11020 White Rock Road, Suite 200
Rancho Cordova, CA 95670

T: 916-444-0123

Brown AND Caldwell

February 28, 2024

Ms. Sherry Kimura
Water Quality Compliance Specialist
City of Davis
1717 Fifth Street
Davis, CA 95616 158716

Subject: Submittal of 2023 Water System Optimization Plan

Dear Ms. Kimura:

Our team is pleased to submit to you this 2023 Water System Optimization Plan (2023 WSOP). The purpose of the 2023 WSOP is to develop financial and managerial strategies to guide the continued operation of the water system on the most reliable and cost-effective path forward. Specifically, the 2023 WSOP develops an understanding of existing water demands and how future growth within the City of Davis (City) water service area impacts water demands, identifies strategies for sustained supplies to meet existing and future demand, analyzes well head treatment opportunities and corresponding increases in available and reliable groundwater pumping capacity, evaluates maximum day water demands, develops an understanding of relative pipe risk to inform distribution piping replacement, and updates the City water distribution Capital Improvement Plan (CIP). Brown and Caldwell looks forward to continuing to assist the City of Davis in the development of future water planning projects. Thank you for this opportunity to work with you on this project.

Very truly yours,

Brown and Caldwell

John Abrew, P.E.
Project Manager

JA:ds

Attachments (1)

1. 2023 Water System Optimization Plan

FINAL

2023 Water System Optimization Plan

Prepared for

City of Davis

Davis, California

February 28, 2024

FINAL

2023 Water System Optimization Plan

Prepared for

City of Davis, Davis, California

February 28, 2024

Brown AND Caldwell

11020 White Rock Road, Suite 200
Rancho Cordova, CA 95670
T: 916.444.0123

Acknowledgements

Brown and Caldwell acknowledges the valuable contributions made by the City of Davis in conducting the Water System Optimization Plan.

Specifically, the project team recognizes the following personnel for their efforts:

- Sherry Kimura, Project Manager
- Stan Gryczko
- Adrienne Heinig

The project team members included:

- John Abrew, Project Manager
- Micaela Swain
- Melanie Holton
- Sean Kilpatrick
- Timothy Lee
- Joseph Wong

Table of Contents

List of Figures v
List of Tables vii
List of Abbreviations ix
Executive Summary ES-1
Description of Existing System ES-1
Water Demand Analysis ES-1
Water Supply ES-3
Water System Capacity Evaluation ES-4
Existing System Pipe Risk Analysis ES-7
Capital Improvement Program ES-7
1. Introduction 1-1
1.1 WSOP Objectives 1-1
1.2 WSOP Approach 1-2
1.3 Other Relevant Reports 1-3
2. Description of Existing System 2-1
2.1 Description of Service Area 2-1
2.2 Water Supply Facilities 2-4
2.2.1 WDCWA Supply 2-4
2.2.2 Groundwater Wells 2-4
2.3 Water Distribution System 2-5
2.3.1 Pipelines 2-5
2.3.2 Storage Facilities/Booster Pump Stations 2-6
2.3.3 Interties 2-7
3. Water Demand Analysis 3-1
3.1 Water Service Area Population, Connections, and Land Use 3-1
3.1.1 Population and Connections 3-2
3.1.2 Land Use 3-4
3.1.3 Growth Projections 3-9
3.2 Existing and Projected Water Demand 3-13
3.2.1 Historical Water Use 3-13
3.2.2 Non-Revenue Water 3-13
3.2.3 Physical (Real) Water Loss 3-15
3.2.4 Existing Unit Water Demand Factors 3-15
3.2.5 Climate Change Impacts on Water Demand 3-17
3.2.6 Water Use Goals 3-17
3.2.7 Recommended Unit Water Demand Factors 3-20

3.2.8 Water Demand Projections ... 3-20
3.2.9 Water Demand Peaking Factors ... 3-26
4. Water Supply ... 4-1
4.1 Water Supply Overview ... 4-1
4.2 Surface Water ... 4-1
4.3 Groundwater ... 4-3
4.3.1 Basin Description and Management ... 4-3
4.3.2 Groundwater Wells ... 4-4
4.4 Supply Reliability ... 4-7
4.5 Climate Change Impacts on Water Supply ... 4-9
4.6 Water Treatment ... 4-9
4.7 Water Quality ... 4-9
4.7.1 Annual Water Quality Report ... 4-10
4.7.2 Inorganic Chemicals ... 4-12
4.7.3 Organic Chemicals ... 4-13
4.7.4 Secondary Drinking Water Standards ... 4-13
4.7.5 Lead and Copper Rule and Lead and Copper Rule Revisions ... 4-15
4.7.6 Contaminants with Notification Level and Response Level ... 4-16
4.7.7 Unregulated Contaminant Monitoring Program ... 4-17
4.7.8 Contaminant Candidate List ... 4-17
4.8 Wellhead Treatment Evaluation ... 4-17
4.8.1 Wellhead Treatment Types ... 4-18
4.8.2 Wellhead Treatment Summary ... 4-19
5. Water System Capacity Evaluation ... 5-1
5.1 Desktop Storage Analysis ... 5-1
5.1.1 Step 1 – Evaluate Sufficiency of Firm Supply Capacity ... 5-1
5.1.2 Step 2 – Size Recommended Storage ... 5-2
5.2 Water Distribution System Hydraulic Capacity Analysis ... 5-4
5.2.1 Hydraulic Analysis Evaluation Criteria ... 5-5
5.2.2 Hydraulic Model Tool ... 5-5
5.2.3 Modeling Scenarios ... 5-6
5.2.4 Hydraulic Analysis Results ... 5-7
5.2.5 Identified Capacity Improvements ... 5-14
6. Existing System Pipe Risk Analysis ... 6-1
6.1 Pipe Risk Analysis Development ... 6-1
6.2 Desktop Condition Assessment ... 6-1
6.3 Likelihood of Failure ... 6-2
6.4 Consequence of Failure ... 6-7
6.5 Asset Risk ... 6-12
6.6 Risk Assessment Results ... 6-13

6.7 Recommendations ... 6-15
7. Capital Improvement Program ... 7-1
7.1 Cost Estimating Assumptions and Unit Costs ... 7-1
7.2 Near Term (0-5 Year) Capital Improvement Program ... 7-2
7.3 6-10 Year Capital Improvement Program ... 7-2
7.4 Long Term (>10 Year) Capital Improvement Program ... 7-2
7.5 Overall CIP Summary ... 7-2
8. References ... 8-1
Appendix A: Additional Modeling Results ... A-1
Appendix B: Basis of Estimate ... B-1

List of Figures

Figure ES-1. Existing and projected population and connections ... ES-2
Figure ES-2. Historical and projected per capita water use versus goals ... ES-2
Figure ES-3. Projected water demands ... ES-3
Figure ES-4. Existing system recommended capacity improvements ... ES-5
Figure ES-5. Buildout system recommended capacity improvements ... ES-6
Figure ES-6. Annual pipeline replacement program ... ES-8
Figure ES-7. Overall CIP ... ES-9
Figure 1-1. The City's Objectives for the WSOP work towards managing the water system in a way that balances cost effectiveness and reliability. ... 1-2
Figure 2-1. City of Davis water system map ... 2-2
Figure 2-3. Length of pipe by material and diameter ... 2-6
Figure 3-1. Water demand estimate analysis progression ... 3-1
Figure 3-2. Existing and projected population and connections ... 3-4
Figure 3-3. Existing land use (currently served by City water system) ... 3-6
Figure 3-5. 2028 to buildout land use (to be served by City water system) ... 3-8
Figure 3-6. Historical water production ... 3-13
Figure 3-7. Revenue and NRW components ... 3-14
Figure 3-8. Historical NRW ... 3-14
Figure 3-9. Historical unit water demands by billing class ... 3-16
Figure 3-10. Projected water demands ... 3-21
Figure 3-11. Water use projections versus goal ... 3-21
Figure 3-12. Historical and projected per capita water use versus goals ... 3-25

Figure 3-13. Historical water production 3-26
Figure 3-14. Historical MDD peaking factor 3-28
Figure 3-15. MDD diurnal pattern 3-29
Figure 4-1. Estimation of annual surface water capacity 4-2
Figure 4-2. Groundwater subbasin (Subbasin 5-21.67) 4-3
Figure 4-3. Estimation of annual groundwater well capacity 4-6
Figure 4-4. 2045 water supply reliability 4-8
Figure 4-5. Monthly year supply vs demand analysis 4-9
Figure 5-1. Existing system operational storage capacity analysis 5-3
Figure 5-2. Buildout system operational storage capacity analysis 5-3
Figure 5-3. Existing system maximum unit headloss 5-9
Figure 5-4. Existing system available fire flows 5-10
Figure 5-5. Existing system fire flow deficiencies 5-11
Figure 5-6. Buildout system maximum unit headloss 5-12
Figure 5-7. Buildout system available fire flow 5-13
Figure 5-8. Existing system recommended capacity improvements 5-17
Figure 5-9. Buildout system recommended capacity improvements 5-18
Figure 6-1. Risk analysis steps 6-1
Figure 6-2. Basis for determining risk score 6-2
Figure 6-3. Pipe material and work orders map 6-3
Figure 6-4. Pipe install year map 6-4
Figure 6-5. Overlay of pipe network onto corrosive soils 6-5
Figure 6-6. Combined LOF factor rating map 6-6
Figure 6-7. Pipeline diameter 6-7
Figure 6-8. Pipelines in proximity to critical customers 6-8
Figure 6-9. Road type 6-9
Figure 6-10. Existing peak hour flows 6-10
Figure 6-11. Combined COF factor rating map 6-12
Figure 6-12. Risk assignments for LOF/COF pairings 6-13
Figure 6-13. Overall risk categorization 6-14
Figure 6-14. Pipeline risk rating 6-15
Figure 6-15. Cumulative pipeline replacement needs 6-16
Figure 6-16. Annual pipeline replacement program 6-18
Figure 7-1. Overall CIP 7-8

Figure 7-2. Overall CIP Annual and Cumulative 7-9
Figure 7-3. CIP per Planning Year and Cumulative 7-10

List of Tables

Table ES-1. Overall CIP by Planning Year ES-7
Table 2-1. Groundwater Supply Wells 2-4
Table 2-2. Water System Piping Material Summary 2-5
Table 2-3. Water System Storage Tank Facilities 2-7
Table 2-4. Water System Pump Stations 2-7
Table 2-5. Water System Interties 2-8
Table 3-1. Historical Connections 3-2
Table 3-2. Historical Ratio of Population per Residential Connection 3-3
Table 3-3. Land Use Served by City's Water System Through Buildout 3-5
Table 3-4. Existing to 2028 Development and Connections 3-10
Table 3-5. Connection Growth to Buildout 3-12
Table 3-6. Estimated Physical (Real) Water Loss Performance Standard 3-15
Table 3-7. Existing Unit Water Demand Factors 3-16
Table 3-8. Summary of Overall City Draft Water Use Goal, gpcd 3-18
Table 3-9. Estimated Area by Irrigation Status 3-19
Table 3-10. Estimated Indoor and Outdoor Usage by Sector 3-19
Table 3-11. Recommended Unit Water Demand Factors 3-20
Table 3-12. Additional Water Demand due to Growth through 2028 3-22
Table 3-13. Additional Water Demand due to Growth of Vacant Parcels from 2028 through Buildout 3-24
Table 3-14. Projected Water System Demands for Key Planning Years 3-25
Table 3-15. Existing and Projected Water System Demand Analysis 3-27
Table 4-1. Historical Surface Water Volume Supplied, AFY 4-2
Table 4-2. Well Operations and Water Levels 4-4
Table 4-3. Historical Groundwater Volume Pumped, AFY 4-5
Table 4-4. Groundwater Pumping Capacity 4-6
Table 4-5. Normal Year Supply and Demand Comparison, AFY 4-7
Table 4-6. Dry Year Supply and Demand Comparison, AFY 4-7
Table 4-7. Water Quality Summary 4-10

Table 4-8. Regulatory Requirements for Inorganic Chemicals 4-12
Table 4-9. Regulatory Requirements for Secondary Standards 4-14
Table 4-10. Summary of Groundwater Water Quality Constituents and Treatment Recommendations 4-18
Table 4-11. Wellhead Treatment Summary 4-19
Table 5-1. Existing and Buildout Firm Supply Capacity Evaluation with Existing Storage 5-2
Table 5-2. Storage Volume Sizing 5-4
Table 5-3. Hydraulic Analysis Evaluation Criteria 5-5
Table 5-4. Modeling Scenarios 5-7
Table 5-5. Recommended Capacity Improvements 5-14
Table 6-1. Miles of Water Pipelines by Diameter and Material 6-3
Table 6-2. LOF Factors and Ratings for the Water System 6-6
Table 6-3. COF Factors and Ratings for the Water System 6-11
Table 6-4. LOF & COF Factors and Weightings for the Water System 6-14
Table 6-5. Pipeline Material Useful Life Assumptions 6-15
Table 6-6. Recommended Pipeline Improvements 6-17
Table 7-1. Unit Costs 7-1
Table 7-2. Near Term (0-5 Year) Annual CIP 7-3
Table 7-3. 6-10 Year Annual CIP 7-5
Table 7-4. Long Term (> 10 Year) Annual CIP 7-7
Table 7-5. Overall CIP by Planning Year 7-9
Table 7-6. Overall CIP by Constraint 7-10

List of Abbreviations

AACE	Association for the Advancement of Cost Engineering
AC	asbestos cement
ADD	average day demand
AF	acre-feet
AFY	acre-feet/year
APN	Assessors Parcel Number
Ave	Avenue
AWWA	American Water Works Association
BC	Brown and Caldwell
Blvd	boulevard
BPS	booster pump station
CI	cast iron
CII	commercial, industrial, and institutional
City	City of Davis
CIP	Capital Improvement Plan
Cir	Circle
CO	commercial
COF	consequence of failure
CPG	Conaway Preservation Group
CSA	county service areas
DDW	Division of Drinking Water
DI	ductile iron
DLR	detection limit for purposes of reporting
DOF	Department of Finance
Dr	Drive
DWR	Department of Water Resources
eAR	electronic annual reporting
EPS	extended period simulation
ET	evapotranspiration
ft	feet
GIS	geographic information systems
gpcd	gallons per capita per day
gpm	gallons per minute
GSP	Groundwater Sustainability Plan
HGL	hydraulic grade line
HPC	Health Protective Concentration
IAP	InfoAsset Planner program
In	inches
IN	industrial
IRR	irrigation
LCR	lead and copper rule
LDD	low day demand
LF	linear feet
LOF	likelihood of failure
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
MDD	maximum day demand
MFR	multi-family residential
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MWELO	Model Water Efficient Landscape Ordinance
NDM	North Davis Meadows
NL	Notification Level
No	number
NRW	non-revenue water
OEHHA	Office of Environmental Health Hazard Assessment
O&M	Operations & Maintenance
PFAS	per- and poly-fluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFHxS	perfluorohexane sulfonic acid
PFOS	perfluorooctanesulfonic acid PVC polyvinyl chloride
PHD	peak hour demand
PHG	public health goals
Pl	Place
psi	pound per square inch
PVC	polyvinyl chloride
Rd	road
RL	Response Level
RPM	rotations per minute
RWTF	Regional Water Treatment Facility
SB	Senate Bill
SC	school
SCADA	Supervisory Control and Data Acquisition

SFR	single-family residential
SGMA	Sustainable Groundwater Management Act
St	street
SNL	State Notification Level
SWRCB	State Water Resources Control Board
UCD	University of California, Davis
µg/L	micrograms per liter
UPPR	Union Pacific Railroad
USGS	United States Geological Survey
UWDF	unit water demand factors
UWMP	Urban Water Management Plan
UWUO	Urban Water Use Objective
VFD	variable frequency drive
WDCWA	Woodland Davis Clean Water Agency
WSOP	Water System Optimization Plan
WO	work order
yr	year
YGSA	Yolo Subbasin Groundwater Agency

Executive Summary

The objective of the 2023 Water System Optimization Plan (WSOP) is to develop financial and managerial strategies to guide the continued operation of the water system on the most reliable and cost-effective path forward. Specifically, the 2023 WSOP develops an understanding of existing water demands and how future growth within the City of Davis (City) water service area impacts water demands, identifies strategies for sustained supplies to meet existing and future demand, analyzes well head treatment opportunities and corresponding increases in available and reliable groundwater pumping capacity, evaluates maximum day water demands, develops an understanding of relative pipe risk to inform distribution piping replacement, and updates the City water distribution Capital Improvement Plan (CIP).

Description of Existing System

The City is located 12 miles west of Sacramento in the southeastern corner of Yolo County. Water service is provided to all residential (single and multi-family), commercial, industrial, and irrigation customers, and for open space and fire protection uses within the service area.

The water system is supplied by surface water from the Woodland Davis Clean Water Agency (WDCWA) Regional Water Treatment Facility (RWTF) and local groundwater wells. A portion of the WDCWA surface water is delivered to University of California, Davis (UCD) via the City's surface water transmission mains. There is approximately 199 miles of piping within the water system as well as three storage tanks and two booster pump stations.

Water Demand Analysis

Currently, the City has a population of 68,886 and 17,241 connections. The City is projected to have a population of 72,884 and a total number of connections of 18,383 at buildout. The existing and projected population and connection information within the City is shown in Figure ES-1.

Buildout unit water demand factors (UWDFs) are developed by reviewing the City's historical water demand by customer category in comparison to the land area served and the number of connections by category. In addition, buildout UWDFs assume the City will meet its water use goals that consist of draft Department of Water Resources (DWR) water use objectives. The projected buildout per capita water use is 126 gallons per capita per day (gpcd) and is shown in Figure ES-2.

The buildout water demands are estimated by combining the estimated number of buildout connections with the buildout water use per connection UWDF for each customer category. The City's buildout water demand is projected to be 10,291 acre-feet per year (AFY). The City's historical water production and projected water demand is shown in Figure ES-3.

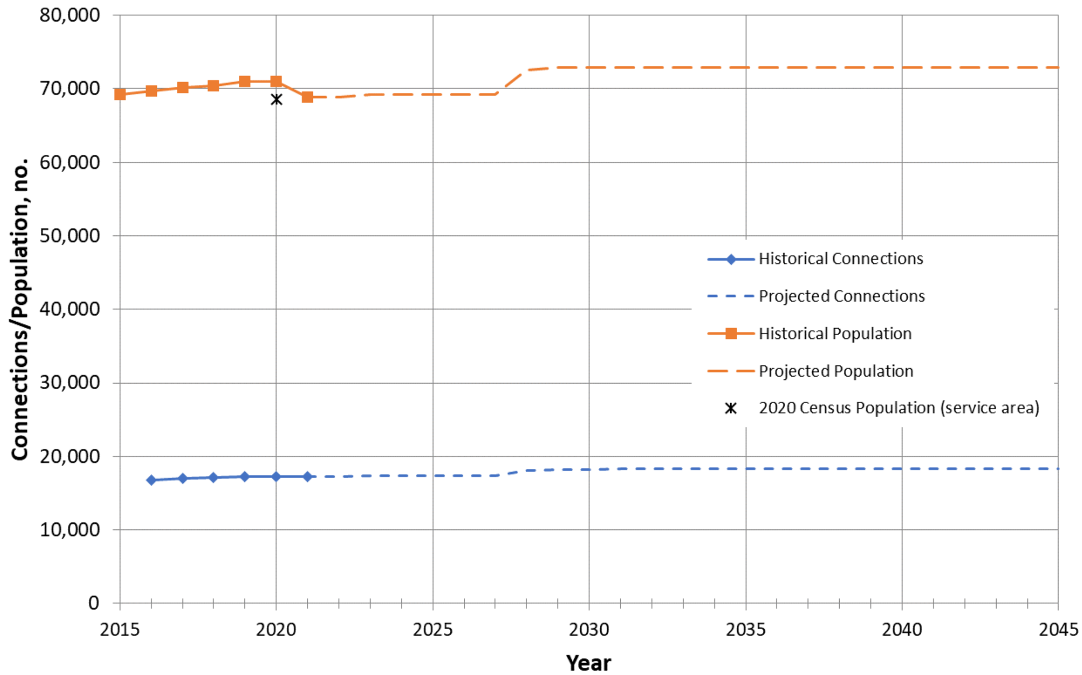

Figure ES-1. Existing and projected population and connections

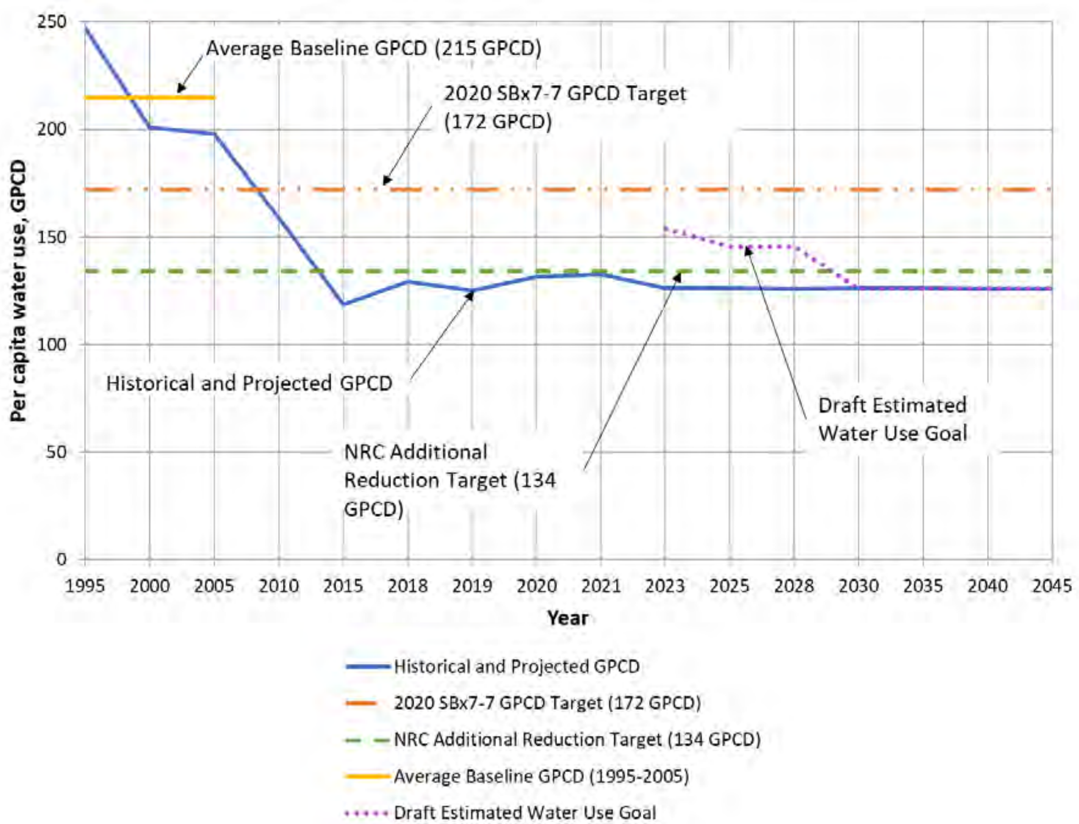

Figure ES-2. Historical and projected per capita water use versus goals

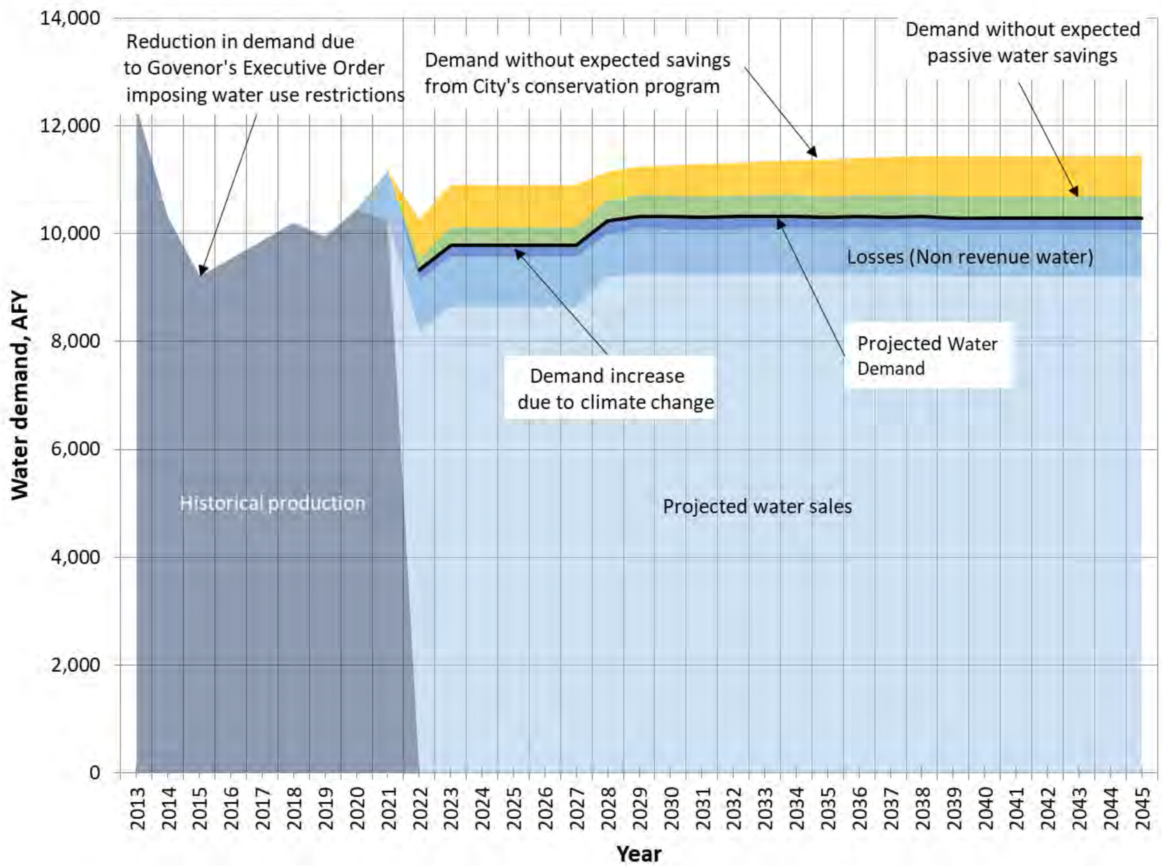

Figure ES-3. Projected water demands

Water Supply

The City receives surface water from the WDCWA as its primary water source and continues to operate nine groundwater wells to meet peak demands and provide a reliable supplemental water source for the water system. The City is entitled to deliveries of 10.2 million gallons per day (mgd) from the WDCWA in normal years, totaling approximately 11,425 AFY. 3 mgd is the minimum supply available to the City in dry years. It is unlikely that the City would ever rely entirely on surface water supplies in dry years due to curtailments.

The groundwater basin underlying the City is in the California Department of Water Resources' Yolo Subbasin (5-021.67), which is part of the larger Sacramento Valley Groundwater Basin. The Yolo Subbasin Groundwater Agency (YSGA) is a joint powers authority responsible for overall management of the YSGA including implementation of the Sustainable Groundwater Management Act (SGMA) and YSGA's Groundwater Sustainability Plan (GSP). The projected sustainable yield for the Yolo Subbasin of 346,000 AFY is expected to be met in the future by collaboration of all YSGA entities through management actions to ensure beneficial use is protected. Approximately 70 percent of the City's deep well capacity (approximately 12,800 AFY) is usable on an annual basis considering the variation in monthly demands.

It is estimated that the City will have sufficient supply (in both normal and dry years) to meet its projected demands in 2045. Furthermore, it is projected that the City will be able to meet its 2045 demands with only groundwater supply from deep wells. It is unlikely that the City ever would rely entirely on surface water supply in dry years due to curtailments (3 mgd is minimum available in dry years).

Water is treated at both surface water and groundwater supply sources. For surface water treatment, raw water from the Sacramento River is treated at the RWTF by the treatment processes of flash mixing, clarification, ozonation, granular media filtration, chlorination, and ortho-phosphate (corrosion control). Groundwater is treated at each well head with chlorine for disinfection. In addition, Well 32 has a manganese treatment facility to remove manganese from the source water before entering the distribution system. Per the City's most recent Annual Water Quality Report, also referred to as the Consumer Confidence Report, the City's water is compliant with all state and federal drinking water requirements.

Recommendations for wellhead treatment are provided for five of the City's wells. Ion exchange and ferric coagulation w/green sand filtration are treatment type recommendations with construction costs ranging from $700,000 to $3,000,000. In all cases, recommended treatment equipment improvements cannot be accommodated within the existing well sites.

Water System Capacity Evaluation

The City's storage and distribution facilities were analyzed. A desktop storage analysis concludes that the existing storage pumping capacity and storage volume criteria are both met without the need for additional pumping or storage capacity. Firm supply pumping capacity is analyzed and met for maximum day demand (MDD), MDD plus fire flow, and peak hour demand (PHD). A storage volume analysis concluded that existing storage tank facilities provide equalization/operational and fire storage requirements and approximately half (12 hours) of emergency storage capacity. The groundwater aquifer storage (deep and intermediate wells combined) can supply the remaining emergency storage requirements and therefore additional storage is not necessary.

The distribution facilities analysis evaluated existing and buildout scenarios that include pressures, velocities, and unit headlosses throughout the pipe network as well as fire flow availability. The City's Innovyze InfoWater water system hydraulic model was utilized for the analysis. The modeling analysis concludes for the existing system that minimum and maximum pressures and maximum velocities met the evaluation criteria, however maximum unit headlosses and MDD plus Fire Flow criteria are not met in some areas. After incorporating improvements to meet existing system deficiencies, all evaluation criteria are met at buildout except for velocity in one area and maximum unit headloss in eight areas. Both existing and buildout capacity improvements are recommended to alleviate system deficiencies and are illustrated in Figures ES-4 and ES-5.

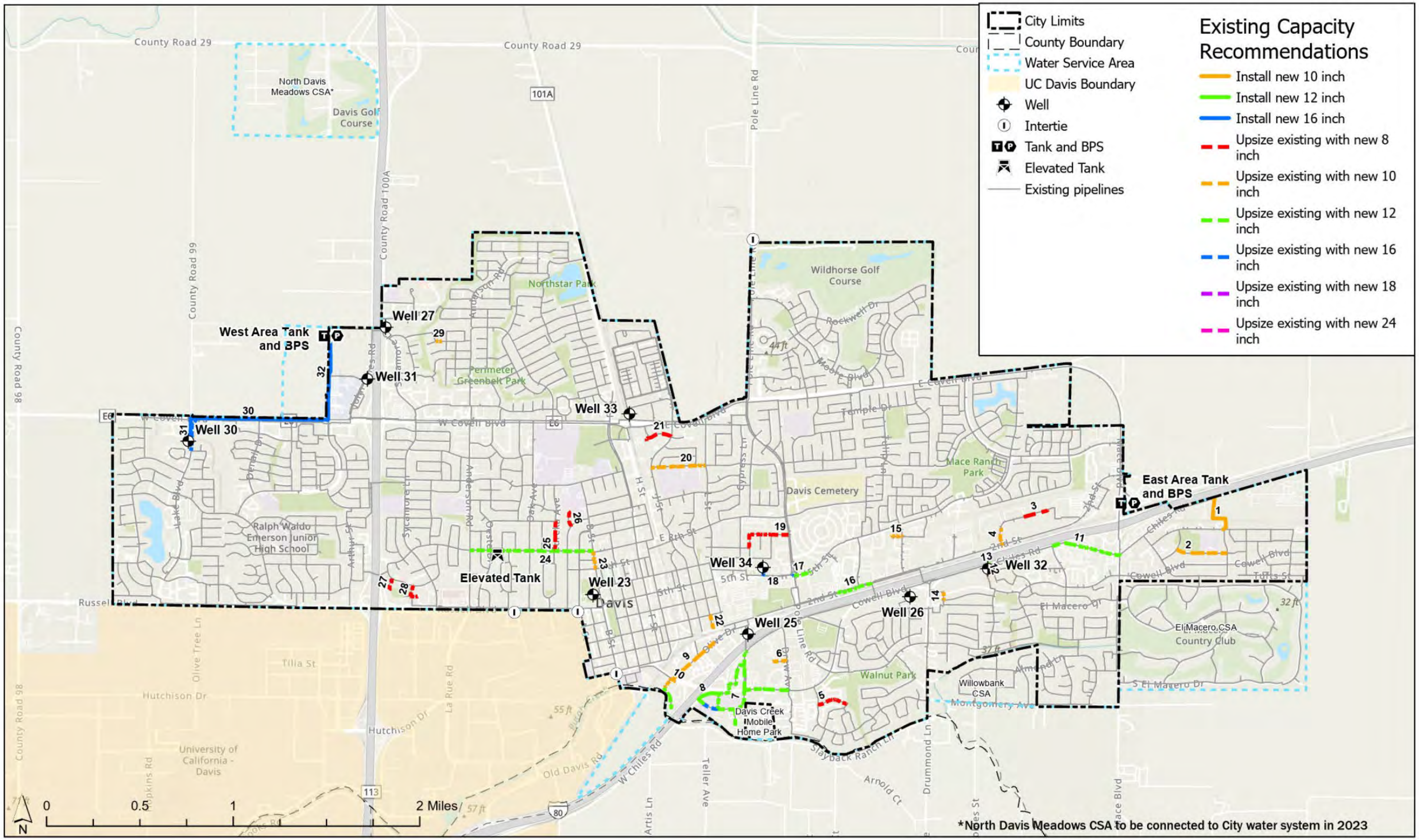

Figure ES-4. Existing system recommended capacity improvements

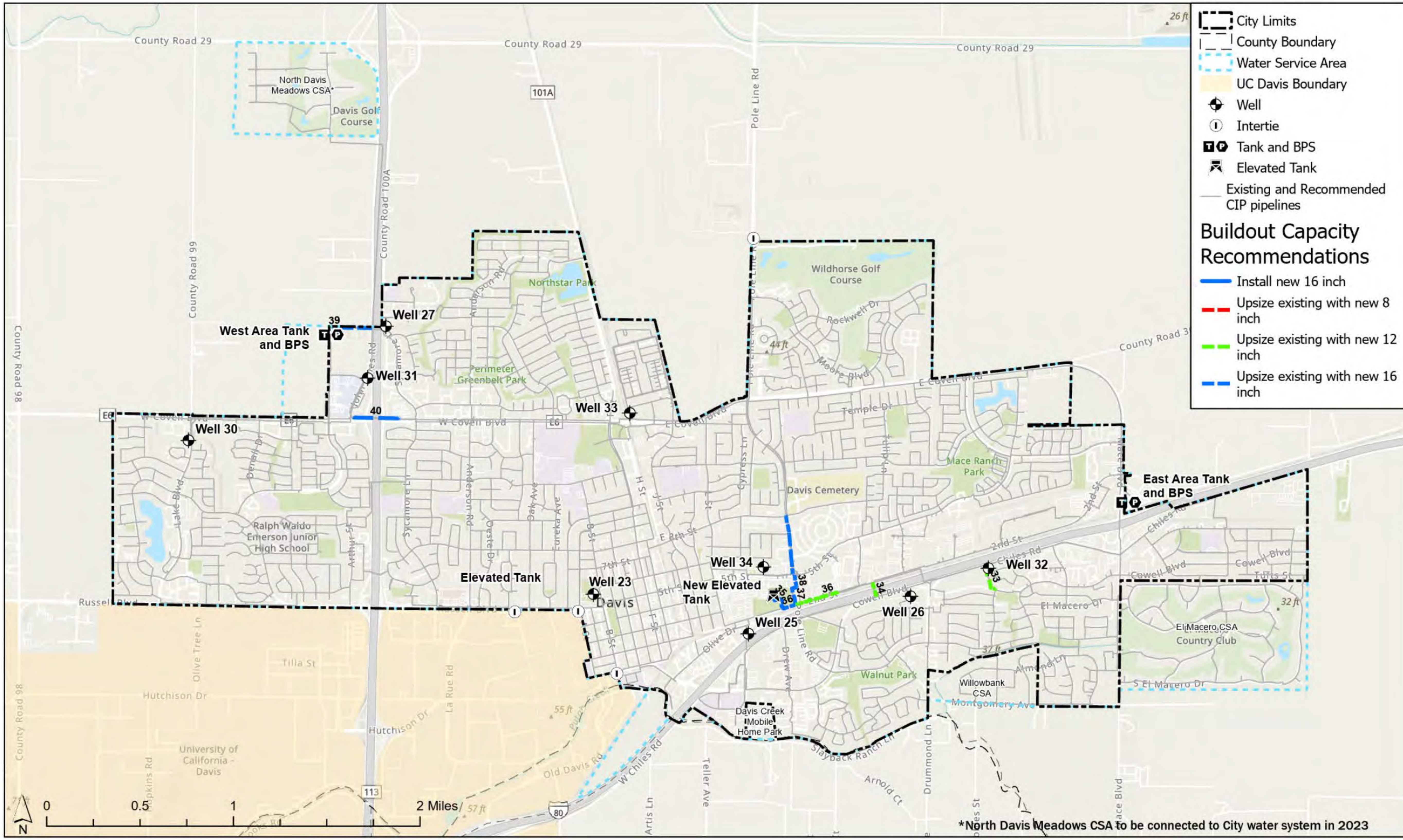

Figure ES-5. Buildout system recommended capacity improvements

Existing System Pipe Risk Analysis

The relative risk of failure for the City's water pipelines is evaluated in a desktop risk analysis by considering likelihood and consequence of failure. Understanding the relative risk of failure for various water pipelines is critical to planning CIP projects effectively by prioritizing the highest risk projects. In general, pipe characteristics (e.g. age, material, pipe diameter, break history), and information associated with the pipe or service location (e.g. proximity to natural hazards, critical customers, roads) are combined to determine overall risk of failure.

In conclusion, the pipe risk analysis identified 16.9 miles of pipe as high risk. Based on recent City pipeline replacement budgets, a replacement rate of approximately 3,200 linear feet (LF) per year would replace over five miles of the identified 16.9 miles of high risk pipe over the next 10 years. Figure ES-6 illustrates the recommended annual pipeline replacement program for the next 10 years.

Capital Improvement Program

The recommended CIP is based on the evaluations described in the water system capacity analysis and existing system pipe risk analysis. The CIP is prepared for 0-5-year, 6–10-year, and >10 year terms. Recommendations are prioritized based on input from the City. Planning level cost information is based on the Association for the Advancement of Cost Engineering (AACE) International Costs Estimate Classification System for Class 4. The recommended CIP shown in Table ES-1 and Figure ES-7 identifies $55 million of recommended improvements.

Table ES-1. Overall CIP by Planning Year

		Annual			Planning Year			
Planning Year	Year	Total LF	%	Cost, $	Total CIP LF	% of CIP Total	Cost, $	Average Annual, LF
Near Term (0-5 years)	2023	15,070	22%	14,372,000	35,160	52%	30,575,000	7,032
	2024							
	2025	11,298	17%	9,187,000				
	2026	4,889	7%	3,790,000				
	2027	3,903	6%	3,226,000				
5-10 years	2028	5,700	8%	5,329,000	25,549	38%	15,636,000	5,110
	2029	4,800	7%	4,318,000				
	2030	9,209	14%	106,000				
	2031	4,295	6%	4,322,000				
	2032	1,545	2%	1,561,000				
Long Term (>10 years)	2033-2045	6,643	10%	9,355,000	6,643	10%	9,355,000	511
Total	-	**67,352**	**100%**	**55,566,000**	**67,352**	**100%**	**55,566,000**	**2,928**

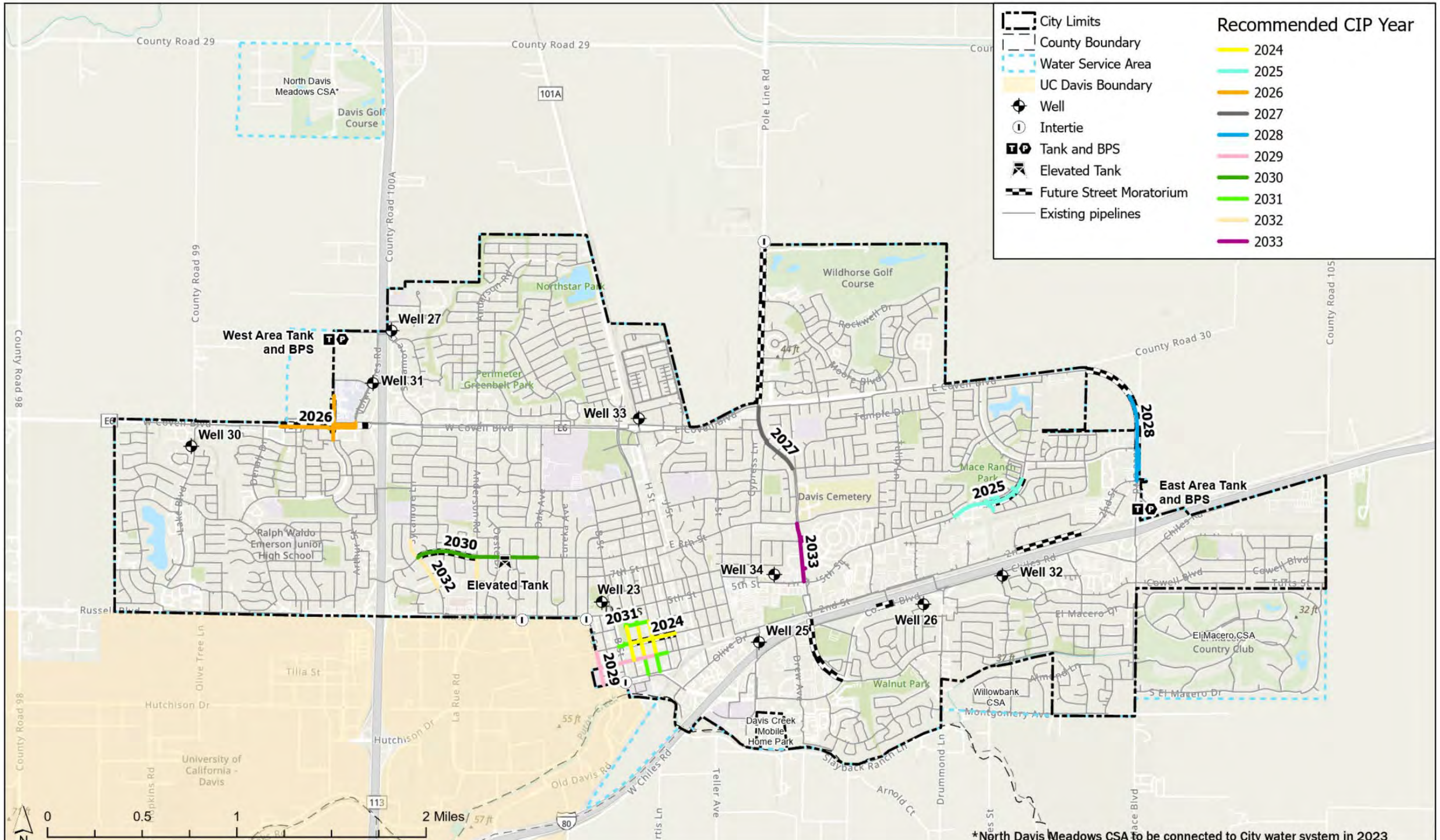

Figure ES-6. Annual pipeline replacement program

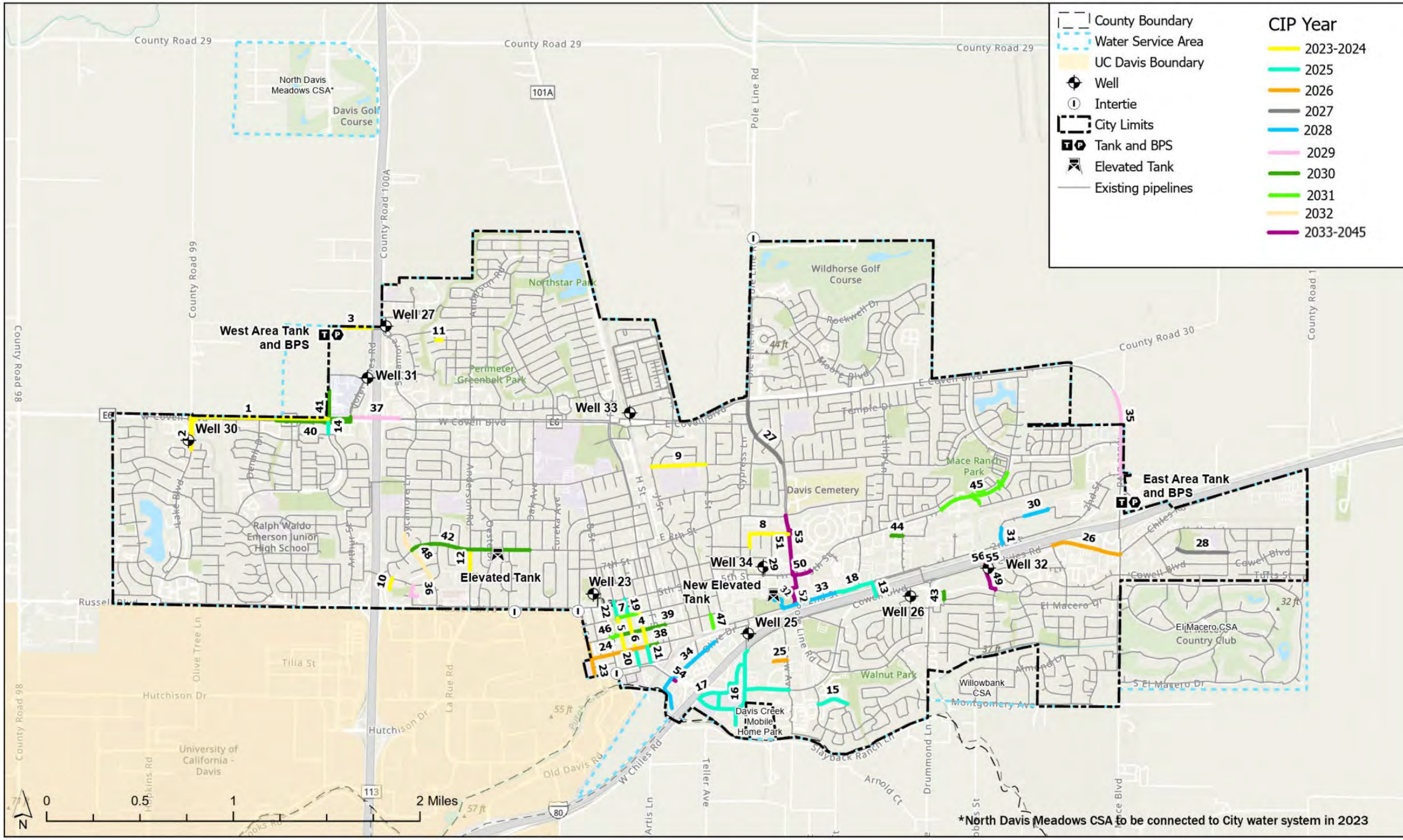

Figure ES-7. Overall CIP

Section 1

Introduction

The City of Davis (City) developed the 2011 Water Distribution System Optimization Plan to guide the integration of the Woodland Davis Clean Water Agency (WDCWA) surface water supply with the City's water system infrastructure (Brown and Caldwell [BC], 2011). The 2011 Water Distribution System Optimization Plan described the hydraulic model tool utilized to analyze the City's distribution system, updated the City's water demand projections, developed a condition assessment and hydraulic evaluation of the existing system, and recommended capital improvements. Now that the WDCWA project has been fully integrated, the purpose of this 2023 Water System Optimization Plan (WSOP) is to update the water demand projections, evaluate the existing system, and recommend updated capital improvements for the City's water system service area.

1.1 WSOP Objectives

The objective of the WSOP is to develop financial and managerial strategies to guide the continued operation of the water system on the most reliable and cost-effective path forward.

Specifically, the WSOP addresses the following objectives and is shown in Figure 1-1:

1. Understand existing water demands and how future growth within the city's water service area impacts water demands.
2. Identify strategies and improvements for sustained supply that will meet existing and future demands.
3. Analyze well head treatment opportunities and corresponding increases in available and reliable groundwater pumping capacity.
4. Evaluate maximum day water demands to appropriately update assumptions with Division of Drinking Water requirements.
5. Understand relative pipe risk to inform distribution piping replacement.
6. Update the City's water Capital Improvement Plan (CIP) to include water system improvements to meet capacity and replacement needs.

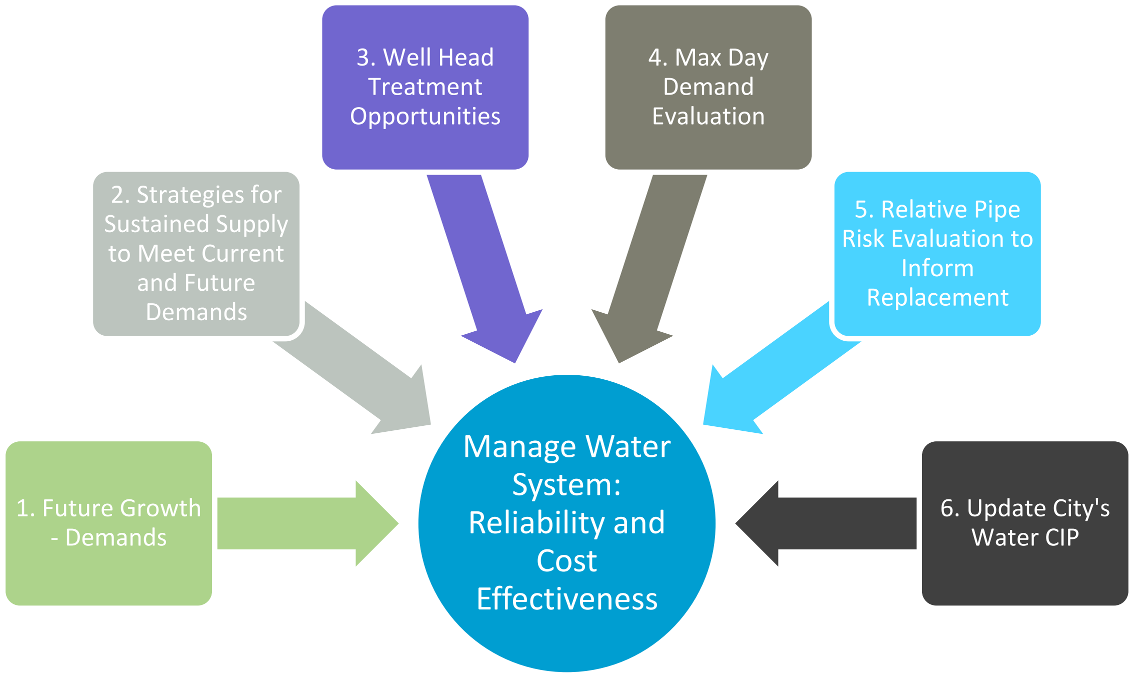

Figure 1-1. The City's Objectives for the WSOP work towards managing the water system in a way that balances cost effectiveness and reliability.

1.2 WSOP Approach

This report is organized into seven sections followed by a series of appendices, which provide supporting information to the body of the report. The sections are listed and described below:

- **Section 1 Introduction** – A description of the WSOP objectives, report organization, and other relevant City reports.
- **Section 2 System Description** – A description of the service area and the water system facilities, including the surface water supply, groundwater wells, piping system, water storage tanks, booster pumping stations, and interties.
- **Section 3 Water Demands** – A summary of the existing and projected water demands.
- **Section 4 Water Supply Evaluation** – A description of the City's water supply to include water quality. The section includes an evaluation of well head treatment opportunities and the corresponding increase in available and reliable groundwater pumping capacity.
- **Section 5 Water System Capacity Evaluation** – A desktop storage and hydraulic analysis to determine capacity driven improvements.
- **Section 6 Pipe Risk Analysis** – A desktop analysis of relative risk of failure for the City's water distribution pipelines using a likelihood and consequence of failure analysis to determine aging infrastructure replacement recommendations.
- **Section 7 Capital Improvement Plan** - A five and ten-year CIP based upon the recommendations provided in Sections 4, 5 and 6.

The WSOP approach integrates the WSOP objectives in the development of the WSOP report sections and is illustrated in Figure 1-2.

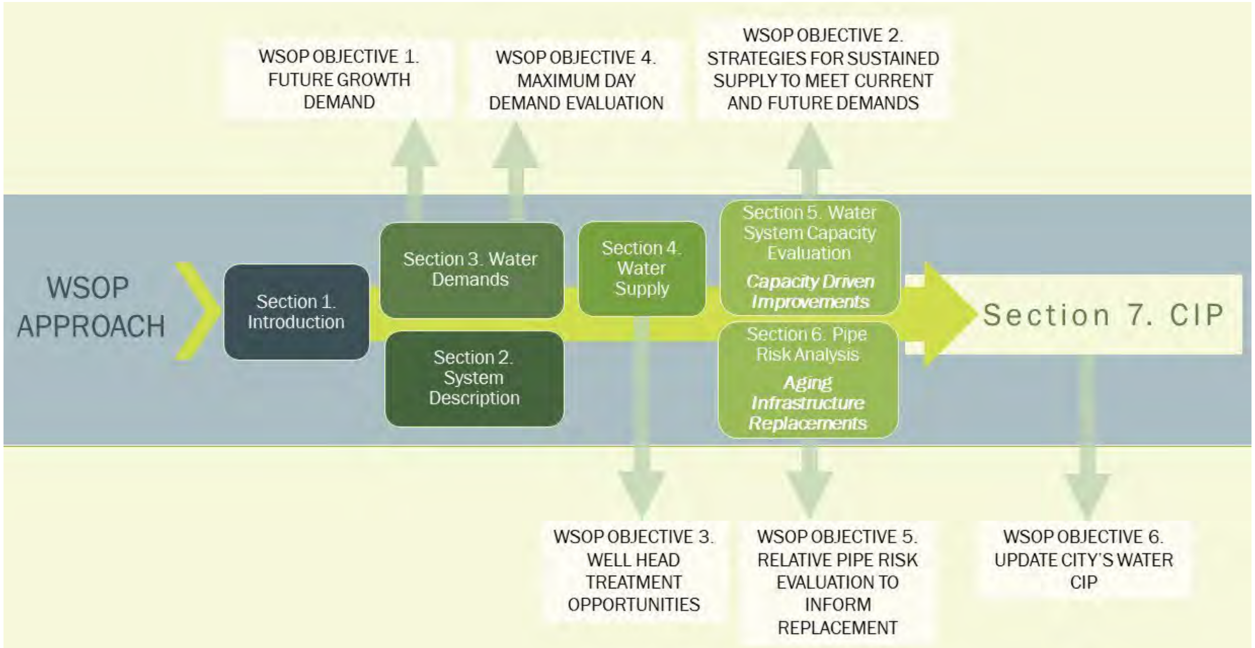

Figure 1-2. WSOP approach

1.3 Other Relevant Reports

This section provides a list of relevant City documents that have been prepared prior to this WSOP, in order of most recent to oldest.

2021 Model Update Report (BC, March 2021) – Describes the City's hydraulic model update including calibration, existing demand calculations, future demand projections, and model scenarios for existing, buildout, and 2025 conditions.

2020 Urban Water Management Plan (BC, June 2021) – Describes the City's water system service area and demographics, analyzes water use and estimates future water demands considering the City's water conservation program and potential climate change impacts, summarizes the City's water supplies and the reliability of those supplies. A 5-year drought risk assessment is included as well as an updated water shortage contingency plan.

2013 Integrated Water Resources Study (BC, August 2013) – Evaluates a variety of water management options to form the elements of a long-term sustainable water supply strategy for the City, identifies options that are practical to implement in addition to the City's existing groundwater supply and planned surface water supply, and identifies the options that are not practical for the City to implement. The objective is to develop a strategy for a sustainable water supply future that consists of various water management options.

2011 Water Distribution System Optimization Plan (BC/Kennedy Jenks, May 2011) – Defines the improvements needed to optimally integrate the WDCWA surface water supply for the City. This Plan describes the hydraulic model tool, water demand projections, condition assessment, hydraulic evaluation, and recommended capital improvements.

Davis Public Works Revised Design Standards (City of Davis, September 1991).

Section 2

Description of Existing System

This section describes the City's existing water system. It contains a description of the service area and the water supply and distribution facilities, including the surface water supply, groundwater wells, piping system, storage facilities, booster pumping stations, and interties.

2.1 Description of Service Area

The City is located in the Central Valley of California, to the east of the coastal mountain range and San Francisco Bay Area and 12 miles west of the state capital of Sacramento in the southeastern corner of Yolo County. Incorporation of the City occurred in 1917. Water service is provided to all residential (single and multi-family), commercial, industrial, and irrigation customers, and for open space and fire protection uses within the service area. As shown in Figure 2-1, the City's water system serves customers within the City of Davis and the El Macero and Willowbank county service areas (CSA) and the Davis Creek Mobile Home Park, located adjacent to the City. The City has one automated intertie and additionally two emergency interties with University of California, Davis (UCD), located just south of the City limits. There is an additional CSA (also known as North Davis Meadows) located north of the City, that is not currently connected to the City's water system. The City is planning to connect North Davis Meadows (NDM) to its existing water system in 2024. Figure 2-1 shows the layout of the City's water system.

The system is supplied by surface water from the WDCWA Regional Water Treatment Facility (RWTF) and local groundwater wells. A portion of the WDCWA surface water is delivered to UCD via the City's surface water transmission mains near Well 33. Figure 2-2 shows a hydraulic schematic of the system which illustrates the relationship between supply, pumping, and storage facilities. The elevation of the storage tanks and the range of customer service elevations are also illustrated in Figure 2-2.

As shown in Figure 2-2, the water system consists of one pressure zone with existing service elevations ranging from 24 to 62 feet (ft) in elevation. The highest elevations are on the west side of the City and lowest are on the east. The hydraulic grade line (HGL) of the water system is dependent on the elevated storage tank and pressures from the WDCWA supply intertie.

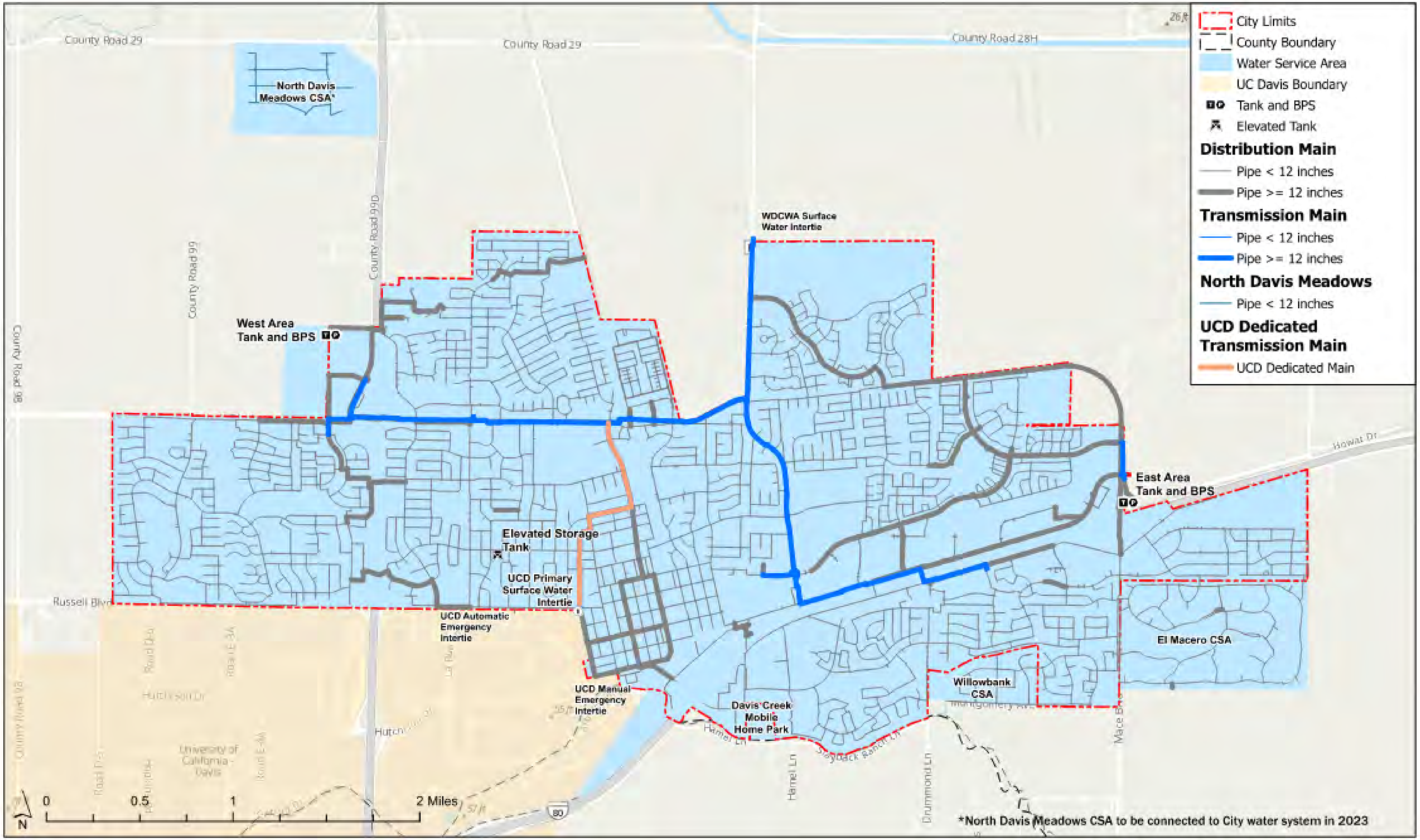

Figure 2-1. City of Davis water system map

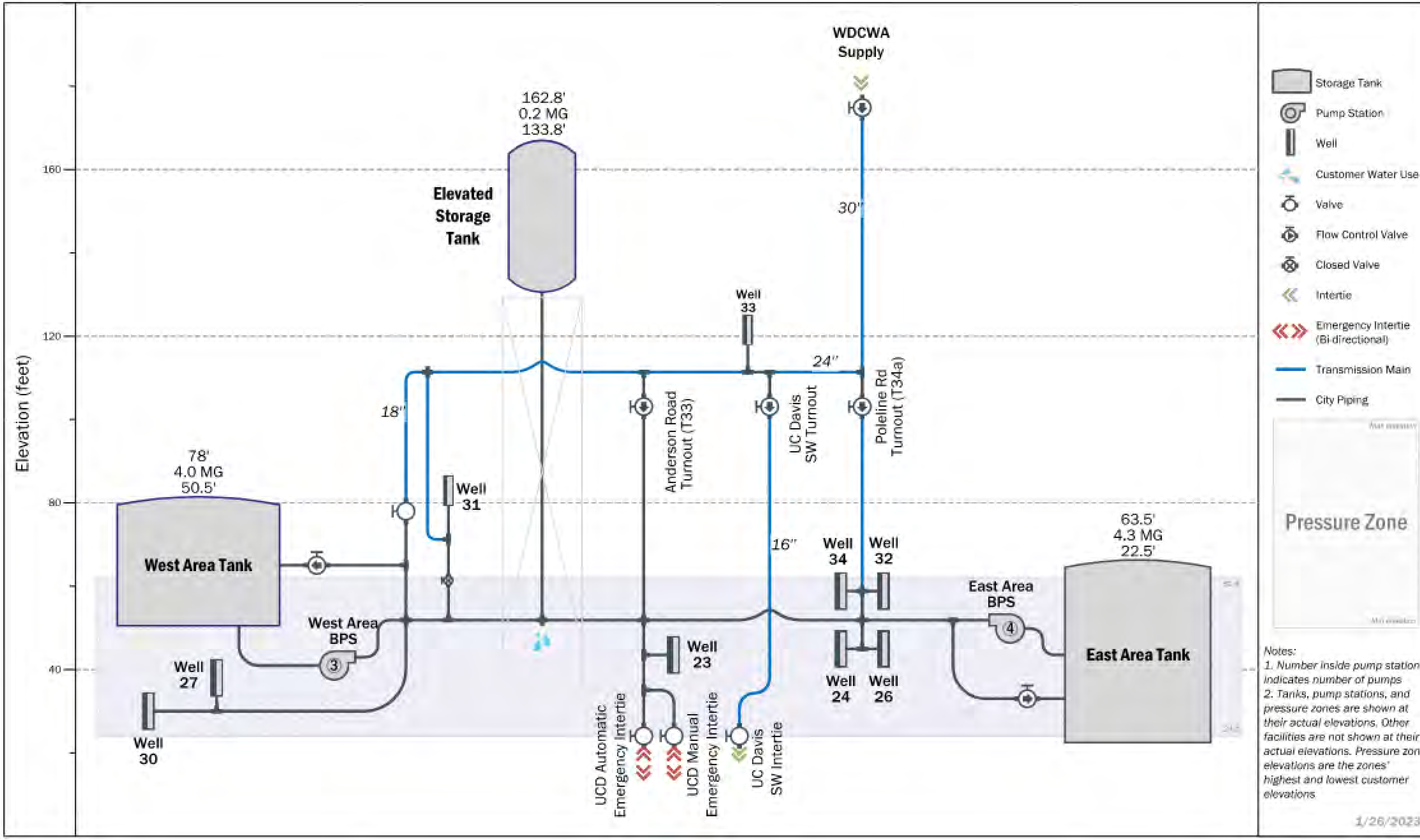

Figure 2-2. Water system hydraulic schematic

2.2 Water Supply Facilities

The City has a conjunctive use water system supplied by surface water from the WDCWA and groundwater from local wells.

2.2.1 WDCWA Supply

The WDCWA operates the RWTF to treat and distribute surface water from the Sacramento River. Surface water from the WDCWA is conveyed to the City from the RWTF approximately seven miles to the north of the City. The WDCWA surface water intertie with the City is located on Pole Line Road at the City limits near Wildhorse Golf Course.

2.2.2 Groundwater Wells

The City has nine active intermediate and deep groundwater wells. Table 2-1 summarizes information about the existing wells gathered from pump tags, pump curves, and City spreadsheets.

Table 2-1. Groundwater Supply Wells

Well Number	Well Depth Classification[a]	Location	Surface Elevation[b] (ft)	Actual Capacity[a] (gpm)	Pump Information					
					Manufacturer	Model	Design Flow (gpm)	Design Head (ft)	Speed (RPM)[c]	VFD[d]
23	Intermediate	527 B St	45	1,600	Peerless Vertical	14MC	1,750	278	N/A[e]	No
24	Intermediate	1600 Olive Dr	44	1,600	Byron Jackson	12HQRL	1,600	250	1,775	No
26	Intermediate	2850 Covell Blvd	38	1,500	Goulds	12DHLC	1,500	236	n/a	No
27	Intermediate	State Route 113	49	1,300	Goulds	12RJHC	1,400	265	1,740	No
30	Deep	Lake Blvd	55	2,300	Flowserve	14ENL	2,632	370	1,775	No
31	Deep	2074 John Jones Rd	48	2,500	Goulds	14RHHC	2,800	343.5	1,770	Yes
32	Deep	3608 Chiles Rd	35	2,650	Flowserve	12EBM	2,250	380	1,775	Yes
33	Deep	Covell Blvd	45	1,800	Flowserve	14EMM	1,800	330	1,775	Yes
34	Deep	1813 Fifth St	45	2,300	Floway Pumps	12 FKH	2,250	345	1,785	Yes

a. *Per City staff*
b. *Per City spreadsheet titled "Supply-2 Static Water Levels.xlsx"*
c. *RPM = rotations per minute*
d. *VFD = variable frequency drive*
e. *N/A = not available*

2.3 Water Distribution System

The City's water piping system consists of both distribution piping and transmission piping from the WDCWA surface water project. The City's system incorporates the use of storage facilities and associated booster pump stations as well as interties with UCD.

2.3.1 Pipelines

The water system consists of approximately 199 miles of piping with diameters ranging from 2 to 30 inches (in). Table 2-2 lists the length of piping by diameter and material. Material type was determined from the City's hydraulic model. Figure 2-3 provides a breakdown of the LF of each pipe diameter by material type. About 94 percent of the water system is 12-inch diameter or less. Approximately 62 percent of the pipelines are ductile iron (DI) pipe or polyvinyl chloride (PVC), 18 percent are cast iron (CI), 17 percent are CI or AC, and 3 percent are unknown.

Table 2-2. Water System Piping Material Summary

Diameter (in)	Length by Material (LF)				Total (LF)
	Cast Iron	CI or AC	Ductile Iron	Unknown	
< 4	0	0	380	0	380
4	3,470	5,750	6,680	0	15,900
6	74,370	61,290	153,200	0	288,860
8	44,180	65,760	228,060	5,600	343,600
10	30,690	36,500	162,900	6,250	236,340
12	15,890	6,430	71,680	5,970	99,970
14	5,590	0	4,720	7,060	17,370
16	5,850	0	5,300	9,580	20,730
18	0	0	11,180	0	11,180
20	0	0	1,020	0	1,020
24	5,010	0	8,490	0	13,500
30	0	0	4,330	0	4,330
Total (feet)	185,050	175,730	657,940	34,460	1,053,180
Total (miles)	35	33	125	7	199
Percent of Length	18%	17%	62%	3%	100%

Source: City's hydraulic model

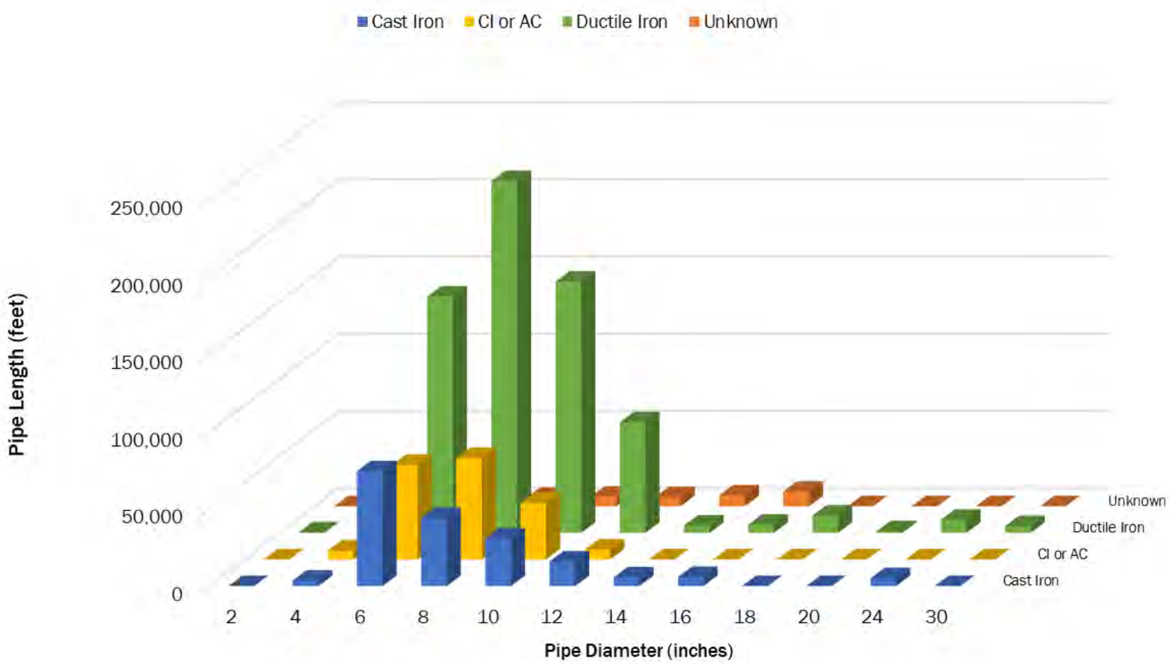

Figure 2-3. Length of pipe by material and diameter

2.3.2 Storage Facilities/Booster Pump Stations

The City utilizes storage facilities and associated booster pump stations to provide additional storage and flow to the water system during peak periods and fire protection events.

2.3.2.1 Storage Facilities

The City has three storage tanks. Two are ground level tanks that have pump stations on site to boost water into the distribution system. The oldest tank is elevated and controls the HGL of the system. The City's storage tanks are summarized in Table 2-3. The data sources listed in the table include spreadsheets and drawings provided by the City.

Table 2-3. Water System Storage Tank Facilities								
Name	Location	Volume (MG)	Floor Elevation (ft)	Height to Overflow (ft)	Inside Diameter (ft)	Material	Description	Data Source
West Area Tank (WAT)	3003 John Jones Road	4.0	50.5	27.5	154	Prestressed concrete	Filled from pressurized WDCWA supply	"WAT Data Sheet.xls"
East Area Tank (EAT)	40085 County Road 32 A	4.0	22.5	41.0	135.33	Reinforced and prestressed concrete	Filled from pressurized WDCWA supply	"EAT Data Sheet.xls" and EAT construction documents, West Yost Associates 2009
Elevated Tank[a]	Corner of West 8th St and Oeste Dr	0.2	133.8	29.0	Varies with depth (22-36)	Steel	Filled by distribution system	"8th Street Tank Elevation.pdf", "Capacity.pdf", and record drawings

MG = million gallons

a. Will be removed and replaced with new elevated 0.5 MG storage tank at City Parks and Recreation Corporation Yard for Buildout scenario. See Section 5.2.2 for further details.

2.3.2.2 Booster Pump Stations

Table 2-4 lists the City's two booster pump stations (BPS). Both BPS pump from ground storage from 9pm to 9am each night to serve the distribution system and to fill the elevated tank.

Pump curves for each pump are in Appendix A.

Table 2-4. Water System Pump Stations										
Pump Station	Location	Pump ID	Manufacturer	Model	Impeller Diameter (in)	Design Flow (gpm)	Design Head (ft)	Speed (RPM)	Elevation (ft)	VFD
WAT BPS	3003 John Jones Road	Pumps 1, 2, 3	Floway Pumps	12 DKM	7.708	3,750	115	1,780	49	Yes
EAT BPS	40085 County Road 32 A	Pumps 1, 2, 3, 4	Floway Pumps	14 DKH	9.125	6,000	150	1,790	30	Yes

Source: Pump information is from tags on the pumps, pump curves, and from the following record drawings: West Yost Associates, East Area Tank, April 2009 Chicago Bridge & Iron Company, November 1947

gpm = gallons per minute

2.3.3 Interties

UCD receives surface water supply from the City through one intertie to supplement UCD's groundwater supply. Additionally, two emergency interties are available to transfer water between the City and UCD. UCD retains ownership and maintenance of all three interties. Operations staff of both the City and UCD coordinate to meet UCD flow requirements. The interties are described in Table 2-5.

Table 2-5. Water System Interties				
Name	Description	Operations		Typical Operations
		To City	To UCD	
UCD Surface Water Turnout	A 16-inch diameter pipe turns out from the City's surface transmission main at Well 33. The pipe is a dedicated pipeline on F Street, owned and maintained by UCD, that runs south to UCD and enters UCD near A street and Russell Blvd.	No	Yes	UCD primary surface water intertie; allotment is 1.8 mgd except during Term 91 conditions
UCD Auto Emergency Intertie	From the distribution system at Russell Blvd and California Ave	Yes	Yes	If pressures drop on the UCD or City side, a valve will open
UCD Manual Emergency Intertie	From the distribution system at B St and 1st St	Yes	Yes	Valve needs to be manually operated and has never been exercised

Section 3

Water Demand Analysis

The development of future customer and water demand projections is estimated based on the progressive process shown in Figure 3-1. The first part of the process examines historical population, customer service connections, and customer billing data provided by the City. For the WSOP, future development information from the City is analyzed to determine customer growth to buildout. Unit water demand factors (UWDFs) are then developed based on historical use per customer classification and utilized in conjunction with land use at buildout to estimate future water demand at buildout.

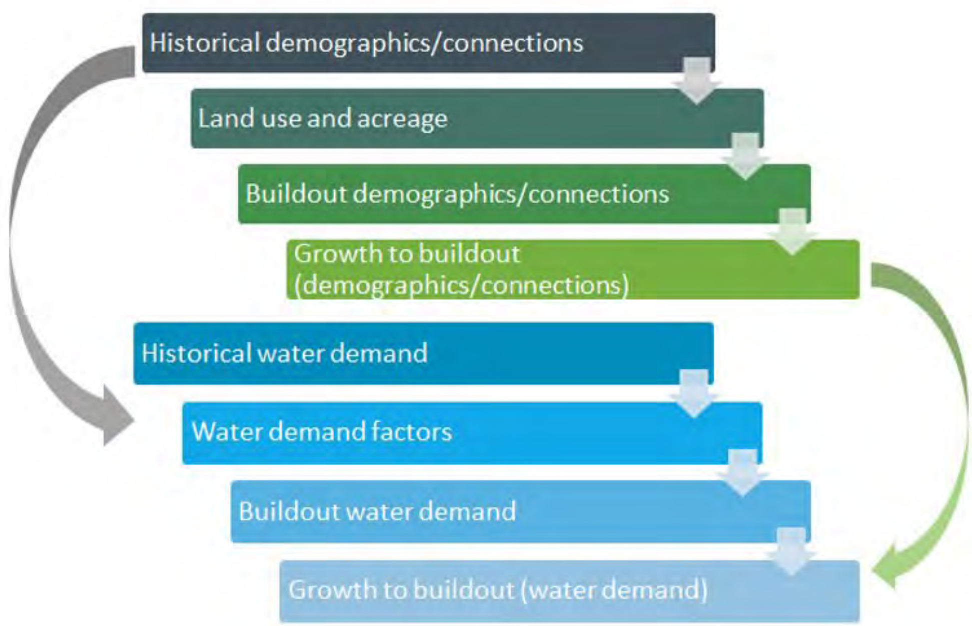

Figure 3-1. Water demand estimate analysis progression

3.1 Water Service Area Population, Connections, and Land Use

The first part of the water demand analysis is focused on examining historical demographics and connections within the City. Also, the land area currently served by the City and land area within the City that will be served at buildout is analyzed. Historical demographics, historical connection data by billing classification, and the land area are used in conjunction with buildout developed land acreage to estimate buildout demographics and connections. Once the buildout demographics are estimated, the rate of annual connection growth or each customer sector is estimated.

3.1.1 Population and Connections

The City's population has been increasing since the 1960's. Most of the City's growth was in the residential and open space land use categories, with a relatively small increase of commercial development. Significant multi-family residential development occurred to meet increasing student population housing needs of the University of California, Davis (UCD). In the commercial sector, there was some growth in high technology and tourist related businesses. The City continues to be primarily a residential community, with modest but growing commercial and industrial sectors. The City has a mix of commercial customers, ranging from restaurants, markets, retail stores, insurance offices, beauty shops, gas stations, and office buildings. The City draws visitors from its close affiliation with UCD, proximity to the Interstate 80 corridor, and annual special events.

The City has a very small industrial sector, primarily centered on technology and light manufacturing. The City has a stable institutional/governmental sector, consisting primarily of local government, schools, public facilities, and hospitals.

The historical number of connections are based on City records by billing classification. Historical connections by classification are listed in Table 3-1. The commercial, industrial, City, and dedicated irrigation connections are combined into one group (commercial, industrial, and institutional [CII] and irrigation).

Table 3-1. Historical Connections

Billing Classification	2016	2017	2018	2019	2020	2021
Single-family	15,036	15,194	15,331	15,387	15,403	15,032
Multi-family	570	568	572	577	583	486
Multi-family Irrigation	-	-	-	-	-	67
CII and Irrigation	1,205	1,202	1,241	1,248	1,277	1,656
Commercial[a]	-	-	-	-	-	584
Industrial	-	-	-	-	-	27
School	-	-	-	-	-	22
City	-	-	-	-	-	38
CII Irrigation	-	-	-	-	-	985
Total	16,811	16,964	17,144	17,212	17,263	17,241

a. *Commercial includes Commercial, Church, Private Day Care, and Other (Garages and State Department of Forestry)*

The population estimate from the 2020 Urban Water Management Plan (UWMP) was based on the Department of Finance (DOF) 2020 estimate for the City limits, combined with the estimated population for the El Macero and Willowbank CSAs and the Davis Mobile Home Park that are located outside of the City limits. The projected population in the 2020 UWMP assumes that the City's population will grow by one percent per year through 2045.

In August 2021, the City adopted its 2021 to 2029 Housing Element which included a population growth projection of 8.1 percent through 2036, an annual average growth rate of 0.5 percent per year (City of Davis, August 2021). A one percent annual average growth rate through buildout is used for this analysis to more conservatively project water demands on the high end. The population projection through 2045 includes the El Macero CSA, the Willowbank CSA, Davis Creek Mobile Home Park, and North Davis Meadows CSA (will be connected to City system in 2023).

The 2020 Census population projection for the City's water service area is shown in Figure 3-2 for comparison purposes (United States Census Bureau, 2021). Population values from the 2020 Census are approximately 6 percent lower than the DOF data for the City of Davis. Population data from DOF will be utilized for this WSOP for consistency with the 2020 UWMP and the City's other planning documents.

Figure 3-2 shows the historical and projected population through 2045. The drop in population in 2021 is associated with a slight decrease in connections. As future developments are proposed to be constructed, population increases. As shown in Table 3-3, this analysis estimates near-term population growth associated with developments currently under construction to be online in 2023, connection of North Davis Meadows in 2023, and developments with completed planning review and pending construction to be constructed in 2028. The 2021 historical ratio of 4.4 people per residential connection is used to estimate the population increase associated with this growth. Buildout connections are estimated directly based on the buildout land area combined with the existing number of connections per acre and then on a one percent growth increase for each customer category through buildout. Population levels off due to the City reaching single- and multi-family buildout in 2029 and 2031, respectively. Table 3-2 shows the historical ratio of people per residential connections.

Table 3-2. Historical Ratio of Population per Residential Connection

Year	2016	2017	2018	2019	2020	2021
Population	69,705	70,129	70,376	70,978	70,963	68,886
Residential Connections	15,606	15,762	15,903	15,964	15,986	15,518
Single-family	15,036	15,194	15,331	15,387	15,403	15,032
Multi-family	570	568	572	577	583	486
Ratio	4.5	4.5	4.4	4.5	4.4	4.4

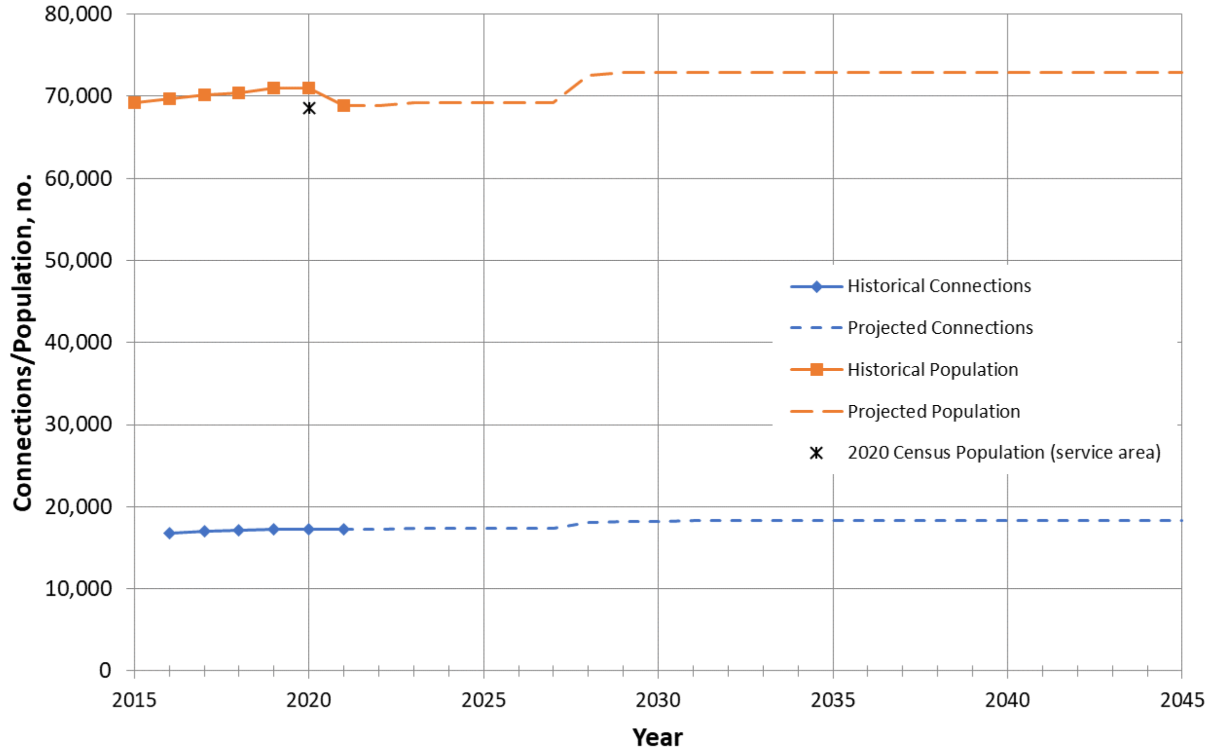

Figure 3-2. Existing and projected population and connections

3.1.2 Land Use

The City's water meters were geolocated to the City's parcels using GIS data from the Yolo County Open Data website (Yolo County, 2022). Approximately, 95 percent of the City's customers were located using GIS data. Parcels served were then spatially joined to land use data from the City's General Plan (City of Davis, 2022a). A list of the land use categories from the City's General Plan and the correlating billing classification assumed for this analysis is provided in Table 3-3. Parcels currently served by the City water system are shown in Figure 3-3. The parcels not currently served by the City's water system (no connection as of 2021) were visually verified as vacant using Google maps aerial photography. Based on the vacant land use in the service area, 93 percent of the City's service area is currently developed and served by the City's water system. It is assumed that currently vacant land within the City's service area will be developed in the future and served by the City's water system.

Table 3-3 also shows the growth in acreage and number of connections in 2023, 2028, and at buildout. Figure 3-4 shows the location and land use types of the currently proposed development. This figure includes projects that are currently under construction (assumed to be online in 2023) and those that have completed planning review and been approved by voters but are pending construction (assumed to be online in 2028).

Figure 3-5 identifies the vacant parcels that are expected to be developed and served by the City in the future according to the City's General Plan land use types. There are currently some parcels in the City's service area served by private wells. It is assumed that these parcels will remain supplied by private wells (e.g., El Macero Golf Course) and this land area will not be served by the City at buildout.

Table 3-3. Land Use Served by City's Water System Through Buildout									
Billing Classification	County Land Use	Existing (Currently Served)		Increment of Growth from Existing to 2028[c]		Increment of Growth from 2028 to Buildout[c]		Total Served by Buildout	
		Acreage	No. of Connections	Acreage	No. of Connections	Acreage	No. of Connections	Acreage	No. of Connections
Single-family Residential	Residential Low Density Residential Medium Density	2,826	15,032	355	836	11	56	3,192	15,924
Multi-family Residential	Residential Medium High Density Residential High Density Residential Very High Density	414	486	33	24	24	11	470	521
Multi-family Residential Irrigation	Multi-family Residential	190	67	33	24	24	11	247	102
Commercial[a, b]	Commercial Service Business Park Community Service Community Retail Core Retail with Stores General Commercial General Retail Mixed Use Neighborhood Mixed-Use Neighborhood Retail Retail Service Commercial	738	584	8	14	75	54	821	652
School	Public/Semi-Public	222	22	-	-	-	-	222	22
Industrial	Industrial	61	27	0.2	1	-	-	61	28
City	Public/Semi-Public	338	38	-	-	-	-	338	38
Irrigation	Agricultural/Park/school/commercial	2,101	985	1	1	25	110	2,127	1,096
Total		6,890	17,241	429	900	159	242	7,479	18,383

a. *Commercial includes Commercial, Church, Private Day Care, and Other (Garages and State Department of Forestry).*

b. *The City plans to update commercial classes to match those recommended by DWR for water use objectives in the future.*

c. *Growth projections do not currently include "build up" or revised land use zoning that may occur especially in the downtown area. This will be updated when the next City General Plan is updated.*

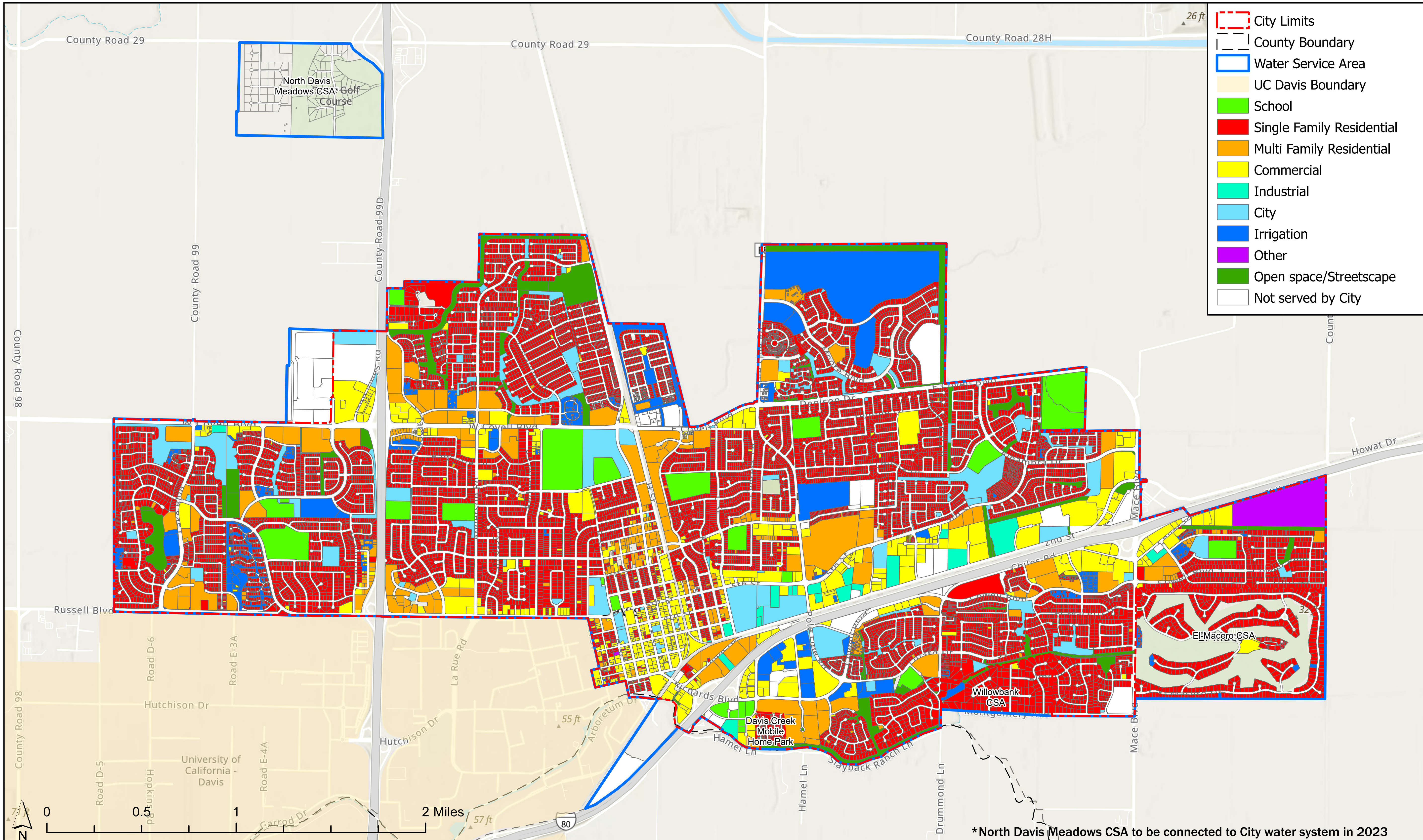

Figure 3-3. Existing land use (currently served by City water system)

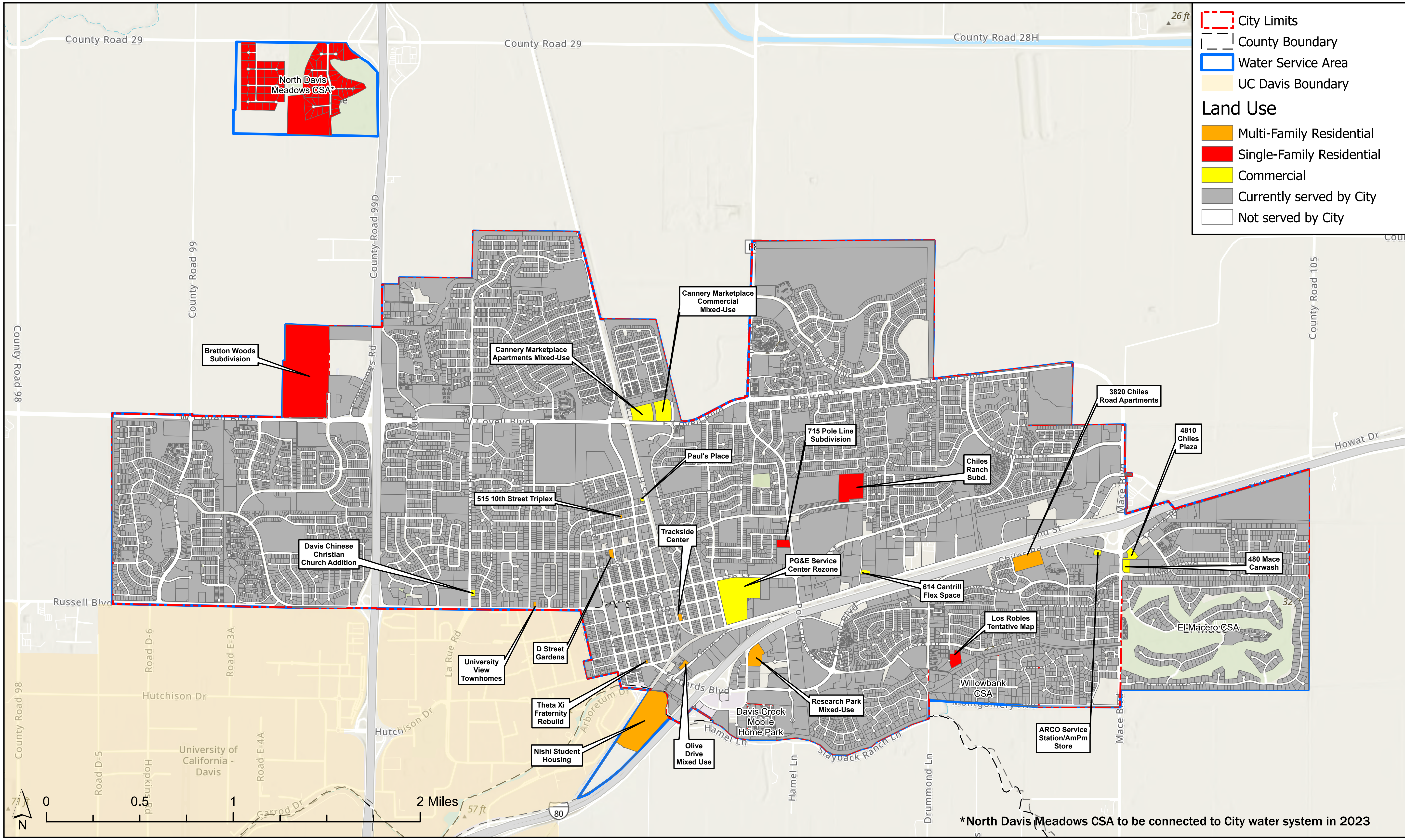

Figure 3-4. Existing to 2028 land use (to be served by City water system)

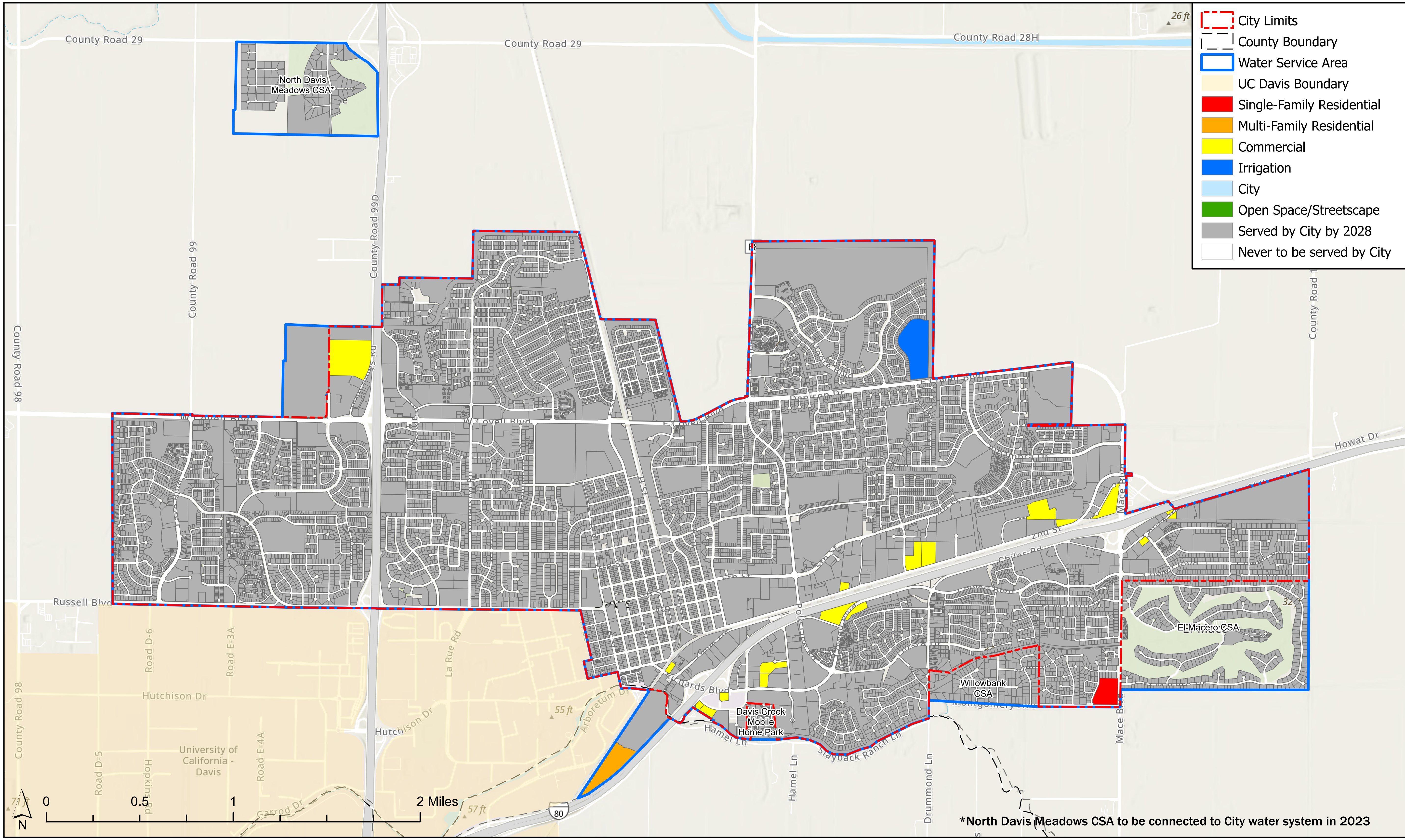

Figure 3-5. 2028 to buildout land use (to be served by City water system)

3.1.3 Growth Projections

Proposed development projects are listed in Table 3-4 and shown on Figure 3-4. The timing that the proposed developments will be added to the water system is summarized in Table 3-4. The proposed developments are projected to be constructed by 2028. Water system connections by classification are listed for each development to be constructed and served by the water system by 2028 in Table 3-4. The historical and projected connections are illustrated in Figure 3-2.

The number of connections at buildout is based on the estimate of the buildout area by land use type presented in Section 3.1.2. Buildout connections are estimated directly based on the buildout land area combined with the existing number of connections per acre and then on a one percent growth increase for each customer category through buildout (as shown in Table 3-5) as well as the following assumptions:

- Single-family residential connections
  - Projected single-family connections for developments to be constructed by 2028 are based on a dwelling unit to connection ratio of 1 (1 dwelling unit/single-family residential connection).
  - For single-family development to be constructed and served after 2028 through buildout, single-family connections are estimated based on remaining to be developed single-family land use acreage combined with the existing single-family connection per acre ratio (5.2 single-family residential connections/acre).
- Multi-family connections
  - Projected multi-family residential connections for developments to be constructed by 2028 are based on the 2021 ratio of multi-family residential dwelling units to connections (40 dwelling units/multi-family residential connection). For developments with a planned quantity of beds (or dorm style multi-family housing) the number of beds is divided by 5 and rounded up to the next highest whole number to determine the calculated number of units.
  - For multi-family development to be constructed and served after 2028 through buildout, multi-family connections are estimated based on remaining to be developed multi-family land use acreage combined with the existing multi-family connection per acre ratio (0.6 multi-family residential connections/acre).
  - Projected multi-family residential irrigation connections are assumed to be installed at the same rate as multi-family residential indoor connections (1:1).
- CII connections
  - Projected commercial connections are assumed to be one per development for developments to be constructed by 2028.
  - For CII development to be constructed and served after 2028 through buildout, CII connections are estimated based on remaining to be developed CII land use acreage combined with the existing CII connection per acre ratio (0.7 commercial connections/acre, 4.3 irrigation connections/acre, and 1.9 City connections/acre).

Table 3-4. Existing to 2028 Development and Connections

Existing Projects		Land Use Type	Demographics				
			Number of Beds	Square Footage (SF)	Acres	Dwelling Units	Number of Connections
Under Construction (2023)	3820 Chiles Rd Apartments	MFR[a]	-	N/A	8	225	6
		MFR IRR[b]	-	-		-	6
		CO[c]	-	N/A		-	1
	Cannery Marketplace Apartments Mixed-Use	CO	-	N/A	-	84	1
	Paul's Place	CO	14	N/A	0.2	21	1
	Theta Xi Fraternity Rebuild	MFR	35	N/A	-	7	1
		MFR IRR	-	-		-	1
Connection of CSA (2023)	North Davis Meadows	SFR[c]	-	-	130	-	97
Completed Planning Review and Pending Construction (2028)	480 Mace Carwash	CO	-	5,758	0.1	-	1
	515 10th Street Triplex	MFR	-	N/A	0.1	3	1
		MFR IRR	-	-		-	1
	614 Cantrill Flex Space	IN[e]	-	10,246	0.2	-	1
	715 Pole Line Subdivision	SFR	-	N/A	1.9	30	30
	4810 Chiles Plaza	CO	-	13,241	0.3	-	1
	4480 Chiles (ARCO Service Station/AmPm Store)	CO	-	2,800	0.1	-	1
	Bretton Woods Subdivision	SFR	-	-	200	610	610
	Bretton Woods Activity Center	CO	-	25,000	0.6	-	4
	Cannery Marketplace Commercial Mixed-Use	CO	-	138,000	3.2	-	1
		IRR	-	46,000	1.1	-	1
	Chiles Ranch Subdivision	SFR	-	N/A	9	96	96
	D St Gardens	MFR	-	N/A	-	7	1
		MFR IRR	-	-		-	1

Table 3-4. Existing to 2028 Development and Connections							
Existing Projects		Land Use Type	Demographics				
			Number of Beds	Square Footage (SF)	Acres	Dwelling Units	Number of Connections
	Davis Chinese Christian Church Addition	CO	-	5,280	0.1	-	1
	Los Robles Tentative Map	SFR	-	N/A	9	2	2
	Olive Drive Mixed Use	MFR	-	1,100	0.03	47	2
		MFR IRR	-	-		-	2
	PG&E Service Center Rezone	-	-	N/A	21	-	-
	Research Park Mixed-Use	CO	-	22,950	0.5	-	1
		SFR	-	N/A	4	144	1
	Trackside Center	MFR	-	-	0.5	27	1
		MFR IRR	-	-		-	1
		CO	-	8,950	0.2	-	1
	University View Townhomes	MFR	-	N/A	0.4	4	1
		MFR IRR	-	-		-	1
	Nishi Student Housing – Part 1[g]	MFR	-	-	24	350	11
		MFR IRR	-	-		-	11
Total			-	-	-	1,657	900

Source: City Planning Department and Yolo County GIS data for missing parcel acreage (Yolo County, 2022)

a. MFR = Multi-family residential

b. IRR = Irrigation

c. CO = Commercial

d. SFR = Single-family residential

e. IN = Industrial

f. Growth projections do not currently include re-densification or revised land use zoning that may occur especially in the downtown area. This will be updated when the next City General Plan is updated.

g. The second part of Nishi Student Housing is anticipated to be developed after 2028, so connections are included in Table 3-5.

As shown in Table 3-5, School and City land uses are already built out, while single-family residential and industrial land uses are not anticipated to reach Buildout until 2028. Multi-family residential and irrigation land uses are projected to reach buildout in 2031. Commercial and Irrigation land uses are not expected to be completely developed until 2037 and 2039, respectively. Growth projections do not currently include densification or revised land use zoning that may occur especially in the downtown area. This will be updated when the next City General Plan is updated.

Table 3-5. Connection Growth to Buildout

Year	Single-family Residential	Multi-family Residential	Multi-family Residential Irrigation	Commercial[a, b]	School	Industrial	City	Irrigation	Total
2021 (Existing)	15,032	486	67	584	22	27	38	985	17,241
Increment of additional annual growth from existing to 2028[c]									
2022	-	-	-	-	-	-	-	-	-
2023	97	7	7	3		-			114
2024	-	-	-	-	-	-	-	-	-
2025	-	-	-	-	-	-	-	-	-
2026	-	-	-	-	-	-	-	-	-
2027	-	-	-	-	-	-	-	-	-
2028	739	17	17	11		1	-	1	786
Increment of additional annual growth from 2028 to buildout[c]									
2029	56	5	5	6	-	-	-	11	83
2030	-	5	5	6	-	-	-	10	26
2031	-	1	1	6	-	-	-	10	18
2032	-	-	-	6	-	-	-	9	15
2033	-	-	-	6	-	-	-	10	16
2034	-	-	-	6	-	-	-	10	17
2035	-	-	-	6	-	-	-	10	17
2036	-	-	-	6	-	-	-	11	17
2037	-	-	-	4	-	-	-	11	15
2038	-	-	-	-	-	-	-	11	11
2039	-	-	-	-	-	-	-	7	7
2040	-	-	-	-	-	-	-	-	-
Total at buildout	15,924	521	102	652	22	28	38	1,096	18,383
Buildout year	2029	2031	2031	2037	2021	2028	2021	2039	-

a. *Commercial includes Commercial, Church, Private Day Care, and Other (Garages and State Department of Forestry)*
b. *The City plans to update commercial classes to match those recommended by DWR for water use objectives in the future.*
c. *Growth is only within vacant parcels within the existing City service area.*

3.2 Existing and Projected Water Demand

This section includes a discussion on historical water consumption, non-revenue water (NRW), physical (real) water loss, existing unit water demand factors, climate change impacts on water demand, water use goals, recommended unit water demand factors, water demand projections, and water demand peaking factors.

3.2.1 Historical Water Use

Water use includes water consumption by customers and NRW. The City's historical water use is illustrated in Figure 3-6. Typically, an average of recent years is used to estimate existing water use, but because the City made some adjustments to billing classifications in 2021 and previous years cannot accurately be broken down to the same level, 2021 data is used. The City's water use has not fluctuated much the last 3 years, as shown in Figure 3-6.

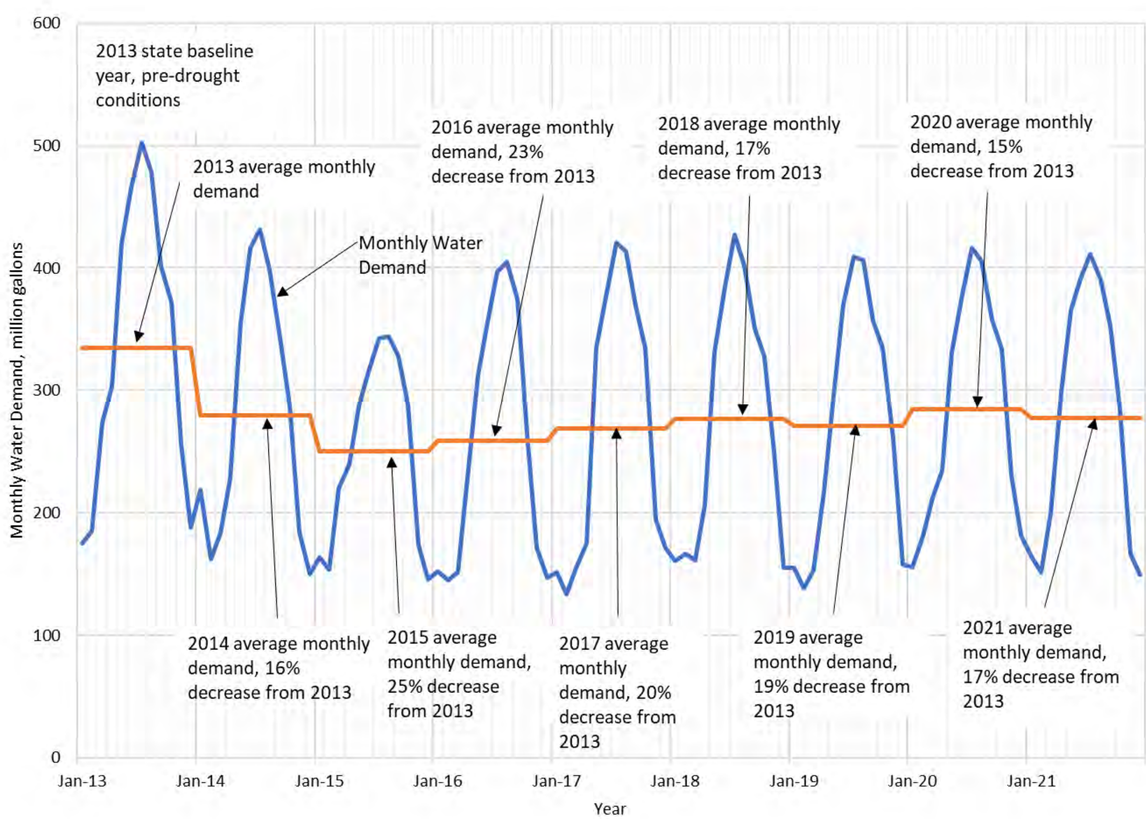

Figure 3-6. Historical water production

3.2.2 Non-Revenue Water

The difference between water production and billed water use is NRW. NRW includes the "sum of unbilled authorized consumption (water for firefighting, flushing, etc.) plus apparent losses (customer meter inaccuracies, unauthorized consumption and systematic data handling errors) plus physical (real) losses (system leakage and storage tank overflows)" (American Water Works Association [AWWA], 2012). NRW, as a part of total system production, and the breakdown of components are summarized in Figure 3-7. NRW over the last 3 years averages approximately 9 percent of the total production within the system as shown in Figure 3-8. With the incorporation of AMI throughout the City and the future addition of pressure sensors and acoustic leak detection sensors to be placed strategically within the distribution system the water loss percentage is expected to decrease in the future.

System Input Volume (Water Production)	Authorized Consumption	Billed	Metered	Revenue Water (Typically 91% of System Input Volume)
			Un-Metered	
		Unbilled	Metered	NRW (Typically 9% of System Input Volume)
			Un-Metered	
	Water Losses	Apparent	Unauthorized Consumption	
			Customer Meter Inaccuracies and Data Handling Errors	
		Physical (Real)	Leakage in Transmission and Distribution Mains	
			Storage Leaks and Overflows from Water Storage Tanks	
			Service Connection Leaks Up to the Meter	

Figure 3-7. Revenue and NRW components

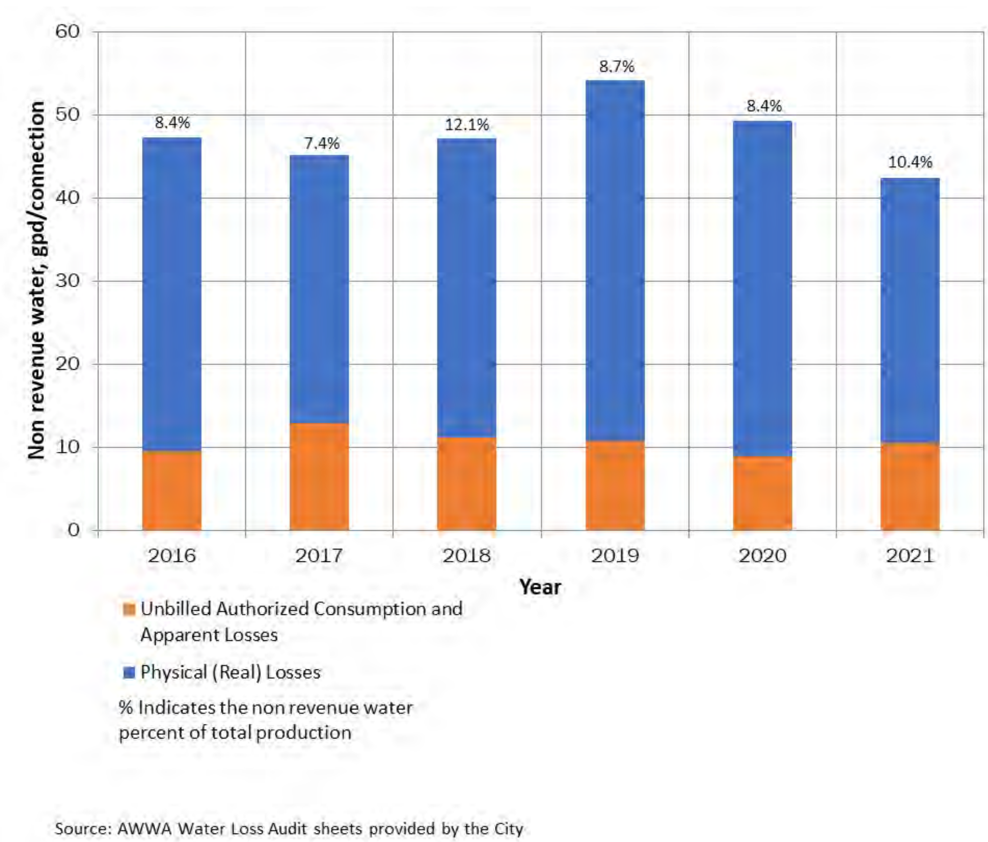

Figure 3-8. Historical NRW

3.2.3 Physical (Real) Water Loss

California Water Code Section 10608.34 required the State Water Resources Control Board (SWRCB) to develop water loss performance standards for urban retail water suppliers. On September 9, 2022, the SWRCB released Individual System Water Loss Standards for the City for physical (real) water loss shown in Table 3-6. Table 3-6 also shows how the City's existing water loss compares with the 2028 performance standard. The City is working towards reducing its water loss and this WSOP assumes the standard will be met in 2028 in the demand projections below.

Table 3-6. Estimated Physical (Real) Water Loss Performance Standard

	Estimated physical (real) loss		
	MG	gpd/connection	% of Total Production
Existing (2021)	2.6	38.1	7.5
Performance Standard (2028)	2.1	31.1	5.4

Source: SWRCB Individual System Water Loss Standards (Released September 9, 2022)

3.2.4 Existing Unit Water Demand Factors

Land use based UWDFs were calculated by geolocating the City's meters to City parcels using GIS data from the Yolo County Open Data website (Yolo County, 2022). Average 2021 water use for each customer classification was then divided by the total land area served for the associated land use. Table 3-7 summarizes existing UWDFs that are calculated on both a per connection and per land use area basis using billed water usage data for the City's billing classifications. Figure 3-9 summarizes the historical unit demands by classification.

Table 3-7. Existing Unit Water Demand Factors[a, d]					
Billing Classification	Billing Classification Abbreviation	gpd/ acre	gpd/ connection	gpd/ dwelling unit	gpcd[e]
Single-family	SFR	1,501	304	304	-
Multi-family	MFR	1,915	3,457	86	-
Multi-family Irrigation	IRR-MFR	837	615	15	-
CII and Irrigation	-	-	-	-	-
Commercial[b, c]	CO	956	1,027	-	-
Industrial	IN	424	1,233	-	-
School	SC	258	1,971	-	-
City	City	1,240	669	-	-
Irrigation	IRR	1,379	1,180	-	-
Physical (Real) Water Loss			38.1	-	-
Apparent Water Loss	--	--	9.6	-	-
Overall City (Weighted) Without Water Loss	-	1,392	473	-	129

a. *2021 data used because the City made some adjustments to billing classifications and previous years cannot accurately be broken down this far. Previous years compared to 2021 are shown in Figure 3-9 with the same groupings for comparison purposes.*

b. *Commercial includes Commercial, Church, Private Day Care, and Other (Garages and State Department of Forestry).*

c. *The City plans to update commercial classes to match those recommended by DWR for water use objectives in the future.*

d. *North Davis Meadows area water demands not included in calculation of existing customer unit water demand.*

Gpd for each classification is divided by the total 2021 City population to determine gpcd.

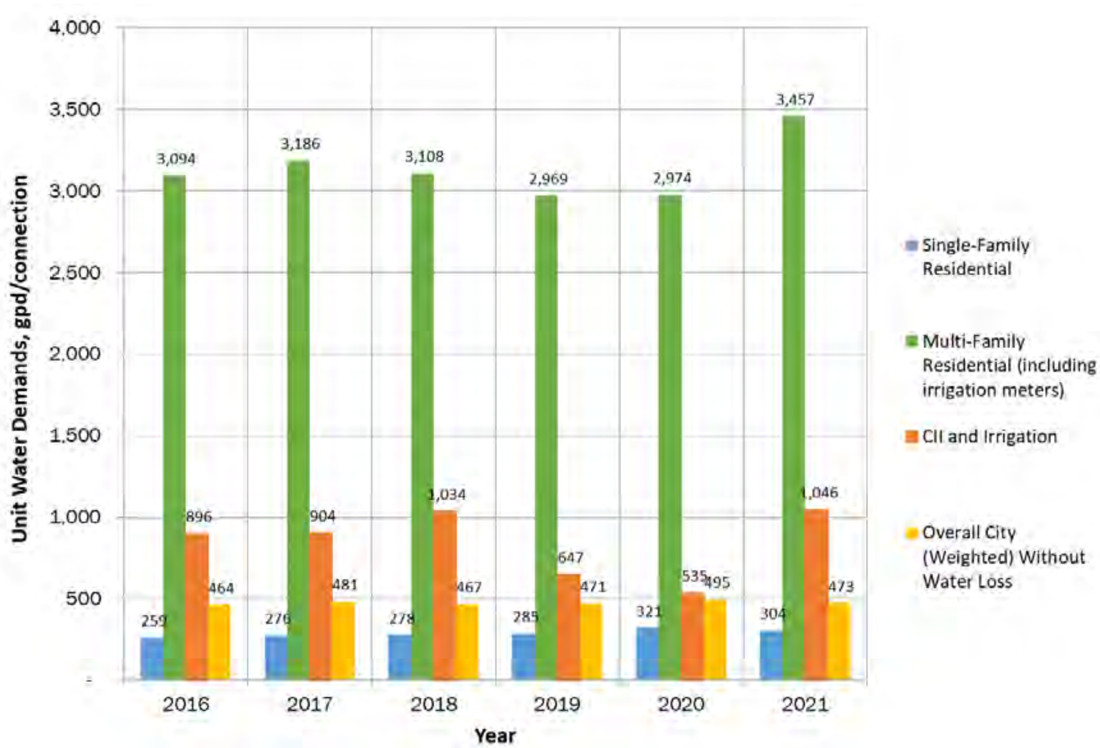

Figure 3-9. Historical unit water demands by billing class

3.2.5 Climate Change Impacts on Water Demand

As discussed in the 2020 UWMP, climate change is expected to increase average temperatures and cause more variability in rainfall amounts. The higher temperatures are expected to increase evapotranspiration (ET) from plants, water loss from plant leaves through transpiration during photosynthesis. Per the 2020 UWMP, the increase in rainfall variability will likely result in increased outdoor irrigation demand of 5 percent by mid-century. Furthermore, climate change could likely increase the variability of seasonal runoff and affect water quality.

3.2.6 Water Use Goals

The 2018 legislation, Senate Bill (SB) 606 and Assembly Bill 1668, directed the DWR, in coordination with the SWRCB, to conduct necessary studies and investigations to recommend standards for outdoor residential water use, CII outdoor irrigation of landscape areas with dedicated irrigation meters, appropriate variances for unique uses, guidelines and methodologies for calculating the Urban Water Use Objective (UWUO), and performance measures for CII water use for adoption by the Water Board. On August 31, 2022, SB 1157 was passed including revised residential indoor water use objectives to amend Section 10609.4 of, and to add Section 10609.33 to the Water Code.

Table 3-8 summarizes the City's draft water use goals that include the water use objectives by water use type according to the requirements under the draft regulations. The regulations to implement SB 606 and AB 1668 have not yet been finalized or adopted by the state. Table 3-8 also includes assumed water use goals for the water use types for which DWR Water use Objectives are not yet identified (i.e. non-residential outdoor) or not included (i.e. non-residential indoor and apparent losses). Table 3-9 shows the estimated area by type of irrigation status as determined by the City's DWR Landscape Area Estimates Project (Quantum Spatial, 2020).

Table 3-8. Summary of Overall City Draft Water Use Goal [a], gpcd					
Water Use Type	2023-2024	2025-2027	2028-2029	2030 and thereafter	Reference/Assumption
Residential (Single-family and Multi-family)					
Indoor [b]	55	47	47	42	SB 1157
Outdoor	62 (ETF=0.80 existing customers) 42 (ETF=0.55 new development)	62 (ETF=0.80 existing customers) 42 (ETF=0.55 new development)	62 (ETF=0.80 existing customers) 42 (ETF=0.55 new development)	49 (ETF=0.63 existing customer), 42 (0.55 for new development)	Evapotranspiration factor (ETF) from DWR's recent Long Term Framework recommendations to the State Water Board (September 29, 2022). Outdoor objective calculated based on DWR Water Use Objective tool with ETF and an assumption that non-irrigable land is 8 percent of the City. [c]
Subtotal	=55+62=117 (existing) =55+42=97 (new development)	=47+62=109 (existing) =47+42-89 (new development)	=47+62=109(existing) =47+42=89 (new development)	=42+49=91 (existing) =42+42=84 (new development)	
Non Residential (CII+other)					
Indoor	19	19	19	19	Not included in State Water Use Objective calculation. Assumed to be same as for existing customers per DWR Water Use Objectives tool.
Outdoor	7	7	7	7	Objective coming soon! – Interim: assumed to be equal to landscape deliveries in Davis EAR (same as existing per DWR Water Use Objectives tool).
Subtotal	28	28	28	28	Rounded to match DWR Water Use Objectives Exploration tool.
Water Loss					
Physical (Real) water loss (standard is gpd/connection)	9 (38.1/4.4 people/connection)	9 (38.1/4.4 people/connection)	7 (31.1/4.4 people/connection)	7 (31.1/4.4 people/connection)	Assume existing until 2028. 2028, thereafter SWRCB Individual System Water Loss Standards (Released September 9, 2022).
Apparent water loss (standard is gpd/connection)	2 (9.6/4.4 people/connection)	2 (9.6/4.4 people/connection)	2 (9.6/4.4 people/connection)	2 (9.6/4.4 people/connection)	Not included in State Water Use Objective calculation. SWRCB Individual System Apparent Water Loss Standard is equal to baseline (Released September 9, 2022).
Subtotal	11	11	9	9	
Total					
Existing System	154	146	144	126	
New Development	134	126	124	119	

a. *This table summarizes the assumed City's draft water use goals that include the water use objectives by water use type according to the requirements under the draft regulations as identified on the State Water Resources Control Board on-line Water Use Objective Exploration Tool in 2023. The regulations to implement SB 606 and AB 1668 have not yet been finalized or adopted by the state. The values in this table are draft and will likely vary when the regulations are finalized. Table 3-8 also includes assumed water use goals for the water use types for which DWR Water use Objectives are not yet identified (i.e. non-residential outdoor) or not included (i.e. non-residential indoor and apparent losses).*

b. *Residential Indoor: SB1157 reduced 2025 through 2030 and thereafter from current law because water savings due to passive and active water conservation activities are incorporated in the future demands.*

c. *Outdoor: 8 percent landscape area consistent with the estimated area by irrigation status level per the City's Landscape Area Estimates Project (Quantum Spatial, 2020)*

Table 3-9. Estimated Area by Irrigation Status[a, b]		
Irrigation Status	**Total Area (SF)**	**% of Total Area**
Not-Irrigable	69,774,443	48.6
Irrigable Irrigated	62,721,549	43.7
Irrigable Not-Irrigated	10,946,010	7.6

a. *Source: Davis City of California DWR Landscape Area Estimates Project prepared by Quantum Spatial, Inc an NV5 Company dated November 23, 2020 (Table 4).*
b. *North Davis Meadows was not included in the land area irrigation analysis, so there may be some changes in the future.*

Water savings assumed from codes, standards, ordinances, or transportation and land use plans are referred to as passive savings. These passive water savings are tied into the water use goals described in this section. Below is a summary of the applicable state codes and ordinances that are considered in this analysis to reduce the City's water demand in the future.

- Model Water Efficient Landscape Ordinance (MWELO) – Effective on December 1, 2015, this ordinance reduces the typical residential outdoor landscape demands for new construction by up to 20 percent from the estimated demand using the prior ordinance provisions. Commercial landscape for new construction may reduce outdoor water demand by up to 35 percent over the prior ordinance. These residential and commercial savings are included in this analysis.
- California Energy Commission Title 20 appliance standards for toilets, urinals, faucets, and showerheads – This standard impacts both new construction and replacement fixtures in existing homes. This is included in the CALGreen assumption for new construction described below. Indoor water use in existing homes is reduced by five percent in this analysis.
- CALGreen Building Code – Requires residential and non-residential water efficiency and conservation measures for new buildings and structures. A reduction of residential and non-residential indoor water use on new construction by up to 20 percent is included in this analysis.

The City's indoor and outdoor usage for each customer category is estimated based on current water use trends. Indoor usage annual percent of total is estimated to be 90 percent of the January demand in 2021 for each customer classification multiplied by 12 and divided by total annual demand for that sector. Table 3-10 lists the annual indoor and outdoor percentages for each customer category.

Table 3-10. Estimated Indoor and Outdoor Usage by Sector		
Classification	**Indoor**	**Outdoor**
Single-family	54%	46%
Multi-family	74%	26%
CII and Irrigation	17%	83%

Combining outdoor single-family and multi-family water use and weighting by total water use in each classification, indicates that the City's overall residential water use is approximately 41 percent outdoor thus meeting DWRs draft recommendations. It is assumed that future developments will meet the 55 percent outdoor residential recommendations.

Active conservation activities are those that are implemented as part of the City's water conservation program. Per the 2020 UWMP, beginning in 2021, the City's current active conservation efforts are assumed to result in an annual 5 percent reduction in water use each year starting in 2021 for each water use sector in addition to savings achieved in previous years.

3.2.7 Recommended Unit Water Demand Factors

Table 3-11 summarizes the recommended existing and future UWDFs for the City. Future UWDFs (for new connections and/or development) are calculated by the water use goals for 2030 for future development.

Table 3-11. Recommended Unit Water Demand Factors[a]

Billing Classification	Existing – For Existing Customers and New Development through 2028				Future – For Post 2028 New Development			
	gpd/acre	gpd/ connection	gpd/ dwelling unit	gpcd	gpd/acre	gpd/connection	gpd/ dwelling unit	gpcd
Single-family	1,501	304	304	-	1,330	270	270	-
Multi-family	1,915	3,457	86	-	1,680	3,032	76	-
Multi-family Irrigation	837	615	15	-	837	615	15	-
CII and Irrigation								
Commercial[b]	956	1,027	-	-	956	1,027	-	-
Industrial	424	1,233	-	-	424	1,233	-	-
School	258	1,971	-	-	258	1,971	-	-
City	1,240	669	-	-	1,240	669	-	-
Irrigation	1,379	1,180	-	-	1,379	1,180	-	-
Physical (Real) Water Loss	-	38.1	-	-	-	31.1	-	-
Apparent Water Loss	-	9.6	-	-	-	9.6	-	-
Total	-	-	-	129	-	-	-	119
Water Use Goal	-	-	-	154	-	-	-	119

a. North Davis Meadows area water demands not included in calculation of existing customer unit water demand.
b. Commercial also includes Church, Private Day Care, and Other (Garages and State Department of Forestry)

3.2.8 Water Demand Projections

Projected demands in Table 3-12 were estimated by applying the existing UWDFs (without assumptions for water reductions to meet water use goals) in Table 3-7 to the existing to 2028 growth in connections and land use in Table 3-5 (shown in Figure 3-4). Table 3-13 summarizes the annual projected water use by billing classification for key planning years. After 2028, growth and increased demands are based on the connection growth in Table 3-5 as shown in Figure 3-10. Figure 3-10 and Table 3-12 include assumptions that the City will meet the water use goals discussed in Section 3.2.6 as well as the water loss standards discussed in Section 3.2.3. Climate change assumptions discussed in Section 3.2.5 as well as passive and active water savings discussed in Section 3.2.6 are also included. Figure 3-11 shows the City's projected water use by type in comparison to its water use goals.

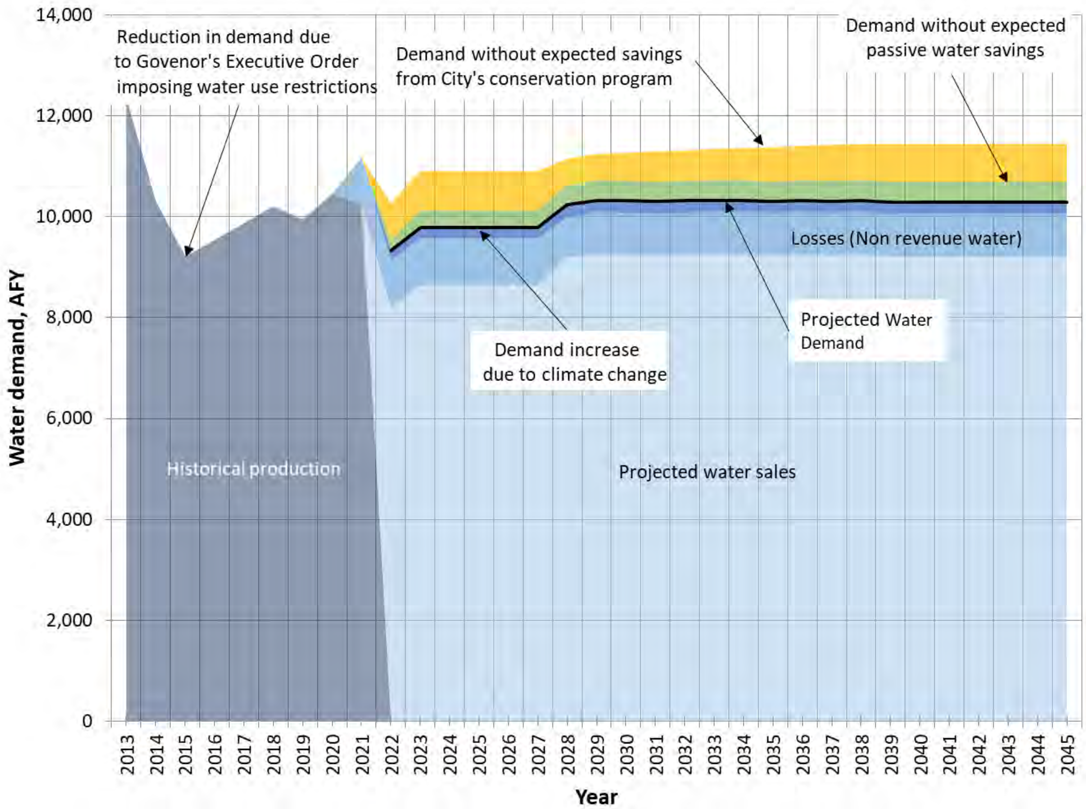

Figure 3-10. Projected water demands

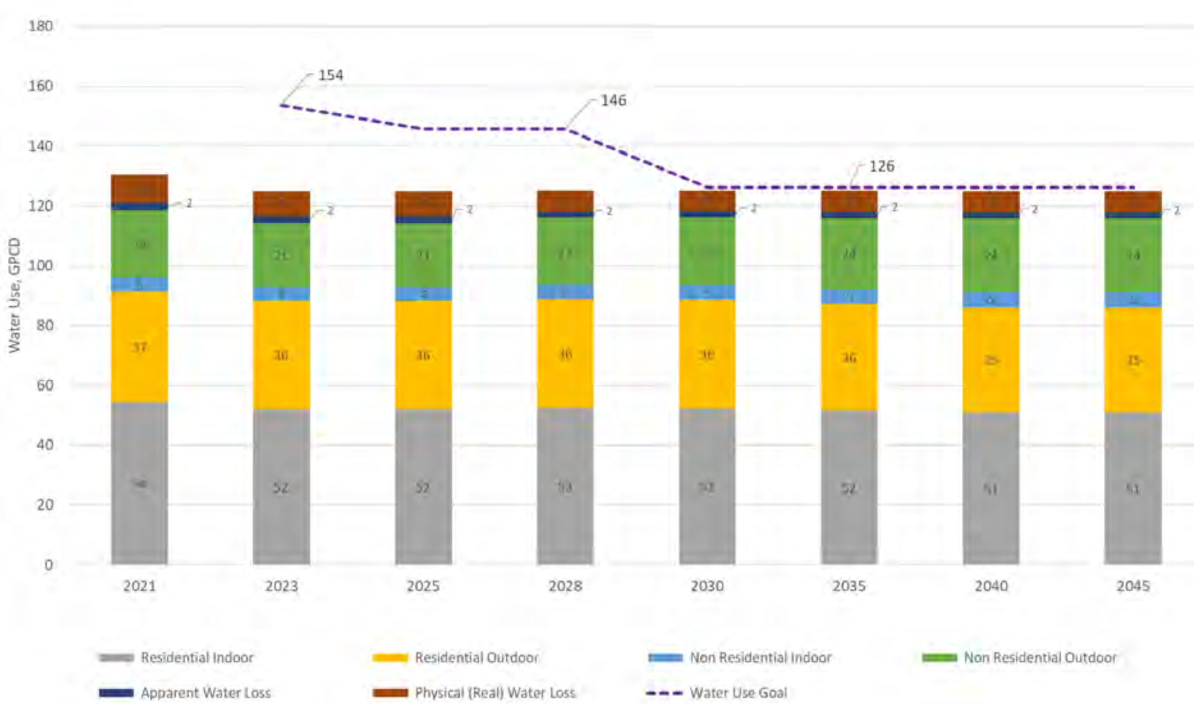

Figure 3-11. Water use projections versus goal

Table 3-12. Additional Water Demand due to Growth through 2028

Existing and Potential Projects		Billing Classification Abbreviation	Unit Water Demand Factor (gpd/connection)	Demand	
				gpd	AFY
Under Construction (2023)	3820 Chiles Rd Apartments	MFR	3,457	20,745	23
		MFR IRR	615	3,689	4.1
		CO	1,027	1,027	1.1
	Cannery Marketplace Apartments Mixed-Use	CO	1,027	1,027	1.1
	Paul's Place	CO	1,027	1,027	1.1
	Theta Xi Fraternity Rebuild	MFR	3,457	3,457	3.9
		MFR IRR	615	615	0.69
Connection of CSA (2023)	North Davis Meadows[a]	SFR	-	508,800	570
Completed Planning Review and Pending Construction (2028)	480 Mace Carwash	CO	1,027	1,027	1.1
	515 10th Street Triplex	MFR	3,457	3,457	3.9
		MFR IRR	615	615	0.69
	614 Cantrill Flex Space	IN	1,233	1,233	1.4
	715 Pole Line Subdivision	SFR	304	9,134	10
	4810 Chiles Plaza	CO	1,027	1,027	1.1
	4480 Chiles (ARCO Service Station/AmPm Store)	CO	1,027	1,027	1.1
	Bretton Woods Subdivision	SFR	304	185,728	208
	Bretton Woods Activity Center	CO	1,027	4,106	4.6
	Cannery Marketplace Commercial Mixed-Use	CO	1,027	1,027	1.1
		IRR	1,180	1,180	1.3
	Chiles Ranch Subdivision	SFR	304	29,229	33
	D St Gardens	MFR	3,457	3,457	3.9
		MFR IRR	615	615	0.69

Table 3-12. Additional Water Demand due to Growth through 2028

Existing and Potential Projects	Billing Classification Abbreviation	Unit Water Demand Factor (gpd/connection)	Demand	
			gpd	AFY
Davis Chinese Christian Church Addition	CO	1,027	1,027	1.1
Los Robles Tentative Map	SFR	304	609	0.68
Olive Drive Mixed Use	MFR	3,457	6,915	7.7
	MFR IRR	615	1,230	1.4
PG&E Service Center Rezone	-	-	-	-
Research Park Mixed-Use	CO	1,027	1,027	1.1
	SFR	304	304	0.34
Trackside Center	MFR	3,457	3,457	3.9
	MFR IRR	615	615	0.69
	CO	1,027	1,027	1.1
University View Townhomes	MFR	3,457	3,457	3.9
	MFR IRR	615	615	0.69
Nishi Student Housing – Part 1[b]	MFR	3,457	38,032	43
	MFR IRR	615	6,763	7.6
Total[c]		-	848,325	950

a. Demand per North Davis Meadows Connection to City of Davis Potable Water System Technical Memorandum dated December 12, 2017. Maximum day demand (MDD) of 424 gpm calculated based on a MDD to average day demand (ADD) peaking factor of 1.2 gpm. ADD used in this analysis is 353 gpm (converted to 508,800 gpd and 570 AFY).

b. The second part of Nishi Student Housing is anticipated to be developed after 2028. Demands are included in Table 3-13.

c. Total demands in this table are based on existing UWDFs and do not include assumptions on climate change or water savings to meet water use goals. See Table 3-13 for future demands with these assumptions included.

Table 3-13. Additional Water Demand due to Growth of Vacant Parcels from 2028 through Buildout								
Assessors Parce Number (APN)	Address	GIS Acres	Buildout Land Use	ADD (gpm)	MDD (gpm)	LDD (gpm)	Model Junction ID	Notes
071403025000	2881 2nd St/534 Pena Dr	6.08	Commercial	4.0	6.5	1.9	J-5275 J-5277 J-7453	
069290063000	1910 Galileo Ct	4.01	Commercial	2.7	4.3	1.2	J-4375	
068050004000	5060 Chiles Road	0.70	Commercial	0.5	0.7	0.2	J-2279	
068050003000	5067 Chiles Road	0.34	Commercial	0.2	0.4	0.1	J-2279	
069300058000	1851 Cowell Blvd	2.17	Commercial	1.4	2.3	0.7	J-2280	
071411016000	3901 2nd Street	1.96	Commercial	1.3	2.1	0.6	J-3581	
069060032000	1510 Newton Court	1.36	Commercial	0.9	1.4	0.4	J-6178	
071405008000	2401 2nd Street	1.25	Commercial	0.8	1.3	0.4	J-7443	
071425001000	4600 Fermi Place	6.98	Commercial	4.6	7.4	2.2	J-7478 J-7347	
069530004000	2600 Research Park Drive	2.54	Commercial	1.7	2.7	0.8	J-2487 J-2023	
036060029000	3003 John Jones Road	27.48	Commercial	18.3	29.2	8.5	J-3383 J-3689	Sutter vacant land
069060036000	1036 Research Park Drive	2.30	Commercial	1.5	2.4	0.7	J-6455	
71140011000	3003 E Covell Blvd	25.34	Irrigation	24.3	38.8	11.3	J-6162	Potential Palomino Place
069100025000	1000 Montgomery Avenue	10.61	Single Family Residential	11.1	17.7	5.1	J-4339	
068010009000	4920 Chiles Road	0.99	Commercial	0.7	1.1	0.3	J-2258	
069530004000	2600 Research Park Drive	6.71	Commercial	4.5	7.1	2.1	J-2483 J-2485	
069060031000	1002 Research Park Drive	0.95	Commercial	0.6	1.0	0.3	J-6455	
071411012000	4009 Faraday Avenue	8.43	Commercial	5.6	9.0	2.6	J-4820	
070260022000	1021 Olive Drive	1.10	Commercial	0.7	1.2	0.3	J-2171	
Total	-	111	-	85	137	40	-	

Table 3-14. Projected Water System Demands for Key Planning Years						
Units	Acre-feet/year (AFY)	gpcd	AFY	gpcd	AFY	gpcd
Year	2023		2028		2045	
Single-family Residential	5,103	-	5,380	-	5,198	-
Multi-family Residential	1,750	-	1,848	-	1,840	-
CII	599	-	791	-	847	-
CII Irrigation	1,410	-	1,412	-	1,569	-
Water Loss	927	-	799	-	837	-
Total	9,789	126	10,230	127	10,291	126

Figure 3-12 illustrates the historical and projected water use in terms of gpcd. Also shown are past gpcd targets and the most recent water use goals. With increased conservation activities the future per capita demand is projected to be less than the City's Natural Resources Commission (NRC) driven target of 134 gpcd and the water use goals of 154 gpcd, 146gpcd, 144 gpcd, and 126 gpcd in 2023, 2025, 2028, and 2030, respectively.

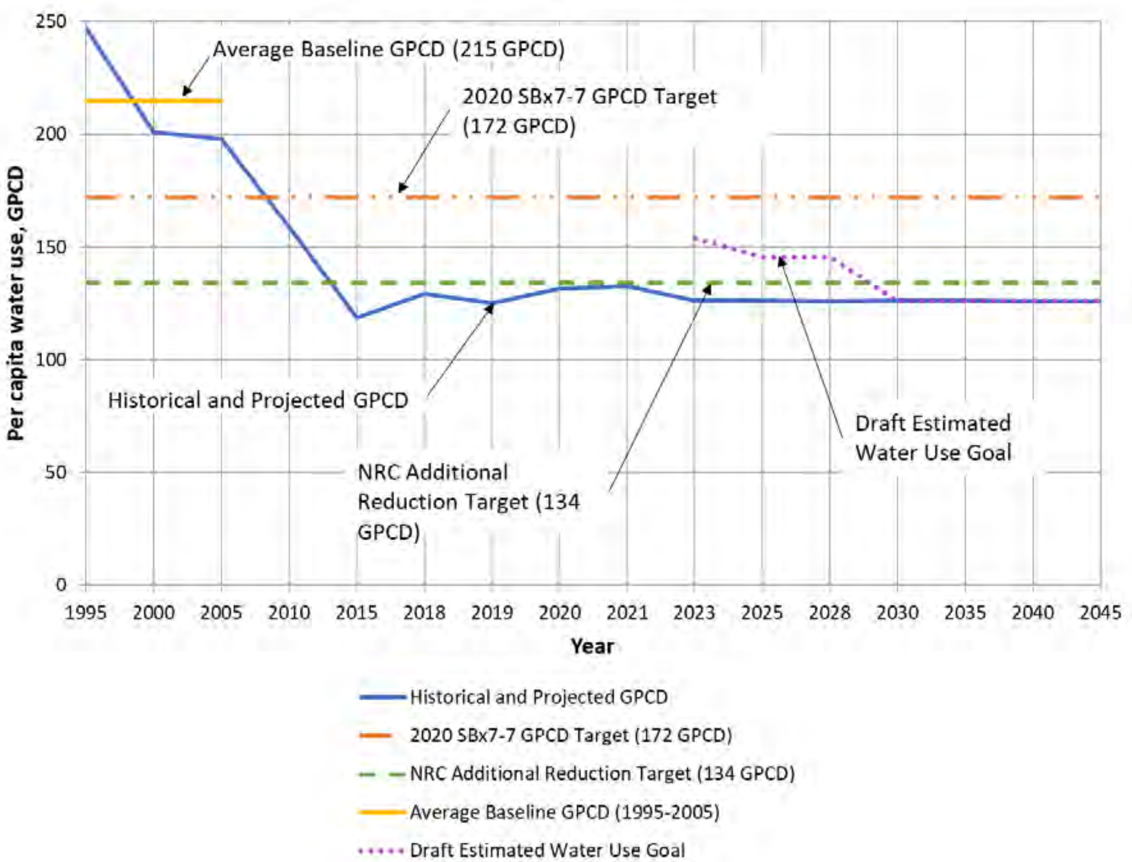

Figure 3-12. Historical and projected per capita water use versus goals

3.2.9 Water Demand Peaking Factors

The historical peaking factors were reviewed for this analysis, primarily to verify whether the maximum day demand peaking factors should be updated. The MDD peaking factor is important because it is used to project the MDD and is the basis for projecting PHD. Water supply and conveyance infrastructure is sized based on the MDD and PHD projections. Overestimating the projected MDD and PHD can result in investing in oversized infrastructure capacity which is not cost efficient and can have poor water quality implications. Low day demand (LDD) peaking factors are also useful for analyses such as water age.

Figure 3-13 shows water production calculated from the City's Supervisory Control and Data Acquisition (SCADA) production records from 2018 through 2021. Extremely high or low values are considered outliers and were removed from the data presented below.

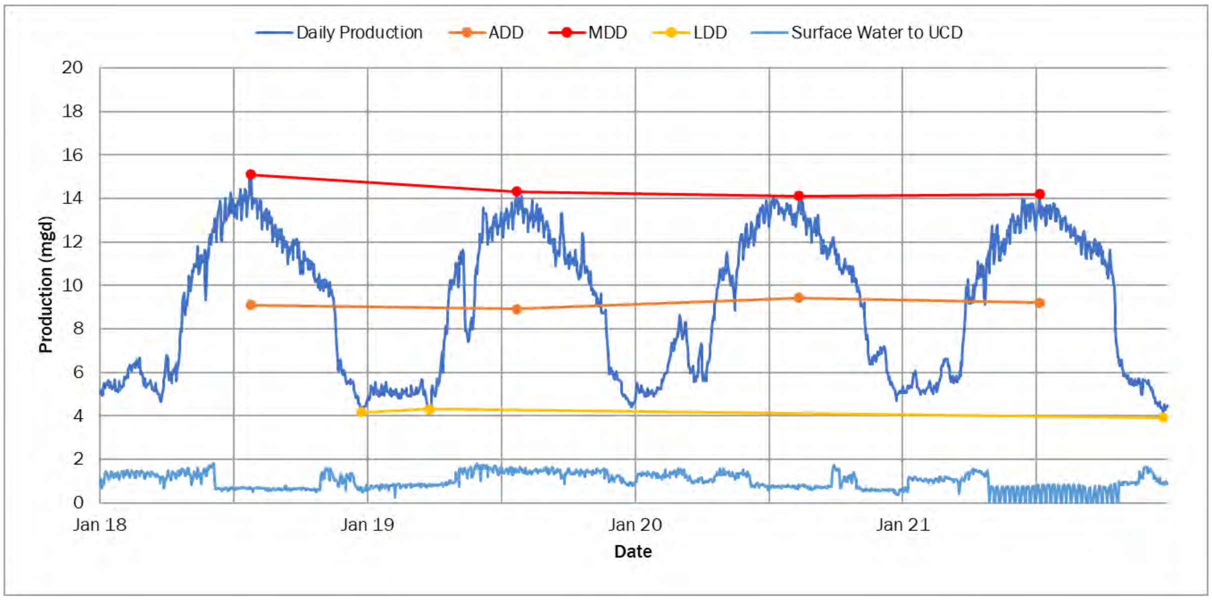

Figure 3-13. Historical water production

Table 3-15 lists average day demand (ADD), maximum day demand (MDD), peak hour demand (PHD), and low day demand (LDD) for 2012 through 2021 and for key planning years. Peaking factors in the table were calculated by comparing ADD, MDD, and LDD.

The historical maximum day demand peaking factors were developed from actual recorded flows and estimated demands as follows:

- The actual maximum day demands for 2018 to 2021 were available for this analysis from SCADA data provided by the City.
- The historical maximum day demand peaking factors for 2015 to 2017 were provided by City staff from SCADA data.
- The historical maximum day demand for 2012 to 2014 were estimated using a 1.5 peaking factor based on Electronic Annual Report (eAR) data.

The projected peaking factors recommended in this analysis consider the Title 22, California Waterworks Standards (Standards) Chapter 16. Section 64551.30 states that MDD is defined as the amount of water used by consumers during the day of highest demand (midnight to midnight). Section 64554 (b)(1) states that if daily water usage data are available, identify the day with the highest usage during the past 10 years to obtain MDD and multiply by a peaking factor of at least 1.5 to obtain the PHD. PHD is defined as the amount of water used by consumers during the hour of highest use during the maximum day, excluding fire flow. The existing PHD/MDD factor of 1.52 is recommended for future planning.

As can be seen in Figure 3-14, the MDD/ADD peaking factor was 1.60 to 1.85 from 2000 to 2009 and then increased to as high as 2.23 in 2015 and has declined to the 1.50 to 1.60 range during the last three years. The recommended peaking factor for future planning is 1.60.

The Standards approach to determining MDD is modified for this analysis to reflect that the City's actual MDD has been declining over the past 10-year period. To more accurately project future demands, the maximum day demand for this analysis is considered the 24-hour usage on the day of highest demand for a three-year period rather than the Standards based MDD (i.e. highest usage during the past ten years).

Table 3-15. Existing and Projected Water System Demand Analysis

Year	ADD		MDD		LDD[b]		PHD[c]	Peaking Factors		
	mgd	AFY	mgd	gpm	mgd	gpm	gpm	MDD/ADD	LDD/ADD	PHD/MDD
2012[a]	10.90	12,216	17.90	12,431	-	-	26,460	1.60	-	1.50
2013[a]	11.00	12,338	21.00	14,583	-	-	25,300	1.90	-	1.50
2014[a]	9.20	10,304	16.44	11,417	-	-	22,460	1.79	-	1.50
2015[a]	8.22	9,212	18.35	12,743	-	-	19,900	2.23	-	1.56
2016[a]	8.51	9,535	10.10	7,014	-	-	18,200	1.19	-	2.59
2017[a]	8.85	9,912	15.00	10,417	-	-	21,199	1.70	-	2.04
2018	9.11	10,201	15.09	10,478	4.16	2,890	15,891	1.66	0.46	1.52
2019	8.92	9,990	14.31	9,935	4.31	2,990	15,479	1.60	0.48	1.56
2020	9.43	10,566	14.12	9,802	4.57	3,173	14,890	1.50	0.48	1.52
2021 (Existing)	9.19	10,210	14.20	9,861	3.92	2,724	15,009	1.54	0.43	1.52
3-year Average (2019-2021)	9.18	10,255	14.21	9,866	4.27	2,963	15,126	1.55	0.46	1.53
2023	8.74	9,789	13.98	9,710	4.06	2,820	14,779	1.60[d]	0.46[e]	1.52[f]
2028	8.87	10,230	14.61	10,148	4.24	2,947	15,445			
2045	9.33	10,291	14.70	10,208	4.27	2,965	15,537			

a. 2012-2017 from City spreadsheet MDD ADD PHD.xlsx
b. 2011 data not available and LDD data not available for 2005-2017
c. PHD is estimated using 1.5 peaking factor based on EAR data for 2012 - 2014, all other values are from SCADA data from City records.
d. Proposed MDD/ADD peaking factor of 1.60 is based on review of historical MDD data. See Figure 3-14.
e. Proposed LDD/ADD peaking factor of 0.46 is based on 3-year average for 2019-2021.
f. Proposed PHD/MDD peaking factor is based on the 2021 existing PHD/MDD peaking factor. This exceeds the recommended Title 22, California Waterworks Standards (Standards) Chapter 16 PHD/MDD peaking factor of 1.50.

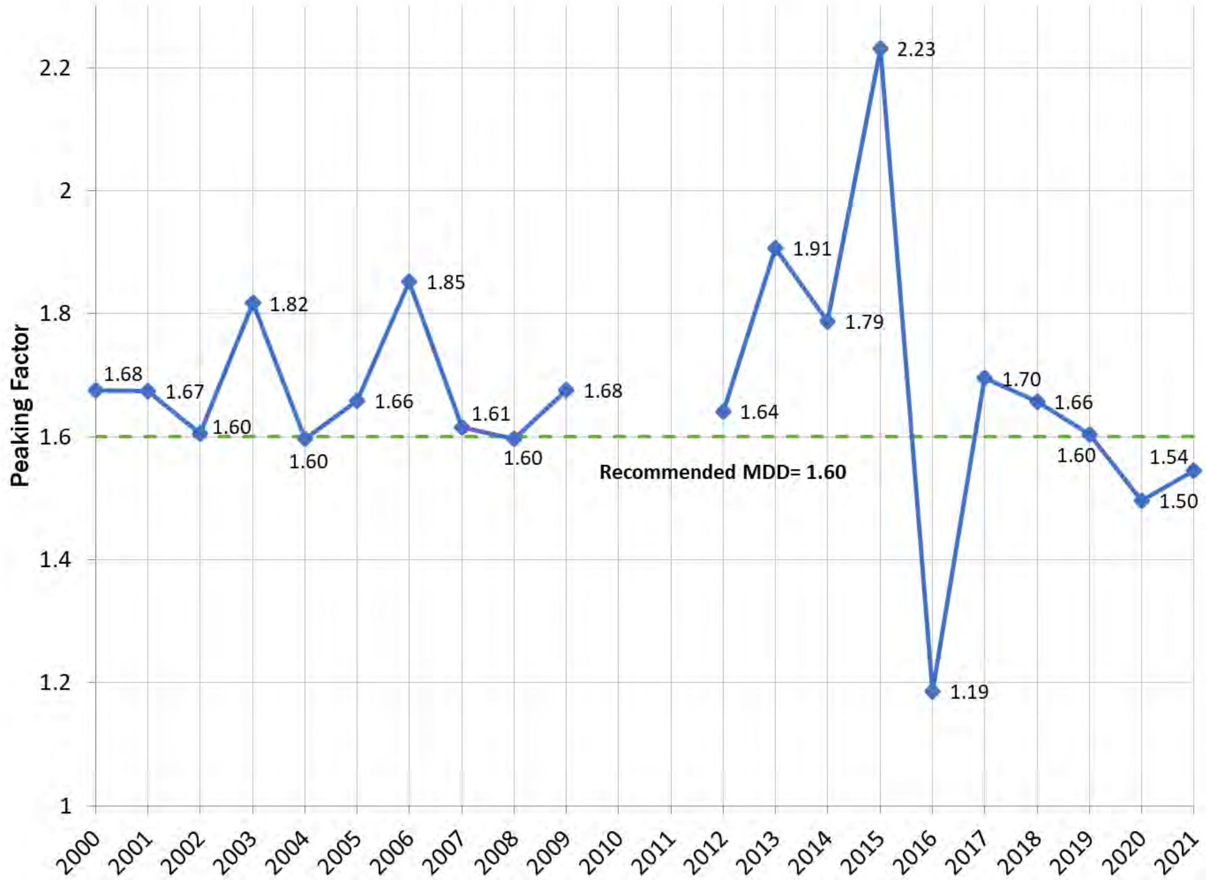

Figure 3-14. Historical MDD peaking factor

Diurnal patterns are calculated using flow data from the City's SCADA system. Historical diurnal curves for the MDD within the City and UCD are shown in Figure 3-15. The proposed diurnal curves are shown in black.

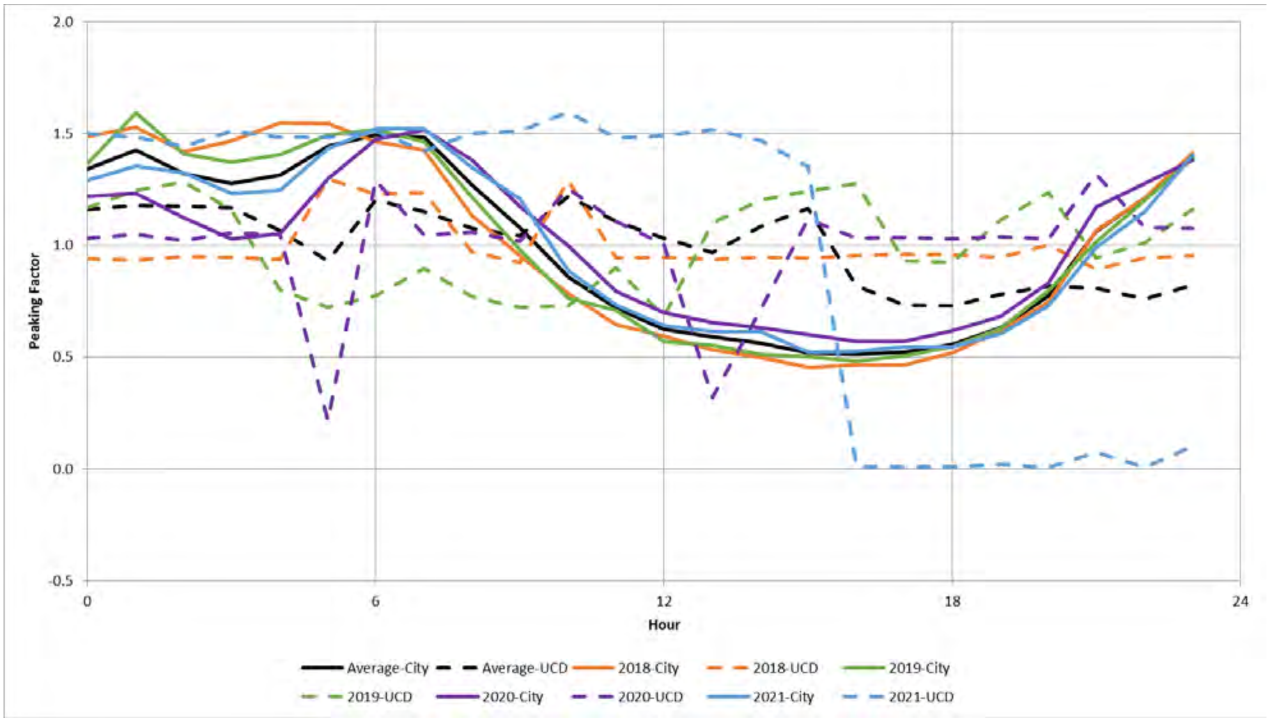

Figure 3-15. MDD diurnal pattern

Section 4

Water Supply

This section describes the sources, quantities, constraints, reliability, climate change impacts, and quality of the City's water supply sources. Additionally, this section evaluates well head treatment alternatives and corresponding increases in available and reliable groundwater pumping capacity of the City's wells.

4.1 Water Supply Overview

Since the 2011 Water Distribution System Optimization Plan completion, the City has reprioritized its utilization of water supply sources by transitioning from groundwater as its primary water supply to surface water as the primary water supply. In June 2016, the WDCWA began providing the City wholesale surface water that is now utilized as the City's primary water source. The City continues to operate nine groundwater wells that are utilized to meet peak demand periods and provide a reliable supplemental water source for the water system.

4.2 Surface Water

The City began purchasing surface water from the WDCWA in 2016. The WDCWA was created in 2009 to undertake and implement a project to convey water from the Sacramento River, transmit the water for treatment to a new water treatment facility, and deliver wholesale treated surface water to the City, the City of Woodland, and UCD for use in their respective service areas.

The WDCWA has two separate surface water rights; 45,000 AFY from Permit 20281 and up to 10,000 AFY from a supplemental water right purchased from the Conaway Preservation Group (CPG). Both surface water rights have conditions that can limit WDCWA's ability to divert water. Permit 20281 is subject to the State Water Board's Term 91 that requires permittees to cease diverting water when the State Water Project and the Central Valley Project are releasing stored water to meet water quality and flow requirements in the Sacramento-San Joaquin Delta. The CPG water right is subject to limitation based on Lake Shasta water levels.

The City is entitled to deliveries of 10.2 mgd from the WDCWA, totaling approximately 11,425 AFY. WDCWA surface water deliveries to the City are limited by Term 91 and Lake Shasta conditions as follows:

1. If Term 91 curtailments are not in effect (normal years)
   a. The City is limited by its share of WDCWA RWTF capacity, which is 10.2 mgd.
   b. 10.2 mgd of supply is available from WDCWA year-round.
2. If Term 91 curtailments are in effect (dry years)
   a. The City is limited by the lesser of its share of RWTF capacity and its share of the WDCWA secondary water rights obtained from the CPG water, depending on the duration of the curtailment.
      i. When levels in Lake Shasta are normal, the City is entitled to 4,440 AFY of CPG water.
      ii. When levels in Lake Shasta are critical, that total is reduced by 25 percent to 3,330 AF or lower based on ongoing drought conditions in the future.

3. 3 mgd is minimum supply available to the City. In years where there is a short duration Term 91 curtailment (such as in 2012), the City lacks the RWTF capacity to make use of its full allocation of CPG water. In a longer curtailment, however, the CPG water availability becomes the limiting factor.

Table 4-1 summarizes historical surface water volume supplied by WDCWA to the City (not including water wheeled to UCD). Figure 4-1 summarizes the surface water that the City is estimated to receive (not including supply for UCD) throughout the year considering the variation in monthly demands. The City has no plans to ever rely entirely on surface water supplies.

Table 4-1. Historical Surface Water Volume Supplied, AFY

Water Supply/Constraint	2016	2017	2018	2019	2020	2021
Purchased Water from WDCWA	3,130	8,626	8,124	8,683	7,982	6,501
Supply Constraint	Term 91	--	Term 91	--	Term 91	Term 91

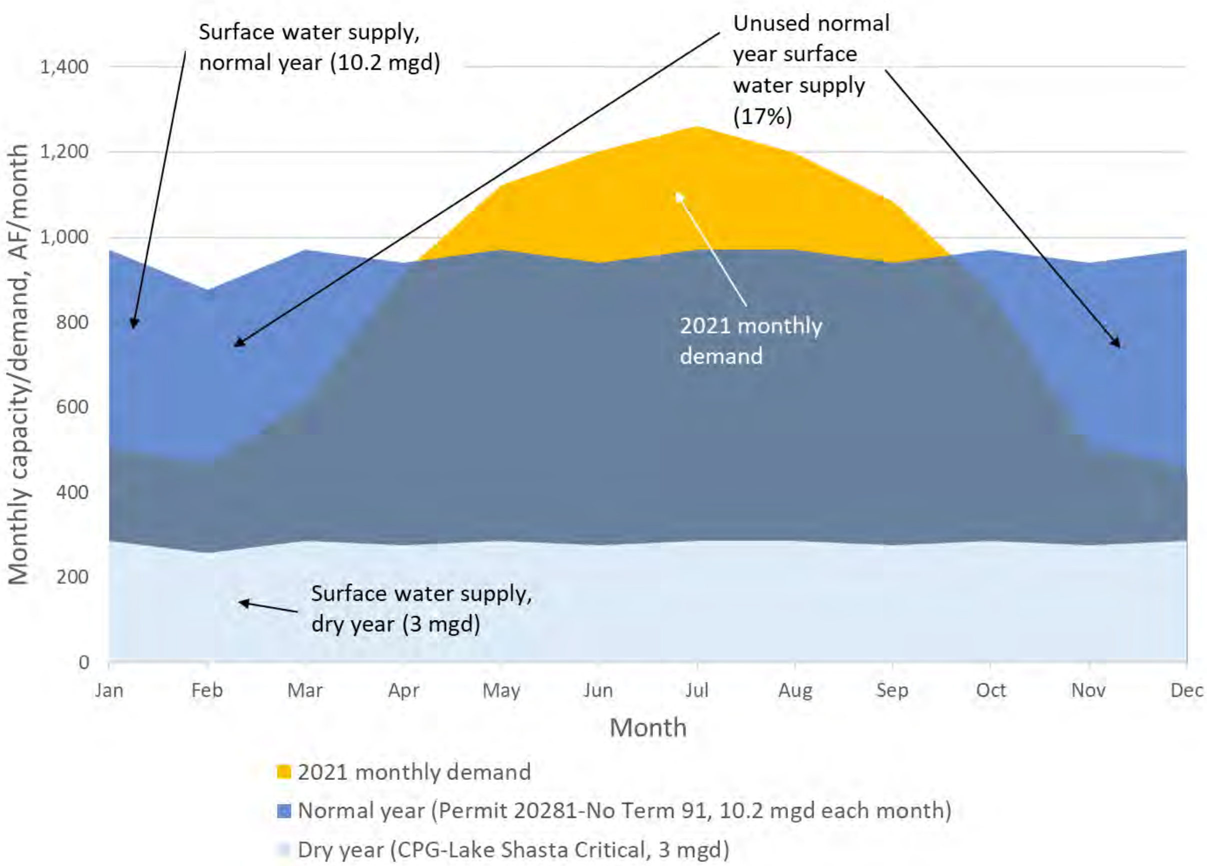

Figure 4-1. Estimation of annual surface water capacity

The City does not anticipate any agreement changes impacting the WDCWA supply.

4.3 Groundwater

This section describes the groundwater basin and basin management as well as the groundwater supply wells.

4.3.1 Basin Description and Management

The groundwater basin underlying the City is in the California Department of Water Resources' Yolo Subbasin (5-021.67), which is part of the larger Sacramento Valley Groundwater Basin. The Yolo Subbasin shares boundaries with five adjacent subbasins including Colusa, Sutter, North American, South American, and Solano as shown in Figure 4-2. The Yolo Subbasin Groundwater Agency (YSGA) is a joint powers authority comprised of twenty members (including the City) and six affiliated parties and is responsible for overall management of the YSGA including implementation of the Sustainable Groundwater Management Act (SGMA) and YSGA's Groundwater Sustainability Plan (GSP) (YSGA, 2022).

Per the YSGA GSP, the aquifer system under the Yolo Subbasin consists of alluvium and the upper Tehama Formation and can be described by dividing the aquifer into three zones, shallow, intermediate, and deep zones. Overall, there is high-quality water in the portion of the aquifer that public community water systems draw from (YSGA, 2022).

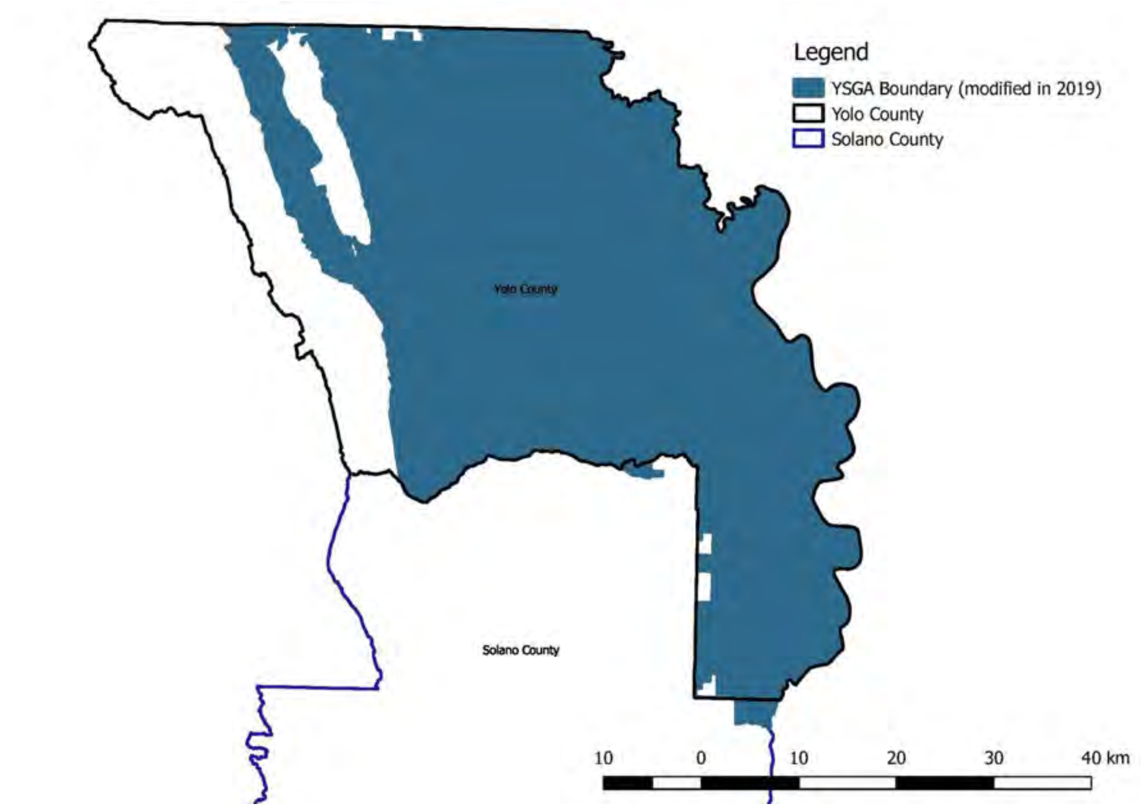

Figure 4-2. Groundwater subbasin (Subbasin 5-21.67)

However, community water systems encounter boron, hexavalent chromium, nitrate, and salinity as primary constituents of concern (YSGA, 2022).

The Yolo Subbasin is a relatively stable basin, with groundwater levels maintaining a relatively consistent long-term average elevation or depth to groundwater (YSGA, 2022). While groundwater levels decline during dry conditions due to reduced recharge from precipitation, local runoff, and seepage, and continued reliance on groundwater for agricultural and municipal demands, groundwater levels substantially recover during wet years (YSGA, 2022).

The projected sustainable yield for the Yolo Subbasin of 346,000 AFY is expected to be met in the future by collaboration of all YSGA entities through management actions to ensure beneficial use is protected.

4.3.2 Groundwater Wells

Table 4-2 shows a summary of the existing City wells operational information (control settings and capacity). The system overview map in Section 3 (Figure 3-2) shows well locations. As shown in Table 4-2, the deep wells have higher elevated storage tank level set points and will turn on before intermediate wells. Section 2 (Table 2-1) includes other pertinent well information such as ground elevation and pump type.

Table 4-2. Well Operations and Water Levels

Well	Well Depth Classification	Year Installed	Actual Capacity (gpm)	Static Water Level, August 2022 (ft)	Well Set Points (Elevated Tank level, ft)		VFD Pump	Modeled VFD Pressure Setting	Notes
					On	Off			
23	Intermediate	1981	1,600	-26.4	12	14	No	-	The intermediate wells connect directly to the distribution system.
24	Intermediate	1982	1,600	-42.1	16	19	No	-	
26	Intermediate	1987	1,500	-49.5	15	17	No	-	
27	Intermediate	1992	1,300	-3.3	14	16	No	-	
30	Deep	2000	2,300	-89.5	22.5	23.5	Yes	65	Well 30 currently connects directly to the distribution system, but the City is planning to construct a blending station to blend surface water and groundwater prior to entering the distribution system and is currently evaluating locations for optimal water quality. The City is also considering Manganese treatment at this location.
31	Deep	2001	2,500	-71.7	21.5	24.8	Yes	55	The surface water transmission extends to Well 31 to blend surface water and groundwater prior to entering distribution system. The City is currently considering treatment for CrVI at this well.
32	Deep	2006	2,650	-48.7	22	25.5	Yes	60	The surface water transmission extends to each of these wells to blend surface water and groundwater prior to entering the distribution system.
33	Deep	2006	1,800	-61.5	21	23.5	Yes	60	
34	Deep	2010	2,300	-58.6	22.5	26	Yes	60	

The amount of groundwater pumped in 2016 through 2021 is shown in Table 4-3. More water is pumped from the deep aquifer via the City's deep groundwater wells than from the intermediate wells.

The City's continuous pumping capacity is 28,309 AFY, as shown in Table 4-4. The total well capacity is the monthly continuous pumping capacity for the deep and intermediate wells. This continuous pumping capacity may not be used due to the variation in monthly demands. Approximately 70 percent of the City's deep well capacity (approximately 12,800 AFY) is usable on an annual basis considering the variation in monthly demands as illustrated in Figure 4-3 and summarized below.

- The City's average monthly continuous deep well pumping well capacity is 1,552 AF/month. (This monthly volume varies by month based on the number of days in each month).
- The City's monthly demand pattern based on 2021 usage shows less water use in winter, spring, and fall months compared to the summer months.
- The maximum annual demand that can be supplied by the deep wells is simulated using the same demand pattern as the City's 2021 demand and setting the maximum monthly use to the City's deep well monthly continuous pumping capacity (1,582 AF/month of July).
- The usable annual deep well capacity, based on the simulated demand, is 12,800 AFY, which is approximately 70 percent of the deep well total pumping capacity.
- The resulting unused deep well pumping capacity is that capacity that is not needed to meet demands in winter, spring, and fall, which is approximately 5,800 AFY.
- It is assumed that the intermediate deep wells are used for peak demands only.

Table 4-3. Historical Groundwater Volume Pumped, AFY

Groundwater Type	Location or Basin Name	2016	2017	2018	2019	2020	2021
Alluvial Basin	Intermediate aquifer, within City service area, Sacramento Valley, Yolo Subbasin (5-21.67)	1,548	12	4	3	6	4
Alluvial Basin	Deep aquifer, within City service area, Sacramento Valley, Yolo Subbasin (5-21.67)	4,885	1,273	2,069	1,304	2,499	3,687
Total		6,433	1,285	2,073	1,307	2,505	3,871

Table 4-4. Groundwater Pumping Capacity							
Well	Intermediate Depth Wells			Deep Wells			Total [a]
	gpm	mgd	AFY	gpm	mgd	AFY	AFY
Well 23	1,600	2.3	2,581				2,581
Well 24	1,600	2.3	2,581				2,581
Well 26	1,500	2.2	2,420				2,420
Well 27	1,300	1.9	2,097				2,097
Well 30				2,300	3.3	3,710	3,710
Well 31				2,500	3.6	4,033	4,033
Well 32				2,650	3.8	4,274	4,274
Well 33				1,800	2.6	2,903	2,903
Well 34				2,300	3.3	3,710	3,710
Total	6,000	8.7	9,679	11,550	16.6	18,630	28,309

a. *Total well capacity in this table is based on all wells running continuously, 365 days per year.*

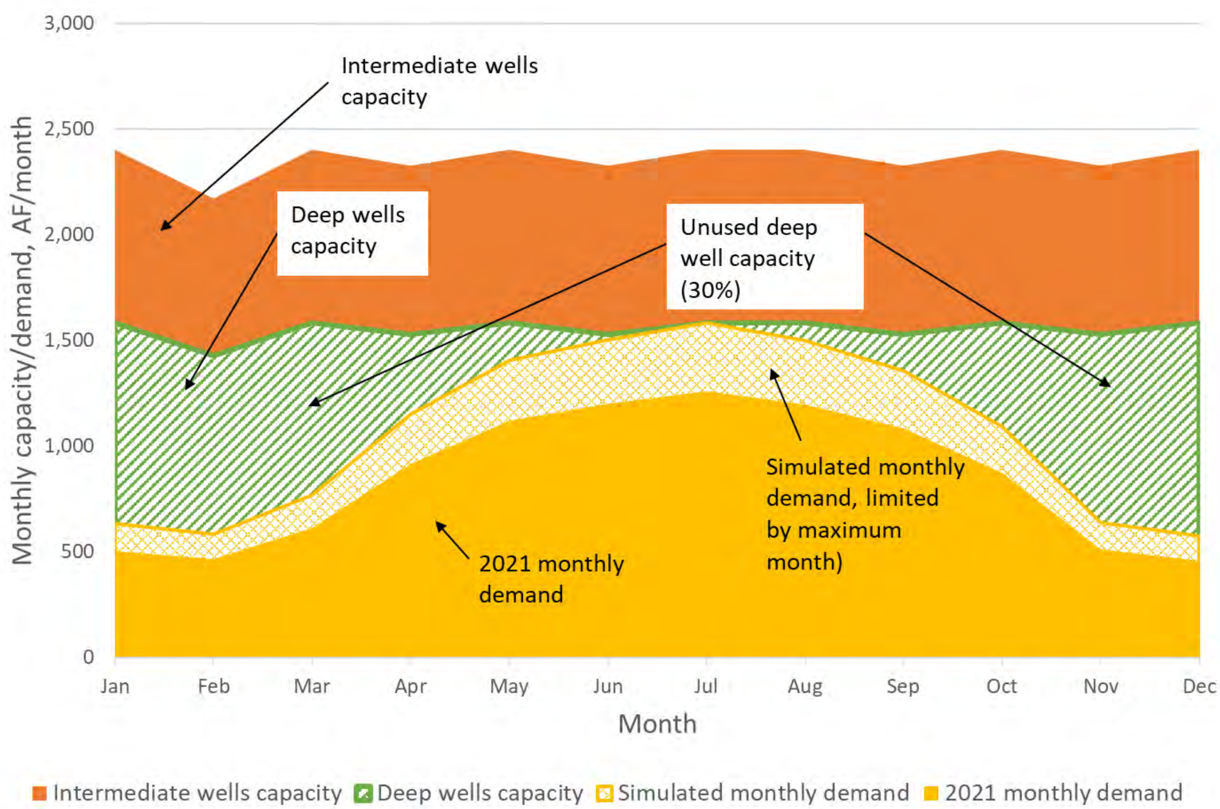

Figure 4-3. Estimation of annual groundwater well capacity

4.4 Supply Reliability

This section provides a comparison of normal and dry water year supply and demand for the City. Water demands are addressed in Section 3. The existing and projected water supplies are compared to the demands for a normal year in Table 4-5. The bottom row indicates that there is a surplus of supply for the City in normal years.

Table 4-5. Normal Year Supply and Demand Comparison, AFY

	2023	2028	2045
Surface Water [a]	11,425	11,425	11,425
Groundwater [b]	12,800	12,800	12,800
Supply totals	24,225	24,225	24,225
Potential future climate change reductions in surface water supply [c]	900	900	900
Demand totals [d]	9,789	10,230	10,291
Difference [e]	13,536	13,095	13,034

a. As discussed in Section 4.2 and shown in Figure 4-1, 10.2 mgd is available year-round to the City in normal years (11,425 AF).
b. As discussed in Section 4.3.2 and shown in Figure 4-2, the usable annual deep well capacity based on the simulated demand is 12,800 AFY, which is approximately 70 percent of the deep well total pumping capacity.
c. As discussed in Section 4.5, the resulting predicted Term 91 curtailments due to climate change equate to a maximum of 900 AFY through the 2040 planning horizon.
d. From Table 3-14
e. Supply minus demand

The existing and projected water supplies are compared to the demands for a dry year in Table 4-6. In a dry year, surface water supply from WDCWA is expected to decrease from what is available during a normal year. This assumes water curtailments to be in effect for the Sacramento River. The remaining water demand not met by available surface water will be supplied using groundwater. Demands in Table 4-6 are the same as those in a normal year, but it is projected that in dry years water demand will increase in the summer due to decreased precipitation and increased ET rates. These demand projections do not assume mandated conservation measures. The bottom row indicates that there is a surplus of supply for the City in dry years.

Table 4-6. Dry Year Supply and Demand Comparison, AFY

	2023	2028	2045
Surface Water [a]	3,360	3,360	3,360
Groundwater [b]	12,800	12,800	12,800
Supply totals	16,160	16,160	16,160
Potential future climate change reductions in surface water supply [c]	900	900	900
Demand totals [d]	9,789	10,230	10,291
Difference [e]	5,471	5,030	4,969

a. As discussed in Section 4.2 and shown in Figure 4-1, 3 mgd is available to the City in dry year months which totals to 3,360 AF.
b. As discussed in Section 4.3.2 and shown in Figure 4-2, the usable annual deep well capacity based on the simulated demand is 12,800 AFY, which is approximately 70 percent of the deep well total pumping capacity.
c. As discussed in Section 4.5, the resulting predicted Term 91 curtailments due to climate change equate to a maximum of 900 AFY through the 2040 planning horizon.
d. From Table 3-14. Demand during dry years may be slightly increased from normal years due to expected increase in outdoor water demands for irrigation.
e. Supply minus demand

As shown in Figure 4-4 water supply shortages are not projected because the groundwater supply can meet demands during the dry years when minimal surface water is available. During a dry year, the City's surface water supplies would be reduced. However, groundwater supplies from the deep aquifer would be increased to help meet demands. At maximum day demand, use of intermediate depth wells could be used to meet peak demand as necessary. Figure 4-5 shows monthly supply and demand comparisons in normal years and single dry years when Term 91 is in effect.

Climate change in is assumed 900 AFY in Figure 4-4, (as discussed in Section 4.5). In Figure 4-5, climate change is assumed to be an average of 75 AF/month which equates to a maximum of 900 AFY divided evenly over the year.

It is estimated that the City will have sufficient supply (in both normal and dry years) to meet its projected demands in 2045. Furthermore, it is projected that the City will be able to meet its 2045 demands with only groundwater supply from deep wells. It is unlikely that the City ever would rely entirely on surface water supply in dry years due to curtailments.

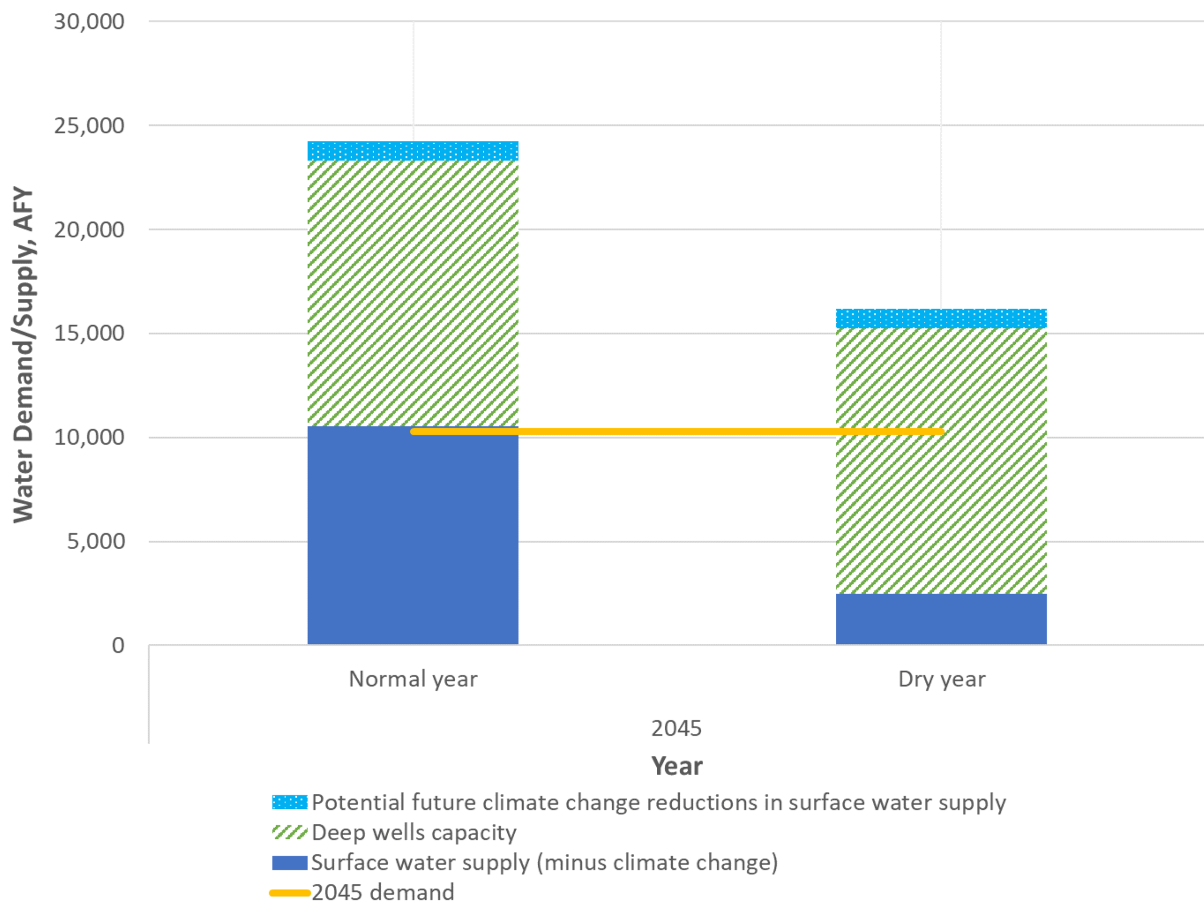

Figure 4-4. 2045 water supply reliability

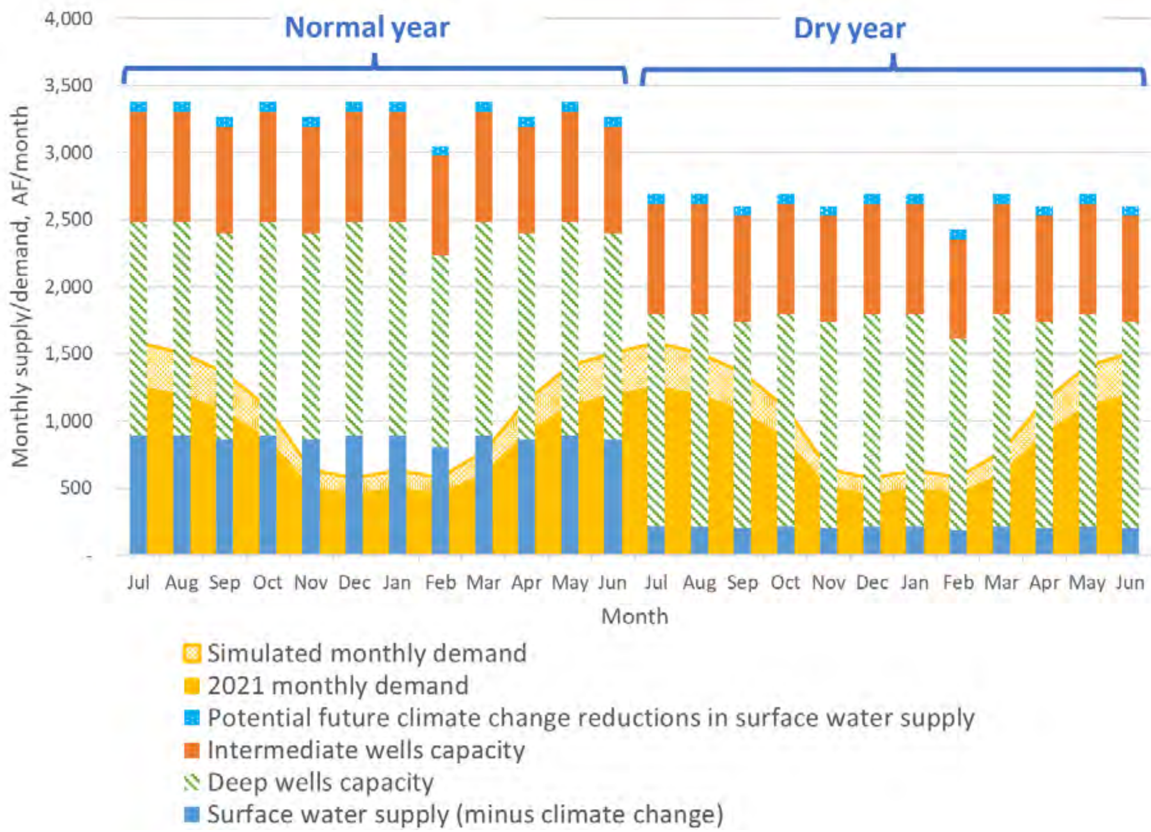

Figure 4-5. Monthly year supply vs demand analysis

4.5 Climate Change Impacts on Water Supply

As discussed in the 2020 UWMP, climate change is expected to impact the timing and frequency at which the State Water Resources Control Board imposes Term 91 curtailments as they are applied to WDCWA's primary water right. More specifically, Term 91 curtailments are predicted to occur 15 to 20 percent more frequently (BC, 2021). The resulting predicted Term 91 curtailments equate to an average reduction in WDCWA's primary water right diversion from 500 to 900 AFY for the City of Davis through the 2040 planning horizon (BC, 2021).

4.6 Water Treatment

Water is treated at both surface water and groundwater supply sources. For surface water treatment, raw water from the Sacramento River is treated at the RWTF by the treatment processes of flash mixing, clarification, ozonation, granular media filtration, chlorination, and ortho-phosphate (corrosion control). Groundwater is treated at each well head with chlorine for disinfection. In addition, Well 32 has a manganese treatment facility to remove manganese from the source water before entering the distribution system.

4.7 Water Quality

This section describes the City's water quality and regulations based on the City's most recent Consumer Confidence Report and testing data. This section also discusses key water quality constituents in the City's groundwater and potential impacts to the water supplies in the City's system based on upcoming drinking water regulations.

4.7.1 Annual Water Quality Report

Per the City's most recent Annual Water Quality Report, also referred to as the Consumer Confidence Report, for calendar year 2021, the City's water supply water quality is complied with all state and federal drinking water requirements. A summary of the results from the 2021 Annual Water Quality report is shown in Table 4-7.

Table 4-7. Water Quality Summary

Primary Regulated Substances					
Constituent	Units	MCL	DLR[a]	Recorded Concentration	
				Average Amount Detected	Range Low-high
Aluminum	ug/L	1000	50	ND[b]	ND
Antimony	ug/L	6	6	0	ND
Arsenic	ug/L	10	2	0.4	ND to 9.7
Asbestos	MFL	7	0.2	ND	ND
Barium	ug/L	1,000	100	1.9	ND to 200
Beryllium	ug/L	4	1	0	ND
Cadmium	ug/L	5	1	0	ND
Chromium	ug/L	50	10	0	ND to 48
Hexavalent Chromium	ug/L	-	1	0.5	ND to 47
Cyanide	ug/L	150	100	1.0	ND to 31
Fluoride	mg/L	2	0.1	0.01	ND to 0.37
Mercury	ug/L	2	1	0	ND
Nickel	ug/L	100	10	0	ND
Nitrate (as nitrogen)	mg/L	10	0.4	0	ND
Nitrite (as nitrogen)	ug/L	1,000	0.4	0	ND
Selenium	ug/L	50	5	0	ND to 27
Thallium	ug/L	2	1	0	ND
Gross Alpha Particle Activity	pCi/L	15	3	0.0	ND to 5.34
Tetrachloroethylene [PCE]	mg/L	0.005	0.0005	ND	ND
Trichloroethylene [TCE]	mg/L	0.005	0.0005	ND	ND
Secondary Regulated Substances					
Substance	Units	SMCL[c]	DLR	Average Amount Detected	Range Low-high
Aluminum	ug/L	200	50	ND[b]	ND
Chloride	mg/L	250	-	7.9	5.4 to 93
Color	Units	15	-	0	ND
Copper	ug/L	1,000	50	0	ND

Table 4-7. Water Quality Summary

Foaming Agents (MBAS)	mg/L	0.5	-	0	ND
Iron	ug/L	300	30	0	ND to 180
Manganese	ug/L	50	20	0.7	ND to 52
Odor	T.O.N.	3	1	1.8	ND to 2
Silver	ug/L	100	10	0.0	ND
Specific Conductance	umhos/cm	900	-	224	180 to 1,500
Sulfate	mg/L	500	0.5	16.3	13 to 150
Total Dissolved Solids	mg/L	500	-	234	220 to 870
Turbidity	NTU	5	0	0.1	0.1 to 0.75
Zinc	ug/L	5,000	50	0.0	ND
Lead and Copper Monitoring Program					
Substance	**Units**	**MCL**	**DLR**	**Average Amount Detected**	**Range Low-high**
Lead	ug/L	15	5	0	ND
Copper	ug/L	1300	50	0	ND
Disinfection Byproducts - Collected in the Distribution System					
Substance	**Units**	**MCL**	**DLR**	**Highest Compliance Result**	
Total Trihalomethanes (TTHMs)	ppb	80	-	23	
Haloacetic Acids (HAAs)	ppb	60	-	9.1	
Disinfectants - Collected in the Distribution System					
Substance	**Units**	**MRDL**	**Average Amount Detected**		**Range Low-high**
Distribution System Chlorine Residual	mg/L	0.01	0.68		0 to 1.35
Other Substances Of Interest					
Substance	**Units**	**MCL**	**DLR**	**Average Amount Detected**	**Range Low-high**
Total Alkalinity as CaCO3	mg/L	-	-	80	64 to 540
Boron	ug/L	-	100	130	56 to 1000
Calcium	mg/L	-	-	11.6	11 to 56
Magnesium	mg/L	-	-	6.2	5.3 to 120
Sodium	mg/L	-	-	25.4	17 to 130
Total Hardness as CaCO3	mg/L	-	-	54	49 to 620
pH	pH units	-	-	8	8 to 8.5

a. *DLR= Detection limit for reporting*

b. *ND= Not detected*

c. *Substances with Secondary MCLs do not have MCLGs; these limits are primarily established to address aesthetic concerns*

4.7.2 Inorganic Chemicals

Several inorganic chemicals measured in the City's groundwater are discussed in this section and their regulatory indicators are summarized in Table 4-8. These indicators include maximum contaminant levels (MCLs), detection limits for purposes of reporting (DLRs), and public health goals (PHGs) of the California regulations, as well as MCLs and maximum contaminant level goals (MCLGs) of the federal regulations. For regulatory compliance, water systems must sample for inorganic chemicals at every entry point to the distribution system which is representative of each water source after treatment. Recent regulatory activities related to inorganic chemicals and what this means for the City are summarized in this section.

Table 4-8. Regulatory Requirements for Inorganic Chemicals

Regulated Contaminant	Units	California			Federal	
		MCL	DLR	PHG	MCL	MCLG
Arsenic	µg/L	10	2	0.004	10	0
Chromium, Total	mg/L	0.05	0.01	Withdrawn	0.1	0.1
Chromium, Hexavalent	µg/L	--	--	0.02	--	--
Nitrate	mg/L as N	10 as N	0.4	10	10	10
Selenium	mg/L	0.05	0.005	0.03	0.05	0.05

4.7.2.1 Arsenic

A 10 µg/L federal MCL for arsenic has been in effect since January 2006. California revised its arsenic MCL from 50 µg/L to 10 µg/L in November 2008. Because of concerns over adverse health effects (mainly cancer effects), Division of Drinking Water (DDW) is currently investigating the technological and economic feasibility of lowering the MCL below the current California and federal MCL.

DDW is also considering revising the DLR for arsenic from 2 µg/L to 0.5 µg/L. A workshop was held by DDW in November 2022 to present the proposed regulatory package and comments were due later that month.

What this means for the City: Wells 27, 32, 33, and 34 are being monitored closely for Arsenic levels. While all four wells are below the MCL, the annual quarterly running average for Arsenic levels ranges from 3.5 to 6.4 µg/L.

4.7.2.2 Chromium and Hexavalent Chromium

The MCL for total chromium in California is 50 µg/L. The same MCL was required at the federal level, but the U.S. EPA relaxed the total chromium MCL to 100 µg/L in 1991. DDW, however, maintained the California MCL at 50 µg/L.

In July 2014, DDW published an MCL of 10 µg/L for hexavalent chromium. In May 2017, the Superior Court of Sacramento County issued a judgment invalidating the MCL on the basis that the Drinking Water Program who established the MCL had not properly considered the economic feasibility of complying with the MCL. The hexavalent chromium MCL was no longer in effect starting on September 11, 2017. As part of the next steps in reissuing an MCL for hexavalent chromium, DDW sought stakeholder involvement in developing options for evaluating economic feasibility during MCL development process. As such, DDW released a White Paper on "Economic Feasibility

Analysis in Consideration for a Hexavalent Chromium MCL" early March 2020. In March 2022, DDW released a draft regulation that proposed an MCL of 10 µg/L and a DLR of 0.05 µg/L for hexavalent chromium. Two virtual workshops were held early April 2022 and the comment period closed on April 29, 2022. Since then, DDW has not released any information regarding the outcome of its review.

What this means for the City: Total chromium is being closely monitored in Wells 23 and 27. Well 23 has an annual quarterly running average of 17.8 µg/L and Well 27 has an annual quarterly running average of 46.8 µg/L.

As mentioned above, although the MCL is no longer in effect, hexavalent chromium levels are closely monitored at all nine City wells with levels ranging from ND to 9.3 µg/L.

4.7.2.3 Nitrate and Selenium

What this means for the City: Nitrate and selenium are also inorganic chemicals that were detected in the City's production wells, although these contaminants were detected at concentrations much lower than their respective MCLs shown in Table 4-8. Nitrate levels are being closely monitored in Wells 23, 24, 26, and 27 with annual quarterly running averages ranging from 5.2 to 6.0 µg/L. Selenium is being closely monitored in Well 23 and has an annual quarterly running average of 25.8 mg/L.

4.7.3 Organic Chemicals

From a regulatory perspective, organic chemicals in drinking water include volatiles organic chemicals (VOCs) and non-volatile synthetic organic chemicals (SOCs). There are currently 60 regulated VOCs and SOCs, but in the City's water only carbon tetrachloride (at Well 24 only) showed concentrations near or above the regulatory requirements, which are an MCL of 0.5 µg/L (the DLR is also 0.5 µg/L) with a PHG of 0.1 µg/L in California, and an MCL and MCLG of 5 and zero µg/L, respectively, at the federal level. Currently, carbon tetrachloride is not on the list of contaminants subject to potential future regulations either by DDW of the U.S. EPA. DDW.

4.7.4 Secondary Drinking Water Standards

The U.S. EPA has established National Secondary Drinking Water Regulations (NSDWRs) that set non-mandatory, non-enforceable (at the federal level) water quality standards for 15 contaminants. An exception is made for fluoride and copper, which have both primary and secondary standards. California regulates 16 secondary standards, which are enforceable. Table 4-9 summarizes the regulatory requirements for secondary standards. These regulations only apply to treated water.

Table 4-9. Regulatory Requirements for Secondary Standards							
Regulated Contaminant	Units	California					Federal
		MCL			DLR	PHG	MCL
Color	Units	15			--	--	15
Copper	mg/L	1.0			0.05	0.3	1.0
Corrosivity	-	--			--	--	Non-corrosive
Foaming agents (MBAS)	mg/L	0.5			--	--	0.5
Iron	mg/L	0.3			0.1	--	0.3
Manganese	mg/L	0.05			0.02	--	0.05
Methyl-tert-butyl ether (MBTE)	mg/L	0.005			0.003	0.013	--
Odor	TON	3			1	--	3
pH	-	--			--	--	6.5 – 8.5
Silver	mg/L	0.1			0.01	--	0.1
Turbidity	NTU	5			0.1	--	--
Zinc	mg/L	5.0			0.05	-	5
		Recommended	Upper	Short Term			
TDS	mg/L	500	1,000	1,500	--	--	500
Specific Conductance	µS/cm	900	1,600	2,200	--	--	--
Chloride	mg/L	250	500	600	--	--	250
Sulfate	mg/L	250	500	600	0.5	--	250

In addition to having a secondary MCL of 50 µg/L, manganese has a Notification Level (NL) of 500 µg/L and a Response Level (RL) of 5,000 µg/L. DDW has initiated the process of developing revised NL and RL for manganese. As part of this process, DDW requested for the Office of Environmental Health Hazard Assessment (OEHHA) to review and comment on a derivation of a manganese Health Protective Concentration (HPC) of 20 µg/L. The HPC could serve as the basis for future OEHHA recommendations to revise the current NL and RL. OEHHA has concurred with DDW's assessment regarding the minimum HPC but advised DDW that additional documents should be considered to do a thorough health effects analysis leading to RL and NL recommendations.

As part of its DLR revision, DDW is also considering implementing DLRs for contaminants with secondary standards. These contaminants do not yet have DLRs. For manganese, DDW proposed a DLR of 20 µg/L in the first phase of implementation of this potential new regulation, and a lower level of 10 µg/L that would become the revised DLR three years after the regulation becomes effective. For iron, the proposed DLR is 0.1 mg/L.

Manganese is also on DDW's list of contaminants subject to future regulations. In addition, manganese is on the U.S. EPA's proposed fifth list of Contaminant Candidate List (CCL). Additional information about the CCL is presented below.

What this means for the City: Although iron was detected in one of the City's well, manganese is the contaminant in which DDW is most interested. Currently Well 32 is treated for Manganese. Wells 30, 33, and 34 are being closely monitored and have annual quarterly running averages of manganese ranging from 8.0 to 38.5 µg/L.

4.7.5 Lead and Copper Rule and Lead and Copper Rule Revisions

The Lead and Copper Rule (LCR) established MCLGs of 0 mg/L for lead and 1.3 mg/L for copper, and action levels (ALs) of 0.015 mg/L for lead and 1.3 mg/L for copper. The regulation determines compliance by comparing the 90th percentile (i.e., the concentration above which only 10 percent of the data are found) of lead and copper concentrations measured at all customer taps during each sampling period with the ALs for these two contaminants.

The LCR has undergone several revisions and corrections since its original publication in 1991. The most recent are the Lead and Copper Rule Revisions (LCRR), published on January 15, 2021. The LCRR proposes the same ALs of 1.3 and 0.015 mg/L for copper and lead, respectively, based on 90th percentile concentrations of samples collected during each monitoring round. The following summarizes the most critical changes to the LCR published by the U.S. EPA:

- Addition of a Trigger Level of 0.010 mg/L for lead, based on the 90th percentile, to compel water systems to take proactive actions. Should the 90th percentile lead level exceeds this Trigger Level, systems are required to take various actions based on whether they practice corrosion control treatment (CCT) and whether they have lead service lines (LSLs) or service lines made of unknown materials. Water systems on reduced monitoring are also required to sample annually at the standard number of distribution system sites.
- Requirement to conduct a service line material inventory by October 16, 2024 and update the inventory annually. The service line material inventories differ from the inventories that the California Senate Bill 427 of September 2017 (Section 116885 of Health and Safety Code, HSC) required from California water systems. The California inventories focused only on the system side of the service lines whereas the LCRR requires systems to inventory both the system sides and customer sides of each service lines. The purpose of these inventories is to identify the areas most impacted by higher lead concentrations, plan replacement of concerning service lines made of concerning materials, and revised sampling sites accordingly.
- Changes in sampling site selection to target locations with high lead levels based on the service line material inventory. Although the number of sampling sites remains the same as stated in the LCR and continues to be based on population served, this provision requires water systems to sample from sites served by verified LSL. Sampling includes alternate sites only if the minimum required number of samples cannot be collected from LSLs. This provision also includes several improvements to the sampling procedure, including the use of wide-mouth bottles only.
- Strengthening of CCT requirements by requesting more water systems to implement such treatment, and mandating systems that exceed the Trigger Level or Action Level for lead to re-optimize their CCT. In addition, calcium hardness adjustment is no longer considered a CCT.
- Addition of a "find-and-fix" assessment focusing on CCT and water quality parameters (WQPs). This provision requires water systems to conduct additional samplings if customer tap(s) exceed 0.015 mg/L for lead. Within five days of this finding, systems need to collect WQP sample(s) at or near the site(s) where lead concentrations exceeded 0.015 mg/L and collect follow-up lead sample(s) within 30 days at each site where lead concentrations exceeded 0.015 mg/L. Systems need to notify the affected customer(s) within 3 days if follow-up sample(s) exceed

0.015 mg/L for lead. Systems need to recommend solutions to the State (i.e., DDW) within six months of the end of the monitoring period when the high lead concentrations were measured.

- Changes to the LSL replacement program by requesting water systems with LSLs to prepare an LSL Replacement Plan (Plan) by October 16, 2024. Systems need to implement this Plan if their 90th percentile for lead exceeded the Trigger Level of 0.010 mg/L.
- Improvement to the public education and customer notification components to the LCR to strengthen risk communication. Water systems with 90th percentile lead levels that exceed the Action Level of 0.015 mg/L need to provide public education to all of their customers within 24 hours. Additional consumer notifications are also required depending on the outcome of the service line material inventory.
- Addition of a requirement for water systems to develop a list of customers that provide water to licensed schools or child-care facilities and verify this list every five years. Each year, the water provider must test 20 percent of these facilities for lead such that all facilities are sampled every five years.

Following the publication of the LCRR in January 2021, the U.S. EPA reviewed this new regulation to further evaluate if the LCRR protected families and communities, particularly those that have been disproportionately impacted by lead in drinking water. The agency concluded that there are significant opportunities to improve the LCRR and decided to develop a new proposed rule, the Lead and Copper Rule Improvements (LCRI). The LCRI may impose requirements upon public water systems (PWSs) requiring the replacement of 100 percent of lead service lines, changing the requirements for conducting compliance sampling for lead and copper, and changes to the trigger and action levels for lead which may result in more systems modifying or installing and maintaining corrosion control treatment and conducting public education programs. The U.S. EPA does not expect to propose changes to the requirements that pertain to the initial lead service line inventory or the associated October 16, 2024, compliance date. The U.S. EPA recognizes that continued progress to identify lead service lines is integral to lead reduction efforts regardless of potential revisions to the rule. The U.S. EPA expects to release a draft regulation in 2023.

4.7.6 Contaminants with Notification Level and Response Level

DDW establishes health-based notification levels (NL) for selected contaminants for which MCLs have not yet been established but may present health risks. Water systems are required to notify DDW and their governing bodies when NLs are exceeded (HSC Section 116455). In these circumstances, DDW recommends that systems notify their customers and consumers. DDW also establishes response levels (RL) for certain contaminants with NLs. When a contaminant is detected above its RL, DDW recommends removing a drinking water source from service or conduct additional sampling and notification. NL and RL are non-enforceable standards for drinking water systems, i.e., contaminants with NLs or RLs do not trigger mandatory monitoring, except for recycled water systems.

As of November 2022, 32 chemicals had NLs and 9 contaminants had RLs. Three of these contaminants were part of the per- and poly-fluoroalkyl substances (PFAS) group, i.e., perfluorooctanoic acid (PFOA) with an NL of 0.0000051 mg/L (5.1 ng/L), perfluorooctanesulfonic acid (PFOS) with an NL of 0.0000065 mg/L (6.5 ng/L), and perfluorobutanesulfonic acid (PFBS) with an NL of 0.0005 mg/L (0.5 µg/L). PFOA and PFOS also have of 10 and 40 ng/L, respectively. More recently, DDW issued proposed NL and RL of 3 and 20 ng/L, respectively, for perfluorohexane sulfonic acid (PFHxS). Water systems may be required to monitor for PFAS if ordered to do so by DDW (HSC Section 116378).

4.7.7 Unregulated Contaminant Monitoring Program

The 1996 Amendments to the SDWA required the U.S. EPA to establish criteria for a monitoring program for unregulated contaminants, and to publish, once every five years, a list of no more than 30 contaminants to be monitored by water systems. Four rounds of Unregulated Contaminant Monitoring Rule (UCMR) have been completed thus far, and the fifth round was published on December 27, 2021. UCMR 5 will include 29 PFAS and lithium. Water systems are notified directly by and report to the U.S. EPA for this special monitoring.

4.7.8 Contaminant Candidate List

The Contaminant Candidate List (CCL) is a list of contaminants currently not subject to any proposed or promulgated Federal regulations but known or anticipated to occur in water systems and may require future regulation. The second amendment of the SDWA requires the U.S. EPA to publish the CCL every five years. Each list is not limited by a fixed number of contaminants; however, the U.S. EPA must make regulatory determinations for at least five contaminants from each list. Regulatory determinations may include: 1) a positive determination when a regulation is deemed necessary for a contaminant, 2) a negative determination when a regulation is not needed, or 3) in need of further research pertaining to one or more of the following—health effects, treatability, analytical methods, and occurrence.

On October 28, 2022, the U.S. EPA released the CCL 5. The list includes 66 contaminants, three chemical groups (PFAS, cyanotoxins, and DBPs), and 12 microbes. The CCL does not impose any requirements on water systems.

4.8 Wellhead Treatment Evaluation

This section provides a preliminary evaluation of potential wellhead treatment for five of the City's nine groundwater wells. The analysis provides of summary of existing water quality constituents, wellhead treatment recommendations, and preliminary planning costs for wellhead treatment recommendations.

To determine the five groundwater wells to evaluate for wellhead treatment recommendations, BC, in coordination with the City, analyzed the City's nine groundwater wells based on criteria such as:

- Age
- Capacity
- Water quality
- Site Conditions

In conclusion, Wells 24 & 26 were eliminated from further study based on the above criteria and Wells 30 and 32 were removed from consideration because the City is already evaluating water quality at those two locations. Table 4-10 provides a summary of groundwater water quality constituents and treatment recommendations for Wells 23, 27, 31, 33, and 34.

Table 4-10. Summary of Groundwater Water Quality Constituents and Treatment Recommendations

	Well 23	Well 27	Well 31	Well 33	Well 34	MCL/SNL
Actual capacity, gpm	1,600	1,300	2,500	1,800	2,300	-
Arsenic, ug/L	ND	3.4	2.5	*9.0*	*4.6*	10
Boron, ug/L	830	1,000	720	920	700	1,000 (SNL)
Hexavalent Chromium, ug/L	*20*	*47*	*9.3*	ND	ND	10[a]
Selenium, ug/L	*27*[e]	11	ND	ND	ND	50
Nitrate, mg/L as N	*5.7*	*5.7*	ND	ND	ND	10
Manganese, ug/L	ND	ND	ND	*25*	12	50[b]
Total Dissolved Solids, mg/L	870	740	370	350	360	500[c]/1,000[d]
pH, pH units	8.2	8.3	8.4	8.5	8.5	6.5-8.5
Total Alkalinity, mg/L as $CaCO_3$	540	510	220	200	200	-
Calcium, mg/L	56	35	18	17	18	-
Magnesium, mg/L	120	87	22	9.2	13	-
Sulfate, mg/L	150	100	53	34	46	250[c]/500[d]
Chloride, mg/L	93	47	35	21	30	250[c]/500[d]
Potential Treatment Processes	Ion exchange or biological with filtration	Ion exchange or biological with filtration	Ion exchange	Ferric coagulation with greensand filtration	Iron media adsorption	-

MCL=Maximum Contaminant Level
SNL=State Notification Level

a. *MCL rescinded due to a lawsuit from small utilities regarding costs; new MCL development in progress.*
b. *Secondary MCL; may be reduced in California in the future.*
c. *Recommended MCL for Consumer Acceptance*
d. *Upper MCL for Consumer Acceptance*
e. *The selenium concentration of 27 ug/L is a little higher than half of the MCL. Selenium removal depends on the form of selenium species present in the water: selenate (+6) and selenite (+4). Regular anion exchange resin that can remove hexavalent chromium and nitrate can also remove selenite but not selenate. For selenate removal it must be reduced to elemental selenium using biological treatment or zero valent iron media and then filtration which is expensive and more difficult to operate. It is recommended that the City speciate selenium in the next sampling event. If selenite is present in significant proportion, then the ion exchange system for hexavalent chromium and nitrate removal can reduce selenium to below half of the MCL.*

Based on the water quality constituents of each of the wells, wellhead treatment recommendations are made in Table 4-10 for water quality constituent levels indicated in italics. Wellhead treatment recommendations are based on industry standard treatment processes and for this analysis, treatment is recommended when a water quality constituent meets the 50 percent threshold of an MCL. For Well 23, partial treatment recommendations are also provided in Table 4-11 due to water quality constituents not meeting the 50 percent MCL threshold but still having detectable levels of regulated constituents. Although Well 34 does not have Manganese levels at the 50 percent threshold of an MCL, the City has directed BC to evaluate wellhead treatment for both Arsenic and Manganese at this location and therefore will recommend ferric coagulation with greensand filtration for wellhead treatment in Table 4-11.

4.8.1 Wellhead Treatment Types

Based on the water quality constituents present in Table 4-10, treatment technologies are described in this section.

4.8.1.1 Ion Exchange

Utilizing weak-base and strong-base anion exchange resins have demonstrated the use of anion exchange technology to remove hexavalent chromium and nitrate. Treatment equipment typically consists of treatment vessels, tanks for brine storage and waste, and a brine precipitation unit to remove hexavalent chromium from the brine so that the brine can be disposed of as non-hazardous waste.

4.8.1.2 Ferric Coagulation with Greensand Filtration

In this process chlorine or hypochlorite is used to oxidize arsenic and manganese to a higher oxidation state. A ferric salt is used to form ferric hydroxide that will co-precipitate/adsorb arsenic. The greensand filter serves to filter out the co-precipitated ferric hydroxide/arsenic particles and remove dissolved and particulate manganese from the water. Treatment equipment typically consists of a filter with multiple cells for backwashing, backwash recovery tank, chemical feed pumps, and storage systems.

4.8.2 Wellhead Treatment Summary

Table 4-11 summarizes the recommended wellhead treatment and provides estimated costs for Wells 23, 27, 31, 33, and 34. In all cases, recommended treatment equipment improvements cannot be accommodated within the existing well sites. Equipment cost estimate information was solicited from industry vendors and construction estimates to improve well site and install equipment was estimated at twice the cost of the equipment estimate.

Annual Operations & Maintenance (O&M) costs are estimated based on based on chemical consumptions, electricity usage, waste disposal, and media replacement costs. Labor costs are not included.

Table 4-11. Wellhead Treatment Summary

	Well 23	Well 27	Well 31	Well 33	Well 34
Capacity, gpm	1,600	1,300	2,500	1,800	2,300
Treatment type	Ion exchange	Ion exchange	Ion exchange	Ferric coagulation w/green sand filtration	Ferric coagulation w/green sand filtration
Space available onsite	No	No	No	No	No
Available adjacent space	Yes	Yes	Yes	No	Yes
Land acquisition required	No	Yes	Yes	Yes	No
Equipment cost only (estimate)	Full Treatment - $3,000,000 Partial Treatment - $2,000,000	$2,000,000	$2,000,000	$700,000	$840,000
Construction Cost (x2)	$4,000,000 - $6,000,000	$4,000,000	$4,000,000	$1,400,000	$1,680,000
Annual O&M Cost (estimated)	$75,000 - $150,000	$150,000	$150,000	$50,000	$64,000

Section 5

Water System Capacity Evaluation

This section presents the results of an analysis of the City's storage and distribution facilities. The analysis is based on existing and projected customer demands, operational criteria, and fire protection considerations. The water system capacity analysis includes an evaluation of the following:

- Distribution storage adequacy
- Pressures, velocities, and unit headlosses throughout the pipe network
- Fire flow availability

5.1 Desktop Storage Analysis

This section analyzes existing storage facilities to determine the need for additional above ground storage facilities to meet existing and future equalization, fire flow, and emergency needs. The storage analysis considers both the storage volume and the storage pumping capacity. There are two steps to this analysis.

5.1.1 Step 1 – Evaluate Sufficiency of Firm Supply Capacity

The initial step of the desktop storage analysis is to compare the recommended supply capacity to the existing firm supply capacity for the following existing and buildout demand conditions:

- MDD
- MDD plus fire flow
- PHD

Table 5-1 compares the firm supply capacity to the existing capacity under the three demand conditions in existing and buildout system conditions. Below are observations of the evaluation:

- MDD
  - Existing and Buildout MDD is expected to be met utilizing firm supply capacity without storage pumping capacity.
  - The firm supply capacity is sufficient to meet the existing MDD conditions. Buildout MDD shows a slight deficit (189 gpm) when compared with firm supply capacity however is considered acceptable based on the City's additional available supply sources such as intermediate wells.
- MDD plus fire flow
  - Existing and Buildout MDD plus fire flow show a firm supply capacity surplus under these conditions.
- PHD
  - Existing and Buildout PHD show a firm supply capacity surplus under these conditions.

Table 5-1. Existing and Buildout Firm Supply Capacity Evaluation with Existing Storage							
	MDD		MDD plus fire flow		PHD		Notes
	Existing (2021)	Buildout (2045)	Existing (2021)	Buildout (2045)	Existing (2021)	Buildout (2045)	
Demand, gpm	9,861	10,208	13,861	14,208	15,009	15,357	Fire flow assumed is 4,000 gpm (See Section 5.2). MDD and PHD from Table 3-14.
Required supply capacity, gpm							
Firm surface water and well capacity	9,861	10,208	9,861	10,090	9,861	10,090	Firm capacity must be able to supply at least MDD.
Storage pumping capacity	-	-	4,000	4,000	5,148	5,412	Storage pumping capacity must be adequate to supply demand that exceeds the MDD.
Total	9,861	10,208	13,861	14,208	15,009	15,357	
Existing firm supply capacity, gpm							
Firm surface water capacity	2,083	2,083	2,083	2,083	2,083	2,083	From Section 4.2, 3 mgd
Firm well capacity	7,936	7,936	7,936	7,936	7,936	7,936	From Table 4.3.2, 12,800 AFY
Subtotal firm supply capacity	10,019	10,019	10,019	10,019	10,019	10,019	Total existing firm supply capacity meets required firm capacity for MDD.
Storage pump station capacity	-	-	9,750	9,750	9,750	9,750	From Section 2-4.
Total	10,019	10,019	19,769	19,769	19,769	19,769	
Total existing firm supply capacity minus total required supply capacity, gpm	158	(189)	5,908	5,561	4,760	4,412	

5.1.2 Step 2 – Size Recommended Storage

The second step of the desktop storage analysis is to size a storage tank assuming that the firm supply capacity is utilized to meet no more than the Existing and Buildout MDD.

Recommended storage volume consists of equalization, fire storage, and emergency reserve, as described below.

- Equalization or operational volume represents the volume of storage that is needed to supply the increment of demand that is greater than the average flow rate for the day. The equalization volume is calculated by multiplying the equalization factor by the MDD. The equalization factor is calculated as the area under the diurnal demand curve and above the average flow rate for the day divided by the total demand for the day (See Figures 5-1 and 5-2).
- The equalization factor and operational volume are affected by the shape of the diurnal demand curve. Diurnal demand curves that exhibit higher peak demands that last for a longer duration result in higher equalization factors and larger equalization volumes. A standard design

equalization factor of 20 percent is assumed for this analysis. Figures 5-1 and 5-2 show that the estimated actual operational storage volumes for existing and buildout respectively, are slightly lower than 20 percent based on the City's 2021 and projected 2045 diurnal curves. Actual existing operational storage is approximately 2.3 MG or 15 percent of the MDD volume, and buildout operational storage is approximately, 2.5 or 16 percent of the MDD volume. Also shown are the existing and buildout firm surface water, well, and storage pumping capacity to meet all demand conditions.

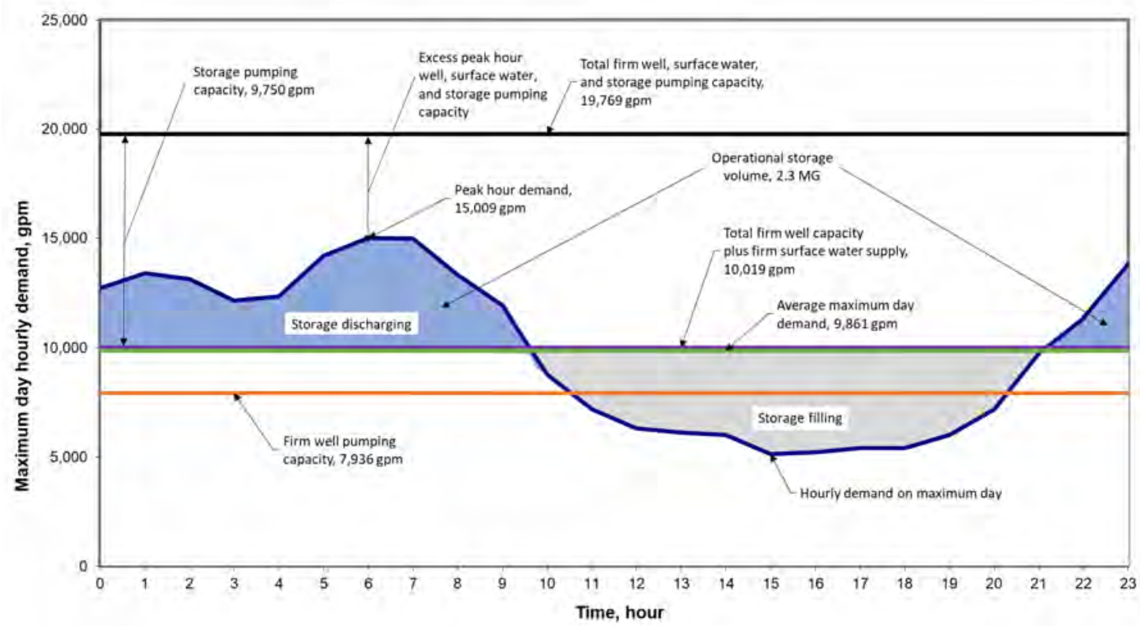

Figure 5-1. Existing system operational storage capacity analysis

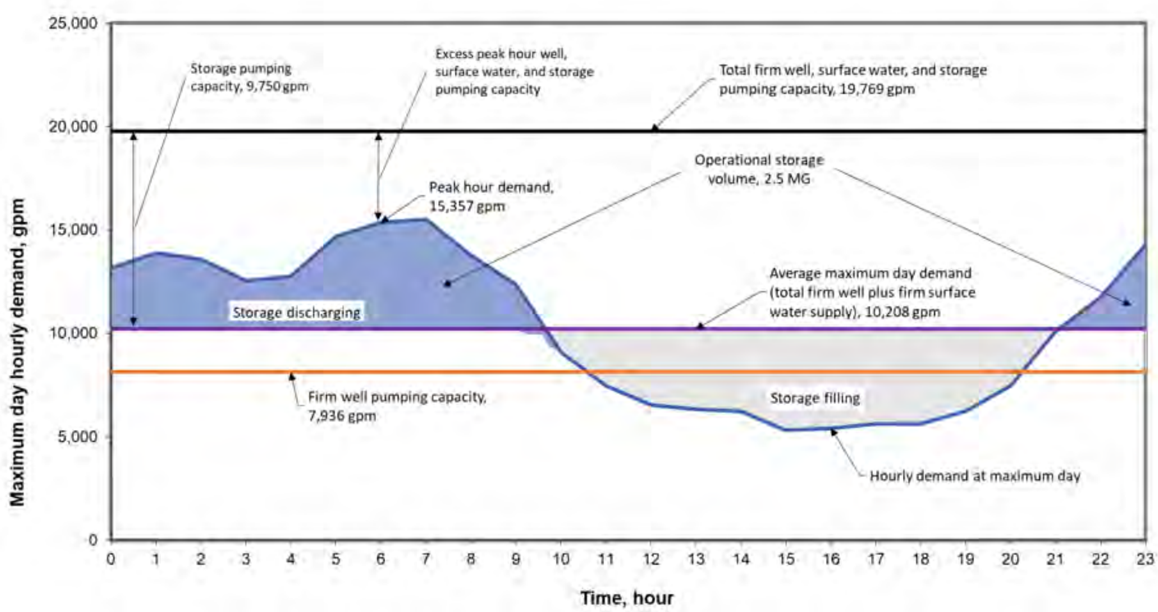

Figure 5-2. Buildout system operational storage capacity analysis

- Fire storage is quantified for this analysis based on one fire flow at 4,000 gpm for a duration of four hours, or 0.96 MG. For this analysis, the storage is sized to provide all the fire flow.
- Emergency reserve is used to provide supply for a short period of time in which other water sources became unavailable. Although not a requirement, a common practice is to provide one average day of demand as the volume of the emergency storage component if possible.

The storage volume sizing presented in Table 5-2 is based on the firm supply capacity supplying no more than the Existing and Buildout MDD. As shown in Table 5-2, the existing storage volume provides operational, fire, and approximately half of emergency storage.

Table 5-2. Storage Volume Sizing [a]

	Existing (2021)	Buildout (2045)	Notes
MDD, mgd	14.2	14.7	From Table 3-14.
Recommended Storage Volume, MG			
Operational	2.8	2.9	Equalization factor (20%) times MDD.
Fire	0.96	0.96	Assumed 4,000 gpm for 4 hours.
Emergency	9.2	9.3	Assumed one average day demand for emergency storage from Table 3-14.
Total	13.0	13.2	
Existing Storage Volume, MG	8.2	8.5	For Existing (2021), From Table 2-3 (WAT, EAT, & Elevated Tank combined volume). For Buildout (2045), WAT, EAT, and proposed relocated Elevated Tank (0.5 MG) combined volume.
Storage Surplus/(Deficit), MG	(4.8)	(4.7)	

a. *This analysis based on the firm supply capacity supplying no more than the Existing and Buildout MDD*

The storage analysis results in the following conclusions:

1. 13.0 MG and 13.2 MG of storage volume is recommended for existing and buildout conditions, respectively.
2. Without utilizing firm supply capacity, the City does not have enough storage volume capacity to meet the recommended storage volume. The City's existing storage tank facilities provide equalization/operational and fire storage requirements and approximately half (4.4 MG & 4.6 MG) of emergency storage capacity.
3. The groundwater aquifer storage (deep and intermediate wells combined) can supply the remaining emergency storage requirements and therefore additional storage is not necessary.

5.2 Water Distribution System Hydraulic Capacity Analysis

The hydraulic evaluation and modeling results of the City's existing and buildout water distribution system are described in this section. The hydraulic analysis evaluation criteria including pressures, velocities, unit headlosses, and fire flow are defined. Recent updates to the City's hydraulic model and its scenarios are identified. Pipelines that do not meet the hydraulic analysis evaluation criteria are summarized as well as recommended improvements to alleviate these deficiencies.

5.2.1 Hydraulic Analysis Evaluation Criteria

Table 5-3 lists the hydraulic analysis evaluation criteria utilized to evaluate the water system.

Table 5-3. Hydraulic Analysis Evaluation Criteria

Criteria	Value/Description	Reference
System Pressures		
Minimum at PHD	35 psi	Allowable for existing system based on the elevation of the elevated storage tank.
Minimum during non PHD and non-fire flow conditions	40 psi	AWWA M32, pg 119 2 CCR § 64602 (b) (for new Developments)
Minimum during fire flow at MDD	20 psi	2 CCR § 64602 (a)
Velocity		
Maximum (Not Applied to Fire Flow)	5 ft/sec – New Pipelines 10 ft/sec – Existing System	BC recommendation
Unit Headloss		
Maximum (Not Applied to Fire Flow)	7 ft/1000 ft	BC recommendation
Fire Flow at MDD[a]		
Single-family Residential	1,000 gpm, 1-hour duration	BC recommendation (Confirmed with City of Davis Fire Department)
Multi-family Residential	2,500 gpm, 2-hour duration	
Commercial	3,000 gpm, 3-hour duration	
Institutional (Schools, Hospitals, etc.)	4,000 gpm, 4-hour duration	
Industrial/Business Park	4,000 gpm, 4-hour duration	

a. *The nearest model junction to each fire hydrant lateral and hydrant, was assigned a "YES" in the "AT_HYDRANT" field in the model. The largest required fire flow demand associated with land use parcels estimated to be served by each hydrant was allocated to the Fire Flow table for the corresponding model junction. The InfoWater Pro Fire flow tool was used to simulate fire flow demands at the nearest model junctions to each hydrant lateral connection.*

5.2.2 Hydraulic Model Tool

The City's hydraulic model tool was updated as part of the 2021 Final Hydraulic Model Development Report (BC, 2021). As part of the 2021 model update, the City's Innovyze InfoWater water system hydraulic model was updated to reflect existing water utility infrastructure from the City's GIS and input from City staff. The model was calibrated with both hydrant flow tests and operational SCADA data.

Since the 2021 model update that following additions to the model have been made:

- Pipelines
  - Update North Davis Meadows existing and proposed pipelines within North Davis Meadows consistent with North Davis Meadows Connection to City of Davis Potable Water System – Updated Recommendations to Serve Existing Residential Fire Suppression Systems (West Yost Associates, 2022).
  - Upsize 8-inch diameter pipe on Chiles Rd to 12-inch (from near Well 32 to Ensenada Dr) per recent 2022 CIP project.
  - Extend surface water transmission main to Well 30 for Buildout scenario.
  - Extend surface water transmission main up to WAT piping on Risling Ct for Buildout scenario.

  - Remove existing elevated storage tank and replace with new elevated 0.5 MG storage tank at City Parks and Recreation Corporation Yard for Buildout scenario with the following assumptions:
    - HGL is 15 ft higher than existing tank (ground elevation approximately 43 ft)
    - Low water level is 106 ft above grade (elevation approximately 149 ft)
    - High water level is 135 ft above grade (elevation approximately 178 ft)
- Controls
  - Update intermediate well controls (add controls for Well 30).
  - Update controls for Buildout scenario to maintain pressures in North Davis Meadows after connection to City water system.
  - Add proposed Well 30 blending station and adjust controls consistent with blending analysis. Note: analysis is not yet finalized, but there is not anticipated to be any lost capacity from Well 30. Increased headloss associated with proposed blending station and treatment system will be overcome by a new well pump at Well 30.
  - Raise VFD settings for WAT and EAT booster pump stations by 6.5 psi (15 ft HGL) for Buildout scenario.
- Scenarios
  - Add Term 91 surface water curtailment scenarios.

5.2.3 Modeling Scenarios

Table 5-4 lists the modeling scenarios updated as part of this analysis and identifies the scenarios simulated and discussed in Section 5.2.4. These analyses are based on PHD and MDD plus fire flow conditions. The PHD conditions were modeled as an extended period simulation (EPS) as part of the diurnal pattern in the MDD scenarios.

Table 5-4. Modeling Scenarios

Scenario	Description	City Demand (gpm)	UCD Demand (gpm)	Additional Fire Flow Demand (gpm)	Total Demand (gpm)	Supply Used (gpm)		
						Surface Water	Ground Water	Storage/ BPS
1	Existing (2021) ADD	6,383	826	-	7,209	7,083	126	-
2[a]	Existing (2021) MDD	9,861	826	-	10,687	7,083	3,604	-
2a	Existing (2021) MDD, Term 91	9,861	826	-	10,687	2,083	8,604	-
2b[a, b]	Existing (2021) MDD plus Fire Flow	9,861	826	Varies by location/land use served (1,000 – 4,000)	10,687	7,083	3,604	Varies by location/l and use served (1,000 – 4,000)
3	Existing (2021) LDD	2,724	826	-	3,550	3,472	-	-
4	Buildout (2045) ADD	6,380	826	-	7,132	7,083	49	-
5[a]	Buildout (2045) MDD	10,208	826	-	11,034	7,083	3,951	-
5a	Buildout (2045) MDD, Term 91	10,208	826	-	11,034	2,083	8,951	-
5b[a, b]	Buildout (2045) MDD plus Fire Flow	10,208	826	Varies by location/land use served (1,000 – 4,000)	11,034	7,083	3,951	Varies by location/l and use served (1,000 – 4,000)
6	Buildout (2045) LDD	2,965	826	-	3,791	3,472	319	-

a. *Scenarios simulated as part of this analysis. All model scenarios were updated for consistency with Section 3, but only MDD and MDD plus fire flow scenarios are used for the capacity analysis.*

b. *The InfoWater Pro Fire flow tool was used to simulate fire flow demands at the nearest model junctions to each hydrant lateral connection. Individual hydrant laterals and/or hydrants are not modeled; demands are simulated in the system on the City's mains. Note that the fire flow analysis does not take into consideration use of multiple hydrants for one location. As a result, fire flow availability may be underestimated in areas where multiple hydrants would be used.*

5.2.4 Hydraulic Analysis Results

A summary of the hydraulic analysis results is provided below. The pressure, velocity, and unit headloss results are illustrated in Appendix A.

- Existing (2021) System:
  - MDD:
    - Minimum pressures meet the City's evaluation criteria as they range from 38 to 57 psi within the existing distribution system (see Appendix A for results).
    - Maximum pressures range from 51 to 65 psi within the existing distribution system (see Appendix A for results).
    - Maximum velocities are sufficient as they range from 0 to 9 feet per second within the existing system (see Appendix A for results).

        - Maximum unit headlosses exceed the City's evaluation criteria of 7 ft/1,000 ft (per Table 5-3) as shown in Figure 5-3. Unit headlosses exceeding 10 ft/1,000 ft of pipe may cause decreased pumping efficiency and increased operating costs.
    - MDD plus Fire Flow:
        - There are some locations where the City's distribution system cannot meet the desired fire flow demands (shown in Table 5-5). Available fire flow and fire flow deficiencies for the existing distribution system are shown in Figure 5-4 and 5-5, respectively. Note that the fire flow analysis does not take into consideration use of multiple hydrants for one location. As a result, fire flow availability may be underestimated in areas where multiple hydrants would be used.
- Buildout (2045) (After incorporating improvements to meet existing system deficiencies identified in the existing system):
    - MDD
        - Minimum pressures meet the City's evaluation criteria as they range from 40 to 61 psi for buildout distribution system (see Appendix A for results).
        - Maximum pressures range from 57 to 76 psi within the buildout distribution system (see Appendix A for results).
        - Maximum velocities meet the City's criteria everywhere except for one location (see Appendix A for results).
            - Velocity criteria is exceeded in the pipeline that conveys water to and from the WAT. Due to the connection to North Davis Meadows, the WAT must pump one hour longer to sustain pressures in North Davis Meadows. Increased pumping time means there is one hour less to fill the tank requiring higher fill rates.
            - Maximum unit headlosses exceed the City's evaluation criteria of 7 ft/1,000 ft (per Table 5-3) as shown in Figure 5-6. Headloss criteria is exceeded near the proposed location of the Elevated Storage Tank and in the pipeline that conveys water to and from the WAT. As mentioned above, this is due to higher fill rates for the WAT.
    - MDD plus Fire Flow
        - The City's distribution system can sufficiently meet the desired fire flow demands at buildout once the recommended improvements to address existing fire flow deficiencies are installed (shown in Table 5-3). Available fire flow and fire flow deficiencies for the existing distribution system are shown in Figure 5-7 and Appendix A, respectively.

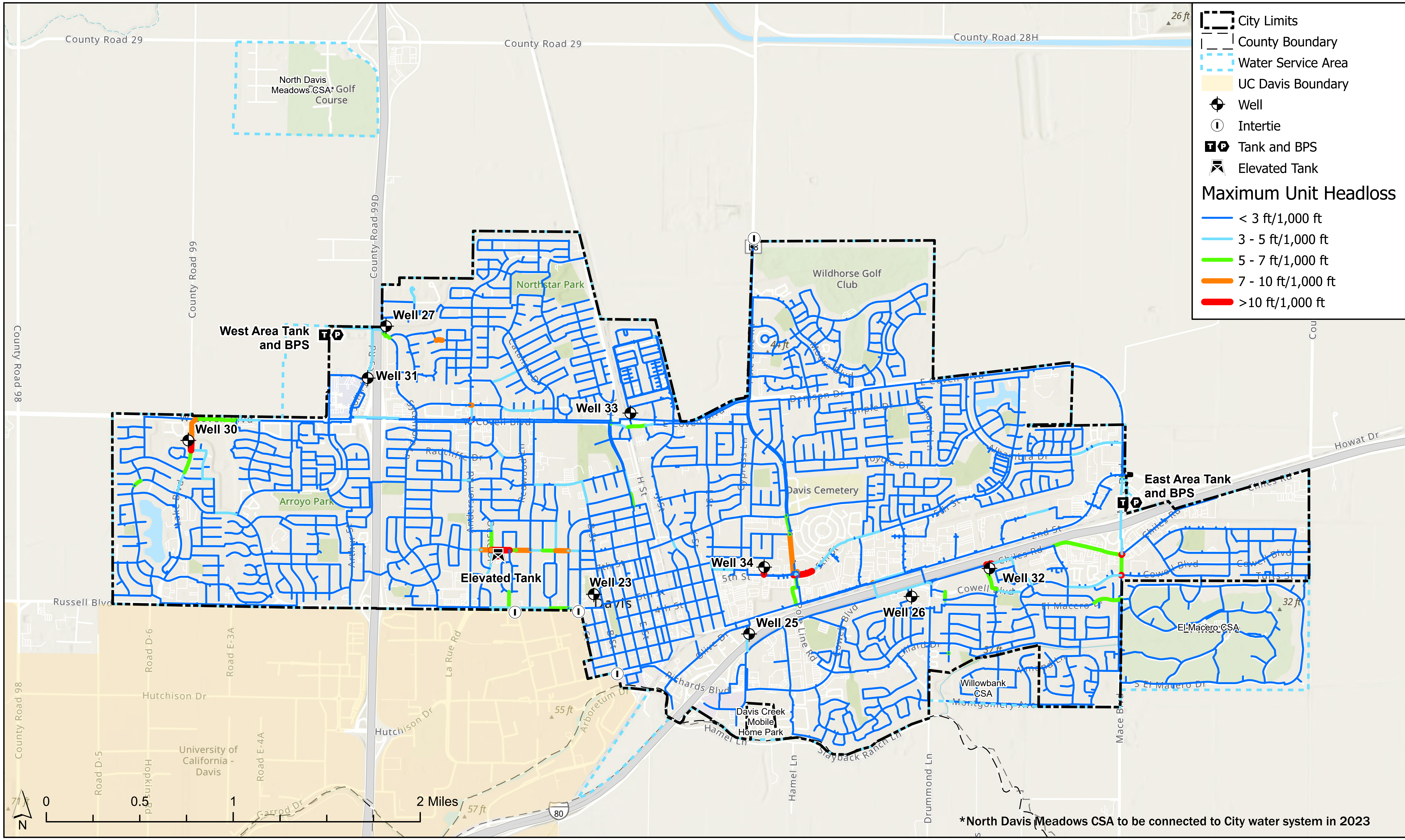

Figure 5-3. Existing system maximum unit headloss

Brown AND Caldwell

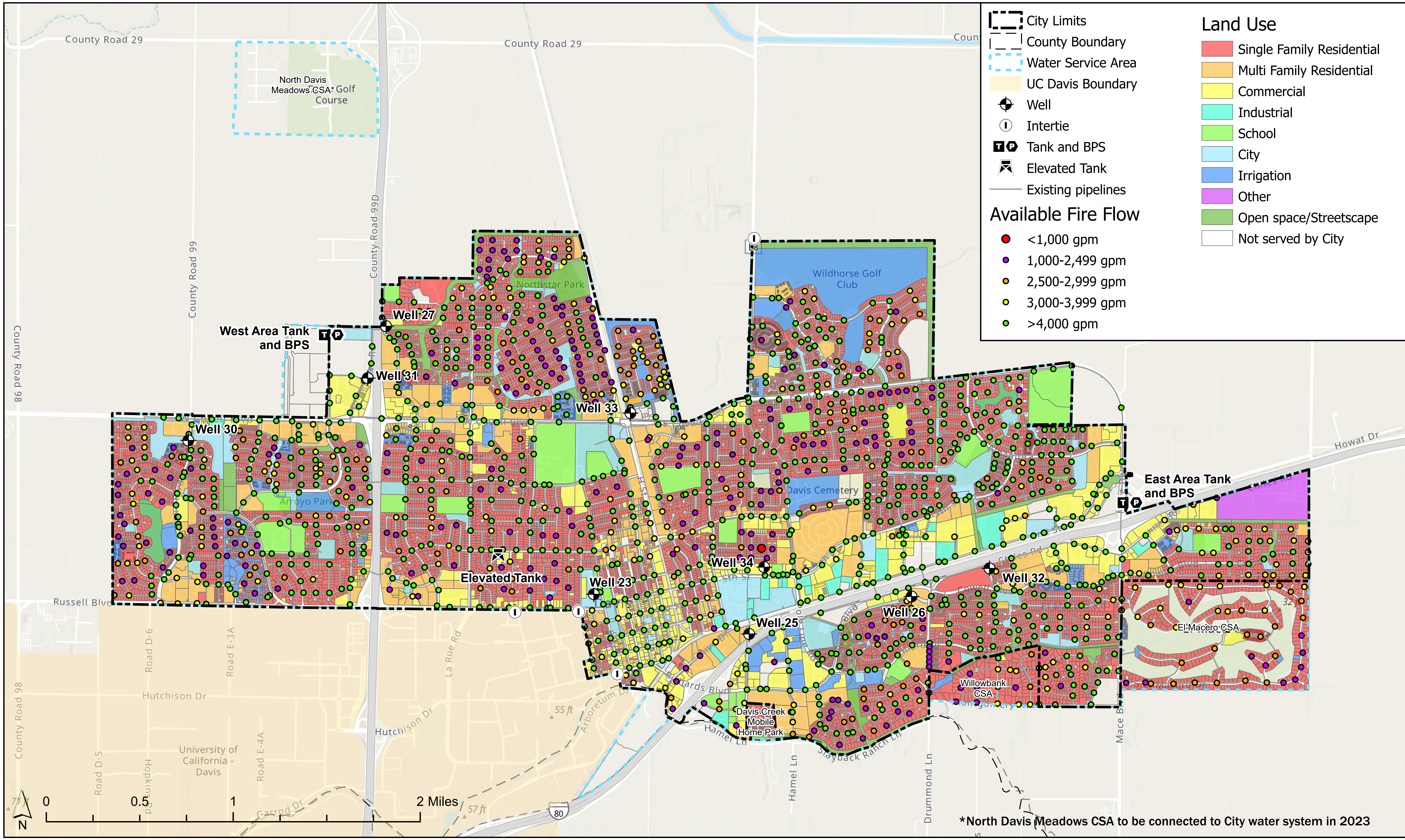

Figure 5-4. Existing system available fire flows

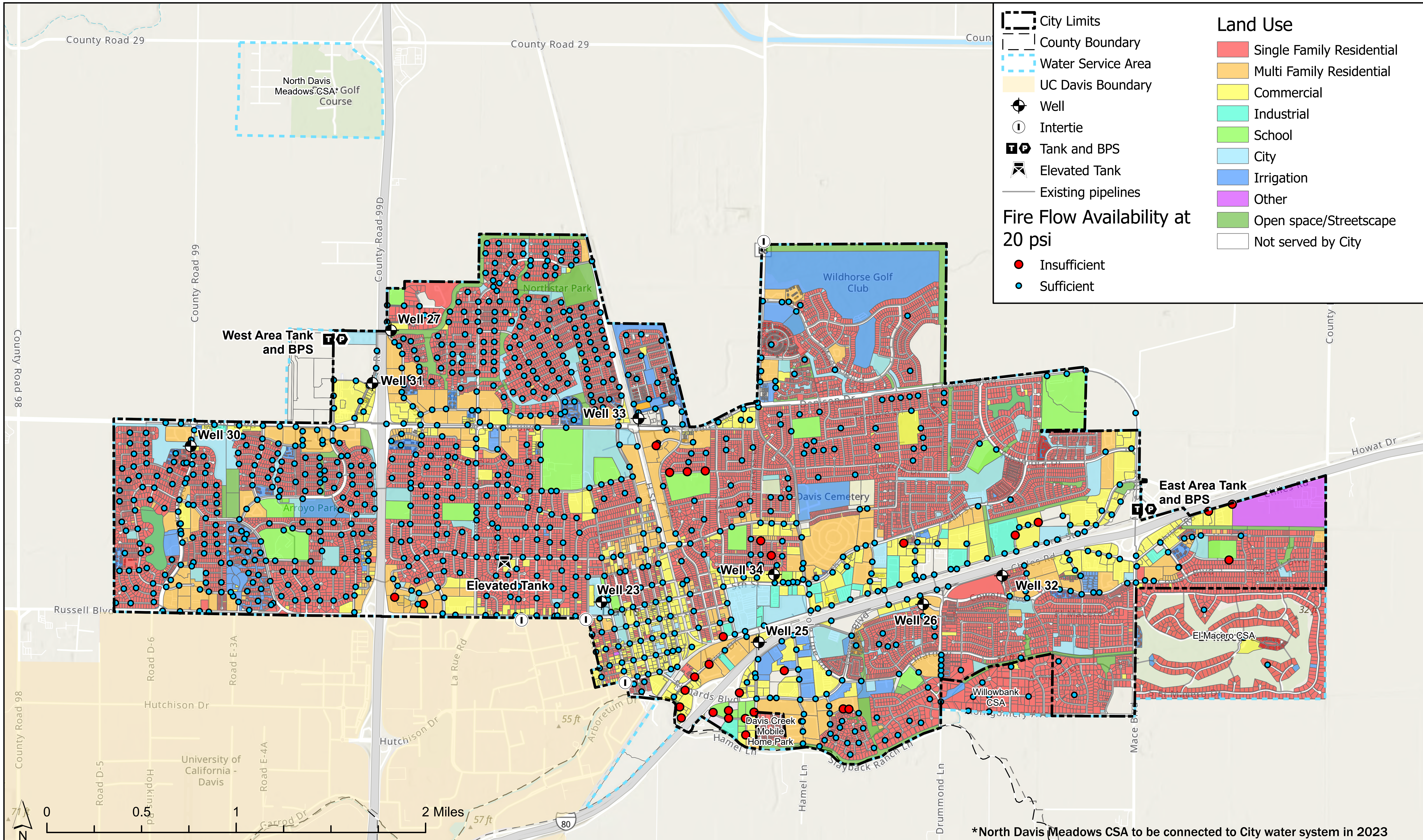

Figure 5-5. Existing system fire flow deficiencies

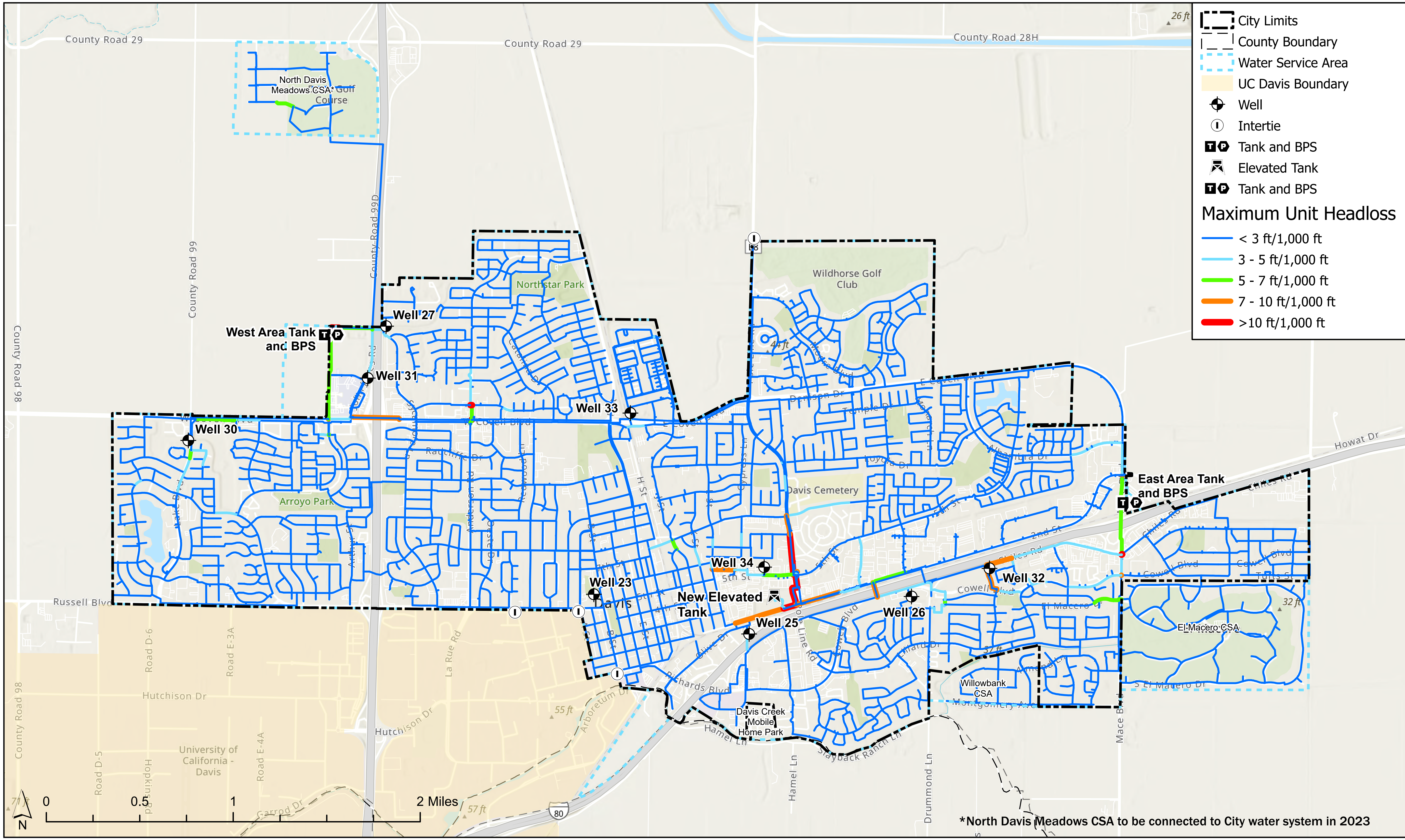

Figure 5-6. Buildout system maximum unit headloss

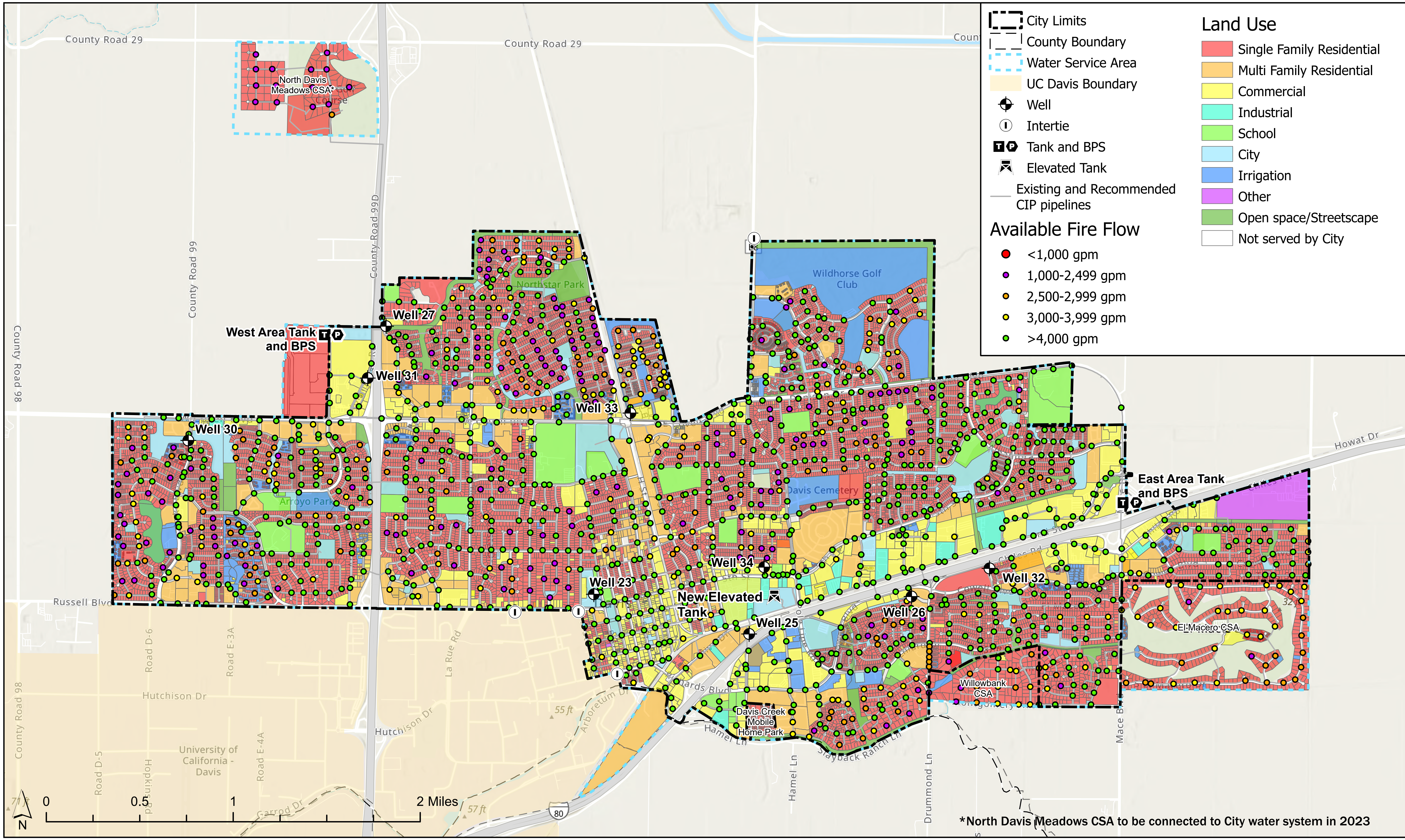

Figure 5-7. Buildout system available fire flow

Brown AND Caldwell

5.2.5 Identified Capacity Improvements

Recommended pipeline capacity improvements to alleviate existing and buildout unit headloss and fire flow deficiencies are shown in Figure 5-8 and 5-9 respectively. Details on these recommendations are also listed in Table 5-5.

Table 5-5. Recommended Capacity Improvements

Existing System						
Number	Recommendation/Location	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Constraint	Notes
1	Loop dead end on Chiles Rd to Caddy Ct cul-de-sac	N/A	10	1,300	Fire flow	Dead end main
2	Upsize pipeline on Hamel St	8	10	1,500	Fire flow	Near Pioneer Elementary School
3	Upsize pipeline on Faraday Ave (east)	6	8	700	Fire flow	
4	Upsize pipeline on Faraday Ave (west)	8	10	400	Fire flow	
5	Upsize pipeline on Barony Pl	6	8	800	Fire flow	
6	Upsize pipeline on Galileo Ct	6	10	400	Fire flow	
7	Upsize pipelines on Research Park Dr, Da Vinci Ct, and Cowell Blvd from Research Park Dr to Drew Ave	8 8	12 16	5,500 500	Fire flow	Near UC Davis Neuroscience Building
8	Loop pipeline from end of Research Park Dr	N/A	12	800	Fire flow	Near UC Davis Neuroscience Building
9	Upsize pipeline on Olive Dr from end to past Hickory Ln	6 8 10	10 12 12	1,600 300 500	Fire flow	
10	Upsize pipeline at end of Richards Blvd from Olive Dr	6	10	100	Fire flow	
11	Upsize pipeline on Chiles Rd from Mace Blvd to Ensenada Dr	8	12	2,000	Unit headloss	
12	Upsize pipeline from Well 32	10	16	300	Unit headloss	
13	Upsize pipeline on Chiles Rd from near connection to Well 32	10	12	200	Unit headloss	
14	Upsize pipeline on Koso St (N/S) from Koso St (E/W) to Cowell Blvd	8	10	200	Unit headloss	
15	Upsize pipeline on Del Rio Pl	6 8	10 10	500 100	Fire flow	
16	Upsize pipeline 2nd St near intersection with Cantrill Dr	10	12	900	Unit headloss	
17	Upsize pipeline on 5th near Pole Line	10	16* 12	500	Unit headloss	*12-inch would be sufficient for existing but will need 16-inch once Elevated Tank is relocated.
18	Upsize pipelines from Well 34	12	16	300	Unit headloss	
19	Upsize pipelines on Lehigh Dr and N St	6	8	1,500	Fire flow	

Table 5-5. Recommended Capacity Improvements

Number	Recommendation/Location	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Constraint	Notes
Existing System						
20	Upsize on pipeline on Drexel between J St and L St	6	10	1,500	Fire flow	Near Oliver Wendel Holmes Jr High
21	Upsize pipeline Cranbrook Ct	6	8	800	Fire flow	
22	Upsize pipeline on K St from 2nd St to 3rd St	6	10	400	Fire flow	
23	Upsize pipeline on B St from 7th St to E 8th St	6	10	500	Unit headloss	These improvements will not be necessary once the City relocates the Elevated Storage Tank.
24	Upsize piping from Elevated Storage Tank and on W 8th St from Anderson Rd to B St	8 8	12 16	3,400 200	Unit headloss	These improvements will not be necessary once the City relocates the Elevated Storage Tank.
25	Upsize pipeline on Eureka Ave between Antioch Dr and W 8th St	6	8	800	Unit headloss	These improvements will not be necessary once the City relocates the Elevated Storage Tank.
26	Upsize pipeline on Ovejas Av	6	8	400	Fire flow	
27	Upsize pipeline on Guava Ln	6	8	400	Fire flow	
28	Upsize pipeline on Oxford Cir	6	8	500	Fire flow	
29	Upsize portion of pipeline on Valencia Ave	6	10	200	Unit headloss	
30	Extend surface water transmission main to Well 30 and install Well 30 blending station	N/A	16	5,000	Water quality and supply	Project is already in planning/design stage
31	Upsize Well 30 piping and distribution piping on Lake Blvd where Well 30 discharges	10	16	1,100	Unit headloss and velocity	Project is already in planning/design stage
32	Extend surface water transmission main from Covell Blvd to WAT site as a secondary line to/from tank/BPS on Risling Ct	N/A	16	2,600	Water quality and supply	Project is already in planning/design stage
Buildout						
Number	Recommendation/Location	Existing Pipe Diameter (if applicable)	Recommended Pipe Diameter	Length, LF	Constraint	Notes
33	Upsize piping from Well 32 between Chiles Rd and Cowell Blvd	10	12	900	Unit headloss	
34	Upsize pipeline crossing Union Pacific Railroad (UPRR) near intersection of 2nd St and Cantrill Dr	10	12	400	Unit headloss	May not be advantageous due to location under UPRR
35	Install new piping to connect new Elevated Storage Tank and upsize existing stub off of 2nd St	10 N/A	16 16	100 500	Unit headloss and velocity	Install new piping to connect new Elevated Storage Tank and upsize existing stub off of 2nd St

Table 5-5. Recommended Capacity Improvements						
Existing System						
Number	Recommendation/Location	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Constraint	Notes
36	Upsize piping on 2nd St near connection to proposed elevated tank to past Pole Line Rd	10	16	1,600	Unit headloss	Proposed connection of new elevated tank at the Parks and Recreation Corporation Yard results in increased headlosses in surrounding piping
37	Upsize piping on Kendall Wy from 2nd St to Pole Line Rd	10	16	600	Unit headloss	Proposed connection of new elevated tank at the Parks and Recreation Corporation Yard results in increased headlosses in surrounding piping
38	Upsize piping on Pole Line Rd from Kendall Wy to 5th St and 5th St to E 8th St	10	16	2,200	Unit headloss	Proposed connection of new elevated tank at the Parks and Recreation Corporation Yard results in increased headlosses in surrounding piping
39	Upsize piping to fill and pump from WAT	14	16	1,200	Unit headloss and velocity	Increased fill rates associated with connection of North Davis Meadows
40	Upsize surface water transmission main on W Covell Blvd near John Johns Rd	12	16	1,300	Unit headloss	

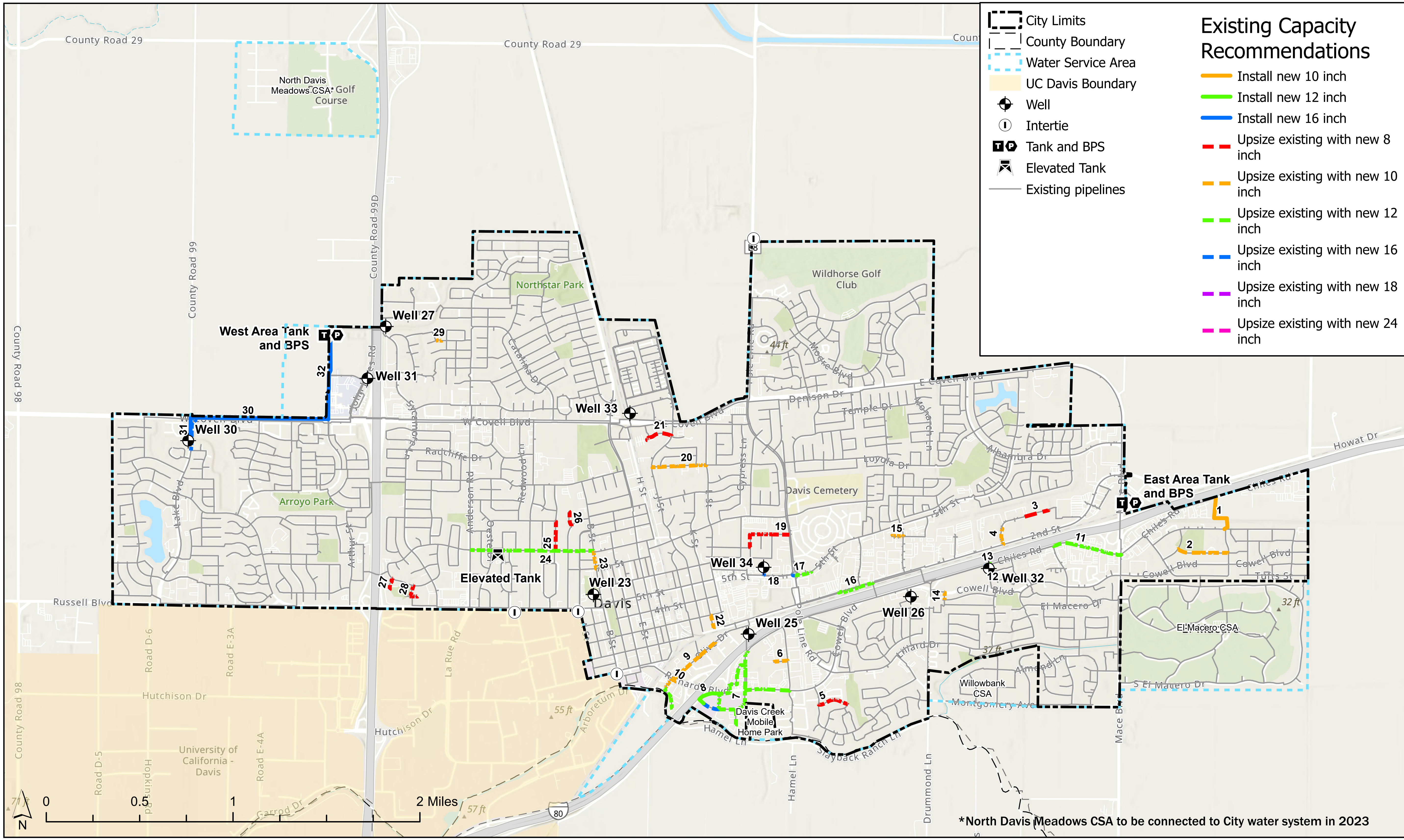

Figure 5-8. Existing system recommended capacity improvements

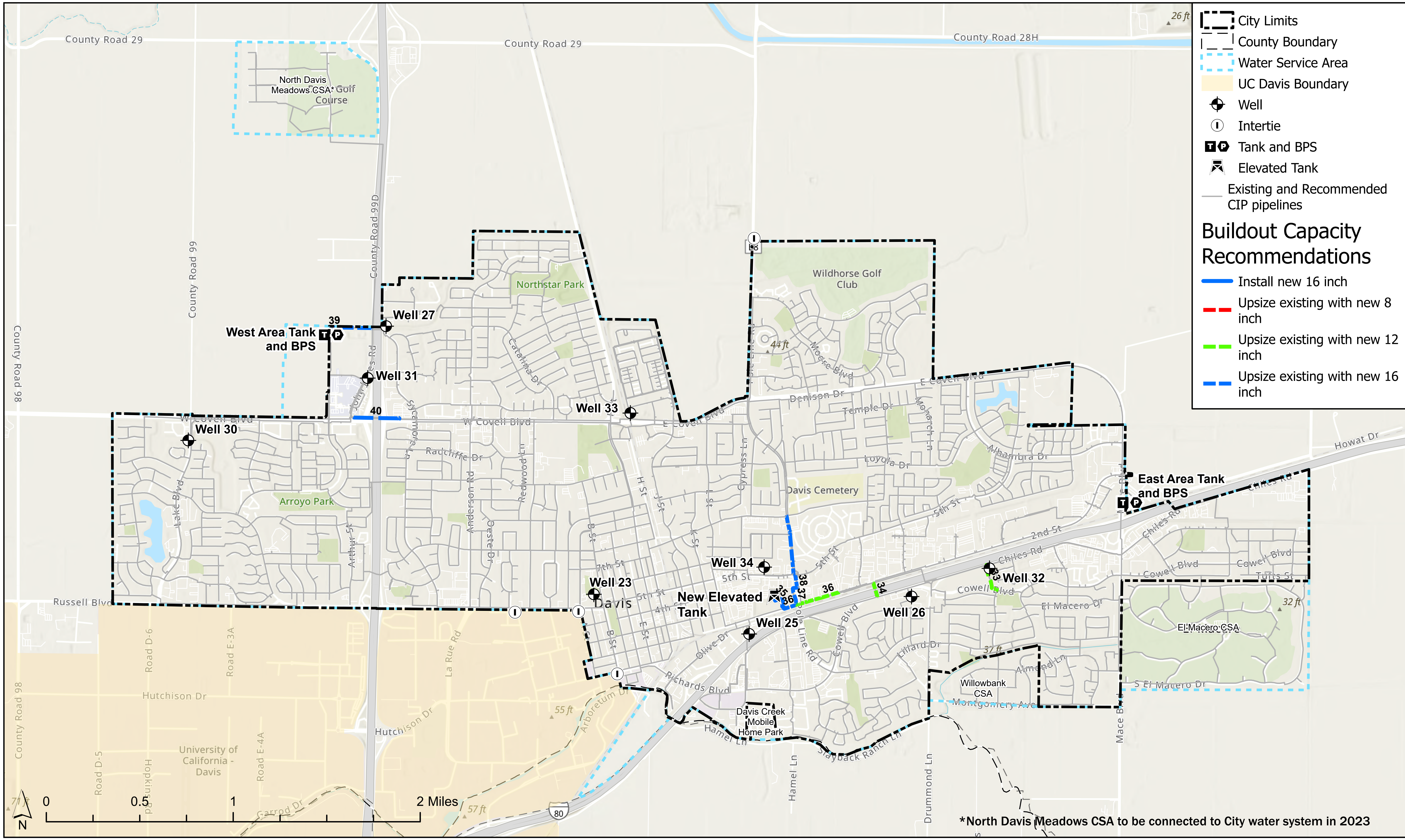

Figure 5-9. Buildout system recommended capacity improvements

Section 6

Existing System Pipe Risk Analysis

The relative risk of failure for the City's water pipelines is evaluated in this desktop risk analysis by considering likelihood and consequence of failure. Understanding the relative risk of failure for various water pipelines is critical to planning CIP projects effectively by prioritizing the highest risk projects. In general, pipe characteristics (e.g. age, material, pipe diameter, break history), and information associated with the pipe or service location (e.g. proximity to natural hazards, critical customers, roads) are combined to determine overall risk of failure. This section describes the failure ranking and weighting system used to predict risk of failure in this analysis. The CIP Section 7 lists and discusses the final pipeline replacement recommendations grouped by project.

6.1 Pipe Risk Analysis Development

This analysis will provide the City with applicable water pipe condition and risk information to support prioritization of the pipeline replacement CIP. The steps associated with this pipeline replacement risk analysis are summarized in the Figure 6-1 below:

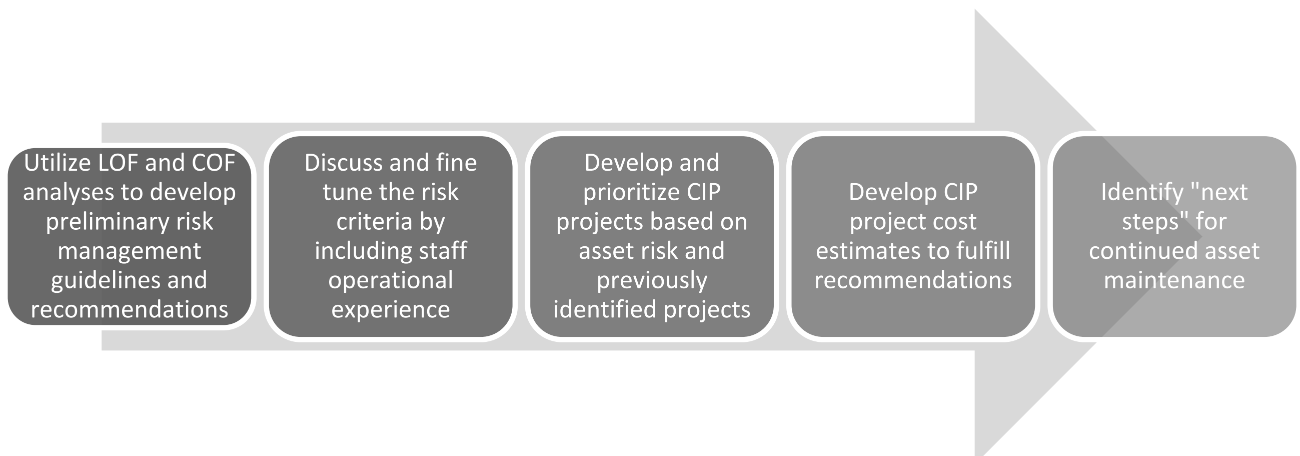

Figure 6-1. Risk analysis steps

6.2 Desktop Condition Assessment

A desktop condition assessment is used to assess asset risk for all pipe segments. The overall risk of pipeline failure considers both the *likelihood* that a pipe is unable to provide its intended function, as well as the *consequence* or impacts resulting from a pipe's failure.

Overall likelihood of failure (LOF) and consequence of failure (COF) scores considered both **factor ratings** and **factor weightings**. The LOF factor rating predicts how likely the pipe is to fail and the COF factor rating predicts how consequential the pipe failure would be. Assigned factor ratings range between one and five, with one being the least likely/least consequential to fail and five being the most likely/most consequential to fail.

The LOF and COF factor weighting values reflect the relative importance of a specific factor category compared to other factor categories assigned. More critical factors receive greater weighting values than less critical factors.

Figure 6-2 below provides a basis for determining risk scores.

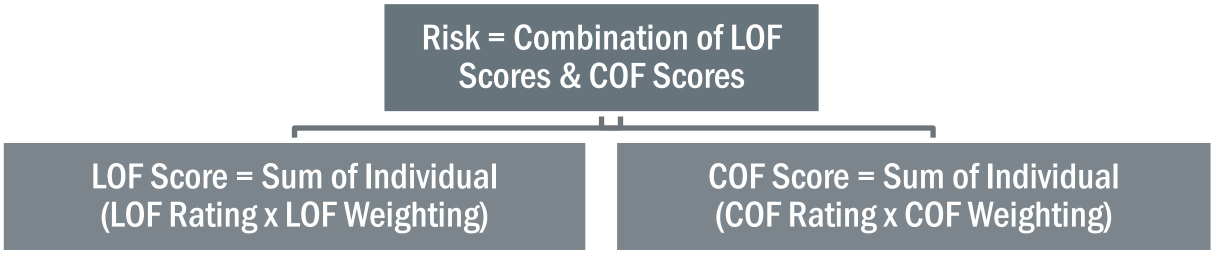

Figure 6-2. Basis for determining risk score

6.3 Likelihood of Failure

The LOF analysis predicts the likelihood that a pipeline is unable to provide its intended function, determined by assigned ratings and weightings. City water pipelines are evaluated using factors typical for desktop risk analysis as described in this section. Also described are factors that were considered and eliminated because they were not relevant to City.

LOF analysis considers known pipeline characteristics, pipeline condition and pipeline location. In all cases, unknown data items are assigned a moderate risk (3 out of 5). BC used the following LOF factors:

- **Pipe Material** – Different pipe material has different life expectancy and failure modes. Pipelines range from 2-inch to 30-inch diameter throughout the City's water system and consist of asbestos cement (AC), cast iron (CI), polyvinyl chloride (PVC), and ductile iron (DI) materials, with 64 percent of pipes being DI pipes as shown in Figure 6-3. Table 6-1 summarizes the miles of water main by diameter and material (City of Davis, June 2023).

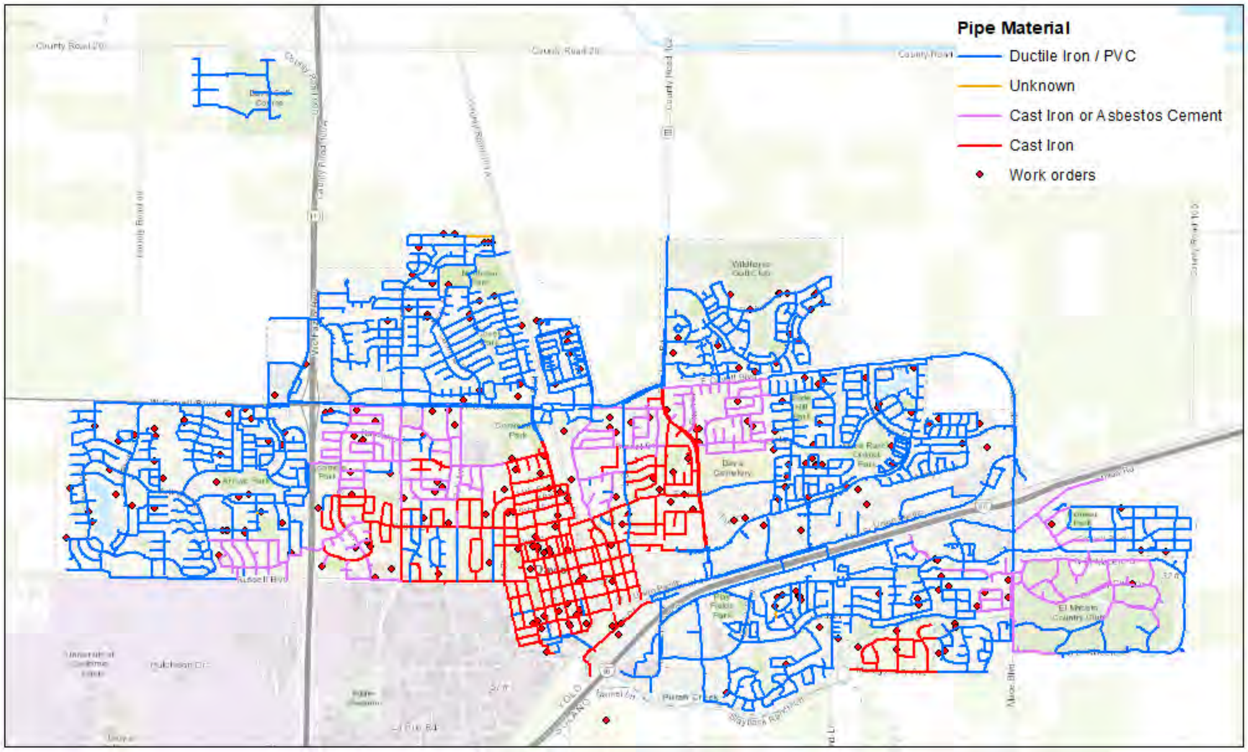

Figure 6-3. Pipe material and work orders map

Table 6-1. Miles of Water Pipelines by Diameter and Material						
Pipe Diameter Range, inches	Cast Iron	Cast Iron or Asbestos Cement	Ductile Iron/PVC	Unknown	Total, miles	Percent of total by diameter
<= 6	14.7	10.4	36.4	3.4	**64.9**	32%
6 < x <= 8	7.9	10.3	46.7	0.2	**65.1**	33%
8 < x <= 12	6.6	7.3	46.1	0.0	**60.1**	30%
12 < x <= 20	2.3	0.0	4.0	0.0	**6.3**	3%
Greater than 20-in	1.0	0.0	2.4	0.0	**3.4**	2%
Total	**32.5**	**28.0**	**135.7**	**3.5**	**199.8**	100%
Percent of total by material	16.3%	14.0%	67.9%	1.8%	100%	-

- **Pipe Age** - In general, as a pipe ages, it has a higher likelihood to fail. The installation dates from the City's GIS are used for each pipe to rank by age as shown in Figure 6-4. (City of Davis, August 2022a)

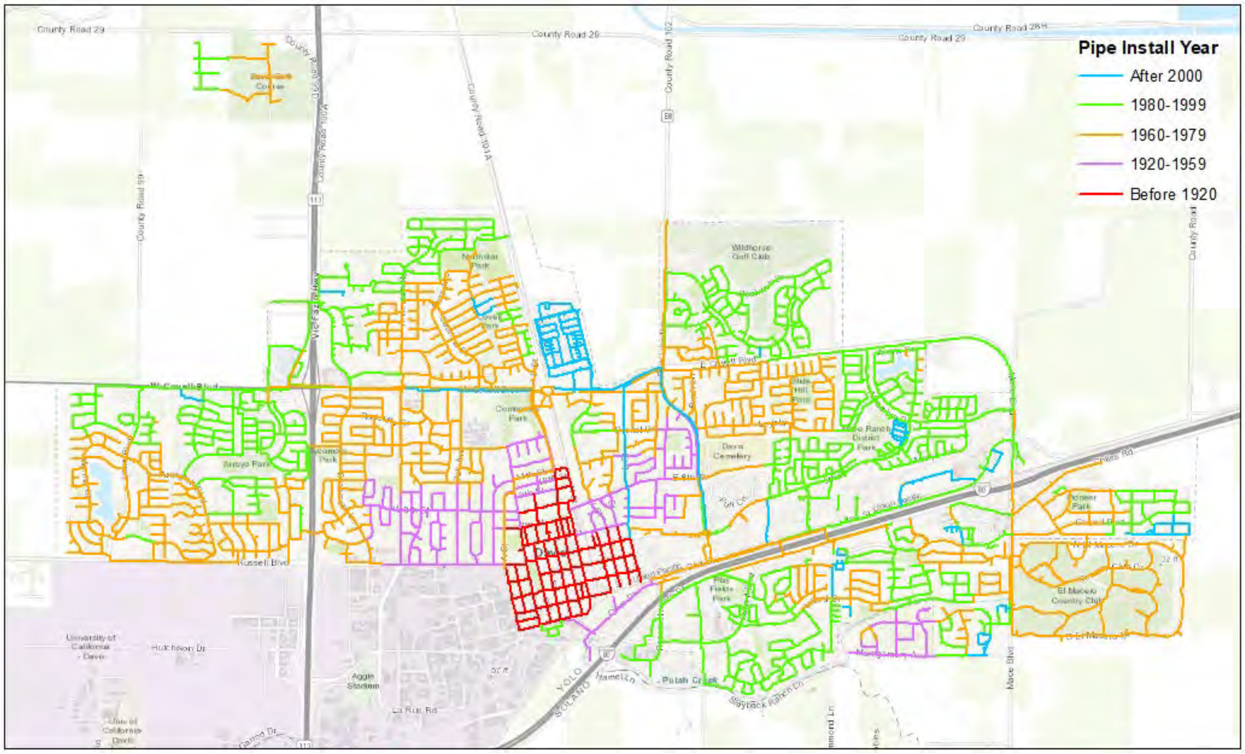

Figure 6-4. Pipe install year map

- **Main Break and Water Quality Work Orders (WO)** – Pipes that have experienced breaks and/or had water quality issues are more likely to fail. The City provided Main Break Work Order GIS data with repair and replacement activities and Water Quality Work Orders for its water pipelines (City of Davis, 2022b). Main Break Work orders not related to repair, replacement, inspection, or flushing were not considered in this analysis. There were approximately 30 breaks per year between 2003 and 2022 as shown in Figure 6-3 above (609 relevant work orders, excluding 243 work orders not related to repair, replacement, inspection, or flushing). It should be noted that the City has done an exceptional job of tracking its work orders in GIS (which is easier to use in pipe risk analysis than CMMS or Excel).
- **External Corrosion by Soil** – The USGS Web Soil Survey provides risk of corrosion for steel and risk of corrosion for concrete. Risk of corrosion for steel and concrete pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete respectively. The risk of corrosion is expressed as "low," "moderate," or "high."
  - The corrosion for steel was assumed to be correlated with the corrosion of other metal pipes such as cast iron and ductile iron.
  - Per the USGS Web Soil Survey:
    - “The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.” (USGS, 2023)
    - “The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design

may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer." (USGS, 2023)

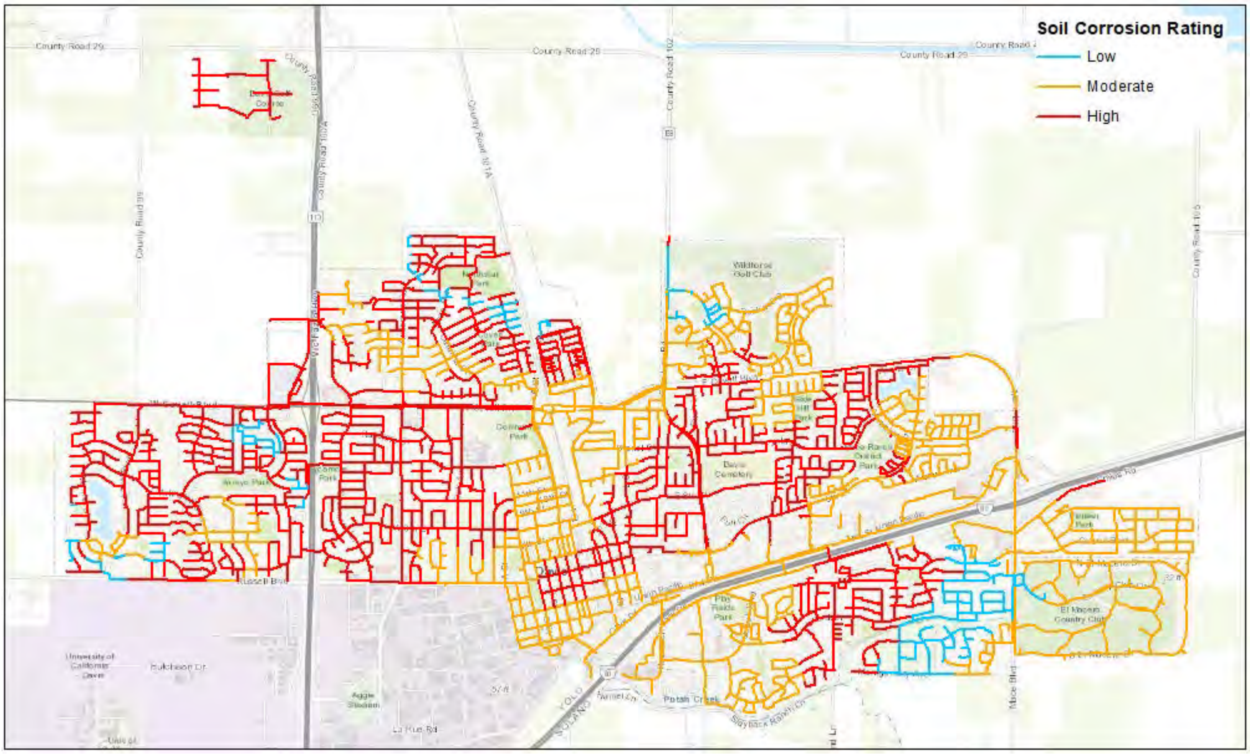

Figure 6-5. Overlay of pipe network onto corrosive soils

The following LOF factors were also considered but it was decided not to include them in this risk evaluation as described below.

- **Proximity to Earthquake Faults** – Pipes near earthquake fault lines are more likely to fail, due to the shifting of the earth during quakes. The quaternary fault zone GIS layer from the United States Geological Survey (USGS) website was reviewed for the City. No faults were identified within City limits; therefore, this is not considered to be a high LOF for the City service area.
- **Local Geology (Liquefaction)** – Liquefaction can be defined as the loss of soil strength or stiffness due to a buildup of pore-water pressure during a seismic event and is associated primarily with relatively loose, saturated fine- to medium-grained unconsolidated soils. A liquefaction layer from USGS provides soil resiliency ratings to seismic events. This factor also accounts for the impact of smaller seismic events on pipe structural integrity. USGS has no available liquefaction layer for the City. Therefore, this is not considered to be a high LOF for the City.
- **Pipe Capacity Issues** –The City's hydraulic model was used to identify pipes that have capacity issues as discussed in Section 5. These include pipelines with high velocities, low pressures, and/or increased unit head loss during peak hour or fire flow demands. Maximum velocities generated as results of the model update were reviewed and were not determined to be a high LOF for the City.

Table 6-2 defines the scoring basis for each LOF factor. A pipe is assigned a LOF rating (1 through 5) for each factor. Figure 6-6 ranks the water system pipelines for their LOF based on criteria including pipe properties and condition data.

Table 6-2. LOF Factors and Ratings for the Water System

Category	LOF Factor	LOF Rating					Factor Weighting (percent)
		1 (Least Likely to Fail)	2	3	4	5 (Most Likely to Fail)	
Asset Characteristics	Pipe age	2000 or newer	1980-1999	1960-1979	1920-1959	1919 or older	25
	Pipe material	DI		Unknown	CI/AC	CI	25
Work Orders	Pipe Repair/ Break WO	>100 feet of WO		Within 100 feet of WO		Within 50 feet of WO	25
	Water Quality WO	>100 feet of WO		Within 100 feet of WO		Within 50 feet of WO	
Soil Corrosion	Soil Corrosion Rating	Low		Moderate		High	25

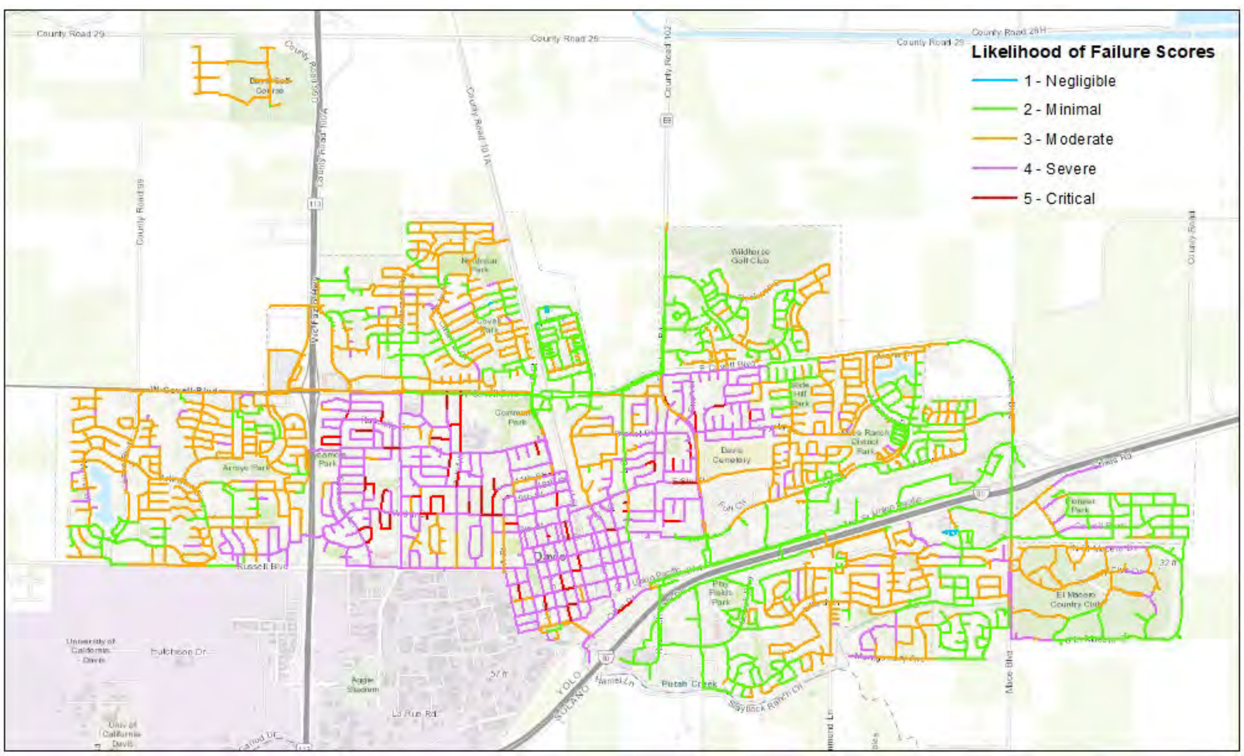

Figure 6-6. Combined LOF factor rating map

6.4 Consequence of Failure

The COF analysis predicts the impact resulting from the failure of a pipeline by assigned ratings and weightings. COF categories capture both community impacts and cost of replacement. In a similar fashion to the LOF analysis, typical COF factors are evaluated for this desktop risk analysis and some factors are eliminated if determined to be irrelevant to City's water system. COF factor descriptions and data include:

- **Pipe Size (Pipe Diameter)** – Larger diameter pipes are more expensive to replace, provide a greater capacity than smaller diameter pipes, result in greater water loss when broken, and draw more publicity upon failure. Figure 6-7 illustrates the distribution pipeline diameter (City of Davis, August 2022a).

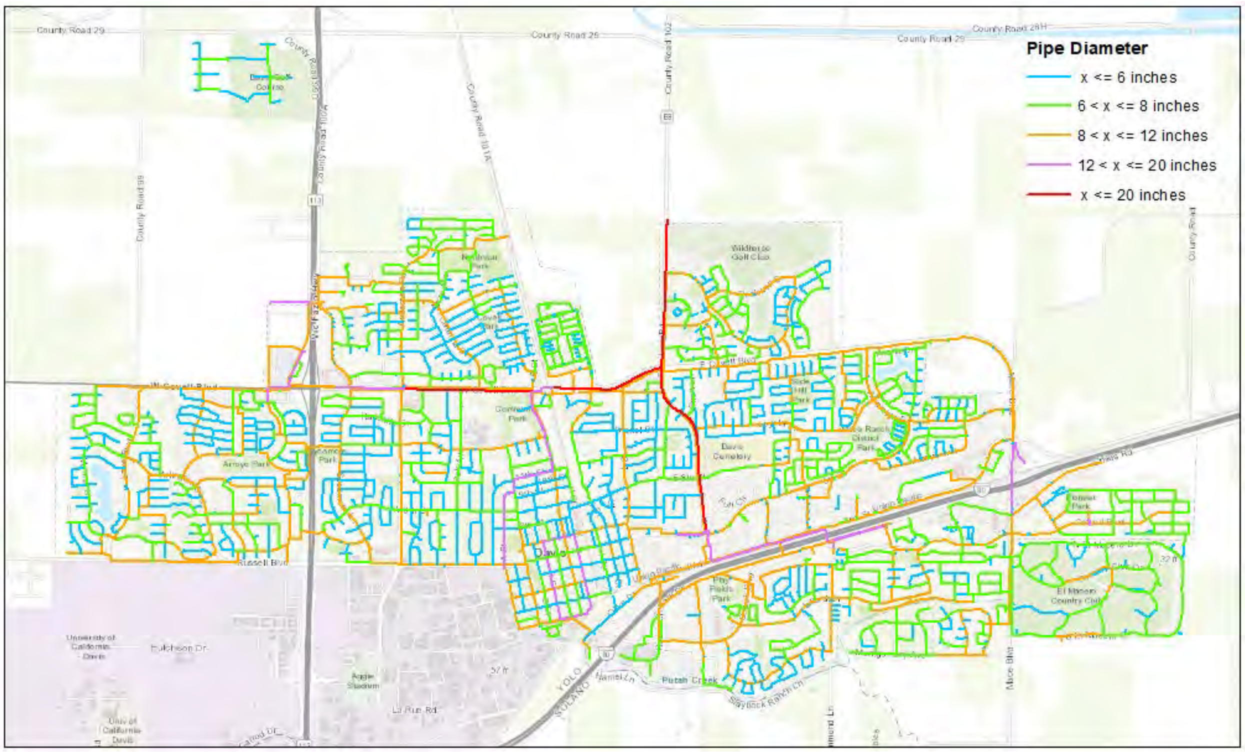

Figure 6-7. Pipeline diameter

- **Critical Customers** – The City identified customers that would be significantly impacted by loss of water supply resulting in a higher COF than others. These included hospitals, schools, community centers, dialysis centers, and city government offices. The County parcel layer was reviewed to identify these types of properties; a map showing these parcels is shown in Figure 6-8 (Yolo County, 2022).

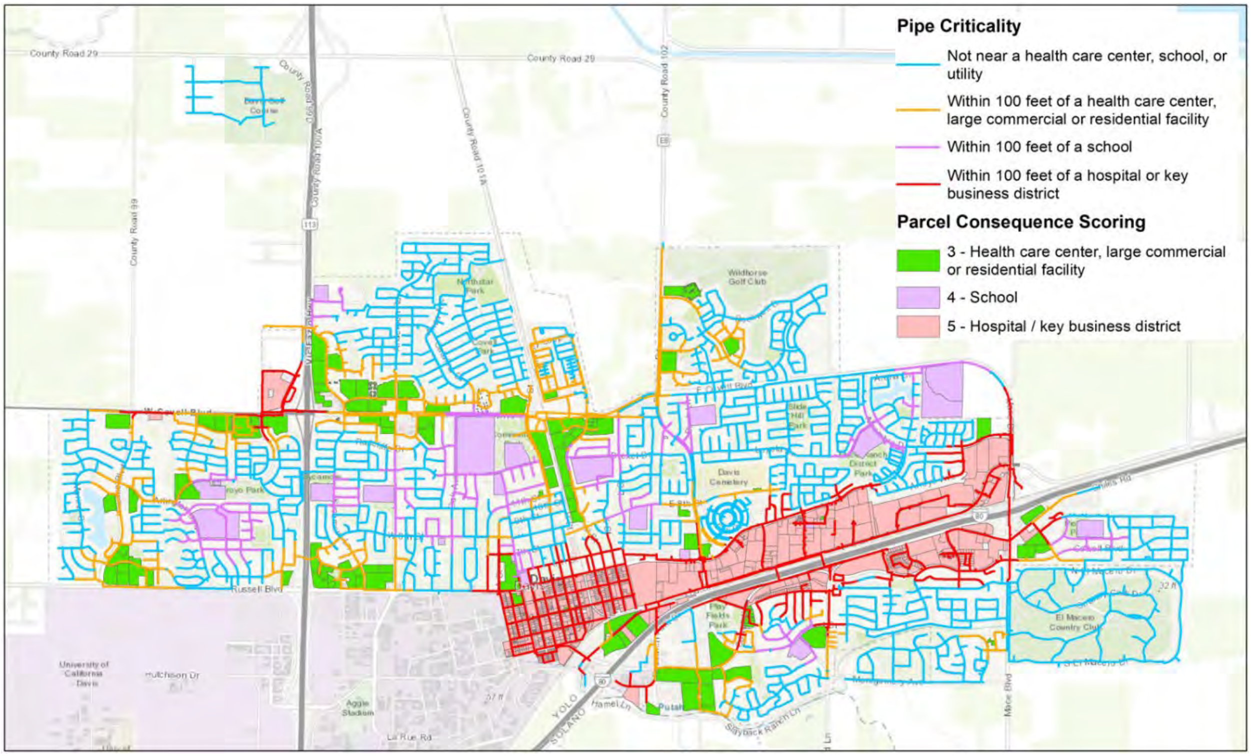

Figure 6-8. Pipelines in proximity to critical customers

- **Road Type** – Arterial or highway road types will have a greater impact on the public compared to neighborhood streets. Therefore, pipe proximity to major traffic conveyance routes such as freeways, state routes, arterial streets, or major roads are identified. The GIS for major roads centerlines from the Yolo County Open Data website was used (Yolo County, 2022). A buffer of 20 feet is applied to the major roads layer to capture potential leak or breakage impact and GIS alignment differences between the road type and pipe layers.

  Pipes within 100 feet of a railroad are also flagged as a critical pipe (5 out of 5 consequence score).

  Additional analysis was performed to highlight pipes associated with roads under an upcoming paving program. It is expected that these pipes would be covered by a future paving moratorium. These pipes were flagged as a critical pipes (5 out of 5 consequence score).

  These criteria were combined to apply the highest value of these three analyses. A map showing these is shown in Figure 6-9 based on COF score. Table 6-3 COF Factors and Ratings for the Water System provides the road types assigned to each score.

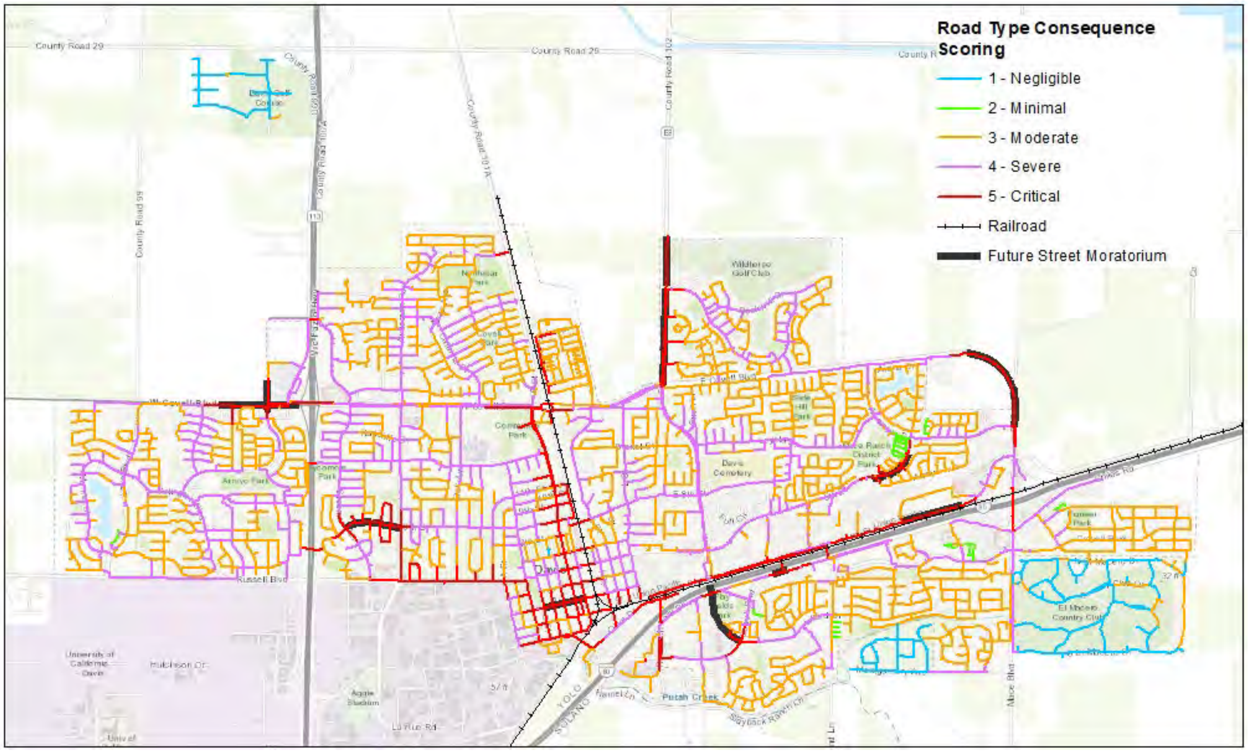

Figure 6-9. Road type

- **Model Flow** – As discussed in Section 5, the City's hydraulic model was used to identify pipes that convey large volumes of flow throughout the system. These are the pipelines City of Davis is more reliant upon to deliver water to its customers. Existing peak hour flows simulated in the model are incorporated into the risk assessment, as shown in Figure 6-10.

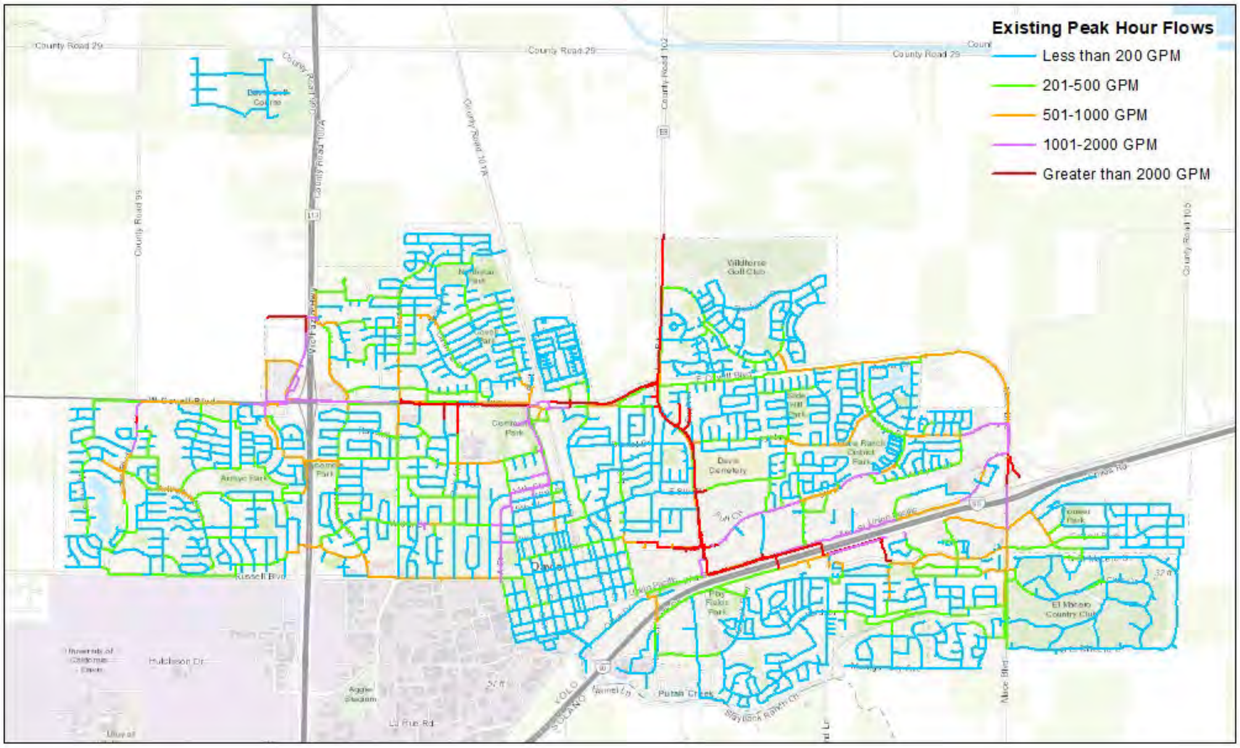

Figure 6-10. Existing peak hour flows

Pipe depth was also considered as a COF factor but was not included in this risk evaluation, as data was not available. Because depth could provide information on pipe replacement cost, BC recommends City begin collecting data. This is more concerning in areas where water mains may be installed deeper than normal (e.g. utility, creek, or railroad crossings). In the absence of depth data, diameter and road type drivers are included in this risk analysis to provide insight on correlations with pipe replacement cost.

Table 6-3 defines the scoring basis for each COF factor. A pipeline is assigned a COF rating (1 through 5) for each factor. Figure 6-11 ranks the water system pipelines for their consequence of failure based on criteria including diameter, high flow, critical customers, and road type.

Table 6-3. COF Factors and Ratings for the Water System							
Category	COF Factor	COF Rating					Factor Weighting (percent)
		1 (Negligible Consequence)	2 (Minimal Consequence)	3 (Moderate Consequence)	4 (Severe Consequence)	5 (Critical Consequence)	
Service Interruptions and Overflow Potential	Diameter	Less than or equal to 6 inches	8 inches	10 or 12 inches	14 to 20 inches	24 or 30 inches	10
	High Flow	Less than or equal to 200 gpm	201 to 500 gpm	501 – 1,000 gpm	1,001 to 2,000 gpm	Greater than 2,000 gpm	35
	Critical Customers	Not near a health care center, school, or utility		Within 100 feet of a health care center, large commercial or residential facility.	Within 100 ft of a school	Within 100 ft of a hospital or key business district	20
Transportation/Transit	Road Type [a]	Local Rural, Private Road Rural, Bike Path, Proposed Road	Minor Arterial Rural, Major Collector Rural, Minor Collector Rural, Private Road Urban	Other Principal Arterial Rural, Local Urban, Unknown	Minor Arterial Urban, Collector Urban	Arterial, Highway, Other Principal Arterial Urban; w/in 100-ft of railroad; w/in 50-ft of a future road moratorium	35

a. *Road type data and names are from the Yolo County Street Centerlines GIS layer (Yolo County, 2022)*

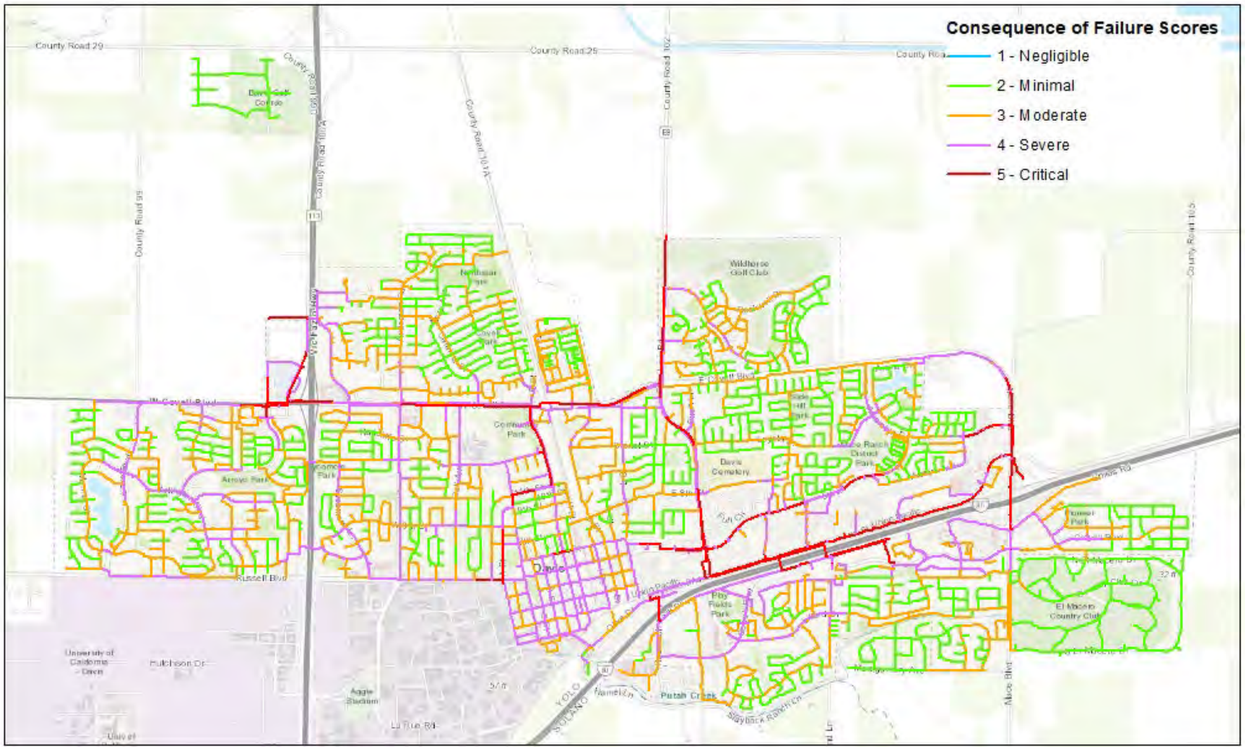

Figure 6-11. Combined COF factor rating map

6.5 Asset Risk

Once the LOF and COF rating and weighting have been determined for individual factors, an overall risk score can be determined by the LOF and COF scores for each pipe. Combining the two overall LOF and COF scores determines the overall asset risk. Total asset risk was calculated as low risk, high COF, high LOF, or high risk based on the paired LOF and COF data. The matrix shown in Figure 6-12 illustrates the risk assignments for varying LOF and COF pairings.

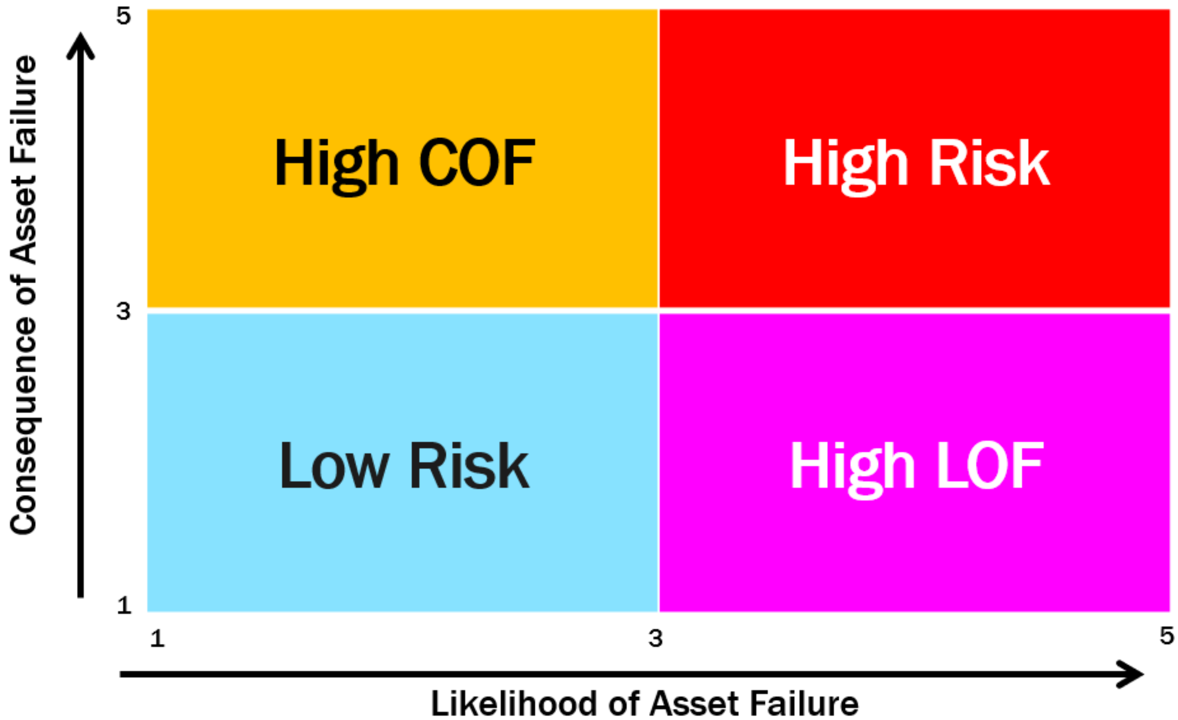

Figure 6-12. Risk assignments for LOF/COF pairings

Innovyze's InfoAsset Planner program (IAP), a GIS extension tool, is used to perform a desktop risk assessment. Using the LOF and COF criteria described in this section, the tool predicts the relative LOF and COF for each asset based on its GIS data and spatial interaction with other GIS layers. This approach evaluated all pipeline assets in detail using data as documented in Sections 6.3 and 6.4.

Likewise, COF analysis determines the severity of impact on the water system of each pipeline asset if it fails. The tool scores each pipe for COF based on asset information as documented in Section 6.4. Once the user defines the rating (1 through 5) for each factor and weighting of these factors relative to one another, the tool produces a holistic risk score for each pipe GIS asset. This risk score is adjusted so that the lowest scoring pipes receive a one of five (least at risk) and the highest scoring pipes receive a five of five (most at risk).

6.6 Risk Assessment Results

The risk analysis determined overall LOF and COF score assignments for all pipe segments, based on the criteria outlined in Tables 6-2 and 6-3 (and summarized again in Table 6-4). Then a total risk score was determined by plotting the overall LOF and COF scores on Figure 6-13. After initial model results were analyzed, the boundaries between low and high likelihood and consequence of failure were adjusted to be 60% of the potential maximum. This allowed the model to further focus on the pipes with the highest LOF & COF factors.

Table 6-4. LOF & COF Factors and Weightings for the Water System			
Broad Category	COF Factor	Factor Weighting (percent)	Total LOF/COF Percentage
COF	Diameter	10	100
	High Flow	35	
	Critical Customers	20	
	Road Type	35	
LOF	Age	25	100
	Pipe Material	25	
	Break History	25	
	Corrosive Soils	25	

Figure 6-13 summarizes the risk results from the risk tool by LOF/COF. This data will be used to help prepare the CIP. Figure 6-14 presents the risk scores for all water pipelines.

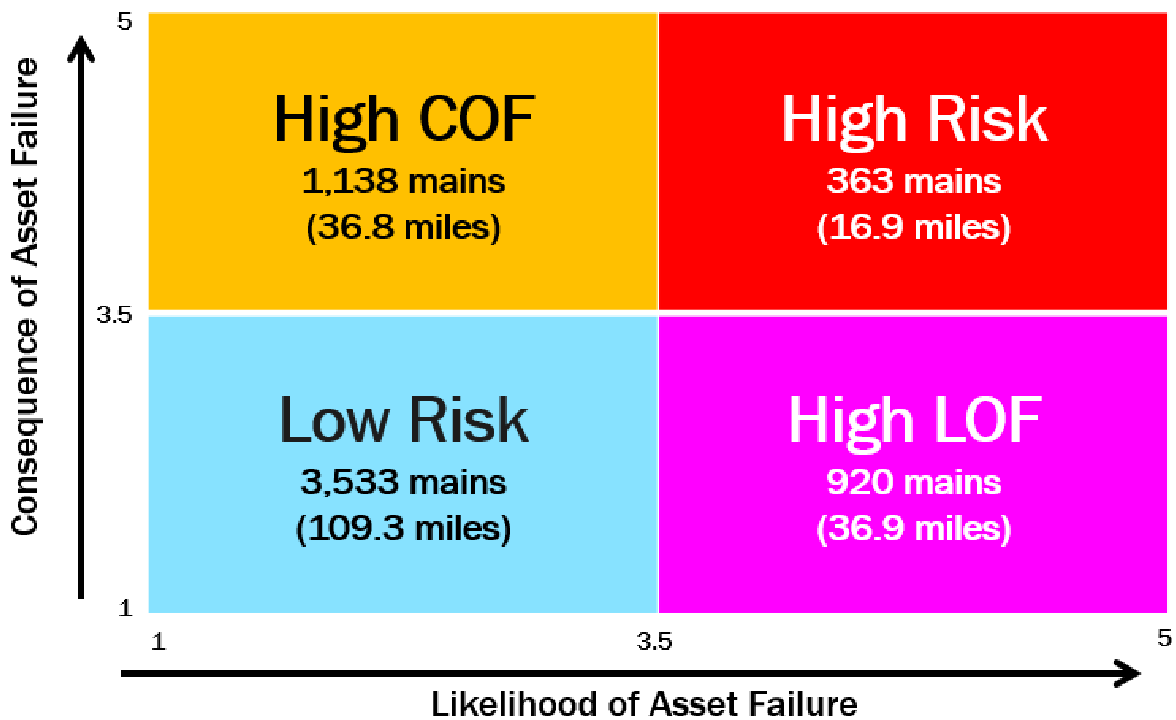

Figure 6-13. Overall risk categorization

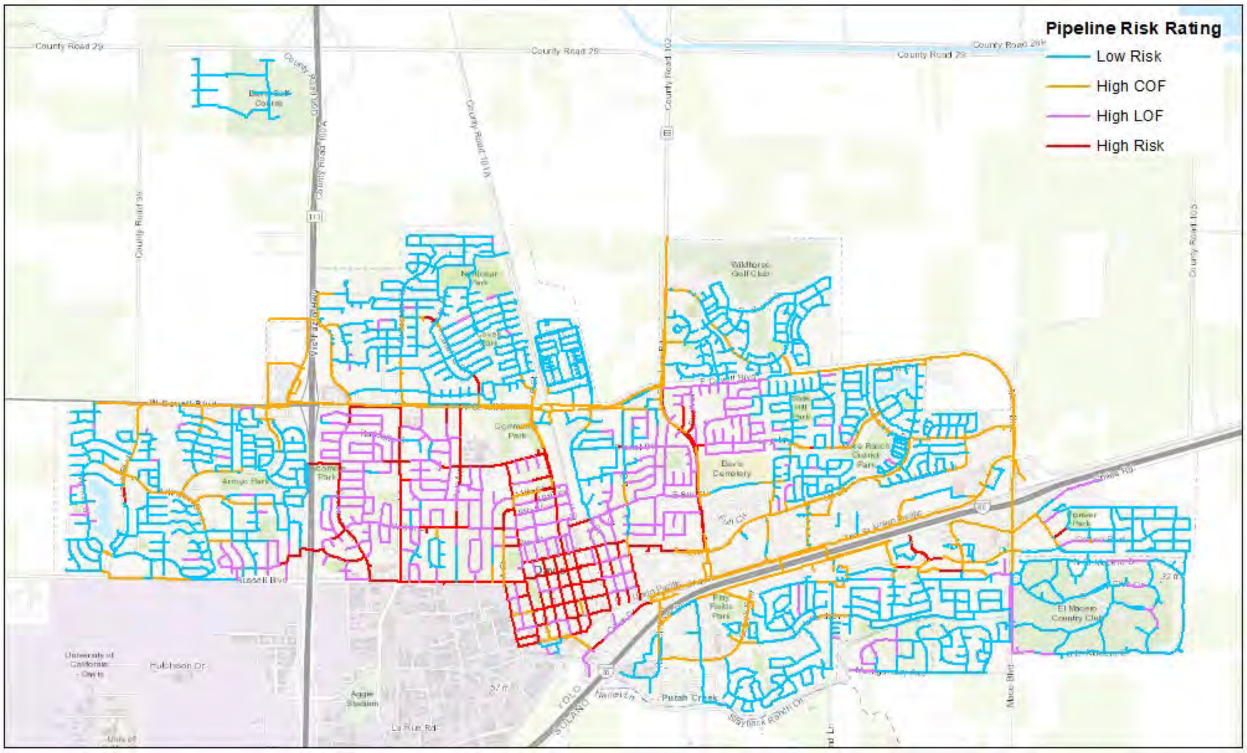

Figure 6-14. Pipeline risk rating

6.7 Recommendations

This section includes the approach used to determine the rate of pipeline replacement. For the pipeline replacement rate analysis, useful life assumptions based on material are assigned in Table 6-5.

Table 6-5. Pipeline Material Useful Life Assumptions

Material	Useful Life, years
Asbestos cement (AC)	80
Ductile iron (DI)	100
Cast Iron (CI)	115
Unknown (AC or CI)	80

Based on the age of the City's water system pipelines and the useful life assumptions in Table 6-5, the City's long term cumulative replacement needs are shown in Figure 6-15. Several replacement rate alternatives are shown ranging from 0.25 percent replacement rate (2,700 LF per year) to 1.25 percent replacement rate (13,400 LF per year). A replacement rate of 1.25 percent per year or approximately 13,400 LF per year will allow the City to catch up to the number of pipes not exceeding useful life by 2050.

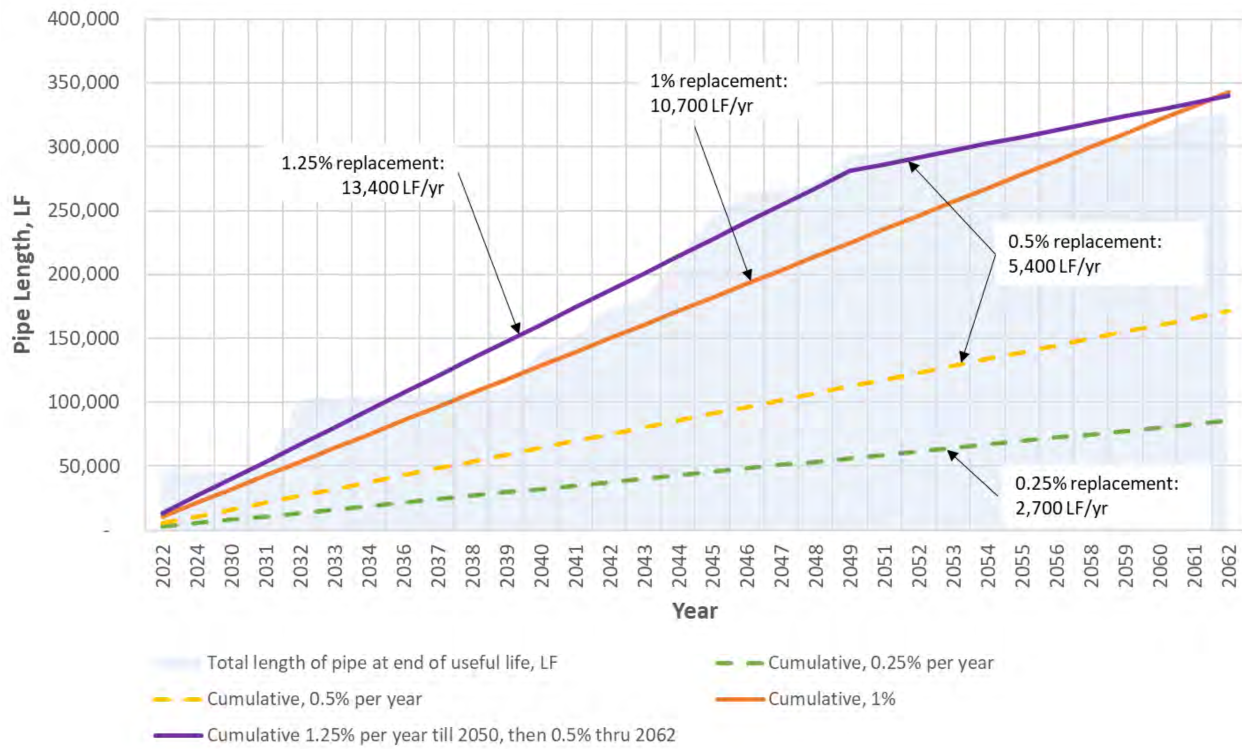

Figure 6-15. Cumulative pipeline replacement needs

To proactively replace the 16.9 miles mains that have been identified as having high risk, a programmatic annual approach is recommended as the most cost-effective solution to replace the pipelines. This would enable the City to minimize replacements which tend to result in higher costs, while also strategically reducing construction costs. Table 6-6 summarizes the recommended pipeline improvements by priority.

Table 6-6 presents a 10-year recommended annual pipeline improvement program based on pipes that are categorized as high risk or high COF, within a future roadway moratorium, and total approximately 3,200 LF of pipe replacement. The annual program replacement rate of 3,200 LF is based on the City's recent average submitted bids for CIP 8190, received in May 2023, utilizing an annual pipe replacement of budget of $2,500,000. The 10-year program would replace approximately 5.1 miles of the identified 16.9 miles high risk pipes.

Table 6-6. Recommended Pipeline Improvements

Replacement Plan Year	Length of Pipe (LF) by Pipe Diameter								
	2-in	6-in	8-in	10-in	12-in	14-in	16-in	18-in	Total (LF)
2024			1,899		1,238	908			4,045
2025	117		673	381	2,322				3,493
2026					3,141		427	595	4,162
2027		5		2,098					2,103
2028		23			2,977				3,000
2029		1,571			918				2,489
2030			3,122						3,122
2031		1,499	491		371	1,003			3,364
2032				2,230					2,230
2033		145		1,698					1,843
Total	117	3,243	6,185	6,407	10,966	1,911	427	595	29,851

Figure 6-16 illustrates the project locations of the 10-year annual pipeline replacement program.

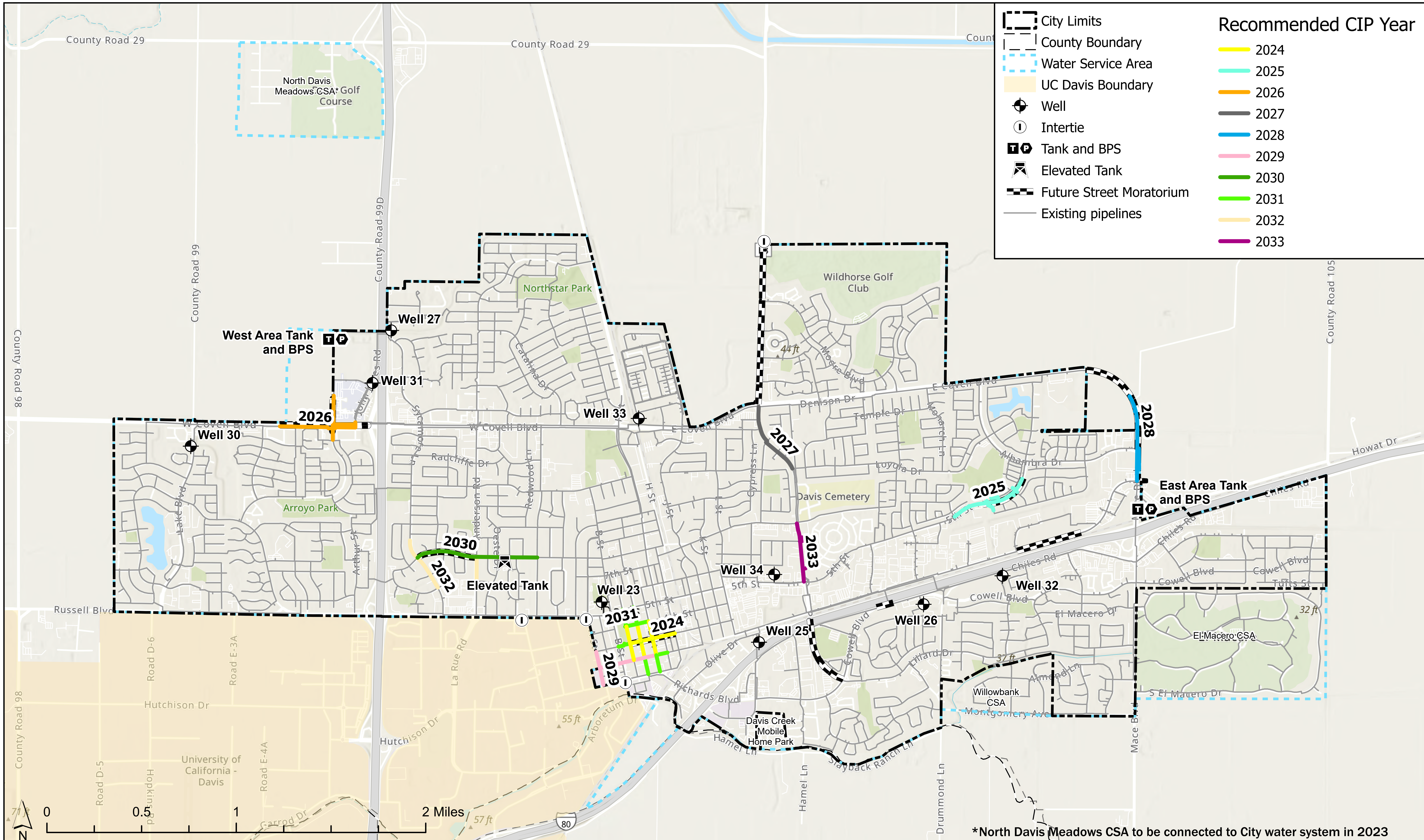

Figure 6-16. Annual pipeline replacement program

Brown AND Caldwell

Section 7

Capital Improvement Program

This section summarizes the overall recommended Capital Improvement Program (CIP) based on the hydraulic capacity, fire flow, and supply evaluations described in Section 5 (Water System Capacity Analysis) and the risk evaluations described in Section 6 (Existing System Pipe Risk Analysis). The CIP is prepared for 0-5-year and 6–10-year terms. Recommendations have been prioritized based on input from the City. Planning level cost information is based on the Association for the Advancement of Cost Engineering (AACE) International Costs Estimate Classification System for Class 4.

7.1 Cost Estimating Assumptions and Unit Costs

Cost estimating information prepared for this WSOP is in accordance with the guidelines of the AACE International for a Class 4 Estimate. AACE International defines a Class 4 Estimate in the following manner:

> Class 4 Estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary (buy generally not final) budget approval. Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative schedule analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage. The expected accuracy range for a Class 4 Estimate is from -30% to +50%.

For this WSOP it is assumed that the recommended pipeline improvements will be constructed in paved public rights-of-way and therefore land acquisition costs are not included. For the purposes of developing estimates, unit costs are developed for a project size of 1,000 LF (see Table 7-1).

A complete description of assumptions to include the basis of estimate is included in Appendix B.

Table 7-1. Unit Costs

Item	Unit Cost ($/LF)[a,b, c]									
	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033-2045[d]
8" PVC pipe	609	640	672	705	740	777	816	857	900	945
10" PVC pipe	684	718	754	792	831	873	916	962	1,010	1,061
12" PVC pipe	756	794	834	876	919	965	1,014	1,064	1,117	1,173
14" PVC pipe	921	967	1,015	1,066	1,119	1,175	1,234	1,296	1,361	1,429
16" PVC pipe	1,078	1,132	1,188	1,248	1,310	1,376	1,445	1,517	1,593	1,672
18" PVC pipe	1,200	1,260	1,323	1,389	1,459	1,532	1,608	1,689	1,773	1,862
16" DIP pipe	1,339	1,406	1,477	1,551	1,628	1,709	1,795	1,885	1,979	2,078

a. *Unit costs are developed for a project size of 1,000 LF of pipe including all valves, appurtenances, and construction costs. Note: that there are likely to be increased economies of scale for larger projects and reduced economies of scale for smaller projects.*

b. *Pipe costs associated with trenchless construction are not included in this table but are included in the tables below.*

c. *Cost from 2025 through 2033 is escalated by 5 percent annually.*

d. *Unit cost for 2033-2045 based on escalation through 2033 only.*

7.2 Near Term (0-5 Year) Capital Improvement Program

As shown in Table 7-2, the 0-5 year CIP represents 35,160 LF of recommended improvements totaling $30.6 million.

7.3 6-10 Year Capital Improvement Program

As shown in Table 7-3, the 6-10 year CIP represents 25,549 LF of recommended improvements totaling $15.6 million.

7.4 Long Term (>10 Year) Capital Improvement Program

As shown in Table 7-4, the >10 year CIP represents 6,643 LF of recommended improvements totaling $9.4 million.

7.5 Overall CIP Summary

Figure 7-1 illustrates the recommended CIP locations by CIP Number listed in Tables 7-2, 7-2, and 7-4.

Table 7-2. Near Term (0-5 Year) Annual CIP									
CIP Number	CIP Year	Recommendation/ Location	Additional Description	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Constraint	Unit Cost, $/LF	Estimate of Probable Cost, $
1	2023-2024	Extend surface water transmission main to Well 30 and install Well 30 blending station	Project is already in planning/design stage	N/A	16[a]	5,000	S	1,339	6,697,000
2	2023-2024	Upsize Well 30 pipeline and distribution pipeline on Lake Blvd where Well 30 discharges	Project is already in planning/design stage	10	16	1,100	H	1,078	1,186,000
3	2023-2024	Upsize pipeline from WAT to system	18-in diameter pipeline currently being installed to allow for upsizing of WAT pumps	14	16	1,200	H	1,078	1,294,000
4	2024	Replace pipeline on C St - 2nd to 4th St	Replace in kind	8	8	945	R	609	576,000
5	2024	Replace pipeline on D St - 2nd to 4th St	Replace in kind	14	14	908	R	921	836,000
6	2024	Replace pipeline on E St - 2nd to 4th St	Replace in kind	8	8	954	R	609	581,000
7	2024	Replace pipeline on 4th St - C to E St	Replace in kind, 8-inch minimum	6	8	678	R	609	413,000
8	2024	Upsize pipeline on Lehigh Dr and N St		6	8	1,500	F	609	914,000
9	2024	Upsize on pipeline on Drexel between J St and L St	Near Oliver Wendel Holmes Jr High	6	10	1,500	F	684	1,026,000
10	2024	Upsize pipeline on Guava Ln		6	8	400	F	609	244,000
11	2024	Upsize portion of pipeline on Valencia Ave		6	10	200	H	684	137,000
12	2024	Replace pipeline on Anderson - Sunset to W. 8th St	Replace in kind	10	10	685	R	684	468,000
13	2025	Upsize pipeline crossing Union Pacific Railroad (UPRR) near intersection of 2nd St and Cantrill Dr	May not be advantageous due to location under UPRR and requires trenchless construction	10	12	400	H	-[b]	320,000
14	2025	Replace pipeline on Shasta from Covell to about 375' south	Replace in kind, 8-inch minimum	16	16	427	R	1,132	483,000
15	2025	Upsize pipeline on Barony Pl		6	8	800	F	640	512,000
16	2025	Upsize pipelines on Research Park Dr, Da Vinci Ct, and Cowell Blvd from Research Park Dr to Drew Ave	Near UC Davis Neuroscience Building	8	12	5,500	F	794	4,368,000
				8	16	500	F	1,132	566,000

Table 7-2. Near Term (0-5 Year) Annual CIP									
CIP Number	CIP Year	Recommendation/ Location	Additional Description	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Constraint	Unit Cost, $/LF	Estimate of Probable Cost, $
17	2025	Loop pipeline from end of Research Park Dr	Near UC Davis Neuroscience Building	N/A	12	800	F	794	635,000
18	2025	Upsize pipe 2nd St near intersection with Cantrill Dr		10	12	900	H	794	715,000
19	2025	Replace pipeline on D St - 4th to 5th	Replace in kind	14	14	469	R	967	453,000
20	2025	Replace pipeline on D St - 1st to 2nd St	Replace in kind	14	14	534	R	967	516,000
21	2025	Replace pipeline on E St - 1st to 2nd St	Replace in kind	8	8	491	R	640	314,000
22	2025	Replace pipeline on C St - 4th to 5th	Replace in kind, 8-inch minimum	6	8	477	R	640	305,000
23	2026	Replace pipeline on A St - 1st to 3rd St	Replace in kind	12	12	918	R	834	765,000
24	2026	Replace pipeline on 2nd St - A to E St	Replace in kind, 8-inch minimum	6	8	1,571	R	672	1,055,000
25	2026	Upsize pipeline on Galileo Ct		6	10	400	F	754	302,000
26	2026	Upsize pipeline on Chiles Rd from Mace Blvd to Ensenada Dr		8	12	2,000	H	834	1,668,000
27	2027	Replace pipeline on Pole Line - Covell to Loyola	Replace in kind, 8-inch minimum	6	8	5	R	705	4,000
			Replace in kind	10	10	2,098	R	792	1,661,000
28	2027	Upsize pipeline on Hamel St	Near Pioneer Elementary School	8	10	1,500	F	792	1,187,000
29	2027	Upsize pipelines from Well 34		12	16	300	H	1,248	374,000
					Total	35,160	-	-	30,574,000

H=Hydraulic capacity deficiency
F=Fire flow availability
R=High Risk
S= Supply
a. DIP is assumed pipe material for surface water transmission main replacements.
b. Trenchless construction is assumed to be required.

Table 7-3. 6-10 Year Annual CIP

CIP Number	CIP Year	Recommendation/ Location	Additional Description	Constraint	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Unit Cost, $/LF	Estimate of Probable Cost, $
30	2028	Upsize pipeline on Faraday Ave (east)		F	6	8	700	740	518,000
31	2028	Upsize pipeline on Faraday Ave (west)		F	8	10	400	831	332,000
32	2028	Install new piping to connect new Elevated Storage Tank and upsize existing stub off of 2nd St	Install new piping to connect new Elevated Storage Tank and upsize existing stub off of 2nd St	H	10	16	100	1,310	131,000
					N/A	16	500	1,310	655,000
33	2028	Upsize piping on 2nd St near connection to proposed elevated tank to past Pole Line Rd	Proposed connection of new elevated tank at the Parks and Recreation Corporation Yard results in increased headlosses in surrounding piping	H	10	16	400	1,310	524,000
						12	1,200	919	1,103,000
34	2028	Upsize pipeline on Olive Dr from end to past Hickory Ln	To be installed with NISHI	F	6	10	1,600	831	1,330,000
					8	12	300	919	276,000
					10	12	500	919	460,000
35	2029	Replace pipeline on Mace - 2nd St to farm Rd 30B on Mace curve	Replace in kind, 8-inch minimum	R	6	8	23	777	18,00
			Replace in kind		12	12	2,977	965	2,874,000
36	2029	Upsize pipeline on Oxford Cir	Notes	F	6	8	500	777	389,000
37	2029	Upsize surface water transmission main on W Covell Blvd near John Johns Rd		H	12	16	1,300	-[a, b]	1,037,000
38	2030	Replace pipeline on 2nd St - E to F St	Replace in kind, 8-inch minimum	R	6	8	313	816	7,000
39	2030	Replace pipeline on 3rd St- C to G St	Replace in kind	R	12	12	1,238	1,014	12,000
40	2030	Replace pipeline on W. Covell Blvd - John Jones and west to greenbelt	Replace in kind	R	12	12	2,239	1,014	12,000
				R	18	18	595	1,608	29,000
41	2030	Replace pipeline on Risling Ct	Replace in kind	R	12	12	902	1,014	12,000
42	2030	Replace pipeline on W. 8th - Sycamore to Oak Ave	Replace in kind (upsizing would be necessary for capacity reasons if the elevated tank were not being relocated)	R	8	8	3,122	816	7,000

Table 7-3. 6-10 Year Annual CIP									
CIP Number	CIP Year	Recommendation/ Location	Additional Description	Constraint	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Unit Cost, $/LF	Estimate of Probable Cost, $
43	2030	Upsize pipeline on Koso St (N/S) from Koso St (E/W) to Cowell Blvd		H	8	10	200	916	9,000
44	2030	Upsize pipeline on Del Rio Pl		F	6	10	500	916	9,0000
					8	10	100	916	9,000
45	2031	Replace pipeline on 5th St - San Sebastian to Verona Terrace + side streets	Replace in kind, 8-inch minimum	R	2	8	117	857	100,000
			Replace in kind		8	8	673	857	577,000
			Replace in kind		10	10	381	962	367,000
			Replace in kind		12	12	2,322	1,064	2,471,000
46	2031	Replace pipeline on 3rd St - B to C St	Replace in kind, 8-inch minimum	R	6	8	31	857	27,000
			Replace in kind	R	12	12	371	1,064	395,000
47	2031	Upsize pipeline on K St from 2nd St to 3rd St		F	6	10	400	962	385,000
48	2032	Replace pipeline on Sycamore - Wake Forest - Harvard	Replace in kind	R	10	10	1,545	1,010	1,561,000
						Total	25,549	-	15,634,466

H=Hydraulic capacity deficiency
F=Fire flow availability
R=High Risk
S= Supply

a. DIP is assumed pipe material for surface water transmission main replacements.
b. Trenchless construction is assumed to be required.

Table 7-4. Long Term (> 10 Year) Annual CIP

CIP Number	CIP Year	Recommendation/ Location	Additional Description	Constraint	Existing Pipe Diameter, inch (if applicable)	Recommended Pipe Diameter, inch	Length, LF	Unit Cost, $/LF	Estimate of Probable Cost, $
49	2033-2045	Upsize piping from Well 32 between Chiles Rd and Cowell Blvd		H	10	12	900	1,173	1,056,000
50	2033-2045	Upsize pipeline on 5th near Pole Line	*12-inch would be sufficient for existing but will need 16-inch once Elevated Tank is relocated.	H	10	16*	500	1,672	836,000
51	2033-2045	Replace pipeline on Pole Line - 5th St to E. 8th St	Replace in kind, 8-inch minimum	R	6	8	145	945	137,000
			Replace in kind		10	10	1,698	1,061	1,801,000
52	2033-2045	Upsize piping on Kendall Wy from 2nd St to Pole Line Rd	Proposed connection of new elevated tank at the Parks and Recreation Corporation Yard results in increased headlosses in surrounding piping	H	10	16	600	1,672	1,003,000
53	2033-2045	Upsize piping on Pole Line Rd from Kendall Wy to 5th St and 5th St to E 8th St	Proposed connection of new elevated tank at the Parks and Recreation Corporation Yard results in increased headlosses in surrounding piping	H	10	16	2,200	1,672	3,679,000
54	2033-2045	Upsize pipeline at end of Richards Blvd from Olive Dr		F	6	10	100	1,061	106,000
55	2033-2045	Upsize piping from Well 32		H	10	16	300	1,672	502,000
56	2033-2045	Upsize pipeline on Chiles Rd from near connection to Well 32		H	10	12	200	1,173	235,000
						Total	6,643	-	9,355,000

H=Hydraulic capacity deficiency
F=Fire flow availability
R=High Risk
S= Supply

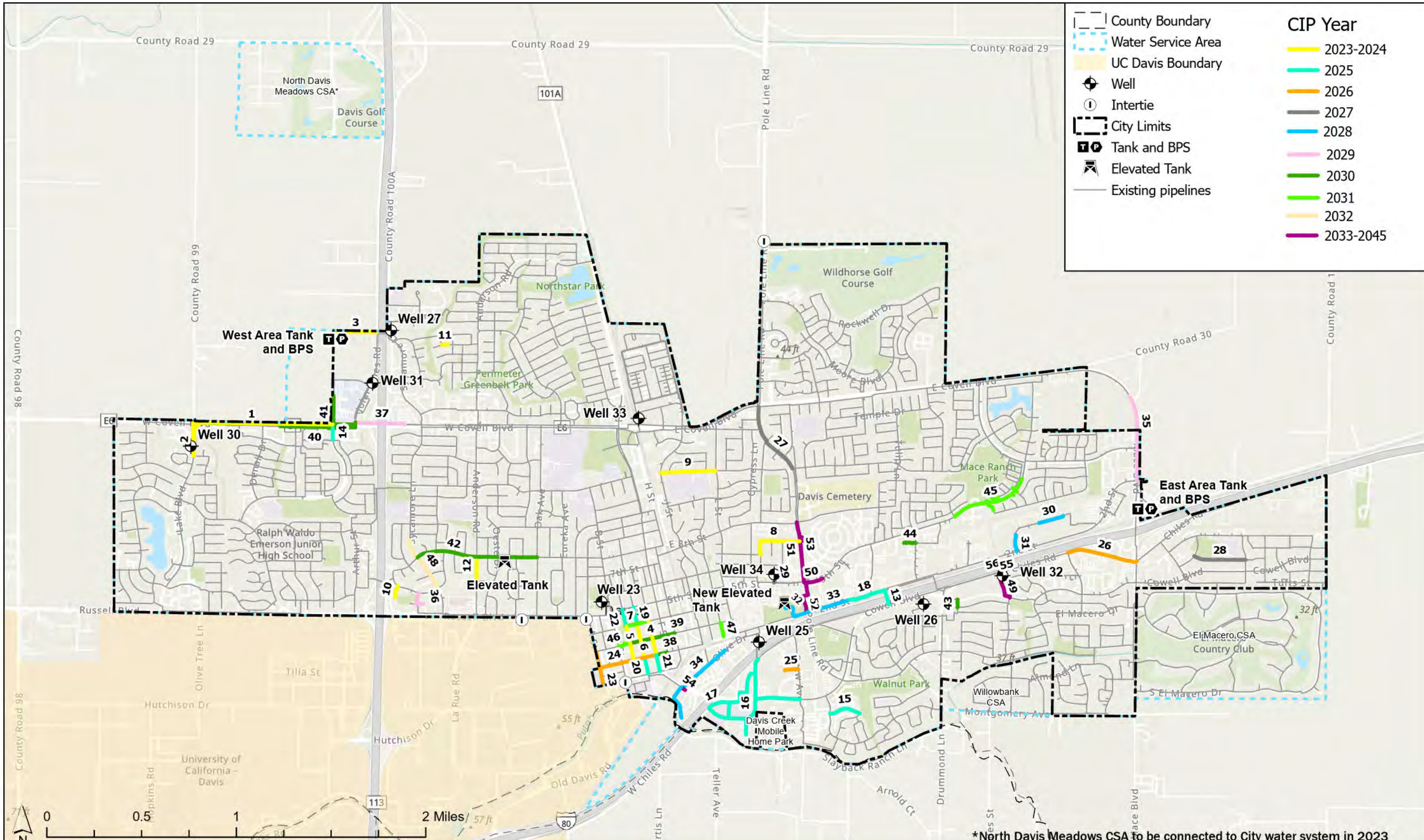

Figure 7-1. Overall CIP

Brown AND Caldwell

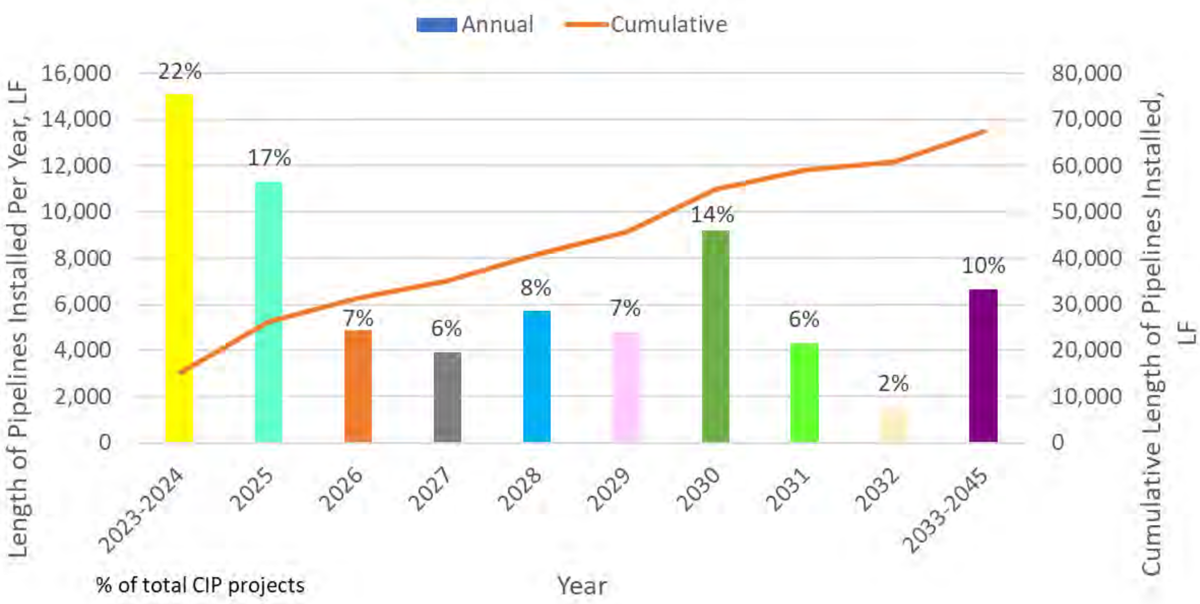

Figure 7-2. Overall CIP Annual and Cumulative

Table 7-5. Overall CIP by Planning Year

Planning Year	Year	Annual			Planning Year			
		Total LF	%	Cost, $	Total CIP LF	% of CIP Total	Cost, $	Average Annual, LF
Near Term (0-5 Year)	2023	15,070	22%	14,372,000	35,160	52%	30,575,000	7,032
	2024							
	2025	11,298	17%	9,187,000				
	2026	4,889	7%	3,790,000				
	2027	3,903	6%	3,226,000				
5-10 Year	2028	5,700	8%	5,329,000	25,549	38%	15,636,000	5,110
	2029	4,800	7%	4,318,000				
	2030	9,209	14%	106,000				
	2031	4,295	6%	4,322,000				
	2032	1,545	2%	1,561,000				
Long Term (>10 Year)	2033-2045	6,643	10%	9,355,000	6,643	10%	9,355,000	511
Total	-	**67,352**	**100%**	**55,566,000**	**67,352**	**100%**	**55,566,000**	**2,928**

Table 7-6. Overall CIP by Constraint			
Planning Year	Total		
	Total CIP LF	% of CIP total	Cost, $
High Risk	29,852	44%	18,837,000
Hydraulic Capacity Deficiency	14,500	22%	16,464,000
Fire Flow Availability	18,000	27%	13,568,000
Supply Availability	5,000	7%	6,697,000
Total	67,352	100%	55,566,000

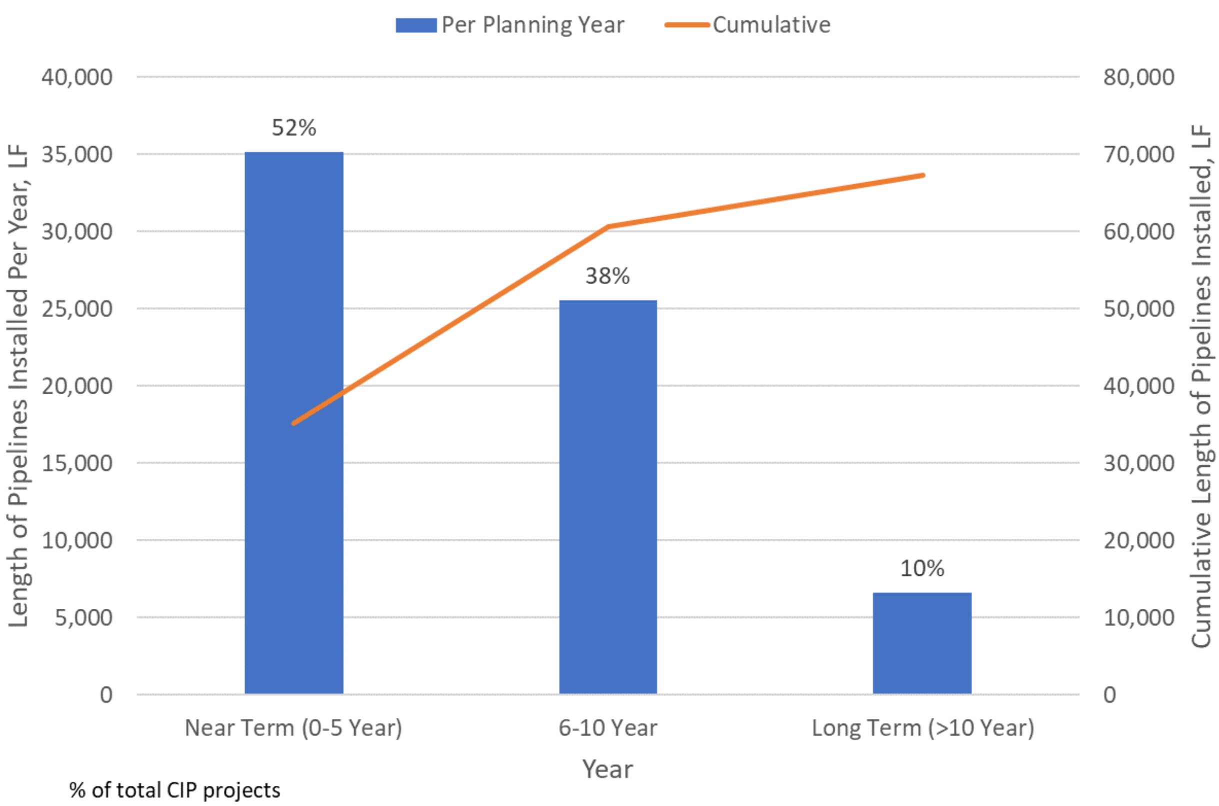

Figure 7-3. CIP per Planning Year and Cumulative

Section 8

References

Brown and Caldwell/Kennedy Jenks. 2011 Water Distribution System Optimization Plan. May 2011.

Brown and Caldwell. 2013 Integrated Water Resources Study. August 2013.

Brown and Caldwell. 2020 Urban Water Management Plan. June 2021.

Brown and Caldwell. 2021 Model Update Report. March 2021.

City of Davis. 2021 to 2019 Housing Element. August 2021.

City of Davis. City of Davis GIS. Provided August 2022a.

City of Davis. City of Davis Water Pipe Break History. Provided August 2022b.

City of Davis. Davis Public Works Revised Design Standards. September 1991.

City of Davis. Pipe Materials, City of Davis GIS. Provided June 2023.

City of Davis with PMC. 2013-21 Housing Element Update, General Plan Update. Adopted February 2014.

US Census Bureau. Quick Facts- Davis City, California. https://www.census.gov/quickfacts/daviscitycalifornia. Accessed January 2021.

USGS. Web Soil Survey. Accessed 2023. https://websoilsurvey.nrcs.usda.gov/app/

Yolo County. Yolo County Open Data website. 2022

Yolo Subbasin Groundwater Agency, Basin Boundary – Yolo. https://www.yologroundwater.org/basin-boundaries-yolo. Accessed January 2021.

Yolo Subbasin Groundwater Agency, Groundwater Sustainability Plan. 2022

Quantum Spatial, Inc an NV5 Company. Davis City of California DWR Landscape Area Estimates Project. November 23, 2020.

Appendix A: Additional Modeling Results

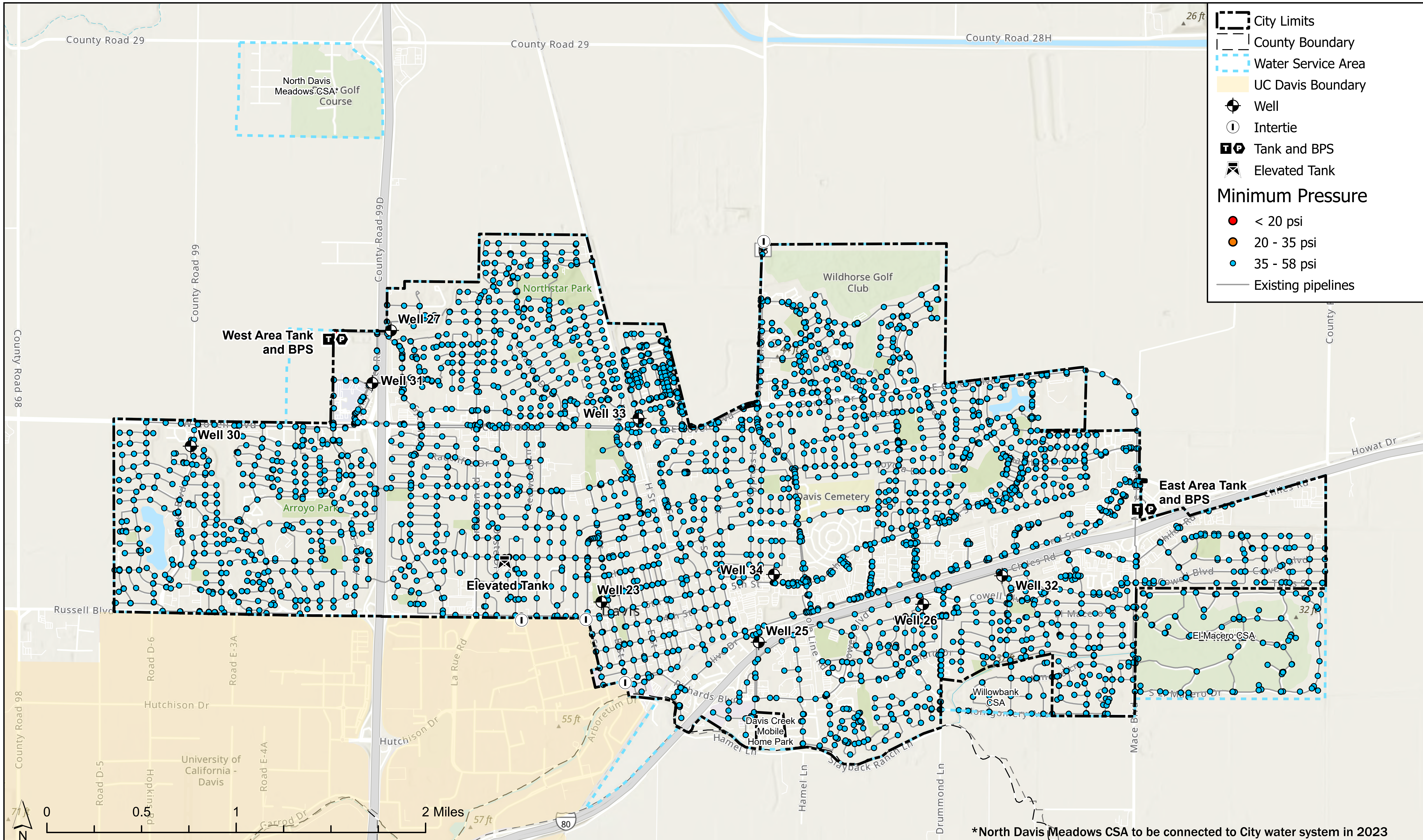

Figure A-1. Existing system minimum pressure

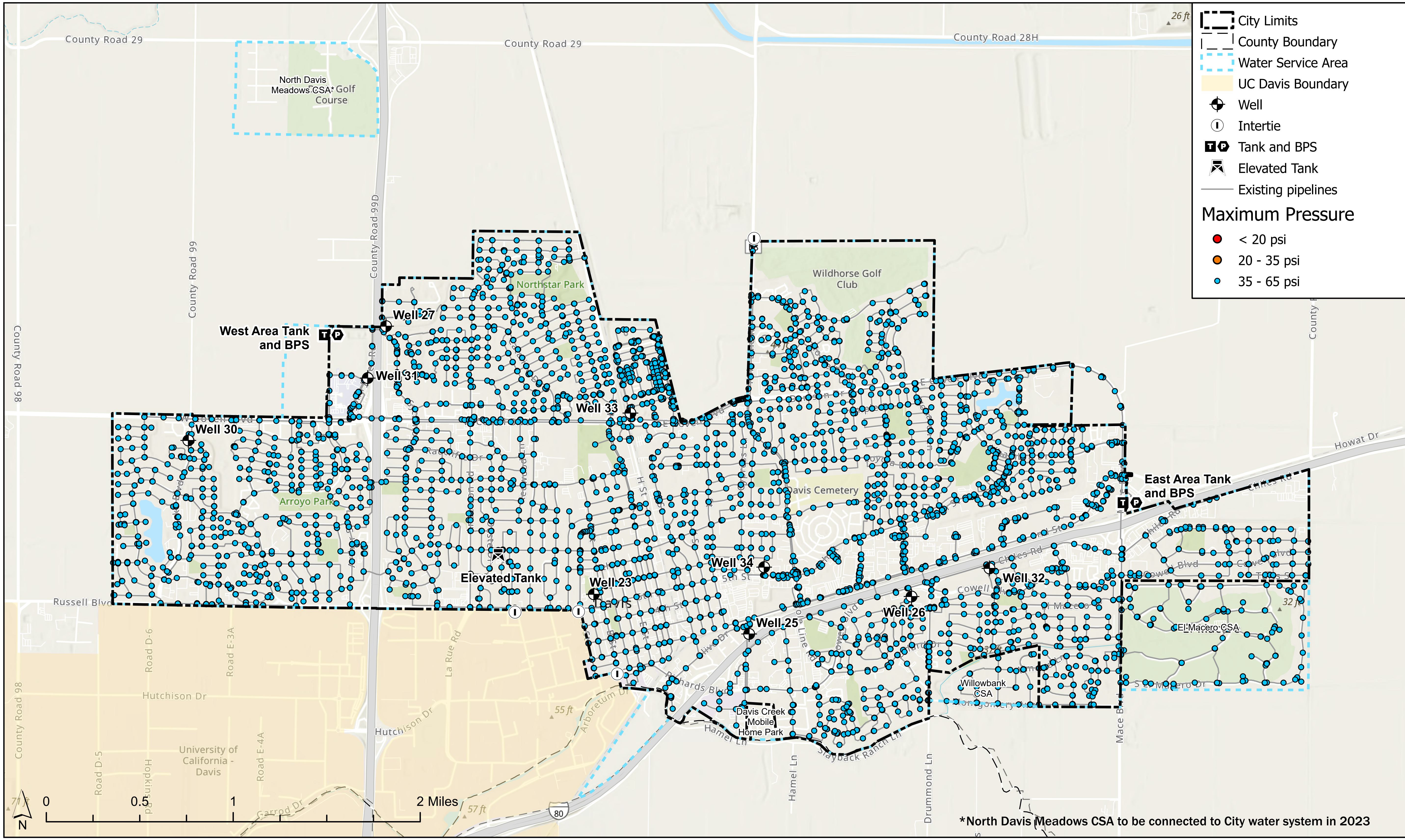

Figure A-2. Existing system maximum pressure

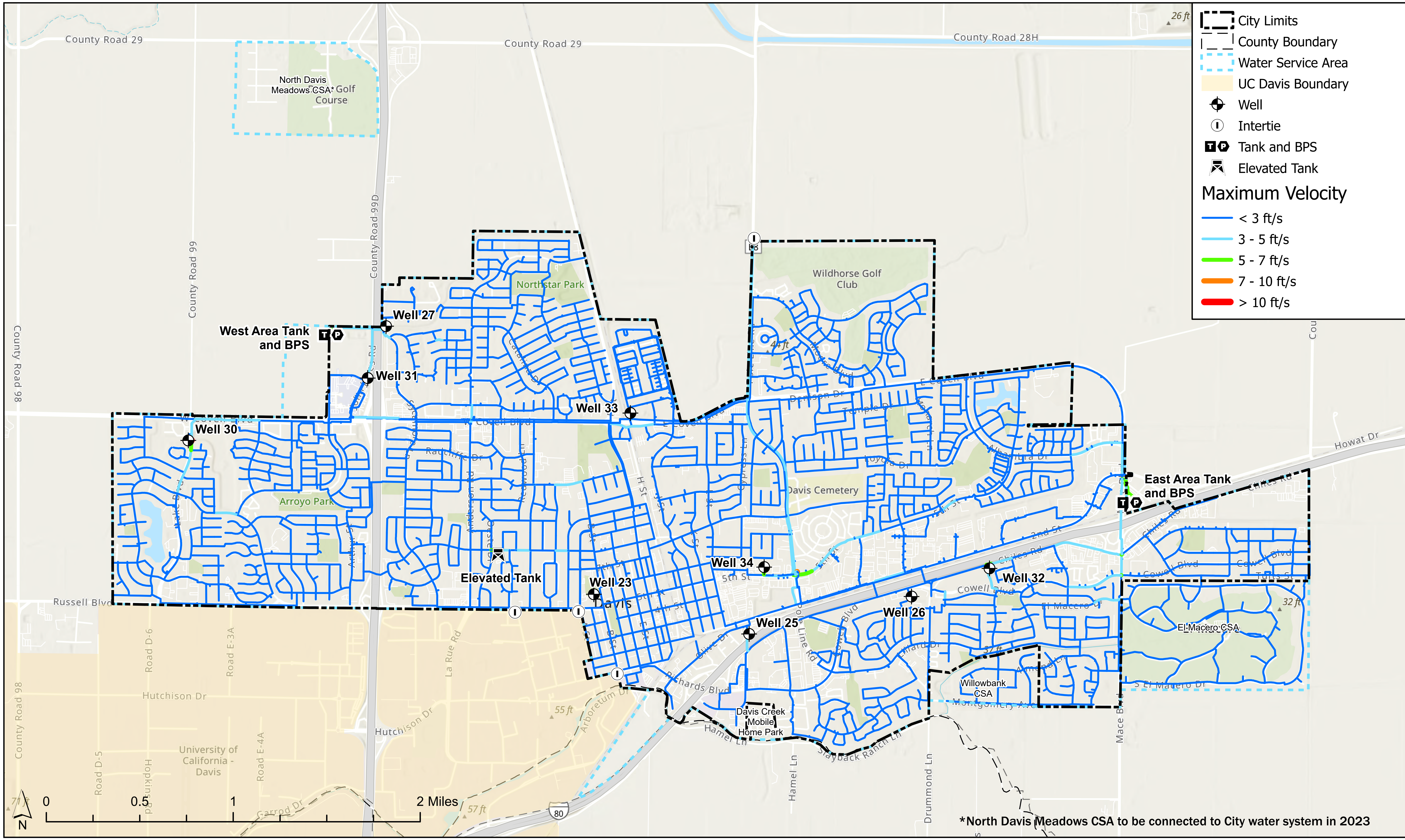

Figure A-3. Existing system maximum velocity

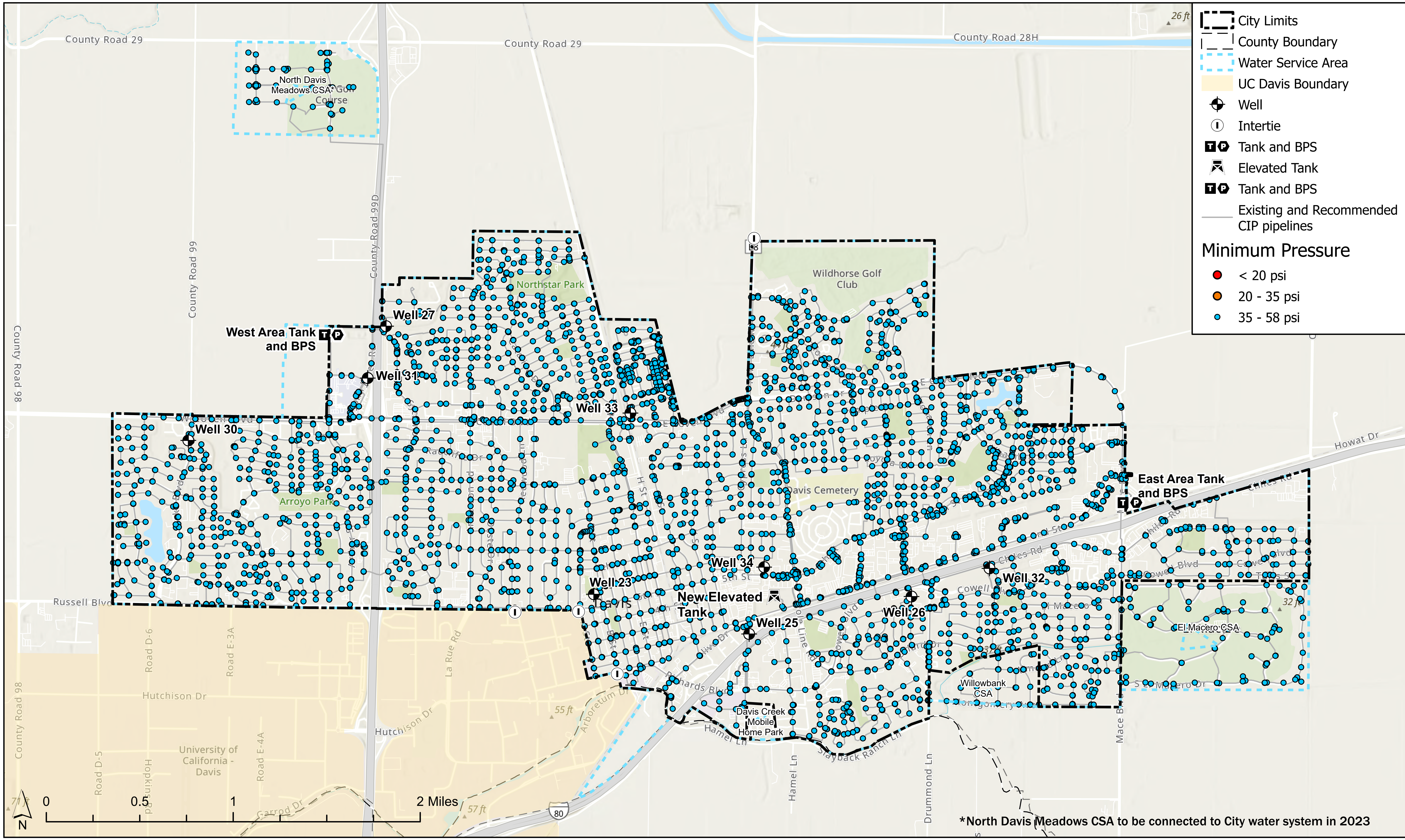

Figure A-4. Buildout system minimum pressure

Brown AND Caldwell

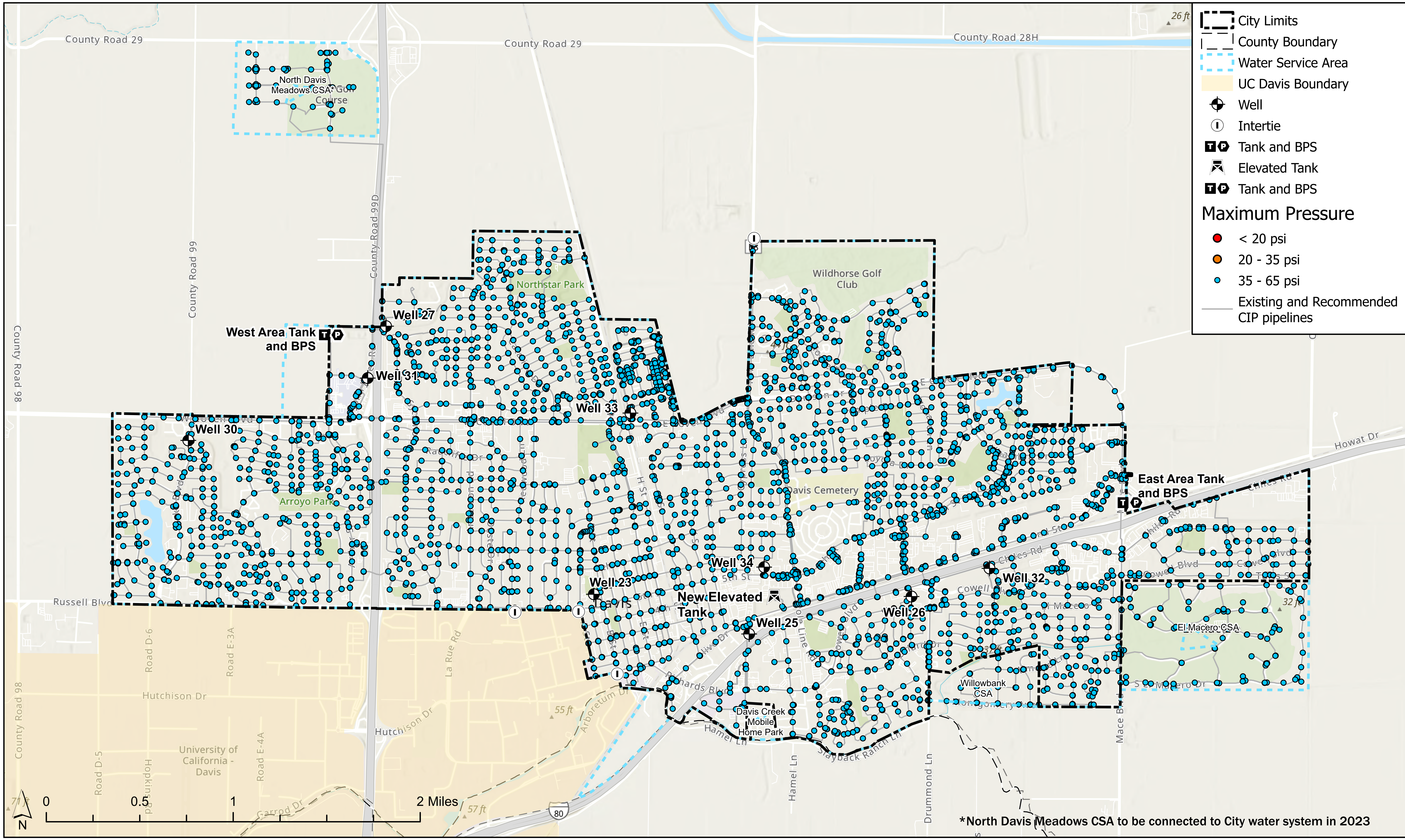

Figure A-5. Buildout system maximum pressure

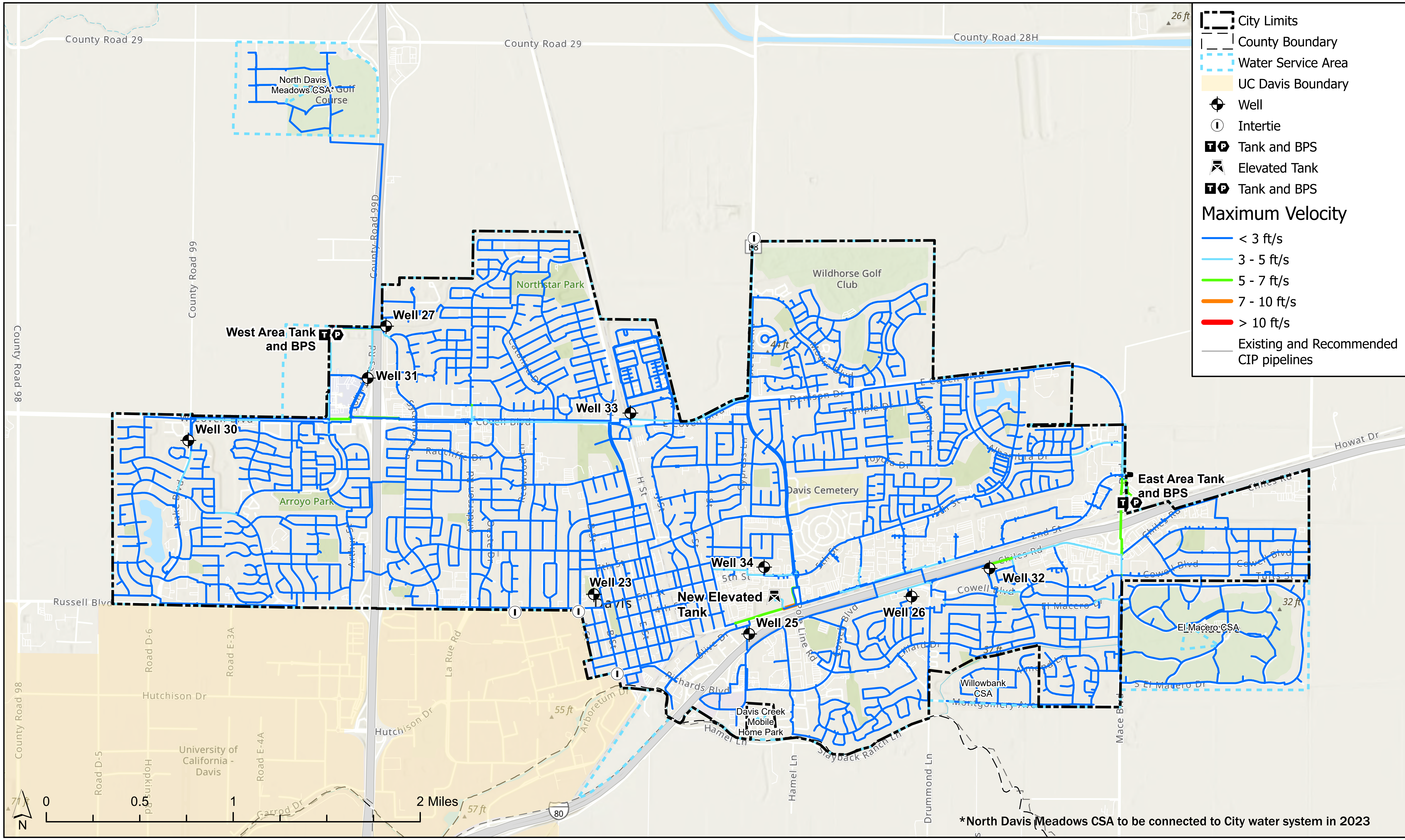

Figure A-6. Buildout system maximum velocity

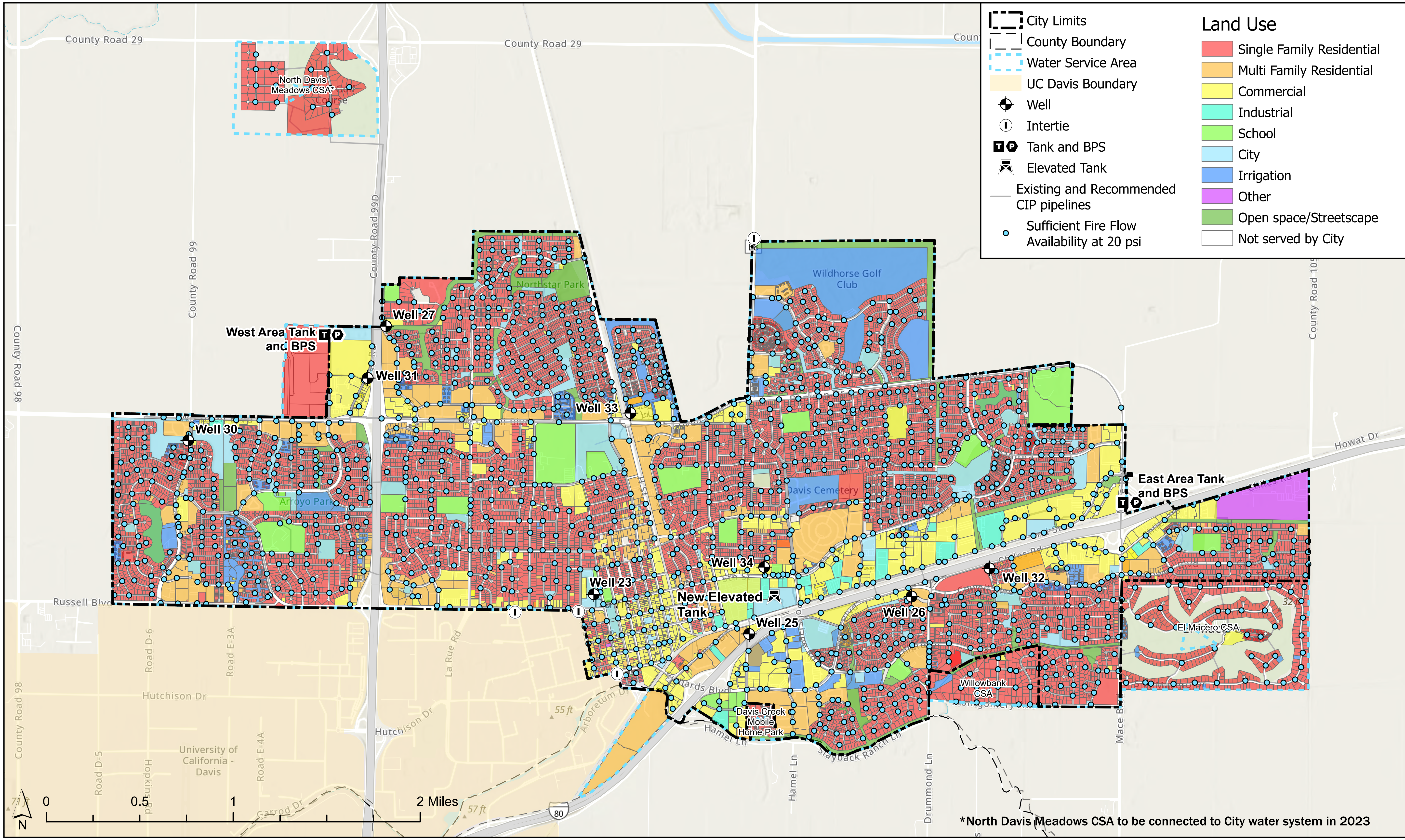

Figure A-7. Buildout System Fire Flow Deficiencies

Appendix B: Basis of Estimate

Memorandum

Date: January 02, 2023

To: John Abrew, Sacramento

From: Nitesh Poladia, Dallas

Project No.: 158716

Subject: 2023 Water System Optimization Plan
Planning/Conceptual Design Completion
Basis of Estimate of Probable Construction Cost

The Basis of Estimate Report and supporting estimate reports for the subject project are attached. Please call me if you have questions or need additional information.

Enclosures (3):

1. Basis of Estimate Report
2. Estimate Summary Report
3. Estimate Detail Report

Basis of Estimate Report

Water System Optimization Plan

Introduction

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the City of Davis's 2023 Water Systems Optimization Plan, Davis, CA.

Summary

This Basis of Estimate contains the following information:

- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Contractor and other estimate markups

Background of this Estimate

The attached estimate of probable construction cost is based on documents dated December 2023, received by the Estimating and Scheduling Group (ESG). These documents are described as planning/conceptual level complete based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

Class 4: 1 to 15 Percent Design Completion

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate. A Class 4 estimate is defined as a Planning Level or Design Technical Feasibility Estimate. Typically, engineering is from 1 to 15 percent complete. Class 4 estimates are used to prepare planning level cost scopes or to evaluate alternatives in design conditions and form the base work for the Class 3 Project Budget or Funding Estimate.

Expected accuracy for Class 4 estimates typically range from -30 to +50 percent, depending on the technological complexity of the project, appropriate reference information and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of Sage Construction and Real Estate 300 estimating software engine (formerly Timberline) using RS Means database, historical project data, the latest vendor and material cost information, and other costs specific to the project location.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel) and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and worker's compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Local sales tax has been applied to material and equipment rentals. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data.

The contractor's cost for builder's risk, general liability and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost and are added after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Contractor's credentials, applicable to the type of project.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions, or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. The pipe installation is assumed to be open cut trench with 5 feet of cover.
2. The pipe material assumed is Polyvinyl Chloride (PVC) for pipe sizes 8-inches to 16- inches with 1,000 linear feet of pipe. One segment of pipe is prized as Ductile Iron Pipe (DIP) which is 16-inches in diameter.
3. The trenchless piping is assumed to be horizontal directional drilling (HDD) for 12-inches pipe at 400 linear feet and 16-inches pipe at 1,300 linear feet. The pipe material for these two segments is assumed to be High Density Polyethylene (HDPE).
4. The water service connections is assumed to be at every 100 feet resulting in 10 total connections for 1,000 linear feet of pipe.
5. The cost for fire hydrants is included and assumed to have four for every 1,000 linear feet of pipe.
6. The cost for gate valve is included and assumed to have five for every 1,000 linear feet of pipe.
7. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
8. Contractor has complete access for lay-down areas and mobile equipment.
9. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
10. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
11. Bulk material quantities are based on manual quantity take-offs.
12. There is enough electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project except for the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups

Item	Rate (%)
Net Cost Markups	
Labor markup	15
Materials and process equipment	10
Equipment (construction-related)	10
Subcontractor	10
Sales Tax (State and local for materials, process equipment and construction equipment rentals, etc.)	8.75

Material Shipping and Handling	2
Gross Cost Markups	
Contractor General Conditions	15
Start-up, Training and O&M	2
Construction Contingency	35
Builders Risk, Liability and Auto Insurance	2
Performance and Payment Bonds	1.5

Labor Markup

The labor rates used in the estimate were derived from RS Means latest national average wage rate tables and city cost indexes. These include base rate paid to the laborer plus fringes. A labor burden factor is applied to these such that the final rates include all employer paid taxes. These taxes are FICA (which covers social security plus Medicare), Workers Comp (which varies based on state, employer experience and history) and unemployment insurance. The result is fully loaded labor rates. In addition to the fully loaded labor rate, an overhead and profit markup is applied at the back end of the estimate. This covers payroll and accounting, estimator's wages, home office rent, advertising, and owner profit.

Materials and Process Equipment Markup

This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup

This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all the equipment needed for the job, but to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is like the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup

This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Sales Tax (Materials, Process Equipment and Construction Equipment)

This is the tax that the contractor must pay according to state and local tax laws. The percentage is applied to both the material and equipment the GC purchases as well as the cost for rental equipment. The percentage is based on the local rates in place at the time the estimate was prepared.

Contractor Startup, Training, and O&M Manuals

This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup, and O&M manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and troubleshoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings and coordination with the plant personnel in other areas of the plant operation.

Builders Risk, Liability, and Vehicle Insurance

This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and the contractor's insurability at the time the project is bid.

Material Shipping and Handling

This can range from 2 to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paperwork, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the value of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies, e.g., oil, gaskets and bolts that may be missing from the equipment or materials shipped.

Undesigned/Undeveloped Contingency

The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that cannot be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage and area factors, construction contingency can range from 10 to 50 percent.

Performance and Payment Bonds

Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity, and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

Estimate Summary Report

1/2/2024

BC Project Number: 158716
Lead Estimator: Nitesh Poladia

WATER SYSTEMS OPTIMIZATION PLAN

CITY OF DAVIS PUBLIC WORKS DEPARTMENT
WATER SYSTEMS OPTIMIZATION PLAN
CLASS 4: PLANNING/CONCEPTUAL

Estimator Nitesh Poladia

BC Project Manager John Abrew
BC Office Sacramento
BC Project Number 158716

WATER SYSTEMS OPTIMIZATION PLAN

Phase	Description	Takeoff Quantity	Grand Total Price	Gross Total Cost with Markups
01 WATER SYSTEMS OPTIMIZATION PLAN				
02 8" PVC Pipe		1,000.00 LF	609.16 /LF	609,163
03 10" PVC Pipe		1,000.00 LF	683.83 /LF	683,826
04 12" PVC Pipe		1,000.00 LF	756.31 /LF	756,305
05 14" PVC Pipe		1,000.00 LF	920.90 /LF	920,903
06 16" PVC Pipe		1,000.00 LF	1,078.00 /LF	1,077,998
07 18" PVC Pipe		1,000.00 LF	1,200.01 /LF	1,200,011
08 16" DIP Pipe		1,000.00 LF	1,339.39 /LF	1,339,386
09 Trenchless - 12" Pipe		400.00 LF	798.90 /LF	319,561
10 Trenchless - 16" Pipe		1,300.00 LF	797.37 /LF	1,036,585

Estimate Detail Report

1/2/2024
BC Project Number: 158716
Lead Estimator: Nitesh Poladia

WATER SYSTEMS OPTIMIZATION PLAN

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
01 WATER SYSTEMS OPTIMIZATION PLAN											
02 8" PVC Pipe											
01999 Mobilization & Demobilization											
01-99-99.99	Mob & Demob	1.00 ls	-	-	-		35,000.00	35,000.00	35,000	59,414.59 /ls	**59,415**
	Mobilization & Demobilization	**1.00 ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.59 /ls**	**59,415**
01999 Erosion and Water Pollution Control											
01-99-99.99	Erosion Control	1.00 ls	-	-	-		10,000.00	10,000.00	10,000	16,975.59 /ls	**16,976**
	Erosion and Water Pollution Control	**1.00 ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.59 /ls**	**16,976**
01999 Traffic Control											
01-99-99.99	Traffic Control	1.00 ls	-	-	-		15,000.00	15,000.00	15,000	25,463.39 /ls	**25,463**
	Traffic Control	**1.00 ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.39 /ls**	**25,463**
02221 Pavement Removal											
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00 lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90 /lf	**9,803**
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56 sy	8.38	-	3.46	-	-	11.85	6,582	22.02 /sy	**12,232**
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73 cy	9.06	-	10.27	-	-	19.33	1,193	36.10 /cy	**2,228**
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31 lcy	7.20	-	9.05	-	-	16.25	1,338	30.37 /lcy	**2,499**
	Pavement Removal	**1.00 ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.61 /ls**	**26,763**
32740 Asphaltic Paving											
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56 sy	0.72	-	0.60	-	-	1.32	733	2.46 /sy	**1,366**
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56 sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49 /sy	**25,274**
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56 sy	1.90	-	1.52	-	-	3.42	1,898	6.37 /sy	**3,539**
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11 gal	0.32	7.09	0.21	-	-	7.62	846	14.49 /gal	**1,610**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56 sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56 /sy	**20,309**
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56 sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55 /sy	**3,636**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56 sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81 /sy	**17,119**
	Asphaltic Paving	**556.00 sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03 /sy**	**72,854**
32740 Curb & Gutter											
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11 sy	0.72	-	0.60	-	-	1.32	15	2.46 /sy	**27**
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00 lf	16.88	28.05	-	-	-	44.93	4,493	84.62 /lf	**8,462**

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32740 Curb & Gutter											
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	**1,560**
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.65 /sf	**365**
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	**10,414**
33490 Trench for Utilities - 8"											
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	658.44 bcy	2.46	-	2.17	-	-	4.63	3,045	8.63 /bcy	**5,680**
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	**8,921**
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	**16,175**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	250.45 bcy	7.24	-	1.75	-	-	9.00	2,254	16.69 /bcy	**4,180**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	454.32 lcy	13.72	30.11	2.03	-	-	45.85	20,832	86.52 /lcy	**39,310**
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	395.06 bcy	3.26	-	0.79	-	-	4.05	1,600	7.51 /bcy	**2,967**
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	658.44 bcy	0.71	-	0.46	-	-	1.17	768	2.17 /bcy	**1,431**
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	823.05 lcy	17.74	-	22.27	-	-	40.01	32,926	74.75 /lcy	**61,520**
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	**37,125**
	Trench for Utilities - 8"	**1,000.00 lf**	**30.62**	**13.68**	**50.22**			**94.53**	**94,525**	**177.31 /lf**	**177,311**
33531 PVC Pipe, C905 - 8"											
33-14-13.25	Water supply distribution piping, piping polyvinyl chloride, pressure pipe, 8", AWWA C900, Class 150, SDR 18, excludes excavation or backfill	1,000.00 lf	12.69	9.70	1.06	-	-	23.44	23,443	43.91 /lf	**43,909**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, 90 degree, 8" diameter, class 150, 18, excludes excavation or backfill	5.00 ea	41.88	198.97	3.49	-	-	244.33	1,222	462.99 /ea	**2,315**
33-14-13.25	Water supply distribution piping,fitting w/rubber gasket,polyvinyl chloride,bend 45 degree,8"diameter,class 150,18,excludes excavation backfill	3.00 ea	67.00	338.35	5.58	-	-	410.93	1,233	778.89 /ea	**2,337**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, tee, 8" diameter, class 150, DR 18, excludes excavation or backfill	3.00 ea	47.86	494.90	3.99	-	-	546.74	1,640	1,038.75 /ea	**3,116**
33-14-13.25	Water supply distribution piping,fitting w/rubber gasket,polyvinyl chloride,repair coupling,8"diameter,class 150,18,excludes excavation backfill	5.00 ea	56.16	132.31	-	-	-	188.47	942	355.82 /ea	**1,779**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, plug end, 8" diameter, class 150, 18, excludes excavation or backfill	2.00 ea	56.17	94.94	-	-	-	151.11	302	284.64 /ea	**569**
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	40.00 hr	85.34	-	37.85	-	-	123.19	4,928	229.03 /hr	**9,161**
	PVC Pipe, C905 - 8"	**1,000.00 lf**	**17.05**	**14.04**	**2.62**			**33.71**	**33,710**	**63.19 /lf**	**63,186**
33999 Fire Hydrant											
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.31 /ea	**41,353**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
	Fire Hydrant	**4.00**	**ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.31**	**/ea**	**41,353**
33999 Water Service Connections													
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00	ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68	/ea	**53,927**
	Water Service Connections	**1.00**	**ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.80**	**/ea**	**53,927**
33999 Gate Valve													
22-05-23.30	Gate Valve - 8"	5.00	ea	1,234.09	4,904.90	358.66	-	-	6,497.66	32,488	12,300.29	/ea	**61,501**
	Gate Valve	**5.00**	**ea**	**1,234.09**	**4,904.90**	**358.66**			**6,497.66**	**32,488**	**12,300.29**	**/ea**	**61,501**
	02 8" PVC Pipe	**1,000.00**	**LF**	**73.31**	**104.50**	**63.05**	**30.00**	**60.00**	**330.86**	**330,863**	**609.16**	**/LF**	**609,163**

WATER SYSTEMS OPTIMIZATION PLAN

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
03 10" PVC Pipe													
01999 Mobilization & Demobilization													
01-99-99.99	Mob & Demob	1.00	ls	-	-	-		35,000.00	35,000.00	35,000	59,414.58	/ls	**59,415**
	Mobilization & Demobilization	**1.00**	**ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.58**	**/ls**	**59,415**
01999 Erosion and Water Pollution Control													
01-99-99.99	Erosion Control	1.00	ls	-	-	-		10,000.00	10,000.00	10,000	16,975.60	/ls	**16,976**
	Erosion and Water Pollution Control	**1.00**	**ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.60**	**/ls**	**16,976**
01999 Traffic Control													
01-99-99.99	Traffic Control	1.00	ls	-	-	-		15,000.00	15,000.00	15,000	25,463.39	/ls	**25,463**
	Traffic Control	**1.00**	**ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.39**	**/ls**	**25,463**
02221 Pavement Removal													
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00	lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90	/lf	**9,803**
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56	sy	8.38	-	3.46	-	-	11.85	6,582	22.02	/sy	**12,232**
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73	cy	9.06	-	10.27	-	-	19.33	1,193	36.10	/cy	**2,228**
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31	lcy	7.20	-	9.05	-	-	16.25	1,338	30.37	/lcy	**2,499**
	Pavement Removal	**1.00**	**ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.60**	**/ls**	**26,763**
32740 Asphaltic Paving													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56	sy	0.72	-	0.60	-	-	1.32	733	2.46	/sy	**1,366**
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56	sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49	/sy	**25,274**
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56	sy	1.90	-	1.52	-	-	3.42	1,898	6.37	/sy	**3,539**
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11	gal	0.32	7.09	0.21	-	-	7.62	846	14.49	/gal	**1,610**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56	sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56	/sy	**20,309**
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56	sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55	/sy	**3,636**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56	sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81	/sy	**17,119**
	Asphaltic Paving	**556.00**	**sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03**	**/sy**	**72,854**
32740 Curb & Gutter													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11	sy	0.72	-	0.60	-	-	1.32	15	2.46	/sy	**27**
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00	lf	16.88	28.05	-	-	-	44.93	4,493	84.62	/lf	**8,462**

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32740 Curb & Gutter											
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	**1,560**
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.65 /sf	**365**
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	**10,414**
33490 Trench for Utilities - 10"											
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	717.08 bcy	2.46	-	2.17	-	-	4.63	3,317	8.63 /bcy	**6,186**
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	**8,921**
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	**16,175**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	277.14 bcy	7.24	-	1.75	-	-	9.00	2,494	16.69 /bcy	**4,626**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	482.72 lcy	13.72	30.11	2.03	-	-	45.85	22,134	86.52 /lcy	**41,767**
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	419.75 bcy	3.26	-	0.79	-	-	4.05	1,700	7.51 /bcy	**3,153**
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	717.08 bcy	0.71	-	0.46	-	-	1.17	837	2.17 /bcy	**1,558**
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	896.35 lcy	17.74	-	22.27	-	-	40.01	35,859	74.75 /lcy	**67,000**
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	**37,125**
	Trench for Utilities - 10"	**1,000.00 lf**	**32.77**	**14.53**	**52.13**			**99.44**	**99,440**	**186.51 /lf**	**186,512**
33531 PVC Pipe, C905 - 10"											
33-14-13.25	Water supply distribution piping, piping polyvinyl chloride, pressure pipe, 10", AWWA C900, Class 150, SDR 18, excludes excavation or backfill	1,000.00 lf	15.23	13.18	1.27	-	-	29.68	29,677	55.64 /lf	**55,636**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, 90 degree, 10" diameter, class 150, 18, excludes excavation or backfill	5.00 ea	67.00	388.85	5.58	-	-	461.43	2,307	875.09 /ea	**4,375**
33-14-13.25	Water supply distribution piping,fitting w/rubber gasket,polyvinyl chloride,bend 45 degree,10"diameter,class 150,18,excludes excavation backfill	3.00 ea	67.00	661.55	5.58	-	-	734.13	2,202	1,394.60 /ea	**4,184**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, tee, 10" diameter, class 150, DR 18, excludes excavation or backfill	3.00 ea	83.75	1,464.50	6.98	-	-	1,555.23	4,666	2,957.84 /ea	**8,874**
33-14-13.25	Water supply distribution piping,fitting w/rubber gasket,polyvinyl chloride,repair coupling,10"diameter,class 150,18,excludes excavation backfill	5.00 ea	56.16	278.76	-	-	-	334.92	1,675	634.82 /ea	**3,174**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, plug end, 10" diameter, class 150, 18, excludes excavation or backfill	2.00 ea	56.17	151.50	-	-	-	207.67	415	392.39 /ea	**785**
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	50.00 hr	85.34	-	37.85	-	-	123.19	6,160	229.03 /hr	**11,451**
	PVC Pipe, C905 - 10"	**1,000.00 lf**	**20.68**	**23.20**	**3.23**			**47.10**	**47,102**	**88.48 /lf**	**88,479**
33999 Fire Hydrant											
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.32 /ea	**41,353**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
	Fire Hydrant	**4.00**	**ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.32**	**/ea**	**41,353**
33999 Water Service Connections													
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00	ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68	/ea	53,927
	Water Service Connections	**1.00**	**ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.79**	**/ea**	**53,927**
33999 Gate Valve													
22-05-23.30	Gate Valve - 10"	5.00	ea	1,402.38	8,958.95	358.66	-	-	10,719.99	53,600	20,334.42	/ea	101,672
	Gate Valve	**5.00**	**ea**	**1,402.38**	**8,958.95**	**358.66**			**10,719.99**	**53,600**	**20,334.42**	**/ea**	**101,672**
	03 10" PVC Pipe	**1,000.00**	**LF**	**79.93**	**134.78**	**65.57**	**30.00**	**60.00**	**370.28**	**370,281**	**683.83**	**/LF**	**683,826**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
04 12" PVC Pipe													
01999 Mobilization & Demobilization													
01-99-99.99	Mob & Demob	1.00	ls	-	-	-		35,000.00	35,000.00	35,000	59,414.58	/ls	**59,415**
	Mobilization & Demobilization	**1.00**	**ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.58**	**/ls**	**59,415**
01999 Erosion and Water Pollution Control													
01-99-99.99	Erosion Control	1.00	ls	-	-	-		10,000.00	10,000.00	10,000	16,975.58	/ls	**16,976**
	Erosion and Water Pollution Control	**1.00**	**ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.58**	**/ls**	**16,976**
01999 Traffic Control													
01-99-99.99	Traffic Control	1.00	ls	-	-	-		15,000.00	15,000.00	15,000	25,463.40	/ls	**25,463**
	Traffic Control	**1.00**	**ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.40**	**/ls**	**25,463**
02221 Pavement Removal													
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00	lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90	/lf	**9,803**
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56	sy	8.38	-	3.46	-	-	11.85	6,582	22.02	/sy	**12,232**
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73	cy	9.06	-	10.27	-	-	19.33	1,193	36.10	/cy	**2,228**
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31	lcy	7.20	-	9.05	-	-	16.25	1,338	30.37	/lcy	**2,499**
	Pavement Removal	**1.00**	**ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.62**	**/ls**	**26,763**
32740 Asphaltic Paving													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56	sy	0.72	-	0.60	-	-	1.32	733	2.46	/sy	**1,366**
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56	sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49	/sy	**25,274**
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56	sy	1.90	-	1.52	-	-	3.42	1,898	6.37	/sy	**3,539**
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11	gal	0.32	7.09	0.21	-	-	7.62	846	14.49	/gal	**1,610**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56	sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56	/sy	**20,309**
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56	sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55	/sy	**3,636**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56	sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81	/sy	**17,119**
	Asphaltic Paving	**556.00**	**sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03**	**/sy**	**72,854**
32740 Curb & Gutter													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11	sy	0.72	-	0.60	-	-	1.32	15	2.46	/sy	**27**
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00	lf	16.88	28.05	-	-	-	44.93	4,493	84.62	/lf	**8,462**

32740 Curb & Gutter

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	**1,560**
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.65 /sf	**365**
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	**10,414**

33490 Trench for Utilities - 12"

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	777.78 bcy	2.46	-	2.17	-	-	4.63	3,597	8.63 /bcy	**6,710**
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	**8,921**
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	**16,175**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	304.26 bcy	7.24	-	1.75	-	-	9.00	2,738	16.69 /bcy	**5,079**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	511.11 lcy	13.72	30.11	2.03	-	-	45.85	23,436	86.52 /lcy	**44,224**
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	444.44 bcy	3.26	-	0.79	-	-	4.05	1,800	7.51 /bcy	**3,338**
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	777.78 bcy	0.71	-	0.46	-	-	1.17	908	2.17 /bcy	**1,690**
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	972.22 lcy	17.74	-	22.27	-	-	40.01	38,894	74.75 /lcy	**72,671**
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	**37,125**
	Trench for Utilities - 12"	**1,000.00 lf**	**34.98**	**15.39**	**54.11**			**104.47**	**104,473**	**195.93 /lf**	**195,934**

33531 PVC Pipe, C905 - 12"

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
33-14-13.25	Water supply distribution piping, piping polyvinyl chloride, pressure pipe, 12", AWWA C900, Class 150, SDR 18, excludes excavation or backfill	1,000.00 lf	18.01	17.93	1.50	-	-	37.44	37,439	70.26 /lf	**70,259**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, 90 degree, 12" diameter, class 150, 18, excludes excavation or backfill	5.00 ea	111.67	575.70	9.30	-	-	696.67	3,483	1,320.59 /ea	**6,603**
33-14-13.25	Water supply distribution piping,fitting w/rubber gasket,polyvinyl chloride,bend 45 degree,12"diameter,class 150,18,excludes excavation backfill	3.00 ea	111.67	1,035.25	9.30	-	-	1,156.22	3,469	2,196.07 /ea	**6,588**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, tee, 12" diameter, class 150, DR 18, excludes excavation or backfill	3.00 ea	167.50	2,095.75	13.95	-	-	2,277.21	6,832	4,328.30 /ea	**12,985**
33-14-13.25	Water supply distribution piping,fitting w/rubber gasket,polyvinyl chloride,repair coupling,12"diameter,class 150,18,excludes excavation backfill	5.00 ea	56.16	353.50	-	-	-	409.66	2,048	777.21 /ea	**3,886**
33-14-13.25	Water supply distribution piping, fitting w/rubber gasket, polyvinyl chloride, plug end, 12" diameter, class 150, 18, excludes excavation or backfill	2.00 ea	56.17	204.02	-	-	-	260.19	520	492.44 /ea	**985**
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	60.00 hr	85.34	-	37.85	-	-	123.19	7,392	229.03 /hr	**13,742**
	PVC Pipe, C905 - 12"	**1,000.00 lf**	**24.92**	**32.38**	**3.89**			**61.18**	**61,183**	**115.05 /lf**	**115,047**

33999 Fire Hydrant

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.31 /ea	**41,353**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
	Fire Hydrant	**4.00**	**ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.31**	**/ea**	**41,353**
33999 Water Service Connections													
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00	ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68	/ea	53,927
	Water Service Connections	**1.00**	**ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.79**	**/ea**	**53,927**
33999 Gate Valve													
22-05-23.30	Gate Valve - 12"	5.00	ea	1,814.85	12,212.20	538.00	-	-	14,565.04	72,825	27,632.16	/ea	138,161
	Gate Valve	**5.00**	**ea**	**1,814.85**	**12,212.20**	**538.00**			**14,565.04**	**72,825**	**27,632.16**	**/ea**	**138,161**
	04 12" PVC Pipe	**1,000.00**	**LF**	**88.44**	**161.08**	**69.10**	**30.00**	**60.00**	**408.62**	**408,621**	**756.31**	**/LF**	**756,305**

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
05 14" PVC Pipe											
01999 Mobilization & Demobilization											
01-99-99.99	Mob & Demob	1.00 ls	-	-	-		35,000.00	35,000.00	35,000	59,414.57 /ls	59,415
	Mobilization & Demobilization	**1.00 ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.57 /ls**	**59,415**
01999 Erosion and Water Pollution Control											
01-99-99.99	Erosion Control	1.00 ls	-	-	-		10,000.00	10,000.00	10,000	16,975.60 /ls	16,976
	Erosion and Water Pollution Control	**1.00 ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.60 /ls**	**16,976**
01999 Traffic Control											
01-99-99.99	Traffic Control	1.00 ls	-	-	-		15,000.00	15,000.00	15,000	25,463.40 /ls	25,463
	Traffic Control	**1.00 ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.40 /ls**	**25,463**
02221 Pavement Removal											
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00 lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90 /lf	9,803
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56 sy	8.38	-	3.46	-	-	11.85	6,582	22.02 /sy	12,232
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73 cy	9.06	-	10.27	-	-	19.33	1,193	36.10 /cy	2,228
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31 lcy	7.20	-	9.05	-	-	16.25	1,338	30.37 /lcy	2,499
	Pavement Removal	**1.00 ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.61 /ls**	**26,763**
32740 Asphaltic Paving											
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56 sy	0.72	-	0.60	-	-	1.32	733	2.46 /sy	1,366
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56 sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49 /sy	25,274
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56 sy	1.90	-	1.52	-	-	3.42	1,898	6.37 /sy	3,539
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11 gal	0.32	7.09	0.21	-	-	7.62	846	14.49 /gal	1,610
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56 sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56 /sy	20,309
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56 sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55 /sy	3,636
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56 sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81 /sy	17,119
	Asphaltic Paving	**556.00 sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03 /sy**	**72,854**
32740 Curb & Gutter											
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11 sy	0.72	-	0.60	-	-	1.32	15	2.46 /sy	27
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00 lf	16.88	28.05	-	-	-	44.93	4,493	84.62 /lf	8,462

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32740 Curb & Gutter											
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	**1,560**
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.64 /sf	**364**
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	**10,414**
33490 Trench for Utilities - 14"											
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	840.54 bcy	2.46	-	2.17	-	-	4.63	3,888	8.63 /bcy	**7,251**
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	**8,921**
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	**16,175**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	331.83 bcy	7.24	-	1.75	-	-	9.00	2,986	16.69 /bcy	**5,539**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	539.51 lcy	13.72	30.11	2.03	-	-	45.85	24,738	86.52 /lcy	**46,680**
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	469.14 bcy	3.26	-	0.79	-	-	4.05	1,900	7.51 /bcy	**3,524**
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	840.54 bcy	0.71	-	0.46	-	-	1.17	981	2.17 /bcy	**1,827**
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	1,050.67 lcy	17.74	-	22.27	-	-	40.01	42,032	74.75 /lcy	**78,535**
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	**37,125**
	Trench for Utilities - 14"	**1,000.00 lf**	**37.24**	**16.24**	**56.15**			**109.62**	**109,625**	**205.58 /lf**	**205,577**
33531 PVC Pipe, C905 - 14"											
33-14-13.25	Water supply distribution piping, piping polyvinyl chloride, 14" diameter, AWWA C905, PR 100, DR 25, excludes excavation or backfill, unless specified	1,000.00 lf	15.73	18.99	1.31	-	-	36.03	36,026	67.70 /lf	**67,701**
33-14-13.25	Water supply distribution piping, PVC pipe joint restraint, 14" diameter	87.00 ea	175.51	191.90	-	-	-	367.41	31,965	689.85 /ea	**60,017**
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	70.00 hr	85.34	-	37.85	-	-	123.19	8,624	229.03 /hr	**16,032**
	PVC Pipe, C905 - 14"	**1,000.00 lf**	**36.97**	**35.68**	**3.96**			**76.61**	**76,615**	**143.75 /lf**	**143,750**
33999 Fire Hydrant											
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.31 /ea	**41,353**
	Fire Hydrant	**4.00 ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.31 /ea**	**41,353**
33999 Water Service Connections											
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00 ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68 /ea	**53,927**
	Water Service Connections	**1.00 ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.79 /ea**	**53,927**
33999 Gate Valve											
22-05-23.30	Gate Valve - 14"	5.00 ea	2,373.26	24,924.90	538.00	-	-	27,836.16	139,181	52,882.31 /ea	**264,412**
	Gate Valve	**5.00 ea**	**2,373.26**	**24,924.90**	**538.00**			**27,836.16**	**139,181**	**52,882.31 /ea**	**264,412**
	05 14" PVC Pipe	**1,000.00 LF**	**105.54**	**228.81**	**71.21**	**30.00**	**60.00**	**495.56**	**495,560**	**920.90 /LF**	**920,903**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
06 16" PVC Pipe													
01999 Mobilization & Demobilization													
01-99-99.99	Mob & Demob	1.00	ls	-	-	-		35,000.00	35,000.00	35,000	59,414.59	/ls	**59,415**
	Mobilization & Demobilization	**1.00**	**ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.59**	**/ls**	**59,415**
01999 Erosion and Water Pollution Control													
01-99-99.99	Erosion Control	1.00	ls	-	-	-		10,000.00	10,000.00	10,000	16,975.60	/ls	**16,976**
	Erosion and Water Pollution Control	**1.00**	**ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.60**	**/ls**	**16,976**
01999 Traffic Control													
01-99-99.99	Traffic Control	1.00	ls	-	-	-		15,000.00	15,000.00	15,000	25,463.40	/ls	**25,463**
	Traffic Control	**1.00**	**ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.40**	**/ls**	**25,463**
02221 Pavement Removal													
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00	lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90	/lf	**9,803**
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56	sy	8.38	-	3.46	-	-	11.85	6,582	22.02	/sy	**12,232**
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73	cy	9.06	-	10.27	-	-	19.33	1,193	36.10	/cy	**2,228**
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31	lcy	7.20	-	9.05	-	-	16.25	1,338	30.37	/lcy	**2,499**
	Pavement Removal	**1.00**	**ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.61**	**/ls**	**26,763**
32740 Asphaltic Paving													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56	sy	0.72	-	0.60	-	-	1.32	733	2.46	/sy	**1,366**
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56	sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49	/sy	**25,274**
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56	sy	1.90	-	1.52	-	-	3.42	1,898	6.37	/sy	**3,539**
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11	gal	0.32	7.09	0.21	-	-	7.62	846	14.49	/gal	**1,610**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56	sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56	/sy	**20,309**
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56	sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55	/sy	**3,636**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56	sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81	/sy	**17,119**
	Asphaltic Paving	**556.00**	**sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03**	**/sy**	**72,854**
32740 Curb & Gutter													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11	sy	0.72	-	0.60	-	-	1.32	15	2.46	/sy	**27**
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00	lf	16.88	28.05	-	-	-	44.93	4,493	84.62	/lf	**8,462**

Brown AND Caldwell

Estimate Detail Report

WATER SYSTEMS OPTIMIZATION PLAN

1/2/2024
BC Project Number: 158716
Lead Estimator: Nitesh Poladia

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32740 Curb & Gutter											
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	1,560
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.65 /sf	365
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	10,414
33490 Trench for Utilities - 16"											
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	905.35 bcy	2.46	-	2.17	-	-	4.63	4,188	8.63 /bcy	7,810
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	8,921
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	16,175
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	359.84 bcy	7.24	-	1.75	-	-	9.00	3,238	16.69 /bcy	6,006
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	567.90 lcy	13.72	30.11	2.03	-	-	45.85	26,040	86.52 /lcy	49,137
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	493.83 bcy	3.26	-	0.79	-	-	4.05	2,000	7.51 /bcy	3,709
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	905.35 bcy	0.71	-	0.46	-	-	1.17	1,056	2.17 /bcy	1,967
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	1,131.69 lcy	17.74	-	22.27	-	-	40.01	45,273	74.75 /lcy	84,590
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	37,125
	Trench for Utilities - 16"	**1,000.00 lf**	**39.55**	**17.10**	**58.25**			**114.90**	**114,895**	**215.44 /lf**	215,443
33531 PVC Pipe, C905 - 16"											
33-14-13.25	Water supply distribution piping, piping polyvinyl chloride, 16" diameter, AWWA C905, PR 100, DR 25, excludes excavation or backfill, unless specified	1,000.00 lf	16.75	25.76	1.40	-	-	43.90	43,901	82.64 /lf	82,642
33-14-13.25	Water supply distribution piping, PVC pipe joint restraint, 16" diameter	87.00 ea	241.26	258.56	-	-	-	499.82	43,484	938.31 /ea	81,633
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	80.00 hr	85.34	-	37.85	-	-	123.19	9,855	229.03 /hr	18,322
	PVC Pipe, C905 - 16"	**1,000.00 lf**	**44.57**	**48.25**	**4.42**			**97.24**	**97,240**	**182.60 /lf**	182,597
33999 Fire Hydrant											
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.31 /ea	41,353
	Fire Hydrant	**4.00 ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.31 /ea**	41,353
33999 Water Service Connections											
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00 ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68 /ea	53,927
	Water Service Connections	**1.00 ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.78 /ea**	53,927
33999 Gate Valve											
22-05-23.30	Gate Valve - 16"	5.00 ea	3,085.24	35,435.40	717.33	-	-	39,237.97	196,190	74,558.91 /ea	372,795
	Gate Valve	**5.00 ea**	**3,085.24**	**35,435.40**	**717.33**			**39,237.97**	**196,190**	**74,558.91 /ea**	372,795
	06 16" PVC Pipe	**1,000.00 LF**	**119.01**	**294.78**	**74.67**	**30.00**	**60.00**	**578.46**	**578,465**	**1,078.00 /LF**	1,077,998

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
07 18" PVC Pipe											
01999 Mobilization & Demobilization											
01-99-99.99	Mob & Demob	1.00 ls	-	-	-		35,000.00	35,000.00	35,000	59,414.58 /ls	**59,415**
	Mobilization & Demobilization	**1.00 ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.58 /ls**	**59,415**
01999 Erosion and Water Pollution Control											
01-99-99.99	Erosion Control	1.00 ls	-	-	-		10,000.00	10,000.00	10,000	16,975.60 /ls	**16,976**
	Erosion and Water Pollution Control	**1.00 ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.60 /ls**	**16,976**
01999 Traffic Control											
01-99-99.99	Traffic Control	1.00 ls	-	-	-		15,000.00	15,000.00	15,000	25,463.39 /ls	**25,463**
	Traffic Control	**1.00 ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.39 /ls**	**25,463**
02221 Pavement Removal											
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00 lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90 /lf	**9,803**
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56 sy	8.38	-	3.46	-	-	11.85	6,582	22.02 /sy	**12,232**
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73 cy	9.06	-	10.27	-	-	19.33	1,193	36.10 /cy	**2,228**
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31 lcy	7.20	-	9.05	-	-	16.25	1,338	30.37 /lcy	**2,499**
	Pavement Removal	**1.00 ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.62 /ls**	**26,763**
32740 Asphaltic Paving											
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56 sy	0.72	-	0.60	-	-	1.32	733	2.46 /sy	**1,366**
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56 sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49 /sy	**25,274**
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56 sy	1.90	-	1.52	-	-	3.42	1,898	6.37 /sy	**3,539**
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11 gal	0.32	7.09	0.21	-	-	7.62	846	14.49 /gal	**1,610**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56 sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56 /sy	**20,309**
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56 sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55 /sy	**3,636**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56 sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81 /sy	**17,119**
	Asphaltic Paving	**556.00 sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03 /sy**	**72,854**
32740 Curb & Gutter											
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11 sy	0.72	-	0.60	-	-	1.32	15	2.46 /sy	**27**
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00 lf	16.88	28.05	-	-	-	44.93	4,493	84.62 /lf	**8,462**

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32740 Curb & Gutter											
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	**1,560**
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.65 /sf	**365**
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	**10,414**
33490 Trench for Utilities - 18"											
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	972.22 bcy	2.46	-	2.17	-	-	4.63	4,497	8.63 /bcy	**8,387**
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	**8,921**
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	**16,175**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	388.29 bcy	7.24	-	1.75	-	-	9.00	3,494	16.69 /bcy	**6,481**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	596.30 lcy	13.72	30.11	2.03	-	-	45.85	27,342	86.52 /lcy	**51,594**
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	518.52 bcy	3.26	-	0.79	-	-	4.05	2,100	7.51 /bcy	**3,895**
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	972.22 bcy	0.71	-	0.46	-	-	1.17	1,135	2.17 /bcy	**2,113**
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	1,215.28 lcy	17.74	-	22.27	-	-	40.01	48,618	74.75 /lcy	**90,839**
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	**37,125**
	Trench for Utilities - 18"	**1,000.00 lf**	**41.92**	**17.95**	**60.41**			**120.28**	**120,285**	**225.53 /lf**	**225,531**
33531 PVC Pipe, C905 - 18"											
33-14-13.25	Water supply distribution piping, piping polyvinyl chloride, 18" diameter, AWWA C905, PR 100, DR 25, excludes excavation or backfill, unless specified	1,000.00 lf	20.94	31.31	1.74	-	-	53.99	53,992	101.62 /lf	**101,619**
33-14-13.25	Water supply distribution piping, PVC pipe joint restraint, 18" diameter	87.00 ea	254.60	318.15	-	-	-	572.75	49,829	1,076.48 /ea	**93,654**
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	90.00 hr	85.34	-	37.85	-	-	123.19	11,087	229.03 /hr	**20,612**
	PVC Pipe, C905 - 18"	**1,000.00 lf**	**50.77**	**58.99**	**5.15**			**114.91**	**114,909**	**215.89 /lf**	**215,885**
33999 Fire Hydrant											
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.32 /ea	**41,353**
	Fire Hydrant	**4.00 ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.32 /ea**	**41,353**
33999 Water Service Connections											
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00 ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68 /ea	**53,927**
	Water Service Connections	**1.00 ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.79 /ea**	**53,927**
33999 Gate Valve											
22-05-23.30	Gate Valve - 18"	5.00 ea	3,856.55	42,942.90	717.33	-	-	47,516.77	237,584	90,286.18 /ea	**451,431**
	Gate Valve	**5.00 ea**	**3,856.55**	**42,942.90**	**717.33**			**47,516.77**	**237,584**	**90,286.18 /ea**	**451,431**
	07 18" PVC Pipe	**1,000.00 LF**	**131.44**	**343.91**	**77.56**	**30.00**	**60.00**	**642.92**	**642,917**	**1,200.01 /LF**	**1,200,011**

Estimate Detail Report

WATER SYSTEMS OPTIMIZATION PLAN

1/2/2024
BC Project Number: 158716
Lead Estimator: Nitesh Poladia

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
08 16" DIP Pipe													
01999 Mobilization & Demobilization													
01-99-99.99	Mob & Demob	1.00	ls	-	-	-		35,000.00	35,000.00	35,000	59,414.59	/ls	**59,415**
	Mobilization & Demobilization	**1.00**	**ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.59**	**/ls**	**59,415**
01999 Erosion and Water Pollution Control													
01-99-99.99	Erosion Control	1.00	ls	-	-	-		10,000.00	10,000.00	10,000	16,975.59	/ls	**16,976**
	Erosion and Water Pollution Control	**1.00**	**ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.59**	**/ls**	**16,976**
01999 Traffic Control													
01-99-99.99	Traffic Control	1.00	ls	-	-	-		15,000.00	15,000.00	15,000	25,463.40	/ls	**25,463**
	Traffic Control	**1.00**	**ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.40**	**/ls**	**25,463**
02221 Pavement Removal													
02-41-19.25	Selective demolition, saw cutting, asphalt, up to 4" deep	2,000.00	lf	1.77	0.11	0.76	-	-	2.63	5,268	4.90	/lf	**9,803**
02-41-13.17	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	555.56	sy	8.38	-	3.46	-	-	11.85	6,582	22.02	/sy	**12,232**
02-41-13.33	Minor site demolition, for disposal to 5 miles, excludes hauling, add	61.73	cy	9.06	-	10.27	-	-	19.33	1,193	36.10	/cy	**2,228**
31-23-23.20	Cycle hlng(,load,travl,unld dump&rtrn) time per cycle,excvt borrw,loose cubic yards,15 min ld/w/,12 cy truck,cycle 10 miles,15 mph,excld loadng eqpmnt	82.31	lcy	7.20	-	9.05	-	-	16.25	1,338	30.37	/lcy	**2,499**
	Pavement Removal	**1.00**	**ls**	**9,339.55**	**226.00**	**4,815.07**			**14,380.62**	**14,381**	**26,762.59**	**/ls**	**26,763**
32740 Asphaltic Paving													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	555.56	sy	0.72	-	0.60	-	-	1.32	733	2.46	/sy	**1,366**
32-11-23.23	Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base,12"deep	555.56	sy	1.97	20.20	1.80	-	-	23.96	13,310	45.49	/sy	**25,274**
32-11-23.23	Base course drainage layers, prepare and roll sub-base, small areas to 2,500 S.Y.	555.56	sy	1.90	-	1.52	-	-	3.42	1,898	6.37	/sy	**3,539**
32-11-26.19	Bituminous-stabilized base courses, for roadways and large paved areas, liquid application to gravel base, asphalt emulsion	111.11	gal	0.32	7.09	0.21	-	-	7.62	846	14.49	/gal	**1,610**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, binder course, 4" thick, no hauling included	555.56	sy	2.35	15.86	1.06	-	-	19.27	10,706	36.56	/sy	**20,309**
32-11-23.23	Base course drainage layers, for roadways and large paved areas, stabilization fabric, polypropylene, 6 oz./S.Y.	555.56	sy	0.26	3.14	0.04	-	-	3.44	1,913	6.55	/sy	**3,636**
32-12-16.13	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 3" thick, no hauling included	555.56	sy	2.19	13.06	1.00	-	-	16.25	9,029	30.81	/sy	**17,119**
	Asphaltic Paving	**556.00**	**sy**	**9.45**	**53.63**	**6.05**			**69.13**	**38,436**	**131.03**	**/sy**	**72,854**
32740 Curb & Gutter													
31-22-16.10	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	11.11	sy	0.72	-	0.60	-	-	1.32	15	2.46	/sy	**27**
32-16-13.13	Cast-in place concrete curbs & gutters, straight, wood forms, 0.066 C.Y. per LF, 6" high curb, 6" thick gutter, 30" wide, includes concrete	100.00	lf	16.88	28.05	-	-	-	44.93	4,493	84.62	/lf	**8,462**

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
32740 Curb & Gutter											
32-06-10.10	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 6" thick, excludes base	100.00 sf	4.20	4.12	-	-	-	8.32	832	15.60 /sf	**1,560**
32-06-10.10	Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick bank run gravel base, add	100.00 sf	0.79	1.08	0.06	-	-	1.94	194	3.65 /sf	**365**
	Curb & Gutter	**100.00 lf**	**21.95**	**33.25**	**0.13**			**55.33**	**5,533**	**104.14 /lf**	**10,414**
33490 Trench for Utilities - 16"											
31-23-16.13	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering	905.35 bcy	2.46	-	2.17	-	-	4.63	4,188	8.63 /bcy	**7,810**
01-54-33.40	Rent trench box, 9500 lbs, 8' x 20'	30.00 day	-	-	157.76	-	-	157.76	4,733	297.38 /day	**8,921**
31-23-23.19	Trench box, move and reset	50.00 ea	92.15	-	81.30	-	-	173.45	8,673	323.51 /ea	**16,175**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	359.84 bcy	7.24	-	1.75	-	-	9.00	3,238	16.69 /bcy	**6,006**
31-23-23.16	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	567.90 lcy	13.72	30.11	2.03	-	-	45.85	26,040	86.52 /lcy	**49,137**
31-23-23.23	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	493.83 bcy	3.26	-	0.79	-	-	4.05	2,000	7.51 /bcy	**3,709**
31-23-23.19	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	905.35 bcy	0.71	-	0.46	-	-	1.17	1,056	2.17 /bcy	**1,967**
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	1,131.69 lcy	17.74	-	22.27	-	-	40.01	45,273	74.75 /lcy	**84,590**
01-54-33.50	Roadway plate, steel, 1" x 8' x 20'	500.00 day	-	-	39.39	-	-	39.39	19,695	74.25 /day	**37,125**
	Trench for Utilities - 16"	**1,000.00 lf**	**39.55**	**17.10**	**58.25**			**114.90**	**114,895**	**215.44 /lf**	**215,443**
33521 Ductile Iron Pipe - 16"											
33-14-13.15	Water supply distribution piping,ductile iron pipe,cement lined,mechanical joint,fittings,18'lengths,16"diameter,class 50,excludes excavation backfill	1,000.00 lf	46.06	144.43	3.84	-	-	194.33	194,329	367.48 /lf	**367,482**
33-14-13.15	Water supply distribution piping,fitting,90 degree bend elbow,mechanical joint,ductile iron,cement lined,awwa c110,16"diameter,class 50 water piping	5.00 ea	460.81	2,878.50	38.39	-	-	3,377.69	16,888	6,407.44 /ea	**32,037**
33-14-13.15	Water supply distribution piping,fitting,45 degree bend,ductile iron,cement lined,mechanical joint,awwa c110,16"diameter,class 50 water piping	3.00 ea	460.81	2,449.25	38.39	-	-	2,948.44	8,845	5,589.70 /ea	**16,769**
33-14-13.15	Water supply distribution piping, fitting, reducer, ductile iron, cement lined, mechanical joint, AWWA C110, 16" x 6" diameter, class 50 water piping	3.00 ea	335.01	1,287.75	27.91	-	-	1,650.66	4,952	3,124.79 /ea	**9,374**
33-00-00.01	Utility pipe testing, nondestructive hydraulic pressure test	80.00 hr	85.34	-	37.85	-	-	123.19	9,855	229.03 /hr	**18,322**
	Ductile Iron Pipe - 16"	**1,000.00 lf**	**57.58**	**170.03**	**7.26**			**234.87**	**234,870**	**443.99 /lf**	**443,985**
33999 Fire Hydrant											
33-14-19.30	Water utility distribution fire hydrant, two way, 10'-0" depth, 5-1/4" valve, includes mechanical joints, excludes excavation and backfill	4.00 ea	670.01	4,721.75	55.81	-	-	5,447.58	21,790	10,338.32 /ea	**41,353**
	Fire Hydrant	**4.00 ea**	**670.01**	**4,721.75**	**55.81**			**5,447.58**	**21,790**	**10,338.32 /ea**	**41,353**
33999 Water Service Connections											
33-99-99.99	Water Service Connections (assumed connection every 100 feet)	10.00 ea	-	-	-	3,000.00	-	3,000.00	30,000	5,392.68 /ea	**53,927**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
	Water Service Connections	**1.00**	**ea**				**30,000.00**		**30,000.00**	**30,000**	**53,926.79**	**/ea**	**53,927**
33999 Gate Valve													
22-05-23.30	Gate Valve - 16"	5.00	ea	3,085.24	35,435.40	717.33	-	-	39,237.97	196,190	74,558.91	/ea	**372,795**
	Gate Valve	**5.00**	**ea**	**3,085.24**	**35,435.40**	**717.33**			**39,237.97**	**196,190**	**74,558.91**	**/ea**	**372,795**
	08 16" DIP Pipe	**1,000.00**	**LF**	**132.03**	**416.56**	**77.50**	**30.00**	**60.00**	**716.09**	**716,095**	**1,339.39**	**/LF**	**1,339,386**

Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
09 Trenchless - 12" Pipe											
01999 Mobilization & Demobilization											
01-99-99.99	Mob & Demob	1.00 ls	-	-	-		25,000.00	25,000.00	25,000	42,438.98 /ls	**42,439**
	Mobilization & Demobilization	**1.00 ls**					**25,000.00**	**25,000.00**	**25,000**	**42,438.98 /ls**	**42,439**
01999 Erosion and Water Pollution Control											
01-99-99.99	Erosion Control	1.00 ls	-	-	-		5,000.00	5,000.00	5,000	8,487.80 /ls	**8,488**
	Erosion and Water Pollution Control	**1.00 ls**					**5,000.00**	**5,000.00**	**5,000**	**8,487.80 /ls**	**8,488**
01999 Traffic Control											
01-99-99.99	Traffic Control	1.00 ls	-	-	-		10,000.00	10,000.00	10,000	16,975.59 /ls	**16,976**
	Traffic Control	**1.00 ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.59 /ls**	**16,976**
33999 Horizontal Directional Drilling - 12"											
33-05-07.24	Horizontal Directional Drill (HDD), HDPE pipe, midi (12" dia to 24" dia)	400.00 ft	-	-	-	350.00	-	350.00	140,000	629.15 /ft	**251,658**
	Horizontal Directional Drilling - 12"	**400.00 lf**				**350.00**		**350.00**	**140,000**	**629.15 /lf**	**251,658**
	09 Trenchless - 12" Pipe	**400.00 LF**				**350.00**	**100.00**	**450.00**	**180,000**	**798.90 /LF**	**319,561**

Phase	Description	Takeoff Quantity		Labor Cost/Unit	Material Cost/Unit	Equip Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount	Grand Total Price		Grand Total Amount
10 Trenchless - 16" Pipe													
01999 Mobilization & Demobilization													
01-99-99.99	Mob & Demob	1.00	ls	-	-	-		35,000.00	35,000.00	35,000	59,414.59	/ls	59,415
	Mobilization & Demobilization	**1.00**	**ls**					**35,000.00**	**35,000.00**	**35,000**	**59,414.59**	**/ls**	**59,415**
01999 Erosion and Water Pollution Control													
01-99-99.99	Erosion Control	1.00	ls	-	-	-		10,000.00	10,000.00	10,000	16,975.58	/ls	16,976
	Erosion and Water Pollution Control	**1.00**	**ls**					**10,000.00**	**10,000.00**	**10,000**	**16,975.58**	**/ls**	**16,976**
01999 Traffic Control													
01-99-99.99	Traffic Control	1.00	ls	-	-	-		15,000.00	15,000.00	15,000	25,463.39	/ls	25,463
	Traffic Control	**1.00**	**ls**					**15,000.00**	**15,000.00**	**15,000**	**25,463.39**	**/ls**	**25,463**
33999 Horizontal Directional Drilling - 16"													
33-05-07.24	Horizontal Directional Drill (HDD), HDPE pipe, midi (12" dia to 24" dia)	1,300.00	ft	-	-	-	400.00	-	400.00	520,000	719.02	/ft	934,731
	Horizontal Directional Drilling - 16"	**1,300.00**	**lf**				**400.00**		**400.00**	**520,000**	**719.02**	**/lf**	**934,731**
	10 Trenchless - 16" Pipe	**1,300.00**	**LF**				**400.00**	**46.15**	**446.15**	**580,000**	**797.37**	**/LF**	**1,036,585**
	01 WATER SYSTEMS OPTIMIZATION PLAN									**4,302,802**			**7,943,737**

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		7,237 hrs	729,718	
Material			1,684,428	
Subcontract			870,000	
Equipment		33,649 hrs	498,656	
Other			520,000	
			4,302,802	**4,302,802**
Labor Mark-up	15.00 %		109,458	
Material Mark-up	10.00 %		168,443	
Subcontractor Mark-up	10.00 %		87,000	
Construction Equipment Mark-up	10.00 %		49,866	
			414,767	**4,717,569**
Material Shipping & Handling	2.00 %		33,689	
Material Sales Tax	8.75 %		191,020	
Net Markups			**224,709**	**4,942,278**
Contractor General Conditions	15.00 %		741,342	
			741,342	**5,683,620**
Undesign/Undevelop Contingency	35.00 %		1,989,266	
			1,989,266	**7,672,886**
Bldg Risk, Liability Auto Ins	2.00 %		153,458	
			153,458	**7,826,344**
Payment and Performance Bonds	1.50 %		117,395	
			117,395	**7,943,739**
Escalation to Midpoint				
Gross Markups				**7,943,739**
Total				**7,943,739**