ENGINEERING STUDY
FOR
MONUMENT RIDGE EAST
WATER RESOURCES REPORT

Prepared For:

Monument Ridge East, LLC
Colorado Springs, CO 80919

Prepared By:

Whitehead Engineering, LLC
18 Pacifica Cir., Hot Springs Village, AR 71909

Project No. 21008

April 2024

August 2024

September 2024

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SECTION 1 - EXECUTIVE SUMMARY

This report presents the results of the engineering study for Water Resources serving the Monument Ridge East development. The development is located south and east of the I-25 and County Line Rd. interchange in northern El Paso County.

The Monument Ridge East development consists of approximately 63 acres. The development is a mixture of single & multi-family residential and open space uses. The development is located in northern El Paso County, within Section 2, Township 11 South, Range 67 West of the 6th Principal Meridian.

The development is on vacant land except for one single family home which has been abandoned. The abandoned home will be demolished.

The development is proposing a Metro District that will provide funding for initial construction costs of public infrastructure and provide and coordinate stormwater and open space maintenance among other services. Woodmoor Water and Sanitation District will provide water and sanitary sewer services to the Development. Natural gas will be provided by Black Hills Energy and Mountain View Electric Association will provide electric service.

Monument Ridge East proposed land uses consist of 37 single family detached residential lots on 7.99 acres and 303 multi-family attached units/lots on 40.52 acres.

The average annual water demand for Monument Ridge East is estimated to be 94.72 acre-feet of water per year (84,563 gallons per day). Woodmoor Water and Sanitation District is the service provider through extensions of the existing distribution system**.**

To meet Drinking Water Standards water suppliers' filter and disinfect source water prior to storage and have met Colorado Department of Health and Environment Drinking Water Standards. The Woodmoor Water and Sanitation District PWSID is CO 0121950.

SECTION 2 – INTRODUCTION

2.1 Purpose

The purpose of this report is to present water system improvements recommended to serve Monument Ridge East; a land development project located in El Paso County. It is also intended to serve as a guideline for the ensuing design of recommended improvements.

2.2 Scope

The scope of this report includes:

1. The definition of the service areas as well as identification of significant physical and environmental characteristics and constraints.

2. An analysis of available data to determine existing and to project future water supplies, demands and quality.

3. A description of legal, institutional, and managerial arrangements that ensure adequate control of the proposed improvements; and,

4. A preliminary recommendation for a selected supply, treatment, pumping and transmission alternatives.

SECTION 3 - EXISTING CONDITIONS

3.1 Description of the Service Area

The Monument Ridge East Preliminary Plan development is approximately 63 acres consisting of multifamily residential and single family residential and open space uses. Located southeast of the I-25 and County Line Rd. interchange in northern El Paso County and is within Section 2, Township 11 South, Range 67 West of the 6th P.M. (Parcel Nos. 71022-00-006, 71022-00-008, 71022-00-010, 71022-00-013, 71022-01-001, 71022-01-014).

3.2 Land Use

The Monument Ridge East development is located in El Paso County at its the northern edge. Vacant land can be found north within Douglas County which is protected by a conservation easement. I-25 borders the property to the west with vacant commercial and large lot residential beyond. Large lot residential borders the property to the East. To the south is the Misty Acres PUD development which has a mixture of single-family lot sizes.

3.3 Topography and Floodplains

The topography of the service area is typical of a high desert, short grass prairie and is generally sloping gradually to moderately to the north. The subject property drains generally from south to north through the eastern portion of the site. The site drains into the Plum Creek basin and north to Chatfield Reservoir.

The Federal Emergency Management Agency (FEMA) floodplain mapping for the Monument Ridge East development is shown in Figure 2. There is no Federal Emergency Management Agency (FEMA) established floodplain on the subject property.

3.4 Geology

The site is comprised of several different soil types. From the Soil Survey of El Paso County, the subject property falls into the following soil types:

1. "1" Alamosa loam, 1 to 3 percent slopes; Type D Soil
2. "41" Kettle gravelly loamy sand, 8 to 40 percent slopes; Type B Soil
3. "69" Peyton-Pring complex, 8 to 15 percent slopes; Type B Soil
4. "92" Tomah-Crowfoot loamy sands, 3 to 8 percent slopes; Type B soil

Note: "#" indicates Soil Conservation Survey soil classification number.

3.5 Groundwater

Soil borings in the Monument Ridge East development area have indicated shallow groundwater near areas mapped as designated wetlands.

3.6 Existing Well

There is an existing well on parcel # 7102201001 platted as Heights Filing No. 1. The address is 20255 Monument Hill Rd. The well permit number is 167104-A. The permit shows the well to be in the NE Quarter of the NW Quarter of section 2, Township 11, Range 67W, of the 6th PM.
Pug and Abandon is the preference of the Woodmoor Water & Sanitation District.

The State Engineers Web Site shows this well to be abandoned.

Figure 1: Vicinity Map

PRC ENGINEERING

Figure 1 – Vicinity Map

(Source: Google Earth Imagery 2019)

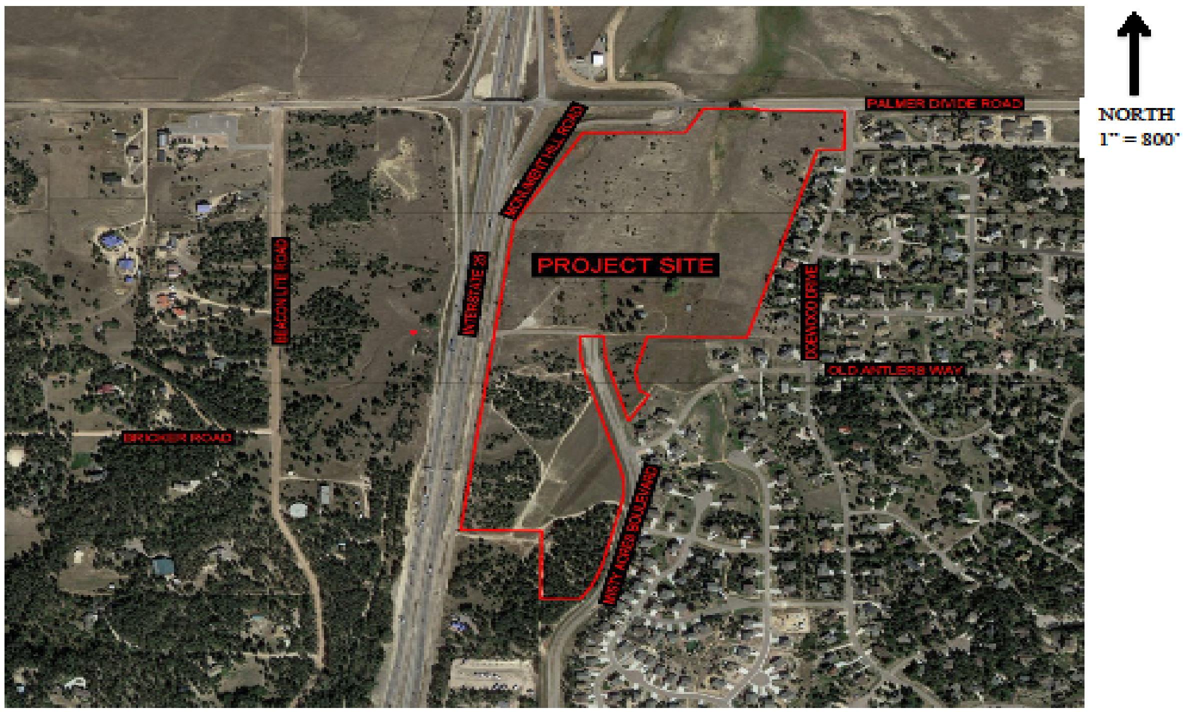
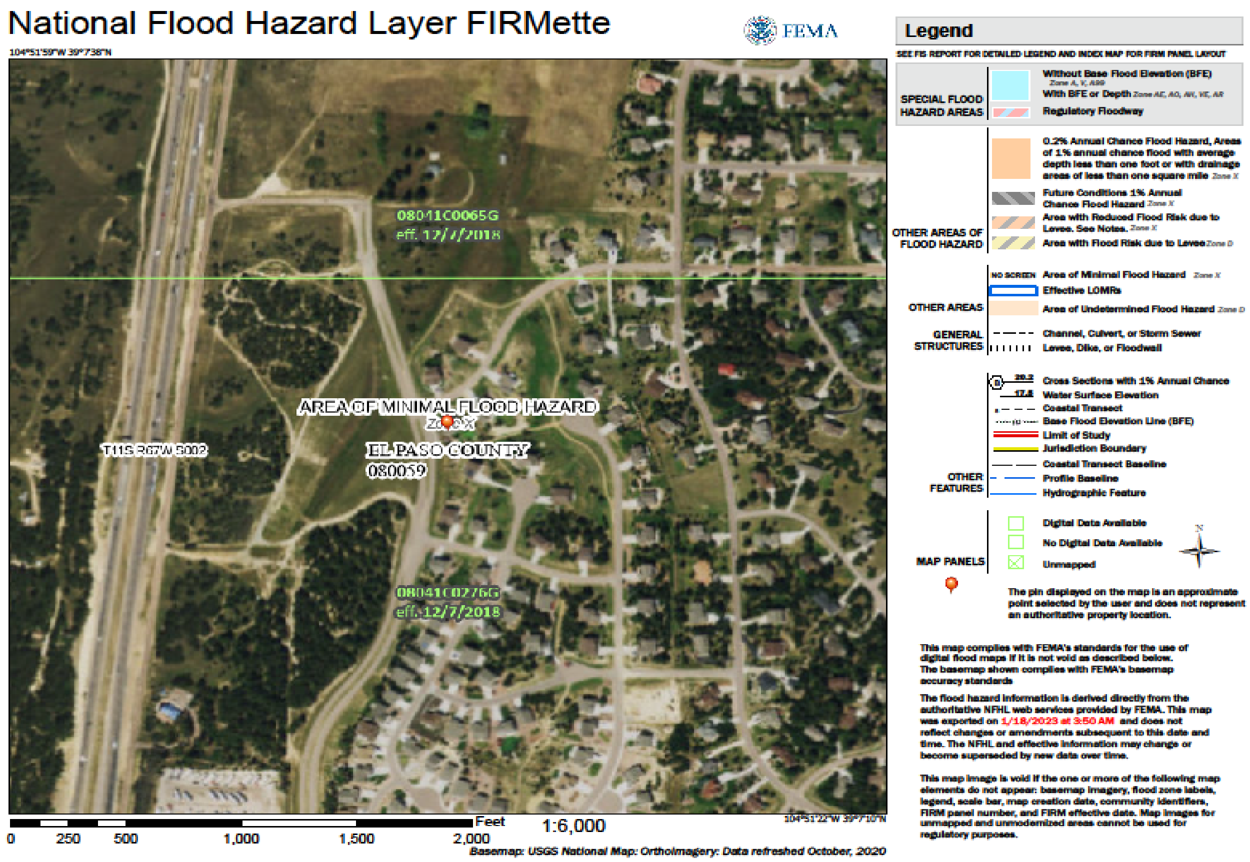
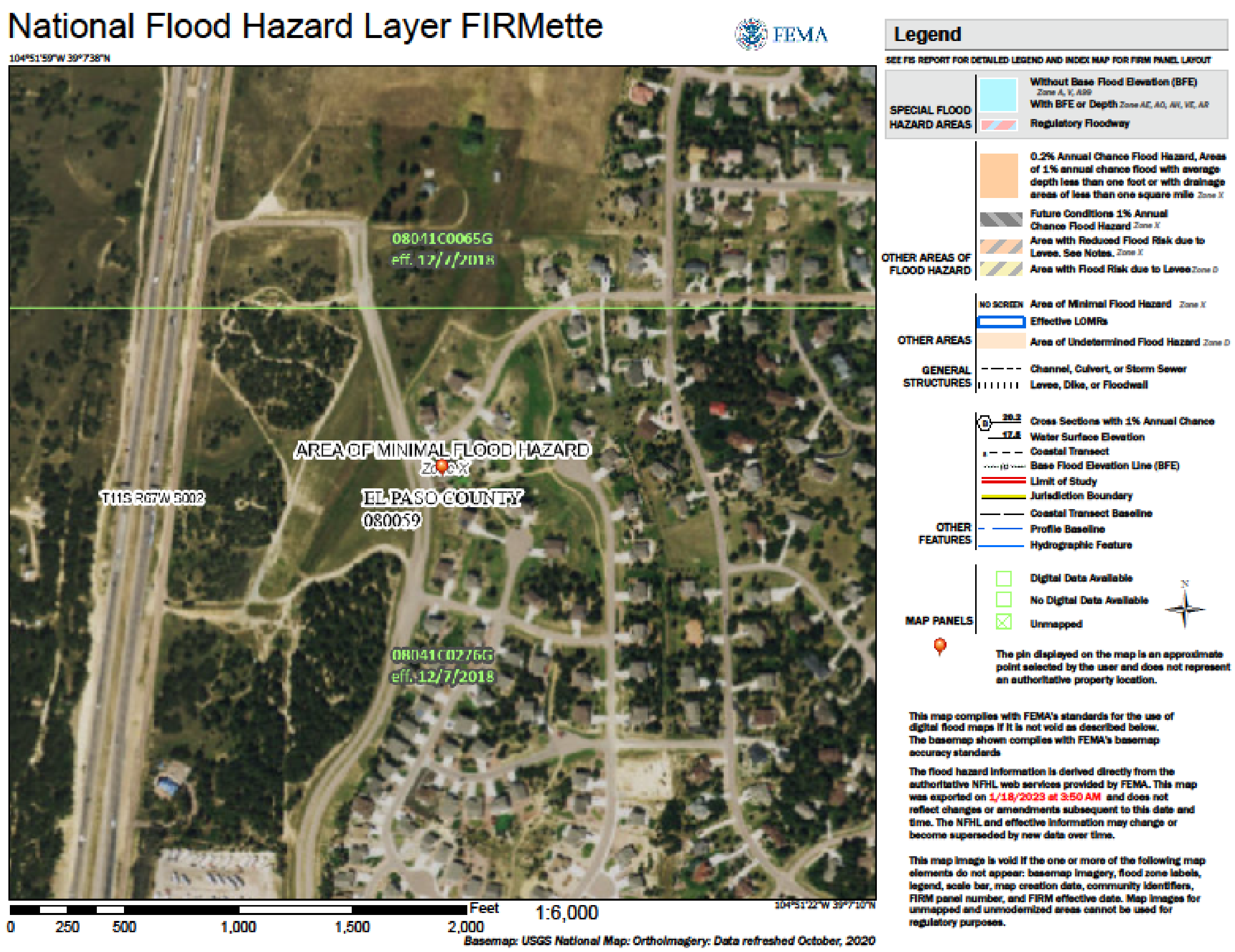


Figure 2: FEMA Floodplain Map





3.7 Climate

The climate of the study area is characterized by mild summers and winters, light precipitation, high evaporation and moderately high wind velocities.

The average annual monthly temperature is 48.4 F with an average monthly low of 20 F in the winter and an average monthly high of 70 F in the summer. Two years in ten will have a maximum temperature higher than 98 F and a minimum temperature lower than -16 F.

Precipitation averages 21.93 inches annually, with 80% of this occurring during the months of April through September. The average annual Lake evaporation is between 45-50 inches.

3.8 Natural Hazards Analysis

Natural hazards analysis indicates that no unusual surface or subsurface hazards are in the service area. However, because the soils are described to have expansive characteristics, proper mitigation will need to be performed as stated in the Soil, Geology, and Geologic Hazard report prepared by Entech Engineering, Inc.

3.9 Organizational Context

Monument Ridge East is not situated within any El Paso County identified Drainage Basin. There are three water and sanitation utility providers near or adjacent to the development.

A portion of this development currently has a Metropolitan District in place (Misty Acres Metropolitan District.) to provide and coordinate services including drainage and open space maintenance among other services.

Monument Ridge East lies within and is annexed onto the Woodmoor Water and Sanitation District. The district will be the entity responsible for the continuing operation and maintenance of water and wastewater improvements.

The adjacent service providers include:

1. Town of Monument water department. West of I-25
2. Monument Sanitation District, West of I-25
3. Triview Metropolitan District, to the South

3.10 Water Facilities

The Woodmoor Water and Sanitation District has been providing potable water service for a long period of time in accordance with the Colorado Department of Health and Environment. The district will provide water, water treatment, water storage and water distribution for the development in exchange for fees and recurring periodic charges.

Appendix A contains the current Woodmoor Water and Sanitation District Long Range Plan and The Supplemental water Service Policy.

3.11 Relationship to Neighboring Water and Wastewater Facilities

The locations of other major water and wastewater Districts, relative to the Monument Ridge East, are shown on Figure 3.

Figure 3 also identifies water wells and habitable buildings within a 1-mile radius of the center of Monument Ridge East. There are several wells within the 1-mile radius of the development. These wells consist of mostly private domestic wells outside of the Woodmoor Water & Sanitation District.

3.12 Water Demand

The Monument Ridge East development will be serviced by Woodmoor Water and Sanitation District. The average district wide water demands for the district are indicated below:

Woodmoor Water and Sanitation District: 0.3584 ac-ft./year per Single Family Equivalent (SFE)

Woodmoor Water and Sanitation District: 0.2688 ac-ft./year per Multi Family Equivalent (MFE)

The demands have been developed from actual usage records and are recognized by the State Engineers Office. These water demands include irrigation for single-family residences where no separate meters are provided for irrigation.

These water demands have been used to project use for Monument Ridge East.

Figure 3: 1-Mile Radius Map

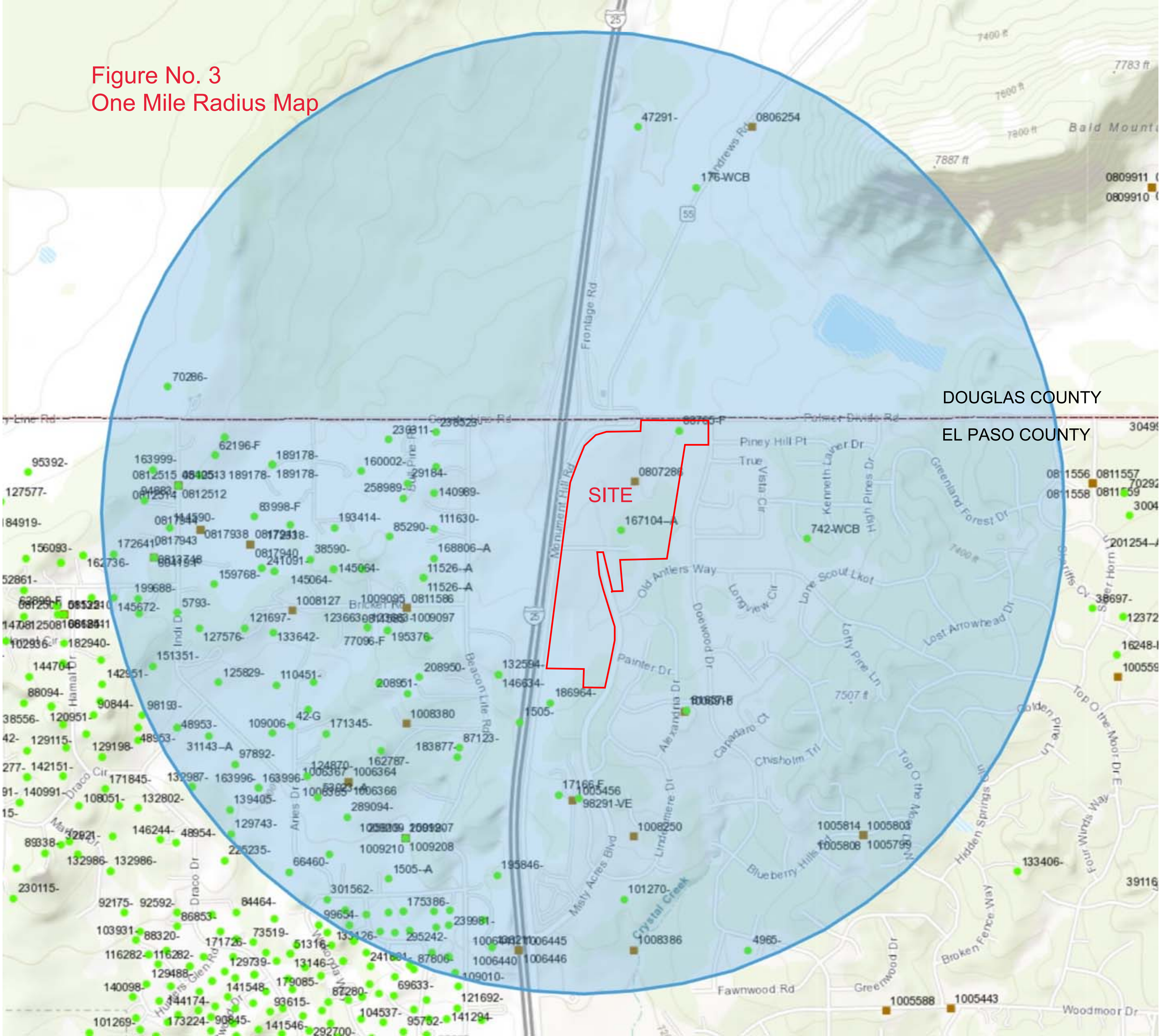


Figure No. 3
One Mile Radius Map
SITE
DOUGLAS COUNTY
EL PASO COUNTY
Frontage Rd
Monument Hill Rd
Old Antlers Way
Painter Dr
Piney Hill Pt
Greenland Forest Dr
Lost Arrowhead Dr
Chisholm Trl
Crystal Creek
Misty Acres Blvd
Fawnwood Rd
Woodmoor Dr
Bald Mounta

SECTION 4 - DEVELOPED CONDITIONS

4.1 Land Use

A portion of this development (approx. 25 acres) lies within the Misty Acres Ranch PUD Development Plan approved June 28, 2001. This area shows 8.5 acres of Commercial/Office and the remainder as multi-family at 8-11 du/ac. The remainder of this development does not lie within any approved land use plan.

The Monument Ridge East Preliminary Plan supports the rezoning of approximately 63 acres, including the area within the Misty Acres PUD, with a mixture of single-family residential, multi-family residential and open space uses.

The Preliminary Plan consists of 2 general areas. For the purposes of this report the Western area (west of Misty Acres Blvd extended) will be developed into multifamily homes, Townhomes, and patio homes. This area consists of approximately 40.52 acres. The eastern area (East of Misty Acres Blvd extended) will be developed into single-family homes. This area consists of approximately 7.99 acres. The currently projected unit count for each area is shown in Table 1 below.

The following tabulates land use for the Monument Ridge East development.

Table 1 – Land Use Plan Preliminary Plan – Monument Ridge East

Land Use	Land Area (AC)				Units				Population				Population Equivalents			
	Phase				Phase				Phase				Phase			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Single Family Residential																
Proposed Development 7.26 DU/Ac	**3.17**				**23**				**68**				**68**			
Proposed Development (2.9 DU/Ac)	**4.82**				**14**				**41**				**41**			
Multi Family																
7.77 Units / acre	**11.46**				**89**				**223**				**223**			
7.98 Units / acre		**29.06**				**214**				**535**				**535**		
Commercial																
Light Industrial																
School																
Parks, Open Space	**3.52**															
TOTAL (All Phases)								**340**				**867**				**867**

***Bold** numbers identify Monument Ridge East proposed multifamily residential development*

Assumptions: Single family units at 2.9 persons/unit
Multi-family units at 2.5 persons/unit
Commercial units at 600 square feet/employee Employees are considered to be 0.2 SFE

4.2 Population

By using the land use information noted above and applying standard unit densities of 2.9 persons per dwelling for single family residential uses, 2.5 persons per dwelling for multifamily residential uses and 600 square feet per employee for commercial/industrial uses, permanent resident and employment forecasts for Monument Ridge East are shown in the above table.

4.3 Water Demand

Water demand was determined by applying Woodmoor Water and Sanitation District unit water demand factors to the above land use forecasts. Water demands have been developed for Monument Ridge East as shown in the following table:

WATER DEMAND

Land Use	SKETCH PLAN			
Potable	AFY	ADD (gpm)	MDD (gpm)	PHD (gpm)
SF Residential (include irr.)				
Phase 1	13.26	8.22	14.8	19.40
Phase 2	0.00	0.00	0.00	0.00
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Multifamily				
Phase 1	23.93	14.83	26.70	35.00
Phase 2	57.54	35.66	64.19	84.16
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Commercial				
Phase 1	0.00	0.00	0.00	0.00
Phase 2	0.00	0.00	0.00	0.00
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Light Industrial				
Phase 1	0.00	0.00	0.00	0.00
Phase 2	0.00	0.00	0.00	0.00
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Park/Open Space	0.00	0.00	0.00	0.00
Subtotal	94.72	58.72	105.70	138.59

Irrigation				
Multifamily				
Phase 1	0.00	0.00	0.00	0.00
Phase 2	0.00	0.00	0.00	0.00
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Commercial				
Phase 1	0.00	0.00	0.00	0.00
Phase 2	0.00	0.00	0.00	0.00
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Light Industrial				
Phase 1	0.00	0.00	0.00	0.00
Phase 2	0.00	0.00	0.00	0.00
Phase 3	0.00	0.00	0.00	0.00
Phase 4	0.00	0.00	0.00	0.00
Park/Open Space	0.00	0.00	0.00	0.00
Subtotal	0.00	0.00	0.00	0.00
TOTAL	94.72	58.72	105.70	138.59
Monument Ridge East Demands				
Phase 1	37.19			
Phase 2	57.53			
Phase 3	0.00			
Phase 4	0.00			

***Bold** numbers identify Monument Ridge Easts proposed residential development*

Unit water demands are based on actual District records as described in section 3.11 (the Single-Family Residential and Multi-Family residential demands include irrigation per Woodmoor Water and Sanitation District), 1200 gallons per acre per day for inside commercial uses and 0.0566 acre feet per year per 1000 square feet of landscaped area for irrigation of commercial properties. It has been assumed that 10% of commercial and multifamily property will be irrigated.

Water demand is first calculated in acre-feet per year (AFY) to determine water supply needs. This value is then factored to determine the average daily demand (ADD) in gallons per minute (gpm), which is used to project maximum day and peak hour demands as well as to estimate revenues and operating costs. Maximum day demand (MDD) and peak hour demand (PHD) have been determined by applying accepted peaking factors of 1.8 and 2.36 to the ADD, respectively. The MDD is used to determine storage needs and the PHD is used for modeling system delivery pressures and to size distribution piping.

Fire flow demand is another demand typically included in the design of water systems. A fire flow demand of 1500 gpm in residential areas and 3500 gpm in commercial areas will be delivered at a minimum pressure of 20 psi by the water system.

4.4 Water Supply

The Woodmoor Water and Sanitation District has numerous ground water and surface water rights; these water supply sources are summarized in Appendix A.

Based on the water demand and the available water sources the district can service the proposed Monument Ridge East development.

4.5 Water Quality

The Woodmoor Water and Sanitation District has been providing potable water in accordance with El Paso County Health Department and Colorado Department of Health and Environment standards and reporting requirements for several decades. The district provides treatment and disinfection of their raw water sources prior to distribution. Water Quality is summarized in Appendix A.

SECTION 5 - WATER SYSTEM IMPROVEMENTS

5.1 General

The water system operated by Woodmoor Water and Sanitation District is classified as a "community water system" and meets the applicable requirements of the Colorado Department of Health and Environment (CDHE).

Filtration and disinfection facilities provide treatment of the raw water sources to ensure good water quality. Elevation differences that exist throughout the district boundaries require different pressure zones to ensure that water is delivered at no less than 40 psi during peak hour flow and at no more than 120 psi during periods of low use. In addition, storage facilities and distribution piping will be provided to ensure that residual pressure requirements are achieved both during peak hour demands and during maximum day demands with a superimposed fire flow of 3500 gpm. The pressure zones are served by both storage facilities as well as transfer pumping equipment.

Monument Ridge East will be served by Woodmoor Water and Sanitation District. The Monument Ridge East development lies within Pressure Zone 1 of the district. Service will be extended to the property through extensions of existing system piping from the vicinity of Misty Acres Blvd and from Doewood Drive.

5.2 Groundwater Wells

The district has multiple sources of water including groundwater wells as outlined in Appendix A.

5.3 Water Treatment

Treating and filtering of the water sources meets Drinking Water Standards.

In addition, CDHE standards require that the water supply be disinfected and that the supply receives minimum chlorine contact time of 30 minutes before first use.

5.4 Storage

Storage reservoirs are ground mounted steel tanks designed in accordance with CDHE and AWWA Standards.

Storage is sized to provide a minimum of 30% of maximum day demand and includes a reserve to supply a minimum fire flow of 1250 gpm to all fire hydrants.

5.5 Distribution

The water distribution system provides water at a maximum static pressure of 120 psi during periods of low use, at a minimum residual pressure of 40 psi during peak hour demand and at a minimum residual pressure of 20 psi during maximum day demand with a superimposed fire flow. Because the storage tank is ground mounted within the development the system must be pressurized by pumps. The pressure zone will use a loop type system of piping to maximize the efficiency of the system and will be provided with minimum 6-inch diameter pipe and fire hydrants throughout. All pipe and appurtenances will be designed to meet or exceed AWWA and or District Standards.

5.6 Other Costs and Gains

Estimated Costs

Item	Units	Quantity	Unit Price	Extension
Water Main Extension	LF	10,000	$75	$750,000
Total Estimated Cost				*$750,000*

The costs included above only include capital costs for water system improvements required to serve Monument Ride East and are estimated from best available data. These costs do not include other costs or gains that may be incurred in the acquisition of land, financing, investment, local distribution, the salvage value of equipment or other necessary infrastructure, among others, unless specifically noted.

5.7 Rates and Charges

The Woodmoor Water and Sanitation District will impose charges to recoup the cost of constructing water system improvements as well as regular periodic billings to recoup continuing costs for operations, maintenance, and equipment replacement. This system of rates and charts is published by district annually.

WATER SUPPLY INFORMATION SUMMARY

Section 30-28-133,(d), C.R.S. requires that the applicant submit to the County, "Adequate evidence that a water supply that is sufficient in terms of quantity, quality and dependability will be available to ensure an adequate supply of water.

1. NAME OF DEVELOPMENT AS PROPOSED **MONUMENT RIDGE EAST**

2. LAND USE ACTION Preliminary Plan

3. NAME OF EXISTING PARCEL AS RECORDED

SUBDIVISION ____ FILING ____ BLOCK ____ LOT ____

4. TOTAL ACREAGE 63

5. NUMBER OF LOTS PROPOSED 342 PLAT MAP ENCLOSED ☒ YES

6. PARCEL HISTORY - Please attach copies of deeds, plats or other evidence or documentation.

A. Was parcel recorded with county prior to June 1, 1972? ☐ YES ☐ NO

B. Has the parcel ever been part of a division of land action since June 1, 1972? ☒ YES ☐ NO

If yes, describe the previous action ____

7. LOCATION OF PARCEL - Include a map deliniating the project area and tie to a section corner.

____ 1/4 OF ____ 1/4 SECTION 2 TOWNSHIP 11 ☐ N ☐ S RANGE 67 ☐ E ☐ W

PRINCIPAL MERIDIAN: ☐ 6TH ☐ N.M. ☐ UTE ☐ COSTILLA

8. PLAT - Location of all wells on property must be plotted and permit numbers provided.

Surveyors plat ☐ Yes ☐ No If not, scaled hand drawn sketch ☒ Yes ☐ No

9. ESTIMATED WATER REQUIREMENTS - Gallons per Day or Acre Feet per Year

HOUSEHOLD USE # 340 of units	84,563	GPD	94.72	AF
COMMERCIAL USE # 0 of S.F.		GPD		AF
IRRIGATION # 0.00 of acres	0.00	GPD	0.00	AF
STOCK WATERING # 0 of head		GPD		AF
OTHER 0		GPD		AF
TOTAL	84,563	GPD	94.72	AF

10. WATER SUPPLY SOURCE

☐ EXISTING WELLS ☐ DEVELOPED SPRING

WELL PERMIT NUMBERS

____

☐ NEW WELLS - PROPOSED AQUIFERS - (CHECK ONE)

☐ ALLUVIAL ☐ UPPER ARAPAHOE
☐ UPPER DAWSON ☐ LOWER ARAPAHOE
☐ LOWER DAWSON ☐ LARAMIE FOX HILLS
☐ DENVER ☐ DAKOTA
☐ OTHER ____

☐ MUNICIPAL
☐ ASSOCIATION
☐ COMPANY
☒ DISTRICT
NAME WOODMOOR WATER & SANITATION DISTRICT

LETTER OF COMMITMENT FOR SERVICE ☐ YES ☐ NO

WATER COURT DECREE CASE NO.'S ____

11. ENGINEER'S WATER SUPPLY REPORT ☐ YES ☐ NO IF YES, PLEASE FORWARD WITH THIS FORM. (This may be required before our review is completed.)

12. TYPE OF SEWAGE DISPOSAL SYSTEM

☐ SEPTIC TANK/LEACH FIELD

☒ CENTRAL SYSTEM - DISTRICT NAME WOODMOOR WATER AND SANITATION DISTRICT

☐ LAGOON

☐ VAULT - LOCATION SEWAGE HAULED TO ____

☐ ENGINEERED SYSTEM (Attach a copy of engineering design)

☐ OTHER ____

WOODMOOR
Water & Sanitation District No. 1
P. O. Box 1407 • Monument, Colorado 80132
Phone (719) 488-2525 • Fax (719) 488-2530

August 7, 2024

To: Monument Ridge East, LLC
Attn: Norbie Larsen
Monument Ridge East, LLC
5055 List Drive
Colorado Springs, CO 80919

RE: Water & Wastewater Service Commitment
El Paso County Parcel Numbers: 7102200013, 7102200006, 7102200010, 7102200008, 7102201001

Dear Mr. Larsen:

The above referenced development, incorporating the above referenced parcel numbers, is located within the service boundaries of Woodmoor Water and Sanitation District No. 1 (the District).

It is the District's understanding that the Developer intends to construct 303 multi-family units on 40.52 acres of land and 37 single-family units on 7.99 acres of land within the Monument Ridge East Development, with a projected total water demand of 94.719 Acre-Feet per year.

The District is committed to providing water and sewer services to the development once the following terms and conditions are met:

1. The Developer must apply for, be subsequently allocated, and enter into an agreement with the District for Supplemental Water Service. Supplemental Water Service is allocated by the District's Board (in its sole and absolute discretion) and therefore is not guaranteed. The District makes no representation herein (expressed or implied) as to whether Developer will or won't be successful in obtaining Supplemental Water Service for the Development.
2. The Development must comply with all District rules, regulations, specifications, and policies regarding water and wastewater service, including the District's System Specifications regarding installation of Water and Sewer utilities, granting of water and sewer utility easements, and construction of offsite improvements if required.

If you should have any questions or need further assistance, please contact me.

Sincerely,

Jessie J. Shaffer
District Manager

Cc: Dan LaFontaine – Operations Superintendent

2022 Long Range Plan

FOR THE

Woodmoor Water and Sanitation District No. 1

December 2022

2022 LONG RANGE PLAN

FOR THE

WOODMOOR WATER AND SANITATION DISTRICT NO. 1

JVA, Inc.

1675 Larimer Street, Suite 550

Denver, CO 80302

phone: 303-444-1951

JVA Project No. 1051.8e

BBA Water Consultants, Inc.

333 W. Hampden Avenue, Suite 1050

Englewood, CO 80110

phone: 303-806-8952

BBA Project No. 9026.52

DECEMBER 20, 2022

EXECUTIVE SUMMARY

A summary of the water and wastewater projects identified in the Long Range Plan (LRP) for 2022 are presented herein. As with previous LRPs, this document includes evaluations of raw water supply, operations, treatment, water distribution, and wastewater collection. Growth projections were based on historical trends and input from the District. The previous six years of billing records were analyzed to identify current water demand and wastewater flows and loading. A margin of safety was added to estimate future water demands and wastewater flows and loading based on expected growth. These future water demands and wastewater flows and loading were compared with existing facilities to determine capital improvement projects recommended to meet water and wastewater needs through buildout. The capital improvement projects are presented with R&R projects in the Capital Improvements Plan in Section 7 of the LRP. To assist the District with planning and budgeting, a cash flow model was updated for use in the District's existing rate model.

As of December 2021, the District had 4,358 single-family equivalents (SFEs) and an average annual water demand of approximately 1,098 acre-feet per year (af/yr). Between 2017 and 2022, the annual growth rate has varied from 0.02 percent to 1.0 percent, with an average annual growth rate of 0.6 percent. Due to impending known developments and rapid growth expected between 2022 and 2026, the District selected a design growth rate of approximately 4.0 percent for the 2022 to 2026 period, and a design growth rate of 2.0 percent for the planning period from 2026 onward. Under these growth conditions, current buildout is expected to occur in 2037 with approximately 6,481 SFEs and 1,974 af/yr, and ultimate buildout is expected to occur in 2047 with approximately 7,815 SFEs and 2,381 af/yr. Each scenario assumes an additional 148 af/yr of non-potable water demand. The Wissler Trust is the only development that could potentially be incorporated into the District's service area for the ultimate buildout scenario.

In previous LRPs, the wastewater system growth rates were calculated based on number of taps with a standard water demand conversion ratio used to estimate the amount of wastewater generated. This LRP update instead established wastewater SFEs (WSFEs) to estimate wastewater growth rates and used winter water usage to correlate wastewater flows from months without irrigation. As of December 2021, the District had 4,165 WSFEs. This value was compared to the 4,358 SFEs in December 2021 to establish a conversion factor of 0.96 (where 0.96 x SFEs = WSFEs) for future projections. Approximately 6,194 WSFEs are expected at current buildout and approximately 7,469 WSFEs are expected at ultimate buildout.

The District maintains digital water distribution system and sanitary sewer collection system models to help simulate projected water demand and wastewater flows and determine limiting capacities in the water and sewer systems. These existing models were updated to reflect the most recent information provided by the District. A new effort performed in this LRP was to outline a condition summary and prioritization system for existing system assets based on the asset condition and criticality. The results of this condition and criticality assessment can be used to help the District prioritize specific areas of the water distribution system and sanitary sewer collection system for repair and replacement.

WATER PROJECTS

For this LRP update, data was analyzed from January 2016 through December 2021 to determine the most recent water system demand. Previous LRPs averaged multiple demand values from overlapping datasets to try to capture a larger period, which appears to overestimate current water system demand by counting the historical years with higher demand more than once. The average water system demand calculated for the 2016 to 2021 period is 236 gpd/SFE. A 15 percent safety factor was used to account for the impact of dry-year irrigation demand, which results in a planning level average annual demand of 272 gpd/SFE for this LRP. Based on daily demands, the peak day to average annual peaking factor for this LRP is 2.2.

This LRP describes a short-term water supply plan to supplement the declining groundwater wells, and a long-term infrastructure plan to integrate water from the Ranch into the District's operation. Past LRPs favored indirect potable reuse (IPR) to address the short-term water supply. This LRP instead outlines an initial focus on construction of Ranch water delivery facilities due to (1) concern regarding brine waste disposal and total dissolved solids (TDS) escalation in recycled Tri-Lakes Wastewater Treatment Facility (TLWWTF) effluent using IPR and (2) a desire to balance supply and demand with water quality targets. This LRP provides recommendations to pilot Ranch treatment to gain certainty in necessary water treatment processes and waste disposal.

The water level in the Denver Basin aquifers continues to decline. The District has noted a decrease in well production rates and expressed a desire to broadly shift from non-renewable well water supplies to more reliable surface water supplies for raw water. The long-term water supply plan for the District describes a three-phased construction approach for Ranch facilities to delay capital expenditures while the District conjunctively uses Ranch water with existing well water supplies:

- Phase I includes construction of a raw water transmission pipeline from the Ranch to the District. This phase aims to construct the base facilities required to fill the water supply gap between District demand and supply without drilling new wells. This raw water would be blended with existing water supplies to manage TDS. Process improvements at the Central Water Treatment Plant (WTP) and South WTP would target water quality constituents such as pharmaceuticals and trace organics that are typically found in waterways heavily influenced by wastewater treatment facility effluent.
- Phase II entails construction of a new WTP at the Ranch to reduce TDS and other constituents as the District's demand increases and the groundwater supply available for blending declines.
- Phase III is to enlarge Callahan Reservoir to an estimated capacity of 1,300 acre-feet (af) to provide additional raw water storage as District demand increases.

WASTEWATER PROJECTS

The District's existing sanitary sewer collection system model evaluation is currently in progress to better account for existing and future buildout conditions. The model can evaluate the capacity of the gravity sewers, lift stations, and force mains in the District. Flows were programmed based on input from the District to best represent the existing, current buildout, and ultimate buildout scenarios.

This LRP recommends the District continue the current annual manhole rehabilitation projects to further help mitigate inflow and infiltration in the collection system. The only capital improvement project identified at this time is to install permanent backup power at each of the lift stations in the District. The collection system model evaluation is currently awaiting pending survey information; as such, other capital improvement projects may be recommended based on the survey results.

Previous studies identified the need to plan, design, and construct upgrades to the TLWWTF to comply with impending and future effluent limits, and to ensure the design capacity could accommodate future growth. Phase I was completed in 2017. Phase II is anticipated to start in 2024, and Phase III is dependent on future regulations taking effect.

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- af – acre-feet
- af/mo – acre-feet per month
- af/yr – acre-feet per year
- af/ac/yr - acre-feet per acre per year
- AOP – advanced oxidation process
- ARWRF – advanced regional water reclamation facility
- BAF – biologically active filtration
- BOD_5 – 5-day biochemical oxygen demand
- BMPs – best management practices
- CDPHE – Colorado Department of Public Health and Environment
- CEC – contaminant of emerging concern
- cfs – cubic feet per second
- CIP – capital improvements plan
- CPDWR – Colorado Primary Drinking Water Regulations (Regulation 11)
- CWTP – Central Water Treatment Plant
- cy – cubic yards
- DBPs – disinfection by-products
- DIP – ductile iron pipe
- District – Woodmoor Water & Sanitation District No. 1
- DOC – dissolved organic carbon
- Donala – Donala Water and Sanitation District
- DWC – Dirty Woman Creek
- DWR – Division of Water Resources
- EC – electroconductivity
- EPA – Environmental Protection Agency
- FAT – full advanced treatment
- fps – feet per second
- ft – feet
- ft/yr – feet per year
- GAC – granular activated carbon
- gpd – gallons per day
- gpm – gallons per minute
- HAAs – haloacetic acids
- HOA – homeowner's association
- HVAC – heating, ventilation, and cooling
- I&I – inflow and infiltration
- IFC – International Fire Code
- IPR – indirect potable reuse
- JUC – Tri-Lakes Joint Use Committee
- Lake – Lake Woodmoor
- LAS – liquid ammonium sulfate
- LIRF – lawn irrigation return flows
- LPS – Lake Pump Station

- LRP – long range plan
- MCE – Monument Creek Exchange
- MCL – maximum contaminant limit
- MCLG – maximum contaminant level goal
- MF - microfiltration
- MGD – million gallons per day
- MIB – 2-methylisoborneol
- MMADF – maximum month average daily flow
- MSD – Monument Sanitation District
- NBPS – North Booster Pump Station
- NDMA - N-Nitroso-dimethylamine
- NF – nanofiltration
- ng/L – nanograms per liter
- NPDES – National Pollutant Discharge Elimination System
- O&M – operations and maintenance
- OPC – opinion of probable cost
- PFAS – per- and polyfluoroalkyl substances
- PFOA – perfluorooctanoic acid
- PFOS – perfluorooctane sulfonic acid
- PLSD – Palmer Lake Sanitation District
- PPCPs – pharmaceuticals and personal care products
- PRV – pressure reducing valve
- psi – pounds per square inch
- PSV – pressure sustaining valve
- PVC – polyvinyl chloride
- PWL – pumping water level
- R&R – rehabilitation and replacement
- RO – reverse osmosis
- SBPS – South Booster Pump Station
- SCADA – supervisory controls and data acquisition
- SFE – single family equivalent
- SMCL – secondary maximum contaminant limit
- SWL – static water level
- SWTP – South Water Treatment Plant
- TDS – total dissolved solids
- THMs – trihalomethanes
- TIN – total inorganic nitrogen
- TLMFPD – Tri-Lakes Monument Fire Protection District
- TLWWTF – Tri-Lakes Wastewater Treatment Facility
- TN – total nitrogen
- TOC – total organic carbon
- TOM – Town of Monument
- TP – total phosphorus
- TSS – total suspended solids
- UF – ultrafiltration
- ug/L – micrograms per liter

- UV – ultraviolet
- UVAOP – ultraviolet disinfection with an advanced oxidation process
- VFD – variable frequency drive
- WLMP – water level monitoring program
- WQCC – Water Quality Control Commission
- WSFE – wastewater single family equivalent
- WTP – water treatment plant
- WWTF – wastewater treatment facility

SECTION 1 - INTRODUCTION

The Woodmoor Water and Sanitation District No. 1 (District) is a quasi-municipal entity that provides water and wastewater services to its customers. The District regularly prepares a long range plan (LRP) to assess the water and wastewater infrastructure in the system, to project future needs based on anticipated population growth, and to propose and budget for capital improvement projects required to maintain the system and meet future needs. The District started this effort in 1991, and has since updated the LRP in 1994, 1997, 2002, 2006, 2012, and 2017. The LRP updates build on the information of their predecessors with the most recent information available. The District references the LRPs on a regular basis to help with annual budgeting, planning, and modeling development impact.

Since the 2017 LRP, the following development projects were completed or are currently under construction:

- Village Center at Woodmoor Filing 4A (2018)
- The Dunes Residential Subdivision (2018)
- Cipriani Loop Shopping Center Addition (2019)
- Lot 3, Greater Europe Mission Subdivision Filing No. 1, Monument Hill Business Center (2021)
- The Beach at Woodmoor Filing No. 1 (2021)
- Lot 2, Greater Europe Mission Subdivision Filing No. 1, Steel Structures America (2022)
- Cloverleaf (2023)
- Monument Junction West Filing No. 1 (2023/2024)

The District has started or completed the following capital improvement projects that were identified in the 2017 LRP:

- Arapahoe Well No. 21 and Transmission Pipeline to the Central Water Treatment Plant (CWTP) and Lake (2020)
- 2020 Capital Improvement Projects, which include:
    - South Water Treatment Plant Improvements (2021)
    - Central Water Treatment Plant Improvements (2022)
    - Lake Pump Station (LPS) No. 2 and Transmission Pipeline to the CWTP (2022)
- Arapahoe Well No. 22 (2022)
- Equipping of Well 19 (2022)

1.1. Scope

This LRP update evaluates the District's existing water and wastewater demands, as well as those of current and ultimate buildout scenarios. The LRP follows the outline below:

- **Section 1: Introduction** – The introduction summarizes the history of the LRP effort, identifies the focus of this LRP, describes the methodology of the LRP, reviews the current customer classes and counts, and projects population growth for current and ultimate buildout conditions.

- **Section 2: Current Water System** – This section provides an overview of the three water system components: raw water supply (sources, wells, pump stations, and transmission lines), water treatment and storage, and water distribution. This section summarizes current potable demands, irrigation usage, water treatment plant production, water resources, and water rights, and identifies any limiting capacities in the existing water system.
- **Section 3: Future Water System** – Future water demand projections are provided based on growth forecasts from Section 1. Needs of the current water system that are required to meet future demands are identified and evaluated in this section. Capital improvement projects are recommended based on those identified needs.
- **Section 4: Current Wastewater System** – This section provides an overview of the two wastewater system components: the collection system, including lift stations, and the wastewater treatment facility. This section summarizes current wastewater flows and loading and identifies any limiting capacities or deficiencies in the existing wastewater system.
- **Section 5: Future Wastewater System** – Future wastewater flows and loading projections are provided based on growth forecasts from Section 1. Needs of the current wastewater system are summarized to provide a road map to meet future wastewater collection and treatment. Regulatory drivers that will influence the wastewater treatment facility (WWTF) are discussed. Capital improvement projects (CIPs) are recommended based on the identified needs.
- **Section 6: Asset Management Plan** – This section provides an overview of the asset management plan for the existing water distribution system and existing wastewater collection system. A condition summary and prioritization system are outlined based on the level of service and the identified critical assets.
- **Section 7: Capital Improvements Plan** – An opinion of probable cost was developed for each of the capital improvement projects identified in Sections 3 and 5. The capital improvement projects were prioritized based on criticality and growth and assigned an anticipated start date. A cash flow model was created presenting capital improvement project costs based on single family equivalent count. This model is used for annual budgeting purposes and by the District's rate consultant for financial planning.

The main focuses of this LRP are as follows:

- Determine the current water demand per single family equivalent and evaluate single family equivalents (SFEs) for each billing category.
- Establish a current wastewater SFE to analyze existing and estimate future wastewater flows and loading.
- Develop a water supply plan to accommodate current and future buildout.
- Evaluate the abilities of the existing water distribution system and sanitary sewer collection system to accommodate current and ultimate buildout
- Consider the most efficient transfer of water from the South Tank to the North Tank.
- Evaluate the benefits of expanding Pressure Zone 4 to encompass more area in and around the South Tank.

- Refine the existing asset management plan for the water distribution system and the wastewater collection system.
- Identify necessary capital improvement projects for input to a cash flow model.

Upon observing diminishing well yields in the Denver Basin groundwater wells, the District anticipated the need for a renewable water supply and purchased renewable surface water rights, located near Fountain, Colorado, in 2011 ("the Ranch" Water Rights). This venture will ultimately replace the use of non-renewable groundwater as the District's primary water supply. This LRP describes a short-term water supply plan to supplement the declining groundwater wells, and a long-term infrastructure plan to integrate water from the Ranch into the District's operation.

1.2. METHODOLOGY

The LRP identifies a plan to meet the water supply and demand differential through use of in-District resources with minimal cooperation from surrounding entities. Future LRPs should evaluate and incorporate any projects by neighboring entities that would be beneficial to the District. While the District is still investigating opportunities for partnerships or collaboration, assumptions made in this LRP lean towards a scenario where the District must independently supply water to its customers moving forward.

This LRP outlines capital improvement projects required to be completed now through ultimate buildout. Due to increased and ongoing supply chain disruptions, material shortages, labor challenges, market volatility, and general uncertainty surrounding construction, the details, costs, and schedules of long-term projects are recommended to be revisited when approaching implementation. Costs included in this LRP are presented in 2022 dollars and do not account for future inflation or construction cost escalation.

1.3. CURRENT CUSTOMERS

The District bases its growth forecast on SFEs, which are intended to compare all customers' water demand to a single-family residence. Customer water demand is the amount of water that enters a customer's service line and is typically measured by meter and billing data. This demand is different than the water system demand, which is described further below. The District classifies customers as single family residential, multi-family residential, commercial, school, potable irrigation, and non-potable irrigation. Irrigation customers are either potable or non-potable water service connections used for irrigation purposes, including:

- Homeowner's associations (HOAs) irrigating common and other areas within their development
- Management companies irrigating common areas with multi-family developments
- Commercial developments irrigating common areas shared by multiple businesses
- Irrigation of sports fields and landscaping at schools

The District has three non-potable customers (Lewis Palmer High School, the Country Club Golf Course, and the Village Center HOA) that are served raw water for irrigation purposes and have been accounted for separately. Thus, they are excluded from the potable water demand calculations. The raw water demand from these customers is discussed in further detail in Section 2.1.1.4.

Table 1-1 provides a breakdown of the current number of customers in each customer category and the corresponding number of SFEs. As with previous LRPs, water usage from irrigation customers was incorporated into the appropriate single family, muti-family, commercial, or school customer class, and the count of irrigation customers was omitted from these calculations. This method accurately captures potable water demand from irrigation for future growth projections based on the customer class since irrigation demands differ based on the category of water usage.

Table 1-1 – Customer and SFE Count by Class as of December 2021

Customer Class	Number of Customers as of 12/31/2021	2016-2021 Average SFE	Number of SFEs as of 12/31/2021
Single Family	3,569	1	3,569
Multi-Family	376	0.73	274
Commercial	48	5.6	267
Schools	7	35.5	248
Total	4,000	-	4,358

- Potable water usage from irrigation was incorporated into the corresponding customer class, and the count of irrigation customers was omitted from these calculations.

SFEs were last calculated during the 2002 LRP. These assumed values were utilized for each of the following LRPs. To confirm these values, the average SFE was re-calculated for each customer class. This metric is a conversion from the number of customers to the number of SFEs. The percentage of flow from each customer class was determined from 2016-2021 billing data. These percentages were multiplied by total water system demand to estimate the portion of total water system demand from each customer class. Total water system demand includes total water produced from all water treatment plants (WTPs), water leaving the storage tanks, daily process water used at the WTPs, and distribution system losses.

SFEs were determined for each customer class by dividing the respective water system demand by the demand of a single family residence. For each class, the number of SFEs divided by the number of customers yields the SFE value (the SFE for single family homes is 1.0 by definition):

$$\frac{(Total\ Class\ Water\ System\ Demand)}{(Total\ Water\ System\ Demand\ per\ Single\text{-}Family\ Class)} = (Number\ of\ SFEs\ in\ Class)$$

$$\frac{(Number\ of\ SFEs\ in\ Class)}{(Number\ of\ Customers\ in\ Class)} = (Average\ SFE\ Equivalent)$$

The current multi-family SFE remained similar to the value presented in the 2017 LRP. However, the SFEs for the commercial and school classes used in this LRP differ from those values in the 2017 LRP since the number of customers differs between the two reports. The previous LRPs appear to have overestimated the commercial customer count by summing the number of taps, which double-counts customers with multiple taps for the same location and may have omitted Prairie Winds Elementary from the school customer count since this school is served by the District but is physically located outside of District boundaries.

1.4. Future Growth Projections

As in previous LRPs, the two scenarios used for growth predictions are current buildout and ultimate buildout. Current buildout is defined as the cumulative SFE count if every parcel currently platted and all unplatted land currently included within the District's boundaries is developed. Ultimate buildout is defined as current buildout plus parcels likely to petition the District for inclusion. A discussion on ultimate buildout is included later in this Section.

The District currently has 21 remaining undeveloped parcels within its current boundaries. The water system demand for each parcel was estimated based on the number of acres in the parcel and existing District agreements. The undeveloped water system demand ranges from 1.5 to 184.0 acre-feet per year (af/yr) for individual parcels, with a total of 2,123 SFEs and about 647 af/yr collectively. The undeveloped parcels and demands are summarized in Table 1-2. Figure 1-1 shows the current District service area and the projected number of SFEs for each of the 21 undeveloped parcels included in the current buildout scenario.

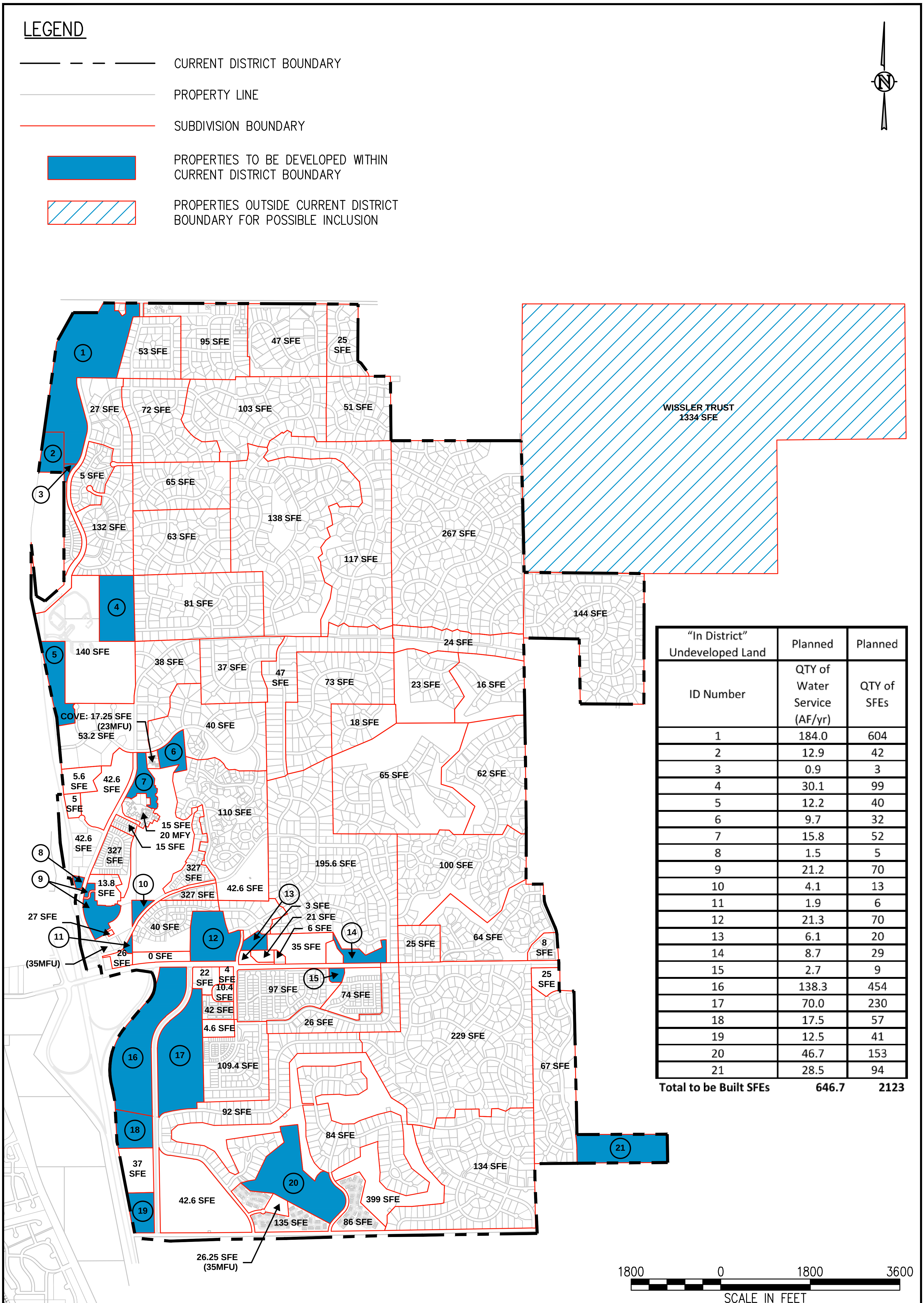
Table 1-2 – Estimated Demand for Undeveloped Parcels

Parcel ID Number	Water System Demand Allocated (af/yr)	Number of SFEs (based on 272 gpd/SFE)
1	184.0	604
2	12.9	42
3	0.9	3
4	30.1	99
5	12.2	40
6	9.7	32
7	15.8	52
8	1.5	5
9	21.2	70
10	4.1	13
11	1.9	6
12	21.3	70
13	6.1	20
14	8.7	29
15	138.3	454
16	70.0	230
17	17.5	57
18	12.5	41
19	46.7	153
20	28.5	94
21	2.7	9
Total	**646.7**	**2,123**

Projected water demands for the unplatted lands currently inside the District boundaries range from 0.5 acre-ft/acre/year (af/ac/yr) up to 1.5 af/ac/yr. The number of SFEs to be added through current buildout was determined by converting the estimated usage for unplatted lots to SFEs using the planning demand of 272 gallons per day (gpd) per SFE established in Section 2.1.1.1. The number of current buildout SFEs was calculated by summing the SFEs to be added with the current count of SFEs.

For ultimate buildout, the only inclusion identified in this LRP is the Wissler Trust, which is approximately 812.9 acres. Using a water allotment of 0.5 af/ac/yr and the planning demand of 272 gpd/SFE established in Section 2.1.1.1, this parcel is estimated to represent 1,334 SFEs and 406 af/yr. Figure 1-1 shows the current District service area and the Wissler Trust.

N:\1051.8e - Long Range Plan\Drawings\Exhibits-Figures\Section 1\Figure 1-1 - District Boundary and SFEs.dwg, 8/24/2022 - 12:32 PM, mht



"In District" Undeveloped Land	Planned	Planned
ID Number	QTY of Water Service (AF/yr)	QTY of SFEs
1	184.0	604
2	12.9	42
3	0.9	3
4	30.1	99
5	12.2	40
6	9.7	32
7	15.8	52
8	1.5	5
9	21.2	70
10	4.1	13
11	1.9	6
12	21.3	70
13	6.1	20
14	8.7	29
15	2.7	9
16	138.3	454
17	70.0	230
18	17.5	57
19	12.5	41
20	46.7	153
21	28.5	94
Total to be Built SFEs	**646.7**	**2123**

FIG 1-1: CURRENT DISTRICT BOUNDARY AND SFE'S

WWSD 2022 LONG RANGE PLAN

SEPTEMBER 2022

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1.4.1. Current Buildout

The current buildout for the District based on the methodology described above is 6,481 SFEs, or 1,974 af/yr, plus an additional 148 af/yr of non-potable water service. This is shown graphically in Figure 1-2.

Three population growth rates are forecasted in the LRP: a 4.0 percent accelerated growth rate, a 3.0 percent moderate growth rate, and a 2.0 percent slow growth rate.

For the period from 2023 to 2026, taps for active developments were converted to SFEs based on the relevant construction schedules for the Cloverleaf, Monument Junction, Waterside, and Northbay developments. Rapid growth is expected during this near-term period.

Historically, the District's growth rate has varied depending on the local housing market. Since 2017, the growth rate has ranged between 0.02 percent and 1 percent per year, with an average annual growth rate of 0.6 percent between 2017 and 2022. **A two percent growth rate is assumed for the purposes of this LRP**, so current buildout is expected to occur in 2037.

1.4.2. Ultimate Buildout

The ultimate buildout for the District is projected to be 7,815 SFEs, or 2,381 af/yr, plus an additional 148 af/yr of non-potable water service. The same three growth rates were used for the current and ultimate buildout scenarios.

While adding the Wissler Trust could increase the growth rate, it was assumed that the additional inclusion will extend the buildout date while maintaining the same growth rate used to reach current buildout. It is not anticipated that inclusion of the Wissler Trust will occur before the next LRP update in 2027, so its predicted effect was not applied to the short-term growth. Using the two percent growth rate established in Section 1.4.1, ultimate buildout is expected to occur in 2047.

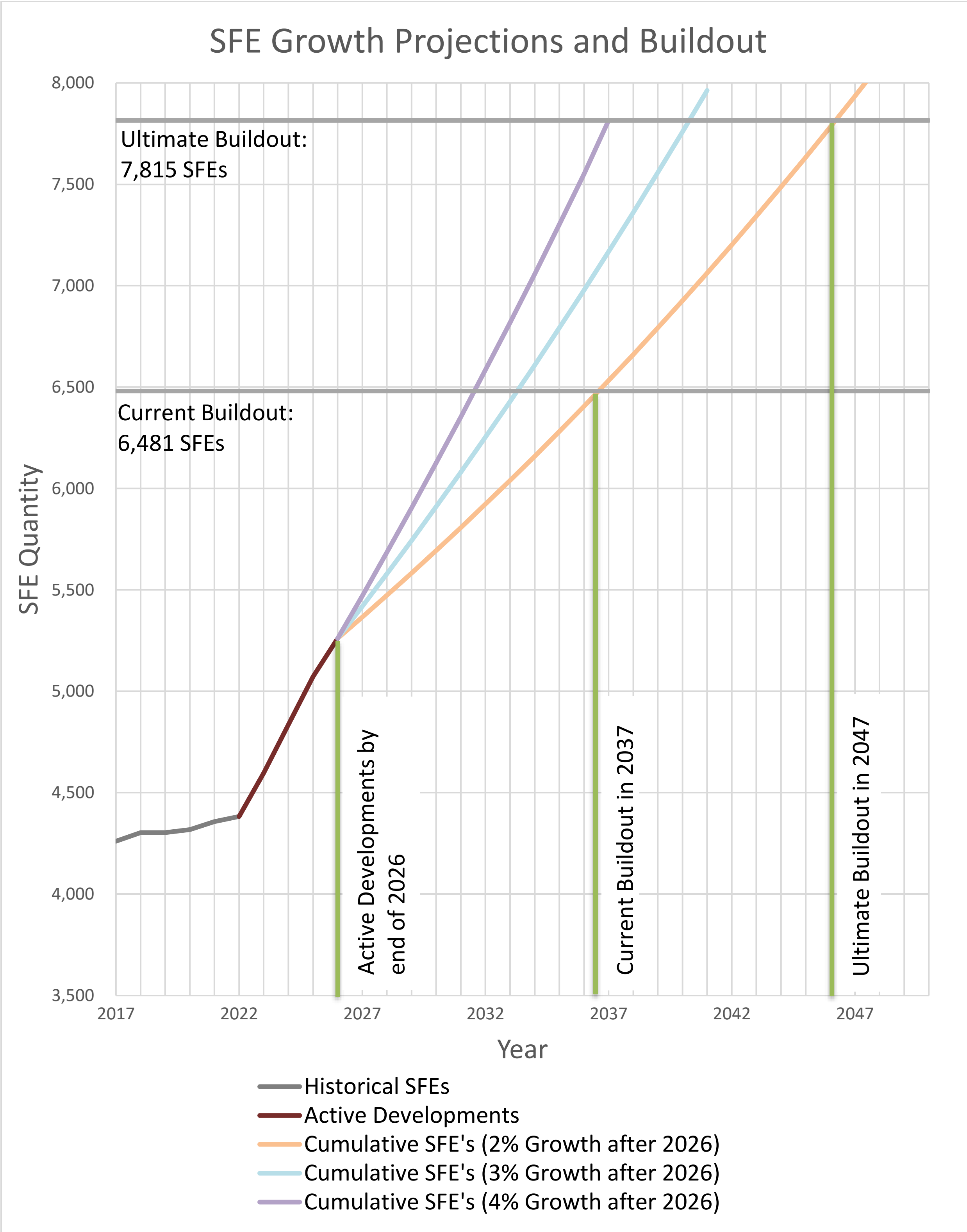

Figure 1-2 – Growth Projections and Average Annual Demand

SECTION 2 - CURRENT WATER SYSTEM

This section of the report analyzes the District's existing potable water system, calculates current water demands, summarizes the capacities of the existing water facilities, and identifies deficiencies. There are three main components of the potable water system. The first component is source water. The District currently uses three main physical sources of raw water:

- Groundwater pumped from wells
- Exchange water from Monument Creek and Dirty Woman Creek (DWC)
- Water from Lake Woodmoor (Lake) stored from prior well pumping and exchange

The second main component of the water system is the WTPs that treat the water to drinking water standards in compliance with Colorado's Primary Drinking Water Regulations. The last component is the distribution system that conveys treated water to customers throughout the District. Each one of these components requires analysis with respect to capacity and identification of deficiencies in order to maintain a system that delivers sufficient amounts of high-quality water to customers.

2.1. Current Water System Summary

The existing water system consists of 24 groundwater wells that are each described further in Section 2.2.1. The existing water system also includes two surface water diversion structures, four raw water transfer pump stations, raw water storage, two WTPs, individual treatment systems for Wells 8 and 11, two potable water booster pump stations, and three potable water storage tanks. Figure 2-1 depicts the overall system in schematic form.

The four raw water transfer pump stations move raw water throughout the District. The Monument Creek Exchange (MCE) pump station pumps raw water from Monument Creek through a transmission pipeline that can discharge to either Lake Woodmoor or to the South Water Treatment Plant (SWTP). Lewis Palmer High School and Tract H of the Village Center both draw raw water from the MCE pipeline for irrigation. There are two pump stations at Lake Woodmoor. LPS No. 1 pumps to SWTP and Augusta Pit and LPS No. 2 pumps to CWTP. The Augusta Pit is also equipped with a raw water pump that can send raw water to the Country Club Golf Course for irrigation.

The District's distribution system is divided into five pressure zones that are described further in Section 2.5. Zone 1 is located north of Woodmoor Drive and is served by the North Booster Pump Station (NBPS). Zone 2 is located south of Zone 1 and includes most of the eastern portion of the District. The North Tank feeds and maintains working pressure in Zone 2. The CWTP and South Booster Pump Station (SBPS) boost the pressure in Zone 2 when they are running. Zone 3 is located southwest of Zone 2. The South Tank maintains the working pressure in Zone 3 and SWTP boosts the pressure in Zone 3 when running. Zone 4 is a small pressure zone in the southeast corner of the District that is served by the SBPS. Zone 5 is a future pressure zone planned to serve the southwest corner of the District currently located in Zone 3. For this LRP, Zone 5 was considered built and is included in all pressure zone analyses and current modeling scenarios. The pressure zones and boundaries are also shown in Figure 2-8 in Section 2.5.

2.1.1. Water Demand and Water Use

To evaluate the capacity of the existing water system the water system demand must be understood. The current water system demand is used to project future water system demand and to size future infrastructure. It should be noted that this LRP considered District confidence in the analyses presented from previous LRPs. As such, water resources analyses consider the 2017 to 2021 period, while water treatment and demand analyses consider the 2016 to 2021 period.

The four primary goals of the water demand analysis are:

- Determine the total water system demand from current and projected future SFE's
- Estimate irrigation demand from residential and commercial customers
- Evaluate non-revenue water usage
- Evaluate demand from non-potable customers

2.1.1.1. Residential and Commercial Demand

The District tracks water usage through customer billing, WTP production, water storage tank levels, and WTP process water usage. Total daily water system demand (which includes non-revenue water) is calculated from the supervisory control and data acquisition (SCADA) system by adding the daily WTP production volume, the daily change in volume in the water storage tanks, and the daily process water used at the WTPs. Non-revenue water includes: (1) unbilled authorized consumption from fire hydrant flows, (2) WTP process water, (3) apparent losses from meter inaccuracies, and (4) real losses from leaks in transmission mains, storage tanks, and service connections. The average monthly water system demand for the 2016-2021 period is summarized below in Table 2-1.

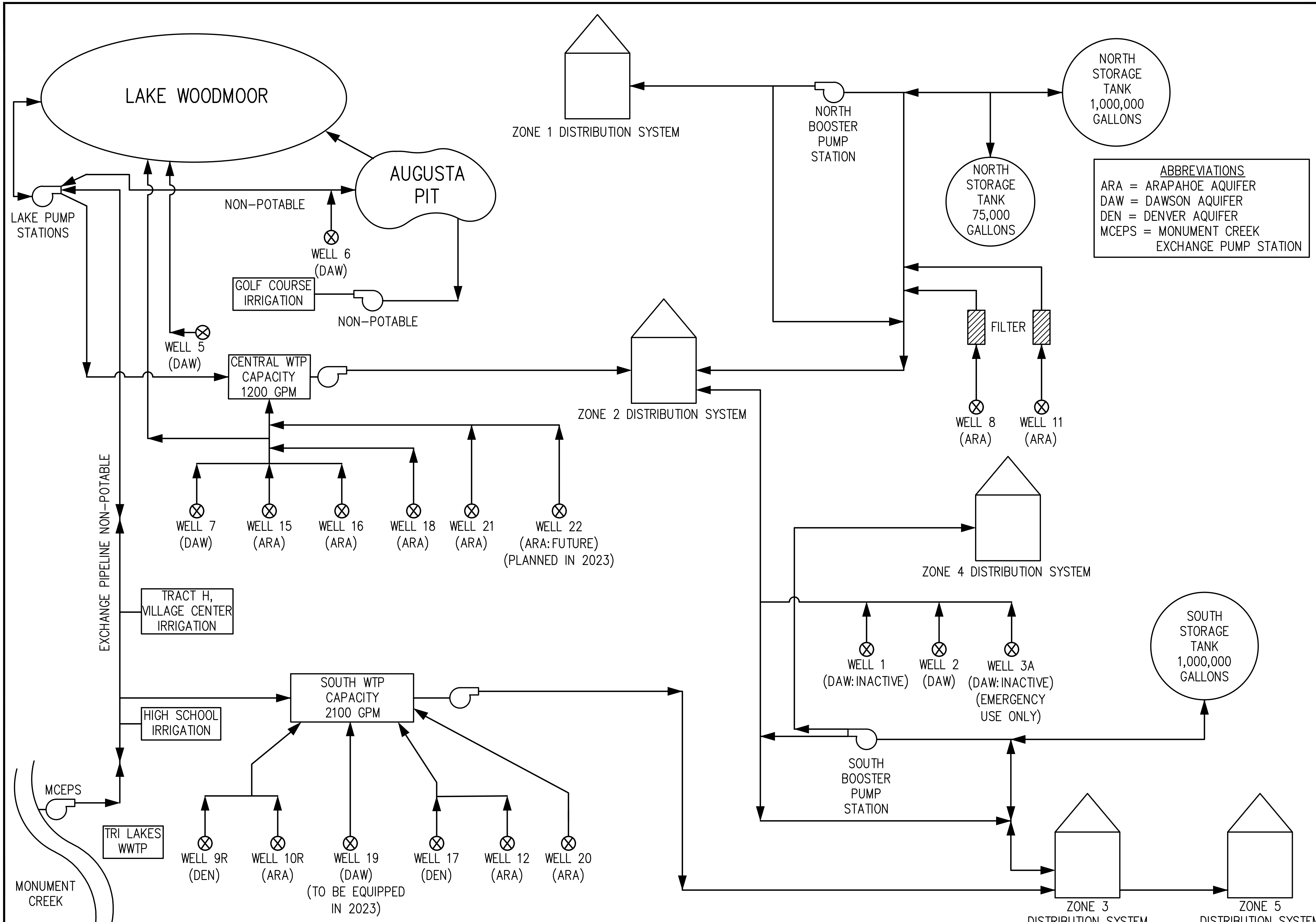

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FIGURE 2-1: WOODMOOR WATER SYSTEM SCHEMATIC

WWSD 2022 LONG RANGE PLAN

OCTOBER 2022

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Table 2-1 – Average Monthly Total Water System Demand

Month	Total System Demand (MG)						Average Daily Demand / SFE (gpd/SFE)					
	2016	2017	2018	2019	2020	2021	2016	2017	2018	2019	2020	2021
Jan	19	21	23	22	22	25	156	164	173	165	166	184
Feb	18	18	22	19	21	21	155	154	175	153	165	170
Mar	19	22	24	20	21	22	156	173	180	151	157	163
Apr	18	21	22	22	23	21	153	173	171	169	179	162
May	25	26	38	28	39	27	199	198	282	209	289	199
Jun	40	47	55	39	46	46	330	372	424	298	349	353
Jul	49	49	50	47	47	41	386	375	372	353	348	302
Aug	42	37	47	40	52	45	334	282	350	296	382	329
Sep	43	45	46	45	44	42	348	357	352	346	339	324
Oct	31	27	27	26	32	22	241	201	202	192	238	166
Nov	21	22	20	21	25	22	175	169	157	161	188	166
Dec	23	22	21	22	25	22	180	170	161	168	185	163
Average	**29**	**30**	**33**	**29**	**33**	**30**	**235**	**232**	**250**	**222**	**249**	**223**

1. Total Daily System Demand is calculated from the supervisory control and data acquisition (SCADA) system by adding the daily WTP production volume, the daily change in volume in the water storage tanks, and the daily process water used at the WTPs.
2. Non-revenue water includes: (1) unbilled authorized consumption from fire hydrant flows, (2) WTP process water, (3) apparent losses from meter inaccuracies, and (4) real losses from leaks in transmission mains, storage tanks, and service connections.
3. Erroneous SCADA data, days where no data or negative values were recorded, and days with water usage greater than 10 MGD were replaced with the average of the previous or next data available.

Erroneous SCADA data, days where no data or negative values were recorded, and days with water usage greater than 10 million gallons per day (MGD) were replaced with the average of the previous and next data available. For example, the SCADA system reported 65,580,000 gallons of process water used on November 29, 2016, and -65,480,000 gallons of process water used on November 30, 2016. Both of these values were replaced with the average process water used from November 28th and December 1st. A total of 42 days of erroneous SCADA data were adjusted for the 2016-2021 period: 13 days had no data recorded, 9 days showed process water errors, 6 days showed no process water used, 3 days showed customer usage errors, and 11 days showed both customer usage and process water errors.

Water system demand was analyzed from January 2016 through December 2021 and compared to historical demand to determine how water system demand is changing over time. To help determine if the change in water usage during the COVID-19 pandemic would skew the study period, water usage was analyzed for the 2020-2021 period and compared to the 2016-2019 and 2016-2021 periods. The results are summarized below in Table 2-2, which shows a negligible increase in demand during the COVID-19 pandemic.

Table 2-2 – COVID Demand Analysis

Parameter	Total System Demand		Total Demand per SFE		Total Water Billed		Total Billed Per SFE	
January 2016 - December 2019								
Average Annual	1,114	af/yr	236	gpd/SFE	947	af/yr	201	gpd/SFE
Max Annual	1,214	af/yr	248	gpd/SFE	1,021	af/yr	209	gpd/SFE
Min Annual	1,065	af/yr	242	gpd/SFE	913	af/yr	207	gpd/SFE
Max Month (June 2018)	170	af/mo	424	gpd/SFE	148	af/mo	370	gpd/SFE
January 2020 - December 2021								
Average Annual	1,156	af/yr	237	gpd/SFE	1,031	af/yr	211	gpd/SFE
Max Annual	1,215	af/yr	246	gpd/SFE	1,071	af/yr	217	gpd/SFE
Min Annual	1,098	af/yr	228	gpd/SFE	992	af/yr	206	gpd/SFE
Max Month (August 2020)	159	af/mo	395	gpd/SFE	163	af/mo	404	gpd/SFE
January 2016 - December 2021								
Average Annual	1,128	af/yr	236	gpd/SFE	975	af/yr	204	gpd/SFE
Max Annual	1,215	af/yr	246	gpd/SFE	1,071	af/yr	217	gpd/SFE
Min Annual	1,065	af/yr	242	gpd/SFE	913	af/yr	207	gpd/SFE
Max Month (August 2020)	159	af/mo	395	gpd/SFE	163	af/mo	404	gpd/SFE
Peak Day (August 18, 2020)	2.24	MGD	512	gpd/SFE	1.77	MGD	404	gpd/SFE

The total water system demand per SFE is used to project future water system demand through ultimate buildout. Water use fluctuates over time, so a larger dataset can provide a more complete picture of long-term trends. Previous LRPs averaged multiple demand values from overlapping datasets to try to capture a larger time period. For example, the 2017 LRP relied on a 293 gpd/SFE demand value by averaging the 2002-2016 demand value of 258 gpd/SFE, the 2002-2006 demand value of 314 gpd/SFE, and the 2006-2012 demand value of 305 gpd/SFE. This approach appears to overestimate current water system demand by counting the historical years with higher demand more than once.

For this LRP update, data was analyzed from January 2016 through December 2021 to determine the most recent water system demand. The average water system demand for the 2016-2021 period is 236 gpd/SFE, which compares with the 2002-2016 water system demand value of 258 gpd/SFE. Recent water system demand is expected to be lower than historical demand due to water conservation efforts and the installation of low-flow water fixtures, which can reduce indoor water usage by up to 30 percent. For more conservative future projections, a 15 percent safety factor was applied to the 236 gpd/SFE average 2016-2021 water system demand, rounded up to the nearest gallon. The 15 percent safety factor is considered consistent with estimates of the impact of dry-year irrigation demand on District demand and is less than reported dry-year increases in water demand for other Front Range communities. **Therefore, the planning level average annual demand to be used for future projections is 272 gpd/SFE.** This value is defined as the “planning demand” and is greater than actual water system demand during any year in the 2016 through 2021 period.

2.1.1.2. Residential and Commercial Irrigation Water Demand

The amount of potable irrigation water used by customers was also evaluated by comparing the summer water demand with the winter water demand for the 2016 through 2021 period. Since most homes and businesses stop irrigating during the winter months, the difference between summer and winter water demand can provide an estimate of the irrigation demand. For this analysis, summer was defined as May through September, winter was defined as November through March, and April and October were shoulder months that were not classified as winter or summer. A summary of the total water billed and produced in the summer and winter months is shown in Table 2-3, and the average water use for each month of the year is shown in Table 2-4.

Table 2-3 – Seasonal Potable Water Use Evaluation (2016-2021)

Parameter	Total Annual	Summer Months (May - Sept)	Winter Months (Nov - Mar)
Average Monthly Water Billed (MG/mo)	26	38	17
Average Monthly Water Billed (gpd/SFE)*	203	290	131
Average Monthly System Demand (MG/mo)	31	42	21
Average Monthly System Demand (gpd/SFE)*	234	323	164
Peak Day System Demand (MGD)	2.2	2.2	1.1
Peak Day System Demand (gpd/SFE)*	515	515	258

*Based on the December 2021 count of 4,358 SFEs

Table 2-4 – Monthly Potable Water Use Distribution (2016-2021)

Month	Average Water Billed (af/mo)	Average System Demand (af/mo)	Average Water Billed (gpd/SFE)	Average System Demand (gpd/SFE)	Average Monthly Percentage of Annual Water Produced
Jan	54	67	136	168	6%
Feb	49	61	134	166	6%
Mar	51	66	128	163	6%
Apr	54	66	137	168	6%
May	79	93	195	230	8%
Jun	125	140	317	354	13%
Jul	130	145	319	356	13%
Aug	130	135	317	329	12%
Sep	119	136	301	344	12%
Oct	77	84	188	207	7%
Nov	56	67	143	170	6%
Dec	51	70	126	171	6%
Nov-Apr Average	**53**	**66**	**134**	**168**	**6%**
Jun-Sep Average	**126**	**139**	**313**	**346**	**12%**
May, Oct Average	**78**	**89**	**191**	**218**	**8%**

The average annual potable water production from 2016 through 2021 was about 367.6 MG per year. The average winter potable water production (from November through March) during this period was about 20.8 MG per month, which equates to about 249.6 MG per year. Therefore, the average irrigation demand on the potable water system is approximately 118 MG per year, or about 32 percent of the total water produced annually. This irrigation usage is about one percent less than the same period of irrigation usage reported in the 2017 LRP.

Outdoor irrigation typically accounts for about 55 percent of the residential water use in urban areas along the Front Range of Colorado, so the irrigation demand in the District is lower than comparable communities in the region. This could be partly due to water conservation efforts described in Section 2.1.2 and lower irrigation demand relative to other Front Range communities due to elevation and substantial natural tree canopy.

2.1.1.3. Non-Revenue Water

Another goal of the water system demand analysis was to examine and quantify the sources of non-revenue water. Average non-revenue water varies from about 10 to 30 percent of total water production for typical communities. Non-revenue water is composed of three categories:

- Unbilled Authorized Consumption – this is water usage that is authorized by the District but is not paid for by customers. This includes water taken from hydrants for firefighting, construction, and distribution system flushing, and process water used at the WTPs.
- Apparent Losses – this category of losses includes customer meter inaccuracies, systematic data handling errors, and unauthorized consumption from illegal taps.
- Real Losses – this is water that is physically leaving the distribution system from pipe leaks and storage tank overflows.

A summary of the annual average water usage and measurable non-revenue water is provided below in Table 2-5. Columns 1, 2, and 3 show adjusted data from the SCADA system. The system demand (3) is the sum of the customer usage (1) and the process water (2). Column 4 shows a summary of customer billing data. The percentage of non-revenue water (5) was calculated by subtracting the volume of water billed (4) from the total system demand (3) then dividing by the total system demand (3). The percentage of process water (6) was calculated by dividing the volume of process water (2) by the total system demand (3). The percentage of apparent and real losses (7) is the percentage of non-revenue water (5) minus the percentage of process water (6). This method of calculation includes flows from fire hydrants (considered unbilled authorized consumption) in apparent and real losses. In 2021, the amount of water billed (4) exceeded the amount of customer usage measured (1), which reduced the percentage of non-revenue water.

Table 2-5 – Summary of Non-Revenue Water

Year	Customer Usage	Process Water	Total System Demand	Water Billed	Non-Revenue Water	Process Water	Apparent and Real Losses
	(gpd)	(gpd)	(gpd)	(gpd)	(%)	(%)	(%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
2016	866,425	82,189	948,614	830,581	12.4%	8.7%	3.8%
2017	884,107	95,212	979,320	826,454	15.6%	9.7%	5.9%
2018	1,003,579	80,385	1,083,964	924,306	14.7%	7.4%	7.3%
2019	880,456	83,398	963,854	846,517	12.2%	8.7%	3.5%
2020	981,292	100,531	1,081,824	969,345	10.4%	9.3%	1.1%
2021	886,472	93,598	980,070	897,686	8.4%	9.6%	-1.1%
2016-2021 Volumetric Average:					**12.3%**	**8.9%**	**3.4%**

From 2016 through 2021, the non-revenue portion of water averaged about 12.3 percent of the total system demand, of which about 8.9 percent was used for the WTP processes, and the remaining 3.4 percent accounted for apparent and real losses. The 2017 LRP calculated approximately 15 percent non-revenue water with about 7 percent accounting for fire hydrant use, apparent losses, and real losses. The District continues to reduce non-revenue water by locating and repairing leaks, testing and replacing flow meters, and optimizing distribution flushing.

2.1.1.4. Non-Potable Water Demand

The final goal of the water demand analysis was to examine usage from the District's three non-potable customers (Lewis Palmer High School, the Village Center HOA, and the Country Club Golf Course) that are served raw water for irrigation purposes. For each customer, the monthly non-potable water demand was analyzed and averaged for the 2016 through 2021 period. The peak demand was calculated by summing the demand for June through August.

Non-potable demand for Lewis Palmer High School is shown below in Table 2-6. The greatest irrigation water demand year in the period was 2018. The high school accounts for approximately 20 percent of the total non-potable water demand in the District.

Table 2-6 – Lewis Palmer High School Non-Potable Demand 2016-2021

Month	Lewis Palmer High School Monthly Non-Potable Demand (af)						
	2016	2017	2018	2019	2020	2021	Average
Jan	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Feb	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Mar	0.02	0.04	**0.00**	0.00	0.00	0.00	0.01
Apr	0.48	0.68	**0.85**	0.00	0.00	0.00	0.33
May	1.36	0.98	**3.60**	2.52	4.51	0.00	2.16
Jun (1)	4.42	8.08	**5.98**	6.69	2.92	2.86	5.16
Jul	6.72	6.89	**7.50**	4.71	8.05	2.92	6.13
Aug	8.13	4.53	**8.20**	2.65	4.71	3.03	5.21
Sep	5.05	6.28	**2.81**	3.39	2.61	1.29	3.57
Oct	4.53	5.45	**5.36**	0.37	4.14	1.98	3.64
Nov	1.59	0.00	**0.00**	0.00	0.00	0.00	0.27
Dec	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Total	32.31	32.92	**34.29**	20.33	26.95	12.08	26.48
Peak (2)	19.27	19.49	**21.68**	14.05	15.69	8.81	16.50

(1) Heavy rain in June 2021 resulted in lower irrigation demand for the year.
(2) Peak demand was calculated by summing demand for June through August.

Non-potable demand for the Village Center HOA is shown below in Table 2-7. The greatest irrigation water demand year in the period was 2018. The HOA accounts for approximately 14 percent of the total non-potable water demand in the District.

Table 2-7 – Village Center HOA Non-Potable Demand 2016-2021

Month	Village Center HOA Monthly Non-Potable Demand (af)						
	2016	2017	2018	2019	2020	2021	Average
Jan	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Feb	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Mar	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Apr	0.00	1.06	**1.39**	0.00	0.00	0.00	0.41
May	0.00	1.32	**1.89**	0.85	2.92	0.75	1.29
Jun (1)	0.22	3.86	**4.31**	3.18	3.11	2.91	2.93
Jul	2.45	5.28	**5.23**	2.53	2.96	2.47	3.49
Aug	2.71	3.72	**4.39**	2.42	3.64	2.80	3.28
Sep	4.11	5.08	**3.70**	2.68	3.25	2.39	3.54
Oct	2.06	0.29	**1.57**	0.68	1.16	0.06	0.97
Nov	1.10	0.00	**0.00**	0.00	0.00	0.00	0.18
Dec	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Total	12.65	20.61	**22.47**	12.33	17.04	11.38	16.08
Peak (2)	5.37	12.86	**13.92**	8.12	9.71	8.18	9.69

(1) Heavy rain in June 2021 resulted in lower irrigation demand for the year.
(2) Peak demand was calculated by summing demand for June through August.

Non-potable demand for the Country Club Golf Course is shown below in Table 2-8. The greatest irrigation water demand year in the period was 2020. The golf course accounts for approximately 66 percent of the total non-potable water demand in the District.

Table 2-8 – Country Club Golf Course Non-Potable Demand 2016-2021

Month	Country Club Golf Course Monthly Non-Potable Demand (af)						
	2016	2017	2018	2019	2020	2021	Average
Jan	1.08	0.00	0.00	0.61	**0.00**	0.00	0.28
Feb	1.08	0.00	0.00	0.00	**0.00**	0.00	0.18
Mar	1.08	0.00	1.07	0.00	**0.00**	0.00	0.36
Apr	1.08	2.16	0.96	1.07	**0.97**	1.07	1.22
May	4.92	4.63	12.14	5.91	**15.57**	7.92	8.52
Jun (1)	8.72	17.02	23.78	15.60	**16.05**	15.25	16.07
Jul	19.20	13.40	16.72	13.94	**19.84**	17.02	16.69
Aug	13.32	6.91	14.02	11.66	**20.79**	16.70	13.90
Sep	16.43	12.40	16.18	16.27	**17.65**	20.13	16.51
Oct	3.04	2.92	2.75	2.98	**6.37**	4.68	3.79
Nov	0.00	2.88	2.76	1.64	**0.00**	0.91	1.36
Dec	0.00	0.00	0.61	0.00	**1.22**	0.00	0.31
Total	69.98	62.34	90.99	69.68	**98.47**	83.69	79.19
Peak (1)	41.24	37.34	54.51	41.20	**56.68**	48.98	46.66

(1) Peak demand was calculated by summing demand for June through August.

The total demand from the three non-potable customers is presented below in Table 2-9. The greatest irrigation water demand year in the period for all three non-potable customers combined was 2018. The peak 3-month demand from June through August in 2018 was about 90.11 acre-feet (af), which is about 5.39 af higher than the 84.72 af estimate for 2018 presented in the 2017 LRP. The "Max Usage" column is calculated by summing the monthly demand from the highest usage year for each user: 2018 for the high school and HOA and 2020 for the golf course. The peak 3-month demand is about 60 percent of the total annual demand; that percentage does not substantially change between average and dry years.

Table 2-9 – Total Non-Potable Demand 2017-2021

Month	Total Demand from All Non-Potable Customers										
	Monthly Non-Potable Demand (af)								Distribution		
	2016	2017	2018	2019	2020	2021	Avg	Max Usage (1)	Avg Year	2018	Max Usage
Jan	1.1	0.0	**0.0**	0.6	0.0	0.0	0.3	0.0	0.2%	0.0%	0.0%
Feb	1.1	0.0	**0.0**	0.0	0.0	0.0	0.2	0.0	0.1%	0.0%	0.0%
Mar	1.1	0.0	**1.1**	0.0	0.0	0.0	0.4	0.0	0.3%	0.7%	0.0%
Apr	1.6	3.9	**3.2**	1.1	1.0	1.1	2.0	3.2	1.6%	2.2%	2.1%
May	6.3	6.9	**17.6**	9.3	23.0	8.7	12.0	21.1	9.8%	11.9%	13.6%
Jun	13.4	29.0	**34.1**	25.5	22.1	21.0	24.2	26.3	19.8%	23.1%	17.0%
Jul	28.4	25.6	**29.4**	21.2	30.8	22.4	26.3	32.6	21.6%	19.9%	21.0%
Aug	24.2	15.2	**26.6**	16.7	29.1	22.5	22.4	33.4	18.4%	18.0%	21.5%
Sep	25.6	23.8	**22.7**	22.3	23.5	23.8	23.6	24.2	19.4%	15.4%	15.6%
Oct	9.6	8.7	**9.7**	4.0	11.7	6.7	8.4	13.3	6.9%	6.6%	8.6%
Nov	2.7	2.9	**2.8**	1.6	0.0	0.9	1.8	0.0	1.5%	1.9%	0.0%
Dec	0.0	0.0	**0.6**	0.0	1.2	0.0	0.3	1.2	0.3%	0.4%	0.8%
Total	114.9	115.9	**147.8**	102.3	142.4	107.2	121.8	155.2	100%	100%	100%
Peak (2)	65.9	69.7	**90.1**	63.4	82.1	66.0	72.9	92.3	59.8%	61.0%	59.4%

(1) The "Max Usage" column is calculated by summing the monthly demand from the highest usage year for each user.
(2) Peak demand was calculated by summing demand for June through August.

The highest annual water demand observed for the combined non-potable customers for the 2017 through 2021 period was approximately 148 af/yr in 2018. **Therefore, the planning level average annual non-potable water demand to be used for future projections is 148 af/yr and 90 af/peak 3-month.** 2018 and 2020 were historic dry years at the District and the 2018 dry year irrigation water demand is 21 percent greater than average. Future dry year irrigation water demand is likely to be greater because of climate change. For this LRP, it was assumed that the District will continue to emphasize the need for water wise landscaping through tiered rates and other incentives that will limit non-potable water demand for existing customers from exceeding 148 af/yr.

2.1.2. Water Conservation

The District uses a combination of education, incentives, and enforcement to help conserve water. Strategies targeting irrigation are effective since outdoor watering typically accounts for about 30 percent of the District's water demand. Prior to 2010, the District would only implement watering restrictions during periods of prolonged drought. Restricted water uses include outdoor watering and irrigation, filling water features without fish (e.g. decorative fountains), and washing impermeable surfaces (e.g. driveways and sidewalks).

In 2010, the District adopted a Water Conservation Plan that identified further approaches to reduce water consumption.

The plan includes the following water conservation measures:

- Rebate program for low-flow fixtures and appliances
- Education surrounding xeriscape landscaping, including a demonstration garden at SWTP
- Water metering with tiered rate structure
- Mandatory Outdoor Watering Schedule from June 1 through September 30

Most of the District's water conservation measures target peak day irrigation demand in the summer. The Mandatory Outdoor Watering Schedule outlines acceptable types of outdoor watering and specifies days and times when watering is allowed. Warnings, fines, and flow restrictions are implemented for violations. This important strategy allows the District to reduce peak day demand and regulate water usage for irrigation.

2.1.3. Peaking Factors

The District calculates a daily peaking factor by comparing the peak day water demand to the annual average daily water demand for that calendar year. The daily peaking factor is used to help determine the minimum required size of the WTPs and potable water storage tanks.

Prior to the 2012 LRP, the SCADA system could not measure daily demand, so the daily peaking factors were estimated. The 2002 LRP estimated the daily peaking factor to be 2.2 and suggested demand could be lower than the estimated 1997 LRP daily peaking factor of 2.9. The 2002 LRP ultimately used a conservative daily peaking factor range of 2.6 to 2.9, since the lower 2.2 estimate could not be verified with actual demand data. The 2006 LRP estimated the daily peaking factor to be between 2.6 and 2.9, following the same methodology as the 2002 LRP.

The District began measuring daily water demand through SCADA starting with the 2012 LRP. Daily water demand accounts for: (1) the total daily volume of water entering the distribution system at CWTP and SWTP, and Wells 2, 8, and 11, plus (2) the daily change in volume in the potable water storage tanks, plus (3) the volume of process water used at CWTP and SWTP that day. A daily peaking factor and two-day moving average peaking factor were calculated for 2016 through 2021. A distribution histogram was prepared to demonstrate the probability of how often the District encountered various daily peaking factors during this time. The two-day moving average helps show the likelihood of back-to-back peak day events occurring.

The peaking factor probability histogram is shown in Figure 2-2. The highest daily peaking factor calculated was 2.2 (one occurrence in July 2017), and the second highest daily peaking factor calculated was 2.1 (fourteen occurrences from 2016 through 2021 in June through August). **The planning level peaking factor to be used for future projections is 2.2.**

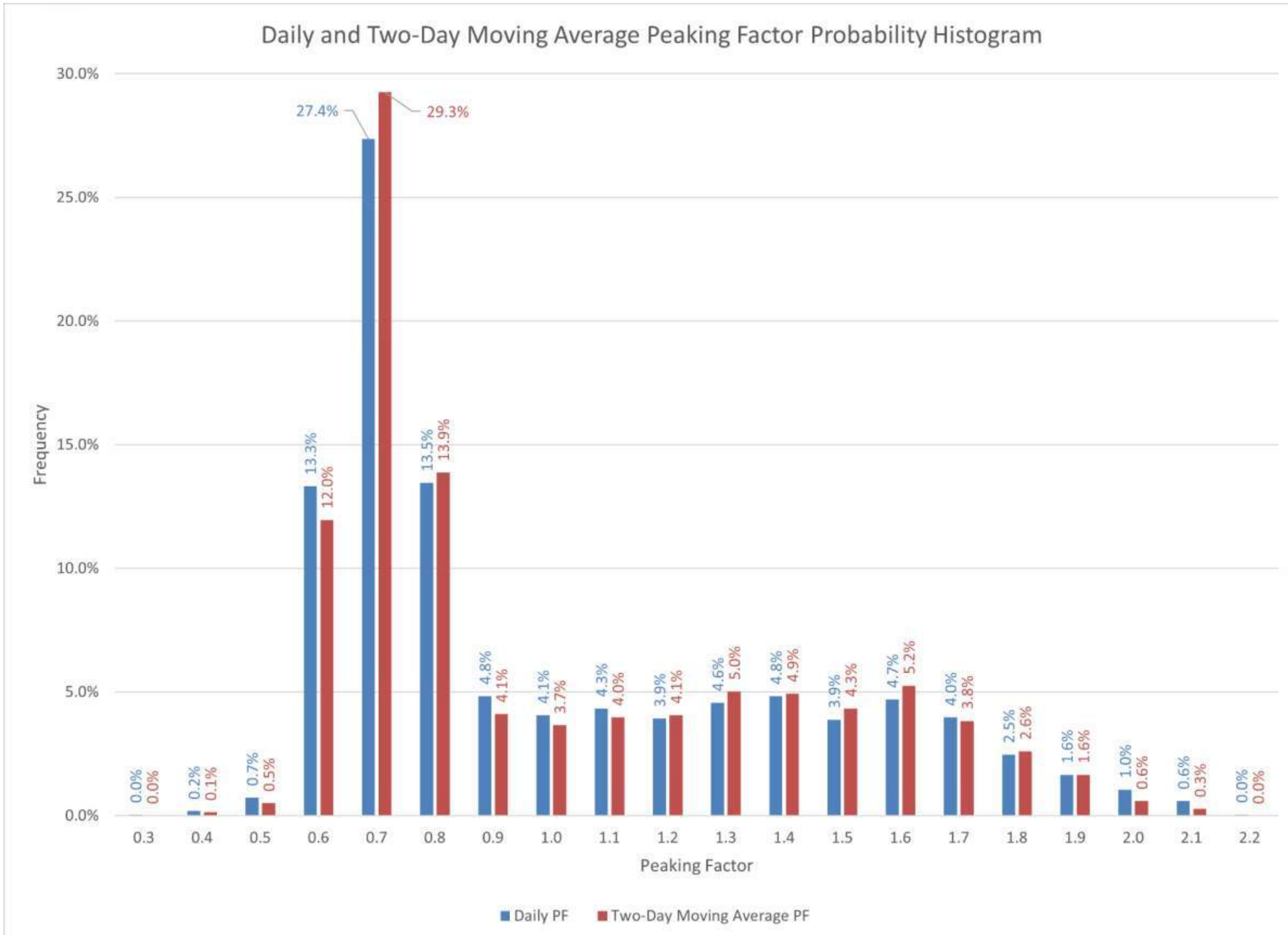

Figure 2-2 – Peaking Factor Probability Histogram

2.1.4. Peak Demand Management

The Mandatory Outdoor Watering Schedule outlined in the Water Conservation Plan continues to be an effective tool to help distribute peak day demand within the District. Peak day demands historically occurred when a large number of customers watered on the same day (usually seen after a hot day). The schedule theoretically spreads out when customers water so that only half of the District's customers are watering on any given day (assuming full compliance). This type of watering schedule is easy to implement, and most customers can comply by simply setting their automatic irrigation controller to their designated watering days and times.

The District has observed a reduction in the peak day demand factor since the Mandatory Outdoor Watering Schedule was implemented in 2010, as shown in Table 2-10.

Table 2-10 – Peak Day Demand Factors 1997-2022

Year	Peak Day Demand Factor
1997	2.9
2002	2.6 to 2.9
2007	2.6 to 2.9
2012	2.7
2017	2.5
2022	2.2

The peak day demand factor was estimated to be as high as 2.9 in 1997 when formal watering restrictions and schedules had not yet been implemented. The 2002 and 2007 LRPs assumed a range of 2.6 to 2.9 for the peak day demand factor since daily demand data was not available to verify the calculation performed for the 1997 LRP. Peak day demand factors have since fallen from 2.7 in the 2012 LRP to 2.5 in the 2017 LRP. Frequency of the highest peak day demand factors have also dropped since the 2017 LRP so that there is only a 0.6 percent chance the peak day is greater than 2.0 (as shown in
Figure 2-2). The reduction in peaking factors over time correlates with implementation of the Water Conservation Plan in 2010. The peak day demand management strategy appears to be effective and should continue to be monitored on a regular basis

2.2. Water Resources

The District currently utilizes ground water and surface water sources for raw water supply. Ground water is supplied by wells constructed in the Denver Basin aquifers. From shallowest to deepest, these aquifers consist of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers. The District owns water rights in each of the four aquifers and owns and operates wells completed in all except the Laramie-Fox Hills aquifer.

Surface water is supplied by diversions from Monument Creek and DWC that occur via an exchange system and can include re-diversion of lawn irrigation return flows (LIRFs) discussed in Section 2.3.2. In the future, surface water will also be provided via the Ranch Water Rights discussed in Sections 2.3.3 and 3.3.1. The exchange system diverts surface water upstream from where the District's reusable wastewater is discharged to Monument Creek at the Tri-Lakes Wastewater Treatment Facility (TLWWTF). The annual amount of water supply diverted from each of these sources to meet the District's total water demand are shown below in Table 2-11.

Table 2-11 – Raw Water Supply Source by Diversion Summary

Year	Total Diversions (af)				
	Dawson	Denver	Arapahoe	Exchange	Total
2017	99	36	802	315	1,252
2018	102	71	909	345	1,426
2019	89	115	788	388	1,379
2020	87	65	891	339	1,382
2021	51	105	842	166	1,164

- During July 2020 through December 2021, the District was not diverting all of the exchange yield available in the stream due to valve issues in 2020 and the CWTP Project in 2021 that required draining the Lake.

Figure 2-3 depicts the average diversion from each water supply over the 2017 through 2021 period. As shown, 76.5 percent of the District's total water supply has been diverted from the Denver Basin aquifers, with the Arapahoe aquifer providing the majority of the ground water. The District was unable to maximize the yield of its exchange system during 2020 and 2021. When these years are excluded, the Denver Basin Aquifers provided 74.2 percent of the District's total water supply for 2017 to 2019. This distribution is similar to values presented in the 2017 LRP, which showed approximately 71 percent of the District's total water supply from the Denver Basin Aquifers.

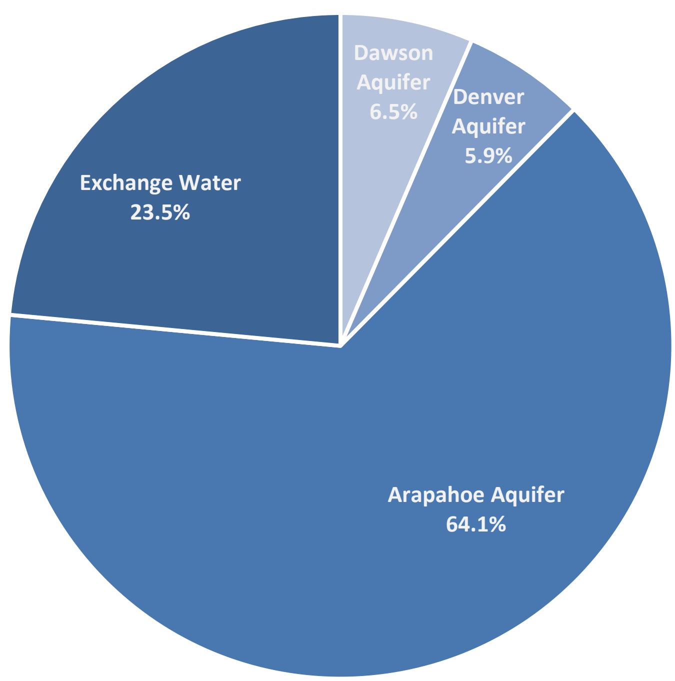

Figure 2-3 – 2017-2021 Average Water Supply Diversion by Source

2.2.1. Existing Wells

The District currently has 24 Denver Basin wells: 15 are online, one is for emergency use only, four are offline, and four are abandoned. **Online** wells (also called active wells) contain working pumping equipment and are readily available for use within the District's water supply system. **Emergency use only** wells are available for use within the District's water supply system but require approval by the Colorado Department of Public Health and Environment (CDPHE) and the Division of Water Resources (DWR) approval prior to use. These wells often do not meet water quality standards and would also require a waiver or public notice prior to use. **Offline** wells are permitted for use by the District but do not presently contain pumping equipment. These wells can be brought online for use within the district's water supply. **Abandoned** wells have been backfilled and/or plugged in accordance with the DWR guidelines for abandoning wells. These wells are no longer available for use.

The District also owns and operates one shallow ground/surface water diversion on DWC at the Augusta Pit that is permitted as an alluvial well (Qal-4). A summary of the District's wells is presented in Table 2-12 along with the date of the last maintenance for the online Denver Basin wells. Locations of the District's Denver Basin wells are shown in Figure 2-4. Seven of the District's Denver Basin wells and Qal-4 can deliver water to Lake Woodmoor.

Table 2-12 – Summary of Existing Wells

Well Name	Permit Number	Year Constructed	Operational Status	Aquifer	Top Screen (ft)	Total Depth (ft)	Pumps to Lake	Date of Last Service
Qal-4	47155-F	1990	online	Alluvial [1]	-	-	yes	-
Well 1	4484-F	1963	*offline*	Dawson	360	846	-	-
Well 2	9260-F	1965	online	Dawson	496	1011	no	Oct 2006
Well 3	9259-F	1965	abandoned	Dawson	390	1123	-	-
Well 3A	9259-R-F	1988	emergency	Dawson	620	1100	no	-
Well 4	9481-F	1965	*offline*	Dawson	400	1126	-	-
Well 5	12278-F	1968	online[2]	Dawson	395	800	yes	May 2021
Well 6	3826-F	1962	online[3]	Dawson	230	800	yes	Jan 2013
Well 7	4949-F	1963	online	Dawson	275	818	yes	Nov 2011
Well 8	16248-F	1971	online[4]	Arapahoe	2074	2500	no	May 2016
Well 9	21126-F	1976	abandoned	Denver	641	1130	-	-
Well 9R	21126-F-R	2001	online	Denver	987	1319	no	May 2019
Well 10	24030-F	1979	abandoned	Arapahoe	1100	1765	-	-
Well 10R	56480-F	2001	online[5]	Arapahoe	1362	1809	no	Jun 2022
Well 11	39116-F	1986	online	Arapahoe	1920	2500	no	Mar 2016
Well 12	36098-F	1990	online	Arapahoe	1410	1927	no	Apr 2014
Well 13	40474-F	1992	*offline*	Denver	918	1438	-	-
Well 14	41030-F	1992	abandoned	Denver	804	1349	-	-
Well 15	41363-F	1992	online	Arapahoe	1300	1874	yes	Jun 2021
Well 16	42450-F	1993	online	Arapahoe	1397	1907	yes	Aug 2016
Well 17	47103-F	1996	online	Denver	527	1352	no	Sep 2020
Well 18	49574-F	1998	online	Arapahoe	1374	1859	yes	Aug 2017 [6]
Well 19	55199-F	2001	*offline* [7]	Dawson	200	616	no	May 2022
Well 20	64594-F	2007	online	Arapahoe	1300	1892	no	Oct 2014
Well 21	81657-F	2018	online	Arapahoe	1834	2302	yes	Oct 2019

- Date of last pump service updated July 2022.

- Online wells contain working pumping equipment and are readily available for use. Emergency wells require CDPHE and DWR approval prior to use. Offline wells are permitted for use by the District but do not presently contain pumping equipment. Abandoned wells are no longer available for use.

[1] Dirty Woman Creek Alluvium.

[2] Well 5 is used to pump to Lake Woodmoor only.

[3] Well 6 can be pumped to Lake Woodmoor during the non-irrigation season and to the golf course during the irrigation season.

[4] Due to declining water levels and limited practical pump setting depths, utility of Well 8 is decreasing and the well may be taken offline in the future.

[5] Well 10R was last cleaned in May 2022 and new pumping equipment was installed in June 2022.

[6] Well 18 pump and motor service occurring in late 2022.

[7] Well 19 was cleaned in May 2022 and is expected to be equipped later in 2022.

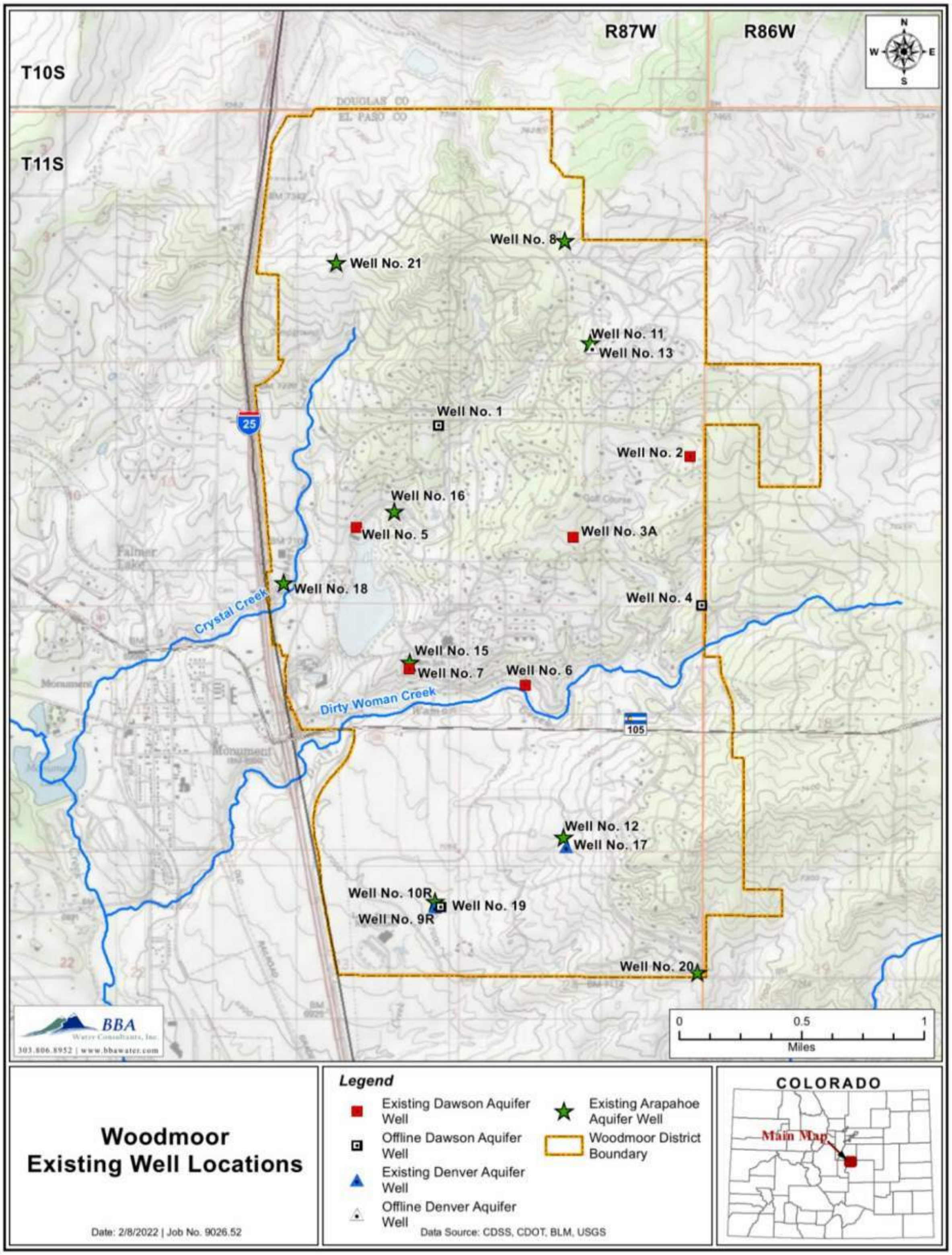

Figure 2-4 – Existing Denver Basin Well Locations

The 15 **online** Denver Basin wells are constructed in the Dawson, Denver, and Arapahoe aquifers. Wells 2, 5, 6, and 7 withdraw water from the Dawson aquifer; Wells 9R and 17 withdraw water from the Denver aquifer; and Wells 8, 10R, 11, 12, 15, 16, 18, 20, and 21 withdraw water from the Arapahoe aquifer. Operational pumping rates, current pump setting depths, and recommended maximum pumping water levels for these wells are summarized in Table 2-14.

Well 15 is exhibiting signs of failure, addressed below in Section 2.2.1.2.

The one **emergency use only** well is Well 3A, located in the Dawson aquifer. Although equipped, Well 3A produces poor water quality and would require public notice in additional to CDPHE and DWR approval. Current pump setting and recommended pumping water levels should this well be needed in the next 5 years are included in Table 2-14.

The four **abandoned** Denver Basin wells include Wells 3, 9, 10 and 14. Wells 3, 9, and 10 were redrilled as Wells 3A, 9R, and 10R, respectively. Well 14 was abandoned due to low yield and the District no longer owns the site.

The four **offline** Denver Basin wells include Wells 1, 4, 13, and 19. To be brought **online**, these wells would require installation of pumping equipment and coordination with CDPHE prior to use. Additionally, down-hole video surveys should be completed to confirm surficial conditions of the offline well structure and pumping tests should be conducted to confirm current achievable yield prior to selection and installation of pumping equipment. Further well maintenance and rehabilitation may also be required.

Well 1 is constructed in the Dawson Aquifer and has a history of high iron concentrations and a yield of 20 to 40 gallons per minute (gpm). In the future, Well 1 may be pumped to Lake Woodmoor to supplement the District's water supply and address water quality considerations through blending in the Lake.

Well 4 is also constructed in the Dawson aquifer. A yield of 55 gpm was reported when the well was constructed in 1965, however current yield is likely lower.

Well 13 is constructed in the Denver Aquifer and during construction cement grout entered the screened portion of the well. Despite improper construction, a yield of 50 to 75 gpm was achieved from Well 13 based on 1992 pumping test data; however, current yield may be far lower due to declining water levels and irreversible well clogging. The well would need to be video surveyed, cleaned, and tested prior to installing permanent pumping equipment. Additional rehabilitation of Well 13 to remove grout from the well screens may enhance yield but is not likely to be cost-effective.

Well 19 is constructed in the Dawson Aquifer and is expected to yield approximately 25 gpm, based on 2001 pump test data when the well was constructed. The District is in the process of bringing Well 19 online. The well was brushed, bailed, and chlorinated in May 2022 and was video surveyed in June 2022 with the plan of installing permanent pumping equipment later in 2022.

2.2.1.1. Aging Wells

Ten of the District's Denver Basin wells are beyond their expected usable lifespan of 25 to 30 years and as a result, well failure would not be unexpected. Offline wells that were constructed more than 30 years ago include Wells 1 and 4. Online wells that were constructed more than 30 years ago include Wells 2, 3A, 5, 6, 7, 8, 11, and 12. Additionally, Wells 13, 15, 16, and 17 were constructed between 25 and 30 years ago. Upon well failure, the District should expect to abandon the old wells and redrill at the well sites.

2.2.1.2. Water Levels and Diminishing Capacity

Historical water level measurements in the District's Denver Basin wells have been collected at regular intervals to monitor changes in aquifer conditions, seasonal water level fluctuations, well performance, and well maintenance needs. This data is also used to project future well performance and to properly size replacement pumping equipment. Water level decline rates in the Dawson, Denver, and Arapahoe aquifers have been recorded and quantified. Denver Basin aquifer water level declines are expected because regional well pumping greatly exceeds aquifer recharge. Hydrographs for each of the District's Denver Basin wells are presented in Appendix A and include the estimated water level decline rates for each well.

Predicting future water level changes is uncertain in the Denver Basin due to complex interbedded geology and changing regional Denver Basin well pumping. As with past LRPs, future water level decline was projected to be linear. However, as the top of the aquifers transition from confined to unconfined conditions, regional water level decline rates may slow in some circumstances. The projections presented herein do not account for any decrease in regional water level decline rate as the aquifers transition from confined to unconfined.

For this analysis, linear regional water level decline rate projections rely on historical pre-irrigation season water levels. The estimated regional water level decline rates were used to project the dates at which the static water level would reach the top well screen and halfway through the production zone in each of the District's online wells, presented below in Table 2-13.

Table 2-13 – Summary of Water Level Declines in the District's Basin Wells

Well Name	Estimated Water Level Decline Rate (ft/yr)	SWL at Top Screen		SWL through Half of Production Zone	
		Date	Years from April 2022	Date	Years from April 2022
Dawson Aquifer					
Well 2	4.2	Mar-26	4	Jun-87	65.2
Well 3A	7	Nov-39	17.6	Jan-72	49.8
Well 5	4	Dec-38	16.7	Jul-89	67.3
Well 6	6.3	Jan-11	below screen	Apr-56	34
Well 7	6.4	Jan-37	14.8	Jun-79	57.2
Average	**5.6**	**Aug-30**	**8.4**	**Dec-76**	**54.7**
Denver Aquifer					
Well 9R	5	Jul-26	4.3	Sep-59	37.5
Well 17	2.5[1]	Jul-29	7.3	May-91	169.1
Average	**3.8**	**Jan-28**	**5.8**	**Jul-25**	**103.3**
Arapahoe Aquifer					
Well 8	17[2]	Dec-32	10.7	Jan-43	20.8
Well 10R	16	Jul-30	8.3	Jun-43	21.2
Well 11	17	Mar-28	6	Apr-42	20.1
Well 12	10	Oct-32	10.5	Sep-53	31.4
Well 15	15	Dec-13	below screen	May-32	10.1
Well 16	17	Dec-17	below screen	Oct-32	10.5
Well 18	20	Jun-18	below screen	Dec-29	7.7
Well 20	12	Apr-23	1	Dec-47	25.7
Well 21	17[3]	Dec-24	2.7	Feb-38	15.9
Average	**16**	**Aug-24**	**2.4**	**Mar-40**	**18**

- Water level decline rates based on linear fit of historical static water level data provided by the District.
- Years from April 2022 static water level at top screen and halfway through production zone based on linear fit of historical water level data and do not reflect possible changes in well operation and are not based upon modeling.
- The projections presented do not account for any decrease in regional water level decline rate as the aquifers transition from confined to unconfined.
- Hydrographs for each of the District's Denver Basin wells are presented in Appendix A and include the estimated water level decline rates for each well.

[1] Based upon water level data during 2011-2021 after full recovery, which typically requires 2-3 weeks of no pumping.
[2] Suspect recent data may be unreliable, decline rate fit to interval of data with most confidence.
[3] Lower confidence in decline rate due to limited period of record and water level monitoring equipment problems.

In general, Dawson aquifer decline rates have moderated relative to values presented in the 2017 LRP. The estimated static water level decline rate in the Dawson aquifer ranges from 4 to 7 ft/yr with an average of 5.6 ft/yr, compared to an average of 6.4 ft/yr in the 2017 LRP. The Dawson formation outcrops within the District and the surrounding area. Accordingly, the Dawson aquifer may benefit from greater recharge rates relative to the other Denver Basin aquifers beneath the District's boundary. From 2017 through 2021, the District pumped 6.5 percent of its ground water supply from the Dawson Aquifer. Future well yields from the Dawson Aquifer are anticipated to be near current pumping rates.

The average decline rate in the Denver aquifer moderated from 8.5 ft/yr estimated in the 2017 LRP to 3.8 ft/yr for this LRP. Available water level data from Well 9R and Well 17 were relied upon to quantify the Denver aquifer static water level decline rate. Based on more accurate and reliable data collected for Well 9R in recent years, the estimated decline rate has decreased significantly from 15 ft/yr to 5 ft/yr. The Well 17 decline rate has increased slightly, likely due to increased use. The lower screens in Well 9R and Well 17 may have a hydraulic connection with the Arapahoe aquifer resulting in complex water level sensitivities. From 2017 through 2021, the District pumped 5.9 percent of its ground water supply from the Denver Aquifer. Despite moderate decline rates, future well yields from the Denver Aquifer are anticipated to decrease over time.

The estimated static water level decline rate in the Arapahoe aquifer ranges from 10 to 20 ft/yr with an average of 16 ft/yr, which is unchanged from the 2017 LRP average. Decline rates have remained relatively steady for most of the District's Arapahoe aquifer wells. Decline rates moderated for Wells 8, 10R, and 15, likely due to reduced use of these wells during 2017 through 2021. Well 21, which was constructed in 2018, has exhibited a decline rate of 17 ft/yr, similar to the Arapahoe aquifer average. From 2017 through 2021, the District pumped 64.1 percent of its water supply from the Arapahoe aquifer. Due to declining water levels, future well yields from the Arapahoe aquifer are anticipated to decrease over time.

Well yield depends upon available drawdown. Available drawdown is the difference between the static ground water level and the deepest practical pumping water level. As regional ground water levels decline, available drawdown decreases, resulting in lower well yields.

Peak seasonal pumping by the District and neighboring water users during the irrigation season results in well-to-well impacts that cause substantial seasonal water level decline and decreased well yield. Most of these seasonal impacts recover during the non-irrigation season when reduced pumping allows the water levels in the aquifers to stabilize.

Well-to-well impacts reduce available drawdown late in the irrigation season. Recent Arapahoe aquifer well performance projections indicate irrigation season well-to-well impacts of approximately 100 feet by the end of the irrigation season in 2022 and 150 feet by the end of the irrigation season in 2027. Since well-to-well impacts are cumulative, constructing additional wells in the Arapahoe aquifer will reduce yield from existing wells resulting in a diminishing return. However, based on current projections, strategically located new Arapahoe aquifer wells will provide incremental increases to overall well field yield.

During 2017-2021, the District replaced pumping equipment in six of its wells, five of which included downsizing equipment to accommodate diminishing well yield:

- In 2017, Well 18 (Arapahoe) experienced pump failure. A larger motor was installed in 2017 to maintain higher rates.
- In 2017, Well 15 (Arapahoe) experienced pump failure. The pump and motor were downsized in 2019 from 200 gpm to 180 gpm. During 2020, substantial work was completed to address down-hole condition of the Well 15 structure.

- In 2019, Well 9R (Denver) was equipped after being offline since August 2016. A new pump, motor, and drop pipe were installed. Pump capacity was downsized from 200 gpm to 100 gpm, and the drop pipe was downsized accordingly.
- In 2020, Well 17 (Denver) experienced pump failure. A new pump, motor, and drop pipe were installed in 2020. Pumping equipment was downsized from 125 gpm to 100 gpm.
- In 2021, Well 5 (Dawson) was equipped with a new pump and motor. Pump capacity was downsized from 30 gpm to 25 gpm.
- In 2021, Well 10R (Arapahoe) experienced pump failure. The pump was downsized from 400 gpm to 250 gpm, and the drop pipe was downsized accordingly.

Peak day District water demand has historically been met by a conjunctive use program utilizing surface water from Monument Creek, storage in Lake Woodmoor, and well pumping. This conjunctive use program has allowed the District to reduce stress on the Denver Basin aquifers and delay construction of additional Denver Basin wells that would otherwise be required to meet peak demands.

In 2022, the District substantially increased its surface water treatment capacity by constructing a new raw water pipeline from the Lake to CWTP and performing surface water treatment upgrades at CWTP. This project allows the District to avoid drilling wells solely to meet peak day demand and allows more sustained use of surface water that reduces stress on the District's Denver Basin water resources.

2.2.1.3. Monitoring

Complete records of both static and pumping water levels along with pumping rates allow full evaluation of aquifer water level decline rates and individual well performance. Static water level trends are used to project future well yields and plan for new District facilities. Pumping water level information is used to evaluate aquifer response, guide well operation, and identify pump or well issues.

In 2004, the District established a minimum standard for Denver Basin water level measurements, which included pre-irrigation season and post-irrigation season static water level measurements from each well using an airline. Starting in 2006, pressure transducers connected to the District's SCADA system were installed in new and existing Denver Basin wells when pumping equipment was installed. Currently, ten wells are equipped with pressure transducers connected to the District's SCADA system, including both of the District's online Denver aquifer wells and all of the District's online Arapahoe aquifer wells except for Well 8. The District's SCADA system records hourly water levels and pumping rates from each of these wells.

Hourly pressure transducer data is of far higher resolution relative to the District's twice per year manual airline measurements and allows the District to make more informed decisions regarding pump sizing, the need for new wells, and optimizing existing facilities. In addition to continued collection of SCADA ground water level and pumping rate data in the District wells that are outfitted with transducers, BBA recommends the following schedule for airline measurements of ground water levels in District wells:

- Wells 2, 3A, 5, 6, and 7 (no transducer):
    - Collect one pre-irrigation season (March through May) static (non-pumping) airline measurement after the well has been off for at least 14 days.
- Wells 9R through 21 (if transducer is working):
    - Collect one pre-irrigation season (March through May) static (non-pumping) airline measurement after the well has been off for at least seven days. These data are used to validate pressure transducer data which can be flawed due to equipment malfunction.
- Wells 9R through 21 (if transducer is not working or data are suspect):
    - Collect one pre-irrigation season (March through May) static (non-pumping) airline measurement after the well has been off for at least 14 days.
    - Following the static airline measurement, collect a pumping airline measurement after the well has been pumping for at least 24 hours and record the pumping rate at that time.
    - Collect one late-irrigation season (September through October) static (non-pumping) airline measurement after the well has been off for at least seven days.

The process of maintaining the SCADA and airline data has evolved over the years into what is now called the "Water Level Monitoring Program" (WLMP). Beginning in Spring 2020, the WLMP has been used to prepare detailed pre- and post-irrigation season memoranda each year. These memoranda guide the District seasonal well operations to maximize well yields, document early indications of well and pump problems, decrease the turn-around time for replacement pump equipment recommendations when pump failures occur, and guide budgeting for annual capital improvement projects.

2.2.1.4. Operational Trends

Typically, the District operates Arapahoe aquifer Denver Basin wells that are located near the District boundary as continuous base yield and reserves its centrally located wells to meet peak demands. This practice minimizes aquifer decline and well-to-well impacts within the District.

Current design and peak pumping rates for the District's Denver Basin wells are summarized in Table 2-14 and range from 25 gpm for some Dawson aquifer wells to over 300 gpm for some Arapahoe aquifer wells. Recommended maximum pumping water levels are also included in Table 2-14 and are based upon available well water level drawdown and observed well efficiency, further limited by pump setting depths.

Table 2-14 – Operational Pumping Rates and Maximum Pumping Water Levels

Well Name	VFD Installed	Design Pump Rate (gpm)	Peak Pump Rate (gpm)	Current Pump Setting Depth (ft)	Recommended Maximum Pumping Water Level Depth (ft)	
					2022 Beginning of Irrigation Season	2027 End of Irrigation Season
Well 2	no	35.5	30	760[1]	680[6]	680[6]
Well 3A	no	-	-	1036[2]	860[4]	860[4]
Well 5	no	25	28	728[3]	598[4]	598[4]
Well 6	no	30	30	727[2]	550[5]	568[5]
Well 7	no	70	60	605[1]	525[6]	525[6]
Well 8	no	50	50	1905[1]	1865[7]	1865[7]
Well 9R	yes	100	100	1260[1]	1155[4]	1163[5]
Well 10R	yes	200	275	1754[1]	1568[4]	1568[4]
Well 11	no	200	230	2300[1]	2155[4]	2155[4]
Well 12	yes	200	265	1756[1]	1620[4]	1620[4]
Well 15	yes	180	200	1794[1]	1660[5]	1660[5]
Well 16	no	252	200	1782[2]	1665[7]	1665[7]
Well 17	no	100	115	1296[1]	885[7]	885[7]
Well 18	yes	200	220	1771[1]	1617[5]	1673[5]
Well 19	no	25	25	570[1]	414[4]	414[4]
Well 20	yes	400	325	1804[1]	1643[4]	1658[5]
Well 21	yes	250	275	2235[1]	2059[4]	2070[5]

- Pump setting depth and design pump rate based on pump system data sheets.
- Peak pumping rates represent peak rates expected in the next 5 years, based on recent operations with current well equipment.
- 2022 Beginning of irrigation season conditions based on SWL decline trendline for 4/1/2022.
- 2027 End of irrigation season conditions estimated based on SWL decline trendline for 9/1/2027.
- Recommended maximum pumping water levels are based upon available well water level drawdown and observed well efficiency.
- Well 8 SWL is only 74 ft above the pump setting, which is the deepest practical setting in this well. Recommended PWL is at 40 ft above the pump.
- Well 16 SWL is below the top well screen. Recommended PWL is limited to 56% total screens dewatered based on notable loss in efficiency observed at deeper PWLs.
- Well 17 SWL is above the top well screen. Halfway through the Well 17 screen is a depth of 785 feet. PWLs as deep as 900 feet have been operable for Well 17 in the past and will continue to be acceptable in the future.
- Well 18 SWL is below the top well screen. Recommended PWL is limited to 62% total screens dewatered based on notable loss in efficiency observed at deeper PWLs.

[1] Pump setting depth based on pump intake depth.
[2] Pump setting depth based on airline depth.
[3] Pump setting depth approximated as total string minus pump length.
[4] SWL projected above the top well screen. Maximum recommended PWL is halfway through the total well screens.
[5] SWL projected below the top well screen. Maximum recommended PWL is halfway through the remaining saturated well screens.
[6] Maximum recommended PWL limited to 80 feet above the pump setting depth.
[7] Maximum recommended PWL based on recent performance projection analysis prepared by BBA and differs from typical criteria listed in [4], [5], and [6].

Historically, the District has "cycled" many of their wells with run times less than 24-hours. This practice allows the District to manage tank storage and surface water treatment but can result in excessive pump/motor wear and sand production during well start-up cycles. Longer pumping cycles maximize the volume of water produced with reduced wear. Longer pumping cycles have proven successful in Arapahoe aquifer Wells 15 and 21. However, due to transducer issues in other District wells, the benefits of longer pumping cycles have not been fully assessed. The District should continue to evaluate ways to increase the duration of pumping cycles, for example by operating selected wells as "base yield" and operating one well to each treatment plant as needed to top off tank levels.

2.2.2. Exchange System

The District's exchange system captures approximately 51 percent of the District's reusable effluent from the TLWWTF. The exchange system diverts native flow in Monument Creek and DWC upstream of the TLWWTF "in exchange" for the amount of reusable treated wastewater effluent. In short, the exchange system is a reuse system. The exchange system diverts at MCE Pump station and the Augusta Pit (Qal 4) on Dirty Woman Creek. The MCE Pump Station diverts water from Monument Creek and pumps it to Lake Woodmoor and/or SWTP. Water from MCE Pump Station can also be used directly for irrigation at Lewis-Palmer High School. The Augusta Pit diverts water from DWC where it can be pumped directly to the golf course for irrigation or flow by gravity into Lake Woodmoor.

The Lake Pump Station can deliver water to (a) Augusta Pit for irrigation use at the golf course, (b) Lewis-Palmer High School for irrigation use, or (c) the WTPs for treatment and distribution. A schematic of the exchange system is provided in Figure 2-5.

2.2.2.1. Exchange System Operation

The District's exchanges are decreed water rights that allow upstream diversion of native flows "in exchange" for downstream discharge of reusable wastewater effluent from TLWWTF. Those exchanges operate in conjunction with the District's decreed augmentation plans and other decreed water rights.

Pursuant to its water rights decrees, the District's reusable wastewater effluent is limited to the daily minimum of the measured wastewater effluent discharge and 90 percent of calculated indoor water use (average monthly November through March water system demand). During much of the year the District is unable to capture, by exchange, all of its reusable wastewater effluent because natural stream flows in Monument Creek and DWC are less than the rate of reusable wastewater effluent discharge.

2.2.2.2. Reusable Effluent

The District's wastewater effluent discharged to Monument Creek via TLWWTF is from use of Denver Basin groundwater or prior exchange diversions. Most of the wastewater effluent from the District's Denver Basin groundwater is reusable.

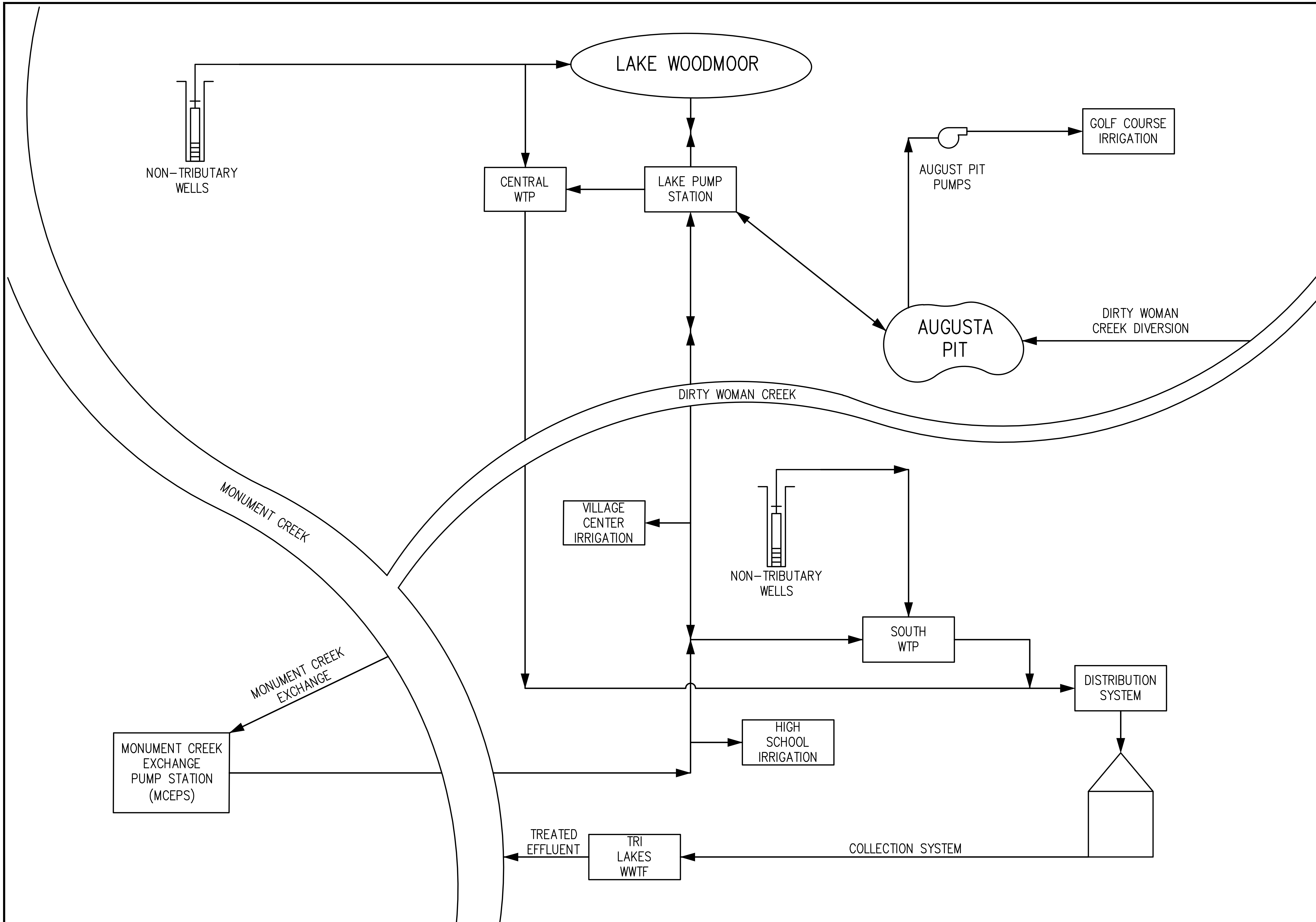

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FIGURE 2-5: EXISTING EXCHANGE SYSTEM SCHEMATIC

WWSD 2022 LONG RANGE PLAN

JUNE 2022

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During the 2017-2021 period, the District discharged an average of 885 acre-feet per year of wastewater effluent from TLWWTF, of which an average of 692 acre-feet per year (78 percent) was reusable based on the indoor water use calculation. This difference results from substantial amount of wastewater system inflow and infiltration (I&I) included in the total effluent discharge and may also be due to a conservatively low decreed 90 percent indoor use return flow factor. During the same 2017-2021 period, an average of 310 acre-feet per year of the District's reusable effluent (45 percent of 692 acre-feet) was diverted by exchange. However, in 2021, the District did not divert its full potential exchange yield due to the CWTP Lake Intake project. During a more representative 2017-2020 period, the District diverted by exchange an average of 347 acre-feet per year of an average 680 acre-feet per year reusable wastewater effluent (51 percent).

The exchange is limited by the amount of natural flow in Monument Creek and DWC. During the spring and during storm events, there is typically adequate flow to exchange all of the reusable wastewater effluent; however, during other times of the year, the exchange is often limited by the amount of water in the stream.

The MCE Pump Station is currently capable of pumping all of the flow in Monument Creek up to the maximum current pumping capacity of 1,000 gpm. Historically, there were times when the MCE Pump Station intake screens became plugged and needed to be cleaned. The efficiency of the exchange system decreases when the intake screens are not operable. Beginning late 2020, the District modified its operational practices to prevent intake screen plugging to increase exchange system yield.

Based on gaged streamflow in Monument Creek, the District captured approximately 87 percent of the native water available for exchange during the 2017-2021 period, which is comparable to the overall system efficiency of 85 percent determined in the 2017 LRP. This calculation excludes the following periods of known operational limitations that prevented the District from maximizing yield from its exchange system: (a) July through October 2017 due to water quality concerns from Monument Creek, (b) September 2019 through June 2020 due to operational convenience, (c) July through September 2020 due to repairs at MCE Pump Station, and (d) October 2020 through December 2021 due to draining Lake Woodmoor as part of the CWTP Project.

2.2.2.3. Lake Woodmoor Operation

The District relies on Lake Woodmoor to meet summer peak demands by storing water in the winter and spring. Typically, the water level (and corresponding volume of storage) in Lake Woodmoor decreases in the summer and increases in the late fall, winter, and spring. The District operates Lake Woodmoor based on the expected change in water volume for each month.

The Lake is filled by the exchange system throughout the year when there is natural flow in Monument Creek or DWC. Wells 5, 6, 7, 15, 16, 18, and 21 can be pumped directly to the Lake to supplement exchange yield during dry years. In the summer, water from the Lake is treated at SWTP and CWTP and pumped into the distribution system. Raw water from the Lake is also sent directly to large irrigation customers (the Country Club Golf Course, the Village Center HOA, and Lewis-Palmer High School).

The District operates the Lake based on the expected change in water volume for each month. If the actual volume of water in Lake Woodmoor is greater than the anticipated volume at that time of year, no action is needed. Conversely, if the actual volume in Lake Woodmoor drops below the anticipated volume at that time of year, the District can pump wells directly to Lake Woodmoor to make up the difference between the actual exchange and anticipated exchange. This operation gives the District flexibility and more certainty that Lake Woodmoor will have enough stored water to meet peak summer demands.

2.2.2.4. Exchange Yield

Annual yields of the District's exchanges for 2017-2021 are summarized in Table 2-15, which also illustrates the anomalously low exchange yield in 2021 due to the CWTP Lake Intake project. Relative to the 2017 LRP, the average 2017-2020 annual exchange yield decreased by just 3 percent from 358 acre-feet to 347 acre-feet. Considering 2018 and 2020 were the first and fourth hydrologically driest years in the 15-year period of record for the Monument Creek gaged data, this minor drop in exchange yield is not alarming. Another notable change since the 2017 LRP is a 14 percent increase in the average annual non-potable use due to the addition of the Village Center HOA as a non-potable customer beginning in August of 2016.

Table 2-15 – Summary of 2017-2021 Annual Exchange Yield

Year	Exchange Water Available for Domestic Use (af)	Golf Course, High School, and HOA Use (af)	Total Water Exchanged (af)
2017	199	116	315
2018[2]	197	148	345
2019	285	102	388
2020[2]	196	142	339
2021	59	107	166[1]
Average	**187**	**123**	**310**
2017-2020 Average	**220**	**127**	**347**

- Exchange water available for domestic use is equal to total water exchanged minus golf course, high school irrigation, and Village Center Metro District non-potable uses.

[1] In 2021 the Lake was being drained, which accounts for the low exchange.

[2] 2018 and 2020 were the first and fourth hydrologically driest years in the 15-year period of record for Monument Creek data, accounting for the minor drop in exchange yield.

During low-flow periods, the District generates reusable effluent at a greater rate than available native stream flow. The average monthly volume of the District's exchange yield for the 2017-2020 period is summarized in Table 2-16, and illustrates greater exchange amounts during December through June and lesser exchange amounts during the July through November post-runoff season.

Table 2-16 – Summary of 2017-2020 Average Monthly Exchange Yield

Year	Golf Course, High School, and HOA Use (af)	Total Water Exchanged (af)
Jan	0.2	37.0
Feb	0.0	31.6
Mar	0.3	47.0
Apr	2.3	59.5
May	14.2	53.9
Jun	27.6	34.8
Jul	26.8	11.0
Aug	21.9	7.0
Sep	23.1	3.4
Oct	8.5	7.7
Nov	1.8	23.1
Dec	0.5	30.6
Total	**127.1**	**346.7**

- 2021 data excluded from averages due to operational constraints preventing the District from maximizing exchange yield.
- Golf course, high school irrigation, and Village Center Metro District non-potable water uses are a subset of the monthly average exchange.

2.2.3. Supplemental Water Service

Supplemental water service is additional commitment above the District's 0.5 af/ac/yr allocation policy. The total theoretical quantity of supplemental water available is derived from the difference in the District's decreed water rights and its base water service commitments while maintaining compliance with both State of Colorado's 100-year rule and El Paso County's 300-year rule.

The quantity of supplemental water projected for undeveloped land is less than the underlying Denver Basin water rights entitlements due to practical development densities and economic considerations in the development and delivery of supplemental water service as well as Board policy regarding the sale and pricing structure of supplemental water.

2.3. Water Rights

The District owns groundwater rights, exchange water rights, storage rights, a plan for augmentation, and senior surface water rights.

The District's ground water rights include tributary, nontributary, and not-nontributary Denver Basin water rights. The District's exchange rights allow diversion by exchange of reusable wastewater effluent and LIRFs on Monument Creek and DWC. A plan for augmentation is decreed to replace evaporation from ponds within the District.

The District owns senior direct diversion and storage surface water rights on Fountain Creek that were changed for storage and municipal use in Case No. 12CW01 (Division 2) known as the "Ranch Water Rights". These senior Fountain Creek surface water rights include 58.0 shares (55 percent) of the Chilcott Ditch, 75 percent of the Liston and Love Ditch, 75 percent of the Lock Ditch, 75 percent of the Lock Ditch No. 2, and the Callahan Reservoir storage right. The Fountain Creek water rights are not yet used at the District northern El Paso County service area.

2.3.1. Denver Basin Water Rights

The District owns all of the Denver Basin water rights beneath the District's boundaries, except for limited reservations that account for historical wells owned by others. All of the District's Denver Basin water rights have been quantified by Water Court decree except for the water beneath the 11-acre Mills Timber inclusion.

The District's Denver Basin water rights include three statutory classifications of ground water: tributary, nontributary, and not-nontributary. The District's tributary ground water is from the Dawson aquifer and is replaced at 25 percent of pumping pursuant to a historical water rights decree. Nontributary groundwater is presently defined as groundwater that when withdrawn will not deplete the flow of a natural stream within one hundred years of continuous withdrawal "at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal." The District's nontributary ground water is from the Denver, Arapahoe, and Laramie-Fox Hills aquifers. Not-nontributary groundwater is groundwater located within the Denver Basin that does not meet the statutory definition of nontributary ground water. Decreed augmentation plans are required prior to pumping not-nontributary water in order to replace depletions both during pumping and after pumping has ceased. The District has not-nontributary ground water in the Dawson, Denver, and Arapahoe aquifers. Prior to the statutory creation of not-nontributary water, some of the District's Denver Basin water rights were decreed as tributary.

Summarized in Table 2-17 below, the District's Denver Basin water rights total approximately 7,390.5 acre-feet per year. Some of the District's decreed Denver Basin water rights are not available for use, including: item [5] not-nontributary water rights not yet included in a decreed augmentation plan and item [6] nontributary water rights reserved for not-nontributary water rights post-pumping augmentation (POPA). The POPA reserve is set aside for the District's future augmentation obligation as a result of current not-nontributary ground water pumping pursuant to Augmentation Plan II decreed in Consolidated Case Nos. 87CW067 (Division 2), 88CW100 (Division 2), and 88CW218 (Division 1) and is owed to Monument Creek and West Cherry Creek for a period of 200 years after pumping has ceased. A granular summary of the District's Denver Basin water rights is included in Appendix B.

Approximately 6,322.4 acre-feet per year of Denver Basin water is available to the District for use, shown in item [7]. However, not all this water can be consumed. Pursuant to the District's existing decrees, a percentage of pumped Denver Basin groundwater must be relinquished to the stream system, including 25 percent of pumped tributary water, 4 percent of pumped not-nontributary water, and 2 percent of certain pumped nontributary water, depending on the various water rights decrees. These relinquishments are typically achieved through assignment of TLWWTF return flows.

Table 2-17 – The District's Decreed Denver Basin Water Rights

Item	Description	Annual Entitlement (af/yr)
[1]	Tributary Water Rights	730.0
[2]	Not-Nontributary Water Rights	3,475.1
[3]	Nontributary Water Rights	3,185.4
[4]	**Total Denver Basin Water Rights**	**7,390.5**
[5]	Not-Nontributary Water Rights w/o Decreed Augmentation Plan	(625.1)
[6]	Nontributary Water Reserved for Post-Pumping Augmentation (POPA)	(443.0)
[7]	**Total Denver Basin Water Rights Available for Use**	**6,322.4**

- Excludes undecreed Mills Timber water, which is estimated to overly 18.1 af/yr of not-nontributary water and 3.2 af/yr of nontributary water.

[1] Total tributary water rights decreed in Case No. W-2647 (Division 2). The tributary water rights operate under an augmentation plan decreed in Case No. 80CW170 (Division 2).

[2] Total not-nontributary water rights decreed in Case No. 81CW230 (Division 2), Case No. 81CW231 (Division 2), Case No. 02CW025 (Division 2), and Consolidated Case Nos. 07CW104 (Division 2) and 08CW263 (Division 1). The not-nontributary water rights decreed in Case No. 81CW230 (Division 2) and Case No. 81CW231 (Division 2) total 2,850.0 af/yr (based upon a 100-year statutory aquifer life) and operate under an augmentation plan decreed in Consolidated Case Nos. 87CW067 (Division 2), 88CW100 (Division 2), and 88CW218 (Division 1). The District's other not-nontributary water rights are not included in a decreed augmentation plan and are not available for use.

[3] Total nontributary water rights are decreed in Case No. W-2647 (Division 2), Case No. W-4544 (Division 2), Case No. 80CW169 (Division 2), Case No. 81CW231 (Division 2), Case No. 02CW025 (Division 2), and Consolidated Case Nos. 07CW104 (Division 2) and 08CW263 (Division 1).

[4] Total Denver Basin water rights equals [1] + [2] + [3].

[5] Not-nontributary water rights decreed in Case No. 02CW025 (Division 2) and Consolidated Case Nos. 07CW104 (Division 2) and 08CW263 (Division 1) total 625.1 af/yr (based upon a 100-year statutory aquifer life) and are not currently included in a decreed augmentation plan. Therefore, these water rights are not currently available for use.

[6] Nontributary water rights totaling 443.0 af/yr (based upon a 100-year statutory aquifer life) are reserved for not-nontributary post pumping augmentation (POPA) requirements in Consolidated Case Nos. 87CW067 (Division 2), 88CW100 (Division 2), and 88CW218 (Division 1). The POPA reserve is set aside for the District's future augmentation obligation as a result of current not-nontributary ground water pumping pursuant to Augmentation Plan II and is owed to Monument Creek and West Cherry Creek for a period of 200 years after pumping has ceased.

[7] Total Denver Basin water rights available to the District for use equal [4] - [5] - [6].

During the 2017-2021 period, the District pumped an average of 1,010 acre-feet of Denver Basin ground water adjudicated in its modern water rights decrees, or approximately 16 percent of the total annual entitlement available for use. Special provisions in the District’s modern Denver Basin water rights decrees allow unused portions of the District’s annual entitlement to be carried over for use in subsequent years, referred to as “banking” or “banked water”; however, the banking provision is not included in the District’s older decrees. The banking provision takes effect once the Denver Basin water rights decree is entered by the water judge. After that time, any portion of the annual entitlement that is not pumped during a year is added to the “bank” of water available for pumping in any subsequent year. This banked water can be withdrawn in addition to the District’s Denver Basin water rights annual entitlements discussed above. For example, through 2021 more than 32,900 acre-feet of Arapahoe aquifer water has been banked pursuant to Case Nos. 81CW231, 02CW025, and 07CW104 (Division 2), and 08CW263 (Division 1).

Despite declines in well yield, the Arapahoe aquifer is the most productive aquifer beneath the District. If all future demands are met solely with the District's decreed Arapahoe aquifer water rights (an unlikely and very conservative scenario) the decreed Arapahoe aquifer annual entitlement would be exceeded before reaching buildout. Currently, Arapahoe aquifer pumping meets less than 65 percent of the District's demand and there is no actual exceedance. Furthermore, banked Arapahoe aquifer water rights could meet projected District demand through at least 2050. Many new Arapahoe aquifer wells would need to be drilled to supply all of the District's demand through 2050 at considerable expense. Therefore, although the District has ample Denver Basin water rights entitlements to meet future demand, it is not cost effective to rely exclusively on this non-renewable resource as a permanent supply.

The District's future water supply planning includes construction of new Dawson aquifer wells in relatively new inclusion areas that are in the western and northern portions of the District. Some of these areas are outside of the geography included in the plan for augmentation decreed in Consolidated Case Nos. 87CW67 (Division 2), 88CW100 (Division 2), and 08CW263 (Division 1). In 2023, the District should file an application for approval of a plan for augmentation for this not-nontributary groundwater.

2.3.1.1. County Water Supply Planning Requirements

El Paso County requires a 300-year water supply for subdivisions relying on Denver Basin ground water (300-year rule) that did not have preliminary plan approval prior to November 20, 1986. The 300-year rule differs from the 100-year aquifer life period used by the State for Denver Basin water rights administration (100-year rule). Since 2017, the District has added two parcel inclusions that fall under the 300-year rule, Lot 1 Mills Timber Subdivision (5.32 acres) and Lot 2 Mills Timber Subdivision (5.65 acres). Including these additions, there are approximately 778 acres of the District's lands subject to the County's 300-year rule. The remaining 2,816 acres of the District's lands were zoned prior to the effective date of El Paso County's 300-year rule and are subject to the State's 100-year rule.

The District relies upon a planning value of 0.5 af/ac/yr for average in-district water demand. By applying a demand of 1.5 af/ac/yr to lands subject to El Paso County's 300-year rule and 0.5 af/ac/yr to lands subject to the State's 100-year rule, the estimated Denver Basin water rights annual entitlement needed to meet planning requirements totals 2,575 af/yr. These amounts are summarized in Table 2-18. Currently, the District's decreed Denver Basin water rights annual entitlement available for use totals 6,322.4 af/yr; therefore, even before considering banked water and undecreed Denver Basin groundwater beneath the Mills Timber subdivision, the District has an excess of 3,747.4 af/yr of Denver Basin water rights annual entitlement available for future water commitments.

Table 2-18 – Woodmoor Water Commitments

Commitment Type	Lands with Water Commitments (ac)	Demand (af/ac)	Annual Demand (af)
Not Subject to El Paso County's 300-Year Rule	2,816	0.5	1,408
Subject to El Paso County's 300-Year Rule	778	1.5	1,167
Total	**3,594**	**-**	**2,575**

2.3.2. Reusable Credits

The District may use, reuse, and successively use the portion of its pumped Denver Basin ground water that is not required to be relinquished to the stream (“reusable credits”). Reusable return flows occur as either indoor reusable wastewater effluent that is discharged to Monument Creek at the TLWWTF or LIRFs that accrue to Crystal Creek, DWC, and Teachout Creek, tributaries to Monument Creek. The District can use its reusable credits as a source of augmentation within the District, by direct re-diversion, or as substitute supply in the District’s exchange system.

Currently, the District leases its unused reusable wastewater effluent to downstream water users. In the future, this water can be rediverted downstream and reused within the District. More discussion on future plans for reuse are addressed in Sections 3.2.3, 3.3.1, and 0. A summary of the District’s reusable credits is presented in Table 2-19.

Table 2-19 – Summary of Reusable Credits

Water Year	Reusable Effluent Credit	Total LIRF Credit	Purchased Reusable Effluent Credit	Total Available Credits	Reusable Credit Used for Exchange	Reusable Credit Used for Augmentation	Remaining Reusable Credit Available for Other Uses
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
2012	632	0	47.1	679	345	51	283
2013	634	0.9	21	656	370	58	229
2014	657	8.4	0	665	500	42	123
2015	654	9.1	3.3	666	347	37	282
2016	691	9.9	0	701	341	43	317
2017	703	9.4	0	712	327	59	327
2018	710	10.4	0	721	357	51	312
2019	642	10.1	89.1	741	397	56	288
2020	667	11.3	70.2	748	345	50	354
2021	737	11.2	0	749	139	49	560
'12-'16 Average	**654**	**5.6**	**14.3**	**673**	**380**	**46**	**247**
'17-'21 Average	**692**	**10.5**	**31.9**	**734**	**313**	**53**	**368**

Table 2-19 Notes:
(1) Equal to lesser of the District's measured effluent to Monument Creek through TLWWTF and 90% of the District's average base monthly water use for the previous November through March period generally based upon "Augmentation Plan II".
(2) Daily LIRF credit is equal to monthly LIRF credit determined in Woodmoor's LIRF accounting, distributed equally for all days of the subsequent month.
(3) Effluent credit purchased from Donala, Monument, or Triview.
(4) Equal to (1) + (2) + (3).
(5) Equal to sum of (a) net volume delivered to Lake Woodmoor from either MCE Pump Station or Augusta Pit, (b) amount delivered directly to the Golf Course via Qal 4, and (c) stored by exchange in the Golf Course ponds. Amounts differ from Exchange Supply in Table 2-11 and Total Water Exchanged in Table 2-15 due to a difference in timing, where Tables 2-11 and 2-15 reflect the timing of the diversion of exchange water from the stream and values in this table represent the time at which the exchange water is used within the District
(6) Equal to sum of augmentation requirement for (a) District wells, (b) Participating Ponds, and (c) King's Deer HOA.
(7) Equal to (4) - (5) - (6).

2.3.2.1. Woodmoor's Reusable Effluent Credits

Methodology to determine the District's indoor reusable effluent credit is provided in the District's Augmentation Plan II decree. These credits are available as an augmentation source for (a) replacement of tributary Denver Basin water pursuant to the Augmentation Plan I decree in 80CW170 (Division 2), (b) replacement of not-nontributary Denver Basin water pursuant to the Augmentation Plan II decree, and (c) exchange pursuant to the decree in 14CW3058 (Division 2).

From Table 2-19, the District averaged 692 af/yr of reusable effluent credit during 2017-2021, an increase of about 6 percent over the 2012-2016 period. As summarized in Table 2-19, an average of 313 af/yr of that amount was exchanged by the District in the 2017-2021 period.

2.3.2.2. Supplemental Effluent Credits

In order to divert water by exchange at a higher rate than the District's own reusable effluent credit allows, the District can purchase additional reusable effluent from neighboring entities whose wastewater is treated at either TLWWTF or the Upper Monument Creek Regional Wastewater Treatment Plant. These entities include the Town of Monument (TOM), Triview Metropolitan District, and Donala Water and Sanitation District (Donala). As shown in Table 2-19, the District purchased credits from other entities during two periods over the 2017-2021 period: (1) March through July of 2019 (89.1 af) and (2) March through June of 2020 (70.2 af). Diversion by exchange of supplemental effluent credits is not part of the District's exchange decrees and is operated instead by administrative approval.

Purchased effluent credits allow the District to fill Lake Woodmoor at a faster rate than would otherwise be possible and is advised whenever there is more native flow in Monument Creek at the MCE Pump Station than the District's reusable wastewater effluent credit. By using surface water, the District extends the economic life of its Denver Basin water supplies.

2.3.2.3. Lawn Irrigation Return Flows

The District can use reusable outdoor use return flows (also known as Lawn Irrigation Return Flows or "LIRFs") as an augmentation source for (a) replacement of evaporative depletions from in-District ponds pursuant to the decree in Case No. 2010CW28 (Division 2), (b) replacement of not-nontributary Denver Basin water pursuant to the Augmentation Plan II decree, and (c) exchange pursuant to the decree in 14CW3058 (Division 2).

LIRFs result from outdoor lawn irrigation that percolates below the lawn root zone and accrues to the stream system over time. The District quantifies LIRFs using a fixed return flow percentage equal to 15 percent of outdoor water use within identified LIRF areas. LIRF areas are located within the Crystal Creek, DWC, and Teachout Creek drainage basins in the District's boundaries that overlie alluvial or colluvial deposits outside of dense tree canopy, shown in Figure 2-6. The LIRF areas comprise approximately 760 acres out of the District's 3,909 acres, or approximately 19 percent of the current District area.

Based upon the fixed return flow percentage, total unlagged LIRF credits current and buildout conditions equal 16.8 af/yr and 33.3 af/yr, respectively, summarized in Table 2-20. Those annual amounts accrue to Crystal Creek, DWC, and Teachout Creek over time and will not be available in their full amounts until some years after buildout.

Table 2-20 – Estimated Unlagged Lawn Irrigation Return Flows

LIRF Area	Current Conditions within LIRF Areas		Buildout Conditions within LIRF Areas	
	2021 Outdoor Water Use (af/yr)	2021 Unlagged LIRF (af/yr)	Annual Outdoor Water Use (af/yr)	Annual Unlagged LIRF (af/yr)
[1]	[2]	[3]	[4]	[5]
Crystal Creek	12.4	1.9	12.5	1.9
Dirty Woman Creek	48.5	7.3	105.3	15.8
Teachout Creek	50.9	7.6	103.9	15.6
Total	**111.8**	**16.8**	**221.7**	**33.3**

[1] LIRF areas include areas within the Crystal Creek, Dirty Woman Creek and Teachout Creek drainage basins in the District's boundaries that overlie alluvial or colluvial deposits outside of dense tree canopy. LIRF areas comprise approximately 760 ac out of the District's 3,909 ac, or approximately 19 percent of current District area.

[2] Current outdoor water use based upon November 2020 - October 2021 water use data for accounts located within the LIRF areas. Annual outdoor water use equals total monthly water use during the April through October period less calculated average monthly indoor water use, which equals the average monthly water use during the previous November through March period. In the LIRF areas, lawn areas tend to be much greater than other areas in the District and outdoor water use is typically 45 – 75 percent of total water use, which is a much higher outdoor water use percentage than the District-wide average percentage of outdoor water use. For this reason, in the Crystal Creek basin, current outdoor water use exceeds the projection of buildout outdoor water use.

[3] Current annual unlagged LIRF equals 15-percent of current outdoor water use. Equals [2] * 15 percent. LIRFs currently available for augmentation purposes depend on the timing of the LIRFs accretion to the stream system. LIRFs from Crystal Creek, Dirty Woman Creek and Teachout Creek accrue to the stream system over a period of years.

[4] Buildout outdoor water use calculated based on total estimated SFE units within LIRF Areas, average water use of 272 gallons per day per SFE, the District-wide current demand distribution (36 percent outdoor water use), and potable system losses of 6 percent.

[5] Annual buildout unlagged LIRF equals 15-percent of buildout outdoor water use. Equals [4] * 15 percent. LIRFs available for augmentation purposes during buildout conditions depend on the timing of the LIRFs accretion to the stream system. LIRFs from Crystal Creek, DWC, and Teachout Creek accrete to the stream system over a period of years.

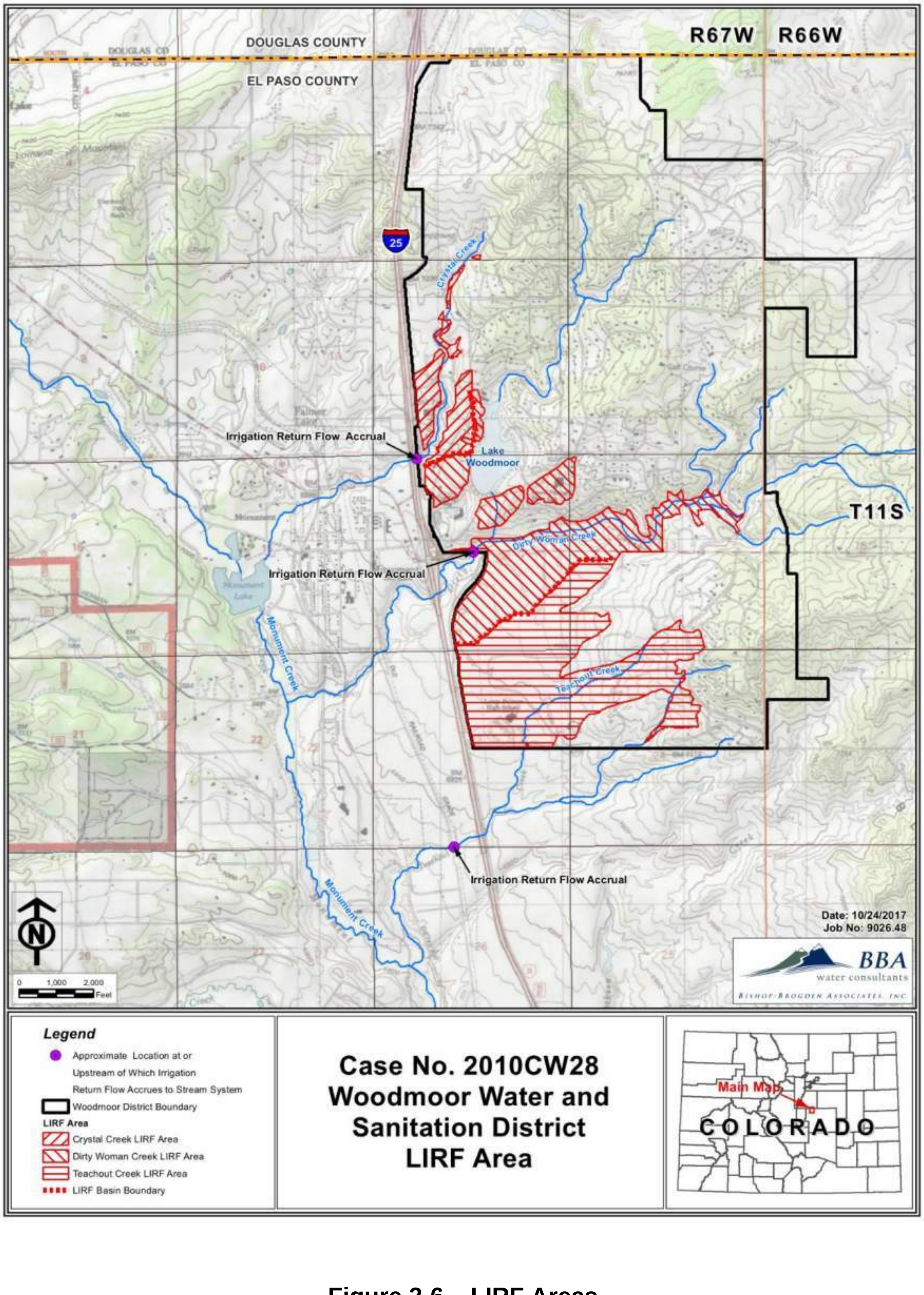


Figure 2-6 – LIRF Areas

LIRFs available to the District for augmentation purposes depend on the lagged timing of the LIRFs accretion to Crystal Creek, DWC, and Teachout Creek over a period of months and years. LIRFs are only available for the District's use after they have accrued to the stream. During November 2020 through October 2021 total LIRF accrual was 11.28 af, summarized in Table 2-21. The rate of LIRF accrual will increase over time and ultimately reach the buildout projection.

Table 2-21 – 2021 Lagged LIRF Credits

Month	Crystal Creek Basin (af)	Dirty Woman Creek Basin (af)	Teachout Creek Basin (af)	Total (af)
Nov-20	0.42	0.70	0.17	1.29
Dec-20	0.33	0.64	0.17	1.14
Jan-21	0.27	0.56	0.17	1.00
Feb-21	0.22	0.50	0.17	0.90
Mar-21	0.18	0.46	0.17	0.81
Apr-21	0.15	0.42	0.17	0.75
May-21	0.13	0.39	0.18	0.69
Jun-21	0.11	0.38	0.18	0.67
Jul-21	0.17	0.45	0.18	0.80
Aug-21	0.16	0.57	0.18	0.92
Sep-21	0.24	0.69	0.18	1.11
Oct-21	0.26	0.77	0.18	1.21
Total	**2.64**	**6.55**	**2.09**	**11.28**

Notes: Monthly amounts copied from Woodmoor LIRF accounting forms. Lagging based on URFs included as Appendix 3 in 10CW28 decree.

The District currently uses a portion of the lagged LIRFs to augment evaporative depletions resulting from the operation Participating Ponds within the District. The 10CW28 decree included four ponds at Monument Hill Country Club totaling approximately 4.4 acre-feet per year (evaporation from three of the four ponds; the fourth pond is accounted for by the Country Club on a daily basis through reservoir accounting). In 2018, the District added seven Participating Ponds to the 10CW28 decree, with a total of up to 8.13 acre-feet per year of evaporative depletions. Table 2-22 summarizes the District's LIRF credits, along with the amount used for augmentation of ponds within the District. The remaining LIRF credits are available for use in Augmentation Plan II, for exchange, or for lease to downstream entities. Shown in column (3) of Table 2-22, the District may not be using 3.6 af /yr of its LIRF credits. **The District should modify its water accounting to divert and account for this otherwise unused LIRF credit.**

Table 2-22 – Summary of LIRF Credits

Water Year	Total LIRF Credit (af)	LIRF Credit Used (af)	LIRF Credit Available for Other Uses (af)
	(1)	(2)	(3)
2012	0.0	0.0	0.0
2013	0.9	0.0	0.9
2014	8.4	4.5	3.9
2015	9.1	4.3	4.7
2016	9.9	4.7	5.2
2017	9.4	5.1	4.2
2018	10.4	7.0	3.4
2019	10.1	7.1	3.0
2020	11.3	7.8	3.5
2021	11.2	7.5	3.7
'12-'16 Average	**5.6**	**2.7**	**2.9**
'17-'21 Average	**10.5**	**6.9**	**3.6**

(1) Daily LIRF credit is equal to monthly LIRF credit determined in District's LIRF accounting, distributed equally for all days of the subsequent month.

(2) Equal to LIRF Credits Used accounted for in District's daily accounting workbook.

(3) Equal to (1) - (2).

2.3.3. Ranch Water Rights

The District acquired the Ranch Water Rights in 2011. The Ranch is located in El Paso County, near the City of Fountain, as shown in Figure 2-7. Approximately 2,040 acres on the Ranch were irrigated from Fountain Creek through the Chilcott Ditch using Chilcott Ditch, Liston and Love Ditch, Lock Ditch, Lock Ditch No. 2, and Callahan Reservoir water rights. The Ranch Water Right amounts and priority dates are summarized in Table 2-23.

On February 7, 2014, a decree was entered in Case No. 12CW01 (Division 2) that changed the use of the Ranch water rights from irrigation to municipal use and other uses, including the right to "reuse, successively use, and use to extinction all return flows including, but not limited to, indoor use return flows and lawn irrigation return flows." The change of use will allow the Ranch water rights to be diverted from Fountain Creek at their current point of diversion, stored in a reservoir, and ultimately delivered to the District via pipeline to meet municipal demands.

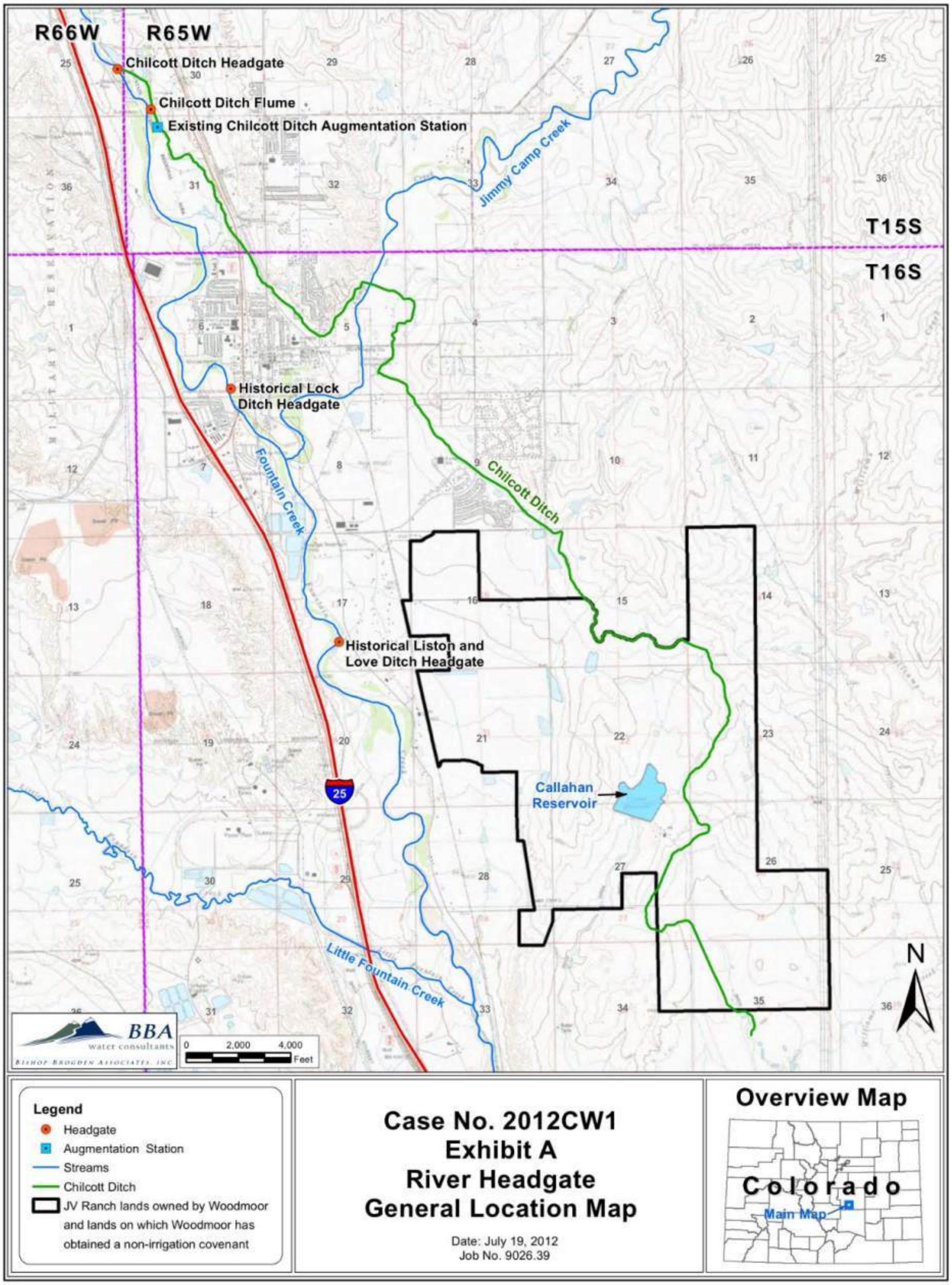


Figure 2-7 – Ranch Water Rights Map

Table 2-23 – Summary of Ranch Water Rights

Case No.	Fountain Creek Priority No.	Appropriation Date	Adjudication Date	Water Right Amount	
				Total	District
Chilcott Ditch Water Rights (Woodmoor owns 58/105 shares)					
CA 751	27	March 21, 1866	February 15, 1882	27.0 cfs	14.914 cfs
CA 751	39	March 21, 1874	February 15, 1882	20.63 cfs	11.396 cfs
CA 10146	172	December 18, 1905	June 2, 1919	30.95 cfs	Abandoned (1)
Liston and Love Ditch Water Rights (Woodmoor owns 75%)					
CA 751	14	March 21, 1863	February 15, 1882	8.82 cfs	6.615 cfs
CA 751	33	December 31, 1871	February 15, 1882	3.6 cfs	2.7 cfs
Lock Ditch and Lock Ditch No. 2 Water Rights (Woodmoor owns 75%)					
CA 751	15	December 31, 1863	February 15, 1882	6.3 cfs	4.725 cfs
CA 751	22	December 31, 1864	February 15, 1882	8.38 cfs	6.285 cfs
CA 751	45	December 31, 1880	February 15, 1882	5.02 cfs	3.765 cfs
Callahan Reservoir Water Right (Woodmoor owns 100%)					
CA 10146	51 (2)	November 20, 1909	June 2, 1919	716 af	716 af

(1) District's share of Chilcott Priority No. 172 was abandoned in Case No. 12CW1.
(2) Reservoir priority.

2.3.3.1. Current Operations

Future municipal water use of the Ranch Water Rights will occur pursuant to the terms of the 12CW01 decree. Unlike the Denver Basin well supplies, the District's system for diverting and storing the rights will vary from year-to-year with wet and dry cycles. Future operations of the Ranch and associated water rights are discussed in Section 3.2.3.

To-date, the District has not used the Ranch Water Rights for any changed uses. Irrigation continued on the Ranch through 2015. Beginning in 2016, the District began irrigation to establish new vegetation to comply with decreed revegetation requirements.

In 2014, a measurement flume was installed to measure deliveries to the Ranch, but records were not kept until 2015. The District began preparing and submitting accounting for the Ranch Water Rights to the State on a monthly basis beginning in June 2018. The accounting forms include tracking of volumetric limits pursuant to decreed terms and conditions.

During 2017 and 2018, the District had difficulty managing unmeasured inflows to the Chilcott Ditch, resulting in more delivery at the Ranch than was diverted at the river headgate, a challenge common to historical irrigation ditches. That issue has since been controlled and typical operations now consist of higher than historical ditch losses that are associated with lower than historical diversions.

2.4. WATER TREATMENT CAPACITY

The District currently operates four WTPs: CWTP, SWTP, and two small WTPs for Well 8 and Well 11. Most of the water introduced into the distribution system is from one of these four WTPs. A small amount of water from Well No. 2 is simply chlorinated before being introduced into the distribution system. Well No. 3A is plumbed for chlorination prior to distribution but is currently in “emergency use only” status and not used regularly. Since the 2017 LRP, Well No. 6 was disconnected from the distribution system and re-plumbed to the Lake Woodmoor/Augusta Pit raw water transmission pipeline.

The WTPs for Well 8 and Well 11 are equipped to only treat groundwater. SWTP is equipped to treat both groundwater and surface water. The recently completed CWTP Improvements Project approved CWTP for seasonal treatment of either groundwater or surface water with standard operating procedures implemented when changing sources. The District intends to operate CWTP using groundwater in the winter months and using both groundwater and surface water in the summer months to meet peak day demand. Following completion of the new Lake Pump Station in 2022, water from Lake Woodmoor can be sent to CWTP and/or SWTP for treatment.

Iron, manganese, and radium are the primary constituents of concern in the Denver Basin aquifers that the District targets for treatment. Each of the four WTPs dose potassium permanganate to help precipitate these prior to filtration. CWTP and SWTP use Trident filter units, and Wells 8 and 11 use pressure filters. While treating surface water or a surface and groundwater blend, the water is chlorinated post-filtration for disinfection before entering the distribution system. The water is chlorinated prior to filtration when treating groundwater only. Both CWTP and SWTP utilize two coagulants (Nalco 8185 and Nalco 8187) to enhance surface water treatment and adjust the dosing to target total organic carbon (TOC) removal.

The CWTP is equipped with three Trident filter units and three high service pumps, each rated for 0.576 MGD (400 gpm), which results in a total capacity of 1.728 MGD and a firm capacity of 1.152 MGD for CWTP. Wells 7, 15, 16, 18, and 21 currently supply water to the CWTP with Well 22 planned for connection in 2023. Based on the pumping rates described in Section 2.2.1.4, these active wells currently produce a maximum of 1.371 MGD, which leaves approximately 0.357 MGD, or 248 gpm, of capacity available for treatment of Well 22 at CWTP when operating in groundwater mode only.

The SWTP is equipped with three Trident filter units, each rated for 1.008 MGD (700 gpm), and three intermediate transfer pumps, each rated for 2.016 MGD (1,400 gpm). The SWTP also has three high service pumps; two are rated for 2.304 MGD (1,600 gpm) and one is rated for 1.008 MGD (700 gpm). The filters and transfer pumps currently limit the treatment capacity at SWTP, and there is space to install a fourth filter unit. The SWTP currently has a total capacity of 3.024 MGD and a firm capacity of 2.016 MGD. Wells 9R, 10R, 12, 17, and 20 currently supply water to the SWTP. These wells produce a maximum of 1.440 MGD, which leaves about 1.584 MGD, or 1,100 gpm, of capacity available for treatment when operating in groundwater mode only.

Well No. 8 has an 85-gpm treatment system installed but is limited by the 50-gpm well pump. The CDPHE approved the Well 8 treatment system for 0.122 MGD (85 gpm) based on the capacity of the treatment system. Using the pumping rates described in Section 2.2.1.4, Well 8 has a pumping capacity of 0.072 MGD (50 gpm) and Well 11 has a capacity of 0.288 MGD (200 gpm) for both the well pump and the treatment system. These systems were designed for the specific capacity of each well without consideration for future expansion, so the Well 8 and 11 treatment systems are at buildout.

The firm treatment capacity of the District was evaluated by considering one filter out of service at SWTP with all transfer pumps and HSPs operating, all filters in service at CWTP with one HSP out of service, and no water supplemented directly from wells. Under this scenario, the District has sufficient treatment capacity to accommodate a peak day demand of 3.701 MGD. Using the planning demand of 272 gpd/SFE established in Section 2.1.1.1 and the planning level peaking factor of 2.2 established in Section 2.1.3, the District currently has enough firm treatment capacity to serve its customers through current buildout. However, additional treatment capacity will be needed to meet ultimate buildout demand. The need for this additional capacity is expected to occur when the number of customers reaches about 7,000 SFEs. Using the two percent growth rate established in Section 1.4.1, the District could exhaust its current WTP firm treatment capacity around the year 2041.

There are two options to further increase the capacity of the water treatment system. A fourth 1.01 MGD filter could be installed at SWTP to increase this firm capacity to 3.024 MGD, which would provide a District firm capacity of 5.206 MGD and allow the District to meet the 4.7 MGD total peak day system demand expected at ultimate buildout with enough excess treatment capacity to serve approximately 1,230 additional SFE’s. If demand increases more than expected, the District could install a fourth 0.576 MGD filter in the maintenance area at CWTP and a fourth high service pump, which would bring the total firm WTP treatment capacity to 5.782 MGD and allow the District to serve up to 9,660 total SFE’s. The addition of a fourth high service pump at CWTP may require modifications to the transmission pipeline and distribution system to alleviate high pressures near the WTP.

2.4.1. Lake Woodmoor Summer Operation

The District typically only uses the groundwater wells to meet demand in the winter months, then draws water from Lake Woodmoor to meet peak irrigation demands in the summer months. Using surface water to supplement peak demand allows the groundwater wells to be pumped at a relatively consistent rate year round, which maximizes annual withdrawal from the least number of wells and helps to minimize stress on the wells. The District has substantially delayed well drilling projects by using lake water to meet peak demands and has implemented best management practices (BMPs) to help keep the lake maintained and operational during the summer months.

Prior to 2017, the District received taste and odor complaints from customers when Lake Woodmoor was used for raw water supply. Customers reported noticeable odors described as “earthy” or “fish-like” when hot water was used. Taste and odor compounds in drinking water are usually associated with geosmin or 2-methylisoborneol (MIB), which are produced by blue-green algae and filamentous bacteria. Geosmin and MIB have a distinct earthy or musty odor with a very low odor detection threshold of about 6 nanograms per liter (ng/L). Geosmin is also attributed to the muddy smell of catfish and carp. Greater reports of odor in hot water than cold water suggest the odor compounds are semi-volatile, which is consistent with geosmin and MIB.

Starting in 2012, the District began sampling Lake Woodmoor to measure the concentrations of geosmin and MIB. The District observed geosmin levels as high as 117 ng/L in 2013, with elevated concentrations above the detection threshold found in 2014 and 2015. The District conducted treatment alternative analyses in 2016 and 2017 and implemented the following BMPs for the lake:

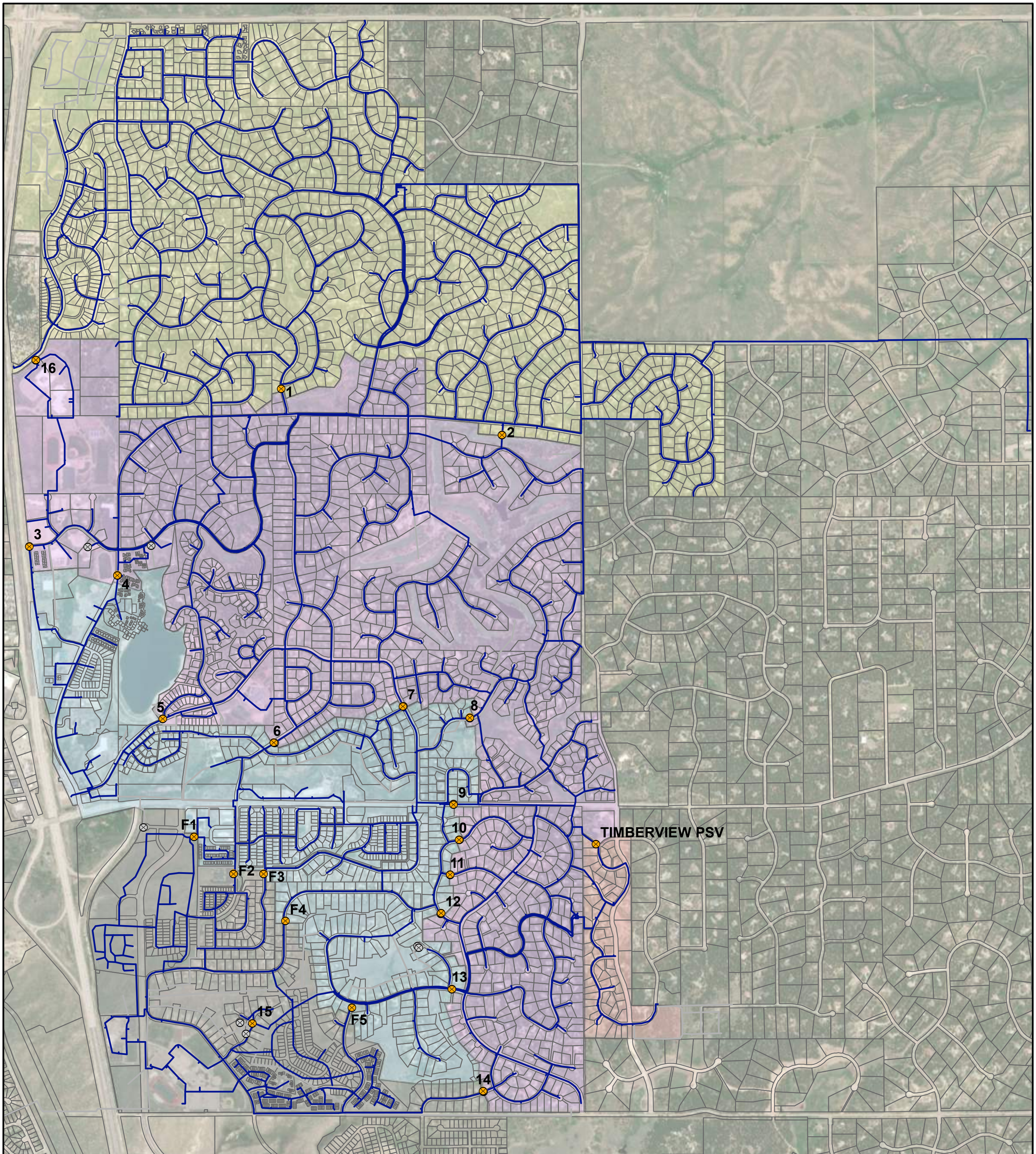
- Blending with low-nutrient well water
- Aeration using fine bubble diffusers
- Suppression of invasive/noxious aquatic weeds

Since implementing the BMPs, the District has seen a reduction in taste and odor complaints, improved mixing and increased oxygen levels, and minimal concentrations of geosmin and MIB. The Lake Pump Station Project completed in 2022 installed replacement/upgraded air compressors, actuators, hoses, and fine bubble diffusers. The District continues to monitor geosmin levels to determine if further treatment is needed.

2.5. DISTRIBUTION SYSTEM CAPACITY

The District maintains and operates approximately 450,000 linear feet of potable water distribution system piping that ranges from 4-inch to 12-inch diameter, with the majority (approximately 87 percent) composed of 6-inch diameter pipe. Roughly 60 percent of the distribution system piping is polyvinyl chloride (PVC), with approximately 40 percent composed of cast iron, and a small portion composed of ductile iron pipe (DIP). Most service lines are composed of Type-K copper, with a few HDPE service lines installed. There are no galvanized water mains or lead service lines in the District. The distribution system is currently split into four pressure zones with a fifth pressure zone being implemented, as shown in Figure 2-8:

- Zone 1 is located north of Woodmoor Drive and is served by the NBPS.
- Zone 2 is located south of Zone 1 and includes most of the eastern portion of the District. The North Tank feeds and maintains working pressure in Zone 2. The CWTP and SBPS boost the pressure in Zone 2 when they are running
- Zone 3 is located southwest of Zone 2. The South Tank maintains the working pressure in Zone 3, and SWTP boosts the pressure in Zone 3 when running.
- Zone 4 is a small pressure zone located in the southeast corner of the District. The SBPS feeds and maintains pressure in Zone 4.
- Zone 5 is a future pressure zone planned to serve the southwest corner of the District that is currently located in Zone 3. This impending pressure zone is expected to serve the Cloverleaf, Monument Junction, and Walters Estate developments. For this LRP, Zone 5 is included in all pressure zone analyses and current modeling scenarios.



LEGEND

PRESSURE ZONE

- 1
- 2
- 3
- 4
- 5

- PRV (ACTIVE)
- PRV (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)

FIG 2-8: PRESSURE ZONES AND PRV LOCATIONS

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Each of the pressure zones is equipped with pressure reducing valves (PRVs) near the pressure zone boundaries to allow the higher elevation zones to feed the lower elevation zones when demand increases. While the system is also equipped with pressure sustaining valves (PSVs), for simplicity, all PRVs and PSVs will be referred to as PRVs in this LRP. The SBPS currently discharges into Zone 2 and can also be used to transfer water to the NBPS and North Tank via the distribution system. SBPS can pump up to approximately 800 gpm before the pressure supplied to nearby customers in Zone 2 increases to elevated levels that can damage the distribution piping or water service lines. This limitation is discussed further in Section 2.5.4. A summary of the PRVs in the District's system is provided below in Table 2-24.

Table 2-24 – District PRVs Summary

Name	Approximate Location	Boundaries
PRV 1	Top O' the Moor Dr W & Old Fort Ln	Separates Pressure Zones 1 and 2
PRV 2	Woodmoor Dr & Misty Morning Dr	
PRV 3	Deer Creek Rd & Hwy 85-87	Separates Pressure Zones 2 and 3
PRV 4	Deer Creek Rd & Woodmoor Dr	
PRV 5 (Beach PRV)	Lake Woodmoor Dr & Coronado Beach Dr	
PRV 6	Knollwood Blvd & South Park Dr	
PRV 7	Lake Woodmoor Dr & Towne Ct	
PRV 8	Augusta Dr & Bent Oak Ln	
PRV 9	Hwy 105 & Briarhaven Ct	
PRV 10	New London Rd & Tomboy Way	
PRV 11	New London Rd & Portland Rd	
PRV 12	New London Rd & Bowstring Way	
PRV 13	Caribou Dr W & Muzzle Loader Way	
PRV 14	Harness Rd & Scrub Oak Cir	
PRV 15	Leggins Way east of SWTP	Separates the 10-inch South Tank Transmission Line and Pressure Zone 3
PRV 16	Palmer Ridge High School near Hwy 85-87	Separates Pressure Zones 1 and 2
"PSV"	Furrow Rd & Loverly Way	Separates Pressure Zones 2 and 4
"PSV"	Caribou Dr E & Cobblestone Way	

A hydraulic profile of the District's system is shown below in Figure 2-9.

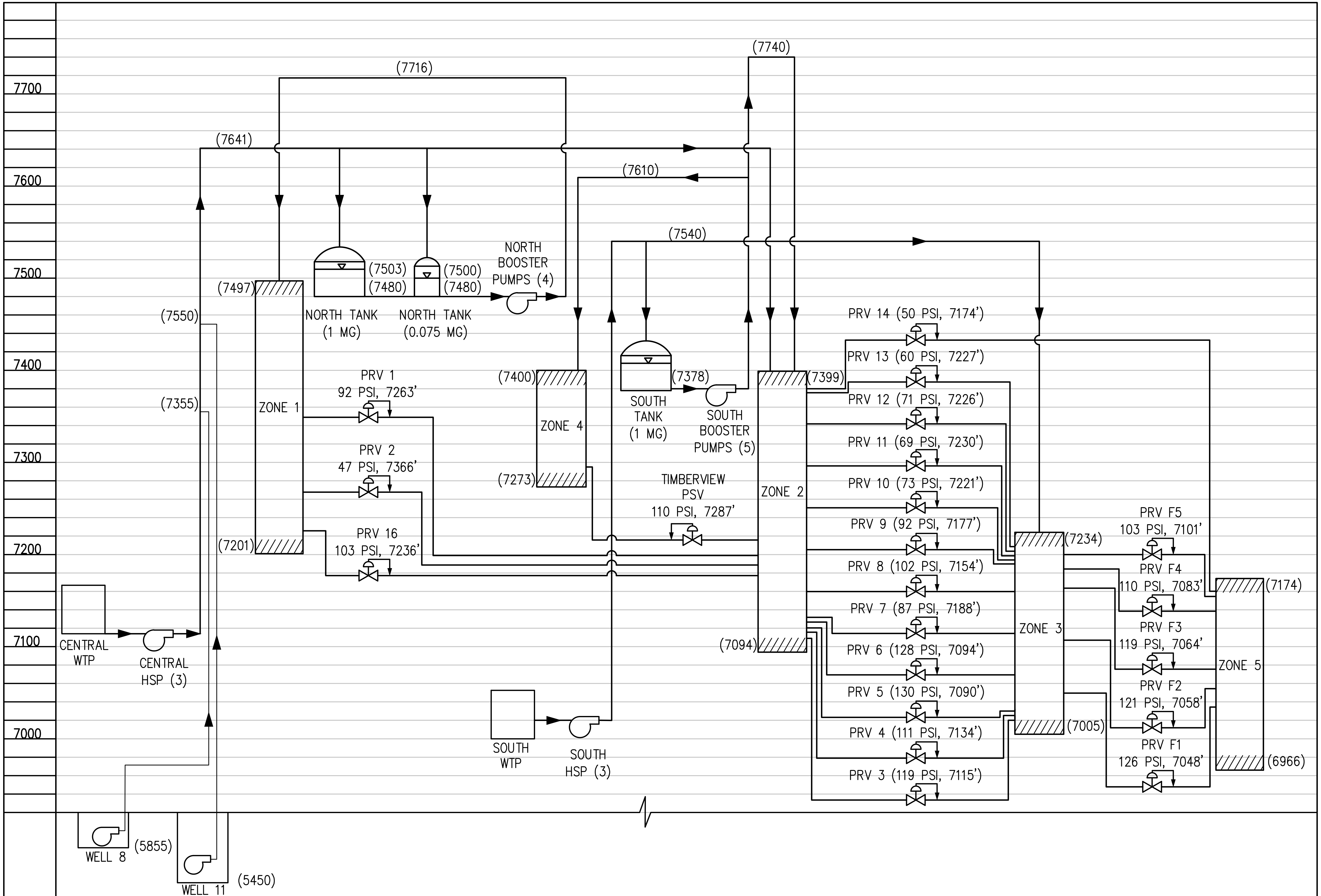

FIG. 2-9 - DISTRIBUTION SYSTEM HYDRAULIC PROFILE

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2.5.1. Distribution System Model Update

The District maintains a water system model using the InfoWater Pro GIS based software program. The model is generally used for domestic distribution system analysis during development reviews and for fire flow capacity analysis.

2.5.1.1. Assumptions

The existing model is regularly used and updated by the District; therefore limited updates are required as part of the 2022 LRP. Data that was not adjusted within the model during the 2022 LRP includes:

- Pipe diameter
- Roughness coefficient
- Spatial location
- PRV settings for Pressure Zones 1-4
  - Zone 5 PRV settings were updated per District information
- Pipe closed or open settings
- Tank sizes and settings
- Pump sizes and settings
- Reservoir elevations
- Fire flow demands and locations
- Active and inactive features

2022 LRP Model updates included:

- New scenario for Average Day Demand (2022A)
  - Utilize demand allocator function within InfoWater Pro to reallocate the demand inputs into the systems existing nodes
    - Utilize SFE numbers for commercial, residential, school and multi-family to input correct SFE per customer class
      - Utilize District figure to confirm customer class throughout system
    - Demand per SFE, 272 gpd/SFE, 0.189 gpm/SFE
- Created new scenario Max Day Demand (2022B)
  - Multiplied the demands by peaking factor of 2.2
- Created domains for active system model as provided by the District
- Monument Junction and Cloverleaf developments demands were included in the existing model
- Water line improvements from the CO-105 utility relocation project were included in the existing model
- 2-inch PRVs and Jockey Pumps switched to inactive
  - The 2-inch PRVs are only utilized in daily demand operation scenarios. The model was analyzed for fire flow analysis and max day demand scenarios, during which the flow is too high for a 2-inch PRV and is diverted to a 6-inch PRV. Rather than switching between 2-inch and 6-inch PRVs during the fire flow

scenario, only the 6-inch PRVs are included in the model. This will not affect the model results.
  - The jockey pumps are only utilized in daily demand operation scenarios to prevent cavitation. The model was analyzed for fire flow analysis and max day demand scenarios, so it was not necessary to include the jockey pumps in the updated model.
- Raw water system inactivated
- Inactivate Wells 2, 8, and 11 for fire flow analysis

2.5.1.2. Calibration/Model to Measured Comparison

Calibration is limited to verifying that the model max day demands based on a summation of the total flow results in the model node summary report are consistent with the 2022 LRP max day demand reported based on District billing records. As shown in Table 2-2, the peak day total system demand between January 2016 and December 2021 was 2.24 MGD. The planning demand established in Section 2.1.1.1 is 272 gpd/SFE. This value includes a 15 percent factor of safety. The hydraulic model has been updated to reflect the 272 gpd/SFE assumption as the basis for demand allocation to each SFE. The customer type and SFE count by class as outlined in Table 1-1 was used as the demand multiplier to account for the different water usages by customer type. The planning level peaking factor of 2.2 established in Section 2.1.3 was used to model the max day demands.

The Average Day Demand (2022A) model was created by taking each active existing parcel within the district boundary and assigning an SFE value to the parcel dependent on its customer class. The demand allocation function within InfoWater Pro was used to allocate the demands throughout the system at each active node, placing the demand at the closet node to the center of the parcel. The Max Day Demand (2022B) model was created by multiplying the demands in the 2022A model by the peaking factor. The node output report for the max day demand scenario has a total demand of 2.64 MGD. Accounting for the 15 percent safety factor described in Section 2.1.1.1, the percent error between the model demand and measured demand is 0.2 percent. This is well within a typical industry standard of expected percent error from a hydraulic model.

While the developments at Monument Junction and Cloverleaf developments are included in the existing model, the associated demands were not included in the total 2.64 MGD demand for the purposes of calibration, as these developments are not included in the billing records.

2.5.1.3. Results

The following results for the Max Day Demand model include:

- Reservoir and Tank Flows
- Domestic Pressures
- Fire Flows

2.5.1.3.1. Reservoir and Tank Flows

The model is set up such that the demands are being drawn from two reservoirs and three tanks. The reservoirs are identified in the model as RES9004 and RES9006, and the tanks are T-1, T-4, and T-13. RES9004 represents the pressure head and flow from NBPS and feeds Zone 1. RES9006 represents flow from SWTP that Timberview pumps use to feed Zone 4. T-1 represents the South Storage Tank, which is fed by SWTP and supplies Zone 2 through SBPS. T-4 and T-13 represent the North Storage Tanks. T-4 and T-13 gravity flow into Zone 2 and represent the flow from CWTP into Zone 2. T-4 is being filled in the model runs. Zones 3 and 5 are fed through PRVs off of Zone 2. Model-reported flows from each reservoir for the max day demand model are as follows:

- RES9004 – 610 gpm
- RES9006 – 45 gpm
- T-1 – 1,085 gpm
- T-13 – 911 gpm
- T-4 – 466 gpm

While the CWTP, SWTP, and Wells 2, 8, and 11 contribute directly to the potable water in the District's distribution system, the model's potable sources were simplified for this calibration since the focus of the model results in this LRP is for results during a fire flow. The WTPs and well capacities are not designed for providing fire flow, so the primary sources of water during a fire are the water storage tanks.

2.5.1.3.2. Domestic Pressures

Under peak day conditions, a node report was analyzed to identify the service nodes with the lowest available pressure in each pressure zone. Results are shown in Figure 2-10 and are summarized in Table 2-25.

Table 2-25 – Modeled Available Service Pressure by Zone at Peak Day Demand

Pressure Zone	Lowest Available Pressure (psi)	Highest Available Pressure (psi)
Zone 1	57.8	189.7
Zone 2	24.6	175.4
Zone 3	64.3	166.2
Zone 4	60.6	115.6
Zone 5	77.6	166.8

Note: Model nodes J10, J11, J12, J979, J1073, J1369, and J1378 have lower pressures than what is reported in the table. These low-pressure nodes are on lines to and from the storage tanks, and they don't correspond to a service connection or fire hydrant.

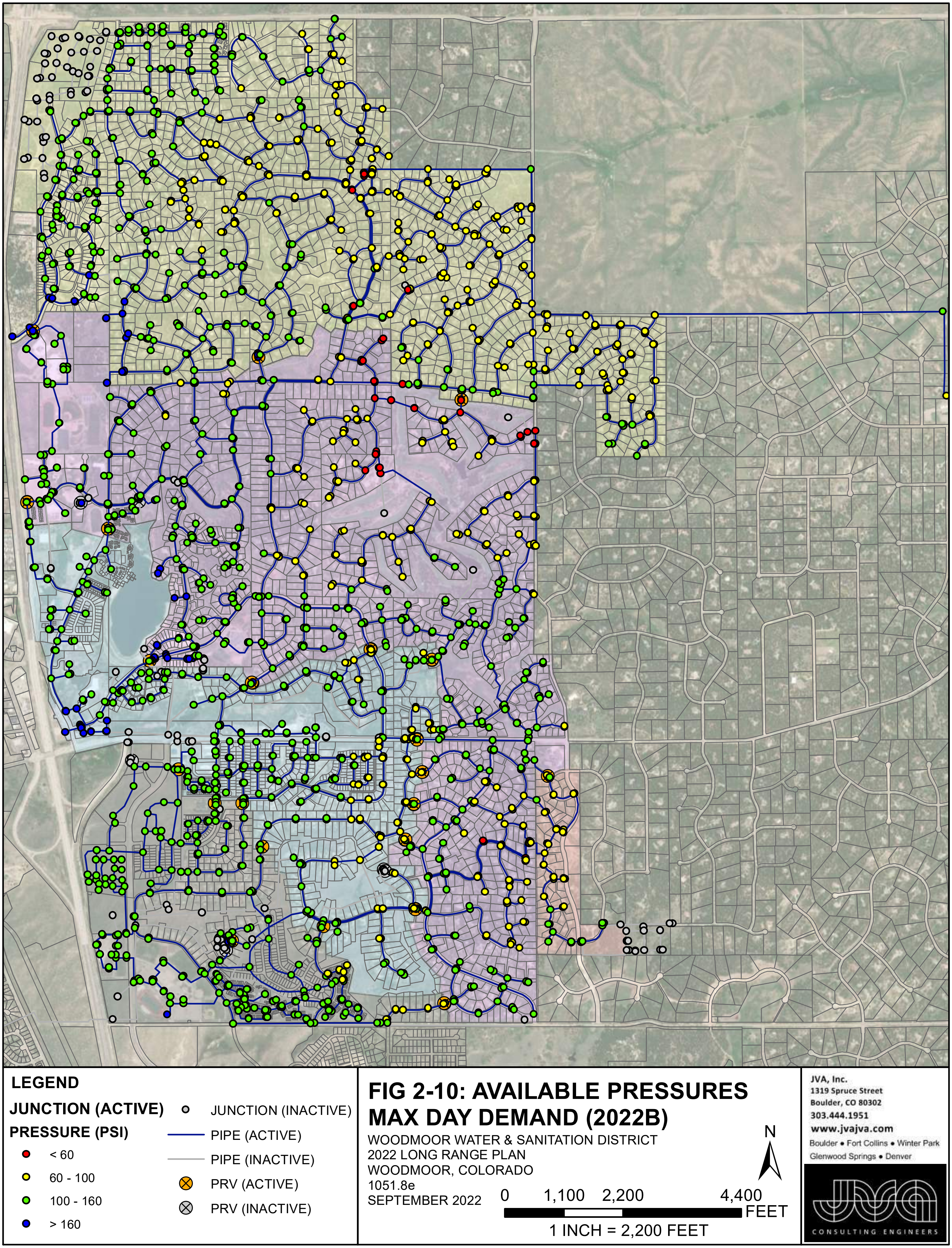

FIG 2-10: AVAILABLE PRESSURES MAX DAY DEMAND (2022B)

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2.5.1.3.3. Fire Flows

To analyze the fire flow available at each hydrant across the District's service area, a fire flow simulation was run under peak day demand conditions. To run this scenario, a design fire flow was specified with a minimum pressure of 20 pounds per square inch (psi) required, and the critical node search range was set to "Entire Network" instead of just the fire hydrant nodes. This setting ensures that the maximum fire flow reported is based on providing a minimum pressure of 20 psi across the whole system, and not just at the open hydrant.

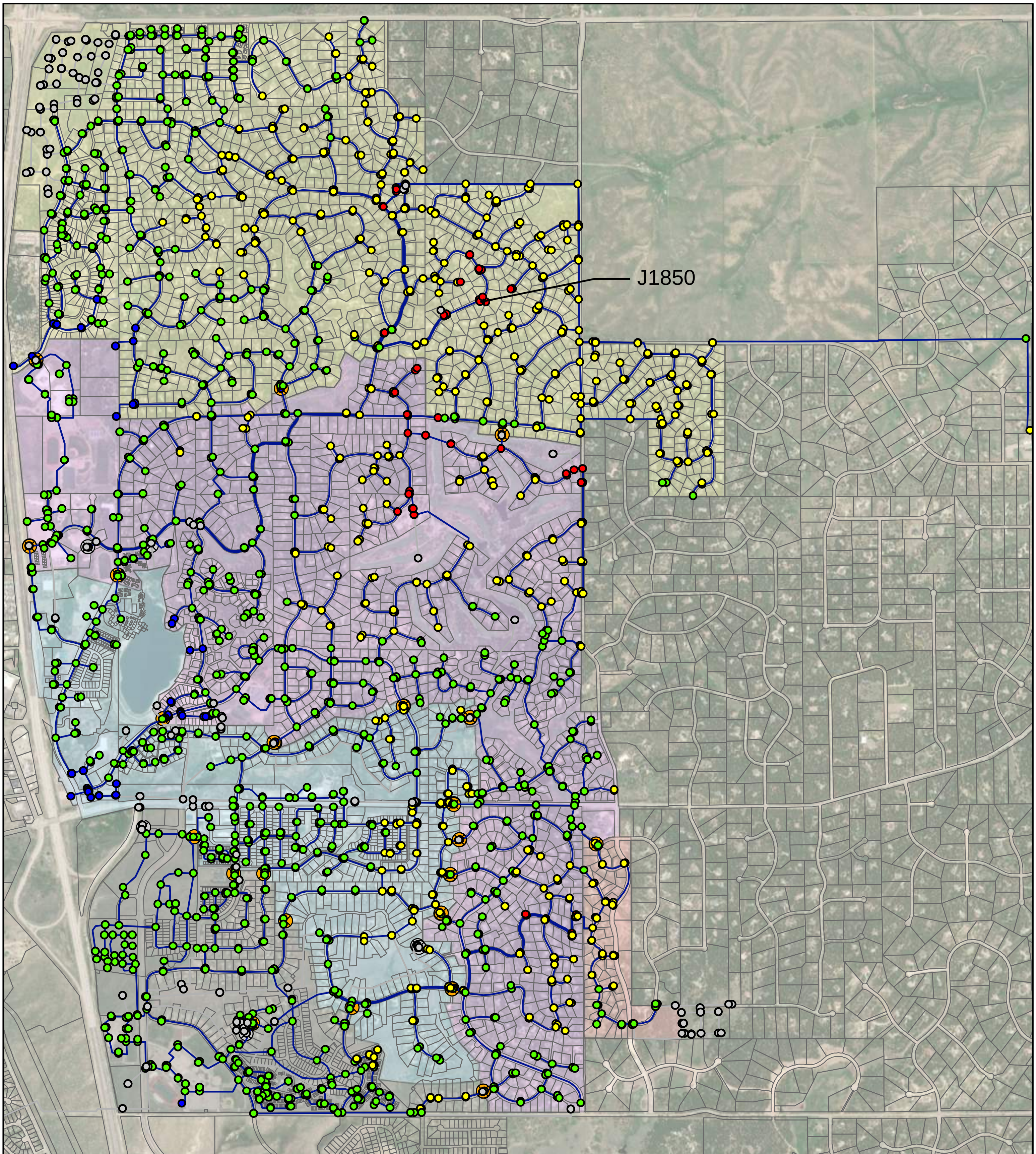
The District aims to supply a minimum of 1,250 gpm at all fire hydrants. To model the pressures across the distribution system in the event of a fire, the fire hydrant node with the lowest pressure based on the domestic results in each pressure zone was identified (as shown in Figures 2-11 through 2-15 on the following pages).

- Zone 1 = Hydrant J1850
- Zone 2 = Hydrant J520
- Zone 3 = Hydrant J174
- Zone 4 = Hydrant J1922
- Zone 5 = Hydrant J74

A fire flow scenario was run for each of these hydrants by specifying a fire flow input of 1,250 gpm. A node report was analyzed for pressures at all active nodes in the distribution system. The results identifying the lowest pressure nodes for each of the five fire flow scenarios are shown in Figure 2-11, Figure 2-12, Figure 2-13, Figure 2-14, and Figure 2-15.

A hydrant node report was analyzed in order to identify which hydrants have an available fire flow of less than 1,250 gpm while maintaining a minimum pressure of 20 psi across the system. Results are shown in Figure 2-16. The minimum available fire flow in each zone is summarized below:

- Zone 1 – 756 gpm at Hydrant J1449
- Zone 2 – 864 gpm Hydrant J57
- Zone 3 – 1,258 gpm at Hydrant J87
- Zone 4 – 1,350 gpm at Hydrant J1922
- Zone 5 – 1,961 gpm Hydrant J74



LEGEND

JUNCTION (ACTIVE)
PRESSURE (PSI)
- < 60
- 60 - 100
- 100 - 160
- > 160

- JUNCTION (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)

FIG 2-11: AVAILABLE PRESSURES FIRE IN ZONE 1 (AT J1850)

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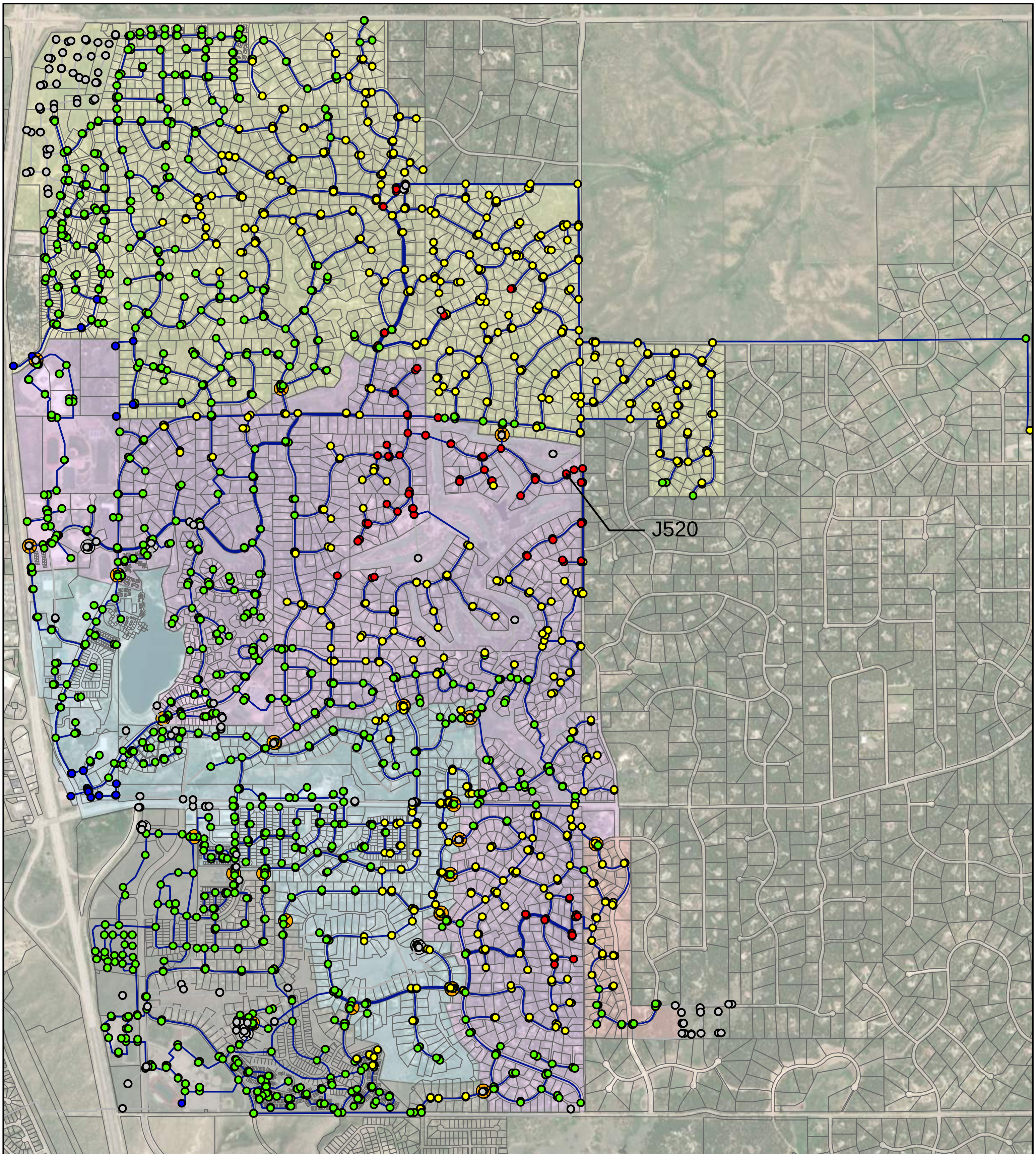

LEGEND

JUNCTION (ACTIVE)
PRESSURE (PSI)
- < 60
- 60 - 100
- 100 - 160
- > 160

JUNCTION (INACTIVE)
PIPE (ACTIVE)
PIPE (INACTIVE)
PRV (ACTIVE)
PRV (INACTIVE)

FIG 2-12: AVAILABLE PRESSURES FIRE IN ZONE 2 (AT J520)

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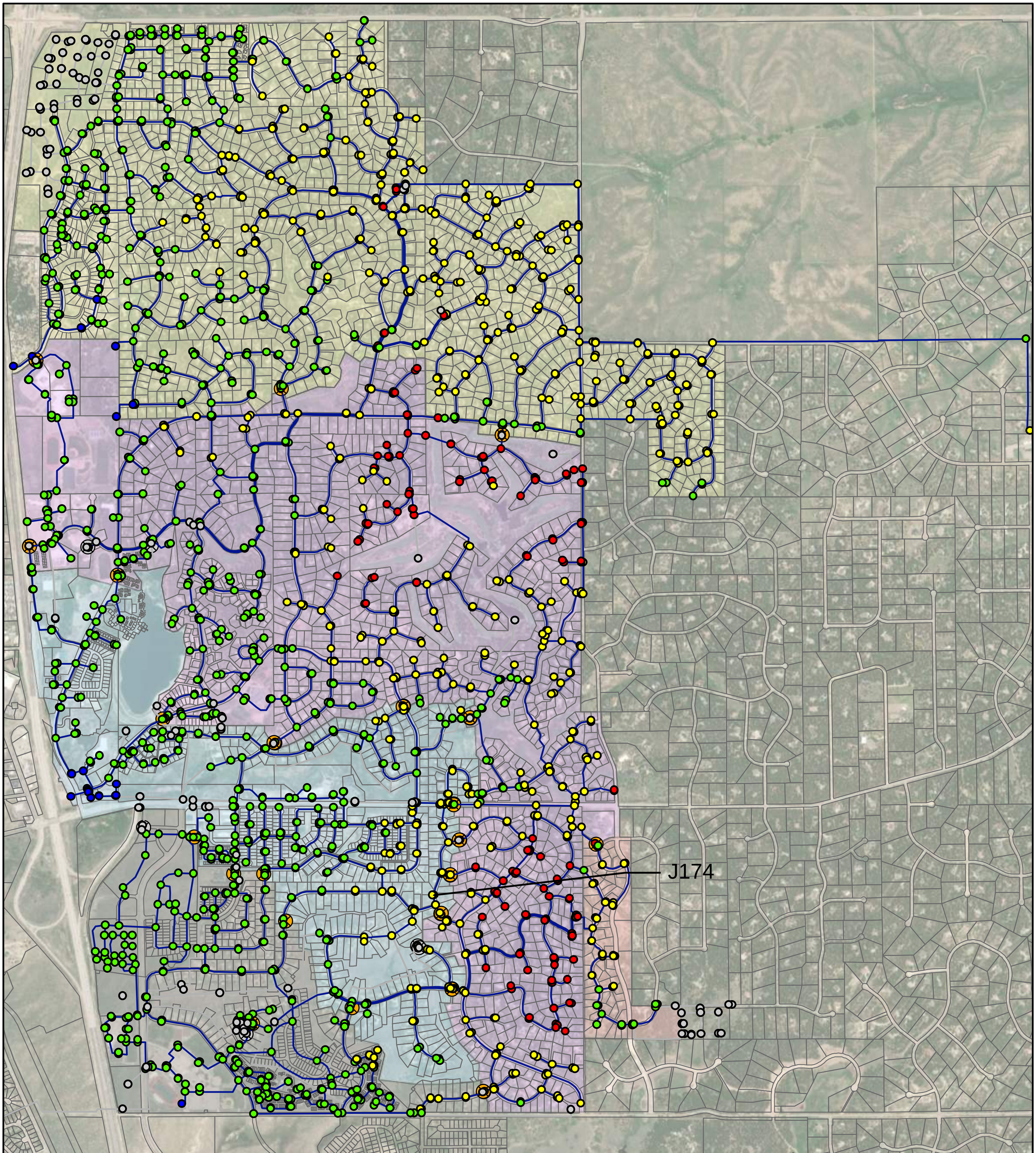

LEGEND

JUNCTION (ACTIVE) PRESSURE (PSI)
- < 60
- 60 - 100
- 100 - 160
- > 160

JUNCTION (INACTIVE)
PIPE (ACTIVE)
PIPE (INACTIVE)
PRV (ACTIVE)
PRV (INACTIVE)

FIG 2-13: AVAILABLE PRESSURES FIRE IN ZONE 3 (AT J174)

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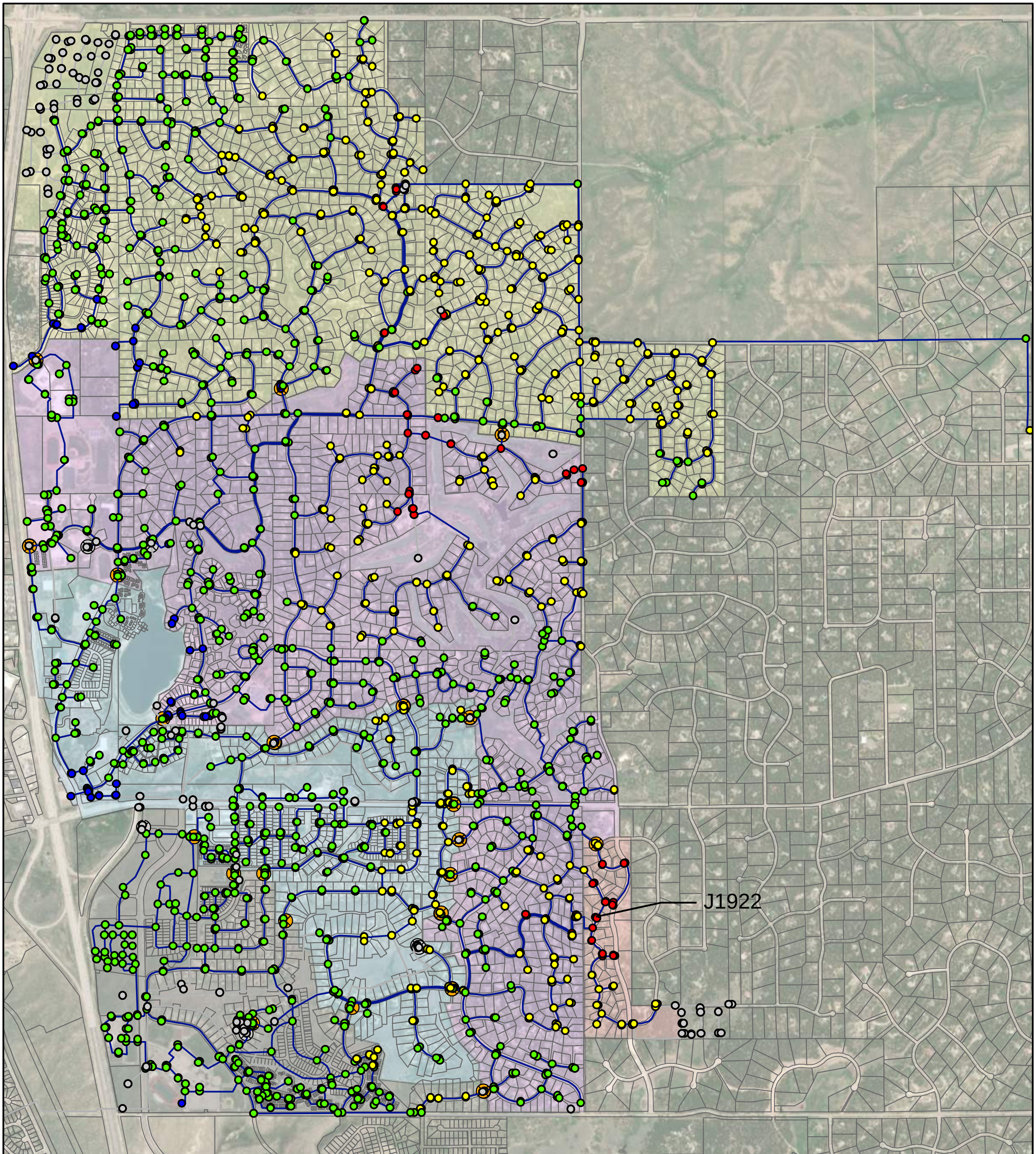

LEGEND

JUNCTION (ACTIVE) PRESSURE (PSI)
- < 60
- 60 - 100
- 100 - 160
- > 160

- JUNCTION (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)

FIG 2-14: AVAILABLE PRESSURES FIRE IN ZONE 4 (AT J1922)

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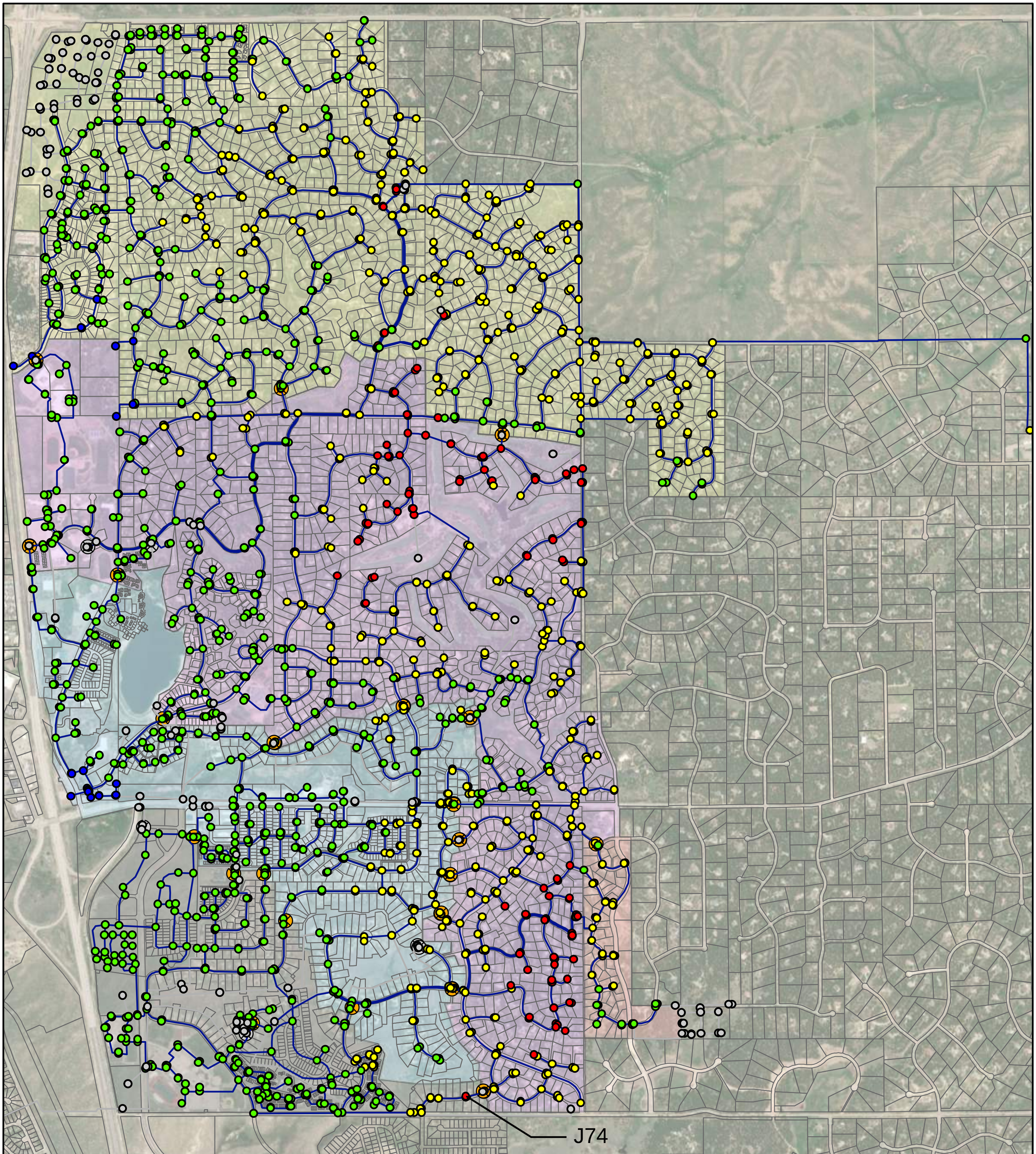

LEGEND

JUNCTION (ACTIVE) PRESSURE (PSI)
- < 60
- 60 - 100
- 100 - 160
- > 160

- JUNCTION (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)

FIG 2-15: AVAILABLE PRESSURES FIRE IN ZONE 5 (AT J74)

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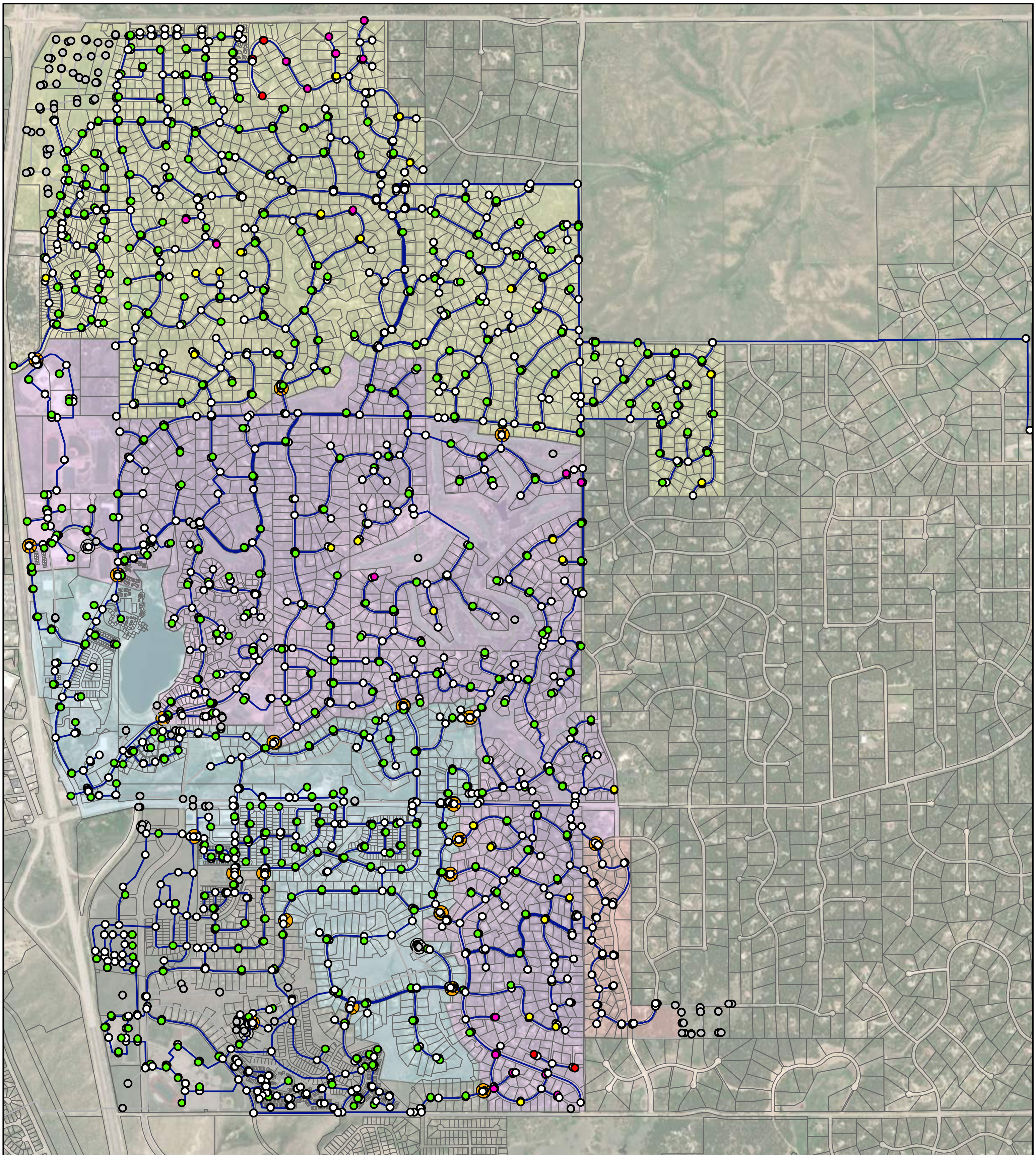

LEGEND

JUNCTION (ACTIVE) FLOW (GPM)

- NOT HYDRANT
- < 900
- 900 - 1100
- 1100 - 1250
- > 1250

- JUNCTION (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)

FIG 2-16: AVAILABLE HYDRANT FLOW FIRE ANALYSIS

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2.5.2. Treated Water Storage

The District has three treated water storage tanks in the distribution system. The NBPS is equipped with a 1-MG storage tank constructed in 1968 and a 0.075-MG storage tank that was moved to the NBPS site in 1986. The SBPS is equipped with a 1-MG storage tank that was constructed in 1987. A summary of the tank dimensions and calculated volumes is provided below in Table 2-26.

Table 2-26 – Storage Tank Summary

Tank Location	Pressure Zone	Tank Diameter (ft)	Height to Overflow (ft)	Highest Operations (ft)	Calculated Volume (MG)
NBPS	Zone 1	85	23	22.0	0.934
NBPS	Zone 1	24	23	22.0	0.074
SBPS	Zone 2	93	19	18.3	0.930
				Total Calculated Volume:	**1.938 MG**

Three components were analyzed for the storage tank capacity analysis:

- Operating Storage (Equalization Storage)
- Fire Storage
- Emergency Storage

Operational storage is used to meet peak day demands and is typically sized to accommodate four hours of peak day flow. Using the historical 236 gpd/SFE average annual demand determined in Section 2.1.1, the annual average demand is currently about 1.028 MGD. Using the planning level peaking factor of 2.2 established in Section 2.1.3, the peak day flowrate is currently about 2.263 MGD. Four hours of peak day demand equates to about 0.377 MG.

Minimum fire flow requirements for a permitted building are recommended by the local fire protection district. The Tri-Lakes Monument Fire Protection District (TLMFPD) is the authority having jurisdiction in the District. TLMFPD references the International Fire Code (IFC) for fire flow calculations within District boundaries since all structures in the service area are located within 500 feet of a fire hydrant and have adequate water supply for firefighting purposes. The 2015 IFC is currently used by the TLMFPD, and the 2021 IFC is expected to be adopted within the next year.

IFC fire flows vary based on the type of building construction and the calculated fire flow area, with a minimum of 20 psi residual pressure required in the distribution system. Single family homes less than 3,600 square feet have a minimum fire flow of 1,000 gpm for one hour. Large commercial buildings can require as much fire flow as 8,000 gpm for four hours. The District has a minimum goal of 1,250 gpm for new developments but does not otherwise mandate fire flows. If the TLMFPD requires a fire flow rate greater than the District can provide, the builder is responsible for providing additional fire flows (via internal fire suppression systems) or upgrading the District's distribution system to meet the minimum fire flow requirements. For this analysis, a 1,250 gpm fire flow for a two hour duration was used to account for an average fire within District boundaries. The calculated fire storage volume for this scenario is about 150,000 gallons.

Emergency storage is typically sized to accommodate twenty-four hours of flow at the average summer flowrate. When evaluating both customer billing data and WTP production data, the historical ratio of average summer demand (May through September) to average annual demand is 1.4. Therefore, a 1.4 summer peaking factor was used for emergency storage calculations. Using the historical 236 gpd/SFE average annual demand determined in Section 2.1.1, the annual average demand is currently about 1.028 MGD, which equates to about 1.440 MGD of summer demand.

The total storage calculations are presented below in Table 2-27. The 1.938 MG of total storage currently available between the three storage tanks is about 98.5 percent of the total 1.967 MG storage volume recommended for operating storage, fire storage, and emergency storage. The District aims to always maintain a minimum of 1-MG in their storage tanks.

Table 2-27 – Total Recommended Storage as of December 2021

Scenario	Storage Volume Required (MG)
Operating Storage[1]	0.377
Fire Storage[2]	0.15
Emergency Storage[3]	1.44
Total Required Storage =	**1.967**

[1] Operating storage is used to meet peak day demands and is typically sized to accommodate four hours of peak day flow. Storage volume required assumes a daily peaking factor of 2.2.
[2] The Tri-Lakes Monument Fire Protection District (TLMFPD) and the 2015 International Fire Code (IFC) provide recommended storage volumes. A 1,250 gpm fire flow for a two hour duration was assumed to account for an average fire.
[3] Emergency storage is sized to accommodate 24 hours of flow at the average summer flowrate (May through September). A summer peaking factor of 1.4 was used.

If the North Storage Tank was not operational, demand from Zones 1 and 2 would have to be met from the SBPS (which is currently limited to an 800 gpm flowrate to maintain appropriate system pressures) and the South Storage Tank. There is currently insufficient storage in the distribution system and insufficient capacity at SBPS to meet the minimum storage requirement of 1.967 MGD and demand from Zones 1 and 2. For additional resiliency, the District could add 0.75-MG treated water storage tanks at both the south tank and the north tanks.

2.5.3. Booster Pump Stations

Characteristics of the District's booster pump stations are summarized below in Table 2-28. The NBPS was expanded in 2004 to a firm capacity of 2,300 gpm, which is sufficient pumping capacity to meet ultimate buildout conditions.

Table 2-28 – Booster Pump Station Summary

Booster Pump Station Name	Pressure Zone Location	Storage Capacity	Pump Quantity and Design Points	Pump Drive Type
South Booster Pump Station	Zone 2	One 1-MG tank	Two Pumps at 125 GPM and 230 ft TDH Two Pumps at 530 GPM and 360 ft TDH One Pump at 800 GPM and 360 ft TDH [1] (High-Flow Pump Model 3YB-100-2)	Variable, Variable Variable, Constant Constant
North Booster Pump Station	Zone 1	One 1-MG tank One 0.075-MG tank	Three Pumps at 1,150 GPM and 240 ft TDH One Pump at 392 GPM and 190 ft TDH	Variable Speed Variable Speed

[1] This pump can run at up to 800 gpm, but is typically operated at 530 gpm

The SBPS is configured to serve the Timberview neighborhood in Zone 4 using the 125-gpm pumps and to transfer water to Zone 2 using the 530-gpm pumps. The 800-gpm pump is connected to both Zone 2 and Zone 4. This high-flow pump is programmed to automatically activate when the pressure on the discharge side of the pump drops below 20 psi.

The SBPS recently had one of the 125-gpm pumps replaced and currently has a firm capacity of 125 gpm for Zone 4. The PLC for the Timberview pumps is programmed to maintain 75 psi in Zone 4. If Zone 4 loses pressure (i.e. when a fire hydrant is opened), the high-flow pump is activated and bypasses the 125-gpm pumps.

The transfer side of the SBPS is configured to operate at no more than 800 gpm to maintain acceptable pressures in the homes located near the SBPS in the lowest end of Zone 2. While the 530-gpm pumps are rated for this flow at the 360-ft TDH design point, each pump can run at up to 800 gpm at the lower pressure setpoint currently selected by the District. Therefore, the firm capacity of SBPS to serve Zone 2 is 800 gpm with one of the 530-gpm pumps out of service.

During the summer months with high demand when the SBPS is not pumping into Zone 2, the homes surrounding the SBPS report low pressure. The District desires to expand the boundary of Zone 4 to capture more properties near the SBPS that experience this low pressure and increase the capacity of the Zone 4 pumps if needed.

2.5.4. Distribution Pressure and Fire Flow

The District's distribution system is composed primarily of 6-inch pipe, with some larger transmission pipelines located near the WTPs, water storage tanks, and groundwater wells. A 6-inch pipe network can limit the amount of fire flow that can be drawn from the distribution system while maintaining the minimum 20 psi residual pressure required. Pipe sizes are typically selected to keep fluid velocities below 5 feet per second (fps) under all conditions. Fluid velocities above 5 fps increase the risk of damage to valves, fittings, and pipe connections. Higher pipe velocities also increase the friction losses in the system, which results in larger pressure losses that require larger pumps to move a given amount of flow. Properly designed pipe networks ultimately reduce the cost of operations and maintenance for the District.

Previous LRPs and modeling efforts confirmed that portions of the distribution system are at risk of a pressure drop below 20 psi when more than 1,250 gpm of fire flow is drawn from select fire hydrants. This is a limitation of the existing system if 1,500 gpm is a required fire flow rate. Recent modeling verified that the District can safely draw 1,250 gpm of fire flow from the existing system while maintaining 20 psi residual pressure at all locations.

One limitation of the existing distribution system configuration identified is a deficiency of the SBPS to convey water from the south tank to the north tanks at high flow rates. Most of the District's treatment capacity conveys treated water to the south tank while much of the District's demand (mostly from Zones 1 and 2) is met using the north tanks. The SBPS is currently programmed in SCADA to supplement flows to the north storage tanks as needed to help meet demands in Zones 1 and 2. However, when the SBPS operates at a flow rate above 800 gpm, the pressure in Zone 2 can reach elevated levels that approach the rated capacity of the distribution system infrastructure near SBPS.

The District has recognized the need to convey more water from the SBPS to north tanks without causing pressure spikes in Zone 2 near the SBPS. The District could increase the capacity of the pipes between the SBPS and the north tank by increasing the size of the piping connecting the pressure zones or constructing a new transmission pipeline directly between the SBPS and north tank. This effort is discussed further in Section 3.

2.5.5. Disinfection-By-Product Formation

Disinfection by-products (DBPs) are regulated water quality contaminants that form when disinfection compounds like chlorine interact with naturally occurring organic matter in the water supply. The primary DBPs of concern resulting from the chlorination of drinking water are trihalomethanes (THMs) and haloacetic acids (HAAs). DBP formation is a function of the disinfection dose, the amount of organic matter in the water supply, and the residence time in the distribution system. Reducing any of these factors can help lower the formation of DBPs. Since the disinfection dose remains relatively consistent at the WTPs, the District can help control DBP formation by selecting source water with less organic matter, and by maintaining and improving the distribution system to reduce water age. Lower distribution system residence times can be achieved by regular hydrant flushing for dead-end water lines or installing additional distribution system loops to eliminate dead ends. Groundwater typically contains less organic matter than surface water and can be a more reliable source water to minimize DBP formation.

The District recognizes an increased potential for DBP formation as they utilize a greater portion of surface water sources to meet increasing demands since surface water typically has higher concentrations of total dissolved solids (TDS) than groundwater, and therefore, contains more organic matter. The District monitors DBP formation by frequently sampling locations with a potential for high water age, which is an approach that complies with CDPHE requirements. The District is currently in compliance with the maximum contaminant limits (MCLs) for THMs, HAAs, and bromate. The last five years of DBP testing results are included below in Table 2-29. The District recently improved aeration in the Lake with the Lake Pump Station Improvements project completed in 2022. As the District utilizes more surface water, switching from the current sampling method to utilizing a calibrated dynamic water model may be more cost effective and accurate over time. It is recommended to periodically re-evaluate the source water quality as a higher portion of surface water is used to confirm that DBPs are being appropriately controlled.

Table 2-29 – Summary of DBP Testing Results 2017-2021

Parameter	Maximum Contaminant Limit (ug/L)	2017	2018	2019	2020	2021
Total Trihalomethanes (TTHMs)	80.00	25.61	29.7	19.45	19.96	14.00
Total Haloacetic Acids (HAAs)	60.00	9.78	11.55	7.95	8.04	5.97
Bromate	10.00	7.67	N/A	N/A	N/A	N/A
MCL Violations?		No	No	No	No	No

The existing InfoWater model is not currently calibrated to accurately perform water age modeling. The existing model is a static system that can simulate point demands and inputs but only produces a steady-state output to see flow rates or pressure drops at specific locations. By incorporating dynamic operations data into the model (like pumping rates and durations, fluctuations in storage tank levels, and PRV operating setpoints), the District would have increased model functionality that could simulate water age within the distribution system. This would be valuable to not only help determine regions at risk of DBP formation, but to also help operators better understand and balance water storage requirements to meet demands and fire flows. Calibration of the water model for dynamic analysis is recommended to better predict DBP formation moving forward.

SECTION 3 - FUTURE WATER SYSTEM

This section of the report identifies water system improvement projects needed to meet the future water demands of the district as the population grows. Short-term projects are intended to meet demands through the current buildout scenario, and long-term projects are identified to meet demands through the ultimate buildout scenario.

3.1. Water System Growth

The population forecasts from Section 1 - and the planning demand of 272 gpd/SFE established in Section 2.1.1.1 were used as a basis to project the water demand for each buildout scenario.

3.1.1. Current Buildout Water Demand

The District served 4,404 SFEs as of August 2022 and plans to serve approximately 2,000 additional SFEs within the District's current boundaries. The current buildout scenario is expected to serve approximately 6,433 SFEs. The methodology for calculating SFEs is provided in Sections 1.3 and 1.4. The District currently serves 1,474 SFEs in Pressure Zone 1, 1,373 SFEs in Pressure Zone 2, 996 SFEs in Pressure Zone 3, 69 SFEs in Pressure Zone 4, and 492 SFEs in Pressure Zone 5. Future SFE growth expected for each zone is summarized below in Table 3-1. Additional information for each anticipated development is summarized in Table 3-2.

Table 3-1 – Existing and Current Buildout SFEs by Zone

Pressure Zone	August 2022 SFEs	Anticipated SFEs	SFEs at Current Buildout	Percent of Overall Growth
Zone 1	1,474	649	2,123	30.6%
Zone 2	1,373	201	1,574	9.5%
Zone 3	996	243	1,239	11.5%
Zone 4	69	94	163	4.4%
Zone 5	492	936	1,428	44.1%

Table 3-2 – Future Growth by Zones for Current Buildout

Figure Reference No.	Development Name	Total SFEs at Buildout	Pressure Zone
1	M.G.O. (Mahlomn Plowman)	604	Zone 1
2	Unplatted - Woodmoor Vista Prof. Park	42	Zone 1
3	Unplatted Misty Acres	3	Zone 1
4	Williams Subdivision	99	Zone 2
5	Unplatted - Greater European Mission	49	Zone 2
6	Colorado Lakeshore Holdings	32	Zone 2
7	Colorado Lakeshore Holdings	52	Zone 2/3
8	Rusinak Property	5	Zone 3
9	Colorado Lakeshore Holdings	70	Zone 3
10	Brookmoor Office Park	13	Zone 3
11	Crossroads at Monument	6	Zone 3
12	Unplatted - Jim Maguire	70	Zone 3
13	Unplatted - Jim Maguire	20	Zone 3
14	Cheyenne Village	29	Zone 3
15	Unplatted - Pine Tree Properties	407	Zone 5
16	Unplatted - Pine Tree Properties	229	Zone 5
17	Unplatted - Jackson Creek Land Co.	57	Zone 5
18	Unplatted - Jackson Creek Land Co.	41	Zone 5
19	Unplatted - Walters Estate	153	Zone 5
20	Mills Subdivision	94	Zone 4
21	AMA	9	Zone 3

As shown in Table 3-1, most of the growth is expected to occur in Zone 5, followed by Zone 1, with less growth anticipated in Zone 2 and Zone 3. Zone 4 is expected to have the least growth.

Using the population forecasts from Section 1 - and the planning demand of 272 gpd/SFE established in Section 2.1.1.1, the anticipated annual water demand for each zone was estimated, as summarized below in Table 3-3. The results for the peak day water demand using the planning level peaking factor of 2.2 established in Section 2.1.3 are presented in Table 3-4.

Table 3-3 – Average Annual Water Demand per Zone for Current Buildout

Year	Zone 1 SFEs	Zone 1 Avg Annual Demand (af/yr)	Zone 2 SFEs	Zone 2 Avg Annual Demand (af/yr)	Zone 3 SFEs	Zone 3 Avg Annual Demand (af/yr)	Zone 4 SFEs	Zone 4 Avg Annual Demand (af/yr)	Zone 5 SFEs	Zone 5 Avg Annual Demand (af/yr)	Total SFEs	Total Avg Annual Demand (af/yr)
2022	1,474	449	1,373	418	996	303	69	21	492	150	4,404	1,342
2023	1,475	449	1,374	419	997	304	70	21	702	214	4,618	1,407
2024	1,476	450	1,392	424	1,005	306	71	22	912	278	4,856	1,480
2025	1,477	450	1,410	430	1,013	309	72	22	1,122	342	5,094	1,552
2026	1,478	450	1,428	435	1,021	311	73	22	1,282	391	5,282	1,609
2027	1,507	459	1,457	444	1,041	317	74	23	1,308	399	5,388	1,642
2028	1,537	468	1,486	453	1,062	324	76	23	1,334	407	5,495	1,674
2029	1,568	478	1,516	462	1,083	330	77	24	1,361	415	5,605	1,708
2030	1,599	487	1,546	471	1,105	337	79	24	1,388	423	5,717	1,742
2031	1,631	497	1,577	480	1,127	343	81	25	1,416	431	5,832	1,777
2032	1,664	507	1,608	490	1,150	350	82	25	1,444	440	5,948	1,812
2033	1,697	517	1,641	500	1,173	357	84	26	1,473	449	6,067	1,849
2034	1,731	527	1,673	510	1,196	364	86	26	1,503	458	6,189	1,886
2035	1,766	538	1,707	520	1,220	372	87	27	1,533	467	6,312	1,923
2036	1,801	549	1,741	530	1,244	379	89	27	1,563	476	6,439	1,962
2037	1,837	560	1,776	541	1,269	387	91	28	1,595	486	6,568	2,001

Note: The projections in this table are based on a starting SFE value of 4,404 from August 2022 and differ from Figure 1-2 which is based on a starting SFE value of 4,358 from December 2021.

Table 3-4 – Peak Day Water Demand per Zone for Current Buildout

Year	SFEs	Peak Day Demand (MGD)	Peak Day Demand (gpm)	SFEs	Peak Day Demand (MGD)	SFEs	Peak Day Demand (MGD)	SFEs	Peak Day Demand (MGD)	SFEs	Peak Day Demand (MGD)	SFEs	Peak Day Demand (MGD)
	Zone 1			Zone 2		Zone 3		Zone 4		Zone 5		Total	
2022	1,474	0.88	612	1,373	0.82	996	0.60	69	0.04	492	0.29	4,404	2.64
2023	1,475	0.88	613	1,374	0.82	997	0.60	70	0.04	702	0.42	4,618	2.76
2024	1,476	0.88	613	1,392	0.83	1,005	0.60	71	0.04	912	0.55	4,856	2.91
2025	1,477	0.88	614	1,410	0.84	1,013	0.61	72	0.04	1,122	0.67	5,094	3.05
2026	1,478	0.88	614	1,428	0.85	1,021	0.61	73	0.04	1,282	0.77	5,282	3.16
2027	1,507	0.90	626	1,457	0.87	1,041	0.62	74	0.04	1,308	0.78	5,388	3.22
2028	1,537	0.92	639	1,486	0.89	1,062	0.64	76	0.05	1,334	0.80	5,495	3.29
2029	1,568	0.94	652	1,516	0.91	1,083	0.65	77	0.05	1,361	0.81	5,605	3.35
2030	1,599	0.96	665	1,546	0.93	1,105	0.66	79	0.05	1,388	0.83	5,717	3.42
2031	1,631	0.98	678	1,577	0.94	1,127	0.67	81	0.05	1,416	0.85	5,832	3.49
2032	1,664	1.00	691	1,608	0.96	1,150	0.69	82	0.05	1,444	0.86	5,948	3.56
2033	1,697	1.02	705	1,641	0.98	1,173	0.70	84	0.05	1,473	0.88	6,067	3.63
2034	1,731	1.04	719	1,673	1.00	1,196	0.72	86	0.05	1,503	0.90	6,189	3.70
2035	1,766	1.06	734	1,707	1.02	1,220	0.73	87	0.05	1,533	0.92	6,312	3.78
2036	1,801	1.08	748	1,741	1.04	1,244	0.74	89	0.05	1,563	0.94	6,439	3.85
2037	1,837	1.10	763	1,776	1.06	1,269	0.76	91	0.05	1,595	0.95	6,568	3.93

Note: The projections in this table are based on a starting SFE value of 4,404 from August 2022 and differ from Figure 1-2 which is based on a starting SFE value of 4,358 from December 2021.

3.1.2. Ultimate Buildout Water Demand

The ultimate buildout scenario includes the current buildout scenario plus the Wissler Trust land area of 813.8 acres. The Wissler Trust is located northeast of the District's current service area and includes the northwest quarter of Section 5 and all of Section 6 in the 11S Township and 66W Range of the Sixth Meridian. Based on the District's current water policy, no supplemental water is allocated for future inclusions, so the base allocation of 0.5 af/ac/yr was assigned for the Wissler Trust. This equates to approximately 406 af/yr, or 1,334 SFEs of demand, which will be served by the existing Zone 1 infrastructure. Total growth from 2022 to Ultimate Buildout is distributed between the pressure zones as follows:

- Zone 1: 1,983 new SFEs (about 57 percent of the overall growth)
- Zone 2: 201 new SFEs (about 6 percent of the overall growth)
- Zone 3: 243 new SFEs (about 7 percent of the overall growth)
- Zone 4: 94 new SFEs (about 3 percent of the overall growth)
- Zone 5: 936 new SFEs (about 27 percent of the overall growth)

As with the Current Buildout analysis, the anticipated annual water demand for each zone was estimated for Ultimate Buildout and summarized in Table 3-5. The results for the peak day water demand using the planning level peaking factor of 2.2 established in Section 2.1.3 are presented in Table 3-6.

Table 3-5 – Average Annual Water Demand per Zone for Ultimate Buildout

Year	SFEs	Avg Annual Demand (af/yr)	SFEs	Avg Annual Demand (af/yr)	SFEs	Avg Annual Demand (af/yr)	SFEs	Avg Annual Demand (af/yr)	SFEs	Avg Annual Demand (af/yr)	SFEs	Avg Annual Demand (af/yr)
	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Total	
2021 to 2037	See Table 3-3											
2038	1,874	571	1,811	552	1,295	394	93	28	1,626	496	6,699	2,041
2039	1,911	582	1,848	563	1,321	402	94	29	1,659	505	6,833	2,082
2040	1,950	594	1,885	574	1,347	410	96	29	1,692	516	6,970	2,123
2041	1,989	606	1,922	586	1,374	419	98	30	1,726	526	7,109	2,166
2042	2,028	618	1,961	597	1,401	427	100	31	1,760	536	7,251	2,209
2043	2,069	630	2,000	609	1,429	435	102	31	1,796	547	7,396	2,253
2044	2,110	643	2,040	622	1,458	444	104	32	1,832	558	7,544	2,299
2045	2,152	656	2,081	634	1,487	453	106	32	1,868	569	7,695	2,344
2046	2,195	669	2,122	647	1,517	462	108	33	1,906	581	7,849	2,391

Note: The projections in this table are based on a starting SFE value of 4,404 from August 2022 and differ from Figure 1-2 which is based on a starting SFE value of 4,358 from December 2021.

Table 3-6 – Peak Day Water Demand per Zone for Ultimate Buildout

Year	Zone 1 SFEs	Zone 1 Peak Day Demand (MGD)	Zone 2 SFEs	Zone 2 Peak Day Demand (MGD)	Zone 3 SFEs	Zone 3 Peak Day Demand (MGD)	Zone 4 SFEs	Zone 4 Peak Day Demand (MGD)	Zone 5 SFEs	Zone 5 Peak Day Demand (MGD)	Total SFEs	Total Peak Day Demand (MGD)
2021 to 2037	See Table 3-4											
2038	1,874	1.12	1,811	1.08	1,295	0.77	93	0.06	1,626	0.97	6,699	4.01
2039	1,911	1.14	1,848	1.11	1,321	0.79	94	0.06	1,659	0.99	6,833	4.09
2040	1,950	1.17	1,885	1.13	1,347	0.81	96	0.06	1,692	1.01	6,970	4.17
2041	1,989	1.19	1,922	1.15	1,374	0.82	98	0.06	1,726	1.03	7,109	4.25
2042	2,028	1.21	1,961	1.17	1,401	0.84	100	0.06	1,760	1.05	7,251	4.34
2043	2,069	1.24	2,000	1.20	1,429	0.86	102	0.06	1,796	1.07	7,396	4.43
2044	2,110	1.26	2,040	1.22	1,458	0.87	104	0.06	1,832	1.10	7,544	4.51
2045	2,152	1.29	2,081	1.25	1,487	0.89	106	0.06	1,868	1.12	7,695	4.60
2046	2,195	1.31	2,122	1.27	1,517	0.91	108	0.06	1,906	1.14	7,849	4.70

Note: The projections in this table are based on a starting SFE value of 4,404 from August 2022 and differ from Figure 1-2 which is based on a starting SFE value of 4,358 from December 2021.

3.2. Future Water Resources

The District will continue to rely on Denver Basin groundwater and its Monument Creek Exchange System to meet water demands in the near-term. However, the Denver Basin aquifers are finite resources and will not provide an economical long-term water supply. In 2011, the District acquired surface water rights associated with the Ranch that will provide a reliable long-term water supply. The Ranch Water Rights were changed in Water Court Case No. 12CW1, Division 2, to be used in the District's municipal water system, including the right to reuse the return flows (reusable wastewater effluent and LIRFs) until full consumption. These return flows will be captured via the District's existing exchange system that may include re-diversion at the Chilcott Ditch Fountain Creek headgate or a future indirect potable reuse (IPR) system, which is discussed further in Section 3.3.1.

Prior to utilizing the Ranch Water Rights in the District's municipal system, additional infrastructure will be needed to convey the water supply to the District. Design and construction of additional infrastructure will take many years; therefore the District will need to construct additional Denver Basin wells to meet interim water supply demands until the Ranch water supply is phased in.

3.2.1. Groundwater Wells

On an annual basis, the Denver Basin wells meet approximately 75 percent of District demand and provide the backbone of the current water supply. The remaining 25 percent of water supply is effectively reuse of Denver Basin water via exchange. New well construction is driven by growth in demand and decline in well yield due to declining Denver Basin water levels and associated production rates. Target locations for future well sites are shown in Figure 3-1.

Most of the District's future well sites are simulated as "well pods," allowing construction of a well in the Dawson and Arapahoe aquifers (the Denver and Laramie-Fox Hills aquifers are not expected to be economical). An Arapahoe aquifer well is recommended to be constructed first at each well pod so that the Arapahoe aquifer geophysical log can be analyzed to evaluate potential yield of the Dawson and Denver aquifers at that well site.

A naming convention has been adopted where well pods are numbered and wells are identified by aquifer. For example, Arapahoe aquifer well 21 is "AR Well 21" and the proposed Dawson aquifer well at the Arapahoe aquifer well 18 site is "DA Well 18".

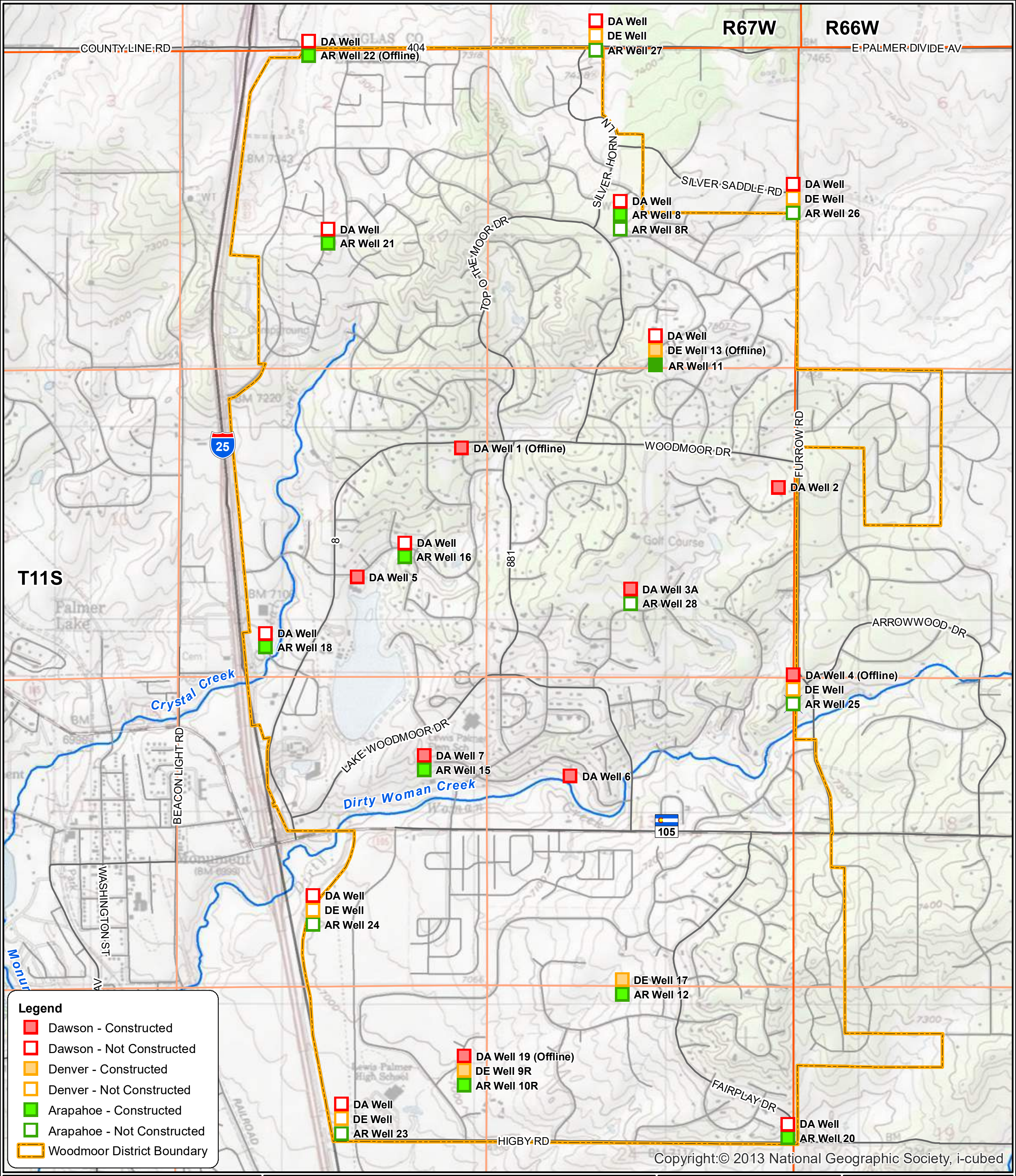
Discussed in the sections below, the Denver Basin aquifer system was analyzed to project future well yields from existing and future wells within the District's boundary. Projected pumping rates are compared to the difference between the projected future demand and the projected firm (dry year) yield of the District's other water supplies. Timing for well capital improvement projects is determined by preventing projected deficits in total water supplies. Projected well yield is a function of well spacing, estimated aquifer characteristics, and projected aquifer water levels. Well locations should be reevaluated prior to drilling based upon:

1. Spacing from new wells installed by neighboring water districts
2. New water level and aquifer characteristic information
3. Future analysis of aquifer geometry beneath the District
4. Changes in water right status
5. Land acquisition considerations
6. Cooperative agreements with neighboring municipal water users
7. Status of the District's Ranch renewable water supply

3.2.1.1. Arapahoe Aquifer Groundwater Model

An Arapahoe aquifer ground water model was developed for the 2006 LRP and is updated and used regularly to project future well pumping rates for the District's existing and future Arapahoe aquifer wells (the "Well Field Model"). The Well Field Model simulates the Arapahoe aquifer because that aquifer is the primary source of supply for the District, providing 64 percent of the District's total water supplies and 84 percent of the District's Denver Basin supplies during 2017-2021 (see Section 2.1.4). Despite declining well yields resulting from water level declines and well-to-well interference, Arapahoe aquifer wells are still projected to be the most productive in-District water supply.

The Well Field Model allows for inputs of well construction, well location, max pumping rate, pumping period, and available drawdown parameters for each well. The model utilizes the Theis equation for drawdown calculations and superposition to account for well-to-well interference. The District's Water Level Monitoring Program discussed in Section 2.2.1.3 provides the data needed to evaluate individual well performance and regional aquifer characteristics that serve as assumptions used in the Well Field Model.



BBA Water Consultants, Inc.

Date: 9/19/2022
Job No. 9026.52
Note: Well locations have not been field checked.

Figure 3-1: Future Denver Basin Well Locations

N
W E
S
1 inch = 2,200 feet
0 1,100 2,200
Feet

Overview Map

Individual well performance data is used to assess pumping well performance. For this analysis, hourly water level and flow rate data were analyzed for well operation, pumping water level with respect to well screens, and well efficiency in terms of specific capacity (pumping rate divided by drawdown).

Regional aquifer characteristics influence well-to-well impacts and include the aquifer's transmissivity (capacity to transmit water, equal to the product of hydraulic conductivity and saturated aquifer thickness) and the aquifer's storativity (ability to release water from storage, equal to the product of specific storage and saturated aquifer thickness). These parameters can be estimated empirically by conducting constant rate pumping tests and analyzing the observed impacts to neighboring wells constructed in the same aquifer, known as an "observation well test".

The District conducted an observation well test for its Arapahoe aquifer wells in 2005 by pumping from Well 11 and observing water levels at Well 8. Results from that test produced the aquifer storativity value that has been used for the entire District in all prior versions of the Well Field Model.

Wells 11 and 8 are constructed in the northeastern portion of the District, and the Well Field Model has historically projected lower than actual well yields for wells constructed in the southern portion of the District. As part of this LRP update, the District conducted an observation well test for its Arapahoe aquifer wells located in the southern portion of the District, the "2022 Arapahoe Aquifer Observation Well Test" discussed in Section 3.2.1.2 below. Results of this test were incorporated into the Well Field Model used for projections presented in Section 3.2.1.3.

3.2.1.1.1. Inputs and Assumptions for the Well Field Model:

a) Water level decline for each well was projected based on linear decline rates presented in Table 2-13. Recent well-specific water level decline rates are similar to rates used in the 2017 LRP version of the Well Field Model.
b) If the projected static water level was above the top well screens, the pumping water level was simulated at half-way through the production zone for that well. If the estimated static water level was below the top well screens, the pumping water level was simulated at 50-percent of the total remaining drawdown for that well. Pumping water levels were also limited to current pump setting depths summarized in Table 2-14. These pumping water level criteria are consistent with District well operational guidelines.
c) Simulated well yield was adjusted to account for observed efficiency losses resulting from dewatering of aquifer sands when the pumping water level was below the top well screen. This is incorporated in the model by adjusting well transmissivity as follows: 1) if the pumping water level is at 50-percent of the well production zone, then the well transmissivity is reduced by 25-percent; 2) if the pumping water level is below 50-percent of the well production zone, then the remaining 75-percent of transmissivity is reduced linearly based on the amount of remaining screen dewatered by the projected pumping water level.

d) **Well-to-well impacts were calculated based on the aquifer transmissivity and storativity surrounding the non-pumping well. This is a change in model logic from prior versions of the Well Field Model, based on observations from the 2022 Arapahoe Aquifer Observation Well Test discussed in Section 3.2.1.3.**
e) For wells located north of DWC, aquifer storativity was estimated to be 2.5×10^{-4}, based on results determined from the District's 2005 Arapahoe Aquifer Observation Well Test. For wells located south of DWC (except for Well 10R), aquifer storativity was estimated to be 3.2×10^{-4}, based on results determined from the District's 2022 Arapahoe Aquifer Observation Well Test. For Well 10R, aquifer storativity was estimated to be 1.0×10^{-3}, based on results determined from the District's 2022 Arapahoe Aquifer Observation Well Test.
f) Projected potable demands were based upon end of year SFEs from the 2 percent growth forecast in Figure 1-2, the planning demand of 272 gpd/SFE established in Section 2.1.1.1, and a 3-month peak demand of 39.14 percent of the total annual demand. Projected non-potable demands were based upon the 2018 dry-year demand for the District's non-potable customers presented in Table 2-9.
g) Projected yield of the District's existing Dawson and Denver aquifer wells were based on yields presented in Appendix C. No future Dawson or Denver aquifer wells were included in the model.
h) Projected exchange yield was based upon the dry year modeled exchange yield in Table 3-7.
i) New wells were added to the model within the District's current boundaries when the total modeled well field production was less than the difference between the projected demands in input/assumption (f) and projected total other supplies in inputs/assumptions (g) and (h). New wells were added to maximize yield vs. capital expense.

The concept of an out-of-District well field ("satellite well field") has been considered in the past. Practical satellite well field locations are located to the north and northeast of the District. Although satellite well fields would reduce well-to-well interference, the concept has not been financially efficient due to the cost of acquiring additional water rights and installation of transmission lines required to bring the supply into the District. Furthermore, due to a lack of Arapahoe aquifer wells located to the north and northeast of the District, there is substantial uncertainty in well yield. Indications from Well 22 are that the Denver and Arapahoe aquifer may not be strong producers to the north of the District.

3.2.1.2. Arapahoe Aquifer Observation Well Test – South District

In July 2022, the District conducted a 13-day observation well test by pumping Well 12. The purpose of this test was to quantify the extent to which Arapahoe aquifer well-to-well impacts in the southern portion of the District are less severe than in the northern portion of the District.

During the observation well test, Well 12 (Arapahoe) was pumped at 225 gpm for 13 days while water levels were monitored in Wells 9R (Denver), 10R (Arapahoe), 12 (Arapahoe), 17 (Denver), and 20 (Arapahoe). Analysis of the data included adjustment to water level drawdown during testing to account for background water level trends measured in each well.

At the end of 13 days of testing, total adjusted drawdown was measured as follows: 8.36 feet in Well 9R (Denver), 0.55 feet in Well 10R (Arapahoe), 226 feet in Well 12 (Arapahoe, pumping well), 0.76 feet in Well 17 (Denver), and 8.76 feet in Well 20 (Arapahoe).

Water level drawdown on Well 20 from Well 12 was as expected; the well-to-well impact was slightly less severe than observed in the northern District wells. Wells 9R (Denver) and 10R (Arapahoe) are located next to each other, as are Wells 12 (Arapahoe) and 17 (Denver). Drawdown measured at Well 17 was as expected; the District has historically observed Denver aquifer water level impacts from Arapahoe aquifer pumping. However, the Well 9R and 10R site exhibited unexpected results during testing: (a) more water level drawdown was observed at Well 9R than expected and (b) far less water level drawdown was observed at Well 10R than expected. These unexpected aquifer responses may be attributable to a thick sequence of Denver and Arapahoe aquifer sands located at Wells 9R and 10R.

Arapahoe aquifer characteristics were determined from the 2022 observation well test. Those results were incorporated into the Well Field Model, as addressed above.

The net effect of lower well-to-well impacts in the southern portion of the District and unusually minor well-to-well impacts to Well 10R is to allow lesser Arapahoe aquifer well spacing. Prior LRPs focused new Arapahoe aquifer wells in the northern portion of the District to maximize well spacing and minimize well-to-well interference. This LRP recommends new Arapahoe aquifer well sites in the southern portion of the District to take advantage of existing infrastructure and what appear to be more favorable aquifer conditions.

3.2.1.3. Projected Well Yields and Denver Basin Water Supply

Yield projections for individual wells are included in this Section and Appendix C. The District's wells completed in the Dawson aquifer are typically low-yielding and are best suited to meeting base flow demand. These wells can typically sustain 25 gpm for very long pumping cycles and require minimal time for static water level recovery.

Beneath the District, the Denver aquifer is extremely variable, and it is difficult to accurately predict yield until a well is drilled, constructed, and tested. In the past, the District has experienced some lower than desired well yields from Denver aquifer wells, for example Well 14 that was plugged and abandoned. The District's two online Denver aquifer wells produce 40-60 gpm for 3-month peak pumping cycles but tend to require multiple weeks for water level recovery. For this reason, future Denver aquifer wells are conservatively estimated to yield 31 gpm as a long-term average.

The Arapahoe aquifer is the most productive aquifer beneath the District, and will continue to be in the future, despite declining water levels. As a result, Arapahoe aquifer well yields were evaluated using the Well Field Model introduced above, and the results are discussed in more detail below.

The District does not currently have any Laramie-Fox Hills aquifer wells; therefore, little data is available. Based on yields from a Triview Metropolitan District Laramie-Fox Hills well, it is expected that a Laramie-Fox Hills well in the District will yield approximately 78 gpm; however, the water quality is expected to be high in total dissolved solids (greater than 1,000 mg/l) and other undesirable constituents. In addition, depth to the base of the Laramie-Fox Hills aquifer is in most cases more than 2,500 feet, which results in high well construction costs. For these reasons, construction of Laramie-Fox Hills aquifer wells is not recommended at this time.

The Arapahoe aquifer Well Field Model was run for three scenarios: (1) average annual yield, (2) 3-month “peak season” yield, and (3) 3-month peak season firm yield. A three-month peaking period between June and August was selected because these months represent the greatest increase in demand due to outdoor irrigation use. Past LRPs considered 3-month peak well field capacity as the driving factor for new well construction. However, the 3-month peak is no longer a critical limitation on District water supply due to upgrades at CWTP that allow that facility along with SWTP to treat water from Lake Woodmoor.

The District can now operate its wells at more consistent rates throughout the year to maximize the annual volume of water withdrawn through use of Lake Woodmoor to store well water during off-peak times. With at least 700 af usable capacity in Lake Woodmoor, there is adequate storage to meet 80-percent of total outdoor water demands at current buildout and 70-percent at ultimate buildout. For this reason, new wells are recommended in this LRP based on annual well yield and annual water demand instead of peak three month well yield and water demand.

Results of the Well Field Model projections and the details pertaining to the assumptions for each projection are presented in Tables A-1 through A-6 in Appendix D. Tables A-1, A-3, and A-5 are presented in gallons per minute, which represents an average constant rate for the duration of the pumping period simulated (365 days for the annual scenario and 92 days for the 3-month peak scenarios). For example, well pumping may be modeled at an average rate of 100 gpm. However, this well may actually be operated at 200 gpm and cycled on and off during the simulated period.

Model projections are also presented in acre-feet in Tables A-2, A-4, and A-6, which represents the total volume produced in the duration of the pumping period simulated (365 days for the annual scenario and 92 days for the 3-month peak scenarios). Actual well yields will depend on site specific conditions, including the depth, amount, and quality of the sands in the aquifers.

As expected, the Arapahoe aquifer well field model predicts diminishing returns from future Arapahoe aquifer well drilling due to increased well-to-well interference and declining well yields due to declining well water levels.

Yield projections for existing Arapahoe aquifer wells in this LRP are similar to those presented in the 2017 LRP. However, wells in the southern portion of the District are projected with greater yield in this LRP due to more favorable aquifer conditions confirmed by the 2022 Arapahoe Aquifer Observation Well Test. Wells in the northern portion of the District are projected with lower yield in this LRP due to information collected during testing of Arapahoe aquifer Well 22.

Presented operational pumping rates in Tables A-1, A-3, and A-5 are not peak day rates and the wells will be operated for shorter pumping periods and at higher pumping rates than simulated in the Well Field Model. Actual short-term well yields should be determined on a well-by-well basis and will depend on pumping equipment, aquifer water levels, aquifer characteristics, and well efficiency. We note that operating wells with daily on-off cycles results in greater wear on pumping equipment. It is more efficient to operate wells for multi-day or multi-week pumping cycles.

3.2.2. Projected Annual Exchange Yield

The District diverts natural Monument Creek and DWC streamflow in exchange for reusable effluent discharged downstream at TLWWTF. The exchanged water can be pumped to Lake Woodmoor for subsequent use, to SWTP for treatment and use in the District's potable water system, or directly to non-potable use at the golf course or Lewis-Palmer High School. The District operates its exchange under four decrees:

1. Case No. 94CW0073, Division 2, allows up to 1,000 gpm to be diverted from Monument Creek at the MCEPS
2. Consolidated Case Nos. 87CW0067, Division 2, and 88CW0218, Division 1, allow for up to 700 gpm to be diverted from Dirty Woman Creek by alluvial wells, which currently only include Qal-a (a.k.a. Augusta Pit)
3. Case No. 10CW0029, Division 2, allows 2.5 cubic feet per second (cfs) to be diverted at the four Woodmoor Pines Golf Course Ponds
4. Case No. 14CW3058, Division 2, allows up to 1,050.5 gpm combined additional diversions from MCEPS and/or DWC

Currently, the reusable effluent relied upon for the exchange results entirely from the District's use of Denver Basin ground water, most of which can be reused and successively used to extinction. In the future, reusable effluent will also include the District's fully consumable water supplies from the Ranch Water Rights, discussed further in Section 3.2.3.

A spreadsheet model was used to project yield of the District's exchange system based on reusable effluent released at TLWWTF and the available streamflow (the "Exchange Yield Model"). A schematic of the Exchange Yield Model is illustrated in Figure 3-2. The Exchange Yield Model relies upon available hydrologic data from three stream gages located on Monument Creek: Monument Creek at Palmer Lake, Monument Creek below Monument Lake, and Monument Creek at North Gate Blvd. at USAF. Using this data, streamflow available for exchange in Monument Creek and DWC were synthesized for the study period from November 1986 through October 2021.

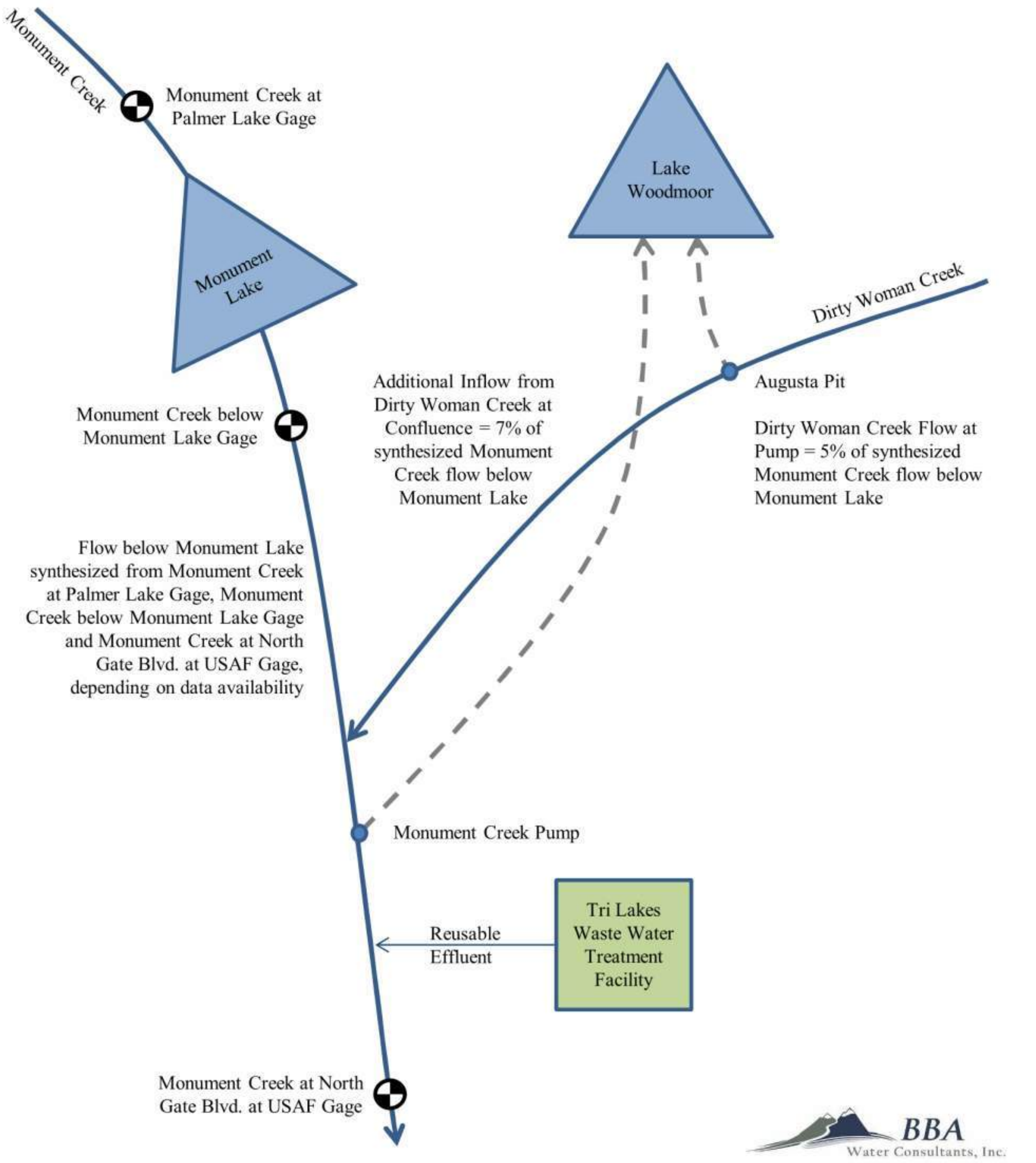


Figure 3-2 – Schematic Diagram of Woodmoor Exchange Yield Model

The model simulates the exchange yield based on the lesser of the available streamflow, the amount of reusable effluent available to the District, and the decreed exchange rates. Available streamflow often limits the District's exchange yield.

The amount of reusable effluent available to the District is estimated in the Exchange Yield Model based on the projected number of SFEs, the demand per SFE, the percent of total demand that is for indoor uses, estimated treatment and system losses, and augmentation use of reusable effluent. The amount of reusable effluent will increase until ultimate buildout is achieved as indoor use increases.

LIRF credits can also be used as a source for the Case No. 14CW3058 exchange but were not included in this analysis because such credits are used primarily for pond augmentation per the Decree in Case No. 10CW28. The remaining LIRF credits available for exchange may be as little as 3-4 af/yr (see Section 2.3.2.3).

3.2.2.1. Exchange Yield Model Calibration

In the 2017 LRP, the Exchange Yield Model was calibrated using the District's actual exchange yield data from 2007 through 2016. This calibration was confirmed for the 2017 through 2021 period in two steps. First, simulated exchange yield was compared with the District's actual exchange yield on days when exchange was operated to confirm that streamflow is accurately simulated. The simulated exchange yield was within 4 percent of the actual exchange yield during the recent 5-year period, which is very good calibration. However, the model understates exchange yield during dry periods (actual yield exceeded simulated yield). This may be due to: (a) a conservative assumption that prevents diversion below 0.04 cfs streamflow in the Exchange Yield Model, intended to reflect historical issues with diversions under low flow conditions and (b) poor model calibration under low flow conditions.

Second, simulated exchange yield was compared with actual exchange yield available every day (not just when the District was actively operating the exchange) to determine efficiency of the District's exchange operations. In the 2017 LRP, that efficiency was determined to be 85 to 88 percent, and 85 percent was used for the projections. For 2017-2021, overall efficiency was 76 percent, but that apparent efficiency is in large part due to operational constraints that limited the exchange yield including: (a) operational issues during July through October of 2017; (b) maintenance in September 2019 through early 2020; and (c) infrastructure updates throughout 2020 and 2021. When these periods are excluded, the exchange efficiency was 87 percent, which is similar to the 85 percent previously determined. For the Exchange Yield Model results presented in this LRP, an estimated 85 percent exchange efficiency was used.

3.2.2.2. Exchange Yield Model Results

The Exchange Yield Model was run for five scenarios, including current (2022) through ultimate buildout conditions. Modeled results are summarized in Table 3-7 below and in Appendix E. Simulated wet, moderate (mod), and dry water year exchange yields are based upon hydrologic data from 2016, 2014, and 2012, respectively.

Table 3-7 – Projected Future Exchange Yield

Modeled Conditions	SFEs	Exchangeable Effluent		Modeled Exchange Yield (af/yr)		
		(af/mo)	(af/yr)	Wet Year	Mod Year	Dry Year
2022	4,358	60.54	726	582	431	260
2027	5,261	72.32	868	678	479	286
2032	5,807	79.83	958	739	507	301
Buildout (2037)	6,481	89.1	1,069	814	539	319
Ultimate Buildout (2047)	7,815	107.43	1,289	955	600	352

- Number of SFEs based on anticipated growth through 2027 and 2% growth thereafter, as shown in Figure 1-2.
- Exchangeable effluent equal to actual amount available in 2022 and calculated for all other modeled conditions as SFEs x 272 gpd/SFE x 64% indoor water use x (1 - 6% treatment and system loss) x 90% decreed reusable credit.
- Modeled values incorporate exchange system efficiency of 85%, determined through model calibration.
- Representative year types based on conditions in 2016 for Wet Year, 2014 for Moderate (Mod) Year, and 2012 for Dry Year.
- Monthly summaries of modeled results can be found in Appendix E.

Both the dry and moderate year projected annual exchange yield shown in Table 3-7 do not increase significantly as the District's water demand grows. This is because the District's actual exchange yield is limited by natural streamflow in Monument Creek and DWC. Figure 3-3 below presents a comparison between gaged streamflow available in Monument Creek and the District's exchangeable effluent credit at current buildout. On average, the District's reusable effluent credit exceeds the available streamflow during most of the non-irrigation season, from approximately August through March. During a dry year like 2012, the District may be streamflow limited from June through March.

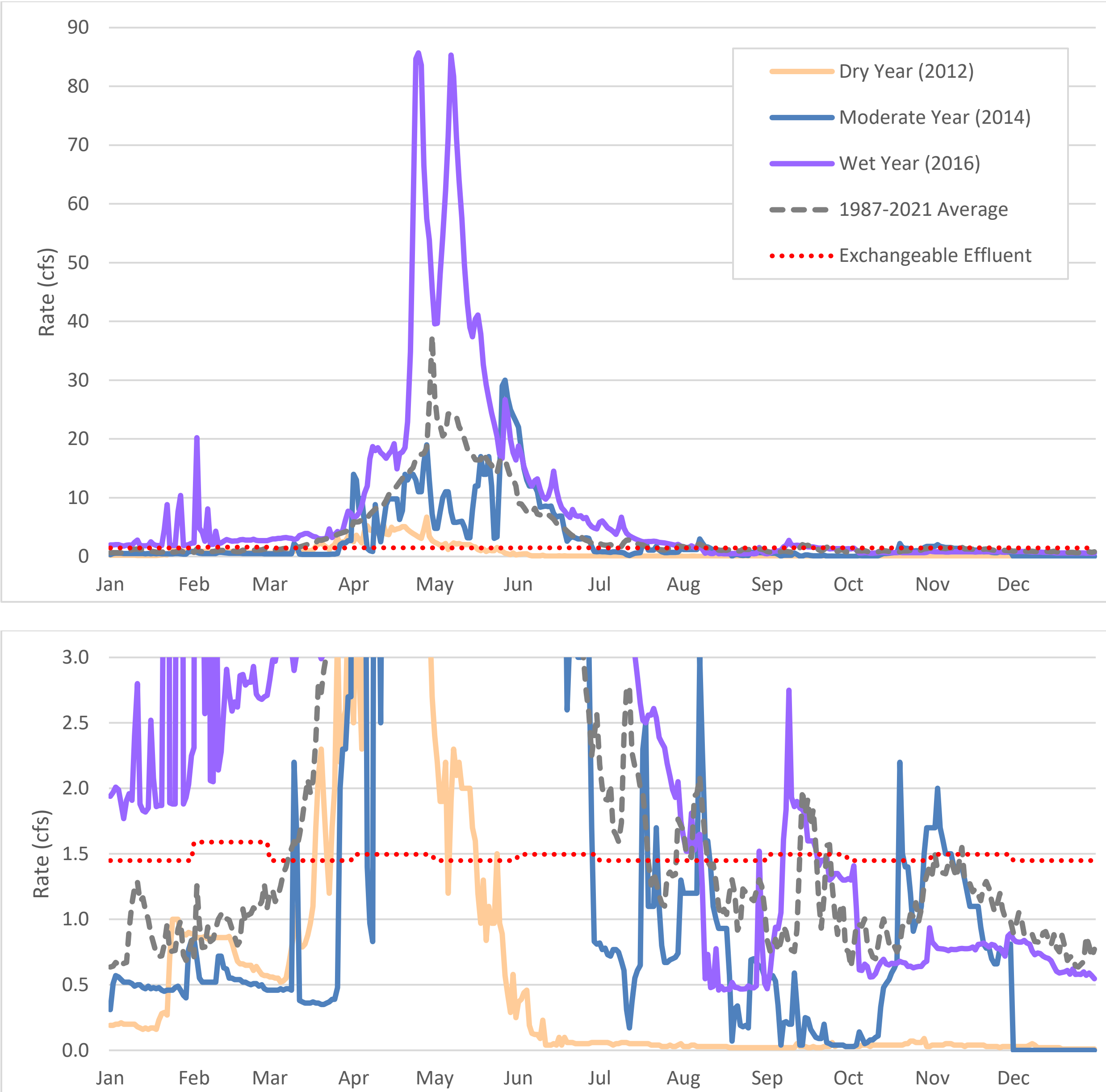


Figure 3-3 – Streamflow in Monument Creek vs. Exchangeable Effluent at Buildout

The District may purchase additional effluent credits from other entities in order to increase its exchange yield during months when streamflow is not the limiting factor, such as April through July. Conversely, during low-flow conditions, the District would need to capture its reusable effluent credits by means other than the exchange system, as discussed in Sections 3.2.3 and 3.3.1.

3.2.3. Ranch Renewable Water

The Ranch Water Rights were acquired by the District in 2011 as a step in the District's long-term renewable water supply planning. The Ranch Water Rights consist of renewable surface water supply that will ultimately replace the District's non-renewable Denver Basin water supply. The Ranch Water Rights include Chilcott Ditch, Liston and Love Ditch, Lock Ditch, Lock Ditch No. 2, and Callahan Reservoir water rights. Priorities and diversion rates for the Ranch Water Rights are presented in Section 2.3.3.

Currently the District's Ranch water supply is in the conversion phase from historical irrigation use and cannot be used in the District's municipal system until revegetation of historically irrigated lands is complete and additional infrastructure is constructed. Analysis of the Ranch water supply was completed to evaluate the District's additional infrastructure needs, discussed in more detail in the following sections.

3.2.3.1. Recommended Ranch Operation

Upon completion of revegetation of historically irrigated lands, the Ranch Water Rights will continue to be diverted at the Chilcott Ditch headgate on Fountain Creek and will be delivered to storage for municipal use in Callahan Reservoir or released to Fountain Creek near the Chilcott Ditch headgate as a "consumptive use credit". Generally, infrastructure for the Ranch renewable water supply will include: (a) storage in Callahan Reservoir, (b) treatment near Callahan Reservoir, and (c) delivery via pipeline and pumpstations to Lake Woodmoor.

During times when the Ranch Water Rights yield more water than is needed by the District, for example prior to buildout and when Denver Basin wells continue to be used, the District can lease excess "consumptive use credits" to other water users on Fountain Creek or deliver excess Ranch Water Rights to other water users via the proposed pipeline.

Daily measurement and accounting of diversions and delivery of the Ranch Water Rights is required by the District's water rights decree both for continued agricultural use and future municipal uses including lease of the Ranch Water Rights. The District has begun completing daily accounting of Ranch Water Rights diversions, but future municipal uses including lease of the Ranch Water Rights will require additional measurement, accounting, and operations specified in the District's Case No. 12CW01 water rights decree (the "12CW01 decree").

3.2.3.2. Raw Water Storage Volume

The District's future operations using the Ranch water supply were simulated using a monthly spreadsheet model to evaluate reservoir storage and pipeline size. The modeled conceptual delivery plan is shown schematically in Figure 3-4 below.

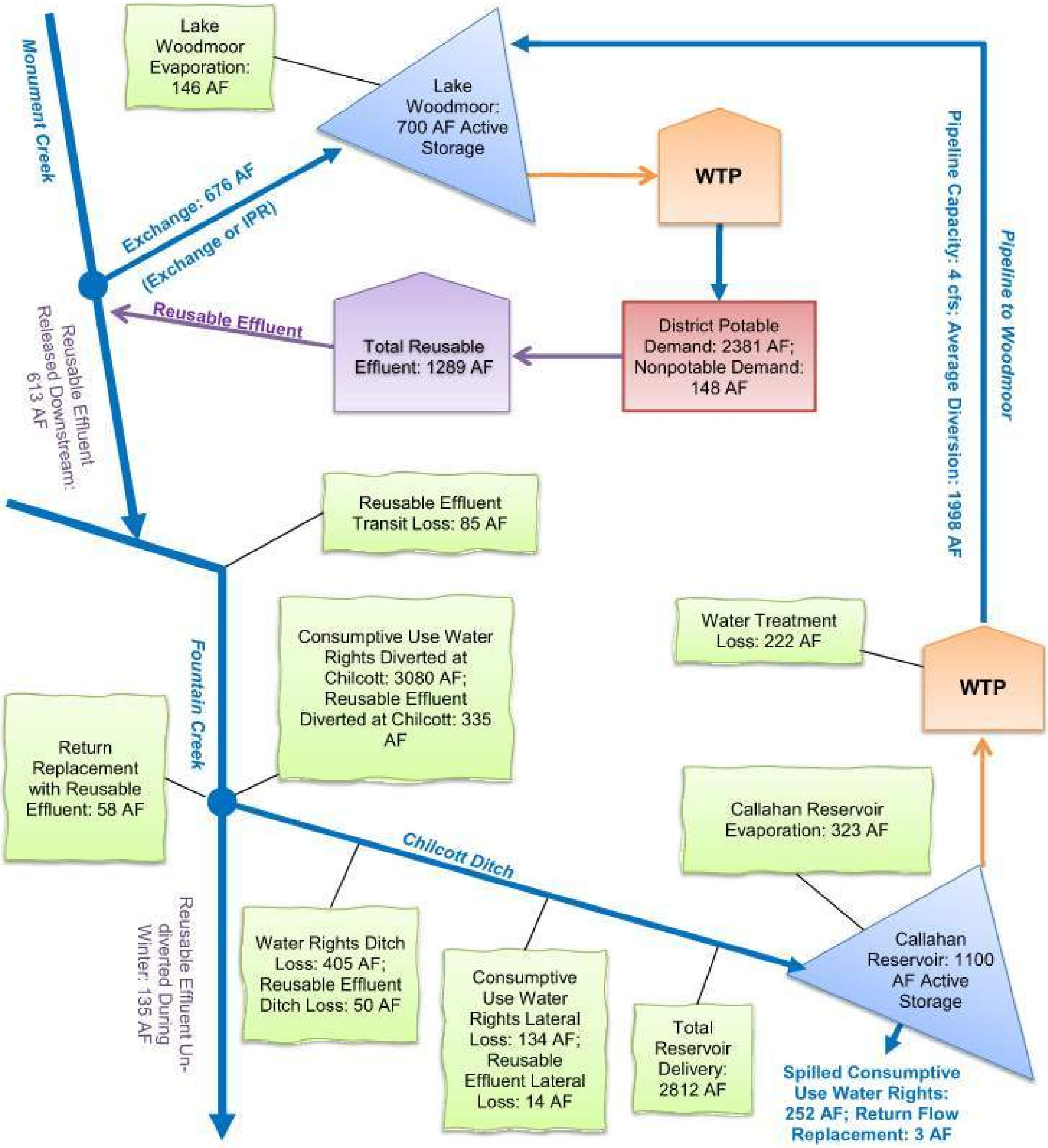


Figure 3-4 – Renewable Model with Conservative Diversions and No IPR

The Ranch water supply model uses a 48-year simulation period, computed on a monthly time-step. Model inputs include water right diversions, reservoir storage capacity, ultimate buildout demand, exchange, re-diversion, or IPR of wastewater effluent, and system losses. The model also accounts for fluctuations in reservoir storage, pipeline capacities, and lagged return flow obligations.

3.2.3.2.1. Ranch Water Rights Diversion Analysis

One of the most sensitive variables in the Ranch water supply model is future water rights diversions. Although the Ranch Water Rights have been operated for over a century, there is uncertainty whether recorded historical Ranch Water Rights diversions reflect future water availability. On one hand, future diversions may be lower at times because competition for water may increase with greater municipal use of Fountain Creek water rights and stricter water rights administration by the Division of Water Resources. On the other hand, future diversions may be greater at times due to conservatively low projection of historical diversions and more sophisticated future operations.

Future diversions were based upon a 1987-2010 hydrologic period that includes average, wet, and dry years. Hydrology after 2010 was not considered due to changes in Chilcott Ditch operations starting in 2011.

Two sets of water rights diversion data were used for the Ranch water supply model: "Conservative Diversions" and "Probable Diversions". Conservative Diversions provide a low estimate of future water availability and were based upon historical diversions during 1987 through 2010 at the Chilcott Ditch headgate, analyzed by the following steps:

1. Tabulate total daily diversion of water rights diverted at the Chilcott headgate that were historically diverted for delivery to the Ranch.

2. Determine potential diversion amount for each Ranch Water Right limited to daily historical water rights call record.

3. Limit diversion for each Ranch Water Right based upon volumetric limits contained in the 12CW01 decree.

4. Diversions for two years, 1995 and 2007, were set to average monthly amounts because historical diversion amounts were well below average, yet gaged Fountain Creek stream flow was above average. Diversions during 1999, a flood year, were also well below average, but were not adjusted to account for typical infrastructure challenges that can occur on Fountain Creek.

Conservative Diversions are less than the long-term volumetric limits included in the 12CW01 decree due to less refined operation of the water rights in the recent past. Annual diversions and consumptive use credit in this scenario averaged 4,096 af/yr and 2,675 af/yr, respectively. [1] Minimum annual useable water rights yield in the Conservative Diversions Scenario was 1,476 af/yr or 55 percent of average. The inter-annual variability of the adjusted historical diversions represents a conservatively low estimate for the District's operation of the Ranch Water Rights. Improved regulation of water diversions by the District will likely reduce inter-annual variability in water right yield, and consequently allow for a higher firm yield of the water rights and smaller reservoir sizing.

Probable Diversions provide a moderate estimate of future water availability and were determined by setting diversions by the Liston and Love Ditch and Lock Ditch water rights at their respective long-term 10-year and 20-year monthly volumetric limits contained in the 12CW01 decree for most months. Review of recent Fountain Creek call records indicate that this assumption is likely valid except during extreme drought periods when monthly water rights yield will be more variable.

Probable Diversions for the Chilcott Ditch water rights were assumed to be the same as the Conservative Diversion amount, which is conservatively low. Annual diversions and consumptive use credit in this scenario averaged 4,457 af/yr and 2,906 af/yr, respectively.[2] Minimum annual useable water rights yield in the Conservative Diversions Scenario was 2,242 af/yr or 77 percent of average. The Probable Diversions are a reasonable estimate of future Ranch Water Rights diversions, but likely underestimate future diversions by the Chilcott Ditch water rights during many years and may over-estimate diversions by the Liston and Love Ditch and Lock Ditch water rights during extreme drought years.

The water right diversion analyses used for the Ranch water supply model are appropriate for general facilities sizing and planning, but do not reflect a refined water availability analysis.

3.2.3.2.2. Key Model Inputs

In addition to water rights diversions and monthly District water demand, the Ranch water supply model includes the following inputs and assumptions:

1. Evaporation at Callahan Reservoir and Lake Woodmoor was simulated as location-specific variable monthly and annual amounts based upon historical climate data

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[1] Those amounts are slightly lower than in the 2017 LRP due to refinements in the analysis, with a 3% reduction in river headgate diversion and 1% reduction in consumptive use credit.

[2] Those amounts are greater than in the 2017 LRP analysis due to refinement of operations to optimize diversions with respect to volumetric limits. Initial review of Fountain Creek call records indicate that the senior Liston and Love Ditch (Priority 14) and Lock Ditch (Priority 15) will be in priority each month for a sufficient period to reach average long-term volumetric limits in most years. Diversions were increased by 6% resulting in an 8% increase in consumptive use credit.

provided by the Colorado Division of Water Resources. This is a major refinement in the model since the 2017 LRP and results in more realistic and greater evaporation loss.

2. The volume of Callahan Reservoir was adjusted until no projected water supply shortages occur. Lake Woodmoor was simulated with a 750 af capacity, of which 700 af is active storage and 50 af is dead storage (actual dead storage may be as little as 25 af.) Model simulations were optimized to minimize Callahan Reservoir storage due to higher evaporation rates, which results in substantial fluctuations in Lake Woodmoor water level, consistent with current practices.

3. Losses were simulated in the Chilcott Ditch at 10 percent (Chilcott water rights) to 15 percent (Liston and Love Ditch water rights, Lock Ditch water rights, and reusable effluent).

4. Losses for on-Ranch conveyance were simulated at 5 percent.

5. Exchange of reusable effluent was based upon the results of the analysis presented in Section 3.2.2.

6. An alternative analysis using both exchange and IPR simulated use of 85 percent of reusable effluent, based upon 10 percent treatment loss and 5 percent consumptive loss due to stream transit and evaporation.

7. Reusable effluent that is not re-captured via exchange or is discharged as reject IPR waste was simulated to flow to the Chilcott Ditch headgate suffering 9 to 17 percent transit loss in Monument Creek and Fountain Creek. Reusable effluent arriving at the Chilcott Ditch headgate was used to meet water rights return flow obligations or re-diverted at the Chilcott Ditch headgate. No re-diversion of effluent was simulated during December through February to account for potential icing in the Chilcott Ditch.

8. 10 percent treatment and system losses were simulated for pipeline deliveries from the Ranch to the District.

9. The capacity of a pipeline between the Ranch and the District was simulated. The operational range that results in no shortages is 3 to 5 cfs.

10. Demand was based on Ultimate Buildout (2,381 af/yr potable demand plus 148 af/yr non-potable use), distributed based upon monthly water use trends.

3.2.3.2.3. Analysis Results

The analysis adjusted minimum storage capacity at the Ranch in Callahan Reservoir to meet average monthly District water demands over a range of pipeline sizes. Reservoir capacity is dependent on pipeline capacity: at lower pipeline capacities, more reservoir capacity is needed to store irrigation season diversions at the Ranch prior to delivery to the District.

The model was executed by adjusting three sets of variables: (1) Available water rights supply was simulated with Conservative Diversions that are more variable year-to-year or Probable

Diversions that are more consistent year-to-year; (2) Reuse of effluent was simulated with existing MCE and DWC exchange and recapture of reusable effluent at the Chilcott Ditch or existing MCE and DWC exchange and recapture of reusable effluent via IPR; and (3) the Chilcott Ditch was simulated as unlined (current status) or piped to eliminate losses and allow year-round operation.

Without IPR, a minimum of 4 cfs pipeline capacity and 1,300 af of Callahan Reservoir storage is needed for the Conservative Diversion scenario. This is the base planning scenario. As noted above, it is probable that the Ranch Water Rights yield will be greater than the Conservative Diversion scenario. In the Probable Diversion scenario, a minimum of 4 cfs pipeline capacity and 300 af of Callahan Reservoir storage is needed.

The Conservative Diversion and Probable Diversion Callahan storage requirements are 500 af and 100 af lower than the same scenarios in the 2017 LRP due to: (a) reduced Ultimate Buildout Woodmoor water demand, (b) refinement of conservative diversion annual variability, and (c) refinement of exchange efficiency percentage and available reusable effluent.

Table 3-8 below summarizes minimum pipeline and reservoir capacities without IPR at the District.

Table 3-8 – Reservoir and Pipeline Capacities *without* IPR

Pipeline Capacity	Callahan Reservoir (af)		Lake Woodmoor (af)
	Conservative Diversions	Probable Diversions	
4 cfs	1,300	300	750
5 cfs	800	200	750

With IPR, a minimum of 3 cfs pipeline capacity and 800 af of Callahan Reservoir storage is needed for the Conservative Diversions scenario. The District's annual Ultimate Buildout water demand is projected to average approximately 3.5 cfs. Accordingly, facility designs including a pipeline capacity less than 3.5 cfs will require local reuse of wastewater.

The Probable Diversions results indicate that only 300 af of Callahan Reservoir storage would be needed at 3 cfs pipeline capacity. Storage volumes for Probable Diversions are slightly greater than in the 2017 LRP due to a 15 percent assumed IPR loss comprised of treatment losses and system losses.

Table 3-9 below summarizes minimum pipeline and reservoir capacities with IPR at the District.

Table 3-9 – Reservoir and Pipeline Capacities *with* IPR

Pipeline Capacity	Callahan Reservoir (af)		Lake Woodmoor (af)
	Conservative Diversions	Probable Diversions	
3 cfs	800	300	750
4 cfs	400	200	750

3.2.3.2.4. Consideration of piping the Chilcott Ditch

Model simulations identify that an average of 339 af/yr of losses occur due to the open unlined nature of the Chilcott Ditch: (a) seepage losses to Ranch Water Rights and reusable effluent between the Ranch farm headgate and Callahan Reservoir are estimated at 160 af/yr; (b) losses to reusable effluent in the Chilcott Ditch during irrigation season carriage are estimated at 52 af/yr; and (c) losses to reusable effluent due to inability to divert low flows (1.2 cfs) due to icing in December through February are estimated at approximately 127 af/yr.

Model analyses show that minimum Callahan Reservoir storage capacity could be reduced by up to 700 af if the Chilcott Ditch was piped to Callahan Reservoir. However, the cost for that project does not appear to justify reduced minimum reservoir capacity.

3.2.3.2.5. Consideration of IPR

Model simulations identify that an average of 376 af/yr of losses can be avoided through IPR due to: (a) eliminating transit loss on Monument and Fountain Creeks of 66 af/yr; (b) eliminating reusable effluent ditch loss of 38 af/yr; (c) eliminating December through February reusable effluent loss due to Chilcott Ditch icing of approximately 128 af/yr; (d) reducing reservoir evaporation loss by 96 af/yr; and (e) reducing Ranch treatment loss of 48 af/yr.

In addition, IPR is projected to reduce average annual pipeline deliveries from the Ranch to the Lake by 430 af/yr from 1,998 af/yr to 1,568 af/yr. This could result in pumping and treatment operations and maintenance (O&M) cost savings compared to pumping from the Ranch.

3.2.3.2.6. Consideration of incremental Ranch renewable supply facilities

As documented in Section 3.2.1.3, construction, operation, and maintenance of Denver Basin aquifer wells results in diminishing returns, yet more wells are needed to meet the District's future demands. Instead of investing in additional wells, the District should consider prioritizing construction of renewable Ranch water supply components to develop additional supply in lieu of well drilling. Two alternatives can be considered: (1) construction of IPR including advanced oxidation process (AOP) treatment to address trace organic compounds or (2) construction of the Ranch pipeline and AOP treatment without adding treatment at the Ranch or expanding Callahan Reservoir.

Construction of IPR will add approximately 513 af/yr of firm water supply for the District in 2032, based upon 85 percent of 958 af/yr total reusable effluent minus 301 af/yr of dry-year exchange yield. That is equivalent to approximately 320 gpm of annual well capacity, or approximately six new Arapahoe aquifer wells. As addressed above, IPR implemented as part of the Ranch renewable water system will reduce the size of Ranch reservoir, treatment, and pipeline facilities, and will also reduce losses and operational costs.

Water could be brought from the Ranch for use by the District without expansion of Callahan Reservoir or initial treatment. This alternative would require construction of the Ranch pipeline and AOP treatment at SWTP and CWTP to address trace organic compounds and could add at least 1,700 af/yr of firm supply for the District. The full firm Ranch Water Rights supply could not be added to the District supply without additional water treatment due to high total dissolved solids in Fountain Creek. However, a certain amount of untreated Ranch water could be blended in Lake Woodmoor without creating water quality concerns. **To further evaluate this alternative, the District should collect regular water quality samples of Chilcott Ditch water as it is delivered to the Ranch to determine acceptable blending.**

3.3. Future Water Treatment and Infrastructure

Peak day demand for current buildout is 3.3 MGD and ultimate buildout is 3.9 MGD. The current firm capacity of CWTP and SWTP is 3.7 MGD. The Well 8 and Well 11 WTPs can supply an additional 0.2 MGD but these WTPs are not included in the future treatment capacity analysis due to their inevitable production decline. This section evaluates improvements to the District's water infrastructure so the District can supply water for current and ultimate buildout.

3.3.1. Indirect Potable Reuse

The District has explored IPR as a potential alternative to secure more renewable sources of raw water. IPR is a process in which treated wastewater is discharged into a water body upstream of a drinking water intake. The treated wastewater effluent combines with native flows in the water body and is diluted and partially treated through natural processes before being diverted to a WTP for treatment to drinking water standards. While IPR inherently takes place throughout the United States, the intentional design of IPR facilities and systems is a relatively new practice. As such, there is little regulatory framework in place in Colorado and regulations implemented in other states are typically drafted on a project-by-project basis.

In the case of the District, IPR would involve discharging treated wastewater effluent from the Tri-Lakes WWTP to Monument Lake, Monument Creek, or Lake Woodmoor prior to treatment at CWTP and SWTP, or a new WTP. The District has evaluated pursuing IPR independently and jointly with TOM. Based on water quality test results from Callahan Reservoir, the District may see benefits by treating water from both IPR and the Ranch at a new WTP. This section examines the infrastructure required to implement IPR under various scenarios.

Under any of the alternatives presented, IPR would trigger the need to implement pretreatment using either ozone or chlorine dioxide and ultraviolet (UV) disinfection at CWTP and SWTP.

3.3.1.1. Background of IPR Studies

In 2014, Tetra Tech consulted with Donala, TOM, and the District to complete a conceptual level plan for IPR entitled *Regional Water Reclamation Facility Concept Study*. The study developed two recommended treatment alternatives and provided preliminary design criteria and cost estimates for each.

The recommendation included an Advanced Regional Water Reclamation Facility (ARWRF) with microfiltration and nanofiltration discharging to Monument Creek upstream of Monument Lake. The District would capture reclaimed water using their existing MCE pump station. The District's share of the $44.1M total project cost is about $18.75M in 2014 dollars.

In 2016, Forsgren Associates Inc. (Forsgren) consulted with TOM to complete a conceptual level plan to independently construct IPR infrastructure ahead of the timeline proposed in the 2014 Tetra Tech memo entitled *Reuse Plan*. Like the 2014 Tetra Tech memo, the plan developed alternatives and cost estimates for treatment, conveyance, and discharge facilities. The plan outlined alternatives to complete an IPR project for TOM both independently and jointly with the District.

The recommended Forsgren alternative is *Monument Creek Surface Withdrawal Upstream of the TLWWTF*. Upgrades at the TLWWTF include new cloth media disc filters for phosphorus removal and a new pump station to convey treated effluent to Monument Lake. Depending on water quality test results, the District could opt to install ultraviolet disinfection with an advanced oxidation process (UVAOP) at SWTP and CWTP. The plan assumes that ozonation would take place at SWTP and CWTP prior to the filtration processes. The alternative also recommends upgrades to the MCE pump station including expansion of the intake structure and installation of a third pump and ancillary equipment to increase the overall capacity. The District's share of the $18.2M total project cost is about $6.5M in 2016 dollars.

In 2016, Alan Plummer Associates (Plummer) reviewed the 2014 Tetra Tech memo and the 2016 Forsgren Reuse Plan and completed an independent assessment. The Plummer review analyzed the previous evaluations, discussed potable reuse treatment criteria, assessed expected pathogen removal for the two treatment alternatives proposed by Tetra Tech and Forsgren, and provided an alternative treatment approach.

The Plummer review provided six major comments and recommendations:

- Model detention time and dilution effects in the Monument Lake system to determine expected detention times and pathogen and contaminant removal rates.
- Sample WWTF effluent for one year. Increase redundancy and robustness of treatment.
- Use dual-media filters instead of disc filters for increased pathogen removal.
- Model Monument Lake for TDS cycling and buildup.
- Perform nanofiltration feasibility study for effects on water quality.
- Evaluate impact of effluent on Monument Lake water quality.

The alternative treatment approach recommended by Plummer expands on the Forsgren recommendation by substituting the cloth media disc filter at the TLWWTF with a dual-media filter for improved pathogen, turbidity, and phosphorus removal. If enhanced nitrate removal is desired, the dual-media filter could be equipped with a deep bed granular activated carbon (GAC) layer and sand media for operation as a denitrification filter. Depending on the discharge permit limit and water quality results, post-aeration may be needed prior to discharge since dual-media filters can reduce dissolved oxygen concentrations.

The Plummer review also expands on the Forsgren recommendations for water treatment by substituting a single pre-filtration ozonation train with dual ozonation before and after the pretreatment unit. This technique could oxidize iron and manganese upstream of the pretreatment unit and oxidize organics and taste and odor compounds prior to filtration. The review recommends the District upgrade the existing Trident filters at each WTP to achieve biologically active filtration (BAF) for partial removal of oxidized organics and increased filtration of turbidity and pathogens. One option is to substitute the existing anthracite media with replaceable GAC media for adsorption treatment to remove a broader variety of potential contaminants.

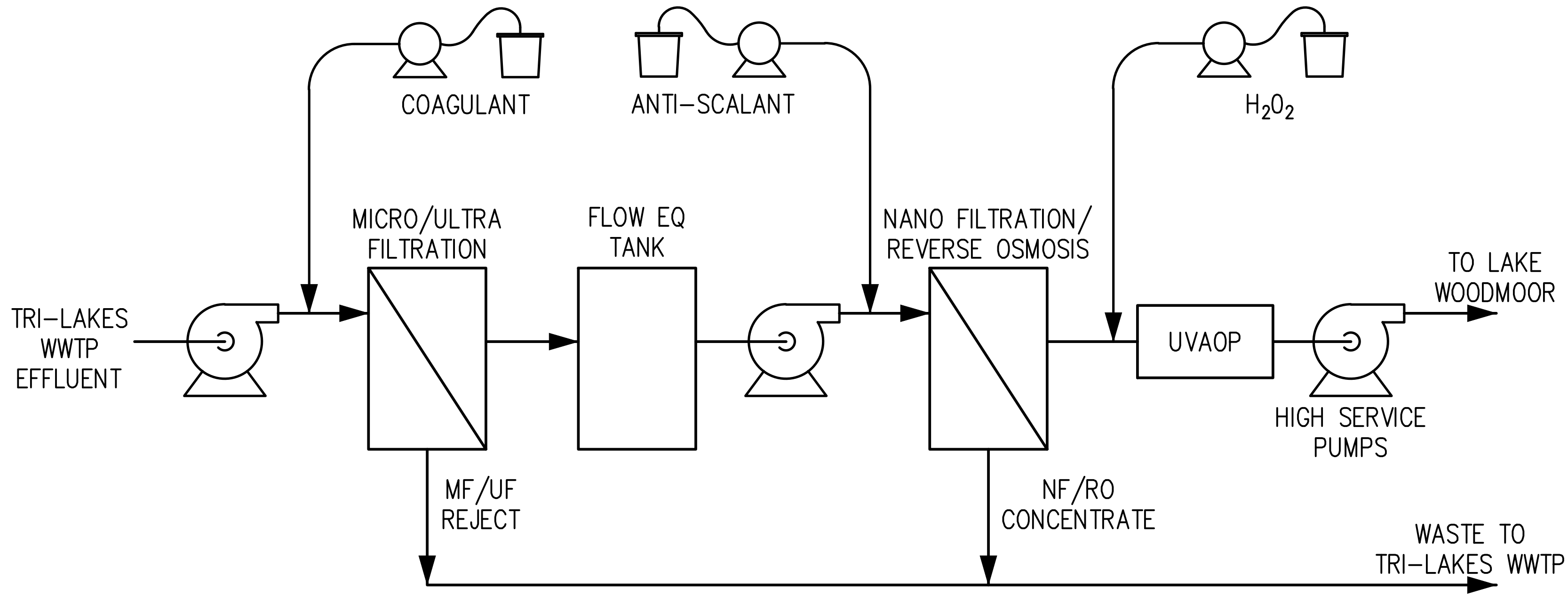
Downstream of the BAF, UV reactors are proposed for additional pathogen disinfection and N-Nitroso-dimethylamine (NDMA) treatment, followed by free chlorine for virus treatment prior to distribution. If DBPs are a concern, liquid ammonium sulfate (LAS) could be added following chlorination to produce a chloramine residual in the distribution system. If additional contaminants are present that require treatment via UVAOP, either the ozone or UV system could be upgraded accordingly. A proposed variation of the treatment concept is to use chlorine dioxide for iron and manganese removal instead of ozonation. The Plummer review did not provide a cost estimate for the alternative treatment approach.

In 2017, the District, TOM, and Tetra Tech met to discuss potential IPR concepts. Tetra Tech provided a technical memo that introduced two advanced treatment alternatives for IPR and provided preliminary capital and O&M opinions of probable cost for evaluation. A process flow diagram for each of the two proposed alternatives is provided below in Figure 3-5 and Figure 3-6, and a comparison of the two options is provided below in Table 3-10.

Table 3-10 – IPR Alternatives

Characteristic	FAT Process Train	Low-FAT Process Train
Treatment Method	MF/UF, NF/RO, UVAOP	MF/UF, Ozone, BAF, UVAOP
Design Flow	2.05 MGD	2.05 MGD
System Efficiency	71.20%	94.10%
Life Cycle Cost (in 2016 dollars)	$46M	$43M

The first alternative, termed the full advanced treatment (FAT) option, consists of low-pressure membranes for particulate removal, high pressure membranes like nanofiltration (NF) or reverse osmosis (RO) for further contaminant removal, and UVAOP to help treat molecules that pass through the membranes. The second alternative, termed the low-FAT option, replaces the NF/RO process with ozonation followed by BAF. Further analysis of the two IPR options is provided in the following sections.



NOTES:

1. FURTHER ANALYSIS REQUIRED TO CONFIRM IF UV/AOP PROCESS COULD BE ADDED AT CWTP AND SWTP INSTEAD OF THE IPR WTP.
2. FURTHER ANALYSIS REQUIRED TO CONFIRM IF TDS CYCLING WOULD BE AN ISSUE FOR IPR.
3. FURTHER ANALYSIS COULD INDICATE THAT THE EXIST CWTP AND SWTP PROCESSES COULD BE UPGRADED TO INCLUDE OZONE AND BAF.

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FIG 3-5: FAT TREATMENT

IPR ALTERNATIVES

SEPTEMBER 2022

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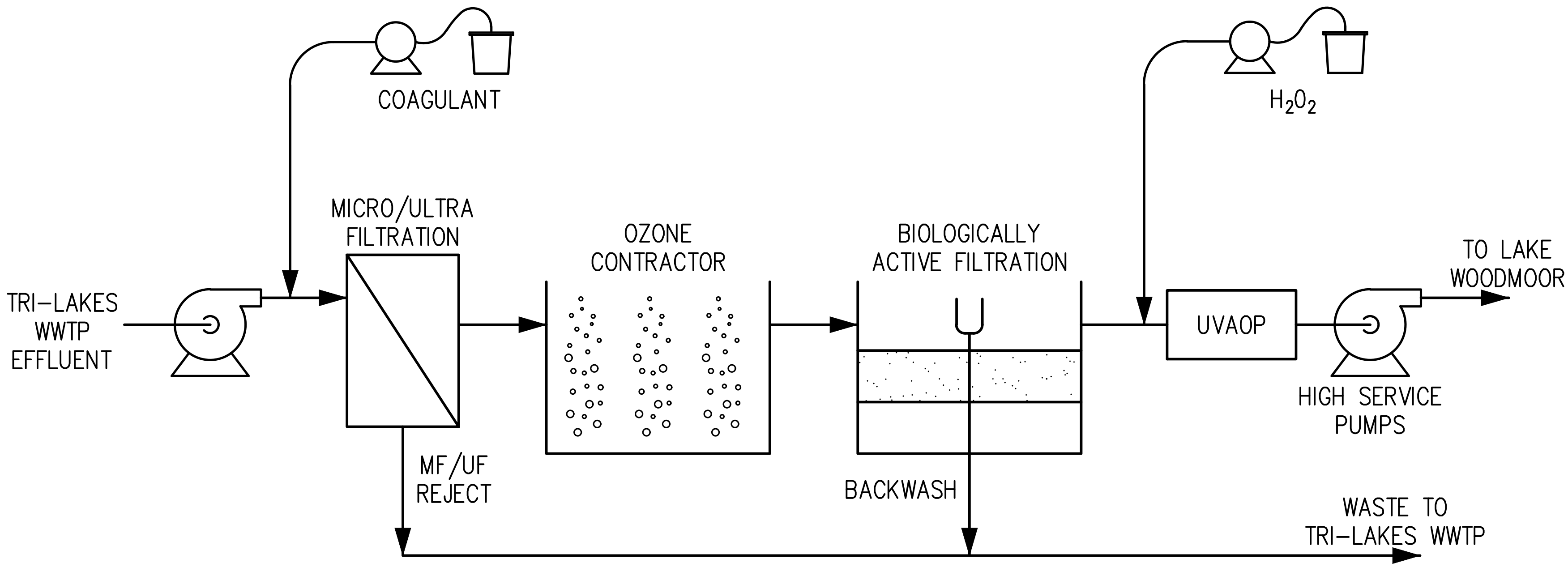

NOTES:

1. FURTHER ANALYSIS REQUIRED TO CONFIRM IF UV/AOP PROCESS COULD BE ADDED AT CWTP AND SWTP INSTEAD OF THE IPR WTP.
2. FURTHER ANALYSIS REQUIRED TO CONFIRM IF TDS CYCLING WOULD BE AN ISSUE FOR IPR.
3. FURTHER ANALYSIS COULD INDICATE THAT THE EXIST CWTP AND SWTP PROCESSES COULD BE UPGRADED TO INCLUDE OZONE AND BAF.
4. FURTHER ANALYSIS REQUIRED TO CONFIRM IF PH ADJUSTMENT PRE AND POST OZONE IS REQUIRED TO CONTROL BROMATE FORMATION.

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FIG 3-6: LOW-FAT TREATMENT
IPR ALTERNATIVES
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3.3.1.2. IPR Alternatives Analysis

The most notable difference between the FAT and low-FAT treatment options is the difference in salinity removal. Ozone and BAF are ineffective at salinity removal, while NF and RO reject most divalent and many monovalent ions and reduce the TDS of the finished water. Trace organic removal is greater using high pressure membranes, especially for compounds like per- and polyfluoroalkyl substances (PFAS), bromate, and perchlorate.

The FAT option is the more robust and comprehensive alternative that addresses a wider variety of contaminants. It provides greater microbial inactivation and trace organic removal than the low-FAT option. However, brine disposal is a major logistical challenge, the overall water efficiency of the system is low, and the FAT alternative has higher capital and O&M costs than the low-FAT alternative.

The 2012 LRP was concerned with rising TDS levels within the loop if TDS was not removed from the loop water. A model showed TDS concentrations would increase by 30 percent in just two years. The 2012 LRP performed iterative water quality modeling that showed with an assumed source concentration of 350 mg/L TDS, the TLWWTF effluent could reach a TDS concentration of about 715 mg/L. TDS cycling and buildup is a risk that the District should consider when considering and selecting treatment technologies. If IPR is implemented concurrently with a new WTP for the Ranch, TDS could be removed from the system at the Ranch using lined evaporation ponds to avoid discharging TDS back to the source water.

Improvement Considerations

Regardless of the treatment process selected for IPR, the District should plan to complete improvements at the MCE pump station. The intake structure is in poor condition and should be expanded. A third pump and ancillary equipment can be installed to increase the overall capacity of the pump station. This work is anticipated to be completed under the District's rehabilitation and replacement (R&R) program.

The preferred treatment process for IPR will depend on whether microfiltration (MF)/ultrafiltration (UF) or dual media/GAC filters are installed as a tertiary treatment process at TLWWTF. If NDMA treatment is needed, UVAOP could be installed. The use of chlorine dioxide, ozone, or LAS could be influenced by the concentration of bromide and risk tolerance of DBP formation. Additional modeling of Lake Woodmoor for water quality and TDS cycling could help determine whether NF/RO should be considered for IPR. At this time implementing IPR is not anticipated.

3.3.1.3. Sampling Program and Results

A sampling program was recommended in the 2017 LRP to better characterize the source water and help determine if the low-FAT option is viable. Samples were collected from the TLWWTF effluent from February through April 2018 and again from January 2019 through February 2020.

Weekly field samples were collected for pH, TDS, electroconductivity (EC), and temperature, with weekly lab tests for TDS and total suspended solids (TSS). Monthly samples were lab tested for alkalinity, hardness, total calcium, UV transmittance, total magnesium, total coliforms, total hardness, TOC, and E. Coli. Quarterly samples were lab tested for Cryptosporidium, Giardia, Helminth Ova, enteric virus, Norovirus, 1,4-Dioxane, Gross Beta particles, bromide, iopromide, meprobamate, NDMA, Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), primidone, sucralose, TCEP, and trimethoprim.

Bacteria and microorganism test results are presented below in Table 3-11. Total Coliforms, E. Coli, Cryptosporidium, and Giardia are all regulated contaminants with a maximum contaminant level goal (MCLG) of zero. Helminth Ova are infectious eggs of parasitic worms with regulated limits in biosolids for land application. Total Coliforms were detected in all 15 samples collected and E. Coli was detected in 14 of the 15 samples. Cryptosporidium was detected in three of the five samples collected, Giardia was detected in four of the five samples, and Helminth Ova was detected in all five samples.

Table 3-11 – Sample Results for Bacteria and Microorganisms

Analysis	Total Coliform	E. Coli	Cryptosporidium	Giardia	Helminth Ova
	MPN/100 mL	MPN/100 mL	Number	Number	Viable Ova/L
Minimum	10	1	0	0	<0.09
Maximum	580	75	1	143	<1
Average	152	16.5	1	32	< 0.46

Virus test results are presented below in Table 3-12. Enteric viruses are a regulated contaminant with an MCLG of zero. Enterovirus and Norovirus are standard pathogen indicators that help characterize the virus content of the source water. Enteric Viruses were detected in four of the five samples collected. Norovirus GIA was detected in one sample at 15.76 GC/L. Enterovirus, Norovirus GIB, and Norovirus GII were not detected in any of the samples.

Table 3-12 – Sample Results for Viruses

Analysis	Enteric Virus (total culturable)	Enterovirus (PCR)	Norovirus GIA (PCR)	Norovirus GIB (PCR)	Norovirus GII (PCR)
	MPN/L	NA	GC/L	GC/L	GC/L
Minimum	0.00	0	0.00	0	0
Maximum	0.42	0	15.76	0	0
Average	0.09	0	3.15	0	0

Test results for pharmaceuticals and personal care products (PPCPs), and endocrine disrupters are presented below in Table 3-13. These compounds are contaminants of emerging concern (CECs) that are increasingly being detected at low levels in surface water. The impact of these compounds is not yet known, so they do not yet have regulatory limits applied, but could in the future. Iopromide was detected in two of the five samples collected. Each of the other compounds were measured in all five samples.

Table 3-13 – Sample Results for Contaminants of Emerging Concern

Analysis	Iopromide	Meprobamate	Primidone	Sucralose	TCEP	Trimethoprim
	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Minimum	0.0	22	140	53,000	140	67
Maximum	77.0	73	230	81,000	220	690
Average	17.0	46	184	67,200	188	427

PFOA and PFOS are CEC's that fall into the category of PFAS. The Environmental Protection Agency (EPA) has established a lifetime exposure health advisory of 70 ng/L for PFOA and PFOS in drinking water. Test results for PFOA and PFOS are presented below in Table 3-14. Both compounds were measured all five samples collected.

Table 3-14 – Sample Results for PFOA and PFOS

Analysis	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)
	ug/L	ug/L
Minimum	2.1	15
Maximum	6.8	22
Average	4.9	18

Table 3-15 summarizes the test results for Bromide and NDMA. Although there are not yet regulatory requirements for either Bromide or NDMA in drinking water, there are guidelines set forth by the EPA.

Table 3-15 – Sample Results for Bromide and NDMA

Analysis	Bromide	N-Nitroso-dimethylamine (NDMA)
	ug/L	ng/L
Minimum	64.0	3.1
Maximum	96.0	5.2
Average	81.8	4.1

Bromate is a regulated DBP that is produced during water treatment when bromide-containing waters are ozonated. Bromate formation is a concern for standard ozone treatment when bromide levels exceed about 200 micrograms per liter (ug/L). Fresh surface water systems can have bromide concentrations between 14 and 200 ug/L. U.S. drinking water sources were characterized during the 1996 EPA Information Collection Rule with bromide values ranging from 95 to 132 ug/L. The 64 to 96 ug/L bromide concentration range observed at TLWWTF appears to be in line with other U.S. drinking water sources.

EPA risk assessments indicate that an NDMA drinking water concentration of 0.7 ug/L represents a cancer risk of 1 x 10^{-6}. The EPA has accordingly assigned a drinking water unit risk of 0.0014 ug/L for NDMA. Since the NDMA results for TLWWTF are orders of magnitude above the EPA risk thresholds, treatment methods to specifically target NDMA removal should be considered if IPR is implemented.

Alkalinity, hardness, Calcium, and Magnesium have established drinking water limits and are good indicators of how treatment processes are performing. Table 3-16 presents the results for these parameters. These parameters are not a concern as both SWTP and CWTP are already equipped to treat these to an acceptable level.

Table 3-16 – Sample Results for Alkalinity, Hardness, Calcium, and Magnesium

Analysis	Alkalinity in CaCO3	Calcium Hardness as CaCO3	Total Hardness as CaCO3	Calcium, Total	Magnesium, Total
	mg/L	mg/L	mg/L	mg/L	mg/L
Minimum	62	67	90	27	5.5
Maximum	110	95	130	38	8.1
Average	92	79	106	32	6.6

Table 3-17 presents the results for pH, temperature, TDS, Total solids, EC, TOC, and Dissolved UV absorption at 254 nm. Like alkalinity and hardness, all of these parameters are regularly monitored with effluent limits established for TLWWTF. SWTP and CWTP also have drinking water limits for these parameters and can effectively treat to the established limits.

Table 3-17 – Sample Results for pH, Temp, TDS, Total Solids, ED, TOC and UV Abs.

Analysis	pH	Temperature	TDS	Total Solids	EC	TOC	Dissolved UV Abs. at 254 nm
	s.u.	°F	mg/L	mg/L	us/com	mg/L	cm
Minimum	6.38	29.6	280	170	474	4.6	0.092
Maximum	7.53	73.4	400	500	738	11.0	0.170
Average	7.06	45.4	331	349	605	8.0	0.139

3.3.2. Ranch Water

As previously discussed, the District's preferred approach is to develop renewable supplies versus continued well drilling. The District owns significant water rights on the Chilcott Ditch at the Ranch, approximately 47 miles south of the District. Previous LRPs and the recent 2022 El Paso County Water Loop Study (Loop Study) have identified challenges with bringing Ranch water online: improvements to Chilcott Ditch, an expansion of Callahan Reservoir, water quality that requires treatment beyond the capabilities of SWTP or CWTP, and construction of an approximately 47-mile-long system of pipelines and pump stations.

Past LRPs favored initial focus on IPR. This LRP favors initial focus on construction of Ranch water delivery facilities due to two factors: (a) demand/supply balance and (b) concern regarding

IPR brine stream and TDS escalation in recycled TLWWTF effluent. Future water demands are lower and future well yields are higher than in past LRPs. On net, this results in drilling 11 instead of 20 wells over the first 10 years after this LRP update is issued. Consideration of IPR waste stream disposal necessary to maintain low total dissolved solids in District potable water favors treatment at the Ranch instead of near the District, where heavily laden TDS brine can be easily disposed of.

IPR offers a remedy that can be implemented in approximately 5 years and can delay drilling of approximately 6 or more wells. However, IPR does not provide a new water supply to the District, rather it increases the efficiency in use of existing supplies. Construction of the Ranch water delivery system is estimated to take approximately 10 years to bring renewable water online. Due to reduced demand and need for well construction in the near term, focusing capital toward bringing a new physical supply of water online is favored.

This LRP provides recommendations to pilot both IPR and Ranch treatment to gain certainty in necessary water treatment processes and waste disposal. Results of such pilot studies may shift focus back toward IPR if, for example, IPR waste stream concerns are found to be overstated.

Unlike past LRPs, this LRP contemplates three-phase construction of Ranch facilities to delay capital expenditures while the District conjunctively uses Ranch water with existing well water supplies:

1. Bring Ranch water to the District: Construct minimum facilities to fill the water supply gap between District demand and supply without drilling new wells. In this phase, the District will construct initial Callahan reservoir intake structures, a transmission pipeline with pump stations, and add finishing at SWTP and CWTP to address emerging contaminants. This initial phase will increase physical water supply at the District but will require blending with existing well supplies to manage total dissolved solids and other water quality constituents in Fountain Creek. The percent that can be acceptably blended and allow the District to meet water quality goals will need to be determined through further water quality testing and treatment evaluation.

2. Upgrade Ranch treatment: In this phase, the District will construct Ranch treatment to address Fountain Creek water quality issues and reduce the need for blending with well water in the District. Treatment will focus on reducing constituents that cannot be removed by the polishing processes at SWTP or CWTP.

3. Enlarge Callahan Reservoir: Ultimately, the District will need to enlarge Callahan Reservoir to an estimated capacity of 1,300 af to provide a firm water supply in absence of well water supplies.

3.3.2.1. Chilcott Ditch Improvements

By purchasing the Ranch, the District became the majority shareholder in Chilcott Ditch Company. The Chilcott Ditch (Ditch) is approximately 9.6 miles long and conveys water from Fountain Creek to Callahan Reservoir. The responsibility for Ditch improvements and maintenance are proportionate to ownership in the ditch and the work is completed by the Ditch superintendent. The 2012 LRP included an assessment of the Ditch's condition, noting two areas of concern.

An area of concern of previous LRPs is an inverted siphon below Jimmy Camp Creek. All water in the Ditch entered a single siphon pipe and crossed under the creek. There was a coarse bar screen on the inlet of the siphon pipe to keep out large debris. Debris had to be manually cleared from the bar screen. The siphon was a potential single point of failure, but the District addressed this issue since the previous LRP, so it is no longer a concern.

The second area of concern is where the Ditch passes below the railroad tracks in the City of Fountain. The crossing below the railroad is shallow, and the Ditch capacity may be limited to maintain sufficient clearance from the railroad track. Historically, the Ditch has been capable of conveying water to the Ranch sufficiently. If additional water rights are added to the Ditch in the future, the District should consider evaluating the capacity of the culvert.

A third area of concern is seepage, or water loss, from the Ditch. Relining or piping the Ditch could increase the District's yield. Initial analysis indicates the additional water is not necessary for the District to meet their goals, however, the concept can be evaluated in the future if water supply changes.

Improvement Considerations

No improvements to the Chilcott Ditch are anticipated at this time.

3.3.2.2. Callahan Reservoir

In 2011, URS Corporation completed an assessment and alternatives analysis for expanding Callahan Reservoir entitled *Summary of Calhan Dam Due Diligence, Dam Inspection and Preliminary Feasibility Study*. The report references an existing reservoir capacity of 374 af and found the existing Calhan Dam deficient of current safety standards. Due to the deficiencies, the State Engineer Office restricts the reservoir level. The study proposes three options to expand reservoir capacity by abandoning the existing dam and constructing a new one. A summary of the three options is presented below in Table 3-18.

Table 3-18 – Callahan Dam Alternatives

Characteristic	Option A	Option B	Option C
Max Height (ft)	40	45	60 (Main Embankment) 15 (Saddle Dike)
Length (ft)	4,560	4,940	5,700 (Main Embankment 1,200 (Saddle Dike)
Embankment Volume (cy)	430,000	600,000	1,270,000 (Main Embankment) 30,000 (Saddle Dike)
Reservoir Capacity (af)	2,200	3,200	8,400

As previously discussed, a reduction in future water demands results in a recommended storage volume in Callahan Reservoir of 800 af or 1,300 af, dependent on a transmission pipeline capacity of 4 cfs or 5 cfs respectively.

Improvement Considerations

The smallest reservoir capacity the study considered was 2,200 af. Since the new recommended volume is much less and the study is eleven years old, updating the Callahan Reservoir expansion study should be considered. The dam is currently classified as low hazard, but preliminary design of the improvements should include a re-evaluation of the hazard classification with consideration to downstream development.

3.3.2.3. Ranch Water Quality

The CDPHE regulates and sets MCLs and secondary maximum contaminant limits (SMCLs) for drinking water constituents through the Colorado Primary Drinking Water Regulations (CPDWR, also known as Regulation 11). Regulated constituents include cryptosporidium, coliform, inorganics, organics, and radionuclides. MCLs are enforceable, while SMCLs are recommendations for constituents that effect aesthetics such as taste, odor, or color. Previous LRPs analyzed United States Geological Survey water quality data sampled from Fountain Creek near the Ditch headgate and identified arsenic and lead as primary constituents of concern and iron and manganese as secondary constituents of concern. Several wastewater treatment plants discharge treated effluent into Monument Creek and Fountain Creek upstream from the Ditch diversion. Wastewater effluent includes trace organic compounds such as pharmaceuticals, personal care products, and pesticides that can be health hazards, though not regulated directly by the CDPHE.

Additional water quality samples were collected in December 2021 and January 2022 as part of the Loop Study. According to the Loop Study, the test results indicated manganese concentrations of 0.039 mg/L and 0.148 mg/L at the Chilcott Headgate and Callahan Reservoir, respectively, as well as TOC and dissolved organic carbon (DOC) concentrations two to three times higher at Callahan Reservoir compared to the Chilcott headgate. TOC and DOC are the precursors for DBPs which are regulated by the CPDWR.

The District collected grab samples to test for TDS on September 7, 2022. The results indicated 433 mg/L TDS at the Chilcott headgate, 442 mg/L TDS at the Ranch diversion flume, and 976 mg/L TDS in Callahan Reservoir. The concentration of TDS in Ranch water determines the type of treatment processes required at the Ranch WTP and when the Ranch WTP needs to be online.

Improvement Considerations

A site specific water quality analysis, including one to three years of TDS data, should be completed. The CDPHE requires a minimum two full sample sets collected in different calendar quarters to permit a new water source. One sample set must be collected during the water supply’s critical period, typically spring run-off. Table 3-19 includes a complete list of the required parameters for all community water systems and the required parameters based on the likely treatment processes discussed below. The initial sample results will provide insight on whether further testing of specific parameters will be beneficial to the overall treatment process design. Since previous test results show water quality in the Ditch varies from water quality in Callahan Reservoir, sampling from both locations would provide useful data.

Table 3-19 – Water Quality Parameters for Chilcott Ditch and Calhan Reservoir

Parameter			
Total Coliform	Nitrate / Nitrite	Inorganic Chemicals*	Organic Chemicals*
Radionuclides	Total Manganese	Turbidity	Alkalinity
pH	Temperature	Total Nitrogen	Total Phosphorous
Dissolved Oxygen	TOC / DOC	Total Iron	TDS
Hydrogen Sulfide	Ammonia	Dissolved Manganese	Bromide
Total Hardness	Calcium	Lead	Copper
Chloride	Sulfate	TSS	

* Refer to Table 11.19-I, Table 11.21-I, and Table 11.21-II in the CPDWR for a complete list of regulated inorganic and organic chemicals

3.3.2.4. Ranch Water Treatment

Ranch water quality varies from the District's current sources, and the District's current WTPs are not equipped to treat Ranch water. Previous LRPs evaluated three alternatives to locate a new WTP to treat Ranch water. Table 3-20 includes a summary of the alternatives and their advantages and disadvantages. The best solution to remove TDS from the Ranch water is via NF/RO and disposing the brine. NF/RO produces approximately 20 to 30 percent of forward flow as brine. The large volume of brine can be difficult to dispose of. Common solutions include deep well injection and evaporation ponds. Deep well injection is expensive and has had varying success. Locating NF/RO treatment within the District will require deep well injection for brine disposal to prevent TDS concentrations from increasing within the Loop over time. The Ranch has much more land available for evaporation ponds and is better suited location to install NF/RO to remove TDS from the Ranch water.

Table 3-20 – WTP Location Alternatives

Alternative		Advantages	Disadvantages
1	Full Treatment at the Ranch	▪ Consolidate Treatment ▪ Ample Land for NF/RO Brine Evaporation Ponds and Solids Drying Beds	▪ Ranch is Far from the District ▪ Requires Chlorine Booster Stations ▪ High Water Age and Potential for Elevated DBPs ▪ Greater water conveyance losses relative to Alternative 3
2	Partial Treatment at the Ranch, Polishing Treatment at the District	▪ Ample Land for NF/RO Brine Evaporation Ponds and Solids Drying Beds ▪ Chlorination at the Ranch may not be necessary	▪ District Must Operate Multiple WTPs ~47 Miles Apart ▪ Greater water conveyance losses relative to Alternative 3
3	No Treatment at the Ranch, Full Treatment at the District	▪ Consolidate Ranch and IPR Treatment at One Facility within the District ▪ Reduced water conveyance losses relative to Alternatives 1 and 2	▪ Limited Land Available within the District ▪ Difficult to Dispose of NF/RO Brine

Previous LRPs and the Loop Study identified two main alternatives for treating Ranch water and focused on the following constituents of concern: TDS, TOC, DOC, manganese, iron, lead, arsenic, trace organics, and DBPs. Table 3-21 includes a summary of the treatment alternatives and their advantages and disadvantages. Removal or reduction of trace organics from the upstream wastewater effluent was the main driver in the process selection. Both alternatives include MF or UF primary treatment, followed by secondary and tertiary processes to remove trace organics. The main difference is the use of NF/RO in the first alternative will also remove TDS.

Table 3-21 – Treatment Process Alternatives

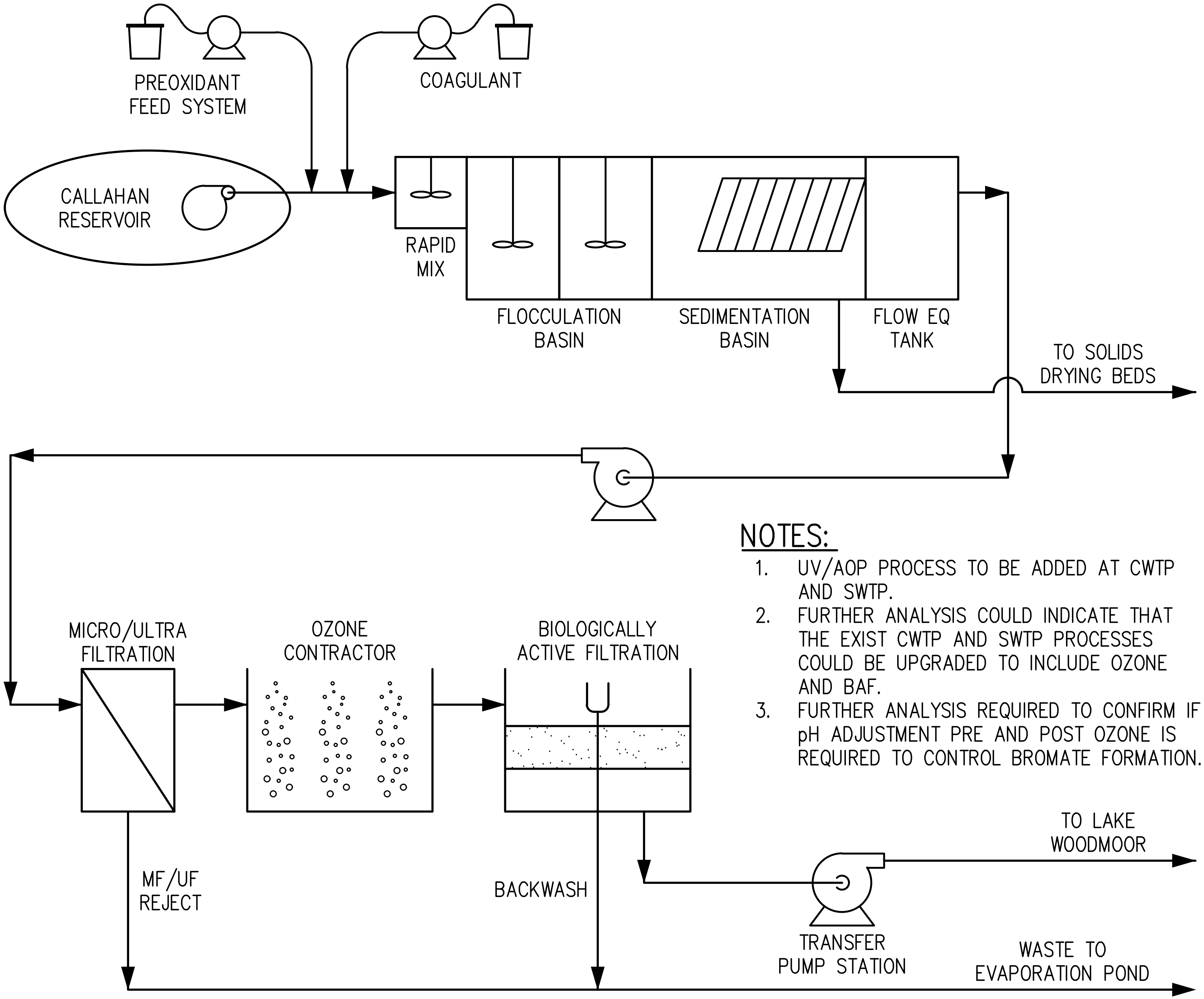
	Alternative	Advantages	Disadvantages
1	MF/UF, NF/RO, UVAOP	▪ Most Robust Treatment System ▪ Removes TDS	▪ High Power Cost ▪ Large Volume of Waste ▪ Requires Installation at the Ranch
2	MF/UF, O3, BAF, UVAOP	▪ Lower Power Cost ▪ Less Waste ▪ Potential to Retrofit Exist Trident Filters into BAF	▪ Not as Effective at Removing Trace Organics ▪ Limited to No TDS Removal ▪ Lower UV Transmissivity and Higher H2O2 Use in BAF Filtrate

Depending on the extent and nature of the trace organics in the Ranch water, omitting NF/RO in favor of ozonation and BAF could be a good alternative. Ozonation and BAF is not as robust as NF/RO but still achieves good removal of organics without the removal of TDS. One consideration for ozonation is if bromide is present in the water. If so, it will react with ozone to form bromate which is a regulated compound. pH suppression can be used to control bromate formation but will require chemicals to suppress the pH and then bring it back up to target levels for corrosion control. It may be possible to retrofit SWTP and CWTP with ozonation, BAF, UV, and AOP.

Improvement Considerations

For this high level planning effort, the most robust treatment processes should be considered until further evaluation eliminates specific processes. Pretreatment with preoxidation, coagulation, flocculation, and sedimentation provides the most effective removal of TSS, oxidized inorganics, and some TOC. This pretreatment process also provides protection against sudden changes in water quality and high turbidity events resulting from upstream storms and wildfires. Treatment with MF/UF provides a robust barrier for bacteria and viruses and sufficient filtration ahead of RO. Following MF/UF with a side stream of NF/RO will remove trace organics and TDS in the side stream.

Treatment processes should be further evaluated following the completion of the Ranch water quality assessment. Once the preferred treatment processes are selected, a pilot treatment study should be completed to confirm the efficacy of the processes. Treatment of the Ranch water will require improvements to the SWTP and CWTP to remove remaining trace organics and pharmaceuticals.



NOTES:

1. UV/AOP PROCESS TO BE ADDED AT CWTP AND SWTP.
2. FURTHER ANALYSIS COULD INDICATE THAT THE EXIST CWTP AND SWTP PROCESSES COULD BE UPGRADED TO INCLUDE OZONE AND BAF.
3. FURTHER ANALYSIS REQUIRED TO CONFIRM IF pH ADJUSTMENT PRE AND POST OZONE IS REQUIRED TO CONTROL BROMATE FORMATION.

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ALTERNATIVE A

RANCH WTP TREATMENT ALTERNATIVES

AUGUST 2022

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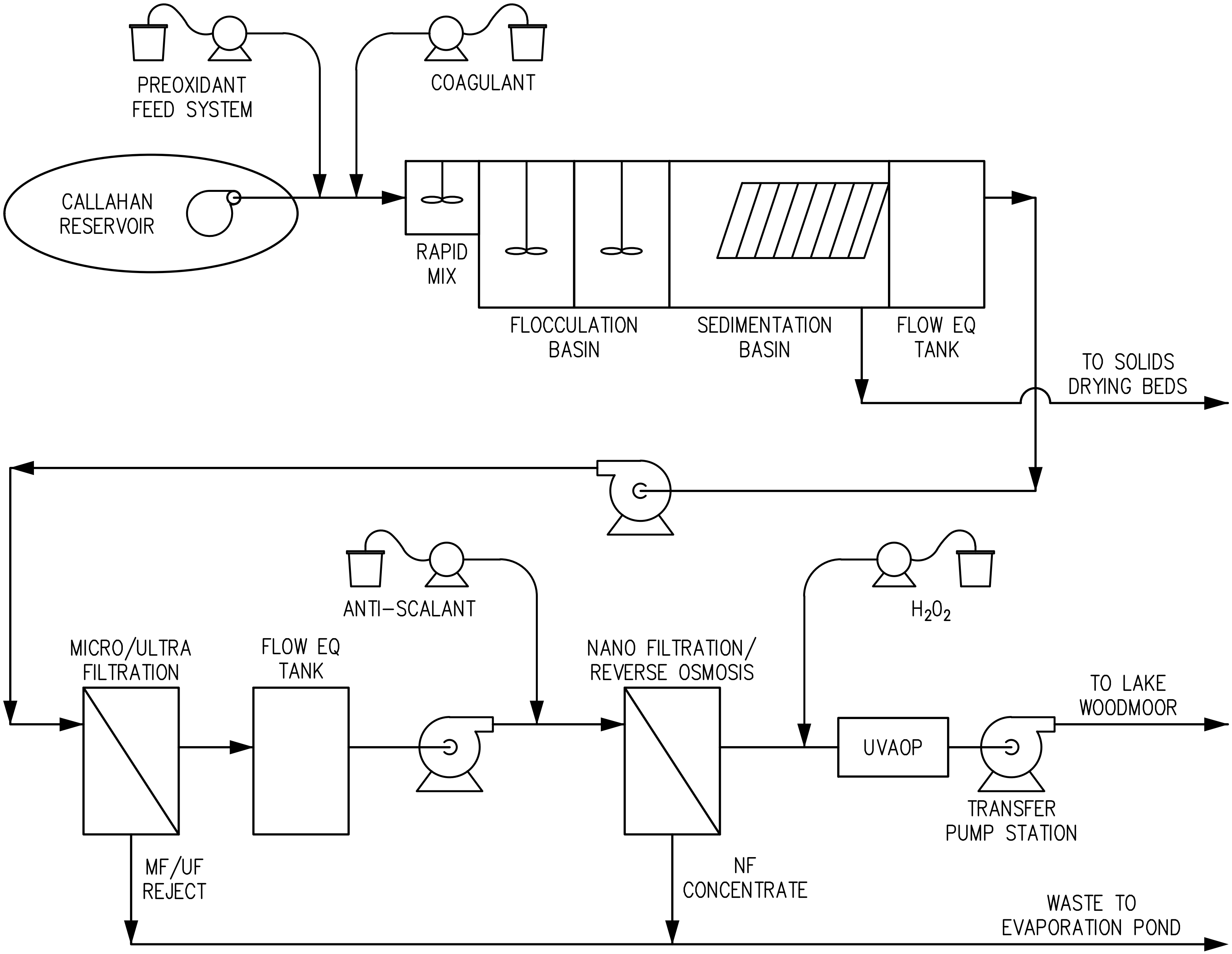

NOTES:

1. FURTHER ANALYSIS REQUIRED TO CONFIRM IF UV/AOP PROCESS COULD BE ADDED AT CWTP AND SWTP INSTEAD OF THE RANCH WTP.

ALTERNATIVE B

RANCH WTP TREATMENT ALTERNATIVES

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3.3.2.5. Ranch Treated Water Conveyance

The 2012 LRP and 2017 LRP evaluated several alternatives to convey 3,000 to 4,500 gpm of water approximately 47 miles from the Ranch to the District. A pipeline alignment was selected and connects the new WTP at Callahan Reservoir to a new WTP on Higby Road. The alignment follows unimproved county roads and open space south of Black Forest. Then the alignment follows paved roadways to Higby Road. The starting elevation at Callahan Reservoir is approximately 5,470 ft, and the highest elevation is approximately 7,530 ft at mile 32. Pressure reducing valves installed on the downhill portion of the pipeline after mile 32 prevent over pressurization in the pipeline.

Previous LRPs evaluated five alternatives to locate pump stations along the alignment. Table 3-22 summarizes the five options. The goal for the first alternative was to convey peak day demand to the District. The goal for Alternatives 2 and 3 was to consider a conveyance system with sufficient capacity for the District's ultimate buildout needs and to provide room for water for potential partnering communities. The goal for Alternatives 4 and 5 was to consider various pump configurations allowing for various flow rates.

Table 3-22 – Previous LRP Conveyance Alternatives

Characteristic	Alt 1 (2012)	Alt 2 (2012)	Alt 3 (2012)	Alt 4 (2017)	Alt 5 (2017)
Acceptable Pressure Range (in)	30 - 150	30 - 150	30 - 150	20 - 350	20 - 350
Pipe Diameter (in)	16	18	24	16	18
Target Velocity Range (fps)	3.5 - 7	3.5 - 7	3.5 - 7	4.5 – 7.5	5 – 7.5
Min Flow (gpm)	2,200	2,800	4,900	3,000	1,500
Max Flow (gpm)	4,400	5,600	9,900	3,000	4,500
Qty of Booster Pump Stations	15	14	13	5	5

The maximum acceptable pipeline pressure changed from 150 psi to 350 psi between the 2012 to 2017 LRP. The quantity of booster pump stations decreased from fifteen to five as a result. Water pipelines with operating pressures exceeding 250 psi require specialty pipe materials, fittings, valves, and appurtenances. Pipe failures can be hazardous to operations staff and result in significant damage. Repair can be complicated by the need to find high pressure rated parts. The District should carefully consider setting a high end pressure of 250 psi or 350 psi for the pipeline. Due to PVC catastrophically failing under high pressure, ductile iron, steel, or HDPE is the preferred pipe material. HDPE will provide better resistance to corrosive soils and conveyed water. Previous LRPs targeted velocities between 3.5 to 7.5 fps. The water should consist of little to no TSS following treatment with NF/RO membranes. Velocities as low as 2 fps and as high as 7.5 fps are acceptable.

Since the new Ranch water plan does not include a new WTP on Higby Road, the Ranch water will need pump to Lake Woodmoor, adding roughly two miles to the total transmission pipeline length. The southern portion of the previously selected alignment has been adjusted to utilize utility easements within rural county roads. The updated alignment is shown in Figure 3-9.

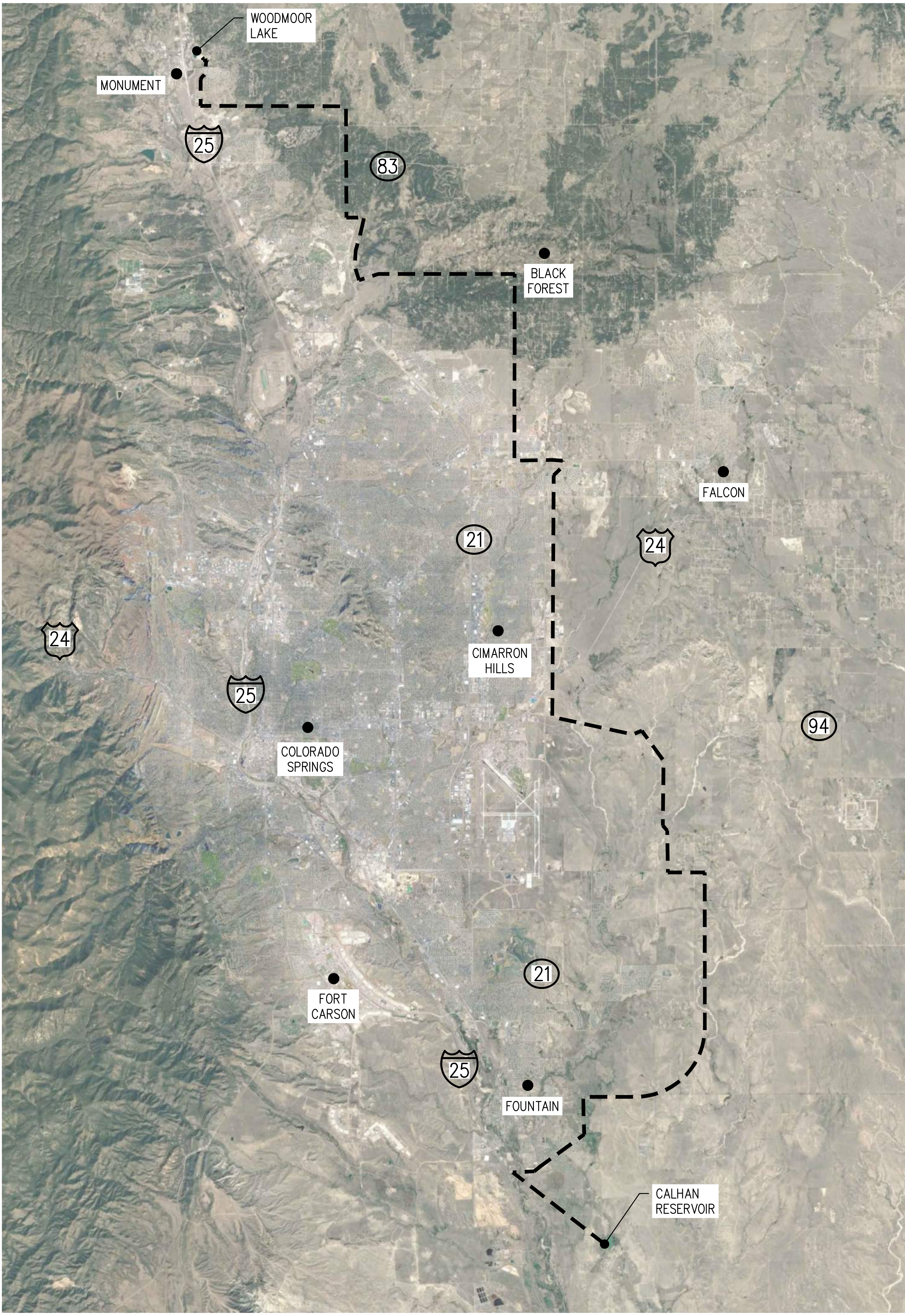

FIG 3-9: PIPELINE ALIGNMENT

WOODMOOR LRP
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Based on the lower demand projections in this LRP a lower capacity of 5 cfs, or 2,244 gpm, is recommended for the pipeline. This flow rate results in approximately 11 ft/1000 LF of headloss at 5.9 fps through a 12 inch pipeline and results in 5.3 ft/1000 LF of headloss at 4.4 fps through a 14 inch pipeline. Assuming the pump station is equipped with three pumps in lead, lag, and standby configuration, one pump running at 1,122 gpm results in a velocity of 2.9 fps and 2.2 fps in a 12inch or 14 inch pipeline. A 14 inch pipeline is recommended since the headloss is half that of a 12 inch pipeline, and the flow velocities in a 14 inch pipeline are within the acceptable range. A larger diameter pipeline will result in velocities too low with a single pump running.

Figure 3-10 shows the approximate ground surface elevation and hydraulic grade line for a transmission pipeline system with a minimum pressure of 20 psi and maximum pressure of 250 psi in a 14 inch pipeline. Seven booster pump stations would be necessary to convey the water from the Ranch to Lake Woodmoor.

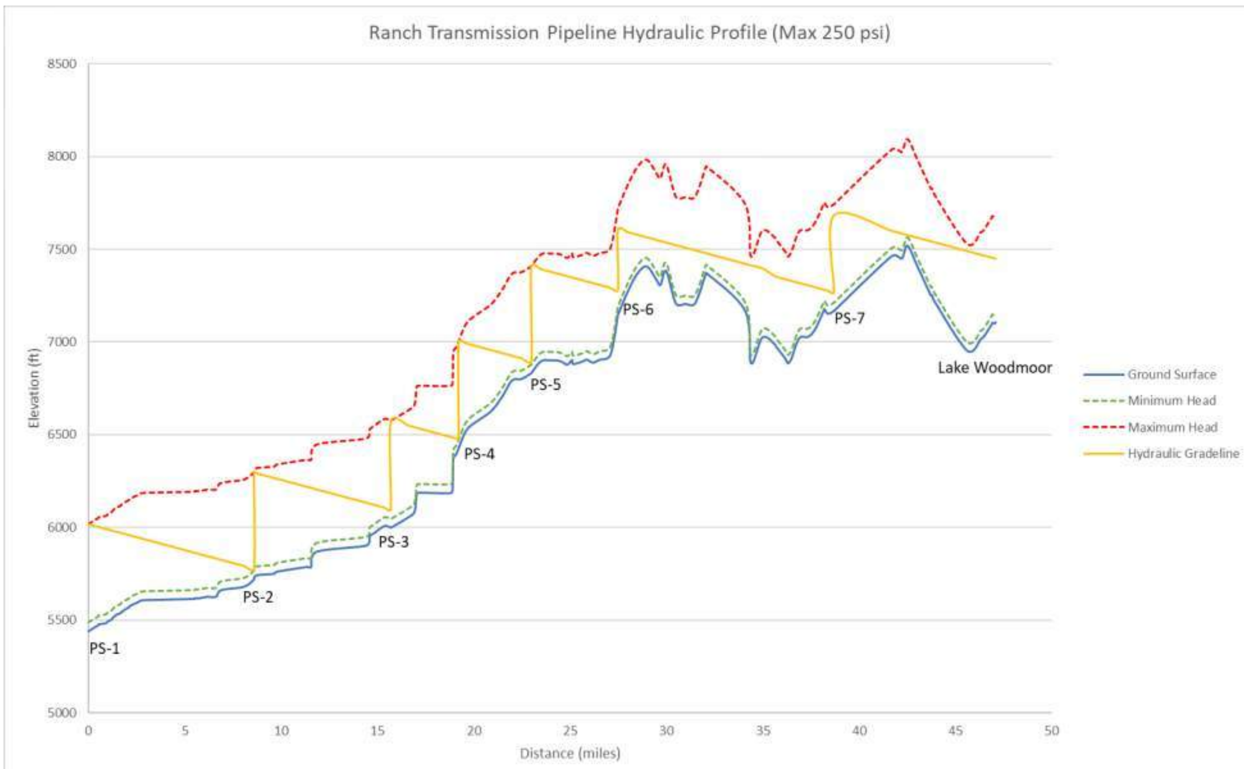


Figure 3-10 – Ranch Transmission Pipeline (250 psi Max Pressure)

Figure 3-11 shows the approximate ground surface elevation and hydraulic grade line for a transmission pipeline system with a minimum pressure of 20 psi and maximum pressure of 350 psi in a 14 inch pipeline. Five booster pump stations would be necessary to convey the water from the Ranch to Lake Woodmoor.

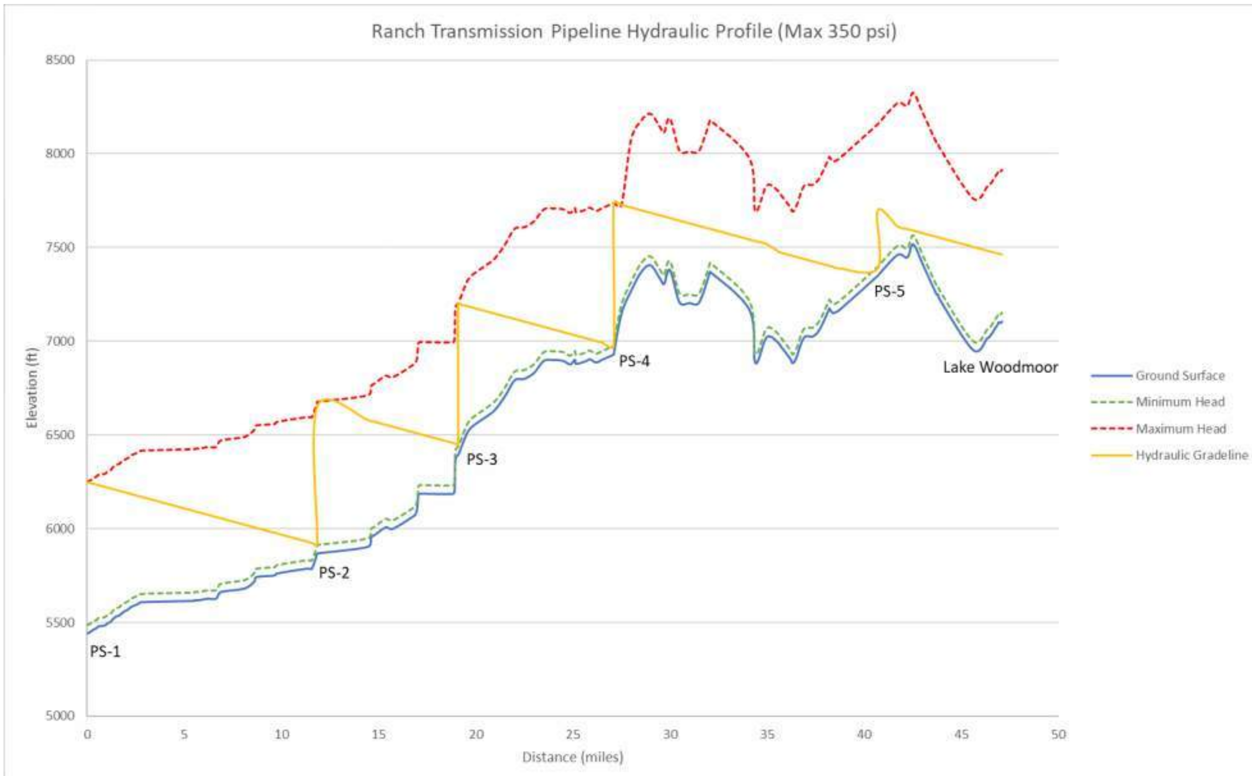


Figure 3-11 – Ranch Transmission Pipeline (350 psi Max Pressure)

Improvement Considerations

Partially treated water will need to be conveyed from the Callahan WTP to the District to meet future demand as the District's non-renewable groundwater wells continue to decline. The larger regional water delivery system was explored in detail in the Loop Study, and the goal for this LRP is to focus on a "go-it-alone" approach for the District. According to 2016 to 2021 water usage, the current buildout and ultimate buildout peak day demand is 2,272 gpm and 2,715, respectively, not including non-potable irrigation water use. Table 2-9 indicates the maximum non potable water demand occurs in August and is 33.4 af, or 210 gpm.

The previously selected alignment will need to be extended 1.5 miles from Higby Road to Lake Woodmoor. The extension will follow along Jackson Creek Parkway, through existing easements on private property, and terminate on the southeast side of Lake Woodmoor. The new pipeline will cross the existing MCE pipeline at Jackson Creek Parkway. MCE could be tied into the Callahan pipeline, which would create a dedicated pipeline from Lake Woodmoor to SWTP and improve operations between SWTP, MCE, and LPS.

Based on a maximum velocity of 7.5 fps, a 14-inch pipeline can convey the required 2,244 gpm of water from the Ranch to the District. The minimum flow in a 14-inch pipe at 2 fps is approximately 1,040 gpm.

Each pump station should be designed for a firm capacity of 2,244 gpm and include booster pumps, a flow equalization tank, and a backup generator. Multi-stage vertical turbine pumps are the best pump type for this high head application. Three pumps on variable frequency drives (VFDs) operating in lead, lag, and standby will allow for an efficient flow range with a firm capacity of 2,244 gpm. A 67,000 gallon flow equalization tank will provide 30 minutes of operations storage at each pump station. The backup generator should be sized to accommodate two pumps; heating, ventilation, and cooling (HVAC); instrumentation and controls; and ancillary power.

The next step in developing the Ranch treated water conveyance plan is to complete a preliminary design report, including a detailed analysis of the alignment. The preliminary design report should finalize the pipeline alignment and pump station locations, identify required easements, and confirm each individual pump and pump station design criteria. Since a sudden power outage or pump failure can cause water column surge resulting in very high or negative pressures, a surge analysis should be completed during preliminary design to confirm whether surge anticipating valves or surge tanks should be included at pump stations.

3.3.3. South and Central Water Treatment Plants

To accommodate either IPR or a new source of water from the Ranch, additional improvements will be required at CWTP and SWTP. Whether the low-FAT option is implemented for IPR or to treat water from the Ranch, ozonation and BAF could be installed at CWTP and SWTP. Bench-scale testing is recommended to help determine if bromate formation from ozonation would be a risk. Depending on the results of UV transmittance testing, UV disinfection may be a viable option for increased pathogen removal. This process could also be upgraded to AOP if water quality testing indicates that advanced treatment is needed. AOP is used for removing contaminants coming from heavy industries that produce PPCPs, NDMA, and other CECs.

Improvement Considerations

Ranch water quality varies from the District's current sources, and new treatment processes will be necessary once the District begins using Ranch water. Due to Ditch water being heavily influenced by upstream WWTPs and based on the limited Ranch water quality data advanced treatment processes targeting trace organics, pharmaceuticals, and inorganics will be required to meet the District's water quality goals. Further water quality testing is recommended to confirm that retrofitting SWTP and CWTP will address the concern of trace organics and pharmaceuticals. Treatment for inorganics will occur at SWTP and CWTP, and eventually at the Ranch WTP, if TDS becomes a concern as discussed previously.

Development beyond current buildout will trigger the need to expand SWTP. The District can meet the increased demand by adding a fourth Trident skid in the space allocated at SWTP.

3.3.4.Treated Water Storage

As noted in Section 2.5.2, the District currently has three treated water storage tanks in the distribution system with a total storage capacity of about 1.938 MGD. As with the current storage tank capacity analysis, the three components analyzed for the buildout scenarios were operating/equalization storage, fire storage, and emergency storage. The fire storage calculation remained constant for the current, current buildout, and ultimate buildout scenarios.

3.3.4.1. Storage for Current Buildout

Operational storage is used to meet peak day demands and is typically sized to accommodate four hours of peak day flow. Using the planning demand of 272 gpd/SFE established in Section 2.1.1.1, the annual average demand at current buildout is projected to be about 1.763 MGD. Using the planning level peaking factor of 2.2 established in Section 2.1.3, the peak day flowrate at current buildout is projected to be about 3.878 MGD. Four hours of peak day demand equates to about 0.646 MG.

Emergency storage is typically sized to accommodate twenty-four hours of flow at the average summer flowrate. Like the current storage capacity scenario, a 1.4 summer peaking factor was used for emergency storage calculations. Using the planning demand of 272 gpd/SFE established in Section 2.1.1.1, the annual average demand at current buildout is projected to be about 1.763 MGD, which equates to about 2.468 MG of summer demand per day.

The total storage calculations at current buildout are presented below in Table 3-23. The 1.938 MG of total storage currently available between the three storage tanks is not sufficient to meet the total 3.264 MG storage volume recommended for operating storage, fire storage, and emergency storage at current buildout.

Table 3-23 – Total Required Storage at Current Buildout

Scenario	Storage Volume Required (MG)
Operating Storage[1]	0.646
Fire Storage[2]	0.150
Emergency Storage[3]	2.468
Total Required Storage =	**3.264**

Notes:
[1] Operating storage is used to meet peak day demands and is typically sized to accommodate four hours of peak day flow. Storage volume required assumes a daily peaking factor of 2.2.
[2] The Tri-Lakes Monument Fire Protection District (TLMFPD) and the 2015 International Fire Code (IFC) provide recommended storage volumes. A 1,250 gpm fire flow for a two hour duration was assumed to account for an average fire.
[3] Emergency storage is sized to accommodate 24 hours of flow at the average summer flowrate (May through September). A summer peaking factor of 1.4 was used.

Improvement Considerations

Additional treated water storage is recommended to meet the anticipated water demand at current buildout. About 75 percent of the demand growth anticipated between 2022 and current buildout is expected to take place in Zones 1 and 5. To accommodate this growth, construction of an additional 0.65-MG storage tank is recommended at both the NBPS and the SBPS sites. Due to the proximity of neighboring properties at the SBPS site, easement acquisition may be required to construct a new tank.

3.3.4.2. Storage for Ultimate Buildout

The storage tank capacity analysis examining operating/equalization storage, fire storage, and emergency storage was also completed for the ultimate buildout scenario. The fire storage calculation remained constant for the current, current buildout, and ultimate buildout scenarios.

Operational storage is used to meet peak day demands and is typically sized to accommodate four hours of peak day flow. Using the planning demand of 272 gpd/SFE established in Section 2.1.1.1, the annual average demand at ultimate buildout is projected to be about 2.126 MGD. Using the planning level peaking factor of 2.2 established in Section 2.1.3, the peak day flowrate at ultimate buildout is projected to be about 4.676 MGD. Four hours of peak day demand equates to about 0.779 MG.

Emergency storage is typically sized to accommodate twenty-four hours of flow at the average summer flowrate. Like the current and current buildout storage capacity scenarios, a 1.4 summer peaking factor was used for emergency storage calculations. Using the planning demand of 272 gpd/SFE established in Section 2.1.1.1, the annual average demand at current buildout is projected to be about 2.126 MGD, which equates to about 2.976 MG of summer demand per day.

The total storage calculations at ultimate buildout are presented below in Table 3-24. The 1.938 MG of total storage currently available between the three storage tanks is not sufficient to meet the total 3.905 MG storage volume recommended for operating storage, fire storage, and emergency storage at ultimate buildout.

Table 3-24 – Total Required Storage at Ultimate Buildout

Scenario	Storage Volume Required (MG)
Operating Storage[1]	0.779
Fire Storage[2]	0.150
Emergency Storage[3]	2.976
Total Required Storage =	**3.905**

Notes:
[1] Operating storage is used to meet peak day demands and is typically sized to accommodate four hours of peak day flow. Storage volume required assumes a daily peaking factor of 2.2.
[2] The Tri-Lakes Monument Fire Protection District (TLMFPD) and the 2015 International Fire Code (IFC) provide recommended storage volumes. A 1,250 gpm fire flow for a two hour duration was assumed to account for an average fire.
[3] Emergency storage is sized to accommodate 24 hours of flow at the average summer flowrate (May through September). A summer peaking factor of 1.4 was used.

Improvement Considerations

Additional treated water storage is recommended to meet the anticipated water demand from inclusion of the Wissler Trust. All the demand growth anticipated between current buildout and ultimate buildout is expected to take place in Zone 1. Construction of a 0.65-MG storage tank is recommended to satisfy this extra demand.

3.3.5. Distribution System Booster Pump Stations

The District has two booster pump stations within the distribution system. The NBPS pumps water from the North Tanks to Zone 1 and has sufficient capacity to meet peak day demand plus fire flow for ultimate buildout within Zone 1. The SBPS pumps water from the South Tank into Zone 4, Zone 2, and to the North Tanks.

For the District to meet peak demands from Zones 1 and 2, the SBPS must have sufficient capacity to supplement output from CWTP. The current firm capacity of CWTP is 800 gpm. The average annual and peak day demands for Zones 1 and 2 at current buildout are about 683 gpm and 1,500 gpm respectively. CWTP and SBPS are therefore sufficiently sized to meet peak day demand for Zones 1 and 2 through current buildout without exceeding the District's high pressure limits in the distribution system.

The average annual and peak day demands for Zones 1 and 2 at ultimate buildout are approximately 816 gpm and 1,792 gpm respectively. Considering this ultimate buildout demand and a firm capacity of 800 gpm from CWTP, the SBPS must be able to supplement approximately 992 gpm to meet the demand from Zones 1 and 2. While the SBPS is not limited by pump capacity, the 800-gpm limitation to maintain adequate system pressures does not allow the SBPS to meet the Zone 1 and 2 demands at ultimate buildout. The District should continue to explore options to alleviate this limitation as the population grows and development occurs.

Improvement Considerations

SBPS is in need of R&R improvements. The existing PLC is an Allen Bradley SLC-series, which is no longer supported by the manufacturer, so the PLC should be replaced. The two constant speed pumps limit flow control into Zone 2, and VFDs should be added for each pump.

Expanding Zone 4 should be considered to address the low pressure concern near SBPS when SBPS is offline and the high pressure concern when SBPS pumps more than 800 gpm. Minor modifications to the distribution system piping and Zone boundaries can address the issues. The improvements should take into account the anticipated Zone 5 PRV on Harness Way.

If the Wissler Trust is incorporated into the District, the District should begin plans to expand the pumping capacity from SBPS. The planning stages should incorporate an analysis of pipelines from SBPS focused on reducing headloss created when pumping flows over 800 gpm to the North Tanks.

3.3.6. Current Buildout Model Evaluation

The Future Max Day Demand (2022C) model was created by activating the proposed pipes and junctions that were already within the existing model and labeled as proposed. This model represents current buildout and includes the demands in the existing max day demand model (2022B) plus the planned development flows calculated in Section 1 - and shown in Figure 1-1. The values on Figure 1-1 were used as the basis for assigning demands to the proposed nodes in the future max day model. Demand values for each planned development were converted to gpm and added to the nearest node in the model. The total planned development demands added to the model is 534 gpm.

3.3.6.1. Current Buildout Results

The following current buildout results for the Future Max Day Demand model include:

- Reservoir and Tank Flows
- Domestic Pressures
- Fire Flows

3.3.6.1.1. Reservoir and Tank Flows

The model is set up such that the demands are being drawn from two reservoirs and three tanks. The reservoirs are identified in the model as RES9004 and RES9006, and the tanks are T-1, T-4, and T-13. RES9004 represents the pressure head and flow from NBPS and feeds Zone 1. RES9006 represents flow from SWTP that Timberview pumps use to feed Zone 4. T-1 represents the South Storage Tank, which is fed by SWTP and supplies Zone 2 through SBPS. T-4 and T-13 represent the North Storage Tanks. T-4 and T-13 gravity flow into Zone 2 and represent the flow from CWTP into Zone 2. T-4 is being filled in the model runs. Zones 3 and 5 are fed through PRVs off of Zone 2. Model reported flows from each reservoir for the future max day demand model are as follows:

- RES9004 – 921 gpm
- RES9006 – 84 gpm
- T-1 – 1,105 gpm
- T-13 – 917 gpm
- T-4 – 306 gpm

While the CWTP, SWTP, and Wells 2, 8, and 11 contribute directly to the potable water in the District's distribution system, the model's potable sources were simplified for this calibration since the focus of the analysis is fire flow results. The WTPs and well capacities are not designed to provide fire flow, so the primary sources of water during a fire are the water storage tanks.

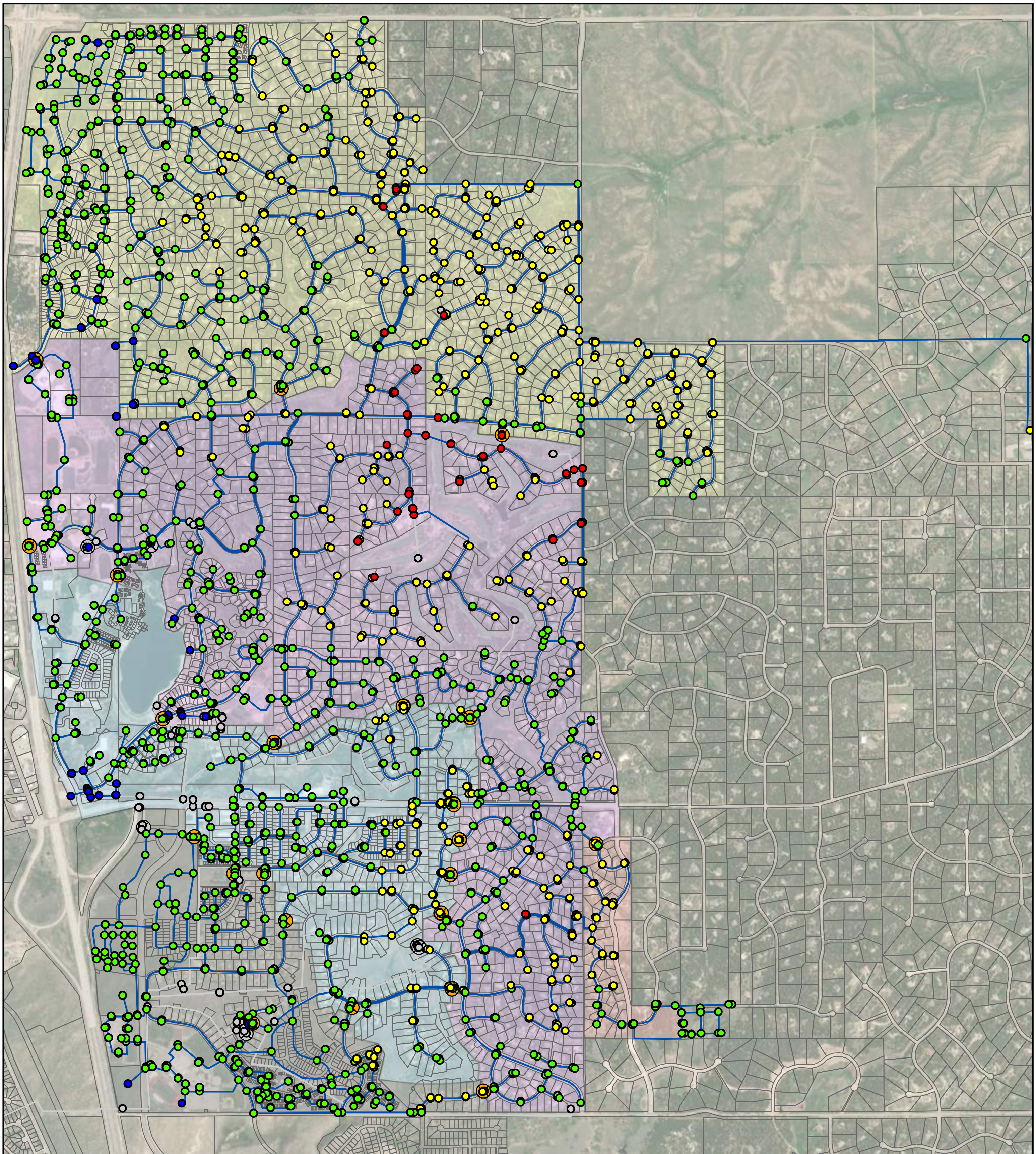
3.3.6.1.2. Domestic Pressures

Under peak day conditions, a node report was completed to identify the service nodes with the lowest available pressure in each pressure zone. Results are summarized in Table 3-25 and shown in Figure 3-12.

Table 3-25 – Modeled Available Service Pressure by Zone at Peak Future Day Demand

Pressure Zone	Lowest Available Pressure (psi)	Highest Available Pressure (psi)
Zone 1	56.4	183.1
Zone 2	24.6	169.5
Zone 3	64.3	166.1
Zone 4	60.5	129.6
Zone 5	77.6	166.8

Note: Model nodes J10, J11, J12, J979, J1073, J1369, and J1378 have lower pressures than what is reported in the table. These low-pressure nodes are on pipelines to and from the storage tanks, and they don't correspond to a service connection or fire hydrant.



LEGEND

JUNCTION (ACTIVE)

PRESSURE (PSI)

- < 60
- 60 - 100
- 100 - 160
- > 160

- JUNCTION (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)

FIG 3-12: AVAILABLE PRESSURES FUTURE MAX DAY DEMAND (2022C)

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2022 LONG RANGE PLAN
WOODMOOR, COLORADO
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0 1,100 2,200 4,400
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3.3.6.1.3. Fire Flows

To analyze the fire flow available at each hydrant across the District's service area, a fire flow simulation was run under peak day demand conditions for current buildout. To run this scenario, a design fire flow was specified with a minimum pressure of 20 psi required, and the critical node search range was set to "Entire Network" instead of just the fire hydrant nodes. This setting ensures that the maximum fire flow reported is based on providing a minimum pressure of 20 psi across the whole system, and not just at the open hydrant.

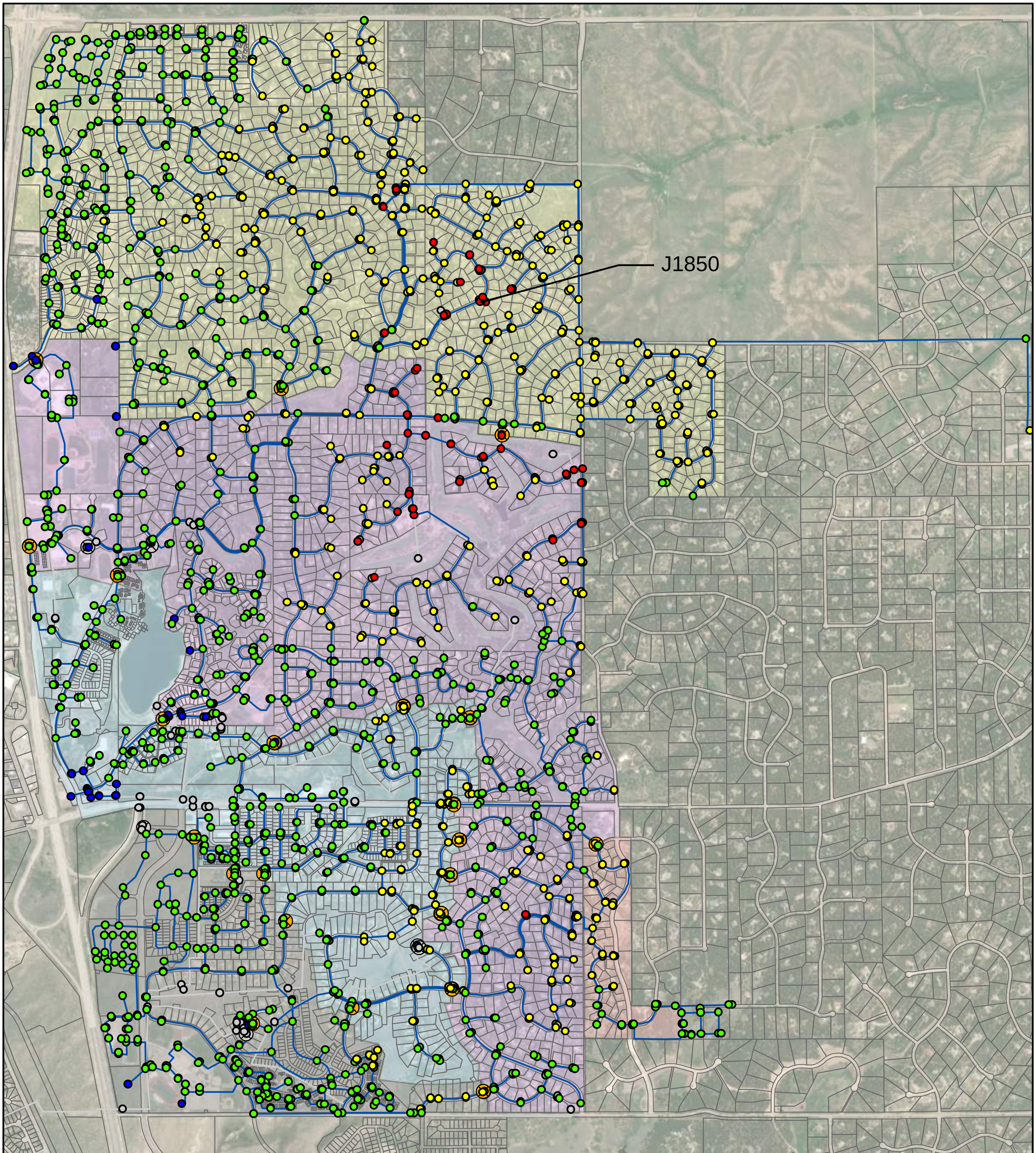
The District aims to supply a minimum of 1,250 gpm at all fire hydrants. To model the pressures across the distribution system in the event of a fire, the fire hydrant node with the lowest pressure based on the domestic results in each pressure zone was identified (as shown in Figures 3-13 through 3-17 on the following pages).

- Zone 1 = Hydrant J1850
- Zone 2 = Hydrant J520
- Zone 3 = Hydrant J174
- Zone 4 = Hydrant J1922
- Zone 5 = Hydrant J74

A fire flow scenario was run for each of these hydrants by specifying a fire flow input of 1,250 gpm. A node report was completed for pressures at all active nodes in the distribution system. The results identifying the lowest pressure nodes for each of the five fire flow scenarios are shown in Figure 3-13, Figure 3-14, Figure 3-15, Figure 3-16, and Figure 3-17.

A hydrant node report was completed to identify which hydrants have an available fire flow of less than 1,250 gpm while maintaining a minimum pressure of 20 psi across the system. Results are shown in Figure 3-18. The minimum available fire flow in each zone was identified:

- Zone 1 – 714 gpm at Hydrant J1449
- Zone 2 – 844 gpm Hydrant J57
- Zone 3 – 1,257 gpm at Hydrant J87
- Zone 4 – 1,323 gpm at Hydrant J1922
- Zone 5 – 1,950 gpm Hydrant J74



LEGEND

JUNCTION (ACTIVE)

PRESSURE (PSI)

- < 60
- 60 - 100
- 100 - 160
- > 160

JUNCTION (INACTIVE)

PRV (ACTIVE)

PRV (INACTIVE)

PIPE (ACTIVE)

PIPE (INACTIVE)

FIG 3-13: AVAILABLE PRESSURES FUTURE FIRE IN ZONE 1 (AT J1850)

WOODMOOR WATER & SANITATION DISTRICT
2022 LONG RANGE PLAN
WOODMOOR, COLORADO
1051.8e
SEPTEMBER 2022

N

0 1,100 2,200 4,400 FEET

1 INCH = 2,200 FEET

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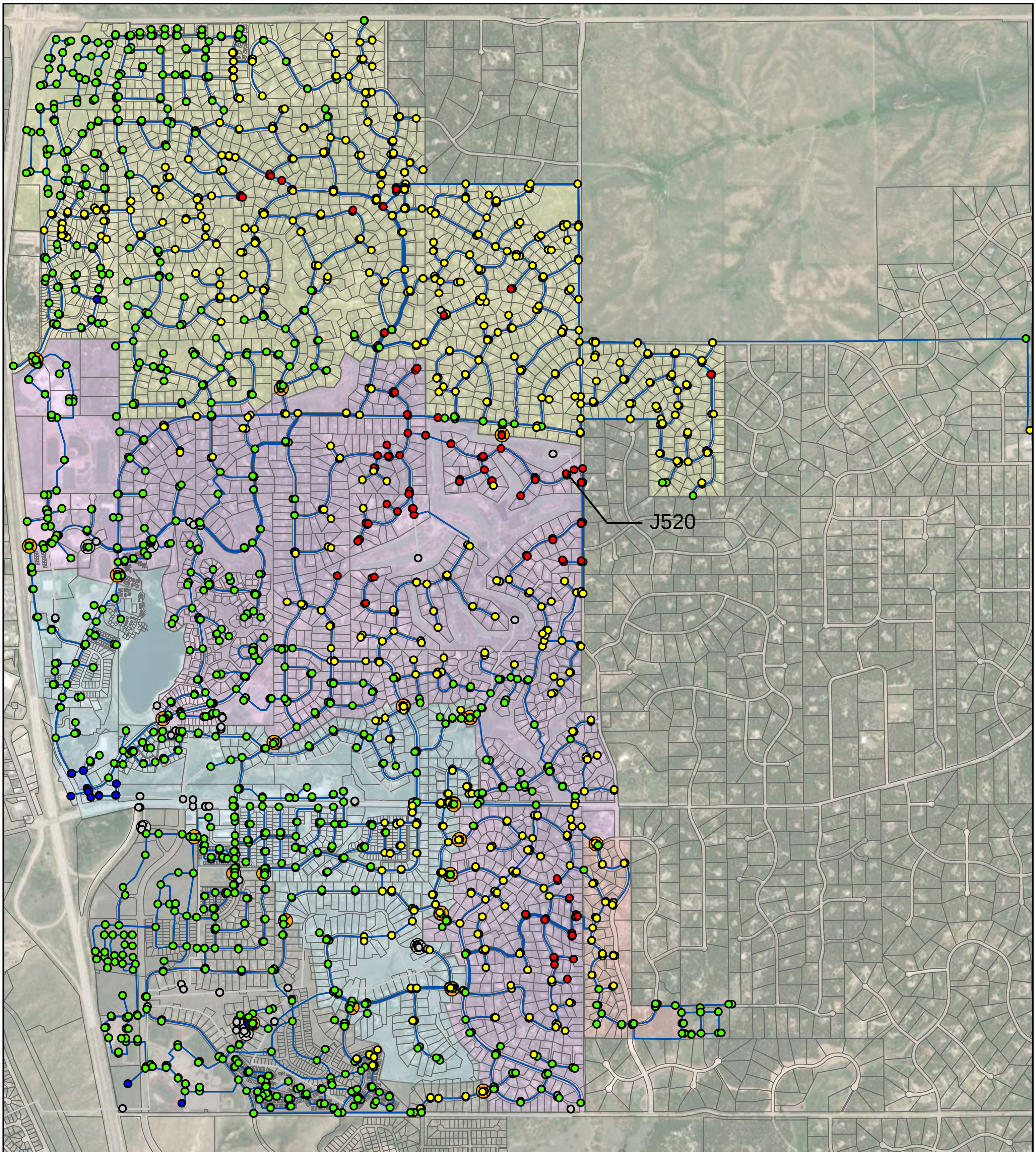

LEGEND

JUNCTION (ACTIVE)

PRESSURE (PSI)

- < 60
- 60 - 100
- 100 - 160
- > 160

- JUNCTION (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)

FIG 3-14: AVAILABLE PRESSURES FUTURE FIRE IN ZONE 2 (AT J520)

WOODMOOR WATER & SANITATION DISTRICT
2022 LONG RANGE PLAN
WOODMOOR, COLORADO
1051.8e
SEPTEMBER 2022

N

0 1,100 2,200 4,400 FEET

1 INCH = 2,200 FEET

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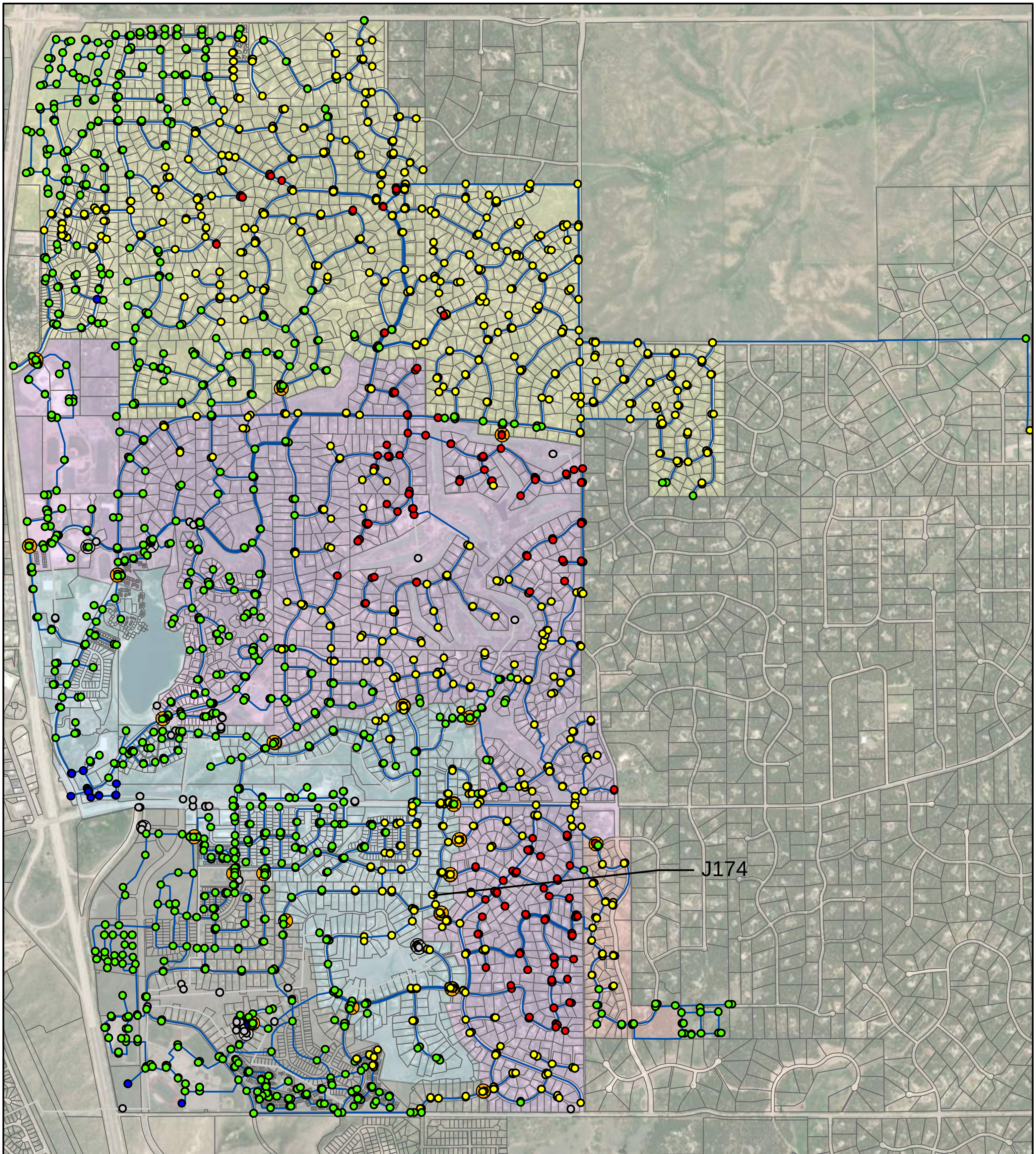

LEGEND

JUNCTION (ACTIVE)

PRESSURE (PSI)

< 60

60 - 100

100 - 160

> 160

JUNCTION (INACTIVE)

PRV (ACTIVE)

PRV (INACTIVE)

PIPE (ACTIVE)

PIPE (INACTIVE)

FIG 3-15: AVAILABLE PRESSURES FUTURE FIRE IN ZONE 3 (AT J174)

WOODMOOR WATER & SANITATION DISTRICT
2022 LONG RANGE PLAN
WOODMOOR, COLORADO
1051.8e
SEPTEMBER 2022

N

0 1,100 2,200 4,400 FEET

1 INCH = 2,200 FEET

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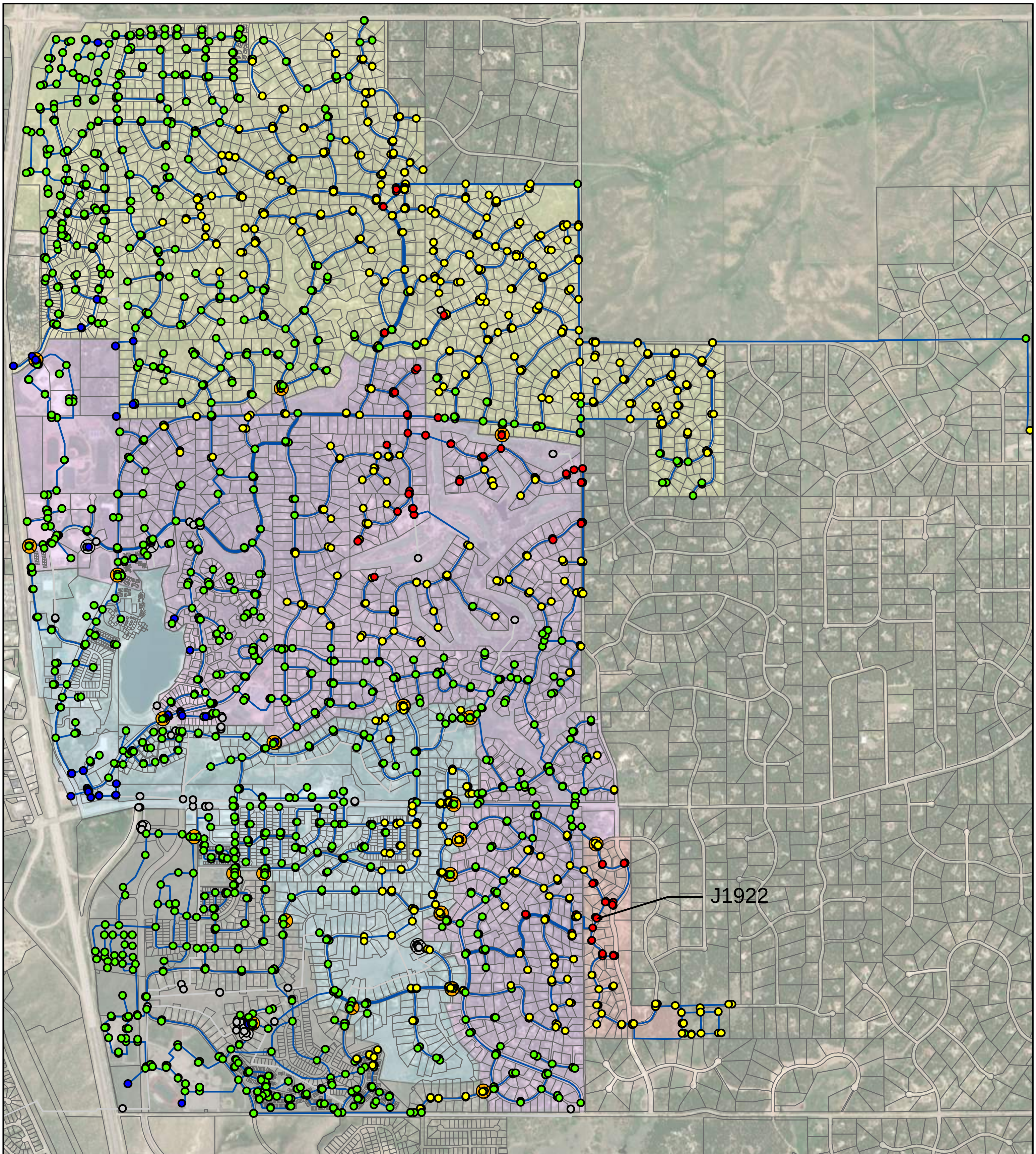

LEGEND

JUNCTION (ACTIVE)

PRESSURE (PSI)

- < 60
- 60 - 100
- 100 - 160
- > 160

- JUNCTION (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)

FIG 3-16: AVAILABLE PRESSURES FUTURE FIRE IN ZONE 4 (AT J1922)

WOODMOOR WATER & SANITATION DISTRICT
2022 LONG RANGE PLAN
WOODMOOR, COLORADO
1051.8e
SEPTEMBER 2022

N

0 1,100 2,200 4,400 FEET

1 INCH = 2,200 FEET

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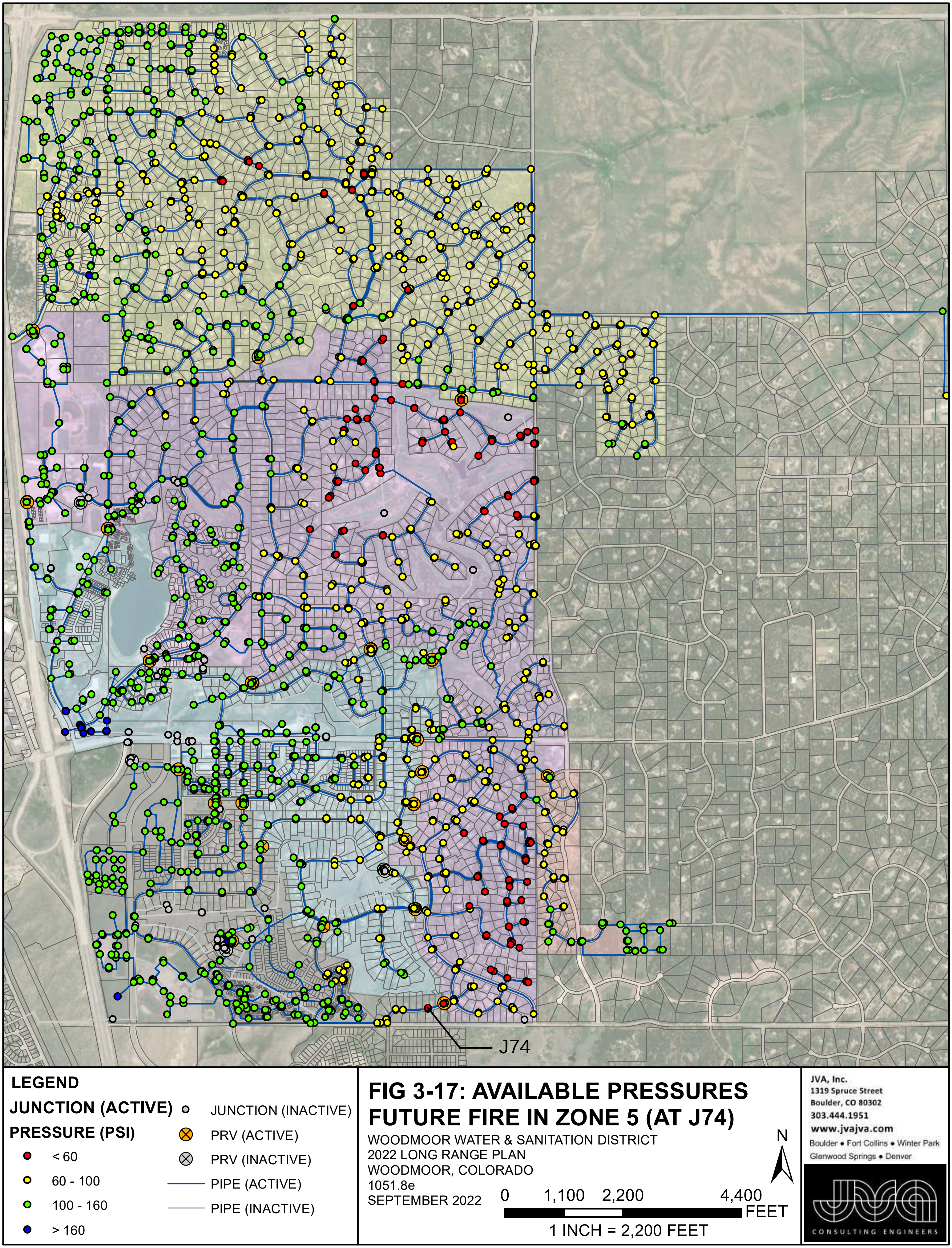

FIG 3-17: AVAILABLE PRESSURES FUTURE FIRE IN ZONE 5 (AT J74)

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2022 LONG RANGE PLAN
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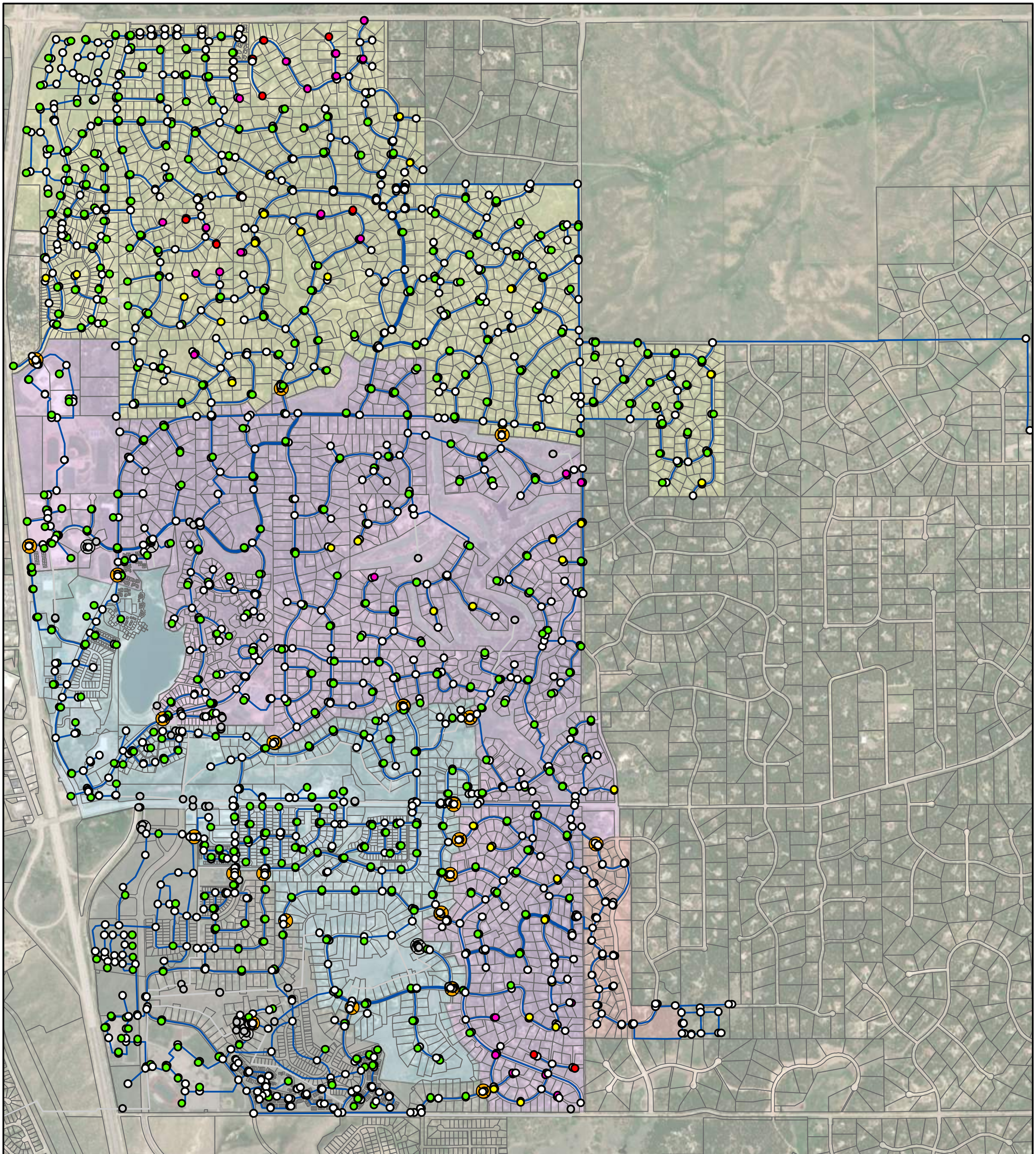

LEGEND

JUNCTION (ACTIVE)

FLOW (GPM)

- NOT HYDRANT
- < 900
- 900 - 1100
- 1100 - 1250
- > 1250

- JUNCTION (INACTIVE)
- PRV (ACTIVE)
- PRV (INACTIVE)
- PIPE (ACTIVE)
- PIPE (INACTIVE)

FIG 3-18: AVAILABLE HYDRANT FLOW FUTURE FIRE ANALYSIS

WOODMOOR WATER & SANITATION DISTRICT
2022 LONG RANGE PLAN
WOODMOOR, COLORADO
1051.8e
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N

0 1,100 2,200 4,400 FEET

1 INCH = 2,200 FEET

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3.3.6.2. Ultimate Buildout Scenario

The Ultimate Buildout Max Day Demand (2022D) model was created to model the development of Wissler Trust and represents ultimate buildout conditions. The 2022D scenario is a copy of the 2022C future max day demand model with the addition of Wissler Trust. This property will add 1,334 SFEs to Zone 1. With the planning demand of 272 gpd/SFE established in Section 2.1.1.1 and the planning level peaking factor of 2.2 established in Section 2.1.3, it is anticipated that Wissler Trust will add a demand of 554 gpm to the ultimate buildout max day demand model.

The Wissler Trust property has an approximate surface elevation range between 7270 and 7495 feet. This elevation range falls within the current elevation range of 7201 and 7550 feet across Zone 1. Nodes were placed at the approximate high and low points on the property, with the demand added to the node at the low point. Ten-inch pipes were added between the nodes to provide looping across Wissler Trust with two tie-in points to the existing system along Furrow Road.

Model results indicate that the static pressure at the lowest point on the Wissler Trust property is approximately 162 psi. Under future peak day conditions with the steady state demand of 554 gpm added to the lowest point, the model results indicate that the pressure at Wissler Trust is 156 psi. Thus, it can be assumed that the Wissler Trust property can be added into the District’s Pressure Zone 1 without needing a PRV.

APPENDIX J
Supplemental Water Service Policy

RESOLUTION
OF THE
BOARD OF DIRECTORS
OF THE
WOODMOOR WATER AND SANITATION DISTRICT NO. 1

Repealing Excess Water Service Policy and Establishing A Supplemental Water Service Policy

WHEREAS, Woodmoor Water and Sanitation District No. 1 (the "District") is a quasi-municipal corporation and political subdivision of the State of Colorado formed pursuant to Title 32, C.R.S.; and

WHEREAS, because the District's water supply is substantially dependent upon non-renewable and finite resources, though the District has been and continues to supplement this supply by developing renewable resources, it is the District's policy that waste will not be tolerated and that water will be conserved and water consumption managed to insure that the District's water resources will not be unnecessarily depleted; and

WHEREAS, pursuant to Section 5-7 of the Woodmoor Water & Sanitation District Rules and Regulations (the "Regulations"), the District's Board of Directors may allocate and authorize taps for service within its service area on any reasonable basis determined by the Board; and

WHEREAS, El Paso County land use regulations permit a maximum annual water usage equal to 1/3 of one percent of Denver Basin resources; that is, a theoretical 300 year aquifer life and the State of Colorado Department of Water Resources regulations permit a maximum annual water usage equal to one (1) percent of Denver Basin resources; that is, a theoretical 100 year aquifer life; and

WHEREAS, consistent with Colorado State and El Paso County regulations and the District's goals for conserving the District's water resource and the Denver Basin Aquifers and for the purposes of long term planning for the needs of the District residents and future residents, the District allocates one-half (½) acre foot of water per acre per year; and

WHEREAS, from time to time, owners have requested and the District has for adequate consideration agreed to allocate part of the District's water resources to permit service to new development in an amount over and above the one-half (½) acre foot of water per acre per yearto certain lands within the District; and

WHEREAS, pursuant to Section 32-1-1001(1)(j), C.R.S., the District is authorized to fix and from time to time to increase or decrease fees, rates, tolls, penalties, or charges for services, programs, or facilities furnished by the District; and

WHEREAS pursuant to Section 7-1-1 of the Regulations, the District's rates, tolls and charges are for the purpose of providing for the payment of all costs of operating, maintaining, repairing, replacing, and expanding the District system; and

WHEREAS, pursuant to Section 7-1-1 of the Regulations, all rates, tolls and charges are determined by the Board as it deems necessary and may be changed at any time; and

WHEREAS, the Board desires that payments collected by the District from charges to an owner for allocation of water resources to the owner's land in excess of one-half (½) acre foot of water per acre per year be used for the continuing development of renewable water resources and related facilities; and

WHEREAS, the Board adopted Resolution 04-03 and thereby established an Excess Water Policy and established an account for the continued development of renewable water resources and facilities necessary therefor; and

WHEREAS, the District has determined that the "Excess Water Policy" referred to in Resolution 04-03 would be better described and referred to as "Supplemental Water Service Policy."

NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE WOODMOOR WATER AND SANITATION DISTRICT NO. 1 AS FOLLOWS:

1. **Assumptions.** For purposes of establishing a policy regarding allocating service of Supplemental Water, as defined below, the Board accepts the following assumptions:

a. The District's current boundaries contain 3721 acres of which 347 acres are currently undeveloped. The estimated annual water resource beneath the 3721 acres is 6470 acre feet/per year.

b. The current estimate of the total water projected for current District build-out is 3344 acre feet per year based on the one-half (½) acre foot per acre per year policy and existing commitments.

c. The El Paso County 300 year policy together with the Colorado Department of Water Resources 100 year policy will allow annual withdrawals of 6470 acre feet per year; available supplemental water of 3126 acre feet per year, above the projections (the "Supplemental Water").

d. The allocation of the Supplemental Water to current undeveloped lands within the current District boundaries is set at one (1.0) acre foot per acre per year.

2. **<u>Supplemental Water Base Rate</u>.** There is hereby established a rate to be charged for the Supplemental Water (the "Supplemental Water Base Rate") of $20,000 per acre foot (Twenty Thousand Dollars/af).

3. **<u>Resource and Facilities Surcharge</u>.** The District shall charge a Resource and Facilities Surcharge for each acre foot of supplemental water service in an amount determined by the District. The District shall base the determination on the additional resources and facilities required to serve the supplemental water and/or the diminishment of existing resources and facilities capacities. The amount of the Resource Facilities Surcharge will vary depending upon the costs attributable to service location, quantity, pipe sizes, pumping capacity, and such other factors as determined applicable by the District in its sole discretion.

4. **<u>Periodic Review</u>.** Periodically, the District Manager shall review, and if necessary, revise the assumptions contained in Section 1 of this Resolution and complete Table A, attached hereto, to reflect any changes as of the date of such review, and if warranted, recalculate the allocation of the Supplemental Water contained in Section 1(d) and submit the same to the Board. At a subsequent meeting, and at such other times as appropriate, the Board shall consider whether to accept the revised assumptions and the District Manager's recalculated allocation of the Supplemental Water and whether to change the Supplemental Water Base Rate. Any such change in the calculation of the allocation of Supplemental Water and the Supplemental Water Base Rate shall be effective as of the day the Board approves such changes, unless the Board provides otherwise.

5. **<u>Tier 1 – Standard One-Half (½) acre foot per acre</u>.** The District intends for there to be available one-half (½) acre foot per acre for every acre of undeveloped real property within the District. The owner of undeveloped real property may assume availability of one-half (½) acre foot per acre for each acre of his/her property, subject to the Board, in its sole discretion, providing otherwise.

6. **<u>Tier 2 – Allocation of Supplemental Water/WWSD Standard Demand Basis</u>.** The owner of undeveloped real property within the boundaries of the District may request his/her allocation of service from Supplemental Water (determined by applying assumptions contained in Paragraph 1 of this Resolution) by submitting such request to the Board. The Board may grant the request, subject to such terms and conditions as the Board shall determine necessary and provided that the owner calculates his/her projected water demand based on the then current Woodmoor Water & Sanitation District Standard Demand Table (the "WWSD Standard") and the Board concurs with the calculation. Nothing herein is intended to be, nor shall it be construed as a limitation on the ability of the owner of undeveloped property to seek to conserve water by installing water saving equipment and implementing conservation measures.

7. **<u>Tier 2 - Allocation of Supplemental Water/Other Basis</u>.** The owner of undeveloped real property within the boundaries of the District may request his/her allocation of service from Supplemental Water utilizing a projected demand methodology other than the WWSD Standard by submitting such request to the Board. The Board may:

a. Reject the request if, in the Board's sole determination, the District's reserves of water are not sufficient to support the request, given the circumstances then existing, or even if sufficient, there is no adequate mechanism for protecting the District's financial resources; or

b. Grant the request provided that:

i. *Demand.* The owner bases his/her water demand on a methodology, which in the District's sole determination is reasonable; and

ii. *Charge.*

1) The owner enter into a supplemental water agreement that: (a) sets forth the charge for the Supplemental Water (Supplemental Water Base Rate) and the amount of the Resource Facilities Surcharge; (b) provides that by January 31 of every year following the effective date of the supplemental water agreement, owner pay the District, in one lump sum, the amount of actual water used in excess of the projected demand at a rate equal to the Supplemental Water Base Rate multiplied by 1.65 and that the District shall have a lien against all of the property for the amount of such lump sum payment, if any is due; (c) sets forth, as the remedy for failure to pay in full by January 31st, water service shut off to the entire permitted premises or such other remedies as the District may have, including without limitation, certifying the amount to the county assessor for collection; (d) requires the creation of a covenant setting forth the payback provisions of (b) and remedy provisions of (c) of this subsection 6 (b)(ii) burdening owner's real property and binding on owner's heirs and successors; (e) provides that in the event the use of the property for which owner's request for Supplemental Water is based changes or is enlarged, the Board may, in its sole discretion, amend the supplemental water agreement to increase the allocation of Supplemental Water and impose such conditions as the District in its sole discretion deems appropriate and that owner, or his or her heirs or assigns shall notify the District ninety (90) calendar days prior to such change in or enlargement of use; (f) provides that use and availability of Supplemental Water will be subject to all then existing rules, regulations, resolutions and policies; and (g) such other terms as the District may require.

8. **<u>Tier 3 – Additional Supplemental Water - WWSD Standard Demand or Other Basis</u>**. The owner of undeveloped property within the boundaries of the District use may request service over and above his/her allocation of Supplemental Water Service (hereinafter called "Tier 3 Supplemental Water") by submitting such request to the Board. The Board may:

a. Reject the request if, in the Board's sole determination, the District's reserves of water are not sufficient to support the request, given the circumstances then existing, or even if sufficient, there is no adequate mechanism for protecting the District's financial resources; or

b. Grant the request provided that:

i. *Demand.* The owner calculates his/her projected water demand based on: the WWSD Standard and the Board concurs with that calculation; or on another methodology, which in the District's sole determination is reasonable; and

ii. *Charge.*

1) If the owner's request is based on the WWSD Standard, the owner enter into an excess water agreement with the District which shall set forth the charge for the Tier 3 Supplemental Water (the Supplemental Water Base Rate multiplied by 1.50) and such other terms as the District shall require; or

2) If the owner's request is based on another methodology, which is satisfactory to the District, the owner enter into a supplemental water agreement that: (a) sets forth the charge for the Tier 3 Supplemental Water (Supplemental Water Base Rate multiplied by 1.50); (b) provides that by January 31st of every year following the effective date of the supplemental water agreement, owner pay the District, in one lump sum, the amount of actual water used in excess of the projected demand at a rate equal to the Supplemental Water Base Rate multiplied by 1.65 and that the District shall have a lien against all of the property for the amount of such lump sum payment, if any is due; (c) sets forth, as the remedy for failure to pay in full by January 31st, water service shut off to the entire permitted premises or such other remedies as the District may have, including without limitation, certifying the amount to the county assessor for collection; (d) requires the creation of a covenant setting forth the payback provisions of (b) and remedy provisions of (c) of this subsection 8 (b)(ii)(2) burdening owner's real property and binding on owner's heirs and successors; (e) provides that in the event the use of the property for which owner's request for Tier 3 Supplemental Water is based changes or is enlarged, the Board may, in its sole discretion, amend the agreement to increase the allocation of Tier 3 Supplemental Water and impose such conditions as the District in its sole discretion deems appropriate and that owner, or his or her heirs or assigns shall notify the District ninety (90) calendar days prior to such change in or enlargement of use; (f) provides that use and availability of Tier 3 Supplemental Water will be subject to all then existing rules, regulations, resolutions and policies; and (g)such other terms as the District may require.

9. **Factors for Board's Consideration.** In considering all requests for all supplemental water service, the Board may, but is not limited to considering the following factors:

Current resource and planned resource availability;
Current delivery capacity;
Adjudicated water and water rights;
Timing and availability of new water resources;
Offsite facilities required for service – pipelines, booster pumps, storage facilities and the like;

Use patterns; and
Other.

10. **No Speculation Allowed.** Any person who purchases Supplemental Water service shall, within 365 days of the District's tender of a supplemental water agreement to the owner, have : a) completed the physical tap onto the District's main water line necessary to utilize the Supplemental Water service and have passed all required inspections and paid all District charges; or b) where the District permits, in its sole discretion, obtained the District's conditional acceptance of utilities installation in accordance with all District rules, regulations and policies and all applicable laws. **[I'm assuming that the District's preference is that actual tapping occur; thus I've moved it to first position]** The District shall charge the owner who fails to have obtained conditional approval or completed such tap and the owner shall pay to the District the difference between the previous year's purchase price of the Supplemental Water and the then current purchase price of the initial transaction(s). The purchaser shall be responsible for paying such fee within 10 days after the District provides written notice ("Notice") to the purchaser and thereafter annually, by either July 31 (if the Notice was provided after January 1 but prior to July 20) or January 10 (if the Notice was provided after July 20 but before December 31). The purchaser's obligation to make said annual payment shall terminate only upon the purchaser having: x) completed the physical tap onto the District's main water line necessary to utilize the Supplemental Water service; or y) where the District permits, in its sole discretion, obtained the District's conditional acceptance of utilities installed in accordance with all District rules, regulations and policies and all applicable laws. Regardless of when purchaser obtains the District's conditional acceptance of utilities or completes a physical tap necessary to utilize the Supplemental Water service, purchaser is not entitled to receive a rebate on any portion of the annual payment(s) due under this paragraph 10.

11. **Necessary Information from Applicant for Supplemental Water Service**. The District Manager is hereby authorized to develop the requirements to be satisfied by any applicant for service from Supplemental Water. All persons applying for service from Supplemental Water shall comply with the District Manager's requirements.

12. **Supplemental Water Agreements**. The District will develop all agreements and pay the costs associated with preparing the same provided the Board has authorized the sale of supplemental water service. The District will deliver such agreement to the owner for the owner's review. If the owner requests any changes to the agreement of any kind, the District will consider such changes. However, the owner shall pay all costs associated with any modifications, alterations, changes or revisions to the agreement. Similarly, any party to any excess water agreement or supplemental water agreement shall pay all costs associated with any modifications, alterations, changes or revisions to the agreement requested to be made by that party.

13. **Re-Development of Property and Inclusions.** Requests from any owner of already developed property within the District, (any property other than vacant property), or any person intending on petitioning for inclusion of property, in either case regardless of how the property is zoned, may be considered on a case by case basis by the District.

14. **WWSD Standard.** There is hereby established a Woodmoor Water & Sanitation District Standard Demand Table, which is attached hereto as Table B. The District Manager is hereby authorized to update and change the Woodmoor Water & Sanitation District Standard Demand Table from time to time as the District Manager deems it necessary.

15. **Water Resource Account.** There is hereby established a water resource account. The monies from such account may be used for the continuing development of renewable water resources and related facilities, as the Board determines in its sole discretion. All charges, surcharges and penalties as described in this Resolution, collected by the District for Supplemental Water, may be deposited into said account, unless otherwise directed by the Board. Such account shall not be considered a fund within the meaning of the Local Government Budget Law of Colorado.

16. Notwithstanding any contrary provision, nothing herein is intended to nor shall it be construed as a grant of any water right (decreed or undecreed) owned by the District.

[Remainder of page left blank intentionally.]

DONE AND ADOPTED as of the 11th day of January 2007, by the Board of Directors of Woodmoor Water and Sanitation District No. 1.

James W. Taylor, President

ATTEST:

Elizabeth Hacker, Secretary

Table A

Pursuant to Resolution 06-11, on this _____ day of ___________, 20__, the District Manager submits the following assumptions and recommendations to the Board of Directors for the Board's acceptance:

a. The District's current boundaries contain ____ acres of which ___ acres are currently undeveloped. The estimated annual water resource beneath the ____ acres is ______ acre feet/per year.

b. The current estimate of the total water projected for current District build-out is _____ acre feet per year based on the one-half (½) acre foot per acre per year policy and existing commitments.

c. The El Paso County 300 year policy together with the Colorado Department of Water Resources 100 year policy will allow annual withdrawals of ______ acre feet per year; available supplemental water of _______ acre feet per year, above the projections (the "Supplemental Water").

d. The allocation of the Supplemental Water to current undeveloped lands within the current District boundaries is set at _____ acre foot per acre per year.

Supplemental Water Base Rate $20,000/af.

Table B
Woodmoor Water and Sanitation District
Standard Demand Table

Type of Establishment	Usage(gpd) Per Unit of Measurement	Unit of Measurement
Banks	0.13	Square Foot
Barber Shops	0.19	Square Foot
Bathhouses for swimming pools	10.2	Per Swimmer
Beauty Salons	0.41	Square Foot
Bowling Alleys	0.08	Square Foot
Car Dealerships	0.07	Square Foot
Car Washes	3.81	Square Foot
Car Washes-Self-Service	0.693	Square Foot
Child Day-Care School	13	Per Student
Churches	1	Per Building
Churches with Day-Care Schools	2	Use
Dental Offices	0.48	Square Foot
Department Stores with and without Food Service	0.04	Square Foot
Drug Stores	0.09	Square Foot
Dry Cleaning Pick-Up and Drop-Off	0.01	Square Foot
Dry Cleaning On-Site	0.38	Square Foot
Dry Cleaning and Laundry On-Site	0.45	Square Foot
Dry Cleaning, Laundry and Coin-Wash	1.28	Square Foot
Dry Goods Stores (Clothing)	0.06	Square Foot
Fire and Rescue Services	0.19	Square Foot
Funeral Homes	0.05	Square Foot
Furniture Stores	0.02	Square Foot
Gasoline Service Stations	816	Per Station
Hospitals	0.37	Square Foot
Indoor Tennis Courts	153	Per Court
Kennels and Animal Hospitals	0.15	Square Foot
Laundromats	2.9	Square Foot
Luxury Campsites	114	Per Campsite
Manufacturing-Public Water not used in Processing	20	Per Employee
Medical Office Buildings	0.3	Square Foot
Medical Practitioners Metered Separately	0.19	Square Foot
Motels with Restaurant	168	Unit
Motels without Restaurant	117	Unit
Multi-Family Dwelling (Patio homes,	240	Per Dwelling

Apartments, Condos)		
Newspaper Offices	16	Per Employee
Nursery and Garden Centers	2	Site
Nursing Homes	0.35	Square Foot
Office Buildings with Cafeteria	0.2	Square Foot
Office Buildings without Cafeteria	0.09	Square Foot
Restaurants	0.59	Square Foot
Retail Stores (small, quick-service, convenience)	0.21	Square Foot
Retirement Homes	0.18	Square Foot
Schools-Elementary (186 days)	5.5	Per Student
Schools-Junior High (186 days)	9.5	Per Student
Schools-Public High (186 days)	6.5	Per Student
Schools-Private (186 days)	20	Per Student
Single-Family Dwellings	320	Per Dwelling
Supermarkets	0.12	Square Foot
Swimming Pools (bathhouse separate)	21.3	Per Swimmer
Theaters-Drive-in	2.52	Per Car Space
Theaters-Walk-in	0.9	Per Seat
Warehouses	0.01	Square Foot