CHAPTER 1
Introduction

1.1 WATER SYSTEM MASTER PLAN PURPOSE

The purpose of this Water System Master Plan (WSMP) for the City of Dixon (City) is to identify existing water system deficiencies and required water system improvements, based on updated demand estimates and system evaluations, and to formulate a comprehensive Capital Improvement Program (CIP) which meets the needs of the City's existing and future water customers.

This WSMP was completed based on information for the City's water distribution system at the end of 2016. Updates to the system and operational changes for 2017 have not been incorporated as part of this WSMP.

1.2 WATER SYSTEM MASTER PLAN OBJECTIVES

The objectives of this WSMP are to:

- Develop operational and design criteria under which the existing system will be analyzed and future facilities will be formulated;
- Evaluate existing water demands and project future water demands;
- Analyze the existing capacity and operation of pump stations, and water storage facilities to meet existing and 2040 water demands;
- Identify potential new water storage facilities;
- Evaluate water service to new development areas;
- Evaluate the effect of operating limitations placed on wells (due to water quality issues);
- Evaluate potential new supply delivery points (e.g., wells); and
- Address the question: "What triggers the timing of construction of specific infrastructure improvements?"

1.3 AUTHORIZATION

West Yost Associates (West Yost) was authorized to prepare this WSMP by the City on March 14, 2016.

1.4 REPORT ORGANIZATION

This WSMP is organized into the following chapters:

- Chapter 1: Introduction
- Chapter 2: Existing Water System
- Chapter 3: Water Demands
- Chapter 4: Water Supply
- Chapter 5: Planning and Design Criteria

- Chapter 6: Hydraulic Model Development
- Chapter 7: Existing Water System Evaluation
- Chapter 8: Future Water System Evaluation
- Chapter 9: Strategic Asset Management Planning
- Chapter 10: Capital Improvement Program

The following appendices to this WSMP contain additional technical information, assumptions, and calculations:

- Appendix A: Dixon Hydrant Test Plan
- Appendix B: Hydraulic Model Calibration Results
- Appendix C: Asset Registry
- Appendix D: Facility Inspection Forms
- Appendix E: Cost Estimating Assumptions

1.5 ACKNOWLEDGMENTS

The development of this WSMP would not have been possible without the key involvement and assistance of City staff. In particular, the following staff provided comprehensive information, significant input and important insights throughout the WSMP development:

- Joe Leach, City Engineer/Public Works Director, City of Dixon
- Jason Riley, Senior Civil Engineer, City of Dixon
- Frank Mora, Severn Trent, Plant Manager Dixon

CHAPTER 2
Existing Water System

The purpose of this chapter is to describe the City's existing water service area and potable water system facilities. System information was obtained through the review of previous reports, maps, plans, operating records, and other available data provided to West Yost by the City.

2.1 EXISTING WATER SERVICE AREA

The City provides potable water service to portions of the City, located in the northeastern portion of Solano County approximately 20 miles west of the City of Sacramento and the Sacramento River, and 65 miles northeast of San Francisco. The City is relatively flat at an average elevation of 64 feet (ft) above mean sea level (MSL).

The City receives water service through two agencies: the City and California Water Service Company (Cal Water). The City's water service area is divided into three sub-areas: North Zone, Core Zone, and South Zone. There are no existing City-owned pipelines that connect the South Zone with the North and Core Zones. The City provides potable water to the residences and businesses within its water service area. The remaining residences and businesses within the City limits are served by Cal Water. The City's water service area and Cal Water's service area boundary is shown on Figure 2-1.

2.2 EXISTING SERVICE CONNECTIONS AND POPULATION SERVED

The purpose of this section is to describe the existing number of services and population served, as of 2015, within the City's water service area.

2.2.1 Existing Service Connections

The City's water system is currently fully metered. The City's customers have been broken down into six different revenue classes which make up its 2,727 service connections in 2015. A breakdown of the number of connections by revenue class is provided in Table 2-1. As shown in Table 2-1, approximately 93 percent of the City's connections are either single family or multi-family residential.

Table 2-1. Existing 2015 Service Connections by Revenue Class

Revenue Class	Number of Connections in 2015	Percent of Total Connections
Single Family	2,460	90.2
Multi-Family Residential	64	2.3
Commercial	86	3.2
Industrial	24	0.9
Government	5	0.2
Landscape	88	3.2
Total	2,727	100.0

Source: Data provided by City (Consumption by Address 2006-053116.xlsx) on August 5, 2016.

The City's existing land uses by location are shown on Figure 2-2.

2.2.2 Water Service Area Population

Historical populations for the City of Dixon, and the City's water service area are presented in Table 2-2. As shown in Table 2-2, the population of the City's water service area increased from 7,803 people in 2005 to 8,431 people in 2015, representing an 8 percent increase.

The direct use of traditional sources for the City's historical water service area population was not possible since the City only serves a portion of the City within the Dixon City limit boundary (as described above, Cal Water serves the remaining portion of the City). To determine the City's water service population, the U.S. Census block population data for the 2010 Census was overlaid with the City's water service area boundary. The 2010 population shown in Table 2-2 is based on the Census Block data. To estimate 2005 through 2009 and 2011 through 2015 City water service area population, the California Department of Finance (CDOF) population estimates and annual change in population for the entire City of Dixon was used. The City's water service area population was calculated assuming growth within the City's water service area was similar to population growth for the entire City of Dixon. Table 2-2 shows the population total for the City of Dixon, annual change in population, and estimated population within the City's water service area. Based on the CDOF population data, the City experienced a slight decline in population after 2010. This decline in population is most likely a result of the Great Recession. The City has seen a slow increase in population since 2010. The City's estimated average annual growth rate between 2000 and 2015 is approximately 1 percent.

Table 2-2. Historical Population Data (2005-2015) for City Water Service Area

Year	City of Dixon Total Historical Population[a,b]	City of Dixon Annual Percent Change in Total Population	City of Dixon Water Service Area Historical Population[c]
2005	17,449		7,803
2006	17,914	2.7%	8,016
2007	18,105	1.1%	8,103
2008	18,148	0.2%	8,122
2009	18,293	0.8%	8,187
2010	18,441	0.8%	8,254
2011	18,282	-0.9%	8,183
2012	18,302	0.1%	8,192
2013	18,308	0.0%	8,194
2014	18,752	2.4%	8,393
2015	18,836	0.4%	8,431

(a) CDOF, E-4 Population Estimates for Cities, Counties, and the State, 2001-2010, with 2000 and 2010 Census Counts, November 2012.

(b) CDOF, E-4 Population Estimates for Cities, Counties, and the State, 2011-2016, with 2010 Benchmark.

(c) Population for the City's water service area calculated using 2010 census block population information for the City's water service area and estimated for other years using annual population change for the City of Dixon.

2.3 EXISTING WATER SUPPLIES

The City's existing water supply relies solely on groundwater. In 2015, 580.5 million gallons (MG) of groundwater was produced in the City's water service area.

The City operates a total of five groundwater wells capable of producing nearly 12.2 million gallons of water per day (mgd). The City's groundwater wells are located in the Solano Subbasin (Subbasin 5-21.66), which is part of the Sacramento Valley Groundwater Basin as defined in the California Department of Water Resources (DWR) Bulletin 118. The Solano Subbasin is not adjudicated, and DWR has not identified Subbasin 5-21.66 as either in overdraft or expected to be in overdraft. The City's water supplies are discussed in detail in *Chapter 4 Water Supply*.

2.4 EXISTING WATER SYSTEM FACILITIES

The City's existing potable water distribution system facilities are shown on Figure 2-3. Figure 2-4 shows the City's potable water facilities based on their hydraulic grade line (HGL). The City's existing water system facilities are discussed in more detail below. The evaluation of facility capacities and their ability to meet existing and future water demands is described in *Chapter 7 Existing Water System Evaluation* and *Chapter 8 Future Water System Evaluation*, respectively.

2.4.1 Groundwater Well Facilities

Table 2-3 summarizes the City's existing groundwater wells and their capacities. As shown, the City's current total groundwater well capacity is approximately 12.2 mgd, or 8,500 gallons per minute (gpm).

Table 2-3. Existing Groundwater Well Capacity

Well No.	Facility Name	Well Capacity, gpm
North and Core Zones		
1	DW-37: Watson Ranch Well	1,500
2	DW-44: Industrial Park Well	800
3	DW-48: School Well	1,800
	North and Core Zones Subtotal	4,100
South Zone		
4	DW-52: Valley Glen Well	1,900
6	DW-54: Park Lane Well	2,500
	South Zone Subtotal	4,400
	Total	8,500

Source: City of Dixon Division of Drinking Water Supply Permit No. 02-04-14P-4810009, 2014.

The firm supply capacity for the City is calculated based on the largest well out of service. Since the City's North and Core Zones do not interconnect with the South Zone, the firm supply for each of the zone areas is calculated separately as follows:

- North and Core Zones:
  - Total well capacity is 4,100 gpm
  - Firm well capacity is 2,300 gpm (assuming the School Well is out of service)
- South Zone:
  - Total well capacity is 4,400 gpm
  - Firm well capacity is 1,900 gpm (assuming the Park Lane Well is out of service)

Groundwater well locations are shown on Figure 2-3.

2.4.2 Emergency Water Supply Interties

The City has three interties with Cal Water's Dixon District water distribution system that are used for the mutual benefit of increased supply reliability and emergency use. Therefore, these interties are closed under normal conditions. The locations of the existing interties are shown on Figure 2-3 and are described below:

- Core Zone Interties
  - Intertie #1: Located in the northeast part of the Core Zone along North First Street between Regency Parkway and Stratford Avenue (one 2-way 6-inch meter)
  - Intertie #2: Located in the southwest part of the Core Zone on Rehrmann Drive at North Lincoln Street (two 6-inch meters)
- South Zone Interties
  - Intertie #3: Located in the north central part of the South Zone on South First Street north of Valley Glen Drive (one 2-way 8-inch meter)

2.4.3 Storage Tanks

The City currently operates four water storage tanks as shown on Figure 2-3. The City has a total storage capacity of approximately 4.3 MG. While the total storage capacity reports the internal volume of the tanks, not all of that volume can be accessed for use. The usable volume of the storage tank is calculated using the depth to overflow, minus 1 foot to high water level, and minus 4 feet for dead storage at the bottom of the tank. The dead storage is the volume of water at the bottom of the tank that cannot be pumped out of the tank. The dead storage is calculated based on an assumed Net Positive Suction Head (NPSH) required to prevent damage to the pumps. Many of the City's booster pumps are closed coupled vertical in-line pumps which require the suction water level be above the pump at all times. Therefore, since the original pump curves are not available, the assumed NPSH was determined based on the pump suction pipe springline distance above the tank bottom of 2-feet and a factor of safety of 2-feet; resulting in a 4-foot minimum water level in the tanks to operate the pump safely. Consequently, dead storage level of 4 feet is assumed in this study to calculate usable storage. A summary of the existing storage tanks with their key characteristics is provided in Table 2-4.

Table 2-4. Existing Storage Tank Capacities

Facility Name	Diameter, feet	Overflow Height, feet	High Water Height, feet	Low Water Level, feet	Total Volume, MG	Usable Volume, MG
Core Zone						
Fitzgerald Drive	103	24	23	4	1.5	1.2
Watson Ranch	92	16.5	15.5	4	0.8	0.6
				Core Zone Subtotal	2.3	1.8
South Zone						
Park Lane Tank 1	80	28	27	4	1.0	0.9
Park Lane Tank 2	80	28	27	4	1.0	0.9
				South Zone Subtotal	2.0	1.8
				Total	4.3	3.6

(a) Total volume is calculated using the tank diameter and overflow height.
(b) Usable volume is calculated using the tank diameter and assuming a high water level 1-foot below overflow level and a low water level of 4-feet to account for dead storage and pump suction requirements.

2.4.4 Pump Stations

As shown on Figure 2-3, the City currently operates three booster pump stations. The City’s booster pump stations provide adequate pressure within the distribution system by transferring water from the City’s tanks to the distribution system. The City operates the pump stations based on pressure in the system. A summary of the existing pump stations with their key characteristics is provided in Table 2-5.

Table 2-5. Existing Booster Pump Station Capacities

Facility Name	Pump Number	Pump Type	Backup Power	Horsepower (hp)	Design Head, feet	Design Capacity, gpm
Core Zone						
Fitzgerald Drive	1	VFD	Yes	20	150	330
	2	VFD		50	130	1,000
	3	VFD		50	130	1,000
Watson Ranch 2	2-1	VFD	Yes	20	150	330
	2-2	VFD		20	150	330
	2-3	VFD		50	150	1,000
	2-4	VFD		50	150	1,000
South Zone						
Park Lane	1	VFD	Yes	20	150	330
	2	VFD		20	150	330
	3	VFD		50	150	1,000
	4	VFD		50	150	1,000
	5	VFD		50	150	1,000

VFD = variable frequency drive

2.4.5 Pipelines

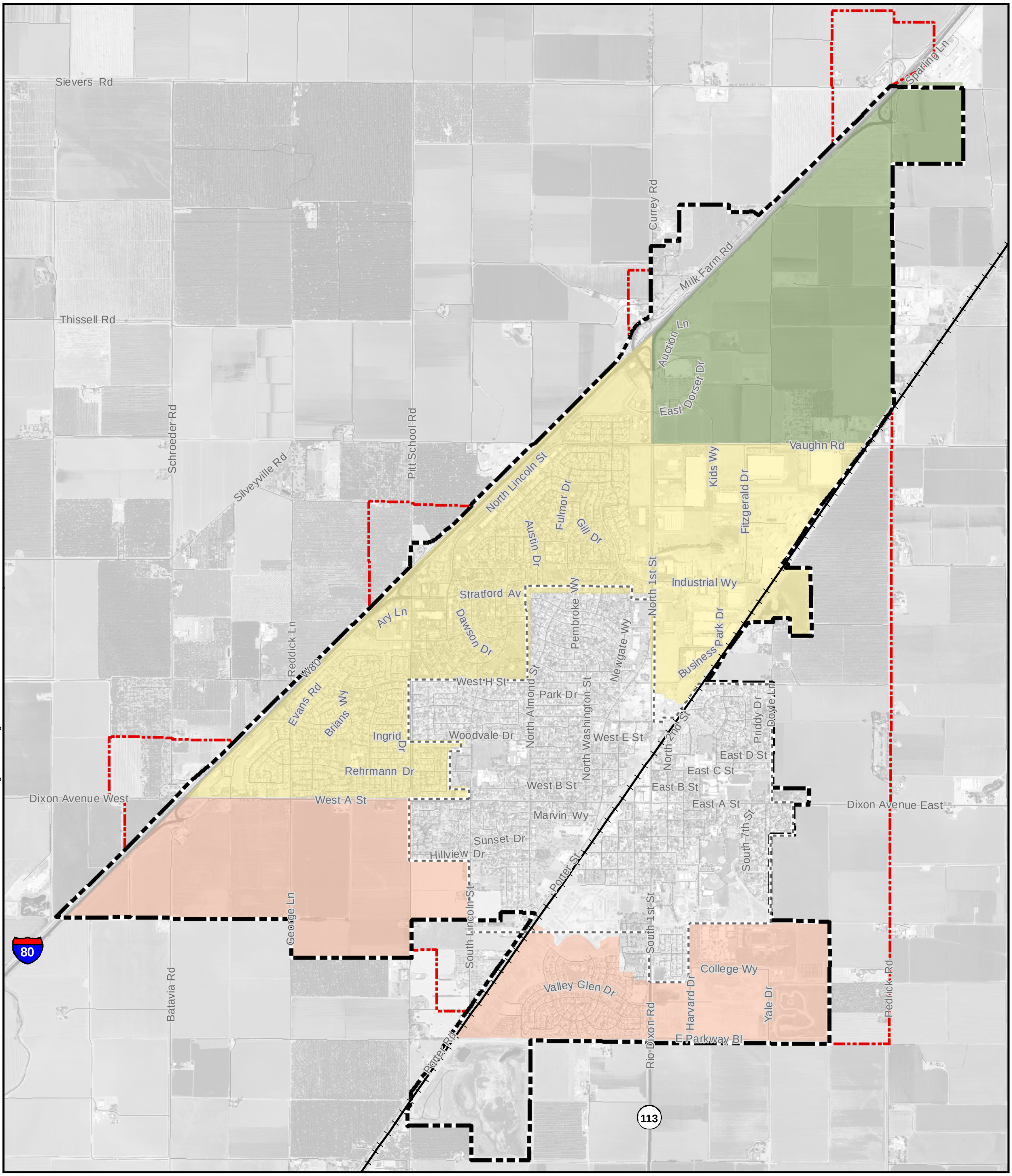
The City's water distribution network consists of approximately 40 miles (211,000 lineal feet) of pipeline ranging from 4 to 14 inches in diameter. Approximately 59 percent of the pipelines are 8-inch diameter, while another 34 percent are 12-inch diameter. Approximately 75 percent of the pipelines are constructed of polyvinylchloride (PVC). The majority of the remainder of the pipelines are constructed of asbestos cement (ACP), with some unknown materials based on the database provided. Table 2-6 summarizes the quantity of existing pipeline in the City's potable water distribution system by diameter and material type. Figure 2-3 illustrates the City's water distribution pipeline network.

Except for the interties discussed above, there are no pipeline connections between the South Zone and either the Core or North Zones.

Table 2-6. Existing Pipeline Lengths by Diameter and Material[a]

Pipeline Diameter	Material	Length of Pipeline, feet
4-inch	ACP	56
	Total 4-inch	56
6-inch	PVC	1,245
	ACP	1,510
	Unknown	82
	Total 6-inch	2,837
8-inch	PVC	97,870
	ACP	21,948
	Unknown	4,332
	Total 8-inch	124,150
10-inch	PVC	5,997
	ACP	4,902
	Unknown	129
	Total 10-inch	11,028
12-inch	PVC	53,984
	ACP	2,064
	Unknown	15,451
	Total 12-inch	71,499
14-inch	Unknown	1,686
	Total 14-inch	1,686
	Pipeline Total	211,256

[a] Pipeline information obtained from City GIS file developed from the City's AutoCAD system maps.



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Symbology

- Union Pacific Railroad
- Dixon City Limits
- Dixon Sphere of Influence
- Cal Water Service Area

City Water Service Area

- Core Zone
- North Zone
- South Zone

N

0 1,500 3,000

Scale in Feet

Figure 2-1

Dixon Water Service Area

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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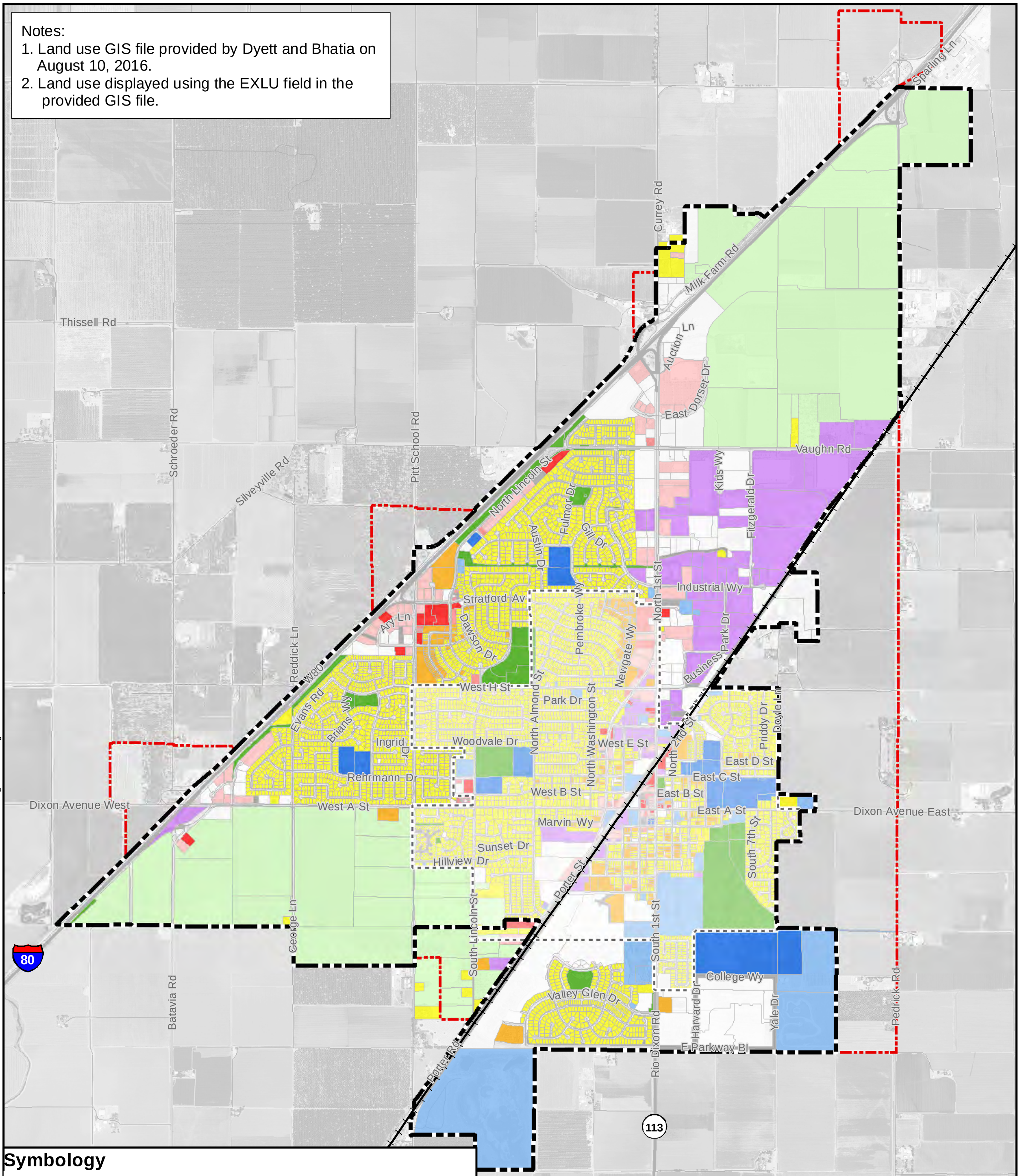
Notes:
1. Land use GIS file provided by Dyett and Bhatia on August 10, 2016.
2. Land use displayed using the EXLU field in the provided GIS file.



Symbology

- Low Density Residential
- Medium Density Residential
- Commercial Services
- Office
- Mixed Use
- Government/Institutional
- Dixon City Limits
- Cal Water Service Area
- School Buildings
- General Industrial
- Parks
- Agricultural
- Right-of-Way
- Vacant
- Dixon Sphere of Influence

N

0 1,500 3,000
Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-2

Dixon Existing Land Use

City of Dixon
Water System Master Plan and Hydraulic Model Update

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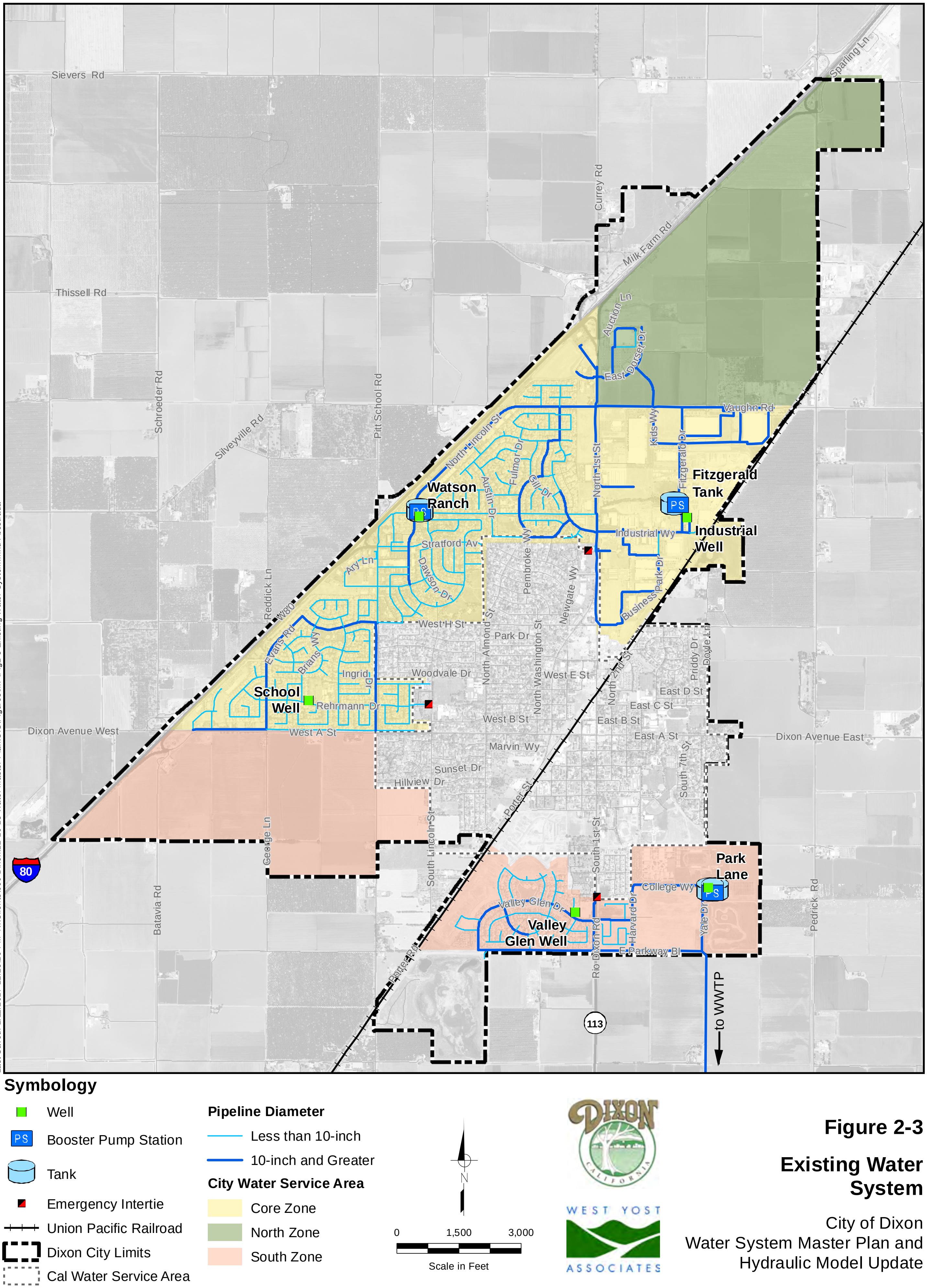

Figure 2-3

Existing Water System

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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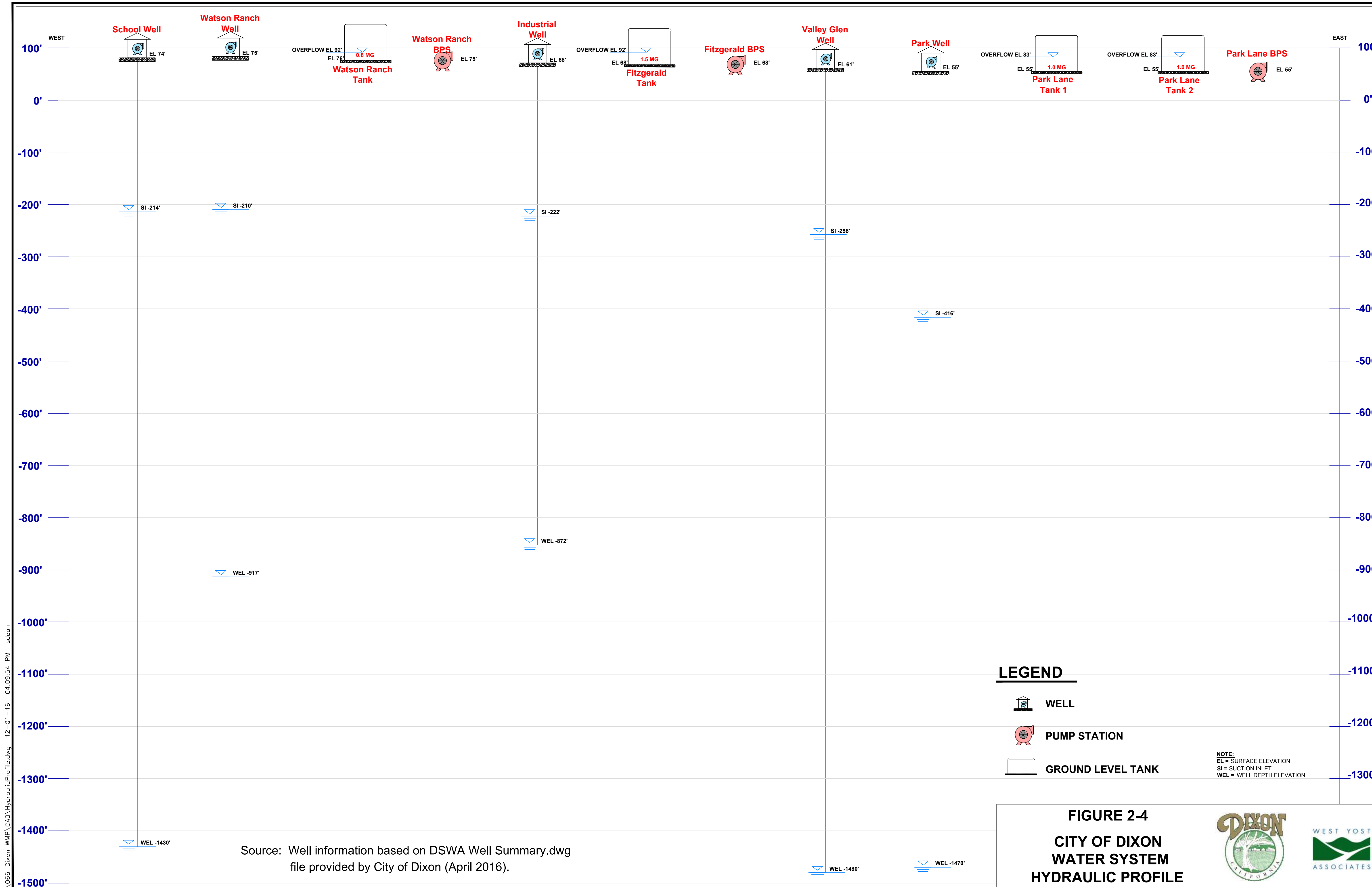

Source: Well information based on DSWA Well Summary.dwg file provided by City of Dixon (April 2016).

FIGURE 2-4

CITY OF DIXON WATER SYSTEM HYDRAULIC PROFILE

DIXON CALIFORNIA

WEST YOST ASSOCIATES

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CHAPTER 3
Water Demands

The purpose of this chapter is to present the current and projected potable water demands served by the City within its service area. Accurate and detailed potable water demand estimates are required to develop and calibrate the potable water system hydraulic model, help identify deficiencies in the existing potable water system, and assist in the assessment of future system capacity and future CIPs based on planned development. Future water demand projections also play a key role in helping the City identify and secure sufficient water supplies to serve their customers under various hydrologic conditions.

3.1 PREVIOUS WATER MASTER PLAN

The City's last Water Master Plan was completed in 2000. The Master Plan for the Water Supply and Delivery System Through Buildout (Summers Engineering, January 2000) (2000 Master Plan) looked at the infrastructure requirements based on the 1993 General Plan. The 2000 Master Plan excluded some areas shown in the 1993 General Plan as they were estimated to occur beyond the 2010 planning horizon. The areas not included were composed of the area east of the existing City limit boundary and in the existing Sphere of Influence (SOI), a supplemental study area of the Southwest Dixon Specific Plan, and the area northwest of Interstate 80. The 2000 Master Plan calculated the maximum day demand to be 8,462 gpm.

The recommendations from the 2000 Master Plan were reviewed. The City has constructed the recommended South Park (Valley Glen) Well and the Fitzgerald Tank. The City has also constructed the Park Lane Well and storage tanks which were not included in the 2000 Master Plan recommendations.

3.2 WATER SERVICE AREA CHARACTERISTICS

The City tracks the number of services within its water service area using multiple revenue classes in its billing. For this WSMP, the billing classes have been consolidated into six water use classes: Single Family Residential, Multi-Family Residential, Commercial, Industrial, Government, and Landscape. The Single Family Residential class usually designates a service typically served by an individual meter and an individual account, while the Multi-Family Residential class usually designates an individual meter with more than one account (e.g., duplex, triplex, 4-plex, and apartment complex).

The Commercial and Industrial classes designate typical commercial and industrial uses, such as a retail store for commercial or a manufacturing company for industrial. The Government class includes all uses operated by a governing body (e.g., Fire Station) and Landscaping has its own designation.

Table 3-1 summarizes the historical number of service connections within the City's water service area by water use type between years 2008 and 2015. The City experienced relatively low growth throughout the 8-year span with a typical annual increase in number of service connections of approximately 2 percent. Single Family Residential experienced the greatest growth in 2013 with a 6 percent increase in connections.

Table 3-1. Historical Service Connections by Water Use Type

Water Use Type	2008	2009	2010	2011	2012	2013	2014	2015
Single Family	2,102	2,141	2,174	2,217	2,267	2,405	2,443	2,460
Multi-Family[(a)]	50	51	53	55	56	61	63	64
Commercial[(b)]	70	76	80	81	81	84	86	86
Industrial	20	20	20	21	21	23	24	24
Government[(c)]	3	3	3	5	5	5	5	5
Landscape	83	84	85	86	86	88	88	88
Total	2,328	2,375	2,415	2,465	2,516	2,666	2,709	2,727

(a) Multi-family water use type includes billing classes of duplex, triplex, 4-plex, and apartment complex.
(b) Commercial water use type includes billing classes of commercial, and church.
(c) Government water use type includes billing classes of fire station and school.

3.2.1 Historical Population

As described in Chapter 2, the City's water service area includes only a portion of the population within the City's limits. Therefore, the use of traditional sources of the City's historical population data was not possible to determine the existing population served water by the City. Consequently, the population served by the City was estimated using United States Census data for Census blocks located within the City's water service area and annual citywide population growth estimates (see Section 2.2.2 Water Service Area Population and Table 2-2 in Chapter 2).

The CDOF estimates historical housing densities and population for the area within the City's limits. The overall citywide population includes the area outside of the City's water service area which includes Cal Water's Dixon District. The City serves approximately half of the developed parcels within the City and therefore, the CDOF estimates provide a good approximation of changes in housing densities and population within the City's water service area over time. Historical housing densities from 2000 to 2015 were downloaded from the CDOF website[1], and plotted on Figure 3-1. These historical housing densities were developed for the entire area within the City limits. For this WSMP, it is assumed the City's water service area housing density is consistent with the overall citywide calculated housing density.

The historical population for the City's water service area was estimated using 2010 Census block population information and adjusted annually based on the citywide annual population growth percentages. As shown on Figure 3-2, the estimated population served by the City has increased, at a relatively stable growth rate, with a 17 percent increase between 2000 and 2015, or about 1 percent per year.

[1] Historical housing densities for the City of Dixon were downloaded from the CDOF Reports E-5 and E-8 on August 24, 2016. These housing densities do not include the population in Group Quarters.

3.2.2 Existing and Projected Future Land Use

West Yost obtained the 1993 City of Dixon General Plan and 2008 City of Dixon General Plan Update from the City's website. The General Plan Update provides a summary of the issues that will be addressed in an updated General Plan, currently being prepared. The General Plan Update designates buildout land uses and includes amendments that have been made through April 27, 2010. The amendments were included in this WSMP so that future demand and supply projections would reflect the most current data available. Figure 3-3 illustrates designated land uses contained in the 1993 General Plan and within the City's SOI.

West Yost received Geographic Information System (GIS) files from the City's General Plan consultant (Dyett & Bhatia) which contain existing land use information and the 1993 General Plan land use. The existing land use provides detailed information on parcel usage including vacant and agricultural land use. The agricultural land within the City's water service area does not receive water from the City. The existing land use map for the City's water service area is presented on Figure 2-2. The total acreages for existing land use designation for the parcels within the City's water service area in 2015 are summarized in Table 3-2. The land uses are also grouped into water use type categories.

Table 3-2. Existing Land Use and Water Use Type[a,b]

Water Use Type	Existing Land Use Designation	Total Acreage[a]
Single Family Residential	Single Family Residential	578
Multi-Family Residential	Multi-Family Residential	40
	Two Family Residential	7
Commercial	General Commercial	70
	Service Commercial	38
	Commercial Mixed Use	8
	Hotel	6
	Office	2
	Church/Religious Facilities	32
Industrial	General Industrial/Warehousing	256
Government/Public	Public	140
	School	51
	Utilities	2
Landscape	Greenway/Track	11
	Parks & Recreation	27
None	Agricultural	1,063
	Open Space	13
	Parking	7
	Right of Way	10
	Vacant	231
	Total	2,592

(a) Developed land use within the City's water service area based on GIS data file GP_Alts_111616.
(b) Includes land uses not defined previously in Table 3-1.

Existing land use served water was estimated by spatially locating water meter locations by linking the data to individual parcels using an address. Several parcels within the City's water service area have multiple meters. These parcels typically have separate connections for domestic and landscape irrigation needs. For parcels with multiple meters that include a landscape water use type, the area of a parcel that is irrigated was estimated to be approximately 10 percent of the total parcel area.

For planning purposes in this WSMP, it was assumed that any parcel currently receiving water from the City was classified as developed from a water supply planning perspective (i.e., currently using water). The City will provide water to areas located within the City's existing water service area, as well as the future developments within the City's SOI. The City's General Plan breaks the City into seven development areas as shown in Figure 3-4. Table 3-3 summarizes existing and projected land use within the seven development areas within the City's water service area.

Table 3-3. City's Water Service Area Future Land Use by Growth Area[a], Ac

Water Use Type	General Plan Land Use[b]	Existing	Downtown	SR-113	South	Northeast		East		North of I-80		Total
						Existing City Limits	SOI	Existing City Limits	SOI	Existing City Limits	SOI	
Single Family Residential	Future Residential								579			579
	Low Density Residential	343		6	383			32				764
Multi-Family Residential	High Density Residential				5							5
	Medium Density (High) Residential	82			5							87
	Medium Density (Low) Residential	35			131							166
Industrial	Planned Business/Industrial	116		140					80			336
Commercial	Commercial Services	9	7	92								108
	Community Commercial				127							127
	Employment Center				61	589						650
	Highway Commercial	13			0.4	2	71			11	225	322.4
	Highway Commercial/Prof/Admin Offices	65										65
	Neighborhood Commercial	6		6	6							18
	Professional/Administrative Offices	4										4
Government	Governmental/Institutional			2	138			31				171
	School Buildings/Play Areas	10			41							51
Landscape	Buffers	10										10
	Parks	25			7							32
None	Agricultural									51		51
	Total	718	7	246	904.4	591	71	63	659.3	62	225	3546.7

[a] Growth areas based on regional areas within the existing City limit boundaries and adopted sphere of influence locations.

[b] Land use based on 1993 General Plan designations. The City is in the process of updating its General Plan. However, information was not available on the proposed land uses at the time of the WSMP preparation.

3.3 HISTORICAL WATER CONSUMPTION

Water production is the combined quantity of water produced by the City's groundwater wells, while water consumption is the quantity of water actually consumed or used by its customers. As will be discussed later, the difference between production and consumption is unaccounted-for water (UAFW).

The City currently tracks all of the water produced by its wells and meters all of its customers within the City's water service area. Consequently, the City tracks water use in two ways: production records and meter (consumption) records. Both are discussed in more detail below, along with a discussion on UAFW.

The City meets its customer's water demands within the City's water service area with groundwater pumped from its own groundwater wells; the City does not have an existing surface water supply used to meet potable water demands. Table 3-4 presents the City's historical water production from 2005 to 2015.

Table 3-4. Historical Annual Water Production[(a)]

Year	Groundwater, AF	Groundwater, MG
2005	2,294	748
2006	2,275	741
2007	2,640	860
2008	2,599	847
2009	2,458	801
2010	2,168	707
2011	2,129	694
2012	2,239	730
2013	2,384	777
2014	1,772	578
2015	1,781	581
10-Year Average[(b)]	2,245	731
5-Year Average[(c)]	2,061	672

(a) Data provided by the City.
(b) 10-Year Average: 2006-2015.
(c) 5-Year Average: 2011-2015.
AF = Acre-feet

As shown in Table 3-4, groundwater production plateaued around 2007 and began to decrease, leading to a 32 percent decrease in 2015 from the 2007 level. This is likely due to several factors including the City's successful water conservation efforts implemented by the City in response to the on-going drought.

Figure 3-5 compares total historical water production and historical annual rainfall. As shown in Figure 3-5, the City's water demands increased sharply between 2005 and 2007 which was the peak production year. From 2007 to present, water production showed a steady decrease which correlates to the Great Recession. In addition, between 2013 and 2014 the water production showed a steep decrease of approximately 25 percent. This drop in production correlates to the on-going drought.

3.3.1 Metered Water Consumption

Historical water consumed between 2008 and 2015, within each of the City's water use types, is summarized in Table 3-5.

A review of the data from 2008 to 2015 indicates that the continued drought in California is having significant impacts on the amount of water consumed by City customers. The City has seen a strong response from its customers on the request to conserve water during the drought. The City has had a decrease in water consumption since 2013 with a significant decrease in 2014 and 2015 from previous years.

3.3.2 Unaccounted for Water

UAFW or non-revenue water is the difference between the quantity of water produced and the quantity of water consumed by customers, which is measured at customer meters. Most water systems experience a difference of about 5 to 10 percent which American Water Works Association (AWWA) considers to be within acceptable limits.

UAFW typically includes water used for incidental purposes such as fire hydrant testing and flushing, storage tank drainage and maintenance. UAFW also includes unintended uses or sources of error such as leaks in pipelines, breaks in main lines, inaccurate meters, unauthorized use, and unmetered services, which can vary widely and are difficult to pinpoint.

For planning purposes in this WSMP, the City's UAFW is calculated to be 14 percent which is based on the 8-year average of production and consumption information provided. The 14 percent UAFW is considered a high UAFW percentage by AWWA. However, the high UAFW for the City is not unexpected. The City's overall demands are small and any hydrant testing, flushing or tank maintenance would have a significant impact to the overall percentage of UAFW.

Table 3-5. Historical Water Consumption by Water Use Type, AF

Year	Single Family Residential	Multi-Family Residential	Commercial	Industrial	Government	Landscape	Sales	Total Consumption[a]	Production[b]	UAFW	Total % of UAFW
2008	1,322	105	241	123	9	578		2,378	2,599	221	9%
2009	1,179	104	196	112	10	427		2,029	2,458	429	17%
2010	1,053	100	175	141	10	375		1,853	2,168	315	15%
2011	1,013	110	168	135	5	367		1,798	2,129	331	16%
2012	1,089	97	174	136	7	458		1,960	2,239	278	12%
2013	1,110	95	169	136	7	477		1,994	2,384	391	16%
2014[c]	1,023	104	156	172	30	405		1,890	1,772	(118)	-7%
2015	773	68	146	157	7	351		1,502	1,781	280	16%

[a] Information on consumption based on billing records provided by the City for 2008 through 2015.

[b] Information on production provided by the City.

[c] Information for 2014 meter consumption has potential meter errors that could not be verified which results in an overestimation of demand.

3.4 UNIT WATER DEMAND FACTORS

Water demands were projected through buildout of the City's water service area using a unit demand methodology based on land uses in the General Plan. A land use based methodology was used instead of a per capita demand methodology because per capita water demand projections uniformly distribute water use over the entire water service area and therefore, do not account for specific land uses and associated water demands in specific locations.

Subsequent sections describe the land use based methodology used, followed by a discussion of total projected water demands.

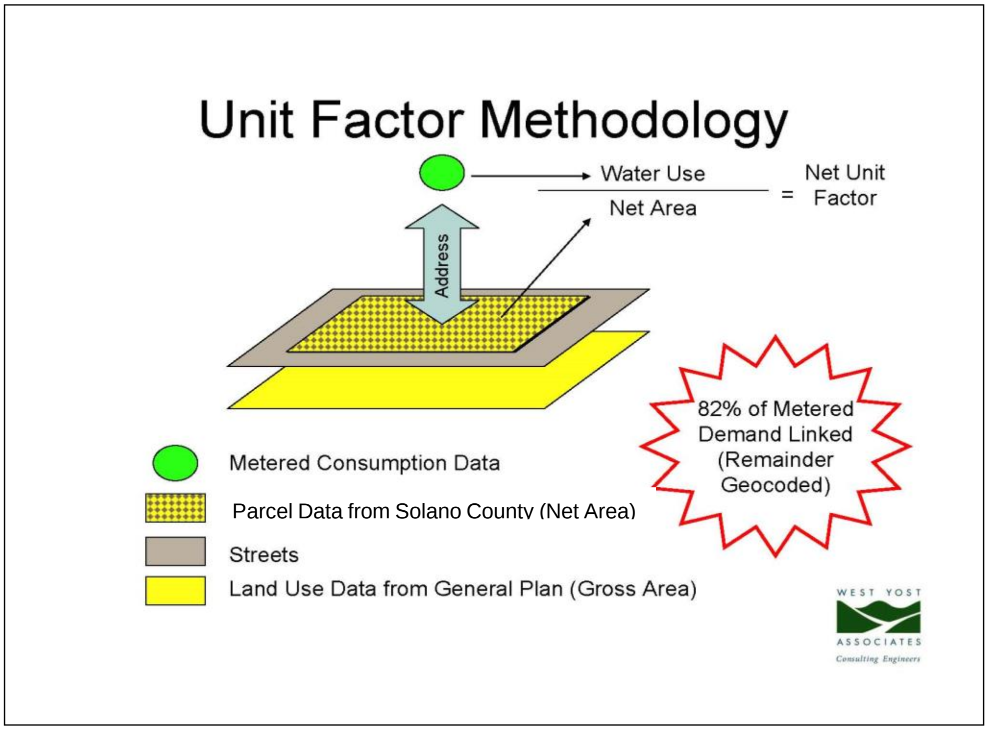
3.4.1 Development of Unit Water Demand Factors

Unit demand factors from 2008 to 2015 were determined using meter data obtained from the City, parcel data obtained from Solano County, and land use data obtained from the City's General Plan consultant. Individual water use (by meter) was linked to individual parcels using addresses (see green dot on Figure 3-6); 96 percent of all available water meter data was linked to a parcel. The remaining 4 percent that did not link directly with a parcel address (usually due to street name nomenclature being different between the meter data and the parcel data), were moved spatially to their parcel address. Only 5 meter points (0.18 percent) were not linked and not located spatially. Ultimately, 99.8 percent of metered demands were allocated in the hydraulic model (see Chapter 6 for further discussion).

The unit demand factor for each land use designation was calculated by dividing the total water use by the total parcel area for which it was linked; however, the parcel area used in this initial calculation did not include streets (see grey area on Figure 3-6) and therefore, represented net area. Accordingly, the unit demand factors calculated were net unit demand factors.

The net unit demand factors were used to project future demands by multiplying the appropriate net unit demand factor by the future acreage. However, acreage for future developments is gross area and therefore, includes the streets. Typically, the net unit demand factor would not be used to calculate demands for gross areas. However, to be consistent with the use of the same unit demand factor for existing and future developments and to provide additional conservatism for planning level purposes in this water system, the net unit demands factors were used to project future demands.

Figure 3-6. Illustration of Unit Demand Factor Methodology



Subsequent sections present the calculated unit demand factors for each land use designation.

3.4.2 Single Family Residential Unit Water Demand Factor

The single family residential water use type represents, per the 1993 General Plan, one housing unit in a site ranging from 7,000 to 19,999 square feet. This land use designation accounts for a majority of the services in the City's water service area.

Figure 3-7 illustrates the calculated single family residential unit demand factor between 2008 and 2015 for the City's water service area. As shown in Figure 3-7, the demand factor has seen a significant decrease between 2013 and 2015 which is attributed to the mandatory conservation imposed due to the prolonged severe drought.

For planning purposes, it was assumed that all future single family development would use the average unit demand factor of 2.7 acre-feet per acre per year (ac-ft/ac/yr).

3.4.3 Multi-Family Residential Unit Water Demand Factor

The multi-family residential water use type represents, per the 1993 General Plan, medium low and medium high density land use with one housing unit in a site ranging from 2,000 to 6,999 square feet.

Figure 3-8 illustrates the calculated multi-family residential unit demand factor between 2008 and 2015 for the City's water service area. As shown in Figure 3-8, the demand factor has been fairly constant but shows a significant decrease in 2015 which is attributed to the mandatory conservation imposed due to the prolonged severe drought.

For planning purposes, it was assumed that all future multi-family development would use the average unit demand factor of 3.9 ac-ft/ac/yr.

3.4.4 Commercial Unit Water Demand Factor

The commercial water use type represents, per the 1993 General Plan, multiple categories which include establishments that cater from light to heavy commercial use and professional services.

Figure 3-9 illustrates the calculated commercial unit demand factor between 2008 and 2015 for the City's water service area. As shown in Figure 3-9, the demand factor has been fairly constant but shows a decreasing pattern between 2013 and 2015 which is attributed to the mandatory conservation imposed due to the prolonged severe drought.

For planning purposes, it was assumed that all future commercial development would use the average unit demand factor of 1.3 ac-ft/ac/yr.

3.4.5 Industrial Unit Water Demand Factor

The industrial water use type represents, per the 1993 General Plan, a mix of light and heavy industrial uses such as manufacturing, research institutions, and administrative facilities.

Figure 3-10 illustrates the calculated industrial unit demand factor between 2008 and 2015 for the City's water service area. As shown in Figure 3-10, the demand factor has been fairly constant for the industrial use category with only a slight decrease in 2015 due to the recent drought.

For planning purposes, it was assumed that all future industrial development would use the average unit demand factor of 1.5 ac-ft/ac/yr.

3.4.6 Government Unit Water Demand Factor

The government water use type represents, per the 1993 General Plan, property owned and operated by the City, County, State and Federal agencies, special districts, and public utilities.

Figure 3-11 illustrates the calculated government unit demand factor between 2008 and 2015 for the City's water service area. As shown in Figure 3-11, the demand factor has been fairly constant for the government use category with one spike in 2014. The City includes schools in the government water use type which typically have large irrigation needs. However, the City has separate landscape accounts for the schools which has minimized the impact of the drought on the government water use category.

For planning purposes, it was assumed that all future government development would use the average unit demand factor of 0.3 ac-ft/ac/yr.

3.4.7 Landscape Unit Water Demand Factor

The landscape water use type represents, per the 1993 General Plan, property that is irrigated and includes parks and median landscaping, as well as parcels which have a separate meter for landscape areas such as schools.

Figure 3-12 illustrates the calculated landscape unit demand factor between 2008 and 2015 for the City's water service area. As shown in Figure 3-12, the demand factor has varied over time. However, the use shows a decreasing pattern between 2013 and 2015 which is attributed to the mandatory conservation imposed due to the prolonged severe drought.

For planning purposes, it was assumed that all future landscape development would use the average unit demand factor of 3.0 ac-ft/ac/yr.

3.4.8 Recommended Unit Water Demand Factors

Table 3-6 summarizes the unit water demand factors recommended in this WSMP for projecting future water demands. These unit demand factors are based on 99.8 percent of the meter data from 2008 to 2015 for the City's water service area. The average factor over this time period was increased by 5 percent to account for potential demand "bounce back" after the prolonged drought.

Table 3-6. Recommended Unit Water Demand Factors

Water Use Type	Unit Water Demand Factor[a], af/ac/yr
Single Family Residential	2.7
Multi-Family Residential	3.9
Commercial	1.3
Industrial	1.5
Government	0.3
Landscape	3.0

[a] Unit demand factors based on 2008-2015 average usage which was increased by 5 percent to adjust for recent decreased usage due to increased conservation from the on-going drought.

3.4.9 Peaking Factors

Water system facilities are generally sized to meet peak water demand periods. The peaking conditions of most concern for water facility sizing are maximum day demand with fire flow and peak hour demand. Peak water use is typically expressed as a ratio, or peaking factor, dividing the peak water use by the annual average day demand. Data from recent years (2010 to 2014) was evaluated to be representative of recent water use trends. Data from 2015 was excluded as the demand patterns seen for this year were greatly impacted by increased conservation due to the drought.

Table 3-7 summarizes the City's maximum day demand between 2010 and 2013 and includes the calculated maximum day peaking factors. The maximum day peaking factor ranged from 2.6 to 2.0, with an average of 2.2. The recommended average day to maximum day demand peaking factor is 2.2.

Table 3-7. Summary of Maximum Day Peaking Factors

Year	Maximum Day	Maximum Day Water Demand, mgd[a]	Average Day Demand, mgd	Average Day to Maximum Day Peaking Factor
2010	July 25	4.0	1.9	2.1
2011	July 21	4.9	1.9	2.6
2012	June 11	3.9	2.0	2.0
2013	July 7	4.1	2.1	2.0
			Average Maximum Day Peaking Factor	2.2

[a] Data calculated based on information from the City's Water Permit No. 02-04-14-P-481009.

Insufficient data was available to determine a historical peak hour demand factor. Therefore, the Title 22, Chapter 16 requirement for calculating a peak hour demand was used. A minimum of 1.5 times the maximum day demand is the recommended minimum peak hour demand factor. Therefore, the recommended average day to peak hour demand peaking factor is 3.3 (1.5 times the 2.2 maximum day peaking factor).

Table 3-8 shows the recommended demand peaking factors to use with future demand projections.

Table 3-8. Recommended Maximum Day and Peak Hour Demand Peaking Factors

Type of Factor	Recommended Factor
Average Day to Maximum Day Demand	2.2
Average Day Demand to Peak Hour Demand[a]	3.3

[a] The average day demand to peak hour demand meets the minimum Title 22 requirement of a maximum day demand to peak hour 1.5 peaking factor.

3.5 PROJECTED WATER DEMAND

Total projected water demands at buildout for the City's water service area were calculated by multiplying the recommended unit demand factors (see Table 3-6) by the projected developed acreage from the City's 1993 General Plan. The resulting demand projections include adjustments for UAFW and resulted in a projected buildout water demand of 7,994 acre-feet per year (ac-ft/yr) as shown in Table 3-9. The demands in Table 3-9 are developed based on the proposed land uses as designated by development areas defined in the General Plan. The existing development area in Table 3-9 does not represent the actual existing water use demands.

Table 3-9. City's Water Service Area Projected Demand by Development Area, ac-ft/yr

Water Use Type	General Plan Land Use[a]	Existing Development Area[b]	Downtown	SR-113	South	Northeast		East		North of I-80		Total
						Existing City Limits	SOI	Existing City Limits	SOI	Existing City Limits	SOI	
Single Family Residential	Future Residential	0	0	0	0	0	0	0	1,564	0	0	3,627
	Low Density Residential	926	0	16	1,034	0	0	86	0	0	0	
Multi-Family Residential	High Density Residential	0	0	0	20	0	0	0	0	0	0	1,006
	Medium Density (High) Residential	320	0	0	20	0	0	0	0	0	0	
	Medium Density (Low) Residential	137	0	0	511	0	0	0	0	0	0	
Industrial	Planned Business/Industrial	174	0	210	0	0	0	0	120	0	0	504
Commercial	Commercial Services	12	9	120	0	0	0	0	0	0	0	1,683
	Community Commercial	0	0	0	165	0	0	0	0	0	0	
	Employment Center	0	0	0	79	766	0	0	0	0	0	
	Highway Commercial	17	0	0	1	3	92	0	0	14	293	
	Highway Commercial/Prof/Admin C	85	0	0	0	0	0	0	0	0	0	
	Neighborhood Commercial	8	0	8	8	0	0	0	0	0	0	
	Professional/Administrative Offices	5	0	0	0	0	0	0	0	0	0	
Government	Governmental/Institutional	0	0	1	41	0	0	9	0	0	0	67
	School Buildings/Play Areas	3	0	0	12	0	0	0	0	0	0	
Landscape	Buffers	30	0	0	0	0	0	0	0	0	0	126
	Parks	75	0	0	21	0	0	0	0	0	0	
None	Agricultural											0
UAFW	14% of total demand	251	1	50	268	108	13	13	236	2	41	982
	Total	2,041	10	404	2,179	876	105	109	1,920	16	333	7,995

[a] Land use based on 1993 General Plan designations. The City is in the process of updating its General Plan. However, information was not available on the proposed land uses at the time of the WSMP preparation.

[b] Growth areas based on regional areas within the existing City limit boundaries and adopted sphere of influence locations and shown in Figure 3-4. The Existing Development Area represents a portion of the existing City water service area and includes development of vacant and underutilized parcels.

Currently, two specific plan projects are in the planning stages for the City: Northeast Quadrant and Southwest Dixon Specific Plan. For this WSMP, these specific plans are assumed to be developed in the near-term (by 2030). The Northeast Quadrant Specific Plan is located in the Northeast development area and contains approximately 660 acres of commercial development. The Southwest Dixon Specific Plan is located in the South development area and contains approximately 434 acres of a mix of commercial and residential development. Table 3-10 shows the phased demands of the City's water service area.

Table 3-10. City Water Service Area Phased Demands, ac-ft/yr

		Near-Term (by 2030)			2050	
Water Use Type	Existing Demands[a]	Existing Water Service Area Development	Northeast Quadrant SP	Southwest Dixon SP	SOI	Total
Single Family Residential	1,024	427		612	1,564	3,627
Multi-Family Residential	104	827		75		1,006
Industrial	172	212			120	504
Commercial	156	223	768	244	292	1,683
Government	30	37				67
Landscape	105	21				126
UAFW	223	245	108	130	277	982
Total	1,814	1,992	876	1,061	2,253	7,995

(a) Existing demands based on actual billed 2014 demands due to the drought impacts to 2015 demands.

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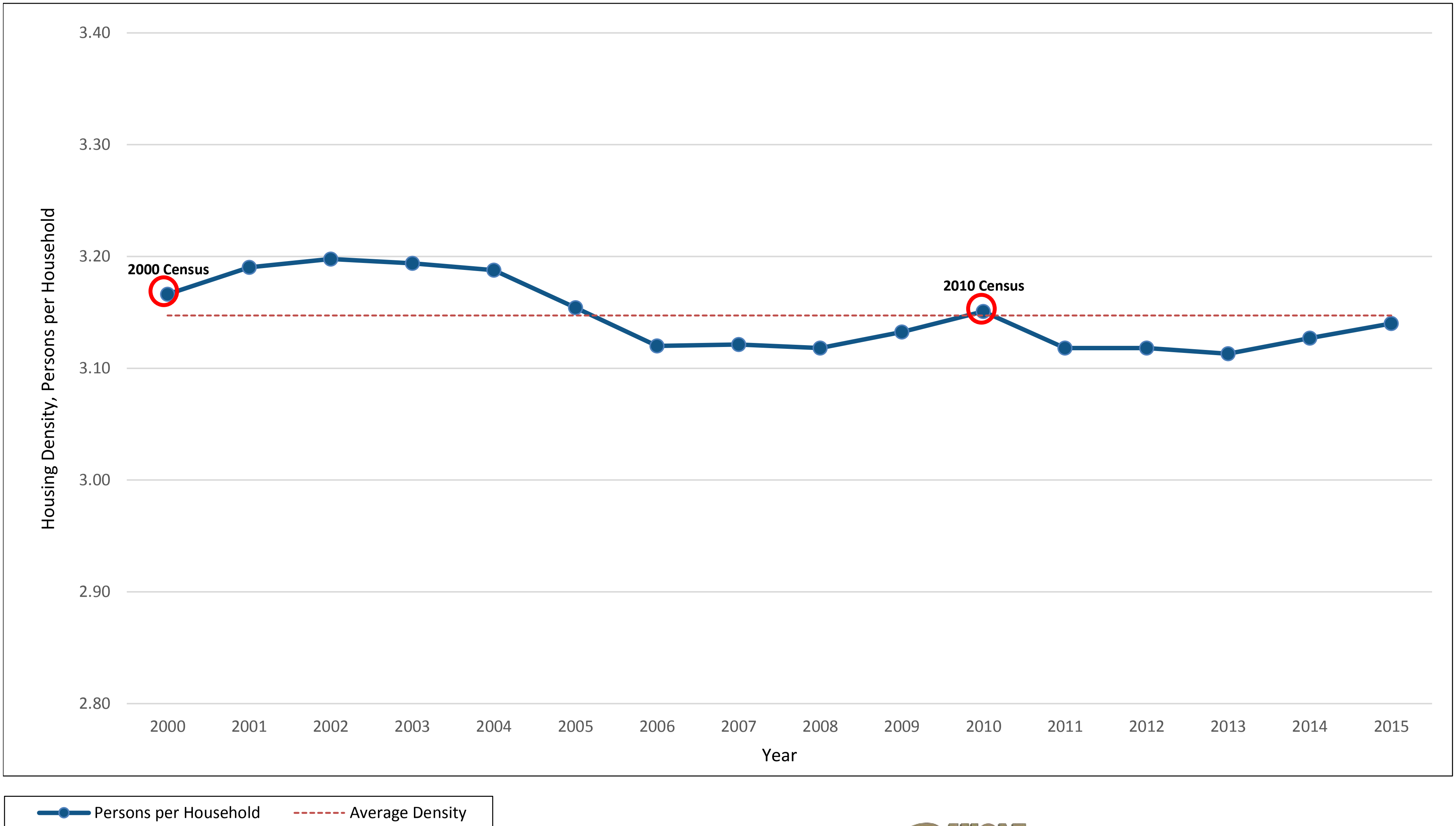

Notes:

1. Historical housing densities downloaded from the California Department of Finance reports (E-5 and E-8) on 08/24/2016.
2. Historical housing densities represent the entire City of Dixon and not only the City's water service area.

Figure 3-1

Historical Housing Density

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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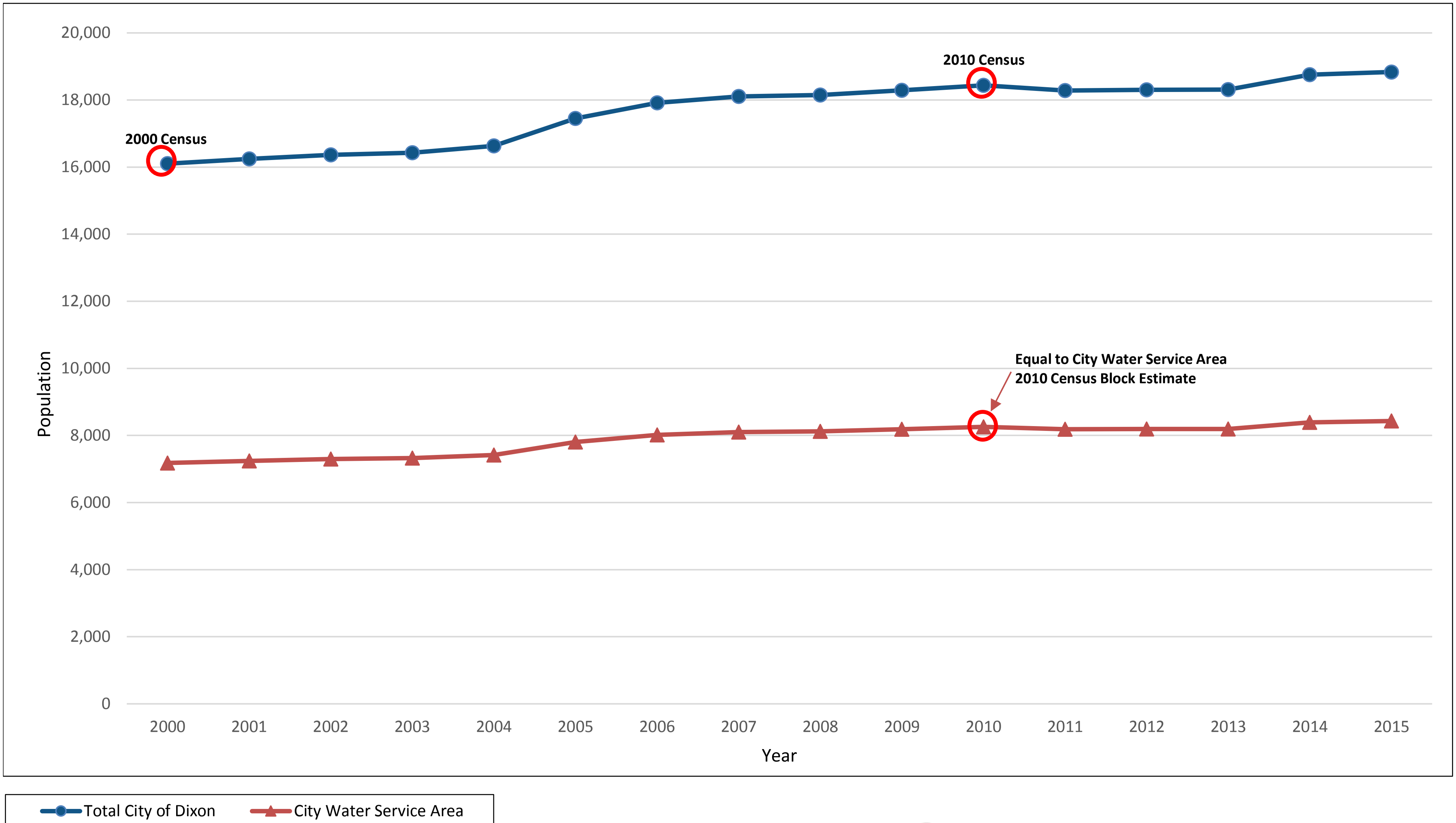

Notes:

1. Historical City population downloaded from the California Department of Finance reports (E-5 and E-8) on 08/24/2016.
2. Historical City water service area population estimate calculated using 2010 Census block population within the City's water service area and annual growth for the entire City.

Figure 3-2

Historical Population Served

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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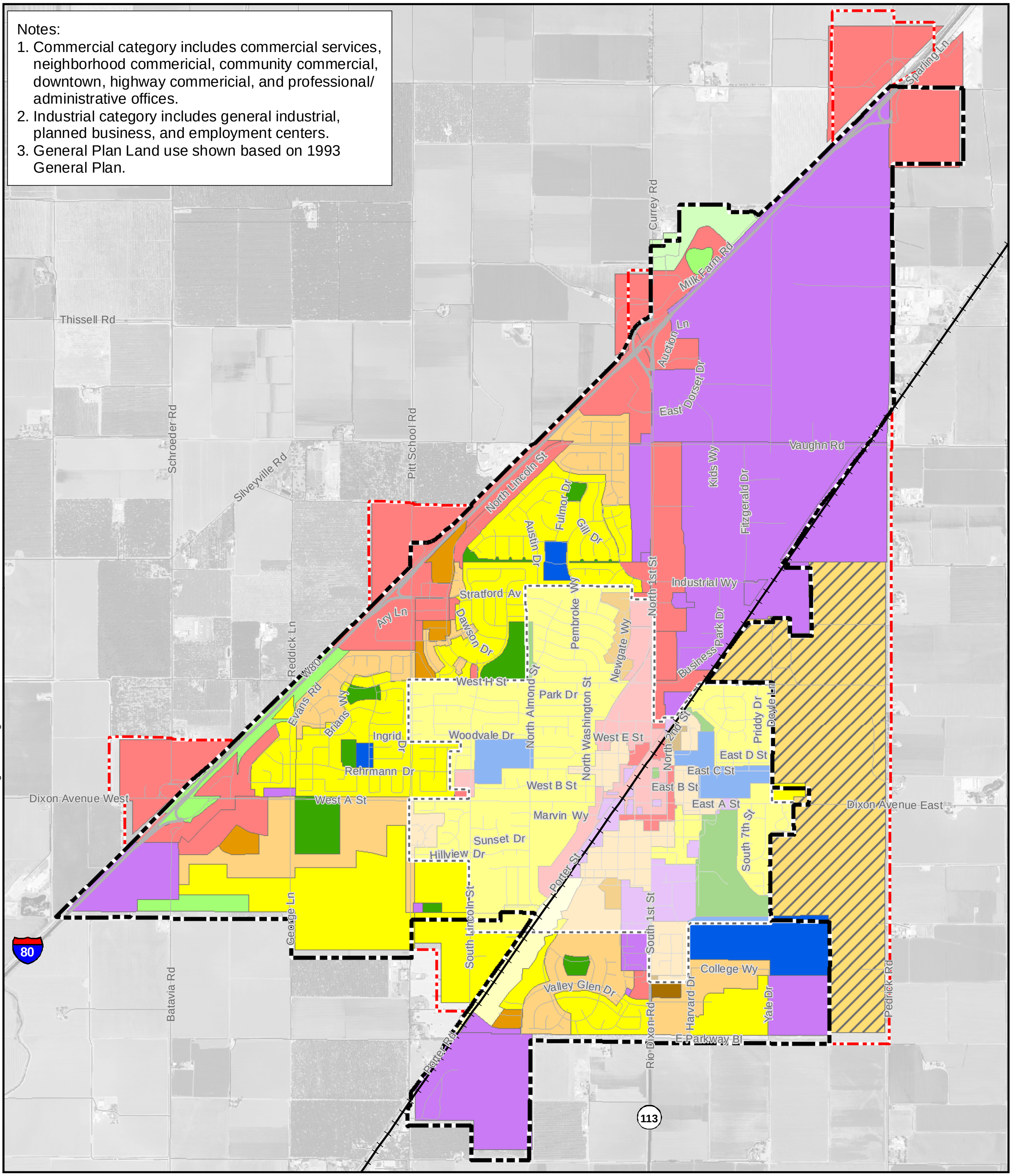

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Symbology

- Very Low Density Residential
- Low Density Residential
- Medium Low Density Residential
- Medium High Density Residential
- High Density Residential
- Future Residential
- Commercial (see Note 1)
- Dixon City Limits
- School
- Industrial (see Note 2)
- Core Area Mixed Use
- Agriculture
- Parks
- Functional (Buffers)
- Dixon Sphere of Influence
- Cal Water Service Area

0 1,500 3,000
Scale in Feet

N

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 3-3

General Plan Land Use

City of Dixon
Water System Master Plan and Hydraulic Model Update

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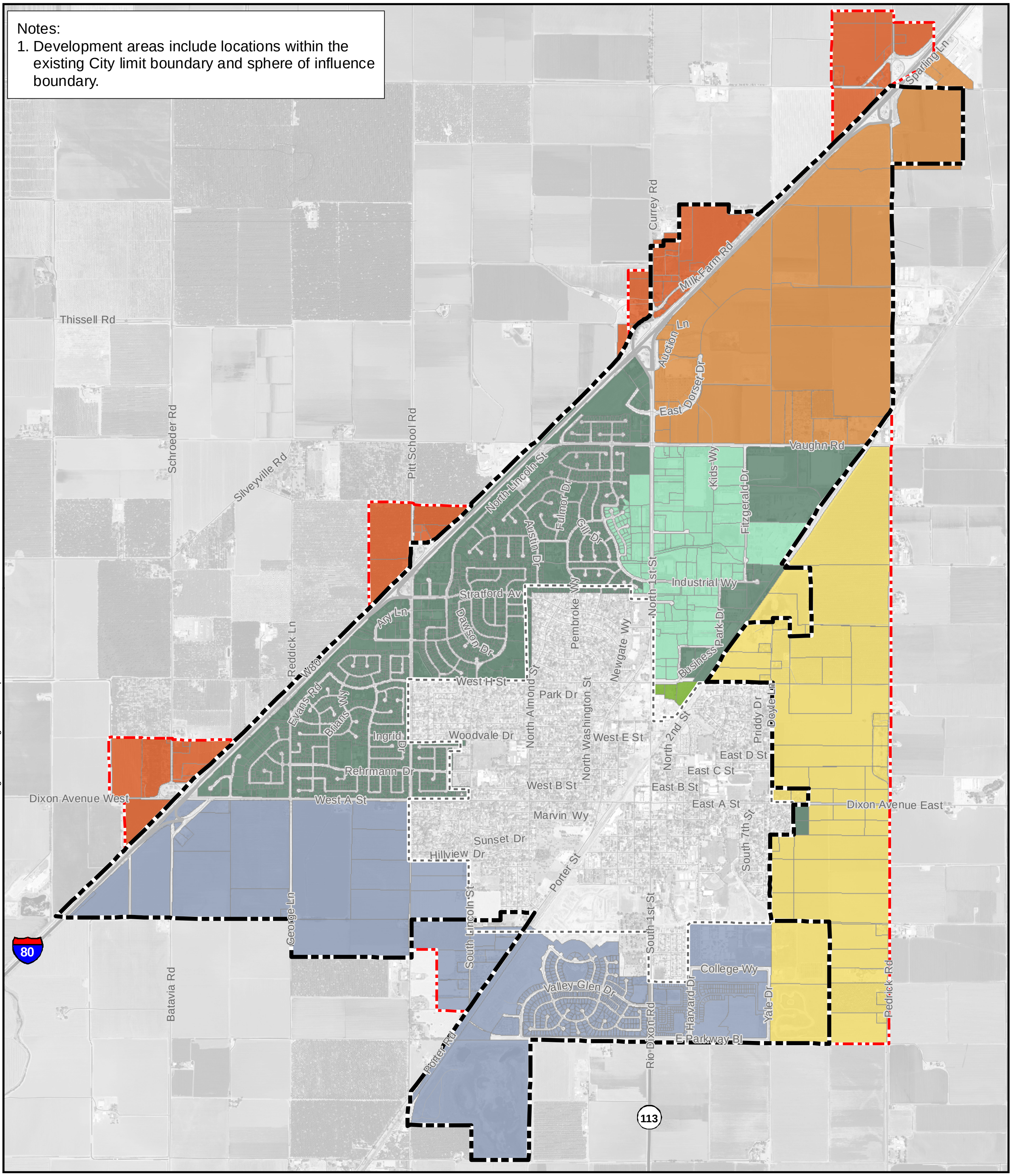

Symbology

Regional Development Areas

- Existing
- Downtown
- SR-113 Corridor
- South
- Northeast
- East
- North of I-80

- Dixon City Limits
- Dixon Sphere of Influence
- Cal Water Service Area

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 3-4

General Plan Development Areas

City of Dixon
Water System Master Plan and Hydraulic Model Update

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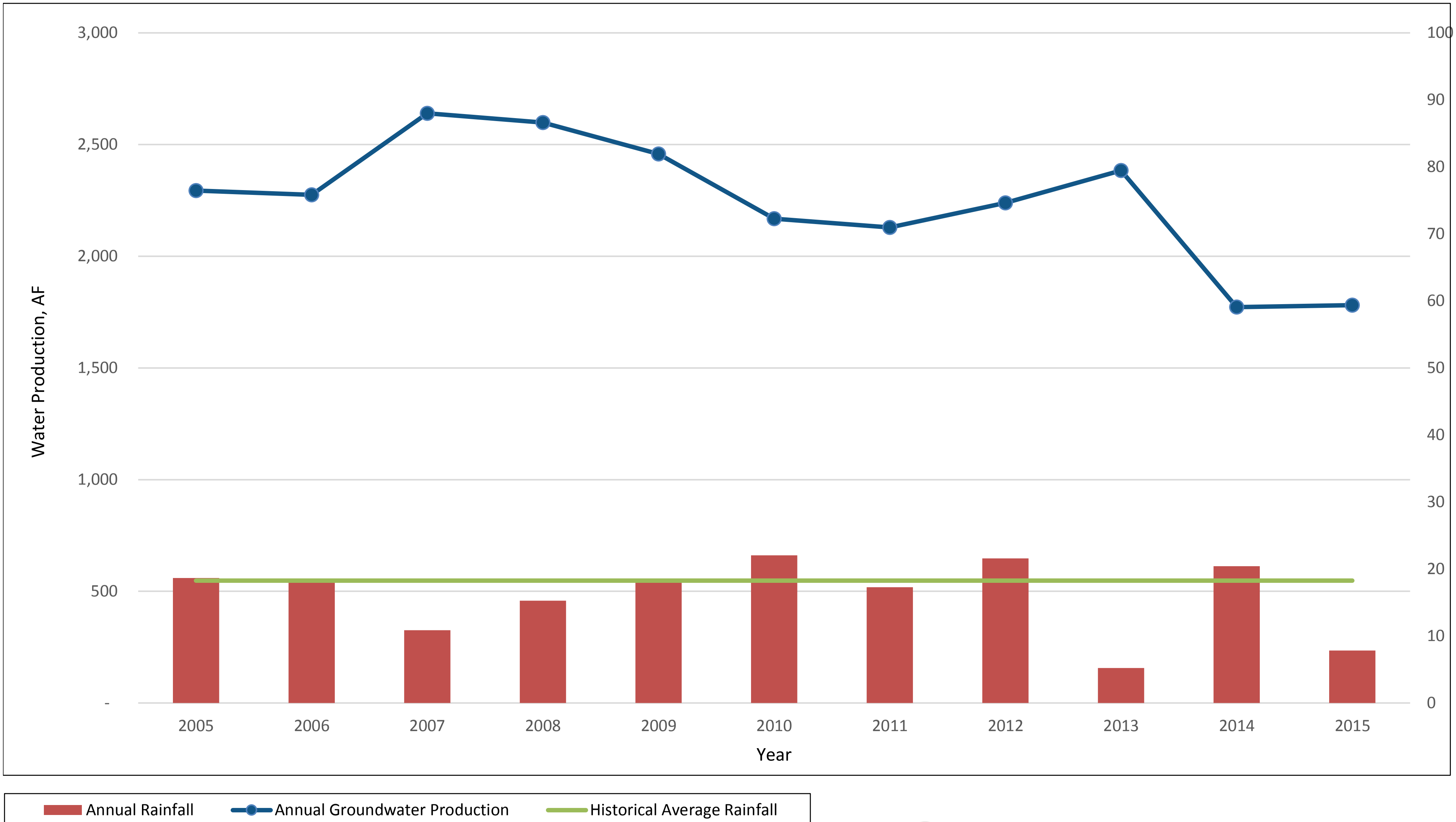

Notes:

1. Rainfall data from the Western Regional Climate Center, Station: Davis 2 WSW EXP FARM, CA

Figure 3-5

Historical Water Production Versus Historical Rainfall

City of Dixon
Water System Master Plan and Hydraulic Model Update

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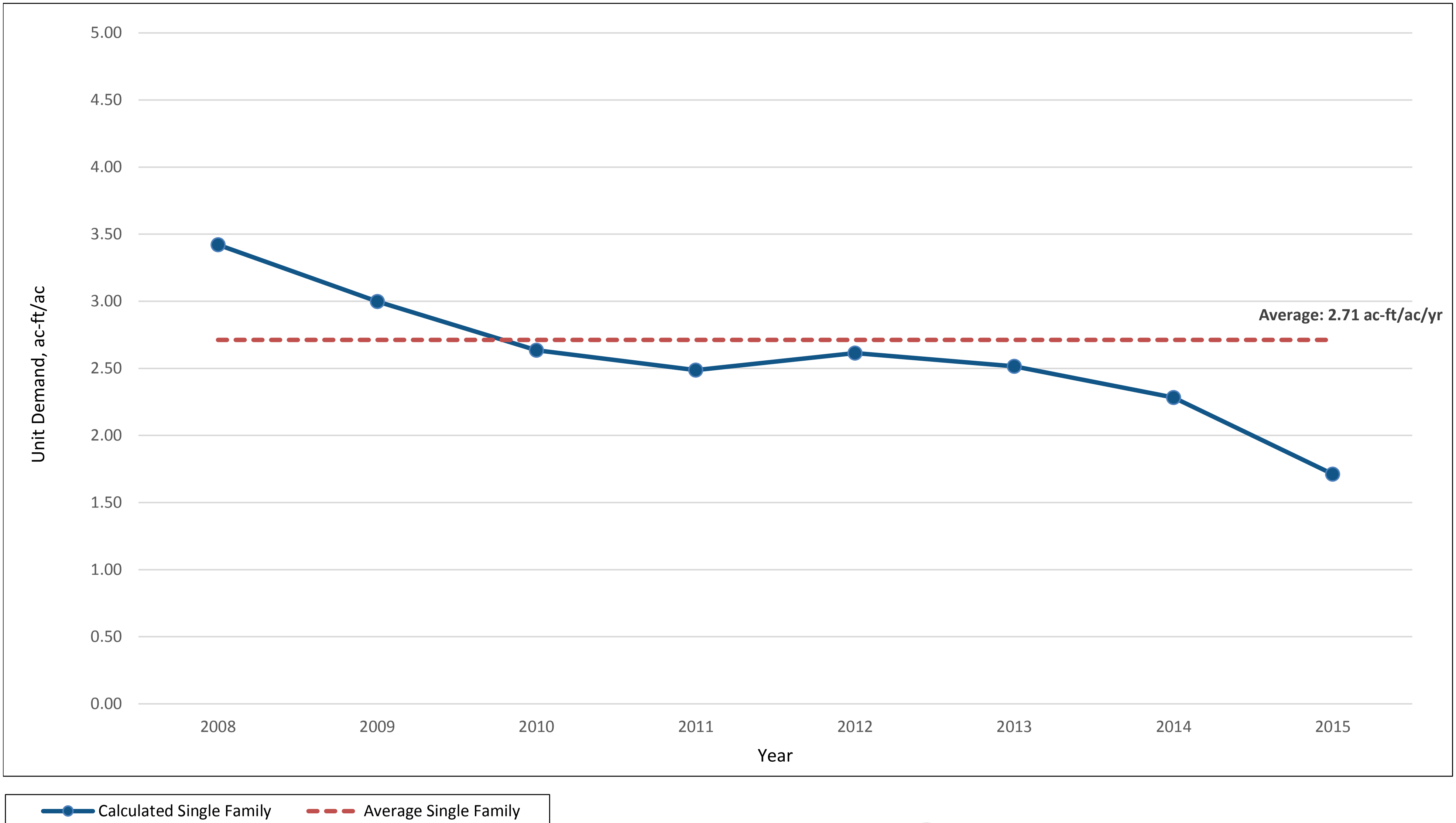

Notes:

1. Data obtained from customer billing reports and parcel information.
2. Average values increased by 5% to account for gross acres in future demand projections.

Figure 3-7

Historical Unit Demand Factor: Single Family

City of Dixon
Water System Master Plan and Hydraulic Model Update

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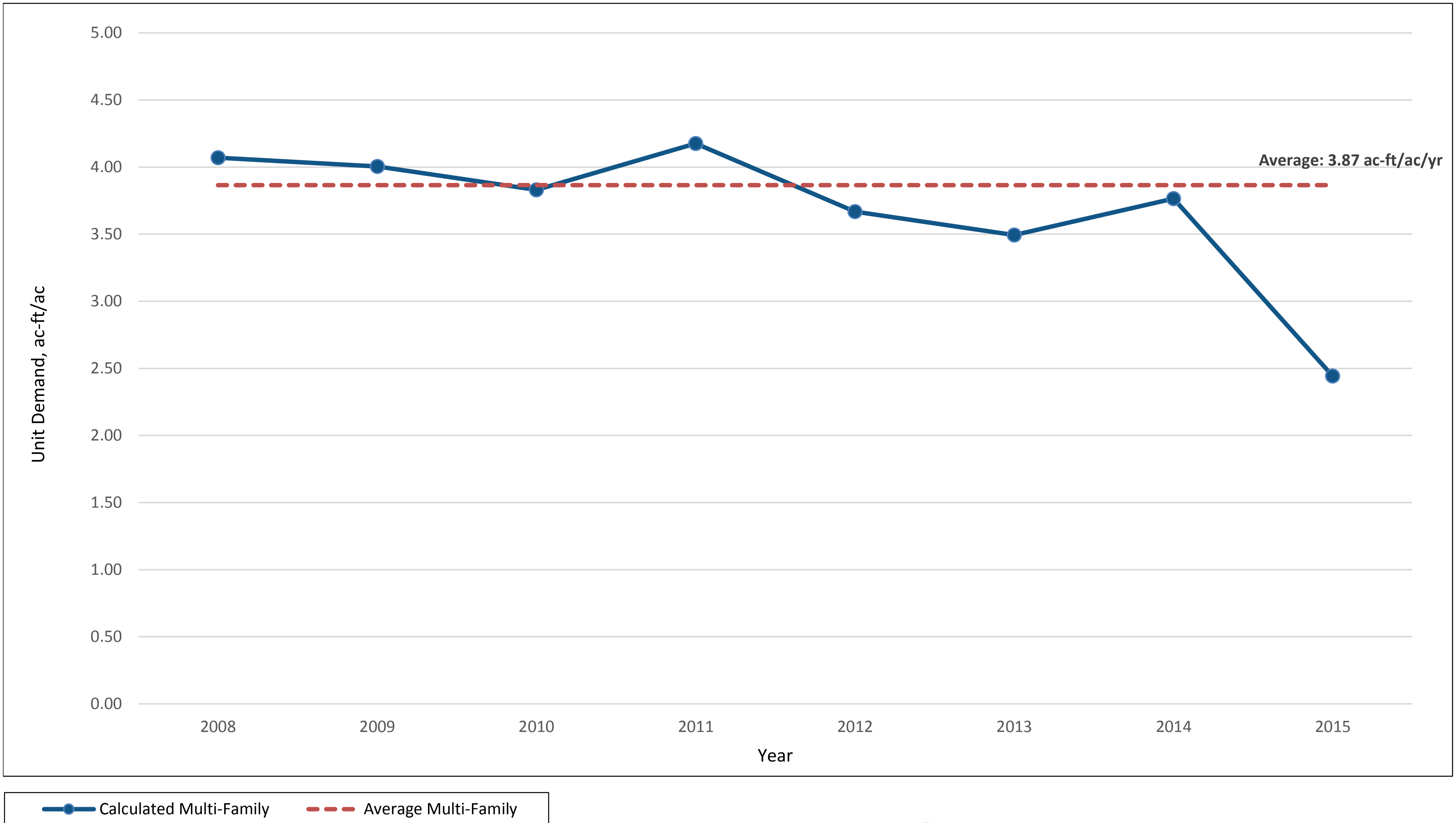

Notes:

1. Data obtained from customer billing reports and parcel information.
2. Multi-Family includes land uses designations of duplex, triplex, 4-plex, and apartment complex.
3. Average values increased by 5% to account for gross acres in future demand projections.

Figure 3-8

Historical Unit Demand Factor: Multi-Family

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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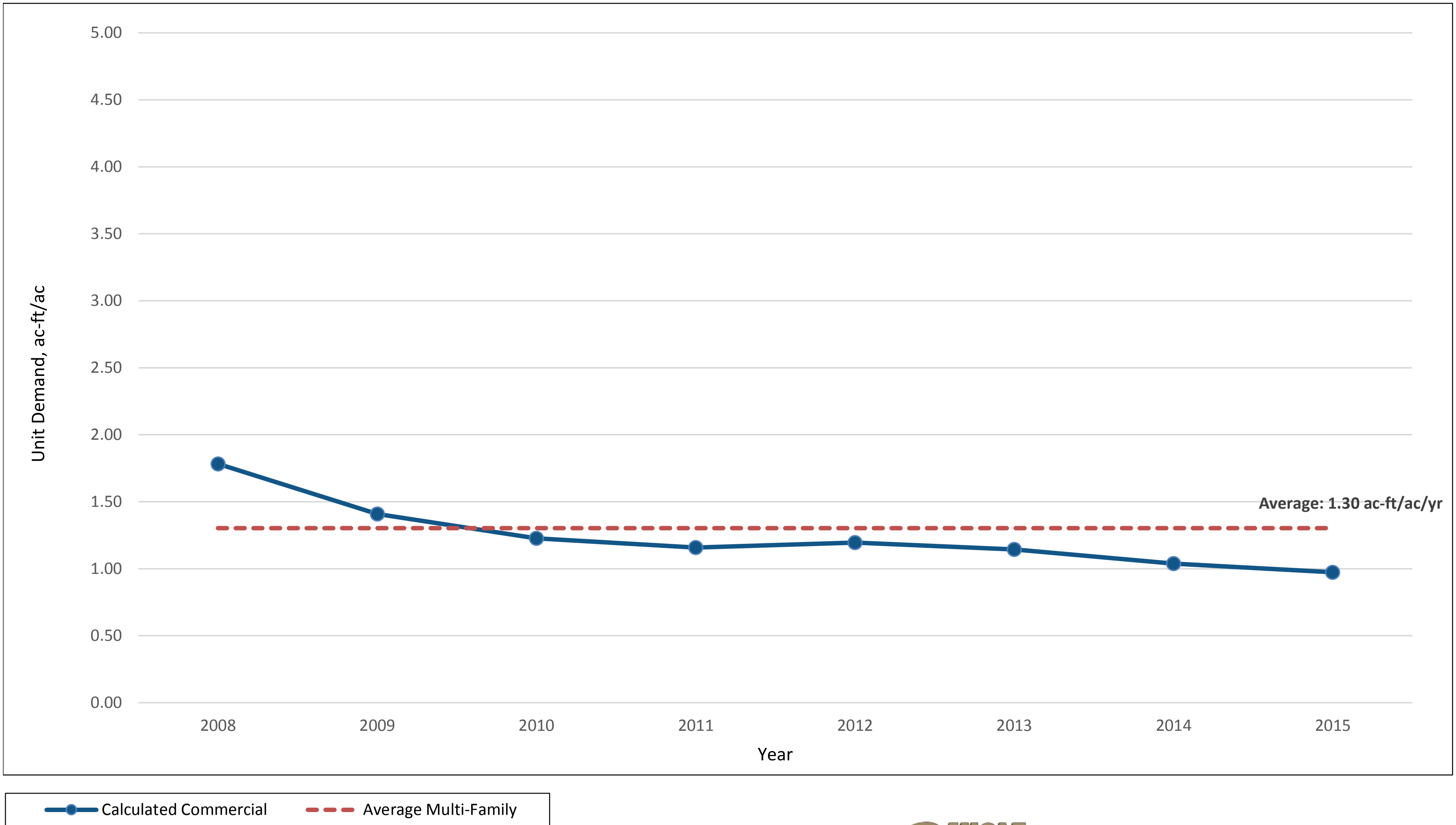

Notes:

1. Data obtained from customer billing reports and parcel information.
2. Commercial includes land uses designations of C& I, church & conval, commercial, and motel.
3. Average values increased by 5% to account for gross acres in future demand projections.

Figure 3-9

Historical Unit Demand Factor: Commercial

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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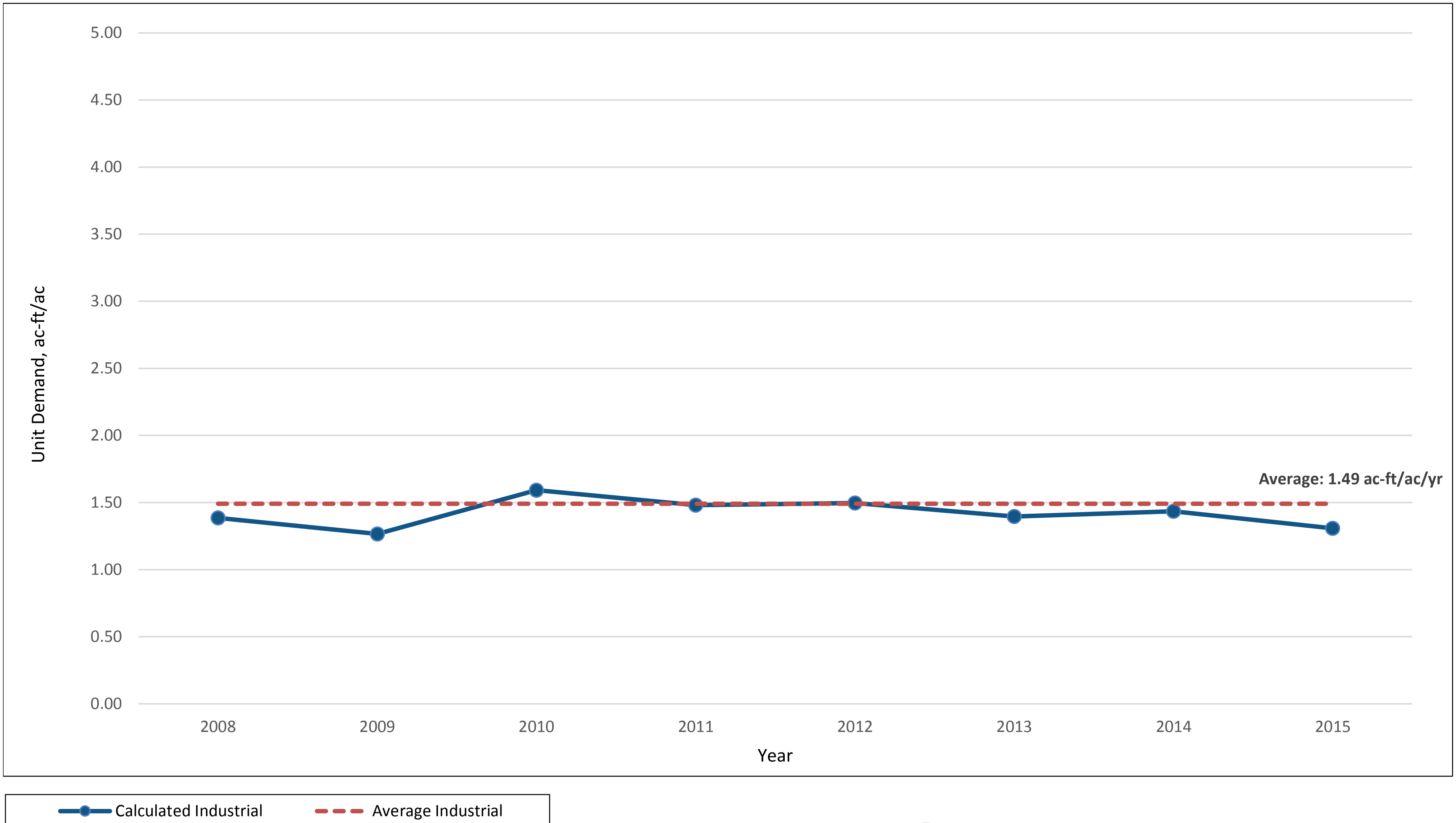

Notes:

1. Data obtained from customer billing reports and parcel information.
2. Average values increased by 5% to account for gross acres in future demand projections.
3. Average values increased by 5% to account for gross acres in future demand projections.

Figure 3-10

Historical Unit Demand Factor: Industrial

City of Dixon
Water System Master Plan and Hydraulic Model Update

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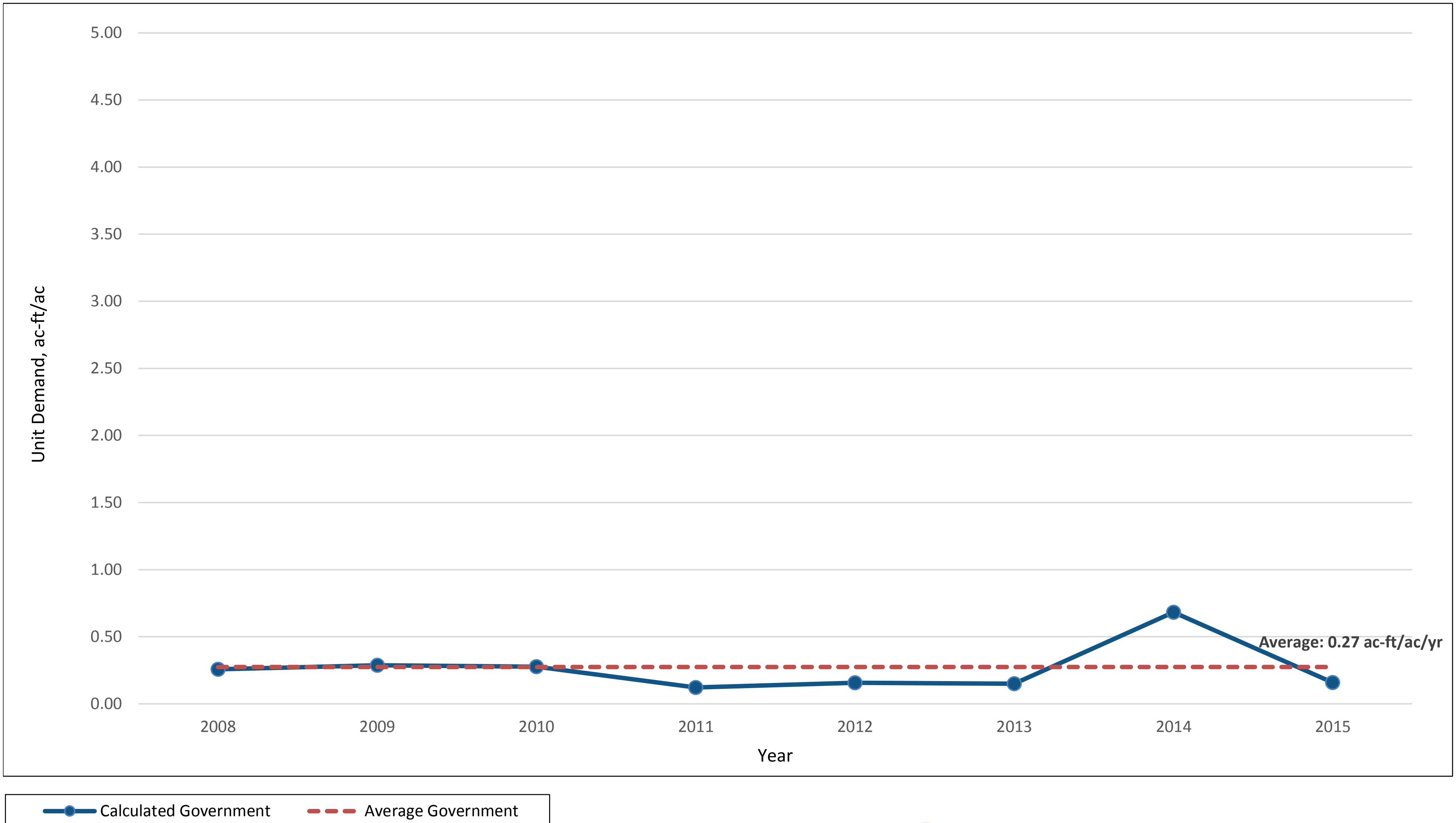

Notes:

1. Data obtained from customer billing reports and parcel information.
2. Government includes land use designations of firehouse and school.
3. Average values increased by 5% to account for gross acres in future demand projections.

Figure 3-11

Historical Unit Demand Factor: Government

City of Dixon
Water System Master Plan and Hydraulic Model Update

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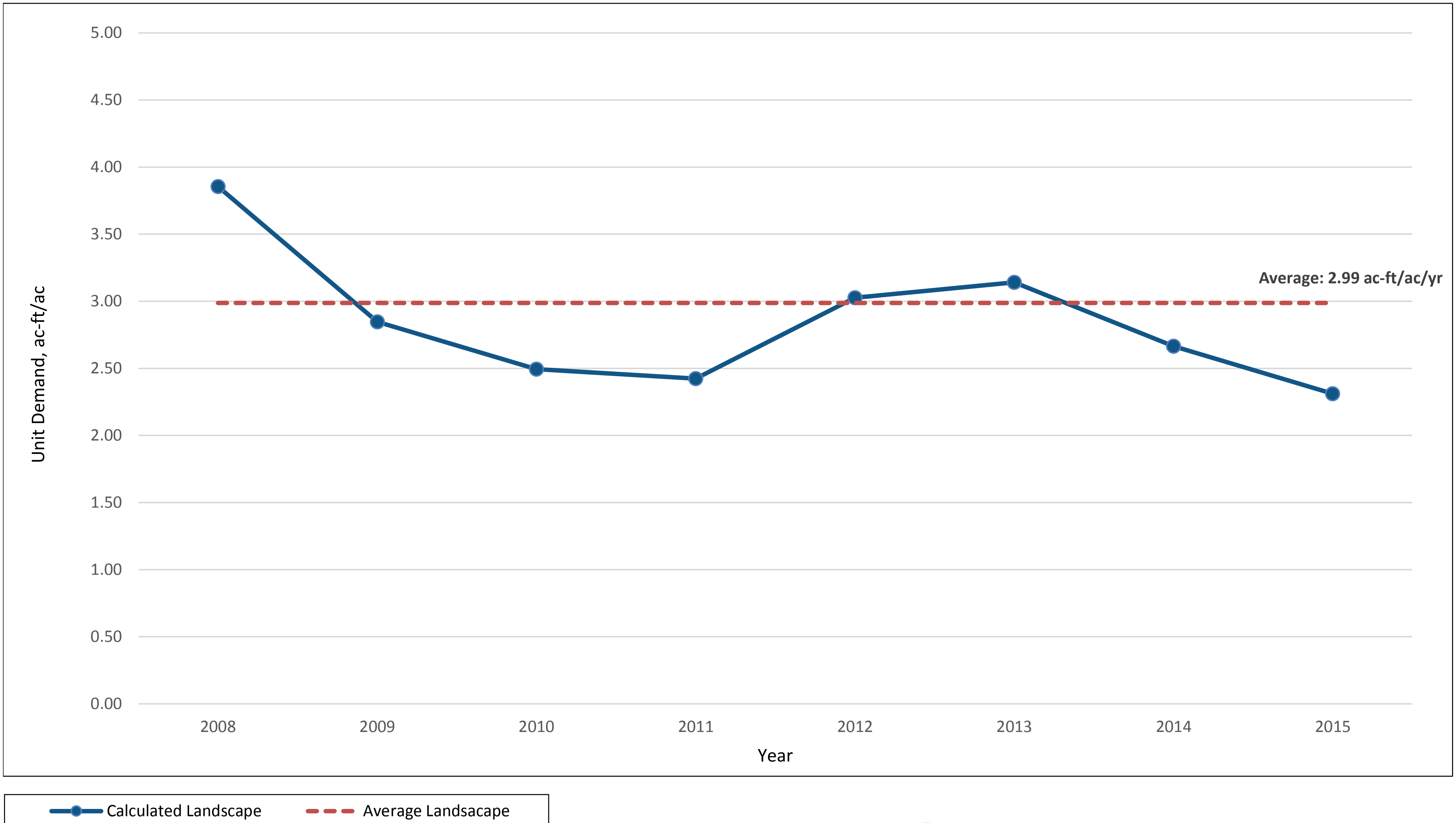

Notes:

1. Data obtained from customer billing reports and parcel information.
2. Average values increased by 5% to account for gross acres in future demand projections.

Figure 3-12

Historical Unit Demand Factor: Landscape

City of Dixon
Water System Master Plan and Hydraulic Model Update

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The purpose of this chapter is to provide an overview of the capacity and reliability of the City's existing water supply sources. The City currently relies solely on groundwater supplies to meet all of its water demands.

4.1 EXISTING GROUNDWATER FACILITIES

The City provides domestic water service to the northern, northwestern, and southern portions of the City of Dixon that are not currently served by Cal Water. The City operates a total of five groundwater wells, which have a total capacity of about 8,500 gpm (12.2 mgd). Table 4-1 summarizes information about the wells. Figure 4-1 shows the locations of the wells.

Wellhead treatment is currently not provided at any of the City's wells, but is being considered to address hexavalent chromium (Cr(VI)) concentrations in excess of the maximum contaminant level (MCL).

Table 4-1. City Groundwater Well Production Capacity[a]

Well Number and Name	Area	Year Constructed	Total Depth, feet	Reported Specific Capacity[b], gpm/ft	Estimated Flow Capacity	
					gpm	mgd
DW-37: Watson Ranch	Core/North	1978	917	-	1,500	2.2
DW-44: Industrial	Core/North	1977	872	-	800	1.2
DW-48: School	Core/North	1989	1,430	34	1,800	2.6
DW-52: Valley Glen	South	2003	1,480	7	1,900	2.7
DW-54: Park Lane	South	2007	1,470	18	2,500	3.6
				Total	8,500	12.2

(a) City of Dixon Division of Drinking Water Supply Permit No. 02-04-14P-481009, 2014. Estimated capacities for DW-44, DW-52 and the total system capacity are updated based on well improvements completed after issuance of the permit.
(b) Reported in California Department of Water Resources (DWR) Water Well Driller's Reports.

The City's water service area is divided into three zones: Core, North and South Zones (see Figure 4-1).

The Core and North Zones are hydraulically connected and operate as a single distribution system. The Core and North Zones are served by the Watson Ranch Well (DW-37), Industrial Well (DW-44) and the School Well (DW-48), all of which are located in the Core Zone; there are no wells in the North Zone. The Core and North Zones also have a fourth well which has been constructed at Conejo Park, which is currently capped for potential future use. The Conejo Park well is a former irrigation well which is not currently permitted, and its condition and production and water quality characteristic are unknown. The total groundwater pumping capacity in the North and Core zones is approximately 4,100 gpm (5.9 mgd).

The South Zone is a smaller area, which operates as a hydraulically independent distribution system. The South Zone is served by the Valley Glen Well (DW-52) and the Park Lane Well (DW-54) (see Figure 4-1). The total groundwater pumping capacity in the South Zone is approximately 4,400 gpm (6.3 mgd).

The following sections provide a description of the City's five groundwater wells based on their California DWR Water Well Drillers Reports and City of Dixon Division of Drinking Water Supply Permit No. 02 04 14P 481009, 2014.

4.1.1 Watson Ranch Well, DW-37

Well DW-37, the Watson Ranch Well, is located on North Lincoln Street just north of Renee Court (see Figure 4-1). It was constructed in June 1978 to serve the Watson Ranch development. A 26-inch diameter borehole was drilled to 925 ft below ground surface (bgs) and a 16-inch diameter steel casing was installed to a depth of 917 ft bgs. The well casing has louver-type openings of unspecified size from 319 to 917 ft bgs. Per the DWR Water Well Drillers Report, the well is graveled packed using a 16x4 gravel from the ground surface to 925 ft bgs. However, the DWR Water Well Drillers Report also states that the well has a cement surface seal extending to a depth of 50 ft bgs.

The first significant aquitard is located between the depths of 140 and 360 ft bgs.

Based on the reported well construction information, the gravel pack may enable a hydraulic connection between shallow aquifer zones located at depths between approximately 50 to 140 ft bgs and the well intake starting at a depth of 319 ft bgs. These shallow aquifer zones are probably comprised of Older Alluvium and may have inferior water quality, including high nitrate and Cr(VI) concentrations (see Section 4.2).

The specific capacity was not reported in the DWR Water Well Drillers Report.

The well is equipped with a 75 horse power (hp) vertical turbine pump with a soft start and is capable of producing 1,500 gpm.

In July 1995, an 800,000 gallon welded steel tank was constructed at the Watson Ranch Well site to help meet water demand and provide storage capacity for fire suppression. The well pumps chlorinated water into the tank, which then supplies water into the distribution system via a booster pump station.

4.1.2 Industrial Well, DW-44

Well DW-44, the Industrial Well, is located on Fitzgerald Drive (see Figure 4-1). It was constructed and brought on-line in February 1977 to serve the City's Industrial Park. A borehole was drilled to 881 ft bgs and a 16-inch diameter steel casing was installed to the depth of 872 ft bgs. Well screens of unspecified type and size are reported at the following depths bgs:

- 234 and 245.7 ft
- 514.7 and 525.2 ft
- 760.2 and 780.9 ft
- 816.9 and 837.4 ft
- 852.4 and 859.1 ft

Per the DWR Water Well Drillers Report, the well is gravel packed with a "3-1 mix", but the depth of the gravel pack is not specified. The DWR Water Well Drillers Report states that the well has a cement surface seal extending to a depth of 66 ft bgs. Based on the DWR Water Well Drillers Report, the cement surface seal is placed around a 24-inch diameter conductor casing. The annular fill between the conductor casing and the well casing is not specified.

The first significant aquitard is located between the depths of 57 to 98 ft bgs.

Based on the reported well construction information, the gravel pack may enable a hydraulic connection between shallow aquifer zones located at depths beginning at approximately 98 ft bgs and extending to the well intakes starting at a depth of 234 ft bgs. These shallow aquifer zones are probably comprised of Older Alluvium and may have inferior water quality, including high nitrate and Cr(VI) concentrations (see Section 4.2).

The specific capacity was not reported in the DWR Water Well Drillers Report.

The well is equipped with a 125 hp vertical turbine pump with a VFD. The pump motor was replaced in 2015, and the well is currently capable of producing approximately 800 gpm.

The well pumps into the 1.5 MG Fitzgerald storage tank located on a parcel across the street from the well site.

4.1.3 School Well, DW-48

Well DW-48, the School Well, is located on Rehrmann Drive at the western edge of Tremont Elementary School (see Figure 4-1). It was constructed and brought on-line in May 1989. A 28-inch diameter borehole was drilled to 1,430 ft bgs. An 18-inch diameter steel casing was installed from ground level to the depth of 766 ft bgs and continued by a 12-inch diameter steel casing to the full depth of the well.

Wire wrapped well screens with 0.060-inch openings are reported at the following depths bgs:

- 315 to 335 ft
- 405 to 427 ft
- 565 to 581 ft
- 656 to 678 ft
- 706 to 766 ft
- 840 to 850 ft
- 875 to 887 ft
- 1,035 to 1,042 ft
- 1,068 to 1,075 ft
- 1,201 to 1,206 ft
- 1,250 to 1,260 ft
- 1,292 to 1,302 ft
- 1,395 to 1,407 ft

Based on the DWR Water Well Drillers Report, gravel pack consisting of a "#21 Mix" was placed from 120 ft to 1,430 ft bgs, and the cement surface seal extends to a depth of 120 ft bgs.

The reported geologic profile is predominantly fine-grained to a depth of approximately 188 ft bgs. Based on the reported well construction information, the well appears to have an effective seal across potential shallow aquifer zones.

The specific capacity estimated from the DWR Water Well Drillers Report is 34 gpm per foot of drawdown (gpm/ft) (see Table 4-1).

The well is equipped with a 200 hp vertical turbine VFD pump with a capacity of up to 1,800 gpm which is pumped directly into the distribution system.

4.1.4 Valley Glen Well, DW-52

Well DW-52, the Valley Glen Well, is located on Valley Glen Drive at the intersection of Norton Court (see Figure 4-1). It was constructed in 2003 to serve the Valley Glen Development. A 48-inch diameter conductor casing extends to 50 ft bgs, and a 32-inch diameter borehole extends to the depth of 1,500 ft bgs. The well is constructed with a 20-inch diameter steel casing to a depth of 1,480 ft bgs.

Louvered openings with 0.050-inch apertures are reported at the following depths bgs:

- 290 to 310 ft
- 350 to 370 ft
- 440 to 530 ft
- 620 to 660 ft
- 930 to 950 ft
- 1,020 to 1,210 ft
- 1,330 to 1,460 ft

Based on the DWR Water Well Drillers Report, gravel pack consisting of Silica Resources, Inc. (SRI) 8x12 sand was installed from depths of 220 to 1,500 ft bgs. The cement surface seal extends to a depth of 220 ft bgs. A 40-inch diameter steel conductor casing was installed from ground level to the depth of 50 ft bgs.

Geologic information was not available with the DWR Water Well Drillers Report. However, based on the reported construction information, the well appears to have an effective seal across potential shallow aquifer zones.

The specific capacity estimated from the DWR Water Well Drillers Report is 7 gpm/ft (see Table 4-1).

The well is capable of pumping up to 1,900 gpm and has a submersible pump with a 300 hp motor equipped with a VFD. There is no storage tank at this well site and the well pumps water directly into the distribution system. However, water pumped from the Valley Glen Well is high in nitrates and is only used as a back-up supply. The well is exercised on a weekly basis to ensure that it remains operational.

4.1.5 Park Lane Well, DW-54

Well DW-54, the Park Lane Well, is located on Yale Drive near College Way (see Figure 4-1). It was completed and brought on-line in January 2007. A 48-inch diameter conductor casing was installed to 50 ft bgs. The 32-inch diameter borehole extends from the base of the conductor casing to the depth of 1,500 ft bgs.

A 20-inch diameter steel casing was extended from ground surface to the full depth of the well (1,470 ft bgs).

Well screens with a slot size of 0.050-inch and unspecified construction are reported between the depths of 430 to 1,450 ft bgs.

Based on the DWR Water Well Drillers Report, gravel pack consisting of SRI 8x12 sand was installed from depths of 360 to 1,490 ft bgs. The cement surface seal extends to a depth of 360 ft bgs. A 35-inch diameter steel casing was installed from ground level to the depth of 50 ft bgs.

Based on the reported geologic profile, the first significant aquitard is located between the depths of 340 to 430 ft bgs. Based on the reported well construction information, the well appears to have an effective seal across potential shallow aquifer zones.

The specific capacity estimated from the DWR Water Well Drillers Report is 18 gpm/ft (see Table 4-1).

This well is equipped with a 300 hp vertical turbine pump with a soft start that is capable of producing 2,500 gpm. Water is pumped from the Park Lane Well into two 1.0 MG tanks located at the well site and then boosted into the distribution system through a booster pump station located at the well site.

4.2 GROUNDWATER SUPPLY

The following sections describe the City's groundwater resources, including a description of the groundwater basin and subbasins, estimated groundwater operational yield, groundwater management activities, historical groundwater flow and level trends, and groundwater quality issues and concerns.

4.2.1 Groundwater Basin Description

The City overlies the Sacramento Valley Groundwater Basin, which has been divided into several smaller subbasins using institutional boundaries established by DWR. The Sacramento Valley Groundwater Basin is located in the north central California, and is bounded on the east by the Sierra Nevada and Cascade Ranges, and on the west by the North Coast Range. The Sacramento Valley Groundwater Basin also extends from about five miles north of Red Bluff southward for 150 miles to the Sacramento-San Joaquin Delta and covers an area of approximately 6,000 square miles.

4.2.1.1 Subbasin Description

The City's groundwater wells are located in the Solano Subbasin (Subbasin 5-21.66) of the Sacramento Valley Groundwater Basin as defined in the DWR Bulletin 118 update. Characteristics of the Solano Subbasin are summarized in Table 4-2.

Table 4-2. Characteristics of the Solano Subbasin[a]

Groundwater Basin Name	Subbasin Name	DWR Basin Number	Surface Area
Sacramento Valley	Solano	5-21.66	425,000 acres (664 square miles)

[a] Source: DWR, 2004. California's Groundwater Bulletin 118, Sacramento Valley Groundwater Basin, Solano Subbasin.

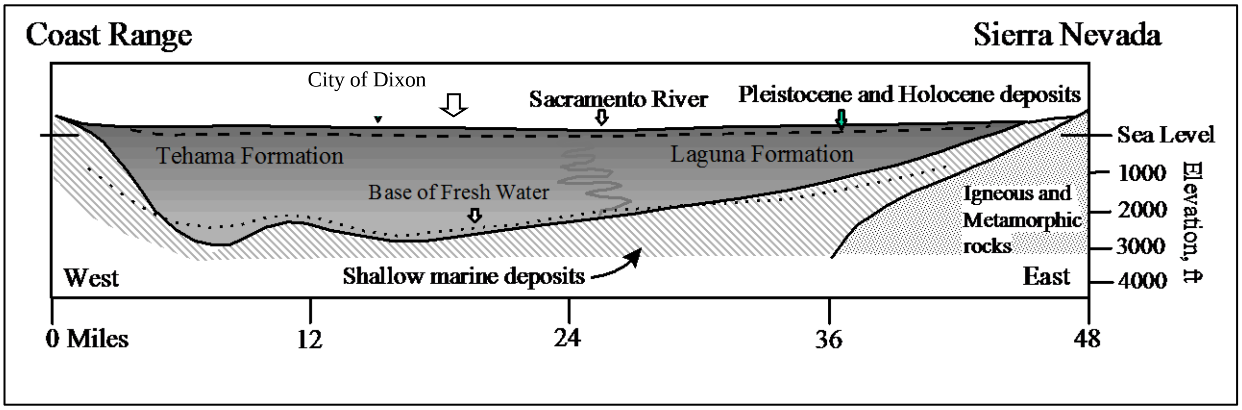
Figure 4-2 shows the location of the groundwater subbasin. The subbasin is bounded by Putah Creek on the north, the Sacramento River on the east, Delta channels to the southeast and south, and a hydrologic divide on the west. The western hydrologic divide corresponds to the crest of the English Hills and Montezuma Hills, and separates the Solano Subbasin from the Suisun-Fairfield Groundwater Basin.

As of summer 2016, DWR approved a Subbasin Boundary Modification Request submitted by the Yolo County Flood Control and Water Conservation District. The revised boundary expands the subbasin to encompass most of Yolo County, thereby reducing the size of the Solano Subbasin by removing the area lying within southern Yolo County (DWR, 2016).

4.2.1.2 Hydrogeology

The Sacramento Valley, in the vicinity of Dixon, is filled by a thick sequence of marine sedimentary rock of Late Jurassic (159 million years before present) to Eocene (34 million years) age, unconformably overlain by a relatively thin sequence of continental sedimentary deposits of Pliocene (5 million years) and younger age. A generalized geologic cross-section for the Sacramento Valley is shown in Figure 4-3.

Figure 4-3. Generalized Geologic Cross-Section of the Southern Sacramento Valley



Source: California Department of Water Resources, 1978

The older, deeper marine rocks contain saline water. The freshwater aquifers in the vicinity of Dixon occur in the overlying continental sedimentary deposits, which are presented from oldest to youngest in the following discussion. Table 4-3 summarizes the major water-bearing formations within the Solano Subbasin.

Table 4-3. Water Bearing Formations within the Solano Subbasin[a]

Formation	Typical Thickness[b], feet
Tehama Formation	1,500 to 2,500
Older Alluvium	60 to 130
Stream Channel and Basin Deposits	0 to 40
Flood Basin Deposits	0 to 150

(a) Source: DWR, 2004. California's Groundwater Bulletin 118, Sacramento Valley Groundwater Basin, Solano Subbasin.
(b) Thickness is not synonymous with depth. For example, depth to the base of the Tehama Formation is the thickness of the Tehama Formation plus the thickness of any younger, overlying formations.

4.2.1.2.1 Tehama Formation

The Tehama Formation forms the oldest, deepest and thickest part of the freshwater aquifer in the vicinity of the City. The Tehama Formation consists of up to nearly 2,500 ft of moderately compacted silt, clay, and silty fine sand enclosing thin, discontinuous lenses of sand and gravel, silt and gravel deposited in a fluvial (river-borne) environment. Based on the mineralogy of surface exposures, the sediments were derived from erosion of the Coast Ranges and Klamath Mountains.

The Tehama Formation is exposed at the land surface to the west of Dixon, in the English Hills and the eastern flank of the Vaca Mountains (see Figure 4-2). The Tehama Formation is buried beneath younger sediments to the east of the English Hills.

The regional hydrostratigraphic framework for the Tehama Formation is defined in U. S. Geological Survey Water-Supply Paper 1464, Geology and Usable Ground-Water Storage Capacity of Part of Solano County, California (Thomasson, et. al., 1960). Thomasson, et al (1960) shows three broad hydrostratigraphic zones within the Tehama Formation and related continental sediments:

- A relatively coarse-grained zone extending to a depth of approximately 1,500 ft.
- A predominantly fine-grained zone between depths of approximately 1,500 and 1,800 ft.
- A predominantly coarse-grained zone between depths of approximately 1,700 and 2,700 ft.

The permeability of the Tehama Formation varies but is generally less than in the overlying unconsolidated alluvial deposits. Because of the thickness of the producing zones, production from the Tehama Formation can be up to several thousand gpm per well. The majority of irrigation and municipal wells in the Solano Subbasin are completed in the Tehama Formation.

4.2.1.2.2 Older Alluvium

Older Alluvium consists of loose to moderately compacted silt, silty clay, sand and gravel deposited in alluvial fans during the Pliocene and Pleistocene ages. Thicknesses range from approximately 60 to 130 ft. Wells penetrating the sand and gravel units produce between 300 and 1,000 gpm. The majority of the private domestic wells in the vicinity of Dixon produce water from the Older Alluvium.

4.2.1.2.3 Stream Channel and Basin Deposits

Holocene stream channel and basin deposits are the youngest sediments in the Dixon area, with ages of roughly 10,000 years or less. The stream channel and basin deposits consist of up to 40-foot sections of unconsolidated clay, silt, sand and gravel reworked from older formations by streams. According to DWR, which also refers to these deposits as younger alluvium, these deposits form a shallow unconfined aquifer of moderate to high permeability but with limited capacity due to the relatively restricted lateral and vertical extents of the deposits (DWR, 2004).

4.2.1.2.4 Flood Basin Deposits

Holocene flood basin deposits are very young surficial deposits formed during flood events when streams overtopped their natural levees flooding the surrounding area. These deposits are primarily found to the east of Dixon in the Yolo Flood Basin of the Sacramento River (see Figure 4-2). As the flood water spread, the current velocity and stream competency decreased, resulting in deposition of silts, clays and fine sands. Flood basin deposits reach thicknesses up to 150 ft and may be interbedded with stream channel deposits. Because of their low permeability, limited extent, and generally poor water quality, flood basin deposits are typically not used for groundwater production.

4.2.2 Groundwater Basin Management

This section discusses historical groundwater management in the Solano Basin and evolving management structures required by the Sustainable Groundwater Management Act of 2014 (SGMA).

The Solano Subbasin is not adjudicated, and DWR has not identified Basin 5-21.66 as either in overdraft or expected to be in overdraft. A “water master” is not appointed to resolve groundwater pumping issues, nor are there established limits on groundwater pumping by individuals or agencies within the basin. However, neighboring water agencies sharing the Solano Subbasin have adopted groundwater management plans. Those agencies include the City of Vacaville, Reclamation District #2068, Maine Prairie Water District, and Solano Irrigation District.

Prior to the completion of the Solano Project in 1959, groundwater was extensively used in Solano County for municipal and agricultural supplies. The Solano Project refers to United States Bureau of Reclamation project to store surface water in Lake Berryessa for potable and non-potable uses primarily in Solano County. One of the primary reasons behind the Solano Project was to correct the overdraft of groundwater, which was occurring in agricultural areas. Since then, the Solano Project has halted the overdraft of groundwater, and the groundwater levels have rebounded in most areas of the Solano Subbasin. Groundwater level data presented in the North Central Solano

County Groundwater Resources Report and additional data published by DWR, show that the subbasin is in a state of equilibrium. The groundwater levels are not permanently impacted by multiple dry years and data also shows slight variations in response to climatic conditions.

SGMA, a three-bill legislative package composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), was passed in September 2014. The legislation provides a framework for sustainable management of groundwater supplies by local authorities, with a limited role for state intervention when necessary to protect the resource. The legislation lays out a process and a timeline for local authorities to achieve sustainable management of groundwater basins. It also provides tools, authorities and deadlines to take the necessary steps to achieve the goal. For local agencies involved in implementation, the requirements are significant and can be expected to take years to accomplish. The State Water Resources Control Board (SWRCB) may intervene if local agencies do not form a Groundwater Sustainability Agency (GSA) and/or fail to adopt and implement a Groundwater Sustainability Plan (GSP).

The SGMA implementation steps and deadlines are shown in Table 4-4.

Table 4-4. Sustainable Groundwater Management Act Implementation Steps and Deadlines

Implementation Step	Implementation Measure	Deadlines
Step One	Local agencies must form local GSAs within two years	• June 30, 2017
Step Two	Agencies in basins deemed high- or medium-priority must adopt GSPs within five to seven years, depending on whether a basin is in critical overdraft	• January 31, 2020 for critically overdrafted basins • January 31, 2022 for high- and medium-priority basins not currently in overdraft
Step Three	Once plans are in place, local agencies have 20 years to fully implement them and achieve the sustainability goal	• January 31, 2040 for critically overdrafted basins • January 31, 2042 for high- and medium-priority basins not currently in overdraft

SGMA applies to basins or subbasins designated by the DWR as high or medium priority basins, based on a statewide ranking that uses criteria including population and extent of irrigated agriculture dependent on groundwater. The final Basin Prioritization findings indicate that 127 of California's 515 groundwater basins and subbasins are high and medium priority basins. These high and medium priority basins account for 96 percent of California's annual groundwater pumping and supply 88 percent of the population which resides over the groundwater basins. The ranking for the Solano Subbasin is shown in Table 4-5. As shown, the Solano Subbasin has been ranked as a medium priority basin.

Table 4-5. Groundwater Basin Prioritization for Sustainable Groundwater Management Act

Rank(a,b)	Basin Number	Basin Name	Subbasin Name	Overall Basin Ranking Score	Overall Basin Priority
107	5-22.66	Sacramento Valley	Solano	15.5	Medium

(a) CASGEM Groundwater Basin Prioritization Results, run version May 26, 2014.
(b) Out of a total of 515 basins, of which 127 were high- or medium-priority basins.

In the region where the City is located, groundwater resources are regionally monitored and managed by the Solano County Water Agency (SCWA) and Solano Irrigation District. Other agencies in the subbasin include Solano County, the Rural North Vacaville Water District, the cities of Dixon, Rio Vista and Vacaville, Cal Water, Maine Prairie Water District and Reclamation District 2068. These agencies are seeking to manage the basin to the benefit of all stakeholders, while maintaining their individual groundwater management plans.

Since late 2015, the Groundwater Sustainability Agency Working Group (GSAG), in conjunction with Ag Innovations, a consultant retained by SCWA, held both public workshops and numerous working meetings and have produced a number of recommendations for the governance guiding principles and proposed structure of the GSA. The GSAG originally recommended one Solano Subbasin GSA that would be formed and operated under a Joint Powers Agreement (JPA) governance structure.

While collaboration remained productive, in January 2017, the Solano Irrigation District (SID) Board of Directors authorized staff to take preemptive action to submit the appropriate paperwork to DWR with the intent to form the Solano Irrigation District GSA in the event that SID's interests were not adequately protected in the overall GSA JPA formation. Subsequently, SID staff participated in regular meetings to discuss the JPA document.

At the March 8, 2017 GSAG meeting, it was determined that the development of the GSA JPA document could no longer progress and meet the required formation/submittal deadline of June 30, 2017 and continue to incorporate SID's participatory requirements. Pivotal among these requirements were:

- Formation of a SID Special Management Area;
- Document credit for SID's contribution to the groundwater recharge; and
- Veto power by the SID Board for any action enacted by the overall GSA JPA Board that SID deemed contrary to their interests.

Additionally, on Tuesday, April 11, 2017, the Vacaville City Council elected to proceed with forming their own GSA.

Membership of the Solano GSA Board includes the following (11 Board members total):

- Municipal representation from Dixon and Rio Vista (1 each = 2 reps)
  - — A portion of Fairfield lies within the basin limits but they have determined that the viability of obtaining groundwater within this area is remote.
  - — As noted above, Vacaville has elected to proceed with developing their own GSA.
- Cal Water, as a non-signatory GSA JPA member (1 rep)
  - — Per SGMA, investor-owned water purveyors are to engage in GSAs through coordinating agreements.
- District representation from Maine Prairie Water District and Reclamation District 2068 (1 each = 2 reps)
- Rural North Vacaville Water District has elected to not participate in the GSA
- Unincorporated Area representation from Solano County (2 reps), Solano County Resource Conservation District (1 rep), Dixon Resource Conservation District (1 rep), Solano County Agricultural Advisory Committee (1 rep) and Solano County Farm Bureau (1 rep)

Since the submittal of GSA formation documents prior to the June 30, 2017 deadline, the Solano GSA Technical Advisory Committee has met several times to work with SCWA and a consultant to develop a grant application for the development of the required Groundwater Sustainability Plan (GSP) prior to the 2022 deadline.

4.2.3 Groundwater Level Trends

The DWR Bulletin 118 reports that the groundwater elevations prior to 1912 represent the groundwater basin in its natural state (DWR, 2004). Between the years 1912 and 1932, precipitation was below average, which resulted in lower groundwater levels. In 1932 to 1941 groundwater levels recovered slightly because of above average precipitation. After 1941, groundwater levels declined due to increasing agricultural and urban development and the levels reached their lowest in the 1950s. After 1959, when the Solano Project began to supply surface water to Solano County, groundwater levels began to rise. Since the 1980s, the groundwater levels have been stable with low levels in the dry season and high levels in the wet season of each year.

4.2.4 Groundwater Quality

The quality of groundwater underlying the City was evaluated by considering the SWRCB Groundwater Ambient Monitoring and Assessment (GAMA) Program reports, DWR Bulletin 118, active groundwater contamination cases in the area, and reviewing historical water quality data from each municipal well operated by the City.

4.2.4.1 Water Quality per DWR Bulletin 118

According to DWR Bulletin 118, groundwater in the Solano Subbasin is good quality and is suitable for domestic and agricultural purposes. Total dissolved solids (TDS) concentrations generally range from 250 to 500 milligrams per liter (mg/L) and are comprised predominantly of calcium, magnesium and sodium cations and bicarbonate anions. The groundwater is hard to very hard.

4.2.4.2 USGS GAMA Study

Growing concern over the closure of public water supply wells because of groundwater contamination led the SWRCB to establish the GAMA Program. With the aid of the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory, the program goals are to enhance understanding and provide a current assessment of groundwater quality in areas where groundwater is an important source of drinking water. The GAMA study included sampling selected wells for a wide-range of chemical constituents at levels that are significantly below currently accepted health or advisory standards.

The Southern Sacramento Valley (SSACV) study unit covers an estimated 2,100 square miles across six hydrologic study areas in the counties of Placer, Sacramento, Solano, Sutter, and Yolo. The study areas are situated on the North American Subbasin, South American Subbasin, Solano Subbasin, Yolo Subbasin, the upland area on the eastern sides of the North and South American Subbasins, and the DWR-defined Suisan-Fairfield groundwater basin. Groundwater quality data collected as part of the GAMA program were documented in the USGS report titled "Ground-Water Quality Data in the Southern Sacramento Valley, California 2005 - Results from the California GAMA Program" (USGS Data Series 285).

From March 2005 to June 2005, 87 samples were collected from 83 wells in the SSACV study area and analyzed for a number of constituents including: 88 volatile organic compounds (VOCs), 118 pesticides, five nutrients, dissolved organic compounds (DOC), nine major ions, 25 trace elements, four constituents of special interest (N-nitrosodimethylamine, 1,2,3-trichloropropane, Cr(VI), perchlorate), eight isotopic constituents, five dissolved noble gases, and the microbial constituent's coliform and coliphage. Detections of these constituents in samples do not represent quality of water delivered to consumers as samples are from raw groundwater.

Only samples collected from wells in Solano Subbasin were assessed, for this evaluation. In Table 2 of the GAMA study, thirteen wells are listed as being located in the Solano Subbasin.

The SSACV study (2005) produced the following findings:

- VOCs, including gasoline oxygenates, were collected at all wells sampled, but concentrations were not greater than an MCL or threshold value.
- Cyclopentane and sulfur dioxide were found in the Solano Subbasin.
- Pesticide concentrations were found in the Solano Subbasin, but there were not greater than an MCL or threshold values.
- Nutrients such as ammonia, nitrates, and orthophosphates were found in the Solano Subbasin, but were lower than an MCL or threshold value.

- Major ions were detected in Solano Subbasin wells, but concentrations did not exceed the Secondary MCL (SMCL).
- Trace inorganic elements were detected in Solano Subbasin wells. In Well SOL-06, boron and iron were found to be in concentrations higher than the threshold.
- Total chromium, Cr(VI), total arsenic, arsenic(III), and total iron, and iron(II) were found in two Solano study area wells, but concentrations did not exceed MCL or threshold values in place in 2005 (see Section 4.2.4.3 below for additional discussion).
- Naturally occurring isotopic constituents and dissolved noble gases were found in various wells in Solano Subbasin, but they did not exceed the MCL or threshold.
- Microbial constituents were not detected in groundwater samples collected for study area wells in Solano Subbasin.

4.2.4.3 Hexavalent Chromium in City Wells

The City operates five drinking water wells, all of which have Cr(VI) concentrations above 10 µg/l, which was the California MCL for Cr(VI) that became effective on July 1, 2014. Senate Bill 385 required full compliance with the Cr(VI) MCL "at the earliest feasible date prior to January 1, 2020". However, on May 31, 2017, the Superior Court of Sacramento County issued a judgement that invalidated the Cr(VI) MCL and the change became effective September 11, 2017. The primary reason for the court finding the MCL invalid was that the California Department of Public Health (CDPH) primarily "failed to properly consider the economic feasibility of complying with the MCL." SWRCB, who is now responsible for the State's drinking water program, does not plan to appeal the court's decision. Instead, SWRCB felt it would be more expedient to begin the process of adopting a new MCL rather than appeal the court's order. It is anticipated that the SWRCB will establish a new Cr(VI) MCL which may be at the same level as the invalidated MCL.

Although the SWRCB will not be enforcing any previously prepared compliance plans that public water systems entered into for Cr(VI) compliance, the MCL for total chromium of 50 µg/l will remain in place. The City had been actively studying treatment alternatives to address Cr(VI) in its groundwater supply to reduce it below the invalidated MCL and develop a Corrective Action Plan, prior to the court's decision. A series of technical memoranda were prepared discussing the City's steps to be taken towards Cr(VI) compliance. In anticipation that SWRCB will establish a new MCL that may be at the same level as the invalidated MCL, information on the actions previously taken by the City are summarized in this WSMP.

Compliance with the invalidated Cr(VI) MCL was to be determined based on an average of water samples taken over four consecutive calendar quarters. The Cr(VI) in City wells ranges from a low of 7.8 µg/l to a high of 27 µg/l. Table 4-6 provides a summary of the Cr(VI) and total chromium concentrations for the active City wells. As shown, all City wells are currently out of compliance with the invalidated MCL (10 µg/l), but within compliance of the total chromium MCL (50 µg/l).

Table 4-6. Chromium Concentrations of Drinking Water Wells[a]

Parameter	Units	Watson Ranch, DW-37	Industrial, DW-44	School, DW-48	Valley Glen, DW-52	Park Lane, DW-54
Total Chromium	µg/l	20	23	16	19	27
Chromium (VI)						
Dec-14	µg/l	7.8	24	11	10	20
Dec-14	µg/l	11	14	12	16	14
Apr-15	µg/l	16	23	17	19	27
Jun-15	µg/l	14	20	16	20	24
Sep-15	µg/l	12	16	12	10	23
Dec-15	µg/l	12	16	12	13	22

[a] Source: City of Dixon Cr(VI) Management Strategies – Water Demand and Supply Optimization Technical Memorandum, Kennedy-Jenks, January 29, 2016, Table 1.

In groundwater, chromium exists in either a reduced trivalent form (Cr(III)) or the more oxidized hexavalent form (Cr(VI)); with total chromium being the sum of Cr(III) and Cr(VI). Typical of oxidized groundwater with naturally occurring chromium, almost all of the total chromium is the hexavalent form Cr(VI).

4.2.4.3.1 Cr(VI) Treatment Options

The City has considered Cr(VI) treatment alternatives, and centralized treatment plants within the combined Core/North Zones and the South Zone is the apparent preferred alternative. Centralized Cr(VI) treatment plants would be located at the Watson Ranch Well site in the combined Core/North Zones and at the Park Lane Well site in the South Zone (Kennedy Jenks, 2016).

Sizing of the centralized Cr(VI) treatment plants depends in part on the available water production capacity, storage available and ability to meet demands with the largest well off-line in each water service zone. The following sections provide a summary of the production capacity for the combined Core/North Zone and the South Zone followed by recommended actions centered around optimizing the size of the Cr(VI) treatment plants.

4.2.4.3.1.1 Core and North Zones Existing System

The Core and North Zones groundwater production capacity is sufficient to meet maximum day demand with the largest well off-line based on recent water use trends, but there is limited capacity to meet demand growth.

With the largest well off-line, the School Well, groundwater capacity is reduced to 2,300 gpm and is almost equal to the maximum day demand of 1,930 gpm for these zones in 2014. Account information from 2008 through 2015 show the highest maximum day demand for these zones occurred in 2008 at approximately 2,480 gpm (3.6 MGD). Since 2008, demands have decreased. The maximum day demand average from 2009 through 2015 is approximately 1,950 gpm.

4.2.4.3.1.2 South Zone Existing System

In general, the South Zone has surplus capacity and storage, but high fire flow potential and irrigation demands support the need for the two tanks in the South Zone. With the largest well off-line, the Park Lane Well, groundwater capacity is reduced to 1,900 gpm. The highest maximum day demand for the South Zone occurred in 2008 at approximately 620 gpm. Since 2008, demands have decreased.

4.2.4.3.1.3 Future System Demands

The City needs to plan for future demands when determining the treatment option for Cr(VI). The WSMP projects near-term and buildout demand conditions based on the City's projected General Plan land uses. The projected demand assumptions are discussed in detail in Chapter 3.

As development occurs in the City's Southwest Dixon Specific Plan, the recommendation is to hydraulically interconnect the Core Zone with the South Zone. The Core Zone has relatively small growth as it is mostly built out currently. The South Zone and North Zone both show large increases in demands. The projected maximum day demands for the entire City water service area in 2030 is 7,832 gpm. The projected maximum day demands for the entire City water service area at buildout is 10,904 gpm.

4.2.4.3.1.4 Cr(VI) Treatment Recommendations

The recommendations that the City has received for Cr(VI) treatment have focused on the City's existing system. Based on the existing system facilities and operations, the construction of two centralized treatment facilities appear to be the recommended option.

The City's future system has not been evaluated at this time for Cr(VI) treatment options. Additional evaluation needs to occur, taking into consideration the City's future demand growth and system improvements, to ensure facilities will meet the City's existing needs as well as the planned future growth. A comprehensive evaluation for recommended options should include evaluation of impacts to system operations, distribution facility requirements, and existing and future capacity needs once SWRCB has established a new Cr(VI) MCL.

This WSMP was not scoped to evaluate the different Cr(VI) treatment option impacts to system operations or infrastructure. Improvement recommendations made in *Chapter 7 Existing Water System Evaluation* and *Chapter 8 Future Water System Evaluation* are based on the City continuing to operate existing and future facilities in a similar manner. No costs have been included for Cr(VI) treatment facilities in the CIP presented in Chapter 10.

4.3 HISTORICAL WATER PRODUCTION

The following sections provide a summary of the City's historical water production totals.

4.3.1 Total Groundwater Use

The City pumped approximately 580.5 MG of groundwater for potable water consumption in 2015. From 2010 to 2015, the City's groundwater production has decreased by approximately 18 percent. The City's decline in groundwater production over the past years is largely due to California's ongoing drought and conservation efforts. Table 4-7 summarizes the City's historical groundwater production from 2005 to 2015.

Table 4-7. Historical Groundwater Production (2005-2015)[a]

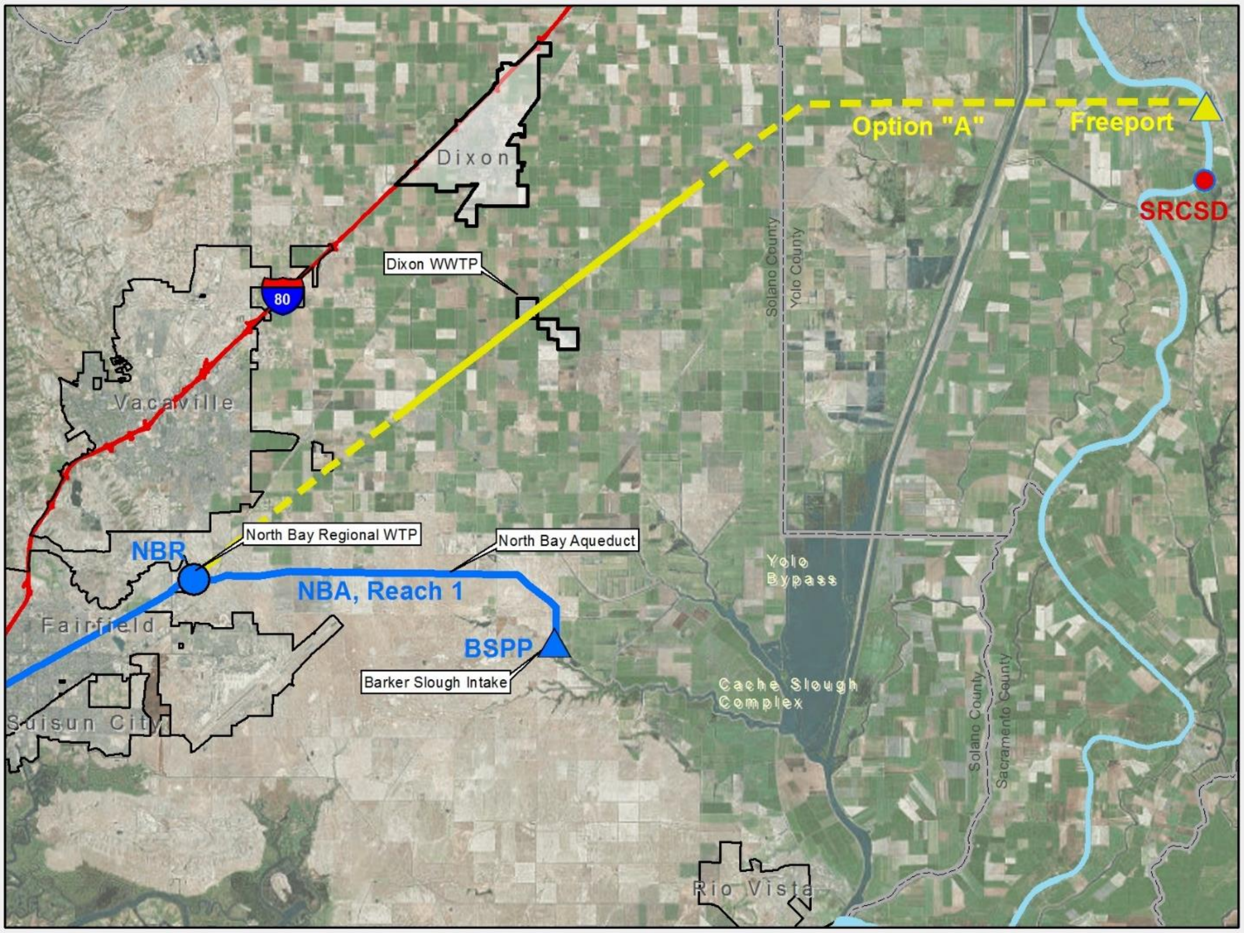
Year	Total Production for Retail System, MG	Average Day Demand, mgd
2005	747.5	2.0
2006	741.5	2.0
2007	860.0	2.4
2008	845.6	2.3
2009	801.0	2.2
2010	706.5	1.9
2011	693.9	1.9
2012	729.6	2.0
2013	777.0	2.1
2014	577.6	1.6
2015	580.5	1.6

(a) Source: 2005 to 2015 data provided by City staff.

4.4 SURFACE WATER RIGHTS

The City may want to begin exploring the possibility of using its surface water rights in conjunction with groundwater. One potential surface water option the City has is through the North Bay Aqueduct (NBA) Intake Project being implemented by DWR. This project will bring water from the Sacramento River through a new intake facility near River Mile 51 upstream of the Freeport Regional Water Authority intake through a pipeline connecting to the existing NBA system near Fairfield. The proposed preliminary Option "A" alignment for the pipeline crosses the City's wastewater treatment plant (WWTP), as shown in Figure 4-4. With the preliminary Option "A" alignment, the City may have the opportunity to access the water at their WWTP location and bring the surface water supply to the City's water distribution system.

Figure 4-4. North Bay Aqueduct Alternate Intake Project



Source: Solano County Water Agency North Bay Aqueduct Alternate Intake Project Flier

As regulations become more stringent and regional water resources become scarcer, integration of other water supply sources could be desirable to strengthen management and sustainability of the groundwater resources, and provide the City with additional supply reliability. However, costs for a surface water feasibility study have not been included because it was assumed that the City will rely on groundwater only to meet future demands.

4.5 WATER SUPPLY SUMMARY

In the future, the City can rely on continued use of groundwater to meet projected water demands provided Cr(VI) compliance is being met. Consequently, for planning purposes in this WSMP, it was assumed that City will meet all future demands with groundwater.

4.6 REFERENCES

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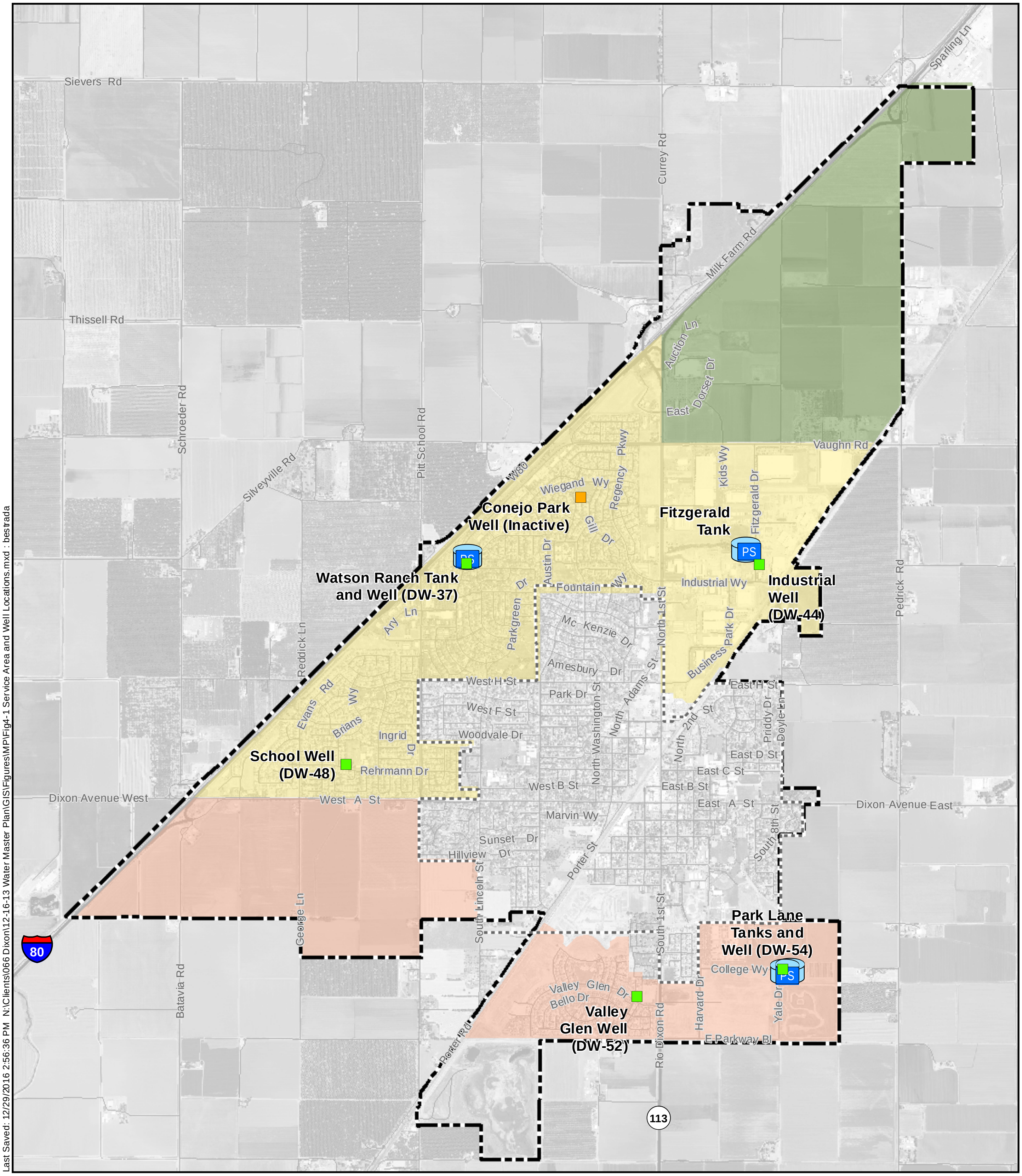

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Symbology

- Active Municipal Well
- Inactive Irrigation Well
- PS Booster Pump Station
- Tank
- Dixon City Limits
- Cal Water Service Area

City Water Service Area

- Core Zone
- North Zone
- South Zone

N

0 1,500 3,000

Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 4-1

Service Area and Well Locations

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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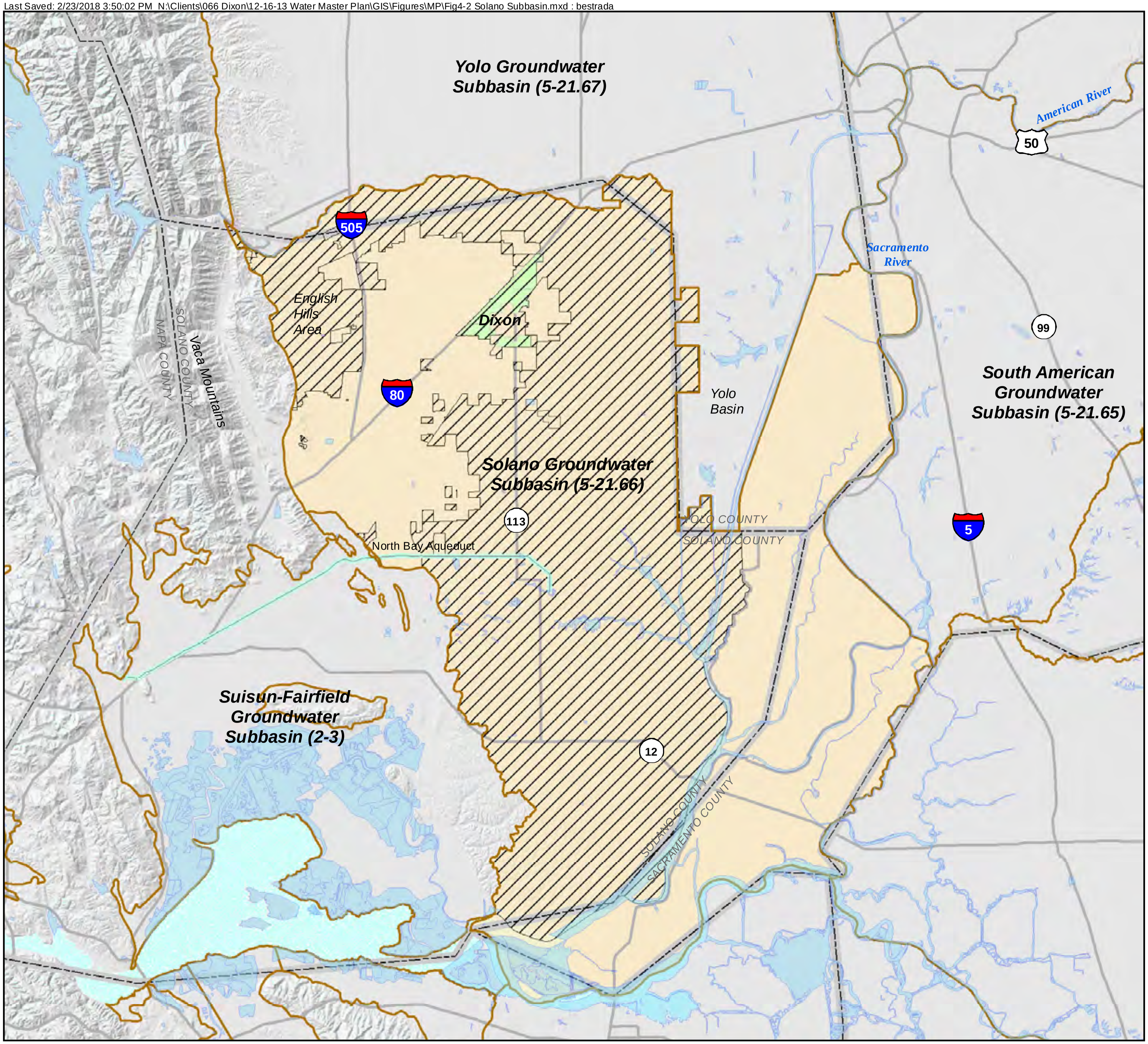

Notes:
1. Groundwater basin boundaries based on DWR Bulletin 118 basin boundaries posted in October 2016.

Symbology

- North Bay Aqueduct
- DWR Groundwater Subbasin Boundary
- Solano Subbasin GSA
- Solano Subbasin
- City Water Service Area
- Dixon City Limits
- County Boundary

Figure 4-2

Solano Subbasin Location Map

City of Dixon
Water System Master Plan and Hydraulic Model Update

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CHAPTER 5
Planning and Design Criteria

The purpose of this chapter is to define the planning and design criteria for analyzing the performance of the City's potable water distribution system. This chapter summarizes the following planning and operational criteria for the City's water system:

- Demand Factors
- Distribution System Performance
- Facilities Sizing

These criteria, summarized in Table 5-1, reflect typical water system industry standards, including the California Safe Drinking Water Act and related laws, California Waterworks Standards, and the California Fire Code standards.

The system performance and facility sizing criteria used for the WSMP is based on the City's Engineering Design Standards (August 2014) and criteria used in the 2000 Master Plan. West Yost reviewed nearby water agency criteria to assess how the City's criteria compares to other agencies in the general vicinity and determine if the City should revise their criteria. Table 5-2 shows a comparison of the City's criteria compared to Cal Water Dixon, Woodland, Sacramento, and West Sacramento. The City's criteria were found to be similar to other agencies in the nearby area and, therefore, no revisions to the City's criteria are recommended.

5.1 DEMAND FACTORS

5.1.1 Unit Demand Factors to Calculate Average Daily Demand

The methodology for projecting future water demands uses information from the City of Dixon General Plan projected land use, along with unit water demand factors to estimate future demands. Details for the methodology for existing and future demand projections are discussed in Chapter 3.

The General Plan provides planning information on land use within the existing City limits and the City's Sphere of Influence. Table 5-3 summarizes the recommended unit water demand factors to be used in the WSMP analysis. These factors are applied to parcels that are currently undeveloped or within the Sphere of Influence for future development.

Table 5-1. Summary of Recommended Potable Water System Performance and Operational Criteria

Component	Criteria	Remarks / Issues
Fire Flow Requirements (flow [gpm] @ duration [hours])[a]		
Single Family Residential	1,000 gpm @ 3 hrs	
Multi Family Residential	2,500 gpm @ 3 hrs	
Commercial and Industrial	3,500 gpm @ 3 hrs	Includes schools
Commercial and Industrial in Northeast Quadrant	4,000 gpm @ 3 hrs	
Water Supply Capacity[b]		
Supply / Pumping Capacity	Provide firm supply capacity equal to maximum day demand for each zone	Firm groundwater supply capacity is defined as the largest facility out of service for maintenance.
Water Distribution System Capacity[b]		
Maximum Day Demand plus Fire Flow	Provide firm capacity equal to maximum day demand plus fire flow	
Peak Hour Demand	Provide firm capacity equal to peak hour demand	
Pumping Facility Capacity[b]		
Pumping Capacity	Provide the greater of maximum day concurrent with fire flow or peak hour demand	Assume firm pumping capacity. Firm pumping capacity is defined as the total booster pump station capacity with the largest pump out of service.
Backup Power	Provide backup power at all wells and pump stations	
Water Storage Capacity[b]		
Operational	20 percent of maximum day demand	
Fire	3,500 gpm @ 3 hrs = 0.63MG	
Emergency	1 x average day demand (minimum)	Provided by the City's backup power at all pumping facilities.
Total Water Storage Capacity	Operational + Fire + Emergency	
Distribution System Pressures[a]		
Minimum Pressure - Normal Operating Conditions	35 psi	
Minimum Pressure - Peak Hour Conditions	30 psi	
Maximum Pressure	70 psi	
Minimum Pressure - Fire Flow Conditions	20 psi	At all customer service connections
Water Transmission and Distribution Pipelines[a]		
Minimum Pipeline Diameter	6-inch; 12-inch for multi-family residential, commercial, and industrial developments with more than two units	Locate new distribution pipelines within designated utility corridors wherever possible.
Maximum velocity - Normal Operating Conditions	6 ft/s	Criteria based on requirements for new development. Existing distribution mains will be evaluated on case-by-case basis. Evaluation will include age, material, type, velocity, headloss and pressure.
Maximum velocity - Fire Flow Conditions	12 ft/s	
Hazen Williams "C" Factor	130	For consistency in hydraulic modeling.
Pipeline Material	PVC	For consistency in hydraulic modeling.

[a] Criteria based on the City's Engineering Design Standards, August 2014 Section 5.
[b] Criteria included in the City's 2000 Master Plan.
hrs = hours
psi = pounds per square inch
ft/s = feet per second

Table 5-2. Nearby Water Agency System Performance and Operational Criteria

Criteria	City of Dixon		Cal Water Dixon[a]		Woodland[b]		Sacramento[c]		West Sacramento[d]	
Fire Flow[e]										
	Flow, gpm	Duration, hours	Flow, gpm	Duration, hours	Flow, gpm	Duration, hours	Flow, gpm	Duration, hours	Flow, gpm	Duration, hours
Single Family Residential	1000	3	1500	3	1000	2	1500	2	1000	2
Multi Family Residential	2500	3	2500	3	1500	2	2000	2	1500	2
Commercial	3500/4000	3	4000	3	3000	3	3500	4	2000	2
Industrial	3500/4000	3	4000	3	4500	4	4500	4	5000	5
Government	3500	3	4000	3	4500	4	4500	4	2000	4
School									4000	4
System Pressure, psi										
Average Day Min	35		50		40		30		40	
Peak Hour Min	30		40		40		30		20	
Max Day + fire Flow	20		20		20		20		20	
Max Day + fire Flow	70		125		70		80		70	
Maximum Velocity, ft/sec										
Average Day	6		5		5		6		7	
Max Day	6		5		5		6		7	
Peak Hour	6		7		8		8		7	
Fire Flow	12		10		10		12		10	
Storage										
Operational	20% of Maximum Day		25% of Maximum Day		25% of Maximum Day		8% of Maximum Day		25% of Maximum Day	
Emergency	1 Average Day		1 Average Day		1 Average Day		1.5 x Average Day		50% of Maximum Day	
Fire Flow	Max Fire Flow		Max Fire Flow		Max Fire Flow		Concurrent Industrial and Single Family Fire Flows		Max Fire Flow	
Emergency Storage Credit	Equal to pumping capacity of wells with backup power		Equal to pumping capacity of wells with backup power				Firm groundwater supply equipped with auxiliary power			
Operational Storage Credit			38% of firm groundwater pumping capacity		50% of firm groundwater pumping capacity		Treated surface water credit equal to the smaller of available treated water supply sources			

(a) Cal Water Dixon 2009 Water Supply and Facilities Master Plan.

(b) City of Woodland 2010 Water Focus Study.

(c) City of Sacramento 2013 Water Supply Master Plan.

(d) West Sacramento 2005 Master Plan.

(e) Fire flow requirements shown assume buildings are equipped with fire sprinklers.

Table 5-3. Recommended Unit Water Demand Factors	
Water Use Type	Unit Demand Factor, af/ac/yr
Single Family Residential	2.7
Multi-Family Residential	3.9
Commercial	1.3
Industrial	1.5
Government	0.3
Landscape	3.0

5.1.2 Peaking Factors

Water system facilities are generally sized for peak demands. The peaking conditions of most concern for water facility sizing are maximum day demand plus fire flow and peak hour demand on the maximum demand day. Average day demand is the average annual water use divided by the number of days in the year. Maximum day demand is the highest demand day of the year, averaged over a 24-hour period. Peak hour demand is the highest demand rate occurring over a 1-hour period during the maximum day demand. Peak water use is typically expressed as a ratio, or peaking factor. The maximum day demand peaking factor is calculated by dividing the maximum day water use by the average daily water use and the peak hour demand peaking factor is calculated by dividing the peak hour water use by the average day water use. These peaking factors are then used, along with existing and future average day demands, to project maximum day and peak hour water use for existing or future customers.

The peaking factors used in the WSMP analysis are as follows:

- Maximum Day Demand Factor = 2.2 times average day demand; and
- Peak Hour Demand Factor = 3.3 times average day demand.

5.2 DISTRIBUTION SYSTEM PERFORMANCE

5.2.1 Peak Supply Capacity

To meet demands, the City must have adequate supply available. The City's peak supply capacity is sized to meet maximum day demand for each of its zones. Per California Waterworks Standards, a system must be able to meet four hours of peak hour demand with source capacity, storage capacity, and/or emergency source connections.

For systems that rely solely on groundwater, a minimum of two supply sources is needed. The City must also be capable of meeting maximum day demand with the highest capacity well off-line. Since the City's North and Core Zones are not interconnected with the South Zone, these supply capacity requirements are applied to each area.

5.2.2 Distribution System Pressures

Adequate system pressure is a basic indicator of acceptable distribution system performance. For normal operating conditions, the water system shall be capable of providing at least 35 pounds per square inch (psi) to existing and future customers and a maximum pressure of 70 psi. System pressures during peak hour demands may drop to 30 psi. The City's typical system pressure operation for normal operations is between 55 and 65 psi. Table 5-1 contains a summary of the performance criteria for the distribution system pressures.

5.2.3 Fire Flow Requirements

The City operates and maintains the water distribution system within its water service area, but the City's Fire Department (Fire Department) is concerned with the availability of adequate water supply for firefighting purposes. Consequently, the Fire Department establishes minimum water flows and residual system pressures during a fire fighting event and provides these criteria to the City for use in master planning.

The Fire Department uses the California Fire Code (CFC) Appendix B, to establish minimum fire flows and durations for individual structures. In contrast, this WSMP evaluates available fire flows to assess distribution system adequacy under existing and buildout demand conditions, using general land use categories that represent different types of development. Therefore, the fire flow requirements set forth in this WSMP are intended only for general planning purposes, and may not be reflective of the actual fire flow requirements sought for specific development approvals, and will not identify existing non-conforming developments.

Table 5-4 presents the recommended fire flow requirements for new development for the WSMP fire flow evaluation based on general land use designations and guidelines. Areas within the City are assumed to meet the fire flow standards that were in place at the time of development, and the City does not replace existing system pipelines that do not meet current fire flow standards, unless improvements are also required for other purposes.

For planning purposes, fire flows are assumed to be met concurrently with a maximum day demand condition, while maintaining a minimum residual system pressure of 20 psi throughout the City's water service area. The 20 psi minimum residual pressure for fire flow is based on requirements in CFC Appendix B Section B102. Additionally, as discussed in subsequent sections of this chapter, fire flows presented in Table 5-4, and their expected duration, are also used to establish storage capacity requirements for the future water system.

Table 5-4. Fire Flow Requirements for New Development[a,b,c]		
Structure	Flow, gpm	Duration, hours
Single Family (Residential)	1,000	3
Multi-Family (Residential)	2,500	3
Commercial[d]	3,500	3
Commercial in North East Quadrant (NEQ)	4,000	3
Industrial	3,500	3
Industrial in NEQ and Future Areas East of Railroad Tracks	4,000	3

(a) Construction type and fire flow calculation area are not generally known during the development of a master plan. Requirements shown are based on general land use designations.
(b) Unique projects or projects with alternate materials may require higher fire flow and should be reviewed by the Fire Marshal on a case-by-case basis.
(c) Fire flows to be supplied at a minimum residual pressure of 20 psi.
(d) Commercial & Industrial includes schools.

5.3 FACILITY SIZING

5.3.1 Pumping Facility Sizing

The City's distribution system relies heavily on booster pump stations for supplying water. Therefore, reliability at the booster pump stations is important. Pump station capacity calculations use firm pumping capacity, where firm capacity is defined as the capacity available with the largest pump reserved as a standby.

Sufficient water system pumping capacity should be provided to meet the greater of these two demand scenarios:

1. A maximum day demand concurrent with a maximum fire flow event with the largest pump at each booster pump station in standby mode.
2. A peak hour demand with the largest pump at each booster pump station in standby mode.

To ensure the City's supply is both adequate and reliable, the system design standards for pumping facilities require the following equipment:

- Each well and pumping facility should be fed by two separate underground electrical lines from different directions.
- All wells and booster pump stations shall have emergency power to operate during power outages, whether due to emergencies or scheduled maintenance, along with a five-day fuel supply.
- Planned pumping facilities will have a minimum of three pumps with one of the pumps dedicated as a standby pump and the remaining being primary pumps.

5.3.2 Storage Facility Sizing

The total water storage capacity requirement is based on providing storage capacity to cover fluctuations in system demands, provide water for fire suppression, and provide supply for emergencies. The total storage required is determined by summing the storage volumes for the following three components:

- Operational Storage,
- Fire Storage, and
- Emergency Storage.

Storage requirements based on these three components define the “usable storage” in the tank, the volume between the tank overflow level and the “dead” or unusable storage, based on the tank outlet. Usable storage is in contrast to the total storage, which is calculated based on the volume of water between the bottom tank elevation and the tank shell height.

For the WSMP, calculations of required tank volumes are assumed to be usable storage. For developing tank sizes for capital costing, required tank volumes are computed based on the nominal tank volume.

5.3.2.1 Operational Storage

The City’s operational storage criterion consists of equalization storage. Equalization storage is used to balance the difference between supply to the zone and demands in the zone. Supply is typically provided at a rate equal to maximum day demand.

Over any 24-hour period, water demands will vary. Typically, higher water demands will occur during the early morning hours when people are irrigating landscape and getting ready to go to work or school. Water demands will then decline to some nominal baseline level (depending on the proximity to water use patterns of adjacent commercial/industrial areas), and will then begin to increase again depending on outdoor water needs (and corresponding temperature), until it reaches a higher water demand in the early evening hours as people return home from work or school. Throughout the year, the peaks of this cycle will vary according to customer needs; thereby, creating maximum day and peak hour demands.

The City’s operational storage requirement is equal to 20 percent of the total volume of water used on a maximum day.[1] As shown in Table 5-2, the City’s operational storage requirement is similar to other nearby water agencies.

[1] Dixon Solano Municipal Water Service Master Plan for the Water Supply and Delivery System Through Buildout, January 2000.

5.3.2.2 Fire Storage

Fire storage is the volume of water stored in reserve for fire flows. The fire storage volume is determined by multiplying the required maximum fire flow rate, determined based on land uses within the zone, by the required duration. The required fire storage for each zone in the water service area is summarized in Table 5-5.

Table 5-5. Fire Storage Requirements

Zone	Maximum Fire Flow Land Use Type	Required Storage Calculation	Required Fire Storage Volume, MG
North	NEQ Commercial and Industrial	4,000 gpm x 3 hours	0.72
Core	Commercial, Industrial, and School	3,500 gpm x 3 hours	0.63
South	Commercial and School	3,500 gpm x 3 hours	0.63

The City's North and Core Zones are hydraulically connected and fire storage requirements for these areas are evaluated as a single fire storage requirement. Therefore, the fire storage volume for the North Zone, as shown in Table 5-5, is used in this WSMP to determine the total storage for the North and Core Zones. The South Zone is currently not hydraulically connected directly with the City's North or Core Zones. Therefore, for the existing system it is assumed the total required fire storage is contained in the tanks located in the South Zone.

5.3.2.3 Emergency Storage

A reserve of stored water is also required to meet demands during an emergency. An emergency is defined as an unforeseen or unplanned event that may degrade the quality or quantity of potable water supplies available to serve customers. There are three types of emergency events that a water utility typically prepares for:

- Minor Emergency. A fairly routine, normal, or localized event that affects few customers, such as a pipeline break, malfunctioning valve, hydrant break, or a brief power loss. Utilities plan for minor emergencies and typically have staff and materials available to correct them.
- Major Emergency. A disaster that affects an entire, and/or large, portion of a water system, lowers the quality and quantity of the water, or places the health and safety of a community at risk. Examples include water treatment plant failures, raw water contamination, or major power grid outages. Water utilities infrequently experience major emergencies.
- Natural Disaster. A disaster caused by natural forces or events that create water utility emergencies. Examples include earthquakes, forest or brush fires, hurricanes, tornados or high winds, floods, and other severe weather conditions such as freezing or drought.

Determination of the required volume of emergency storage is a policy decision based on the assessment of the risk of failures and the desired degree of system reliability. The amount of required emergency storage is a function of several factors, including the diversity of the supply sources, redundancy and reliability of the production facilities, and the anticipated length of the emergency outage.

Because the City's water supply includes wells, the groundwater basin can account for emergency storage requirements. Sufficient water transmission facilities, however, must be available to distribute this water to demand areas. The City's groundwater supply must be reliably accessed in the event of a power outage or any other emergency that would interrupt system-wide operations. In the case of the City, all wells and pump stations are equipped with auxiliary power which make them a reliable emergency supply. Therefore, the City's total required storage tank capacity does not include an emergency storage component.

5.3.2.4 Total Storage Capacity Recommended

The City's water storage capacity should be the sum of the following components:

- Operational. Volume of water necessary to meet diurnal peaks observed throughout the day, usually designed to be equivalent to at least 20 percent of the maximum day demand.
- Fire Flow. Volume of water necessary to provide the maximum fire flow in the service area multiplied by the duration of the flow rate that must be maintained.

The amount of total system storage and system peaking capacity required to meet these criteria will change over time as the City continues to grow and demands increase. Table 5-6 shows the existing system storage requirements based on the storage criteria.

Table 5-6. Existing System Storage Requirements

Zone	Operational, MG[b]	Fire Flow, MG	Total Storage, MG
North and Core Zone[a]	0.55	0.72	1.27
South	0.14	0.63	0.77

(a) The North and Core Zone are hydraulically connected and therefore storage requirements are calculated based on the combined operational requirement and the higher fire flow requirements.
(b) Operational storage equal to 20 percent of maximum day demand.

5.3.3 Water Transmission and Distribution Pipeline Sizing

Table 5-1 contains the guidelines for new transmission and distribution pipeline sizing. While the guidelines indicate the maximum velocity allowed for pipelines, per the City's Engineering Design Standards section 2.1.2.D, the City prefers an operating velocity of 3 to 4 ft/s. The City uses pipeline velocity criteria for establishing pipeline deficiencies and sizing new pipelines. The City's existing water system will be evaluated using system pressure as the primary criterion. Secondary criteria, such as pipeline velocity, head loss, age, and material type, are used as indicators to locate, and to help prioritize where water system improvements may be needed. Therefore, deficiencies identified in the City's existing water system will be evaluated on a case-by-case basis. For example, if an existing pipeline experiences velocity in excess of the criteria described in Table 5-1, this condition, by itself, does not necessarily indicate a problem as long as the minimum system pressure criterion is satisfied. Other conditions such as pipeline age, material type, and location in the system will also be considered.