC-16DI-8DO-12AI-DP-TP12-CLF-0](#) panel would be used for the RTU back panel replacement.

The existing RTU is of adequate size (42x20” inside the MCC), so a cost-effective method of upgrading the RTU is to replace the back panel only, leaving the existing MCC enclosure in place, so no conduits are impacted. The new back panel can be installed and existing field wiring re-terminated on the new field terminal blocks. The new HMI touch panels will feature touch controls to replace standard pilot device controls (switches, pushbuttons, etc.) for local station operation functions, therefore RTU doors with pilot devices will be replaced with a new door, and only an HMI mounted on the face. The stations where no pilot devices are present will keep the door in place, and have a new hole cut out for HMI mounting on the door face.



For this scope of work the system integrator will perform a field visit to validate all field wiring and confirm wire numbers to develop a wiring cross-reference list in preparation for the back panel replacement. A City electrician can remove the existing back panel, install the new panel, and re-terminate field wires on the new back panel's field terminals. The City electrician will also need to install a new conduit for the cellular antennas cables, which shall be installed on a ridge pipe mast above the station's roof (similar to the associated photo). The systems integrator will validate the process controls and communication. It is expected the electrician and systems integrator can perform their work in two (2) full days of work.



The pricing table below assumes the use of City-staffed electricians to perform the electrical contractor installation services along with the RTU back panel equipment and system integration services. The estimate assumes the RTU replacement is a stand-alone project, but some electrical contractor and integration services can be reduced when combined into an overall Forked Horne Butte upgrade encompassing both RTUs, and the communication system.

Table 12 – FHB Transfer Station RTU Upgrade - Cost Estimate

<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Extended Price</i>
Site Visit for Field Wiring Evaluation & Cross Reference Sheet Development	\$1,500	1	\$1,500
RTU (X42MCC-16DI-8DO-12AI-DP-TP12-CLF-0)	\$44,080	1	\$44,080
Electrical Contractor Services (per day)	\$2,600	2	\$5,200
Commissioning Services (per day)	\$1,375	2	\$2,750
Total:			\$53,530

4.2.3.4.1.2 FHB Water Pump Station RTU Upgrade

As described previously, the FHB Transfer Station is 16 years old and approaching the end of its product lifecycle; additionally, the HMI touch panel is so old that it is stuck in TiaPortal v14 and cannot migrate to the latest versions which are continuing to be released. Because the RTU is at the very end of life, replacing only the HMI is not a wise investment, instead, the Utility should invest in an RTU replacement of all products in the near future. The Utility can also save money by changing the architecture of the FHB site to make the Water Pump Station a remote IO (RIO) control panel, controlled by the PLC at the Transfer Station. This change provides several key benefits:

1. Simplifies the architecture
2. Reduces the cost of automation hardware in the control panels
3. Reduces the cost of software development as both stations are then controlled by 1 single PLC program, and the HMI screens are duplicates of one another.
4. The HMI touch screen at both stations is identical, and the operators can control any piece of the Forked Horn Butte site from either of the 2 touch panels.

To change to a Remote IO control panel, this upgrade project must be sequenced to occur **at the same time** as the FHB RTU upgrade (section 4.3.3.4.2), Water Pump Station VFD Upgrades (4.3.1.1.4), and the fiber optic cable addition the the FHB site (section 4.3.2.2.3). This change is strongly recommended and is therefore described and priced below.

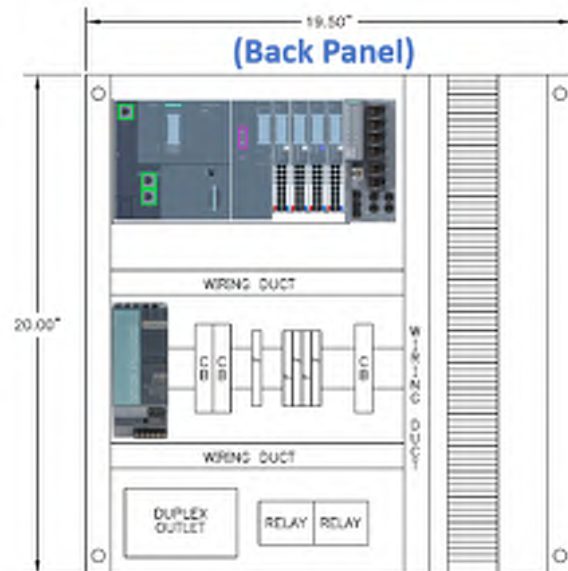
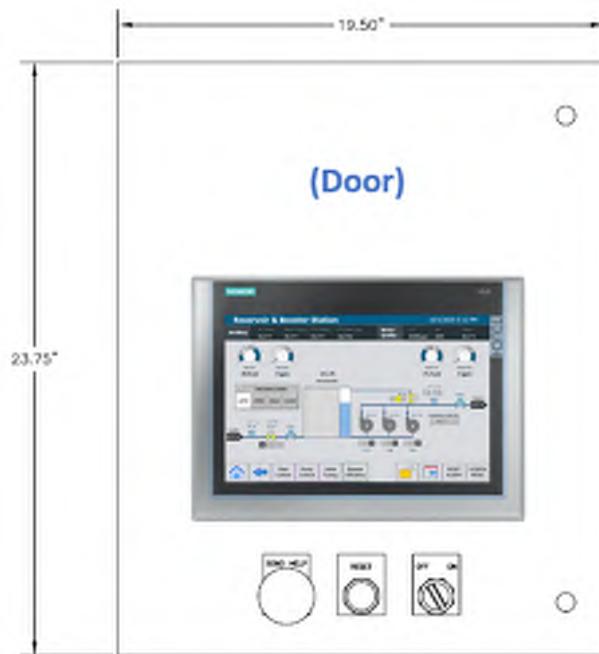
The existing RTU is mounted inside the MCC, across two 24"H x 20"W bucket sections. MCC mounted RTUs are often the most difficult to replace as they are in tight spaces and are constrained by the the MCC

33F	33F	33F	34F	34F	34F
A	A	A	A	A	A
			RTU	RTU	
			SPACE	SPACE	
WTD	WTD	WTD	WTD	WTD	WTD



bucket size. Unique to the FHB Water Pump Station application, is that the Utility can update the processor (which is being changed to a RIO interface), HMI, and Power Supply – all of which are in the left cabinet. The right side RTU cabinet would remain in place, as it houses all the terminal blocks for

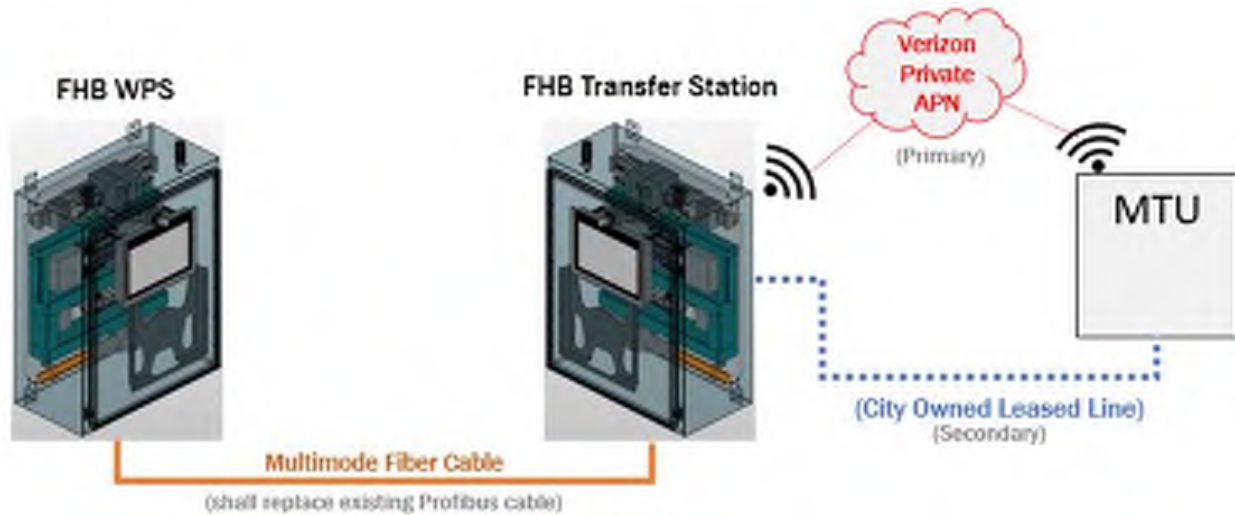
field connections. It is recommended that the upgrade the RTU rather than replace the entire RTU assembly – especially because the RTU is split between two MCC bucket sections.



Space is a consideration whenever the PLC and HMI are upgraded with modern, replacement equipment. The existing PLC chassis takes up about 11" in width, which is the only available area for the PLC. The new Remote IO chassis will use 16-channel digital inputs, 8-channel digital outputs, and 8-channel analog inputs for a high density IO terminations – just like the existing PLC. A new Copper/Fiber ethernet switch will allow the RIO to connect to the Transfer Station over multimode fiber (as described in section 4.3.2.2.4). A new Power Supply is included in the upgrade as they have an expected life of 10 years, and it should be replaced to match the PLC lifecycle starting point. Lastly, the HMI on the MCC door front will be upgraded with a new unit, and up-sized to a 12" model to provide more usable screen space for the pumps. A diagram of the new equipment in the existing space is provided below.

The Water Pump Station is currently a subsidiary control system to the Transfer Station site, which is why no wide area network (WAN) communication sysem is required. The Copper/Fiber switch will enable the

Water Pump Station's RIO interface to connect to the Transfer Station via fiber when the existing Profibus communication cable is replaced with a fiber optic cable.



The described method of upgrade is a timely and cost-effective method of replacement which shall not impact field wiring conduits or conductors. All work performed is inter-panel wiring and shall be done by the System Integrator. For this scope of work the system integrator will develop design drawings to reflect the updated equipment in the existing control panel. A system integrator field engineer shall perform the equipment exchange where they will remove the existing Siemens automation and communication equipment, and replace it with the like-kind equivalent from Siemens. The systems integrator will validate the process controls and communication. It is expected the systems integrator can perform the equipment exchange and facility checkout in two (2) full days of work.

The pricing table below includes the cost of the control panel modification design, new equipment, new Profinet Control Units on the existing G120 VFDs (just one of the five drives), and Profinet cabling to link the VFD to the new network switch. The estimate also includes the installation and startup services performed by the system integration.

Table 13 – FHB Water Pump Station RTU Upgrades - Cost Estimate

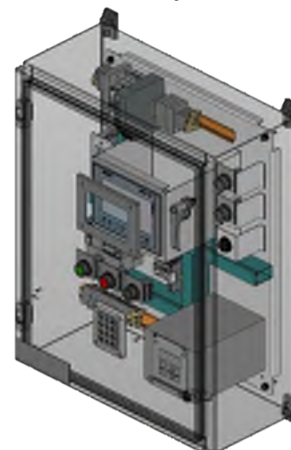
Item Description	Unit Price	Qty	Extended Price
Control Panel & System Upgrade Design	\$1,500	1	\$1,500
PLC/HMI/Power Supply/Switch Upgrades	\$18,005	1	\$18,005
CU230-2 PN Control Units for existing G120 VFDs	\$385	1	\$385
Profinet Cable	(included)	1	(included)
Commissioning Services (per day)	\$1,375	2	\$2,750
Total:			\$22,640

4.2.3.4.2 Water Dispensing Station RTU Replacement

The S&B model Water Dispensing Station (WDS) is currently 25 years and at the end of life, and the PLC & HMI are deemed “mature” products by the manufacturer. Additionally, the RTU is currently a stand-alone system, but if the City wished in the future to ever bring the data into the SCADA system, the hardware must first be upgraded as well. **Immediate RTU replacement is required to reset the lifecycle of the hardware.**

The existing control panel is very small, a 20x16x8” sized unit. To meet current UL requirements for power, the RTU must be re-sized to a 30x24x12” unit. This means that when the RTU is replaced, the electrical contractor will have some minor conduit re-work to attached existing rigid conduits to the RTU enclosure.

The new cellular enabled WDS RTU would follow an S&B model “WDS” RTU layout. This model RTU is a 4-row layout design which features 24Vdc power distribution, PLC with integral IO, HMI touch panel display, communication modem(s), cellular antennas, pluggable relays, and field terminals on an angled bracket for easy reading and termination. These RTUs feature hot swappable IO cards and use high density hardware to allow for future expansion within the enclosure space. The WDS uses a stainless steel enclosure as it will be out in the elements, and feature the Siemens S7-1200 nano-sized PLC. The WDS can be upgraded with a cellular modem and programmed to share data with the SCADA visualization system for an additional cost.



The WDS send summary data values to the master telemetry unit for monthly water usage by the City’s customers. The data sets can be added to an automated report for improved billing. The WDS will also come equipment with a single HMI screen for showing Tank Level, as it is intended to be first used at the Reservoir 7 site for monitoring level for about 1- year, before then serving to replace the existing water dispensing station. The WDS will send Reservoir #7 level information to the master telemetry for the operations staff to monitor level.

For this scope of work the system integrator will perform a field visit to validate all field wiring and confirm wire numbers to develop a wiring cross-reference list in preparation for RTU replacement. The City can utilize staffed electricians to perform the equipment exchange, saving typical electrical contractor service expense. Staffed electricians shall remove the existing enclosure, install the new enclosure, modify conduits (as required), and re-terminate field wires on the panel’s field terminals. The systems integrator will validate the process controls. It is expected the electrician and systems integrator can perform their work each in 1 full day of work, one after the other.

The pricing table below includes estimated electrical contractor installation services along with the RTU replacement and system integration. The Stand-Alone version is what is quoted. But the line item for the WDS with cellular linkage to SCADA is also included for your reference. The estimate assumes each RTU replacement is treated as a stand-alone project.

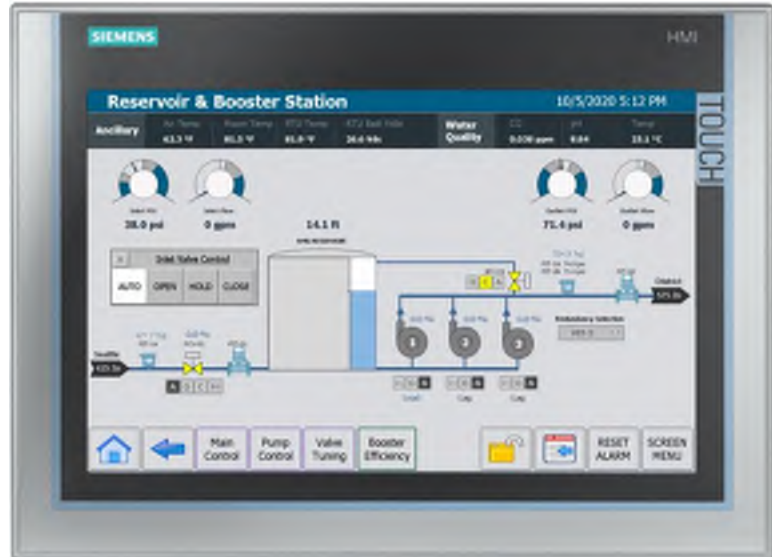
Table 14 – Water Dispensing Station Replacement - Cost Estimate

<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Extended Price</i>
Site Visit for Field Wiring Evaluation & Cross Reference Sheet Development	\$800	1	\$800
WDS w/ cellular to SCADA (D-WDS-KTP7-C-4X)	\$26,200	1	\$26,200
Res7 Level Usage - Commissioning Services	\$1,375	1	\$1,375
Electrical Contractor Services (per day)	\$2,600	0	\$0

Commissioning Services (per day)	\$1,375	1	\$1,375
Total:			\$29,750

4.2.3.4.3 HMI Upgrades

Three HMI touch panels are of an older vintage, and unable to upgrade beyond Siemens TIAPortal software version 14. Both the PLC and HMI software are developed in TIAPortal, meaning that an older HMI will then prevent the PLC software from also being migrated beyond version 14. TIAPortal is currently up to version 17, and new versions are released annually, meaning these older HMI units will anchor the automation system and continue to prevent them from being migrated to newer software versions. Software migration is typically performed in conjunction with an process control update to a site, or on an ad-hoc basis for security patching. S&B's software library is constantly migrated with each TIAPortal software release, so if the City uses automation hardware which cannot be migrated to current software offerings, it will limit the capabilities of application software used for process control. Therefore, the City must upgrade three HMI touch panels to enable their automation system to meet use current TIAPortal software versions, security patches, and S&B software libraries.



When the City upgrades their HMI units, the application software used for the process control system (TIAPortal) is migrated to the current version release, which will include all known security patches. The HMI touch screen interfaces will also be upgraded to the most current offerings. Some additional features the new Touch Panels will offer, which are not currently offered on the existing units, include:

- PLC Network Screen
- PDF Copy of the Operating Narrative of the Station
- PDF Copy of the Station's Drawings
- VNC remote access capability

The HMI screens should be sized based upon quantity of field devices needing to be displayed on screen. The Well 2 site has very few devices, and a 7" sized unit is ideal. The Well 6 site has lots of devices with a well, two reservoirs, and a booster pump station, so a 12" screen needs to be used so that the screen has enough "real estate" to show all devices on screen in a process overview. The Centennial Fountain also has 8 pumps at the facility where a 12" touch panel would best fit the application. The Well 6 and Centennial Fountain sites will require minor size modifications to the existing HMI cutout to accommodate the 12" units, which can be performed by the S&B Field Engineer. The list of the sites require HMI replacement and the associated HMI size is found in the table below.

No.	Site	New HMI Size
1	Well 2	7"
2	Well 6 & Reservoirs	12"
3	Centennial Fountain	12"

The pricing table below identifies the HMI units, application software updates, and commissioning service required to perform the HMI upgrades. The estimate assumes all HMI replacements are bundled together as a single upgrade project, where 1-day of field commissioning can upgrade all three sites in a single day.

Table 15 – HMI Upgrades - Cost Estimate

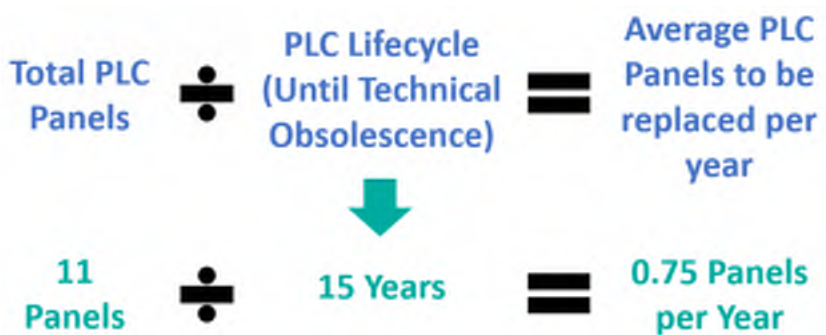
Item Description	Unit Price	Qty	Extended Price
Well 2 Replacement HMI (7")	\$1,610	1	\$1,610
Well 6 & Reservoirs Replacement HMI (12")	\$3,580	1	\$3,580
Centennial Fountain Replacement HMI (12")	\$3,580	1	\$3,580
Well 2 Site HMI Application SW Development	\$1,500	1	\$1,500
Well 6 Site HMI Application SW Development	\$2,200	1	\$2,200
Centennial Fountain HMI Application SW Development	\$1,500	1	\$1,500
Commissioning Services (per day)	\$1,375	1	\$1,375
Total:			\$15,345

4.2.3.5 Scheduled O&M Replacements

4.2.3.5.1 Planning for Annual Upgrades to Existing Equipment

The Utility currently uses 11 PLC control panels (an MTU, nine RTUs and one water dispensing station) to support their water system. PLCs typically reach technological maturity in 15-20 years, therefore, the Utility should budget for and perform annual upgrades of existing equipment in an effort to stay current with technology. By performing upgrades on a regular cadence, it reduces surges in CIPs as well reduces as the burden of change to the Utility's staff.

The Utility can use a simple estimating method to develop an annual budget to address obsolete automation equipment: divide the total number of PLC panels by the PLC lifecycle years to find the average number of PLC panels to be replaced per year. Based upon the current quantities of PLC panels, the



Utility should be budgeting to replace 0.75 PLC panels per year. Using the average panel price calculation, the Utility should be budgeting for about \$34,230 as their annual replacement budget for PLC panels (as per the table below). But if/when the City adds more PLC panels to the system in the future, the panel quantities should be updated and the unit costs updated with an estimated 5% annual price increase, and the calculations re-run to maintain a more current capital improvements budget.

The following table provides an approximate replacement cost for each PLC control panel in the system, and calculates the annual budget for future RTU replacements using the average value.

Table 16 – Annual Budget for Funding Future RTU Replacements

Site	S&B RTU Model #	Approximate Replacement Value
Well 2	D-16DI-8DO-12AI-DP-TP12-C-1	\$40,000
Well 3	C-24DI-8DO-8AI-TP12-C-1	\$39,000
MTU (Well 4 & FHB BP#3)	F-32DI-16DO-12AI-TP12-C-0	\$55,000
Well 5	G-32DI-16DO-12AI-DP-TP12-C-1	\$46,000
Well 6 + Reservoirs	X60MCC-48DI-32O-16AI-DP-TP12-C-1	\$55,000
Well 7 Res 6	X72MCC-48DI-40O-20AI-4AO-DP-TP12-C-1	\$60,000
Well 8 Res 7 Bstr 1A	G-48DI-32O-32AI-4AO-DP-TP12-C-1	\$69,000
FHB Transfer Station	X42MCC-16DI-8DO-12AI-DP-TP12-C-0	\$45,000
FHB Water Pump Station	X24MCC-RIO-16DI-8DO-12AI-DP-TP12-C-0	\$33,000
Water Dispensing Station	D-WDS-KTP7-C-4X	\$27,000
Centennial Fountain	C-24DI-8DO-12AI-TP12-C-1	\$35,000
Sum Total:		\$504,000
Avg. RTU Price:		\$45,820
Annual RTU Replacements:		0.75 /year
Annual Replacement Budget:		\$34,370

4.2.3.6 Benefits of RTU Upgrades

There are several benefits to the system's overall operability and increased levels of support, as outlined in the following sections, which will be gained when the City upgrades their RTUs.

4.2.3.6.1 Remote Access to HMI Screens

New Siemens "comfort series" touch panels (the City's SCADA standard), will come with a free single license for remote access. This provides the City the capability to access the HMI touch screens if TCP/IP communications are used (cellular, DSL, cable, or fiber). In the event of the SCADA visualization system is not working, or there are communication issues at the MTU, the City will have a method to remotely access the HMI to view information at an individual site basis.

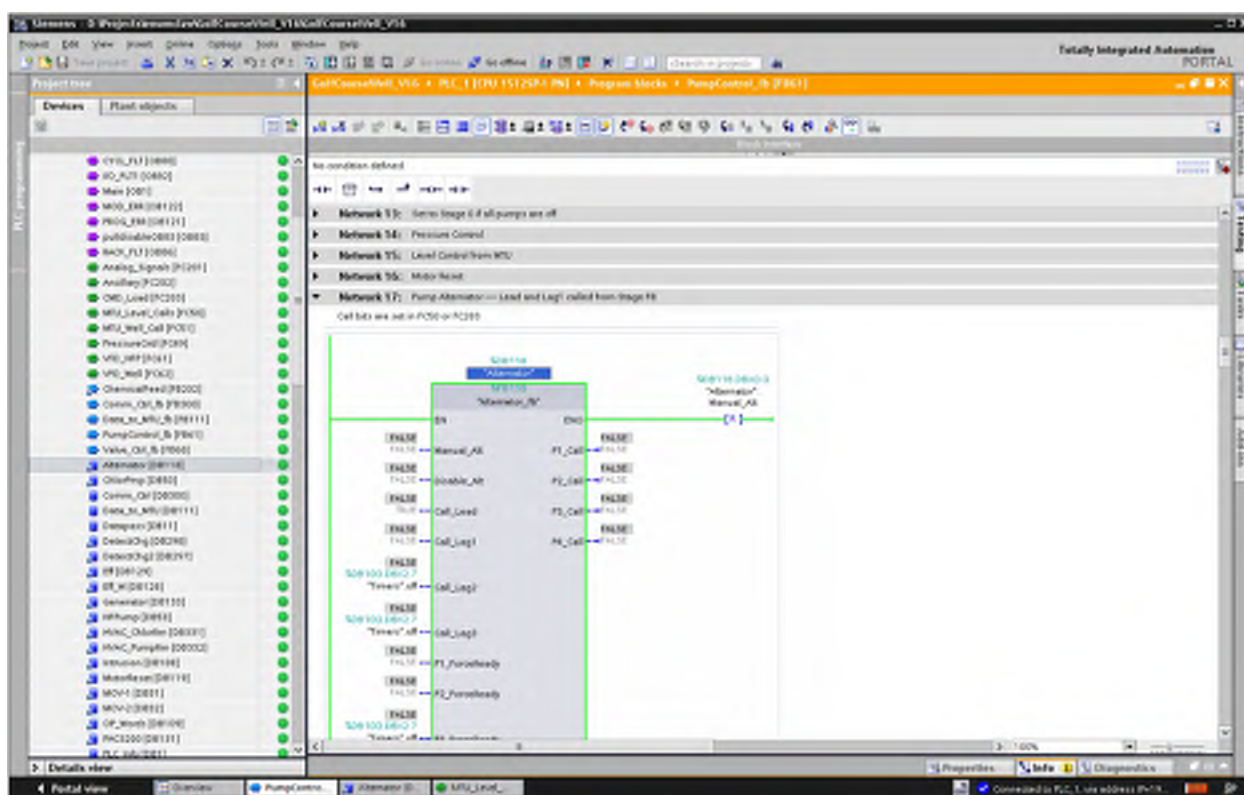
Remote access can be achieved by a VNC connection where a network address and password must be entered. After authentication, the operator's computer will display the exact touch panel screens. If the remote user wishes to command the control system, they must also login with a username and password into the touch panel to be granted access to make changes to the process control system. This feature provides additional resiliency



for SCADA viewing to the City's system. (This method assumes the use of a Security Stack to manage security for the Utility).

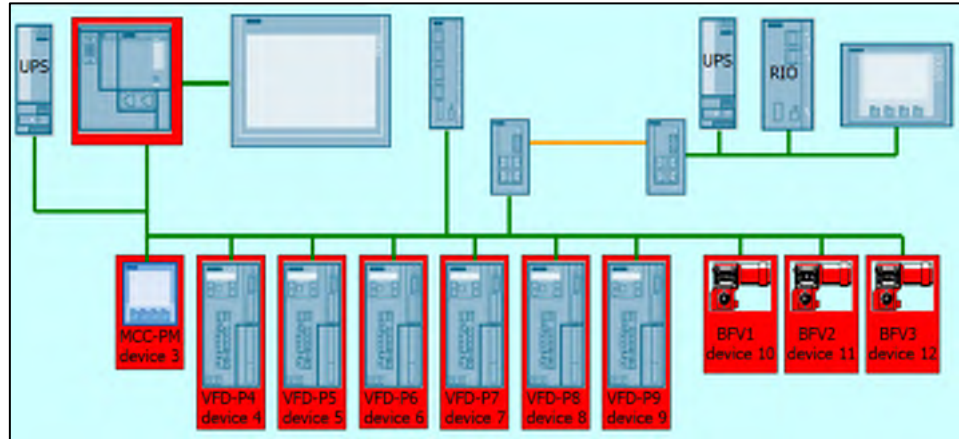
4.2.3.6.2 Digital Presence by S&B Inc

With the new Verizon Private APN cellular communication network for SCADA added in 2020-2021, it enabled the ability for S&B to have a remote "digital presence" at an RTU. S&B is able to go "online" with the remote PLC & HMI and provide remote diagnostics while the PLC remains in "RUN", providing support with no operational impact, without the need for travel to the facility. S&B can monitor process control in real time while on the phone with City personnel and provide higher levels of support within minutes of a service request. When upgrades are completed at the Forked Horn Butte Sites, S&B will have a digital presence at every site in the water distribution currently using telemetry (this does not include the water dispensing station at this time).



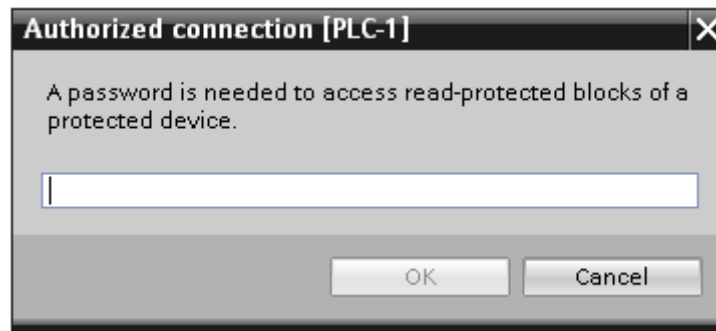
4.2.3.6.3 Network Topology Views

New RTUs will provide clear network topology views of field equipment connected to the processor and viewed in the HMI. These views provide quick assessment to the health of the process field network and the connected devices.



4.2.3.6.4 Security

All new RTUs will come with the latest firmware level updates for security, patching any known vulnerabilities to previous hardware versions. PLC code blocks are also locked with password protection to provide protection in the unlikely event that a “bad-actor” gains access to the system.



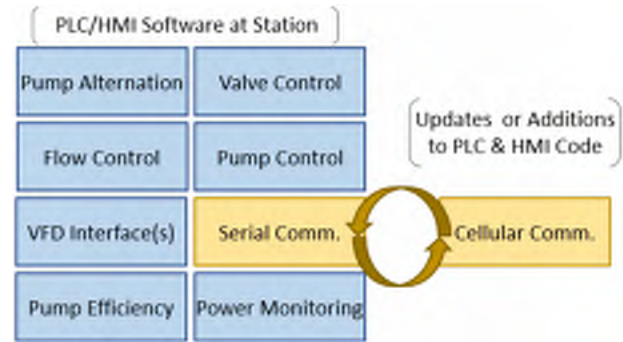
4.2.3.6.5 Flexibility

New RTUs will utilize the Siemens S7-1500 series processors (the City’s SCADA standard). This is the latest PLC line from Siemens and offers the most options for network connectivity and will be updated first to accommodate emerging technologies, providing the most flexibility to the City.

Media Capabilities	S7-1500
Profinet Communication	✓
Profibus Communication	✓
Modbus TCP	✓
Modbus RTU	✓
Two NICs (for Dual Path)	✓
Supports 50+ Network Connections	✓
OPC UA Server / Client	✓

4.2.3.6.6 Application Software Engineering Efficiency

All new RTUs utilize the Siemens TIAPortal software. TIAPortal combines PLC, HMI, and motor starter programming into a single interface. S&B has found this platform to be 20-25% more efficient for programming than other programming environment offerings in the marketplace. So, when the City looks to modernize an RTU or add additional features to an RTU on TIAPortal, like moving from Serial to Digital communication, the level of effort for system integration work will be reduced in the TIAPortal platform.



4.2.4 Visualization



The SCADA visualization's current state is in fair overall health as the software platform reflects an older vintage of software development and is lacking in more modern tools and display methods. Additionally, the computer hardware is approaching its end of life. The Utility must address three areas to close the gap between the current and ideal state:

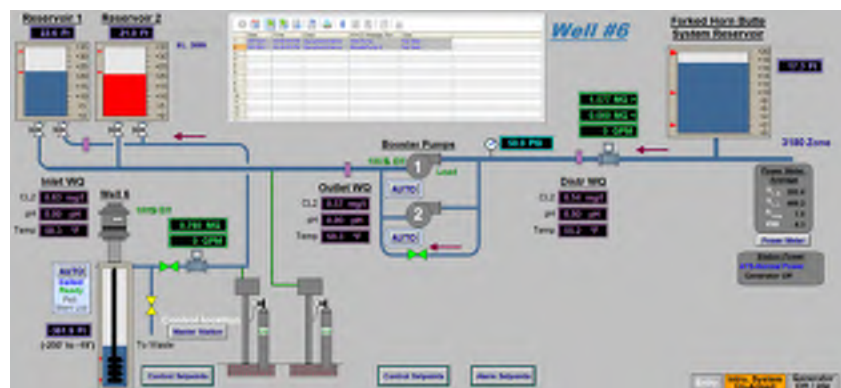
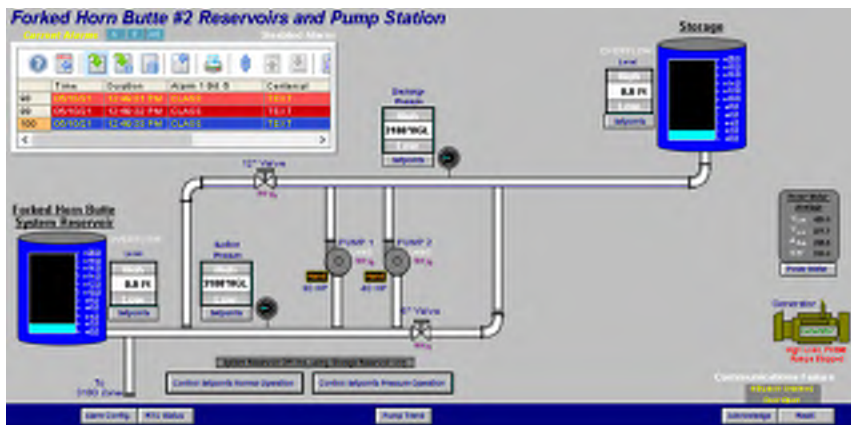
1. Computer Hardware Upgrades
2. Improved SCADA Graphics
3. Additional Reports

4.2.4.1 Brief History of City's Existing Visualization System

4.2.4.1.1 Existing SCADA Process Control Screens

The existing SCADA Graphics were originally developed in the early 2000s using common objects and graphics for that time period. Since that time, the City's the SCADA computers have been functionally replaced about every 5 years with new hardware and the associated SCADA software is then migrated to the latest software offering, but no new software engineering is performed. The most recent hardware upgrade was the 2017 upgrade, which simply re-indexed the life of the computer hardware and operation systems, but software engineering to re-program the graphics was not part of the scope of supply.

In 2020, when the MTU was upgraded as part of the communication upgrade, some graphical revisions were performed to refresh very old process control screens. But the fixes were only minor and did not address the color pallet or pop-up windows.



A major point of emphasis in the industry since about 2016 has been a shift in the presentation of SCADA graphics, concentrating on simplified graphics to ensure the animation of abnormal conditions are easily recognized, and additional toolsets to provide context to an asset's operational behavior. This new way of showing content on-screen is now classified as ISA-101 graphics with situational awareness. As shown in the associated screen shot of the City's current SCADA visualization deployment, the City's current SCADA process overview screens reflect the previous generation of screen development methodologies (use of many colors, use of 3D piping, use of 3D objects, etc.). The City's current software development of the SCADA graphics do not meet the industry best practices and should be upgraded.

Additionally, the deployed SCADA visualization reflects an older vintage of S&B software library functions, as the visualization software was last engineered in the mid-2000s, and only minor upgrades are added when field equipment is upgraded. There are opportunities to upgrade the visualization so that the visualization functionality can match the automation software.

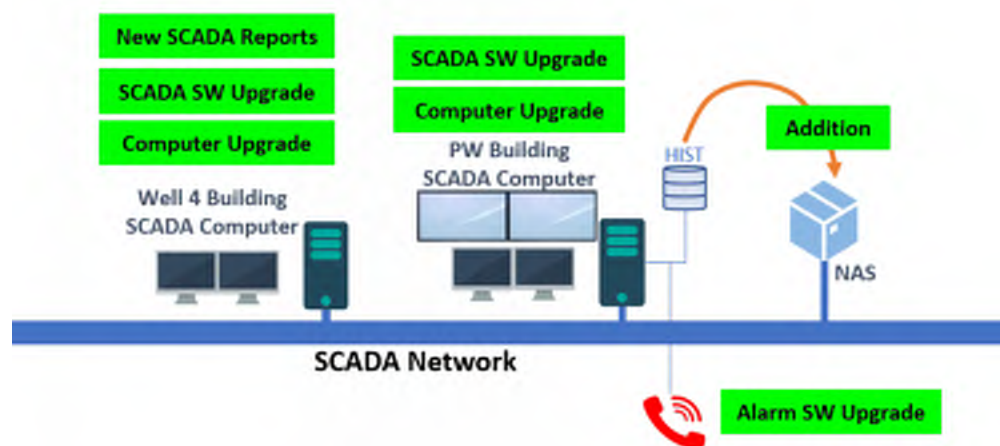
4.2.4.1.2 Existing Reporting Software

The existing SCADA system uses a program called DataMonitor from Siemens. It is a web/excel-based tool to generate automatic reports. The DataMonitor is currently setup to run only 1 auto-generated report, a Well Production report. Operators currently perform ad-hoc reporting to create other reports including Booster Flows and Reservoir summary information. Additional report templates would be beneficial to the operations staff and free up time.

4.2.4.2 Visualization Upgrades

SCADA visualization computers run 24/7/365 and are not planned to be shutdown until decommissioning. These machines' lifecycles should be well managed so not to exceed the 5-year limit, as the risk of hardware failure will result in an operator losing the primary ability to see all water system conditions in a single view and command the water system according to system needs. The City's SCADA computers are 4-years old and should be replaced in the next year (before June of 2022). The upgrades described in the following sections would be best timed with the computer hardware replacement so that all hardware and software can be shop tested at the same time, reducing commissioning costs of al la carte upgrades, and reducing risk associated with multiple computer system stoppages for upgrade. It is strongly recommended to perform the following upgrades as one single project function:

1. SCADA Computer Upgrades (2x) + Secondary Storage Location / NAS for Historical Data.
2. WinCC v7 SCADA Visualization Upgrades
3. Win911 Alarm Notification Software Upgrades
4. SCADA Reports Additions



4.2.4.2.1 Computer Hardware Upgrade

The City's SCADA computers were commissioned in June of 2017, leaving 1-year of remaining life on the existing two computers. The Computers require replacement to mitigate the risk of hardware failure. Two new computers are needed to replace the existing units. The computer hardware specs are dictated by the Siemens WinCC SCADA software requirements. The following BOM is required for the SCADA Computers:

1. Intel NUC (or equal) Workstation Computer (2 units)
 - a. 16GB RAM
 - b. 240GB SSD (boot drive)
 - c. 2TB SSD (storage drive)
 - d. Windows 10 Enterprise LTSC
2. Monitor, 23" (2 per computer)
3. Common peripherals (mouse, keyboard, etc)

The associated Siemens WinCC SCADA Graphics must also be upgraded so that the SCADA software matches the operating system and the latest software patching from the Siemens WinCC product is loaded for security. WinCC software upgrades are well below the industry average at approximately 15% of the new license cost, without the requirement of maintaining annual support costs. The City would need to purchase the latest WinCC software (version 7.5 as of May 2021) when the new computers are purchased. The WinCC software is then loaded to the new computer and validated for functionality by connecting to a replica MTU processor in a shop test environment.

The Win911 alarm notification software must also be upgraded to match the operating system of the host computer. But the City's current Win911 software version (v7 Pro) is now obsolete, and the new "Interactive" or "v2021" software offerings from Win911 are the new functional replacements. The City is currently on support for Win911, and therefore there is no cost associated with procuring the new "Interactive" or "v2021" software, only software configuration programming. Unfortunately, there are major differences from the City's existing "v7 Pro" software to either of the new offerings that there is no automated migration tool offered. The software migration effort requires system integrator labor to program the new alarm notification software. The new software offerings offer notification via voice, VOIP, email, or push notifications via the Win911 App.

Pricing for the computer upgrade is found below. The pricing estimate assumes a field engineer will perform on-site field commissioning of the system, as well as the migration of the existing historical data to ensure data values are available on the new system. It is expected that commissioning will take one day to complete.

Table 17 – SCADA Computer Upgrade - Cost Estimate

<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Extended Price</i>
Drawings & Documentation Updates	\$300	1	\$300
Computer Workstations (2x) w/ WinCC and Win911 software version upgrades and associated shop test simulation services	\$14,425	(lot)	\$14,425
Commissioning Services (per day)	\$1,375	1	\$1,375
Total:			\$16,100

4.2.4.2.2 WinCC SCADA Graphics Overhaul

To meet the best practices and SCADA Standards, the 15+ year-old software development should be re-engineered to provide improved operability and insight into the SCADA System (as described in section 2.3.4). The upgrades would provide a completely new look/feel to all screens, grey/blue color schemes, KPIs added to the station pages, integral trends on all tanks, alarms and events organized by type, tabbed pop-up windows, and more logical organization of process control parameters for a station. The software development would allow the City to utilize more capabilities of the WinCC SCADA software, as significant software engineering has not been performed since the early 2000s.

Some of the new visualization features will require additional references to PLC datapoints (called “tags”). The City has two licenses for 2,048 tags and will require a tag upgrade to the next size (8,192). To perform the graphics overhaul, a system integrator will perform in-house application software development, shop test the system using simulated PLC values, and commission the system. On-site commissioning is a downloaded configuration and testing scope of work expected to last one full day. Pricing for the SCADA graphics overhaul is shown in the table below.

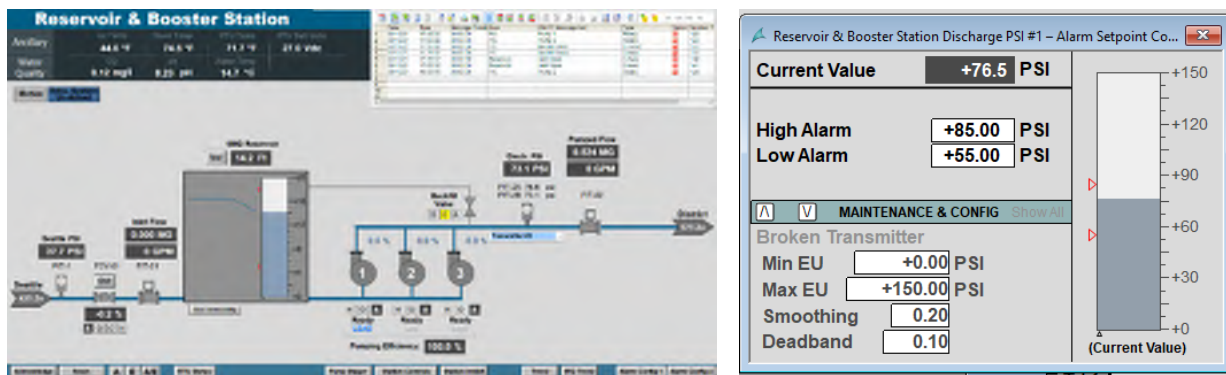


Table 18 – SCADA Graphics Overhaul- Cost Estimate

Item Description	Unit Price	Qty	Extended Price
Tag upgrade from 2,048 -> 8,192	\$800	2	\$1,600
WinCC v7.5 Graphics Re-development	\$11,525	1	\$11,525
Commissioning Services (per day)	\$1,375	1	\$1,375
Total:			\$14,500

4.2.4.2.3 Additional Reports Development Upgrades

Historized SCADA data can be used as a data source for auto-generated SCADA reports. Auto-generated report generation cadence is typically performed on a daily and monthly basis, but the Owner can also perform ad hoc report generations, outside of the pre-set schedule. Reports can be formatted based on user need and can even be arranged to mimic Department of Health (DOH) report templates.

Currently, only one (1) report template has been made for automatic generation, but additional reports for well flow, booster flow, net system demand, water quality, and reservoir level/volume will provide greater insight into the system’s performance. These new reports should feature hourly summaries in a daily format, and daily values in a monthly format. The daily reports will allow the operators to see hour-

by-hour summaries of the SCADA system, and the Monthly reports will be best used for agency reporting and planning. Below is a table defining the additional reports that would be added.

No.	Current Reports	New Reports
1	Well Flow Summary (daily values for 1-month)	
2		Well Flow Summary (hourly values for 1-day)
3		Booster Flow Summary (daily values for 1-month)
4		Booster Flow Summary (hourly values for 1-day)
5		Net System Demand (daily values for 1-month)
6		Net System Demand (hourly values for 1-day)
7		Water Quality Summary (daily values for 1-month)
8		Water Quality Summary (hourly values for 1-day)
9		Reservoir Level & Volume (daily values for 1-month)
10		Reservoir Level & Volume (hourly values for 1-day)
11		Average Pumping Efficiency (daily values for 1-month)
12		Average Pumping Efficiency (hourly values for 1-day)

Additionally, new application software is developed to form an “instantaneous demand” tracking value of the system, with outputs in 15-minute snapshots. (The City does not have the required inlet and outlet flow meters on each reservoir to provide a true instantaneous demand, therefore, an estimated calculation at 15-minute segments is provided using PLC software). The 15-minute demand snapshot will be a trend value which will provide key performance indication of the system. The trend window will also be able to be exported for reporting purposes.

PLC application software is required to be added to the existing master telemetry unit to provide the “socket” for the reporting software to connect and then pull in data values. Report generation development time is also required to develop the template format, link the appropriate PLC data points, and schedule the reporting cadences. Operator training time is also added to ensure the staff able to self-perform reporting functions. It is expected the system integrator will perform all PLC and reporting application software programming, as well as the required field commissioning. The cost estimate for the reporting addition is shown below.

Table 19 – Report Additions- Cost Estimate

<i>Item Description</i>	<i>Unit Price</i>	<i>Qty</i>	<i>Extended Price</i>
MTU Application SW Updates	\$4,400	1	\$4,400
Reports Development (11 new reports)	\$8,225	1	\$8,225
Commissioning Services (per day)	\$1,375	1	\$1,375
Total:			\$14,000

4.3 Organizational Impact

The gap closure requirements to take the Utility from the current state to the ideal state have been identified and explained in detail. The gap analytics also evaluates the organizational and human capital requirements of the Utility to move to the ideal state and maintain it. The Utility is already in very good health and standing currently where modern technologies and best practices are already in place, requiring far less organizational change than most utilities.

The Utility already subscribes to a lean staffing model where personnel are well rounded in their abilities and able to service many items in their water system. The SAI does not intend to change the lean staffing philosophy of the Owner, but the SAI will provide recommendations of organizational change which will complement the staffing methodology of the Utility. The requirements for each layer of the SCADA system is found below.

4.3.1 Field Devices

4.3.1.1 Smart Motor Starter Diagnostics Training



The Utility is excelling in the use of Smart Motor Starters throughout their system. Although these units provide great insight into motor starter and pump performance, there is a learning curve associated with gaining proficiency and diagnostic skills with the Smart motor starters. Smart motor starters can be in three varieties: VFD, RVSS, or a smart overload device. Each one behaves uniquely, and the operator controls on the motor starter bucket and HMI interface are all different. For each motor starter type, it is recommended the operations staff is proficient with the following items.

- adjusting the configuration settings of the motor starter
- reading diagnostic codes
- understanding the alarms associated with the starter
- modifying the ramp speed of a motor
- identifying the process interlocks connected to a motor starter

While some of the Utility's operational staff understands these items, not all personnel have the knowledge to perform all items in the list above. To move to have all staff personnel gain the motor starter diagnostics and tuning skills, additional training is required. It is recommended that the Utility spend one day of training with their systems integrator, S&B Inc, on an annual basis to review the motor starter diagnostic and tuning capabilities of starters throughout their system. It is recommended to have the training on an annual basis for at least 3 consecutive years to improve the retainage of the information. The costs associated with a single day of training is shown below.

Table 20 - Motor Starter Training Cost Estimate

Item Description	Price
<i>Training Day (8-hours)</i>	\$1,375

4.3.2 Networks

4.3.2.1 Cellular Diagnostics Training



As the Utility moves to a hybrid communication topology, over a private cellular network, diagnostic skillsets for digital communication and cellular modem hardware will need to be acquired by the City's operations staff. These skills should be well maintained as the City transitions from leased line to cellular, therefore, ongoing training for digital communication diagnostics should occur on an annual basis. The digital communications training should include the following topics:

- Resetting cellular modem hardware

- Replacing cellular lighting arresters
- Diagnostics for MTU's VPN appliance
- Diagnostics for RTU cellular modem
- Evaluation of cellular signal (gain and dB)

These diagnostics skills are very attainable for existing personnel to learn. It is anticipated that annual training can keep the operations staff educated and ready to perform digital communication diagnostics tasks. Telemetry communication is vitally important to the SCADA system, and due to its high criticality, it is recommended the Utility engage in training on an annual basis. A full 8-hour day of training, provided by the control system integrator who commissions the SCADA communication system, is recommended for all operations personnel.

Table 21 - Cellular Network Diagnostic Training Cost Estimate

Item Description	Price
<i>Training Day (8-hours) by control system integrator</i>	\$1,375

4.3.3 Automation

4.3.3.1 Automation Hardware Training + Equipment Supply



The gap closure requirements to update or modernize existing hardware will utilize the two automation hardware platforms which are standard for the Utility – the Siemens S7-1500 line and S7-300 line of processors. The gap closures represent no additional educational or training burden to the Utility as this equipment is already in place throughout the Utility.

PLCs are regarded as the most reliable piece of equipment in a facility as the published mean-time-between-failure rates are between 25-to-50 years. PLC failures are incredibly rare. But in the event of a failure, the Operations staff should be prepared to perform a cold-backup PLC exchange in the field. The City employs 11 PLC panels, and the future SCADA system is designed around the Siemens S7-1512 processor to serve all sites. Therefore, having a cold-backup of the new SCADA standard PLC is recommended as it will be able to serve all upgraded facilities.

In the event of a failure, the cold backup PLC can be rapidly exchanged as it plugs into the PLC chassis in seconds. The old PLC's memory card is removed and inserted into the cold-backup PLC as it will boot up off a removable memory card which contains the stations process control instructions. The procedure to exchange a PLC is very simple and achievable by all the operations staff. A 1-hour training session is expected to suffice to educate staff members on how to exchange a PLC and answer any other PLC questions. The estimated costs assumes the training session will be conducted when the systems integrator is on-site for other work, and therefore, the City does not pay for the upfront travel time costs. associated with a cold-backup PLC and a 1-hour training session are shown below.

Table 22 - Automation Hardware Training Cost Estimate

Item Description	Price
<i>Training session (1-hours) by control system integrator</i>	\$150

Cold Backup PLC, Processor Only (Siemens S7-1512)	\$1,400
Total	\$1,550

As a cost savings alternative, the City can elect to not carry a spare, and rely upon the stocking levels of their System Integrator, who carries Siemens PLC equipment, and supply a stocked PLC to the City typically within 24-hours of a replacement request. Only the training session would be required.

4.3.3.2 Automation Software Training



Training for Automation application software is typically provided for organizations who utilize in-house talent for PLC/HMI software development. In-house development is most commonly found at the largest of municipal water organizations (e.g. Seattle Public Utilities). Most small through large sized water utilities rely upon third parties, like a systems integrator, to provide application software. The City currently follows industry norms of utilizing a systems integrator for application software. With no City personnel developing PLC/HMI application software, no training is required.

It is important to note that with the current need to upgrade most of the automation system, the new equipment will support system integration services via on-site and/or remote access by trained engineers – a new feature for the Utility. The response time for support cases will be greatly improved as each RTU is upgraded.

4.3.4 Visualization

4.3.4.1 SCADA Visualization Training via Implementation Firm



Training for SCADA Visualization application software is typically provided for organizations who utilize in-house talent for visualization software development. In-house development is most commonly found at the largest of municipal water organizations (e.g. Seattle Public Utilities). Most small through large sized water utilities rely upon third parties, like a systems integrator, to provide application software. The City currently follows industry norms of utilizing a systems integrator for application software. With no City personnel developing visualization application software, no training is required.

4.4 Annual Investment in New Technologies

The healthiest SCADA systems are built by spending a small annual budget to invest in trials of new SCADA technologies for evaluation of system wide deployments. The Utility should plan to estimate \$10,000-\$20,000 per year to experiment with a new technology offering. Examples of technology offerings may include:

- new communication media for RTUs
- new PLC/HMI application software
- new motor control devices and/or application software
- new instrumentation
- new modules or licenses for SCADA Visualization
- new reporting functions

Annual sampling of new technologies allows the Utility to make informed decision about upgrades in their system based on in-field results. The experimenting allows for operator feedback to fine-tune how a technology should be implemented Utility-wide. And this annual investment keeps the Utility in a leading (rather than lagging) position with technology.

Table 23 – Annual Investment in New Technologies Cost Estimate

Item Description	Price
Annual Investment / Budget	\$10,000 - \$20,000

Section 5 – Cost Summary

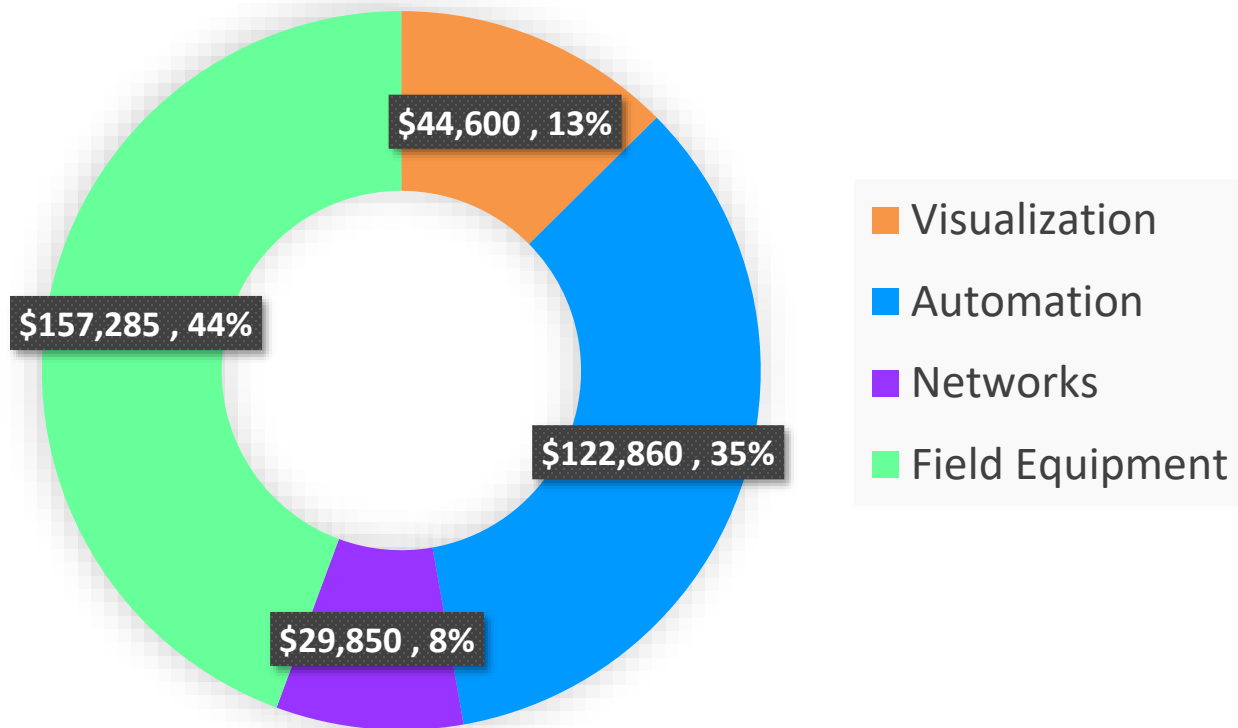
The cost estimates associated with the gap closures for the four layers of SCADA (field devices, networks, automation, and visualization) are shown in the table below. Costs are separated by project execution costs (e.g., motor starter replacement) and future re-occurring costs (e.g., budgeting for future replacement of RTU control panels).

Table 24 – Gap Closure Cost Summary

Description of Work	Doc. section	sub-total (initial purchase)	Qty	ROM Price Estimate	Future Re- Occurring Costs
Field Devices		\$157,285			
Smart Motor Starters	4.3.1.1				
Well 5 VFD	4.3.1.1.1		1	\$49,645	
Well 6 Site - Booster Pump #1 Simocode	4.3.1.1.2		1	\$4,615	
FHB Water Pump Station VFDs	4.3.1.1.3		4	\$48,990	
Data Set Context Software	4.3.1.1.4		8	\$17,750	
Training - Smart Motor Starter Diagnostics (1-day)	4.4.1.1		1	\$1,375	
Instruments	4.3.1.2				
Water Quality Analyzers	4.3.1.2.1		3	\$24,810	
Submersible Level Probes	4.3.1.2.2		5	\$6,890	
Pressure Transmitters	4.3.1.2.3		2	\$3,210	
Networks		\$29,850			
Added Resiliency for MTU Cellular Modem	4.3.2.1.2		1	\$120	
Fiber Optic Cable Replacement at FHB	4.3.2.2.3		1	\$2,255	
Hybrid Topology	4.3.2.3		6	\$26,100	
Training - Cellular Diagnostics (1-day)	4.4.2.1		1	\$1,375	
Automation		\$122,860			
Forked Horn Butte Facilities	4.3.3.4.1				
FHB Transfer Station RTU Upgrade	4.3.3.4.1.1		1	\$53,530	
FHB Water Pump Station RTU Upgrade	4.3.3.4.1.2		1	\$22,685	
Water Dispensing Station RTU Replacement	4.3.3.4.2		1	\$29,750	
HMI Upgrades	4.3.3.4.3		3	\$15,345	
Annual Replacement of Obsolete Equipment	4.3.3.5		0.75		\$34,370
Annual Investment in New Technologies	4.5				\$10,000
Training + Cold Backup PLC	4.4.3.1		1	\$1,550	
Visualization		\$44,600			
Computer Hardware Upgrade	4.3.4.2.1		2	\$16,100	
WinCC SCADA Graphics Overhaul	4.3.4.2.2		1	\$14,500	
Additional Reports Development	4.3.4.2.3		11	\$14,000	
Total:				354,595	44,370

The cost breakdown by percentage between each area of the SCADA hierarchy is shown in the associated figure.

Category	Cost	Percentage
Visualization	\$44,600	13%
Automation	\$122,860	35%
Networks	\$29,850	8%
Field Equipment	\$157,285	44%
Total:	\$354,595	100%



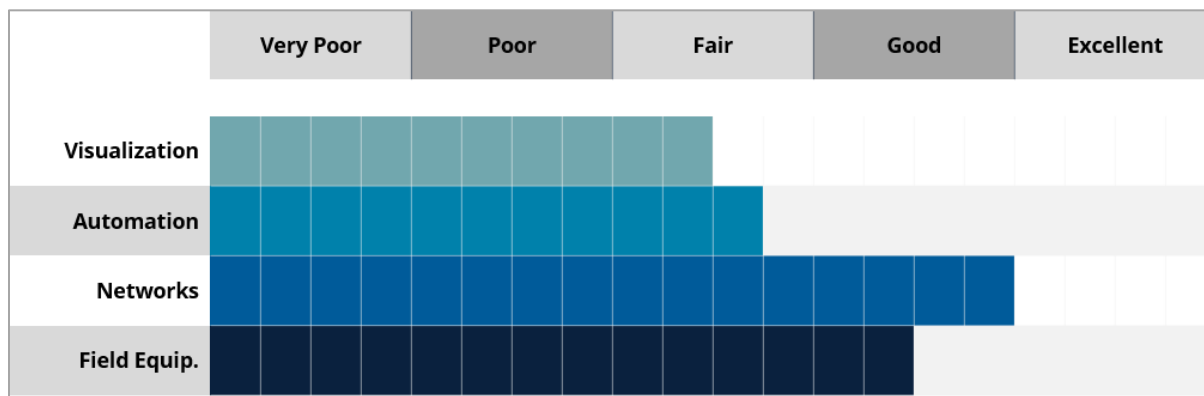
Section 6 – Gap Closure Analysis

6.1 Brief Review

The City's system is in very good health. The system represents a very advanced SCADA system with modern technologies and high-quality standards of design. The vast majority of all of the City's shortcomings in the Gap Analysis (section 4) are due to aged equipment that is now technologically obsolete or approaching the end of the products forecasted lifecycle. The City did not have issues of poorly performing equipment (which is very rare to find). Our analysis finds that the City has excelled in maintaining their SCADA infrastructure, and additional coordination and effort is needed in the next five years to stay ahead of several pieces of SCADA equipment reaching the end of their life.

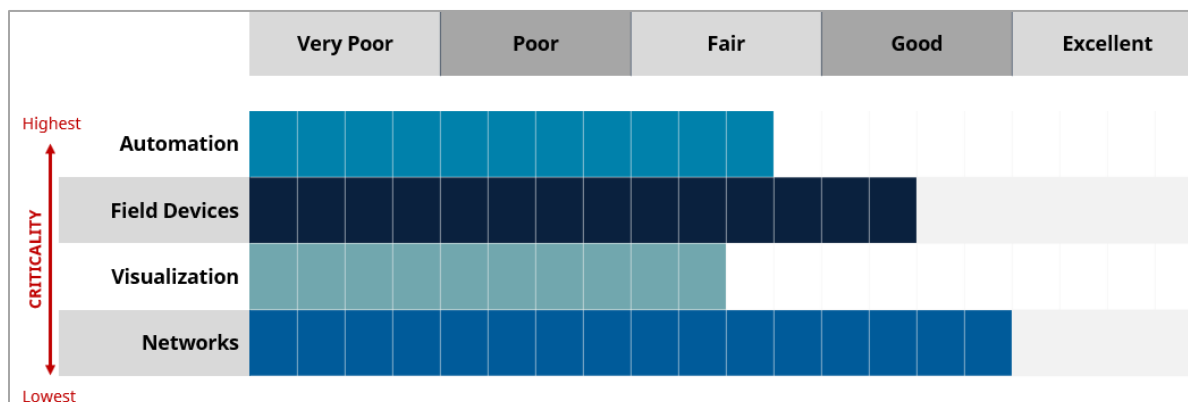
6.2 System Health Bar Charts

Below is a bar chart showing the overall health of the City's SCADA system. The order follows the SCADA hierarchy of data flow starting with the field equipment all the way up to visualization system.



The same information is now reorganized by overall criticality – based upon the system's current needs. The three major upgrade requirements are:

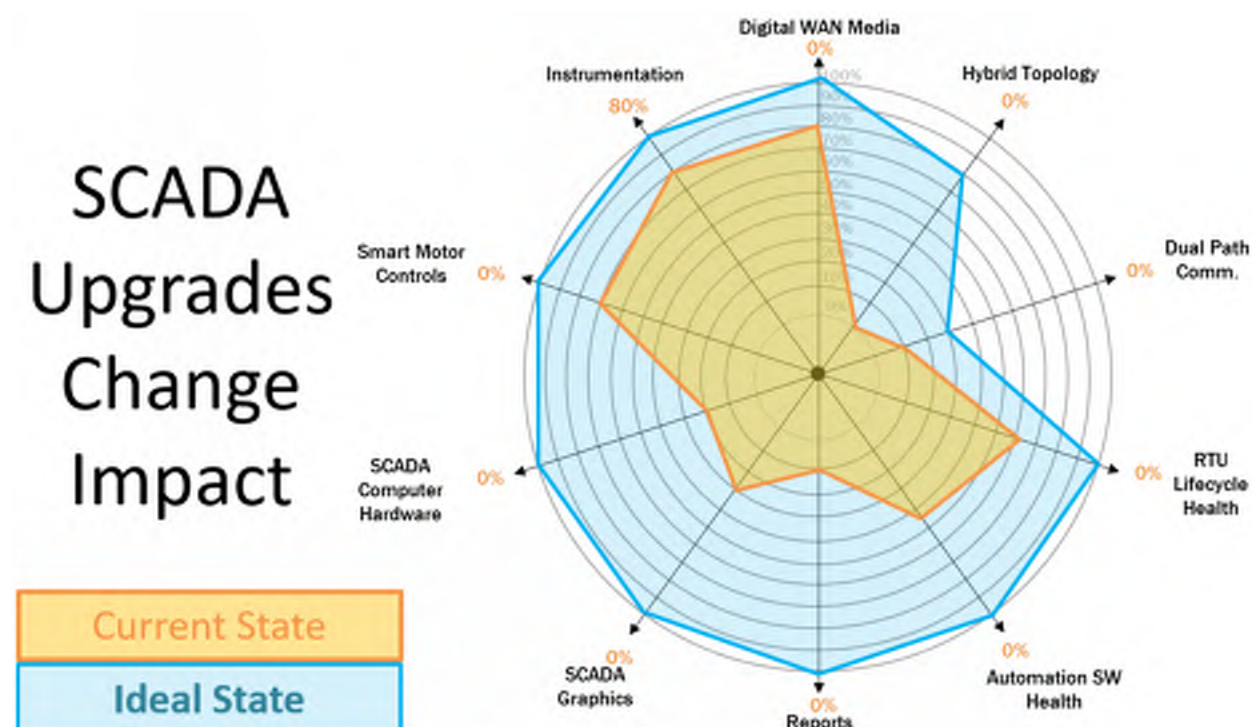
- Automation: Forked Horn Butte Facilities and the Water Dispensing Station
- Field Devices: Forked Horn Butte Pump Station VFDs
- Visualization: SCADA Computer Hardware



6.3 Radar Chart Analysis

A radar chart is used to compare the current SCADA state against the envisioned SCADA state. The orange color of the chart represents the current SCADA system's progress on a 0-100% scale, where 100% represents achieving the full buildout and maturity of the envisioned SCADA state. The blue section represents the ideal system as defined by the Utility's selected SCADA standards (section 2). With both the current and ideal SCADA states overlaid on the 0-100% scaled radar chart, the gaps and magnitude of effort required for gap closures can be visualized.

The Utility shows strong progress towards the ideal state in categories related to smart motor starters, instrumentation, use of digital communication media, and RTU lifecycle health, but the Utility has large gap closure efforts in areas of the SCADA visualization system, hybrid communication architecture buildout and automation upgrades. Brief descriptions explaining the gaps are found in the sections below.



6.3.1 Chart Details

6.3.1.1 Smart Motor Starters

The Utility is in good health as only 8 of 29 smart motor starters have reached end of life and require replacement. The remaining 21 smart motor starter units are in good health.

6.3.1.2 Instrumentation

Focusing on the core instrumentation (level, flow, pressure, and water quality devices), the Utility is in good health and only has 10 of 49 devices requiring replacement due to products reaching the end of their expected life.

6.3.1.3 Digital WAN Communication Media

The Utility recently upgraded from analog to digital communication media (2020-2021). Only the Forked Horn Butte site remains to be upgraded to digital (cellular communication).

6.3.1.4 Hybrid Topology

The hybrid topology architecture is a future design implementation, and it does not exist currently. When implemented, only 8 of the 10 facilities will require peer-to-peer overlay connections.

6.3.1.5 Dual Path Communication

Dual path communication is used for added resiliency, and is therefore not implemented at all sites. Currently only 1 site (the MTU) uses two, simultaneous, communication media. But when the Forked Horn Butte site is upgraded, it will become the second site with dual path, fulfilling the resiliency requirement.

6.3.1.6 RTU Lifecycle Health

Four of the 11 RTUs in the system have reached end of life and will require replacement to refresh their technological capability. These RTUs are technologically obsolete, and two of the four are deemed “mature” by the manufacturer.

6.3.1.7 Automation Software Health

Six of the 11 RTUs in the system have a pieces of their equipment which does not support migration to the latest Siemens TIAPortal Software and will require replacement. (Of the six sites, three are already slated for RTU replacement).

6.3.1.8 Reports

The Utility’s SCADA visualization system only utilizes one automatic reporting template. An additional eleven reports are recommended to be constructed which will provide greater detail and operation insight for the operators.

6.3.1.9 SCADA Graphics

The Utility’s SCADA visualization graphics are mature, as they were developed in the early 2000s. A re-engineering effort will bring out more capabilities and greater situational awareness to the water system for improved use.

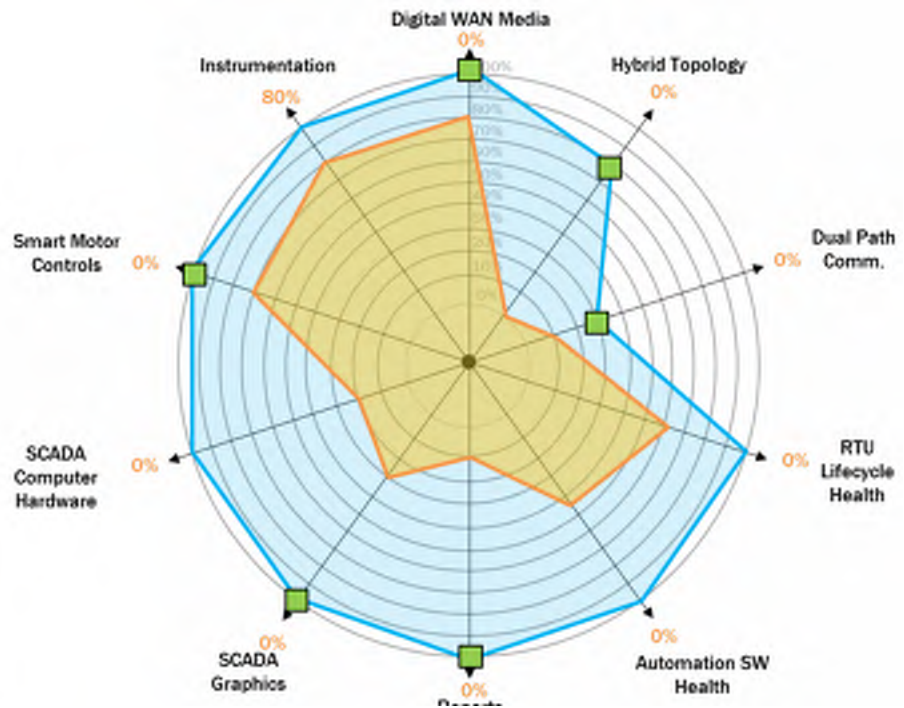
6.3.1.10 SCADA Computer Hardware

The two SCADA computers were commissioned in 2017 and have 1 year of remaining life on their 5-year lifecycle. Computer hardware replacement with the associated WinCC and Win911 software package upgrades will reset the lifecycle of the computer system.

6.3.2 Organization Impact Associated with SCADA Upgrades

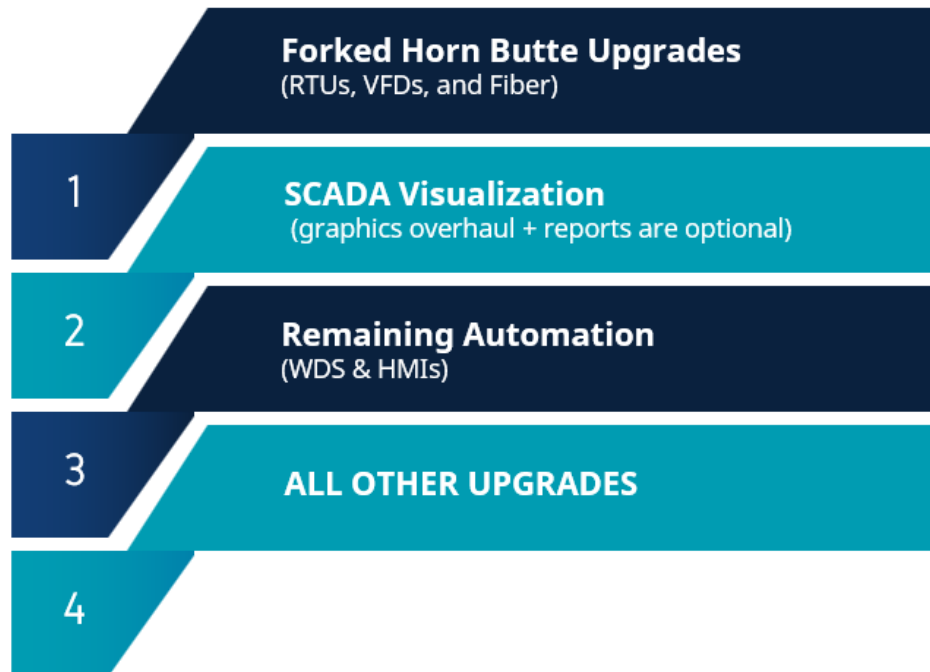
In addition to gaps, the radar chart also shows the organizational impact required to achieve the ideal state. The Utility is in a healthy position to undertake gap closure projects as all project categories represent upgrades which only require new training – and some do not require training. No gap closures require a new role within the department, or rely upon outside departments, which allows for the fastest pace of project implementation – but the Utility can select to go at any pace they wish. Most of the training will concentrate on post-commissioned maintenance or troubleshooting tasks. Gap closures requiring additional organizations/roles outside of operations typically require the most planning and specification to ensure all parties can understand the scope, level of effort, available resources, and policies associated with cross-departmental work – but there is no such requirement present in this gap analysis.

SCADA Upgrades Change Impact



Section 7 - Gap Closure Order-Of-Solve Sequence

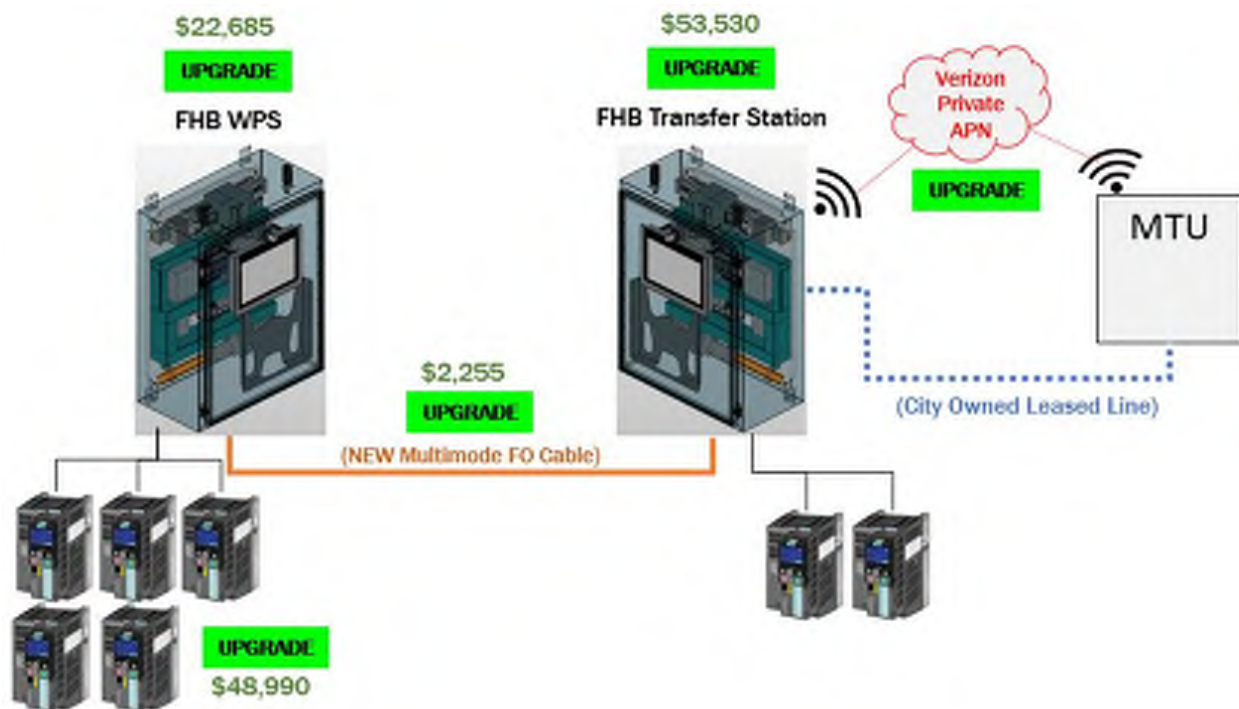
Based upon the gap closure requirements required to move from the current state to the ideal state, a general order-of-solve should be followed to minimize expense and engineering efforts, while also providing immediately realizable benefits to the owner. Our recommendation is to follow this general order of solve sequence: Forked Horn Butte, SCADA Visualization (hardware only), Automation, and all other upgrades.



(Details on each upgrade step are found on the following pages)

7.1 Forked Horne Butte Upgrades

The Forked Horn Butte facility is the highest criticality of all stations in the City, and its aging automation and VFD motor starters must be addressed right away. But with the addition of the Well8/Res7/Booster1A site, the Forked Horn Butte pumps may be resized to accommodate new pumping demands, therefore the City must first coordinate with their design consultant, MurraySmith, to ensure the replacement VFDs will match any pumps which may be re-sized. There are cost savings and reduction of risk to perform all Forked Horn Butte work together in a single project, and the City is encouraged to use this approach.



A summary of the combined costs (found in section 4) for the Forked Horn Facility gap closures are shown below.

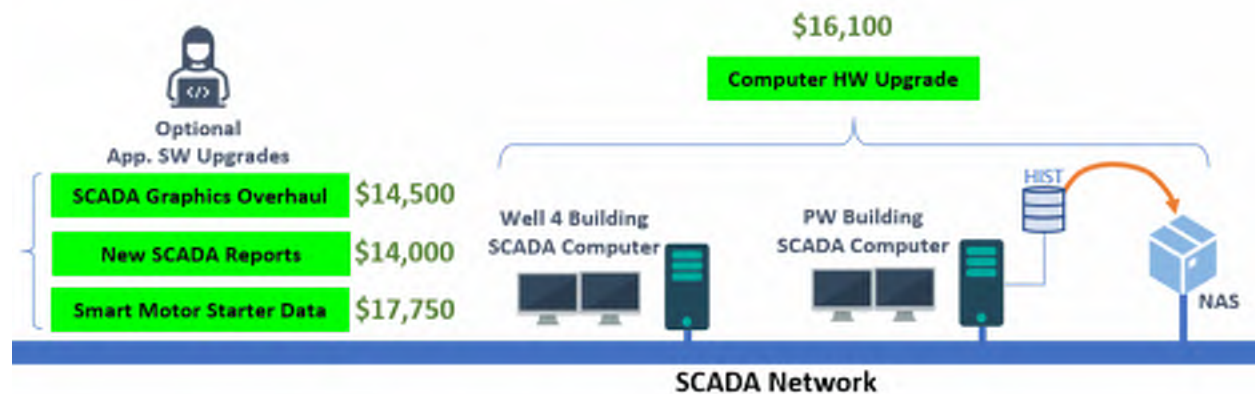
Table 25 – FHB Upgrades (combined) - Cost Estimate

Item Description	Extended Price
FHB Transfer Station RTU Upgrade	\$53,530
FHB Water Pump Station RTU Upgrade	\$22,685
FHB Water Pump Station VFDs	\$48,990
Fiber Optic Cable Replacement at FHB	\$2,255
TOTAL:	\$127,460

7.2 SCADA Visualization Upgrades

The SCADA computers have one year of remaining life and the computer hardware must be upgraded. The associated WinCC SCADA software and Win911 alarm notification software are to be migrated to the current version and deployed on the replacement computer hardware. This hardware upgrade is the only timely upgrade requirement.

The City has the flexibility to perform the three additional upgrades which are associated with the SCADA visualization system on their timeframe: 1) graphics overhaul, 2) reports development, and 3) smart motor starter data context. These three optional upgrades can be performed individually at different times or bundled together as part of a larger visualization project.



A summary of the combined costs (found in section 4) for the SCADA visualization and smart motor starter context gap closures are shown below.

Table 26 – SCADA Visualization System (combined) - Cost Estimate

Item Description	Extended Price
Computer Hardware Upgrade	\$16,100
Optional: WinCC SCADA Graphics Overhaul	\$14,500
Optional: Additional Reports Development	\$14,000
Optional: Smart Motor Starter Data Context	\$17,750
TOTAL:	\$62,350

7.3 Automation Upgrades

The remaining automation equipment requires modernization of touch panels at three station to allow for the foundational software of the PLC/HMI equipment to be migrated to current software offerings, which will in turn provided the security patching for the automation equipment. Additionally, the water dispensing station (WDS) is at end of life, and ready for replacement. The City has plans to use the new WDS as the Reservoir 7 level monitoring device during facility construction, then re-purposed as the new water dispensing station when the Well 8/Res7/Booster 1A facility is commissioned. Therefore, the need for the new WDS will be dictated by the Reservoir 7 construction schedule.



A summary of the combined costs (found in section 4) for the remaining automation gap closures are shown below.

Table 27 –Automation System Upgrades - Cost Estimate

Item Description	Extended Price
Water Dispensing Station RTU Replacement	\$29,750
HMI Upgrades	\$15,345
TOTAL:	\$45,095

7.4 All Remaining Upgrades

Upon completion of the Forked Horn Butte, Visualization, and Automation upgrades, the criticality significantly drops, and the City should perform upgrades based upon both a product lifecycle and need. The table below outlines the outstanding projects, their associated timeframe for project execution, and the cost estimate from section 4. All projects can be performed as a stand-alone gap closure effort, grouping is not required.

Table 28 –All Remaining Upgrades - Cost Estimate

<i>Item Description</i>	<i>Timeline</i>	<i>Price</i>
<i>Cellular Diagnostics Training</i>	Now / Annually	\$1,375
<i>Smart Motor Starter Diagnostics Training</i>	Now / Annually	\$1,375
<i>MTU Resiliency Addition (Relay for Modem Reset)</i>	Now	\$120
<i>Well 6 Reservoir Level Probe Replacements (2x)</i>	Now	\$2,060
<i>Well 6 Booster #1 Simocode Addition</i>	Now	\$4,615
<i>FHB Transfer Station (new tank) Level Probe Replacement</i>	Now	\$1,000
<i>Automation Exchange Training + Cold Backup PLC</i>	Now	\$1,550
<i>Well 5 Level Probe Replacement</i>	Before 2024	\$1,440
<i>FHB Transfer Station Pressure Transmitter Replacements (2x)</i>	Before 2025	\$3,210
<i>Well 5 VFD Replacement</i>	Before 2025	\$49,645
<i>Well 7 Level Probe Replacement</i>	Before 2025	\$2,390
<i>Well 3 Water Quality Analyzer Addition</i>	Flexible	\$8,270
<i>Well 4 Water Quality Analyzer Addition</i>	Flexible	\$8,270
<i>Well 5 Water Quality Analyzer Addition</i>	Flexible	\$8,270
<i>Hybrid Communication Topology Implementation</i>	Flexible	\$26,100
Total:		\$119,690

Appendix F

Cost Estimating Methodology

Introduction

This Appendix summarizes the development of unit costs required for the cost estimating used to identify solutions for the development of the City of Redmond's (City) Water Master Plant (WMP). Project unit costs presented here provide the cost basis for the optimization process used to evaluate water system alternatives, as referenced in **Section 3 – System Analysis**. Unit costs were developed for each type of water system infrastructure considered in the system analysis (e.g., waterlines, new wells, booster stations). Project unit costs are also used for development of the final Capital Improvement Project (CIP) budgets associated with the water system improvements recommended for adoption by the City; see **Section 4 - Capital Improvement Plan**. All costs identified in this section reference U.S. dollars. The Engineering News Record Construction Cost Index (ENR CCI) basis is 12,945 (Seattle, April 2021).

Cost Basis

All costs identified in this section reference U.S. dollars. The Engineering News Record Construction Cost Index (ENR CCI) basis is 12,945 (Seattle, April 2021).

Project unit cost estimates were prepared in accordance with the guidelines of American Association of Cost Engineers (AACE) International, the Association for the Advancement of Cost Engineering. (*AACE International Recommended Practice No. 56R-08 Cost Estimate Classification System - As Applied for the Building and General Construction Industries - TCM Framework: 7.3 - Cost Estimating and Budgeting Rev. March 6, 2019*). AACE International's description of a Class 5 Estimate is quoted as follows:

Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner.

Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.

Typical accuracy ranges for Class 5 estimates are -20% to -30% on the low side, and +30% to +50% on the high side, depending on the construction complexity of the project,

appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks.

The unit project cost estimates have been prepared for the purpose of evaluating project alternatives and budgeting for master plan implementation. Unit project cost estimates were prepared from information available at the time of the estimate and are based on a low level of project definition. Unit project costs developed herein produce “rough cost estimates” consistent with the definition of Oregon Administrative Rules 660-011-0005(2) and 660-011-035. The true cost and resulting feasibility of a planned project will depend on the actual labor and material costs, competitive market conditions, site conditions, final project scope, implementation schedule, continuity of personnel, and other variable factors. Therefore, the actual unit project costs will vary from the estimates presented here. Because of these factors, project feasibility, benefit-to-cost ratios, risks and funding must be carefully reviewed prior to making specific financial decisions or establishing project-specific budgets.

Water System Components Subject to Project Unit Cost Analysis

Project unit costs were developed for two classes of water system components: waterline assets and facility assets.

Waterline assets include:

- Trenched new/replacement waterline
- Trenchless waterline crossing river, canal, railroad, and highway

Facility assets include:

- New well
- Existing booster station hydraulic upgrades
- Condition improvements (as described in **Section 3 System Analysis**)

Cost Items Excluded

The following elements were not included in the development of unit project costs:

- Water system studies, planning, or modeling.
- Finance charges accrued during the planning, design, or construction of assets.
- Groundwater control during asset construction; groundwater is not a typical cost factor for underground and above-ground constructions in the City. (It is assumed that canal crossings are constructed during non-irrigation season.)

- Electrical distribution line extensions, service lines, or transformers as needed to serve wells, booster stations reservoirs. (It is assumed that the utility provider will construct these facilities with the expectation of cost recovery through user charges.)
- Improvements to water distribution, pumping, storage, or treatment facilities in response to changes in regulatory standards or rules.
- Remediation or fines.
- Decommissioning or rehabilitation costs at an asset's end of life.

Project Unit Cost Development

Project unit costs were developed through a progression of steps and methodologies. The steps include development of component unit costs, construction unit costs and, finally, project unit costs. These methodologies will be discussed throughout this section.

The component unit cost includes the sum of materials, labor and equipment of easily identifiable features of a project. The construction cost is the sum of component unit costs and markups to determine the probable cost of construction (i.e., the contractor bid price). The project unit cost is the sum of construction unit costs with additional cost allowances for engineering, legal, and administrative fees to determine the total project cost to the City.

Cost Approach

To develop project unit costs, one of the three following approaches was used:

Approach 1: Component Costs

References component costs of specific work readily available from cost estimating sources such as *RS Means*. Component costs for specific work were developed from the sum of material, labor, and equipment costs for individual elements that make up the specific work. In some cases, an estimate of component cost for construction of specific work was solicited from construction contractors with recent and applicable experience with the subject technology, means, methods, and materials.

Approach 2: Bid Tabs

References available data for the total cost of construction for similar projects undertaken in the Oregon and the northwest within last 15 years. Available construction cost data was escalated from the year the project was bid or constructed to the year 2019.

Approach 3: Facility Condition Assessment

References component cost of specific work done during the itemization of existing facilities during condition assessments. Component costs for individual elements of specific work were

developed from the sum of material, labor, and equipment costs for specific work. Composite facility costs were compared to other approaches to ensure the condition assessment approach provided representative costs.

Construction Unit Costs

Construction unit cost account for elements of projects during construction such as mobilization or erosion control and sums the cost of component unit costs plus markups. Markups were applied differently depending on which of the three cost approaches was used and a summary is provided in **Table F-1**. For Approach 2 markups were not applied to obtain the construction unit cost because it was already included in component unit cost.

Construction Mobilization

Mobilization markup accounts for the cost of the contractor's administrative and direct expenses to mobilize equipment, materials and labor to the work site.

Traffic Control

Traffic control markup accounts for the cost of signage, flagging and temporary barriers, street widening, pavement markings, lane delineators and lighting at flagging locations. The level of effort and cost for traffic control depends on the size and scope of a project, and local conditions at the time of construction.

Erosion Control

Erosion control markup accounts for materials and practices to protect adjacent property, storm water systems, and surface water in accordance with regulatory requirements. The level of effort and cost for erosion control depends on the size and scope of a project, and the local conditions at the time of construction.

Construction Contractor Overhead and Profit

This markup accounts for the contractor's indirect project costs and anticipated profit.

Construction Contingency

Water system improvements considered in planning-level evaluations were subject to a contingency to account for the cost of uncertain and unanticipated factors. These factors include unanticipated utilities, relocation and connection to existing infrastructure, minor elements of work not addressed in component unit cost development, details of construction, changes in site conditions, and variability in construction bid climate. The sum of component unit costs was marked up by the construction contingency.

A summary of markups is provided in **Table F-1**.

Table F-1 | Markups on Component Unit Costs to Obtain Construction Unit Cost by Approach

Description	Approach 1 Project Markup	Approach 2 Project Markup	Approach 3 Project Markup
Construction Mobilization	10%	Included in Component Cost	10%
Traffic Control	2% Local Road 4% Arterial Road	Included in Component Cost	0%
Erosion Control	1%	Included in Component Cost	0%
Construction Contractors Overhead and Profit	15%	Included in Component Cost	15%
Construction Contingency	30%	Included in Component Cost	30%

Project Unit Costs

To develop project unit costs, markups for engineering and the City's legal and administrative costs were added to the construction unit cost developed and are applicable to all three cost approaches. The markups are summarized in **Table F-2**.

Engineering

Construction unit cost was subject to markup for engineering to account for the cost of professional services associated with survey, design and production of contract documents. The markup for engineering includes the cost of construction period support services generally consisting of submittal review, supplemental information and change evaluation.

City's Legal and Administrative Expenses

Construction unit cost was subject to markup for City's legal and administrative expenses to account for the direct and indirect cost of project management staff, finance and purchasing assistance, legal services, and City's testing agency deployed during construction.

Table F-2 | Markups on Construction Unit Costs to Obtain Project Unit Cost

Description	Project Markup
Engineering	20%
City's Legal and Administrative Expenses	10%

Waterline Asset Project Unit Cost Assumptions

Assumptions applied in development of waterline asset project unit costs are described here.

Rock Excavation

It was assumed that blasting and rock excavation would be required for all new trenching at depths greater than one foot below existing ground surface.

Fittings, Valve and Water Meters

Waterline costs includes costs for fittings, valves, fire hydrants, and water meters. Fittings, valves and fire hydrant are included as 29 percent of pipe costs to account for inline valves, fitting and valve clusters and fire hydrants. The costs of water service lines is included as 2 percent of pipe costs, which includes excavation, construction materials, backfill, and surface restoration for the water services from main to meter.

Surface Restoration

Project unit costs for waterline assets are differentiated according to surface restoration requirements for local, collector and arterial roads. For development of specific project costs, surface restoration was assigned to waterline assets according to the road classification with half road extents. Surface restoration includes existing surface demolition and disposal, aggregate base and asphalt replacement, striping, etc. Project unit costs associated with surface restoration were developed using Approach 1. No highway surface restoration is included in any cost estimates and only trenchless highway crossing projects are included in the analysis.

Trenched and Trenchless Waterlines

Project unit costs for waterlines are differentiated according to the trenching requirements. Trenchless construction is targeted at locations where open-cut methods are not practical or permissible, including river, railroad or highway crossings. All other projects were assumed to include open-cut trenches. The trench construction costs are a function of pipe diameter and were developed using Approach 1.

Waterline Asset Project Unit Costs

The following tables present project unit costs used in calculation of capital cost (initial cost) for the referenced category of work. Operation and Maintenance (O&M) costs are not included in the project unit costs.

New Waterlines

Project unit costs for trenched new waterlines are presented in **Table F-3**. Project unit costs are based on ductile iron (DI) used for waterlines pipes: Class 52 used for waterlines 6 to 12-inches in diameter and Class 50 used for waterline pipes 16 inches in diameter and larger. Project unit costs include the cost of fittings, valves, and water meters, but do not include the cost of surface restoration for the roadway surface associated with the alignment of a specific project.

Table F-3 | Trenched New Waterlines Project Unit Costs

Pipe Diameter (inches)	Project Cost (\$/ft)
8	\$298
12	\$383
16	\$422
18	\$456
24	\$615
30	\$731
36	\$873
42	\$1,020

Trenchless River/Canal/Railroad/Highway Waterline Crossing

Project unit costs for trenchless river/canal/railroad/highway crossing waterlines are presented in **Table F-4**. These costs assume horizontal directional drilling in rock, using HDPE pipe materials installed directly in a new bore. Cost allowances provide for excavation and restoration of bore pits at each end of the crossing segment, support and protection of utilities in the work area, and coordination with utilities. Surface restoration along the waterline route is not a typical consideration for directional drilling work, so no cost allowance is provided. Project unit costs were developed assuming no fittings, valves, hydrants or reconnection of water services in the trenchless area.

Table F-4 | Trenchless River/Railroad/Highway Crossing Waterline Project Unit Costs

Pipe Diameter (inches)	Project Cost (\$/ft)
8	\$2,271
12	\$2,920
16	\$3,223
18	\$3,483
24	\$4,694
30	\$5,581
36	\$6,663
42	\$7,788

Surface Restoration

Surface restoration costs used in calculating the project unit cost of a project are presented in **Table F-5** and **Table F-6** in dollars per linear foot (\$/LF). These costs include the costs to remove existing surface and replace. The cost of surface restoration during construction of waterlines is dependent on the existing roadway surface in the following alignments: local road, or arterial road. The cost of surface restoration is also dependent on the surface restoration extents: trench patch, half road, full road, full right-of-way.

Table F-5 | Local Road Surface Restoration Project Unit Costs

Pipe Diameter (inches)	Project Cost (\$/ft) Trench
8	\$56
12	\$56
16	\$56
18	\$56
24	\$61
30	\$65
36	\$69
42	\$74

Table F-6 | Arterial Road Surface Restoration Project Unit Costs

Pipe Diameter (inches)	Project Cost (\$/ft) Trench
8	\$79
12	\$79
16	\$79
18	\$79
24	\$86
30	\$92
36	\$99
42	\$103

Facility Asset Project Unit Cost Assumptions

The following cost assumptions, where applicable, have been included in the development of project unit costs for facility assets. Details on developed cost curve and what it includes are presented in below.

Access, Security, Landscape

Basic access, security and landscape costs are included in the reference cost data used to formulate project unit cost curves.

Utility Services

Costs for water, sewer, gas and communication utility service are included in the reference cost data used to formulate project unit cost curves. The cost of substantial upgrade or extension of primary power service (and other utilities) required for planned projects was assumed to be carried by the utility provider, with provisions for cost recapture through user fees.

Facility Asset Project Unit Costs

New Well

Project unit costs for this category of work are applicable to a new well in a new service area, expansion of well field in an existing area or replacement of an existing well to address hydraulic deficiencies. Project unit cost curves for wells were developed using a combination of Approach 1 and Approach 2 with cost as function of firm capacity (gpm). New wells are considered shallow, average and deep depending on the depth to groundwater in the area of the well.

Booster Station Hydraulic Upgrade

Project unit costs for this category of work are applicable to booster station upgrades within an existing facility to address hydraulic deficiencies. Project unit cost curves for booster station hydraulic upgrades was developed using Approach 1 with cost as a function of firm installed pump horsepower.

Existing Facility Condition Upgrades

Project unit costs for this category of work are applicable to address condition deficiencies as described in **Appendix C (Condition Assessment)**. Facility upgrades projects are included as separate projects and not hydraulic upgrade projects. Upgrades are assumed to fit within the site area occupied by existing facilities with no expansion of land ownership or easement required. Using Approach 3, construction unit costs were multiplied by markup for engineering and administrative expenses to generate project unit costs.

Facility Asset Project Unit Costs

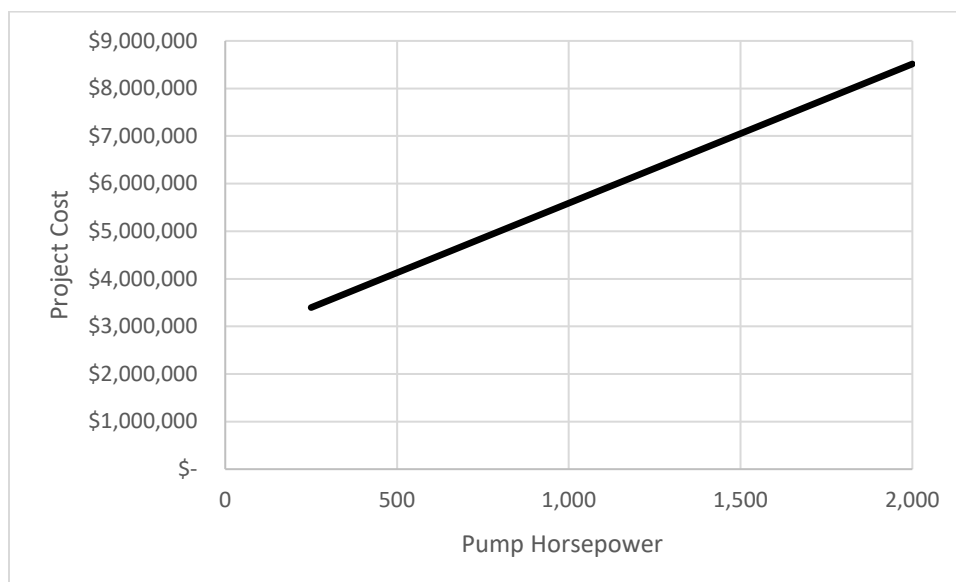
The following cost equations and cost curves provide project unit costs for estimating the capital cost (initial cost) of the referenced category of work.

New Well

Equation F-1 was used as the project cost basis for new wells, with cost as a function of gallon per minute capacity. The equations accounts for site development, building systems, mechanical, electrical, and instrumentation and controls. Project unit costs include drilling well, installing casing, well pump, mechanical, well house and basic site improvements. Project unit costs include electrical and control equipment housed in the well house; a standby generator provides back-up power. Installations include flow monitoring, pressure monitoring, and telemetry equipment. The footprint of the facility is assumed to be 800 square feet. Required well facility land area is assumed to be 0.5 acres.

Equation F-1: $\text{Project Cost}(\$) = 2,925 * \text{HP} + 2,665,000$

Figure F-1 | New Well - Project Costs

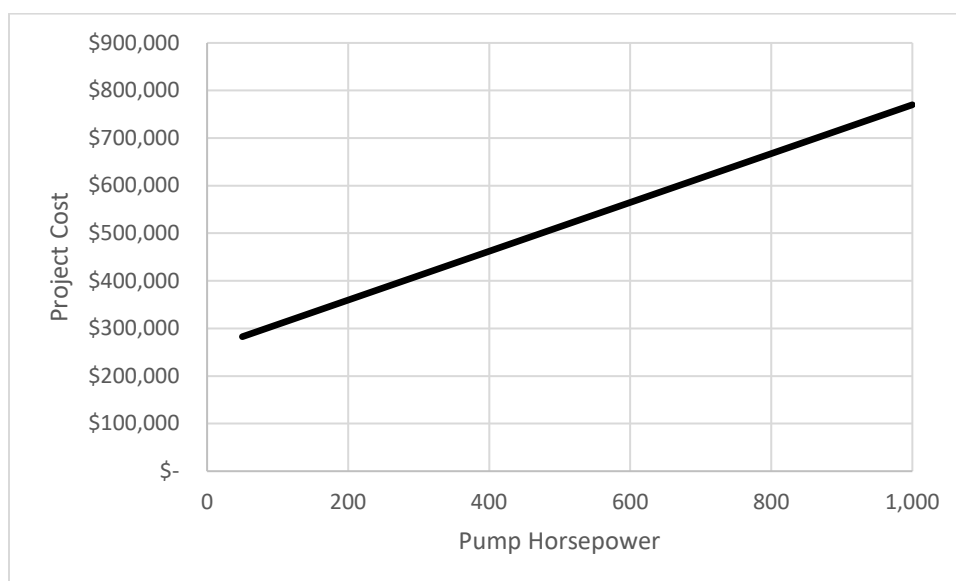


Booster Station Upgrade

Equation F-2 was used as the project cost basis for booster stations upgrades, with cost as a function of replacement pump horsepower. The equation accounts for cost of a single pump at a facility and should be used for each pump to be replaced. Project costs account for the cost of pump replacement with modifications to the mechanical and electrical system to incorporate the larger pump and motor.

Equation F-2: $\text{Project Cost}(\$) = 513 * \text{HP} + 257,000$

Figure F-2 | Booster Station Upgrade - Project Costs



Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: No HVAC just louvers and heaters. | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: Standard lighting | 1 |

- | | |
|---|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: Old concrete slab with one floor drain that can back up | 1 |

- | | |
|---|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments:Interior walls are crumbling but roof was redone in 2016 | 3 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: No comments | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: Located in a grass park, wet/snow conditons limit vechicle access | 2 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments:Locks are good, door switches not armed, only one side of buliding is lighted | 3 |

Equipment Assessment

- | | |
|--|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments: Pump new in 2019 and motor rewound with new bearings. Well was brushed to open perfs | 1 |

- | | |
|---|------------------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.)
Comments: | Score (1-3):

1 |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.)
Comments: new depth transducer 2020 | Score (1-3):

1 |
| 11. Rate the existing condition of pump motors.
Comments: rebuilt 2019 | Score (1-3):

1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules?
Comments:yes | Score (1-3):

1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.)
Comments: | Score (1-3):

1 |

Chlorination System Assessment

- | | |
|--|------------------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA?
Comments:yes,yes | Score (1-3):

1 |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty?
Comments: regulators could be updated | Score (1-3):

1 |

Water Assessment

- | | |
|---|------------------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.)
Comments: Entrained air | Score (1-3):

3 |
| 17. Describe any water quantity or pressure concerns.
Comments: | Score (1-3):

1 |

Electrical Assessment

- | | |
|---|--------------------------------|
| 18. Rate existing condition of motor controls.
Comments:new soft start 2015 | Score (1-3):

2 |
| 19. Rate existing condtion of electrical system.
Comments: | Score (1-3):

3 |
| 20. Do control cabinets require open door venting to remain operational?
Comments: No | Score (1-3):

n/a |

21. **Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above.

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: No HVAC, louvers only | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: Good, adequate lighting | 1 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: waste discharge tank/drain is too small and can flood back into the building | 3 |

- | | |
|---|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: Concave box roof with heat tape so snow won't build up and leak into building | 2 |
| Cracks in brick walls | |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments: Locks are good, door switches not armed, only one side of buliding is lighted | 3 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments:new pump/shaft/and bearing in 2017, well has a dogleg in it so an oil lube had to be reinstalled to avoid a bind | 1 |

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: | 1 |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments: | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments: Rebuilt in 2017 | 1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: YES | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: None | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments:yes,yes | 1 |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments:yes | 1 |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: None | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: None | 1 |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments: Good New in 2019 | 1 |
| 19. Rate existing condtion of electrical system. | Score (1-3): |
| Comments: New main distribution panel 2019 | 1 |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |
| Comments: n/a | |

21. **Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) **Score (1-3):**

Comments: booster pump room can over heat in summer louver only, fan and louver in well room 3

2. **Rate the existing condition of the facility lighting.**
(i.e. does the facility have sufficient lighting for operators to service equipment at night?) **Score (1-3):**

Comments: inside lighting is good,outside is bad 3

3. **Rate the existing condition of facility plumbing.**
(i.e. need floor drains, ponding water, flooding, etc.) **Score (1-3):**

Comments: 1

4. **Rate the existing condition of facility structure.**
(i.e. roof, walls, floor, doors. cracks, corrosion, etc.) **Score (1-3):**

Comments: Well room is good, cl2 rm/booster pmp room/and scada room need lots of love 3

5. **Rate the existing facilities safety accommodations.**
(i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) **Score (1-3):**

Comments: 1

Site Assessment

6. **Rate the existing condition of the site and site accessibility.** **Score (1-3):**

Comments: Good 1

7. **Rate the existing condition of facility security.**
(i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) **Score (1-3):**

Comments: Locks are good,gate pushesopen, door switches not armed , only one side of one bulidings are lighted 3

Equipment Assessment

8. **Rate existing condition of pumps.**
(i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) **Score (1-3):**

Comments: New 2010 1

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: | 1 |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments: CL2 scales should be on scada,new depth transducer 2018 | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments: New Motor 2010/rebuilt 2014 | 1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments:yes,yes | 1 |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments:yes | 1 |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: None | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: None | 1 |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments: Good | 2 |
| 19. Rate existing condtion of electrical system. | Score (1-3): |
| Comments: old A-B main distribution panel | 3 |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |
| Comments: | n/a |

21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?

Score (1-3):

Comments: Doesn't have auto exercise will only run the well or the booster but not both

3

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: No HVAC fans and louvers and heaters | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: Yes | 1 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: Good,fenced | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments:door switches not armed fenced site | 1 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments: rebuilt 1999 | 2 |

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: | |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments: | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments: rebuilt 2020 | |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments:yes,yes | 1 |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments:yes | 1 |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: None | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: None | 1 |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments: older VFD | 3 |
| 19. Rate existing condtion of electrical system. | Score (1-3): |
| Comments: | 2 |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |
| Comments: | n/a |

- 21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: Louvers and heaters | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: Great | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments: door switches not armed, fenced | 2 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments:well pump new 2016 booster pumps are original 06' | 1 |

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: | |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments:chlorine scales not digital and not on scada | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments:well motor rebuilt 2016, booster 2 replaced 2008 original motor on 1 | |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: Yes | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments:yes,yes | 1 |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments:yes | 1 |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: None | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: None | 1 |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments: new soft start 2021 on well and booster 2. Booster 1 new soft start in 2016 | 1 |
| 19. Rate existing condtion of electrical system. | Score (1-3): |
| Comments: Good | 1 |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |
| Comments: | n/a |

- 21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: Sealed positive air pressure system | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: Good | 1 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments: door switches not armed, fenced | 1 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| | 2 |

Comments: well pump new 2008, booster pump 1 & 3 new in 2018. Booster pump 2 new 2021,
booster pump 4 going in to see whats wrong. Xylem pumps suck

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: Good | |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments: Good | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments: well new 2008, booster pump 1,2,3&4 new in 2018 | 1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: Yes | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments:yes,yes | 1 |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments:yes | 1 |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: None | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: None | 1 |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments: Good | 2 |
| 19. Rate existing condtion of electrical system. | Score (1-3): |
| Comments: Good | 2 |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |

Comments:

n/a

- 21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: lighting on one side of building | 2 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments: door switches not armed, only onside of building is lighted | 2 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments: rebuilt pump 1&2 2020 | 1 |

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: | 1 |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments: | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments: rebuilt Motor 1&2 2020 | 1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments: | n/a |
| 15. Does the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments: | n/a |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: | |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments: pump 1 new vfd 2018 | 1 |
| 19. Rate existing condition of electrical system. | Score (1-3): |
| Comments: | |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |
| Comments: | |

- 21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: Louvers only | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: | 2 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 2 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments:door switches not armed | 2 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments: rebuilt 2019 | 1 |

- | | |
|---|------------------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.)
Comments: | Score (1-3):

1 |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.)
Comments: | Score (1-3):

 |
| 11. Rate the existing condition of pump motors.
Comments: rebuilt 2018 | Score (1-3):

1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules?
Comments: overhead piping | Score (1-3):

2 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.)
Comments: generator,pumps, electrical panels to close together, | Score (1-3):

3 |

Chlorination System Assessment

- | | |
|---|--------------------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA?
Comments: | Score (1-3):

n/a |
| 15. Dos the gas chlorine feed automatically switch to a full tank when empty?
Comments: | Score (1-3):

n/a |

Water Assessment

- | | |
|---|------------------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.)
Comments: | Score (1-3):

1 |
| 17. Describe any water quantity or pressure concerns.
Comments: | Score (1-3):

1 |

Electrical Assessment

- | | |
|--|--------------------------------|
| 18. Rate existing condition of motor controls.
Comments: new vfd 2018 | Score (1-3):

1 |
| 19. Rate existing condtion of electrical system.
Comments: | Score (1-3):

2 |
| 20. Do control cabinets require open door venting to remain operational?
Comments: | Score (1-3):

n/a |

- 21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Genset undersized for the station

1

Description

The purpose of this questionnaire is to utilize operator knowledge about the well/pumping facilities to help establish a baseline condition assessment of each facility for the Water Master Plan. This survey includes the applicable questions and answers received from the operations staff.

Instructions

Please provide comments and a rating between 1 and 3 (1 = good or not applicable, 2= average, 3 = poor) describing the condition in each question.

Pump House Facility Assessment

Rate the existing condition of the facility HVAC system.

- | | |
|---|---------------------|
| 1. (i.e. does the facility require special accommodations to stay cool, warm, or has the facility experienced any/experiences patterns of HVAC system failures?) | Score (1-3): |
| Comments: | 1 |

- | | |
|---|---------------------|
| 2. Rate the existing condition of the facility lighting. | Score (1-3): |
| (i.e. does the facility have sufficient lighting for operators to service equipment at night?) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 3. Rate the existing condition of facility plumbing. | Score (1-3): |
| (i.e. need floor drains, ponding water, flooding, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 4. Rate the existing condition of facility structure. | Score (1-3): |
| (i.e. roof, walls, floor, doors. cracks, corrosion, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 5. Rate the existing facilities safety accommodations. | Score (1-3): |
| (i.e. Missing handrails, access ladders, steps, non-slip surfaces, and concerns?) | |
| Comments: | 1 |

Site Assessment

- | | |
|---|---------------------|
| 6. Rate the existing condition of the site and site accessibility. | Score (1-3): |
| Comments: | 1 |

- | | |
|--|---------------------|
| 7. Rate the existing condition of facility security. | Score (1-3): |
| (i.e. site protection from trespassers, vandalism, saboteurs. Locks, site lighting, site fencing) | |
| Comments: door switch not armed | 2 |

Equipment Assessment

- | | |
|---|---------------------|
| 8. Rate existing condition of pumps. | Score (1-3): |
| (i.e. vibrations, irregular noises, pump seals, are pumps still on curves, etc.) | |
| Comments: | 1 |

- | | |
|--|---------------------|
| 9. Rate the existing condition of piping and valves.
(i.e. sticking valves, valve leaks, corrosion, paint, etc.) | Score (1-3): |
| Comments: | 1 |
| 10. Rate the existing condition of monitoring equipment.
(i.e. pressure gauges, pressure transmitters, flow meters, etc.) | Score (1-3): |
| Comments: | 1 |
| 11. Rate the existing condition of pump motors. | Score (1-3): |
| Comments: | 1 |
| 12. Are pump, valving and motor components maintained at manufacturer recommended schedules? | Score (1-3): |
| Comments: | 1 |
| 13. Describe any equipment access or maintenance concerns.
(i.e. equipment replacement interference concerns, clearances, etc.) | Score (1-3): |
| Comments: | 1 |

Chlorination System Assessment

- | | |
|--|---------------------|
| 14. Is the gas chlorination equipment located in a separate room, vented to the outside, and provided with working Chlorine leak detection alarms? If alarmed, does the alarm notify locally and through SCADA? | Score (1-3): |
| Comments: | n/a |
| 15. Does the gas chlorine feed automatically switch to a full tank when empty? | Score (1-3): |
| Comments: | n/a |

Water Assessment

- | | |
|--|---------------------|
| 16. Describe any water quality issues associated with the facility.
(i.e. sand production, e-coli, turbidity, etc.) | Score (1-3): |
| Comments: | 1 |
| 17. Describe any water quantity or pressure concerns. | Score (1-3): |
| Comments: | 1 |

Electrical Assessment

- | | |
|---|---------------------|
| 18. Rate existing condition of motor controls. | Score (1-3): |
| Comments:pump 1 new vfd 2010,pump 2 new vfd 2013 | |
| 19. Rate existing condition of electrical system. | Score (1-3): |
| Comments: | |
| 20. Do control cabinets require open door venting to remain operational? | Score (1-3): |
| Comments: | |

- 21. Does facility have a dedicated generator? If yes, is the switchover automatic? Does generator power entire facility or select operations? Is there a status notification via SCADA?**

Score (1-3):

Comments: Yes to all of the above

1



J-100 Compliant Risk Assessment
Water System

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Name: Redmond

I. Executive Summary

This report was generated in PARRE and is provided as an appendix to the AWIA Risk and Resilience Assessment Technical memorandum for the information and use of the City of Redmond Oregon (City). This report outlines the risk and resilience assessment that was completed for the City in PARRE for compliance with the EPA's AWIA certification and includes all the input and output data compiled as part of the assessment.

II. Introduction

Since the middle of the last decade, the US water sector has slowly become aware of the need to better understand the reliability of their systems. Increased world tensions made owners/operators concerned that publically accessible water systems were inviting targets that garner significant public attention and concern when they are maliciously disturbed. Tools began appearing in the late 1990s to measure the vulnerability of water systems to directed attacks against them. Since that time, research and substantial practice has led to the development of new tools to support whole-system evaluations. At the same time, the leadership of public water systems has evolved to better understand how to interpret an assessment and how to make wise decisions concerning its protection. In the past 20-years, public utility systems have expanded their thinking from looking only at the vulnerability of their system to directed attacks to a more robust understanding of the "Risks" their systems face from directed as well as natural hazards. At the end of the day however, the real goal is to increase the resilience of the system to be able to endure the attack and be able to promptly restore service to the customer when the threat has passed.

What is a J-100 Complaint Risk Assessment ?

Benefits of a J-100 Compliant Assessment

Redmond

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Unlike earlier water sector assessments, the J-100 uses a strict process of probability-driven determinations that consider the likelihood that a threat will occur, the most probable consequences of that threat, as well as the vulnerability of the critical assets to that threat. The resulting risk assessment is then used as a baseline against which countermeasures can be tested in an attempt to lower the risk and improve the resilience of the asset and/or system. The ability to measure the cost of the countermeasure(s) against the reduction in risk that results produces a return on investment (ROI) analysis of the system. The frequent outcome of such analysis is the awareness of low cost, but highly effective measures that can be taken (the proverbial "low hanging fruit") to reduce risk. More costly but important investments can be programmed as capital investment opportunities avail themselves.

US Department of Homeland Security SAFETY Act & SAFETY Act Designation

The SAFETY Act is a US Department of Homeland Security program designed to encourage the development of anti-terrorism tools and processes without extraordinary liability exposure. The act is described by DHS as: The SAFETY Act provides important legal liability protections for providers of Qualified Anti-Terrorism Technologies - whether they are products or services. The goal of the SAFETY Act is to encourage the development and deployment of new and innovative anti-terrorism products and services by providing liability protections. (2) The SAFETY Act limits the liability exposure of utilities that use designated product in the event that they are the victims of a directed attack. This coverage limit typically coincides with the insurance coverage of most utilities, picking up liability protection above existing insurance limits. The J-100 standard has already been granted SAFETY Act designation, implying that utilities that complete a risk and resilience assessment in accordance with the standard and put into place a program consistent with the findings of that assessment, can benefit from the flow-down protection provisions of the act.

1. ANSI/AWWA J100-10 Risk Analysis and Management for Critical Asset Protection (RAMCAP) Standard for Risk and Resilience Management of Water and Wastewater Systems using the ASME-ITI RAMCAP Plus(R) Methodology, July 1, 2010(1st edition).
2. SAFETY Act, 6 CFR Part 25 (USCG-2003-15425) RIN 1501-AA15

What is the PARRE Assessment Support Tool?

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The J-100 standard requires the methodical application of the principles of probability and statistics to calculate risk-based assessments of every critical asset against every probable directed and random (natural) threat. While no single threat-asset pair analysis is difficult or exceptionally time consuming, a complete system analysis can entail thousands or even hundreds or thousands of threat-asset pairs. The Program to Assist Risk and Resilience Examination (PARRE) is an open-source, database tool written in Java-Code intended for use by a utility's risk assessment team. PARRE stores the data as well as completes the numerous calculations in the background, freeing the team to understand the results and formulate options for reducing risk to the critical assets. A PARRE assessment will assure that the team has completed all required steps required by the J-100 standard. Once completed, the assessment, together with the notes, decisions, and options of the team, is contained in an accessible database, available for running "what-if" scenario drills or determining current risk status. The PARRE tool has been submitted for DHS SAFETY Act designation; further reinforcing the coverage and protections afforded the utility that uses the tool to conduct their assessments.

III. Assessment Team

The City's risk and resilience assessment was completed by Murrysmith with input from City staff.

Successful assessments are the result of collaboration between the key information centers of the utility. These team members may be part of the senior leadership, but in many cases, individuals with specific expertise and in-depth information of the operations of the utility are included. The broad and diverse viewpoints of the team provide the richness and insight needed to achieve understanding of risk and the creativeness needed to reduce that risk while maintaining restricted operating budgets. Not all members of the team needed to be involved in every phase of the assessment, but their reviews and reactions to the team's collective decisions is key to producing an effective, actionable plan.

The J-100 complaint Risk & Resilience Assessment Team consisted of:

Assessment Approach

Assessment Tasks

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Task	Title	Comments
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Work Sessions

Three workshops were held between Murraysmith and City staff to define critical assets, relevant threats, and

IV. R & R Assessment Process

The J-100 standard describes a stepped process for conducting risk and resilience assessments based on the RAMCAP approach. While these steps can be done in any order, the standard does require that each step must be considered in order to complete a compliant analysis. The assessment followed the standard using the PARRE tool to record information and to support the decision making of the team. The steps and key findings of each step are described in this section.

Description of the Utility

Mission Statement

The focus of any utility system assessment starts by achieving team understanding the mission of that utility. This concise statement of the goals and aspirations provides the direction for decision-making, especially the classification of critical assets and probable threats. The assessment team identified missions as follows (in no particular order):

Review of Assets and Identification of Critical Assets

A risk assessment is conducted to better understand the risks to a utility's assets. Assets can be physical, human, cyber or knowledge (information), all of which are exposed to a degree of risk to their integrity and sustainability. Through a process of evaluating those risks whose loss or impairment would prevent the utility from meeting its mission(s) in a meaningful way, the team identified a series of key assets that were critical to the operation.

Table 2: Critical Assets

Redmond

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Asset System	Critical Asset
Booster pump station	Forked Horned Butte Pump Station
Distribution System	Distribution System
External Asset	Well 4 SCADA
Groundwater Well	Well 2
Groundwater Well	Well 7
Groundwater well	Well 3
Groundwater well	Well 5
Groundwater well and pumpstation	Well 4
PRV	Pressure Zone 1A PRV
Physical Asset	Well 6
Software	Enterprise/Billing System
Software	IT/Security Systems
Storage Reservoir	Storage Reservoir
Storage Reservoir	System Reservoir
System Wide SCADA	System Wide SCADA
Transfer Pump Station	Forked Horn Butte Transfer Pump
Warehouse	Facilities Warehouse
Well complex	South Redmond Facility

Table 3: Most Probable Threats

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Threat Class	Threat
Product Contamination	Chemical
Sabotage	Physical - Outsider
Sabotage	Cyber - Outsider
Theft or Diversion	Physical - Outsider
Theft or Diversion	Cyber - Outsider
Attack: Automotive	Car
Attack: Assault Team	1 Assailant
Natural	Earthquake
Natural	Ice Storms

Formation and Prioritization of Asset-Threat Pairs

Table 4: Existing Countermeasures

Asset	Current Countermeasures
Well 2	[Lighting, Alarms, Door, Lock]
Well 3	[Building, Lighting, Alarms, Door, Lock]
Well 4	[Lighting, Alarms, Fence, Door, Lock]
Well 4 SCADA	[Firewall]

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Asset	Current Countermeasures
Well 5	[Lighting, Alarms, Fence, Door, Lock]
Well 6	[Lighting, Alarms, Fence, Door, Lock]
Well 7	[Lighting, Alarms, Fence, Door, Lock]
Forked Horned Butte Pump	[Alarms, Door, Lock]
Forked Horn Butte Transfer	[Alarms, Door, Lock]
System Reservoir	[Fence]
Storage Reservoir	[Partially buried, Fence]
South Redmond Facility	[Lighting, Alarms, Fence, Door, Lock]
System Wide SCADA	[Firewall]
IT/Security Systems	[Firewall]
Enterprise/Billing System	[Firewall]
Facilities Warehouse	[Lighting, Fence, Door, Lock]
Pressure Zone 1A PRV	[Door, Lock]

Calculation of Consequences

Table 5: Top 50 Financial Consequences (sorted in order of decreasing cost)

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Asset	Threat	Consequence (\$)
South Redmond Facility	C(C)-Chemical	29,500,000
South Redmond Facility	S(PU)-Physical - Outsider	22,807,000
South Redmond Facility	(V1)-Car	22,807,000
Well 6	C(C)-Chemical	19,441,000
Well 6	S(PU)-Physical - Outsider	19,441,000
Well 6	(V1)-Car	19,441,000
Well 7	(V1)-Car	18,949,000
Well 7	S(PU)-Physical - Outsider	18,949,000
Well 7	C(C)-Chemical	18,949,000
Storage Reservoir	C(C)-Chemical	12,775,000
System Reservoir	C(C)-Chemical	11,875,000
Well 4	(V1)-Car	9,623,000
Well 4	C(C)-Chemical	9,623,000
Well 4	S(PU)-Physical - Outsider	9,623,000
Well 5	(V1)-Car	5,742,000
Well 5	S(PU)-Physical - Outsider	5,742,000
Well 5	C(C)-Chemical	5,742,000
Forked Horned Butte Pump	(V1)-Car	3,748,000
Forked Horned Butte Pump	S(PU)-Physical - Outsider	3,748,000
Well 3	C(C)-Chemical	2,879,000
Well 3	S(PU)-Physical - Outsider	2,879,000
Forked Horn Butte Transfer	S(PU)-Physical - Outsider	2,750,000
Well 2	(V1)-Car	2,171,000
Well 2	S(PU)-Physical - Outsider	2,171,000
Well 3	(V1)-Car	2,171,000
Well 2	C(C)-Chemical	2,171,000
Well 5	T(PU)-Physical - Outsider	1,150,000
Forked Horned Butte Pump	T(PU)-Physical - Outsider	1,083,000
South Redmond Facility	T(PU)-Physical - Outsider	1,080,000
Well 4	T(PU)-Physical - Outsider	1,080,000

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Asset	Threat	Consequence (\$)
Well 6	T(PU)-Physical - Outsider	926,000
Well 7	T(PU)-Physical - Outsider	926,000
Pressure Zone 1A PRV	S(PU)-Physical - Outsider	820,000
Forked Horn Butte Transfer	(V1)-Car	732,000
Forked Horn Butte Transfer	T(PU)-Physical - Outsider	732,000
Well 3	T(PU)-Physical - Outsider	611,000
Well 2	T(PU)-Physical - Outsider	463,000
Well 4	N(E)-Earthquake	150,000
Storage Reservoir	N(E)-Earthquake	150,000
South Redmond Facility	N(E)-Earthquake	150,000
Well 3	N(E)-Earthquake	150,000
System Reservoir	N(E)-Earthquake	150,000
Well 2	N(E)-Earthquake	150,000
Well 5	N(E)-Earthquake	150,000
Well 6	N(E)-Earthquake	150,000
Well 7	N(E)-Earthquake	150,000
Pressure Zone 1A PRV	N(E)-Earthquake	70,000
Facilities Warehouse	N(E)-Earthquake	50,000
System Wide SCADA	N(I)-Ice Storms	50,000
Well 4 SCADA	N(I)-Ice Storms	45,000

Table 6: Fatalities (sorted in order of decreasing number of deaths)

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Asset	Threat	Fatalities
Storage Reservoir	C(C)-Chemical	200
South Redmond Facility	C(C)-Chemical	200
System Reservoir	C(C)-Chemical	200
Well 6	C(C)-Chemical	5
Well 4	C(C)-Chemical	5
Well 7	C(C)-Chemical	5
Well 3	C(C)-Chemical	5
Well 5	C(C)-Chemical	5
Well 2	C(C)-Chemical	5
Well 7	(V1)-Car	1
Facilities Warehouse	(V1)-Car	1
Forked Horn Butte Transfer	(V1)-Car	1
Forked Horned Butte Pump	(V1)-Car	1
Forked Horned Butte Pump	S(PU)-Physical - Outsider	1
South Redmond Facility	N(E)-Earthquake	1
Facilities Warehouse	(AT1)-1 Assailant	1
Facilities Warehouse	N(E)-Earthquake	1
Well 5	(V1)-Car	1
Well 4	(V1)-Car	1
Well 2	(V1)-Car	1
South Redmond Facility	(V1)-Car	1
Well 6	(V1)-Car	1
Forked Horned Butte Pump	T(PU)-Physical - Outsider	1
Well 3	(V1)-Car	1

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Table 7: Serious Injuries (sorted in order of decreasing serious injury)

Asset	Threat	Injuries
Storage Reservoir	C(C)-Chemical	10,000
South Redmond Facility	C(C)-Chemical	10,000
System Reservoir	C(C)-Chemical	10,000
Well 6	C(C)-Chemical	5
Well 4	C(C)-Chemical	5
Well 7	C(C)-Chemical	5
Well 3	C(C)-Chemical	5
Well 5	C(C)-Chemical	5
Well 2	C(C)-Chemical	5

Calculation of Asset Vulnerabilities

Vulnerability is a measure of the effectiveness of the attacker and of the countermeasures that are in place. Vulnerability is a calculated value, expressed as a probability ranging from very low vulnerabilities (ineffective attackers and/or highly effective countermeasures), to the other extreme of very high vulnerabilities (very effective attackers and/or very ineffective countermeasures). The J-100 permits the team to evaluate the vulnerabilities using a variety of approaches ranging from expert elicitation to the logic-based tools of Path Analysis, or Decision Tree Analysis. The characteristics of each threat-asset pair tend to dictate the best approach to use. The team used all three approaches in arriving at the vulnerabilities for the identified threat-asset pairs.

Expert Elicitation

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Path Analysis Discussion

Event Tree Discussion

An event tree is a probability based decision matrix that breaks an attack into its component parts and then evaluates the probability that each of the parts will achieve success against the asset. A well-defined event tree can be used to evaluate similarly situated assets

Table 8: Vulnerabilities (sorted in order of decreasing vulnerability)
(Type Analysis: PA = Path Analysis, ET = Event Tree, EE = Expert Elicitation)

Asset	Threat	Type Analysis	Vulnerability
System Reservoir	C(C)-Chemical	EE	1
Facilities Warehouse	(V1)-Car	EE	0.5
Forked Horned Butte	(V1)-Car	EE	0.5
Forked Horn Butte	(V1)-Car	EE	0.5
South Redmond Facility	(V1)-Car	EE	0.5
Well 2	(V1)-Car	EE	0.5
Well 4	(V1)-Car	EE	0.5
Well 6	(V1)-Car	EE	0.5
Well 7	(V1)-Car	EE	0.5
Forked Horned Butte	S(PU)-Physical - Outsider	ET	0.2
Forked Horned Butte	T(PU)-Physical - Outsider	ET	0.2
Forked Horn Butte	S(PU)-Physical - Outsider	ET	0.2
Forked Horn Butte	T(PU)-Physical - Outsider	ET	0.2
Pressure Zone 1A PRV	S(PU)-Physical - Outsider	ET	0.2
Well 2	C(C)-Chemical	ET	0.175
Well 2	S(PU)-Physical - Outsider	ET	0.175

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Asset	Threat	Type Analysis	Vulnerability
Well 2	T(PU)-Physical - Outsider	ET	0.175
Well 3	C(C)-Chemical	ET	0.175
Well 3	S(PU)-Physical - Outsider	ET	0.175
Well 3	T(PU)-Physical - Outsider	ET	0.175
Facilities Warehouse	(AT1)-1 Assailant	ET	0.105
Enterprise/Billing System	S(CU)-Cyber - Outsider	EE	0.1
Enterprise/Billing System	T(CU)-Cyber - Outsider	EE	0.1
IT/Security Systems	S(CU)-Cyber - Outsider	EE	0.1
IT/Security Systems	T(CU)-Cyber - Outsider	EE	0.1
System Wide SCADA	S(CU)-Cyber - Outsider	EE	0.1
System Wide SCADA	T(CU)-Cyber - Outsider	EE	0.1
Well 4 SCADA	S(CU)-Cyber - Outsider	EE	0.1
Well 4 SCADA	T(CU)-Cyber - Outsider	EE	0.1
Well 3	(V1)-Car	EE	0.05
Storage Reservoir	C(C)-Chemical	EE	0.05
South Redmond Facility	S(PU)-Physical - Outsider	ET	0.03
South Redmond Facility	C(C)-Chemical	ET	0.03
South Redmond Facility	T(PU)-Physical - Outsider	ET	0.03
Well 4	C(C)-Chemical	ET	0.03
Well 4	S(PU)-Physical - Outsider	ET	0.03
Well 4	T(PU)-Physical - Outsider	ET	0.03
Well 5	C(C)-Chemical	ET	0.03
Well 5	S(PU)-Physical - Outsider	ET	0.03
Well 5	T(PU)-Physical - Outsider	ET	0.03
Well 5	(V1)-Car	ET	0.03
Well 6	C(C)-Chemical	ET	0.03
Well 6	S(PU)-Physical - Outsider	ET	0.03
Well 6	T(PU)-Physical - Outsider	ET	0.03
Well 7	C(C)-Chemical	ET	0.03
Well 7	S(PU)-Physical - Outsider	ET	0.03

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Asset	Threat	Type Analysis	Vulnerability
Well 7	T(PU)-Physical - Outsider	ET	0.03

Note: Because of the J-100 method used to evaluate the vulnerability of the natural threats Hurricane, Tornado, Floods, and Earthquake, assets subject to these threats, PARRE assigns a pseudo vulnerability value of 0.99 as vulnerability and threat likelihood use a combined metric in this method. The pseudo vulnerabilities are not included

Threat Likelihood

The element that makes a risk assessment different from a vulnerability assessment is the inclusion of threat likelihood. Threat likelihood seeks to understand the probability that the specified threat will even attack the critical asset. For natural threats, the likelihood is embodied in the concept of its "return period", thus the likelihood of the threat such as flood, can be seen in the 100-year rain event which by definition has a threat likelihood in any given year of $1/100 = 1\%$. Threat likelihood for directed threats is a bit more complicated. In these cases, the J-100 permits the use of at least three approaches; Proxy Analysis, Expert Elicitation, and/or Conditional Likelihood.

Best Estimate

For many directed threats, the best information concerning the likelihood of a specific threat is obtained from utility personnel or their governmental colleagues. Called the "Best Estimate" in J 100, this method of evaluating threat likelihood is very similar to the expert elicitation approach in vulnerability determination

Proxy Analysis

The proxy indicator was developed and included in the J-100 tools to fill a very large gap in the ability of the local and national intelligence/ policing agencies to accurately predict or share their information with local utility owners/operators. The proxy indicator is based on the 2007 work of the RAND Corporation and the 2008 work of the Risk Management Solutions Corporation. These publically available summaries detail directed threats recorded up to the time of their publication around the world. The proxy is an attempt to characterize the relatively infrequent attacks, parsed by country and type of infrastructure

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Conditional Likelihood

Asset	Threat	Type Analysis	Likelihood
Enterprise/Billing System	S(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
Enterprise/Billing System	T(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
Facilities Warehouse	(AT1)-1 Assailant	CONDITIONAL_RISK	1
Forked Horned Butte	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Forked Horned Butte	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Forked Horn Butte	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Forked Horn Butte	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
IT/Security Systems	S(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
IT/Security Systems	T(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
Pressure Zone 1A PRV	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
South Redmond Facility	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
South Redmond Facility	C(C)-Chemical	CONDITIONAL_RISK	1
South Redmond Facility	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Storage Reservoir	C(C)-Chemical	CONDITIONAL_RISK	1
System Reservoir	C(C)-Chemical	CONDITIONAL_RISK	1
System Wide SCADA	S(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
System Wide SCADA	T(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
Well 4 SCADA	S(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
Well 4 SCADA	T(CU)-Cyber - Outsider	CONDITIONAL_RISK	1
Well 2	C(C)-Chemical	CONDITIONAL_RISK	1
Well 2	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 2	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 3	C(C)-Chemical	CONDITIONAL_RISK	1
Well 3	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 3	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 4	C(C)-Chemical	CONDITIONAL_RISK	1

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Asset	Threat	Type Analysis	Likelihood
Well 4	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 4	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 5	C(C)-Chemical	CONDITIONAL_RISK	1
Well 5	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 5	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 6	C(C)-Chemical	CONDITIONAL_RISK	1
Well 6	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 6	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 7	C(C)-Chemical	CONDITIONAL_RISK	1
Well 7	S(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 7	T(PU)-Physical - Outsider	CONDITIONAL_RISK	1
Well 3	(V1)-Car	BEST_ESTIMATE	0.01
Facilities Warehouse	(V1)-Car	BEST_ESTIMATE	0.01
Forked Horned Butte	(V1)-Car	BEST_ESTIMATE	0.01
Forked Horn Butte	(V1)-Car	BEST_ESTIMATE	0.01
South Redmond Facility	(V1)-Car	BEST_ESTIMATE	0.01
Well 2	(V1)-Car	BEST_ESTIMATE	0.01
Well 4	(V1)-Car	BEST_ESTIMATE	0.01
Well 5	(V1)-Car	BEST_ESTIMATE	0.01
Well 6	(V1)-Car	BEST_ESTIMATE	0.01
Well 7	(V1)-Car	BEST_ESTIMATE	0.01

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Table 9: Top Threat Likelihoods (sorted in order of decreasing likelihood)

Notes: (1) A threat likelihood of 99% implies a virtual certainty that this threat will occur in any given year. The threat likelihood of a natural threat is characterized by its return period.

(2) Because of the J-100 method used to evaluate the vulnerability of the natural threats Hurricane, Tornado, Floods, and Earthquake, assets subject to these threats, PARRE assigns a pseudo vulnerability value of 0.99 as vulnerability and threat likelihood uses a combined metric in this method. The natural hazard vulnerabilities are included as a part of the threat likelihood value in this table.

(3) Any values less than 0.00001 are not shown.

Risk Determination $(R = C \times V \times T)$

Risk, as developed by the RAMCAP process and detailed in the J-100 standard, is defined as the product of the consequences suffered by the critical asset by a threat, times the vulnerability probability, times the threat likelihood probability. $R = C \times V \times T$: Since the consequence is dollar denominated, while vulnerability and threat likelihood are probabilities, the value of risk using this approach is a dollar-valued amount. The physical meaning of these risk dollars may or may not be of great significance when used to compare risks between assets and prepare prioritized listings of asset-threat pairs. The dollar value of risk may be interpreted as the annual amount that a utility would have to put into savings (sinking fund) at zero interest to reconstruct the asset after it has been successfully attacked by the threat.

Table 10: Top-50 Risks (sorted in order of decreasing risk)

Asset	Threat	Risk (\$)
System Reservoir	C(C)-Chemical	11,875,000
South Redmond Facility	C(C)-Chemical	885,000
Forked Horned Butte Pump	S(PU)-Physical - Outsider	749,600
South Redmond Facility	S(PU)-Physical - Outsider	684,210

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Asset	Threat	Risk (\$)
Storage Reservoir	C(C)-Chemical	638,750
Well 6	C(C)-Chemical	583,230
Well 6	S(PU)-Physical - Outsider	583,230
Well 7	C(C)-Chemical	568,470
Well 7	S(PU)-Physical - Outsider	568,470
Forked Horn Butte Transfer	S(PU)-Physical - Outsider	550,000
Well 3	C(C)-Chemical	503,825
Well 3	S(PU)-Physical - Outsider	503,825
Well 2	C(C)-Chemical	379,925
Well 2	S(PU)-Physical - Outsider	379,925
Well 4	C(C)-Chemical	288,690
Well 4	S(PU)-Physical - Outsider	288,690
Forked Horned Butte Pump	T(PU)-Physical - Outsider	216,600
Well 5	C(C)-Chemical	172,260
Well 5	S(PU)-Physical - Outsider	172,260
Pressure Zone 1A PRV	S(PU)-Physical - Outsider	164,000
Forked Horn Butte Transfer	T(PU)-Physical - Outsider	146,400
South Redmond Facility	(V1)-Car	114,035
Well 3	T(PU)-Physical - Outsider	106,925
Well 6	(V1)-Car	97,205
Well 7	(V1)-Car	94,745
Well 2	T(PU)-Physical - Outsider	81,025
Well 4	(V1)-Car	48,115
Well 5	T(PU)-Physical - Outsider	34,500
South Redmond Facility	T(PU)-Physical - Outsider	32,400
Well 4	T(PU)-Physical - Outsider	32,400
Well 6	T(PU)-Physical - Outsider	27,780
Well 7	T(PU)-Physical - Outsider	27,780
Forked Horned Butte Pump	(V1)-Car	18,740
Well 2	(V1)-Car	10,855

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Asset	Threat	Risk (\$)
Forked Horn Butte Transfer	(V1)-Car	3,660
Well 5	(V1)-Car	1,722
Well 3	(V1)-Car	1,085
System Wide SCADA	N(I)-Ice Storms	488
Well 2	N(E)-Earthquake	21
Well 4	N(E)-Earthquake	21
Storage Reservoir	N(E)-Earthquake	21
Well 3	N(E)-Earthquake	21
System Reservoir	N(E)-Earthquake	21
Well 5	N(E)-Earthquake	15
Well 6	N(E)-Earthquake	15
Well 7	N(E)-Earthquake	15
South Redmond Facility	N(E)-Earthquake	15
Facilities Warehouse	N(E)-Earthquake	7
Pressure Zone 1A PRV	N(E)-Earthquake	7

Table 11: Summary Rankings

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Asset	Threat	Risk	Pair Resilience	Deaths	Serious Injuries	Owner Financial
System Reservoir	C(C)-Chemical	1	3	3	3	0
South Redmond	C(C)-Chemical	2	5	2	2	1
Forked Horned	S(PU)-Physical -	3	1	0	0	0
South Redmond	S(PU)-Physical -	4	8	0	0	2
Storage Reservoir	C(C)-Chemical	5	0	1	1	10
Well 6	C(C)-Chemical	6	0	4	4	4
Well 6	S(PU)-Physical -	7	0	0	0	5
Well 7	C(C)-Chemical	8	0	6	6	9
Well 7	S(PU)-Physical -	9	0	0	0	8
Forked Horn Butte	S(PU)-Physical -	10	2	0	0	0
Well 4	C(C)-Chemical	0	0	5	5	0
Well 3	C(C)-Chemical	0	0	7	7	0
Well 5	C(C)-Chemical	0	0	8	8	0
Well 2	C(C)-Chemical	0	0	9	9	0
Well 7	(V1)-Car	0	0	10	0	7
Well 3	S(PU)-Physical -	0	4	0	0	0
Forked Horned	T(PU)-Physical -	0	6	0	0	0
Well 2	S(PU)-Physical -	0	7	0	0	0
Well 4	S(PU)-Physical -	0	9	0	0	0
Well 5	S(PU)-Physical -	0	10	0	0	0
South Redmond	(V1)-Car	0	0	0	0	3
Well 6	(V1)-Car	0	0	0	0	6

VI. Risk Management

The concluding step of a J-100 risk assessment is the development of a risk reduction plan for those risks that exceed the tolerance level of the utility

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Risk Reduction Options

Table 12: Investment Options

Option	Countermeasures	No. of Sites Applied	Cost(\$) per Site	Total Investment Cost(\$)
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Table 13: Investment Assessment Results

Option	Total Gross Annual Benefits (\$)	Present Value Annual Cost (\$)	Net Annual Benefits (\$)	B/C Ratio
--------	----------------------------------	--------------------------------	--------------------------	-----------

VII. Resilience

Resilience is the ability of an asset or the utility system to promptly recover from the consequences of a successful attack and restore service to some meaningful level. The J-100 standard describes the approach to be applied for both the asset-threat resilience and also for the system resiliency determinations.

Threat-Asset Pair Resilience

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The resilience of a single critical asset to a defined threat carries with it much of the same considerations as the risk to that asset. There may be situations where the utility is particularly interested in the resilience of a specifically critical asset and would want to investigate ways to further enhance the robustness of this asset so as to make it better able to recover from an attack. The J-100 describes the development of an asset resilience metric that is service denial due to the loss of the asset, weighted by the vulnerability and threat likelihood. If the asset is capable of continuing to support the mission throughout the attack and restore service with little or no loss in service, then the metric would return a zero as there are no service outage consequences. The greater this metric, the less resilient the asset is to the defined threat. The resilience of the 50 least-resilience asset-threat pairs are shown in Table 14

Table 14: Bottom-50 Least Financially Resilient Asset-Threat Pair Summary
(Sorted from least to most resilient)

Asset	Threat	Pair Resilience (\$)
Well 4 SCADA	N(I)-Ice Storms	0
Pressure Zone 1A PRV	N(E)-Earthquake	0.0000023296
Well 3	(V1)-Car	0.000008
Well 2	N(E)-Earthquake	0.0000168
Well 5	(V1)-Car	0.00002064
South Redmond Facility	N(E)-Earthquake	0.00002496
Well 3	N(E)-Earthquake	0.00002688
System Reservoir	N(E)-Earthquake	0.0000336
Storage Reservoir	N(E)-Earthquake	0.00003528
Distribution System	N(E)-Earthquake	0.0000384384
Well 6	N(E)-Earthquake	0.000041184
Well 7	N(E)-Earthquake	0.000041184
Well 5	N(E)-Earthquake	0.000059904
Well 4	N(E)-Earthquake	0.00007224
Well 2	(V1)-Car	0.00028
Forked Horned Butte Pump	(V1)-Car	0.000344
South Redmond Facility	(V1)-Car	0.000344
Well 4	(V1)-Car	0.000344
System Wide SCADA	N(I)-Ice Storms	0.000405816937292730471
Forked Horn Butte Transfer	(V1)-Car	0.000616

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Asset	Threat	Pair Resilience (\$)
Well 6	(V1)-Car	0.000924
Well 7	(V1)-Car	0.000924
Well 6	C(C)-Chemical	0.001188
Well 7	C(C)-Chemical	0.001188
Storage Reservoir	C(C)-Chemical	0.00126
Well 4	C(C)-Chemical	0.001548
Well 5	C(C)-Chemical	0.001548
Well 6	T(PU)-Physical - Outsider	0.001584
Well 7	T(PU)-Physical - Outsider	0.001584
South Redmond Facility	T(PU)-Physical - Outsider	0.002064
Well 4	T(PU)-Physical - Outsider	0.002064
Well 5	T(PU)-Physical - Outsider	0.002064
Well 2	C(C)-Chemical	0.0021
Enterprise/Billing System	S(CU)-Cyber - Outsider	0.00264
Enterprise/Billing System	T(CU)-Cyber - Outsider	0.00264
IT/Security Systems	S(CU)-Cyber - Outsider	0.00264
IT/Security Systems	T(CU)-Cyber - Outsider	0.00264
System Wide SCADA	S(CU)-Cyber - Outsider	0.00264
System Wide SCADA	T(CU)-Cyber - Outsider	0.00264
Well 4 SCADA	S(CU)-Cyber - Outsider	0.00264
Well 4 SCADA	T(CU)-Cyber - Outsider	0.00264
Well 2	T(PU)-Physical - Outsider	0.0028
Well 3	C(C)-Chemical	0.00336
Well 3	T(PU)-Physical - Outsider	0.00448
Pressure Zone 1A PRV	S(PU)-Physical - Outsider	0.00448
Well 6	S(PU)-Physical - Outsider	0.005544
Well 7	S(PU)-Physical - Outsider	0.005544
Forked Horn Butte Transfer	T(PU)-Physical - Outsider	0.00704
South Redmond Facility	S(PU)-Physical - Outsider	0.007224
Well 4	S(PU)-Physical - Outsider	0.007224

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Asset	Threat	Pair Resilience (\$)
Well 5	S(PU)-Physical - Outsider	0.007224
Well 2	S(PU)-Physical - Outsider	0.0098
Forked Horned Butte Pump	T(PU)-Physical - Outsider	0.01376
South Redmond Facility	C(C)-Chemical	0.01548
Well 3	S(PU)-Physical - Outsider	0.01568
System Reservoir	C(C)-Chemical	0.024
Forked Horn Butte Transfer	S(PU)-Physical - Outsider	0.02464
Forked Horned Butte Pump	S(PU)-Physical - Outsider	0.04816

System Resilience

Another useful metric for evaluating the robustness of the utility is the “System Resilience”. This indicator attempts to evaluate the ability of the utility system to recover from an attack and reestablish service in a timely manner. To understand the ability of the system to accomplish this, two areas are evaluated. First, the system's operational robustness (called its Operational Resilience Index -- ORI) to deal with the aftermath of an attack is measured through such efforts as the level of emergency response plan implementation, NIMS compliance, WARN program involvement, critical parts inventory, and emergency power. It should be noted that specific critical assets are not part of this system analysis nor are the specific threats. The second factor in determining a system's resilience (called its financial resilience index – FRI) is its financial ability to recover. This ability is informed by such indicators as its Business Continuity Plan, Bond rating, and level of GASB Assessment. In addition, two indices are included in the financial resilience including the general level of unemployment in the area, and the median household income. The purpose of these last two indicators is to weight the outcome by the ability of the served community to support the extraordinary costs that inevitably result from a major attack on the utility system

Financial Resilience Index (FRI)

Business Continuity Plan (BCP)(0.00-5.00) :No BCP

Utility Bond Rating(1.00-6.00) :AAA

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 GASB Assessment(0.00-2.00) :<= 20% assessed

Unemployment(0.00-4.00) :>= 5% National Average

Median Household Income(0.00-5.00) :<= 10% State Median

Operational Resilience Index (ORI)

Emergency Response Plan(0.75-14.00) :Resource Typed assets/teams defined and inventoried

National Incident Management System (NIMS) Compliance(0.50-16.00) :ICS 700/800 provided to key

Mutual Aid and Assistance(0.50-19.00) :Local-Local (with adjacent city/town)

Emergency power for critical operations(1.00-6.00) :>= 73 hours

Ability to meet minimum daily demand (water) or treatment (wastewater) when production or treatment plant is nonfunctional(1.00-10.00) :>= 73 hours

Critical parts and equipment(0.25-9.00) :1-2 weeks

Critical staff resilience(1.00-6.00) :76-100%

VIII. Appendix

Summary tables of the Top-20 Risks as well as the Top 10 natural threat risks are provided in the following tables. For complete information on all asset-threat pairs and the results of their assessments, the reader is referred to the PARRE tool database.

Appendix: Table 15: Top-20 Risks

Asset	Threat Class	Threat	Fatalities	Serious Injuries	Financial Impact	Financial Total	Vulnerability	Threat Likelihood	Risk	Financial Resilience
Well 6	Threat	(V1)-Car	1	0	19,441,00	19,441,00	0.5	0.01	97,205	0.000924
Well 7	Threat	(V1)-Car	1	0	18,949,00	18,949,00	0.5	0.01	94,745	0.000924
South	Threat	C(C)-Chemical	200	10,000	29,500,00	29,500,00	0.03	1	885,000	0.01548
Well 2	Threat	T(PU)-Physical -	0	0	463,000	463,000	0.175	1	81,025	0.0028
Forked Horned	Threat	S(PU)-Physical -	1	0	3,748,000	3,748,000	0.2	1	749,600	0.04816
Facilities	Threat	N(E)-Earthquake	1	0	50,000	50,000	1	0.00014	7	0
Pressure Zone	Threat	N(E)-Earthquake	0	0	70,000	70,000	1	0.000104	7	0.00000232
South	Threat	S(PU)-Physical -	0	0	22,807,00	22,807,00	0.03	1	684,210	0.007224

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Asset	Threat Class	Threat	Fatalities	Serious Injuries	Financial Impact	Financial Total	Vulnerability	Threat Likelihood	Risk	Financial Resilience
Storage	Threat	C(C)-Chemical	200	10,000	12,775,00	12,775,00	0.05	1	638,750	0.00126
Well 6	Threat	C(C)-Chemical	5	5	19,441,00	19,441,00	0.03	1	583,230	0.001188
Well 6	Threat	S(PU)-Physical -	0	0	19,441,00	19,441,00	0.03	1	583,230	0.005544
Well 7	Threat	C(C)-Chemical	5	5	18,949,00	18,949,00	0.03	1	568,470	0.001188
Well 7	Threat	S(PU)-Physical -	0	0	18,949,00	18,949,00	0.03	1	568,470	0.005544
Forked Horn	Threat	S(PU)-Physical -	0	0	2,750,000	2,750,000	0.2	1	550,000	0.02464
Well 3	Threat	C(C)-Chemical	5	5	2,879,000	2,879,000	0.175	1	503,825	0.00336
Well 3	Threat	S(PU)-Physical -	0	0	2,879,000	2,879,000	0.175	1	503,825	0.01568
System Wide	Threat	N(I)-Ice Storms	0	0	50,000	50,000	0.124676	0.0430549	488	0.00040581
Well 4	Threat	(V1)-Car	1	0	9,623,000	9,623,000	0.5	0.01	48,115	0.000344
Well 2	Threat	C(C)-Chemical	5	5	2,171,000	2,171,000	0.175	1	379,925	0.0021
Well 2	Threat	S(PU)-Physical -	0	0	2,171,000	2,171,000	0.175	1	379,925	0.0098

Appendix: Table 16: Top 10 Risks to Natural Threats

Asset	Threat Class	Threat	Fatalities	Serious Injuries	Financial Impact	Vulnerability x Threat Likelihood	Risk	Financial Resilience
Facilities	Threat Class	N(E)-	1	0	50,000	0.00014	7	0
Pressure Zone	Threat Class	N(E)-	0	0	70,000	0.000104	7	0.000002329
System Wide	Threat Class	N(I)-Ice Storms	0	0	50,000	0.005367948	488	0.000405816
Storage	Threat Class	N(E)-	0	0	150,000	0.00014	21	0.00003528
System	Threat Class	N(E)-	0	0	150,000	0.00014	21	0.0000336
Well 2	Threat Class	N(E)-	0	0	150,000	0.00014	21	0.0000168
Well 3	Threat Class	N(E)-	0	0	150,000	0.00014	21	0.00002688
Well 4	Threat Class	N(E)-	0	0	150,000	0.00014	21	0.00007224
South Redmond	Threat Class	N(E)-	1	0	150,000	0.000104	15	0.00002496
Well 5	Threat Class	N(E)-	0	0	150,000	0.000104	15	0.000059904

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Probable Cost of Construction
Condition Assessment - Well No. 2 Site Improvements

Project: Condition Assessment
Submittal: Well No. 2 Site Improvements
Owner: City of Redmond
Project No.: 18-2269
Date: May 24, 2021

Item No.	Item	Quantity	Unit Costs			Total Cost
			Material	Labor/Equipment (L/E)	Total	
Civil						
A1	Topsoil Stripping and Stockpiling	150 CY		\$0.74	\$0.74	\$111
A2	Rough Grading	1 EA		\$1,274.75	\$1,274.75	\$1,275
A3	Fine Grading	350 SY		\$2.98	\$2.98	\$1,043
A4	Asphalt Concrete Paving	500 SF	\$2.84	\$0.58	\$3.42	\$1,710
A5	Hauling	300 CY		\$9.45	\$9.45	\$2,835
SubTotal:						\$6,974
Material & Labor Total:						\$6,973.75
Erosion Control		1%				\$70
Traffic Control		2%				\$139
Bonds and Insurance:		2%				\$139
Mobilization:		10%				\$697
State Revolving Fund (AIS, Prevailing Wage):		0%				\$0
Contractor's Overhead & Profit:		15%				\$1,046
Subtotal						\$9,066
Owner's Allowance/Contingency:		30%				\$2,720
Environmental Mitigation		Not included				
Right of Way Acquisition		Not included				
Estimated Construction Cost						\$12,000
Engineering		20%				\$2,400
Construction Eng./Admin.		10%				\$1,200
Estimated Project Cost						\$16,000
Construction Cost w/ sales Tax and Owner's Allowance (minimum range: -20%)						\$10,000
Construction Cost w/ sales Tax and Owner's Allowance (maximum range: +100%)						\$24,000



Probable Cost of Construction Condition Assessment - Well No. 3 - Wellhouse Improvements

Project: Condition Assessment
 Submittal: Well No. 3 - Wellhouse Improvements
 Owner: City of Redmond
 Project No.: 18-2269
 Date: May 24, 2021

Item No.	Item	Quantity	Unit Costs			Total Cost
			Material	Labor/Equipment (L/E)	Total	
Area 1						
A1	Demo Existing Roof and Appurtenances	1 LS		\$10,000.00	\$10,000.00	\$10,000
A2	New Roof	700 SF		\$68.14	\$68.14	\$47,698
A3	Replace Lighting and Exhaust fan	1 LS	\$15,000.00		\$15,000.00	\$15,000
A4	Repair CMU	5 SF		\$5.16	\$5.16	\$26
SubTotal:						\$72,724
Material & Labor Total:						\$72,723.80
Bonds and Insurance:		2%				\$1,454
Mobilization:		10%				\$7,272
State Revolving Fund (AIS, Prevailing Wage):		0%				\$0
Contractor's Overhead & Profit:		15%				\$10,909
Subtotal						\$92,359
Owner's Allowance/Contingency:		30%				\$27,708
Environmental Mitigation Not included						
Right of Way Acquisition Not included						
Estimated Construction Cost						\$120,000
Engineering		20%				\$24,000
Construction Eng./Admin.		10%				\$12,000
Estimated Project Cost						\$156,000
Construction Cost w/ sales Tax and Owner's Allowance (minimum range: -20%)						\$96,000
Construction Cost w/ sales Tax and Owner's Allowance (maximum range: +100%)						\$240,000

<i>Estimated Construction Cost</i>			<i>\$1,006,000</i>
	Engineering	20%	\$201,200
	Construction Eng./Admin.	10%	\$100,600
<i>Estimated Project Cost</i>			<i>\$1,308,000</i>
<i>Construction Cost w/ sales Tax and Owner's Allowance (minimum range: -20%)</i>			<i>\$805,000</i>
<i>Construction Cost w/ sales Tax and Owner's Allowance (maximum range: +100%)</i>			<i>\$2,012,000</i>



**Update of
2018 Wastewater Facility Plan**

Redmond Water Pollution Control Facility

November 12, 2019



Prepared for:

City of Redmond WPCF
411 SW 9th Street
Redmond, OR 97756

Prepared by: Heather Stephens, P.E. / Adam
Odell P.E. / Dr. Chris Machado P.E.

Stantec
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Abbreviations

AA	Average annual	MMF	Maximum moth flow
AAF	Average annual flow	MML	Maximum month load
AAGR	Average annual growth rate	MPN	Most probable number
AAL	Average annual load	N/A	Not applicable, no information
BFP	Belt filter press	NH3	Ammonia
BOD ₅	5-day biochemical oxygen demand	NO2	Nitrite
CCTV	Closed circuit television	NO3	Nitrate
CFR	Code of Federal Regulations	OAR	Oregon Administrative Rule
CFU	Colony forming unit	PF	Peak Flow
DEQ	Department of Environmental Quality (Oregon)	ppm	Parts per million
FOG	Fats, oils and grease (generally)	RAS	Return activated sludge
Gal	Gallons	SCADA	Supervisory controls and data acquisition
gpcd	Gallons per capita per day	TDS	Total dissolved solids
GPM	Gallons per minute	TKN	Total Kjeldahl nitrogen
L	Liters	TN	Total nitrogen
lb	Pound (mass)	TS	Total solids
mg	Milligrams (mass)	TSS	Total suspended solids
MGD	Million gallons per day	UGB	Urban Growth Boundary
MLR	Mixed liquor return	WAS	Waste activated sludge
MM	Maximum month	WPCF	Water pollution control facility

1.0 BASIS OF PLANNING

1.1 INTRODUCTION AND NEED FOR PROJECT

The City of Redmond Water Pollution Control Facility (WPCF) was constructed in 1978. Since then, several upgrades have occurred to meet the community's growing needs. Upgrades include replacement of the original biological treatment system with Orbal® brand concentric biological nutrient removal reactors, additional clarifiers, a belt filter press, and biosolids drying pad and disinfected effluent infiltration basins. The population of Redmond and surrounding areas is expected to increase, together with commerce and industry as the region develops. As such, the need for future facility planning is vital to provide facilities to serve growth, as well as maintain, improve and protect the investment local citizens have made in the existing facilities.

The WPCF is located in a dry canyon, about 1.5 miles northwest of the Redmond City Center. The facility is surrounded by residential homes situated along the canyon walls, and more rural residential and farmland generally to the north. The City of Redmond (City) has an active farm which produces orchard grass (hay) using effluent from the WPCF for irrigation and biosolids from the WPCF as fertilizer. The WPCF also owns land to the northwest of the facility, where disinfected effluent is infiltrated into the ground or stored in an irrigation pond for hay irrigation, and biosolids are dried and land applied.

The purpose of this WPCF Facility Plan is to assess the ability of the existing system to address current and projected future service needs with respect to system capacity, ability to meet current and potential future regulatory requirements, and reliability of unit process performance. This Facility Plan focuses primarily on the WPCF, but also describes the ability of the conveyance and pumping system to meet the same objectives. The contents of this Wastewater Facility Plan are based on the State of Oregon *Guidelines for Preparing Wastewater Planning Documents and Environmental Reports* (June 2018).

The planning period for this Facility Plan Update is 20 years from the date of completion of the first phase of improvements. Planning projections are provided through 2045, which extends slightly beyond the anticipated completion of the first phase of improvements to the WPCF. This section identifies and documents planning drivers including flow and loading projections and existing and future potential regulatory requirements.

1.2 PROJECT PLANNING AREA

The City of Redmond is located in Deschutes County in the high desert region of central Oregon, along the US 97 corridor. The main WPCF is situated just inside the City Limits in the northwest portion of the city and at the north end of a 'dry canyon,' which was once an ancient river bed. Residential areas are located on both sides of the dry canyon, above the WPCF. Other WPCF components including the biosolids drying pads, irrigation pond (effluent storage), irrigation pivots, and infiltration basins are located to the north of the main site, outside of the City Limits and Urban Growth Boundary. The study area, Redmond City Limits and Urban Growth Boundary are identified in **Figure 1-0**.

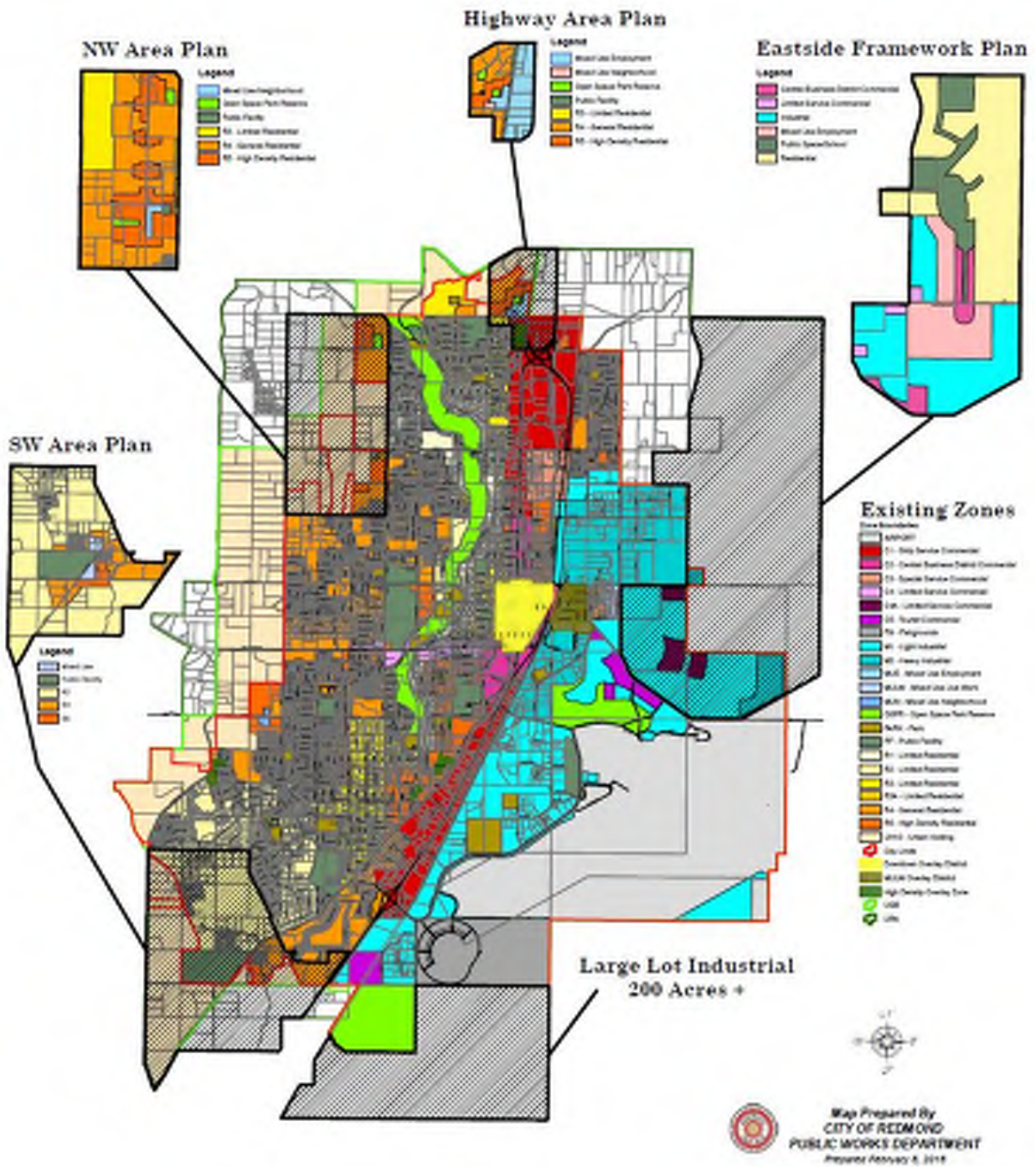


Figure 1-0: Zoning and Comprehensive Plan

1.3 LOCAL PHYSICAL ENVIRONMENT

1.3.1 Topography

Topography in the City service area is relatively flat with the exception of scarred canyons and other volcanic remnants scattered throughout the landscape. Elevations within Redmond range from approximately 2,700 to 3,100 feet, with the main WCPF located at elevation of 2,865 feet. See **Figure 1-1** for a map of local topography.

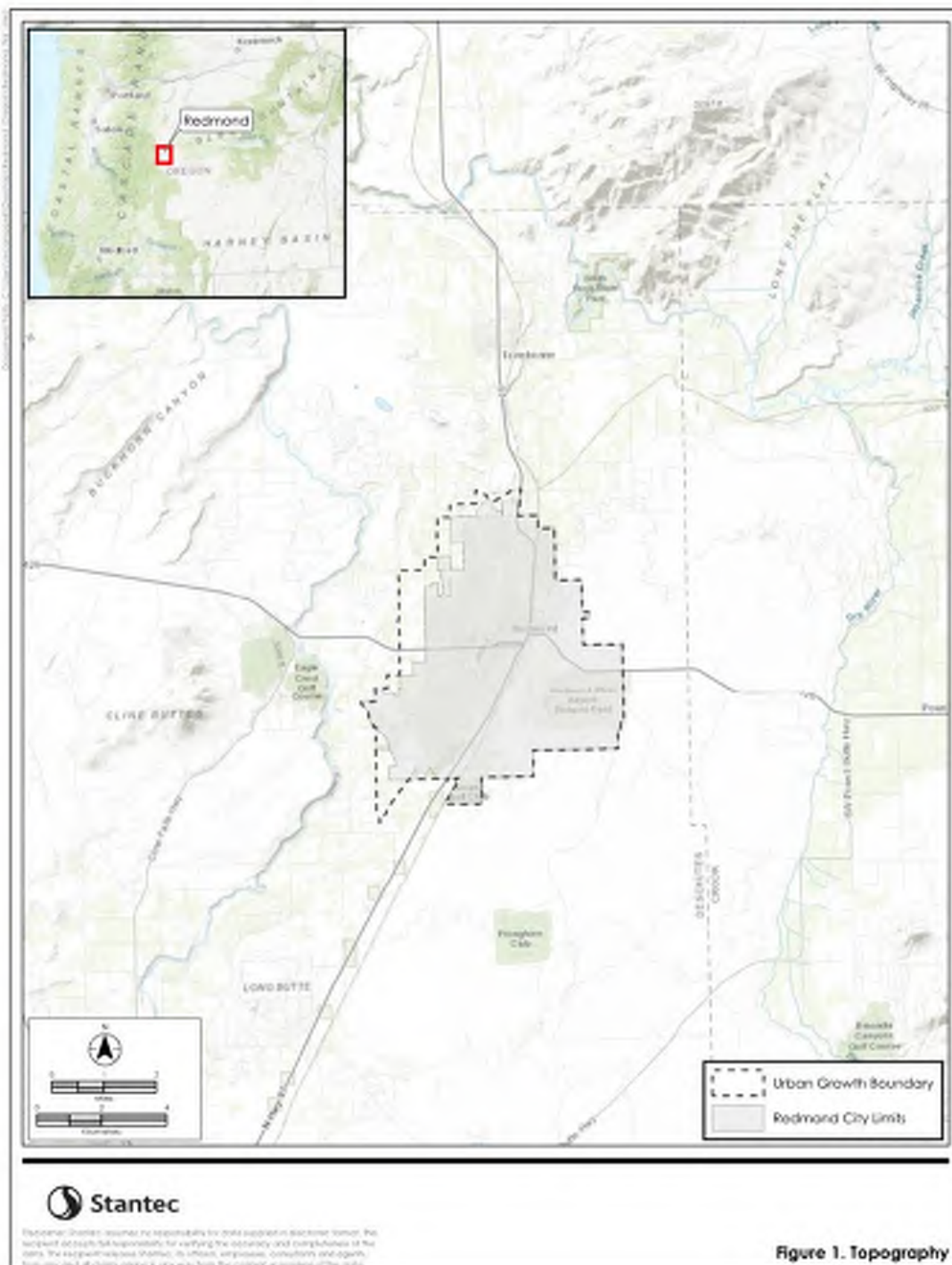


Figure 1-1: Topography and Local Physical Environment

1.3.2 Geology & Soils

The predominant geologic conditions in the City result from ancient lava flows and other volcanic features and consisting primarily of basalt. The City sits on a relatively flat plateau to the east of the Deschutes River, which has carved a deep canyon. The main WPCF sits in a unique dry canyon – remnants of an ancient river bed. Soils typically range from sandy loams to rock outcroppings. See **Figure 1-2** and **Figure 1-3** for a map of geologic and soils conditions.

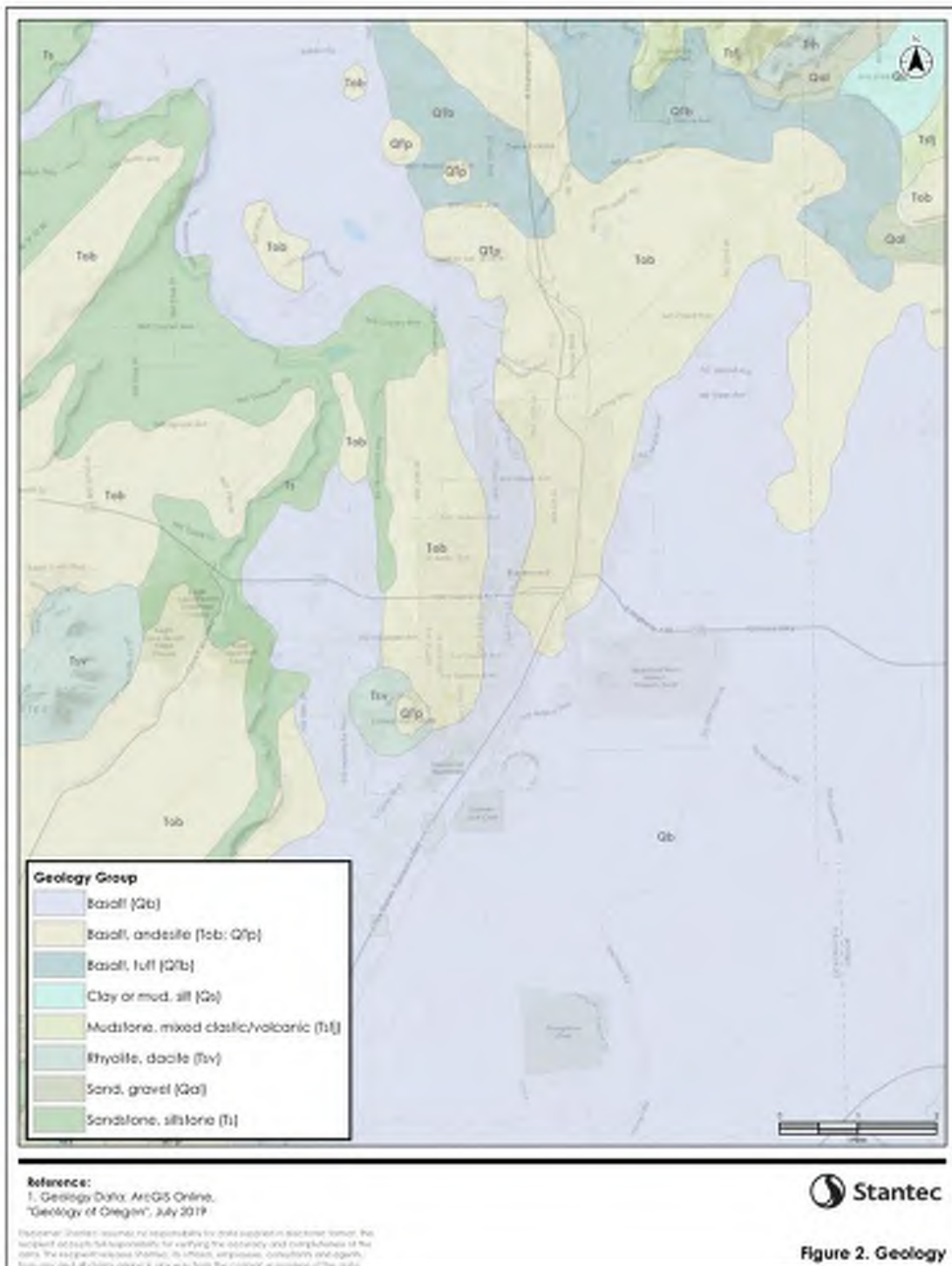


Figure 1-2: Local Geology of Redmond

CHAPTER 1 BASIS OF PLANNING

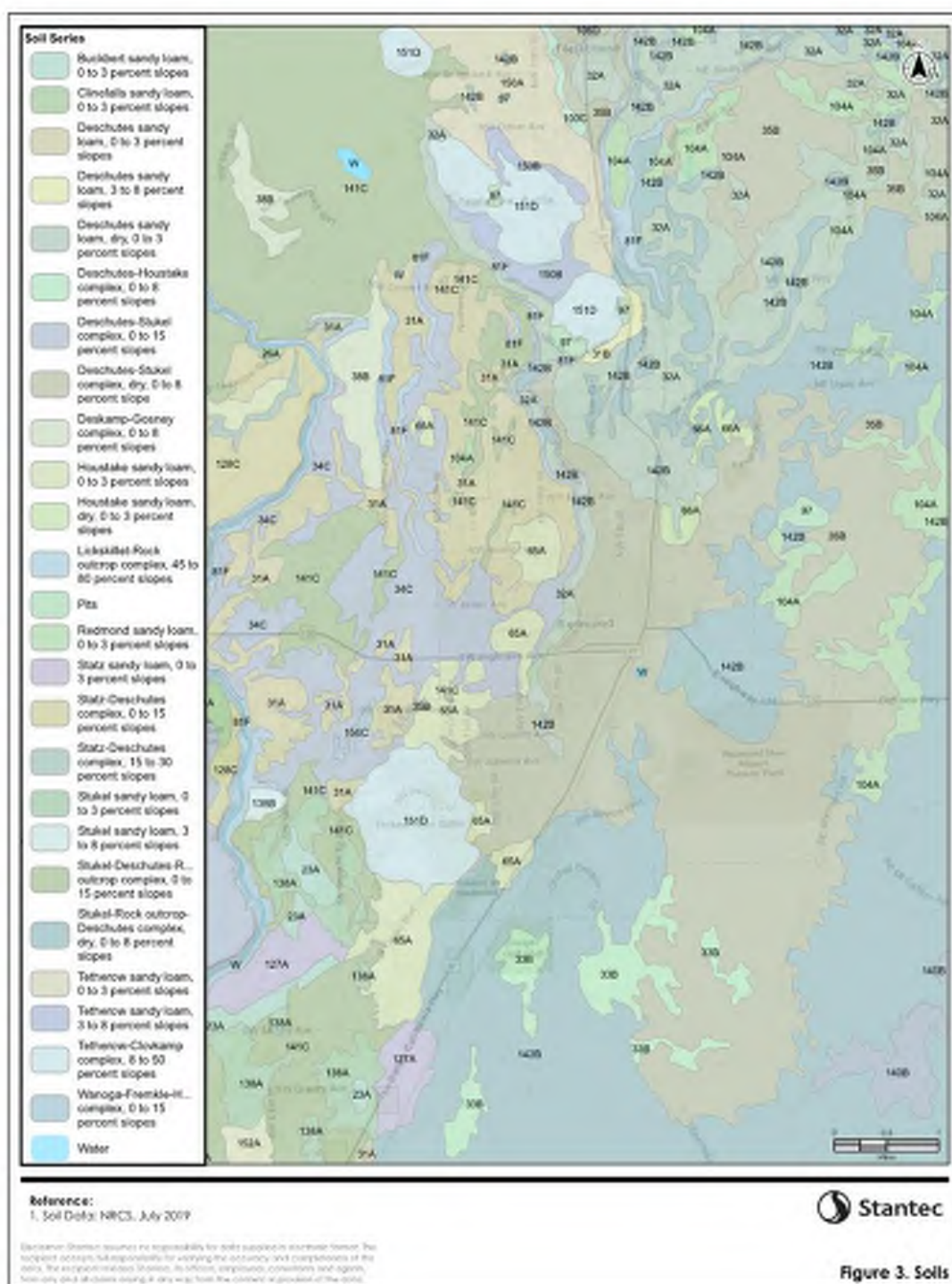


Figure 1-3: Local Soil Condition in Redmond

1.3.3 Climate

Redmond has a four-season, semi-arid climate characterized by warm, dry summers with occasional afternoon thunderstorms, mild autumns, cold winters with snow followed by a mild spring. City and County records indicate rainfall averages of 8.64 inches annually. High temperatures during summer days average about 85°F while winter lows reach an average of 20°F.

1.3.4 Water Resources

The Deschutes River located to the west of the City flows generally south to north. Several smaller creeks and streams flow into the Deschutes watershed. Other water bodies include small lakes and ponds, and a few wetlands as shown in **Figure 1-4**. According to the figure reference, there are no identified wetlands on or adjacent to the main WPCF facility or the solids, irrigation and infiltration facilities.

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1.3.4.1 Integrated Water Resources Strategy

The Oregon Integrated Water Resources Strategy (IWRs) is a planning document that highlights the water resources of the State. The IWRs focuses on “instream” – related to conditions within water bodies and “out-of-stream” – related to irrigation or use/transfer of water from natural features to man-made locations. The IWRs has two main goals; 1 – to improve our understanding of Oregon’s water resources; 2 – to meet Oregon’s water resources needs.

The Oregon Department of Environmental Quality (DEQ) Facilities Plan Guidelines (DEQ 2018) has recommended several actions from the IWRs which apply to wastewater planning. See the following actions on **Table 1-1** with responses:

Table 1-1: Integrated Water Resources Strategy Actions

	Recommendation	Response
7A	Develop and upgrade water and wastewater infrastructure	This facilities plan (WWFP) provides a capacity analysis and recommendations for upgrades to the WPCF infrastructure over a 20+ year planning horizon.
7B	Encourage regional (sub-basin) approaches to water and wastewater systems	The City wishes to provide class A treated biosolids from the WPCF to interested members of the public. The city currently grows orchard grass (hay) from wastewater effluent, which, if it meets nitrogen limits, can be used as animal feed.
9A	Continue to undertake place-based integrated, water resources planning	Does not apply to WPCF
10C	Encourage additional water reuse projects	A portion of the disinfected WPCF effluent is already used to irrigate city-owned orchard grass (hay) fields. There are no plans for additional water reuse currently.
10D	Reach environmental outcomes with non-regulatory alternatives	Does not apply to WPCF
12B	Reduce the use of and exposure to toxics and other pollutants	The City plans to replace the existing sodium hypochlorite disinfection system with UV disinfection, reducing chemical use at the WPCF.
12C	Implement water quality pollution control plans	The WPCF meets its TMDL and discharge permits as required. The recommendations of this facility plan will further ensure water quality and pollution control compliance into the future.
13C	Fund communities needing feasibility studies for water conservation, storage and reuse projects	Does not apply to WPCF

1.4 SERVICE AREA DESCRIPTION

The main treatment components of the WPCF are located within the City Limits and Urban Growth Boundary in the northwest region of Redmond. This property is zoned as a public facility with area of approximately 12.1 acres. Additional facility infrastructure including the biosolids drying pad, irrigation pond, City-owned orchard grass (hay)

fields and infiltration basins located to the north of the main WPCF and are outside of Redmond's City Limits and Urban Growth Boundary. These are zoned as EFU – Terrebonne Subzone. See **Figure 1-1** above for service area map.

1.5 EXISTING AND FUTURE POPULATION, FLOWS AND LOADS

Operational capacity and performance of wastewater treatment plants are dependent on influent wastewater characteristics, including flow and concentrations of five-day biochemical oxygen demand (BOD₅), total suspended solids (TSS), ammonia (NH₃), and total Kjeldahl nitrogen (TKN). The City provided Stantec with historical daily flows from April 2008 to April 2018 (10-year study period) and loading from January 2014 to April 2018 (4-year study period). Historical operational and influent water quality data were evaluated to estimate the future unit process capacity and identify bottlenecks or necessary process upgrades through the year 2045.

Flows and loads are commonly characterized on a per capita basis, therefore, an evaluation of historical and future population growth was also conducted to project future influent flows and loads to the Redmond WPCF.

In addition to municipal wastewater received, Redmond WPCF also accepts high-strength wastewater from various industries. Historical flows and loads from these industries are included in this section.

1.5.1 City of Redmond Population

The City provided Stantec with historical and projected population growth for Urban Growth Boundaries (UGB) in Deschutes County, OR from the *Portland State University: Oregon Population Forecast Program* (**Table 1-2**). The projections include average annual growth rates defined for the periods 2010-2018, 2018-2043, and 2043-2068.

Table 1-2: Historical and Projected Population Data for Deschutes County

	Historical			Forecast					
	2000	2010	AAGR (2000-2010)	2018	2043	2068	AAGR (2010-2018)	AAGR (2018-2043)	AAGR (2043-2068)
<i>Deschutes County</i>	116,277	157,905	3.1%	187,621	301,999	432,930	2.1%	1.9%	0.7%
Bend	52,163	77,010	4.0%	91,373	162,336	255,291	2.1%	2.3%	1.8%
La Pine	899	1,653	6.3%	1,833	3,594	5,894	1.3%	2.7%	2.0%
Redmond	15,524	26,508	5.5%	29,364	51,617	82,575	1.2%	2.3%	1.9%
Sisters	961	2,038	7.8%	2,691	5,169	8,431	3.4%	2.6%	2.0%
Outside UGBs	45,820	50,524	1.0%	62,360	79,236	80,739	2.6%	1.0%	0.1%

The population projection, shown in **Figure 1-5**, shows population growth from 2000 to 2045 using average annual growth rates (AAGR) from **Table 1-2**. This forecast suggests population may increase to approximately 54,000 people by the end of 2045 using an AAGR of 2.3% (2018-2043) and an AAGR of 1.9% (2044-2045).

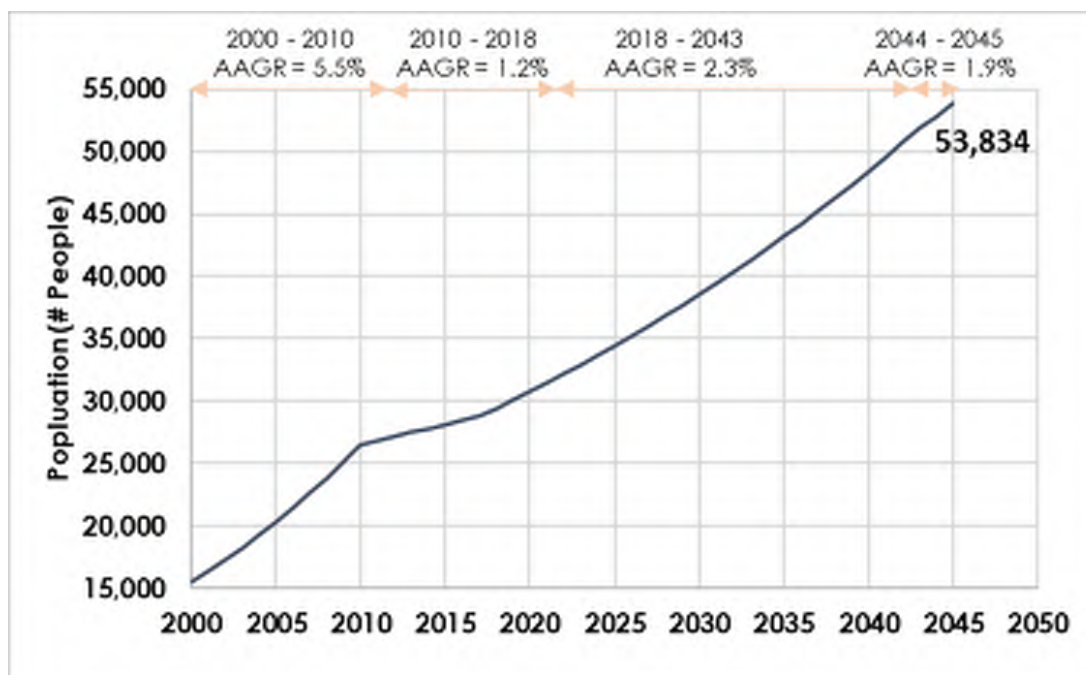


Figure 1-5: Population Projection, Redmond 2000-2045

1.5.1.1 Socio-Economic Conditions

Based on US Census Bureau estimates, Redmond has a current unemployment rate of approximately 7.7% with a median income ranging between \$30,250 and \$57,494 for nonfamily and family households alike. The poverty rate in Redmond is approximately 16.2%.

1.5.2 Historical Wastewater Flows and Loads

Historical wastewater characteristics, including influent flow, BOD₅, total suspended solids (TSS), ammonia (NH₃), and Total Kjeldahl Nitrogen (TKN) loading rates, were evaluated between 2008 and 2018. Daily flow and loading data were provided by the City.

1.5.2.1 Historical Influent Wastewater Flow

Daily influent flow was evaluated during a 10-year study period (2008-2018). **Figure 1-6** shows a plot of the daily wastewater flow and the 30-day moving average. Maximum 30-day average influent flow reached approximately 2.1 MGD between the middle of 2008 and beginning of 2009. Subsequently, it decreased to approximately 1.4 MGD by the end of 2009, which could have been a reflection of the countrywide recession peaking in 2008. From 2010 to 2012, influent flow appears to stabilize and follow a flat trend. Since the beginning of 2012, the WPCF has seen a steady flow increase to the current average flow rate of 1.9 MGD. Stantec and the City concluded that data between 2012 and 2018 accurately represents the current flow trend. Therefore, data from 2008-2012 was removed for this flow analysis (**Figure 1-7**).

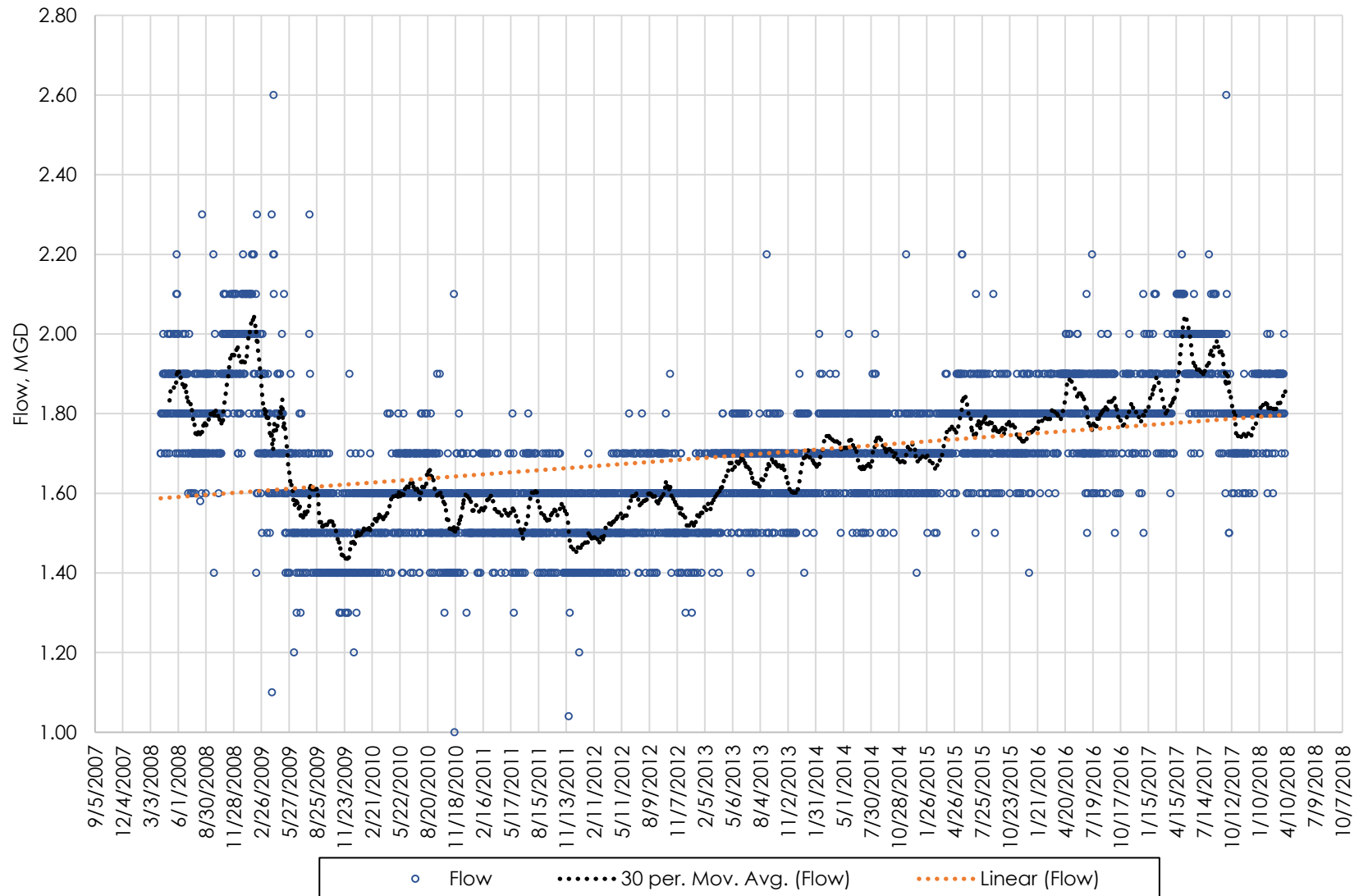


Figure 1-6: Historical Daily Flow (MGD), 2008-2018

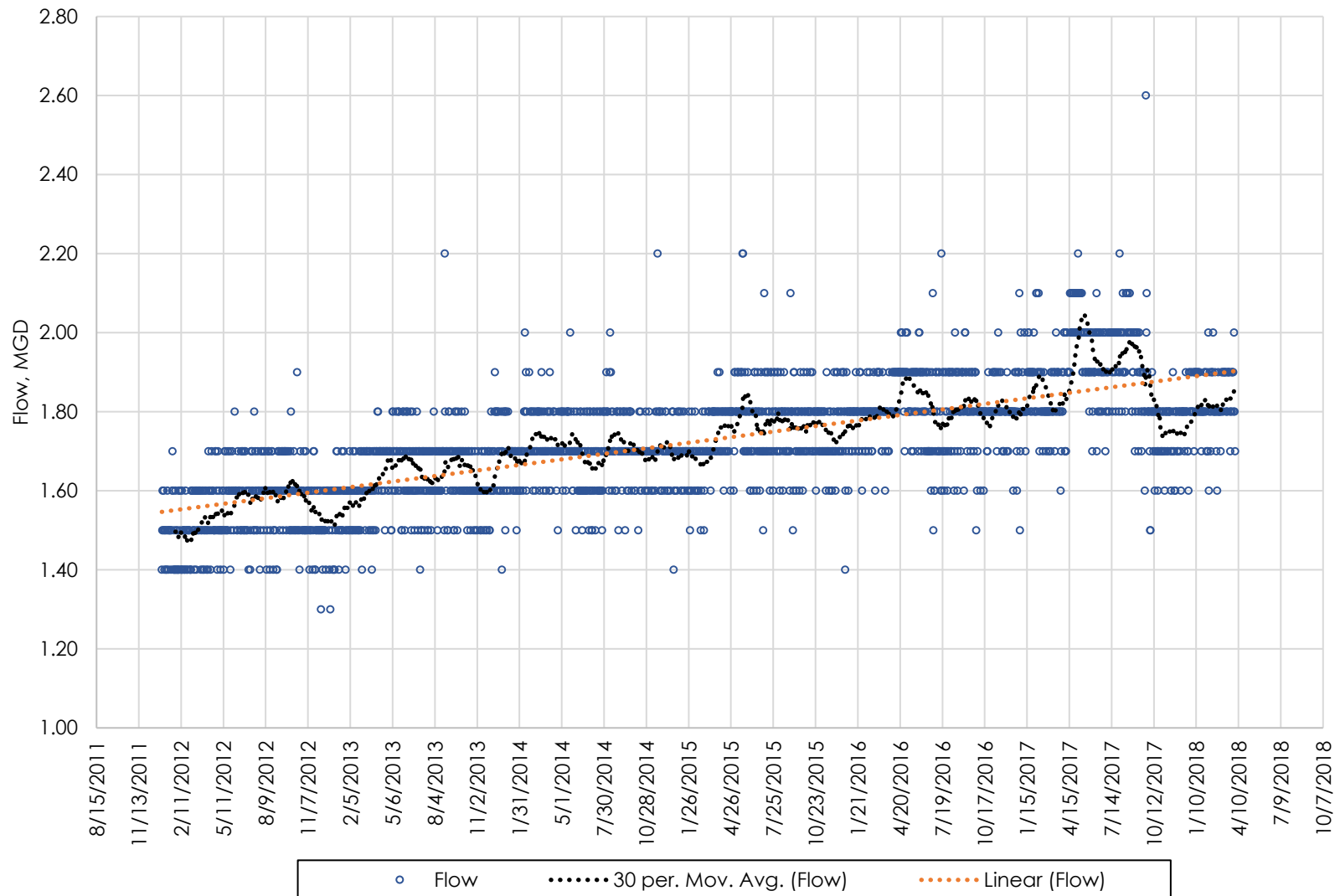


Figure 1-7: Historical Daily Flow (MGD), 2012-2018

Table 1-3 summarizes the average annual, maximum month, maximum week, peak day, and peak hour flow rates for the years 2012 – 2017, as well as the associated peaking factors (PF). Each parameter is defined below:

- **Average Annual Flow (AAF)** = Average of the daily flow for each year
- **Maximum Month Flow (MMF)** = Maximum value in 30-day moving average for each year
- **Maximum Month Flow PF** = Maximum Month Flow ÷ Average Annual Flow
- **Maximum Week Flow (MWF)** = Maximum value in 7-day moving average for each year
- **Maximum Week Flow PF** = Maximum Week Flow ÷ Average Annual Flow
- **Peak Day Flow (PDF)** = Maximum value of daily influent in each year
- **Peak Day Flow PF** = Maximum daily flow ÷ Average Annual Flow
- **Peak Hour Flow (PHF)** = Peak hour flow was provided for only 2017 by the City
- **Peak Hour Flow PF** = Peak hour flow ÷ Average Annual Flow

Table 1-3: Redmond WPCF Historical Flow Data

Year	AAF	MMF	Month PF	MWF	Week PF	MDF	Day PF	PHF	PHF PF
2012	1.55	1.70	1.10	1.70	1.10	1.90	1.22	--	--
2013	1.64	1.80	1.10	1.80	1.10	2.20	1.34	--	--
2014	1.70	1.80	1.06	1.90	1.11	2.20	1.29	--	--
2015	1.75	1.90	1.08	1.90	1.08	2.20	1.26	--	--
2016	1.81	1.90	1.05	2.00	1.11	2.20	1.22	--	--
2017	1.87	2.00	1.07	2.10	1.12	2.60	1.39	5.00 ¹	2.68 ¹
¹ From the 2017 Redmond WPCF Modeling Project Summary Report									

Historical Per Capita Flow

Per capita flow rates estimate the amount of flow used per person per day. To calculate this parameter, the annual average flow is divided by the population. **Figure 1-8** summarizes the per capita flow rate in each year of the study period. Per capita flow rate has steadily increased between 2012 and 2017. As water conservation is becoming a larger part of normal practice, it is expected that per capita usage would decrease over time. However, Redmond per capita flow rates suggest production is increasing. The increase of per capita flow is likely due to the growth in industrial contributions. Current per capita production is approximately 65 gallons/person/day. For this Facilities Plan, it is recommended that this per capita flow of 65 gallons/person/day be used. However, for the next planning period, Stantec recommends the City conduct a collection system evaluation to baseline the per capita flow contributions by assessing all industrial and potential infiltration and inflow flow components.

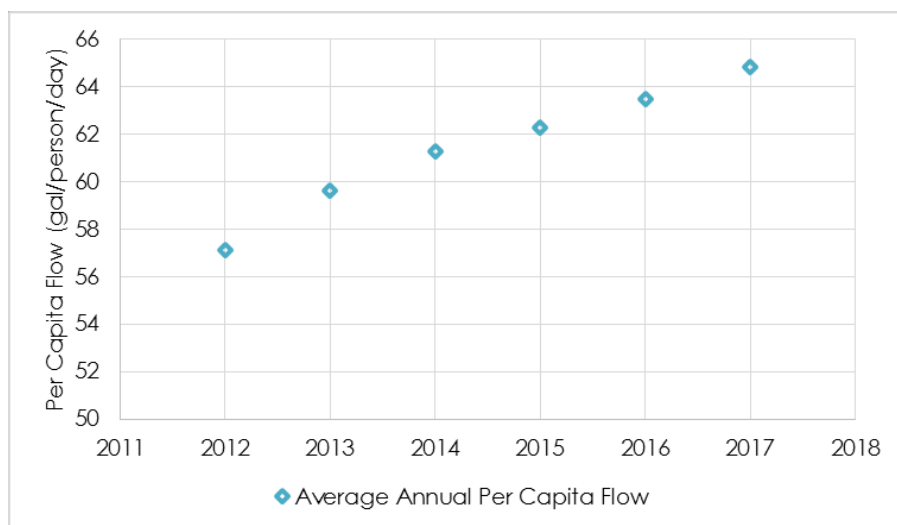


Figure 1-8: Average Annual Per Capita Flow (gal/person/day)

1.5.2.2 Influent BOD₅ Loading

Daily influent BOD₅ concentration and loading rates were evaluated during the study period, between 2014 and 2017. **Figure 1-9** and **Figure 1-10** show daily wastewater BOD₅ concentration and load, 30-day moving average, and the linear regression. Data between July 2017 and October 2017 was removed due to analytical error. Influent BOD₅ concentrations gradually increase between 2014 and 2016. Towards the end of 2017 and beginning of 2018, BOD₅ concentrations have more variation, which might be attributed to industrial growth in Redmond. A typical high-strength domestic wastewater BOD₅ concentration is 350 mg/L (Metcalf & Eddy 2003). Average concentrations in the order of 600 mg/L were observed early 2018. These high concentrations are likely attributed to the accelerated industrial growth in the City and result in a significant load increase to the WPCF. Stantec recommends that the City closely monitor the BOD₅ load to the WPCF, especially from industrial contributions (if feasible). Stantec also recommends that the City implement a capacity review and evaluation as part of planning and approval of new industry establishments.

Table 1-4 summarizes the average annual, maximum month, and maximum month flow peaking factors (PF) for BOD₅ loading between 2014 and 2017. Historical annual average and maximum month values are rounded, while the monthly peaking factor is calculated based on the complete set of historical data.

Table 1-4: Redmond WPCF Historical BOD₅, lb/day

Year	Average Annual	Maximum Month	Monthly PF
2014	6,200	7,800	1.26
2015	6,900	9,300	1.36
2016	7,700	9,800	1.28
2017	8,200	11,000	1.34

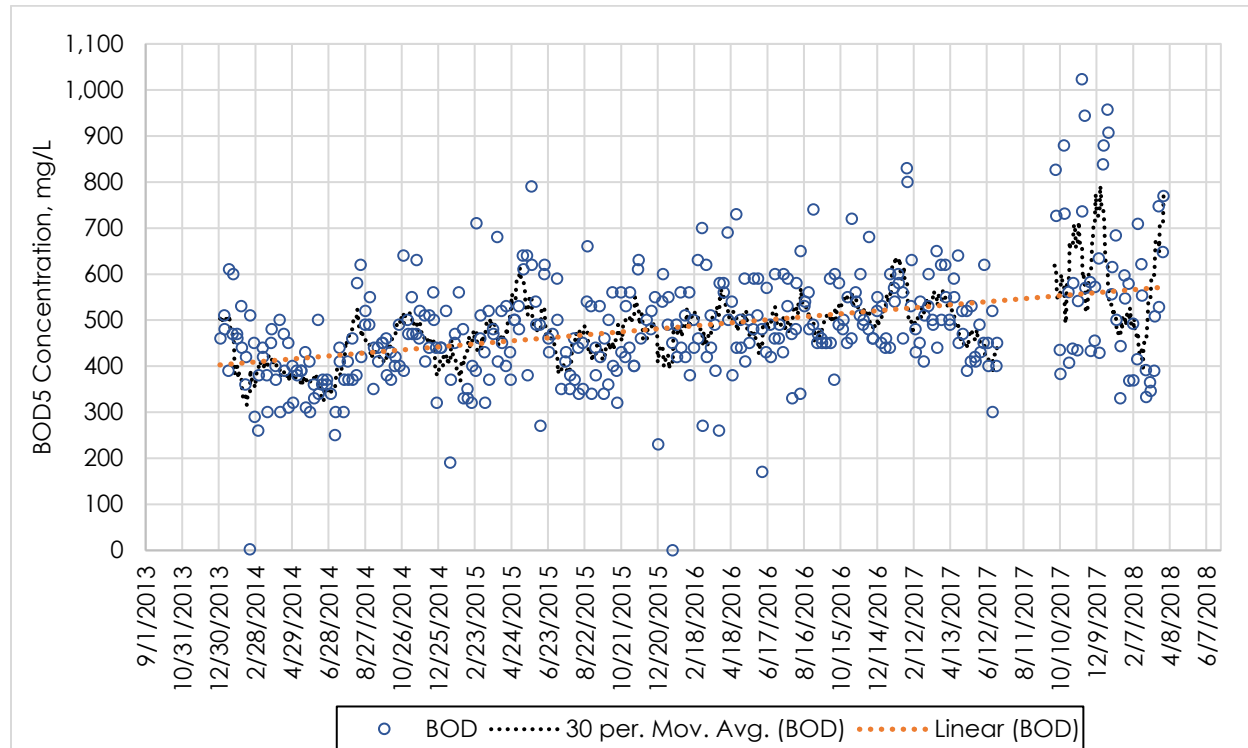


Figure 1-9: Historical Daily BOD₅ Concentration, mg/L

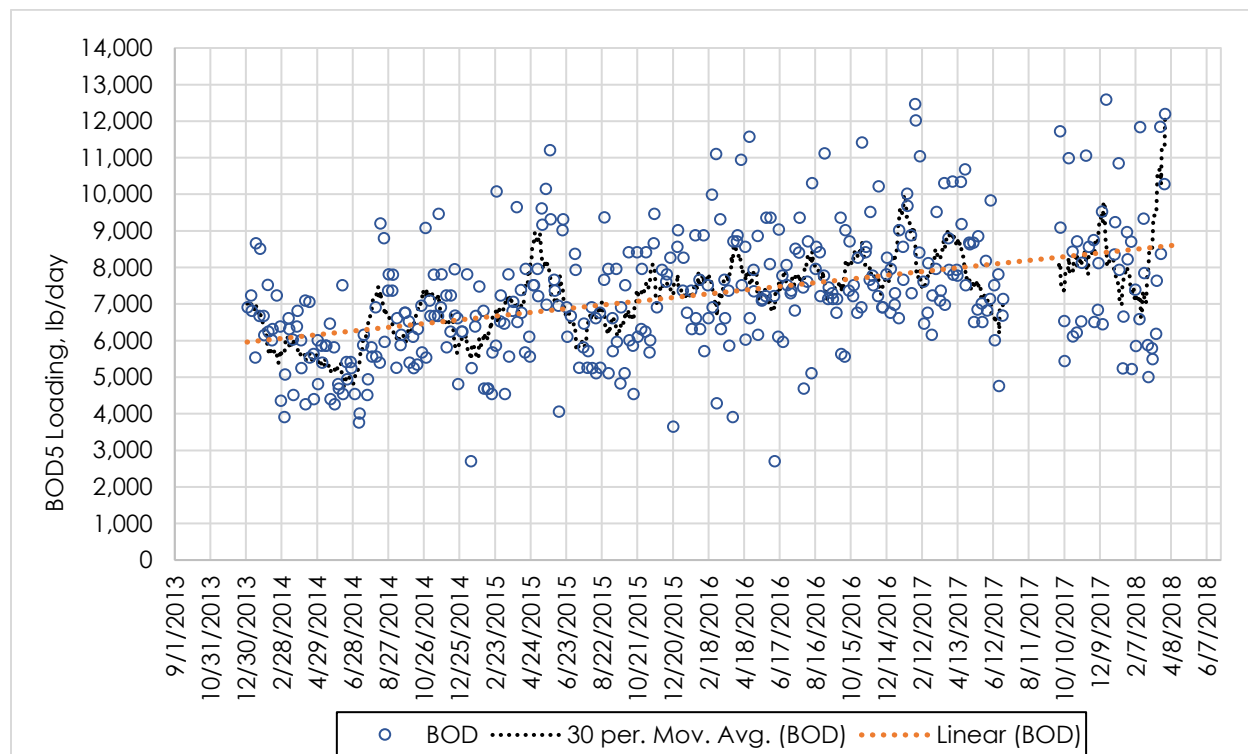


Figure 1-10: Historical Daily BOD₅ Load, lb/day

Historical Per Capita BOD₅ Load

Figure 1-11 summarizes the per capita BOD₅ load in each year of the study period. Similar to the per capita flow, per capita BOD₅ steadily increases from 2014 to 2017, which might be due to the increase of industrial growth. Current per capita loading is approximately 0.28 lb/person/day, however due to analytical errors and high variation of data in 2017, Stantec recommends using the per capita load from 2016 of 0.27 lb/person/day for planning. A typical domestic wastewater BOD₅ per capita load varies from 0.11 to 0.26 lb/person/day (Metcalf & Eddy 2003). This high per capita contribution may also be attributed to the accelerated industrial growth in the City.

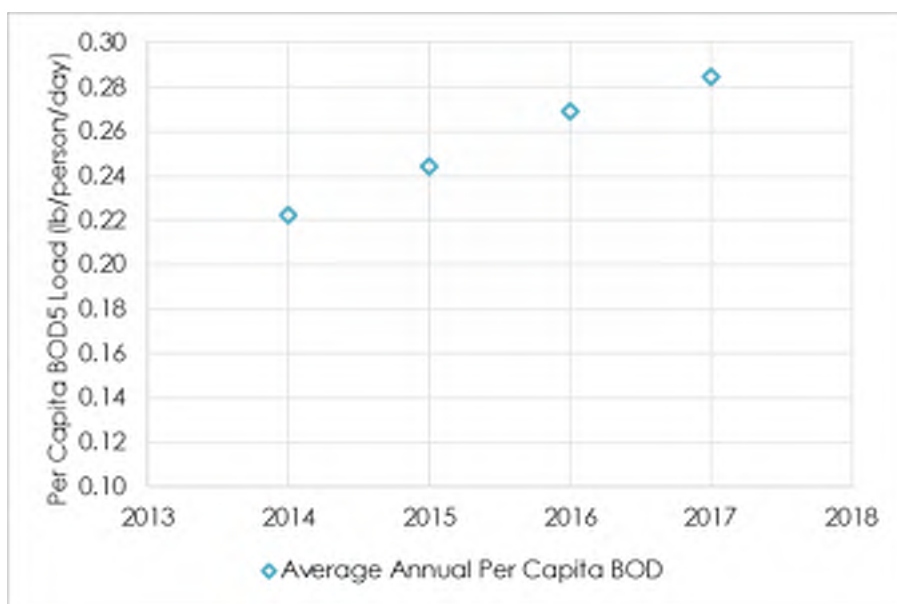


Figure 1-11: Average Annual Per Capita BOD₅, lb/person/day

1.5.2.3 Influent Total Suspended Solids Loading

Daily influent TSS concentration and loading rate were evaluated during the study period between 2014 and 2017. **Figure 1-12** and **Figure 1-13** show daily wastewater TSS concentration and load, moving 30-day average and the linear regression. Influent TSS concentration show a slight decrease since 2014 however TSS loading rate is relatively constant during the study period. While TSS concentration decreases, BOD₅ concentrations increase which suggests the increase in BOD₅ concentration in the wastewater is mainly from soluble BOD₅, rather than particulate sources.

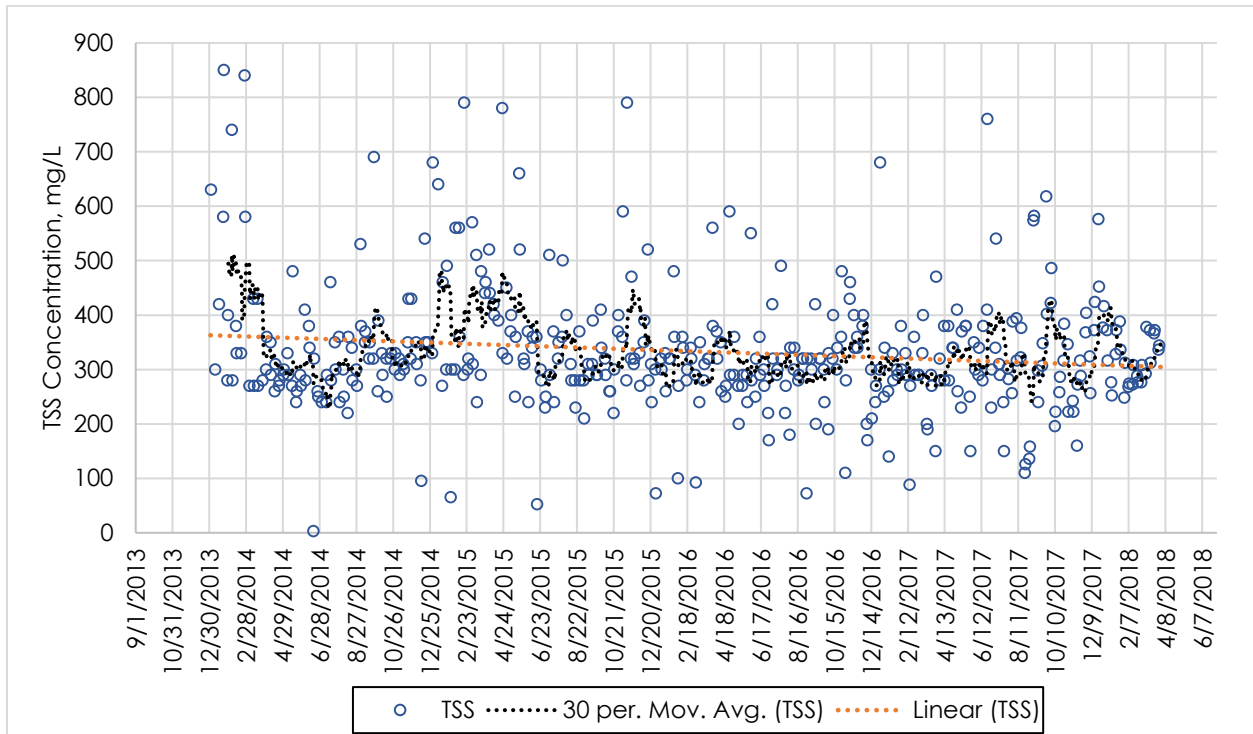


Figure 1-12: Historical Daily TSS Concentration, mg/L

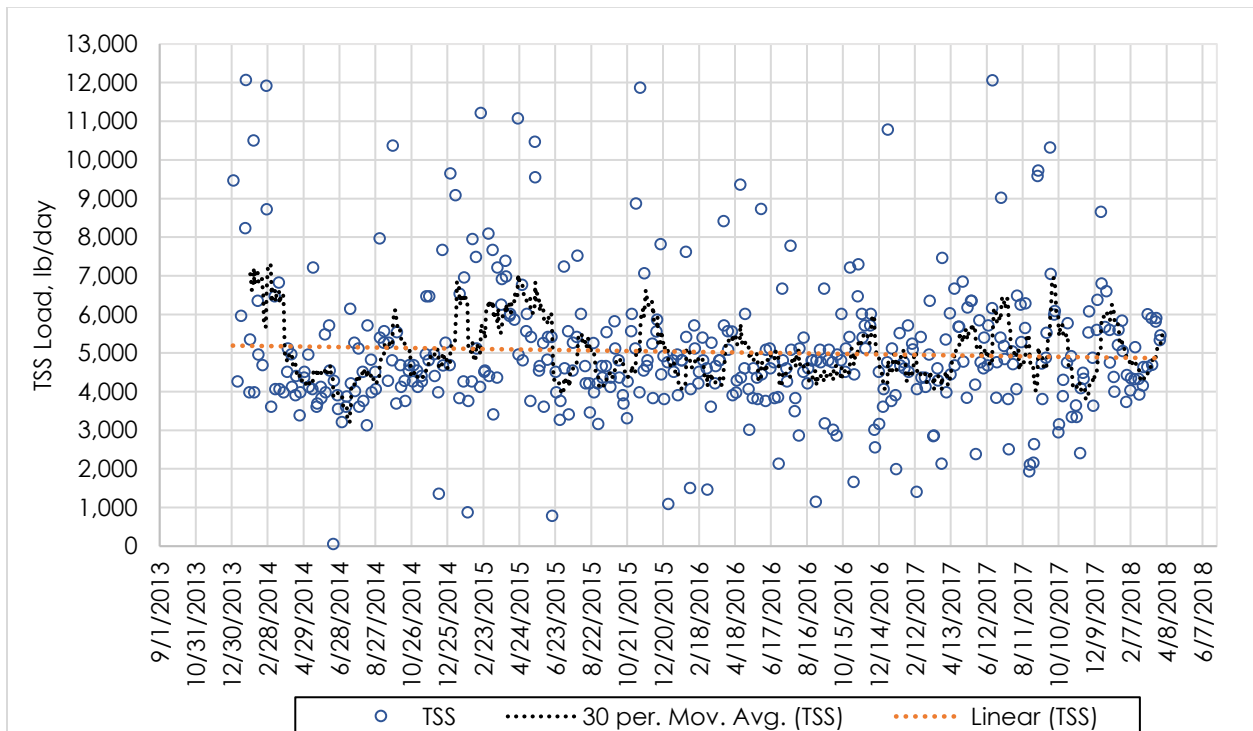


Figure 1-13: Historical Daily TSS Loading, lb/day

Table 1-5 summarizes the average annual, maximum month, and maximum month load peaking factors (PF) for TSS loading between 2012 and 2017. Historical annual average and maximum month values are rounded, while the monthly peaking factor is calculated based on the complete set of historical data.

Table 1-5: Redmond WPCF Historical TSS Load, lb/day

Year	Average Annual	Maximum Month	Monthly PF
2014	5,000	8,300	1.64
2015	5,300	8,100	1.51
2016	4,800	7,000	1.47
2017	5,000	7,000	1.39

Historical Per Capita TSS Load

Figure 1-14 summarizes the per capita TSS loading in each year of the study period, which shows a relatively constant per capita TSS loading. Current TSS per capita loading is approximately 0.17 lb/person/day. A typical domestic wastewater TSS per capita load varies from 0.13 to 0.33 lb/person/day (Metcalf & Eddy 2003). Therefore, the per capita contribution for TSS is within typical range. Stantec recommends using 0.17 lb/person/day for planning.

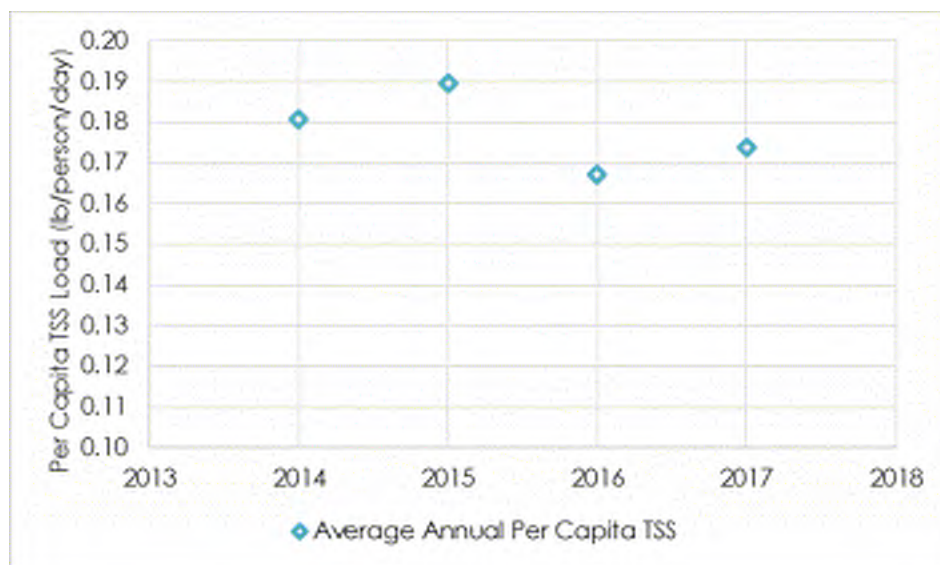


Figure 1-14: Average Annual Per Capita TSS, lb/person/day

1.5.2.4 Influent Ammonia Loading

Daily influent $\text{NH}_3\text{-N}$ concentration and loading rate were evaluated during the study period between 2014 and 2017. **Figure 1-15** and **Figure 1-16** present the daily wastewater $\text{NH}_3\text{-N}$ concentration and load, the moving 30-day average, and linear regression. Influent $\text{NH}_3\text{-N}$ concentration has been relatively constant since 2014, whereas $\text{NH}_3\text{-N}$ loading rate slightly increased due to flow increase during the study period. This observation potentially indicates that the industrial contributions have a higher impact on BOD_5 loading than ammonia loading.

Table 1-6 summarizes the average annual, maximum month, and maximum month load peaking factors for NH_3 loading between 2012 and 2017. Historical annual average and maximum month values are rounded, while the monthly peaking factor is calculated based on the complete set of historical data.

Table 1-6: Redmond WPCF Historical NH_3 Load, lb/day

Year	Average Annual	Maximum Month	Monthly PF
2014	550	650	1.17
2015	600	700	1.16
2016	600	750	1.23
2017	600	750	1.22

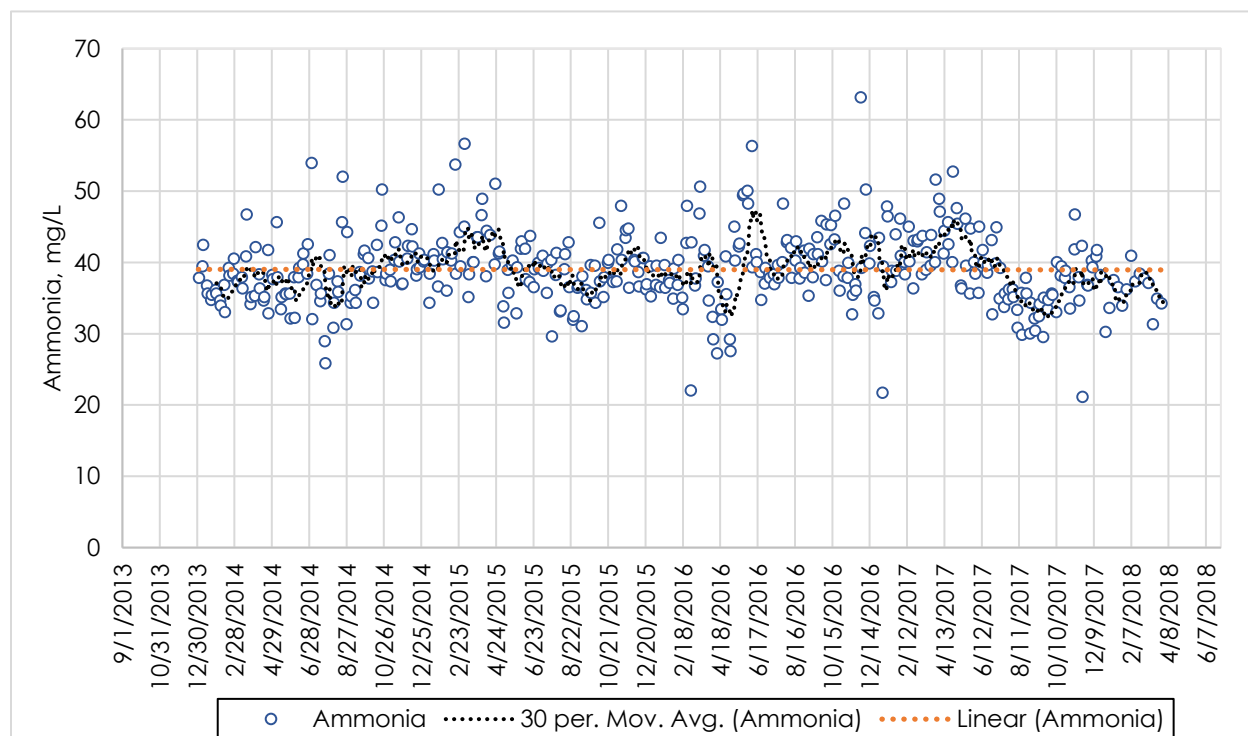


Figure 1-15: Historical Daily Ammonia Concentration, mg/L

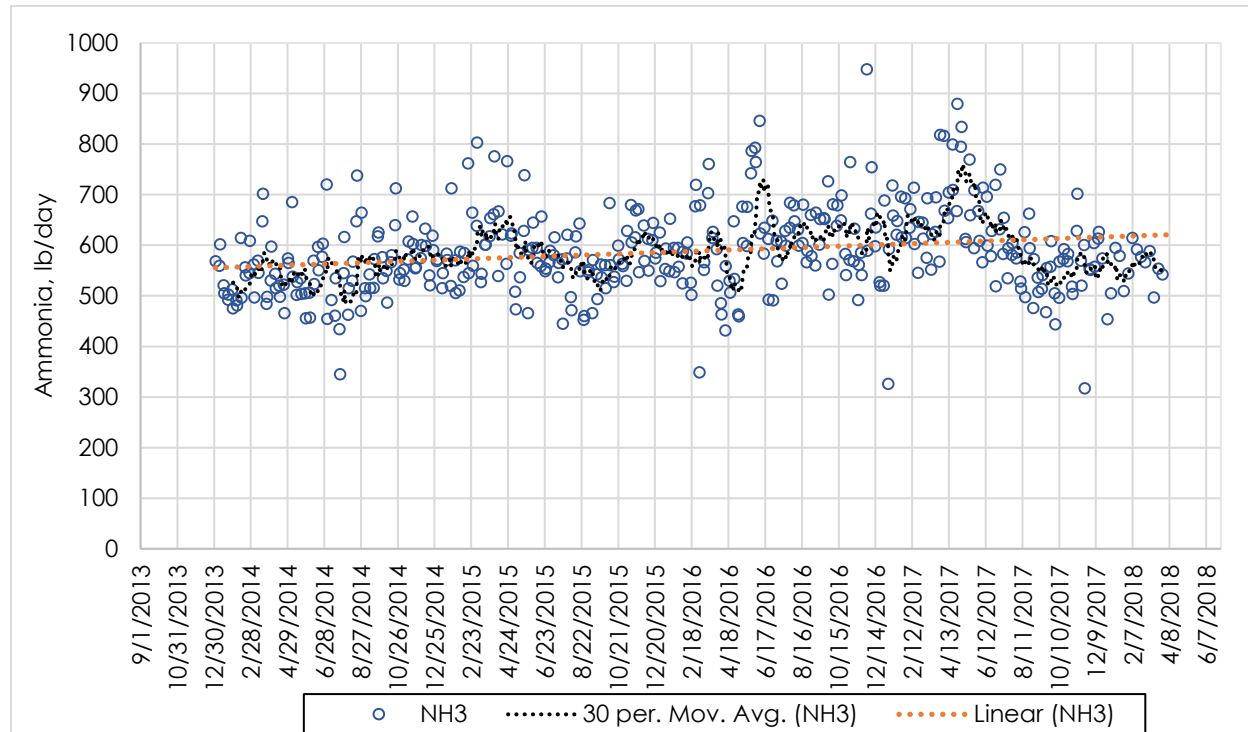


Figure 1-16: Historical Daily Ammonia Loading, lb/day

Historical Per Capita Ammonia Load

Figure 1-17 summarizes the per capita $\text{NH}_3\text{-N}$ loading in each year of the study period. Current per capita $\text{NH}_3\text{-N}$ loading rate is approximately 0.021 lb/person/day. A typical domestic wastewater $\text{NH}_3\text{-N}$ per capita load varies from 0.011 to 0.026 lb/person/day (Metcalf & Eddy 2003). Therefore, the per capita contribution for $\text{NH}_3\text{-N}$ is within typical range and Stantec recommends using 0.021 lb/person/day for planning.

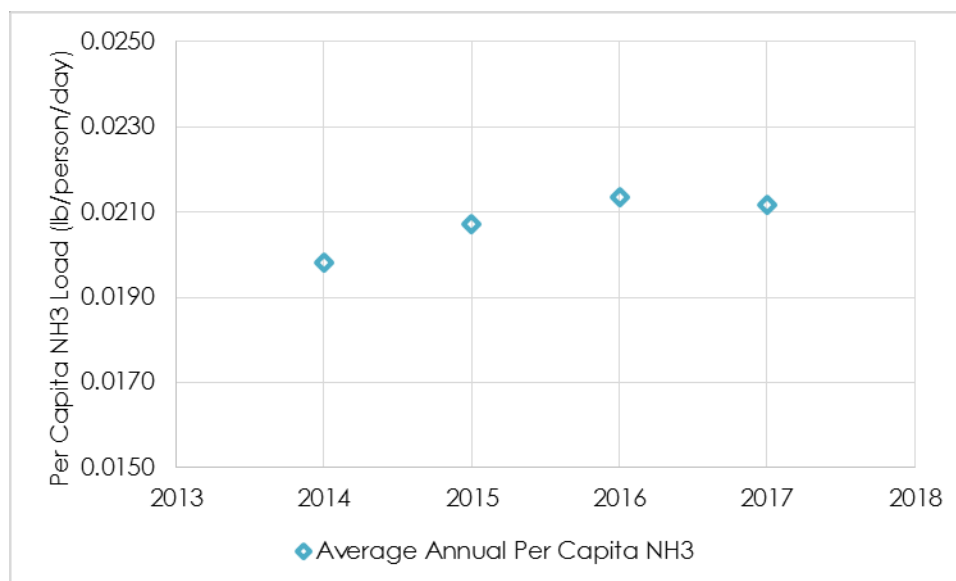


Figure 1-17: Average Annual Per Capita NH₃ (lb/person/day)

1.5.2.5 Historical Influent Total Kjeldahl Nitrogen Loading

Daily influent TKN concentration and loading rate were evaluated during the study period between 2014 and 2017. **Figure 1-18** and **Figure 1-19** present the daily wastewater TKN concentration and load, the moving 30-day average, and linear regression during the study period. Influent TKN concentration and loading rate slightly increased during the study period. The observed increase in TKN concentrations did not correspond to an increase in NH₃-N concentrations, which indicated that the increase was driven by the organic nitrogen fraction of TKN. This observation may be related to the increase in BOD₅ load due to industrial contributions.

Table 1-7 summarizes the average annual, maximum month, and maximum month load peaking factors for TKN loading between 2012 and 2017. Historical annual average and maximum month values are rounded, while the monthly peaking factor is calculated based on the complete set of historical data.

Table 1-7: Redmond WPCF Historical TKN Load, lb/day

Year	Average Annual	Maximum Month	Monthly PF
2014	750	950	1.26
2015	900	1,200	1.33
2016	900	1,200	1.33
2017	1,000	1,200	1.23

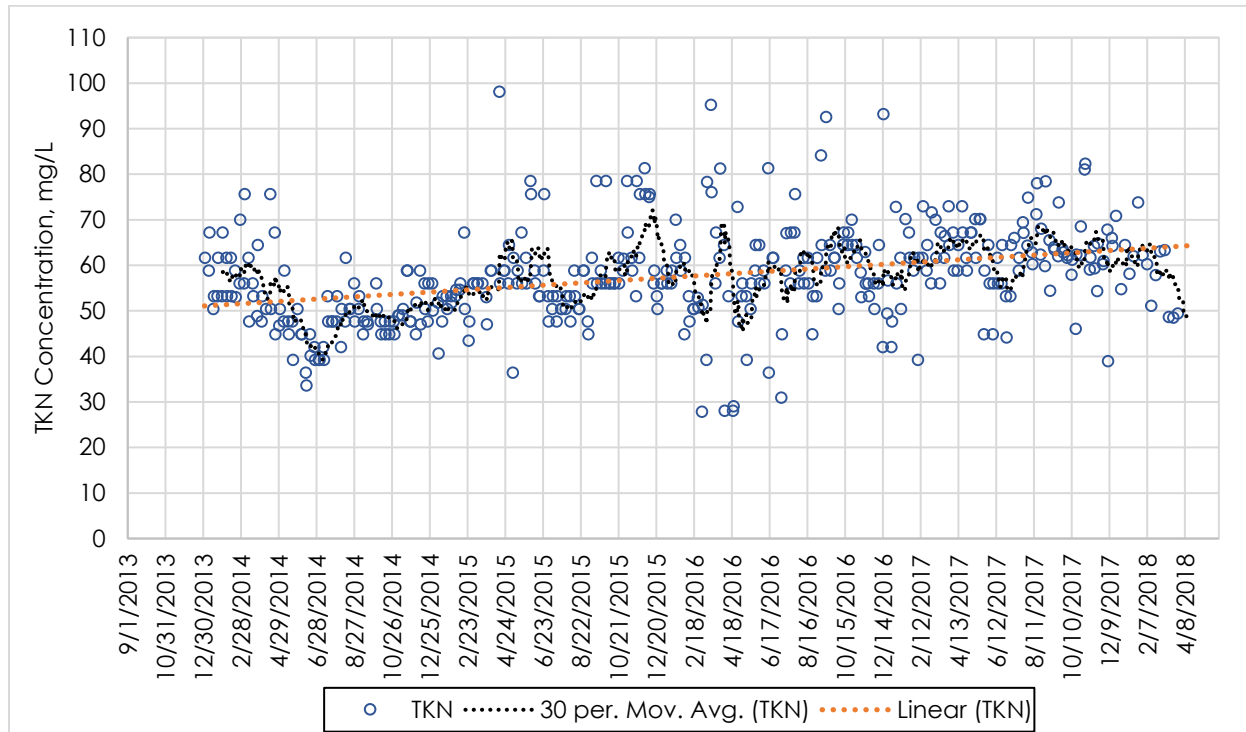


Figure 1-18: Historical Daily TKN Concentration, mg/L

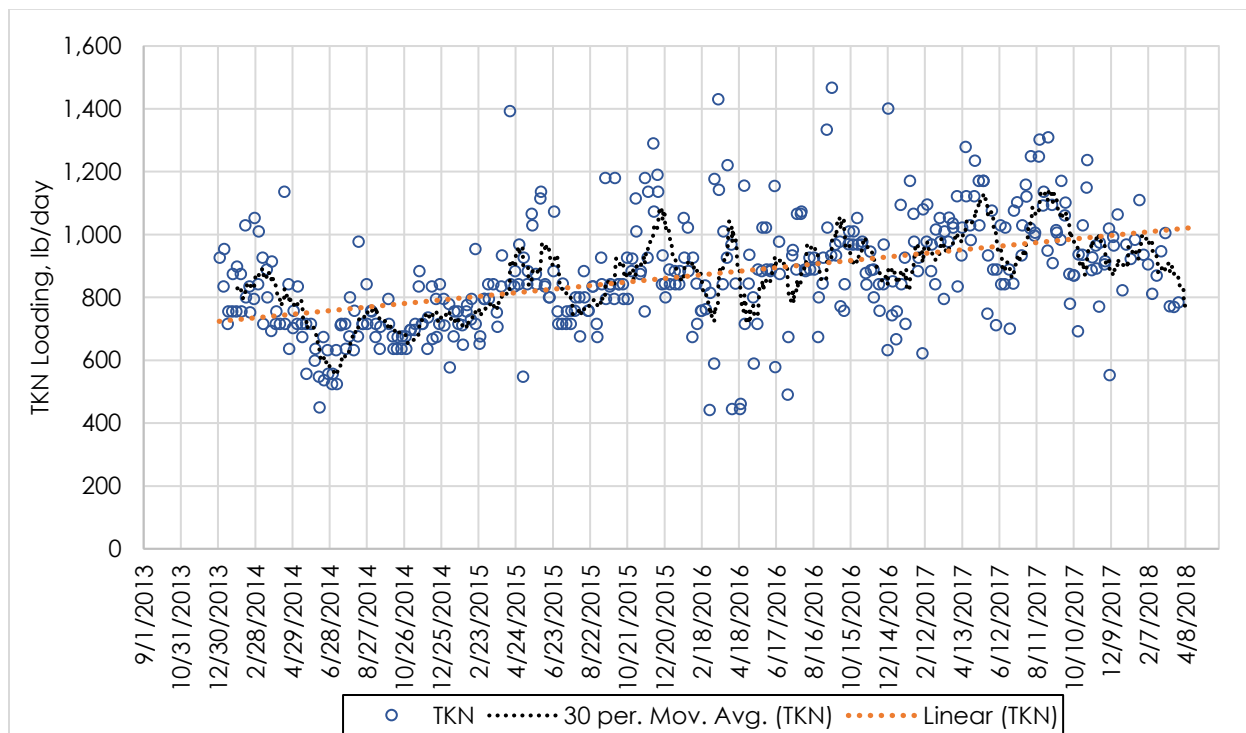


Figure 1-19: Historical Daily TKN Loading, lb/day

Historical Per Capita TKN Load

Figure 1-20 summarizes the per capita TKN loading in each year of the study period. Current per capita TKN loading rate is approximately 0.035 lb/person/day. A typical domestic wastewater TKN per capita load varies from 0.020 to 0.048 lb/person/day (Metcalf & Eddy 2003). Therefore, the per capita contribution for TKN is within typical range and Stantec recommends using 0.035 lb/person/day for planning.

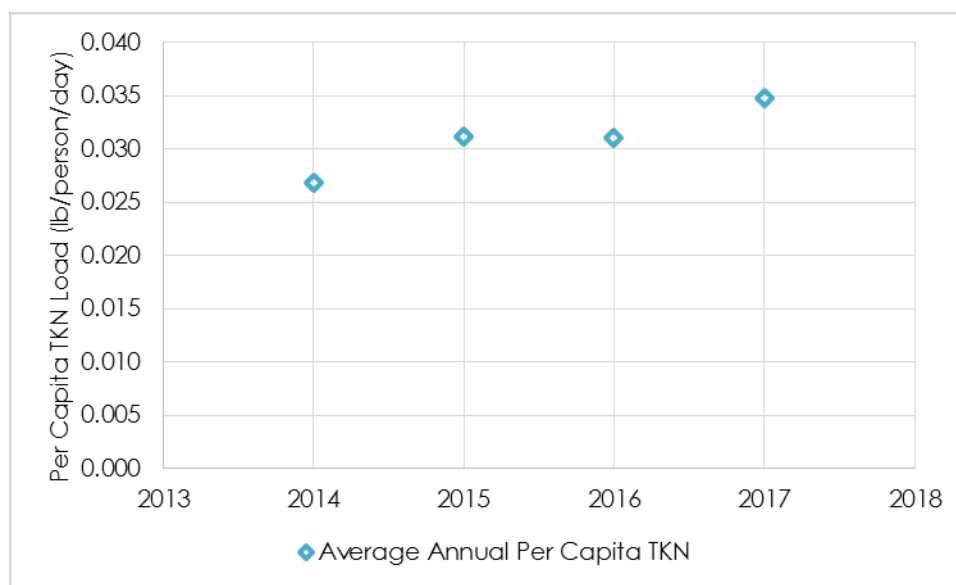


Figure 1-20: Average Annual Per Capita TKN, lb/person/day

1.5.2.6 Existing Industrial Contributions

Redmond WPCF receives high-strength wastewater from industries within the UGB. There are nine industries the City anticipates receiving discharge permits as Significant Industrial Users (SIUs); permits have been issued to two of these and the remaining are pending. Several permittees have installed some initial pretreatment facilities under previous direction from the City. The City has inspected and conducted outreach at all of these facilities and does not anticipate major challenges. Staff will continue to coordinate with industrial dischargers, especially smaller facilities, to assure they have the appropriate financial resources to construct and operate effective pretreatment facilities

The City provided influent flow, BOD₅, TSS, and FOG (fat, oil, and grease) loading from existing industries to the WPCF, which are summarized in **Table 1-8**. Redmond anticipates three new breweries to open in the next few years. The City has an approved industrial pretreatment program and is implementing applicable measures to address specific industrial contributions.

Table 1-8: Average Existing Industrial Contributions

User Name	Business Type	Flow (avg GPD)	BOD5 (lbs/day)	TSS (lbs/day)	FOG (lbs/day)
Aircraft Rubber	Rubber molding/fab	300	N/A	N/A	N/A
Cascade Lakes	Beer brewery	4,100	250	200	N/A
Eberhards	Creamery	18,000	550	150	100
Nosler	Ammunition (copper former)	300	N/A	N/A	N/A
PCC Structurals (main)	Titanium casting	49,000	N/A	N/A	N/A
PCC Structurals (east)	Titanium casting	11,500	N/A	N/A	N/A
Pyrotect	Rubber molding/fab	200	N/A	N/A	N/A
Redmond Metal	Metal finisher (chromate)	800	N/A	N/A	N/A
Silver Moon	Beer brewery	4,100	250	200	N/A
Smith Brothers	Metal finisher (black oxide)	900	N/A	N/A	N/A
Wild Ride	Beer brewery	4,400	250	200	N/A
Sum		93,600	1,300	750	100

1.5.2.7 Summary of Historical Data

Flows and Loads used for Planning

Table 1-9 and **Table 1-10** summarize the flow and load projections from Redmond WPCF historical data used in the following section to project the flows and loads during the planning period. Data was used from 2017 for flow, TSS, NH₃-N, and TKN, as this data represents the most current full year of data. However, 2016 data was used to project future BOD₅ loading due to analytical errors and high variability of data in 2017. Average peaking factors from 2014 to 2017 were used to project the maximum month, peak day, and peak hour flows, and average and maximum month loads.

Table 1-9: Historical Flows and Loads for Planning

Parameter	Unit	Year	Average Annual	Maximum Month	Peak Day	Peak Hour
Flow	MGD	2017	1.87	2.0	2.60	5.00
BOD₅	lb/day	2016	7,700	9,900	--	--
	mg/L		500	600	--	--
	PF		--	1.31	--	--
TSS	lb/day	2017	5,000	7,000	--	--
	mg/L		300	400	--	--
	PF		--	1.50	--	--
NH₃	lb/day	2017	600	700	--	--
	mg/L		40	45	--	--
	PF		--	1.20	--	--
TKN	lb/day	2017	1,000	1,200	--	--
	mg/L		65	75	--	--

	PF		--	1.28	--	--
--	----	--	----	------	----	----

Table 1-10: Per Capita Usage for Planning

Parameter	Per Capita Usage
Flow, gal/person/day	65
BOD ₅ , lb/person/day	0.27
TSS, lb/person/day	0.18
NH ₃ , lb/person/day	0.021
TKN, lb/person/day	0.035

1.5.3 Projected Wastewater Flows and Loads

Projected flows and loads for the planning period were calculated based on the following methodology:

- **Average Annual Flow (AAF):** Multiply Per Capita Flow (**Table 1-10**) by Projected Population
- **Maximum Month Flow (MMF):** Multiply Monthly PF (**Table 1-9**) by Projected AAF
- **Average Annual Load (AAL):** Multiply Per Capita Load (**Table 1-10**) by Projected Population
- **Maximum Month Load (MML):** Multiply Monthly PF (**Table 1-9**) by Projected AAL

1.5.3.1 Influent Wastewater Flow Projection

Figure 1-21 presents the projected average annual and maximum month flow rate. AAF is projected to increase from 1.90 to 3.50 MGD, and MMF is projected to increase from 2.0 to 3.8 MGD by the end of the planning period (year 2045).

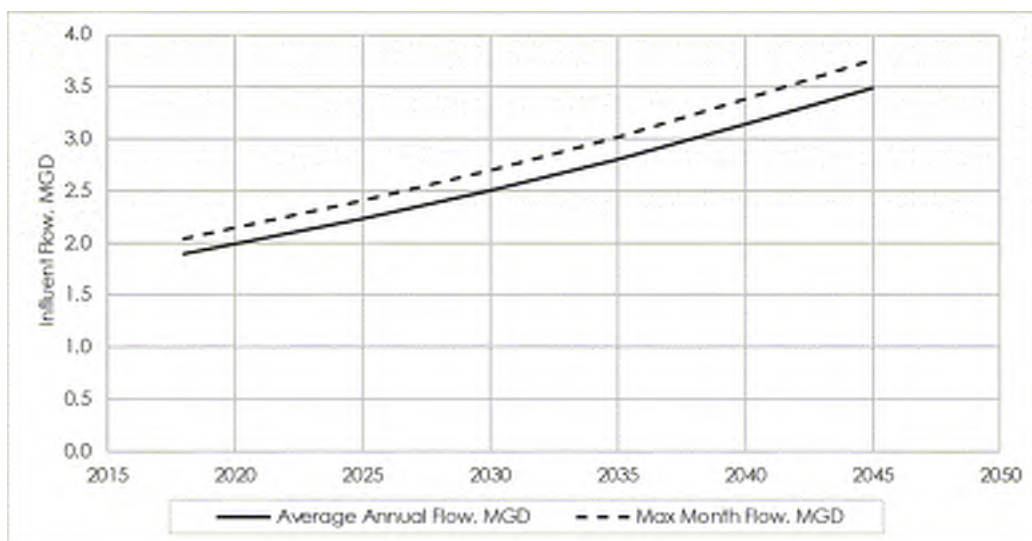


Figure 1-21: Projected Influent Flow

Table 1-11 summarizes annual average and maximum month flow projections for the planning period. These flows will be used in the Capacity Review of each process to determine when maximum capacity will be reached.

Table 1-11: Summary of Flows used for Planning

YEAR	Average Population	Average Annual Flow, MGD	Max Month Flow, MGD
2017	28,800	1.87	2.00
2020	30,700	1.99	2.14
2025	34,400	2.23	2.40
2030	38,600	2.50	2.69
2035	43,200	2.80	3.02
2040	48,400	3.14	3.38
2045	53,800	3.49	3.76

1.5.3.2 Influent BOD₅ Load Projection

BOD₅ load projections were estimated using historical data from 2016 due to the data anomalies in the 2017 as shown in **Figure 1-9** and **Figure 1-10**. **Figure 1-22** presents the average annual and maximum month BOD₅ loading rate projections.

Maximum month projections suggest BOD₅ loading is expected to increase from approximately 10,000 to 19,000 lb/day at the end of the planning period. Average annual projections suggest BOD₅ loading is expected to increase from approximately 8,000 to 14,500 lb/day by 2045.

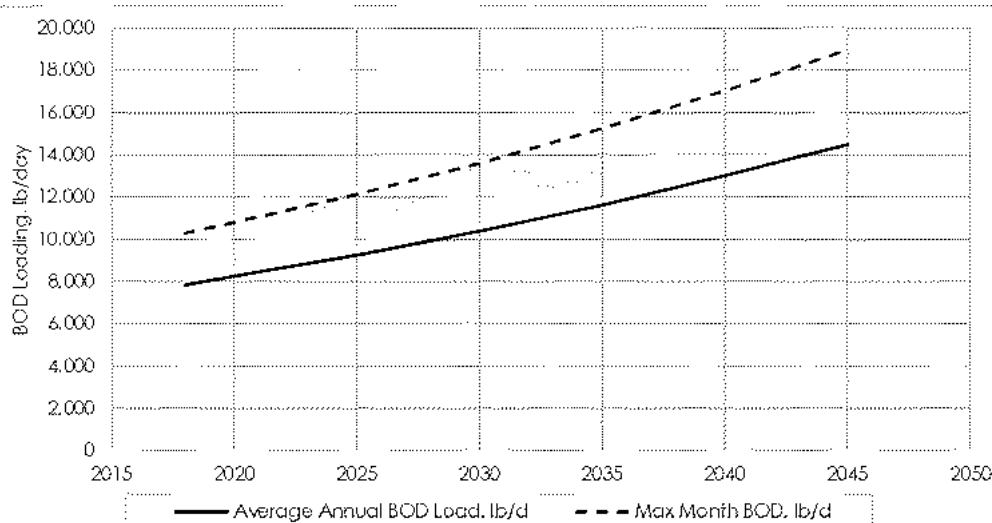


Figure 1-22: Projected BOD₅ Loading

Table 1-12 summarizes annual average and maximum month BOD₅ load projections for the planning period. These loads will be used in the Capacity Review of each process to determine when maximum capacity will be reached.

Table 1-12: Summary of BOD₅ Load used for Planning

YEAR	Average Population	Average Annual BOD ₅ Load, lb/day	Max Month BOD ₅ Load, lb/day
2016	28,800	7,700	9,800
2020	30,700	8,300	10,800
2025	34,400	9,300	12,100
2030	38,600	10,400	13,600
2035	43,200	11,600	15,200
2040	48,400	13,000	17,100
2045	53,800	14,500	19,000

1.5.3.3 Influent Total Suspended Solids Load Projection

Figure 1-23 presents the average annual and maximum month TSS loading rate projections. Maximum month projections suggest TSS loading is expected to increase from approximately 7,000 to 14,400 lb/day at the end of the planning period. Average annual projections suggest TSS loading is expected to increase from approximately 5,000 to and 9,600 lb/day at the end of the planning period.

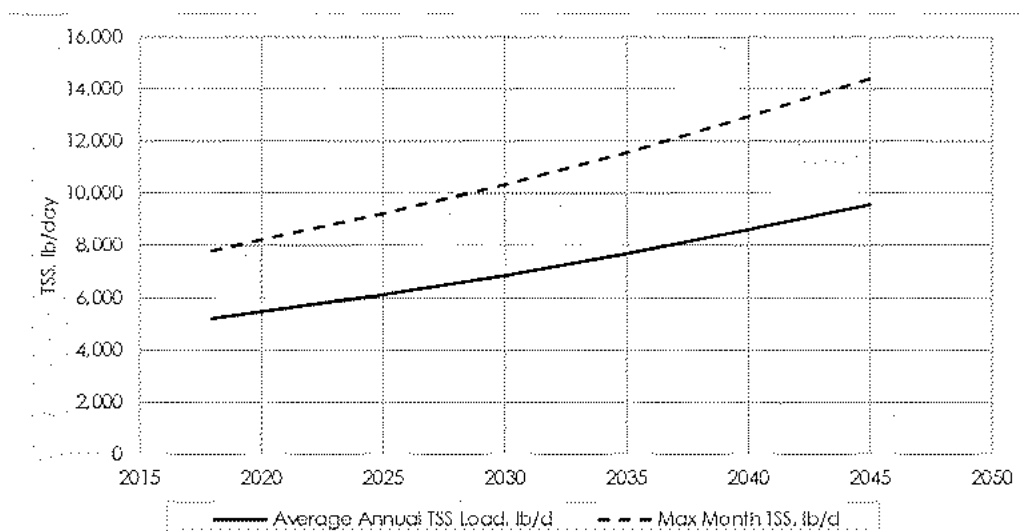


Figure 1-23: Projected TSS Loading

Table 1-13 summarizes annual average and maximum month TSS load projections for the planning period. These loads will be used in the Capacity Review of each process to determine when maximum capacity will be reached.

Table 1-13: Summary of TSS Load used for Planning

YEAR	Average Population	Average Annual TSS Load, lb/day	Max Month TSS Load, lb/day
2017	28,800	5,000	7,000
2020	30,700	5,500	8,200
2025	34,400	6,100	9,200
2030	38,600	6,900	10,300
2035	43,200	7,700	11,600
2040	48,400	8,600	13,000
2045	53,800	9,600	14,400

1.5.3.4 Influent TKN Load Projection

Figure 1-24 presents the average annual and maximum month TKN loading rate projections. Maximum month projections suggest TKN loading is expected to increase from approximately 1,200 to 2,400 lb/day at the end of the planning period. Average annual projections suggest TKN loading is expected to increase from approximately 1,000 to 1,900 lb/day at the end of the planning period.

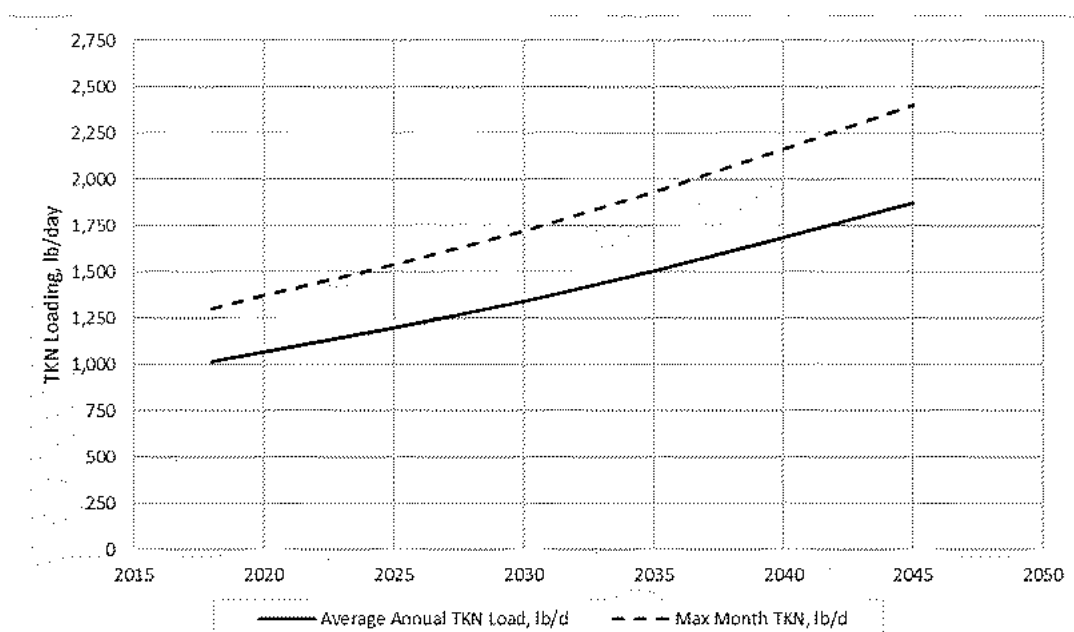


Figure 1-24: Projected TKN Loading

Table 1-14 summarizes annual average and maximum month TKN load projections for the planning period. These loads will be used in the Capacity Review of each process to determine when maximum capacity will be reached.

Table 1-14: Summary of TKN Load used for Planning

YEAR	Average Population	Average Annual TKN Load, lb/day	Max Month TKN Load, lb/day
2017	28,800	1,000	1,200
2020	30,700	1,100	1,400
2025	34,400	1,200	1,500
2030	38,600	1,300	1,700
2035	43,200	1,500	2,000
2040	48,400	1,700	2,200
2045	53,800	1,900	2,400

1.6 SUMMARY

Influent flow and load projections were estimated using per capita flow and load demand and projected population presented in Section 1.2.2. Average projections were selected to determine future capacity of each process unit during the planning period. **Table 1-15** presents the flows and loads used in the following sections.

Table 1-15: Projected Flows and Loads

YEAR	Population	Average Annual Flow, MGD	Max Month BOD ₅ Load, lb/day	Max Month TSS Load, lb/day	Max Month TKN Load, lb/day
2017	28,800	1.90	9,800	7,000	1,200
2020	30,700	2.00	10,800	8,200	1,400
2025	34,400	2.20	12,100	9,200	1,500
2030	38,600	2.50	13,600	10,300	1,700
2035	43,200	2.80	15,200	11,600	2,000
2040	48,400	3.10	17,100	13,000	2,200
2045	53,800	3.50	19,000	14,400	2,400

2.0 EXISTING FACILITIES EVALUATION

2.1 BACKGROUND OF EXISTING SYSTEM

The City of Redmond's wastewater system consists of the collection system, pump stations, WPCF, biosolids drying pad, effluent infiltration basins, and agricultural fields. **Figure 2-1** identifies the collection system, pump station and force main locations, WPCF, effluent conveyance, storage, discharge, and reuse facility locations.

CHAPTER 2 EXISTING FACILITIES EVALUATION

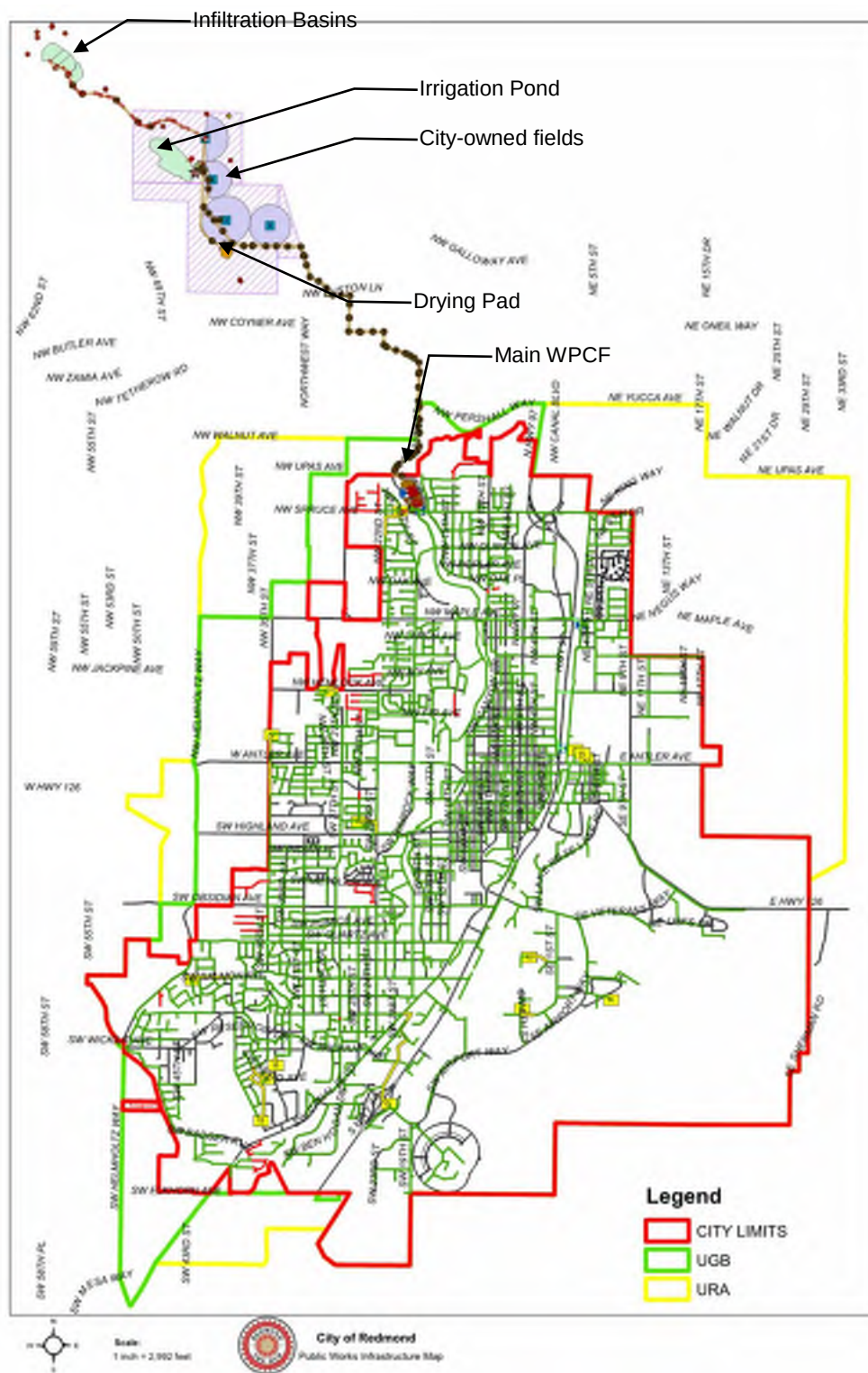


Figure 2-1: Redmond Wastewater System Map

2.2 COLLECTION SYSTEM SUMMARY

The City's collection system includes 150 miles of sewer pipe from 8-inch to 36-inch diameter, and 10 pump stations and force mains. The City provides comprehensive operations and maintenance activities for the collection system, including cleaning and TV inspection, pump station monitoring and maintenance, and minor repair activities. The oldest parts of the collection system are less than 50 years old, and much of the system was installed in the last 20 years.

2.2.1 Overall System Performance

The collection system provides adequate capacity for existing users, and projected future development. The City's last Collection System Master Plan (*Wastewater [Collection System] and Water System Master Plan, CH2M Hill*) was completed in 2007 and evaluated system needs to serve a projected population of 58,000. Capital improvements identified in the Master Plan were associated primarily with sewer extension and interceptor construction required to serve future development.

The City recently completed construction of the Eastside Sewer Interceptor (ESSI) project including over 8,000 linear feet of new interceptor. Construction on portions of the Far East and Far West interceptors is proceeding as needed to serve growth closer to the eastern and western boundaries of the service area.

The City is proactively managing collection system capacity and system-wide inspection, maintenance and rehabilitation practices. The Master Plan did not identify any capacity improvements required to address existing or near-term capacity needs; the majority of capital projects were recommended to provide infrastructure to serve future development within the UGB. The Master Plan also recommended that the City conduct a city-wide flow monitoring program to determine optimum locations for permanent continuous flow monitoring devices. This work was completed in approximately 2014, and confirmed that the system has sufficient capacity for current and anticipated future needs. The City plans to self-fund future collection system improvements therefore a detailed collection system analysis is not included as part of this Facility Plan Update.

2.2.2 Maintenance Practices

Redmond has implemented a proactive maintenance program for the collection system and pump stations, resulting in a well-maintained and functioning system. Routine maintenance includes cleaning and TV inspection of all sewer pipes on a 5-year cycle. Pipelines are assessed using the industry-standard Pipeline Assessment and Certification Program (PACP) with defects, when identified, prioritized for improvements. Based on the inspection results, the City conducts root treatment, spot repairs, or cured-in-place pipe (CIPP) lining to address noted pipe defects. City staff also inspect manholes and assess condition using the Manhole Assessment and Certification Program (MACP) and have begun using Armorock polymer/concrete manholes for some new construction. The City is also replacing cast iron lids and rims with polymer-based materials in manholes that have a higher risk of corrosion from hydrogen sulfide.

CHAPTER 2 EXISTING FACILITIES EVALUATION

The City also has an aggressive fats, oils and grease (FOG) program to prevent FOG accumulation and maintain sewer capacity. City staff maintain an inventory of priority lines that receive semi-annual cleaning and inspection and encourage food service establishments to use the City's Preferred Pumper Program to identify and contract for grease removal.

Pump stations are monitored using remote telemetry, and collection system staff conduct weekly round on all pump stations. Pump ragging used to be a significant issue, with some pumps requiring de-ragging more than once a week. By upgrading pumps, the City has resolved this issue and has not been required to pull a pump for rag removal in more than two years. Three mobile generators provide standby power for pump stations, and all generators are tested monthly to confirm they are in reliable operating condition.

2.2.3 Inflow & Infiltration Assessment

Influent flow and local precipitation data were reviewed to confirm that infiltration and inflow are not excessive based on guidelines developed by EPA (40 CFR 35.2120 and 40 CFR 133.103(3)). These guidelines define non-excessive infiltration and inflow as follows:

- Infiltration: Domestic wastewater plus non-excessive infiltration ≤ 120 gpcd
- Inflow: Total daily flow during wet weather event ≤ 275 gpcd

Historical flow and population data presented in Section 1 were used to evaluate Redmond's flow relative to the EPA criteria.

Infiltration is a measure of water that is not associated with a specific event (commonly due to high groundwater) entering the sewer system through broken pipes, defective pipe joints, or illicit connections of foundation drains. Infiltration is estimated based on data from periods of seasonally high groundwater (December through May) with little or no rainfall.

Inflow and infiltration were evaluated using total daily flow measured at the Redmond WPCF over a 10-year period from April 2008 through April 2018, as well as daily rainfall totals measured at the Redmond Airport. Daily influent flow data was used as the basis of the I/I analysis because hourly flow data at the WCPF were not available, therefore nighttime low flow could not be determined. The highest measured daily flow rate occurred on March of 2009 as was recorded as 2.60 MGD. Rainfall records show little or no rainfall occurring during the preceding week (five days show no recorded rainfall, with two days of 0.07 inches of recorded rainfall). Based on the 2009 population of 25,135, the resulting flow rate is 103 gpcd. This rate is lower than the EPA criteria of 120 gpcd, indicating the City's infiltration rate is not excessive, even during peak flow. Redmond's average influent flow does not vary seasonally, and average wet season infiltration is low (as shown in **Table 2-1**), suggesting that runoff from agricultural irrigation does not contribute to infiltration in the collection system. The fact that the average infiltration measured during the wet season is much lower than this single event suggests that an unusual circumstance such as a large industrial discharge may have contributed to the high value.

Inflow measures runoff from rainfall events that enter the system through manhole covers, cleanouts, cross-connections between storm and sanitary sewers, or illicit connections such as roof or area drains. The highest rainfall observed during the 10-year period of analysis occurred during the week ending January 24, 2012. Flows of 1.70 MGD were generated after receiving rainfall of 1.16 inches in one day (and 1.41 inches of total rainfall including the

preceding 6 days). Based on the 2012 population of 27,148, the resulting system flow is 63 gpcd and inflow is non-excessive. The results of the inflow and infiltration analysis are summarized in **Table 2-2**.

Table 2-1: Summary of Historical Infiltration

Year	Average Influent Flow During High Groundwater Season (MGD)	Estimated Population	Average Influent Rate (gpcd)
2008	1.9	23,824	80
2009	1.7	25,135	70
2010	1.5	26,508	59
2011	1.5	26,826	58
2012	1.5	27,148	56
2013	1.6	27,474	59
2014	1.7	27,803	62
2015	1.7	28,137	62
2016	1.8	28,816	64
2017	1.9	28,816	65
2018	1.8	29,364	62

Table 2-2: Summary of Inflow and Infiltration

Parameter	EPA Established Criteria	City of Redmond Value
Infiltration	Domestic wastewater plus non-excessive infiltration ≤ 120 gpcd	103 gpcd
Inflow	Total daily flow during wet weather event ≤ 275 gpcd	63 gpcd

2.3 WASTEWATER TREATMENT SYSTEM: RELIABILITY

This section provides a review of the existing facilities and unit processes at the Redmond WPCF to identify and present rankings of those processes based on their overall reliability. Each unit process was evaluated for reliability and redundancy by the use of qualitative criteria, operational history, professional judgement, site visits, and staff interviews. All major plant processes have been evaluated, including headworks, Orbal® units, clarifiers, disinfection, effluent, dewatering and biosolids handling. This section will help establish the overall condition and performance of each unit process for use in determining future plant upgrades and for development of the capital improvement plan (CIP).

Figure 2-2 depicts the existing overall process flow diagram for the Redmond WPCF. Liquid streams are in black and sludge and/or solids streams are depicted in red. The figure shows City-owned facilities; a limited number of private fields are also available for Class B biosolids land application.

Figure 2-2: Existing Redmond WPCF Process Flow Diagram

Four general categories of reliability criteria were established, each with a 'good', 'acceptable' or 'poor' weighting system. Each unit process at the Redmond WPCF was evaluated against these criteria. The four criteria include:

1. The process functions as intended (for example, the screens capture rags/material, or the disinfection process meets total coliform effluent standard)
2. Equipment downtime for cleaning, maintenance, and problems associated with mechanical or electrical equipment failure
3. Can the process operate at nameplate flow and load conditions using established operational criteria (max month, peak week, etc.)?
4. Other factors affecting equipment such as age, general condition, available parts, etc.

Criteria is rated as 'good', 'acceptable' or 'poor' and numerically scored as 3, 2, and 1 for good, acceptable, and poor, respectively. The highest overall scores represent the most reliable unit processes while the lowest scores represent the least reliable processes. Definitions of the criteria are as follows:

CHAPTER 2 EXISTING FACILITIES EVALUATION

1. Good – Score of 3
 - a. The process works properly
 - b. The process has minimal downtime
 - c. The process can meet established flow/load criteria with the requisite redundancy
 - d. The process or equipment is generally in good condition, within its operable lifespan, and can be maintained easily with available parts
2. Acceptable – Score of 2
 - a. The process works but may experience periodic upsets or manageable capacity limitations
 - b. The process has some downtime, but operators have methods for mitigation
 - c. The process is nearing established nameplate flow/load conditions
 - d. The process or equipment is nearing its operable lifespan and parts and maintenance are becoming more difficult to obtain
3. Poor – Score of 1
 - a. The process is overloaded
 - b. The process downtime is high
 - c. The process is up against established flow/load conditions and frequently uses redundant equipment. Or, in some cases, operators have been forced to utilize other, more costly methods for liquids or solids handling
 - d. The process or equipment is generally in poor condition, at or past its service lifespan, difficult to maintain and operators have difficulty obtaining replacement parts

2.3.1 Headworks

The headworks has two 3 mm rotary drum screens and equal number of screenings conveyors which operate well with little to no downtime. Each screen and conveyor can accommodate peak flow conditions with one screen out of service (not including the manual bypass). The electrical and mechanical infrastructure of the headworks are in good condition and were installed as part of the most recent plant upgrades in 2010. A 1-inch manual bar screen was removed in 2016 due to excessive maintenance and cleaning. There have been no major issues with the downstream rotary drum screens as a result of the bar screen removal. The headworks facility does not have the ability to measure flow to each Orbal. The headworks reliability score is shown in **Table 2-3**.

Table 2-3: Headworks Reliability Score

Criteria	Score
A - Process Function	3
B - Equipment Maintenance/Downtime	3
C - Nameplate Flow/Load Criteria Met	3
D - Age, Condition and Spare Parts	3
Average	3.0

2.3.2 Orbal®

Two Orbal® reactors were constructed in Y2000 for nitrogen removal to meet permit requirements of 9 mg/L total nitrogen and 6 mg/L total nitrate and nitrite ($\text{NO}_3^- + \text{NO}_2^-$). Treated wastewater from the two Orbal® units flows into secondary clarifiers, where solids settle and are returned to the Orbal® as return activated sludge (RAS). Each Orbal® unit has six aerators and a mixed liquor recycle pump. Inline flow meters were installed in 2017 to monitor mixed liquor flow.

Stantec conducted a process modeling study in 2017 (2017 Redmond WPCF Modeling Project Summary Report) that estimated the capacity of the biological treatment for existing flows and loads. Loading observed at the time of the study indicated the Orbal® reactors were reliable with respect to reducing nitrogen and BOD_5 concentrations below the WPCF's discharge permit requirements. The study suggested that the Orbal® could be approaching design capacity with potential limitations on bioreactor volume.

The Orbal® reactors were designed to treat maximum month flow of 3.15 MGD and influent concentrations of 436 mg/L BOD_5 , 371 mg/L TSS, 32 mg/L $\text{NH}_3\text{-N}$, and 50 mg/L TKN. Nameplate flow capacity for the Orbal® reactors is currently being met. However, the organic loading to the WPCF has increased substantially as discussed in Section 1.5.1.1 resulting in constraints in taking Orbal® units offline for maintenance. Influent loading rates for TSS and $\text{NH}_3\text{-N}$ are still below the nameplate design load. However, BOD_5 and TKN loading rates are approaching their respective nameplate capacities. Despite the load increase the Orbal® reactors can meet discharge permit limitations. The overall Orbal® reliability score is shown in **Table 2-4**.

Table 2-4: Orbal® Reliability Score

Criteria	Score
A - Process Function	3
B - Equipment Maintenance/Downtime	3
C - Nameplate Flow/Load Criteria Met	2
D - Age, Condition and Spare Parts	3
Average	2.8

2.3.3 Clarifiers

The plant has four circular clarifiers including three identical units which were built in 1978, 1994 and 2000 respectively and a larger fourth unit installed in 2010. Solids from the Orbal® units settle in the clarifiers and are recycled back to the Orbal® units as return activated sludge (RAS). A small portion of the settled sludge is wasted daily as waste activated sludge (WAS).

Immediately upstream of the clarifiers is a 4-way flow splitting junction box which directs wastewater from the two Orbal® units to the clarifiers. Plant operators report the junction box does not distribute flow equally and flow into the clarifiers is not measured, causing over and under loading to the secondary clarifiers and reducing the overall reliability of the clarifiers. The lack of a balance flow split is confirmed by the historical sludge blanket measurements and were discussed in the 2017 Redmond WPCF Modeling Project Summary Report.

The four clarifiers operate well with downtime only required for cleaning. The units meet the operability requirements for flow and loading conditions with the largest unit out of service and the clarifiers are in good condition physically. The fourth and largest unit was built in 2010 and the oldest unit, built in 1978 was recently retrofitted as part of the 2010 plant upgrade.

The three RAS pumps for Clarifiers 1-3 are located in a dedicated below ground RAS pump station, and can reliably meet sludge recycle requirements up to 900 gpm each, however the manifold system is configured such that RAS is not distributed equally during nighttime low flows. The electrical systems are also dated and it is recommended that they be further evaluated and replaced. Clarifier 4 has two RAS submersible pumps, each with 590 gpm rating. Problems with discharge check valve operation have resulted in the need to run both pumps to achieve the target RAS flow rate, however this condition is being addressed with planned replacement of the check valves. The clarifier reliability score is shown in **Table 2-5**.

Table 2-5: Clarifier Reliability Score

Criteria	Score
A - Process Function	3
B - Equipment Maintenance/Downtime	2
C - Nameplate Flow/Load Criteria Met	3
D - Age, Condition and Spare Parts	2
Average	2.5

2.3.4 Disinfection

The chlorine disinfection basin was constructed in 1978 and is split into two channels with baffles, which were recently raised to increase capacity and the chlorine contact time. Disinfection of secondary effluent is accomplished by dosing liquid sodium hypochlorite upstream of two parallel under/up flow chlorine contact basins. The facility is not required to dechlorinate.

Per WPCF operator testimony, the disinfection process has experienced little downtime however it has become problematic during peak flow conditions (potentially over-dosing sodium hypochlorite) and needs to be replaced. Sodium hypochlorite pumps and tanks generally work well, and the disinfection basins are in good condition.

The chlorine measurement and dosing system are not operating properly. The filters in the analyzer become clogged daily, which prevents a representative sample from being analyzed, thus affecting the feed-back loop-controlled sodium hypochlorite dosing pumps resulting in slight overdosing (or under-dosing) of sodium hypochlorite. The reliability score of the disinfection process is shown in **Table 2-6**.

Table 2-6: Disinfection Process Reliability Score

Criteria	Score
A - Process Function	2
B - Equipment Maintenance/Downtime	2
C - Nameplate Flow/Load Criteria Met	2
D - Age, Condition and Spare Parts	2
Average	2.0

The current disinfection strategy has disadvantages including the increasing cost of sodium hypochlorite, and future concerns regarding chloride concentrations in the effluent. Redmond wishes to be proactive and replace the current disinfection system with a new technology applicable for the long-term.

2.3.5 Effluent Pipelines

Effluent leaving the chlorine contact basins enters a junction box which can split flow into two, roughly parallel 24-inch, 3-mile-long pipes, which transport disinfected effluent to a second junction box near the irrigation pond. The original effluent pipe was installed in 1978 and is currently used. A second, unused pipe was constructed as part of the major plant upgrades in 2010. At the second junction box, flow can be manually delivered to the adjacent irrigation pond or to the infiltration basins via a single 24-inch, 1.25 mile-long pipe to the infiltration basins. There is a weir downstream of the second junction box on the infiltration basin line to allow for flow measurement if desired.

WPCF operators reported that the effluent pipelines are working as designed with minimal downtime and can easily meet peak flow conditions with one of the pipelines out of service. Due to the age of the older pipe, an inspection or assessment with closed-circuit television (CCTV) or other means is recommended to ensure that pipe is indeed reliable and has no detrimental features. Overall the effluent pipelines and associated structures are very reliable as shown in

Table 2-7: Effluent Pipeline Reliability

Criteria	Score
A - Process Function	3
B - Equipment Maintenance/Downtime	3
C - Nameplate Flow/Load Criteria Met	3
D - Age, Condition and Spare Parts	3
Average	3.0

2.3.6 Infiltration Basins

There are four infiltration basins located about 4.9 miles from the WPCF, which allow for effluent infiltration. Basins 1 through 4 are 7.41, 4.15, 5.35 and 4.81 acres, respectively. Flow into each basin is controlled via onsite manual valves. The WPCF permit allows the basins to be filled up to 24 inches at a “moderate” rate, which is not quantitatively defined. The infiltration basins are typically used between October and May, or when the irrigation pond requires maintenance. During the summer, effluent is used for irrigation of the nearby, City-owned hay fields. Groundwater elevation and samples are collected from several monitoring wells near the infiltration basins. The fourth basin was installed in 2010.

Of the four infiltration basins, only two (1 & 2) meet the “moderate” infiltration rates of approximately 0.16 MGD/acre as required by the WPCF permit and are used exclusively. The other two basins (3 & 4) have a much faster rate of infiltration (exceeding 0.65 MGD/acre) and plant operators report that they have not been able to fill the basins at past or current effluent flow rates. Given the “moderate” infiltration permit stipulation, operators have been hesitant to utilize basins 3 and 4. In this case, it may be necessary to ‘slow’ the infiltration rate of these basins to meet a “moderate” infiltration rate.

The infiltration basins are generally in good condition, with little downtime and can operate well within the maximum month flow conditions. WPCF operators do complain about mosquito infestations in the basins and would like to explore vector control strategies. A summary of the reliability is shown in **Table 2-8**.

Table 2-8: Infiltration Basin Reliability Summary

Criteria	Score
A - Process Function	2
B - Equipment Maintenance/Downtime	3
C - Nameplate Flow/Load Criteria Met	3
D - Age, Condition and Spare Parts	3
Average	2.8

2.3.7 Irrigation Pond/Irrigation Pump Station

The irrigation pond is 32 acres with a capacity of 271 acre-feet (88.3 MG). The pond is used for about 4 months in the summer to supply water for irrigation pumps that irrigate 146 acres of City-owned farmland. The pond is located 3 miles away from the treatment plant. Disinfected effluent is transported to the pond via two 24-inch effluent pipes to a junction box about 100 yards from the irrigation pond. At the junction box, the operations staff can manually route effluent towards the irrigation pond or infiltration basins. Effluent is directed to the irrigation pond only as needed to supply water for the irrigation pump station. Staff typically begin sending effluent to the irrigation pond in March or April and cease sending effluent to the irrigation pond in October. Four irrigation pumps located inside the pump house at the edge of the pond provide water to the adjacent farm fields. The pond and irrigation pump house were constructed in 1978.

The pond generally works as designed. Instances have occurred where pump intakes become clogged with fish improperly introduced by humans (carp and goldfish); the pond is not hydraulically connected to a natural waterbody that would be a source of aquatic species, so this is an unusual occurrence and not encountered in normal operation. There is little process downtime when the pond is in use (mostly summers) and the overall process meets all flow conditions. No known leak testing or inspection of the pond liner has been conducted, although there are no known issues and Shotcrete liner repairs are performed as needed. The pump electrical infrastructure, particularly the breakers, need replacement due to age. The irrigation pumps are entirely manual, and operators are required to drive to the site, several miles from the facility to operate the irrigation pumps. A reliability summary is shown in **Table 2-9**.

Table 2-9: Irrigation Pond Reliability Summary

Criteria	Score
A – Process Function	3
B – Equipment Maintenance/Downtime	3
C – Nameplate Flow/Load Criteria Met	3
D – Age, Condition and Spare Parts	1
Average	2.5

2.3.8 WAS Storage

The two WAS storage basins were installed in 1978 and store waste activated sludge (WAS) from the four clarifiers prior to dewatering with the belt filter press (BFP). The two basins each have a capacity of 135,000 gallons. The BFP currently operates mostly during normal operating hours and the WAS storage basin allows sludge storage for overnight WAS flow and any periods where the BFP may be offline for maintenance. The WAS storage basins are aerated to mix the WAS and minimize odors via one K-Turbo blower installed in 2010 as part of plant upgrades. Although the intention of the basins is not to act as a reactor, there is likely some reduction of volatile solids or biological oxygen demand as well as a slight odor from the process. The WAS from the clarifiers is typically about 0.5% solids however a “decanting” process can be performed to increase the solids to about 1.5%, allowing for additional solids storage capacity in the case of longer-term BFP maintenance. This is done by turning off the aerator/mixers and allowing the solids to settle in the basins. A telescoping pipe can then be extended into the supernatant liquid and pumped to the headworks. This procedure can be repeated multiple times.

The WAS storage basins work as designed and have little downtime. Operators report difficulties in emptying the basins for temporary maintenance. Overall, the WAS storage basins are generally in good condition and reliable.

The blower provides sufficient air to the basins and is redundant with two older positive displacement blowers. A summary of the WAS Storage process reliability is shown in **Table 2-10**.

Table 2-10: WAS Storage Reliability Summary

Criteria	Score
A – Process Function	3
B – Equipment Maintenance/Downtime	3
C – Nameplate Flow/Load Criteria Met	3
D – Age, Condition and Spare Parts	3
Average	3.0

2.3.9 Solids Stabilization and Dewatering

Redmond produces Class A and Class B biosolids (depending on time of year) with the use of a single belt filter press (BFP) and lime stabilization mixer. The WAS from the storage basins is dosed with polymer just prior to the BFP, where it is then dewatered to about 12-14% total solids. Lime is added to the dewatered cake to meet the pathogen reduction requirements for Class A or Class B biosolids. Limed biosolids are then fed via conveyor to a 10-cubic yard dump truck and taken to the drying pad for further drying. The BFP and polymer injection system are located in the same building. Lime is stored just outside the building and carried by screw feeder into the mixer where it is combined with the BFP-dried cake. The drying pad is located a few miles from the main treatment plant.

Solids and liquids loading to the BFP is exceeding the nameplate rated capacity and runtime of the unit has regularly been extended into the weekend and during holidays. The average dewatered cake is about 11.5% total solids, which is below the expected performance of the BFP. Typical BFP performance ranges are 12 to 20 percent total solids (Metcalf & Eddy 2003). The low cake solids concentrations result in extended periods of drying and additional truck trips/traffic. The BFP was installed in 2000 and spare parts are now becoming difficult to source. As a result, the belt filter press is not operating within optimal conditions and has become overloaded to a point where maintenance and overall reliability is a concern. Without a redundant dewatering unit, any equipment maintenance or downtime requires adequate solids storage, discussed in Section 0.

Just after dewatering, lime is mixed by use of pug mill into the dewatered cake. WPCF operators report the lime stabilization hopper and mixer are not particularly reliable and lime is often not mixed well into the biosolids. In some cases, operators have had to manually spread lime once it has been delivered to the drying bed due to nuisance odors. Operators have reported that pulverized quicklime is single supplier sourced resulting in higher bulk lime fees. Additionally, the lime supplier haul route can be unreliable, and the facility may have periods without available lime. The lime hopper and mixer experiences relatively little downtime and can meet peak solids loading. It is an aging system in generally good condition. A summary of the dewatering reliability is shown in **Table 2-11**.

Table 2-11: Dewatering Process Reliability Summary

Criteria	Score
A – Process Function	2
B – Equipment Maintenance/Downtime	2
C – Nameplate Flow/Load Criteria Met	1
D – Age, Condition and Spare Parts	1
Average	1.5

2.3.10 Biosolids Drying

Dewatered cake from the belt filter press and lime stabilization is transported by 10-cubic yard dump truck to the 4-acre asphalt drying pad located three miles from the plant. A storage building next to the drying pad stores dried biosolids before they are ideally land applied or sent to the local landfill if necessary.

During the summer months (late May to September) environmental conditions allow the biosolids to dry sufficiently to meet regulator requirements for Class A treatment and be distributed to the public. During the rest of the year (October to early May), it is much more difficult to dry the dewatered cake. As a result, the plant is only able to produce a Class B biosolids, which is much less desirable due to its odors and its limited disposal opportunities.

The biosolids drying pad works well in the summer under high solar intensity and minimal precipitation, therefore the capacity of the asphalt pad is sufficient for that part of the year. During the winter, and typically during below freezing temperatures, snow and/or rain, the biosolids cannot be sufficiently dried or land applied. Long durations, up to two months have been reported where the capacity of the drying pad has been exceeded.

Stormwater runoff from the asphalt pad is required to be collected and managed. Currently, all stormwater is collected in ponds and basins adjacent to the drying pad. Stormwater runoff, generally high in solids concentration, is removed by tanker truck and discharged back to the plant headworks.

The overall function of the drying pad and storage building depends on the time of year and weather conditions. The physical condition of the asphalt pad and the Class A biosolids storage structure is in generally good condition. A summary of the biosolids drying process is shown in **Table 2-12**.

Table 2-12: Reliability Summary for Biosolids Drying Process

Criteria	Score
A - Process Function	1
B – Equipment Maintenance/Downtime	2
C – Nameplate Flow/Load Criteria Met	1
D – Age, Condition and Spare Parts	2
Average	1.5

2.3.11 Land Application

The dried biosolids which meet either Class A or Class B rating are applied to city-owned property and local private land owners. Class A biosolids can usually be easily given away to private parties and disposal is not an issue. Class B biosolids are less desirable due to their higher pathogen concentrations and odors.

Currently, city-owned fields are overloaded with Class B biosolids which has resulted in hay production with a high concentration of nitrate which is of low (if any) commercial value. In addition, private land owners have been moving away from, or not allowing, Class B product to spread on their field due to odor concerns by their neighbors. As a result, disposal of Class B product is becoming a concern for the WPCF. A reliability summary for this process is shown in **Table 2-13**.

Table 2-13: Reliability Summary for Biosolids Land Application

Criteria	Score
A – Process Function	2
B – Equipment Maintenance/Downtime	2
C – Nameplate Flow/Load Criteria Met	1
D – Age, Condition and Spare Parts	1
Average	1.5

2.3.12 Standby Generator

The emergency standby generator was installed in 2000 and is rated for 600 kW capacity. It is in good working order. Operators report that power outages to the WPCF are intermittent, and the generator system was not used during an emergency event. Facility operators are currently unaware of which equipment would operate during a power failure, but the WPCF currently requires about 800 kW of electrical load during “normal” operation, which does not include dewatering activities. A summary is shown in **Table 2-14**.

Table 2-14: Standby Generator Reliability Summary

Criteria	Score
A – Process Function	3
B – Equipment Maintenance/Downtime	3
C – Nameplate Flow/Load Criteria Met	2
D – Age, Condition and Spare Parts	2
Average	2.5

2.3.13 Summary

The majority of the processes at the Redmond WPCF are relatively reliable, work as designed, have little downtime, can meet the operational requirements at design flows and loads and are within their useful service life.

The overall process reliability is shown in **Table 2-15** below with the four stages of reliability criteria and a total value, indicating the most and least reliable processes within the WPCF. The liquid processes of the plant are generally very reliable. The solids processes have critical reliability issues which will be further addressed in this facilities plan.

Table 2-15: Process Reliability Summary, ranked in order of least to most reliable

Process	Reliability Criteria				Average Reliability
	Process Function	Equipment Maintenance/ Downtime	Nameplate Flow/ Load Criteria Met	Age, Condition and Spare Parts	
Dewatering	2	2	1	1	 1.5
Land Application	2	2	1	1	 1.5
Biosolids Drying	1	2	1	2	 1.5
Disinfection	2	2	2	2	 2.0
Clarifiers	3	2	3	2	 2.5
Irrigation Pond	3	3	3	1	 2.5
Standby Generator	3	3	2	2	 2.5
Infiltration Basins	2	3	3	3	 2.8
Orbal	3	3	2	3	 2.8
Headworks	3	3	3	3	 3.0
Effluent Pipes	3	3	3	3	 3.0
WAS Storage	3	3	3	3	 3.0

2.4 WASTEWATER TREATMENT SYSTEM: CAPACITY

This section outlines the capacity of each unit process at the Redmond WPCF and provides a projected timeline through 2045 to predict when each process is expected to reach its individual capacity. This evaluation will also help the WPCF identify any process “bottlenecks” or hydraulic control points which may be affected as the flows and loads to the plant are expected to increase.

The term “capacity” differs for each unit process and depends on the individual process. Capacity could include hydraulic or other parameters. While some processes are governed by hydraulics (i.e. headworks screens and pump stations), other unit processes are governed by other parameters (i.e. organic loading, solids loading, or other process specific parameters). The approach for capacity review of major processes is described in the following section.

2.4.1 Capacity Criteria

Criteria have been developed to evaluate the capacity of each unit process capacity. Some processes require more than one criterion for analysis. **Table 2-16** shows the breakdown of major capacity criteria.

Table 2-16: Hydraulic and Process Capacities

Capacity Criteria	Critical Parameters
Hydraulic Capacity	Average Annual Flow (MGD)
	Peak Hour Flow (MGD)
Organic Loading Capacity	Biochemical Oxygen Demand (BOD ₅ , lb/day)
	Total Kjeldahl Nitrogen (TKN, lb/day)
Solids Loading Capacity	Dry Solids (lb/day)

Hydraulic capacity is based on peak hour (PF) flows. Peak hour flow conditions assume that the process is operating at full capacity with all units in service. Average annual flow (AAF) conditions are also considered and, in this case, “normal” operation with one redundant unit offline is assumed. The hydraulic capacity for each unit process was based on record drawings, name plate ratings, and staff interviews. Hydraulic modeling was not included as part of the planning effort. Therefore, if hydraulic limitations are identified by this analysis, Stantec would recommend a more detailed approach with development and calibration of a hydraulic model. The hydraulic capacity is considered across WPCF unit processes but have particular importance for headworks, clarification, and disinfection processes.

Organic loading capacity is specifically used for the Orbal® and clarifiers where the capacity of BOD₅ and TKN maximum month organic loading determine the overall treatment capacity of those processes. The organic loading capacity evaluation built upon the results of the 2017 Redmond WPCF Modeling Project Summary Report.

Solids loading capacity determines the maximum “dry solids” capacity for each applicable process based on nameplate rating, size and other loading conditions. This criterion is used for solids handling processes.

Finally, each process will be identified as either “meeting capacity”, “nearing capacity” or “at/exceeding capacity.” **Table 2-17** shows the overall capacity criteria for each process.

Table 2-17: Capacity Criteria for Annual Average and Peak Hour Flow Conditions

Capacity Criteria	Condition
Meets Capacity (green)	Based on planning assumptions. It is anticipated that the process can meet capacity for more than 5 years
Nearing Capacity (yellow)	Based on planning assumptions. It is anticipated that the process has less than 5 years of capacity left
At/Over Capacity (orange)	Based on planning assumptions. It is anticipated that the process is at or over capacity

2.4.2 Hydraulic and Organic Loading Capacities

The hydraulic and organic loading capacities of each process have been evaluated to estimate when limiting conditions will be reached. Hydraulic and organic loading process capacities are shown in **Table 2-18**. Cells in green meet capacity. Yellow cells are nearing or at capacity and orange cells are over capacity.

Table 2-18: Summary of Hydraulic and Organic Loading Capacity of Each Unit Process

Process	Redundancy	Process Capacity ⁴	Capacity Type		Current & future projected loading to each process						
					Current	2020	2025	2030	2035	2040	2045
Headworks	2+0	12.0	MGD	Peak Hour	5.0	5.3	6.0	6.7	7.5	8.4	9.3
Orbal®	2+0	11,500	lb/day	Max Month BOD ₅	9,800	10,800	12,100	13,600	15,200	17,100	19,000
	2+0	1,300 ⁵	lb/day	Max Month TKN	1,200	1,400	1,500	1,700	1,900	2,200	2,400
Clarifiers	4+0	9.3	MGD	Peak Hour	5.0	5.3	6.0	6.7	7.5	8.4	9.3
	3+1	400	gpd/ft ²	Annual Average	165	176	197	221	248	278	309
	4+0	1,000		Peak Hour	442	471	528	592	663	743	826
Disinfection	2+0	12.0 ²	minutes	Peak Hour	16	15	13	12	10	9	8
Effluent (Outfall)	1+1	12.0	MGD	Annual Average	1.7	1.8	2.1	2.3	2.6	2.9	3.2
	2+0	24.0		Peak Hour	4.7	5.0	5.7	6.3	7.1	8.0	8.8
Infiltration Basins	2+2	1.9	MGD	Annual Average ¹	1.7	1.8	2.1	2.3	2.6	2.9	3.2
	4+0 ³	8.5 ³		Peak Hour	4.7	5.0	5.7	6.3	7.1	8.0	8.8
¹Basins 1&2 only											
²Ten State Standards recommends 15 minutes contact time for disinfection											
³Design capacity. These were not derived from modeling or infiltration field tests											
⁴Design, calculated or nameplate process capacity, in various units											
⁵ Reference the <i>Redmond WPCF Modeling Project Summary Report</i> prepared by Stantec (2017) for future aeration system capacity recommendations											

2.4.3 Headworks

The headworks are expected to meet the hydraulic capacity of the plant through 2045 for both average annual and peak hour flows. The rotary drum screens and screenings conveyors have a capacity of 6.0 MGD each and were installed as part of the upgrades in 2010. The screens and conveyors can operate at 1+1 redundancy, which allows for routine maintenance.

2.4.4 Secondary Treatment

The capacity of biological treatment system was evaluated in the 2017 Redmond WPCF Modeling Project Summary Report. The treatment capacity combines the bioreactor capacity, the aeration system capacity, and the secondary clarifier capacity. The study concluded that the capacity is limited by the bioreactor capacity and was estimated to be in the 2.1 to 2.4 MGD range. The Orbal® units have a combined maximum month capacity of 3.15 MGD and the clarifiers have a combined peak hour capacity of 9.27 MGD. A full description of biological capacity review is presented in the full report. During the study a discrepancy was observed in the MLSS concentration modeled under certain conditions and the MLSS reported in the field under the same conditions. The City performed field testing and confirmed stratification within the Orbal® Channels particularly in the outer channel. MLSS concentration increases from approximately 2,000 mg/L at a depth of about 2.0 feet up to approximately 3,000 mg/L at the bottom of the bioreactor. This observation and the fact that under these high load conditions the sludge blanket in the clarifiers increases substantially enforces the modeling results that predict a high MLSS concentration in the Bioreactor at flows of approximately 2.0 MGD. For planning a BOD₅ loading capacity of approximately 11,500 lbs/day will be assumed based on the original design criteria.

2.4.5 Disinfection

Per the record drawings from 2010, the disinfection basins are designed to provide at minimum 12 minutes of hydraulic retention time (HRT) for chlorine contact at a projected peak hour flow rate of 6.30 MGD. It is estimated that this retention time will be exceeded during peak flow conditions before 2030. For annual average flows, the HRT is expected to remain well above the minimum requirements through 2045. As a result, chlorine dosing will need to increase proportionally to the annual average and peak hour flow rates to ensure the effluent does not exceed the coliform limits described in the WPCF permit.

Redmond is already considering an update to their disinfection system and alternatives to sodium hypochlorite dosing to improve disinfection and minimize downstream chloride concentration.

2.4.6 Effluent Pipelines

The twin 24-inch diameter pipelines to the irrigation pond and infiltration basins are sufficient to meet the plant effluent flow needs through 2045. Each pipe is estimated to have a capacity of approximately 12 MGD with a total expected capacity of 24 MGD. However, to ensure the effluent pipelines continue to meet their capacity, an inspection of the older pipeline with a pipeline inspection device and closed-circuit television (CCTV) is recommended to ensure there are no obstructions or inflow/infiltration which may limit the process capacity.

2.4.7 Infiltration Basins

The four infiltration basins deliver WPCF effluent to groundwater during the winter months when effluent is not being used for irrigation. The basins are currently operated at 2+2 redundancy for annual average flows which can be increased to 4+0 during peak hour events.

Currently, basins 1 & 2 are primarily used and have combined estimated infiltration rates of about 1.9 MGD. This rate is expected to provide “moderate” infiltration through 2025 when the annual average flow of 1.9 MGD is expected to be exceeded. Basins 3 & 4 are reported to have infiltration rates that exceed the current flow rates, however their capacity has not been measured. As a result, it is very likely that all four infiltration basins can meet the average annual flow rates through 2045. Additional evaluation of peak flow infiltration rates in basins 3 & 4 is recommended, either during a major storm in the near future, or as flow rates increase to ensure they meet peak flow capacity requirements through 2045.

2.4.8 Solids Processes

Solids processes are shown in **Table 2-19** for the WAS storage, dewatering and biosolids drying. The table shows the capacity, current and projected future solids loading to each unit process. The green cells represent the years in which the process meets its capacity. The yellow cells represent the years when the process is expected to near capacity and the orange cells represent processes that are at or over capacity, as explained in **Table 2-18** above.

Table 2-19: Summary of Solids Unit Process Capacities

Process	Redundancy	Process Capacity		Condition	Current & future projected loading to each process						
					Current	2020	2025	2030	2035	2040	2045
WAS Storage ¹	2+0	11,300	lb/day	MM as dry solids	10,700	11,700	13,100	14,700	16,500	18,500	20,500
	2+0	0.27	MG (WAS)	MM as WAS	0.25	0.28	0.31	0.35	0.39	0.44	0.49
Dewatering	1+0	4,000	lb/day	MM as dry solids	10,500	11,600	13,000	14,600	16,300	18,300	20,300
		67.0 ²	Gpm (WAS)	MM as WAS	98	193	216	242	271	304	338
Drying Pad	1+0	Class A Biosolids		Summer	Typically meets Class A						
				Winter	Does not meet Class A						
		Class B Biosolids		Summer	Meets or exceeds Class B						
				Winter	Inconsistent Class B production						
Fields ³	4+0	150	lb N/acre	Summer	Ample Nitrogen provided to fields for orchard grass						

¹ At 0.5% Total Solids from secondary clarifiers. Assume 1% volatile solids destruction in the storage basins

² Nameplate rating of 240 gpm normalized to one day at average daily operational run time of 6.7 hours per day.
240gpm x (6.7h/24h) = 67.0 gpm

³ As total Nitrogen. Typical nitrogen loading for hay fields

2.4.8.1 WAS storage

WAS storage was projected using the ratio of daily historical WAS flow to influent BOD₅ loading for years 2015 and 2016 to determine annual average and maximum month WAS production per pound of influent BOD₅. The annual average and maximum month ratios were then applied to the projected annual average and maximum month influent BOD₅ loading during the planning period (2018-2045) presented in Section 0. **Figure 2-3** shows the WAS flow projection. Current average annual and maximum month WAS flow is approximately 0.13 MGD and 0.25 MGD, respectively. WAS flow is expected to increase to 0.25 (AA) and 0.49 (MM) MGD by 2045.

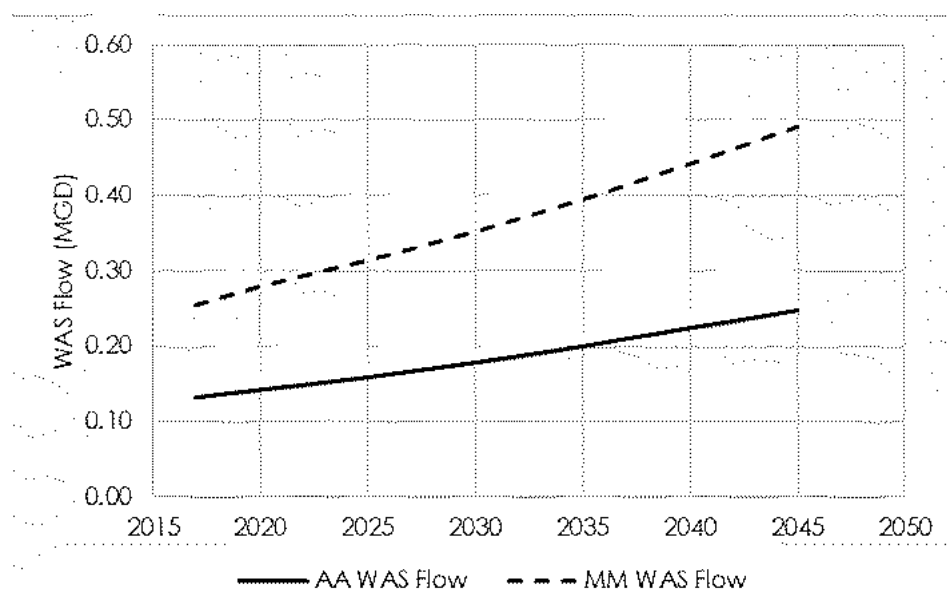


Figure 2-3: WAS Flow Projection

The WAS storage basins contain waste activated sludge (WAS) from the clarifiers prior to dewatering. Each of the two basins have a solids capacity of approximately 5,650 lb at 0.5% total solids (TS), the typical concentration fed into the belt filter press. WAS storage basin capacity will not be exceeded during the planning study based on annual average projections. However, WAS storage capacity is exceeded during prolonged maximum month events by 2020.

Solids capacity can be increased by a “decanting” procedure where the aeration blower is turned off to allow solids settling and removal of supernatant back to the headworks. This procedure is done during belt filter press maintenance and can increase solids loading capacity in each basin to nearly 8,500 lbs at a solids content up to about 1.5%. This procedure is currently performed on a manual basis as a temporary solids storage solution as it is reported the downstream belt filter press does not operate as well at higher total solids concentrations, but could be automated in the future to increase WAS storage capacity.

Although the WAS flow into the storage basins is expected to increase annually, the capacity of the WAS storage basins is highly dependent on the belt filter press operation. As a result, the capacity and lifespan of these basins may increase as the plant moves towards more efficient dewatering alternatives.

2.4.8.2 Dewatering

The dewatering process includes a preliminary polymer injection, a belt filter press (BFP) and lime mixing to stabilize and pH treat the dewatered cake to meet Class A or B biosolids requirements. The belt filter press has a nameplate hydraulic and solids loading capacity of 240 gpm and 560 lb TS/hr respectively. This capacity has long been exceeded and current hydraulic and solids loading rates may reach 350 gpm and 900 lb TS/hr. Plant operators report efforts to increase influent WAS percent total solids (using the decanting procedure from Section 2.4.8.1) to lower the hydraulic loading have actually decreased the dewatering efficiency of the belt filter press. To meet the nameplate hydraulic loading capacity of 240 gpm, the BFP would currently need to be operated over 10 hours every day. By about 2030, the BFP would need to be operated 24 hours a day, 7 days a week to meet this capacity.

As influent loading and WAS flow continues to increase, the BFP will become further overloaded, require extended operational run time, and run the risk of increased maintenance burden due to this heavy operation. As a result, additional and/or alternative dewatering processes should be immediately evaluated to provide a dewatering capacity solution as soon as possible.

The lime hopper, mixer and polymer injection systems have adequate capacity to meet the needs of the plant through 2045.

2.4.8.3 Biosolids Handling

The drying pads provide excellent biosolids drying capacity in the summer months during high temperatures and low precipitation. During these times, the WPCF produces Class A biosolids which may be sold or given to the public. During the winter months however biosolids drying is much slower due to high precipitation and low temperatures and the WPCF can produce, at best, a Class B biosolids. During the winter, the biosolids often pile up on the drying pad, further limiting the drying capacity and causing significant odors. In worst case scenarios, biosolids are delivered to the local landfill and a tipping fee is charged for disposal.

To increase the biosolids drying capacity, the WPCF is planning to add a second drying pad. This will certainly improve biosolids drying, however the new pad will still be subject to weather conditions and may not significantly improve drying capacity, especially during the winter months. The WPCF has indicated an interest in producing year-round Class A biosolids which requires alternative solids stabilization and drying methods, to be discussed in Task 3 of this report.

2.4.8.4 Biosolids Land Application Capacity

The city-owns 146 acres of fields which have an allowable agronomic total nitrogen loading of 150 lb/acre to grow orchard grass (hay). The WPCF is applying their Class B and any remaining Class A biosolids on these fields during the spring and summer months. The hay produced at the fields is used as animal feed. Annual testing is conducted on fields used for land application to determine allowable spreading quantities and assure that the total nitrogen loading stays within allowable limits.

Table 2-189 summarizes the annual use of biosolids based on Annual Biosolids Report submitted over the last five years, and **Table 2-20** shows total biosolids land application rates and nitrogen loading as reported in the 2018 Wastewater Solids and Biosolids Annual Report. Detailed land application site information and soil testing results are included in Appendix E.

Table 2-20: Annual Biosolids Production

Item (DT/year)	2014	2015	2016	2017	2018
Class B – Produced	580.35	687.5	718.8	669.9	405.23 ¹
Class B – Applied	1054.33	949.38	893.53	770.94	740.96
Class A – Produced				857.25	282.57
Landfilled	0	0	131.2	140	0

1. An additional 50 dry tons of Class A biosolids produced in 2017 were mixed with Class B biosolids, for a combined 2018 Class B production of 455.23 DT.

Table 2-21: 2018 Biosolids Land Application

Site	Crop	Application Rate (lb N/ac)	Total Applied (DT/site)	Soil Tested
1	Orchard Grass	55.52	89.76	Y
2	Orchard Grass	30.98	69.17	Y
3	Orchard Grass	58.00	46.88	Y
4	Orchard Grass	78.56	75.60	Y
5	Orchard Grass	48.47	63.43	Y
6	Orchard Grass	37.90	58.35	Y
7	Orchard Grass	61.57	59.25	Y
8	Orchard Grass	71.18	16.44	Y
9	Orchard Grass	48.62	37.43	Y
10	Orchard Grass	33.19	53.66	Y
11	Orchard Grass	61.96	23.85	Y
12	Orchard Grass	71.32	104.33	Y
13	Orchard Grass	61.78	42.81	Y

Producing Class A solids year-round would benefit the City by increasing the quantity of solids distributed to nearby farms in addition to applying biosolids on City-owned fields.

2.5 WASTEWATER TREATMENT SYSTEM: ELECTRICAL/SCADA

The onsite generator has a capacity of approximately 600 kW with diesel supply for about 12 hours which is below the reported 800 kW requirements to keep the basic plant processes (minus dewatering) in operation during an outage. Even during power outages, the generator is reportedly rarely used, and the operators are unsure exactly which circuits or equipment it powers. As such, a more thorough capacity review of the generator is recommended.

A more thorough review of the supervisory control and data acquisition (SCADA) system is recommended, especially in regard to process updates to be discussed in Task 3.

2.6 SUMMARY

The City of Redmond's wastewater system has been well-maintained, and much of it provides sufficient capacity to meet long-term system needs. The collection system has adequate capacity to serve current needs, and the City continues to expand the collection system to serve future growth as planned in the 2008 Master Plan. Proactive collection system maintenance practices allow the City to maintain a high level of service in the collection system.

Many of the unit processes at the Redmond WPCF were upgraded in 2010 and provide sufficient capacity to meet projected treatment requirements through 2043. Of the liquid processes the Orbal® and disinfection processes are expected to exceed their peak hour treatment capacity before 2043.

The capacities of the solids processes are not sufficient to meet near-term or long-term requirements. The belt filter press already exceeds its nameplate capacity. The biosolids drying bed is often full during the winter months, which reduces the effective drying capability and causes odors.

The WPCF typically meets Class A biosolids requirements during the summer months using the uncovered drying beds. During the winter and rainy seasons, Class B biosolids are produced with the addition of lime. The WPCF has expressed interest in producing Class A biosolids year-round. As a result, the current method of lime stabilization and cake drying is not sufficient.

3.0 REGULATORY REQUIREMENTS

3.1 SUMMARY OF REGULATORY REQUIREMENTS

Effluent water quality standards, defined by the State of Oregon Department of Environmental Quality (DEQ), set the effluent quality required at the City of Redmond WPCF. The City of Redmond was issued a new WPCF Permit in 2010 (Permit Number: 101500) which expires on December 31, 2020. This section reviews current regulatory requirements that define the City's treatment and reuse programs and identifies issues that may drive future regulatory requirements.

3.2 COMPLIANCE WITH DISCHARGE PERMIT LIMITS

Wastewater effluent discharged to the infiltration basins must be treated and disinfected to the water quality conditions defined by the WPCF permit (Permit Number: 101500, included in **Appendix A**). **Table 3-1** summarizes the permit requirements for effluent BOD₅, total suspended solids (TSS), nitrate plus nitrite as nitrogen (NO₃-N and NO₂-N), total nitrogen (TN) concentrations, and pH.

The WPCF permit also requires the infiltration basins to be maintained at a maximum depth of two feet (24 inches), and properly managed to ensure erosion does not cause a direct connection between the bottom of the basin and the underlying basalt.

Table 3-1: Effluent Discharge Requirements

Location	Parameter	Limitation	Units	Comments
Process Flow	Flow	2.99	MGD	Monthly Average Daily Flow
Effluent Water Quality	BOD ₅	20	mg/L	Monthly Average
	TSS	20	mg/L	Monthly Average
	NO ₃ + NO ₂ -N	6	mg/L	Monthly Average
	Total Nitrogen	9	mg/L	Monthly Average
	pH	6.0 – 9.0		
	E. Coli	126*	# cells per 100 mL	Monthly log mean
	E. Coli	406*	# cells per 100 mL	Single Measurement Limitation
Infiltration Basins	Depth	≤ 2	feet	

*Total E. Coli Count requirements depend on the discharge location of the effluent. This permit limitation is only valid for effluent discharge to the infiltration basins. If water is irrigated, E. Coli count is limited to a weekly median of 23 cells/100 mL.

The City operates the treatment facility in compliance with these effluent discharge requirements and has not experienced any permit violations since issuance of the current WPCF Permit.

3.2.1.1 Land Applied (Recycled) Water

Redmond WPCF irrigates approximately 146 acres of perennial grass, alfalfa, and other crops with treated and disinfected plant effluent during the summer months per the City's approved Recycled Water Management Plan. Recycled water management is reported to DEQ annually in the City's Recycled Water Annual Report; the 2018 Recycled Water Annual Report is included in **Appendix B**. The WPCF is permitted to land apply effluent that meets Class C Recycled Wastewater regulations defined in OAR 340-055-0012(5)(b). Wastewater must be treated to discharge requirements outlined in **Table 3-1** with more stringent disinfection limits to reduce the weekly average E. Coli count. **Table 3-2** summarizes the permit requirements for Class C Recycled Wastewater.

Table 3-2: Land Applied (Recycled) Water Requirements

Location	Parameter	Limitation	Units	Comments
Effluent Water Quality	BOD ₅	20	mg/L	Monthly Average
	TSS	20	mg/L	Monthly Average
	NO ₃ + NO ₂ -N	6	mg/L	Monthly Average
	Total Nitrogen	9	mg/L	Monthly Average
	pH	6.0 – 9.0		
Class C Recycled Wastewater	E. Coli	23	# cells per 100 mL	7-day Median
Recycled Water Application	SQ. FT of Land	146	acres	Perennial grass, alfalfa, or other cover crops

In addition to meeting WPCF water quality limits, effluent reuse must be monitored for its contribution to the total nitrogen loading on the City's fields. **Table 3-3** summarizes the water balance and total nitrogen loading for 2014-2018. Effluent applied to pivots includes effluent directed to all four of the City's irrigation pivots during the calendar year. Irrigation and biosolids application are managed to stay within the allowed crop loading rate for nitrogen (150 lb N per acre for orchard grass), and annual testing is conducted to determine the amount of biosolids spread on a given field during that year.

Table 3-3: Water Balance and Total Nitrogen Loading

	Water Balance (Million Gallons)			Nitrogen Loading (lb N/acre)		
	Infiltration Basins	Irrigation Basins	Applied to Pivots	Recycled Water	Biosolids	Total
2014	402.1	165.7	139.0	30.65	49.20	79.85
2015	380.4	202.3	152.6	35.99	90.80	126.80
2016	386.0	210.0	175.5	30.76	113.52	144.27
2017	350.7	266.5	174.23	48.6	91.28	139.88
2018	452.5	193.1	163.7	43.27	50.07	93.34

3.2.1.2 Groundwater Quality Monitoring

The City conducts groundwater monitoring as outlined in the DEQ-approved Groundwater Monitoring Plan submitted as part of the 2011 WPCF permit renewal application. Groundwater up gradient and downgradient of the infiltration basins is monitored to ensure effluent seepage does not impact the quality of the groundwater. The City has installed a total of 17 monitoring wells, however the wells used to evaluate permit compliance have changed over time as water levels in the underlying aquifer have decreased. Most recently, the City's 2018 Annual Groundwater Monitoring Report identified that a replacement well (MW-18) had been approved by DEQ and constructed to replace the shallow well monitoring well MW-1 which had become completely dry.

The WPCF permit sets requirements on groundwater quality at two compliance wells maintained by the City of Redmond WPCF. Total dissolved solids (TDS) and nitrate as nitrogen (NO₃-N) are monitored at the compliance points, where concentrations cannot exceed 500 mg/L TDS and 9 mg/L NO₃-N (**Table 3-4**).

Table 3-4: Groundwater Permit Limitations

Location	Parameter	Limitation	Units	Comments
Groundwater Quality	NO ₃ -N	9	mg/L	Monthly Average
Groundwater Quality	TDS	500	mg/L	

The City's Annual Groundwater Monitoring Reports from 2014 through 2018 demonstrate that none of the wells exceeded concentrations in the City's WPCF. **Appendix C** includes the City's 2018 Groundwater Monitoring Report. The groundwater analysis conducted in support of the 2011 Groundwater Monitoring Plan indicated that groundwater nitrogen concentrations were stable and permit limits appear to be protective of the groundwater resource. Data collected since development of the Groundwater Monitoring Plan continue to support this finding.

3.3 COMPLIANCE WITH BIOSOLIDS MANAGEMENT PLAN

City prepared original Biosolids Management Plan in 2001 and revised it in 2005. The Biosolids Management Plan was amended in 2011 as part of the WPCF Permit modifications, and again in 2017 (**Appendix D**) to describe the means for production of Class A Exceptional Quality (EQ) biosolids. Under the 2011 Plan, the City produced Class B biosolids for land application on sites approved by DEQ and at application rates developed based on OSU Extension Service Fertilizer Guide #38 and through discussion with DEQ based on operating experience for crop nitrogen requirements (set at 150 lb N per acre for orchard grass). The 2017 Addendum described additional treatment processes and monitoring requirements to meet Class A EQ requirements supporting giveaway or sale of biosolids.

The WPCF is permitted to land apply the treated and dried biosolids to designated hay fields owned by the City of Redmond. **Table 3-5** outlines the permit limitations for Class B biosolids prior to land application or Class A biosolids prior to distribution. Biosolids generated in the Orbal® oxidation ditch are settled in the secondary clarifiers and then pumped to waste activated sludge (WAS) holding tanks before dewatering via belt filter press (BFP). Dewatered sludge cake is then mixed with lime to meet the vector attraction and pathogen reduction requirements for Class B biosolids, which is defined in 40 CFR 503.33(b)(6) and 503.32(b)(3) Alternative 2, respectively. Treated biosolids are stored on drying beds and a covered storage area during the fall and winter, which can be left to further dry to Class A standards.

Table 3-5: Biosolids Treatment Requirements

Location	Parameter	Limitation	Comments
Class B Biosolids	pH	≥12 for 2 hours	Vector attraction and pathogen reduction requirements
Class B Biosolids	pH	≥ 11.5 for 22 hours	Vector attraction and pathogen reduction requirements
Class B Biosolids	Fecal Coliform	< 2.0 Million CFU or MPN per gram	Geometric mean of 7 samples collected before use over a 2-week period
Class A Biosolids	Fecal Coliform	< 1000 MPN per gram	Specific sampling locations set per Part 503 Rule. One of these two criteria must be met for pathogen classification
Class A Biosolids	<i>Salmonella sp.</i>	< 3 MPN per 4 grams	
Class A Biosolids	Enteric viruses	< 1 plaque-forming unit per 4 grams	Both criteria must be met under the process used by the City to meet Class A treatment requirements
Class A Biosolids	Helminth ova	< 1 per 4 grams	

While Class A biosolids have non-detectable levels of pathogens, Class B biosolids have a reduced level of pathogens which is considered safe for applications as long as public exposure is prevented. Overall, process requirements to meet Class A biosolids are based on 40 CFR Part 257 with specific Processes to Further Reduce Pathogens (PFRPs). Part 503 allows for alternative and equivalent processes with proper demonstration and testing. Process requirements to meet Class B biosolids are set by 40 CFR Part 503 with specific Processes to Significantly Reduce Pathogens (PSRPs) with provisions for alternative processes based on performance demonstration. In addition to these requirements Class A and B biosolids must meet vector attraction requirements set by 40 CFR Part 503. This rule establishes 12 options for vector attraction reduction. The most common options are volatile solids reduction (minimum 38 percent), oxygen uptake rate - SOUR (> 1.5 mg of oxygen/hour/g of biosolids at 20°C), and alkali addition (raise to pH 12 for 2 hours-pH and maintain pH 11.5 for additional 22 hours). Other options include sludge drying, injection, soil amendment, and soil cover.

The City's Annual Biosolids Reports document the biosolids production and use, monitoring for pathogen reduction and vector attraction reduction to meet Class B or Class A treatment requirements, and nutrient and pollutant monitoring. **Table 3-6** and **Table 3-7** summarize the results of annual nutrient and pollutant monitoring, respectively, from 2014 through 2018, and **Appendix E** includes the 2018 Biosolids Annual Report.

Table 3-6: Annual Biosolids Production

Item	Annual Average Concentration (mg/kg)				
	2014	2015	2016	2017 (% DW)	2018
Organic N	43925	52175	52275	0.654	--
TKN	48250	57000	58250	0.746	41825
NO3-N	20.05	10.05	14.2	<0.00023	4.55
Ammonia-N	1430	4817.5	4232.3	0.0362	2203
Phosphorus (P)	--	--	--	--	1.36
Potassium (K)	5557.5	5690	7332.5	0.0488	3997.5
pH	12.2	12.35	12.4	12.0	11.44
Total Solids	14.2	14.08	13.3	12.5	13.65
Volatile Solids	53.5	52.4	66.0	56.55	--

Table 3-7: Annual Pollutant Monitoring

Metals	Annual Average Concentration (mg/kg)				
	2014	2015	2016	2017 (% DW)	2018
As	7.38	2.09	3.74	<3.67	0.637
Cd	1.17	0.99	0.455	0.424	0.053
Cr	8.34	9.35	7.605	11.93	--
Cu	62.4	67.8	79.5	61.1	8.693
Pb	6.9	7.98	5.80	<5.62	1.338
Hg	0.529	0.395	0.502	0.419	0.028
Mo	19.05	3.995	7.54	6.56	0.783
Ni	7.69	7.297	6.70	6.39	1.272
Se	3.76	2.62	1.93	<2.09	1.21
Zn	156	157	177	164.7	23.55

3.4 POTENTIAL FUTURE REGULATORY CONSIDERATIONS

No major changes to the regulatory framework affecting the WPCF are anticipated for the near term. It is recommended that the City conduct a meeting with DEQ to discuss upcoming permit renewal in 2020. Potential regulatory considerations that may be relevant for this planning effort include reuse, effluent discharge, and biosolids requirements.

3.4.1.1 Future Reuse Regulatory Considerations

The City already produces Class C water for beneficial reuse through irrigation. Class B water for beneficial reuse must not exceed a total coliform concentration of 2.2 MPN per 100 mL in a 7-day median and 23 MPN/100 mL in any single sample (OAR 340-055-0005 to 340-055-0030). The production of Class B water would provide the following additional options for reuse, based on DEQ's Recycled Water Beneficial Purposes Table: 1) Stand-alone fire suppression systems in commercial and residential buildings; 2) Non-residential toilet or urinal flushing, floor drain trap priming; and 3) Restricted recreational impoundments. The City does not intend to change their beneficial reuse approach therefore the Class C criteria is assumed to drive effluent requirements for planning.

3.4.1.2 Effluent Discharge Regulatory Considerations

Discharge through infiltration is typically regulated based on nitrogen impact to groundwater quality. Nitrate is the main constituent of concern, but Total Nitrogen is often regulated. Nitrate nitrogen and Total Nitrogen limits for infiltration discharge are typically less than 10 mg/L. Therefore, the current discharge and monitoring limits set for the City by DEQ are within and perhaps slightly more restrictive than typical limits. City staff should continue discussions with DEQ to review groundwater monitoring results and anticipate potential revisions to total nitrogen discharge limits.

Total dissolved solids (TDS) may also be a concern for infiltration disposal applications. The use of chemicals in treatment processes (such as chlorine for disinfection) adds to the incoming wastewater background TDS and results

in higher concentrations at the effluent. If effluent concentrations are approaching the limit, it is recommended that alternative treatment technologies be considered.

3.4.1.3 Biosolids Regulatory Considerations

The City currently meets Class A treatment requirements through a combination of lime stabilization and air drying. This approach is suitable for a portion of the biosolids generated at the WPCF but is not a reliable method for achieving Class A treatment standards on a year-round basis. Adopting a Class A treatment technology would allow the City to further diversify potential reuse opportunities for biosolids. This diversification would also allow a greater percentage of the total nitrogen loading on the City's farm fields to be met through application of recycled water.

3.4.1.4 Additional Considerations

State regulatory trends documented by the Oregon Association of Clean Water Agencies also considers temperature, priority pollutants, contaminants of emerging concern, disinfection by products, ammonia, and metals limitations in effluent water quality. Although these trends are mostly applicable to surface water discharges, it is recommended that the City coordinates with DEQ to verify if these trends may impact their upcoming discharge permit renewal.

Growing concern is arising at the state and federal level regarding per- and polyfluoroalkyl substances (PFAS), a group of persistent toxic chemicals used in firefighting foam and a variety of consumer products. PFAS have been detected in biosolids and in soils associated with land application of biosolids. The EPA released a PFAS Action Plan in early 2019 outlining an approach to determine the risk and potential regulatory pathways to monitoring and regulate release of PFAS to the environment.

4.0 ALTERNATIVES ANALYSIS

Reliability and capacity reviews were conducted in Chapter 2 to determine which process areas are recommended for improvement. The reliability review qualitatively assessed each unit process, whereas the capacity review quantitatively assessed each unit processes ability to meet nameplate and rated capacity utilizing the criteria below.

Reliability Criteria:

1. Equipment functionality
2. Maintenance and downtime
3. Nameplate and Design Loading
4. General condition (age, spare parts)

Capacity Criteria:

1. Hydraulic capacity
2. Organic loading capacity
3. Solids loading capacity

Based on these analyses, process areas that are nearing the end of their useful life and/or reaching the design rated capacity were considered in the alternatives analysis, such as biological treatment, solids handling, and disinfection.

This alternative analysis was developed in collaboration with the City in two phases:

- **Phase 1** – Technology screening with a “go” or “no-go” workshop
 - During the technology screening phase, a total of twenty-two technology alternatives were considered and discussed with the City. Six technology alternatives were selected for further development and analysis in Phase 2
- **Phase 2** – Alternative analysis with OPCC and estimated life cycle costs followed by workshop with the City.
 - The selected alternatives were evaluated, including site layout and configurations to meet year 2045 (Y2045) flows and loads, capital cost estimation, and annual power and chemical cost estimations.

4.1 TECHNOLOGY SCREENING

Technology screening was conducted in a workshop format where Stantec presented and discussed a wide variety of technology alternatives for biological treatment, solids stabilization, solids handling, and disinfection with the City. Stantec listed various alternatives based on their technical and operational application to the Redmond WPCF. Each technology was evaluated on the following criteria:

1. Operation and Maintenance (O&M) Impacts
2. Process Impacts
3. Technology Maturation

Operation and maintenance impacts were ranked by the level of change to the current mode of operation and process controls: low, medium and high impact. Low impact to O&M describes technologies that do not alter the current mode of operation, where minimal operator training is required, process controls are not changed, and/or O&M costs are similar to current operation. Medium impact to O&M describes technologies that slightly alter the current process, where a moderate amount of operator training is required, instrumentation and process controls are moderately altered, and/or O&M costs are moderately increased. High impact to O&M describes technologies that require a significant amount of operator training, new instrumentation and process controls, and/or O&M costs are significantly higher than current operation. **Table 4-1** summarizes the O&M impact criteria.

Table 4-1: O&M Impact Criteria

O&M Impact	Criteria		
	Operator Training	Process Controls and Instrumentation	O&M Costs
Low	Minimal to None	Minimal to No Changes	Minimal Increase
Medium	Moderate	Moderate Changes	Moderate Increase
High	Significant	New Instrumentation and Process Controls	High Increase

Process impacts qualitatively describe the advantages and disadvantages of each technology, including reliability, constructability, and technical application to the Redmond WPCF.

Technology maturation describes the development and level of industry adoption of each technology. Technology begins to enter the industry through research and development. As the technology improves and is adopted by industry, the number of installations and performance increases over time. Technology reaches obsolescence when it reaches full potential and is no longer considered for new installations. At any point on the curve, technology may take “potential off ramps” where industry interest rapidly decreases due to technological inefficiencies or high capital/O&M costs.

Table 4-2 presents the technology alternatives evaluated and discussed during the initial technology screening workshop, including the decision to either eliminate or select for further evaluation.

Table 4-2: Initial Technology Screening

	Technology	Decision	Key Reason for Decision
Biological Treatment	Install a New Orbal®	<i>Selected</i>	Current and reliable operation.
	CAS/MLE Basin in Parallel to Orbals®	<i>Selected</i>	Increases biological capacity with new basin in phases. Potential for phased capacity increases to reduce capital outlay.
	Magnetite Ballasted Treatment	<i>Selected</i>	Increases biological capacity without construction of new aeration basin. Increased settle-ability in secondary clarifiers.
	Convert Existing Orbal® to CAS/MLE	<i>Eliminated</i>	Difficult retrofit. Potential high construction costs with minimal increase of biological capacity.
	Integrate Fixed-Film Activated Sludge	<i>Eliminated</i>	Difficult retrofit. Potential high construction costs.
	Membrane Bioreactor (MBR)	<i>Eliminated</i>	Potential high capital and O&M costs. Higher process complexity.
Disinfection	UV	<i>Selected</i>	Eliminates chlorine addition to effluent. May be implemented in existing chlorine contact basins.
	UV plus Tertiary Filtration	<i>Selected</i>	Preliminary effluent sampling shows potential need for filtration pre-UV treatment.
	Chlorine	<i>Eliminated</i>	The City decided to explore other alternatives for disinfection and phase out the use of chlorine-based disinfection.
	Ozone	<i>Eliminated</i>	High capital and O&M costs. Safety concerns for nearby neighbors.
	Peracetic Acid (PAA)	<i>Eliminated</i>	Requires significant piloting to gain approval by DEQ.
	Advanced Oxidation Processes (AOP)	<i>Eliminated</i>	Would require chemical addition of PAA or chlorine. Chemical injection is not desired.
Solids Handling	Huber® Solar Dryer	<i>Selected</i>	Produces Class A Biosolids.
	FKC® Thermal Drying	<i>Selected</i>	Produces Class A Biosolids.
	Biological Composting	<i>Eliminated</i>	Similar to current operation. Staff has tried composting without significant improvement to process. The City decided to focus on alternatives that lead to Class A.
	Thermal Drying	<i>Eliminated</i>	High capital O&M costs.
	Anaerobic Digestion	<i>Eliminated</i>	High capital O&M costs. Produces Class B Biosolids with options to produce Class A. Close proximity to the public and odor concerns.
	Aerobic Digestion	<i>Eliminated</i>	High capital O&M costs. Produces only Class B Biosolids.
	ATAD	<i>Eliminated</i>	High capital O&M costs. Close proximity to the public and odor concerns.
	BCR Clean B®	<i>Eliminated</i>	High O&M costs. High chemical consumption and handling. May require significant piloting to gain approval by DEQ.
	BCR Neutralizer®	<i>Eliminated</i>	High O&M costs. High chemical consumption and handling. May require significant piloting to gain approval by DEQ.
	Dewatering	<i>Selected</i>	Is considered secondary to the solids stabilization process and is included within cost estimate for the Huber Solar Dryer.

4.2 ALTERNATIVE ANALYSIS

The selected alternatives were further developed and evaluated for conceptual site layout, capital cost, and O&M costs as summarized below.

Cost estimations presented below are Class 5 opinion of probable construction costs (OPCC) which were prepared to compare the six process alternatives. Class 5 cost estimates are prepared on limited information and generally have an accuracy range of Low = (-) 20 percent to (-) 50 percent, and High = (+) 30 percent to (+) 100 percent as defined by the American Association of Cost Engineering (AACE) International. This level of estimate is used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval.

4.2.1 Biological Treatment Alternatives

Three biological treatment alternatives were selected for analysis: construction of a new Orbal® basin, construction of a CAS/MLE basin operating in parallel to the existing Orbal® system, and retro-fitting the existing system with BioMag™ process. Each alternative was planned to meet projected future (Y2045) flows and loads and current permit requirements presented in Chapter 1. It is recommended that these alternatives be re-evaluated when the City renews its discharge permit within the next two years. The following subsections present a description of the alternatives, a qualitative comparison of the advantages and disadvantages of each alternative, and a cost comparison.

4.2.1.1 Alternative 1 – Expand Orbal® System

The Redmond WPCF currently operates two 1.6 million-gallon (MG) Orbal® basins with three channels. This alternative proposes the installation of a third Orbal® basin with the same volume as the existing Orbals®, as shown in **Figure 4-1**. Influent and RAS piping will tie into the existing pipelines, new Orbal® effluent piping will be installed into the existing flange on the secondary clarifier splitter box.

Installing a new Orbal® basin in parallel to the existing system is not expected to have significant O&M impacts, since the core treatment process is not changing. Additional operator training is not anticipated, and instrumentation and process controls are expected to be similar to current Orbal® operation. There may be slight changes as technology is improved by the manufacturer, such as improved aeration discs and aeration system layout in the basins. Bioreactor volume and capacity will be increased by 50 percent with the additional Orbal®. Secondary clarification capacity can be increased by adding a fifth clarifier, in the future as needed.

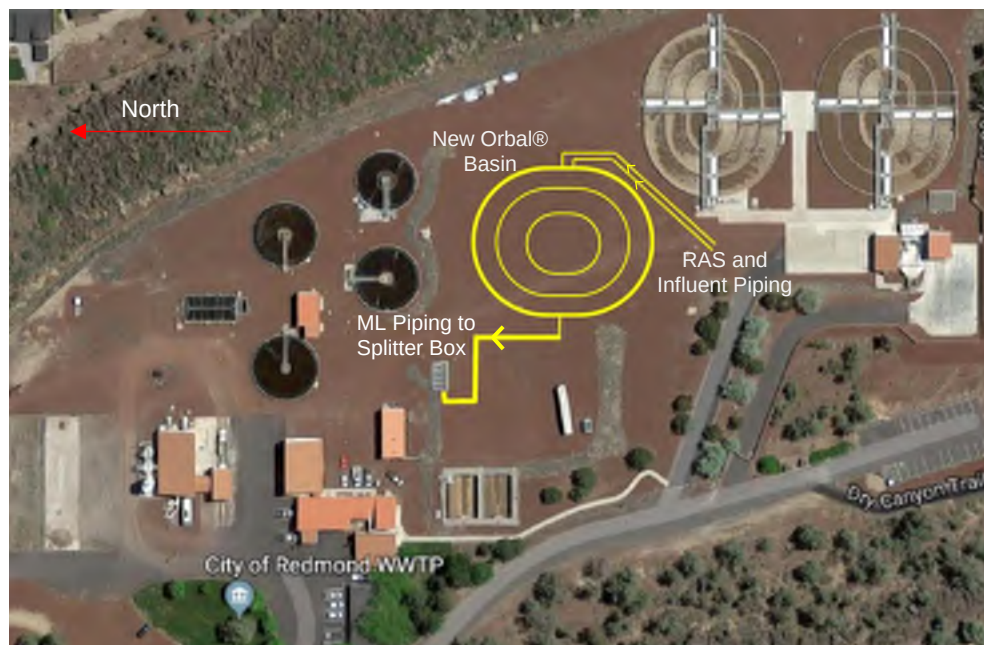


Figure 4-1: Orbal® Conceptual Site Layout

4.2.1.2 Alternative 2 – Conventional Activated Sludge (CAS) for Nitrogen Removal in Parallel to Existing Orbal® Basins

Activated sludge systems are commonly used for secondary treatment systems that require nitrogen removal. Unlike the Orbal® basins, these systems operate as a plug flow reactor with baffling walls to separate the anoxic and aerobic zones. **Figure 4-2** illustrates a conventional activated sludge (CAS) system for nitrogen removal commonly known as Modified Ludzack-Ettinger (MLE) process where mixed liquor first flows through an anoxic zone of approximately 20 to 30 percent of the total volume, then it flows through an aerobic zone. Return activated sludge (RAS) is pumped from the secondary clarifiers to the CAS/MLE basin anoxic zones, and a mixed liquor return (MLR) recycles nitrified mixed liquor from the end of the aerobic zone to the beginning of the anoxic zone for denitrification. Blowers supply air to the fine bubble diffusers in the aerobic zone from a new blower building while mechanical mixers maintain the solids in suspension in the unaerated zones.

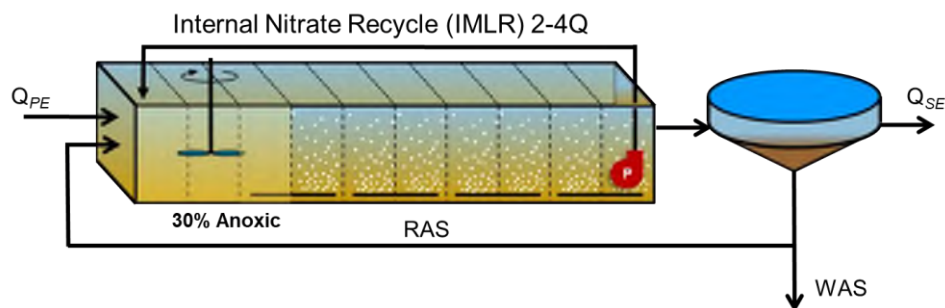


Figure 4-2: CAS/Modified Ludzack-Ettinger (MLE) Process

This alternative proposes constructing a CAS/MLE basin with grit removal (no primary treatment) and using it in parallel to the existing two Orbal® basins. Similar to installing a new Orbal®, the influent and RAS pipelines will tie into the existing pipelines, new piping will be installed for the aeration basin effluent and air supply to the aerated zone. This alternative is expected to have a higher O&M impact than the existing system and will require additional operator training. Operators will be required to learn new process controls and instrumentation for the CAS/MLE basin, while operating the Orbal® system in parallel. However, it provides opportunities for process optimization for energy savings with the use of advanced aeration control technology, such as ammonia-based control. The biggest advantage of this alternative is the opportunity for phasing. For this evaluation, it was assumed that the CAS/MLE basins would be implemented in two phases with each phase increasing capacity by approximately 0.5 MGD with current maximum loading conditions. Another benefit is the potential optimization of the available site since the CAS/MLE basins are more compact and have rectangular geometry. **Figure 4-3** illustrates the implementation of this alternative in two identical phases. Each phase increases capacity by approximately 0.5 MGD, totaling 1 MGD at the end of 2045. Phase 1 includes the construction and materials for a vortex grit removal system, a 0.8 million CAS gallon basin, a blower building, yard piping, and excavation. Phase 2 includes the construction and materials for a second 0.8-million-gallon CAS basin adjacent to the first basin, installation of additional blowers, yard piping, and excavation.

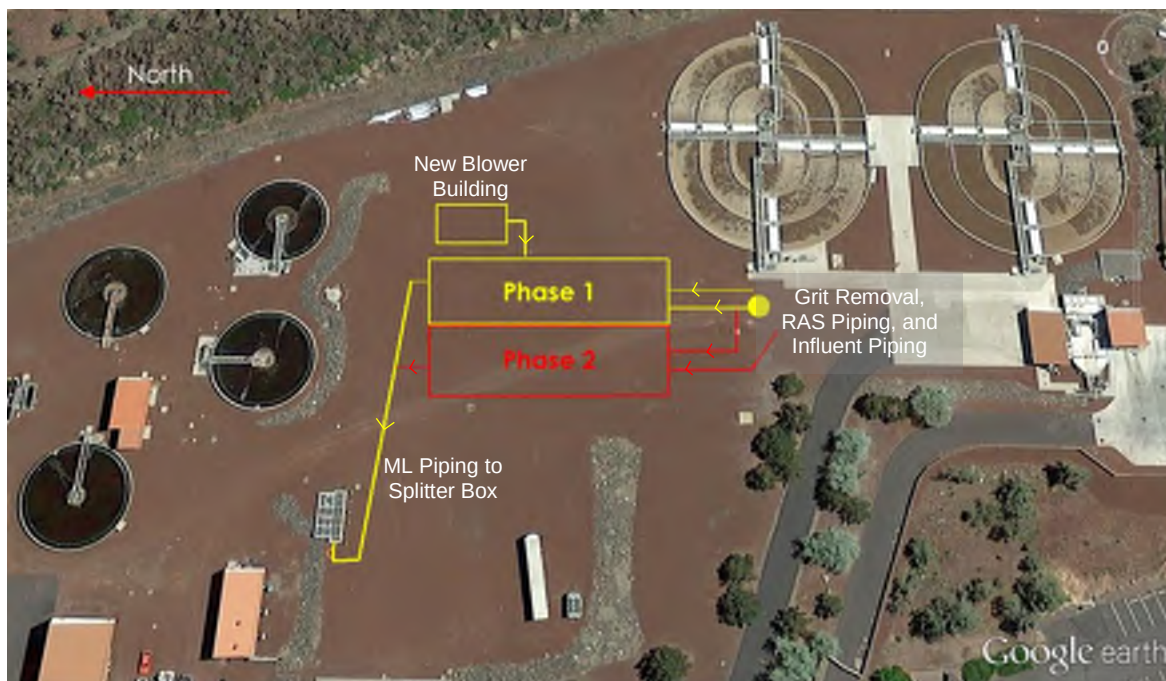


Figure 4-3: CAS Basin Conceptual Site Layout

4.2.1.3 Alternative 3 – Retrofit Existing System with BioMag™

BioMag™ is a new technology in the early adoption stage on the technology curve, which uses magnetite (Fe_3O_4 , specific gravity = 5.2) to create a ballasted activated sludge and improve settle-ability in the secondary clarifiers. By improving the settling capacity, Orbals® can operate at higher MLSS concentrations (4,000-8,000 mg/L) compared to typical operating ranges for CAS and Orbal® systems (2,000-4,000 mg/L). Overall biological capacity is increased with minimal additional footprint.

Figure 4-4 presents the process flow diagram for BioMag™ where magnetite is injected into the system using a side stream of RAS which passes through a magnetite mix tank before returning to the aeration basin. The ballasted activated sludge settles rapidly in the secondary clarifiers due to the high density of magnetite. Waste activated sludge (WAS) flows through a magnetic drum separator to recover magnetite from the wasted sludge.

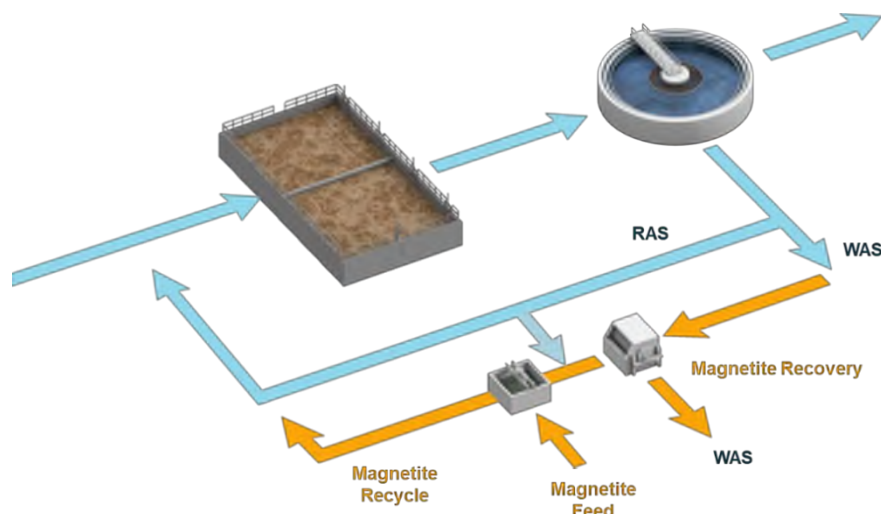


Figure 4-4: BioMag™ Treatment Process

Retro-fitting the existing Orbal® basins to BioMag™ will increase biological capacity by increasing the MLSS concentration. The aeration capacity would also be increased by upgrading the existing Orbal® aeration system with larger disk aerators. The addition of magnetite may help effluent turbidity entering the disinfection system. Stantec recommends piloting this technology prior to designing a full-scale upgrade. This alternative is considered an “equivalent” capacity expansion to year 2045 on-par with the first two alternatives so that a true comparison of capital cost and capacity increase can be conducted.

Figure 4-5 illustrates a conceptual site layout to retro-fit the existing system to BioMag™, which includes construction of an equipment building, upgrading the existing Orbal® aeration system, and re-routing RAS and WAS pipelines to the BioMag™ building for injection and separation of the magnetite. The BioMag™ equipment building will house a magnetic drum separator, a magnetite silo, magnetite mix tank, a shearing mill, and air compressors. Upgrading the aeration system includes replacing the aeration disks and motors in the existing Orbal® basins. WAS flow will pass through the magnetic drum separator before entering the sludge holding tanks, and RAS flow will pass through the magnetite mix tank before returning to the Orbal® basins. Additionally, submersible mixers may be required to keep solids in suspension.

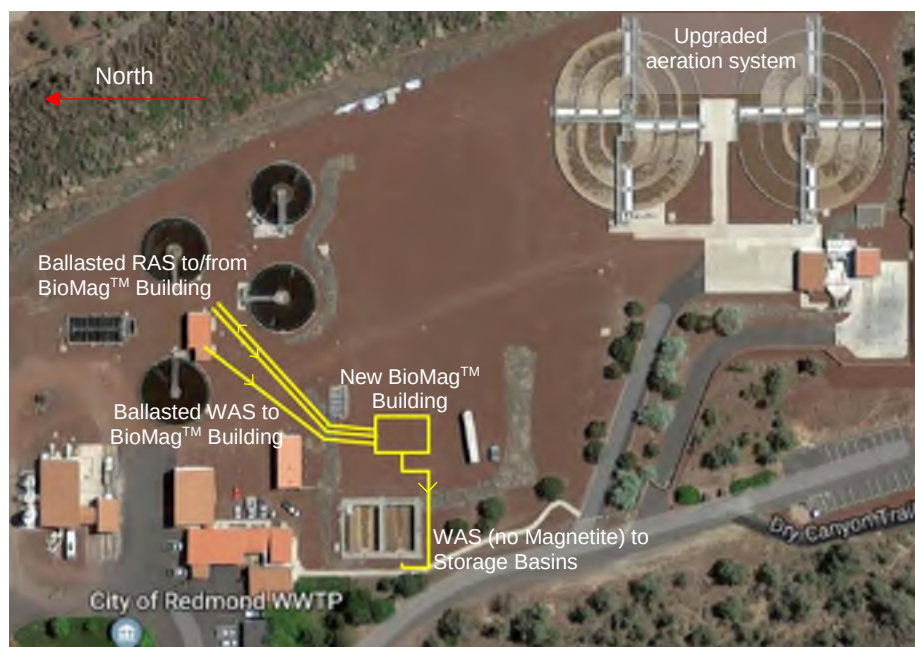


Figure 4-5: BioMag™ Conceptual Site Layout

4.2.1.4 Summary of Biological Treatment Alternatives

Table 4-3 compares and summarizes the biological treatment alternatives based on process function, operability, and constructability.

Table 4-3 Summary of Biological Alternatives

Alternative	Advantages	Disadvantages
Install New Orbal® Basin	• Maintain existing process approach • Simple operation • No operator training required • Relatively low electrical costs compared to CAS/MLE • Fully compatible with existing controls system • Site was already planned for an additional basin • Favorable constructability conditions	• Solids stratification issue may continue • Challenges with mixed liquor settle-ability may continue being a limitation • The secondary treatment would operate with excess capacity for several years • Difficult retrofit if more stringent nutrient limits are imposed in the future • Relatively high area requirements
CAS/MLE Basin	• Relatively smaller footprint than Orbal® system • Modular construction allows for phasing • Easy retrofit if more stringent nutrient limits are imposed in the future	• Operation of CAS/MLE and Orbal® basin simultaneously adds complexity • More complex maintenance • Operator and maintenance training required • Not fully compatible with existing controls • Less favorable constructability conditions • Require construction of a blower building • May require modifications of the RAS splitting and influent flow splitting.
Retrofit Orbals® with BioMag™	• No additional basin construction • Mixed liquor settle-ability improved • Biological capacity increased by process intensification • Relatively less complex implementation	• Re-route RAS piping to BioMag™ building • Pilot testing recommended • Increase O&M costs with annual magnetite expenditures • May exacerbate stratification issues • Still requires upgrades of aeration system • Installation of submersible mixers may be required • Fairly new technology • More complex mechanical system • More maintenance

4.2.1.5 Biological Alternatives Cost Estimation

Table 4-4 summarizes the capital and O&M costs of each biological alternative. Capital costs were provided in the Class 5 OPCC cost estimation, and annual O&M costs were based on power and chemical costs only.

Table 4-4 OPCC Summary Biological Alternatives

	Alternative 1 New Orbal® (Million \$)	Alternative 2 CAS Phase 1&2 (Million \$)	Alternative 3 BioMag™ (Million \$)
Site Work	0.60	0.80	0.10
New Bioreactor	2.00	3.00	-
Modifications to Existing Bioreactors	-	-	1.20
Grit Removal	-	0.50	-
BioMag™ Building	-	-	0.50
Mechanical Equipment	1.00	1.50	3.20
Power and Control Equipment	0.80	1.10	1.50
Total Cost of Work	4.4	6.9	6.5
Allocation of Prime Cost (20%)	0.88	1.40	1.30
General Conditions and General Allowances (6.0%)	0.26	0.60	0.40
Cost of Work Total Plus Contingencies	5.6	8.9	8.2
Engineering, Administration, and CM (22%)	1.22	1.90	1.80
Total Project Cost	6.8	10.8	10.0²
Annual O&M¹	0.07	0.15	0.21
¹ Power and chemical costs only			
² Piloting is recommended for this alternative. Cost is estimated to be an additional \$100,000.			

4.2.2 Disinfection Treatment Alternatives

Several disinfection technology alternatives were reviewed and discussed during Phase 1. Ultraviolet light (UV) disinfection is the preferred technology to replace the existing chlorine disinfection system. This approach would eliminate potential chlorine residual from the effluent and provide compatible performance.

Per the discharge permit and regulatory requirements presented in Section 1.4, Redmond WPCF is required to meet Class D disinfection standards for groundwater infiltration and Class C reuse requirements for irrigation. At minimum, the new disinfection alternatives must meet these regulatory requirements.

Redmond WPCF has expressed interest in exploring future effluent disinfection improvements to meet non-potable Class A reuse requirements where the public may come into contact with the effluent. This would, however, require an even more robust disinfection process (e.g. filtration plus disinfection to meet a median of 2.2 total coliform organisms per 100 mL).

The following two sections describe the UV disinfection alternative coupled with tertiary filtration. Initial planning was based on results of a preliminary collimated beam test performed on Redmond WPCF effluent on June 18, 2018 by Trojan Technologies. High variability of the settling characteristics of the mixed liquor in the secondary treatment leads to fluctuations in clarification performance. Tertiary filtration is recommended to provide a more robust treatment process and increase overall treatment reliability. Nevertheless, Redmond may choose to perform additional testing and validate the need for tertiary filtration. This testing must be performed in multiple seasons of the year given the high variability on mixed liquor settle-ability through the course of the year.

4.2.2.1 Ultraviolet (UV) Disinfection

UV light disinfection is a late majority, effective technology for disinfection of wastewater plant effluent. It provides disinfection through the use of ultraviolet light to inactivate bacterial and viral cells. Effluent flows through “banks” of UV lights which provide effective “doses” of UV light for disinfection. Redmond will likely be able to convert the existing chlorine contact basin into a UV disinfection system with limited modifications to the basin itself. The existing baffles, chlorine injection and monitoring will need to be removed to provide adequate space for the UV light banks.

Collimated beam testing in June 2018 of the clarifier effluent suggests that pre-filtration may be required to reduce turbidity and increase ultraviolet transmittance (UVT) prior to UV disinfection. Additional collimated beam testing will likely be required to confirm the need for pre-filtration. For planning purposes in this document, it is assumed that pre-filtration will be required to provide effective UV dosing for adequate disinfection.

4.2.2.2 Tertiary Filtration

Tertiary filtration is a late majority method of removing additional suspended solids and microbes from the effluent water prior to disinfection and discharge. Filtration is often coupled with UV light disinfection to provide adequate microbial deactivation. As a result, tertiary filtration is not a standalone method of disinfecting effluent to meet permit requirements.

Rotary cloth or screen filters are suggested as the most effective filtration technology due to their small footprint and low hydraulic head loss. These filters may be backwashed for extended operation and are replaced easily. Individual filters may be backwashed, allowing continual operation.

4.2.2.3 Alternative 1 – Tertiary Filtration & UV Disinfection

Based on collimated beam tests and to ensure Redmond meets its discharge permit requirements, it is recommended that the UV disinfection system be preceded by tertiary filtration. **Figure 4-6** below shows a conceptual site layout of the coupled tertiary filtration and UV disinfection system.

Combined filtration and UV disinfection will likely provide effective effluent water quality for Redmond WPCF to continue meeting its discharge and irrigation requirements. To reduce energy needs, the UV system may be configured to turn on or off banks of UV lights depending on the effluent requirements. During the winter when Redmond WPCF does not irrigate, some UV light banks may be turned off to reduce energy costs but continue to meet the permit requirements for groundwater infiltration. When Redmond WPCF wishes to irrigate fields, additional banks may be turned on to provide Class C reuse disinfection rates.

At this time, there are no significant drivers for the WPCF to provide higher quality Class A recycled water for public use. Additional facility technology upgrades at the WPCF and substantial infrastructure will be required in the future if Redmond WPCF decides to provide this resource to its citizens.

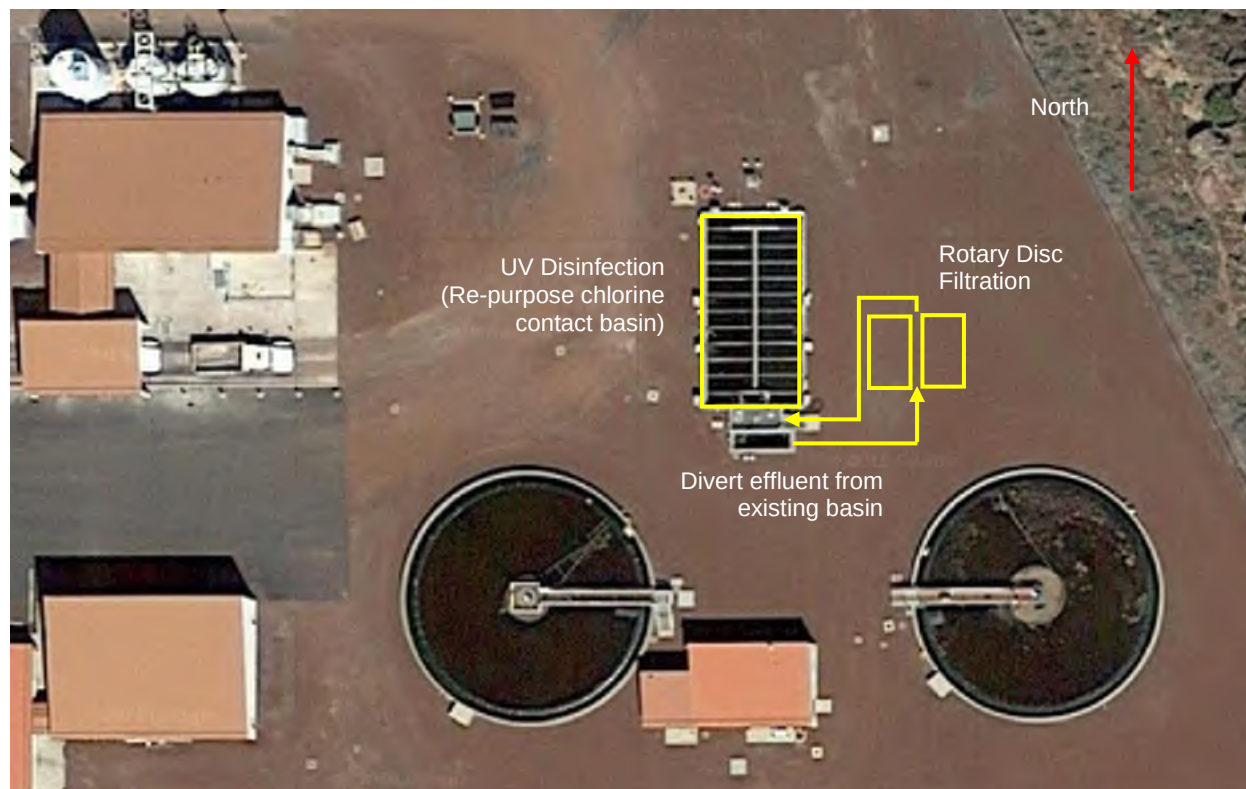


Figure 4-6: Combined Tertiary Filtration and UV Disinfection

4.2.2.4 Tertiary Filtration & UV Disinfection Cost Estimation

Table 4-5 summarizes the capital and O&M costs to install tertiary pre-filtration via rotary disc filters and UV disinfection. Capital costs were provided in the Class 5 OPCC cost estimation, and annual O&M costs were based on power only.

Table 4-5: Disinfection Cost Estimate

Equipment	Alternative 1 Filtration & UV (Millions \$)
Site Work	0.10
New Disinfection and Filtration Basin	0.95
Enclosed Disinfection Building	0.28
Mechanical Equipment	1.60
Power and Control Equipment	0.20
Total Cost of Work	3.13
Allocation of Prime Cost (20%)	0.63
General Conditions and General Allowances (6.0 %)	0.19
Cost of Work Total Plus Contingencies	3.94
Engineering, Administration, and CM (22%)	0.87
Total Project Cost	4.81
Annual O&M¹	0.05
¹ Power and bulb replacement costs only	

4.2.3 Solids Handling Treatment Alternatives

The following solids handling alternatives were developed to provide the WPCF with an upgraded solids management process to provide Class A biosolids product per 40 CFR 503.32 (b)(3) and 503.33(b)(6). The benefits to Class A are reduced odors and the ability to sell or easily dispose of the product in a beneficial manner.

4.2.3.1 Alternative 1 – Solar Drying

Solar dryers are comprised of multiple long rows of ‘greenhouses’ with controlled ventilation where dewatered sludge is evaporated until it meets Class A biosolids requirements. For Y2045 sludge production the Solar Active Dryer will consist of two rows within the ‘greenhouse’ structure with a mechanical turner in each row that slowly agitates, moves, dries dewatered cake through solar evaporation, and stores the dried solids for up to one year. Dewatered and dried sludge may enter or exit the solar dryers through conveyors or via driver-operated mobile equipment. The general preliminary layout of each of the solar dryers differs based on their geometries and vendor estimates. **Figure 4-7** shows a conceptual layout for the Huber® Solar Active Dryer located at the WPCF, however, it could also be located off-site near the current drying bed. To provide space for the solar dryers onsite of Redmond’s WPCF, some demolition and tree removal may be required. The existing drying pad a few miles to the North of Redmond WPCF likely has space for these solar dryers however there are concerns over vandalism at that location and it has not been considered as a viable option for the WPCF in this report.

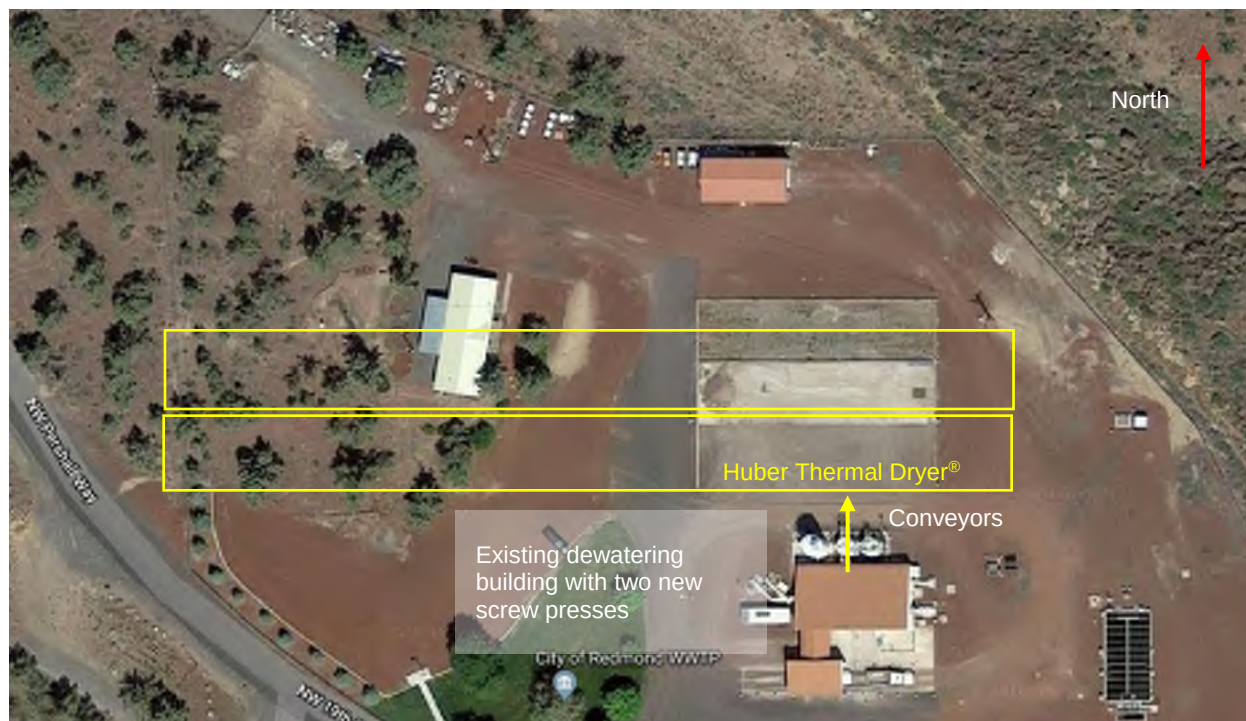


Figure 4-7: Onsite Solar Dryer Layout

4.2.3.2 Alternative 2 – FKC® Thermal Dryer and Lime Stabilization

The FKC® Thermal Dryer with Lime Stabilization produces Class A biosolids with a high pH lime treatment followed by heated screw press dewatering. The process requires pre-thickening, lime stabilization to meet the 40 CFR title 503 regulations, followed by heated screw press dewatering. This process requires lime and heat addition to provide complete treatment. The final product is a Class A biosolids with 30% or greater total solids which can be sold or given to the public. For the FKC process to effectively provide Redmond with Class A biosolids through Y2045, a new dewatering building is required. This building will provide thickening, lime silos and mixing, thermal screw press dewatering, and accessory equipment such as boilers and odor control. The existing WAS basins can be retrofitted to provide 'batching' for the lime/WAS mixing requirements. If a suitable market cannot be established for timely removal of the Class A biosolids, enclosed storage would also be required. **Figure 4-8** provides a conceptual site layout for the new dewatering building and retrofitted WAS storage basins. The current dewatering building could be repurposed or demolished after this upgrade is complete.

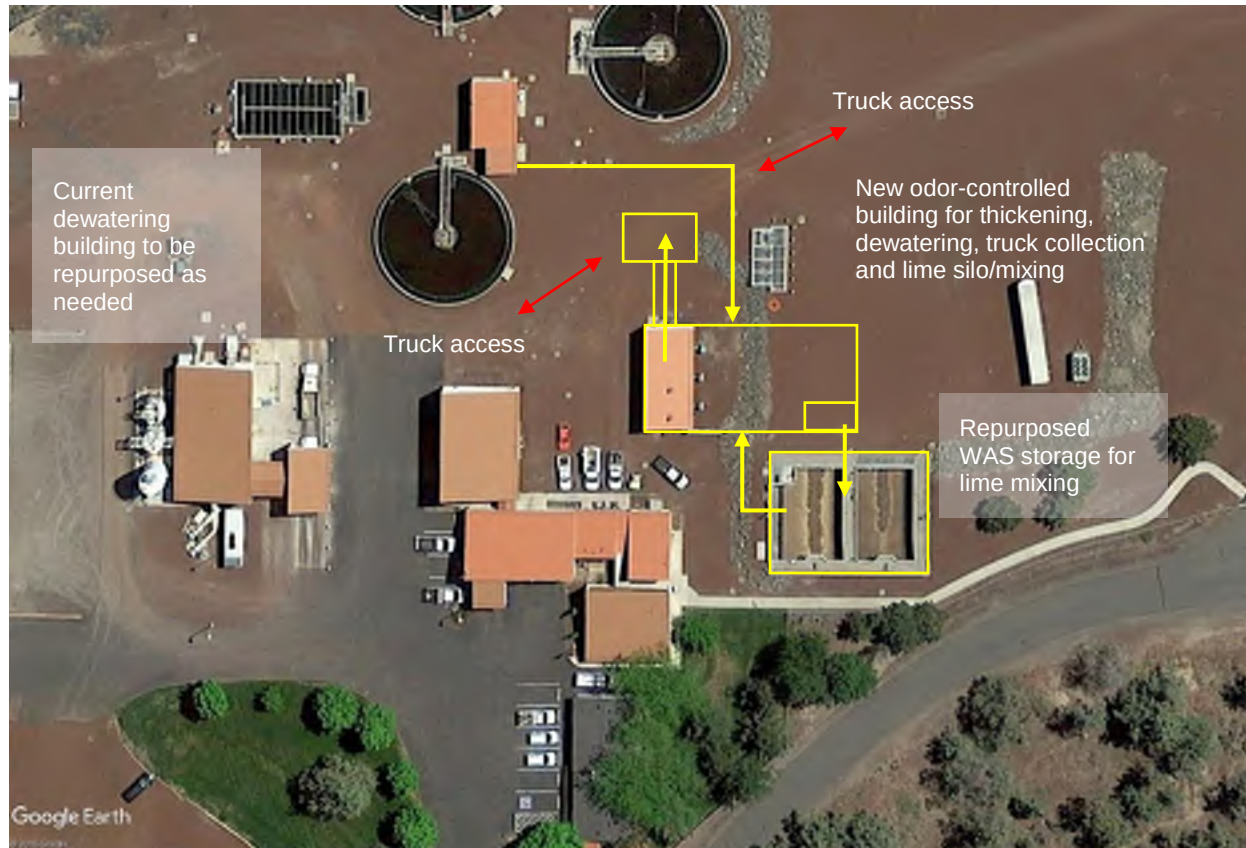


Figure 4-8: FKC® Lime and Thermal Screw Press Layout

4.2.3.3 Summary of Solids Handling Alternatives

Both the solar dryer and thermal lime/screw press solids handling alternatives will provide the Redmond WPCF with Class A biosolids during all or most of the year. In very cold & cloudy winter weather, it is possible that the solar dryer alternatives may only be able to produce a Class B biosolids. However, any Class B biosolids could be stored and recirculated back into the solar dryer for further treatment to achieve Class A requirements.

Table 4-6 provides a comparative summary of the solids drying alternatives for Redmond WPCF.

Table 4-6: Solids Handling Alternatives Summary

Solids Handling Alternative	Advantages	Disadvantages
Solar Dryers	• Relatively simple operation • No new chemical addition • Lime addition eliminated • Upgrades within an existing building • Includes storage for 1 year at buildout	• Large footprint • Drying is still weather dependent • May not produce Class A during winter • Odor could be an issue
FKC® Lime Stabilization and Thermal Screw Press	• Consistent Class A end product • Relatively small footprint • Could “turn off” heat demand during warm weather	• Continued (and increased) lime use • Heating required with natural gas or diesel • Substantial infrastructure improvements • Significant odor control needed • Best to operate the screw press continuously • Requires natural gas infrastructure

4.2.3.4 Solids Handling Alternatives Cost Estimation

Table 4-7 summarizes the capital and O&M costs for the two solids handling alternatives. Capital costs were provided in the Class 5 OPCC cost estimation, and annual O&M costs were based on power only.

Table 4-7 Solids Handling Alternatives Cost Estimate

Equipment	Alternative 1 Solar Dryers (Millions \$)	Alternative 2 FKC (Millions \$)
Site Work	0.20	0.10
Solids Dewatering Building and Equipment	1.45	1.30
Odor Control	0.30	--
Natural Gas Connection	--	1.00
Mechanical Equipment	3.65	4.20
Power and Control Equipment	0.20	0.90
Total Cost of Work	5.8	6.5
Allocation of Prime Cost (20%)	1.16	1.30
General Conditions and General Allowances (6.0 %)	0.35	0.50
Cost of Work Total Plus Contingencies	7.3	8.3
Engineering, Administration, and CM (22%)	1.61	1.80
New Natural Gas Connection	--	1.00
Total Project Cost	8.9^{2 3}	11.1
Annual O&M¹	0.02	0.3
¹ Power and chemical costs only		
² If odor control is not desired, subtract \$0.5M from the total cost of the project. New total would be \$8.4M		
³ For screw press installation only (i.e., only replacing the belt filter press) the total project cost is \$1.45M		

4.2.4 Support Facility Improvements

Wastewater treatment, collections staff and administrative functions are currently housed in three separate buildings at the WPCF: the original administration building, the collections trailer, and the lower admin trailer. The trailer structures are aging and near the end of their useful life. Furthermore, the separated buildings impact the ability of the group to function efficiently and lack sufficient spaces such as conference rooms, lunch rooms, and shower/locker facilities. The buildings do not adequately support the operational needs of the current wastewater staff, and the staffing needs of the division are anticipated to grow. The Wastewater Division staff currently includes 19 individuals including two open positions. In addition to personnel spaces, the WPCF currently includes equipment bays that have been repurposed for storage, and North and South vector garages. The irrigation site includes a garage that houses the slinger truck and provides limited tool storage, and open storage bays for biosolids and material storage.

A questionnaire was provided to Division staff (see **Appendix F**) to solicit information on the existing spaces, identify limitations associated with existing spaces, and define future division needs that drive space requirements. Needs were established based on near-term (2030) and buildout assessments of facility requirements. Because these needs were very similar, the information provided in this section is based on buildout support facility needs.

Based on information provided in the questionnaire, the Recommended Plan includes the following facility needs:

- **Operations/Administration Building: 9,600 SF**
This building provides capacity for the existing 19 staff (including open positions) and accommodates expansion to 32 staff at buildout. The building also includes space for restrooms, kitchen/lunch, file storage, work room, control room, server room, and large and small conference rooms. It was beyond the scope of the Facility Plan to evaluate the condition of the existing operations building, therefore it is assumed it would not be cost effective to expand the existing structure. City staff noted that some areas (such as the existing laboratory space) are sufficient for future needs. Future analysis should consider whether it is more cost-effective to expand or replace the existing administration building.
- **Heated Equipment Parking: 9,960 SF**
These fully-enclosed areas provide secure, heated storage for Division equipment at the WPCF and Biosolids sites. The following equipment are included in heated equipment parking space needs:
 - **WPCF Site:**
 - Vacuum/Jetter Truck
 - CCTV Truck
 - Sewer Tapping Trailer
 - Gator Runabout
 - Boss Snow Plow Attachment
 - **Biosolids Site:**
 - Front End Loader
 - Tractor

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- Slinger Truck
- Covered Parking & Storage: 9,450 sf
This includes open-air, potentially three-sided storage areas that could be converted to enclosed parking or storage in the future. Although staff identified the need for additional bulk material storage at the biosolids site, the solar dryer recommended in the Phase 1 improvements provides storage for up to one year of biosolids. Therefore it is assumed that the existing covered storage is suitable for future needs.
 - WPCF Site:
 - Forklift
 - Backhoe
 - Tanker Truck
 - Mobile Generator and Pump
 - Scissor Lift
 - Biosolids Site:
 - Backhoe
- Uncovered Storage: 9,140 sf
This includes paved parking and storage areas for equipment and materials that do not require cover, including:
 - Dump Truck
 - Service Trucks
 - Utility Trailer
 - Water Storage
 - Diesel Tank

The facility needs assessment also identifies site needs associated with visitor and employee parking, site contingency (easements, setbacks, etc.), and landscaping and stormwater facilities. An allowance of 20,000 sf of new or rehabilitated paving is included in the Phase 1 cost estimate. These needs should be further defined during predesign of the Phase 1 site improvements.

Cost estimates for these support structures are provided in Table 5-1.

4.2.5 Recommendations

Based on the results of the alternative analysis, the following recommendations are presented:

1. Installation of a new Orbal® is recommended for expansion of the biological treatment. This alternative will increase capacity to Y2045 while maintaining the current process approach.
2. Addition of new industrial contributions shall be carefully evaluated and documented.

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3. UV disinfection was selected as the preferred disinfection method. It is recommended that the UV system be coupled with cloth media filtration to increase the reliability of the disinfection process.
4. UV transmittance and collimated beam tests are recommended to be conducted periodically across all four seasons to further understand the water quality characteristics for UV disinfection.
5. The solar dryer coupled with screw presses for dewatering is recommended for improvement of solids handling. This option will produce Class A Biosolids during most of the year.
6. A site visit to a wastewater treatment plant that currently uses solar drying technologies in similar climates is recommended to inquire about winter operations and potential odor issues.

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5.0 RECOMMENDED IMPROVEMENTS

This section describes recommended infrastructure improvements for the Redmond WPCF and outlines a financial plan to fund the improvements.

5.1 RECOMMENDED PLAN OVERVIEW

The recommended improvements plan includes installation of updated biological treatment, tertiary filtration, effluent disinfection and solids handling infrastructure at the WPCF. A preliminary site plan showing the improved infrastructure upgrades is presented in **Figure 5-1** below. The footprint of the new support facility adjacent to the current administration reflects the total area described in Chapter 4, however future design efforts will determine the precise configuration of the new building and whether or to what extent the existing facility remains in use. Note that offsite improvements including storage and vehicle parking at the solids drying facility and irrigation site are not shown.

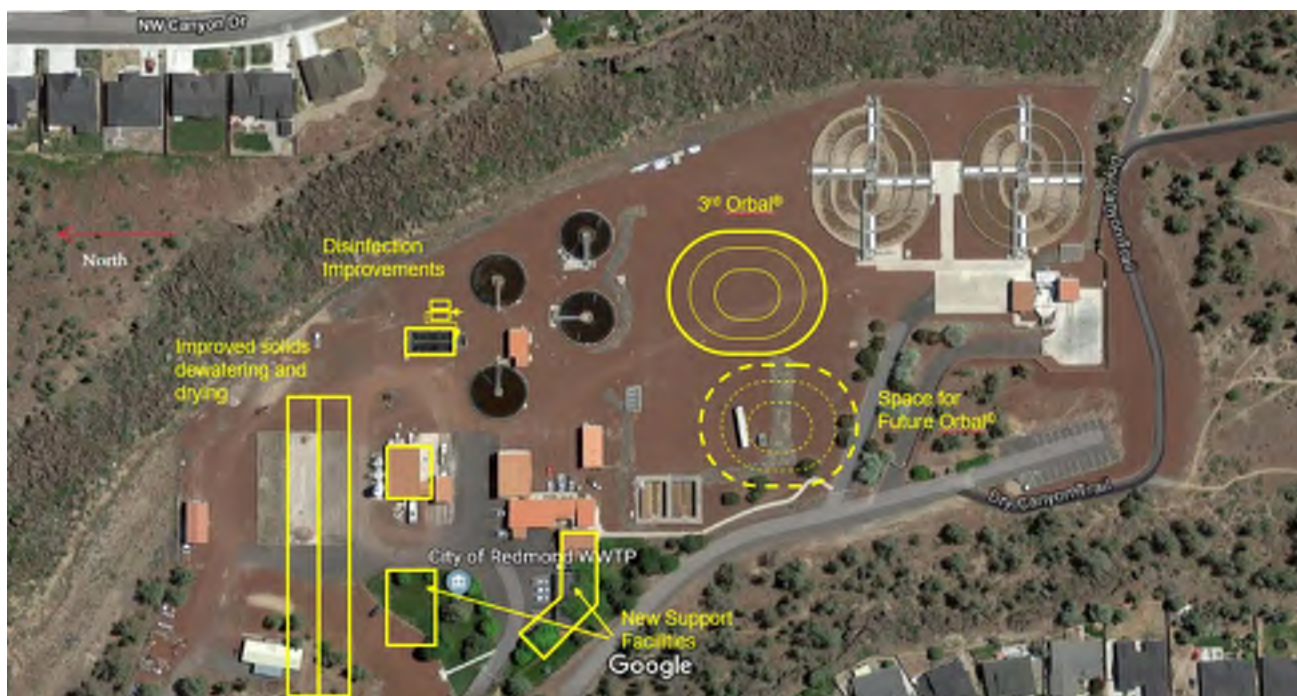


Figure 5-1: Recommended Infrastructure Improvements

5.2 PHASED IMPLEMENTATION PLAN

Analysis from Chapter 2 has shown that a number of projects are required at the WPCF in the near term including; biological process capacity expansion, expanded solids handling capabilities, and new disinfection facilities. These projects will likely be executed during a single phase of work (noted as Phase 1 below) which will help reduce overall project cost associated with three separate construction solicitations, each with mobilization/demobilization and other

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project specific costs and will provide full liquids and solids handling capabilities up to, and in some cases through 2045.

Redmond's treatment facility is expected to reach buildout capacity by mid-2050. The execution of Phase 2 projects includes projects intended to meet build-out needs. All costs presented in Phase 1 and Phase 2 are based on 2018 dollars escalated to the mid-point of construction and are based on design-bid-build delivery. Use of alternative delivery contracting and state or federal funding could impact the project construction cost. Assumptions are provided below. Some assumptions may be eligible for a sewer System Development Charge (SDC).

Phase 1 Assumptions:

- Disinfection is both a capacity expansion (SCD eligible) and a new treatment technology (partially SDC eligible) to reduce chlorides in the effluent waste stream.
- The solids handling expansion includes new facilities to achieve Class A biosolids (partially SDC eligible) and dewatering equipment replacement (SCD eligible).
- A standby engine generator will be added for additional electrical back-up needs
- New facilities will be provided at the sizes estimated to meet buildout needs. Remodeling and expanding the existing operations building may result in some cost savings.

Phase 2 Assumptions:

- New clarifier is 65-ft in diameter
- Tankage required for additional filtration and disinfection has been assumed to be constructed during Phase 1 and is therefore included in Phase 1 cost estimates.
- Costs for Phase 2 include installation of additional process equipment (filters and UV bulbs) only.

The City has also identified maintenance improvements that are outside the capital needs but may be most efficiently addressed as part of the Phase 1 improvements. These should be considered as Phase 1 design begins, to the extent that funding is available:

- Addition of flow measurement to Orbal units
- Replacement of outdated Programmable Logic Controllers (PLCs)
- Replacement of WAS pumps
- Upgrade of electrical equipment in RAS pump building
- Addition of Variable Frequency Drives (VFDs) to existing mixed liquor recycle pumps

5.3 BUILDOUT CAPITAL IMPROVEMENT PLAN

Phase 1 of the Capital Improvement Plan provides a broad capacity expansion as well as increased reliability of Class A biosolids production. Phase 1 includes a new Orbal oxidation ditch, addition of rotary disk cloth filtration to provide reliable effluent turbidity for UV disinfection, retrofit of the existing chlorine contact basins with UV disinfection, new solids dewatering equipment, and a new solar dryer facility. This will provide sufficient capacity to treat anticipated flow and loading through year 2045.

To meet buildout conditions, the Facility Plan allocates space for the addition of one more Orbal unit adjacent to the entrance road, additional clarifier and flow split structures north of the third Orbal, additional disinfection and filtration facilities, and an additional solar dryer unit. Expansion of dewatering capabilities would require a new dewatering building, however the dewatering equipment added in the Phase 1 improvements could also be operated for extended hours to increase dewatering capacity.

5.4 PRELIMINARY FINANCIAL PLAN

The City has several options to provide the necessary funding for the Phase 1 expansion. Funding options for the recommended improvements include:

- Existing Rate/SDC Revenue
- Revenue Bonds
- Full Faith and Credit Bonds
- Loan/Grant Funding

5.4.1 Current Rates and SDCs

The City's adopted FY 2019/20 Fiscal Year budget included a 1% increase in wastewater rates to support rising O&M costs and expected growth. The base monthly sanitary sewer rate is \$31.63 per single-family residential unit and \$24.59 per dwelling unit in multi-family residences. Commercial sewer accounts are charged the base monthly sanitary rate for discharge up to 7 ccf (hundred cubic feet) plus a volumetric charge based on waste strength and winter water consumption. Commercial accounts are classified as Low, Medium, High, or Very High discharges, with charges ranging from \$2.77 (per 100 ccf over base discharge) for low strength dischargers to \$4.72 for very high strength dischargers.

The sewer System Development Charge (SDC) was last adopted in 2008 and last increased in 2019. The current SDC is \$4,087 per equivalent dwelling unit, including a \$2,963 improvement fee and \$1,124 reimbursement fee. The last approved SDC resolution which increased SDCs also included a provision for annual adjustment of the wastewater SDC based on the annual Construction Cost Index published by the Engineering News-Record.

5.4.2 Other Funding Options

The City can pursue other funding sources to provide capital necessary for the Phase 1 improvements. These funding sources include:

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- **Revenue Bonds.** Revenue bonds are loans secured with revenue associated with the wastewater utility. SDC revenue is often used to secure revenue bonds, and bond repayment is made through debt service collected as part of the SDC.
- **Full Faith and Credit Bonds.** Full Faith and Credit bonds are also loans used for capital improvements, but they are backed by the taxing authority of the City and must ultimately be repaid through tax collection not specifically associated with the wastewater utility in the event wastewater utility revenues are unable to support the annual debt service.
- **Federal Loan Programs.** The Water Infrastructure Finance and Innovation Act (WIFIA) provides low-interest loans for regionally significant projects (\$20 million minimum project size for large communities; \$5 million minimum project size for communities of 25,000 or less).
- **State Grant and Loan Programs.** The Clean Water State Revolving Fund (CWSRF) allows public agencies to obtain low interest loans for planning, design, and construction of wastewater treatment projects. The Community Development Block Grant (CDBG) program administered by Business Oregon provides funding for projects that benefit low-and moderate-income residents or address serious and immediate threats. Business Oregon also administers the Special Public Works Fund (SPWF) which provides support for projects that enable economic and community development.
- **Grant Programs.** Energy Trust of Oregon provides funding to help communities offset capital investments in equipment replacement or facility upgrades that result in energy savings, offset energy demand, or produce energy.

5.4.3 Planned Funding Approach

The City is planning to fund Phase 1 improvements through a combination of Wastewater Fund revenue collected through SDCs and CWSRF loans. The Wastewater Fund had a balance of \$7.3 million at the beginning of FY2019/20, with \$0.5 Million allocated to reserves associated with previous loans and \$5.4 million allocated for support of the WPCF expansion. The remainder will be financed through a CWSRF loan.

Table 5-1: Phase 1 and Phase 2 Capital Projects

Item	2018 Construction Cost Plus Contingencies (Million \$)	Engineering, Admin, and CM (22%) (Million \$)	Total Capital Cost (Million \$)	Capacity Related % (SDC Eligible)	Non-SDC %	Total SDC Eligible Funding (Million \$)	Total Non-SDC Funding (Million \$)
Phase 1: 2018 - 2040 in Y2018 Fiscal Dollars							
<i>New Oxidation Ditch</i>							
Site Work	0.60	0.13	0.73	100%	0%	0.73	0.00
New Bioreactor	2.00	0.44	2.44	100%	0%	2.44	0.00
Mechanical Equipment	1.00	0.22	1.22	100%	0%	1.22	0.00
Power and Control Equipment	0.80	0.18	0.98	100%	0%	0.98	0.00
Allocation of Prime Cost (20%)	0.88	0.19	1.07	100%	0%	1.07	0.00
General Conditions and General Allowances (6.0%)	0.26	0.06	0.32	100%	0%	0.32	0.00
<i>New Disinfection and Filtration</i>							
Site Work	0.10	0.02	0.12	70%	30%	0.09	0.04
Mechanical Equipment	1.60	0.35	1.95	70%	30%	1.37	0.59
Power and Control Equipment	0.20	0.04	0.24	70%	30%	0.17	0.07
New Disinfection and Filtration Basin	1.30	0.29	1.58	70%	30%	1.11	0.47
Allocation of Prime Cost (20%)	0.639	0.14	0.78	70%	30%	0.55	0.23
General Conditions and General Allowances (6.0%)	0.192	0.04	0.23	70%	30%	0.16	0.07
<i>New Solids Handling Facilities</i>							
Site Work	0.20	0.04	0.24	70%	30%	0.17	0.07
Solids Dewatering Building and Equipment	1.45	0.32	1.77	70%	30%	1.24	0.53
Odor Control	0.30	0.07	0.37	70%	30%	0.26	0.11
Mechanical Equipment	3.65	0.80	4.45	70%	30%	3.12	1.34
Power and Control Equipment	0.20	0.04	0.24	70%	30%	0.17	0.07
Allocation of Prime Cost (20%)	1.16	0.26	1.42	70%	30%	0.99	0.42
General Conditions and General Allowances (6.0%)	0.35	0.08	0.42	70%	30%	0.30	0.13
<i>New Standby Generator</i>							
Generator	0.75	0.17	0.92	100%	0%	0.92	0.00
<i>New Support Facilities</i>							
General Site Work	0.20	0.07	0.26	70%	30%	0.18	0.08
Heated Equipment Parking	2.06	0.72	2.78	50%	50%	1.39	1.39
Covered Parking and Storage	0.56	0.26	0.83	90%	10%	0.75	0.08
Administration & Operations	4.28	1.52	5.80	60%	40%	3.48	2.32
Total Phase 1, Y2018	24.7	6.5	31.2			23.2	8.0
Total Phase 1, Escalated to Y2021*	28.4	7.4	35.8			26.6	9.2
Phase 1A: Additional Odor Control Additions (2025)							
Odor Control			1.00	0%	100%	0.00	1.0
Total Phase 2, Y2018			1.0				1
Total Phase 1A, Escalated to Y2025*			1.3				1.3
Phase 2: 2040 - Buildout (2050) in Y2018 Fiscal Dollars							
<i>New Oxidation Ditch, Clarifier and Splitter Box</i>			8.80	100%	0%	8.80	0.0
<i>Additional Disinfection and Filtration</i>			1.00	100%	0%	1.00	0.0
<i>Additional Solar Dryer Unit and Dewatering Equipment</i>			2.50	100%	0%	2.50	0.0
Total Phase 2, Y2018			12.30			12.3	
Total Phase 2, Escalated to Y2040*			26.2			26.2	
Total All Phases, Y2018			44.5			35.5	9.0
Total All Phases*			63.3			52.8	9.2

*Assumes 3.5% inflation rate per year

WASTEWATER FACILITY PLAN AMENDMENT - 2020



Prepared for the
City of Redmond, Oregon

WASTEWATER FACILITY PLAN AMENDMENT
FOR
CITY OF REDMOND, OREGON

2020



ANDERSON PERRY & ASSOCIATES, INC.

La Grande, Redmond, and Hermiston, Oregon
Walla Walla, Washington

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Preface

The City of Redmond, Oregon, contracted Anderson Perry & Associates, Inc., to conduct a Lagoon and Wetland Treatment and Disposal Feasibility Evaluation (Evaluation), completed in July 2020 for wastewater treatment alternatives and, subsequently, this Wastewater Facility Plan Amendment (Amendment) to their 2019 Update of the Wastewater Facility Plan (WWFP). This Amendment summarizes the results of the Evaluation and is intended to supplement and not replace the WWFP. Therefore, this Amendment will closely follow the outline of the WWFP to best synchronize the contents of each document. Detailed background on the City of Redmond's physical environment, planning and service area, and existing infrastructure can be found in the WWFP.

Sections that are not addressed in this Amendment can be referred to in the original WWFP.

A1.0 Basis of Planning

A1.1 Introduction and Need for the Project

The City recently completed a WWFP Update in November 2019. The WWFP established a basis of planning, existing facilities evaluation, regulatory requirements, alternatives analysis, and recommended improvements. Several alternatives were evaluated as seen in Section 4.0 of the WWFP; however, all considered alternatives included expanding the existing mechanical treatment plant at its current location. The City wished to also consider abandoning the constrained site of the existing mechanical treatment plant and evaluate the option of lagoon and wetland treatment and disposal. The purpose of this Amendment is to update the design criteria to the year 2045 and add an alternative for a lagoon treatment system with a constructed wetland treatment and disposal system to meet the City's needs.

A1.5 Existing and Future Population, Flows, and Loads

Remaining consistent with the WWFP, this Amendment uses the Portland State University: Oregon Population Forecast Program to estimate future population data. The data suggest the population in Redmond may increase to approximately 54,000 by the end of 2045.

Historic flow data used for this Amendment differ from that used in the WWFP due to a correction in data collected by the City. In October 2019, the City discovered the influent flowmeter was not reading correctly. This provided flows that were less than actual; therefore, the design criteria used in the WWFP were not accurate. The flowmeter has been recalibrated, and the following corrections have been made, along with clarifications:

- **Population - 53,800.** As used in the WWFP.
- **Average Annual Flow - 4.34 million gallons per day (MGD).** A review of the influent flows between January 2015 and October 2019 showed the average per capita flow to be 65.2 gallons per capita per day (gpcd). This flow is a little lower than what would normally be expected. After the flowmeter was reset, the flows between November 2019 and June 2020 were 80.8 gpcd, which provided an increase of 15.6 gpcd. This is in the range normally seen for communities in this region. This increase was added to the flow records before October 2019 to obtain a more accurate indication of historic influent flows. The per

capita flow was then used with the design population to determine the average annual design flows.

- **Maximum Month Flow - 4.51 MGD.** The adjusted per capita flows noted above were used for the highest flow month of each year. These were then averaged and multiplied by the design population.
- **Average Annual Five-day Biochemical Oxygen Demand (BOD₅) - 501 milligrams per liter (mg/L), 18,134 pounds per day (ppd).** The average annual concentration was used with the design flows to determine loadings.
- **Maximum Month BOD₅** - A review of the historic data show the maximum flow months produce less BOD₅ loading than the average. For this reason, the average annual loading should be used.
- **Average Annual Total Suspended Solids (TSS) - 353 mg/L, 12,777 ppd.** The historic average concentration was used with the design flow.
- **Maximum Month TSS - 357 mg/L, 13,428 ppd.** The historic average concentrations from each of the annual maximum months were used with the design maximum month flow to obtain the loading.
- **Average Annual Total Kjeldahl Nitrogen (TKN) - 65 mg/L, 2,353 ppd.** The design concentration from the WWFP Update was used with the flow above.
- **Maximum Month TKN - 75 mg/L, 2,821 ppd.** The design concentration from the WWFP Update was used with the flow above.
- **Peak Hour Flow - 11.63 MGD.** The WWFP Update indicated the peak hour flow can be calculated using a peaking factor of 2.68 with the average annual flow.

A1.6 Summary

The updated projected flows and loads used in this Amendment compared to those used in the WWFP can be seen on Tables 1-1 and 1-2. The projections presented on Table 1-2 are used in the following sections.

**TABLE 1-1
PROJECT FLOWS AND LOADS FROM THE WASTEWATER FACILITY PLAN**

Year	Population	Average Annual Flow, MGD	Maximum Month BOD ₅ Load, ppd	Maximum Month TSS Load, ppd	Maximum Month TKN Load, ppd
2017	28,800	1.90	9,800	7,000	1,200
2020	30,700	2.00	10,800	8,200	1,400
2025	34,400	2.20	12,100	9,200	1,500
2030	38,600	2.50	13,600	10,300	1,700
2035	43,200	2.80	15,200	11,600	2,000
2040	48,400	3.10	17,100	13,000	2,200
2045	53,800	3.50	19,000	14,400	2,400

TABLE 1-2
UPDATED PROJECT FLOWS AND LOADS

Year	Population	Average Annual Flow, MGD	Max Month BOD5 Load, ppd	Max Month TSS Load, ppd	Max Month TKN Load, ppd
2017	28,800	2.33	10,088	7,188	1,510
2020	30,700	2.48	10,753	7,662	1,610
2025	34,400	2.78	12,049	8,586	1,804
2030	38,600	3.12	13,520	9,634	2,024
2035	43,200	3.49	15,131	10,782	2,265
2040	48,400	3.91	16,953	12,080	2,538
2045	53,800	4.34	18,134	13,428	2,821

A3.0 Regulatory Requirements

Section 3 of the WWFP outlines the current water quality standards under the Water Pollution Control Facilities (WPCF) Permit that the City must comply with, as well as potential future regulatory considerations. As this Amendment is focused on evaluating the alternative of lagoon and wetland treatment and disposal, regulatory considerations surrounding this alternative will be outlined.

The City's current WPCF Permit for the existing mechanical treatment plant would be abandoned with the construction of an entirely new treatment system. The existing mechanical treatment plant provides secondary treatment through the use of an activated sludge process with discharge to groundwater via an infiltration gallery. The system proposed in this Amendment would utilize aerated lagoons for secondary treatment, lined constructed wetlands for tertiary treatment, and unlined disposal wetlands with the existing infiltration basins for effluent disposal. The added wetland treatment and disposal areas will enhance water quality using more natural processes but will be completely different than the existing facilities. The new treatment system will require that a new WPCF Permit be obtained. For this reason, an initial meeting was held with Oregon Department of Environmental Quality (DEQ) staff to discuss this treatment and disposal alternative with respect to a new permit. Generally, the DEQ is supportive of this option and feels that it can be permitted.

Since a new permit will be required but not yet obtained, the existing groundwater protection (Oregon Administrative Rules [OAR] 340-040) and effluent reuse rules (OAR 340-055) will be used for guidance in the evaluation of the lagoon and wetland alternative. The contaminate of specific note for groundwater protection from the proposed facility is a Nitrate - N limit of 10 mg/L. No other contaminants shown on OAR 340-040 Tables 1, 2, and 3 are anticipated to be at levels of concern in the treated effluent.

Effluent reuse is governed by OAR 340-055 and an approved Reclaimed Water Use Plan. Currently, the City irrigates crops not for human consumption using Class C effluent. This type of reuse only requires Class D or non-disinfected effluent based on the OARs. The existing WPCF Permit requires Class D effluent for discharge to the infiltration beds. The proposed treatment system would disinfect secondary effluent prior to discharging to treatment wetlands, then disposal wetlands, and ultimately an infiltration gallery. It is proposed that the wetland area be accessible to the public for non-contact use of adjacent walking paths for wildlife viewing and exercise. The area will be posted to prevent human contact with wetland water. For this use, disinfecting the effluent to a Class D level prior to discharging to the treatment wetland is proposed. The natural wetland system and wildlife use would make disinfection limits after the treatment wetland unpredictable.

A4.0 Alternatives Analysis

The City conducted an extensive alternatives analysis as seen in Section 4.0 of the WWFP. Along with the preferred mechanical treatment plant expansion alternative, the City can consider two additional alternatives: using lagoons and wetlands to provide the treatment capacity needed for the future and continue using the headworks and office space at the existing facility, or moving the entire treatment system, offices, and shops to a new location. These three options will be compared considering capital cost, life cycle cost, land and future expandability, and community benefits.

A4.1 Lagoon Treatment

Lagoon treatment can be provided with a facultative lagoon, partially aerated lagoon, or aerated lagoon.

A4.1.1 Facultative

A facultative lagoon provides oxygen for waste decomposition from an air/water interface area and algae photosynthesis. This system would be a minimum two-stage system operating between 3 and 7 feet in depth, with a minimum detention time of approximately 100 days. For this evaluation, an operating depth between 4 and 5 feet was assumed, and the detention time would be well in excess of 100 days due to the area needed for oxygen transfer. The first stage would need to be 290 acres and the second stage would need to be 190 acres, for a total lagoon size of 480 acres. For construction purposes, it is suggested to divide these lagoon cells into maximum 40-acre units. Then, there would be approximately 12 40-acre lagoons.

Solids handling would not be required for this option. Lagoon solids would be anticipated to be removed approximately once every 40 years, once the lagoons reach their design BOD₅ loading. A multi-cell lagoon system would allow a lagoon cell to be taken offline and solids to dry in the bottom of the lagoon for easy and cost-effective removal.

This lagoon type can reduce total nitrogen 40 to 95 percent. A removal efficiency of approximately 85 percent is needed to meet existing WPCF Permit limits. For this reason, adding a treatment wetland for effluent polishing would be recommended.

A4.1.2 Partially Aerated

A partially aerated lagoon would provide some of the oxygen requirements through an aeration system. For purposes of this evaluation, it was assumed that the oxygen for the first stage of the facultative lagoon system would be provided through mechanical aeration. Approximately 2 pounds of oxygen per pound of BOD₅ removed is used in this evaluation to include both BOD₅ and nitrogen reduction, and approximately 2 pounds of oxygen per horsepower (Hp) per hour can be assumed for an aeration system. The first-stage aeration system would mainly be used to increase the dissolved oxygen in the wastewater so it is available for microbial use and provide oxygen that would be consumed during the time water is in this cell. The detention time in this lagoon would be approximately three days. This first stage of the lagoon would then be approximately 10 feet deep to provide for aeration. Approximately 360 Hp of aeration would be needed. This would require a first-stage lagoon of approximately 3.5 acres. The second stage would then be approximately 190 acres and constructed mainly as a facultative system to provide both aerobic and anoxic microbial colonies, but this area would not provide enough

oxygen for the BOD₅ loading, so approximately 240 Hp of additional aeration would still be needed in the second stage.

As with the facultative lagoons, solids handling would not be proposed for this system. Solids reduction would occur naturally in the second-stage lagoons, but solids removal from the lagoons may still be needed approximately every 30 years.

This lagoon type can reduce total nitrogen 40 to 95 percent. A removal efficiency of approximately 85 percent is needed to meet existing WPCF Permit limits. For this reason, it is recommended a treatment wetland be added for effluent polishing.

A4.1.3 Aerated

An aerated lagoon would provide sufficient oxygen through aeration systems. A partially mixed, aerated lagoon would consist of five cells with a total detention time of 20 days. The 20-day detention time is on the longer end of what would normally be anticipated, but it provides a factor of safety and capacity to realize increased reduction in total nitrogen. A total requirement of approximately 750 Hp is needed to provide the required oxygen. The depth of the lagoon cells would be approximately 11 feet. The total wet area needed would be approximately 25 acres.

Solids handling would not be anticipated for this option, as solids reduction would occur in the lagoon cells. Solids removal is still anticipated to be needed approximately once every 20 years, once the flows and loadings reach design levels.

This lagoon type can reduce total nitrogen 60 to 95 percent. A removal efficiency of approximately 85 percent is needed to meet existing WPCF Permit limits. For this reason, a treatment wetland would be recommended to be added for effluent polishing.

A4.1.4 Aerated Lagoon with Orbal Aeration

This alternative utilizes the existing capital investment in the Orbal aeration system to provide pre-aeration and reduce the total capital and operation and maintenance (O&M) requirements at the new lagoon site. The Orbal aeration system capacity would provide enough oxygen to reduce the anticipated BOD₅ loads on the proposed lagoon treatment system to approximately 9,000 ppd. This alternative would abandon the existing mechanical treatment plant facilities except for the headworks, two Orbal units, and one clarifier and associated sludge pump. The clarifier would harvest biosolids (microorganisms) from the ditch effluent and send it back to the ditch. The effluent from the ditches and clarifier would then be combined with any raw wastewater not sent to the ditch. The combined flows would then be sent to the aerated lagoons. This would reduce the total required at the aerated lagoon to approximately 375 Hp, the required detention time to 15 days, and the lagoon size from 23 to 17 acres.

Solids handling and nitrogen reduction would be similar to the aerated lagoon option.

Table 4-1 shows a summary of costs for these treatment alternatives.

**TABLE 4-1
SUMMARY OF LAGOON ALTERNATIVES**

	FACULTATIVE LAGOON	PARTIALLY AERATED LAGOON	AERATED LAGOON	ORBAL PLUS AERATED LAGOON
Mobilization/Demobilization (5% of Construction Cost)	\$1,020,000	\$800,000	\$430,000	\$250,000
Earthwork	1,750,000	860,000	678,000	564,000
Rock Removal	9,680,000	3,876,000	1,920,000	486,000
Liner	21,000,000	8,712,000	1,089,000	828,000
Control Structures	180,000	75,000	60,000	60,000
Piping	336,000	216,000	120,000	120,000
Gravel	162,000	76,000	28,000	22,000
Diffusers	0	1,200,000	1,500,000	900,000
Blowers	0	650,000	800,000	480,000
Blower Building	0	240,000	360,000	240,000
Electrical and Controls	0	500,000	600,000	500,000
Fencing	126,000	60,000	30,000	30,000
Site Work	50,000	50,000	50,000	50,000
Sum of Estimated Construction Cost	\$34,304,000	\$17,315,000	\$7,665,000	\$4,530,000
Construction Contingency (15%)	5,146,000	2,597,000	1,150,000	680,000
Subtotal Estimated Construction Cost	39,450,000	19,912,000	8,815,000	5,210,000
Administration, Legal, and Engineering (10% to 20%)	3,945,000	3,982,000	1,763,000	1,042,000
Total Capital Costs	43,395,000	23,894,000	10,578,000	6,252,000
20-year Estimated O&M Cost	3,029,000	7,976,000	8,923,000	8,462,000
Total Estimated 20-year Life Cycle Cost (2020 Dollars)	\$46,424,000	\$31,870,000	\$19,501,000	\$14,714,000

As seen on Table 4-1, the option of using a facultative or partially aerated lagoon is cost prohibitive due to the overall size and amount of liner required. Further examination of the aerated lagoon and using the City's existing Orbal system plus an aerated lagoon is analyzed considering operational impacts, long-term maintenance, location, odor concerns, future flexibility, energy efficiency, and community benefits. This analysis indicates the aerated lagoon alternative should be pursued by the City. Results of the comparison are included in Section A4.5.

A4.2 Wetlands

Wetlands are a natural treatment system that provide an environment for the healthy growth of microbial colonies that decompose organic materials and return them to their basic molecular structures. For example, complex hydrocarbons found in organic materials are consumed by microbes for their stored energy and turned into carbon dioxide, water, nitrogen gas, and phosphorus. In general, wetlands provide food and shelter for a wide variety of microbes, macro-invertebrates, insects, amphibians, waterfowl, upland birds, mammals, and all forms of life in a complex ecosystem.

A4.2.1 Treatment Wetlands

After biologic stabilization of the waste is provided in the lagoon system, the lagoon effluent should be further “polished” in treatment wetlands to provide a more natural environment to further reduce pathogens and nutrients. The wetlands would provide a shallow surface flow system for increased exposure to light and encourage vegetation growth. The vegetation in the wetlands would provide a substrate for attached growth microbial colonies that would provide for nitrification of any remaining ammonia. Denitrification would then be provided in the bottom anoxic layers of the wetlands and in deeper sections built into the environment. The treatment wetlands would be sized for a six-day detention time at an average depth of 12 inches. The treatment wetland would have a liner installed under 12 inches of native material in which vegetation would grow. The wetland would be seeded and planted. This would require a wetland complex with approximately 70 wet acres. Additional nitrogen reduction would be provided in the wetlands, but nitrogen reduction would be improved when multiple wetland cells constructed in series are provided. See Table 4-2 for a preliminary estimated project cost for these improvements.

TABLE 4-2
TREATMENT WETLAND COST ESTIMATE

Mobilization/Demobilization (5% of Construction Cost)	\$400,000
Earthwork	402,000
Rock Removal	1,944,000
Liner	3,050,000
Control Structures	90,000
Piping	240,000
Gravel	42,000
Topsoil Removal and Replacement	904,000
Seeding and Planting	20,000
Fencing	42,000
Sum of Estimated Construction Cost	\$7,134,000
Construction Contingency (15%)	1,070,000
Subtotal Estimated Construction Cost	8,204,000
Administration, Legal, and Engineering (20%)	1,640,000
TOTAL ESTIMATED PROJECT COST (2020 DOLLARS)	\$9,844,000

A4.2.2 Disposal Wetlands

The existing disposal system utilized by the City is through irrigation and seepage. The area proposed for facility construction contains a concrete sealed irrigation storage pond that holds water and a seepage area that leaks at a high rate. The size of disposal wetlands would depend on their seepage rate. Due to the function of the seepage area and the standing water from the irrigation ditch return water, it is assumed that the natural ground could provide very high infiltration rates or low infiltration rates. The existing seepage area has multiple cells with only one cell operating at a time. Based on current operation, the seepage area appears to have sufficient capacity to serve the City in the future. For this reason, the disposal wetlands are not necessarily needed, but there is an opportunity to beneficially use the effluent in a wetland

environment that could be accessible to the public. This would provide a natural wildlife and park area. It is suggested to set aside approximately \$4,000,000 for construction of publicly accessible wetland and wildlife park features as disposal wetlands between the treatment wetlands and the existing seepage area.

A4.3 Disinfection

After the wastewater is treated in the lagoon system, it would be disinfected. The alternatives for wastewater disinfection that would normally be considered include chlorine, ultraviolet (UV), and ozone. Using lagoon treatment prior to disinfection would make UV and ozone somewhat unreliable due to uncontrolled interferences with disinfection efficiency that come from the lagoon treatment system. For this reason, chlorine disinfection is recommended.

The disinfected lagoon effluent would then flow to the existing irrigation storage pond or into a 70-acre treatment wetland complex before entering a disposal wetland and infiltration basin area for evaporation and seepage into groundwater. The total project cost for this system is summarized on Table 4-3.

**TABLE 4-3
DISINFECTION SYSTEM ESTIMATED PROJECT COST**

Mobilization/Demobilization (5% of Construction Cost)	\$66,000
Building	200,000
Chlorination Equipment	40,000
Chlorine Contact Basin	280,000
Electrical and Controls	100,000
Piping	12,000
Rock Removal	60,000
Gravel	2,000
Steel Building over Basin	500,000
Sum of Estimated Construction Cost	\$1,260,000
Construction Contingency (15%)	189,000
Subtotal Estimated Construction Cost	1,449,000
Administration, Legal, and Engineering (20%)	290,000
TOTAL ESTIMATED PROJECT COST (2020 DOLLARS)	\$1,739,000

A4.4 Support Facilities

Additional support facilities are necessary for all three alternatives. As shown in the WWFP, recommended support facilities upgrades total \$7,100,000. Similar facilities are needed for both the Orbal plus Aerated Lagoon and Lagoon systems. However, continued use of the Orbal system would not require a new headworks, grit chamber, or septage dump. Support facility costs for the lagoon options are shown on Table 4-4.

**TABLE 4-4
SUPPORT FACILITIES COST ESTIMATE**

Mobilization/Demobilization (5% of Construction Cost)	\$600,500
Main Division Building	2,187,500
Maintenance Building	2,100,000
Generator Building	64,000
Roads and Parking	352,000
Operations Building (Motor Control Centers, Control Room, Lab)	750,000
Lift Station	400,000
Vacuum Truck/Septage Dump	90,000*
Sludge Drying Beds	2,250,000
Domestic Water	400,000
Fencing/Site Work	100,000
Headworks	400,000*
Rock Removal	12,000
Electrical and Controls	700,000
Site Piping	240,000
Grit Chamber	300,000*
Rock Processing	250,000
Sum of Estimated Construction Cost	\$11,196,000
Construction Contingency (15%)	1,679,000
Subtotal Estimated Construction Cost	12,875,000
Administration, Legal, and Engineering (20%)	2,575,000
TOTAL ESTIMATED PROJECT COST (2020 DOLLARS)	\$15,450,000

**Not included in the Orbal plus Aerated Lagoon option.*

A4.5 Ranking

The aerated lagoon, existing Orbal aeration system plus aerated lagoon, and recommended expansion of the existing mechanical treatment plant from the WWFP are considered the viable alternatives to be ranked for comparison purposes. The selection of a preferred alternative from a variety of viable alternatives should consider several factors. The factors could include capital cost, total life cycle cost, ease of operation, maintenance, construction risk, odor concerns, future flexibility, energy efficiency, community benefits, and location. Each of these factors does not bear the same level of importance, so a weight factor is also added to assign more value to the more important factors. The factors, their ranks, and the weighted rankings are shown on Table 4-5 below.

**TABLE 4-5
ALTERNATIVE RANKINGS**

Criterion (Weight)	Ranking (Weighted Ranking)		
	Aerated Lagoon	Orbal Plus Aerated Lagoon	Expand Existing Mechanical Treatment Plant
Capital Cost (2)	\$41.6 million 2 (4)	\$38.5 million 3 (6)	\$47.7 million 1 (2)
Life Cycle Cost (3)	\$53.9 million 2 (6)	\$52.8 million 2 (6)	\$62.0 million 1 (3)
Ease of Operation (1)	3 (3)	1 (1)	2 (2)
Maintenance (2)	3 (6)	2 (4)	1 (2)
Construction Risk (2)	1 (2)	1 (2)	2 (4)
Odors (2)	3 (6)	2 (4)	1 (2)
Future Flexibility (1)	2 (2)	2 (2)	1 (1)
Expandability (3)	3 (9)	3 (9)	1 (3)
Energy Efficiency (1)	3 (3)	2 (2)	1 (1)
Community Benefit (2)	3 (6)	2 (4)	1 (2)
Regulatory Flexibility (3)	3 (9)	2 (6)	1 (3)
Location (2)	3 (6)	2 (4)	1 (2)
Total (Weighted Total)	31 (62)	24 (50)	14 (27)

Notes:

1. Highest Ranking = 3, Intermediate Ranking = 2, Lowest Ranking = 1. Weighted ranking is obtained by multiplying the ranking by the weight.
2. Costs for expand mechanical treatment plant are taken from the WWFP and inflated 2 years at 3.5 percent.

A5.0 Recommended Improvements

Based on the analysis above, the alternative to move the entire treatment system, offices, and shops to a new location is proposed. The improvements would include an aerated lagoon system for secondary treatment with a lined treatment wetland for effluent polishing. Disposal would be through reuse in an unlined wetland and the existing infiltration gallery. Primary treatment would be provided with screening and grit removal. Figure 1 shows the proposed treatment process flow schematic and the following details describe each process. Figures 2 and 3 show a conceptual layout on the proposed site. These figures show some of the improvements on property not owned by the City, yet the layout could be modified to utilize City-owned property for everything but the disposal wetlands and infiltration gallery (seepage beds).

A5.1 Headworks (Primary Treatment)

The headworks consists of a screening system to remove rags and debris in wastewater. The headworks would have two rotary drum screens sized for the peak hour flow. Moving the existing screens to the new location is proposed.

After screening, wastewater will flow through a grit chamber where grit would be settled and pumped to a grit classifier for dewatering and disposal in a landfill. An aerated grit chamber could be used since air should be available from the lagoon blowers. The aerated grit chamber would provide approximately three minutes of detention time at peak flow and be dual chambered with approximately 1,620 cubic feet in volume in each chamber. The basins would each be approximately

6 feet deep, 10 feet wide, and 30 feet long. Approximately 300 cubic feet per minute of air would be needed to run the chambers. A vortex pump would remove the settled grit from a sump in the bottom of the chamber and pump it to a dewatering system.

A lift station would be added to pump the screened and de-gritted wastewater to the aerated lagoons. This lift station would meet Level 2 reliability with approximately four submersible pumps each rated at 2,020 gallons per minute.

A5.2 Aerated Lagoon (Secondary Treatment)

A partially mixed, aerated lagoon would consist of five cells with a total detention time of 20 days. A total requirement of approximately 750 Hp would be needed to provide the required oxygen. The operating depth of the lagoon cells would be approximately 11 feet. The total wet area needed would be approximately 25 acres.

The five-cell aerated lagoon system would include a final settling cell area that is a minimum of 2 acres in size to provide adequate solids settling. To avoid needing to clean all ponds at one time, the City could install a small drying bed area with dredge piping from the lagoon cells to the drying beds. City crews could then operate a dredge to pump solids from the bottom of the lagoons to the drying beds on a regular maintenance interval. Even with these improvements, it is anticipated it will take several years before there is enough accumulated biosolids in the bottom of the lagoons to be removed with a dredge.

A treatment wetland for effluent polishing would be recommended. To provide added operator flexibility, improvements could be completed that would allow for a future low head recycle pump to be easily added to recycle nitrified effluent to the first aerated lagoon for denitrification and added total nitrogen reduction.

A5.3 Treatment Wetlands

After biologic stabilization of the waste is provided in the lagoon system, the lagoon effluent should be further “polished” in lined treatment wetlands to provide a more natural environment to further reduce pathogens and nutrients. The wetland would be seeded and planted. This would require a wetland complex with approximately 70 wet acres.

A5.4 Disposal Wetlands and Infiltration Gallery

The existing disposal system utilized by the City is through irrigation and seepage. The area proposed for facility construction contains a concrete sealed irrigation storage pond that holds water and an infiltration gallery that leaks at a high rate. The proposed construction site also contains two irrigation tailwater ponds that hold water. The size of disposal wetlands would depend on the seepage rate of the wetlands. Due to the function of the seepage area, it is assumed that the natural ground could provide high infiltration rates, but the tailwater ponds indicate there are areas that could hold water. The existing seepage area has four cells with only one or two cells operated at a time. Based on current operation, the seepage area appears to have sufficient capacity to serve the City in the future.

A5.5 Capital Cost and Life Cycle Cost

The total estimated capital and life cycle cost for moving the treatment plant is summarized on Table 5-1.

**TABLE 5-1
NEW LAGOON AND WETLAND TREATMENT PLANT
WITH SUPPORT FACILITIES AT NEW SITE**

Item	Estimated Capital Cost	Estimated 20-year Life Cycle Cost
Aerated Lagoon	\$10.6 million	\$19.5 million
Disinfection System	1.7 million	2.4 million
Treatment Wetlands	9.8 million	10.4 million
Disposal Wetlands	4.0 million	4.1 million
Headworks and Support Facilities	15.5 million	17.5 million
Total	\$41.6 million	\$53.9 million

A5.6 Other Beneficial Uses

Although these recommended improvements focus on constructing new wastewater treatment and disposal facilities, considerations could be given to developing other beneficial uses with reclaimed water from the wastewater treatment plant.

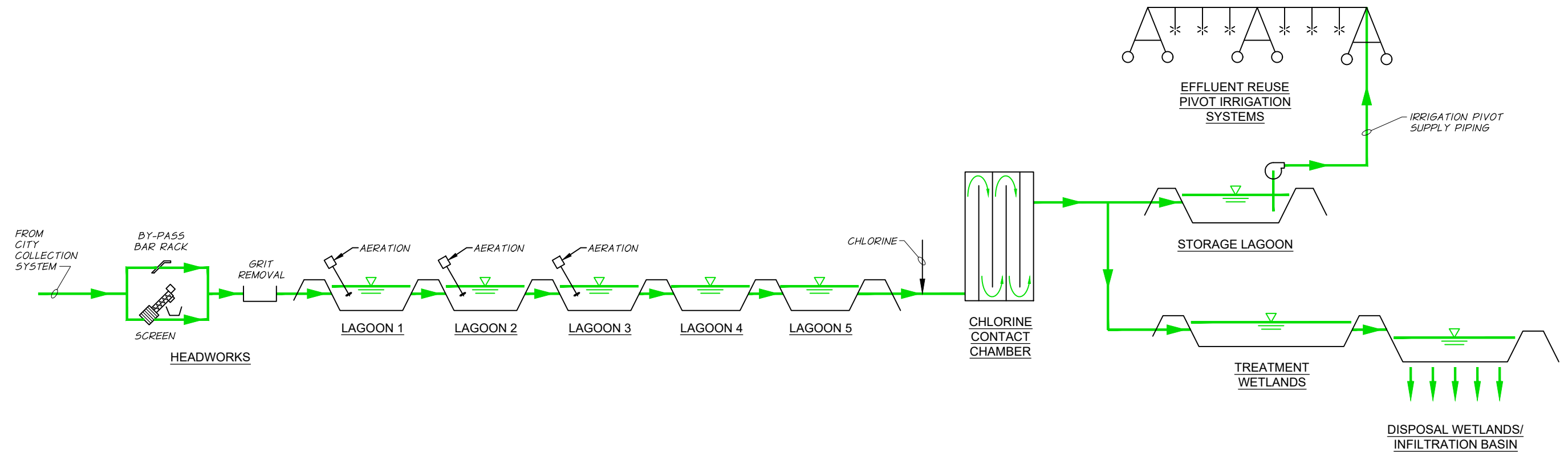
The City could construct public trails, viewing areas, and parking for public access to the wetland areas that will be home to a variety of birds and other wildlife. This trail system through the wetland areas could also be tied to a City-wide trails system as an extension to Dry Canyon. The reuse of the reclaimed water in this manner provides an ancillary benefit to the City that is otherwise not realized.

The City could also utilize treated effluent for additional beneficial uses such as irrigating turf grass for new sports fields in the area. Some added effluent polishing may be needed, depending on the proposed beneficial use. At this time, the City is not planning on changing the current irrigation practices.

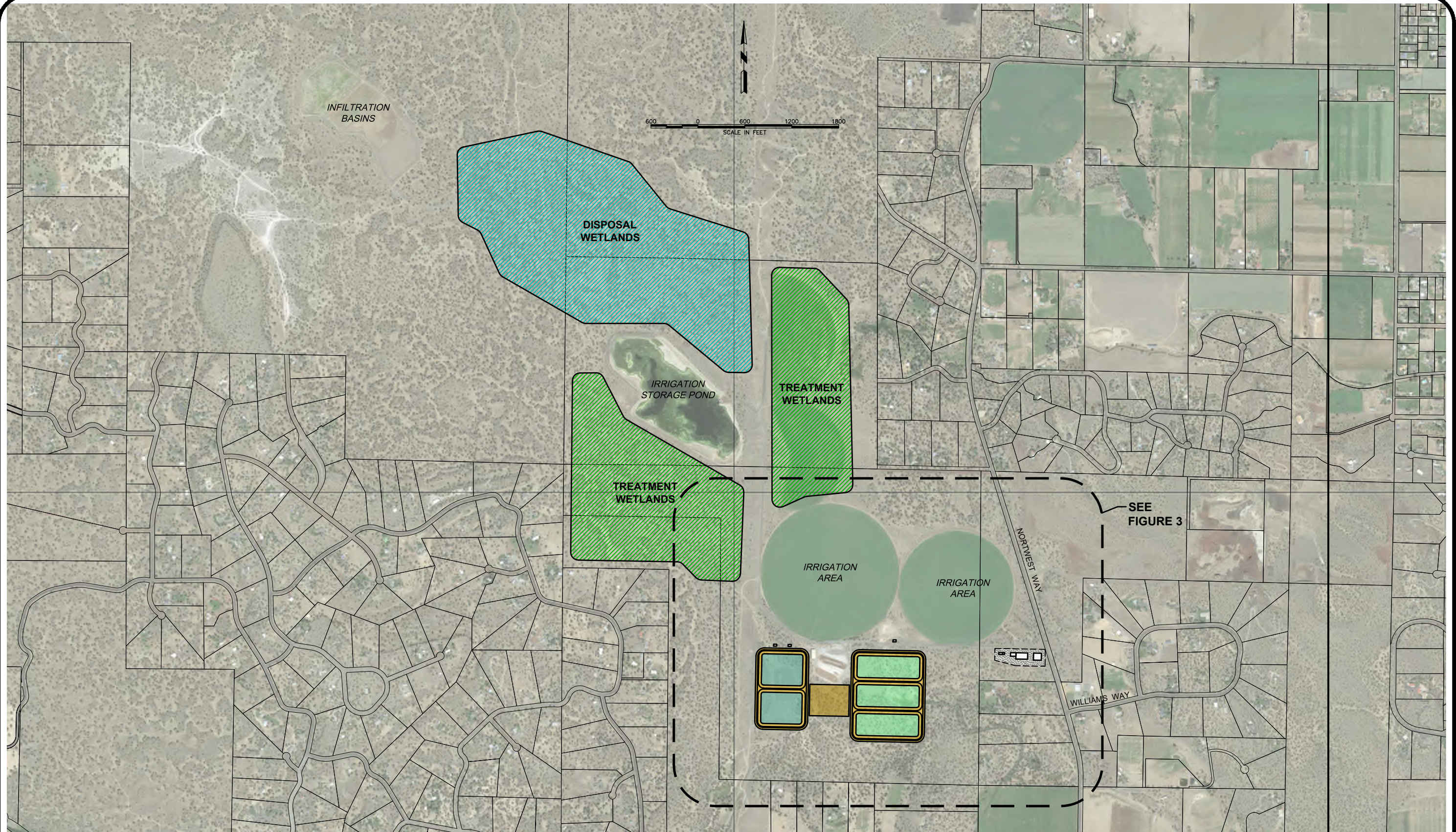
As improvements are pursued for implementation, these other beneficial uses could be considered.

FIGURES

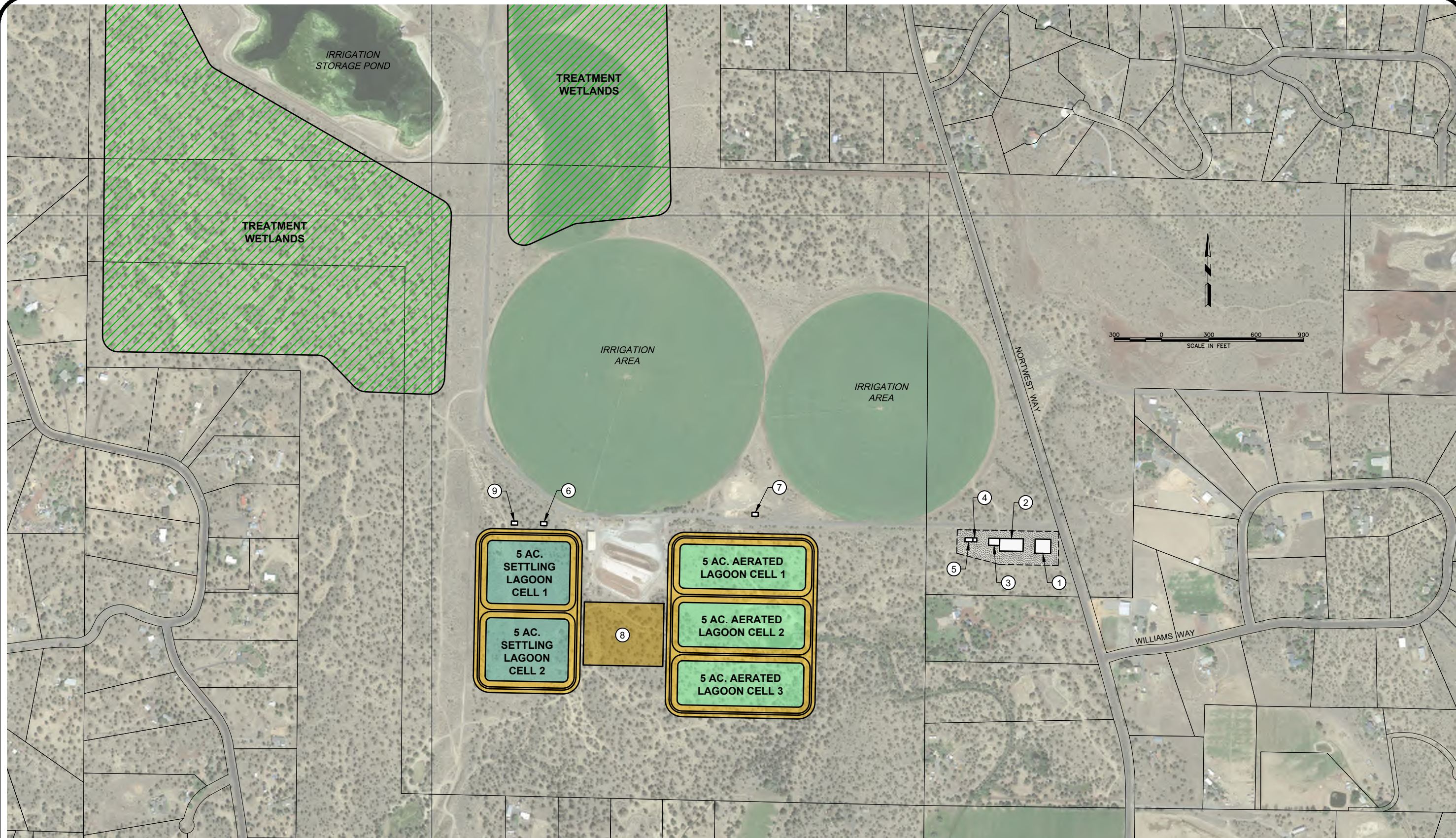
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R:\Redmond\59-00_Reclaimed WwWetlandReuseFeas\Drafting\59-00-020C-100_PRESITE-ALL.dwg, Layout1, 6/15/2020 5:03 PM, dchristman



R:\Redmond\59-00 Reclaimed Ww\WellndReuseFeas\Drafting\59-00-020C-101 PRESITE.dwg, Layout1, 6/15/2020 5:02 PM, dchristman



IMPROVEMENTS SCHEDULE

- | | |
|--|-----------------------------|
| ① MAIN DIVISION BUILDING (8,750 SQ. FT.) | ⑥ DISINFECTION BUILDING |
| ② MAINTENANCE BUILDING (12,000 SQ. FT.) | ⑦ BLOWER BUILDING |
| ③ OPERATIONS BUILDING (3,000 SQ. FT.) | ⑧ FUTURE SLUDGE DRYING BEDS |
| ④ VAC-TRUCK/SEPTAGE DUMP | ⑨ CHLORINE CONTACT BASIN |
| ⑤ HEADWORKS (SCREENS AND LIFT STATION) | |



**CITY OF
REDMOND, OREGON**
RECLAIMED WATER WETLAND REUSE FEASIBILITY EVALUATION
IMPROVEMENTS DETAIL PLAN

**FIGURE
3**



September 12, 2022

VIA E-MAIL

Ms. Teri Jansen, Chair
Redmond Urban Area Planning Commission
Redmond City Hall
411 SW 9th Street
Redmond, OR 97756

Re: Proposed Redmond Development Code ("RDC") Text Amendments

Dear Chair Jansen and Redmond Urban Area Planning Commission (the "Planning Commission") Members,

I am the Director of Government and Legal Affairs for Pahlisch Homes, Inc ("Pahlisch") I have practiced land use law in Oregon since 1991. I am writing to comment on the proposed amendments as they relate to amendments to the Master Plan standards in RDC 8.0270 (*September 12, 2022 Staff Memorandum*). Pahlisch has developed several Redmond residential subdivisions and anticipates further development in Redmond.

Pahlisch appreciates the time and work that staff and the Planning Commission have spent and will spend on the proposed amendments. Pahlisch supports the proposed amendments to the Master Plan standards.

The Staff Memorandum explains that the current Master Plan standards overlap those of the Planned Unit Development standards in RDC 8.0275. Where an applicant proposes a Planned Unit Development concurrently with annexation to the City of Redmond, the Staff Memorandum recommends that the Master Plan standards not be applicable. In any event, the neighborhood meeting will still be required.

Chair Jansen
September 12, 2022
Page 2

Pahlisch appreciates this opportunity to testify in support of the proposed amendments to the Master Plan standards. Pahlisch respectfully requests that the Planning Commission hold a public hearing on the proposed amendments to the Master Plan standards and consider recommending approval of the proposed amendments to the Redmond City Council.

Very Truly Yours,



Michael C. Robinson
Directors of Government and Legal Affairs

CC: Mr. John Roberts (via email)
Mr. Kyle Roberts (via email)
Mr. Jerry Jones(via email)
Ms. Morgan Greenwood(via email)





October 3, 2022

VIA EMAIL publictestimony@redmondoregon.gov

Redmond Planning Commission
411 SW 9th St
Redmond, OR 97756

RE: Proposed Text Amendments to the Redmond City Code, Chapter 8 – Redmond Development Code

Dear Chair Jansen and Commissioners:

On behalf of our 700 plus members, Central Oregon Builders Association (COBA) would like to respectfully request that, rather than amending the development code to require a 10-foot rear setback for an alley-loaded garage, **language is included in the code to simply ensure that there are two dedicated off-street parking spaces for each lot.** This provides developers with the flexibility necessary to provide quality infill development. Given that the development conditions of each infill lot will differ significantly depending upon the size, configuration, access to infrastructure, and surrounding existing development, this flexibility on rear setbacks for alley-loaded lots is necessary to utilize land efficiently while ensuring that the development is compatible with the existing neighborhood.

Thank you sincerely for your time, and for your consideration.

Sincerely,

Morgan Greenwood
VP, Government Affairs
Central Oregon Builders Association
Office 541-389-1058



October 17, 2022

Redmond Planning Commissioners
411 SW 9th St
Redmond, OR 97756

RE: Proposed Development Code Text Amendments to Redmond City Code, Chapter 8 – Redmond Development Code (RDC)

Dear Chair Jansen and Commissioners:

Central Oregon Builders Association (COBA) respectfully requests that the Planning Commission evaluate reducing the minimum lot sizes, as recommended in the 2040 Comprehensive Plan, Policy 10-1-14. COBA supports the evaluation of the following text amendments:

R-3:

- Reduce Minimum Lot Size from 7,500 to 6000 sq ft

R-4:

- Reduce Minimum Lot Size from 5,500 to 5000 sq ft

COBA's request to evaluate these reduced lot sizes aligns with the recommendations made in the 2019 Housing Needs Analysis, in order to support the development of the 6,900 needed housing units identified therein. In addition, COBA respectfully requests that the Planning Commission evaluate the following text amendment:

R-5:

- Reduce Minimum Lot Size from 5,500 to 4,000 sq ft

COBA recognizes that Comprehensive Plan Policy 10-1-4 does not support decreasing the minimum lot size below 5,000 square feet for single family dwellings in the R-5. However, our request to evaluate doing so is due to the potential to provide single-family homes at a more affordable price: land costs currently account for approximately twenty percent of total homebuilding costs. By allowing additional homes per acre, the Planning Commission is helping to close the affordability gap between the median income of Redmond residents, and the median price of Redmond homes.

In addition, this reduced lot size allows for homeownership opportunities of a single family home on a more manageable lot size – one that allows for the ease and small-scale living of a cottage cluster, but with all of the flexibility and privacy of an independently owned lot.

At the October 11th Redmond City Council work session, Council requested that images and photographs accompany these requests, in order to provide a visual representation of the potential outcomes of these requests. Attached to this letter are three exhibits, including photographic examples of existing developments in Redmond that demonstrate what can be built on many of the requested minimum lot sizes.

Exhibit 1 – Prairie Crossing Lots 97-100 – Proposed R-3 6,000 SqFt Minimum Lot Size:

- Prairie Crossing PUD – located near the intersection of Badger Avenue and Canal Blvd, due north of Ridgeview High School
- Approved by Planning Commission approximately 2018; constructed in 2018



- All single-family dwellings on independent lots
- All lots highlighted are less than 7,500 square feet; Lots 97, 99, and 100 meet the requested 6,000 square foot minimum lot size
- Each home has at least a two-car garage; some have a third garage or RV parking
 - All lots include a driveway w/minimum driveway dimensions of 20' x 20'.
- Mix of single-story and two-story residences

Exhibit 2 – Prairie Crossing Lots 101-105 – Proposed R-5 4,000 SqFt Minimum Lot Size:

- Prairie Crossing PUD – located near the intersection of Badger Avenue and Canal Blvd, due north of Ridgeview High School; immediately across the street of the homes shown in Exhibit 1
- Approved by Planning Commission approximately 2018; constructed in 2018
- All single-family dwellings on independent lots
- All lots are less than 4,000 square feet
- Mix of single-story and two-story
- Mix of two-car and one-car garages

Exhibit 3 – Parkland Townhomes Lots 25-30 – Lot Sizes Currently Allowed in R-1 through R-5

- Located near the intersection of SW 28th Street and Xero Avenue
- Each lot is approximately 1,640 square feet
 - Townhomes are currently allowed on a minimum 1,500 square foot lot in all residential zones
 - Due to land cost, townhomes and multi-family dwellings are the currently the most cost-effective dwellings to construct.
 - Reduced lot sizes will help to deliver 60% of new dwelling units as single-family homes, as identified in the 2019 Housing Needs Analysis, by reducing the cost of land per home.

COBA sees the evaluation of these proposed reductions in minimum lot size as an important vehicle for the development of needed housing, delivered to Redmond residents at a more affordable rate. We strongly support the evaluation of these proposed text amendments and are grateful to the Planning Commission for their time, and for their consideration of this matter.

Thank you for your consideration.

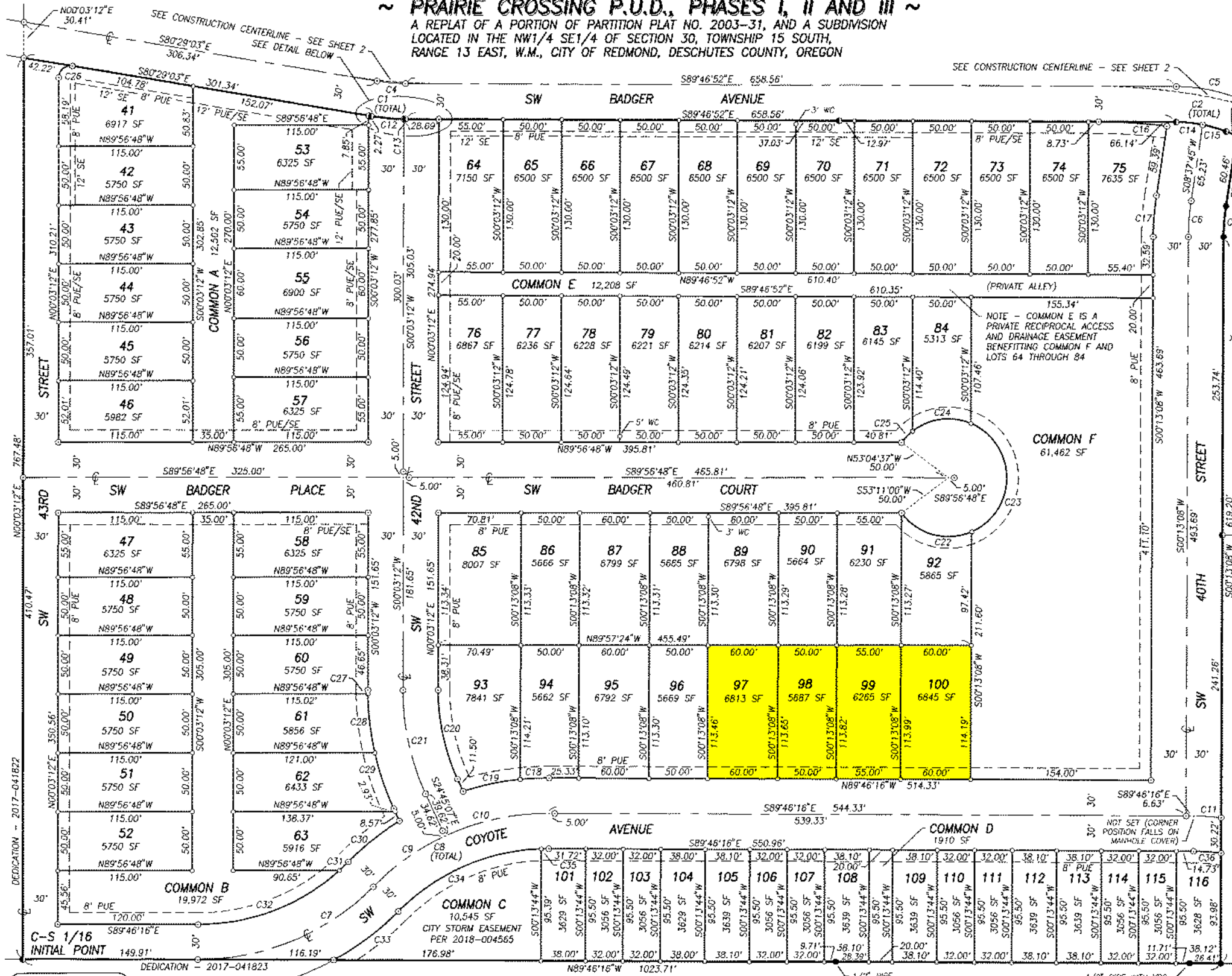
Sincerely,

Morgan Greenwood
VP, Government Affairs
Central Oregon Builders Association

Prairie Crossing 97-100 - Proposed R-3 6,000 SqFt

I-553

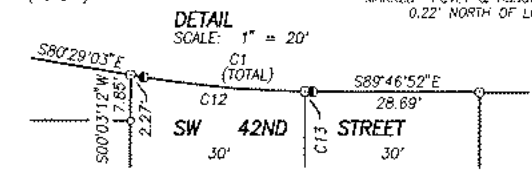
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A REPLAT OF A PORTION OF PARTITION PLAT NO. 2003-31, AND A SUBDIVISION
LOCATED IN THE NW1/4 SE1/4 OF SECTION 30, TOWNSHIP 15 SOUTH,
RANGE 13 EAST, W.M., CITY OF REDMOND, DESCHUTES COUNTY, OREGON



- LEGEND**
- FOUND 5/8" REBAR WITH YPC MARKED "HWA", UNLESS NOTED OTHERWISE
 - SET 3/4" PIPE WITH YPC MARKED "POVEY & ASSOC." IN POSITION OF MONUMENT LOST TO CONSTRUCTION (SEE SHEET 2 FOR ORIGINAL MONUMENT DESCRIPTIONS)
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 - NOT MONUMENTED
 - SA - SQUARE FEET
 - YPC - YELLOW PLASTIC CAP
 - PUE - PUBLIC UTILITY EASEMENT
 - SE - SLOPE EASEMENT
 - C - CENTERLINE
- ACCESS RESTRICTION**
NO DIRECT VEHICULAR ACCESS FROM NORTHERLY LOTS TO SW BADGER AVENUE IS ALLOWED.
- EASEMENTS**
SEE EASEMENT NOTES, AND PUBLIC UTILITY AND SLOPE EASEMENT NOTES, SHEET 2.

CURVE DATA

NO.	RADIUS	LENGTH	DELTA	BEARING	CHORD
C1	180.00'	29.21'	09°17'49"	S85°07'58"E	29.18'
C2	120.00'	43.61'	20°49'15"	S79°22'14"E	43.37'
C3	180.00'	26.42'	08°24'38"	S04°25'27"W	26.40'
C4	150.00'	24.34'	09°17'49"	S85°07'58"E	24.31'
C5	150.00'	54.51'	20°49'15"	S79°22'15"E	54.21'
C6	210.00'	30.83'	08°24'38"	S04°25'27"W	30.80'
C7	210.00'	166.68'	45°28'39"	N67°29'25"E	162.34'
C8	210.00'	166.68'	45°28'39"	N67°29'25"E	162.34'
C9	210.00'	75.13'	20°29'50"	N55°00'01"E	74.73'
C10	210.00'	91.56'	24°58'49"	N77°44'20"E	90.83'
C11	210.00'	23.42'	06°23'26"	S86°34'33"E	23.41'
C12	180.00'	27.90'	08°52'51"	S84°56'29"E	27.87'
C13	180.00'	1.31'	00°24'58"	S89°34'23"E	1.31'
C14	120.00'	22.85'	10°54'29"	S84°19'37"E	22.81'
C15	120.00'	20.76'	09°54'46"	S73°55'00"E	20.74'
C16	480.00'	58.46'	06°58'42"	S86°17'31"E	58.43'
C17	240.00'	35.23'	08°24'38"	S04°25'27"W	35.20'
C18	240.00'	24.72'	05°54'03"	S87°16'43"W	24.71'
C19	240.00'	49.84'	11°53'55"	S78°22'44"W	49.75'
C20	180.00'	77.93'	24°48'19"	N12°20'58"W	77.32'
C21	210.00'	90.92'	24°48'19"	S12°20'58"E	90.21'
C22	50.00'	86.89'	76°39'05"	S75°08'32"E	82.01'
C23	50.00'	116.86'	133°54'52"	N00°25'31"W	92.02'
C24	50.00'	52.89'	60°36'33"	S82°18'46"W	50.46'
C25	50.00'	13.16'	15°05'06"	S44°27'56"W	13.13'
C26	10.00'	17.36'	99°27'45"	N49°47'04"E	15.26'
C27	240.00'	3.35'	00°48'00"	S00°20'48"E	3.35'
C28	240.00'	50.48'	12°02'38"	S06°46'07"E	50.36'
C29	240.00'	50.10'	11°57'41"	S18°46'17"E	50.01'
C30	240.00'	55.78'	13°18'59"	S51°24'35"W	55.65'
C31	180.00'	10.83'	03°26'55"	S46°26'33"W	10.83'
C32	180.00'	132.04'	42°01'43"	S69°12'53"W	129.10'
C33	240.00'	69.21'	16°31'21"	N53°00'46"E	68.97'
C34	180.00'	136.59'	43°28'46"	N66°29'28"E	133.34'
C35	180.00'	6.28'	01°59'53"	N89°13'48"E	6.28'
C36	180.00'	23.45'	07°27'47"	S86°02'22"E	23.43'



REGISTERED PROFESSIONAL LAND SURVEYOR
William G. Bahrke
OREGON
JULY 15, 1983
WILLIAM G. BAHRKE
2039
Renewal Date: 12/31/19

I HEREBY CERTIFY THIS MAP TO BE A TRUE AND EXACT
COPY OF "PRAIRIE CROSSING P.U.D., PHASES I, II AND III"
WILLIAM G. BAHRKE, L.S. 2039
DATE: 4/23/2018

SHEET 3 OF 3
POVEY AND ASSOC. LAND SURVEYORS
P.O. BOX 131, REDMOND, OR 97756
(541) 548-6778 17-0755.DWG

Prairie Crossing Lot 97
6,813 SF
60' x 113.5'
5' Side Yard Setbacks

Prairie Crossing Lot 98
5,687 SF
50' x 113.7'
5' Side Yard Setbacks

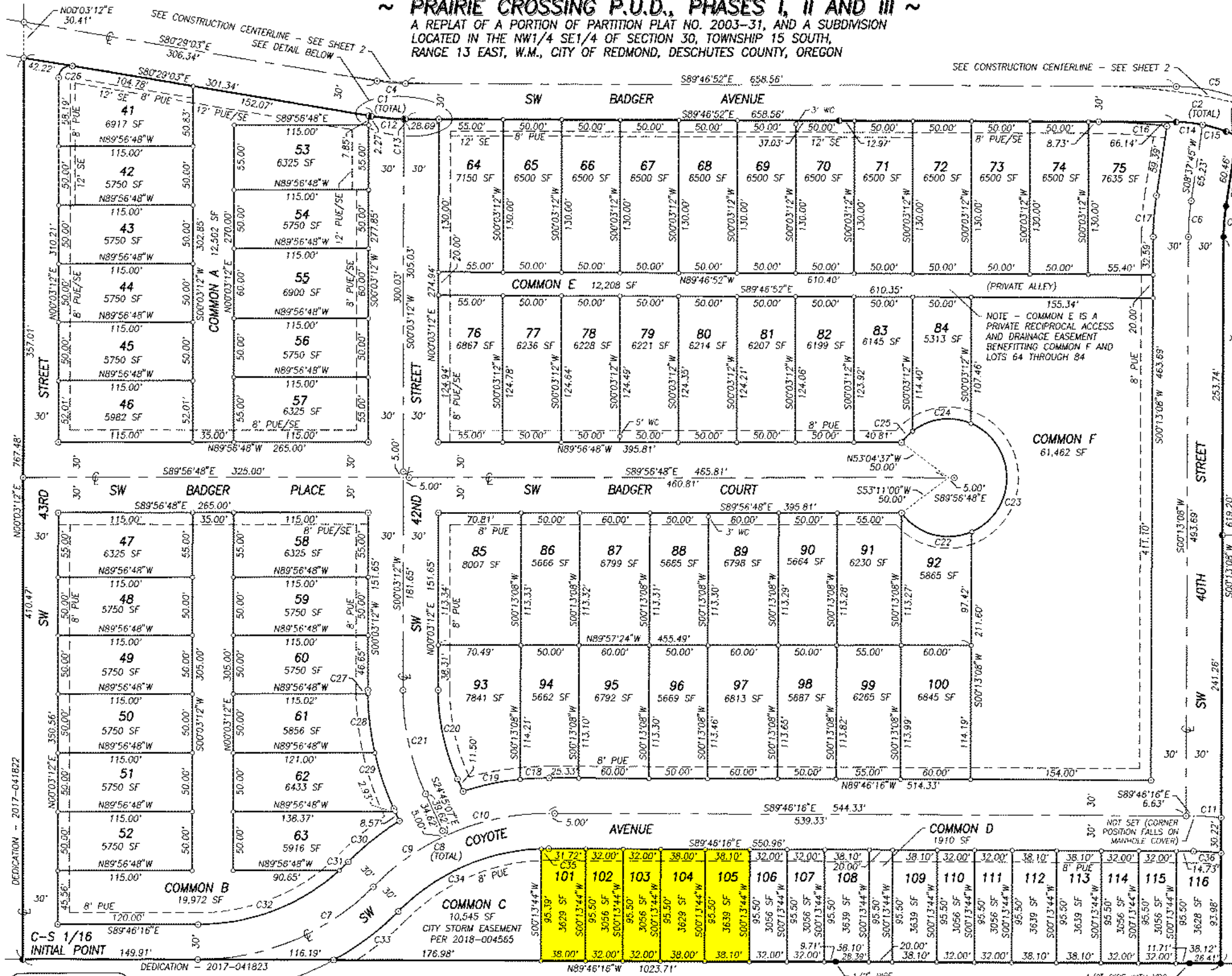
Prairie Crossing Lot 99
6,265 SF
55' x 113.9'
5' Side Yard Setbacks

Prairie Crossing Lot 100
6,845 SF
60' x 114.1'
5' Side Yard Setbacks

4049-4105 SW Coyote Ave
Redmond, OR

Prairie Crossing 101-105 - Proposed R-5 4,000 SqFt

~ PRAIRIE CROSSING P.U.D., PHASES I, II AND III ~
A REPLAT OF A PORTION OF PARTITION PLAT NO. 2003-31, AND A SUBDIVISION
LOCATED IN THE NW1/4 SE1/4 OF SECTION 30, TOWNSHIP 15 SOUTH,
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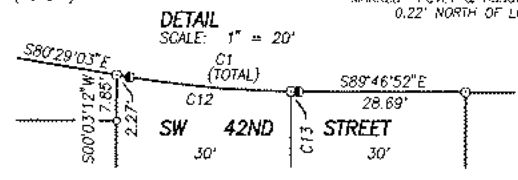


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NO DIRECT VEHICULAR ACCESS FROM NORTHERLY LOTS TO SW BADGER AVENUE IS ALLOWED.
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SEE EASEMENT NOTES, AND PUBLIC UTILITY AND SLOPE EASEMENT NOTES, SHEET 2.
- CURVE DATA**
- | NO. | RADIUS | LENGTH | DELTA | BEARING | CHORD |
|-----|---------|---------|------------|-------------|---------|
| C1 | 180.00' | 29.21' | 09°17'49" | S85°07'58"E | 29.18' |
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| C6 | 210.00' | 30.83' | 08°24'38" | S04°25'27"W | 30.80' |
| C7 | 210.00' | 166.68' | 45°28'39" | N67°29'25"E | 162.34' |
| C8 | 210.00' | 166.68' | 45°28'39" | N67°29'25"E | 162.34' |
| C9 | 210.00' | 75.13' | 20°29'50" | N55°00'01"E | 74.73' |
| C10 | 210.00' | 91.56' | 24°58'49" | N77°44'20"E | 90.83' |
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| C36 | 180.00' | 23.45' | 07°27'47" | S86°02'22"E | 23.43' |

SCALE:
1" = 60'

REGISTERED
PROFESSIONAL
LAND SURVEYOR
William G. Bahrke
OREGON
JULY 15, 1983
WILLIAM G. BAHRKE
2039
Renewal Date: 12/31/19

I HEREBY CERTIFY THIS MAP TO BE A TRUE AND EXACT
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DATE



SHEET 3 OF 3
POVEY AND ASSOC. LAND SURVEYORS
P.O. BOX 131, REDMOND, OR 97756
(541) 548-6778 17-0755.DWG

Prairie Crossing Lot 105
3,629 SF
38' x 95.5'
5' Side Yard Setbacks

Prairie Crossing Lot 104
3,629 SF
38' x 95.5'
5' Side Yard Setbacks

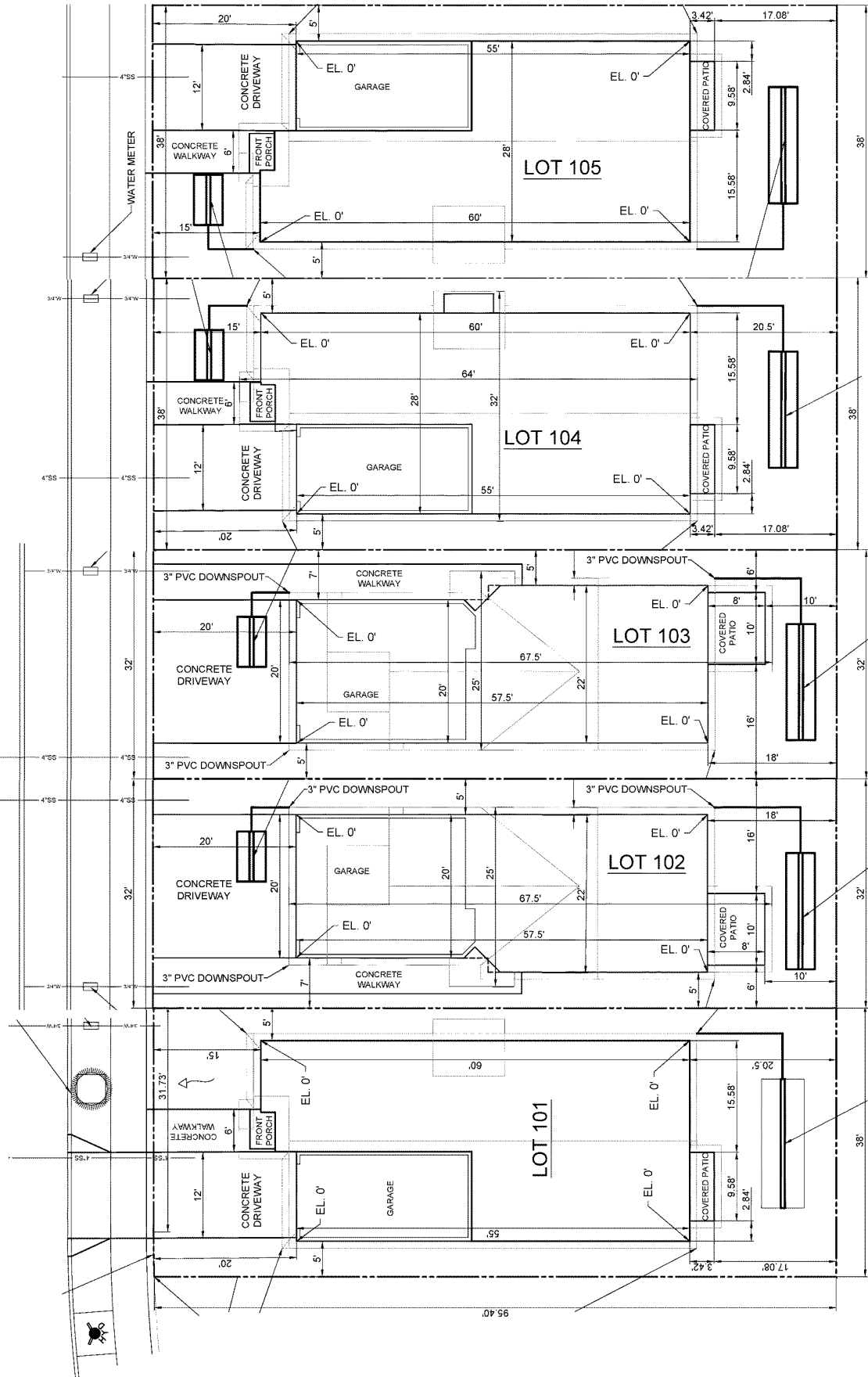
Prairie Crossing Lot 103
3,056 SF
32' x 95.5'
5' Side Yard Setbacks

Prairie Crossing Lot 102
3,056 SF
32' x 95.5'
5' Side Yard Setbacks

Prairie Crossing Lot 101
3,629 SF
38' x 95.5'
5' Side Yard Setbacks

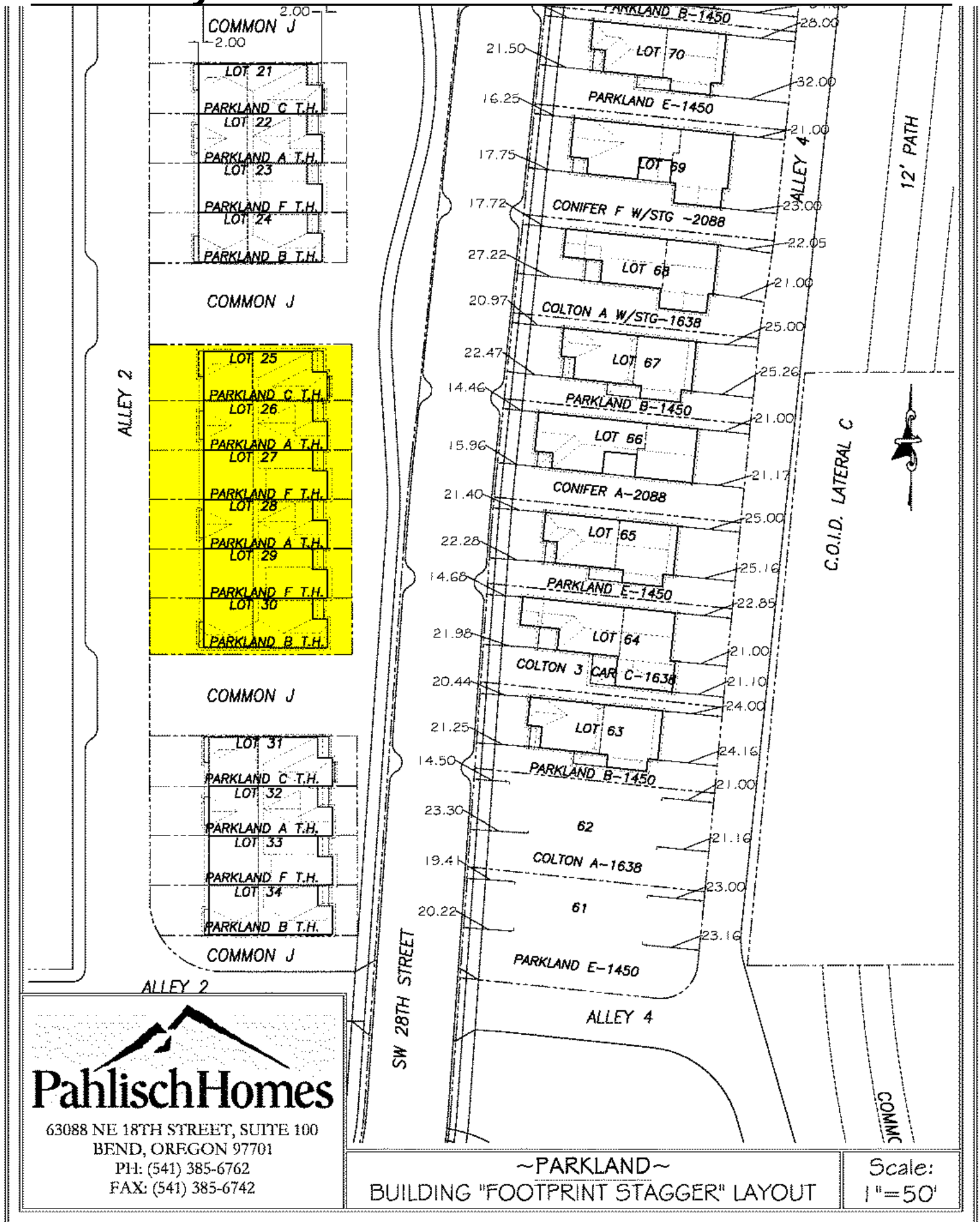
4112-4170 SW Coyote Ave
Redmond, OR

COYOTE RD. (LOCAL)



Parkland Townhomes 25-30

Currently Allowed R-1 thru R-5 Townhomes/MF



PahlischHomes

63088 NE 18TH STREET, SUITE 100
BEND, OREGON 97701
PH: (541) 385-6762
FAX: (541) 385-6742



Parkland Townhomes
Lot 25
1,864 SF
22.73' x 82'
0' Side Yard Setbacks

Parkland Townhomes
Lot 26
1,640 SF
20' x 82'
0' Side Yard Setbacks

Parkland Townhomes
Lot 27
1,640 SF
20' x 82'
0' Side Yard Setbacks

Parkland Townhomes
Lot 28
1,640 SF
20' x 82'
0' Side Yard Setbacks

Parkland Townhomes
Lot 29
1,640 SF
20' x 82'
0' Side Yard Setbacks

Parkland Townhomes
Lot 30
1,864 SF
22.73' x 82'
0' Side Yard Setbacks

3233-3249 SW 28th St
Redmond, OR



November 11, 2022

Attn: Planning Commission
City Of Redmond
411 SW 9th St.
Redmond OR 97756

Subject: Transportation Impact Analysis Modification

Dear Planning Commissioners:

Hayden Homes would like to express our concern over the proposed modifications to the Traffic Impact Analysis (TIA) requirements as they relate to development code update changes. The amendments as written would delay city approval times and force traffic engineers consulting on our projects to make assumptions without having a clear picture from city staff on key transportation issues and priorities.

We encourage City staff and Commissioners to consult with transportation professionals regarding these modifications. Several of the professionals we have spoken with have shared the above concerns with us.

If modifications do need to be made, we suggest adding a preliminary step to the TIA process which would require a scope validation so that both city staff and the applicant can agree on the formal study while preserving shortened review times.

An additional unknown timeline for review would put an additional burden on review times and hinder delivery of much needed housing in Redmond.

We look forward to working on this critical issue with you and appreciate your consideration.

Sincerely,

Megan Norris
Forward Planning Manager, Hayden Homes



November 14, 2022

VIA E-MAIL

Ms. Teri Jansen, Chair
Redmond Urban Area Planning Commission
Redmond City Hall
411 SW 9th Street
Redmond, OR 97756

Re: Proposed Redmond Development Code ("RDC") Text Amendments

Dear Chair Jansen and Redmond Urban Area Planning Commission (the "Planning Commission") Members,

I am the Director of Government and Legal Affairs for Pahlisch Homes, Inc ("Pahlisch"). I am writing to comment on the proposed amendments as they relate to amendments to the Master Plan standards in RDC 8.0270 (*September 12, 2022 Staff Memorandum*). Pahlisch has developed several Redmond residential subdivisions and anticipates further development in Redmond.

Pahlisch appreciates the time and work that staff and the Planning Commission have spent and will spend on the proposed amendments. Pahlisch supports the proposed amendments to the Master Plan standards.

The current Master Plan standards overlap those of the Planned Unit Development standards in RDC 8.0275. Where an applicant proposes a Planned Unit Development concurrently with annexation to the City of Redmond, the Staff Memorandum recommends that the Master Plan standards not be applicable. A neighborhood meeting will still be required. The proposed Master Plan amendments are consistent with Redmond Comprehensive Plan Policies 14-1-4 and 14-1-6 through 14-1-8.

Pahlisch appreciates this opportunity to testify in support of the proposed amendments to the Master Plan standards. Pahlisch respectfully requests that the Planning Commission recommend approval of these amendments to the Redmond City Council at the conclusion of its public hearing on November 21, 2022.

Please place this letter before the Planning Commission at its November 21, 2022 public hearing and in the official Planning Department file for this matter. Please send me notice of the final decision on the amendments.

Very Truly Yours,



Michael C. Robinson
Directors of Government and Legal Affairs

CC: Mr. John Roberts (via email)
Mr. Kyle Roberts (via email)
Mr. Jerry Jones(via email)
Ms. Morgan Greenwood(via email)

